Astrofisica gamma con AGILE

Carlotta Pittori (INAF-OAR)

on behalf of the AGILE Team

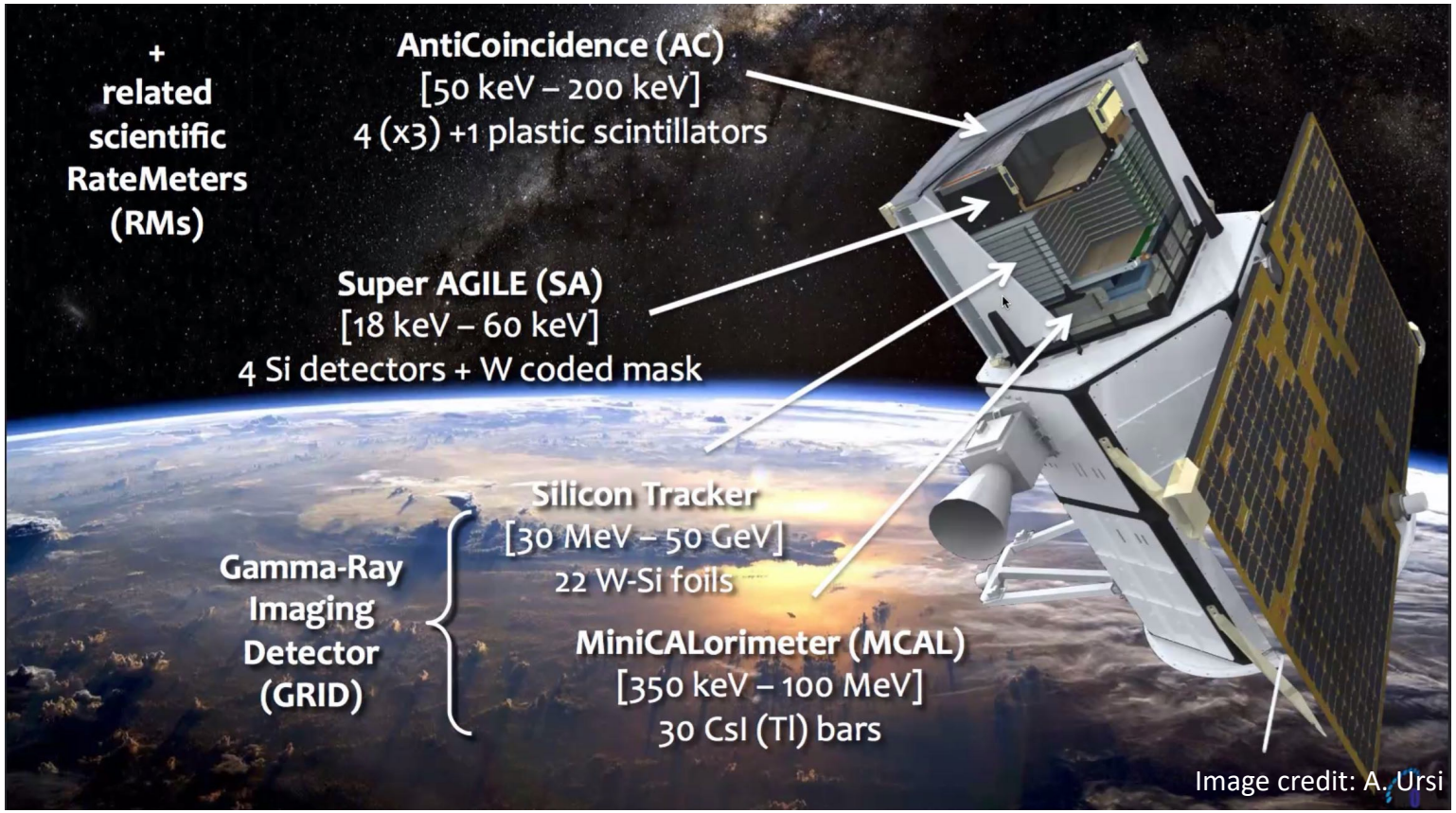
INAF Members:

antonio.addis;lucio.antonelli;andrea.argan;leonardo.baroncelli;andrea.bulgarelli;patrizia.caraveo;martina.cardillo;
claudio.casentini;enrico.costa;guido.dicocco;ambra.dipiano;ettore.delmonte;giuseppe.dipersio;marco.feroci;
valentina.fioretti;fabio.fuschino;fulvio.gianotti;andrea.giuliani;manuela.giusti;ulkar.karimova;claudio.labanti;
francesco.lazzarotto;fabrizio.lucarelli;martino.marisaldi;eloisa.menegoni;sandro.mereghetti;luigi.pacciani;
nicolo.parmiggiani;alberto.pellizzoni;giovanni.piano;maura.pilia;carlotta.pittori;marco.romani;paolo.soffitta;
marco.tavani;massimo.trifoglio;alessio.trois;alessandro.ursi;stefano.vercellone;francesco.verrecchia;valerio.vittorini

The AGILE Mission

- Italian Space Agency (ASI) Mission for the study of the Universe at high energy, with the participation of INAF, INFN, CNR, CIFS, Universities and the national space industry.
- **INAF leadership role**: PI Marco Tavani.

- AGILE unique combination of co-aligned hard X-ray and gamma-ray detectors.
- Launch: April 23, 2007 from India.
- Equatorial low Earth orbit: ~550 km, < 3 deg inclination angle



AGILE in its 15-th year of operations in space

- Gamma-ray detector (GRID): 50 MeV - 1 GeV
- Minicalorimeter (MCAL): 400 keV-100 MeV
- Super-AGILE X-ray detector: 18-60 keV
- Anticoincidence System (AC): 80-200 keV

Fully operational, nominal status, and active in:

- gamma-ray astrophysics
- terrestrial atmosph. & magnetosph. physics
- search of GW counterparts, neutrinos, Fast Radio Bursts and other transients

Scientific status of AGILE

- AGILE strongly affected by **limited ground operations at ASI Malindi** due to the **COVID-19 pandemic**: from March 2020 down to **3 orbits/day** (instead of 14).

- **Satellite nominal status: as of today,** almost nominal data flow from Malindi **(7 orbits/day) resumed since May 6, 2021**. **GRID back in observation**. (SuperAGILE still ratemeters only).

- In this difficult period (*far di necessità virtù)*: much improved RM analysis, automatic processing and burst identification.

- Several GRBs detected by MCAL with **automatic** GCN Notices.

- AGILE contribution to **Fast Radio Bursts** science: very important discovery on April 28, 2020 published in **Nature, Tavani et al. 2021** (2021NatAs...5..401T)

Scheda INAF progetto AGILE (1/3)

Team

- **Team INAF** triennio 2021-2022-2023: **partecipanti 32** di cui 24 TI (75%), 6 assegnisti e 2 ricercatori TD. FTE totali 24. **Associati 9**
- Stima FTE INAF complessive da inizio attività: ~150 di cui ~40 TI
- Stima FTE complessive includendo tutti i partners (ASI, INFN e Università) da inizio attività: ~250
- **Strutture coinvolte 9**: Direzione generale, Direzione scientifica, O. A. Roma, OAS Bologna, IAPS Roma, IASF Milano, O. A. Padova, O. A. Cagliari, O. A. Brera
- **Organizzazione**: PI AGILE: Marco Tavani; Responsabile Scientifico: Carlotta Pittori (da Nov 2020); Payload Manager: Andrea Argan; Sofware Manager: Andrea Bulgarelli. Il centro dati scientifico della missione (AGILE Data Center, coordinato da CP dal 2005) è parte del centro multi-missione ASI-SSDC.
- L' **AGILE Mission Board** (AMB) sovrintende a tutte le questioni scientifiche della Missione AGILE. ASI Mission Director: Fabio D'Amico, ASI (since 2015)

Scheda INAF progetto AGILE (2/3)

Fondi

L'attività relativa al programma AGILE è **cofinanziata tra ASI e INAF**. Il finanziamento ASI avviene tramite Accordi Attuativi nell'ambito dell'Accordo Quadro tra ASI e INAF. La stima dei fondi fino al 2020 parte dall'anno 2012 (ma satellite in orbita dal 2007). **Accordo in essere** è il n. I/028/12/0 "AGILE Attività Scientifiche – Estensione fase operativa e post operativa", dell'ottobre 2012. Ad ottobre 2020 è stato firmato **l'Addendum n.6** (I/028/12.6-2020) di 24 mesi (**scadenza ottobre 2022**) che prevede un finanziamento per INAF pari a circa **370 kEuro** (responsabile ASI Elisabetta Cavazzuti).

Programmazione

La missione AGILE è attualmente in fase operativa estesa E2. Lo status del satellite è nominale. Con l'accordo dell'AGILE Mission Board (AMB), le operazioni sono attualmente finanziate da ASI fino (almeno) a fine Maggio 2022. Si prevede estensione ulteriore. Al termine della fase operativa si prevede una estesa fase scientifica post-operativa.

Scheda INAF progetto AGILE (3/3)

Linee di ricerca

High energy astrophysics; Observational astronomy; Active galactic nuclei; Galactic and extragalactic astronomy; Black Holes; Neutron Stars; Magnetars; Burst astrophysics; Transient sources; Fast Radio Bursts; Plasma Astrophysics; Gravitational wave sources; Neutrino astronomy, Astrophysical processes; Terrestrial Gamma-ray Flashes; Solar flares.

Infrastrutture coinvolte

ASI-SSDC; SRT; CROCE de NORD; SUNDISH; WEBT; REM; ESO-VLT.

Schede collegate

Le linee di ricerca e i campi di azione di AGILE sono connesse a quelle di: CTA; ASTRI; Fermi; INTEGRAL; Swift; Chandra; XMM; Konus/WIND; e delle seguenti **Schede INAF**: GAMMA2 (PI Vercellone); Blazar (PI Vittorini); CRAB (PI Vittorini); Plasmi (PI Vittorini); FRB_Italy (PI Possenti); GAMMA-FLASH (PI Fuschino); GRAPHJC (PI Stamerra); SSDC (PI Perri), RTA (PI Bulgarelli).

Risultati AGILE: summary

- **Pubblicazioni:** La produzione scientifica del Team AGILE consiste in **> 790 rif. bibliografici** in ADS di cui **> 160 articoli con referee**.
- Il **monitoraggio** del cielo gamma con un sistema di allerta rapido ed efficiente ha portato alla pubblicazione di **224 ATel e 97 GCN**. Da Maggio 2019 sono anche attive le **Notice automatiche** su trigger di MCAL.
- Il **sistema SW di Quick Look** (RTA) sviluppato dall'INAF-OAS, distribuito tra il centro dati a SSDC e l'INAF-OAS di Bologna, produce risultati scientifici entro **~ 25 min dal downlink** dei dati alla stazione di Terra ASI Malindi: un record assoluto per l'astrofisica gamma. Il Team ha anche sviluppato una App per monitorare e seguire le osservazioni del satellite AGILE su mobile devices: **AGILEScience – Apps** su Google Play e App Store.
- **AGILE e la ricerca di controparti alle GW**: partecipazione su base volontaria dei membri del Team con turni 24h/7gg durante i run osservativi LIGO-VIRGO. Follow-up AGILE di tutti gli eventi GW con **96 GCN di tipo GW-AGILE** pubblicate e raccolte in una pagina web dedicata in SSDC: *https://agile.ssdc.asi.it/news_gw.html*.

AGILE and GW

- AGILE **unique** combination of two co-aligned X-ray and γ-ray imaging detectors. Excellent for GW counterpart search.
- GRID very large field of view (2.5 sr)
- Spinning observation mode: 200 passes/day over more than 80% of the sky (solar panel constraints).
- **Sensitivity ~ (1-2) 10^{-8} erg cm^{-2} s^{-1} in 100 sec.**
- Also two non-imaging detectors (**4 π**): MCAL (0.3 - 100 MeV), AC (50 keV - 10 MeV)
- GRB – like searches, MCAL, AC, RM

