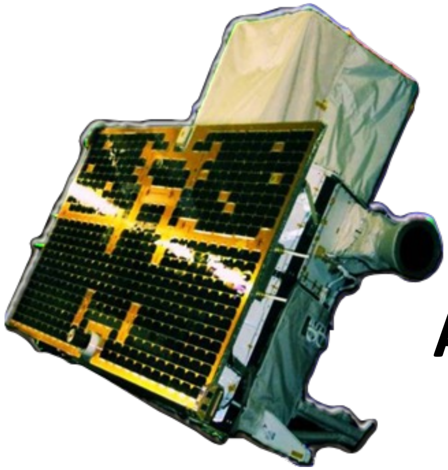


AGILE main scientific achievements in gamma-rays

Carlotta Pittori
INAF-OAR and ASI-SSDC
on behalf of the AGILE Team

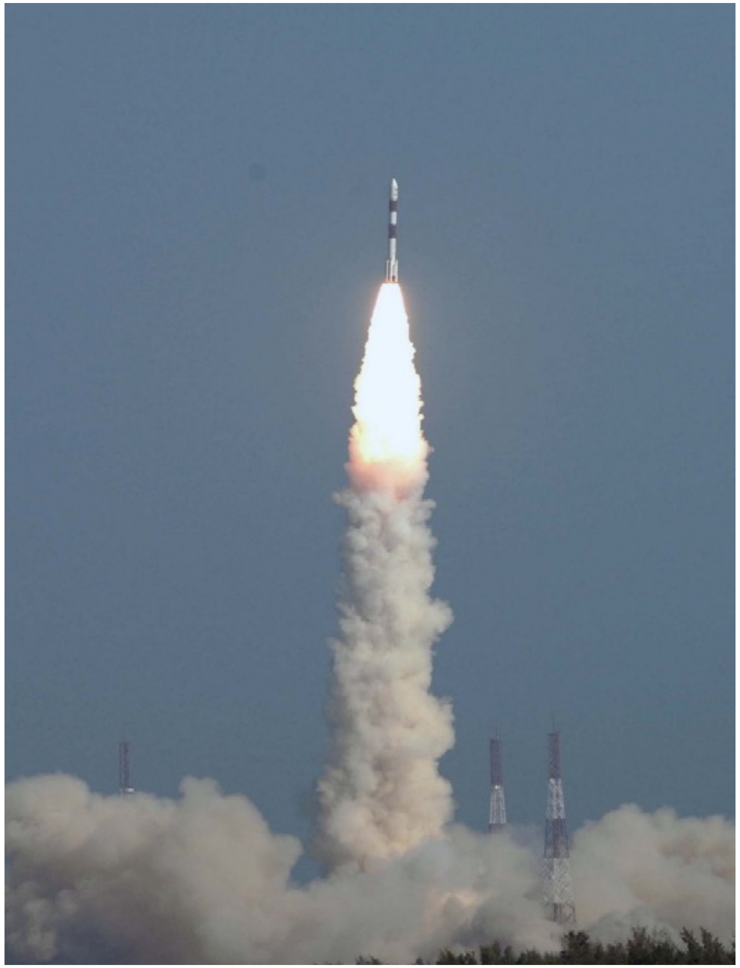
MAGIC
Major Atmospheric Gamma Imaging Cerenkov Telescopes

20 MAGIC Years Conference & Symposium

La Palma, 4 – 7 Oct 2023

India April 23, 2007: AGILE satellite launch

Low Earth equatorial orbit: 550 Km and < 3 deg inclination angle



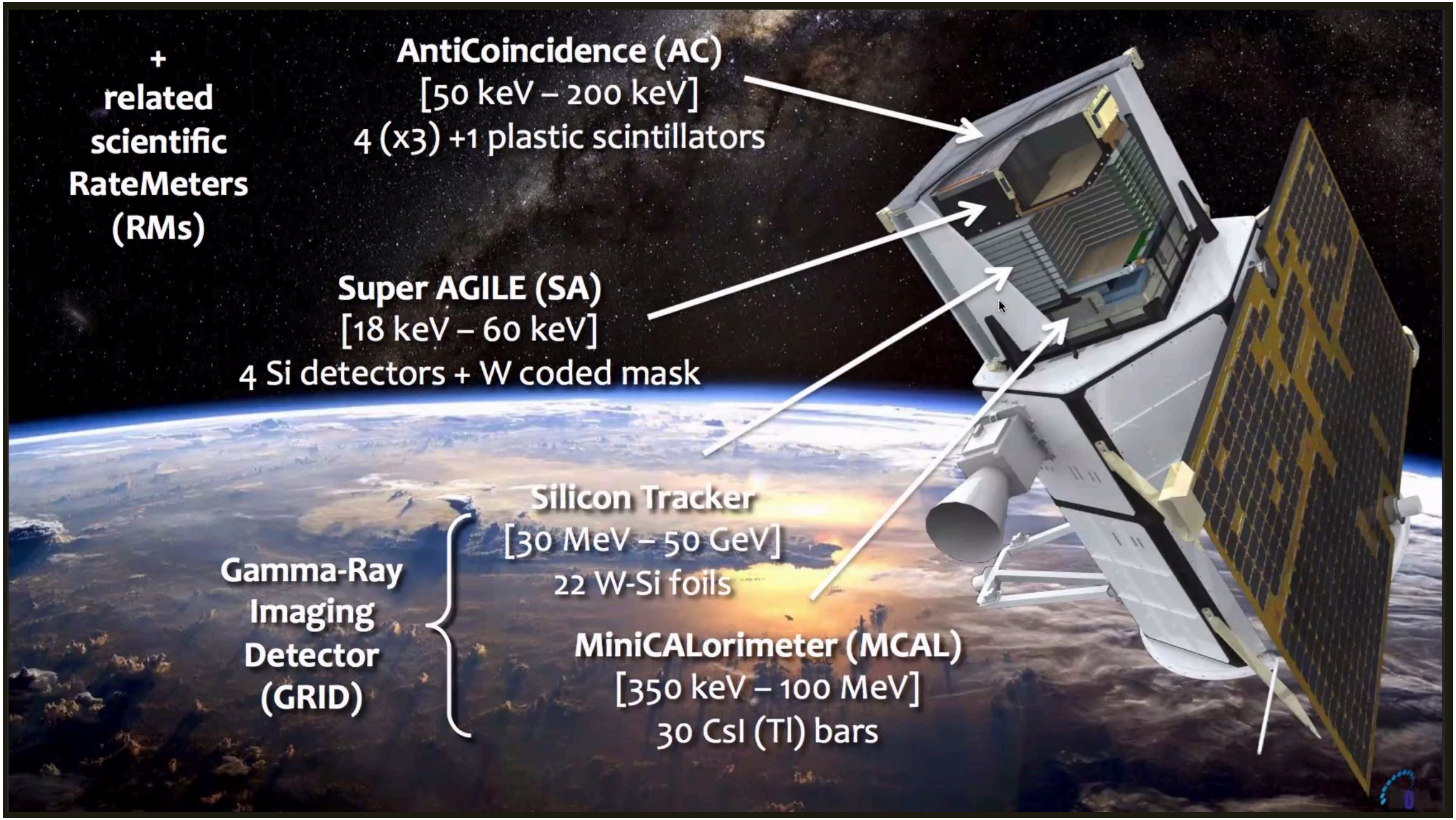
Italian Space Agency (ASI) Mission with INFN, INAF participation

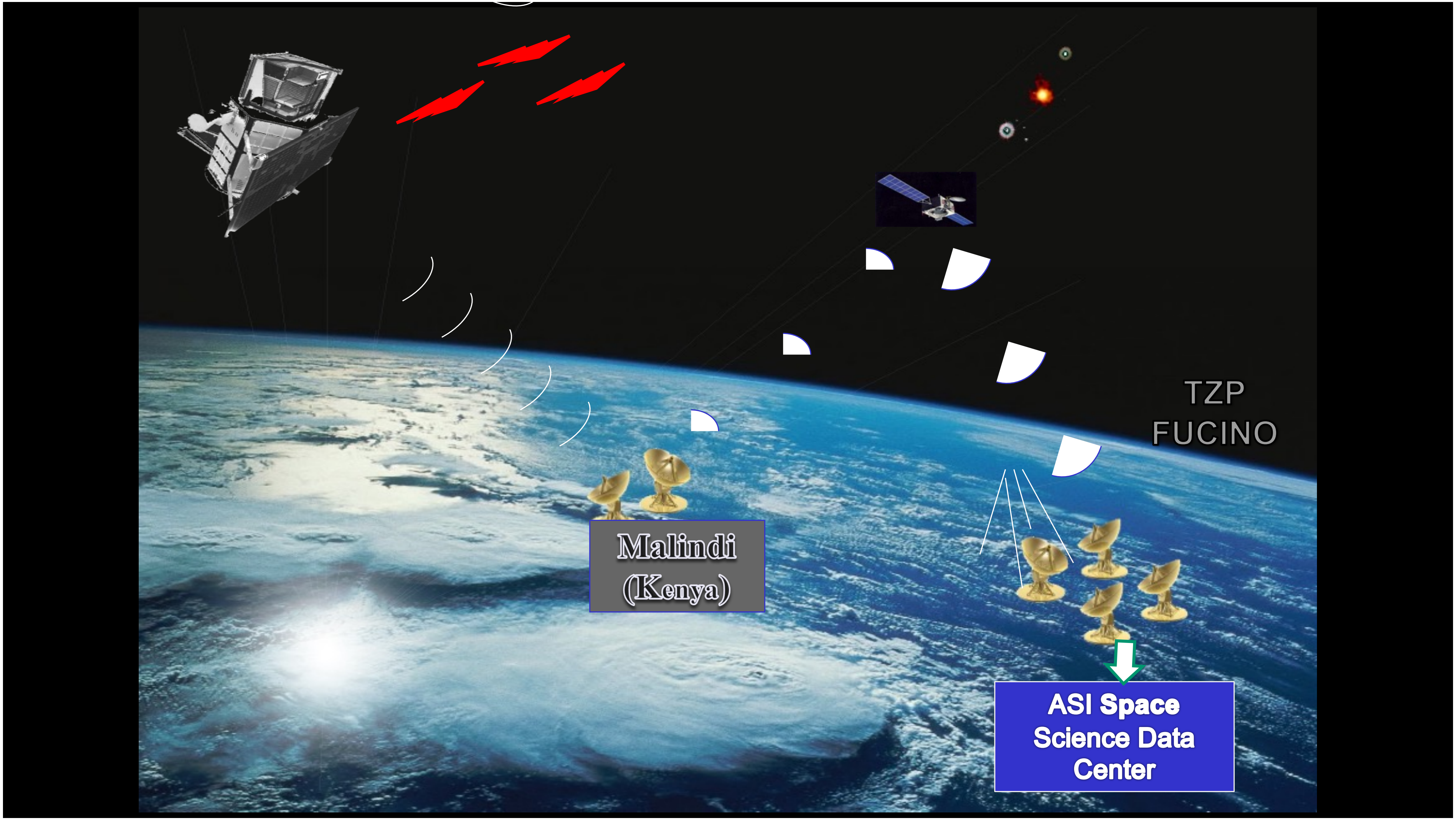
AGILE: more than 16 years of operations in space

- 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


+
related
scientific
RateMeters
(RMs)
AntiCoincidence (AC)
[50 keV – 200 keV]
4 (x3) +1 plastic scintillators
Super AGILE (SA)
[18 keV – 60 keV]
4 Si detectors + W coded mask
Gamma-Ray
Imaging
Detector
(GRID)
Silicon Tracker
[30 MeV – 50 GeV]
22 W-Si foils
MiniCALorimeter (MCAL)
[350 keV – 100 MeV]
30 CsI (Tl) bars


TZP
FUCINO
Malindi
(Kenya)
ASI Space
Science Data
Center

Scientific status of AGILE

- **Nominal status.** Actively involved in the hunt for high-energy electromagnetic counterparts of gravitational waves (GW) during the current LIGO-Virgo-Kagra (LVK) O4 observing run, started in May, 2023.

- **Operations:** currently financed by ASI up to June 2024 (probable satellite reentry?)

- AGILE was strongly affected by **limited ground operations at ASI-Malindi** due to the **COVID-19 pandemic.** For more than one year, from March 2020 to May 2021, AGILE has operated with the GRID in standby, only MCAL and ratemeters (RM) on, due to the limited telemetry budged from Malindi (only **3 AGILE passes/day** served, instead of 14).

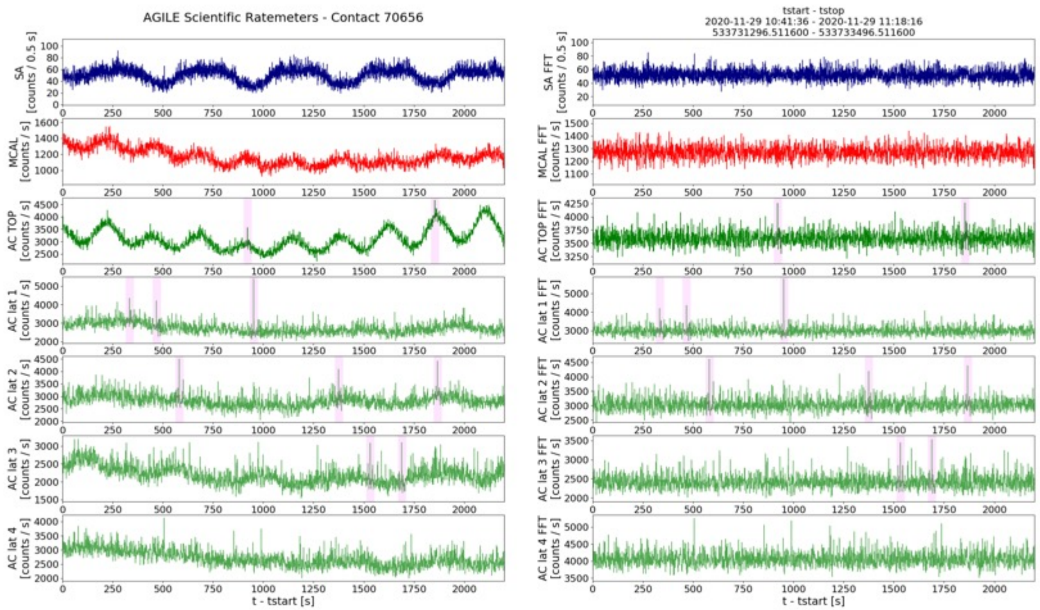
- **On May 6, 2021,** Malindi has resumed serving ~ 7 passes/day to the AGILE mission, and the **GRID observations** could finally be **restarted**. **Since March 21, 2022 ~ 10 pass/day: GRID on and MCAL (often) at its full sensitivity configuration.**

- "Make virtue of necessity": during the limited TM period, **much improved RM analysis**, **automatic processing and burst identification**. The system was also updated for the follow-up of **Solar flares**.

Dedicated automatic pipeline for AGILE Ratemeters analysis

- RM SA
- RM MCAL
- RM AC top
- RM AC Lat 1, Lat 2, Lat 3 , Lat4.

