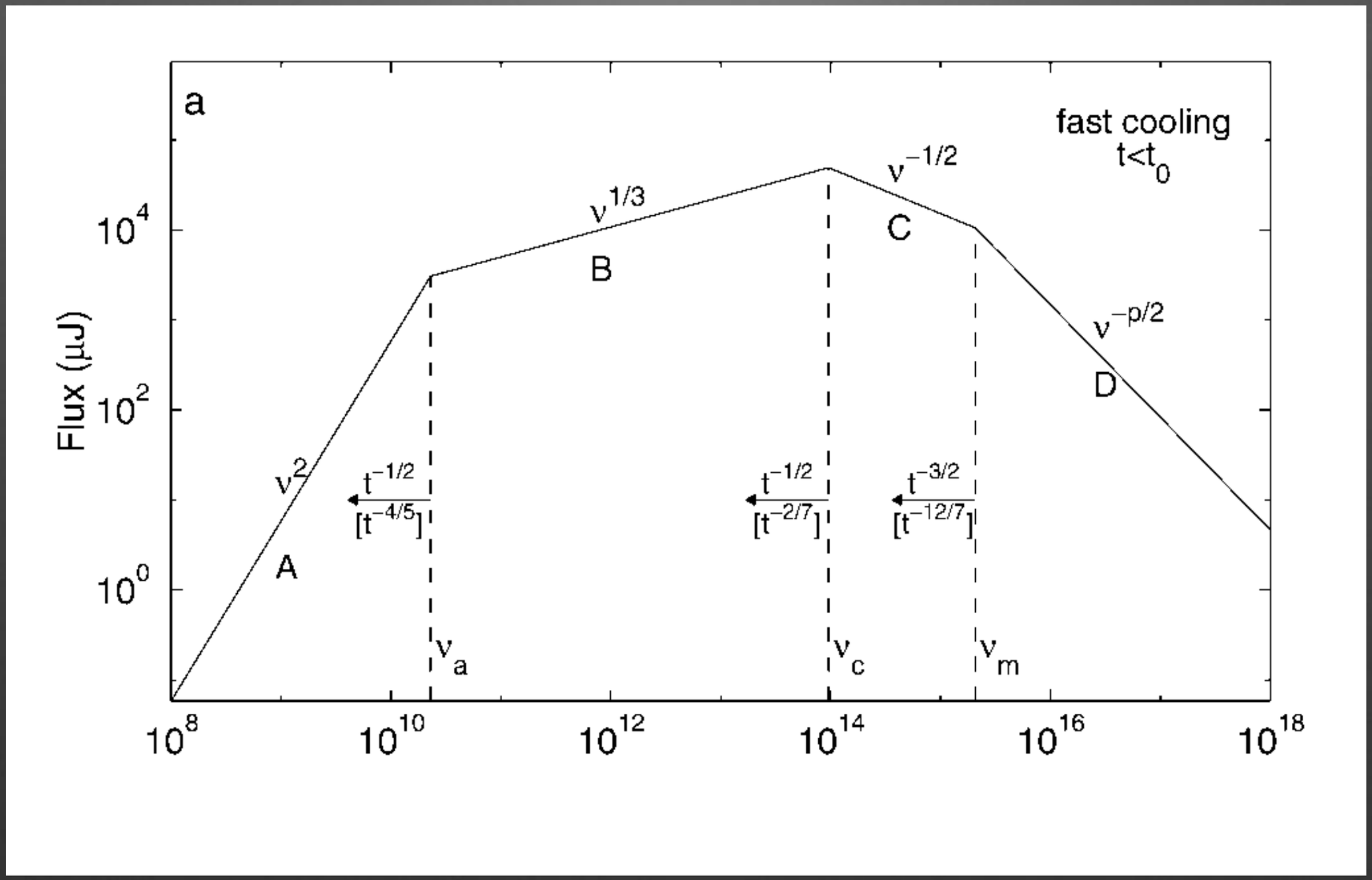
Afterglow spectrum



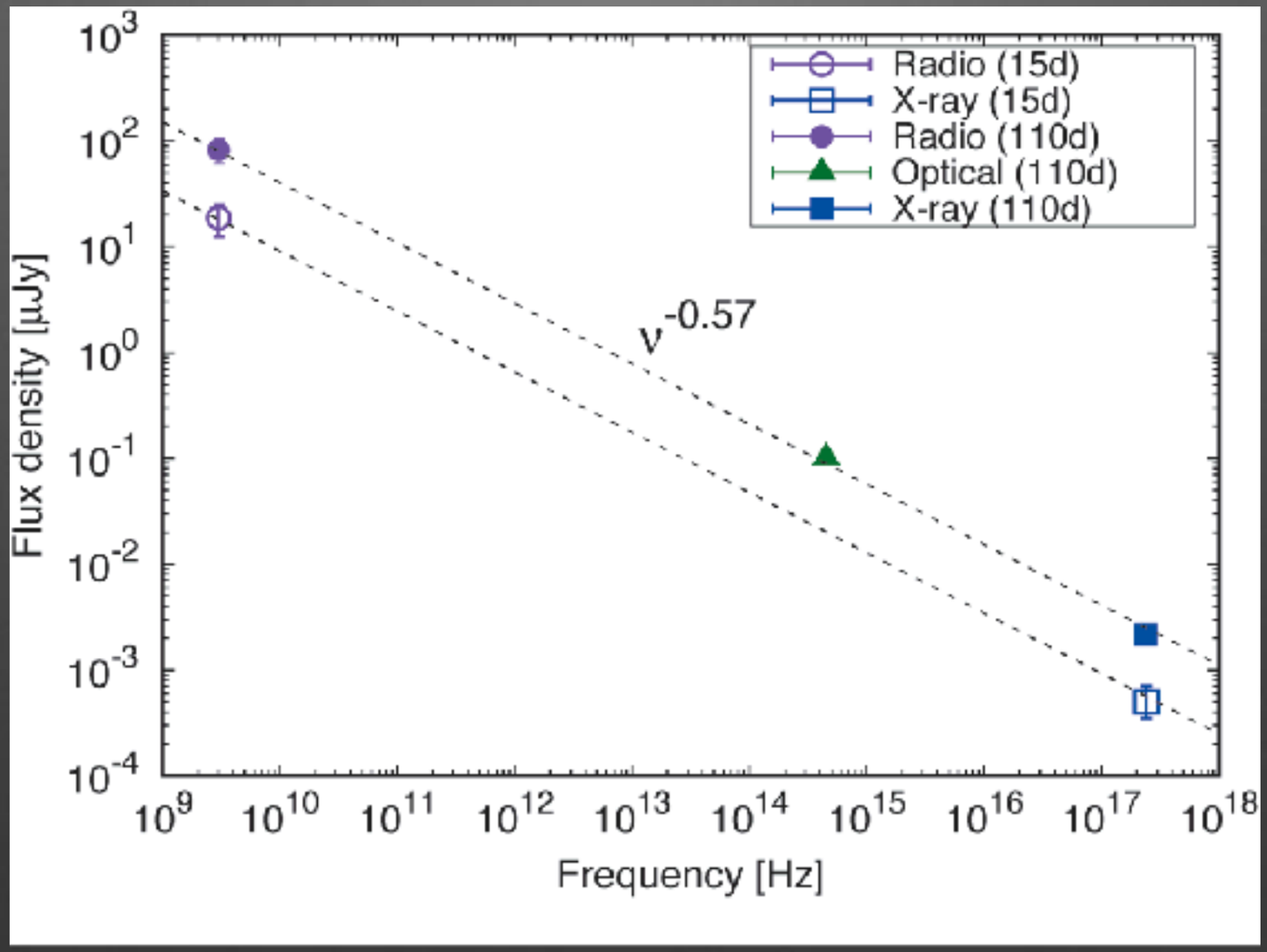
Sari et al 98

Parameter estimate

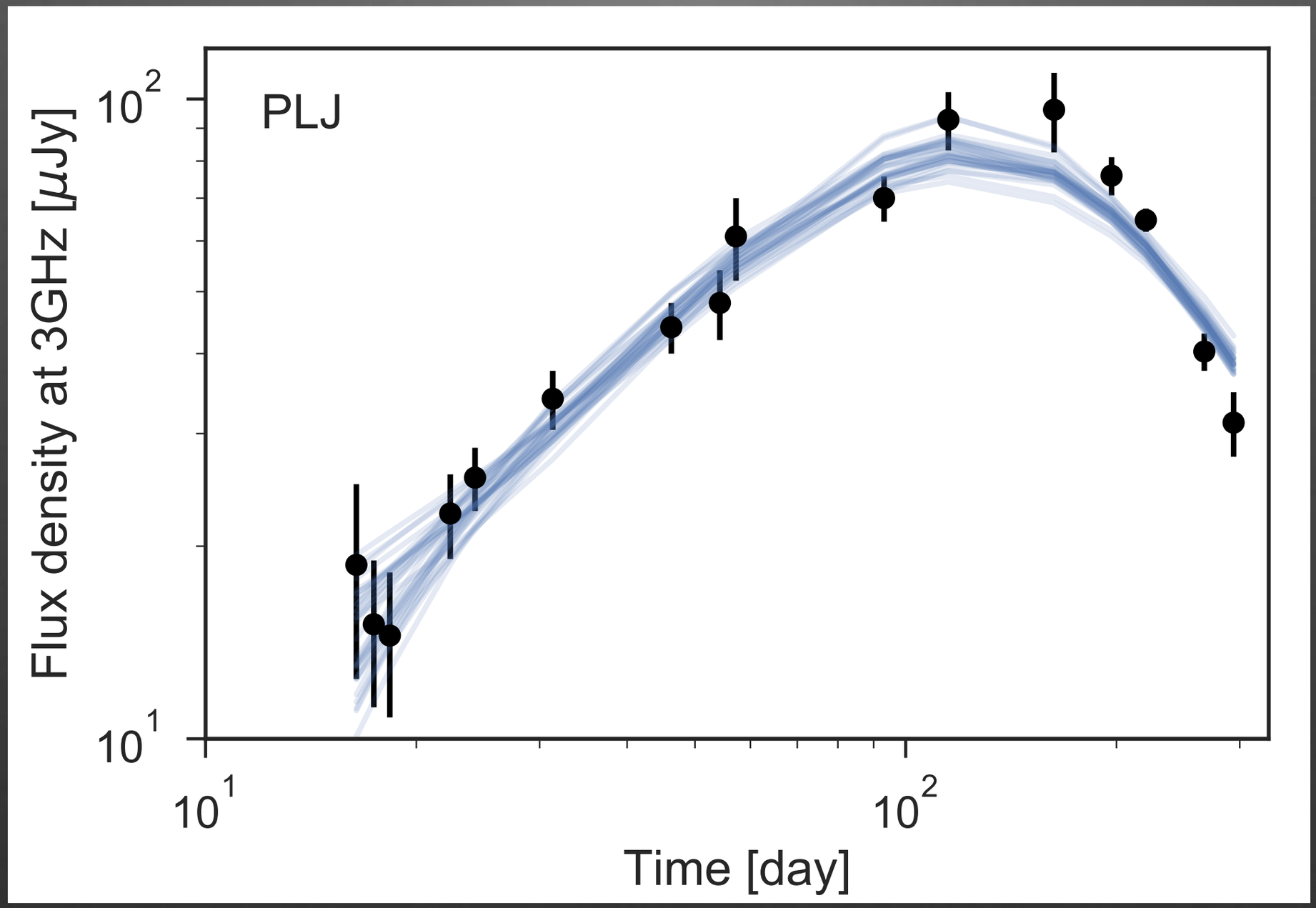
$$\nu_c \approx 2.7 \cdot 10^{12}\,\mathrm{Hz}\,\epsilon_B^{-3/2} E_{52}^{-1/2} n^{-1} t_d^{-1/2}.$$

$$\begin{aligned} \nu_m &\approx 5.7 \cdot 10^{14}\,\mathrm{Hz}\,E_{52}^{1/2}\epsilon_B^{1/2}\epsilon_e^2 t_d^{-3/2}, \\ F_{\nu,m} &\approx 1.1 \cdot 10^5 \mu\mathrm{Jy}\,E_{52} n^{1/2}\epsilon_B^{1/2} d_{28}^{-2}. \end{aligned}$$