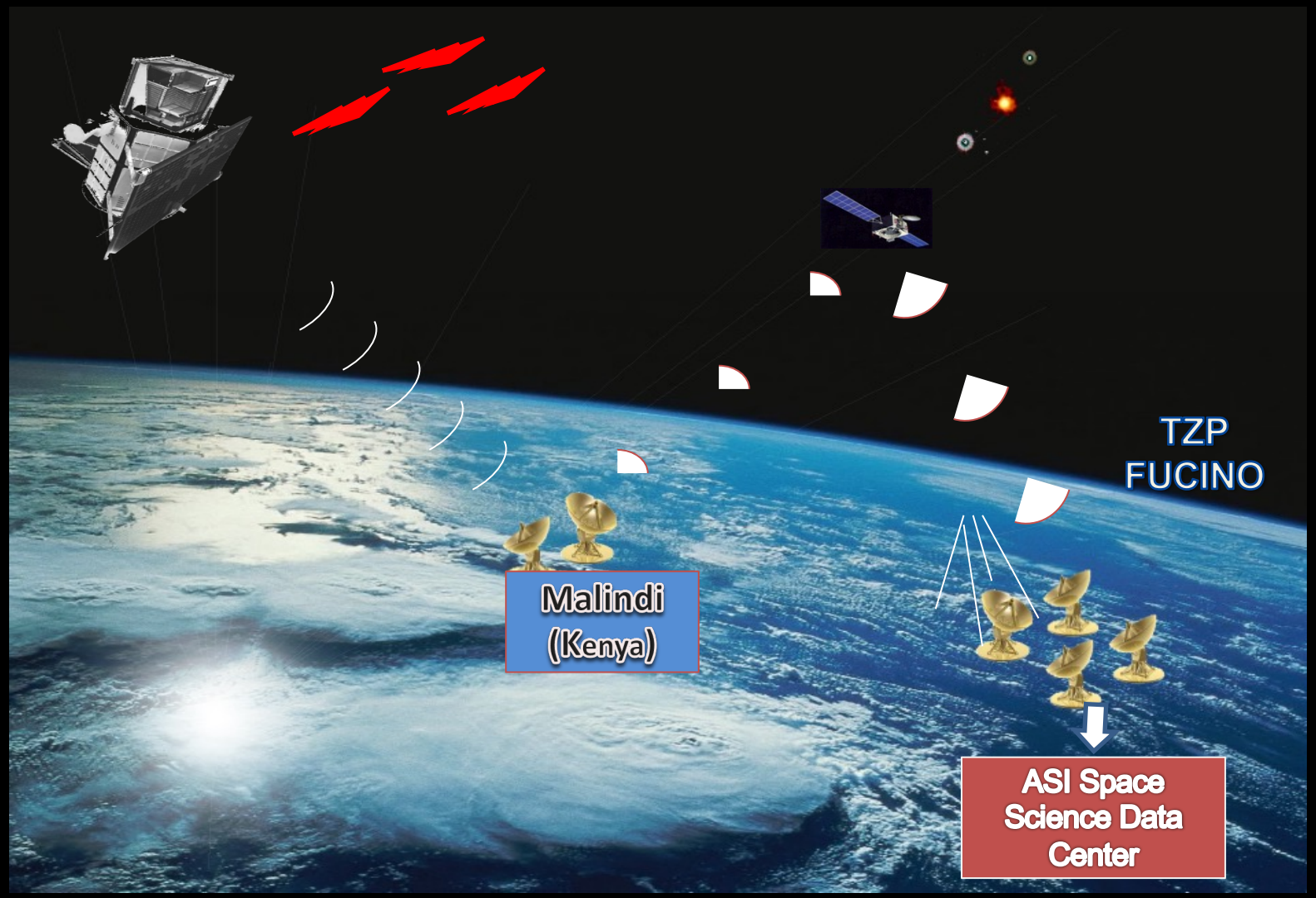
Springer Link

A Decade of AGILE | Published: 05 November 2019

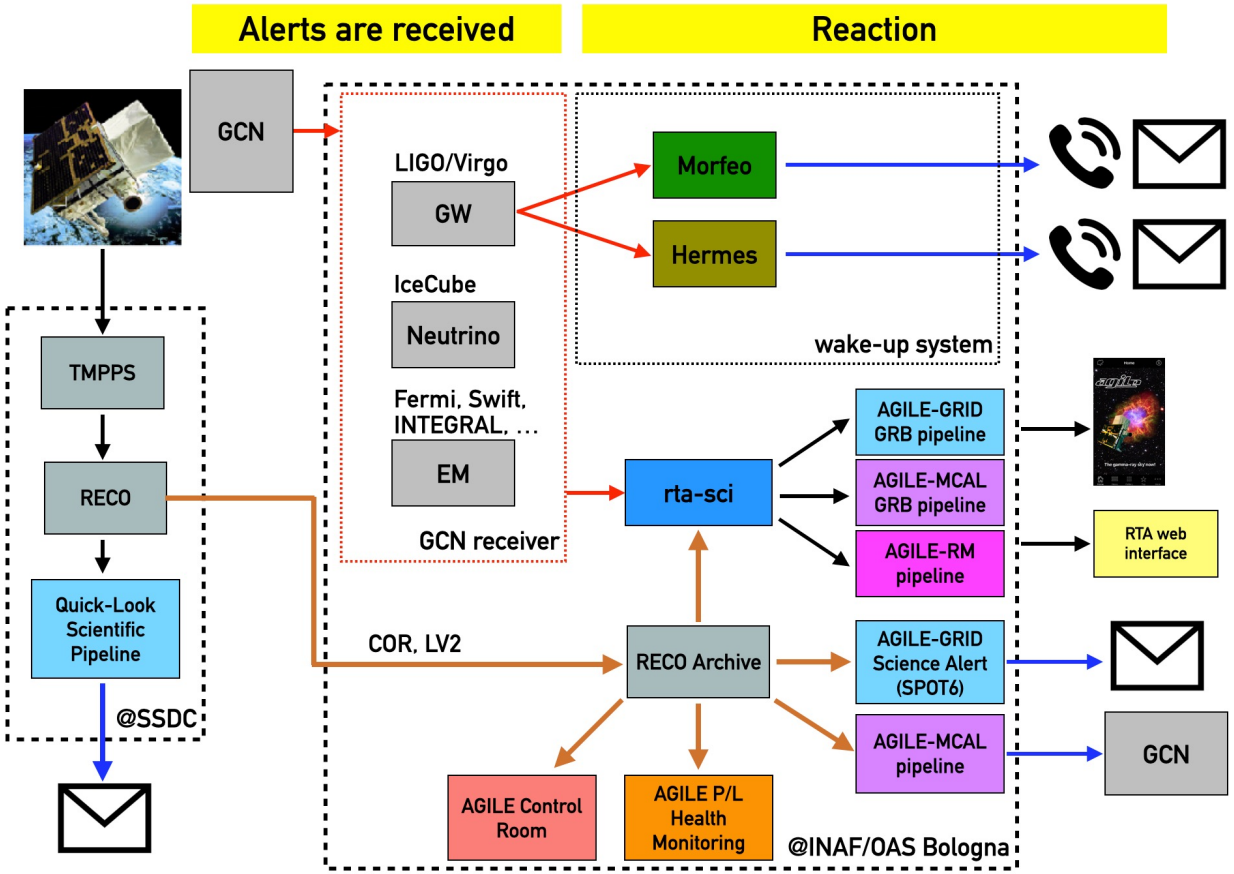
AGILE search for gamma-ray counterparts of gravitational wave events

Francesco Verrecchia, Marco Tavani, Andrea Bulgarelli, Martina Cardillo, Claudio Casentini, Immacolata Donnarumma, Francesco Longo, Fabrizio Lucarelli, Nicoló Parmiggiani, Giovanni Piano, Maura Pilia, Carlotta Pittori, Alessandro Ursi the AGILE Team

Rendiconti Lincei. Scienze Fisiche e Naturali **30**, 71–77(2019) | Cite this article


TZP
FUCINO
Malindi
(Kenya)
ASI Space
Science Data
Center

AGILE Real-Time Analysis



- Analisi automatica dei dati di AGILE (GRID, MCAL, ratemeters)
- Reazione ad allerte esterne (GCN, e.g. GRB/GW)
- Generazione automatica di allerte (via email, SMS) e, per MCAL, connessione diretta con il GCN network
- La scheda RTA (PI A. Bulgarelli) riassume lo sviluppo di pipeline simili (a partire da quella di AGILE) per CTA, COSI, Gamma-FLASH.

Tesi di dottorato Nicolò Parmiggiani: PHD IN COMPUTER ENGINEERING AND SCIENCE "Analysis methods and data management for real-time gamma-ray astrophysics" (2021)

Produzione scientifica e tecnologica

22. Produzione scientifica e tecnologica - Highlights

#	DOI	Descrizione
1	10.1051/0004-6361/200810527	Titolo: The AGILE Mission Autori:M. Tavani and G. Barbiellini and A. Argan and F. Boffelli and A. Bulgarelli and P. Caraveo and P. W .... Publisher:EDP Sciences Rivista: Astronomy \& Astrophysics Anno pubblicazione:2009
2	10.1126/science.1200083	Titolo: Discovery of Powerful Gamma-Ray Flares from the Crab Nebula Autori:M. Tavani and A. Bulgarelli and V. Vittorini and A. Pellizzoni and E. Striani and P. Caraveo and M. .... Publisher:American Association for the Advancement of Science (AAAS) Rivista: Science Anno pubblicazione:2011
3	10.1038/nature08578	Titolo: Extreme particle acceleration in the microquasar Cygnus\hspace0.167emX-3 Autori:M. Tavani and A. Bulgarelli and G. Piano and S. Sabatini and E. Striani and Y. Evangelista and A. T .... Publisher:Springer Science and Business Media LLC Rivista: Nature Anno pubblicazione:2009
4	10.1088/2041-8205/742/2/L30	Titolo: NEUTRAL PION EMISSION FROM ACCELERATED PROTONS IN THE SUPERNOVA REMNANT W44 Autori:A. Giuliani and M. Cardillo and M. Tavani and Y. Fukui and S. Yoshiike and K. Torii and G. Dubner a .... Publisher:American Astronomical Society Rivista: The Astrophysical Journal Anno pubblicazione:2011
5	10.1103/PhysRevLett.106.018501	Titolo: Terrestrial Gamma-Ray Flashes as Powerful Particle Accelerators Autori:M. Tavani and M. Marisaldi and C. Labanti and F. Fuschino and A. Argan and A. Trois and P. Giommi a .... Publisher:American Physical Society (APS) Rivista: Physical Review Letters Anno pubblicazione:2011
6	10.1029/2009JA014502	Titolo: Detection of terrestrial gamma ray flashes up to 40 MeV by the AGILE satellite Autori:M. Marisaldi and F. Fuschino and C. Labanti and M. Galli and F. Longo and E. Del Monte and G. Barbi .... Publisher:American Geophysical Union (AGU) Rivista: Journal of Geophysical Research: Space Physics Anno pubblicazione:2010
7	10.1016/j.nima.2007.07.147	Titolo: SuperAGILE: The hard X-ray imager for the AGILE space mission Autori:M. Feroci and E. Costa and P. Soffitta and E. Del Monte and G. Di Persio and I. Donnarumma and Y. E .... Publisher:Elsevier BV Rivista: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment Anno pubblicazione:2007
8	10.1051/0004-6361/200911783	Titolo: First AGILE catalog of high-confidence gamma-ray sources Autori:C. Pittori and F. Verrecchia and A. W. Chen and A. Bulgarelli and A. Pellizzoni and A. Giuliani and .... Publisher:EDP Sciences Rivista: Astronomy \& Astrophysics Anno pubblicazione:2009
9	10.1088/2041-8205/710/2/L151	Titolo: DIRECT EVIDENCE FOR HADRONIC COSMIC-RAY ACCELERATION IN THE SUPERNOVA REMNANT IC 443 Autori:M. Tavani and A. Giuliani and A. W. Chen and A. Argan and G. Barbiellini and A. Bulgarelli and P. C .... Publisher:American Astronomical Society Rivista: The Astrophysical Journal Anno pubblicazione:2010
10	10.1088/0004-637X/691/1/L13	Titolo: THE JUNE 2008 FLARE OF MARKARIAN 421 FROM OPTICAL TO TeV ENERGIES Autori:I. Donnarumma and V. Vittorini and S. Vercellone and E. Del Monte and M. Feroci and F. D\textquote .... Publisher:American Astronomical Society Rivista: The Astrophysical Journal Anno pubblicazione:2008

The AGILE Mission

Cyg X-3 mQSO flares, *Nature*

CR acceleration in SNR W44

TGFs as powerful p.cle accelerators

HE TGFs seen by AGILE-MCAL

SuperAGILE X-ray Imager on AGILE

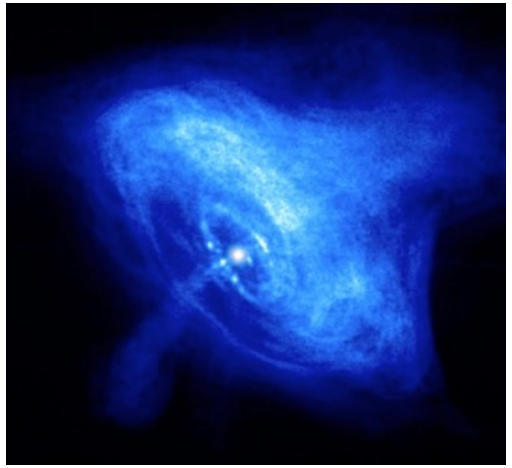
The 1AGL Catalog

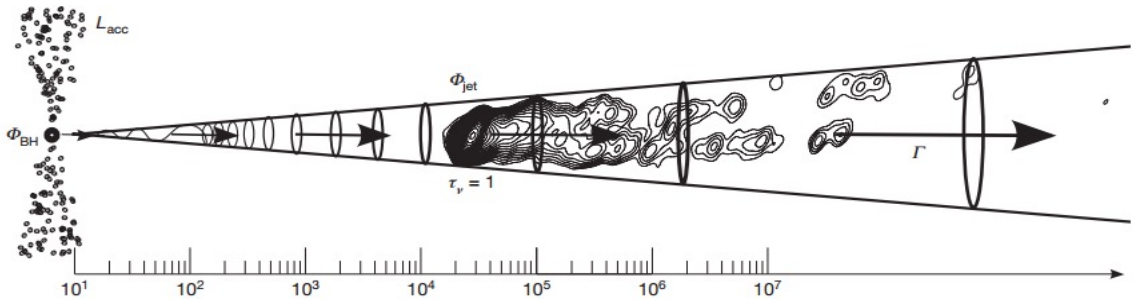
CR acceleration in SNR IC443

MWL analysis of flaring blazar Mrk 421

AGILE lessons:

- Large Field of View (~ 60 deg) HE sky monitoring: fast and intense variability discovered at all scales.
- Extragalactic, Galactic and even Terrestrial physics
- New acceleration mechanisms
- Role of local magnetic field enhancements
- Plasma instabilities





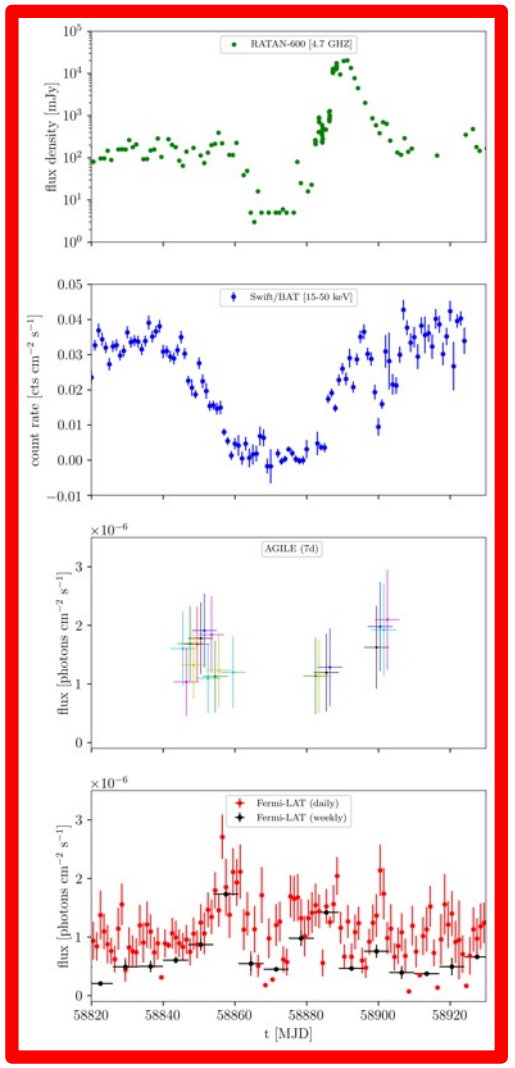
AGILE monitoring of Cygnus X-3 during the quenched states

(G. Piano et al., *in preparation*)

- Transient gamma-ray emission from Cygnus X-3 is observed around the quenched states of the microquasar
- Quenched state: low (or undetectable) hard X-ray and radio emissions, strong soft X-ray flux
- Quenched states usually precede giant radio flares (> 10 Jy)

- ➢ AGILE monitoring of Cygnus X-3 around the quenched states (2016-2020): transient emission on 2d and 7d time scales
- ➢ Multi-wavelength context
- ➢ Phenomenology of the transient jet in a “hypersoft state”: extreme particle acceleration in the jet

