Outliers to the E_p-E_{iso} relation

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Nakar & Piran, 2004, astro-ph/0412232

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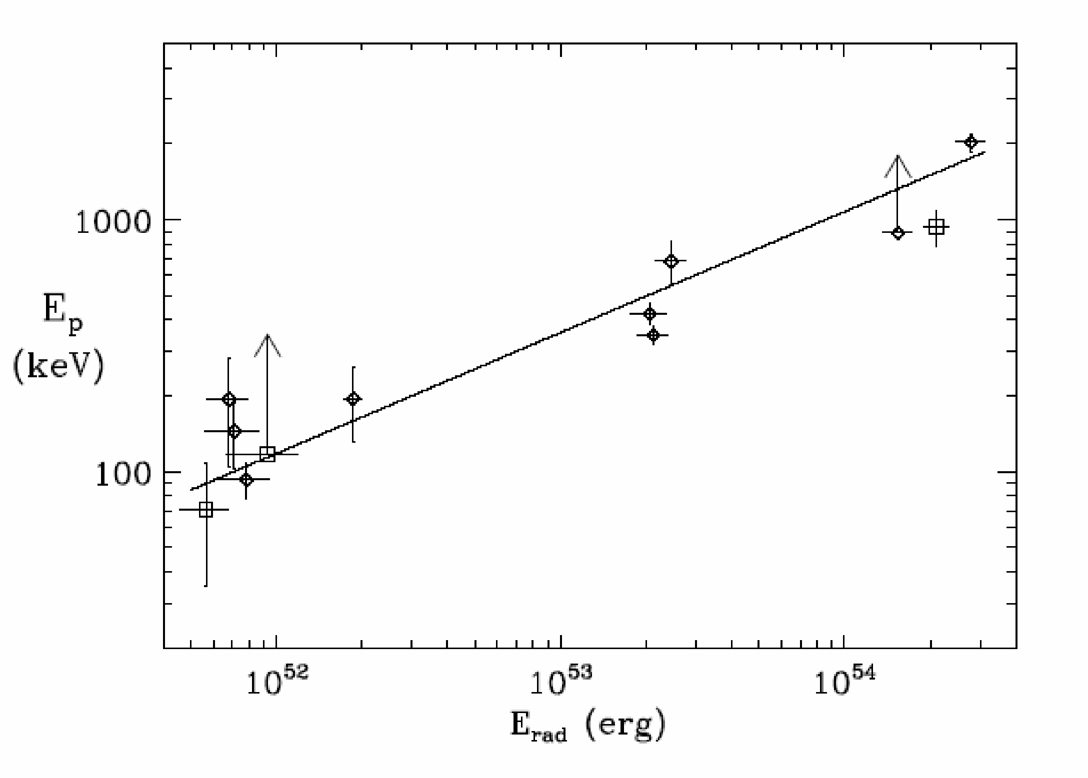
The E_p-E_{iso} relation : BeppoSAX

