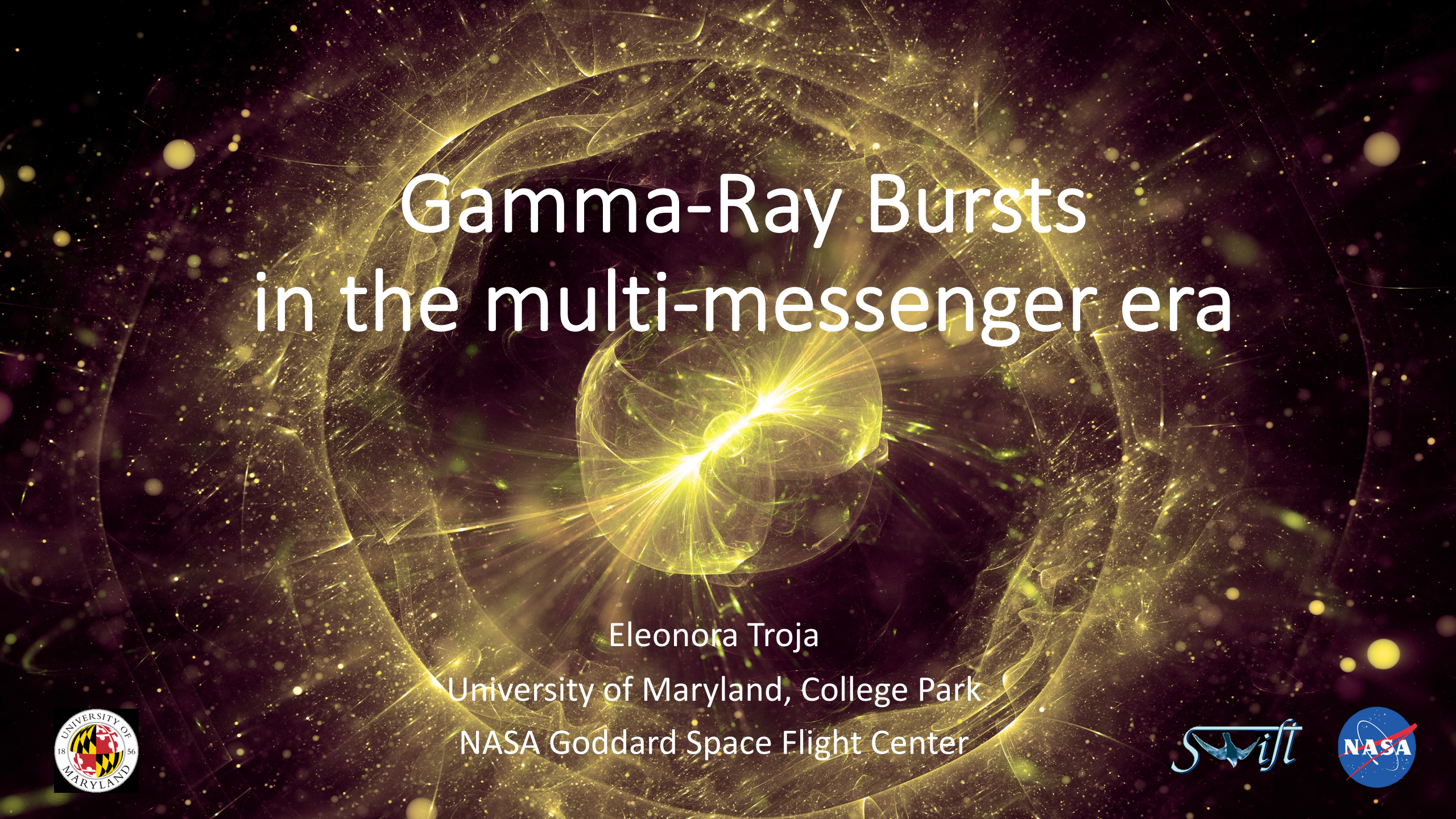


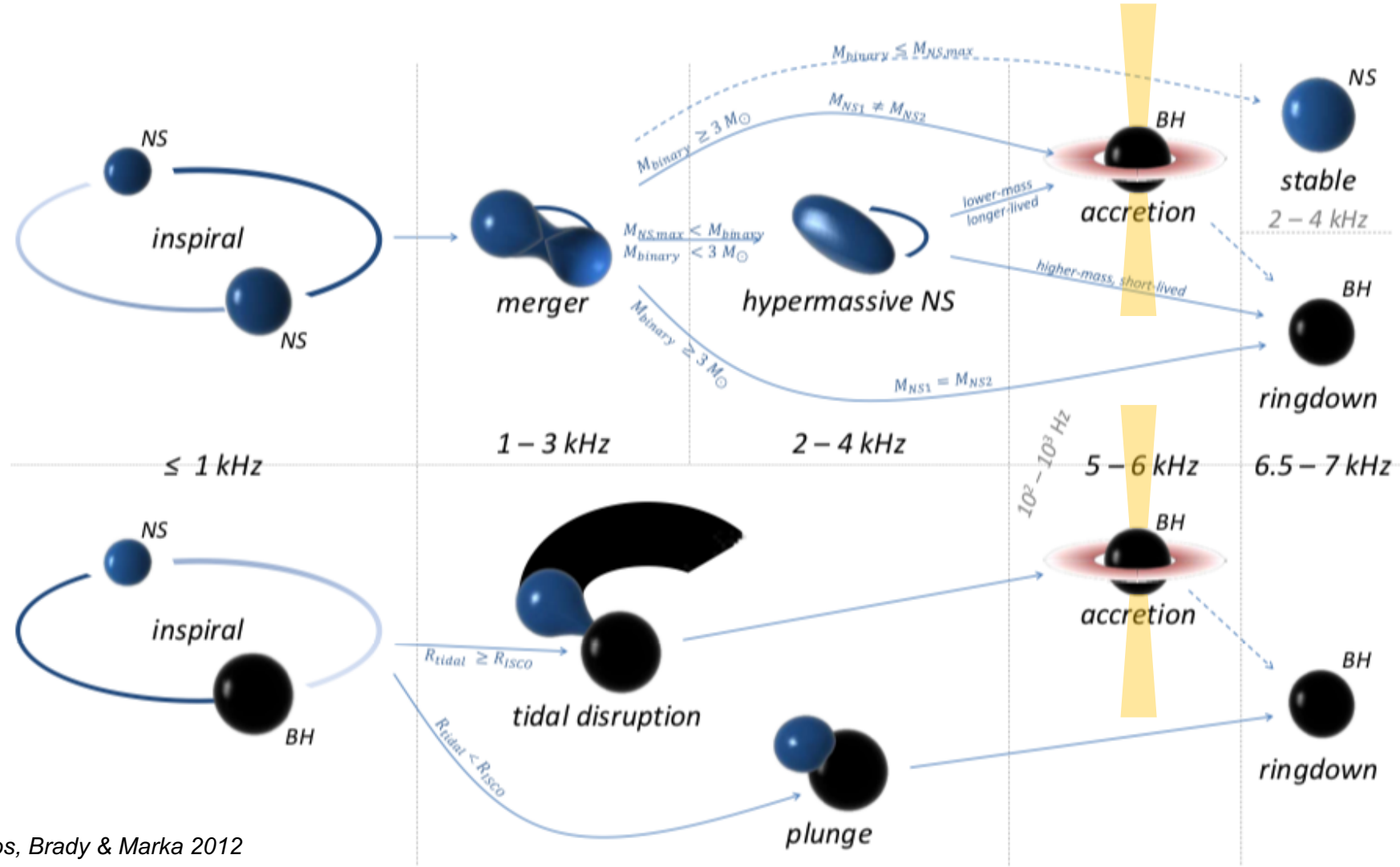
Gamma-Ray Bursts in the multi-messenger era

