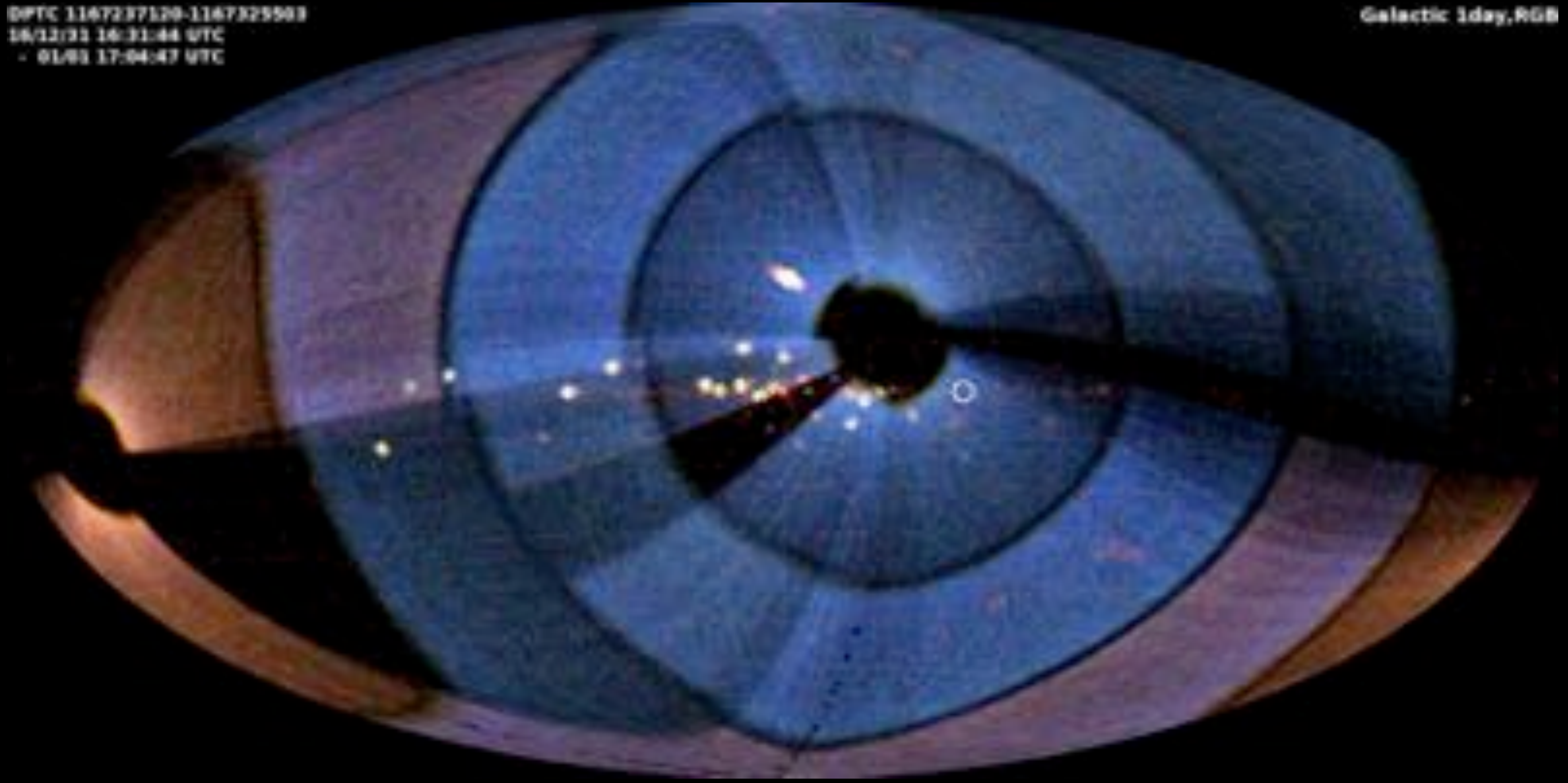
The Transient Sky



MAXI, 2017-18

Transient Energy Release

- Release a lot of energy in small volume
- How do you get the radiation out?

- Time scales:
  - Dynamical: ~ r/v
  - Relaxation: ~ $T^{1.5}/n$
  - Radiation: ~ E/L

Radiative efficiency

- Bremsstrahlung: $L \sim n^2 T^{1/2} \sim p^2/T^{3/2}$ $t_{cool} \sim T^{1/2}/n \sim T^{3/2}/p$
- Synchrotron: $L \sim \sigma \gamma_{max}^2 NB^2 \sim p^2$ $t_{cool} \sim 1/p$
- IC: $L \sim \sigma \gamma_{max}^2 N U_{rad} \sim P^3$ $t_{cool} \sim 1/p^2$
- Blackbody: $L \sim T^4$ $t_{cool} \sim 1/T^3$

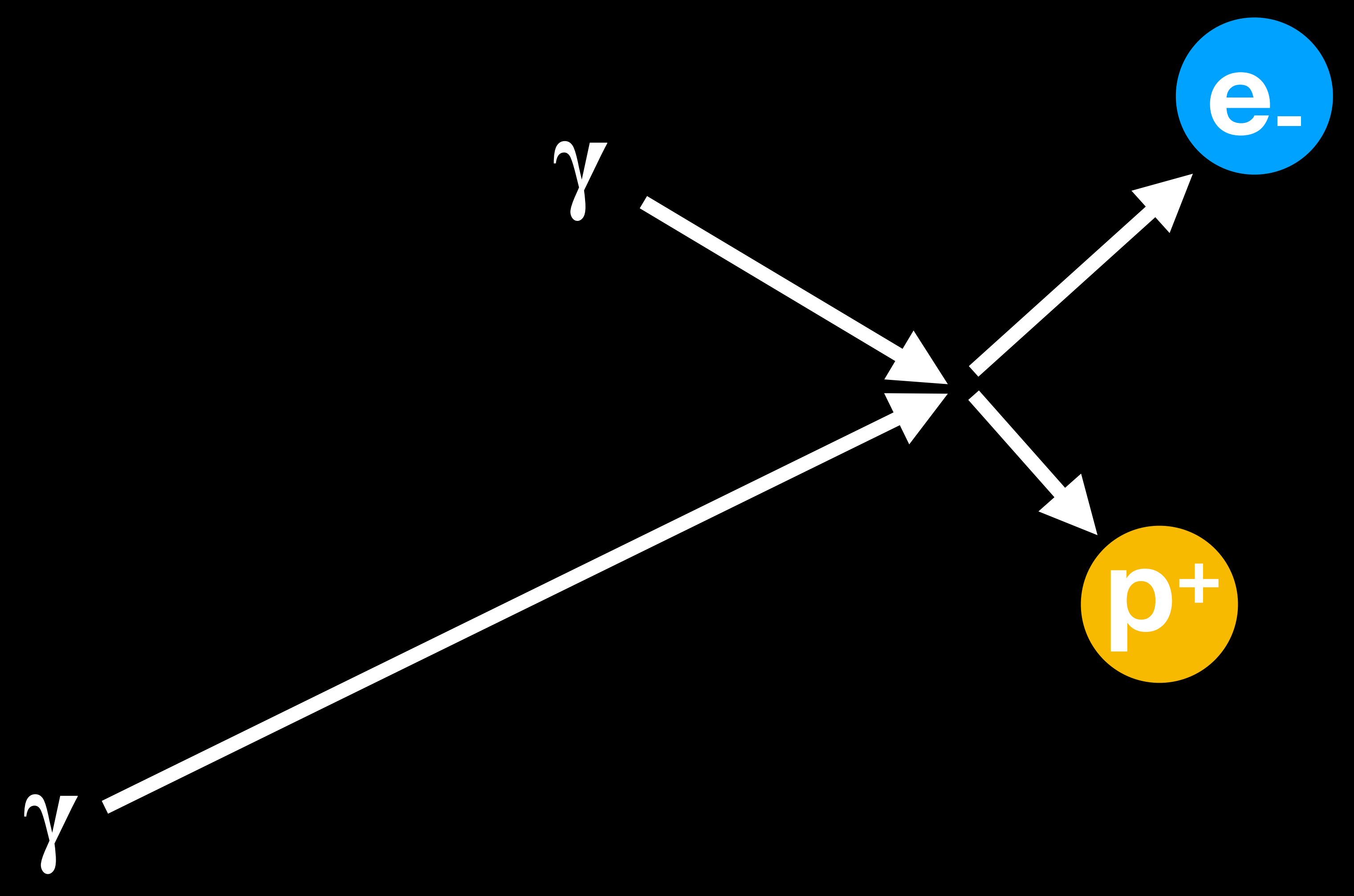
- Dynamics: $t_{dyn} \sim r/v$

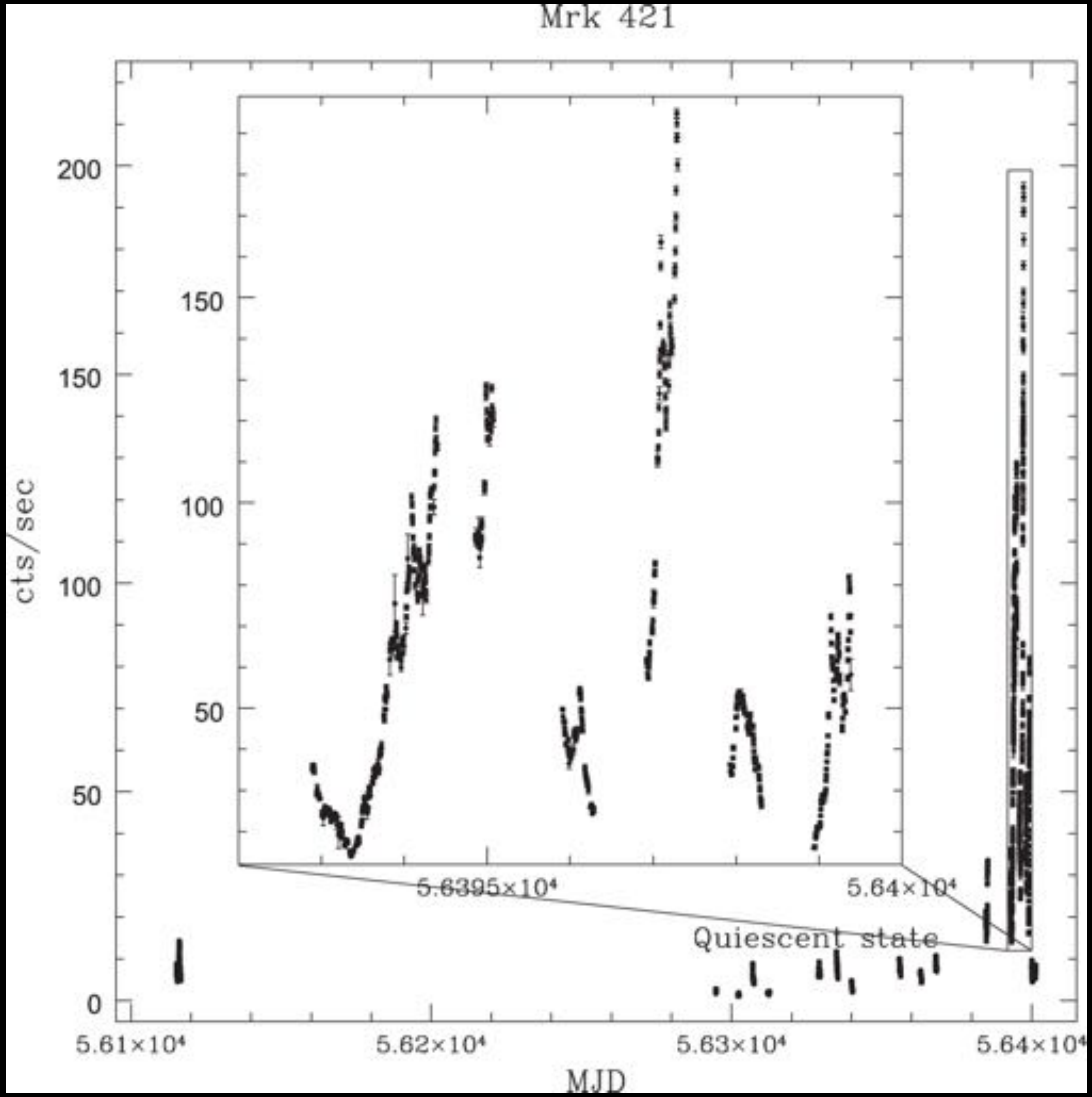
Optical depth

- How long does it take for your radiation to escape?

  - $\tau \ll 1$: $t_{esc} \sim r/c \sim t_{dyn}$
  - $\tau \gg 1$: $t_{esc} \sim \tau^2 \, r/c \gg t_{dyn}$

