

The striped jet model: From the central engine to gamma-rays in GRBs*

Rodolfo Barniol Duran

Associate Professor, Sacramento State

with Michail Damoulakis and Dimitrios Giannios (Purdue), Carly Gip (Sacramento State)

**Damoulakis, Barniol Duran, Giannios (2023, MNRAS, 523, 6250)*

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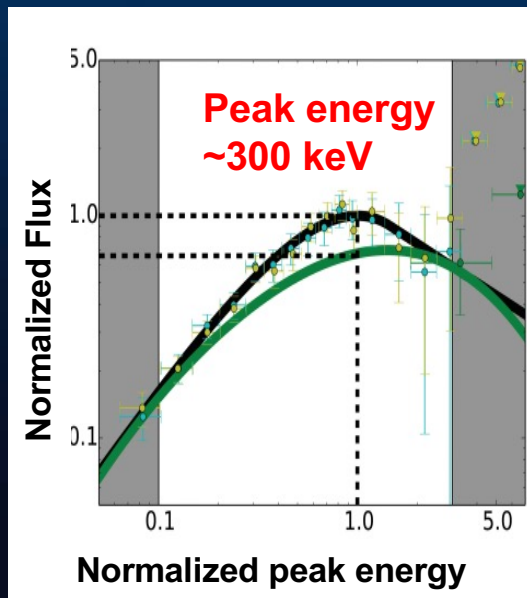
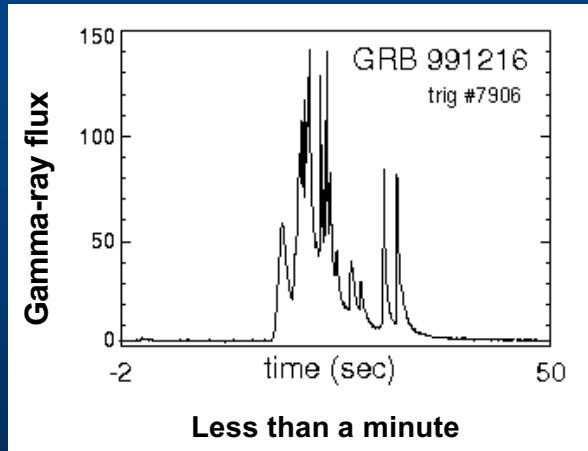


11th Fermi Symposium, UMD, September 10, 2024



GRB prompt emission

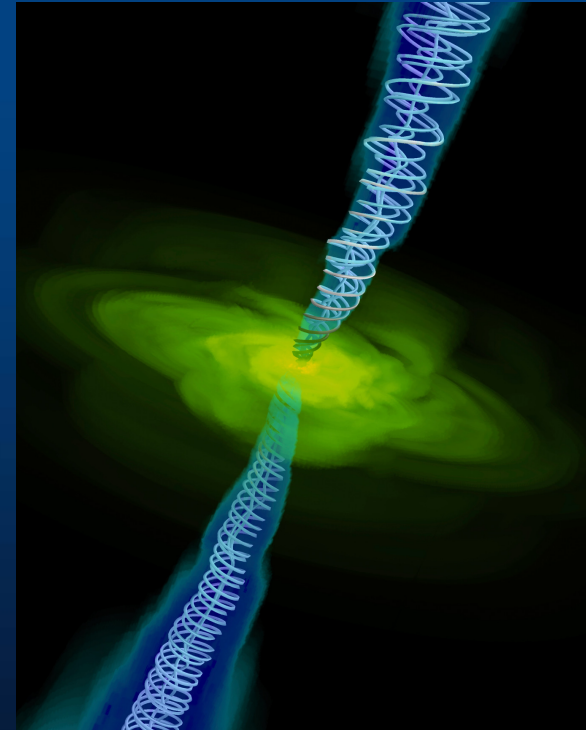
(see short review: *Bosnjak, Barniol Duran, Pe'er 2022*)



Yu et al. (2015)

Luminosities $\sim 10^{51} - 10^{54}$ erg/s
Efficiencies $\sim 10\%$

Main questions

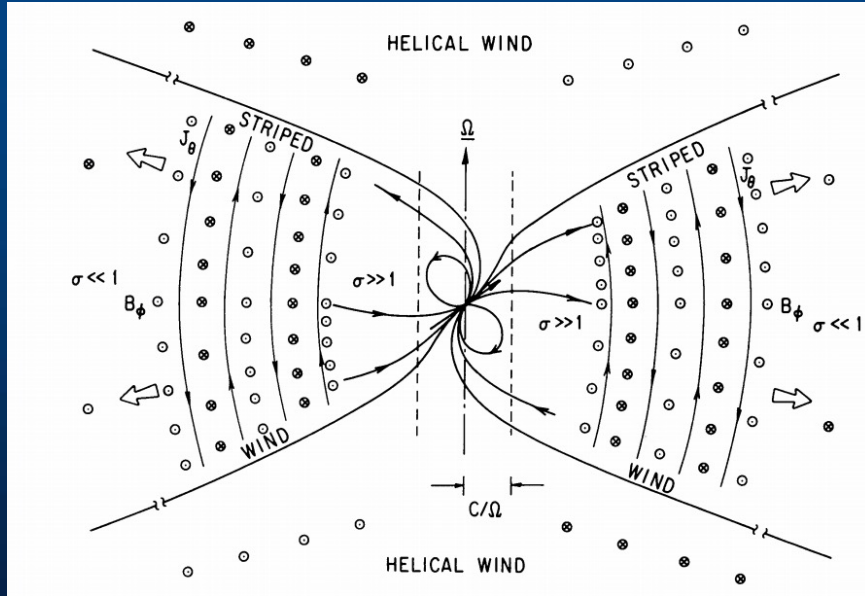


Tchekhovskoy (2014)

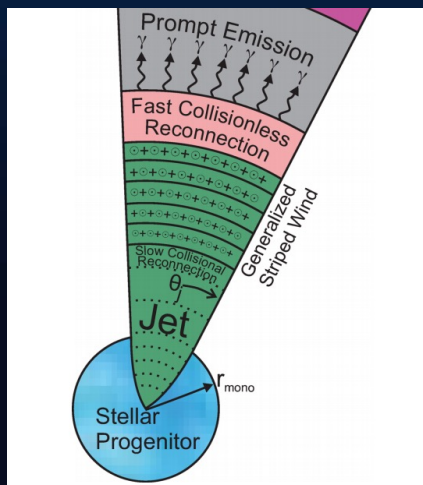
1. How does the jet accelerate?
 2. How are gamma-rays produced?
- Striped (magnetic) jet

Striped jet

Natural outcome of the rotation of a magnetized object (e.g., Drenkhahn 2002, Drenkhahn & Spruit 2002, Giannios & Spruit 2005, ...).



