Fermi Gamma-ray Space Telescope

The correlated variation of the GRB intensity and the spectral shape

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Correlations between spectral parameters during the prompt phase: 9 years of GBM observations

Clue for the physics of the emission mechanism

- Time-resolved spectral analysis
- Individual pulses with > 5 high SNR bins
- Bayesian analysis

Correlations between spectral parameters during the prompt phase: 9 years of GBM observations

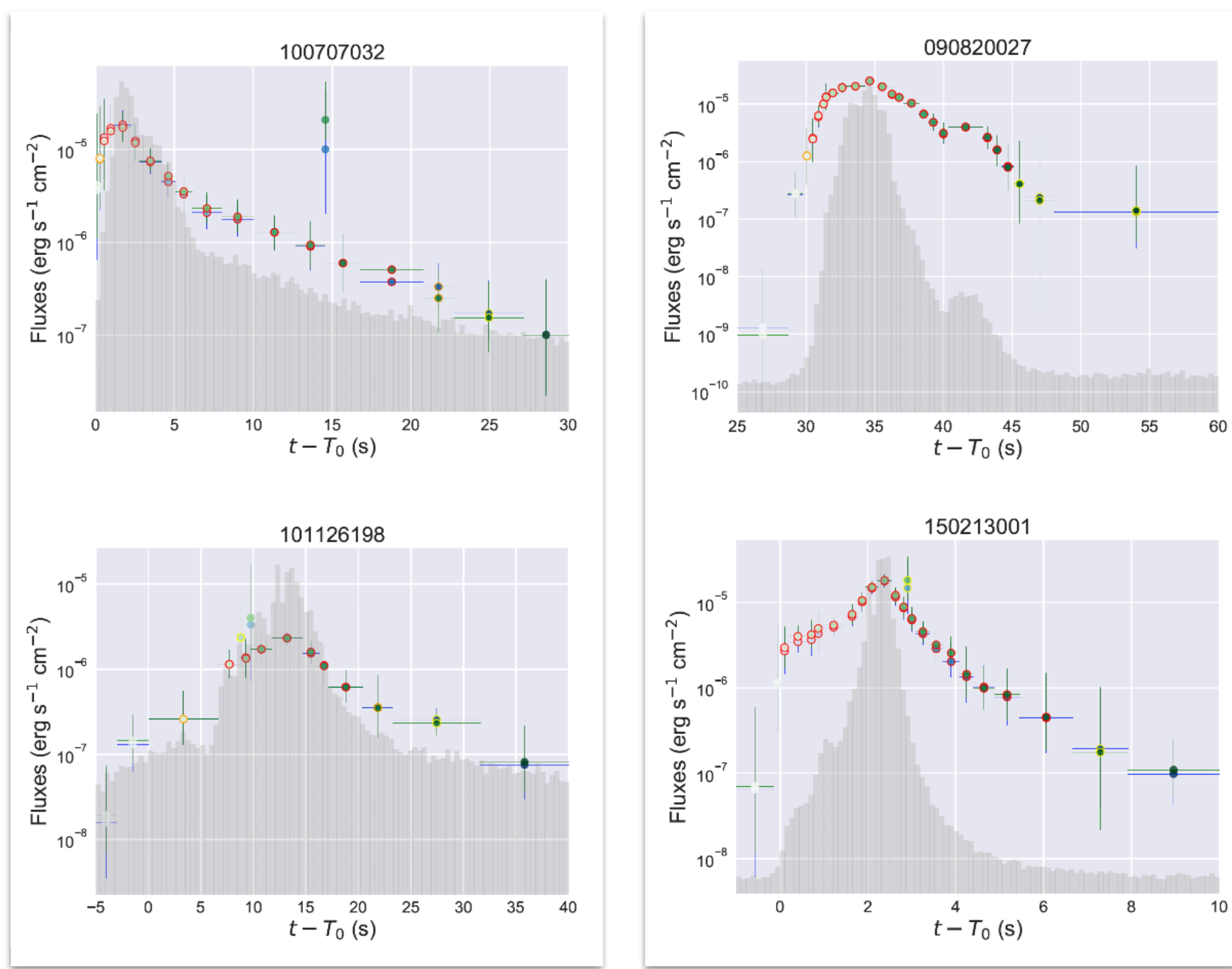
Clue for the physics of the emission mechanism

9 years of GBM observations yielded 38 single pulses with 577 spectra

Analysis performed with 3ML (Vianello+15)

Band function and a cutoff power law were used

See David Yu's poster!
Yu et al., online soon



Time resolved analysis of individual pulses
Fully Bayesian, spectral evolution analysis

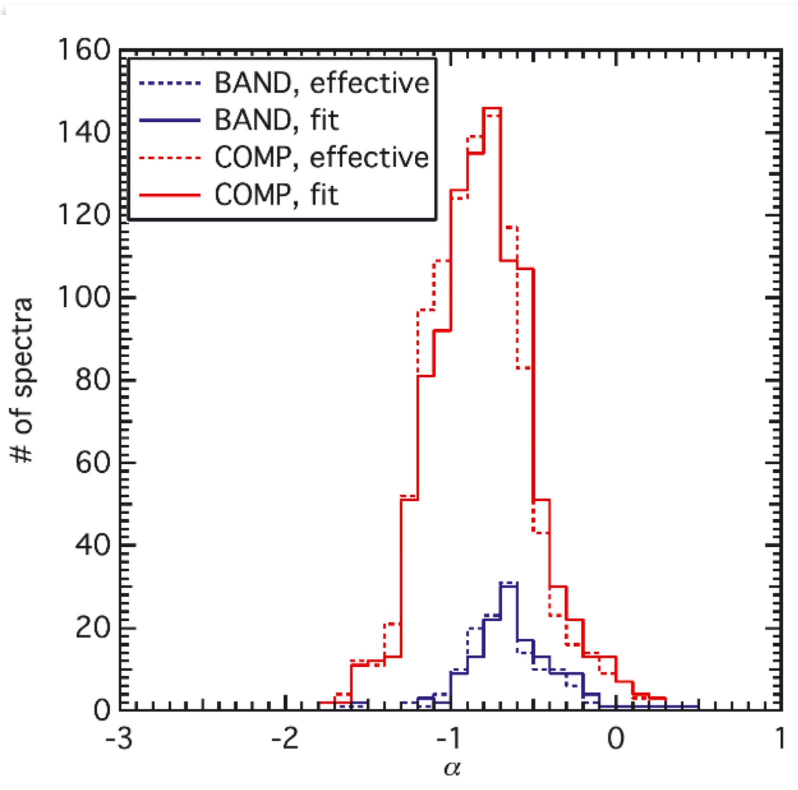
All pulses observed by GBM with more than 5 time bins with SNR >20

See poster:
Yu, Dereli & Ryde

Results and comparison to the GBM catalogue (Yu et al. 2016)

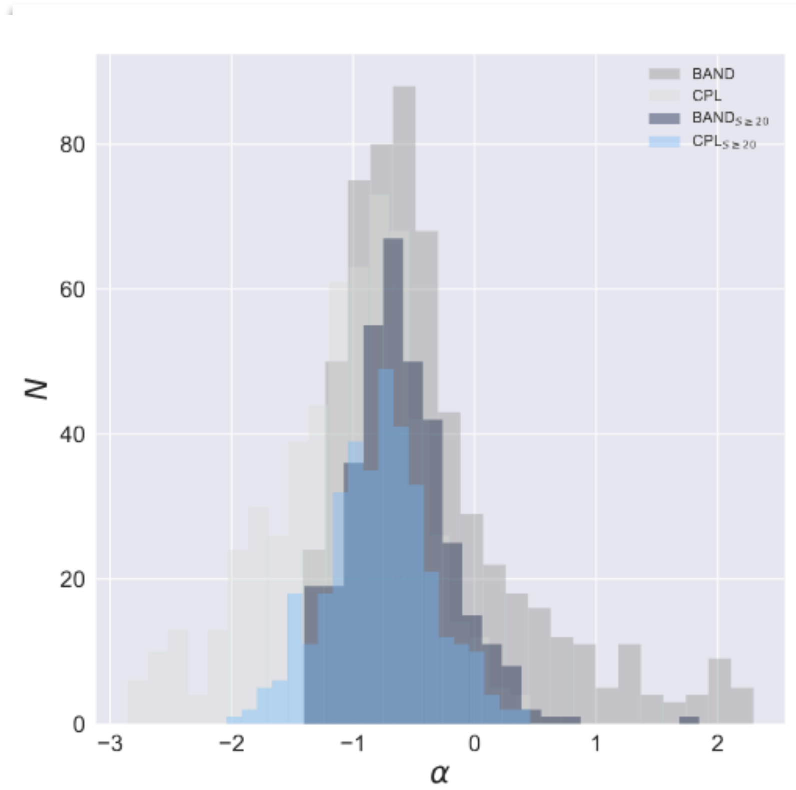
1. α-distribution

(Yu et al. 2016)



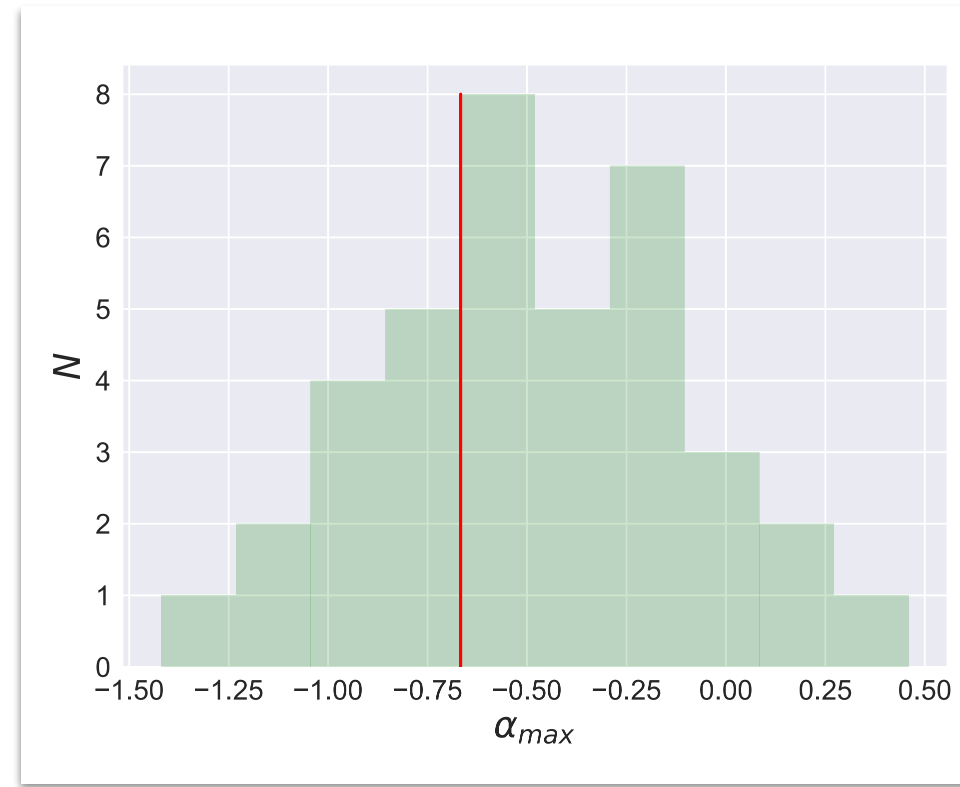
$<\alpha> = -0.802 \pm 0.312$

This work



$<\alpha> = -0.79 \pm 0.43$

Distribution of α_{max}



68% of pulses have $\alpha_{max} > -0.67$

2. Cutoff power law the “best” model

Consistent with Yu et al. (2016)