Eleonora Troja

University of Maryland, College Park

NASA Goddard Space Flight Center

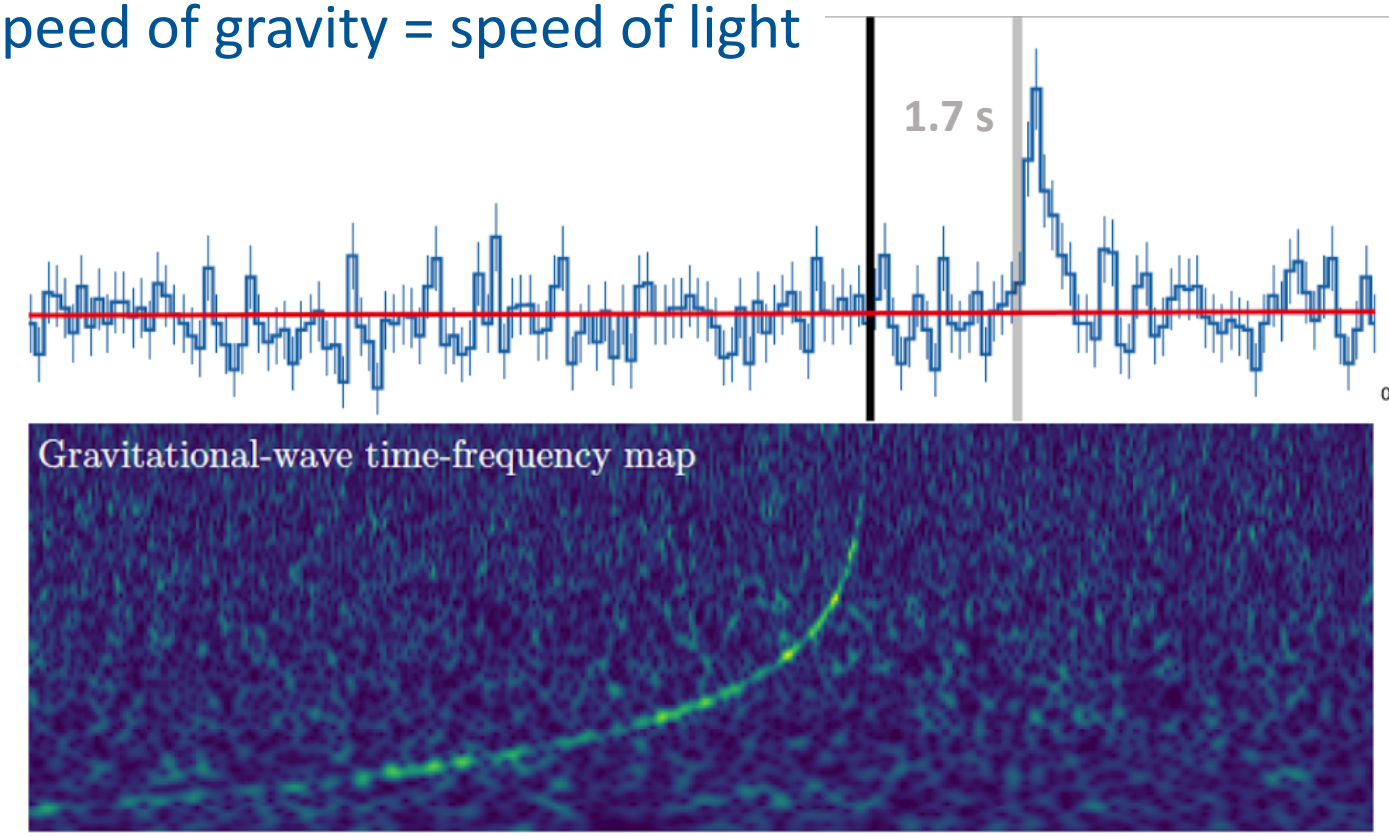
Connection with compact binary mergers

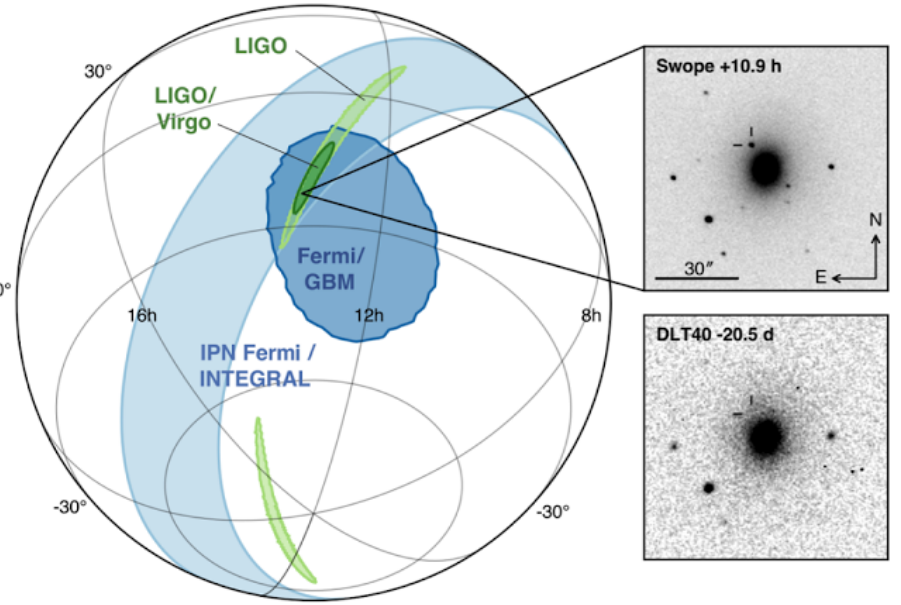


Bartos, Brady & Marka 2012

A short GRB following GW170817

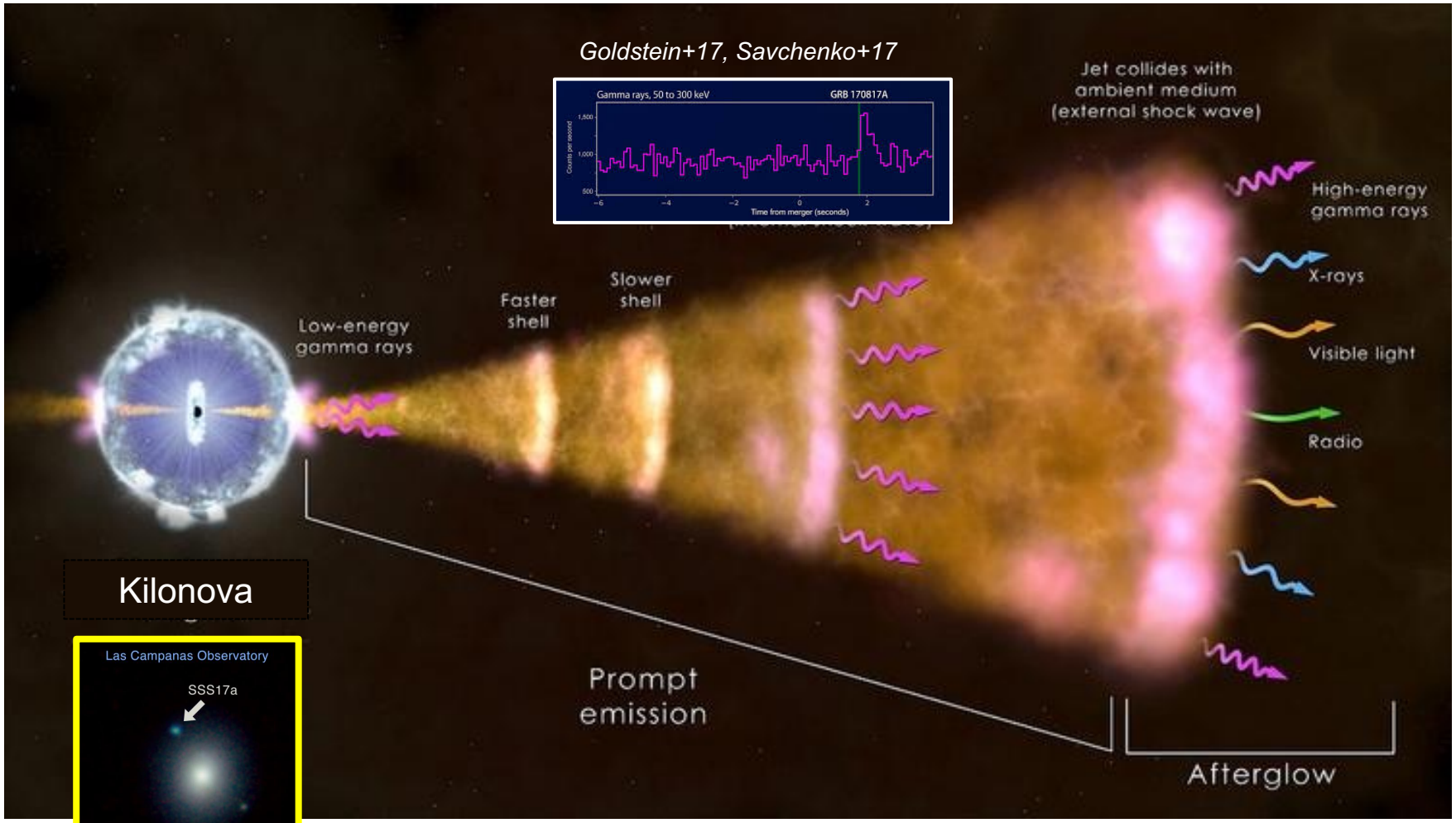
speed of gravity = speed of light





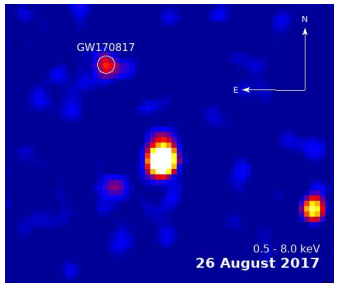
Abbott *et al.* (LIGO Scientific Collaboration and Virgo Collaboration)
2017, Phys. Rev. Lett. **119**, 161101

