
X-rays from
GW 170817
Eleonora Troja (GSFC/UMD)

X-ray observations of GW 170817

Wide FoV
- MAXI, $f_X < 9 \times 10^{-9}$ erg cm^{-2} s^{-1} (2-10 keV) at 4 hrs
- Super-AGILE, $f_X < 3 \times 10^{-9}$ erg cm^{-2} s^{-1} (18-60 keV) at 12 hrs

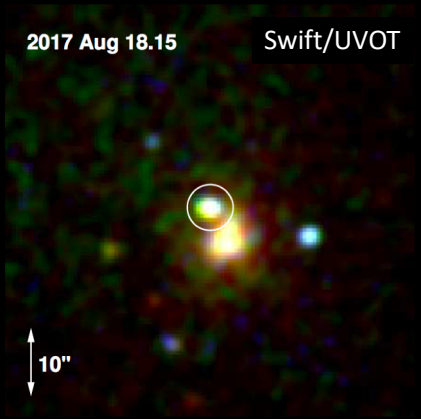
Pointed observations
- Swift
- NuSTAR
- INTEGRAL JEM-X
- Chandra

- XMM-Newton (>3 months later)

see MMA paper for more details

Swift results: evidence of a blue kilonova

- Bright (*u*~18 mag) and rapidly fading UV source (AT2017gfo)
- No X-ray emission $f_X < 5 \times 10^{-14}$ erg cm^{-2} s^{-1} : not a typical afterglow



T_0+ 13 hrs

Evans, Cenko, et al., *Science*, 2017

Chandra: Afterglow discovery

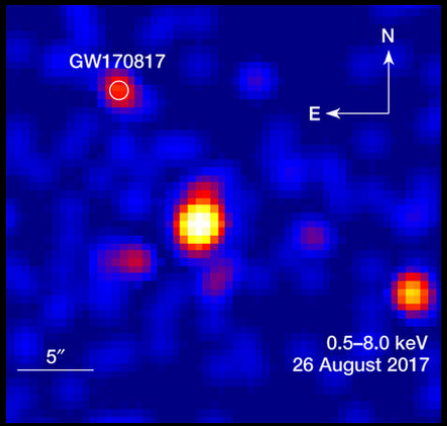
- Aug 19– Sep 02 (~2 days to ~16 days after the LIGO trigger)
- 4 different observations from 3 teams

t=2.2 d (25 ks, Margutti et al. 2017)
no X-rays, $f_X < 2 \times 10^{-15}$ erg cm^{-2} s^{-1}

t=9 d (50 ks, PI: Troja)
first X-ray detection, $f_X \sim 4 \times 10^{-15}$ erg cm^{-2} s^{-1}

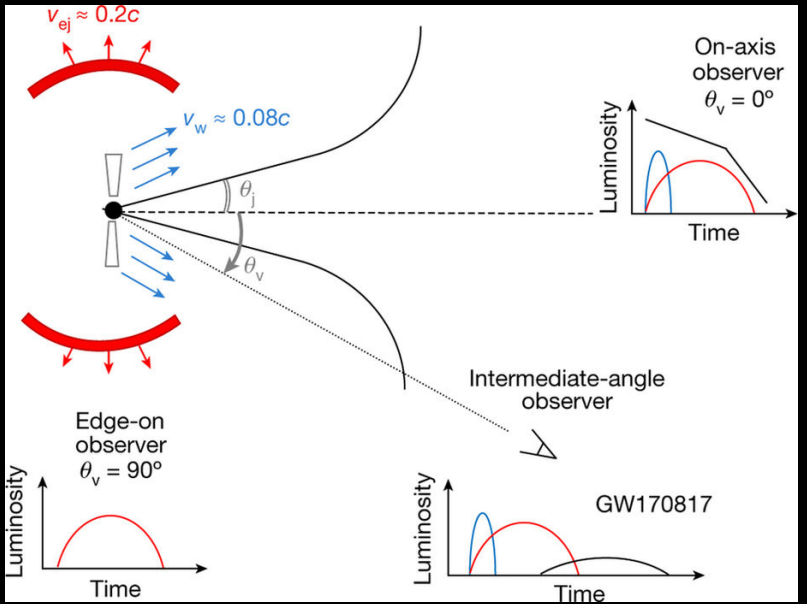
t=15 d (50 ks, PI: Troja)
slowly rising X-rays, $f_X \sim 5 \times 10^{-15}$ erg cm^{-2} s^{-1}

t=16 d (50 ks, Haggard et al. 2017)