Afterglow spectrum GW170817

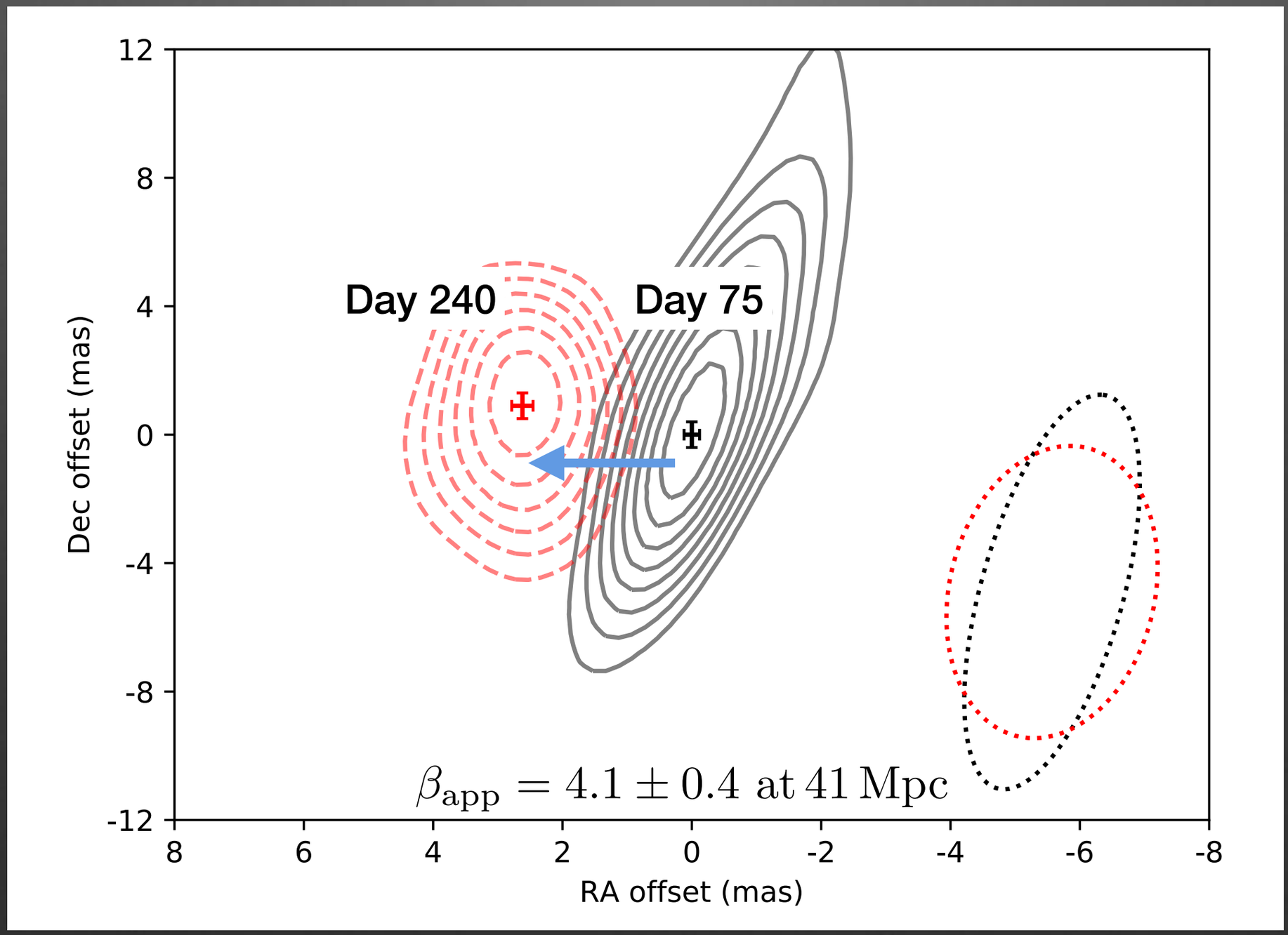


Afterglow light curve: GW170817

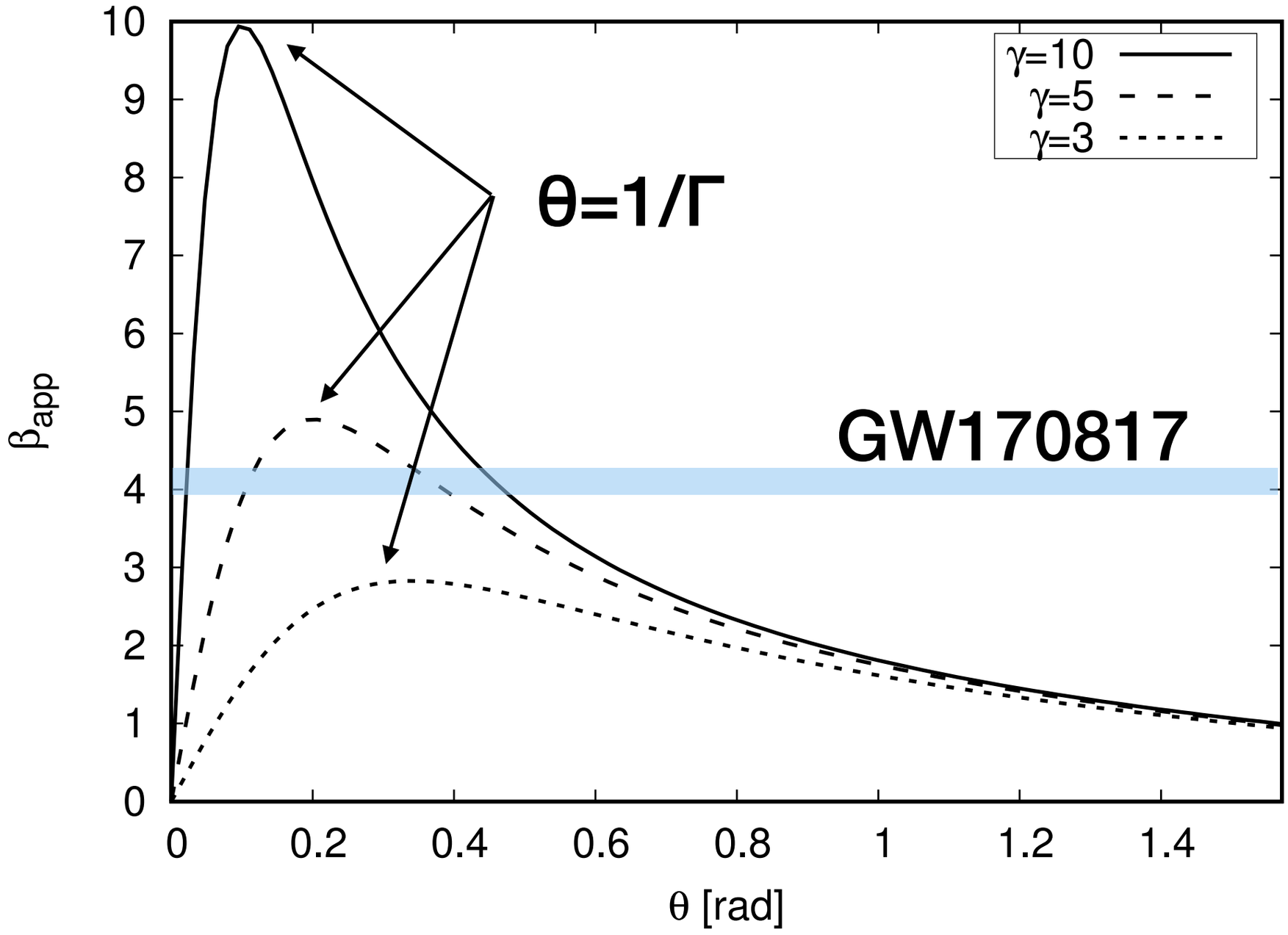


Superluminal Jet in GW170817

VLBI resolve the motion of the radio source associated with GW170817
Mooley et al (2018)

