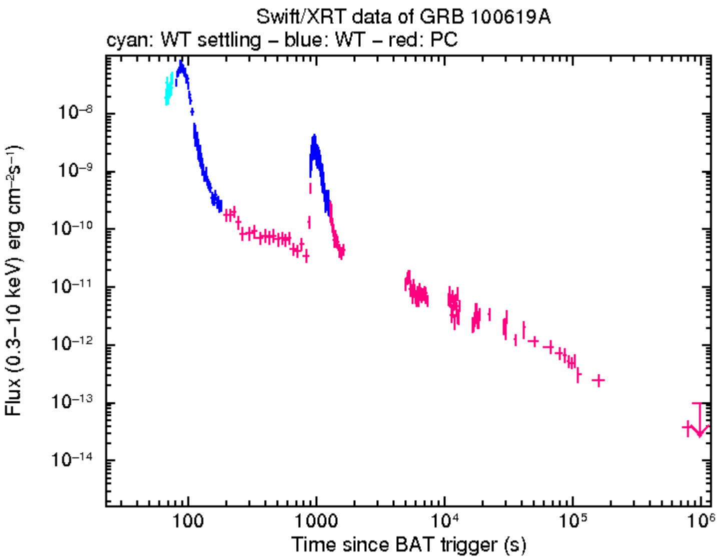
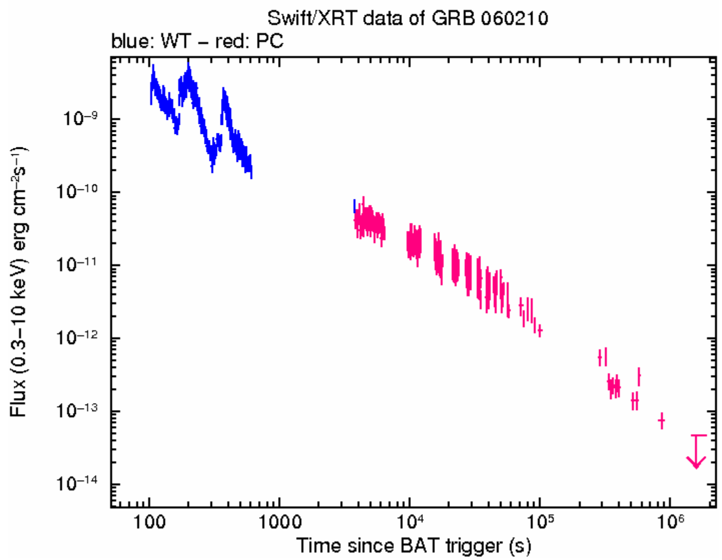
**Do flares in the early X-ray afterglow really imply a late activity of the central engine ?**

R. Mochkovitch, with A. Beloborodov, F. Daigne, R. Hascoët, Z.L. Uhm

Early afterglow Swift surprises: initial steep decay, plateau and **flares** …




**Basic properties of flares:**

- from 100 s to a few $10^5$ s, superimposed to underlying AG light curve
- shape and spectral evolution comparable to that of prompt pulses
- except that $\Delta t/t \sim 0.1 - 0.3 \longrightarrow$ late flares last longer

(Burrows, Falcone, Chincarini et al, 2007)

**Flares: what they are not**

- refreshed shocks (no increase in AG level after flare)
- clumps in the CSM (Nakar & Granot, 2007)

Most flares are incompatible with a FS origin

**Late activity of the central engine ?**

May be, but:

- some very late flares (even in short bursts)
- implies a very specific temporal behavior of the central engine