Troja, Piro, et al., *Nature*, 2017

Geometry of GW170817

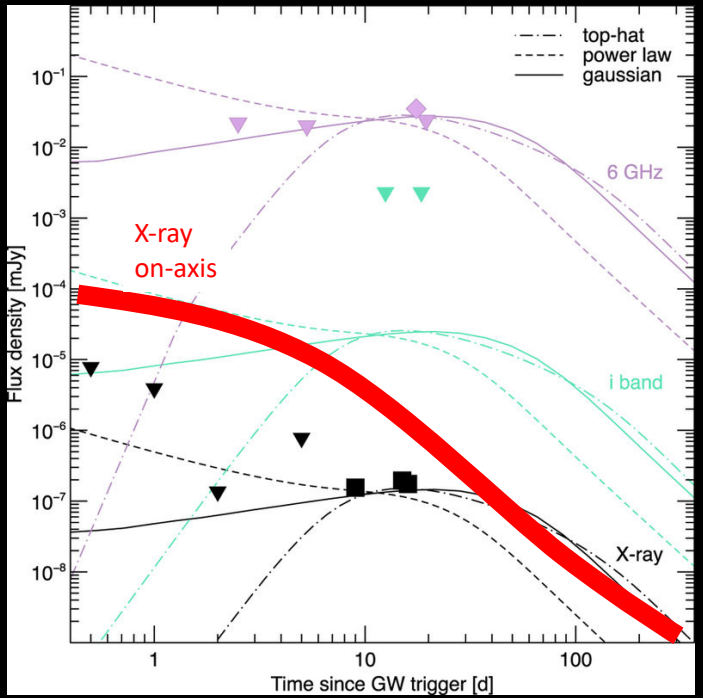


Troja, Piro, et al., *Nature*, 2017

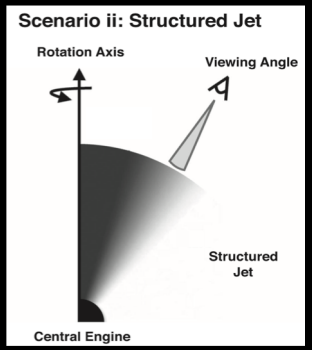
Off-axis jet

GRB 170817A is a standard short GRB with canonical prompt and afterglow emission.

Troja, Piro, et al., *Nature*, 2017



Off-axis jet: structured



Power-law:

$E \sim (\theta_{view}/\theta_{core})^{-2}$

Gaussian:

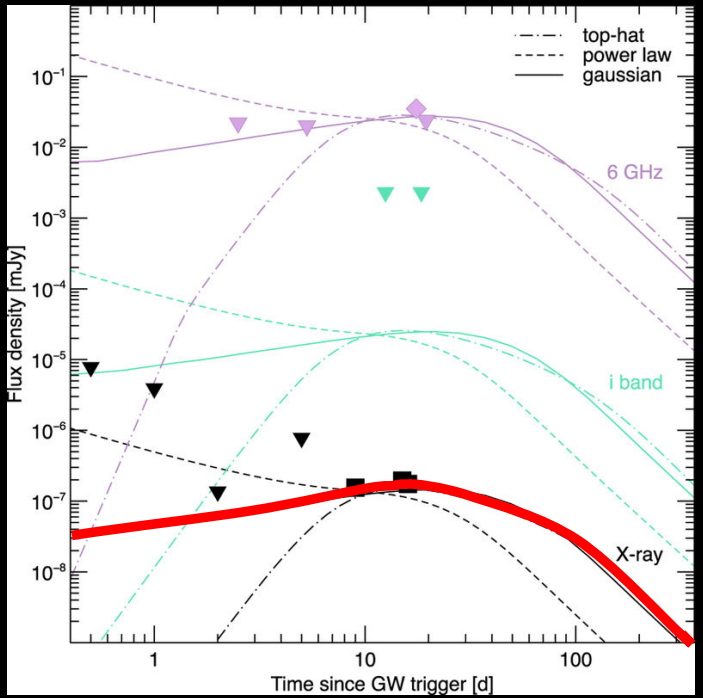
$E \sim \exp(-\theta_{view}/2\theta_{core})^2$

