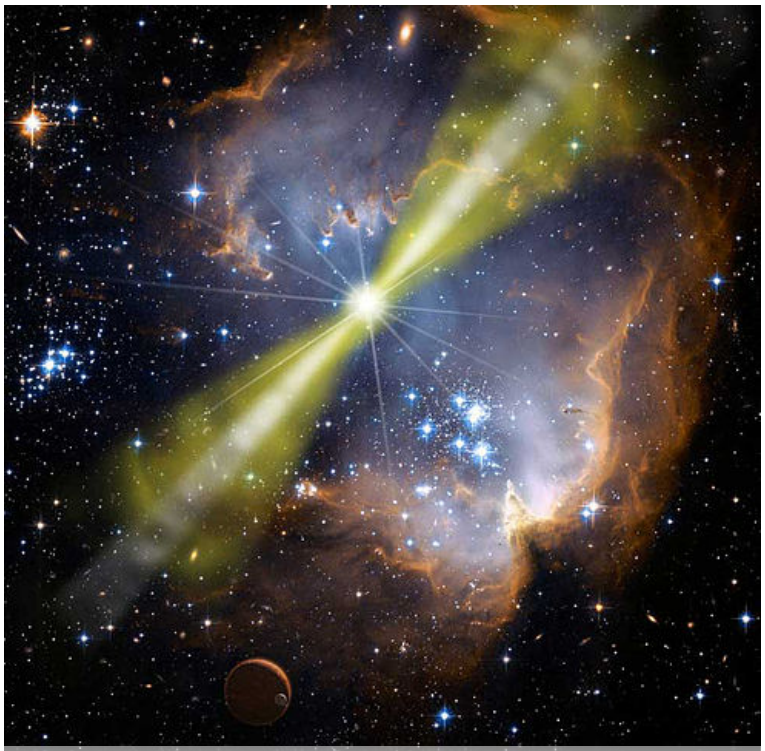
Neutrino signal dependence on gamma-ray burst emission mechanism



Tetyana Pitik
with I.Tamborra and M.Petropoulou

arXiv: 2102.02223

Niels Bohr Institute,
University of Copenhagen

February 25,2021

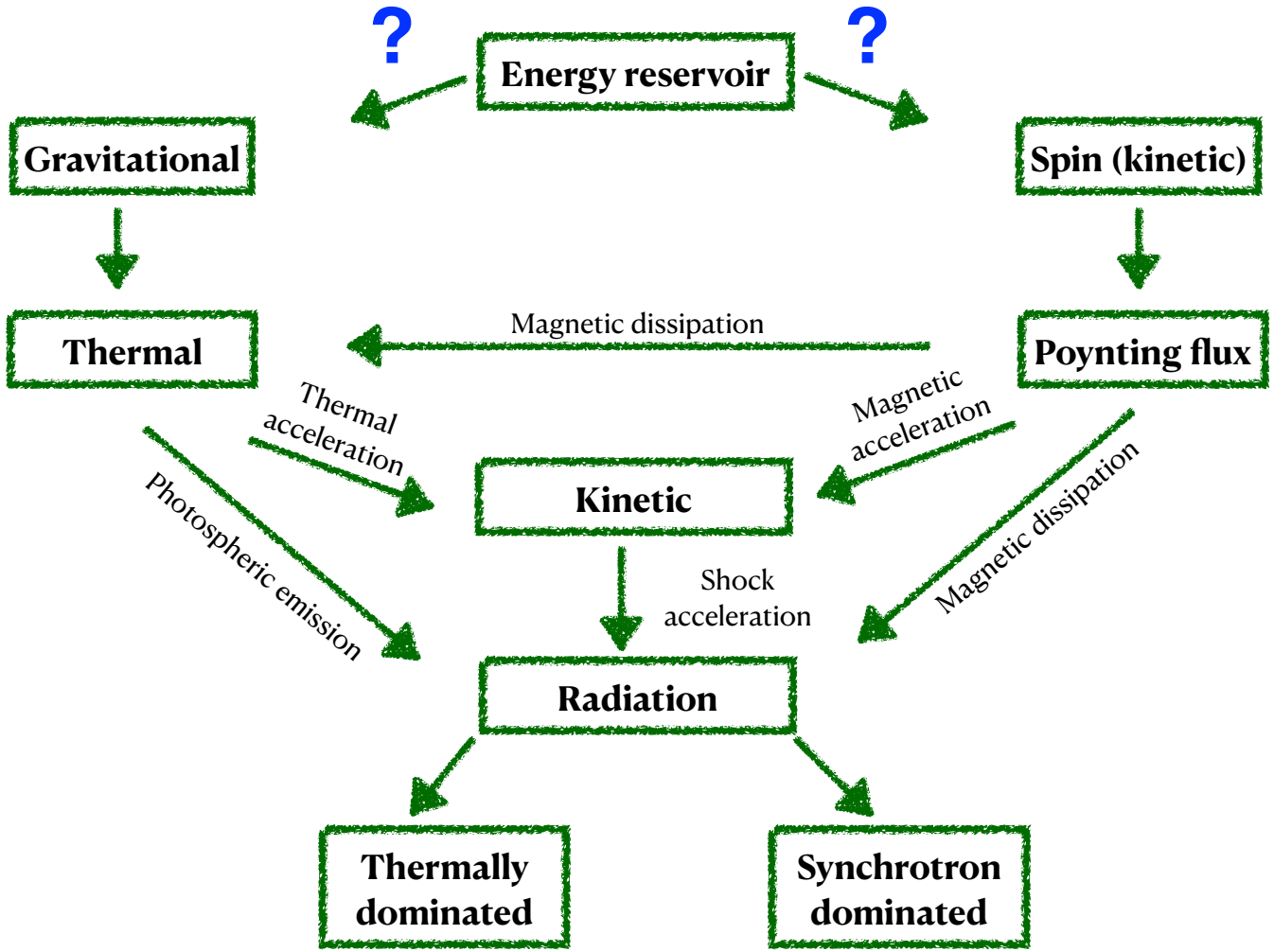
XIX International Workshop on Neutrino Telescopes

