Understanding the spectrum of Gamma-Ray Burst 190114C

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13.01.2022

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HELMHOLTZ WEIZMANN RESEARCH SCHOOL MULTIMESSENGER ASTRONOMY

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

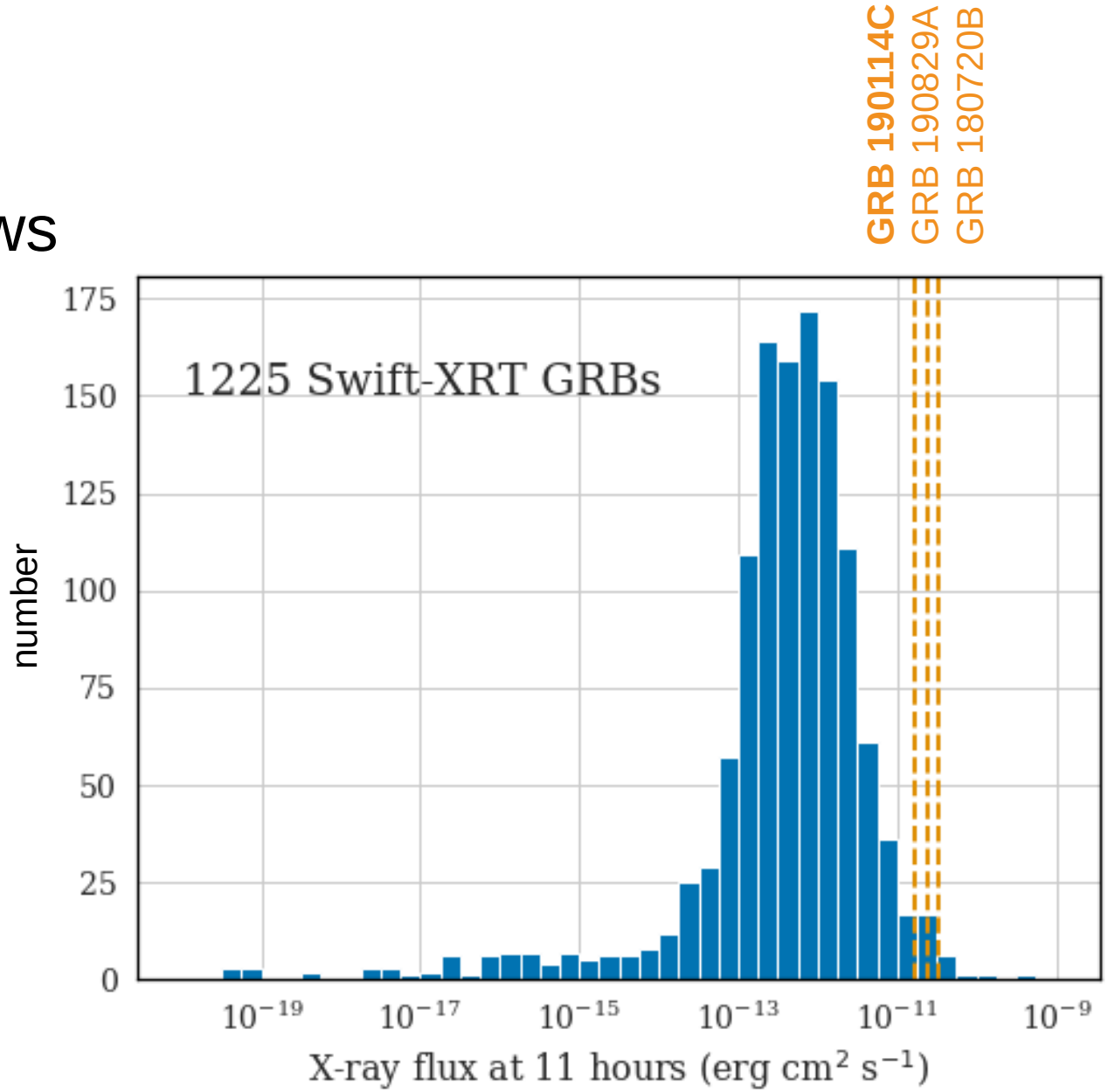
GRB 190114C - Afterglow

- one of the brightest GRB afterglows
- rich dataset

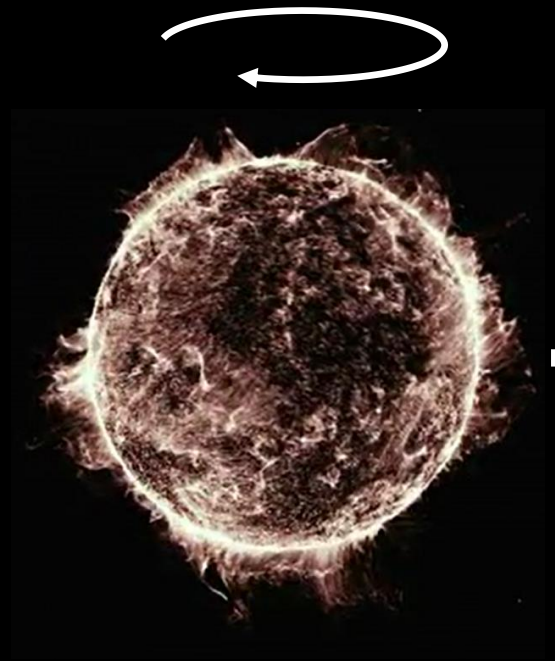
  → Swift: XRT, BAT

  → Fermi: GBM, LAT
- intermediate redshift ($z = 0.42$)

  → VHE detection up to 40min!

