ASTRI Mini-Array Core Science

Stefano Vercellone – INAF Osservatorio Astronomico di Brera

for the ASTRI Project

ASTRI & LHAASO Workshop – Milano, 07-08.03.2023

The ASTRI Mini-Array science papers

Journal of High Energy Astrophysics 35 (2022) 52–68

Contents lists available at ScienceDirect

Journal of High Energy Astrophysics

www.elsevier.com/locate/jheap

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The ASTRI Mini-Array of Cherenkov telescopes at the Observatorio del Teide

Journal of High Energy Astrophysics 35 (2022) 1–42

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ASTRI Mini-Array core science at the *Observatorio del Teide*

Journal of High Energy Astrophysics 35 (2022) 91–111

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Extragalactic observatory science with the ASTRI mini-array at the *Observatorio del Teide*

Journal of High Energy Astrophysics 35 (2022) 139–175

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Galactic observatory science with the ASTRI Mini-Array at the *Observatorio del Teide*

A detailed description of the Project, the Core Science and the Observatory Science can be found in the following papers:

Scuderi et al., 2022, JHEAP, 35, 52

Vercellone et al., 2022, JHEAP, 35, 1

Saturni et al., 2022, JHEAP, 35, 91

D'Ai et al., 2022, JHEAP, 35, 139

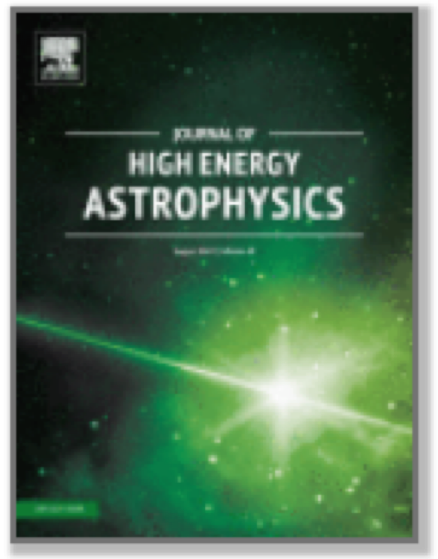
IRF files (Prod2, V1.0) can be retrieved from Zenodo: https://zenodo.org/record/6827882#.Y_N34-zMJ60 [Lombardi et al., 2022]

Ctools [http://cta.irap.omp.eu/ctools/] and **Gammapy** [https://gammapy.org/] can be used to simulate & analyse sources.

Topic of this talk

Mini-Array

Journal of High Energy Astrophysics
Volume 35, August 2022, Pages 1-42
https://doi.org/10.1016/j.jheap.2022.05.005



ELSEVIER

ASTRI Mini-Array core science at the *Observatorio del Teide*

S. Vercellone [a], C. Bigongiari [b], A. Burtovoi [c], M. Cardillo [d], O. Catalano [e], A. Franceschini [f], S. Lombardi [b, g], L. Nava [a], F. Pintore [e], A. Stamerra [b], F. Tavecchio [a], L. Zampieri [h], R. Alves Batista [i], E. Amato [c, j], L.A. Antonelli [b, g], C. Arcaro [h, k], J. Becerra González [l, m], G. Bonnoli [a] … G. Pareschi [a]

Core Science & Pillars

Pillar 1
The origin of cosmic rays

Quest for PeVatrons
Particle propagation
PWN HE emission
UHECR from SB galaxies

Pillar 2
Fundamental physics

IR EBL constraints
Probing IGMF
Blazars & hadron beams
Test on ALPs & LIV

Time-domain

GRB, GW, ν

Synergies

MWL, Legacy

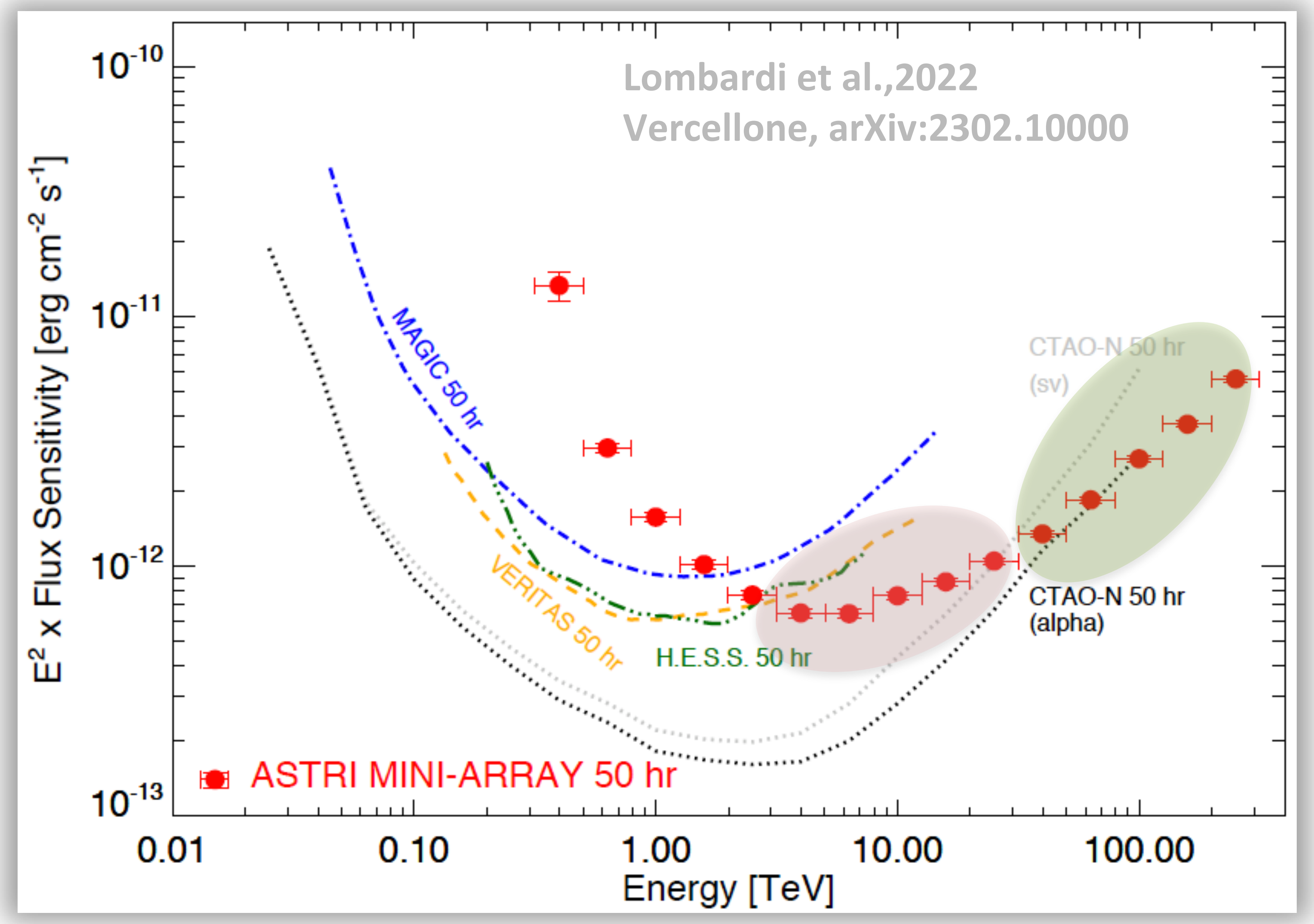
Non γ–ray

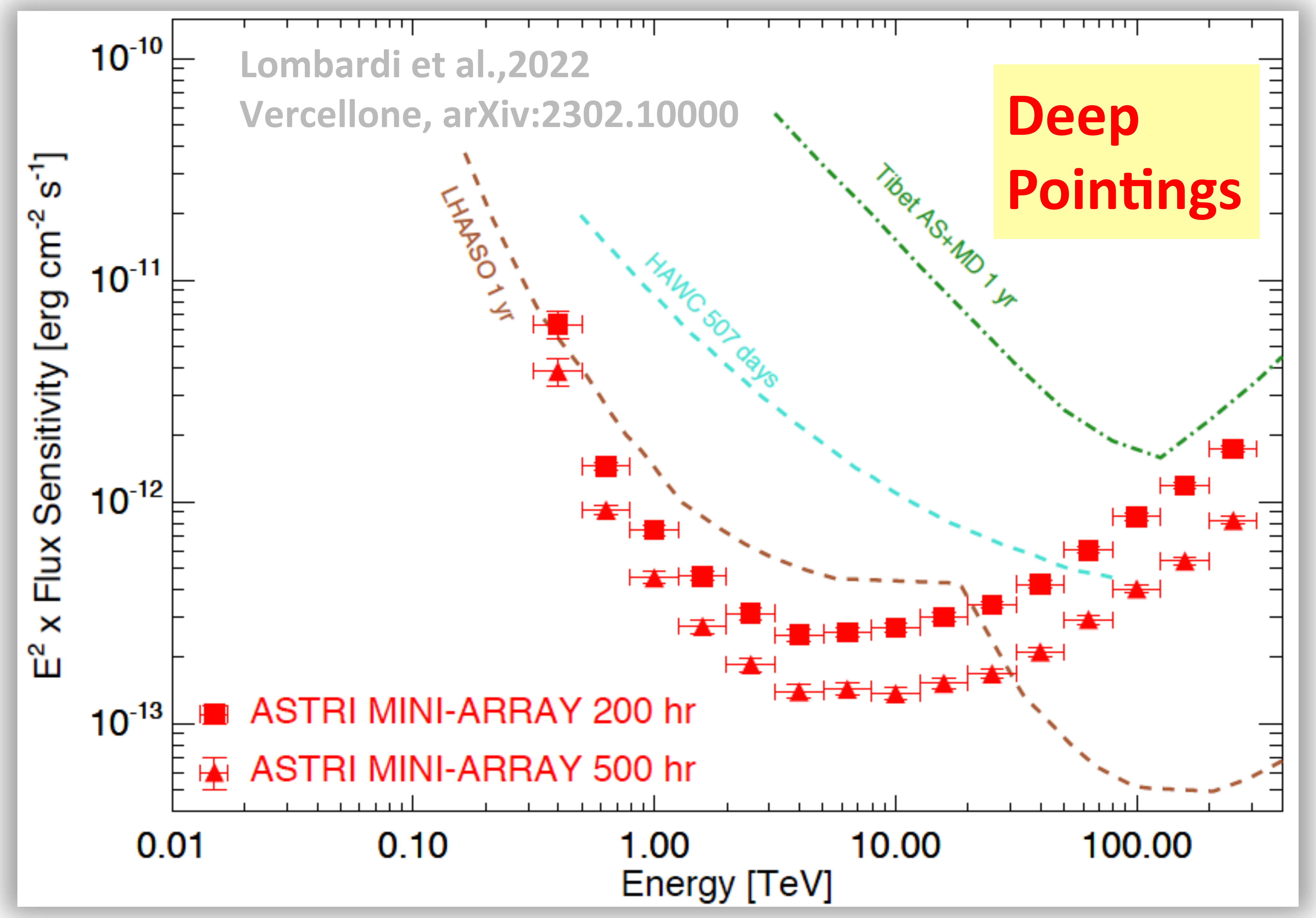
UHECR measure
SI^3

The ASTRI Mini-Array – Performance

We extend current IACTs **differential sensitivity up to several tens of TeV and beyond**