December 2019 – March 2020

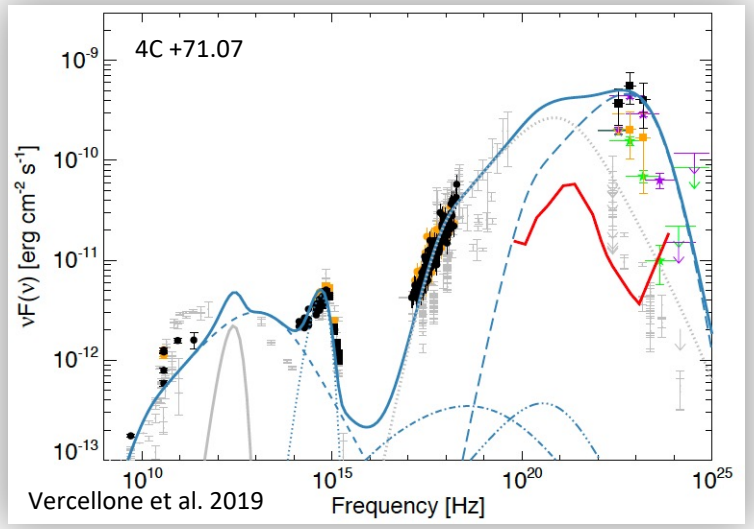


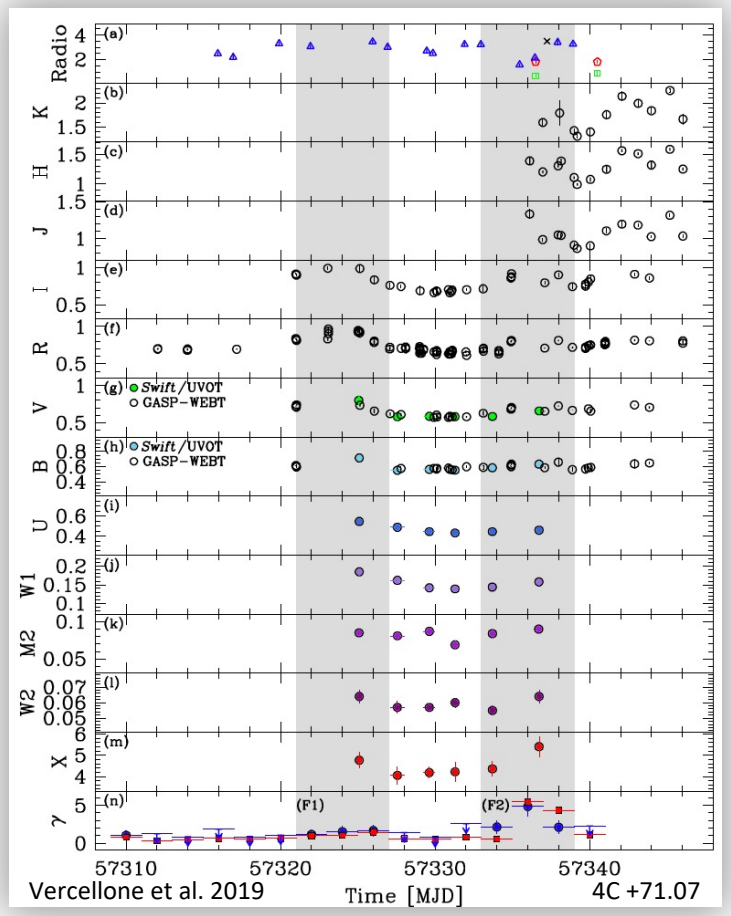
AGILE e lo studio dei nuclei galattici attivi (AGN) – stato attuale

Per riferimento, vedere la scheda: ***GAMMA2 – Coordinatore: Stefano Vercellone***
«Gamma-ray And Multi-wavelength Monitoring of AGNs with AGILE»

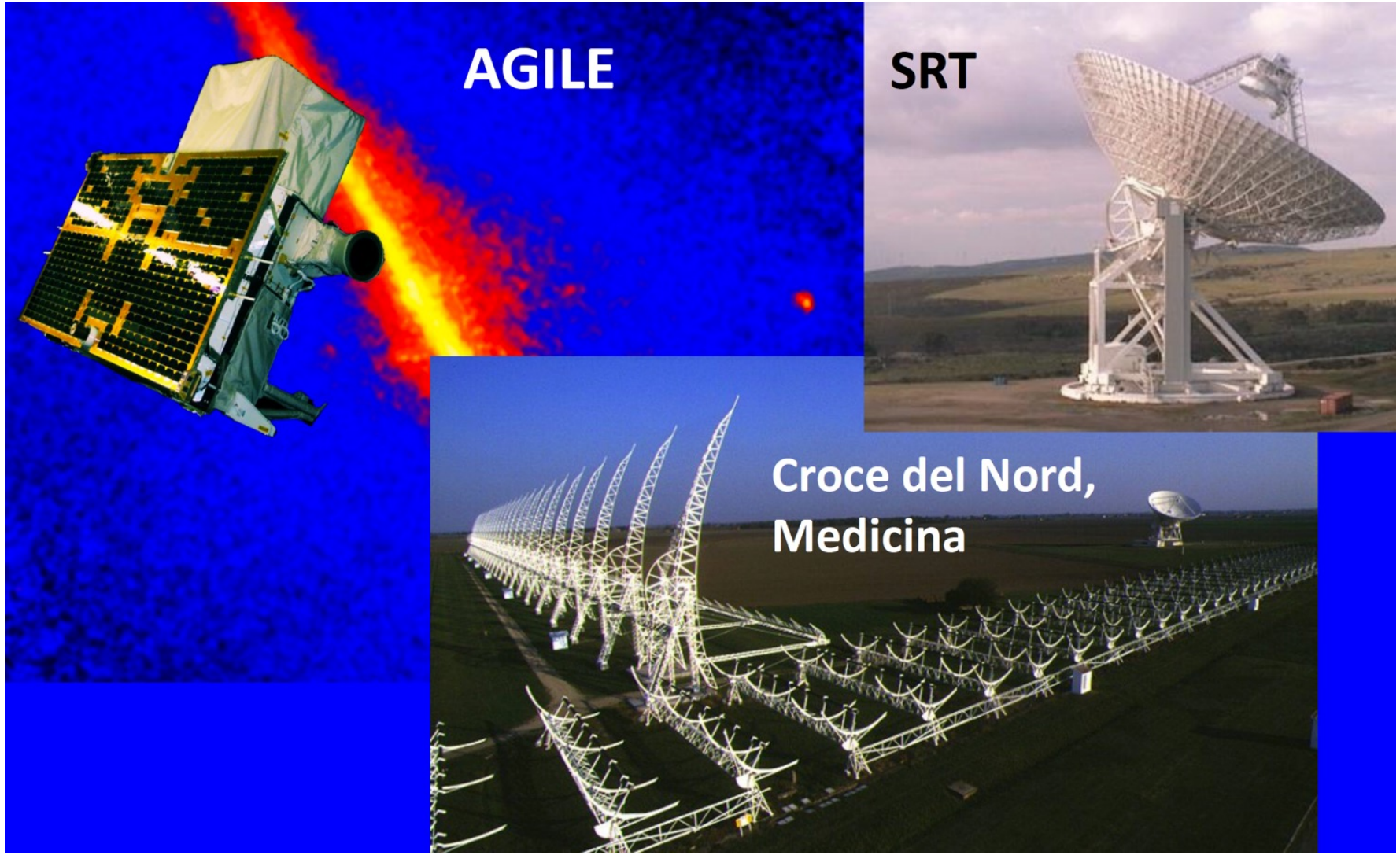
Dal lancio, sono stati pubblicati **più di 40 articoli scientifici** su riviste referate con tema gli AGN osservati da AGILE.

La maggior parte di questi articoli riguarda **osservazioni multifrequenza con dati quasi simultanei** ottenuti grazie a programmi congiunti con altre facility.





Campagne di monitoraggio su specifici FRB repeaters e SGR



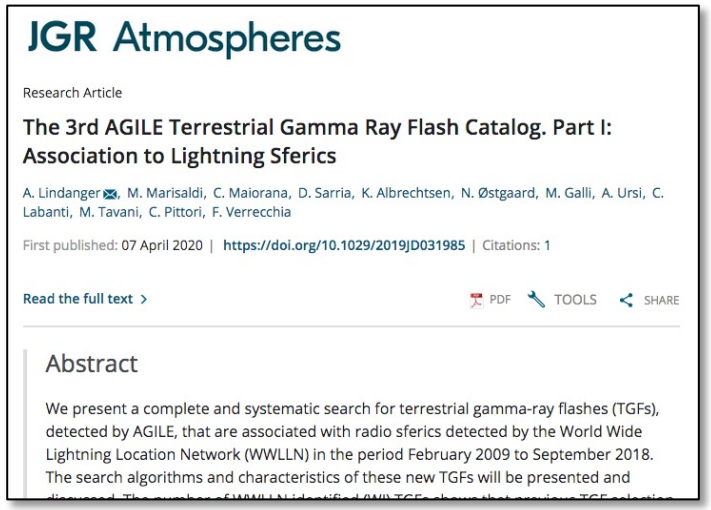
AGILE FRB studies

Present status

Paper	Production	Sign in	Sub.	Sub. to	Revision 1	Revision 2	Accepted for publication	Published
Casentini et al.	✓	✓	✓	*ApJL*	✓	✓	✓	✓
Tavani et al.	✓	✓	✓	*ApJL*	✓	✓	✓	✓
Pilia et al. (SRT coll. paper)	✓	✓	✓	*ApJL*	✓	✓	✓	✓
Tavani et al.	✓	✓	✓	*Nature astronomy*	✓	✓	✓	✓
Verrecchia et al.	✓	✓	✓	*ApJ*	✓	-	✓	-

4 papers published, the last one on Nature Astronomy: "**An X-ray burst from a magnetar enlightening the mechanism of fast radio bursts",** Tavani et al. about SGR1935+2154 X-ray/radio flare; 5° is accepted for publication on ApJ.

3rd AGILE TGF Catalog



JGR Atmospheres

Research Article

The 3rd AGILE Terrestrial Gamma Ray Flash Catalog. Part I: Association to Lightning Sferics

A. Lindanger, M. Marisaldi, C. Maiorana, D. Sarria, K. Albrechtsen, N. Østgaard, M. Galli, A. Ursi, C. Labanti, M. Tavani, C. Pittori, F. Verrecchia

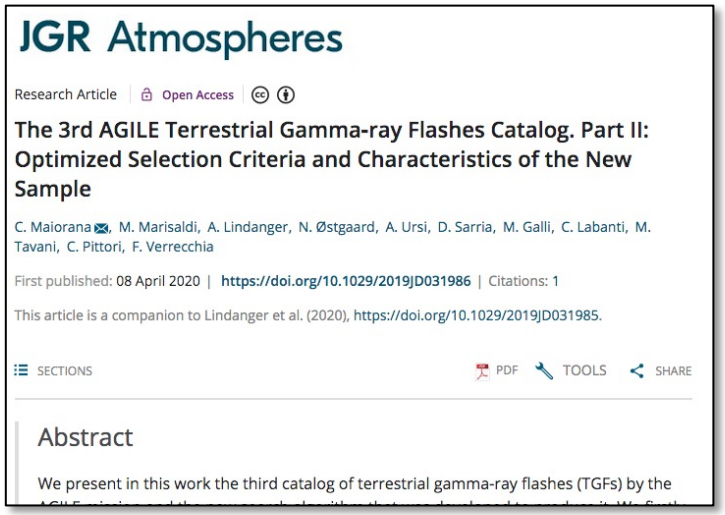
First published: 07 April 2020 | https://doi.org/10.1029/2019JD031985 | Citations: 1

Read the full text › PDF TOOLS SHARE

Abstract

We present a complete and systematic search for terrestrial gamma-ray flashes (TGFs), detected by AGILE, that are associated with radio sferics detected by the World Wide Lightning Location Network (WWLLN) in the period February 2009 to September 2018. The search algorithms and characteristics of these new TGFs will be presented and

***Lindanger, Marisaldi et al.*, 2020, JGR (Atmospheres)**



JGR Atmospheres

Research Article | Open Access

The 3rd AGILE Terrestrial Gamma-ray Flashes Catalog. Part II: Optimized Selection Criteria and Characteristics of the New Sample

C. Maiorana, M. Marisaldi, A. Lindanger, N. Østgaard, A. Ursi, D. Sarria, M. Galli, C. Labanti, M. Tavani, C. Pittori, F. Verrecchia

First published: 08 April 2020 | https://doi.org/10.1029/2019JD031986 | Citations: 1

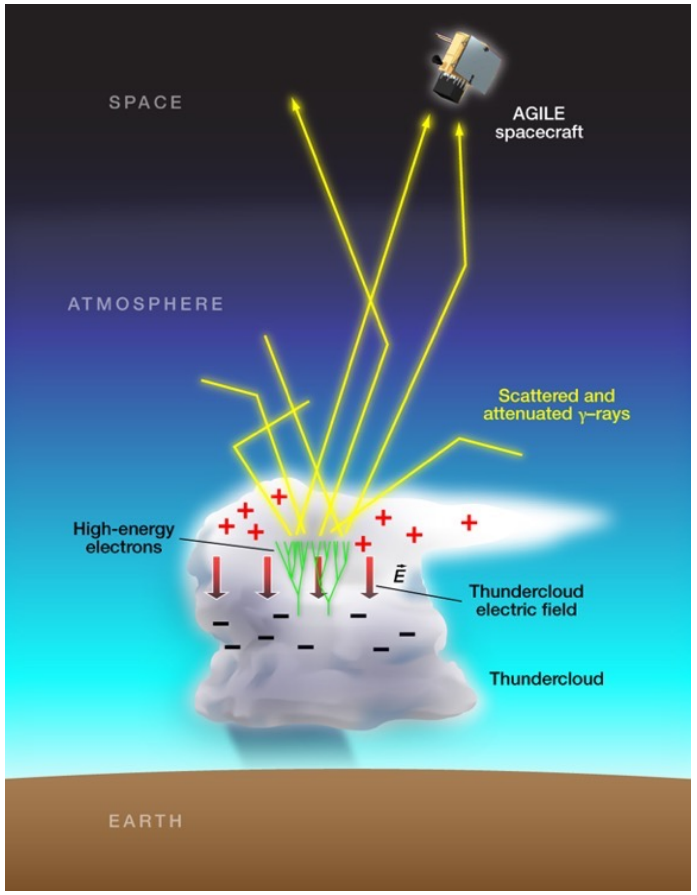
This article is a companion to Lindanger et al. (2020), https://doi.org/10.1029/2019JD031985.

SECTIONS PDF TOOLS SHARE

Abstract

We present in this work the third catalog of terrestrial gamma-ray flashes (TGFs) by the

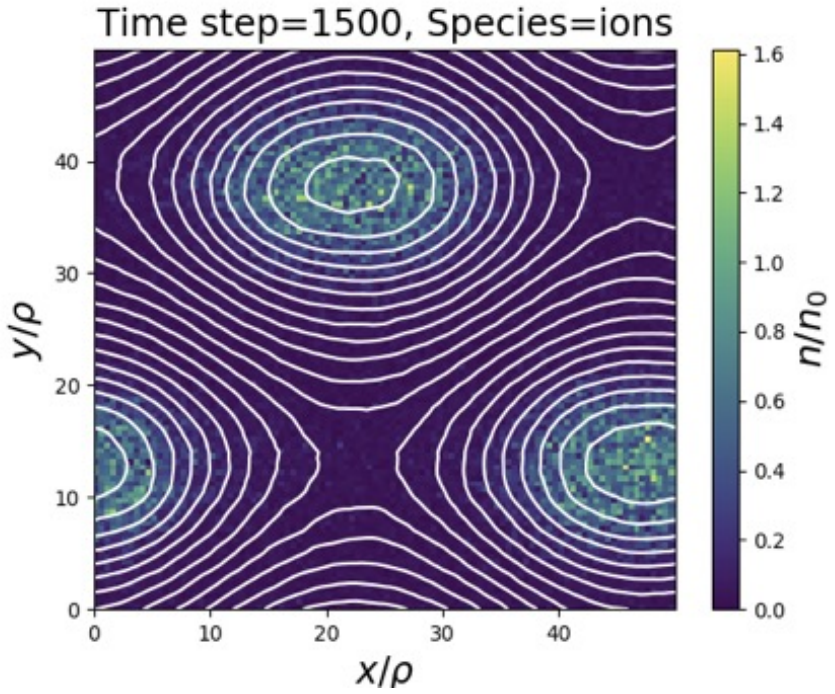
***Maiorana, Marisaldi et al.*, 2020, JGR (Atmospheres)**



Original sample: 2780 events, recently updated to include all events associated with lightning sferics up to October 31, 2020

Interactive SSDC webpage: *https://www.ssdc.asi.it/mcal3tgfcat/*

Scientific Use Case: Magnetic Reconnection



Magnetic Reconnection, especially in the relativistic regime, provides an efficient mechanism for accelerating relativistic particles and thus offers an attractive physical explanation for nonthermal high-energy emission from various astrophysical sources.
Magnetic Reconnection is a **topological rearrangement of magnetic field** that converts magnetic energy to plasma energy.