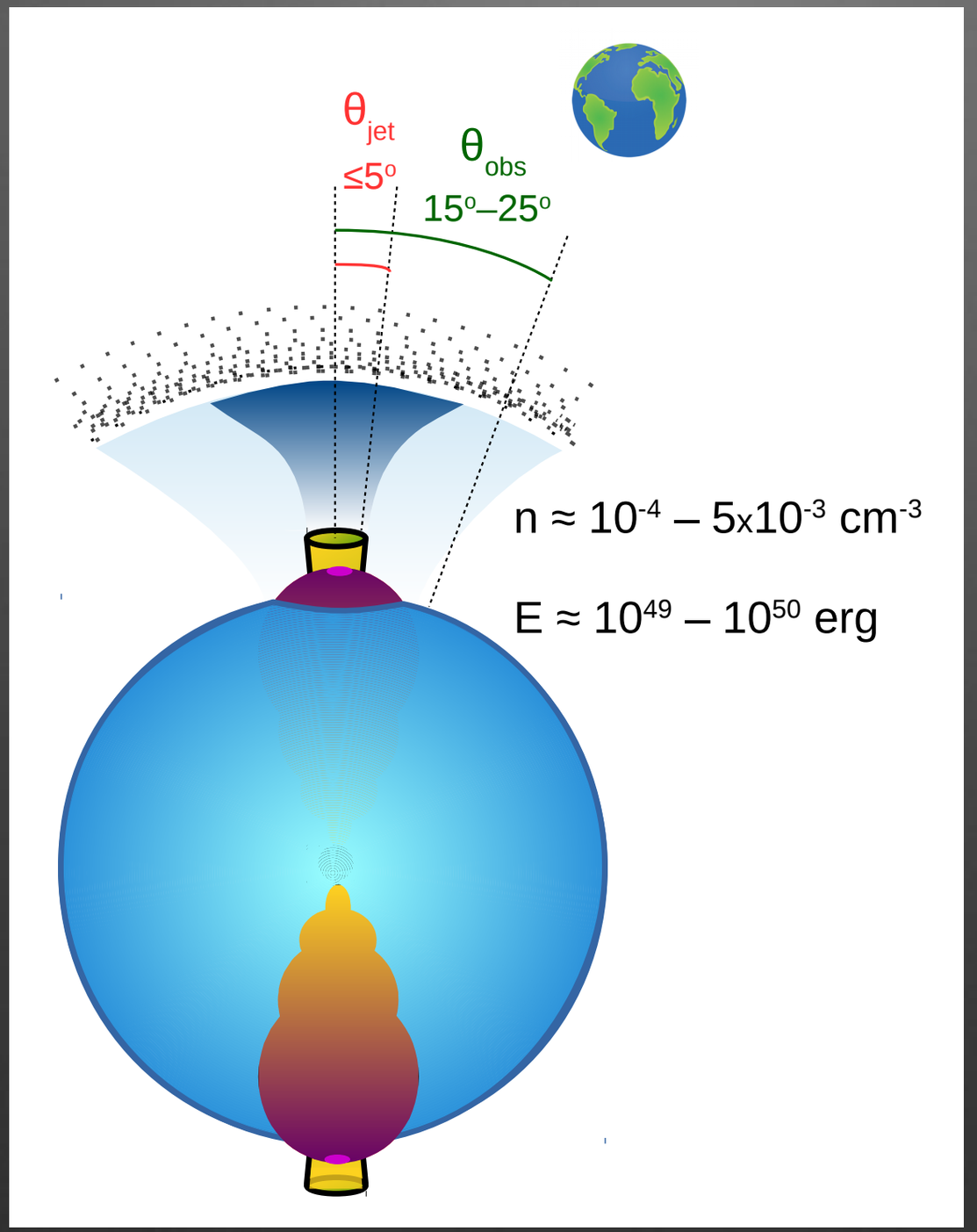


Apparent velocity



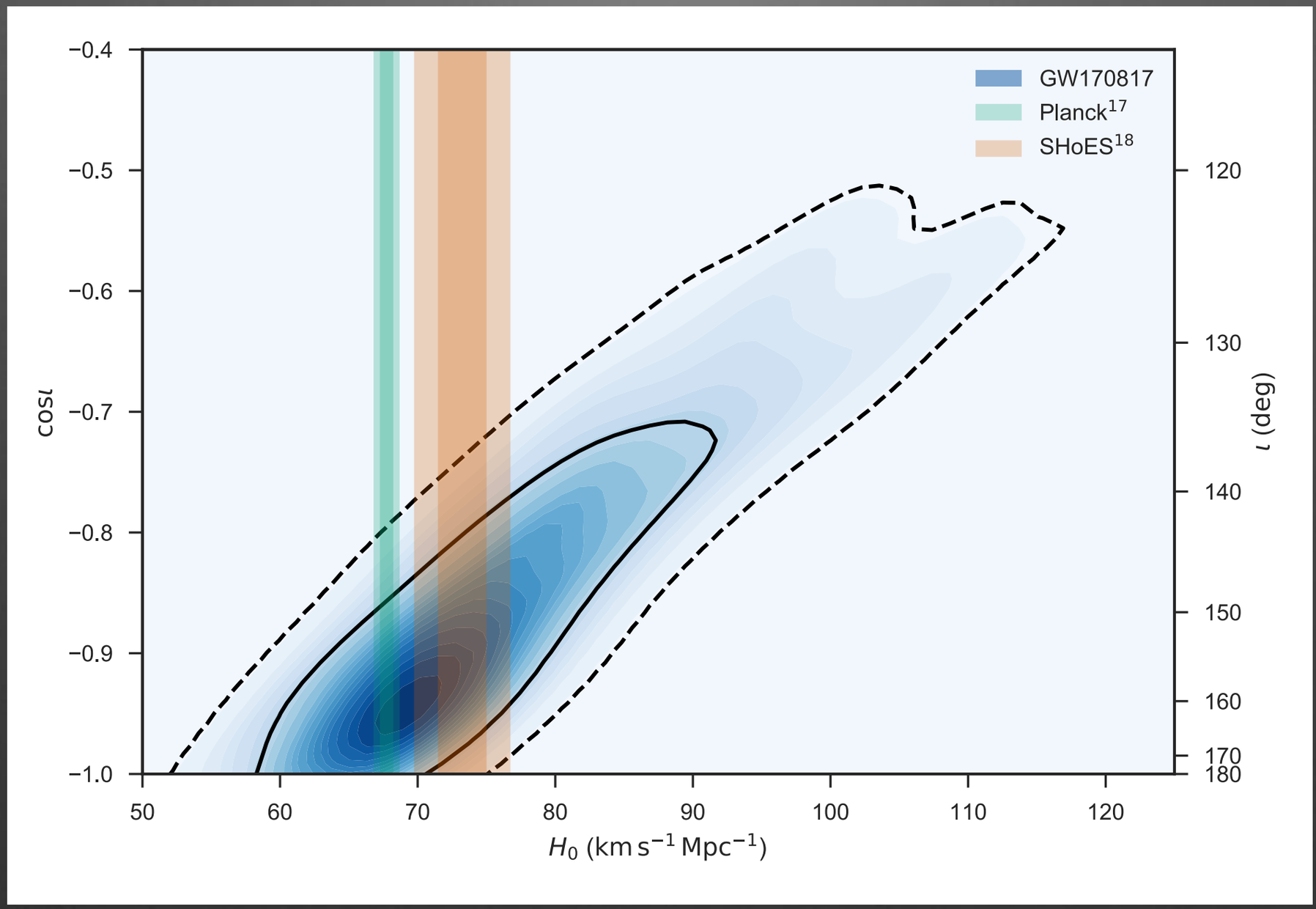
Γ>4 at ~150d and Δθ<0.25 rad (point approx.)

Picture of GW170817 after VLBI



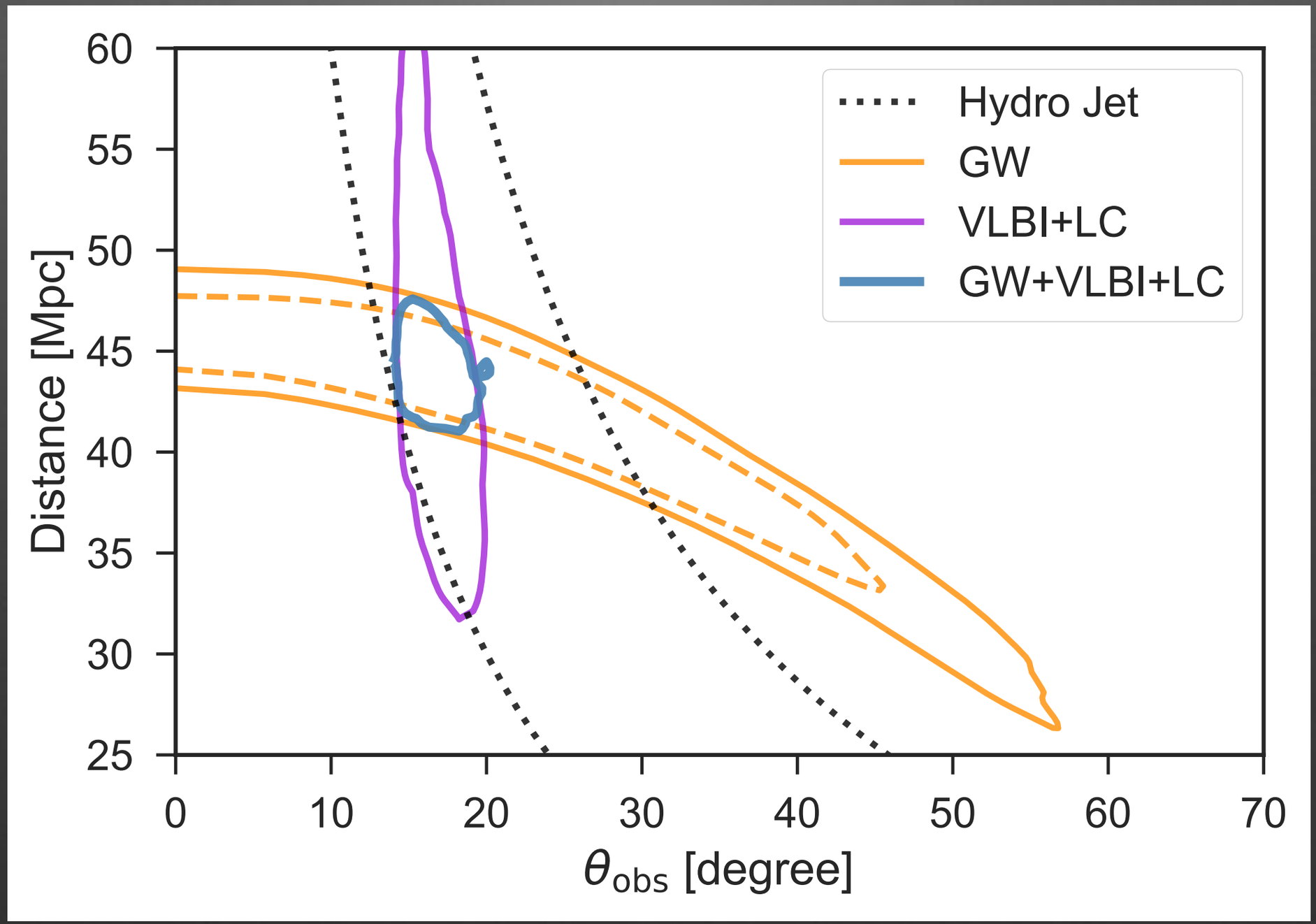
Mooley et al (2018)

