An investigation of the impact of selections and instrumental effects on the observed Ep,i - Eiso correlation

Simone Dichiara (University of Ferrara and INAF - IASF Bologna,Italy), Lorenzo Amati (INAF – IASF Bologna, Italy)

The reliability of the Ep,i - Eiso and other spectrum - intensity correlations is a hotly debated topic, given its relevance for both GRB physics and cosmology. We report on the results on Monte Carlo simulations aimed at evaluating the impact of selection and instrumental effects on the distribution of GRBs in the Ep,i - Eiso plane. By considering both theoretical and real detection and spectroscopic thresholds, together with different possible distributions of the redshift, spectral parameters and radiated energy, we find that the observed Ep,i - Eiso relation cannot be reproduced by assuming the null hypothesis that the two quantites are completely uncorrelated. Moreover, our simulations show that the measured trend in the Eiso - redshift plane could be a consequence (and an evidence) of the existence of the Ep,i - Eiso correlation.

Observed Correlation Coefficient for real distribution in Ep-Eiso plane

Pearson **0,85**

Spearman **0,9**

In our simulation we have taken into account several kinds of SPECIFIC CRITERIA:

i. Mimimum detectable flux
ii. Spectroscopic threshold
iii. Different kinds of original Ep,i distribution and Eiso distribution
iv. Different specral parameters (On the assumption that the spectum is related to a Band function)
v. Different redshift distributions (Uniform, Normal, Nomalized to the real one…)

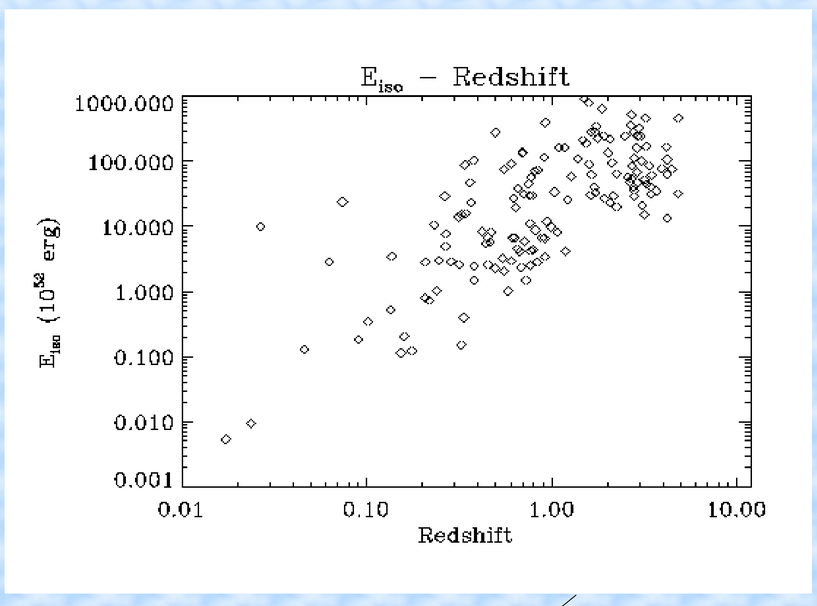
Results obtained with hypothetical Instrumental Thresholds

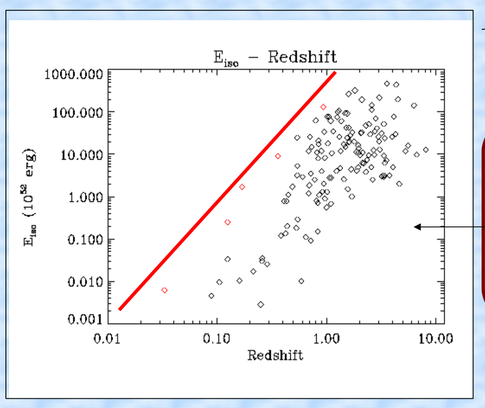
Energy Band Detector	Energy Band Spectroscope	Distributons $E_{p,i}$ and E_{iso}	Threshold Flux	Threshold Fluence	Correlation Coefficient
15–150	25–200	uniform	1.1	11.0	0.506
		gaussian	0.1	91.0	0.41
15–150	35–150	uniform	0.6	1.0	0.506
		gaussian	0.1	81.0	0.51
15–150	8–1000	uniform	2.6	81.0	0.30
		gaussian	0.1	41.0	0.12
20–2000	40–1500	uniform	4.6	91.0	0.44
		gaussian	0.1	91.0	0.22
2–28	40–1500	uniform	2.1	81.0	0.40
		gaussian	0.6	91.0	0.22
2–28	5–600	uniform	2.1	31.0	0.39
		gaussian	0.6	81.0	0.18

No correlation coefficient higher than 0,5 can be otained (and only by assuming an unreliably high fluence threshold!

