Observational Lessons learned (from Fermi & Co.)

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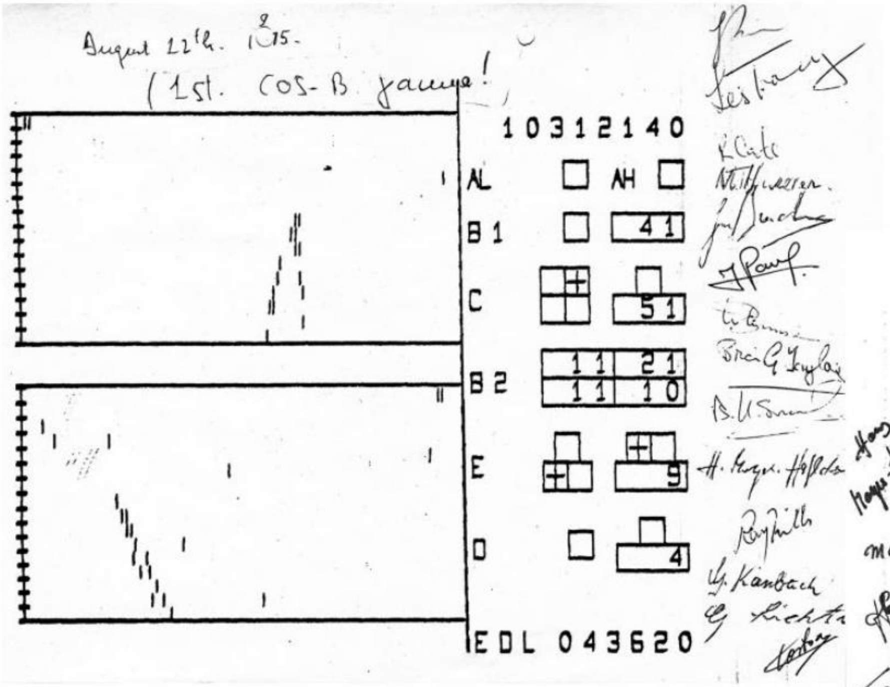
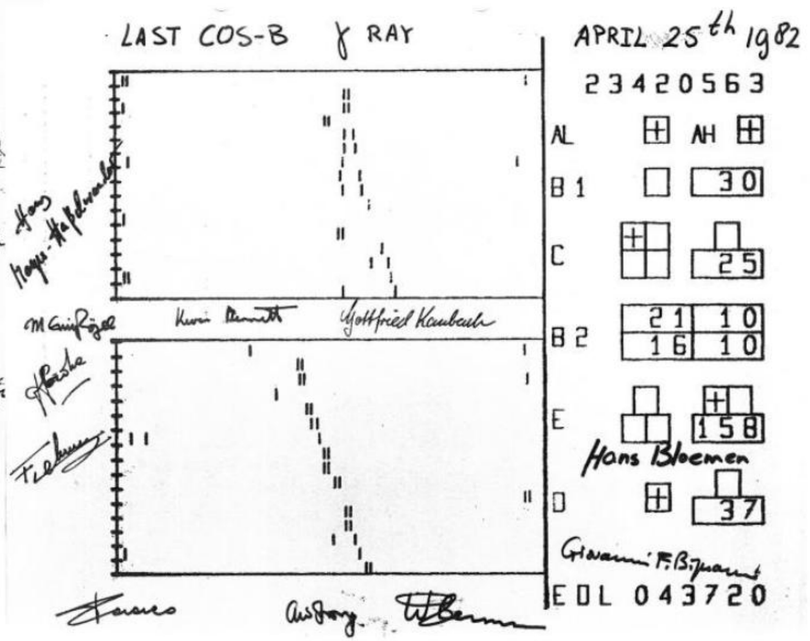
Member of the Fermi GBM and LAT Collaborations
Member of the CTAO Consortium
Affiliate member of the H.E.S.S. Collaboration

First γ ray: Aug. 22, 1975

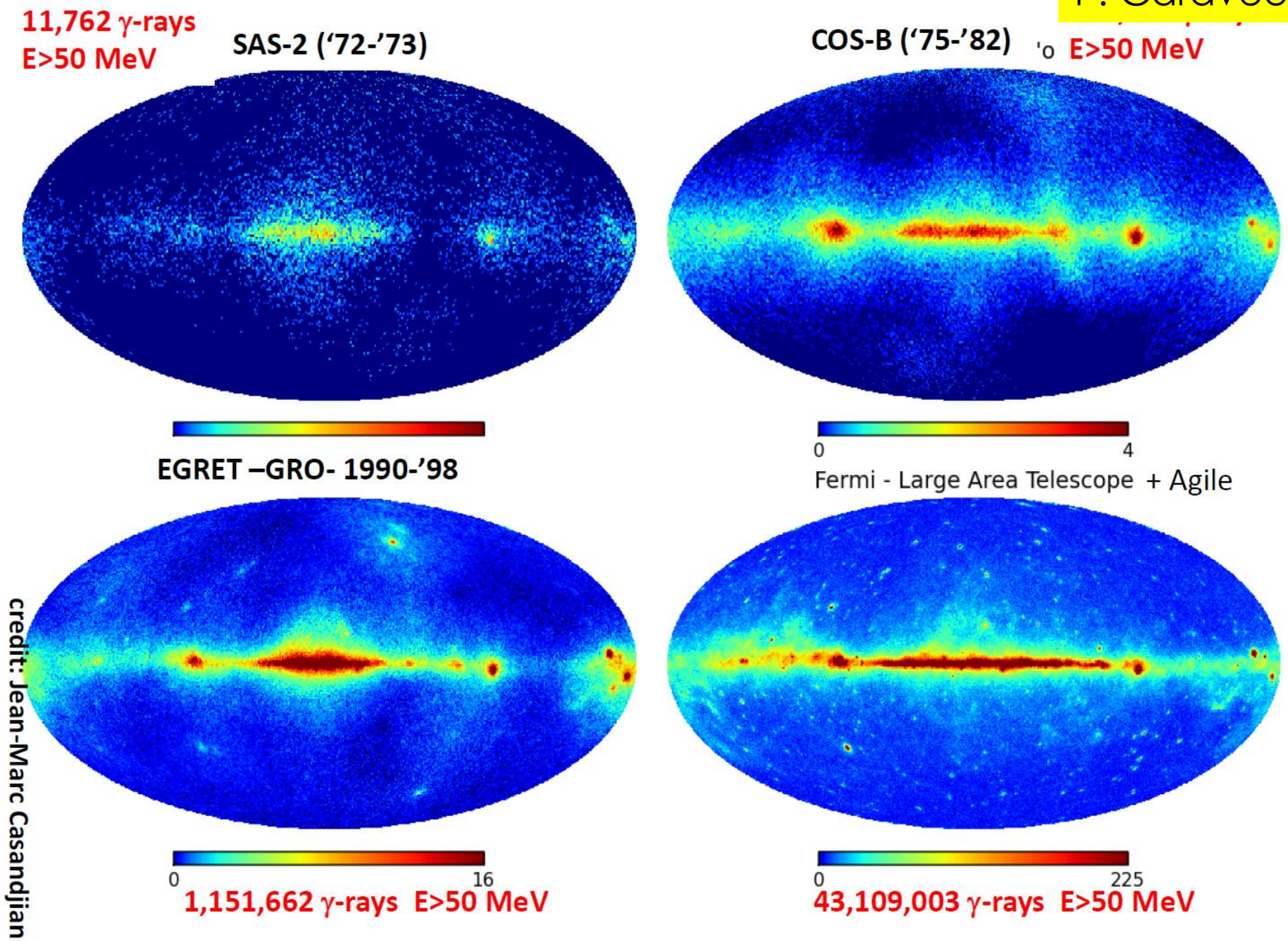


Last γ ray: Apr. 25, 1982

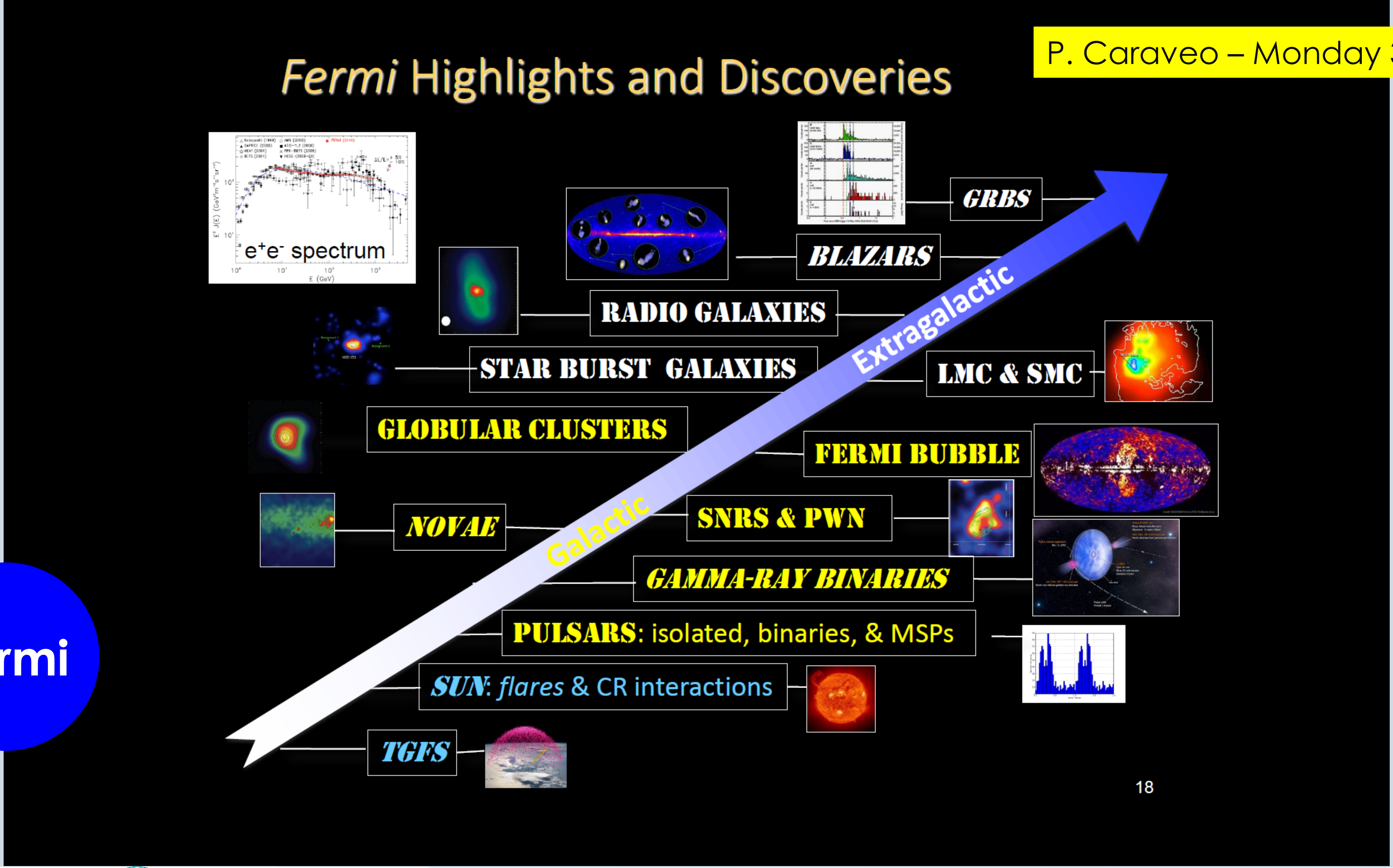


COS-B

P. Caraveo – Monday 30/06

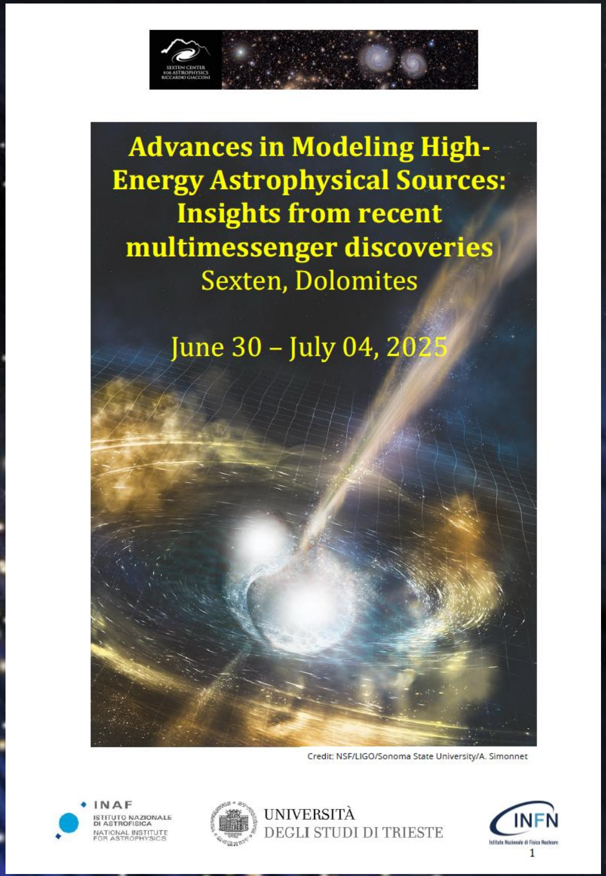


P. Caraveo – Monday 30/06



Fermi

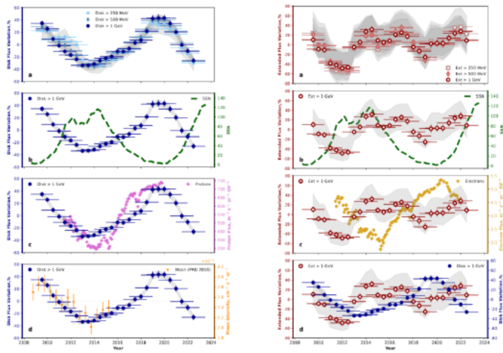
Solar System



Fermi

S. Cutini – Monday 30/06

Variation of Gamma Rays from the Sun over the Solar Cycle



We find that the flux variation of the disk anticorrelates with solar activity and correlates with cosmic-ray protons.
The flux variation of the extended component anticorrelates with solar activity only until mid ~2012.
After that, we no longer observe any correlation or anticorrelation, even with the CR electron flux. This most likely suggests that cosmic-ray transport and modulation in the inner heliosphere are unexpectedly complex and different for electrons and protons or, alternatively, the presence of an additional, unknown component of gamma rays or cosmic rays.

Acharya et al. 2025, 10.48550/arXiv.2505.06348

Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries 30/06/25-5/07/25 - Sesto Pusteria — Sara Cutini (INFN) — 26

A. Liguori – Friday 04/07

Fermi-LAT observations of the Moon

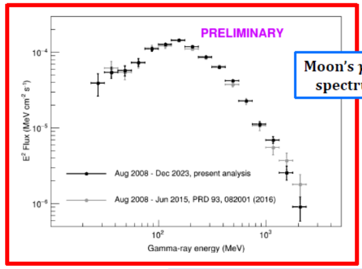
- The **gamma-ray fluxes $\vec{\phi}_s$, $\vec{\phi}_b$ evaluated** from the counts in the signal and in background ROIs $\vec{n}_s, \vec{n}_b$ by **maximizing a Poisson likelihood function** [1]:

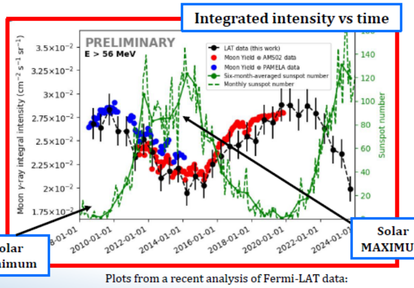
$$\mathcal{L}(\vec{\phi}_s,\vec{\phi}_b|\vec{n}_s,\vec{n}_b)=\prod_i e^{-\mu_s(E_i)}\frac{\mu_s(E_i)^{n_s(E_i)}}{n_s(E_i)!}\prod_i e^{-\mu_b(E_i)}\frac{\mu_b(E_i)^{n_b(E_i)}}{n_b(E_i)!}$$

$$\mu_s(E_i)=\sum_j P_s(E_i|E_j)[\phi_s(E_j)+\phi_b(E_j)]\cdot\Delta E_j\cdot A\cdot t_s$$

$$\mu_b(E_i)=\sum_j P_b(E_i|E_j)\cdot\phi_b(E_j)\cdot\Delta E_j\cdot A\cdot t_b$$

- The **spectral energy distribution $E^2\phi_s(E)$** is **peaked at about 150 MeV** and drops as a power-law with an index ~2
- Same analysis can be carried out in 6-months temporal bins
- Energy-integrated intensity exhibits **anti-correlation with the solar activity and correlation with measured CR intensities**
- The **anti-correlation** tends to **disappear at the higher energies**.





Plots from a recent analysis of Fermi-LAT data:
F. Loparco, Fermi Symposium 2024

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A. Adelfio – Thursday 03707 – A. Zaccaro

Finanziato dall'Unione europea NextGenerationEU — Ministero dell'Università e della Ricerca — Italiadomani — ICSC

Gaussian-FOCuS Results (PRELIMINARY)

- **FFNN: uses the FFNN as background estimation and a rolling standard deviation to estimate the uncertainty.**
- **MA: uses a moving average as background estimation and a rolling standard deviation to estimate the uncertainty.**
- **BNN: uses the FFNN as background estimation for the background estimation and the BNN outputs to get the uncertainty estimations.**

	FFNN (5σ)	MA (5σ)	FFNN (6σ)	MA (7σ)	BNN
SFLARE	39	54	37	1	?
GRB	13	21	13	0	?
TGF	3	7	3	1	?
SGR	2	0	2	0	?
LOCALPART	13	21	10	2	?
DISTPART	1	5	0	0	?
UNCERT	9	12	9	1	?
TOT w/ c.p.	80	120	74	5	
TOT	23k	40k	20k	1k	

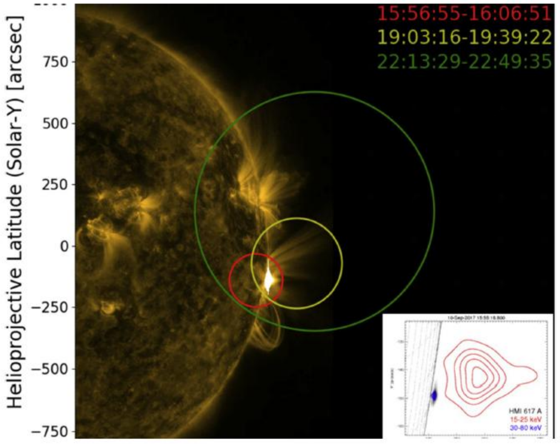
ICSC Italian Research Center on High-Performance Computing, Big Data and Quantum Computing — Missione 4 • Istruzione e Ricerca

Upcoming - Solar Flares Monitoring using Fermi-LAT data

Fermi-LAT data enable detailed investigations of:

- *temporal profiles*
- *photon energy spectra*
- the *proton spectral index* from hadronic interactions
- potential *localization* of the flare site

This line of work has only recently been initiated.



