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Book of Abstracts

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The Power of Relativistic Jets: A Comparative Study

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We present the results of a comparison between different methods to estimate the power of relativistic jets from active galactic nuclei (AGN). We selected a sample of 32 objects (21 flat-spectrum radio quasars, 7 BL Lacertae objects, 2 misaligned AGN, and 2 changing-look AGN) from the very large baseline array (VLBA) observations at 43~GHz of the Boston University blazar program. We then calculated the total, radiative, and kinetic jet power from both radio and high-energy gamma-ray observations, and compared the values. We found an excellent agreement between the radiative power calculated by using the Blandford and Königl model with 37 or 43 GHz data and the values derived from the high-energy γ-ray luminosity. The agreement is still acceptable if 15 GHz data are used, although with a larger dispersion, but it improves if we use a constant fraction of the γ-ray luminosity. We found a good agreement also for the kinetic power calculated with the Blandford and Königl model with 15 GHz data and the value from the extended radio emission. We also propose some easy-to-use equations to estimate the jet power.

Reference: Foschini et al., 2024, *Universe* **10**, 156.

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Revisiting Magnetic Monopoles bounds in light of new results of the Intergalactic Magnetic Field

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Although significantly fainter than the Galactic Magnetic Field (GMF), the Intergalactic Magnetic Field (IGMF) is believed to pervade the vast Cosmic voids. The IGMF was lately constrained by novel upper and lower experimental limits which motivated us to investigate the scenario in which Magnetic Monopoles (MMs) are accelerated in the IGMF and GMF. We found that IGMF acceleration demands an update of the long-standing Parker bound. MMs are fascinating composite fields emerging naturally in several Beyond Standard Model physics. In this contribution we elaborate the acceleration scenario, and are therefore able to connect in a unique framework the MM mass, flux and speed at the Earth. This allows us to revisit the latest experimental limits solely expressed in terms of Lorentz factor. A dedicated attention will be made on the prospects for present and future Imaging Atmospheric Cherenkov Telescopes such as the Cherenkov Telescope Array in search of MMs.

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Proton LIDAR - direct measurement of atmospheric transmission profile with Cherenkov telescopes

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Imaging Atmospheric Cherenkov Telescopes (IACTs), the most sensitive astronomical instruments in the VHE band, rely on the Earth's atmosphere as part of the detector. Therefore the presence of clouds affects observations and introduces biases which need to be corrected. Typical correction methods require knowledge of the instantaneous atmospheric profile, that is usually measured with external atmospheric monitoring devices, such as LIDAR. We present a novel method for measuring the atmospheric profile using directly the data from IACTs. This method exploits the comparison of the average longitudinal distribution of the Cherenkov light recorded in clear atmosphere, with those obtained in the presence of clouds. Using Monte Carlo simulations of a subarray of four Large-Sized Telescopes of the upcoming Cherenkov Telescope Array Observatory we evaluate the accuracy of the method in determining the basic cloud parameters. The method is shown to reconstruct the transmission of typical clouds with an absolute accuracy of a few percent. For low-zenith observations, the height of the cloud centre can be reconstructed with a typical accuracy of a few hundred metres. We evaluate the robustness of the method against the typical systematic uncertainties affecting IACTs.

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Recent optical spectral variability in the first gamma-ray detected NLS1: the case of PMN J0948+0022.

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Narrow-line Seyfert 1 (NLS1) are a subset of AGN that accrete matter near or above the Eddington limit. Some of these galaxies can generate relativistic jets and emit gamma rays, as demonstrated by PMN J0948+0022, the first identified gamma-ray NLS1. In the early 2000s, its optical spectrum showed weak forbidden lines and a narrow Hβ line with a Lorentzian profile, indicating turbulent motion in the nuclear gas. However, recent observations with XSHOOTER and MUSE revealed a composite line profile, with a broad component and a narrow peak, typical of Intermediate Seyfert (IS), a poorly understood class of AGN whose nature is still unclear. The analysis of optical spectra from SDSS, XSHOOTER, and MUSE taken at different epochs suggests a change of the physical conditions around the supermassive black hole. These observations offer new insights into the changing-look AGN phenomena, and, particularly, about the transient nature of IS and NLS1 galaxies within the AGN lifecycle, showing how these two classes of gamma-ray emitting sources can be linked, and enriching our understanding of AGN evolution.

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A novel image correction method for cloud-affected observations with Imaging Atmospheric Cherenkov Telescopes

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The imaging atmospheric Cherenkov observational technique employs the atmosphere as part of the detector, thus it is sensitive to all the changes taking place in it. Particularly, in the presence of clouds, the detector registers incomplete and degraded information caused by additional light absorption. Such data are often rejected from further analyses due to increased systematic errors. In order to exploit data that are affected by the presence of clouds, we developed an innovative correction method on the image parameters based on a simple geometrical model. In this approach, the pixel position on the camera is related to the expected height of the emitted Cherenkov light registered by that pixel.

We present the results of an investigation of a correction method applied to Monte Carlo simulations, imitating the very-high-energy events affected by clouds registered by an array of four Large-Sized Telescopes, at the core of the future Cherenkov Telescope Array Observatory Northern site. We studied the one- and two-layer clouds located at different heights, assuming various transmission parameters. We show the effect of the correction method, which efficiently corrects for the extinction of light in clouds and improves the reconstruction of gamma-ray events, as well as overall system performance. In particular, this correction method does not need additional time-consuming and computationally intensive Monte Carlo simulations in order to be applied to real data.

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Fermi-LAT Discovery of a Gamma-ray Outburst from Comptact Steep Spectrum object 3C 216

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3C 216 is an extra-galactic radio source classified as a Compact-Steep Spectrum. The source is known to have extended radio structure on kpc scale and a blazar core on pc scale. In general high energy emission is more easily observed in blazars, whose jets are closely aligned with the line of sight. Starting from November 2022 Fermi-LAT observed an enhancement in the gamma-ray activity of 3C 216, which culminated in a strong outburst in May 2023. The event was followed up by the Swift telescope. We performed a careful analysis of the multifrequency data (optical, UV, X-ray, Gamma-ray) collected in the first week of May 2023. We observed that the spectral energy distribution of the flaring source evolves in a coherent way, suggesting that the multifrequency emission traces back to the same origin. This result supports the idea that the gamma-ray emission can be interpreted within a single zone Synchrotron Self-Compton model, with important implications on the mechanisms that power energetic radiation in AGN jets.

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INSPIRE: exploring MeV gamma ray sky with a small satellite

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Approximately 300 stable elements exist in nature. However, the origin of r-process elements such as Pt, Au, and other rare-earth elements is still under debate. They may have originated in an explosive event, such as binary neutron star mergers called "kilonova", through a rapid neutron-capture process. In the case of a kilonova, 20–50% of the total radioactive energy can be released in the form of gamma rays on timescales of hours to a month. Therefore, various gamma-ray lines are anticipated in the spectra between 30 keV and 3 MeV. However, MeV observations in space are limited, as represented by past observations made by COMPTEL/CGRO in the 1990s and by SPI/INTEGRAL in the 2000s. These giant detectors with mass exceeding 1000 kg require a long development period of over 10 years. In the 2020s, more than 300 small satellites are launched annually, some of which are being used to promote space science. Waseda University and Tokyo Tech are also developing a 75 kg-class small satellite, tentatively named Innovative Space Probe for Imaging R-process Emission, which is scheduled for launch in 2027. The primary detector of the satellite is a BOX-type Compton Camera (CC-Box) that enables the observation of low-energy gamma rays (30–200 keV) in pinhole mode and high-energy gamma rays (150 keV–3 MeV) in Compton mode. The CC-Box is 19 × 19 × 11 cm in dimensions and weighs 10 kg. The CC-Box consists of a pixelized Ce:GAGG scintillator array comprising a depth-of-interaction structure, which is optically coupled to a Si-PM (MPPC) array. Although the CC-BOX is very small and lightweight, its anticipated sensitivity is comparable to or better than that of COMPTEL below 1 MeV. In this presentation, we briefly reviewed the design concept, observational strategy, and performance of the CC-BOX based on a detailed simulation assuming a sun synchronous orbit. Finally, we review the current status of developing an engineering model and various experimental results using the prototype CC-BOX implemented in nuclear medicine and atmospheric observations, such as atmospheric gamma-ray imaging of thunderclouds.

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On the origin of the spectral features observed in the cosmic ray spectrum

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Recent measurements revealed the presence of several features in the cosmic ray spectrum. In particular, the proton and helium spectra exhibit a spectral hardening at ~ 300 GV and a spectral steeping at ~ 15 TV, followed by the well known knee-like feature at ~ 3 PV. The spectra of heavier nuclei also harden at ~ 300 GV, while no claim can be currently done about the presence of the ~15 TV softening, due to low statistics. In addition, the B/C ratio seems to become rather flat at ~ 1 TeV/n.
We present a novel scenario for cosmic ray sources and transport in the Galaxy that may explain such features. The proposed model is based mainly on two assumptions. First, in the Galactic disk, where magnetic field lines are mainly oriented along the Galactic plane, particle scattering is assumed to be very inefficient. Therefore, the transport of cosmic rays from the disk to the halo is set by the magnetic field line random walk induced by large scale turbulence. Second, we propose that the spectral steepening at ~ 15 TV is related to the typical maximum rigidity reached in the acceleration of cosmic rays by the majority of supernova remnants, while we assume that only a fraction of sources, contributing to ~ 10 − 20% of the cosmic ray population, can accelerate particles up to ~ PV.
We show that, within this framework, it is possible to reproduce the proton and helium spectra from GV to multi-PV, and the p/He ratio, the spectra of cosmic ray from lithium to iron, the pbar flux and the pbar/p ratio and the abundance ratios B/C, B/O, C/O, Be/C, Be/O, Be/B. We also discuss the 10Be/9Be ratio in view of the recent AMS-02 preliminary measurements.

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High Energy Phenomena at the Galactic Center: Fermi Bubbles and Sgr A Lobes

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The center of our Milky Way galaxy hosts a series of energetic outbursts, including the well-known Fermi and eROSITA bubbles, Galactic center chimneys, the inner 15-pc Sgr A lobes. Are they long-lasting or fast evolving explosive events? What causes these structures? Are they PeVatrons related to ultra high energy gamma ray emissions from the central molecular zone and the Galactic center? The Fermi and eROSITA bubbles may correspond to typical galactic feedback processes occurring in our own Galaxy in the near past. Galactic feedback is one central unsolved problem in contemporary astronomy, and the Fermi and eROSITA bubbles are also galactic-scale accelerators of cosmic rays, whose origin remains a century-long mystery. In this talk, I will describe our AGN jet-shock model of the Fermi bubbles, which could explain the X-ray, gamma-ray, and microwave observations of the Fermi bubbles, suggesting that they were produced by a pair of powerful jets emanating from the supermassive black hole at the Galactic center about 5 million years ago. I will also present our new TDE jet model for the origin of the Sgr A lobes, which is expected to contribute significantly to the ultra high energy gamma ray emissions from the Galactic center.

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Observational Evidence for Magnetic Field Amplification in SN 1006

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We report the first observational evidence for magnetic field amplification in the north-east/south-west (NE/SW) shells of supernova remnant SN 1006. SN1006 is one of the most promising sites of the production of galactic cosmic ray (CRs) through diffusive shock acceleration (DSA), although the detailed process of DSA is not well understood. Particularly, the magnetic field strength and structure are vital for determining the maximum energy of particles that can be accelerated in the shock. In previous studies, the strength of magnetic fields in these shells was estimated to be $\mathrm{B}_{\mathrm{SED}}$ ⊠ 25μG from the spectral energy distribution, where the synchrotron emission from relativistic electrons accounted for radio to X-rays, along with the inverse Compton emission extending from the GeV to TeV energy bands. However, the analysis of broadband radio data, ranging from 1.37 GHz to 100 GHz, indicated that the radio spectrum steepened from $_{1}$ = 0.52±0.02 to $_{2}$ = 1.34±0.21 by $_{12}$= 0.85 ± 0.21. This is naturally interpreted as a cooling break under strong magnetic field of B_{HS}⊠2.5 mG. The break indicates that the radio-to-X-ray spectrum may not connect smoothly as the previous study, which is supported by the fact that the optical/ultra-violet counterpart of SN 1006 is extremely faint except for the bright Hα filament in the north-west shell. Therefore, we suggested "double"electron population for the broadband SED; the first population is responsible for the synchrotron emission in hot spots where the magnetic field is 2.5 mG. The second population radiates another synchrotron emission in the "average"magnetic field, B=25μG. Moreover, we investigated the high-resolution MeerKAT image and discovered that the width of the radio NE/SW shells was broader than that of the X-ray shell by a factor of only approximately 10, as measured by Chandra. The ratio of the observed shell width of shells $\mathrm{D}_{\mathrm{R}}/\mathrm{D}_{\mathrm{X}}$ also indicates that the magnetic fields, which mainly contribute to the radio and X-ray emissions, B_{R} and B_{X}, can not be the same. Assuming $\mathrm{D}_{\mathrm{R}}/\mathrm{D}_{\mathrm{X}}$⊠10, we except $\mathrm{B}_{\mathrm{R}}/\mathrm{B}_{\mathrm{X}}$⊠100. This exactly agrees with the amplification ratio which is independently estimated from the SED. If the magnetic field is enhanced by a factor of a ⊠ 100 within "hot spots"along the NE/SW shells, we argue that the filling factor of such hot spots must be as low as k ⊠ 2.5×10^{-5}.

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Measurments of the optical spectral shape of early GRB emission from NUTTelA-TAO

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Instruments such as the ROTSE, TORTORA, Pi of the Sky, MASTER-net, and others have recorded single-band optical flux measurements of gamma-ray bursts starting as early as ~ 10 seconds after gamma-ray trigger. The earliest measurements of optical spectral shape have been made only much later, typically on hour time scales, never starting less than a minute after trigger, until now. We designed and built a unique instrument, the Burst Simultaneous Three-channel Imager, mounted on the 700 mm aperture Nazarbayev University Transient Telescope at Assy-Turgen Astrophysical Observatory (NUTTelA-TAO), to make these measurements. The system can point and track any celestial target above 15◦ altitude in ≤ 8 s, responding automatically to Swift and other real-time GRB alerts, with time resolution down to ~ 0.1 seconds. We observed GRB 201015A and GRB 200925B starting only 58 and 129 seconds, respectively, after the BAT trigger, measuring in three Sloan filter bands, g', r', and i'. We find that the majority of the optical spectral slope evolution is consistent with a monotonic decay of extinction, evidence of dust destruction. I also present the observations of GRB 230328B and GRB 231111A, which started 41 seconds after the trigger. Our work shows that significant information about the early emission phase is being missed without such early observations with simultaneous multi-band instruments.

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Gamma-rays from quasi-spherical explosions

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Some classes of transient sources (e.g. Novae or Kilonovae) can be at first approximation well modeled by quasi-spherical explosions in which central hot objects are surrounded by fast expanding shells. We assume that processes in the shells can turn to the acceleration of relativistic electrons which are able to comptonize soft radiation from the central object. We calculate the time dependent gamma-ray emission expected in such model applying parameters observed in the above mentioned transient sources.

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Development of a background-estimation technique in regions of degree-scale gamma-ray emission for IACTs

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Identifying extended degree-scale γ-ray structures is a challenging task for imaging atmosperic cherenkov telescopes (IACTs). This is primarily due to their comparatively small field-of-view (FOV) of around 3.5° - 5°, and a large background induced by cosmic-rays. In order to estimate this background, many approaches depend on the existence of a γ-ray free region in each observation, from which the background rate, given the respective observation conditions, can be estimated. However, this is only possible in cases in which the extension of the γ-ray emission is significantly smaller than the FOV of the telescopes.

We develop a robust approach to estimate the background for use with open source tools combining a energy-dependent background model, created from archival observations, and estimating its normalisation from separate, matched observations of emission-free sky regions. As a result, no emission-free region is necassary in the FOV of the observation, while the background estimation is afflicted with relatively small statistical uncertainties compared to an estimation using a classical ON/OFF approach. To achieve this, we implement an algorithm that identifies observation pairs with the most similar observation conditions. The open-source analysis package \texttt{Gammapy} is then used to estimate the background rate, enabling easy adaptation of the framework to various γ-ray detection facilities. Public data from the H.E.S.S. array of IACTs is used to validate this method. We demonstrate that this approach provides a reliable way to estimate the background rate in complex sky regions where standard background estimation techniques can not be used.

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Investigating the high-energy & very-high-energy gamma-rays of the Geminga pulsar with Fermi-LAT & CTAO LST-1

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The Crab, Geminga and Vela pulsars are among the brightest gamma-ray pulsars detected so far. Fermi-LAT observations revealed that each of these three pulsars has its GeV pulse profile consisting of two peaks and a bridge between them. There are a number of candidate emission regions in a pulsar magnetosphere, and various leptonic mechanisms were proposed to explain pulsars'gamma-ray emission. Understanding the emission mechanisms for each pulsar has long been a subject of intense debates in recent years, and the currently developing Cherenkov Telescope Array Observatory (CTAO) could play an important role in this aspect. We analysed the ⊠15 GeV gamma-ray data of the first Large Size Telescope (LST-1) of CTAO for Geminga, which have been accumulated for a total observation time >50 hr. The LST-1 phase-folded light-curves (aka. phaseograms) of the Geminga pulsar reveal statistically significant emission ($>10\sigma$). This complements the previously published results of Fermi-LAT and MAGIC. We also update the Fermi-LAT phaseograms with the analysis of 15.5 yrs of data. We compare the phaseograms of the Geminga pulsar among different energy bands (from hundred MeV to tens of GeV). Finally, we explore the similarities and differences between the Crab and Geminga pulsars.

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Finding Pulsar TeV halos among VHE sources

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Recent very-high energy (VHE) observational studies have indicated the presence of the so-called TeV halos around several nearby middle-aged pulsars. Follow-up theoretical studies point out the possible general existence of the TeV halos, although under debate. If they generally exist as suggested, they would contribute significantly to cosmic positrons/electrons in our Galaxy. The full operation of Chinese LHAASO WCDA and KM2A turns out to have provided a valuable source list for finding (candidate) TeV halos. Here we report our series of work that have identified more than 10 (candidate) pulsar TeV halos, mostly among the LHAASO source list. Measurements or data from other VHE facilities, Fermi Gamma-ray Space Telescope, and major X-ray telescopes are used in our identification. Combining our results with previous ones about TeV halos, we are able to draw several features of them, and will report them in this talk. These include the estimated efficiency of converting pulsars'spin-down energies to TeV-halo emissions, and its likely independence on pulsars'characteristic ages. We will also discuss their possible extension and spectral properties, while the latter may be used to differentiate them from the other type of pulsar-related TeV emitters, the pulsar wind nebulae.

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VERITAS Highlights

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VERITAS is one of the world's most sensitive detectors of astrophysical very high energy (E> 100 GeV) gamma rays. The array is located in southern Arizona, USA and is made up of four 12-m imaging atmospheric Cherenkov telescopes (IACTs). With nearly 20 years of operation since the first telescope's installation was complete, the instrument has been able to study Galactic sources such as pulsar wind nebulae, binary systems, and supernova remnants; and extragalactic sources such as the starburst galaxy M82, blazars, radio galaxies, gamma-ray bursts and fast radio bursts. Additionally, the instrument provides measurements with direct impact on multimessenger astrophysics, such as dark matter limits from dwarf spheroidal galaxies and neutrino-triggered blazar observations. The instrument was also used to pioneer the use of IACTs as optical intensity interferometers which can provide high angular resolution observations (< 1 mas) at B photometric wavelengths. Recent highlights from the VERITAS observing program and scientific results will be presented.

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Deciphering the gamma-ray emisson from the Cygnus region

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The Cygnus X region has become a source of great interest since its detection in gamma-rays by Fermi, HAWC and recently LHAASO, the latter having measured photon energies above 1 PeV. This likely indicates the presence of a hadronic source of PeV cosmic rays in the region, although the accelerator has not been yet identified. The emission is coincident with the stellar association Cygnus OB2, which hosts hundreds of OB stars and 3 Wolf-Rayet stars distributed within about 15 pc. The feedback of these powerful stars, through interacting stellar winds, a priori provides efficient channels for particle acceleration up to very high energies. Collective processes around the centre of the cluster, acceleration around large-scale wind termination shocks or supernova events are possible scenarios to account for the gamma-ray emission. In order to identify the most plausible mechanisms contributing to the nonthermal processes in the region, we have run large-scale hydrodynamic simulations, resolving individual massive star winds and their interactions. I will show in this talk that these simulations rule out several of the aforementionned acceleration scenarios, in particular because Cygnus OB2 is too extended to enable efficient stellar wind interactions at large scales. I will then present a detailed model of plausible acceleration processes. In the end it seems that the gamma-ray spectrum can only be understood by invoking recent supernovae explosions in the Cygnus X region or a contribution from the Cygnus X-3 microquasar at the highest energies.

Parallel 2 / **20**

Compton polarization signatures in gamma-ray burst models

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Since the first detection of Gamma-ray Bursts (GRBs) in 1967, GRBs have been an active subject of study with many questions still left unanswered. In particular, the dominant radiation mechanism responsible for the prompt emission of GRBs remains an open question. As the host of possible GRB prompt emission models grows it has become clear that relying on spectral information alone to discern between these models may be insufficient. With IXPE successfully operating and several other high-energy polarimetry missions in the planning, high-energy polarimetry offers a new avenue to disentangle different models. To this extent we employ the use of Monte Carlo inverse Compton scattering simulations of various GRB prompt emission models in order to calculate the associated polarization signatures of these models. A particular focus is placed on calculating not only time-integrated polarization predictions, but also time-resolved polarization predictions in addition to enery-resolved polarization predictions.

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Non-thermal lobe of the Milky Way powered by the Galactic Center outflows

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The large-scale structures such as Fermi Bubbles and eROSITA Bubbles provide a unique opportunity to study our Milky Way. However, the nature and origin of these large structures are still under debate. In this talk, I will present the identification of several kpc-scale magnetised structures based on their polarized radio emission and their gamma-ray counterparts, which can be interpreted as the radiation of relativistic electrons in the Galactic magnetic halo. These non-thermal structures extend far above and below the Galactic plane and are spatially coincident with the thermal X-ray emission from the eROSITA Bubbles. The morphological consistency of these structures suggests a common origin, which can be sustained by Galactic outflows driven by the active star-forming regions located at 3 − 5 kpc from the Galactic Centre. These results reveal how X-ray-emitting and magnetised halos of spiral galaxies can be related to intense star formation activities and suggest that the X-shaped coherent magnetic structures observed in their halos can stem from galaxy outflows.

Parallel 1 / **22**

Constraining particle acceleration in young massive compact star clusters with 3D MHD simulations.

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The number of young star clusters identified as sources of gamma-ray emission has been increasing in recent years, hinting at ongoing particle acceleration within these regions. The interaction between winds from massive stars can create collective shocks and lead to the formation of superbubbles (SBs), whose interior is filled with tenuous, hot, turbulent plasma. Characterising these environments can clarify the role of SBs in the Galactic CR ecosystem, in particular with regard to the origin of CRs beyond the knee. In Haerer et al. 2023, we propose that the ring-like TeV gamma-ray emission encircling the cluster on a ~20 pc scale is produced by inverse Compton emission from electrons accelerated at the cluster-wind termination shock. Both a hadronic model and alternative acceleration sites are disfavoured by the extent of the source and the overall energetics. In this study, we note the importance of environmental parameters, such as the magnetic field, which critically determines the maximum energy and particle transport in SBs. I will present 3D MHD simulations of star clusters, highlighting how interactions between individual winds lead to magnetic field amplification to >100 muG and the complex, highly heterogeneous magnetic field morphology. Furthermore, I will discuss how these results might impact particle acceleration and transport in young massive compact star clusters.

Poster hang / **23**

A Fermi-GBM Subthreshold Search Optimized for Magnetars

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Magnetars are amongst the most extreme astrophysical sources in the universe. With their high densities and magnetic field strengths, they are an ideal test case for fundamental physical processes. However, with only 29 known magnetars, the mechanisms for their gamma-ray emission is not well understood. The Fermi Gamma-ray Burst Monitor (GBM) is an ideal instrument in detecting outbursts of gamma rays from magnetars. We took a previously developed search of Fermi-GBM's continuous data and optimized it to identify magnetar bursts below the GBM triggering threshold. In order to do this optimization, we studied the temporal and spectral properties of known magnetars to develop and implement new spectral model templates, optimal energy range, phases shifts and time windows for the search. Here, we present the results of the study and outline the updates to the GBM Targeted Search that have included for the optimization of this search for Magnetars.

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The Search for Gamma-ray Emission from Fermi-GBM Coincident with LVK O4 Events

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Since the detection of the binary neutron star merger (GW170817) in coincidence with the short gamma ray burst (GRB 170817A), the search for electromagnetic emission from similar events has been an imperative part of multi-messenger astronomy. The LIGO\Virgo\Kagra Collaboration (LVK) is currently in the middle of their fourth observing run (O4), which began in May 2023. Of is the most sensitive gravitational wave search to date and predicts a large number of GW detections. Using Fermi-GBM on-board triggers and two sub-threshold searches, the Targeted and the Untargeted Search, The Fermi-GBM team has been searching for coincident gamma-ray emission to these GW events in real time. To date, no new joint events beyond GRB 170817A and GW170817 have been found, however, we place upper limits on the associated gamma-ray luminosity for the events and present joint upper limit skymaps.

Poster hang / 25

The Potential of Water-Cherenkov Air Shower Arrays for detecting transient sources of high-energy astrophysical neutrinos

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In this work, it is demonstrated the potential of modern and future air shower arrays with water-Cherenkov stations for detecting upward-going neutrino events from tens of GeV to hundreds of TeV. The detection methodology employs a novel machine learning-based analysis of the signal time traces of individual stations with multiple photosensors. This enables the reconstruction of the neutrino's direction and the suppression of the overwhelming background produced by cosmic rays. Our

results showcase the complementarity of this approach to existing and upcoming neutrino-detection experiments, such as IceCube and Hyper-Kamiokande.

Poster hang / 26

Gamma-ray emission from dwarf novae

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Dwarf novae are close binary systems where one of the components is a white dwarf that appears to exhibit abrupt and recurrent changes in viscosity in its accretion disk, causing material to fall towards the surface of the star with the consequent release of energy. As a result, these cataclysmic systems intermittently change brightness at different wavelengths. During outbursts, the increased material flow onto the star can cause shocks that may accelerate particles to high energies, with some of these systems being detected in X-rays. Here, the possibility is proposed that dwarf novae may be gamma-ray emitters too. To investigate this, the entirety of the Fermi telescope archive data between 100 MeV and 500 GeV of some canonical dwarf novae of different types during their respective outbursts has been selectively analyzed. As a result, although there is no evidence of Fermi-LAT emission above 5 sigma in any case, excess gamma-ray emission has been detected in some cases, which could be associated with dwarf novae, opening up a new field of study.

Poster hang / 27

Implications to particle acceleration at relativistic shocks from gamma-ray burst afterglows

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Recent TeV detections of gamma-ray burst afterglows offer new insights into particle acceleration at relativistic shocks. Kinetic simulations have improved our understanding of shock microphysics, enhancing models of particle acceleration relevant to afterglows. We explore scenarios for determining the maximum achievable energy, comparing our findings with data from GRB 190829A. This comparison reveals a tension between observations and theoretical expectations. Motivated by this, we developed a Monte Carlo code to revisit acceleration theory for relativistic shocks in uniform and non-uniform magnetic field configurations. In uniform fields, we demonstrate that acceleration requires only strong scattering on one side of the shock. For non-uniform fields, we consider a cylindrical magnetic-field structure typical of astrophysical jets. We find that curvature drifts enable repeated shock-crossings for particles of favourable charge, and neglecting losses extends the maximum energy to the system's confinement limit. These results challenge the misconception that ultra-relativistic shocks cannot serve as effective accelerators, offering a fresh perspective on relativistic shock acceleration. The findings suggest new features on maximum achievable energy and spectral index, indicating the need to revisit current knowledge on relativistic shocks. This could open promising avenues for producing ultra-high energy cosmic rays.

Parallel 2 / 28

Insights into Extragalactic Background Light constraints with MAGIC archival data

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The Extragalactic Background Light (EBL) is the accumulated light emitted throughout the history of the universe, spanning the UV, optical, and IR spectral ranges.
Stars and dust in galaxies are expected to be the main source of the EBL. However, recent direct measurements performed beyond Pluto's orbit (less affected by foregrounds than those performed from the Earth) hint at an EBL level in the optical band larger than the one expected from the integrated contribution of known galaxy populations.
One approach that could solve this controversy uses Very High Energy (VHE) photons coming from sources at cosmological distances. These photons can interact with the EBL producing electron-positron pairs, a process that leaves an imprint on the observed VHE spectrum. This technique, however, requires assumptions on the intrinsic spectrum of the source, which can compromise the robustness of EBL constraints.
In this contribution, we used Monte Carlo simulations and archival data of the MAGIC telescopes to study the impact that the assumptions adopted in the literature have on the estimate of the EBL density, and how using more generic ones would modify the results.
Our results show how the EBL density constraints obtained highly depend on the intrinsic spectral shape assumed for the source. We have studied two different methods to reduce the assumptions on the intrinsic spectral shape to get more robust results. This will be especially important for upcoming observations with new facilities, where systematic uncertainties are expected to play a more significant role compared to statistical ones.

Parallel 2 / 29

First broadband characterization of the TeV blazars Mrk 421 and Mrk 501 with simultaneous X-ray polarization measurements

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Blazars are among the most luminous objects in the γ-ray sky, but the mechanisms behind their emission are still far from understood. In 2022, IXPE reported the first detection of X-ray polarization of blazars, opening a new window for testing acceleration and radiation models.
In this contribution, we present the insights gained on the two archetypal TeV blazars Mrk 421 and Mrk 501 exploring their multi-wavelength behavior during the first IXPE observations. We investigate the X-ray polarization evolution, and combine it, for the first time, with multi-wavelength data from the radio up to the very-high-energy (>0.2 TeV) regime.
For Mrk 501, we find a clear evidence for an extreme emission state in March 2022 with a synchrotron component peaking above 1 keV. In July 2022, it shifts back to lower energies accompanied by a drop in polarization degree in the X-rays. We explain these observations using a two-zone model which builds on the assumption of an energy-stratified jet as indicated by the IXPE results. The shift of the synchrotron peak can be directly connected with the change in polarization degree by a change of magnetization and/or emission region size.
Mrk 421 shows a variety of emission states during the IXPE campaigns, enabling us to correlate polarization signatures with other multi-wavelength features. In June 2022, a polarization angle

swing is observed by IXPE which we connect with a X-ray flux increase and a clear spectral hardening. Simultaneously, our NuSTAR analysis reveals two spectral hysteresis loops going in opposite directions. We use these unique signatures to constrain acceleration and cooling processes.

