

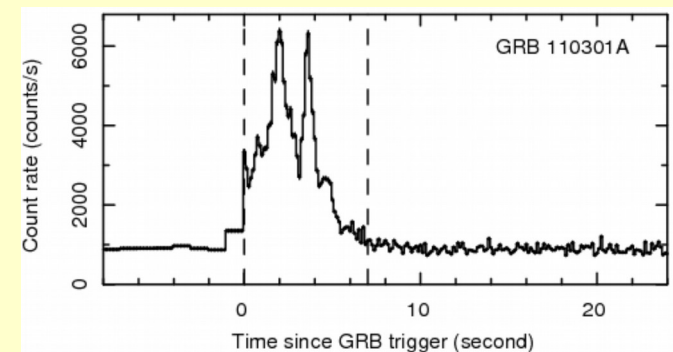
Looking at the black hole that powers Long Gamma Ray Bursts

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Thessaloniki 2015

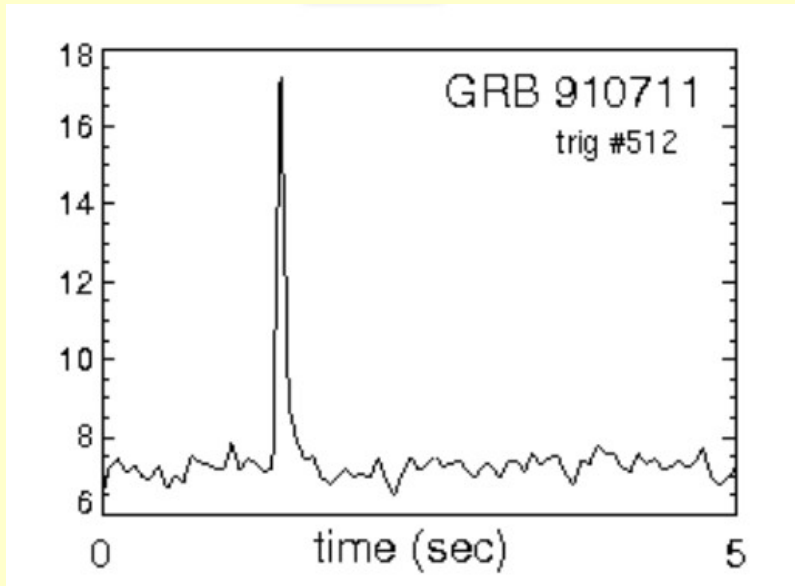


Gamma ray bursts Overview

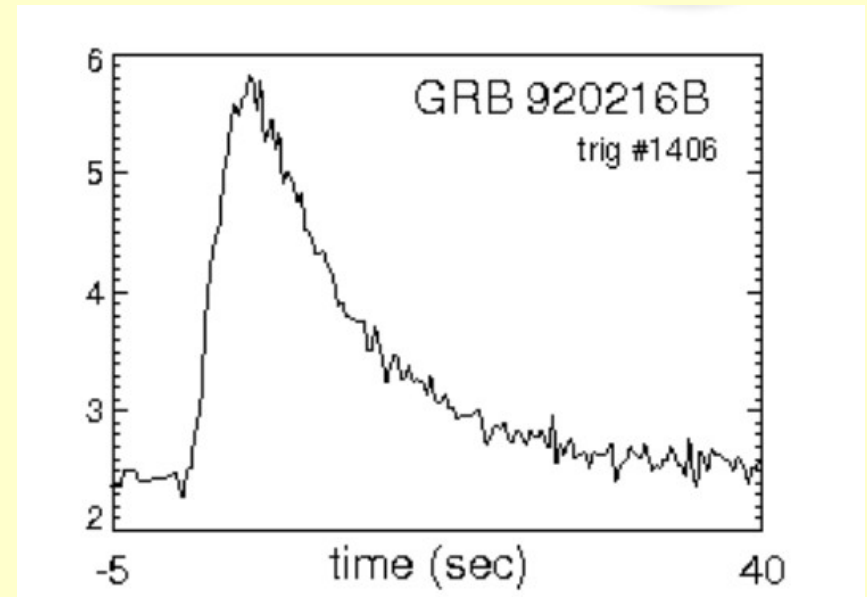
GRBs

Gamma photons

Gamma photons



With
BATSE
1990's



Short GRBs

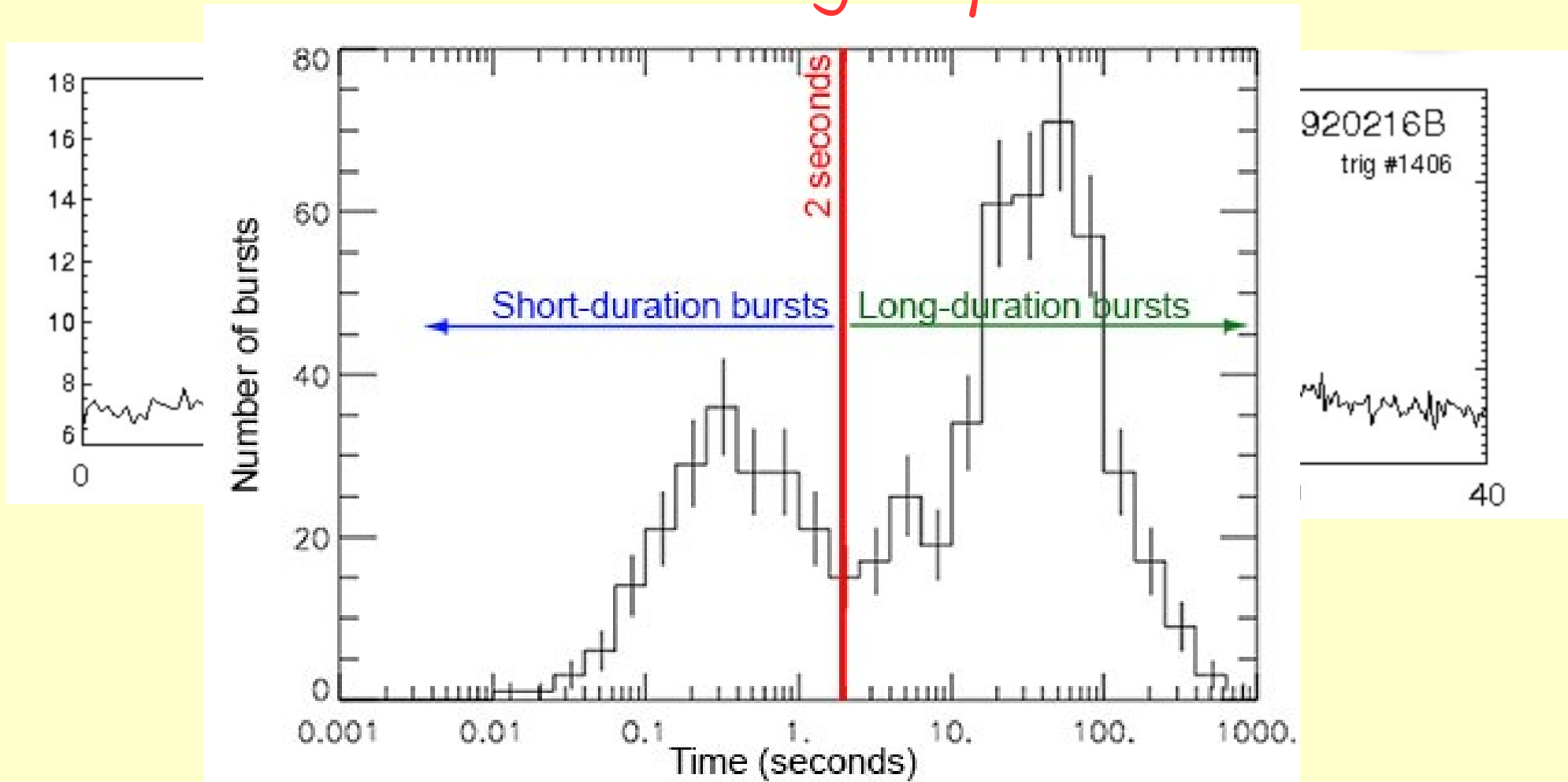


BATSE on Compton GRO

Long GRBs

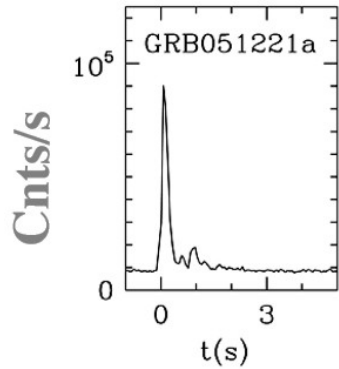
Gamma ray bursts Overview

Two subgroups



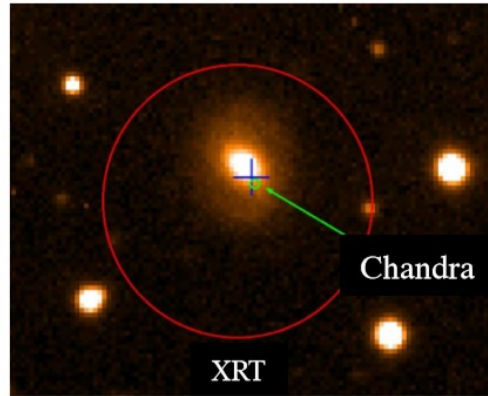
Kouveliotou et al. 1993

Short GRB

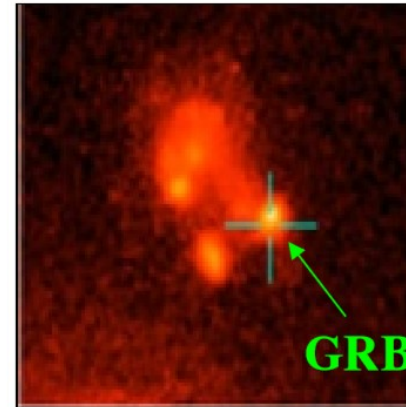


Short vs Long GRBs

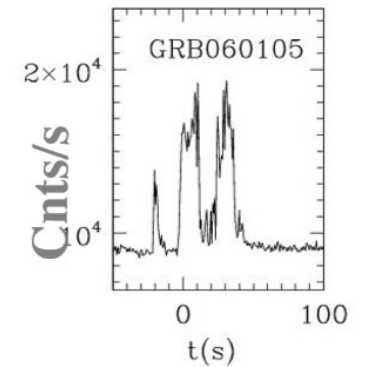
GRB 050724 - *Swift*
elliptical host



