Fermi and Swift Observations of GRB190114C

Tracing the Evolution of High-Energy Emission from Prompt to Afterglow

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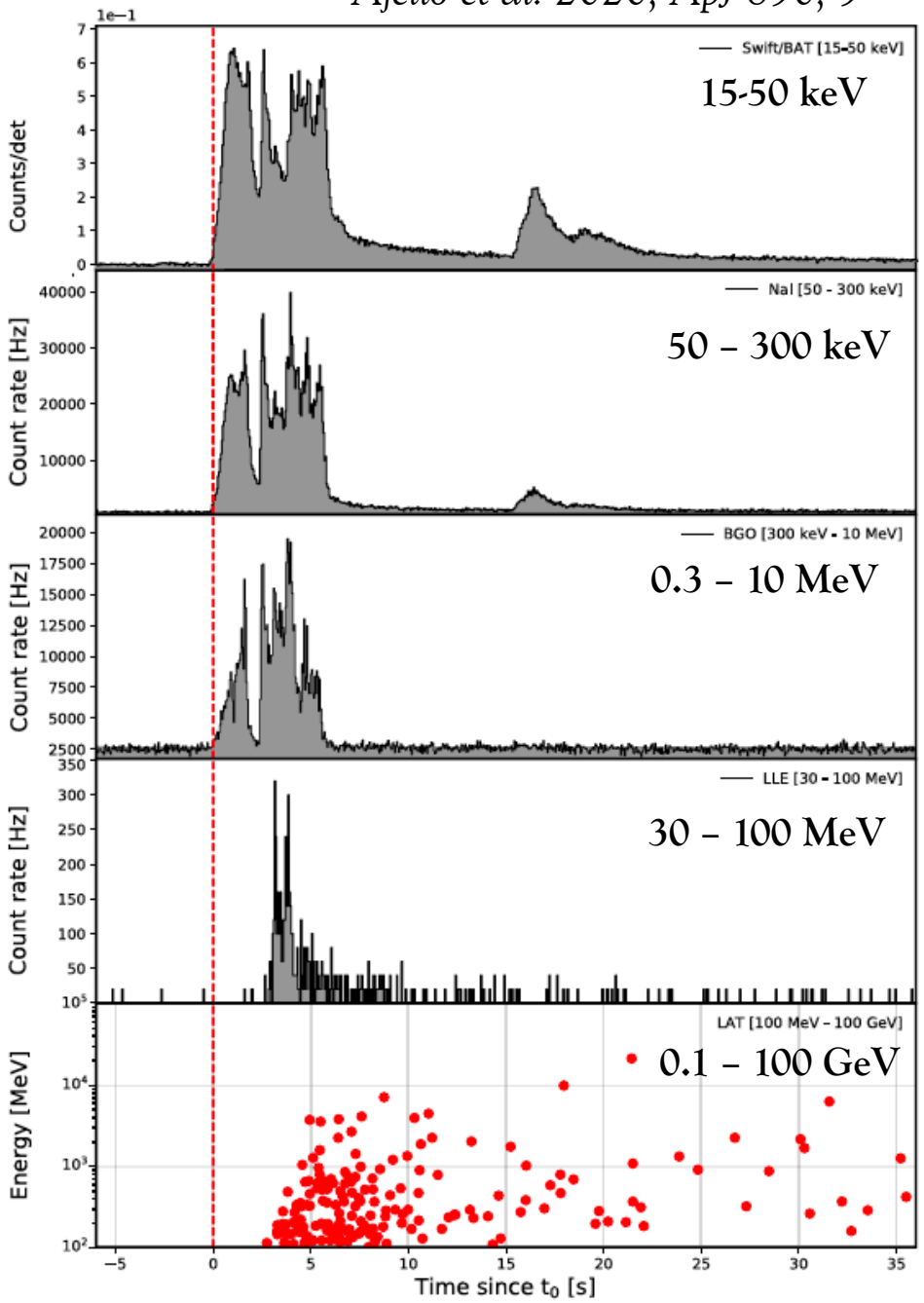
on behalf of the Fermi LAT and GBM Collaboration

GRB 190114C

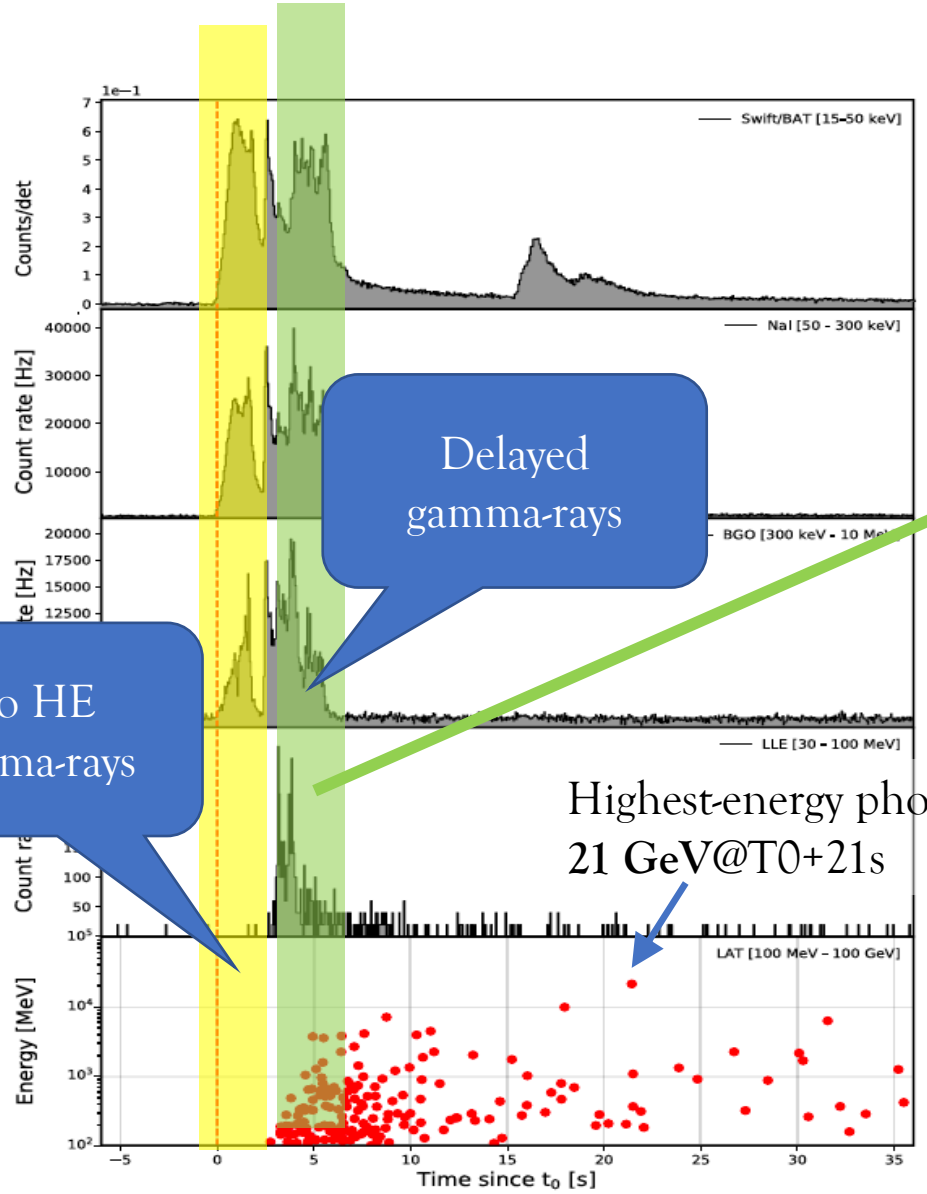
- 2019/1/14 20:57:02 UTC
- ~30,000 counts/s in GBM at the max.
- Significant detection by LAT (>50σ)
- Also detected by Swift BAT(T0 + 0.56 s)
- Swift/XRT & UVOT observations
  - ✓from T0+68 s
- z = 0.42 (host galaxy, Selsing et al. 2019)
- **MAGIC detection at T0+~50 s**