Pair Creation and Compactness

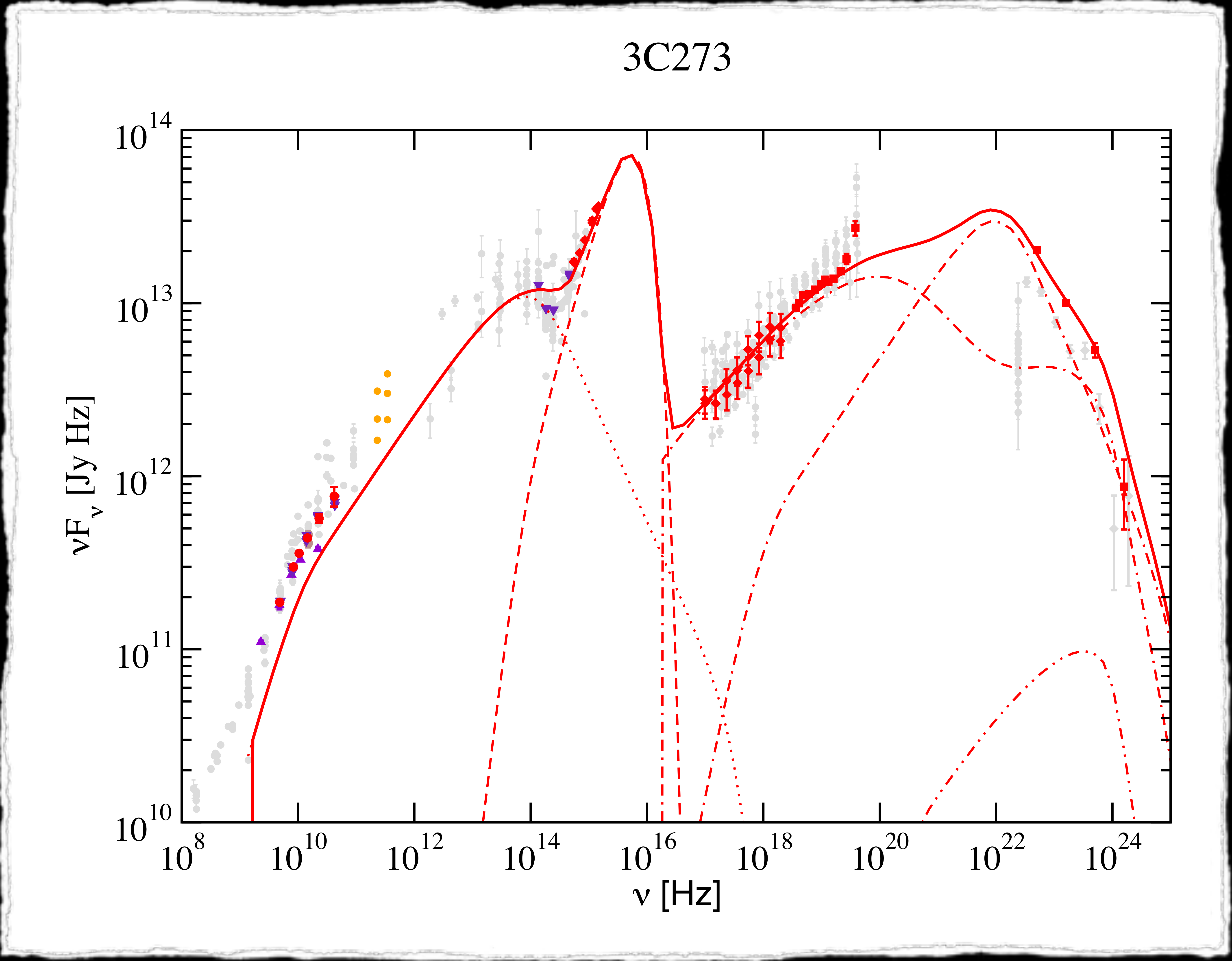




Pandey+2017

Black holes are messy eaters

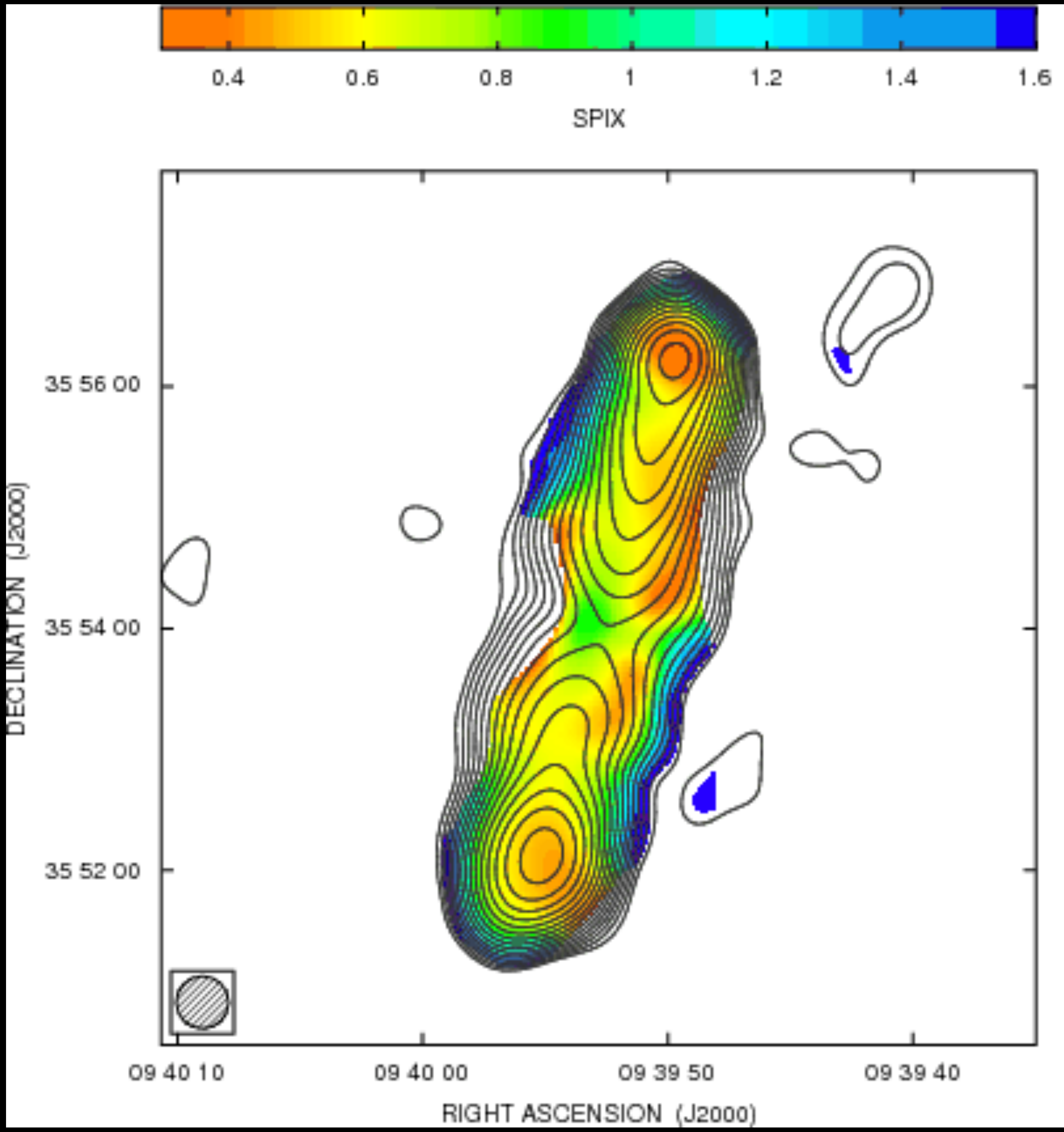
Non-thermal spectra

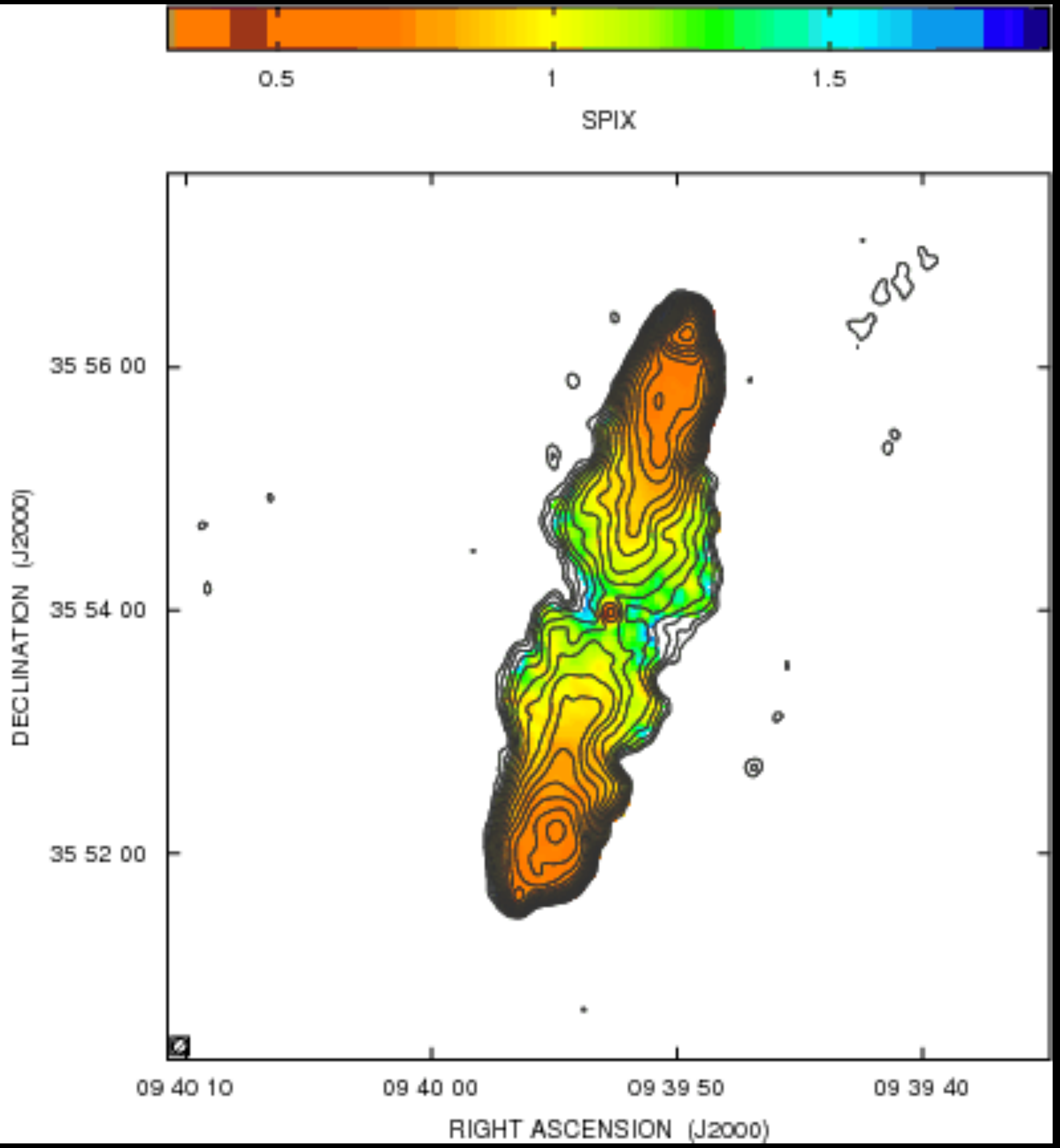


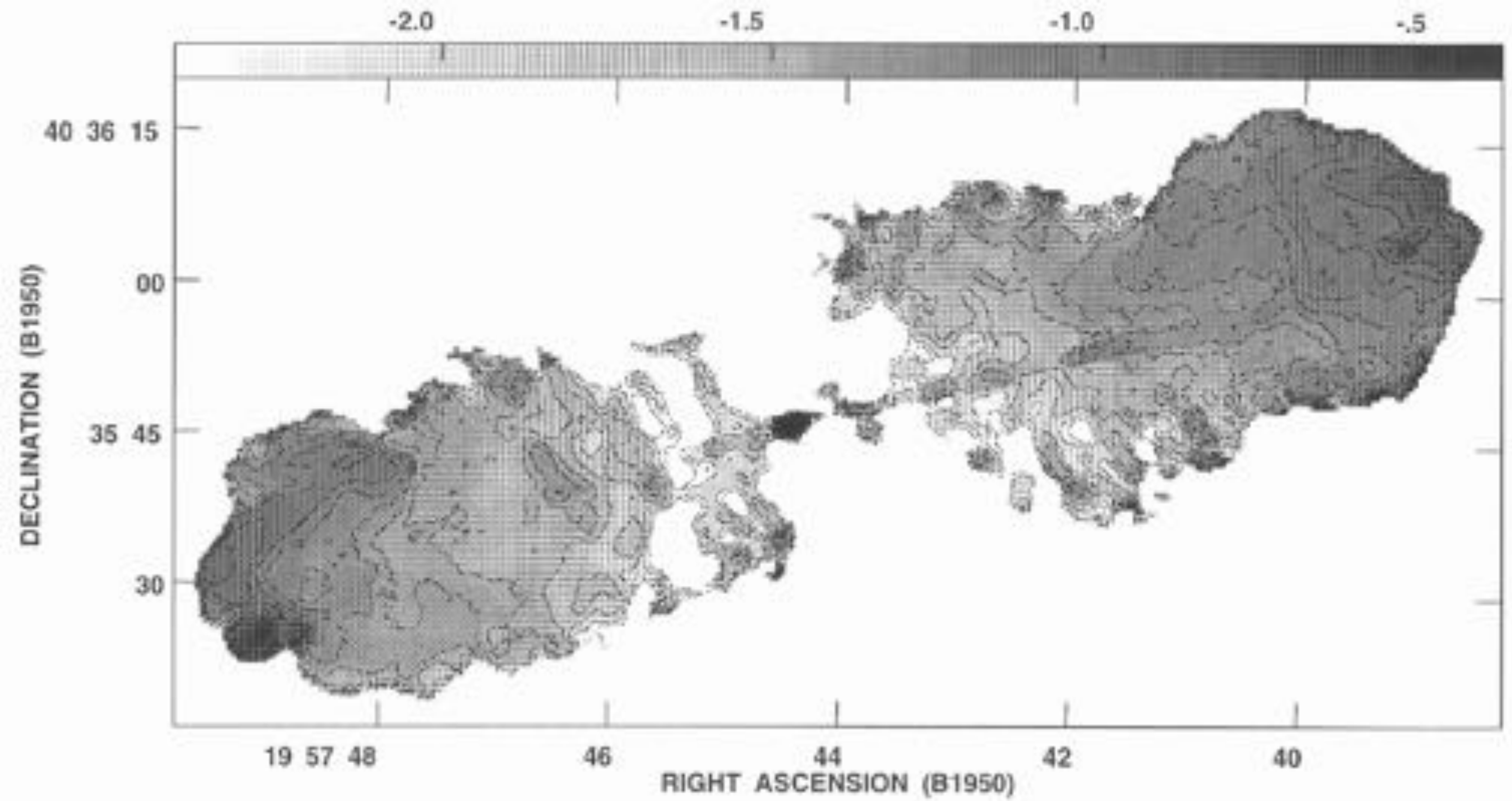
Boettcher+'13

Synchrotron cooling

