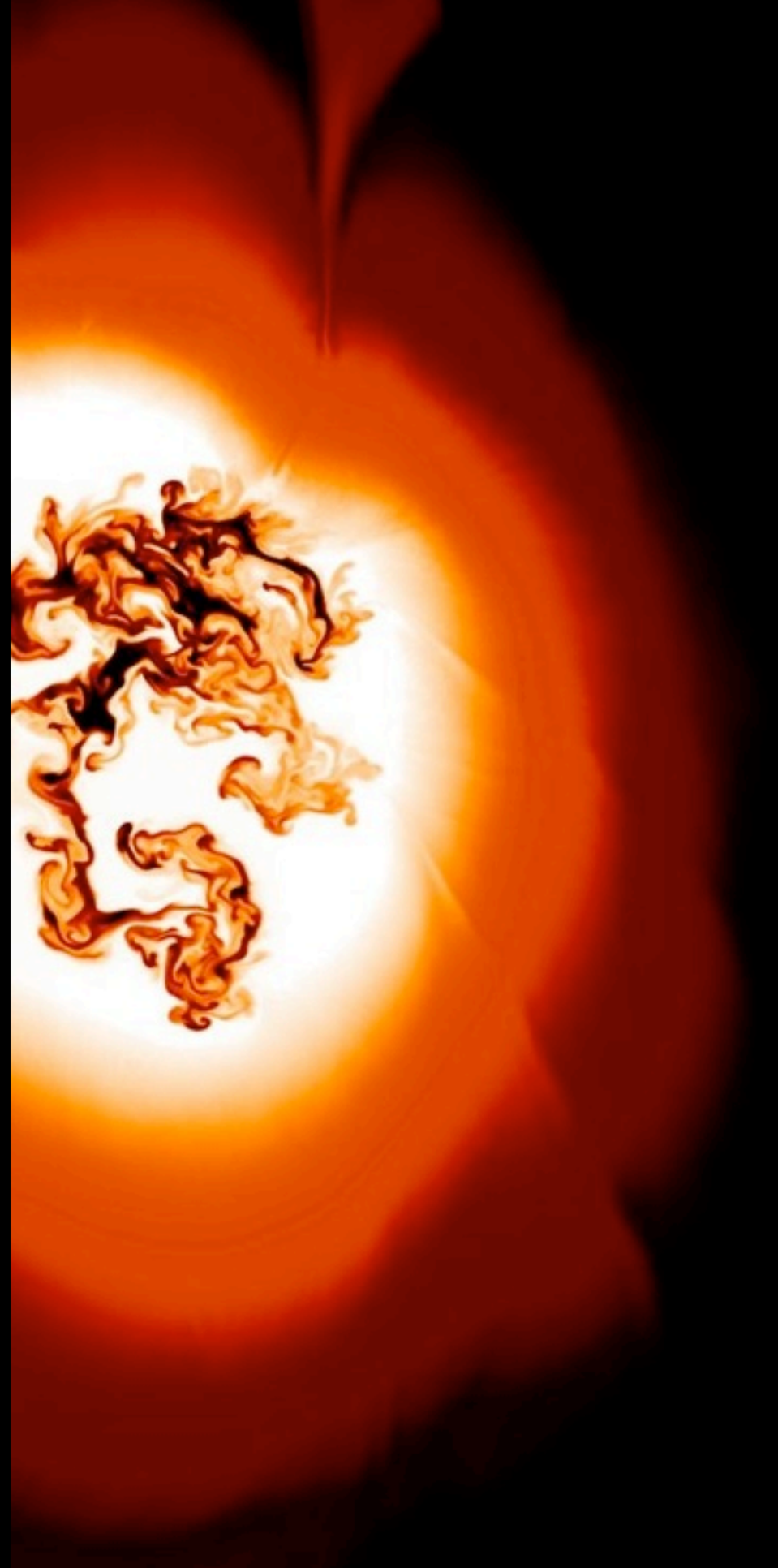
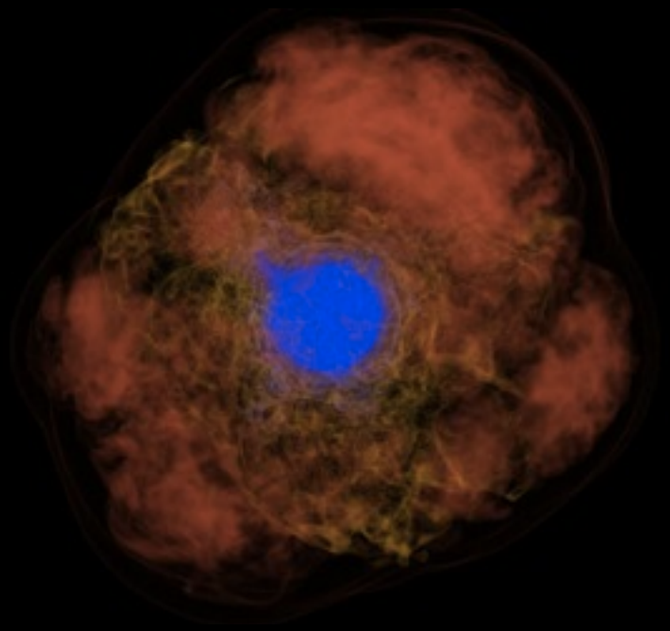
computational explosive astrophysics

