OUTFLOWS and LOWER BAT THRESHOLD

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- Subtraction of the underlying curve
- Cooling & Curvature
- Is the internal – external shock model cracking?
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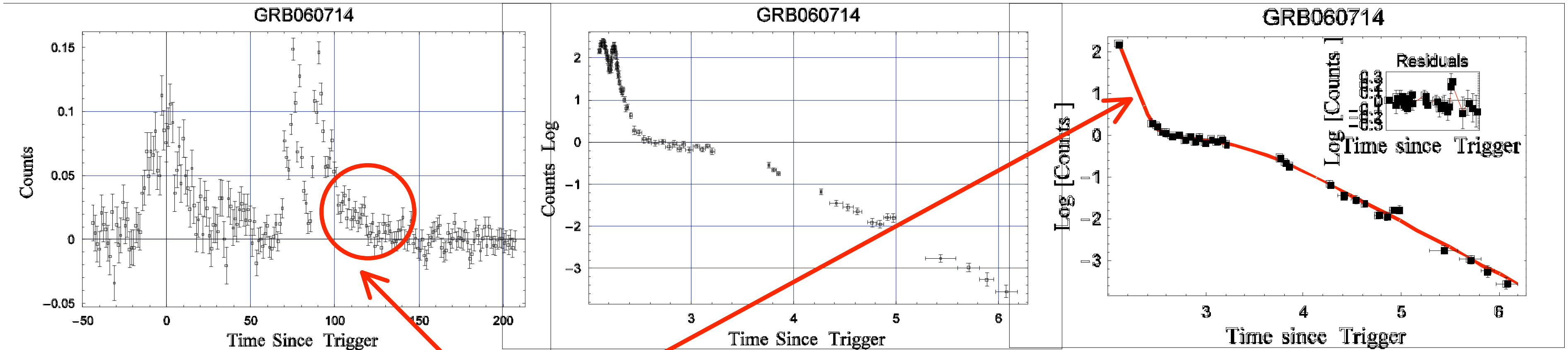
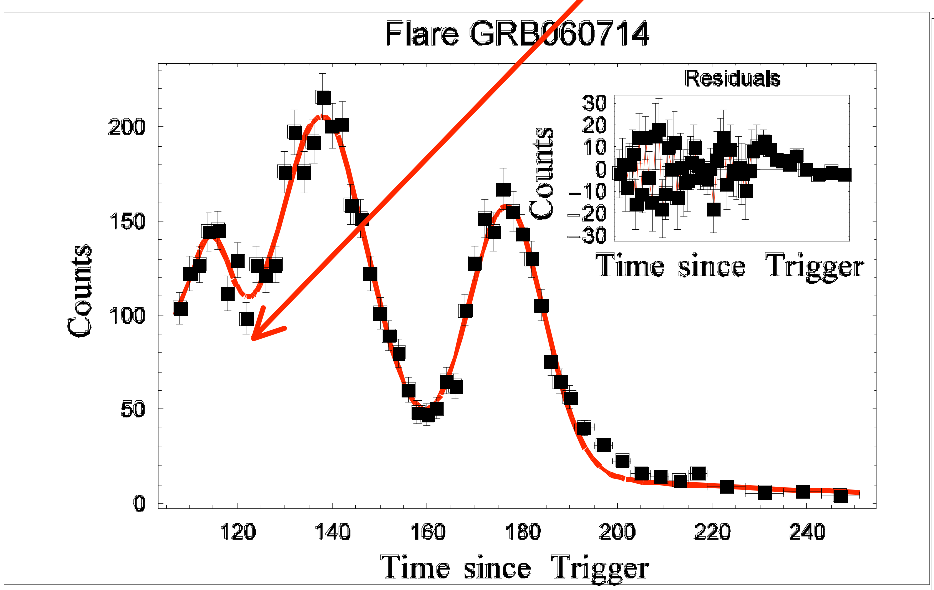
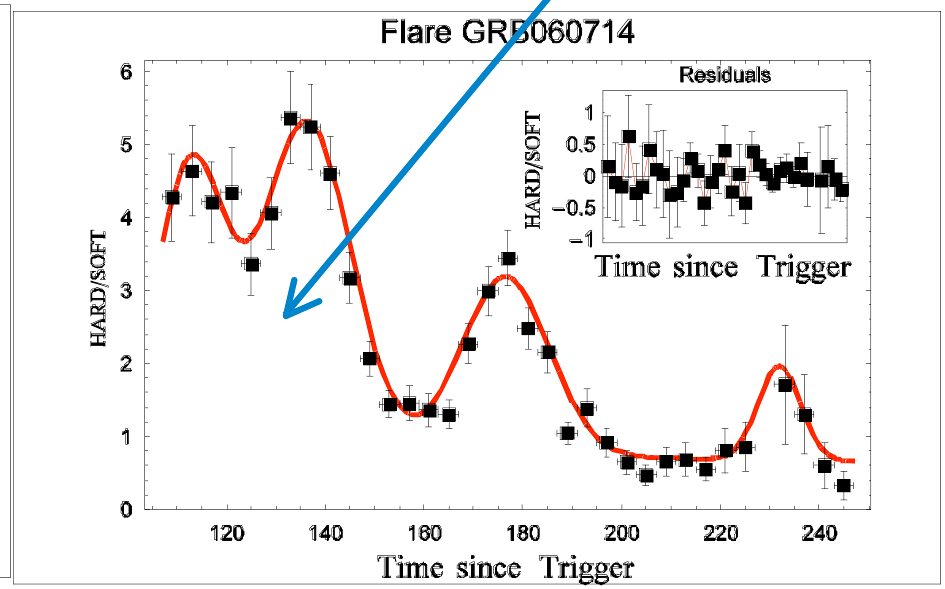
  - Kumar et al.
- Do we need to lower trigger in BAT ?
  - Fainter GRBs
  - High z GRBs

