# Magnetized jets and explosions from the merger of a Neutron star binary

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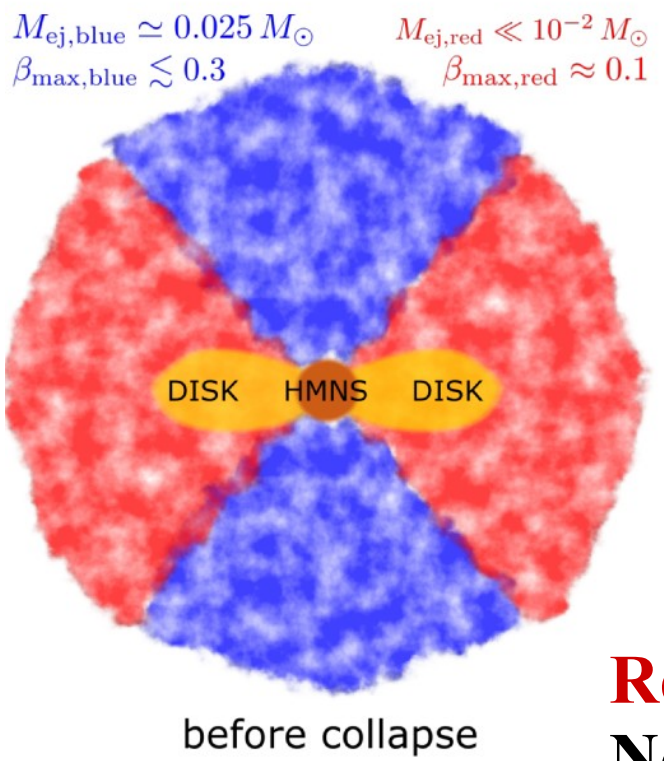
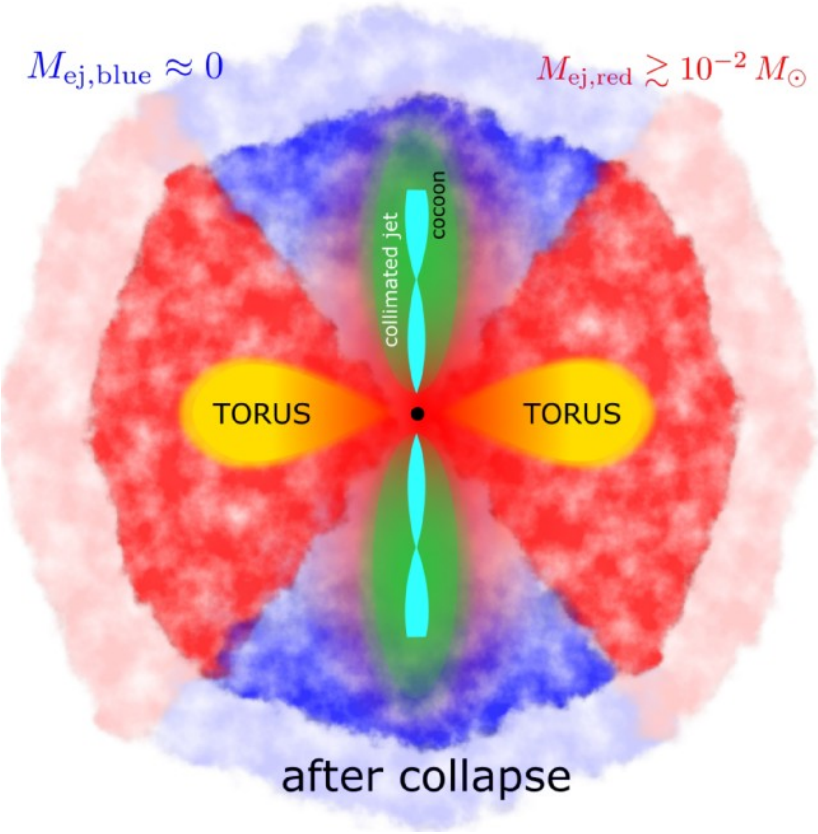
# r-process & Kilonova

"Matter that is expelled in the violent merger of two neutron stars can assemble into heavy elements such as gold and platinum in a process known as rapid neutron capture (r-process) nucleosynthesis. The radioactive decay of isotopes of the heavy elements is predicted to power a distinctive thermal glow (a 'kilonova')."



