Calculation of LGRBs Pseudo-Redshifts using the Amati Correlation

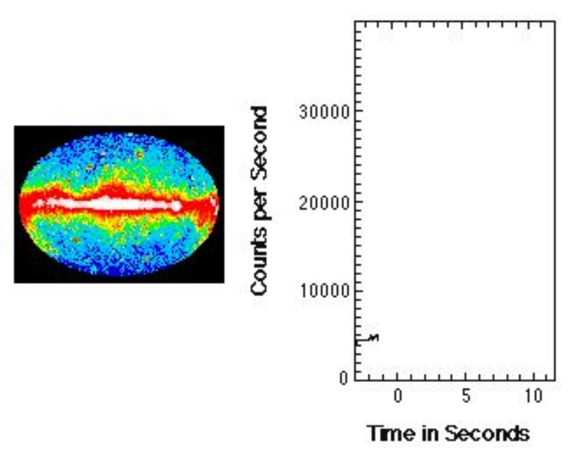
Gabriela Xol
ECFM-USAC

In collaboration with:
Dr. Rodrigo Sacahuí
Dra. Magdalena González
Dr. Yunior Pérez

22nd ISVHECRI - Vallarta, July 2024

Gamma-Ray Burst (GRBs)

- Among biggest explosions in the universe (~ $10^{55} erg$)
- Detectable at redshifts up to $z \approx 9.4$
- Can last from milliseconds to several minutes
- Can outshine entire galaxies



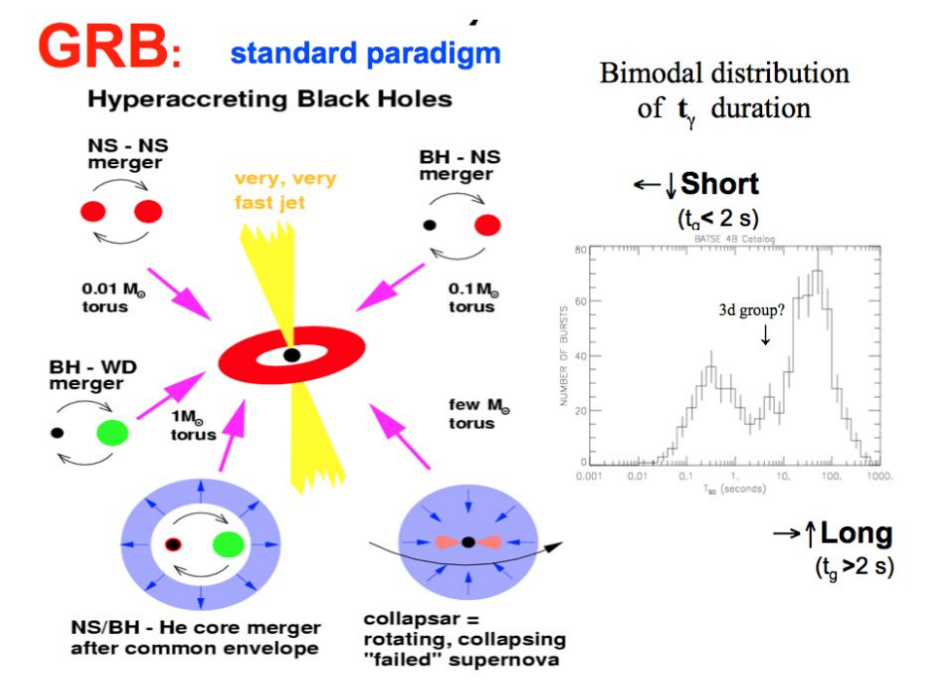
Credits: Laura Whitlock (Imagine The Universe!), GSFC, NASA