Motivation: Crab nebula (Coroniti 1990)



McKinney & Uzdensky (2012)

Model basic picture

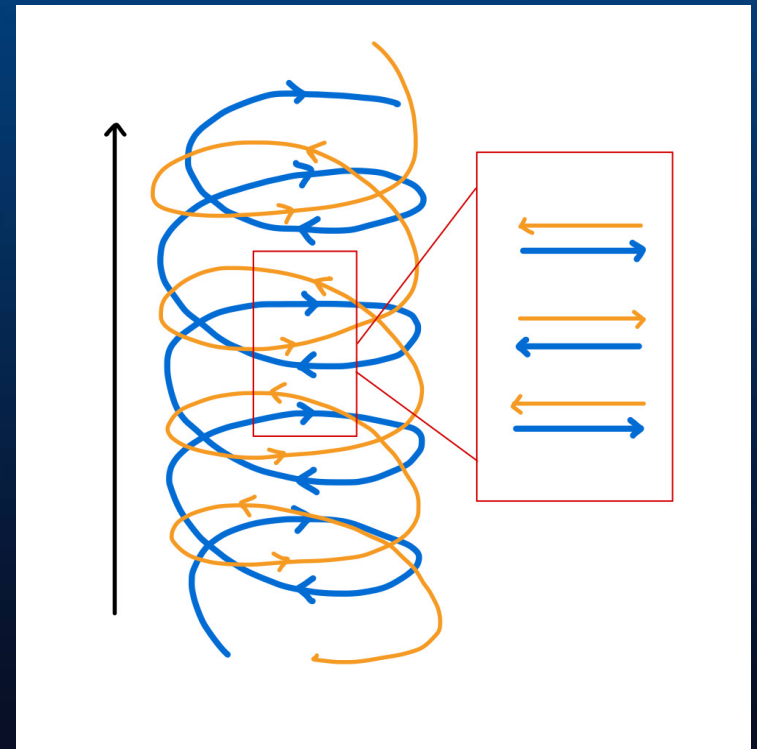
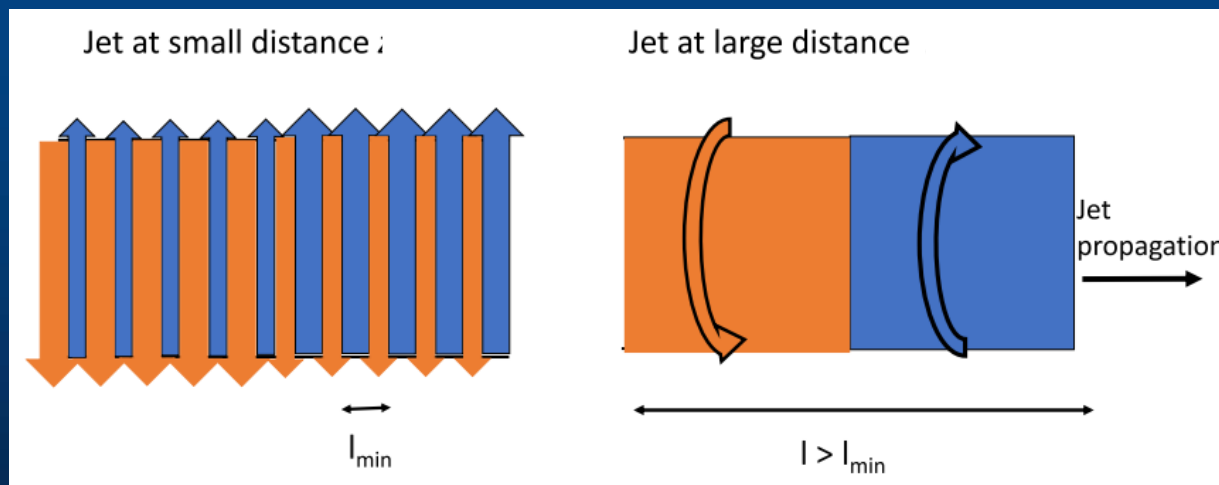


