

# Physical properties of GRB 221009A

## Fermi Summer School 2023

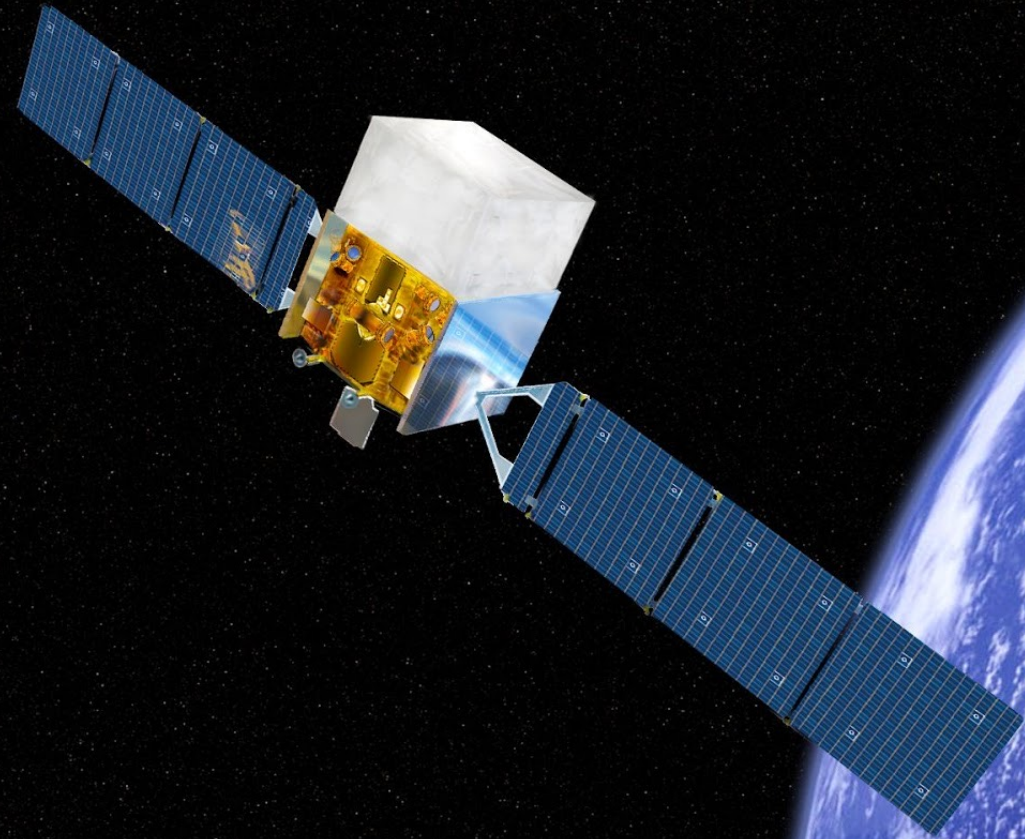
Peter Veres

University of Alabama in Huntsville

on behalf of the *Fermi*-GBM team,  
the *Fermi*-LAT collaboration,  
and friends

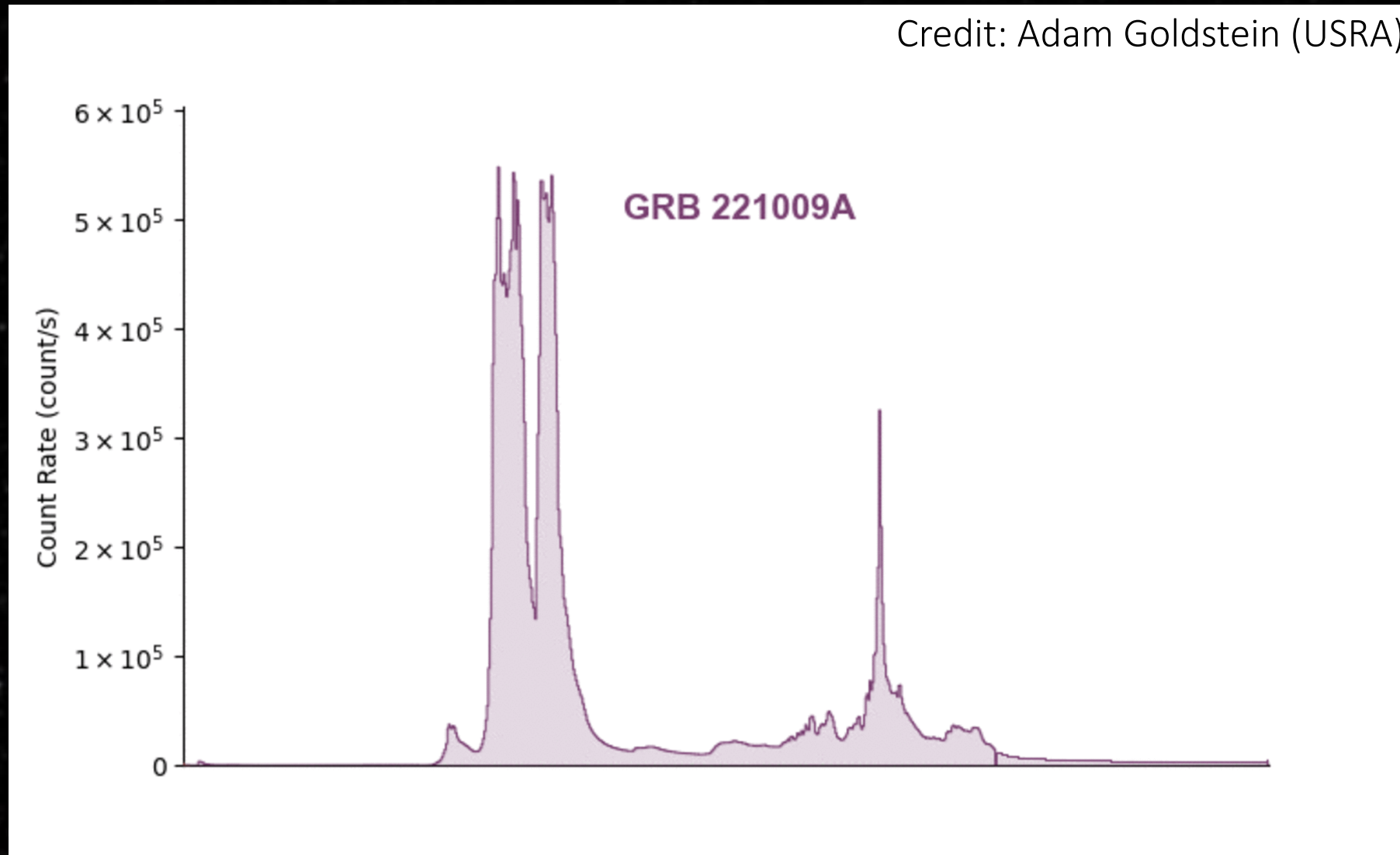
Slides courtesy of Stephen Lesage

**Lesage, PV et al. (2023):** <https://arxiv.org/abs/2303.14172>



# GRB 221009A

Credit: Adam Goldstein (USRA)

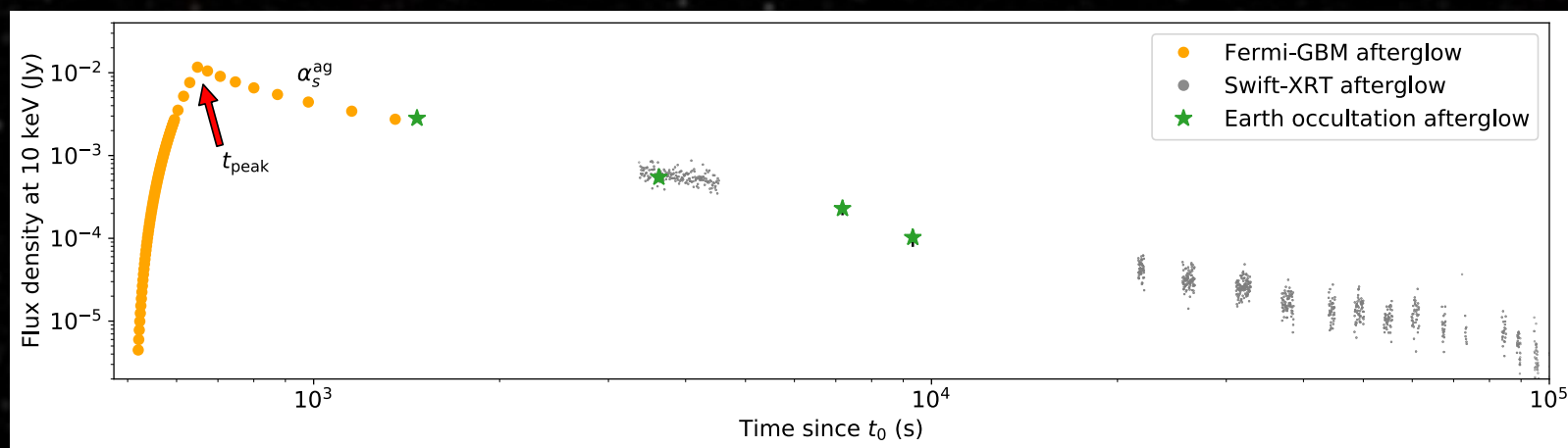
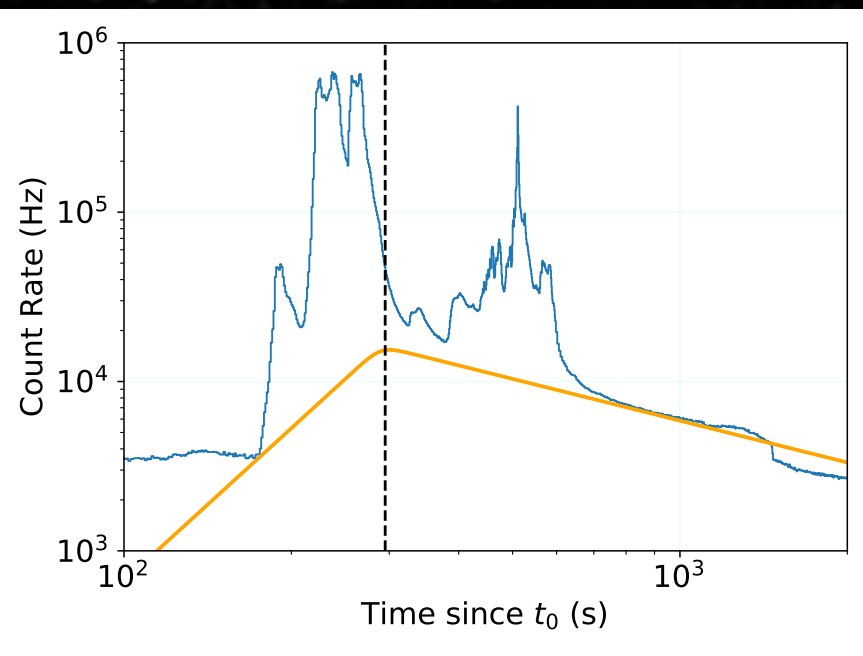
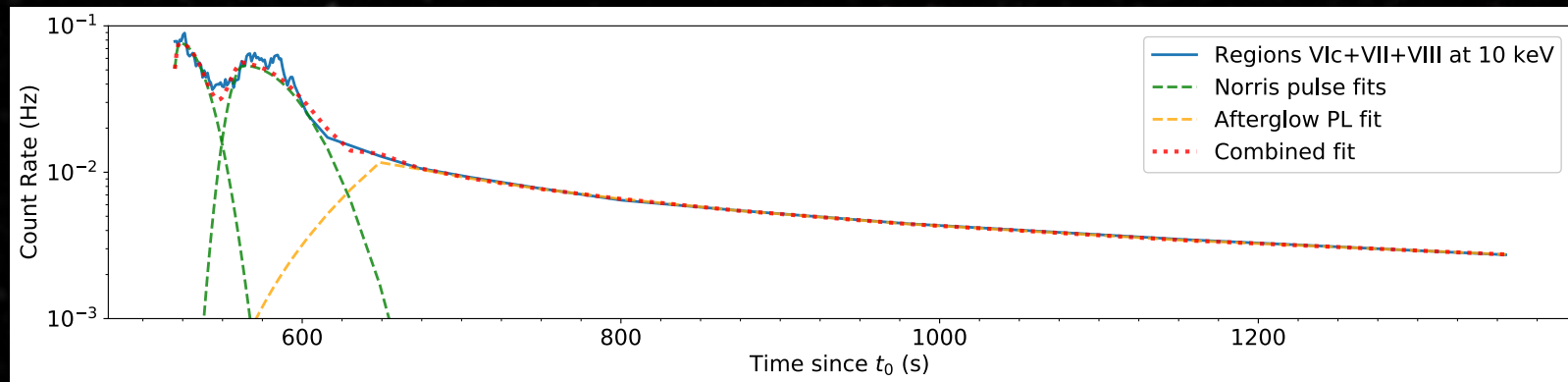