(AC Lat4 always oriented towards the SUN)



(Spinning detrending on the right)

- Daily monitoring with 48-hour shifts → **24-h shifts during GW Run O4**
- MCAL automatic alerts published as Notices in the GCN Network
- ***New:*** Automatic solar flares alerts from AC Lat4 RM (internal emails)
- ***New:*** Automatic RM alerts (internal emails)

AGILE CONTROL ROOM

Control Room - Data Flow

Next Contact

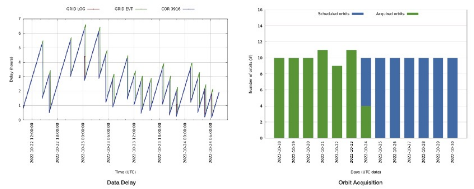
Contact Number = 80625
Configuration = MCAL BASE
Time For Contact = 83 minutes
Start: 2022-10-24 06:02:31 (UTC)
Stop: 2022-10-24 09:22:06 (UTC)
Next Contact Time For Data (Prevision)
MCAL @ Bologna = 2022-10-24 09:47:06 (UTC)
GRID @ Bologna = 2022-10-24 09:52:06 (UTC)

Orbit List

Contact Time (UTC)	Orbit Number	Scheduled	Conf
2022-10-24 01:02:58	80620	Yes	MCAL BASE
2022-10-24 02:42:51	80621	Yes	MCAL1 ON
2022-10-24 04:22:41	80622	Yes	MCAL1 ON
2022-10-24 06:02:31	80623	Yes	MCAL1 ON
2022-10-24 07:42:19	**80624**	Not	MCAL BASE
2022-10-24 09:22:06	80625	Yes	MCAL BASE
2022-10-24 11:01:54	80626	Yes	MCAL1 ON
2022-10-24 12:41:41	80627	Yes	MCAL1 ON
2022-10-24 14:21:27	80628	Yes	MCAL1 ON
2022-10-24 16:01:14	80629	Yes	MCAL1 ON

Full List

Data Flow Status



Operational Snapshot as of Oct 24, 08:07 UTC

Detector	Status	Duration
GEO 600	Unlocked	2:10
LIGO Hanford	Down	>134:19
LIGO Livingston	Down	>134:19
Virgo	Info too old	
KAGRA	Down	>134:21

Detector status summary pages LVK

Ratemeters pipeline - Home Page

AGILE RM | Home | Control Room

Contact List

Show 50 entries Search:

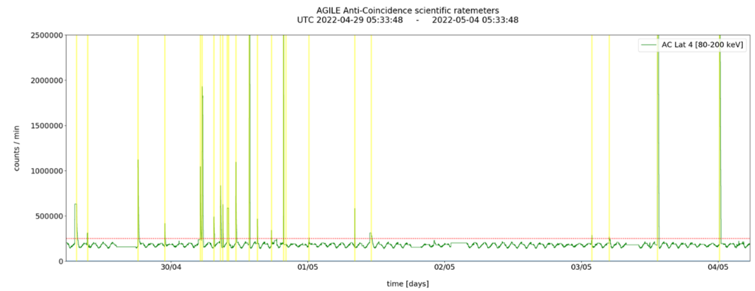
Contact Number	Time Start (UTC)	Time Stop (UTC)	Contact Detail
080623	2022-10-24T04:21:41	2022-10-24T06:10:51	Contact RM · Solar Monitoring LC · Monitoring AC4 · Contact Checked
080622	2022-10-24T02:25:51	2022-10-24T04:23:21	Contact RM · Solar Monitoring LC · Monitoring AC4 · Contact Checked
080621	2022-10-24T00:03:57	2022-10-24T02:34:47	Contact RM · Solar Monitoring LC · Monitoring AC4 · Contact Checked
080620	2022-10-23T21:38:31	2022-10-24T00:09:21	Contact RM · Solar Monitoring LC · Monitoring AC4 · Contact Checked

MCAL pipeline: GRBs, GRBlikes, Sub-threshold events (STEs), TGFs:

MCAL last 5 contacts

Contact Number	First Trigger (UTC)	Last Trigger (UTC)	N of triggers	GRBs	GRBlikes	STEs	TGFs	Actions
085641	2023-10-04 18:15:28	2023-10-04 20:09:35	133	0	4	0	0	Orbit Trend · Triggers · GRB · GRBlike · STE · TGF
085640	2023-10-04 15:29:04	2023-10-04 18:14:42	59	0	1	0	0	Orbit Trend · Triggers · GRB · GRBlike · STE · TGF
085638	2023-10-04 13:34:06	2023-10-04 15:29:04	123	0	3	0	0	Orbit Trend · Triggers · GRB · GRBlike · STE · TGF
085637	2023-10-04 11:24:19	2023-10-04 12:29:22	65	0	0	0	0	Orbit Trend · Triggers · GRB · GRBlike · STE · TGF
085635	2023-10-04 09:05:05	2023-10-04 10:57:36	96	0	1	0	0	Orbit Trend · Triggers · GRB · GRBlike · STE · TGF

Automatic Solar monitoring:



AGILE Science Alert pipeline (GW S230928cb - BBH 99%):

Instrument	LIGO
Triggerid_seqnum	2309280302_2
Coordinates (l,b):	0 , 0
Event T0 (UTC)	2023-09-28T21:58:27.000
Event T0 (MJD)	60215.915590278
Event T0 (TT)	623023107

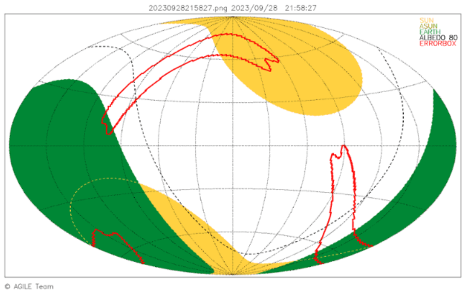
Event ID:	S230928cb
Significant:	1
BNS/NSBH/BBH:	0 / 0 / 0.99
FAR:	9.5e-10
Has NS:	0.0
Has Remnant:	0.0
Mass Gap:	0.0

Show Contour

Archive Status

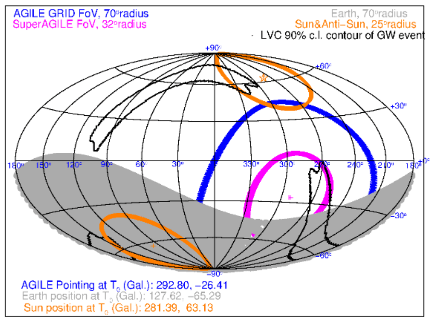
MCAL Coverage COR-3916	2023-10-04 20:24:20.000 UTC -- DeltaT: +512753 s
MCAL-3908 last trigger	2023-10-04 20:09:36.987 UTC -- DeltaT: +511869.987 s
GRID-EVT-coverage	2023-10-04 20:24:14.000 UTC -- DeltaT: +512747 s
LOG	2023-10-04 20:24:13.900 UTC -- DeltaT: +512746.9 s
COR-3913	2023-10-04 20:24:29.092 UTC -- DeltaT: +512762.092 s
SA-3905	2022-05-28 07:40:59.431 UTC -- DeltaT: -42214647.569 s
Next MCAL @BO	2023-10-5 2:43:49 AM UTC
Next GRID @BO	2023-10-5 2:48:49 AM UTC

Visibility (Prevision)

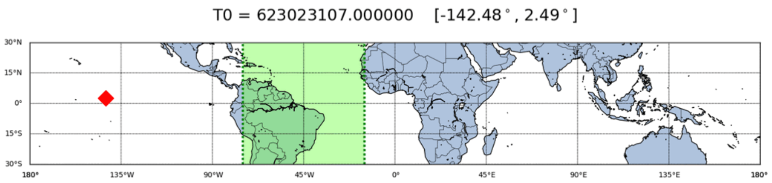


Visibility (Data)

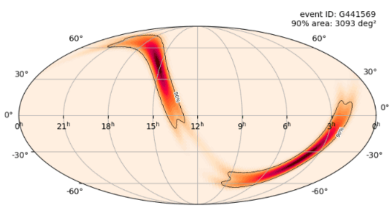
Trigger time T_0: 2023-09-28 21:58:27.00000 (Δt=4.00s)



GEO LOC

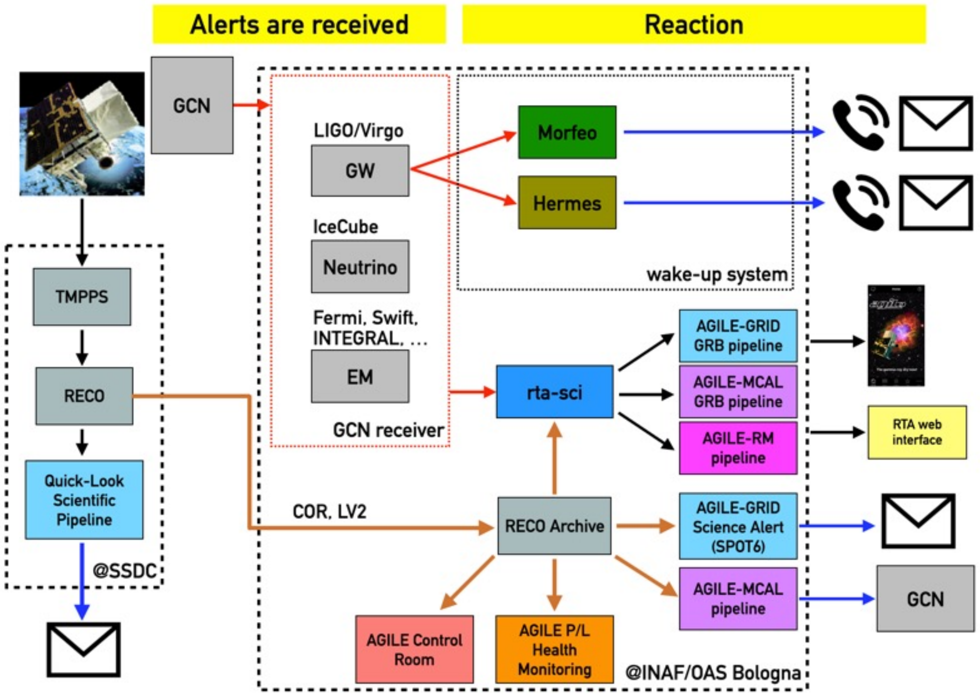


Ligo Sky Map



(still waiting for the "next GW170817"....)

AGILE Fast Real-Time Analysis



- Distributed alert system between SSDC e INAF-OAS Bologna
- Automatic AGILE data analysis (GRID, MCAL, Ratemeters)
- **Fast reaction to external alerts** (GCN, e.g. GRB, neutrinos, GW, ...)
- **Internal automatic alert generation** (via email, SMS) and direct connection with the GCN network for MCAL notices.
- Development of similar pipelines starting from the AGILE **heritage for new missions** such as COSI, Gamma-FLASH, CTA ...

PhD Nicolò Parmiggiani: National award for research on big data and artificial intelligence 2021!

- Parmiggiani, N. et. al.: "The RTApipe framework for the gamma-ray real-time analysis software development", Astronomy and Computing. Volume 39, 2022, https://doi.org/10.1016/j.ascom.2022.100570
- Parmiggiani, N. et. al.: "The AGILE real-time analysis software system to detect short-transient events in the multi-messenger era", Astronomy and Computing. Volume 44, 2023, https://doi.org/10.1016/j.ascom.2023.100726

AGILE main results
and work in progress

Summary of AGILE results in >16 years of operations

- **Publications:** the scientific production of the AGILE Team consists of **> 800 bibliographic references in ADS, of which> 160 refereed articles.**
- The monitoring of the gamma sky with a rapid and efficient alert system led to the publication of **> 230 ATel** and **>200 GCN**. From May 2019, **> 80 MCAL GCN automatic notices** have been published.

- The Quick Look system developed by INAF-OAS, distributed between the data center at SSDC and INAF-OAS in Bologna, produces **scientific results within ~ 25 min** from the data downlink to the ASI Malindi ground station: an absolute record for gamma astrophysics. The Team has also developed **AGILEScience - App on Google Play and App Store** to monitor and follow the observations of the AGILE satellite on mobile devices.

- **AGILE and the search for GW counterparts:** participation of Team members with shifts 24/7 during LIGO-VIRGO observational runs. AGILE follow-up of all **pre-O4 GW events**, with **96 GW-AGILE type GCNs published during O3** and collected in a dedicated web page in SSDC**:** *https://agile.ssdc.asi.it/news_gw.html*

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

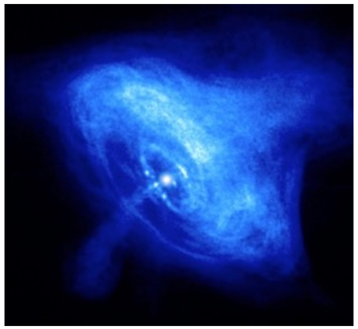
Main AGILE-led publications in descending order of citation in ADS

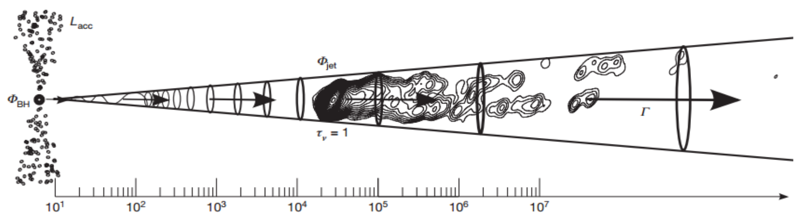
Therefore, neither important MW and MM publications nor the most recent ones are included in this list

#	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	**The AGILE Mission**
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	**Cyg X-3 mQSO flares, *Nature***
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	**CR acceleration in SNR W44**
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	**TGFs as powerful p.cle accelerators**
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	**HE TGFs seen by AGILE-MCAL**
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	**SuperAGILE X-ray Imager on AGILE**
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	**The 1AGL Catalog**
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	**CR acceleration in SNR IC443**
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	**MWL analysis of flaring blazar Mrk 421**

AGILE scientific 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**



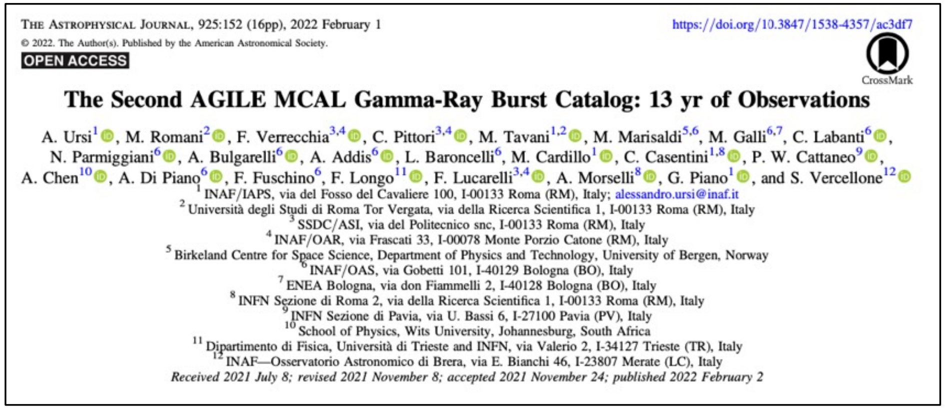


"The AGILE Mission and Its Scientific Results", M. Tavani, C. Pittori and F. Longo (2023),
Handbook of X-ray and Gamma-ray Astrophysics. Bambi, C., Santangelo, A. (eds), Springer, Singapore
https://link.springer.com/referenceworkentry/10.1007/978-981-16-4544-0_57-1

Updates on AGILE and GRBs

AGILE MCAL second GRB catalog

- Comprehensive catalog of all GRB detected by MCAL from 2007 to 2020 (*Ursi et al., ApJ 925, 2022*)


The Astrophysical Journal, 925:152 (16pp), 2022 February 1 https://doi.org/10.3847/1538-4357/ac3df7
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OPEN ACCESS

The Second AGILE MCAL Gamma-Ray Burst Catalog: 13 yr of Observations

A. Ursi[1], M. Romani[2], F. Verrecchia[3,4], C. Pittori[3,4], M. Tavani[1,2], M. Marisaldi[5,6], M. Galli[6,7], C. Labanti[6], N. Parmiggiani[6], A. Bulgarelli[6], A. Addis[6], L. Baroncelli[6], M. Cardillo[1], C. Casentini[1,8], P. W. Cattaneo[9], A. Chen[10], A. Di Piano[6], F. Fuschino[6], F. Longo[11], F. Lucarelli[3,4], A. Morselli[8], G. Piano[1], and S. Vercellone[12]
[1] INAF/IAPS, via del Fosso del Cavaliere 100, I-00133 Roma (RM), Italy; alessandro.ursi@inaf.it
[2] Università degli Studi di Roma Tor Vergata, via della Ricerca Scientifica 1, I-00133 Roma (RM), Italy
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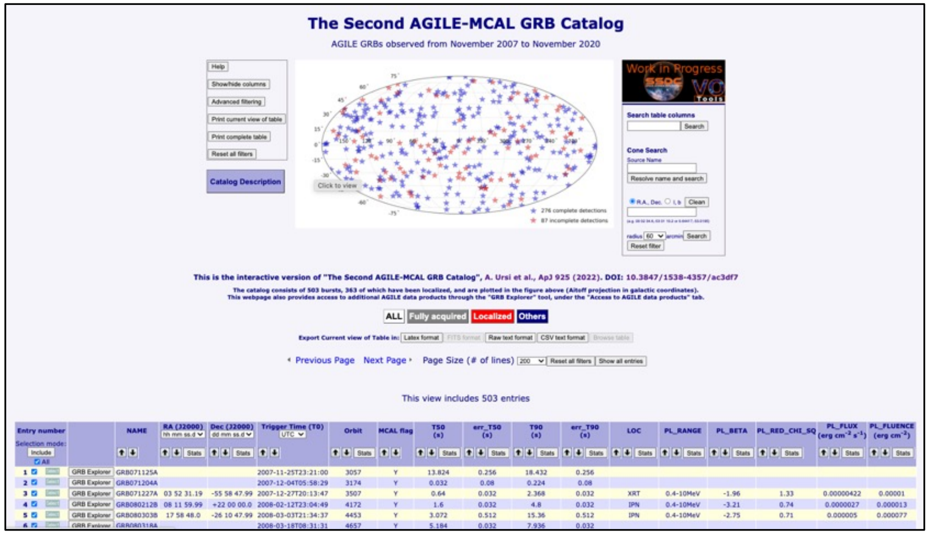
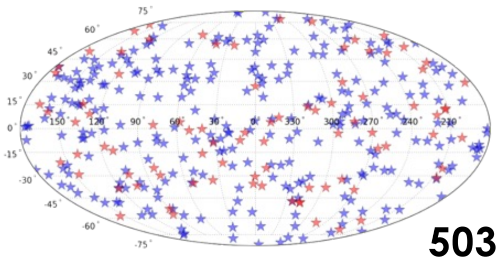
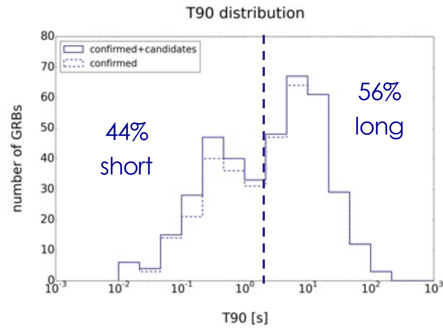
[8] INFN Sezione di Roma 2, via della Ricerca Scientifica 1, I-00133 Roma (RM), Italy
[9] INFN Sezione di Pavia, via U. Bassi 6, I-27100 Pavia (PV), Italy
[10] School of Physics, Wits University, Johannesburg, South Africa
[11] Dipartimento di Fisica, Università di Trieste and INFN, via Valerio 2, I-34127 Trieste (TR), Italy
[12] INAF—Osservatorio Astronomico di Brera, via E. Bianchi 46, I-23807 Merate (LC), Italy
Received 2021 July 8; revised 2021 November 8; accepted 2021 November 24; published 2022 February 2

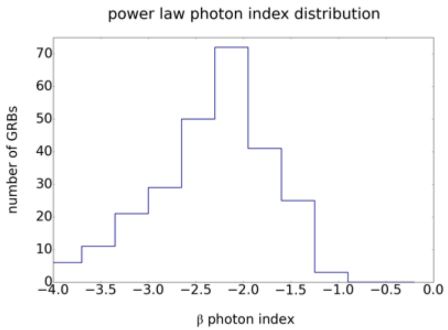


SSDC interactive web page
https://www.ssdc.asi.it/mcal2grbcat/



503 GRBs





Spectra mostly fittable with power-laws (high-energy tail of the spectra in MCAL band)

GRB 190114C

First GRB event detected at very high-energies by MAGIC!!

