

Transients – GRB & FRB

ICRC Discussion Session

Andrew Taylor & Francesco Longo

Summary of “FRB” topics

- GRBs and Magnetar flares
 - Magnetar giant flare in NGC 253 seen by Fermi-GBM (E.Bissaldi)
 - Detection of the third class of gamma-ray bursts: magnetar giant flares (M.Negro)
- Magnetars at VHE
 - High-energy and very high-energy gamma-ray emission from the magnetar SGR 1900+14 outskirts (V.Voitsekhovskiy)
 - Observation of burst activity from SGR1935+2154 associated to first galactic FRB with H.E.S.S. (D. Kostunin)
 - Monitoring the magnetar SGR 1935+2154 with the MAGIC telescopes (A. López-Oramas)
 - Prospects for Galactic transient sources detection with the Cherenkov Telescope Array (A.López-Oramas)
- FRB at HE/VHE
 - Hunting the gamma-ray emission from Fast Radio Burst with Fermi-LAT (G.Principe)
 - Gamma-ray and Optical Observations of Repeating Fast Radio Bursts with VERITAS (M.Lundy)

GRB and Magnetar Flares



GRB 200415A



- **Bright transient** triggered the Inter-Planetary Network (IPN) and ASIM on **April 15th, 2020**

- **Fermi Gamma-ray Burst Monitor (GBM) Trigger**
at 08:48:05.56 UTC

The Fermi GBM team, *GCN 27579 (2020)*

E. Bissaldi, et al., *GCN 27587 (2020)*

O. Roberts et al., *Nature Vol.589, 207 (2021)*

- Triangulated by IPN to a 17 sq. arcmin region centered at RA. 11.88°, Dec. -25.26° (J2000), overlapping with **NGC 253 (Sculptor Galaxy)**, active star-burst spiral galaxy at a distance of 3.5 Mpc (11.4 Mly)

D. Svinkin, et al., *GCN 27585 (2021)*

D. Svinkin, et al., *Nature Vol.589, 211 (2021)*

- **Chance coincidence with NGC 253: 1 in 230,000**

[Talk by M. Negro, ID.793, PoS(ICRC2021)638]

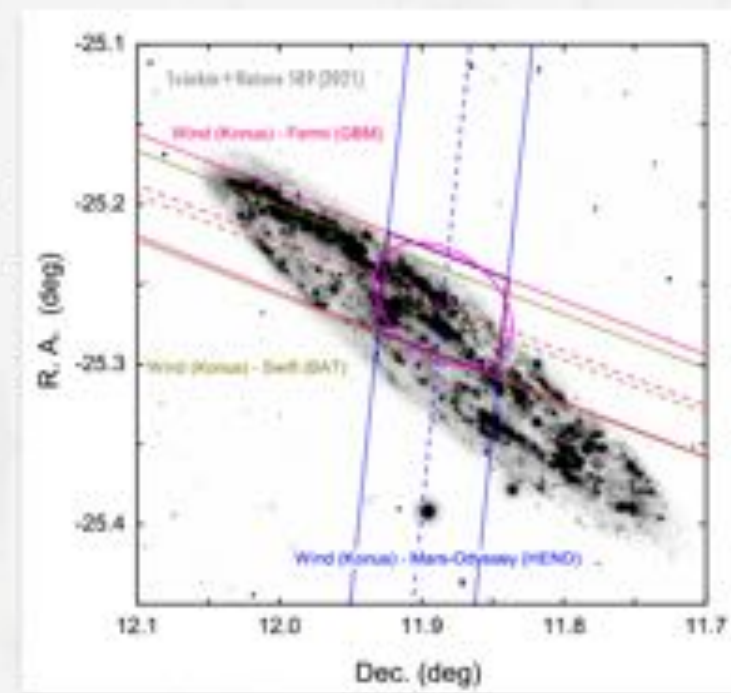
E. Burns et al., *ApJL 907 L28 (2021)*

- **High Energy (GeV) emission** [Highlight Talk by M.O. Lillo, ID.1488, PoS(ICRC2021)819]