Plenary / **30**

SWGO: The Southern hemisphere Wide-field Gamma-ray Observatory

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SWGO is an international proposal for the construction of a wide-field observatory to explore the Southern Hemisphere sky in the energy range from a few hundred GeV to the PeV. It aims to open a new observational window in astronomy by being the first wide-field ground-based gamma-ray instrument to survey the austral sky in the very- to ultra-high-energy range, where observational coverage is currently limited to the northern sky thanks to HAWC and LHAASO. SWGO is to be installed in the Andes, in South America, at an altitude superior to 4400 m a.s.l., and will be based on an array of water-Cherenkov detector (WCD) units deployed over a planned extension of 1 km2, arranged as a dense fill-factor core of circa 80,000 m2 surrounded by a sparse outer array. In this presentation we will provide an overview of the status and future plans for the instrument, as well as its science perspectives and goals.

Poster hang / **31**

Accretion and ejection at work in the gamma-ray emitting jetted Narrow-Line Seyfert 1 galaxy 1H 0323+342

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We present a comprehensive investigation into the optical-to-X-rays properties of the gamma-ray emitting jetted Narrow-Line Seyfert 1 galaxy 1H 0323+342 ($z = 0.063$). Our study spans across the years 2006 to 2023, incorporating a rich dataset with 170 $Swift$ observations in the optical, UV, and X-ray bands, integrated with $Fermi$ LAT observations from 2008 to 2023. Our key findings include the delineation of three distinct zones on the photon index-flux plot. Zone 1 suggests robust jet activity, while zone 2 suggests a phase either preceding or succeeding jet emission. Notably, zone 3 hints at a potential quiescent state of jet activity, particularly evident in recent observations. Stability is observed in UV and optical flux values, exhibiting only a low to moderate correlation with X-ray fluxes. Changes in UV and optical spectral indices allude to fluctuations within the accretion disk, with softer spectra evident in zone 3. Furthermore, gamma-ray data from $Fermi$ LAT confirm $Swift$ XRT observations, revealing a decreasing trend in agreement with X-ray data. The temporal evolution of the object suggests a depletion in jet emission power over time, with potential explanations encompassing the Blandford-Znajek theory and scenarios involving disk instabilities.

Plenary / **32**

Large Array of imaging atmospheric Cherenkov Telescopes (LACT): progress and plans

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LHAASO has found more than 40 UHE cosmic accelerators within the Milky Way, with the highest energy photon reaching 1.4 quadrillion electron-volts, the highest energy photon ever observed. Most of these sources are extended sources that require telescopes with higher angular resolution and sensitivity to observe and study their morphology. Therefore, we propose a new project: Large Array of imaging atmospheric Cherenkov Telescopes (LACT). LACT is designed to have 32 telescopes and achieve the angular resolution better than 0.05° above 10 TeV. 32 telescopes will be placed in the LHAASO detector array, the LHAASO muon detector array can provide huge gamma proton discrimination power, increasing the gamma ray observation sensitivity above 10 TeV. Above 100TeV, the sensitivity, with a 500-hour exposure on a single gamma-ray source, is designed to match the sensitivity of LHAASO for one year. This allows us to identify the gamma ray sources in PeVatrons and measure their morphology in detail, which can help us to reveal the mechanism of the gamma ray emission and then deeply explore the origin of the high energy cosmic rays. Each LACT telescope has a FoV of 8° with pixel size of 0.2°. This talk will introduce the design and properties of the LACT, construction plan, as well as the information of prototypes.

Plenary / **33**

Extra-galactic Science (Rapporteur talk)

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I will summarize and comment on key results in the extragalactic context reported during the meeting.

Plenary / **34**

Extragalactic Background Light In The Infrared And The Local Foregrounds

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After briefly reviewing the astrophysical and cosmological relevance of the diffuse extragalactic background light in the infrared and the impossibility to measure it with current instrumentation, I will discuss the possibility to constrain it effectively from measurements of the photon-photon opacity in the direction of local VHE gamma-ray sources.
An important aspect of this project is the assessment of the local foreground radiations, including those inside the galaxy and inside the structure (galaxy cluster) hosting the gamma source, and the local foregrounds in our Milky Way.
Estimates of such local radiations are also essential in the perspective to use VHE observations to

test possible deviations from the standard model of interactions, like LIV violations and ALP effects, and also useful to assess the effects in the propagation of high-energy particles.

Parallel 1 / 35

Vicissitudes in the propagation of highly-energetic gamma rays in our Galaxy

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Recent gamma-ray observations detect photons up to energies of a few PeV. These highly energetic gamma rays are emitted by the most powerful sources in our galaxy. Propagating over astrophysical distances, gamma rays might interact with background photons producing electron-positron pairs, then deflected by astrophysical magnetic fields. In turn, these charged particles might scatter through inverse Compton the galactic radiation fields, triggering electromagnetic cascades. In this scenario, the characterisation of astrophysical environment in which gamma rays travel, specifically background photons and magnetic fields, is crucial. We explore the impact of propagation effects on observables at Earth by simulating galactic sources emitting gamma rays with energy between 100 GeV and 100 PeV. We analyse the imprint of the galactic environment on observed energy spectra and arrival direction maps, revealing gamma-ray absorption features in the former and "deflection" of gamma rays in the latter. Specifically, owing to interstellar radiation field spatial distribution and the galactic magnetic field structure, propagation effects on observables are found to be closely related to the specific gamma-ray source position and to the prompt emission model.

Poster hang / 36

Investigating AGN Jet Recollimation Shocks: Findings from 2D and 3D RMHD Simulations

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Understanding the structure of active galactic nucleus (AGN) jets is still an open question. Relativistic magnetohydrodynamical (RMHD) simulations help study these jets' dynamics and emission. Recent research focuses on instabilities downstream of recollimation shocks, using 3D simulations to show their complex dynamics and effects on jet structures. Turbulence in these regions can accelerate particles to high energies, which may explain extreme behaviors in high-energy peaked blazars. However, intense magnetic fields can suppress these instabilities, which are still being studied. This work looks at different instabilities downstream of recollimation shocks in AGN jets and how they impact particle acceleration and emission in various jet regions. We use high-resolution 2D and 3D simulations to set the stage for detailed RMHD simulations with the PLUTO code. Our results aim to enhance understanding of the spectral energy distribution, intensity, and polarization of non-thermal emissions, providing new insights into AGN jet dynamics.

Parallel 2 / **37**

Lorentz invariance violation search with the Cherenkov Telescope Array Observatory Large-Sized Telescope

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The fast variability of sources such as pulsars, gamma-rays bursts (GRB) or flares of active galactic nuclei (AGN) can be used to detect or constrain Lorentz invariance violation (LIV) by measuring time lags in time of flight of high-energy photons. However, an important source of uncertainty arises from the intrinsic processes within the source. Combining observations of different sources allows us to increase the precision of these measurements as well as to distinguish LIV-induced lag from intrinsic source effects. This has motivated a collaboration among H.E.S.S., MAGIC, and VERITAS to pool their data together in a consortium called Gamma-ray LIV Working Group (γLIV WG). The Cherenkov Telescope Array Observatory (CTAO) is the next-generation TeV gamma-ray observatory. We will present the first results for LIV searches obtained from AGN observations performed with its first prototype, the Large-Sized Telescope (LST-1). LST-1 has joined the γLIV WG in 2023 and the method of combination of these results with the rest of the data will be presented as well.

Poster hang / **38**

Exploring the impact of electromagnetic dissipation on ultrarelativistic plasma outflows

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Ultra-relativistic plasma outflows are intrinsically connected with gamma-ray bursts. Over the years, a large number of analytical and numerical works has been devoted to understanding the intricacies of their complex dynamics, with most of these past studies performed in the ideal MHD regime. We propose a self-similar formalism, based on the expansion of the equations of resistive relativistic magnetohydrodynamics, for the description of these outflows in the vicinity of their symmetry axis and present semi-analytical solutions describing strongly relativistic jets in both the ideal and resistive MHD regimes. Our solutions provide a clear picture of the impact of electromagnetic dissipation on the acceleration and collimation mechanisms which determine the kinetic and morphological characteristics of these relativistic outflows. The resistive MHD solutions are compared to their ideal MHD counterparts, revealing the key differences between the two regimes. Our comparative analysis sheds light on the possible role of electromagnetic dissipation in shaping the dynamics of the ultra-relativistic outflows associated with gamma-ray bursts.

Parallel 1 / **39**

Connection between the Supernova Remnant G284.3-1.8 and the Gamma-ray Binary 1FGL J1018.6-5856: Implications from X-ray Observations with Suzaku

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G284.3−1.8, also known as MSH 10-53, is a supernova remnant (SNR) with a radio shell (e.g., Milne et al. 1989) and thermal X-ray emission (e.g., Williams et al. 2015). Near the center of the SNR is the gamma-ray binary 1FGL J1018.6−5856, which was discovered in high-energy gamma rays by the Fermi Large Area Telescope (Fermi LAT Collaboration 2012). Follow-up observations found X-ray emission (Fermi LAT Collaboration 2012) and also very-high-energy gamma rays (H.E.S.S. Collaboration 2016) from the binary system. The positional coincidence between the SNR and binary is suggestive of a possible physical association between the two systems. We analyzed Suzaku X-ray data of the SNR G284.3−1.8 to clarify its relation with 1FGL J1018.6−5856. In the spectral analysis, the X-ray absorption column density of G284.3−1.8 was found to be $N_{\rm H} \sim 7 \times 10^{21}~{\rm cm}^{-2}$. The value agrees well with that of 1FGL J1018.6−5856, indicating that the two systems are located at the same distances. The X-ray spectrum of G284.3−1.8 is characterized by the strong Mg K-shell line emission. The obtained Mg/Ne mass ratio is $M_{\rm Mg}/M_{\rm Ne} = 0.84 \pm 0.06$, making it categorized as one of the Mg-rich SNRs. Recent studies of Mg-rich SNRs such as N49B (Sato et al. 2024) and G359.0−0.9 (Matsunaga et al. 2024) suggested that Mg-rich ejecta can be realized by a destratification process inside the progenitor star, the so-called shell merger process (e.g., Yadav et al. 2020). In this process, O-burning or Ne-burning shell is merged with an outer shell before the core-collapse, which results in a higher Mg/Ne ratio. Applying the same scenario to the case of G284.3−1.8, the initial mass of its progenitor is estimated to be $M_{\rm ZAMS} < 15 M_{\odot}$. The estimated mass indicates that the supernova explosion should have left behind a neutron star. The stable orbital modulation of 1FGL J1018.6−5856, on the other hand, would be best reproduced in a scenario where its compact object is a pulsar and particles are accelerated at a shock formed by the collision between the pulsar wind and the stellar wind. Therefore, our result suggests that G284.3−1.8 and 1FGL J1018.6−5856 are both remnants of a common supernova explosion.

Parallel 2 / **41**

Deep observations of the starburst galaxy M82 by the VERITAS gamma-ray observatory

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Assuming galactic cosmic rays originate in supernovae and the winds of massive stars, starburst galaxies should produce VHE gamma-ray emission via the interaction of their copious quantities of cosmic rays with their large reservoirs of dense gas. Such VHE emission was detected by VERITAS from the starburst galaxy M82 in 2008-09. An extensive campaign followed these initial observations, yielding a total of 335 h of VERITAS data on M82 to date. Leveraging modern analysis techniques, these VERITAS data show a significantly stronger VHE signal (6.5 standard deviations). The corresponding photon spectrum is well fit by a power law, and the observed integral flux above 450 GeV is about 0.4\% of the Crab Nebula flux above the same energy threshold. The improved VERITAS measurements, when combined with various multi-wavelength data, enable modeling of the underlying emission and transport processes. A purely leptonic scenario for the gamma-ray spectral energy distribution (SED) is found to be unlikely. A hadronic scenario with cosmic rays following a power-law spectrum in momentum (index s=2.35) provides a good match to the observed SED. The synchrotron emission from the secondary electrons indicates that efficient non-radiative losses of cosmic-ray electrons may be related to advective escape from the starburst core.

Parallel 1 / 42

Clouds illuminated by supernova remnants as an explanation for LHAASO unidentified sources

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Wide field-of-view survey instruments with good sensitivity at the highest energies have recently revealed an unexpectedly large population of galactic gamma-ray sources reaching ultra-high-energies (>100 TeV). Several of these have no known counterpart accelerator. However, the highest energy cosmic rays accelerated by supernova remnants will escape from the shock region at early times in the SNRs evolutionary history. These escaped cosmic rays may then interact with nearby target material such as interstellar clouds, undergoing hadronic interactions that subsequently generate a detectable gamma-ray flux. We apply a model for particle acceleration, transport and interactions to catalogues of SNRs and clouds, searching for potential coincidences with LHAASO sources. For the most promising coincidences, we explore the spectral properties in more detail, in particular with a detailed study of LHAASO J2108+5157.

Poster hang / 43

Expected gamma-ray emission from Stellar Clusters acting as Galactic PeVatrons

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Galactic cosmic rays may be accelerated up to PeV energies due to collective stellar winds surrounding stellar clusters. Further particle acceleration may occur due to supernova remnants within the wind-blown bubble. We apply a model of particle acceleration accounting for the stellar cluster wind termination shock and supernova remnant shocks to young and massive stellar clusters catalogued in Gaia DR2. The resulting gamma-ray and neutrino emission and size of the wind-blown bubble are predicted, from which we identify the most suitable candidates for future observations of stellar clusters. Detection prospects for future experimental facilities, taking the flux and angular size into account, are evaluated, along with the flux range allowed due to model assumptions and uncertainties.

Parallel 2 / 44

Magnetospheric Current Sheets in M87*: Pair Enrichment and Ultra-High Energy Proton Acceleration

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Recent progress in numerical simulations of magnetically arrested accretion onto supermassive black holes has provided significant insights into the formation and dynamics of magnetospheric current sheets near the black hole horizon. Focusing on M87* and by treating the pair magnetization in the upstream region and the mass accretion rate as free parameters, we estimate the magnetic field strength and construct numerical models. These models, inspired by recent 3D particle-in-cell simulations, describe the populations of relativistic electrons and positrons (pairs) within the reconnection region. We compute the non-thermal photon spectra for different magnetization values. Our findings indicate that pairs, accelerated to the energy limit set by synchrotron radiation while traversing the current sheet, can generate MeV flares, regardless of magnetization. Additionally, pairs trapped in transient current sheets can produce X-ray counterparts to these MeV flares, with durations of about a day for current sheets of a few gravitational radii. We also show that photon-photon pair creation can enrich the upstream plasma, leading to a new equilibrium magnetization. Furthermore, we investigate the capability of magnetospheric current sheets to accelerate protons to ultra-high energies. Despite limitations from various loss mechanisms, such as synchrotron and photopion losses due to non-thermal emissions from pairs, we find that protons can achieve maximal energies in the range of a few EeV in these sheets around supermassive sub-Eddington accreting black holes.

Parallel 2 / 45

Gamma-ray Emission from Starburst, Main Sequence, and Dead Galaxies: Contributions to Extragalactic Isotropic Backgrounds

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Star-forming galaxies (SFGs) have been considered to be important contributors to the extragalactic gamma-ray background. Their high energy emission is usually considered to be driven predominantly by hadronic processes, and is regulated by the properties of the underlying galaxy populations —in particular their star-formation rates. In these galaxies, cosmic ray protons are accelerated and interact with interstellar gas, producing gamma-rays via the decay of neutral pions. Neutrinos are also generated in this process through charged pion decays, meaning that SFGs can also contribute to the extragalactic neutrino background. However, models that self-consistently predict SFG contributions to extragalactic neutrino and gamma-ray backgrounds tend to under-predict the observed neutrino flux when using the isotropic gamma-ray background as a constraint. This suggests that a large fraction of the neutrino background may not originate from SFGs, and a stronger leptonic component in the gamma-ray background contribution from galaxies is possible. We explore this scenario by considering populations of millisecond pulsars (MSPs) and pulsar halos as potential sources of high-energy gamma-ray emission in galaxies. Our findings suggest that these sources can make a substantial contribution to the gamma-ray emission from evolved massive galaxies and are able to account for a large fraction of the gamma-ray emission detected from nearby main-sequence galaxies. By applying one of the latest semi-analytical galaxy evolution models, UniverseMachine, we demonstrate how galaxies at different evolutionary stages contribute to high-energy multi-messenger backgrounds over cosmic time. We will also discuss how upcoming gamma-ray observations can distinguish between hadronic cosmic ray processes in SFGs and leptonic-driven emission from MSPs and pulsar halos, providing a clearer assessment of the source populations underlying high-energy extragalactic isotropic backgrounds.

Plenary / 47

Gamma-ray emission from Cygnus region

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Cygnus region harbors the most active star forming regions in our Galaxy and is regarded as one of the most promising site for cosmic ray accelerations. This region is also studied intensively in multiwavelength. in this talk I will review the gamma-ray observations towards Cygnus region and discuss the possible applications on the cosmic ray propagation and acceleration.

Parallel 2 / 48

Describing the ultra fast very-high-energy gamma-ray flare of IC 310 with relativistic reconnection models

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Blazars and radio galaxies are famously known to be variable sources across the entire electromagnetic spectrum due to rather close alignment of their jet with our line of sight and relativistic jet speeds. In the very-high-energy (VHE, $E > 100$ GeV) gamma rays, the fastest flares reach hour-to-minute timescales that cannot be explained by the typical shock acceleration scenario. Magnetic reconnection has been proposed as a prospective mechanism on several blazar cases, and models have been applied in the past successfully via a simulated light curve comparison. We build on the past work by using particle-in-cell simulations of plasmoids generated in a relativistic reconnection event in combination with radiative transfer to describe an extremely fast flaring event of the radio galaxy IC 310. Using literature values to restrict our initial simulation priors, we statistically searched for models that reproduce the observed spectral energy distribution (SED) and the light curve simultaneously. We compared the resulting simulated light curves in a statistical manner developed in our previous work. The results of our analysis show that simulations that produce realistic light curves and spectra are necessary in gaining a better understanding of the parameters that describe the jet physics.

Parallel 1 / 49

Ultra-high energy emission from gamma ray binaries

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Gamma ray binaries are a new kind of binary systems whose energy spectrum peaks at gamma rays. The detection of gamma rays from such system is difficult due to its weak and instable signal, and the origin of the complex emission is under debate. With the operation of LHAASO, there are evidences for UHE emission from gamma binary systems, such as LSI +61303, LS 5039 and so on, which may provide crucial information about particle acceleration at highest energy range. This report will give a brief introduction about the detection of UHE emission from gamma ray binaries with LHAASO.

Poster hang / 50

Photo-hadronic pair creation in magnetospheric current sheets of accreting black holes

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A ubiquitous feature of accreting black hole systems is their hard X-ray emission which is thought to be produced through Comptonization of soft photons by electrons and positrons (pairs) in the vicinity of the black hole. The origin and composition of this hot plasma source, known as the corona, is a matter open for debate.
In this contribution we investigate the role of relativistic protons accelerated in black-hole magnetospheric current sheets in the pair enrichment of AGN coronae.
We find cases where photohadronic interactions between protons and photons in the magnetospheric region can produce enough secondary pairs to create coronae with Thomson optical depths, $\tau \sim 0.10 - 10$. More importantly we find a significant dependence of the secondary pair density on the Eddington ratio, defined here as the ratio of the intrinsic X-ray luminosity to the Eddington luminosity of the source: systems with the same Eddington ratio are found to behave in similar ways. We also present the predicted high-energy neutrino spectrum and discuss our results in light of the recent IceCube observations of TeV neutrinos from NGC 1068. We finally discuss the implications of our model for coronae of stellar-mass black hole systems.

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Highlights of the LST Project

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The array of four Large-Sized Telescopes is under construction at La Palma, Spain, under the framework of the Cherenkov Telescope Array Observatory. It will be completed by the end of 2025. The LST consists of a 23m diameter primary reflector with 198 high precision segmented mirrors, a high-resolution camera comprising 1855 channel high Q.E. PMTs and GHz sampling fast readout electronics, and covering 4.5 degrees of FoV. The LST, weighing 110 tons, can fast re-positioning within 20 seconds between any two points in the sky through a high-power flywheel. This allows LST to perform follow-up observations on transient sources such as GRBs. LST can obtain an energy threshold of 20GeV and 50GeV in the zenith and 45-degree observations, respectively, and the distant AGNs can be observed up to the redshift z = 2. The Arrays of LSTs in the North and South will survey the all-sky with unprecedented sensitivity and extend the energy range as low as 20GeV. The first Large-Sized Telescope, LST-1, has been in mono-mode operation for scientific observation since 2020 and has accumulated more than 2000 hours of scientific data. We report highlights of the LST instrumentation and early science results with a mono-mode observation from LST-1.

Poster hang / 53

Modelling a PeVatron source associated with a SNR

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The observation and modelling of the gamma-ray emission from molecular clouds (MCs) is currently the best tool to study Galactic cosmic rays. The highest energy that Galactic cosmic rays achieve is believed to be ~ 10^15 eV, this is 1 PeV, that way a PeVatron is a source accelerating protons up to this energy. The quest for PeVatron sources aims to identify the astrophysical sources of Galactic cosmic rays and is one of the major goals of gamma-ray astronomy. Recently, gamma-ray detectors have reported several Galactic PeVatrons. The identification of the sources is not clear in many of the observed PeVatrons, mainly due to source contamination. One of the favourite PeVatron candidates are supernova remnants (SNRs) associated with molecular clouds. Among the sources that LHAASO detected at energies ~ 100 TeV, only one of them is associated with a SNR+MC system - the source J1908+0621 associated with SNR G40.5-0.5. In this work, using a spatially extended model, we calculate the high-energy emission produced in the interaction of SNR G40.5-0.5 with the ambient medium. We are able to fit the observed gamma-ray emission from a wide range of energies. Our predictions might contribute with the perspectives for the next generation arrays of Cherenkov telescopes on the identification of Galactic PeVatrons.

Parallel 2 / 54

Recent Highlights from the VERITAS AGN Discovery Program

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VERITAS began full-scale operations in 2007 and it remains one of the world's most sensitive very-high-energy (VHE; E > 100 GeV) gamma-ray observatories. More than 8,300 hours (~50%) of its good-weather data were targeted on active galactic nuclei (AGN). Many of these observations were

taken as part of an ongoing, comprehensive program to discover new VHE AGN. Upon discovery, the VERITAS collaboration leverages VHE spectral and variability measurements, and accompanying broadband observations to probe the underlying jet-powered processes in AGN. Recent scientific highlights from the VERITAS AGN discovery program, including the VHE discoveries of RBS 1366 and 1ES 1028+511, and any new announcements, will be presented.

Poster hang / 55

Probing signatures of particle acceleration in blazar flares in a time-dependent SSC model.

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Rapid flux variability over a large range of wavelengths is a well-known signature of blazar emission, with variability time scales of the order of a few days and below frequently observed at high energies.
Radiative models with varying degrees of complexity are generally successful in reproducing individual flare events or overall statistical behaviour, but the physical origin of blazar flares is still unclear. Our study focuses on the shape of light curves of rapid flares considered as individual events from compact emission regions. We have explored the parameter space of a one-zone synchrotron self-Compton model for several physical scenarios leading to flares due to the injection fo additional relativistic electrons, initial acceleration and re-acceleration of electrons due to Fermi-I and Fermi-II mechanisms.
The time-dependent EMBLEM code has been used to solve the kinetic equation describing the evolution of the electron distribution, simulate broad-band spectral distributions and multi-wavelength light curves, taking into account adiabatic expansion and the internal light-crossing effect. We have identified observable signatures in the shapes of the resulting light curves and in the relative amplitudes between different bands that are specific to these generic scenarios.

Parallel 2 / 56

A Multi-wavelength Study of a Long-Duration VHE flare from BL Lacertae with VERITAS

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Blazar variability, specifically in the very-high-energy (VHE; E>100 GeV) regime, can powerfully probe the inner workings of jet dynamics that drive the emission we observe. In late Fall 2022, the Very Energetic Radiation Imaging Telescope Array System (VERITAS) observed VHE flaring activity from BL Lacertae on a much longer timescale than ever seen before. On October 15, 2022, the Fermi-Large Area Telescope detected elevated GeV activity originating from BL Lacertae. This triggered a multi-wavelength campaign, including observations from VERITAS, Swift, and optical and radio observatories. The VERITAS observations resulted in a strong VHE detection. While many rapid (≤1 day) VHE flares from the source have been observed previously, VERITAS continued to detect flaring activity from the source for over a month after the original flaring activity was detected, making this the longest duration VHE flare observed from BL Lacertae. While the spectral energy distribution is well described by a synchrotron self-Compton model with an external inverse-Compton component, the unprecedented duration of the flaring activity represents a challenge for current blazar emission models.

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Deriving Pulsar Properties from Pulsar Wind Nebulae Using Gamma-Ray And Radio Data

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A significant fraction of the highest energy gamma-ray astrophysical sources observed are associated with Pulsar Wind Nebulae (PWNe). Given recent observations, the postulated, but unverified, hadronic component from PWNe requires renewed attention. We estimate possible ranges for the average pulsar pair production multiplicity on 29 sources in the Australia Telescope National Facility (ATNF) catalogue. We then use the latest gamma-ray data from H.E.S.S. and LHAASO in combination with radio data available in the literature to further constrain associated pulsar properties for a set of well-known PWNe. These include lower limits for the pulsar birth period and average pair production multiplicity. Based on these, for all but one source, we cannot exclude the presence of hadrons in the PWN.

Poster hang / 58

Intrinsic time delays and Lorentz invariance violation searches with the Cherenkov Telescope Array Observatory: A feasibility study for flaring blazars

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Lorentz Invariance Violation (LIV) effects could be spotted by Imaging Atmospheric Cherenkov Telescopes (IACTs) by searching for energy-dependent time delays in the gamma-ray photons coming from distant and highly variable astrophysical sources. As part of its scientific program, The Cherenkov Telescope Array Observatory (CTAO) will explore problems in fundamental physics, including studying and constraining the Extragalactic Background Light (EBL), searching for LIV effects and setting constraints on the characteristic LIV energy scale. This work presents the results from a feasibility study performed by simulating realistic observations with the CTA-AGN-VAR pipeline, a Python package based on Gammapy. Using an AGN Evolution Simulator Code (AGNES), the broadband spectra of a TeV blazar flare were modelled using a time-dependent one-zone Synchrotron-Self-Compton (SSC) scenario, and the presupposed LIV delays were introduced as linearly energy-dependent time-lags. Observations with the CTAO Alpha and Omega configuration arrays were assumed for our simulations, taking into account observational constraints. The

response and significance to intrinsic and LIV time delays are predicted for both configurations under the assumed scenario, and one method to discriminate LIV from intrinsic time delays is also presented.

Poster hang / 59

Gamma-rays from active region within stationary inhomogeneous non-local AGN jet

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Two stages of non-thermal emission from relativistic jets in active galaxies can be distinguished: a low level persistent emission and a short period flaring emission. It has been recently proposed that both stages are produced in the inner (parsec scale) jet region when electrons are expected to be accelerated to TeV energies. The low level persistent emission originate in the extended, parsec scale jet but the flaring emission is produced by electrons accelerated in small scale localized region of the jet.
We modify the stationary, non-local, inhomogeneous AGN jet model for the stationary jet emission by introducing a localized flaring active region within the stationary jet which physical parameters differ significantly from those in the extended large scale jet. In such two component jet model the radiation produced by electrons in the stationary part of the jet can interact with particles present in the active region of the jet and the radiation produced in the active region of the jet can interact with electrons in the stationary jet. We show how these different emission components depends on the propagation of the active region within the stationary jet. Their evolution in time can be tested with the future observations with the gamma-ray observatories.

Parallel 1 / 60

Clustering analysis of Fermi-LAT unidentified point sources

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In this work we study clustering of unassociated Fermi-LAT sources and check for counterpart extended sources in TeV catalogues. The goal is to determine whether an extended source model is preferred compared to a cluster of point-like sources. The work is motivated by prior observations of extended TeV gamma-ray sources, such as HESS J1813-178, and their GeV counterparts. In the case of HESS J1813-178, two unidentified Fermi-LAT point sources were detected in the region. Subsequent multiwavelength analysis combining TeV and GeV data showed that a single extended source is a better description of the emission in this region than two point-like sources. In this talk I will present the first results from a systematic study of clusters of unassociated Fermi LAT sources, where we test whether a single extended source has a better description than several point-like sources.

Poster hang / 62

Searching for Axion-like particles: insights from blazar observations with the LST1 telescope

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Axion-like particles (ALPs) are pseudo-Nambu-Goldstone bosons predicted as an extension of the Standard Model of elementary particles, also considered as viable candidates for Dark Matter. When propagating through astronomical environments embedded with magnetic fields, very-high-energy (VHE) gamma rays may undergo conversion into ALPs, thereby altering the spectral energy distribution (SED) of the observed target, and causing energy dependent oscillations in the photon flux. For ALP masses in the neV range and magnetic field strengths of O(μG), these oscillations occur in the GeV energy range, making the Large-Size Telescope (LST) an optimal instrument for testing the ALPs hypothesis in the VHE gamma-ray range. In our study, we use LST1 data of blazars, including Mrk421, Mrk501, and BL Lac. Through the exploration of their observed spectra, we establish constraints on ALP models within the accessible part of the parameter space. This study and its results provide a unique opportunity to study the combined constraints on the ALPs parameter space using different sources observed with the LST1, along with the challenges and advantages that such approach offers.

Parallel 1 / 63

The Galactic diffuse gamma-ray and neutrino emission at the PeV frontier

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The Tibet ASγ and LHAASO collaborations recently provided the first evidence of a diffuse γ-ray emission from the Galactic plane up to the PeV. Due to the challenges this imposes to current theoretical models it is crucial to carefully study different scenarios of diffuse γ-ray production, specially towards the centre of the Galaxy. In particular, the current models of Galactic diffuse γ-ray emission struggle to reproduce ASγ and LHAASO measurements, while consistently reproducing the lower energy data.
In this contribution, we show that these measurements seem to favour an inhomogeneous transport of cosmic rays throughout the Galaxy, specially motivated by the Fermi-LAT detector. Moreover, we discuss the relevance of non-uniform cosmic-ray transport scenarios and the possible detectability of the associated diffuse Galactic neutrino emission by IceCube or Km3Net in the next years.