The Magnetic Reconnection process is is arousing the interest of high energy astrophysicists as it is an excellent candidate for producing the rapid acceleration of charges even up to extreme energies, a process necessary for the γ emission of some sources such as pulsar wind nebulae and blazars.
Our team is working in collaboration with ENEA's Proto-Sphera experiment in order to simulate this phenomenon inside the plasma.

Vedere anche scheda Plasmi (PI Vittorini)

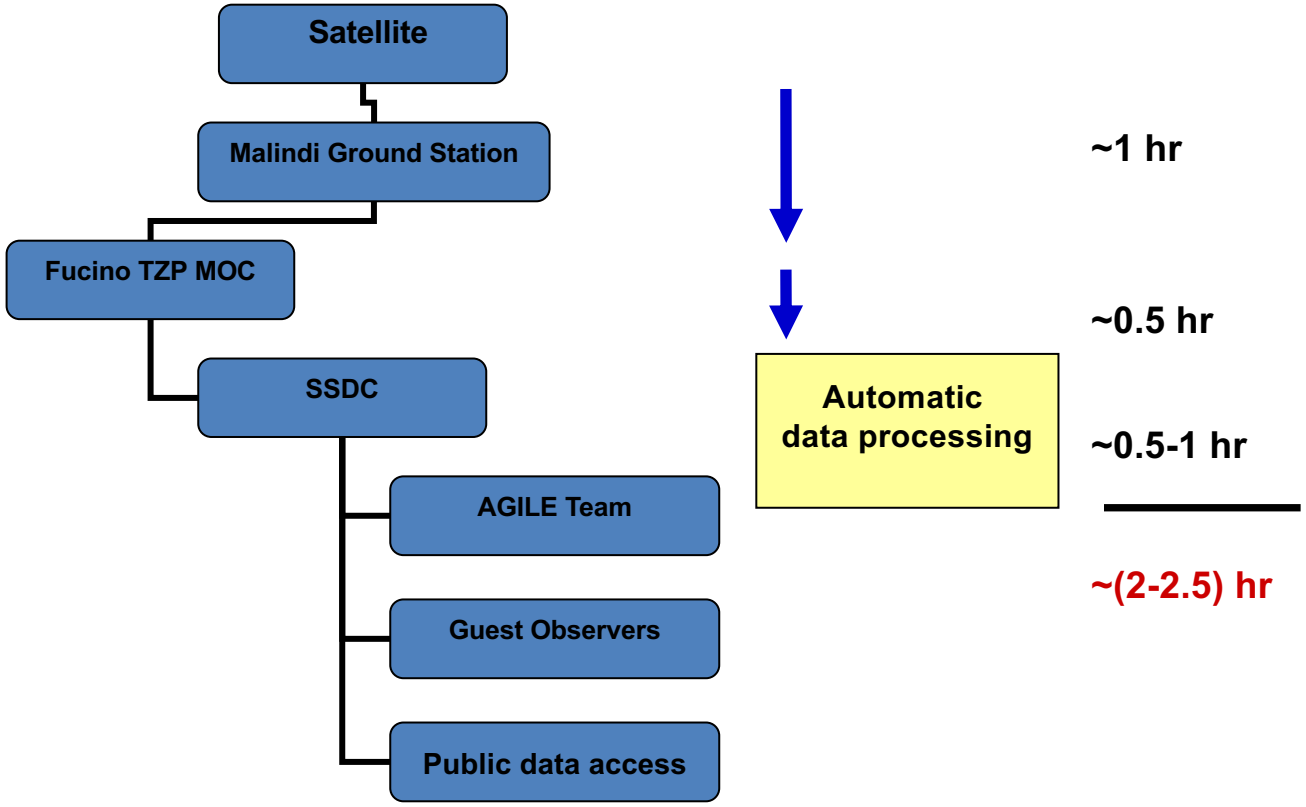
Conclusions: THE AGILE SKY SCANNING GOES ON

- ***Fully integrated in a network of multi-frequency and multi-messengers observers from ground and space***
- ***Enhanced detection capabilities for transients: GW and neutrino follow-up, short and long GRB detection, FRBs***
- ***AGILE plays a crucial role in TFG and Solar science***
- ***The success of scientific observations relies on the great collaboration between ASI, industry and scientific Team***
- ***ASI Malindi orbit-by-orbit transmission (14 orbits/days) needed for 100% efficiency.***

BACKUP slides

Main scientific and technological results

AGILE: “very fast” Ground Segment



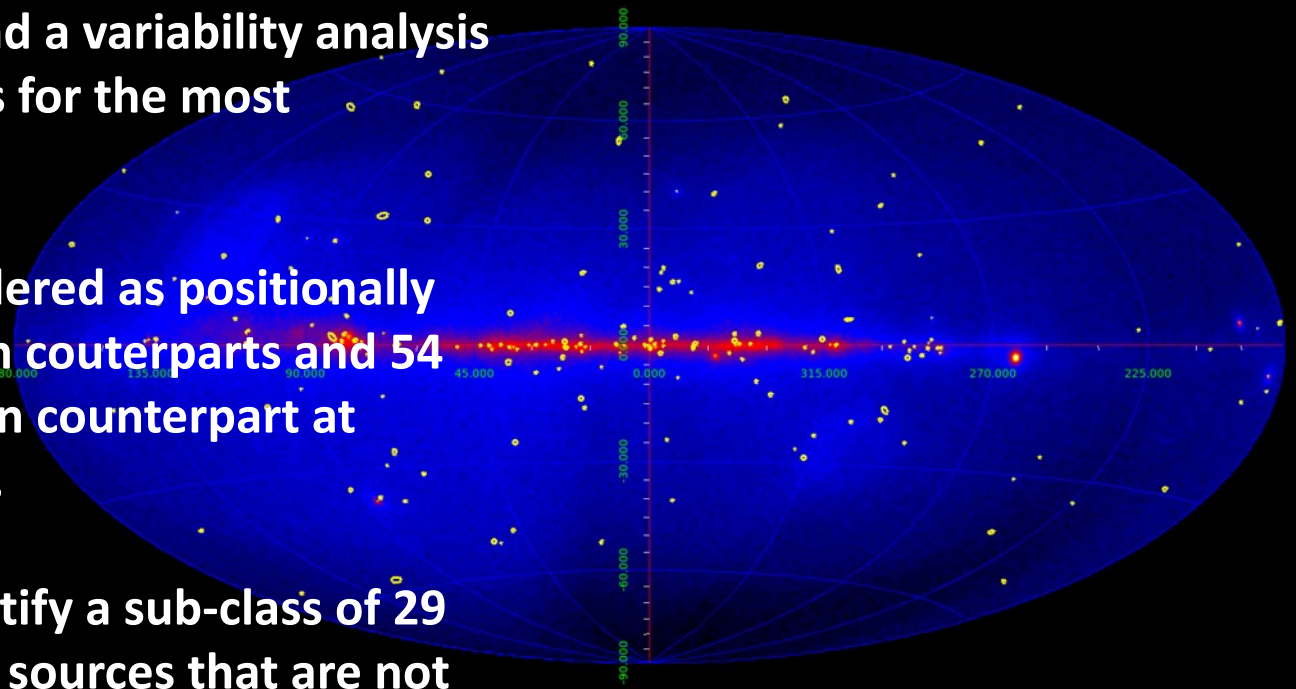
Now even faster: ˜25 min latency. Optimized for GW counterpart hunt.

Record for a gamma-ray mission! App AGILEScience for mobile dev

- The 2AGL Catalog is based on the first 2.3 years of AGILE science data (pointing mode)

- 175 high-confidence sources (above 4σ) with spectral properties, and a variability analysis with 4-day light curves for the most significant ones.

- 121 sources are considered as positionally associated with known couterparts and 54 sources have no known counterpart at different wavelengths.



- Among these, we identify a sub-class of 29 AGILE-GRID-only γ-ray sources that are not present in previous Femi-LAt Catalogs 1FGL, 2FGL or 3FGL.

- In the paper an extension of the analysis of 2AGL sources detected in the 50 -- 100 MeV energy range is also presented.

AGILE GRB and fast transients

- **Many Gamma-ray bursts and other transients** detected by AGILE and published as **GCN Circulars**
- **MCAL automatic alerts (Notices):** AGILE MCAL TRIGGER from https://gcn.gsfc.nasa.gov/agile_mcal.html
- **2° MCAL GRB Catalog** *in progress* (A. Ursi et al.)
- **AGILE e il GRB 190114C: breakthrough** GRB visto per la prima volta anche alle energie del TeV *(Magic Coll. et al., I*

THE ASTROPHYSICAL JOURNAL

AGILE and Konus-Wind Observations of GRB 190114C: The Remarkable Prompt and Early Afterglow Phases

A. Ursi[1], M. Tavani[1,2], D. D. Frederiks[3], M. Romani[2], F. Verrecchia[4,5], M. Marisaldi[6,7], R. L. Aptekar[3], L. A. Antonelli[5], A. Argan[1], A. Bulgarelli[7] + Show full author list

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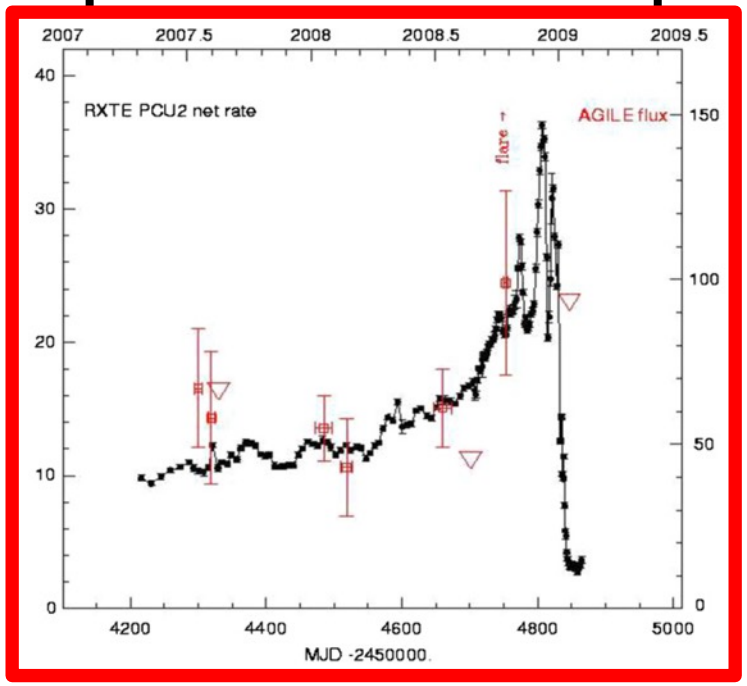
The Astrophysical Journal, Volume 904, Number 2

AGILE and gamma-ray binaries

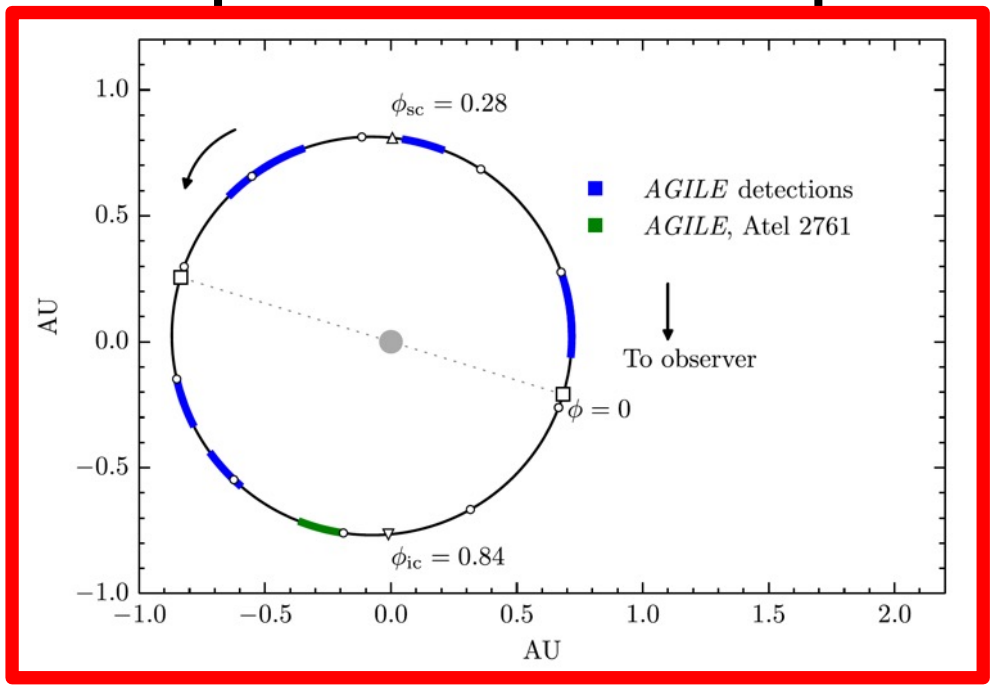
Gamma-ray binaries detected by AGILE

(from G. Piano, Review, Rendiconti Lincei – March 2019)