- participation to the multi-frequency paper [*MAGIC Collaboration, Nature, 2019*]
- dedicated analysis of the prompt phase with AGILE and Konus-Wind data [*Ursi et al., ApJ, 2020*]

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Article | Published: 20 November 2019

Observation of inverse Compton emission from a long γ-ray burst

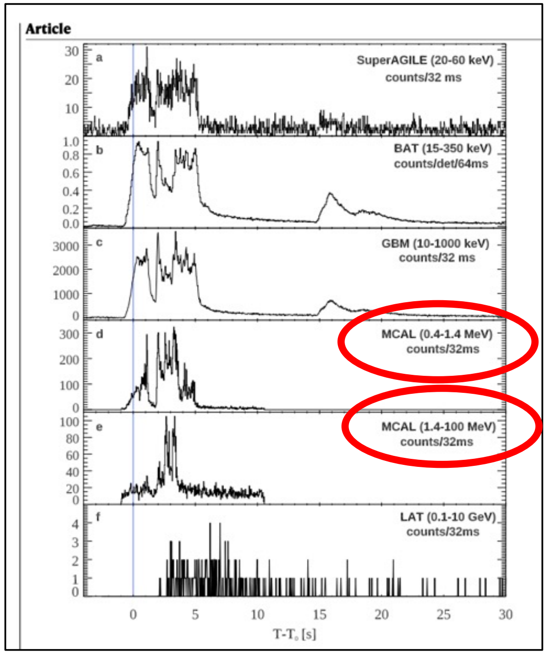
MAGIC Collaboration, P. Veres, ... D. R. Young + Show authors

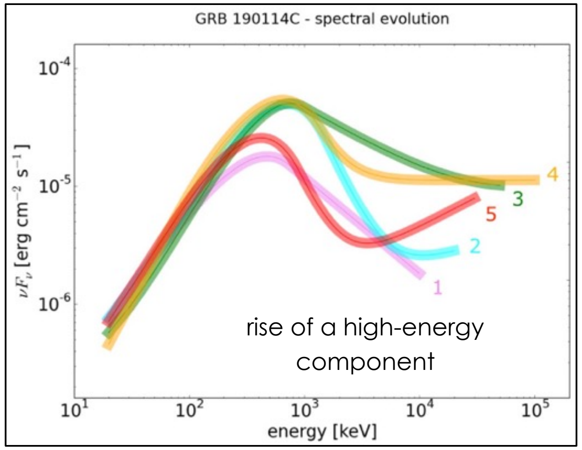
Nature 575, 459–463 (2019) | Cite this article

10k Accesses | 91 Citations | 821 Altmetric | Metrics

Abstract

Long-duration γ-ray bursts (GRBs) originate from ultra-relativistic jets launched from the collapsing cores of dying massive stars. They are characterized by an initial phase of bright





The Astrophysical Journal, 904:133 (17pp), 2020 December 1
https://doi.org/10.3847/1538-4357/abc2d4
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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], G. Barbiellini[8], P. Caraveo[9,10], M. Cardillo[1], C. Casentini[1], P. W. Cattaneo[10], A. Chen[11], E. Costa[1], I. Donnarumma[12], Y. Evangelista[1], M. Feroci[1], A. Ferrari[13], F. Fuschino[7], M. Galli[7,14], A. Giuliani[9], C. Labanti[7], F. Lazzarotto[15], F. Longo[8], F. Lucarelli[4,5], A. Morselli[16], F. Paoletti[1,17], N. Parmiggiani[7], G. Piano[1], M. Pilia[18], C. Pittori[4,5], D. S. Svinkin[3], A. Trois[18], A. E. Tsvetkova[3], S. Vercellone[19], and V. Vittorini[1]
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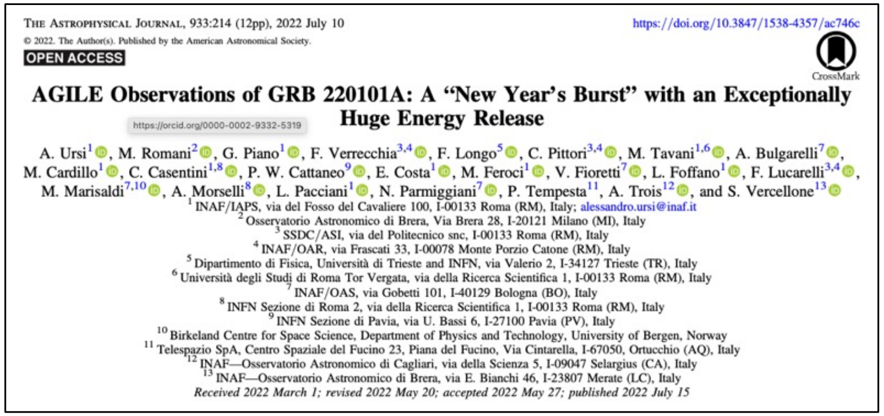
New Year’s Burst GRB 220101A

Event with the highest E_{iso} ever detected up to Jan 2022

• analysis of the prompt phase using AGILE ratemeters data [*Ursi et al., ApJ, 2022d*]


THE ASTROPHYSICAL JOURNAL, 933:214 (12pp), 2022 July 10
https://doi.org/10.3847/1538-4357/ac746c
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AGILE Observations of GRB 220101A: A “New Year’s Burst” with an Exceptionally Huge Energy Release

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Received 2022 March 1; revised 2022 May 20; accepted 2022 May 27; published 2022 July 15


TRA LE COSTELLAZIONI DI PEGASO E DI ANDROMEDA

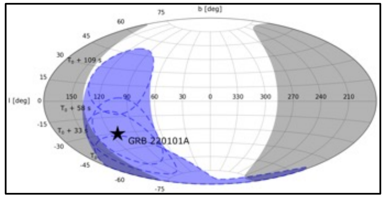
Capodanno col botto: visto un Grb da record

Ha viaggiato per oltre 12 miliardi di anni, è arrivato sulla Terra all’alba del primo gennaio ed è uno dei lampi di raggi gamma più potenti e lunghi mai registrati. Fra i primi strumenti al mondo a intercettarne e caratterizzarne il segnale, quelli a bordo del telescopio spaziale “made in Italy” Agile e quelli dei telescopi dell’Osservatorio di Asiago dell’Inaf di Padova. Ne parliamo con due fra i protagonisti dell’osservazione, Alessandro Ursi e Lina Tomasella dell’Inaf

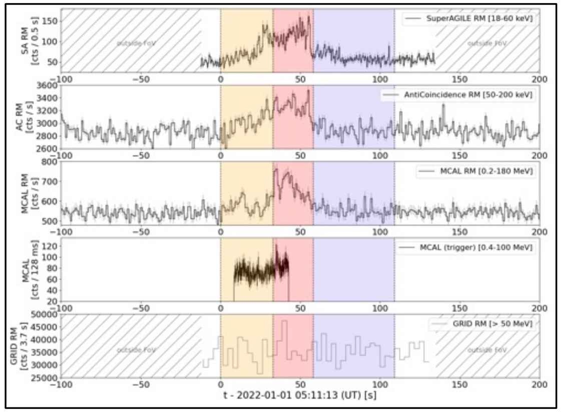
Marco Malaspina 03/01/2022 Tweet Condividi 1321

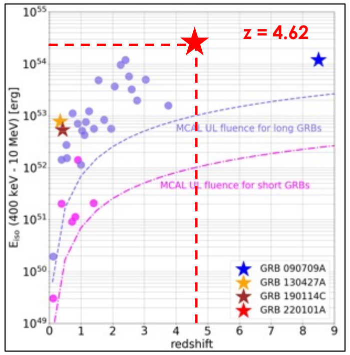
news on Media INAF

fully inside the AGILE FoV
for most of the duration
of the prompt phase



news on ASI website



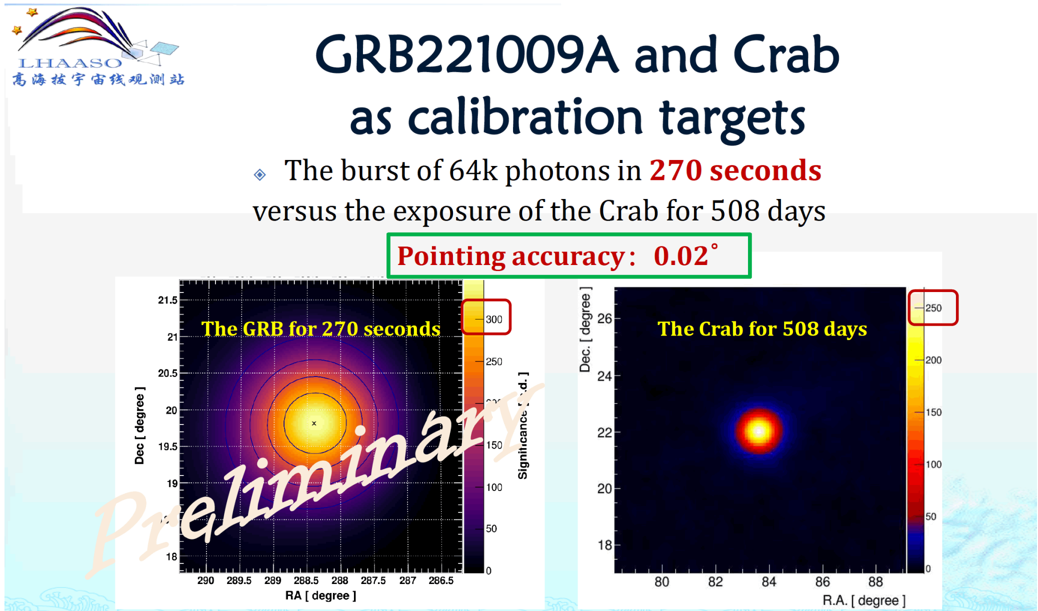


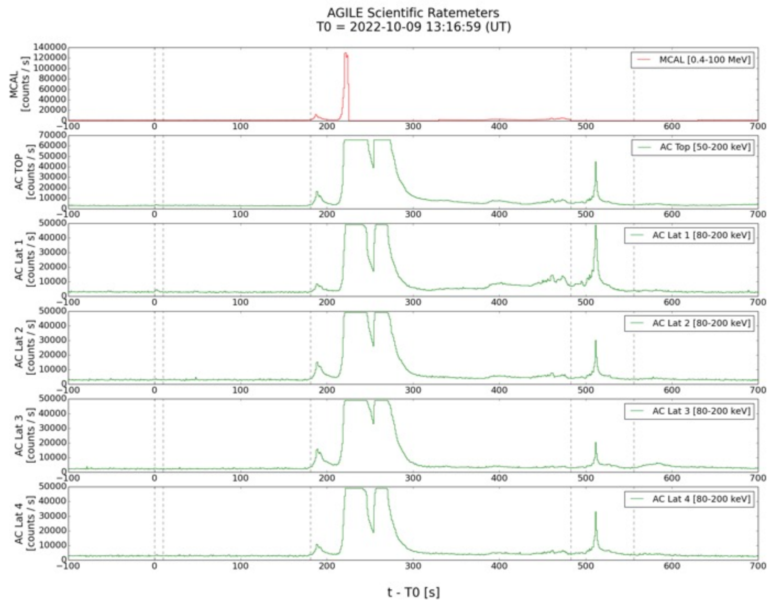
Gamma-ray Detection by AGILE of the exceptional GRB 221009A

Tavani et al. 2023, to appear in **ApJL**, *http://arxiv.org/abs/2309.10515*

The BOAT = Brightest Of All Time. Distance of 750 Mpc (z=0.15095)

LHAASO: first detection of photons **above 10 TeV** from GRBs (GCN #32677):





2022 October 9, T0 =13:16:59.00 UT

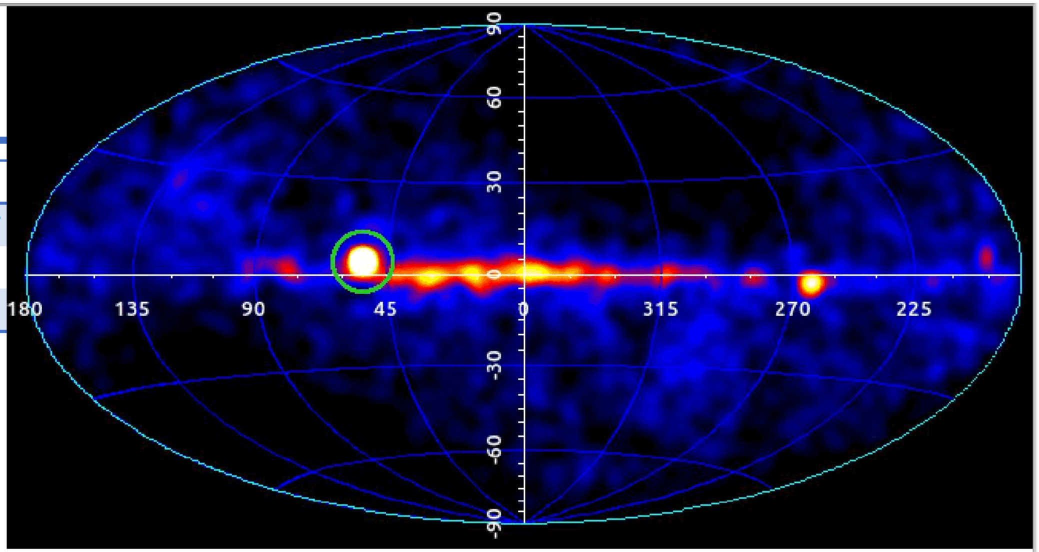
Saturated AGILE RM (GCN #32650)

AGILE observations provide crucial flux and spectral gamma-ray information regarding the early phases of GRB 221009A during which emission in the TeV range was reported.

GRB 221009 A: The BOAT

- T0=2022-10-09 13:16:59.99 UTC
- Fluence [20 keV-10 MeV]: $> 5 \cdot 10^{-2}\ {erg}/{cm^2}$
- Redshift = 0.15095 ± 0.00005 [D ≈750 Mpc]

Coords	GRB 221009 A
Equat.	19^h13^m, 19°47’
Equat.	288.3, 19.8
Galactic	53.0, 4.3

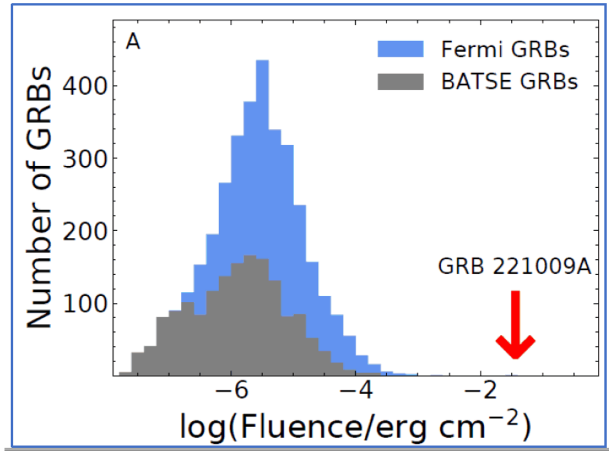


24h AGILE-GRID Intensity Map
Credits: Tavani et al. (2023)

Observations

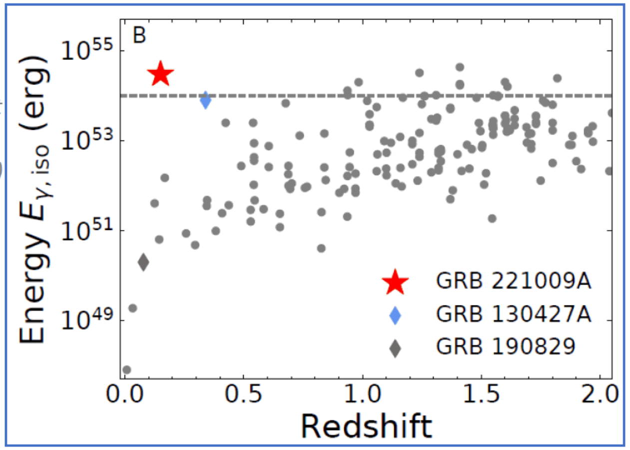
- Detected at *keV/MeV/GeV* by Swift, AGILE, Fermi…
- *X-ray* Prompt emission scattering in Galactic dust clouds caused *Rings* visible for weeks
- Detected by LHAASO up to *18 TeV*!!!
- No *neutrino* counterpart
- *Optical* and *IR* detection of afterglow

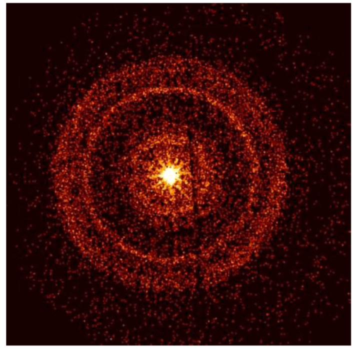
Swift-XRT: GRB 221009A
X-ray Rings. Map: [0.5°x0.5°]
Credits: Tiengo et al. (2023)



Left
Fluence [10-1000] keV distribution of Fermi-GBM detected GRBs.
Credits: O’Connor et al. (2023)

Right
Energy vs Redshift of long GRBs.
Credits: O’Connor et al. (2023)