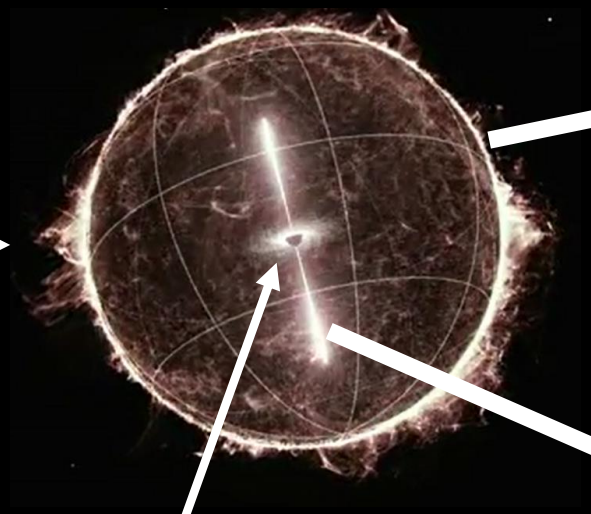


Standard model: Long GRB



massive star
rotating

$\sigma(10^{10} cm)$



core collapse

compact object
$\sigma(10 km \sim 10^{6} cm)$

supernova

jet

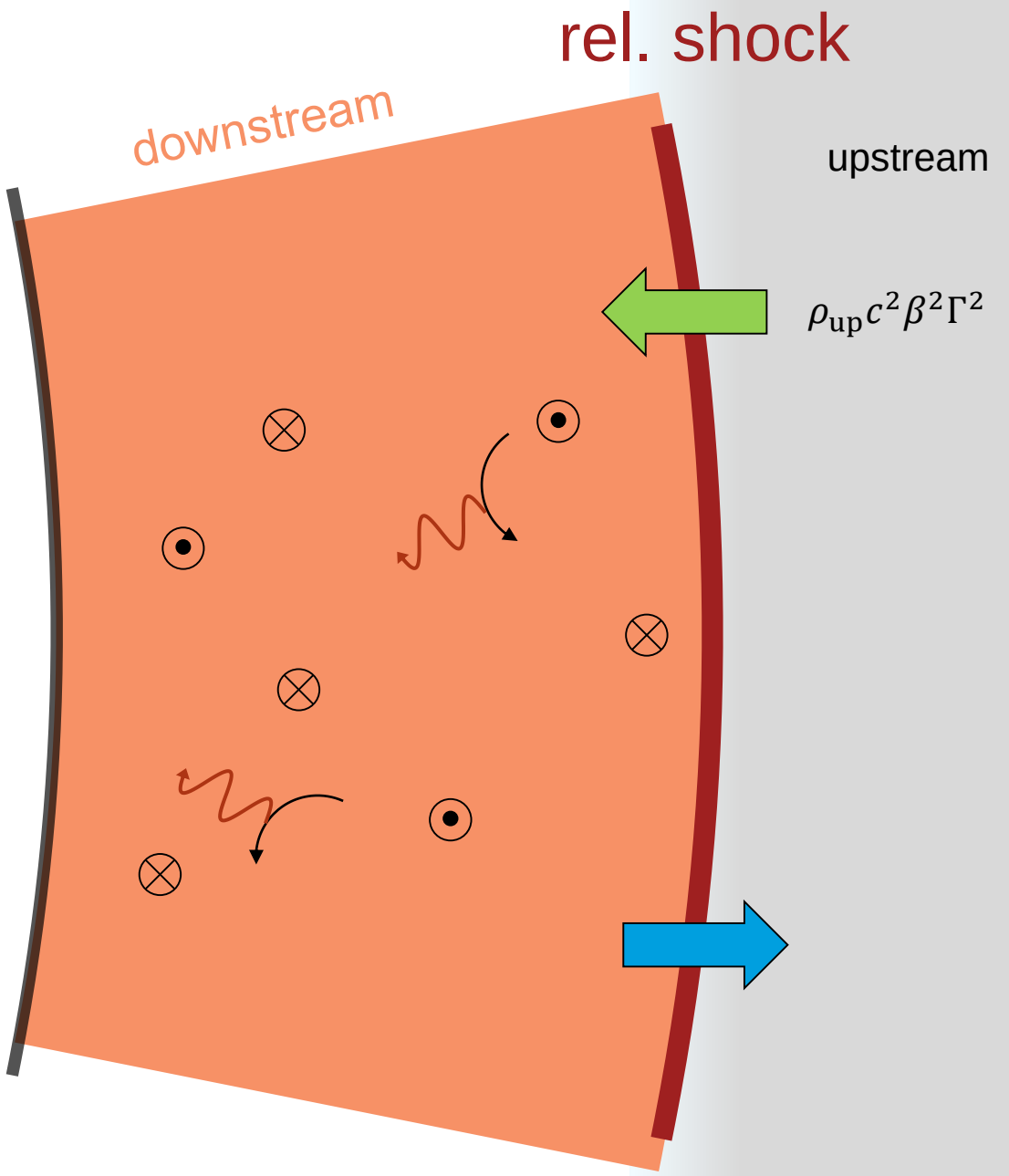
remnant
=
afterglow

relativistic plasma shell