Radio Galaxy Spectra

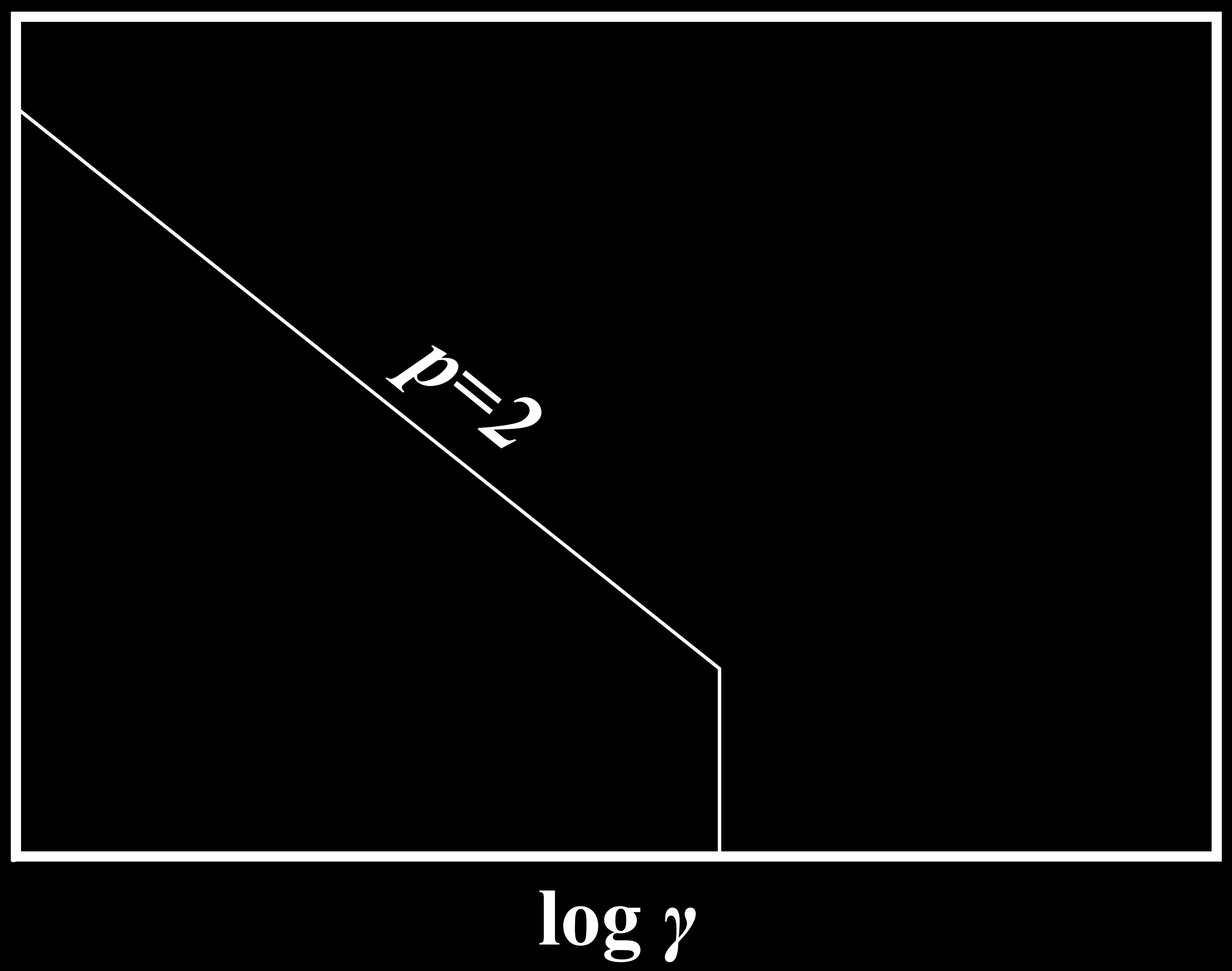


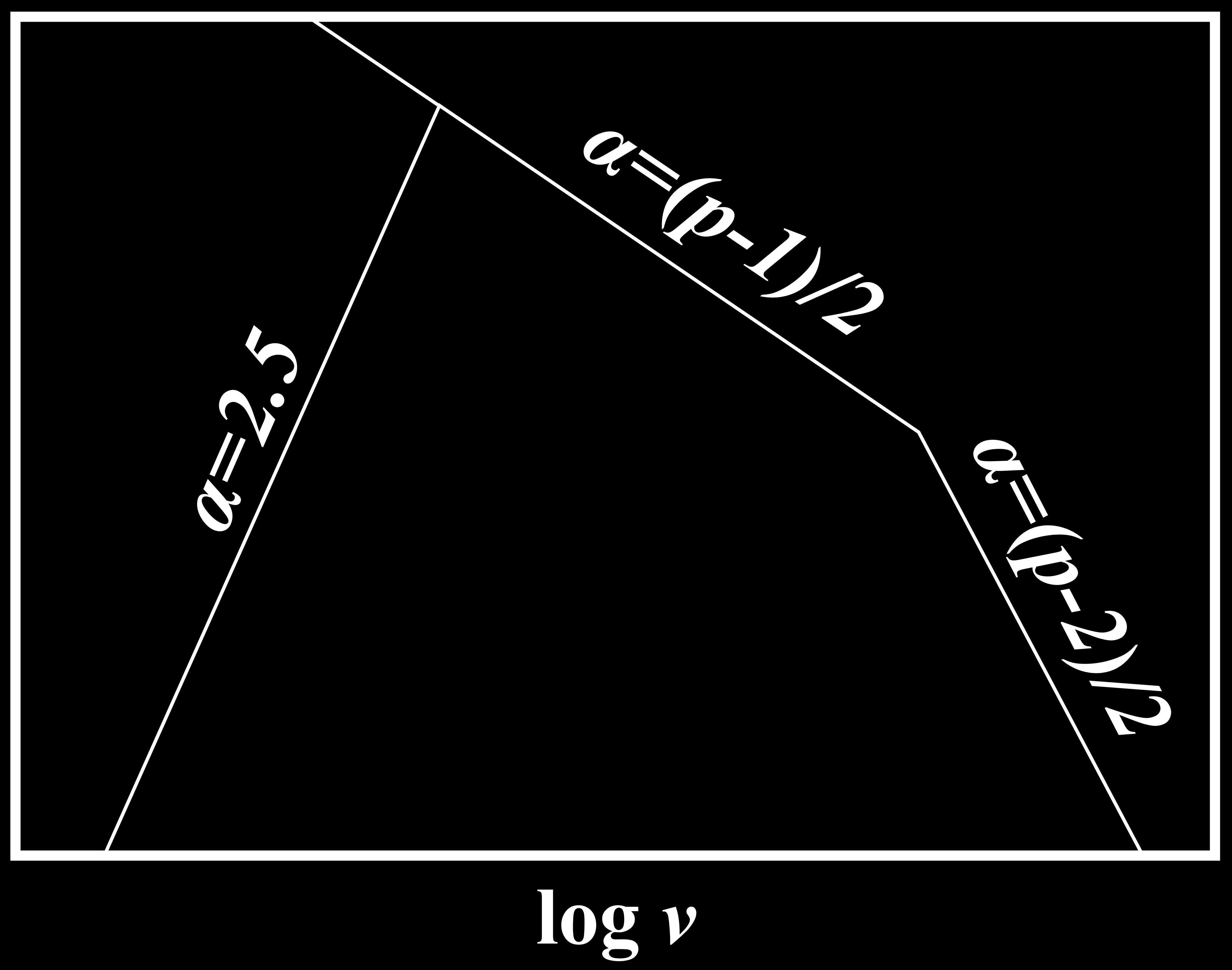




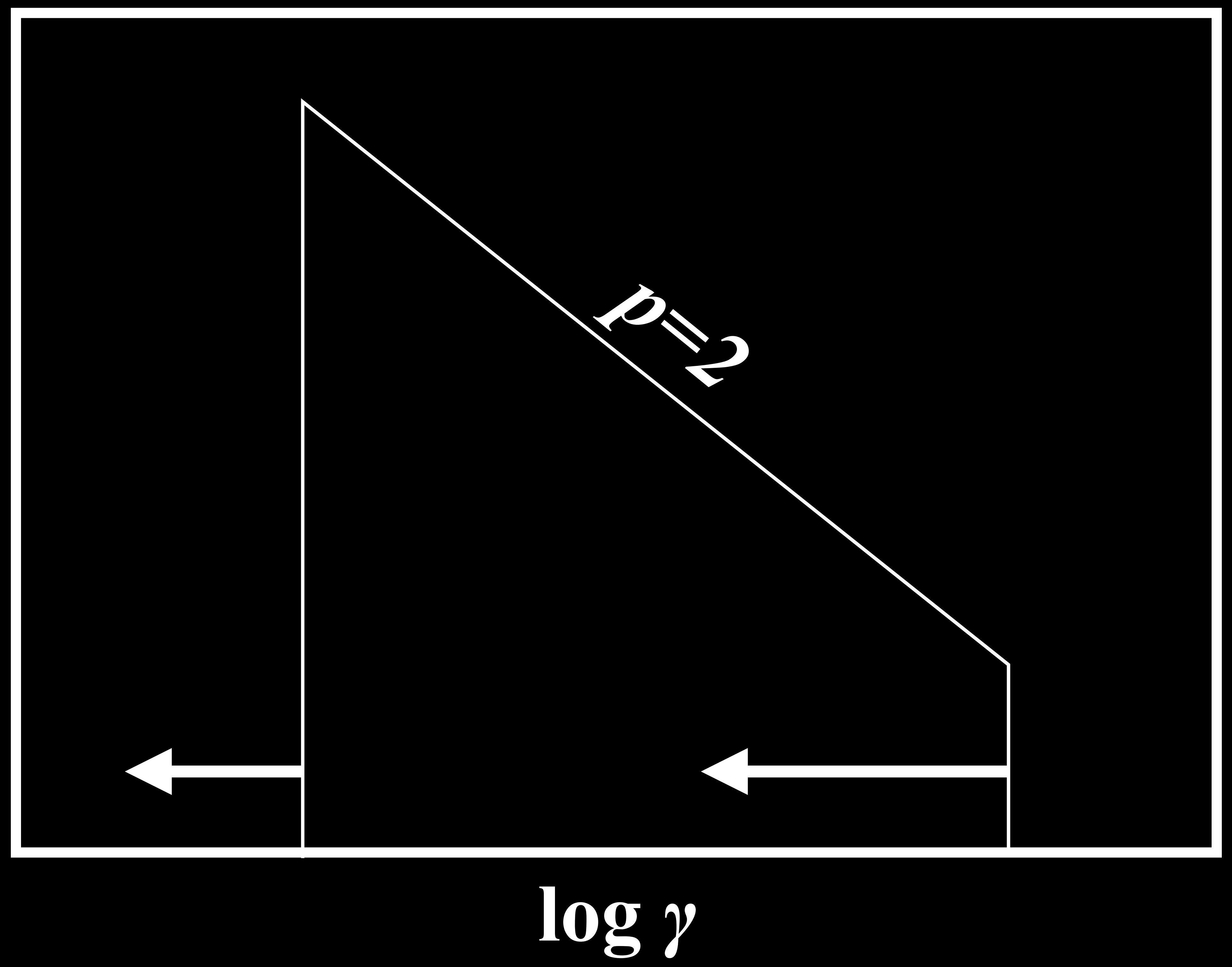
Carilli & Barthel 1996

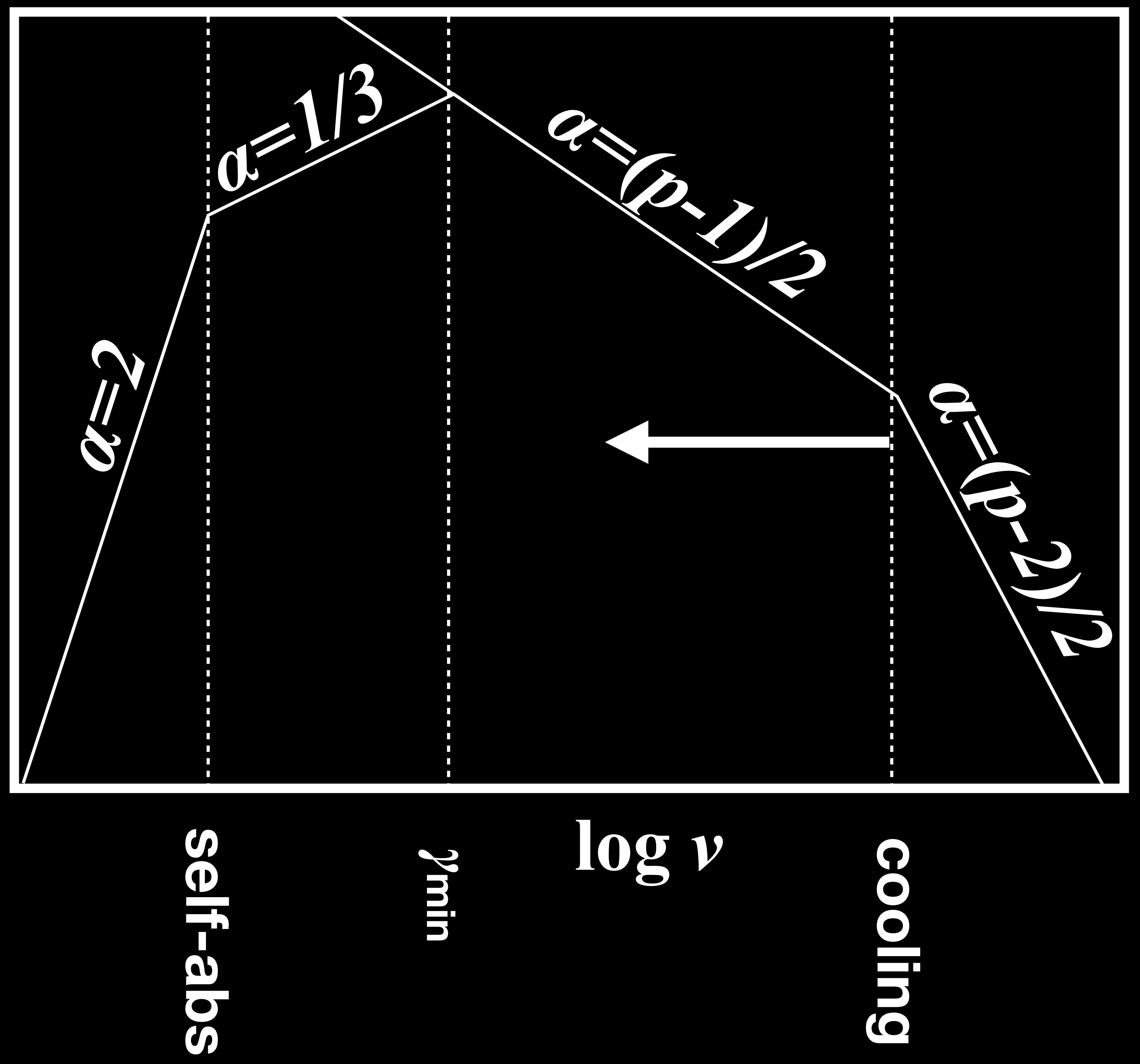
Full synchrotron spectrum: low-Γ





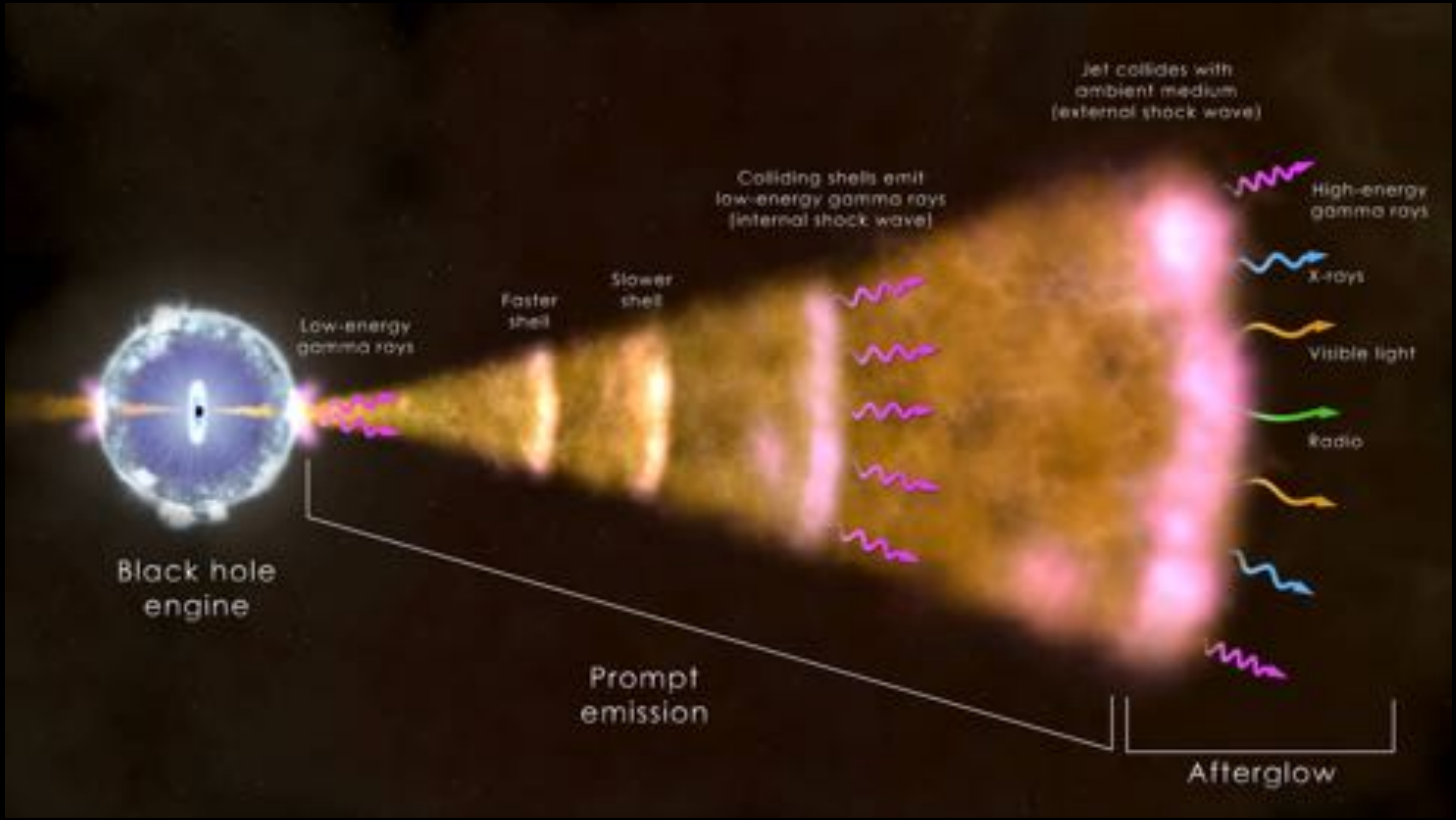
Full synchrotron spectrum: high-Γ