The aftermath of a NS merger

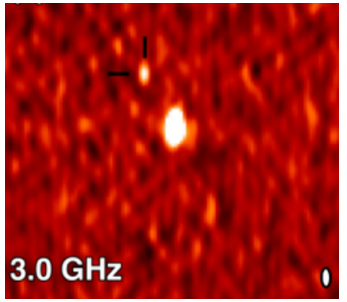


Coulter+17
Arcavi+17, Lipunov+17, Soares-Santos+17, Tanvir+17, Valenti+17

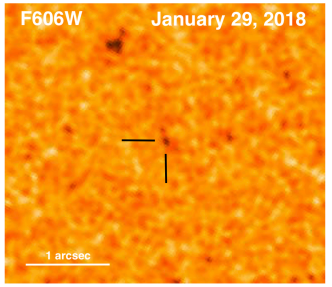
Troja+17



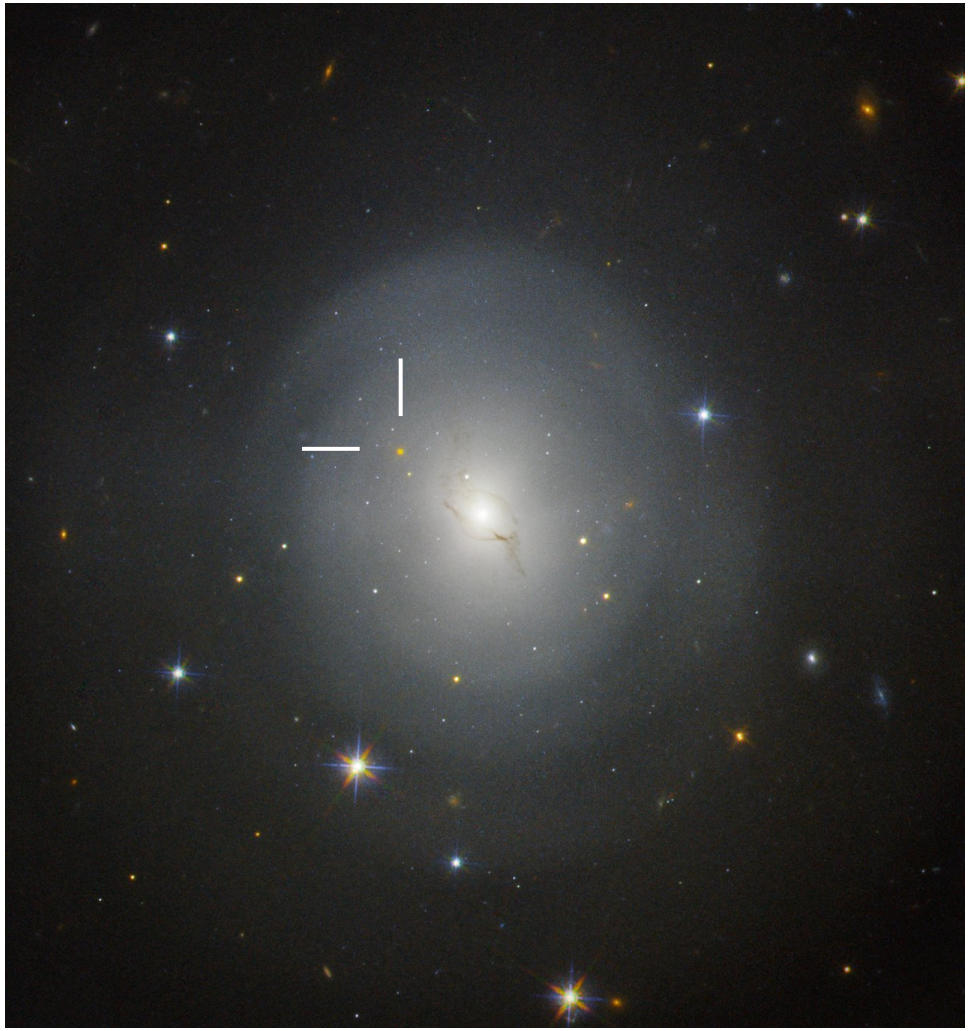
Hallinan,Corsi+17



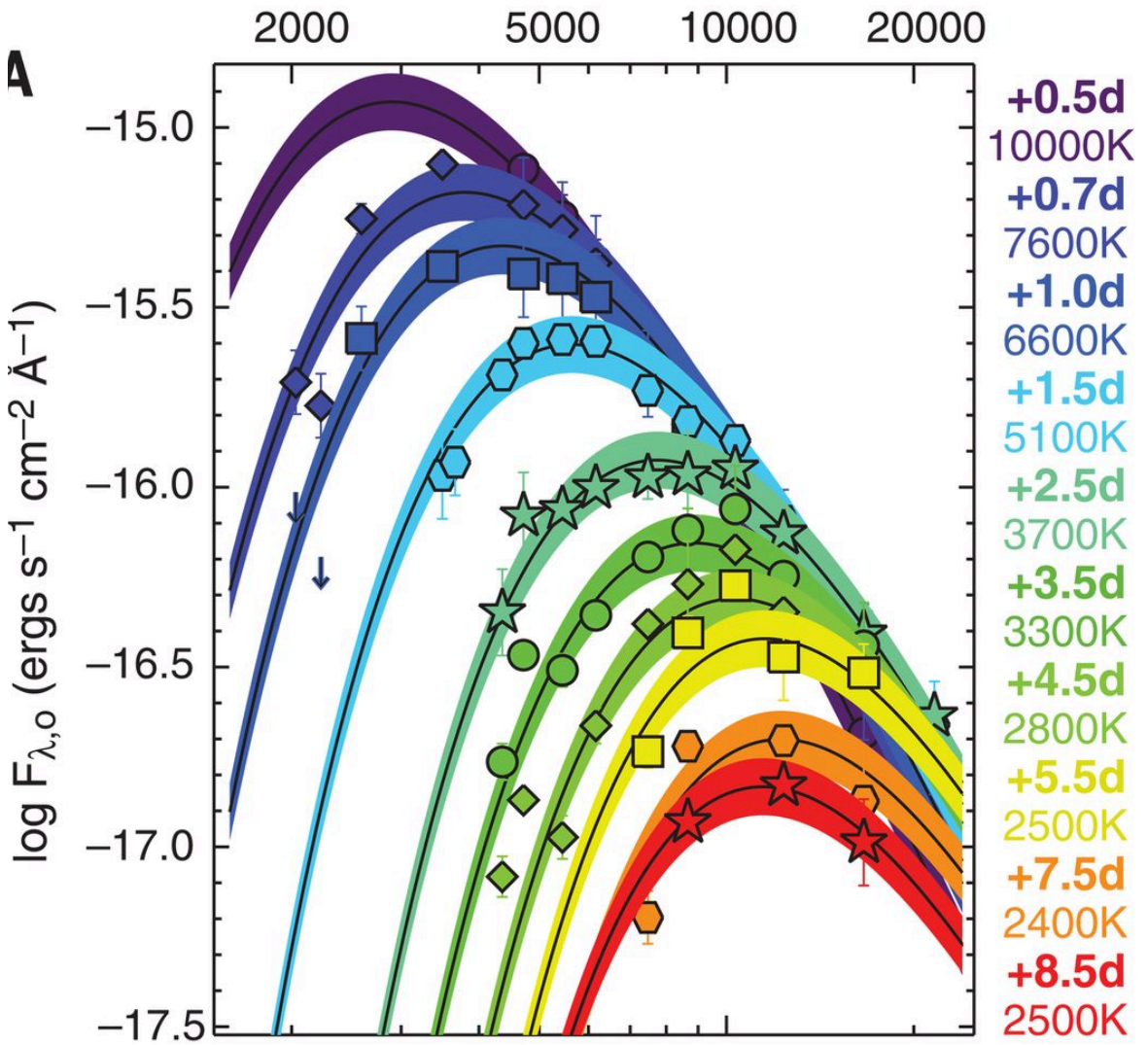
Lyman+18



The kilonova AT2017gfo