# Afterglow

Unusual but not unprecedented

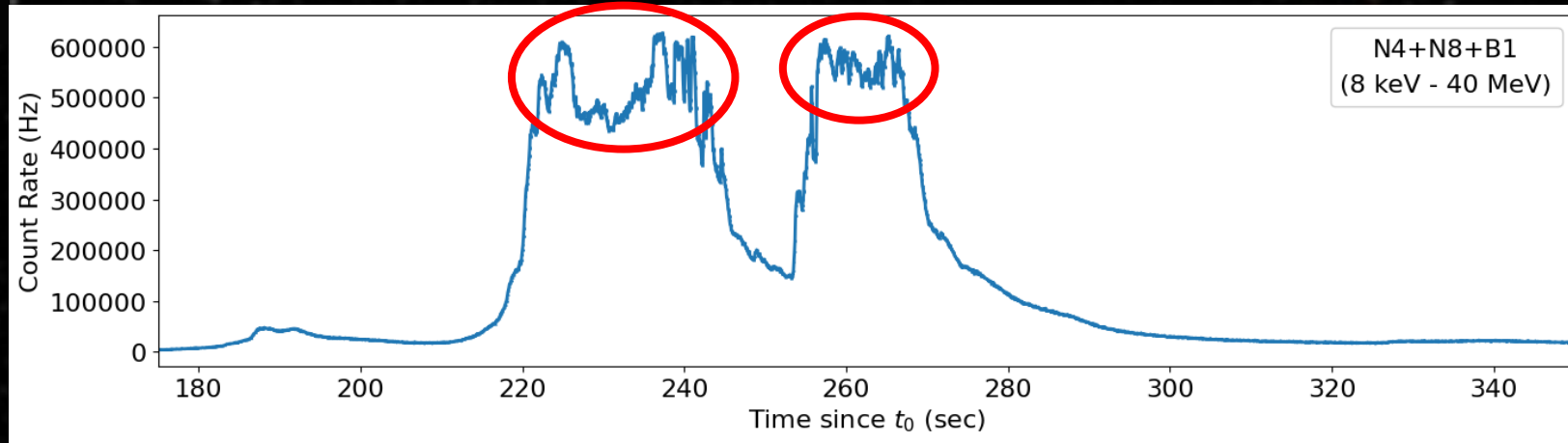
$$t_{\text{peak,ag}} \approx t_0 + 280 \text{ s}$$

$$\Gamma_{\text{ag}} \approx 270$$

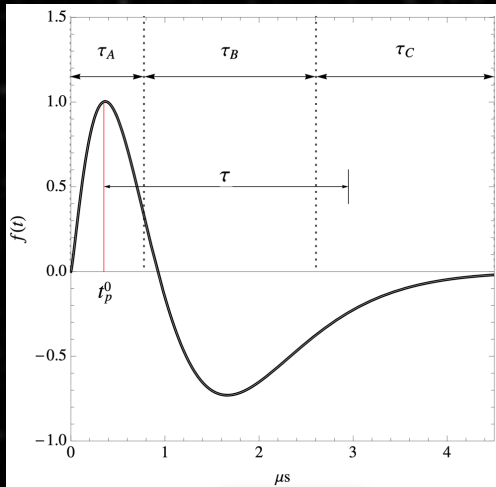




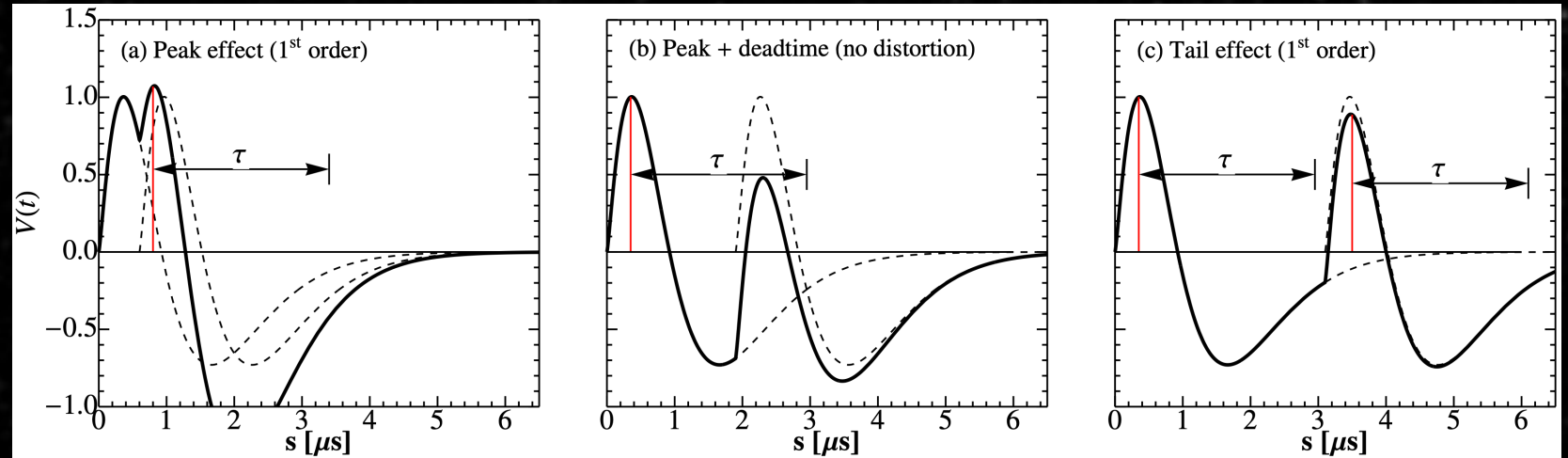
# Pulse Pile-up (PPU)