Ajello et al. 2020, ApJ 890, 9



Fermi lightcurve & SED

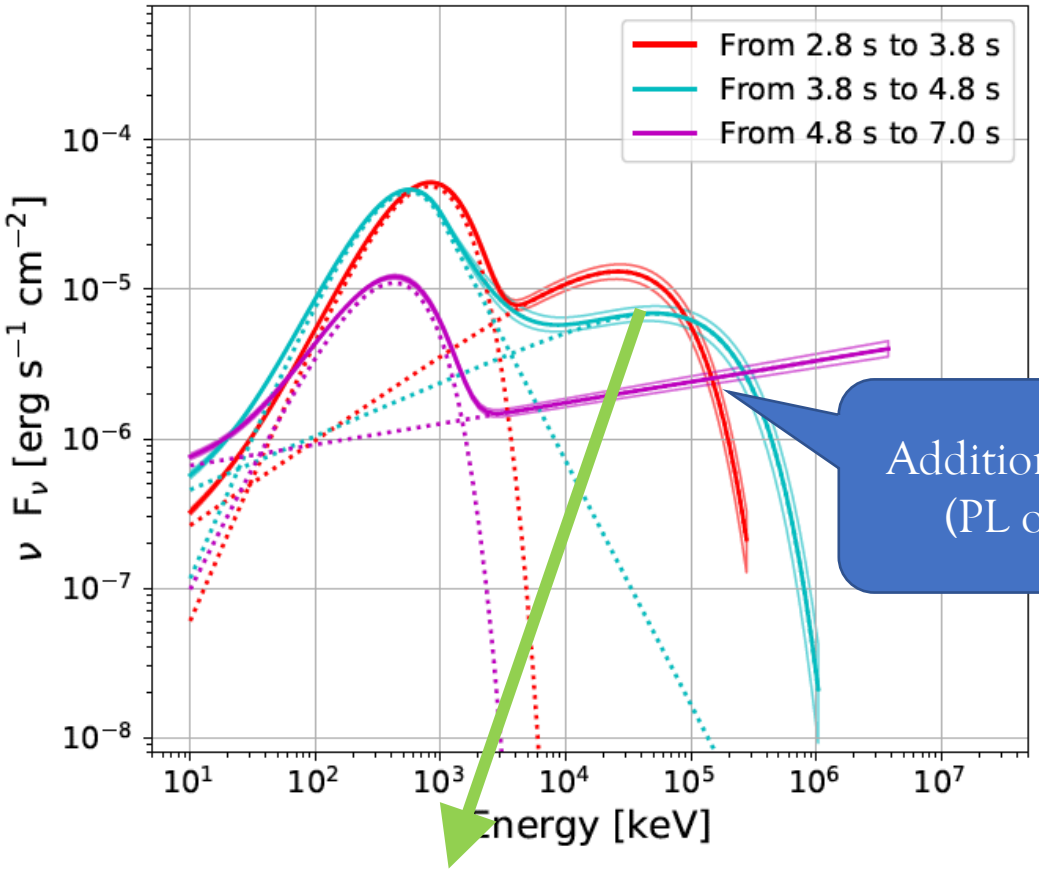
Ajello et al. 2020



Delayed gamma-rays

No HE gamma-rays

Highest-energy photon
21 GeV@T0+21s

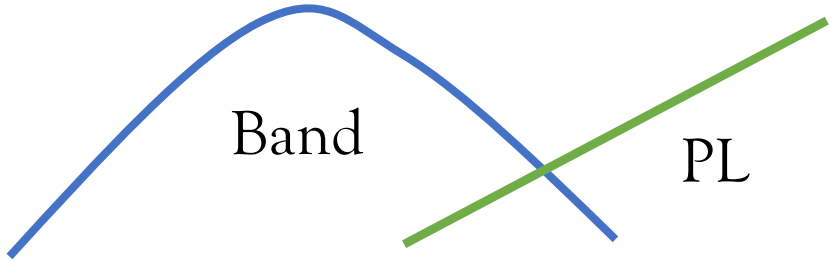


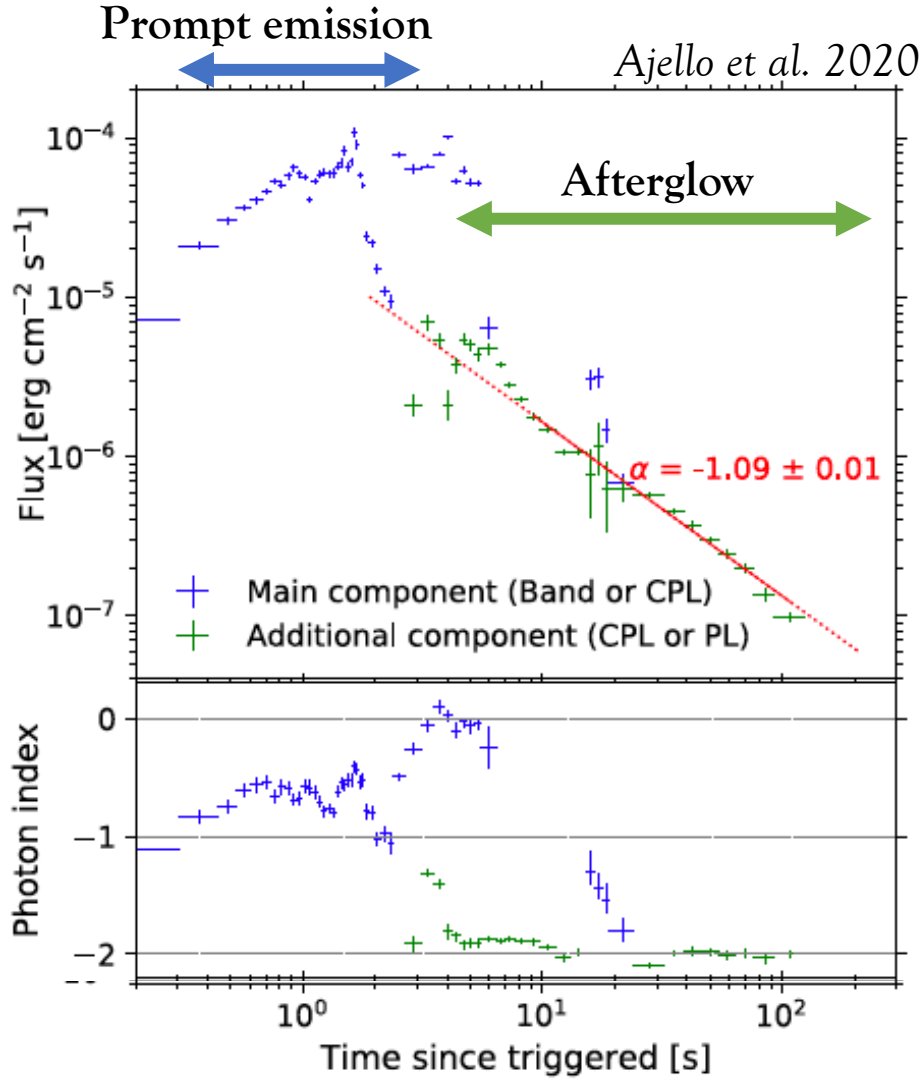
Additional component (PL or cutoff PL)

- Spectral break in additional PL
