Thermal and non-thermal emission from the cocoon of LGRBs

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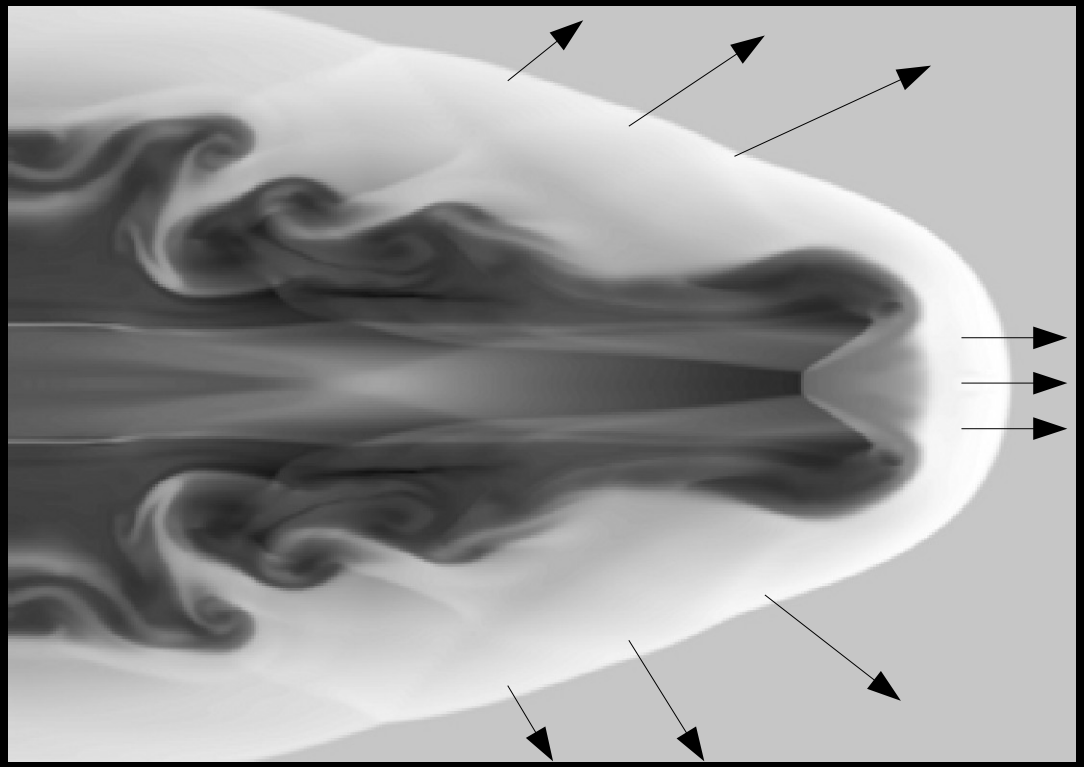
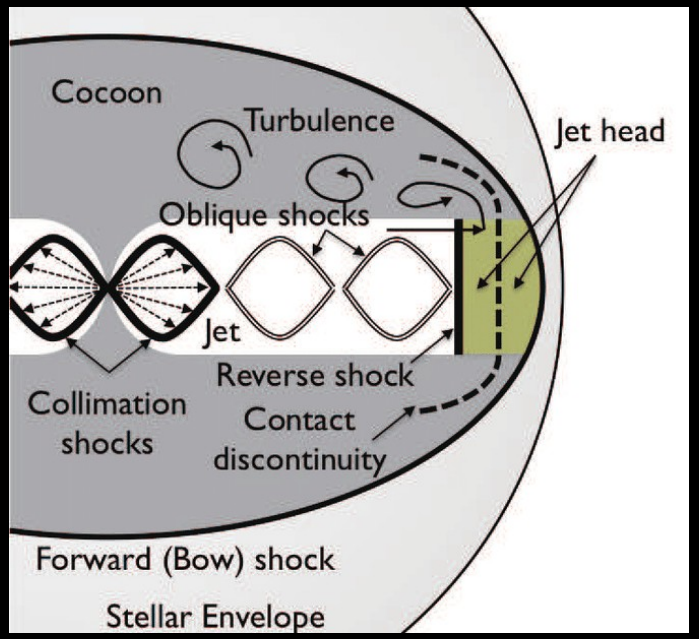
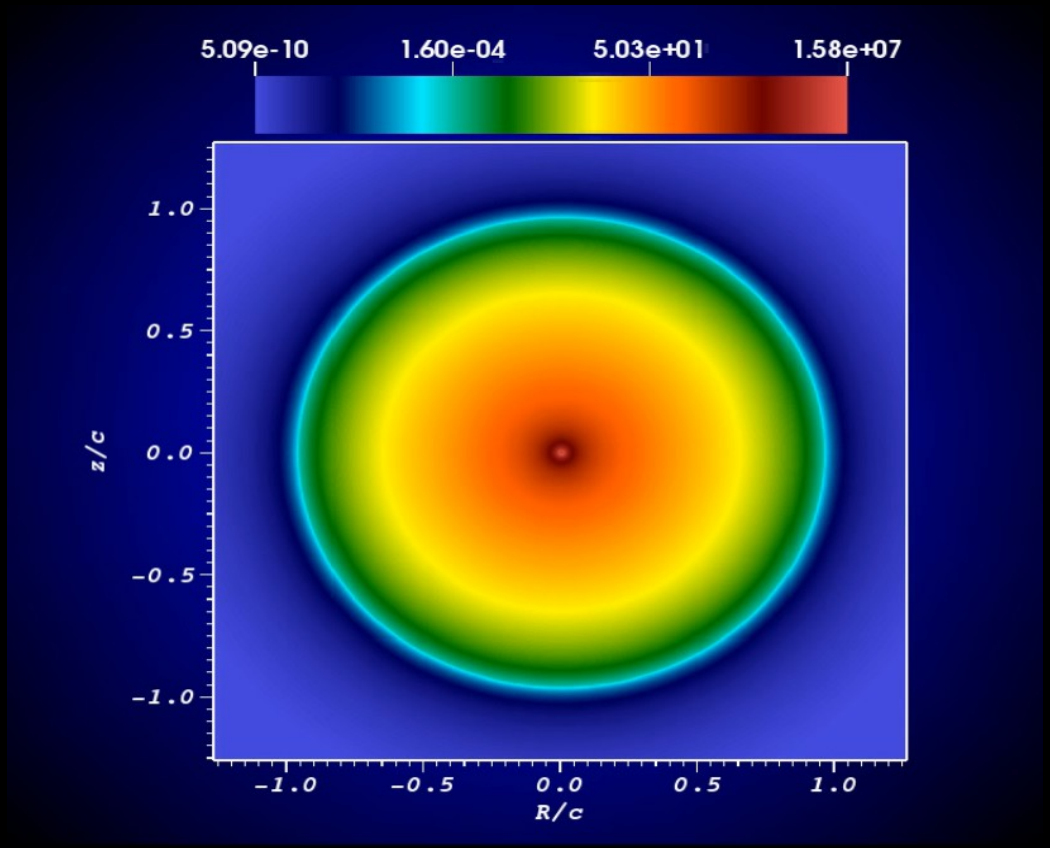
See papers by Bromberg, Gottlieb, Gill, Granot, Irwin, Lazzati, López-Cámara, MacFadyen, Mizuta, Mooley, Morsony, Nakar, Piran, Salafia, Suzuki, etc. etc.



