Kilonova In Short Gamma Ray Bursts

The Transient Universe 2023, IESC Cargèse

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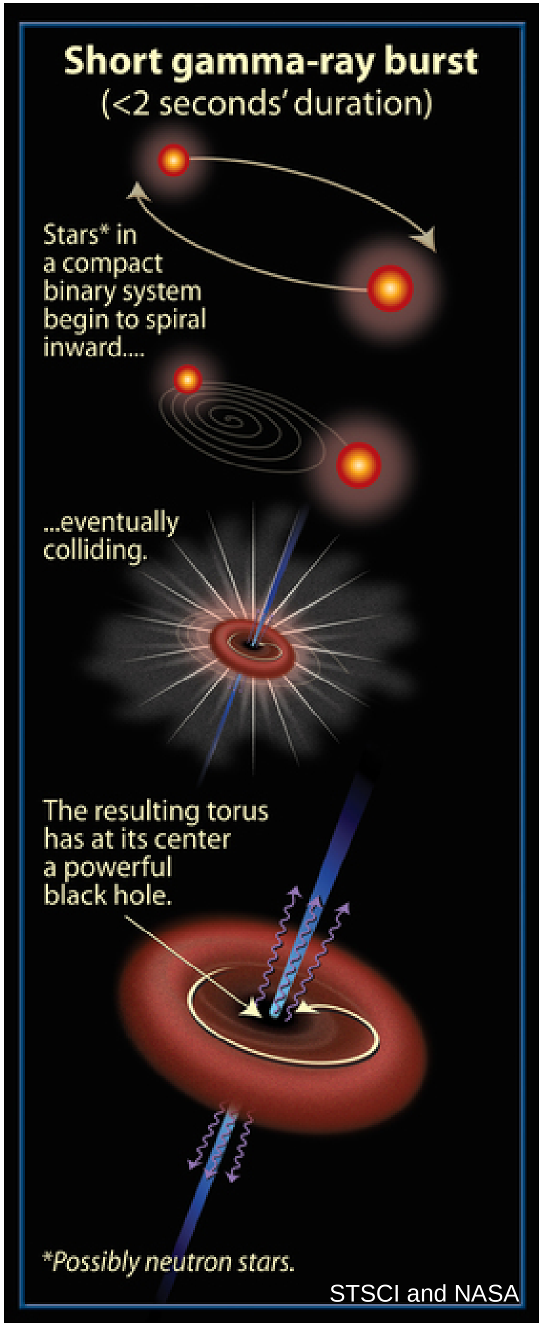
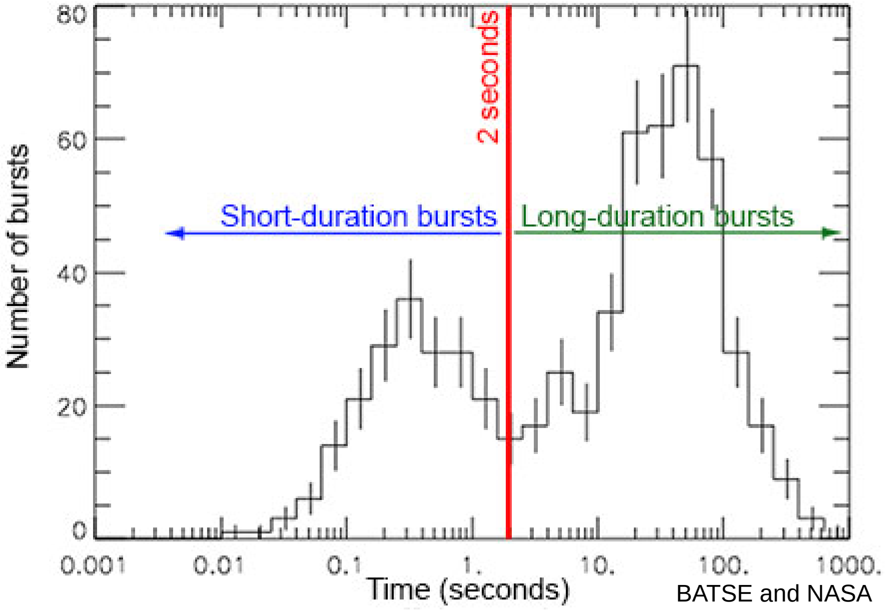
Outline

- Introduction: short and long of GRBs
- Timescales of observations and compact mergers
- Electromagnetic counterparts: afterglow and kilonova
- Sample of the short GRBs
- Radiative transfer code: POSSIS
- Preliminary results

