Probing the multiwavelength emission scenario of GRB 190114C

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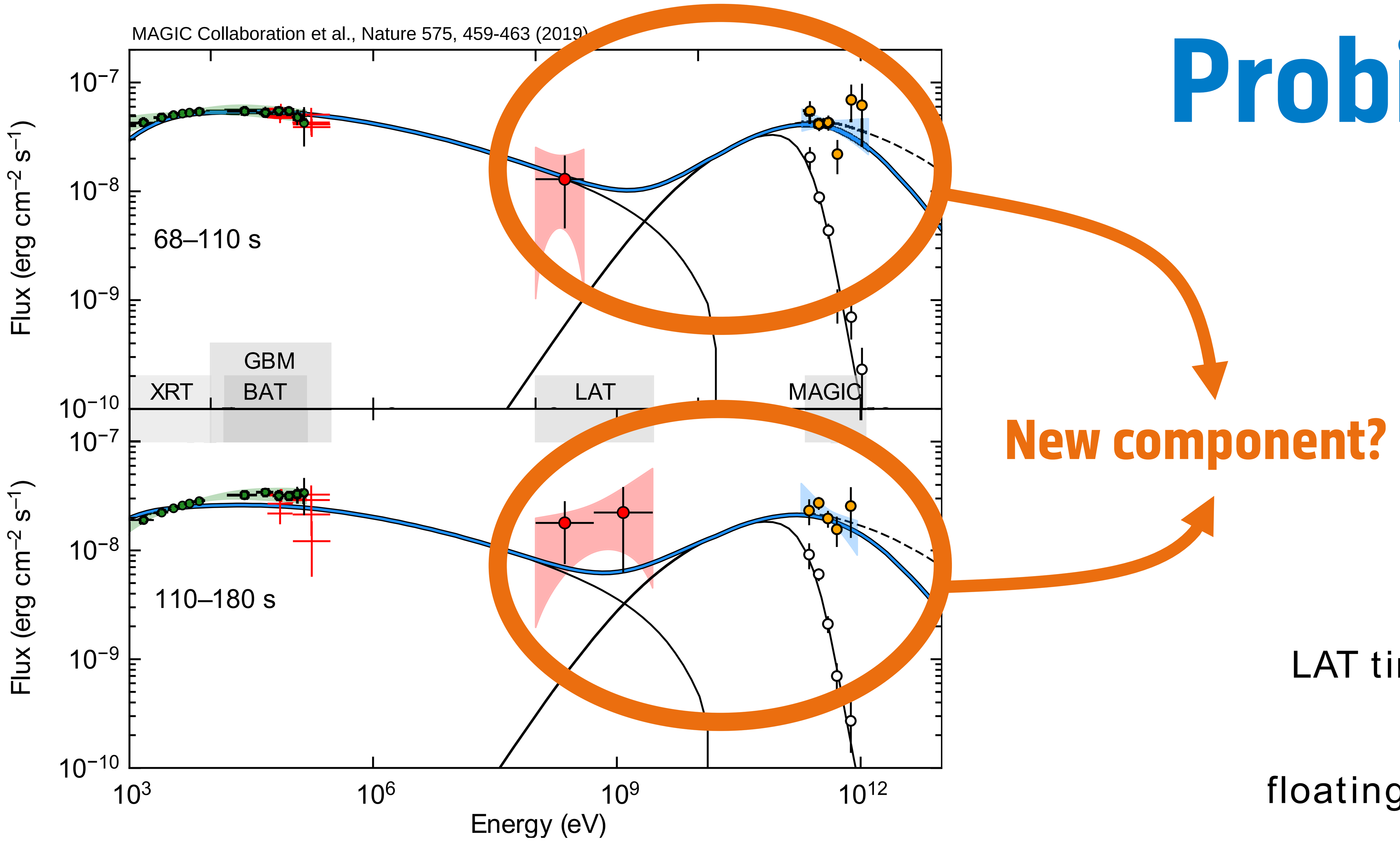
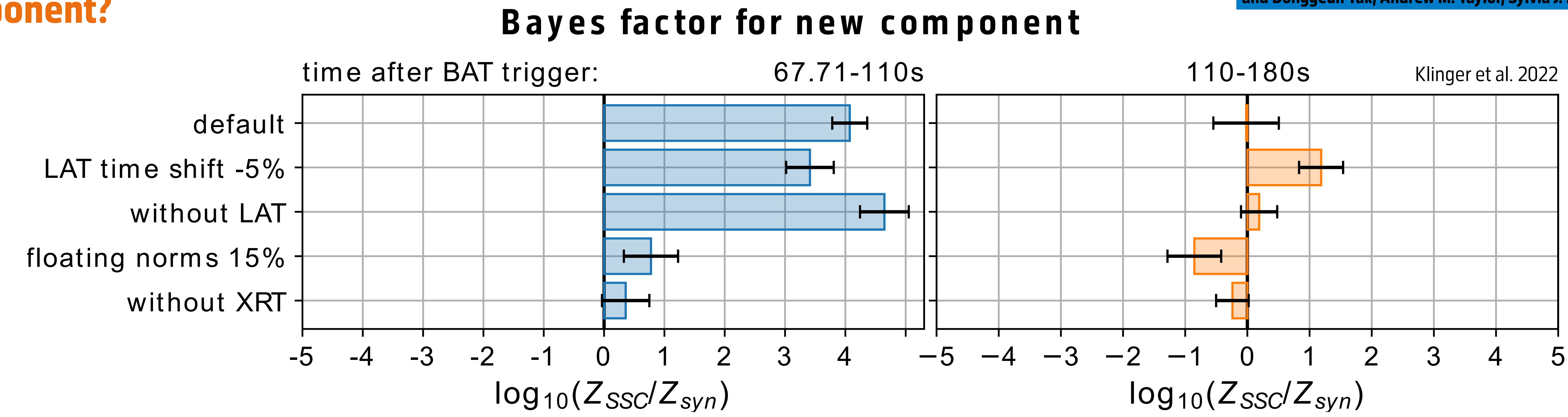
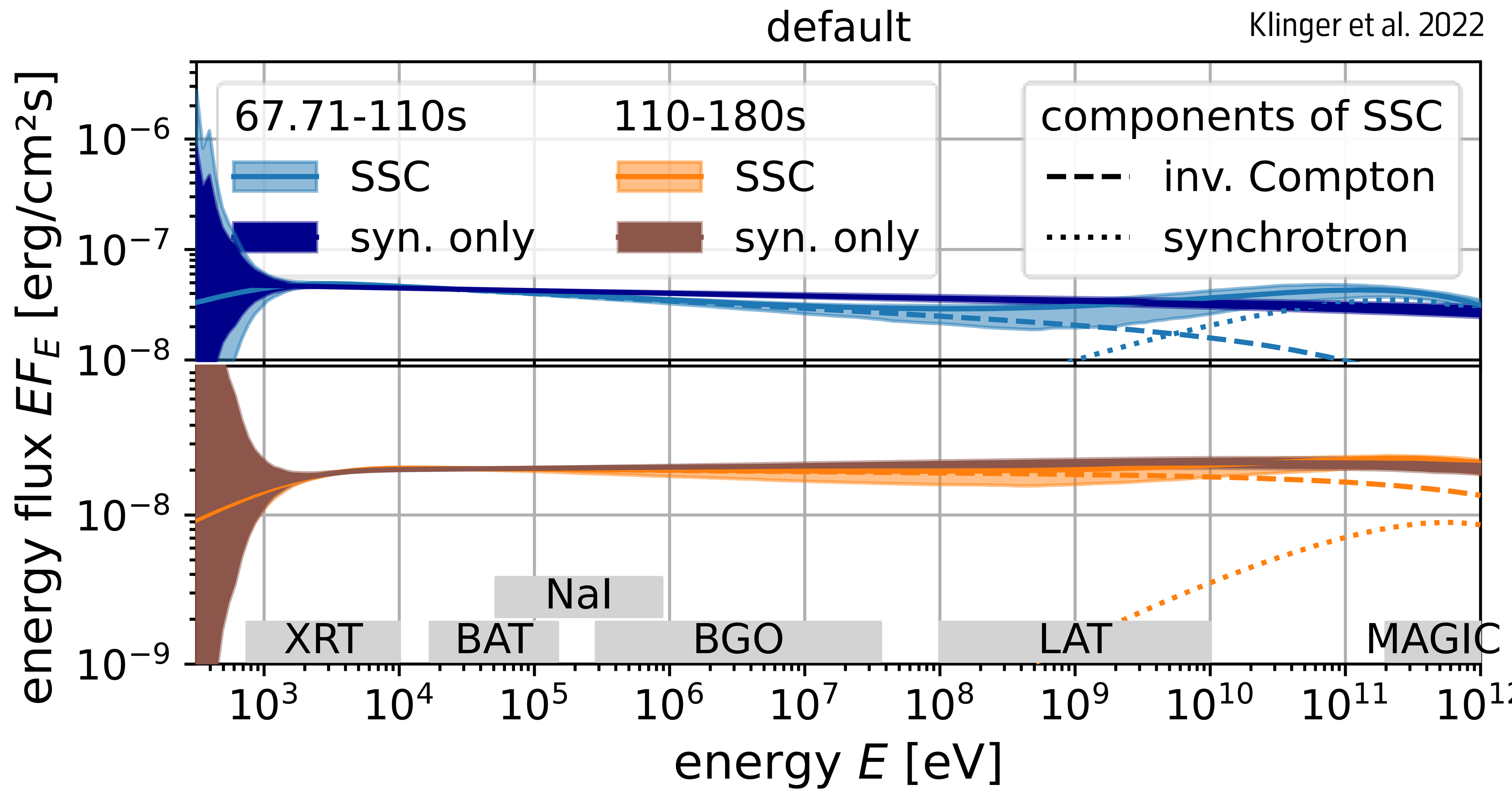