white dwarf and neutron star mergers

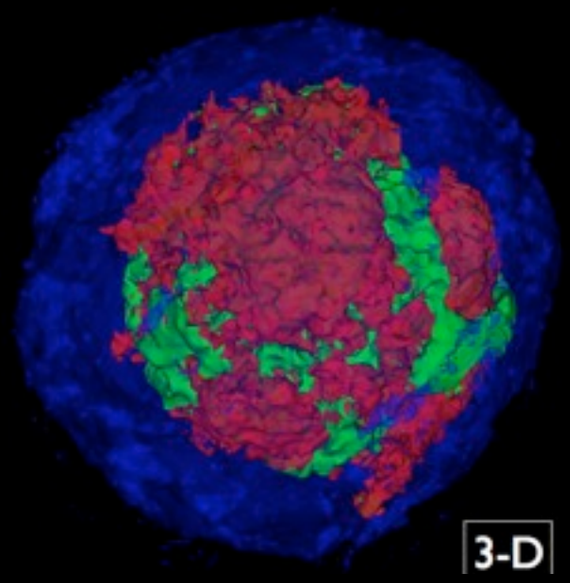
daniel kasen





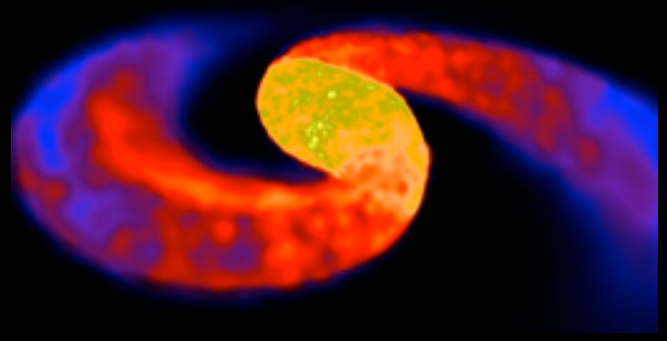
core collapse supernovae

How do they explode? What neutrino physics is probed?



thermonuclear supernovae

What are the progenitors (single or double white dwarfs)? How does fusion ignite and propagate?



neutron star mergers

What are the electromagnetic and gravitational wave signatures? What is the contribution to r-process nucleosynthesis?

codes for end-to-end simulation

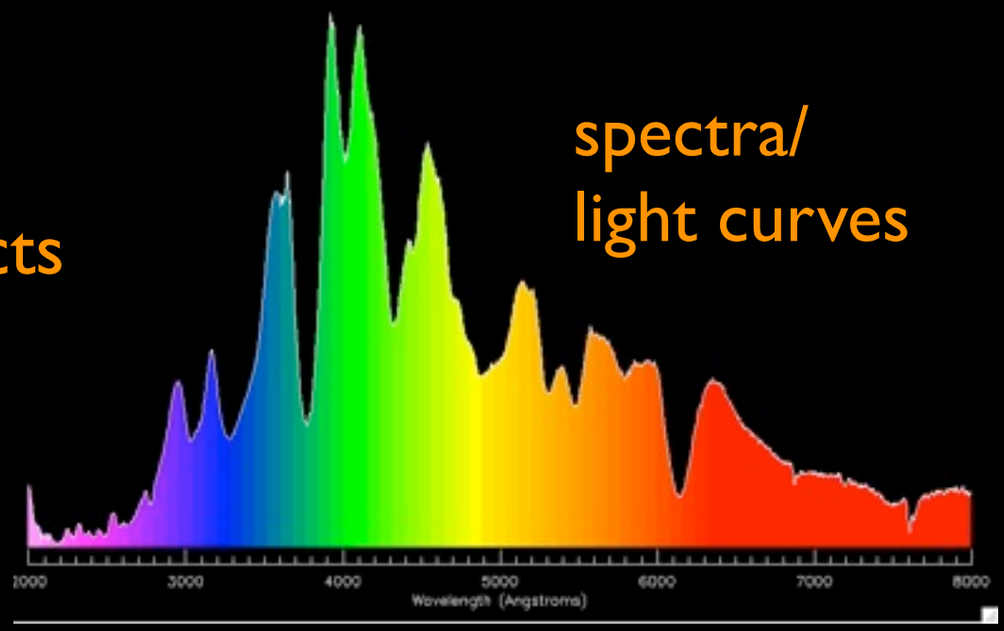
stellar evolution
MESA, KEPLER

hydrodynamics,
gravity
nuclear reactions
neutrino physics
equation of state
CASTRO, SNSPH

stellar evolution (> 10^6 years)

explosion (seconds-hours)

radioactive decay
boltzmann transport
non-equilibrium effects
SEDONA
SEDONA-BOX



spectra/
light curves

radioactive debris (months)

observations

a few computational challenges

- high resolution (spatial and wavelength), scalable monte carlo transfer for light curves and spectra
- coupled radiation-hydrodynamics
- interfacing model and observational data sets

domain decomposed monte carlo transport

w/ Bell, Almgren, Zhang in LBNL Computational Research Division

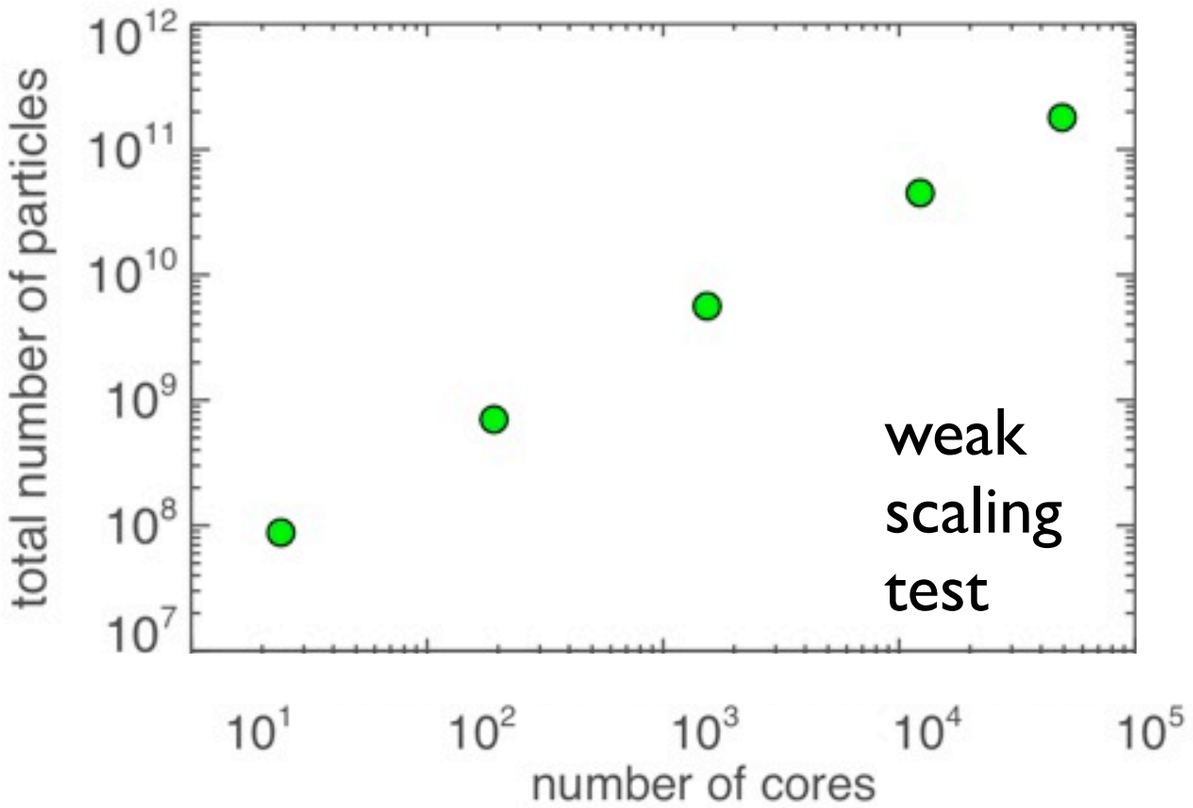
boltzmann particle transport in the BoxLib AMR framework