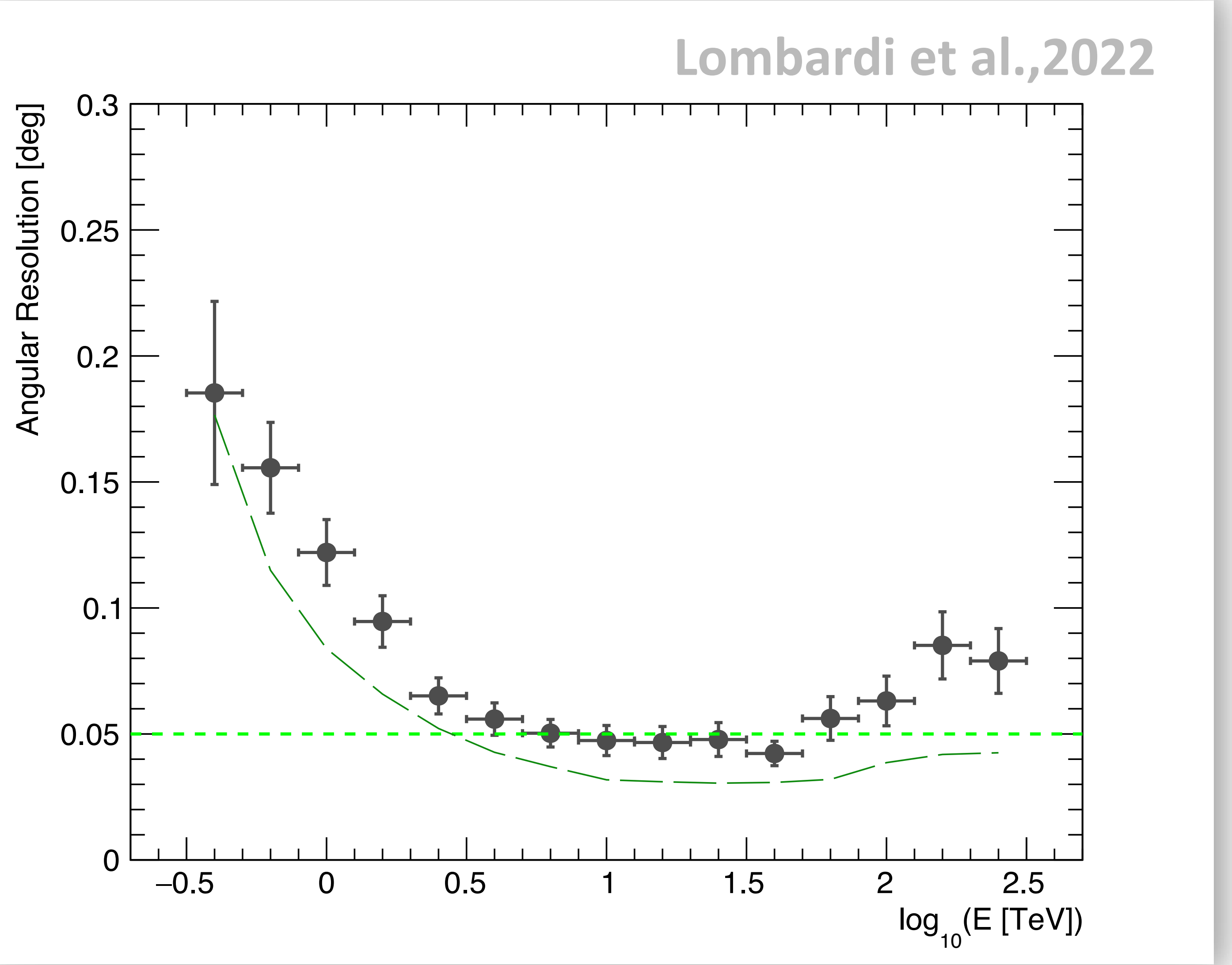
Investigate possible spectral features at VHE, such as the presence of **spectral cut-offs** or the detection of emission at several tens of TeV expected from **Galactic PeV sources**

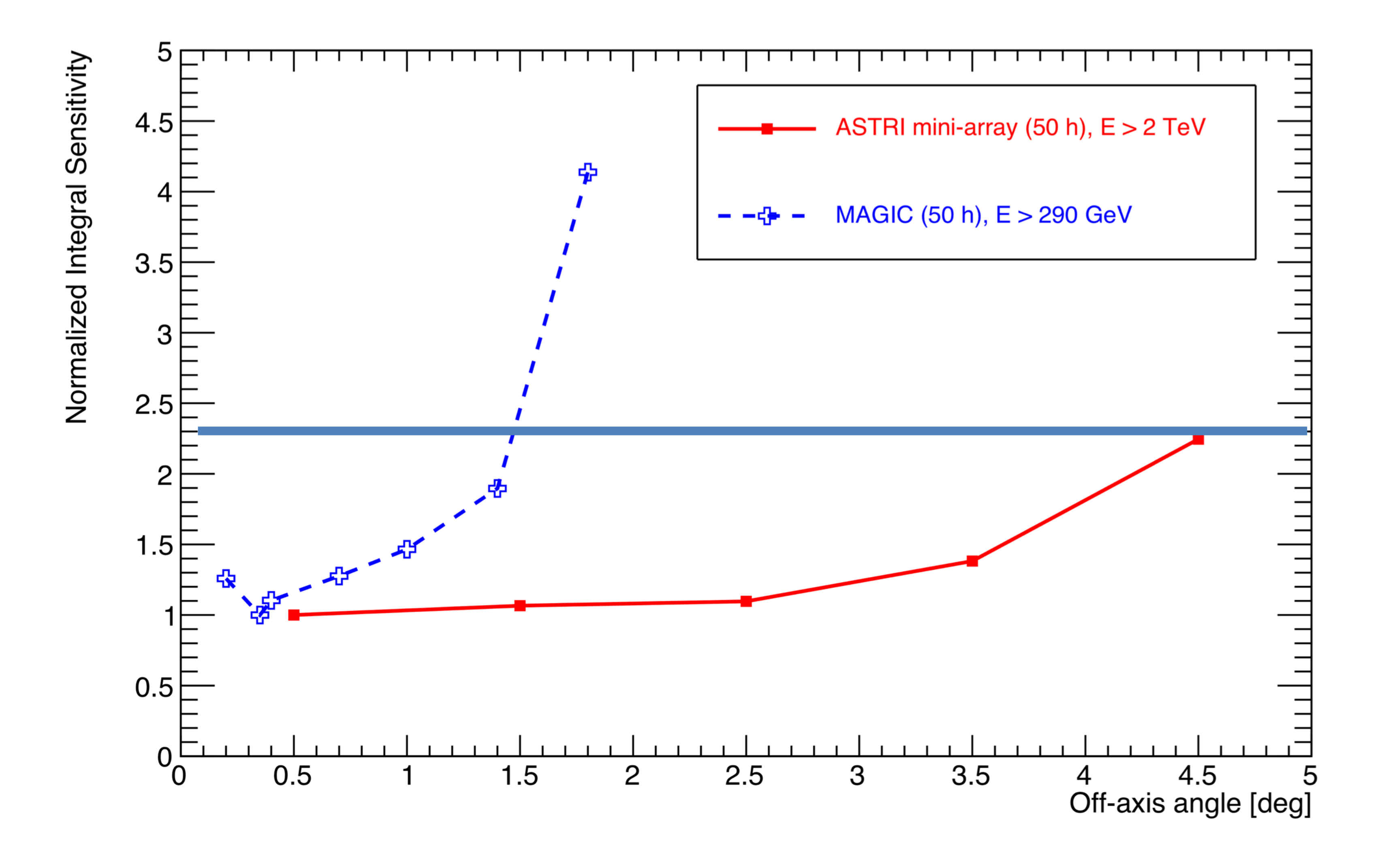


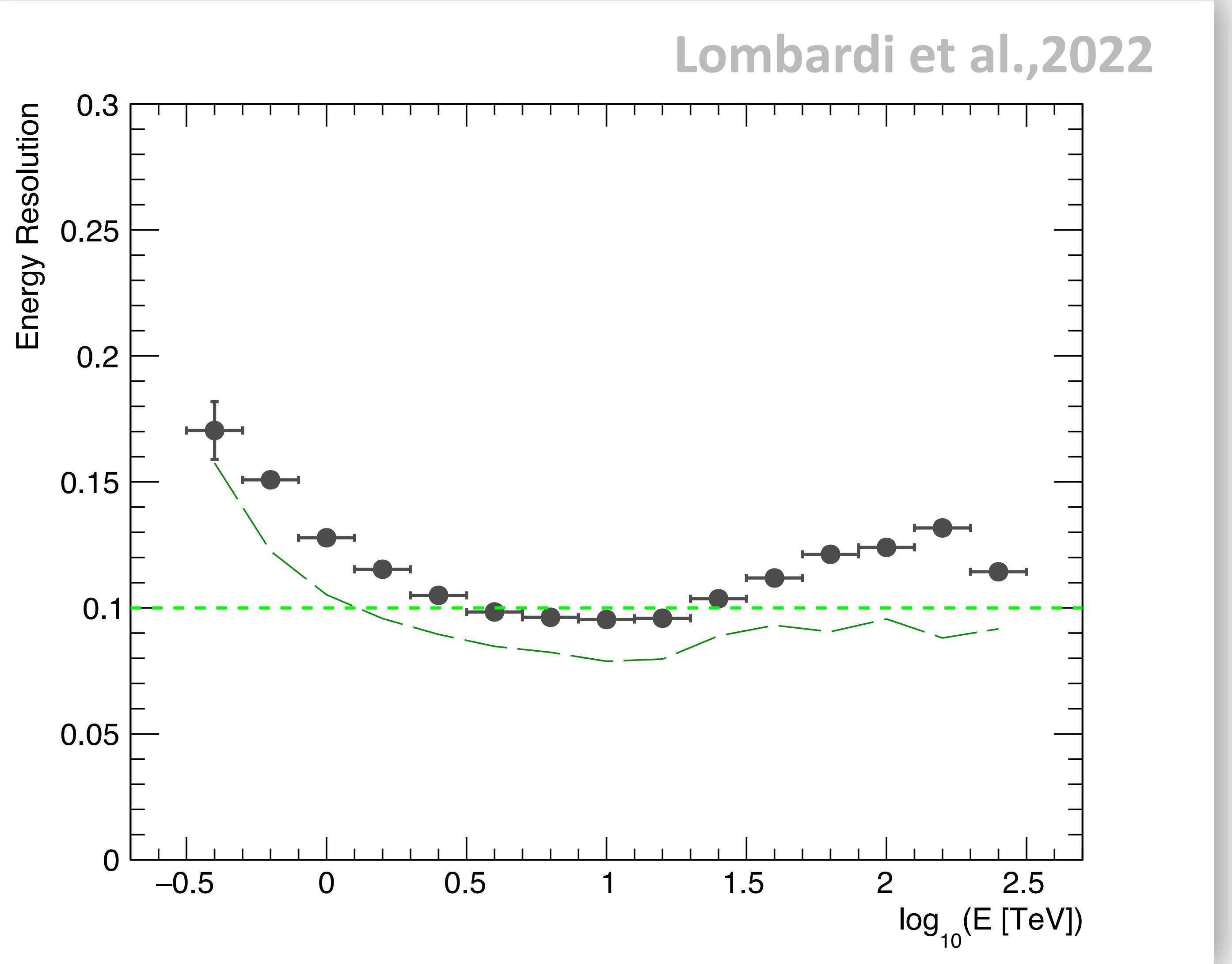


FoV, Angular and Energy resolution

ASTRI Mini-Array







Sensitivity: better than current IACTs (E ≳ 3 TeV)

- Broad-band spectrum
- Spectral cut-off constraints

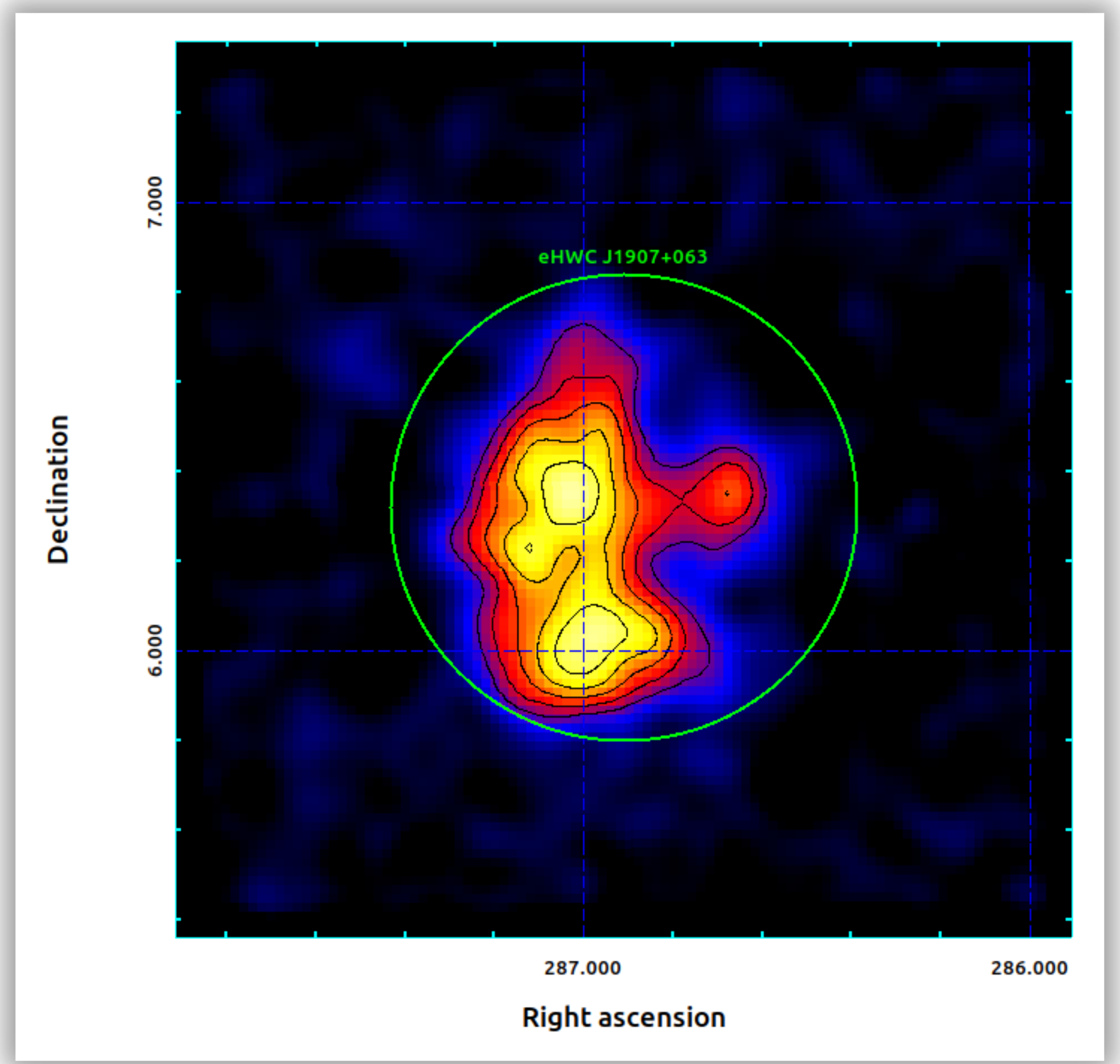
Energy/Angular resolution: ~10% / ~0.05° (E ~10 TeV)

