The E_p – E_{iso} relation: intrinsic GRB property or/and selection effects ?

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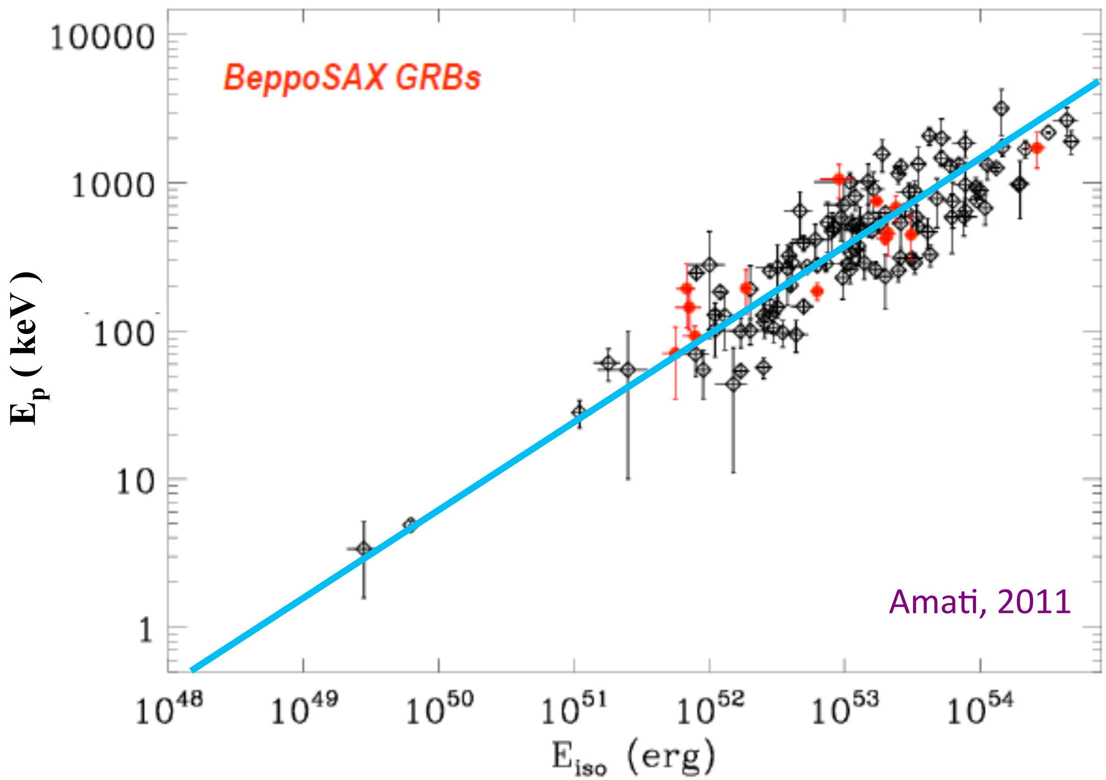
Observational evidences: starting with Amati et al (2002)

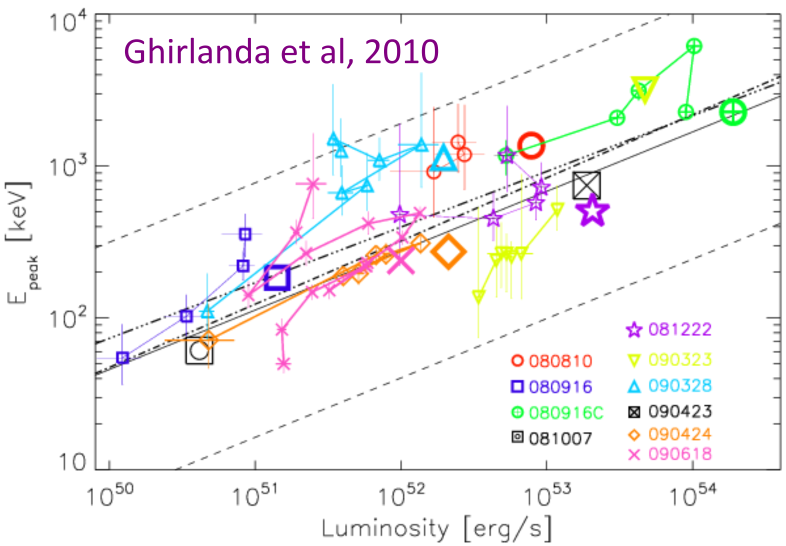
Now includes bursts from the pre-Swift, Swift and Fermi eras