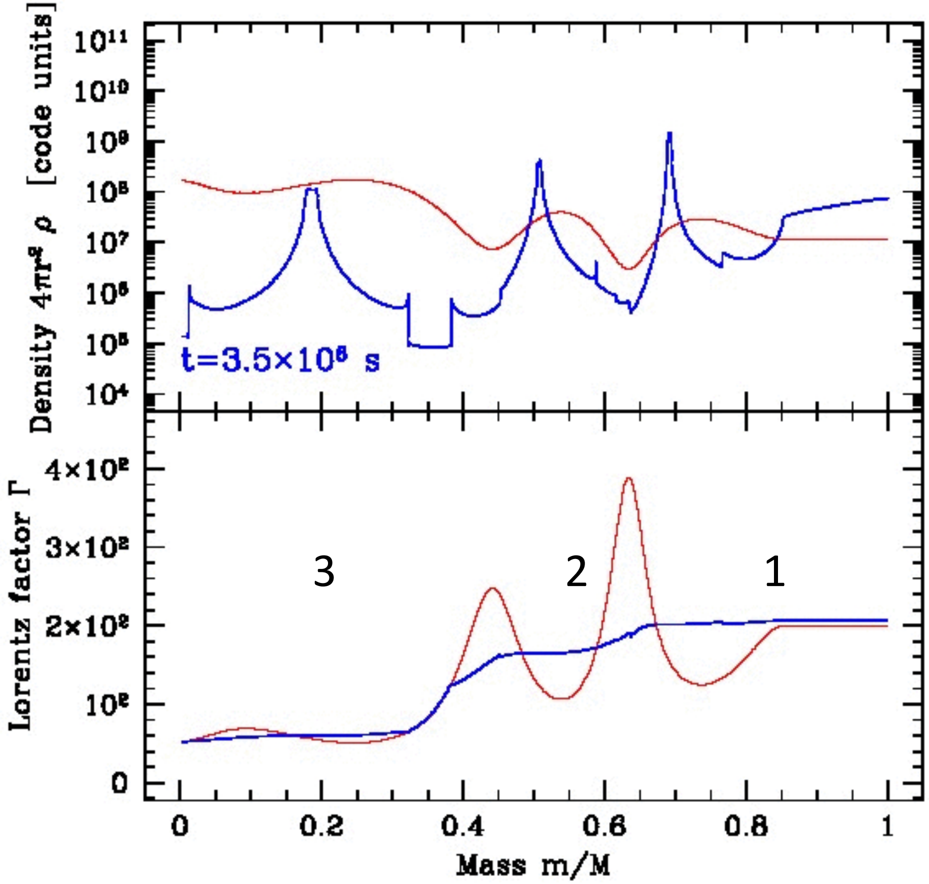
**An alternative to late activity:**

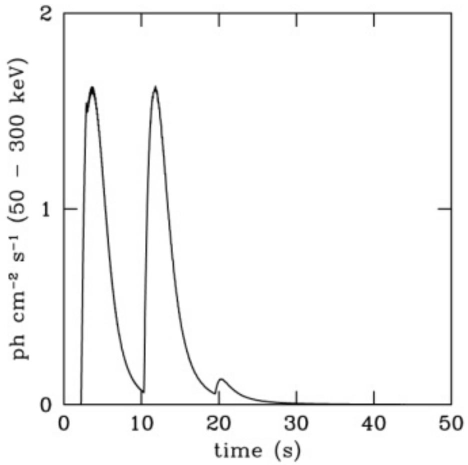
Flares from the sequence: IS + RS ?

Structuration of the ejecta by IS followed by « tomography » by the RS

What happens during the internal shock phase ?

$\Gamma$ is redistributed into the ejecta with slower material decelerating faster one until only a few dense shells remain with ordered $\Gamma$ values (decreasing from front to tail)