- If the break is caused by pair opacity (R. Gill+18),
  - ✓ Bulk Lorentz factor $\Gamma_{bulk} \sim 210$

Extended emission

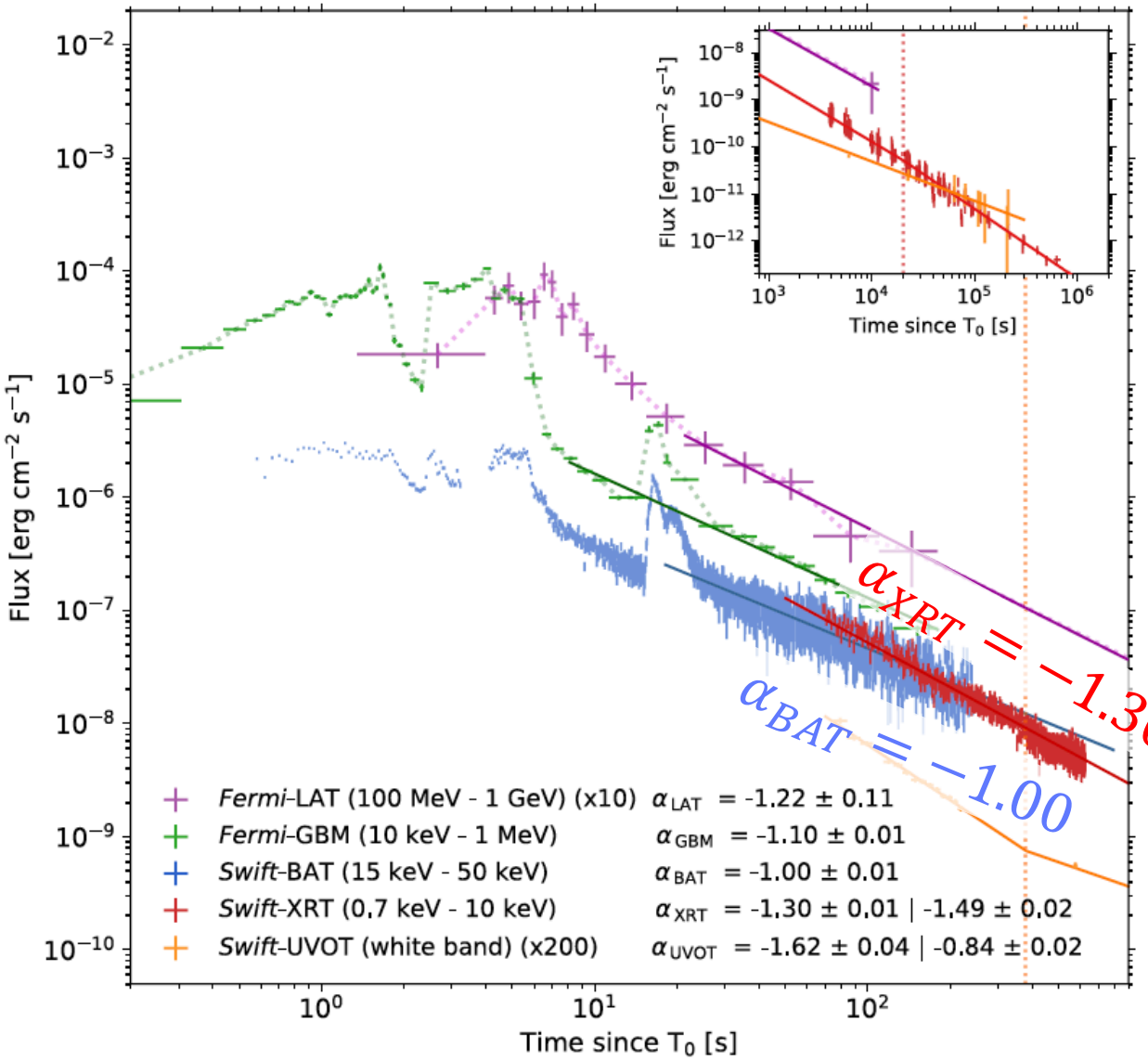
- Low-energy emission in GBM
  - ✓Band component
  - ✓Drastically variable
  - ✓**Internal-shock origin**
- Additional PL component in LAT
  - ✓Smooth decay
  - ✓**Afterglow origin**