Summary:

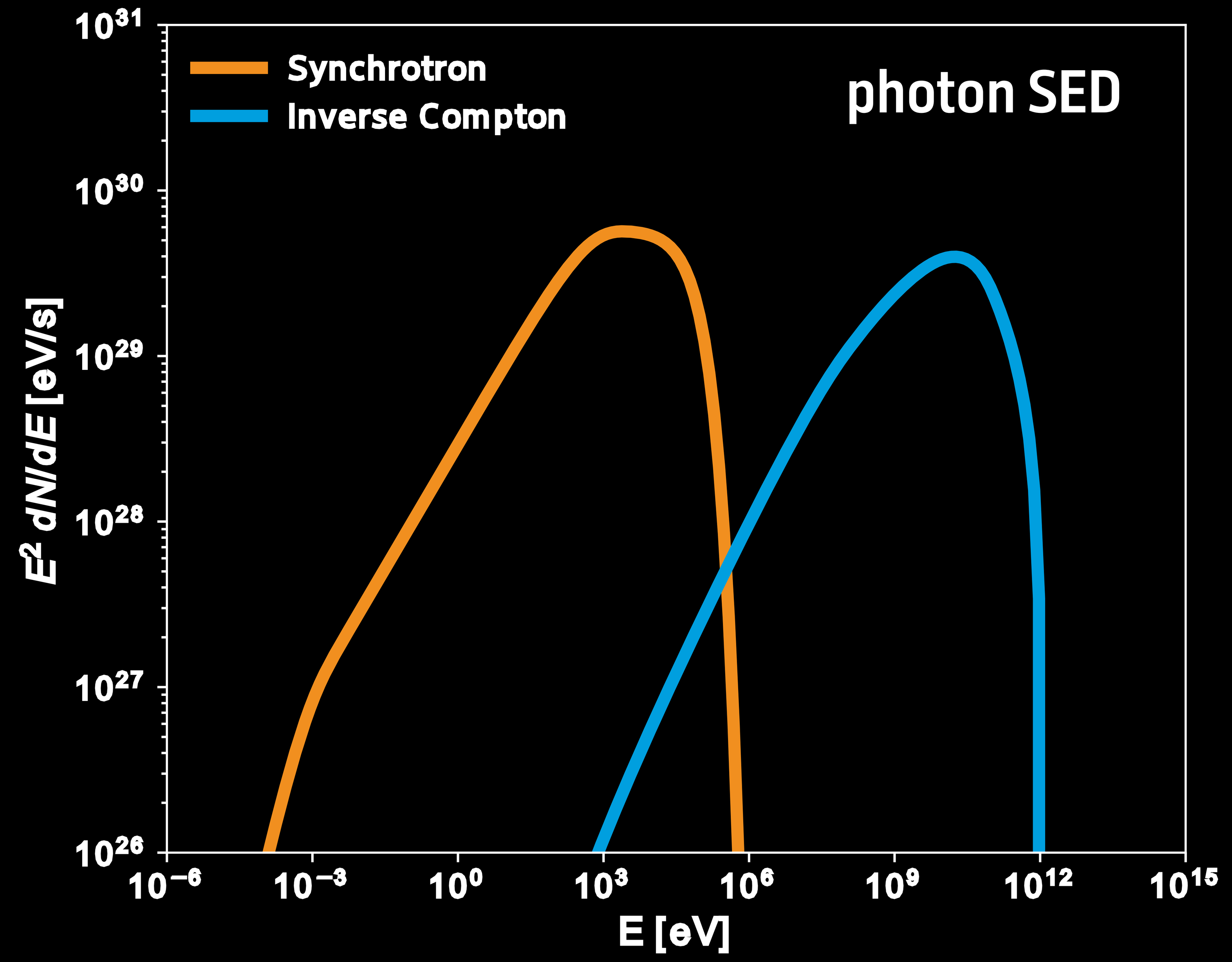
- Synchrotron-Self Compton (SSC) proposed as natural emission mechanism for Very-High-Energy component of GRB 190114C[1]
- we evaluate the statistical preference for the existence of this component against a single-component synchrotron model[2]
- we find for the first time interval (68-110s):
  - → existing analysis agrees with statistical preference for inverse Compton component
  - → *Fermi*-LAT data at dip is not strong enough for significant constraints
  - → *Swift*-XRT data drives preference for new component, which can be significantly alleviated by including realistic cross-calibration uncertainty
- we find no significant preference in the second time interval (110-180s)