CARLSBERG FOUNDATION

Motivation

- The mechanism powering high luminosity GRBs is still subject to debate

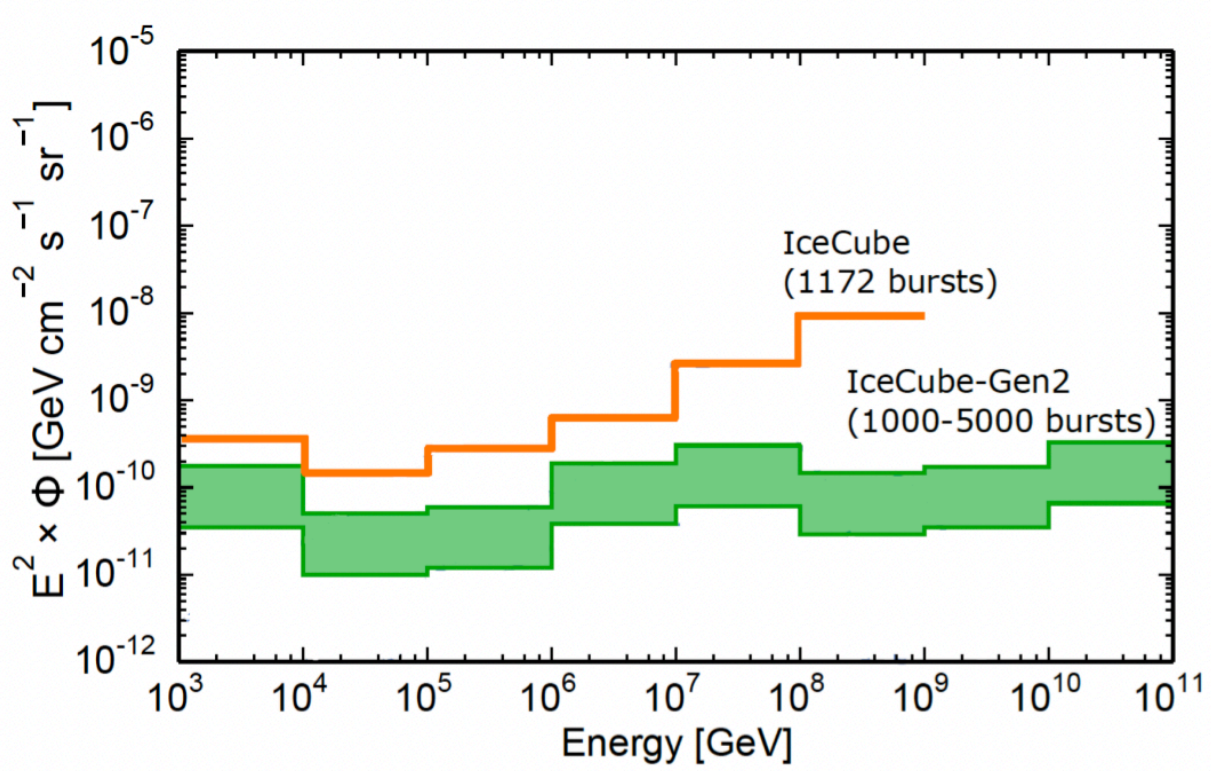
- The GRB prompt spectra alone are not sufficient to diagnose the jet mechanism