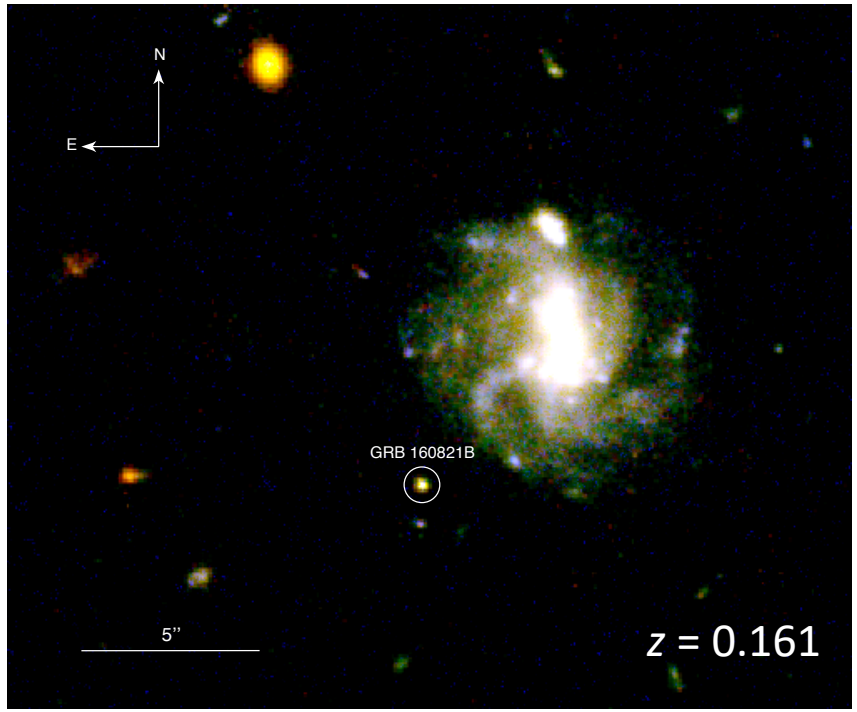


Troja+17, Levan+17, Tanvir+17

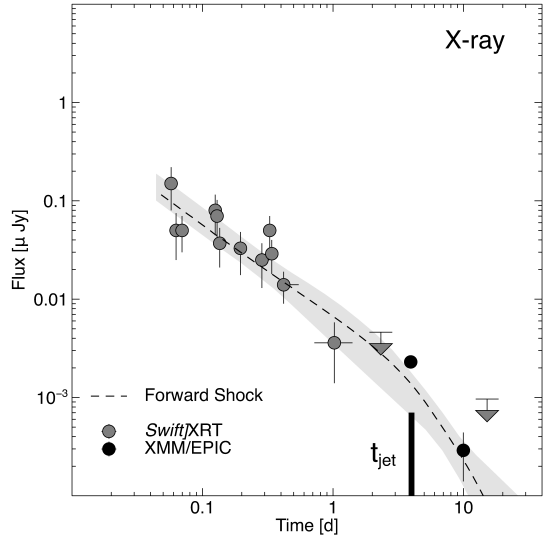


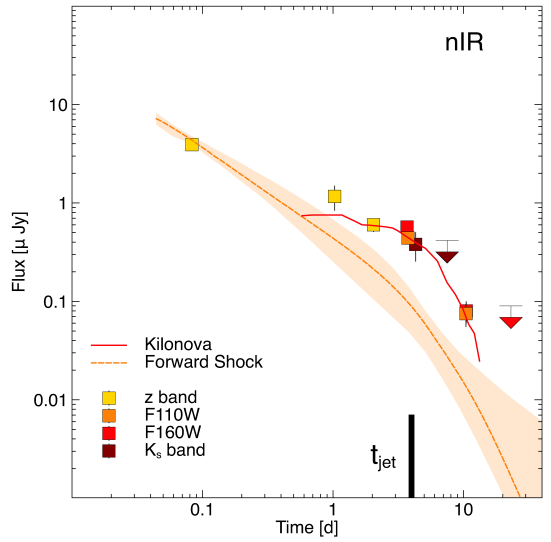
Drout+17, Pian+17, Smartt+17

A kilonova in GRB160821B

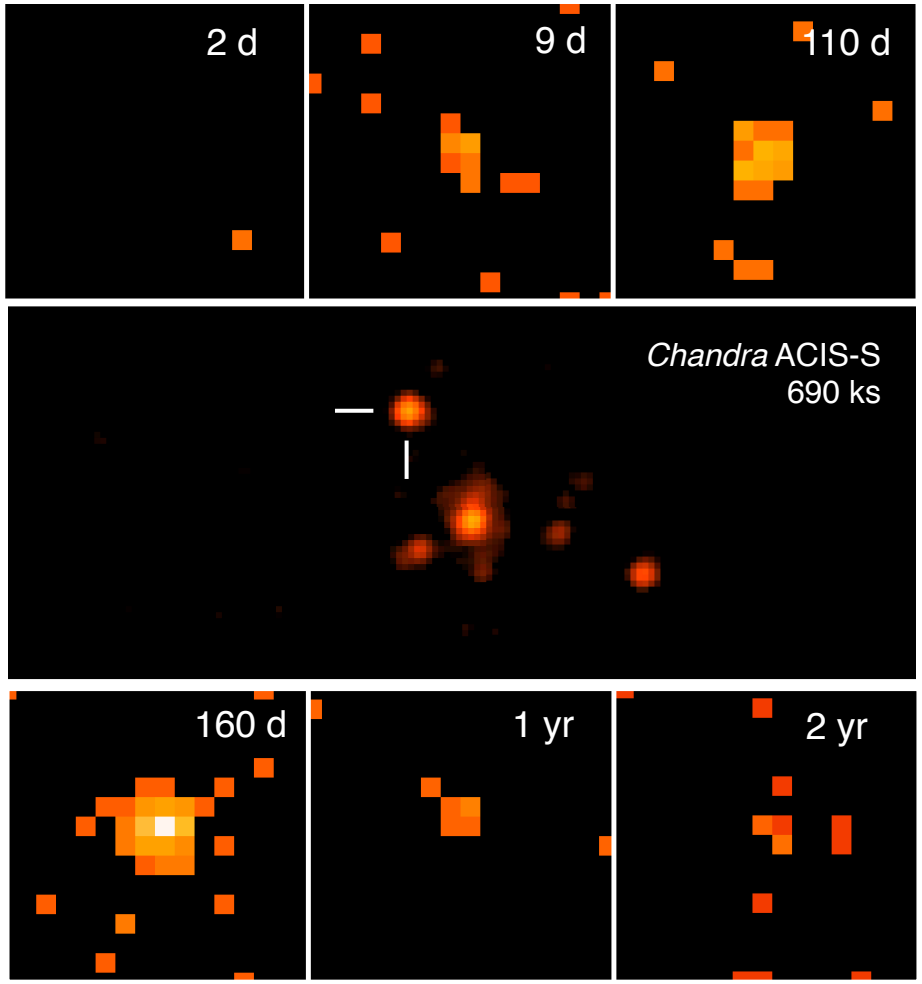


Troja, Castro-Tirado et al. 19
See also Gompertz+18, Rossi+19, Lamb+19





The X-ray afterglow