Poster hang / 64

Exploring the Multi-Messenger Universe with VERITAS

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The promise of multi-messenger astrophysics was clearly shown through coordinated observation campaigns of TXS 0506+056 and GW170817 in 2017. These led to the detection of a flaring gamma-ray blazar that was potentially associated with a high-energy neutrino event, and the first detection of gravitational waves from a neutron star merger by LIGO/Virgo. The multi-messenger group in VERITAS has been using real-time and archival data to search and study potential very-high-energy gamma-ray counterparts of various transients, including GRBs, AGN flares, high-energy neutrinos and gravitational wave events. In this talk, we will present target-of-opportunity observations of the blazars PKS 0735+178, PKS 0446+11, and B3 2247+381 with VERITAS and NuSTAR. We will discuss implications for leptonic and hadronic models of emission in blazars based on the constraints from hard X-ray and TeV gamma-ray observations. We will show VERITAS as a critical component in the global network for a joint study of IceCube neutrino events by combining all four major imaging atmospheric Cherenkov telescopes. We will discuss the prompt search for very-high-energy gamma-ray signals from the LIGO-Virgo-KAGRA O4 run, as well as the investigation of low-significance gravitational wave events using VERITAS archival data.

Parallel 2 / 65

Observation of Astrophysical Sources with SST-1M Telescopes - First Results

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The Single-Mirror Small Size Cherenkov Telescope (SST-1M) was developed by a consortium of institutes in Switzerland, Poland, and the Czech Republic. The SST-1M design is based on the Davies-Cotton concept, featuring a 4-meter mirror and an innovative SiPM-based camera. It is most sensitive to gamma rays in the TeV and multi-TeV energy bands. Since 2021, two SST-1M prototypes have been commissioned at the Ondřejov Observatory in the Czech Republic, where their performance in both mono and stereo observation modes is being tested. During the commissioning phase, several galactic and extragalactic gamma-ray sources have been observed, resulting in multiple detections. In this contribution, we present preliminary results from this observation campaign, focusing on the validation of SST-1M performance based on observations of the Crab Nebula, and discuss future prospects. Additionally, we introduce the data analysis pipeline, sst1mpipe, which is being developed for SST-1M event reconstruction.

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On the nature of the transient gamma-ray source associated with a protostar

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Very recently, gamma-ray emission detected by *Fermi*-LAT was reported from a star forming region NGC 2071. The high-energy radiation was claimed to be associated with occasional mega-flares thought to occur in T Tauri stars. The source, detected at energies $E \sim 100$\,GeV, appears to be transient, and was only detectable during the first two years of observation. In this work, we investigate the nature of the *Fermi* source, assuming that it was produced by particles accelerated in a protostar within NGC 2071. We discuss different scenarios capable of reproducing the detected peculiar spectral energy distribution and the time scale reported for the gamma-ray source.

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Long term multi-wavelength analysis of the Flat Spectrum Radio Quasar OP 313

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The flat spectrum radio quasar OP 313 showed extremely intense γ-ray activity from November 2023 to March 2024, as observed by the Large Area Telescope on board the Fermi Gamma-ray Space Telescope. This initiated a large number of follow-up campaigns at all wavelengths, resulting in a confirmation of the increase of the source activity from the radio to very high energy (VHE) bands. Remarkably, it also led to the first detection of the VHE emission from OP 313 by the Large-Sized Telescope (LST-1) of the Cherennkov Telescope Array Observatory at La Palma and it is also the most distant Active Galactic Nuclei detected at these energies.

We present a multi-wavelength analysis covering 15 years of Fermi-LAT observations, from August 2008 to March 2024. From the Fermi-LAT study of the 15-year light curve, we identify different periods of activity states of the source: one quiescent and two flaring states, soft and hard, that can be compared with the data available from other instruments. In our study, we include X-ray, optical, and radio data collected by Swift Gamma Ray Burst Explorer, the Nordic Optical Telescope, and the Medicina radio telescope. We also make use of public datasets from the FERMI-GST AGN Multi-frequency Monitoring Alliance (F-GAMMA) and the and the Very Long Baseline Interferometry (VLBI) projects Monitoring Of Jets in Active Galactic nuclei with VLBA Experiments (MOJAVE) and VLBA Boston University Blazar. Using this wide multi-wavelength dataset, we want to show that the hard flares are produced outside the broad-line region allowing the relativistic electrons to be accelerated to higher energies. This approach helps us to understand the mechanisms involved in particle acceleration inside the jet, and how radiation in different wavelengths is connected in OP 313.

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An X- and gamma-ray view of the sky region around SNR G69.7+1.0

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In recent years the number of known sources emitting in the TeV-PeV regime has increased significantly thanks to facilities like LHAASO and HAWC. These observations could change our understanding of high-energy processes in our Galaxy. However, many of the observed sources are still unidentified or poorly constrained due to the limited angular resolution of these instruments, and most of the TeV sources are not easily associable with lower-energy counterparts.
In this contribution, we present the first XMM-Newton observation of the sky region around the shell-type radio supernova remnant SNR G69.7+1.0, which recently attracted significant interest due to its spatial coincidence with one of the LHAASO sources emitting at hundreds of TeV.
We also present a reanalysis of Fermi-LAT data, that show the presence of a source spectrally consistent with a pulsar, and a multiwavelength modelization of the whole region.

Poster hang / 69

Searching for highly obscured gamma-ray binaries

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A significant fraction of currently known gamma-ray binaries have bright optical counterparts that were classified as luminous early-type stars in objective prism catalogues compiled more than half a century ago. Representative examples of this statement include, in particular, LS I 61303, LS 5039 and also MWC 148. In previous years, we explored several of these historical catalogues by cross-correlating them with different Galactic plane radio surveys in an attempt to search for weak, non-thermal radio counterparts that could betray new systems where very high-energy phenomena are at work. So far, the degree of success has been low. Nevertheless, it could likely increase in parallel with modern survey sensitivities, hopefully with the new VLA Sky Survey. In this contribution, we report about the recent extension of our approach to the catalogue of highly reddened and distant stars compiled by C. B. Stephenson back in the nineties. As a result, at least one promising candidate has been identified located inside the error circle of the gamma-ray source HAWC J1831−096 and is at present under extensive follow-up study.

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Recent Fermi novae in a multi-wavelength context - [REMOTE]

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Two recent classical novae, V1723 Sco (2024) and V6598 Sgr (2023), were detected by the Fermi-LAT. V1723 Sco is one of the brightest novae observed to date by the LAT, providing a two-week window for detection. The extensive Fermi observations of V1723 Sco, complemented by a rich multi-wavelength dataset including NuSTAR and VLA, enable precise constraints on various parameters of the emission model. On the other hand, despite its brief duration, V6598 Sgr exhibited a unique spectral shape. Interestingly, V6598 Sgr is coincident with a persistent source previously detected by INTEGRAL (IGR J17528-2022) and proposed as an intermediate polar. We will discuss the MWL characteristics of these gamma-ray novae in the light of other novae detected by the LAT, following a unified analysis strategy using the latest Fermi-LAT Pass 8 data, and present constraints derived on the particle acceleration mechanisms.

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A comparative analysis of X-ray lightcurves from X-ray vs GeV/TeV GRB afterglows and its implications.

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Gamma-ray bursts (GRBs) exhibit a rich variety of X-ray lightcurve behaviours, including the presence or absence of plateau/shallow decay phases. There is not yet an agreed consensus about the interpretation of these findings. In this study, we analyse the properties of GRB afterglow X-ray lightcurves, focusing on two distinct populations based on their detection at high and very high energies (HE/VHE) versus X-rays alone. Using available data from the Swift satellite, we systematically compare the X-ray lightcurves (as well as the redshift distributions) of these two GRB populations. Our analysis reveals significant differences in the parameter distributions between the two groups, suggesting simpler lightcurve behaviours for GRBs with HE/VHE emissions, characterised by fewer spectral breaks and distinct slope distributions. These findings support previous research and demonstrate the importance of multi-wavelength observations for better understanding the nature of these emissions. We will also discuss the possible implications of these findings on GRB physics.

Parallel 1 / 72

PeV particles from stellar wind termination shocks

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Young massive stellar clusters have recently brought attention as PeVatrons candidates, to explain the knee of the cosmic ray spectrum and how protons can be accelerated to such energy scale in galactic sources. Since direct verification is not possible because of the diffusion of cosmic rays in the interstellar medium, one can use photons that are produced when cosmic rays interact with ambient matter, especially gamma rays. The new detector LHAASO is the first to probe well the

photon detection band >0.1 PeV corresponding to multi-PeV cosmic rays. Thus, it enables the use of its gamma-ray data to constrain the galactic particle acceleration models and parameters and to identify the contribution from the different categories of galactic accelerators to the observed cosmic ray flux, especially in the PeV domain.

To that extent, we model the escape and the transport of cosmic rays from their accelerator to molecular clouds, where a lot of p-p interactions producing gamma rays occur. We are focusing on the case where the source is a young massive star cluster, hence the particles are accelerated in stellar wind termination shocks before escaping. We try to determine in a semi-analytical approach the parameters needed (distance between cloud and source, time, slope of injection, number of stars, etc) to produce an excess in the gamma-ray flux corresponding to PeV cosmic rays, that could be detectable by LHAASO. This enables to constrain the subspace of the parameter space for which a detectable excess could exist, and therefore constrains the subset of systems (source+cloud) that could produce such an excess. Then, the goal is to find such systems and compare predictions of the models for the gamma-ray flux to LHAASO data in order to determine more precisely different acceleration parameters, such as the wind termination shock efficiency or the injection spectrum in the interstellar medium.

Poster hang / 73

Modeling Nonthermal Emission in a Stellar Bubble

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Recently, massive stars have been suggested as important sources of Galactic cosmic rays. These stars have intense stellar winds that can accelerate particles up to relativistic energies. It is expected that these stellar winds make a substantial contribution to the production of galactic cosmic rays, albeit less than that from supernova remnants. In 2019, the first detection of non-thermal radio emission from a stellar bubble, G2.4+1.4, associated with a Wolf-Rayet star WO2, was reported. In this work we study and model the recently detected emission in this bubble, which is consistent with synchrotron radiation produced by a population of relativistic electrons. The high-energy particles responsible for the synchrotron, also produce non-thermal emission at other wavelengths, with the most significant occurring in the gamma-ray range. At radio frequencies, a competition between Bremsstrahlung and synchrotron mechanisms occurs. Simultaneously, as the bubble covers an extended region of the interstellar medium, the contribution from the background (i.e., from cosmic rays) is expected to be significant. Finally, we analyze the observability of the gamma-ray flux obtained with our model by current and future high-energy detectors.

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High-energy neutrino emission from global accretion flows and outflows around supermassive black holes: a GRMHD simulation-based model

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The spectral energy distributions (SEDs) of the high energy neutrino emitted from the accretion flows are still highly uncertain, because the global structure of the accretion flow can affect the neutrino SEDs. We have calculated very high energy neutrino SEDs by using three-dimensional general relativistic magnetohydrodynamic (GRMHD) simulations data of a magnetized accretion flow around a spinning black hole. We solve the trajectories of the tracer-particles of nonthermal protons along the field lines of GRMHD snapshots. The SEDs of the nonthermal protons are calculated by solving the Fokker-Planck equation in the rest frame of the tracer-particles. We assume the effects of the turbulent accelerations with the hard-sphere approximation and compression/expansion of the fluid elements. For the hadronic processes, we consider the effects of the pp collisions and subsequent high energy neutrino emissions taking into account the effect of the gravitational redshift.

We set a supermassive black hole with 100 million solar mass and the dimensionless spin parameter 0.9375. We have found that the neutrino SED become flatter than the previous 1 zone models because of the superposition of the neutrino SED emerged from the different position of the accretion flows. This is the effect of the global structure of the accretion flows. The nonthermal protons emitting neutrinos can be classified to the three types: (i) Inflowing protons eventually trapped by the black hole, (ii) outflowing protons quickly escape towards an observer, (iii) initially inflowing protons which finally become outflowing protons and escape towards an observer. We have found that the protons of the type (iii) reside in the turbulent accretion flows in longer time than the ones of type (i), so that the emission from nonthermal protons eventually escape as outflows dominates the resulting neutrino SED.

Parallel 1 / **75**

Large zenith angle observation of the PeVatron candidate SNR G106.3+2.7 with the LST-1 and the MAGIC telescopes

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The quest for PeVatrons, sources of galactic cosmic rays accelerated up to PeV energies, has lived exciting developments in the last years, thanks to the many gamma-ray sources detected by ground array experiments at energies above 100 TeV. Among these, the supernova remnant SNR G106.3+2.7 appears to be one of the most promising hadronic PeVatron candidates, for which the ultra-high energy emission (UHE, E > 100 TeV) can be hardly explained with a simple leptonic emission scenario. The interest in this source has been recently validated by the first LHAASO catalogue, which confirms the presence of a highly significant source above 100 TeV inside the radio contour of SNR G106.3+2.7.

Imaging Atmospheric Cherenkov Telescopes (IACTs) are ideal instruments to investigate the nature of the most energetic sources of gamma-rays in the Universe thanks to their optimal angular and energy resolution compared to UHE detectors. Using the LST-1, the Large-Sized Telescope prototype of the Cherenkov Telescope Array Observatory, with its two neighbours IACTs of the MAGIC experiment, we have been observing the SNR G106.3+2.7 at Large Zenith Angles (LZA), which allows us to explore the 1-50 TeV region of the energy spectrum.

Such observations raise challenges for data reconstruction and analysis, due to the strong dependence on the zenith angle of the image properties for LZA observations. In this contribution, we will present the first combined analysis of all the data obtained with each instrument during the current observation campaign, including a preliminary study of the energy-dependent morphology of the source in gamma-rays.

Parallel 2 / **76**

A New Insights for Early Afterglows –"Magnetic Bullet"

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We study the effects of magnetic acceleration on GRB afterglows by our implemented 1D special relativistic MHD simulation code with adaptive mesh refinement. Our simulation can treat magnetization more than 1, which is an efficient condition for magnetic acceleration. We simulate the interaction between a strongly magnetized thin/thick shell jet and an ambient medium. The Lorentz factor evolution is estimated for a wide range of magnetization of jets. Based on our simulation results, we make a semi-analytic model of the dynamics of magnetized jets called "Magnetic Bullet". Our proposed model expects an optical gradual flux increase and an X-ray plateau emission. Besides, the model suggests a gamma-ray very steep flux evolution in the magnetic acceleration phase of early afterglows, which might explain the TeV light curve of GRB221009A. We hope the Cherenkov Telescope Array will detect a lot of TeV afterglows in the next decade, a part of which may have a clear detection of the steep rise in TeV bands.

Parallel 1 / **77**

Can Fermi-LAT unassociated sources be mismodeled interstellar gas?

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The unassociated population represents about 30% of the sources in the latest 4FGL-DR4 release, with about one half lying at low ($|b|<10°$) Galactic latitudes. Many of these low-latitude sources exhibit properties that set them apart from established classes of Galactic gamma-ray emitters, in particular very soft spectra. The latter feature earned them the denomination "soft Galactic unassociated sources" (SGUs).
This presentation discusses whether this population could be compatible with mismodeled interstellar gas. This is addressed by leaving more freedom in the interstellar emission model when fitting the data, by simulating the effect of additional interstellar gas, by simulating slightly extended ($0.1°$ or so) interstellar clumps, and by looking for similar extension in the actual unassociated sources.

Poster hang / **78**

Searching for Lorentz invariance violation with artificial neural networks

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Lorentz invariance violation (LIV) in gamma rays can have multiple consequences, such as energy-dependent photon group velocity, photon instability, vacuum birefringence, and modified electromagnetic interaction. Depending on how LIV is introduced, several of these effects can occur simultaneously. Nevertheless, in experimental tests of LIV, each effect is tested separately and independently. For the first time, we are attempting to test for two effects in a single analysis: modified gamma-ray absorption and energy-dependent photon group velocity. In doing so, we are using artificial neural networks. In this contribution, we will discuss our experiences with using machine learning for this purpose and present our very first results.

Poster hang / 79

MeV gamma from Q-ball decay

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We study the supersymmetric Q balls which decay at present and find that they create a distinctive spectrum of gamma rays at around O(10) MeV. The charge of the Q ball is lepton numbers in order for the lifetime to be as long as the present age of the universe, and the main decay products are light leptons. However, as the charge of the Q ball decreases, the decay channel into pions becomes kinematically allowed towards the end of the decay, and the pions are produced at rest. Immediately, π^0 decays into two photons with the energy of 67.5~MeV, half the pion mass, which exhibits a unique emission line. In addition, $\pi^\pm$ decay into $\mu^\pm$, which further decay with emitting internal bremsstrahlung, whose spectrum has a sharp cutoff at $\sim$50~MeV. If the observations would find these peculiar features of the gamma-ray spectrum in the future, it could be a smoking gun of the supersymmetric Q-ball decay at present.

Parallel 1 / 80

Investigating the hadron nature of high-energy photons with PeVatrons

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In high energy Gamma-Ray Astronomy with shower arrays the most discriminating signature of the photon-induced showers against hadron-induced cosmic-ray ones is the content of muons in the observed events.

In the electromagnetic γ-showers the muon production is due to the dominant channels: photo-production of pions followed by the decay $\pi \rightarrow \mu\nu$, prompt leptonic decay of charmed particles in the shower, and electromagnetic pair production $\gamma \rightarrow \mu^+\mu^-$.
The number of muons is typically a few percent of that in a hadron showers where muons are abundantly generated by charged pions decay.

In high energy photo-production process the photon exhibits an internal structure which is very similar to that of hadrons, with a small relative probability of order α ($\simeq$ 1/137).
Indeed, photon-hadron interactions can be understood if the physical photon is viewed as a superposition of a bare photon and an accompanying small hadronic component which feels conventional hadronic interactions.

Information on photo-production γp and $\gamma\gamma$ cross-sections are limited to $\sqrt{s} \leq$ 200 GeV from data collected at HERA. Starting from $E_{lab} \approx$ 100 TeV the difference between different extrapolations of the cross sections increases to more than 50\% at $E_{lab} \approx 10^{19}$ eV, with important impact in the observables used to select the photon-initiated air showers.

Recently, the LHAASO experiment opened the PeV-sky to observations detecting a number of PeVatrons in a background-free regime starting from about $E_{lab} \approx$ 100 TeV. This result provides a beam of pure high energy primary photons allowing to measure for the first time the photo-production cross section even at energies not explored yet.
The future air shower array SWGO in the Southern Hemisphere, where the existence of Super-Pevatrons emitting photons well above the PeV is expected, could extend the study of the hadron nature of the photons in the PeV region.

Parallel 2 / **82**

LST-1 follow-up of the exceptionally bright gamma-ray burst GRB 221009A

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On October 9th, 2022, the brightest gamma-ray burst (GRB) ever recorded (GRB 221009A) was initially detected by the Fermi-GBM and Swift-BAT telescopes and subsequently by other satellite and ground-based instruments. Its remarkably bright emission, partially due to its close distance to Earth (z=0.151), makes this GRB a unique event. The outstanding characteristics of GRB 221009A, including the TeV detection by the LHAASO experiment, triggered extensive follow-up observations of the source across all wavebands, including very-high-energy (VHE) gamma rays with the Large-Sized Telescope prototype (LST-1) of the future Cherenkov Telescope Array Observatory. LST-1 observations started about one day after the outburst, under strong moonlight conditions. The high night sky background challenged the follow-up with imaging atmospheric Cherenkov telescopes (IACTs) during the first days. The LST-1 observations of GRB 221009A are the first ones performed by an IACT and required a dedicated analysis procedure to obtain the best telescope performance under such extreme conditions. This resulted in a hint of a signal with a statistical significance of about 4σ during the observations at 1.3 days. The monitoring of this source continued until the end of November 2022. This constitutes the deepest observation campaign performed on a GRB with the LST-1. In this contribution, we will present the analysis results of the LST-1 observation campaign on GRB 221009A in October 2022 and discuss them in a multiwavelength context.

Parallel 1 / **83**

Early-time constraints on CR acceleration in the core-collapse SN 2023ixf with Fermi-LAT

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Most known Galactic supernova remnants do not appear to contribute significantly to the cosmic-ray (CR) flux at PeV energies at their current evolutionary stage. However, supernovae (SNe) could still be major contributors to the "knee"of the CR spectrum if their shocks are efficient hadronic accelerators at earlier times –within days or weeks after the collapse of their progenitor's core. Yet testing this hypothesis remains a challenging issue due to the low number of close SNe.

By studying the recent, nearby Type II SN 2023ixf, we present the first effective limits on CR acceleration within a few days after a core-collapse SN through GeV observations. Using Fermi-LAT data and under reasonable assumptions, we obtain a maximum efficiency on the CR acceleration as low as 1% within a week after the SN explosion. We further discuss the possible physical conditions that could loosen the limits back to the expected 10% efficiency for the standard Galactic CR origin scenario and their applicability to SN 2023ixf.

Parallel 2 / **84**

Particle acceleration and high-energy emission in AGN jets: M87 and Cen A

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Jets of active galactic nuclei (AGN) are observed from sub-parsec (pc) to megaparsec (Mpc) scales. They are powerful particle accelerators, producing emissions ranging from radio to gamma rays. In this talk, I will present our analytical and numerical work on particle acceleration in jets. Multi-wavelength (MWL) observations, such as those for Cen A and M87, suggest continuous particle acceleration along the jet. We found that this can be naturally accounted for within the framework of stochastic-type acceleration (Fermi II and shear acceleration) in a spine-sheath type jet. By solving the Fokker-Planck equation, we obtained analytical particle spectra for stochastic-type acceleration, which resemble cutoff-power-law distributions. We found that the MWL emission from the sub-pc scale jet of M87 and the kiloparsec (kpc)-scale jet of Cen A can be well explained by stochastic-shear acceleration. Relativistic magnetohydrodynamic (MHD) simulations and test particle simulations were performed to validate this acceleration process using the MHD-PIC module from the PLUTO code. In the simulations, spine-sheath structures are self-generated mainly through the Kelvin–Helmholtz instability, where simulated cosmic rays are accelerated close to the Hillas limit. Application to Cen A suggests that its kpc-scale jets can account for the dipole anisotropy in ultra-high-energy cosmic rays (UHECRs). These results suggest that stochastic-shear acceleration is both unavoidable and efficient in AGN jets.

Parallel 2 / 85

Constraints on the intergalactic magnetic from Fermi-LAT observations of GRB 221009A

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The observation of delayed GeV emission after a Gamma Ray Burst (GRB) detected at the very-high energies (VHE) beyond 100 GeV could indicate a non-zero magnetic field in the intergalactic medium. Indeed, VHE photons interact with the Extragalactic Background Light (EBL) to produce electron-positron pairs, which in turn can initiate electromagnetic cascades. An intergalactic magnetic field (IGMF) would deflect the pairs, leading to a delay of this emission, a so-called pair echo. The VHE detection of GRB221009A with LHAASO at several TeV offers a unique opportunity to probe the IGMF. Here we use the reported LHAASO VHE spectrum and CRPropa Monte Carlo simulations to generate time and energy dependent predictions of the cascade for different IGMF strengths in the Fermi-LAT energy domain. Using these predictions, we search for the pair echo using the full Poisson likelihood information. Depending on the modelling of the afterglow emission of the GRB, we are able to set new constraints on the IGMF strength, excluding fields below 1e-17 G.

Parallel 1 / 86

Massive star clusters in the gamma-ray sky

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Massive Star Clusters (SCs) have been proposed as additional contributors to Galactic Cosmic rays (CRs), to overcome the limitations of supernova remnants (SNR) to reach the highest energy end of the CR spectrum. Thanks to fast mass losses due to the collective stellar winds, the environment around SCs is potentially suitable for particle acceleration up to PeV energies and the energetics is enough to account for a large fraction of the Galactic CRs, if the system is efficient enough. A handful of star clusters has been detected in gamma-rays confirming the idea that particle acceleration is taking place in this environment, however the contamination of other sources often makes it difficult to constrain the contribution arising from SCs only.
Here I present a new analysis of Fermi-LAT data collected towards a few massive young star clusters. The young age (< 3 Myr) of the clusters guarantees that no SN exploded in the region, allowing us to determine the power contributed by the star component alone, and to quantify the contribution of these types of sources to the bulk of CRs. Moreover I will present a recent statistical investigation that quantifies the degree of correlation between gamma-ray sources and these astrophysical objects and briefly discuss the observational prospect for ASTRI and CTAO.

Parallel 2 / 87

Prospect for detection of pair-echo emission from TeV gamma-ray bursts

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The presence of pair echo GeV emission after a Gamma Ray Burst (GRB) detected in the very-high energy band (VHE, E>100 GeV) can be the signature of the existence of a non zero magnetic field in the intergalactic medium. Indeed, VHE photons interact with the Extragalactic Background Light (EBL) to produce electron-positron pairs, which in turn can initiate electromagnetic cascades. In presence of a not negligible Intergalactic Magnetic Field (IGMF) this emission is delayed. In this contribution we propose a study of the evolution of the pair echo emission during the afterglow of the GRB. We use simulations to estimate the pair echo lightcurves induced by the propagation of primary VHE gamma rays injected instantaneously by the source. The expected pair echo lightcurve is computed convolving the variability pattern of the GRB in the VHE band with the simulation output. We followed this procedure simulating the pair echo signal from a selected synthetic population of GRBs and producing the pair echo lightcurves in the GeV domain for different IGMF strengths. We show that, depending on the characteristics of the GRBs (e.g. jet opening angle, distance and energetic), the pair echo signal may be dominant for late times with respect to the afterglow.

Poster hang / 88

End-To-End Optimization of the Layout of a Gamma-Ray Observatory

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The array layout design of an ultra-high-energy gamma rays water Cherenkov detector represents a big challenge at the time to reach a sensitivity in the PeV energy scale. This is the current phase where the Southern Wide-field Gamma-ray Observatory (SWGO) collaboration is. In this work we address the array layout problem building a continuous model whose parameters are the primary particle energy and direction (E, θ, ϕ), the shower core position (X_0, Y_0), and the tanks positions (x_i, y_i). Using a big dataset of gamma and proton events that covers an energy range from 100 TeV to 10 PeV, and a zenithal angle range from 0-65 deg; we perform a likelihood ratio test statistic to do the gamma/hadron classification and then we applied a stochastic gradient descent algorithm to find the optimized tanks positions. This is done finding the maximal value of a utility function which depends on the instrument resolution (reconstruction of the primary particle energy and direction), gamma-ray flux and the capability of detecting a point-like source with a fixed significance. Thus, after running the pipeline a determined number of epochs, typically where the utility function finds a stable value, any initial array layout evolves to a configuration where the performance in the PeV energy scale is improved.

Parallel 2 / 89

Detection prospects of extended sources with ASTRI, CTA, and LHAASO

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The recent discovery of several ultra high-energy gamma-ray emitters in our Galaxy represents a significant advancement towards the characterization of its most powerful accelerators. Nonetheless, in order to unambiguously locate the regions where the highest energy particles are produced and understand the responsible physical mechanisms, detailed spectral and morphological studies are required, especially given that most of the observed sources were found to be significantly extended. In these regards, pointing observations with the next-generation Imaging Atmospheric Cherenkov Telescopes, like the Cherenkov Telescope Array (CTA) Observatory and the ASTRI Mini-Array (ASTRI), are expected to provide significant improvements. In view of identifying the most promising sources to target in future observations, I will present a comparative analysis of the expected performance of ASTRI and CTA, computing their differential sensitivities towards extended sources, and further exploring their capabilities with respect to specific case studies, including follow-ups of existing gamma-ray source catalogs.

Parallel 1 / 90

Young Massive Star Clusters as Galactic PeVatrons

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PeVatrons constitute a fascinating class of astrophysical objects capable of accelerating particles up to PeV energies (1 PeV = 1015 eV). However, their nature and their acceleration mechanisms are still uncertain. The accelerated particles interact with the surrounding interstellar medium and background radiation fields to produce secondary ultra-high-energy gamma rays (>100 TeV), which are the main signature of both leptonic and hadronic PeVatrons. The air shower observatory LHAASO detected >100 TeV photons from 43 sources in the Galactic Plane, proving the existence of PeVatrons within the Milky Way. In particular, one of the detections was a 1.4 PeV photon in spatial correspondence with Cygnus OB2, providing strong hint that Young Massive Star Clusters (YMSCs) could act as PeVatrons.
The next-generation ground-based Cherenkov imaging telescopes like ASTRI-Mini Array and the CTAO will have energy resolutions of ~ 5 – 10% and angular resolutions of a few arcmin at 1 TeV. Therefore, both observatories will be able to resolve spatially the YMSCs better than LHAASO. We studied a sample of 5 YMSCs and their surrounding regions visible above 1 TeV from either hemisphere by the CTAO or ASTRI Mini-Array, modeling the secondary gamma-ray emission and simulating observations with the ASTRI and the CTAO instrument response functions. We study the morphology of the gamma-ray emission by using different target distribution: either a uniform hydrogen distribution around the sources or a non-uniform distribution based on molecular clouds positions as derived from multiple CO lines surveys data.

Parallel 1 / 91

Contribution of young massive stellar clusters to the Galactic diffuse gamma-ray emission - [REMOTE]

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Young massive stellar clusters (YMSCs) have emerged as a potential
gamma-ray sources, after the recent association of several YMSCs with extended gamma-ray emission. The large size of the detected halos, comparable to that of the wind-blown bubble expected around YMSCs, makes the detection of individual YMSCs rather challenging. As a result, the gamma-ray emission from most of the Galactic YMSCs could be unresolved, thus contributing to the diffuse gamma-ray radiation observed along the Galactic Plane.
In this talk, we present the possible contribution to the Galactic diffuse gamma-ray emission from a synthetic population of YMSCs, and we compare it with observations obtained with different experiments, from 1 GeV to hundreds of TeV, in two regions of the Galactic Plane.
As the population of galactic YMSCs is only known locally, we evaluate the contribution of gamma-ray emission relying on the simulation of synthetic populations of YMSCs based on the observed properties of local clusters. We compute the gamma-ray emission from each cluster assuming that the radiation is purely hadronic and produced by cosmic rays accelerated at the cluster's collective wind termination shock. We also include three different scenarios for particle propagation in the vicinity of the star clusters.
The results show that the gamma-ray emission from unresolved YMSCs can significantly contribute to the observed Galactic diffuse flux, especially in the innermost part of the Galaxy.

Parallel 2 / 92

Towards a TeV blazar sequence and its physical interpretation

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Blazars are a highly energetic subclass of jetted active galactic nuclei, which show a broad band spectral energy distribution (SED) composed of two bumps. They are interpreted as the result of non-thermal emission from the relativistic particles forming the jet.

In 1998, a phenomenological population study –which was later confirmed in 2017 –showed an anticorrelation between the SED integral luminosity and the frequency of the peaks, called the blazar sequence. Despite the large amount of multi-wavelength data collected in recent years, the origin of this observational trend is still unclear with some authors claiming that it could be the result of selection effects.

In this work, we aim at giving a physical interpretation to the blazar sequence, by modeling the sources emission under a unique theoretical framework, in order to have a direct comparison of the results. To do this, we concentrated only on TeV-detected blazars of the BL Lac class.

Differently from the original sequence, we divided the sources into bins based on the frequency of the synchrotron peak, rather than the radio or gamma-ray luminosity. For each bin, we model the SED of one representative candidate with a Synchrotron Self Compton model and investigate different combinations of the physical parameters involved in the emission. For each source, we selected SED data corresponding to an average state of activity to ensure the consistency of the model.