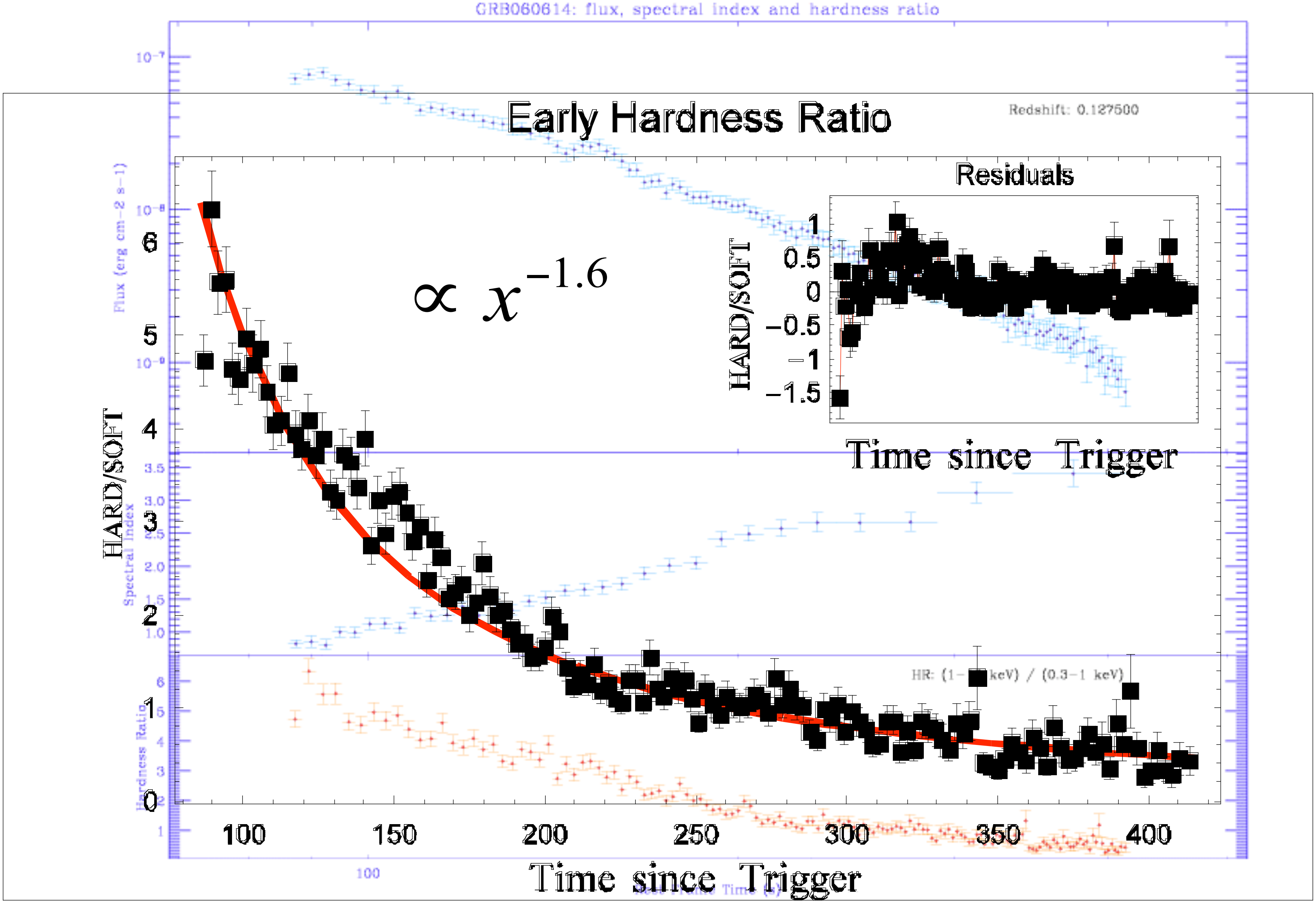


Similar slope BAT_XRT - m=-3. =>-5

Here slope under-laying cont 0.4






GRB060614: flux, spectral index and hardness ratio
Early Hardness Ratio
Redshift: 0.127500
$\propto x^{-1.6}$
Residuals
HARD/SOFT
Time since Trigger
HARD/SOFT
Time since Trigger
Flux (erg cm−2 s−1)
Spectral Index
Hardness Ratio
100
150
200
250
300
350
400

Syn. cooling & curvature

Sari et al.

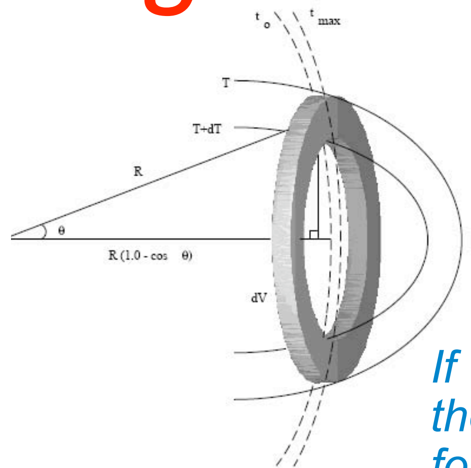
$$\tau_{\rm syn} = (1.4 \times 10^{-2}\ {\rm s})\epsilon_B^{-3/4}\left(\frac{h\nu_{\rm obs}}{100\ {\rm keV}}\right)^{-1/2} \times \left(\frac{t_{\rm dur}}{10\ {\rm s}}\right)^{3/4} l_{18}^{-3/4} n_1^{-3/4}\ .$$

This equation is quite robust.
It is valid for both the forward and reverse shock and it is independent of whether the reverse shock is relativistic or Newtonian

$$t_{\rm dur} = \left(\frac{l}{c}\right)\gamma^{-8/3}\xi^{-2} = (150\ {\rm s})\left(\frac{\gamma}{100}\right)^{-8/3}\xi^{-2} l_{18}$$