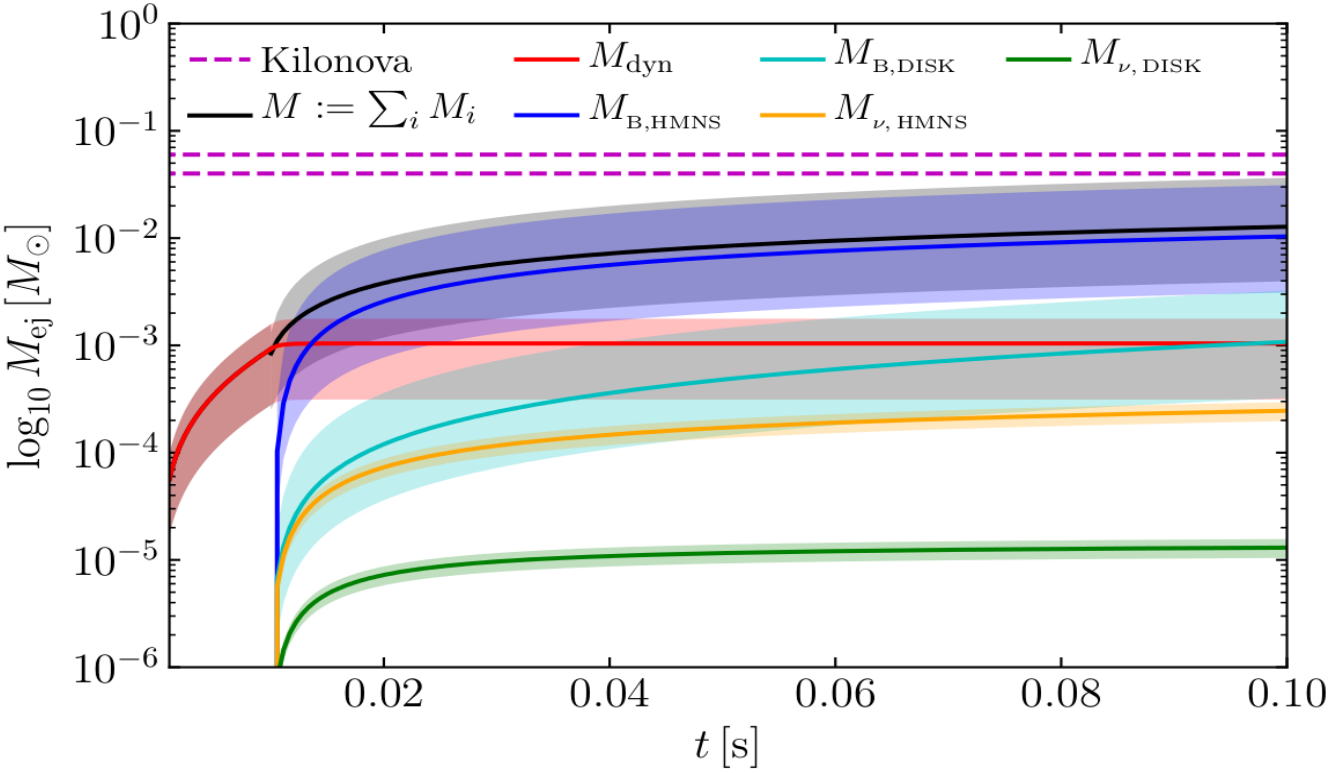

**Blue:**
**Less free neutrons**
**light r-process**
**low opacity**

**Red:**
**Neutron rich**
**Heavy r-process**
**High opacity**

Gill, Nathanail & Rezzolla 2019

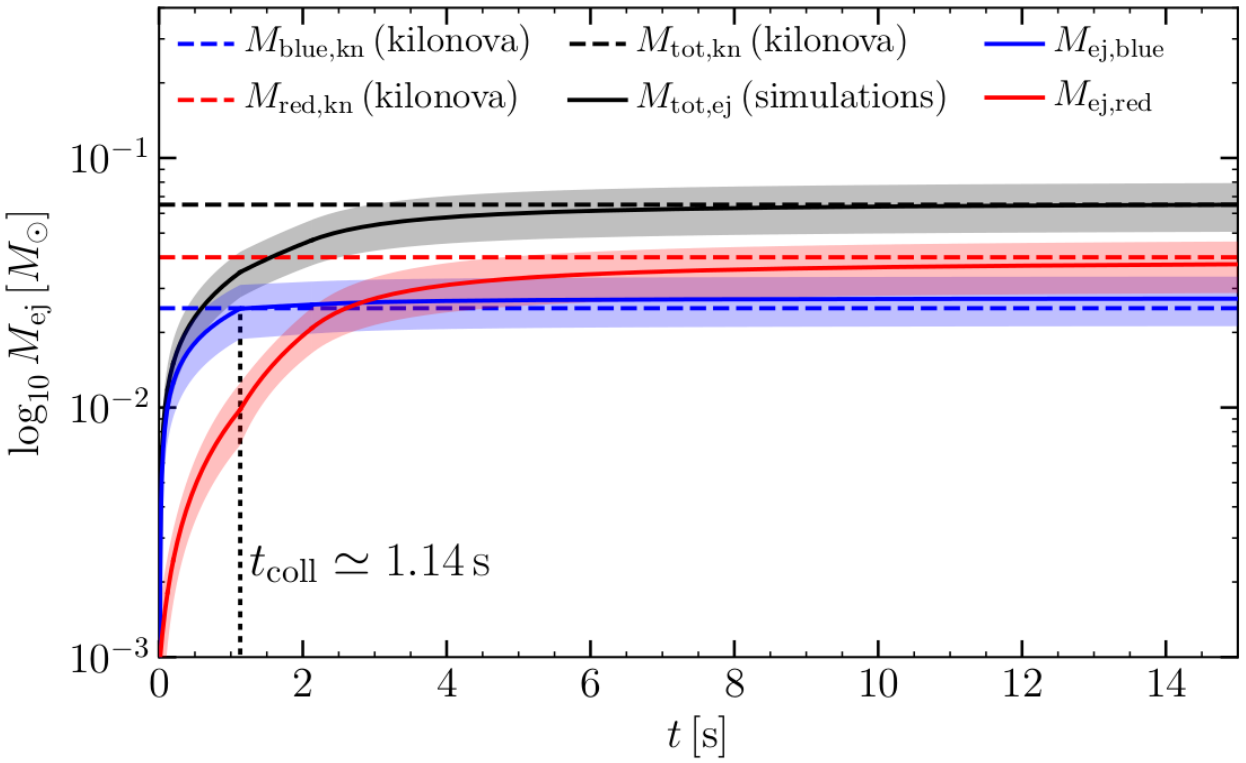
# What about GW170817?

## HMNS lifetime




Gill, Nathanail & Rezzolla 2019

# WHEN DID THE REMNANT OF GW170817 COLLAPSE TO A BLACK HOLE?

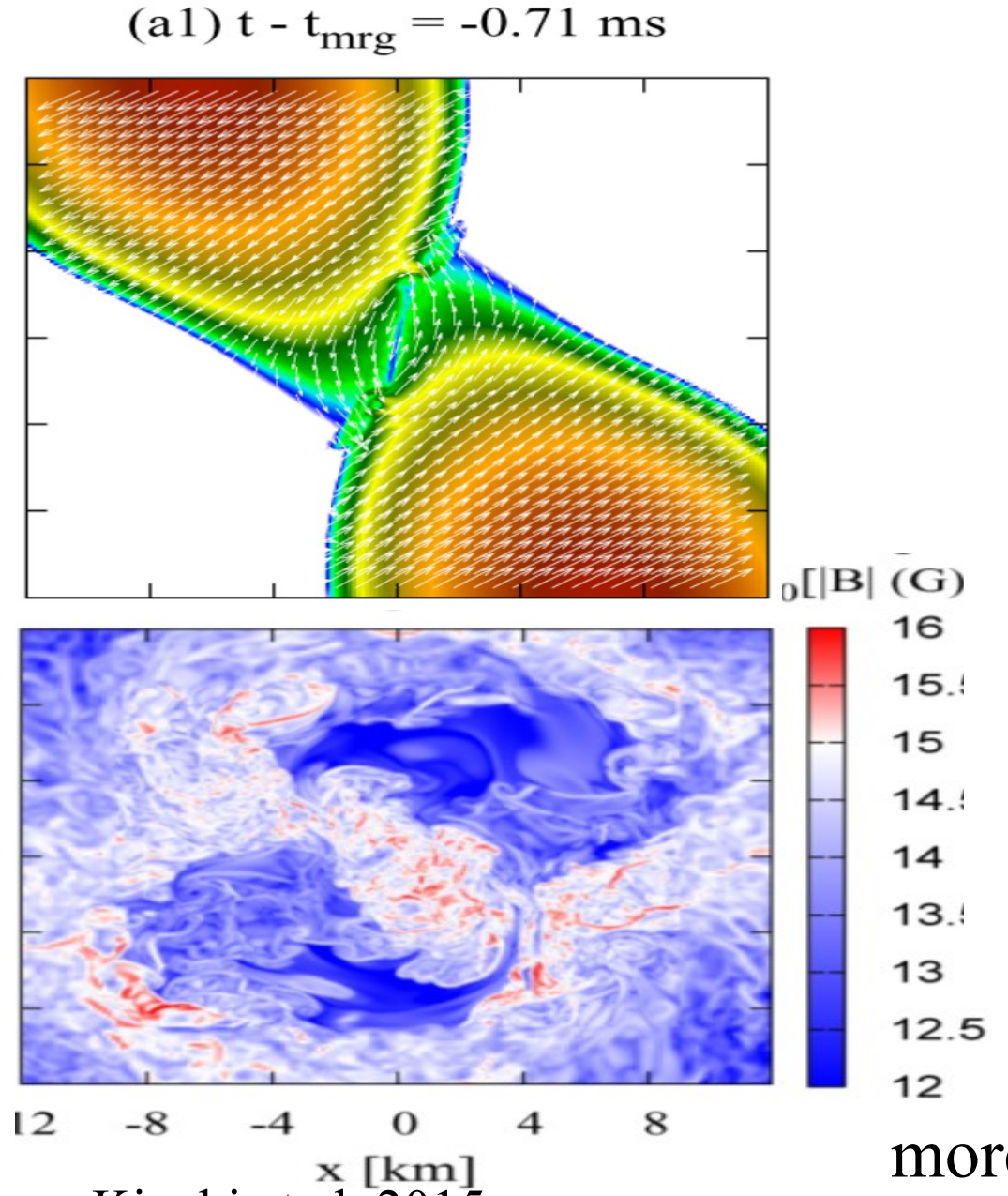



$$t_{\rm coll} = 0.98^{+0.31}_{-0.26}\ {\rm s}$$

$$t_{\rm del} = 1.74 \pm 0.05\,{\rm s} = t_{\rm coll} + t_{\rm br}(t_{\rm coll}) + t_R$$

