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

G. Principe[1,2,3],

N. Omodei[4], N. Di Lalla[4], L. Di Venere[5] and F. Longo[1,2]; on behalf of the *Fermi* Large Area Telescope Collaboration.

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

Abstract: Fast radio bursts (FRBs) are one of the most exciting new mysteries of astrophysics. Their origin is still unknown, but recent observations seems to link them to Soft Gamma Repeaters and, in particular, to magnetar giant flares (MGFs). The recent detection of a MGF at GeV energies by the Fermi Large Area Telescope (LAT) motivated the search for GeV counterparts to the >100 currently known FRBs. Taking advantage of more than 12 years of Fermi-LAT data, we perform a search for gamma-ray emission from all the reported repeating and non-repeating FRBs. We analyse on different-time scales the Fermi-LAT data of each individual source separately, including a cumulative analysis on the repeating ones. In addition, we perform the first stacking analysis at GeV energies of this class of sources in order to constrain the gamma-ray properties of the FRBs that are undetected at high energies. The stacking analysis is a powerful method that allow a possible detection from below-threshold FRBs providing important information on these objects. In this talk we present the preliminary results of our study and we discuss their implications for the predictions of gamma-ray emission from this class of sources.

Introduction

Discovered just over a decade ago [1], 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 Repeaters (SGR 1935+2154) and, in particular, to a Galactic magnetar giant flare (MGF) [FRB 200428, 2]. The recent detection of high energy emission, at GeV energies, from a magnetar giant flare in the Sculptor galaxy (z=0.000811) [3] motivated the search for gamma-ray counterparts to the known FRBs. Thanks to over 12 years of data collected by the Fermi Large Area Telescope (LAT) [4], and to more than 1000 published FRBs, we aim to perform the largest and deepest systematic search for gamma-ray emission from all the reported repeating and non-repeating bursts.

Analysis description

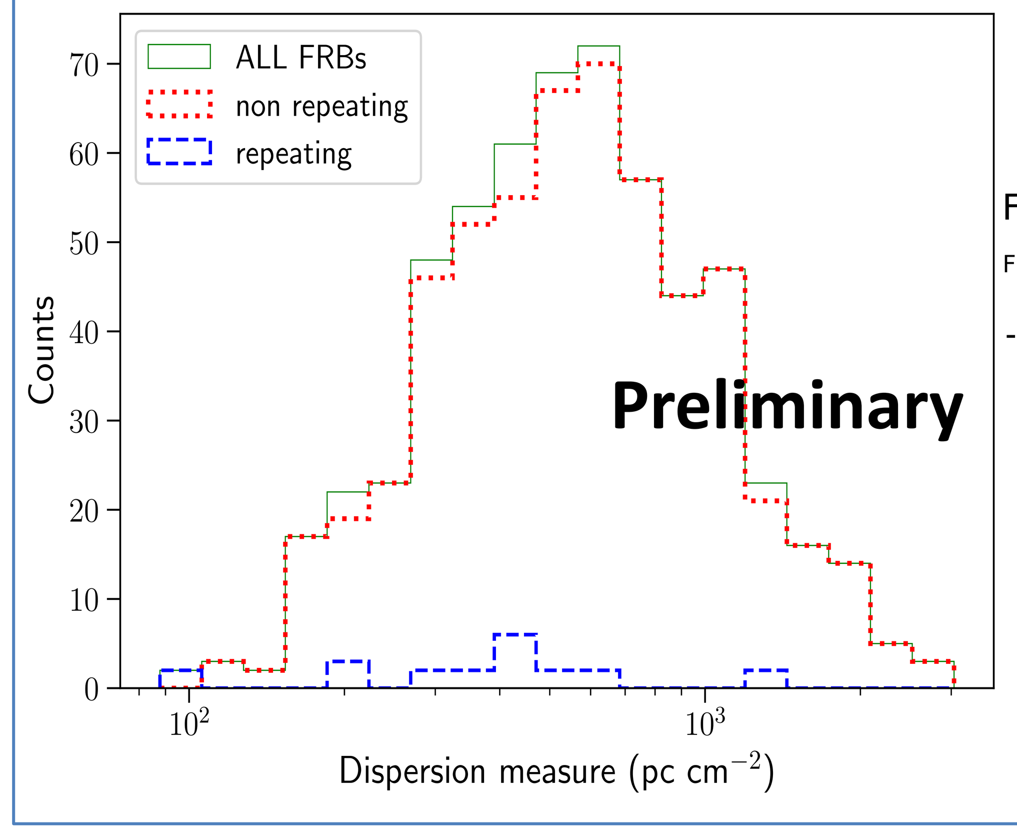
Thanks to its wide-field of view, Fermi-LAT is able to cover the entire sky in ~3hours, making it a very suitable gamma-ray detector for investigating the high-energy counterpart of FRBs. The search was performed using different time scales ranging from few seconds up to several years in the energy range between 100 MeV and 1 TeV. The binned likelihood analysis (which consists of model optimisation, localisation, spectrum and variability analyses) was performed with Fermipy [9]. Special attention has been given to the periodic FRB 180916 (which presents a of period = 16.35 days and all bursts clustered in an active phase of 5.4 days), on which a folding analysis has been performed on the 1000 s time-intervals centred on each event, as well as on the 5.4-day phase window for the 12.7 years of LAT data.