Known redshift for 12 BeppoSax bursts : $E_{p,obs} \rightarrow E_p$

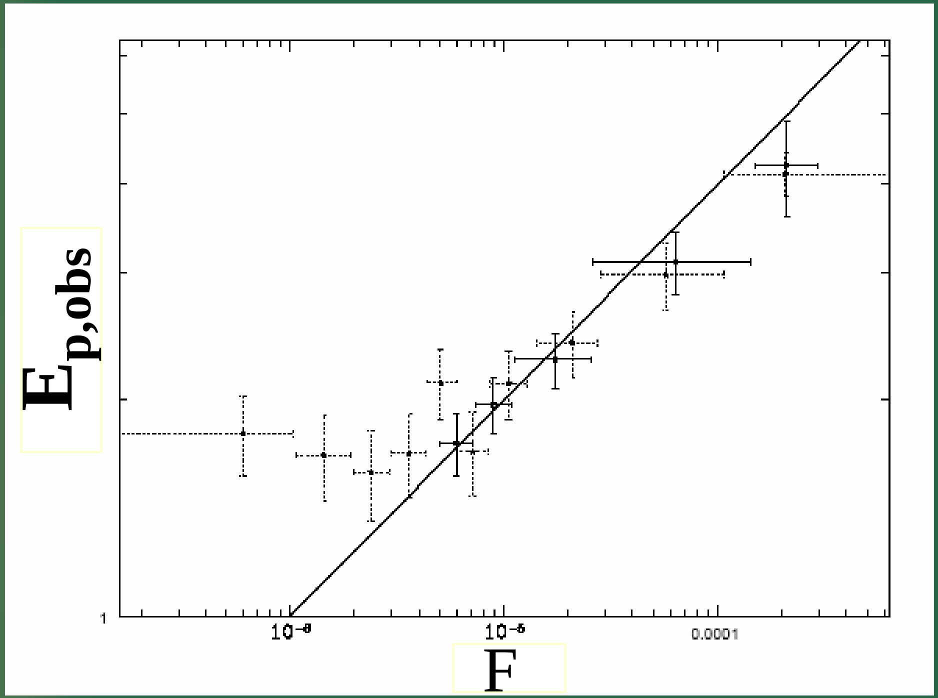
$F \rightarrow E_{iso}$



$$E_{iso} \propto E_p^{1.95 \pm 0.2}$$

Amati et al., 2002

$E_{p,obs}$ - F correlation

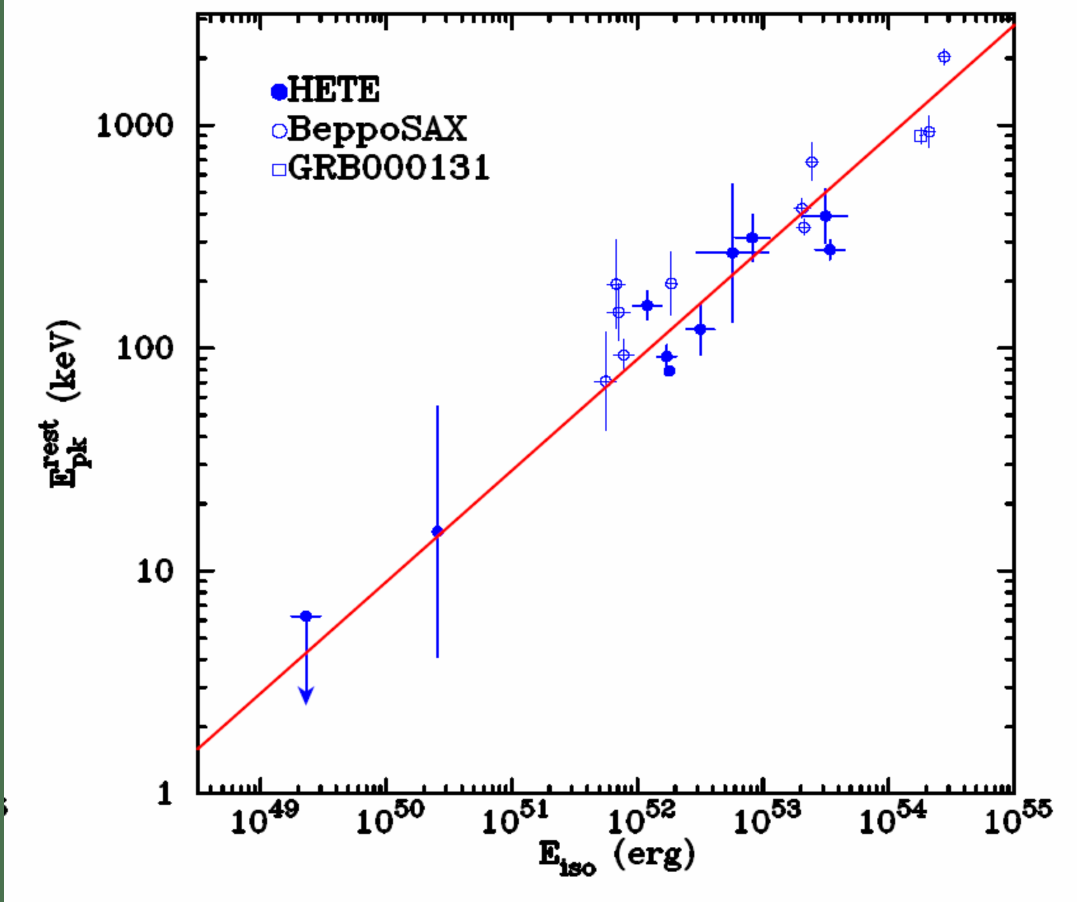


Lloyd, Petrosian, & Mallozzi 2000

Mallozzi et al. 1995
Dezalay et al. 1997
Lloyd et al. 2000
Lloyd & Ramirez-Ruiz 2002