The plot shows the resulting distribution in Eiso - z plane that we have obtained by simulations that considered BeppoSAX response parameters when we take a redshift distribution similar to the real one and assume the existence of the Amati's relation . This risulting trend resemble the real observed trend

If we assume the observed Ep,i - Eiso correlation, we can reproduce observed trend in Eiso - z plane for instruments with narrower energy band (Swift/BAT and BeppoSAX)





Real observed trend in Eiso – z plane. It's clearly visible the absence of more energetic GRB at low redshift

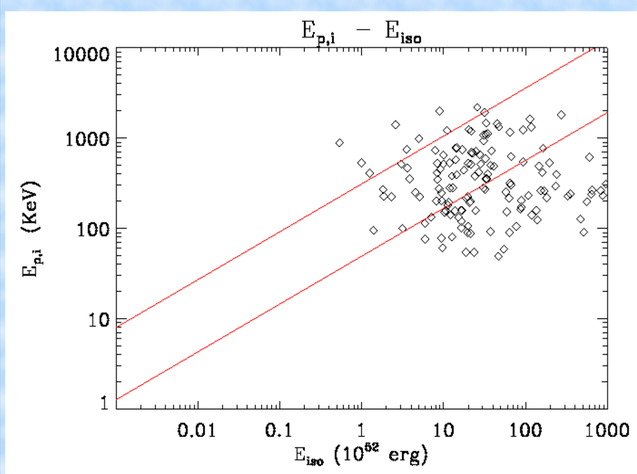
Results obtained with real Instrumental Thresholds (Band 2003)

Detection	Spectrum	Distributions $E_{p,i}$ and E_{iso}	Distr. Redshift	Threshold Fluence $n^o\ \sigma$	Correlation Coefficient
BATSE	BATSE	uniform	observed	8	0.20
				20	0.17
				40	0.12
BATSE	BATSE	uniform	normal	8	0.21
				20	0.11
				40	0.08
BATSE	BATSE	normal	observed	8	0.07
				20	0.09
				40	0.14
BATSE	BATSE	normal	normal	8	0.24
				20	0.32
				40	0.35
Swift/BAT	*Fermi*	uniform	observed	8	0.26
				20	0.33
				40	0.45
Swift/BAT	*Fermi*	uniform	normal	8	0.36
				20	0.33
				40	0.46
Swift/BAT	*Fermi*	normal	observed	8	0.01
				20	0.01
				40	0.05
Swift/BAT	*Fermi*	normal	normal	8	0.24
				20	0.16
				40	0.24
Swift/BAT	*Swift*/BAT	uniform	observed	8	0.31
				20	0.41
				40	0.44
Swift/BAT	*Swift*/BAT	uniform	normal	8	0.30
				20	0.22
				40	0.24
Swift/BAT	*Swift*/BAT	normal	observed	8	0.29
				20	0.36
				40	0.42
Swift/BAT	*Swift*/BAT	normal	normal	8	0.40
				20	0.51
				40	0.53
SAX/WFC	BATSE	uniform	observed	8	0.20
				20	0.17
				40	0.12
SAX/WFC	BATSE	uniform	normal	8	0.21
				20	0.11
				40	0.08
SAX/WFC	BATSE	normal	observed	8	0.06
				20	0.09
				40	0.14
SAX/WFC	BATSE	normal	normal	8	0.25
				20	0.33
				40	0.35
SAX/WFC	SAX/GRBM	uniform	observed	8	0.19
				20	0.29
				40	0.31
SAX/WFC	SAX/GRBM	uniform	normal	8	0.21
				20	0.29
				40	0.24
SAX/WFC	SAX/GRBM	normal	observed	8	0.04
				20	0.04
				40	0.04
SAX/WFC	SAX/GRBM	normal	normal	8	0.03
				20	0.02
				40	0.07

Ep,i-Eiso distribution coming out of the simulation
(red lines indicate the 2σ region of the observed correlation)