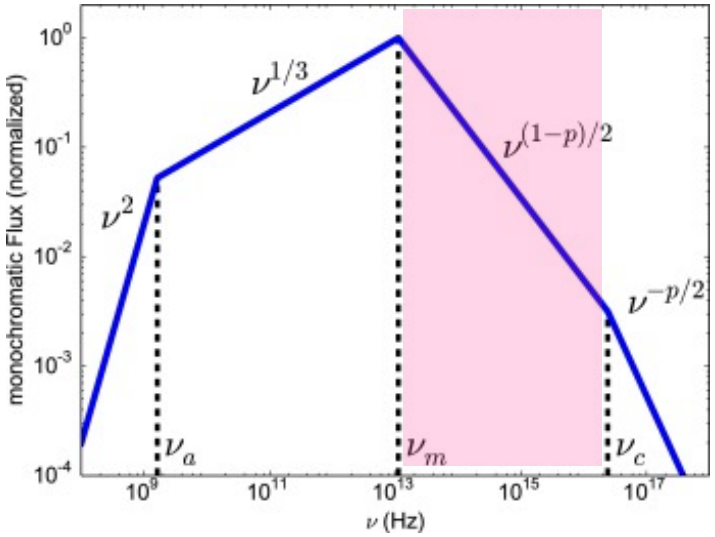


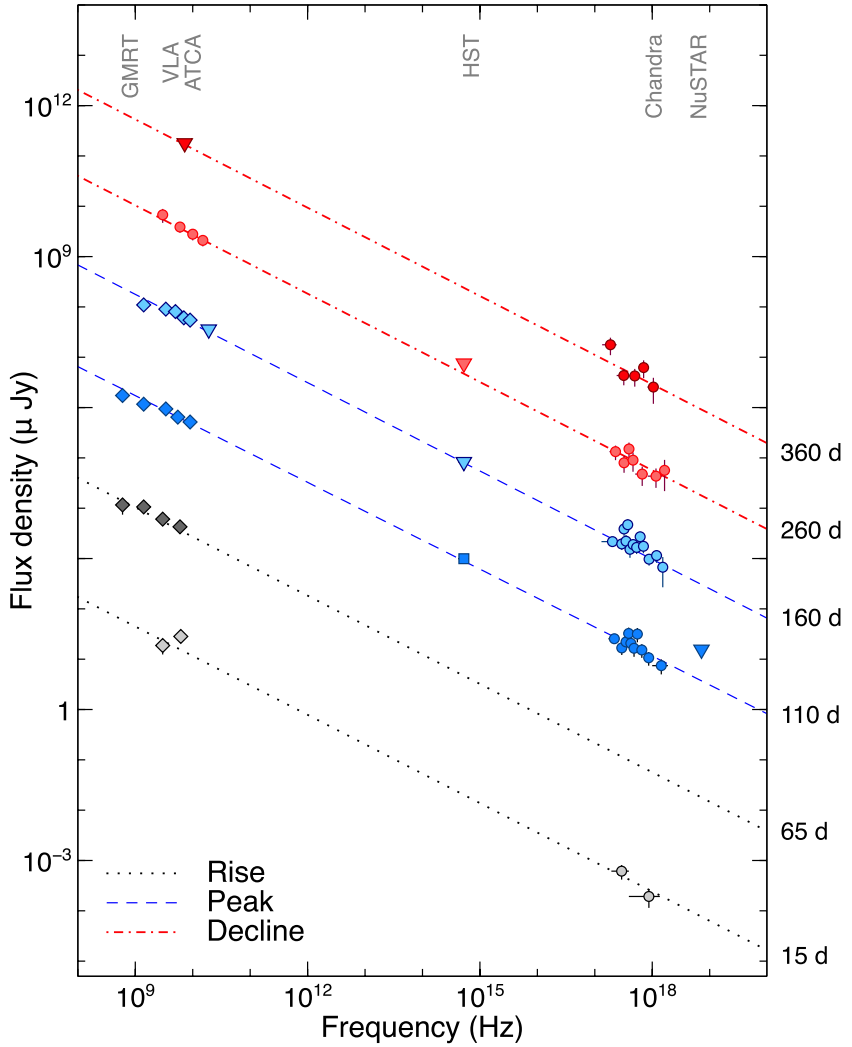
Troja+17
Haggard+17
Margutti+17
Troja+18
Piro+19
Nynka+18
Pooley+18
Alexander+18
Troja+19

No Spectral Evolution

Simple power-law spectrum
over 10 decades in energy

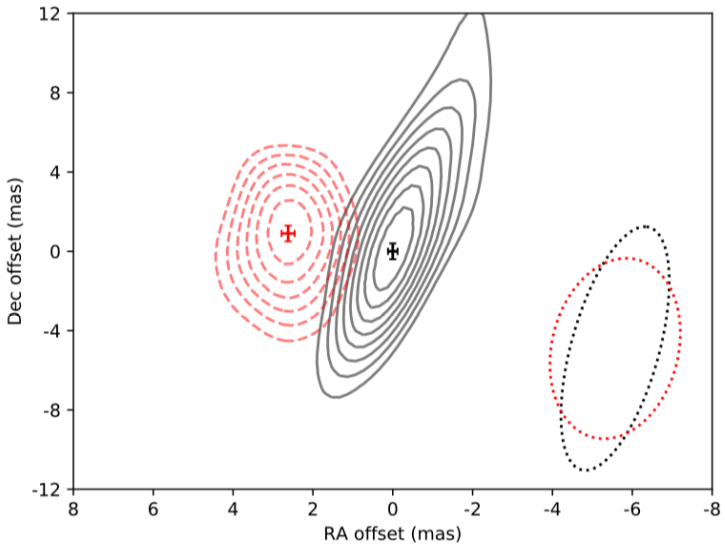
Consistent with synchrotron emission
regime $\nu_m < \nu_r < \nu_X < \nu_c$



