



Discovery  
Frontiers

in Gamma-Ray  
Transient  
Astrophysics

*Raffaella Margutti*

*“We always find something, eh Didi,  
to give us the impression we exist?”*



# (Extragalactic) Gamma-Ray Transients

## TRADITIONAL

- ✓ Gamma-Ray Bursts: SHORT (+GWs)
- ✓ Gamma-Ray Bursts: LONG
- ✓ Jetted TDEs

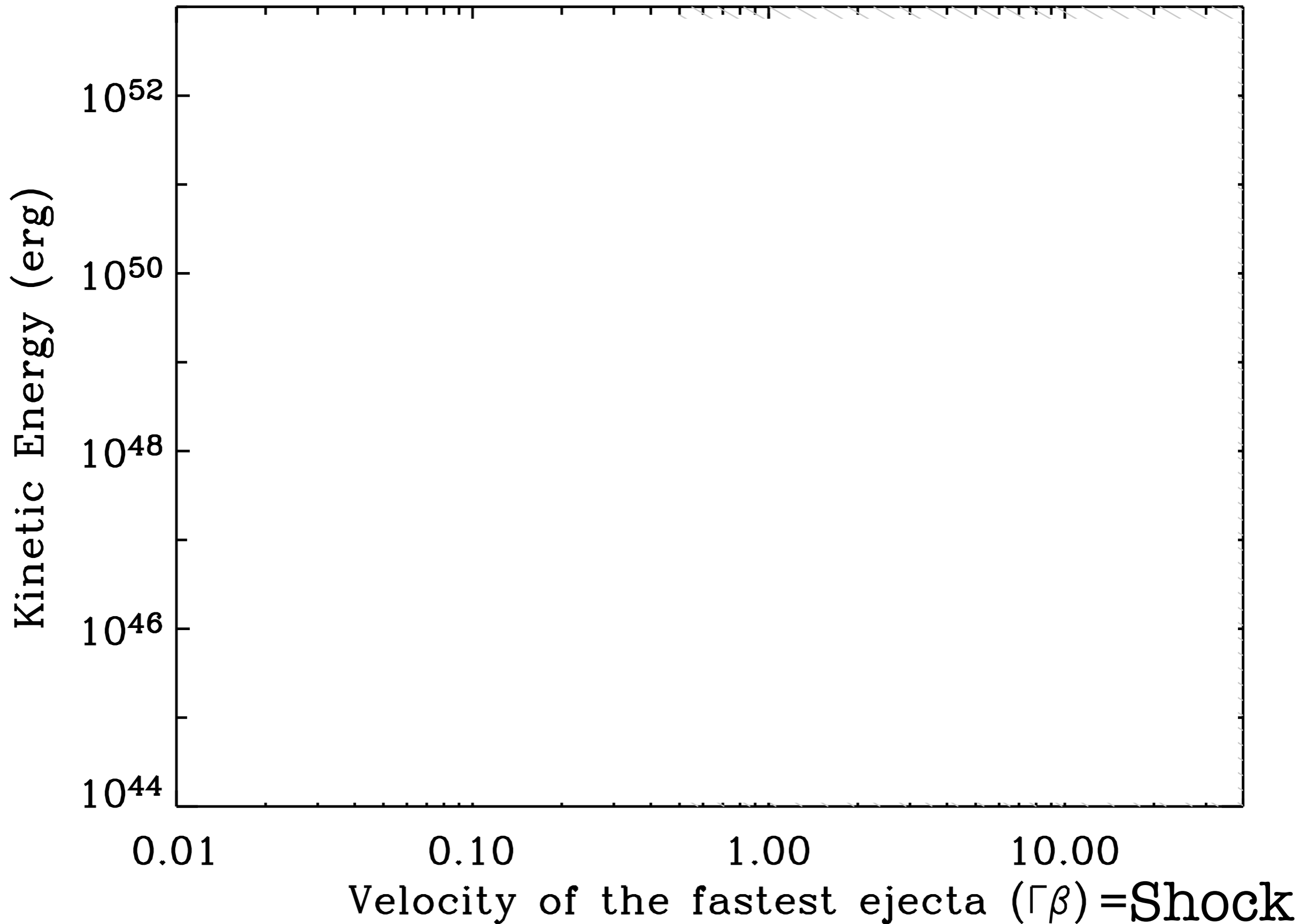
## LESS EXPLORED

- ✓ FBOTs (manifestation of compact objects)  
New class of relativistic transients
- ✓ Strong SN shock interaction
- ✓ FRBs

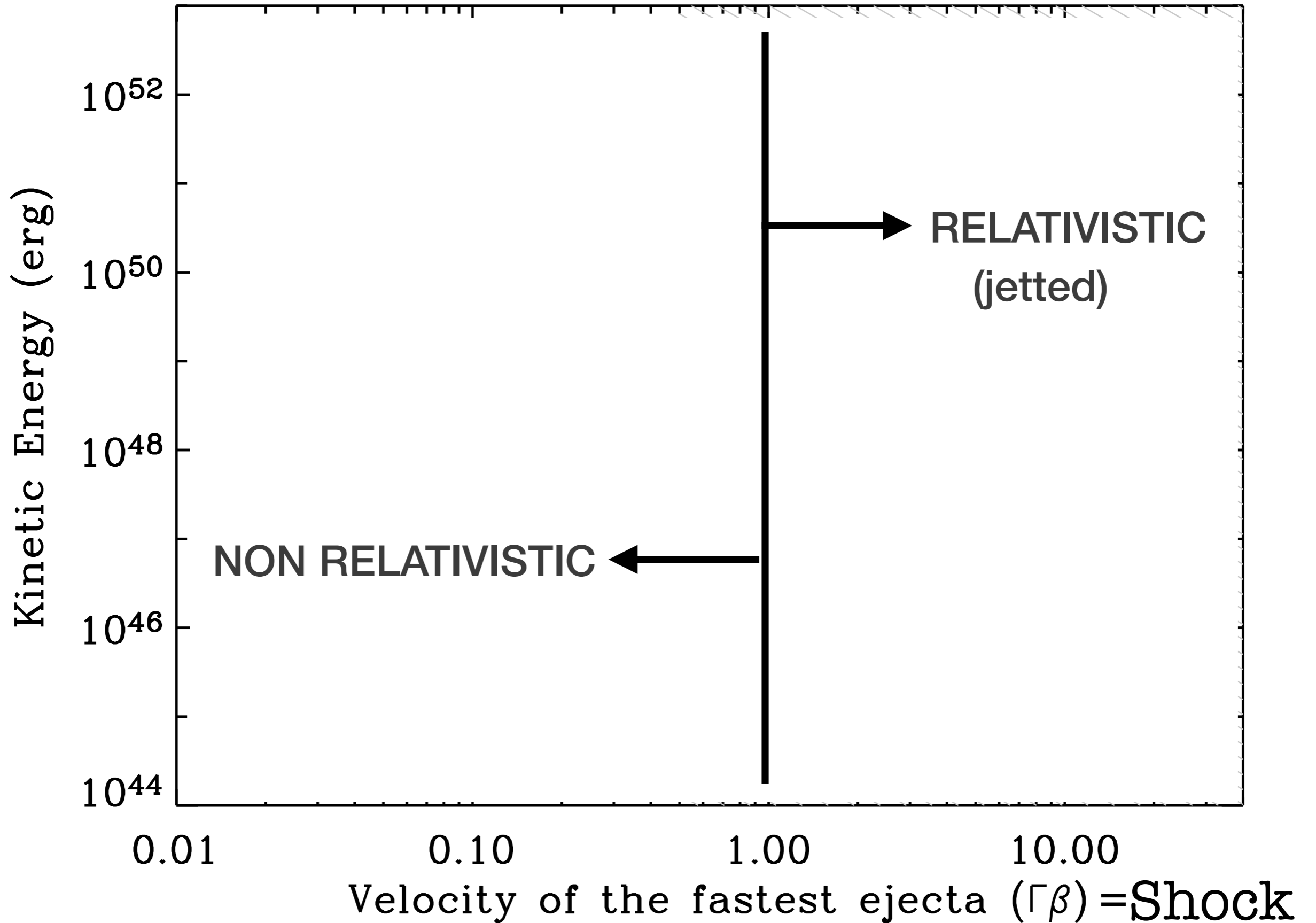
[Shocks]