$$\xi \equiv \left(\frac{l}{\Delta}\right)^{1/2}\gamma^{-4/3}$$

Fennimore et al. Width = k $E^{-0.42}$



Kumar&Panaitescu
Dermer

$$\alpha = 2 + \beta$$

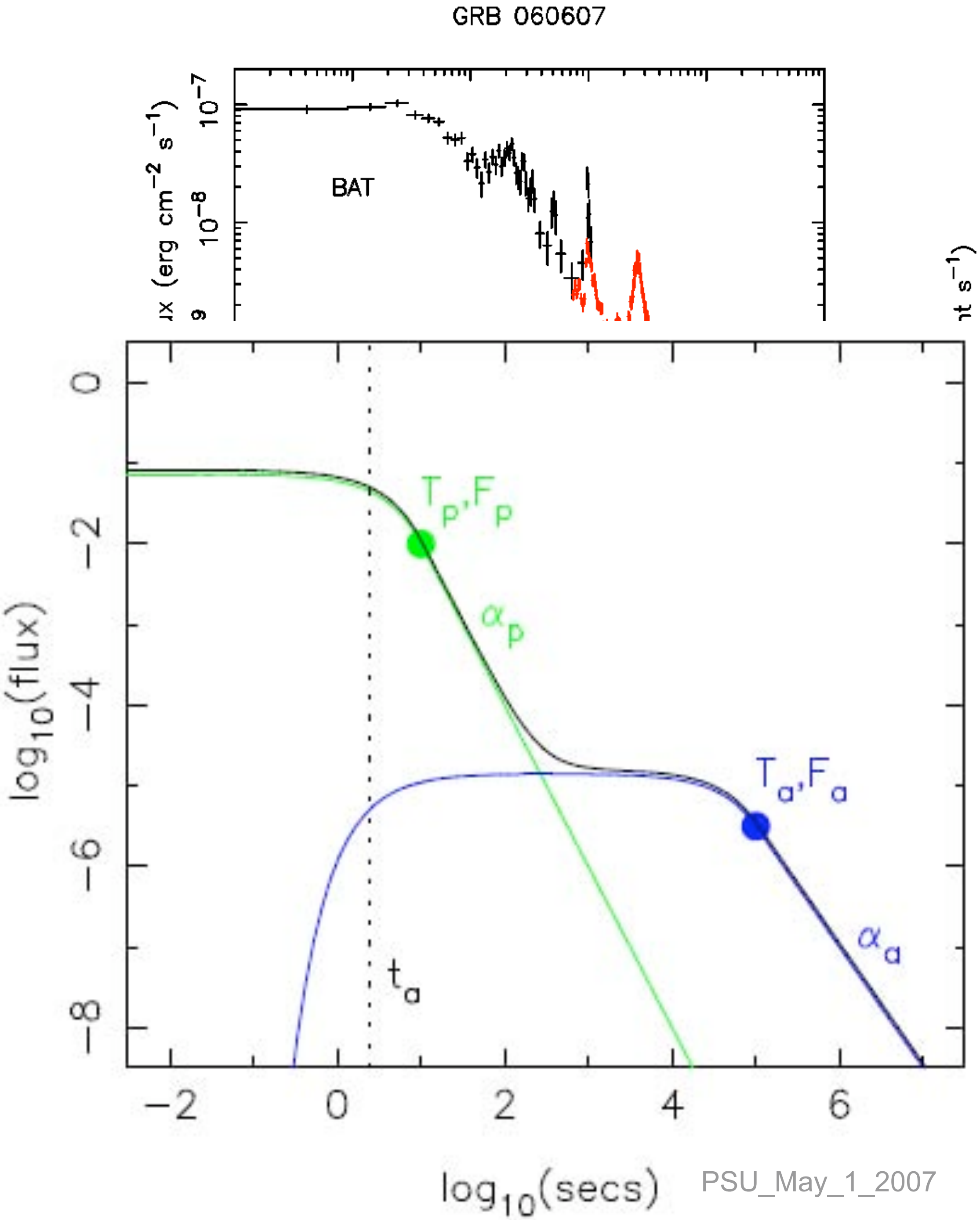
If we assume the main factor is the curvature effect we have the following [The Observer's – my -way, however see later more formal derivation by Lazzati & Perna]

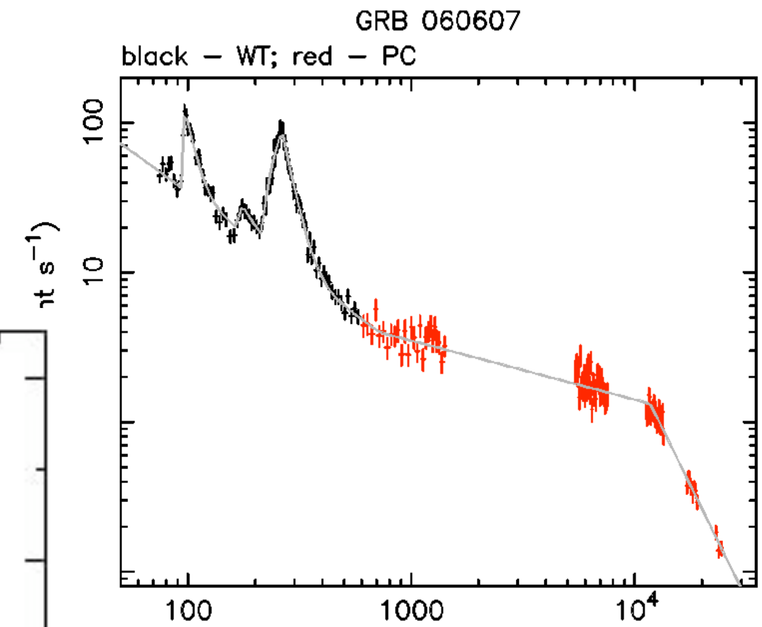
$$f_\nu \propto t^{-\alpha}\ with\ \alpha = 2 + \beta$$

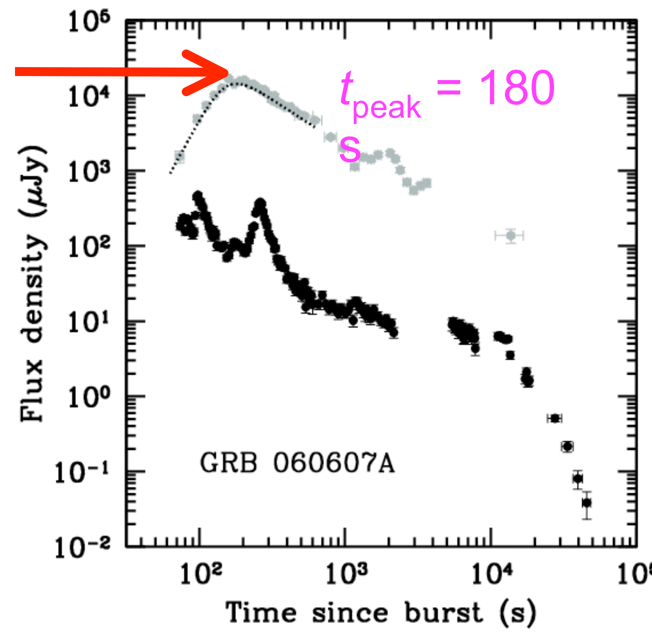
$$t \propto f^{-\frac{1}{\alpha}};\ \frac{t_{\frac{f_{peak}}{2}}}{t_{f_{peak}}} = \frac{\left(\frac{f}{2}\right)^{-\frac{1}{\alpha}}}{f^{-\frac{1}{\alpha}}} = \left(\frac{1}{2}\right)^{-\frac{1}{\alpha}}$$