GRB 020903 - *SAX*
SF dwarf host



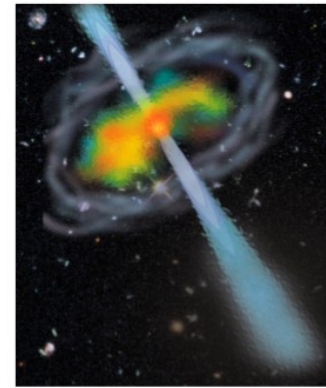
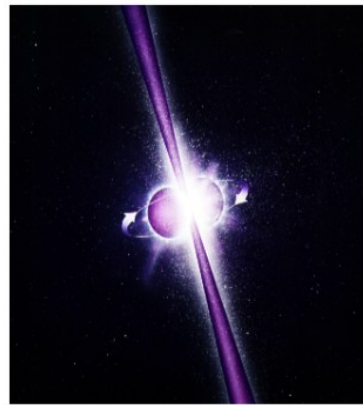
Long GRB



In non-SF
and SF galaxies

No SNe detected

Possible **merger**
model



BH

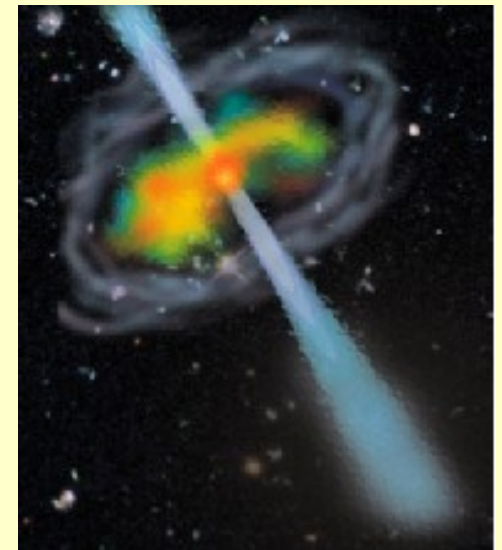
In SF
galaxies

**Accompanied by
SNe**

**Collapsar model
well supported**

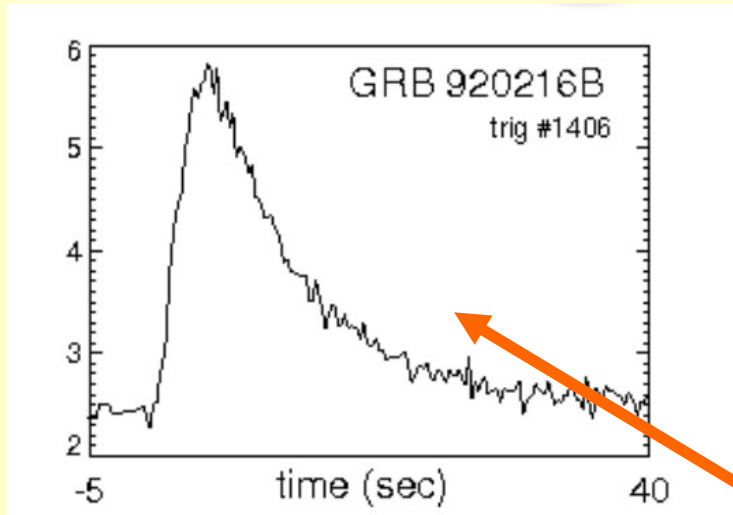
Long Gamma ray bursts Central Engine

- Core Collapse of a supermassive star (e.g. Wolf Rayet)
- Stellar Mass Black Hole formed (Strong Magnetic fields)
- Hyper-accretion drives the GRB (duration depends to surrounding mass)
- Jet launched (Blandford-Znajek or\and neutrino annihilation)



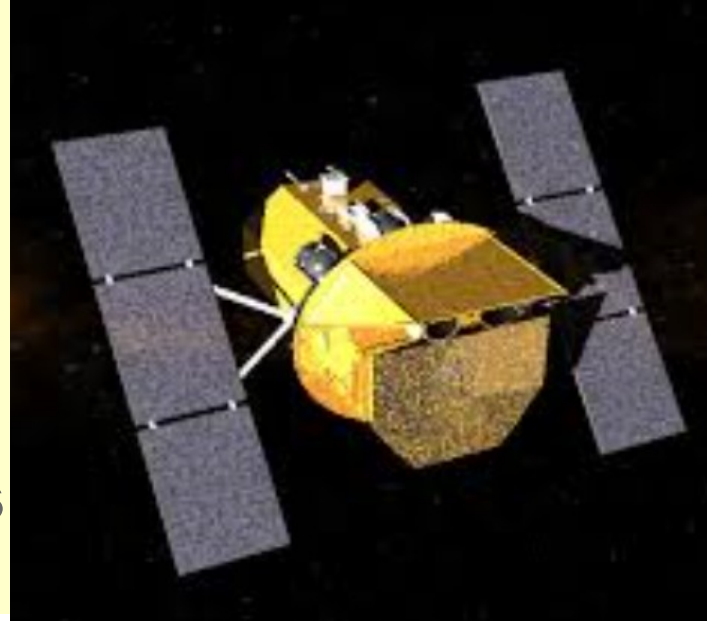
Extensive Literature: see review Kumar & Zhang 2014