$\sigma(10^{16} cm \sim 0.01 lyr)$

Simple Box Assumption

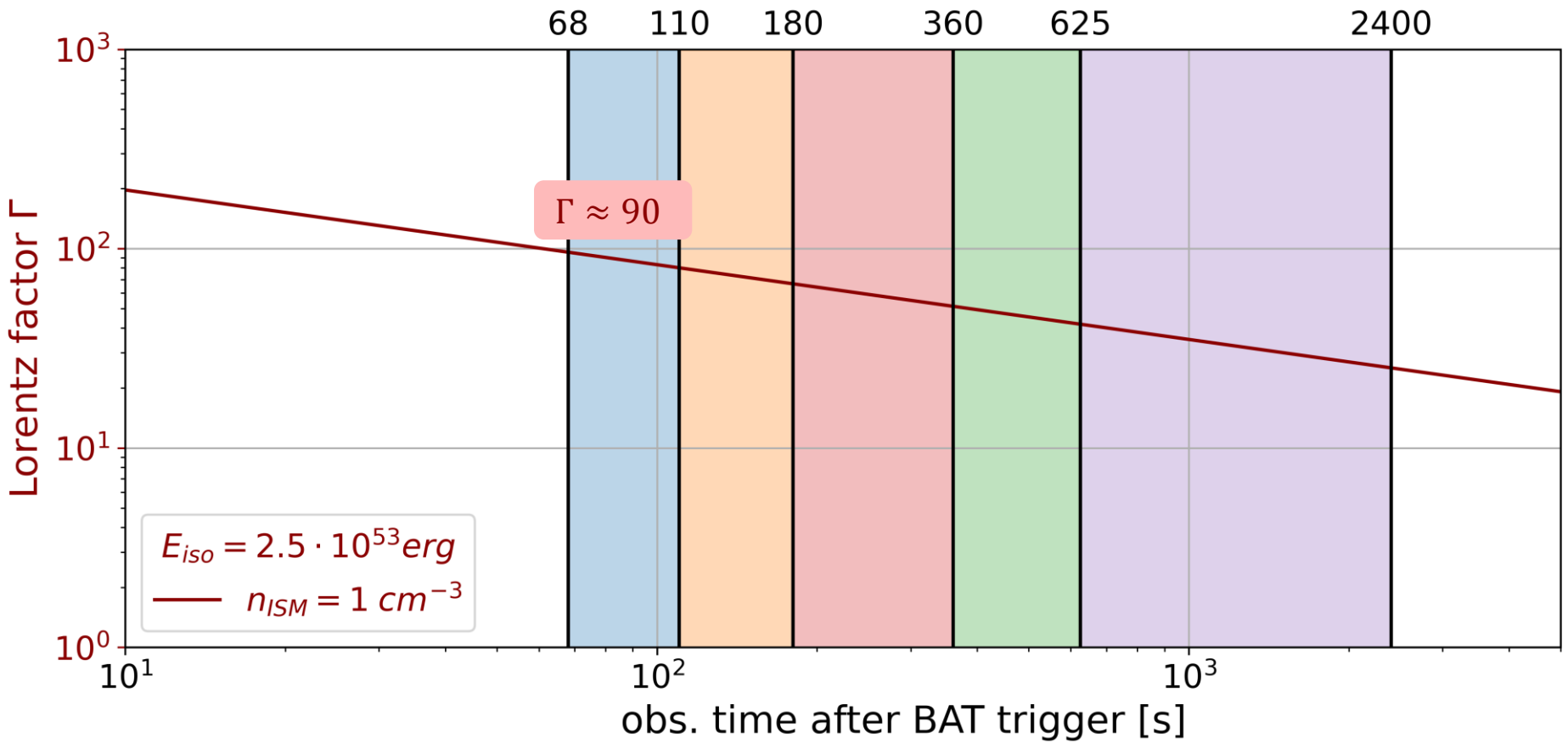
- Homogeneous shell of electrons/positrons and photons
- relativistic shock
  - → injection of non-thermal particles (ε_e, ζ_e)
  - → turbulent magnetic fields (ε_B)
- particles cool
- photons escape