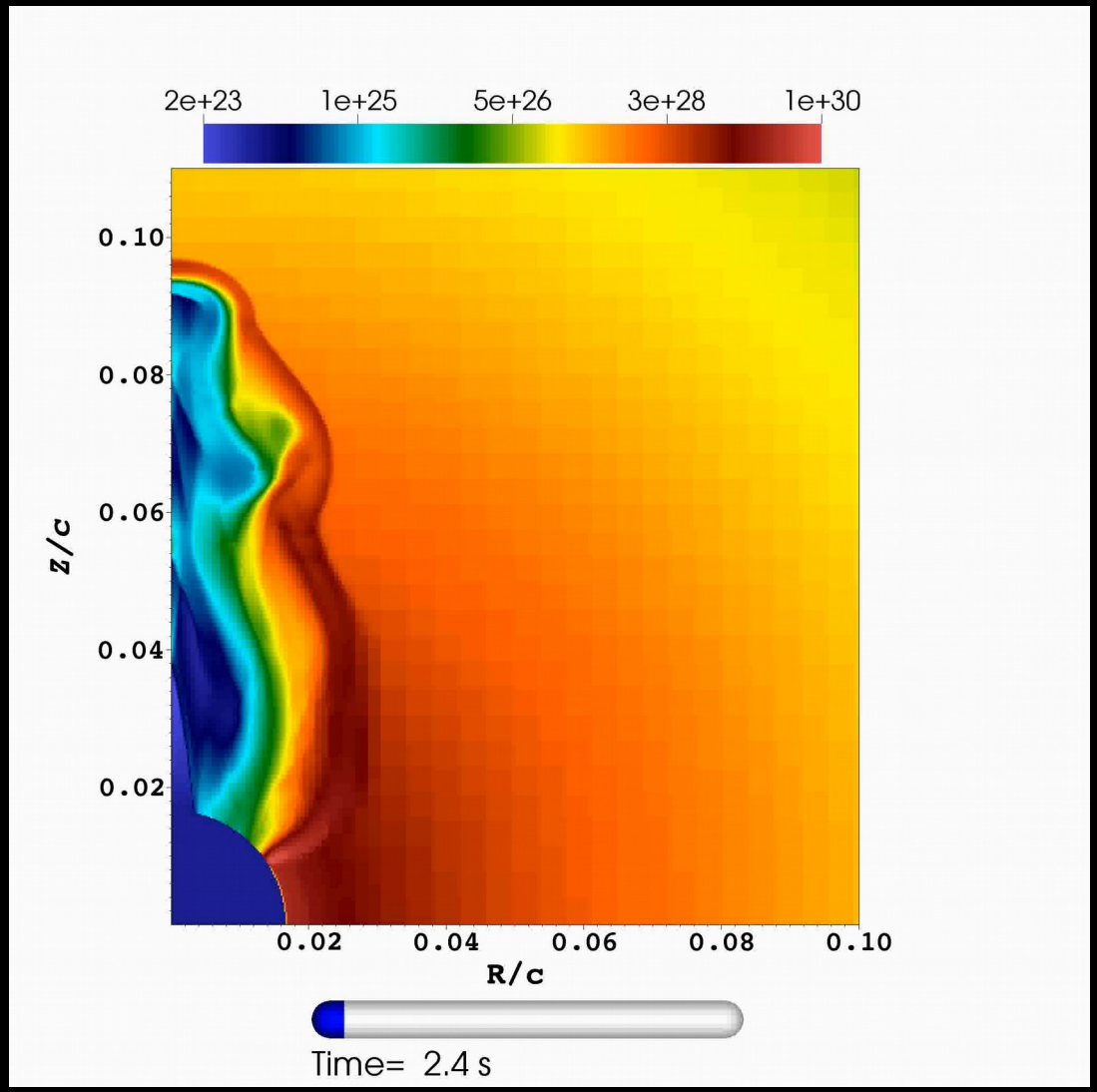


Mizuta & Ioka (2013)