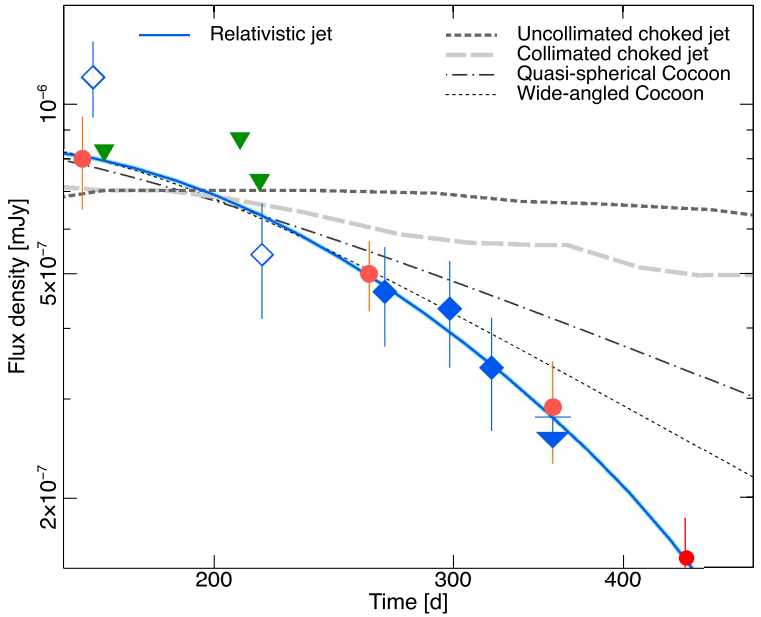


Troja, van Eerten et al., MNRAS, 2019, arXiv:1808.06617

Evidence for a relativistic jet



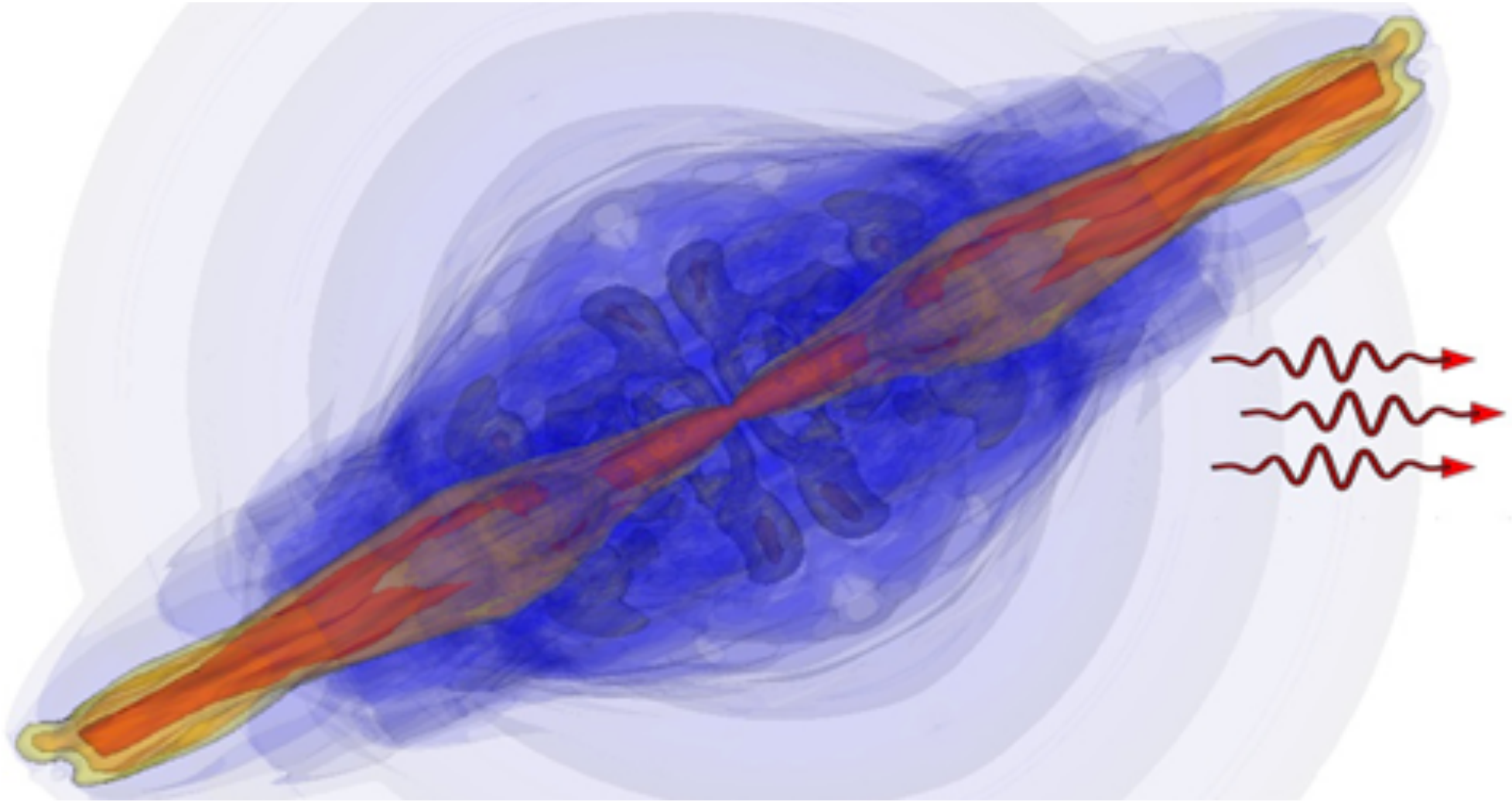
Mooley et al., 2018
Ghirlanda et al., 2019



Troja, van Eerten et al., 2019

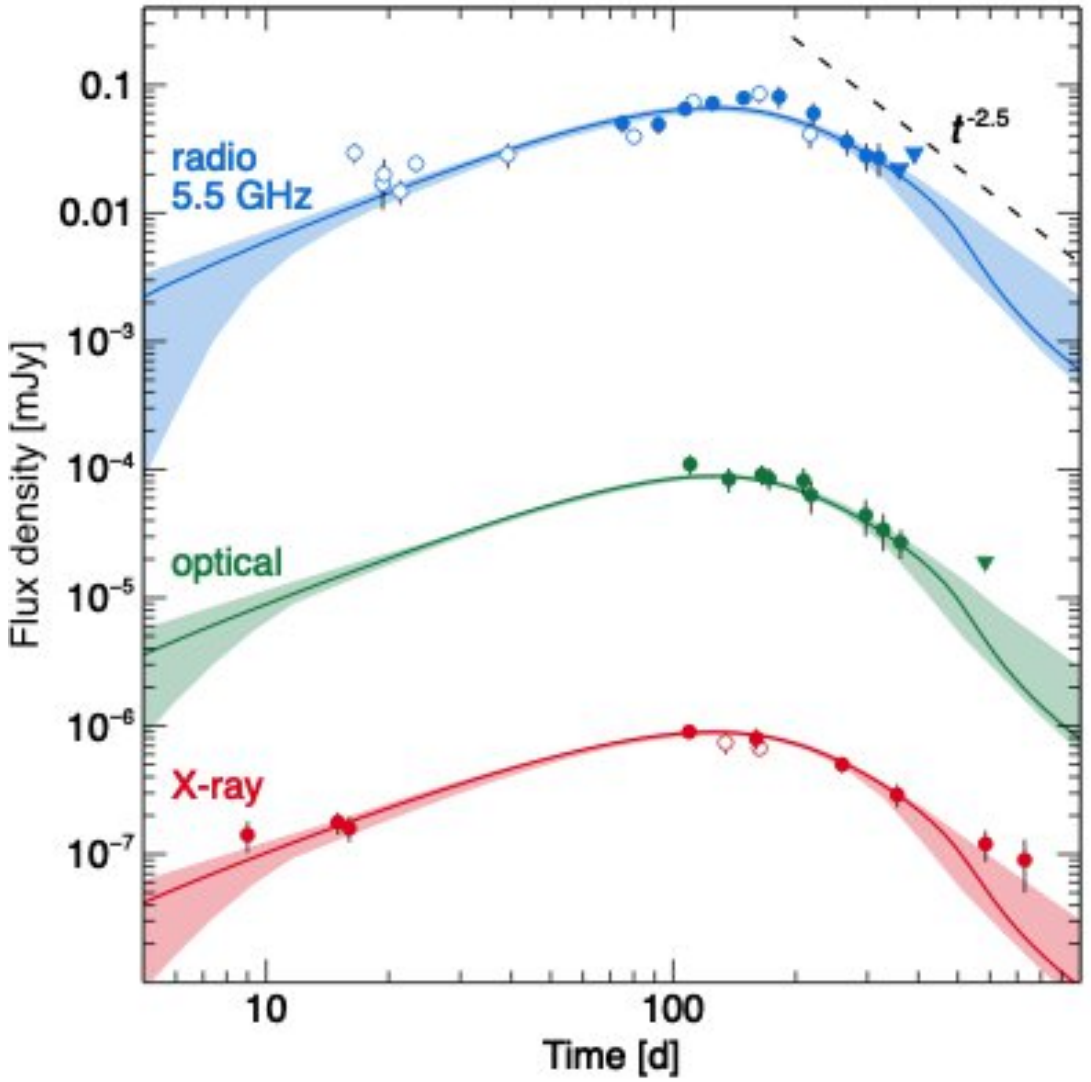
- **High-resolution radio imaging**: compact unresolved radio source superluminal motion
- **Temporal monitoring**: rapid afterglow decline

A structured jet seen off-axis



Zhang & Meszaros 02
Rossi+02
Aloy+05
Janka+05
Lazzati+18
Xu+18
Kathirmagaraju+18
Ryan+19