Ghirlanda+02 found 44%

Time resolved analysis of individual pulses
Fully Bayesian, spectral evolution analysis

All pulses observed by GBM with more than 5 time bins with SNR >20

See poster:
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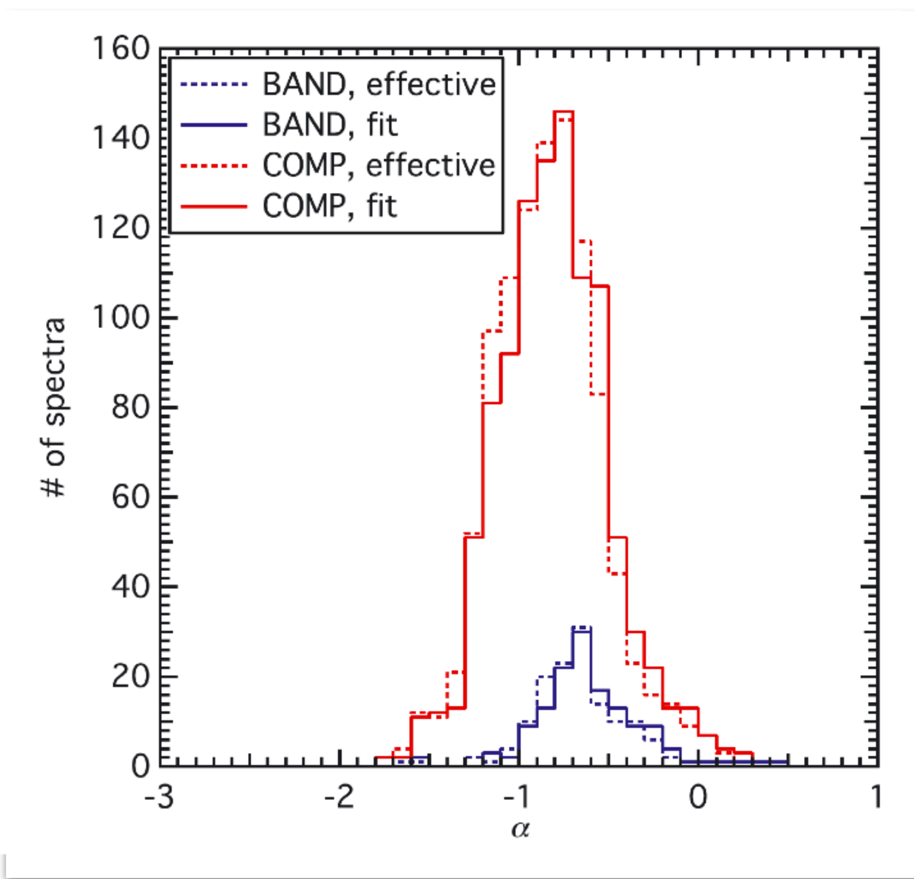
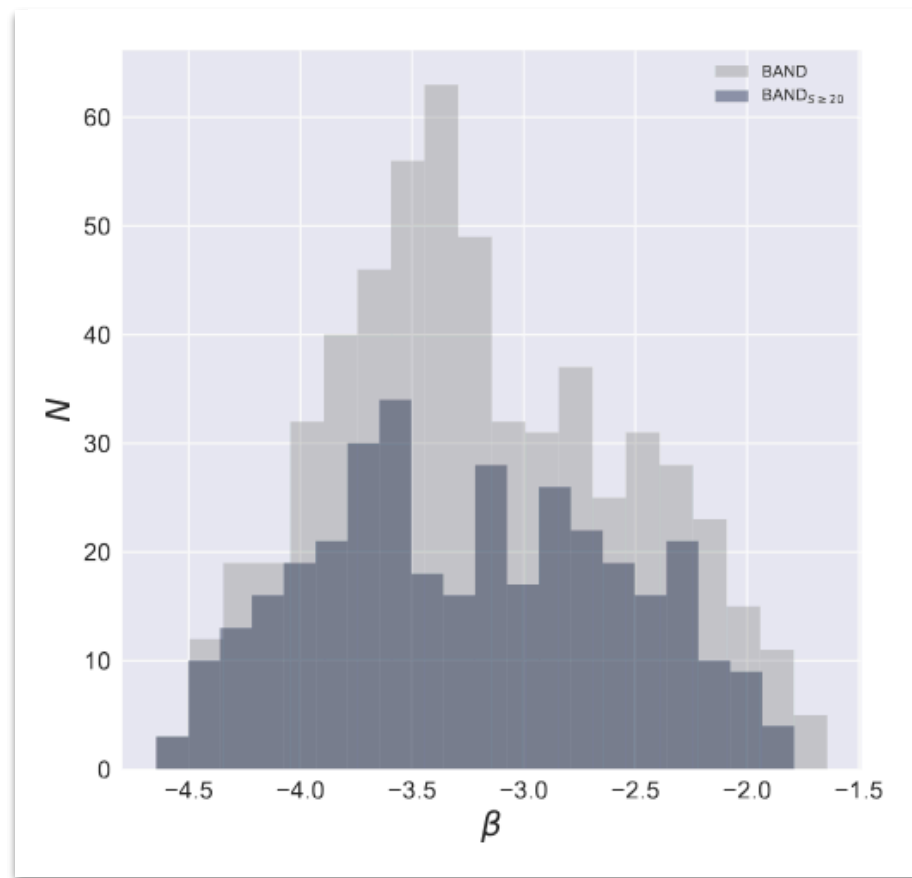
Results and comparison to the GBM catalogue (Yu et al. 2016)

3. β-distribution

(Yu et al. 2016)