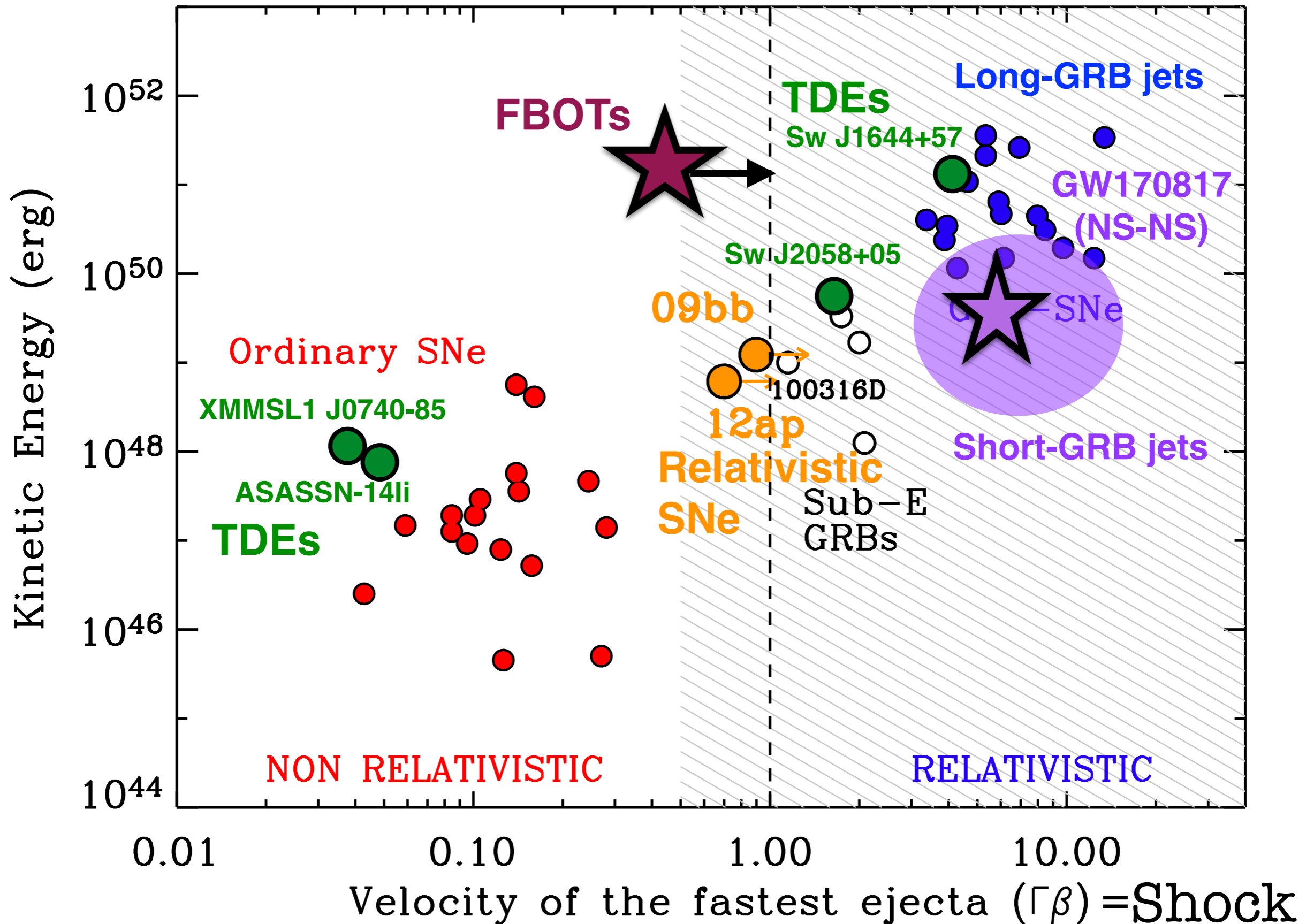
# Physical properties of Shocks from Transients



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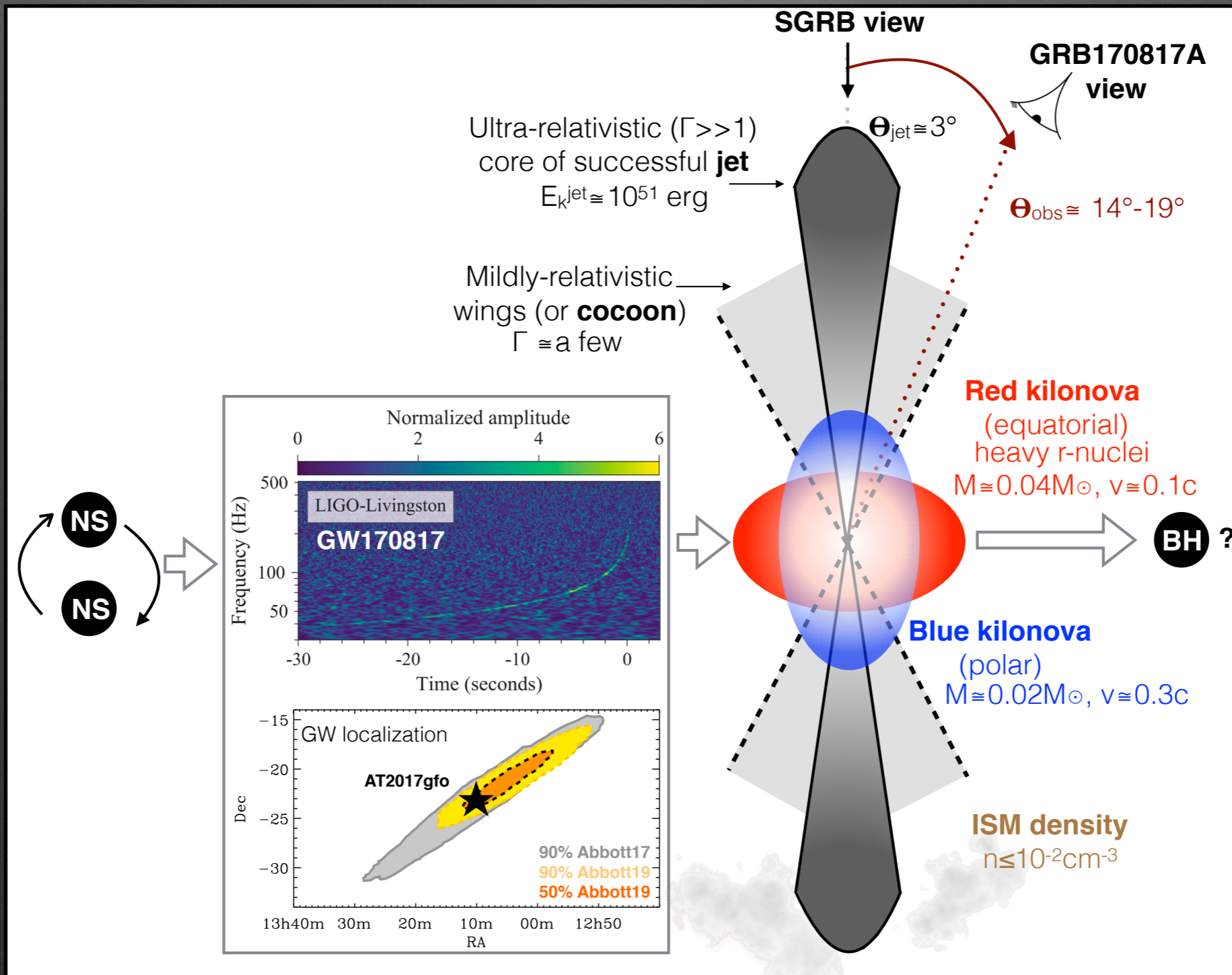


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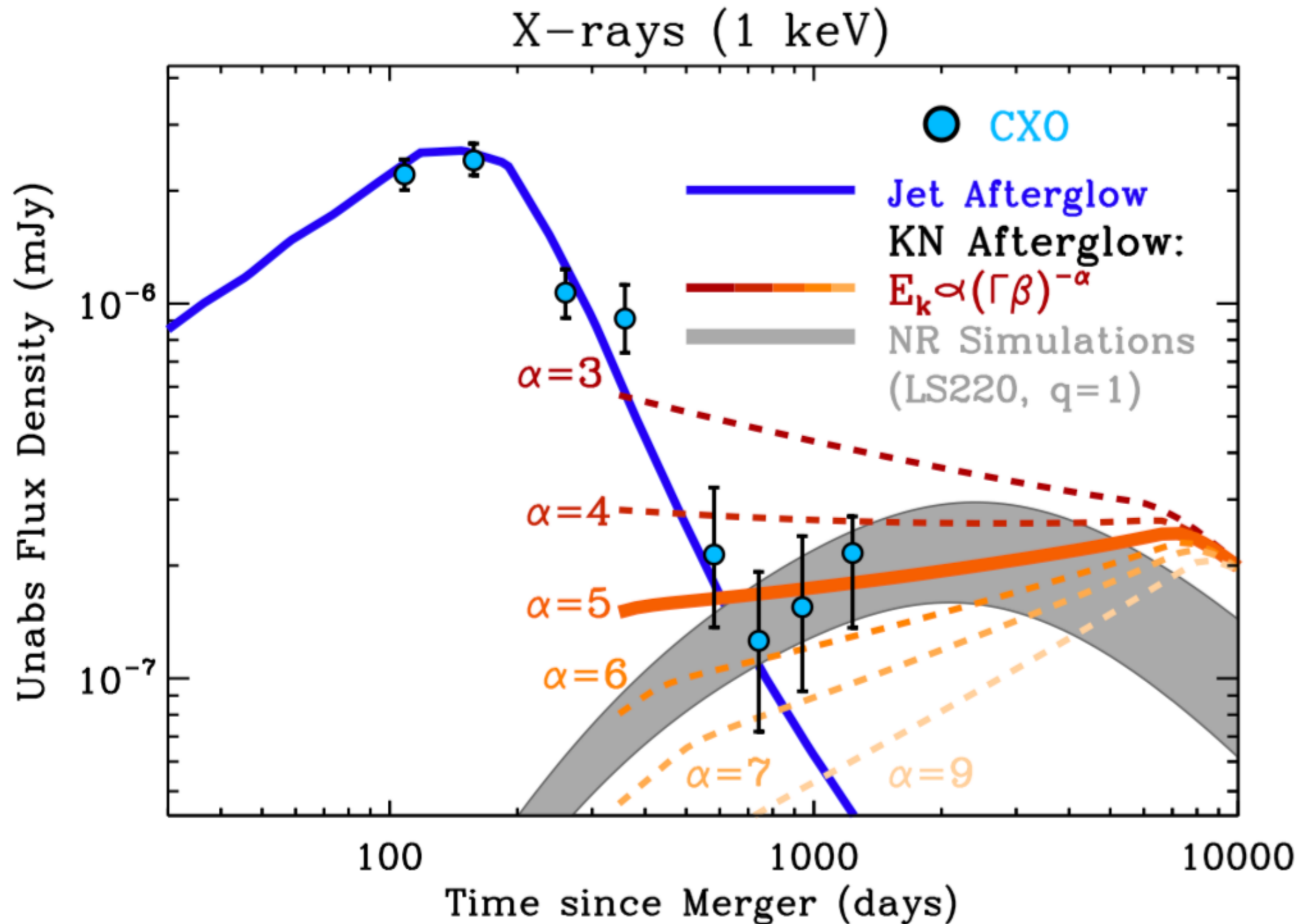