The different scenarios investigated for each bin are discussed and compared, allowing for a comparison of physical properties of BL Lacs belonging to different classes. This will allow us to search for trends hinting at the physical mechanisms underlying the sequence, as well as provide a reference for modeling gamma-ray BL Lacs on a large scale.

Parallel 1 / **93**

On the distribution of cosmic rays in the Galactic Center region: new insights from H.E.S.S.

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The Galactic center region is one of the richest in the Milky Way, hosting a large variety of sources such as supernova remnants, pulsar wind nebulae and stellar clusters. The supermassive black hole Sgr A* is surrounded by dense molecular cloud complexes that shape the so-called central molecular zone (CMZ). Very-high-energy gamma-ray emission has been reported towards this inner 200 pc region of the Galaxy, resulting from the interaction of accelerated protons which propagate through the CMZ. Analyses of this emission revealed a 1/r cosmic-ray density profile, typical of continuous injection near the Galactic center. With almost thrice more observation time, we revisit the very-high-energy gamma-ray emission coming from the CMZ region with the H.E.S.S. telescopes using a spectro-morphological analysis. We investigate the gamma-ray morphology of the diffuse emission, in particular testing for a possible deviation from a 1/r cosmic-ray density profile. Taking into account the foreground large-scale emission, we derive the first intrinsic gamma-ray spectrum of the Galactic center diffuse emission as well as the spectrum of the parent cosmic rays pervading the CMZ. We also present the four H.E.S.S. sources in the region (HESS J1745-290, G0.9+0.1, HESS J1746-285, HESS J1741-302). We finally discuss physical interpretation of these new results.

Parallel 1 / **94**

Investigating hadronic PeVatrons with X-ray and CO observations

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In the recent (sub-)PeV gamma-ray astronomy, we can pinpoint locations of Galactic PeV cosmic-ray accelerators, known as PeVatrons, as LHAASO has detected 43 sources with E>100 TeV. Such ultra-high-energy (UHE) photons likely originate from protons, since the Klein-Nishina effect would suppress leptonic gamma-ray emission. Some of these UHE sources are poorly explored in other

wavelengths, making them "dark" sources without any known counterpart. Here, we report our extensive campaign of multiwavelength observations of hadronic PeVatron sources.

First, X-ray observation can be a new diagnostic tool to probe protons. The proton-proton interaction (which emits hadronic gamma rays) produces charged pions that decay into muons and subsequently into electrons. These secondary electrons from PeV protons are energetic enough to produce synchrotron emission, which can be tested in the X-ray band. We apply this X-ray emission model to observational data (e.g, HESS J1641-463 and the Cygnus bubble) and demonstrate the detectability with future observations and missions.

Second, radio observation of molecular line emission is also crucial for probing hadronic PeVatrons. An extensive survey of CO counterparts in the UHE sources is currently underway using the Nobeyama 45-m radio telescope. We report our first investigation of LHAASO J0341+5258, which detected some molecular clouds and allowed us to infer physical parameters such as distance and density. We will discuss the origin of the gamma rays, combined with newly taken X-ray data by XMM-Newton.

With these new results, we present the importance of multiwavelength observations to understand the origin of PeVatrons.

Parallel 2 / **95**

Time-dependent modelling and spectral analysis of the extraordinary outburst of Mrk421 during April 2013

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During April 2013, the archetypal TeV blazar Mrk421 underwent a very bright outburst. The flare was observed over nine consecutive days from radio to very-high-energy (VHE; E>100GeV). In particular, MAGIC, VERITAS and NuSTAR exposures provided the most extensive simultaneous X-ray/VHE coverage to date during a blazar flare. The flux reached 15 times that of the Crab Nebula at VHE, and the emission varied down to a 15-minute timescale.
In this talk I will present the X-ray and VHE spectral evolution of the flare on sub-hour timescale making use of the MAGIC and NuSTAR dataset. The spectral behaviour is complex, and reveals patterns that go beyond the usual "harder-when-brighter" trend usually reported for blazars. Notably, we find the first evidence of simultaneous spectral hysteresis at X-ray and VHE energies.
I will also present results of a broadband modelling of the entire flare using a time-dependent leptonic radiation code. The model is applied to about 300 simultaneous SEDs, binned in 15 minutes, throughout the flare. This effort constitutes a significant improvement with regard to previous works that usually adopt stationary models to describe blazar SEDs. It allows us to constrain the particle evolution within the radiation zone of the jet down to the shortest timescales, while keeping track of the particle distribution history. In the vast majority of cases, the flux and spectral variability on sub-hour timescale in the X-ray and VHE bands can be well described by only evolving the electron density in the radiation zone, as well as the hardness of the injected electron distribution. To properly reproduce the VHE spectra at the highest energies, a Doppler factor of at least ~100 is needed, implying relativistic motion of the emitting plasma in the jet frame. While this could be realized in plasmoid chains formed in current sheets during magnetic reconnection, the particle hardness evolution would require significant changes in the plasma magnetization during the flare.

Poster hang / **96**

Modeling multiband SED and light curves of BL Lacertae using a time-dependent shock-in-jet model

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The origin of fast flux variability in blazars is a long-standing problem, with many theoretical models proposed to explain it. In this study, we focus on BL Lacertae to model its spectral energy distribution (SED) and broadband light curves using a diffusive shock acceleration process involving multiple mildly relativistic shocks, coupled with a time-dependent radiation transfer code. BL Lacertae was the target of a comprehensive multiwavelength monitoring campaign in early July 2021. We present a detailed investigation of the source's broadband spectral and light curve features using simultaneous observations at optical-UV frequencies with Swift-UVOT, in X-rays with Swift-XRT and AstroSat-SXT/LAXPC, and in gamma-rays with Fermi-LAT, covering the period from July to August 2021 (MJD 59400 to 59450). A fractional variability analysis shows that the source is most variable in gamma-rays, followed by X-rays, UV, and optical. This allowed us to determine the fastest variability time in gamma-rays to be on the order of a few hours. The AstroSat-SXT and LAXPC light curves indicate X-ray variability on the order of a few kiloseconds. Modeling simultaneously the SEDs of low and high flux states of the source and the multiband light curves provided insights into the particle acceleration mechanisms at play. This is the first instance of a physical model that accurately captures the multi-band temporal variability of BL Lacertae, including the hour-scale fluctuations observed during the flare.

Parallel 2 / 97

Mapping the blazar radiation zone with X-ray polarization and TeV gamma-ray observations

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The Imaging X-ray Polarimetry Explorer (IXPE) measures fluxes, spectra, and polarization properties of blazars at X-ray energies (2-8 keV). In its first two years of operation, IXPE has detected X-ray polarization from seven TeV-emitting blazars, constraining the geometry of the magnetic field in the X-ray emitting region and refining models for particle acceleration within relativistic jets. In leptonic models, X-rays detected with IXPE are produced by the same electrons responsible for the TeV radiation detected with ground-based observatories. In this contribution, we will summarize recent X-ray polarization results from blazar observations with IXPE and present the picture that emerges when simultaneous observations at TeV energies are taken into account. In particular, we will focus on recent observations of Mrk 421 with IXPE and the VERITAS observatory. We will end by discussing what observables and metrics from turbulent shocks and magnetic reconnection simulations can better distinguish between the particle acceleration scenarios within jets. These metrics allow us to compare the simulated evolution of accelerated particles with actual X-ray polarization observables.

Parallel 1 / 98

Cosmic ray propagation in the ISM: the importance of mirroring diffusion to produce ultra high energy gamma rays in the Galaxy

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Cosmic rays (CRs) interact with turbulent magnetic fields in the interstellar medium (ISM), generating non-thermal emission. After many decades of studies, the theoretical understanding of their diffusion in the ISM continues to pose a challenge. This study numerically explores a recent prediction termed "mirror diffusion"and its synergy with traditional diffusion mechanism based on scattering. Our study combines 3D MHD simulations of star-forming regions with test particle simulations to analyze CR diffusion. We demonstrate the significance of mirror diffusion in CR diffusion parallel to the magnetic field, when the mirroring condition is satisfied. Our results support the theoretical expectation that the resulting particle propagation arising from mirror diffusion inhibits the much faster diffusion induced by scattering. Our study highlights the necessity to reevaluate the diffusion coefficients traditionally adopted in the ISM based on scattering alone. For instance, our simulations imply a diffusion coefficient $\sim 10^{27} cm^2/s$ for particles with a few hundred TeV within regions spanning a few parsecs around the source, which is 10 to 100 times smaller than standard predictions. This estimate is in agreement with recent ultra high gamma-ray observations, showing the relevance of our results for understanding of diffuse gamma-ray emission in star-forming regions and extended gamma-ray halos.
https://arxiv.org/abs/2405.12146

Plenary / 99

Pulsars in the High-Energy Sky

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Observations at gamma-ray energies over the last ten to fifteen years have revolutionized the study of rotation-powered pulsars. The Fermi Gamma-Ray Space Telescope has now discovered over 300 gamma-ray pulsars at energies above 100 MeV, over half not previously known at other wavelengths. Pulsars were detected for the first time in very-high-energy gamma rays by MAGIC, VERITAS and H.E.S.S. telescopes, pushing known pulsed emission to as high as 30 TeV for the Vela pulsar. In concert with these discoveries were important advances in theoretical models of global pulsar magnetospheres that have finally determined the location of the high-energy particle acceleration and emission. I will review the current status and the open questions and challenges in applying the models to the recent observations.

Poster hang / 100

Recurrence plot analysis of blazar gamma-ray light curves: exploiting the time-domain capabilities of Fermi-LAT

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Fermi-LAT has accumulated continuous, high signal-to-noise, flux monitoring of bright blazars for over a decade in the gamma-ray band, measuring the dynamics of the particle acceleration and radiation zone in the blazar jet. The statistical methods often used to characterize the measured time variability, such as techniques based on the Fourier transform, rely on the underlying assumption that the time series data is stationary, with mean and variance remaining constant over time. However, this is not the case for blazar light curves.
We will present a different approach to characterize the flux variability observed in bright gamma-ray blazars using the recurrence plot analysis technique.
Recurrence plot analysis is well-suited for non-stationary time series, and can provide a quantitative description of complex as well as recurrent variability patterns, providing insight into the stochastic and chaotic processes that cause the observed flux variability. In addition, recurrence plots are robust against noise fluctuations and are applicable to long data sets such as Fermi-LAT light curves.
We will employ this method to gain insight into the non-linear and stochastic behavior of blazar jets at γ-ray energies and probe the importance of processes occurring in time scales from weeks to several years such as the connection between accretion power and jet launching, quasi-periodic oscillations, dynamics of energized plasma in the blazar jet, and jet precession.

Parallel 2 / 101

Preliminary results of the new ASTRI-Horn observing campaigns

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The ASTRI-Horn telescope is a prototype of a compact aplanatic dual-mirror (4 m diameter) Imaging Atmospheric Cherenkov Telescope developed under the leadership of the Italian Istituto Nazionale di Astrofisica (INAF). It is the pathfinder of the small-sized telescopes adopted for both the ASTRI Mini-Array (Tenerife, Canary Islands) and the SST/CTA array (Paranal, Chile) for gamma-ray astronomy at very high-energy. It combines an unprecedented high angular/energy resolution and flux sensitivity across a large Field of View (8°) in the energy band 1–200 TeV. For the first time, the ASTRI-Horn telescope successfully demonstrated the optical behavior of a dual-mirror Schwarzschild-Couder telescope as a Cherenkov system, achieving the detection of the Crab Nebula in 2018. Since ASTRI-Horn operates in a harsh environment on an active volcano, in the period between 2020 and 2022 the telescope has been subject to significant maintenance and refurbishment to restore systems and improve performance. Mirrors have been substituted, adopting high-performance coatings, and the camera electronics have been further optimized. Now the telescope is extensively used to investigate gamma rays, cosmic rays, and to perform the muography of the Etna volcano. In particular, new observations of astrophysical targets were carried out between fall 2022 and spring 2024. The collected data are also very important in the perspective of the ASTRI Mini-array development: the validation and analysis chain could be considered a "kick-off"test for the first data collected by the first three

telescopes of the array (within the first half of 2025). In this contribution, we present the preliminary results achieved with the ASTRI-Horn telescope during the latest observing campaign.

Parallel 2 / 102

Blazar flares at the cosmic dawn: uncovering relativistic jets at z>4

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High-redshift blazars ($z > 3$) allow us to probe their jets at radio frequencies down to the central black hole due to reduced opacity in the rest frame of the source and to study the accretion processes and black hole growth in the early Universe. However, the detection of gamma-ray emission from these distant sources is difficult–only about a dozen have been detected by Fermi-LAT > 100 MeV. We designed a program utilizing Fermi-LAT data during gamma-ray flares to obtain quasi simultaneous multiwavelength data to study the activity of high-z blazars and ultimately determine the gamma-ray production sites and mechanisms and compare them to the blazars in the local Universe. In our presentation we will discuss our findings for the blazars TXS 1508+572 ($z = 4.31$) and B3 1428+422 ($z = 4.71$) during extremely luminous gamma-ray flares, including jet kinematics features from a high-frequency VLBI campaign for TXS 1508+572. Based on gamma-ray luminosity, these flares are among the brightest detected with LAT so far. The multiwavelength data can be well described by a one-zone leptonic model with parameters in agreement with the VLBI data, and which requires black hole masses $> 10^9$ solar masses based on the signature from the accretion disk. In addition, we find that the observed flux variability is strongest in the infrared band, and we measure a significant fraction of polarization in the optical R band from the underlying synchrotron emission component.

Poster hang / 103

Convolutional Neural Network analyses for multi-TeV Gamma-ray Air Shower Observation with a Large Area Surface Detector Array

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The Tibet AS⊠ experiment, which observes gamma-ray/cosmic ray air showers above a few TeV, is located 4,300 m above sea level in Tibet, China. The experiment is composed of a surface air shower array (Tibet-III) and underground water Cherenkov muon detectors (MD).
The surface air shower array is used for reconstructing the primary particle energy and direction, while the underground muon detectors are used for discriminating gamma-ray induced muon-poor air showers from cosmic-ray induced muon-rich air showers.
This study investigated methods to improve the Tibet-III array's gamma-ray/cosmic-ray separation performance and angular resolution.
In recent years, machine learning, especially neural networks, has been widely applied in air shower observation experiments.
In the gamma-ray/cosmic-ray separation study, we applied a method with a convolutional neural network (CNN) to image-like data of particle density measured by the Tibet-III.
The method's AUC values ranged from 0.753 to 0.879 for Monte Carlo gamma-ray and cosmic-ray events from the Crab Nebula in the energy range 10–100TeV. The significance of the gamma-ray detection is expected to be improved by 1.3 to 1.8 times compared with the case without the CNN separation procedure.

Parallel 2 / 104

Leptonic emission from star-forming galaxies

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Cosmic rays are a crucial component of the interstellar medium. Measurements of cosmic ray composition in our Galaxy has shown that they are primarily composed of relativistic protons, with only a subdominant contribution from leptons to the total cosmic ray energy budget. Although the precise origins of cosmic rays are still uncertain, it is widely believed that the interaction of massive stars with the surrounding medium, both during their lifetimes and at their end, is the main mechanism for cosmic ray acceleration on galactic scales. Consequently, star-forming galaxies are expected to contain significant amounts of cosmic rays. These galaxies are notable sources of gamma-ray radiation, with around a dozen detected directly and others possibly contributing collectively to the diffuse gamma-ray background. Contrary to previous expectations, we find that the gamma-ray emission of star-forming galaxies is primarily driven by leptons. We suggest that the commonly accepted dominance of protons over leptons in cosmic ray composition is due to the faster cooling of electrons rather than a fundamental characteristic of cosmic ray accelerators.

Poster hang / 105

Search for DM signal features in the Galactic gamma-ray spectra with the Fermi LAT

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Indirect dark matter searches with gamma rays involve looking for spectral signatures that could be associated to either annihilation or decay of dark matter particles in space. In this work we present the results of a search for line-like and box-like features in the gamma-ray spectra in five sky regions centered on the Galactic Center, optimized for different DM density profiles and annihilation or decay channels, using a 15-year dataset collected by the Fermi Large Area Telescope in the energy range from 1 GeV to 1 TeV. Line-like features may arise from the annihilation of dark matter particles, resulting in the direct production of gamma-ray pairs. Box-like features could arise from the annihilation of pairs of dark matter particles into pairs of light mediators which in turn decay into pairs of gamma rays. In both scenarios, the intensity of the feature is related to the velocity-averaged dark matter annihilation cross section. No statistically significant evidence of such features has been found and we use the upper limits on their intensities to constrain the velocity-averaged cross sections.

Poster hang / 106

Absorbed jets in gamma-ray narrow-line Seyfert 1 Galaxies: the case of SDSS J164100.10+345452.7

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In the last 15 years narrow-line Seyfert 1 galaxies (NLS1) have been investigated mainly in the radio, optical, UV and X-ray energy bands. In 2008, the detection of PMN J0948+0022 by Fermi-LAT allowed us to extend their spectral energy distribution to the gamma-ray energy band, paving the way to include gamma-ray NLS1 galaxies into the class of extra-galactic jetted sources. Indeed, their properties place them at the low-power end of the flat-spectrum radio quasar luminosity function, displaying low black-hole masses, accretion rates close to the Eddington limit, and low jet powers. Despite being considered radio silent, gamma-ray NLS1s may present short and intense radio flares. We carried out an intensive multi-wavelength monitoring of SDSS J164100.10+345452.7 by means of the Metsähovi radio (37GHz) and Swift (Optical, UV, X-ray) observatories over a 2-year baseline with a weekly pace. Our campaign allowed us to obtain Swift data almost simultaneous with a radio flare. Detailed pre-, post-, and flare X-ray spectroscopy allowed us to discover a remarkable difference in the source spectrum in the distinct epochs, which permitted to establish the origin of the 37 GHz radio flare as the emergence of a jet from an obscuring neutral absorber detected in the X-ray observations. This result is the first detection of an absorbed jet in a gamma-ray narrow-line Seyfert 1 galaxy.

Parallel 2 / 107

H.E.S.S. detection and multiwavelength study of the z ~ 1 blazar PKS 0346-27

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We report the detection of a TeV blazar PKS 0346-27 at redshift 0.99 by the High Energy Stereoscopic System (H.E.S.S.) on 3rd November, 2021 with a significance above 5 σ. The spectral energy distribution (SED) consists of the simultaneous observations by Fermi-LAT, Swift XRT and UVOT during the H.E.S.S detection period. We show that a hadronic one-zone model (modified by strong EBL absorption) can provide a satisfactory fit to the data. The lightcurve consists of the multiwavelength

data for all the observation periods and we were able to test some time lag between the GeV and TeV bands.

Poster hang / 108

GammaBayes

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This presentation introduces GammaBayes, https://github.com/lpin0002/GammaBayes, a Bayesian Python package designed for dark matter detection using the Cherenkov Telescope Array Observatory (CTAO). GammaBayes processes CTAO gamma-ray measurements alongside user-defined dark matter particle models, providing the posterior distribution for dark matter parameters such as the dark matter mass and its velocity-averaged annihilation cross-section. Additionally, it calculates Bayesian evidence for model selection.

This talk showcases GammaBayes with 525 hours of simulated data, capturing 10^8 gamma-rays, 10^5 of which originate from the self-annihilation of a 1 TeV mass dark matter particle. The no-signal hypothesis is excluded with nearly 5 sigma credibility. Exclusion limits for the dark matter mass vs. annihilation cross-section are derived as well. We will also discuss potential extensions of GammaBayes to incorporate advanced signal and background models, alongside the computational challenges that accompany these enhancements.

Poster hang / 109

Commissioning and Operation of the SST-1M Stereoscopic Imaging Atmospheric Cherenkov Telescopes

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The small-size single mirror telescopes, SST-1Ms, are two Cherenkov telescope prototypes developed by a consortium of Czech, Polish, and Swiss institutions. Featuring a 9.42 m² multi-segment mirror and a 5.6 m focal length, the SST-1Ms offer a broad 9-degree field of view and have proven capable of detecting gamma rays with energies starting from several hundred GeV. The innovative cameras incorporate a compact photo-detector plane with 1296 hexagonal silicon photomultiplier pixels and a fully digital readout and trigger system utilizing 250 MSps FADCs.

Currently undergoing commissioning at the Ondrejov Observatory in the Czech Republic, the stereoscopic system is actively collecting data from astrophysical gamma-ray sources. This presentation details the commissioning of the optical systems and cameras, including the calibration of the telescope's response to varying night sky background levels. The performance of the instrument in both monoscopic and stereoscopic modes is also discussed.

Poster hang / 110

From light curves to power spectra: unveiling time-domain behavior with gammapy

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Gamma-ray astrophysics increasingly focuses on time-domain studies of variable sources like GRBs and AGNs. As the foundation for CTAO's science analysis tools, the open Python analysis library Gammapy must adapt to support these advancements. This contribution highlights the recent expansion of Gammapy's time-domain capabilities and outlines its near-future plans, particularly regarding power spectrum analysis in Fourier space. Estimating the spectral behavior of a light curve in the frequency domain is crucial for studying variable astrophysical sources. We present Gammapy's novel framework for simulating light curves from a power spectrum model using the Timmer & Koenig and Emmanoulopoulos algorithms. This framework includes a fitting recipe to assess the behavior of observed light curves in the frequency domain. We will also demonstrate the expected reconstruction power of CTAO using this method under various observational scenarios.

Parallel 2 / 111

Elucidating the radio-optical offset in FR I jet with mass entrainment

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The Fanaroff-Riley (FR) classification system provides a fundamental framework for understanding the morphological dichotomy observed in some radio galaxies. Jet properties, acceleration mechanisms, and environmental interactions of extragalactic jets are often discussed to understand FR I/FR II galaxies.
Recent numerical works show the role of mass loading from stellar winds in decelerating the jet and explain the typical characteristics of FR I jets. Additionally, observations have revealed a radio-optical emission offset where the optical centroid emission is detected further down the jet compared to the radio one. This feature challenges the conventional explanations that rely on the presence of recollimation shocks and/or instabilities within the jet.
In this work, we use the radiative transfer code RIPTIDE to simulate synthetic synchrotron maps in both radio and optical bands from jet simulations that incorporated various mass-loading profiles. Our findings highlight the role of mass entrainment in reproducing the extended and diffused radio/optical emission observed in FR I, as well as the radio-optical offsets, whose characteristics depend on the physical properties of the jet, its surrounding environment, and observational biases. Overall, our results demonstrate that positive offset measurements can be used to unveil fundamental properties of FR I galaxies.

Parallel 1 / 112

On the expected orbitally-modulated TeV signatures of spider binaries

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'Spider'binary systems –black widow and redback compact binaries differentiated by their companion's mass and nature –are an important type of pulsar system exhibiting a rich empirical phenomenology, including radio eclipses, optical light curves from the heated companion, as well as non-thermal X-ray and GeV light curves and spectra. Multi-wavelength observations have now resulted in the detection of about 50 of these systems in which a millisecond pulsar heats and ablates its low-mass companion via its intense pulsar wind. Broadband observations establish the presence of relativistic leptons that have been accelerated in the stellar magnetospheres and near the intrabinary shock, as well as a hot companion. This presents an ideal environment for the creation of orbitally-modulated inverse Compton fluxes that should be within reach of current and future Cherenkov Telescopes. We have now included an updated synchrotron kernel, different parametric injection spectra, and several intrabinary shock geometries in our emission code to improve our predictions of the expected TeV signatures from spider binaries. Our updated phase-dependent spectral and energy-dependent light curve outputs may aid in constraining particle energetics, wind properties, shock geometry, and system inclination of several spider binaries.

Poster hang / 113

Towards a joint X-ray and gamma-ray analysis of Pulsar Wind Nebulae with Gammapy

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For detailed studies of Pulsar Wind Nebulae (PWNe), objects that show photon emission across the entire electromagnetic spectrum, multiwavelength analyses are crucial. The comparison of especially X-ray and gamma-ray emission and their angular sizes can help us to constrain the properties of PWNe, such as their particle transport mechanism or their potential for the acceleration of hadronic particles.
In this vein we are working towards a joint analysis of eROSITA X-ray data and H.E.S.S. gamma-ray data. To enable this process eROSITA data is adapted into the framework of Gammapy, a Python package for gamma-ray analysis through a multi-step process of adapting the formats of not only the photon event list, but also all X-ray response functions, into open data formats compatible with Gammapy. This is accomplished using custom newly developed Python converter functions.
In this contribution we present the first eROSITA maps of the PWN MSH 15-52 in Gammapy, which we compare to the associated H.E.S.S. emission, whilst detailing the process of X-ray response format conversion and map creation in gammapy.

Poster hang / 114

Probing the CMB-cosmic ray connection: ultra-local and extra-galactic effects

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The interaction of cosmic rays with the cosmic microwave background (CMB) has been the subject of extensive research in the past 50 years or so. These studies have concentrated on the impact of such interactions on cosmic ray physics while neglecting the potential influence on the CMB itself due to its presumed minimal amplitude. However, the prospects of ultra-high-precision measurements of the CMB, together with recent advancements in cosmic ray propagation simulations, motivate a reevaluation of this influence, both for local effects and for potential signatures on cosmological scales. In this contribution, we present a first estimate of the ultra-local CMB spectral distortion caused by interactions with cosmic ray protons trapped within environments typical of a starburst or active galaxy, which is capable of accelerating particles to the highest energies. Additionally, we provide a preliminary analysis of the large-scale impact of extragalactic protons on the CMB, using catalogs of potential ultra-high-energy cosmic ray (UHECR) sources.

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ASTRI Updates

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ASTRI is an INAF (Italian National Institute for Astrophysics) project for the construction and operation of an array of innovative IACT telescopes for ground-based gamma-ray astronomy in the energy range ~1 TeV to ~200 TeV.

Such an array, called ASTRI Mini-Array, currently under construction at the Teide Observatory in Tenerife, Spain, consists of nine telescopes of small size (~4m diameter) and wide field of view (>10 deg), equipped with cameras based on SiPM photodetectors.

The first telescope has already been built and extensively tested, while the installation of the first camera is expected in autumn 2024 and the commissioning of two additional telescopes with their cameras by the end of 2024.

ASTRI Mini-Array will perform deep observations of astronomical objects in the northern sky with angular and energy resolutions of 3 arcmin and 10 percent at multi-TeV energies, respectively, providing excellent complementarity with the current generation of IACT telescope arrays and extended atmospheric shower detectors such as HAWC and LHAASO.

The feasibility and effectiveness of the Schwarzschild-Couder optical configuration adopted by ASTRI Mini-Array has been demonstrated by the prototype telescope, called ASTRI-Horn, installed at the INAF observatory at Serra La Nave (on Mount Etna, Italy), which detected the Crab Nebula in gamma rays.

ASTRI-Horn, after a major renovation, is currently carrying out extensive observing campaigns of bright gamma-ray sources, providing valuable information on the operation of the telescope and the data reduction and analysis chain.

In this talk we will report on the status of the ASTRI Project, describing the technological solutions adopted and discussing the scientific prospects.

Parallel 2 / 116

Fermi-LAT analysis of the CSO NGC4278 detected by LHAASO

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Compact symmetric objects (CSOs) are sources with radio lobe emission on both sides of an active nucleus and an overall size of less than one kpc.

From the detection of 3 CSOs by the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope, we know that the emission from these objects can extend into the GeV band. Surprisingly, the first LHAASO catalog reported a TeV source, 1LHAASO J1219+2915, detected up to 25 TeV and tentatively associated with the CSO NGC 4278.

In this contribution, we present the analysis of the LAT data in the region of 1LHAASO J1219+2915 at the time of the LHAASO detection. Our analysis revealed evidence for a new point-like source, detected at a statistical significance of TS~29, spatially consistent with the LHAASO detection and the radio position of NGC 4278. We observed a hard spectrum in the Fermi-LAT band, with two very high-energy (VHE) photons (~100 GeV) associated with NGC 4278 with a probability exceeding 99%.

Our results provide further support to the association between the LHAASO source and the CSO NGC 4278, posing new challenges for our understanding of the physical processes acting in relativistic jets.

Poster hang / 117

Parsec-scale simulations of jet-star interaction : dynamical and radiative effects

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X-ray observations by Chandra reveal the presence of bright spherical regions within the kilo parsec-scale jet of Centaurus A. While several models have attempted to explain such high-energy emissions at this distance, a promising scenario involves interactions between the jet and AGB stars.
I will present my recent work on jet-star interactions using 2D/3D RHD and RMHD simulations. Our numerical set up focuses on the interaction between the relativistic jet in Centaurus A and an AGB star stellar wind. From the results of these simulations, we estimate the radiative
output with a radiative transfert code and compare our results with Chandra observations. In the second part of my talk I will present our first simulations of a supernova explosion taking place

inside a relativistic jet and discuss its dynamical and radiative implications.
Recents works suggest that triggered supernovae can occur inside a jet.
Even though this event would be rare, it could the inset of a very important radiative output, in term of neutrino production and gamma-rays emission.

Poster hang / 118

An orphan flare from a plasma blob crossing the broad-line region ?

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The flat-spectrum radio quasar 3C 279 is well known for its prolific emission of rapid flares. One particular event occurred on December 20th, 2013, exhibiting a large flux increase with a doubling time scale of a few hours, a very hard γ-ray spectrum, and a time asymmetry with a slow decay, while no significant variations in the optical range were detected.
We propose a novel scenario to interpret this "orphan flare", based on two emission zones corresponding to a stationary and a fast moving plasma blob.
While the stationary blob is located within the broad-line region (BLR) and accounts for the low-state emission, the moving blob decouples from the stationary zone, accelerates and crosses the BLR. The high-energy flare can be attributed to the variable external Compton emission as the blob moves through the BLR, while the variations in the synchrotron emission remain negligible.
Our description differs from previous interpretations of this flare by not relying on any acceleration mechanisms of the electrons in the plasma blob. Instead, the flare emerges as a consequence of the bulk motion of the blob and the geometry of the external photon fields.

Poster hang / 119

Historical Low-State of the Blazar 1ES 1959+650 at Very High Energies

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The Spectral Energy Distribution (SED) of blazars consists of two components. The low-energy bump is interpreted as synchrotron radiation emitted by accelerated electrons while the high-energy one is produced via inverse Compton scattering of the electrons by low-energy photons. In the leptonic interpretation, the latter photon field can be provided either by the synchrotron radiation of the same accelerated electrons (in the so-called Synchrotron Self-Compton scenario, SSC) or by an external photon field.
Alternatively, hadronic models interpret the high-energy emission as produced by processes involving protons accelerated in the relativistic jet of the source.
Investigating the SED of blazars is crucial for determining which theoretical models better describe the physics of the system. In this context, multi-wavelength (MWL) long-term monitoring observations of blazars is essential to constrain the physics of the ongoing radiative processes during different activity states.
The blazar 1ES 1959+650 represents an ideal laboratory for that, thanks to its brightness at all wavelengths. Its favourable low redshift (z = 0.047) makes it detectable also at very high gamma-ray energies. Additionally, its activity has demonstrated flaring episodes in the past, making it ideal for a variability study.
A long-term MWL monitoring of 1ES1959+650 is ongoing under the coordination of the MAGIC collaboration. Over the 2020-2022 period, the source has experienced one of its lowest states ever reached, mainly at very high energies. This contribution presents the MAGIC and MWL observations and the study of the spectral changes of the source during these three years, focusing on an SSC interpretation of the data.