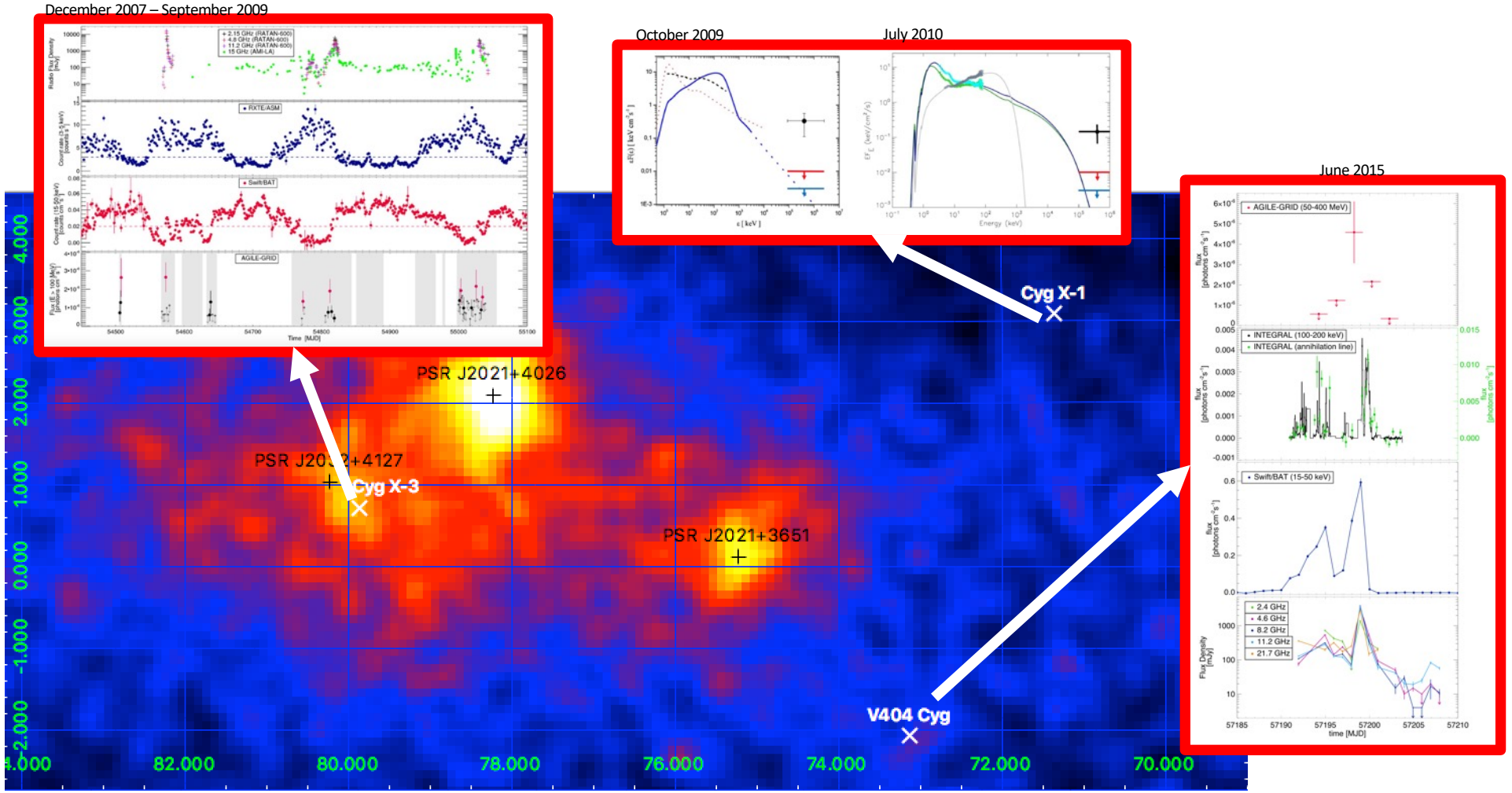
Eta Carinae
(July 2007 – October 2008)



AGL J2241+4454 (MWC 656)
November 2007 – July 2013



Microquasars of the Cygnus region: Cygnus X-1, Cygnus X-1, V404 Cygni



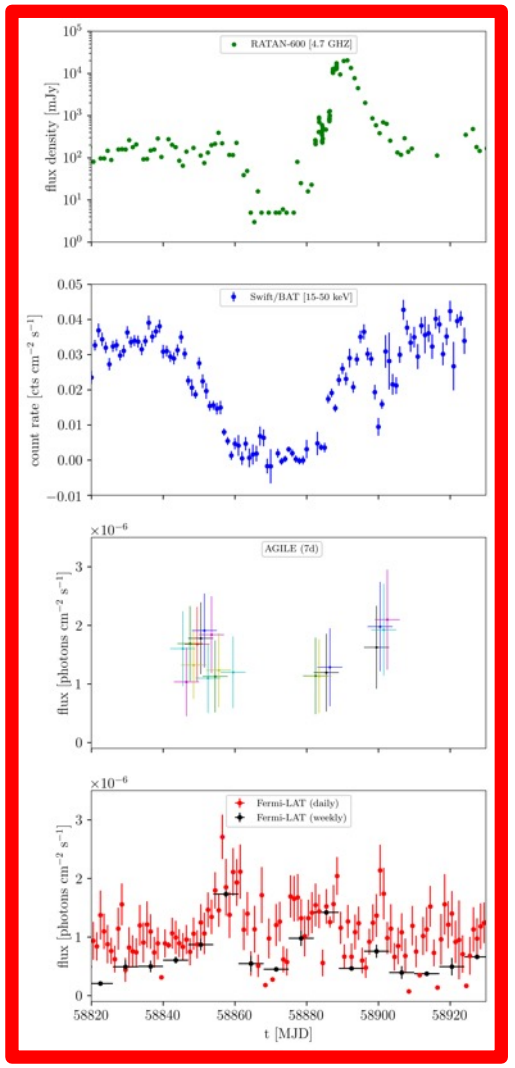
AGILE monitoring of Cygnus X-3 during the quenched states

(G. Piano et al., *in preparation*)

- Transient gamma-ray emission from Cygnus X-3 is observed around the quenched states of the microquasar
- Quenched state: low (or undetectable) hard X-ray and radio emissions, strong soft X-ray flux
- Quenched states usually precede giant radio flares (> 10 Jy)

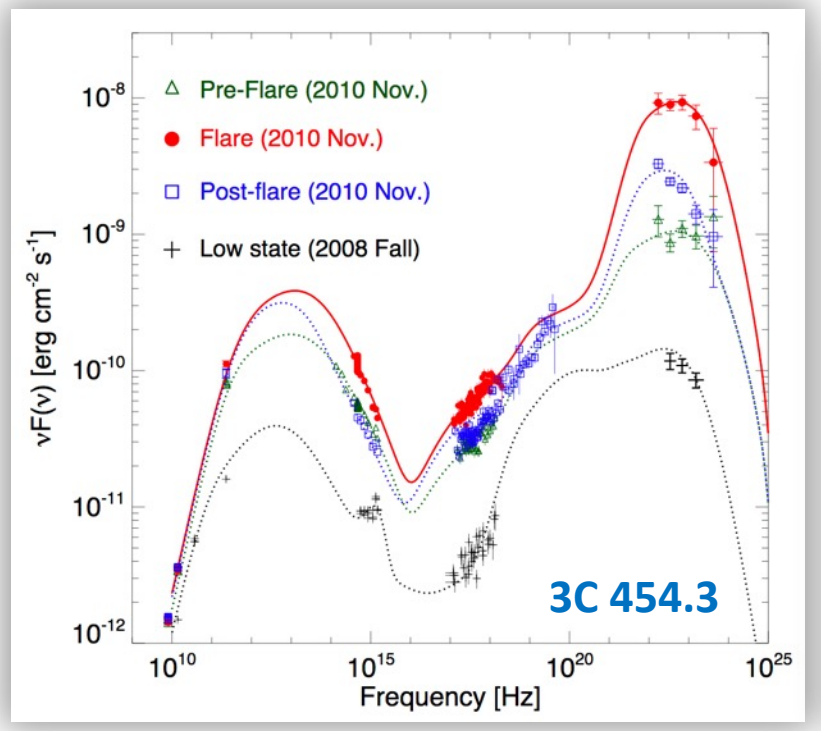
- ➢ AGILE monitoring of Cygnus X-3 around the quenched states (2016-2020): transient emission on 2d and 7d time scales
- ➢ Multi-wavelength context
- ➢ Phenomenology of the transient jet in a “hypersoft state”: extreme particle acceleration in the jet

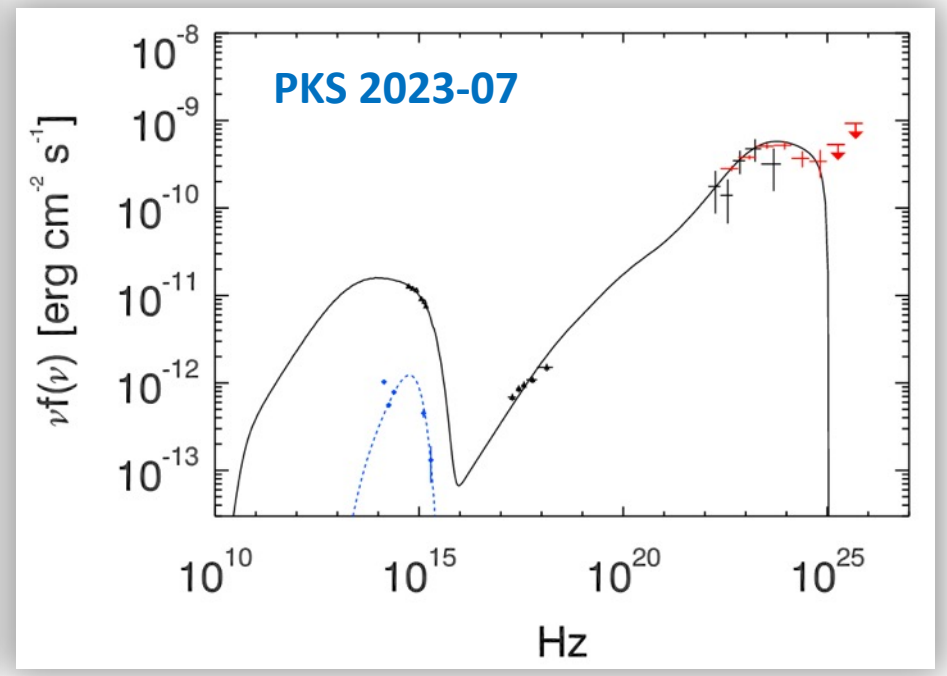
December 2019 – March 2020



AGILE and flaring blazars

Review of a few of the most prominent blazars detected by AGILE





«AGILE and blazars: the unexpected, the unprecedented, and the uncut»

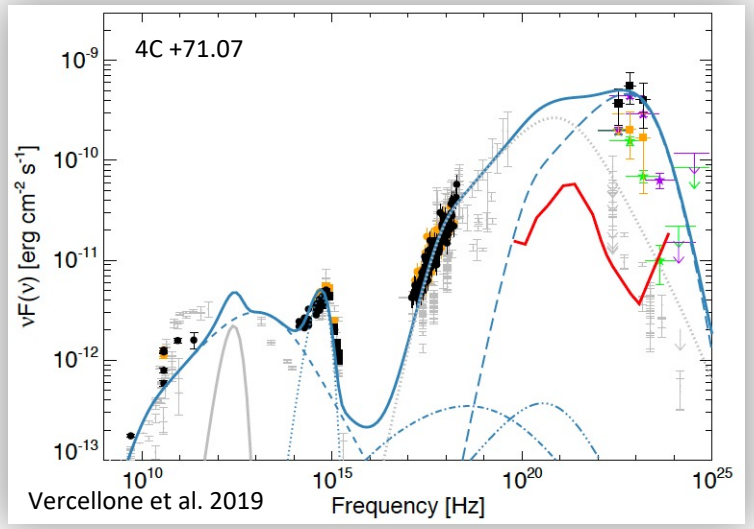
from Vercellone Stefano (INAF/OAB):
Rendiconti Lincei. Scienze Fisiche e Naturali volume 30, pages 131–135 (2019)
DOI: 10.1007/s12210-019-00818-4

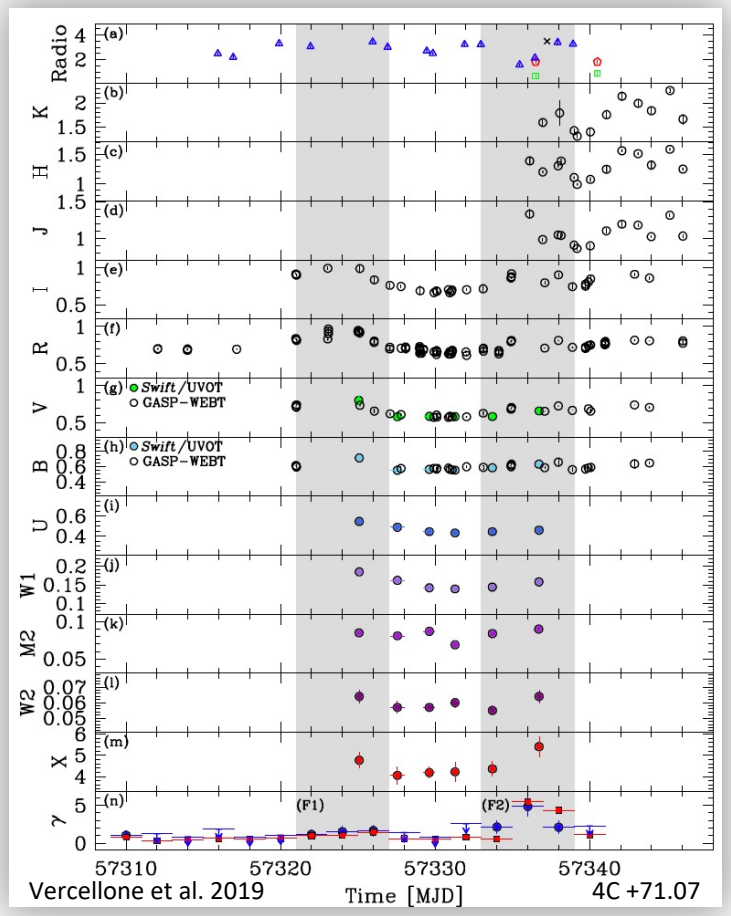
AGILE e lo studio dei nuclei galattici attivi (AGN) – stato attuale

Per riferimento, vedere la scheda: ***GAMMA2 – Coordinatore: Stefano Vercellone***
«Gamma-ray And Multi-wavelength Monitoring of AGNs with AGILE»

Dal lancio, sono stati pubblicati **più di 40 articoli scientifici** su riviste referate con tema gli AGN osservati da AGILE.

La maggior parte di questi articoli riguarda **osservazioni multifrequenza con dati quasi simultanei** ottenuti grazie a programmi congiunti con altre facility.