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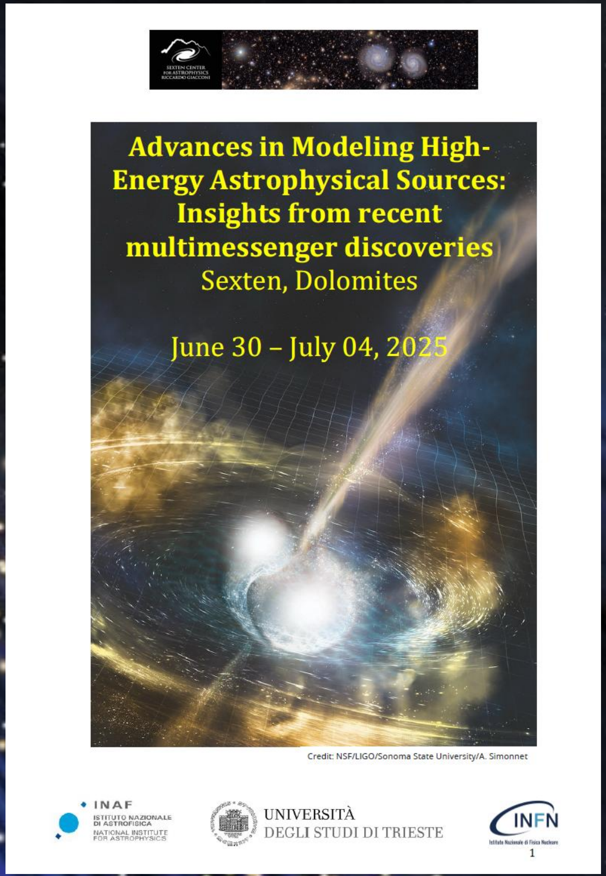
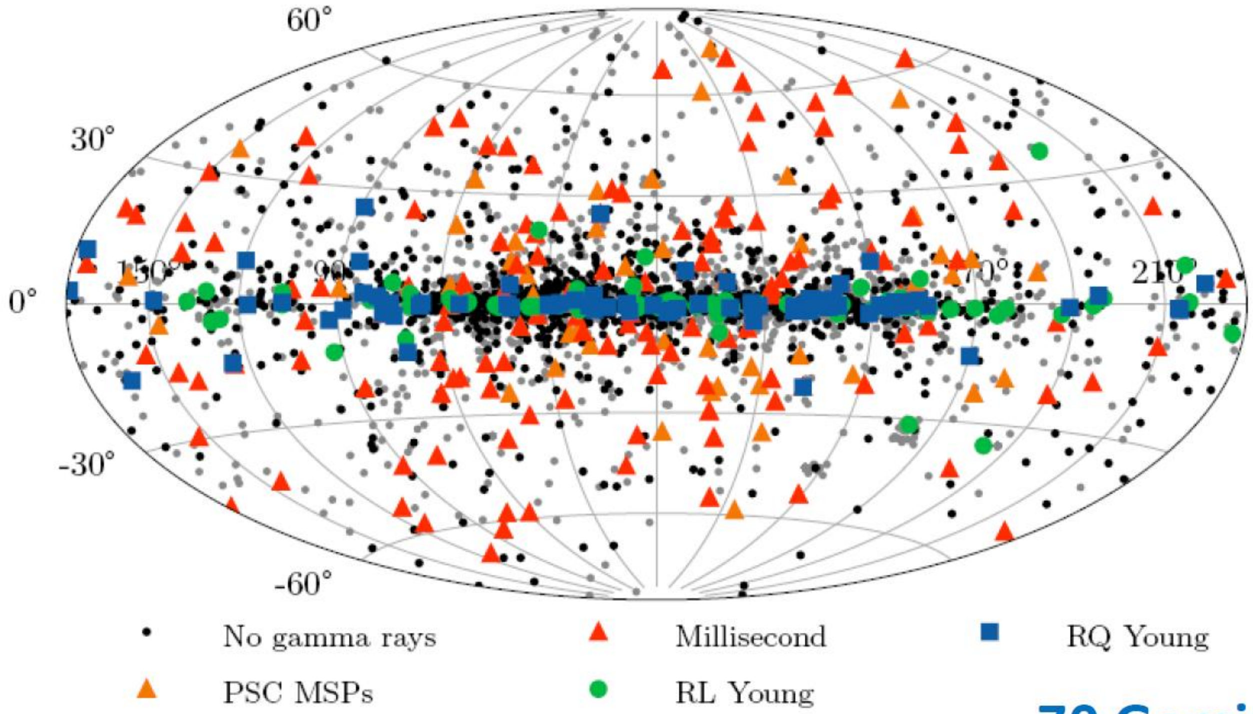
Galactic HE sources

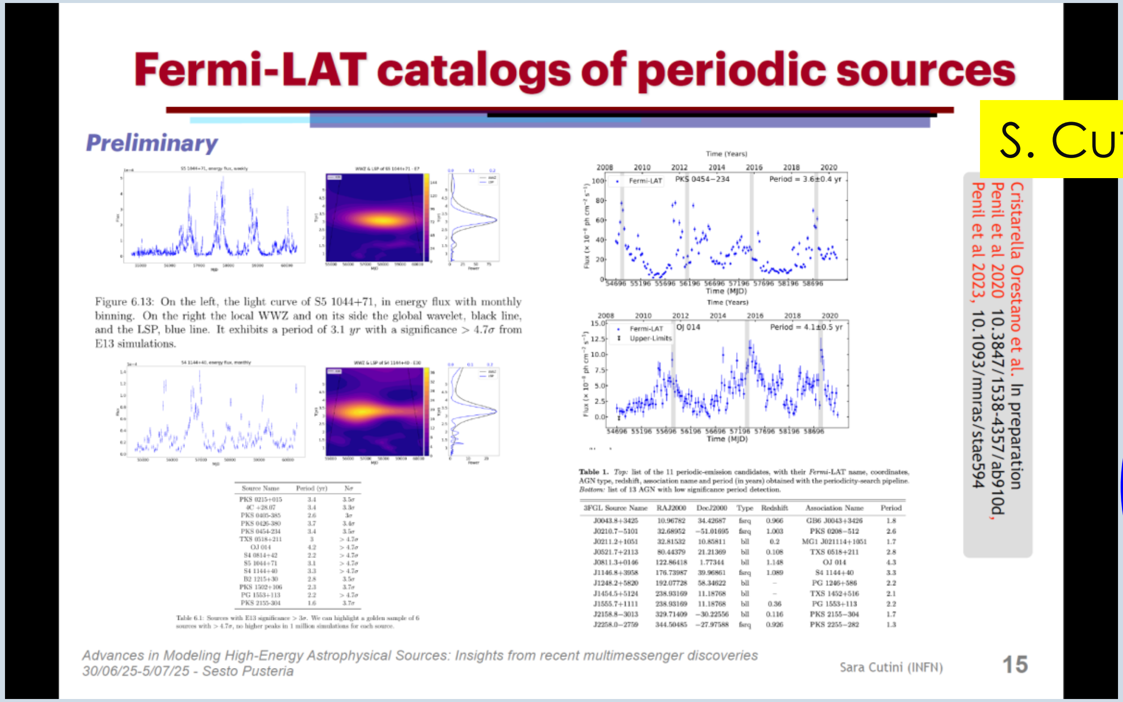


Fermi

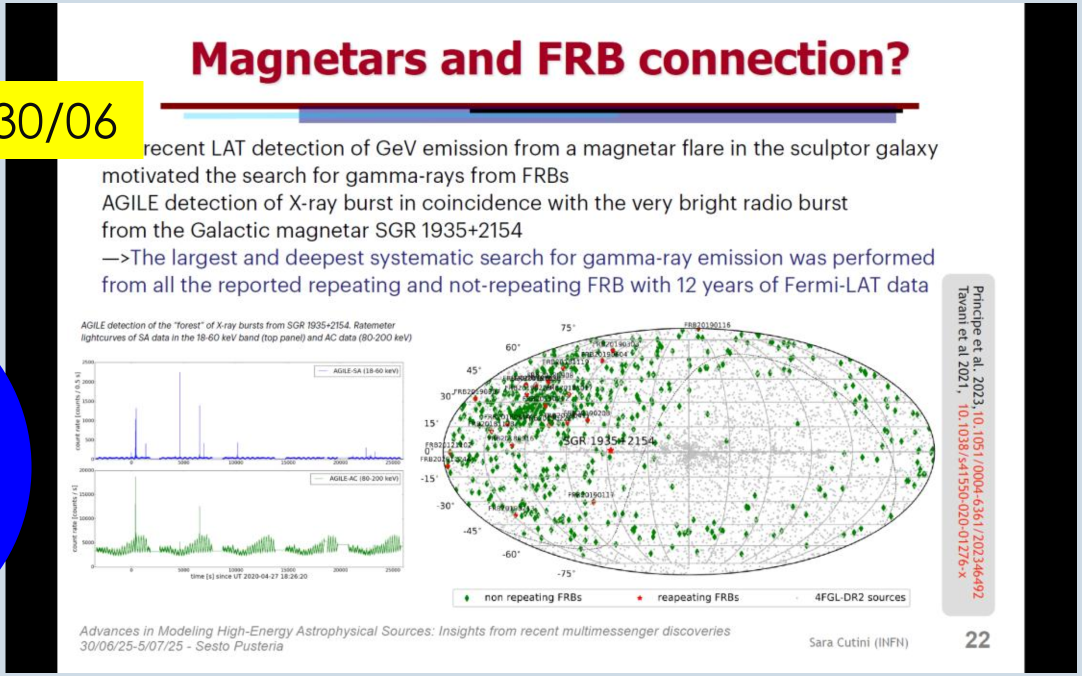


70 Geminga-like

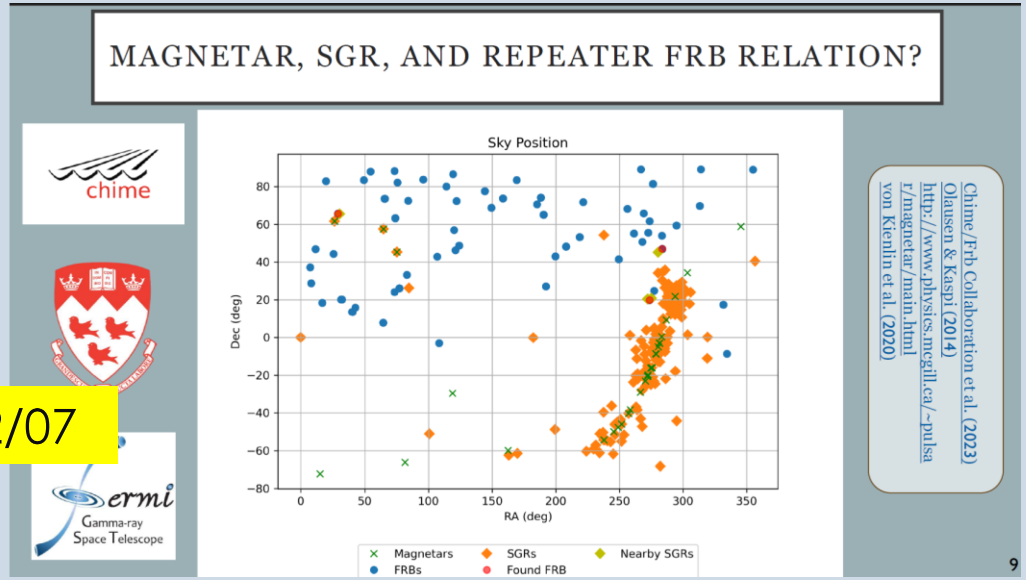
294 pulsar



S. Cutini – Monday 30/06



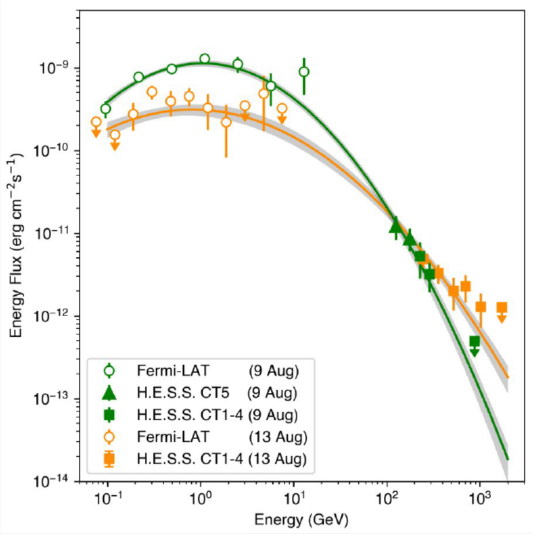
Fermi



K. L. Parrinello – Wednesday 02/07

A. Berti – Tuesday 01/07

Novae



- New class of VHE emitter with the detection of the recurrent nova Rs Ophiuchi in 2021 by H.E.S.S. and then MAGIC
- Modeling suggests that there is acceleration of accelerated to hundreds of GeV in the nova shock
- Waiting for the explosion of another recurrent nova, T Coronae Borealis
  - could be any moment!
  - good target for stellar intensity interferometry with IACTs

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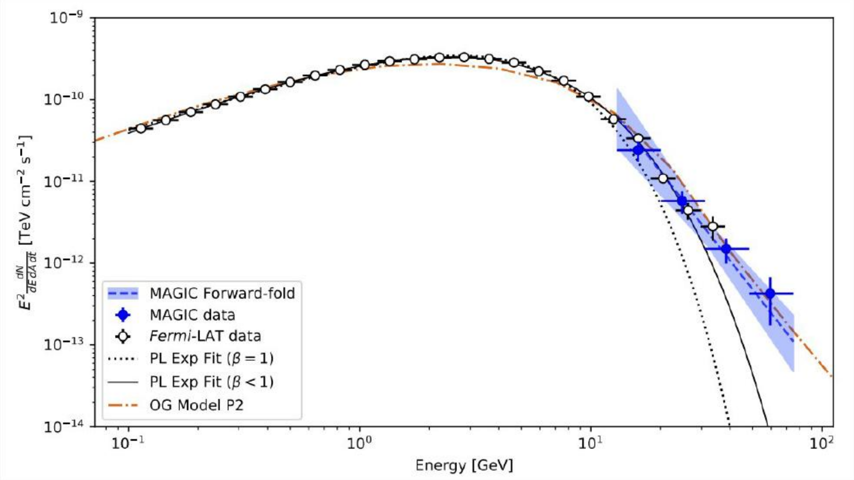
Fermi + IACTs

Pulsars



- Only a few detected at VHE (Crab, Geminga, Vela, PSR B1706−44)
- Crab and Vela show pulsation up to 1 TeV
- Still debates on the location of the emission region

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Persistent Emission

CTAO LST COLLABORATION

- TeV ULs ~ X-ray flux
  - LST-1 improves H.E.S.S. ULs (Index=−2.5, 95% CL)
- Agreement with Magnetar Models
  - Emission break expected in MeV
  - Current MeV ULs $\sim 10^{-10} erg\ s^{-1} cm^{-2}$
  - Current GeV ULs $\sim 10^{-12} erg\ s^{-1} cm^{-2}$
- Emission Detection of FRB Progenitors?
  - PRSs likely powered by pulsar/magnetar in nebulae
  - FRB Progenitors might emit VHE γ-rays (PWNe or SNRs)
- Interesting targets for CTAO

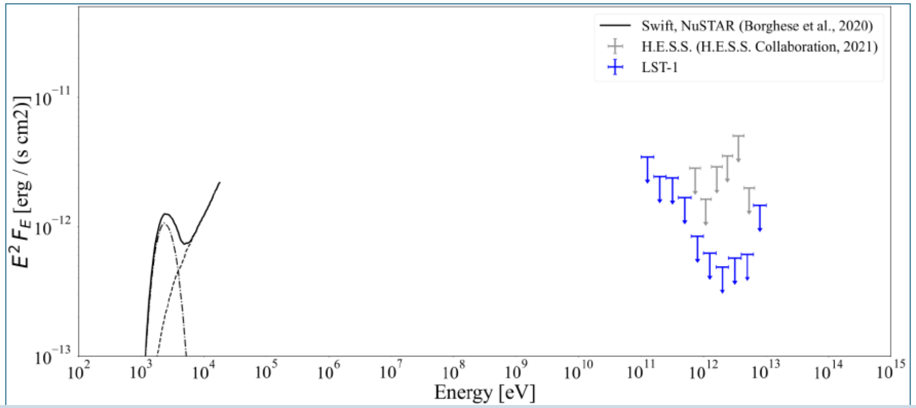


Figure 3
Spectral Energy Distri

G. Panebianco – Friday 04/07

Fermi/ IACTs

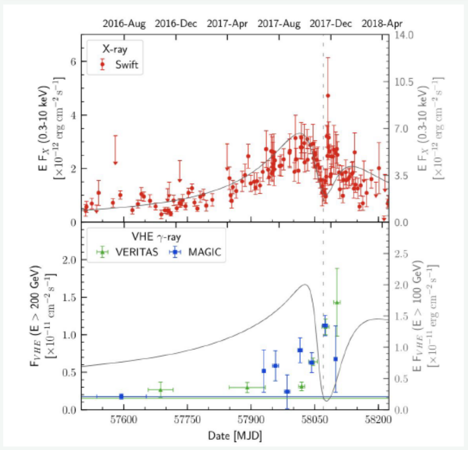
WR 140 MAGIC+LST-1 campaign

Critical configurations of WR 140 in 2024-25

Orbital phenomenon	f	r/a	P.A.	pos	ψ	MJD	Year	Date
conjunction: WC star behind	223	0.56	84	E	30	60506	2024.54	July 15
quadrature	313	0.12	354	N	90	60626	2024.86	Nov 12
periastron passage	0	0.10	327	NW	129	60637	2024.89	Nov 23
conjunction: O star behind	42	0.12	263	W	150	60645	2024.91	Dec 1
quadrature	133	0.51	174	S	90	60751	2025.21	Mar 17

- **Start** of the monitorization in June 2024
- **Increasing cadence** after each orbital phenomenon
- **Quadrature not visible** due to Moon brightness
- **Not visible** anymore **after second conjunction**

PSRJ2032 (Abeysekara et al. 2018)



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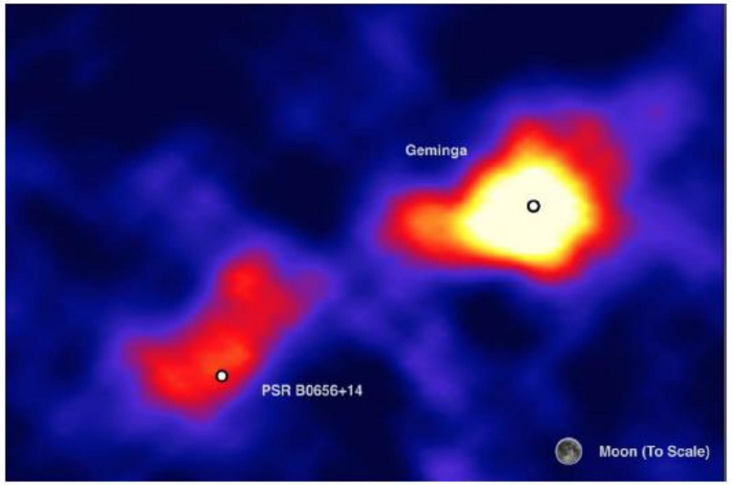
F. Frias – Friday 04/07

J. Hinton – Tuesday 01/07

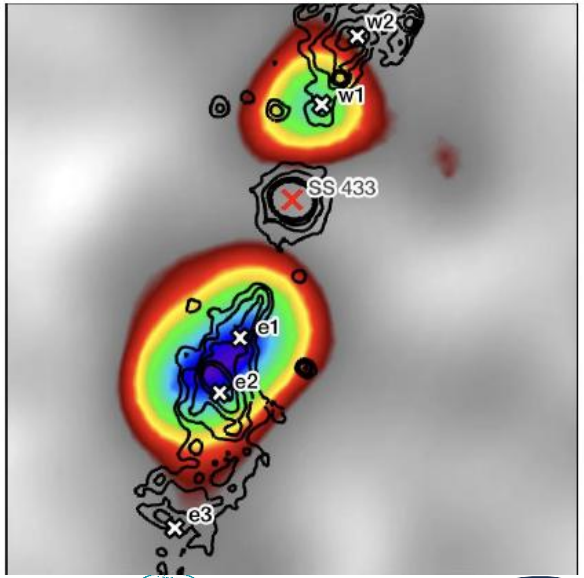
MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

Discoveries?

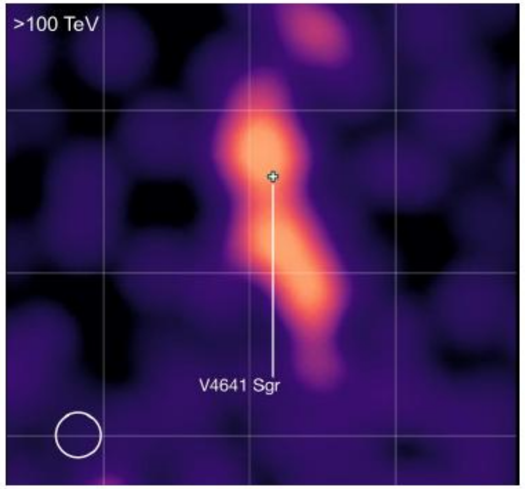
- Very large-scale sources
  - e.g. The 'halos' of Geminga and Monogem



- Very hard spectrum sources
  - e.g. SS 433 'lobes'

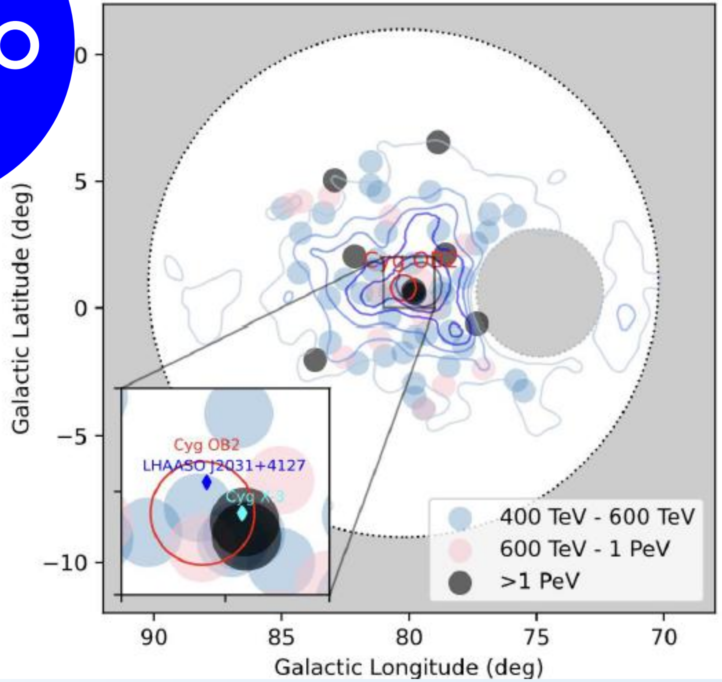


- Off-plane Galactic objects
  - e.g. V4647 Sgr



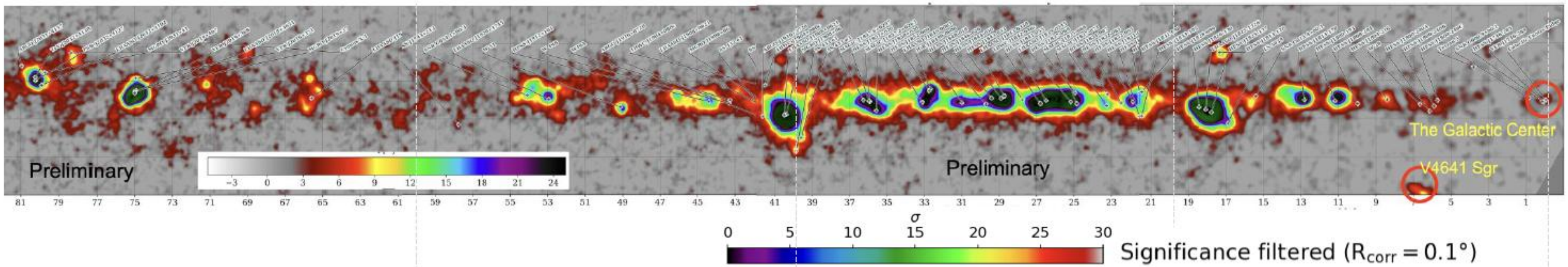
LHAASO

- Emission in to a new energy domain – in particular with LHAASO
  - PeV emission from Galactic Accelerators – e.g. Cygnus 'bubble'