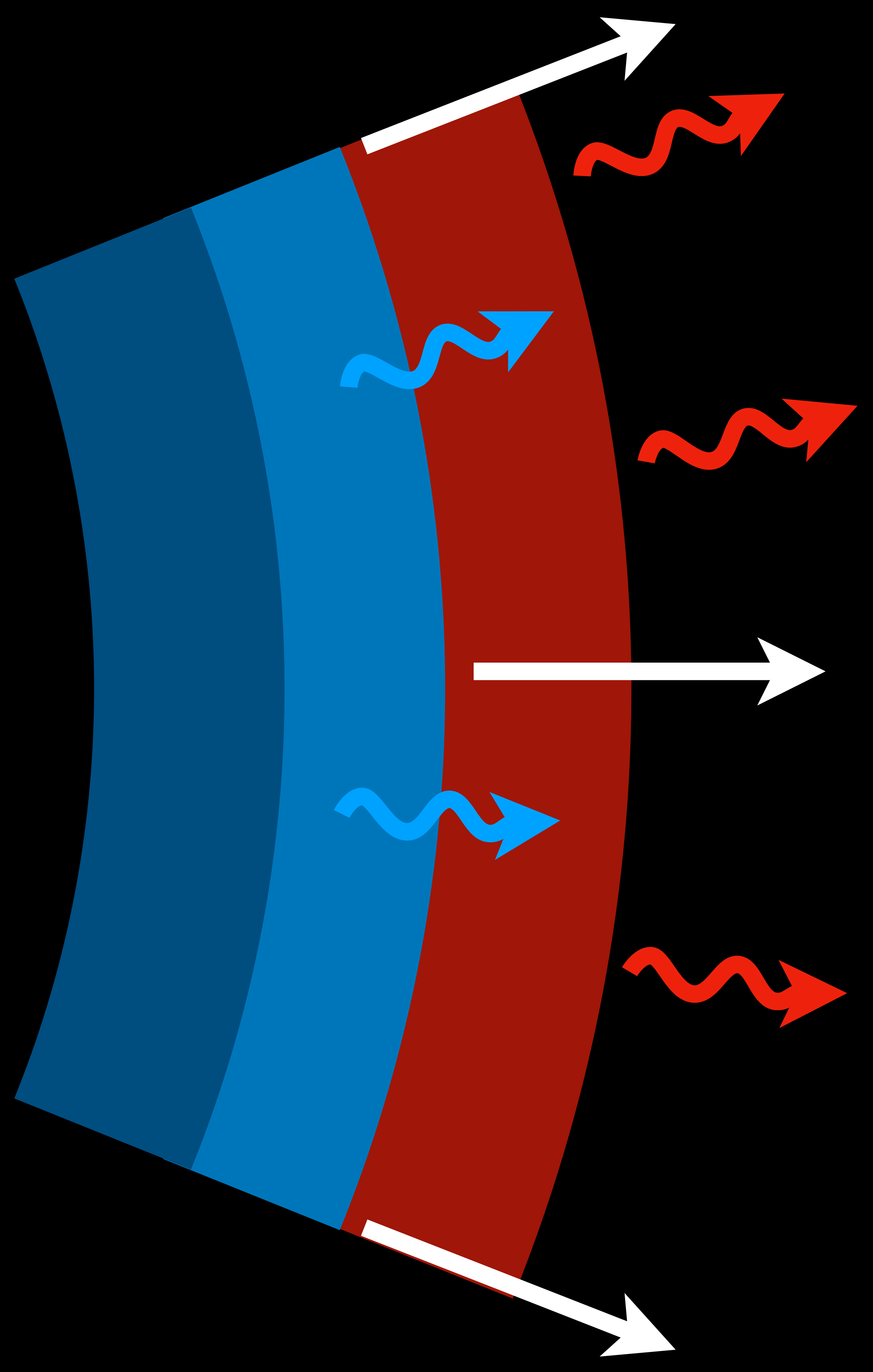
CMS / LHC

Shocks and Afterglows

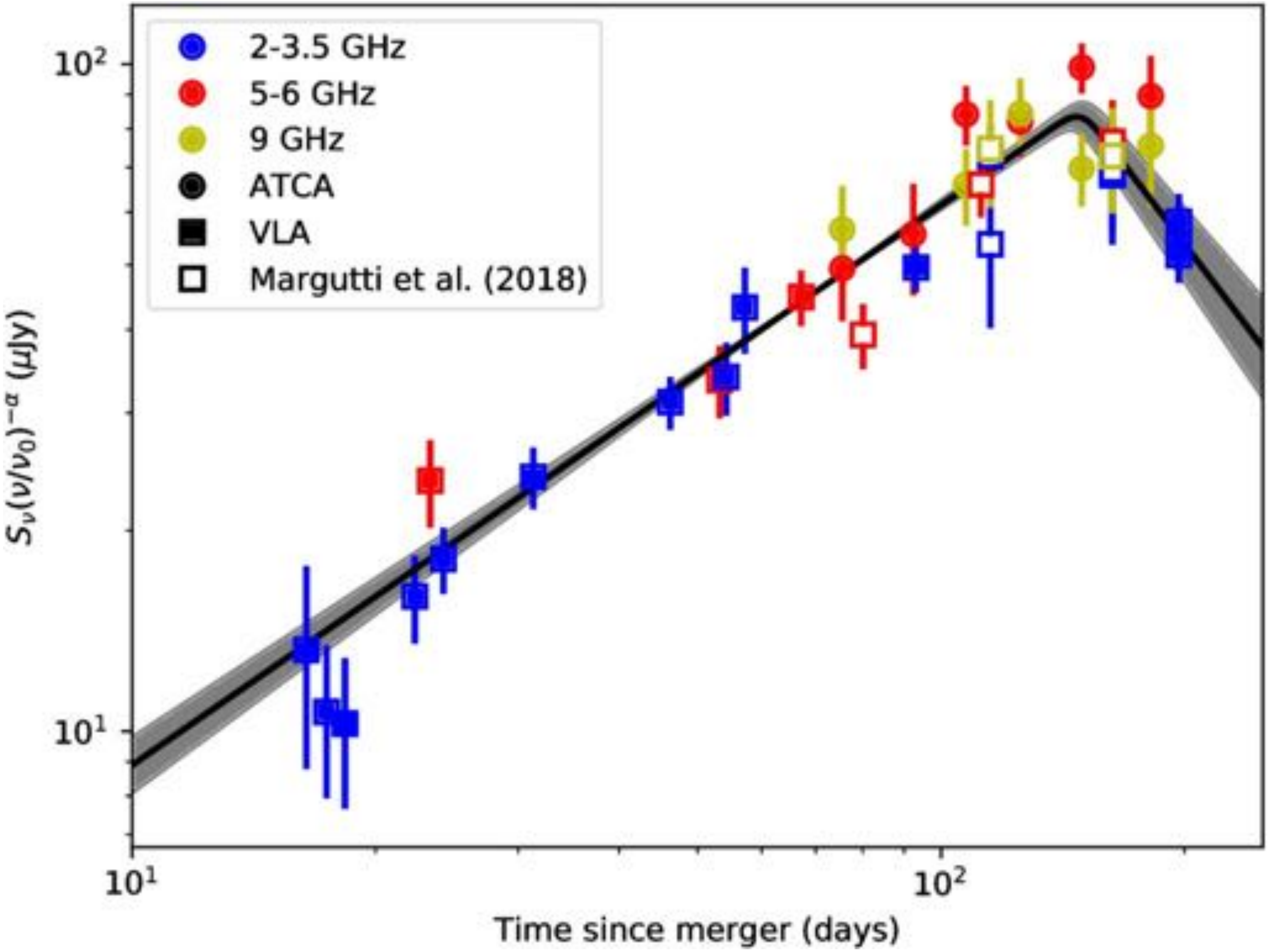


NASA

Outflows and Ejecta



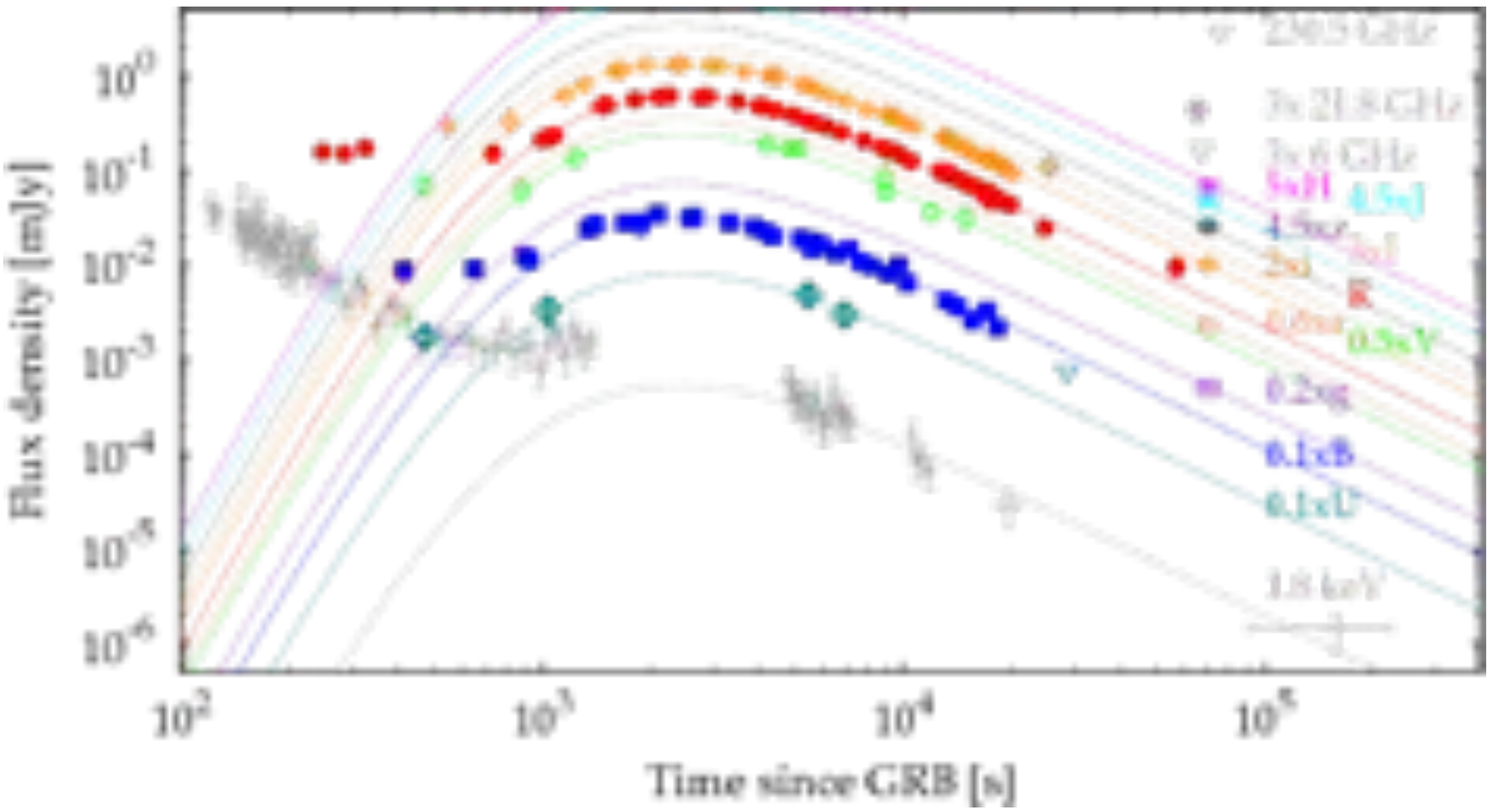
GW170817



- Mildly relativistic
- Quasi-spherical
- Lower energy compared to short GRB afterglows