slope = 0.55
σ = 0.23 dex

Similar Yonetoku ($E_p - L_{iso}$) relation (Yonetoku et al, 2004)

- includes short bursts
- time resolved $E_p(t) - L_{iso}(t)$ correlation within a given burst



If Amati/Yonetoku relations represent intrinsic GRB properties:

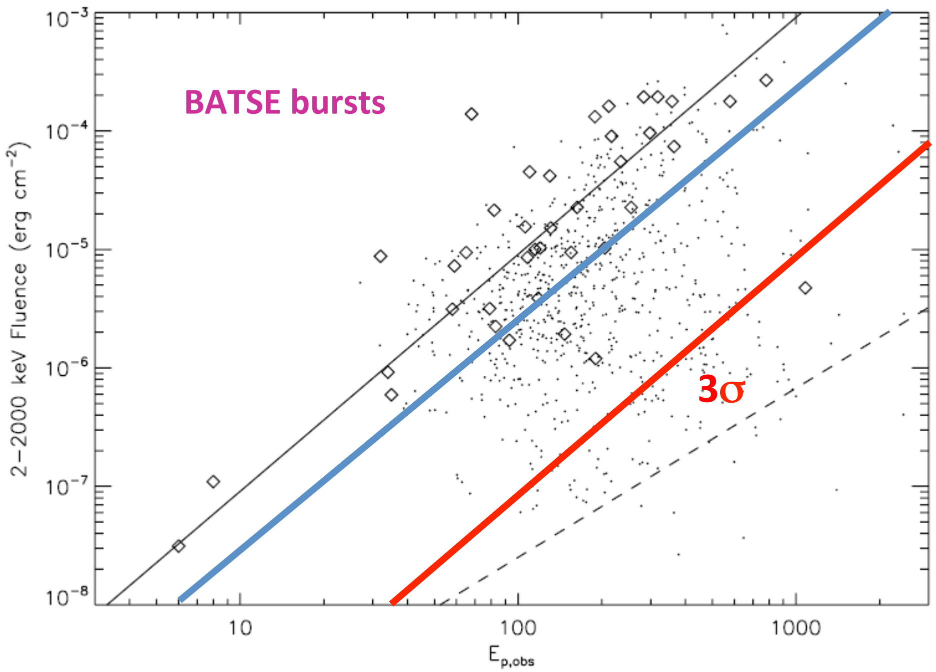
- clues for the prompt emission mechanism
- potential tools for cosmology

Critics: relations largely shaped by selection effects ?

If intrinsic:

- **slope, normalization** of the relations should not depend on detector
  some indications that it is not the case (Butler et al, 2010)