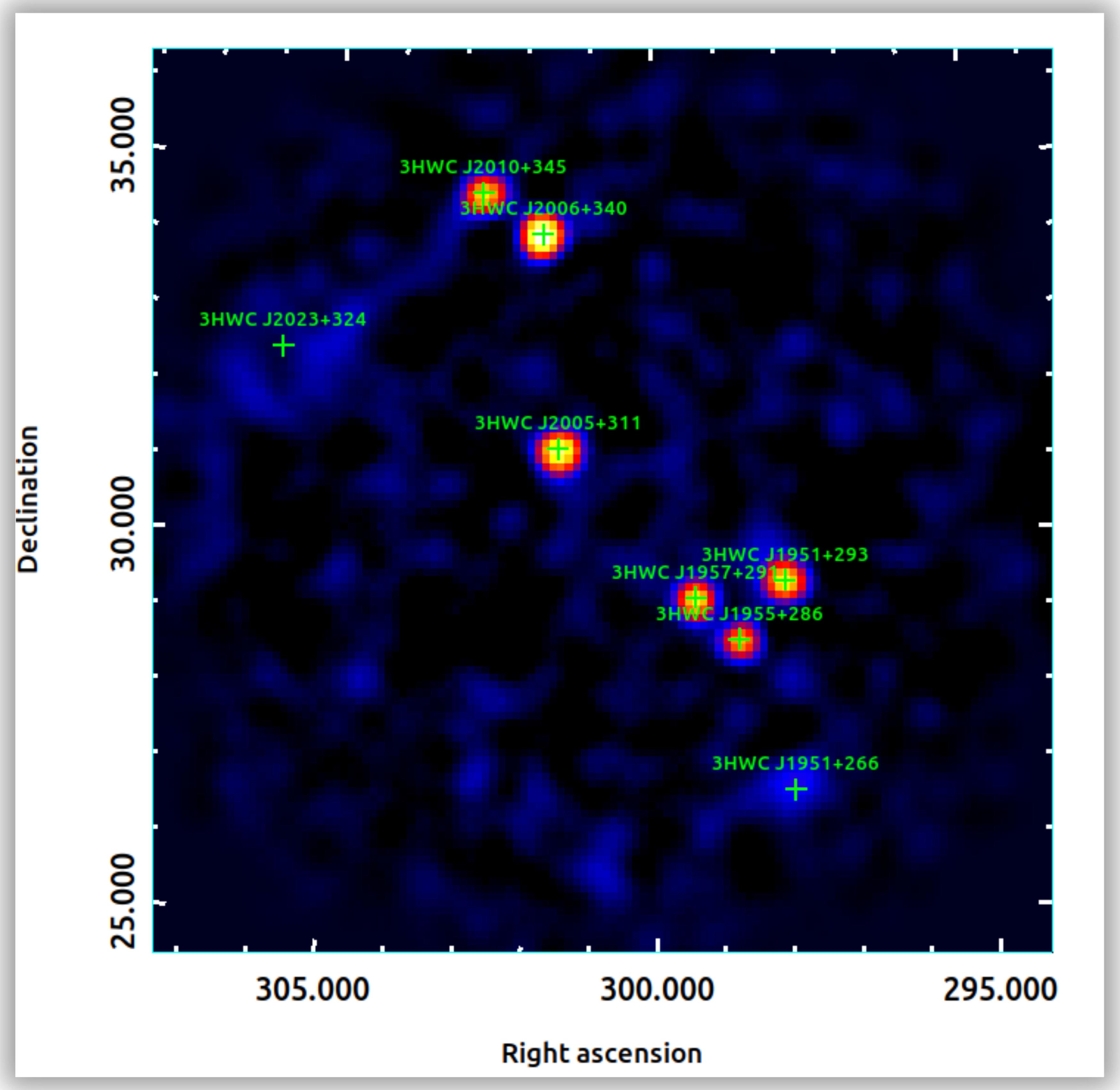
- Extended sources morphology

10° field of view with excellent off-axis performance

- Multi-target fields
- Serendipitous discoveries

Angular resolution and large field of view





ASTRI Mini-Array **200 hr simulation (up to E~200 TeV)** of the region **of the Galactic source 2HWC J1908+063**. The light green circle marks the ~ 0.52° HAWC error-box for $E > 56$ TeV

ASTRI Mini-Array **200 hr simulation of the Cygnus Region**. Green crosses mark the positions of the 3HWC sources in a 10° × 10° field of view → **LHAASO-1 catalog !**

Pillars' main scientific targets

Pillar-1

Name	RA (deg)	Dec (deg)	Type	Zenith Angle[1] (deg)	Visibility[2] (hr/yr)
Tycho	6.36	64.13	SNR	35.8	410+340
Galactic Center	266.40	-28.94	Diffuse	57.2	0+180
VER J1907+062 [L]	286.91	6.32	SNR+PWN	22	400+170
SNR G106.3+2.7 [L]	337.00	60.88	SNR	32.6	460+300
γ-Cygni	305.02	40.76	SNR	12.5	460+160
W28/HESS J1800-240B	270.11	-24.04	SNR/MC	51.6	0+300
Crab [L]	83.63	22.01	PWN	6.3	470+170
Geminga	98.48	17.77	PWN	10.5	460+170
M82	148.97	69.68	Starburst	41.4	310+470

[L] = LHAASO source (Cao et al., 2021)

Source selection and simulations mainly done prior to LHAASO results

Pillar-2

Target IAU Name	Class	RA (J2000)	DEC (J2000)	Obs. time [hr]	ZA [deg]	Moon [%]	Strategy, analysis, notes
IC 310	Radio gal.	03 16 43.0	+41 19 29	50-100	45	25	Better suited for ToO observations of high states
M87	Radio gal.	12 30 47.2	+12 23 51	50-100	45	25	Better suited for ToO observations of high states
Mkn 501	Blazar	16 53 52	+39 45 38	50-100	45	25	Better suited for ToO observations of high states

Target IAU Name	Class	RA (J2000)	DEC (J2000)	Obs. time [hr]	ZA [deg]	Moon [%]	Strategy, analysis, notes
Mkn 501	Blazar	16 53 52.2	+39 45 36.6	50-100	45	25	LIV, ALP. Better suited for ToOs in high states.
1ES 0229+200	Blazar	02 32 48.6	+20 17 17.5	200	45	25	HB, LIV, ALP. Almost steady source, possible "fill in" target.

These lists of sources reflect the science knowledge at the time of writing this paper

We expect to improve these lists according to the new findings from both IACTs and EASs

Pillar 1 – The origin of cosmic rays

Pillar 1
The origin of cosmic rays

Quest for PeVatrons
Particle propagation
PWN HE emission
UHECR from SB galaxies

The LHAASO Sources at ~PeV energies

Mini-Array

Cao et al., 2021, Nature

Source name	RA (°)	dec. (°)	Significance above 100 TeV (×σ)	E_{max} (PeV)	Flux at 100 TeV (CU)
LHAASO J0534+2202	83.55	22.05	17.8	0.88 ± 0.11	1.00(0.14)
LHAASO J1825-1326	276.45	−13.45	16.4	0.42 ± 0.16	3.57(0.52)
LHAASO J1839-0545	279.95	−5.75	7.7	0.21 ± 0.05	0.70(0.18)
LHAASO J1843-0338	280.75	−3.65	8.5	$0.26\ {-0.10}^{+0.16}$	0.73(0.17)
LHAASO J1849-0003	282.35	−0.05	10.4	0.35 ± 0.07	0.74(0.15)
LHAASO J1908+0621	287.05	6.35	17.2	0.44 ± 0.05	1.36(0.18)
LHAASO J1929+1745	292.25	17.75	7.4	$0.71\ {-0.07}^{+0.16}$	0.38(0.09)
LHAASO J1956+2845	299.05	28.75	7.4	0.42 ± 0.03	0.41(0.09)
LHAASO J2018+3651	304.75	36.85	10.4	0.27 ± 0.02	0.50(0.10)
LHAASO J2032+4102	308.05	41.05	10.5	1.42 ± 0.13	0.54(0.10)
LHAASO J2108+5157	317.15	51.95	8.3	0.43 ± 0.05	0.38(0.09)
LHAASO J2226+6057	336.75	60.95	13.6	0.57 ± 0.19	1.05(0.16)

Discovery of **12 sources emitting at several hundreds of TeV**, up to 1.4 PeV

Crab aside, the majority of remaining sources represent **diffuse γ-ray structures with angular extensions up to 1°**

The **actual sources** responsible for the ultra high-energy γ-rays **have not yet been firmly localized and identified** (except for the Crab Nebula), leaving **the origin of these extreme accelerators open**

The **ASTRI Mini-Array** will investigate these and future UHE sources, providing both the opportunity for **their precise identification** and important **information on their morphology and spectra**

PeV-emitting sources – where to look at

SNRs
- No smoking gun from them, yet (Cas A, Tycho…)
  Maybe detectable only in their early stages

Core-collapse SN
- Could be PeVatrons just after the explosion

Massive young stellar clusters
- LHAASO detected emission at 1.4 PeV from a region consistent with the Cygnus Cocoon + a few other YMC

Galactic Center
- Which is the PeV source?