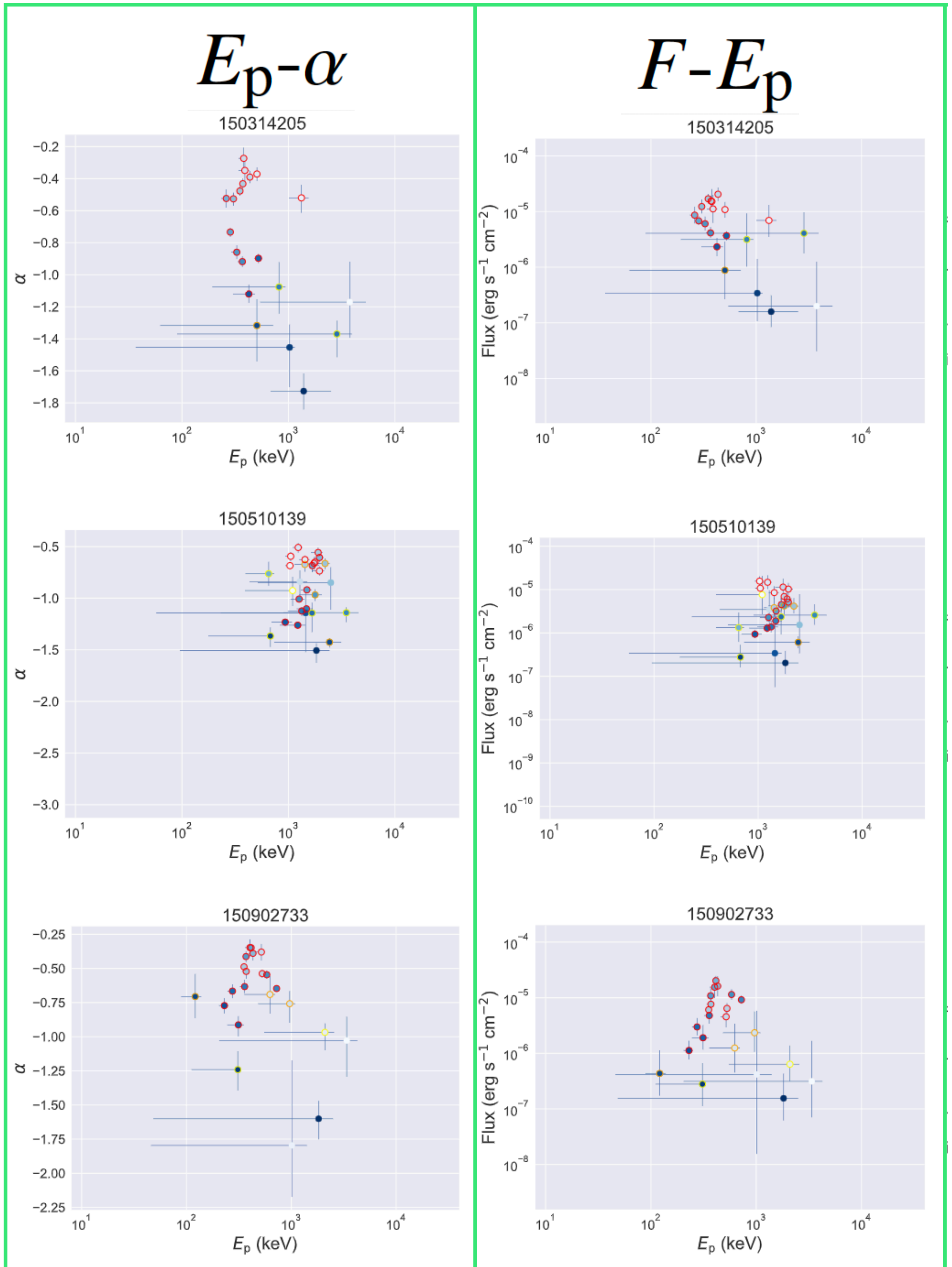


This work

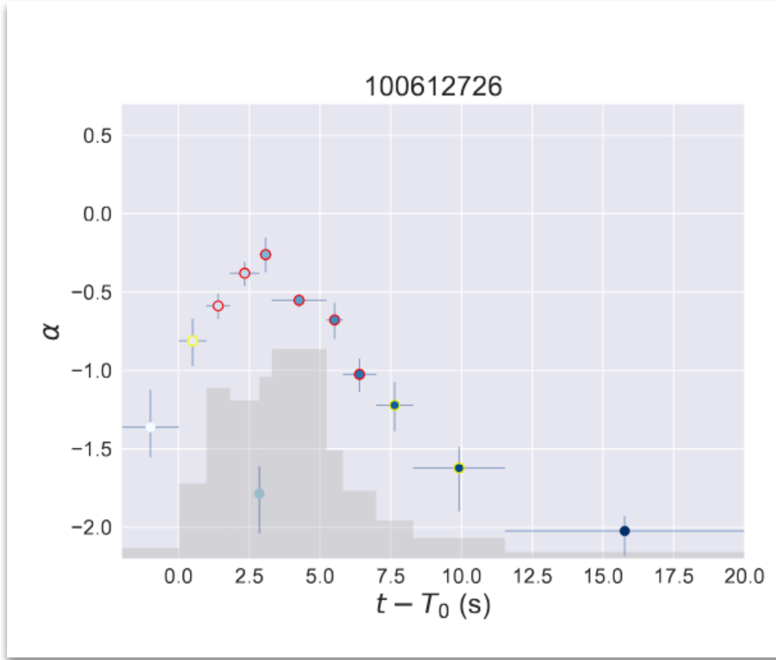


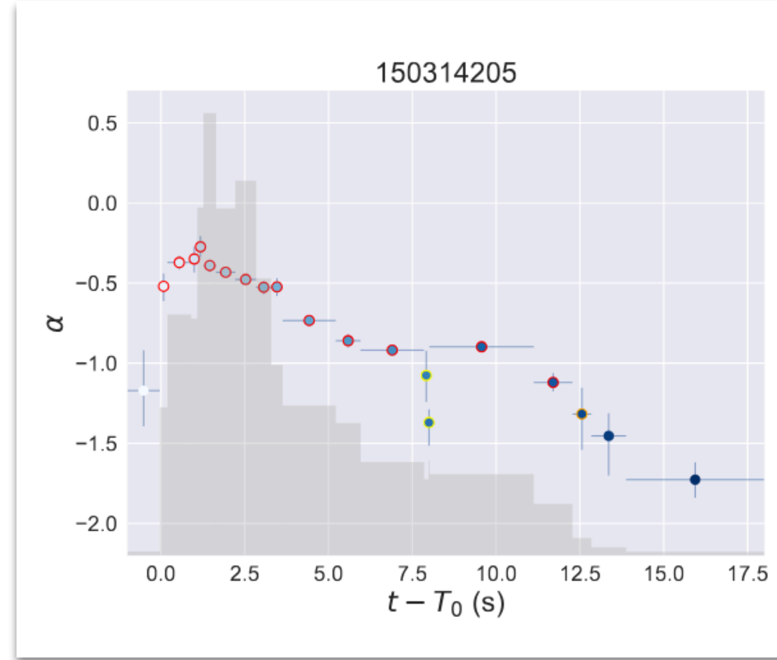
β is softer for the pulses in out sample