Gamma-Ray Burst Types and progenitors

Short gamma-ray burst $T_{90} < 2s$

Long gamma-ray burst $T_{90} > 2s$

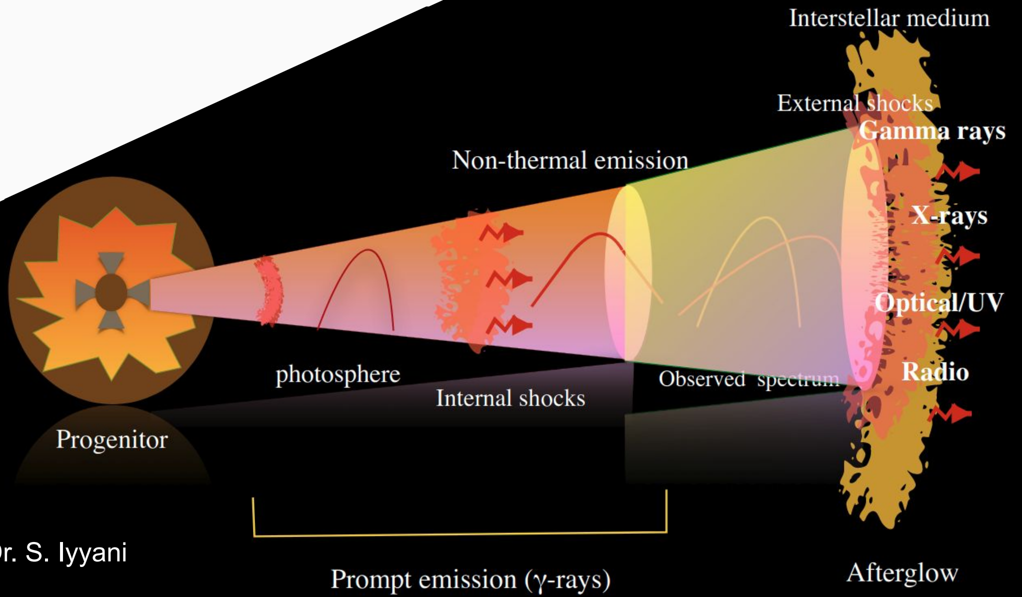
T_{90}: Time interval during which 90% of the total observed counts have been detected



Progenitors of long and short GRBs, after M. Ruffert and H.-Th. Jahnka (1996), duration distribution from Kouveliotou et al. (1993).

Fireball Model

- Prompt emission: Initial and most intense part, where the gamma-rays are released $keV - MeV$, typically last a few seconds
- Afterglow: Radiates in different wavelenghts, initially detected in X-rays. Last much longer than the prompt emission



Credits: Dr. S. Iyyani

Motivation

Few GRBs with z associated (~ 11%)

The measurement of the redshift (hence distance) of a GRB is essential to measuring its intrinsic properties.

Since LGRB are believed to originate from the core-collapse of massive stars, are powerful tools for investigating the early universe at high redshift.

Empirical Correlations to inferred pseudo-redshifts

$$N_E(E) = A\left(\frac{E}{100\ \mathrm{keV}}\right)^{\alpha} \exp\left(-\frac{E}{E_0}\right), \qquad (\alpha - \beta)E_0 \geq E\,,$$

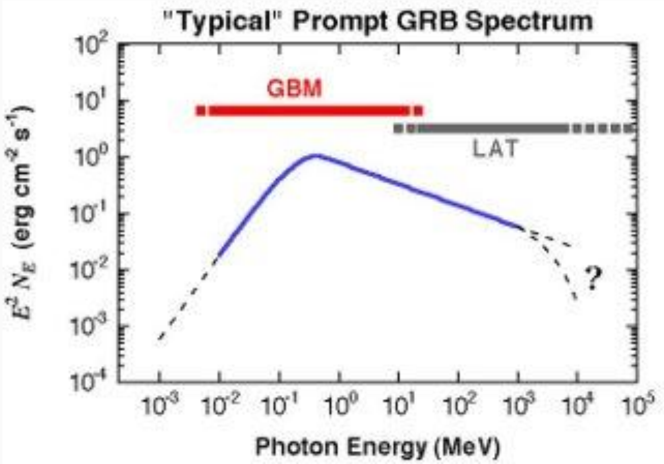
$$= A\left[\frac{(\alpha - \beta)E_0}{100\ \mathrm{keV}}\right]^{\alpha-\beta} \exp\,(\beta - \alpha)\left(\frac{E}{100\ \mathrm{keV}}\right)^{\beta}, \qquad (\alpha - \beta)E_0 \leq E\,,$$

Band. et.al (1993).