AGILE e lo studio dei nuclei galattici attivi (AGN) – prospettive

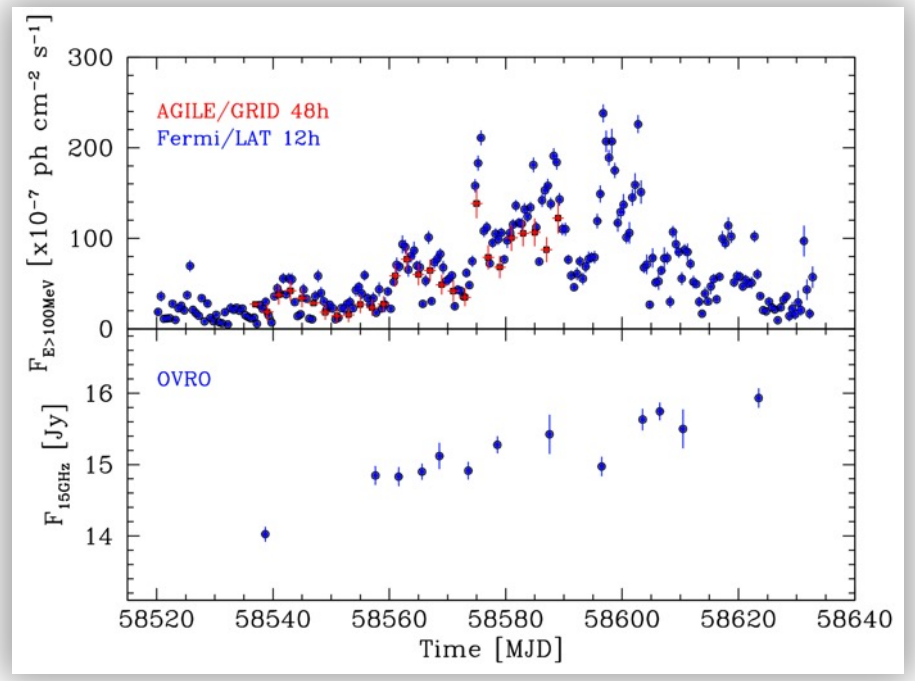
Per riferimento, vedere la scheda: ***GAMMA2 – Coordinatore: Stefano Vercellone***
«Gamma-ray And Multi-wavelength Monitoring of AGNs with AGILE»

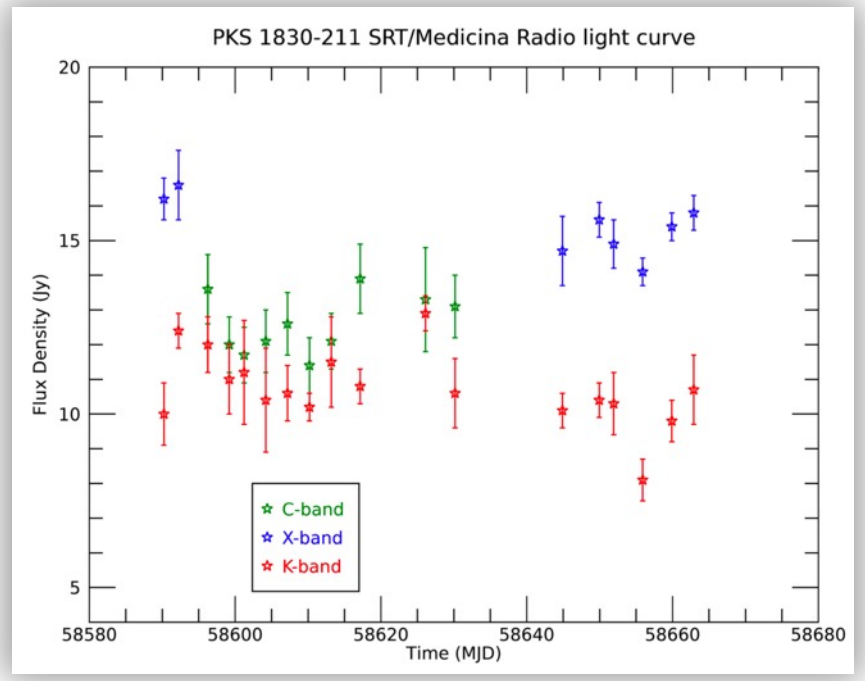
Lo sviluppo del Programma prevede nel medio periodo

- di sfruttare l'enorme mole di dati raccolti in questi anni da AGILE (e Fermi) sugli AGN per studiare **eventuali possibili periodicità nelle curve di luce multi-frequenza** che possano indicare sia la **presenza di perturbazioni nella dinamica del getto** (e.g., 3C 454.3, Vercellone et al. 2010), sia la **presenza di black-hole binari** (e.g., PG 1553+113, Tavani et al. 2018).

- la possibilità di effettuare studi in **sinergia con il prototipo ASTRI-Horn (Proposal approvato, PI Vercellone) e con ASTRI Mini-Array dal 2022-2023** per osservazioni simultanee alle altissime energie.

Work in progress on the γ-ray flare of PKS 1830-210 in 2019



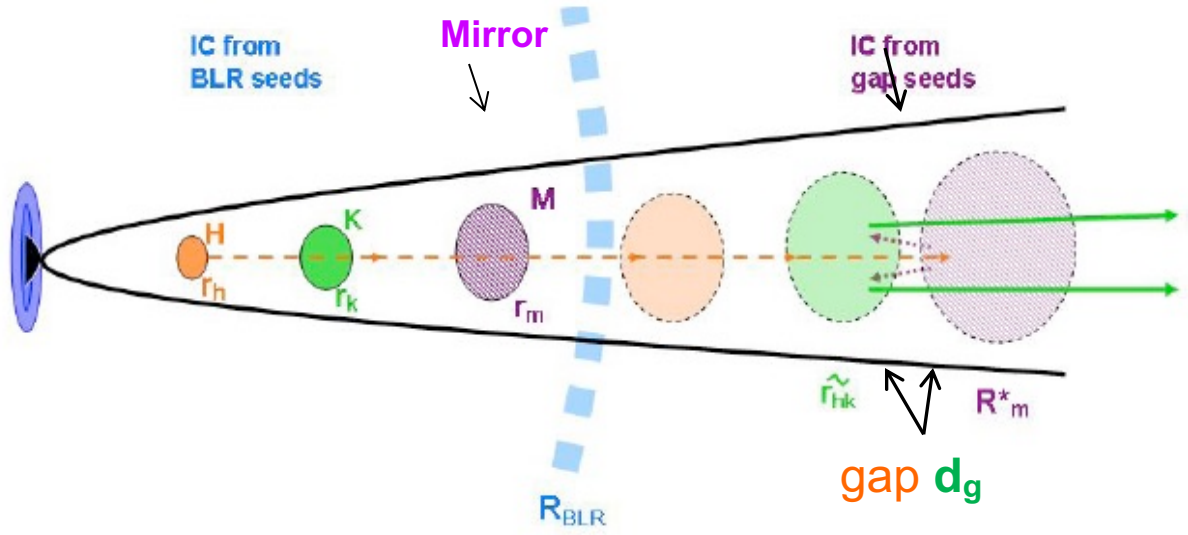


«Multi-wavelength observations of the lensed quasar PKS 1830–210 during a gamma-ray flare», in preparation

Theoretical models for flaring blazars

γ rays from Mirror Inverse Compton in FSRQs

Very fast γ–variability on minute timescale and extreme Compton dominancies in FSRQ can be physically understanded from IC of seed photons mirrored between plasmoids in a structured jet.



A fraction f of Synchrotron photons emitted at r_h by the blob H are reflected by the leading mirror M when this has moved to
$R^*_m \sim 2r_m\Gamma^2_m$.

Reflected photons enter an incoming blob K when this has moved to $\tilde{r}_{hk}$: here, in a "small gap" $d_g \sim R_{BLR}\,(2\Gamma_r)^{-2}$, γ rays are produced by IC with the relativistic electrons of K.

Each blob moves with its bulk Lorentz factor Γ, the relative boost between blobs reads
$\Gamma_r \sim \Gamma / 2\Gamma_m$

V.Vittorini, M. Tavani, A. Cavaliere, M. Cardillo and G. Piano

AGILE and Gravitational Waves

AGILE and GW

- AGILE **unique** combination of two co-aligned X-ray and γ-ray imaging detectors. Excellent for GW counterpart search.
- GRID very large field of view (2.5 sr)
- Spinning observation mode: 200 passes/day over more than 80% of the sky (solar panel constraints).
- **Sensitivity ~ (1-2) 10^{-8} erg cm^{-2} s^{-1} in 100 sec.**
- Also two non-imaging detectors (**4 π**): MCAL (0.3 - 100 MeV), AC (50 keV - 10 MeV)
- GRB – like searches, MCAL, AC, RM

Springer Link

A Decade of AGILE | Published: 05 November 2019

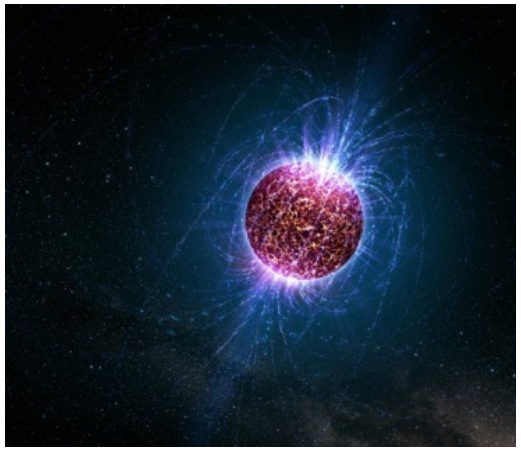
AGILE search for gamma-ray counterparts of gravitational wave events

Francesco Verrecchia, Marco Tavani, Andrea Bulgarelli, Martina Cardillo, Claudio Casentini, Immacolata Donnarumma, Francesco Longo, Fabrizio Lucarelli, Nicoló Parmiggiani, Giovanni Piano, Maura Pilia, Carlotta Pittori, Alessandro Ursi the AGILE Team

Rendiconti Lincei. Scienze Fisiche e Naturali **30**, 71–77(2019) | Cite this article

AGILE limits on magnetar emission for GW170817:

AGILE UL set important constraints in the early phases to exclude a highly magnetized magnetar for the remnant of GW170817- GRB170817A (Verrecchia et al. 2017ApJ...850L..27V)

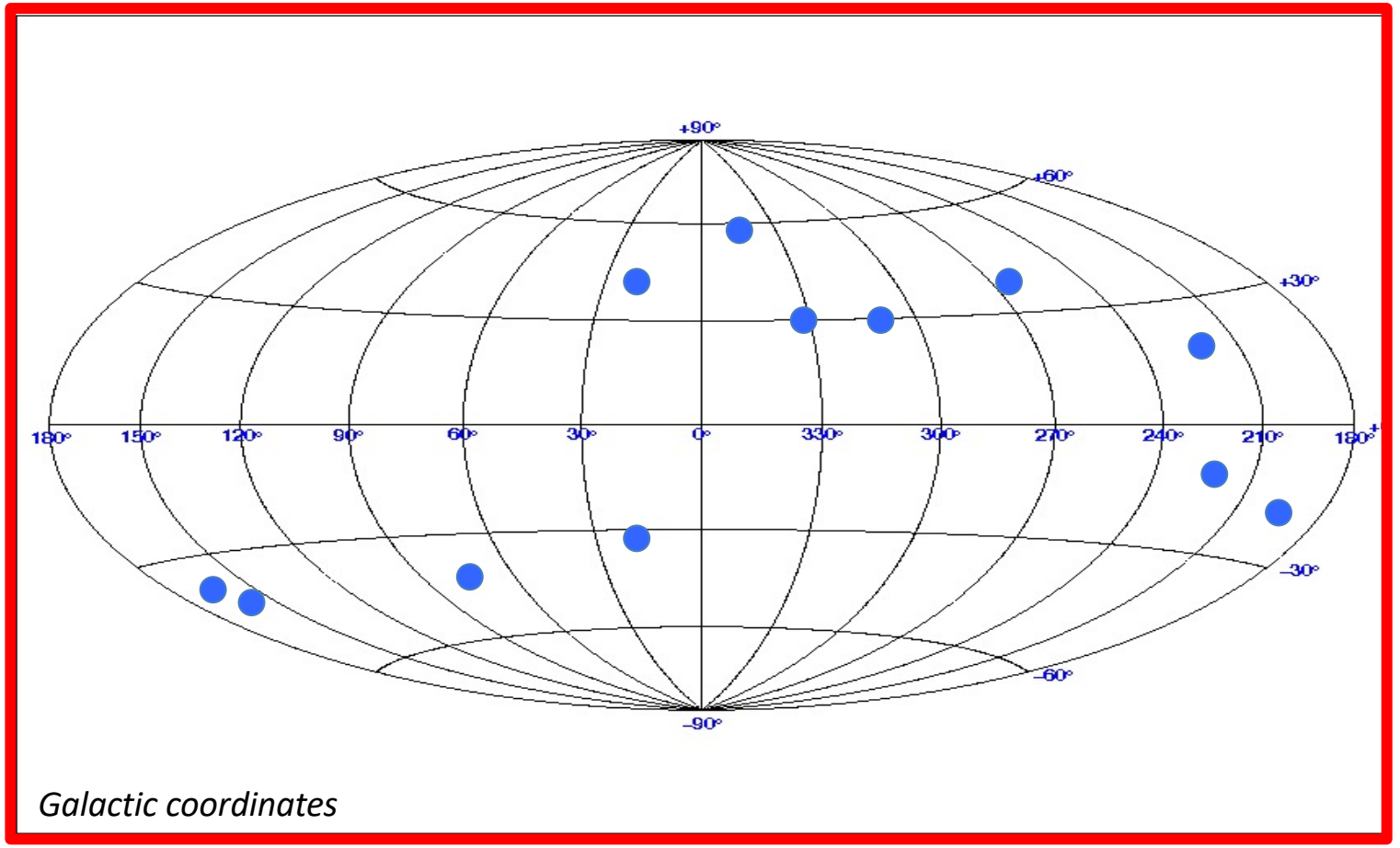


AGILE has re-optimized the MCAL on-board trigger to make sure to detect precursor-like (faint) events

- **Improved performance with new MCAL pipeline developed for "sub-threshold events" btw 4 ÷ 5 sigma pre-trial significance**
- Automatic alerts are now issued for AGILE-detected events: **GCN/AGILE-MCAL TRIGGER ALERT NOTICE**

AGILE and Neutrinos

AGILE detections of IceCube neutrinos



Galactic coordinates

AGILE detections of IceCube neutrinos

Springer Link

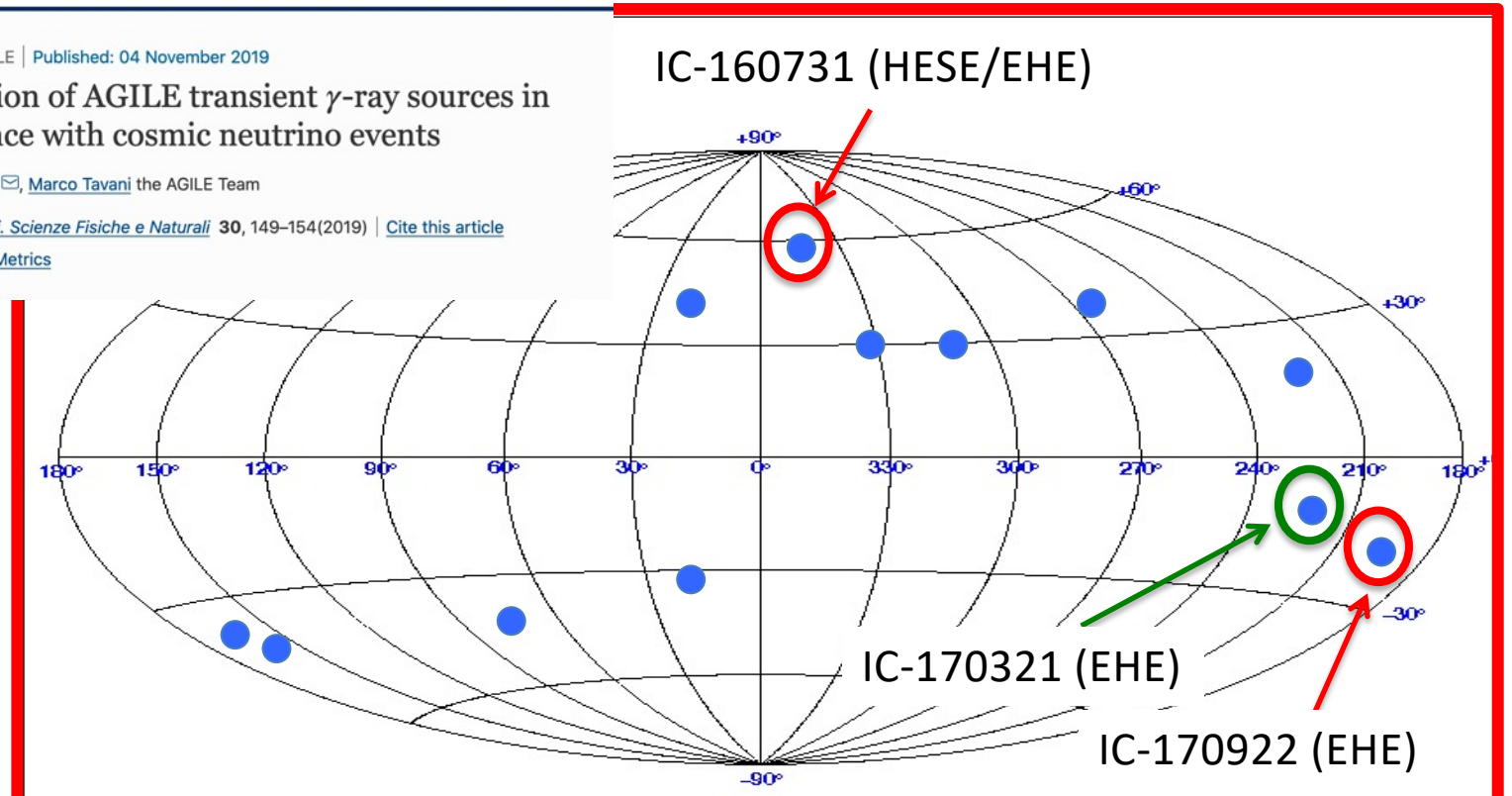
A Decade of AGILE | Published: 04 November 2019