Motivation

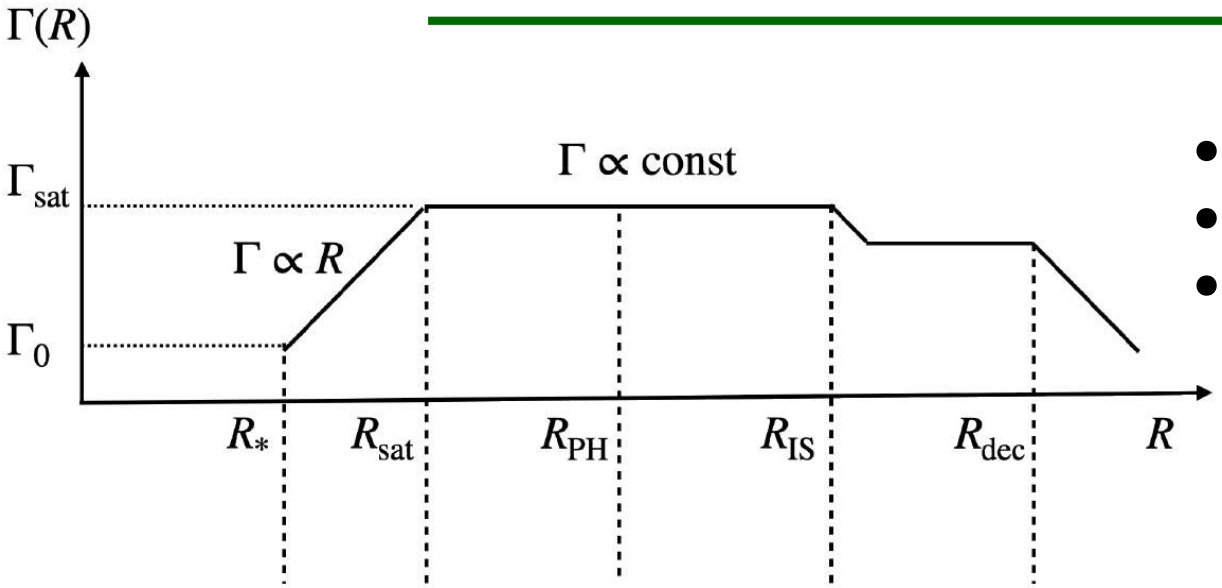
- GRBs are candidate sources of high energy neutrinos (contribution to the diffuse flux < 1%)