GRB spectra typically described by the empirical Band Function

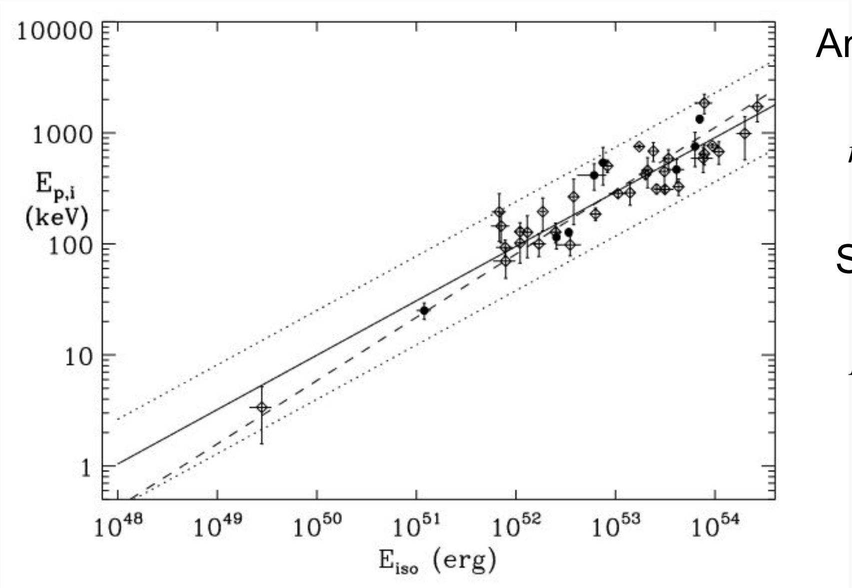
$$E_{p,obs} = E_0 \times (2 + \alpha)$$

Peak energy of the $\nu F\nu$ spectrum



The typical spectrum of a gamma burst Credit: NASA

The Amati Correlation ($E_{p,rest} - E_{iso}$)



$E_{p,i} - E_{iso}$ Correlation for 41 GRBs/XRFs L. Amati (2006)

Amati correlation is given by $E_{p,rest} = k E_{iso}{}^{m}$

$m = 0.57,\ k = 80.0 \qquad \sigma = 0.18$

Since we don´t know the redshift…

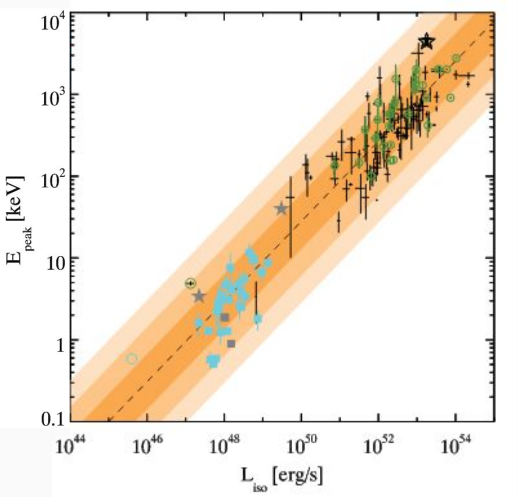
$$E_{p,obs}(1+z) = E_{p,rest} \qquad E_{iso} = \frac{4\pi d_L^2 F}{1+z}$$

Standard cosmological model was used since: $d_L(H_0, \Omega_m, \Omega_\wedge, z)$

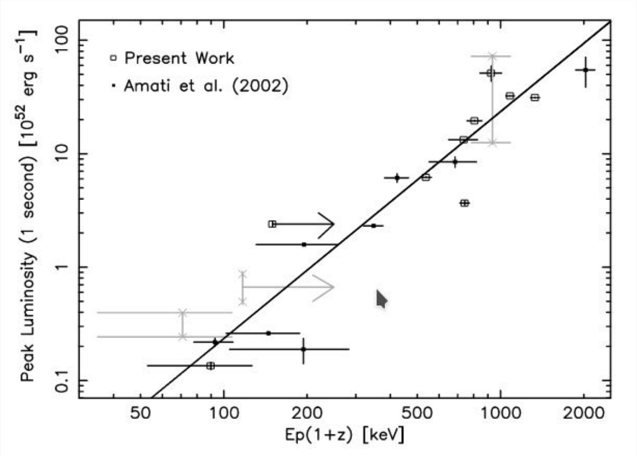
Other correlations

The correlation holds also when E_{iso} is substituted with L_{iso} (Ghirlanda et. al 2011)

or L_{peak} (Yonoteku 2004)