- **Fermi Large Area Telescope (LAT) detection**

N. Omodei, et al., *GCN 27586, GCN 27597 (2020)*

M. Ajello, et al., *Nature Astronomy, Vol.5, 385 (2021)*



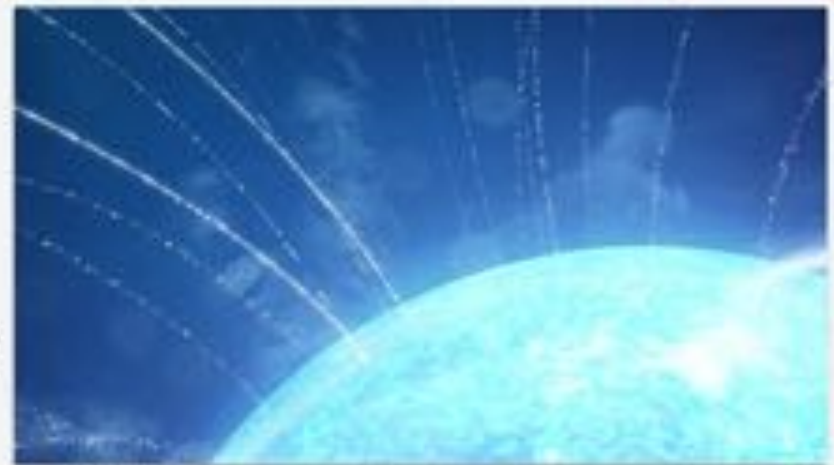
GRB and Magnetar Flares



GRB 200415A Fermi-GBM Observations



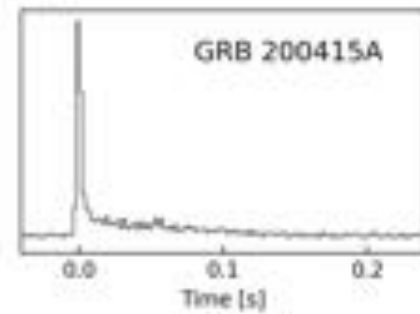
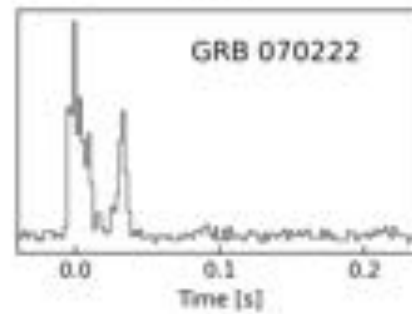
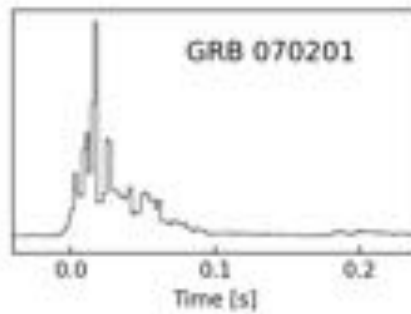
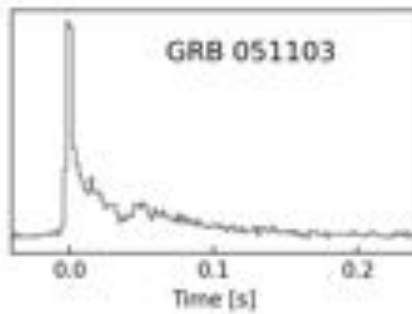
- The flux, and spectral shape of GRB 200415A are **unusual/unlikely for a short GRB**, when compared to catalogs from previous space missions
- Origin of MGFs: Energy release by **crustal fractures** ejects **hot plasma** into the inner magnetosphere
 - MeV-band emission must come from a **relativistic outflow** ($>0.98c$) that is initially highly opaque
 - Spectral index ~ 0 : Wind that is **highly opaque** to electron scattering (so-called "Compton cloud")
 - **Inconsistent** with synchrotron GRB emission scenarios
- Sub-ms spectral evolution: **Relativistic lighthouse beaming effect** or relativistic-boosted wind acceleration and subsequent coasting/cooling
- 77 μ s risetime: **Extremely unlikely for a GRB**



E. Bissaldi

GRB and Magnetar Flares

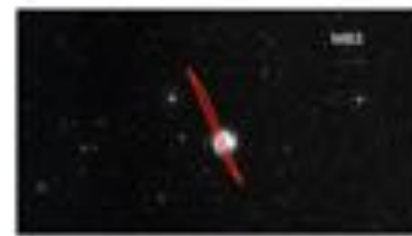
Four local GRBs, hosts, odds of chance alignment



1 in 70,000



1 in 10,000

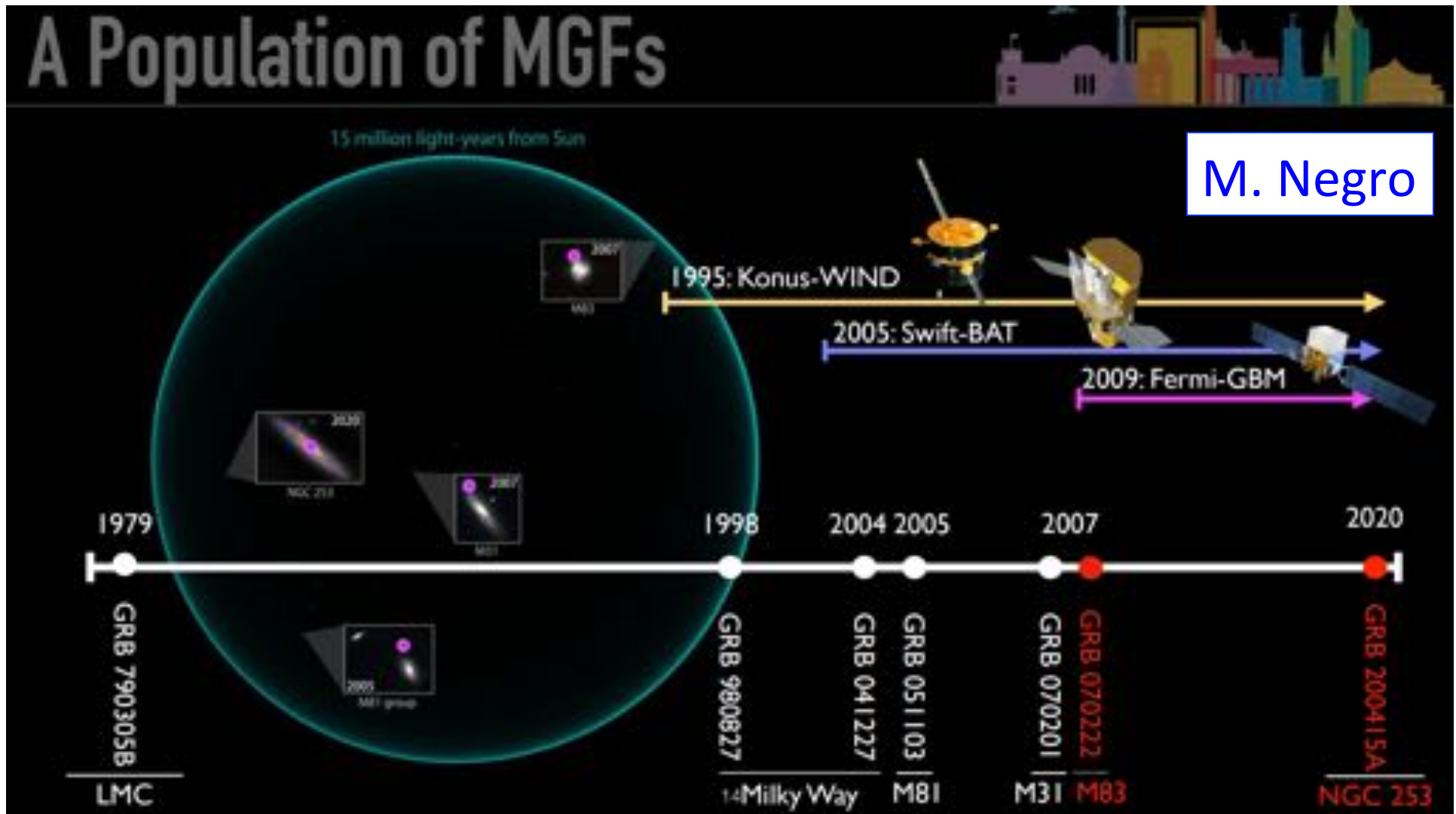


1 in 130,000



1 in 230,000

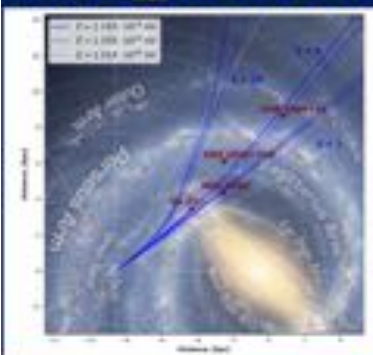
GRB and Magnetar Flares



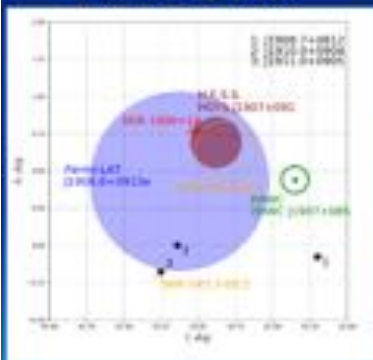
Magnetars at VHE

High-energy and very high-energy gamma-ray emission from the magnetar SGR 1900+14 outskirts *V. Voitsekhovskiy et al.*