Poster hang / **120**

Plasma instabilities in gamma-ray bright AGN

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I will review our recent advances in the study of the origin and development of plasma instabilities, namely Kelvin-Helmholtz and Current-Driven instabilities, at the base of quasar jets such as 3C 279, 3C 273 or 3C 111, which are variable or continuous gamma-ray emitters. We study the evolution of perturbed jets via relativistic (ideal) magnetohydrodynamical numerical simulations. An equilibrium state is generated using 1D simulations, which are used as set-up for 2D or 3D simulations. In my talk, I will focus on 2D simulations of instability development in axisymmetric magnetised jets, where we test the stability properties of different magnetic field configurations. As a result of our simulations, we estimate the amount of kinetic energy that can be dissipated and would be relevant to very-high-energy emission.

Plenary / **121**

What we know about ultra-high-energy cosmic rays after 20 years of operation of the Pierre Auger Observatory

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The Pierre Auger Observatory is the largest detector in the world for ultra-high-energy cosmic rays. After 20 years of operation, many important results about the most energetic particles in the universe

have been obtained. For example, the observation of a dipole in the distribution of the cosmic rays above 8×10^{18} eV pointing away from the Galactic Center, indicates an extragalactic origin for the majority of particles in this energy range.
The Observatory has also undergone many upgrades and extensions allowing, amongst other things, measurements to be extended to energies as low as a few tens of PeVs, getting closer to the high-energy end of the gamma-ray and neutrino observations.
Here we present the latest results obtained with this unprecedented dataset of cosmic rays, with a particular focus on the ones of interest for the community of high-energy astrophysics.

Poster hang / 122

The INTEGRAL view of Fermi sky

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We present preliminary results on likely associations between the latest Fermi catalogue (4FGL DR3) and all INTEGRAL surveys.
The cross correlation analysis (up to a distance of 3 arcmin) finds ~90 associations of which 5+/-2 could be by chance and thus false.
Some interesting findings emerge from the analysis:
1) on the Galactic Plane we find ~20 associations where the emission is likely due to binary systems;
2) out of 23 ultra compact objects detected by INTEGRAL we find that ~40% of these are associated with Fermi detections classified as Globular Clusters;
3) furthermore, we find 5 associations with PSR/PWN and 4 with SNR;
4) in the extragalactic sky, we find ~15 associations with Seyfert/radio galaxies, including M82 and a small set of misaligned radio galaxies; we find 51 INTEGRAL blazars also detected by Fermi;
5) we also find an interesting case of an unidentified INTEGRAL/Fermi association which will be briefly discussed.

Poster hang / 123

Particle acceleration by relativistic shocks induced by density fluctuations

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Cosmic rays (CRs) are high-energy charged particles ($10^9 \sim 10^{20}$ eV) originating from the universe, yet their exact sources remain unknown. CRs are categorized into Galactic CRs (lower energy, $lesssim 10^{15}$ eV) and extragalactic CRs (highest energy, $\sim 10^{20}$ eV). As their names imply, Galactic

CRs are accelerated within our Galaxy, while extragalactic CRs originate from beyond it. High-energy objects like gamma-ray bursts and active galactic nuclei, where they emit relativistic jets, are considered potential sources of extragalactic CRs. These jets generate relativistic shocks that can accelerate CRs through a process known as 1st-order Fermi acceleration.
However, a significant challenge exists: in relativistic shocks, due to the no velocity difference between the shock and particles, they cannot be accelerated efficiently. Consequently, particles struggle to achieve energies up to 10^{20} eV within the propagation of the relativistic shocks. To overcome this, strong turbulence ($\delta B/B_0$
$gtrsim1$) near the shock front must be considered (Lemoine et al., 2006, ApJL; Niemiec et al., 2006, ApJ). However, the origin of this turbulence remains unknown.
In our talk, we propose that such strong turbulence is generated by the interaction between relativistic shocks and shock-upstream density fluctuations. This interaction leads to a corrugated shock front and drives turbulence in the downstream region. This process is well studied in the context of non-relativistic shocks, and it is confirmed that the turbulent structure is generated in the downstream region. On the other hand, in the case of relativistic shocks, it is pointed out that the turbulence generation is suppressed by the relativistic effects. To investigate whether turbulence is sufficiently amplified for particle scattering and acceleration, we conducted large-scale simulations.
First, we performed the interaction between relativistic shocks and upstream density fluctuations by magnetohydrodynamic simulations to obtain a large-scale electromagnetic field. Then, we calculated the particle motions by test-particle simulations, enabling us to study large-scale particle acceleration, particularly for particles like extragalactic CRs with large gyroradii.
Our results reveal that particles are efficiently accelerated by repeatedly crossing the shock front, with energy evolution following $E \propto t$, demonstrating higher efficiency than previous studies. The important thing is that the particles are not scattered isotropically just behind the shock front because the turbulence is not amplified well. Additionally, we found that particles are accelerated only through shock-driven turbulence. This additional acceleration can lead to the injection into the relativistic shock acceleration (Morikawa et al., 2024 ApJL). This injection depends on the size and amplitude of the density fluctuations. This should be significant for the connection between the small-scale acceleration by the Weibel instability or for the CR acceleration scenarios.
In our presentation, we will detail the characteristics of the turbulence and the mechanisms of particle acceleration observed in our simulations.

Parallel 2 / 124

15 Years of Fermi LAT and Multi-wavelength Observations of a Long-term Periodic Flux Modulationin the Blazar PG 1553+113 - [REMOTE]

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We present the results of more than 15 years (August 2008 - November 2023) of Fermi Large Area Telescope (LAT) monitor observations of the high-energy peaked BL Lac object PG 1553+113 at E>100 MeV and E>1 GeV gamma-ray bands, in comparison with optical, radio and X-ray multifrequency monitoring data. A 2.1-year periodic modulation of the gamma-ray flux is continuing to be significant at a 4 sigma level against stochastic red noise, with about seven cycles. This doubling the total time range of data with respect to the previous work by the LAT Collaboration based on 6.9 years of data (Ackermann et al. 2015), where this periodicity was tentatively identified.
Independent determinations of oscillation period and phase based on data published in the earlier work and the new data are in agreement (chance probability <0.01). This cyclic behavior modulates the rapid-term and intermediate-term irregular variability and the flares of PG 1553+113. The discovery allows prospects for investigating pulsational accretion flow in a sub-parsec binary supermassive black hole system, or accretion flow instabilities, disk and jet precession, rotation or nutation and also perturbations by massive stars or compact objects in polar orbit.

Parallel 2 / 125

Searching for Signatures of Internal Gamma-ray Absorption in High-redshift Blazars

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Blazars are a special type of AGN, with jets that happen to point very close to the direction of Earth. The powerful gamma-ray beam from distant blazars represents a unique tool to explore the environment along its path and allows us to probe opacity both inside the source and in the intergalactic medium. Internally, gamma rays experience attenuation due to photon-photon absorption, a result of interactions with AGN-generated photon fields. This interaction introduces distinct features in gamma-ray spectra. Upon exiting the source, gamma rays encounter attenuation due to the Extragalactic Background Light. Understanding and characterizing these absorption processes reveals the complex structure of blazars, including the spatial distribution of the photon fields, and the poorly known location of the gamma-ray emitting zone. In this work, we perform an analysis and detailed physical modeling of Fermi-LAT data of nine high-redshift (z>3) blazars, and search for characteristic features in the gamma-ray spectra induced by the internal absorption. Our results yield important constraints on the precise location of the gamma-ray production site along the blazar jet in these sources.

Poster hang / 126

A Detector Test Facility for SWGO Experiment

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At the Politecnico di Milano (campus Bovisa) we are installing a facility to test various possible sensors detecting the Cherenkov light emitted in water by the charged particles of the extensive air showers produced by ultra-high energy gamma rays (> 100 GeV), within the framework of the SWGO collaboration. We realized a metallic cylindrical tank (diameter 3.36 m, height 3.12 m) containing a black bladder, filled with pure water. Two other tanks, with smaller (2 m) diameter but with analogous features are going to be placed nearby, with the twofold aim to test simultaneously several sensors (e.g. PMTs) and to study coincidence events among the tanks.
Electronic chains for both analog and digital pulse processing have been installed and tested. Both low sensitivity CPSs with fast shapers (CREMAT modules) and a fast digitizer (CAEN, 8 channels, 500 Ms/s, 14 bits) have been prepared for flexible read-out of different options.
Furthermore, by placing on the top of each tank (containing a PMT on the bottom) various kinds of

detectors, such as scintillators and RPCs, will allow us to perform coincidence pulse processing. This contribution describes the state of art of the facility.

Poster hang / 127

Multiwavelength study of the intermittent extreme HBL 1ES2344+514

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1ES2344+514 is a nearby HBL (Extreme high-frequency peaked) BL Lac object, located at a redshift of z=0.044. This source was discovered in VHE by the Whipple 10m telescope during a bright flare in December 1995. Following the event, few multi wavelength (MWL) campaigns have been organised to obtain a better understanding of the source. The extreme nature of the 1ES2344+514 in the X-ray band was observed in 1998 during a bright outburst in the X-ray band detected by Beppo-SAX. After that, several observations found the source in low activity in X-ray and VHE gamma-ray bands. Multiwavelength observations carried out in 2007 and 2008 yielded
a strong flaring activity of the source in both VHE and X-ray bands. In 2016 the source presented again an extreme behavior during a flare in the VHE range which was detected by MAGIC and FACT. During this period, the broadband modelling of the source was carried out using both leptonic and hadronic models and both the models were found to successfully describe the data. In our current work we carried out the longest multiwavelength campaign till date (over a period of 3 years between 2019 and 2021) which includes VHE (E>100 GeV) gamma-ray data from the MAGIC telescopes and near-simultaneous observations with Fermi-LAT, XMM-Newton, NuSTAR, Astrosat, Swift-XRT, Swift-UVOT, WEBT, KAIT and OVRO. Our broadband spectral energy distribution (SED) modelling confirms the extreme nature of the source and also shows that the emission spectrum can be explained by a two-component time dependent leptonic model.

Poster hang / 129

FACT - Highlights from a Decade of Blazar Monitoring

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The First G-APD Cherenkov Telescope (FACT) has been monitoring blazars at TeV energies since October 2011. Within a decade of operation, it collected more than 15000 hours of physics data.

Designed for remote and automatic operation and using semiconductor photosensors, the duty cycle of the instrument is maximized and the gaps in the light curves are minimized. Thanks to the unbiased observation strategy, a unique and unprecedented data sample has been collected. Apart from blazar monitoring which is joined with multi-wavelength campaigns, the physics program includes follow-up observations of multi-wavelength and multi-messenger alerts.

The brightest sources have been observed for up to 3500 hours each, providing insights not only to bright flares but also to the long-term behaviour of the sources and allowing for multi-wavelength and multi-messenger correlation studies.

The presentation summarizes the lessons learned from more than ten years of operation and the results of this legacy data sample.

Poster hang / 130

FACT - AGN Monitoring and Target-of-Opportunity Observations

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The First G-APD Cherenkov Telescope (FACT) is observing gamma-ray sources at TeV energies. Thanks to its unbiased observation strategy, silicon-based photosensors and remote and automatic operation, it features ideal conditions both for monitoring and target-of-opportunity observations. This results in an unprecedented data sample of more than 15000 hours of physics data including monitoring of bright AGN and follow-up observations of more than 65 multi-wavelength and multi-messenger alerts.

This data sample not only allows for information on the gamma-ray emission of the alerts followed up, but also for the correlation study between gamma rays and other messengers thanks to the unbiased monitoring.

The presentation summarizes results of the AGN monitoring programm, correlation studies and the follow-up of multi-messenger alerts from more than ten years of observations at TeV energies.

Poster hang / 131

Unbiased Long-Term Study - Revealing FACTs about the Harder-when-Brighter Behaviour of Mrk 421

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Featuring two peaks in the spectral energy distribution, blazars show a high variability in X-rays and very-high-energy gamma rays. A harder-when-brighter behaviour is found in many studies of the spectral index in correlation with the flux.

Within the FACT monitoring program, more than 3200 hours of physics data have been taken on the blazar Mrk 421 at TeV energies. Thanks to an unbiased observation strategy, this data sample is ideally suited for systematic long-term studies. Owing to the stable photosensors that allow for observation during bright moon and the automatic and remote operation, the data sample spreads over 10 years and covers more than 1100 nights in total.

The presentation summarizes an unprecedented study of Mrk 421 with the focus on the correlation of the spectral index with the flux at very high energies, probing the often observed hard-when-brighter behaviour.

Poster hang / 132

AGILE activity on FRB high-energy counterparts search

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The AGILE space mission, with its unique features (two coaligned imaging X-and gamma-ray detectors, a non-imaging calorimeter, and the observing capability to cover about 80 %if the sky in 7minutes) makes it very suitable in seatch for high-energy counterpar of transient of various nature. AGILE participated in all the recent campaign to search for electromagnetic (e.m.) counterparts to gravitational wave (GW) events detected by the LIGO -Virgo-KAGRA interferometers. We developed a dedicated pipeline to analyze data from all detectors on short timescales around external trigger times, and their spatial extension, which was applied also to GRB triggers or other transients,either on real-time data or on archival search.
We started the search for Fast Radio Bursts (FRBs) high-energy counterpart on 2019, after the increasing discoveries by CHIME/FRB instrument of Repeating-FRBs(R-FRBs) at low Dispersion Measure (DM), on average proportional to distance so that these sources at ~100 pc cm^-3 are at reduced distances with respect to the mean sample of FRBs detected at much higher DM values. We developed a dedicated pipeline to execute archival searches for gamma- and X-ray counterpart in the MCAL and GRID detector data in the context of the AGILE procedures for triggered transient sources.
We first searched a possible gamma-ray emission for two nearby FRBs, FRB20180916B and FRB20181030A, and then we set up the first MW campaign on FRB20180916B ssource, including italian radio telescope (mainly the Northern Cross) and the Swift mission, once has been discovered to have periodic "activity" phases of ~5 days. No detection has been obtained either in AGILE or Swift data, but we could put contraints to the possible gamma-ray emission for a magnetar model, excluding the occurrence of giant flares like the 2005 one from SGR 1806-20 (10^46 erg in MeV range), which could be detectable by AGILE. As first results from the Swift campaign the non-detection in 0.3-10 keV, were described in some works (Tavani et al. 2020, 2021; Pilia et al. 2020; Trudu et al 2021) where we considered various scenarios including a magnetar source or some other model for instance including a BH, comparing the burst L_radio with the L_^UL_x/gamma. The 2020 discovery of a ms radio burst from SGR 1935+2154 simultaneous to a weak X-ray burst, also detected by AGILE, has been interpreted as a possible confirmation of the magnetar model for at least a sub-class of FRBs, and we compare this burst with the X-ray campaign on FRB20180916B. We will discuss the AGILE results within the MW collaboration, either on the specific FRB20180916B source or on a general study of all the sources known in 2021 (Verrecchia et al.2021) that we are currently updating, in order to improve the investigation of E_radio/E_X ratio which for the FRB200428/SGR 1935+2154 was ~10^-5, while, considering FRBs X-ray ULs, it reaches ~10^-8. We will describe current AGILE post-operations activities and the recent MW campaigns.

Parallel 1 / **133**

VERITAS Observations of New LHAASO Sources

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The first LHAASO catalogue has provided many new VHE/UHE sources and potentially new classes of sources that are primed for exploration with IACTs. The improved sensitivity at low energies (E < ~1 TeV) and angular resolution of IACTs make them the ideal instruments to help associate and perform spectro-morphological studies of these newly discovered sources. Most of these sources serendipitously lie in regions coincident with archival VERITAS observations; we have already collected hundreds of hours of data on 19 new VHE sources. In this talk we will present some preliminary results from an archival study of this coincident data, as well as discuss some of the challenges these sources pose to IACT follow-up.

Poster hang / **135**

Twelve years of PG 1553+113

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PG 1553+113 is a BL Lac object located at redshift z=0.433. It is one of the brightest and most observed extragalactic sources in the very-high-energy (VHE, E>100 GeV) gamma-ray band. One of its characteristics is the evidence of quasi-periodic modulation in high-energy (HE, >100 MeV) gamma-rays detected by Fermi-LAT, with a period of about 2.2 years.
In this contribution, we present the MAGIC and multiwavelength data collected in more than a decade of observations. Intra-band correlation analysis, as well as search for periodic emission, suggest that the emission mechanisms may be described by a two-zone synchrotron-self compton (SSC) model with two distinct electron populations. While the low-energy population is responsible for the optical, UV and HE gamma-ray photons, the X-ray and VHE bands are explained by an additional high-energy population.
Very remarkably, in April 2019, PG 1553+113 reached the brightest emission ever observed at VHE. To model this emission, we tested a two-zone SSC model for this source for the first time. This model properly reproduced the data and additionally is in line with the observed correlation among bands.

Parallel 2 / **136**

Development of an Imaging Atmospheric Cherenkov Telescope Array for Ultra-High Energy Gamma-ray Astronomy

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Dozens of gamma-ray sources are now observed to extend their emission up to Ultra-High Energies (UHE, E > 100 TeV). Most of these sources are located along the Galactic Plane and appear largely extended to ground detectors. Imaging Atmospheric Cherenkov Telescopes (IACTs) provide excellent angular resolution and a large effective area, but to build an array which is sensitive to UHE emission would typically be a complex and costly endeavor. However, if the goal is strictly to study the very highest energies (E > 100 TeV), then an array can be constructed with smaller and more affordable telescopes. *The Panoramic Search for Extraterrestrial Intelligence* (PANOSETI) team have designed telescopes that meet these requirements and have already been used to image gamma-ray initiated air showers in coincidence with VERITAS. In March 2024, three PANOSETI telescopes were deployed at Lick Observatory, California to collect data and to test analysis tools developed in conjunction with Monte Carlo simulations. Described here is the telescope technology, status of the array, and plans for future deployment.

Poster hang / 137

Simulation of the gamma-ray flux of electrospheres and study of its detectability in our Galaxy

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Electrospheres are the environments of magnetized and rapidly rotating neutron stars acting like particle accelerators. With their central star slightly less energetic than the one of a pulsar, they do not host electron-positron pair creation processes. They consist of a low density plasma made of primary high energy particles. Even if we do not know their number, they are supposed to be numerous in our Galaxy, accounting for the short life of pulsars and of their progenitors, and the long life of neutron stars. The radiative energy flux emitted by the low density plasma is too low to be observed and no electrospheres have been observed individually up to now. We have revisited this problem and analysed the radiative signature of such objects to check wether they could be responsible for a detectable diffuse gamma-ray flux. A recent code, Pulsar Aroma, computing self-consistent stationary solutions of plasma dynamics of electrospheres with the magnetic moment inclined with respect to the rotational axis of the star, was adapted to solve the radiative transfer of ultra-relativistic particles emitting curvature radiation. The spectra obtained in our simulations show a positive slope characterized by a power law which can peak above the TeV along some lines of sight, before undergoing an exponential cutoff. Accounting for the large number of dead pulsars in our Galaxy, electrospheres are likely to be responsible for a diffuse gamma-flux reaching Earth.

Parallel 2 / 138

Gamma ray flares of Flat Spectrum Radio Quasars: a statistical view

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Based on a 10 years sample of gamma-ray flares of FSRQs collected with Fermi and AGILE, I will report on a statistical study of variability for a sample of more than 300 FSRQs.

I will focus on waiting time between flares (defined as the time intervals between consecutive activity peaks; published paper: L. Pacciani, A&A, 2022, 658, 164). The investigation revealed that gamma-ray activity can be modeled with overlapping bursts of flares, with flares uniformly distributed within each burst, and a typical burst rate of
0.6/y.
Moreover, a statistically relevant fast component with timescale of order of days is revealed.
From these results, constraints on flares emission mechanisms were derived.

I will also discuss the preliminary results on an investigation of flares luminosity and duration in gamma-rays. Simple fitting models will be shown, and the correlation among peak luminosity and duration of gamma-ray flares will be discussed (paper in preparation).

Poster hang / 140

Multiwavelength modeling results of two flaring states of the distant HBL 1ES 0647+250

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1ES 0647+250 is a seemingly distant high-frequency-peaked BL Lac (HBL) object. Its redshift is uncertain but a recent 2023 estimate from the MAGIC Collaboration places 1ES 0647+250 at a redshift of 0.45 +/−0.05, which is in agreement with most estimates and lower limits in the literature. A spectrum taken with the Keck Echellette Spectrograph and Imager on 2022/12/24 shows no spectral lines from the host galaxy. According to TeVCat, adopting a redshift of 0.45 would place 1ES 0647+250 among the most distant HBLs observed at TeV energies. Two VHE flares were observed with the Very Energetic Radiation Imaging Telescope Array System (VERITAS) –in December 2012 and December 2020. We build multi-wavelength SEDs of the flares with VERITAS, Fermi-LAT, Swift-XRT, and Swift-UVOT data, and model the spectral energy distributions (SEDs) with a synchrotron self-Compton model using a tool called Bjet_MCMC. We discuss the SED modeling results and implications in this presentation.

Poster hang / 141

Gamma-Ray Potential Detection of Star-Forming Galaxies in the TeV Range

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Star-forming galaxies, although low in gamma-ray luminosity, offer insights into cosmic ray processes. While gamma-ray emission in the GeV range is closely linked to their star formation rate, the origins of their higher-energy emissions remain unclear due to limited observations.

We gathered a comprehensive sample of galaxies, including those observed by Fermi-LAT in the GeV range and others cataloged in the near-infrared within the Local Volume, with the aim to identify the most promising candidates star-forming galaxies that could be detected by future gamma-ray observatories. We utilized both physical models and empirical data to predict their TeV spectra and evaluated their detectability with the latest instrument response functions.

Our findings indicate that nearly a dozen star-forming galaxies could be detected by the next generation of Cherenkov telescopes. Observing these galaxies in the TeV range is crucial for understanding cosmic ray acceleration, transport mechanisms, and absorption processes, thereby enriching our knowledge of galactic physics.

Parallel 2 / 142

Exploring cosmic gamma rays with the novel Cherenkov plenoscope

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Atmospheric Cherenkov telescopes observe cosmic gamma rays with energies upwards of twenty giga electronvolt in collecting areas which exceed the collecting areas of satellites by orders of magnitude. However, as we further push the concept of the Cherenkov telescope array, the intrinsic limitations of imaging itself become more evident. Aberrations limit our field of view and the angular resolution in the gamma ray sky. Further, the narrowing depth of field in larger telescopes prevents us from lowering the energy threshold for cosmic gamma rays. While aberrations can to some extent be mitigated by more complex optical surfaces, the narrowing depth of field is a physical limitation which can not be overcome by spending more resources. We investigate a novel class of instrument for the atmospheric Cherenkov method which is practically free of aberrations and which turns the narrowing depth of field into the perception of the airshower's depth. We call it the Cherenkov plenoscope. Beside widening the field of view and sharpening our view into the gamma ray sky, the Cherenkov plenoscope might further enable the next generation to build a timing explorer which can collect cosmic gamma rays with energies down to one giga electronvolt in effective areas several orders of magnitude larger than the collecting areas of satellites. We will introduce the concept behind the Cherenkov plenoscope and give an outlook on a specific design for a one giga electronvolt timing explorer.

Parallel 2 / 143

Cosmology and multi-messenger astrophysics with the THESEUS space mission

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The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept aimed at fully exploiting Gamma-Ray Bursts (GRB) for
investigating the early Universe and as key phenomena for multi messenger astrophysics. Developed by a large European collaboration coordinated by INAF and under study by ESA since 2018, THESEUS is currently one of the three candidate M7 missions for a launch in the mid '30s. By providing an unprecedented combination of X-/gamma-ray monitors, on-board IR telescope and spacecraft autonomous fast slewing capabilities, this mission would be a wonderful machine for the detection, multi-wavelength characterization and redshift measurement of any kind of GRBs and many classes of X-ray transients, including high redshift GRBs for cosmology (pop-III stars, cosmic reionization, SFR and metallicity evolution up to the "cosmic dawn") and electromagnetic counterparts to sources of gravitational waves (e.g., short GRBs, soft X-ray and KN emission from NS-NS / NS-BH mergers). Through these unprecedented capabilities and a flexible guest observer programme, THESEUS will also have a great impact on general time-domain astrophysics and, in all respects, will provide an ideal synergy with the very large astronomical facilities of the future in the e.m. (e.g., ELT, CTA, SKA, Athena) and multi-messenger (e.g., Einstein Telescope, Cosmic Explorer, km3NET) domains.

Parallel 2 / **144**

Axion-like particle impact in high-energy astrophysics

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Axion-like particles (ALPs) are neutral, spin zero bosons primarily interacting with photons, are predicted by String Theory and are among the best candidates for dark matter. Due to their low coupling with photons, ALPs are difficult to detect in laboratory experiments, but they produce observable effects in the astrophysical environment, which represents the best opportunity to study ALP physics. In particular, in the presence of external magnetic fields, photon-ALP oscillations arise which produce consequences on spectra and polarization of astrophysical sources, such as blazars and gamma-ray bursts. We discuss ALP-induced effects on astrophysical spectra, which can be detected by observatories, such as ASTRI, CTAO and LHAASO. Therefore, we show that future observational data will provide us with additional information by confirming current indications at ALP existence or further constraining the ALP parameter space (ALP mass, photon-ALP coupling).

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Stochastic acceleration in Extreme TeV BL Lacs

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Active Galactic Nuclei (AGN) are the most powerful persistent sources in the Universe. Blazars, AGN whose jet is pointed towards the Earth, present the most energetic emission. Lately a specific kind of

blazar drew the attention of the gamma ray astronomy community: the Extreme TeV Bl Lacs. These sources exhibit a peak of radiation at TeV energies and a hard intrinsic spectrum at sub-TeV range. In most cases their exceptional TeV emission appears to be steady over years. These properties are difficult to reproduce using models based on a single shock, so several alternative solutions have been proposed. Starting from recent works on recollimation instability in relativistic jets with low magnetization, we proposed a hybrid scenario: non-thermal particles are first accelerated by the recollimation shock and later energized by the turbulence developed in the downstream region. The idea was initially tested on the prototypical extreme TeV Bl Lacs 1ES 0229+200 without considering the damping of the turbulence, which was later included for self-consistency. Afterwards the model was compared with other Extreme TeV Bl Lacs, using a Markov chain Monte Carlo ensemble sampler (i.e. emcee) to automate the search in the large parameters space of the model.

Parallel 2 / **146**

Liquid Argon TPCs in space: The Gamma-Ray and AntiMatter Survey (GRAMS) Project

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Recent breakthroughs in neutrino astronomy indicate that the majority of cosmic-ray accelerators responsible for hadronic emission are not associated with Fermi-LAT's bright sources at GeV energies. Instead, they suggest that the solution to the century-old cosmic-ray mystery may lie at MeV energies. Additionally, precision anti-deuteron measurements provide a background-free indirect dark matter search. The GRAMS (Gamma Ray and AntiMatter Survey) experiment utilizes a cost-effective Liquid-Argon Time Projection Chamber deployed in the upper Earth atmosphere and eventually, space, to target both MeV gamma-rays and anti-matter. In this talk, we present the sensitivity of GRAMS to both MeV gamma-rays and anti-deuterons, and discuss the prospects of the final mission. We also report on the status of pGRAMS, a NASA-funded prototype balloon flight scheduled to deploy in 2025-2026.

Parallel 2 / **147**

Particle acceleration by magnetic reconnection and the production of gamma-rays in AGN relativistic jets and accretion disks

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3D Magnetohydrodynamic (MHD) resistive simulations have highlighted the unequivocal significance of widespread turbulence to drive fast reconnection. Moreover, it has been demonstrated that particle acceleration via reconnection in 3D magnetized flows, where turbulence is embedded within large-scale magnetic fields such as in relativistic jets and accretion flows around compact sources, is remarkably efficient. Particles experience Fermi acceleration across all scales of turbulent reconnection layers, outweighing the considerably slower drift acceleration mechanism. This stands in contrast to recent assertions stemming from Particle-in-Cell (PIC) simulations, that claimed the dominance of the latter process. In this talk, I will review how particle acceleration to very high energies is driven by 3D turbulent reconnection and highlight its potential in magnetized regions of AGN accretion disks and jets to explain the associated gamma-ray and neutrino emissions. Applications to sources such as TXS 0506+056, Mrk 501, and NGC 1068 will be discussed.

Parallel 2 / 148

H.E.S.S. observations of the unprecedented gamma-ray outburst of PKS 0903-57

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The blazar PKS 0903-57 underwent a huge gamma-ray outburst in early 2020, where the gamma-ray flux increased by more than an order of magnitude and the gamma-ray peaked energy increased by almost a factor 100. Follow-up observations with H.E.S.S. over 6 nights reveal a complex evolution of the gamma-ray component suggesting time- and energy-dependent acceleration and cooling processes. The X-ray domain is less active but still varies in flux by a factor of a few with a stable spectral index. The optical domain is hampered by the presence of a Galactic star merely 0.7" away from the radio position of PKS 0903-57. The total optical flux including the star and the blazar is variable wihtin a factor of few, but modeling of the ground state and the flaring state suggests that the optical blazar flux may vary up to a factor 10. The characteristics of the source suggest that PKS 0903-57 is an FSRQ, even though modeling in both ground and flaring state requires low magnetic field values of less than 0.1G. The SEDs derived during the H.E.S.S. observations are reproduced with a leptonic model employing a variable magnetic field, as well as variable electron densities and minimum and maximum Lorentz factors.

Poster hang / 149

Multiwavelength correlation studies in the era of CTAO

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Correlations between various multiwavelength bands are an intermittent feature in blazar light curves; that is, they are observed in some instances but not in others. In order to understand the cause of this intermittency, high-cadence observations are required in as many bands as possible. In turn, correlations have been studied predominantly during flaring states. However, with the CTAO we will obtain detailed VHE gamma-ray light curves for many sources also during their low states enabling correlation studies of the VHE gamma-ray band with all other energy bands during both high and low states. The observed light curves can then be used to feed time-dependent models to reproduce the observed patterns as closely as possible and to check for the required parameter evolution. Here, we present the first steps in an ongoing effort within the CTAO. For two blazars, the HBL Mrk 421 and the FSRQ PKS 1510-089, the long-term X-ray and optical light curves are used to induce variations in input parameters of the lepto-hadronic one-zone code OneHaLe. The important outputs are light curves in the CTA energy range employing 3 different energy thresholds. The main initial results are: 1) the presence of relativistic protons has a significant effect on the correlation of the 3 light curves due to the emerging pair cascade which prolongs flaring states at the highest energies; and 2) comparison of the theoretical light curves with existing VHE gamma-ray data shows that both leptonic and hadronic models can only partially reproduce the data with the current simple setup.