$E_{p,obs}$: peak of the observed νF_ν
F : Total fluence

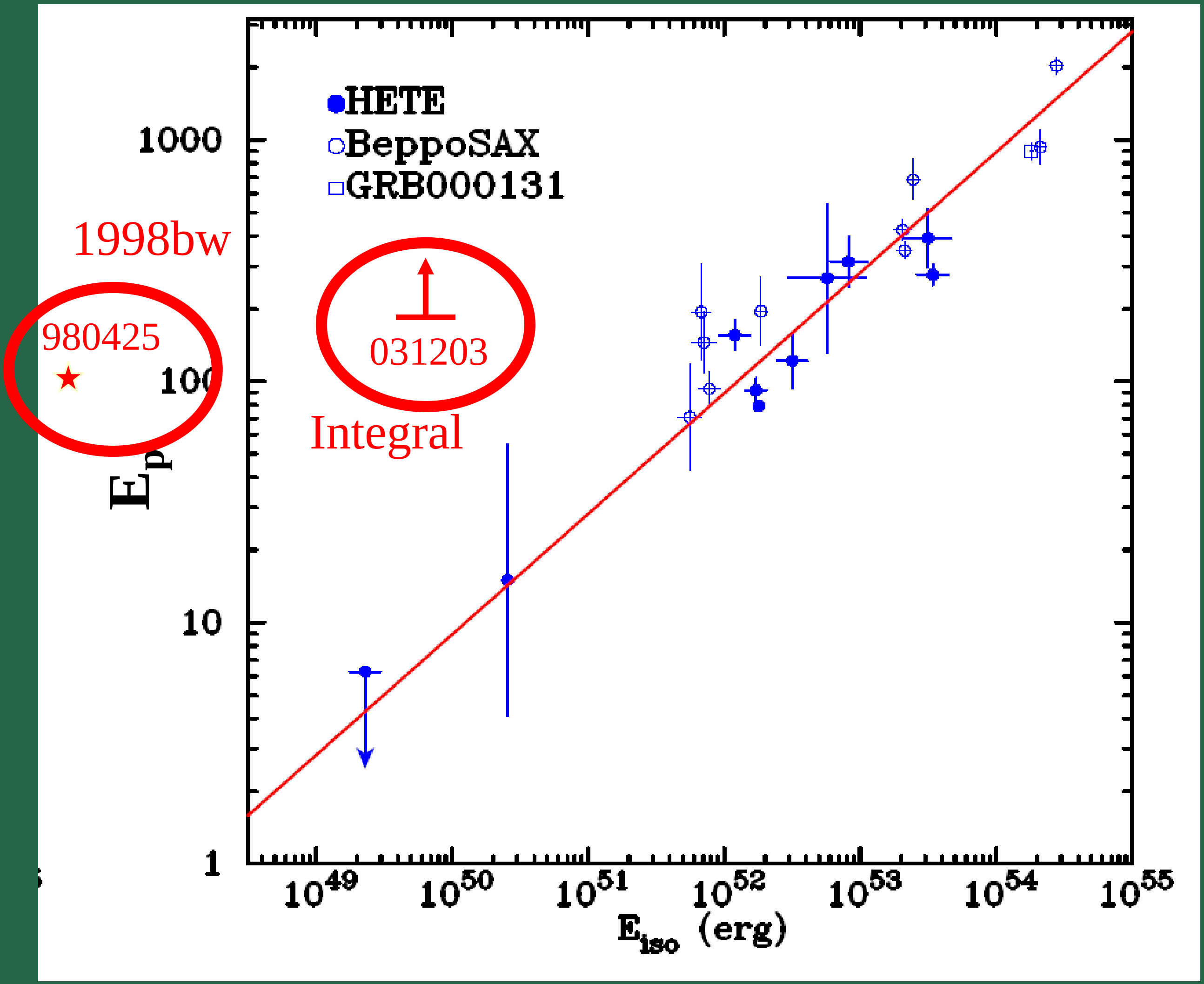
The E_p-E_{iso} relation : Hete-II



Lamb et al., 2003

$$E_{iso} = 1^{+1}_{-0.5} \times 10^{48} \left(\frac{E_p}{1keV} \right)^2 ergs$$

Outliers



The two nearest GRBs are dim and hard

The E_p-E_{iso} relation has a far reaching implications on models of GRBs and on their usage as a tool

But….

- Confirmed only for a small and unique sample
- Two confirmed outliers

Can we test the relation on a larger sample?

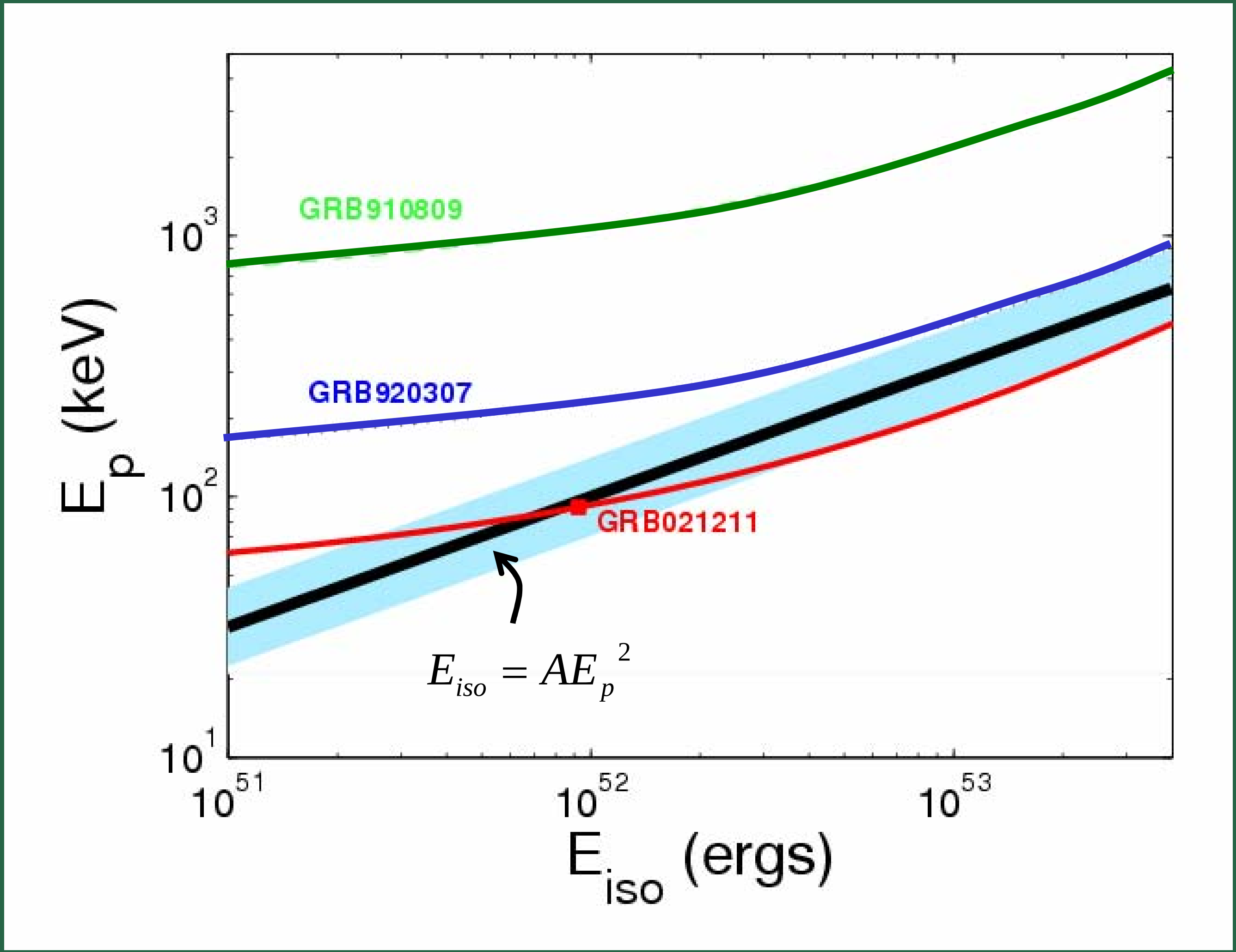
Yes!

Testing the E_p-E_{iso} relation for bursts with an unknown *z*

Given an observed **F** and **$E_{p,obs}$** and assuming **z**:

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

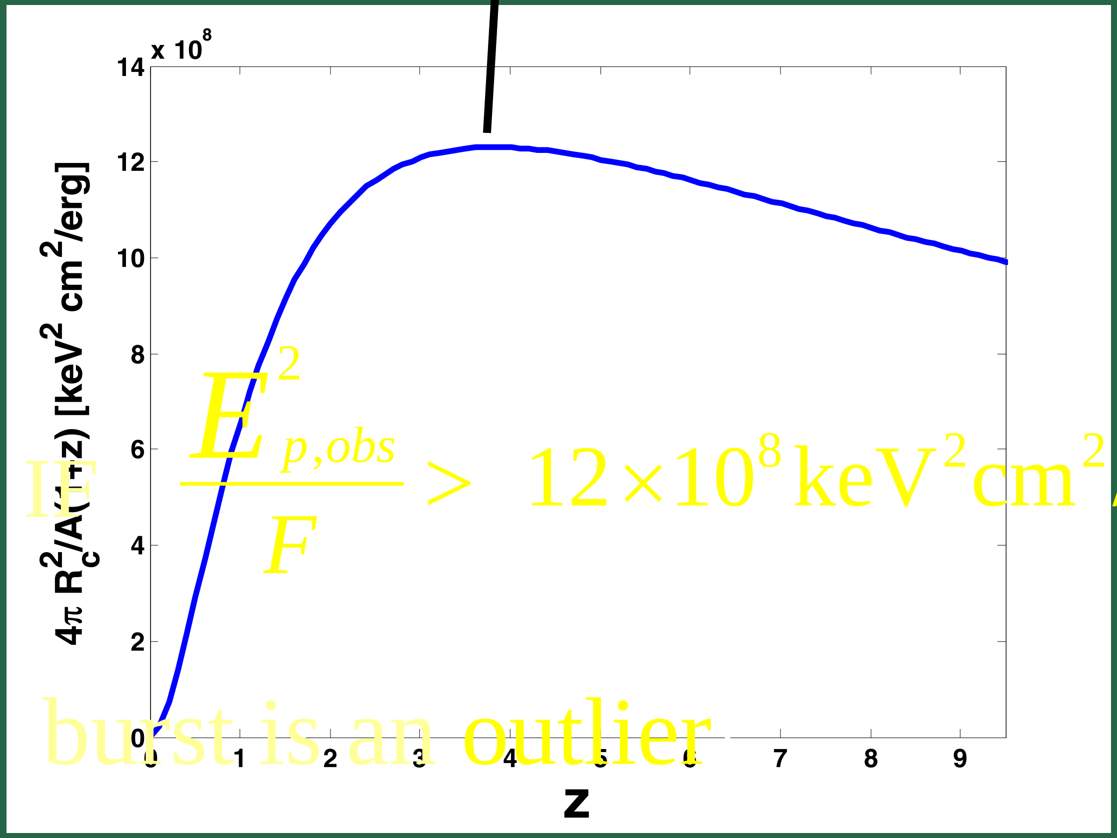
$$E_{iso} = 4\pi F R_c^{\,2}(z)(1+z)$$



GRB910809
GRB920307
GRB021211
$E_{iso} = AE_p{}^2$
E_p (keV)
E_{iso} (ergs)
10^1
10^2
10^3
10^{51}
10^{52}
10^{53}

A burst satisfies $E_{iso}=AE_p^2$ if:

$$\frac{E_{p.obs}^2}{F}=\frac{4\pi R_c^2(z)}{A(1+z)} < 12\times10^8\,\mathrm{keV^2cm^2/ergs}$$



IF $\frac{E_{p,obs}^2}{F} > 12\times10^8\,\mathrm{keV^2cm^2/ergs}$

burst is an outlier

Define:

$$d \equiv 8 \times 10^{-10} \frac{\left(E_{p,obs} / 1keV\right)^2}{F /(ergs / cm^2)}$$

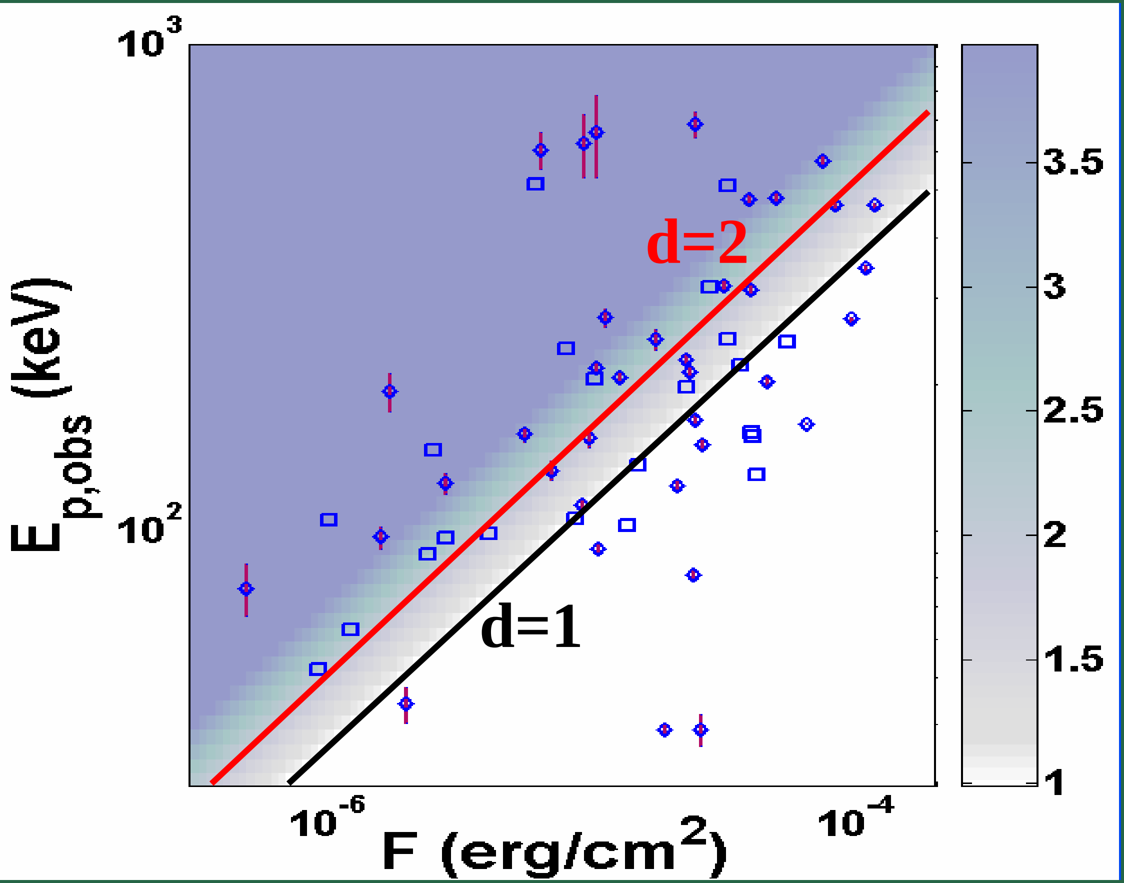
d<1 : A burst can *potentially* satisfy the E_p-E_{iso} relation