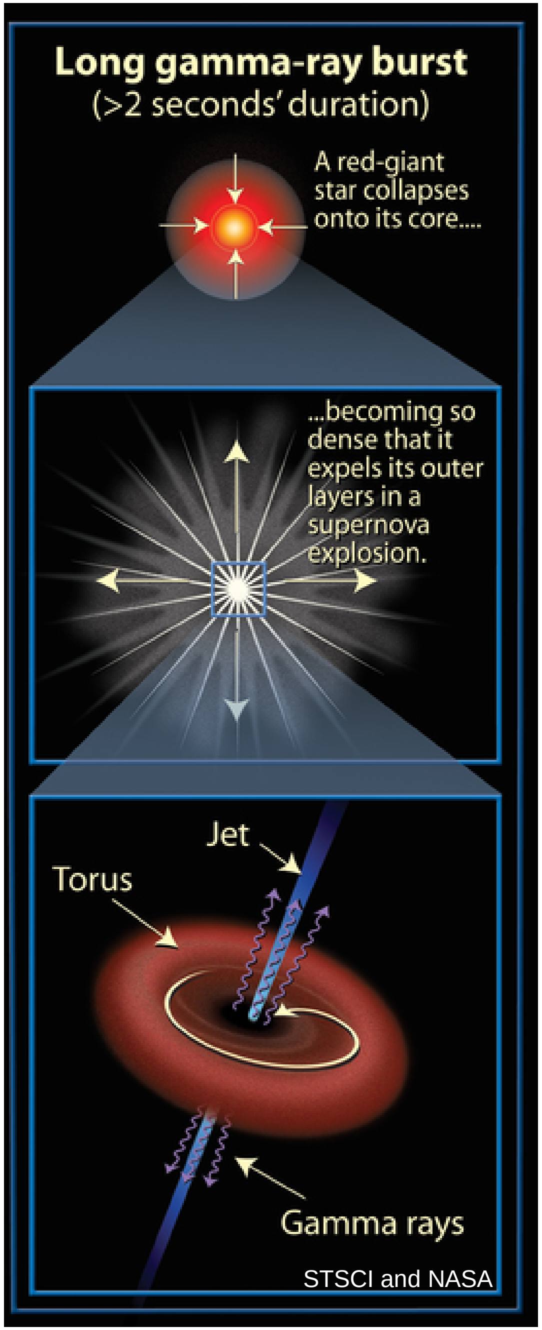
Short And Long Gamma Ray Bursts



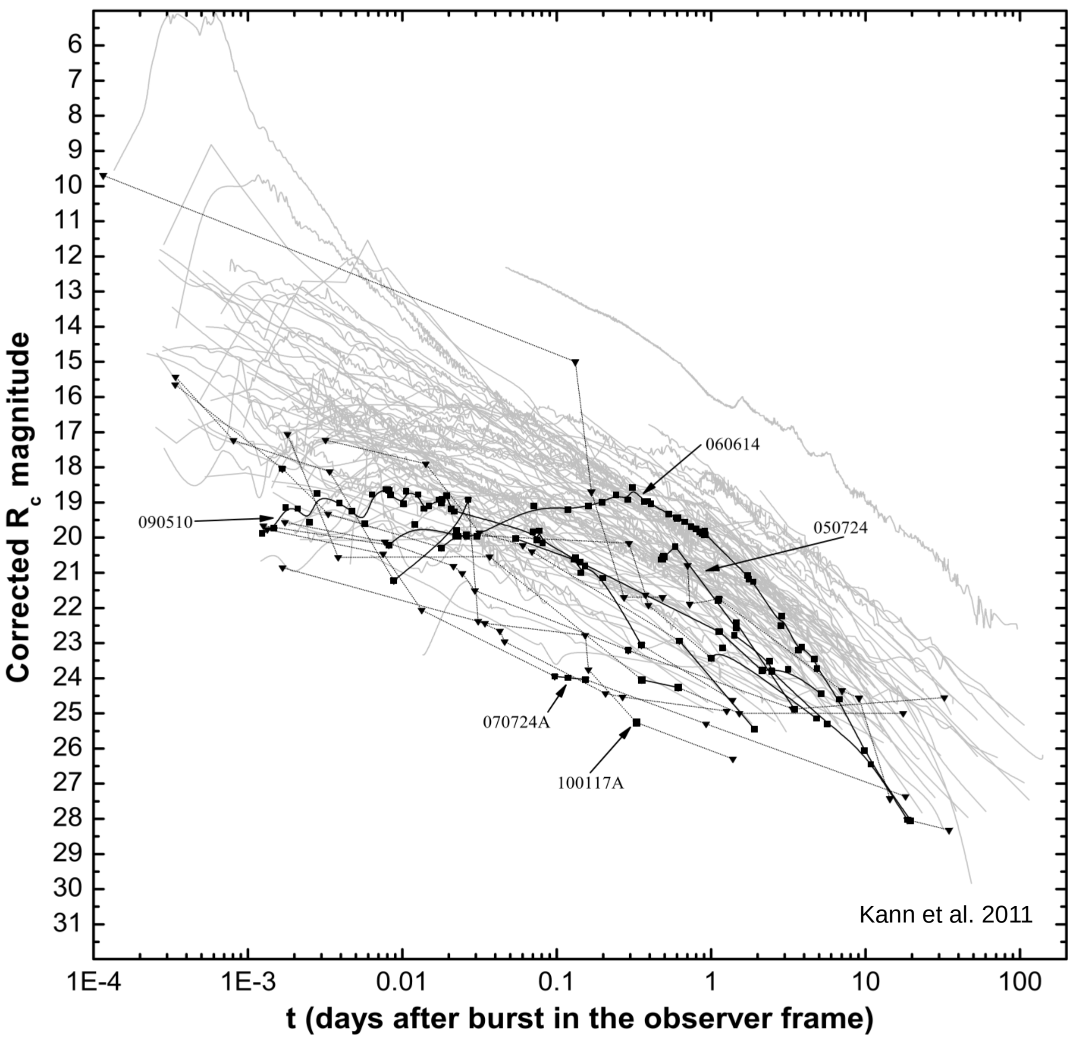


Short GRB duration is less than 2 seconds.

Compact mergers produce short GRBs.