Observation of AGILE transient γ-ray sources in coincidence with cosmic neutrino events

Fabrizio Lucarelli, Marco Tavani the AGILE Team

Rendiconti Lincei. Scienze Fisiche e Naturali **30**, 149–154(2019) | Cite this article

28 Accesses | Metrics

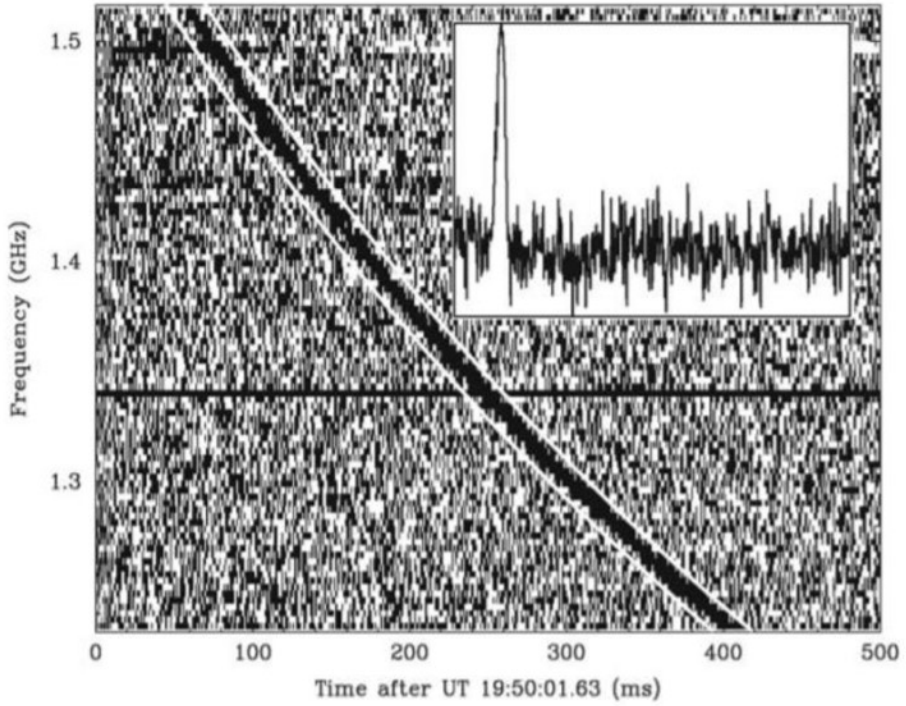


IC-170922 consistent with BL Lac blazar **TXS 0506+056** see paper on MWL observations **Science 361, 2018**

Three AGILE detections (~4σ each) from the automatic QL system consistent with time/position of 3 IC events out of 10 !

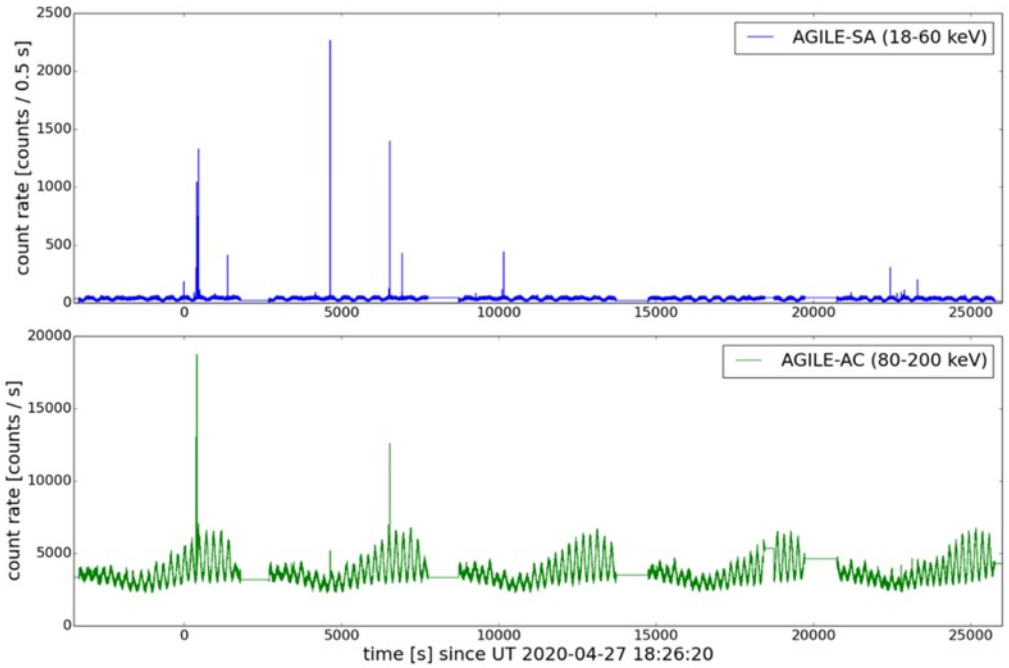
AGILE and Fast Radio Burst

Fast Radio Bursts (FRB)



FRBs are millisecond radio pulses originating from powerful enigmatic extragalactic sources. **Magnetars** (neutron stars with large magnetic fields) are considered as **possible** candidate sources powering the FRBs?

Important detection by AGILE on April 28, 2020: an X-ray burst in temporal coincidence with a bright **FRB-like** radio burst from the **Galactic** magnetar SGR 1935+2154



La magnetar si attiva in X-rays il 27 Aprile:

AGILE observations of the SGR 1935+2154 "burst forest"

ATel #13682; *A. Ursi (INAF/IAPS), C. Pittori (SSDC and INAF/OAR), P. Tempesta (TeleSpazio), F. Verrecchia (SSDC and INAF/OAR), M. Tavani (INAF/IAPS, and Univ. Roma Tor Vergata), M. Cardillo, C. Casentini, G. Piano (INAF/IAPS), A. Bulgarelli, V. Fioretti, N. Parmiggiani (INAF/IASF-Bo), F. Lucarelli (SSDC and INAF/OAR), I. Donnarumma (ASI), S. Vercellone (INAF/OA-Brera), F. Gianotti, M. Trifoglio (INAF/IASF-Bo), A. Giuliani, S. Mereghetti, P. Caraveo, F. Perotti (INAF/IASF-Mi), A. Chen (Wits University), A. Argan, E. Costa, E. Del Monte, Y. Evangelista, M. Feroci, F. Lazzarotto, I. Lapshov, L. Pacciani, P. Soffitta, V. Vittorini (INAF/IAPS), G. Di Cocco, F. Fuschino, M. Galli, C. Labanti (INAF/IASF-Bo), M. Marisaldi (INAF/OAS-Bologna, and Bergen University), A. Pellizzoni, M. Pilia, A. Trois (INAF/OA-Cagliari), G. Barbiellini, E. Vallazza (INFN Trieste), F. Longo (Univ. Trieste and INFN Trieste), A. Morselli, P. Picozza (INFN and Univ. Roma Tor Vergata), M. Prest (Univ. dell'Insubria), P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza), P. W. Cattaneo, A. Rappoldi (INFN Pavia), A. Ferrari (Univ. Torino and CIFS), F. Paoletti (East Windsor RSD Hightstown and INAF/IAPS), A. Antonelli (INAF/OAR), P. Giommi, L. Salotti, G. Valentini, and F. D'Amico (ASI)*

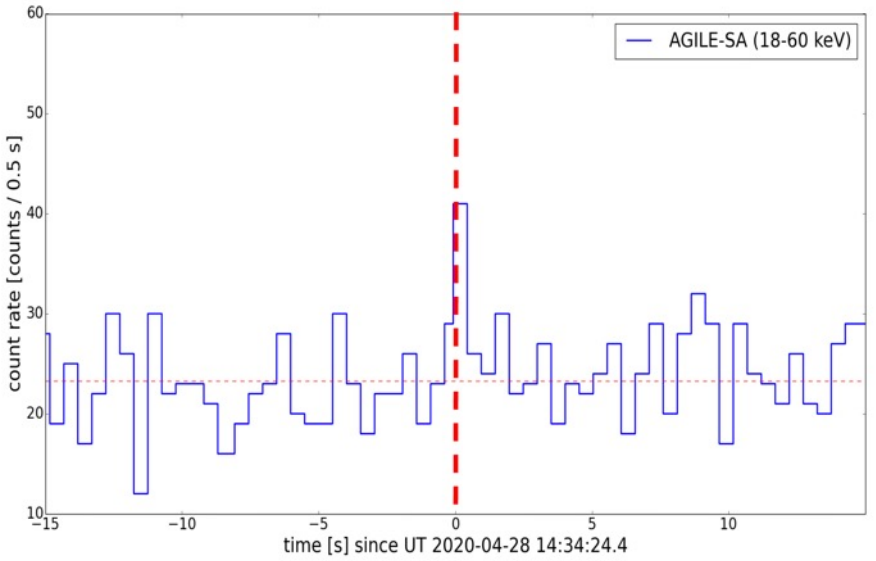
on 28 Apr 2020; 21:40 UT

Il giorno dopo: **radio burst** reported by CHIME/FRB at T0 = 2020-04-28 14:34:33 UTC per la prima volta in coincidenza con un segnale in X-ravs!!!!

AGILE detection of a hard X-ray burst in temporal coincidence with a radio burst from SGR 1935+2154

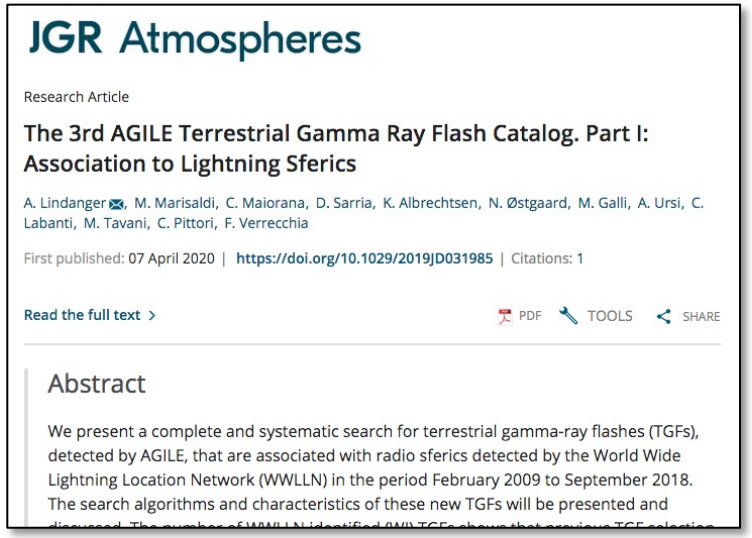
ATel #13686; *M. Tavani (INAF/IAPS, and Univ. Roma Tor Vergata), A. Ursi (INAF/IAPS), F. Verrecchia (SSDC and INAF/OAR), C. Casentini (INAF/IAPS), C. Pittori (SSDC and INAF/OAR), M. Pilia (INAF/OA-Cagliari), M. Cardillo, G. Piano (INAF/IAPS), A. Bulgarelli, V. Fioretti, N. Parmiggiani (INAF/IASF-Bo), F. Lucarelli (SSDC and INAF/OAR), I. Donnarumma (ASI), S. Vercellone (INAF/OA-Brera), F. Gianotti, M. Trifoglio (INAF/IASF-Bo), A. Giuliani, S. Mereghetti, P. Caraveo, F. Perotti (INAF/IASF-Mi), A. Chen (Wits University), A. Argan, E. Costa, E. Del Monte, Y. Evangelista, M. Feroci, F. Lazzarotto, I. Lapshov, L. Pacciani, P. Soffitta, V. Vittorini (INAF/IAPS), G. Di Cocco, F. Fuschino, M. Galli, C. Labanti (INAF/IASF-Bo), M. Marisaldi (INAF/OAS-Bologna, and Bergen University), A. Pellizzoni, A. Trois (INAF/OA-Cagliari), G. Barbiellini, E. Vallazza (INFN Trieste), F. Longo (Univ. Trieste and INFN Trieste), A. Morselli, P. Picozza (INFN and Univ. Roma Tor Vergata), M. Prest (Univ. dell'Insubria), P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza), P. W. Cattaneo, A. Rappoldi (INFN Pavia), A. Ferrari (Univ. Torino and CIFS), F. Paoletti (East Windsor RSD Hightstown and INAF/IAPS), A. Antonelli (INAF/OAR), P. Giommi, L. Salotti, G. Valentini, and F. D'Amico (ASI)*

on 29 Apr 2020; 11:05 UT



AGILE and Terrestrial Gamma-ray Flashes

3rd AGILE TGF Catalog



JGR Atmospheres

Research Article

The 3rd AGILE Terrestrial Gamma Ray Flash Catalog. Part I: Association to Lightning Sferics

A. Lindanger, M. Marisaldi, C. Maiorana, D. Sarria, K. Albrechtsen, N. Østgaard, M. Galli, A. Ursi, C. Labanti, M. Tavani, C. Pittori, F. Verrecchia

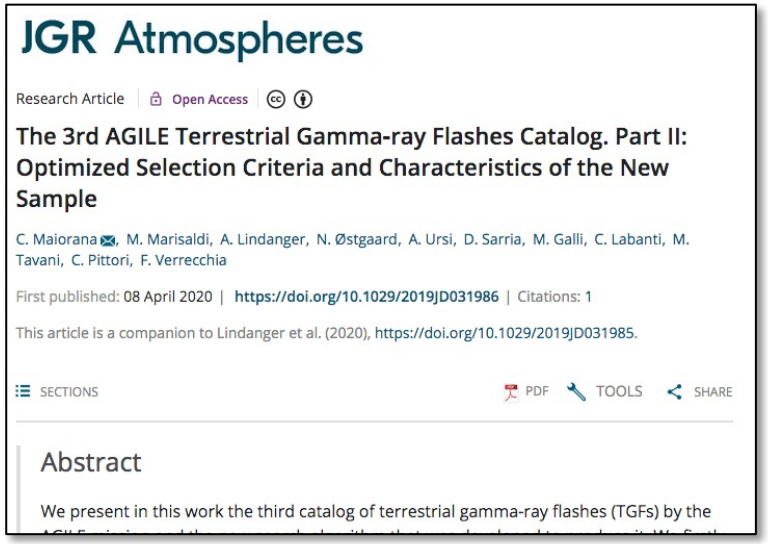
First published: 07 April 2020 | https://doi.org/10.1029/2019JD031985 | Citations: 1

Read the full text › PDF TOOLS SHARE

Abstract

We present a complete and systematic search for terrestrial gamma-ray flashes (TGFs), detected by AGILE, that are associated with radio sferics detected by the World Wide Lightning Location Network (WWLLN) in the period February 2009 to September 2018. The search algorithms and characteristics of these new TGFs will be presented and

***Lindanger et al.*, 2020, JGR (Atmospheres)**



JGR Atmospheres

Research Article | Open Access

The 3rd AGILE Terrestrial Gamma-ray Flashes Catalog. Part II: Optimized Selection Criteria and Characteristics of the New Sample

C. Maiorana, M. Marisaldi, A. Lindanger, N. Østgaard, A. Ursi, D. Sarria, M. Galli, C. Labanti, M. Tavani, C. Pittori, F. Verrecchia

First published: 08 April 2020 | https://doi.org/10.1029/2019JD031986 | Citations: 1

This article is a companion to Lindanger et al. (2020), https://doi.org/10.1029/2019JD031985.