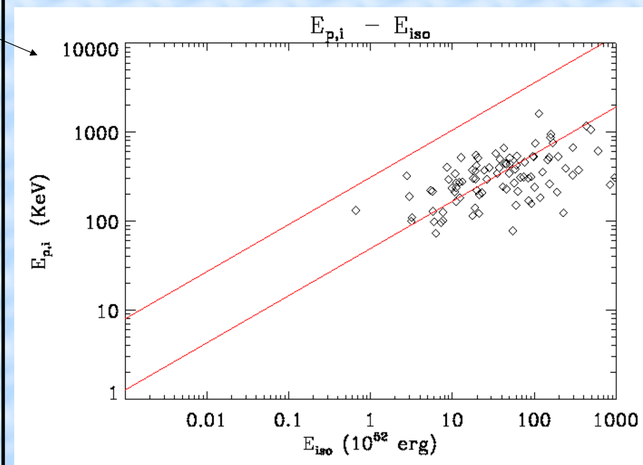
BeppoSAX

Typical example of simulation result!



Swift/BAT

Maximum correlation in Ep,i – Eiso plane



Conclusions

The purpose of this work was to check the effective reliability of Ep,i - Eiso relation by miss of MC simulations. Indeed this is a very important issue becouse it's basic for understand the physic of this specific phenomena and also for the possibility to use it in cosmologic studies.

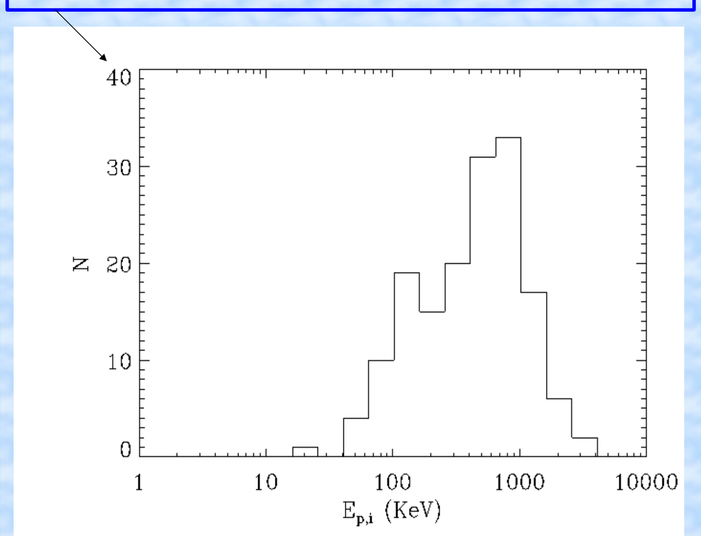
* By assuming the null hypothesis of no correlation we **can't reproduce** the observed trend in Ep,i-Eiso plane

* Maximum correlation coefficient is about 0,5 end is much lower then the observed one (0,9)

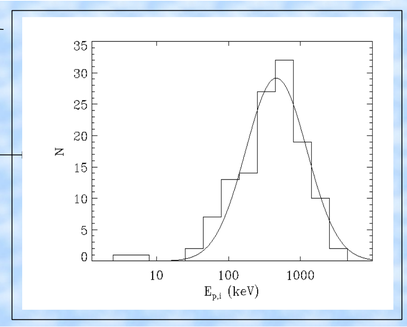
* If we considered hypothetical thresholds, the maximum correlation in Ep,i – Eiso plane was obtained when this instrumental limits are too higher than the real ones

* **If we assume the observed relation** between Ep,i and Eiso, simulations reproduce the others observed trends for Ep,i distribution and in Eiso-z plane

Ep,i distribution coming out of simulation by taking BeppoSAX instrumental threshold. In this case we have assumed at the beginning the observed relation between Ep,i and Eiso. This distribution is quite similar to the real observed trend



Real observed trend for Ep,i distribution



References

-Dichiara et al. 2012, A&A, in preparatioin
-Amati et al. 2002, A&A, 390, 81
-Band, 2003, ApJ, 588, 945-951
-Liang ; Dai & Wu , 2004, ApJ, 606, 29-32
-Nava; Ghirlanda; Ghisellini & Firmani, 2008, MNRAS, 391, 639-652
-Frontera; Amati; Guidorzi; Landi & La Parola, 2009, eprint arXiv:0909.3451
-Ghirlanda; Nava; Ghisellini; Celotti & Firmani, 2009, A&A, 496, 585-595
-Preece R. D. et al. 2000, ApJ Supplement Series, 126, 19-36