SGR1900+14 GF: source of EHECR triplet $E_{mag} > 10^{50}$ eV for $Z \sim 10$



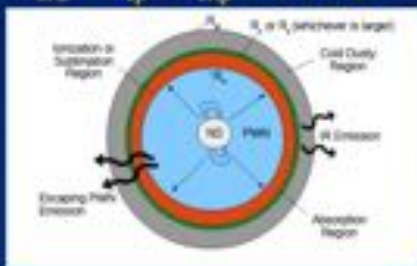
Gamma-sky map



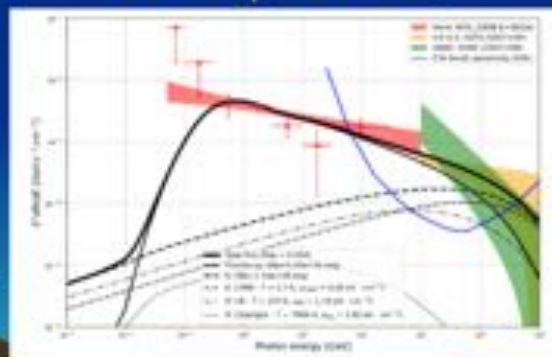
Magnetar-connected SN $t=2$ kyr, $d=12.5$ kpc (Chin. records on 4 BC) was a HN with the explosion energy $E_{HN} = 10^{51}$ erg.

1. CLASSICAL SITUATION: HNR

MWN acceler. ejecta up to 10^{52} erg
 DSA: $E_{cr,p} = (3 - 5) \times 10^{50}$ erg
 $E_{cr,e} = K_{ep} \times E_{cr,p} = 10^{48}$ erg

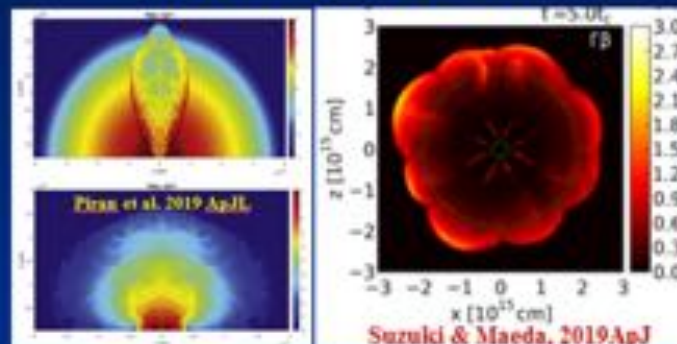


SED in HNR model:
 Best-fit: $W_p = 5 \times 10^{50}$ erg

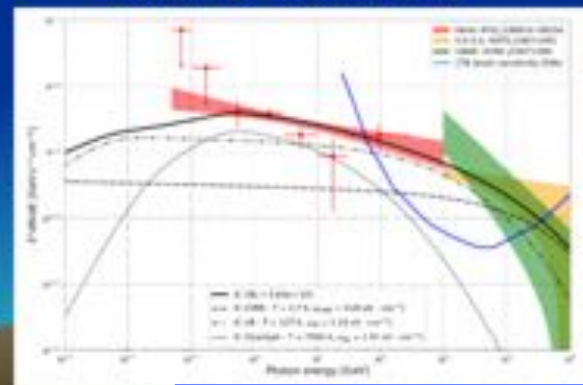


2. EVOLUTION OF MAGNETAR DRIVEN HYPERNOVA

$E_{ejecta} = 10^{51}$ erg, $E_{mag_wind} = E_{rot} = 10^{51}$ erg
 ENERGY DOMINATED MWN SITUATION:
 large MWN ($r > 30$ pc) with $E_{mwn} \leq 10^{52}$ erg