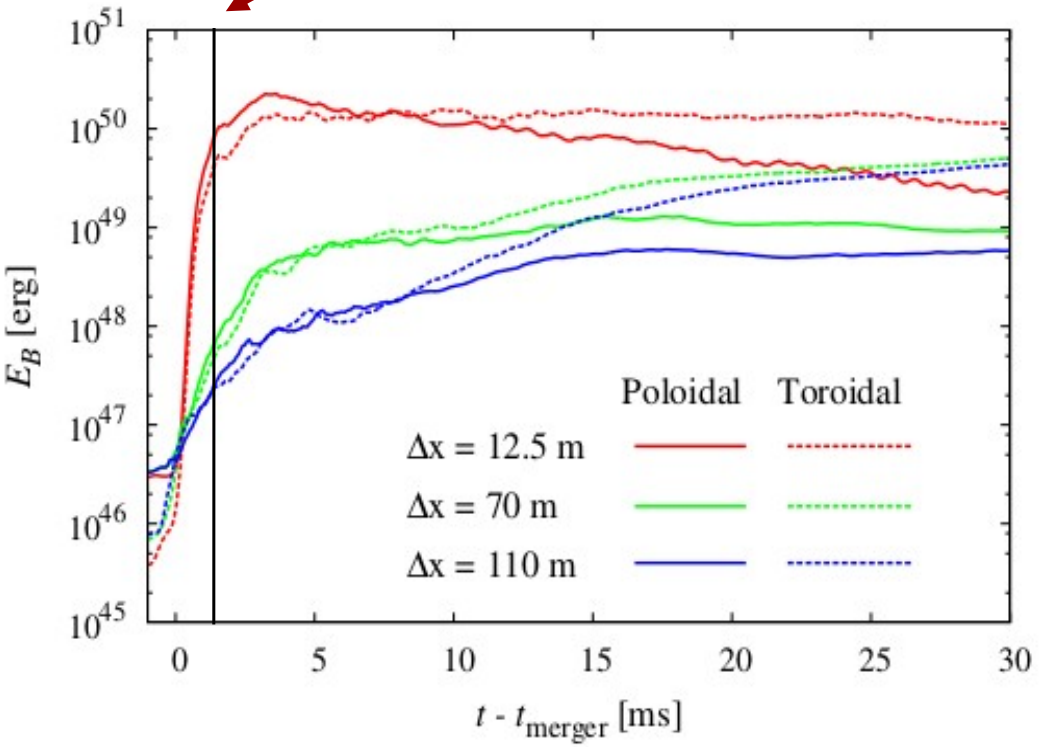
Gill, Nathanail & Rezzolla 2019

# Magneti field amplification




Kiuchi et al. 2015

at 1 ms

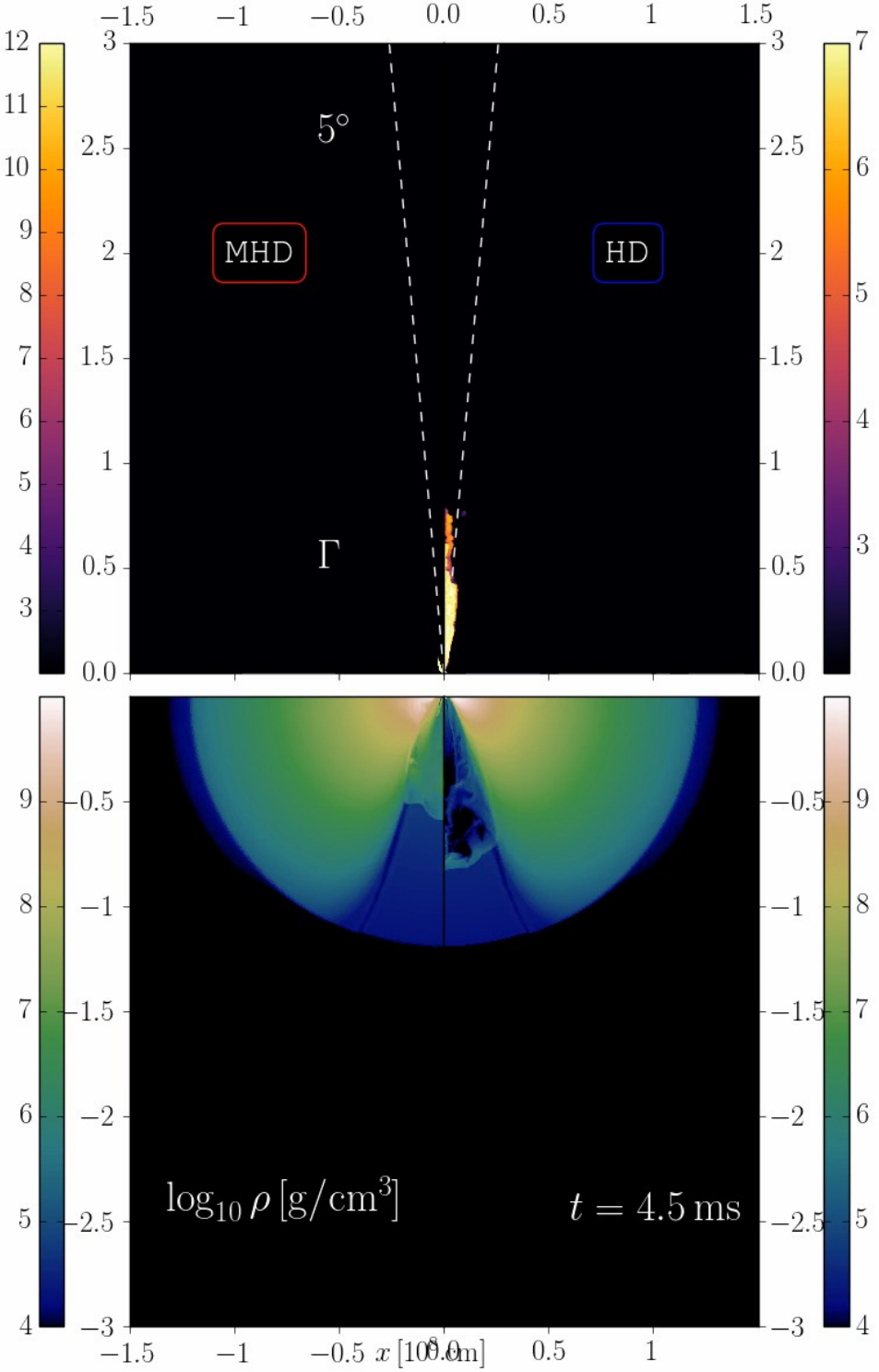



Kiuchi et al. 2017

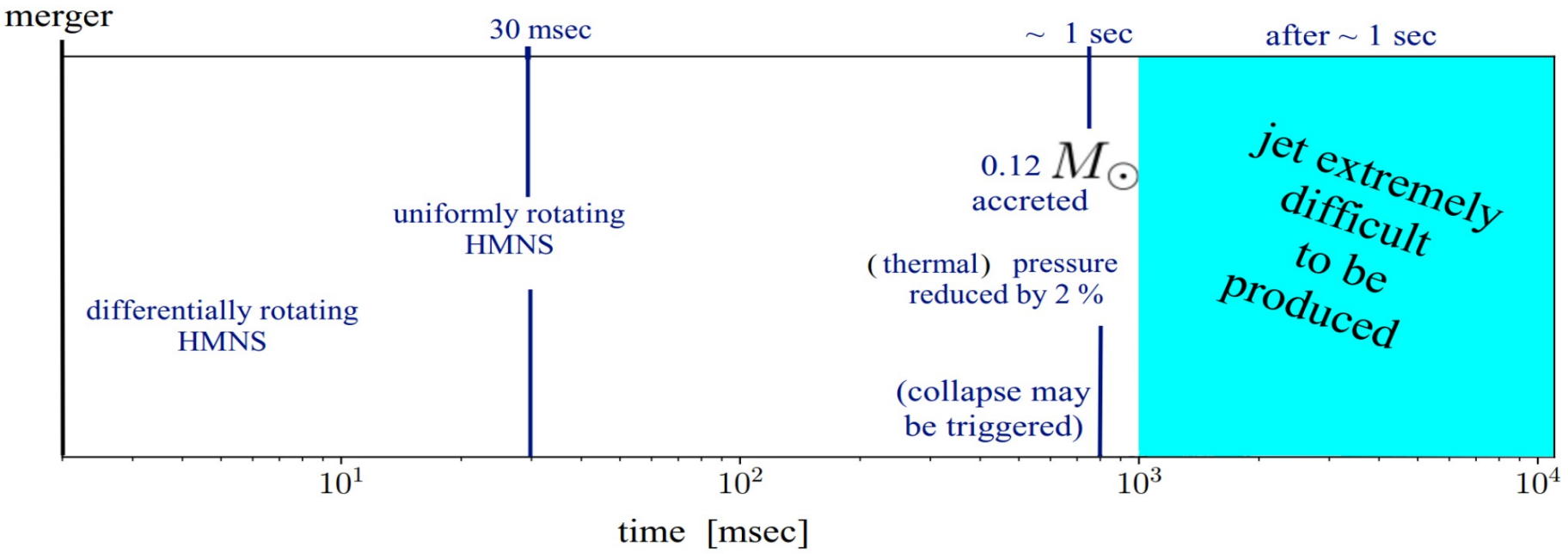
more than $10^{50}$ erg

