GRB detection and studies with THESEUS

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+

WG4

Most in WG4 white paper to appear in Exp. Astron. THESEUS special issue

1) How many GRBs will THESEUS detect?
2) What GRB Science (+ main science drivers)?

Building blocks of GRB populations

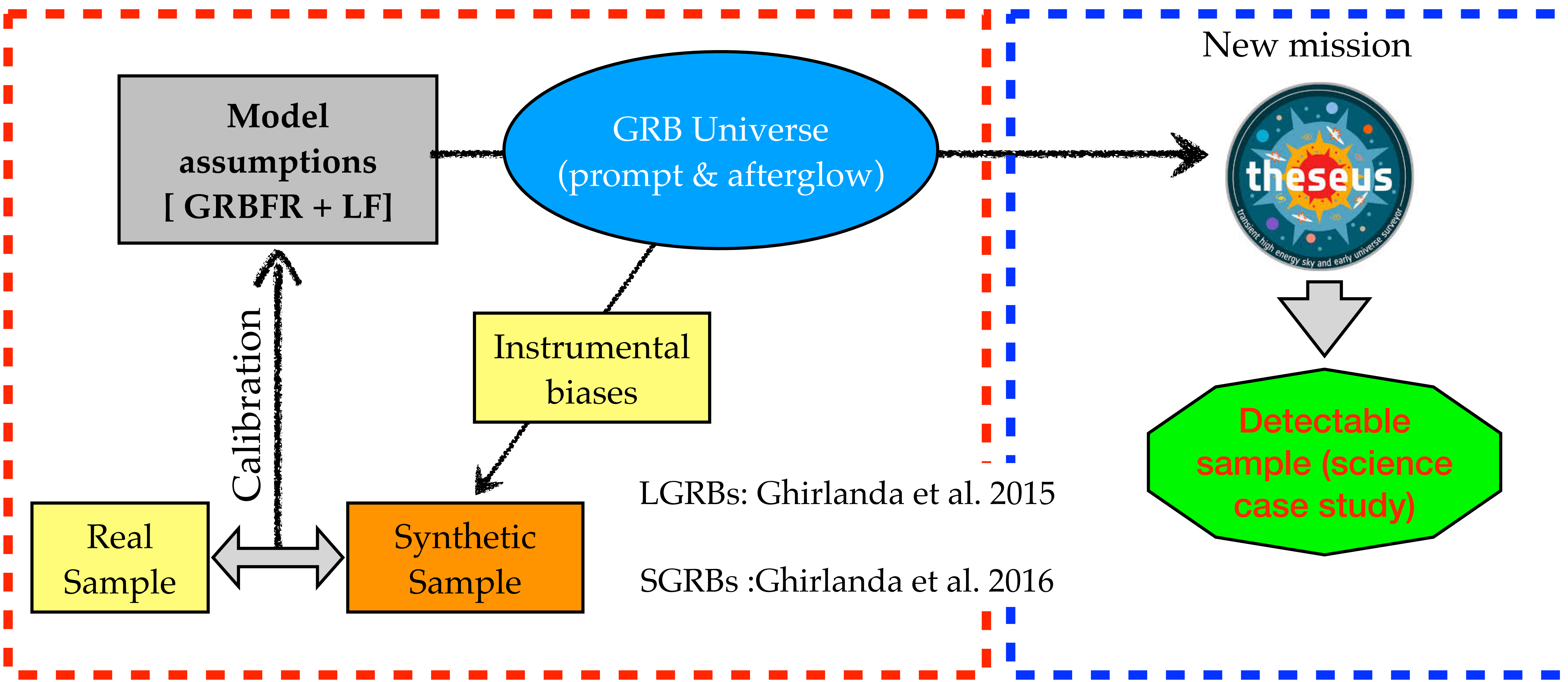
$$N(P_1 < P < P_2) \propto A \int_0^\infty dz \frac{dV(z)}{dz} \frac{\Psi(z)}{1+z} \int_{L(P_1|z,P_{min})}^{L(P_2|z)} \phi(L) dL$$

GRB formation rate (GRBFR)

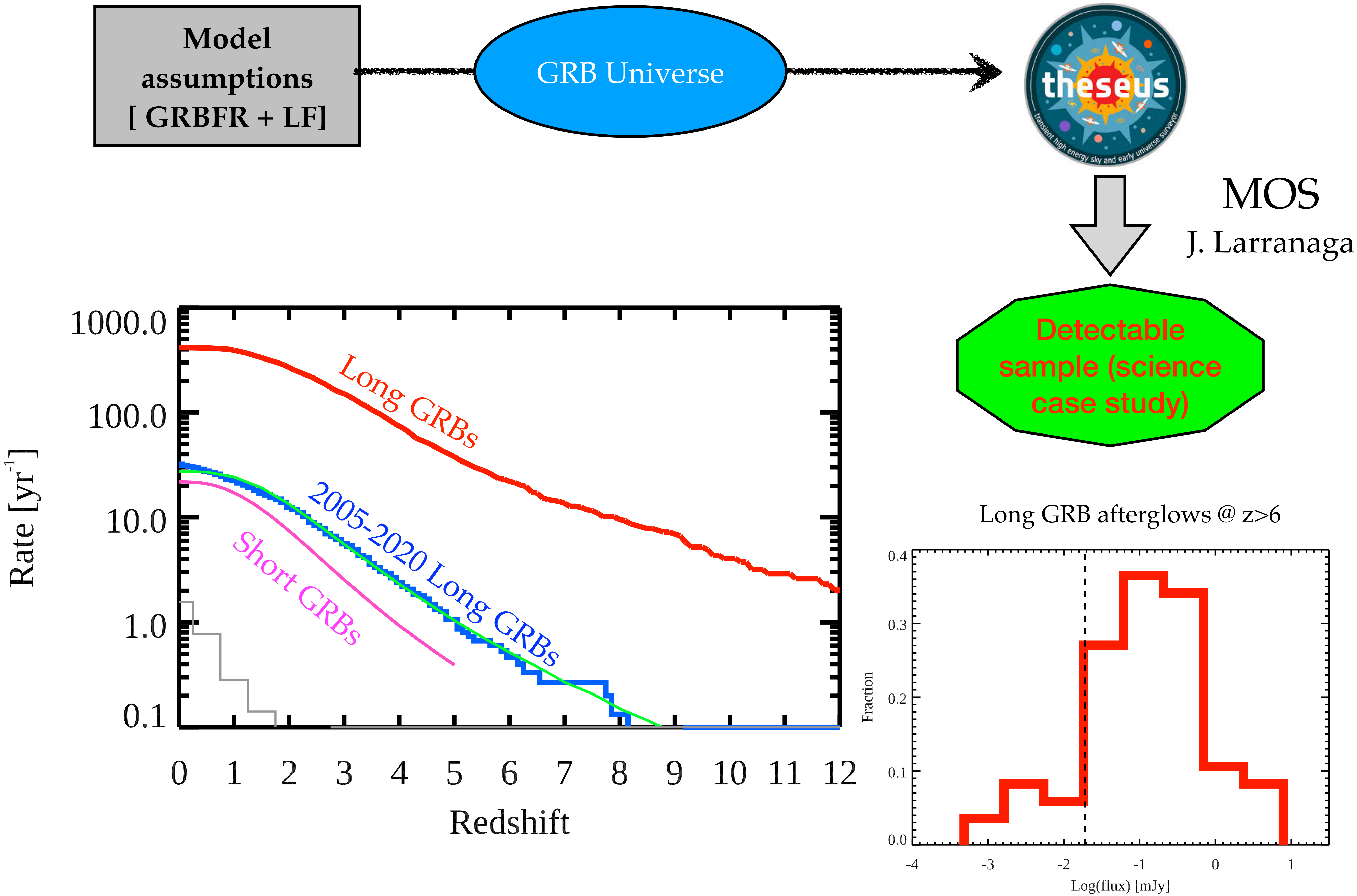
luminosity function (LF)