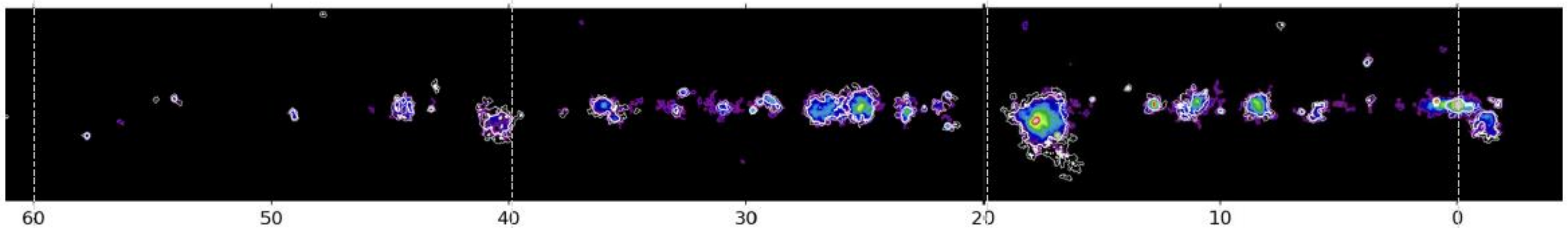


J. Hinton – Tuesday 01/07

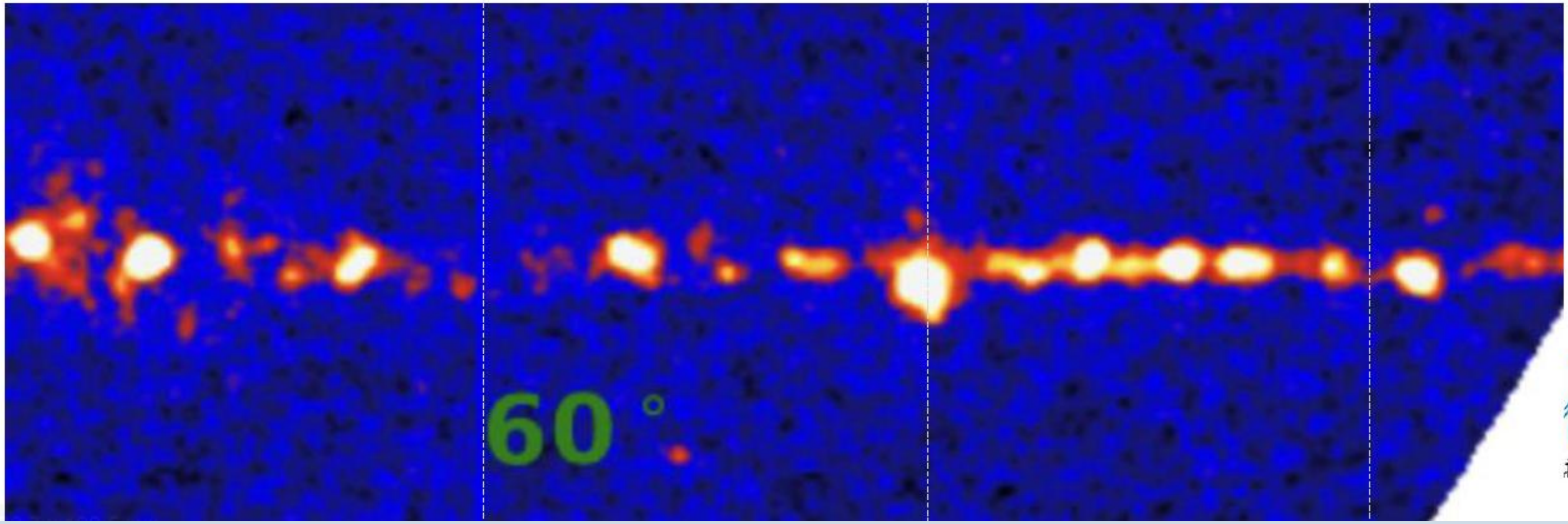
- Pass 5 prelim. Goodman



- Updated HESS GPS (Remy et al ICRC 2023)

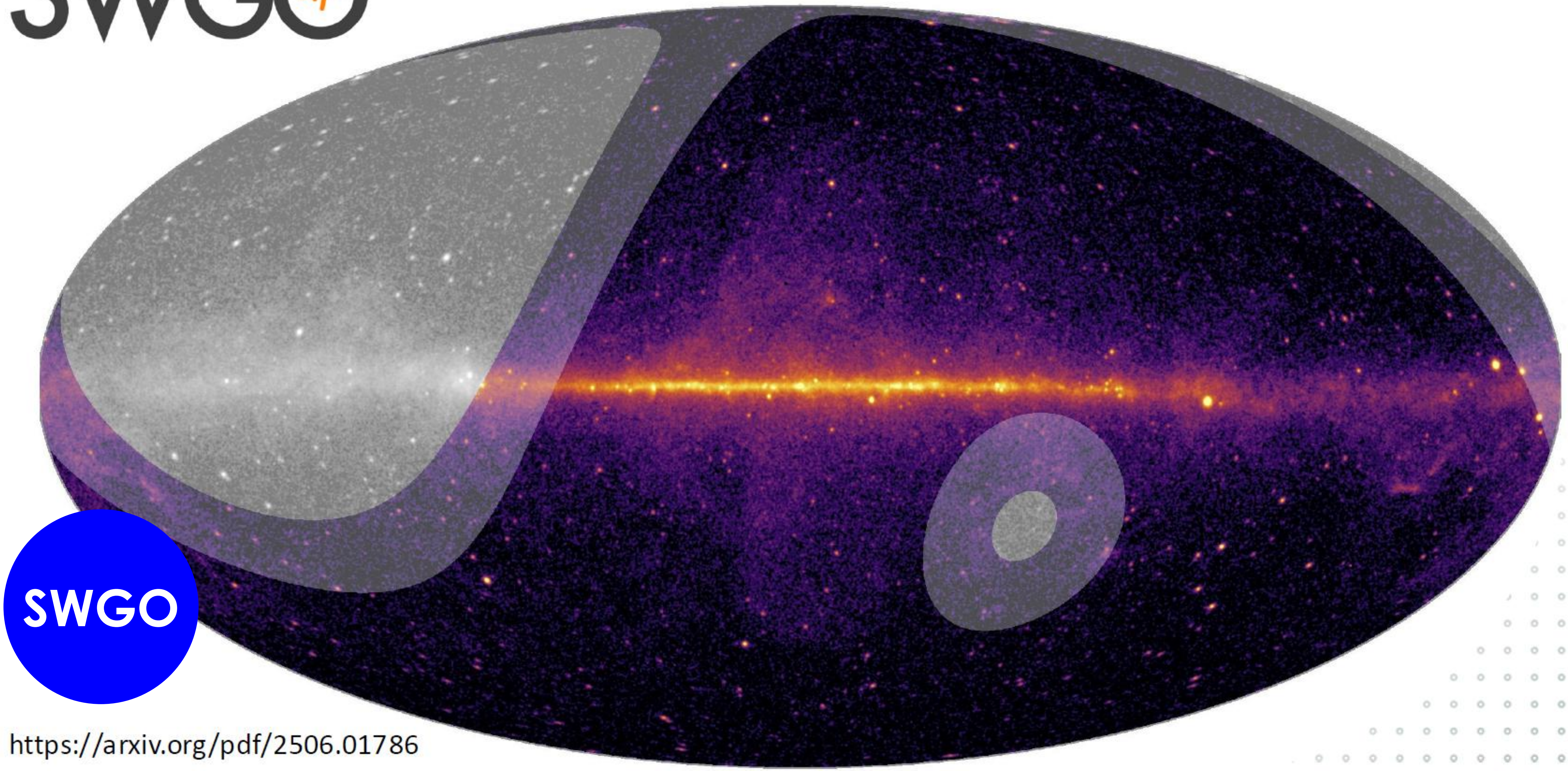


- 1st LHAASO Catalogue : KM2A



HAWK
HESS
LHAASO

J. Hinton – Tuesday 01/07

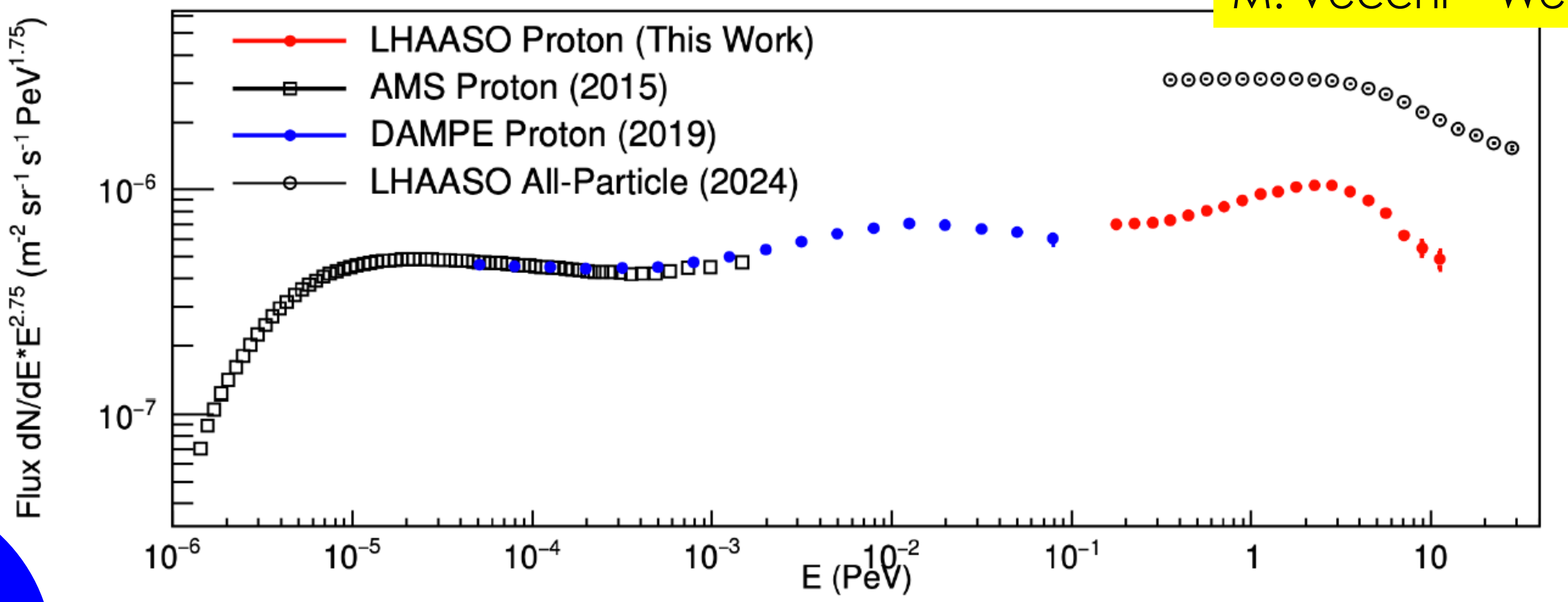


https://arxiv.org/pdf/2506.01786

LHAASO proton flux

The LHAASO collaboration [ground-based detector]
arXiv: 2505.14447

M. Vecchi – Wednesday 02/07



AMS
DAMPE
LHAASO

CR proton measurements from the GeV up to 10 PeV !

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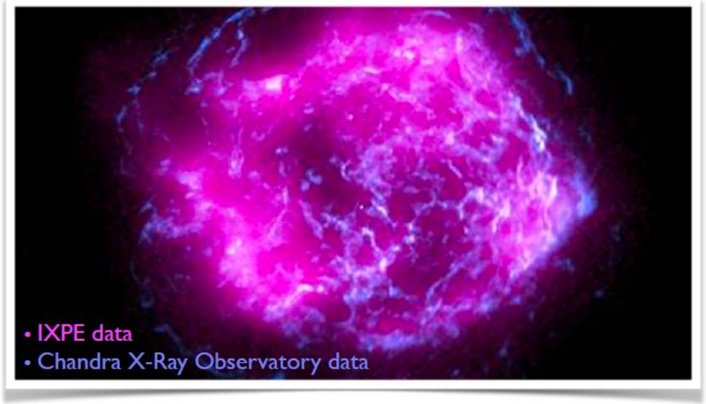
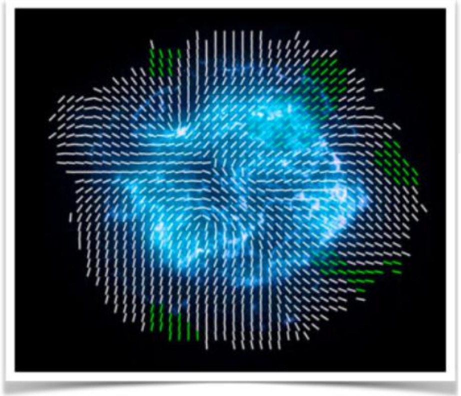
FIRST IXPE SCIENCE TARGET: SNR CASSIOPEIA A





- Overall polarization degree (**PD**) = **1.8±0.3% (5σ)** in the 3-6 keV energy range, by summing over a large region and assuming circular symmetry for polarization vectors
  - *polarization angle* corresponds to a radially-oriented magnetic field, similarly to radio obs. results;
  - *polarization degree* is lower than in the radio band (~ 5%).
- The polarization vectors suggest an **overall radial magnetic-field orientation**

Vink et al. 2022 ApJ

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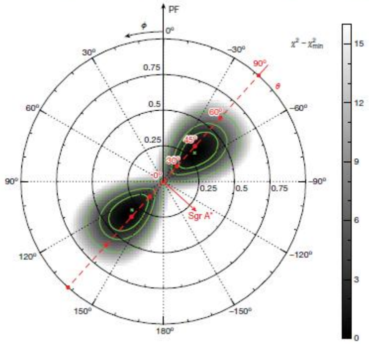
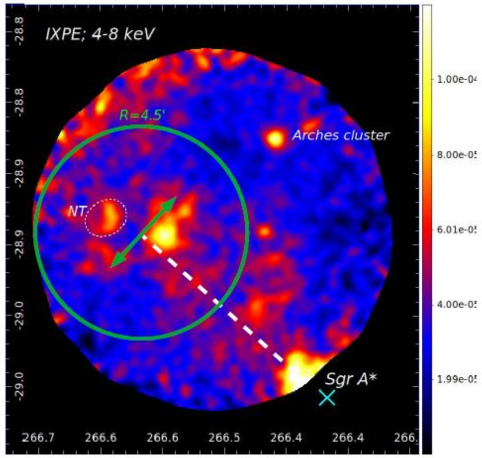
R. Bonino – Thursday 03/07

IXPE

SGR A*

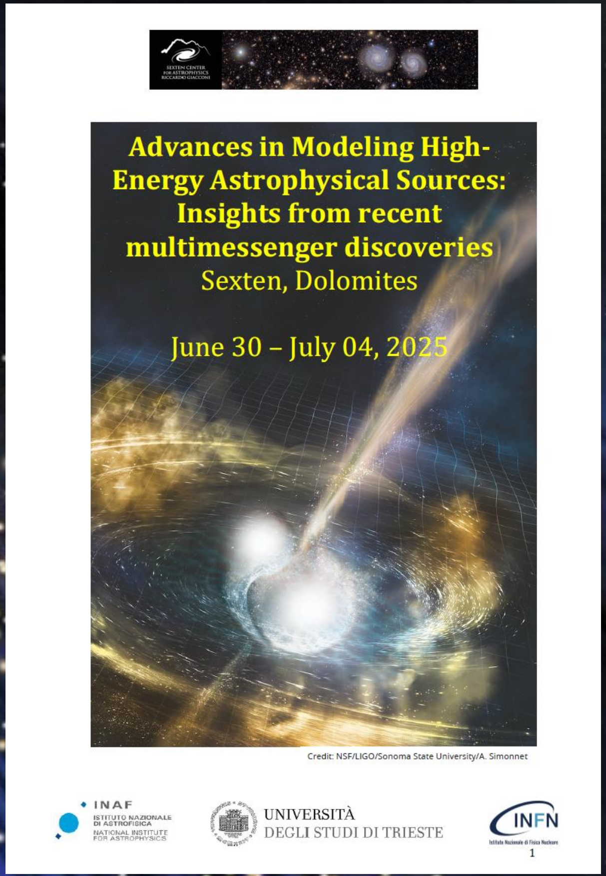
- GC hosts a BH of ~ 4 10^6 M_{SUN}, quiescent at present, with a luminosity << ordinary AGN:
  - Local sources fail to explain the bright X-ray emission observed in molecular clouds near GC
  - Possible explanation: **reflection of past hard X-ray flares** by dense gas in the GC region → reflected X-ray emission should be highly polarized and the PA should point back to GC
- IXPE observed **polarized X-ray emission** in the direction of molecular clouds in GC:
  - PA = - 48° ± 11° → **consistent with Sgr A***
  - PD = 31% ± 11% → 200 years ago Sgr A* briefly had X-ray luminosity comparable to Seyfert galaxy



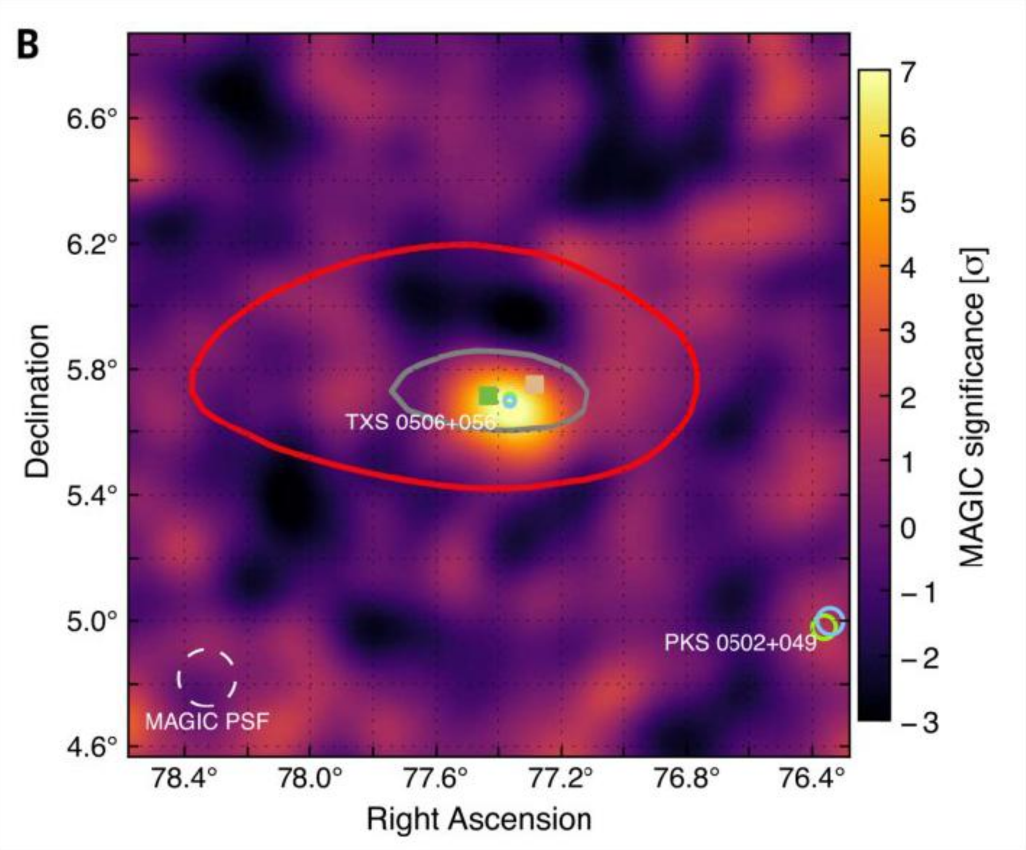


Marin et al. 2023 Nature

Active Galactic Nuclei



TXS 0506+056

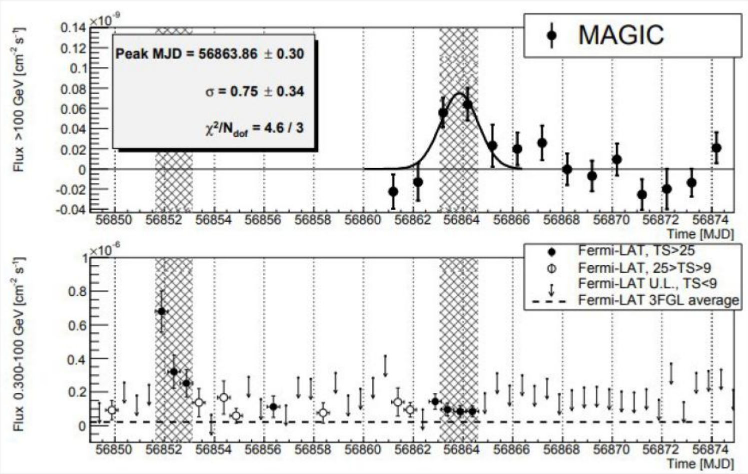


- Association of a high energy astrophysical neutrino (IC170922A) with an astrophysical source (TXS 0506+056, a blazar in this case)
- Detection by MAGIC and VERITAS
- Case of multi-messenger detection!
- Started the hunt for others candidate sources of high energy neutrinos (e.g. NGC 1068)

Fermi+ IACTs

A. Berti – Tuesday 01/07

Gravitationally-lensed blazar



- QSO B0218+357: gravitationally lensed blazar located (z=0.944), splitting the radiation in two components delayed by 10-12 days
- MAGIC detected the VHE emission after Fermi-LAT detected an enhanced emission, with the delay expected