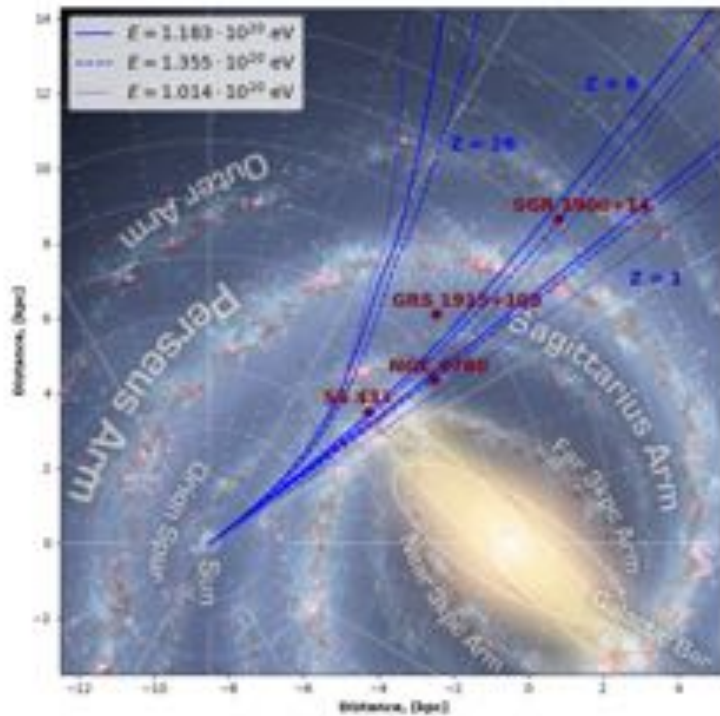


SED in MWN model:
 Best-fit: $W_e = 3.6 \times 10^{50}$ erg

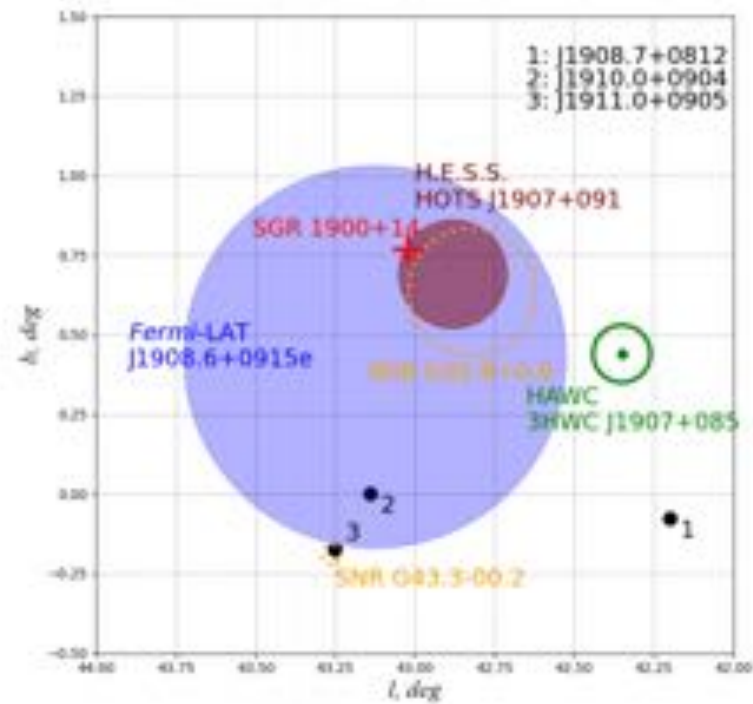


Magnetars at VHE

V.Voitsekhovskiy



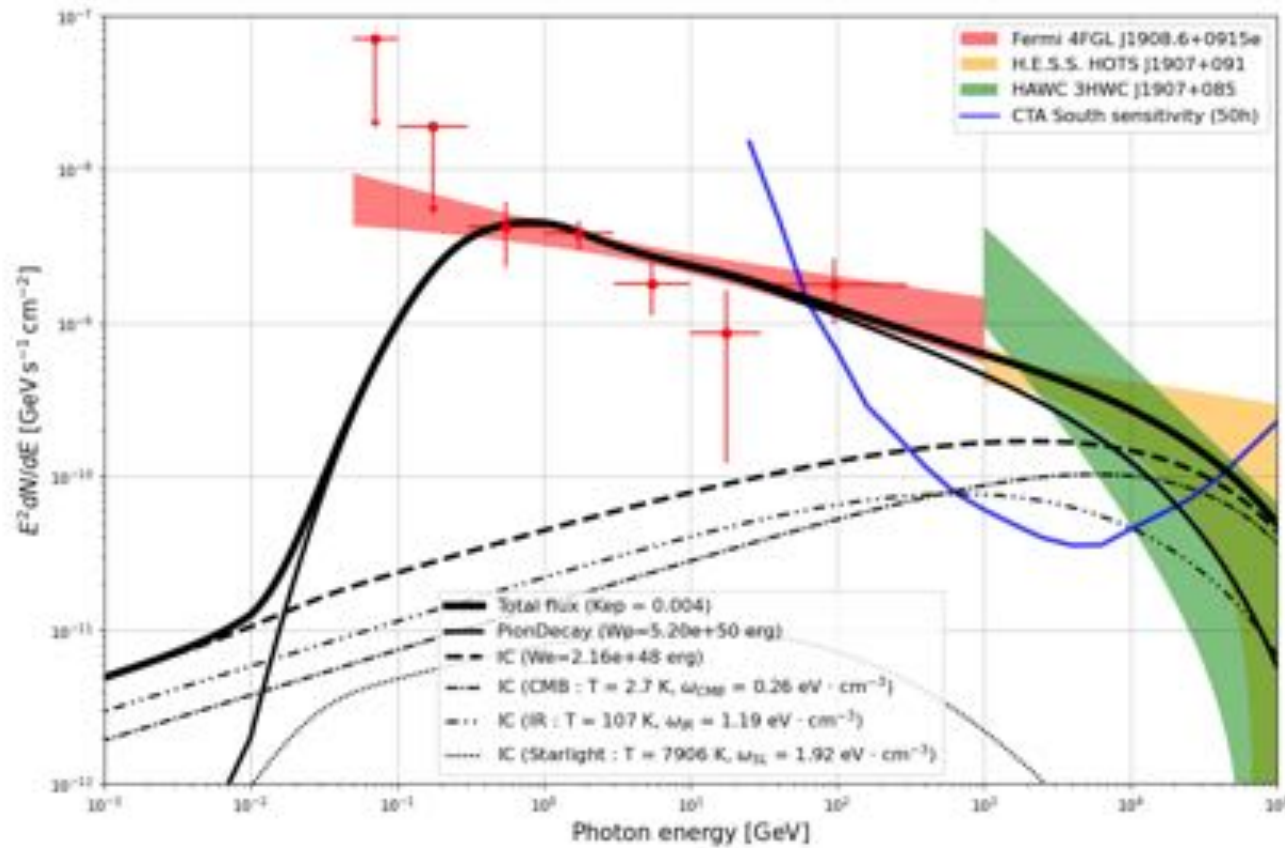
(a)



(b)