# Short gamma-ray burst jets

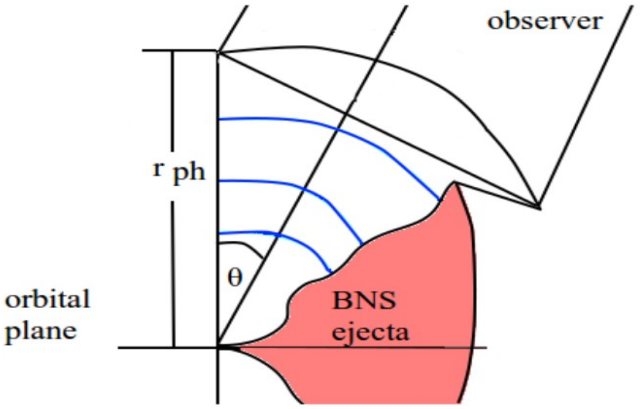
## (MHD vs HD)



# collapse after 1sec ⟶ no jet & short-GRB



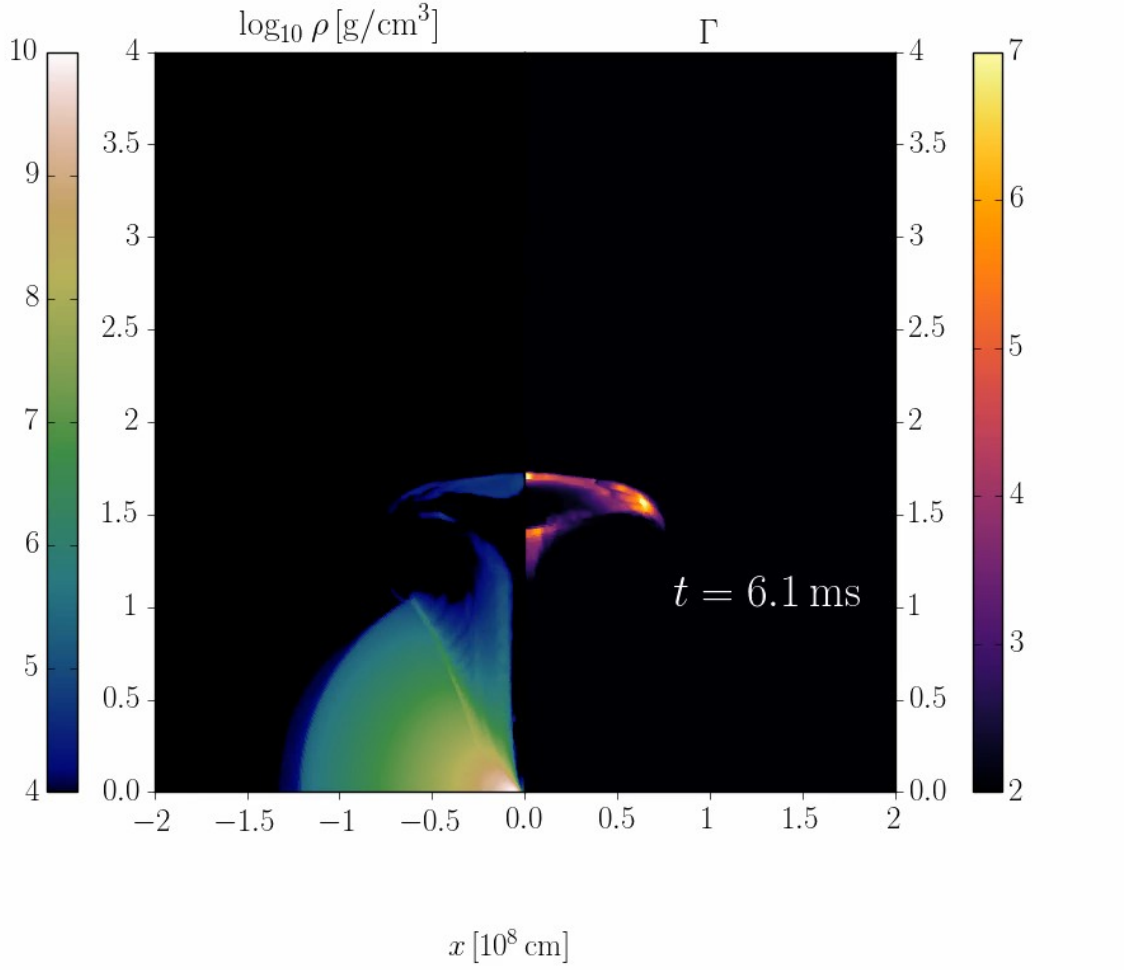

$$B^2_{HMNS}/8\pi \gg 2.6 \times 10^{28}\, dyn/cm^2 \sim \dot{M}c/4\pi r^2_{BH}.$$




The collapse of the compact remnant powers an explosion.....