- IceCube-Gen2 may constrain some electromagnetic models

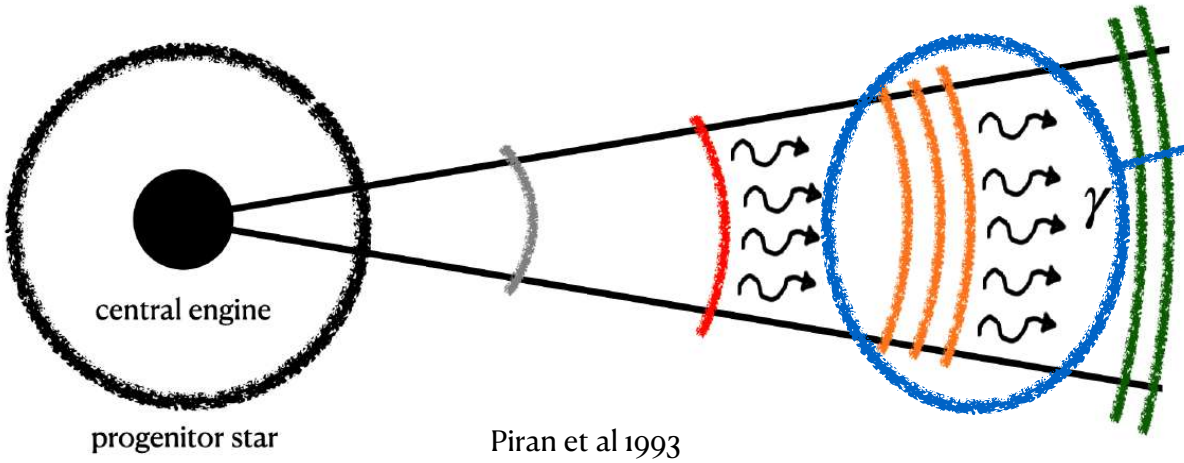


IceCube-Gen2 Collaboration 2020

Matter dominated jets



- Internal shock model
- Dissipative photosphere + Internal Shocks
- 3 component model