see e.g. Piran 2005 for a detailed review

Characteristic values of blast wave parameters

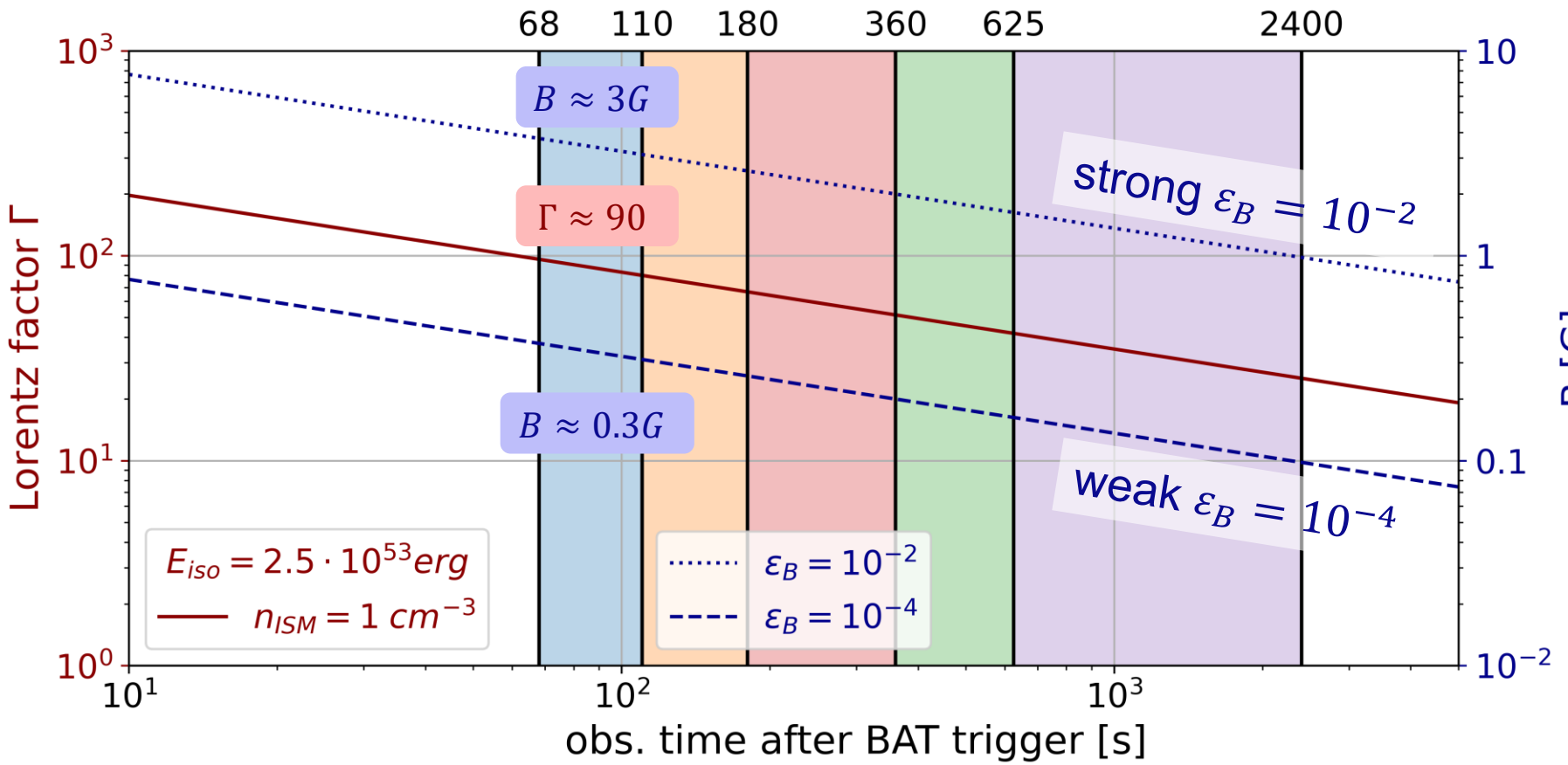
conservation of energy
$E_{kin} = \Gamma^2(r) M(r) c^2$



Characteristic values of blast wave parameters

conservation of energy
$E_{kin} = \Gamma^2(r) M(r) c^2$

fraction ε_B of ram pressure
$\frac{B^2}{8\pi} = \varepsilon_B m_p c^2 n_{up} \beta^2 \Gamma^2$

