IL NUOVO CIMENTO Vol. 28 C, N. 3 Maggio-Giugno 2005
DOI 10.1393/ncc/i2005-10050-4

Towards the E_{peak}^{rest}-E_{iso} correlation in GRBs in the BATSE Catalog: A progress report(*)

G. Pizzichini(1), P. Ferrero(1)(2), M. Genghini(1), F. Gianotti(1) and M. Topinka(3)

(1) *INAF/IASF Bologna - Bologna, Italy*
(2) *Teramo University and Observatory - Teramo, Italy*
(3) *Max-Plank Institute for Astrophysics - D-85741 Garching, Germany*

(ricevuto il 23 Maggio 2005; pubblicato online il 9 Settembre 2005)

Summary. — The present paper is a progress report on our work towards estimating the energy emission involved in the many Gamma-Ray Bursts for which no redshift has been actually measured. Once such an estimate is obtained, we can try to extend the E_{peak}^{rest}-E_{iso} relation found by Amati *et al.* (*Astron. Astrophys.*, **390** (2002) 81) to those events. Following Atteia (*Astron. Astrophys.*, **407** (2003) L1) we obtain a pseudo-redshift ($\hat{z}$) estimate which then allows us to estimate E_{peak}^{rest} and E_{iso} for each burst.

PACS 95.85.Pw – γ-ray.
PACS 98.70.Rz – γ-ray sources; γ-ray bursts.
PACS 01.30.Cc – Conference proceedings.

1. – Introduction

The E_{peak}^{rest}-E_{iso} relation for Gamma-Ray Bursts (GRB) found by Amati *et al.* [1] and its extensions by himself and others [2,9,10,16], has generated much discussion [5,7,8,11-14,17,18,20]. Since E_{peak}^{rest} and E_{iso} must be measured in the burst comoving coordinate system, we need to know the burst redshift or at least to have a good estimate for it. We also need a good estimate of the spectrum. In a previous paper [21] we already used the pseudo-z $\hat{z}$ proposed by Atteia *et al.* [3] in order to extend the Amati relation to GRBs in the BATSE catalog whose spectra have been published by Band *et al.* [6]. We now use the same method for the events, still from the BATSE catalog, which were analysed by Jimenez *et al.* [15]. We find that the E_{peak}^{rest}-E_{iso} Amati relation is valid also for these additional bursts.

(*) Paper presented at the "4th Workshop on Gamma-Ray Burst in the Afterglow Era", Rome, October 18-22, 2004.

2. – Data and procedure used

As explained by Atteia [3,4], in order to obtain the $\hat{z}$ for each burst, we need to know the burst peak energy e_p, the number of photons between $e_p/2$ and $e_p/100$, and t_{90}, the time elapsed between the collection of 5% and 95% of the burst energy. In this paper we make use of the spectral fits given in table I by Jimenez *et al.* [15] For t_{90} we try to use both duration given by the same authors, hereafter t_{JBP} or by the BATSE 4B catalog [19](1).

We find that our estimate of $\hat{z}$ is not very sensitive to the difference between t_{90} and t_{JBP} and that in most cases it agrees with the measured redshift within a factor of 2, as expected [3], but we have a strong discrepancy in the case of GRB970508, which both with the use of t_{90} and of t_{JBP} gives $\hat{z} > 9$, while the measured value is 0.835 and Atteia's [3] estimate is 0.95. The main reason for this discrepancy resides in the spectral fit of this event: the Jimenez *et al.* [15] parameters for the Band function are $\alpha = -1.191$, $\beta = -1.831$ and $E_0 = 480.84$, while the values in [1], wich are also the ones used by Atteia [3], are $\alpha = -1.71$, $\beta = -2.2$ and $E_0 = 275\,\text{kev}$. We find that the discrepancy is due mainly to the difference in E_0. The evaluation of $\hat{z}$ depends on $X = n_\gamma/e_p/\sqrt{t_{90}}$, where $e_p = E_0 \cdot (\alpha + 2)$ and n_γ is the number of photons between $e_p/100$ and $e_p/2$. Actually $\hat{z}$, see fig. 3 in [3], could very roughly be considered inversely proportional to $\sqrt{X}$. Thus too large an estimate for E_0 gives too small a value for X, consequently too large a value for $\hat{z}$.

We also do not find a good agreement between the measured redshift for GRB000131, 4.5 and our $\hat{z}$ (0.99, using t_{JBP}) worse than the estimate (1.35) of [3], which was already too small. The conclusion of Atteia [3] was that this method probably needs additional corrections at high redshifts. We also recall that here the X $\hat{z}$ correlation has been derived only for $\alpha = -1$, $\beta = -2.3$ and $E_0 = 250\,\text{keV}$. It might not give good results for parameters too far from these values, although that does not seem the case in table I of [3].