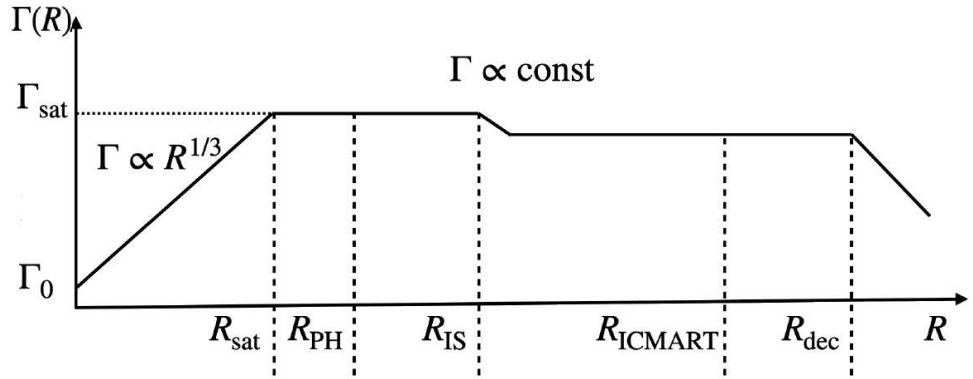


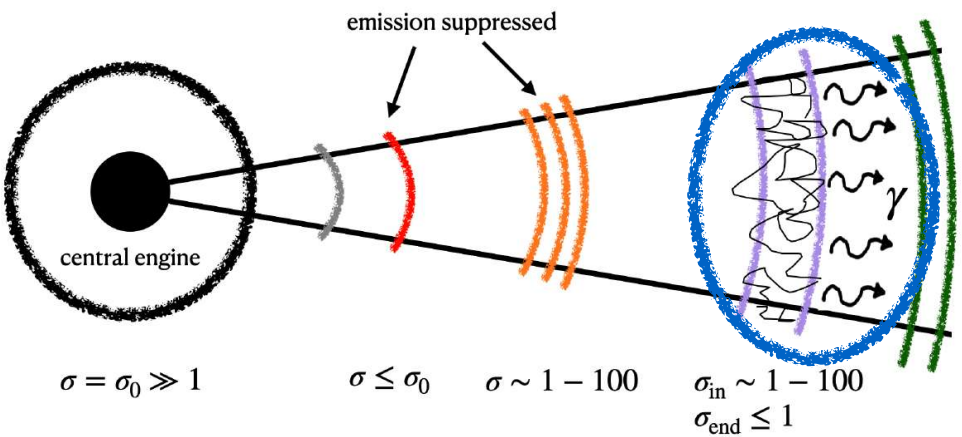
Piran et al 1993

$$
\begin{aligned}
p+\gamma &\rightarrow \Delta \rightarrow n+\pi^{+}, p+\pi^{0} \\
p+\gamma &\rightarrow K^{+}+\Lambda/\Sigma \ . \\
\pi^{+} &\rightarrow \mu^{+}\nu_{\mu} \ , \\
\mu^{+} &\rightarrow \bar{\nu}_{\mu}+\nu_{e}+e^{+} \ , \\
\pi^{-} &\rightarrow \mu^{-}\bar{\nu}_{\mu} \ , \\
\mu^{-} &\rightarrow \nu_{\mu}+\bar{\nu}_{e}+e^{-} \ , \\
K^{+} &\rightarrow \mu^{+}+\nu_{\mu} \ , \\
n &\rightarrow p+e^{-}+\bar{\nu}_{e} \ .
\end{aligned}
$$