Dobie+2018

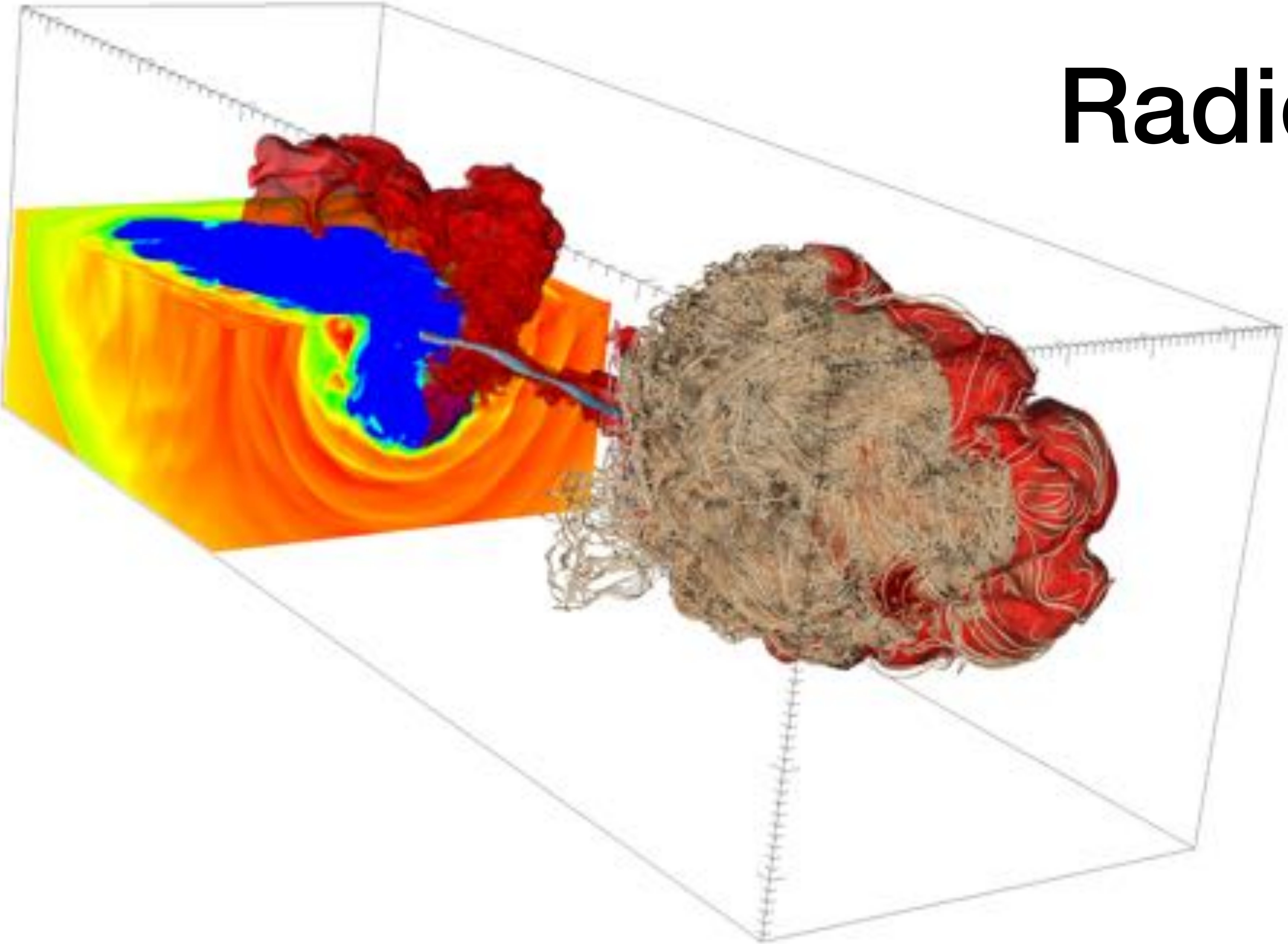
GRB120404



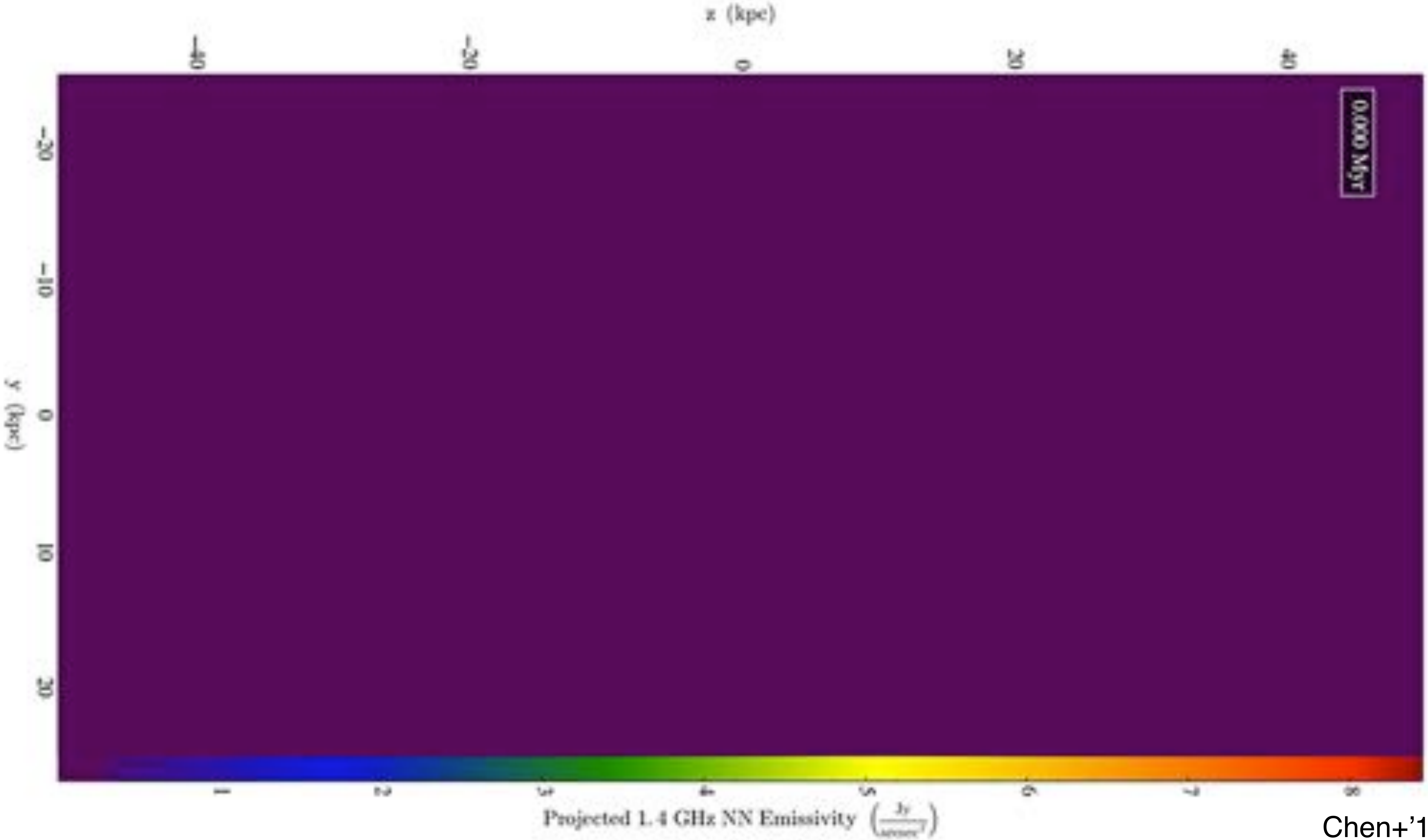
Guidorzi+2014

Cocoon formation

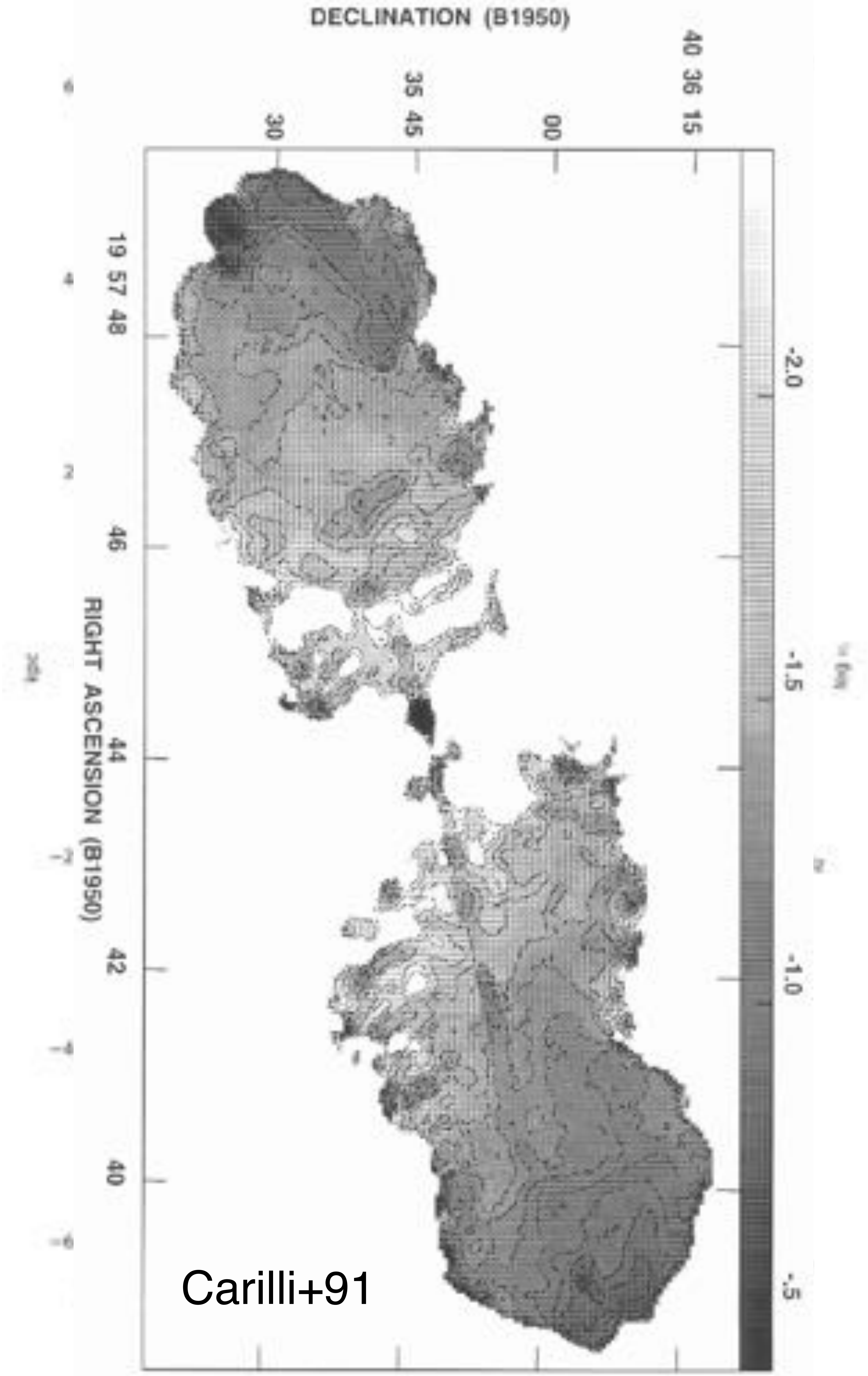
Radio Lobes

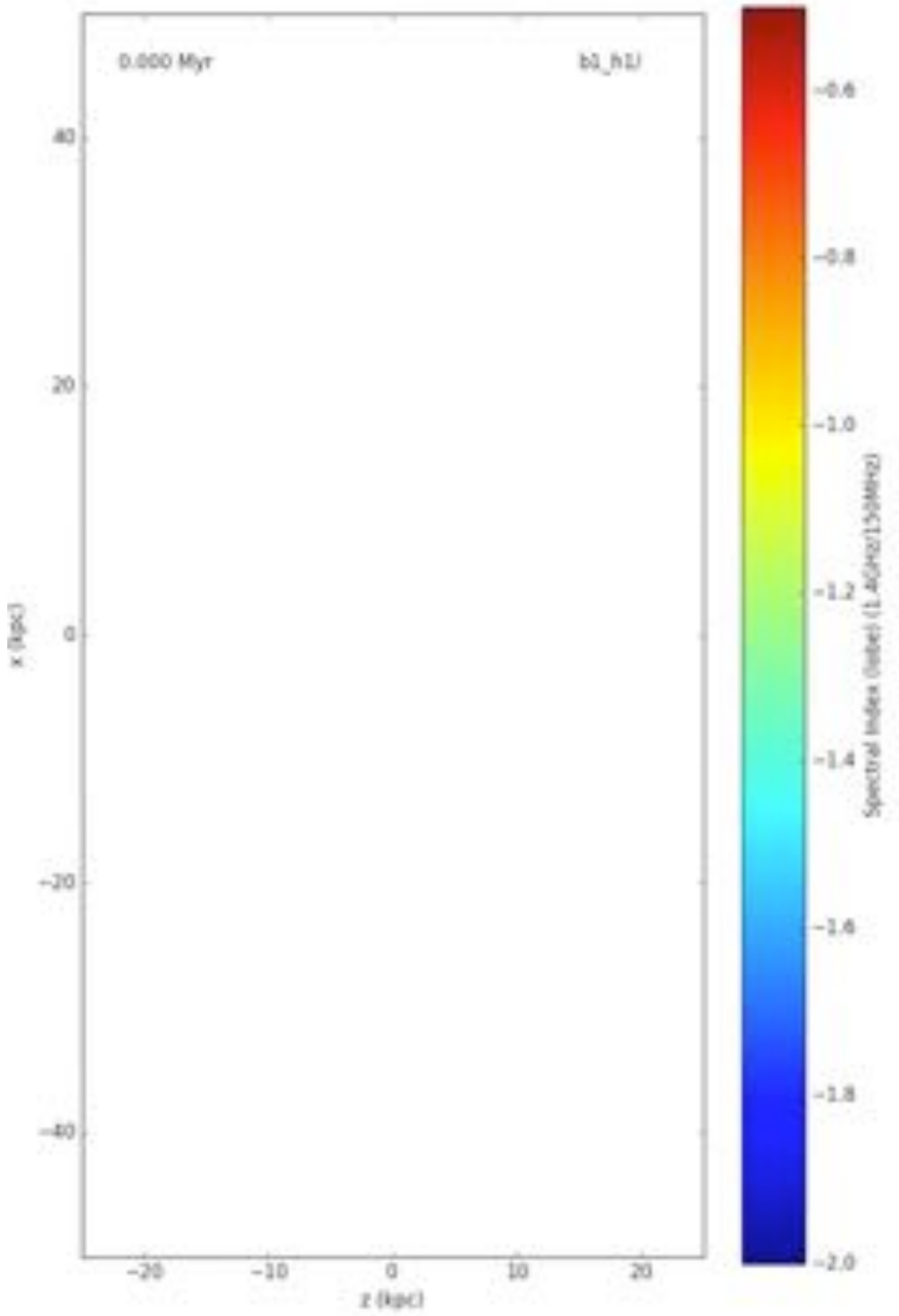


Chen+'18



Chen+'18


DECLINATION (B1950)
RIGHT ASCENSION (B1950)
Carilli+91

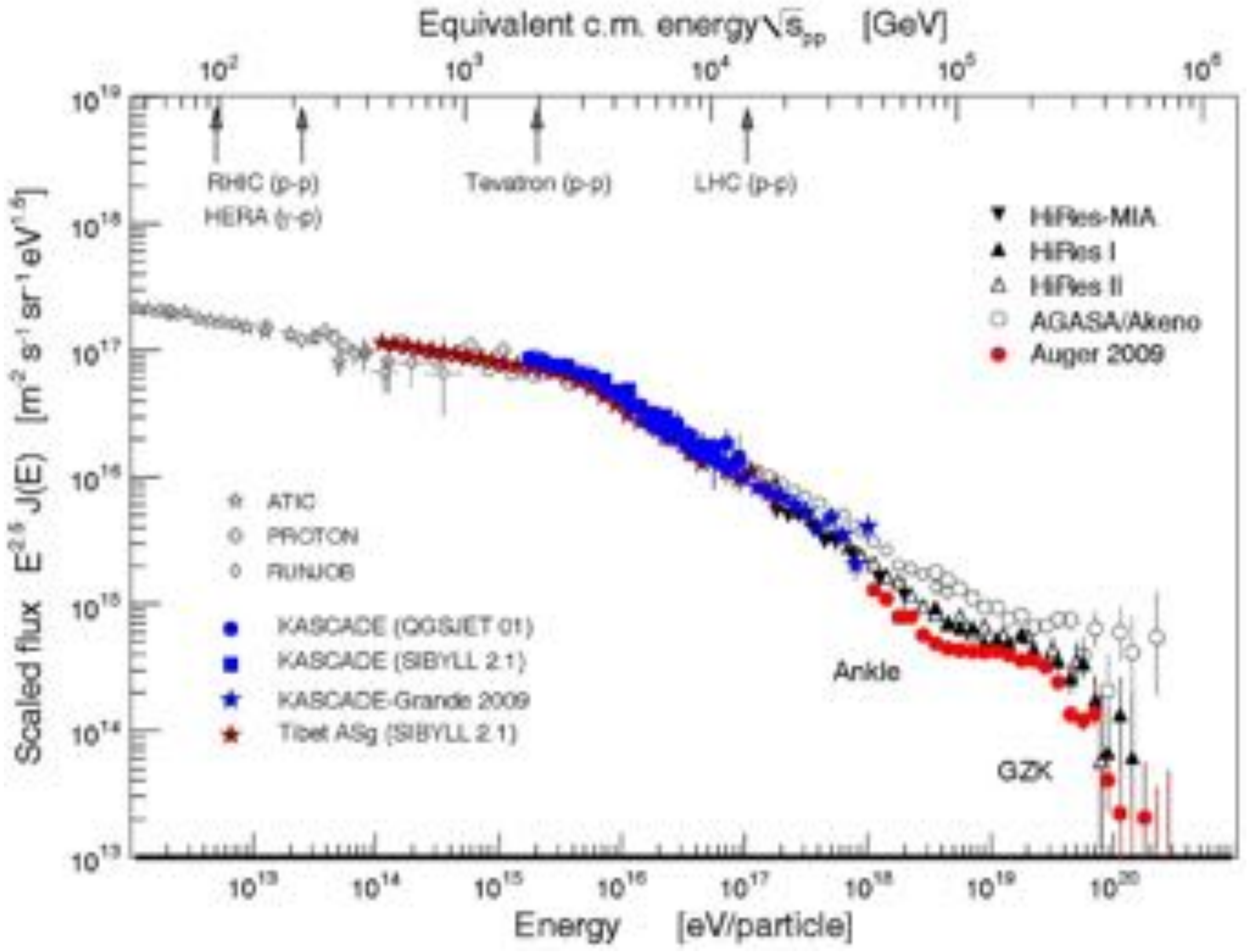

0.000 Myr
z (kpc)
x (kpc)

Ultra-High Energy Cosmic Rays