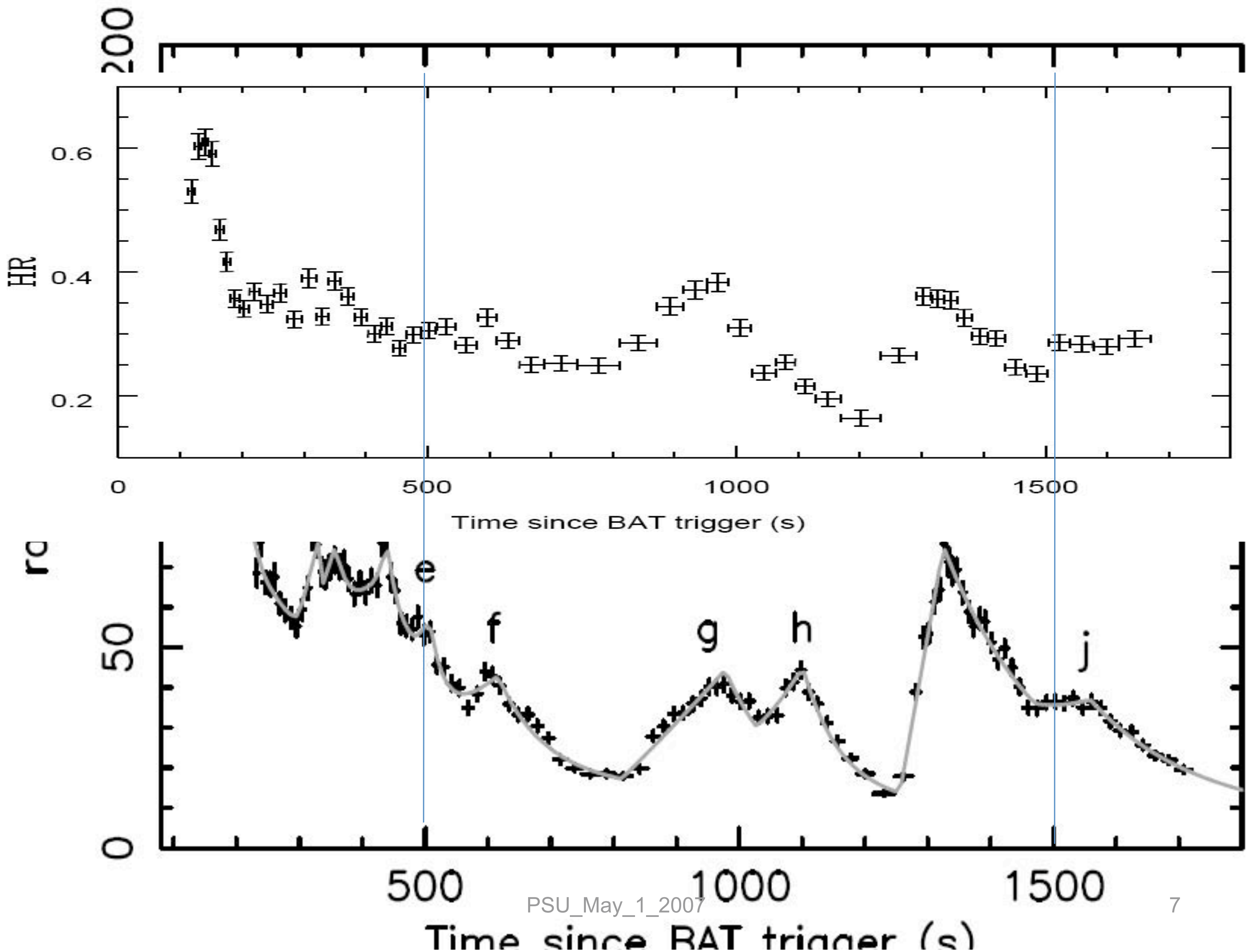
$$HPFW = t_{\frac{f_{peak}}{2}} - t_{f_{peak}} = \left(2^{\frac{1}{2+\beta}} - 1\right) t_{f_{peak}}$$