Numerical simulations

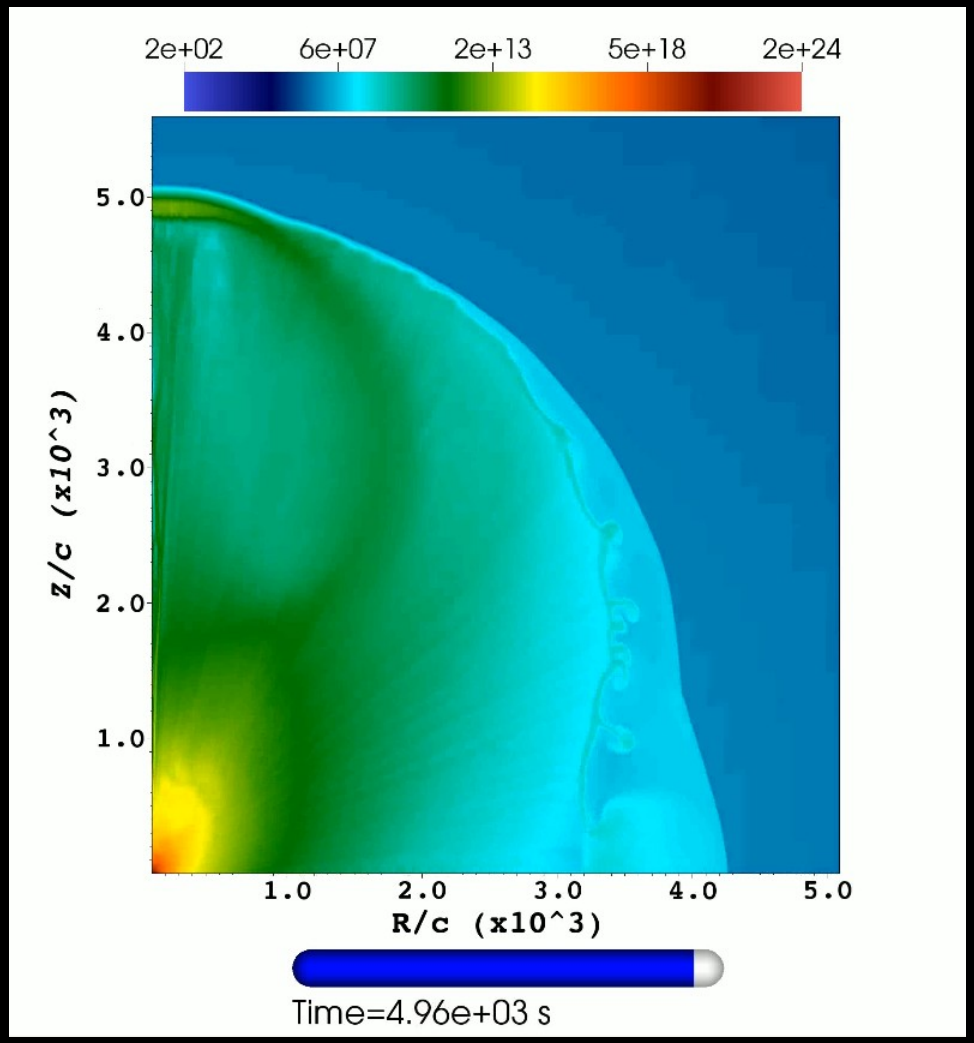


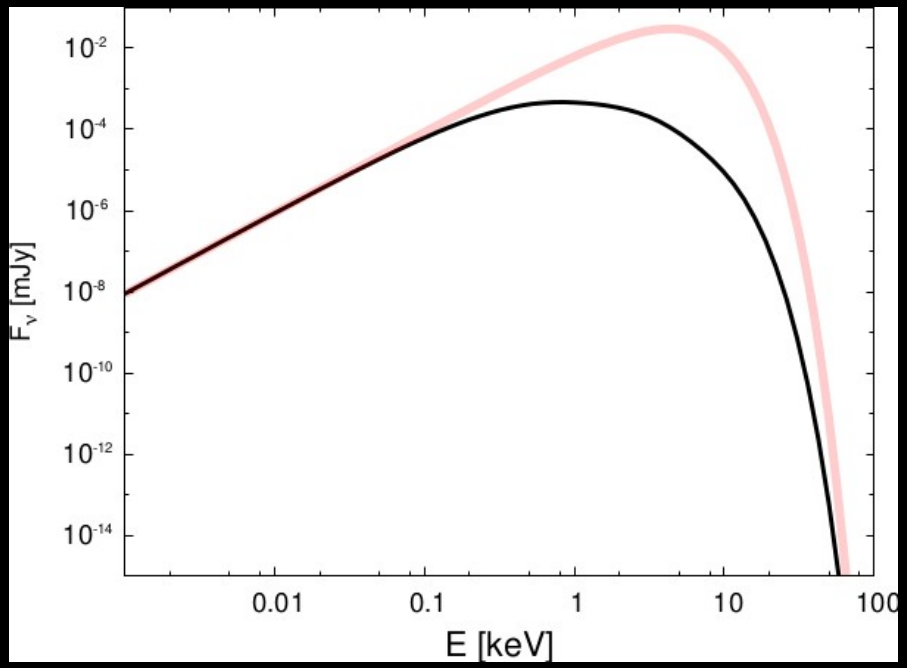
- SRHD equations
- AMR code *Mezcal*
- 26 levels of refinement
- Box: 10^{16} cm
- Resolution: 5×10^{6} cm
- 28 orders of magnitude in density ($10^{6} \rightarrow 10^{-22}$ g cm^{-3})