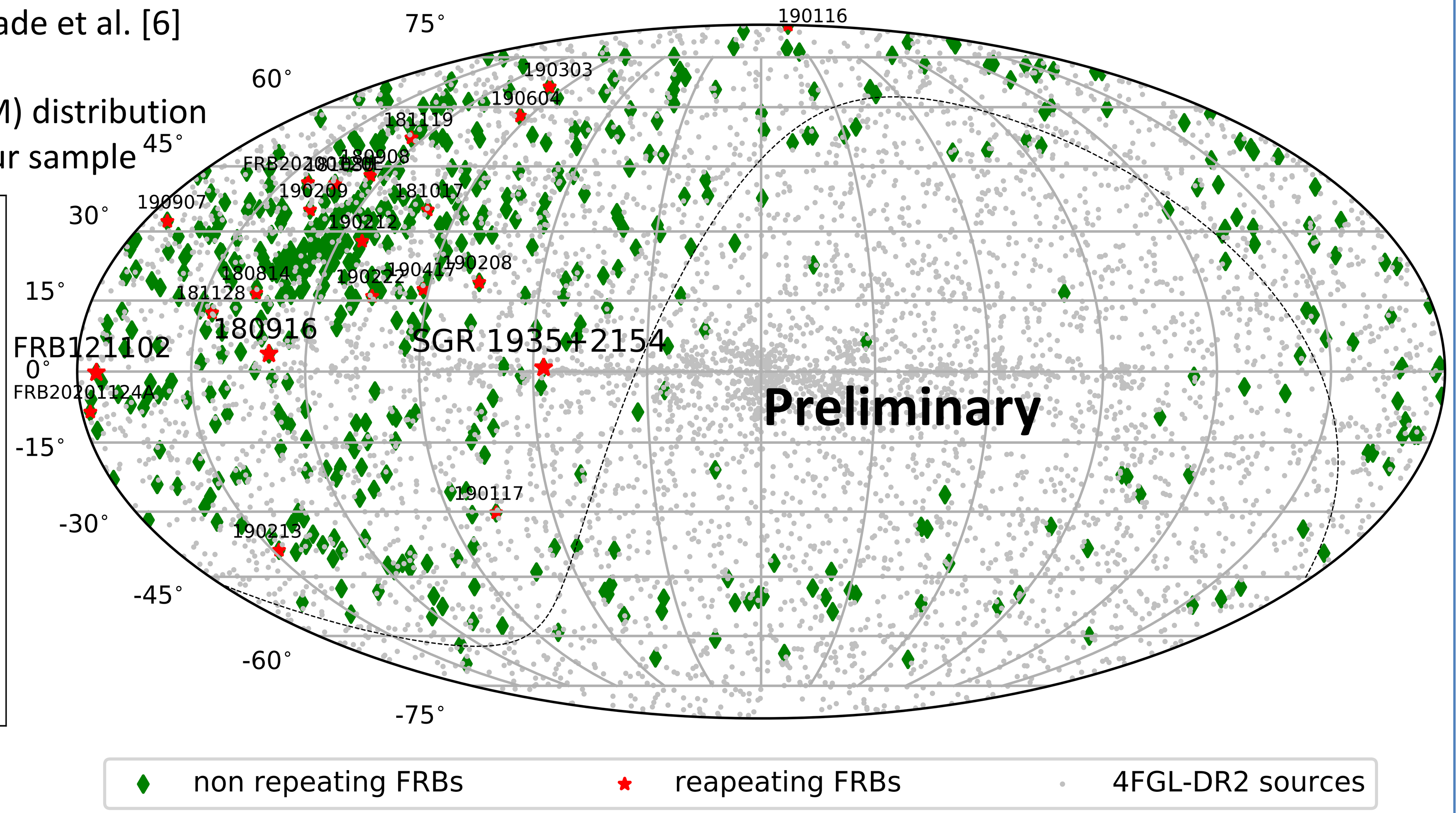
FRB sample

Our sample consists of 1025 FRBs (560 non repeating and 22 repeating ones presenting 465 events) selected from the following resources:

- 535 repeating and non-repeating FRBs reported in the first CHIME/FRB catalog [5];
- 230 bursts from 20 repeating FRBs reported by the CHIME/FRB collaboration (http://www.chime-frb.ca/repeaters) as of