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H.E.S.S. detection of very high energy emission surrounding the microquasar V4641 Sgr - [REMOTE]

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Microquasars present a remarkable opportunity to study particle acceleration in astrophysical jets due to their relative proximity to Earth compared to their extra-galactic counterparts. Yet this opportunity is rather limited since TeV emission has only been firmly associated with the jets of one microquasar so far. Fortunately, this might be about to change: in this contribution we present the result of H.E.S.S. observations of the microquasar V4641 Sgr, following up from the HAWC detection announced in Gamma 2022. Through our study of the spectral and morphological properties of the TeV emission around this system, we aim to answer the question: is V4641 Sgr the particle accelerator responsible for the detected emission? And if so, can the acceleration site be identified? Detecting TeV gamma-rays from the jets of a second microquasar would not only provide valuable insights to the study of particle acceleration in jets in general but also constrain the relative contribution of microquasars as a class to the observed cosmic ray spectrum.

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Transient gamma rays from the 2021 outburst of RS Ophiuchi

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RS Ophiuchi is a recurrent nova which explodes on average every 15 years. These explosions result in nova shocks from which non-thermal particles and radiation are produced. In fact, the most recent outburst of RS Ophiuchi in 2021 has been observed by a few different gamma-ray instruments including FERMI-LAT, HESS and MAGIC. Interestingly, the highest TeV gamma rays are only detected about two days after the detection of GeV gamma rays such that there is a delay of about two days between the peaks of GeV and TeV gamma-ray light curves. Different models have been proposed to explain this delay, e.g. by involving multiple nova shocks or different production mechanisms (leptonic versus hadronic) for GeV and TeV gamma rays. In this talk, we discuss a possibility to explain the delay between GeV and TeV emissions by taking into account the effect of gamma-ray absorption due to interactions between gamma rays and optical photons emitted also during the outburst.

Parallel 2 / 152

Investigating Active Galactic Nuclei variability with the Cherenkov Telescope Array Observatory

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Blazars, a type of active galactic nuclei (AGN) with relativistic jets aimed at the observer, display flux variability across the electromagnetic spectrum due to particle acceleration within their jets. The power spectral density (PSD) of blazars reveals breaks at specific frequencies, especially in X-rays, which correlate with the accretion regime and the mass of the central black hole. However, the predicted break in the very-high-energy gamma-ray PSD has not been explored due to the limitations of current instruments. The upcoming Cherenkov Telescope Array Observatory (CTAO) offers significantly improved sensitivity, up to five to ten times better than existing telescopes. This advancement will not only allow for precise PSD reconstruction but also enable the study of blazar flares with unprecedented temporal resolution. Blazar flares provide crucial insights into particle acceleration, photon production, jet structure, and physical properties. This contribution highlights the AGN long-term monitoring and flare programs within CTAO, essential components of the AGN Key Science Project, which are expected to greatly enhance our understanding of the complex processes driving blazar emissions.

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Blazar emission from gradual magnetic dissipation: the jet as a multitude of communicating segments

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AGN jets are sprawling entities, with structures of differing size and magnetic field strength extending from very close to supermassive black holes up to over a hundred parsecs away. However, it has long been expedient to calculate their emission in one-zone models, which are effectively spheres. This is optimal for variability studies but also sidesteps the issue of irresolvable structure in what are, in the case of blazars, head-on jets. Here we treat blazar jets as a conical series of spherical segments, where energy is constantly being dissipated from magnetic reconnection in the current sheets that form from the alternating polarity of the jet's toroidal field. Within each segment we apply the LeHaMoC code to self-consistently calculate the photon emission from electrons that may be accelerated there, and we iteratively apply the effect of radiation spilling into the rest of the segments across the jet; that is, we treat radiation crossing through each segment from each other segment as an additional injection term in LeHaMoC's kinetic equations. In this way, we investigate the impact of such interactions between segments.

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Radiation-mediated shocks in gamma-ray bursts

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The prompt emission in gamma-ray bursts (GRBs) has been a subject of debate for half a century. Photospheric radiation emitted when the jet transitions from the optically thick to the optically thin regime is a promising candidate. To account for the observations, subphotospheric dissipation should occur before the photons decouple from the plasma. Due to the high radiation pressure, shocks below the photosphere are not collisionless but so called radiation-mediated shocks (RMSs), and the distinction is crucial for the resulting spectrum. In this talk, I present the first-ever fit of a prompt GRB spectrum with an RMS model. I also show that RMS spectra are in many ways similar to the observations, as they consist of a broad, soft power law across the sub-MeV-band with an additional break in X-rays. Finally, I present preliminary results regarding the predicted time-resolved signal.

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X-ray Flares of GRBs in High-Energy Gamma Rays.

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X-ray flares are characterized by a sudden rebrightening of X-ray radiation during the afterglow phase of gamma-ray bursts (GRBs). While the majority of GRBs exhibit a flux temporal decay consistent with the standard afterglow model, approximately one-third of GRBs observed by the Swift X-ray Telescope (XRT) display these flares. These flares, which occur primarily within a thousand seconds after the initial burst (prompt emission), are thought to arise from processes related to the burst's central engine but their origin is still unknown. Proposed mechanisms include reverse shocks from interactions with surrounding material, late-time activity of the central engine, internal shocks within the jet at sub-relativistic velocities, magnetar activity in the central engine, and interactions with a clumpy surrounding medium.
In this talk, I will present a systematic study of X-ray flares using available multiwavelength data, looking at the possible emergence of high-energy (GeV) radiation detected by the Large Area Telescope (LAT) on the Fermi Satellite. This study examines flares' temporal and spectral evolution across keV to GeV energy ranges. Among 351 GRBs with flares detected by Swift-XRT over a 15-year of Fermi observations, 126 GRBs have simultaneous observations of flares from both telescopes. The talk will present the combined X-ray (keV) and gamma-ray (GeV) spectral properties of these flares and their theoretical implications.

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A first comprehensive analysis of the distributions of the ISM, gamma-rays, and X-rays over the Large Magellanic Cloud

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Diffuse gamma-ray emission is thought to be primarily produced by interactions between cosmic-ray protons and interstellar protons via hadronic processes. Therefore, it provides a valuable opportunity to obtain a comprehensive understanding of cosmic-ray distribution and the interstellar gaseous medium. We present the first analysis of the spatial distributions of GeV and TeV gamma-rays, hard and soft X-rays, and interstellar molecular/atomic clouds over the whole Large Magellanic Cloud (LMC). We have found the global distribution of Fermi gamma-rays closely resembles that of interstellar molecular and atomic hydrogen gas, as revealed by the NANTEN CO and ATCA & Parkes HI. Locally, gamma-rays excesses are spatially coincident with the positions of X-ray bright supernova remnants observed with eROSITA. We also found that there are no X-ray and CO/HI counterparts for the gamma-ray excess inside LMC 4, suggesting that localized ionized gas may also act as a target for cosmic-ray protons. In addition, we will discuss the origin of diffuse soft X-rays in the LMC as produced by the supersonic gas collisions as driven by the tidal interaction between the LMC and the SMC. The present comparisons mark a first step toward a full understanding of the interplay between the high energy radiations and the cool ISM in a galaxy.

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ALMA CO Observations toward the Gamma-Ray Supernova Remnant W28

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Investigating the molecular clouds surrounding a supernova remnant (SNR) is essential in understanding the acceleration and diffusion processes of cosmic rays because the clouds act as targets for cosmic-ray protons to produce gamma-rays via the hadronic processes. We present new observations of TeV gamma-ray SNR W28 with the Atacama Large Millimeter/submillimeter Array (ALMA) in ^{12}CO(J = 2–1) and ^{13}CO(J = 2–1) emission lines (PI: H. Sano). Thanks to ALMA's unprecedented sensitivity and angular resolution of $\sim$5 arcseconds (or $\sim$0.05 pc), we unveiled filamentary distributions of molecular clouds which are bright in TeV gamma-rays. The typical widths of molecular filaments are less than $\sim$0.1 pc, possibly suggesting that both the low- and high-energy cosmic-ray protons can easily diffuse the entire filaments and produce the hadronic gamma-rays. Indeed, the good spatial correspondence between the molecular clouds/filaments and TeV gamma-rays is the same as the previous studies using the NANTEN radio telescope and H.E.S.S. (Aharonian et al. 2008). These findings have the potential to advance the theories of cosmic-ray acceleration and diffusion in SNRs by considering the effects of an inhomogeneous gaseous medium. In this presentation, we will discuss the close relation between the NANTEN/ALMA detected molecular clouds/filaments and TeV gamma-rays.

Parallel 1 / **158**

Prospects on detection of the Fermi Bubbles with CTAO

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In 2010, the Fermi Gamma-ray Space Telescope observed two gamma-ray emitting structures, the Fermi Bubbles (FBs), that extend up to 55° above and below the Galactic plane and that seem to emanate from the Galactic center region. Although the spectrum at latitudes |b| > 10° has a softening or a cutoff around 100 GeV, the one at the base of the FBs, |b| <10°, extends up to about 1 TeV without a significant cutoff in the Fermi LAT data. The mechanism behind the FBs production is currently under debate. More observations of the FBs at different energies are required to improve our understanding of their origin.

Recently, H.E.S.S. and HAWC observatory have set upper limits on the FBs. In this work, we assess the sensitivity of the Cherenkov Telescope Array Observatory (CTAO) using the "alpha configuration" to detect the FBs and investigate the optimal strategies for their detection at low latitudes. We simulate the observations using the official CTAO science tool gammapy, considering several benchmark models for the FBs and the interstellar emission and test different observational strategies taking advantage of the proposed CTAO consortium surveys. We use these simulations to estimate the CTAO sensitivity to the FBs.

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Gamma-ray counterpart searches to neutrino astrophysical sources with the Cherenkov Telescope Array Observatory: simulations and performance studies

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Gamma-ray counterparts to astrophysical neutrino sources is a topic of big interest, being the contemporary observation of both these messengers a smoking gun for cosmic-ray production.
The Cherenkov Telescope Array Observatory (CTAO) will be the next major observatory in the Very High Energy gamma-ray band. Based on the imaging atmospheric Cherenkov technique, it will reach unprecedented performances with respect to the current generation of instruments. In particular CTAO will be a leading observatory of the gamma-ray transient sky, given both its sensitivity at short timescales and its rapid repointing system, with a very fast slewing to and from anywhere in the observable sky of the order of 1 minute.
In this work, we explore CTAO performances combined with capabilities of current and future neutrino observatories, like IceCube and Km3NeT.
In particular, we investigate the CTAO ability to detect gamma-ray counterparts to neutrino simulated extragalactic sources, by exploiting the open-source simulation software called FIRESONG. Two types of populations are considered: steady sources and transient "flaring blazar-like"ones . Neutrino simulations are selected by considering IceCube and Km3NeT discovery potentials. The

CTAO performance under different configurations and array layouts is finally computed, giving the detection probability of gamma-ray counterparts for both CTAO sites.

Parallel 2 / 160

Imprint of local opacity effect in gamma ray spectrum of Blazar jets : Constraining the gamma-ray emission site - [REMOTE]

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Black hole-driven relativistic astrophysical jets, such as blazars and gamma-ray bursts (GRBs), are powerful sources of electromagnetic radiation. When these jets are directed toward observers, they intensify emitted radiation, condensing the entire output into a focused, point-like object. Blazars exhibit emissions across the electromagnetic spectrum, spanning from radio frequencies to very high energies. The GeV spectrum within the jets of blazars is shaped primarily by the non-thermal emission processes internal to the jet. However, the external thermal environment surrounding the high-energy emission site is expected to leave an imprint of pair production absorption at high energies, especially if the emission region lies within the influence of the nearby external jet environment. This could potentially refine our understanding of the gamma-ray dissipation sites in blazars.

Our study reveals **GeV breaks at energies above 10 GeV**, explained by gamma-ray absorption through photon-photon pair production on H-alpha or H-beta photons, specifically during the high state of the source. The high redshift of PKS 1424-418 (z=1.522) suggests that the Extragalactic Background Light (EBL) is the primary source of the observed absorption feature. Remarkably, **this feature is absent during the low flux state, indicating an additional absorption effect during the high activity period beyond the expected EBL absorption**. The presence of a GeV break in the high state, contrasted with its absence in the low state, supports the idea that gamma-ray emission sites within or at the edge of the Broad Line Region (BLR) transition to fainter gamma-ray emission zones beyond the BLR.
The detection of high-energy photons in FSRQs is typically believed to occur outside the influence of BLR to avoid pair production. Towards the edge of BLR, the emergence of kink instability could produce magnetic islands, leading to particle acceleration due to magnetic reconnection. Variabilities associated with magnetic reconnection are expected to follow a mini jet-in-jet model, resulting in a log-normal flux distribution observed during high states, in contrast to the Gaussian distribution during low states in our work.
The inferred location of the γ-ray emission zone is consistent with the observed variability timescale of the brightest flare in 2022, assuming the flare is due to external Compton scattering with BLR photons. This supports the interpretation that the **high-energy emission region is primarily confined to the edge of the BLR.**

Parallel 1 / 161

The Galactic Center as seen by the Southern Wide field-of-view Gamma-ray Observatory

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The Galactic Centre (GC) is a complex region with several sources emitting very-high and ultra-high energy photons. It is also a unique place for Dark Matter (DM) searches under the assumption of cuspi profile in the WIMP theory. The Southern Wide field-of-view Gamma-ray Observatory (SWGO) is currently under development aiming to observe the GC region among other interesting regions in the southern hemisphere. We present the expected GC gamma-ray emission as will be seen by SWGO, and its sensitivity to WIMP DM annihilation. The simulations use the updated instrument response functions (IRFs). We study the performance of the different array and detector configuration which is very important in the design phase of the observatory.

Parallel 2 / 162

Application of compact detectors composed of oriented crystals to the observation of VHE gamma rays in space

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High-density and high-Z crystals are a key element of most of the γ-ray telescopes operating at the GeV energy scale (such as Fermi-LAT). The lattice structure of these materials is usually ignored for all practical purposes, such as instrument calibration or simulation. However, recent studies performed by the STORM-OREO collaboration have shown that this is a rough approximation, since high-energy (
$gtrsim5$ GeV) photons impinging along the axis of an oriented crystals interact differently from the ordinary. Specifically, if the angle between the photon trajectory and the crystal axis is smaller than $\sim 0.1°$, a large enhancement of the pair production cross-section is observed, and even at angles as large as $\sim 1°$ there exists a weaker but non negligible effect. The net consequence of this effect is the fact that the electromagnetic shower initiated by a high energy photon develops in a much more compact space than the ordinary.

These effects could be exploited to develop novel compact gamma-ray telescopes. For instance, a telescope composed of oriented crystals could achieve the same performance of a much thicker (and thus heavier and more expensive) non-oriented one, while pointing to a specific source. Otherwise, a larger effective area could be achieved, without increasing the overall volume. Moreover, even in the absence of pointing, the telescope would still perform ordinarily.

This detector concept is highly interesting for $\gamma-$ray astronomy: the enhanced sensitivity to $\gamma-$rays, coupled with a high spatial resolution, could allow to better identify unknown sources in the galactic plane and investigate the nature of the gamma excess in the galactic center. Moreover, the higher sensitivity to very high-energy photons could allow to extend the detector energy range well in the multi-TeV range, thus providing complementary and unique information to that expected in the next generation of ground-based IACTs.

In this contribution we discuss the scientific opportunities that will be opened by the use of oriented crystal in compact detectors for $\gamma-$ray astronomy, along with the techniques used to simulate and assemble such instruments.

Parallel 1 / 163

Probing circumgalactic cosmic rays around the Milky Way via GeV-PeV gamma rays and neutrinos

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Cosmic rays (CRs) in the GeV-PeV range are believed to originate mainly from sources in the Milky Way (MW) disk, propagate diffusively in the interstellar medium, and eventually escape into the circumgalactic medium (CGM) that permeates the MW halo. Circumgalactic CRs (CGCRs) may play important thermal and dynamical roles for the formation and evolution of the MW, but observational evidence for them is very scarce to date. We discuss constraints on CGCRs from available gamma-ray observations and our current knowledge of the MW CGM. Particularly emphasized is the PeV band, with various advantages over the GeV-TeV bands in probing spatially extended emission from the MW CGM, by virtue of gamma-gamma absorption effects with the cosmic microwave background. Using data from Tibet ASgamma, we search for signals associated with intermediate velocity clouds (IVCs) and high velocity clouds (HVCs) seen in HI, and find no clear evidence so far. For IVCs, previous GeV detections combined with our PeV upper limits provide valuable constraints on the propagation of CRs at Galactic heights z~a few kpc, and possibly on their relation to Galactic winds. For HVCs that can probe more distant CGCRs at z~10 kpc, our limits are relatively weaker, but nevertheless offer unique constraints on some non-conventional scenarios for the origin and propagation of PeV CRs. We also touch on the relevance of IceCube neutrino observations for probing CRs in the outer CGM at z~100 kpc. Prospects are discussed for significant advances with LHAASO, SWGO and Mega ALPACA, complementary constraints from CTA and ASTRI, as well as improved knowledge of the MW CGM from future radio, UV and X-ray observations.

Poster hang / 164

Study of Periodicity in Blazar Light Curves with a Machine Learning Approach

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Long-term periodicity in Blazar light curves could be linked to the innermost zone of the complex structure of AGN, such as possible presence of binary system of supermassive black holes.
We analysed 16 years light curves of 1525 gamma-ray sources coming from the Fermi-LAT Light Curve Repository (LCR). First, we set up a periodicity analysis pipeline using Lomb-Scargle Periodogram (LSP) and Weighted Wavelet Z-transform (WWZ), employing Emmanoulopoulos simulations for significance estimation. We found significance periodicities in almost 1% of the sources, consistent with recent works, and identified a golden sample of 6 sources.
Furthermore, we used a machine learning approach to explore similarities not necessarily related to periodicity, and to control, from a different perspective, Quasi Periodic Oscillations against red noise. Hence we used an unsupervised algorithm: t-Stochastic Neural Embedded (t-SNE), it calculates the probability of considering neighbor set of data, defining Euclidean distances without proper meanings. The goal of this work is to highlight similar sources or identify a sample of interesting variable sources.
The t-SNE map for simulations showed signals well separated from white and red noises. Therefore, applying the tuned method to the sources, we obtained a similar morphology, where the golden sources are arranged close to each other.

Parallel 1 / 165

Concurrent spectral and light curve synchro-curvature modelling of pulsars

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In this talk I will present the current status of our development of an effective radiative model versatile enough to be applied to hundreds of
pulsars. The model follows the dynamics of charged particles being accelerated in the magnetosphere of a pulsar and computes their emission via synchro-curvature radiation, with only three free effective parameters involved. The model has succeeded in fitting the gamma-ray spectra of the whole population of gamma-ray pulsars and reproduces well a majority of those pulsars that also have detected non-thermal X-ray pulsations. Complementary to the spectral model, for which we have incorporated several improvements related to the description of the acceleration region, a geometrical representation allows to build synchro-curvature emission maps from which light curves can be obtained. The sample of theoretical light curves created presents features very similar to the zoo of observational gamma-ray light curves of pulsars, in terms of morphology, number of peaks and widths of the peaks. We find a general agreement in global properties with several main conclusions:
Among them 1) that the detection probability due to beaming is much higher for orthogonal rotators (approaching 100 per cent) than for small inclination angles (less than 20 per cent), 2) that the small variation in the synthetic skymaps generated for different pulsars indicates that the geometry dominates over timing and spectral properties in shaping the gamma-ray light curves.

The talk is based on the latest of a series of published papers: Íñiguez-Pascual, Torres, Viganò 2022 (MNRAS, 516, 2475), Íñiguez-Pascual, Torres, Viganò 2024 (MNRAS, 530, 1550).

Poster hang / 166

Multiwavelength and X-ray Polarization Study of BL Lacertae

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The origin of high-energy emission in blazars, a subclass of active galactic nuclei known for their variable, non-thermal emission across the electromagnetic spectrum, remains highly debated. Traditional one-zone models have struggled to explain the dynamic nature of these emissions, prompting more sophisticated approaches. The recent availability of X-ray polarization observations offers a new way to distinguish between competing models. By combining multiwavelength and polarization campaigns with advanced spectral energy distribution models, we focus on X-ray polarization observations of the blazar BL Lacertae during flaring and quiescent γ-ray states. Our results indicate that inverse-Compton scattering from relativistic electrons dominates X-ray emissions across different models.

Parallel 1 / **167**

WITHDRAWN - From gamma rays to gravitational waves: multi-messenger emission from pulsar glitches

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Pulsars are the main population of gamma-ray emitters in the Galaxy. To date, the Fermi Large Area Telescope (LAT) has detected about 300 gamma-ray pulsars, some young and energetic and others belonging to the family of older and fast-rotating millisecond pulsars. Because of their much broader gamma-ray beams, a significant number of LAT pulsars discovered in gamma rays are undetectable in radio, making the LAT an ideal instrument to carry out an unbiased study of pulsars. Gamma-ray pulsars often exhibit glitches, or sudden changes in frequency f and other timing parameters, with Δf/f ranging from ~ 1e−12 to 1e−5. Although studied for decades, the exact nature of pulsar glitches remains unclear. Glitches are believed to affect the magnetospheric emission of a pulsar, and a fraction of the energy released during a glitch is expected to be converted to gravitational waves. The gravitational signature of a pulsar glitch is expected to be a transient signal potentially detectable by current or future ground-based gravitational wave detectors. We will report on the prospects for observing electromagnetic and gravitational wave emission from pulsar glitches, with particular attention to the most interesting candidates among gamma-ray pulsars.

Parallel 2 / **168**

LST-1's Early Achievements in AGN Observations: Discovery of the Farthest Blazar OP 313 at VHE Gamma Rays

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Flat Spectrum Radio Quasars (FSRQs) are some of the most powerful and dynamic sources in the Universe, exhibiting emission across the entire electromagnetic spectrum, from radio to gamma rays. Despite their intense luminosity, detecting FSRQs at very-high-energy (VHE) gamma rays (E>100 GeV) remains a challenge, largely due to internal absorption of these photons within the source itself. To date, only nine FSRQs have been observed at such high energies, underscoring the difficulty of these detections.

The recent detection of OP 313, a notable FSRQ at a redshift of z=0.997, marks a significant milestone. Gamma-ray absorption by extragalactic background light at this redshift presents a formidable challenge for contemporary imaging atmospheric Cherenkov telescopes. However, the Large-Sized Telescope prototype (LST-1), a precursor to the Cherenkov Telescope Array Observatory (CTAO), succeeded in detecting OP 313 at VHE gamma rays during a high-activity state. This success illustrates LST-1's exceptional lower energy threshold, demonstrating the capabilities of the future CTAO in advancing our understanding of FSRQs. This achievement not only adds to the exclusive list of FSRQs detected at VHE but also establishes OP 313 as the most distant blazar detected in this energy range.

In this contribution, we will present the recent results on Active Galactic Nuclei from LST-1, with a focus on the discovery of OP 313, the furthest blazar ever detected so far at VHE gamma rays. The supporting observations from the MAGIC telescopes will also be briefly discussed, highlighting the collaborative effort in this significant detection.

Parallel 1 / 169

Discovery of Multi-TeV Pulsations from PSR J1509-5850 with H.E.S.S.

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We report on the discovery of multi-TeV gamma-ray pulsationsfrom PSR J1509-5850 with the H.E.S.S. array of imaging atmospheric Cherenkov telescopes. The light curve above 500 GeV is similar to the one obtained in the multi-GeV range with Fermi-LAT with no significant evolution with increasing energy.
The pulsed spectrum, as measured in the 500 GeV-10 TeV range, displays a hard index and is reminiscent of the spectrum of the Vela P2 pulse. After the Crab and Vela pulsars, PSR J1509-5850 is the third one detected in the Very-High-Energy domain (>100 GeV) and the second one displaying a hard and multi-TeV spectral component. We will compare the properties of the two multi-TeV pulsars and discuss the implications for high energy emission models of pulsars.

Parallel 1 / 170

Withdrawn - Recent progress in understanding the physics of radio pulsars.

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Radio pulsars are quintessential high-energy astrophysics objects. They emit most of their energy in gamma-rays, accelerate particles to very high energies and produce dense relativistic plasma. Despite decades-long efforts, we still do not have a consistent model of radio pulsars, though significant progress has been achieved in the last two decades thanks to advances in numerical models of pulsar magnetospheres. I will give a brief overview of the most recent development in the modeling of physical processes in pulsar magnetospheres using kinetic plasma simulations. The main emphasis will be on modeling pulsar polar caps, where most of the plasma in the magnetosphere and the pulsar wind is produced.

Parallel 1 / 171

Detection of molecular clouds in the Vela X region by the NANTEN telescope and study of the interaction between the clouds and the pulsar-wind nebula

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Observation with an arc-minute scale resolution of dense molecular clouds located at pulsar-wind nebulae (PWNe) is important to study the interaction between the interstellar gas and PWN and the evolution of the complex morphology of PWNe, as noted in some previous literature. Our study performs the first dedicated research of the molecular clouds located at Vela X, the large PWN around the Vela pulsar, by analyzing the 12CO(J=1-0) line emission data given by the NANTEN telescope. Thanks to the close vicinity of Vela X (290 pc from the solar system) and the good angular resolution of 2.6'of the NANTEN telescope, our study successfully detects the molecular clouds resolved into a sub-pc physical scale. The distribution of the clouds is found to be well correlated with the morphology of the TeV gamma-ray emission of Vela X detected by H.E.S.S., supporting their interaction with the PWN. The presentation gives comparisons between the morphology of the PWN and the distribution of interstellar gas covering a broad range of wavelengths from radio to TeV gamma rays and discusses the role of the interstellar gas in Vela X including potential acceleration of hadronic cosmic rays in the PWN.

Poster hang / 172

Current status of the ALPACA project in Bolivia to search for PeVatrons in the southern sky

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ALPACA (Andes Large-area PArticle detector for Cosmic-ray physics and Astronomy) is a new air shower array observatory to be constructed in Mt. Chacaltaya, Bolivia in 2025. The experiment will mainly be dedicated to the search for Galactic PeVatrons in the yet-unexplored southern sky through the observation of sub-PeV gamma rays. The observatory consists of two parts: a surface air shower array (AS array, 83,000 m2) composed of 401 plastic scintillation detectors to reconstruct energies and arrival directions of primary events and an underground water-Cherenkov-type muon detector array (MD array, 3,600 m2) to discriminate between gamma- and cosmic-ray events. The prototype array ALPAQUITA is in full operation since 2023, and the studies of its performance using the recorded data are ongoing. This presentation gives scientific goals of the ALPACA project and its current status which includes the results of the data analysis using ALPAQUITA and the ongoing construction of an MD for the prototype array.

Poster hang / 173

Artificial Neural Network Classification of the Fermi-LAT Catalog Blazars of Unknown Type and Unidentified Sources

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The Fermi-LAT detected more than 7000 γ-ray sources in 14 years of operation. Many of these sources are still unassociated with counterparts in other wavelengths, others are associated to generic classes, but their classification is still unclear. I present a Machine Learning approach to the classification of Fermi-LAT Unidentified Sources and Blazars of Unknown Type using multiwavelength information. I present the Artificial Neural Network methods used to classify the blazars and to find possible multiwavelength counterparts for the Fermi-LAT Unidentified γ-ray Sources. I then conclude by highlighting the uses of the results obtained with this method and the potential future improvements.

Poster hang / 174

Search for VHE Short-Timescale Variability in PG1553+113

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PG 1553+113 is a high-frequency peaked BL Lac object (HBL), with redshift 0.433, detected with the current generation of IACTs (Imaging Atmospheric Cherenkov Telescopes) up to ~1 TeV. Interestingly, the continuous gamma-ray lightcurve collected by Fermi-LAT since 2008 showed a signature of a periodic modulation of 2.18 ± 0.08 years at energies above 100 MeV and 1 GeV. In addition, the source shows clear variabiliy down to day-scale in all bands. XMM-Newton data recently showed rapid variability in the X-ray band down to 2.4 ± 0.7 ks.

Short-timescale (sub-hour) variabilities are a key observable to constrain the size of the photon-emitting region inside the blazar jet. The LST-1 (first protoype of the Large-Sized Telescope) of the CTAO (Cherenkov Telescope Array Observatory) is located on Roque de los Muchachos in La Palma, Spain. With its high sensitivity at low energies (20-150 GeV), it provides a unique opportunity to investigate such phenomena. In 2023, the source had a very bright flare that triggered LST-1 and multi-wavelength data campaigns. In this study, we present the results of this observation campaign, in particular, the search for short-timescale variabilities.

Plenary / 175

Galactic science (Rapporteur talk)

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I will summarize and comment on key results in the galactic science reported during the meeting.”

Parallel 2 / 176

The Small-Sized Telescopes of CTAO: current status and future development

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The Small-Sized Telescopes (SSTs) are the smallest of the three different sizes of Cherenkov telescopes that will be part of the Cherenkov Telescope Array Observatory (CTAO). Based on a Schwarzschild-Couder-like dual-mirror optical configuration, they have a primary mirror of ~4-m diameter and are equipped with a focal plane camera based on SiPM detectors covering a field of view of ~9°. They will cover the highest energy range of CTAO (up to ~300 TeV) and 37 of them are foreseen to be installed in the alpha-configuration of the southern site of CTAO, in the Chilean Andes. Here we will give an overview on the status of the SST project that is developed by an international consortium of institutes that will provide them as an in-kind contribution to CTAO.

Poster hang / 177

Detection of Transient Gamma-Ray Bursts Signal through Quantum Convolutional Neural Network, A performance study and Benchmarking

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Astrophysics, and specifically gamma-ray astronomy, are transitioning into an era characterized by vast and complex datasets. The ability to make new discoveries depends on the efficient and accurate analysis of this data, necessitating the adoption of innovative methodologies. Deep Learning has become increasingly vital in addressing astrophysical challenges, with its application expanding rapidly. However, the potential of Quantum Deep Learning in this field remains largely unexplored and offers a promising frontier for advancing data analysis capabilities.

On the other hand, efficient detection and analysis of Gamma-Ray Bursts (GRBs) are critical for advancing our understanding of these high-energy events. The Cherenkov Telescope Array (CTA) represents a new era in gamma-ray astronomy, equipped with over a hundred sensitive and fast-reacting Cherenkov telescopes. The CTA's real-time analysis software is designed to promptly generate science alerts and analyze observational data, making rapid and accurate GRB detection a priority.

