Report on the status of the INAF Mini Grant project:

Shock acceleration in Gamma-Ray Bursts

PI: Dr. Lara Nava - OAB

AIM: probe the physics of relativistic shock acceleration through modeling of the GRB afterglow emission

METHOD: **Complete and test** a numerical code for the description of the synchrotron and SSC radiation from a relativistically expanding blast-wave

Extend it to account for:
- fraction of electrons accelerated
- maximum energy of the accelerated electrons
- dependence of magnetic field strength on the distance from the shock front
- temporal variation of microphysical parameters describing relativistic shocks

Apply the model to single GRBs (with VHE emission) and to large GRB samples

Lara Nava

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Project status report

✓ **Finalise and test the afterglow model and its numerical implementation**

The model considers synchrotron and SSC emission from an expandig relativistic jet as an explanation for the afterglow emission from GRBs. The description includes adiabatic losses, synchrotron self-Compton emission, different radial profiles for the external medium, different injection functions for the electron spectrum. The numerical implementation of the model has been completed and tested.

✓ **Application to the MAGIC GRB 201216C**

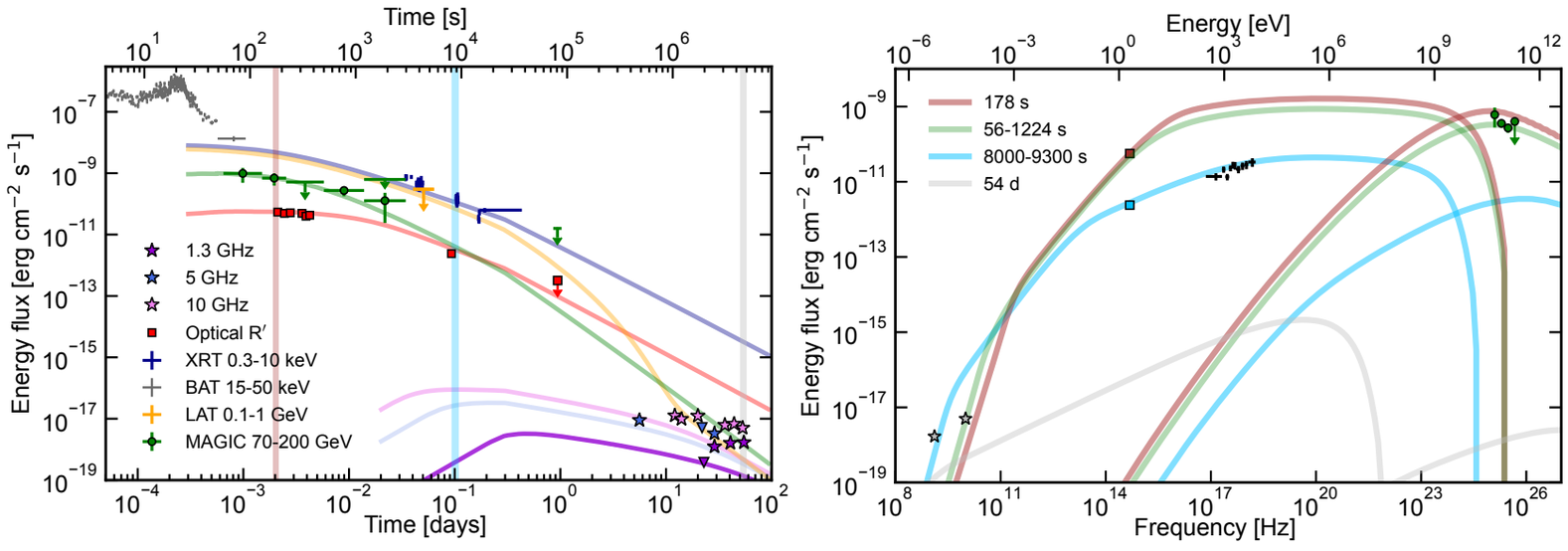

Fig 1: lightcurves (left) and SEDs (right) of the MAGIC GRB 201216C. The proposed modeling (solid lines) explains observations from optical to TeV energies. From MAGIC Collaboration, 2023, MNRAS in press

Results:

- TeV emission succesfully interpreted as SSC component
- Modeling from radio to TeV energies allowed to constrain the physics of particle acceleration

Paper pablished as corresponding author: MAGIC Collaboration, MNRAS in press, arXiv:2310.06473

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✓ Fraction of accelerated electrons

The model has been extended to the more realistic case where only a fraction of electrons is succesfully injected into the Fermi acceleration process.

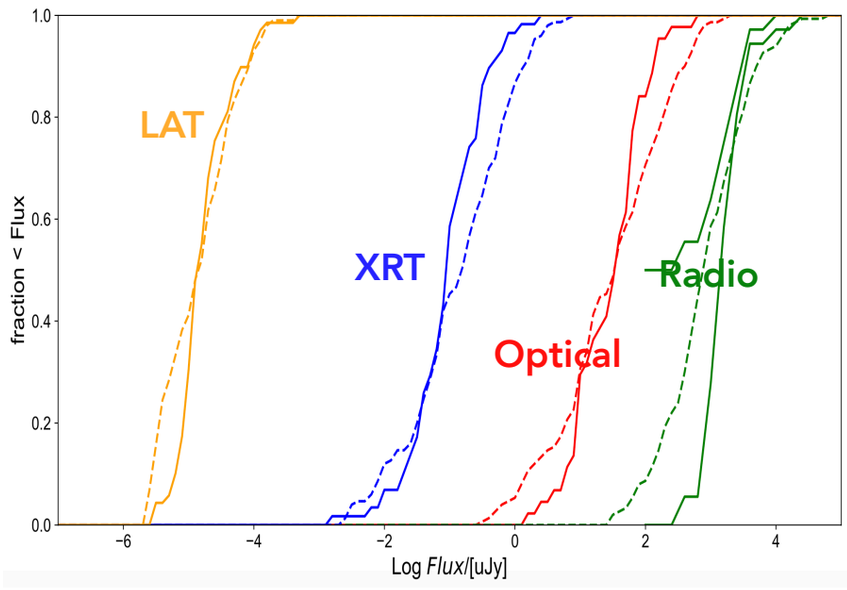

Fig 2: comparison between cumulative distributions of multi-wavelength afterglow fluxes (solid curves) and model predictions (dashed) when the efficiency of the Fermi process in accelerating electrons is set to 20-30%.

Results: a model that assumes that only a fraction of electrons are injected into the Fermi process is able to reproduce observations over the full range of frequencies and times (from radio to TeV, from seconds to days). All the afterglow parameters are well constrained (jet energy, Lorentz factor, energy in electrons and magnetic field, density of the external medium) and their values agree very well with theoretical/observational expectations, contrary to what happens if all electrons are assumed to be efficiently accelerated.

➡ Ongoing work

Perform simulations with the found parameters to predict afterglow TeV emission for large GRB samples. This will serve as input to estimate 1) CTA detection rate (CTA GRB consortium paper), 2) ASTRI Mini-Array detection rate, 3) joint detections LAT-CTA

✓ Conferences / seminars on topics relevant to the project

Invited review talk at GRB50, Warrenton (USA), August 2023
Solicited talk at ASTRI-LHAASO workshop, Milan 2023
Invited seminar at Aachen University, May 2023
(upcoming) Invited talk at 3rd Nanjing GRB Conference, May 2024

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