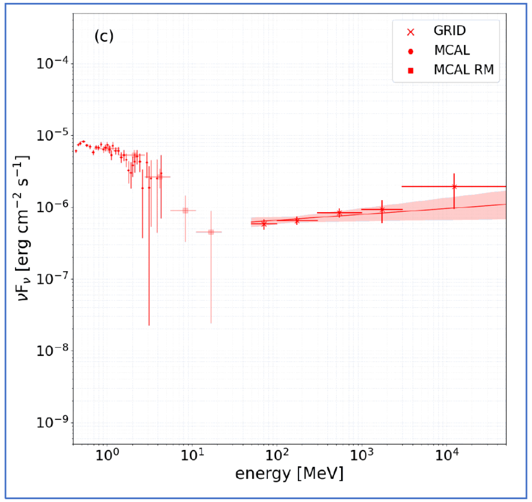




Adapted from G. Panebianco

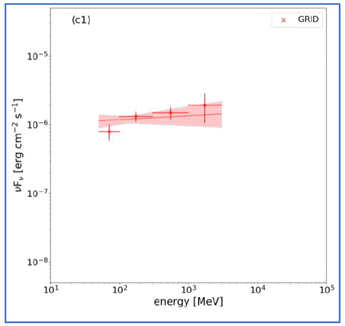
Spectral Analysis: Prompt + Early Afterglow

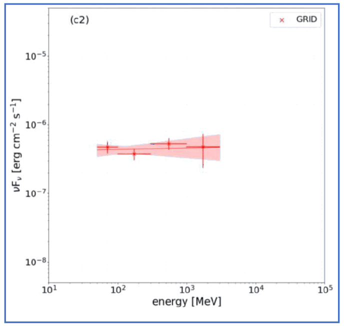
Tavani et al. (2023)



C) MAIN GAMMA EMISSION: 1st GRID WINDOW

- **Two different components coexist: peculiarity of GRB 221009 A**
- MCAL MeV emission: Prompt, Synchrotron
- GRID GeV emission: Early Afterglow, Inverse Compton





Time window	Time interval [s,s]	Energy range [GeV]	Detection Significance	Photon Index	Photon Flux [ph s^{-1} cm^{-2}]	Source counts
C	[273 ÷ 383]	[0.050 ÷ 50]	46.1 σ	1.92 ± 0.06	(8.4 ± 0.6) · 10^{-3}	206 ± 16
C1	[273 ÷ 303]	[0.050 ÷ 3]	32.7 σ	1.9 ± 0.1	(1.5 ± 0.2) · 10^{-2}	206 ± 16
C2	[303 ÷ 383]	[0.050 ÷ 3]	32.2 σ	2.0 ± 0.1	(5.4 ± 0.6) · 10^{-3}	206 ± 16

Adapted from G. Panebianco

Transition between prompt and afterglow emission with a **phase of coexistence of MeV and GeV emissions**
Maybe two different emitting regions:

- An inner, probably optically thick region -> Synchrotron
- An optically thin, relativistically expanding region -> Inverse Compton

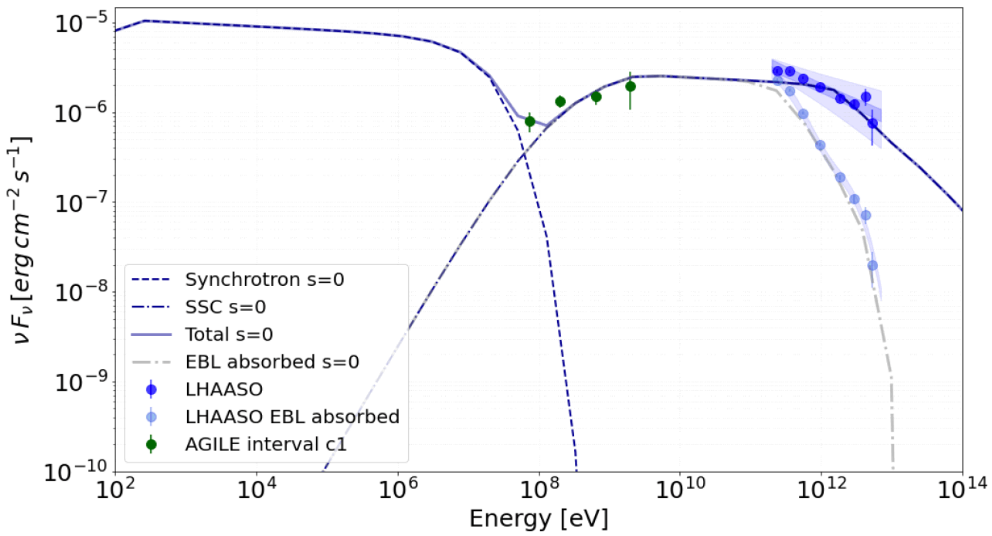
GRB afterglow modeling

How do AGILE data constrain the modeling?

Results being published
Foffano+

- We show here the GRB evolution in a reasonable scenario in a constant density medium s = 0
- A complete set of MWL information is essential for a comprehensive quantitative treatment of GRB 221009A (e.g., GRB 190114C [MAGIC+19])
- The AGILE-GRID data and LHAASO data are well described by IC emission of the afterglow of GRB 221009A in the considered time interval.
- A comprehensive exploration of the model fully applied to the data will be addressed in an upcoming publication [Foffano+ , in preparation]

Energy [erg]	Gamma_0	s	n_0 / A*	p	ee	eb	Event	time_start [s]	time_end [s]
1.5e+55	700	0	0.65	2.08	0.05	0.002	GRB221009A	22	100



Slide from L. Foffano @ TeVPA2023

Deep Learning for AGILE GRB detection

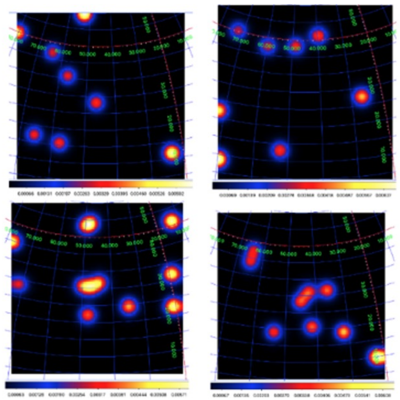
- **Deep Learning technologies** to detect GRBs in the data (time series and sky maps) acquired by the detectors on board the AGILE space missions.

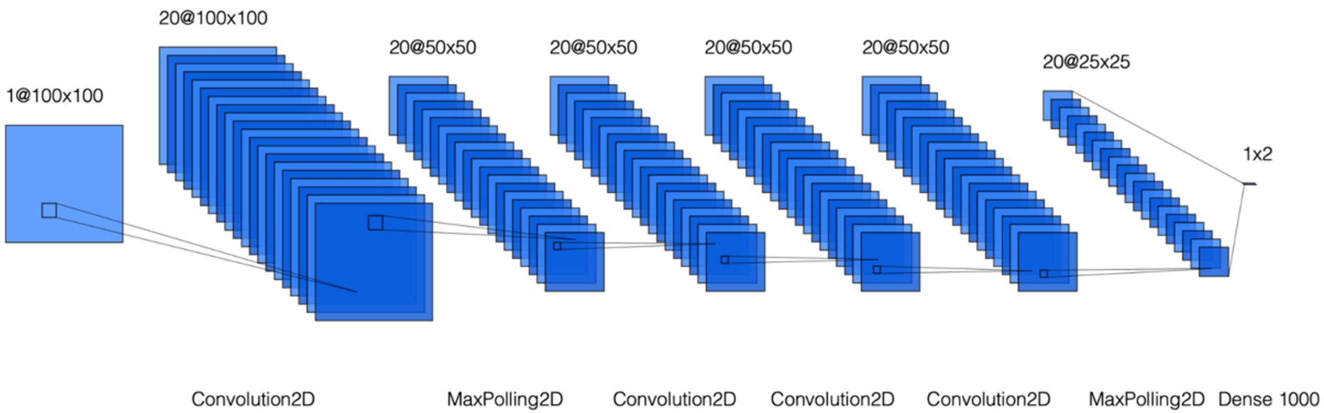
- Convolutional Neural Network (CNN) to detect GRBs inside the AGILE Gamma-Ray Imaging Detector (GRID) counts maps when an external science alert is received.

- The CNN detected 21 GRBs in the AGILE/GRID data with a sigma > 3 from the list of GRBs obtained with Fermi and Swift catalogs outperforming the Li&Ma on the same list and with the same parameters:
  - Parmiggiani N., Bulgarelli A., Fioretti V. et al., “A Deep Learning Method for **AGILE/GRID Gamma-ray Bursts detection**”, ApJ, 914, (2021)

- **New paper:** Parmiggiani N., Bulgarelli A., Fioretti V. et al., "A Deep-learning Anomaly-detection Method to Identify **Gamma-Ray Bursts in the Ratemeters of the AGILE Anticoincidence System**", ApJ, 945, (2023)

- Ongoing applications to GRB localization from GRID sky maps





Flaring sources above 100 MeV

The AGILE-GRID Transient Catalog

Search for GRID transient detections over the whole sky and the whole *AGILE* lifetime using the LV3 Archive as input

The AGILE-LV3 "*post-look*" PIPELINE (E>100 MeV):

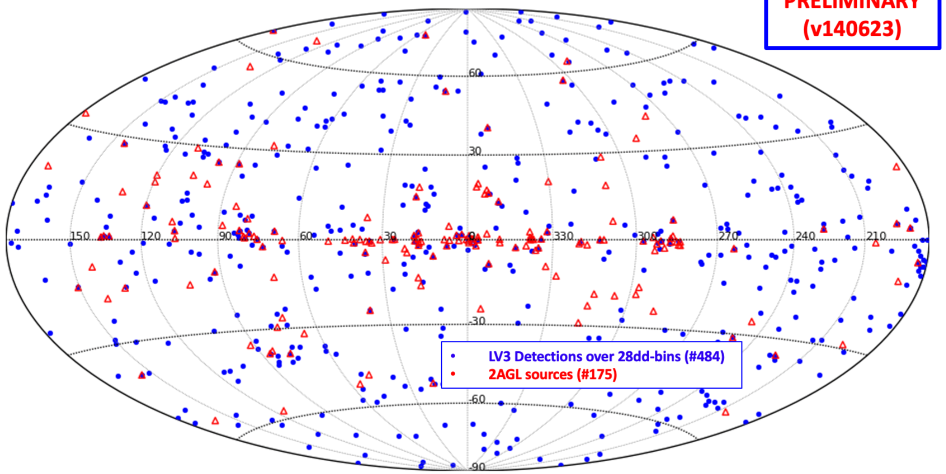
① Blind search on the LV3 count and exposure maps over different time intervals (4-, 7-, and 28-days) using XIMAGE *detect*.

② Evaluate the *detect* excess positions found in the LV3 maps with the AGILE Maximum Likelihood (ML) **using 2AGL as reference catalogue**.

③ LV3PIPE output (ascii format) analyzed with Python and Pandas libraries to extract the most significant detections.

F. Lucarelli, C. Pittori et al., in progress

PRELIMINARY (v140623)

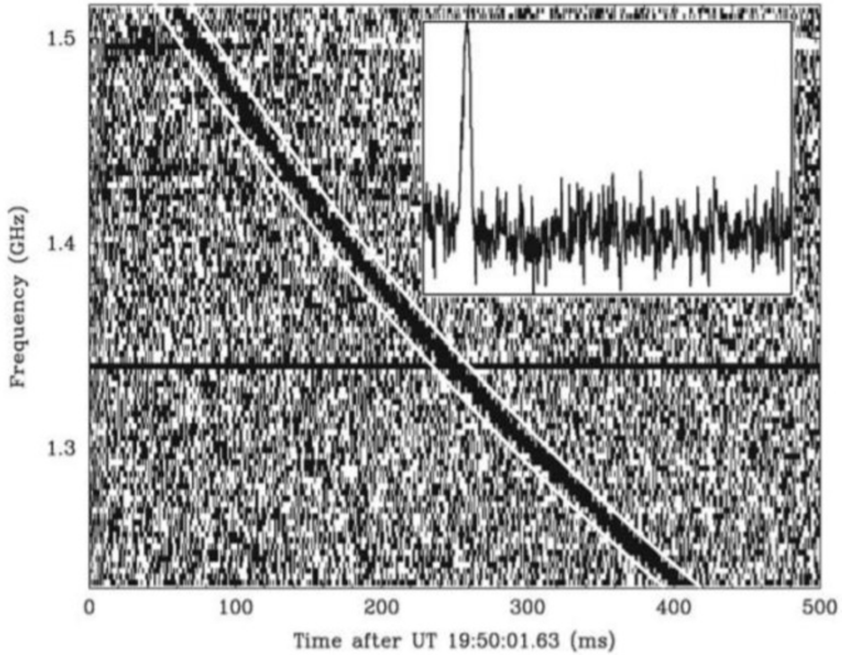


All-sky Aitoff map with LV3-detections over 28-days integration bins. Period: Pointing+Spinning (2007-2020)

- **> 480 source detections (σ>4) on the 28-day time-bins.**
- **> 70% not associated with the 2AGL Catalogue (Pointing period 2007-2009 only).**
- **Other time-bins (7, 4 dd) in evaluation. Cross-match with Fermi catalogs ongoing.**

AGILE and FRB

Fast Radio Bursts (FRB)

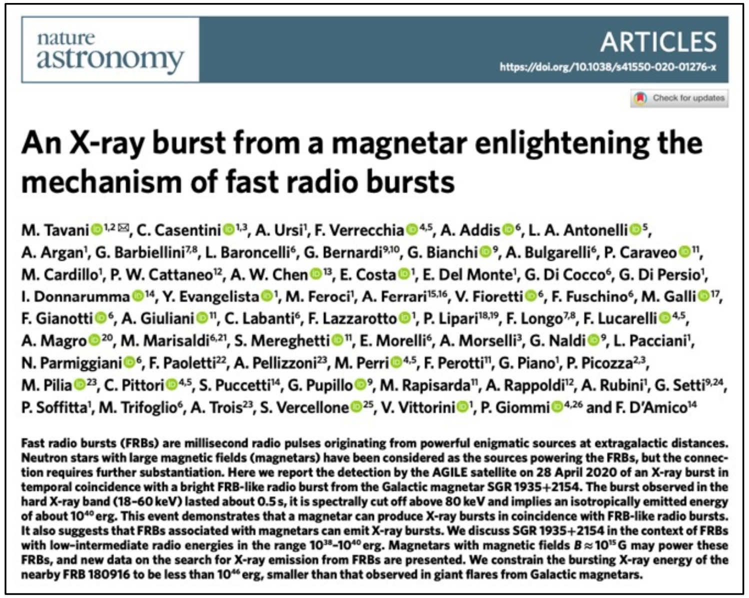


FRBs are millisecond radio pulses originating from powerful enigmatic extragalactic sources. **Magnetars** (neutron stars with large magnetic fields) are considered as **possible** candidate sources powering the FRBs. **Important detection by AGILE** on April 28, 2020: an X-ray burst in temporal coincidence with a bright **FRB-like** radio burst from the **Galactic** magnetar SGR 1935+2154. Support to magnetar models.