Hubble constant



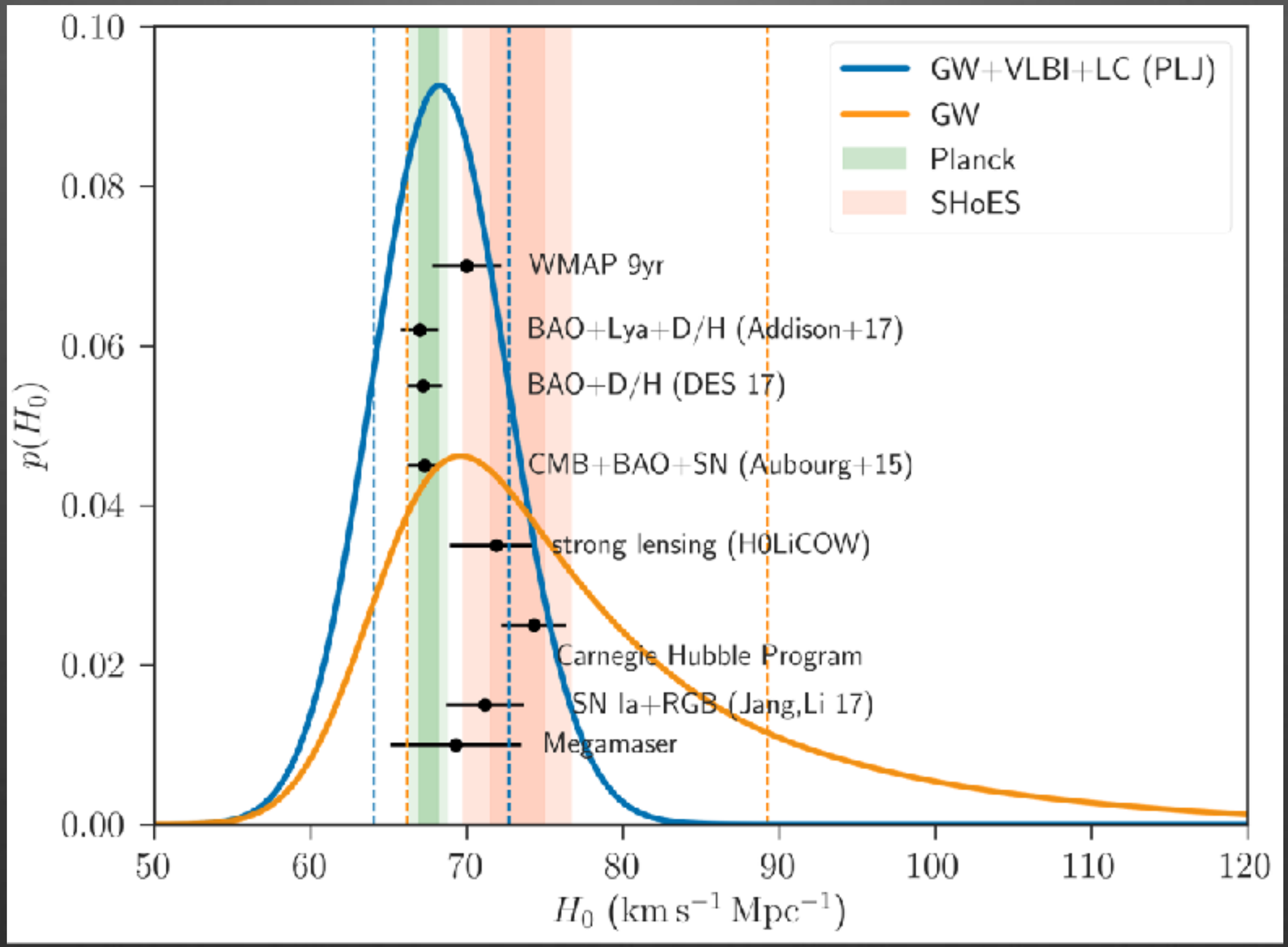
Abbott et al 2017

VLBI constraint



KH et al 2018

Hubble constant (LIGO + VLBI + light curve)