GRB Afterglow X-rays

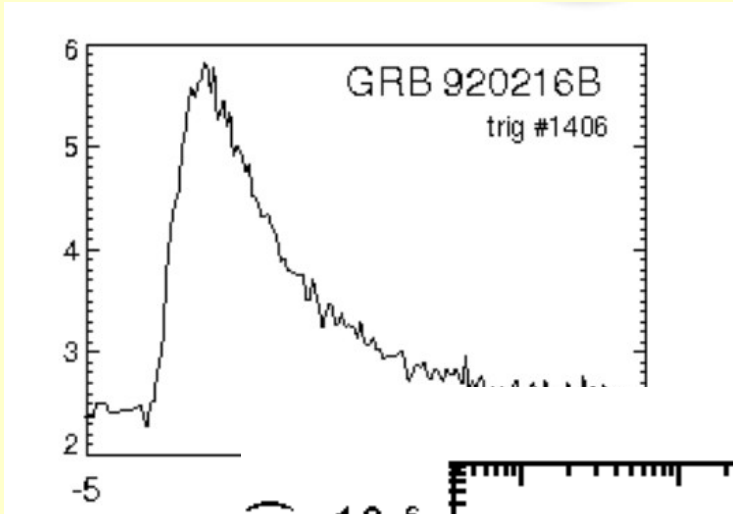


Gamma-rays

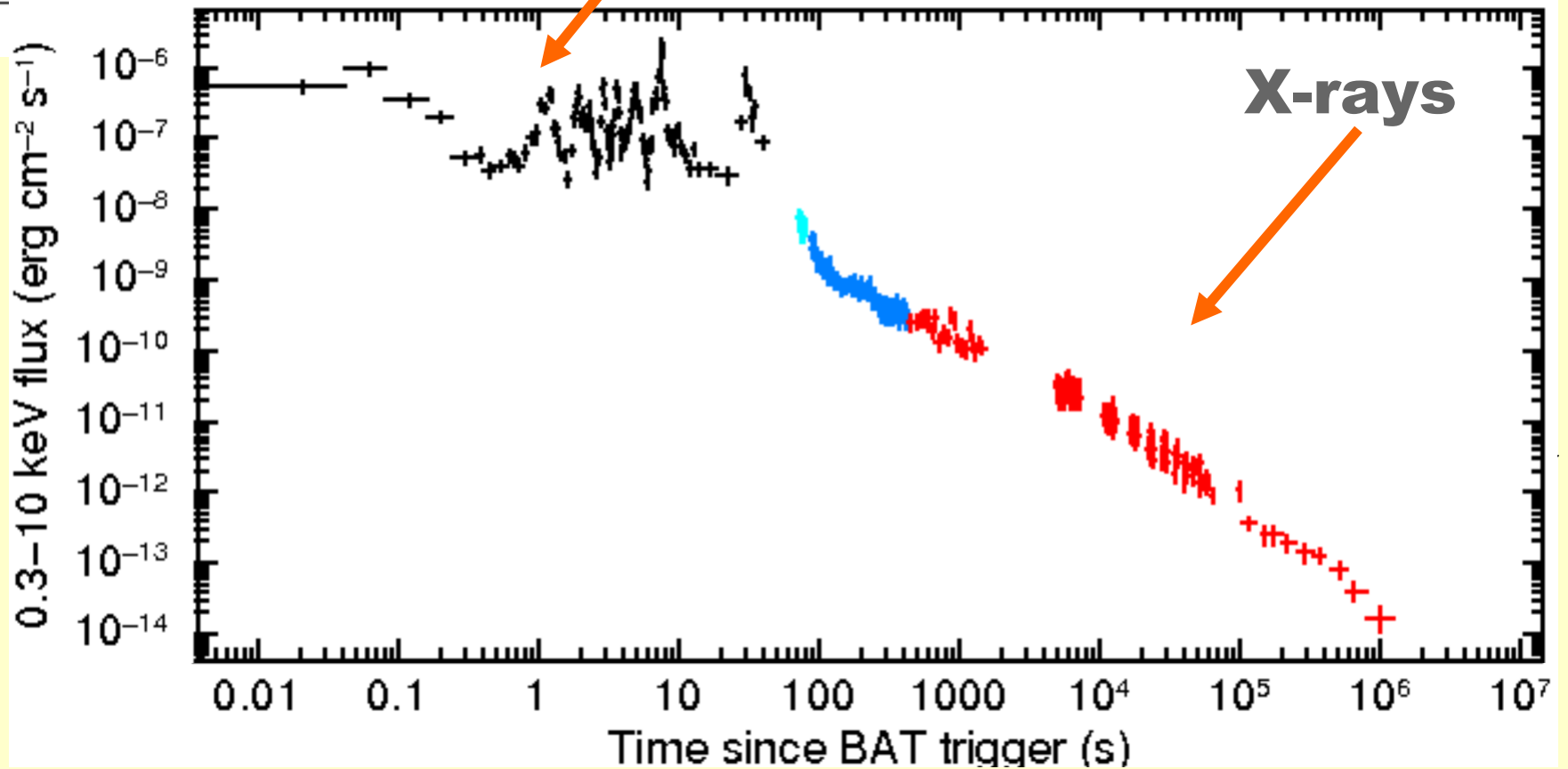
GRB Afterglow X-rays



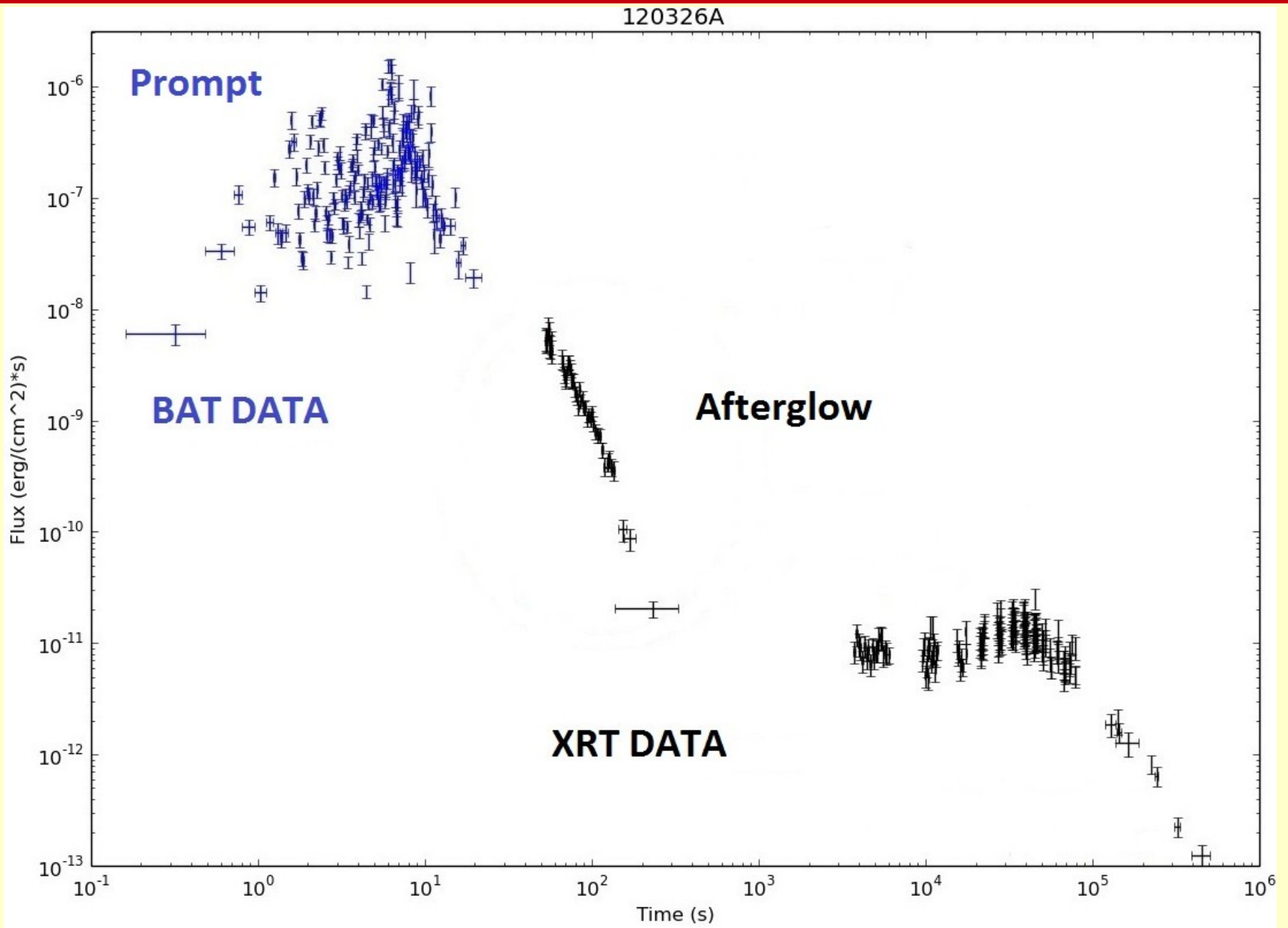
Gamma-rays



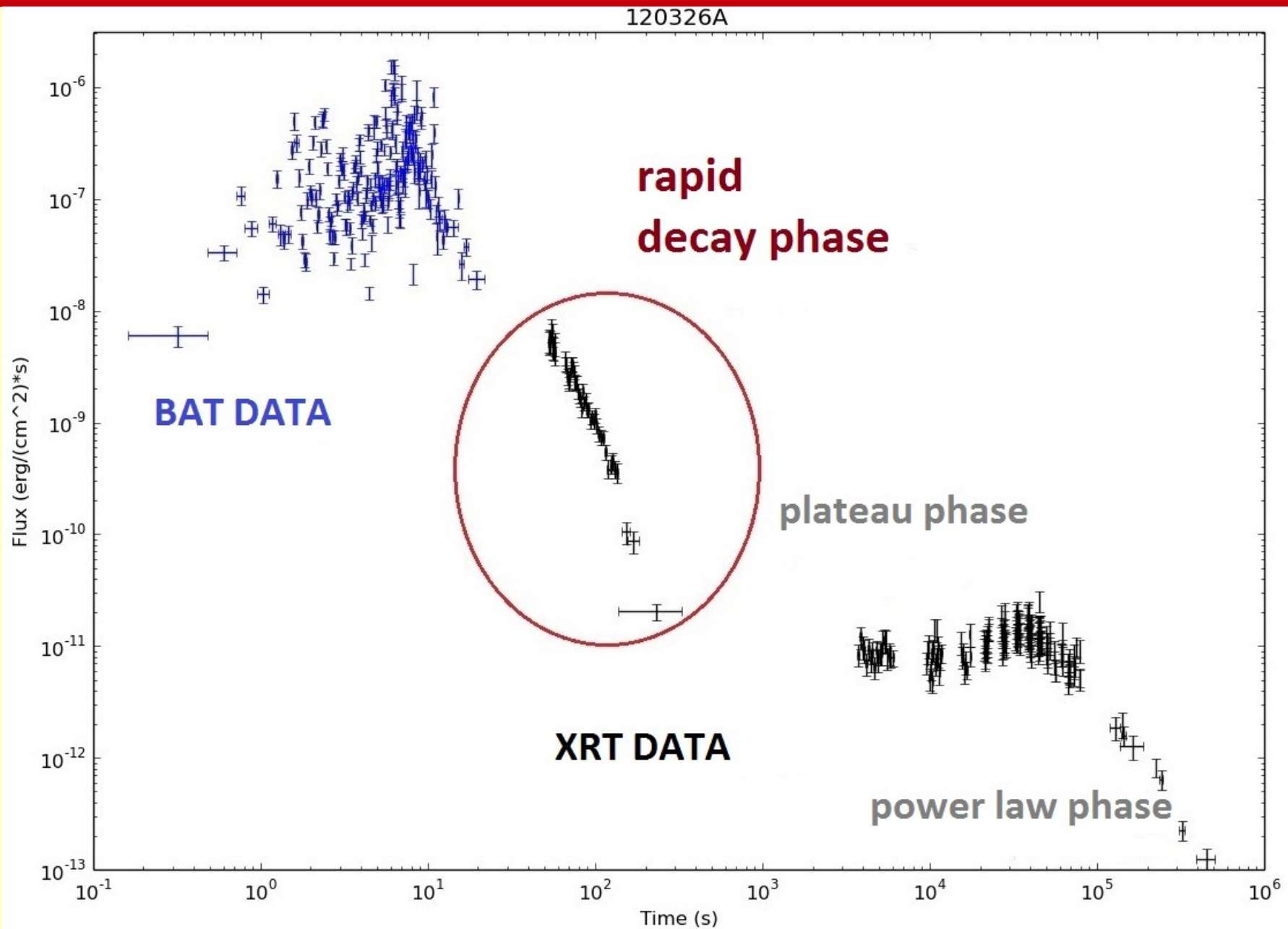
BAT-XRT data of GRB 091020



ANATOMY OF A BURST