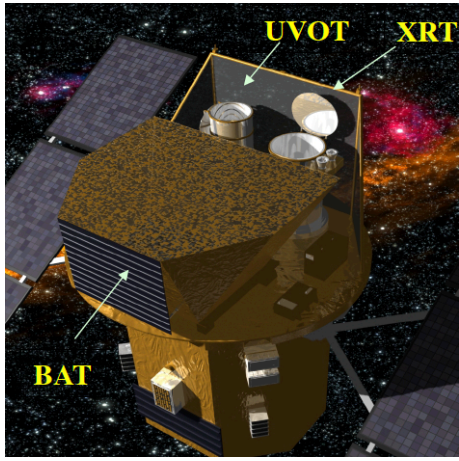




eV – GeV lightcurve

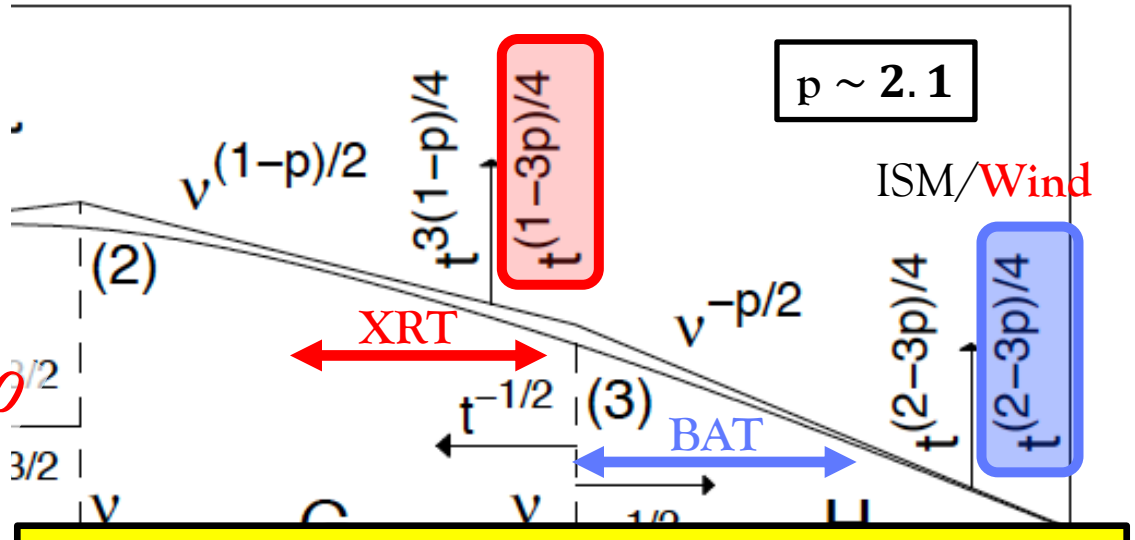
Ajello et al. 2020





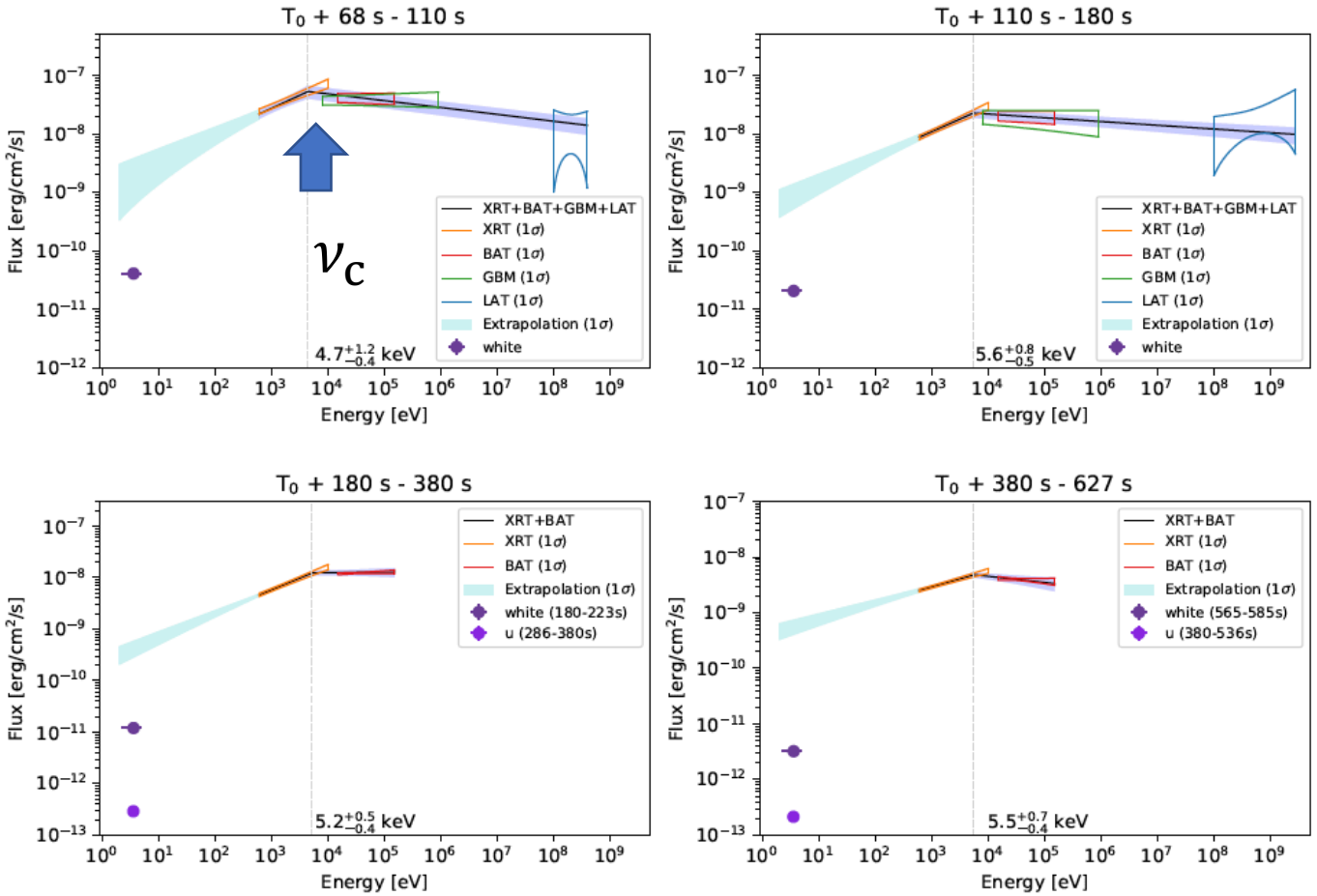
- Swift/BAT & XRT
- Fermi/GBM & LAT
- Smooth decay even in GBM