TeV Halos
- Geminga, Monogem, J0622+3749

See talks at the PeVatron Session

Pillar 2 – Fundamental physics

Pillar 2
Fundamental physics

- IR EBL constraints
- Probing IGMF
- Blazars & hadron beams
- Test on ALPs & LIV

EBL studies in the IR regime

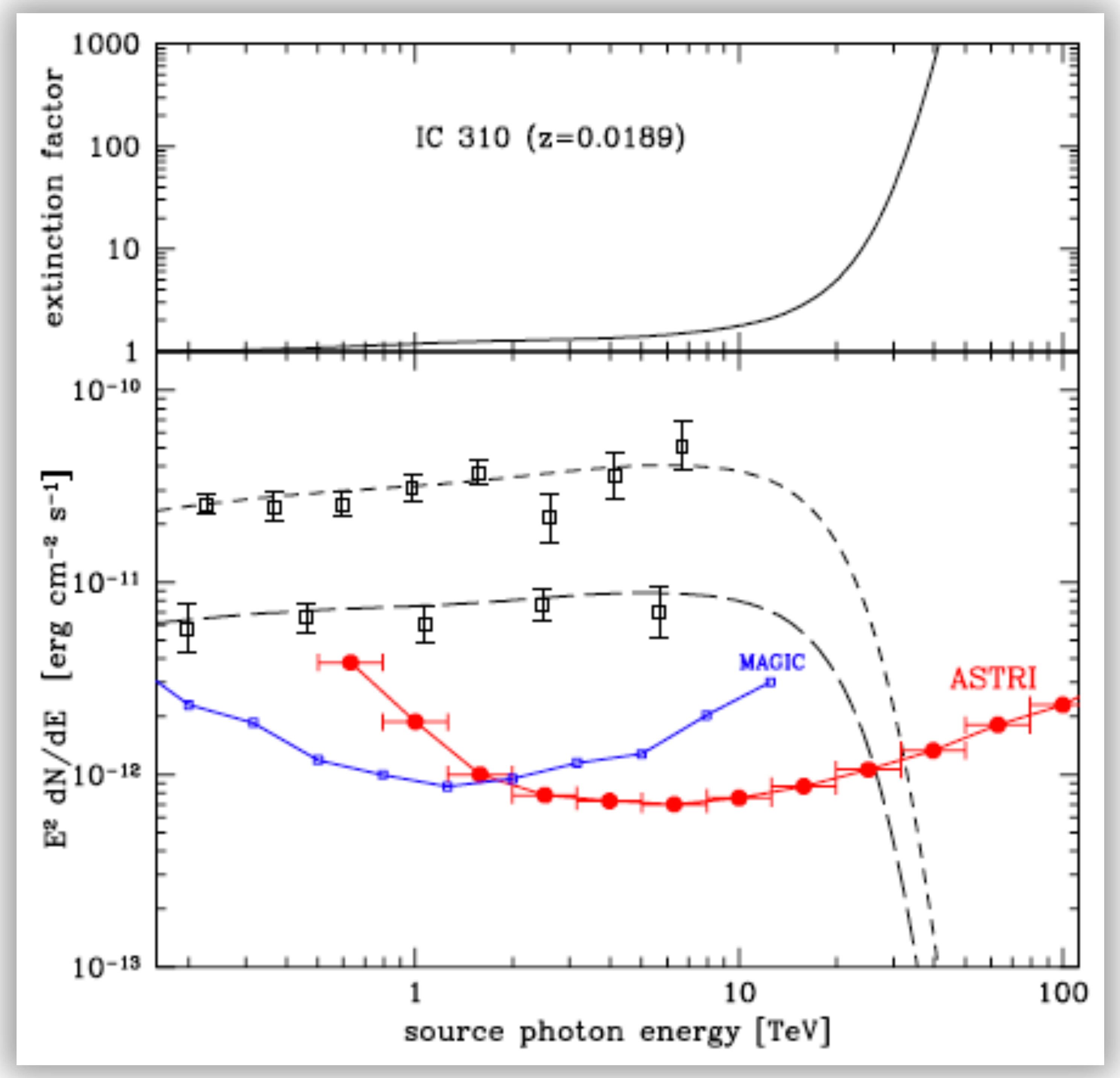
From the **mid-IR to the far-IR**, where the IR background intensity is maximal, **EBL direct measurements are prevented** by the overwhelming dominance of local emission from both the Galaxy and our Solar system

$$\lambda_{max} \sim 1.24 \times E_{TeV} \; [\mu m]$$

Measurements in the **(10-30)TeV energy band probe the EBL in the ~(10-30)μm regime**, otherwise unaccessible

Best candidates to constrain the EBL up to $\lambda \sim 100\mu m$:

- **low-redshift radio galaxies**
  - M 87, **IC 310**, Centaurus A
- **local star-bursting and active galaxies**
  - M 82, NGC 253, NGC 1068



Upper panel: extinction factor for photon-photon interaction on EBL at the IC 310 source distance.

Bottom panel: MAGIC (blue dots) and ASTRI Mini-Array (red dots) **50 hours, 5σ differential sensitivity**

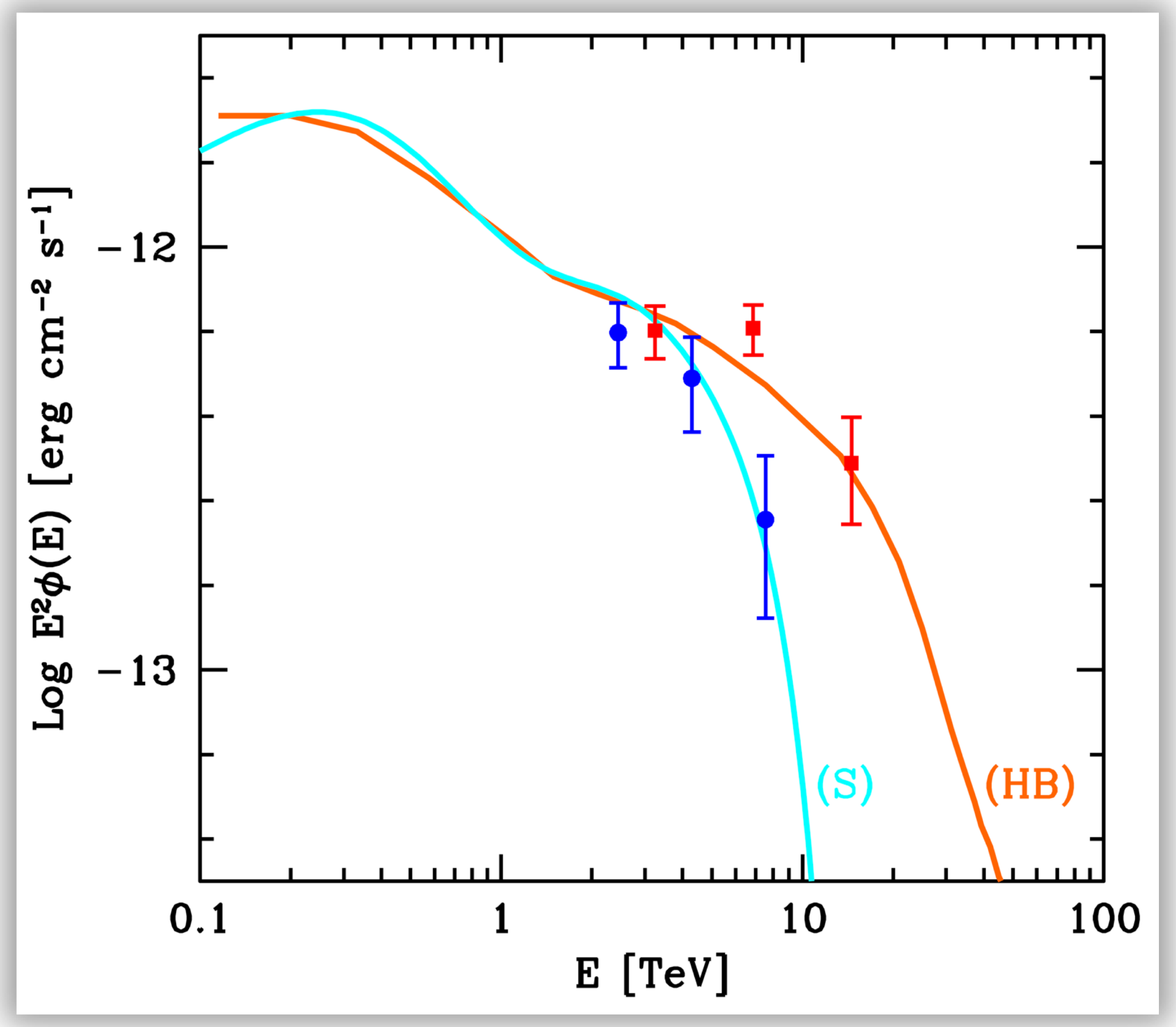
Fundamental physics – hadron beams

Relativitic jets from extreme BL Lacs could be one of the **UHECR acceleration sites**

Jets in extreme BL Lac objects could produce hadron beam (collimated beams of high-energy protons/nuclei)

While travelling towards the Earth

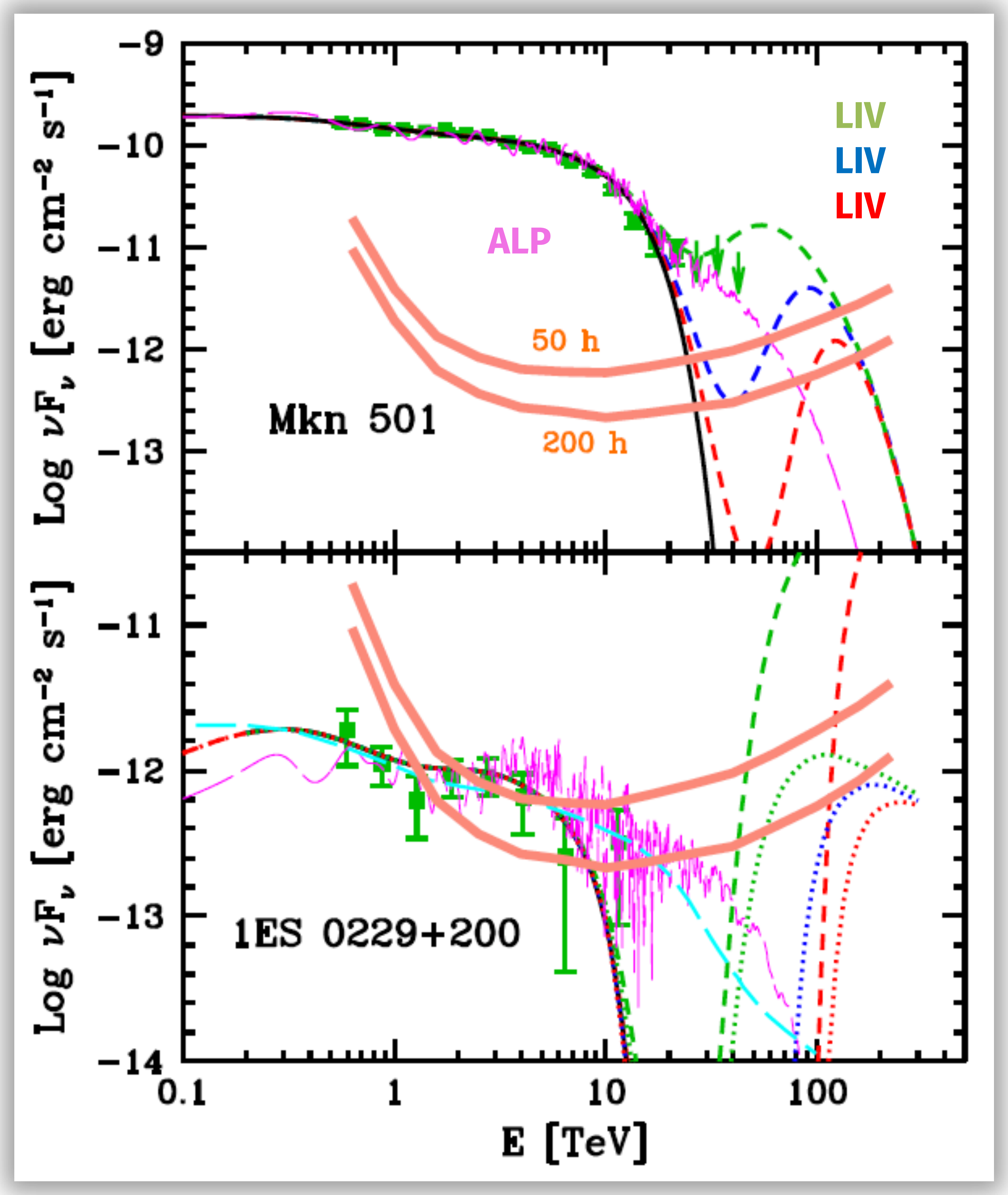
- UHECR lose energy through photo-meson and pair production
- these trigger the development of electromagnetic cascades producing γ and ν
- Because of the reduced distance, **γ experience a less severe EBL absorption**
- The **observed gamma-ray spectrum extends at energies much higher (E > 10TeV)** than those allowed by the conventional EBL propagation