$E_{peak} - L_{iso}$ G. Ghirlanda et al. 2011

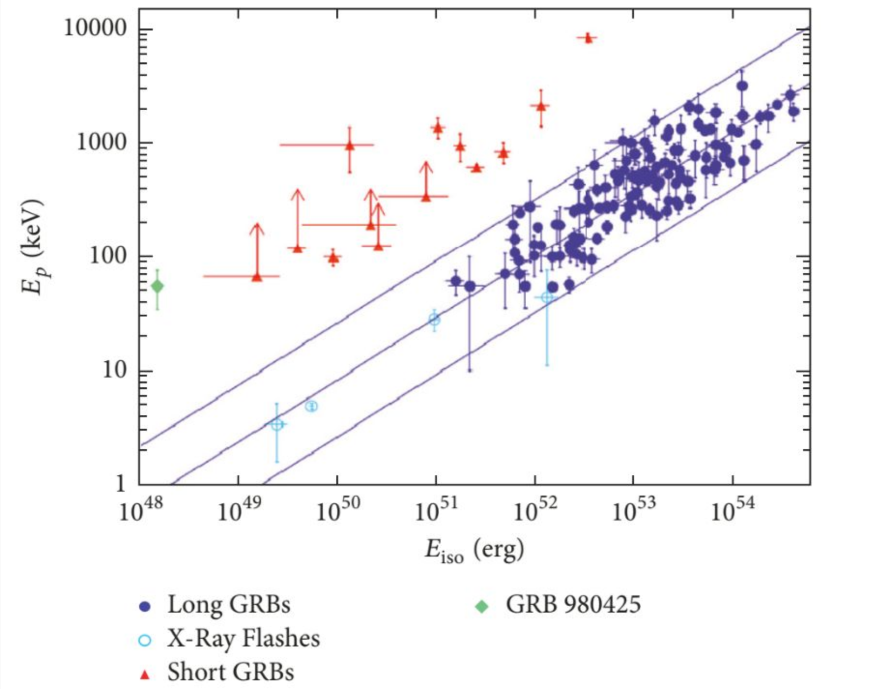


$\log L_{peak} - \log E_{peak}$ Yonetoku et al. 2004

Why Amati Correlation?

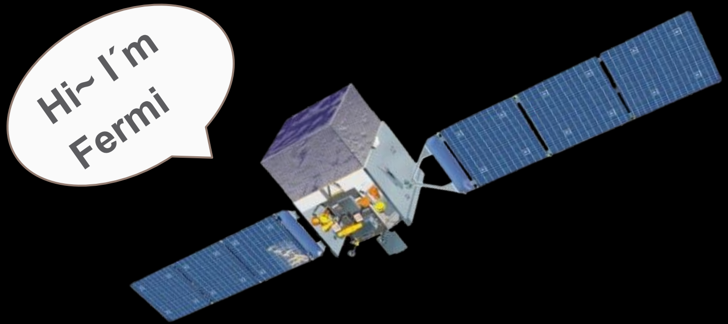
L_p, L_{iso} is subject to more uncertainties (eg. light curves peaks at different times in different energy bands)

The lines indicates the best fit, and the $+2\sigma$ confidence region for LGRBs



Goals

Use the Amati correlation to calculate the pseudo-redshift of a LGRBs sample, detected by Fermi telescope (GLAST)