ISM ($\propto r^0$) / Wind ($\propto r^{-2}$)

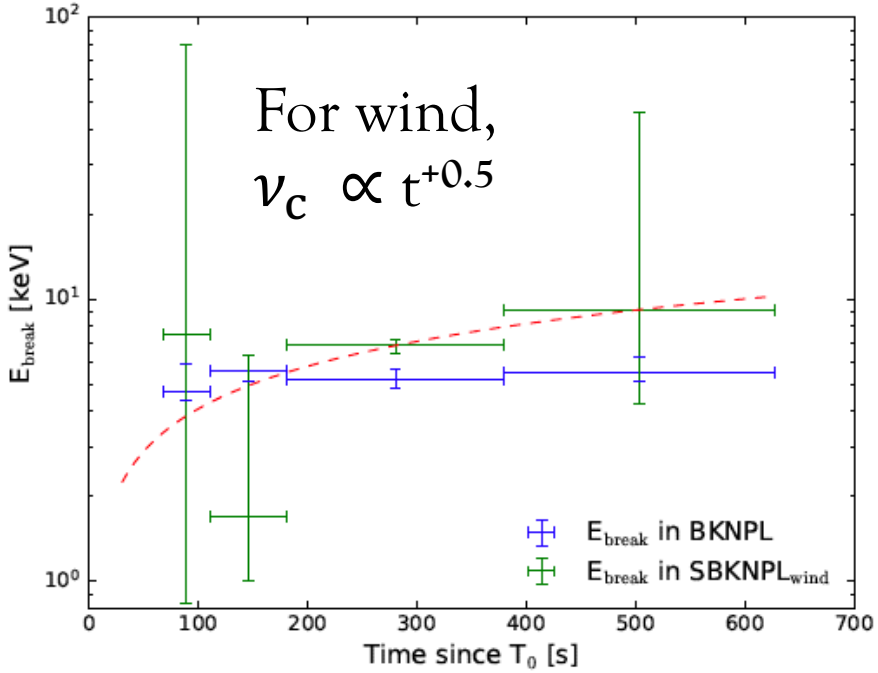


Important for the maximum sync energy and estimating ε_e and ε_B

Afterglow SED for *Swift* + *Fermi*



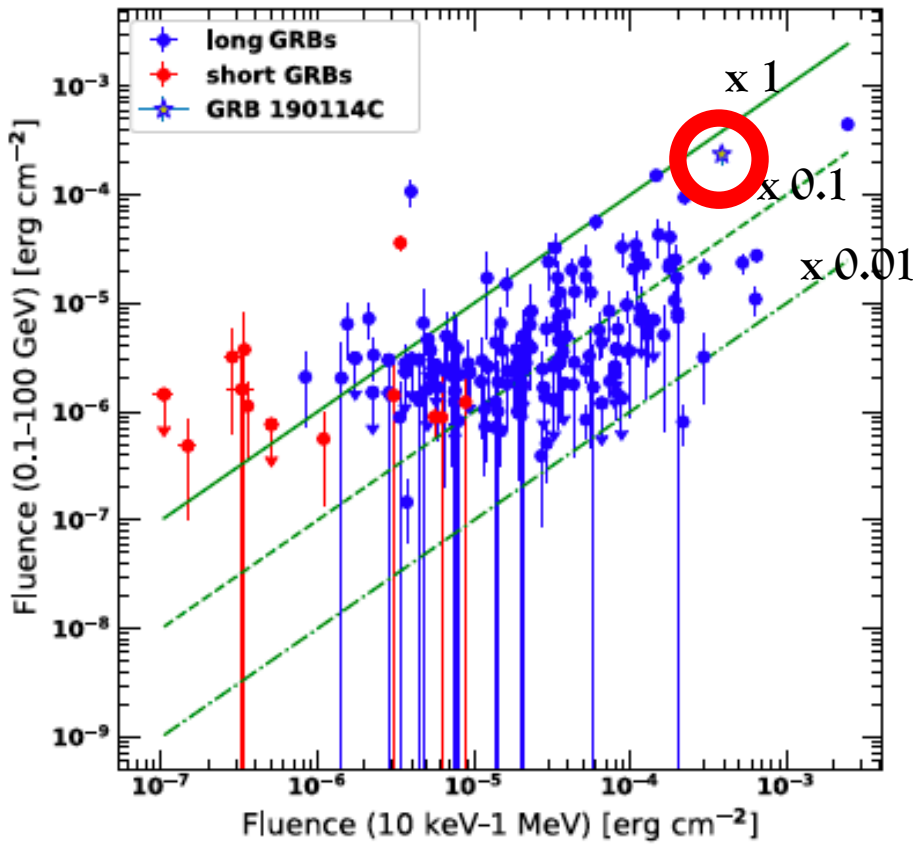
Note: $\nu_c \propto t^{-0.5}$ (ISM)