Rossi,Lazzati & Rees 20002
Kathirgamaraju+17

Afterglow: OK

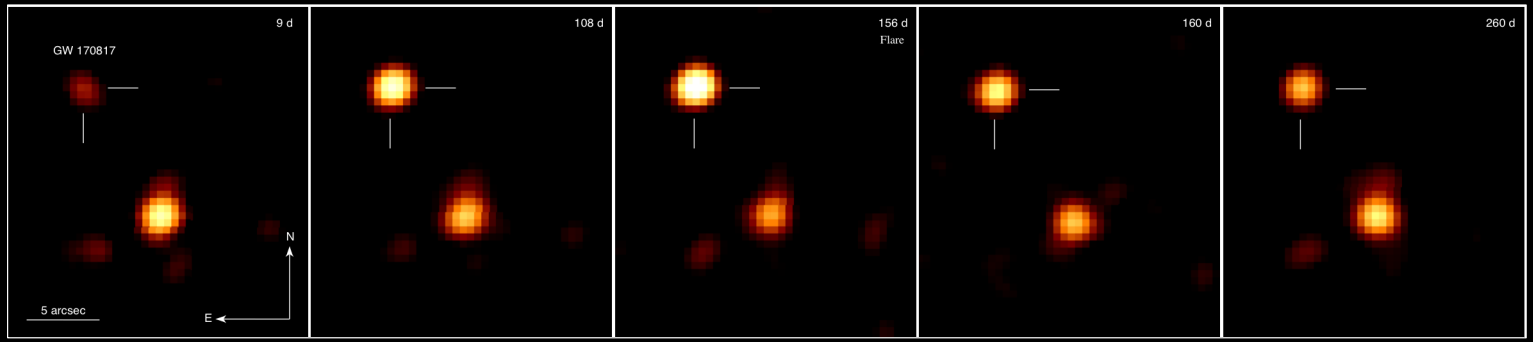
Prompt: OK for a gaussian jet with $\theta_{view} \sim 4\ \theta_{core}$

Troja, Piro, et al., *Nature*, 2017



Time evolution: a structured outflow

Troja, Piro, et al., *MNRAS*, 2018
Piro, Troja, et al., 2018

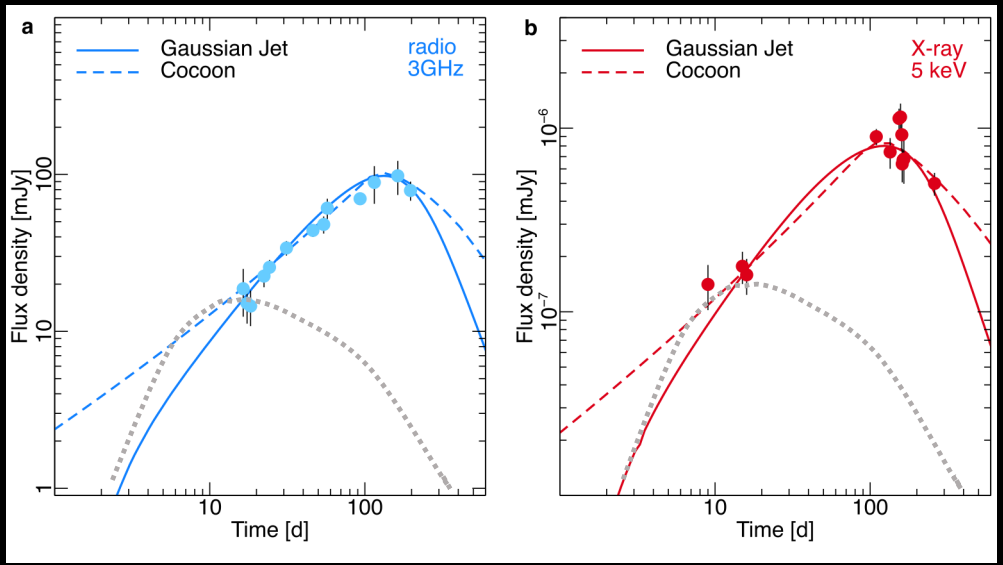


A simple uniform jet cannot reproduce the continued rise of the afterglow emission
Structure: either angular (Gaussian jet) or radial (continued energy injection into a cocoon)

The jet of GW170817: relativistic or chocked?