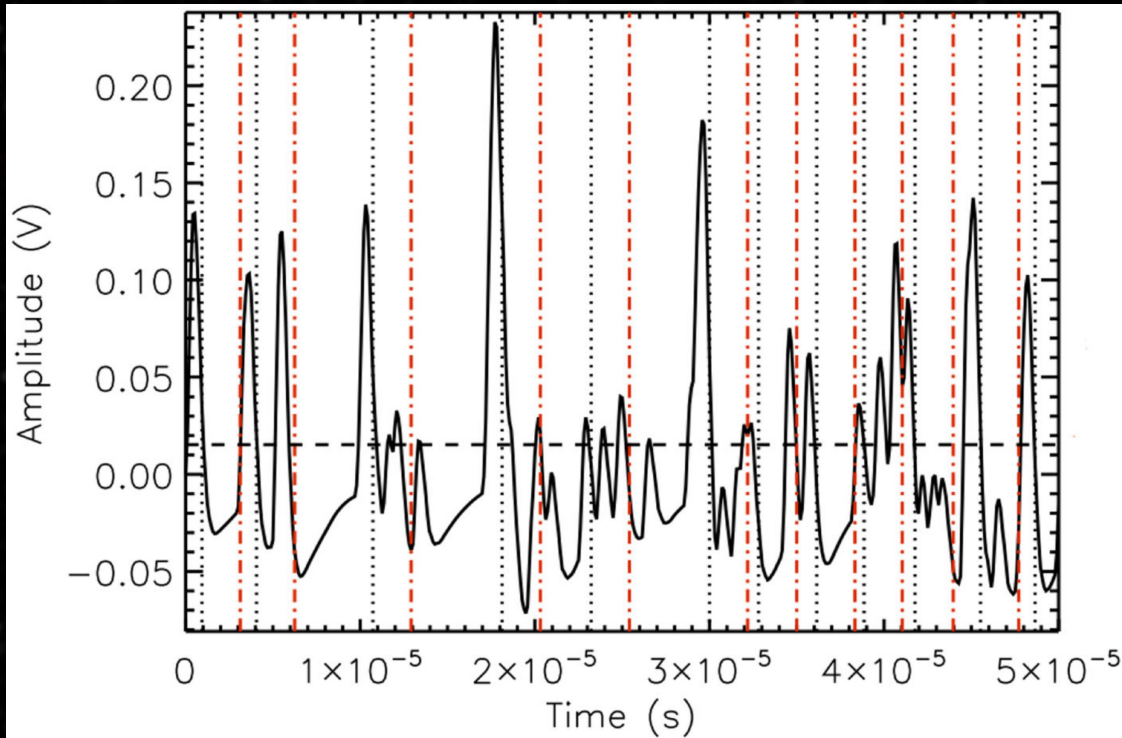
## Standard Pulse



## Types of Pulse Pile-up

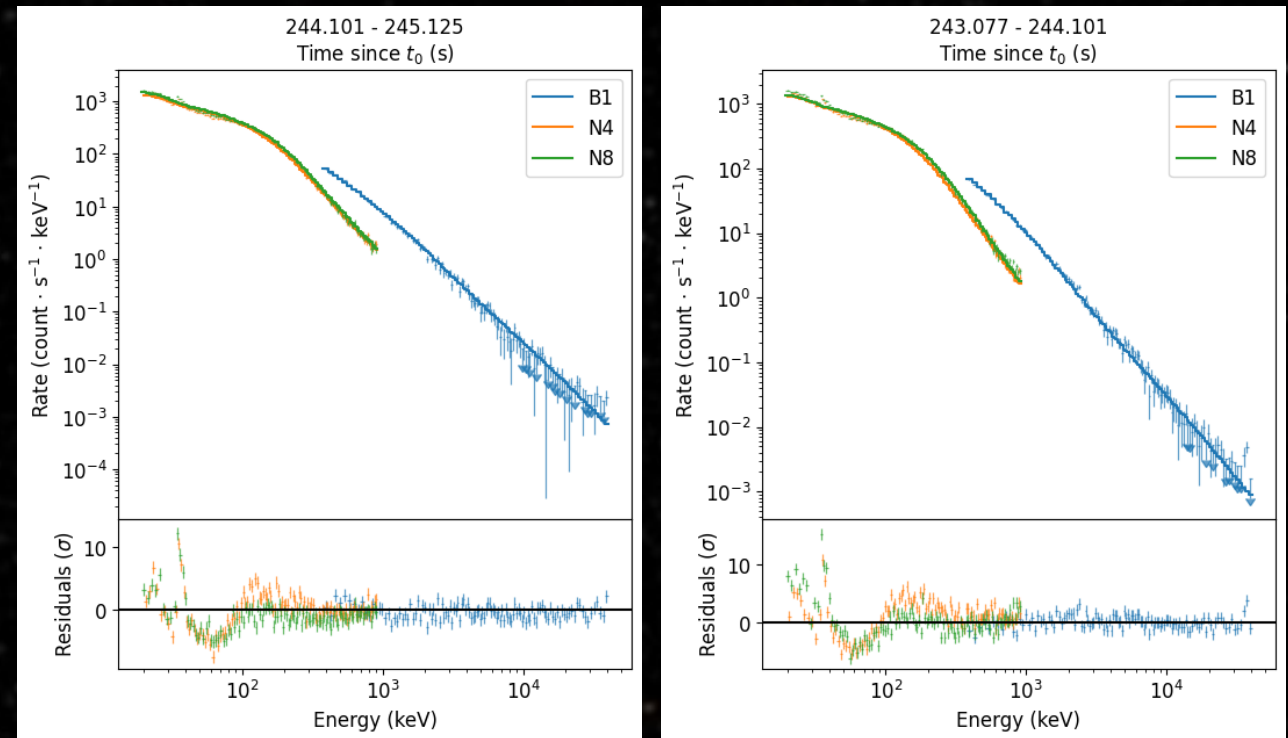


## A More Realistic Perspective



Input rate =  $1.37 \times 10^6$  cps

## Examples of PPU-correction

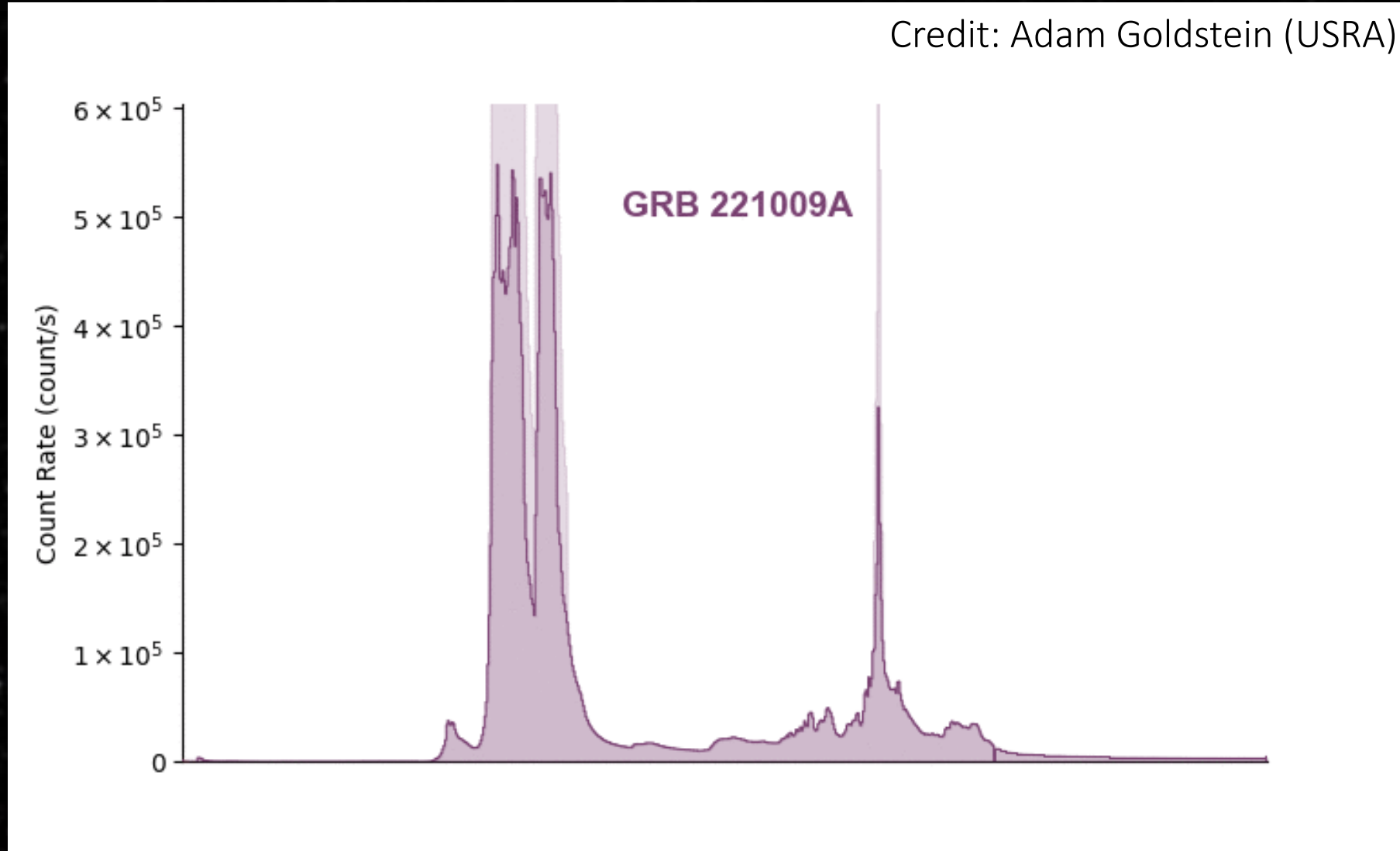


Good enough for energetics

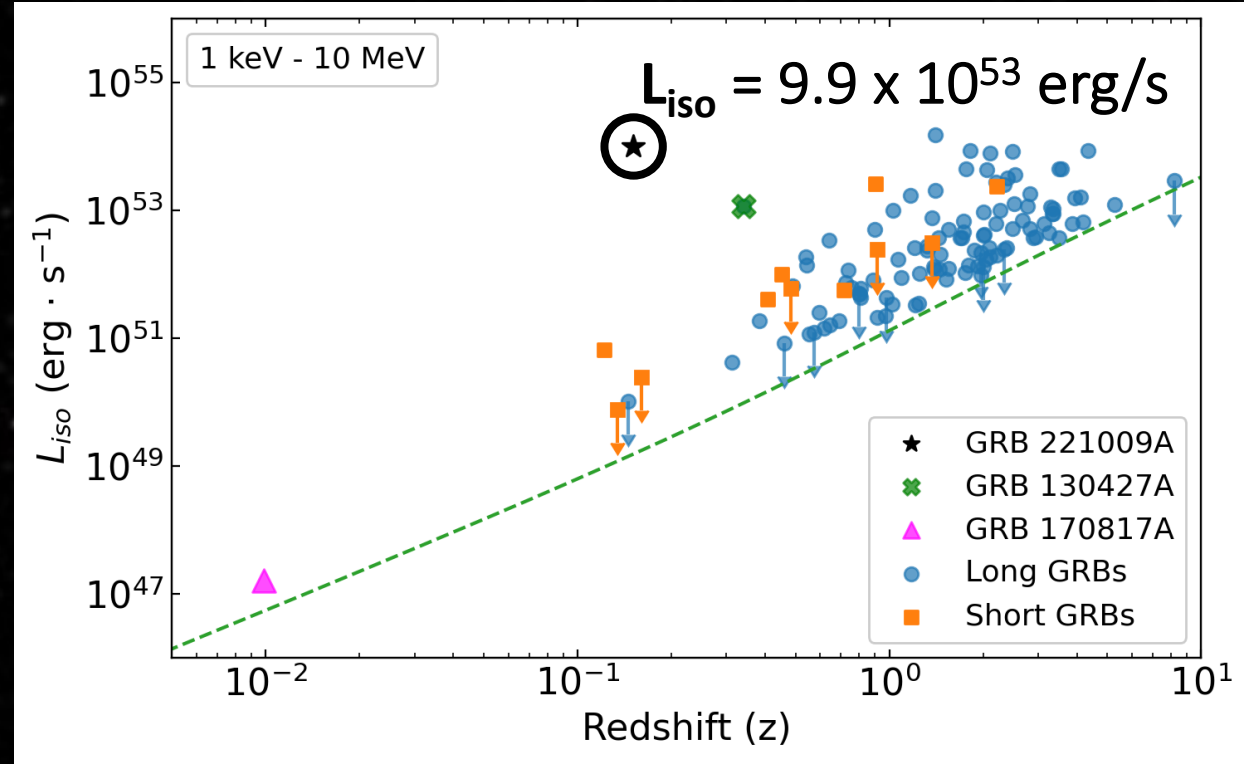
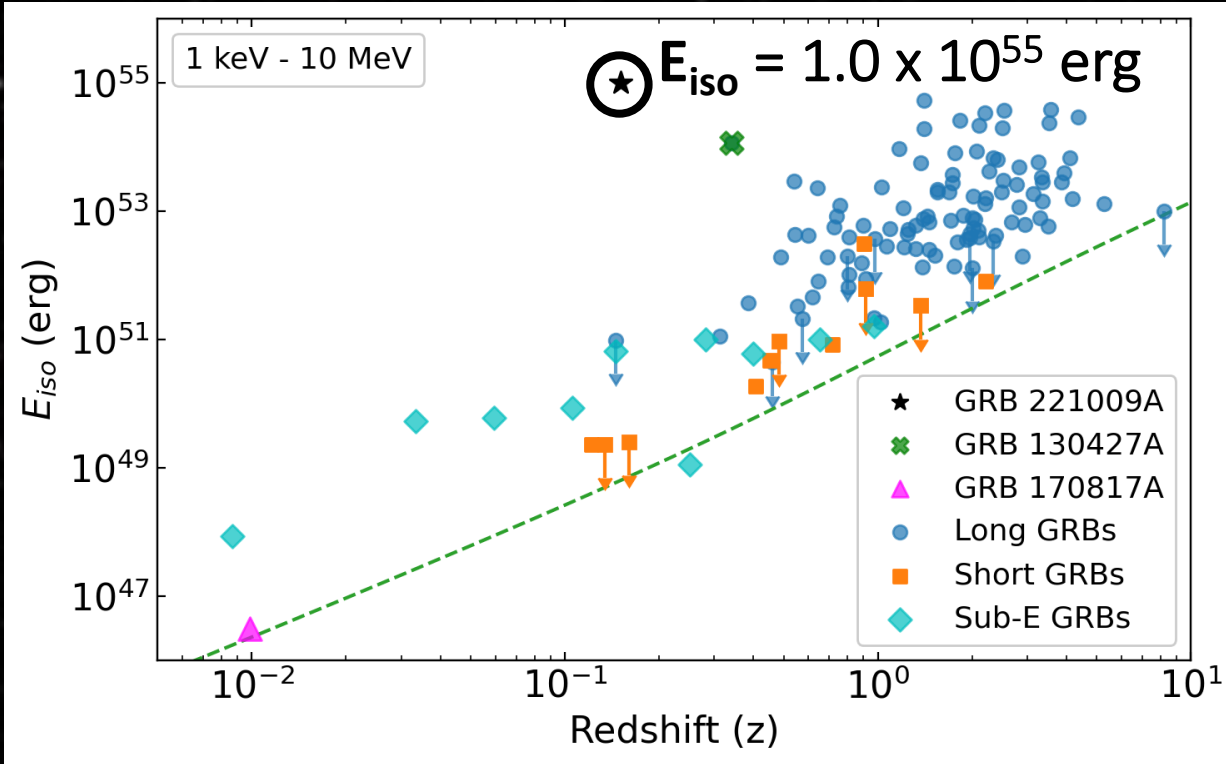
**We can fix it!**