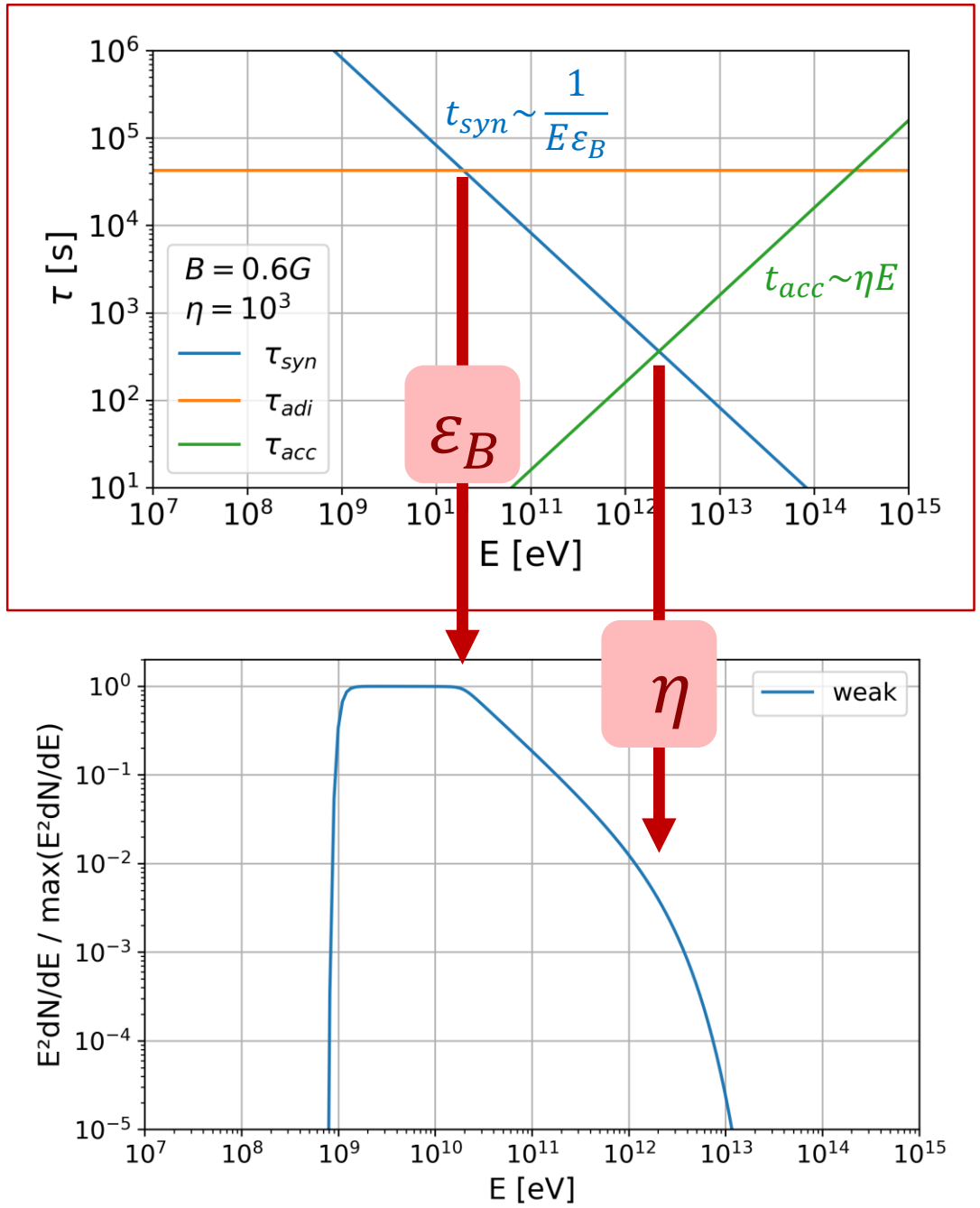


Electron spectrum

- steady state:

$$\rightarrow N \sim Q(E)\,\tau(E)$$

power law injection
spectral index $p \approx 2$



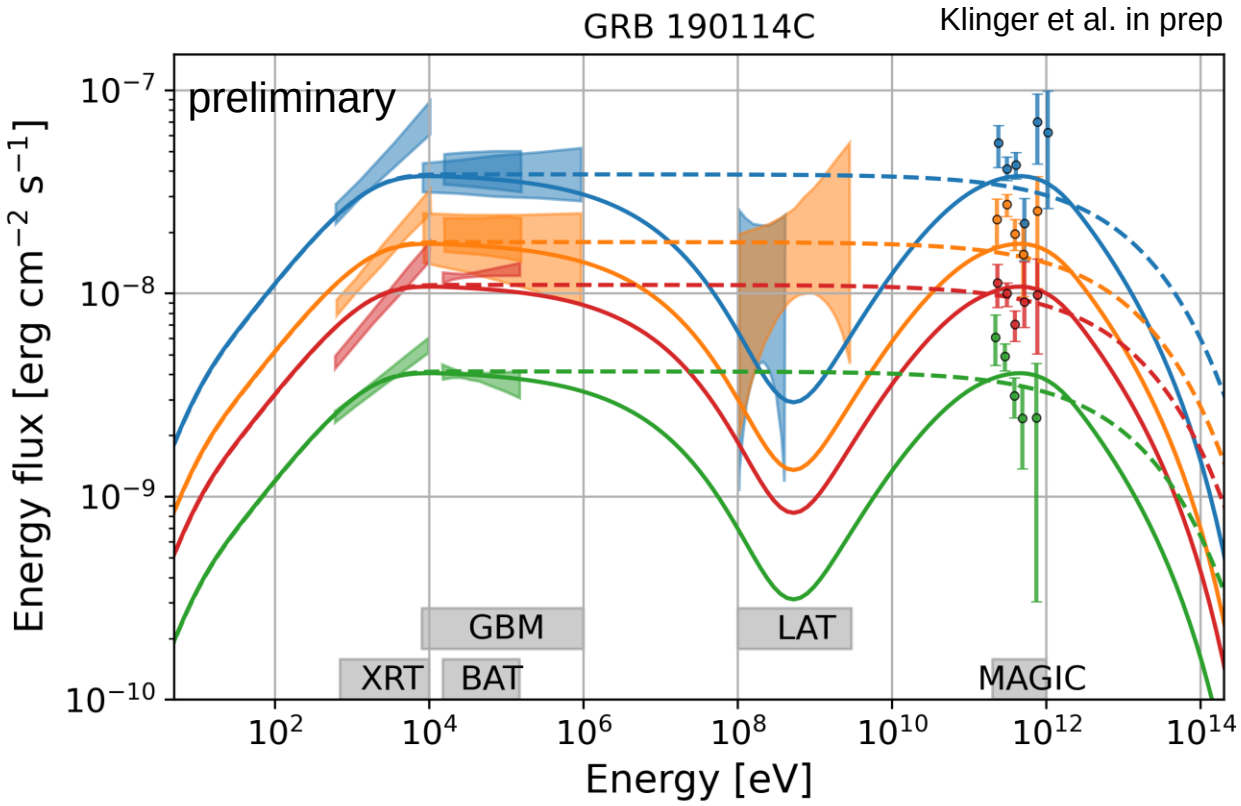
→ weak field required to fit observed break

$$\varepsilon_B \sim 10^{-4} \leftrightarrow B \sim 0.6G$$

Photon spectrum: 2 types of solutions

→ synchrotron self-Compton spectrum

1. double hump solution:
   - → predicts dip: does this dip exist?
   - → requires large η, is this plausible?
2. single hump solution (syn. only)
   - → predicts no dip
   - → syn. burn off limit requires 2 field strengths, is this plausible?