In this study, we focus on enhancing the detection of GRB signals using Quantum Convolutional Neural Networks (QCNNs) on CTA simulation datasets. Building on previous research that demonstrated QCNNs' ability to accurately identify GRB signals in AGILE mission data, we apply and test various QCNN architectures to optimize their performance for the CTA.

We implemented hybrid quantum-classical machine learning models using Parametrized Quantum Circuits, and evaluated their performance through the Pennylane and Qiskit libraries. Our analysis explored different QCNN architectures and encoding methods, including Data Reuploading, Angle, and Amplitude encoding, to identify the most effective configurations.

We compared QCNNs with classical Convolutional Neural Networks (CNNs) to evaluate improvements in model complexity and accuracy. The study also examined how hyperparameters, such as the number of qubits and encoding strategies, affect model performance and stability. Our findings show that QCNNs can achieve comparable accuracy to classical approaches, exceeding 90% accuracy with fewer parameters. However, QCNNs currently lag in training time efficiency due to the developing state of quantum deep learning technologies.

This work highlights the potential of QCNNs for GRB detection in the CTA, paving the way for their integration into next-generation astrophysical research tools. By demonstrating the capabilities and limitations of QCNNs, we set the stage for future advancements in real-time gamma-ray signal detection and analysis.

Parallel 1 / 178

A study of the very-high-energy emission of the Crab pulsar with the LST-1

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Three pulsars, namely Crab, Vela and Geminga, have been detected in gamma rays above 20 GeV using Imaging Cherenkov Atmospheric Telescopes (IACT). Detecting new very-high-energy (VHE) pulsars is challenging due to the limited sensitivity of the current IACTs. The Cherenkov Telescope Array Observatory (CTAO) will be the next generation of Cherenkov telescopes, comprised of dozens of telescopes of different sizes, that will improve the sensitivity by an order of magnitude compared to previous IACTs. The LST-1 is the first Large-Sized Telescope (LST) of the CTAO under commissioning at the Roque de los Muchachos observatory on the island of La Palma. It is designed to explore the gamma-ray sky down to tens of GeV, making it ideally suited for studying gamma-ray pulsars. In this contribution, we report the results of the analysis of ~100 hours of observations of the Crab pulsar with the LST-1. Each pulsar peak has been detected at a statistical significance >10σ. Energy-dependent phaseograms and pulse widths are studied. Phase-resolved spectra are reconstructed with LST-1 from 20 GeV to 450 GeV for the first peak (P1) and up to 700 GeV for the second one (P2). The bridge spectrum is also significantly detected and is characterized below 100 GeV. Additionally, we have used 14 years of Fermi-LAT data to complement the LST-1 results at lower energies, showing good agreement between both instruments below 30 GeV. These results confirm the potential of LSTs to study and detect new VHE gamma-ray pulsars in the future.

Poster hang / **179**

Optical follow-up of a sample of gamma-ray emitting jetted AGN

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The reclassification of approximately 3000 gamma-ray extragalactic sources from the Fourth Fermi LAT Catalog resulted in an increased number of gamma-ray emitting Seyfert galaxies, including Narrow-Line Seyfert 1, misaligned active galactic nuclei (AGN), changing-look AGN, and several ambiguous objects (Foschini et al. 2022). To confirm or reject the new classifications and resolve the ambiguities, we requested new high-quality optical spectra from GranTeCan and ESO/VLT UT1/FORS2. Here, we present the preliminary results of these new observations.

Poster hang / **180**

Very-High-Energy Gamma-ray observations of the Galactic magnetar SGR 1935+2154 with the CTAO Large-Sized Telescope prototype

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Magnetar flares are one of the possible explanations for Fast Radio Bursts (FRBs). The first evidence for the FRB-magnetar connection was provided in April 2020, when the hard X-ray and soft gamma-ray bursts emitted by SGR 1935+2154 (detected by INTEGRAL, AGILE, Insight-HXMT, Konus-Wind) were observed to be associated with FRB emission. SGR 1935+2154 is a Soft Gamma Repeater, i.e. a source of short and irregular non-thermal bursts at keV–MeV arising from a magnetar, and it is the first known source linked to a FRB.
We report on the observations performed on SGR 1935+2154 with the Large-Sized Telescope prototype (LST-1), which will be the first telescope for the Cherenkov Telescope Array Observatory (CTAO), during periods of high-energy activity of the source. We search for a possible TeV counterpart of the emission with LST-1. While we did not detect significant very-high energy signal from this source, we set upper limits to the light curve and spectral energy distribution.
Furthermore, we determined upper limits to the short-scale, very-high energy transient emission of SGR 1935+2154 at the times of known high-energy bursts simultaneous to LST-1 observations.

Plenary / 181

IceCube: The First Decade of Neutrino Astronomy

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Below the geographic South Pole, the IceCube project has transformed one cubic kilometer of natural Antarctic ice into a neutrino detector. IceCube detects more than 100,000 neutrinos per year in the GeV to 10 PeV energy range. Among those, we have isolated a flux of high-energy neutrinos originating beyond our Galaxy, with an energy flux that is comparable to that of the extragalactic high-energy photon flux observed by the NASA Fermi satellite. With a decade of data, we have identified their first sources, which point to the obscured dense cores associated with the supermassive black holes at the centers of active galaxies as the origin of high-energy neutrinos and high-energy cosmic rays. We recently also observed neutrinos originating in our own Milky Way which is, interestingly, not a prominent feature in the neutrino sky.

Poster hang / 182

Schwarzschild-Couder Telescope for the Cherenkov Telescope Array Observatory: Status and Progress

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The 9.7m aperture Schwarzschild-Couder Telescope (SCT) is being developed as an alternative advanced design of the medium-sized telescope for the Cherenkov Telescope Array Observatory (CTAO),

which covers the CTAO's core energy range, from about 150 GeV to 5 TeV. The novel aplanatic dual-mirror optics of the SCT makes it possible to simultaneously achieve a wide 8-degree field of view and unprecedented 0.068-degree imaging resolution of the telescope camera, which is instrumented with 11,328 silicon photomultiplier (SiPM) detectors. The SCT project, with the goal to demonstrate these new capabilities, is advancing at the Fred Lawrence Whipple Observatory in Arizona, USA. The positioning and optical systems of the SCT have achieved design specifications and enabled the detection of the Crab Nebula with a statistical significance of 8.6 sigma using a partially instrumented 1,536-pixel prototype camera. An SCT camera upgrade is currently underway to fully populate it with advanced SiPMs and high-density electronics. Once completed by the end of 2025, the project is expected to verify SCT performance end-to-end and to provide the foundation for SCT subarray deployment during the enhancement phase of the CTAO construction. The sub-array of SCTs in the CTAO installation would offer improved sensitivity and unprecedented angular resolution. These technology advances would significantly boost the observatory's scientific output for detection of multi-messenger transients, mapping the morphology of gamma-ray sources with large angular extent, and conducting galactic plane sky surveys with the improved confusion limit. This poster highlights the SCT project achievements and its transformative science-enabling potentials in the enhanced CTAO configuration.

Parallel 2 / **183**

The Cosmological Optical Convergence: Extragalactic Background Light from TeV Gamma Rays

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The Extragalactic Background Light (EBL) is the aggregate of all photon emissions in the universe since the cosmic dark ages, dominated by the optical and infrared emissions from thermal processes. Using the EBL absorption imprint on the γ-ray spectra of extragalactic sources, we study the decade-old tension between EBL intensities inferred from galaxy counts (IGL) and from direct observations, the optical controversy. We use STeVECat, the most comprehensive catalog of archival TeV spectra resulting from three decades of extragalactic observations. We have developed a Bayesian framework to marginalize over the spectral parameters of the γ-ray data, as well as systematic uncertainties of instrumental origin. By integrating over the EBL redshift evolution, we present for the first time a fully model-independent γ-ray measurement of the EBL at $z = 0$, between 0.18 and 120 μm. In the optical band, at 600 nm, we measure an intensity of 7.4 ± 2.0 nW m^{-2} sr^{-1} $\times$ h_{70}. This value is indistinguishable from IGL measurements, 7.6 ± 0.3 nW m^{-2} sr^{-1} , and is compatible with the latest intensity derived from New Horizons observations. The γ-ray data exclude at the 95% level EBL contributions from diffuse sources with an intensity relative to the IGL $f_{\text{diff}} \geq 19\%$, and we are able to measure the local Hubble constant, $H_0 = 68 \pm 7$ km s^{-1} Mpc^{-1} $\times$ $(1 + f_{\text{diff}})$. γ-rays, IGL and direct measurements are in agreement for the first time on the EBL intensity in the optical band, finally achieving cosmological optical convergence.

Plenary / **184**

Firmamento: a new-concept, web-based, data analysis tool dedicated to multi-messenger astronomical sources.

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Firmamento is a new-concept platform dedicated to multi-messenger astrophysics that combines imaging, spectral, and time-domain data with specific algorithms, machine learning tools, and AI. Firmamento can identify counterparts within the uncertainty regions of sources detected by instruments with non-negligible localization areas, including X-ray, gamma-ray, and astrophysical neutrinos. Additionally, Firmamento can build and automatically characterize broadband spectral energy distributions (SEDs), which can be used for model fitting or to identify/confirm the nature of the source and, in the case of blazars, to predict detectability in the very high energy (VHE) band. The integration with a specialized version of ChatGPT makes Firmamento even more powerful and accessible to non-experts.
Finally, I will present the preliminary results of two studies based on Firmamento: the identification of previously unassociated sources in the Fermi 4FGL-DR4 catalog and the identification of blazars in the eRASS1 survey, along with the corresponding predictions for CTAO detections.

Poster hang / 185

The Gamma Ray Origin in RX J0852.0-4622 Quantifying the Hadronic and Leptonic Components: Further Evidence for the Cosmic Ray Acceleration in Young Shell-type SNRs

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Fukui et al. quantified the hadronic and leptonic gamma-rays in the young TeV gamma-ray shell-type supernova remnant (SNR) RX J1713.7−3946 (RX J1713), and demonstrated that gamma rays are a combination of hadronic and leptonic gamma-ray components with a ratio of $\sim$6:4 in gamma-ray counts Ng. This discovery, which adopted a new methodology of multi-linear gamma-ray decomposition, was the first quantification of the two gamma-ray components. In the present work, we applied the same methodology to another TeV gamma-ray shell-type SNR RX J0852.0−4622 (RX J0852) in 3D space characterized by (the interstellar proton column density Np)-(the nonthermal X-ray count Nx)-[Ng], and quantified the hadronic and leptonic gamma-ray components as having a ratio of $\sim$5:5 in Ng. The present work adopted the fitting of two/three flat planes in 3D space instead of a single flat plane, which allowed suppression of the fitting errors. This quantification indicates that hadronic and leptonic gamma-rays are of the same order of magnitude in these two core-collapse SNRs, verifying the significant hadronic gamma-ray components. We argue that the target interstellar protons, in particular their spatial distribution, are essential in any attempts to identify the type of particles responsible for gamma-ray emission. The present results confirm that cosmic-ray (CR) energy $\leq$100 TeV is compatible with a scheme in which SNRs are the dominant source of these Galactic CRs.

Parallel 2 / 186

Ten years of Gammapy: open source tools for gamma-ray astronomy

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The Gammapy library is an open-source framework designed for gamma-ray astronomy data analysis. Built on scientific Python ecosystem and leveraging open data formats, Gammapy offers a uniform platform for reducing and modeling data from different gamma-ray instruments. It greatly facilitates interoperability between observatories, enabling comprehensive joint analyses. Initiated in 2014 as a toolbox for TeV analysis, Gammapy has evolved, over the past decade, into a robust and versatile tool with a growing community of users, and is now the basis of the CTAO science analysis tools.
We first give an overview of the project history, highlighting its significant milestones and achievements as well as its current status. We then present the main concepts and features of the library, and expose the variety of scientific use cases it supports. Finally, we discuss the future perspectives and planned developments to further enhance the library's functionalities and improve its performance. Gammapy highlights the importance of open-source collaboration in the gamma-ray astronomy community and beyond.

Poster hang / 187

Lowering the HAWC threshold to search for GRB Signals

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GRBs are gigantic extragalactic explosions, known to release 10^{51}-10^{54} ergs of isotropic energy, which outshine all radiation in the sky when they occur. GRBs are thought to arise in dissipation processes in which the energy of the relativistic jet is converted into non-thermal radiation. GRBs are unpredictable events both in time and place and one needs to search for them continuously with monitoring observatories. The Fermi satellite detector have discovered/studied several thousand GRBs with the Fermi Gamma-ray Burst Monitor in the keV-MeV range and with the Fermi-LAT detector at MeV-GeV energies. Recently, H.E.S.S., MAGIC and LHAASO have discovered hundred GeV to TeV emission during the afterglow phase of GRB180720B, GRB190829A, GRB190114C and GRB 221009A. GRBs are thus strong emitters of γ-rays also up to TeV energies, produced by the interactions of cosmic rays (CRs), ultra-relativistic particles accelerated in the extreme environments of these sources, with ambient radiation fields and gas. Radiation above several TeV is attenuated during its travel from extragalactic sources to the Earth. γ-rays with energies between several hundred GeV and several TeV are therefore the highest energy band of the electromagnetic spectrum to be detectable from these extragalactic sources and yield unique information on the mechanisms which power GRBs and accelerate particles up to the highest energies. At TeV energies the HAWC

experiment, which continuously surveys 2/3 of the sky every day, is among the most sensitive γ-ray survey instruments in the world to observe their prompt phase thanks to the lack of observational delays.

A significant improvement in the HAWC sub-TeV sensitivity has been recently achieved thanks to the introduction of novel custom particle recognition (gamma/hadron discrimination) and reconstruction algorithms, included in the Pass5 release of HAWC analysis pipeline in 2023.

We will here introduce the possibility of further lowering the threshold of the PMTs in the water Cherenkov detectors by equipping the WCDs with a carpet of Resistive Plate Counters (RPCs). If testing is promising, we will perform the analysis of new and archival data in search for GRB signals including the lowered threshold energy.

Parallel 1 / 188

The role of the diffuse gamma-ray emission in the study of the Galactic Centre region

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Our Galaxy is known to be a strong source of gamma-ray emission. Besides the active objects liable for the persistent and variable high and very-high energy photons, the interplay between the interstellar matter and cosmic rays is of crucial relevance, as it assumes the role of a passive source of gamma rays. Indeed, the collisions of extremely energetic charged particles with the gaseous environment of the Milky Way result in a diffuse emission permeating the Galaxy itself, especially along the Galactic Plane. This specific kind of emission has a critical role in the analysis of gamma-ray data since it represents the background emission above which we can solve and detect sources. A complete and deepen understanding of the spectral and morphological nature of the large-scale background diffuse emission is fundamental for providing increasingly realistic models to collaborations in order to perform consistent and coherent analysis.
In this contribution some phenomenological models computed to reproduce such diffuse gamma-ray emission are scrutinized against currently available measurements. The choice of a specific parametrization of cosmic-ray transport equations affects the spectrum of the related diffuse gamma-ray emission, as it leads to a variety of potential estimations which play a key role in this context, along with a realistic description of the gas distribution in our Galaxy. In view of the Cherenkov Telescopes Array era, the analysis and comparisons reported in this contribution are of pivotal relevance for the study of the galactic gamma-ray emitters, particularly in complex scenarios like the Galactic Centre.

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Testing for a "Crab-like" Emission Tail above 10 GeV from the Vela Pulsar and PSR B1706-44 using combined H.E.S.S. & Fermi-LAT data.

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Measuring pulsar spectra in the tens of GeV range is essential for constraining their high-energy emission models. However, this task is complicated by the fact that, in this energy domain, *Fermi*-LAT suffers from limited statistics, and the sensitivity of ground-based telescopes is restricted.
In this study, we combine data obtained with the largest H.E.S.S. telescope (CT-5) and *Fermi*-LAT on the Vela pulsar and PSR B1706-44 to precisely measure their spectra in the 1-100 GeV range. By fully accounting for the response functions of both instruments in a joint spectral fit above 10 GeV, we are able to detect significant curvature in the spectra of these two sources. This curvature strongly disfavors the onset of a power-law tail for Vela and PSR B1706-44, distinguishing them from the Crab pulsar. We discuss the possible implications of these results on our understanding of emission mechanisms at play in pulsars.

Poster hang / 190

Machine learning enhancements for Cherenkov telescope data analysis

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We developed deep learning enhancements for the real-time analysis of Cherenkov telescopes data, applicable to the context of the Cherenkov Telescope Array Observatory (CTAO). The CTAO will have a Science Alert Generation (SAG) system tasked with real-time reconstruction and analysis of data, as part of the Array Control and Data Acquisition (ACADA) system. We developed two applications of Convolutional Neural Network (CNN) based models, trained offline on 20k simulations and applicable for online inference. The first model is an auto-encoder trained to learn and subtract the background level of a given observation. The second model computes a 2-dimensional regression to identify candidate sources in the field of view. We compared results with standard techniques and found that our models achieve comparable accuracy without relying on a priori assumptions such as candidate coordinates, background model or instrument response function.

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Micro-quasars at HE, VHE, and UHE

Microquasars are X-ray binaries with relativistic jets, believed to be driven by accretion. Non-thermal processes are known to be very relevant in these sources as shown by observations in different energy bands from several micro-quasars. While the first claims of gamma-ray emission from micro-quasars in the 1980s were not later confirmed and casted serious doubts about the capability of ground based gamma-ray astronomy, micro-quasars are nowadays established sources of gamma-rays at HE, VHE and UHE. Here we discuss the observations of micro-quasars in these energy bands and the physics behind this emission.

Poster hang / 192

Approaching ballistic motion in 3D simulations of gamma-ray burst jets emerging from realistic binary neutron star merger environments

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The concomitant observation of the gravitational wave signal from a binary neutron star (BNS) merger and its electromagnetic counterparts in 2017 confirmed that these events can produce relativistic jets responsible for short Gamma-Ray Bursts (sGRBs). The complex interaction between the jet and the surrounding post-merger environment shape the angular structure of the outflow, that is then imprinted in the prompt and afterglow sGRB emission. The outcome of relativistic (magneto)hydrodynamic simulations of jets piercing through post-merger environments is often used as input to compute the corresponding afterglow signal to be directly compared with sGRB observations. However, for a reliable comparison the jet propagation has to be followed until a nearly ballistic phase, in which jet acceleration is essentially over and the angular structure is no longer evolving. Such a condition is typically met in 2D simulations, but not in 3D. Here, we present the methods that we developed to extend our 3D jet simulations up to a nearly ballistic phase. As reference model, we consider the fiducial case presented in Pavan et al. (2023), representing the first 3D simulation of a magnetized sGRB jet emerging from the realistic magnetized post-merger environment directly imported from a BNS merger simulation. Extending the 3D evolution from about 3 to 10 seconds, the final jet available energy is about 98 per cent kinetic and its angular structure is frozen, offering proper input for computing the afterglow emission.

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Very high energy observations of BNS and BHNS mergers in the Einstein Telescope era

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The recent detections of Very High Energy (VHE) emission from GRB afterglows by the MAGIC and H.E.S.S. telescopes has opened new prospects for observing these energetic transients. Just before these detections, the seminal event GRB170817A, associated with the gravitational wave (GW) signal from a binary neutron star (BNS) merger, marked a new era in multi-messenger astronomy, providing invaluable insights into the origins of short GRBs and the properties of relativistic jets. Despite extensive searches by MAGIC, H.E.S.S., and HAWC, no VHE counterpart was detected for GW170817, largely due to challenges in sky localization and response times. However, the next generation of VHE observatories, such as the Cherenkov Telescope Array (CTA), promise significant improvements.

Building on previous studies where we constructed synthetic cosmological populations of BNS and BHNS mergers and predicted their electromagnetic counterparts for the O4 and O5 observing runs of Advanced LIGO and Virgo, we extended our model to the era of the Einstein Telescope (ET). In this talk, I will present our projections for detecting VHE emission from BNS and BHNS short GRBs in conjunction with next-generation GW detectors like the ET. I will discuss optimal observational strategies to maximize the detection of these VHE counterparts, highlighting the synergy

potential between CTA and ET in the upcoming era of multi-messenger astronomy. This comprehensive approach aims to illuminate the bright future of VHE observations and their critical role in understanding the most energetic events in the Universe.

Poster hang / 194

ASTRI-Horn correlation between the Sky Quality Meter and the variance data.

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The ASTRI Mini-Array is an INAF project devoted to study gamma-ray sources emitting at very high-energy in the TeV spectral band. It consists of an array of nine innovative Imaging Atmospheric Cherenkov Telescopes, that are an evolution of the double-mirror ASTRI-Horn telescope operating at the INAF "M.C. Fracastoro" observing station (Serra La Nave, Mount Etna, Italy). The ASTRI Mini-Array is under installation at the Teide Astronomical Observatory, Instituto de Astrofisica de Canarias, on Mount Teide in Tenerife (Canary Islands, Spain).
Each telescope camera develops the variance method based on the statistical analysis of the signal detected by the front-end electronics whose variance is proportional to the flux impinging on the camera pixel. The variance allows us to indirectly measure the sky flux and to monitor the presence of clouds and stars in the telescope field of view.
The ASTRI Mini-Array is equipped with several auxiliary devices among which the Sky Quality Meter. This device provides during observations, a quick evaluation of the sky quality in the optical band measuring the brightness of the night sky. It is coaxial with the telescope where it is mounted pointing in the same direction, and it returns integral information about the night sky brightness inside its fields of view (about 20o) in units of mag/arcsec.
In this work we present the correlation between the Sky Quality Meter values of the sky brightness and the variance using data from ASTRI-Horn prototype. This correlation can be used to convert the variance to sky absolute flux, helping in identifying high level background periods and in defining the good time intervals in each observation. Moreover, the results obtained with ASTRI-Horn could be a good testbench for the ASTRI Mini-Array telescopes.

Parallel 2 / 195

The Second Fermi-LAT-low-energy catalog (2FLE)

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The Fermi Large Area Telescope (Fermi-LAT) has been continuously observing the sky from 20 MeV to 1 TeV for more than 15 years. Although Fermi-LAT's sensitivity reaches down to 20 MeV, its low-energy range has been largely left under-explored. As we await an all-sky MeV mission such as COSI, it is now the prime time to capitalize on the full capabilities of Fermi-LAT. To complement and improve on the first Fermi-LAT low-energy catalog (1FLE), we have developed a specialized analysis using 14 years of the LAT data with the best angular reconstruction (Pass8 PSF3) to construct a sensitive catalog of point sources between 20-200 MeV. This program will start bridging the gap between the MeV and GeV energy bands, strongly enhancing the legacy of the Fermi mission and supporting the scientific case for future all-sky MeV missions.

Parallel 1 / 196

Indirect dark-matter searches with gamma-rays experiments : status and future plans from 300 KeV to 100 TeV

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Detection of gamma rays and cosmic rays from the annihilation or decay of dark matter particles is a promising method for identifying dark matter, understanding its intrinsic properties, and mapping its distribution in the universe. I will review rthe current status and discuss the prospects for indirect searches to robustly identify or exclude a dark matter signal using upcoming experiments at energies below and above Fermi energy range.

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The ASTRI-Mini Array view of the Cygnus region

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We present the observational capabilities of the ASTRI mini-array, an array of nine small-sized Cherenkov telescopes deployed at the Teide Observatory (Tenerife, Spain), by focusing on the state of the art of TeV emitting sources in the Cygnus region (along the 60-80 longitudinal range of the Galactic plane). This is currently the richest known region of Galactic sources emitting above 1 TeV, including some potential PeVatrons recently discovered by the LHAASO collaboration. The analysis of point-like sources is complicated by their embeddedness in an extended TeV diffuse environment, the Cygnus Cocoon Superbubble, which partially covers this region. We performed a full data challenge (180 pointing observations of 3 hours each) to test the optimal pointing strategy for this type of large survey. Taking advantage of its high angular resolution and large field of view of 12° diameter, the ASTRI Mini-Array will be able to observe multiple sources simultaneously, disentangling contributions from different sources and facilitating spectromorphological studies. Among the results obtained, I will illustrate the determination of spatial and spectral parameters of the Cocoon emission and of the PeVatron candidate LHAASO J2032+4102.

Parallel 2 / 198

The first GRBAlpha and VZLUSAT-2 catalogue: gamma-ray transients and detector sensitivity

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In recent years there have been numerous efforts to build a constellation of small satellites which would provide an all-sky coverage and quick localization of gamma-ray bursts (GRBs). One of the mission proposals is the CAMELOT constellation with a newly developed gamma-ray detector composed of a CsI(Tl) scintillator coupled with silicon photomultipliers (SiPMs). The prototype of this detector is already employed in two space missions, GRBAlpha 1U CubeSat launched in March 2021 and VZLUSAT-2 3U CubeSat launched in January 2022. To date, the satellites have detected over 200 gamma-ray transients. I will show the first catalogue of the transients detected by these two missions and present the empirical sensitivity of the detector. The weakest GRB detection belongs to the faintest 10% of those observed by Fermi/GBM which demonstrates the detector potential for routine observation of GRBs.

Poster hang / 199

A novel image cleaning technique for the VERITAS telescopes

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In addition to capturing the Cherenkov signal triggered by extensive atmospheric showers, cameras from imaging atmospheric Cherenkov telescopes are also subject to signals from the night sky background and electronic noise. Image cleaning methods are employed to eliminate noise-contaminated pixels which do not have information regarding the shower. If not effectively removed, these noisy pixels can introduce significant bias effects during image parameterization. Conventionally, the Very Energetic Radiation Imaging Telescope Array System (VERITAS) employs the double-pass filtering method, in which a $5\sigma/2.5\sigma$ signal threshold is applied for core and neighbouring pixels, respectively.

I present the implementation of the Optimised Next Neighbour Image cleaning technique to the VERITAS reconstruction. Unlike the conventional method, cleaning cuts are determined in the parameter space composed of the minimum charge of a group of pixels and by the time difference in pulse arrival time within neighbouring pixels. With the novel technique, events with energy
$lesssim$ 100 - 300 GeV which were suppressed by the traditional method can now be reconstructed. I show that effective areas of the array increase by a factor of $\sim$ 3 below
$lesssim$ 100 GeV for a particular Monte Carlo configuration. In addition, I show that this method increases the excess counts below
$lesssim$ 100 GeV by a factor of $\sim$ 2.5 for a Crab Nebula dataset consisting of $>$ 300 hours. The validation of the Optimised Next Neighbour Image cleaning is realised by comparisons between Monte Carlo simulations and Crab Nebula data. A systematic error of 4\% below 1 TeV is found against 2\% with the double-pass method. In summary, the Optimised Next Neighbour Image cleaning has proven to be an effective approach for image-cleaning since it lowers the energy threshold of the array and increases gamma-ray rates in the GeV range, which is especially advantageous for sources presenting faint and soft spectra.

Parallel 2 / 200

Search for VHE emission from Tidal Disruption Events with the VERITAS telescopes

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In recent years, associations of tidal disruption events (TDEs) with astrophysical neutrinos detected by IceCube indicate that these transient phenomena could be responsible for accelerating cosmic rays up to PeV energies. These energetic relativistic particles can potentially also give rise to high- and very-high-energy (VHE) gamma-ray components. Although over 100 events have been identified through wide-field high-cadence optical surveys, follow-up observations of TDEs in the VHE regime are scarce. To date, no TDE detection in the GeV or TeV ranges has been confirmed.

I discuss the first target of opportunity campaign dedicated to follow-up observations of TDEs with the Very Energetic Radiation Imaging Telescope Array System (VERITAS). The observing campaign for the events AT2022dbl, AT2022dsb and AT2023clx is presented. No detection is found within more than 10 hours of live-time observations per event. Therefore, flux upper limits were derived in the energy range of $\sim$ 100 GeV up to 10 TeV. We consider the scenario in which the potential gamma-ray emission is attenuated via pair production with ambient photons from the optical and ultra-violet components of the disruption flare. We infer that the medium is essentially optically thick $\tau_{\gamma\gamma} > 1$ at the energy range where VERITAS is sensitive (80 GeV $<$ E $<$ 30 TeV) if the radius of the target photon field, modelled as a blackbody spectrum, is in the range of $5 \cdot 10^{15}$ cm $<$ R $< 1 \cdot 10^{16}$ cm. In addition, we find that the medium should remain optically thick to gamma rays up to approximately 150 days after the peak of the UV light curve. Although no detection is found for AT2022dbl, AT2022dsb or AT2023clx, the flux upper limits enable the development of additional strategies for TDE follow-up in the VHE regime.

Poster hang / 201

Search for VHE emission from Fast Blue Optical Transients with the VERITAS telescopes

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Fast blue optical transients (FBOTs) are extreme instances of interaction-powered supernovae which exhibit high bolometric luminosities ($\sim 10^{43}$ erg s^{-1}) with exceptionally fast rise and decay timescales ($<$ days). Since the discovery of AT2018cow, the landmark FBOT, by the Zwicky Transient Factory (ZTF), these transients have gained increasing attention as potential particle accelerators via mechanisms of shock interactions. As a result, a very-high-energy (VHE) gamma-ray component could be produced.

I present the first target of opportunity (ToO) campaign dedicated to follow-up observations of FBOTs with the Very Energetic Radiation Imaging Telescope Array System (VERITAS). The criteria for observing both bright and distant events, as well as dimmer but closer ones, are discussed. As a result of the ToO campaign, 6.9 hours of live-time data were collected in the follow-up of AT2023ufx. This dataset was obtained over the course of four days, starting one day after the optical peak detected by ZTF-g. No detection is found for AT2023ufx, and flux upper limits are derived in the energy range of $\sim$ 100 GeV up to 10 TeV.

Parallel 1 / 202

Cosmic-ray propagation in the Galaxy: Insights from TeV halos and the diffuse emission - [REMOTE]

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Gamma-ray observations provide important information on cosmic-ray (CR) propagation in our Galaxy.
First, we discuss detected TeV halos. We show that current gamma-ray measurements place interesting constraints on the turbulent magnetic fields around these pulsars, and we examine the implications for CR transport. Also, we suggest that extended gamma-ray sources of a hadronic origin should exist in the data. We show that such a source may exist in the AS-gamma data at 398-1000 TeV. Observations of this new type of sources could be used to constrain the Galactic magnetic field geometry.
Second, we present a new model of anisotropic CR propagation in the Milky Way, where CRs are injected at discrete transient sources in the disc and propagated in Galactic magnetic field models. We then calculate the corresponding diffuse Galactic gamma-ray emission. We find that the expected diffuse gamma-ray emission at >~ 100 TeV is very clumpy, and does not correlate with the gas density along the line of sight. It is substantially different from the relatively smoother emission detected by Fermi at ~ GeV energies. We also discuss how many (hadronic) PeVatrons would be detectable in our simulations, and compare our predictions with LHAASO data. We show that this allows to place interesting constraints on CR transport in the Galaxy.