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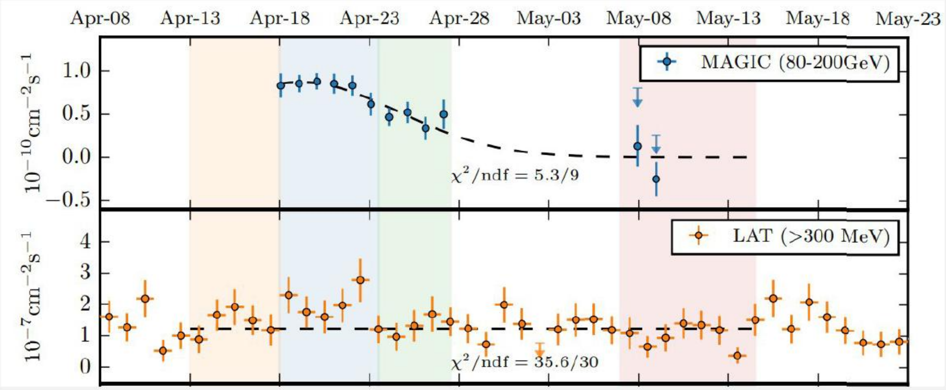
Fermi+ MAGIC

FSRQs: PKS 1441+25



- PKS 1441+25 is a FSRQ at z=0.94, detected by MAGIC after a flare in Fermi-LAT band in April 2015 (farthest source at the time)

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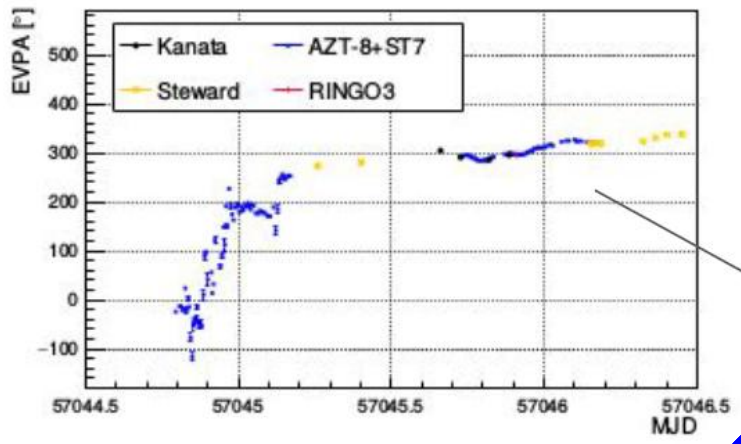
M. Manganaro – Tuesday 01/07

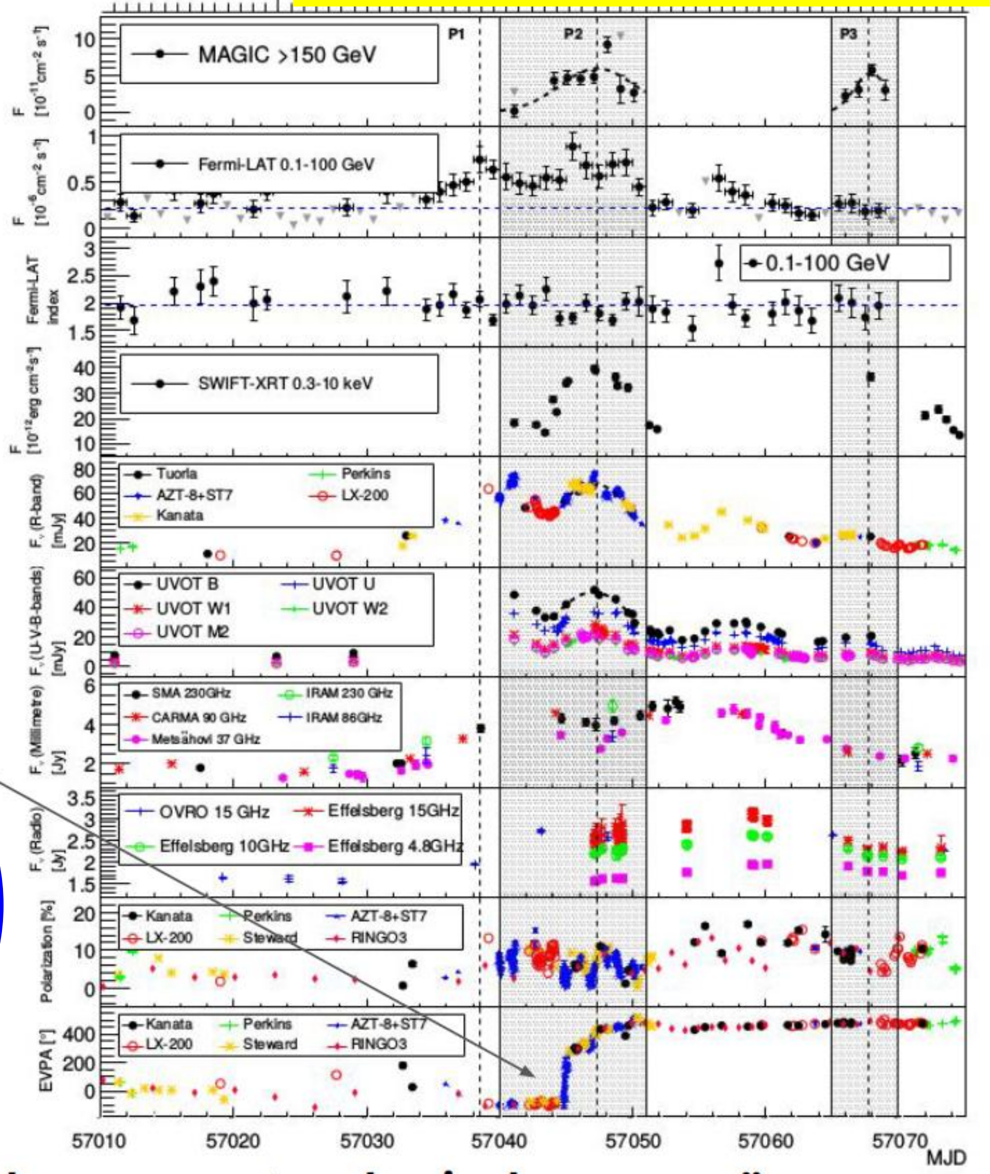
Examples of multi-wavelength studies

Multi-wavelength characterization of the blazar
S5 0716+714 during an unprecedented outburst phase



Ahnen et al., Astronomy & Astrophysics **619**

Fermi+ everybody

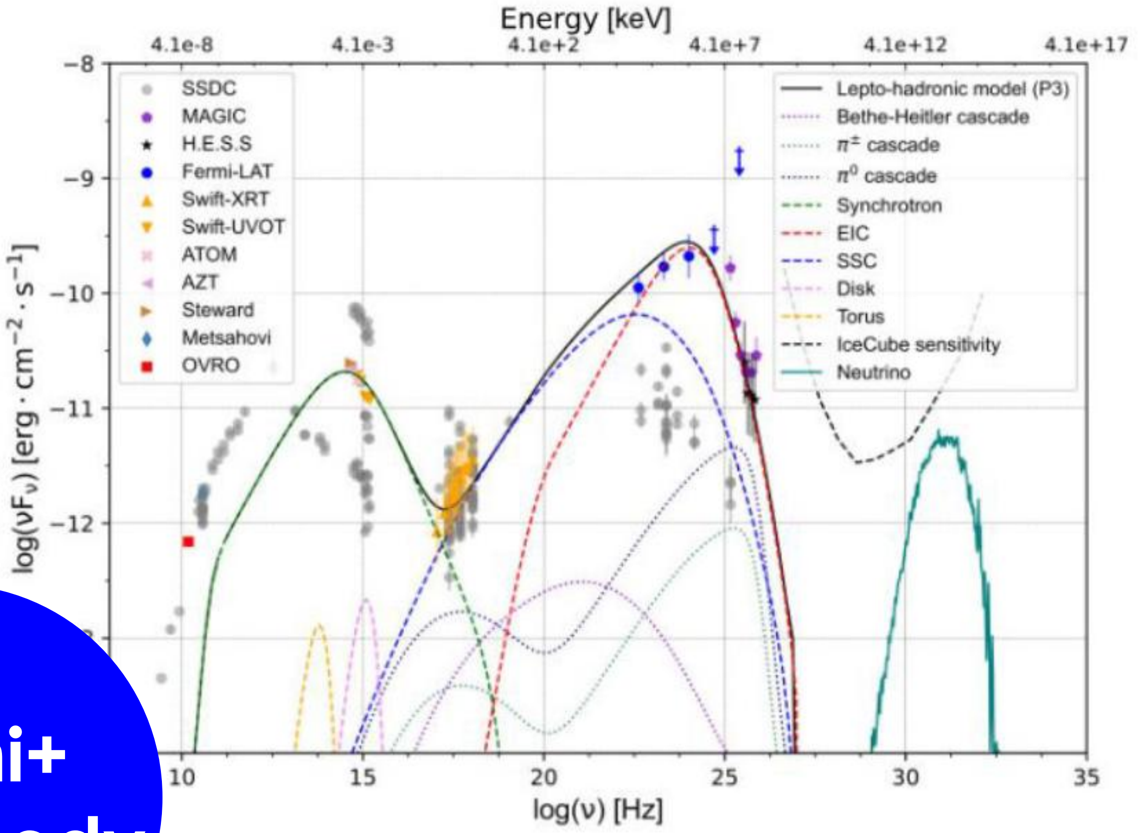


M. Manganaro – Tuesday 01/07

Examples of multi-wavelength studies

OT 081

- One-zone SSC models cannot successfully describe the dataset.
- The high energy bump of the SEDs can not be explained by Compton scattering of low-energy photons by the same electrons producing the synchrotron emission at lower frequencies ...



Fermi+ everybody

[Abe et al., MNRAS 540, 364 (2025)]

01.07.2025 --Sexten PhD School "Advances in modeling high energy astrophysical sources..." --

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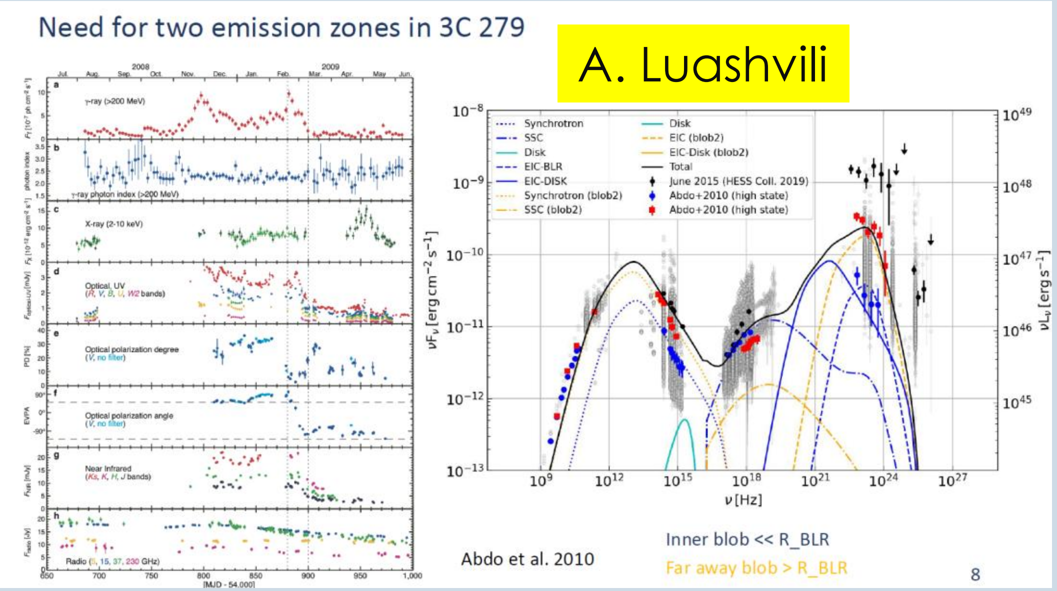
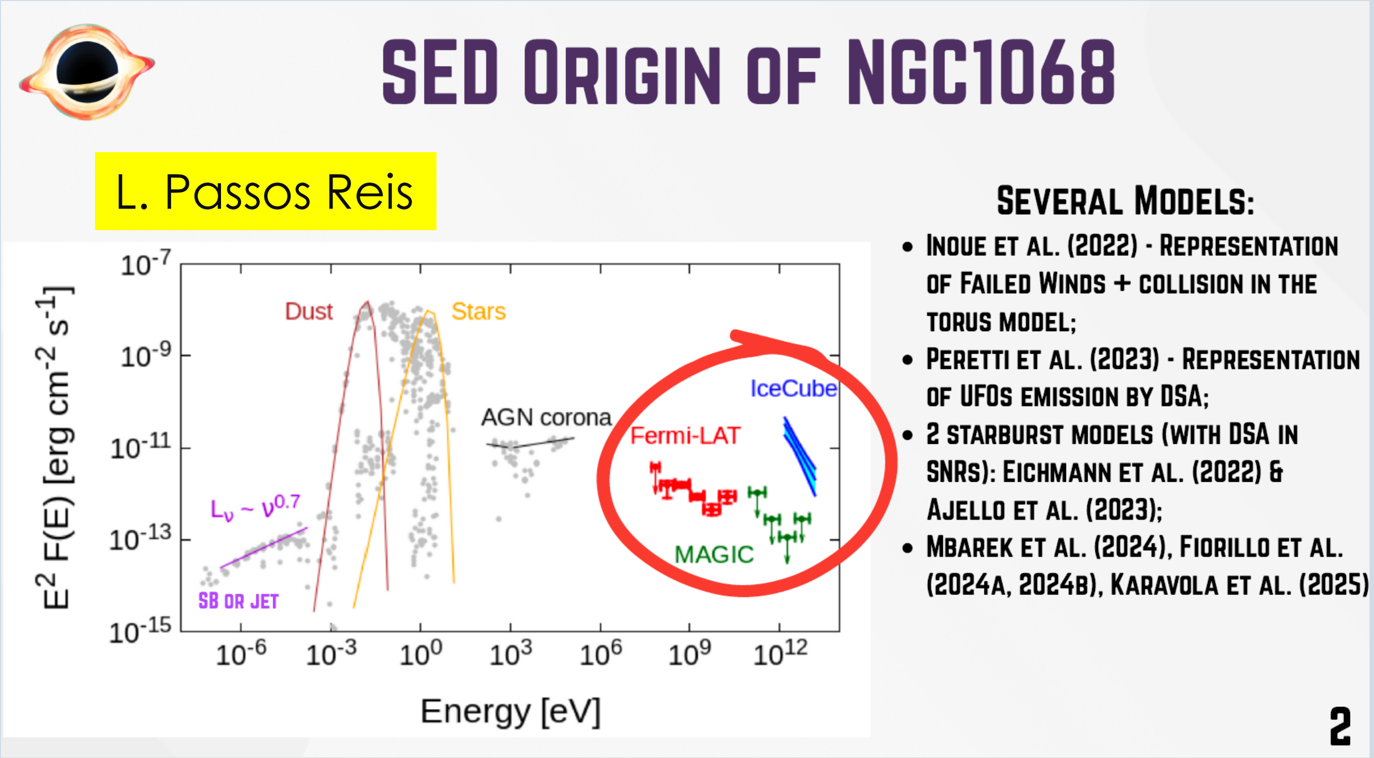
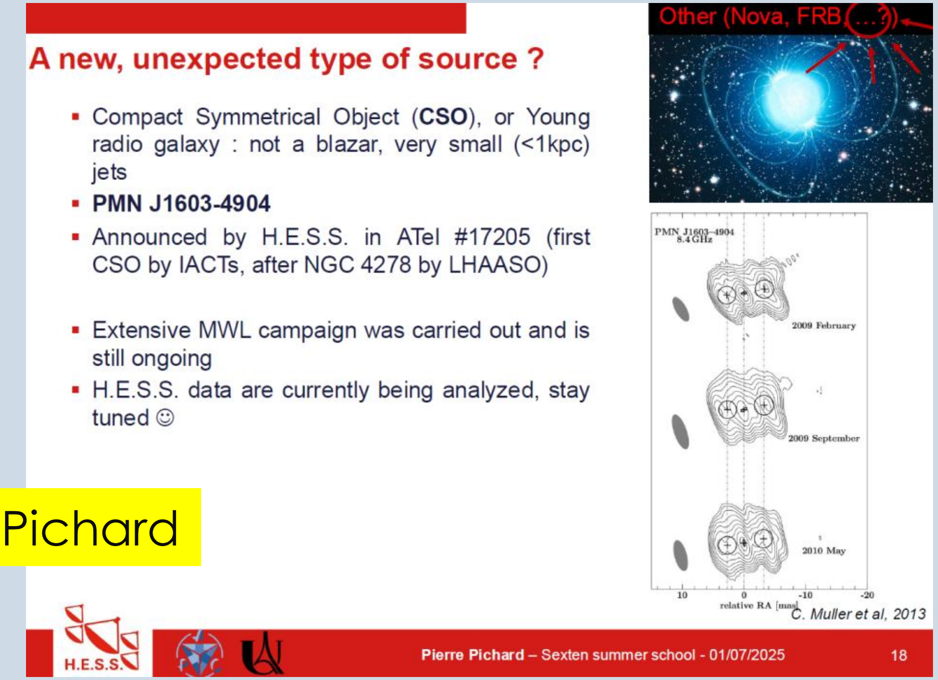
A. Luashvili



L. Passos Reis





P. Pichard

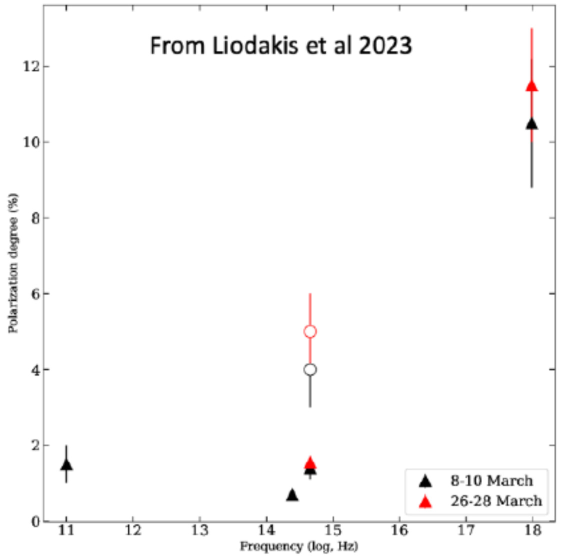
Tuesday 01/07

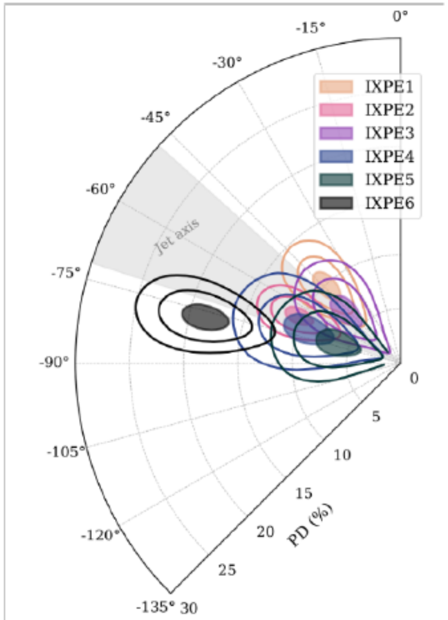
Fermi+ everybody

FIRST BLAZAR RESULT PUBLISHED: MRK 501

IXPE Imaging X-Ray Polarimetry Explorer

- 1st observation: PD of 10% and PA in line with the radio jet axis (*Liodakis et al 2022, Nature*)
- Mostly **steady behavior** from subsequent observations, except for a PD of 17% in the 6th observation (*Chen et al 2024*).





R. Bonino – Thursday 03/07

- **PD higher in X-ray than in optical and radio**

IXPE

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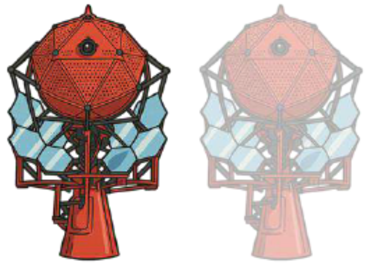
ASTRI Very Early Science

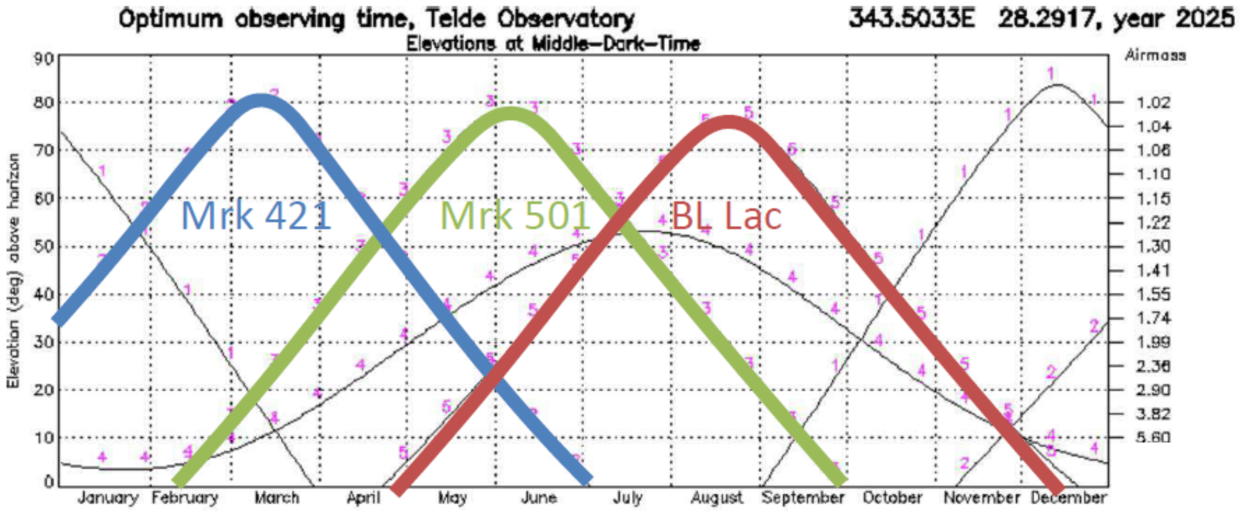
ASTRI Mini-Array

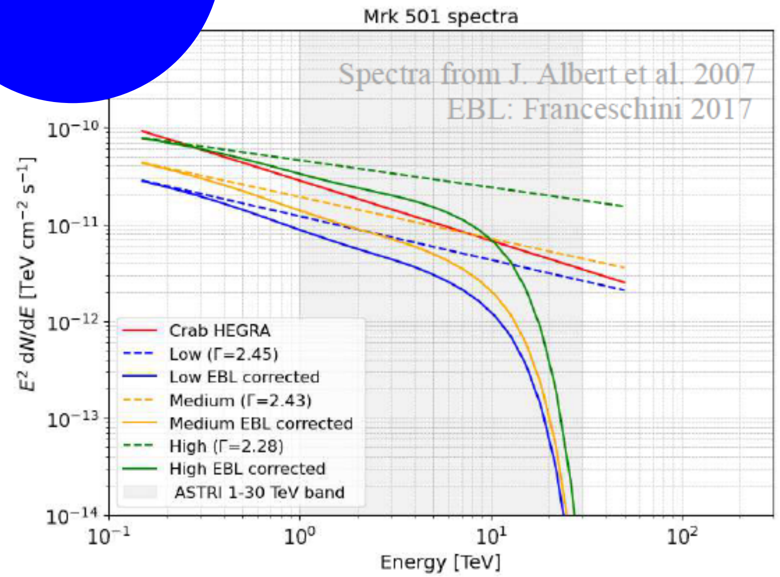
G. Pareschi – Thursday 03/07

This summer, with at most two fully operational telescopes, our goal is to make the most of the available resources by combining scientific observations and technical operations. In this context, we aim to carry out a regular monitoring program of blazars.