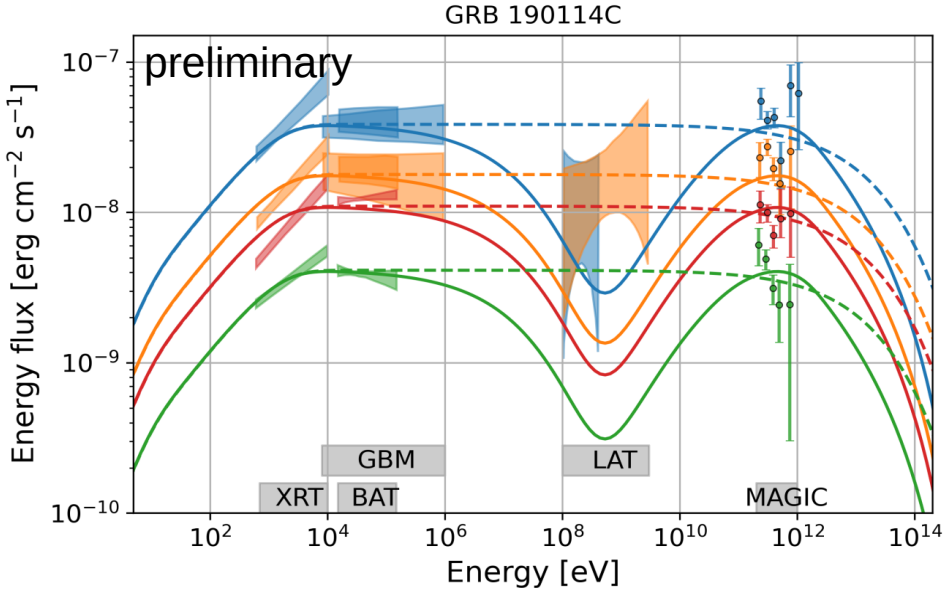
see also GRB 190829A

→ LAT data crucial to distinguish! Are statistics good enough?

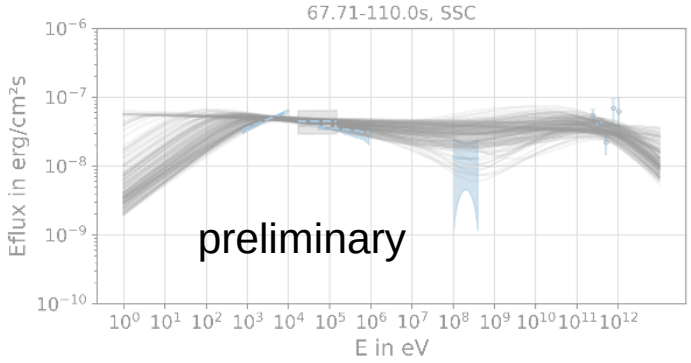
Conclusions

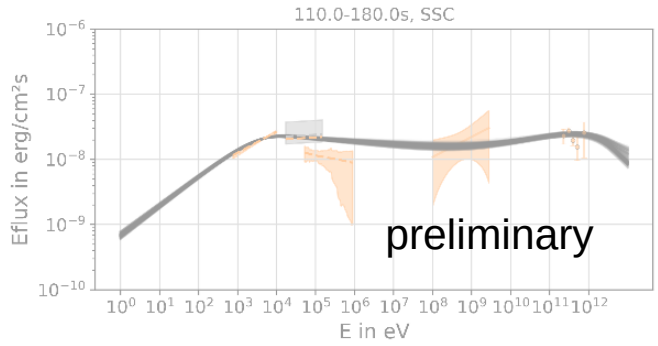
- GRB 190114C offers rich data set
- 2 types of possible solutions

  → LAT data crucial
  to distinguish



- next step: fit data to get most out of it!





Thank you for your attention!

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