# PPU-Corrected Lightcurve (GRB 221009A)

Credit: Adam Goldstein (USRA)



# Source Frame Energetics (*Fermi* sample)

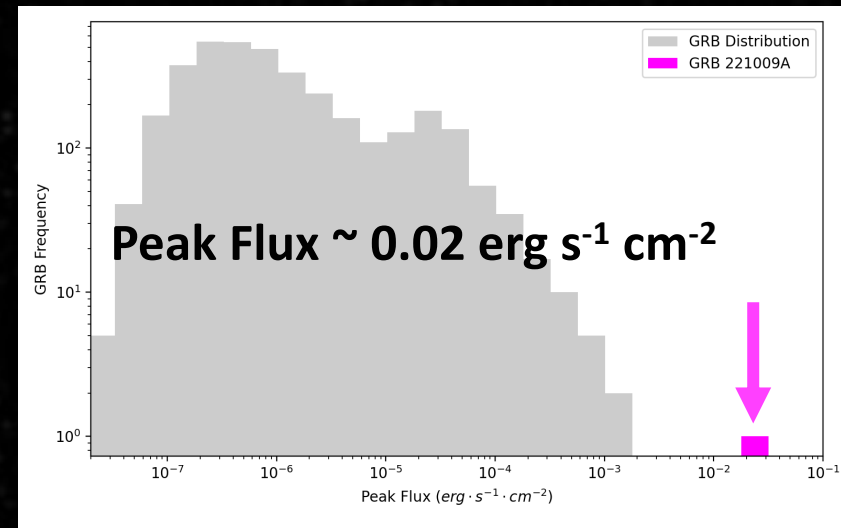
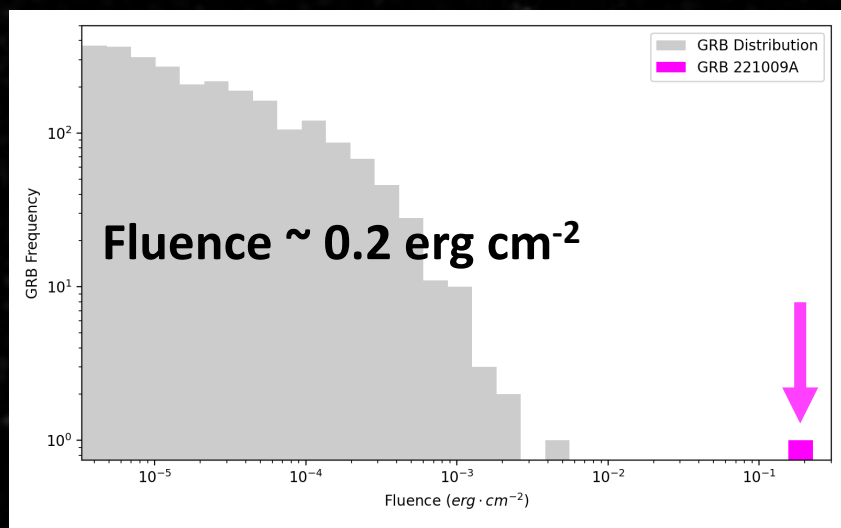
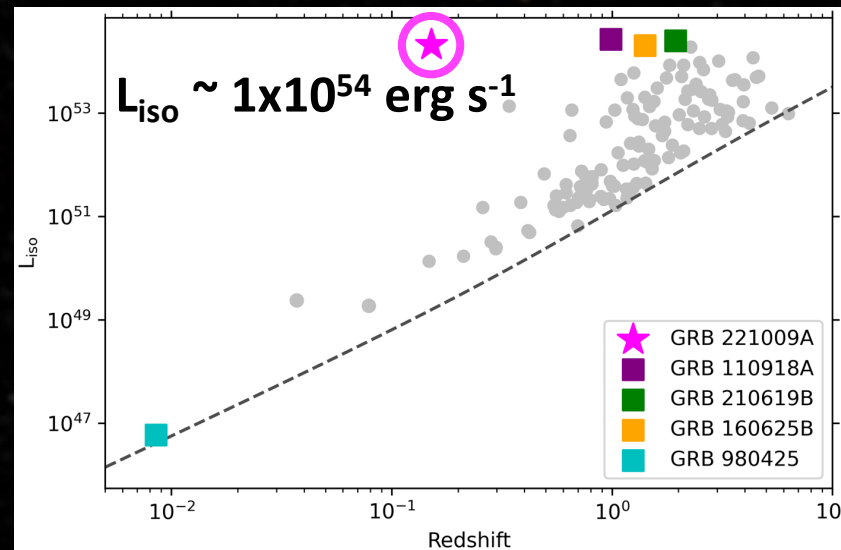
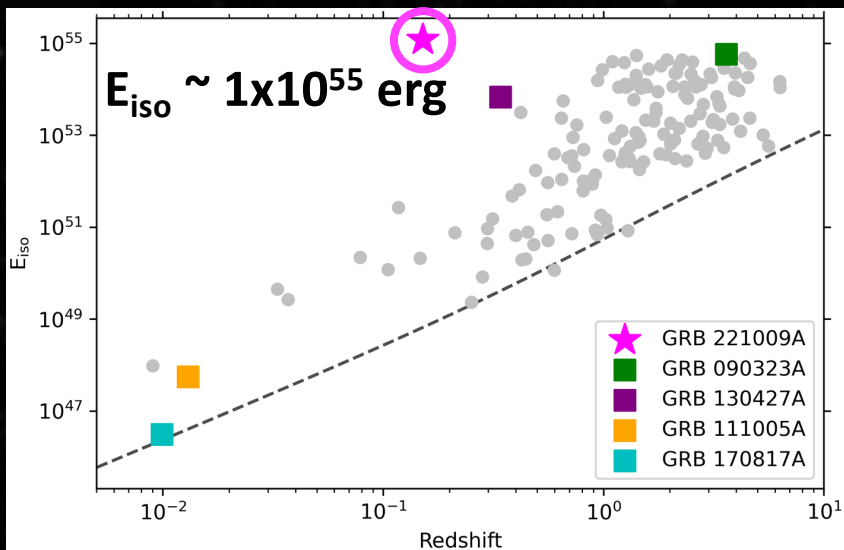


**Consistent with:**

Konus-WIND, GRBAAlpha, Insight-HXMT & GECAM-C



# Is it the B.O.A.T.? (4 measures)



55 years of data  
**Burns et al. (2023)**

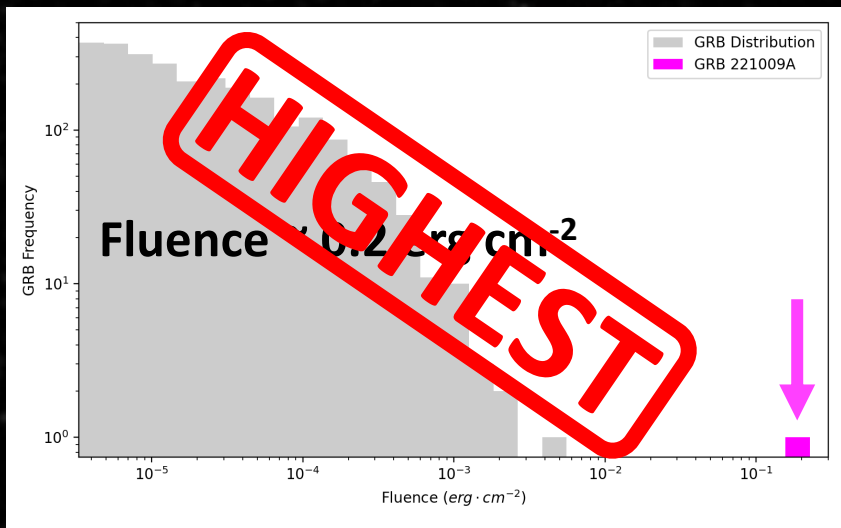
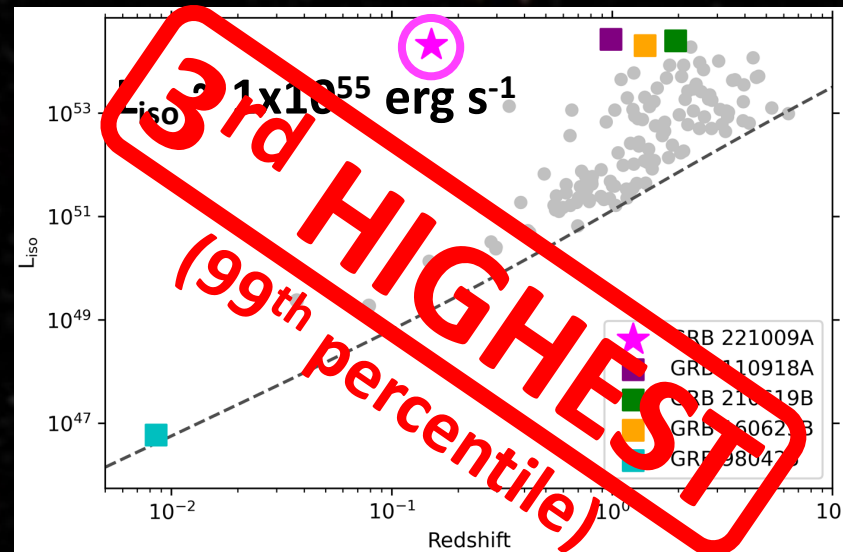
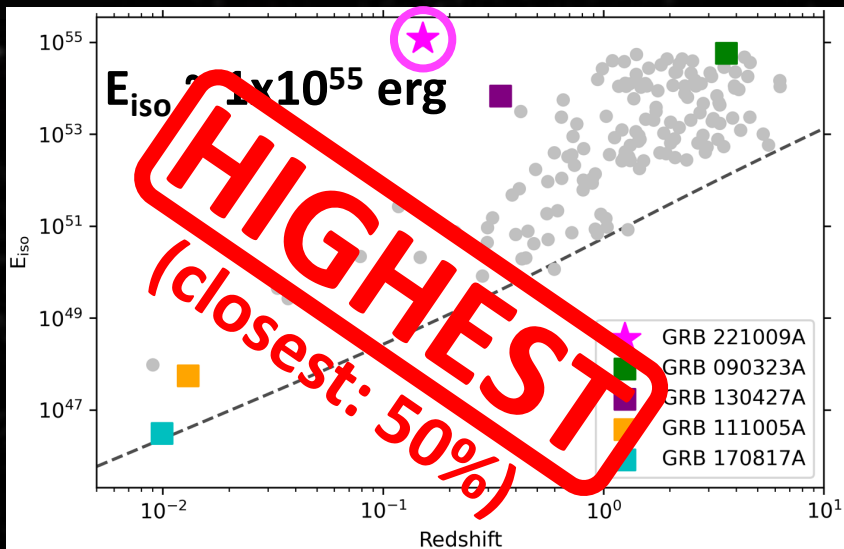