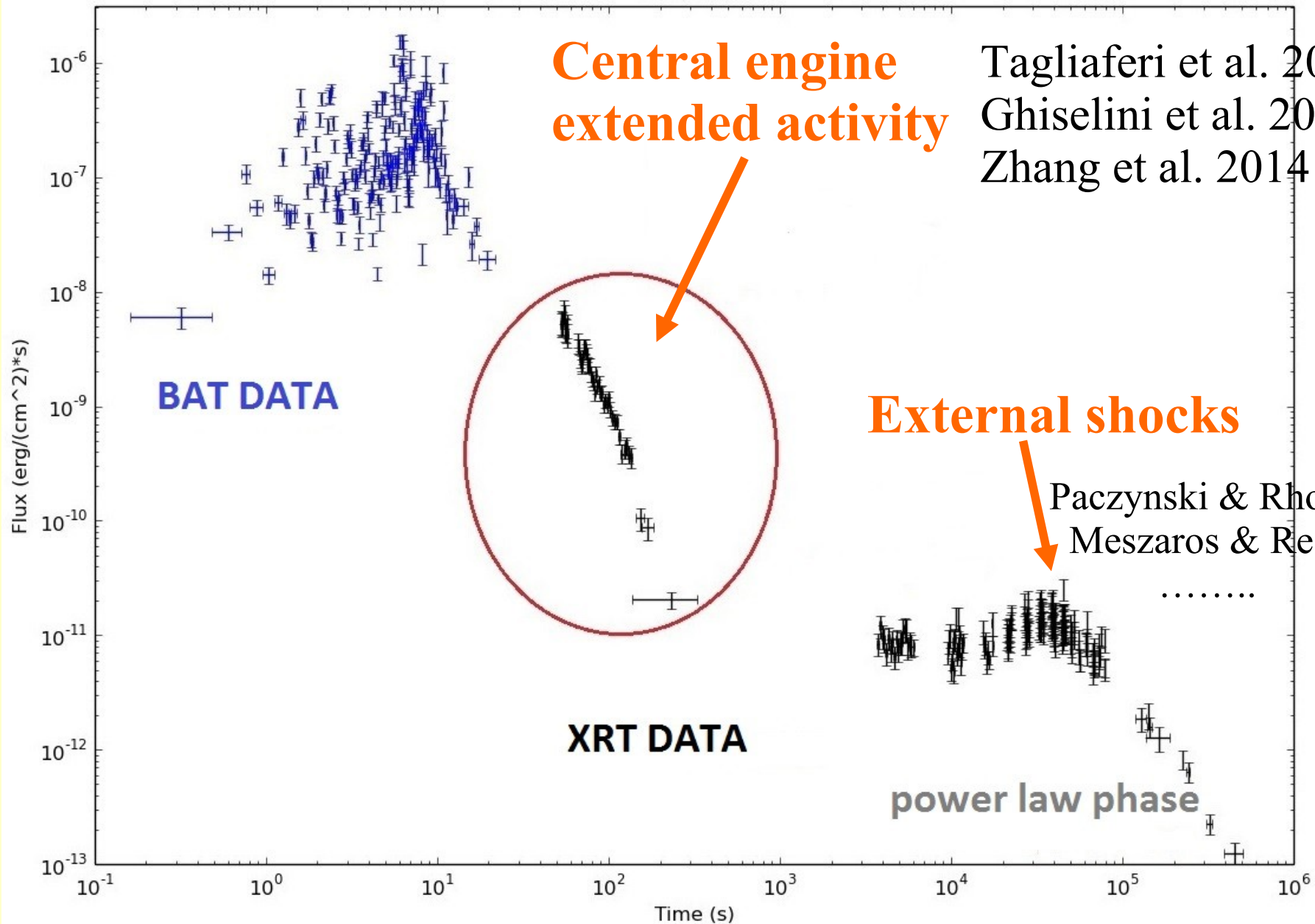


ANATOMY OF A BURST

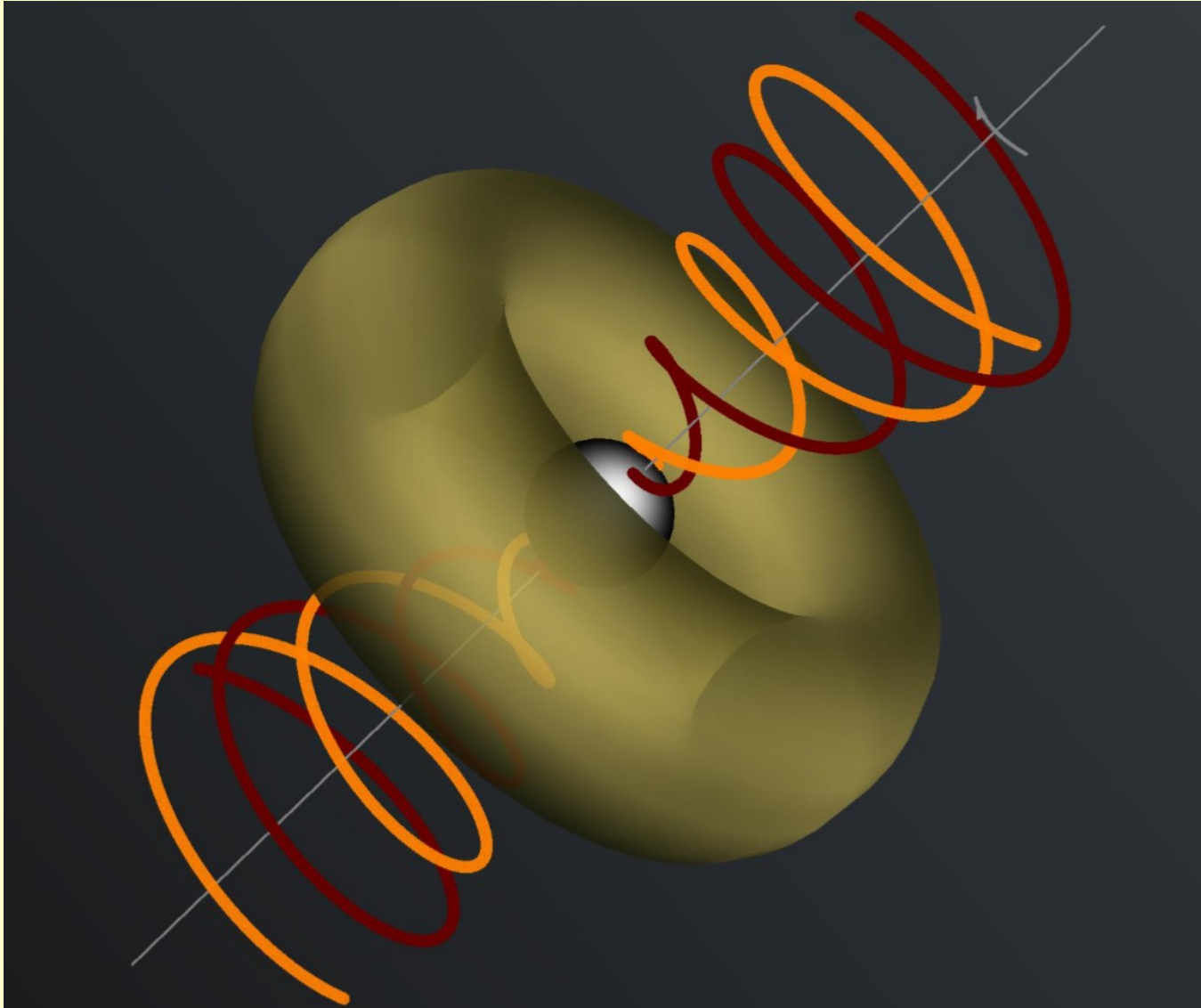


ANATOMY OF A BURST

120326A



Small Break for theory



Small Break for theory

- Stellar mass black hole slowly rotating

$$E_{\text{rot}} \approx \frac{1}{8} M c^2 \left(\frac{\Omega}{\Omega_{\text{max}}} \right)^2$$