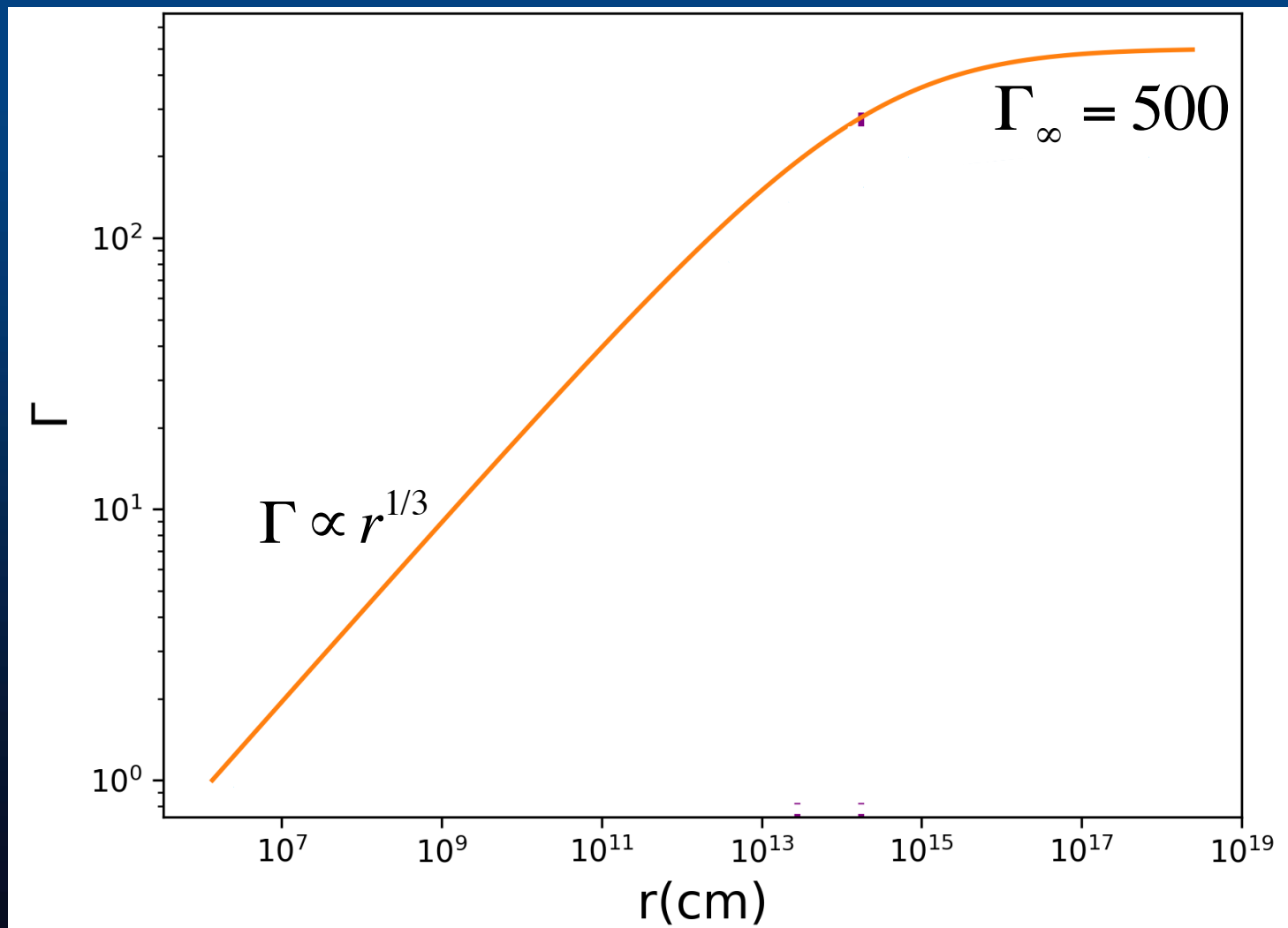
Image credit Carly Gip

Striped jet: Magnetic reconnection

Magnetic reconnection drives jet acceleration and particle acceleration (e.g., *Giannios & Uzdensky 2019*)

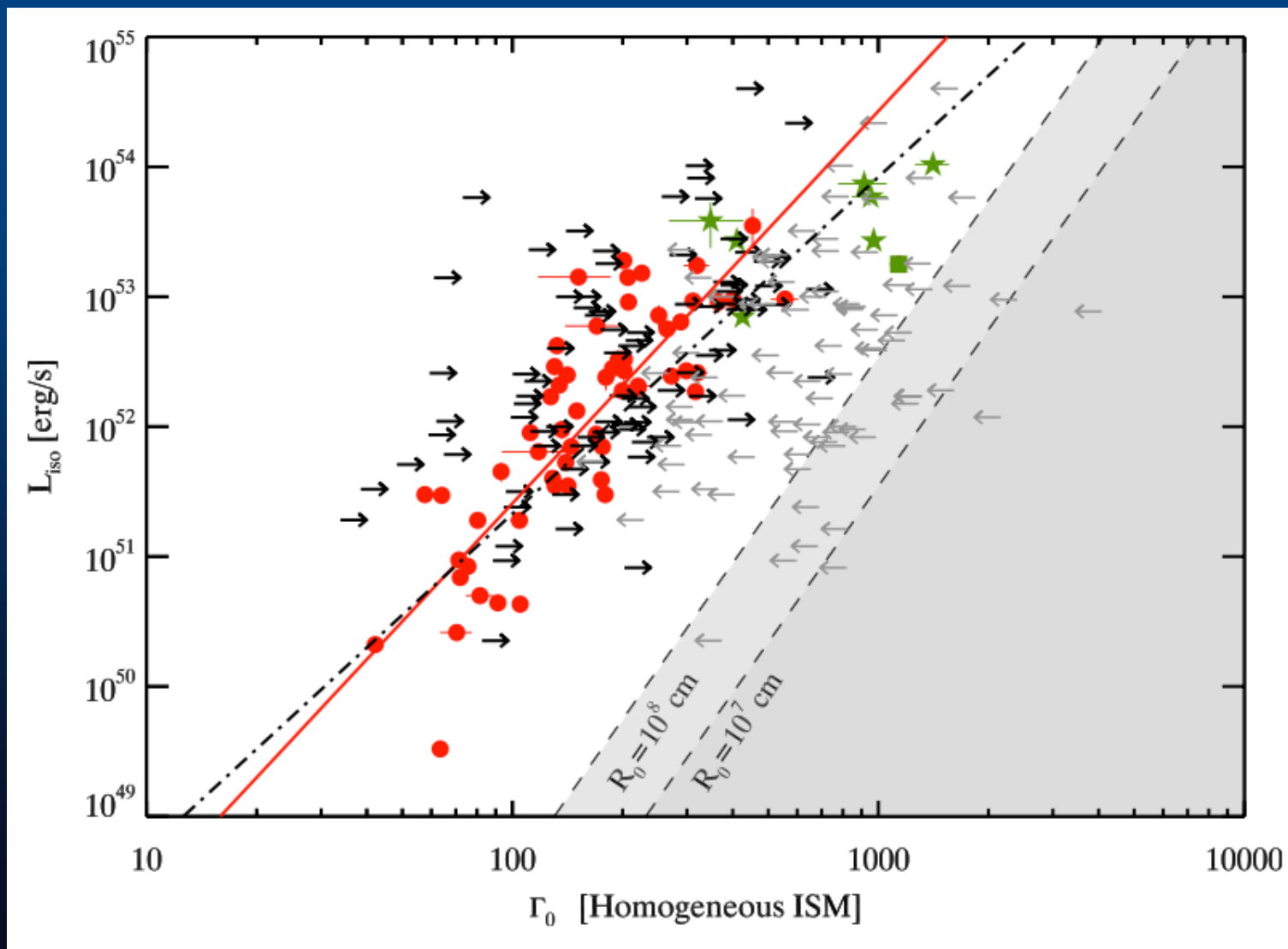


GRB striped jet acceleration



For more information on [magnetic jet acceleration in the context of GRBs](#), see, e.g., *Contopoulos 1995, Drenkhahn 2002, Drenkhahn & Spruit 2002, Giannios & Spruit 2005, Granot et al. 2011, McKinney & Uzdensky 2012, Kumar & Zhang 2015, Giannios & Uzdensky 2019, ...*