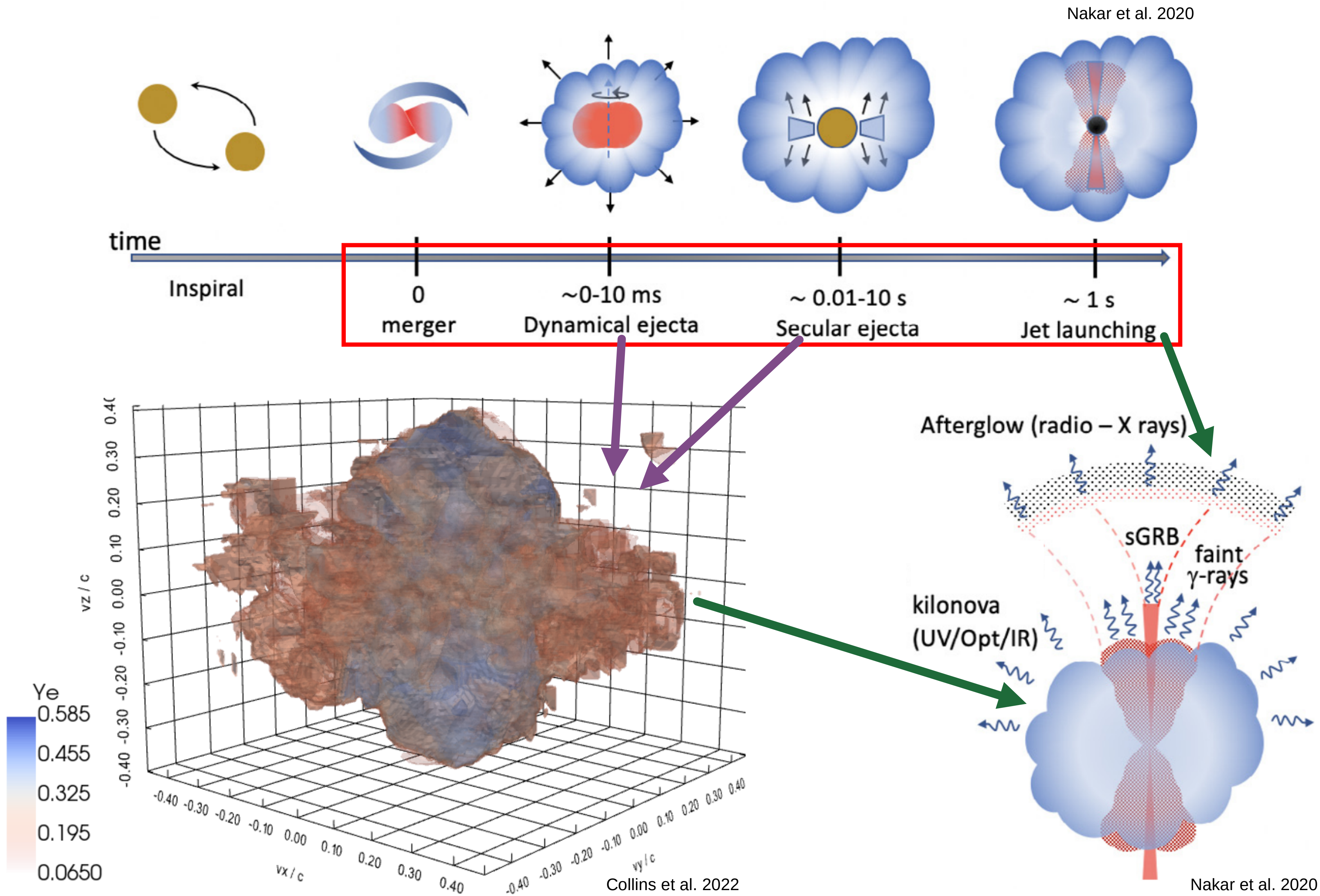


Timescales Of The Observations



Light curves of short and long GRBs afterglow

Timescales Of Compact Mergers

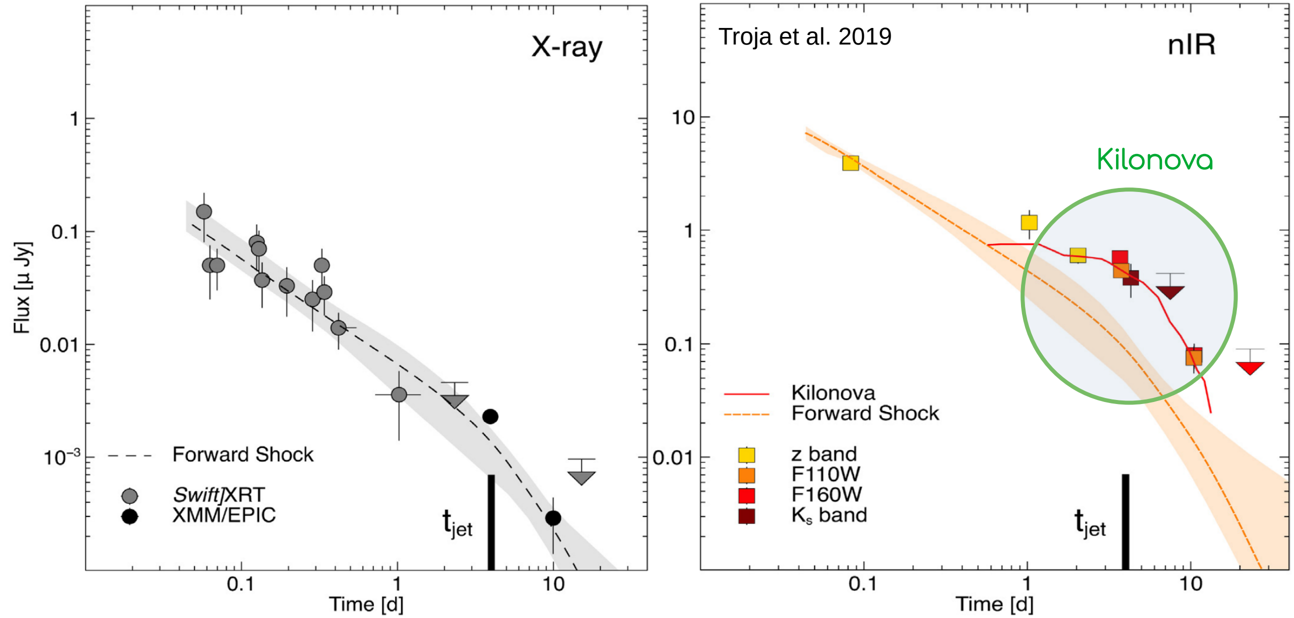


Ejecta geometry

Inclination dependence

Electromagnetic Counterparts

GRB 160821B at z = 0.1619



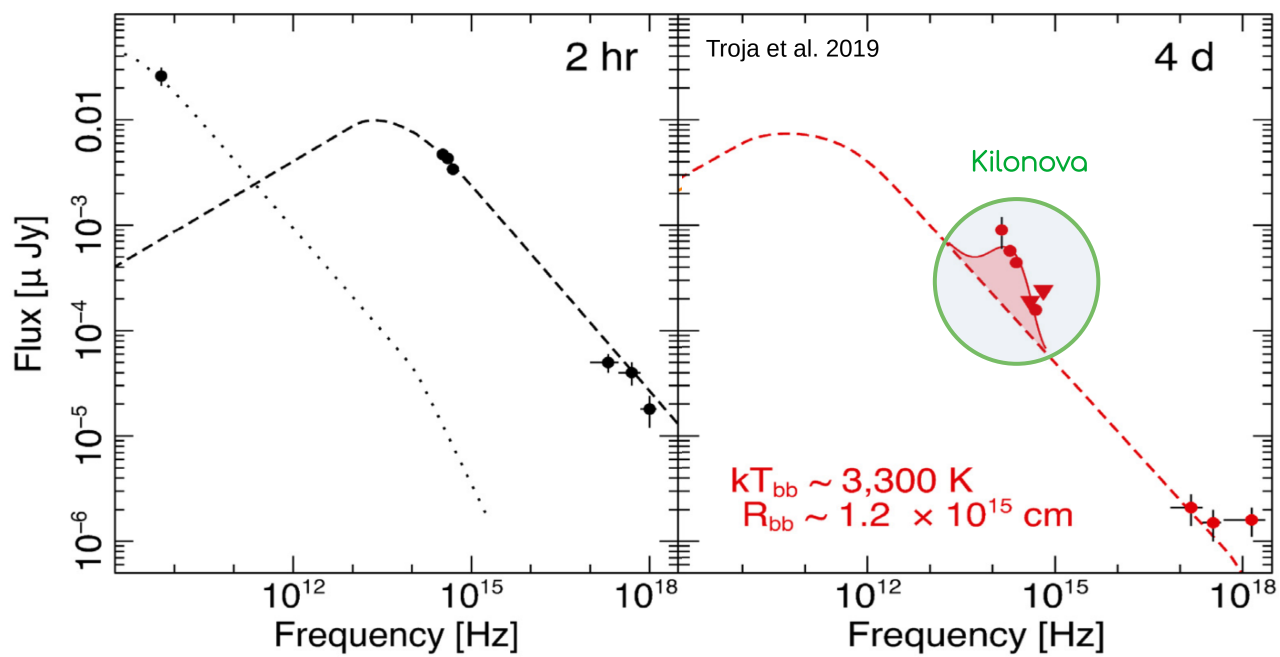
Temporal evolution

Afterglow

The emission from jet in the X-rays, optical and radio. Arising due to synchrotron emission from the relativistic jet.

Kilonova

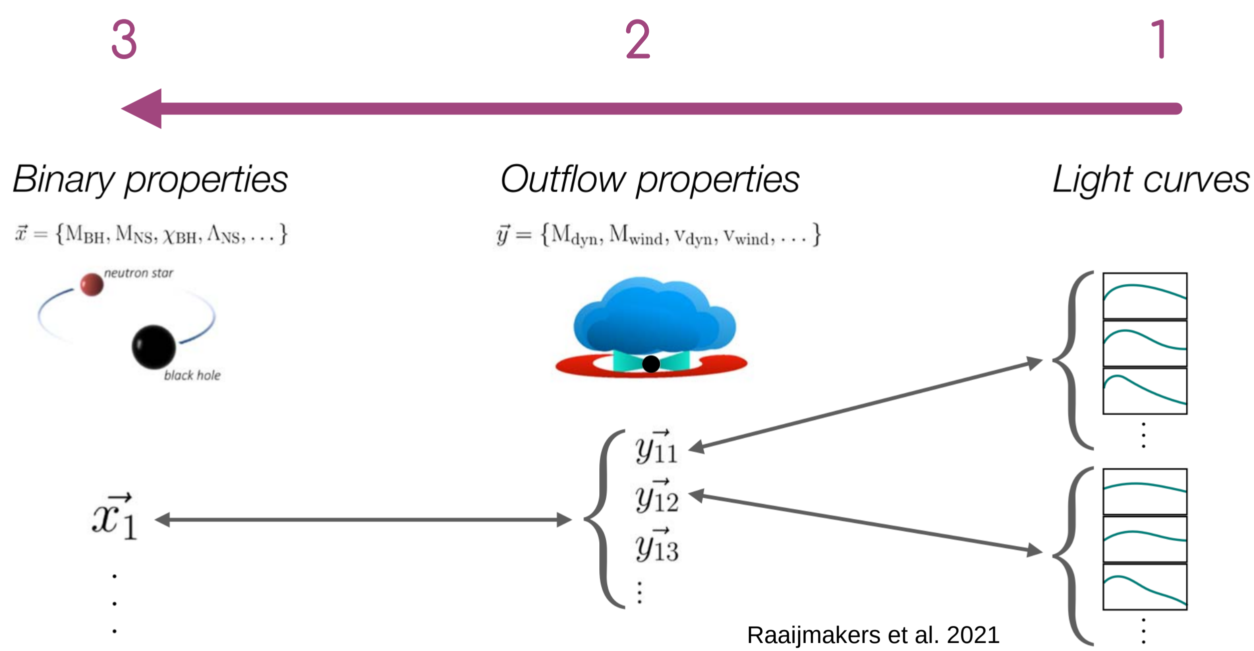
The bright component seen at late time.
Thermal contribution from radioactive decays of the r-process nuclei.



Spectral evolution

Outline Of Our Approach

- Investigate the past short GRBs with known redshift.
- Evaluate UV/Optical/NIR and X-ray data for an evidence of kilonovae.
- Explore the kilonova parameter space with state-of-the-art models.
- Constrain the properties:
  - Mass and velocity:
    - Dynamical ejecta
    - Post merger wind
  - Electron fraction
  - Binary parameters and EOS