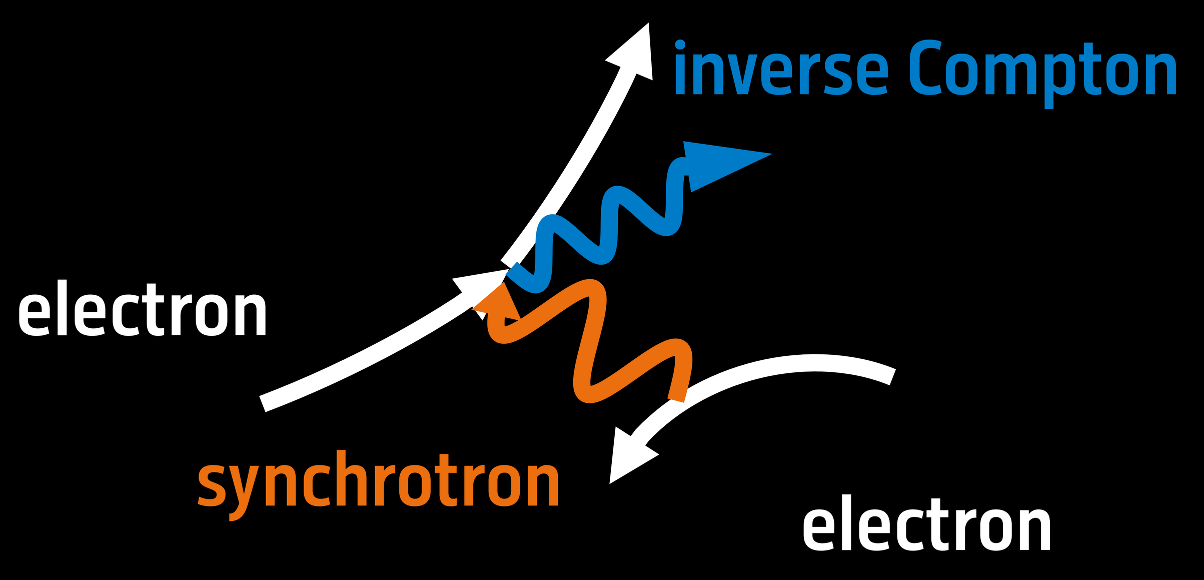
References:

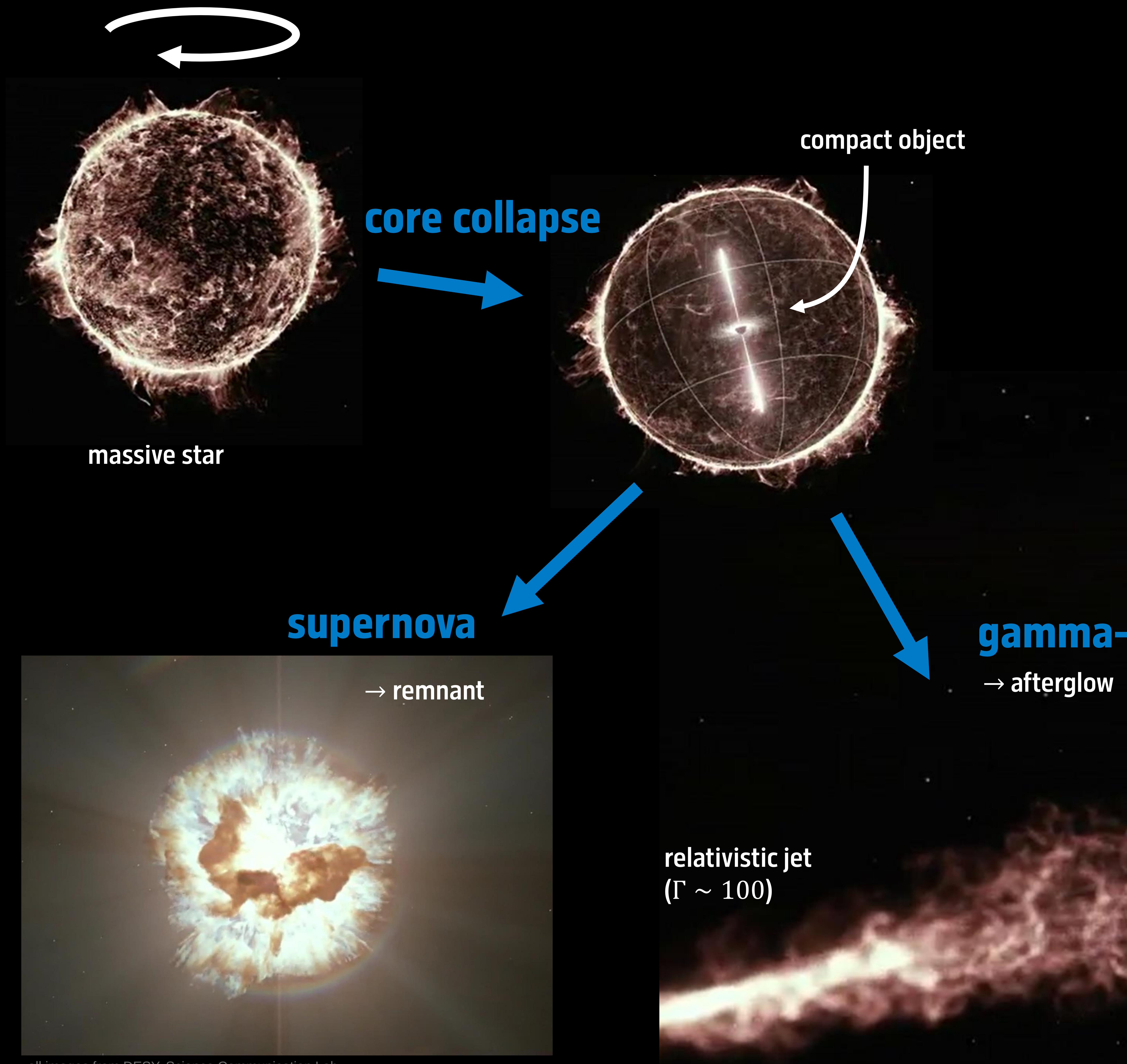
1. MAGIC Collaboration et al., Nature 575, 459-463 (2019)
2. Klinger et al. 2022, submitted to APJL, arXiv: 2206.11148

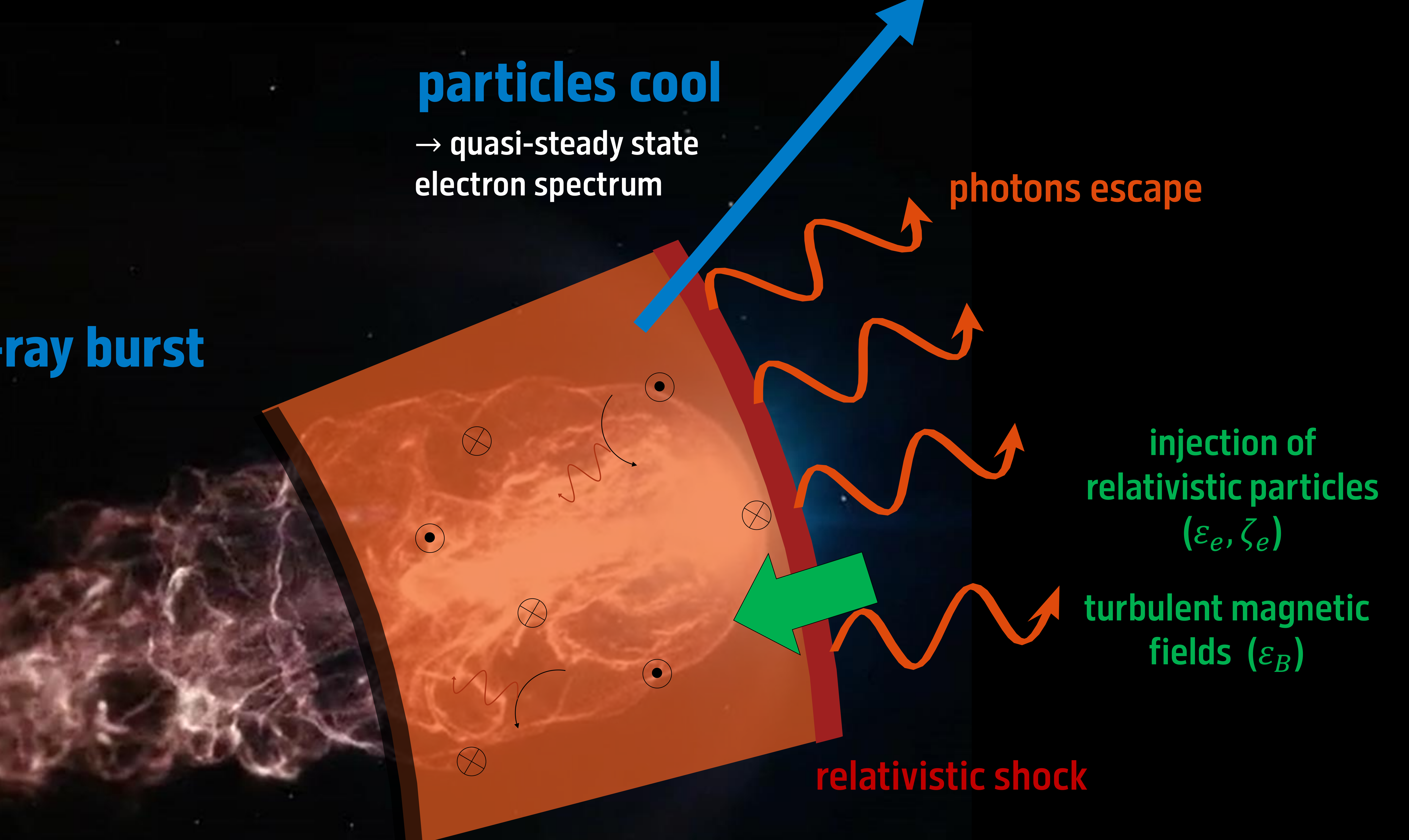
Fireball model: Long GRB



synchrotron self-Compton
(SSC)