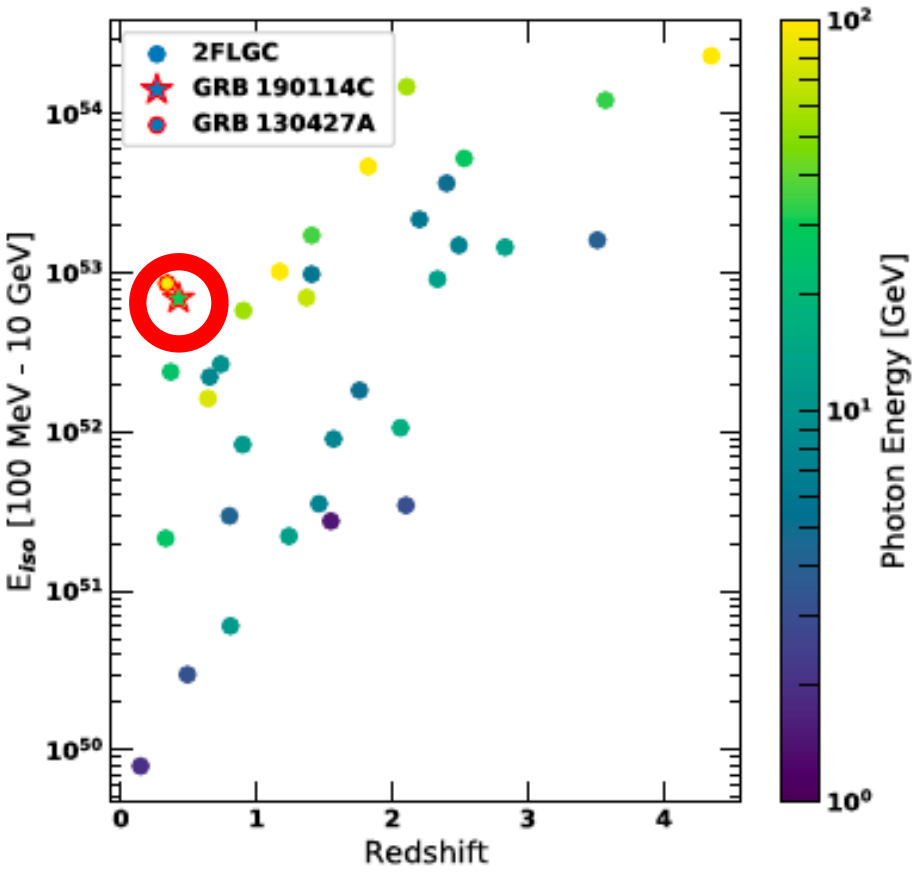
***Wind* scenario is consistent**

Ajello et al. 2020

Energetics



Ajello et al., 2020

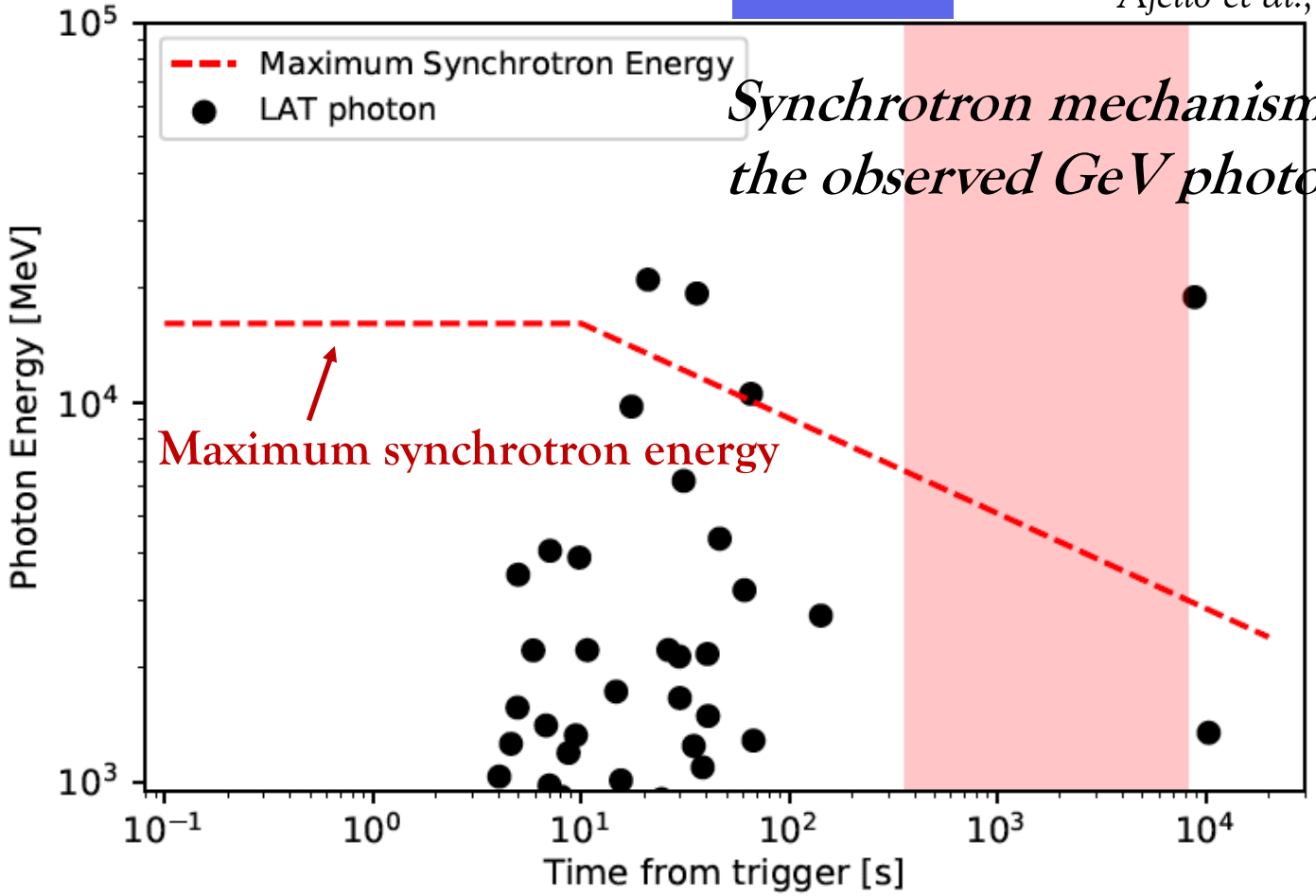


✓ GRB 190114C is very bright among previous LAT GRBs

Beyond synchrotron emission

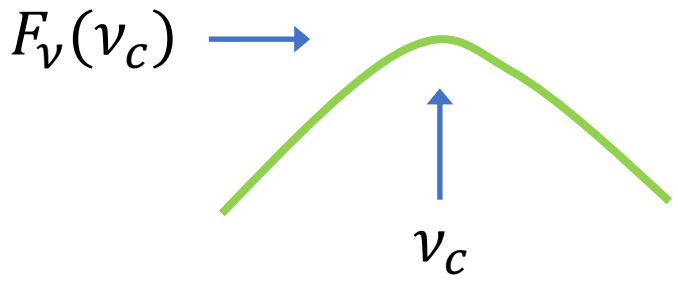