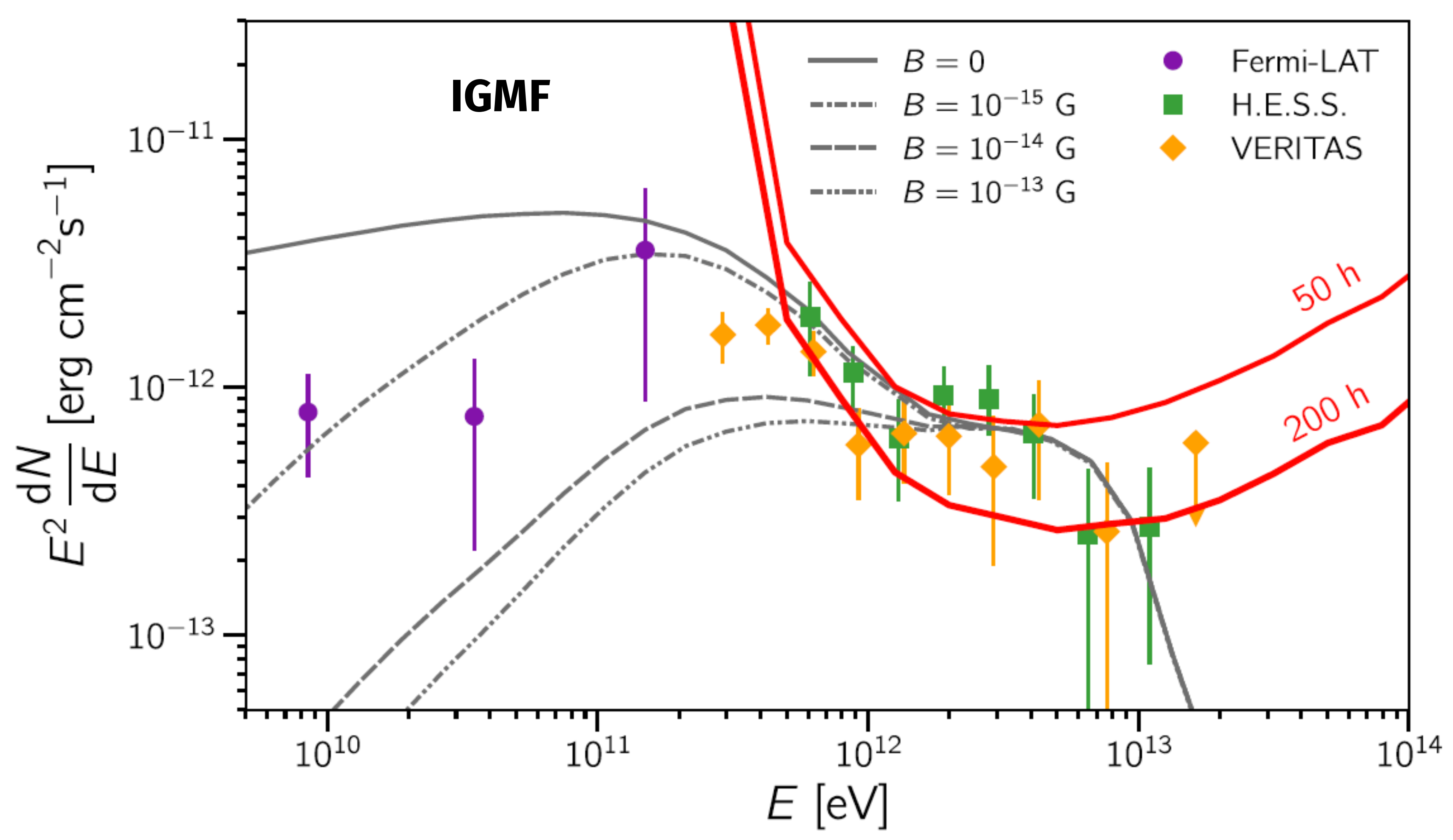


Simulated VHE spectrum of 1ES 0229+220 for the **standard** (light blue, 200 hr) and **hadron beam** (red, 250 hr) scenarios

The ASTRI Mini- Array would be able to obtain a **significative detection up to 20 TeV with a deep observation (~250 hr)**

Fundamental physics – IGMF, LIV, ALPs





The ASTRI Mini- Array should be able to investigate spectral signatures induced by ALPs, LIV and IGMF with **deep observations (~200 hr)**

See Vercellone et al., 2022 for more details

Time-domain astrophysics

Time-domain

GRB, GW, ν

See talks at the GRB Session

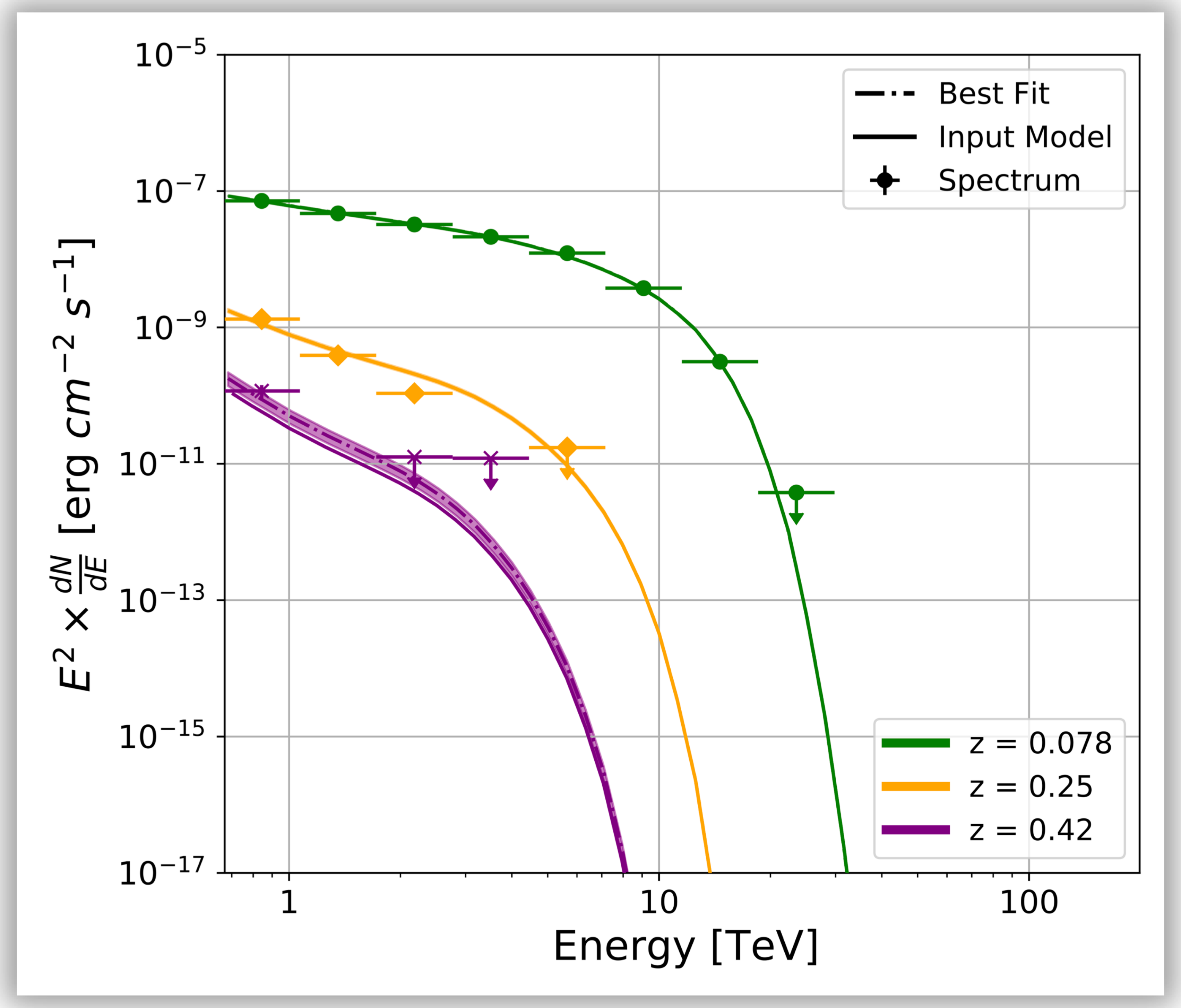
Gamma-ray bursts

- GRBs confirmed as a new class of TeV emitters thanks to the MAGIC detection of GRB 190114C (z=0.42)
- SSC component extending into the TeV energy range
- LHAASO detection of **GRB 221009A (z=0.15) well above 10 TeV challenges the standard physics model**

The ASTRI Mini-Array

- might have detected emission from GRB 190114C
- is able to confirm afterglow emission at E >1 TeV from close (z < 0.4) GRBs if observations start within the first tens of seconds up to few minutes from the onset of the burst
- can measure the spectral cut-off, either originated by the EBL absorption or intrinsic, if greater than 1 TeV

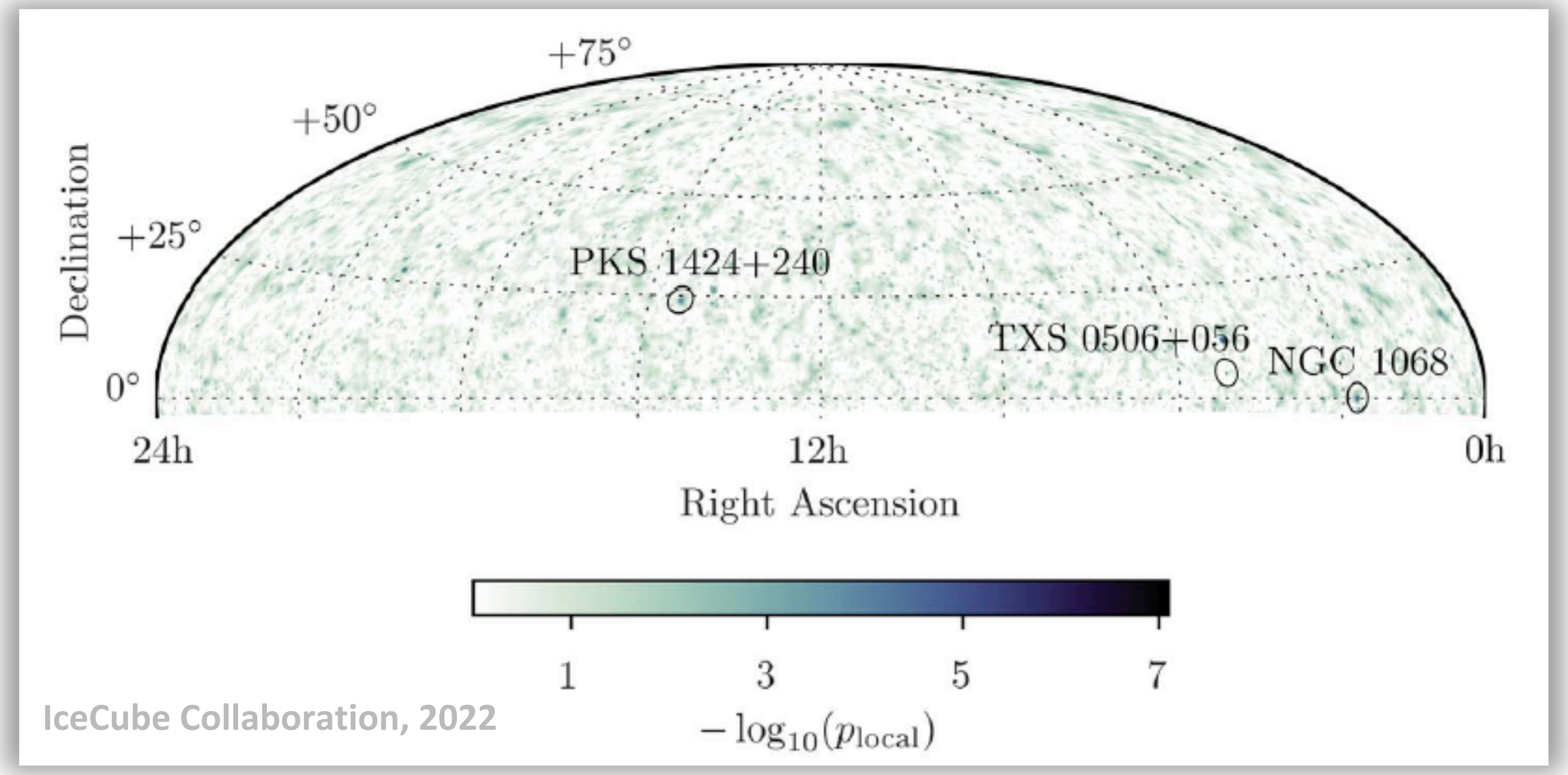
The expected number of follow-ups on observable GRBs is about 1 per month



Simulation of the emission from three GRB 190114C-like bursts, at three different redshifts (z = 0.078, z = 0.25 and z = 0.42)

Simulations of GRB 221009A will start very soon

Neutrino



Currently, at least **three extra-galactic sources** seem to show associations with neutrino emission, namely **NGC 1068, PKS 1424+240 and TXS 0506+056**, associated to different AGN classes: TeV emitting **BL Lac objects** and one **Seyfert galaxy (NGC 1068)**.

There are important constraints imposed from these detections on the **presence and/or absence of γ-ray VHE emission** which could be investigated by means of the ASTRI Mini-Array.