FRB200428 from SGR 1935+2154

First correlation between an FRB-like radio burst and an X-ray flare from SGR

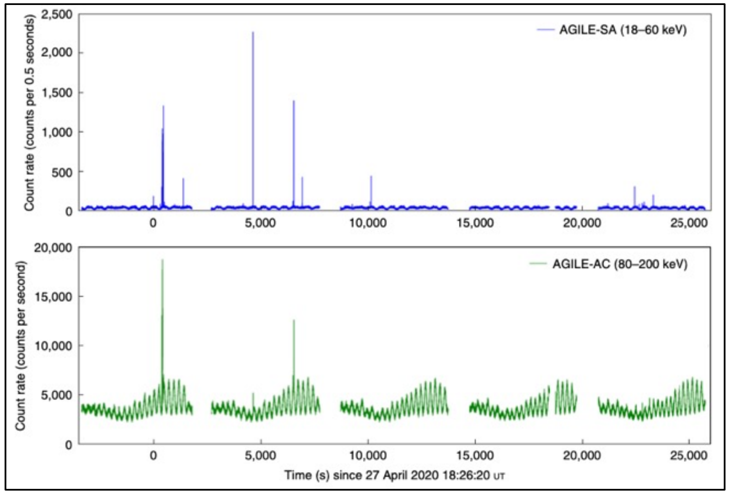
Analysis of the X-ray flare detected by the SuperAGILE ratemeters [*Tavani et al., Nature, 2020*]

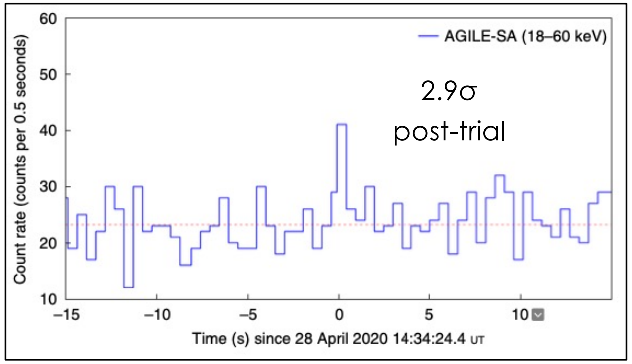

nature astronomy
ARTICLES
https://doi.org/10.1038/s41550-020-01276-x
Check for updates

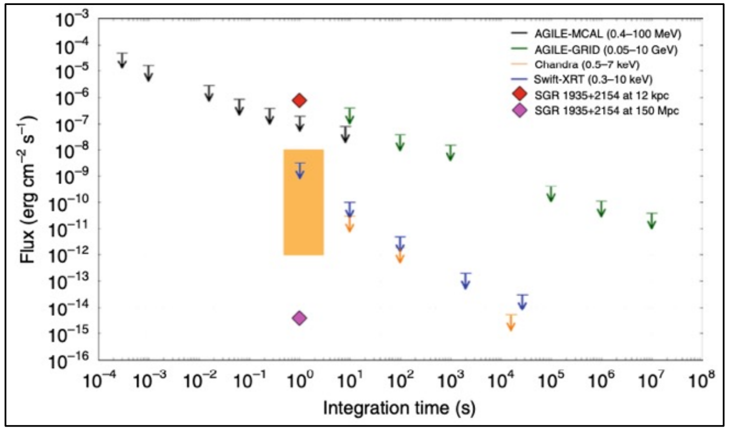
An X-ray burst from a magnetar enlightening the mechanism of fast radio bursts

M. Tavani[1,2], C. Casentini[1,3], A. Ursi[1], F. Verrecchia[4,5], A. Addis[6], L. A. Antonelli[5], A. Argan[1], G. Barbiellini[7,8], L. Baroncelli[6], G. Bernardi[9,10], G. Bianchi[9], A. Bulgarelli[6], P. Caraveo[11], M. Cardillo[1], P. W. Cattaneo[12], A. W. Chen[13], E. Costa[1], E. Del Monte[1], G. Di Cocco[6], G. Di Persio[1], I. Donnarumma[14], Y. Evangelista[1], M. Feroci[1], A. Ferrari[15,16], V. Fioretti[6], F. Fuschino[6], M. Galli[17], F. Gianotti[6], A. Giuliani[11], C. Labanti[6], F. Lazzarotto[1], P. Lipari[18,19], F. Longo[7,8], F. Lucarelli[4,5], A. Magro[20], M. Marisaldi[6,21], S. Mereghetti[11], E. Morelli[6], A. Morselli[3], G. Naldi[9], L. Pacciani[1], N. Parmiggiani[6], F. Paoletti[22], A. Pellizzoni[23], M. Perri[4,5], F. Perotti[11], G. Piano[1], P. Picozza[2,3], M. Pilia[23], C. Pittori[4,5], S. Puccetti[14], G. Pupillo[9], M. Rapisarda[11], A. Rappoldi[12], A. Rubini[1], G. Setti[9,24], P. Soffitta[1], M. Trifoglio[6], A. Trois[23], S. Vercellone[25], V. Vittorini[1], P. Giommi[4,26] and F. D'Amico[14]

Fast radio bursts (FRBs) are millisecond radio pulses originating from powerful enigmatic sources at extragalactic distances. Neutron stars with large magnetic fields (magnetars) have been considered as the sources powering the FRBs, but the connection requires further substantiation. Here we report the detection by the AGILE satellite on 28 April 2020 of an X-ray burst in temporal coincidence with a bright FRB-like radio burst from the Galactic magnetar SGR 1935+2154. The burst observed in the hard X-ray band (18–60 keV) lasted about 0.5 s, it is spectrally cut off above 80 keV and implies an isotropically emitted energy of about 10^{40} erg. This event demonstrates that a magnetar can produce X-ray bursts in coincidence with FRB-like radio bursts. It also suggests that FRBs associated with magnetars can emit X-ray bursts. We discuss SGR 1935+2154 in the context of FRBs with low–intermediate radio energies in the range 10^{38}–10^{40} erg. Magnetars with magnetic fields $B \approx 10^{15}$ G may power these FRBs, and new data on the search for X-ray emission from FRBs are presented. We constrain the bursting X-ray energy of the nearby FRB 180916 to be less than 10^{46} erg, smaller than that observed in giant flares from Galactic magnetars.







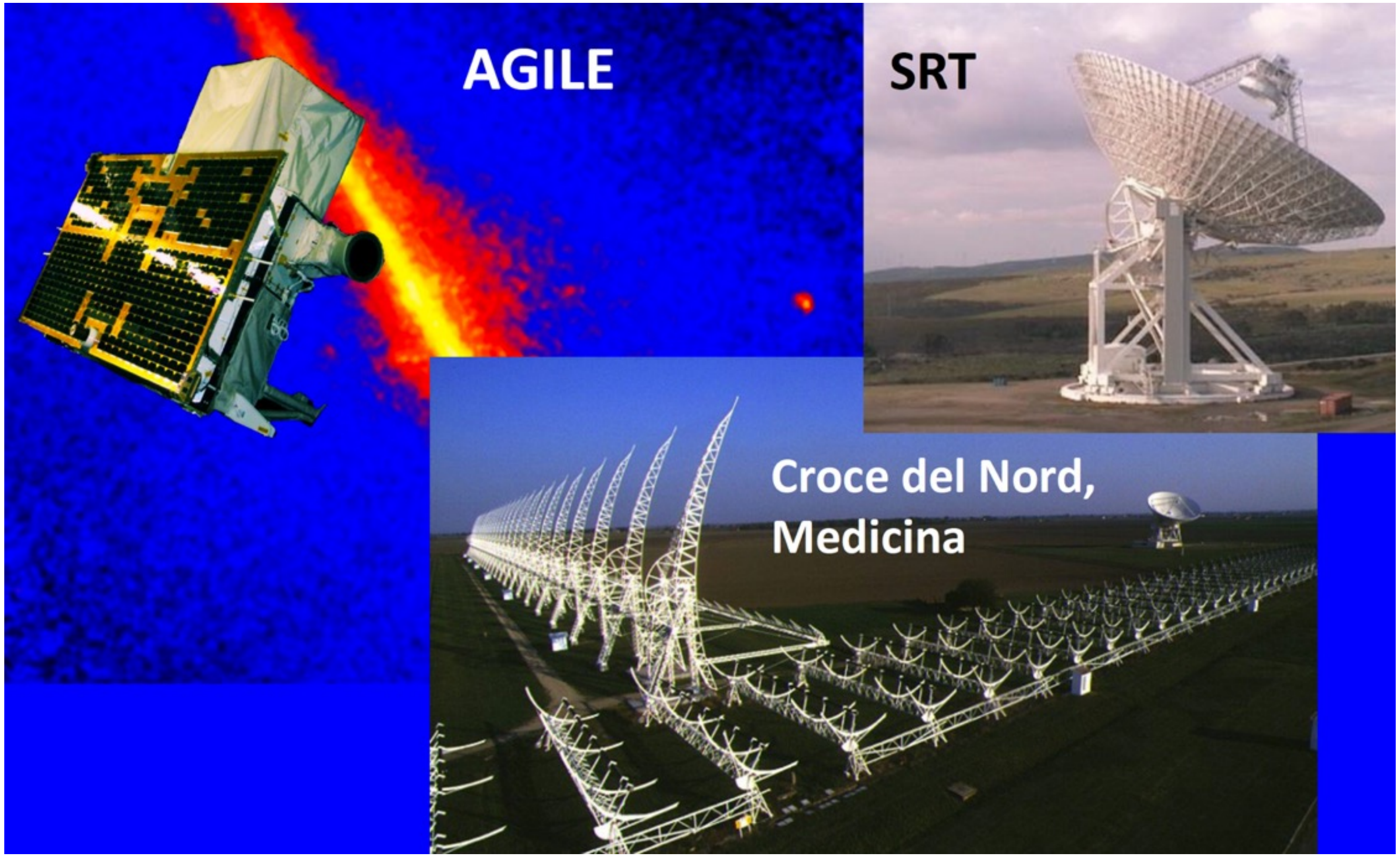
AGILE FRB studies

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*	✓	-	✓	-

5 published AGILE papers on FRB science up to now:

1. Casentini et al., ApJL 2020: paper on two low IGM-DM repeaters, FRB180916.J0158+65 and FRB181030.J1054+73
2. Tavani et al., ApJL 2020: paper on the periodic R-FRBs: FRB20180916B. MW campaign with all AGILE detectors and Swift
3. Pilia et al., ApJL 2020, SRT Collaboration Paper on the periodic FRB 180916 : The Lowest-frequency Fast Radio Bursts at 328 MHz
4. Nature Astronomy: "**An X-ray burst from a magnetar enlightening the mechanism of fast radio bursts", Tavani et al. 2021,** about SGR1935+2154 X-ray/radio flare
5. Verrecchia et al., ApJ 2021: paper on general search of HE counterpart in the AGILE data from sources in FRBCAT and TNS catalogues (89 sources included, 10 R-FRB)

Monitoring campaigns on specific FRB repeaters and SGRs in progress:



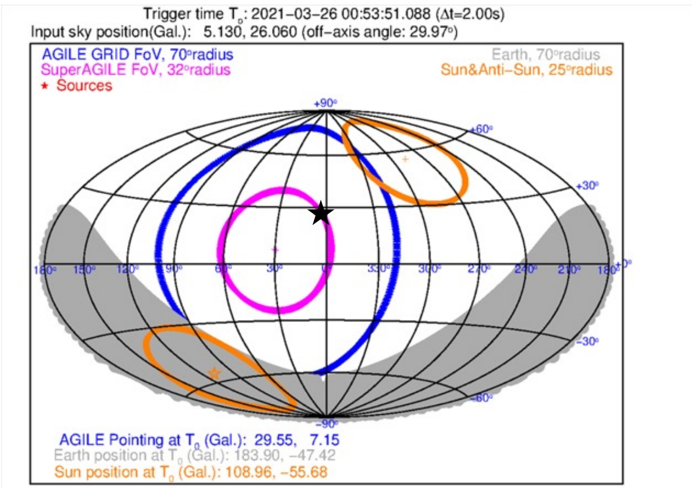
"Simultaneous and panchromatic observations of the Fast Radio Burst FRB 20180916B",
M. Trudu et al., **A&A 676**, A17 (2023)

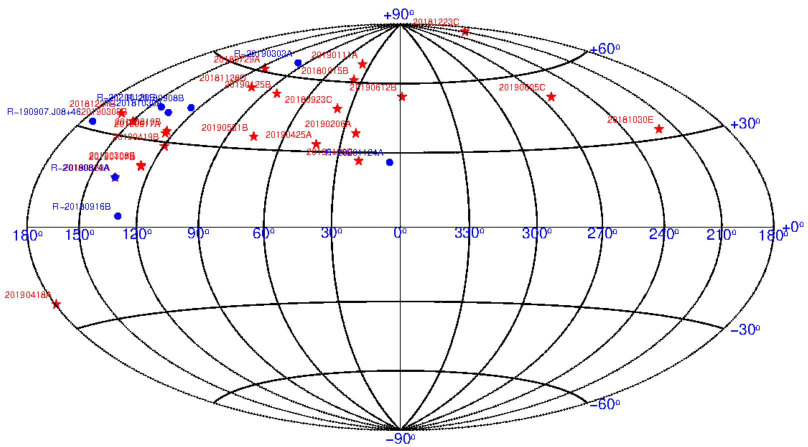
AGILE FRBs studies: update in progress

F. Verrecchia F., C. Casentini, A. Ursi, M. Tavani

After the pubblication of the 1° CHIME/FRB radio catalogue in 2021, a paper on the update of the general search for HE emission in the AGILE data is in preparation.

- **Casentini et al., in progress**: paper on updated general search of HE counterparts in the AGILE data from sources in TNS and CHIME/FRB updated catalogues, selecting only those having DM_IGM <= 200 pc cm^-3 => **31 sources included, 8 R-FRB**





AGILE and Neutrinos

IC-170922 MWL detections

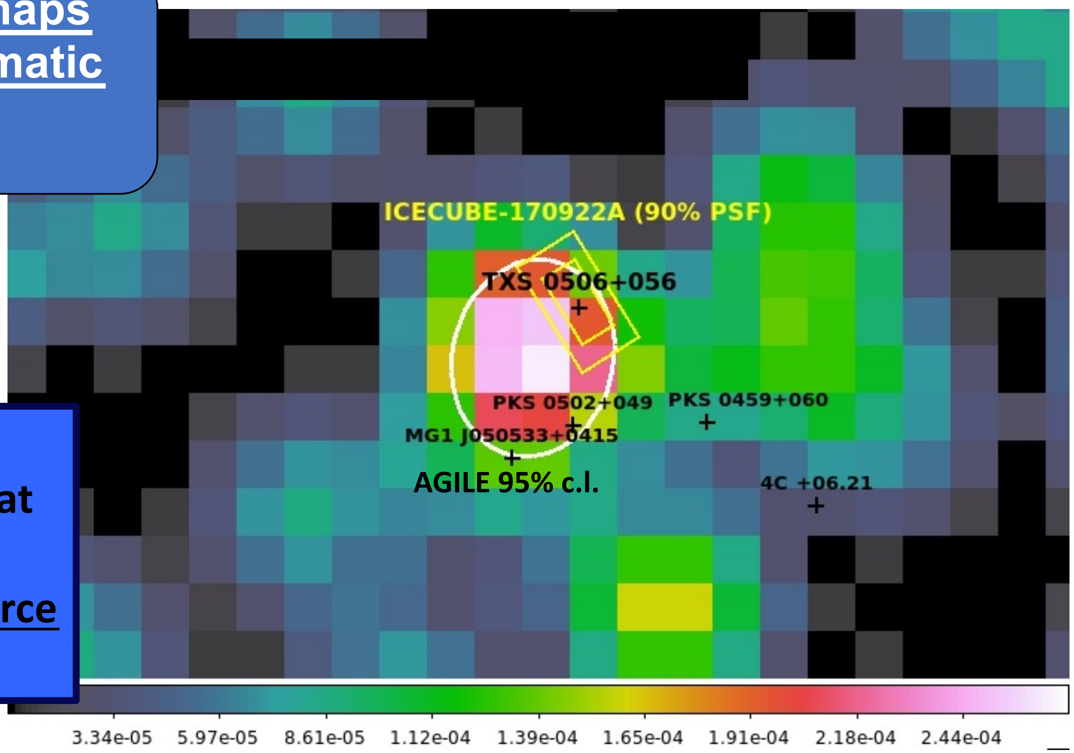
- EHE IceCube event announced on Sept. 22, 2017
- R.A., Decl. (J2000): (77.43, 5.72) deg
- HE γ-rays observed **both by AGILE and Fermi-LAT** consistent with the IceCube error box (ATels #10791 and #10801)
- VHE γ-rays observed by **MAGIC** a few days after the neutrino event T0 (ATel #10817)

The blazar TXS 0506+056 (also known as a 3FGL and 3FHL source) inside the IceCube error region
→ Identification as the IC-170922 neutrino emitter

"Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A", Science 361, 2018

AGILE observation of IC-170922

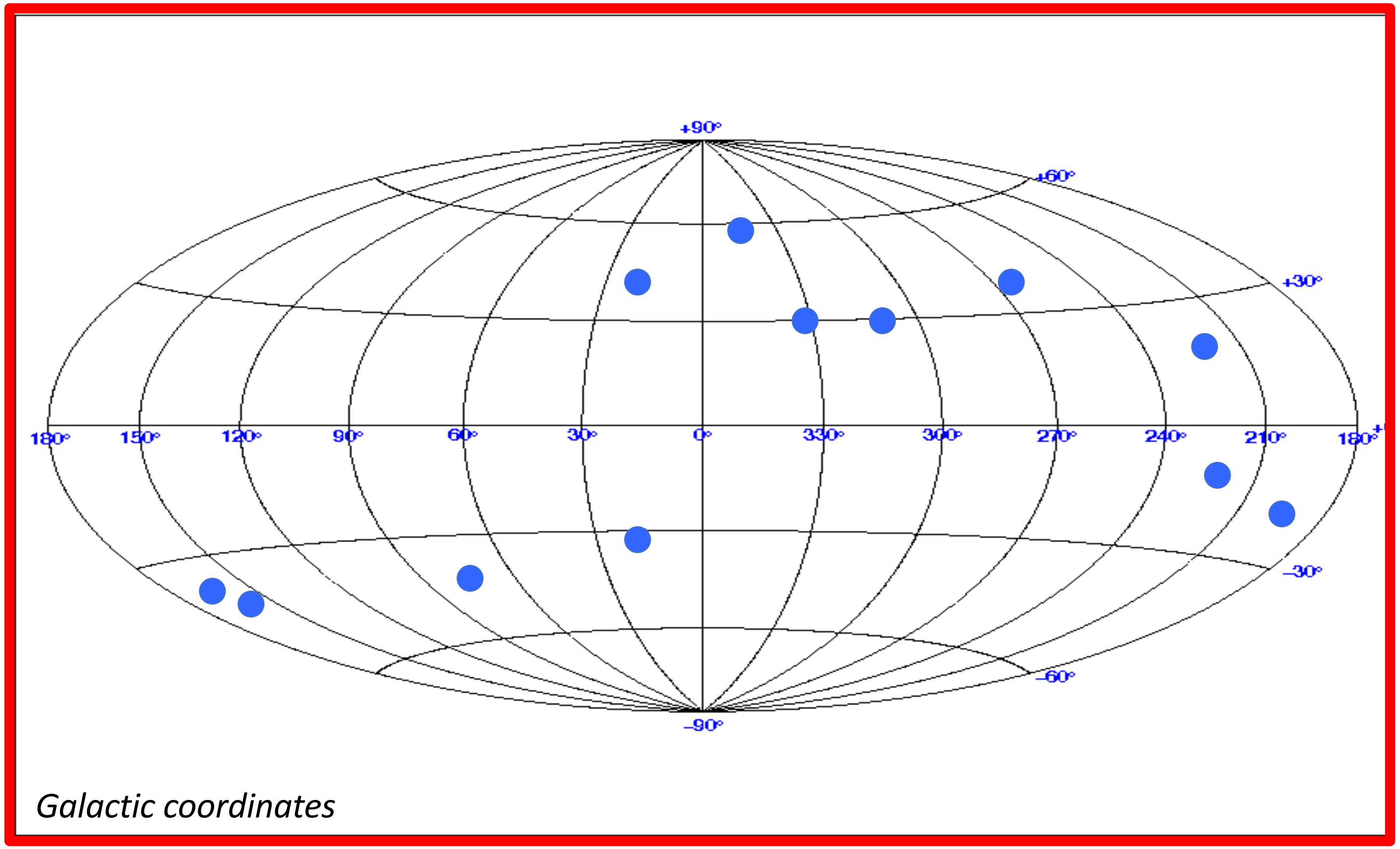
An AGILE detection over 2-day maps near event time T0 from the automatic QL detection systems



Consistent with the position of the BL Lac source TXS 0506+056, seen also at VHE by MAGIC near T_0 (Atel #10817).
TXS 0506 as the first cosmic neutrino source ever detected!