Poynting flux dominated jets

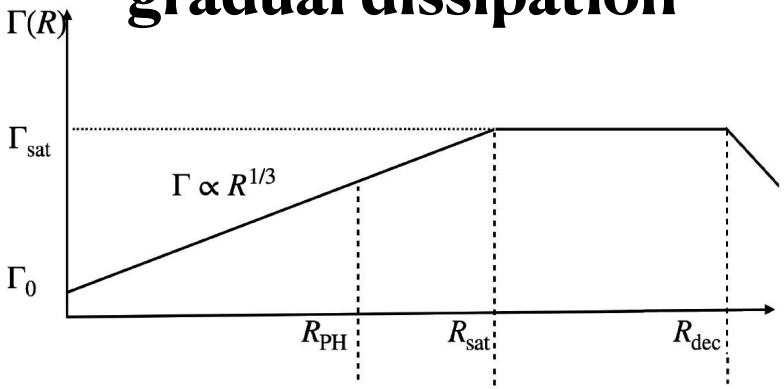
ICMART model

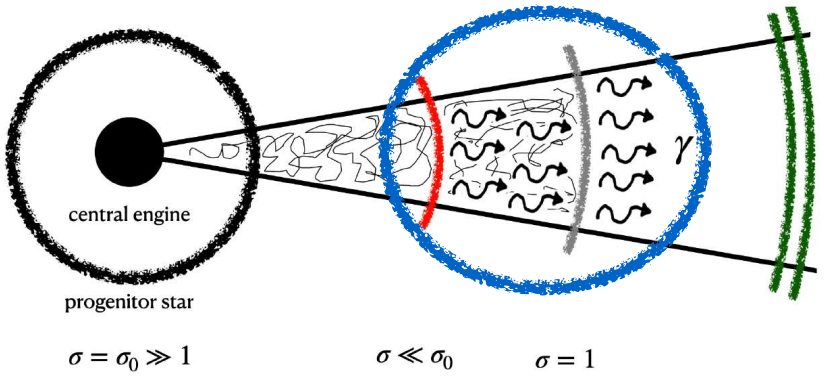




Zhang et al 2010

Magnetized jet model with gradual dissipation

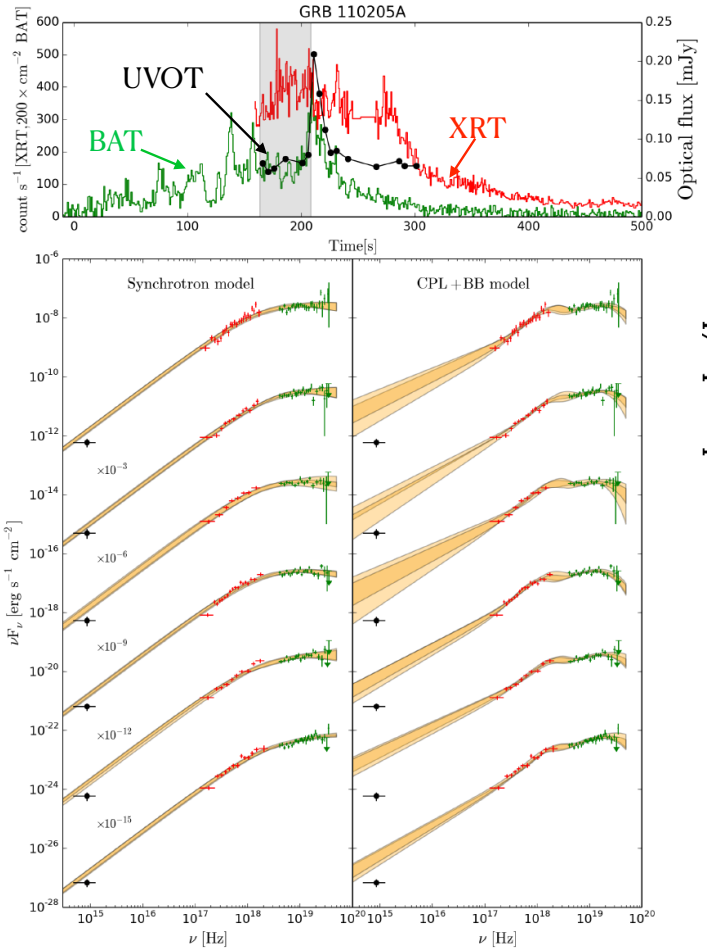




Drenkhahn 2002

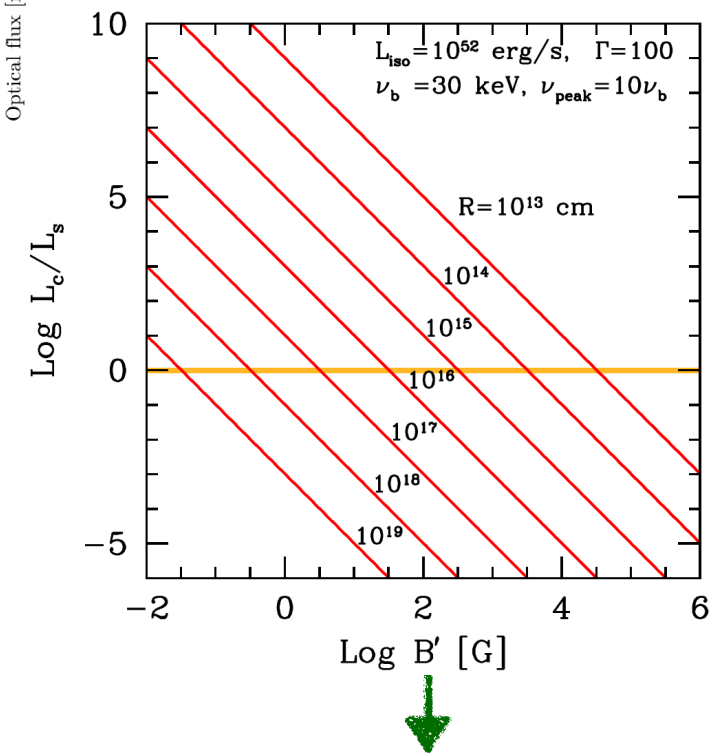
Proton synchrotron model

new break in the KeV range



Oganesyan et al 2019

Ghisellini et al 2020

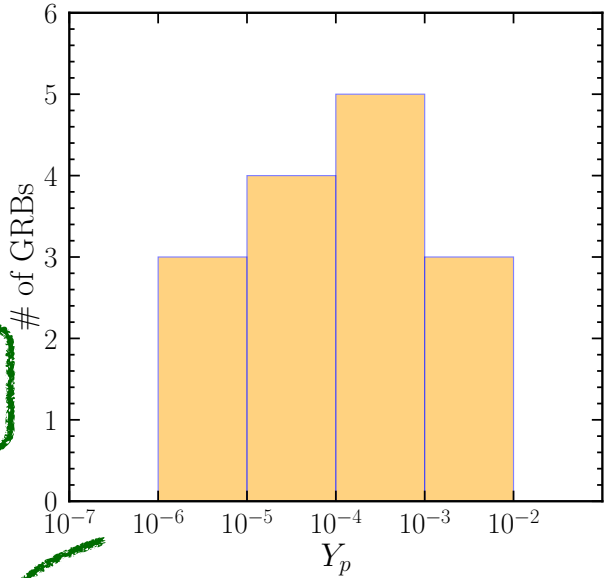


The leptonic scenario is disfavored for standard source parameters

Measured parameters: $E_{\gamma,\mathrm{peak}}$, $E_{\gamma,\mathrm{cool}}$, $F_{\gamma,\mathrm{cool}}$, t_{cool}