Shell 1: $\Gamma$ = 200 ; 40% of $E_{TOT}$

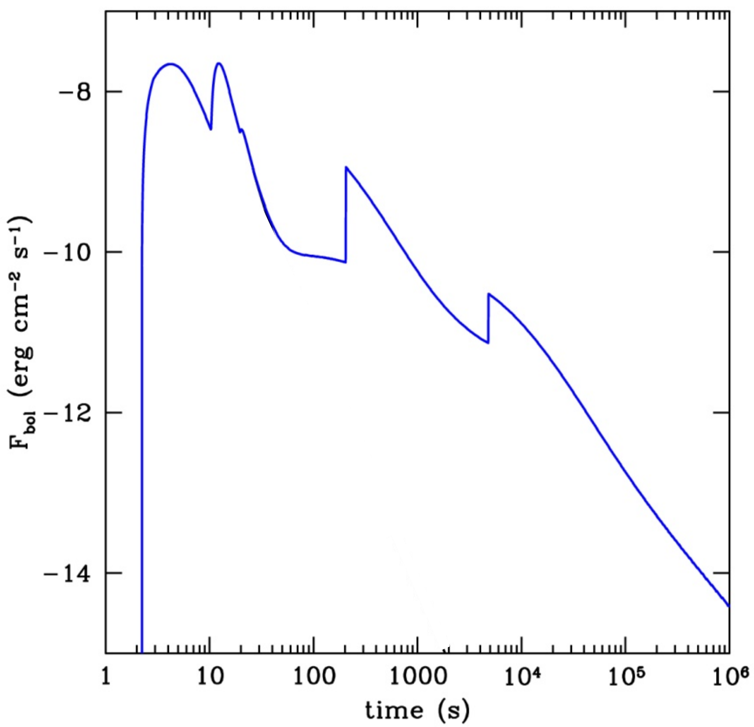
Shell 2: $\Gamma$ = 140 ; 30% of $E_{TOT}$

Shell 3: $\Gamma$ =  50 ; 15% of $E_{TOT}$

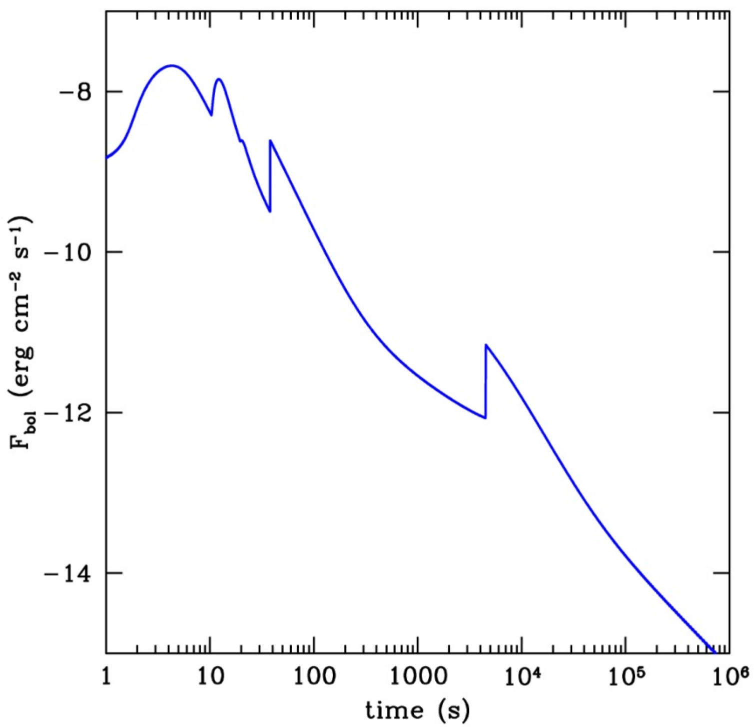
~ 15% unshocked

When this structured ejecta is decelerated by the surrounding medium
the RS produces "accidents" when $\Gamma$ has decreased to respectively 140 and 50

$n = 1\ cm^{-3}$




$A_* = 0.1$



The accidents in the light curve have:

$\Delta t/t$ ~ const (good)
but with const ~ 1 (bad)

If this defect can be corrected
→ the « accidents » become attractive candidates to make the flares

Then, is it possible to reduce $\Delta t/t$ from 1 to 0.1 – 0.3 ?