AGILE detections of IceCube neutrinos

(F. Lucarelli et al, ApJ 870, 2019)



AGILE detections of IceCube neutrinos

(F. Lucarelli et al, ApJ 870, 2019)

Springer Link

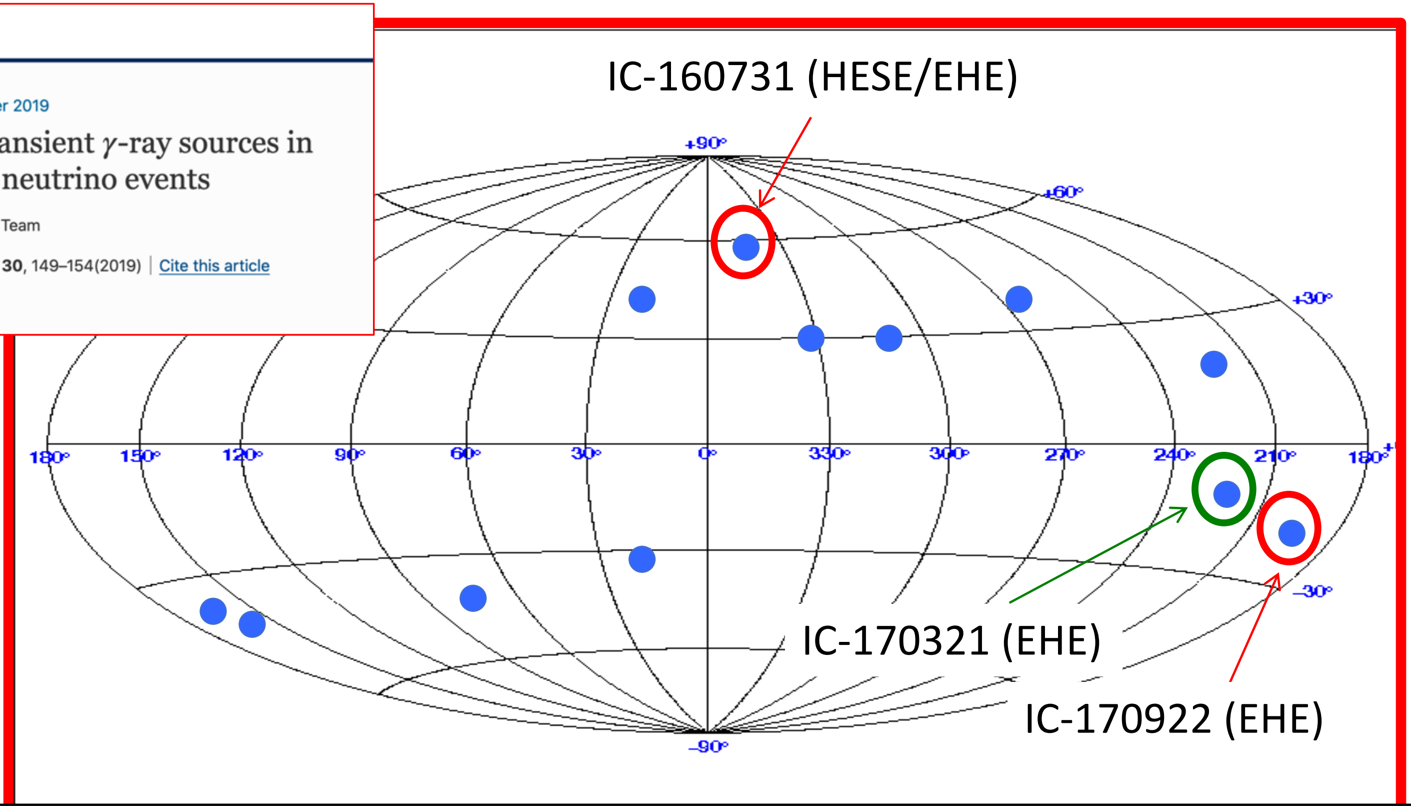
A Decade of AGILE | Published: 04 November 2019

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

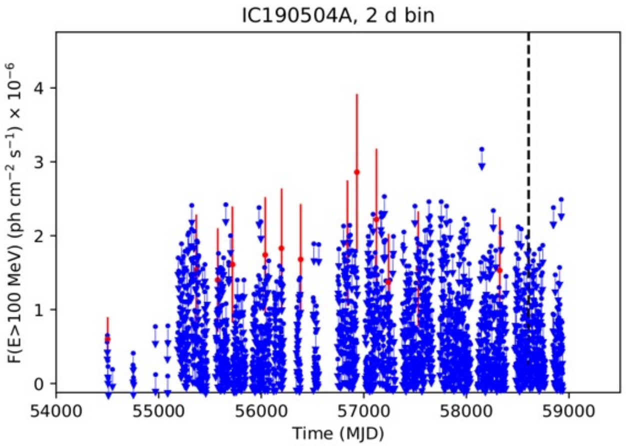
28 Accesses | Metrics

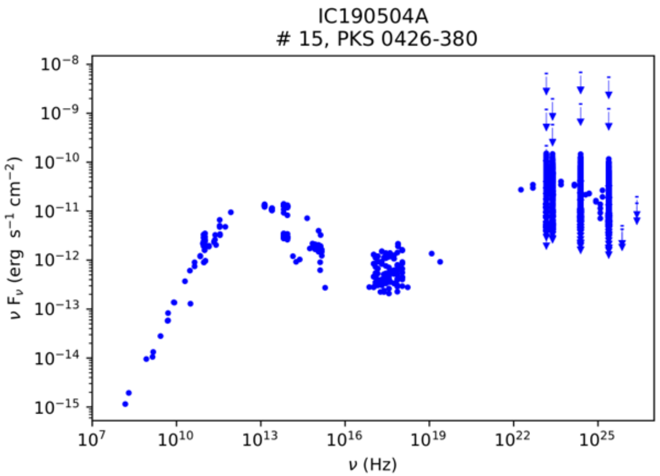


Three AGILE detections (~4σ each) from the automatic QL system consistent with time/position of 3 IC events out of 10!

UPDATE: Search for Gamma-Ray counterparts of IceCube neutrino events in the AGILE public archive

(E. Gasparri, R. Poggiani, C. Pittori, F. Lucarelli, P. Giommi) → See R. Poggiani talk @ TeVPa 2023



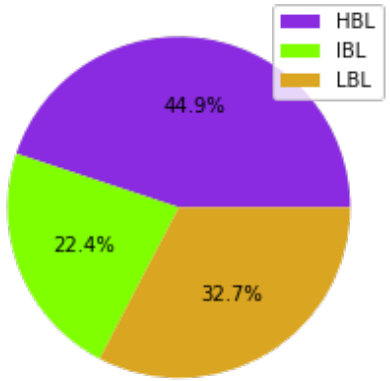


Blazars as possible neutrino sources.

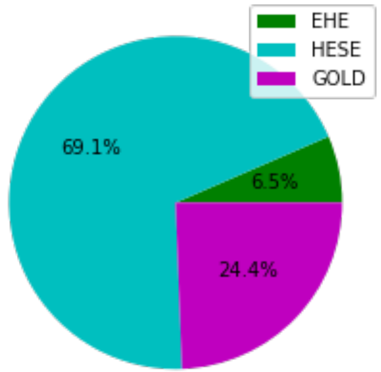
Master thesis by Elena Gasparri (2022) - **Paper in preparation**

Analysis of 16 IceCube neutrino events from September 2018 to March 2020

- Full-mission (16 yrs) AGILE light curves using public data and AGILE-LV3 SSDC tool
- SED of identified candidates with VOU-Blazars
- 8/16 light curves show significant γ-ray detections ($\sqrt{TS}$ > 3) within T_0 ± 1 year:
  - 2/3 EHE neutrinos (IC-180908A e IC-190503A)
  - 3/6 HESE neutrinos (IC-190104A, IC-190221A, IC-190504A)
  - 3/7 GOLD neutrinos (IC-190619A, IC-190922A, IC-191001A)
  - 2/16 light curves with association to 2AGL catalog sources



Classes of candidate blazars



Candidate AGILE detections vs. neutrino event type

Update on AGILE and GW

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
- AGILE observations provided the fastest response and **the most significant upper limits above 100 MeV to all GW events (pre-O4) detected up to now.**

F. Verrecchia et al., AGILE review (2019)
DOI:10.1007/s12210-019-00854-0

SpringerLink

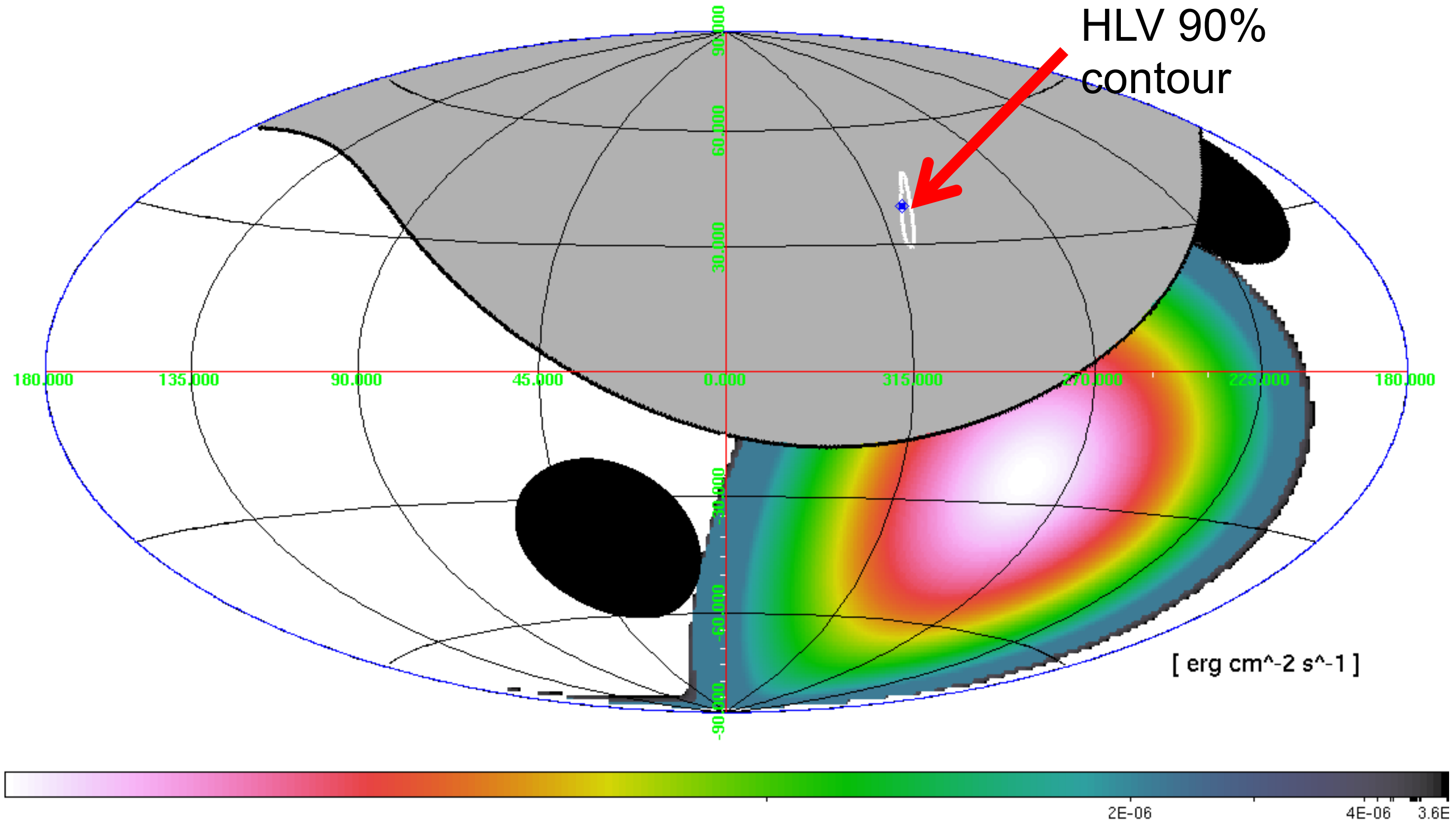
A Decade of AGILE | Published: 05 November 2019

AGILE search for gamma-ray counterparts of gravitational wave events

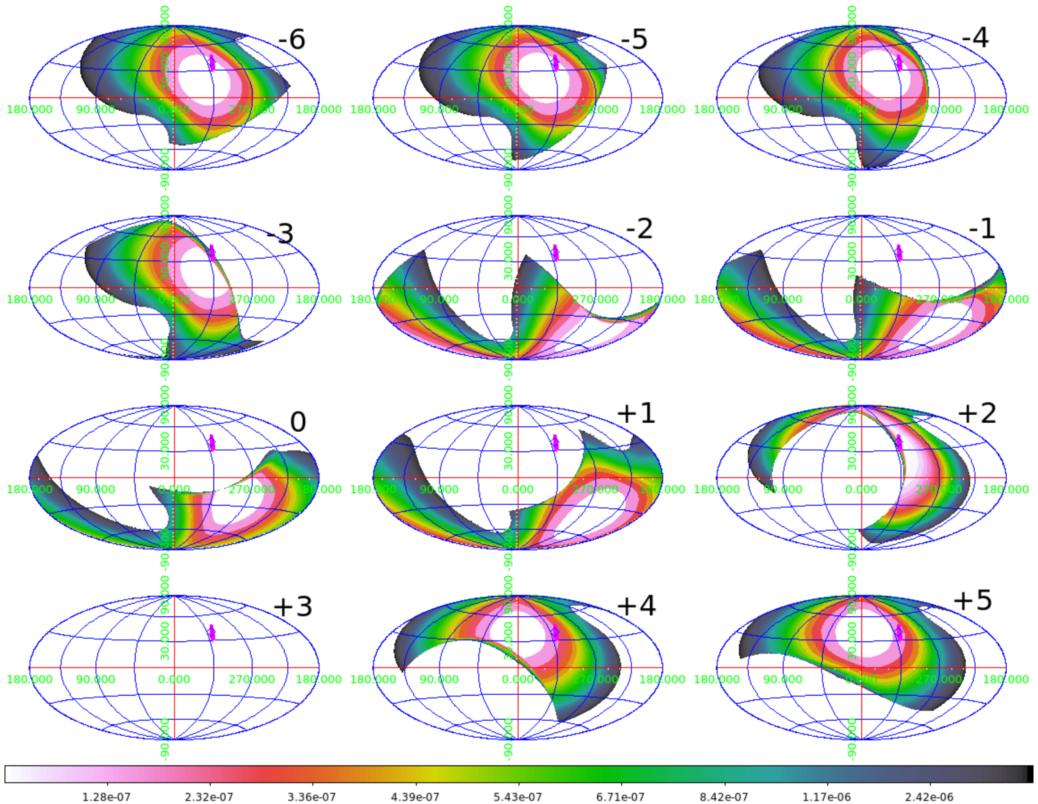
Francesco Verrecchia, Marco Tavani, Andrea Bulgarelli, Martina Cardillo, Claudio Casentini, Immacolata Donnarumma, Francesco Longo, Fabrizio Lucarelli, Nicoló Parmiggiani, Giovanni Piano, Maura Pilia, Carlotta Pittori, Alessandro Ursi the AGILE Team

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

GW170817-GRB170817A NS-NS merger
AGILE exposure at T0 (-2 / +2 sec): occulted by the Earth!