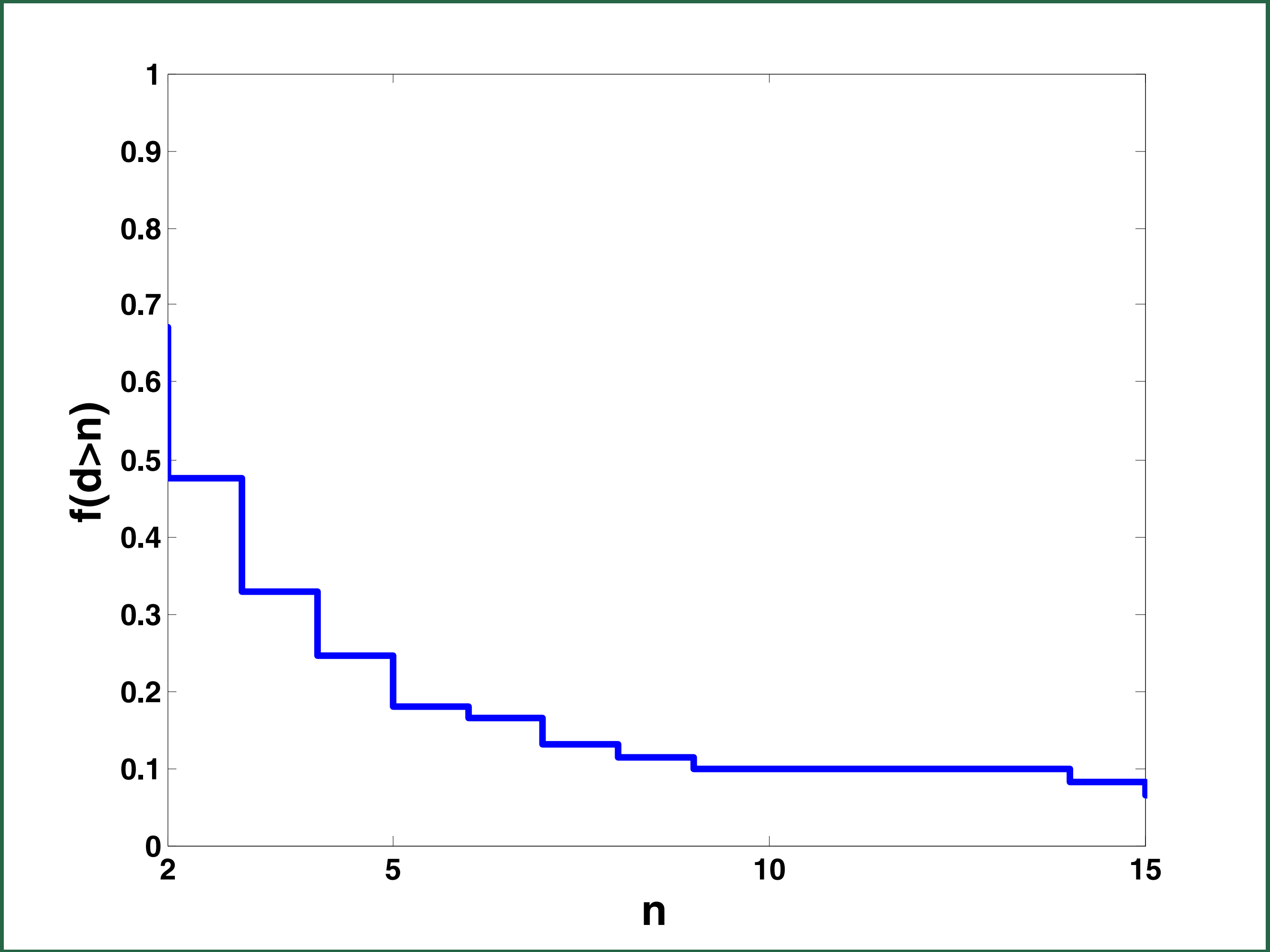
d>1 : An outlier: d measures the “distance” of the burst from the E_p-E_{iso} relation

This test do not apply the relation between E_p and the beaming corrected energy (Ghirlanda et al 2004)

A sample of 61 BATSE bursts with known E_p from Band et al.,(1993) and Jimenez et al., (2001):