Synergies

See talks at the Synergy Session

Strategic VHE/UHE synergies

- Both **MAGIC** and **CTAO-N** will be of paramount importance for their capability to investigate not only the local Universe, but also to reach **redshifts well beyond one**

- Both **MAGIC** and **CTAO-N** will allow us to extend the ASTRI Mini-Array spectral performance in the **sub-TeV regime**, with almost no breaks **from a few tens of GeV up to hundreds of TeV**

- Potential synergies are important to make use of the **ASTRI Mini-Array angular and energy resolution** in combination with the **LHAASO**, HAWC and Tibet ASγ extended energy range

The multi-wavelength landscape at lower energies

- **MeerKat** and **ASCAP** (SKA precursors in the South) will allow us to investigate the Galactic Center and its features
- **LOFAR** (SKA precursor in the North) will open a new science window in the low-frequency radio band and monitor 2/3 of the sky nightly in Radio Sky Monitor mode, being an excellent radio transient factory
- **SRT** has already observed sources of interest for the ASTRI Mini-Array, such as W 44, IC 433 and Tycho, making it an excellent observatory for future synergies in the northern hemisphere
- **TNG** is located in La Palma and can be extremely useful for optical follow-up observations. The **WEBT Consortium** is dedicated to the observation of blazars, and it is fundamental for blazar SEDs. IAC also provides access to several optical telescopes on-site.
- **eROSITA/SRG**, **XMM-Newton**, **Chandra, NuSTAR and IXPE** will provide fundamental photometric,imaging, spectroscopic, and polarimetric data.
- **AGILE, Fermi, INTEGRAL** will be extremely important for their large FoV and ***Swift*** for the ability to promptly react to transients

From *Core* Science to *Observatory* Science

For the first 4 years the ASTRI Mini-Array will be run as an experiment

It will be dedicated to the Core Science Topics

Smooth transition towards an Observatory period

Build-up on the experience and results from the Core Science

Open to observational proposals from the scientific community

Summary

ASTRI Mini-Array

The ASTRI Mini-Array will start **scientific observations in 2025** from the *Observatorio del Teide* with a 4 (core science) + 4 (observatory science) year programme

Its **10° field of view** will allow us to investigate both extended sources (e.g., SNRs) and crowded/rich fields (e.g., the Galactic Center) with a single pointing

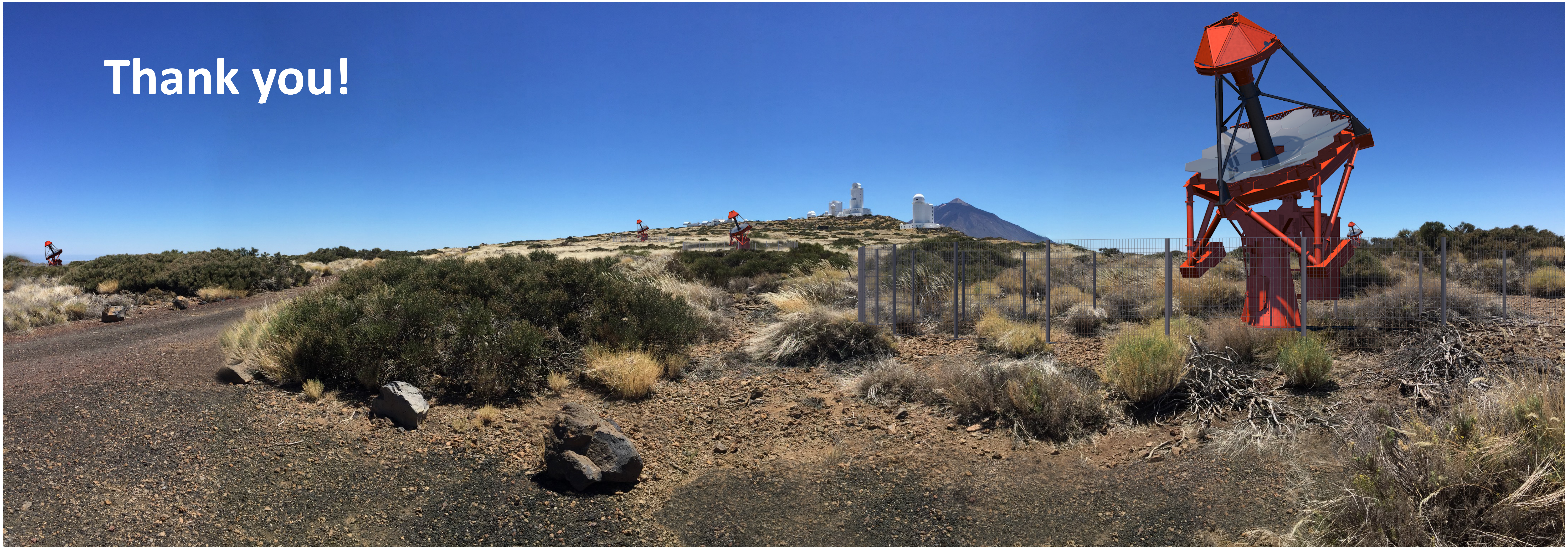
Its **3' angular resolution** at 10 TeV will allow us to perform detailed morphological studies of extended sources

Its **sensitivity extending above 100 TeV** will make it the most sensitive IACT in the energy range 5-200 TeV in the Northern hemisphere before CTAO-N

It will **join together** the ***energy domain*** typical of EASs with the ***precision domain*** (excellent angular and energy resolutions) typical of IACTs

Several **synergies with LHAASO** (PeV-only sources, broad-band spectrum, morphology…)

Questions & Comments



BACKUP

ASTRI: Astrophysics with Italian Replicating Technology Mirrors

Mini-Array

ASTRI-Horn Prototype

INAF-led Project funded by Italian Ministry of Research

End-to-end prototype installed and operational on Mount Etna volcano (Sicily, Italy)

First detection of a gamma-ray source (Crab Nebula) above 5σ **with a dual-mirror, Schwarzschild-Couder Chrenkov telescope** (Lombardi et al., 2020)

Array of 9 ASTRI telescopes

INAF-led Project with international partners: Univ. of Sao Paulo/FPESP (Brazil), North-West Univ. (S. Africa), IAC (Spain), FGG, ASI/SSDC, Univ. of Padova, Perugia and INFN

Being deployed at the *Observatorio del Teide* (Spain) in collaboration with IAC and FGG-INAF.

First 4 yr → *Core Science*, following 4 yr → *Observatory Science*. **Science operation → Q1 2025**

The ASTRI Mini-Array – Performance

	ASTRI Mini-Array	MAGIC	VERITAS	H.E.S.S.	HAWC	LHAASO	Tibet ASγ
Altitude [m]	2,390	2,200	1,268	1,800	4,100	4,410	4,300
FoV	$\sim 10°$	$\sim 3.5°$	$\sim 3.5°$	$\sim 5°$	2 sr	2 sr	2 sr
Angular Res.	0.05° (30 TeV)	0.07° (1 TeV)	0.07° (1 TeV)	0.06° (1 TeV)	0.15° (10 TeV)	(0.24–0.32)° (100 TeV)	$\sim$ 0.2° (100 TeV)
Energy Res.	12% (10 TeV)	16% (1 TeV)	17% (1 TeV)	15% (1 TeV)	30% (10 TeV)	(13–36)% (100 TeV)	20% (100 TeV)
Energy Range	(0.3-200) TeV	(0.05-20) TeV	(0.08-30) TeV	(0.02-30) TeV	(0.1-200) TeV	(0.1-1,000) TeV	(0.1-1,000) TeV

Sensitivity: better than current IACTs (E ≳ 3 TeV)

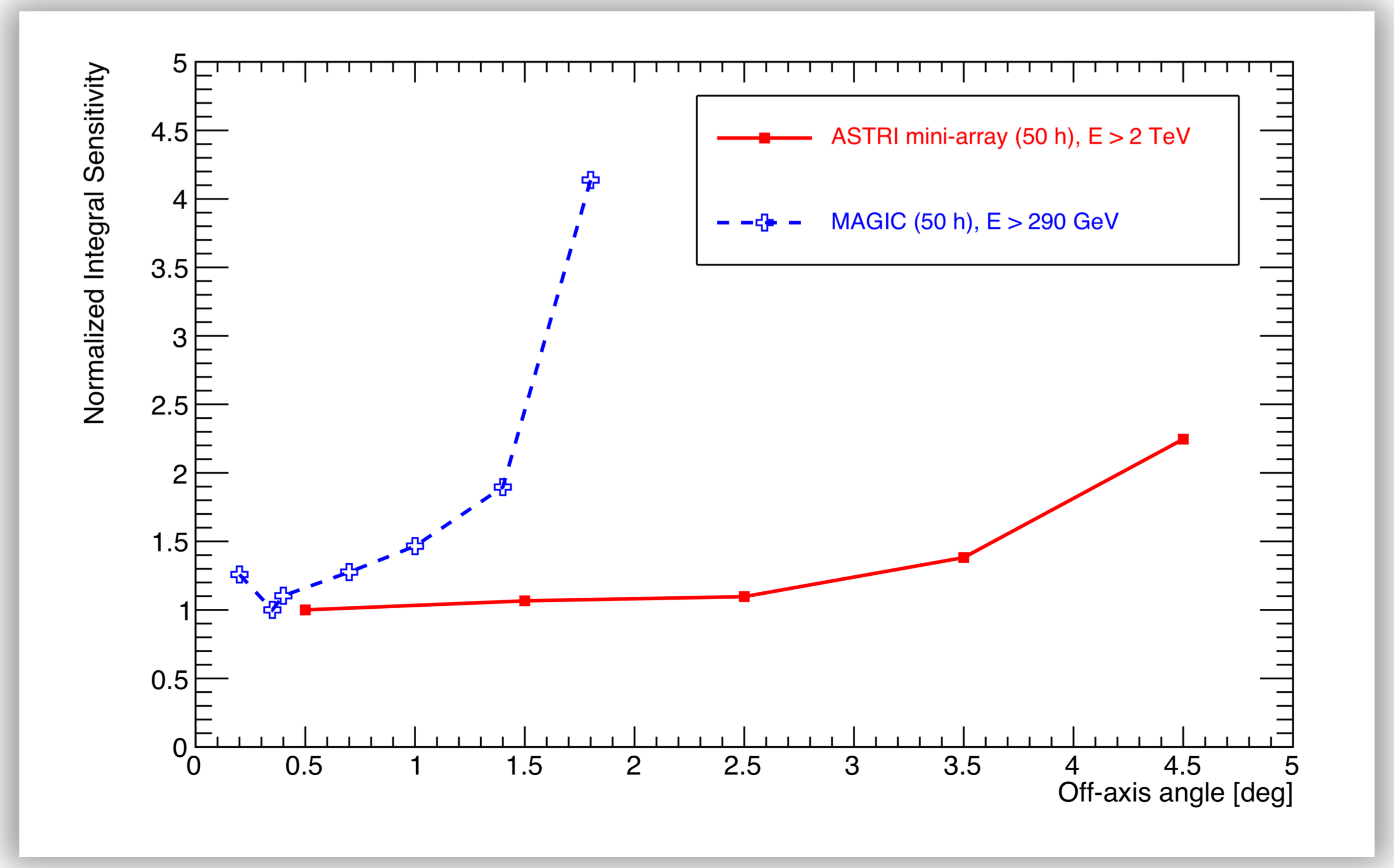
- Broad-band spectrum
- Spectral cut-off constraints

Energy/Angular resolution: ~10% / ~0.05° (E ~10 TeV)

- Extended sources morphology

10° field of view with excellent off-axis performance

- Multi-target fields
- Extended sources in a single pointing
- Serendipitous discoveries