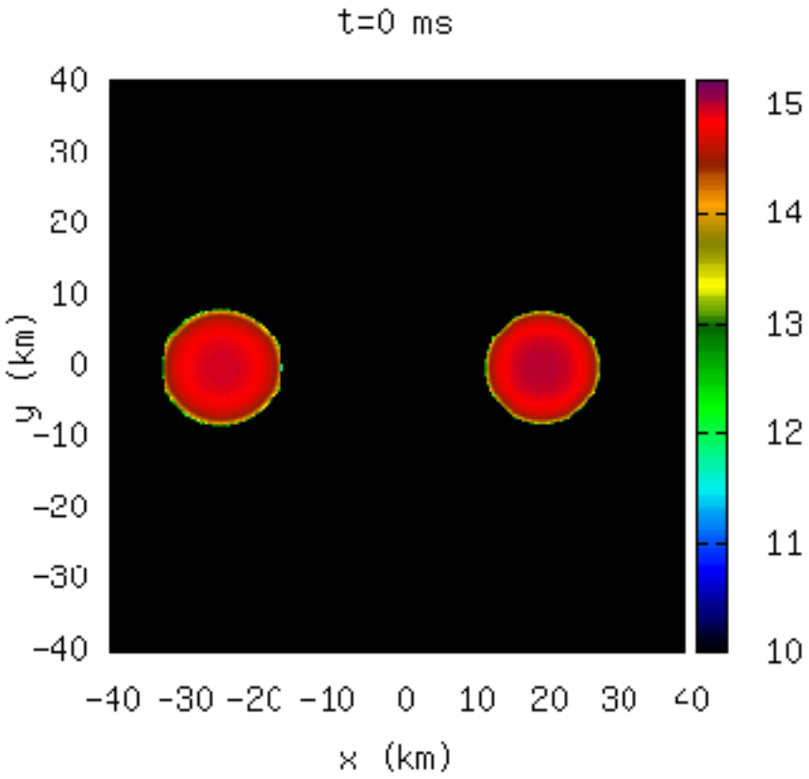
KH et al 2018

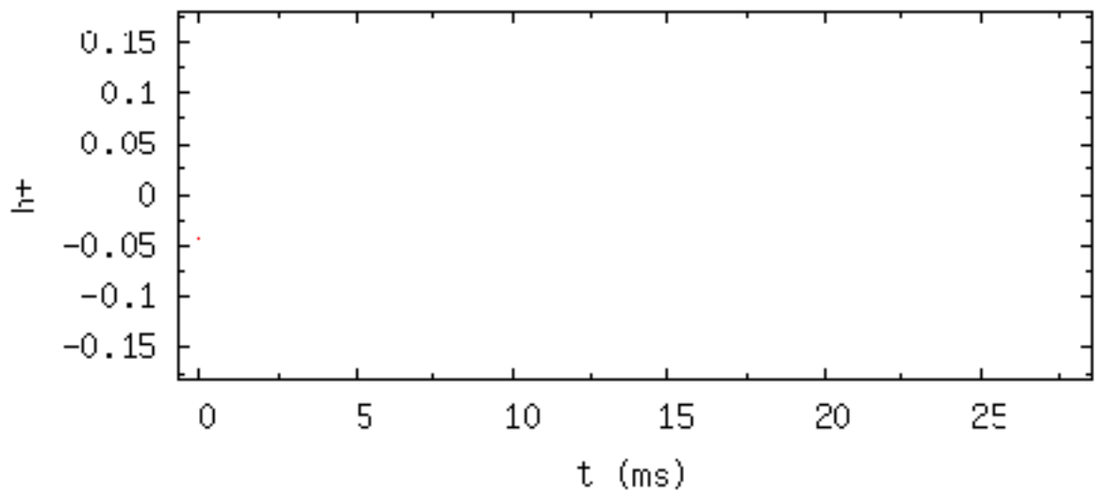
Summary

Last 10ms and after merger

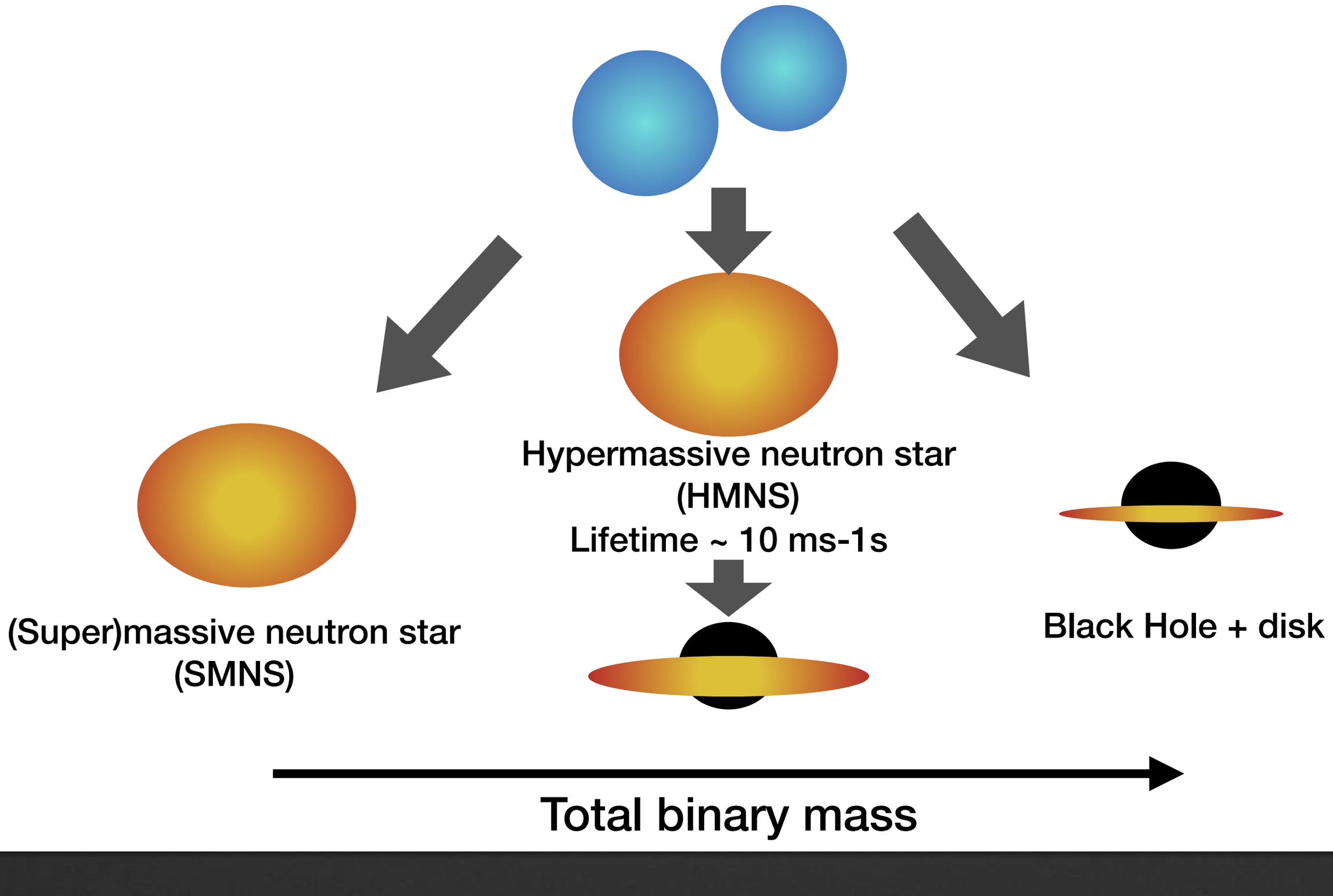
Hotokezaka + 2013

1.3-1.6Msun, EOS=APR



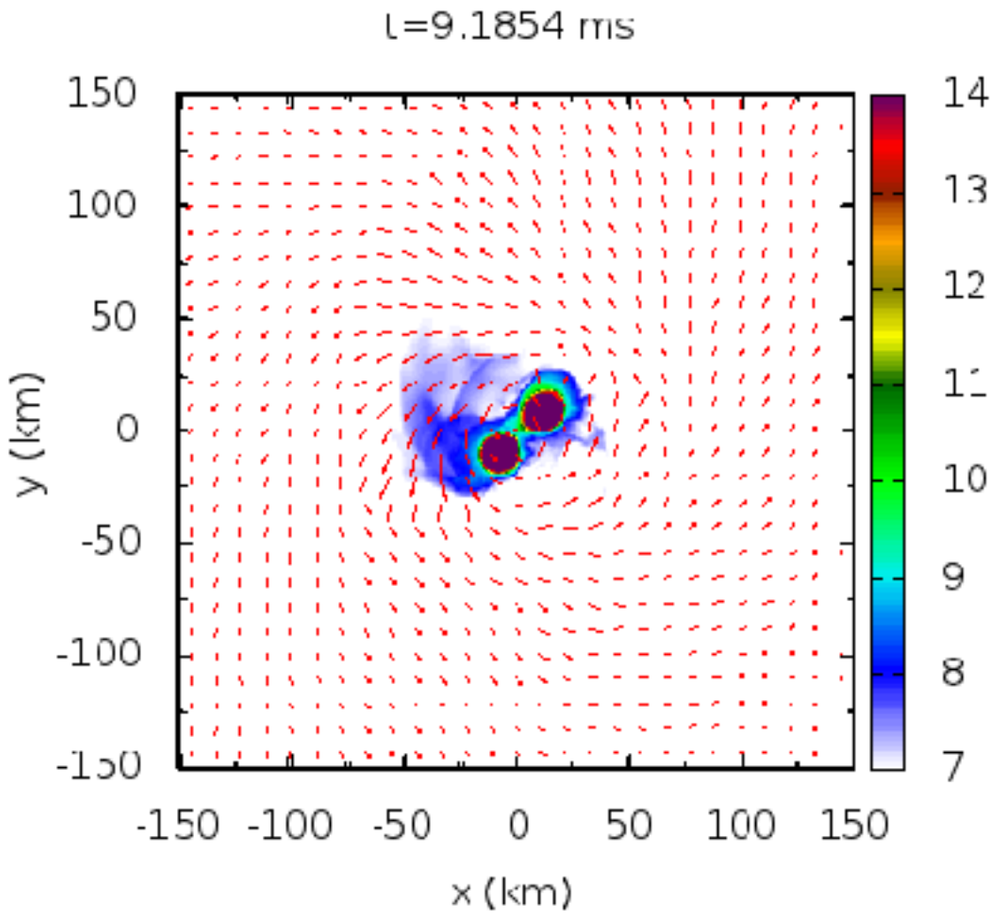


Fates of mergers

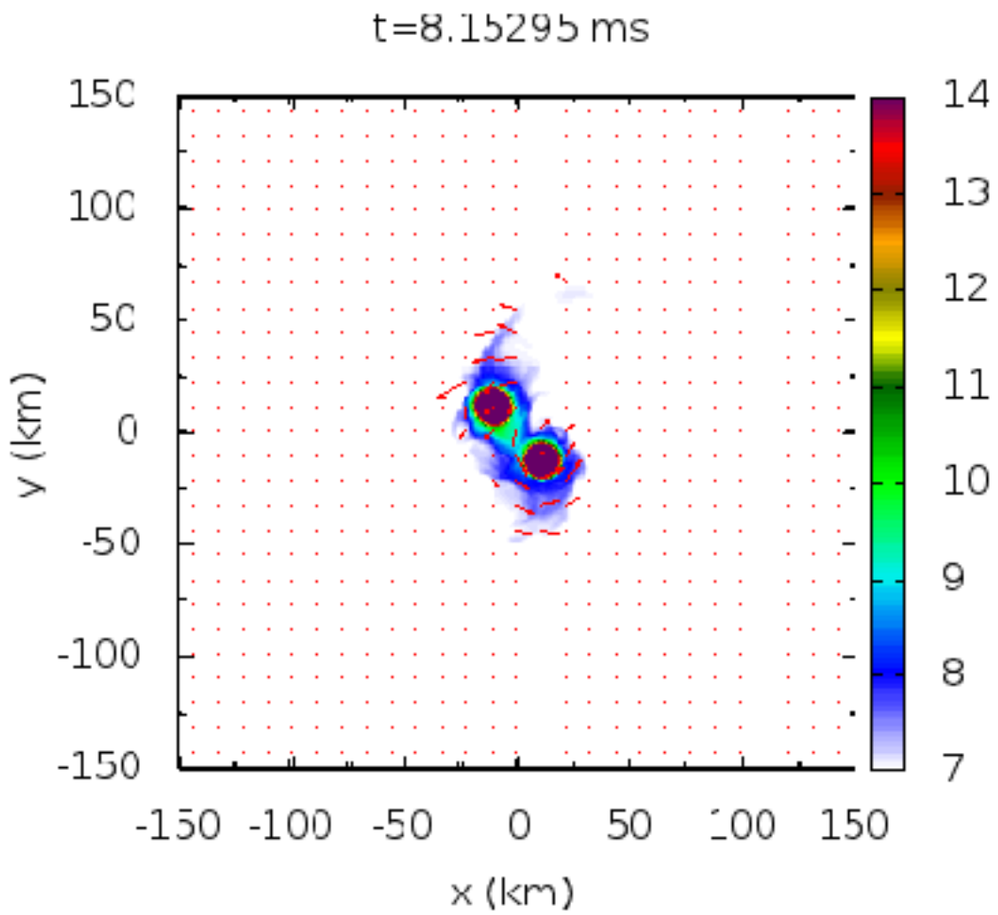


Dynamical mass ejection

$1.5M_{sun}$ and $1.2M_{sun}$

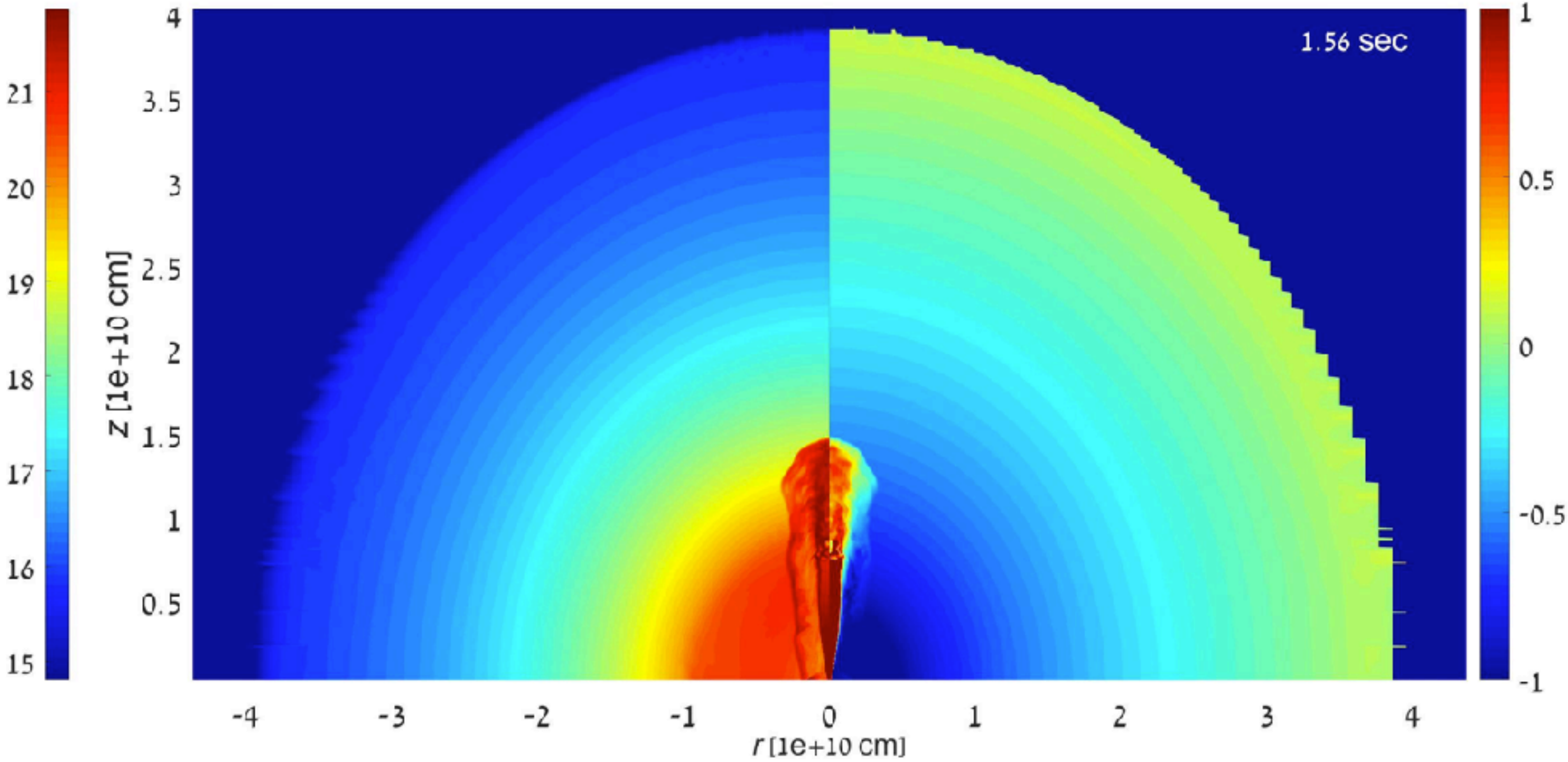


$1.6M_{sun}$ and $1.3M_{sun}$