Nathanail 2018

# Jet or Explosion?

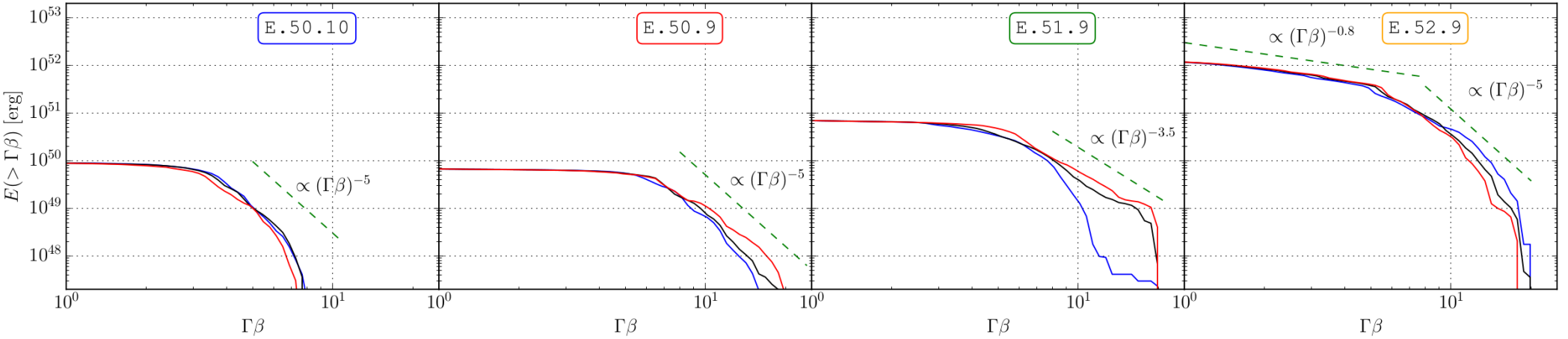


# Jet or Explosion?

A mildly relativistic wide-angle outflow
in the neutron-star merger event
GW170817 (Mooley et al. 2018)

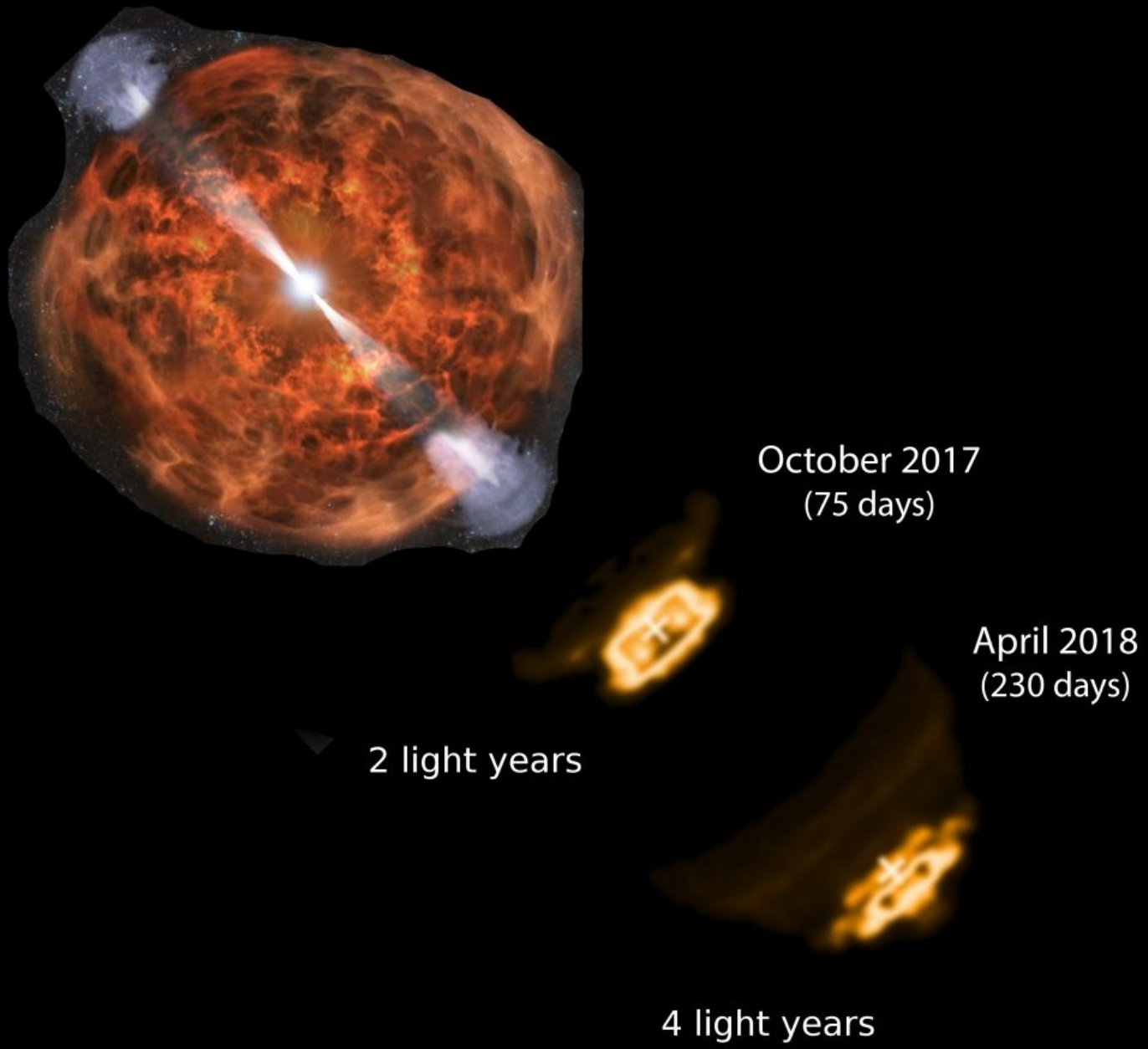
$$E(>\Gamma\beta) \propto (\Gamma\beta)^{-\alpha},$$