Troja, et al., *MNRAS*, 2018

Piro, et al., 2018



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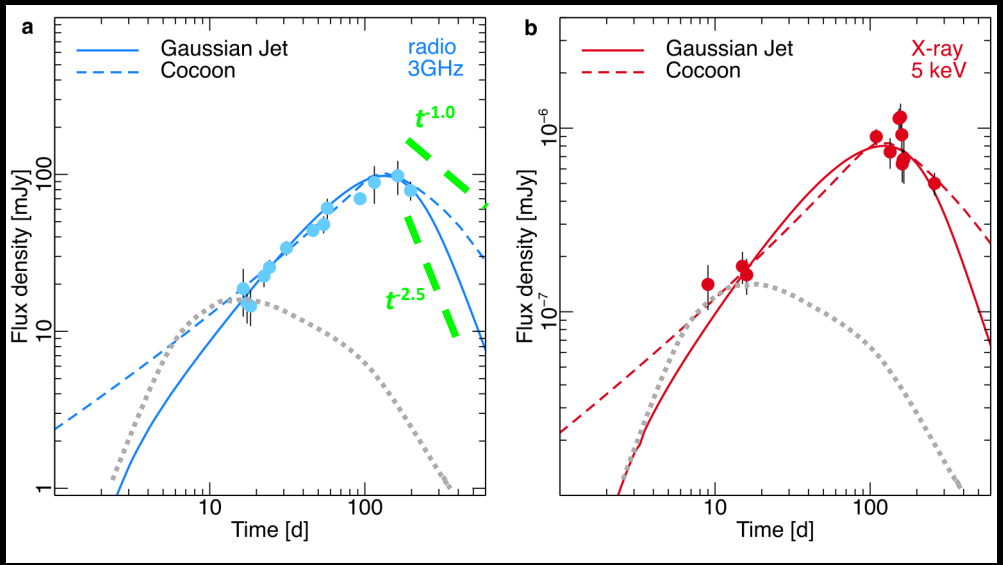
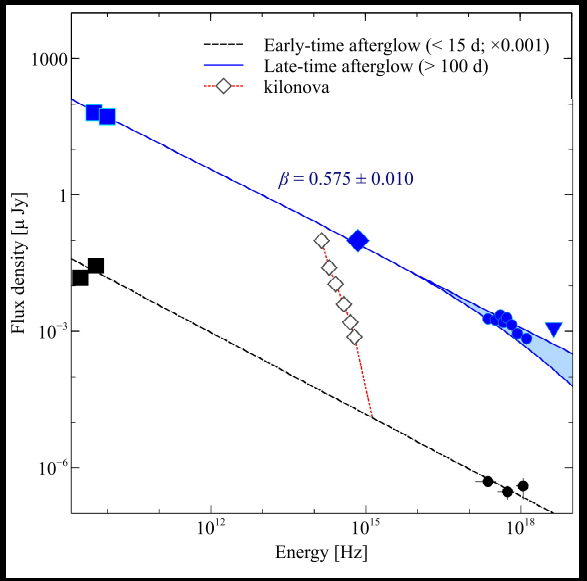


No Spectral Evolution



Troja et al., *MNRAS*, 2018

Consistent with synchrotron emission (regime $\nu_m<\nu_X<\nu_c$)