The LHAASO Sources at ~PeV energies

Mini-Array

LHAASO Source	Possible Origin	Type	Distance (kpc)	Age (kyr)[a]	L_s (erg/s)[b]	Potential TeV Counterpart[c]
LHAASO J0534+2202	PSR J0534+2200	PSR	2.0	1.26	4.5×10^{38}	Crab, Crab Nebula
LHAASO J1825-1326	PSR J1826-1334	PSR	3.1 ± 0.2^{d}	21.4	2.8×10^{36}	HESS J1825-137, HESS J1826-130,
	PSR J1826-1256	PSR	1.6	14.4	3.6×10^{36}	2HWC J1825-134
LHAASO J1839-0545	PSR J1837-0604	PSR	4.8	33.8	2.0×10^{36}	2HWC J1837-065, HESS J1837-069,
	PSR J1838-0537	PSR	1.3^{e}	4.9	6.0×10^{36}	HESS J1841-055
LHAASO J1843-0338	SNR G28.6-0.1	SNR	9.6 ± 0.3^{f}	$< 2^{f}$	—	HESS J1843-033, HESS J1844-030,
						2HWC J1844-032
LHAASO J1849-0003	PSR J1849-0001	PSR	7^{g}	43.1	9.8×10^{36}	HESS J1849-000, 2HWC J1849+001
	W43	YMC	5.5^{h}	—	—	
LHAASO J1908+0621	SNR G40.5-0.5	SNR	3.4^{i}	$\sim 10 - 20^{j}$	—	MGRO J1908+06, HESS J1908+063,
	PSR 1907+0602	PSR	2.4	19.5	2.8×10^{36}	ARGO J1907+0627, VER J1907+062,
	PSR 1907+0631	PSR	3.4	11.3	5.3×10^{35}	2HWC 1908+063
LHAASO J1929+1745	PSR J1928+1746	PSR	4.6	82.6	1.6×10^{36}	2HWC J1928+177, 2HWC J1930+188,
	PSR J1930+1852	PSR	6.2	2.9	1.2×10^{37}	HESS J1930+188, VER J1930+188
	SNR G54.1+0.3	SNR	$6.3^{+0.8\ d}_{-0.7}$	$1.8 - 3.3^{k}$	—	
LHAASO J1956+2845	PSR J1958+2846	PSR	2.0	21.7	3.4×10^{35}	2HWC J1955+285
	SNR G66.0-0.0	SNR	2.3 ± 0.2^{d}	—	—	
LHAASO J2018+3651	PSR J2021+3651	PSR	$1.8^{+1.7\ l}_{-1.4}$	17.2	3.4×10^{36}	MGRO J2019+37, VER J2019+368,
	Sh 2-104	H II/YMC	$3.3 \pm 0.3^{m}/4.0 \pm 0.5^{n}$	—	—	VER J2016+371
LHAASO J2032+4102	Cygnus OB2	YMC	1.40 ± 0.08^{o}	—	—	TeV J2032+4130, ARGO J2031+4157,
	PSR 2032+4127	PSR	1.40 ± 0.08^{o}	201	1.5×10^{35}	MGRO J2031+41, 2HWC J2031+415,
	SNR G79.8+1.2	SNR candidate	—	—	—	VER J2032+414
LHAASO J2108+5157	—	—	—	—	—	—
LHAASO J2226+6057	SNR G106.3+2.7	SNR	0.8^{p}	$\sim 10^{p}$	—	VER J2227+608, Boomerang Nebula
	PSR J2229+6114	PSR	0.8^{p}	$\sim 10^{p}$	2.2×10^{37}	

Cao et al., 2021, Nature

Cosmic-ray propagation: γ-Cygni

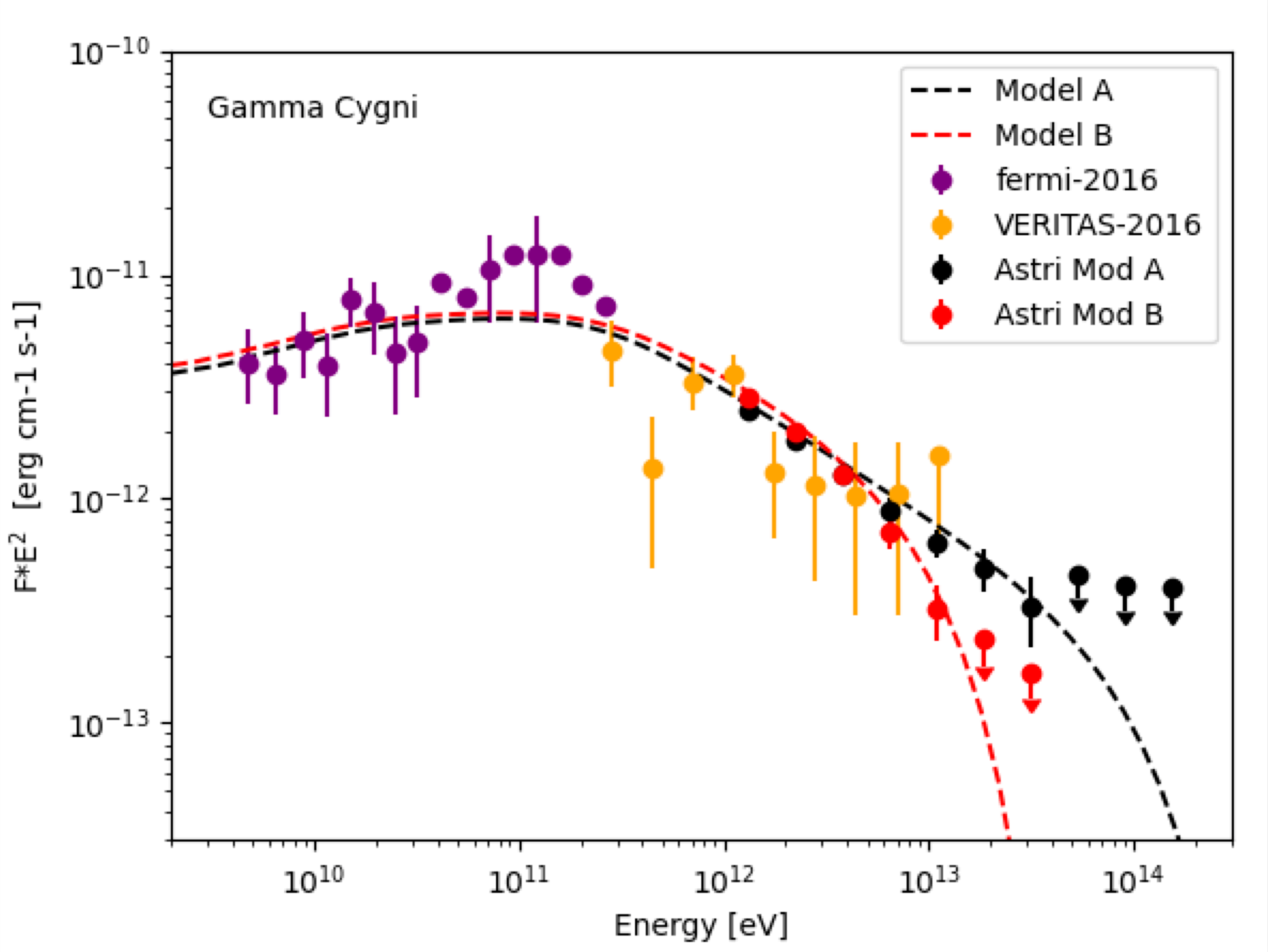
γ-Cygni (G78.2+2.1) is a middle-aged SNR located in the Cygnus region and discovered by VERITAS

HAWC observed this source, but HAWC's low angular resolution does not allow one to drive firm conclusion on the spatial structure

We simulated **2 possible spectral models** (A and B) fitting the combined Fermi-LAT and VERITAS data

The ASTRI Mini-Array will **constrain** some physical parameters such as the **maximum energy reached by protons** and the **diffusion coefficient**

Moreover, it will **investigate the VHE emission morphology**



Black and red dots show the ASTRI Mini-Array simulations for model A and B, respectively, for 200 hr of exposure

The Galactic Center – a challenge in a challenge

Mini-Array

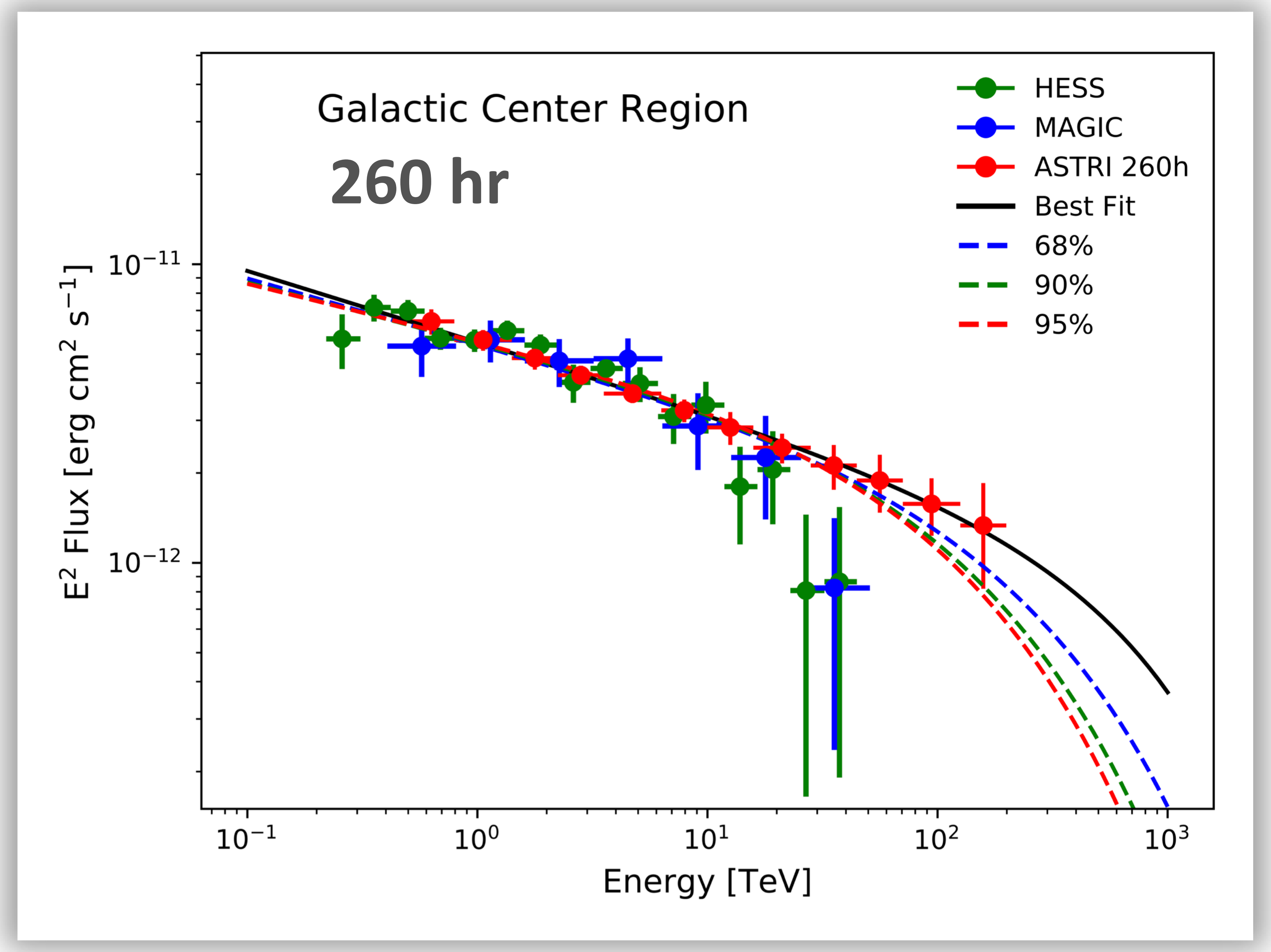
It is a complex region harbouring several potential sources of particle acceleration

It can be observed by the ASTRI Mini-Array only at high zenith angles

Current IACTs detected **non-variable emission with no significant cut-off up to a few tens of TeV**

ASTRI Mini-Array assets

- **the large FoV** will allow us to map the **whole GC region in a single observation**
- **the excellent angular resolution** could help us to **identify any HE source** among several candidates



Spatial and spectral characterization of the inner Galactic Ridge emission → (HESS Collab., 2018)

HESS, MAGIC and ASTRI spectra fitted with a proton population with a best fit cut-off at 120 PeV

Exclude a cut-off in proton pop. below 3.5 PeV, 2.0 PeV, and 1.7 PeV at 68%, 90%, and 95% C.L.