Magnetars at VHE

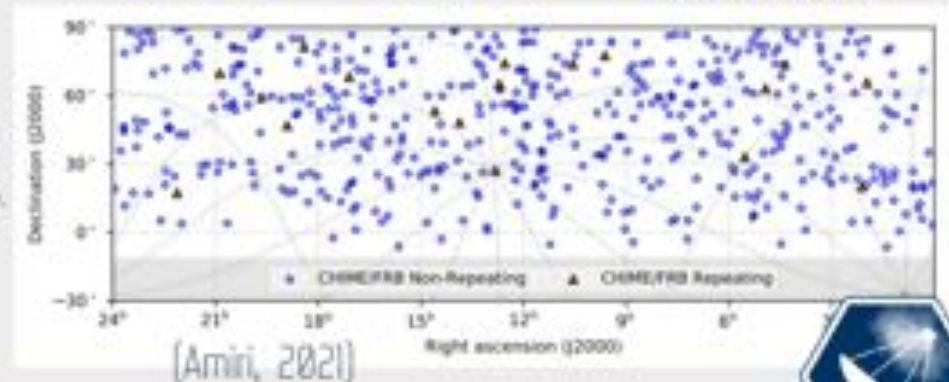
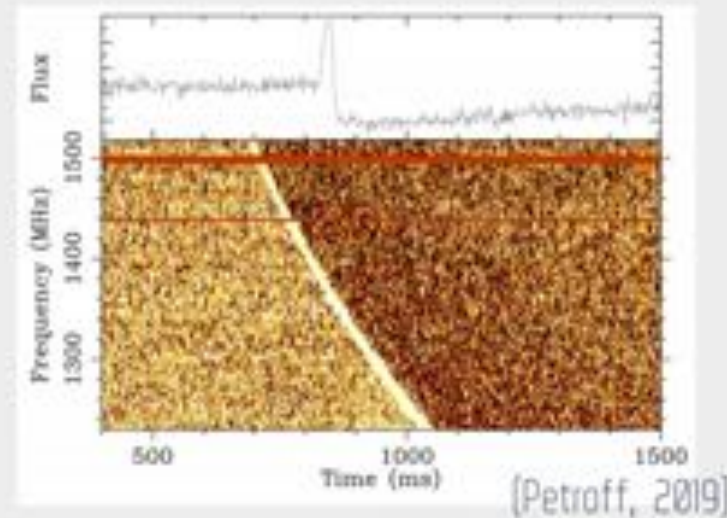
V.Voitsekhovskyi



FRB at HE/VHE

Fast Radio Bursts

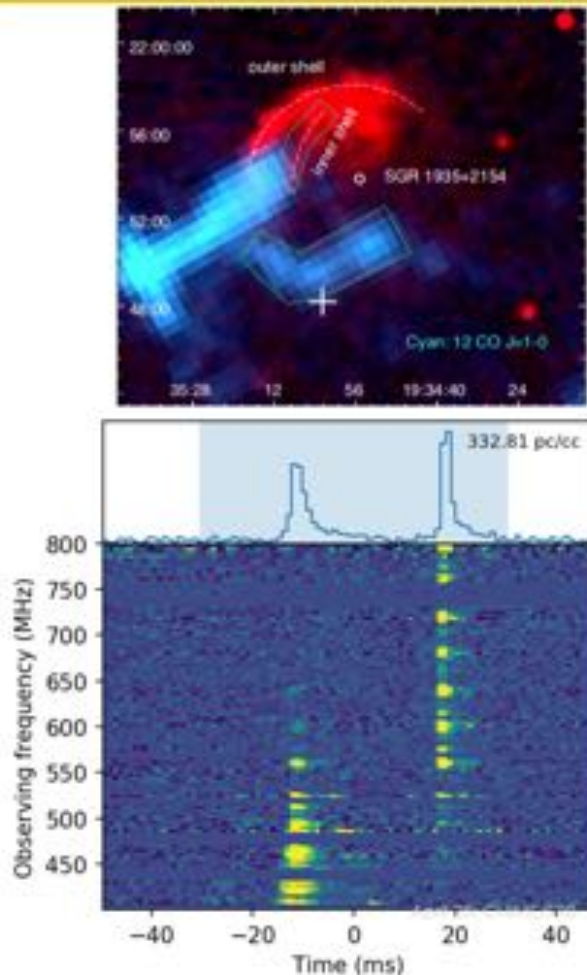
- Fast Radio Bursts (FRBs) are energetic, extragalactic, ms radio bursts of unknown origin.
- Over 600 FRBs have been measured with most of the detections coming in the last 2 years from the CHIME radio telescope
- FRBs demonstrate a variety of phenomena including repetition, and periodicity.
- A handful of repeaters have been localized (~13) but there remains many FRBs with large error regions (~0.5 degrees).