Broadband afterglow modeling



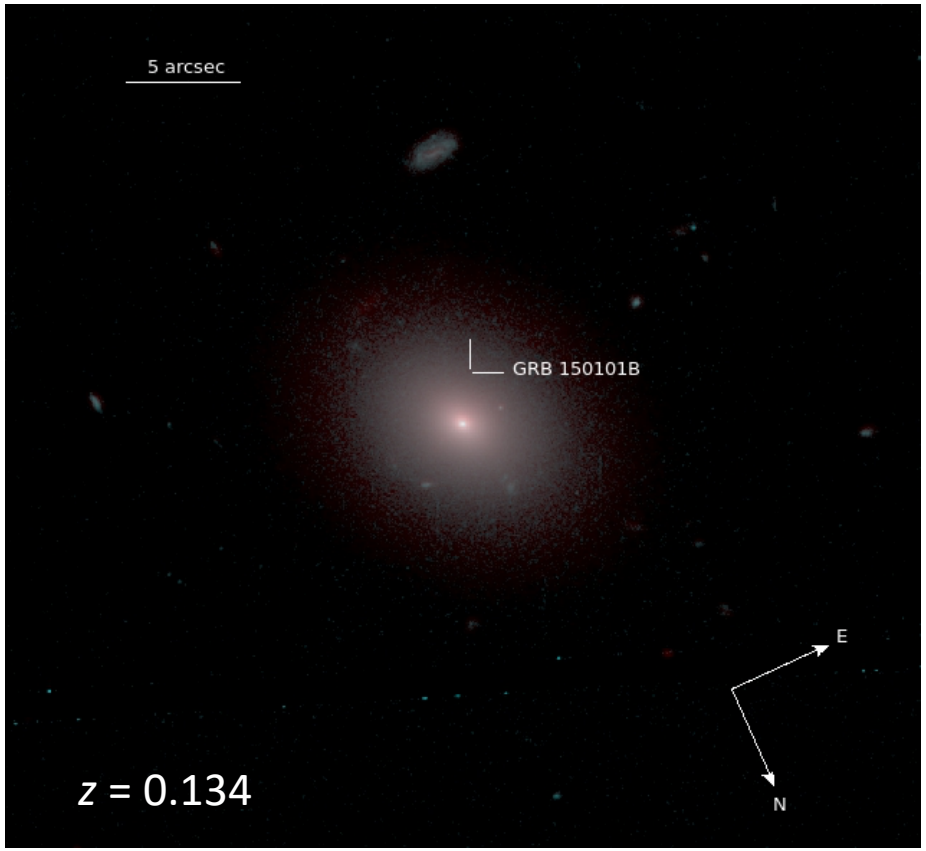
θ_{jet} ~ 5 deg
θ_{view} ~ 25 deg
n ~ 10^{-2} – 10^{-4} cm^{-3}
E ~ 10^{50} erg

Typical of short GRB afterglows

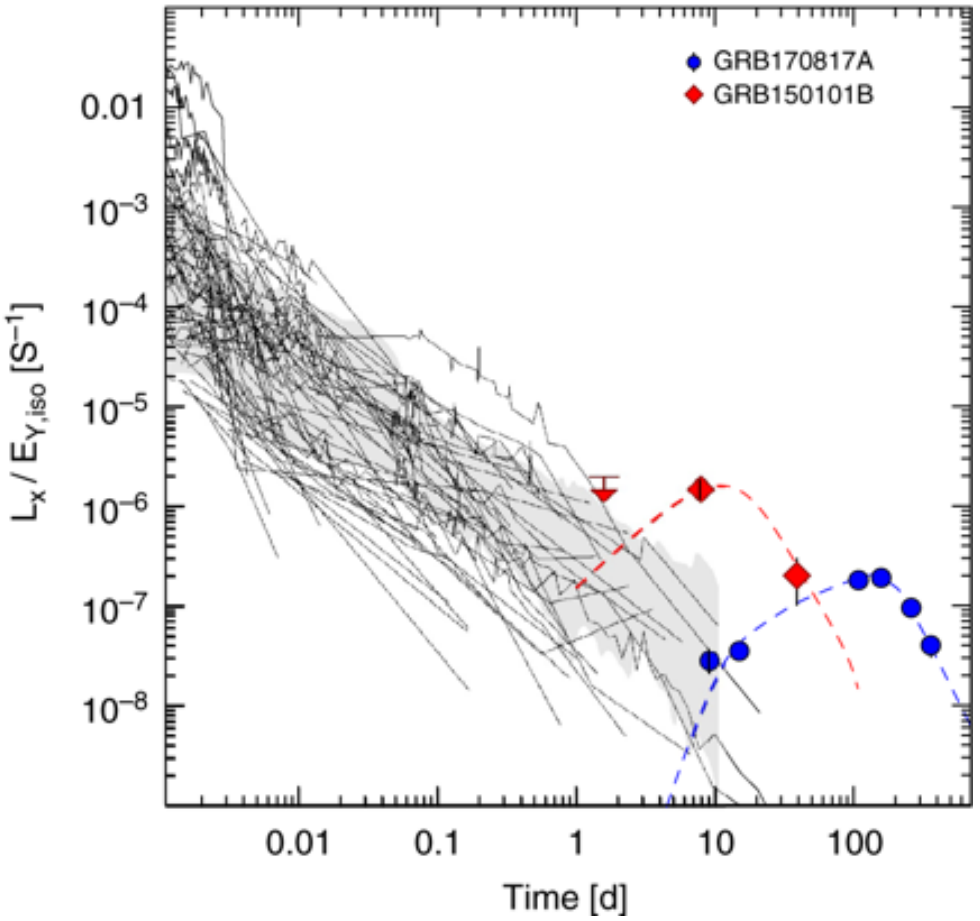
EM viewing angle consistent with the binary inclination from GW data

Updated from
Troja, van Eerten et al., MNRAS, 2019, arXiv:1808.06617

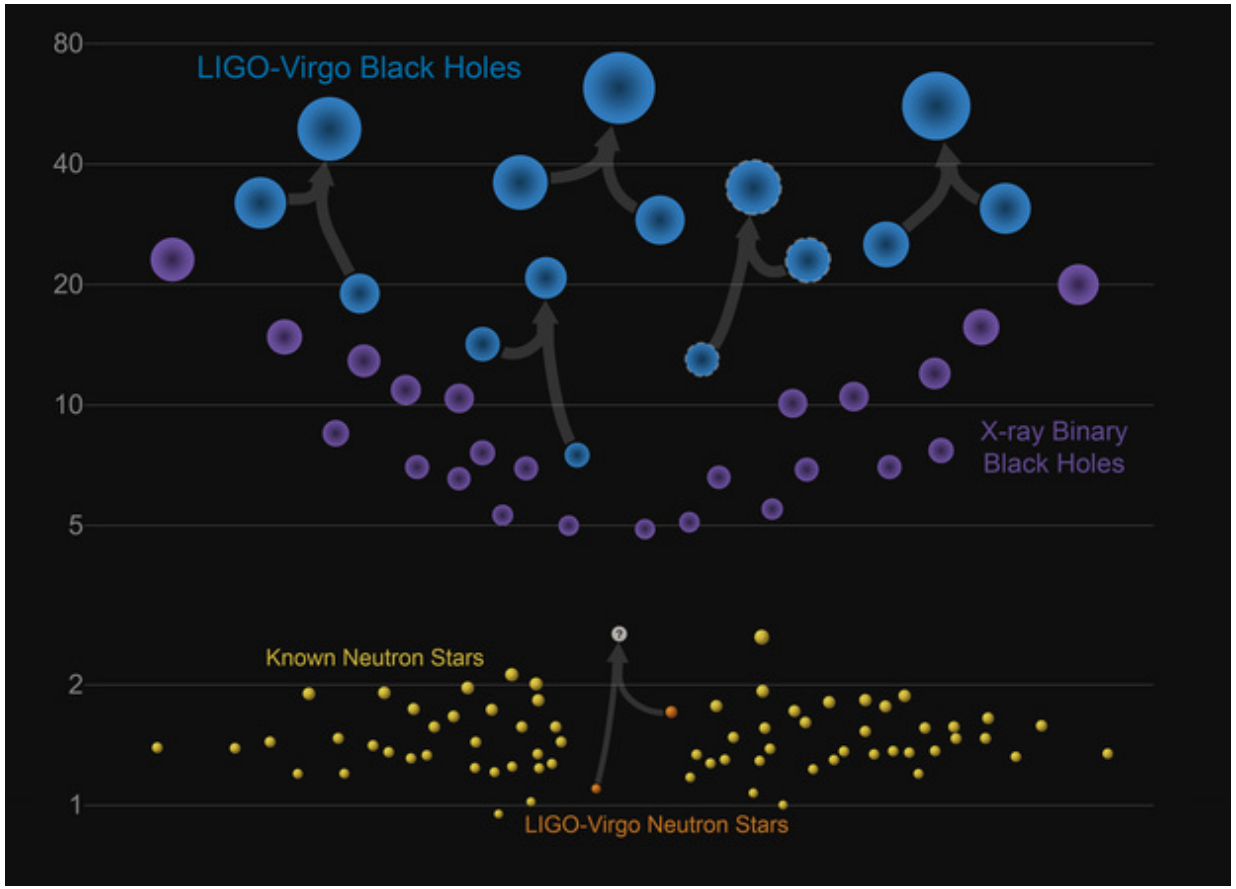
Analogues in the GRB sample: GRB 150101B



Troja, Ryan et al. 18



Constraints on the remnant: NS or BH?