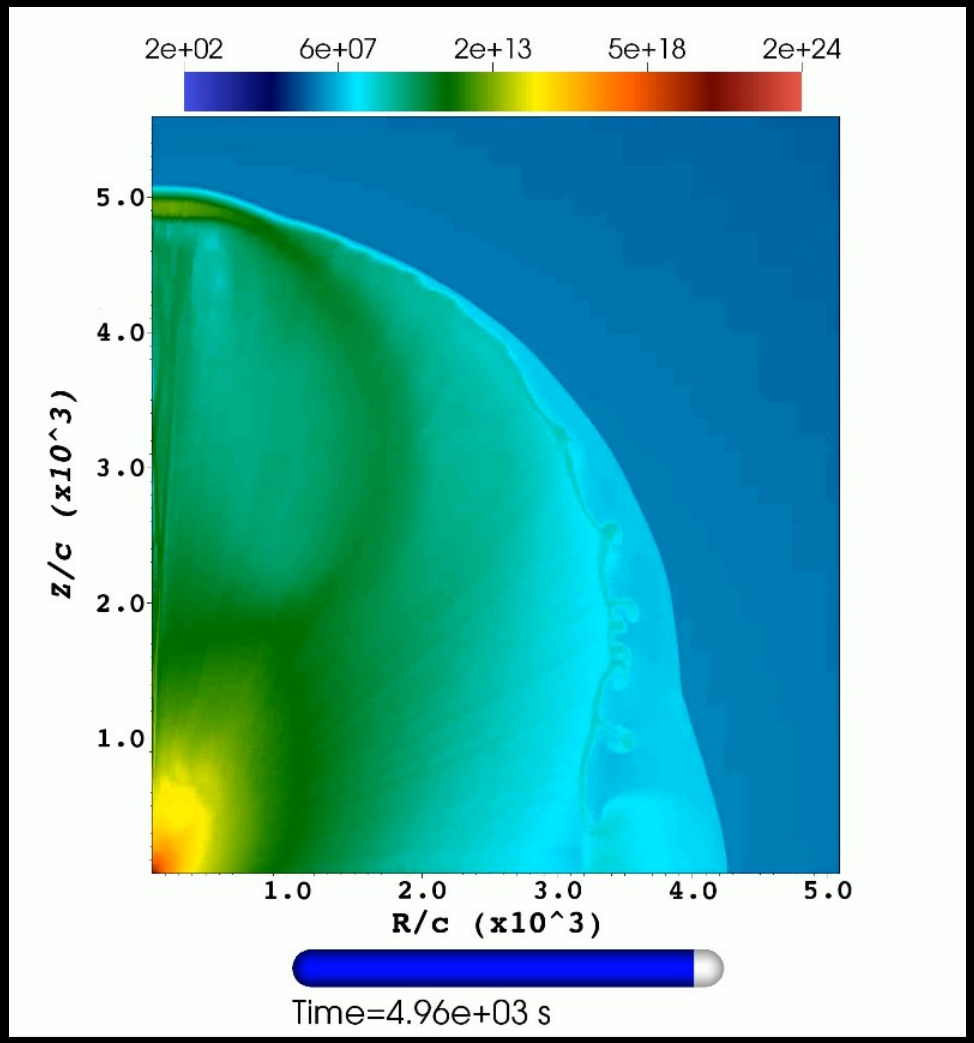
De Colle et al. (2018a, 2018b)

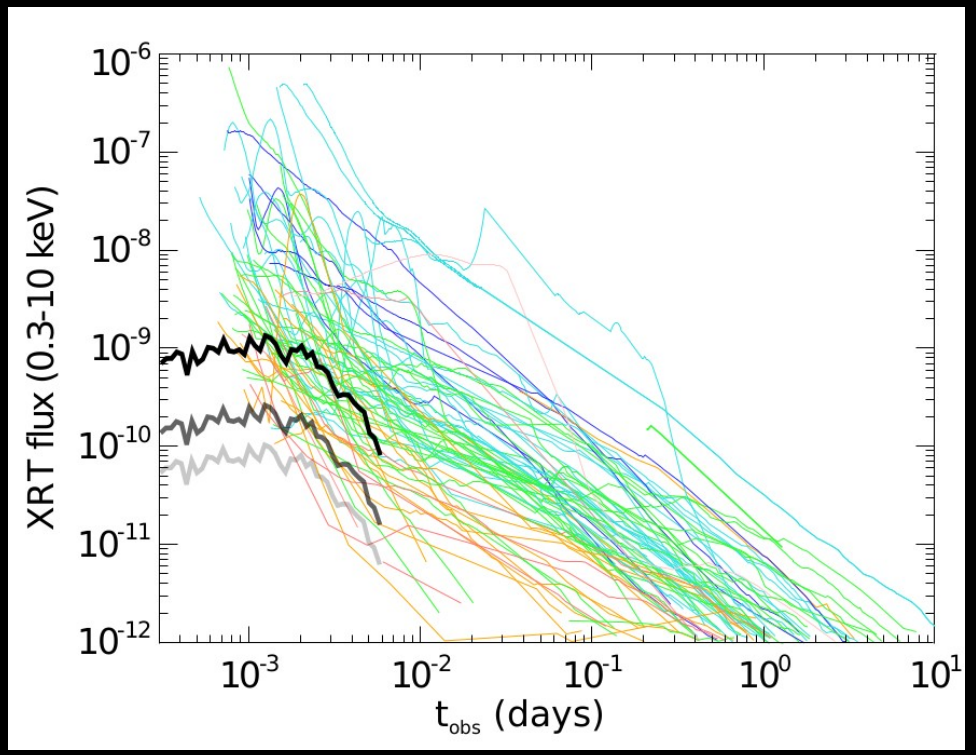
Thermal emission





De Colle et al. (2018a)





De Colle et al. (2018a)

LETTER

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Signatures of a jet cocoon in early spectra of a supernova associated with a γ-ray burst

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Long γ-ray bursts are associated with energetic, broad-lined, stripped-envelope supernovae[1,2] and as such mark the death of massive stars. The scarcity of such events nearby and the brightness of the γ-ray burst afterglow, which dominates the emission in the first few days after the burst, have so far prevented the study of the very early evolution of supernovae associated with γ-ray bursts[3]. In hydrogen-stripped supernovae that are not associated with γ-ray bursts, an excess of high-velocity (roughly 30,000 kilometres per second) material has been interpreted as a signature of a choked jet, which did not emerge from the progenitor star and instead deposited all of its energy in a thermal cocoon[4]. Here we report multi-epoch spectroscopic observations of the supernova SN 2017iuk, which is associated with the γ-ray burst GRB 171205A. Our spectra display metallicity ($12 + \log(\mathrm{O/H}) = 8.41$; Methods). It is much more massive than typical GRB hosts, which are normally metal-poor, star-forming dwarf galaxies, particularly at low redshift[12].