**YES!**

Is it the B.O.A.T.?

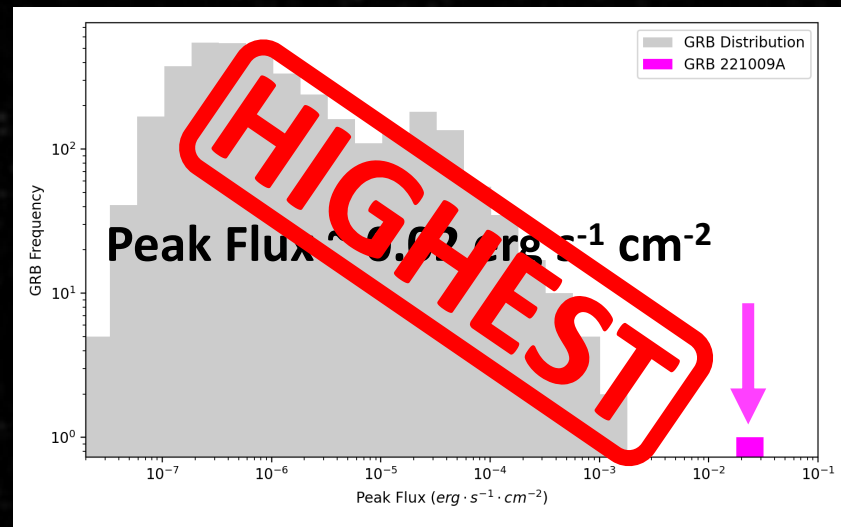
**YES!**

(4 measures)

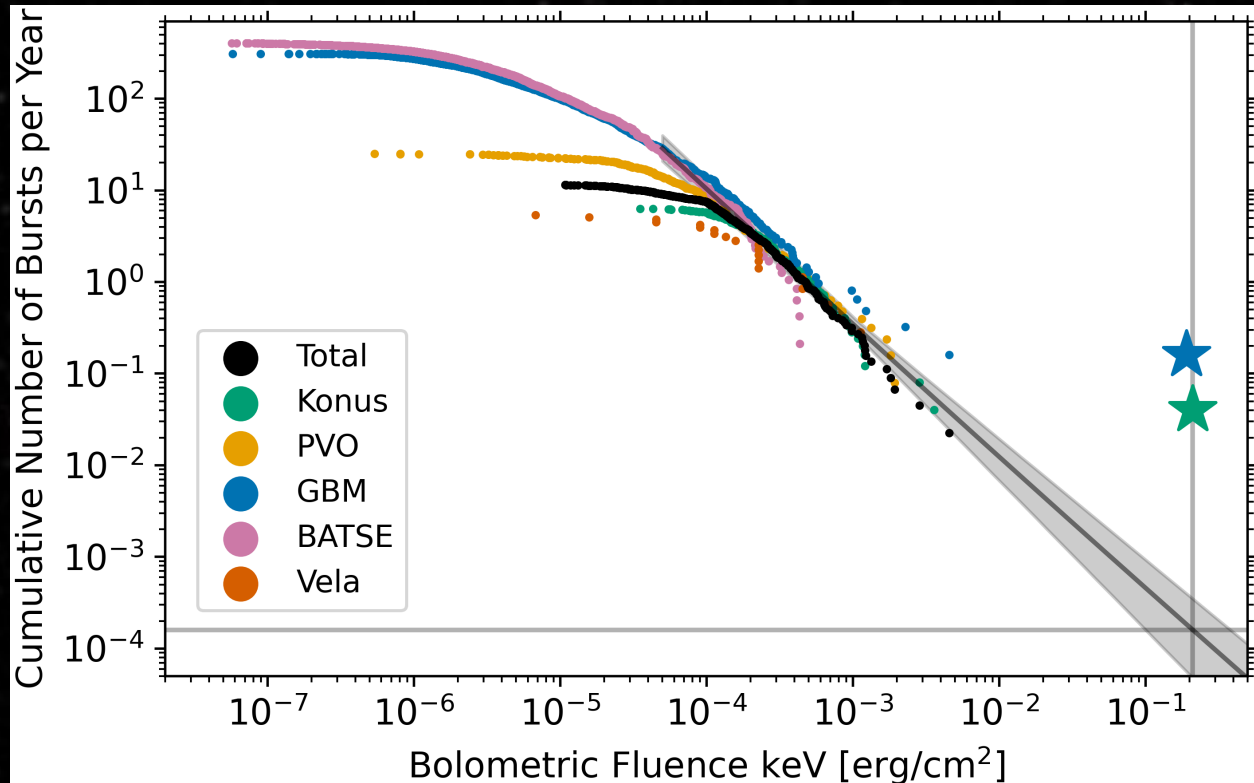
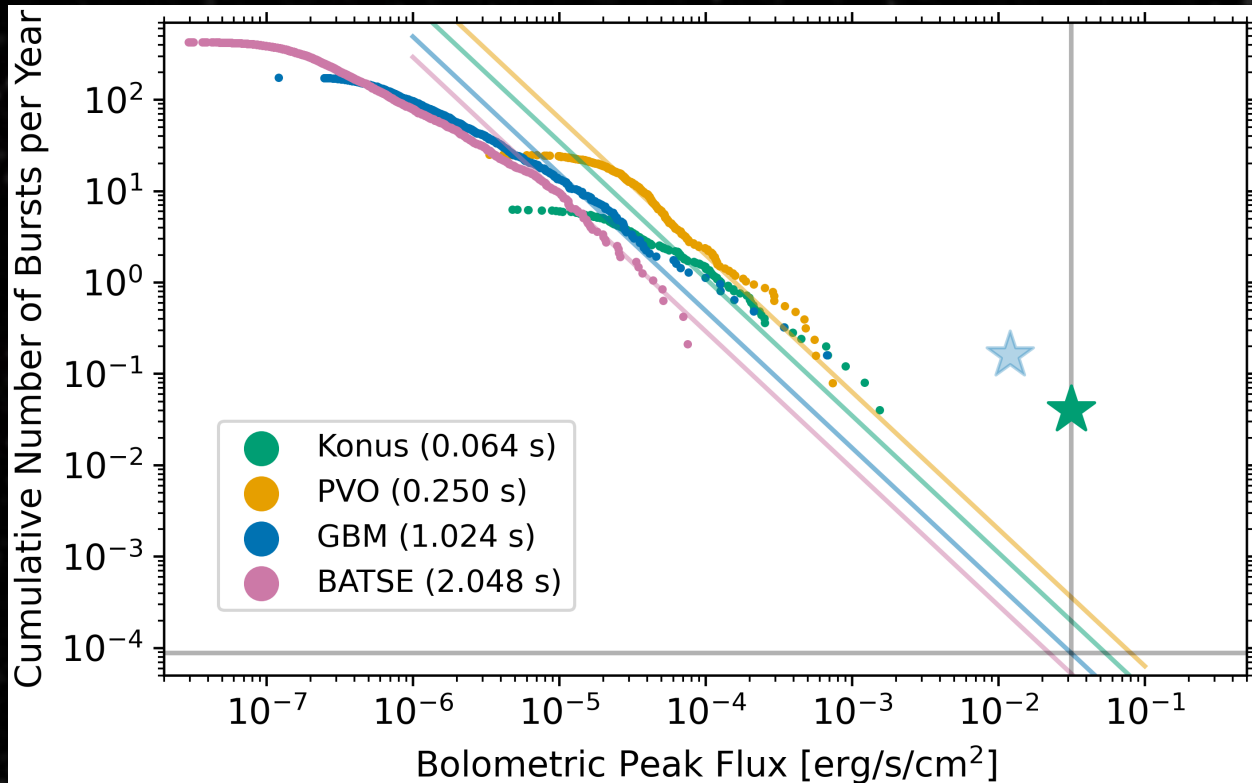