Lorentz factor estimate from early afterglow

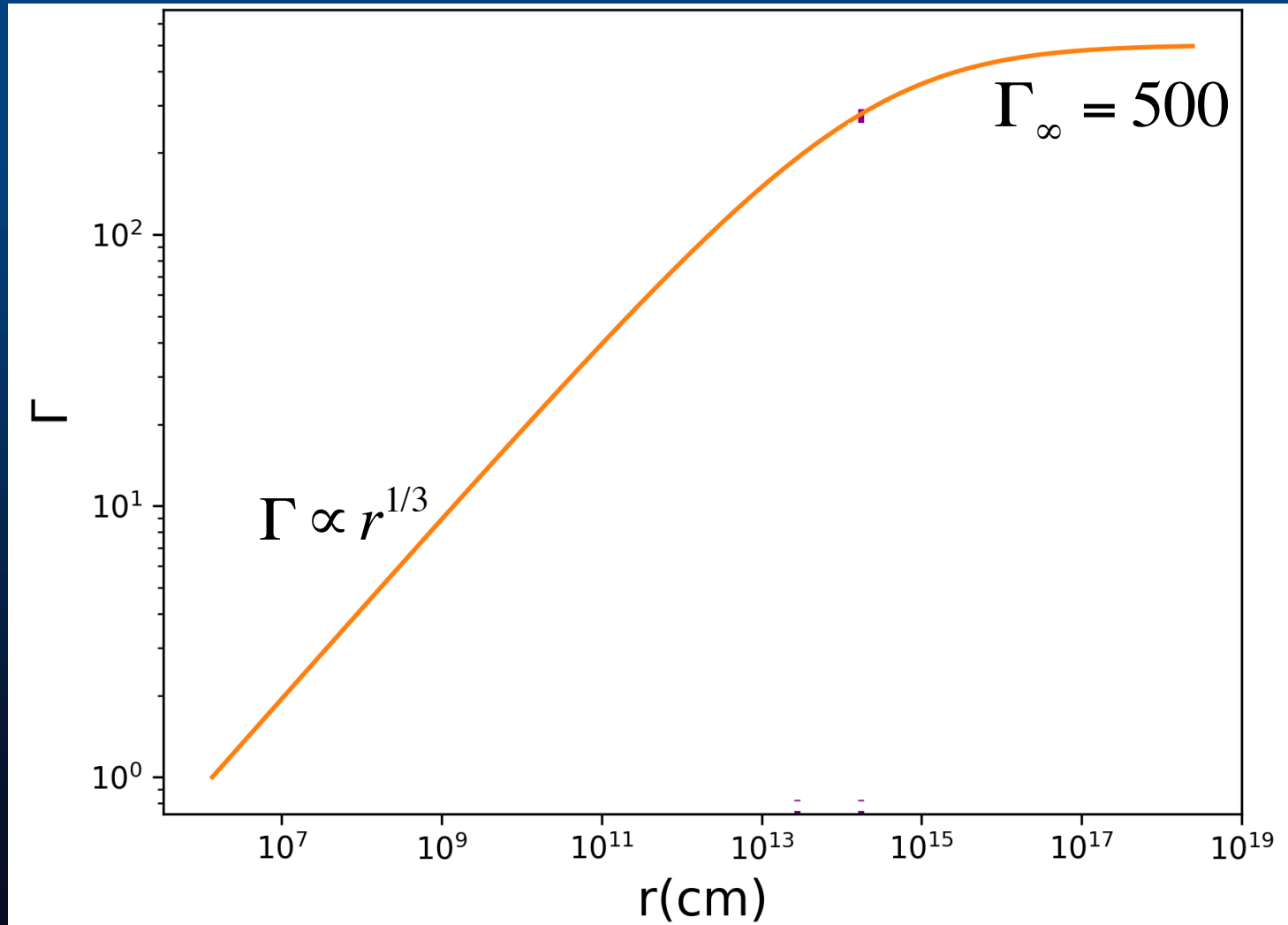


Ghirlanda et al. (2018)

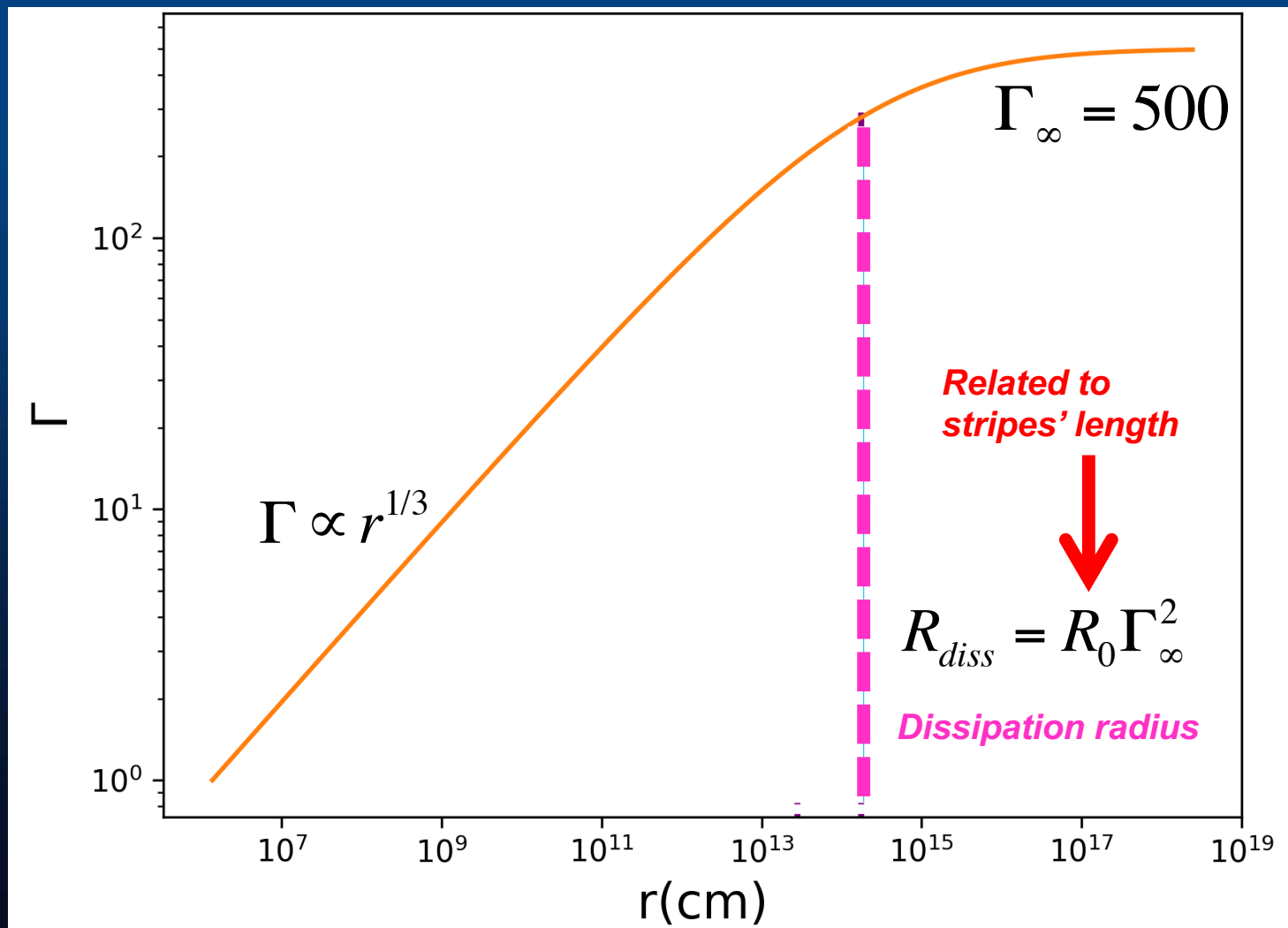
Lorentz factor Γ_∞ estimates for a large sample (67) of GRBs (Ghirlanda et al. 2018, including *Fermi* data!):