The proximity of GRB 171205A motivated us to undertake multi-wavelength photometric and spectroscopic follow-up observations. The light curve exhibits unusual behaviour, with colour evolution of the optical and ultraviolet emission at very early phases, in contrast to the rapid decay observed in X-ray emission. A few minutes after the burst, a first light-curve bump emerged, characterizing the emission during the first two days, with fast evolution from ultraviolet to redder wavelengths (Fig. 1). After the second day, the luminosity of the underlying supernova (SN 2017iuk) started to increase, reaching its maximum *B*-band magnitude on 2017 December 16.4 UT, roughly 11.0 days

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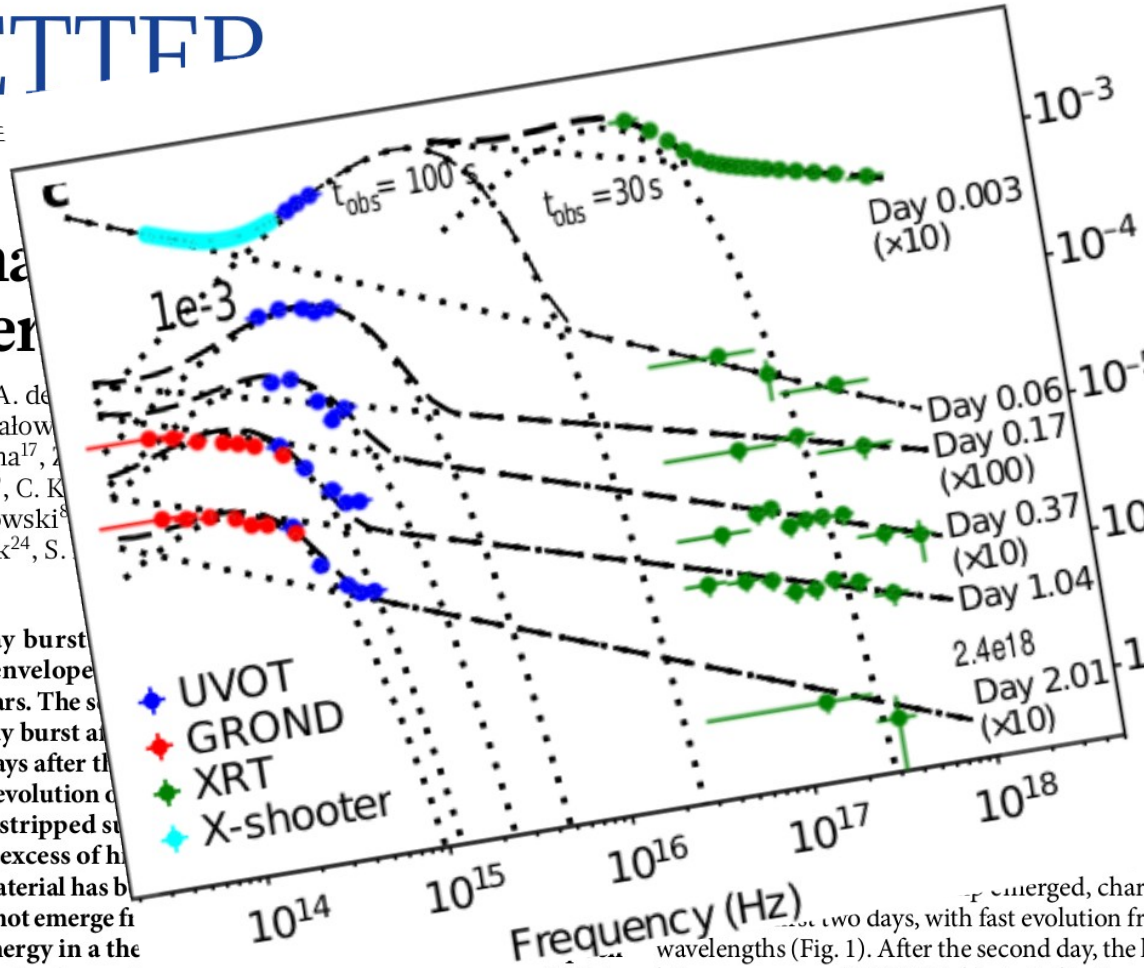

