

**GRB 200415A:  
Gamma-ray Burst  
or Magnetar Giant Flare?**

Oliver J. Roberts

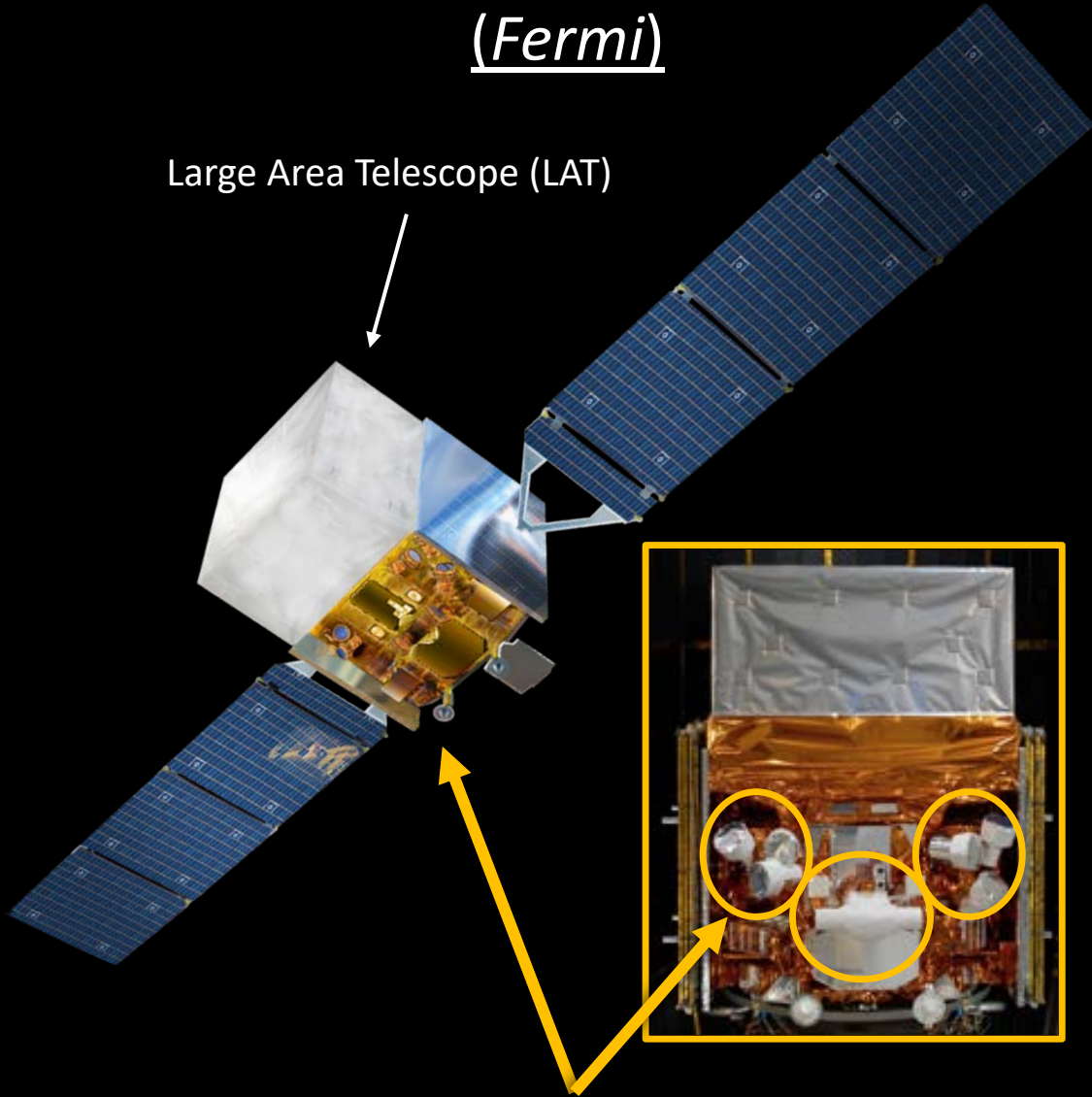
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Huntsville, Alabama



## Fermi Gamma-ray Space Telescope (Fermi)

Large Area Telescope (LAT)