ASTRI

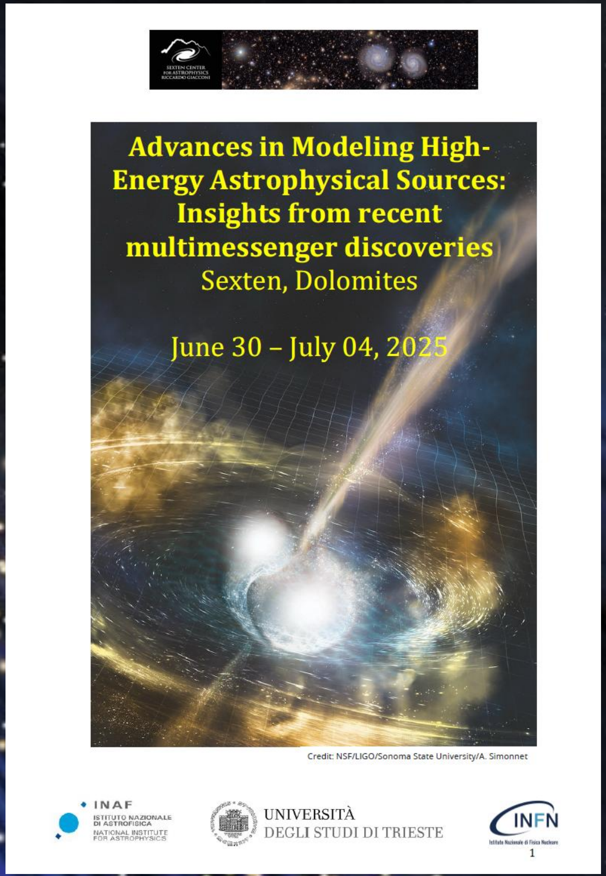




Flares in bright TeV blazars with *Swift* and the ASTRI Mini-Array

S. Vercellone, P. Romano, G. Bonnoli, G. Pareschi, F. Tavecchio (INAF/OAB)
J. Becerra González (IAC), A. Giuliani (INAF/IASFMI), M. Capalbi, S. Lombardi (INAF/OAR)

Gamma-Ray Bursts



Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INFN

GRBs at VHE: the current status

IACTs

5 GRBs detected at > 5σ

	T_{90} s	$E_{\gamma,iso}$ erg	z	T_{delay} s	E_{range} TeV	IACT (sign.)
160821B	0.48	1.2×10^{49}	0.162	24	0.5-5	MAGIC (3.1σ)
180720B	48.9	6.0×10^{53}	0.654	3.64×10^4	0.1-0.44	H.E.S.S. (5.3σ)
190114C	362	2.5×10^{53}	0.424	57	0.3-1	MAGIC ($> 50\sigma$)
190829A	58.2	2.0×10^{50}	0.079	1.55×10^4	0.18-3.3	H.E.S.S. (21.7σ)
201015A	9.78	1.1×10^{50}	0.42	33	0.14	MAGIC (3.5σ)
201216C	48	4.7×10^{53}	1.1	56	0.1	MAGIC (6.0σ)
221009A	289	1.0×10^{55}	0.151	0-3000	0.3-13	LHAASO (250σ)

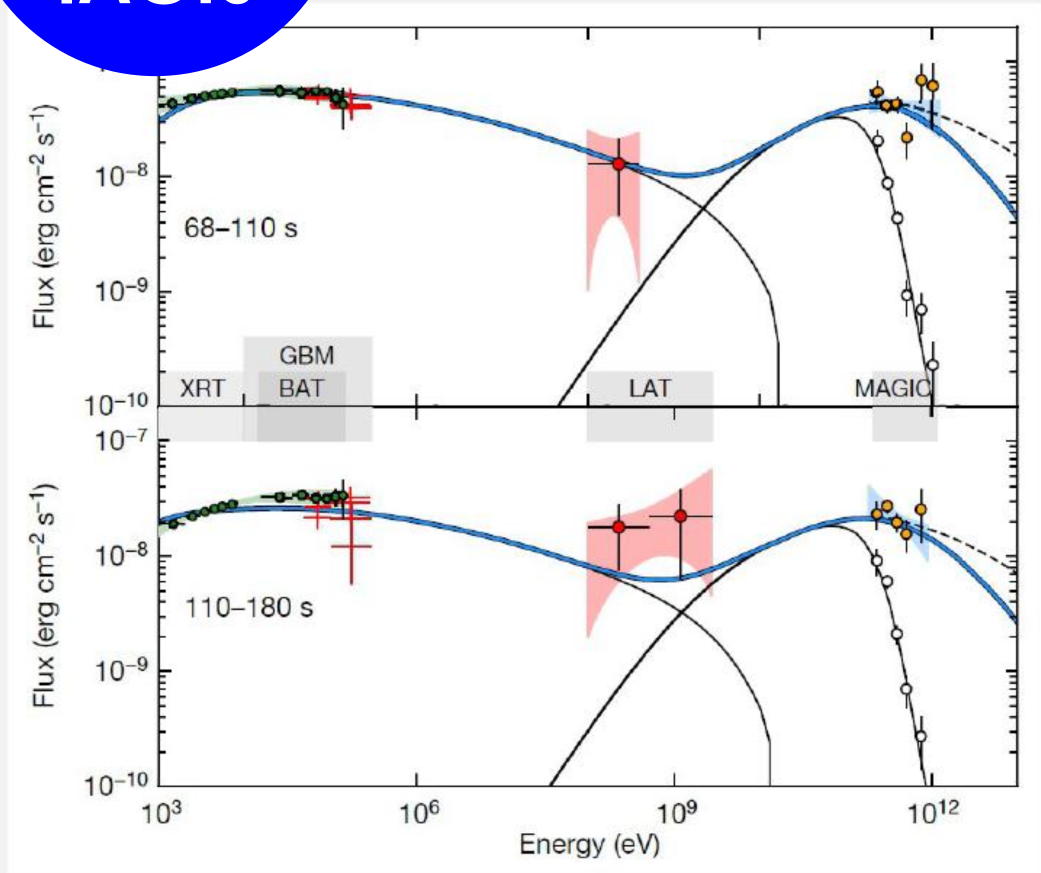
Adapted from DM & Nava, 2022

Fermi+
Swift+
IACTs

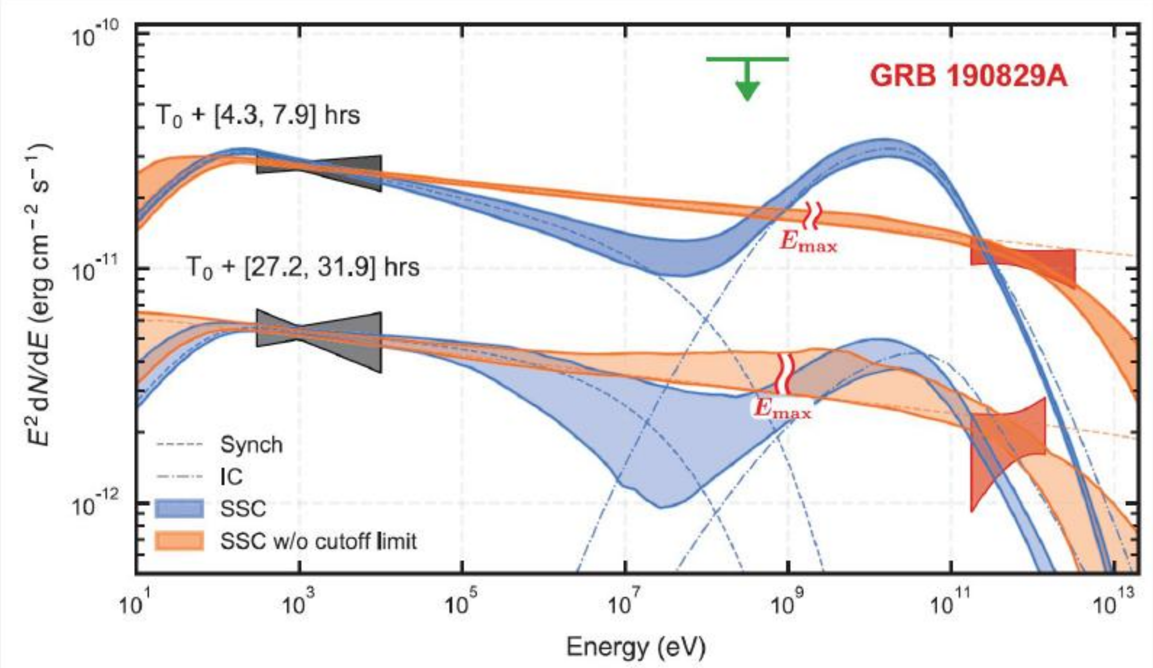
A. Berti – Tuesday 01/07

GRBs at VHE

GRB 190114C



GRBs are VHE emitters!
4 GRBs detected by IACTs from 2018 to 2020
GRB 201216C farthest VHE source (z=1.1)



GRB 190829A

1st July 2025 Sexten Workshop 2025 20

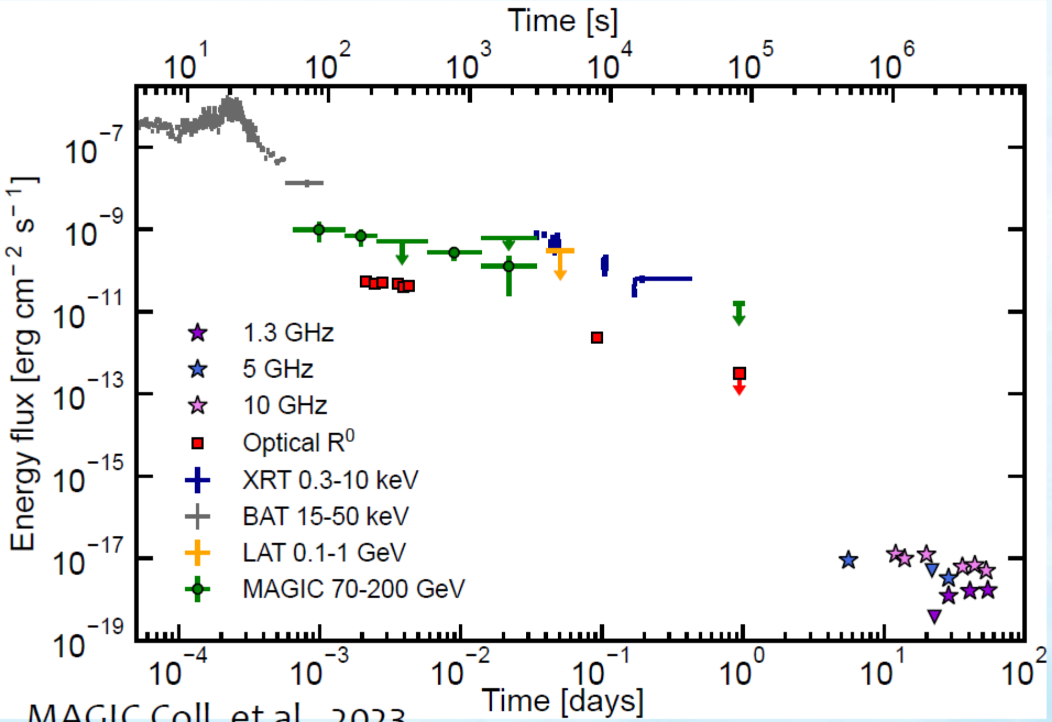
Fermi+ Swift+ IACTs

D. Miceli – Monday 30/06

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | INFN

Population of GRBs in VHE domain

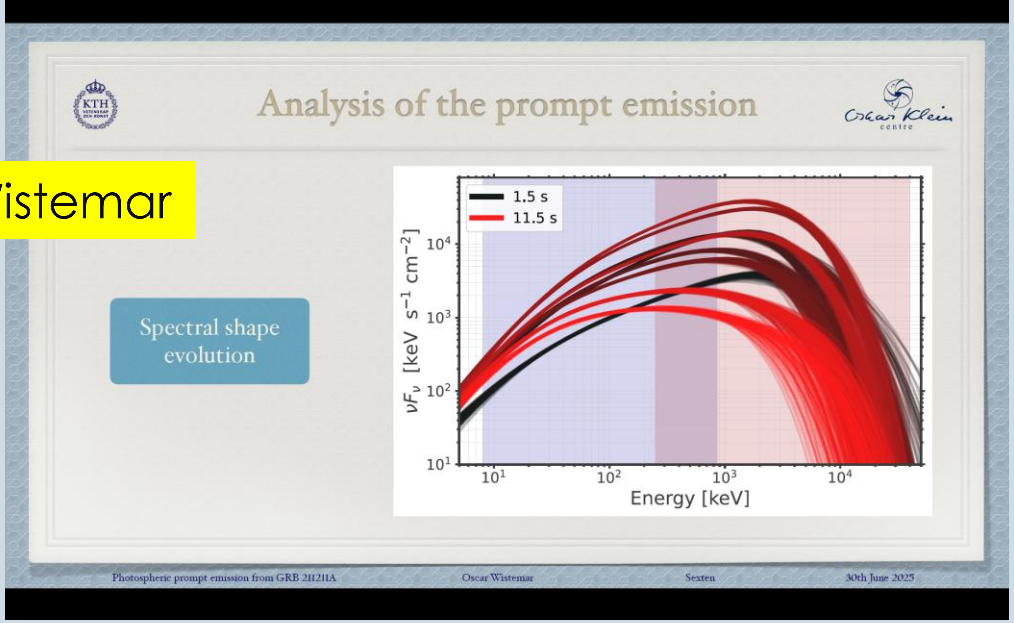
- Broadband intrinsic properties:
  - span more than 3 orders of magnitude in $E_{\gamma,iso}$
  - Span 2 orders of magnitude in terms of L_{VHE}
  - ranging in redshift between 0.079–1.1
- X-ray – TeV connection:
  - similar fluxes and decay slopes
  - similar amount of radiated power
- Data modeling:
  - SSC suggested (not conclusive)
  - no preferences on constant/wind-like medium
  - $\epsilon_e \sim 0.1$, $\epsilon_B \sim 10^{-5}$–10^{-3}, $\xi<1$



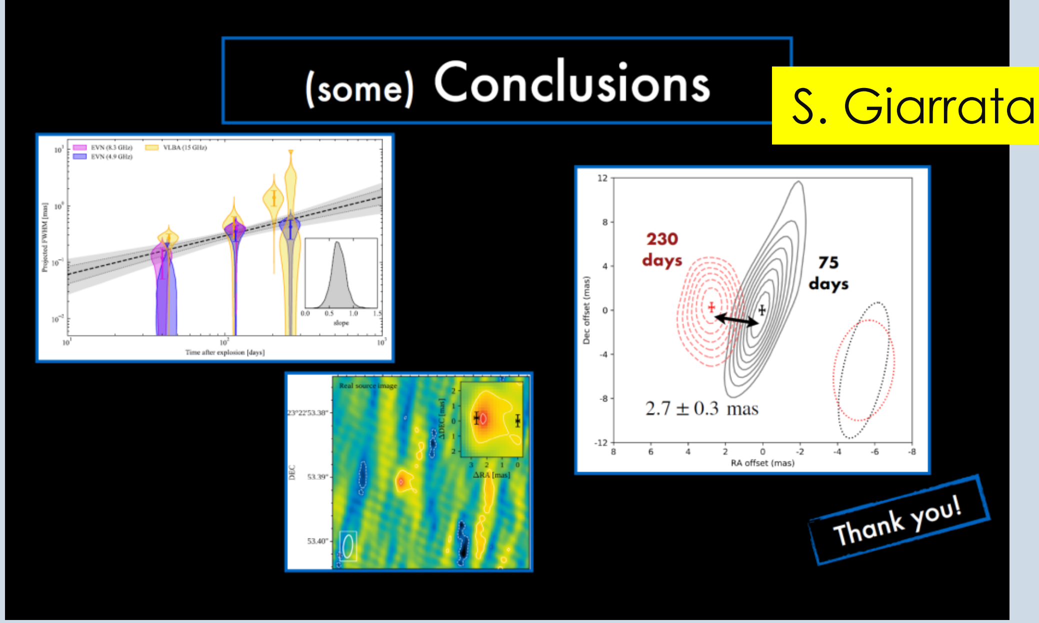
MAGIC Coll. et al., 2023

19 Missione 4 • Istruzione e Ricerca

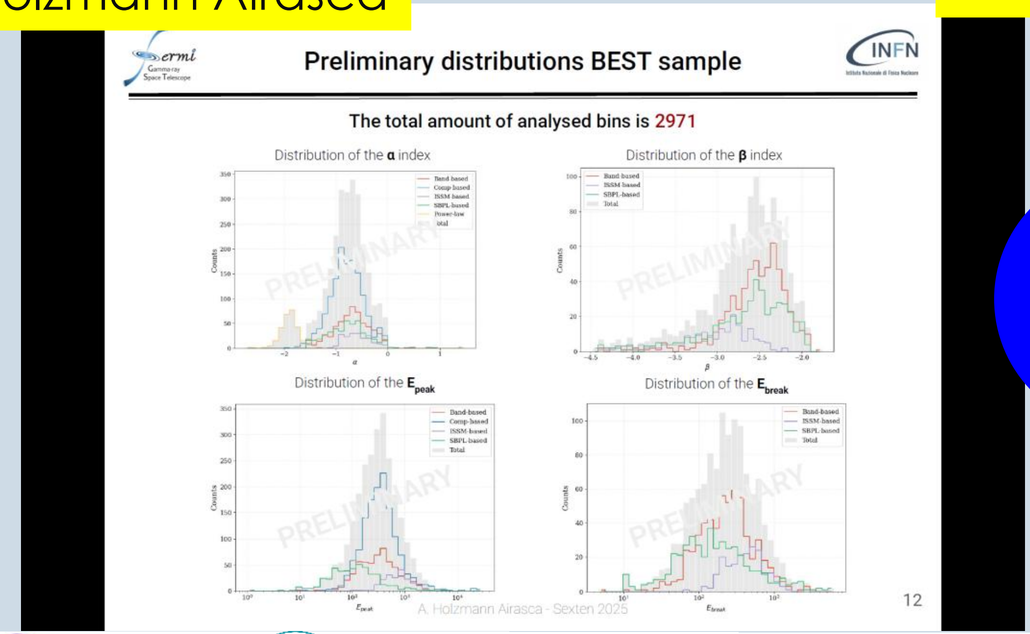
O. Wistemar



S. Giarratana



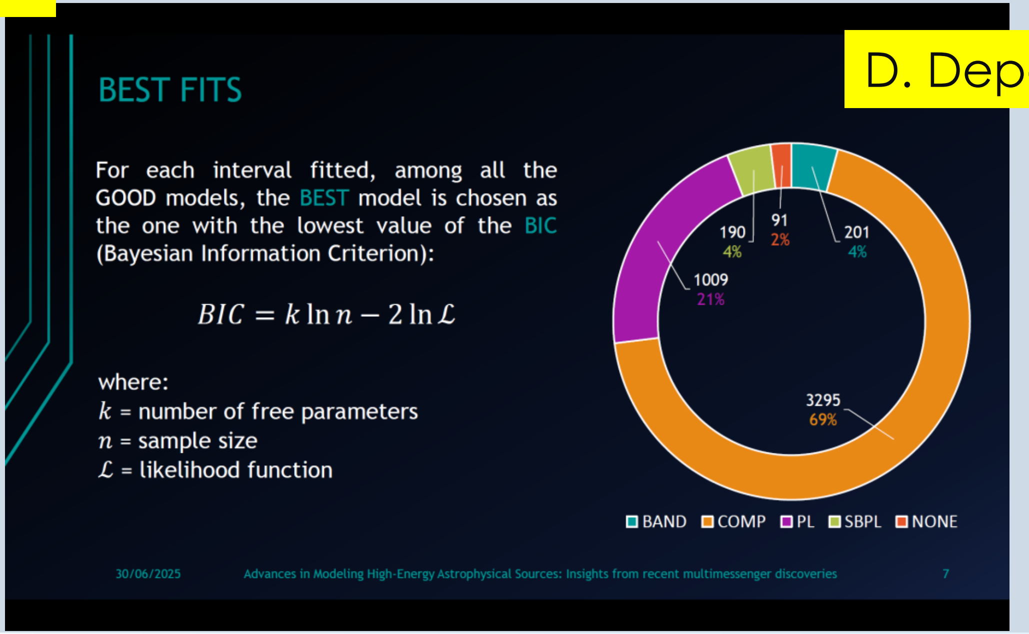
A. Holzmann Airasca



Monday 30/06

Fermi

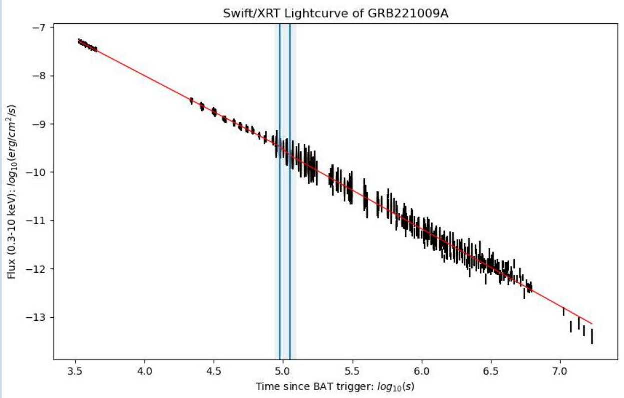
D. Depalo



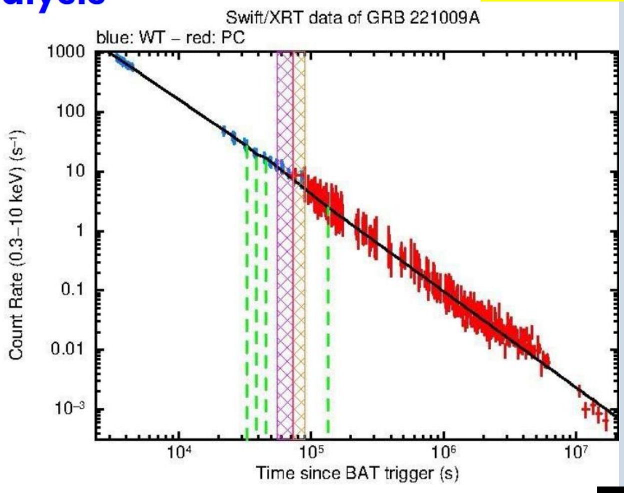
Some Results:

GRB221009A in GRBFit & Swift analysis

A. A. Vigliano



GRB221009A analysis with the new method: no flare and 2 breakpoints identified.