**$\frac{3}{4}$  measures  
of brightness**

55 years of data  
**Burns et al. (2023)**

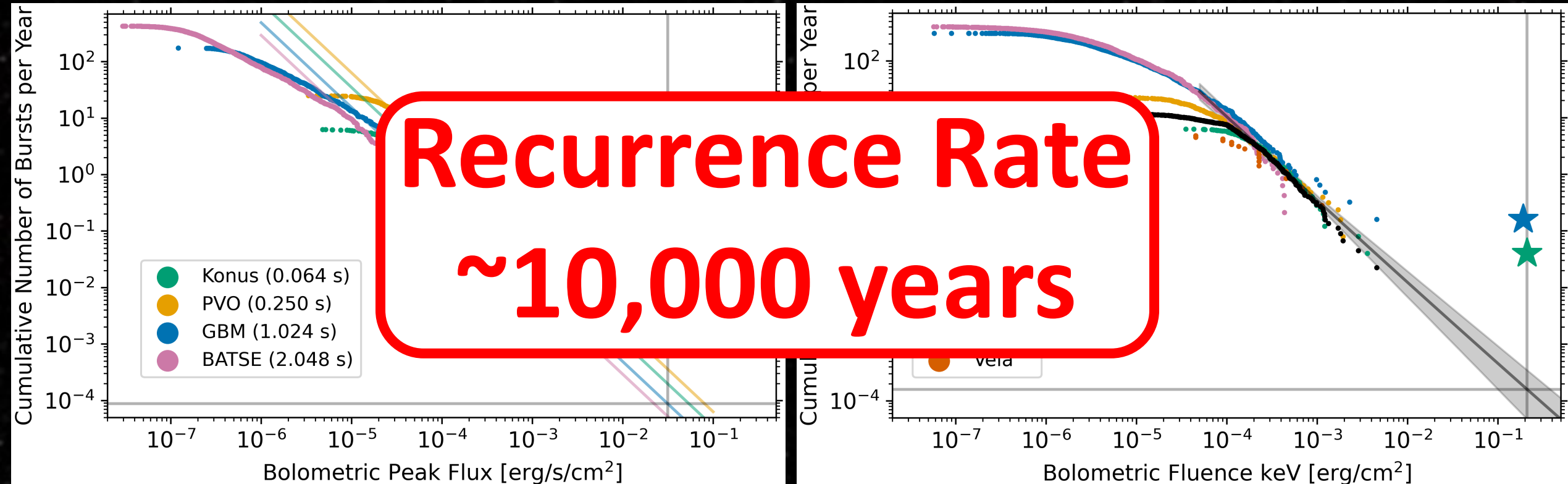


# Rarity



55 years of data

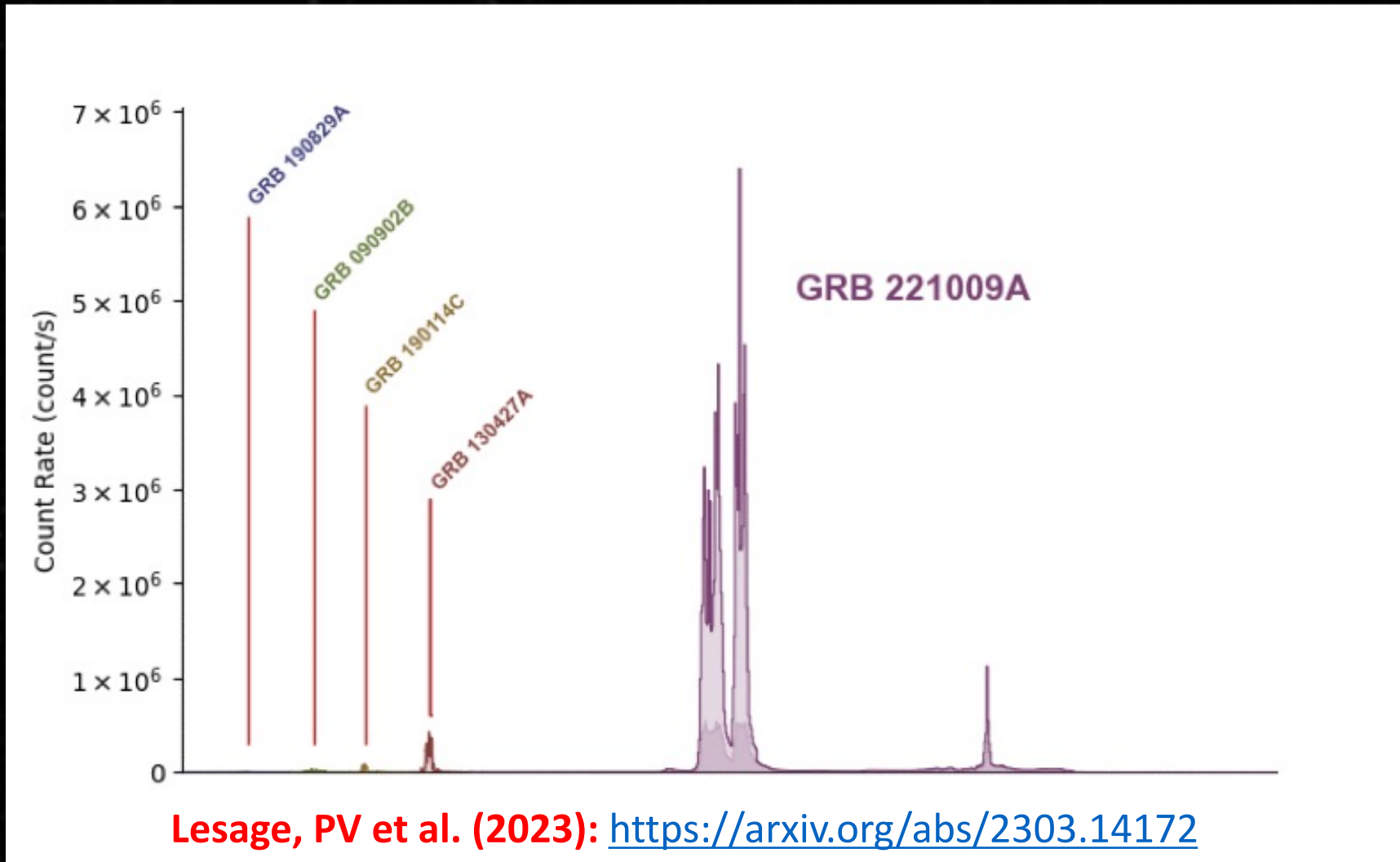
Burns et al. (2023)



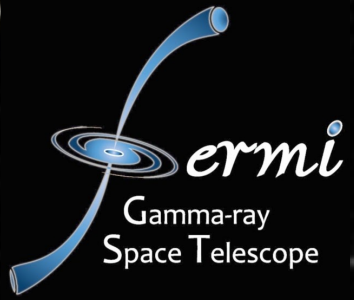
55 years of data

Burns et al. (2023)