gamma-ray burst
→ afterglow

Homogeneous shell of
electrons/positrons and photons

all images from DESY, Science Communication Lab

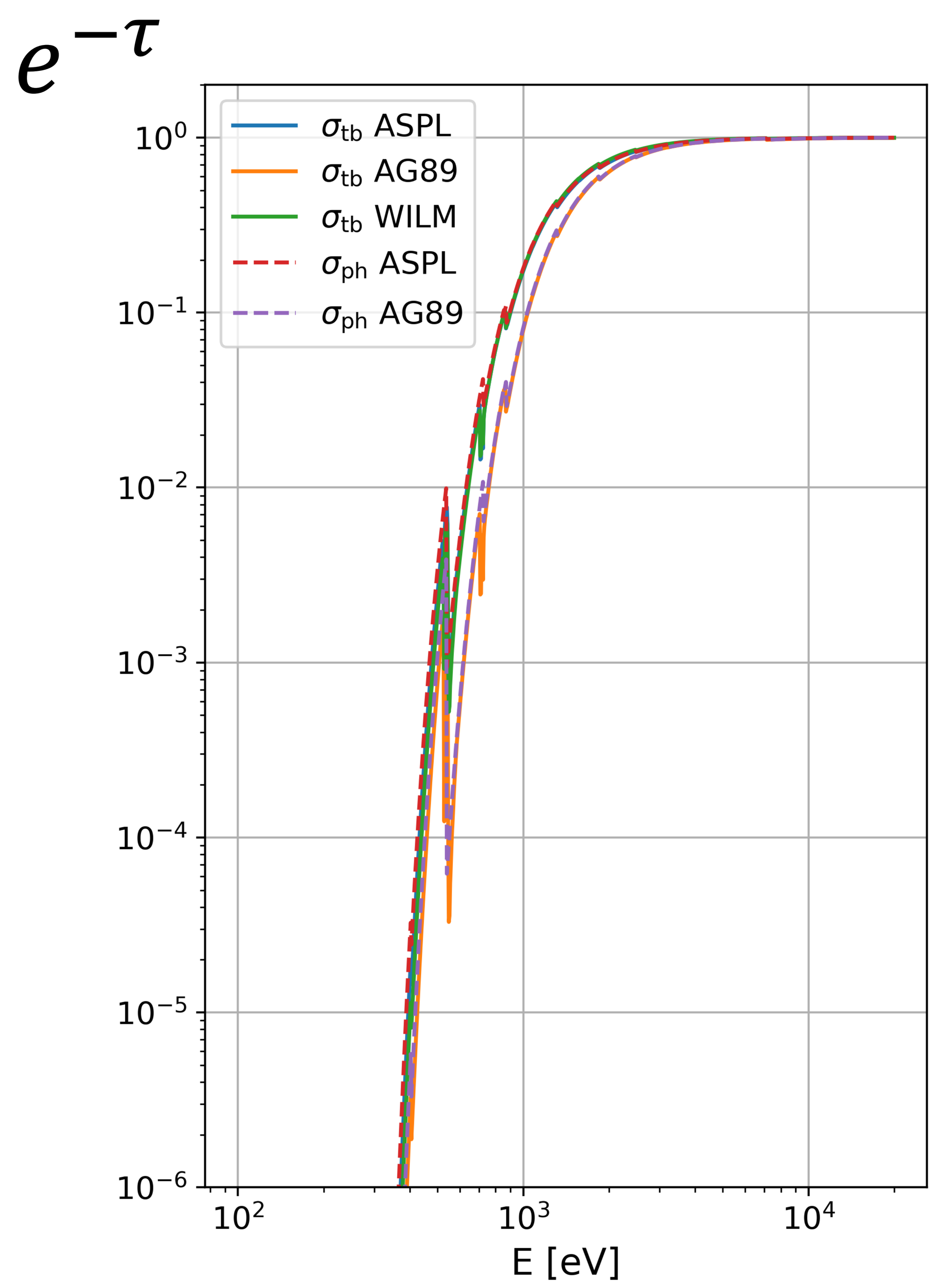
Counts level fitting:

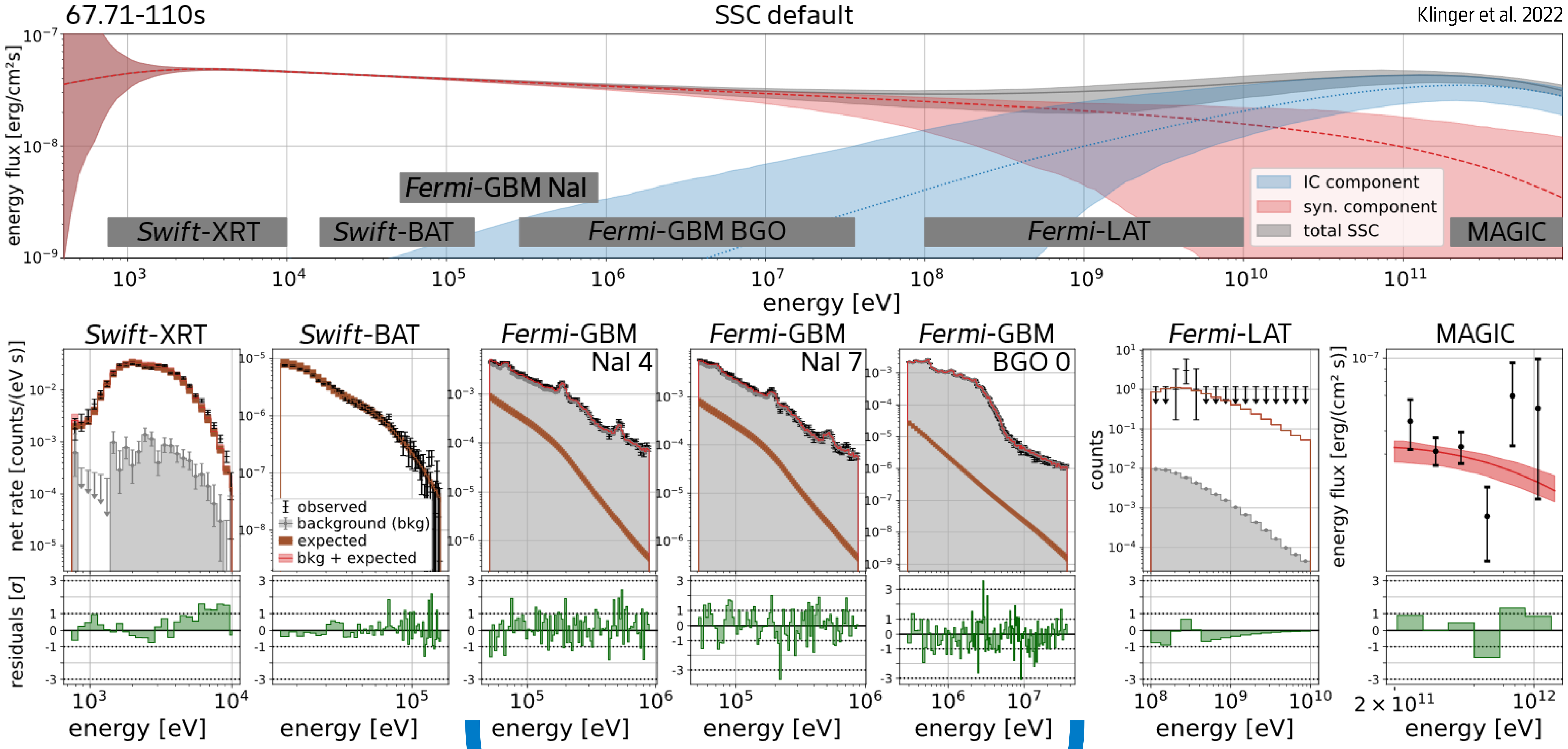
→ first time bin 67.71-110s

Counts rate $(E) = \int \mathrm{d}\hat{E} \, \frac{\mathrm{d}N_{\text{source}}}{\mathrm{d}E\, \mathrm{d}t\, \mathrm{d}A}(\hat{E}) \, \exp\left(-\tau(\hat{E})\right) A_{\text{eff}}(E,\hat{E})\, c_{\text{sys}}$ **+ Background rate**

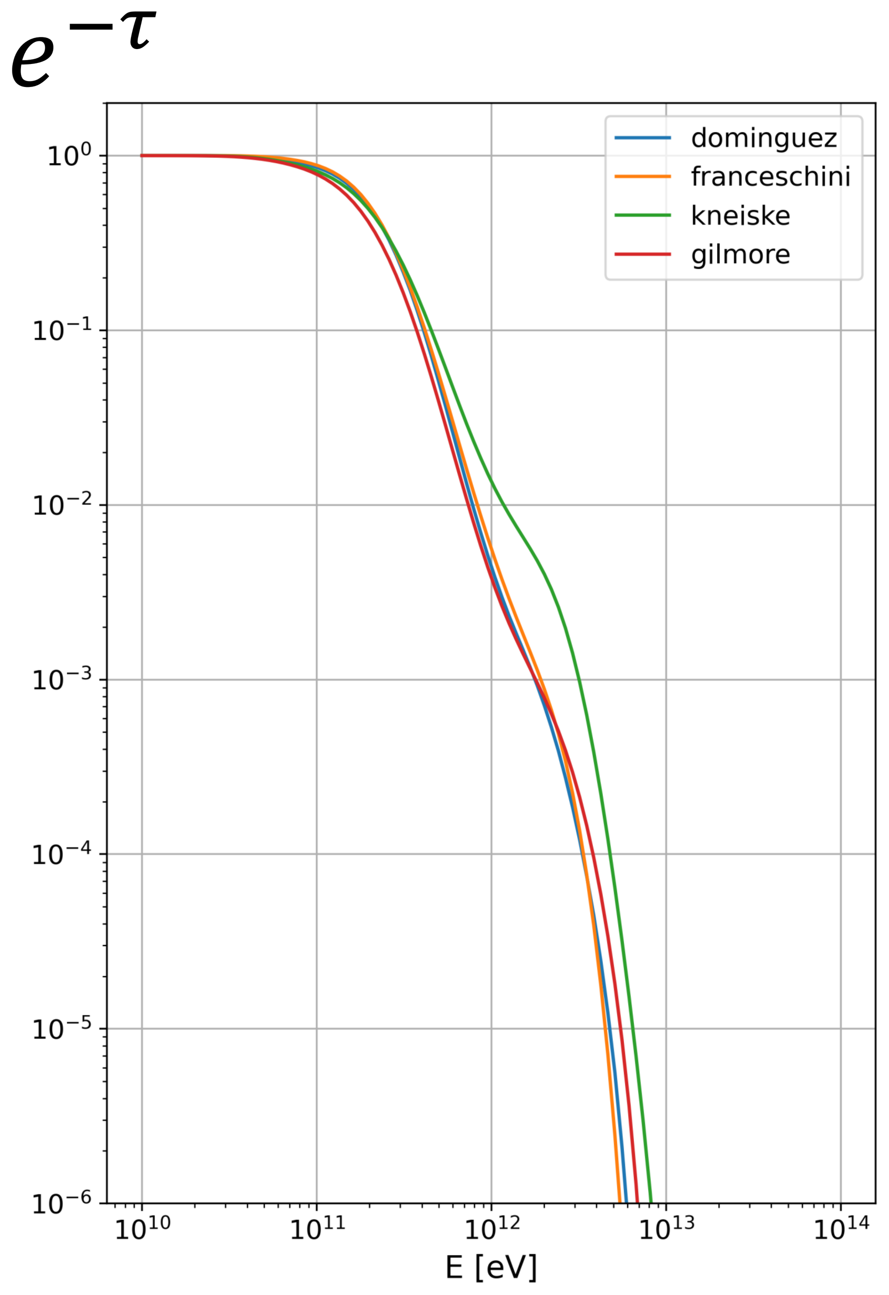
source model flux | absorption | instrument response

photoelectric absorption





EBL absorption (pair production)