GRB221009A analysis with the Swift method: 2 flares and 4 breakpoints identified.

Evans et al., MNRAS 2009, DOI: 10.1111/j.1365-2966.2009.14913.x

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Wednesday 02/07

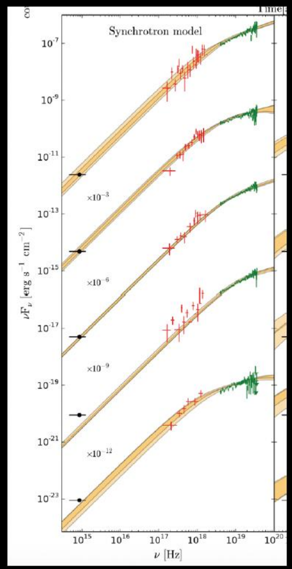
Swift

Fermi

G. Soares

Extrapolating to lower energies indicates RS (fast cooling) would dominate again, softening the spectrum

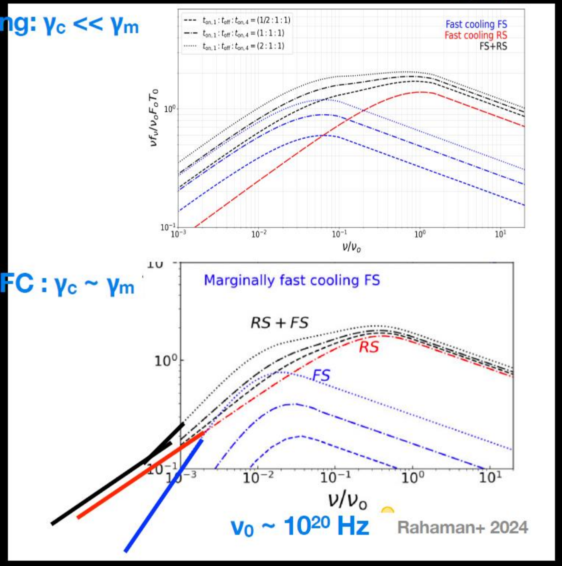
GS+ in prep



Oganesyan+ 2019

Fast cooling: $\gamma_c << \gamma_m$

Marginally FC : $\gamma_c \sim \gamma_m$



$\nu_0 \sim 10^{20}$ Hz

Rahaman+ 2024

Gustavo Soares — Sexten 02/07/2025

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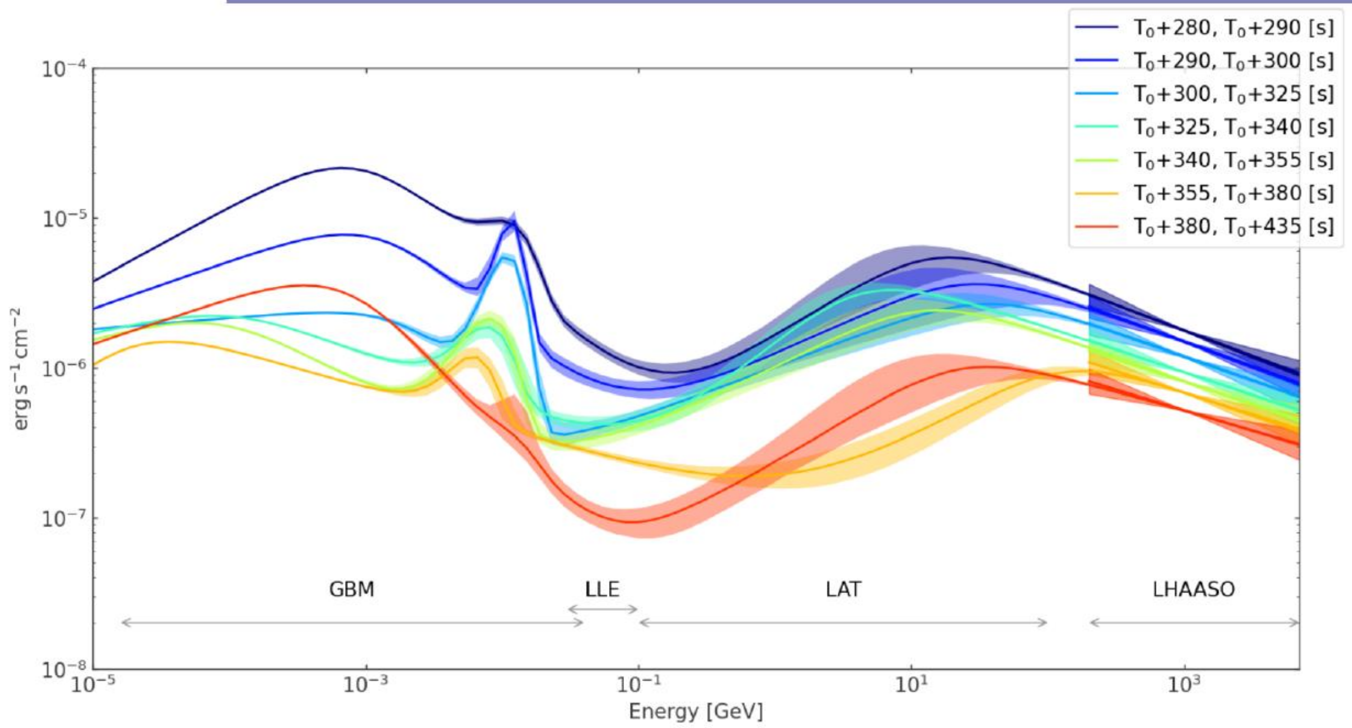
DIPARTIMENTO INTERATENEO DI FISICA «M. MERLIN»

Politecnico di Bari

INFN BARI

S. Cutini – Monday 30/06

GRB 221009A: The BOAT



Axelsson et al 2024 10.3847/1538-4365/ada272
S. Lesage et al. 2023, 10.3847/2041-8213/ace5b4

Fermi+ LHAASO

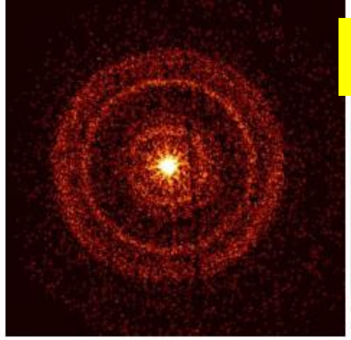
The overall spectrum exhibits a characteristic two-bump structure typical of synchrotron and SSC, In addition, a Gaussian line is statistically significant in the first five intervals, and only marginally significant (or not significant) in the last two.

Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries
30/06/25-5/07/25 - Sesto Pusteria

Sara Cutini (INFN) 17

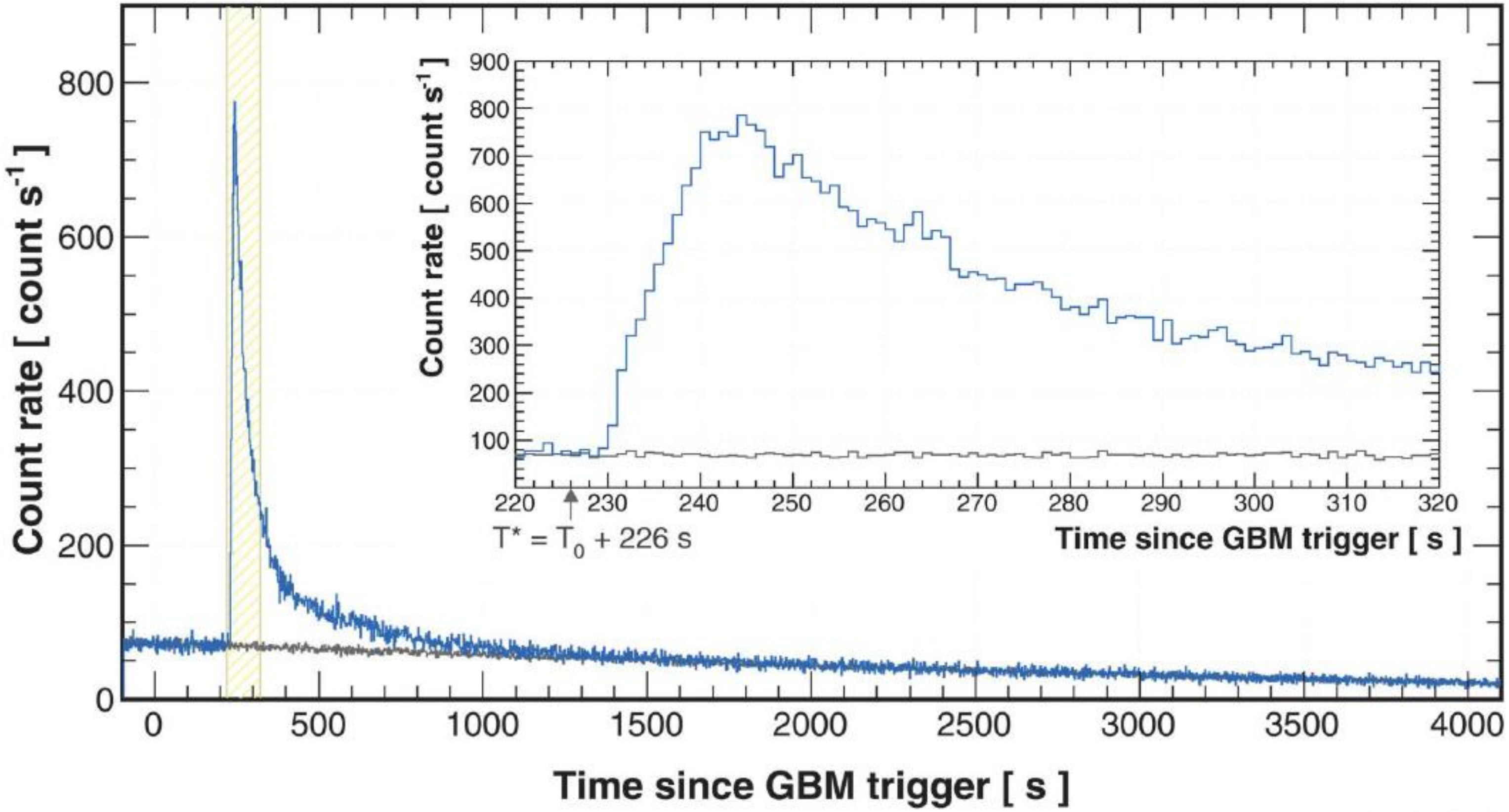
Discoveries?

J. Hinton – Tuesday 01/07



e.g. GRB 221009A

LHAASO



Cao et al,
Science 2023

- z = 0.1505, photons up to (reconstructed) energy of **18 TeV**

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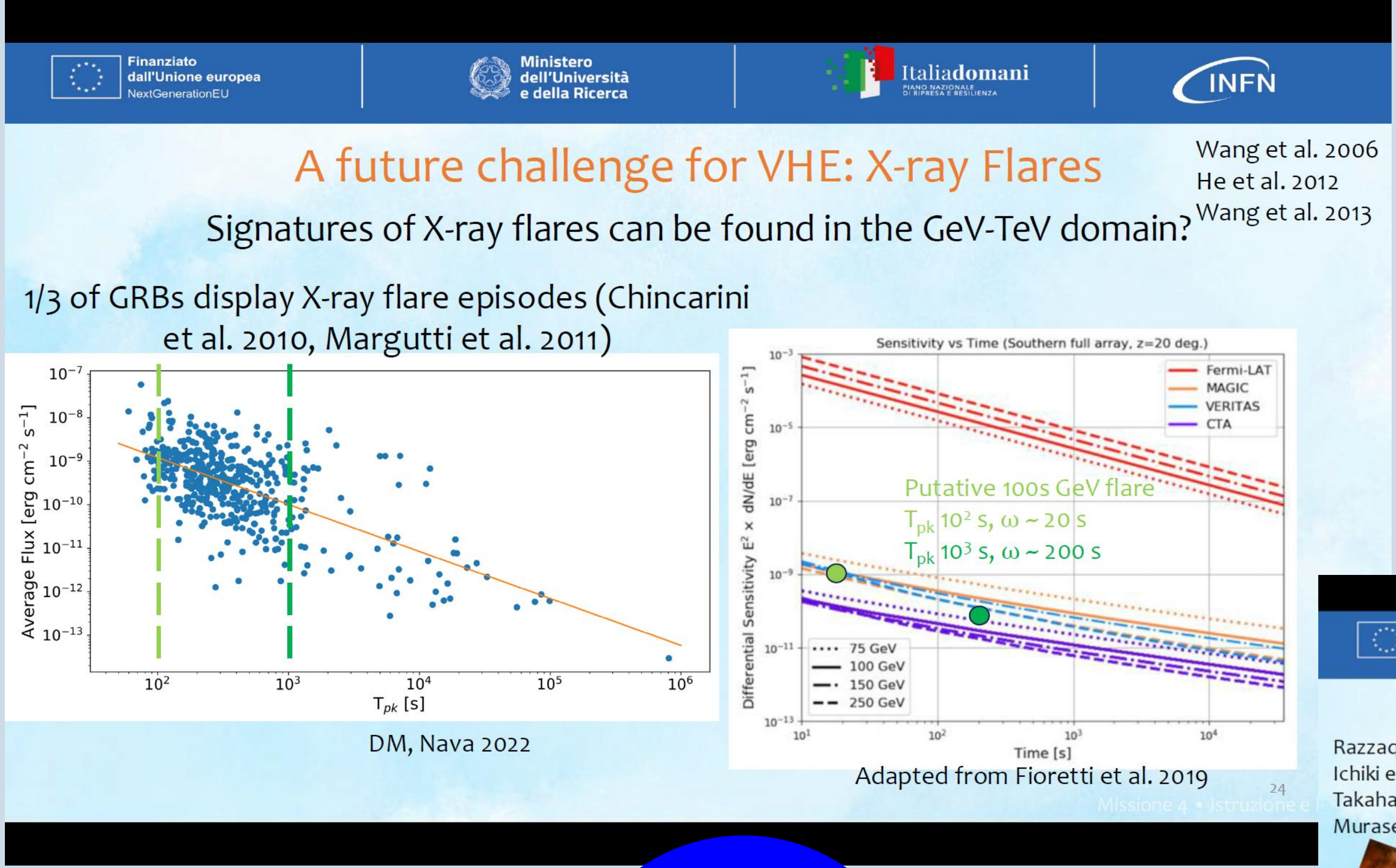
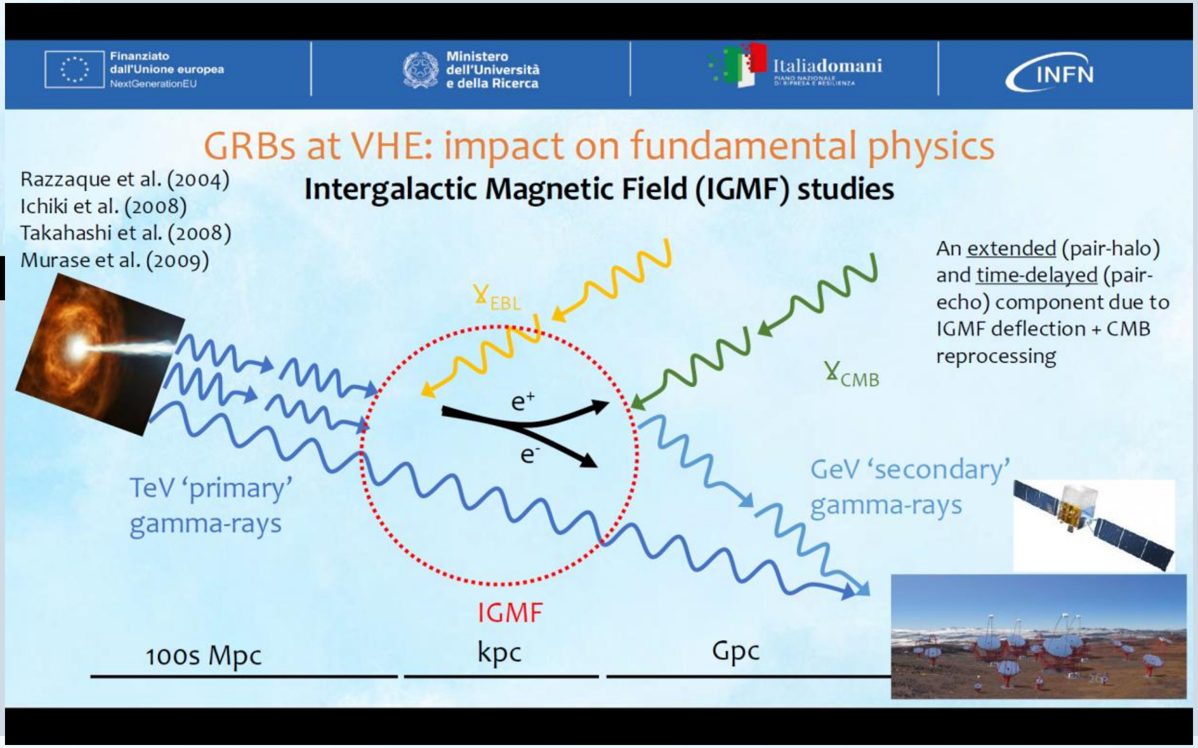
D. Miceli – Monday 30/06