MAGIC

Ajello et al., 2020

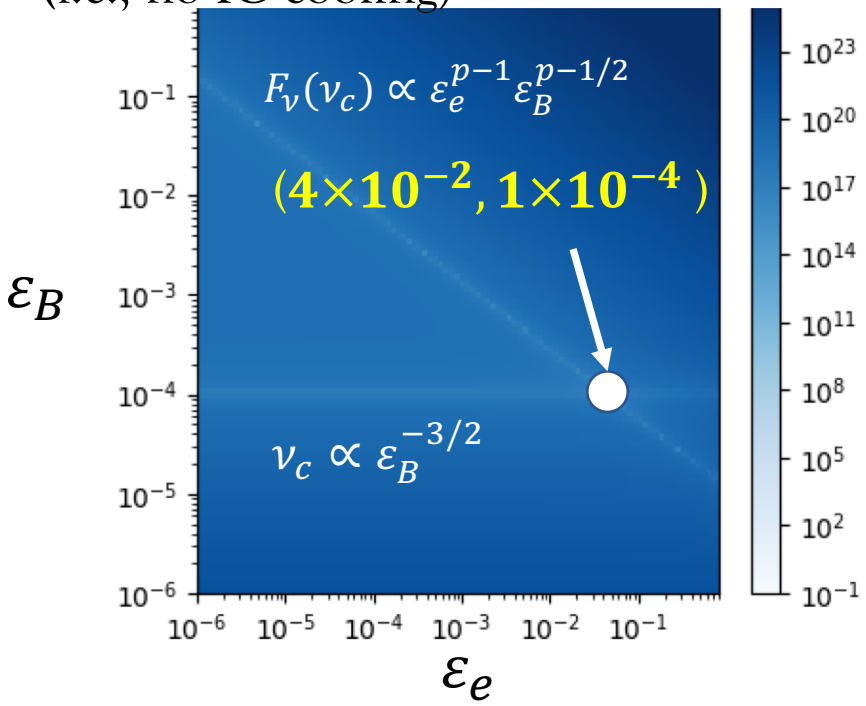


Synchrotron mechanism cannot explain the observed GeV photons.

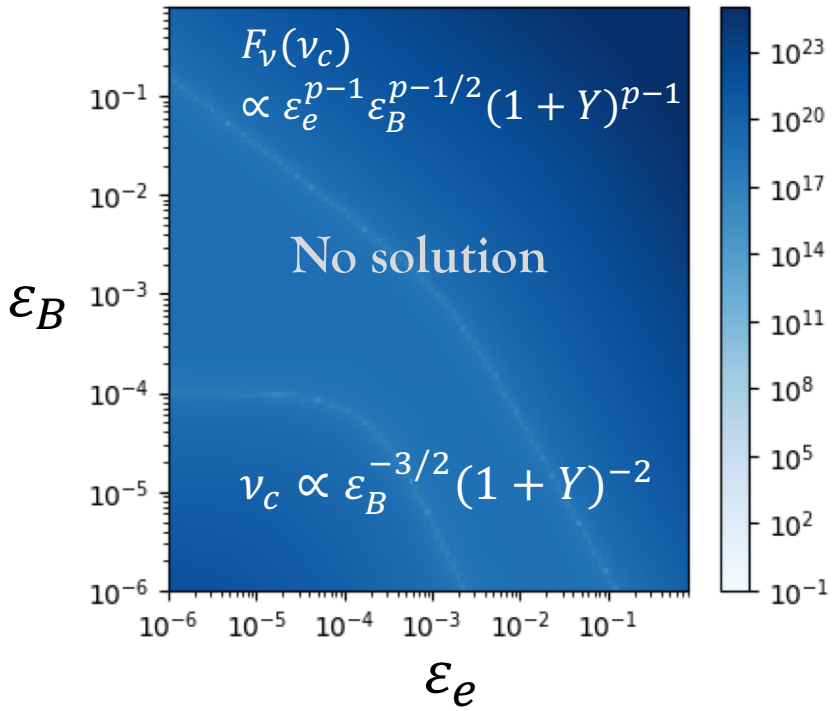
Physical parameters ε_e and ε_B



✓ IC cooling **with KN effect** (i.e., no IC cooling)