Spectral correlations over individual pulses

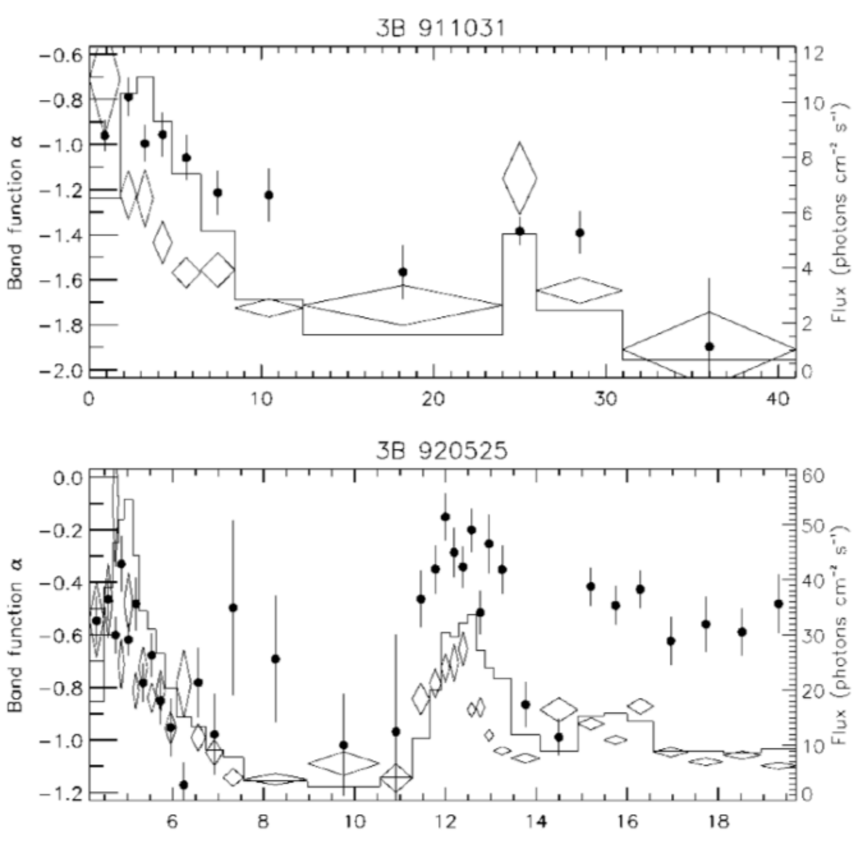


Correlation between energy flux and α

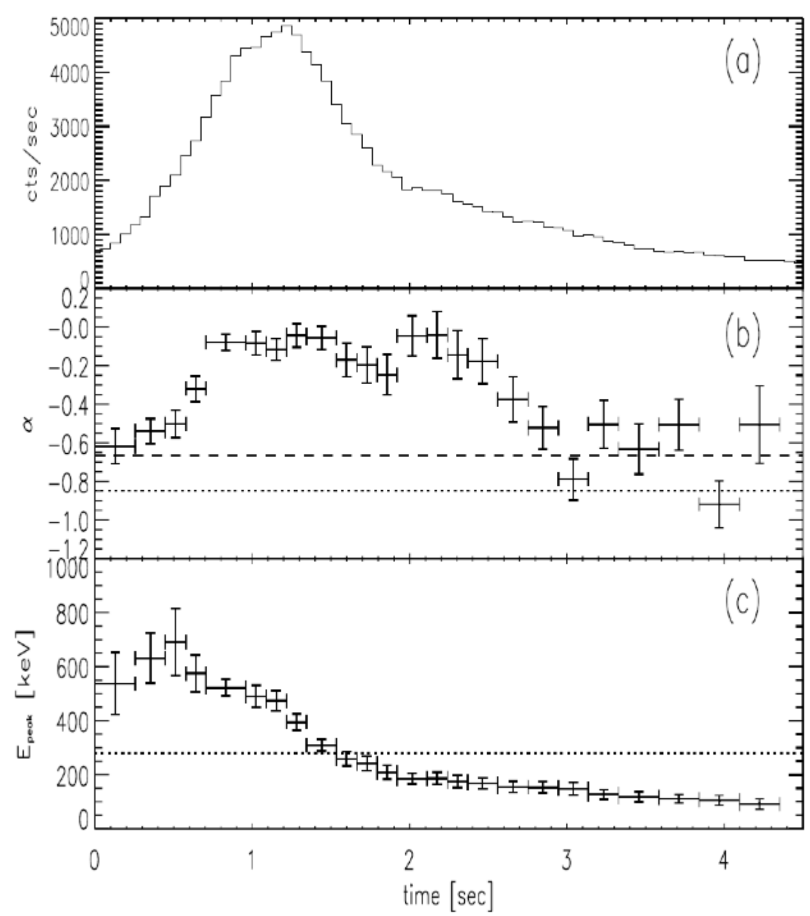




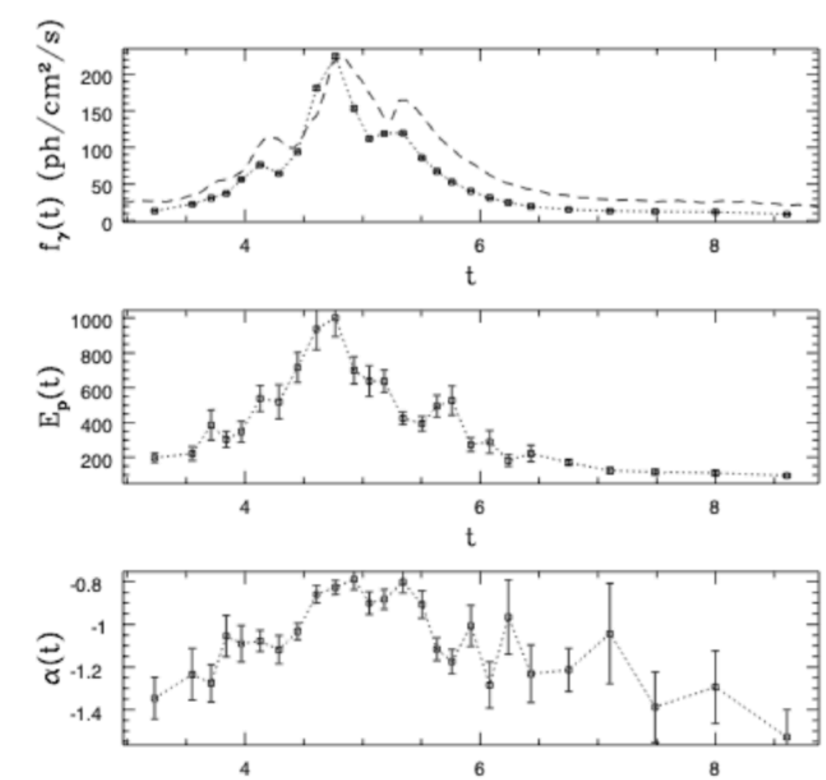
Crider+97



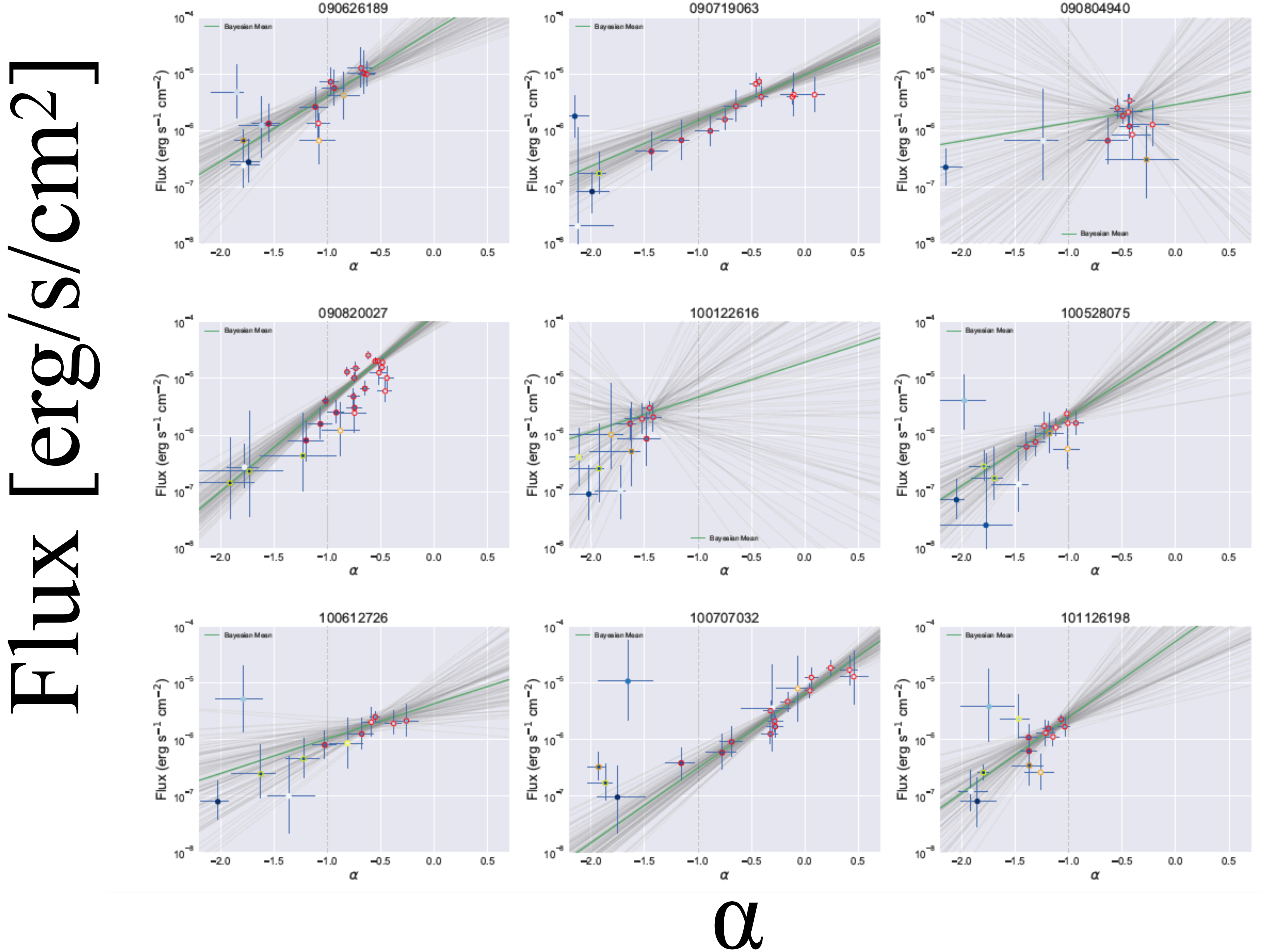
Ghirlanda+02



Lloyd-Ronning+02



Posterior distribution of fits

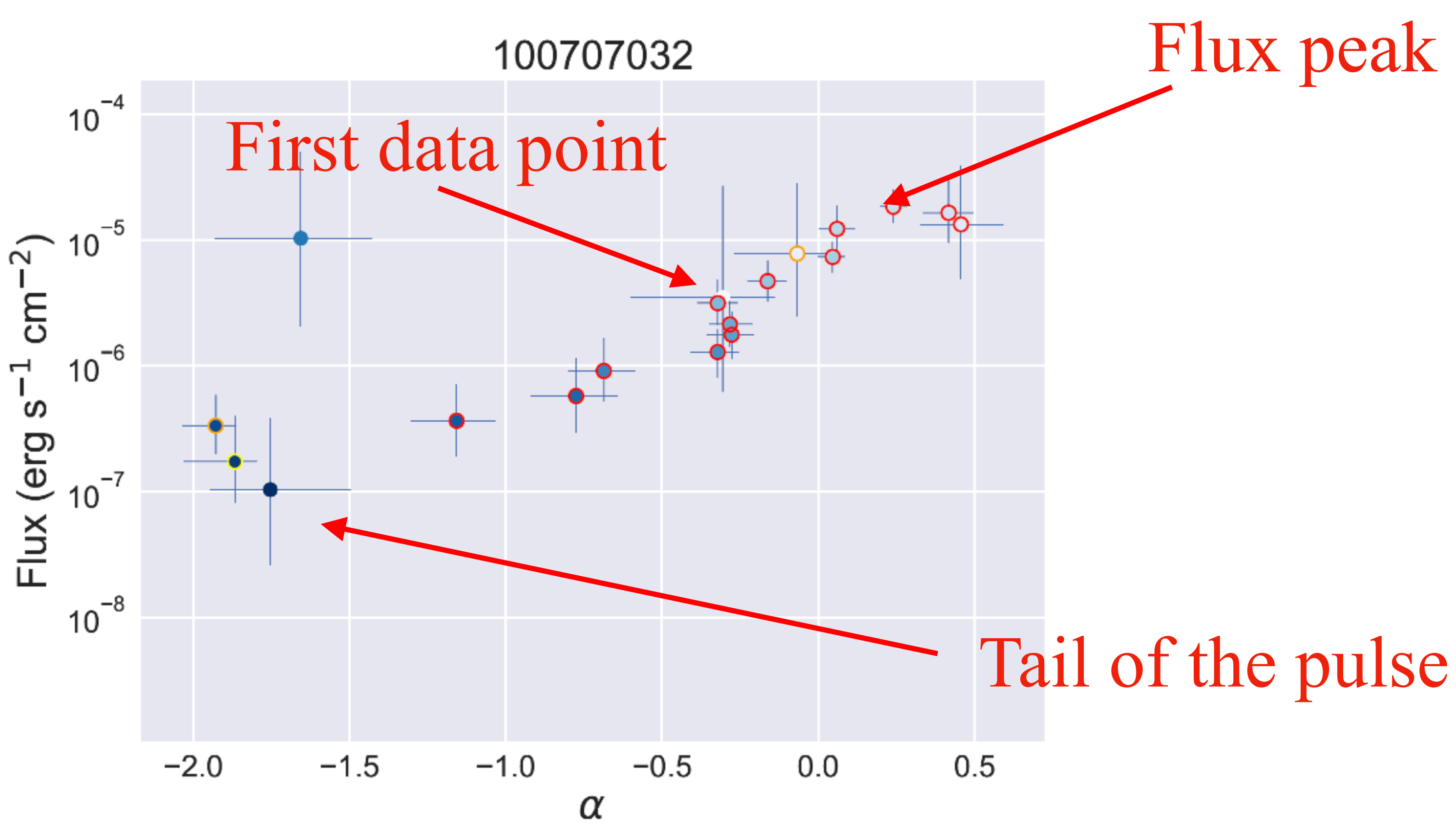


$$F(t) = F_0\, \mathrm{e}^{k\,\alpha(t)}$$

While E_p-α and E_p-F show a variety of behaviours

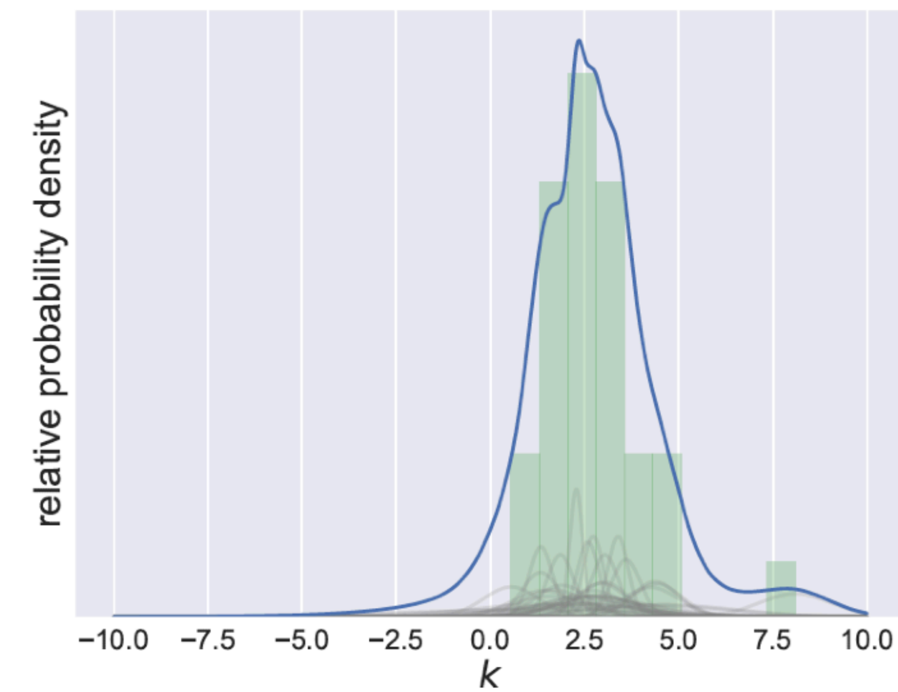
The F-α correlation is similar in most bursts