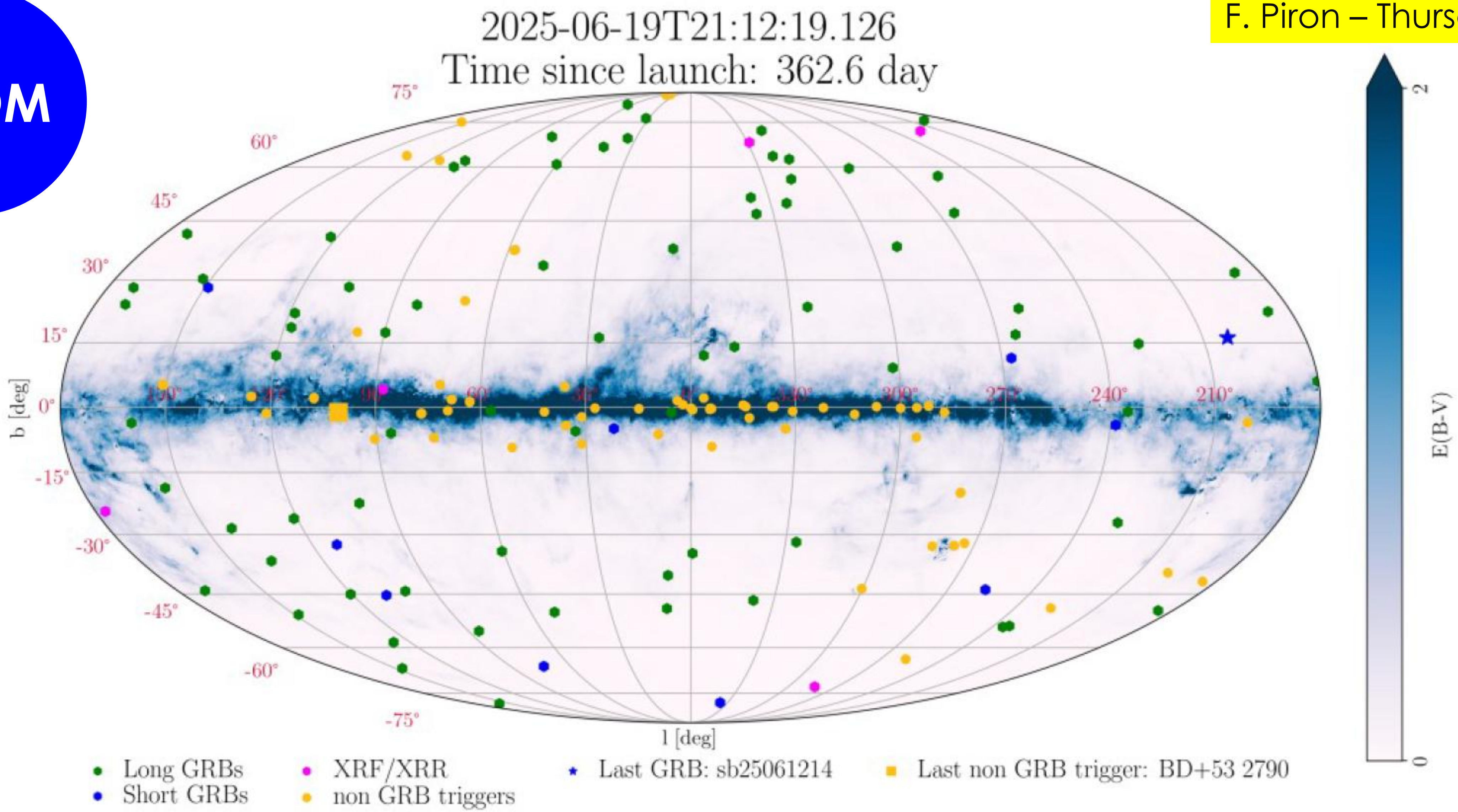


Fermi+ IACTs

The SVOM X-ray/γ-ray transient sky after one year

SVOM

F. Piron – Thursday 03/07



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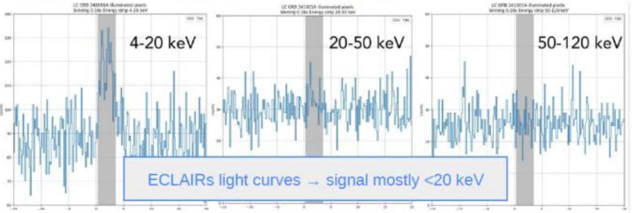
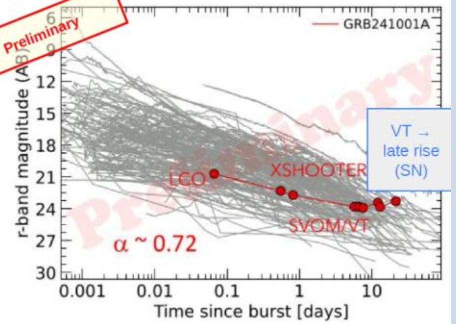
SVOM

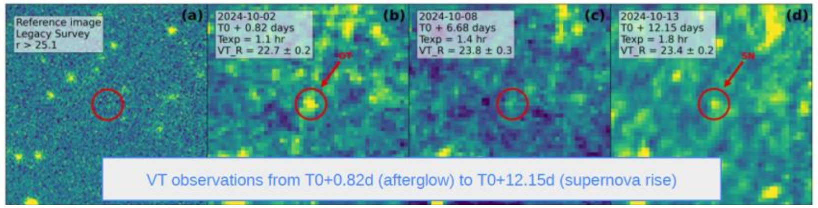
Soft Gamma-Ray Bursts

GRB 241001A (z = 0.573) Schneider et al. (in prep)

- Very soft burst associated with a type Ic SN (JWST at T0+24d)
- ECLAIRs spectrum: BB (1.9 keV) or BPL, PL rejected
- Faint X-ray afterglow, sub-luminous at its redshift
- X-Ray Flash: shock breakout? Off-axis GRB?







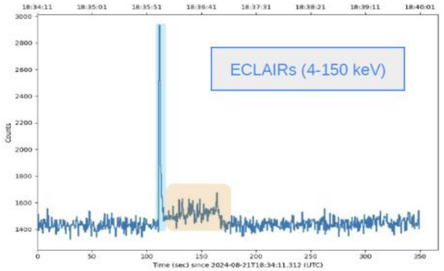
- **Other soft GRBs detected by ECLAIRs are under study:**
  240819A
  240828B?, 250219A?
  250317B Zhao et al. (in prep)
  250419A?
  sb25061207/GRB250612D

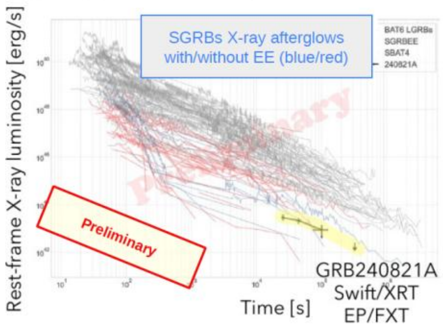
Short Gamma-Ray Bursts

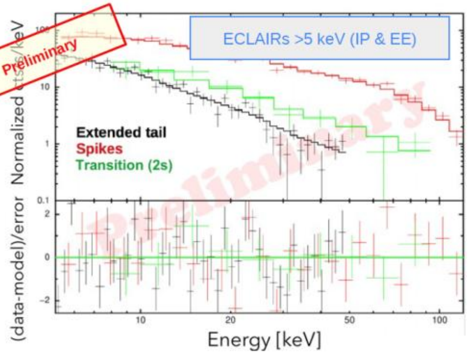
Goal: contribute to build a sample of fully characterized short GRBs, including the properties of the host galaxy

GRB 240821A (z = 0.238) Daigne, Zhang et al. (in prep)

- First ECLAIRs + GRM joint detection (T90 ~ 50 s)
- Initial pulse (IP) + temporally-extended emission (EE)
- EE plateau like, soft (<50 keV), non thermal, no sp. evolution
- Faint X-ray afterglow, but consistent with other SGRBs with EE
- Host galaxy (GTC, VLT, Keck) unusual for LGRB







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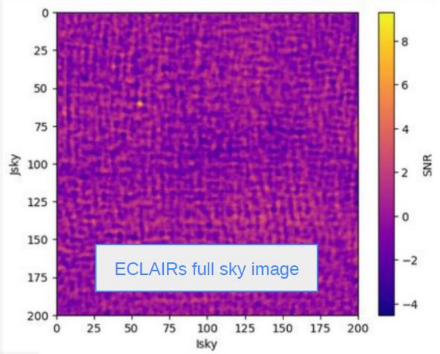
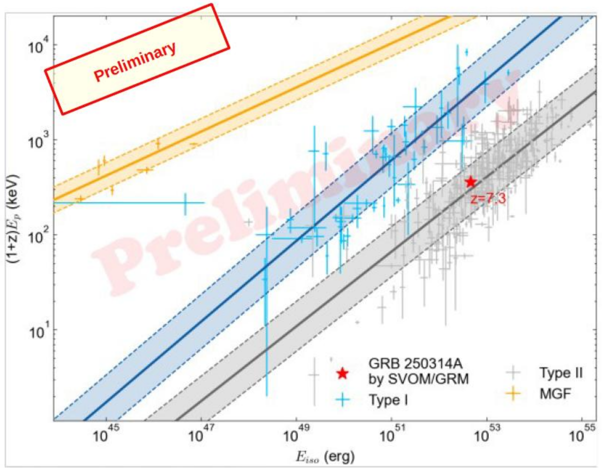
High-z Gamma-Ray Bursts

GRB 250314A at z ~ 7.3 Cordier, Wei et al. (in prep)

- Detected by ECLAIRs and GRM (T90 ~ 10s)
- GRM preliminary analysis: classical LGRB in Ep-Eiso diagram
- Fading X-ray afterglow confirmed by EP/FXT
- No detection by SVOM/VT despite automatic slew
- NIR afterglow discovered by the NOT (T0+12.3h)





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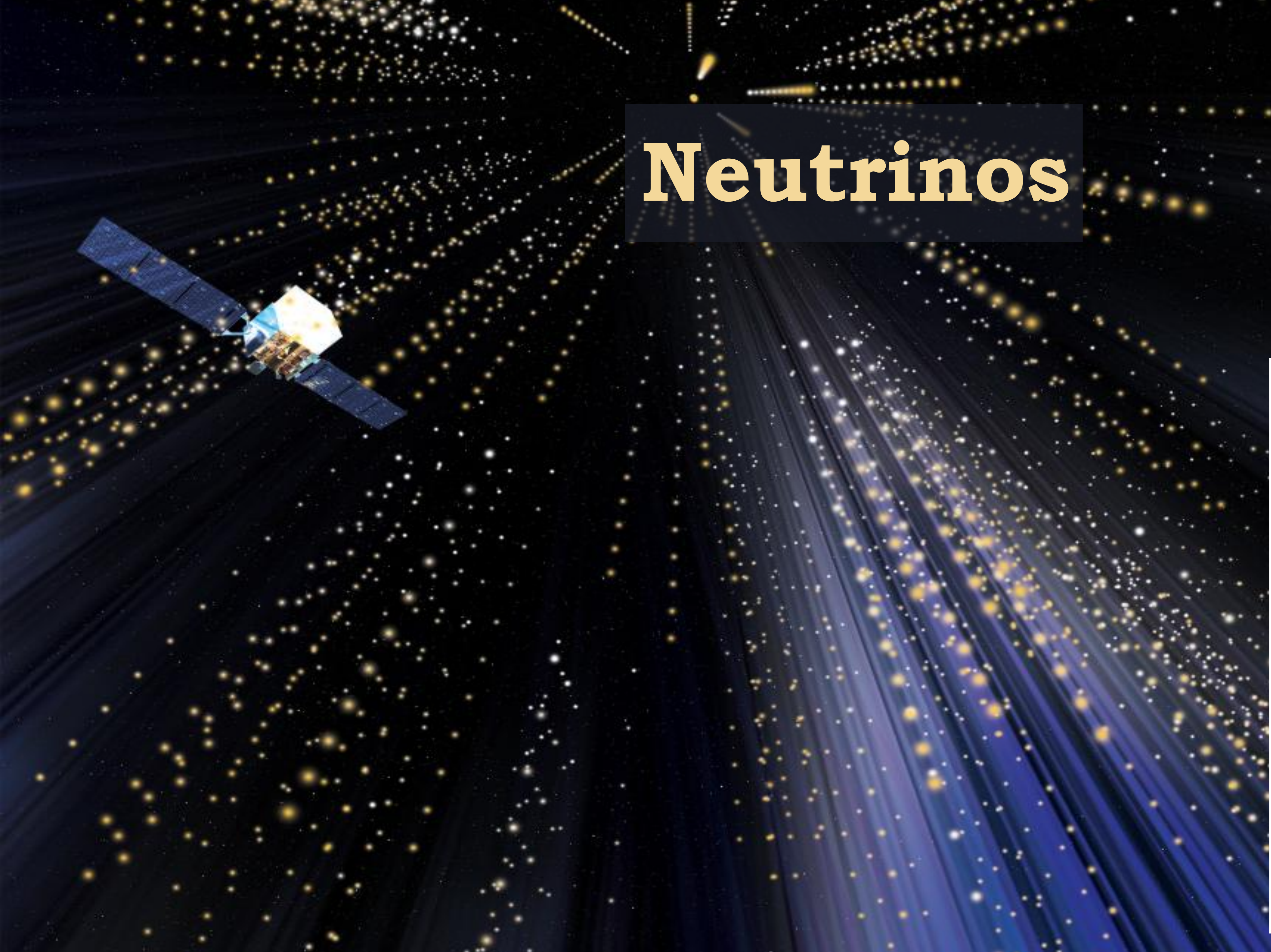
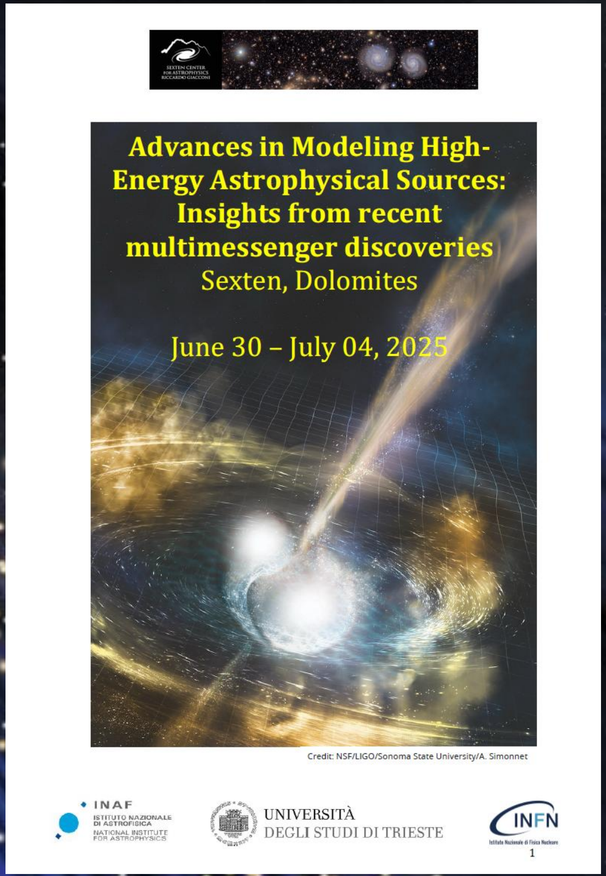
Neutrinos





Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries
Sexten, Dolomites
June 30 – July 04, 2025
Credit: NSF/LIGO/Sonoma State University/A. Simonnet
INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS
UNIVERSITÀ DEGLI STUDI DI TRIESTE
INFN
1

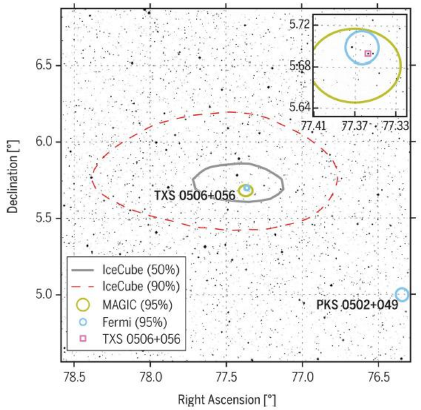
Neutrino - gamma ray connection

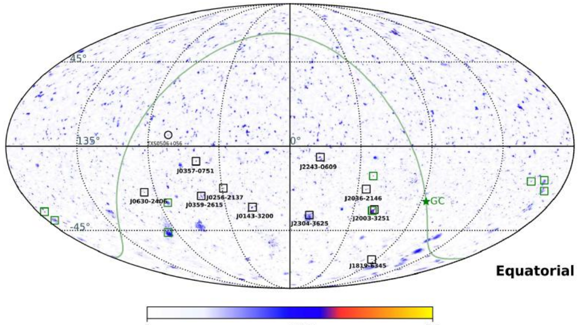
S. Cutini – Monday 30/06

Association of neutrino with flaring blazar TXS 0506+056 sparked interest to identify further counterparts

- So far, no other counterpart has been unambiguously identified—> however 10 IceCube neutrino's hotspots located in the southern sky are likely originated from blazars

IceCube Coll. et al. 2018, 2018Sci...361.1378I; Garrappa et al. 2019, 2022icrc.confE.956G; Buson et al 2022; 2022ApJ...933L..43B





List of PeVatron blazars/Neutrino Hotspot Associations Found by This Work

IceCube Hotspots				Blazar Associations		
	α_{hs}[°]	δ_{hs}[°]	L	5BZCat	z	Separation[°]
IC J2243−0540	340.75	−5.68	4.012	5BZB J2243−0609	0.30[c]	0.47
IC J0359−0746	59.85	−7.78	5.565	5BZQ J0357−0751	1.05	0.42
IC J0256−2146	44.12	−21.78	4.873	5BZQ J0256−2137	1.47	0.17
IC J2037−2216	309.38	−22.27	4.664	,5BZQ J2036−2146	2.299	0.51
IC J0630−2353	97.56	−23.89	4.420	5BZB J0630−2406[a,b]	>1.238[d]	0.28
IC J0359−2551	59.94	−25.86	4.356	55BZB J0359−2615[a]	1.47[c]	0.40
IC J0145−3154	26.28	−31.91	4.937	55BZU J0143−3200[a]	0.375	0.42
IC J2001−3314	300.41	−33.24	4.905	5BZQ J2003−3251	3.773	0.53
IC J2304−3614	346.03	−36.24	4.025	5BZQ J2304−3625	0.962	0.24
IC J1818−6315	274.50	−63.26	4.030	5BZU J1819−6345	0.063	0.53

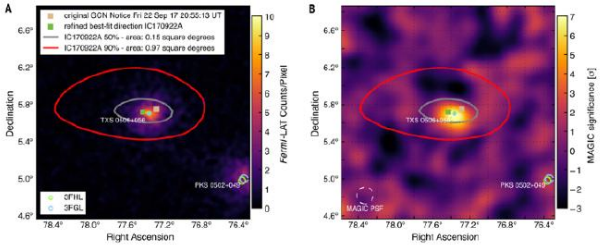
Adv... Energy Astrophysical Sources: Insights from recent multimessenger discoveries ...ria

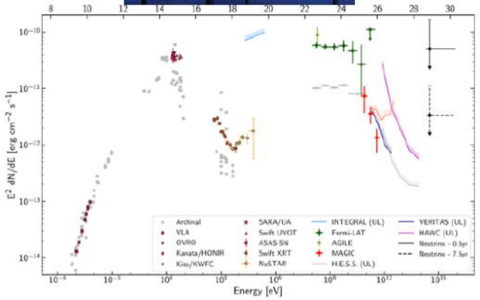
Sara Cutini (INFN) 28

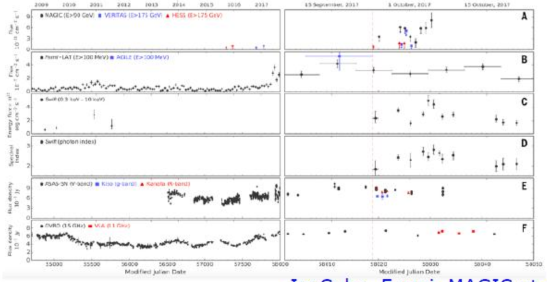
Fermi+ Icecube

IceCube-170922A / TXS 0506+056

Most significant association (3σ) of a high-energy (290 TeV) neutrino with an astrophysical source







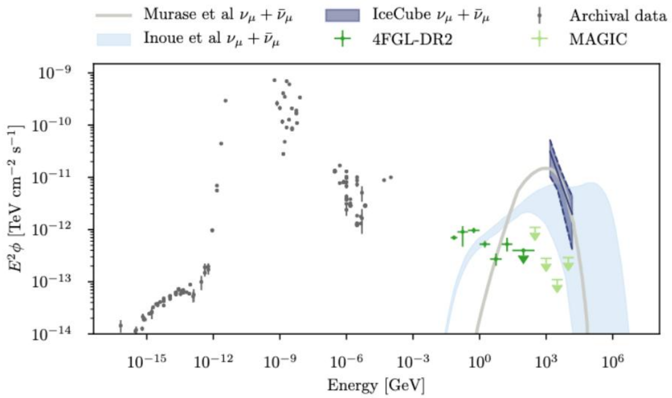
IceCube, Fermi, MAGIC et al. 2018

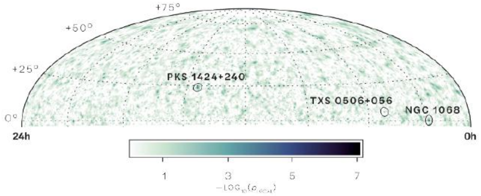
M. Cerruti – Tuesday 01/07

10 Matteo Cerruti

Neutrino - NGC 1068

IceCube collaboration had found an excess of 79^{+22}_{-20} neutrinos associated with the nearby active galaxy NGC 1068 at a significance of 4.2 σ.
NGC 1068 is one of the closest Seyfert II galaxies, it hosts Compton-thick AGN.