- Strong magnetic fields expected Ω angular velocity

Loosing Energy as

Small Break for theory

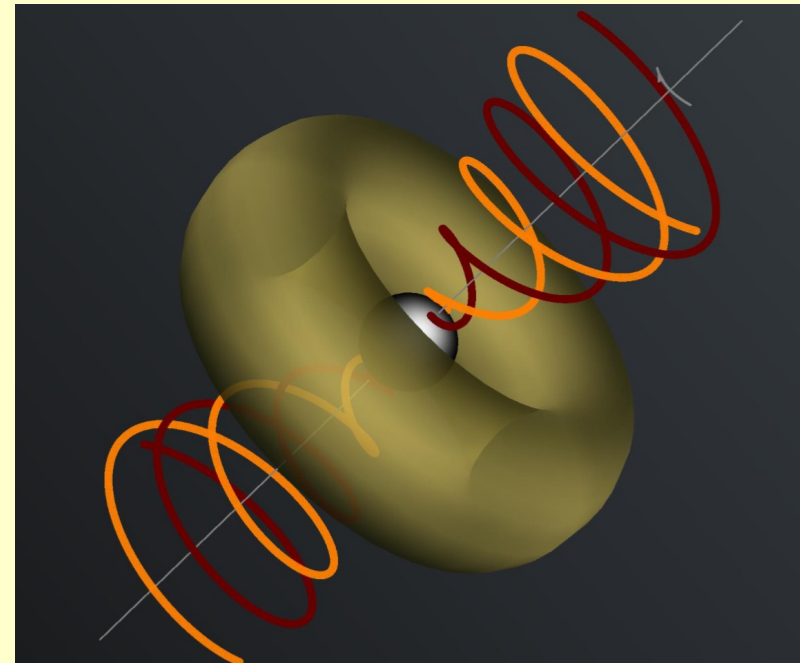
Loosing Energy as

$$\dot{E} \approx -\frac{1}{6\pi^2 c} \Psi_m^2 \Omega^2$$

Blanford & Znajek 1977

.....

Ψ_m magnetic flux



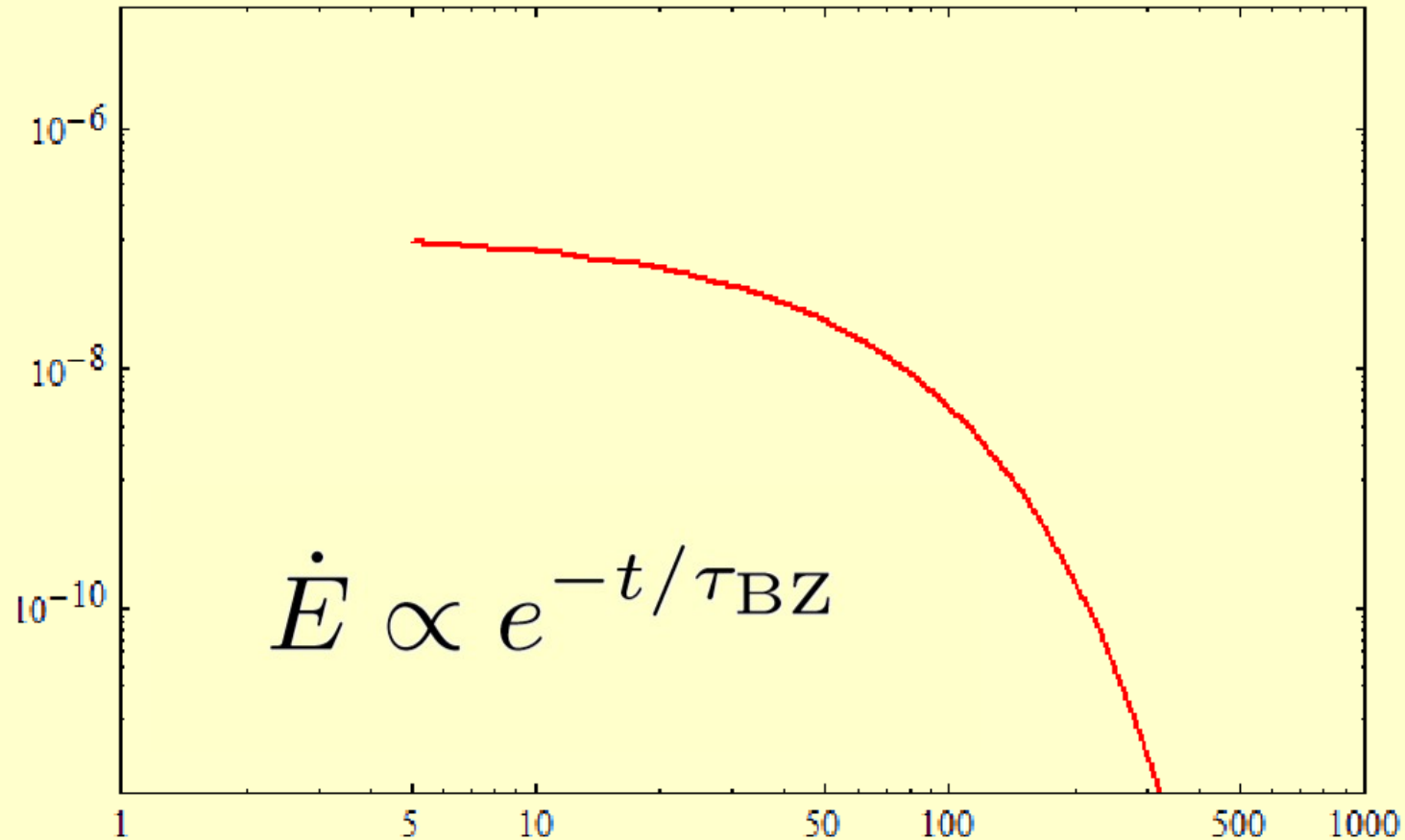
Small Break for theory

Loosing Energy as ...