short GRBs:
BNS,BHNS merger
(delay with respect to SFR)

long GRBs:
associated to SNIb/c
(low Z and then SFR)



THESEUS expected detections



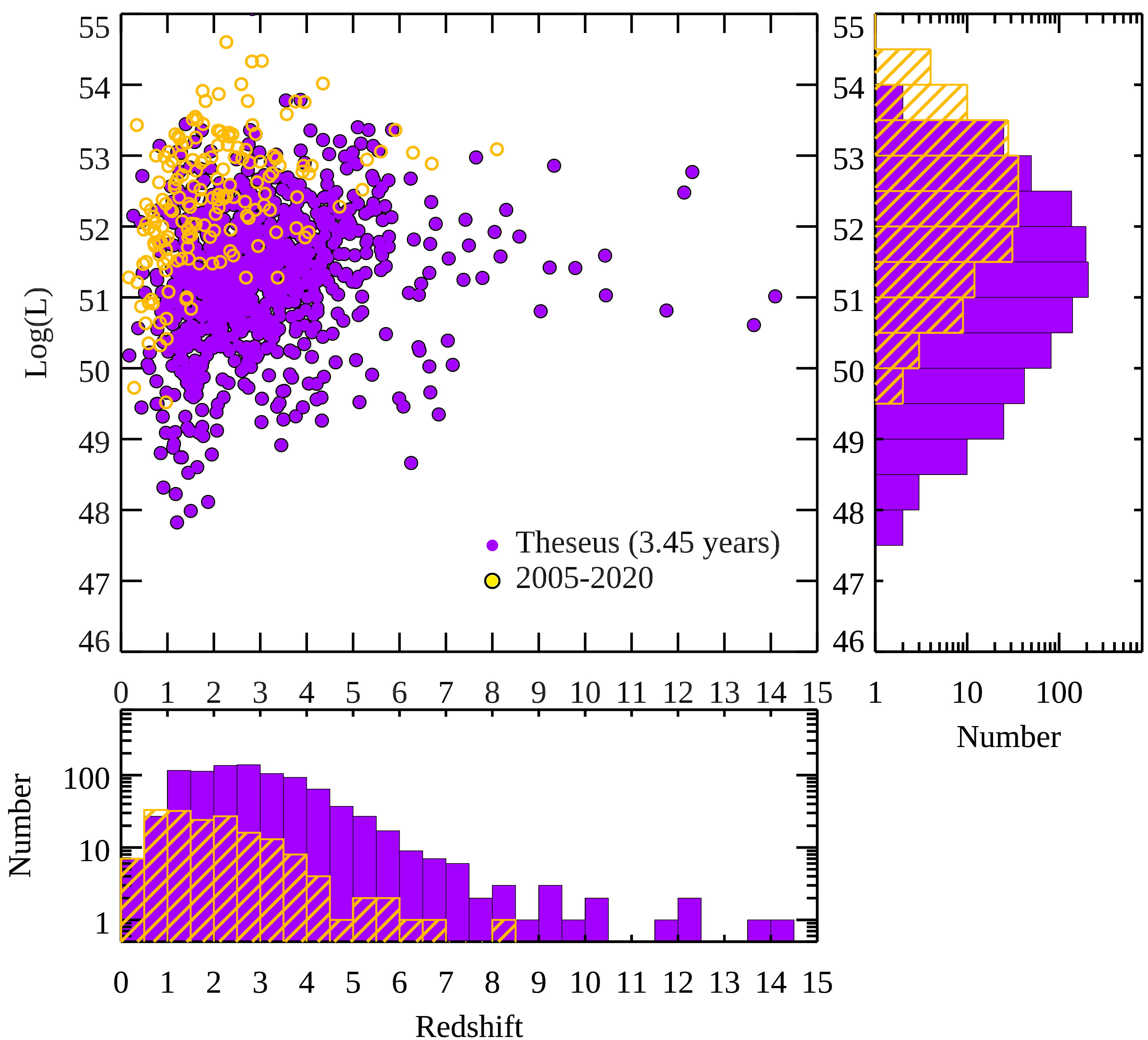
A possible realisation of the THESEUS long GRB sample