IceCube Coll. et al. 2024,
10.1038/s41550-024-02339-z

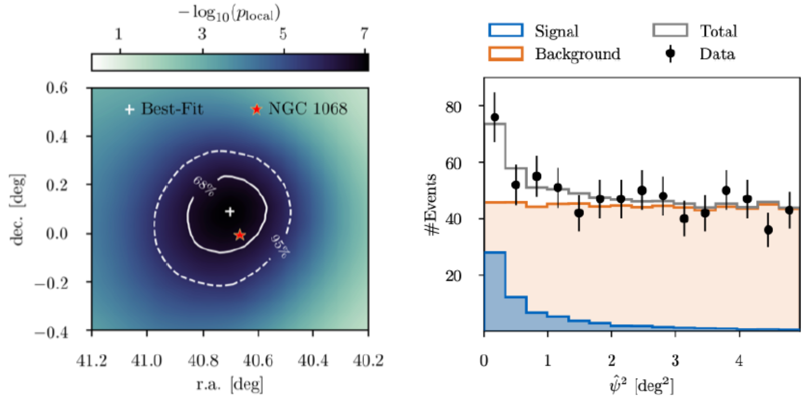
A... Energy Astrophysical Sources: Insights from recent multimessenger discoveries ...ria

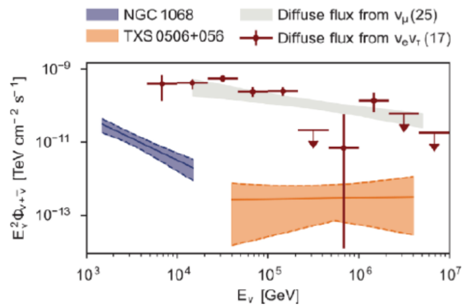
Sara Cutini (INFN)

S. Cutini – Monday 30/06

NGC 1068

4σ excess from the Seyfert galaxy NGC 1068





IceCube et al. 2022

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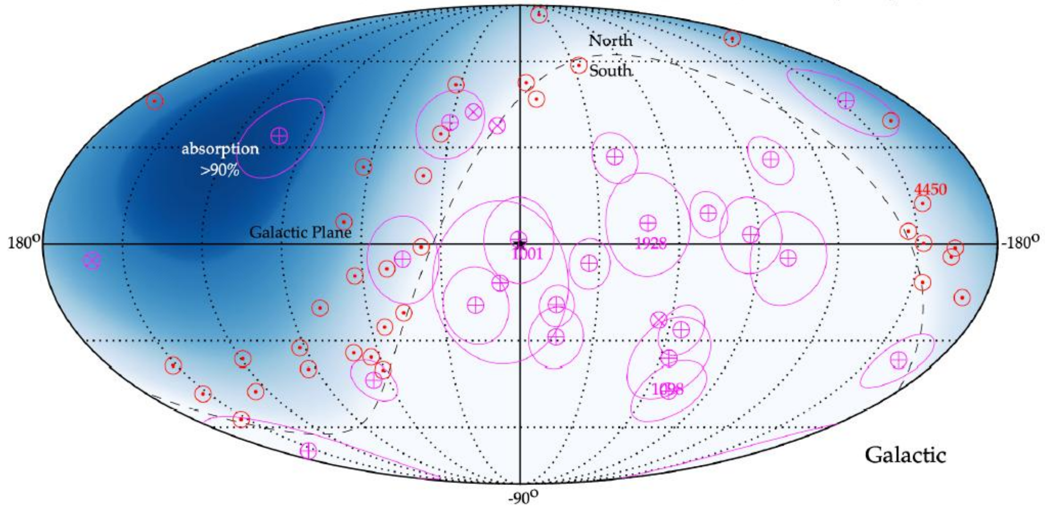
Fermi+ Icecube

M. Cerruti – Tuesday 01/07

neutrinos with probable cosmic origin:
are they correlated to astronomical sources?

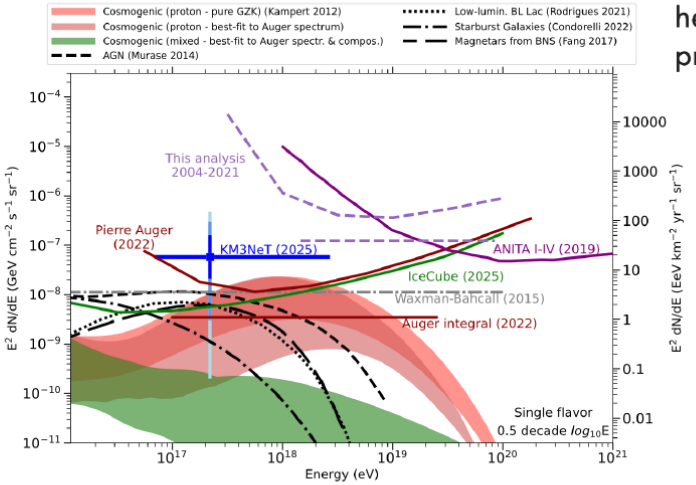
G. Marsella – Wednesday 02/07

Arrival directions of most energetic neutrino events (HESE 6yr (magenta) & $\nu_\mu + \bar{\nu}_\mu$ 8yr (red))



Icecube

CURRENT NEUTRINO SEARCH STATUS IN THE UHE REGIME



- Ultra High Energy (UHE, E $\geq 10^{17}$eV) neutrinos help identify how and where cosmic rays are produced
  - Point right back to the sources (astrophysical)
  - Can also be produced during propagation (cosmogenic)

CURRENT STATUS

- Pierre Auger and IceCube Observatory have performed searches
- Both have complementary limits to UHEνs above 10^{18}eV
- Searches have helped constrain the composition of UHE cosmic rays

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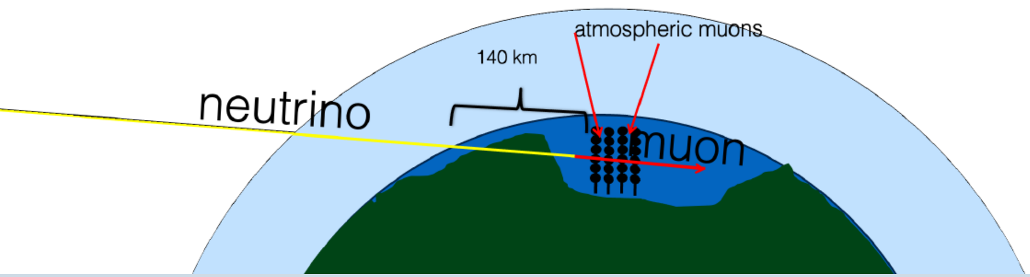
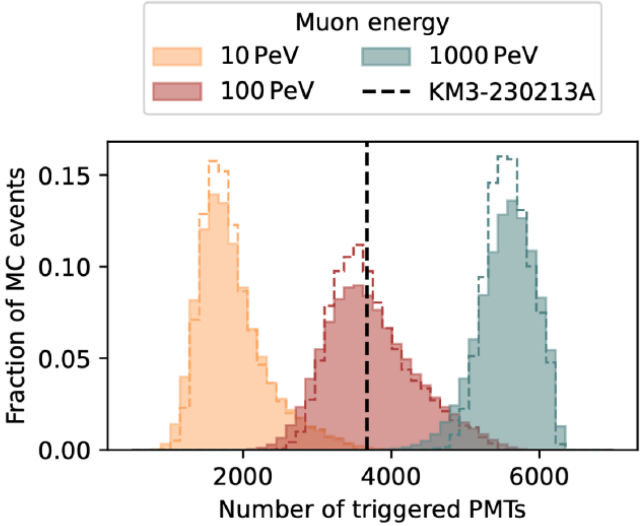
KM3-230213A: features

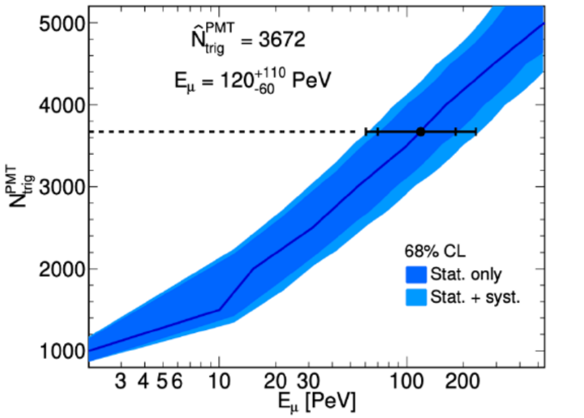
- Trigger time: Feb 13th 2023, 01:16:47 UTC
- **ARCA21** configuration (21 DUs, ~0.2 km^3), **335 days** of livetime
- Bright track selection (length > 250 m, $N^{trigPMT}$ > 1500, logL > 500)
- KM3-230213A: **nearly horizontal** event (0.6° above horizon), **RA=94.3°, DEC=-7.8°** (l=216.1°, b=-11.1°)
- Containment radii: **R(68%)=1.5°**, R(90%)=2.2°, R(99%)=3.0°



S. Celli – Thursday 03/07

KM3-230213A: energy



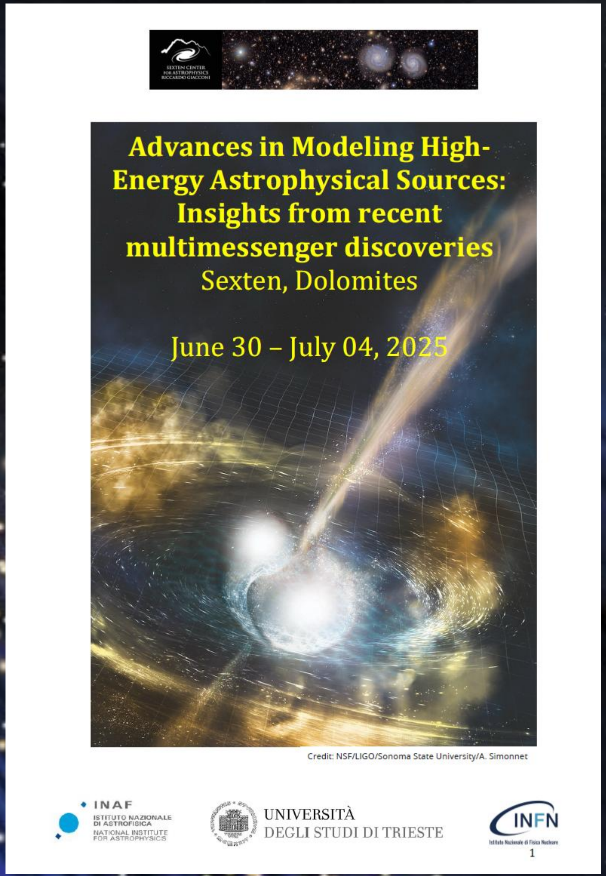


KM3NeT Coll., Nature 638 (2025) 8050

~35% of the detector was recording light

- Energy is measured from the amount of light: $E_\mu = 120^{+110}_{-60}$ PeV
- The parent neutrino energy is estimated to be (E^{-2} source flux): $E_\nu = 220^{+570}_{-100}$ PeV

Gravitational Waves

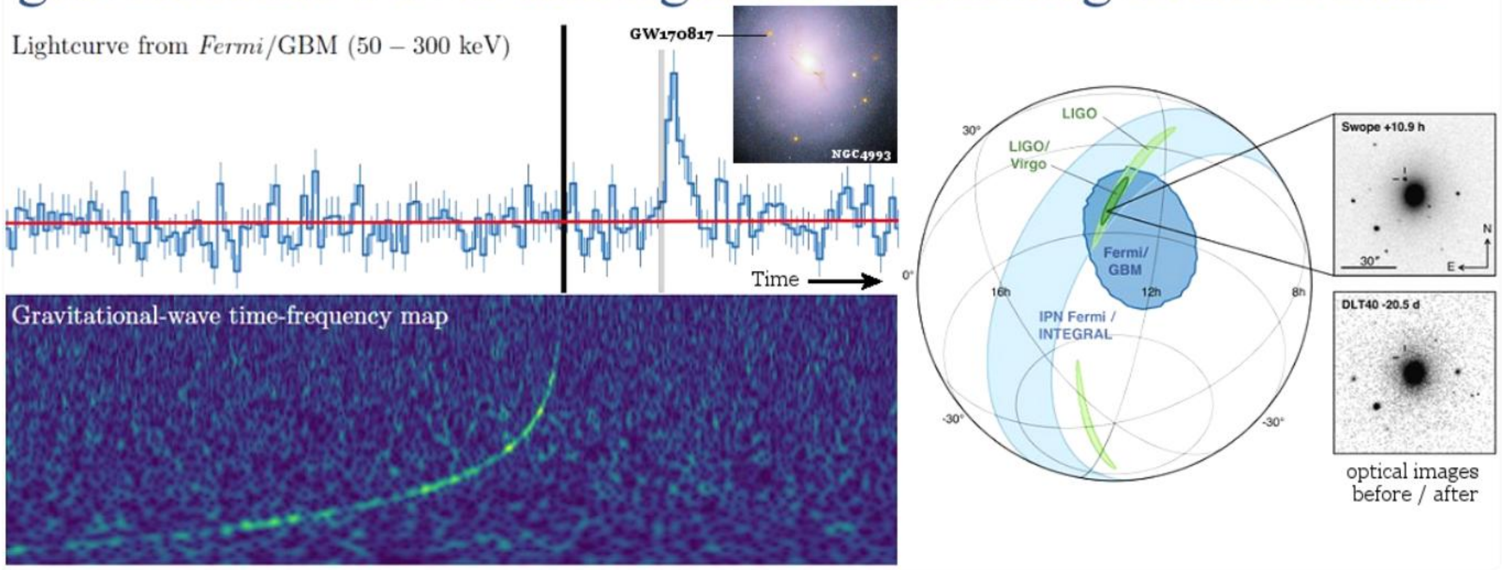


S. Cutini – Monday 30/06

Fermi+
AGILE+
LVK

Gravitational wave follow-up

LIGO, Virgo, and partners make first detection of gravitational waves and light from colliding neutron stars



Abbott et al. 2017; 2017ApJ...848L..12A
Abbott et al. 2017; 2017ApJ...848L..13A

Fermi and AGILE play a fundamental rule in the follow-up of GW
—> huge FoV and good localization
—>Exploring also Fermi ACD data

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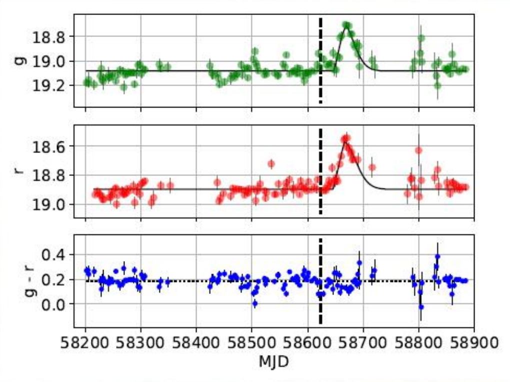
B. Patricelli – Wednesday 02/07

GW190521: an EM counterpart?

The Zwicky Transient Facility (ZTF) detected a candidate optical counterpart in AGN J124942.3+344929

- GW sky localization: 765 deg^2 (90% C.R.)
- ZTF observed 48% of the 90% C.R. of the GW skymap
- An EM flare observed $\sim$ 34 days after the GW event
- It is consistent with expectations for a **BBH merger in the accretion disk of an AGN** (see McKernan et al. 2019, ApJL, 884, 50)



Graham et al. 2020, PRL, 124, 251102

Common origin of the two transients seems to be preferred with respect to random coincidence (Morton et al. 2023; see, however, Ashton et al. 2021, Palmese et al. 2021)

LVK+
ET+
CTAO

4 Methods and Analysis : Expected probability of detection for **NSBH** events

Einstein Telescope + CTAO

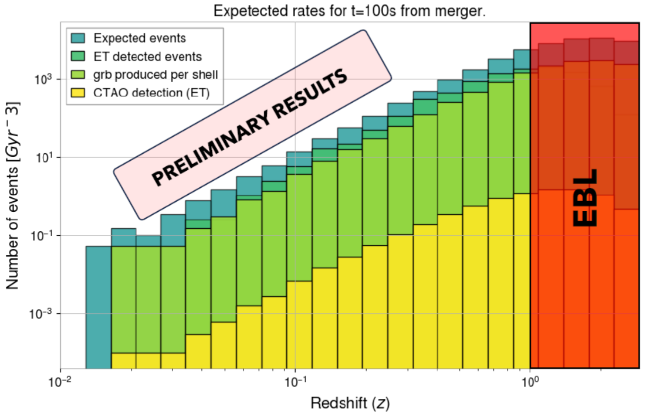


Fig. 6: Histogram of the expected events versus the number of NSBH events detected by ET, the number of GRB produced in every redshift (z) (up to z=2.7) and the number of possible detections with CTAO.

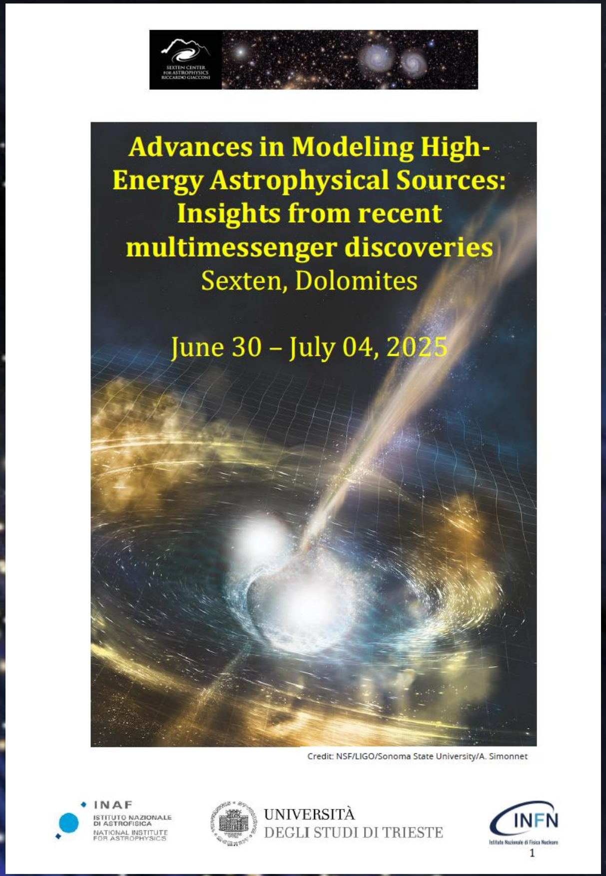
The number of possible detections with CTAO is very low, **Why?**

Possible reasons:

- The **model for the VHE** part of the flux is not the best one: higher flux
- The model used for **the number of expected events is too conservative**: we have more events (especially for low z)
- **Energy conversion** model too conservative

T. Matcovich

Dark Matter



Advances in Modeling High-Energy Astrophysical Sources: Insights from recent multimessenger discoveries
Sexten, Dolomites
June 30 – July 04, 2025
Credit: NSF/LIGO/Sonoma State University/A. Simonnet
UNIVERSITÀ DEGLI STUDI DI TRIESTE
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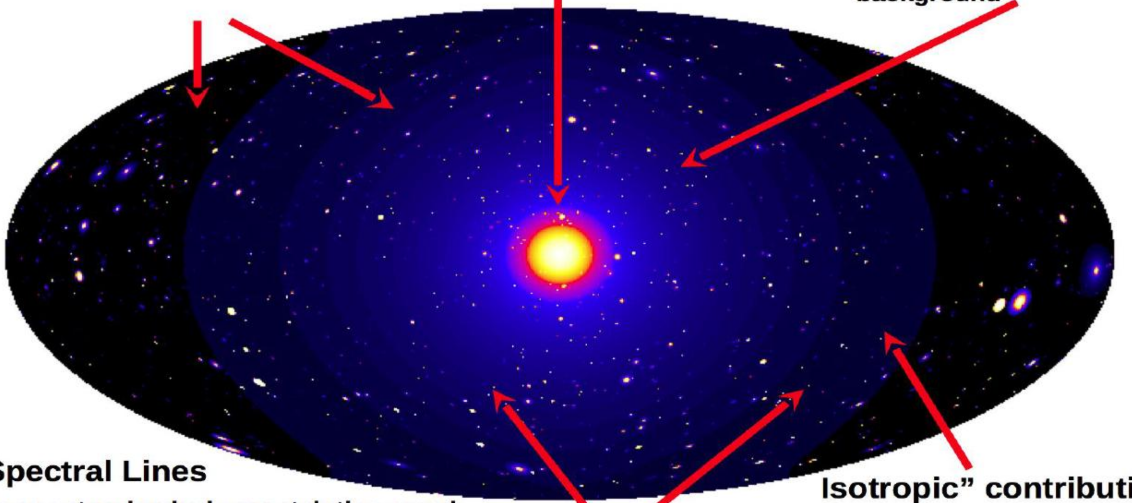
Dark Matter Search: Targets and Strategies

Satellites
Low background and good source id, but low statistics

Galactic Center
Good Statistics, but source confusion/diffuse background

Milky Way Halo
Large statistics, but diffuse background



Spectral Lines
Little or no astrophysical uncertainties, good source id, but low sensitivity because of expected small branching ratio

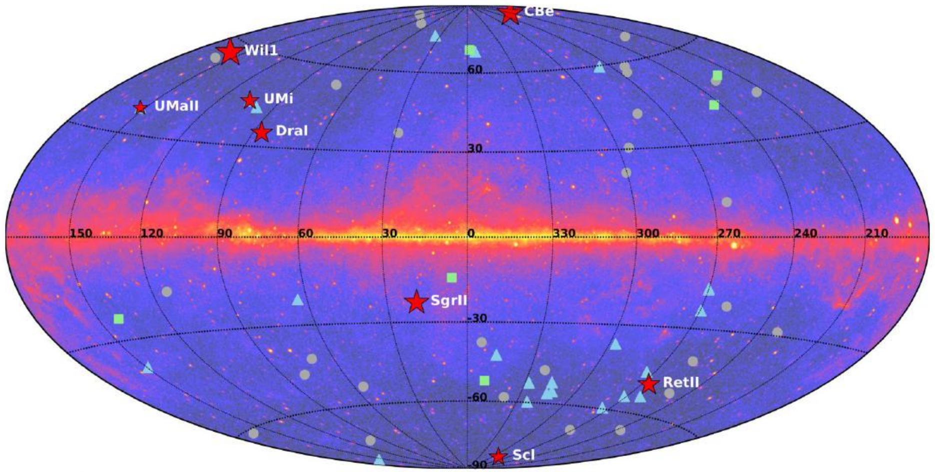
Galaxy Clusters
Low background, but low statistics

Isotropic" contributions
Large statistics, but astrophysics, galactic diffuse background

Dark Matter simulation:
Pieri+(2009) arXiv:0908.0195

A. Morselli – Wednesday 02/07

Dwarf Spheroidal Galaxies: Selection of optimal candidates for CTAO



The optimal targets (red stars) are highlighted with symbols of increasing size, proportional to the value of their dark matter content

MNRAS 000, 1–34 (2025) Preprint 26 May 2025 Compiled using MNRAS LaTeX style file v3.2

Prospects for dark matter observations in dwarf spheroidal galaxies with the Cherenkov Telescope Array Observatory

CTAO Consortium paper in prep. by the dSph task force M. Doro, A. Morselli, G. Rodríguez-Fernández, F. G. Saturni

Thank you!

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