Extragalactic, but no identification of sources

Auger Collaboration

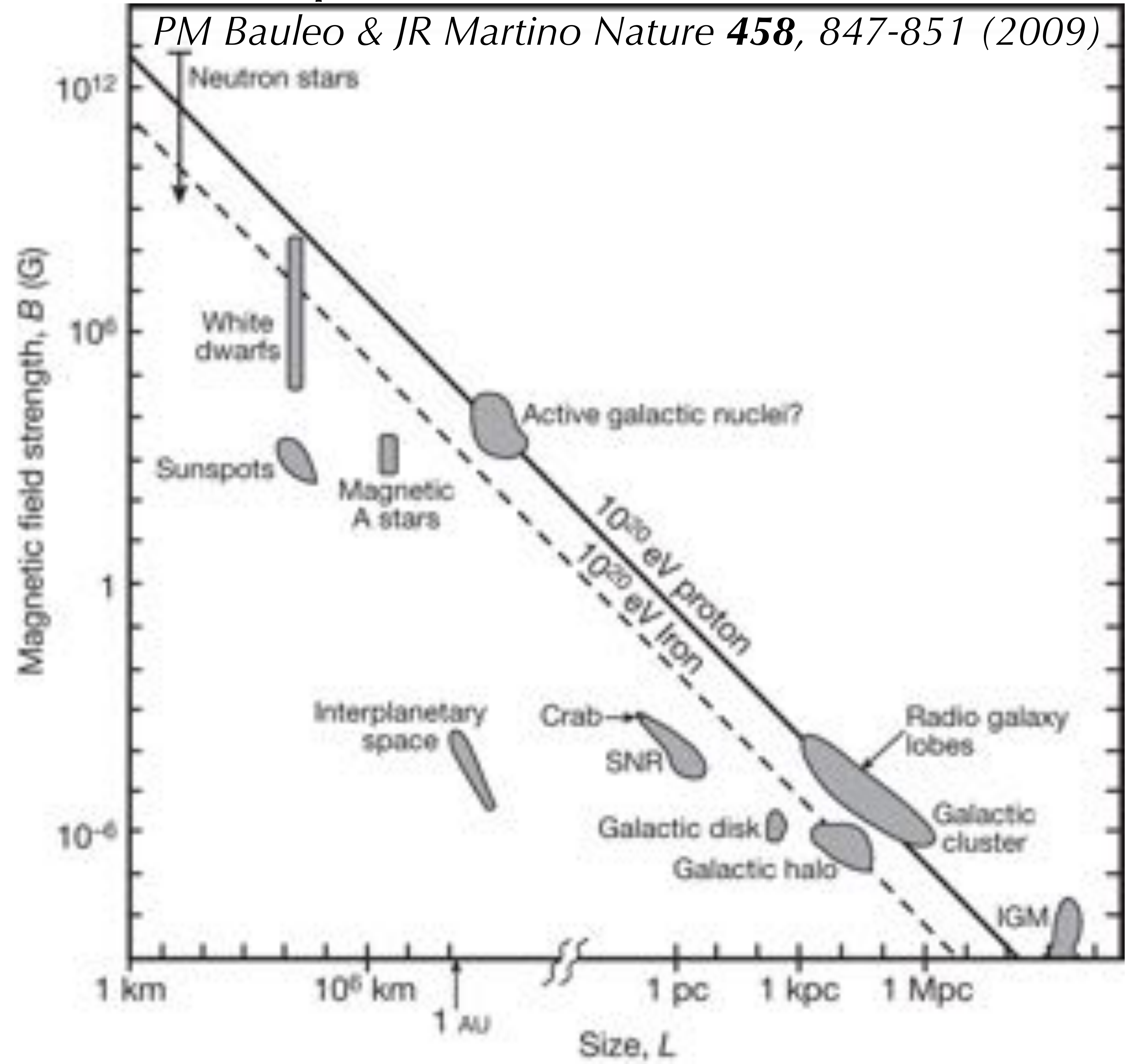
Ultra-High Energy Cosmic Rays



R. Engel, Auger Collaboration 2011

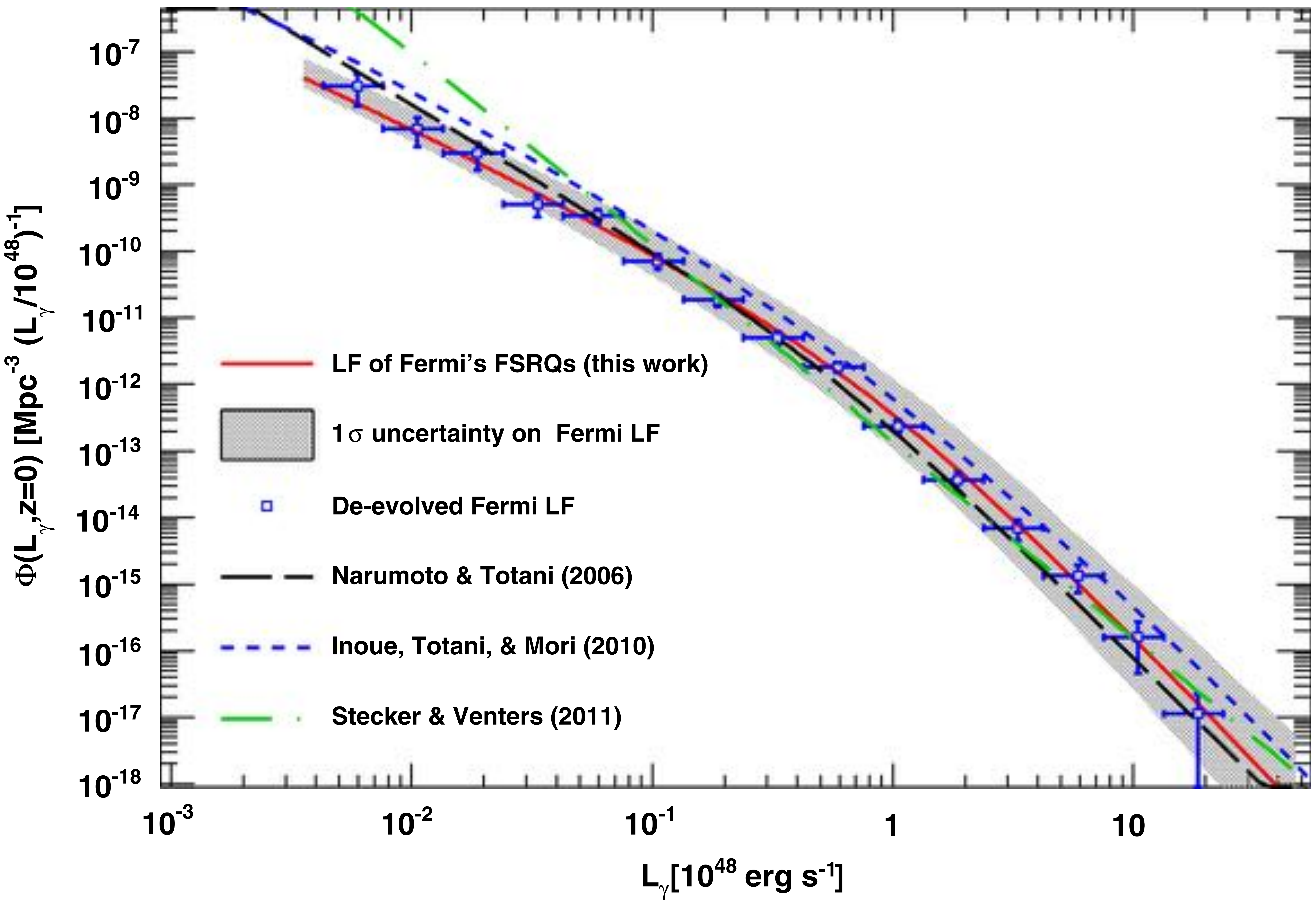
Hillas plot:

*PM Bauleo & JR Martino Nature **458**, 847-851 (2009)*

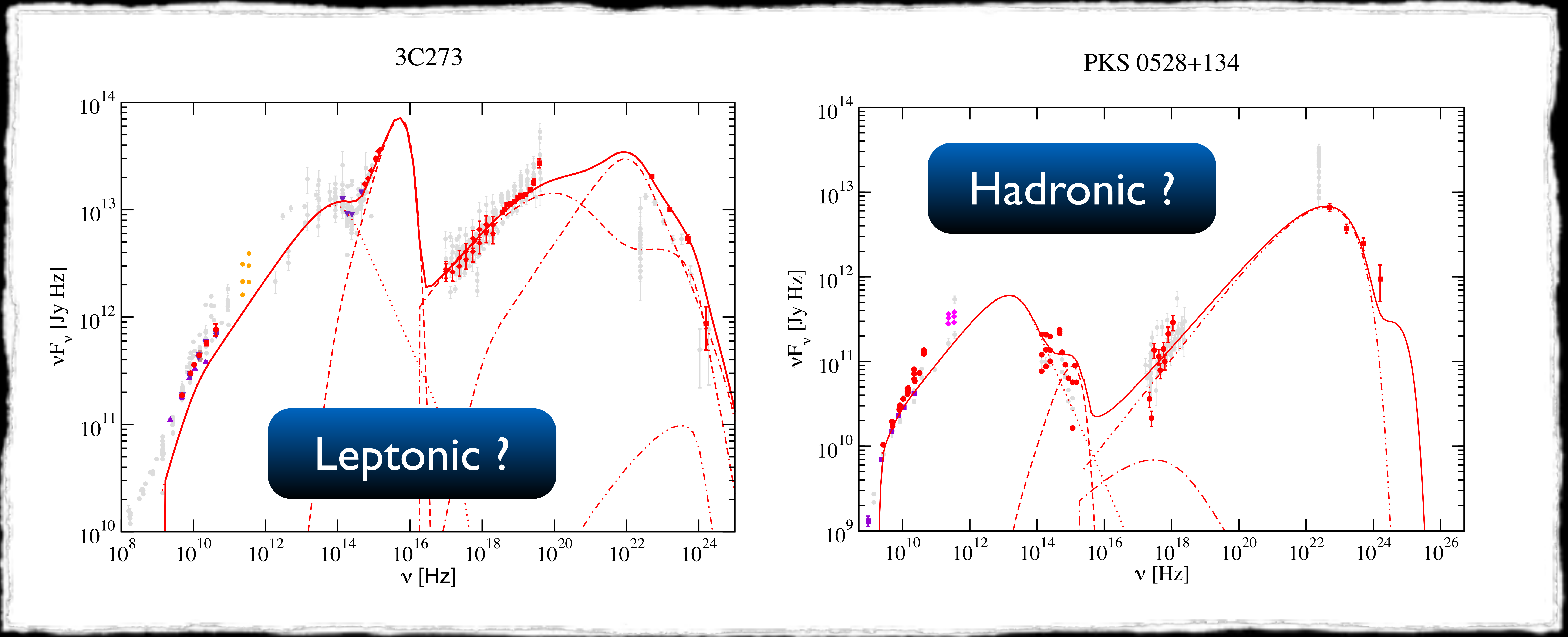


Are AGN the source?

THE ASTROPHYSICAL JOURNAL, 751:108 (20pp), 2012 June 1 AJELLO ET AL.