Need
1) prompt emission spectrum
2) redshift

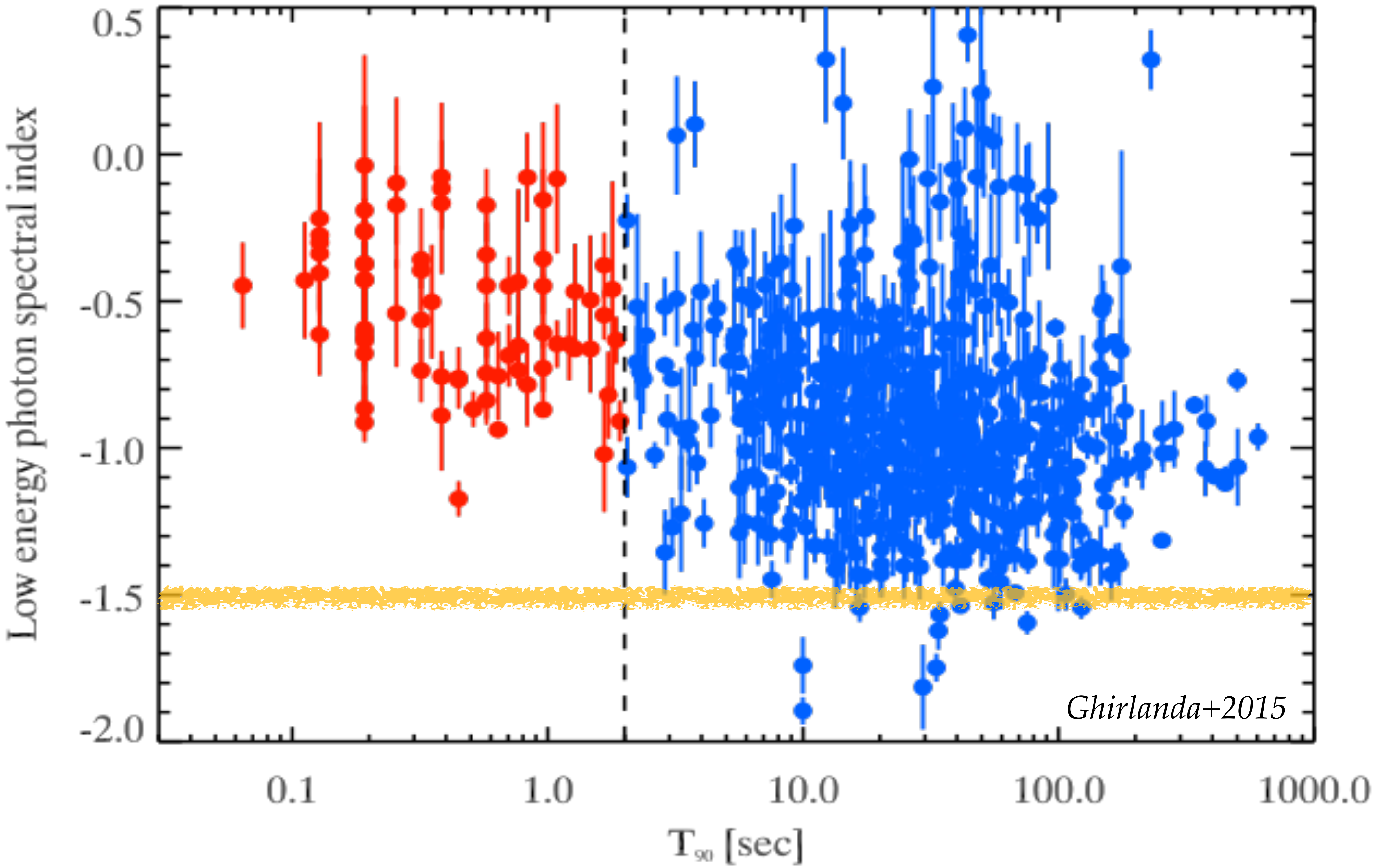
Study the cosmological properties of the GRB population (e.g evolution)

Explore the low luminosity end of the LF

Existence and nature of XRF



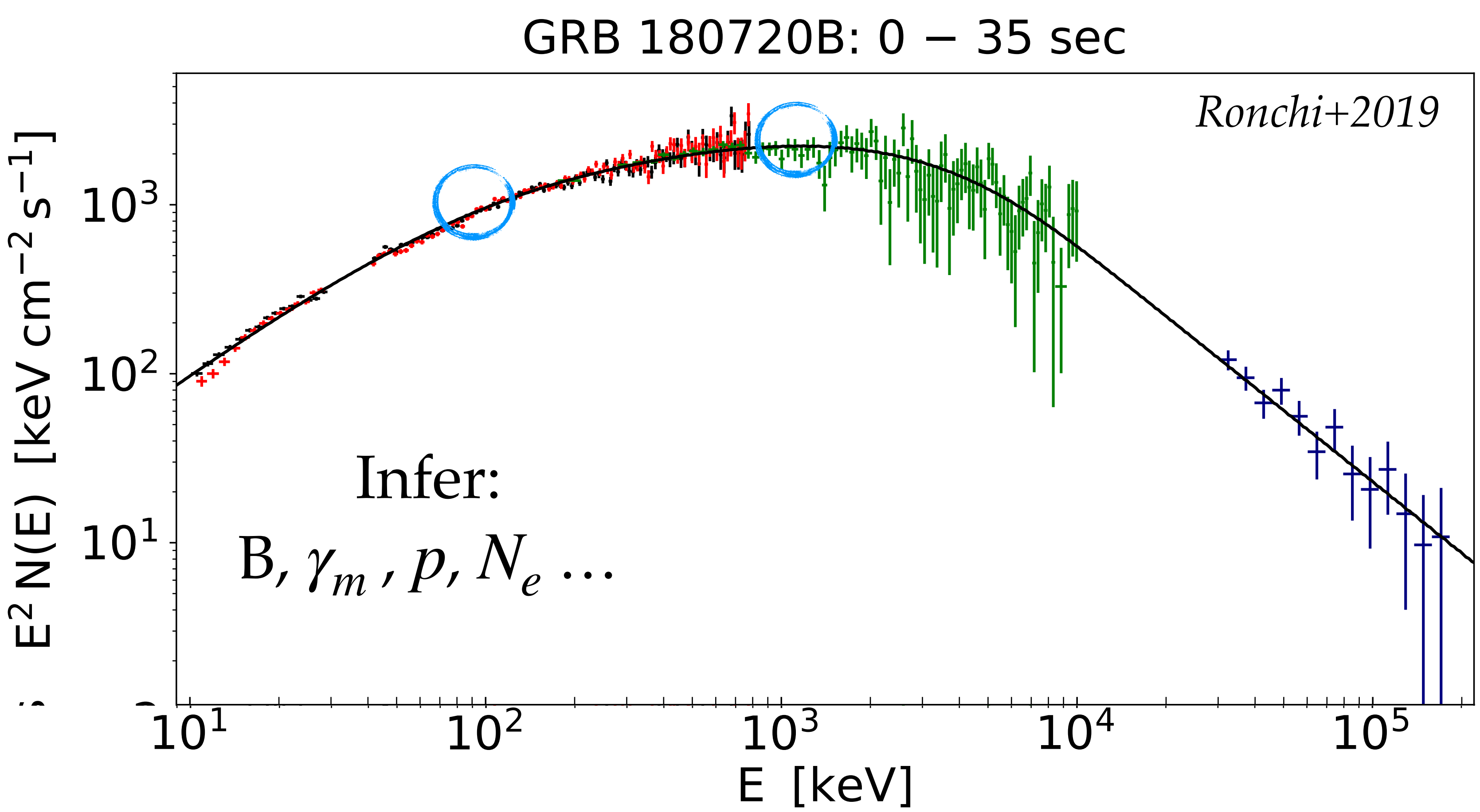
The nature of the radiative process



Observations: e.g. *Preece et al. 1998; Ghirlanda et al. 2002; Kaneko et al. 2006; Frontera et al. 2006; Vianello et al. 2008; Gruber et al. 2014 . …. …*

Theory: e.g. *Sari, Narayan & Piran 1996; Daigne et al. 2012; … Ghisellini et al. 2000;*