$$\dot{E} \propto e^{-t/\tau_{\text{BZ}}}$$

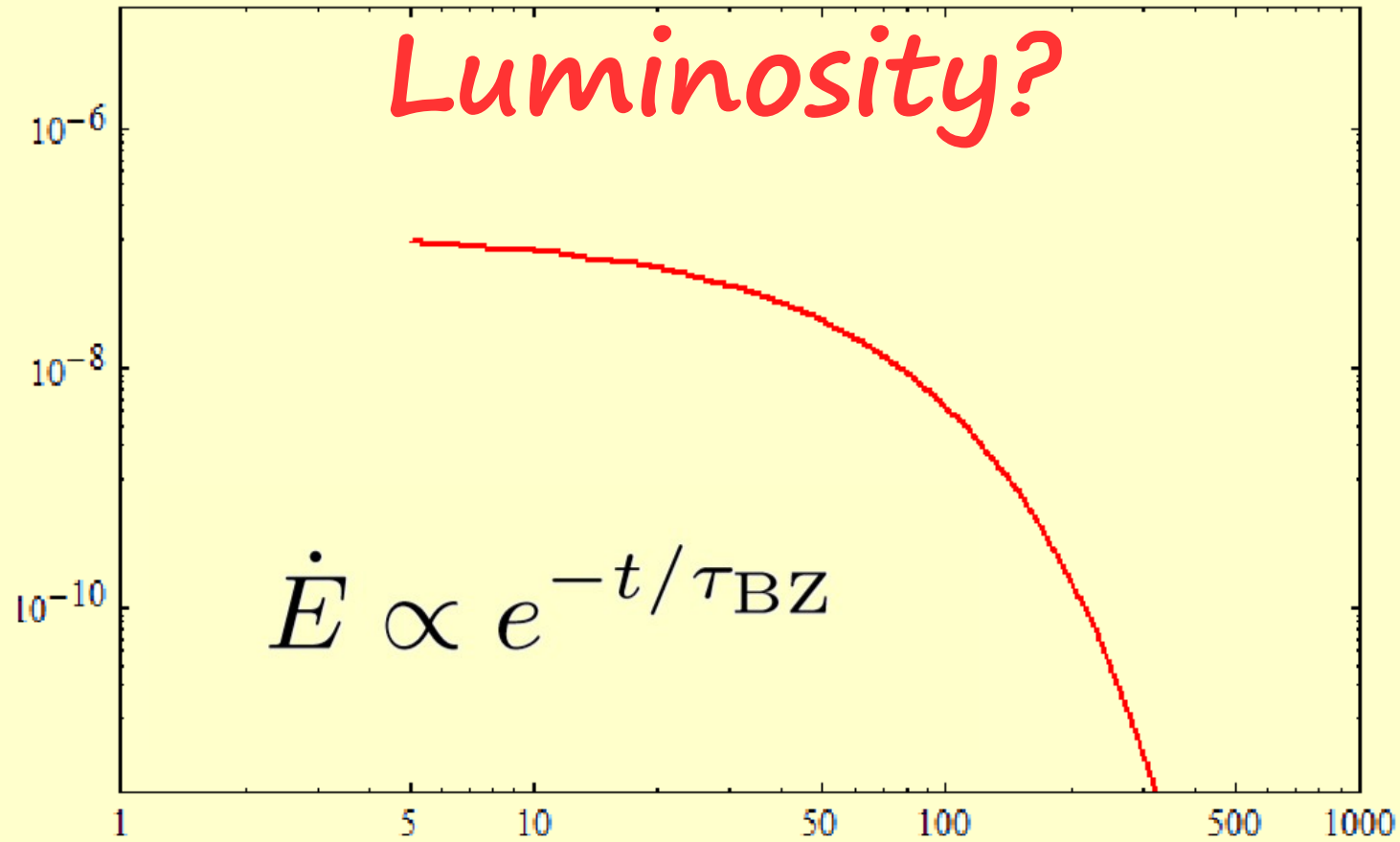
$$\tau_{\text{BZ}} \equiv 50 \left(\frac{B}{10^{15} \text{ G}} \right)^{-2} \left(\frac{M}{10 M_{\odot}} \right)^{-1} \text{sec}$$

Small Break for theory



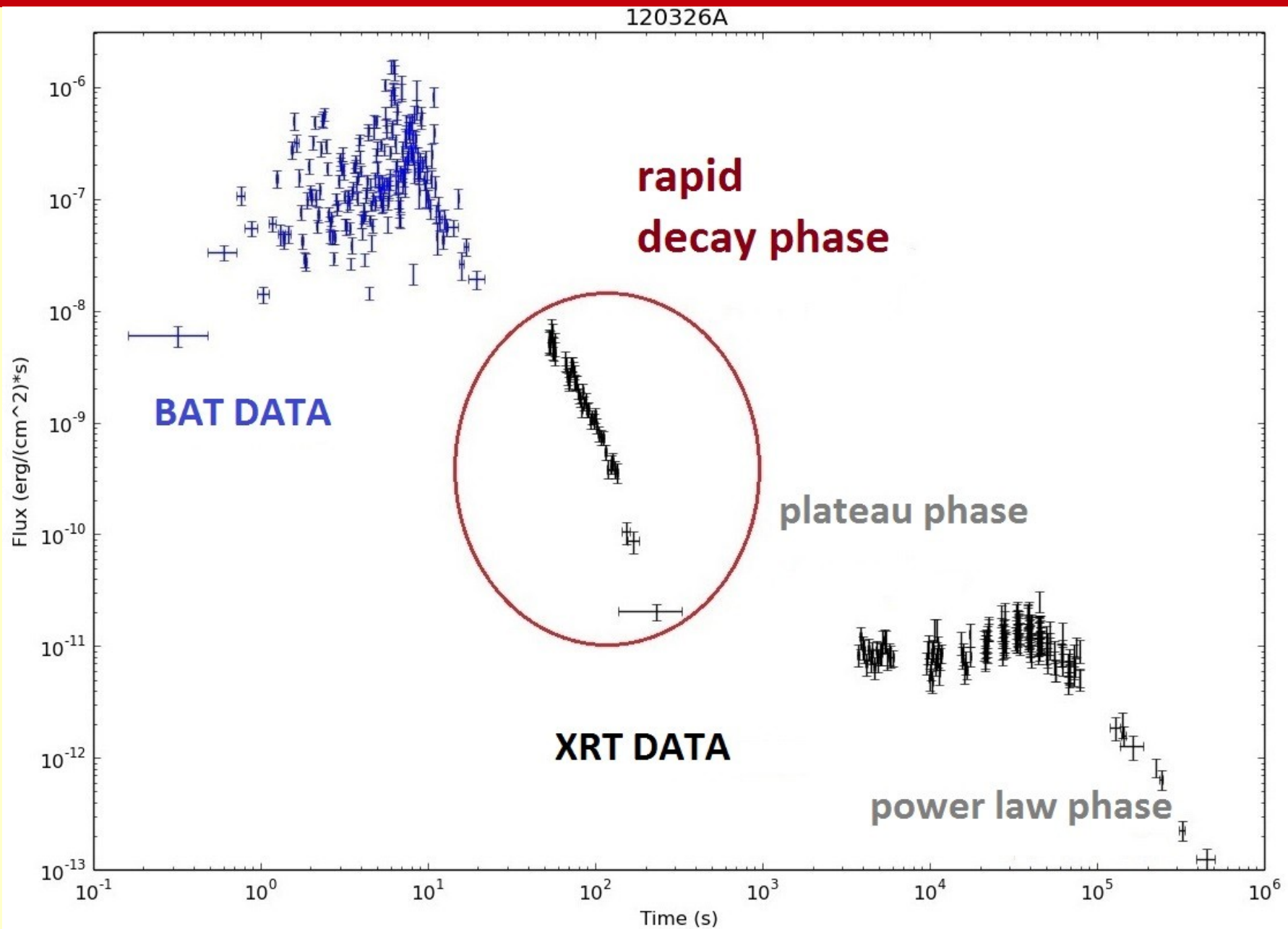
$$\tau_{BZ} \equiv 50 \left(\frac{B}{10^{15} \text{ G}} \right)^{-2} \left(\frac{M}{10 M_{\odot}} \right)^{-1} \text{ sec}$$

Can This Be observed Luminosity?