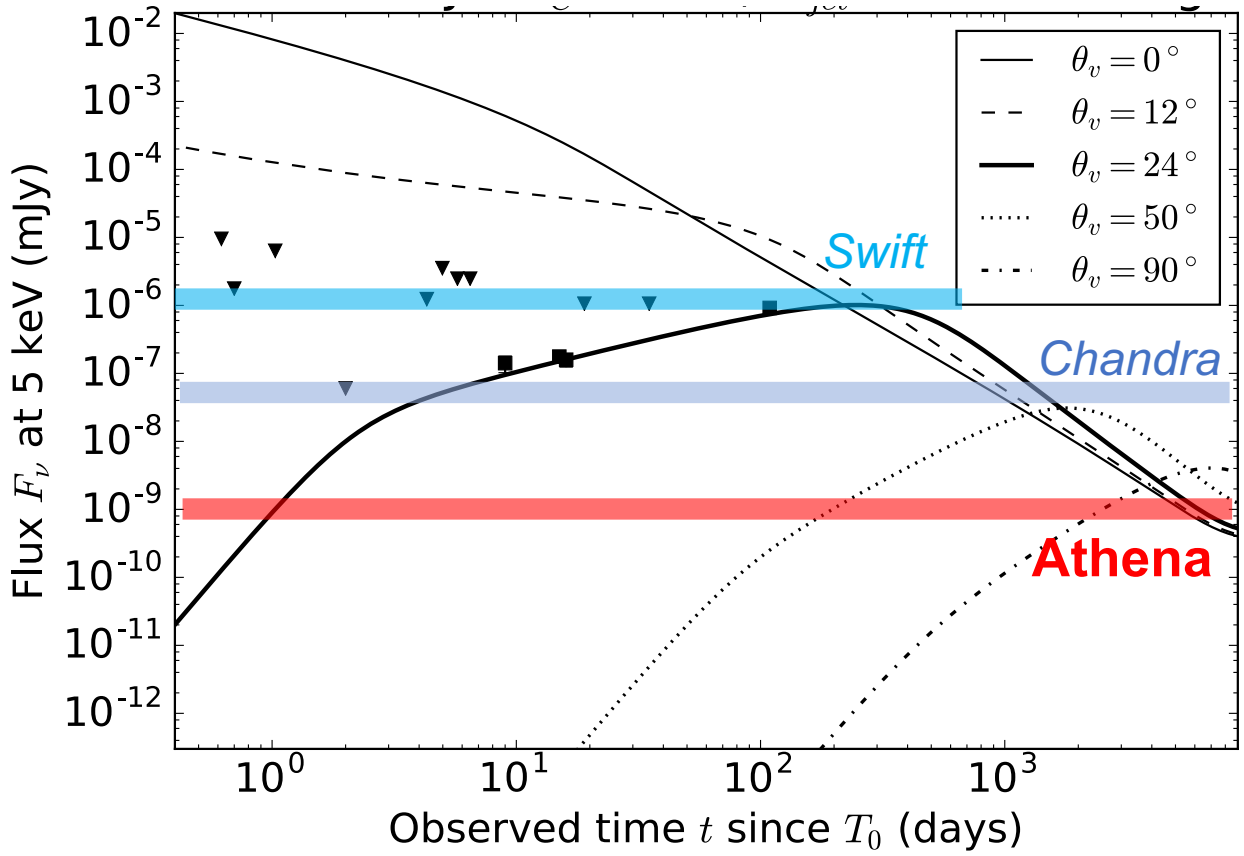
X-ray emission is very sensitive to the GRB central engine: sporadic emission of energy (flares) or continuous spin-down energy injection (plateaus).

$$B < 10^{12}\ G$$

BH *Pooley+18*

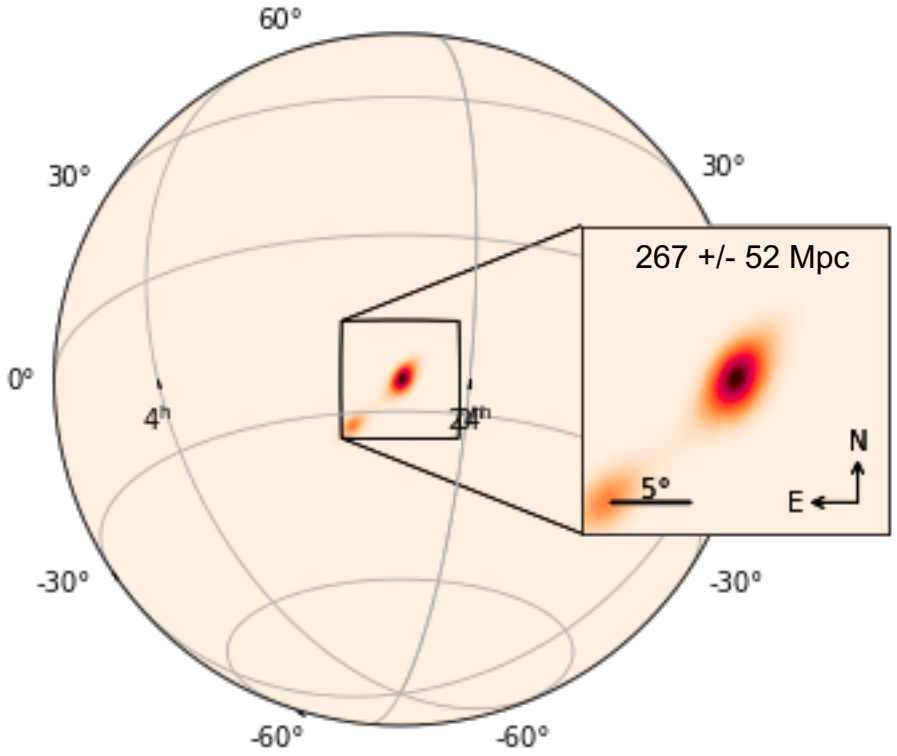
or stable low-B NS *Piro+19*

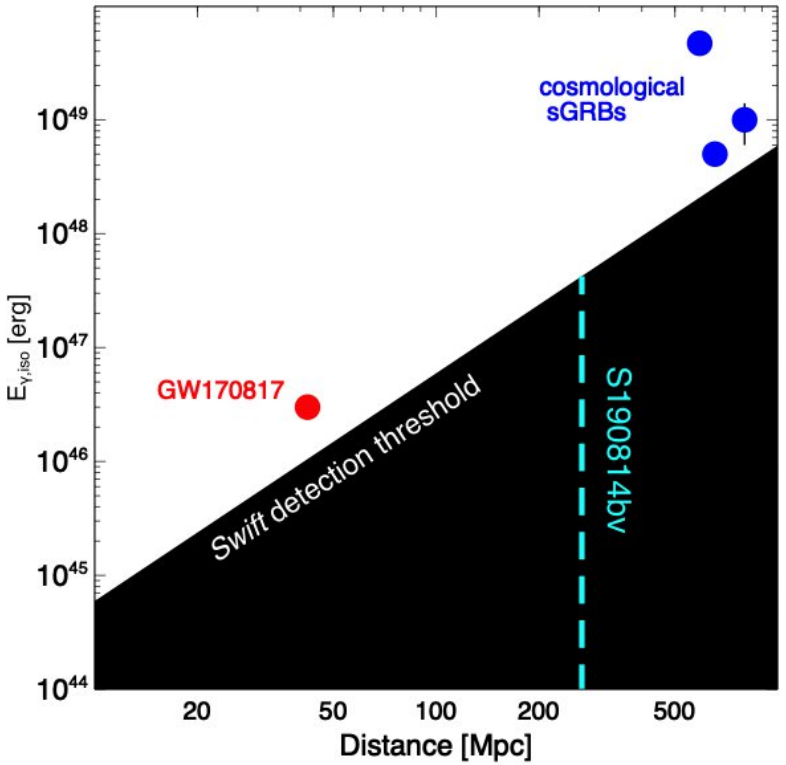
Future perspectives



A NS-BH merger?

S190814bv





Summary

- NS mergers can launch collimated relativistic outflows (jets) powering GRBs

- Viewing angles play an important role:
  Similar explosions might look very different

- GW170817: an extraordinary ordinary short GRB
  A few similar events might have been seen before

- Kilonovae (r-process nucleosynthesis) common in short GRBs

- ATHENA will probe a wider range of explosions