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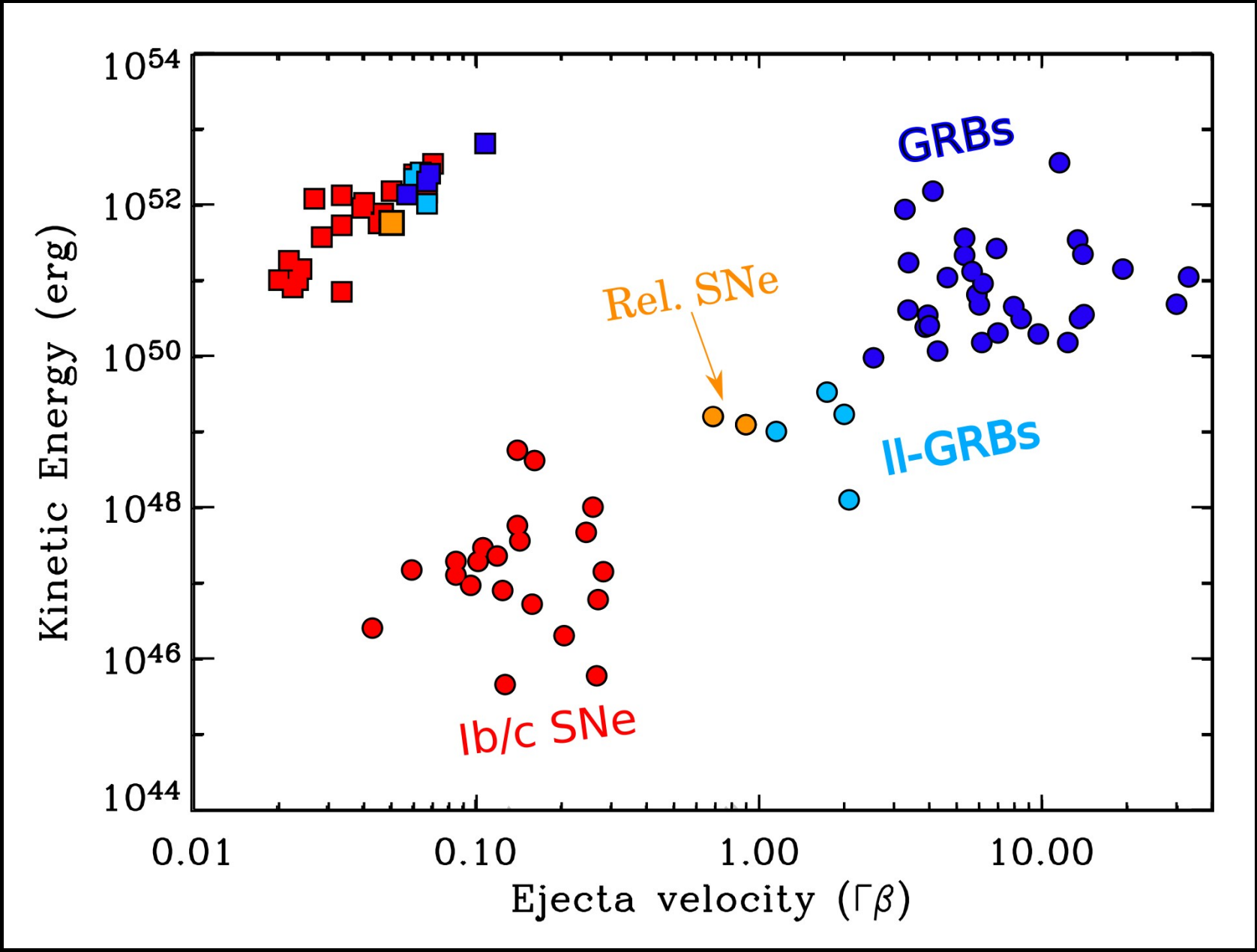
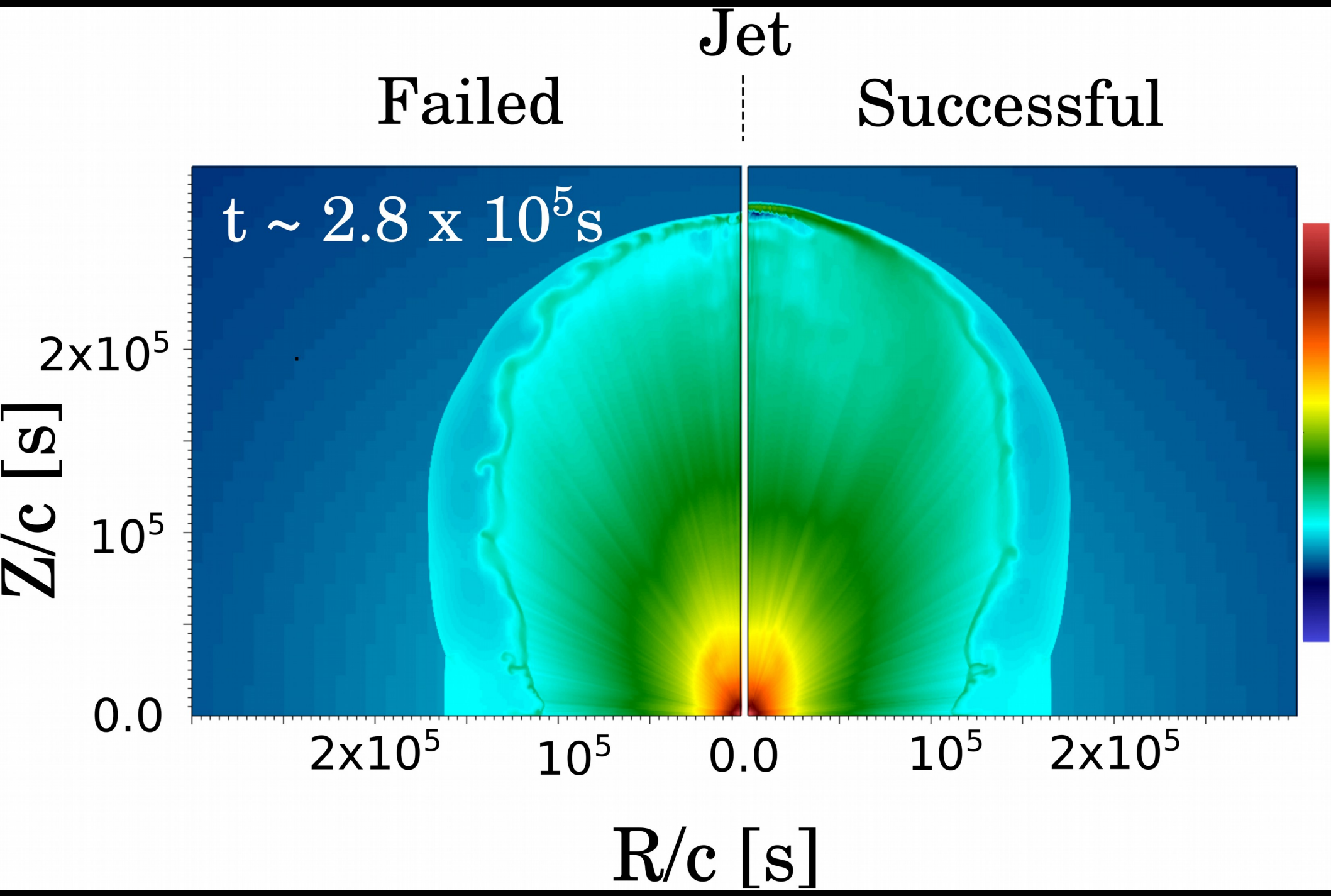