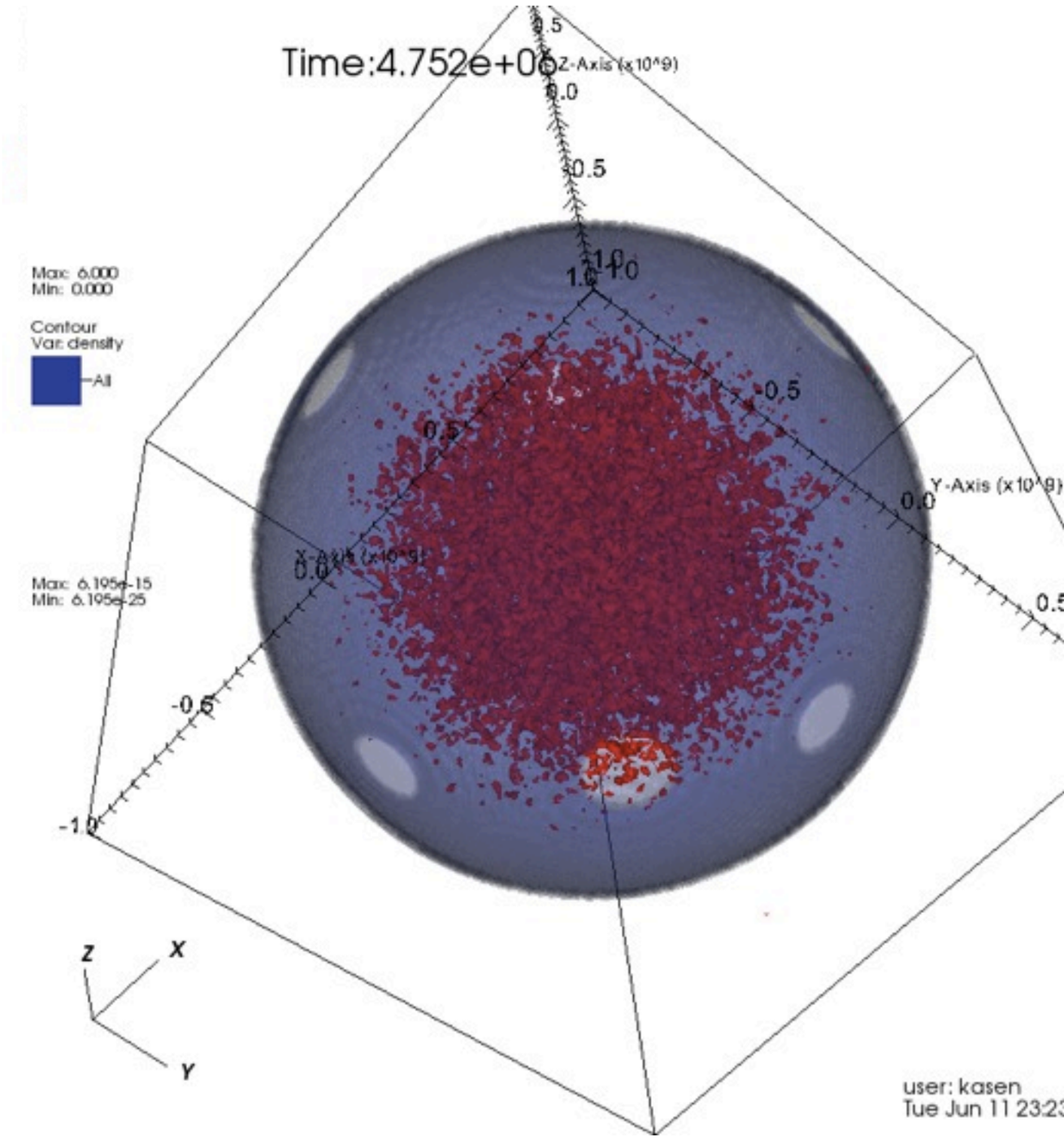
light curve example

1024^3 grid on 24,576 cores

(4096 MPI x 6 thread cores)