- Obtained from the peak of GRB **afterglow** light curve: Deceleration time

GRB striped jet acceleration



GRB striped jet acceleration



R_0 for neutron star (NS) and black holes (BH) are expected to be **different**: $\sim 10^8$ and 10^9 cm, respectively, with large uncertainties (e.g. *Drenkhahn 2002*, *Giannios & Uzdensky 2019*).

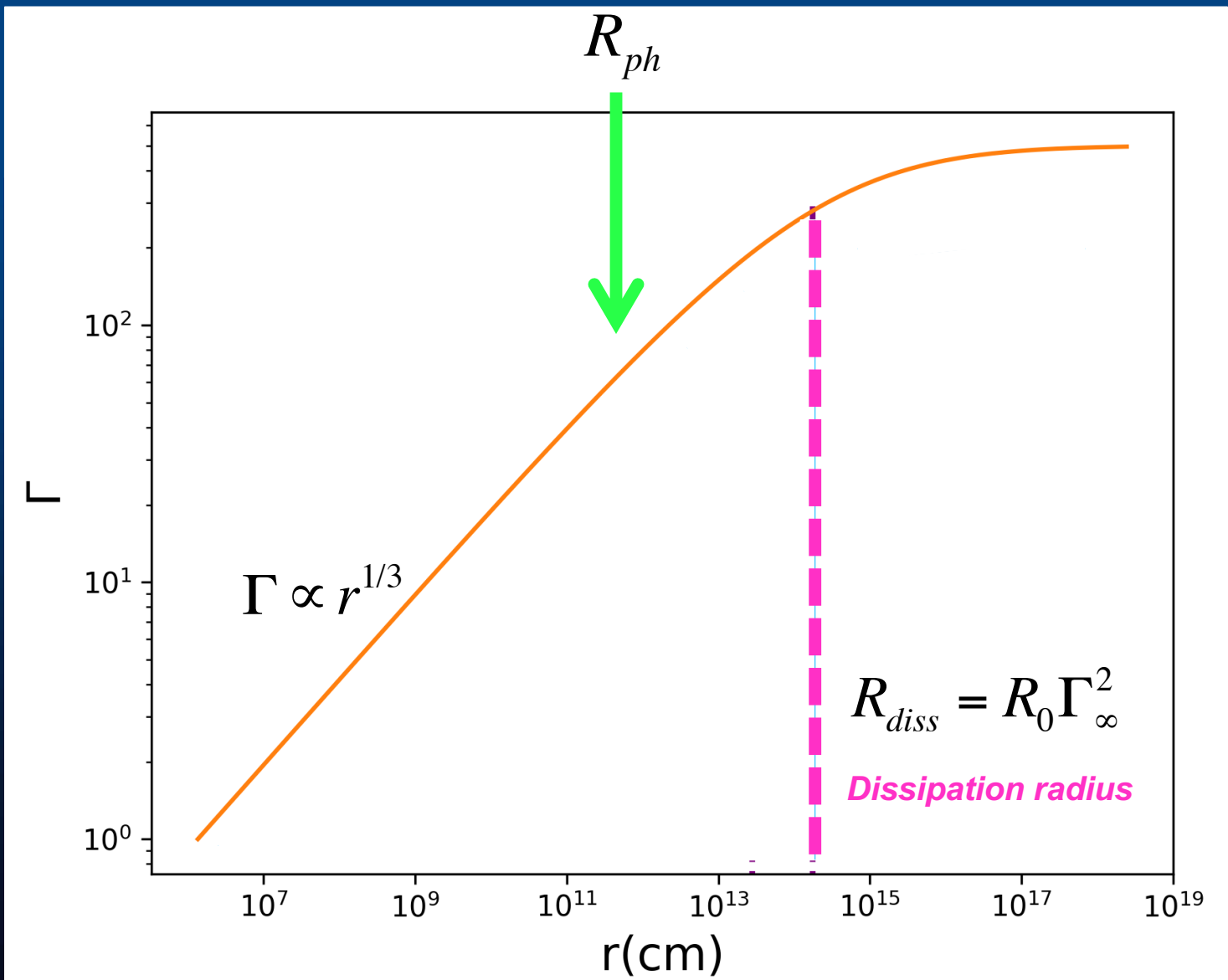