Inferred source parameters: B', γ'_{min}, R_γ, $E_{\gamma,bol}$, Γ

$$Y_p \equiv \frac{L'_{\mathrm{p},p\gamma}}{L'_{\mathrm{p,syn}}}$$



Pitik et al 2021

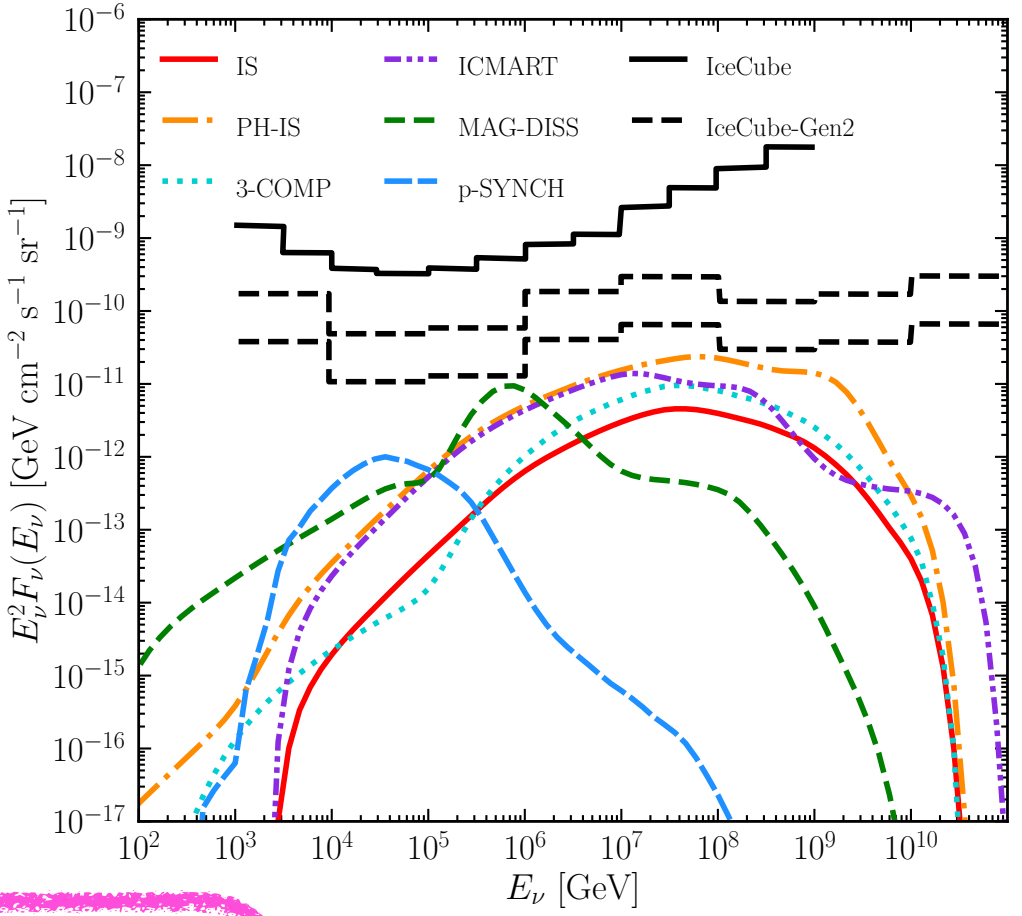
These GRBs are poor neutrino emitters

Results: stacking flux

GRB jet parameters:

- $\tilde{E}_{\rm jet,iso} = 3.4 \times 10^{54}\,{\rm erg}$
- $\Gamma = 300$
- $t_{\rm dur} = 100\,{\rm s}$
- $t_{\rm var} = 0.5\,{\rm s}$
- $z = 2$

GRB rate: $\dot{N} = 667\,{\rm yr}^{-1}$



Variation in neutrino flux up to 1.5 orders of magnitude

Neutrino flux peak energy range from 10^4 GeV to 10^8 GeV

Pitik et al 2021

Conclusions

- Different scenarios for GRB production lead to very different neutrino energy distributions
- We need to take into account different jet models for unbiased stacking searches of neutrinos

Thank you !