10^{10} particles

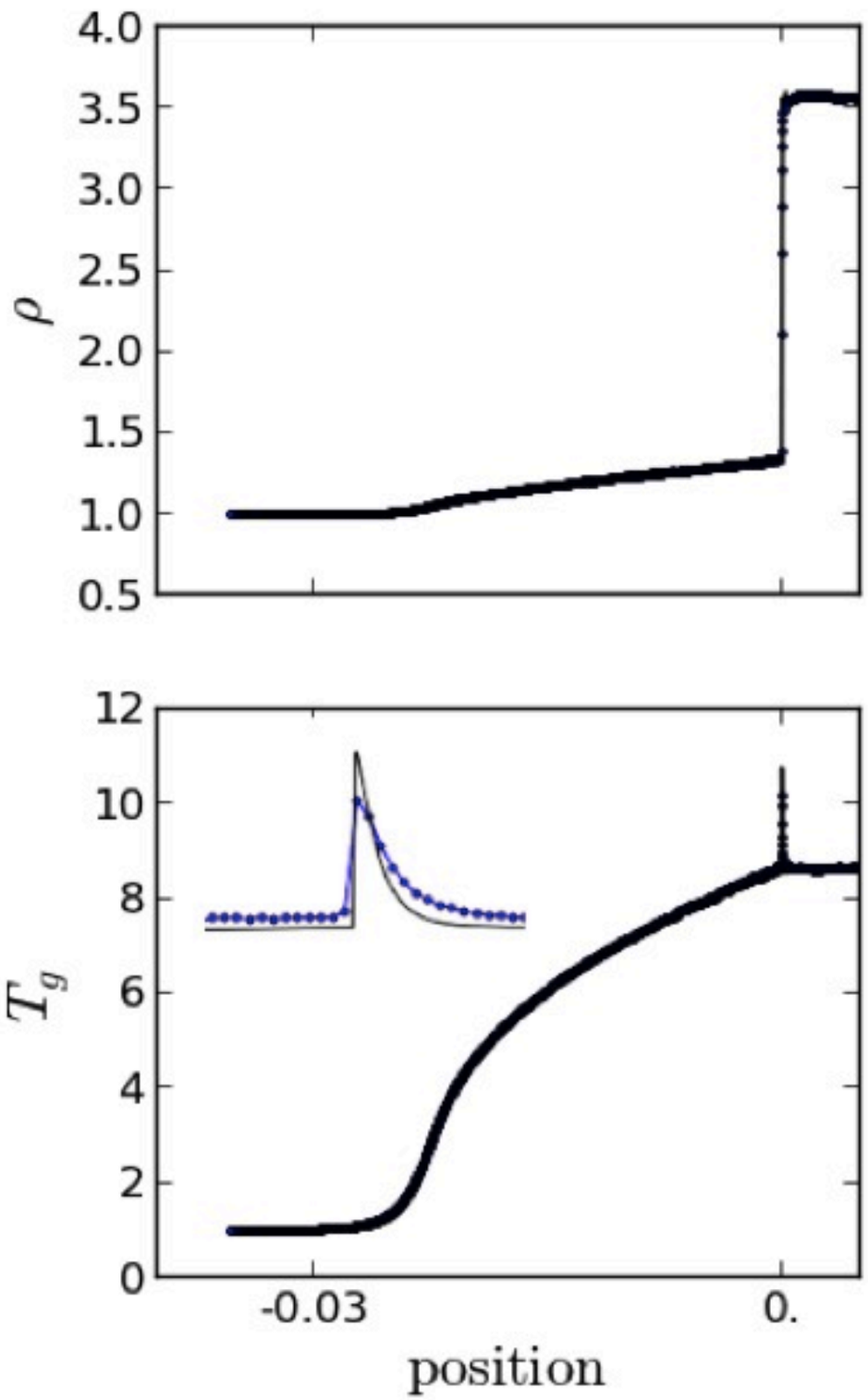


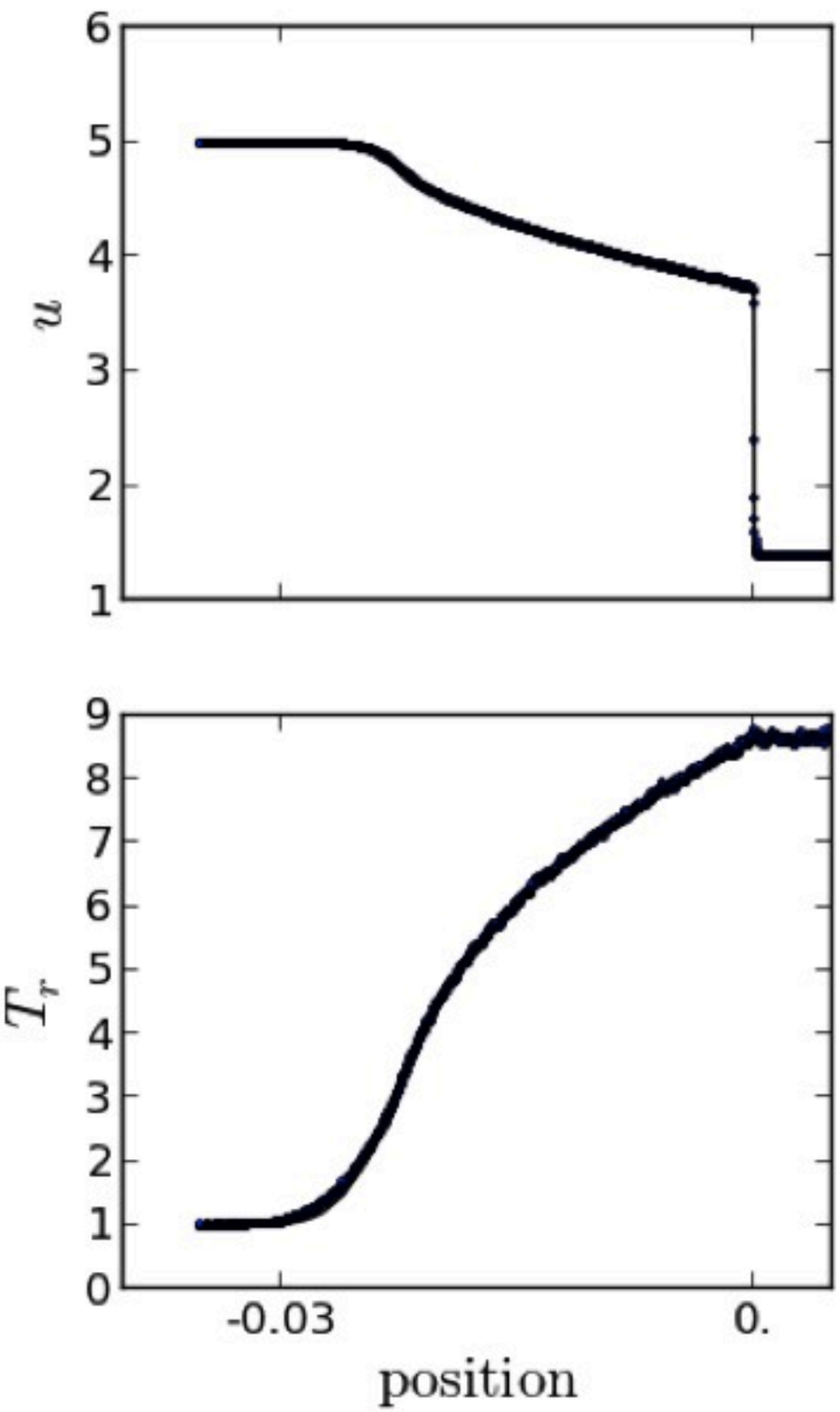


implicit monte carlo