# First multi-messenger observations of the NS merger event GW170817



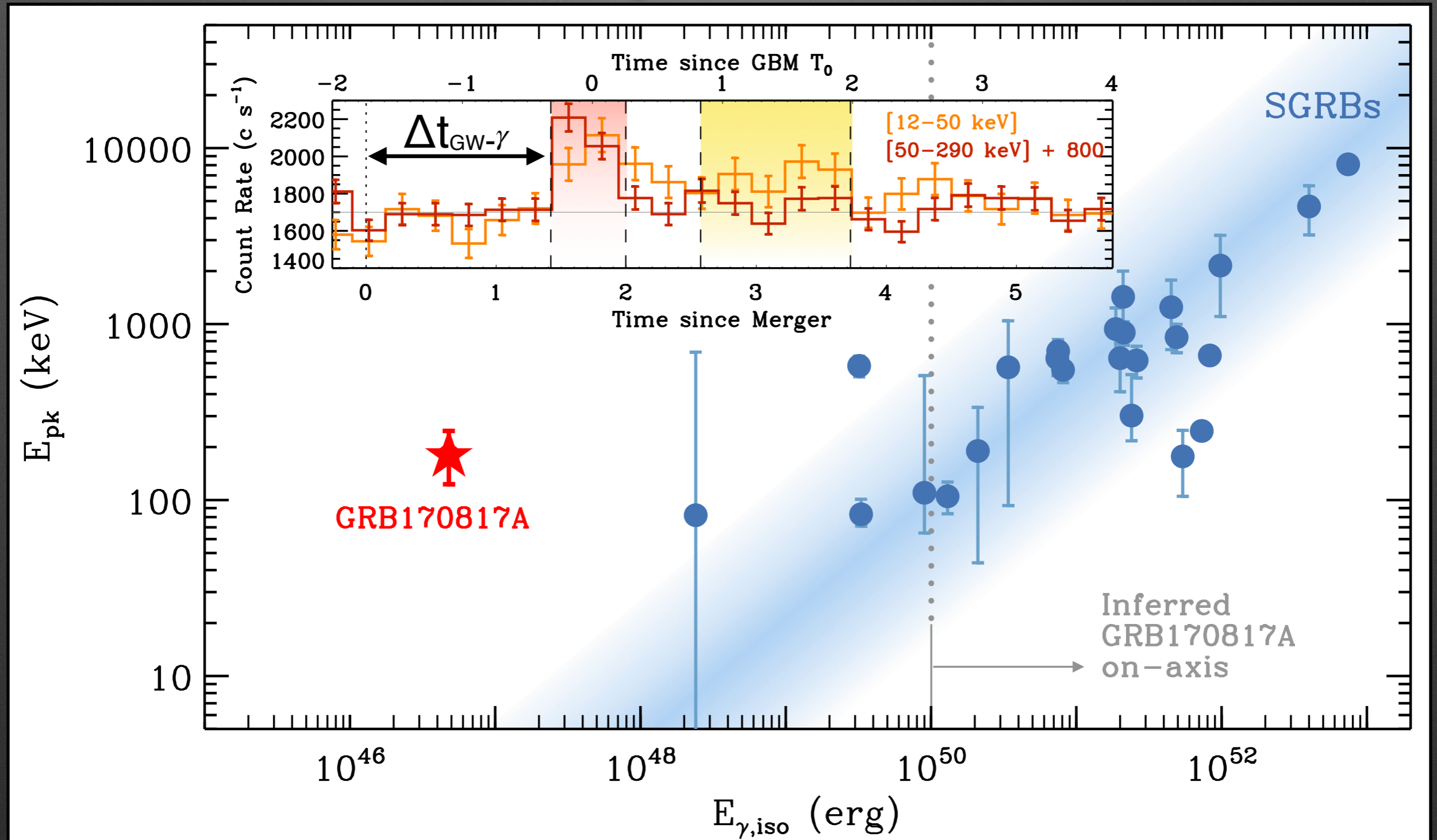


# The emergence of a new X-ray component of emission at 3.5 yrs since merger



# The Gamma-Ray counterpart to GW170817

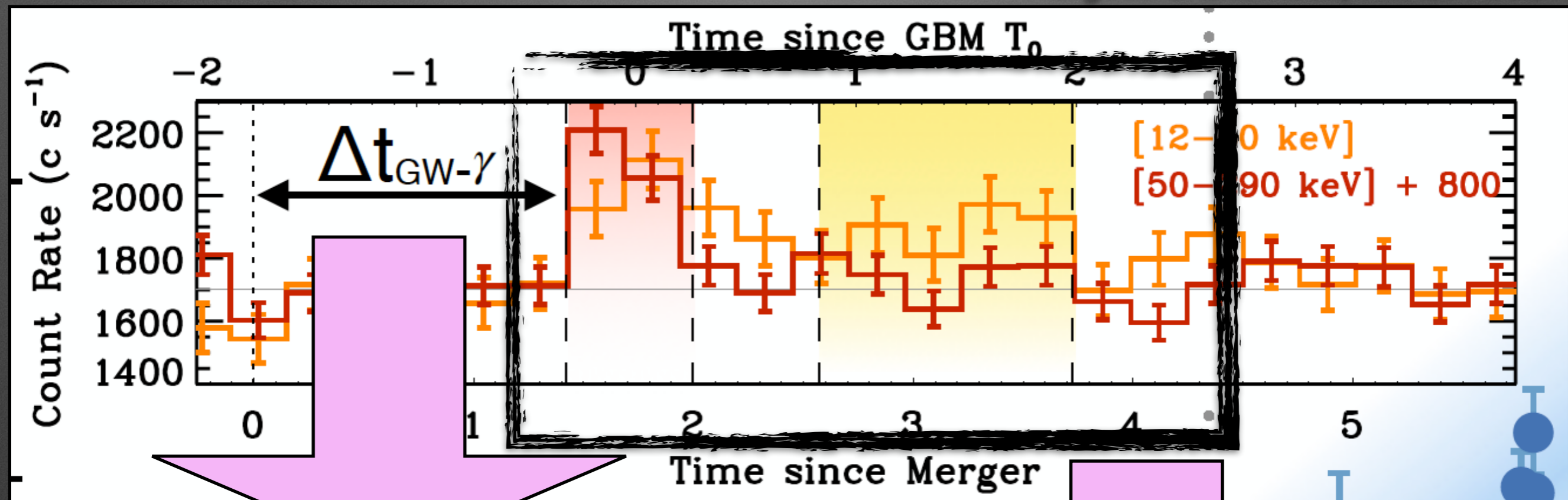
Fermi-GBM (Goldstein+2017) and Integral (Savchenko+ 2017) detection of GRB170817A





# The Gamma-Ray counterpart to GW170817: GRB170817A

Margutti & Chornock, ARA&A 2021



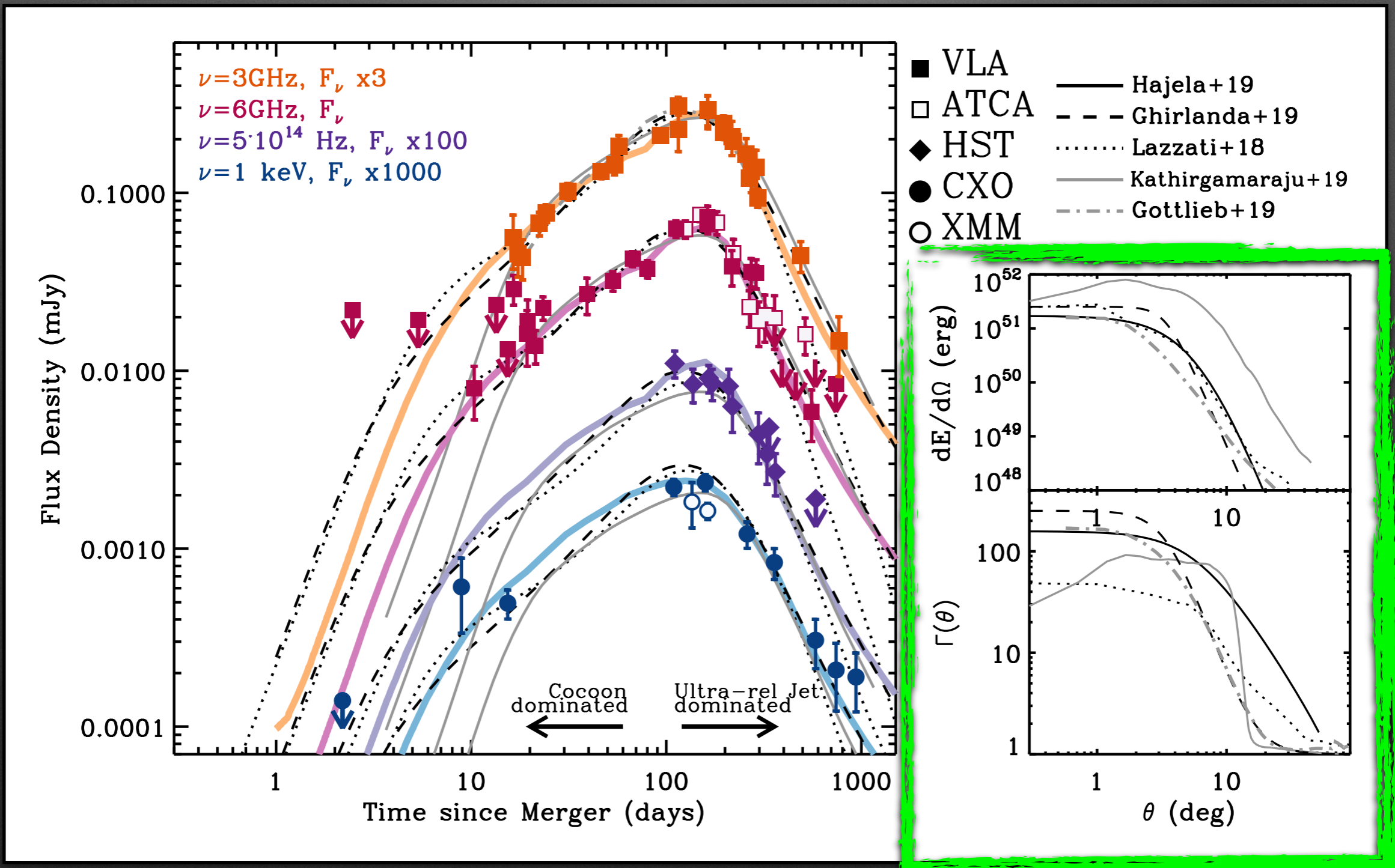
MULTI-MESSENGER parameter =

- ✔ Jet launching time (BH formation?) +
- ✔ Jet/cocoon breakout time +
- ✔ Travel time to transparency radius