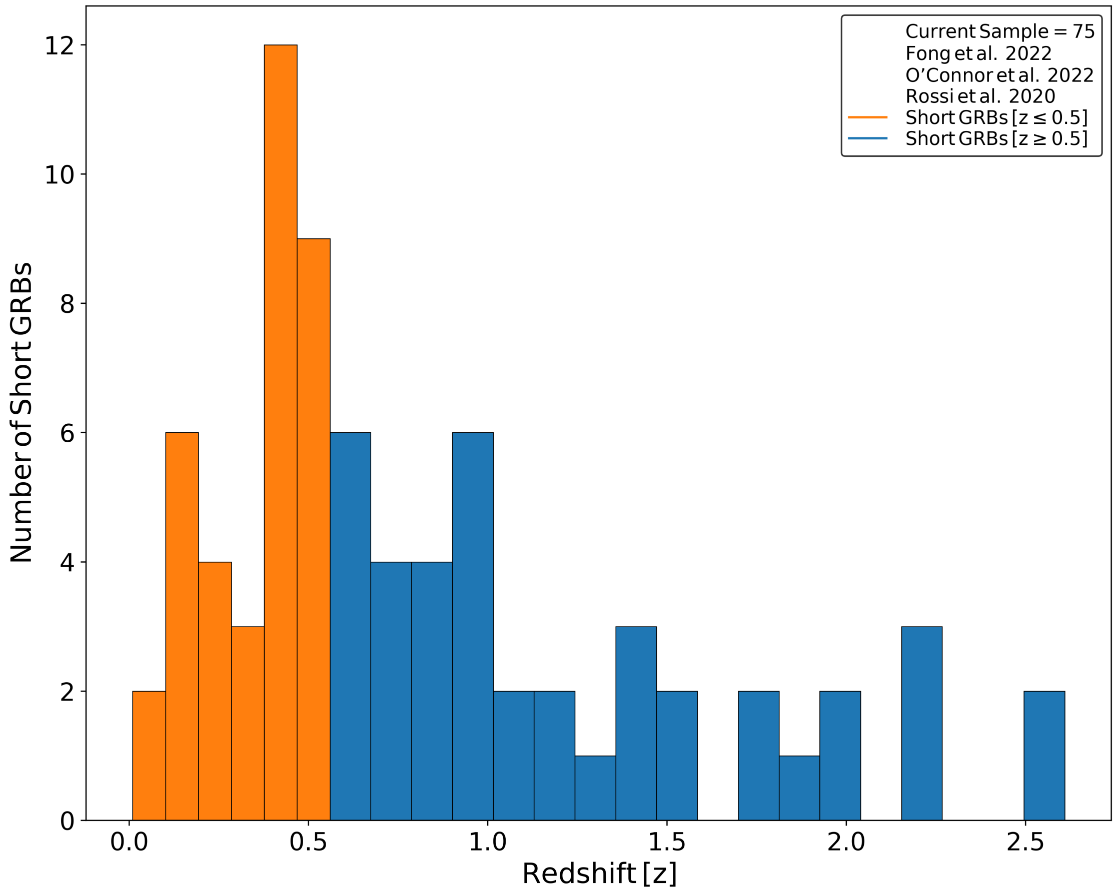


From merger to light curves

Sample Of Short GRBs

GRBs with KN	Redshift	T_{90} (sec)	EE or Hybrid
050709	0.1607	0.07	✓
050724	0.254	98	✓
060505	0.089	4	✓
060614	0.125	108.7	✓
130603B	0.3568	0.8	Short
150101B	0.134	0.018	Short
160821B	0.1619	0.48	Short
180618A	0.52	47.4	✓
200522A	0.5536	0.62	Short
211211A	0.0763	51.4	✓
230307A*	0.065*		