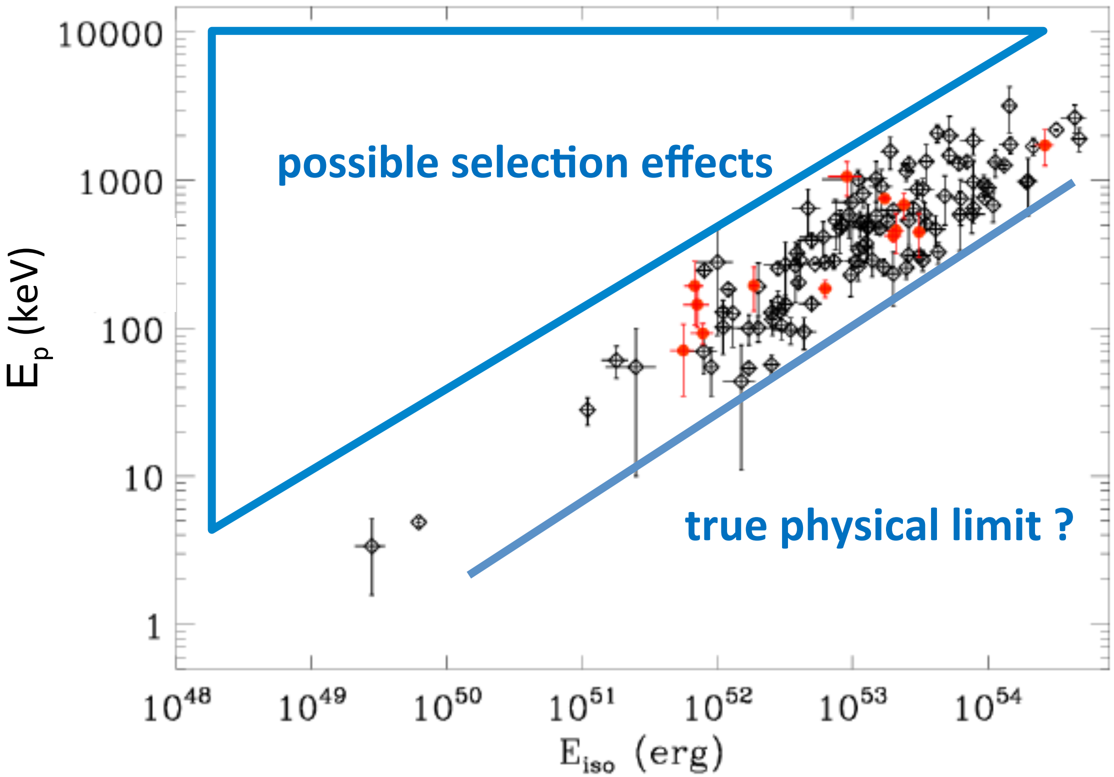
- constraints imposed in observational diagrams **(Fluence, Peak flux – $E_{p,obs}$)**