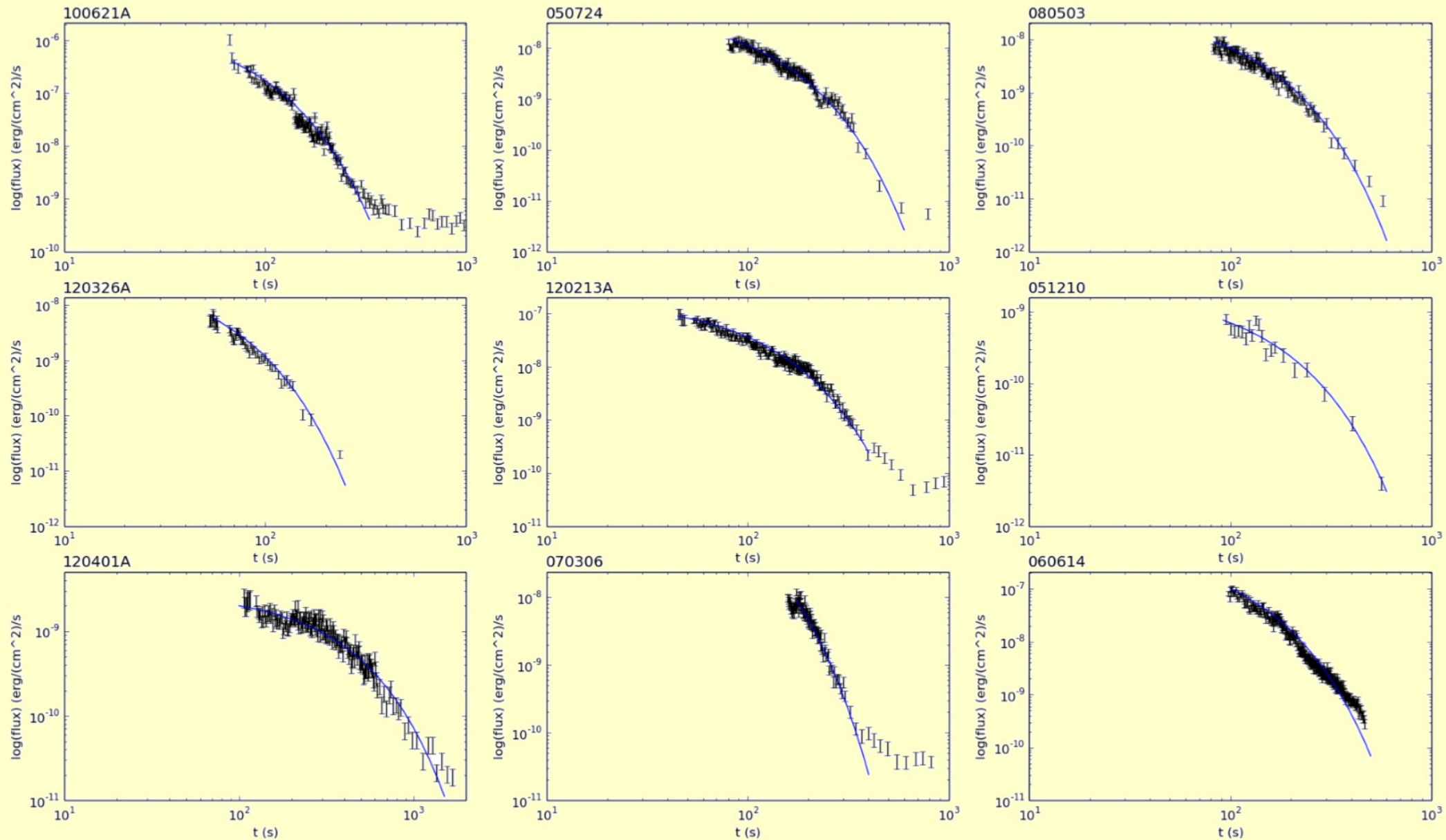


$$\tau_{\text{BZ}} \equiv 50 \left(\frac{B}{10^{15} \text{ G}} \right)^{-2} \left(\frac{M}{10 M_{\odot}} \right)^{-1} \text{ sec}$$

ANATOMY OF A BURST

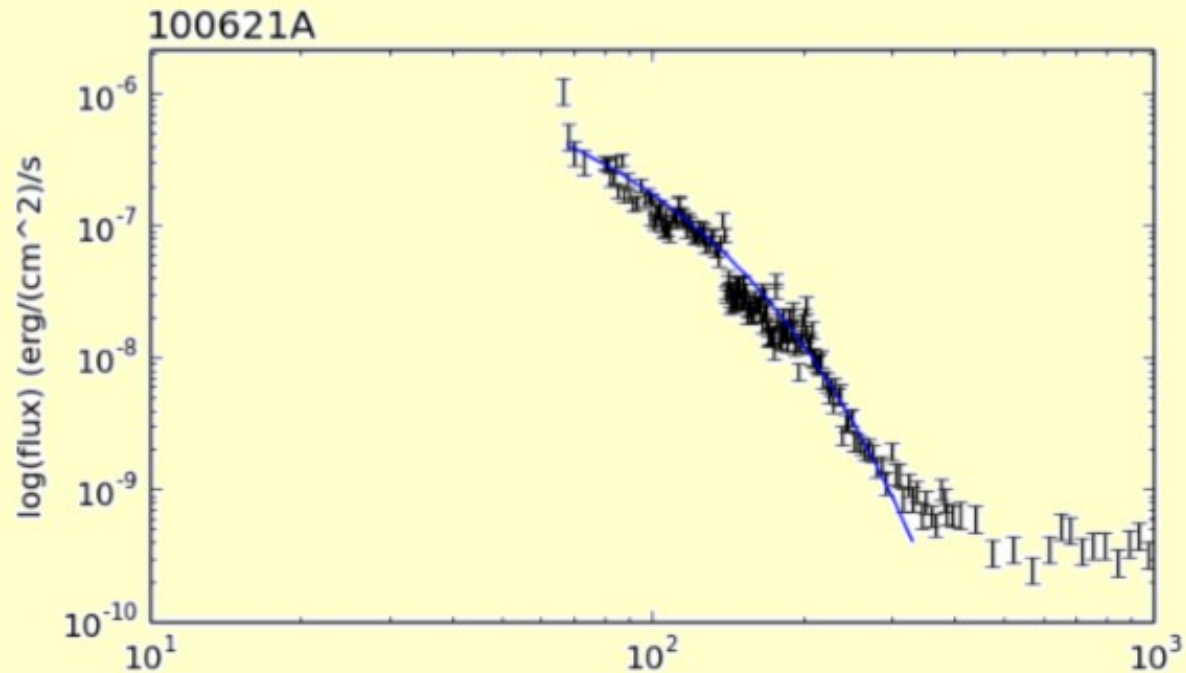


Zoom in the rapid decay phase



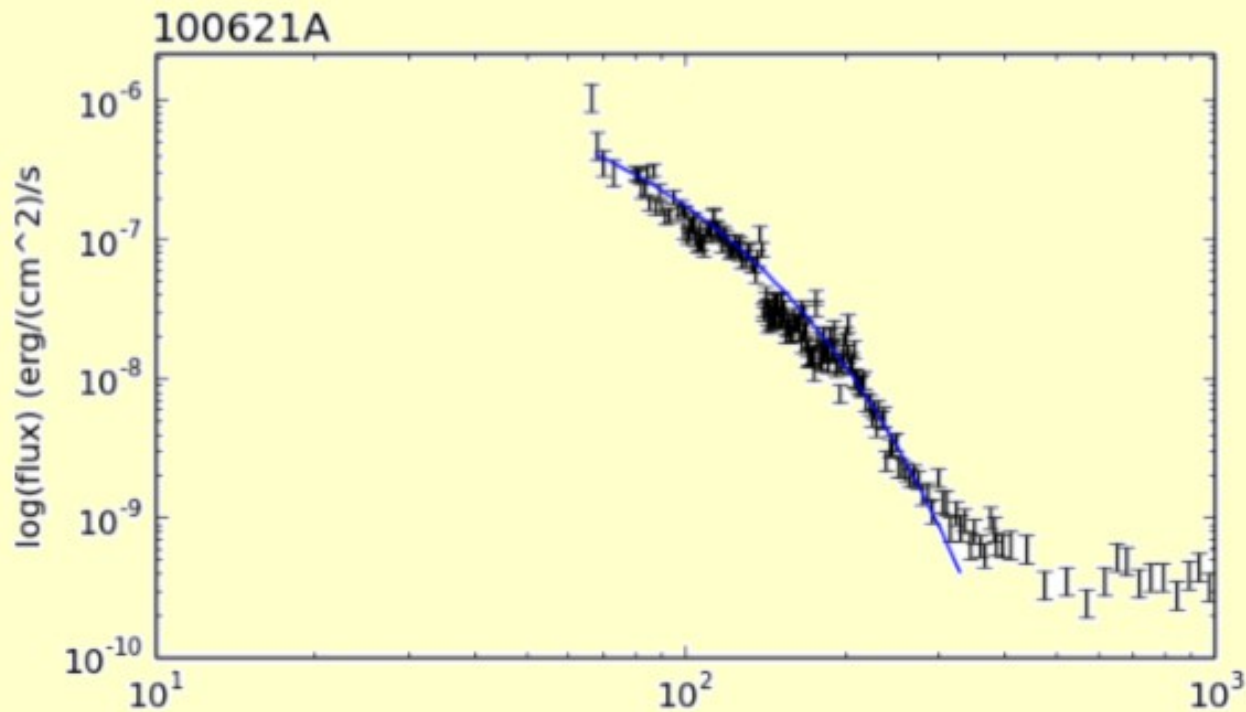
From 343 Long GRBs

30% had this sign



Nathanail, Stranzalis & Contopoulos 2015 (submitted)