STRUCTURE of jets  
launched by NS-NS mergers



# Structure $E(\theta)$ and $\Gamma(\theta)$ of the jet launched by GW170817

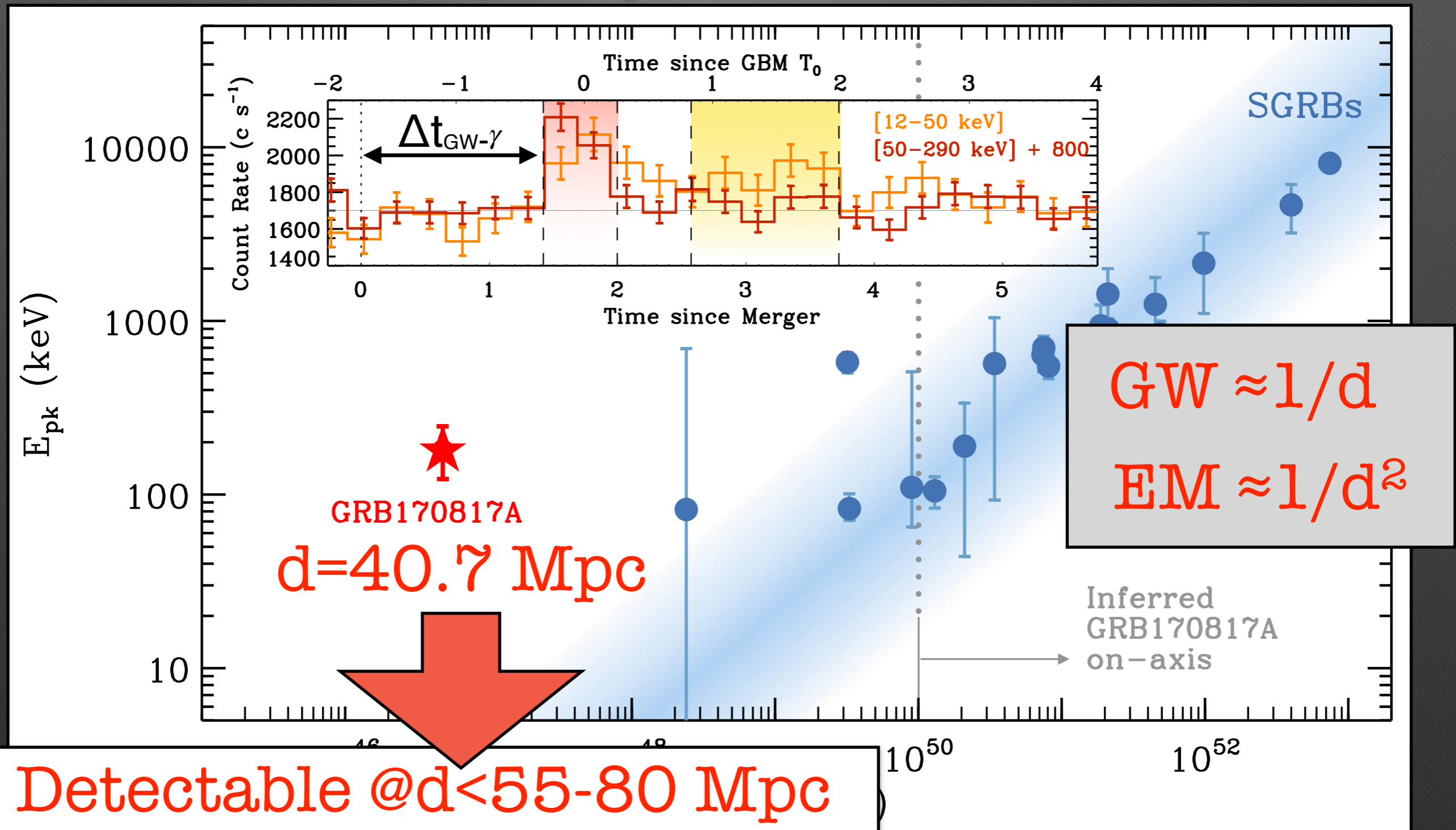




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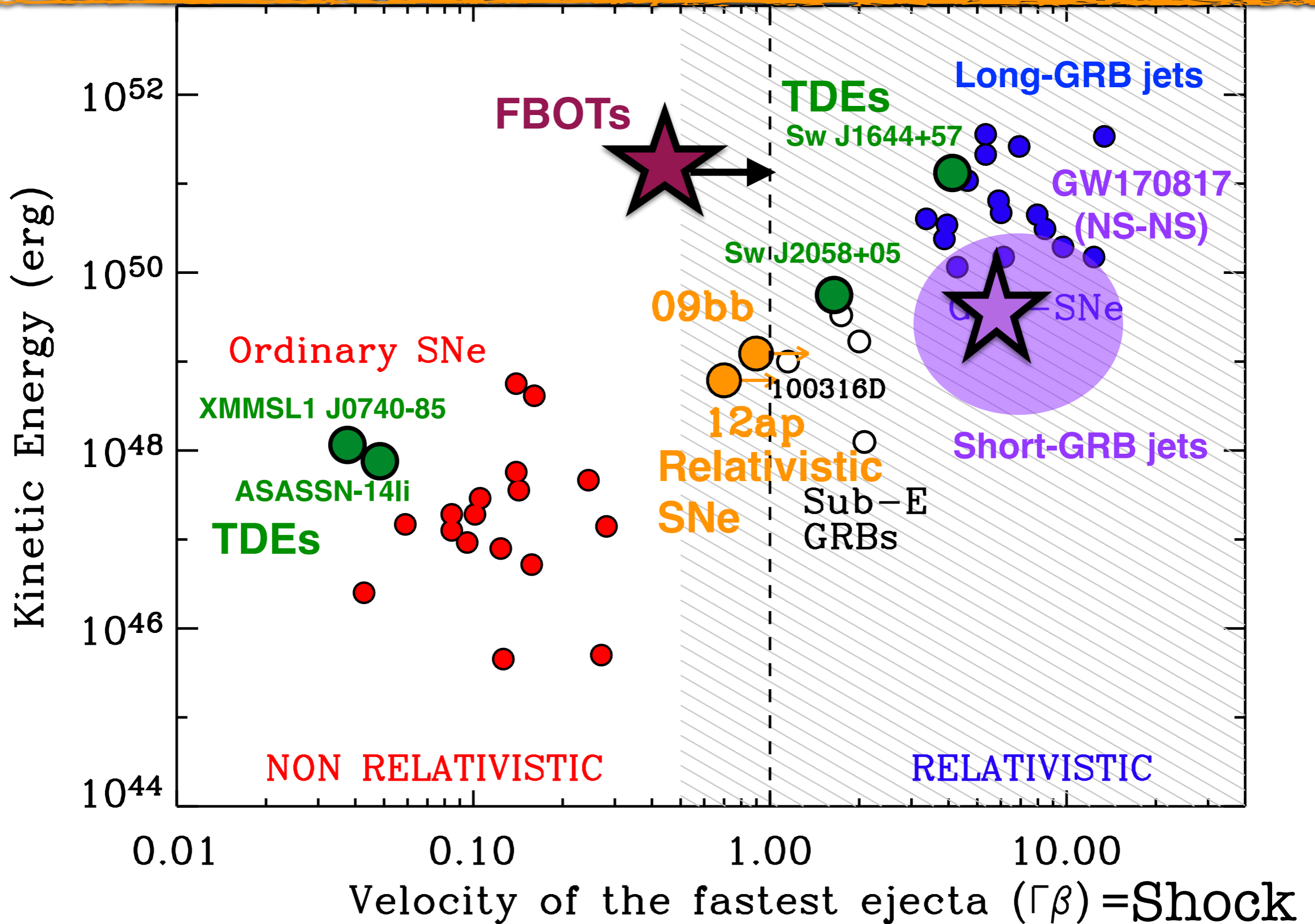
## -SENSITIVITY-

Fermi-GBM (Goldstein+2017) and Integral (Savchenko+ 2017) detection of GRB170817A