May be … if the radiation is anisotropic in the frame of the emitting shell

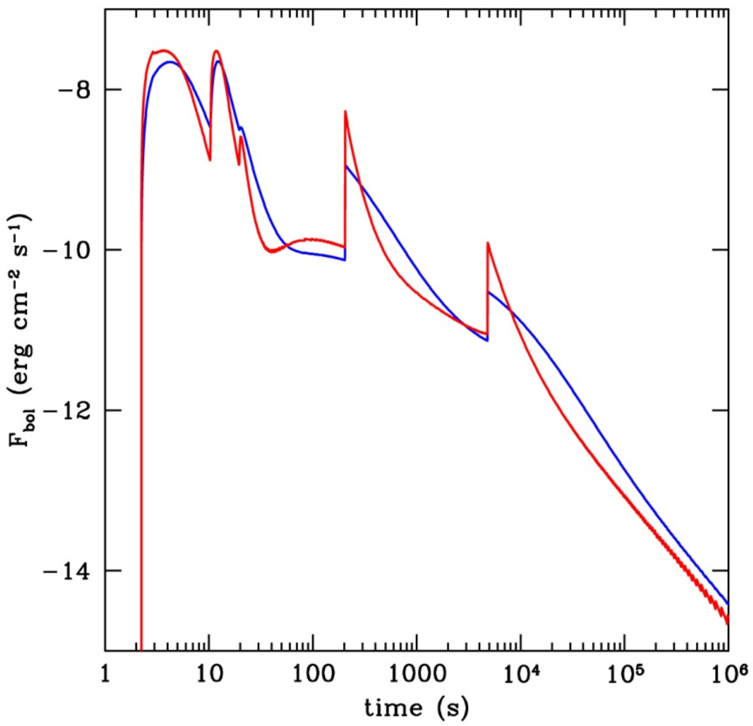
(Beloborodov, Daigne, Mochkovitch & Uhm, 2010)

| Shell rest frame | Observer frame | Decay (bolometric) |
|---|---|---|
| isotropic | $1/\Gamma$ | $t^{-3}$ |
| anisotropic | $1/k\Gamma$ (k>1) | $t^{-\alpha}$ ($\alpha > 3$) |

**Rise time looks OK but may be artificially steep (requires true hydro)**

Anisotropy sharpens the flares

$n = 1\ cm^{-3}$

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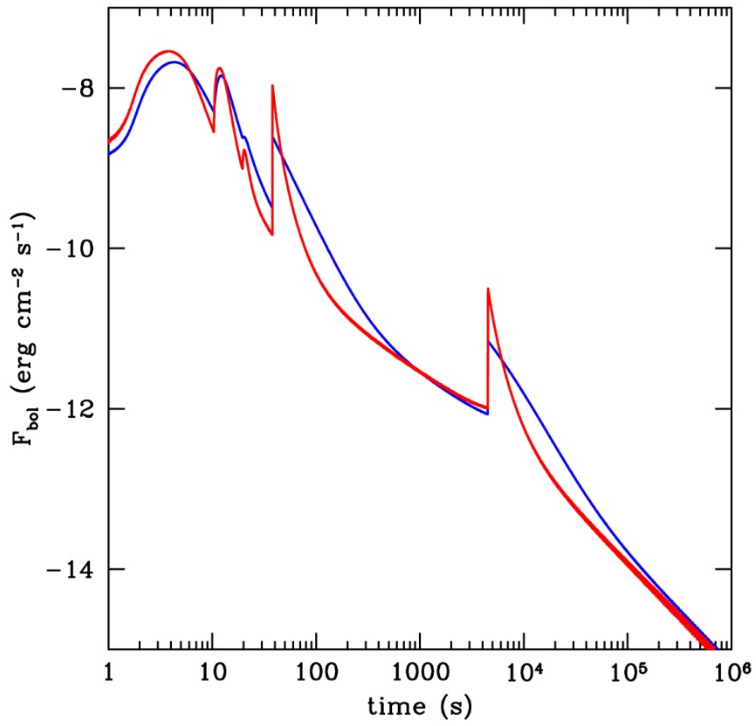
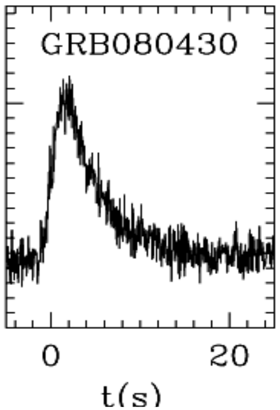
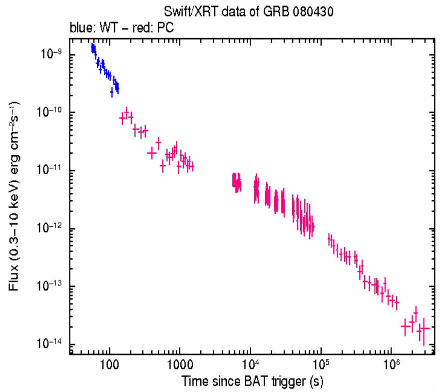