The nature of the prompt emission



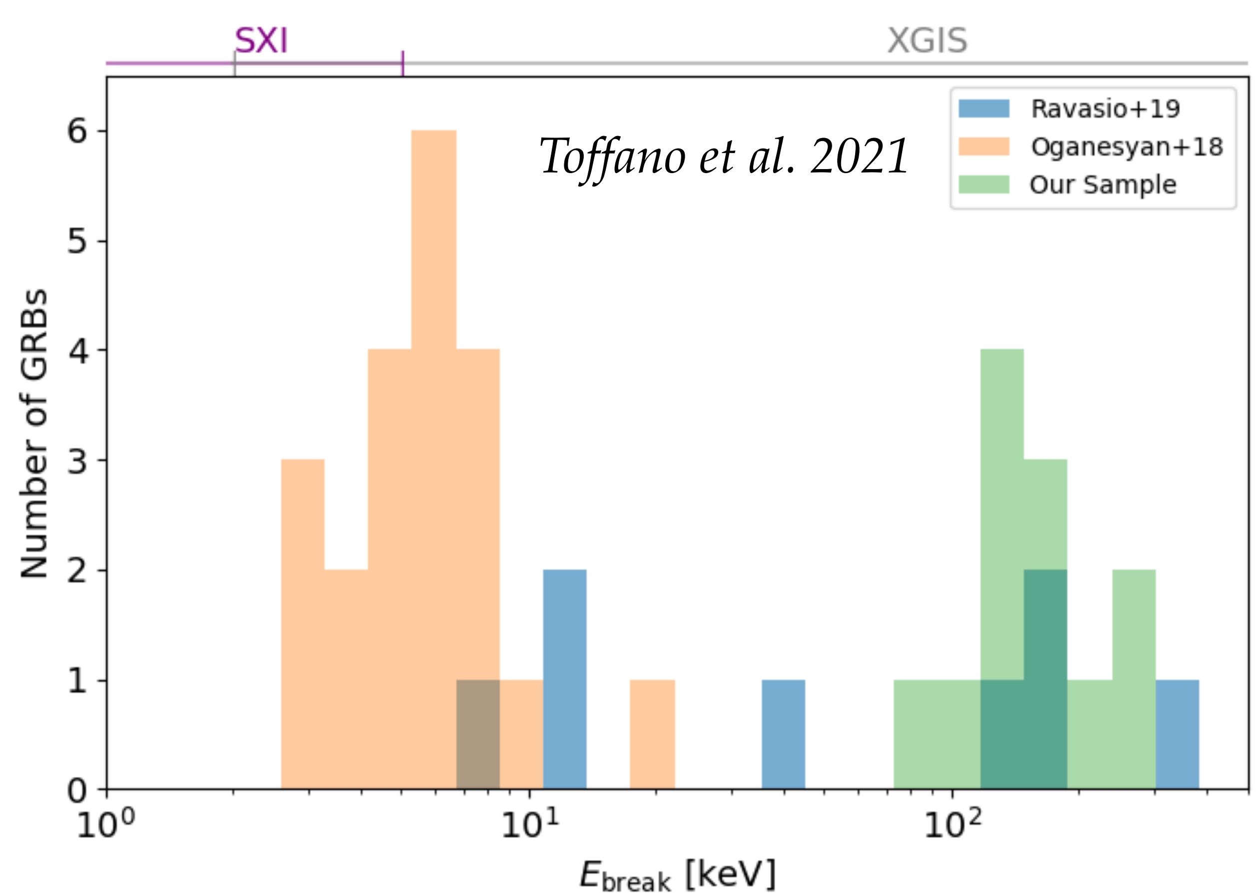
Oganesyan et al. 2017: 14 bright GRBs detected by Swift

Oganesyan et al. 2017a: 34 GRBs detected by Swift

Oganesyan et al. 2018: extension to optical

Fermi/GBM:
- Short and long Fermi GRBs (*Ravasio+2019*) Short Ep ~ Eb
- Synchrotron fits: Bayesian analysis (*Burgess+2019*)

Break distribution currently sparsely sampled (Toffano+2021)

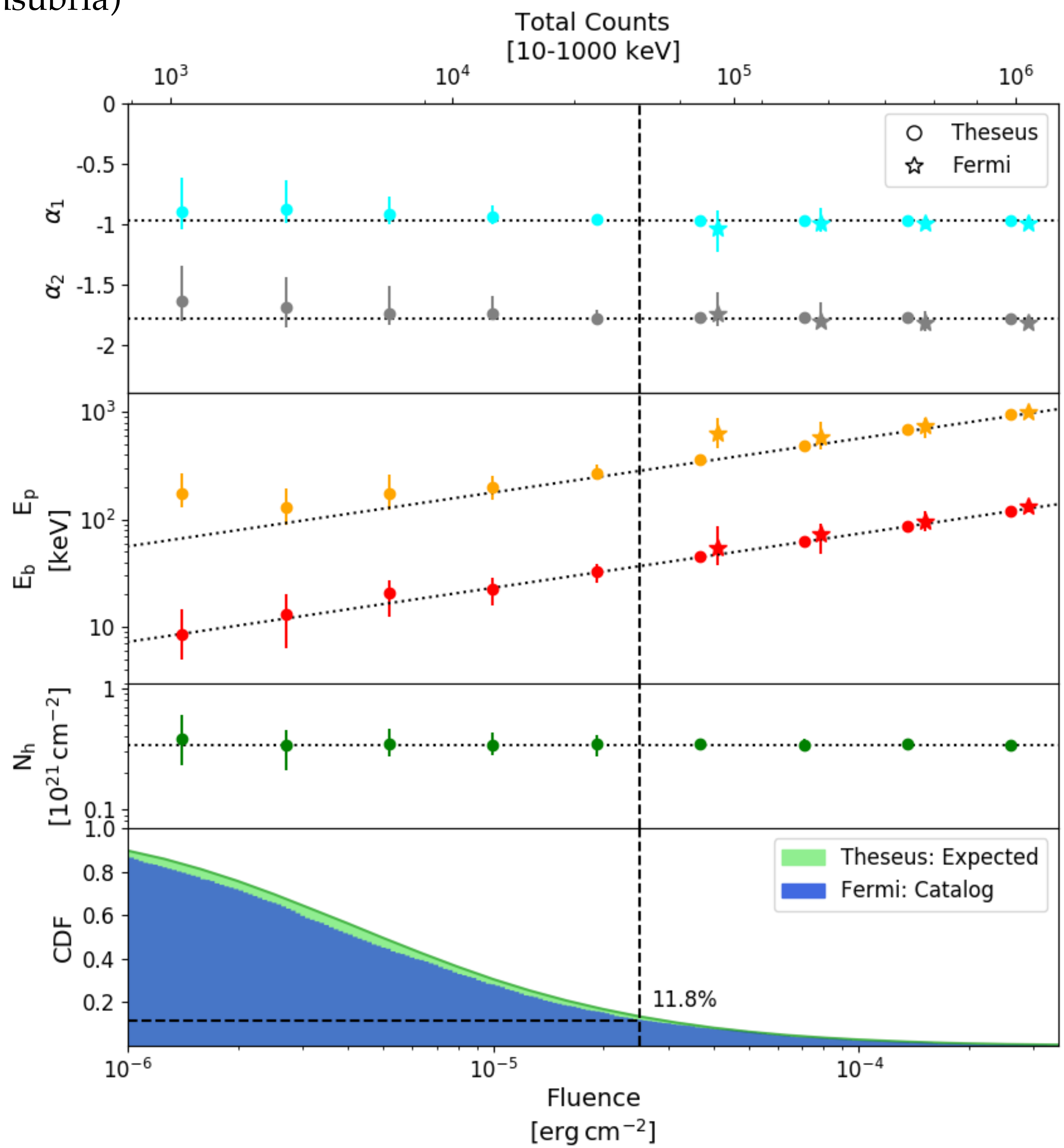


The nature of the prompt emission

Simulations by M. Toffano (PhD Insubria)