with $\alpha = 5$




Nathanail, Porth & Rezzolla 2019

# Superluminal motion

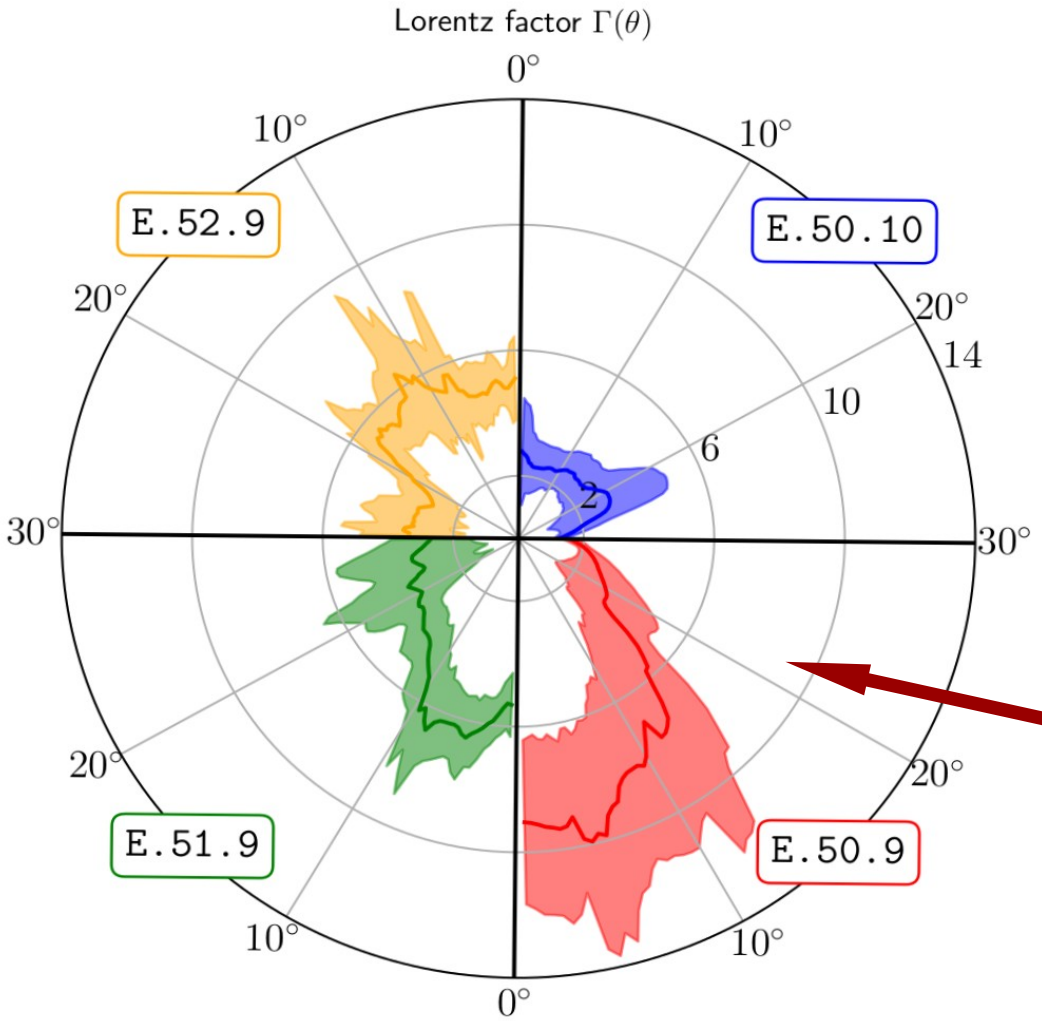


# Jet or Explosion?

## Superluminal motion of a relativistic jet in the neutron-star merger GW170817

(Mooley et al. 2018)

"[...] We conclude that [...] at day 150, the emission is most probably dominated by a narrow component with $\theta_s \ll 0.25$ rad (~ 14 degrees) and $\Gamma \sim 4$ (Lorentz factor)".

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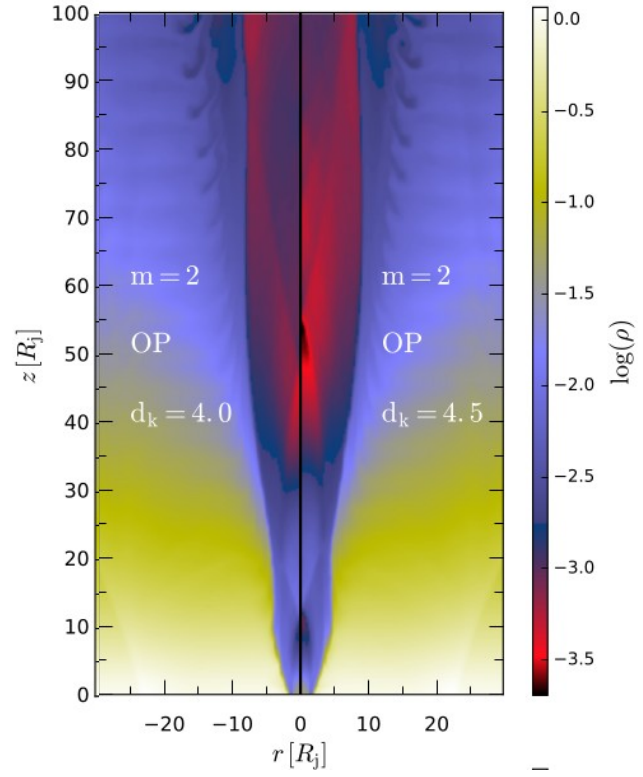
# Afterglow from GR-MHD (3D to 1D)




2D or 3D

GR-MHD start at $10^5$ cm and
Stops at ~ $10^9$ cm

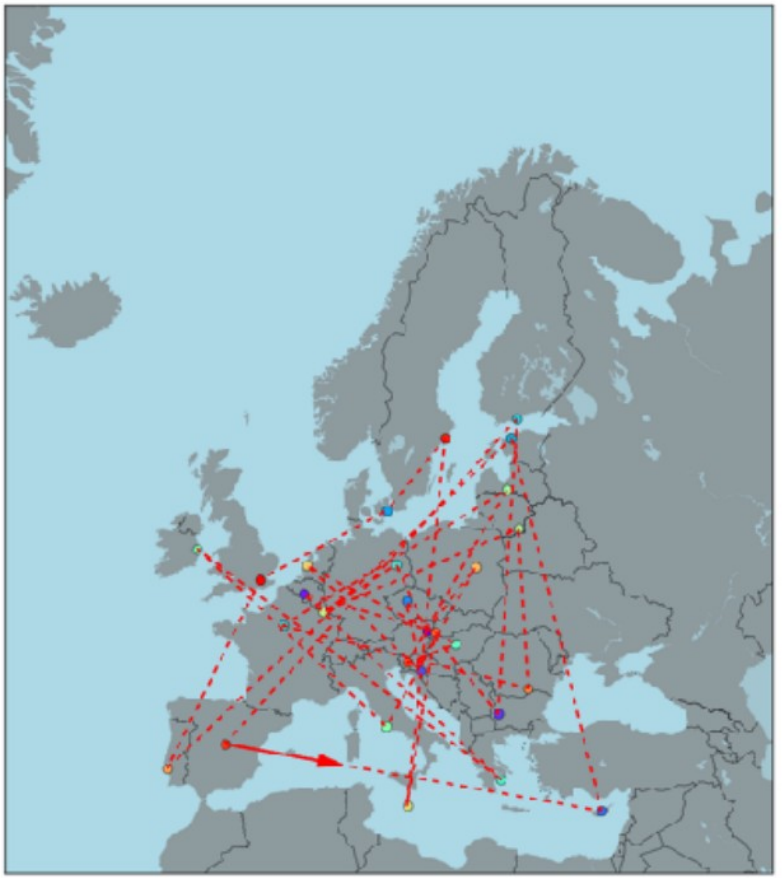
1D for every θ-angle

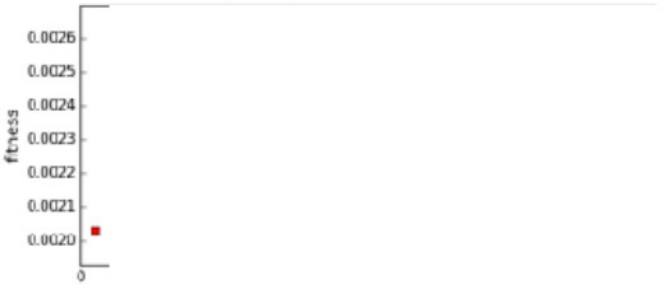
go till $10^{16}$ cm
Calclulate afterglow self-consistently