June 15, 2021, including 73 bursts from the periodic FRB 180916 (period: 16.35 days);
- 235 bursts from FRB 121102 collected by Rajwade et al. [6]
- 118 events from the FRBCAT [7];

Fig. 1 and Fig. 2 show the dispersion measure (DM) distribution and the sky map of the 1025 FRBs contained in our sample





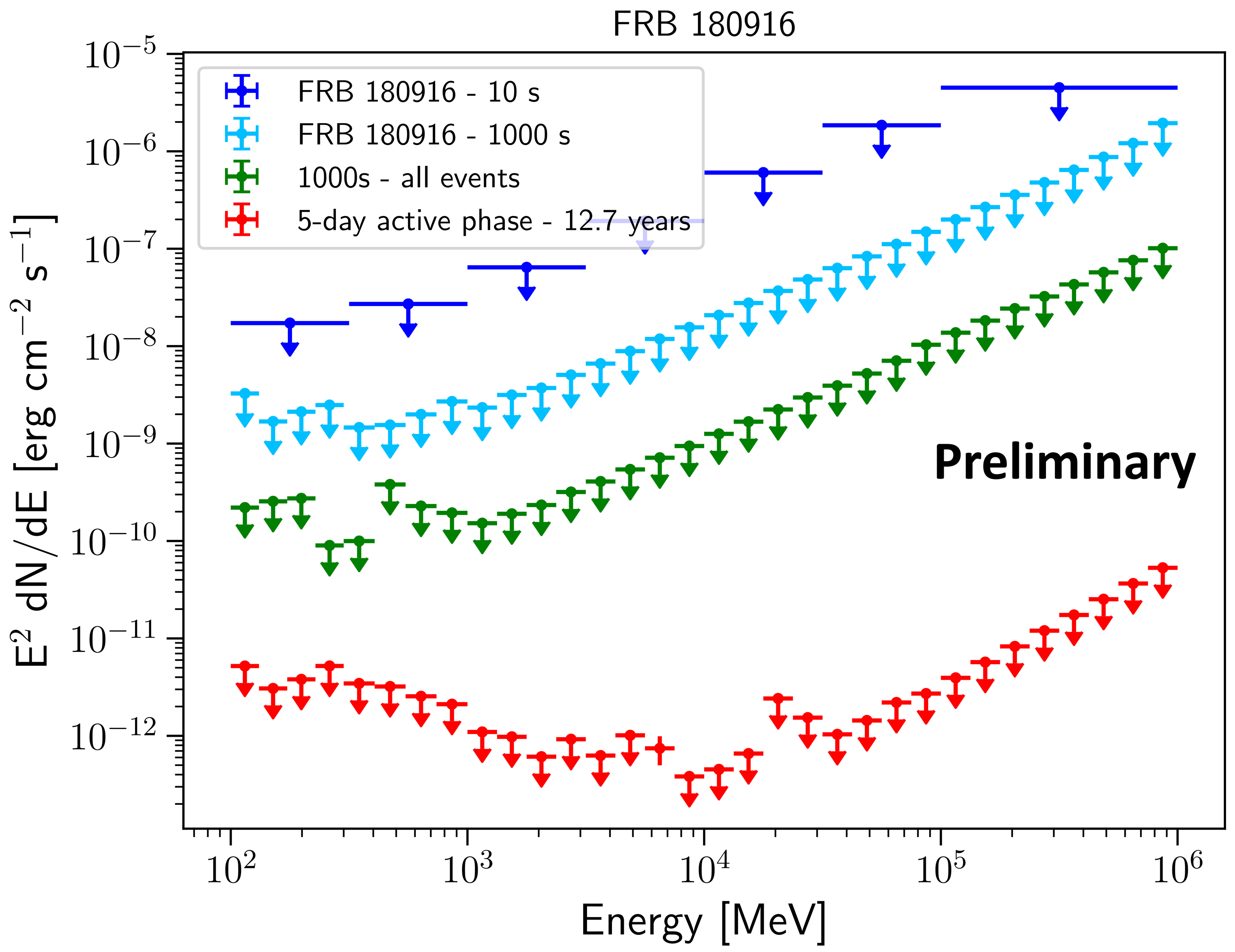
Preliminary results on the periodic FRB 180916