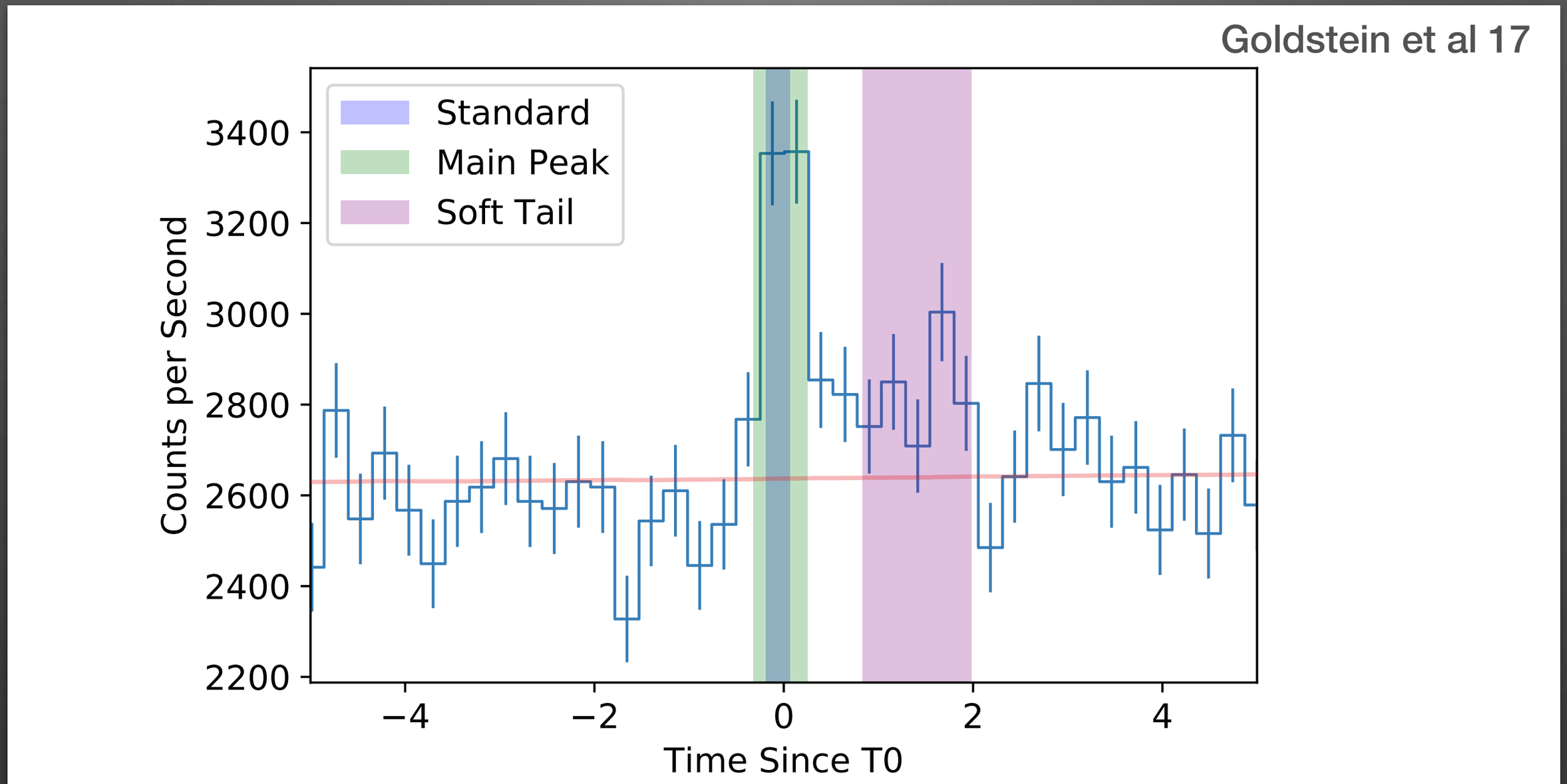
KH+ PRD 2013

also Bauswein + 13, Piran + 13, Rosswog 2013, Kyutoku+15, Sekiguchi + 15, 16, Radice+16


1.56 sec
z [1e+10 cm]
r [1e+10 cm]
21
20
19
18
17
16
15
4
3.5
3
2.5
2
1.5
1
0.5
-4
-3
-2
-1
0
1
2
3
4
1
0.5
0
-0.5
-1

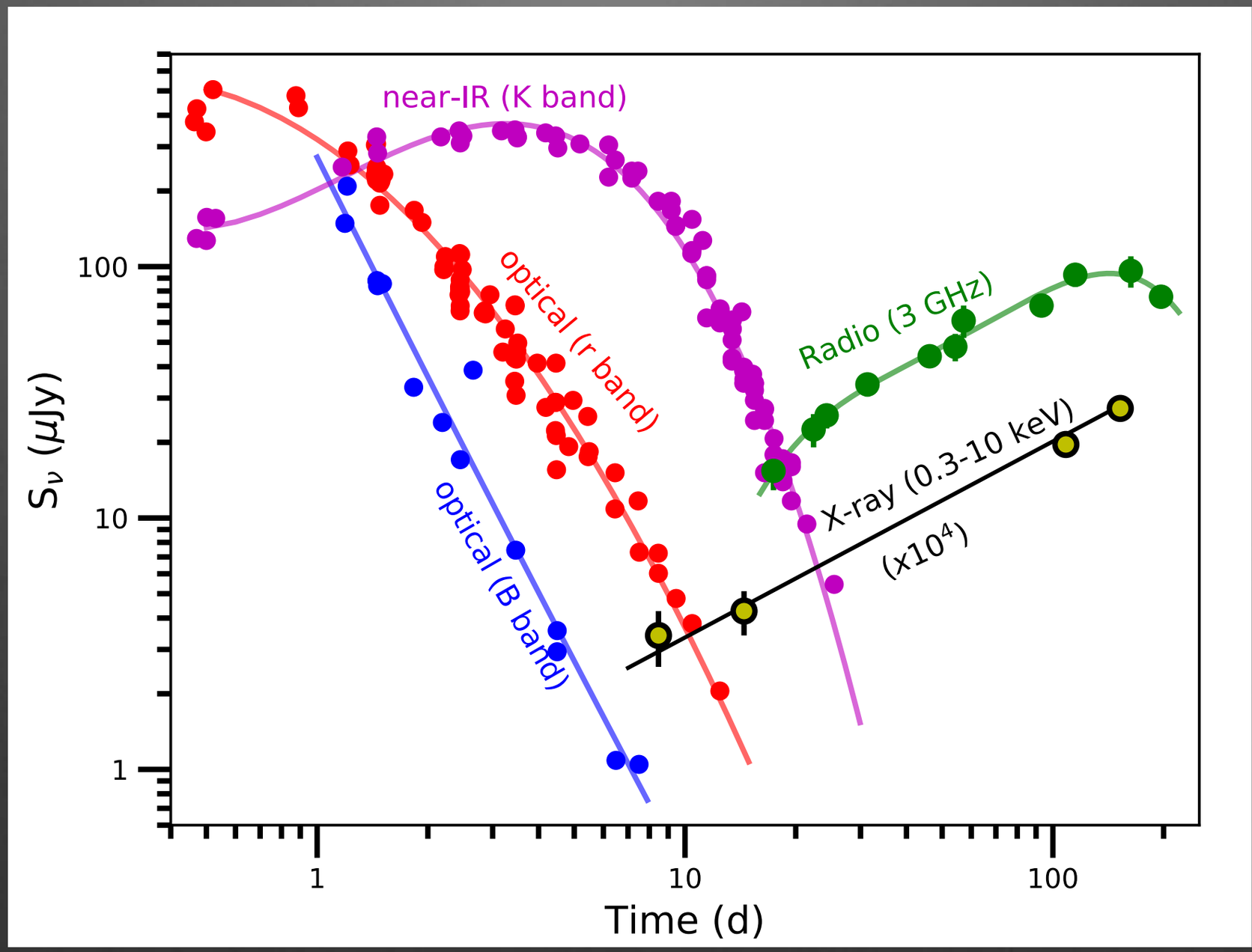
Gottlieb + 17

GRB 170817A

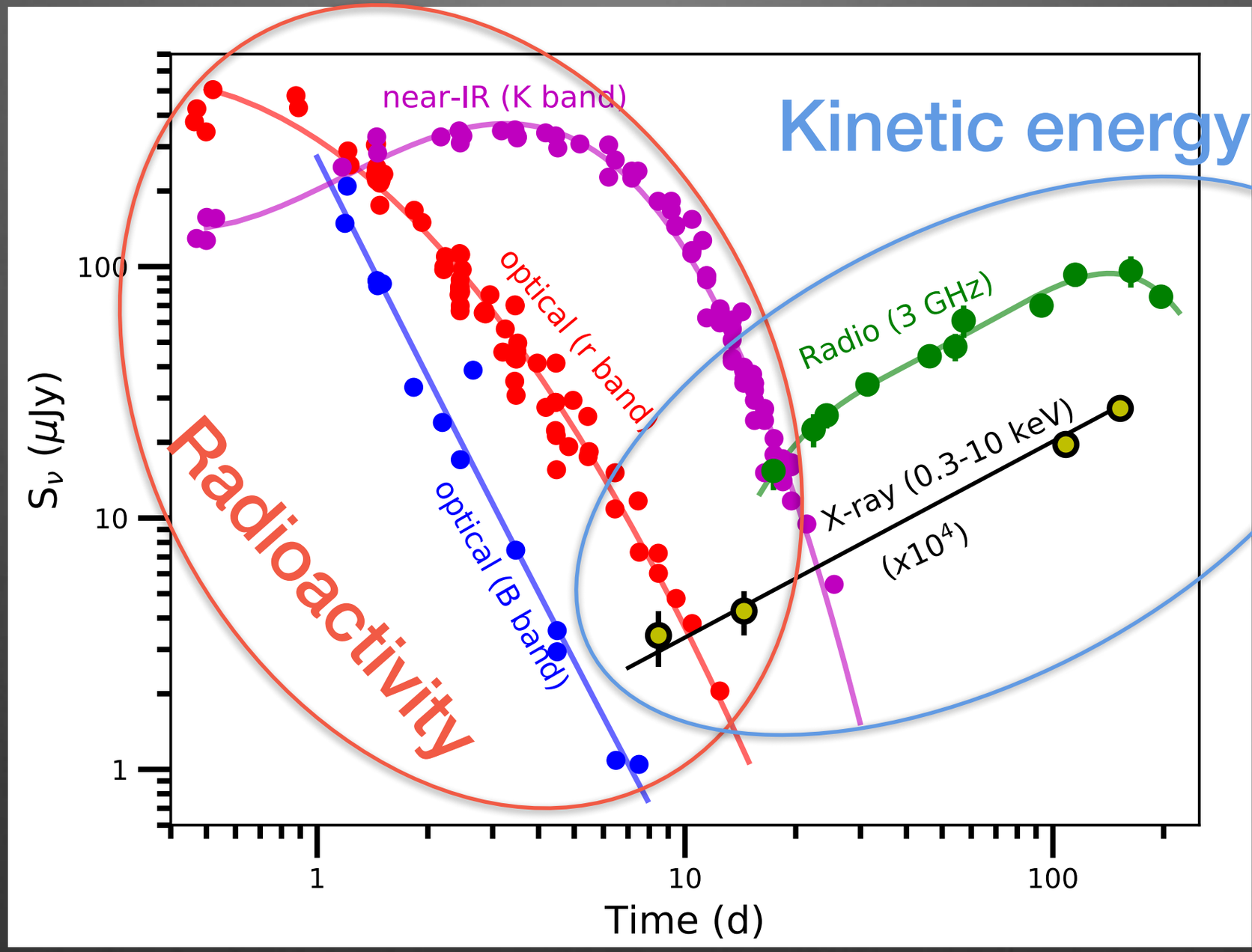


- 1.8 sec delay from the merger and Duration ~ 2 sec.