Magnetars at VHE

SGR 1935+2154

A. López-Oramas

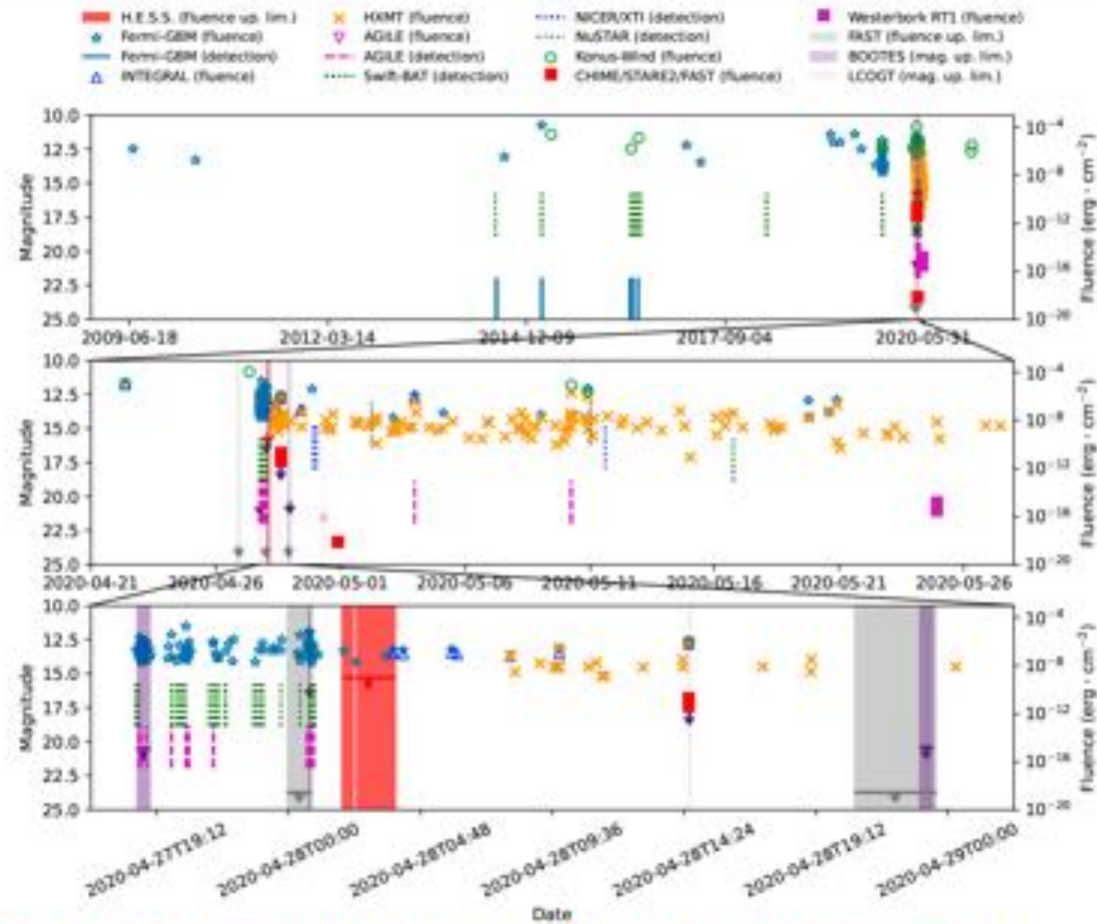


- Galactic magnetar located at 6.6 kpc (Zhou et al. 2020)
- Hosted in an evolved SNR (GG57.2+0.8) and (likely) interacting with a surrounding molecular cloud
- April 2020: a fast radio burst (FRB) is detected by CHIME/FRB in coincidence with this magnetar (Andersen et al. 2020)
 - The burst had a **double-peak** structure with two components ~ 5 ms wide separated by ~ 30 ms
- Confirmation by STARE2 (Bochenek et al. 2020) and European dishes: Westerbork, Onsala, Toruń (Kirsten et al. 2020)
- **X-ray bursts** by Swift (Barthelmy et al. 2020), INTEGRAL (Mereghetti et al. 2020), AGILE (Tavani et al. 2021), Konus-Wind (Ridnaia et al. 2021), NICER (Younes et al. 2021), Insight HXMT (Li et al. 2021)
- MAGIC could not observe due to pandemic lockdown

SGR 1935 +2154 is
the first FRB in the Galaxy and
the first identified FRB source

Magnetars at VHE

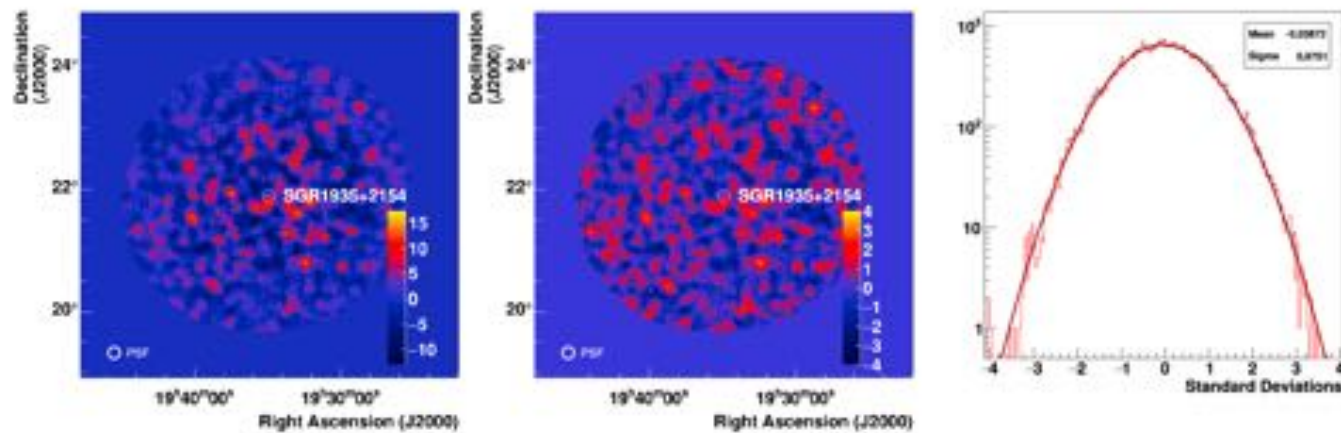
MWL observations of SGR1935+2154



D. Kostunin

Magnetars at VHE

H.E.S.S. observations of SGR1935+2154

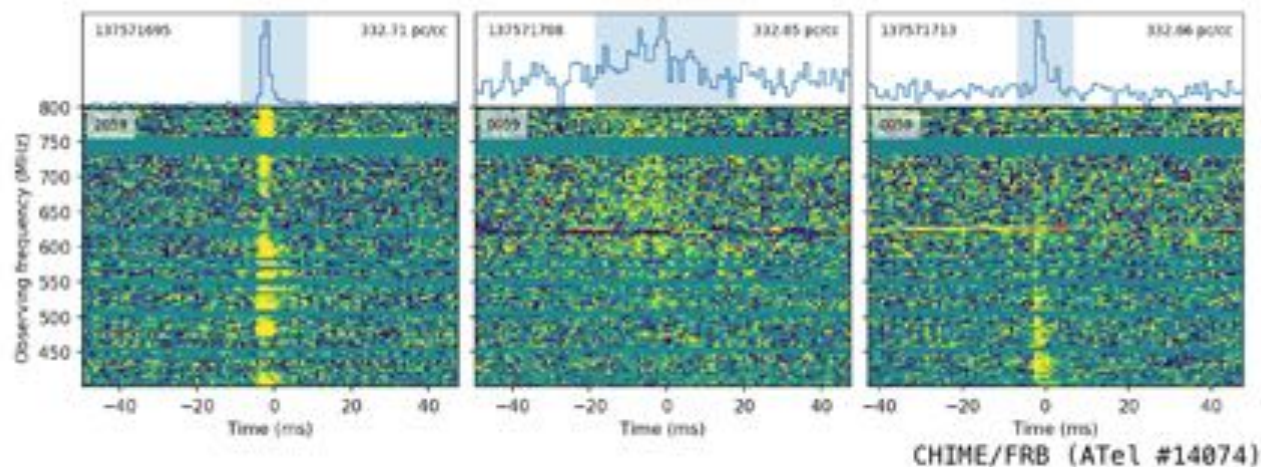


Excess (left) and significance (center) maps for SGR1935+2154 reconstructed by H.E.S.S. One-dimensional significance distribution (right) shows no detection