The data points move along a single track in the F-α plane



$$F(t) = F_0\, e^{k\,\alpha(t)}$$

Typical value $k \sim 3$

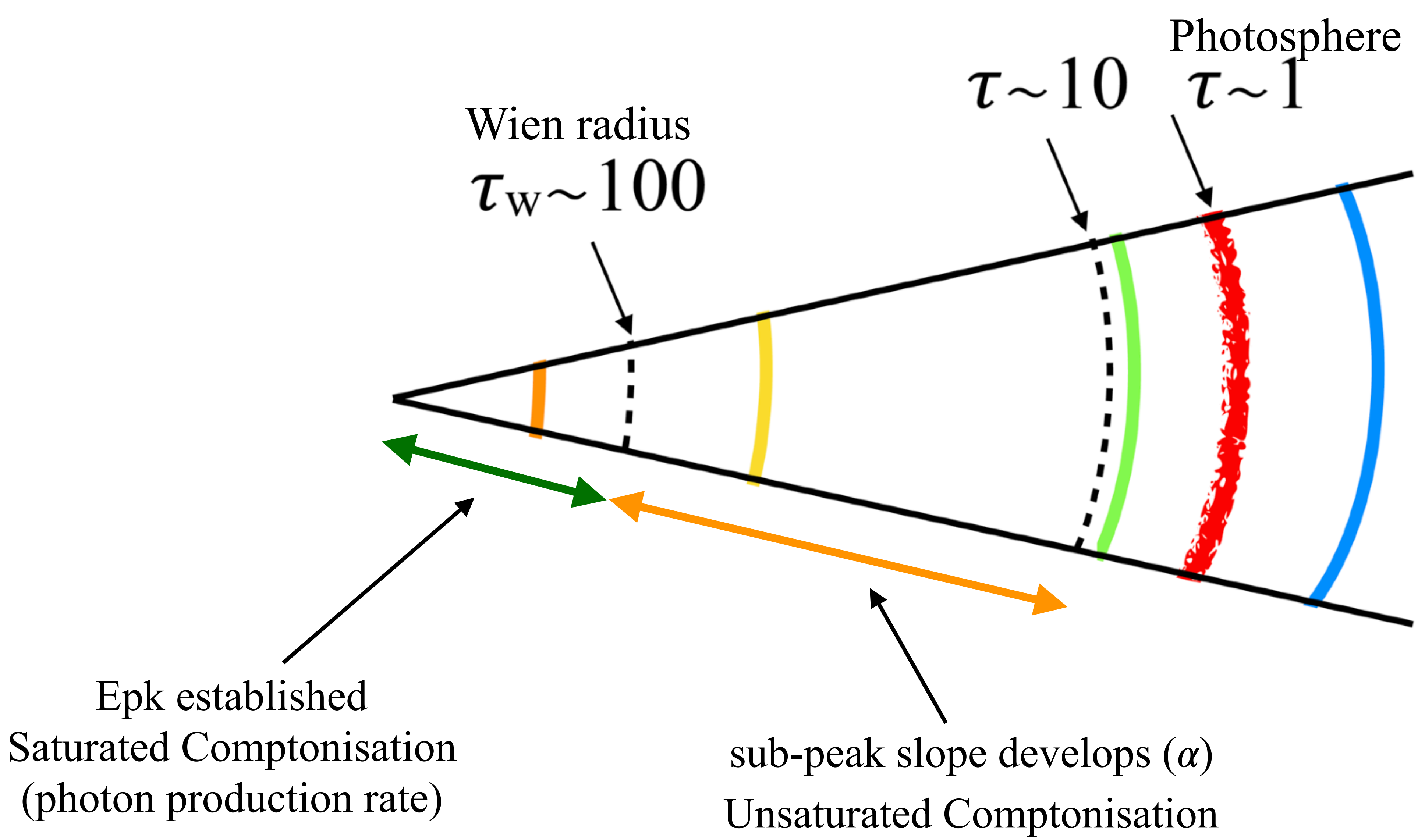


Qualitative explanation: Emission from the photosphere

Intensity and shape of the spectrum depends on

- the heating
- photon production efficiency

Beloborodov13

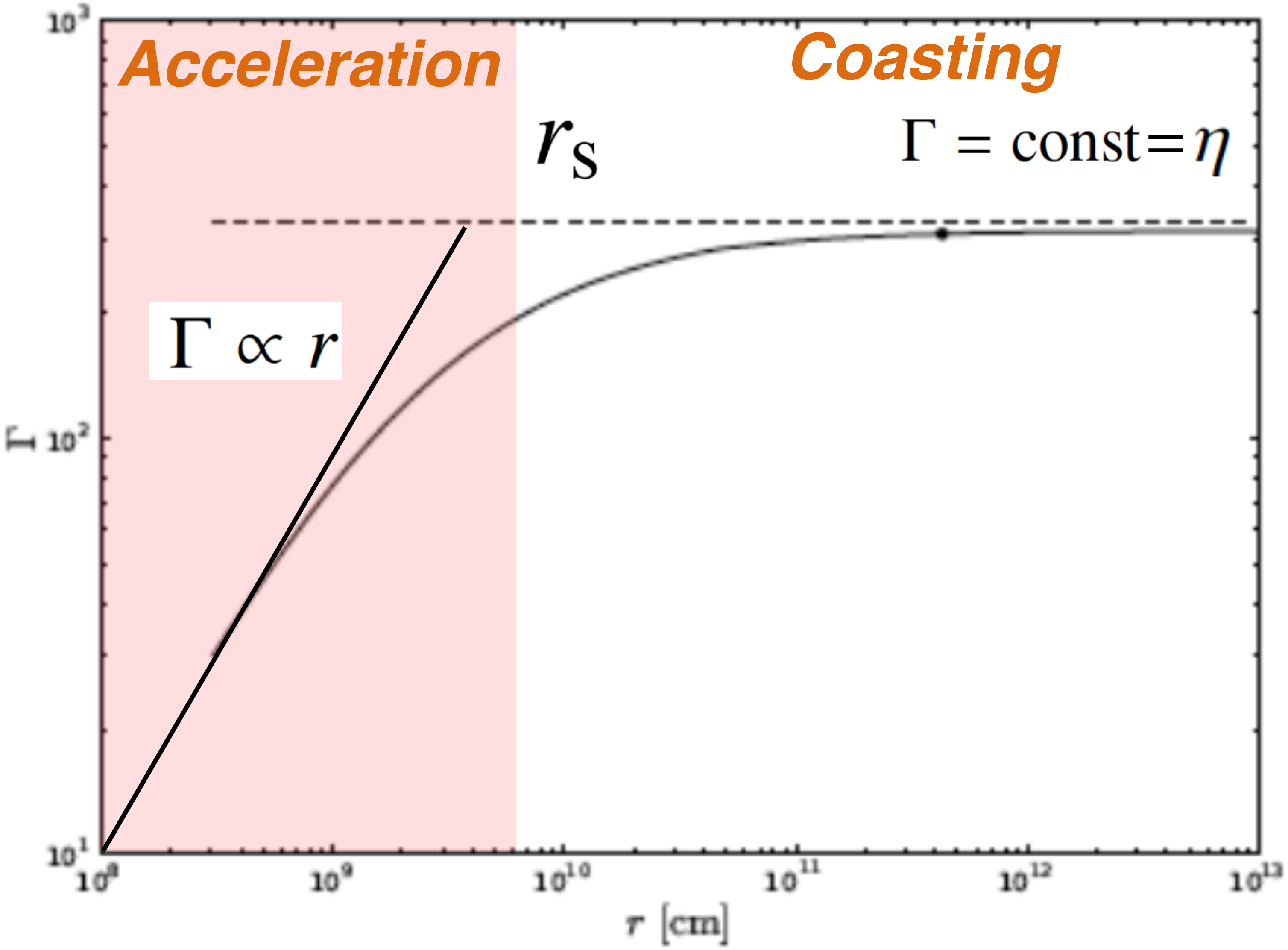


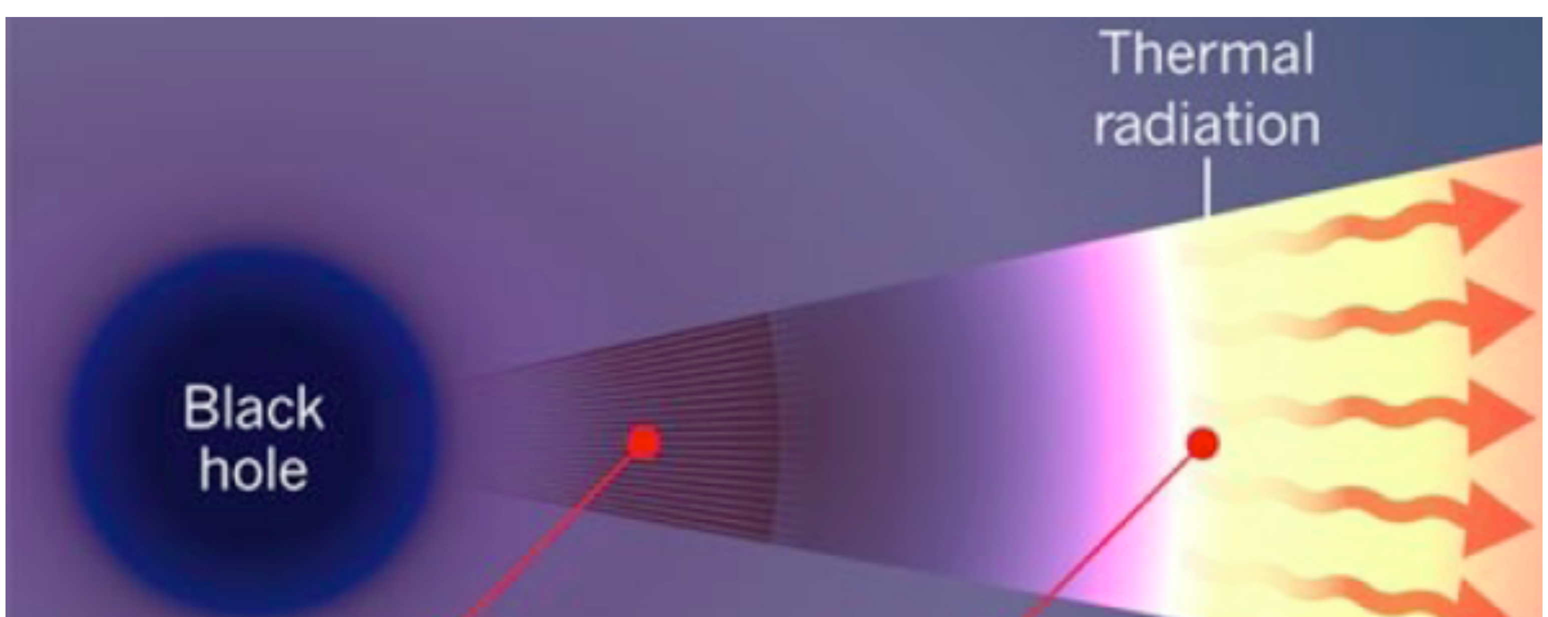
Dissipation by oblique shocks (Meszaros&Rees05)
turbulence (Zrake+18)
B-fields (Giannios+04)