Nakar & Piran, 2005
Band & Preece, 2005
→ 88% outliers

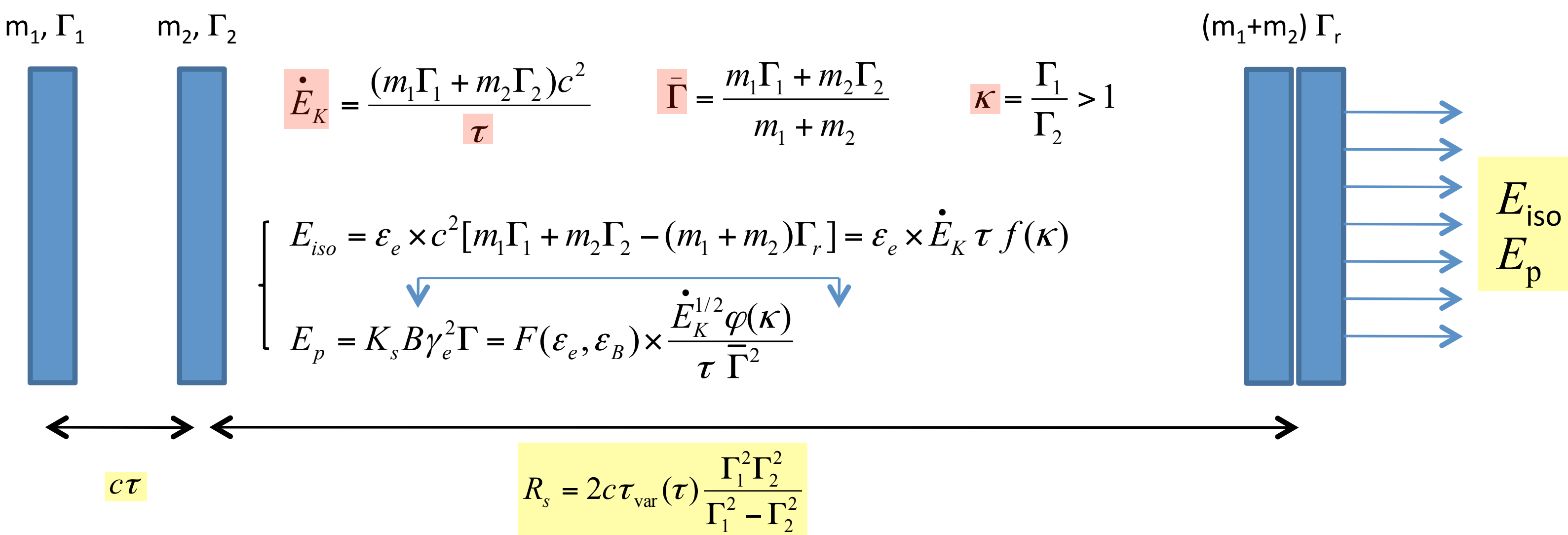
but Nava et al (2011)
→ 9% outliers

Where to expect selection effects in the $E_p - E_{iso}$ diagram ?



Internal shocks and the $E_p - E_{iso}$ relation

Monte-Carlo study with a 2 shell toy model (Barraud et al, 2003)



Ingredients

- $\dot{E}_K$: power law distribution ($s = -1.6$)
- τ : log-normal distribution $[\tau_{\rm var}(\tau)]$
- $\bar{\Gamma}$: uniform distribution from 100 to 300
- κ : uniform distribution from 2 to 6

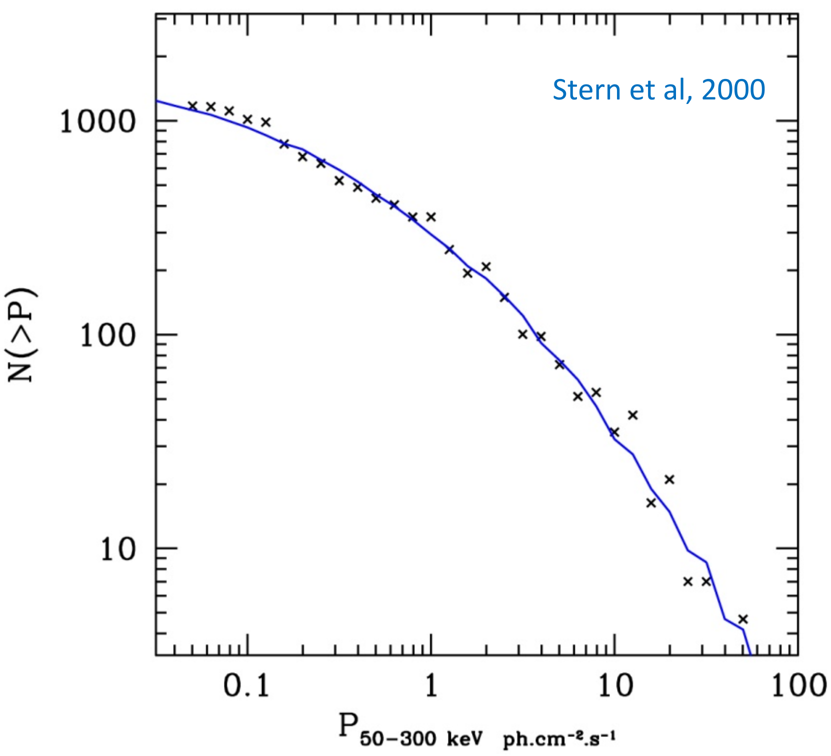
→ Outflow properties (no correlation)