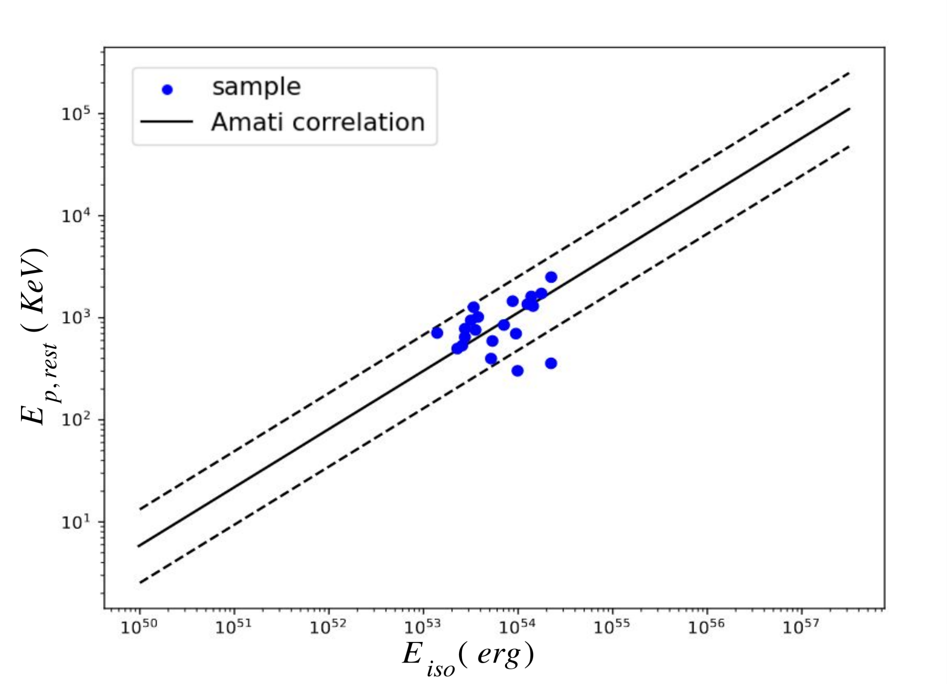
Methods

- Perform a time integrated spectral fitting to the LGRBs sample.
- Obtain from the spectral fitting parameters: Peak energy, low energy index and high energy index
- Perform the calculation of the pseudo-redshift to the sample

The initial sample

22 high fluence Long GRBs detected by Fermi-GBM, with reported redshift

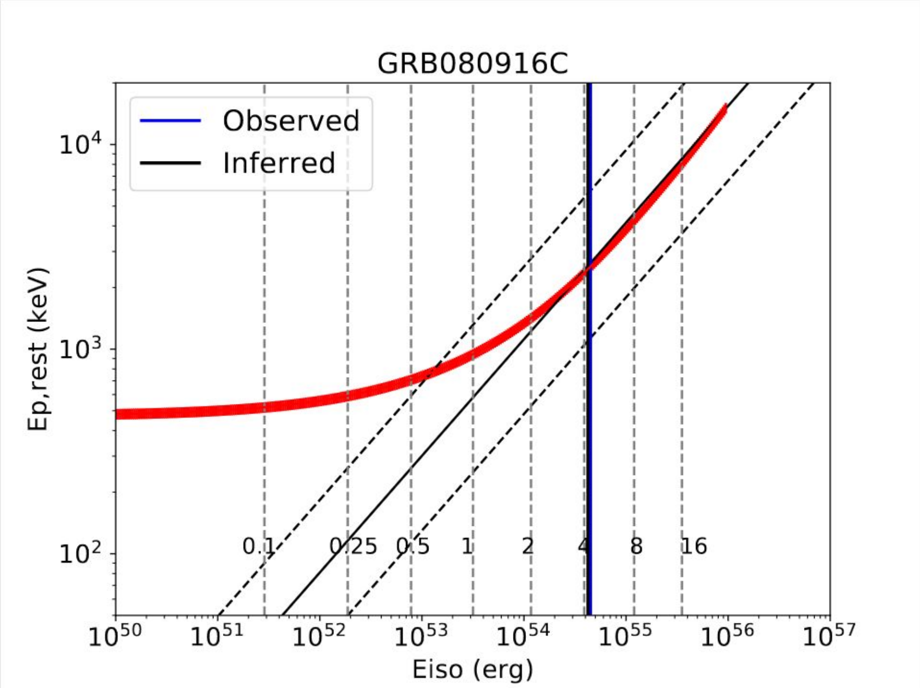
Data show consistency with the Amati correlation