AGILE-GRID precursor/delayed emission search: short time scales (150s within -/+1 hr)



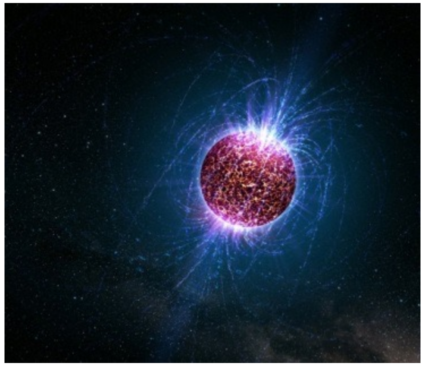
Evaluation of GRID 2σ upper limits Pre/Post T_0 (F. Verrecchia et al., ApJL 850, 2017)

NS-NS merger GW170817-GRB170817A

- **AGILE and GW170817: first γ-ray instrument with exposure on the localization region starting at ~ T_0 + 930 s** (F. Verrecchia et al., ApJL 850, 2017)

- AGILE observations provided the **fastest response and the most significant upper limits above 100 MeV to all GW events detected up to now!!**

- **AGILE limits on magnetar emission:** AGILE UL sets important constraints in the early phases to **exclude a highly magnetized magnetar for the remnant of GW170817- GRB170817**



AGILE observations of GWTC-1 catalog events

• detailed analysis of AGILE MCAL and GRID data in correpondence of LIGO-Virgo GW events [*Ursi et al., ApJ, 2022*]

THE ASTROPHYSICAL JOURNAL, 924:80 (15pp), 2022 January 10 https://doi.org/10.3847/1538-4357/ac332f
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OPEN ACCESS

AGILE Observations of the LIGO-Virgo Gravitational-wave Events of the GWTC-1 Catalog

A. Ursi[1], F. Verrecchia[2,3], G. Piano[1], C. Casentini[1,4], M. Tavani[1,5], A. Bulgarelli[6], M. Cardillo[1], F. Longo[7], F. Lucarelli[2,3], A. Morselli[4], N. Parmiggiani[6], M. Pilia[8], C. Pittori[2,3], and A. Rappoldi[9]
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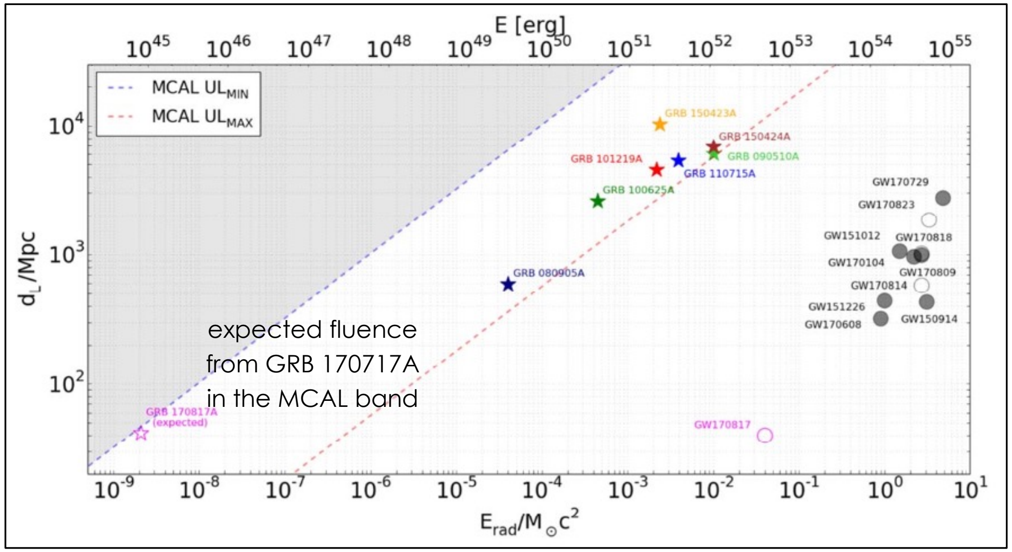
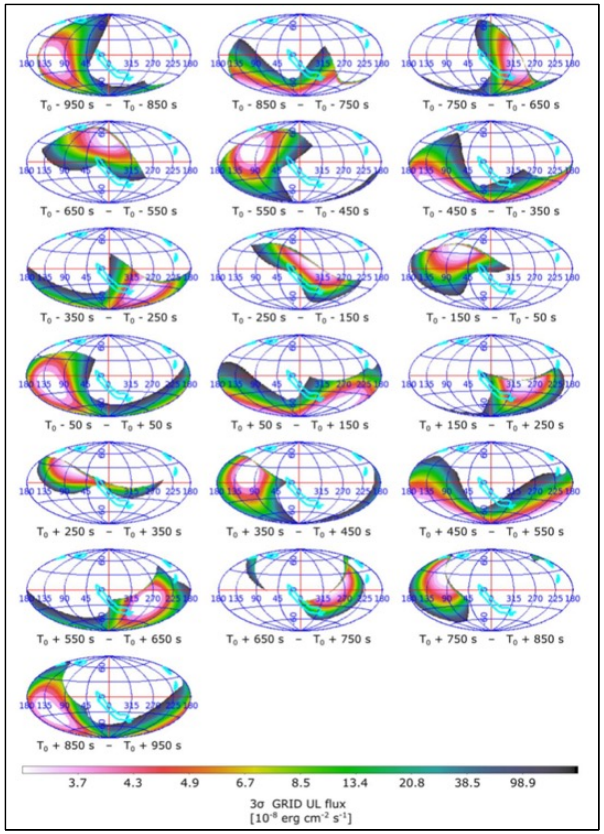
[8] INAF—Osservatorio Astronomico di Cagliari, via della Scienza 5, I-09047 Selargius (CA), Italy
[9] INFN Sezione di Pavia, via Bassi 6, I-27100 Pavia (PV), Italy
Received 2021 September 16; revised 2021 October 22; accepted 2021 October 24; published 2022 January 13

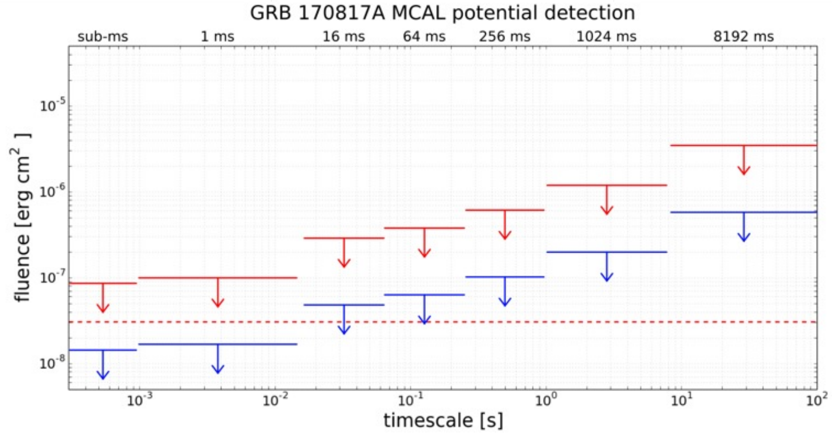




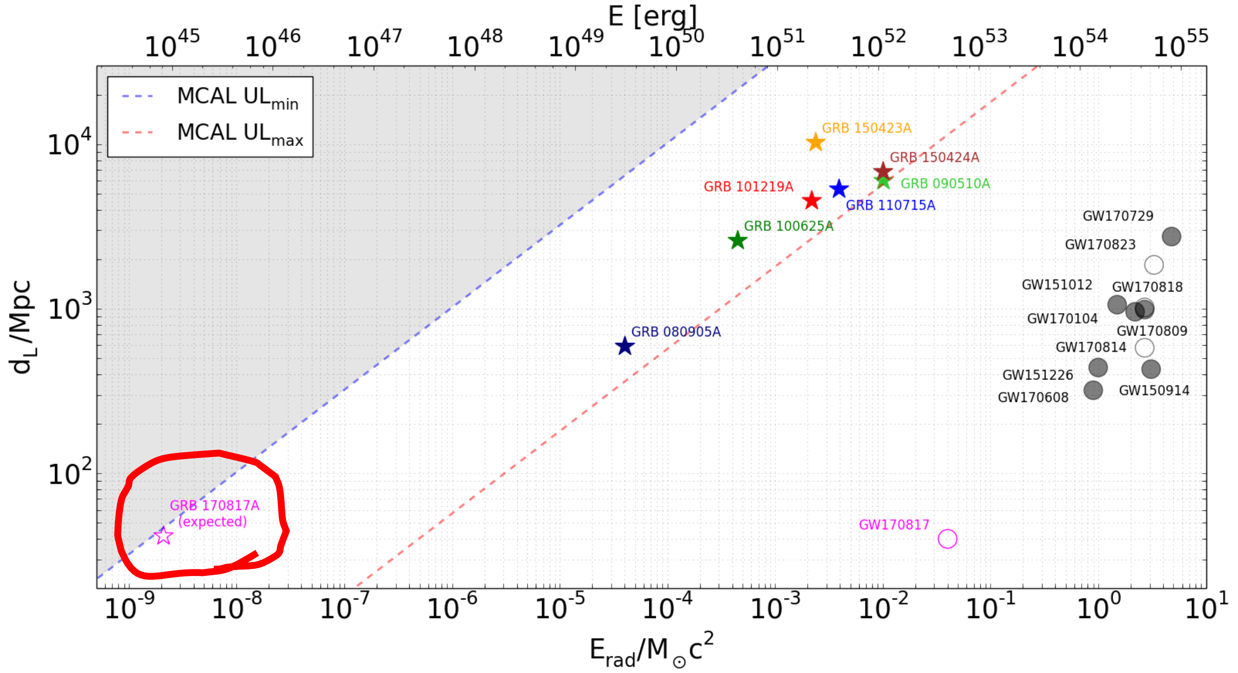
GRID exposure to error box of GW170729

AGILE & GW: Ursi et al. 2022

- GRB170817- GW170817 was occulted by the Earth at T0. Check possible detection with MCAL data (if it were in the FoV): minimum/maximum fluence UL



- Comparison of GW released energies and MCAL detected GRBs of the second GRB catalog (Ursi et al. 2021, ApJ, 925, 152).
- Distance vs energy: expectations for the GRB170817A – GW170817



(Slide adapted from F. Verrecchia)

AGILE and LIGO-Virgo-Kagra ongoing O4 run

- LIGO-Virgo-Kagra (LVK) O4 observing run, started on May 24, 2023. Indeed, the first 2023 GW event (S230518h) was published on May 18, 2023, prior to the official start of O4, during the last days of the so-called ***engineering run*** of the LIGO detectors.

- The LVK GW event **S230518h** has been identified as a significant GW compact binary merger candidate with high probability (86%) to be composed by a Neutron Star-Black Hole (**NSBH**) merger, which has a higher probability to have an electromagnetic counterpart.

- AGILE results from the fast follow-up of **GW S230518h** were published in the GCN Circular #33826, reporting the **AGILE/MCAL flux upper limits in the 0.4 - 1 MeV energy range**, for 1 s integration time from the GW trigger time (T0), at different celestial positions within the accessible Localization Region (LR).

- The detection of a **short pulse** in the same energy band with **S/N ~ 5.7 at T0+10.77 s** was also reported by AGILE. FAR and FAP evaluation *in progress* (soft band E<1.4 MeV).

Last but not least:
AGILE and Solar Flares

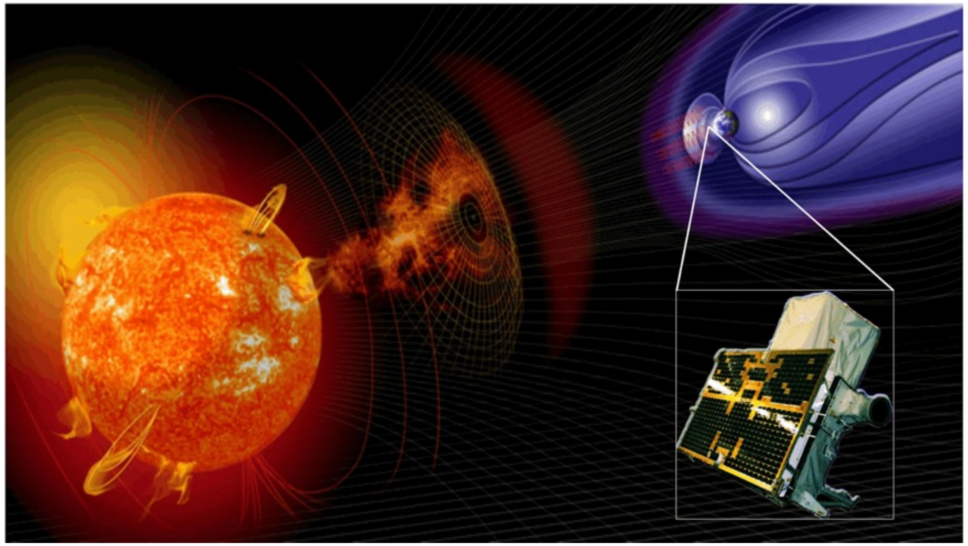
The First AGILE Catalog of Solar Flares: more than 15 years of observations

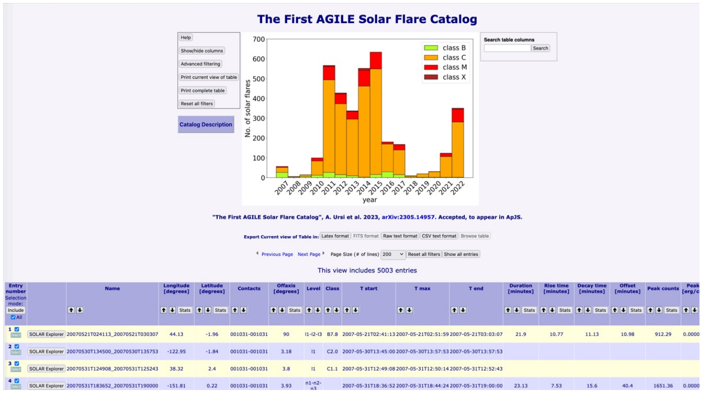
"The First AGILE Solar Flare Catalog" (**A. Ursi et al., ApJS 267, 2023**)

- Catalog of **more than 5000 events** from 2007 and 2022, all cross-related with the official **GOES**, **RHESSI and Fermi GBM**.

- **More than 1400 new "AGILE only"** events constituting a **new dataset** of solar flares detected in the hard X-ray energy band (80-200 keV).

- An **on-line version** of the AGILE solar flare catalog is available as an interactive web page at SSDC, providing access to additional data products (light curves, both in image and text format): *https://www.ssdc.asi.it/agilesolarcat/*

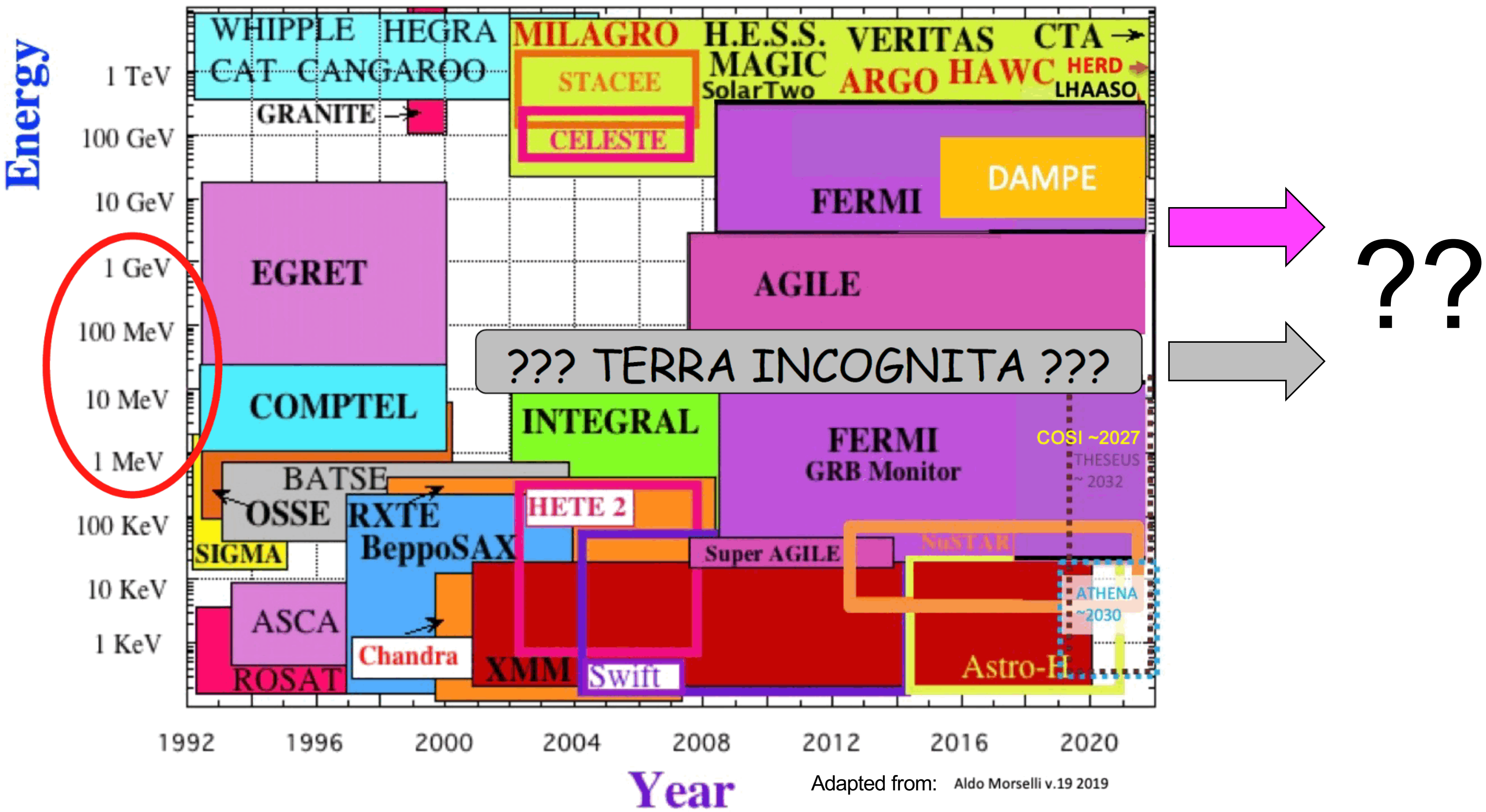




CONCLUSION: THE AGILE ALL SKY SCANNING GOES ON

- **Enhanced detection capabilities for transients: especially for GW and neutrino follow-up, short and long GRBs detection, FRBs.**
- **Fully integrated in a network of multi-frequency and multi-messenger observers from ground and space.**
- **AGILE unique contribution also for Terrestrial Gamma-ray Flashes and Solar Flares.**
- **Automatic pipelines plus human vetting: on-duty 7dd/7 - 24h/24 since the start of the Ligo-Virgo-Kagra O4 GW run in May 2023.**