D. Kostunin

Magnetars at VHE

October 8, 2020: more **radio bursts**



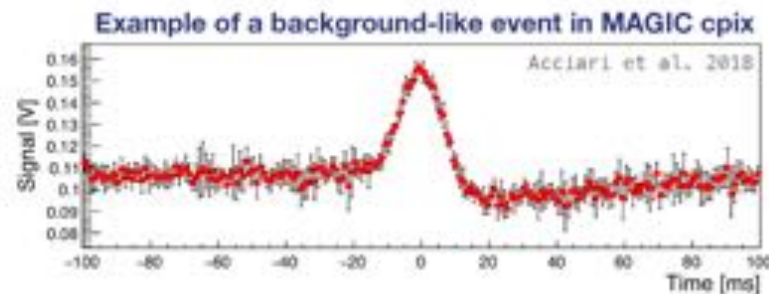
- **Three radio bursts** detected on October 8 by CHIME/FRB (ATel #14074)
 - Confirmed by FAST on October 9 (ATel #14084)
- **No X-ray counterpart**
 - No signal in Swift (ATel #14076)
 - No detection in INTEGRAL (ATel #14087)
- **Radio fluence lower than April 28 burst**

A. López-Oramas

Magnetars at VHE

October radio bursts

- MWL observations triggered on **October 9** (one day after CHIME/FRB detection)
 - **Swift** ToO approved:
 - Period of **bursting activity**: about **25 bursts detected** (Borghese et al. in prep)
 - **MAGIC** observed during the Swift burst window:
 - **Simultaneous gamma+optical observations**
 - **No VHE signal detected**
 - **Optical data with cpix**:
 - **ongoing analysis** for the identification of burst-like signals
 - **cleaning of background events**
 - **Radio data**:
 - No observations scheduled with Westerbork
 - **Onsala** observations did **not reported bursting activity**
 - **FAST** performed 1-h observations on October 9 (ATel #14084): **pulsed emission and radio bursts**



A. López-Oramas

Magnetars at VHE

Galactic transients



- A wide range of sources in our Galaxy exhibit transient emission via **accretion/ejection processes** and interactions between e.g. jets, **outflows and/or strong winds**
- These events can accelerate particles up to relativistic energies, leading to the **production of high-energy (HE, $E > 100$ MeV) radiation**
- **Some objects** such as microquasars, magnetars (giant flares), novae or flares from pulsar wind nebulae (PWNe) **have already been detected in the MeV- (few) GeV regime** (see e.g. Fermi collaboration 2010, Fermi collaboration 2012)

novae



magnetars



microquasars



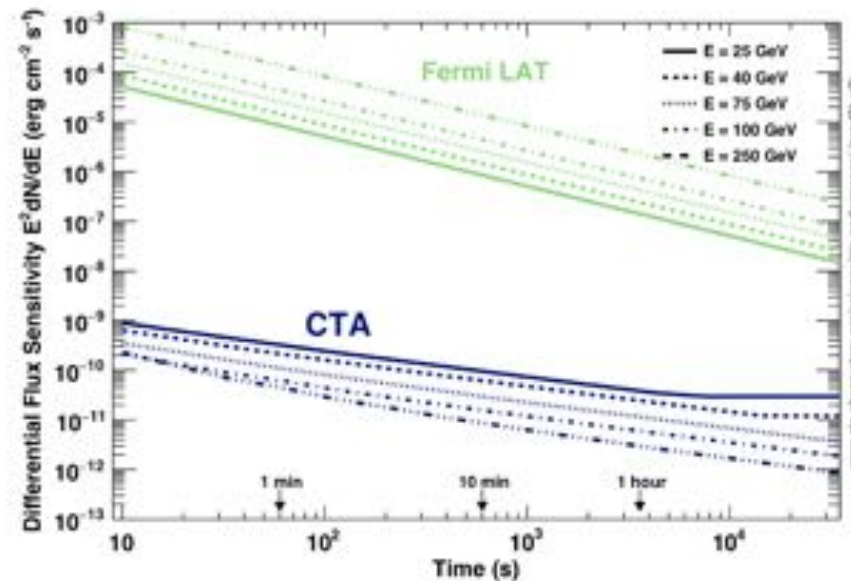
A. López-Oramas

Magnetars at VHE

Galactic transients task force



- Sub-group inside the Transients/MWL working group of CTA consortium
- Study the **capabilities of CTA to detect Galactic transient events**
- Working on a CTA consortium publication "Galactic Transient Sources with the Cherenkov Telescope Array"
 - The results shown in this presentation are part of the **paper in preparation**
- **Short-time sensitivity of CTA will allow unprecedented transient detection**



A. López-Oramas

FRB at HE/VHE

Hunting the gamma-ray emission from Fast Radio Burst with Fermi-LAT

G. Principe^{1,2,3},

N. Orsini⁴, N. Di Lalla⁵, L. Di Venere⁶ and F. Longo^{1,7}, on behalf of the Fermi Large Area Telescope Collaboration.

¹University of Trieste, Department of Physics, Trieste, Italy; ²INFN-Trieste, Trieste, Italy; ³INdA-INdA, Bologna, Italy; ⁴HEPL, KIPAC, Department of Physics and SLAC, Stanford University, Stanford, USA; ⁵INFN Bari and Politecnico Bari, Bari, Italy



Executive Summary

Motivation

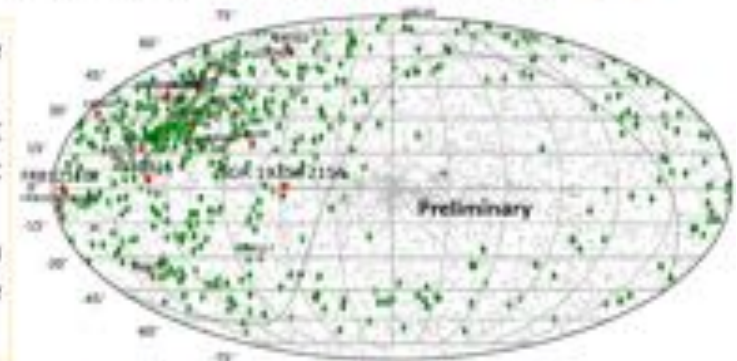
- Discovered just over a decade ago, fast radio bursts (FRBs) are one of the newest astrophysical enigmas.
- Last year, for the first time, an FRB-like event was associated with a Soft Gamma Repeater (SGR 1935+2154) and, in particular, to a Galactic magnetar giant flare (MGF).
- The recent detection of high energy emission, at GeV energies, from a magnetar giant flare in the Sculptor galaxy ($z=0.000811$) motivated the search for gamma-ray counterparts to the known FRBs.