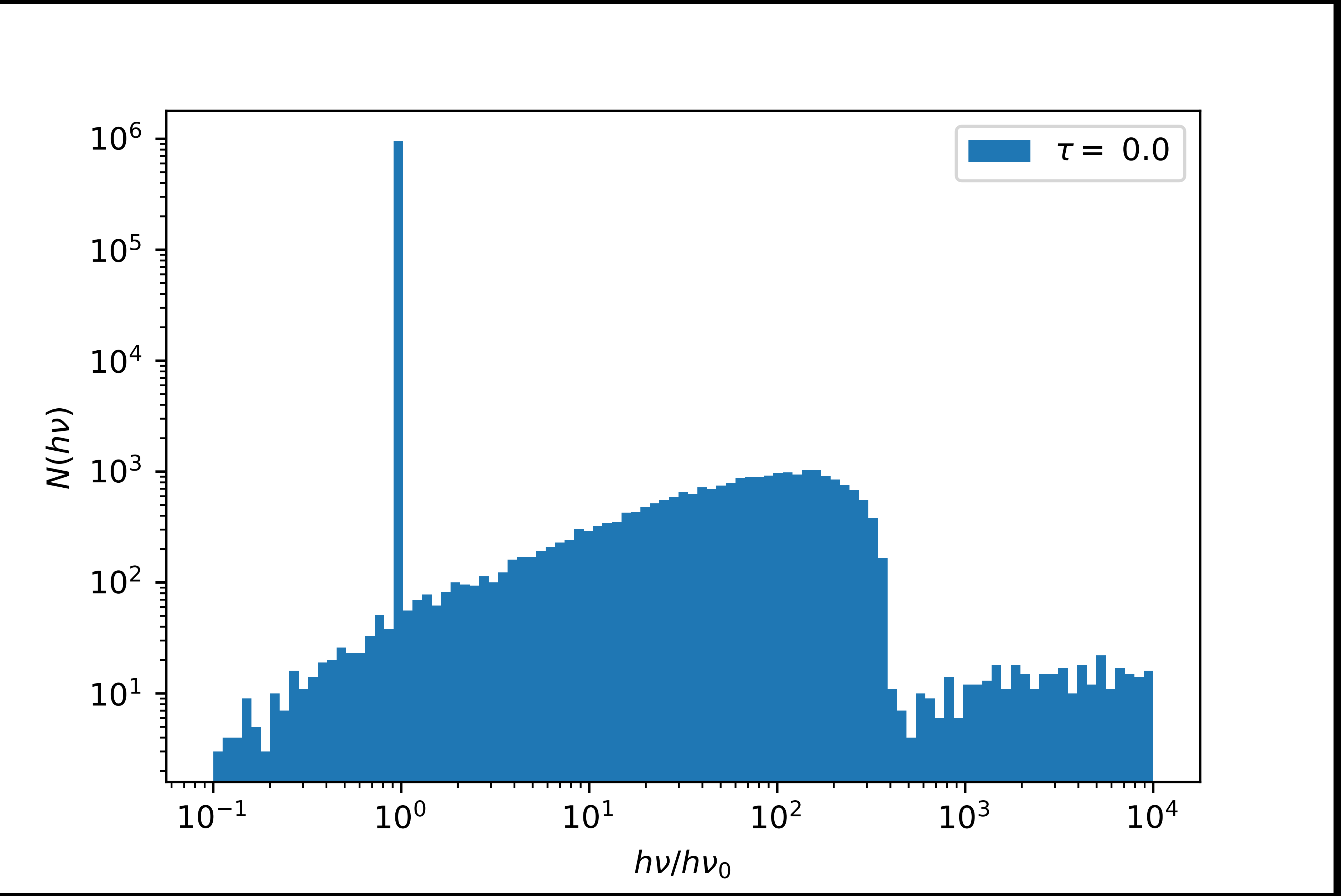


HE Jet Emission

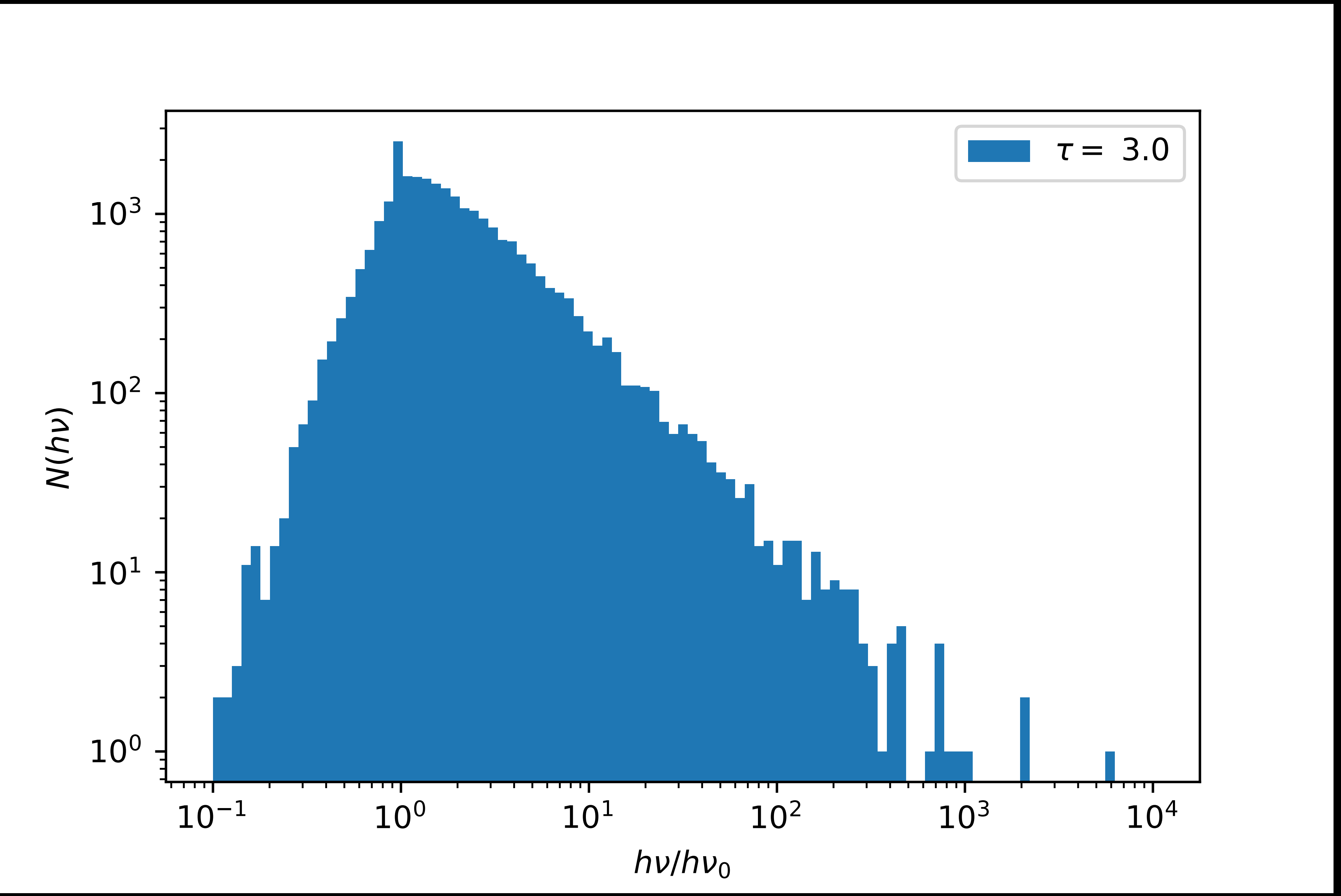


Boettcher+'13

Inverse Compton (again)