- Long bursts
- Unknown z
- High energy spectral index < -2
- E_p<700keV



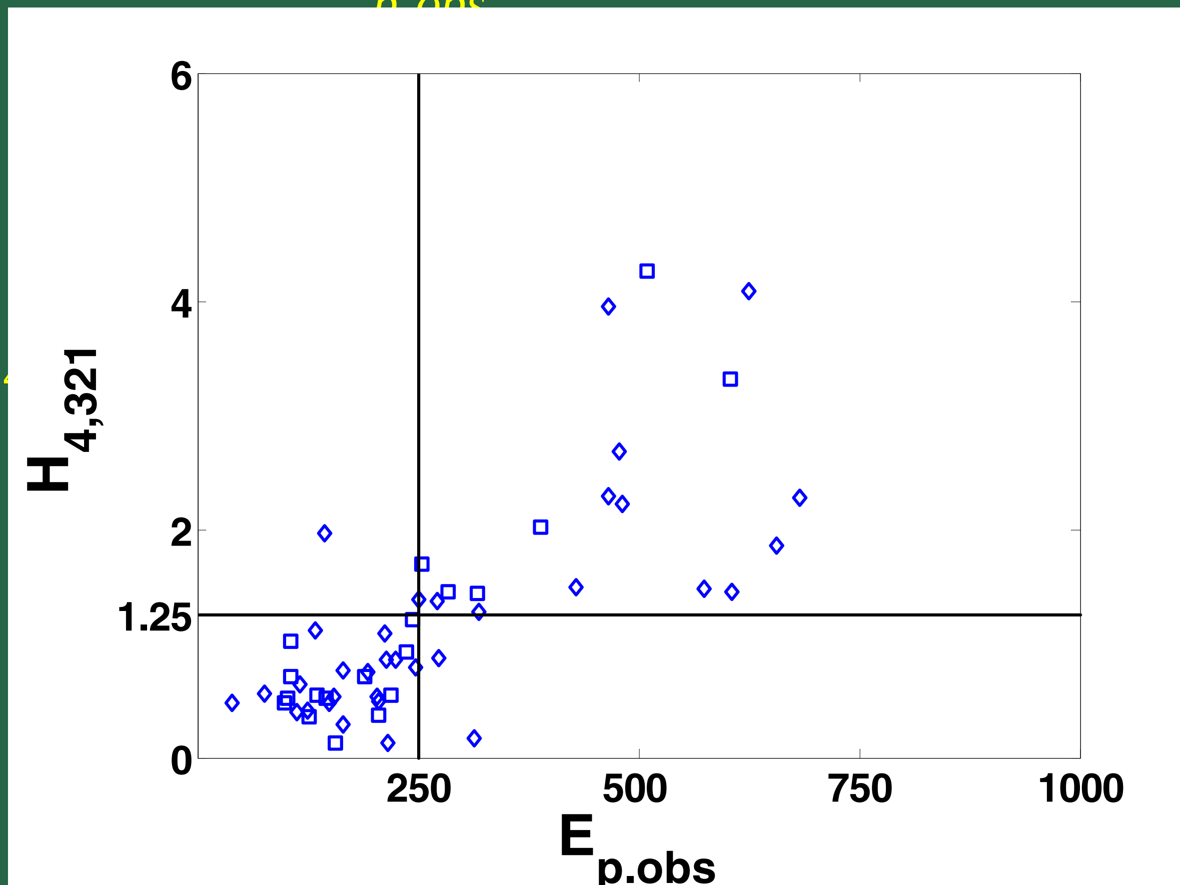


~50%: d>2 ; 25%: d>4 ; 10%: d>10!

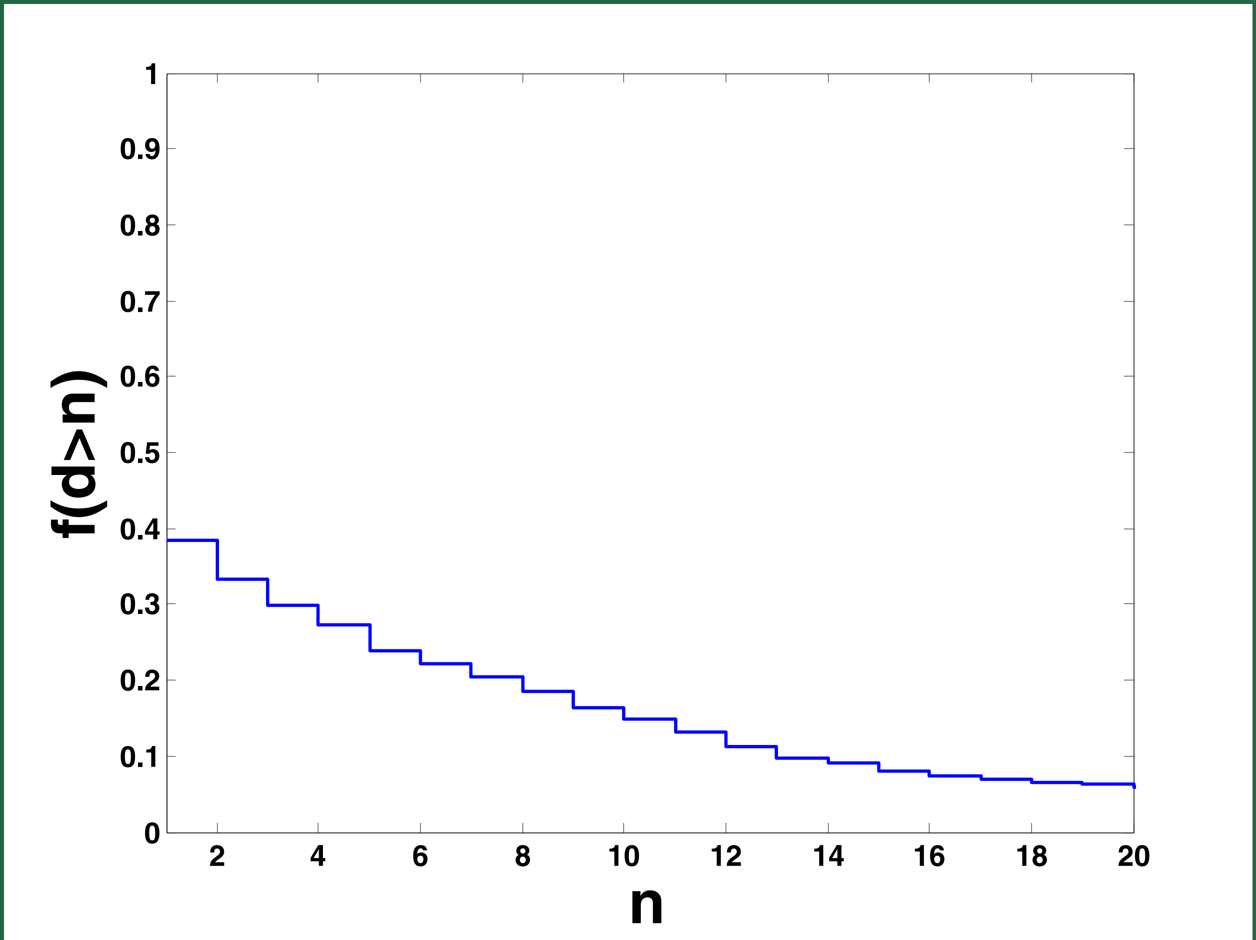
For the rest of the BATSE catalog $E_{p,obs}$ can be constrained using the hardness ratio:

$$E_{p,obs} > 250keV$$

H … 25

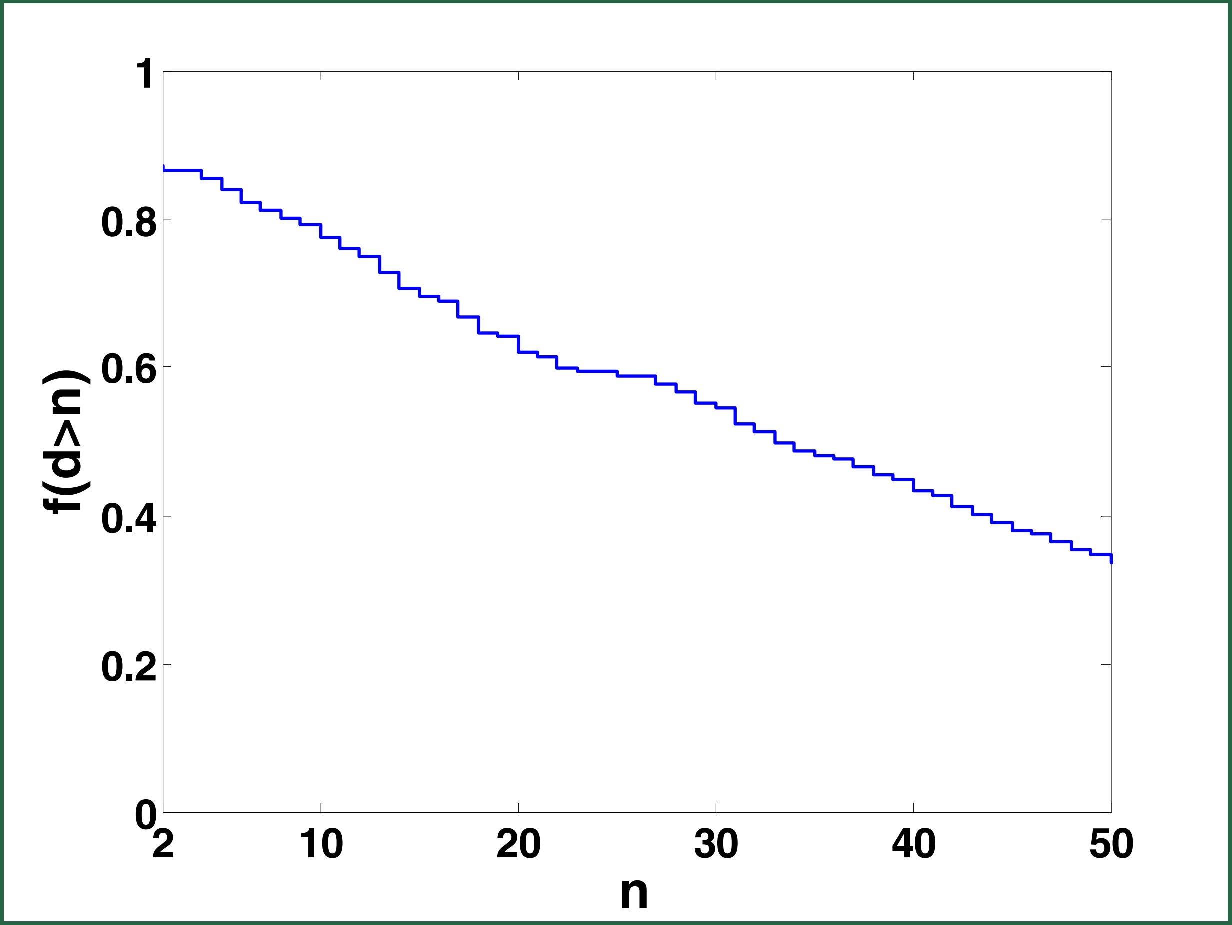


A sample of 751 BATSE long bursts with a good fluence data:



35%: d>2 ; 30%: d>4 ; 15%: d>10!

A sample of 187 BATSE *short* bursts with a good fluence data:



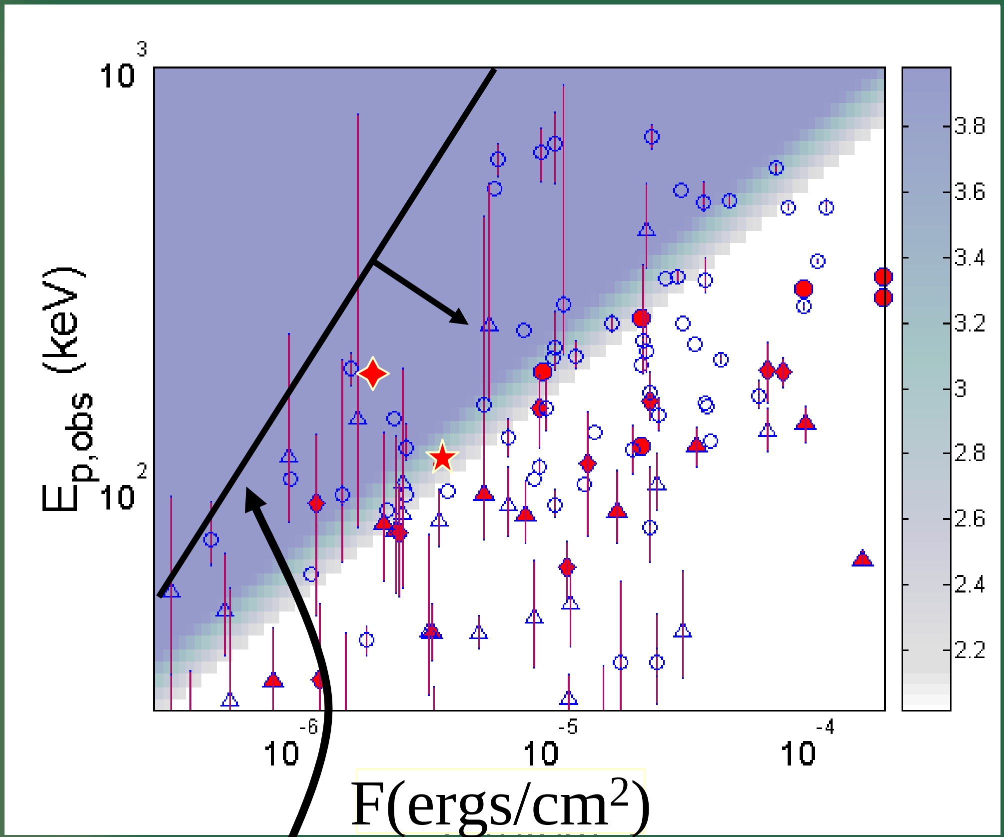
Short bursts do not follow the E_p-E_{iso} relation!