Assume a 2break spectrum
break & peak <—> flux

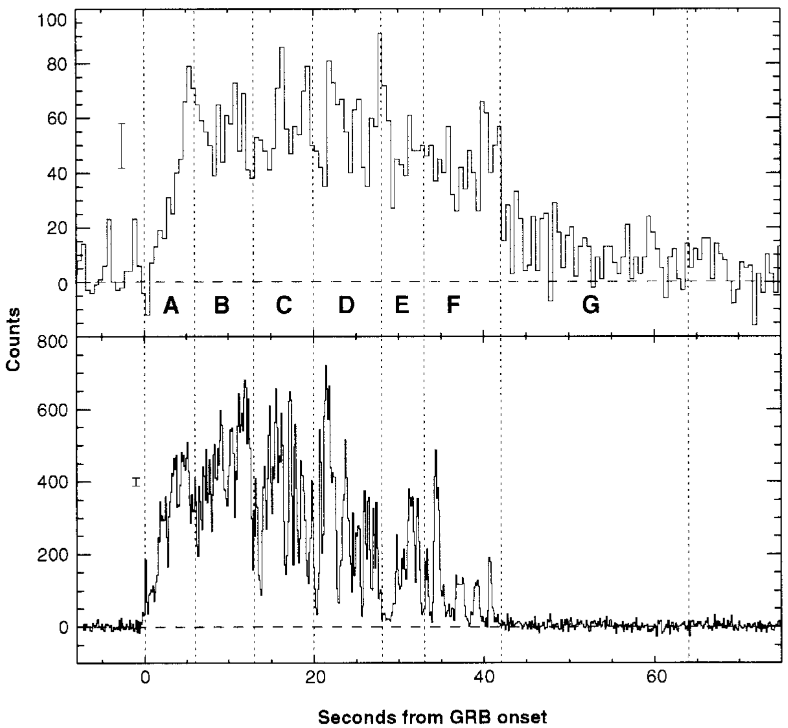
Dotted lines = input values

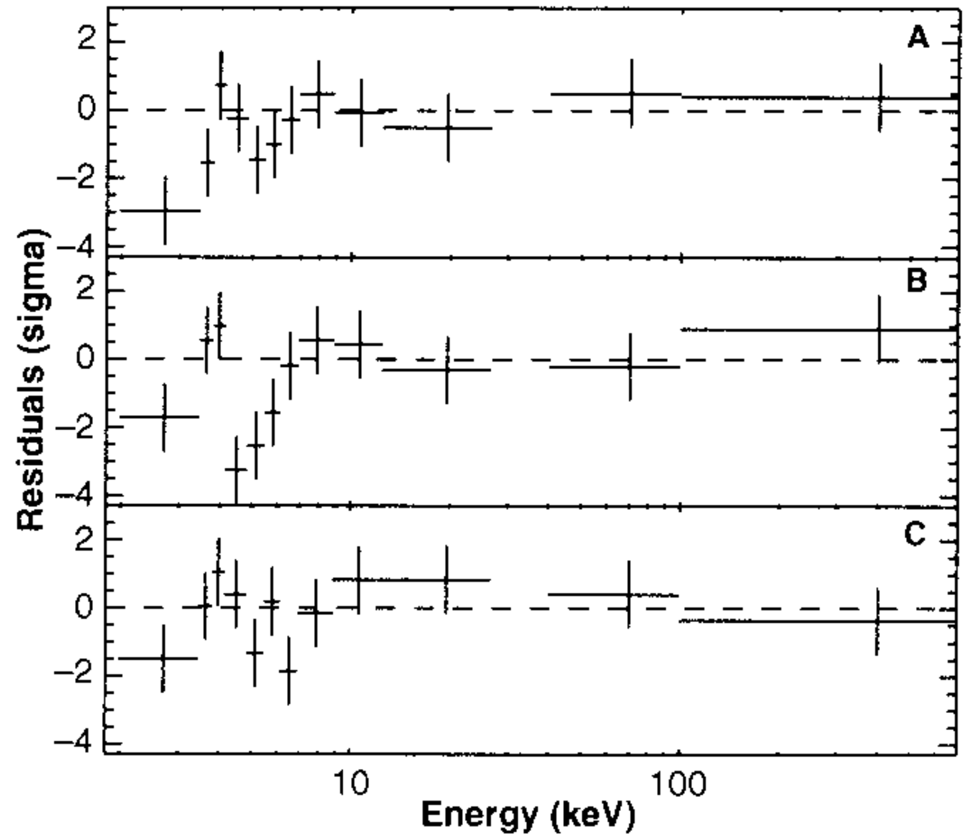


SXI: disentangle intrinsic
from extrinsic curvature

THESEUS: trace the break for
>80% of the XGIS detections

The close ambient: hints on the progenitor





GRB 990507 (Amati+2000)