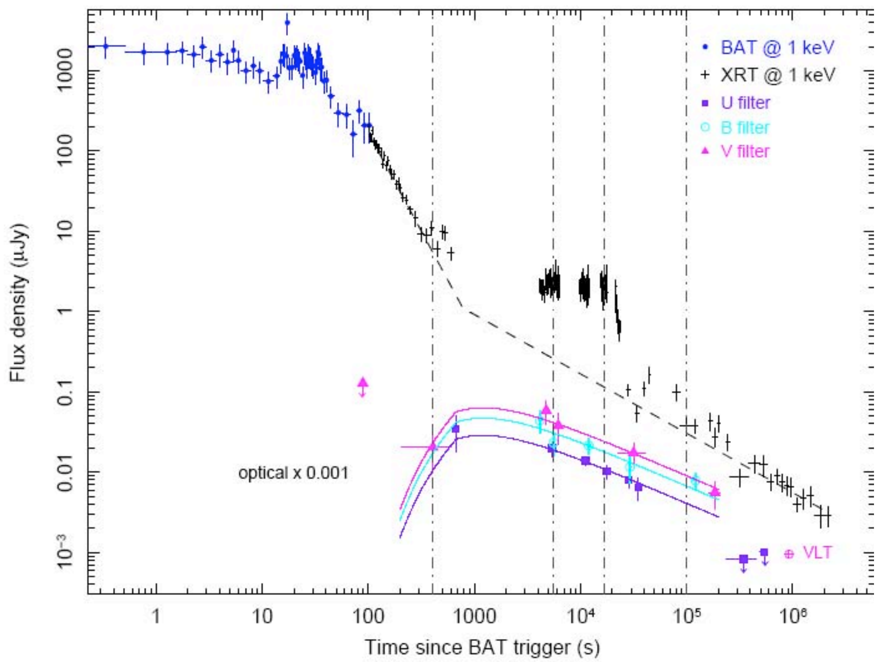
$$\frac{HPFW}{t_{f_{peak}}} = 0.29$$

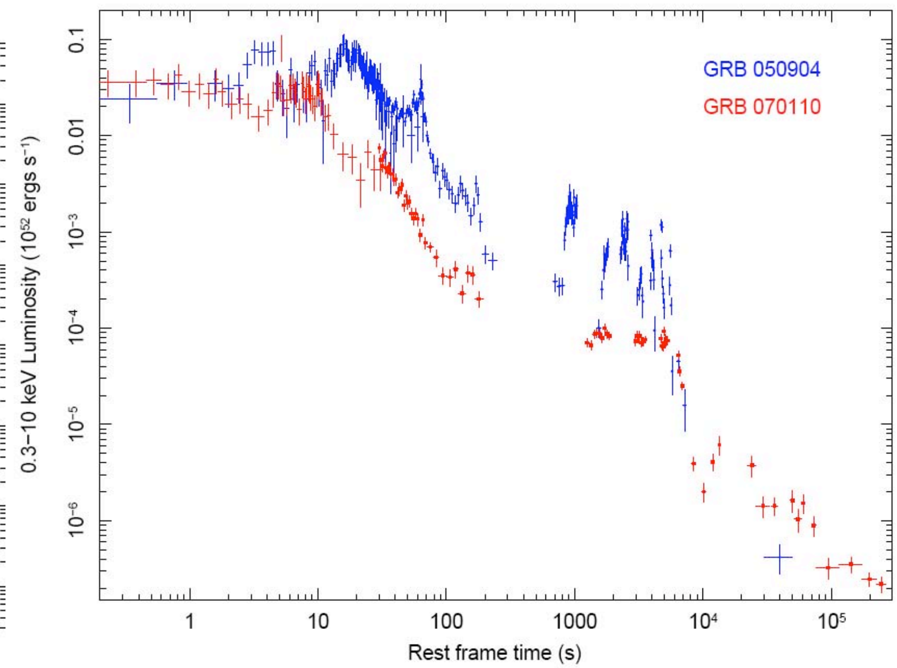

GRB 060607
BAT
10^{-7}
10^{-8}
T_p, F_p
α_p
T_a, F_a
α_a
t_a
$\log_{10}(\text{flux})$
$\log_{10}(\text{secs})$
0
−2
−4
−6
−8
2
4
6

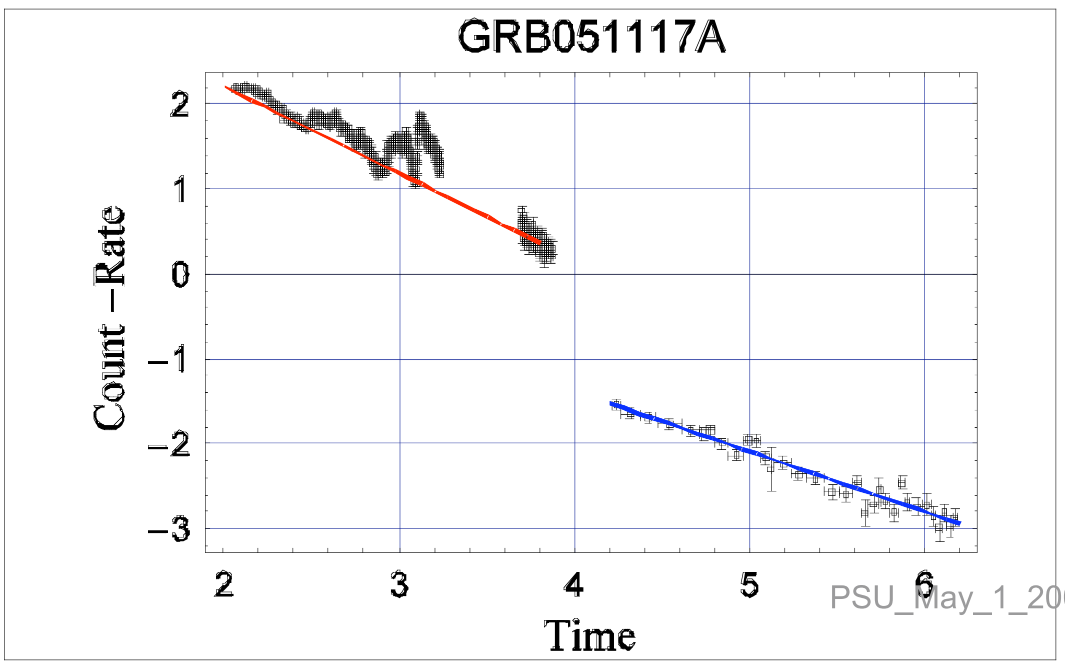

GRB 060607
black — WT; red — PC
100
10
1000
10^4


t_{peak} = 180 s
GRB 060607A
Flux density (μJy)
Time since burst (s)
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
10^4
10^5

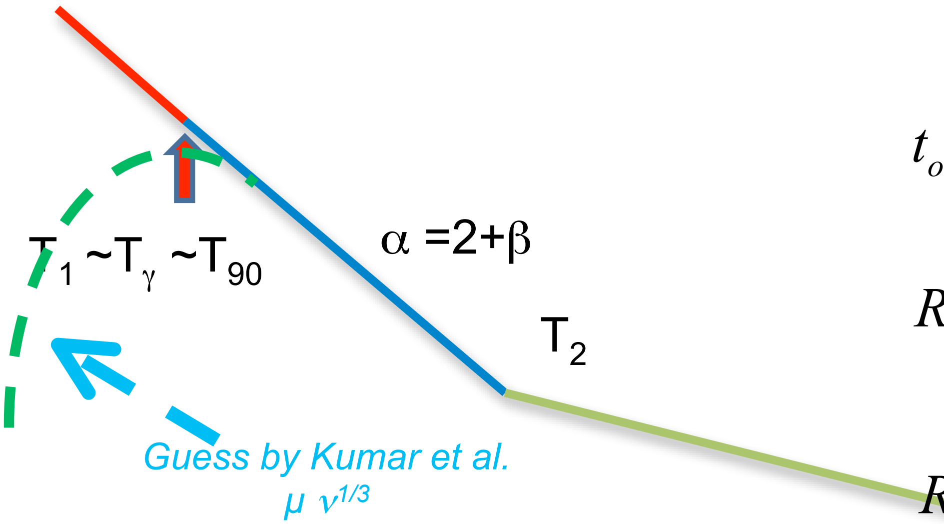

HR
0.6
0.4
0.2
0
500
1000
1500
Time since BAT trigger (s)
e
f
g
h
j
50
0
500
1000
1500
Time since BAT trigger (s)







- The steep decay no external shock ($\alpha \sim p$) & curvature.
- The steep decay may suggest internal origin.
- The plateau [but in this case it is not certain - flares] may be due to spinning down pulsar.
- However see Willingale et al.
- Troja et al. 2007



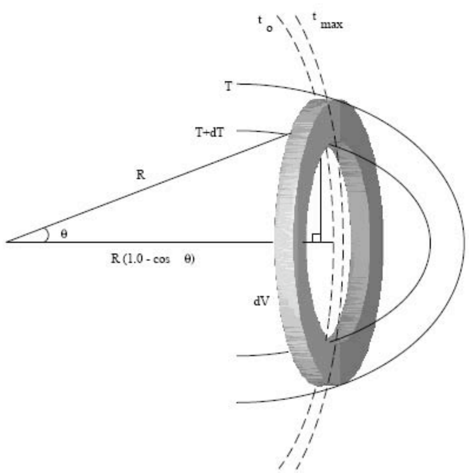
$$t_{obs} = (1+z)\frac{R_\gamma \theta^2}{2c} \qquad I_s \propto \left(1+\theta^2\Gamma_0^2\right)^3$$

$$R_\gamma = 2ct_1 \frac{\Gamma_0^2}{(1+z)} \qquad R_{FS}(t_2) = 2ct_2 \frac{\Gamma_{FS}^2(t_2)}{(1+z)}$$