Swift-XRT

imaging → background region
→Cash-statistic (Poisson-Poisson)

single fit with power law + absorption:
→ spectral index -1.75 ± 0.07

Swift-BAT

coded mask → background fitted
→ χ^2 statistic (Gaussian)

single fit with power law:
→ spectral index -2.009 ± 0.027

Fermi-GBM (NaI + BGO)

photon counter→ background fitted
→ PGstat (Poisson+Gaussian)

single fit with power law:
→ spectral index -1.94 ± 0.1

Fermi-LAT

photon counter→ background templates
→ PGstat (Poisson+Gaussian)

single fit with power law:
→ spectral index not really constrained

MAGIC

only EBL-deabsorbed flux points public
→ χ^2 statistic (Gaussian)

single fit with power law:
→ spectral index $-2.16^{+0.29}_{-0.31}$

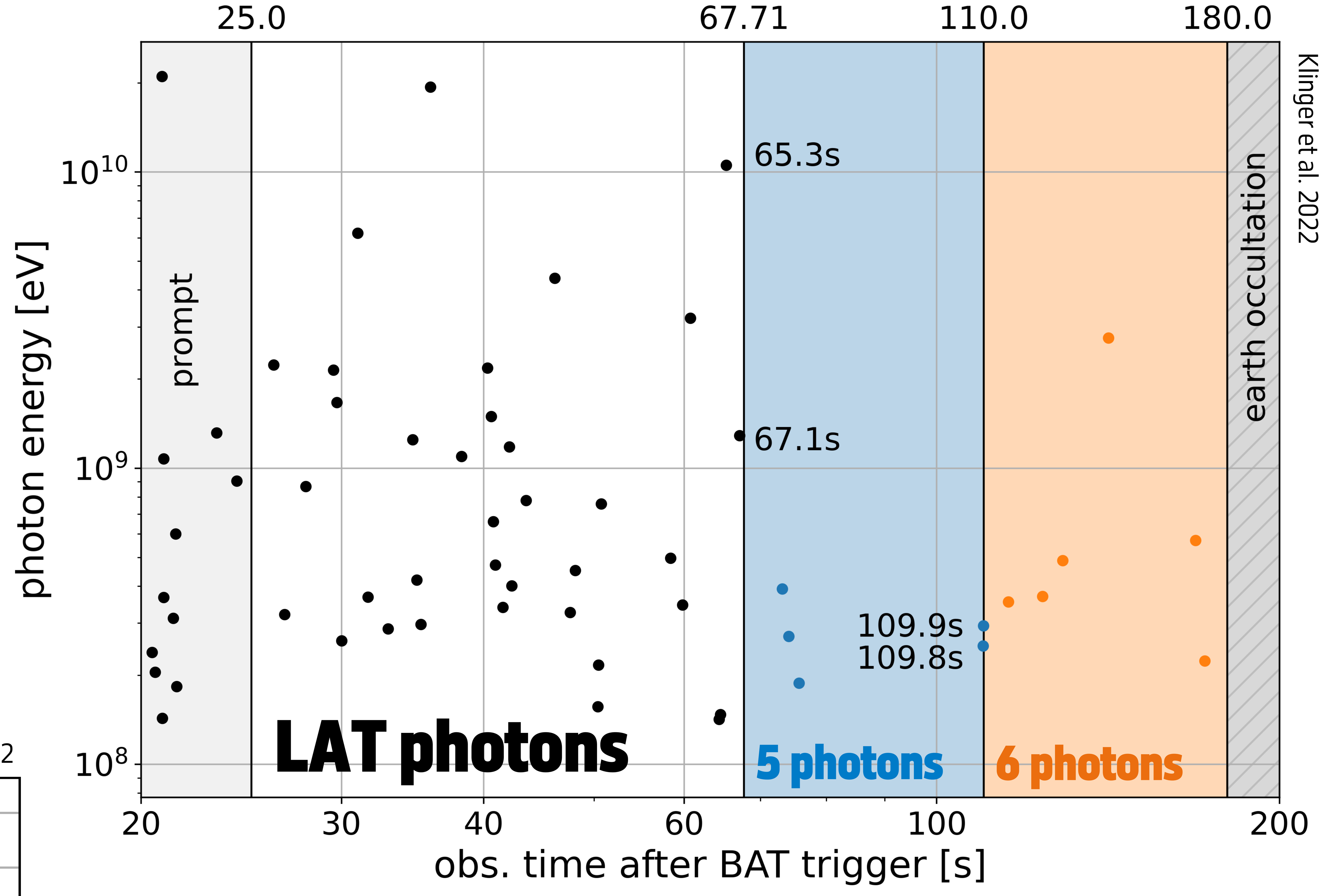
We use the Multi-Mission Maximum Likelihood framework (3ML)
see https://github.com/threeML/threeML