Future prospects for MeV/GeV astronomy

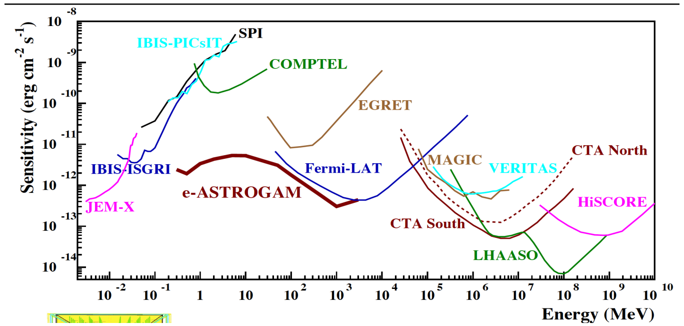


The e-ASTROGAM Proposal

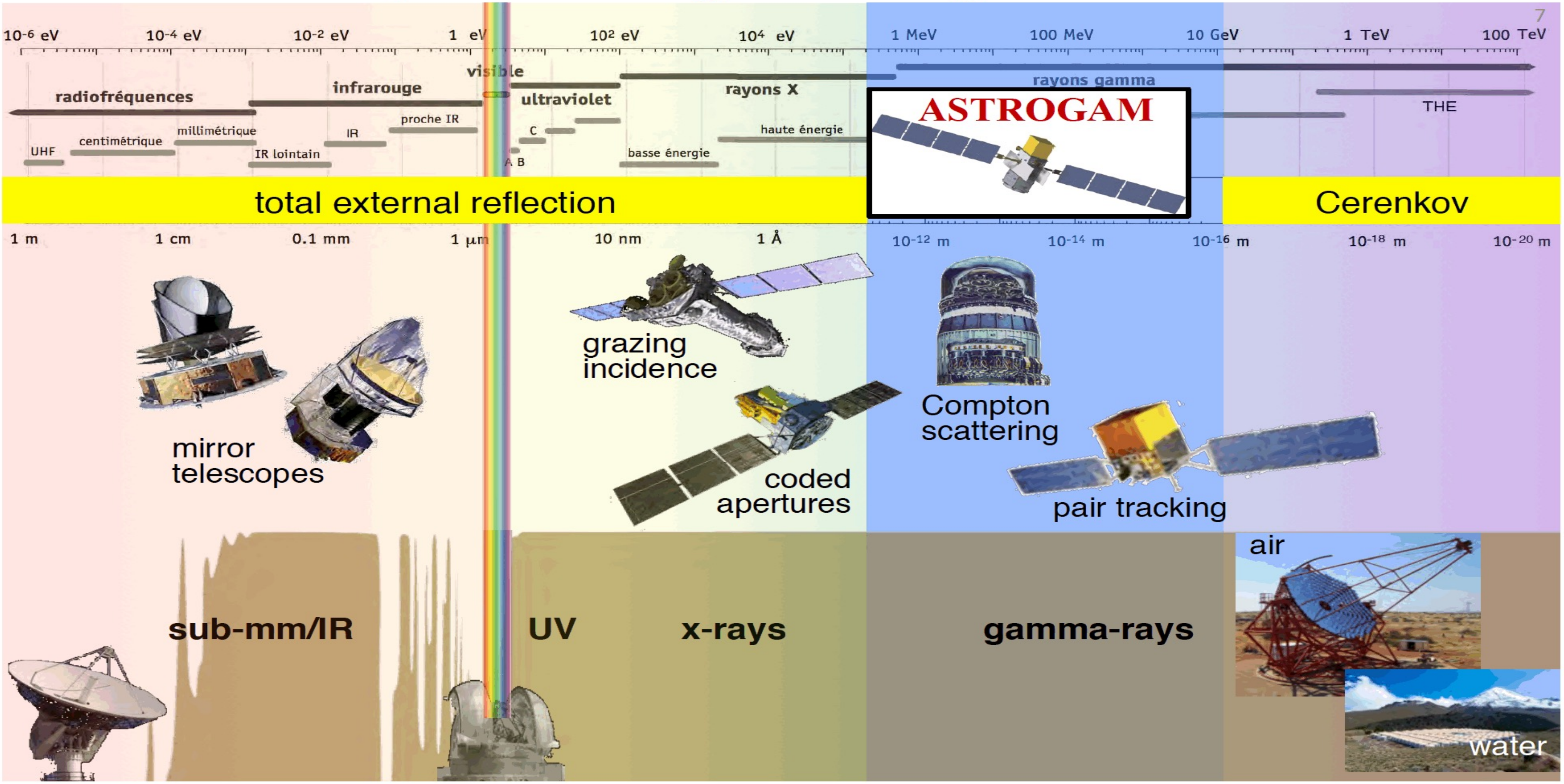
A. De Angelis, V. Tatischeff, M. Tavani et al. ESA M7 2022: Not selected ☹

Compton scattering + Pair Tracking
E = 0.3 MeV – 3 GeV

~ years 2030:
Complementary to observatories such as LIGO-Virgo-GEO600-KAGRA, SKA, ALMA, E-ELT, TMT, LSST, JWST, Athena, **CTA**, IceCube, KM3NeT, LISA...



A single instrument for a complete coverage of the spaceborne gamma-ray domain



Looking forward to future opportunities...

Thank you and congratulations on your first 20 MAGIC years!!

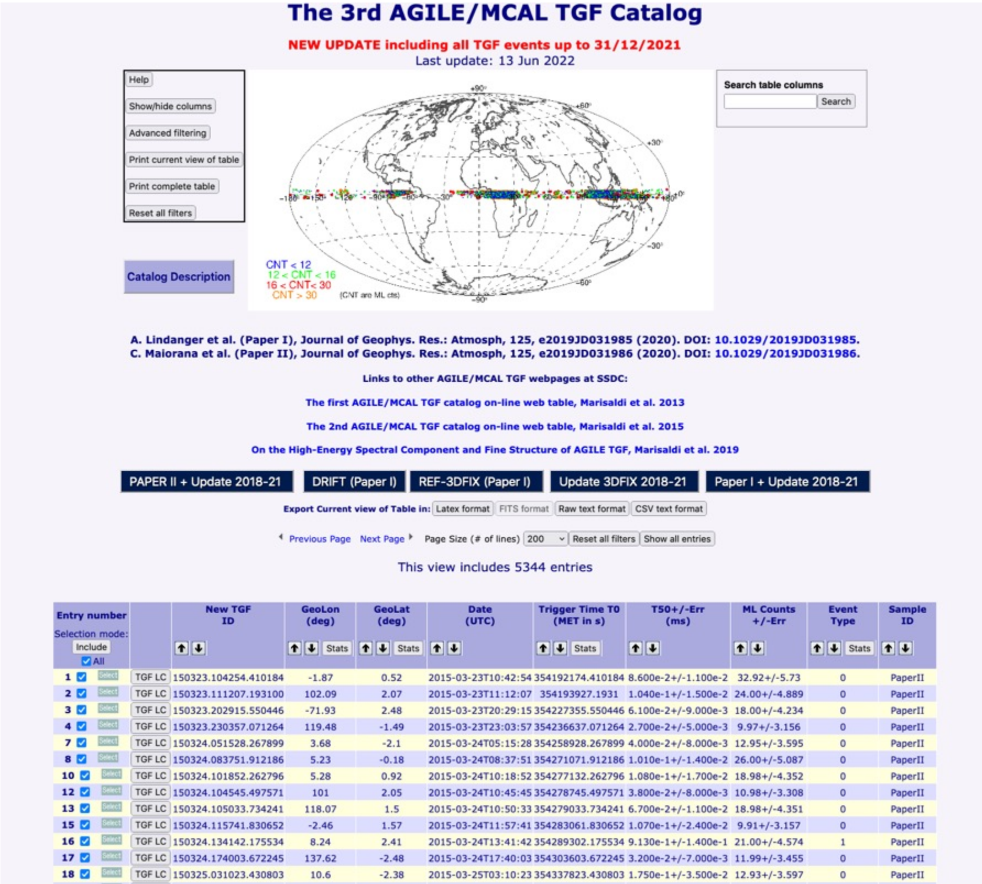
BACKUP SLIDES

AGILE and TGFs

AGILE and Terrestrial Gamma-ray Flashes

3rd AGILE TGF Catalog and lightning associations. Interactive SSDC webpage

NEW update including TGFs with lightning spherics association up to 31/12/2021



The 3rd AGILE/MCAL TGF Catalog

NEW UPDATE including all TGF events up to 31/12/2021

Last update: 13 Jun 2022

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

Search table columns | Search

Catalog Description

CNT < 12
12 < CNT < 16
16 < CNT< 30
CNT > 30 (CNT are ML cts)

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

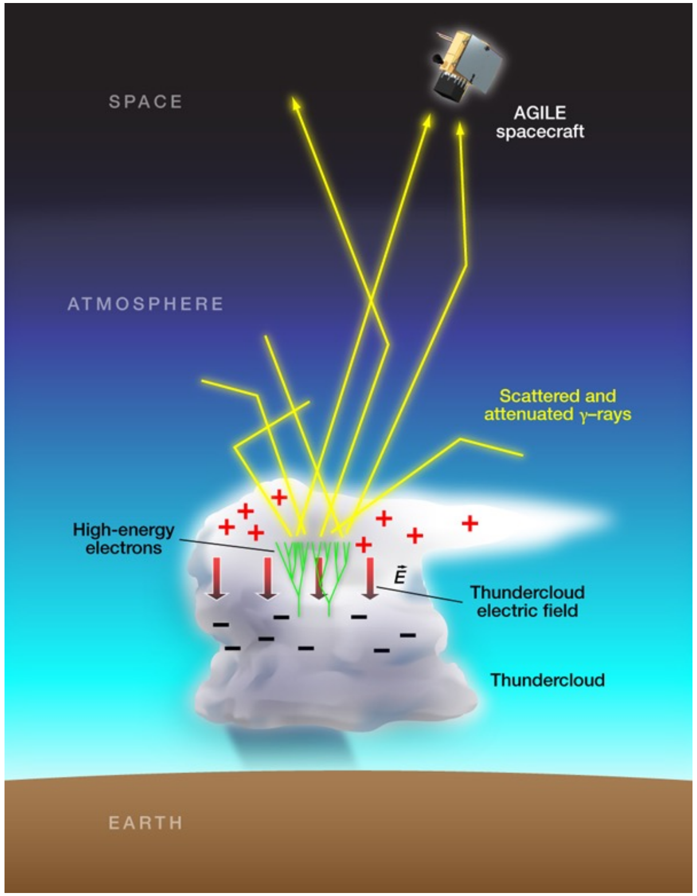
PAPER II + Update 2018-21 | DRIFT (Paper I) | REF-3DFIX (Paper I) | Update 3DFIX 2018-21 | Paper I + Update 2018-21

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 5344 entries

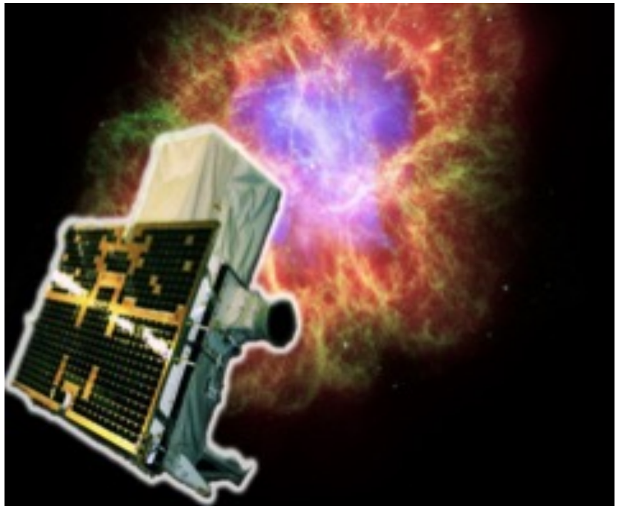
Entry number (Selection mode: Include, All)		New TGF ID	GeoLon (deg)	GeoLat (deg)	Date (UTC)	Trigger Time T0 (MET in s)	T50+/-Err (ms)	ML Counts +/-Err	Event Type	Sample ID
1	TGF LC	150323.104254.410184	-1.87	0.52	2015-03-23T10:42:54	354192174.410184	8.600e-2+/-1.100e-2	32.92+/-5.73	0	PaperII
2	TGF LC	150323.111207.193100	102.09	2.07	2015-03-23T11:12:07	354193927.1931	1.040e-1+/-1.500e-2	24.00+/-4.889	0	PaperII
3	TGF LC	150323.202915.550446	-71.93	2.48	2015-03-23T20:29:15	354227355.550446	6.100e-2+/-9.000e-3	18.00+/-4.234	0	PaperII
4	TGF LC	150323.230357.071264	119.48	-1.49	2015-03-23T23:03:57	354236637.071264	2.700e-2+/-5.000e-3	9.97+/-3.156	0	PaperII
7	TGF LC	150324.051528.267899	3.68	-2.1	2015-03-24T05:15:28	354258928.267899	4.000e-2+/-8.000e-3	12.95+/-3.595	0	PaperII
8	TGF LC	150324.083751.912186	5.23	-0.18	2015-03-24T08:37:51	354271071.912186	1.010e-1+/-1.400e-2	26.00+/-5.087	0	PaperII
10	TGF LC	150324.101852.262796	5.28	0.92	2015-03-24T10:18:52	354277132.262796	1.080e-1+/-1.700e-2	18.98+/-4.352	0	PaperII
12	TGF LC	150324.104545.497571	101	2.05	2015-03-24T10:45:45	354278745.497571	3.800e-2+/-8.000e-3	10.98+/-3.308	0	PaperII
13	TGF LC	150324.105033.734241	118.07	1.5	2015-03-24T10:50:33	354279033.734241	6.700e-2+/-1.100e-2	18.98+/-4.351	0	PaperII
15	TGF LC	150324.115741.830652	-2.46	1.57	2015-03-24T11:57:41	354283061.830652	1.070e-1+/-2.400e-2	9.91+/-3.157	0	PaperII
16	TGF LC	150324.134142.175534	8.24	2.41	2015-03-24T13:41:42	354289302.175534	9.130e-1+/-1.400e-1	21.00+/-4.574	1	PaperII
17	TGF LC	150324.174003.672245	137.62	-2.48	2015-03-24T17:40:03	354303603.672245	3.200e-2+/-7.000e-3	11.99+/-3.455	0	PaperII
18	TGF LC	150325.031023.430803	10.6	-2.38	2015-03-25T03:10:23	354337823.430803	1.750e-1+/-3.500e-2	12.93+/-3.597	0	PaperII



AGILE and Plasma Studies

Scientific Activities of AGILE Astrophysical Plasma Group

Valerio Vittorini, Eloisa Menegoni, Luca Foffano, Marco Tavani at IAPS Roma.



- The AGILE discovery of fast variability of CRAB Nebula at energies around 300 MeV and beyond challenges the Burn-off limit for Synchrotron radiation, this process involves particle acceleration possibly out to PeV energies. Here **we study acceleration mechanisms of leptons in order to radiate beyond the 150 MeV limit from standard MHD**: the principal candidate is the **magnetic reconnection** that, in specific configurations, could locally annihilate magnetic field, producing coherent electric fields on length scale large enough to accelerate charges at extreme energies.

- We are developing **PIC codes** derived by Zeltron, in order to treat the magnetic reconnection and the dynamic of fields in **astrophysical plasma**. Our aim is to apply these techniques **to Blazar jets, PWN, and Galaxy (see FERMI Bubbles**) where the emitted photons cover the range from 50 MeV up to PeV that involve efficient acceleration in situ of particles out to **PeV energies**. We are able to model emission processes in these sources by also considering the effect of EBL absorption and γ-γ absorption in situ.

- We collaborate with **Proto-Sphera experiment at ENEA** in Frascati RM (F. Alladio, P. Buratti, A. Cardinali, S. Mannori, P. Micozzi) and Pisa University (F. Pegoraro)

In prep. - E. Menegoni (now ASI staff) , V. Vittorini, P. Buratti, L. Foffano, M. Tavani.

Table 3: AGILE Scientific Performance

Gamma-ray Imaging Detector (GRID)		
Energy Range	30 MeV – 50 GeV	
Field of view	$\sim$ 3 sr	
Sensitivity at 100 MeV (ph cm^{-2} s^{-1} MeV^{-1})	6×10^{-9}	(5σ in 10^6 s)
Sensitivity at 1 GeV (ph cm^{-2} s^{-1} MeV^{-1})	4×10^{-11}	(5σ in 10^6 s)
Angular Resolution at 1 GeV	36 arcmin	(68% cont. radius)
Source Location Accuracy	$\sim$5–20 arcmin	S/N$\sim$10
Energy Resolution	ΔE/E$\sim$1	at 300 MeV
Absolute Time Resolution	$\sim 1\,\mu$s	
Deadtime	$\sim 200\,\mu$s	
Hard X–ray Imaging Detector (Super-AGILE)		
Energy Range	10 – 40 keV	
Field of view	$107^\circ\times68^\circ$	FW at Zero Sens.
Sensitivity (at 15 keV)	$\sim$5 mCrab	(5σ in 1 day)
Angular Resolution (pixel size)	$\sim$ 6 arcmin	
Source Location Accuracy	$\sim$2-3 arcmin	S/N$\sim$10
Energy Resolution	ΔE<4 keV	
Absolute Time Resolution	$\sim 4\,\mu$s	
Deadtime (for each of the 16 readout units)	$\sim 4\,\mu$s	
Mini-Calorimeter		
Energy Range	0.3 – 200 MeV	
Energy Resolution	$\sim$ 1 MeV	above 1 MeV
Absolute Time Resolution	$\sim 3\,\mu$s	
Deadtime (for each of the 30 CsI bars)	$\sim 20\,\mu$s	