We present here the preliminary results on the search for high-energy emission from the periodic FRB 180916 (z=0.0337) with Fermi-LAT. We analysed LAT data using 10 s and 1000 s time intervals centred on the first observed burst (MJD=58377.42972096). We performed a folding analysis on the cumulative gamma-ray emission from the 73 detected bursts, using time intervals of 1000 s centred on each event, as well as on the 5.4-day active phase windows of the periodic FRB, using the 12.7 years of available LAT data.

We did not find any significant gamma-ray emission from the periodic FRB 180916. We report 95% upper limits on the FRB energy flux above 100 MeV (obtained for a power-law spectral model of spectral photon index of 2):

- 10 s: F < 7.8 x 10^{-8} erg cm^{-2} s^{-1}
- 1000 s: F < 1.4 x 10^{-9} erg cm^{-2} s^{-1}
- folding 1000 s: F < 1.7 x 10^{-10} erg cm^{-2} s^{-1}
- 5.4-d active phase: F < 2.3 x 10^{-12} erg cm^{-2} s^{-1}

Fig. 3 shows the Fermi-LAT spectrum of the periodic FRB 180916 for the different analyses performed.



Conclusions

FRBs are one of the most intriguing topics in astronomy of the last decade. We presently know of more than 1000 burst from 560 non-repeating FRBs and 22 repeating ones. Despite their origin is still unclear, recent observations seem to associate them to Soft Gamma Repeaters and, in particular, to MGFs. Furthermore, the recent detection by the Fermi-LAT of gamma-ray emission from a MGF located in the Sculpture galaxy (z=0.000811) [3] galvanises the search of high-energy emission from FRBs. We aim to perform the largest and deepest systematic search for gamma-ray counterpart to FRBs.

We report here the preliminary results of search for high-energy emission from the periodic FRB 180916 (z=0.0337). Although in our analysis we did not find any detection, we provide the so-far most stringent upper limits on the gamma-ray emission from the FRB 180916 source during its 5-day active-phase window ($F_{\gamma\text{-ray}}$ < 2.3 x 10^{-12} erg cm^{-2} s^{-1}, $L_{\gamma\text{-ray}}$ < 7.5 x 10^{42} erg s^{-1}). Our results provide crucial information on constraining the origin of FRBs and modelling their emission mechanisms. Further results on the search for the high-energy emission from the 1000 selected FRBs will be provided in a forthcoming paper [9].

References

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