radiation hydrodynamics

strong radiative shock test

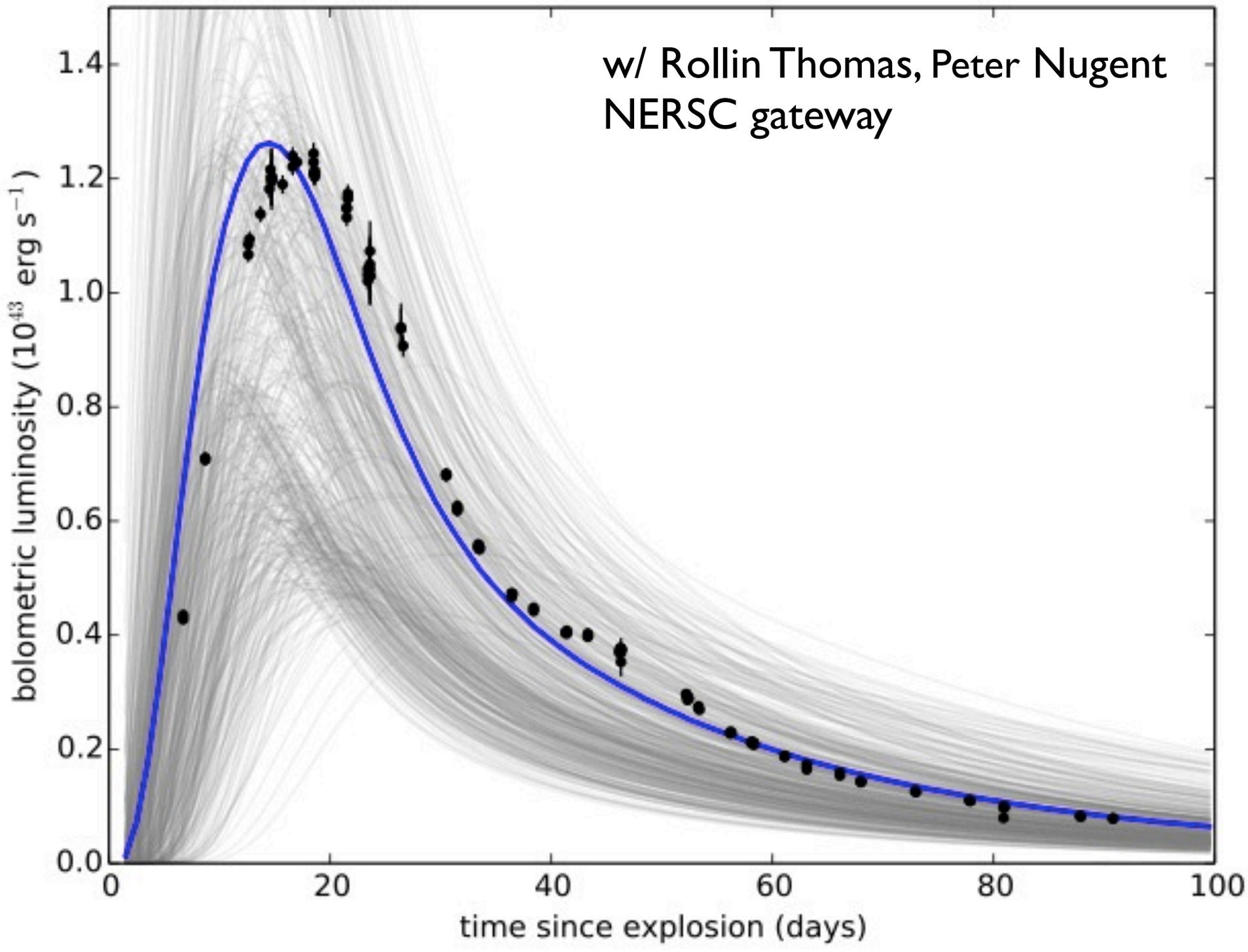
nathan roth & kasen (in prep)