GRB striped jet emission

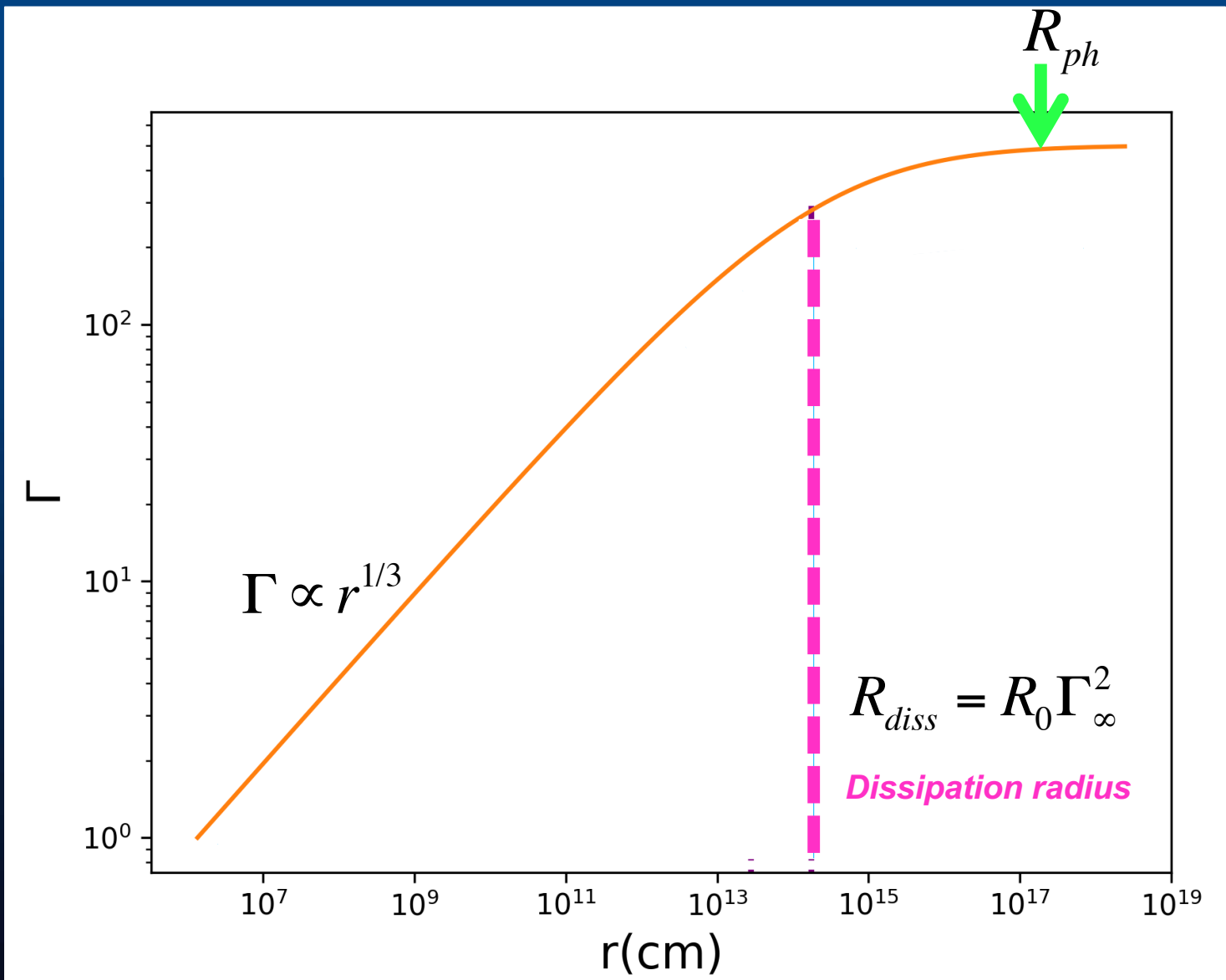
Photospheric emission** is expected in the striped jet model at the photospheric radius:

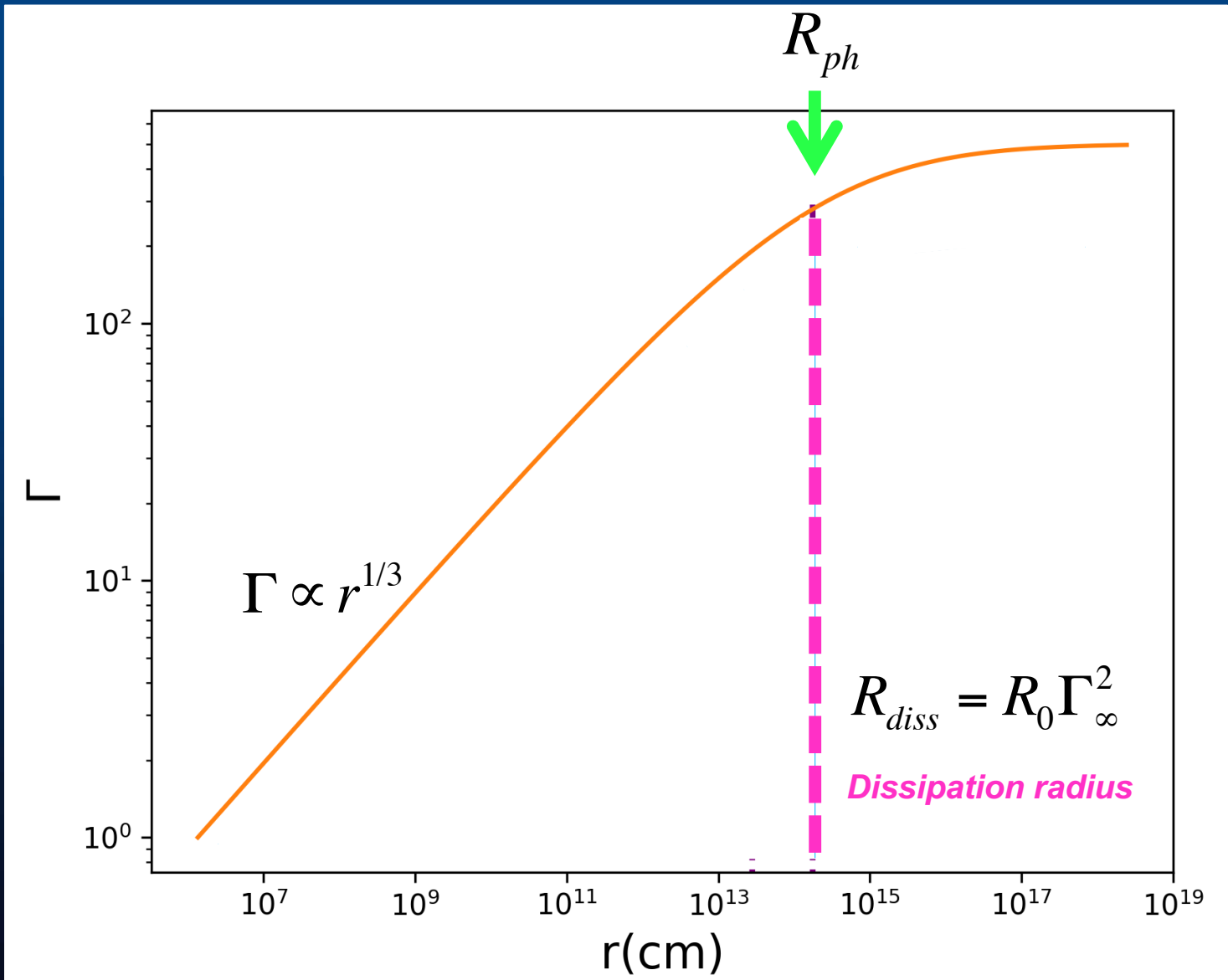
$$R_{ph} \propto \frac{R_0^{2/5}}{\Gamma_\infty}$$

Determining R_{ph} numerically, we can calculate the expected photospheric peak energy and luminosity.