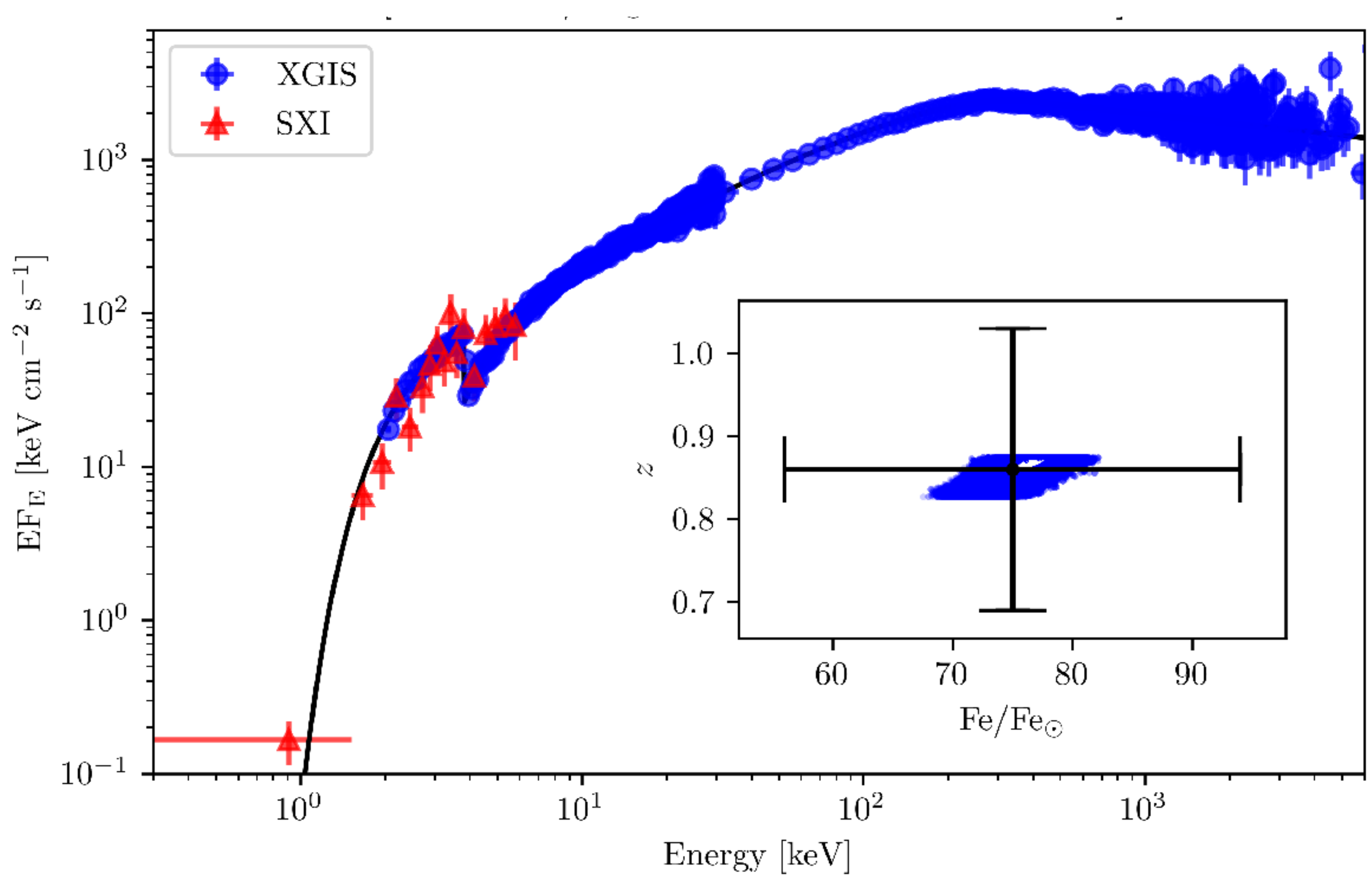
$z = 0.86 \pm 0.17$
$Fe/Fe_{\odot} \sim 75 \pm 19$

σ_z and $\sigma_{\mathrm{Fe/Fe_{\odot}}} \sim 20 - 25\ \%$

GRB 990507 as seen by THESEUS
($N_H = 1.32 \times 10^{22}$ cm^{-2})

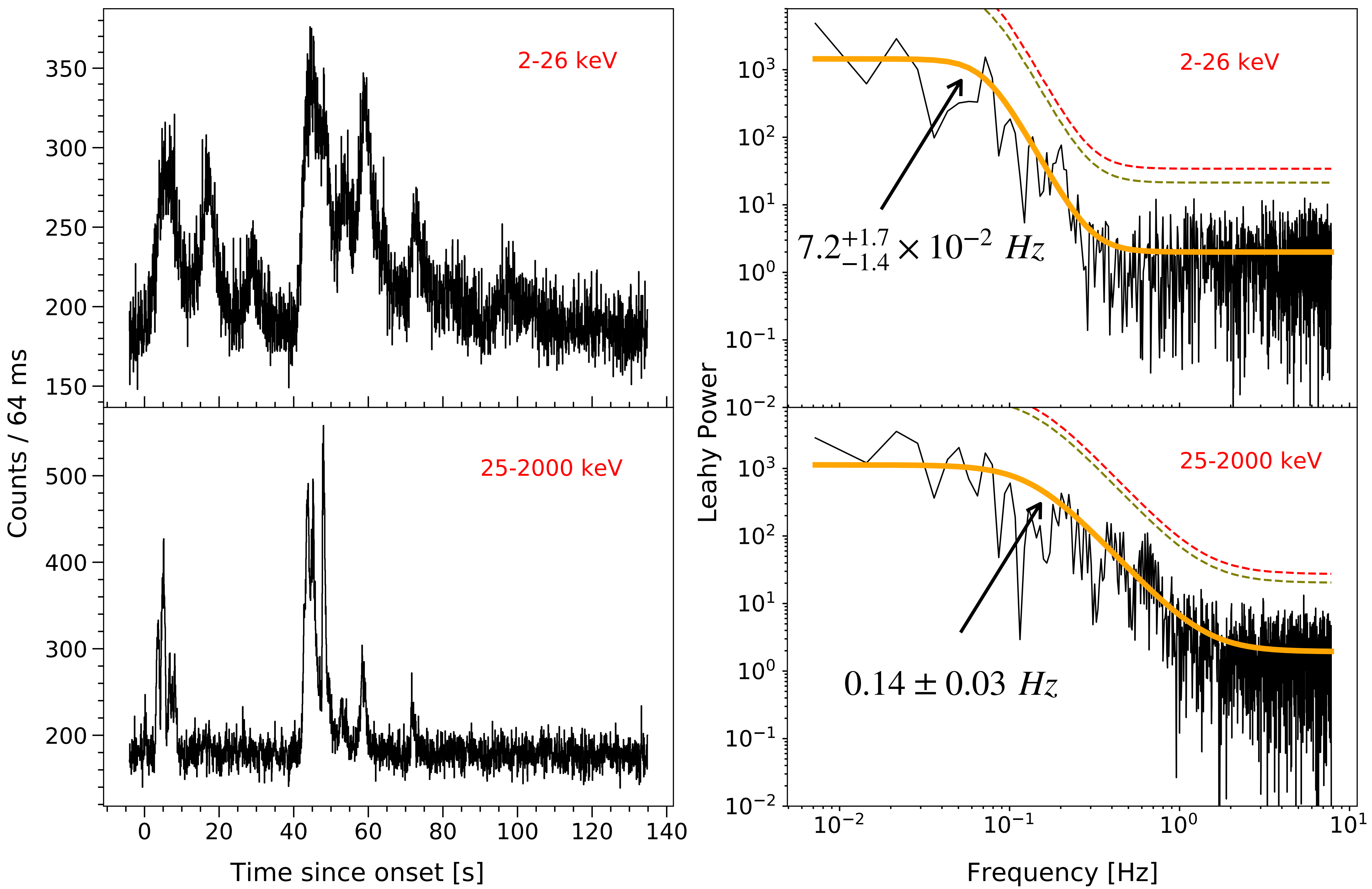
σ_z and $\sigma_{\mathrm{Fe/Fe_{\odot}}} \sim 5\ \%$