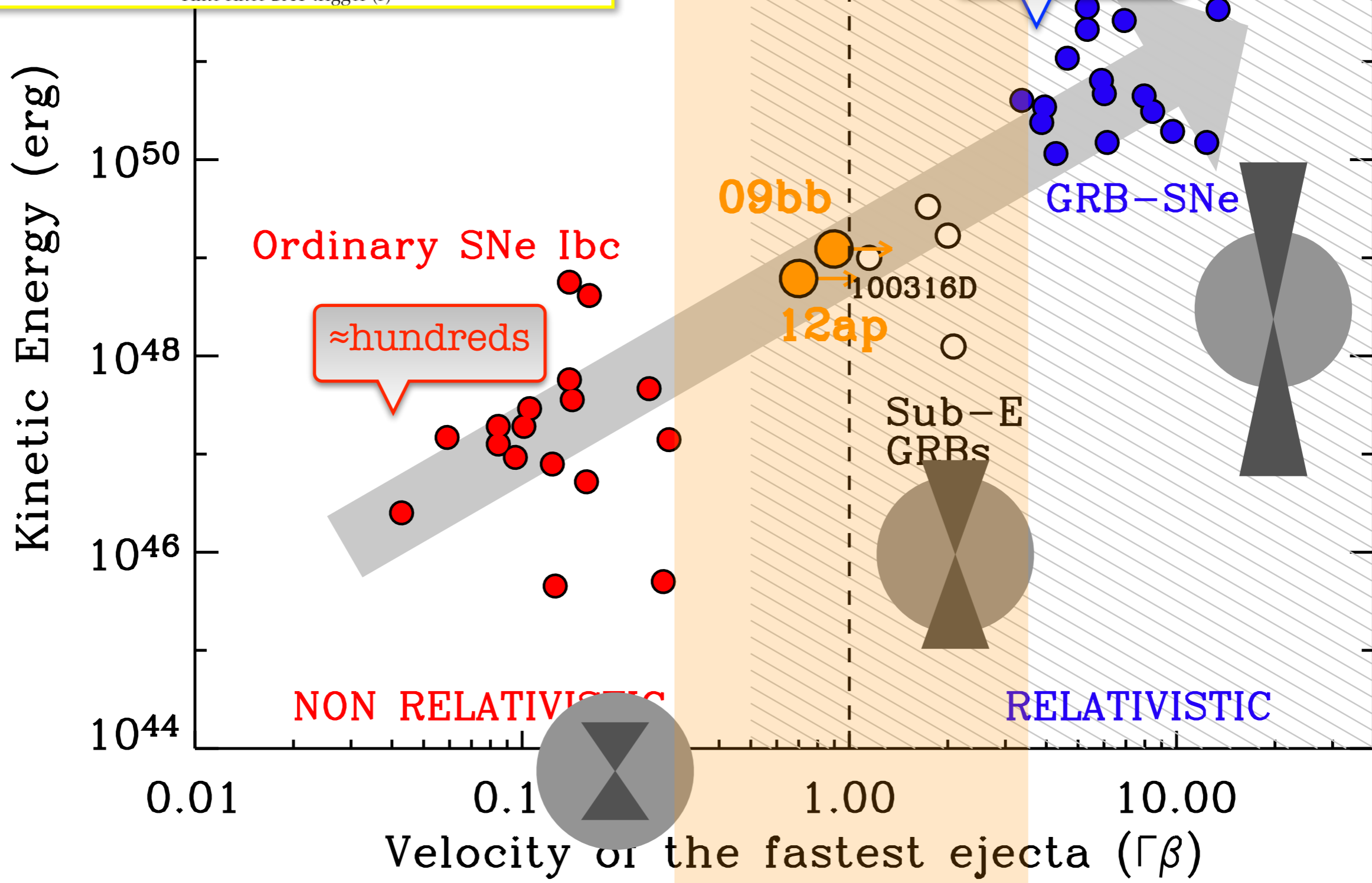
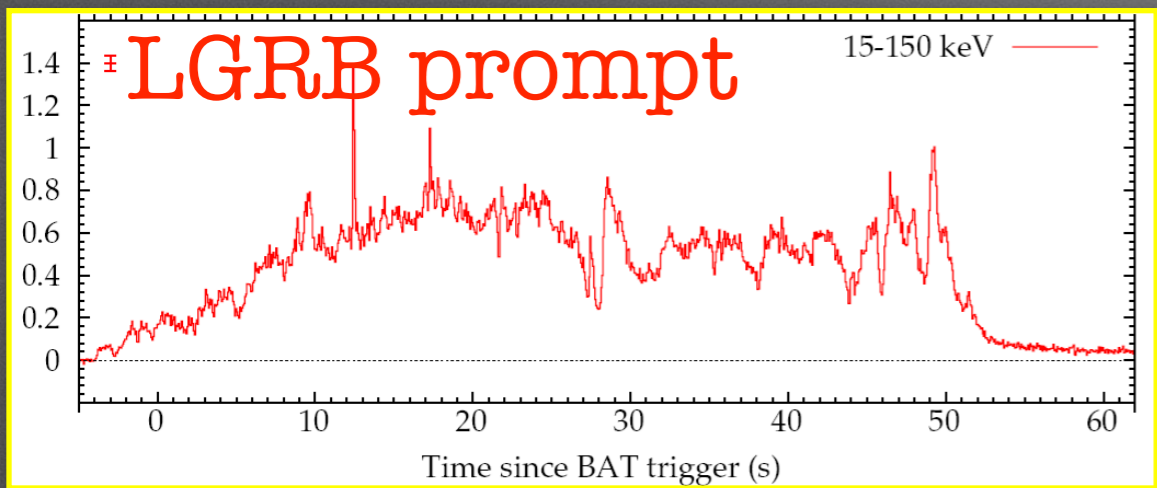


Detectable @  $d < 55-80$  Mpc  
 $P \sim 10\%$  to be better aligned

# Relativistic jets from massive stars

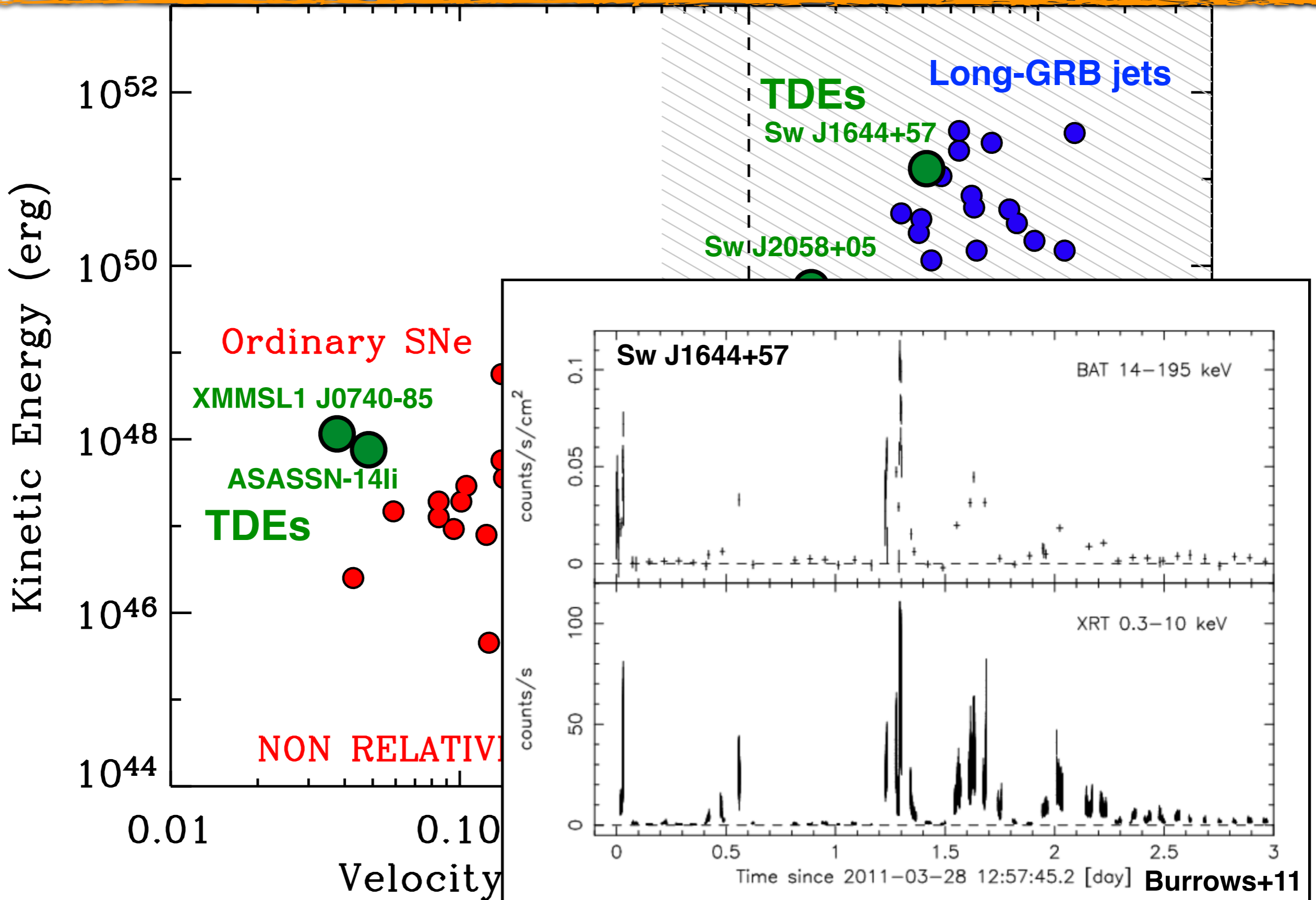






# Relativistic jets from TDEs

Alexander et al., 2020





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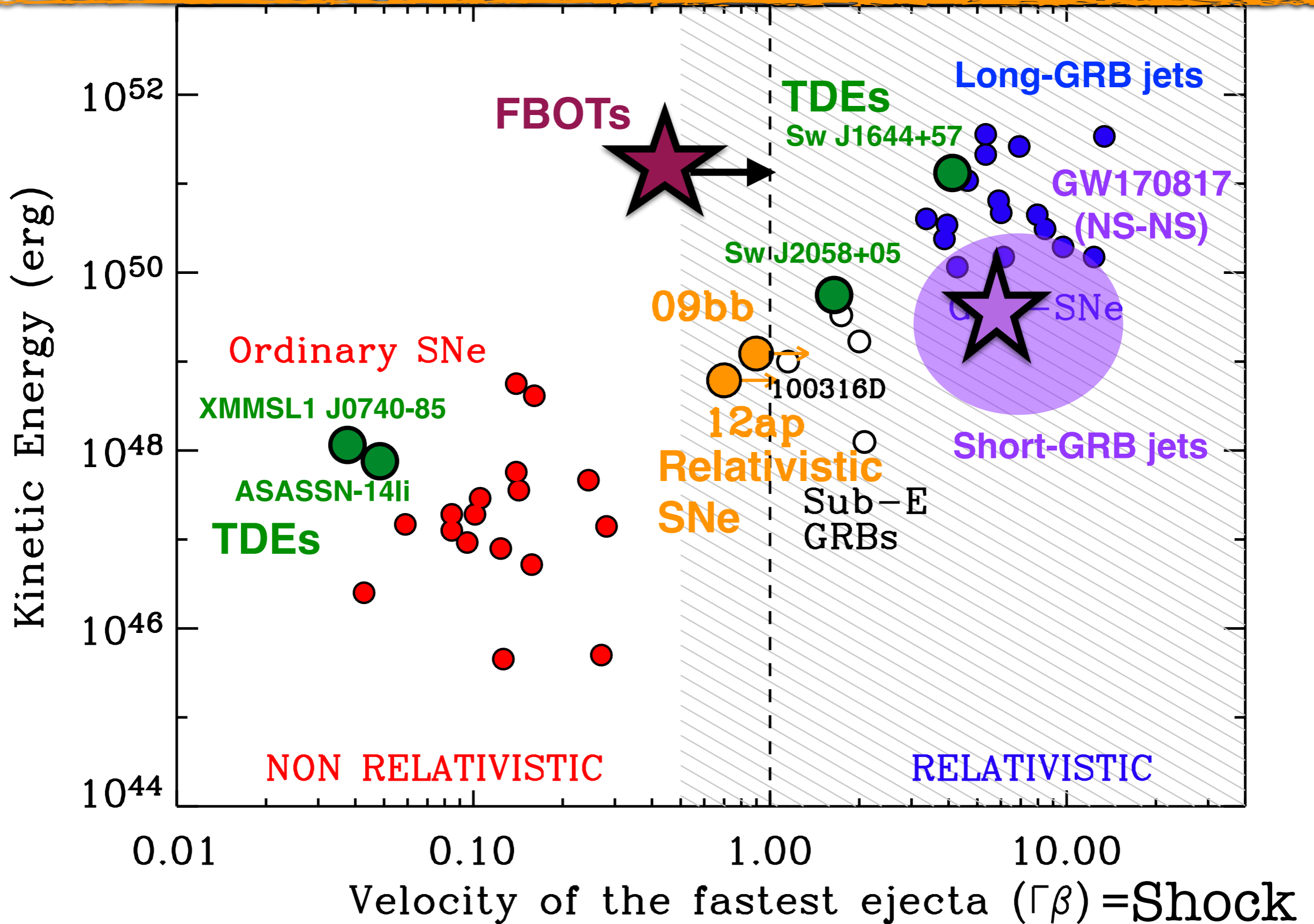
New class of relativistic transients