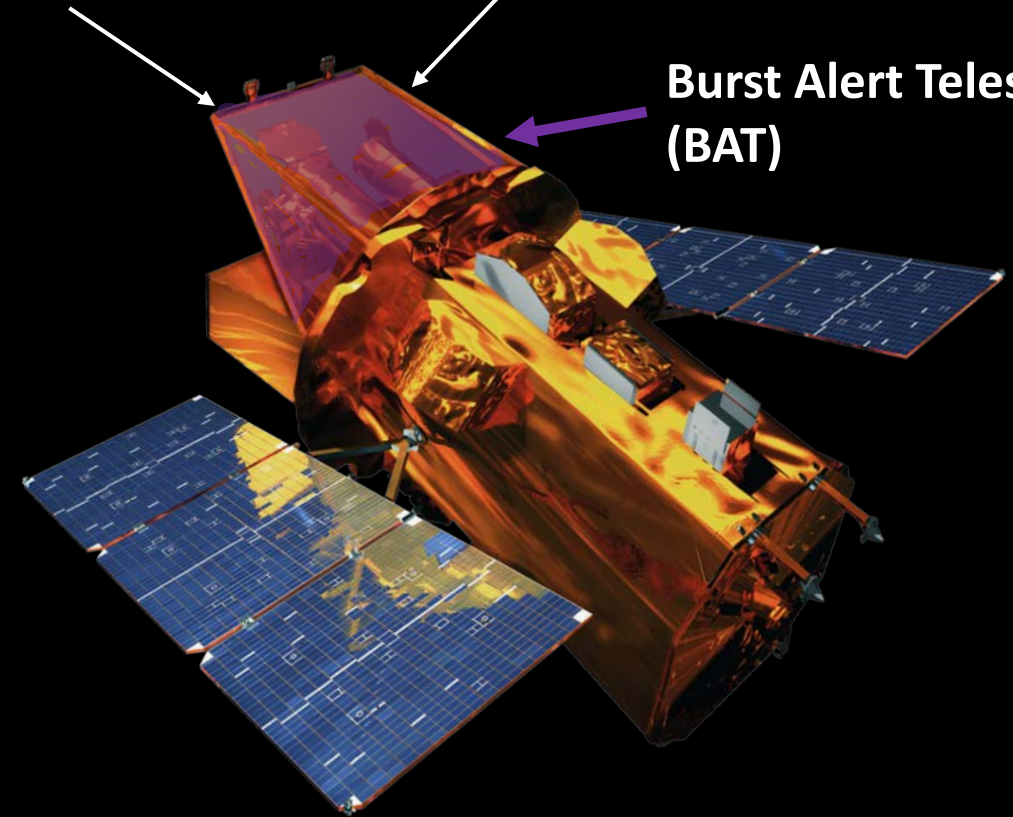
**Gamma-ray Burst Monitor (GBM)**

## Neil Gehrels Swift Observatory (Swift)

X-Ray Telescope (XRT)

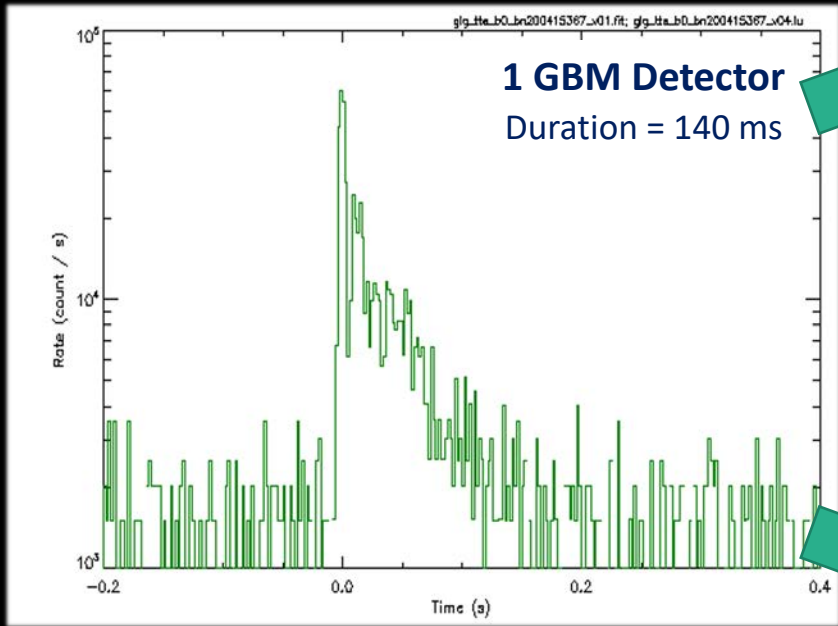
Ultraviolet/Optical Telescope (UVOT)

**Burst Alert Telescope (BAT)**



GRB 200415A detected offline using the Gamma-ray Urgent Archiver for Novel Opportunities (**GUANO**), a BAT pipeline to search for transients coincident with Gravitational waves.