Method

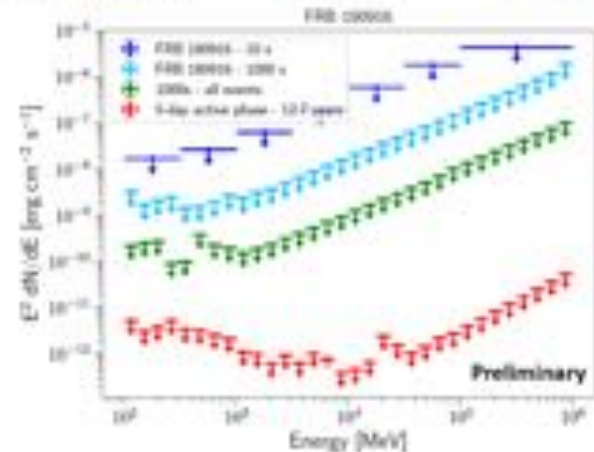
- Thanks to:
- over 12 years of data collected by the Fermi Large Area Telescope (LAT),
 - more than 1000 published FRBs,
- we perform the largest and deepest systematic search for gamma-ray emission from over 1000 repeating and non-repeating bursts.

Outlook

- We present here the preliminary results on the search for high-energy emission from the periodic FRB 180916 ($z=0.0337$) with Fermi-LAT
- Our results provide crucial information on constraining the origin of FRBs and modelling their emission mechanisms.



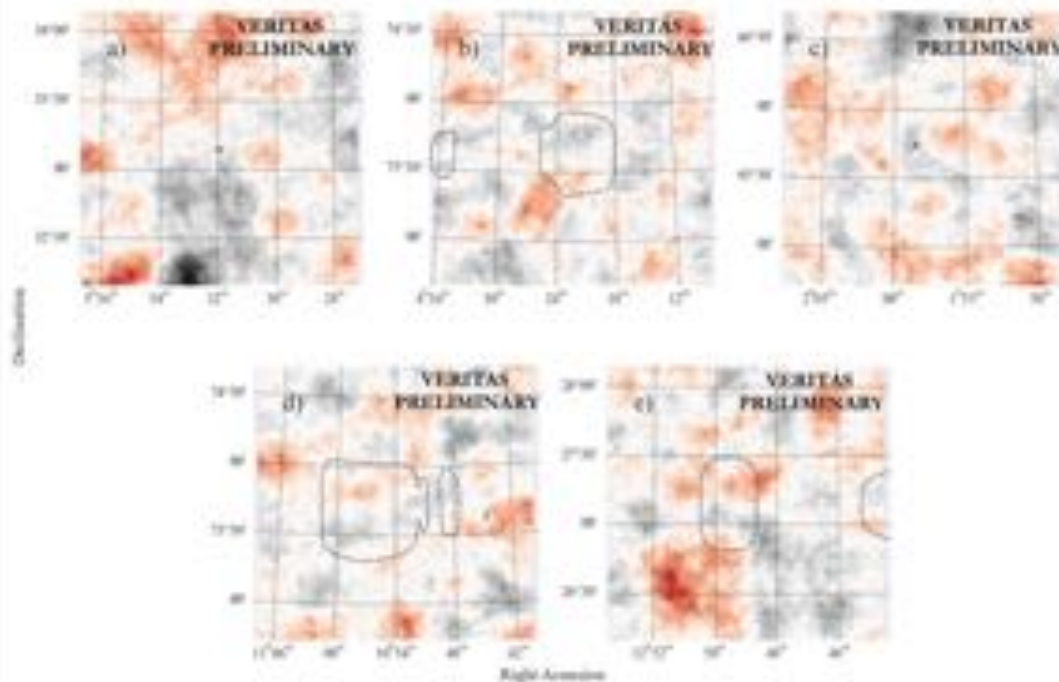
• non-repeating FRBs • repeating FRBs • Fermi-LAT sources



G. Principe

FRB at HE/VHE

Cumulative Analysis



FRB Name	Exposure (min)	On Counts	Off Counts	Significance(σ)
FRB 121102	1216.64	1681	14134	-0.61
FRB 180814.J0422+73	1013.22	966	8955	-0.62
FRB 180916.J0158+65	397.45	522	4907	-0.06
FRB 181030.J1054+73	226.26	277	2650	-0.33
FRB 190116.J1249+27	45.00	111	768	0.83



FRB at HE/VHE

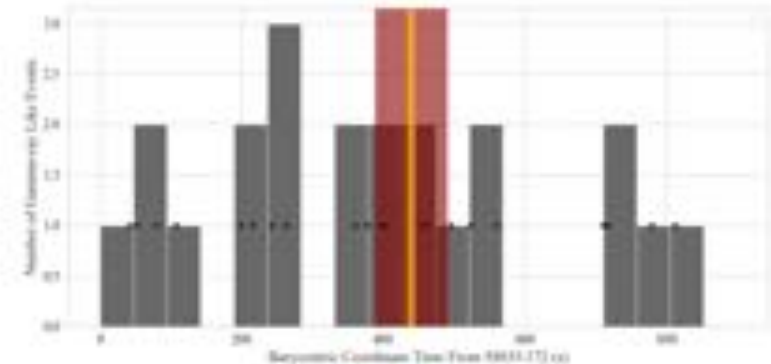
Gamma-ray and Optical Observations of Repeating Fast Radio Bursts with VERITAS

-In this presentation we will discuss the VERITAS FRB observing program which combines both the optical and gamma-ray capabilities of the instrument.

-FRBs remain a mysterious source class but as the population of known FRBs continues to grow the ability study potential multiwavelength counterparts has become feasible.

-We present the results of simultaneous bursts from the repeater FRB J180916.J0158+65 as well as cumulative analysis from 5 repeaters observed by VERITAS.

-Currently, we detect no significant multiwavelength (VHE or optical) counterpart to any FRB.



M.Lundy

Question 1

- Where is the present observational frontier of FRB physics? What area of FRB physics is presently most contested?

Question 2

- Where are the observational bottlenecks limiting our ability to probe FRB physics? How have recent results affected these limitations?

Question 3

- What future observations are now needed to take the field beyond the current observational frontier?

Question 4

- Are the instruments planned for the coming decade sufficient in order to achieve the required next observations needed?

Question 5

- What observational strategies have we learnt to be most effective in ensuring that the most relevant FRB physics is probed? What mistakes have we made? (and what lessons have we learned?)