Kilonova & Afterglow

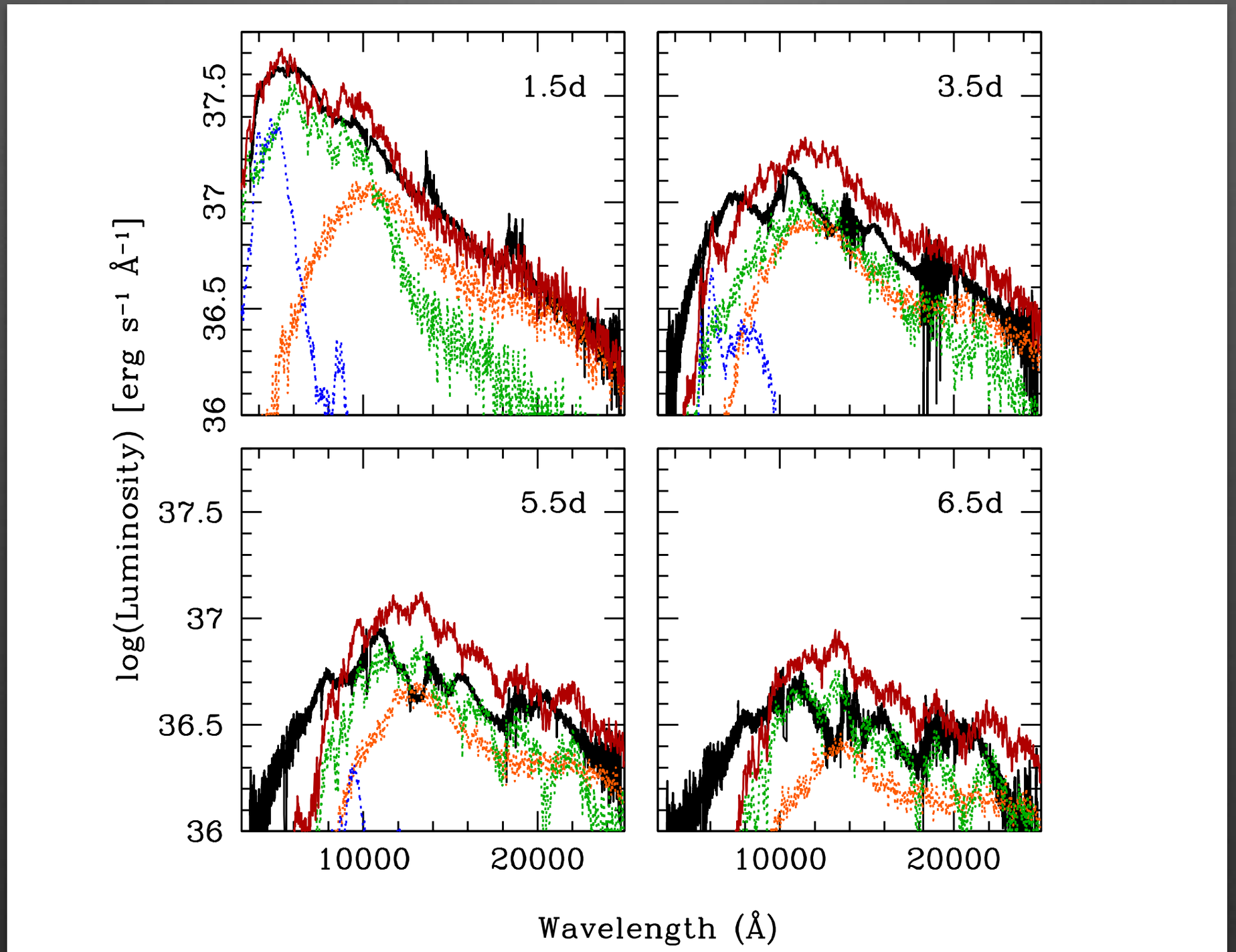


Kilonova & Afterglow



Kilonova: Ejecta mass 0.05Msun (radioactive material), v~0.2c
Afterglow: Kinetic energy $E\sim10^{50}$ erg, $\Gamma>4$

Kilonova Spectrum



Pian + 17

Unsolved Issues

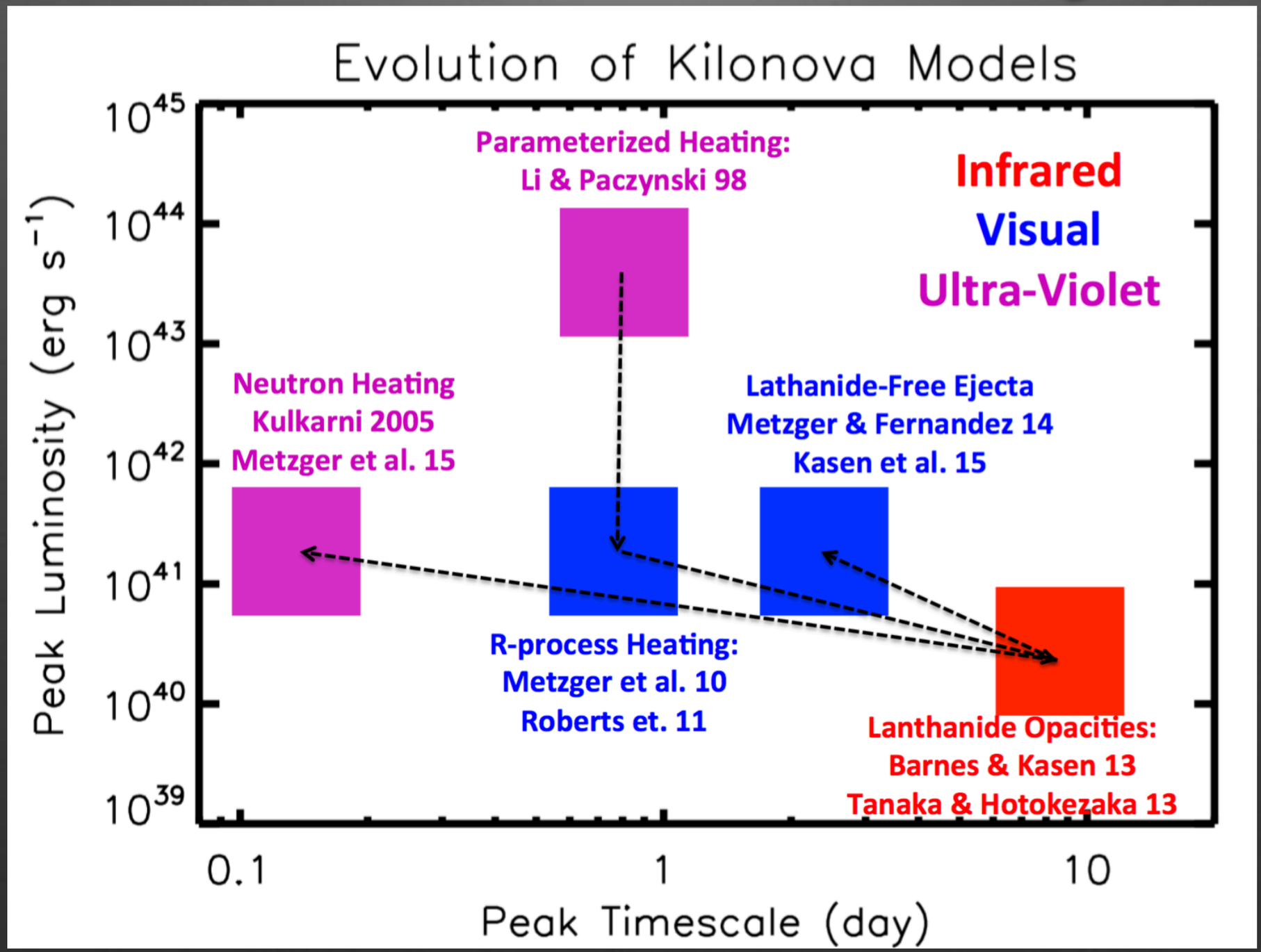
1, Central object and EM counterpart

- What is the merger remnant of GW170817?
- Can we distinguish BH-NS merger from NS-NS using EM counterparts ?
- How did the merger remnant produce a jet?
- What is the role of magnetic field?
- Do we understand the role of neutrinos well?

Unsolved Issues

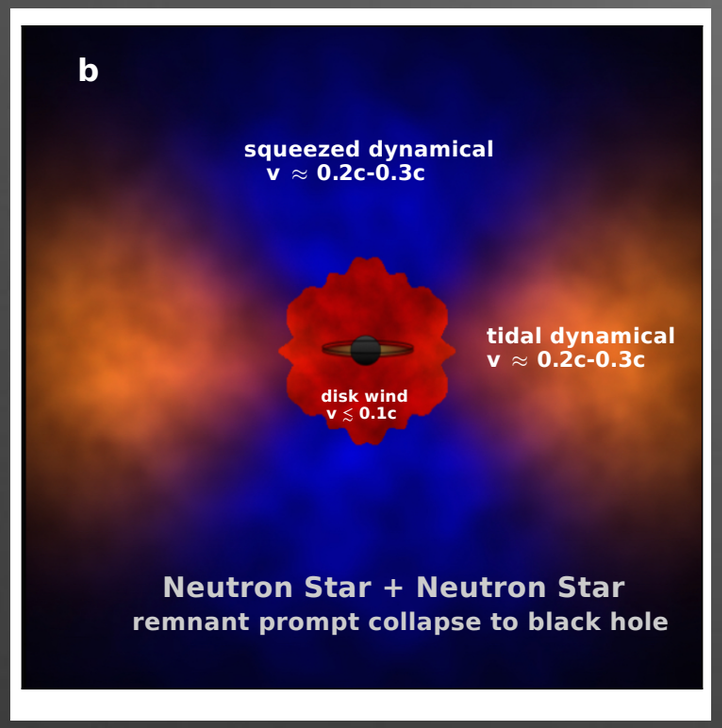
2, Blue and Red

Metzger 2017



Unsolved Issues

2, Blue and Red



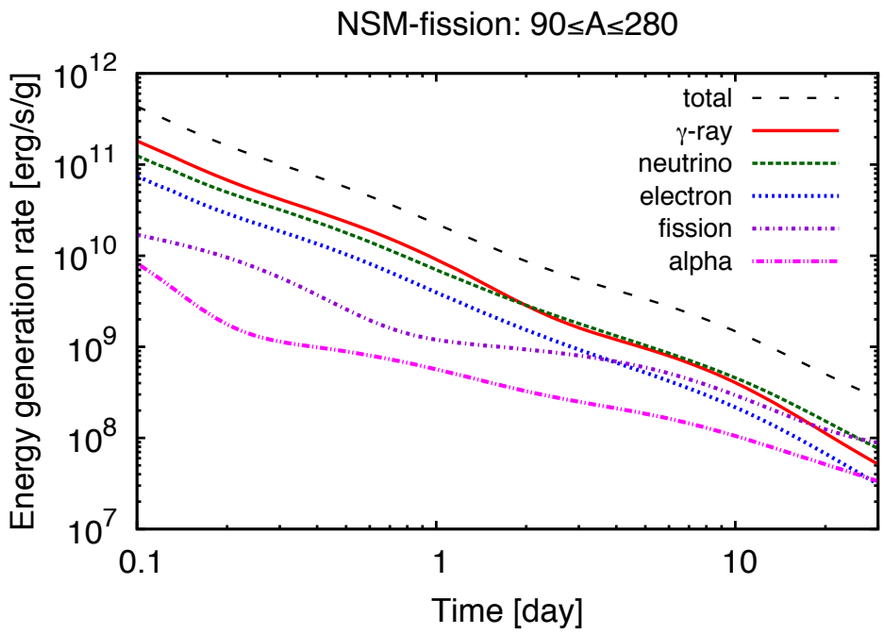
The photometry data and spectrum require both

- low opacity (light elements) at early times
- high opacity (heavy elements) at later times

The origin of these elements is not well understood.