Possible hints of the progenitors' explosive nucleosynthesis



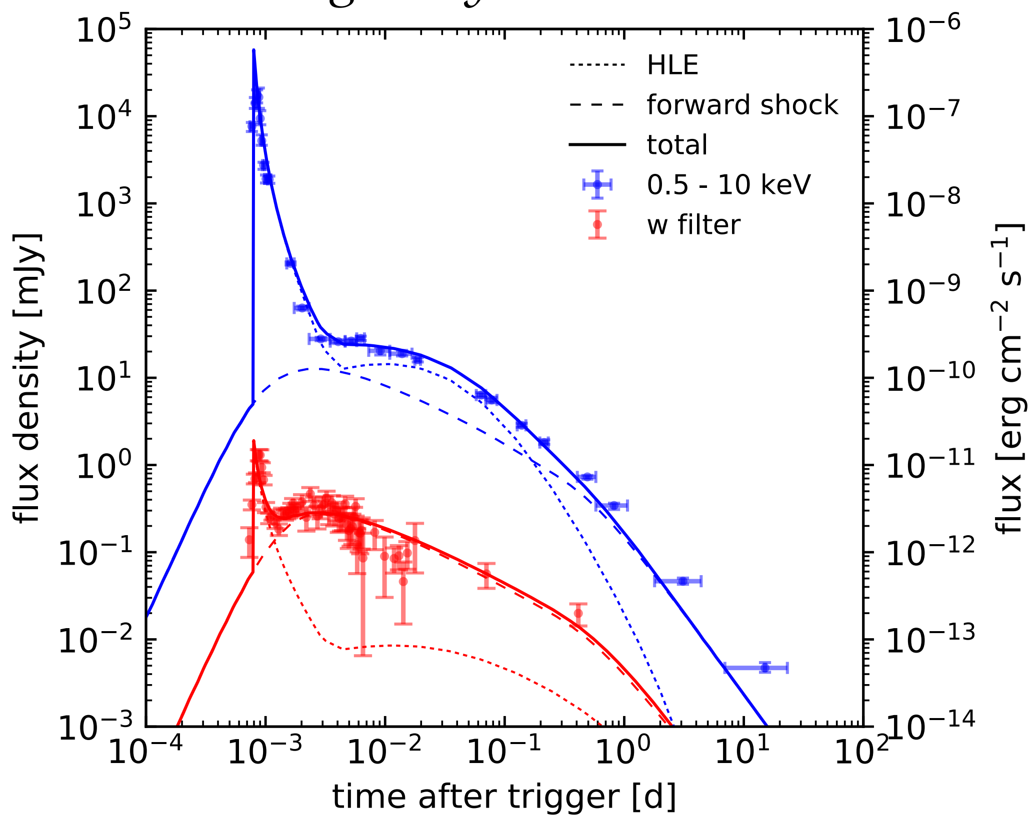
Simulations by C. Guidorzi

GRB 990510



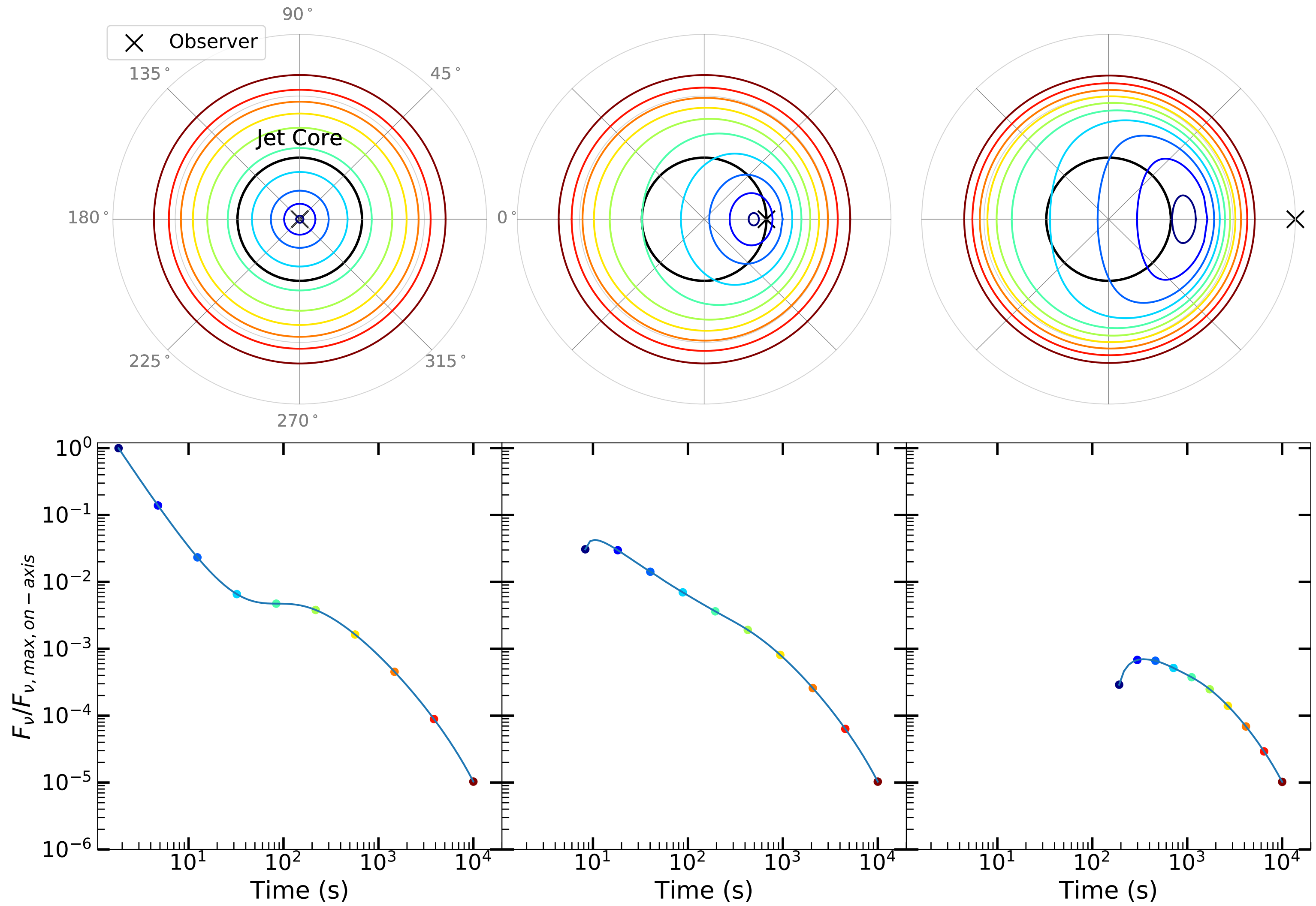
The nature of the early X-ray emission phase

Oganesyan+2020



Steep decay:
High latitude emission from switch off of the prompt emission
Plateau: energy injection in the FS, delayed afterglow emission, two phase structured jet etc ….