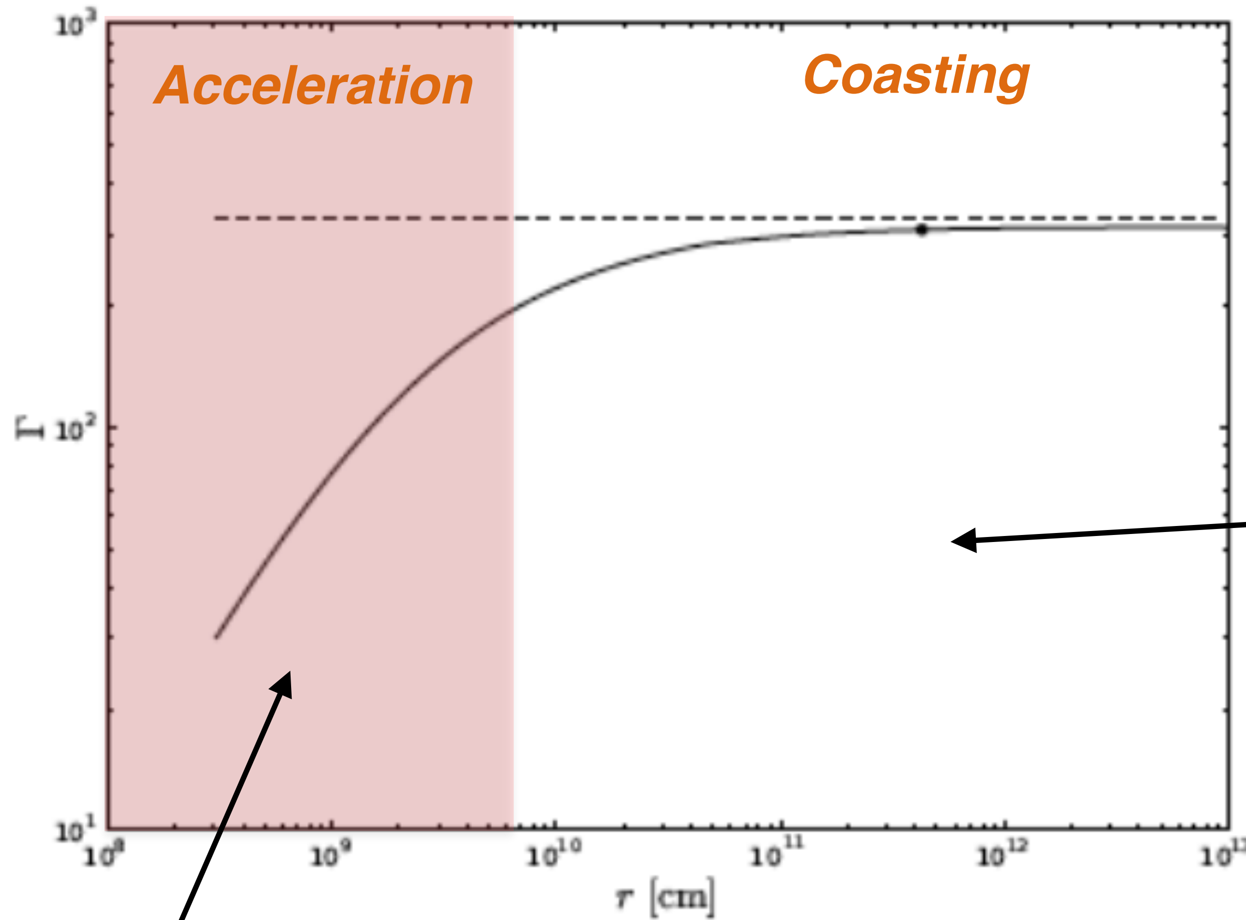
Position of the saturation radius

Fireball model:
Lorentz factor

$$\eta = L/\dot{M}c^2$$







$E_K << E_{rad}$

1. Weak emission
2. Spectral broadening

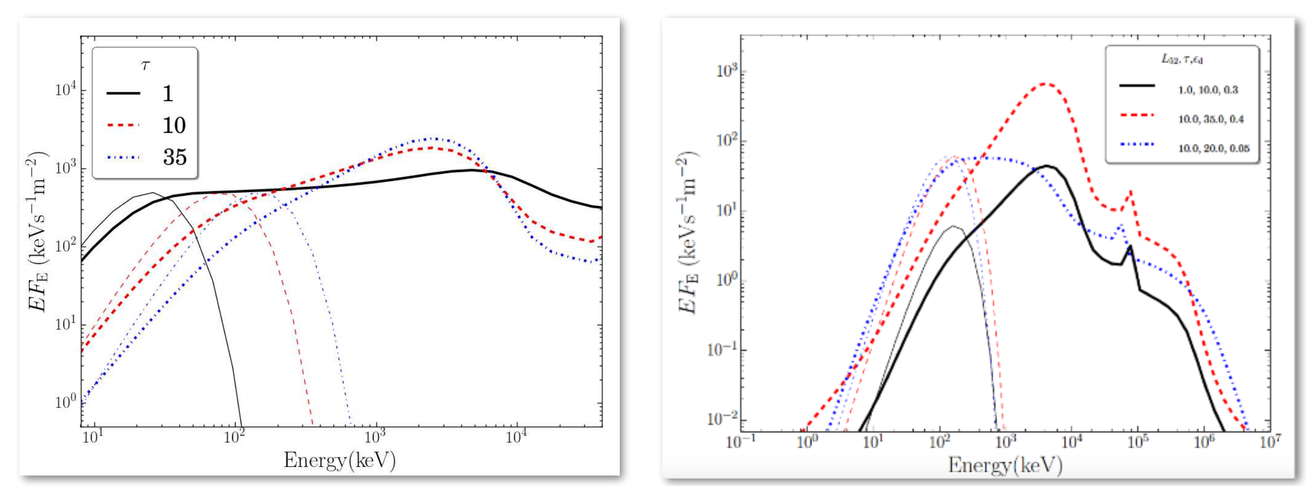
(Dissipation of E_K can easily modify spectrum)

Thermal pressure dominates

$E_K << E_{rad}$

1. Luminous
2. Thermal spectra

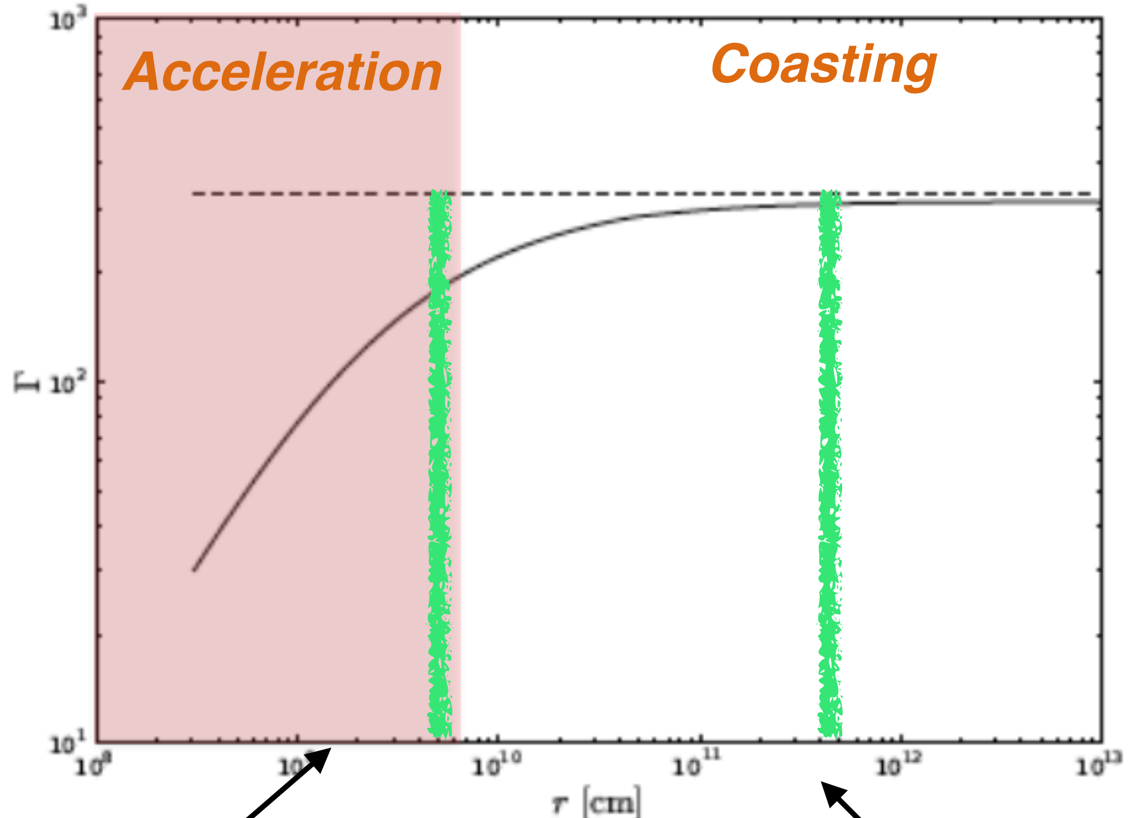
(Small dissipation compared to E_{rad})



Ahlgren+15

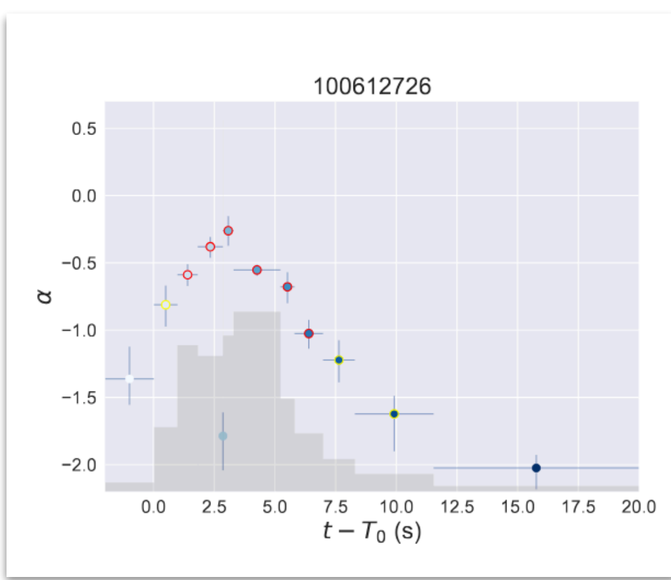
Rees & Meszaros05; Pe'er+06; Giannios06, 08; Ioka+07; Beloborodov10; Lazzati+11; Vurm+13, Vianello+17