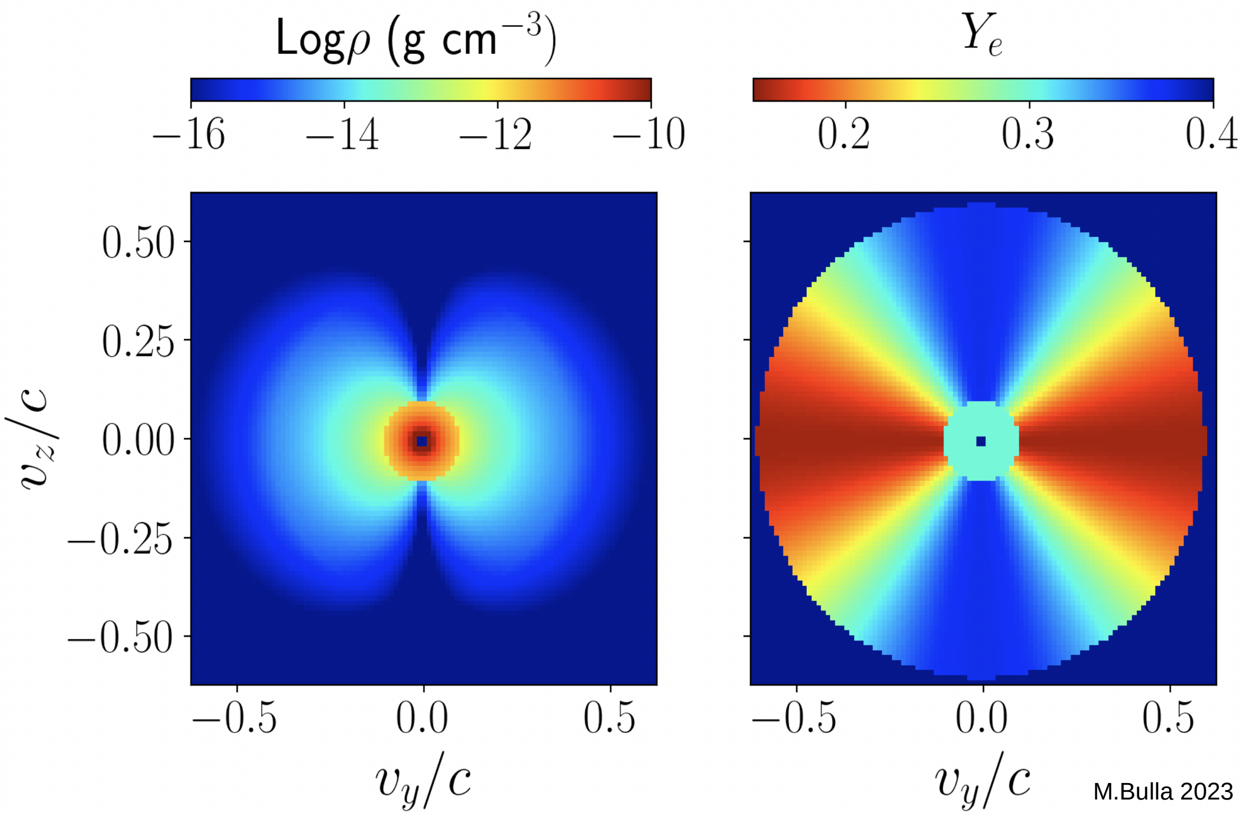
Cases under investigation



Redshift distribution of full sample

Radiative Transfer Code: POSSIS

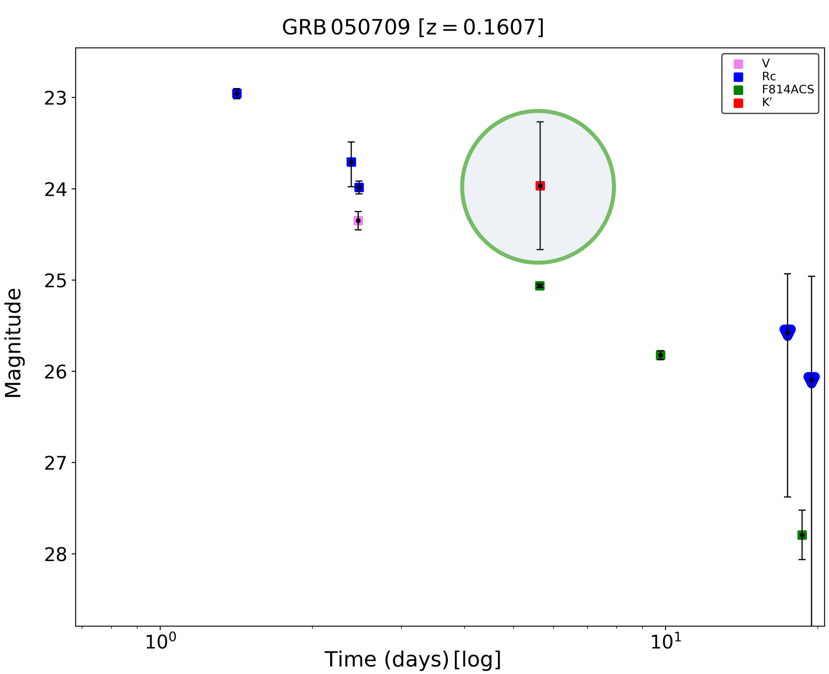
- 3D Monte Carlo radiative transfer code.
- Depends on the local values of density, electron fraction and temperature.
- Dynamical ejecta and post-merger disk wind.
- v_{wind} = [0.05, 0.10, 0.15] c
- m_{wind} = [0.010, 0.050, 0.090, 0.130] $M_\odot$
- v_{dyn} = [0.15, 0.20, 0.25] c
- m_{dyn} = [0.001, 0.005, 0.010] $M_\odot$
- Ye = [0.15, 0.20, 0.25]

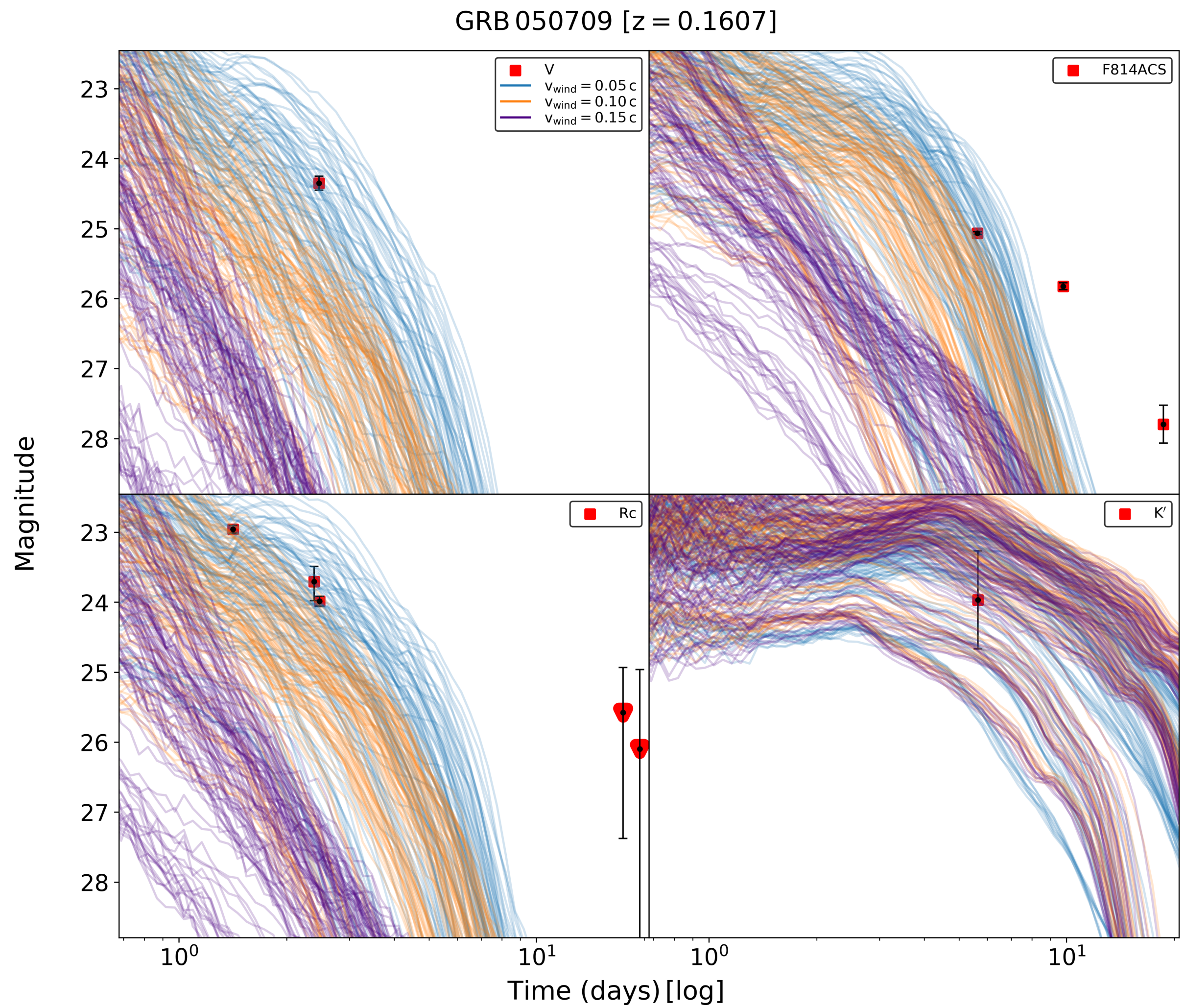


Density and electron fraction distribution

Example: GRB 050709

- IR component allows for all v_{wind} but favors lower $m_{wind} < 0.130, 0.090\ M_\odot$
- Electron fraction is expected to be low
  - Ye < 0.25