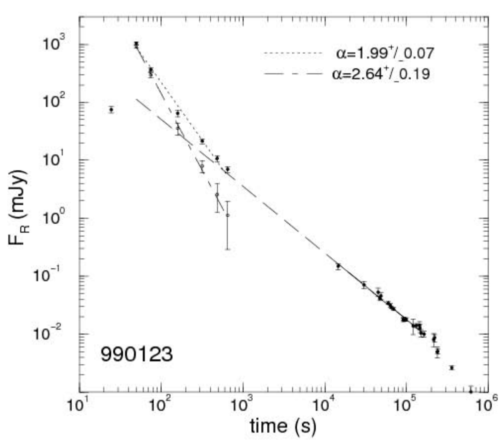
$$\frac{R_{FS}}{R_\gamma} < \frac{t_2}{t_\gamma} \qquad R_{FS} = \left[\frac{3ct_2 E_{iso}}{2\pi m_p c^2 (1+z) \quad n_0}\right]^{\frac{1}{4}}$$

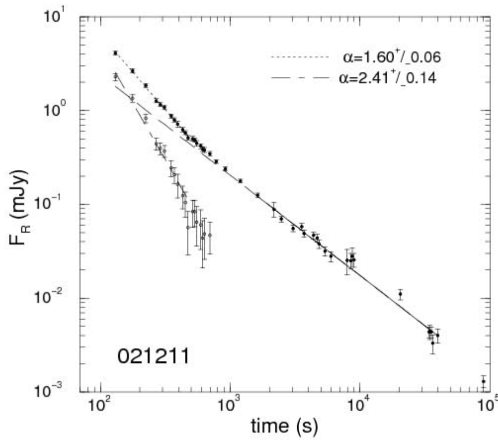
$$\Gamma = \left[\frac{3E_{iso}(1+z)^3}{32\pi c^3 t^3 m_p c^2 \ n_0}\right]^{\frac{1}{8}}$$

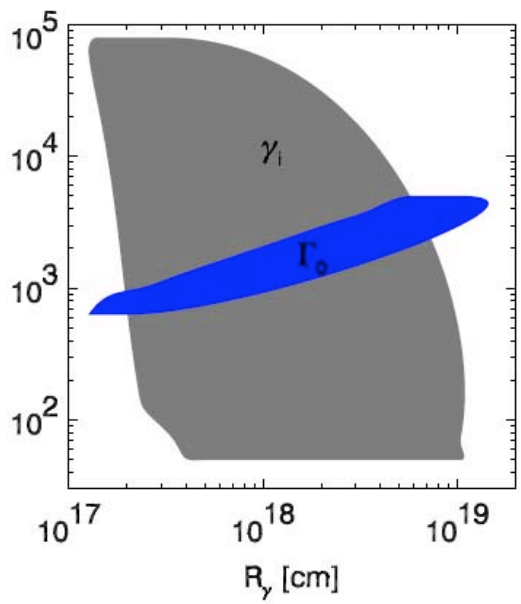
See Molinari et. al. 2007

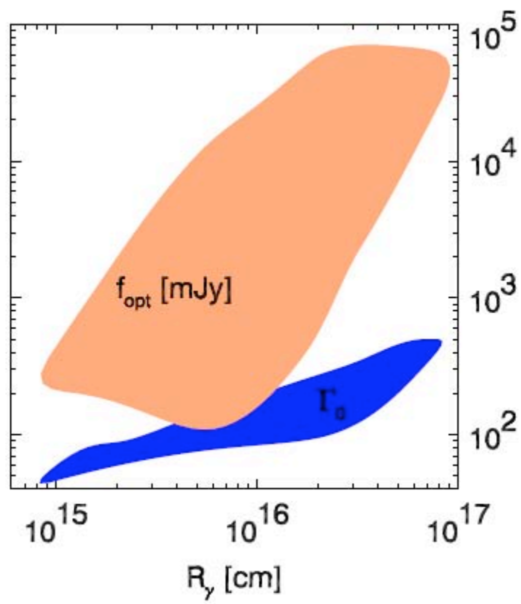


In practice and simple way all the models Accounted for by Kumar et al. are ruled out Because of the low optical emission observed