# GRB 200415A

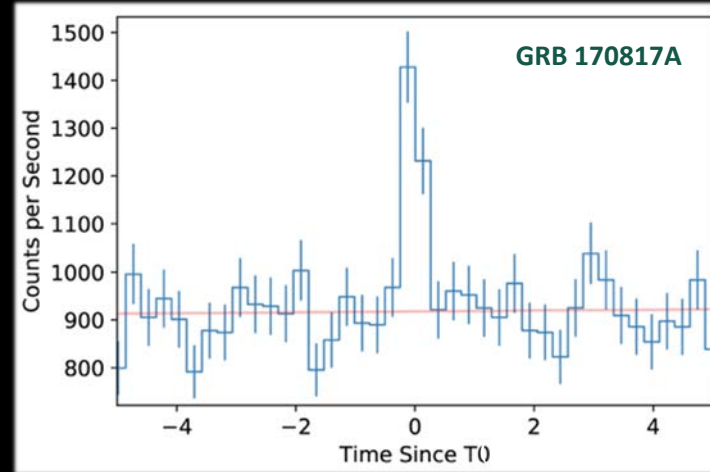


Roberts, O.J., et al. *Nature* 2021 (Accepted).



British Broadcasting Company

# Short Gamma-ray Burst (sGRB)

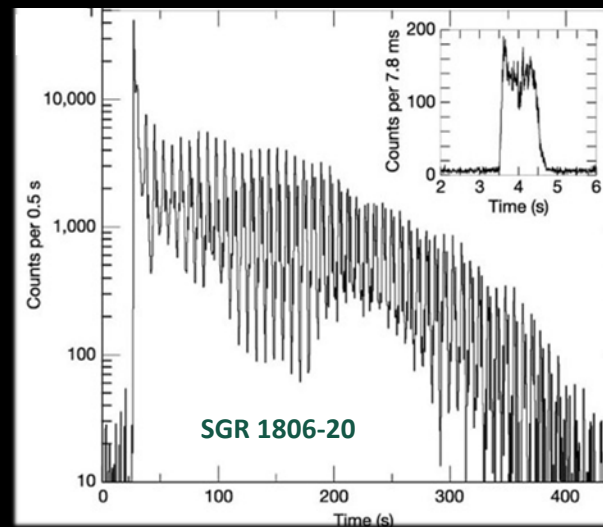


Goldstein, A., et al., *ApJL* 848 (2), L14 2017.

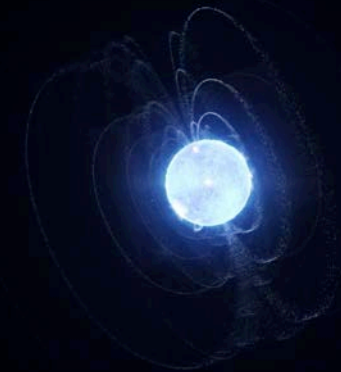


University of Warwick/Mark Garlick

# Magnetar Giant Flare



Hurley, K., Boggs, S., Smith, D. et al. *Nature* 434, 1098–1103 (2005)



NASA Goddard and Chris Smith (USRA)





# GRB 200415A Trivia (Observations)

**Total energy emitted:  $10^{46}$  erg**

- All nuclear tests:  $10^{25}$  erg
- 10 quadrillion times more energy than Chicxulub impact ( $10^{30}$  erg)

**Total luminosity emitted:  $10^{47}$  erg/s**

**Evidence of “starquakes” in neutron star crust**

**Highest energy photon: 3 MeV in GBM**

- A million times more energy than blue light (~3 eV).
- 50x more energy than a typical medical X-ray.

**Variable, submillisecond changes in photon energy**

**Flare onset is 77 microseconds (>10x quicker than camera flash)**

**No modulated tail after the initial, 140 ms bright burst**

**No instrumental limitations due to the source**

**No radio counterpart**



# GRB 200415A Interpretations

- Energy released by crustal fractures ejects hot plasma, like a photon torpedo...
- Highest photon energy of 3 MeV indicates unambiguous relativistic expansion of plasma. Outflow (wind) travels at >98 % the speed of light.
  - Solar wind speed: typ. 400 km/s
  - Outflow: >294,000 km/s
- Evolution of the energy spectrum over the decay time observed suggests a narrow radiation cone that rotates with the star (2-3 degrees over 140 ms).
- The flux and spectral shape of GRB 200415A are unlikely for a short GRB, when compared to catalogs from previous space missions



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*Further Details:*

<https://www.nature.com/articles/s41586-020-03077-8>

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