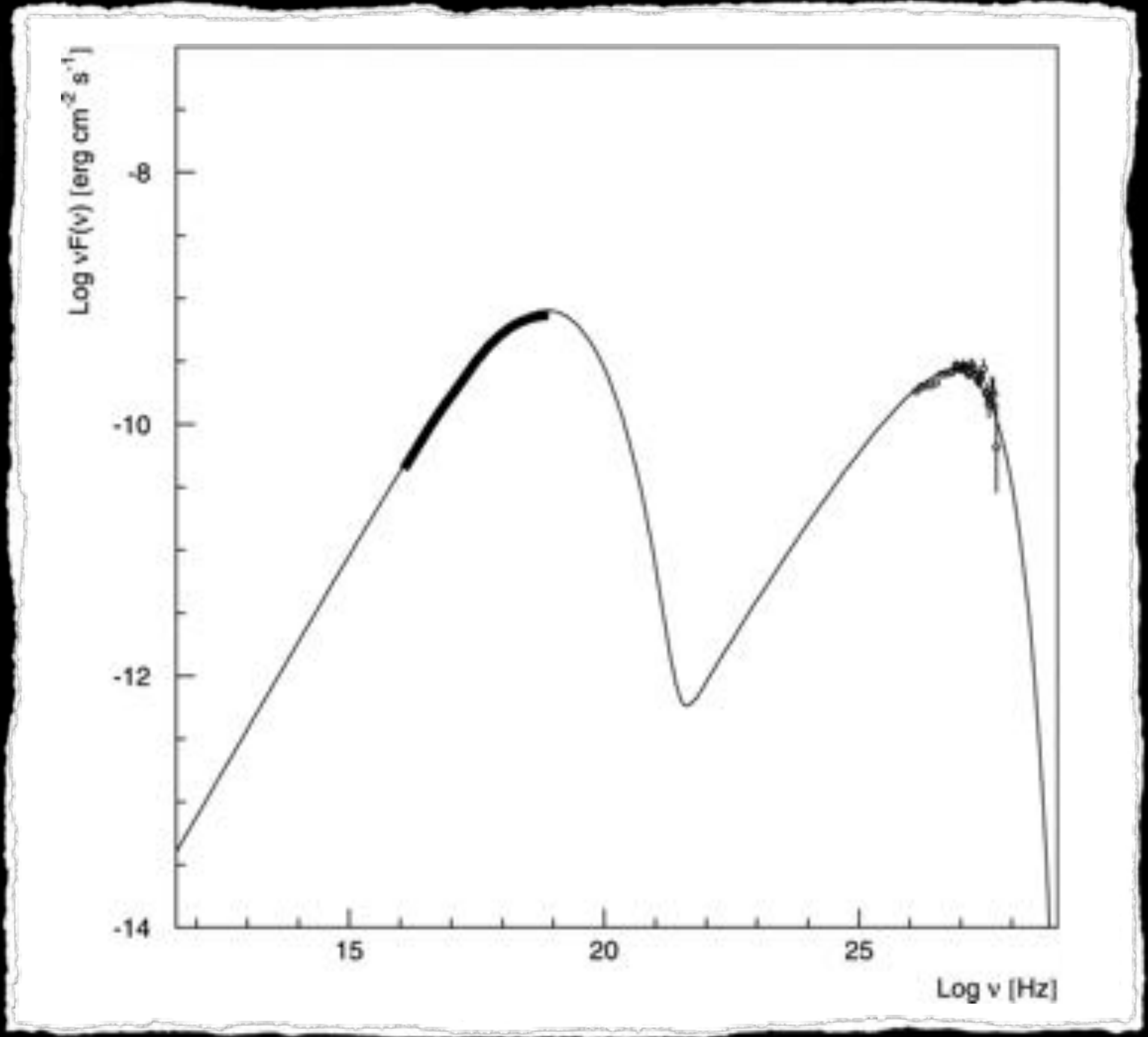


γ=10



γ=1.06

SSC



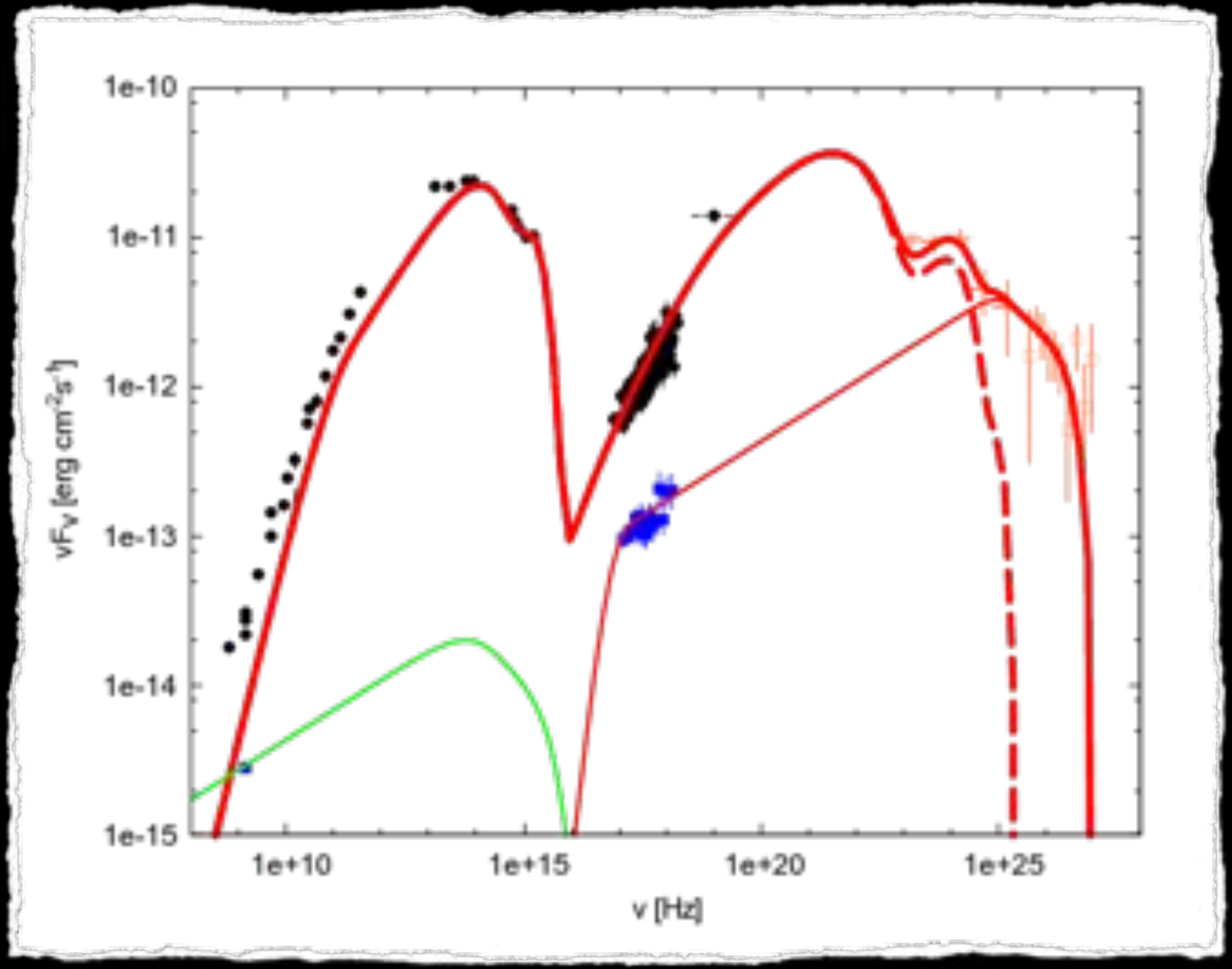
Mrk 501, Konopelko+2003

$$L_{\rm synch} \propto B^{(1+p)/2} P$$

$$L_{\rm SSC} \propto P U_{\rm synch} \propto P^2 B^{(1+p)/2}$$

Estimate B, P independently

EC



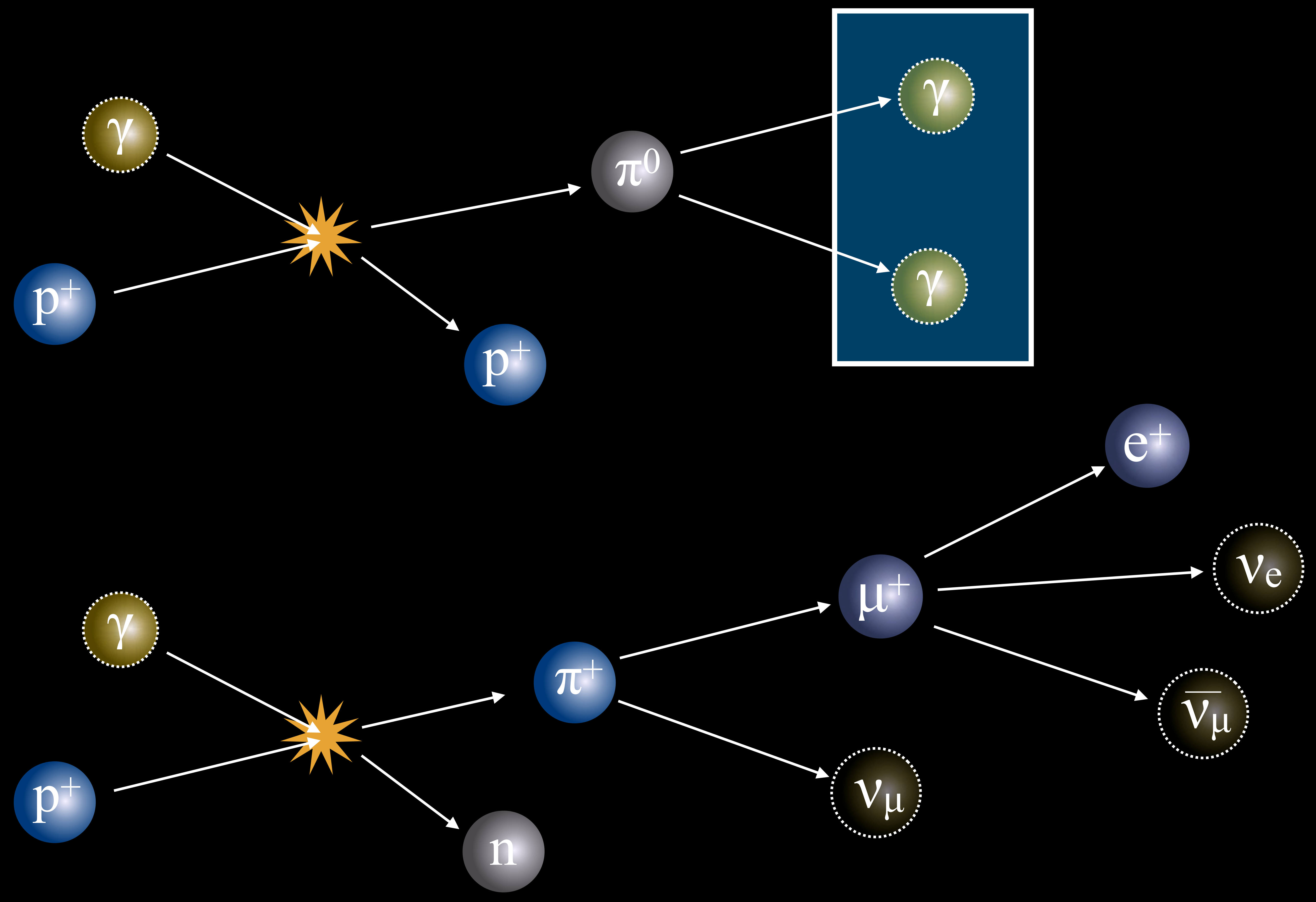
Zacharias+2005

$$L_{\mathrm{sync}} \propto B^{(1+p)/2} P \delta^{2+\alpha}$$

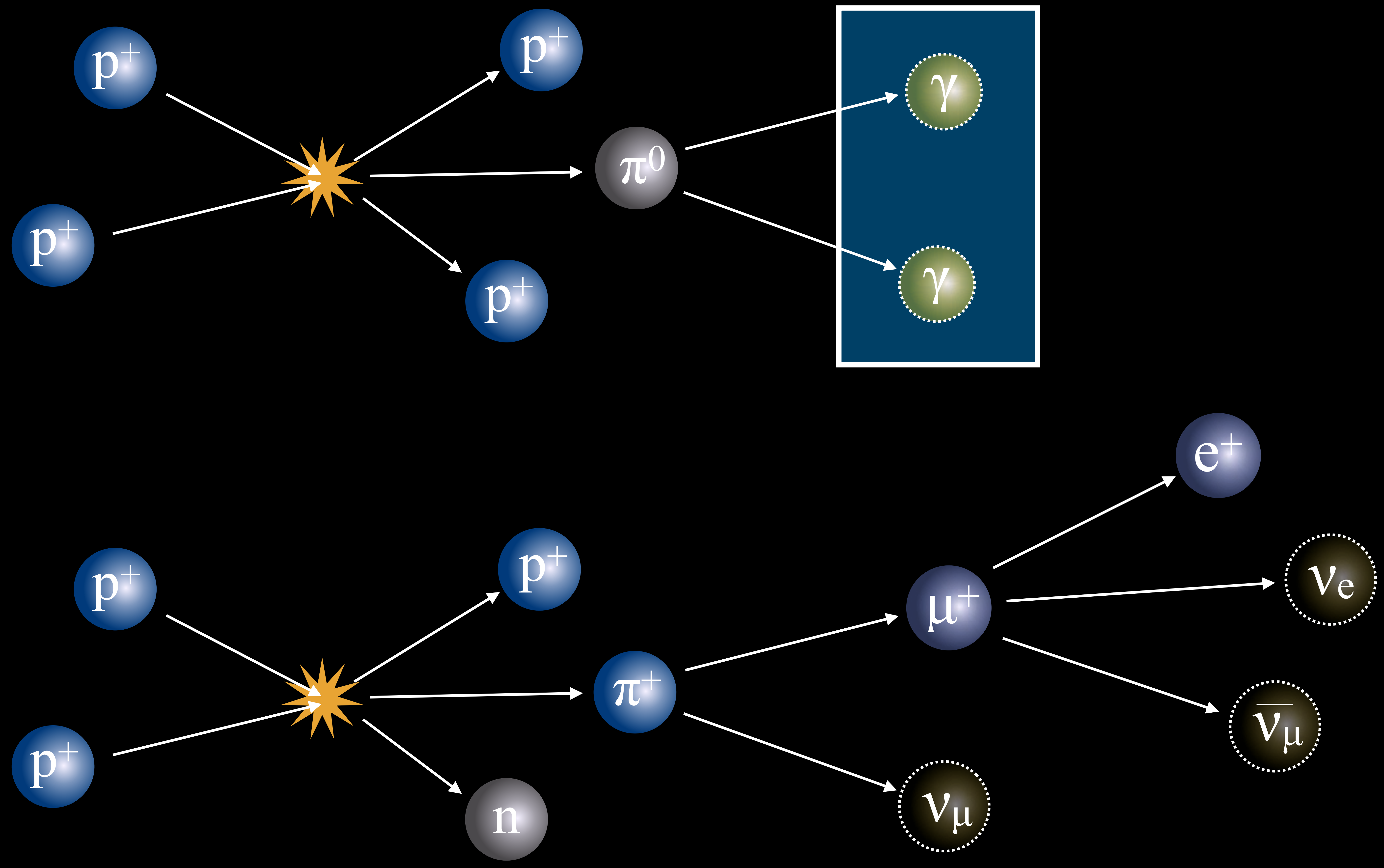
$$L_{\mathrm{IC-CMB}} \propto P U_{\mathrm{CMB}} \Gamma^2 \delta^{2+\alpha}$$

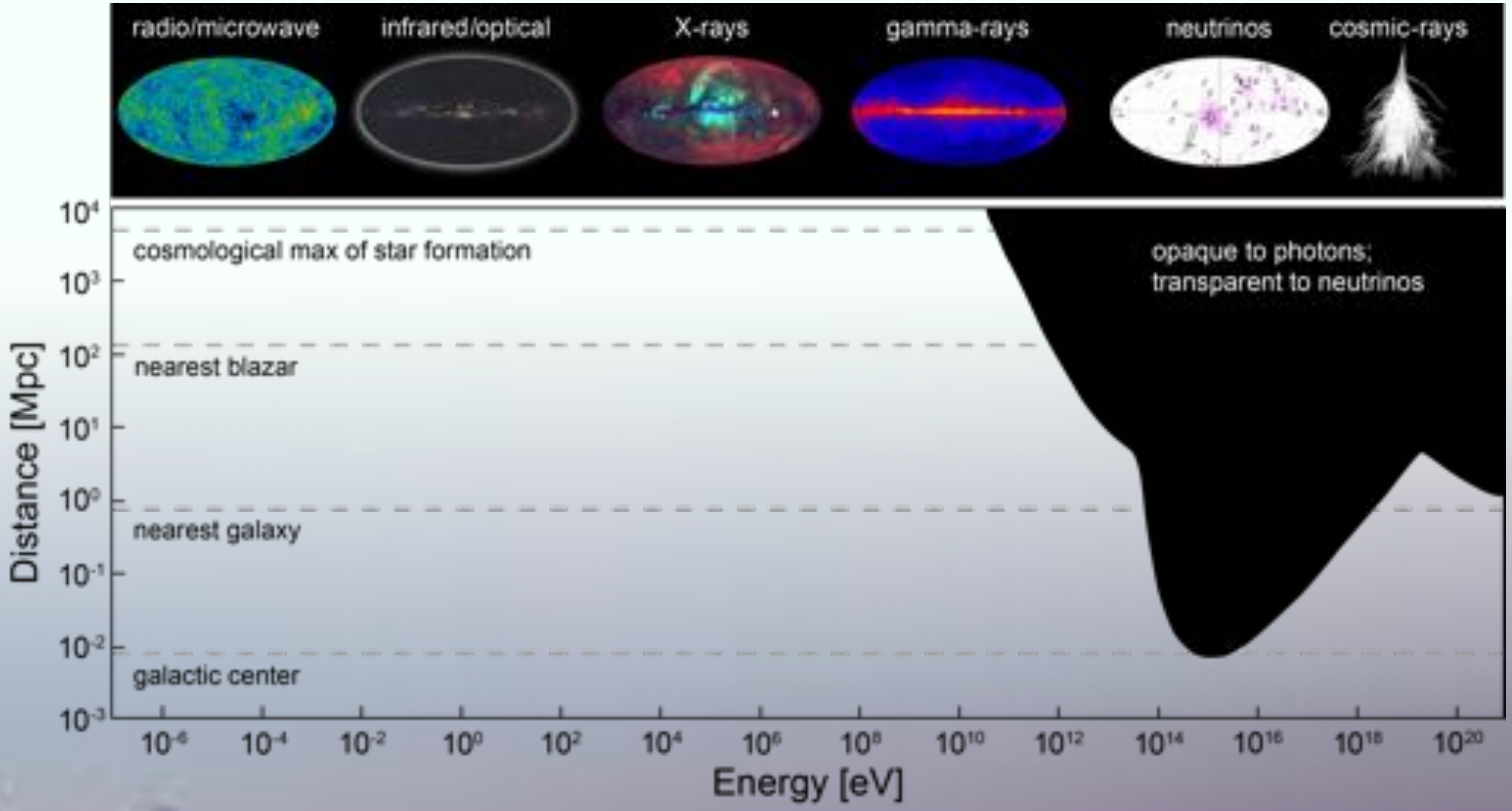
Estimate Γ

IceCube ν_s

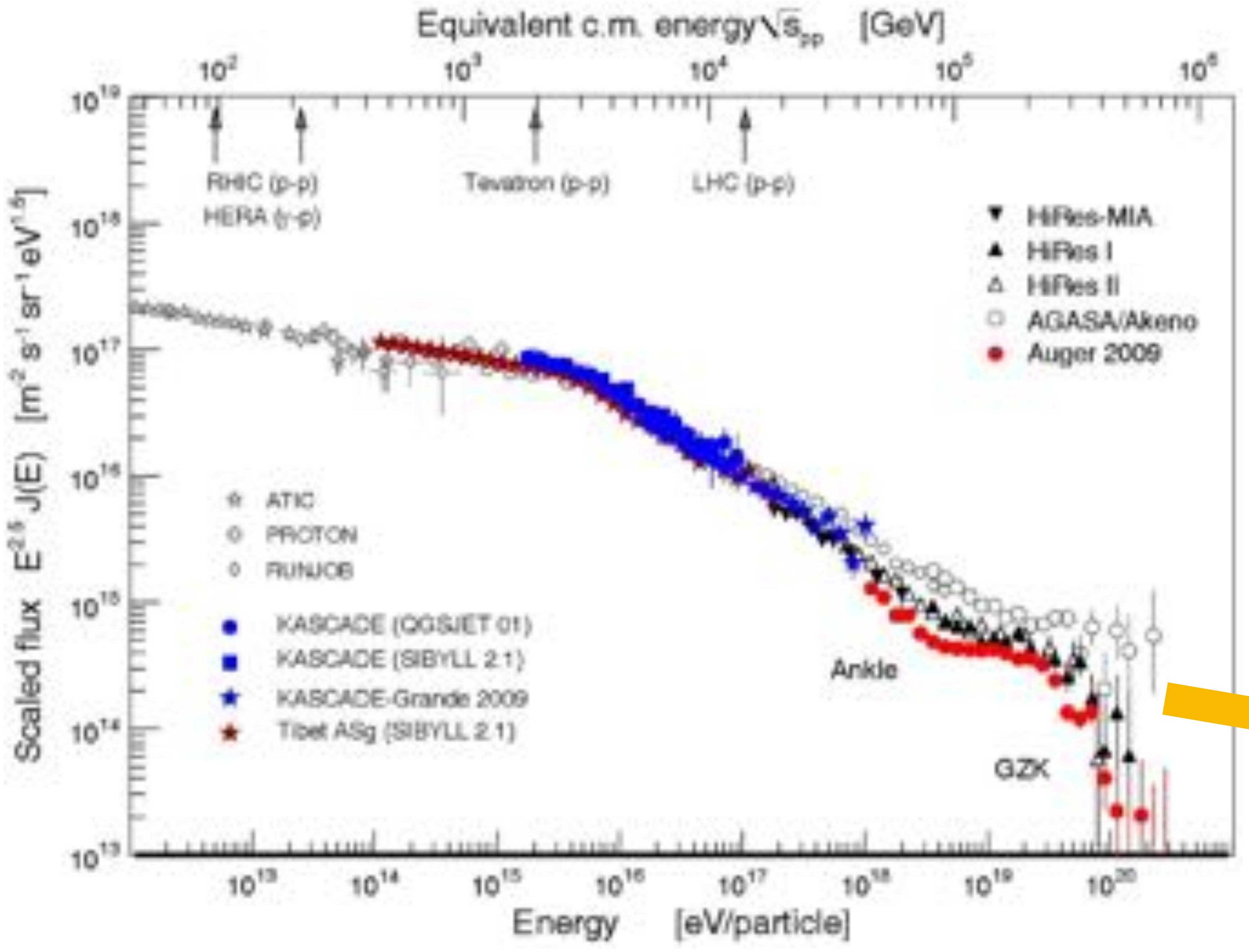


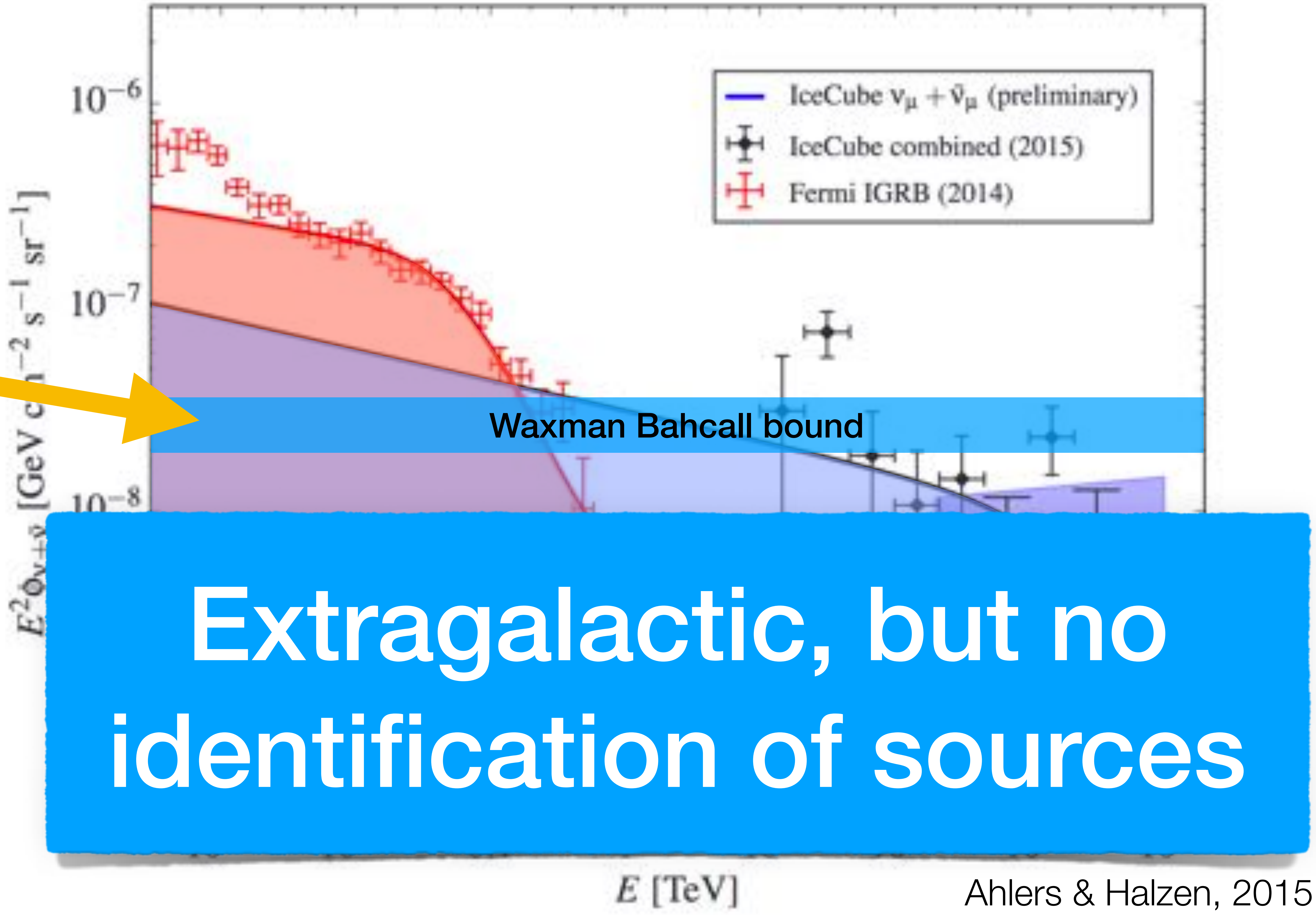
IceCube ν_s




radio/microwave
infrared/optical
X-rays
gamma-rays
neutrinos
cosmic-rays
cosmological max of star formation
nearest blazar
nearest galaxy
galactic center
opaque to photons;
transparent to neutrinos
Distance [Mpc]
10^{4} 10^{3} 10^{2} 10^{1} 10^{0} 10^{-1} 10^{-2} 10^{-3}
10^{-6} 10^{-4} 10^{-2} 10^{0} 10^{2} 10^{4} 10^{6} 10^{8} 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20}
Energy [eV]

TeV Neutrinos





Extragalactic, but no identification of sources

Ahlers & Halzen, 2015