comparison to observations

surrogate modeling, parameter estimation, model inadequacy



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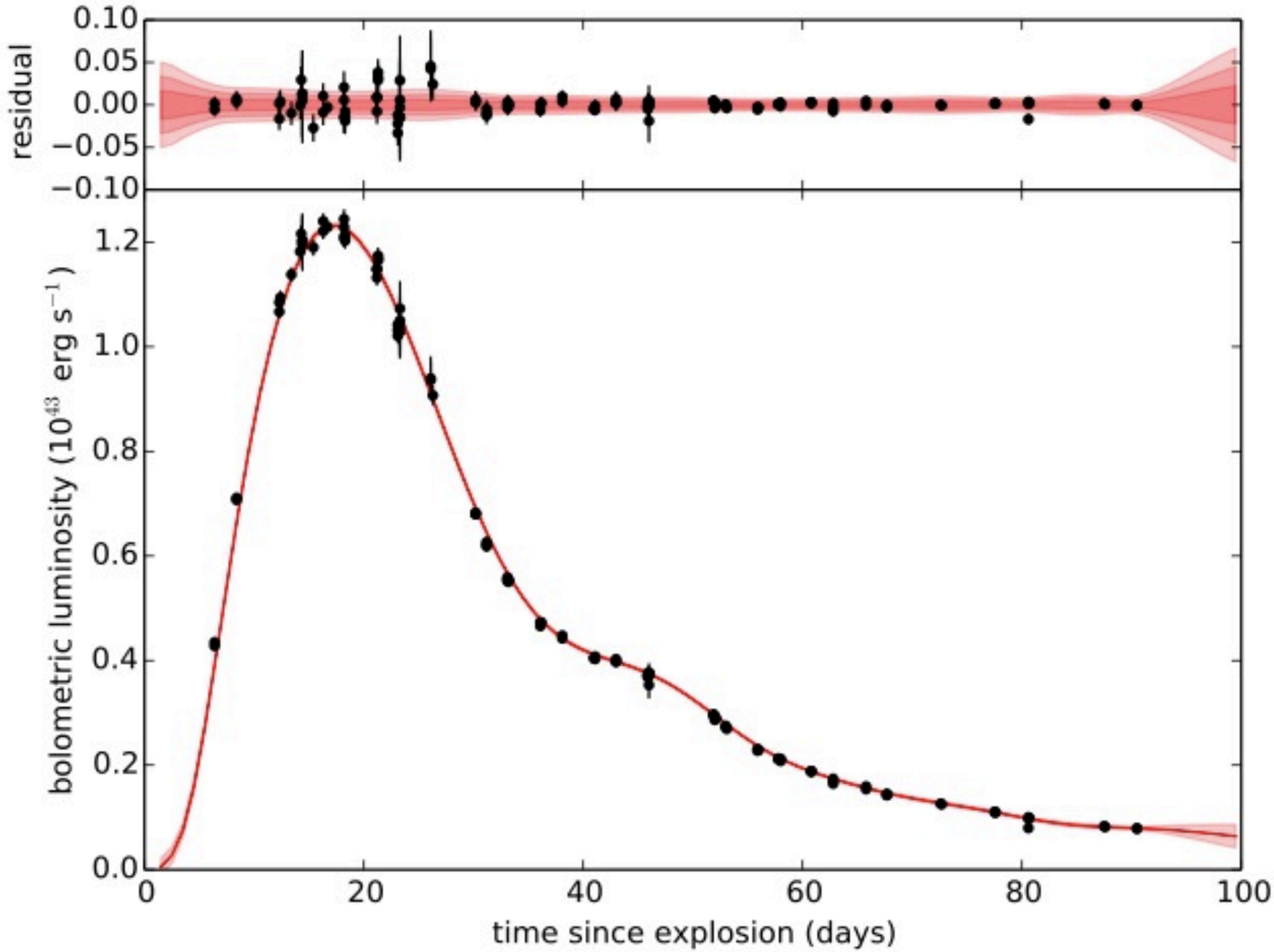
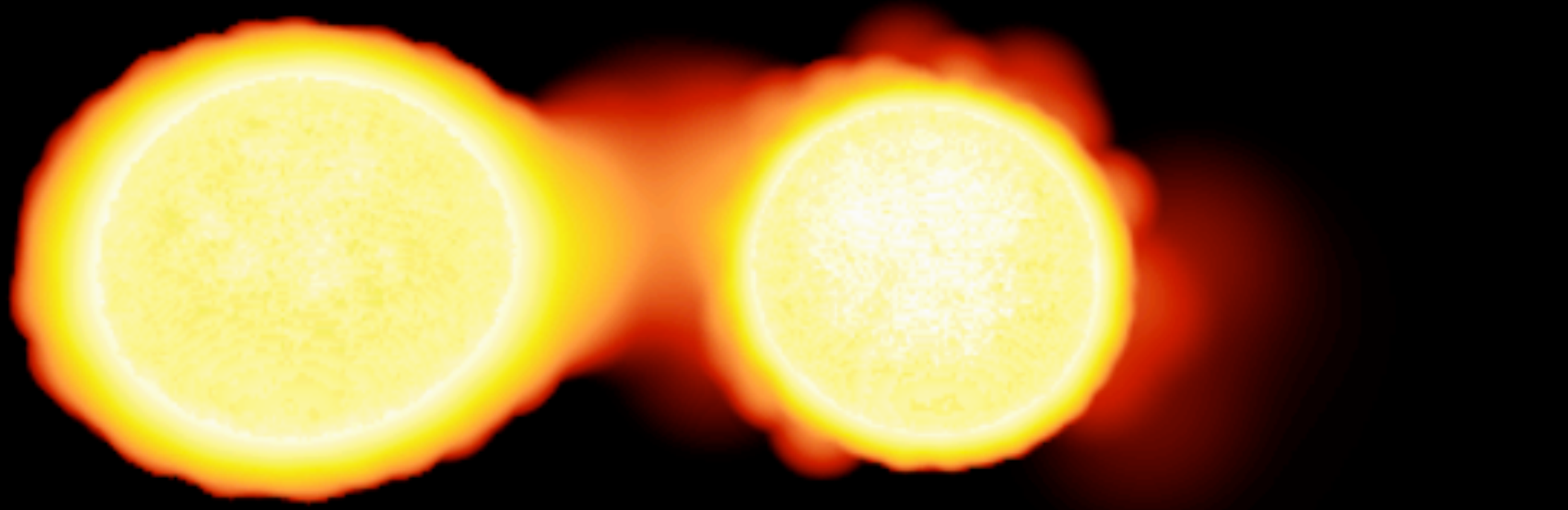


SPH simulation of a carbon/oxygen white dwarf merger model of a Type Ia supernova

raskin and kasen (2013), raskin, kasen et al. (2014)

SPH simulation of a carbon/oxygen white dwarf merger model of a Type Ia supernova