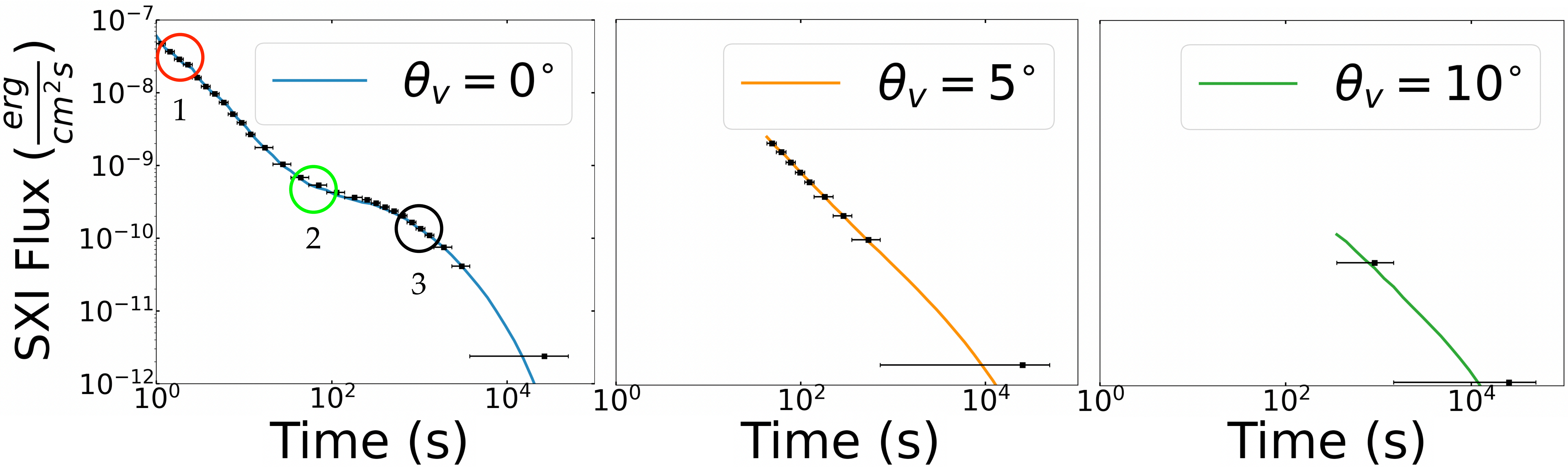
Ascenzi+2021

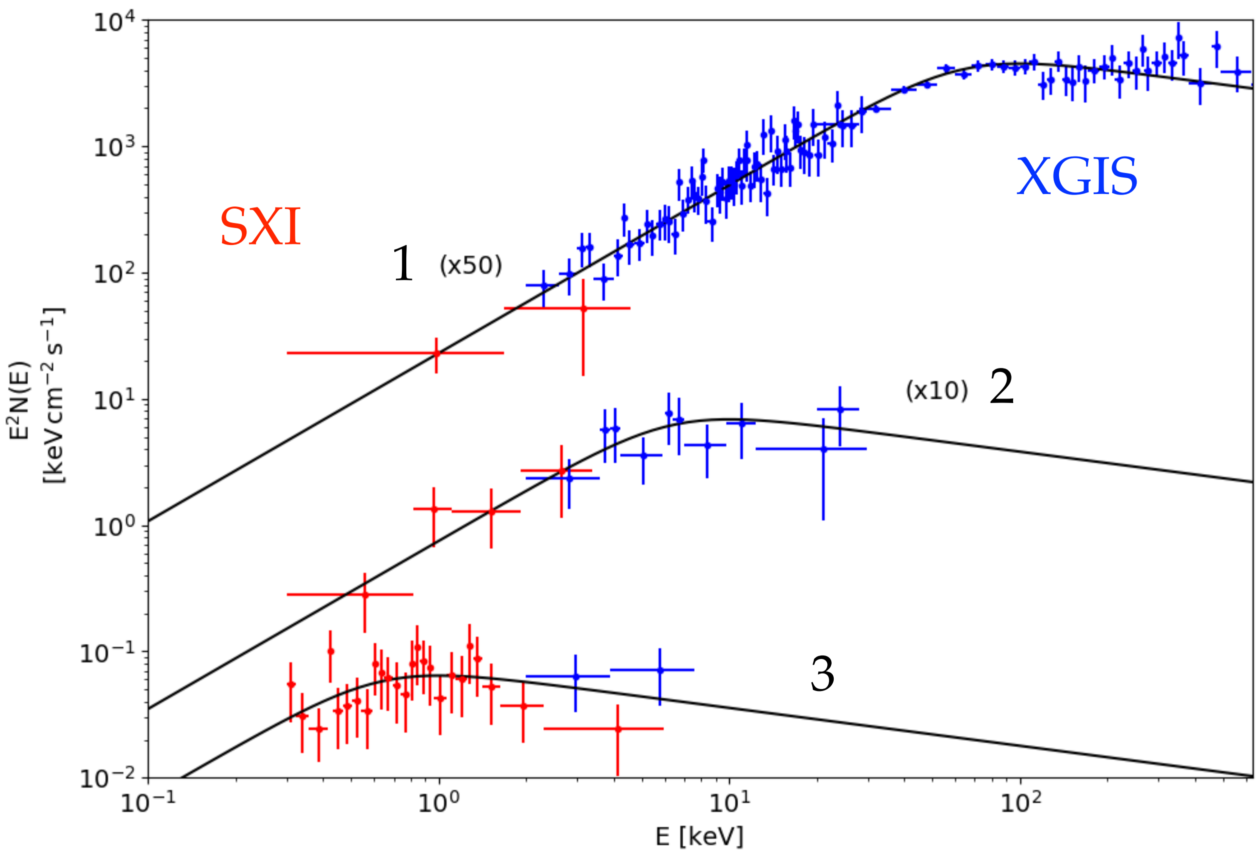


Structured jet

The nature of the early X-ray emission phase

Simulations by S. Ronchini (PhD GSSI)





Simulations by M. Toffano (PhD Insubria)

Ronchini+2021: spectral evolution can reveal the physical nature of the early X-ray emission

THESEUS can monitor it (with the unique extension of XGIS)

Conclusions

- Population studies to estimate GRB detection rates by THESEUS (x 20 current sample of GRBs @ z>6 … stay connected)
- GRB prompt emission: characterise the low energy shape of the spectrum (break and/or thermal component) to infer
  1) nature of the radiative process(es)
  2) jet energy content
  3) Emission region physical properties for >80% of the events
- Study the progenitors through metal absorption signatures
- Understand the nature of the dissipation mechanism through variability studies over unprecedented wide energy range
- Unveil the origin of the steep-plateau emission phases

WG4 white paper on Exp. Astron THESEUS special issue