***Thermal spectrum will be Comptonized (e.g., Drenkhahn 2002, Drenkhahn & Spruit 2002, Giannios & Spruit 2005, Beloborodov 2013; Vurm et al. 2013; Thompson & Gill 2014; Bégué & Pe'er 2015; Vurm & Beloborodov 2016, Pe'er 2017, Giannios 2017, Gill et al. 2020, ...).*







Results: 67 GRBs with Γ_∞

Goal: Can the striped jet model explain the observed gamma-ray peak energy and gamma-ray luminosity?

Photospheric **peak energy** is within a factor of ~ 2 of **observed** peak energy for 75% of GRBs.

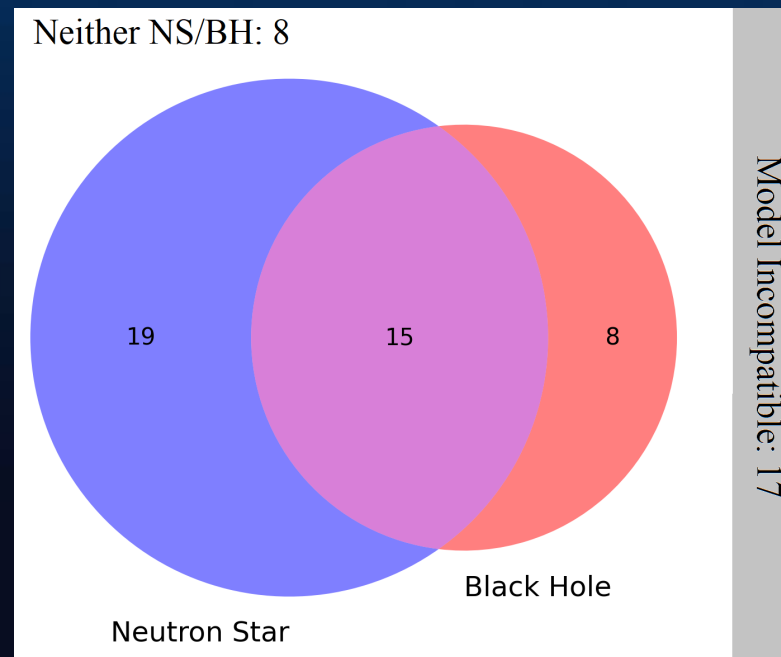
Photospheric **efficiency** is $\sim 10\%$ for these GRBs.

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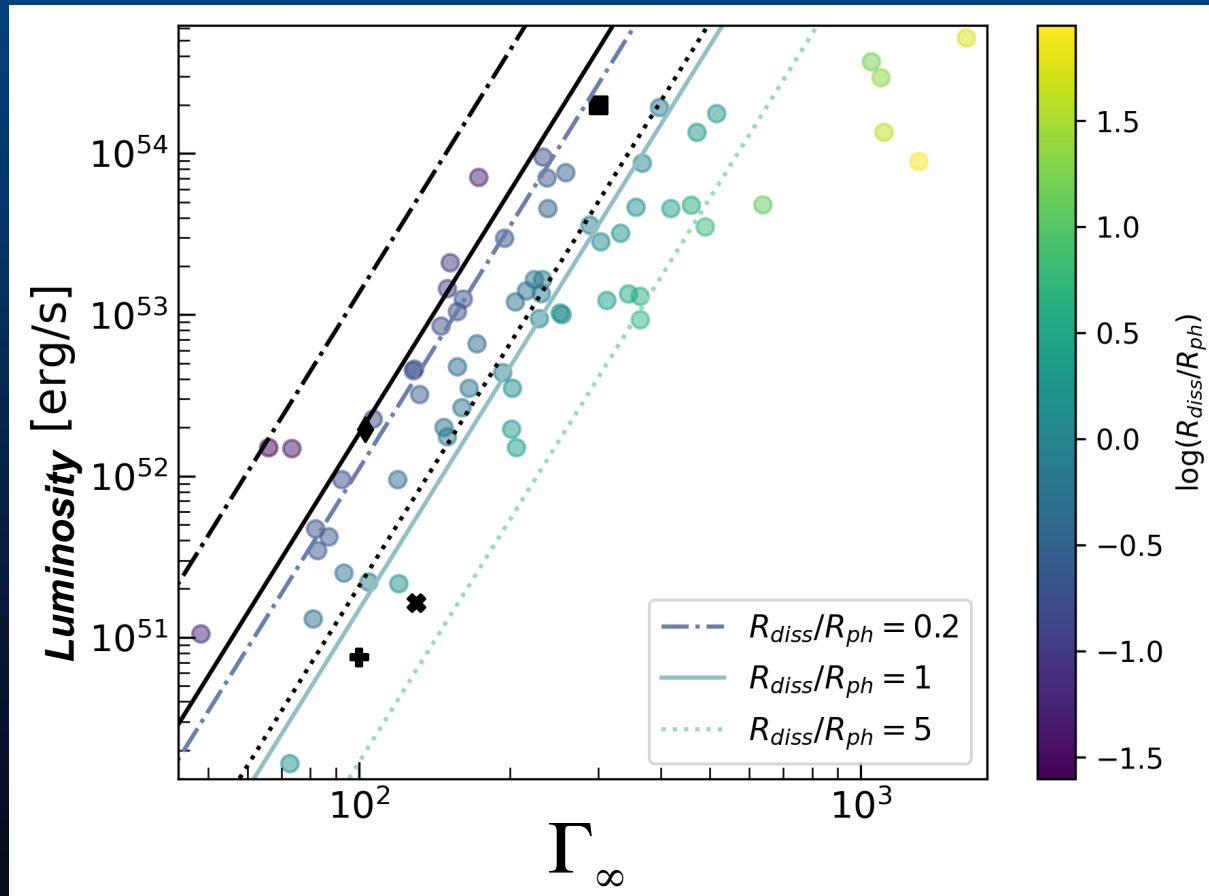
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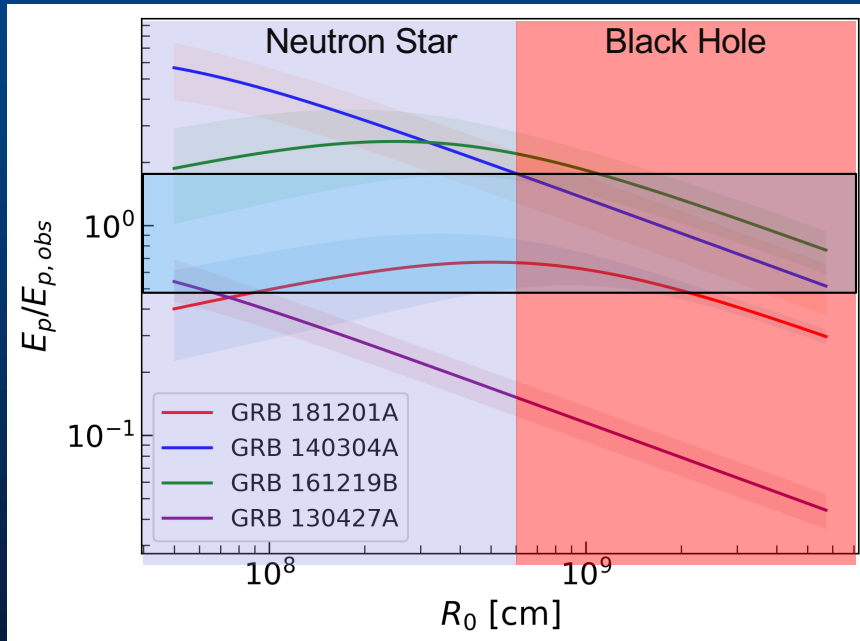
An alternative approach