Tycho

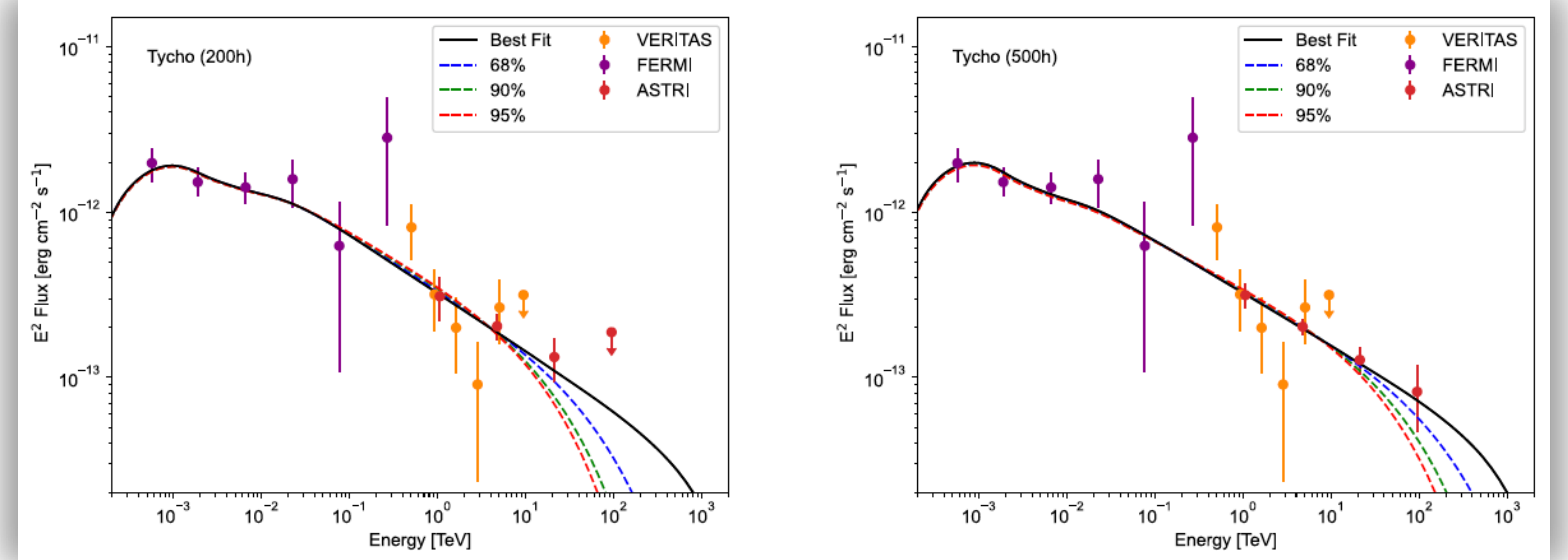
One of the youngest and best studied SNR

VERITAS data suggest a cut-off energy of ~10TeV but a larger value cannot be excluded due to the large error bars.

We modeled the source spectrum as a simple power law with an index of about 2.3, without a cut-off

The goal is to to constrain the γ-ray spectrum of the source taking into account the ASTRI Mini-Array data in combination with lower energy ones collected by Fermi-LAT and VERITAS

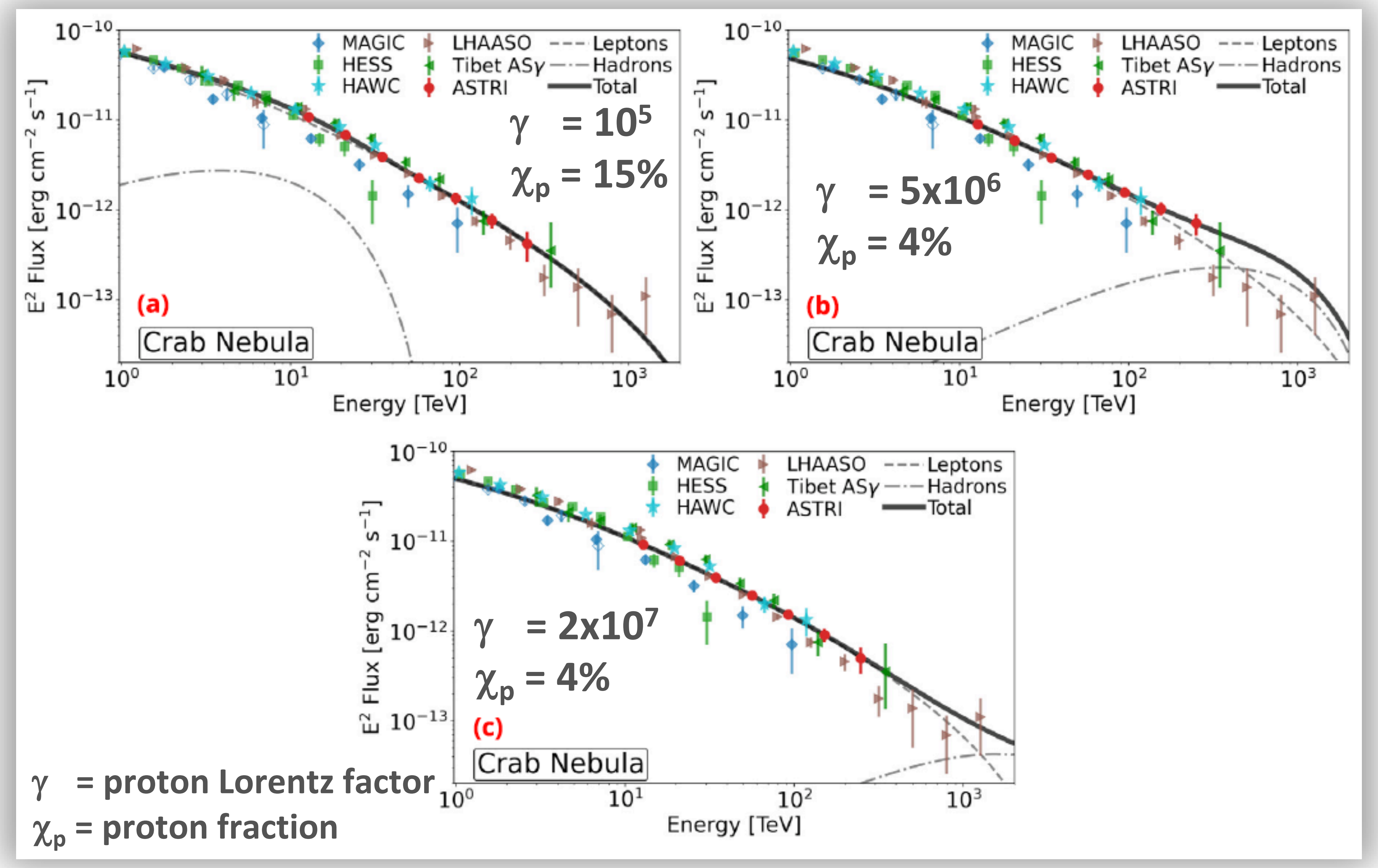
We used the *Naima* package to fit simultaneously Fermi-LAT and VERITAS observations with the ASTRI Mini-Array simulated data in a **purely hadronic scenario, produced by a proton population following a power law distribution with a high-energy cut-off.**



200hr sims → exclude a cut-off below 1.27 PeV, 0.41 PeV and 0.29 PeV at 68%, 90% and 95% confidence level, respectively

500hr sims → exclude a cut-off below 4 PeV and 0.9 PeV at 68% and 95% confidence level, respectively

The Crab – a leptonic PeVatron



The LHAASO data do not require a hadronic contribution, but cannot exclude it either.

As one can see from comparison of panel (b) and (c), **the ASTRI Mini-Array measurements in the 100-300 TeV range should definitely be able to provide constraints on the proton component**

Case (a)

- The hadronic component peaks below 10 TeV
- The leptonic component alone can very well reproduce the measurements by HAWC, Tibet AS-γ and LHAASO in the 1-400 TeV range

Case (b)

- In this case the over-all spectrum is compatible with the highest energy data point by Tibet AS-γ and LHAASO, while LHAASO measurements in the 0.2-0.9 PeV range are over-predicted

Case (c)

- In this case the model spectrum is compatible with all the available data. **All three plots highlight the excellent performance expected by the ASTRI Mini-Array (red symbols): the input spectrum is always recovered with very high accuracy with 500 hr of observations**

LIV + ALPs

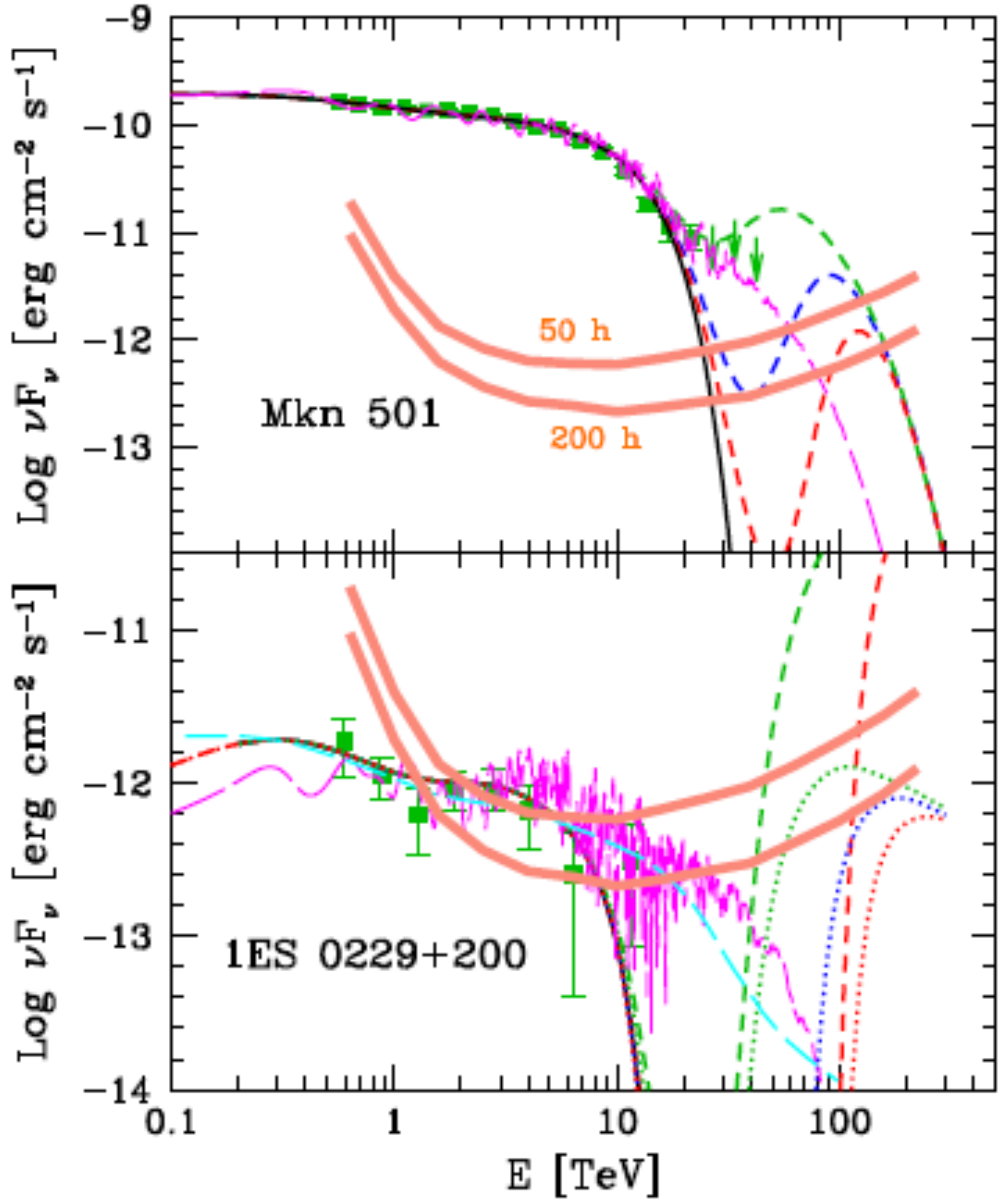


Fig. 32. Upper panel: VHE spectrum of Mkn 501 measured by HEGRA during the extreme outburst in 1997 (green triangles). The black solid curve reports an intrinsic cut-off power-law spectrum absorbed by interaction with EBL. The magenta long-dashed line shows the observed spectrum assuming mixing of photons with ALPs (from Galanti et al. 2020). The dashed curves report the observed spectrum assuming an intrinsic cut-off power-law spectrum and LIV occurring at different energy scales (from Tavecchio and Bonnoli 2016). Lower panel: as above for the case of 1ES 0229+200 (green symbols: data from HESS). For the LIV case we consider the intrinsic spectrum described by an unbroken (short dashed) or a broken (dotted) power law (see Tavecchio and Bonnoli 2016 for details). In both panels, the red thick lines show the expected sensitivity of the ASTRI Mini-Array for 50 hours and 200 hours of exposure.

Core Science and Observing Plan

ASTRI Mini-Array

Baseline

- About 1500 moonless hours/year at the Teide site
- Bad weather, maintanance, calibrations… → **~1000 hours/year for scientific observations**

Room for improvement

- ASTRI Mini-Array camera composed of SiPM, → **observations with a significant fraction of the Moon**, in addition to the 1000 hr/yr
- Main scientific goals focus on the multi-TeV energy band → we can **effectively perform observations at high (~60°) zenith angles**

Sources	Season	Dark hours
Galactic Center	May – June – July	300
VER J1907+062	September – October	300
G106.3+2.7	November – December	400

This example shows that we can observe **several sources per year** thanks to their different sky positions

We expect also **serendipitously detected sources**, thanks to the ASTRI Mini-Array wide field of view