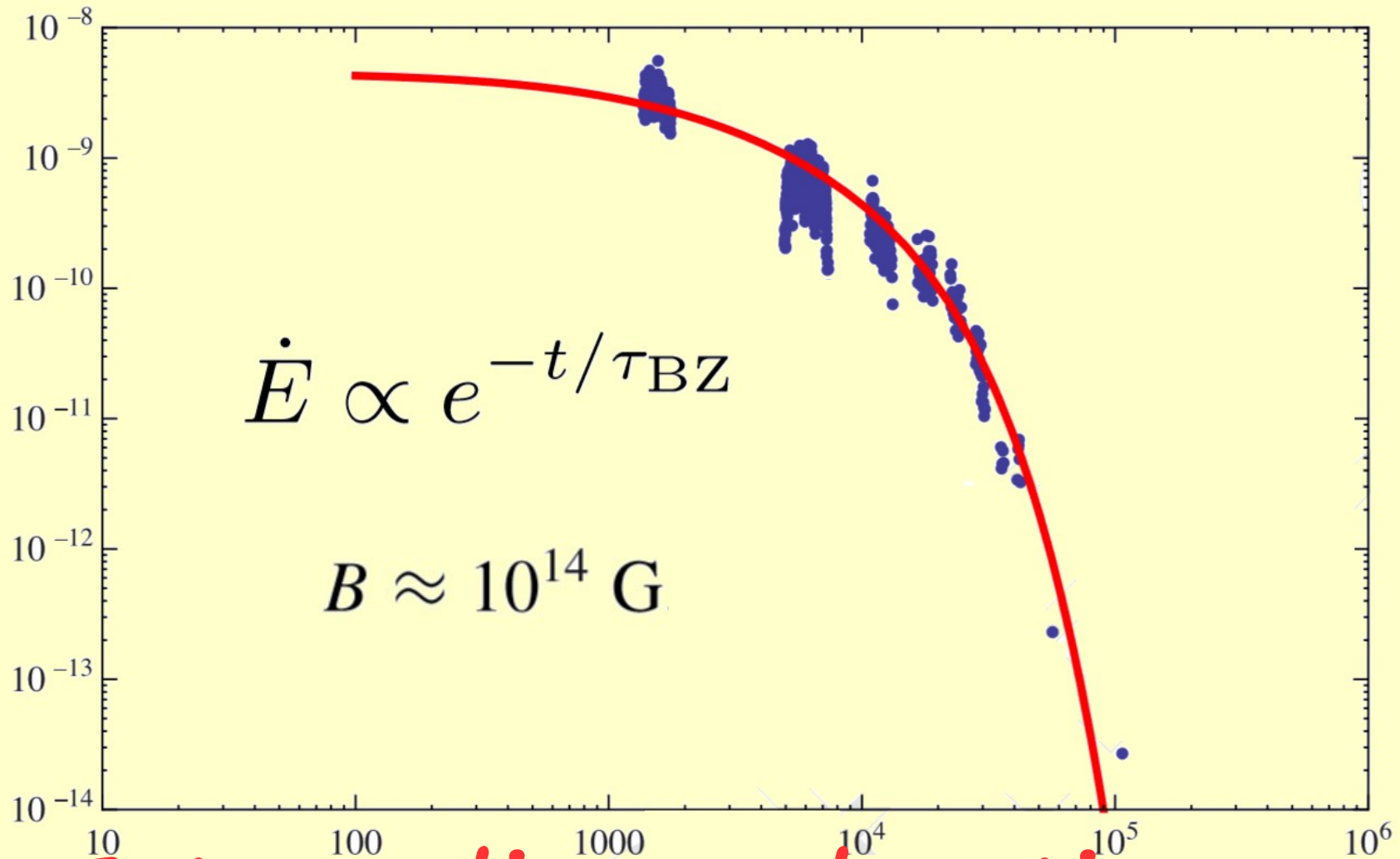
Duration of a GRB depends on the magnetic field strength



Nathanail, Strantzalis & Contopoulos 2015 (submitted)

Easy to explain Ultra Long GRBs

GRB 101225A



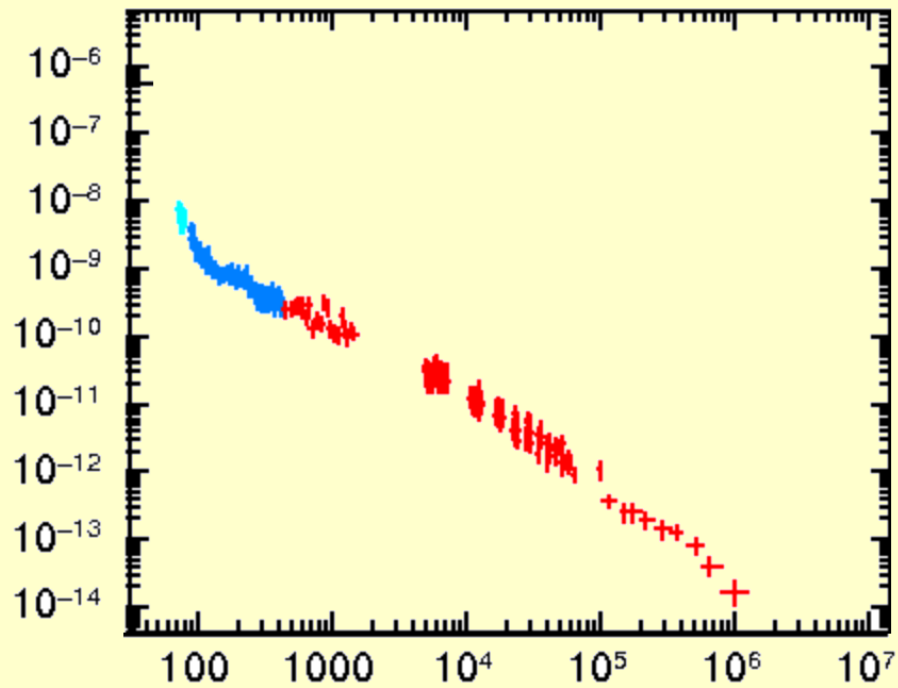
Extraordinary duration ...

Summary

- 30% of Long GRBs show signs of Black Hole Spin Down
- Duration of a GRB depends on the magnetic field strength

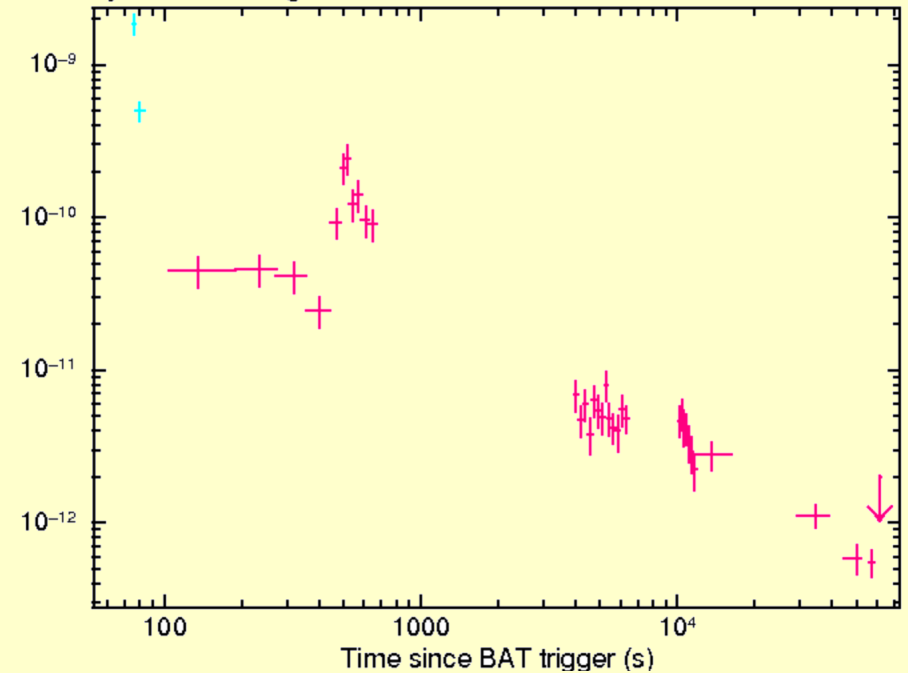
The Rest 70%

XRT data of GRB 091020

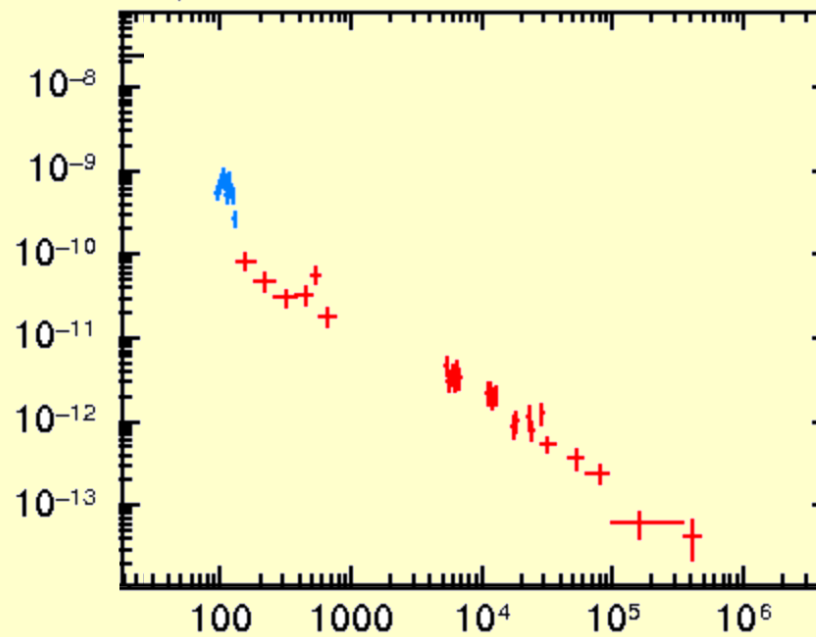


Swift/XRT data of GRB 130803A

cyan: WT settling – red: PC



XRT data of GRB 050915A



Accretion-Mass infall Flaring Activity