Also GRBs 980706 and 000429 (triggers 6904 and 8087) with t_{90}, plus GRBs 991229 and 000301 (7925 and 8005) with t_{JBP}, give $\hat{z} > 9$, which we do not include in our graphs. The $\hat{z}$ distibution which we find is shown later in fig. 2.

With the caveats that individual values of $\hat{z}$ can be very much affected by the estimates of the parameters in the Band spectrum, as seen for GRBs 970508 and 000131, we then proceed, as in [21], to obtain the E_{peak}^{rest}-E_{iso} and E_{iso}-$\hat{z}$ diagrams given in fig. 1 superimposed to those of [21].

We find that the E_{peak}^{rest}-E_{iso} relation of Amati *et al.* [1] is still well reproduced. The E_{iso}-$\hat{z}$ graph is more scattered. This fact might be due to the choice in [15] of spectral fits for time intervals which do not always cover all the burst, therefore they do not correspond to the total burst fluence. We also show in fig. 2 how the E_{peak}^{rest}-E_{iso} correlation for

---

(1) Of all the bursts in table I of ref. [15], if we take t_{90} from the BATSE catalog we can use GRBs 970111, 970508, 970616, 970815, 971024, 971214, 9712227, 980109, 980329, 980425, 980519, 980703, 980706, 990123, 990506, 990510, 990806, 991014, 991105, 991216, 000115, 000201, 000307, 000408, 000429, 000508B and 000519, that is BATSE triggers 5773, 6225, 6274, 6335, 6448, 6533, 6546, 6564, 6665, 6707, 6764, 6891, 6904, 7343, 7549, 7560, 7701, 7803, 7841, 7906, 7954, 7976, 8022, 8069, 8087, 8098 and 8111. If we use t_{JBP} as an estimate of t_{90} we can add 970828, 980326, 991229, 000126, 000131 and 000301A, that is triggers 6350, 6660, 7925, 7971, 7975 and 8005. The list includes some bursts with observed redshifts, namely 970508, 970828, 971214, 980425, 980703, 990123, 990510 and 991216

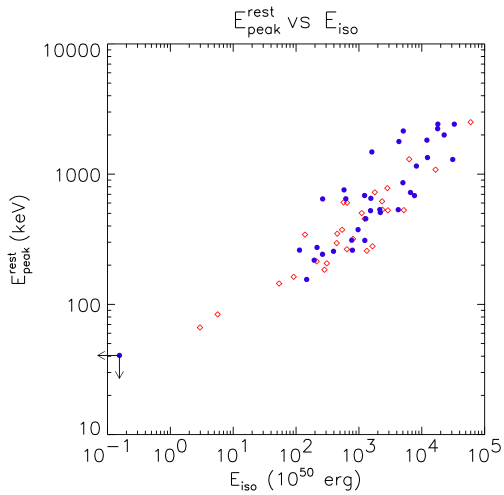

Fig. 1. – E_{peak}^{rest}-E_{iso} and E_{iso}-$\hat{z}$ diagrams for GRBs in this paper (open diamonds) and in [21] (filled circles).

single events behaves if we assume different values of z without changing the spectral parameters.

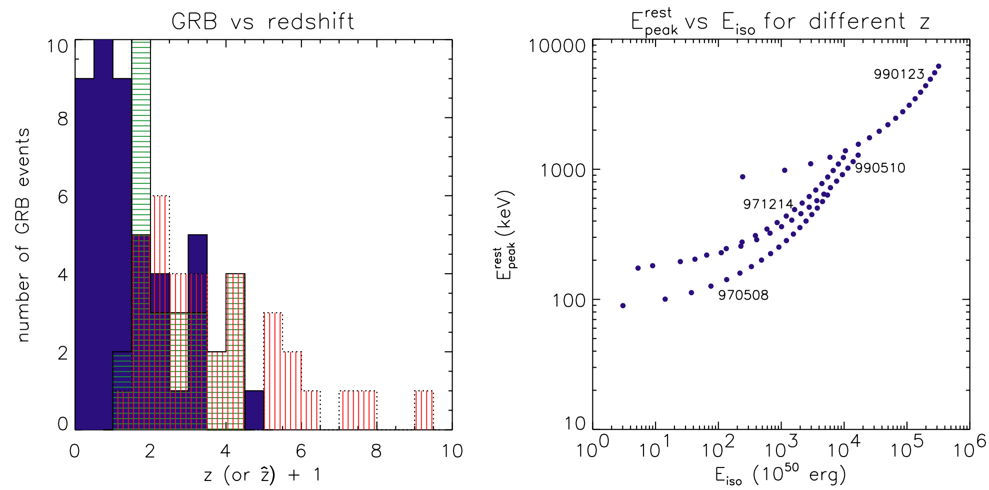

Fig. 2. – Left-hand side: histograms of the pseudo-redshifts $\hat{z}$ for GRBs in this paper (vertical stripes) and in Pizzichini *et al.* [21](horizontal stripes), superimposed to the histogram of measured redshifts. Right-hand side: the E_{peak}^{rest}-E_{iso} diagrams for single events for which we use the spectral parameters given by Atteia [3] and impose different values of z from 0.12 to 6.9.