Preliminary Results

We used the Amati correlation to inferred the range of the redshift in which the burst is consistent

Z reported	Amati min z	Amati z
3.57	0.6	3.38



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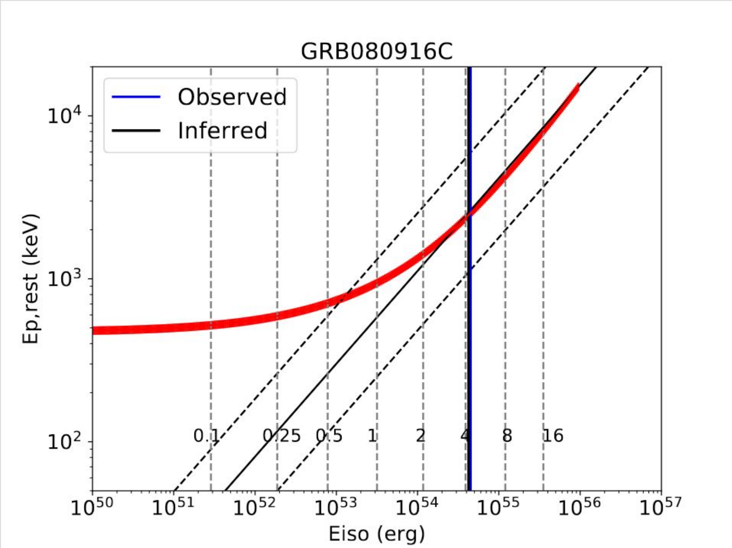
Preliminary Results

GRB	Reported redshift	Min Amati pseudo-redshift	Amati pseudo-redshift
090323	3.57	0.6	3.38
140508A	1.027	0.37	1.09
120711A	5.2	0.54	1.81
170405A	3.51	0.45	1.41

Some of the 22 preliminary results GRBs pseudo-redshifts



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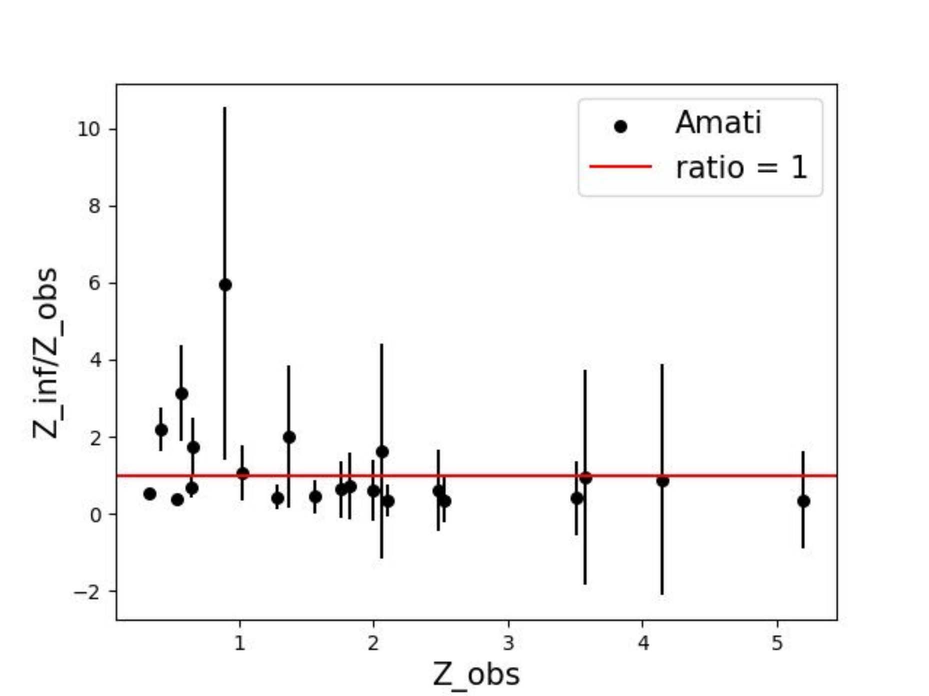
Preliminary Results

Ratio between the pseudo-redshift inferred using the Amati correlation and the redshift observed.