p ~ 2.16

n ~ 0.001 cm^{-3}

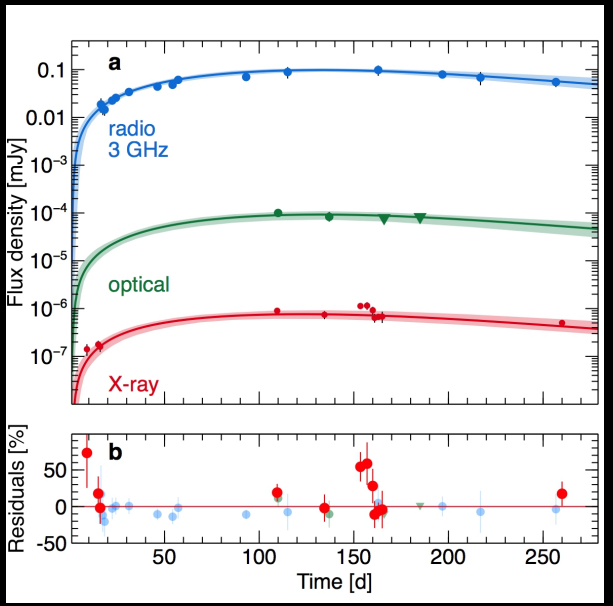
E ~ $3x10^{50}$ erg

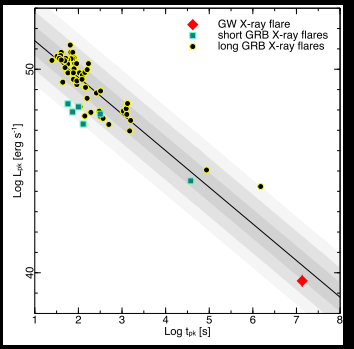
θ ~ 4 deg

θ_w ~ 25-30 deg

Typical of short GRBs

A candidate X-ray flare in GW170817



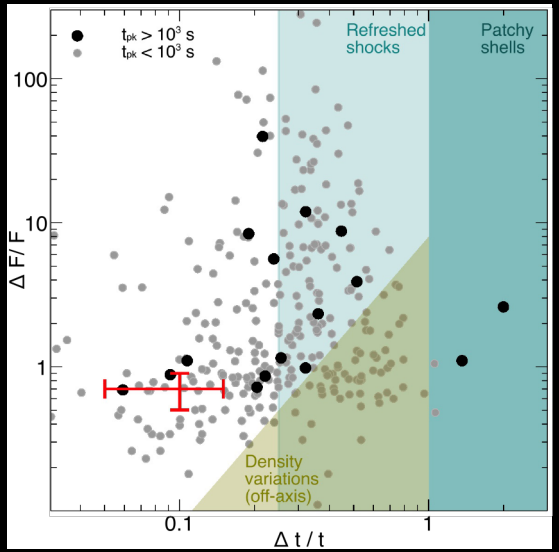


X-ray time variability at ~150 days

Consistent with the behavior of GRB X-ray flares

Piro, et al., 2018

Activity from the merger remnant: a long lived NS?



Piro et al., 2018

Simple afterglow cannot explain the X-ray variability

X-ray flare requires a long-lived central engine

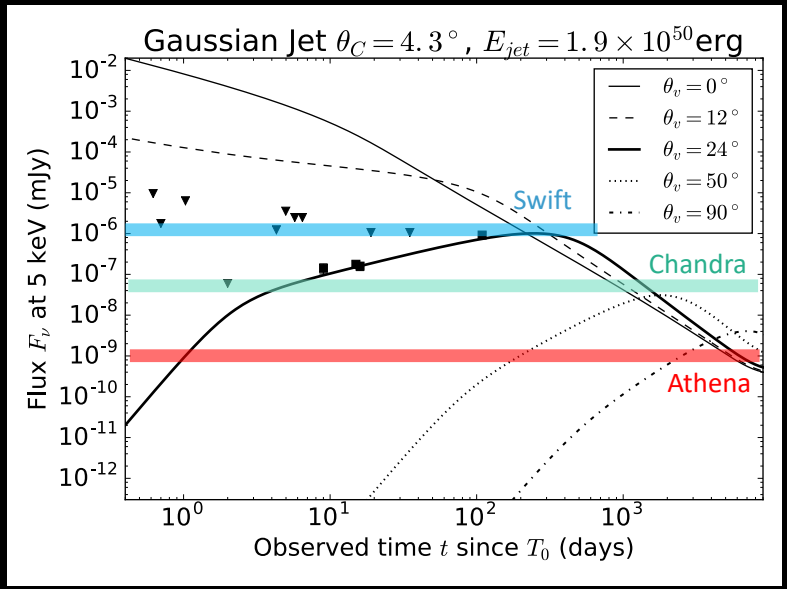
Unlikely to be a BH

A long-lived NS with low poloidal B and high toroidal B can fit all the data

$M_{NS}>2.16\ M_{sun}$

X-ray observations offer a privileged window on to the central object complementary to GW data

Future prospects



Summary

- X-ray observations point to a mildly relativistic outflow ejected from the merger remnant
- Continued monitoring could distinguish between different models (chocked vs. relativistic jet)
- X-ray time variability favor a long lived NS with $M_{NS}>2.16\ M_{sun}$
- Future observations will probe a variety of viewing angles