# The B.O.A.T.

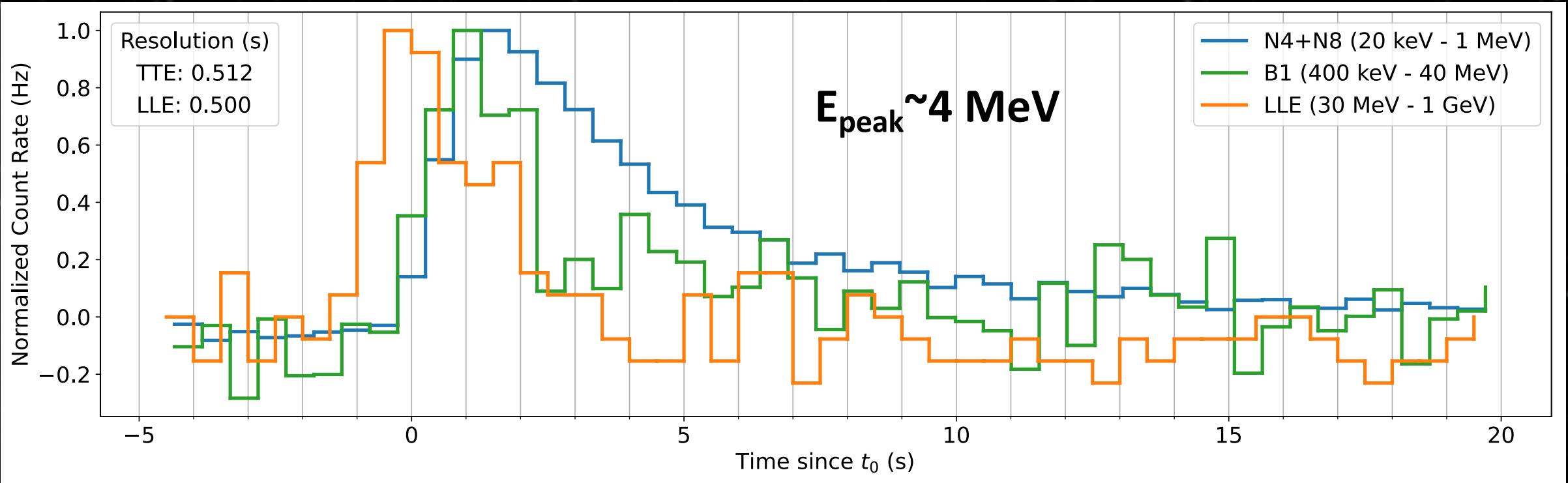






# Backup Slides

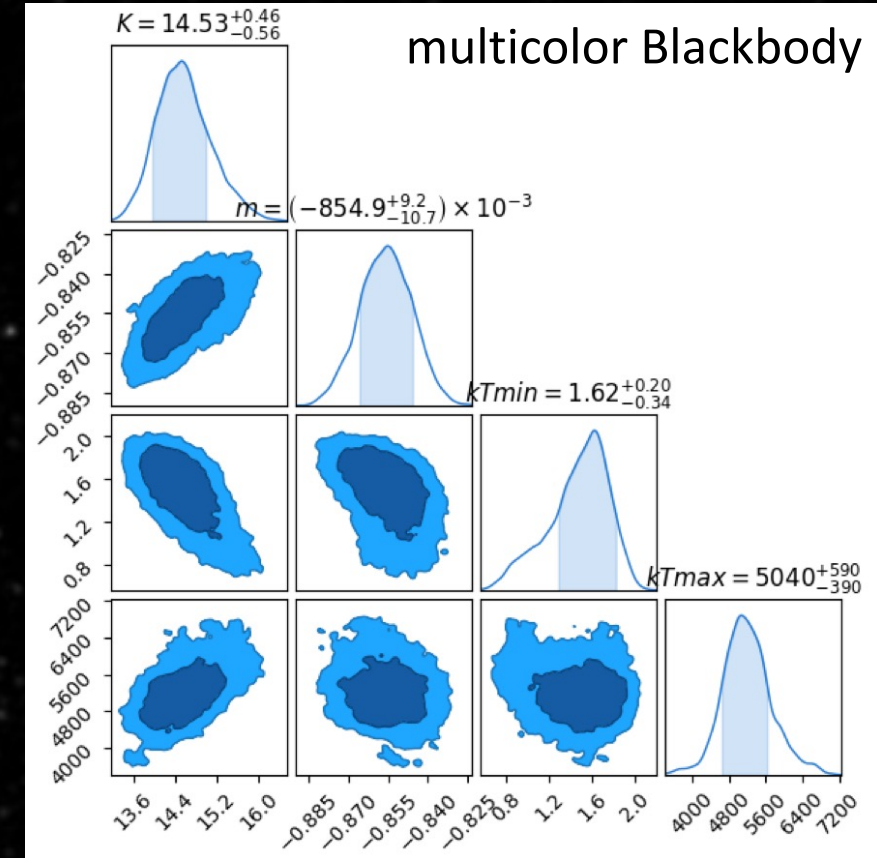
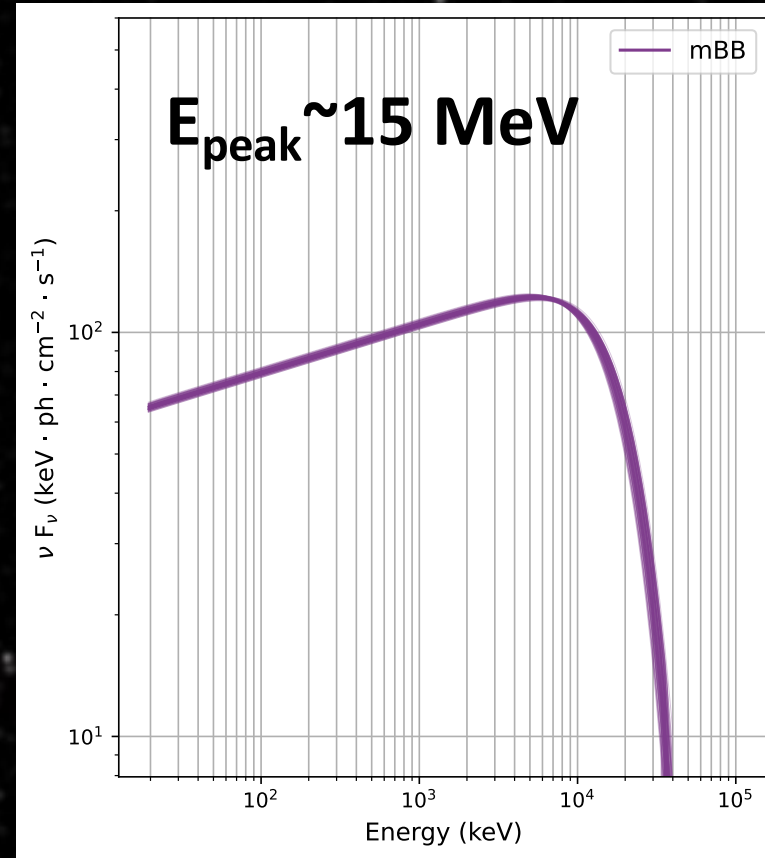
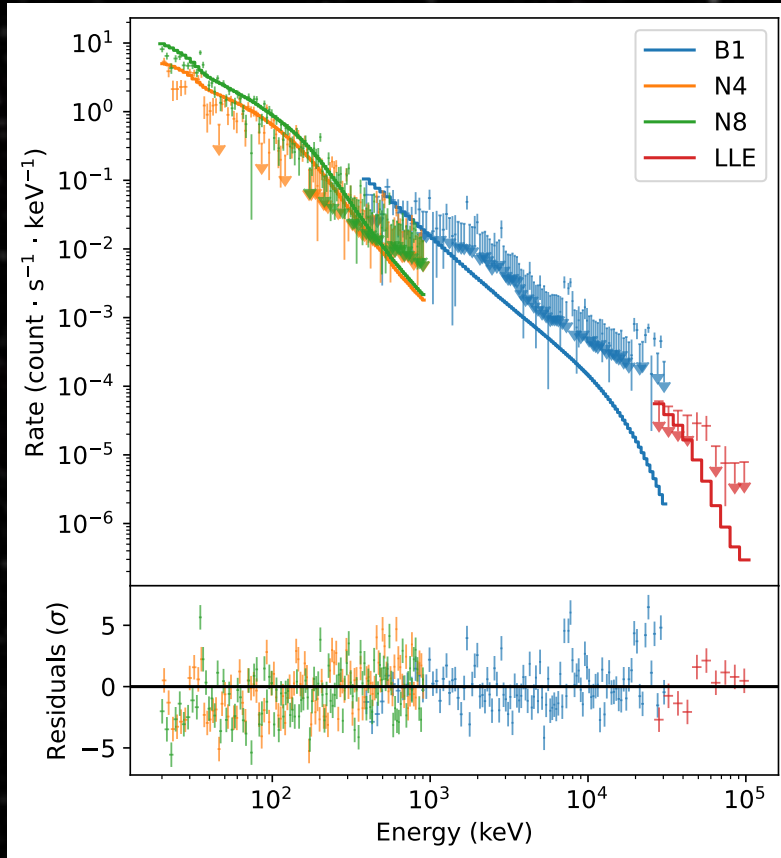
# First few Seconds



Unusual

➤ Same as GRB 130427A

# Triggering Pulse



Potentially shock-breakout

$\triangleright \Gamma_{\text{trigger}} = 300-1000$

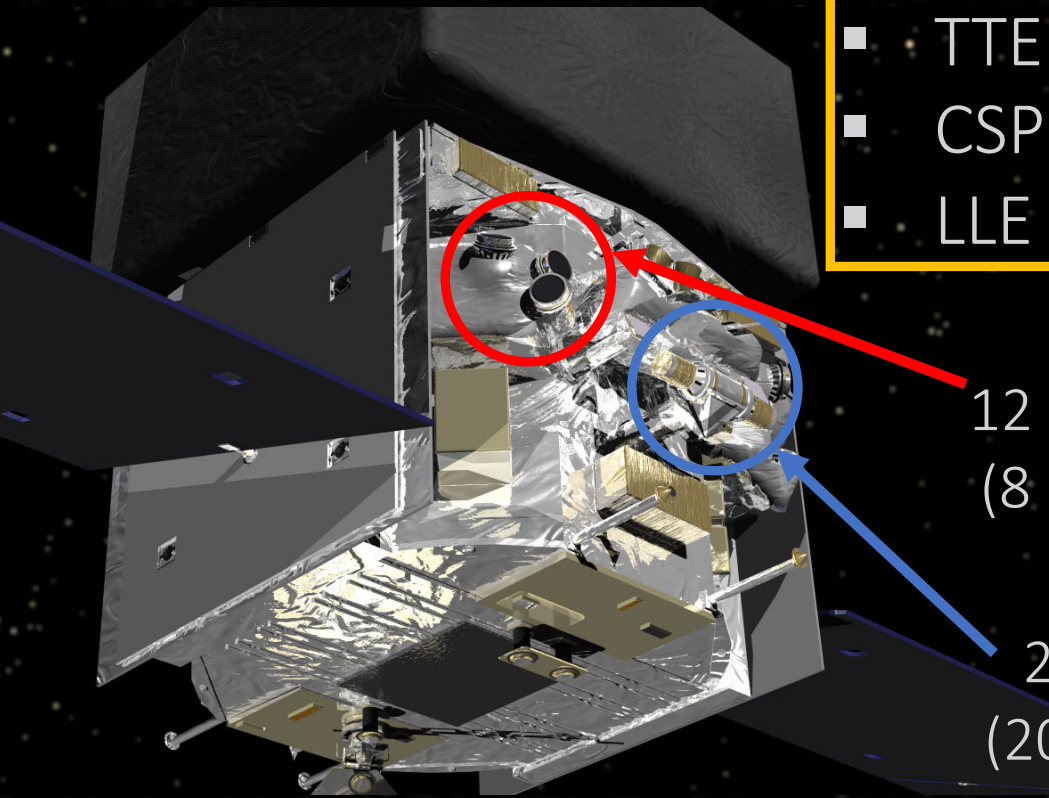


# Fermi Gamma-ray Space Telescope

(<https://gammaray.nsstc.nasa.gov/>)

## Data

- TTE ( $2\mu\text{s}$ )
- CSPEC/CTIME (1.024s)
- LLE (0.1s)

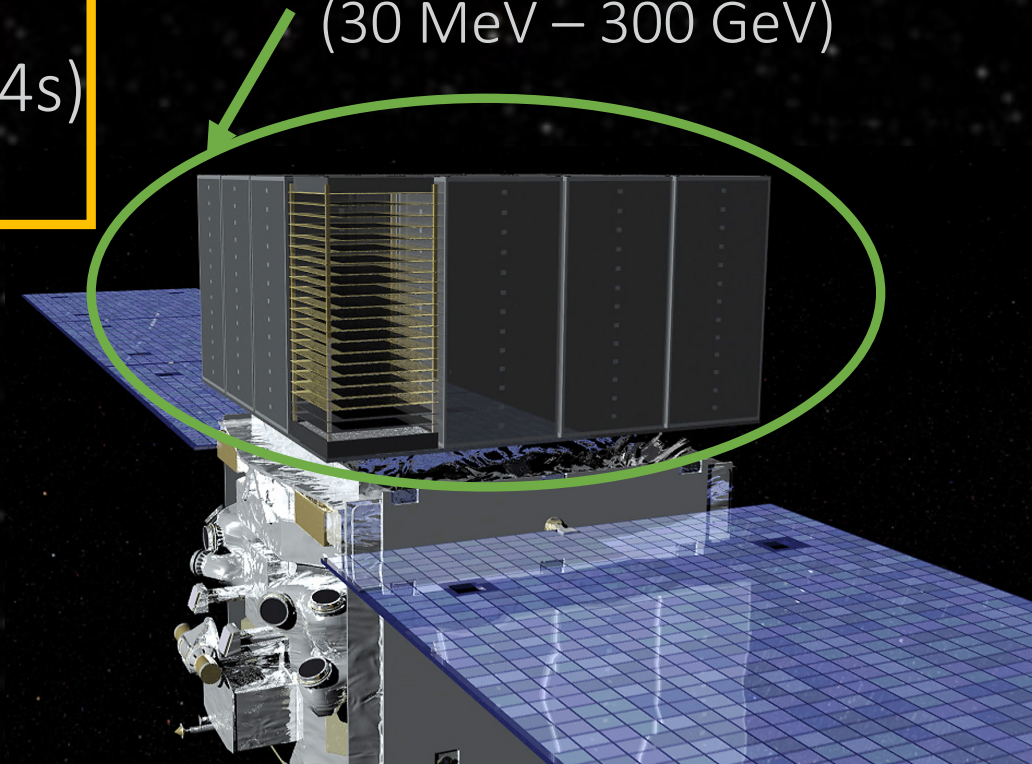


12 NaI Detectors  
(8 keV – 1 MeV)

2 BGO Detectors  
(200 keV – 40 MeV)

Gamma-ray Burst Monitor (GBM)