Strong SN shock interaction

[Shocks]



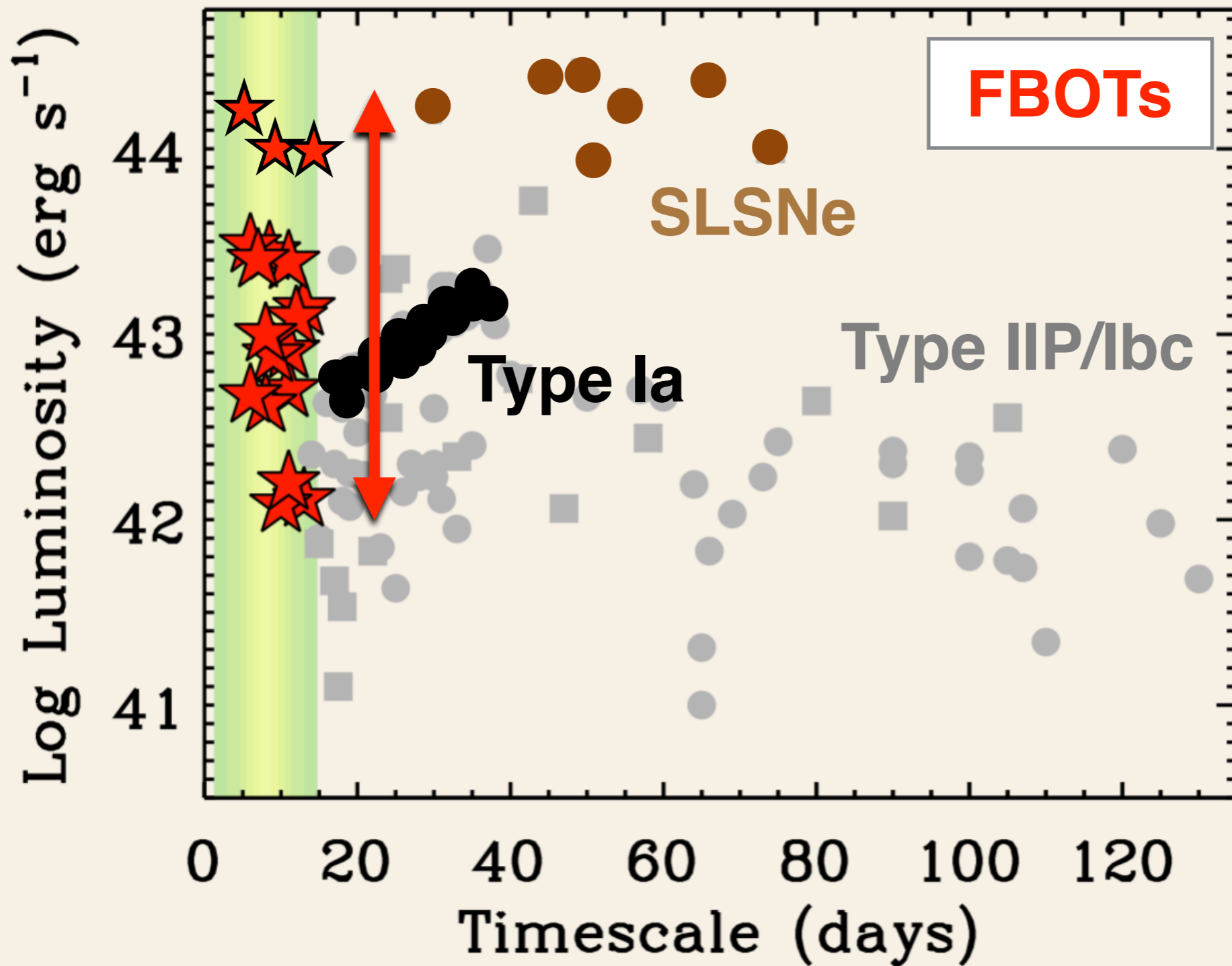
# FBOTs: A new type of relativistic transient





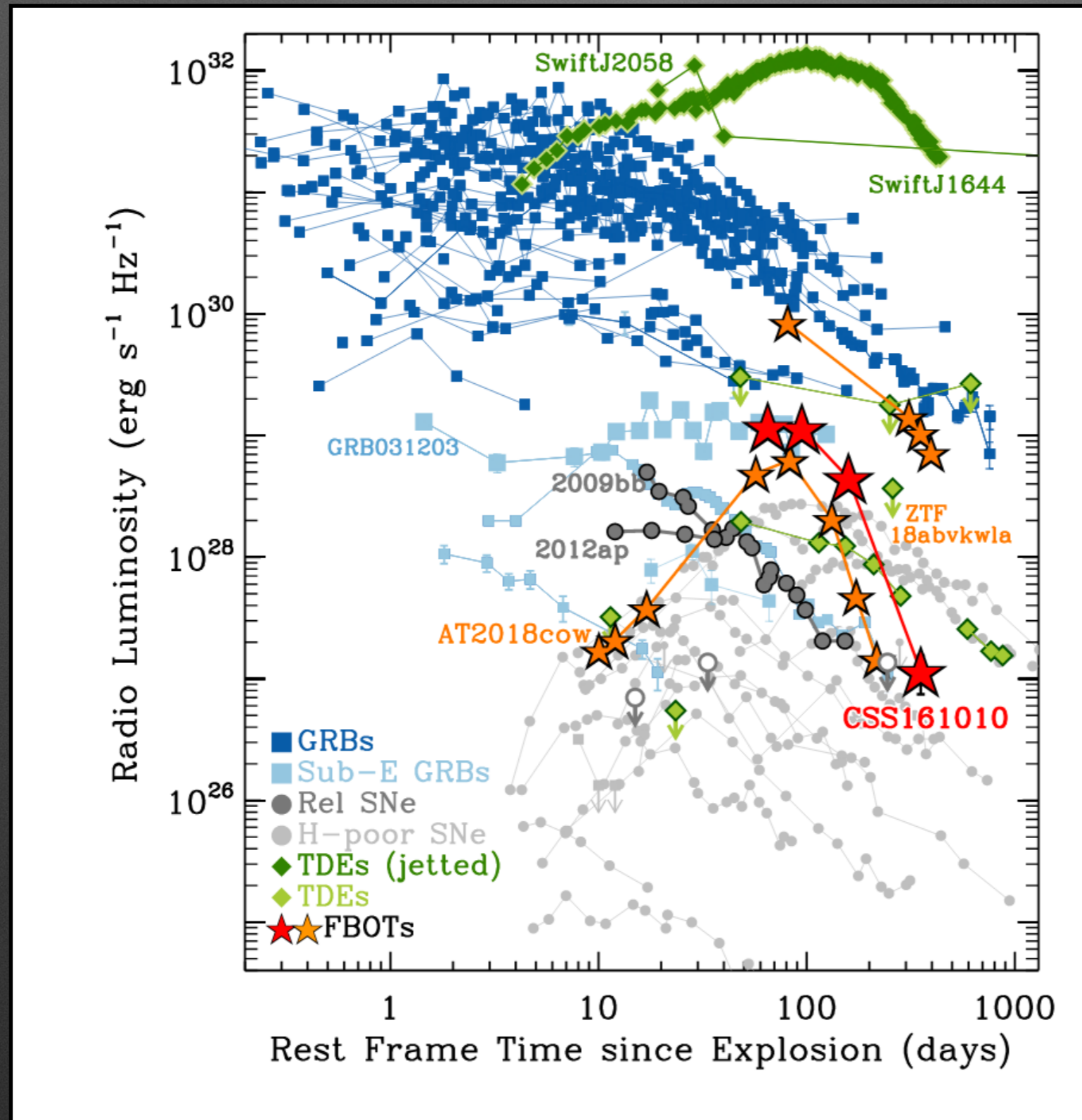
# Fast Blue Optical Transients

Sample studies: Drout+14 (PanSTARSS), Tanaka+16 (Subaru), Arcavi+16 (SNLS+PTF), Pursiainen+18 (DECam)