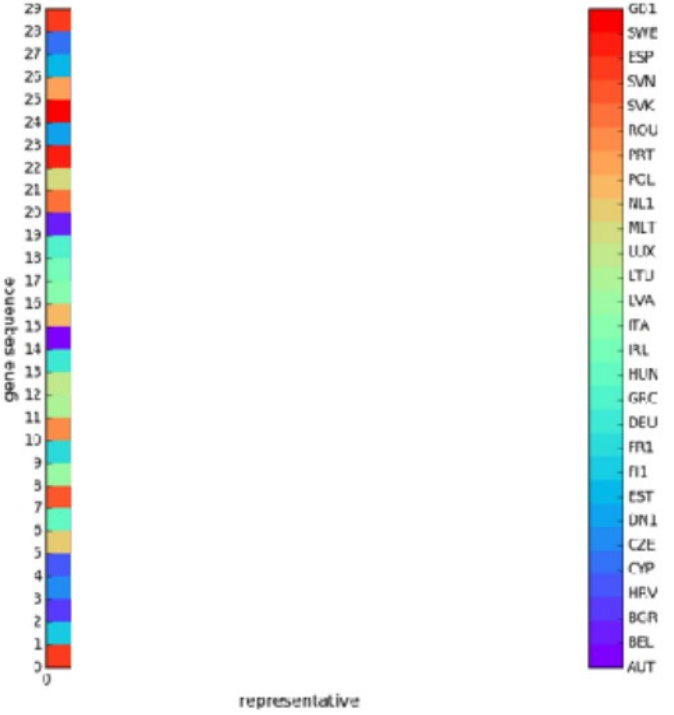
# Genetic algorithm

Travelling Sales Man Problem —> visit EU capitals (28)

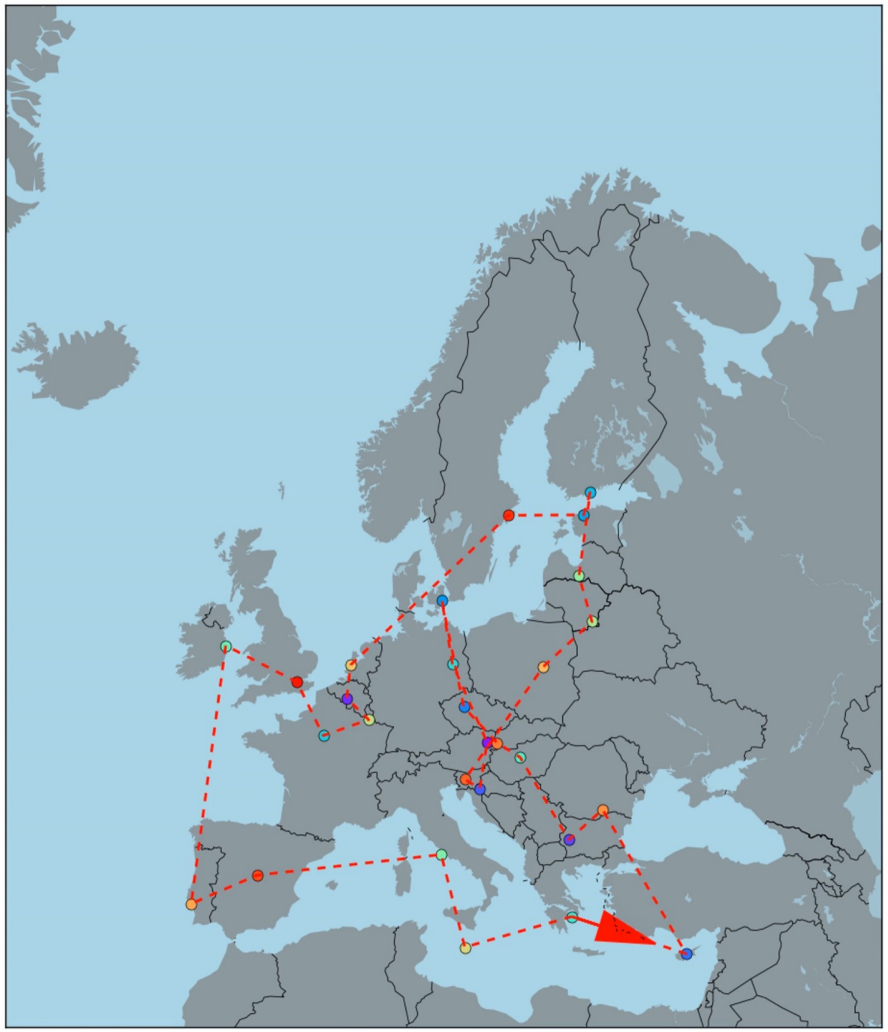
fitness function —> $\mathrm{ft} = \frac{1}{\sum_{i=0}^{n+1} s_i}$