Imposing a large efficiency with $R_{\text{diss}}/R_{\text{ph}} \sim 1$ we find a nice agreement with the data (except for a few Fermi LAT GRBs, which require a non-thermal component, as observed).



Damoulakis, Barniol Duran, Giannios (2023)

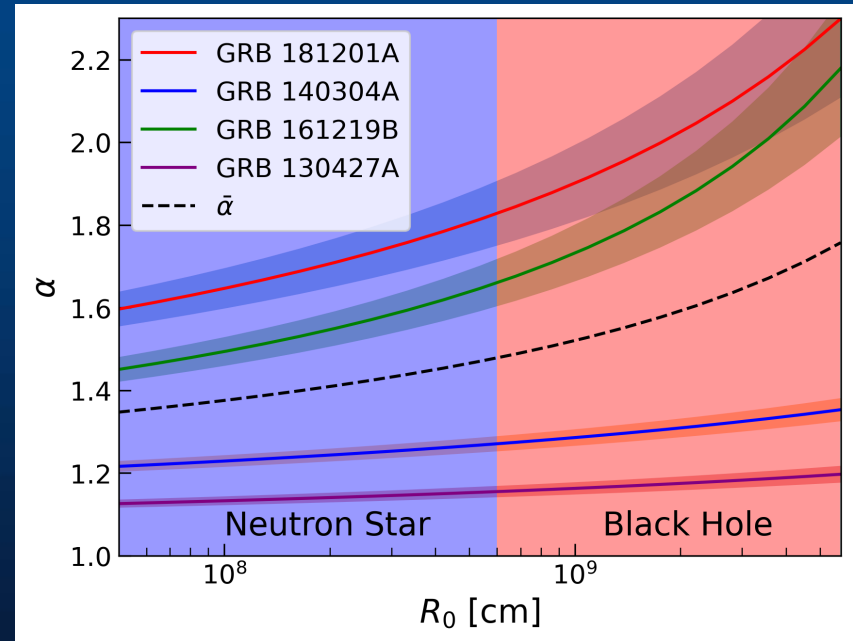
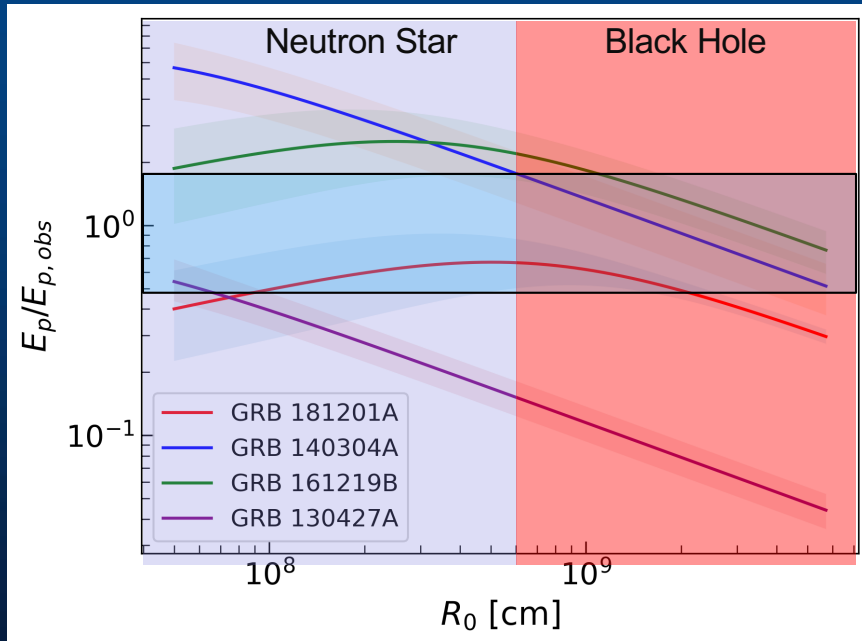
Subsample of 4 GRBs with magnetization estimates from reverse shock



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Constraining the stripes' length distribution $P(L) \sim L^{-\alpha}$

Subsample of 4 GRBs with magnetization estimates from reverse shock



Photospheric **peak energy** is within a factor of ~ 2 of observed peak energy.

Constraining the stripes' length distribution $P(L) \sim L^{-\alpha}$: We find $\alpha < 3$.

Summary

The **striped jet model** is a promising model to explain GRB prompt emission. It allows us to **connect** the afterglow with the central engine.

Peak energies and efficiencies are consistent with prompt observations for most GRBs.

Please, see our **paper** for more information: *Damoulakis, Barniol Duran, Giannios, 2023, MNRAS, 523, 6250.*



For more information:

Rodolfo Barniol Duran (Sacramento State)

barniolduran@csus.edu



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