16 Particle Trackers & Calorimeters  
(30 MeV – 300 GeV)

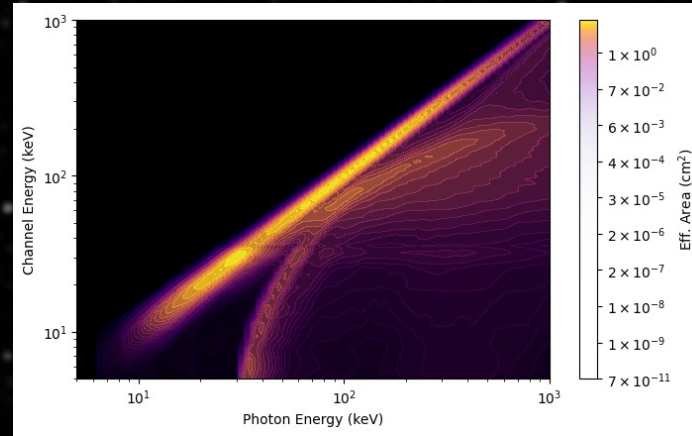


Large Area Telescope (LAT)

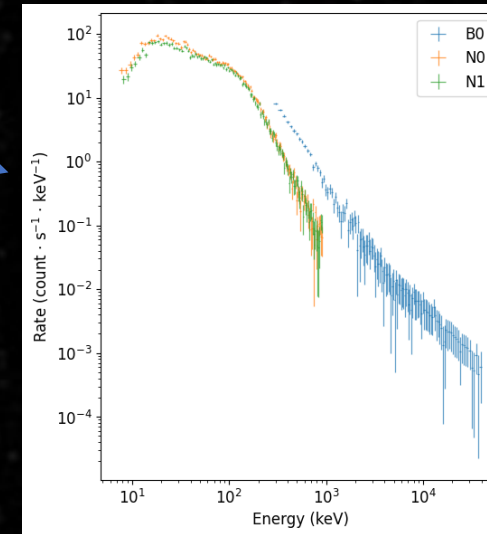


# PPU-Correction Procedure

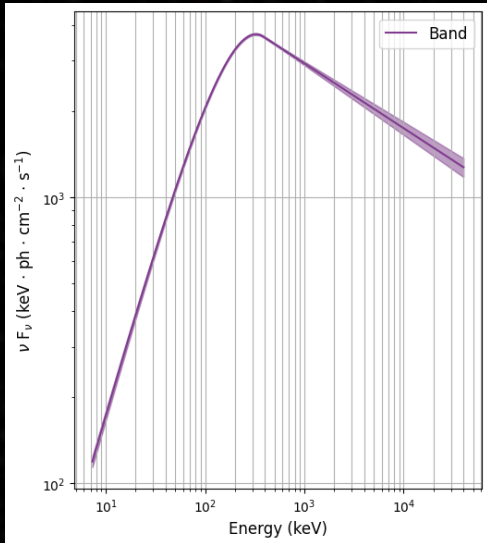
## Detector Response



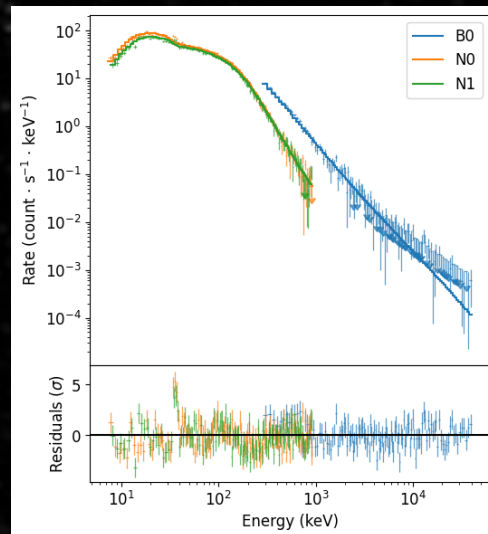
## Counts Spectrum



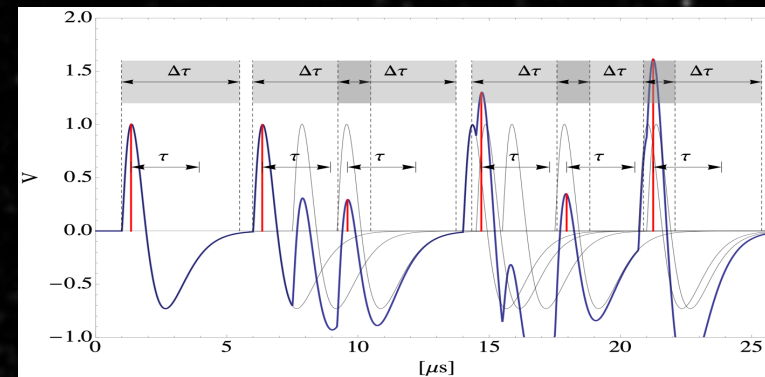
## Photon Spectrum



## Compare

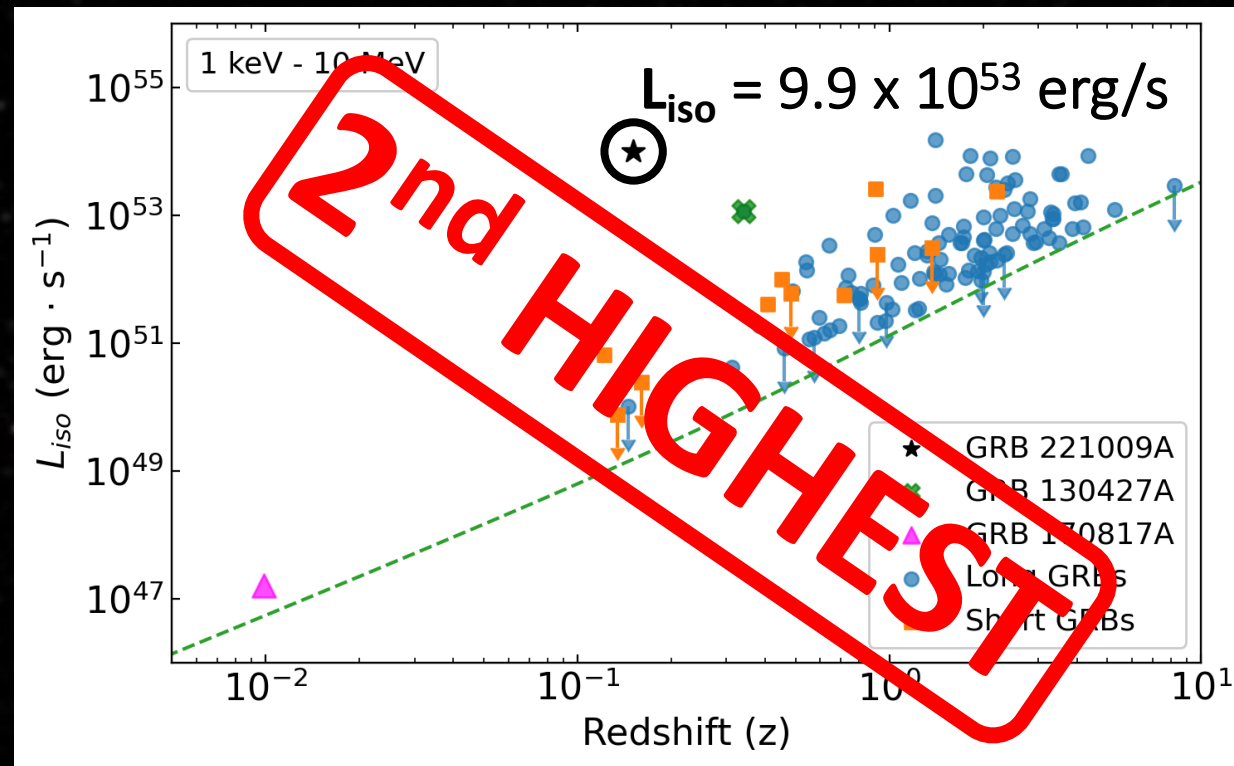
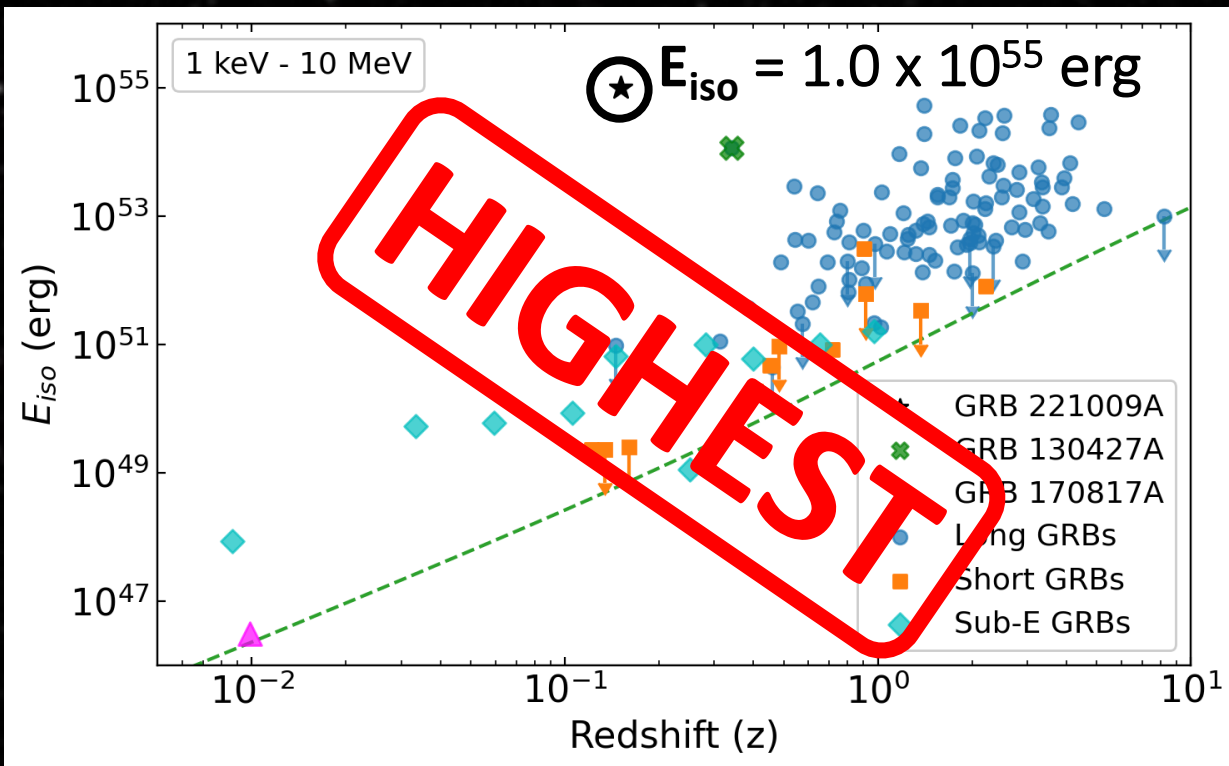


## PPU-Distortion



Maximize  
Likelihood

# Source Frame Energetics (*Fermi* sample)



Consistent with:

Konus-WIND, GRBAAlpha, Insight-HXMT & GECAM-C