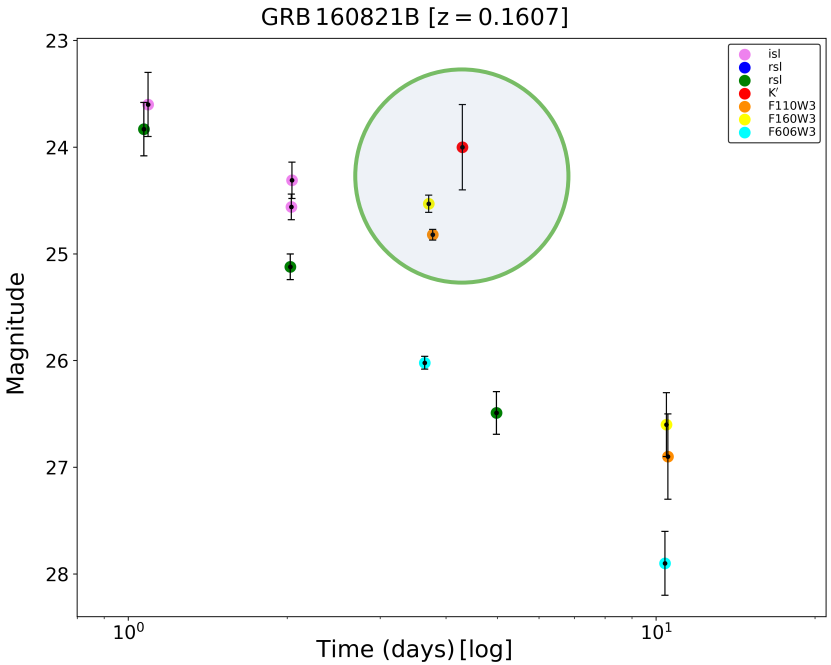


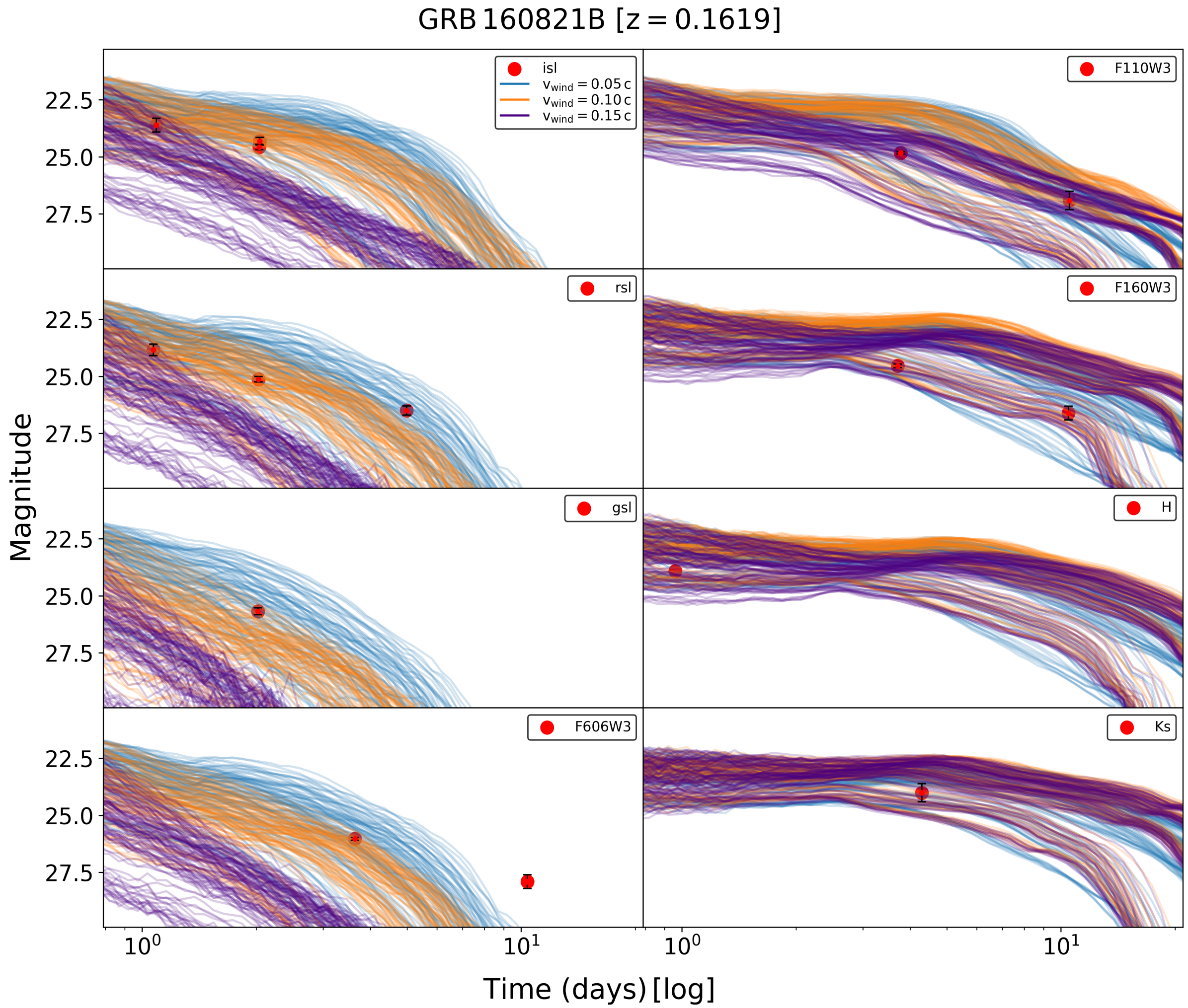


050709 (KN and Afterglow)

Example: GRB 160821B

- Optical is bright for cases with v_{wind} 0.05c. Additional constraints with $m_{wind} < 0.130, 0.090\ M_{\odot}$
- IR light curves spread evenly, with dependence on $m_{wind} < 0.130, 0.090, 0.050\ M_{\odot}$
- Ye < 0.25