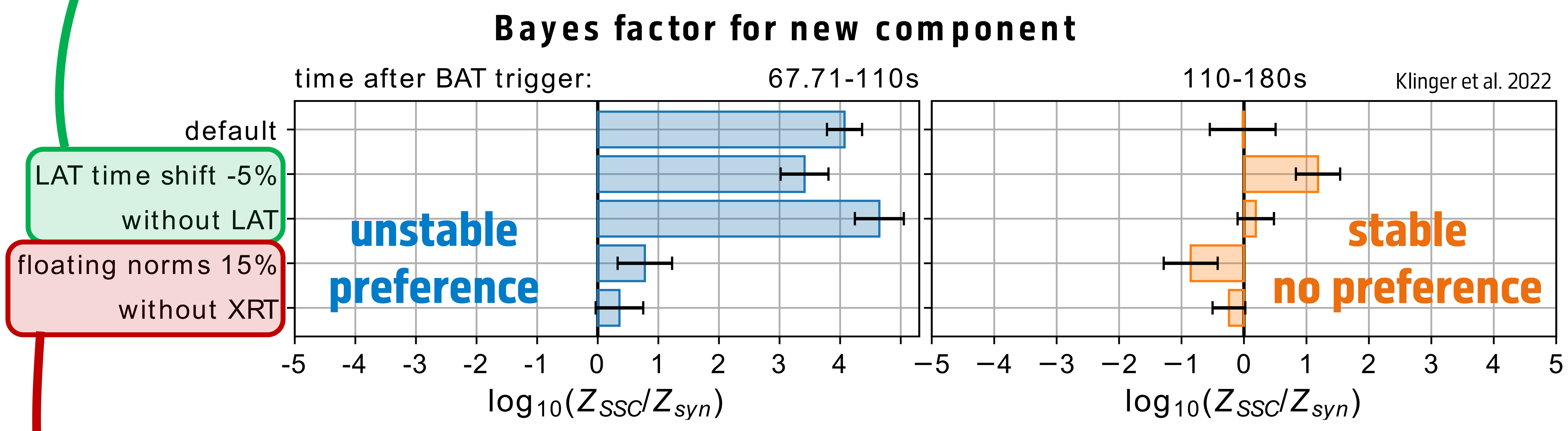
Stability of Preference

***Fermi*-LAT:**

- very few photons:
  → leave out *Fermi*-LAT: no effect
- particular selection time window: photons within 1s of bin edges
  → shift window in time by -2.1s : no effect

→ ***Fermi*-LAT data not very strong!**

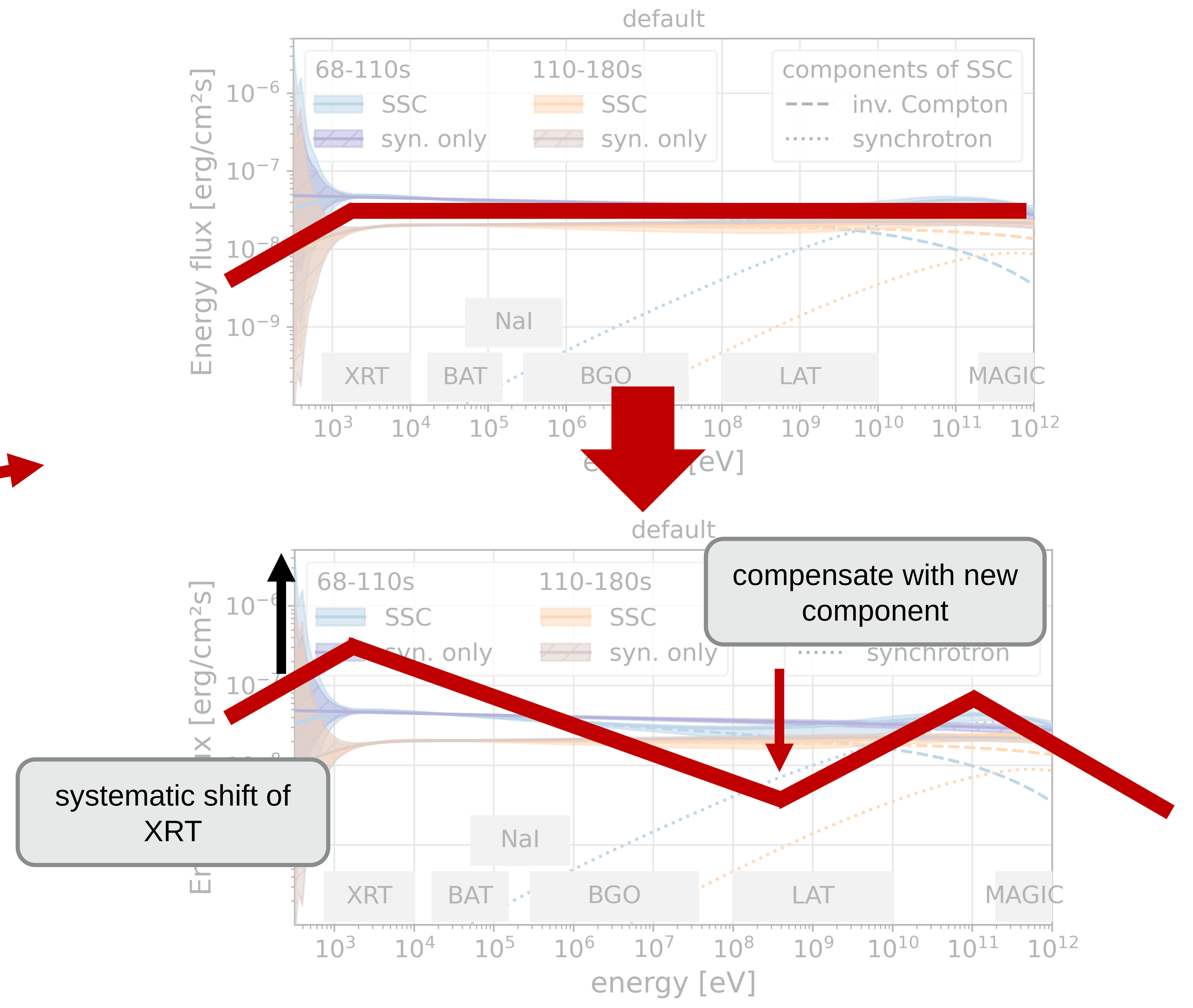




***Swift*-XRT (first time bin 67.71-110s):**

- only instrument with spectral index ≠ -2
  → leave out *Swift*-XRT: no preference anymore
- cooling break very sharp: Swift-XRT norm appears slightly enhanced
  → introduce systematic uncertainty $< \pm 15\%$ for **all** instruments: no preference anymore
  → can not exclude contribution of decaying prompt component

→ ***Swift*-XRT data drives new component!**



Bayesian Model Comparison

- Bayesian approach
  - → $posterior = \frac{likelihood}{evidence} \cdot prior$
  - → (sometimes log) uniform priors
  - → evidence: $Z = \int d\vec{\theta}\ likelihood \cdot prior$
    (→ likelihood averaged over parameter space weighted with priors)
- sample posterior (→ UltraNest: https://johannesbuchner.github.io/UltraNest/)
  - → detect multiple maxima?
- model comparison via Bayes factor
  - → quantitative way of measuring preference of model 1 over model 2
  - → metric scale crucial