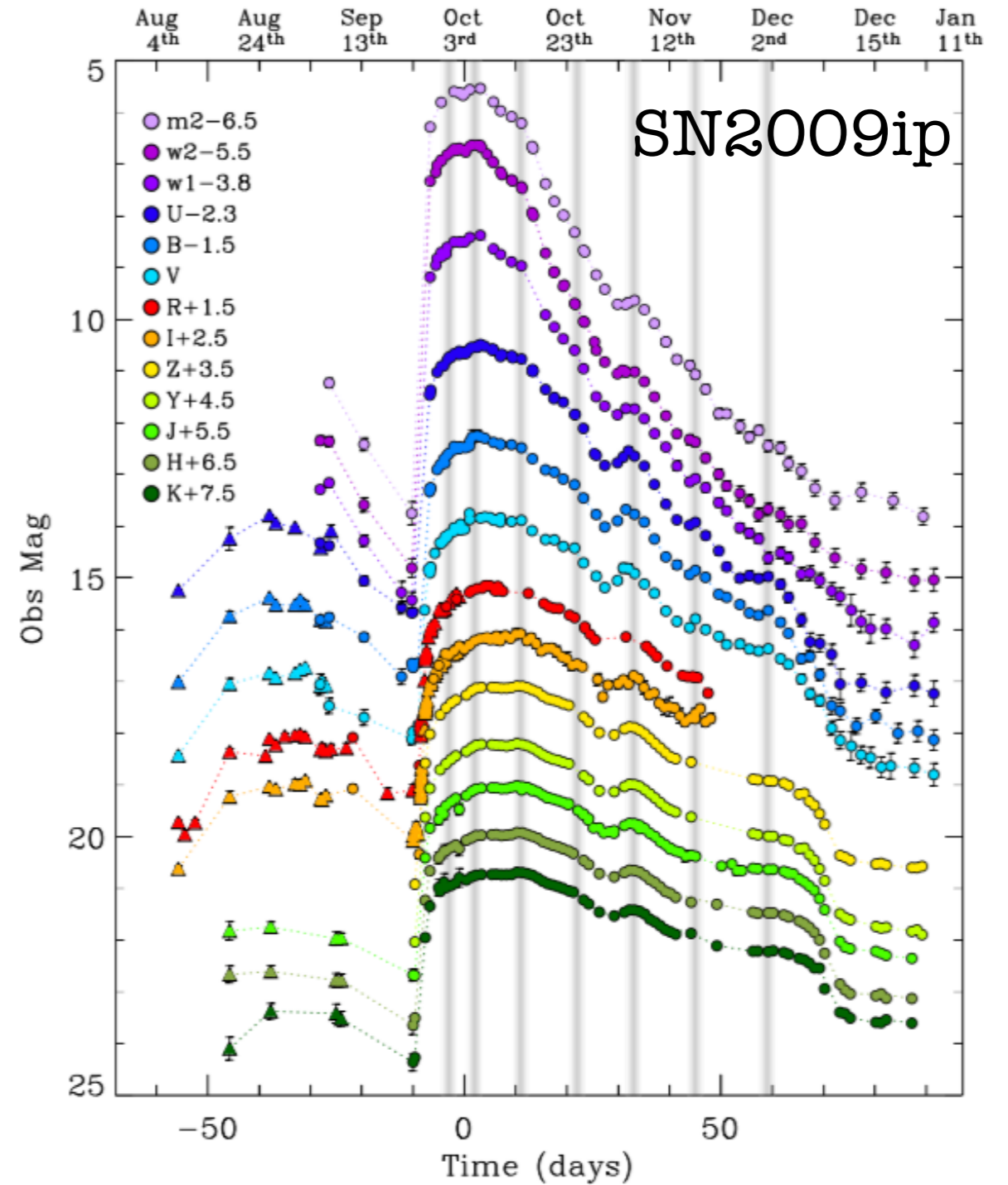
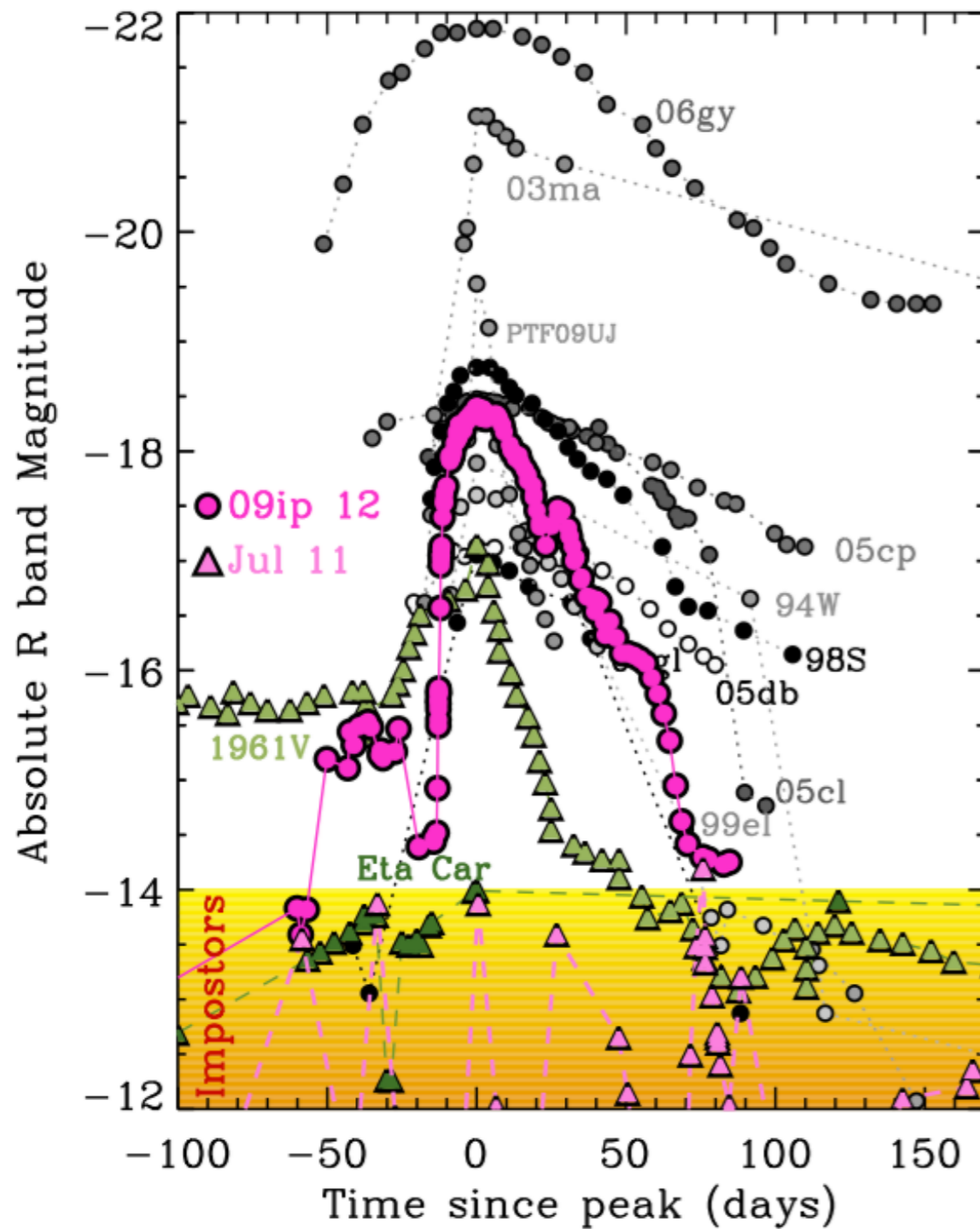
# FBOTs: A new type of relativistic transient



As radio-luminous as long GRB jets, yet clearly different from long GRB progenitors because of the presence of hydrogen