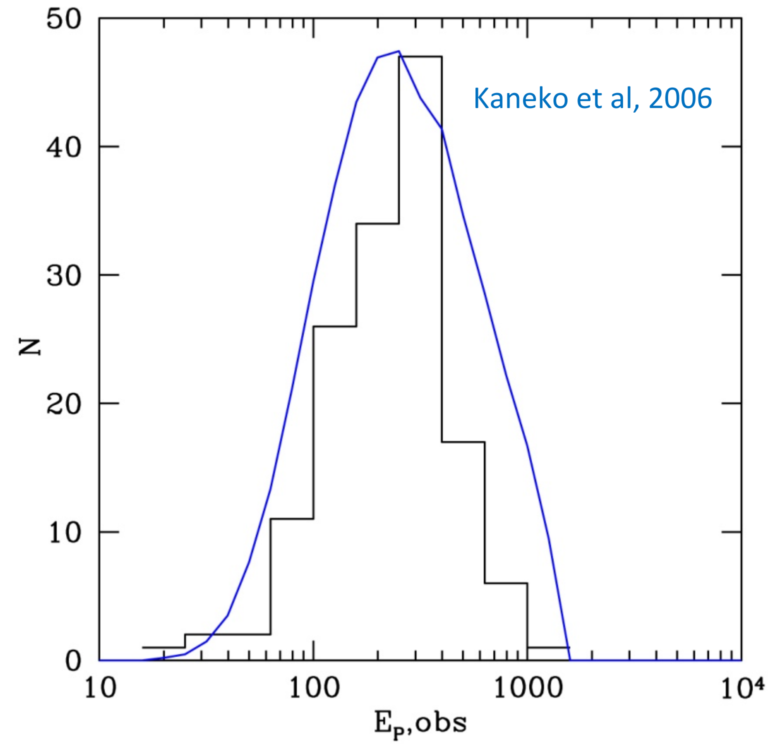
- $F(\varepsilon_e, \varepsilon_B)$: $1 \rightarrow 10$ → Radiative process, microphysics
- $R_{GRB}(z) = k(z) \times SFR(z)$ → Cosmology