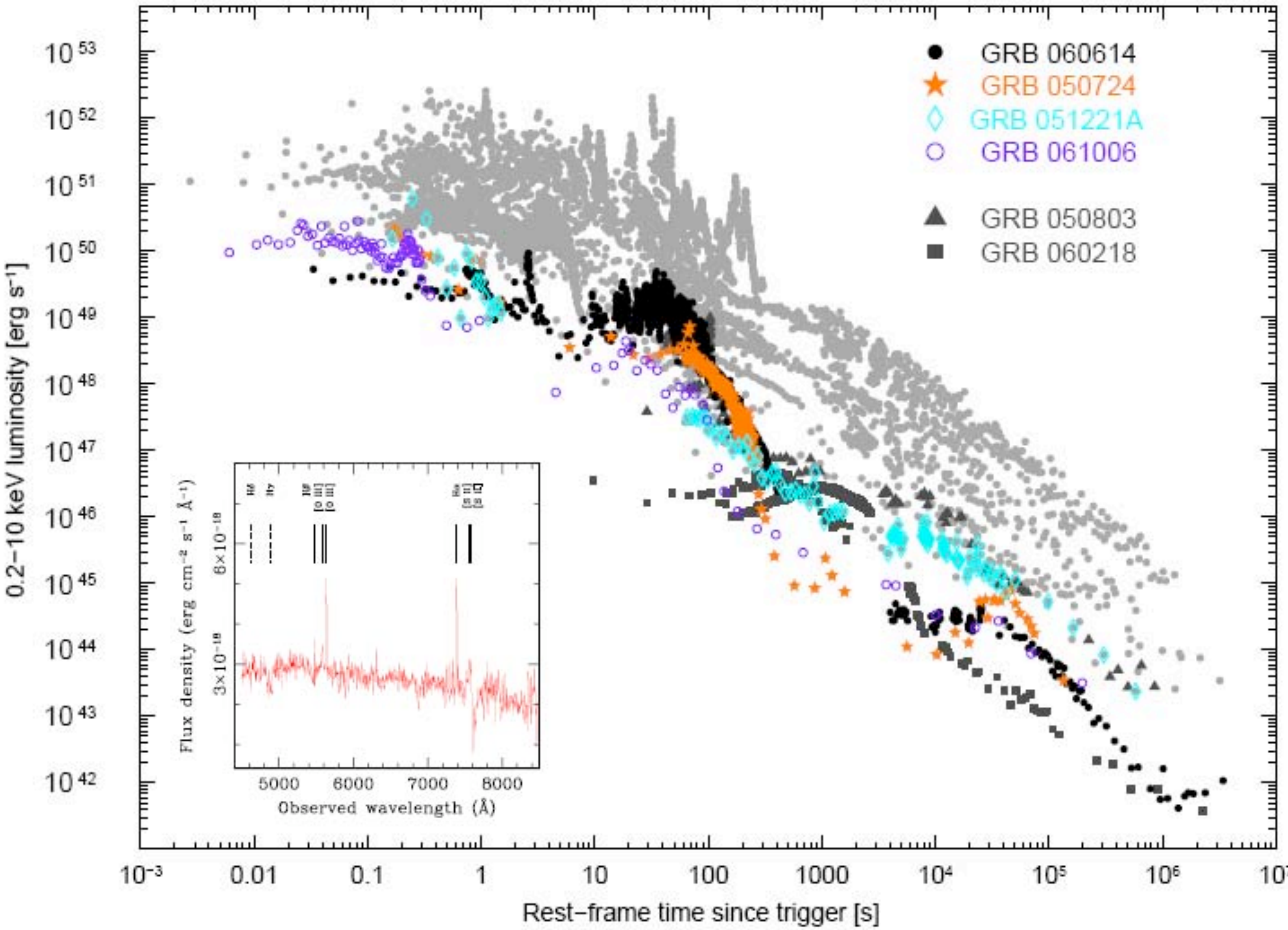


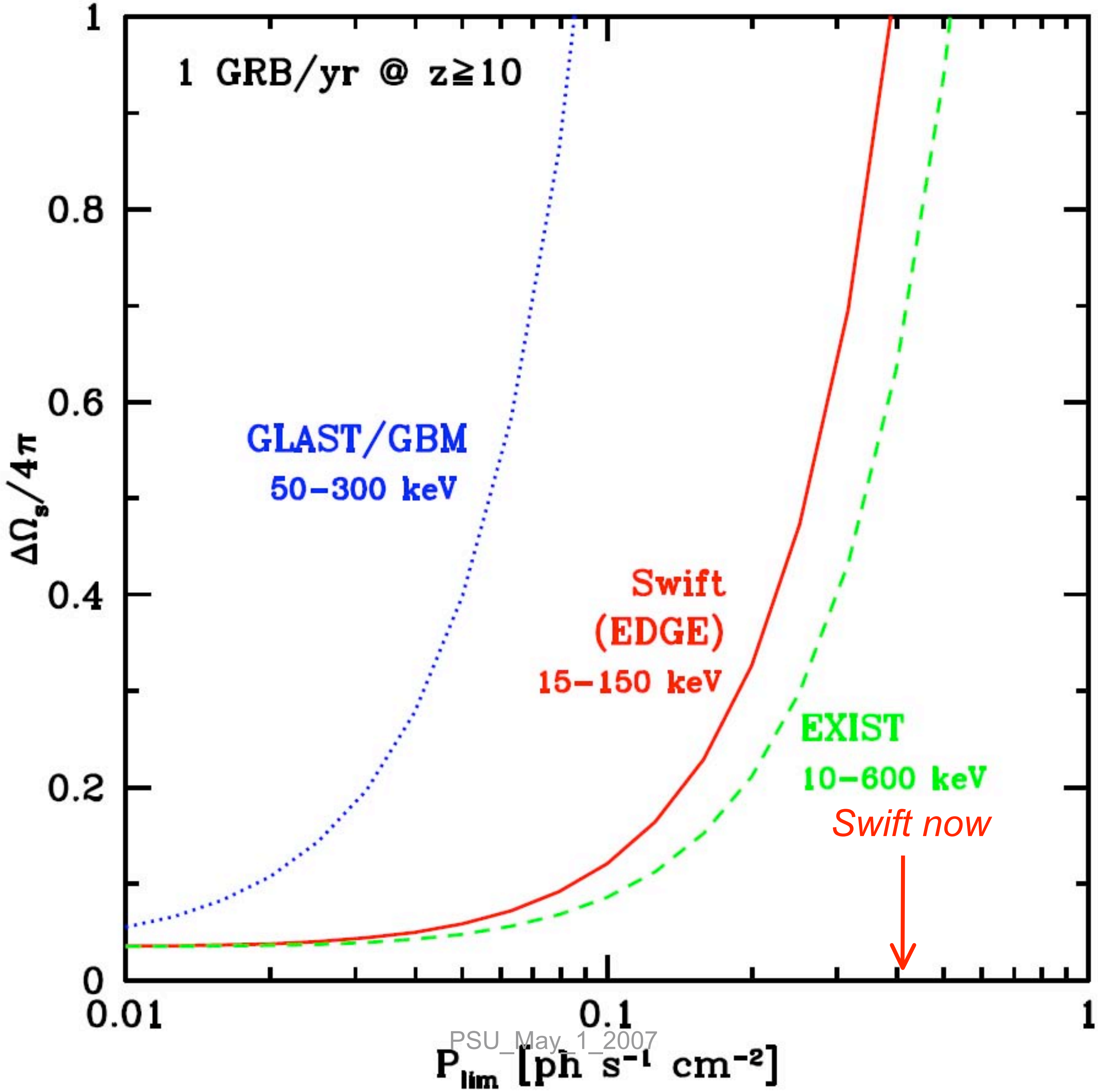




Kumar et al. 2007

1.The optical flux estimated from the X ray light curve & spectrum exceed the observed flux by two order of magnitudes. No forward shock model.
2.Lack evidence of reverse shock – Top left figure decay to steep (-2.5) to be due to reverse shock. Likely same mechanism as X-ray.
3.Rule out synchrotron emission in shock heated medium as prompt emission mechanism.
4.Lack evidence of baryonic matter.
5.Lyutikov & Blandford and however this mechanism has problems with prompt emission variability.