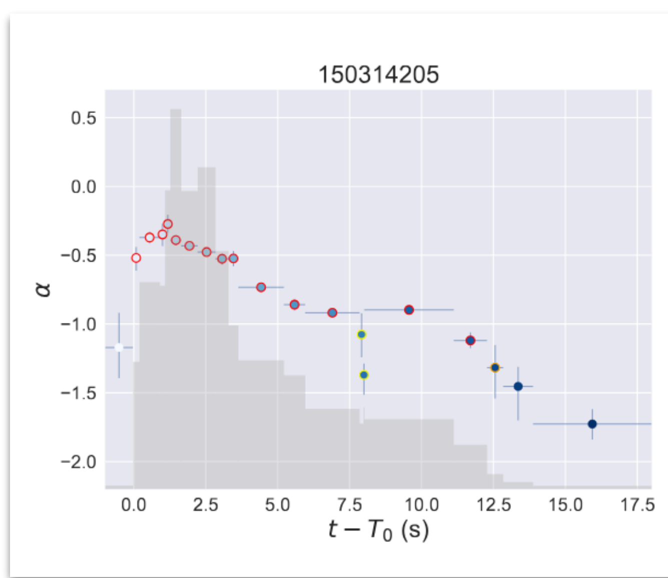
Summary photospheric scenario



Acceleration phase:
- narrow spectra
- bright emission

Coasting phase:
- broader spectra
- weaker emission

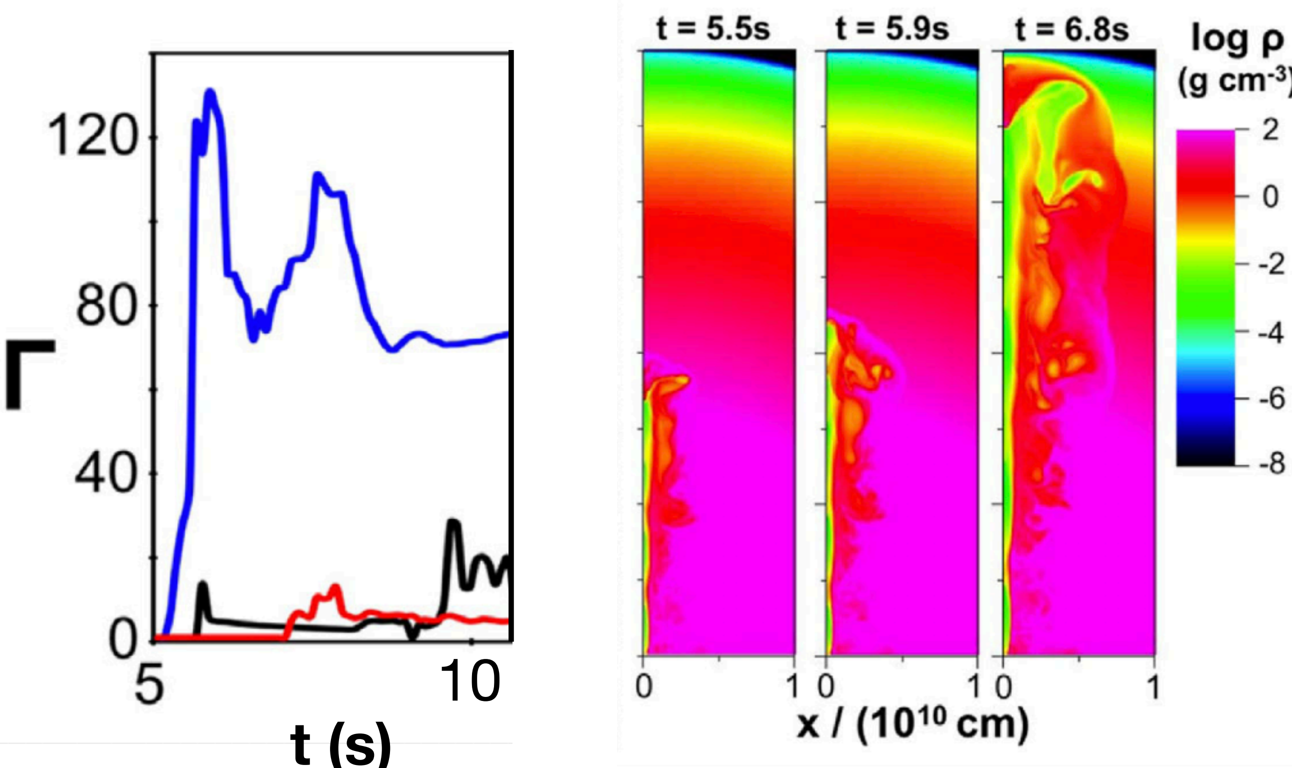




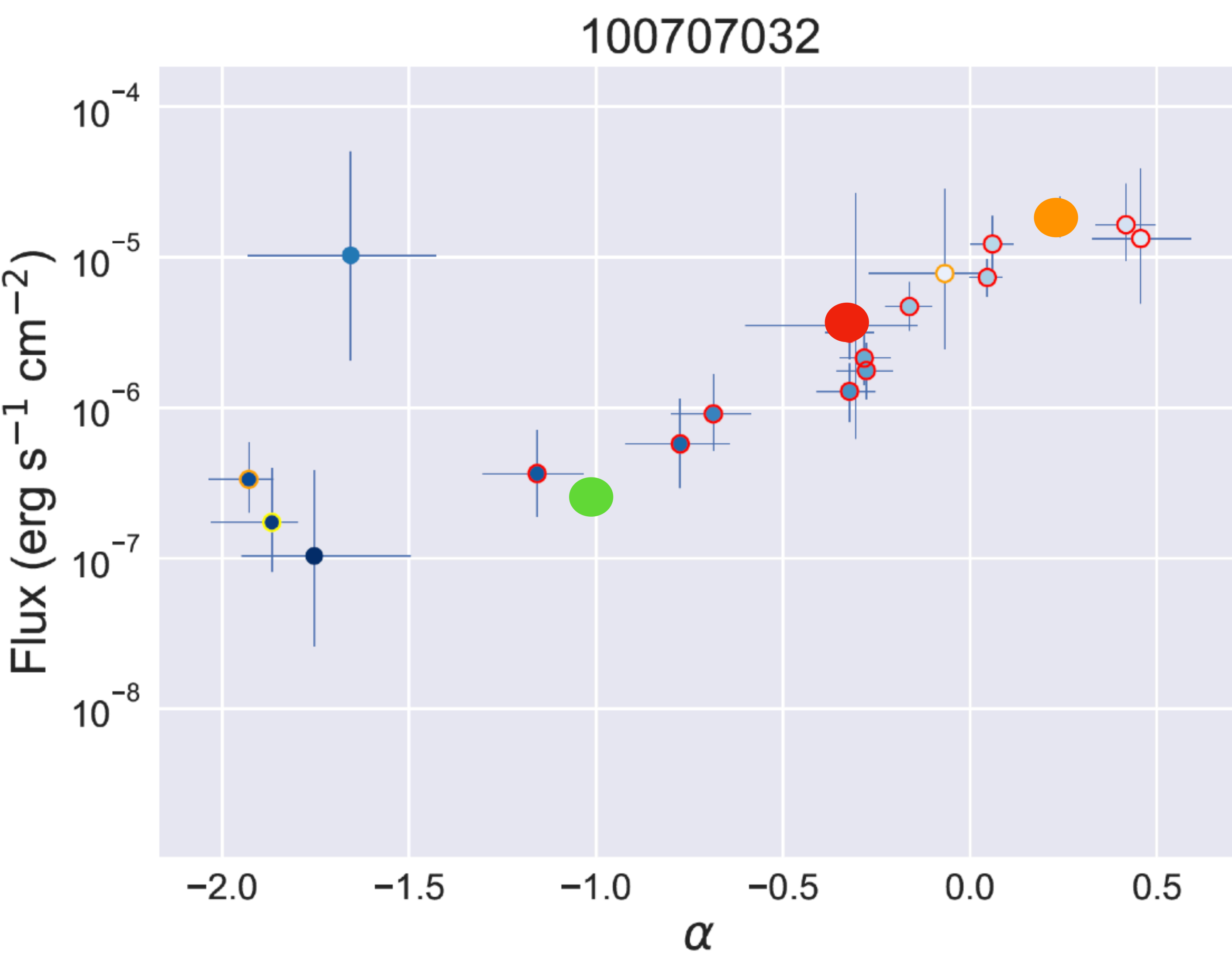
Variation in $\frac{r_{\mathrm{ph}}}{r_{\mathrm{s}}}$:

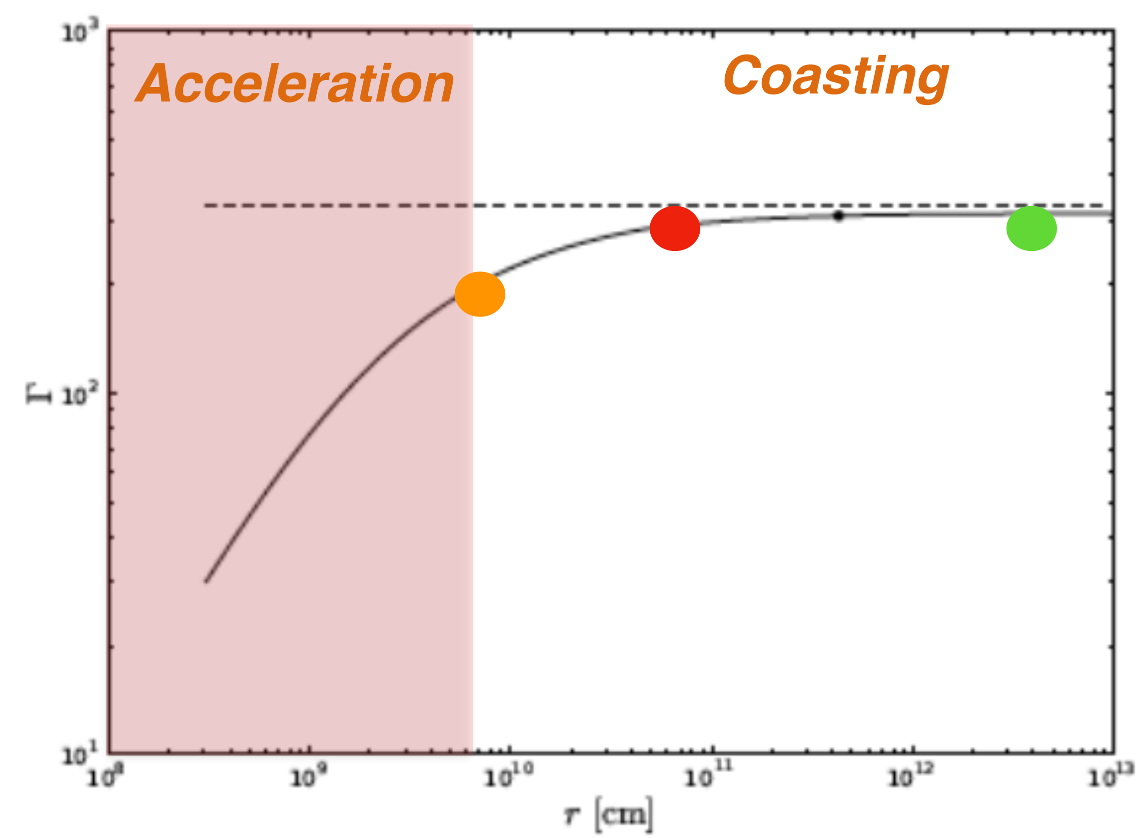
$$\boxed{\frac{r_{\rm ph}}{r_{\rm s}} = \frac{L\sigma_{\rm T}}{4\pi m_{\rm p} c^3 \eta^2 \Gamma^2 r_0} \propto \frac{L}{r_0}\,\eta^{-4}}$$

$$\eta = \Gamma$$

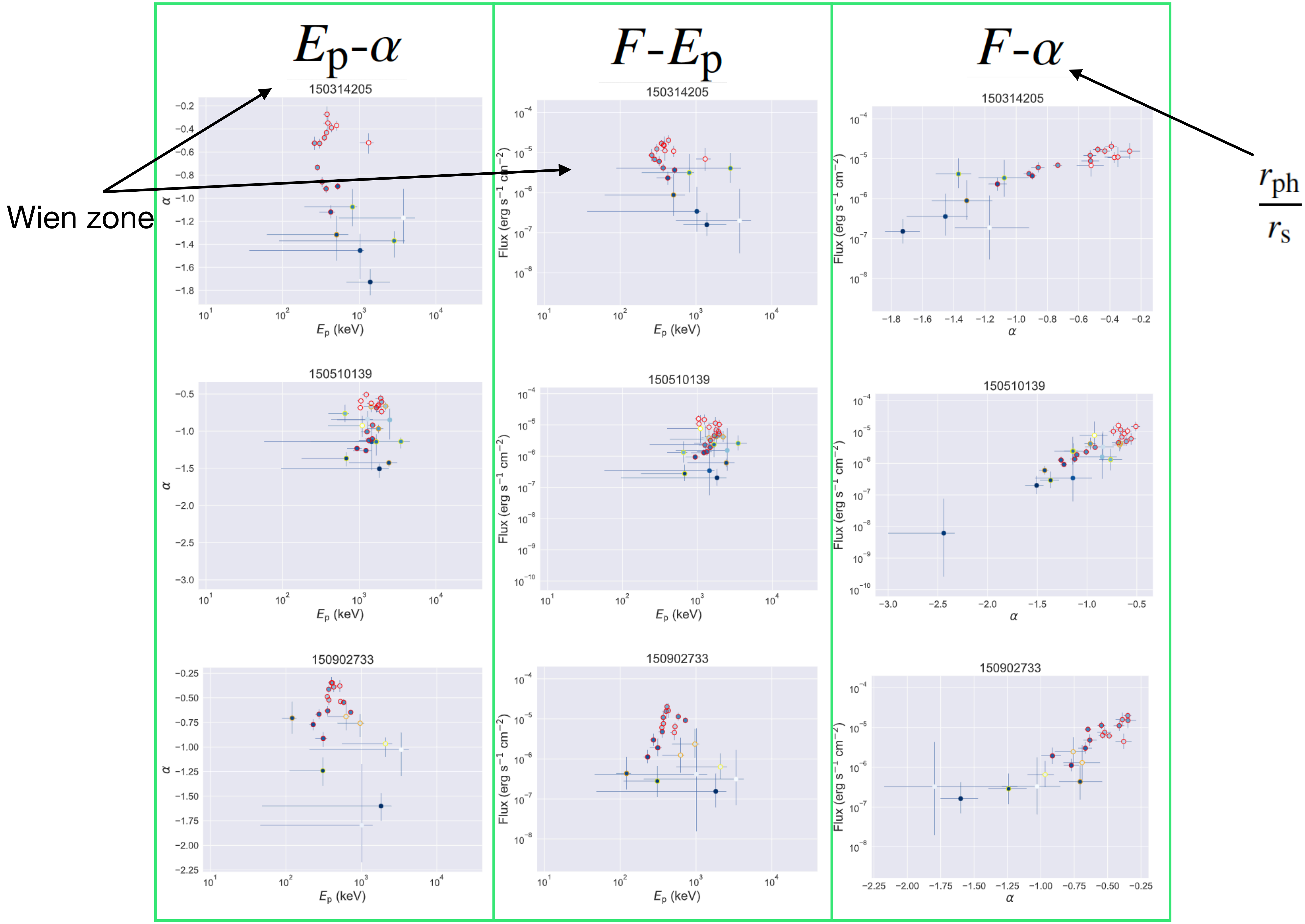


Lopez-Camara+14



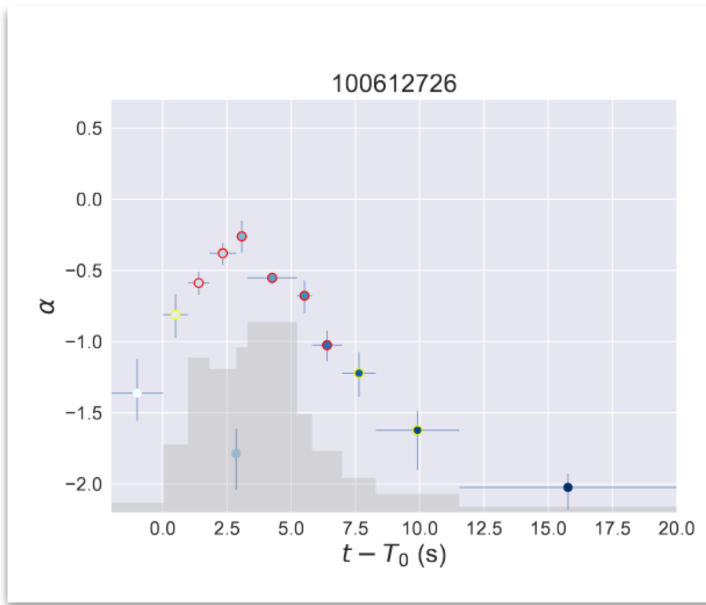


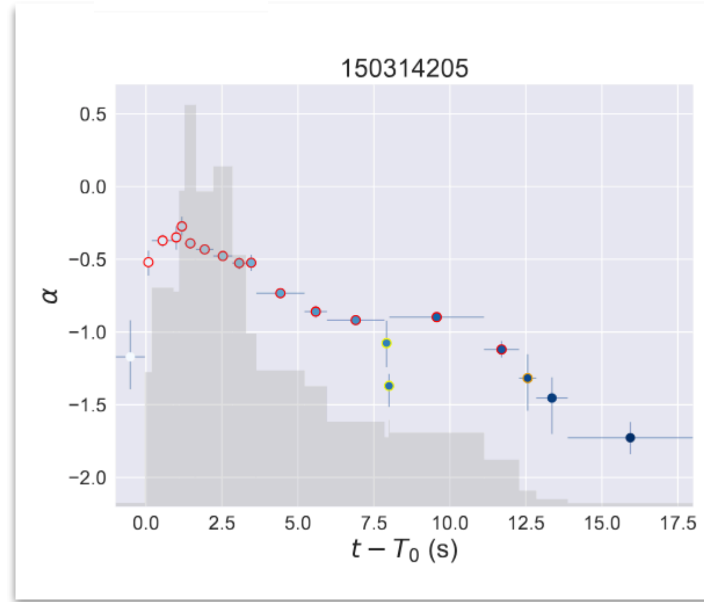
Spectral correlations over individual pulses



Conclusions:

- Time resolved pulses in GBM: 67% have α_{max} > -0.67
  F-α common correlation



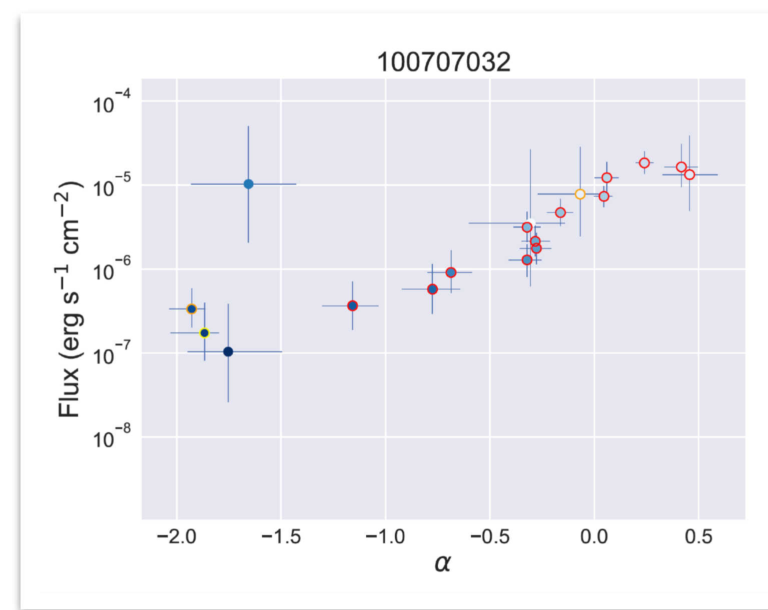


- Subphotospheric emission, with dissipation and a varying entropy.

$$\eta = L/\dot{M}c^2$$

Intense, narrow spectra

weak, broad spectra



- Physical models should be used in spectral analyses
  e.g., Baring+95, Ghirlanda+02, Ahlgren+15, Vianello+18, Burgess+18