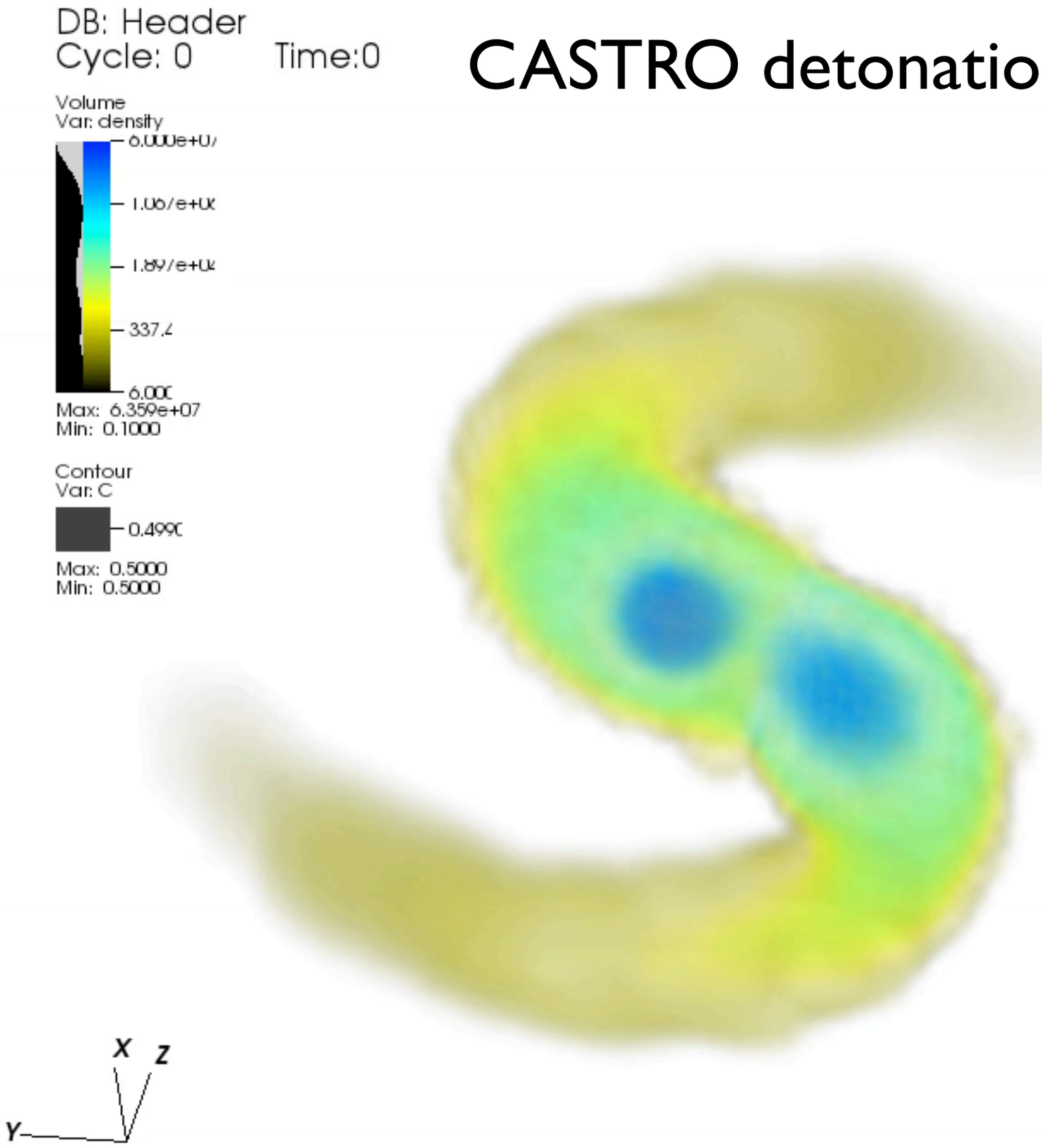


raskin and kasen (2013), raskin, kasen et al. (2014)

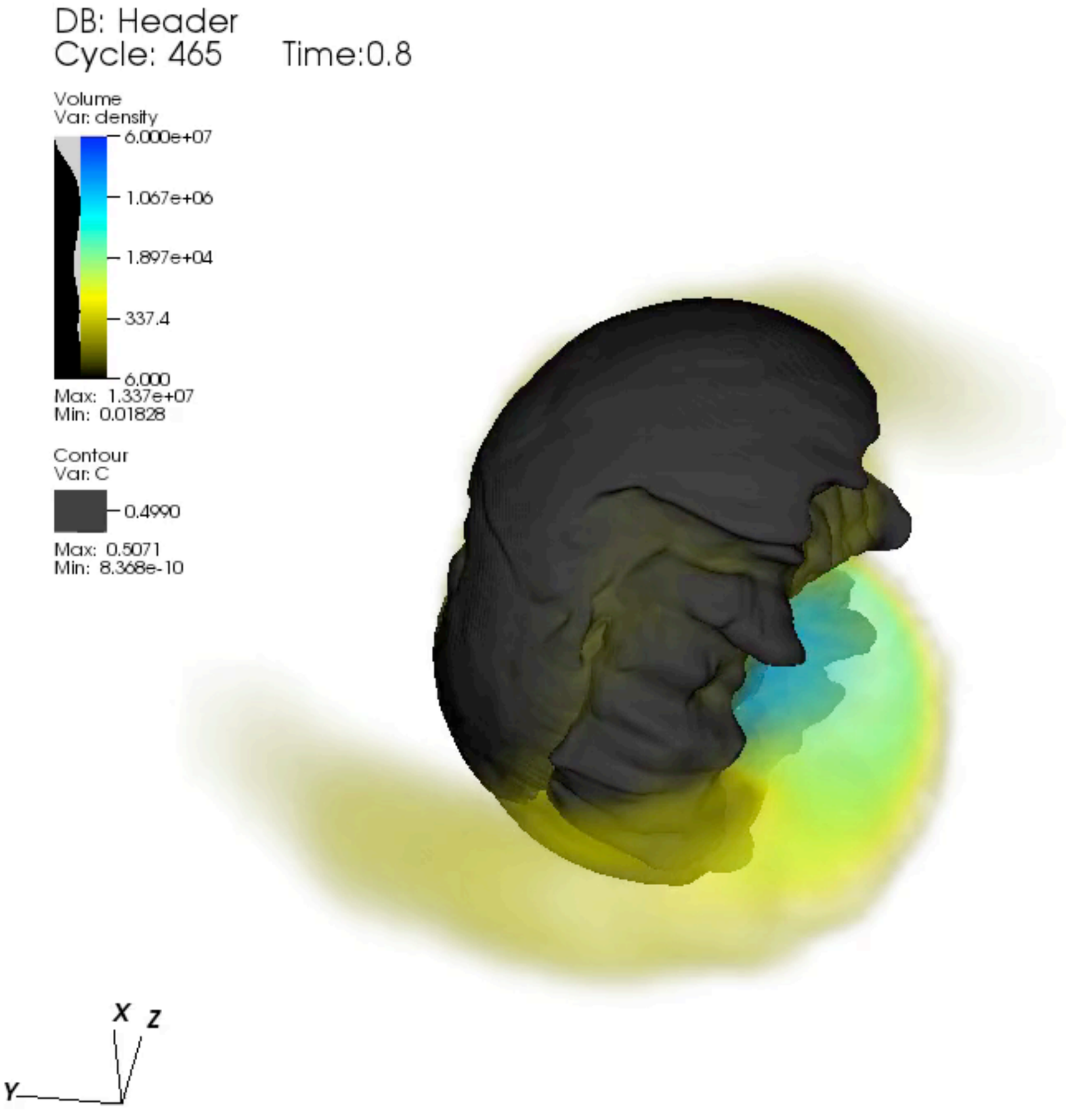
CASTRO detonation calculation

moll, raskin, kasen, woosley (2014)