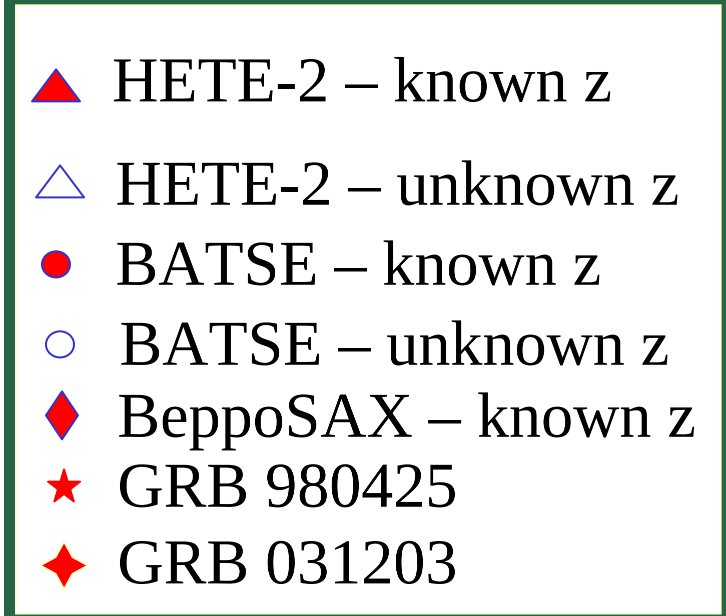
- **At least a quarter of the BATSE long bursts are outliers to E_p-E_{iso} relation.**

- **These outliers are hard and dim.**

- **The rest of the bursts may, *but not necessarily*, follow the E_p-E_{iso} relation.**

Why are there so few outliers in the sample of bursts with known redshift?





Sakamoto et al., 2003
Band et al., 1993
Jimenez et al., 2001
Amati et al., 2002

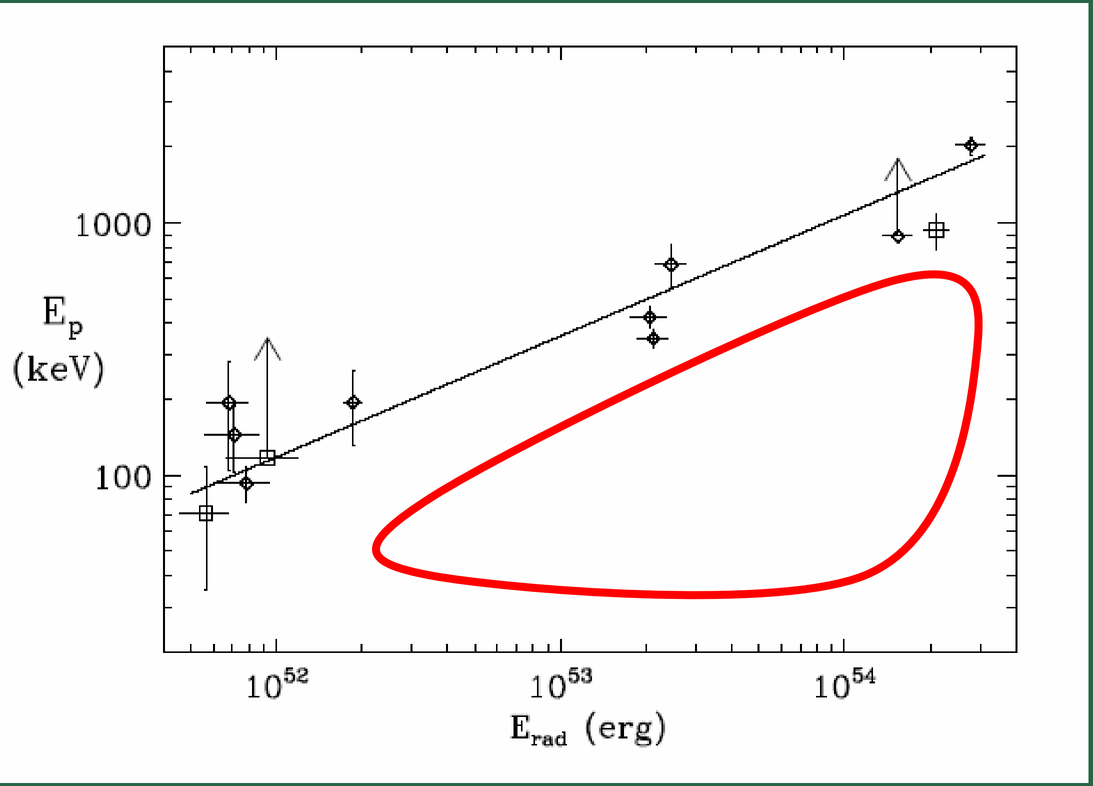
$$N \propto \frac{F}{E_{p,obs}} = const$$

•Dim not detected due to selection effects (Lloyd & Ramirez-Ruiz 2002).

•The Bursts form a single continues population.

•The threshold for detection+localization+afterglow+redshift is *significantly* larger than the threshold for detection alone.

Bright and soft bursts should be detected easily,



Therefore:

$$E_{iso} \leq 2\times10^{48}\left(\frac{E_p}{1keV}\right)^2 ergs$$

Conclusions

- At least 25% of the BATSE long bursts are outliers to E_p-E_{iso} relation.
- Dim and hard bursts are not detected due to selection effects.
- The threshold for detection alone is lower than the threshold for detection+localization+afterglow detection.
- Swift is expected to reduce the threshold for detection + localization + afterglow detection and therefore detect more outliers.
- The Ep-Eiso relation should be replaced by:

$$E_{iso} < A E_p^2$$

Thank you!