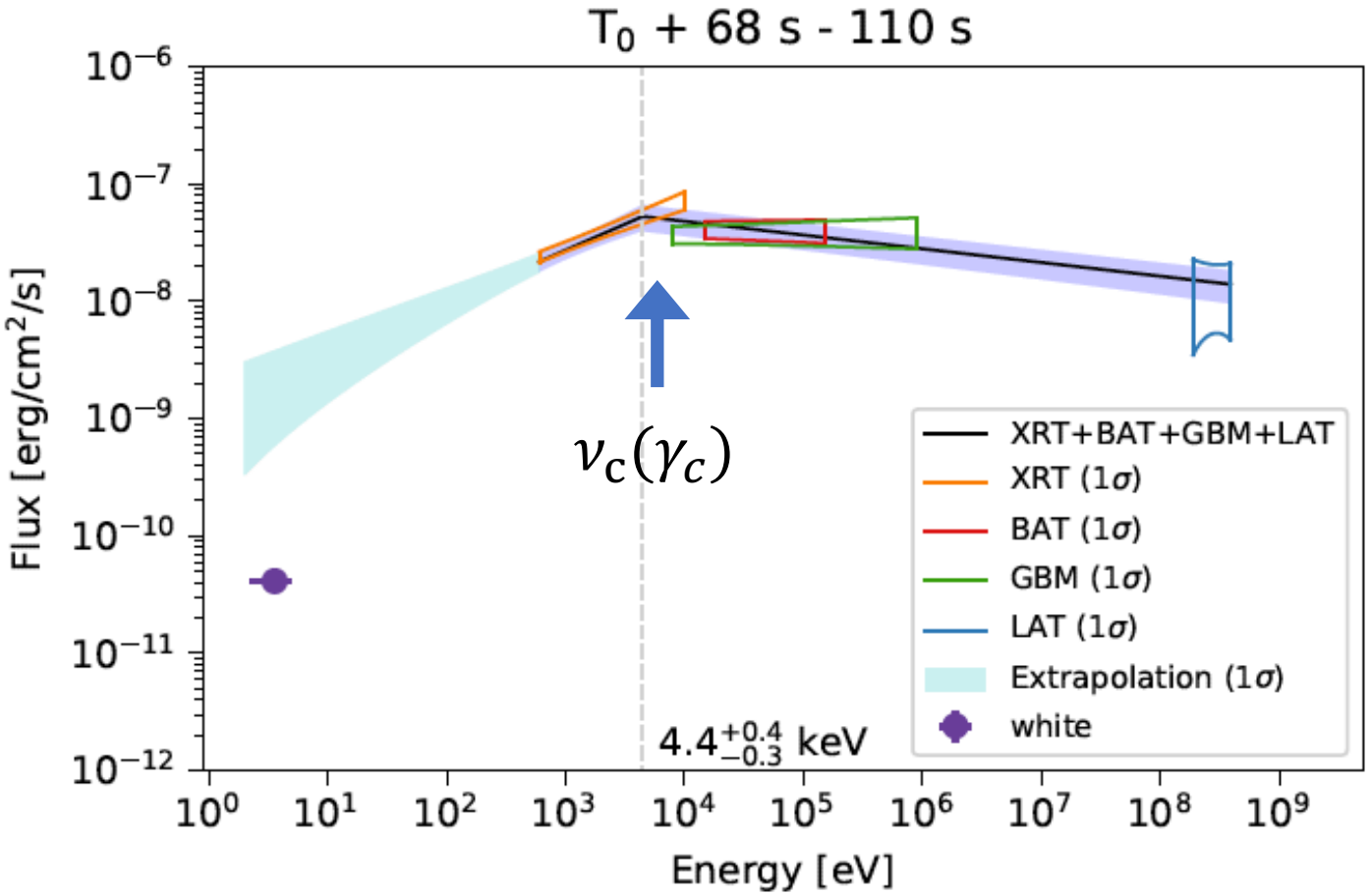
✓ IC cooling **w/o KN effect**



Electrons at ν_c *cannot be cooled with IC,*
but strong IC emission is expected, i.e., $(\varepsilon_e/\varepsilon_B)^{0.5} \sim 20$

→ ***Klein-Nishina (KN) effect is important***

If ν_c is in the KN regime,



Nakar et al., 2009

$\hat{\gamma}$: an energy where KN effect becomes important

$$\hat{\gamma} = \frac{m_e c^2 \Gamma}{h \nu_{\rm syn}(\gamma)} \propto \gamma^{-2},$$

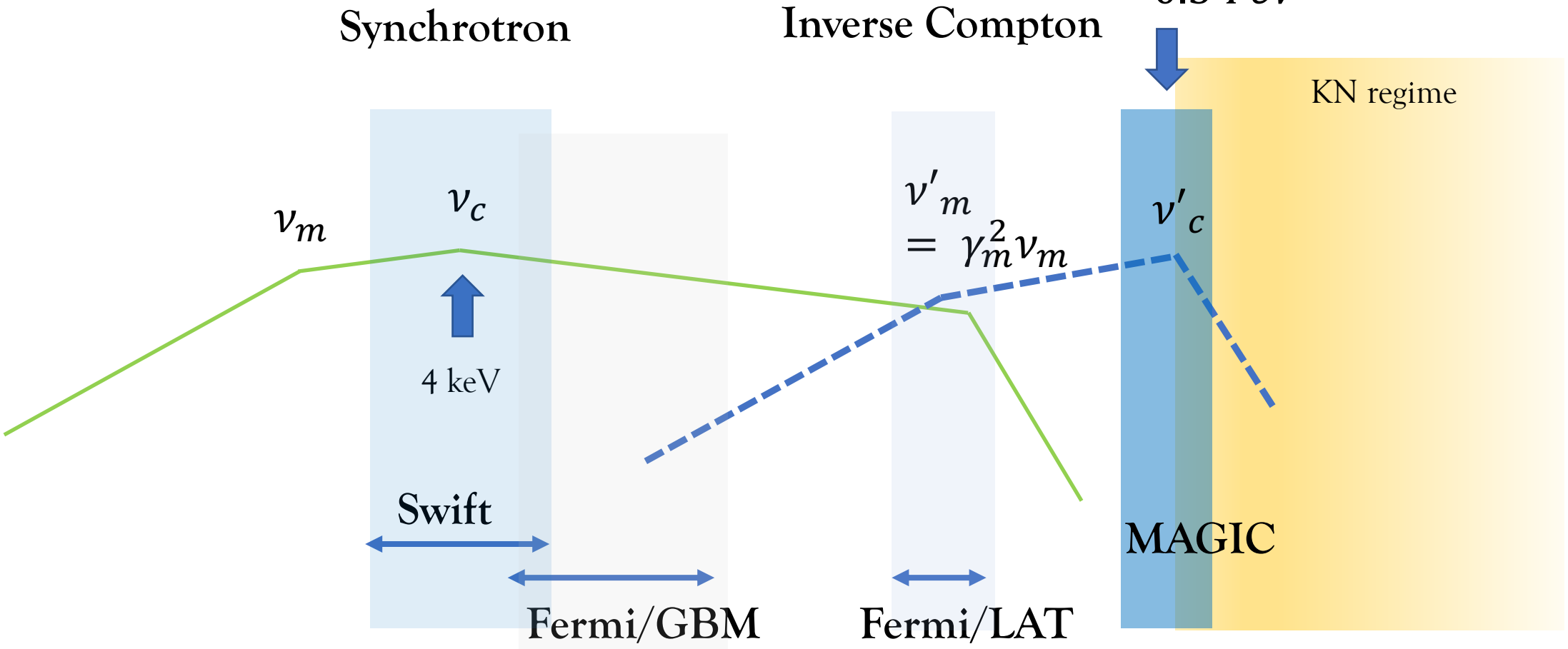
$$= \frac{511\ \text{keV} \times 120}{4\ \text{keV}} \sim 10^4$$

If $\gamma_c \sim \hat{\gamma}$,

$\Rightarrow$ $\gamma_c \sim 10^4$

Swift & Fermi view of *VHE* emission

$$\nu'_c \sim \Gamma_{bulk}\,\hat{\gamma}\,m_e\,c^2$$
$$\sim 100 \times 10^4 \times 511\ keV$$
$$\sim 0.5\ TeV$$



Summary

- **Swift & Fermi observed a very bright GRB (GRB 190114C)**
  - ✓Gamma-ray emission in the LAT band is roughly consistent with synchrotron scenario with external shock
  - ✓*But*, there exist some GeV photons that are inconsistent with synchrotron scenario
    → Our model suggests **$\varepsilon_e/\varepsilon_B \gg 1$ → strong IC emission**

    Details are shown in *Ajello, MA et al., 2020, ApJ, 890, 9*
  - ✓Swift & Fermi view may suggest that
    "the MAGIC saw the high-energy end of gamma-rays"
    → the middle energy range (i.e., LAT range) is still crucial !

Thanks for your attention !