Summary and Future work

Preliminary results show consistency with the Amati correlation

Amati correlation shows consistency for a large range of redshifts: from 0.2 - 5

Combination with other methods and correlations can help us to better determined pseudo-redshifts for GRBs

We are going to extend the work for a bigger sample of LGRBs detected by FERMI-GBM, and combine Amati correlation with other methods

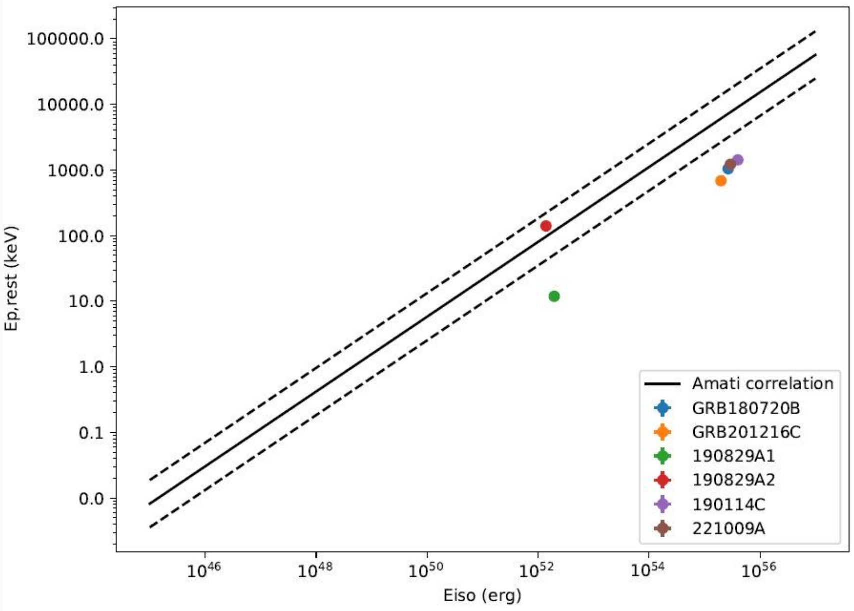
THANKS!

Thanks to the PAPIIT IG101323 project and the organizing committee

Backup Slides

Backup slide 1

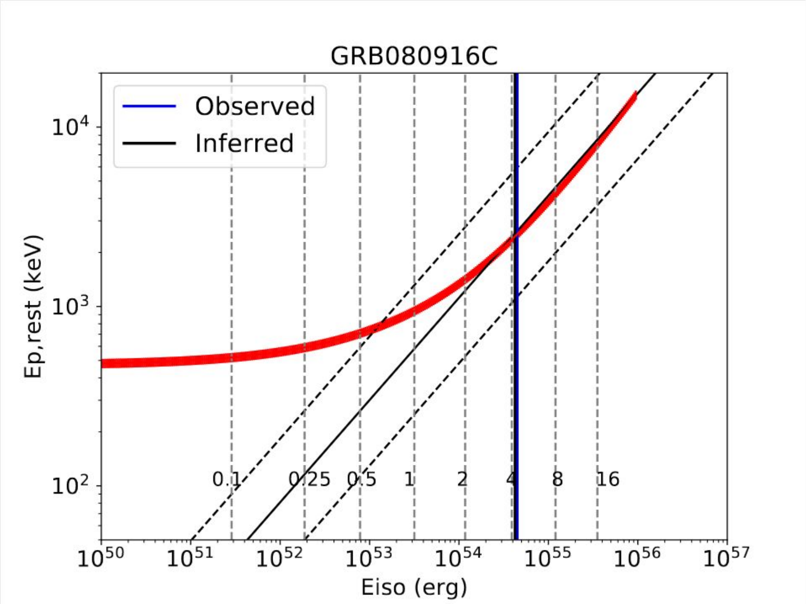
GRBs at GeV - TeV that don´t are consistent with the Amati correlation



Backup slide 2

$$E_{p,obs}(1+z) = E_{p,rest}$$

$$E_{iso} = \frac{4\pi d_L^2 F}{1+z}$$



Backup slide 3

Dashed line: best fitting power law obtained fitting the data without accounting for sample variance