SECTIONS PDF TOOLS SHARE

Abstract

We present in this work the third catalog of terrestrial gamma-ray flashes (TGFs) by the

***Maiorana et al.*, 2020, JGR (Atmospheres)**

Original sample: 2780 events, recently updated to include all events associated with lightning sferics up to October 31, 2020.

AGILE and Terrestrial Gamma-ray Flashes

3rd AGILE TGF Catalog and lightning associations: interactive SSDC webpage

Updated on March 23, 2021:

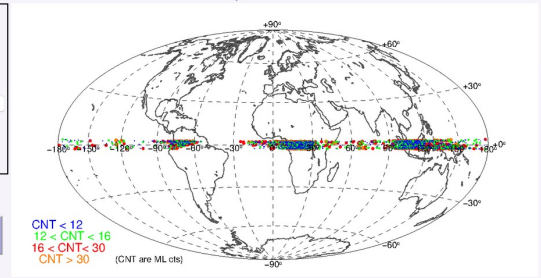
The 3rd AGILE/MCAL TGF Catalog

NEW UPDATE including TGFs with lightning spherics association from 01/10/2018 to 31/10/2020

Last update: 23 March 2021

Help | Show/hide columns | Advanced filtering | Print current view of table | Print complete table | Reset all filters

Search table columns: Search



Catalog Description

A. Lindanger et al. (Paper I), Journal of Geophys. Res.: Atmosph, 125, e2019JD031985 (2020). DOI: 10.1029/2019JD031985.
C. Maiorana et al. (Paper II), Journal of Geophys. Res.: Atmosph, 125, e2019JD031986 (2020). DOI: 10.1029/2019JD031986.

Links to other AGILE/MCAL TGF webpages at SSDC:

The first AGILE/MCAL TGF catalog on-line web table, Marisaldi et al. 2013

The 2nd AGILE/MCAL TGF catalog on-line web table, Marisaldi et al. 2015

On the High-Energy Spectral Component and Fine Structure of AGILE TGF, Marisaldi et al. 2019

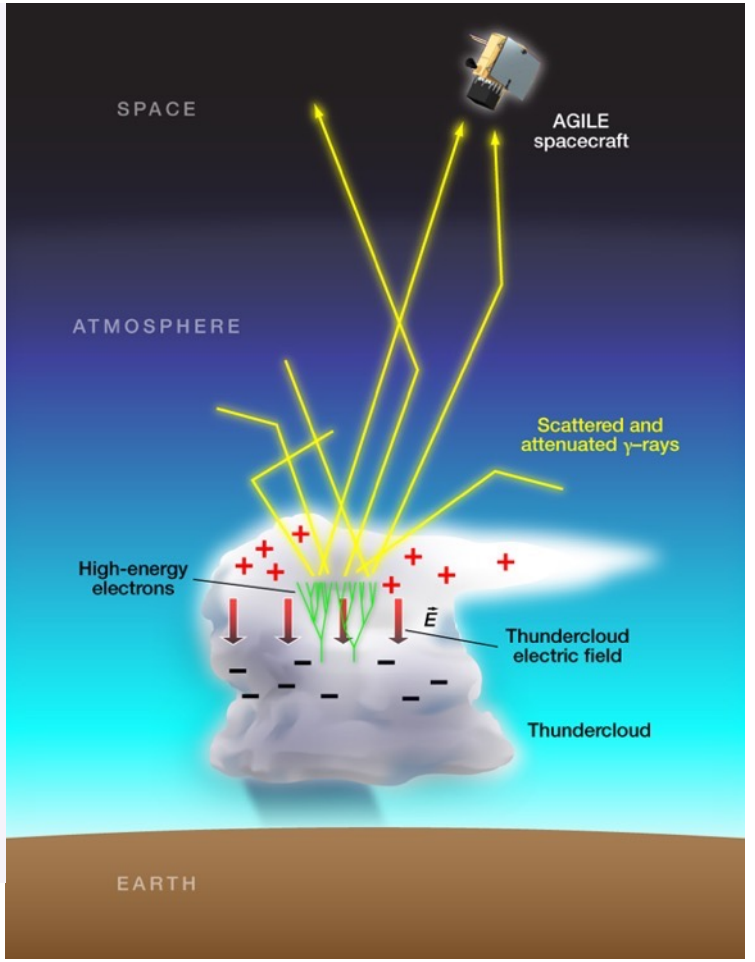
Paper II | DRIFT (Paper I) | REF-3DFIX (Paper I) | Update 3DFIX 2018-20 | Paper I + Update 2018-20

Export Current view of Table in: Latex format | FITS format | Raw text format | CSV text format

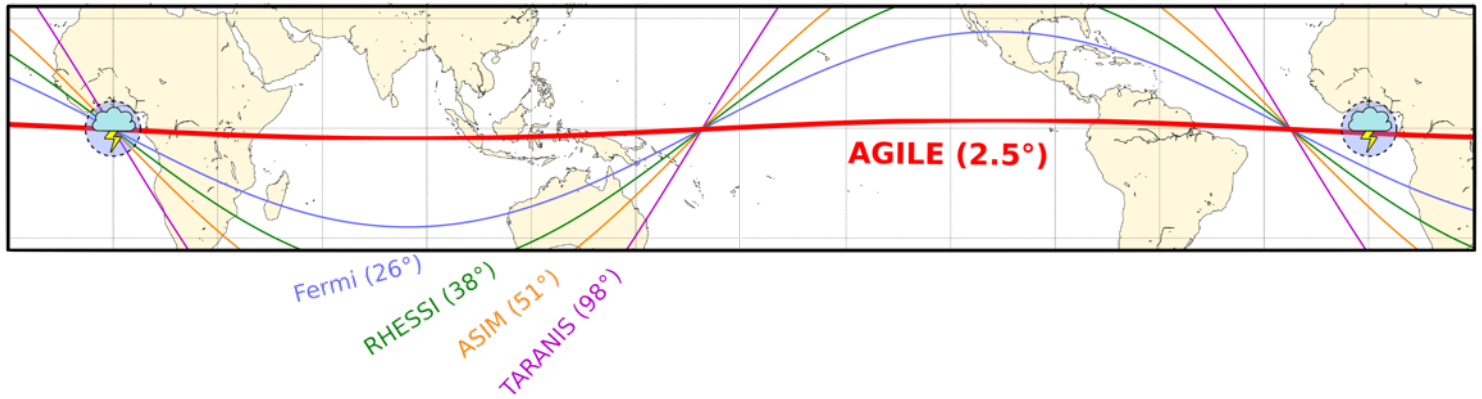
Previous Page | Next Page | Page Size (# of lines) 200 | Reset all filters | Show all entries

This view includes 2902 entries

Entry number (Selection mode: Include, All)		New TGF ID	GeoLon (deg)	GeoLat (deg)	Date (UTC)	Trigger Time T0 (MET in s)	T50+/-Err (ms)	ML Counts +/-Err	Event Type	Sample ID
1	TGF LC	150323.104254.410184	-1.87	0.52	2015-03-23T10:42:54	354192174.410184	8.634e-5+/-1.080e-5	32.92+/-5.73	0	PaperII
2	TGF LC	150323.111207.193100	102.09	2.07	2015-03-23T11:12:07	354193927.1931	1.039e-4+/-1.480e-5	24.00+/-4.889	0	PaperII
3	TGF LC	150323.202915.550446	-71.93	2.48	2015-03-23T20:29:15	354227355.550446	6.070e-5+/-9.440e-6	18.00+/-4.234	0	PaperII
4	TGF LC	150323.230357.71264	119.48	-1.49	2015-03-23T23:03:57	354236637.071264	2.698e-5+/-5.400e-6	9.97+/-3.156	0	PaperII
7	TGF LC	150324.051528.267899	3.68	-2.1	2015-03-24T05:15:28	354258928.267899	4.047e-5+/-8.090e-6	12.95+/-3.595	0	PaperII

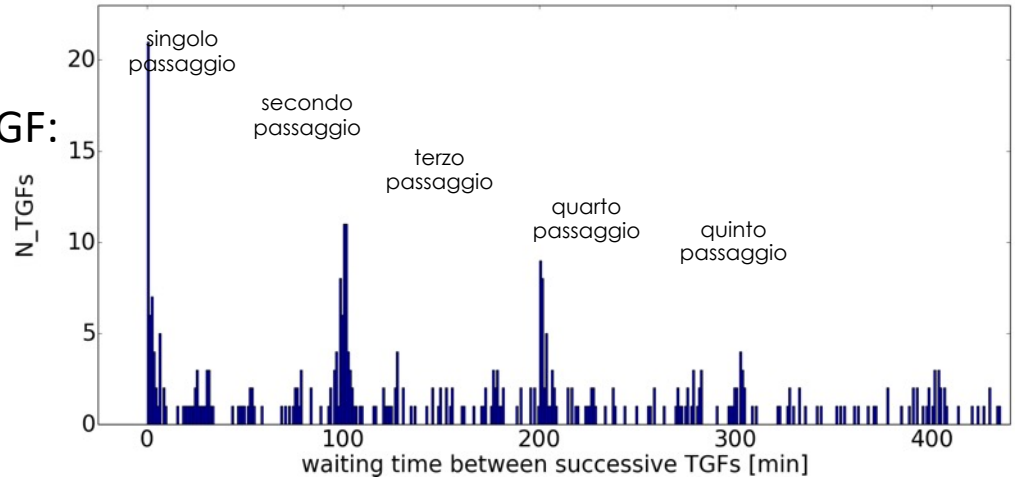


Multiple TGFs



AGILE **unique** capability due to its equatorial orbit:
events generated by the same storm system over a time interval of hours

Waiting time distribution between AGILE TGF:



AGILE and Solar Physics

Latest AGILE development: Solar activity monitoring

AGILE detection of C-class solar flares at the beginning of the new solar cycle 25

ATel #14172; A. Ursi (INAF/IAPS), C. Pittori (SSDC and INAF/OAR), P. Tempesta (Telespazio), M. Tavani (INAF/IAPS, and Univ. Roma Tor Vergata), F. Verrecchia (SSDC and INAF/OAR), M. Cardillo, C. Casentini, G. Piano (INAF/IAPS), A. Bulgarelli, V. Fioretti, N. Parmiggiani (INAF/IASF-Bo), F. Lucarelli (SSDC and INAF/OAR), I. Donnarumma (ASI), S. Vercellone (INAF/OA-Brera), F. Gianotti, M. Trifoglio (INAF/IASF-Bo), A. Giuliani, S. Mereghetti, P. Caraveo, F. Perotti (INAF/IASF-Mi), A. Chen (Wits University), A. Argan, E. Costa, E. Del Monte, Y. Evangelista, M. Feroci, F. Lazzarotto, I. Lapshov, L. Pacciani, P. Soffitta, V. Vittorini (INAF/IAPS), G. Di Cocco, F. Fuschino, M. Galli, C. Labanti (INAF/IASF-Bo), M. Marisaldi (INAF/OAS-Bologna, and Bergen University), A. Pellizzoni, M. Pilia, A. Trois (INAF/OA-Cagliari), G. Barbiellini, E. Vallazza (INFN Trieste), F. Longo (Univ. Trieste and INFN Trieste), A. Morselli, P. Picozza (INFN and Univ. Roma Tor Vergata), M. Prest (Univ. dell'Insubria), P. Lipari, D. Zanello (INFN and Univ. Roma Sapienza), P. W. Cattaneo, A. Rappoldi (INFN Pavia), A. Ferrari (Univ. Torino and CIFS), F. Paoletti (East Windsor RSD Hightstown and INAF/IAPS), L. A. Antonelli (INAF/OAR), P. Giommi, L. Salotti, G. Valentini, and F. D'Amico (ASI)

on ***13 Nov 2020; 20:27 UT***

Credential Certification: Fabrizio Lucarelli (fabrizio.lucarelli@ssdc.asi.it)

Subjects: X-ray, The Sun

Tweet

The AGILE satellite is revealing bright solar activity, starting October 2020.

From October 27 to November 12, 2020 the AGILE Anti-Coincidence scientific ratemeters oriented toward the Sun (AC Lat4; 80-200 keV) detected about 45 intense X-ray emissions from C-class solar flares.

In particular, on October 27 and 29, 2020 and on November 5 and 8, 2020, AGILE clearly observed prominent X-ray emission from the solar flares emitted by the solar active regions AR 12778, AR 12779, and AR 12781, respectively, as reported by GOES satellites (https://www.goes.noaa.gov/).

In our preliminary analysis, using a dedicated Solar Flare event selection, solar activity is identified as X-ray emission with flux >=3 times higher than the typical flux of the Quiet Sun. We report information about the most intense X-ray bursts detected by AC Lat4, together with the class of the corresponding solar flare:

C4.3 | AR 12778 | UT 2020-10-27 06:14:30 | peak counts = 14859 | total counts = 1006398 | mean duration = 150 s

C4.3 | AR 12779 | UT 2020-10-29 11:44:03 | peak counts = 11688 | total counts = 4720341 | mean duration = 1485 s

C7.3 | AR 12781 | UT 2020-11-05 00:08:16 | peak counts = 24444 | total counts = 11149783 | mean duration = 1800 s

C1.4 | AR 12781 | UT 2020-11-05 02:50:12 | peak counts = 11694 | total counts = 396360 | mean duration = 115 s

C2.3 | AR 12781 | UT 2020-11-05 09:54:16 | peak counts = 27906 | total counts = 880041 | mean duration = 520 s

C5.7 | AR 12781 | UT 2020-11-08 05:16:43 | peak counts = 13680 | total counts = 221884 | mean duration = 60 s

The AGILE AC Lat4 ratemeter light curves can be found at http://www.agilescienceapp.it/notices/AGILE_SF_20201022-20201113.png .

Further analysis is still in progress. AGILE (Astrorivelatore Gamma a Immagini LEggero) is an X-ray and Gamma-ray astronomical satellite of the Italian Space Agency (ASI).

http://www.astronomerstelegram.org/?read=14172

AGILE AC Lat 4: efficient Solar activity X-ray monitor!