Observational Constraints

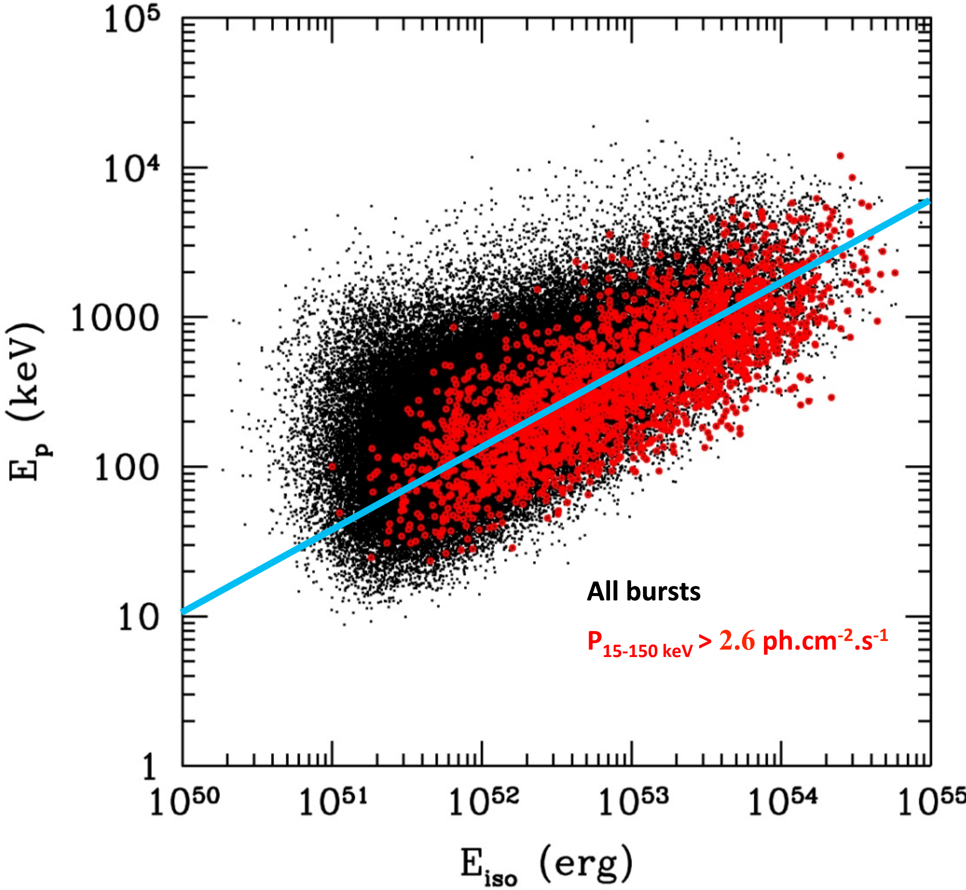
Log $N-$ Log P diagram

Observed distributions of E_p , t_{90} , z



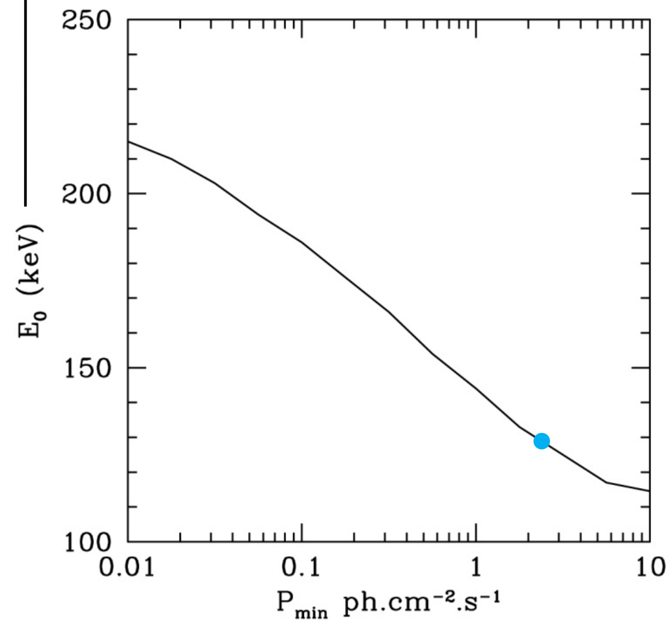