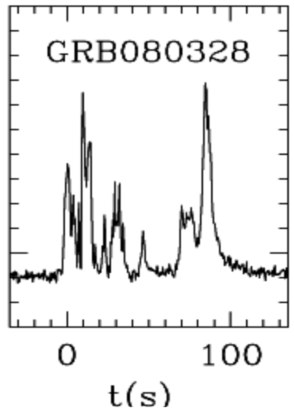
Should one expect a correlation between the prompt light curve and the flaring behavior ?

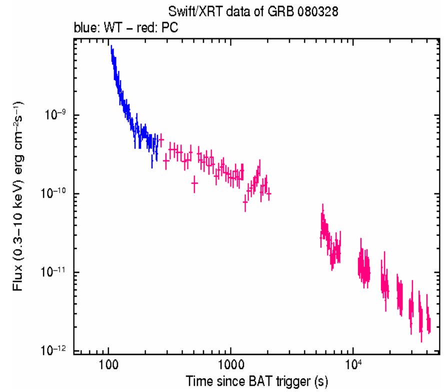
There are good cases

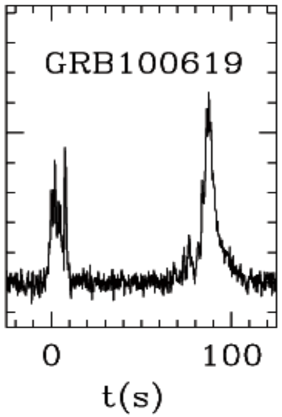
And some less good cases

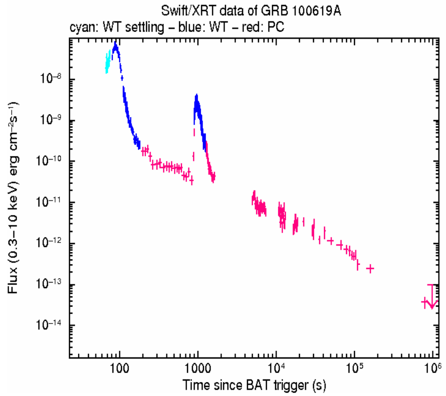


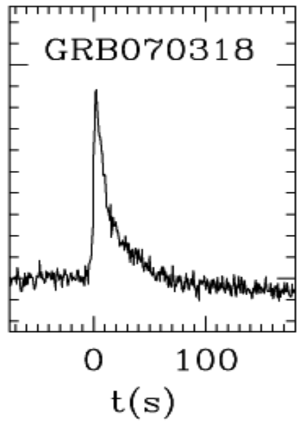



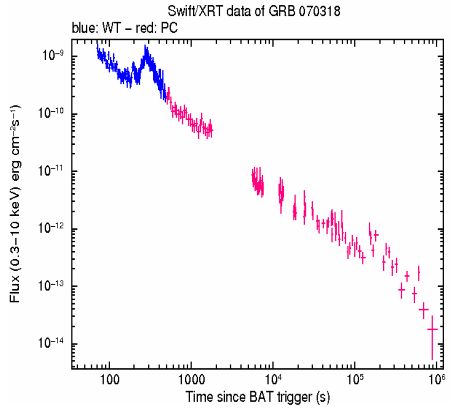




Complex bursts / afterglow with no flare → early flares mixed with prompt emission ?
flares in slow cooling regime?

Simple pulse (FRED) burst / afterglow with flares (less frequent) → « hidden » pulses ?

## Conclusions

Accidents in the early afterglow light curve are expected if internal shocks previously occurred in the ejecta

But basic model predicts $\Delta t/t \sim 1$

$\longrightarrow$ exploring some ways to decrease this to 0.1 – 0.3

- anisotropy (decay)
- full hydro (rise)

Possible test of the proposal by comparing BAT and XRT light curves