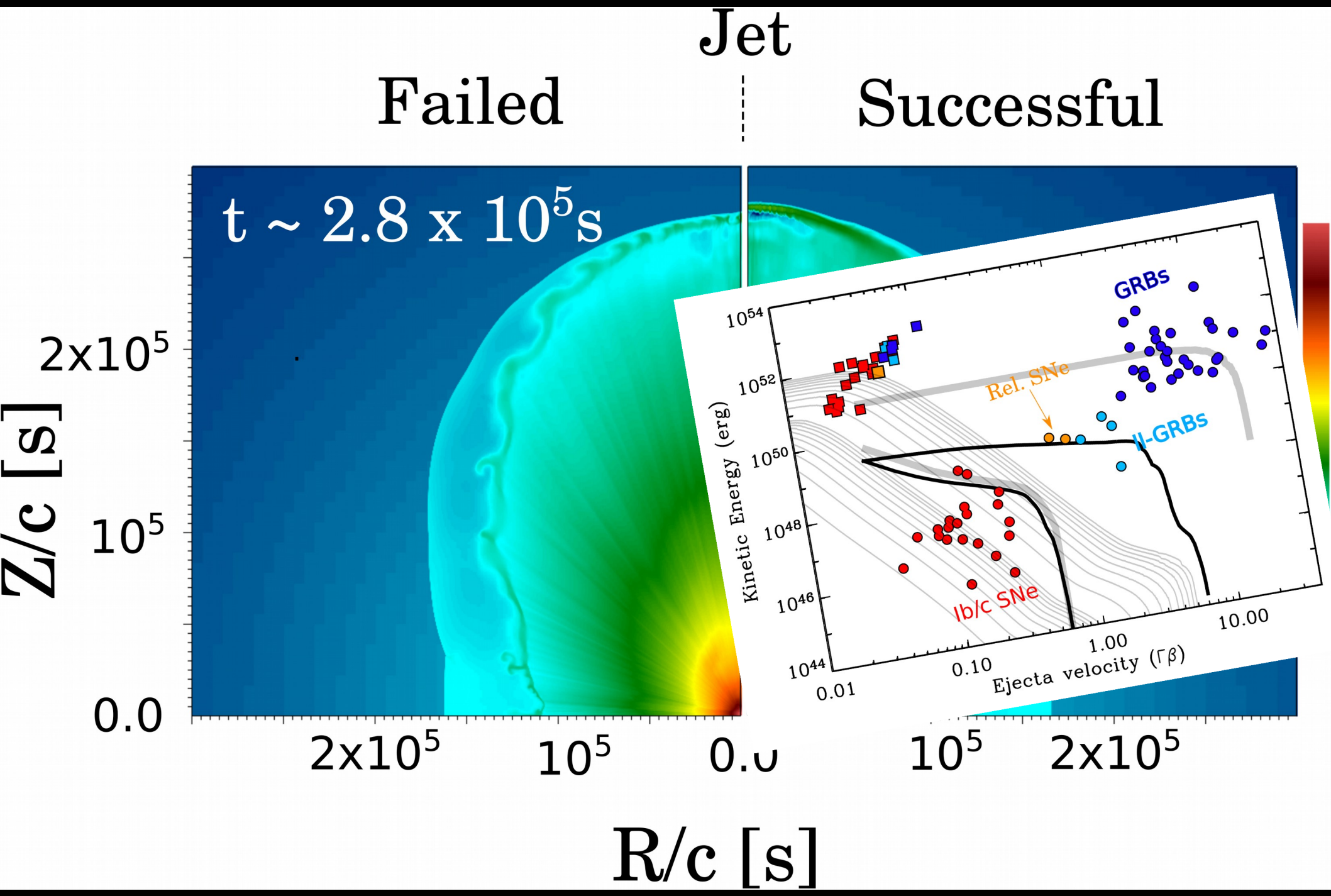
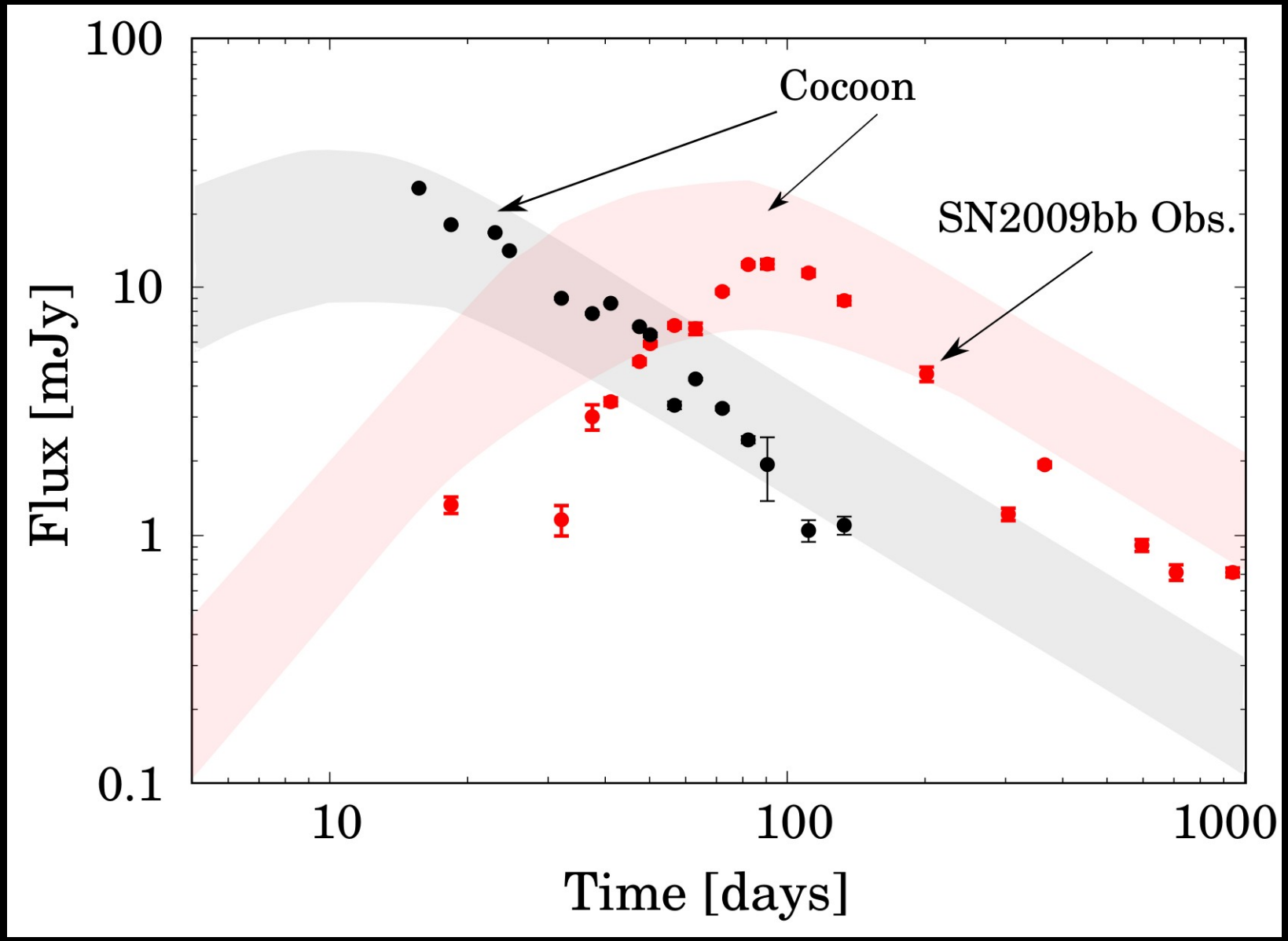
Non-thermal emission from the cocoon