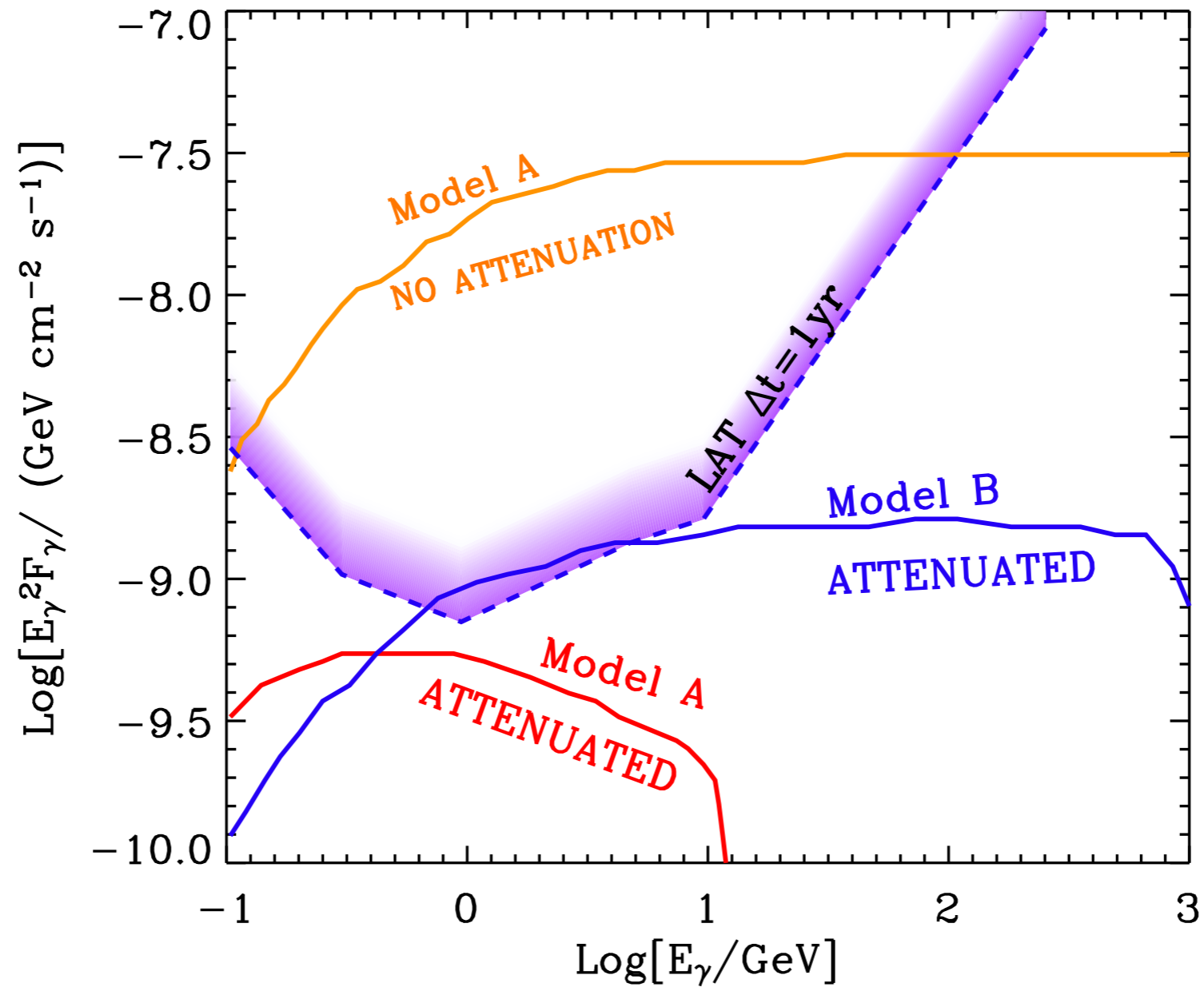


# Strongly interacting SN shocks





# Strongly interacting SN shocks

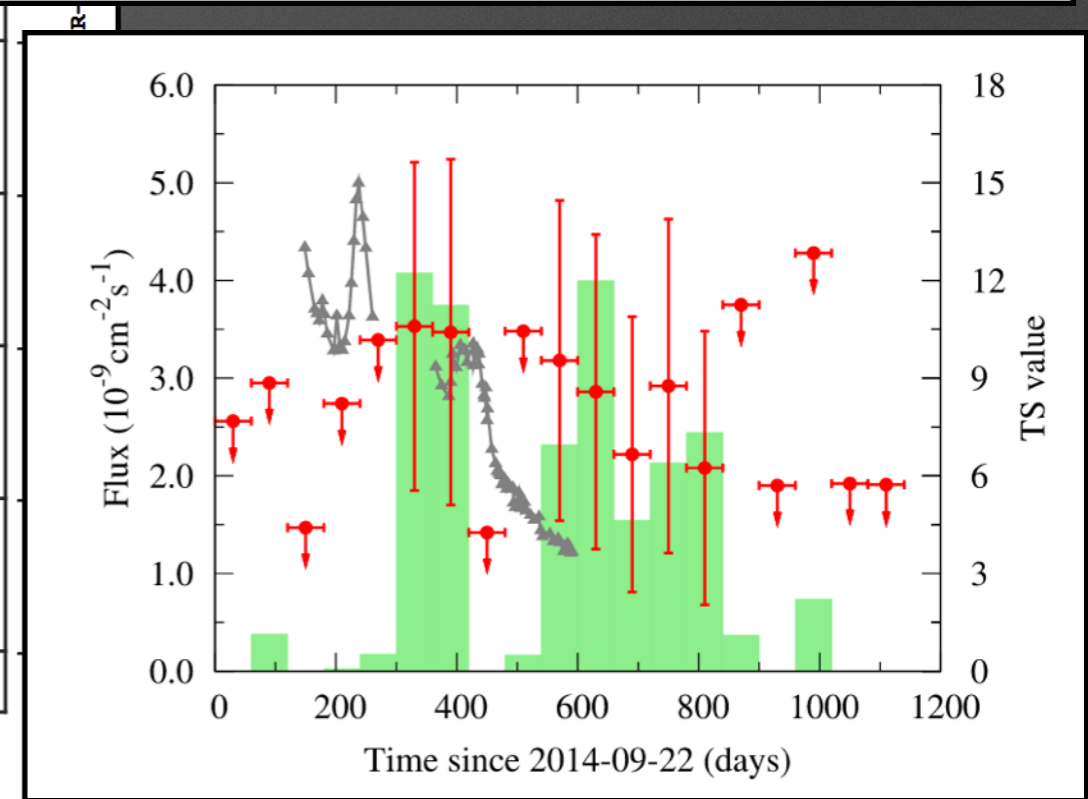
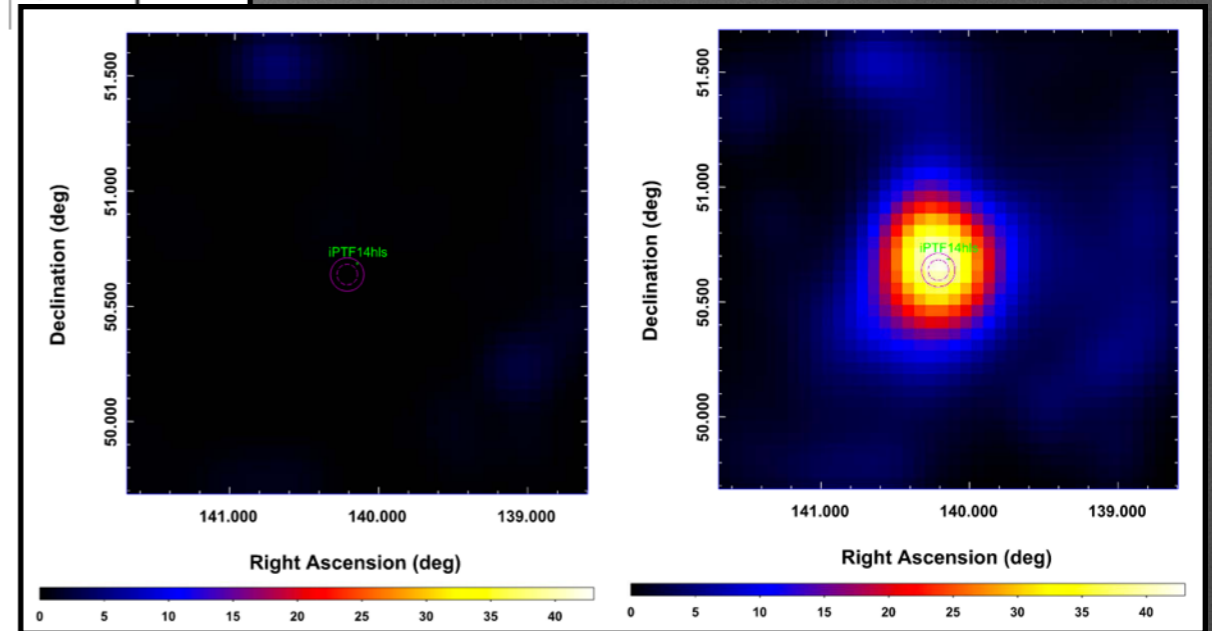
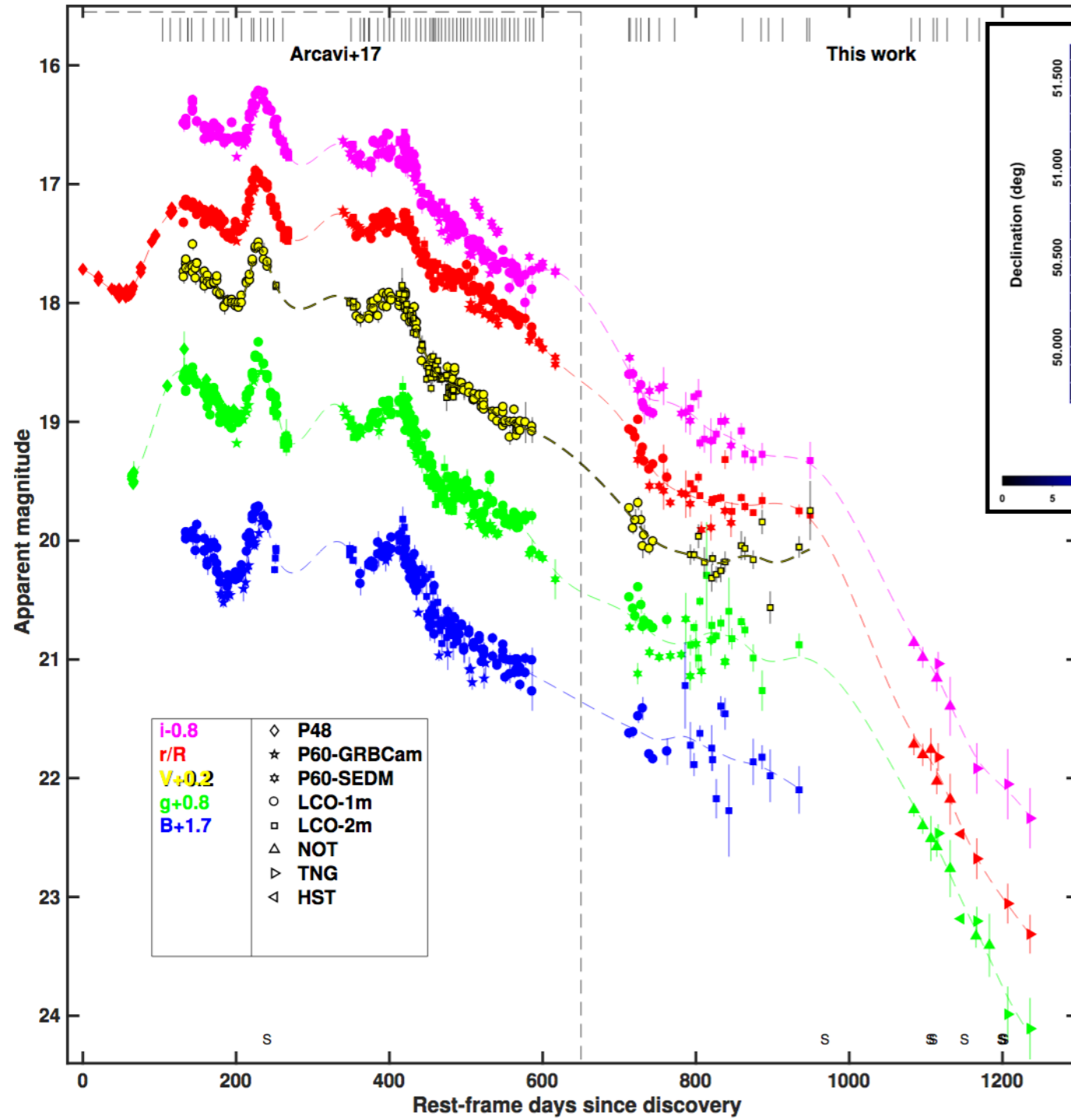


Murase+2013; Katz+2011; 2012



# Transient iPTF14hls

Fermi-LAT detection:



Sollerman+2019

Yuan+2018



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[Shocks]



# Discovery Phase Space

- ✓ Never seen (e.g., shock breakouts from WDs, FBOT jets)
- ✓ Maybe seen one (e.g., shock interaction, FRBs)
- ✓ One (e.g., Gamma-ray counterparts to GWs)
- ✓ A few (e.g., jetted TDEs, low-luminosity GRBs)

**Faint and/or observationally Rare**