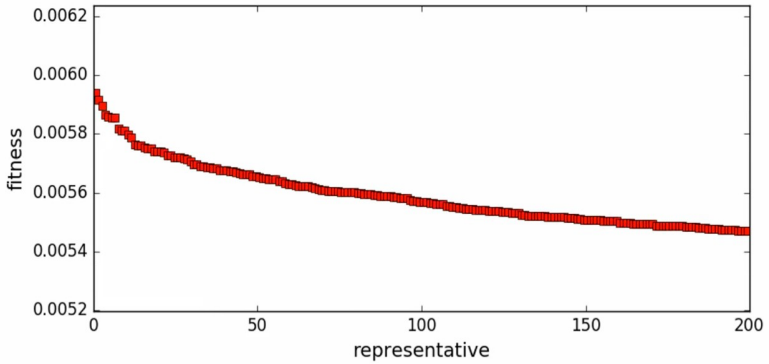


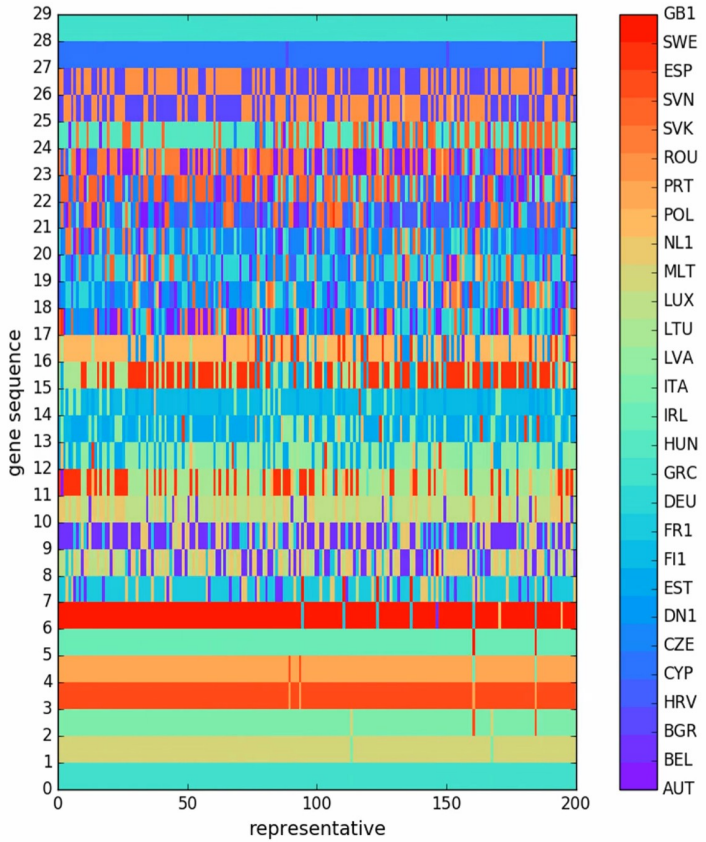


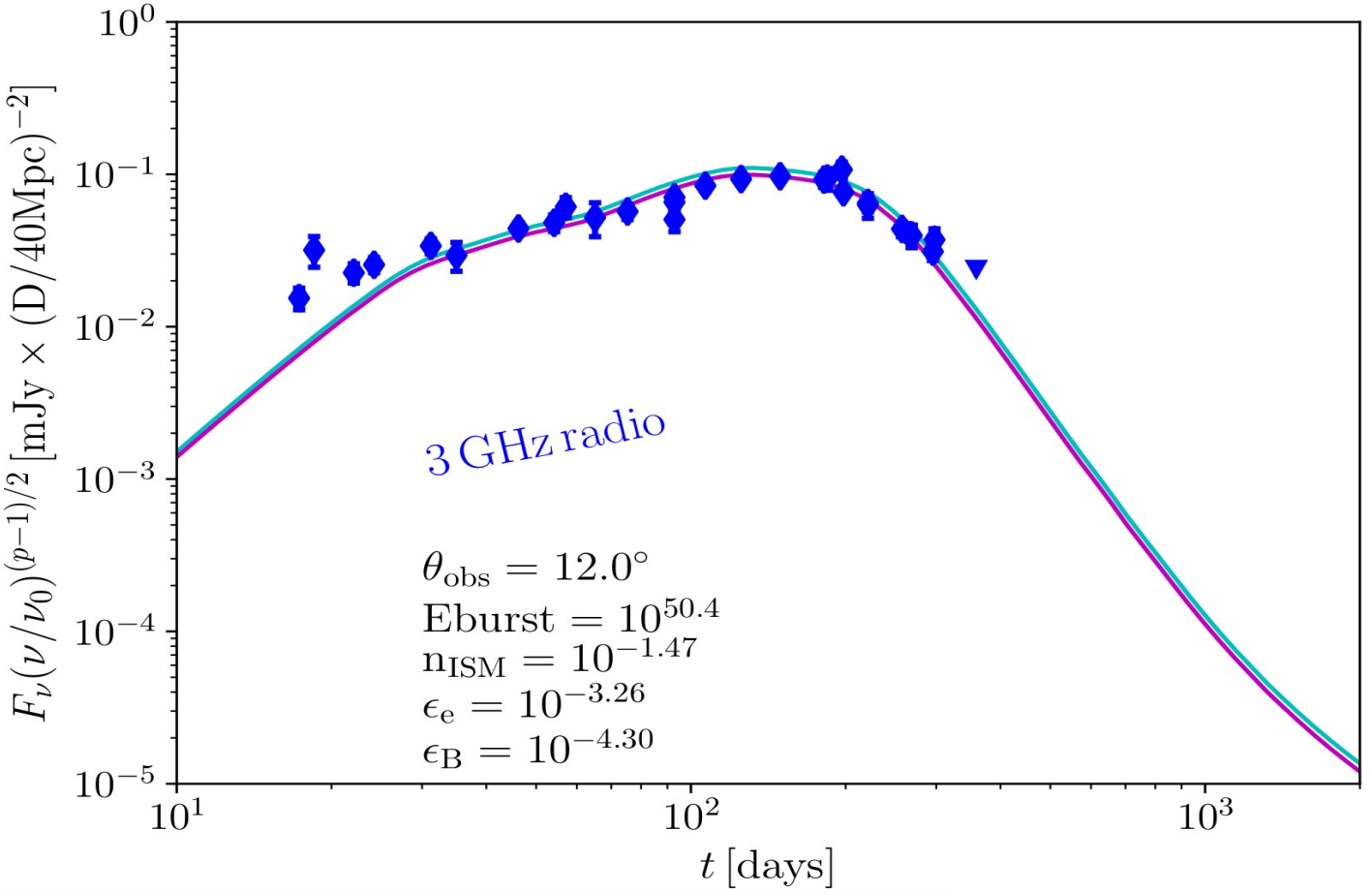
# Genetic algorithm

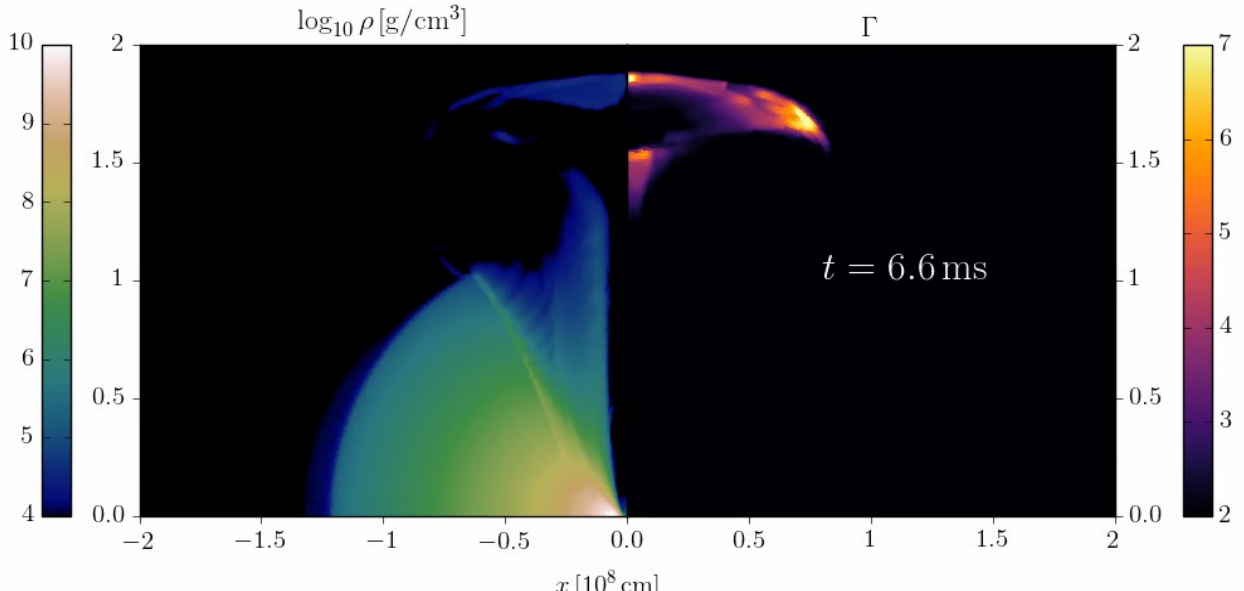




# Jet or Explosion?



Thank you!