Results: E_p – E_{iso} relation

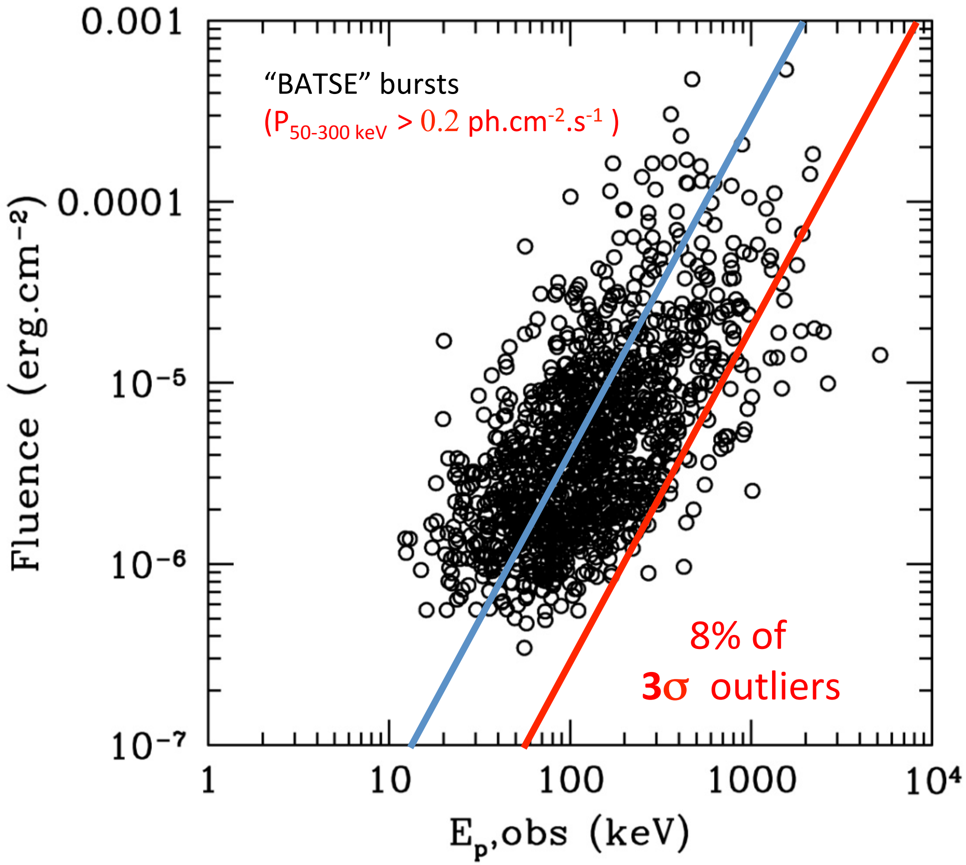


$$E_p = 129 \left(\frac{E_{\rm iso}}{10^{52}\ {\rm erg}} \right)^{0.55} \ {\rm keV}$$