3. – Conclusions

We conclude that $\hat{z}$ gives, on average, a good estimate of z, as long as good care is put in estimating the spectral parameters of the whole burst. Even taking into account possible failures in the $\hat{z}$ estimate for single events, statistical properties should still be well reproduced and, in fact, we find that the Amati E_{peak}^{rest}-E_{iso} correlation is still found and confirmed in our two samples, which include more than twice as many events as [2].

No jet opening angles can be measured when the burst OT was not detected, therefore we cannot check if we have an agreement also with the "Ghirlanda correlation" [13, 14].

By assuming that both correlations hold, one can derive a distribution of jet opening angles, but our sample is too small to be compared to the one used in [14].

The estimates of $\hat{z}$ and E_{iso} are not independent, since, except for t_{90}, which is explicitly used only in $\hat{z}$, they both make use of the average spectral properties of each event. In fact, the "recipe" for $\hat{z}$ [3] is based on the assumption that the E_{peak}^{rest}-E_{iso} "Amati correlation" [1, 2] is valid. However, if a GRB was an outlier in that correlation, not only we would not obtain a good estimate of the true redshift, but it can be shown that the use of $\hat{z}$, instead of a detected z would not mistakenly bring that burst to agree with the correlation.

We find an agreement with the Amati correlation in our sample of BATSE GRBs, while other authors, *e.g.* [17,18], state that even as many as 88% of BATSE bursts cannot agree with it. It is possible either that the present method gives better estimates of $\hat{z}$ or that the spectra of bursts used here were particularly well measured or that, indeed, there are different classes of GRBs. A detailed discussion on this matter is beyond the scope of the present short contribution.

REFERENCES

[1] Amati L. *et al.*, *A. & A.*, **390** (2002) 81-89.
[2] Amati L. *et al.*, *ChJAA Suppl.*, **3** (2003) 455.
[3] Atteia J-L., *A. & A.*, **407** (2003) L1-L4.
[4] Atteia J-L. *et al.*, in *Gamma-Ray Bursts: 30 years of discovery*, edited by Fenimore E. E. and Galassi M., *AIP Conf. Proc.* **727** (Santa Fe, NM) 2004, pp. 37-41.
[5] Bagoly Z. *et al.*, *A. & A.*, **398** (2003) 919-925.
[6] Band D. *et al.*, *ApJ*, **413** (1993) 281-292.
[7] Band D. L., Norris J. P. and Bonnell J. T., *ApJ*, **613** (2004) 484-491.
[8] Band D. L. and Preece R. D., *ArXiv Astrophysics e-prints*, **0501559** (2005) http://xxx.lanl.gov/.
[9] Barraud C. *et al.*, *A. & A.*, **400** (2003) 1021-1030.
[10] Barraud C. *et al.*, in *Gamma-Ray Bursts: 30 years of discovery*, edited by Fenimore E. E. and Galassi M., *AIP Conf. Proc.* **727** (Santa Fe, NM) 2004, pp. 81-85.
[11] Eichler D. and Levinson A., *ApJL*, **614** (2004) L13-L16.
[12] Friedman A. S. and Bloom J. S., *ApJ*, **627** (2005) 1.
[13] Ghirlanda G. Ghisellini G. and Lazzati D., *ApJ*, **616** (2004) 331-338.
[14] Ghirlanda G. *et al.*, *ArXiv Astrophysics e-prints*, **0502488** (2005) http://xxx.lanl.gov/.
[15] Jimenez R., Band D. and Piran T., *ApJ*, **561** (2001) 171-177.
[16] Lamb D. Q., Donaghy T. Q. and Graziani C., *ApJ*, **620** (2005) 355-378.
[17] Nakar E. and Piran T., *ArXiv Astrophysics e-prints*, **0412232** (2004) http://xxx.lanl.gov/.
[18] Norris J. P. *et al.*, *ArXiv Astrophysics e-prints*, **0503383** (2005) http://xxx.lanl.gov/.
[19] Paciesas W. S. *et al.*, *ApJS*, **122** (1999) 465-495.
[20] Piran T., *ArXiv Astrophysics e-prints*, **0502473** (2005) http://xxx.lanl.gov/.
[21] Pizzichini G. *et al.*, *ArXiv Astrophysics e-prints*, **0503264** (2005) http://xxx.lanl.gov/.