GRB 060614
GRB 050724
GRB 051221A
GRB 061006
GRB 050803
GRB 060218
0.2−10 keV luminosity [erg s⁻¹]
Rest−frame time since trigger [s]
Flux density (erg cm⁻² s⁻¹ Å⁻¹)
Observed wavelength (Å)


1 GRB/yr @ z≧10
GLAST/GBM
50-300 keV
Swift
(EDGE)
15-150 keV
EXIST
10-600 keV
Swift now
ΔΩs/4π
Plim [ph s-1 cm-2]
1
0.8
0.6
0.4
0.2
0
0.01
0.1
1

Assumptions and

- Metallicity about 0.1 solar.
- $\Delta\Omega_s$ Field of view of instrument – Band function spectrum at
- Example: $\frac{\Delta\Omega}{4\pi} = 0.5$ find the flux limit to see at least 1 GB/year at z > 10.
- GLAST $\frac{\Delta\Omega = 9}{4\pi} \approx 0.7$ limiting flux required 0.08 and however GLAST reach 0.7 in flight and 0.46 from the ground. NO HOPE.
- EXIST $\frac{\Delta\Omega = 5\ ster}{4\pi} \approx 0.4$ enough to have a sensitivity 0.3 and EXIST flux limit for-seen 0.16. EASY.
- For Swift going from threshold 0.4 to 0.1 we should have 3 – 4 times the GRBs detected at z > 6. GREAT.

How do we select the good cases?

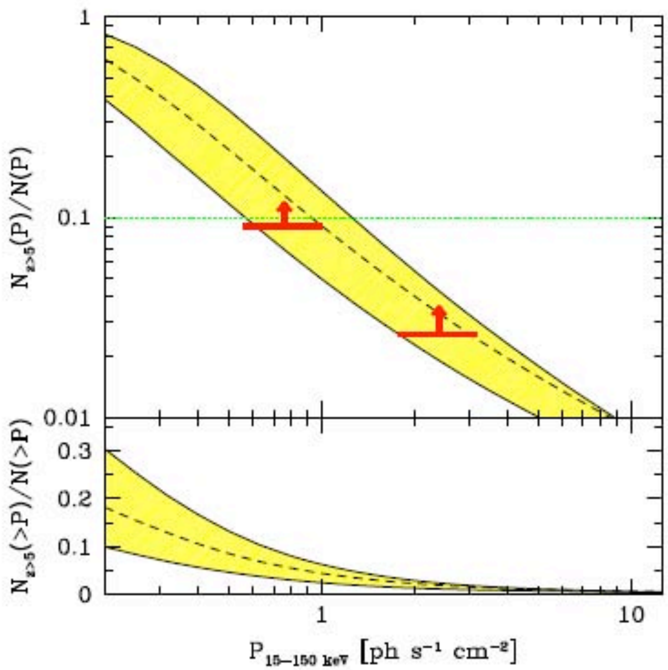


Figure 1. Top panel: probability of a GRB for photon flux P to be at $z \geq 5$ for $0.02\ Z_{\odot} \leq Z_{th} \leq 0.2\ Z_{\odot}$ (shaded area, lower bound refers to higher metallicity threshold). Dashed line refers to the reference model with $Z_{th} = 0.1\ Z_{\odot}$. Horizontal bars refers to lower limits derived from *Swift* $z \geq 5$ identifications. Dotted horizontal line marks the probability threshold of 10%. Bottom panel: fraction of $z \geq 5$ GRBs with photon flux larger than P.

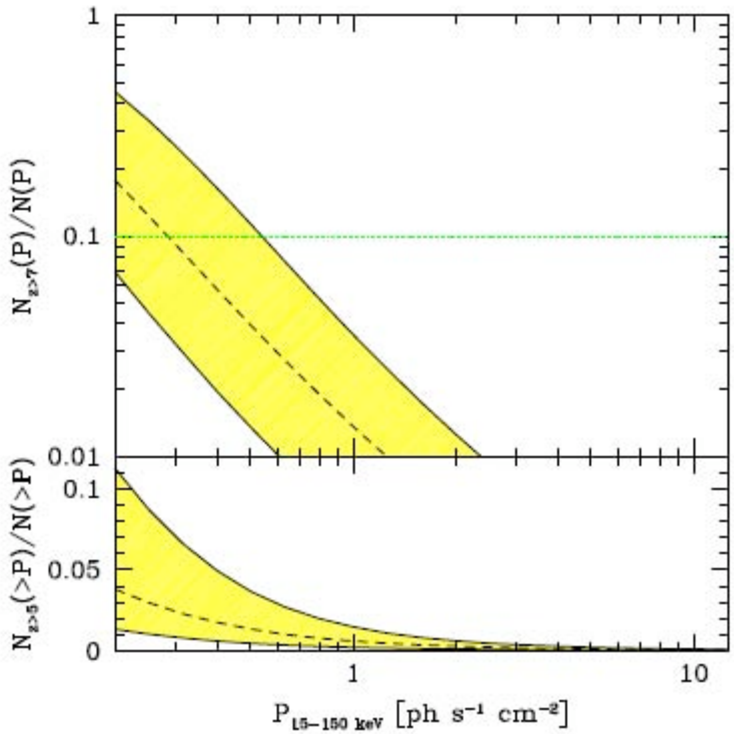


Figure 2. Top panel: probability of a GRB of photon flux P to be at $z \geq 7$. .Bottom panel: fraction of $z \geq 5$ GRBs with photon flux larger than P. Lines as in the previous figure.

We can detect them - Selection criteria

(Salvaterra et al 2007 – Submitted Ap.J.)

- T_{90} > 60s [cosmic time dilation]
- Galactic Extinction E_{B-V} < 0.1 (High Gal. Lat). Operative requirement.
- Lack of UVOT counterpart [UVOT blind at z > 5] based on first short [few tens of seconds] and white image 100s => V > 19 – 21. (see Campana et al. also).
- P < 1 ph s^{-1} cm^{-2} [New criterion]

Example

GRB	T_{90}	P	V	White	E_{B-V}	z	candidat
060904		> 1					Out
060814		> 1					Out
070306	210	4.2	> 20.5		0.03	low	Out
060402	64±5	0.3±0.1	> 20.4		0.05		primary
060510	276±10	0.6±0.1	> 21.2	> 21.9	0.04	4.9	primary
060522	69±5	0.6±0.2	> 20.1	19.7	0.05	5.11	primary
061028	106±5	0.7±0.2	> 20.6	> 18.9	0.16		secondar
070129	460±20	0.6±0.1	> 20.7	> 20.8	0.14		secondar
070223	9±2	0.7±0.1	> 18.9	> 21.4	0.02		secondar y

Conclusions

- The general behavior of the early light curve seems to be reasonably well understood and however we need to fine tune the decay model.
- May need alternative models
- We gain if we go to lower trigger threshold especially for the high z objects