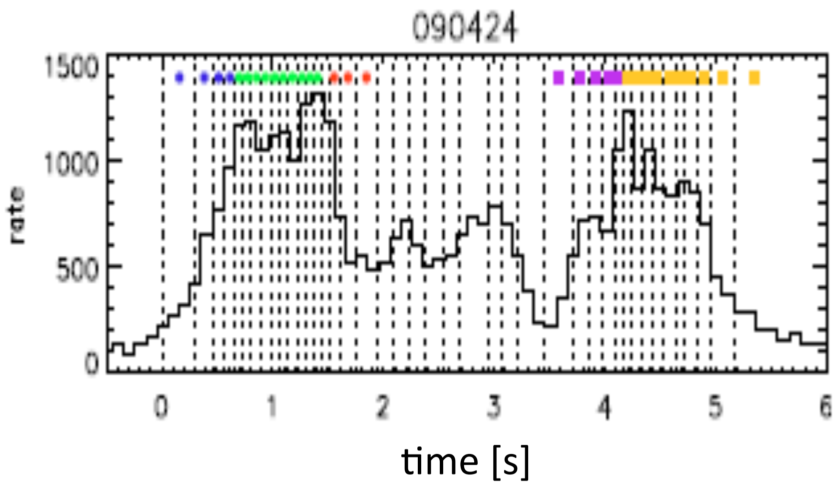
σ = 0.3 dex



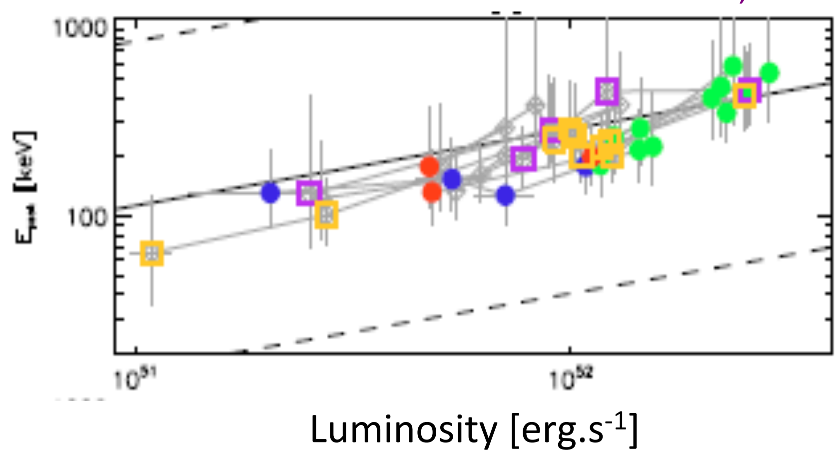
Results: $E_{p,obs}$ – Fluence diagram



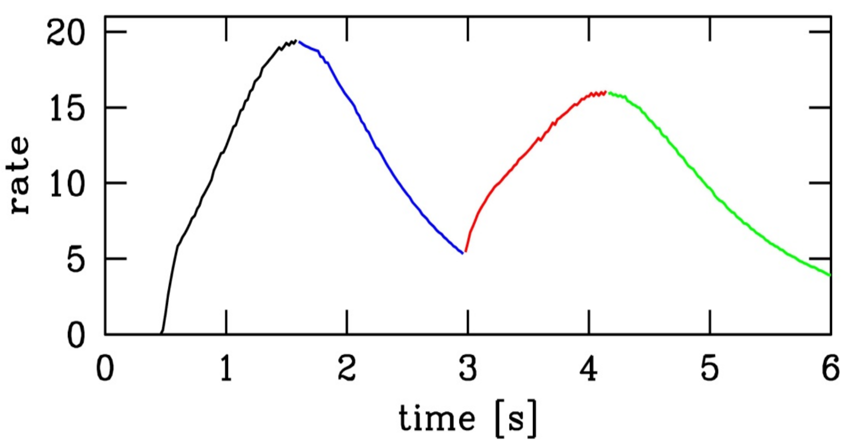
Results: time resolved $E_p(t) - L_{iso}(t)$ correlation

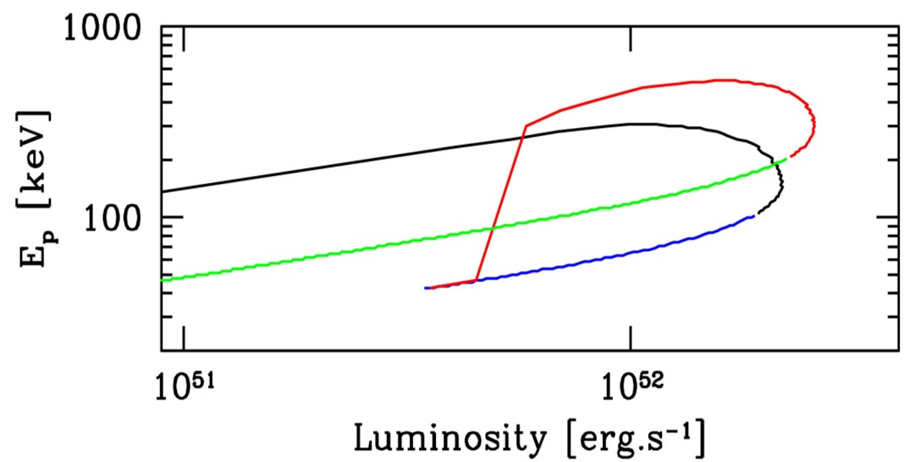


Ghirlanda et al, 2010



Multi-shell internal shock model





Conclusions

- The $E_p - E_{iso}$ relation in the context of the internal shock model

$$\rightarrow E_p = E_{iso}^{1/2} \times Q(\varepsilon_e, \varepsilon_B, \tau, \kappa, \bar{\Gamma})$$

- If the interval of variation of the model parameters is not too large
  $\rightarrow$ $E_p - E_{iso}$ and $E_{p,obs}$ – Fluence relations in agreement with observations
  from a combination of physical origin and selection effects

- The normalization of the $E_p - E_{iso}$ relation changes with detector sensitivity

- Time resolved $E_p(t)$– $L_{iso}(t)$ correlation in individual bursts: global agreement between model and observations but larger variations of E_p for a given L_{iso}

- Extension of the present work
  - refining the threshold condition
  - Yonetoku relation
  - correlation between flow parameters: $\dot{E}_K$, $\bar{\Gamma}$, ...