Unsolved Issues

3, Late time kilonova behavior

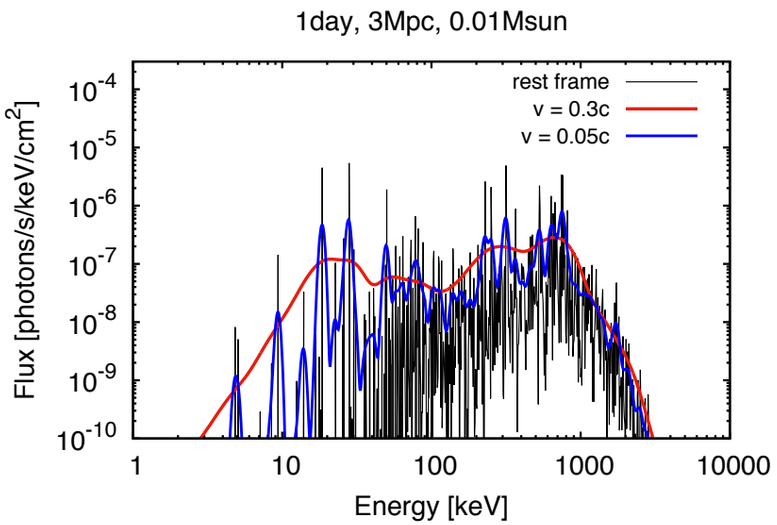


Fission and alpha-decay can dominate the heating at late times.

Can we identify these super-heavy elements?

How kilonova nebulae should look like? (τ<1)

4, What can be the proof of r-process in mergers?



e.g catch escaping γ-rays from beta decay

Success in type Ia supernova

SN 2014J: ^{56}Ni -> ^{56}Co

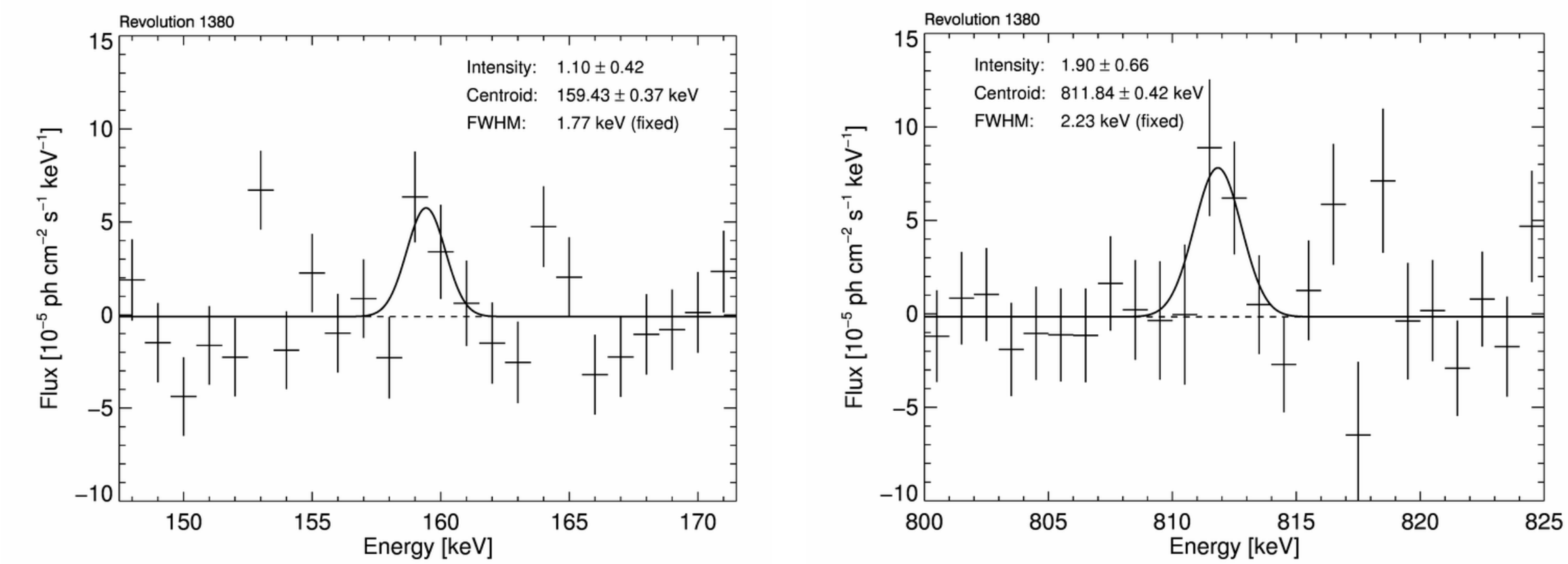
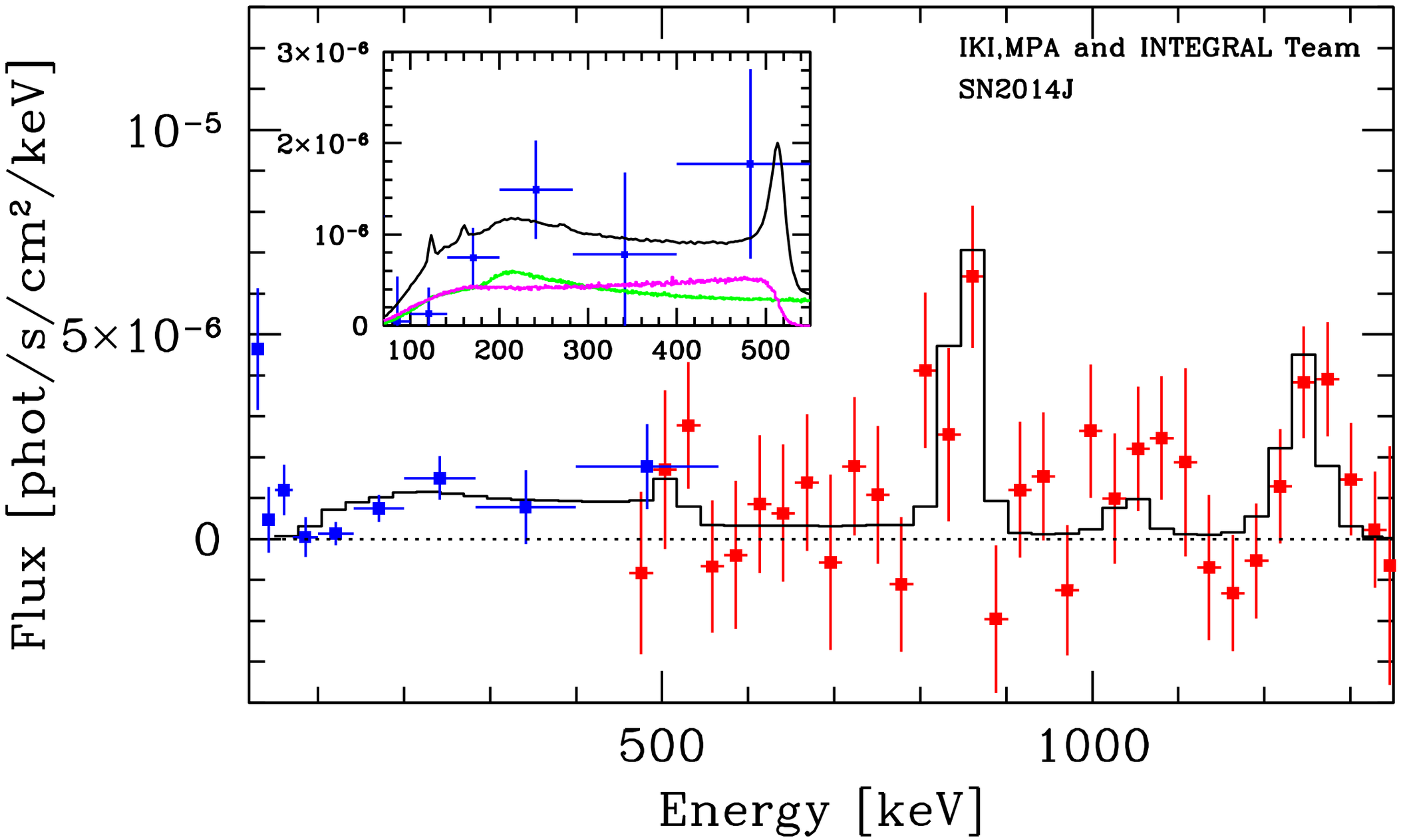


Fig.1: Gamma-ray spectra measured with SPI/INTEGRAL from SN2014J. The observed three-day interval around day 17.5 after the explosion shows the two main lines from ^{56}Ni decay. In deriving these spectra, we adopt the known position of SN2014J, and use the instrumental response and background model. Error bars are shown as 1σ. The measured intensity corresponds to an initially-synthesized ^{56}Ni mass of 0.06 $M_{\odot}$.

Diehl + 2014

SN 2014J: ^{56}Co -> ^{56}Fe



Churazov + 2016

Unsolved Issues

5, Jet and GRB

- What outflow did produce GRB 170817A?
- What is the mechanism created γ-rays?
- How did the merger remnant produce a jet?
- Why the jet is so narrowly collimated?
- What is the origin of the structure of the jet?
- How accurately the viewing angle can be measured from afterglows?

Thanks!