Soderberg et al. (2010), Margutti et al. (2014)

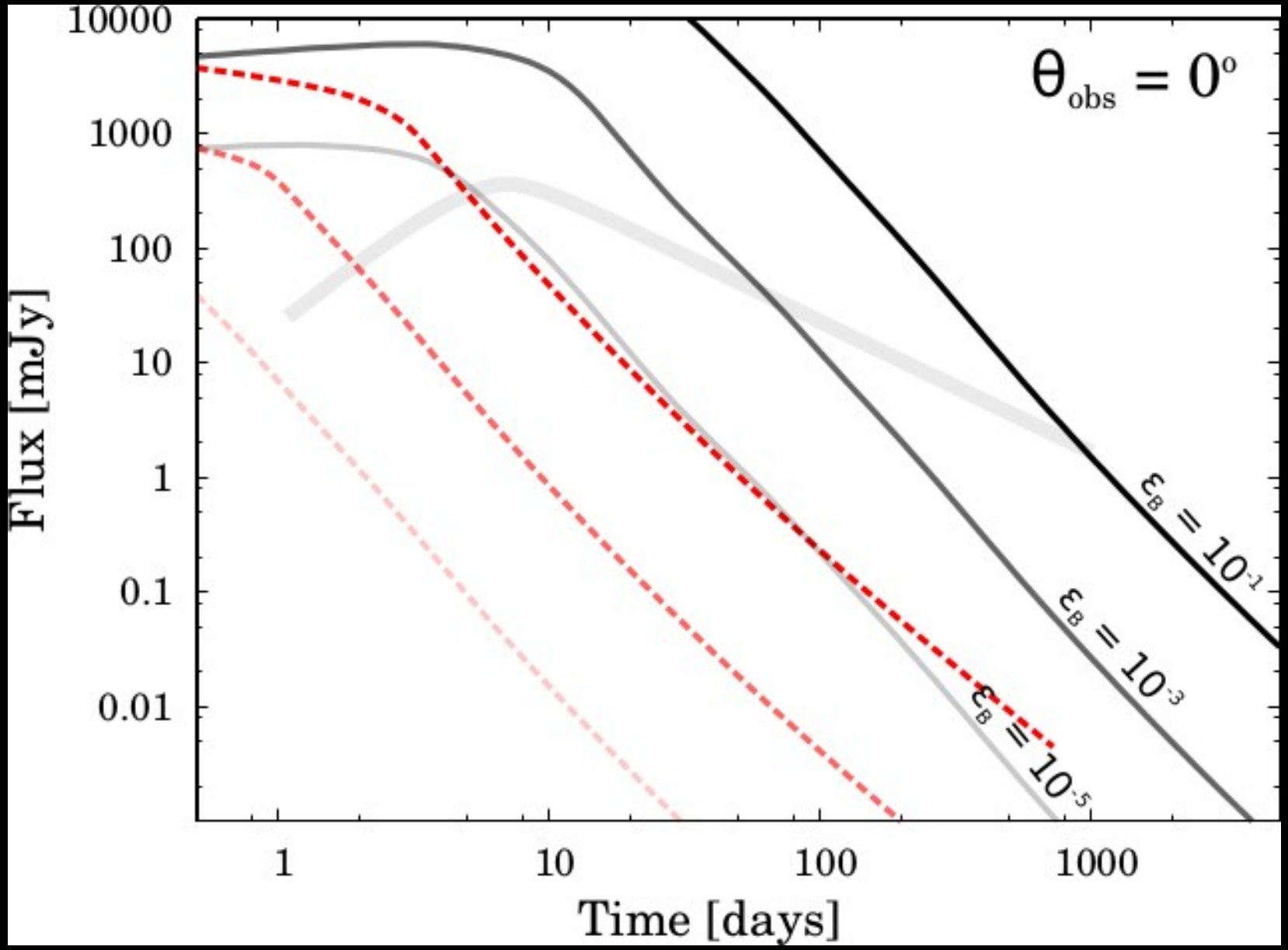

Jet
Failed
Successful
t ~ 2.8 x 10^5s
2x10^5
10^5
0.0
Z/c [s]
2x10^5
10^5
0.0
10^5
2x10^5
R/c [s]


Jet
Failed
Successful
t ~ 2.8 x 10^5s
2x10^5
10^5
0.0
Z/c [s]
2x10^5
10^5
0.0
10^5
2x10^5
R/c [s]
GRBs
Rel. SNe
II-GRBs
Ib/c SNe
Kinetic Energy (erg)
10^54
10^52
10^50
10^48
10^46
10^44
0.01
0.10
1.00
10.00
Ejecta velocity (Γβ)



De Colle et al. (2018b) – 6 Ghz (grey); 3 Ghz (red)

Is the radio emission from “relativistic” SNe the emission from the cocoon of a failed long GRB?



De Colle et al. (2018b)

Conclusions

- E.M. signatures of a relativistic jet in LGRBs:
  - Non-thermal/photospheric emission from the jet axis
  - + Non-thermal coocoon emission
  - + Thermal cocoon emission

- Cocoon emission:
  - Thermal → the stellar structure
  - Non-thermal → environment

- Future surveys (e.g. LSST) will shift our attention to the much more common off-axis grbs, i.e. to the cocoon emission