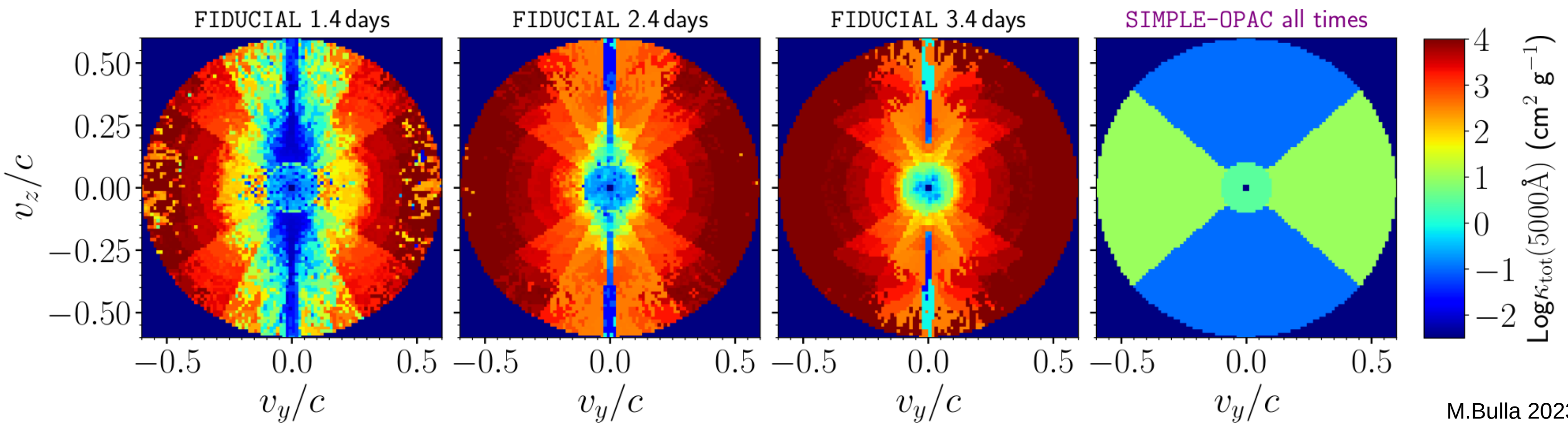
160821B (KN and Afterglow)

Summary And Outlook

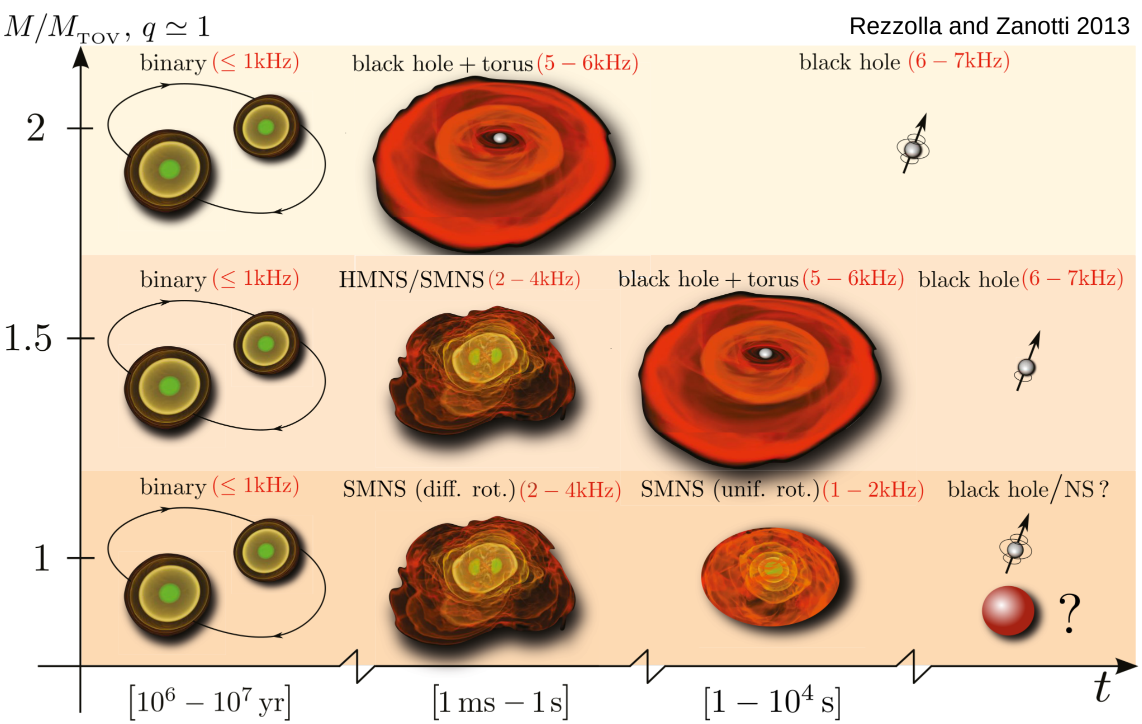
- The compact mergers either BNS or BHNS can produce the Short GRBs.
- The binary parameters and outflow properties dictate the kilonova component and the afterglow emission.
- Using state-of-the-art models we aim to identify the kilonova component and explore the outflow parameter space.
- The best fit templates would be used to constrain the binary parameters and EOS.

Thanks

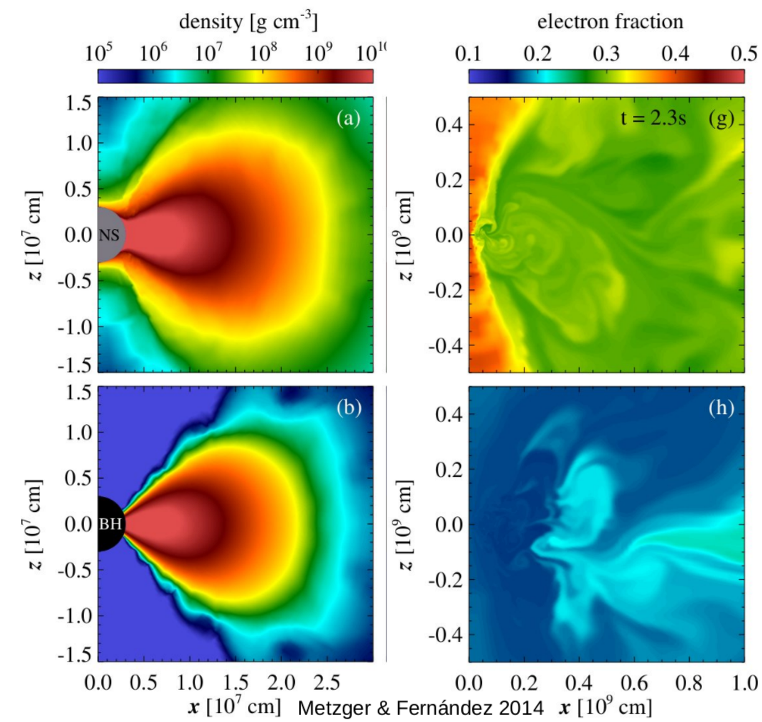
Additional Information



Opacity distribution



Impact of binary parameters on merger



Remnant geometry