Poster hang / 203

Long-Term VERITAS Monitoring and Multi-Wavelength Data on TXS 0506+056: Probing Intergalactic Cascades with VERITAS, Swift, and Fermi Observations

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In September 2017, the IceCube Neutrino Observatory detected a high-energy neutrino event, IceCube-170922A, associated with a gamma-ray flare from the blazar TXS 0506+056, with a probability of chance coincidence rejected at the 3σ level. This remains the most significant photon-neutrino correlation observed to date. Here, we present results from the long-term monitoring of TXS 0506+056 conducted by VERITAS, significantly expanding the observational coverage compared to previous studies. Data from *Swift* and *Fermi*-LAT further complement these observations. Using this comprehensive dataset, we compare the gamma-ray spectrum and neutrino observations to a hadronic model which uniquely includes a cosmic-ray induced cascade component in intergalactic space. We will discuss the implications of these findings for understanding the proton injection spectrum and constraints on proton escape luminosity.

Parallel 1 / 204

The dynamical impact of cosmic rays in Milky Way-like galaxies

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The Milky Way, with its distinctive observational features, is a unique laboratory to constrain physical parameters and test various theories of galaxy evolution ranging from star formation, to the formation of gaseous structures and galactic outflows, such as the Fermi and eRosita bubbles. A particularly important ingredient in the interstellar medium are cosmic rays (CRs), which reveal their impact via gamma rays.
We perform high-resolution magnetohydrodynamical simulations of the Milky Way, in which we follow individual massive stars and include self-consistent stellar feedback such as SNe and CRs, dynamically coupled to the MHD equations. We model the multi-phase interstellar medium using a non-equilibrium chemical network, allowing us to take into account the relevant cooling and heating processes and compare the simulations to observations.
We will present how thermal and CR feedback affect the structure of the galaxy and the gas dynamics. We show how the inclusion of CRs change the structure and thermal phase of outflows and fountains flows in different regions of the galaxy, from the Galactic Center to the solar circle and beyond. We further elaborate how Fermi and eRosita bubbles are periodically launched by supernovae from the galactic center, and how and when they are visible. Finally, we back up our simulations with accurate gamma ray maps both in the solar vicinity as well as for the global galaxy, which we compare to observations of the gamma-ray sky.

Poster hang / 205

Fast turbulent magnetic reconnection and its implications for particle acceleration and high energy emission in compact objects

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Magnetic reconnection is ubiquitous in Astrophysics, from the Earth's magnetotail to the solar and black hole coronae, and becomes an effective mechanism for converting magnetic to kinetic and thermal energy in turbulent environments. We study turbulence's effect on magnetic reconnection rate via high-resolution 3D MHD simulations across an extensive parametric space. With an initial multi-mode perturbation in the system, turbulence is self-generated and sustained in the current sheet - the magnetic reconnection site, resulting in fast rates of $V_{\rm rec}/V_A \sim 0.03 - 0.08$, where $V_A = B/\sqrt{4\pi\rho}$ is the Alfvén velocity. These rates surpass those driven solely by resistive tearing modes/plasmoid instabilities. Our results show that the reconnection rates remain independent of Lundquist and magnetic Prandtl numbers, aligning with the theory of turbulent reconnection proposed by Lazarian and Vishniac (1999) and with solar observations and prior simulations of accretion flows and relativistic jets. Plasma-β shows mild influence, decreasing $V_{\rm rec}$ from 0.036 to 0.028 as β increases from 2.0 to 64.0, for simulations with Lundquist number of $S = 10^5$, being an important consequence for small β plasmas (e.g., sun, accretion disks, and relativistic jets). By injecting thousands of test particles into our turbulent current sheet, we demonstrate that magnetic reconnection is an effective mechanism to accelerate particles to very high energies as a first-order Fermi process.

Plenary / 206

The MAGIC of VHE gamma-ray astronomy

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The instrumentation for gamma-ray astronomy has advanced tremendously during the last two decades. The study of the most violent environments in the Universe has opened a new window to understand the frontier of physics, exploring processes that are beyond the capabilities of Earth-based laboratories to replicate. One of the instruments at the forefront of ground-based gamma-ray astronomy is the MAGIC stereoscopic system, which consists of two 17-m diameter mirror dish telescopes located at 2200m a.s.l. on the Canary Island of La Palma, in Spain. MAGIC is an established world-wide leading instrument for gamma-ray astronomy in the energy range from 20 GeV to beyond 100 TeV, and an active participant in multiple multiwavelength and multimessenger observational campaigns. In the conference, I will provide a status report of MAGIC, including the discussion of a few recent results, and discuss the prospects for the near future.

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Open Questions in Extra-Galactic Jetted Objects

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The launch of the Compton Gamma-Ray Observatory (CGRO) ushered in a new era in our understanding of the phenomenon of relativistic jets produced by compact objects. AGN with radio jets pointed towards us (blazars) turned out to be unexpectedly powerful and rapidly variable gamma-ray sources, while gamma-ray bursts were shown to be distributed isotropically on the sky, significantly increasing the chances that they were extragalactic in origin and thus also incredibly powerful and likely associated with relativistic outflows (jets). In many ways, however, the CGRO observations turned out to be just the "tip of the iceberg." Thirty years later, we now know the gamma-ray emission from jets is even more extreme and complex than originally anticipated, e.g., extending to multi-TeV energies and varying down to minute timescales in the case of blazar AGN. I will review the progress that we have made since CGRO in understanding the nature and the physical implications of the gamma-ray emission from relativistic jets and will highlight the several questions that remain open.

Poster hang / 208

Cherenkov Radiation from Quantum Vacuum in Pulsars

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This work investigates Cherenkov radiation originating from the quantum vacuum in pulsars. These compact astronomical objects, characterized by extreme magnetic fields, emit radiation as they rotate. By analyzing the vacuum polarization near the pulsar's surface, we explore the contribution of Cherenkov radiation to the pulsar's electromagnetic spectrum. Preliminary results, based on the literature, involve using the Euler-Heisenberg Lagrangian. This Lagrangian accounts for vacuum polarization in the weak-field limit and provides the dispersion relation for a photon in a background magnetic field region. Notably, the vacuum in the presence of an extreme magnetic field exhibits an effective permittivity constant that depends on the field's intensity. Analogous to Maxwell's theory in material media, the electromagnetic spectrum of Cherenkov radiation is derived from the Euler-Heisenberg Lagrangian. Our study sheds light on the intriguing nonlinearity of electrodynamics in these astrophysical sources and plays a crucial role in understanding the emission processes of pulsars.

Poster hang / 209

Theoretical Modeling of the Exceptional GRB 221009A

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The gamma-ray burst GRB 221009A stands out as an exceptional event for its intensity, spectral evolution, and duration. We investigate the early afterglow emission of this burst, especially focusing on the unique set of simultaneous GeV-TeV spectral and intensity data obtained by AGILE and LHAASO.
We present the results of a relativistic fireball model with a set of physical parameters that satisfactorily explains the first phases of the afterglow up to 10^4 seconds.
Interestingly, an extension of the model to late times (up to 10^6-10^7 seconds) describes the late X-ray and optical spectral and intensity data in a consistent picture. Our results are important in constraining the physics of particle acceleration and evolution in GRB 221009A and can be extended to the analysis of other powerful GRBs.

Parallel 2 / 210

Observation of a second spectral component in GRB 221009A

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The occurrence of long-duration gamma-ray bursts (GRBs) is linked to ultra-relativistic jets formed soon after the collapse of massive stars. Initially, a highly variable radiation in the MeV range is detected, lasting for a few minutes, which is a result of internal dissipation within the jet. This is followed by afterglow radiation lasting for even several days, originating from non-thermal electrons in the medium accelerated by the relativistic blast wave. The observed afterglow emissions in radio frequencies to TeV energies are commonly explained by the mechanisms of synchrotron and synchrotron self-Compton radiation. However, because of the lack of sensitivity in MeV-GeV observations, the distinct identification of the TeV spectral component for GRBs detected in the high-energy gamma-rays (HE) has been challenging. In this presentation, I aim to highlight the unique

GeV-TeV spectral component of GRB 221009A observed during the initial 30 minutes. The modeling of the data comprising LAT in the initial time bins and AGILE in the late time for the GeV regime, along with the TeV data from LHAASO, provides constraints on the magnetic field and the energy of the electrons accelerated in the relativistic shock. Furthermore, we demonstrate that intense initial MeV radiation impacts early TeV afterglow radiation through external Compton cooling of electrons.

Poster hang / 211

Use of pixel time parameters in ASTRI Mini-Array event reconstruction: application in gamma/hadron separation.

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The ASTRI Mini-Array is an international project led by the Italian National Institute for Astrophysics (INAF) aimed at operating an array of nine small-sized (4-m diameter) Imaging Atmospheric Cherenkov Telescopes (IACTs). This array will conduct extensive galactic and extragalactic gamma-ray sky observations in the 1–200 TeV energy band, and it will be located at the Observatorio del Teide in Tenerife, Spain. The first three telescopes are expected to be operational within the next year.

In preparation for this deployment, the ASTRI team is developing a comprehensive Data Processing system that addresses all aspects of data management, reduction, and analysis. A key focus within this framework is enhancing the efficacy of the standard procedures employed by the Cherenkov data pipeline (A-SciSoft) for event reconstruction.

To improve the sensitivity of the array, particularly in discriminating between gamma-ray induced showers and hadron-induced showers, we are investigating the temporal evolution of the shower images. This temporal information can provide additional discriminatory power beyond the traditional morphological parameters. We have developed and tested a set of parameters derived from the pixel time tags, which record when the photoelectron content of each pixel exceeds the trigger threshold.

Through extensive testing, we have identified a subset of these time parameters that exhibit good discriminatory efficacy. Combining these time parameters with the standard morphological parameters has demonstrated a significant improvement in hadron rejection, especially at the lower end of the energy detection range. These preliminary results are encouraging, and we plan further tests and investigation to optimize their use.

Parallel 2 / 212

A bright and narrow line at mega-electronvolt photon energies in the prompt emission of GRB 221009A

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Gamma-ray bursts (GRBs) are the brightest, yet among the most obscure, explosions in the Universe. Their temporal and spectral properties keep eluding our attempts at understanding them in a systematic way, and surprising events with unprecedented features are observed every year. A recent example is GRB 221009A, the "brightest of all times" (BOAT). The occurrence rate of such an event, based on the extrapolation of the known population, should be less than one in ten thousand years, yet it has been observed in only 50 years of GRB astronomy. Among the riddles posed by the BOAT, one of the most intruiguing is the presence of a bright, narrow emission line in its prompt emission spectra. The line shows up in spectra that follow the peak of the emission, and it has a central photon energy of around 10 MeV. A time-resolved analysis shows evidence of a decrease in both the luminosity and the central energy with time. In this talk, I will discuss the observational properties of this feature and its possible physical interpretation.

Poster hang / 213

Origin of early emission of Gamma-Ray Bursts at GeV energies.

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Prompt emission of GRB is believed to be produced from electrons accelerated up to non thermal energies in the internal shocks. This emission peaks in the keV-MeV energy band, but a high energy (HE; 0.1-100 GeV) component is theoretically expected. While photons in the very high energy (VHE; E>20GeV) domain have been detected by Imaging Atmospheric Cherenkov Telescopes in recent years, prompt-related VHE photons have not been observed yet. Their detection would be crucial for the understanding of the physics related to the prompt emission.
In the last 15 years of LAT operation, many GRBs showed HE gamma-ray emission temporally coincident with prompt emission phase, but with different spectral properties.
This GeV emission has been interpreted by several authors as mostly dominated by the afterglow. I will present new results based on a systematic study of GRBs with an early GeV emission detected by Fermi/LAT. This study uses a physical model to explain the prompt emission. Temporal evolution of the GeV emission from the first seconds up to several hours identifies several GRBs with prompt emission. The systematic temporal and broad-band keV-GeV spectral analysis reveals that in many cases the GeV radiation is part of the main spectral component of the prompt emission. In contrast, in some other cases, these GeV photons are related to a second spectral component, which might peak at VHE gamma rays. I will discuss the physical origin of this component and its implications in light of the new results from this study and prospects for upcoming CTA.

Poster hang / 214

Modelling the very high-energy gamma-ray emission from accreting neutron stars in X-ray binaries: a theoretical framework for future observations

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The search of gamma-ray emission from accreting pulsars in X-ray binaries (XRBs) has been ongoing for some time. Recent marginal detections in high-mass X-ray binaries (HMXBs) have sparked renewed interest in this area. Anticipating future advances in gamma-ray telescopes like the Cherenkov Telescope Array (CTA), we investigate the expected emission above 10 GeV from XRBs using an enhanced Cheng & Ruderman model. This model incorporates Monte Carlo simulations to account for cascade development inside and outside the accretion disc, including pair and photon production processes that involve interaction with nuclei, X-ray photons from the accretion disc, and the magnetic field. Our results yield a wide range of gamma-ray luminosities (up to ~1E35 erg/s) and spectra, with some exhibiting emission below ~100 GeV and others extending to 10-100 TeV. We compare our findings with existing Fermi/LAT and VERITAS data for two HMXBs, and look forward to more comprehensive comparisons with forthcoming, more sensitive instruments.

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The XGIS instrument: an unprecedented wide-band GRB monitor for future space mission opportunities

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We describe the design and the expected performances of the X/Gamma-ray Imaging Spectrometer (XGIS), a GRBs and transients monitor being developed for the THESEUS mission now in Phase A as ESA M7 candidate. XGIS is capable of covering an unprecedented wide energy band (2 keV – 10 MeV), with imaging capabilities and location accuracy <15 arcmin up to 150 keV over a Field of View of 2 sr, a few hundreds eV energy resolution in the X-ray band (<30 keV) and timing resolution down to a few µs. XGIS exploits the coupling between Silicon Drift Detectors (SDD) with crystal scintillator bars and a very low-noise distributed front-end electronics (ORION ASICs). The XGIS particular configuration also allows 3D position sensitive detection which also enables hard x-ray polarimetric capability. Here we also describe the possible improvements that can be applied to this technology in order to further improve the performance of the instrument. Thanks to its modular design, the XGIS instrument can be easily rescaled/reshaped and adapted for fitting the available resources and specific scientific objectives of future high-energy astrophysics missions, and especially those aimed at fully exploiting GRBs and high-energy transients for multi-messenger astrophysics and fundamental physics.

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Radio counterparts of high-energy neutrino sources

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High-energy neutrinos are generated in particularly energetic astrophysical environments. However, it is not easy to identify neutrino sources, given the low spatial resolution of the most sensitive current telescopes, such as IceCube or KM3NeT. The search for electromagnetic counterparts is therefore essential to identify the source and thus to study the physical conditions that lead to neutrino generation. I present a project, funded by Next Generation EU - KM3NeT4RR, aimed at observing radio sources that are potential sources of high-energy neutrinos. We are working on upgrading the 32m radio telescope at Noto (INAF) to extend its observing capabilities up to 100 GHz and have an efficient acquisition system. The observational program aims to perform close cadence monitoring at high radio frequency to build a database of long-term source behavior. By this monitoring, detection of any flares/transients will be used to investigate possible correlations with neutrino events detected by KM3NeT, and thus to consider follow-up observations by both telescopes.

Parallel 2 / 218

Learning from ASTRI-Horn: how to monitor observation quality using the Variance

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ASTRI is an Italian project aimed at the study of the cosmic very high-energy gamma radiation. In the past decade, ASTRI has developed a new kind of Cherenkov telescope, based on a dual mirror Schwarzschild-Couder optical configuration and miniaturized silicon photomultiplier sensors. Nowadays, the realization of a nine-telescopes array of the ASTRI kind working in stereoscopic mode, the so-called ASTRI Mini-Array, is in progress at the Observatorio del Teide, in the Canary Islands. However, the prototype instrument ASTRI-Horn, installed in Italy, is still serving as an important test bench for both observation strategies, hardware upgrades and software solutions. In particular, during the observing campaign of winter 22/23, we implemented major improvements in the usage of the so-called "Variance"mode, an auxiliary output of the ASTRI Cherenkov camera imaging the night sky background in the spectral range between 200-500 nm. As a result, the Variance is currently processed online and onsite by a dedicated pipeline producing a tech file aggregating several relevant quantities: telescope mis-pointing, background level, the number of stars identified by the custom astrometry routine, and also an estimation of the optical point spread function. In this contribution we illustrate these quantities and their importance, together with the algorithms adopted for their calculation. All together, they provide essential pieces of information of the observations quality (health status of the telescope and sky conditions) during scientific data-taking, offering the opportunity to select the best time sequences for Cherenkov data reduction.

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Performance of Small Photomultiplier Tubes with Wavelength Shifting Plates for an SWGO-like Water Cherenkov Detector Using Geant4

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Water Cherenkov detectors (WCDs) detect high-energy particles from air showers in the atmosphere via the Cherenkov radiation they emit in the water. Discussed here is a novel photodetector designed

for use in WCDs, such as the Southern Wide Field Gamma-ray Observatory (SWGO). Traditionally large photomultiplier tubes (PMTs) are used in WCDs; however, this study proposes the use of smaller PMTs coupled with wavelength shifting (WLS) plates to enhance the photodetection efficiency while saving costs. The WLS plate aims to increase the light capture area of a smaller PMT by 'trapping'photons and directing them towards the PMT's photocathode via internal reflection and reflective edges. This method proposes to improve the overall detection rates of a smaller PMT to achieve the same goal, without needing a larger more expensive PMT.

Geant4 Monte Carlo simulations were used to evaluate the performance of various configurations by investigating a range of thicknesses, sizes and materials to determine the optimal geometry for this design. The photodetector is designed for employment in the lower chamber of an SWGO-like double-layered WCD, used for hadronic background rejection. This tank was modelled in these simulations to compare the muon detection efficiency of this design with a larger PMT. The feasibility of implementing this design into an observatory such as SWGO will depend on meeting the requirements for accurate hadronic rejection through muon detection.

Poster hang / 220

Do minerals know about cosmic rays?

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The measurement of the flux of cosmic rays in the past could give some important information about the sources of cosmic rays, the evolution of the neighbourhood of the Solar System in the Galaxy, and the Galaxy itself. It could also inform our understanding of key events in the Earth's history such as mass extinctions.
The paleo-detector technique consists of looking for damages inside of long-aged minerals left in the form of tracks by astroparticles passing. It has been proposed to take advantage of the extremely long mineral exposure to look for weakly interacting particles such as dark matter constituent particles and neutrinos. On the other hand, here we propose to use the paleo-detectors technique to obtain information on the history of cosmic rays detecting the tracks left by past flux of secondary cosmic rays.
Cosmic rays can be shielded, thus selecting minerals with a known and specific geological history, we can measure the flux at a specific moment in time. An example is the Messinian Salinity Crisis, when, after the desiccation of the Mediterranean Sea at the end of the Messinian Age, evaporites formed and were exposed directly to secondary cosmic rays. After a period of time of $\sim 300\,\mathrm{kyr}$ the Mediterranean Sea was filled again by water and the evaporites were shielded by a km-deep overburden of water, retaining information of the cosmic ray flux of that period. In this work, we study the sensitivity of these evaporites to the cosmic ray flux and to a potential flux variation given by the explosion of a nearby supernova.

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Gamma rays from binaries

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In the last 20 years, very-high energy gamma rays have been detected in different types of binary systems, including gamma-ray binaries, X-ray binaries, colliding-wind binaries and novae. Owing

to the nature of the two components in these binaries, different scenarios have been considered for particle acceleration, gamma-ray emission and absorption processes. In this talk I will review our current knowledge and understanding of gamma-ray emitting binaries, with a special focus on recent results and on gamma-ray binaries.

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UHE Galactic gamma-ray sources

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Nowadays, we are witnessing spectacular discoveries of ultra-high energy (E > 100 TeV) gamma-ray sources in the Milky Way, revealing the sites of PeVatrons - Cosmic Ray Factories accelerating protons and electrons to energies of 1 PeV and higher. These perfectly designed by nature particle accelerators represent at least three galactic source populations - pulsars, microquasars, and stellar clusters. On the other hand, quite unexpectedly, there was no direct evidence of ultra-high energy gamma-rays from young Supernova Remnants, a source population that for decades was considered responsible for the locally measured Cosmic Rat flux up to the so-called "knee" at a few PeV. However, it cannot be ruled out that some unidentified UHE gamma-ray sources are associated with giant molecular clouds in the immediate vicinity of middle-aged supernova remnants. I will discuss the implications of these exciting and largely unexpected discoveries for the physics and astrophysics of pulsars and black holes, star formation in the Milky Way, and the origin of Galactic Cosmic Rays.

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Dark matter search prospects in gamma-ray astronomy: from the Galactic Center to external galaxies - [REMOTE]

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I review the arguments for interpretations of the Galactic Center gamma ray excess, the only significant detection to date of a possible indirect dark matter annihilation signal. I describe current search implications for complementary targets, most notably including nearby dwarf spheroidal galaxies, and the prospects for future improvements in gamma ray probes of DM.

Poster hang / 224

High-redshift blazars with AGILE

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High-redshift ($z > 2$) blazars have spectral energy distributions whose inverse Compton peak usually lies in the MeV-GeV energy range. In particular, the AGILE satellite investigated 4C $+71.07$ and PKS 1830$-$211 triggering multi-wavelengths observations from the radio to the gamma-ray energy bands, in response to gamma-ray flares. We report on the multi-wavelength observations, discussing the modelling of their spectral energy distributions, whose extreme Compton dominance (> 100 during the flares) may challenge the canonical one-component emission model, requiring alternative models. Moreover, their high-redshifts make them excellent candidates for future gamma-ray missions such as COSI and e-ASTROGAM.

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Highlights from HAWC

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The High-Altitude Water Cherenkov (HAWC) Observatory in Puebla, Mexico, is a wide field of view (FoV) gamma-ray survey instrument. It effectively covers nearly two-thirds of the entire sky, spanning declinations from $-31°$ to $+69°$. HAWC's wide FoV and high-duty cycle offer advantages for the continuous observation of astrophysical objects such as like pulsar wind nebulae (PWNe), TeV-halos, binaries, star-forming regions, supernova remnants (SNRs) and active galactic nuclei (AGN). With the release of its pass 5 reconstruction data, HAWC has enhanced both statistics and algorithmic precision, providing more accurate data for identifying cosmic-ray accelerators from both galactic and extragalactic sources. In this presentation, I will highlight the latest discoveries in the very-high-energy (VHE) gamma-ray sky survey carried out with HAWC.

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Gamma-Ray bursts

Author: Lara Nava[1]

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The study of GRBs at gamma-ray energies has been recently boosted by the detection of a handful of events at energies above 100 GeV. These observations are revealing the existence of a surprisingly bright TeV component present at least in some of the most energetics GRBs during their afterglow phase.
I this talk I will review the observations and the theoretical interpretations put forward, with a focus on issues and open questions that future observations will help to clarify.

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LHAASO: Progresses in γ-ray Astronomy and CR Physics.

Author: Zhen Cao[1]

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LHAASO keeps operating with high duty cycle and providing unique observations in gamma-ray sources and diffuse charged cosmic rays. Gamma-rays from the BOAT GRB, blazars, near-by AGNs and PeVatrons in our own galaxy are well detected. Physics associated with EBL, new physics searches, radiation mechanism of various sources are discussed. Particle acceleration in the galactic sources and propagation in the Milky Way are investigated using UHE photons. Protons and mixture of protons and α-particles are separated from other charge CRs for the measurements of individual spectra and their knees, while the more traditional spectrum, composition and anisotropy of all charged CR particles are measured. Future prospects of the LHAASO experiment are also presented in this talk.

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Highlights from H.E.S.S.

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The High Energy Stereoscopic System HESS continues to operate with very high efficiency and a high rate of five-telescope stereoscopic data taken every year. The facility is mature and operates in a stable instrumental configuration. This allows for extensive observations of homogeneous data quality - either in deep observations or homogeneous surveys and facilitates high up-time as required for time-domain studies.
This presentations provides an overview of recent highlights in the various domains of gamma-ray astronomy, studies of cosmic rays and a view ahead.

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Gamma rays from space missions

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Space-based gamma-ray telescopes provide insight into energetic astrophysical processes from 100s of keV to 100s of GeV. A rich array of instruments in flight are gathering observations of outbursts from black holes, neutron stars, binary systems and other dynamic environments and mapping the traces of extreme activity in the past. I will talk about ways that space-based observations have expanded our view of where gammas come from, the information they carry, and the ways they connect across wavelengths and to other astrophysical messengers. I will also touch on some questions that have emerged and are awaiting answers.

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Gamma-ray observations with IACT and astro-particle arrays from the ground: the future

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The field of ground-based gamma-ray astronomy is flourishing, with the current generation of instruments providing a rich and complex picture of non-thermal astrophysics in the TeV-PeV domain. At the same time a new generation of instruments is planned or already in construction, promising a fundamental step forward in our understanding of many astrophysical systems as well as deep searches for new physics. I will briefly review the status of these instruments and emphasise the complementarity between ground-level particle based detection systems and imaging Cherenkov telescope arrays. Finally I will address some of the emerging concepts which hold promise for the field beyond the horizon of the major new systems.

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On the acceleration of Galactic cosmic rays

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TBD

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Constraining cosmic ray propagation through gamma-rays

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New instruments in gamma-ray astronomy like Fermi and the next generation IACTs have boosted our understanding of the high-energy Universe and its non-thermal processes. In fact, with the improved spatial and temporal resolutions together with real-time multimessenger astronomy, the instruments now provide us with information that cannot be modeled with the simplifying 1D approaches of leptohadronic modeling that have worked decently before. Instead, the role of 3D cosmic-ray transport has been shown to become more and more important. This talk will provide a short review of how cosmic-ray propagation in different astrophysical environments like the Milky Way can be constrained with the help of state-of-the-art measurements of gamma rays.

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Gamma-ray propagation, magnetic field and EBL constraints from HE and VHE observations

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At first glance, the question of what the universe is made of may seem unrelated to astroparticle physics. It is in fact optical and microwave observations that have revealed that the energy balance of the universe is dominated by the density of dark energy (70%) and dark matter (25%). The nature of these two entities is elusive to this day. The remaining 5% is sometimes erroneously excluded from the realm of cosmology and attributed to gastrophysics, a form of sophisticated cuisine that would incorporate warm-hot plasma (approximately 4%), stars in various stages of evolution (a few per thousand), and supermassive black holes (a few parts per million). These entities would be distinguished by their complexity from the pre-dark ages relics, namely hydrogen, helium, and the diffuse neutrino and microwave backgrounds (total of less than two per thousand). This presentation will demonstrate how astroparticles, particularly gamma rays, are employed as a powerful tool to investigate the components of what is referred to as gastrophysics. Photons in the GeV-TeV energy range emitted in the vicinity of stellar-sized and supermassive black holes at cosmological distances have been used by the astroparticle community to study the plasma of the intergalactic medium and the associated magnetic fields, to measure the photon fields radiated by all the stars and dust grains in the universe, and to constrain the cosmological parameters themselves. The preparation of such culinary delights over the past decade heralds the advent of a more substantial banquet in the decade to come, which will require astroparticle physicists, gamma-ray astronomers, radio astronomers and optical astronomers to gather around the table.

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Gravitational waves and high-energy astrophysics: a multi-messenger approach

Author: Raffaella Margutti[1]

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In this talk I will provide highlights on the current status of the field of gravitational waves and their connection with high-energy transient phenomena, through the lens of multi-messenger astrophysics.

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CTAO updates

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TBD

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Concluding Remarks

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The contribution by Beppo Occhialini and his school to the birth of gamma-ray astronomy

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COS-B: the pioneer project for imaging high-energy astronomy in Europe

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A central team in Europe for the development of high-energy astronomy was the group in Milan that had formed around Bruno Rossi, Giuseppe (Beppo) Occhialini, and since 1966 Giovanni (Nanni) Bignami. They were in contact with groups with similar research interests in Great Britain, France, Germany, and the Netherlands and established a collaboration, named the CARAVANE collaboration, to build and operate the very successful COS-B gamma-ray telescope. COS-B, sensitive to gamma-rays above 70 MeV, was operational as the first ESA mission from 1975 to 1982. The CARAVANE collaboration achieved the first complete survey of the Milky Way, detection of about 25 point sources, among them 2 pulsars and the first extragalactic blazar. COS-B was an adventure in many ways because the operations and science achievements of such a large multi-national team required charismatic scientists able to focus our team on the discoveries made in the high-energy skies: Nanni Bignami was central in this effort.

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50 years of gamma ray astronomy with Nanni and friends

Author: Pietro Ubertini[1]

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I had the privilege to work with Prof. Giovanni Fabrizio Bignami (he was 'Nanni' for me, and I was 'a Piè' for him) since the end of the 70's on several space programs, and scientific endeavours, as well dealing with personal life's challenges. In particular, our first contact happened during the proposal phase of the high energy Gamma-ray camera to be selected aboard the newly approved NASA CGRO satellite, and, just after, on the GAMMA1 Soviet high energy gamma-ray mission, to provide a state of art start traker, that was successfully designed and built, but never delivered to IKI. At the end of 1990-beginning of 2000 we worked together on the EPIC X-Ray XMM focal plane detectors of which he was the ESA PI. In parallel, during the end of the '80s till the middle of the 90's, working to the proposal to launch an ESA gamma ray Observatory, materialized in the faulty proposal of the GRASP satellite (as M1 mission) and just after the successful attempt with the INTEGRAL ESA-NASA-Roskosmos M2 mission, selected to completion in 1995, and launched 7 years later from Baikonur with a Proton rocket. Just after its selection INTEGRAL was close to be cancelled due to the withdrawal of US and English Agencies expected to provide half scientific payload, then rescued by the Italian-French collaboboration, fully supported by ASI and CNES Space Agencies. The Observatory was successfully launched on October 17, 2002, still providing nowadays outstanding science after 22 years in operation. At the time of the crisis I was asked by ESA Executive to re-design the > one ton imaging/timing telescope as Principal Investigator of a new consortium, and was fully encouraged and supported by Nanny, chair of ESA-ISEC (INTEGRAL Science Evaluation Committee). At that moment I was verydoubthful to accept the load: almost 3 decades later, I am so happy to have accepted that challenge, that has finally left an indelible mark on my scientific way.
More recently, when Nanni was INAF President, I was appointed as the first Director of the Institute for Space Astrophysics and Planetology, supported by him, criticized, pushed to do the best in all the common activities among INAF. This was our common walk in the last 5 decades: Nanni was an unargued leader and he was always thinking about the best for Science and for the Astrophysical community at large. He served as President of the Italian Space Agency (2007-2010), of COSPAR (2010-2014), of the National Institute for Astrophysics (2011-2015), and other international bodies.

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The AGILE adventure

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Surprises

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Da Beppo a Nanni le meraviglie dell'astronomia delle alte energie

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University of Milano Representative

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Gamma 2024 Co-Chair

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Session recording

Recording of the whole Historical Session