CASTRO detonation calculation



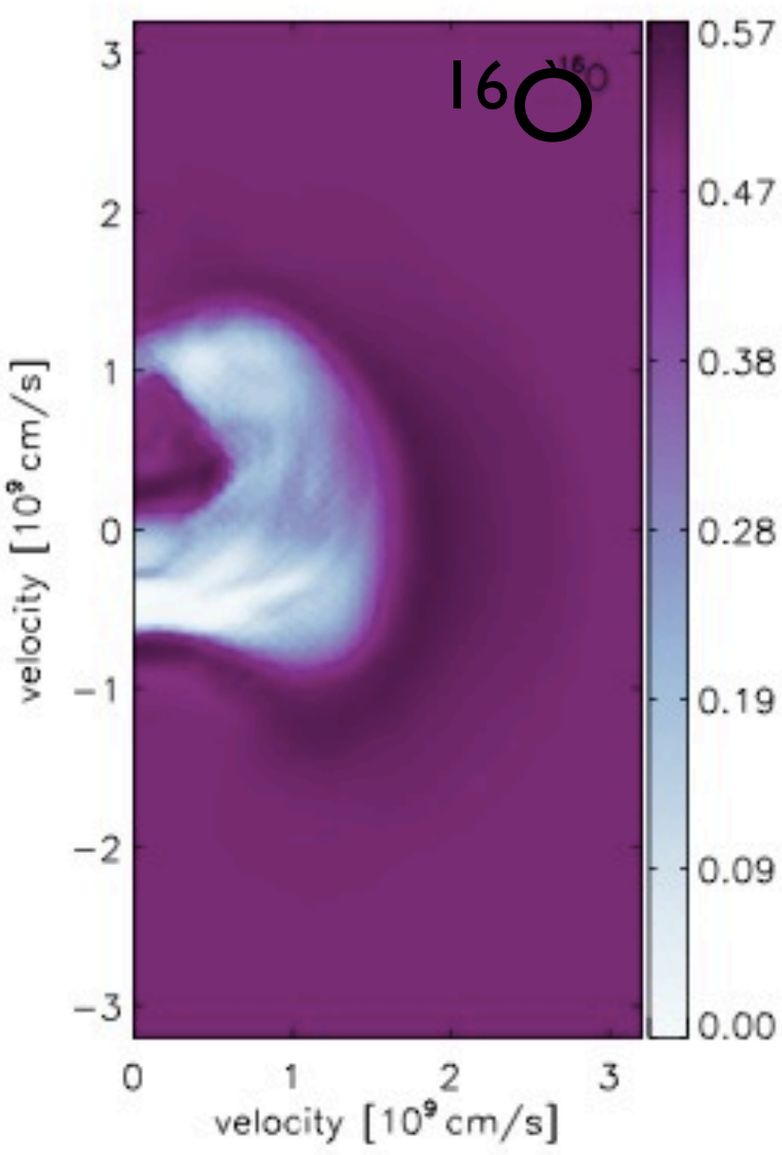
moll, raskin, kasen, woosley (2014)

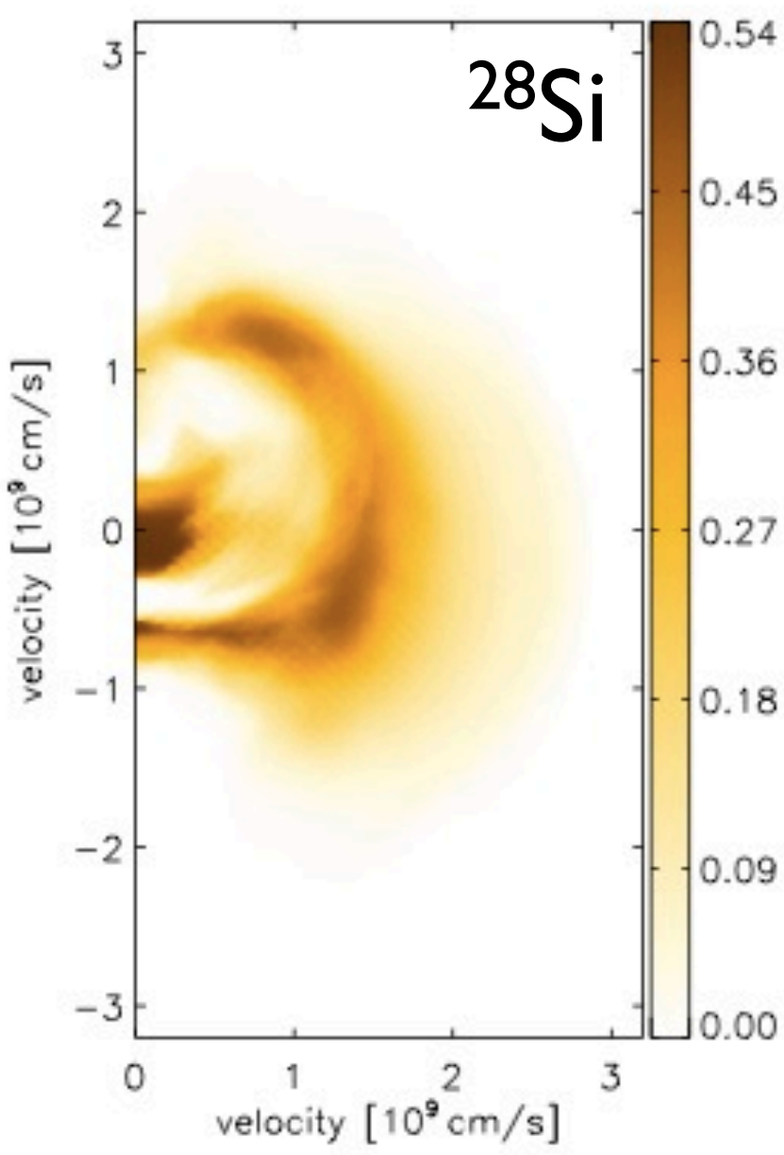


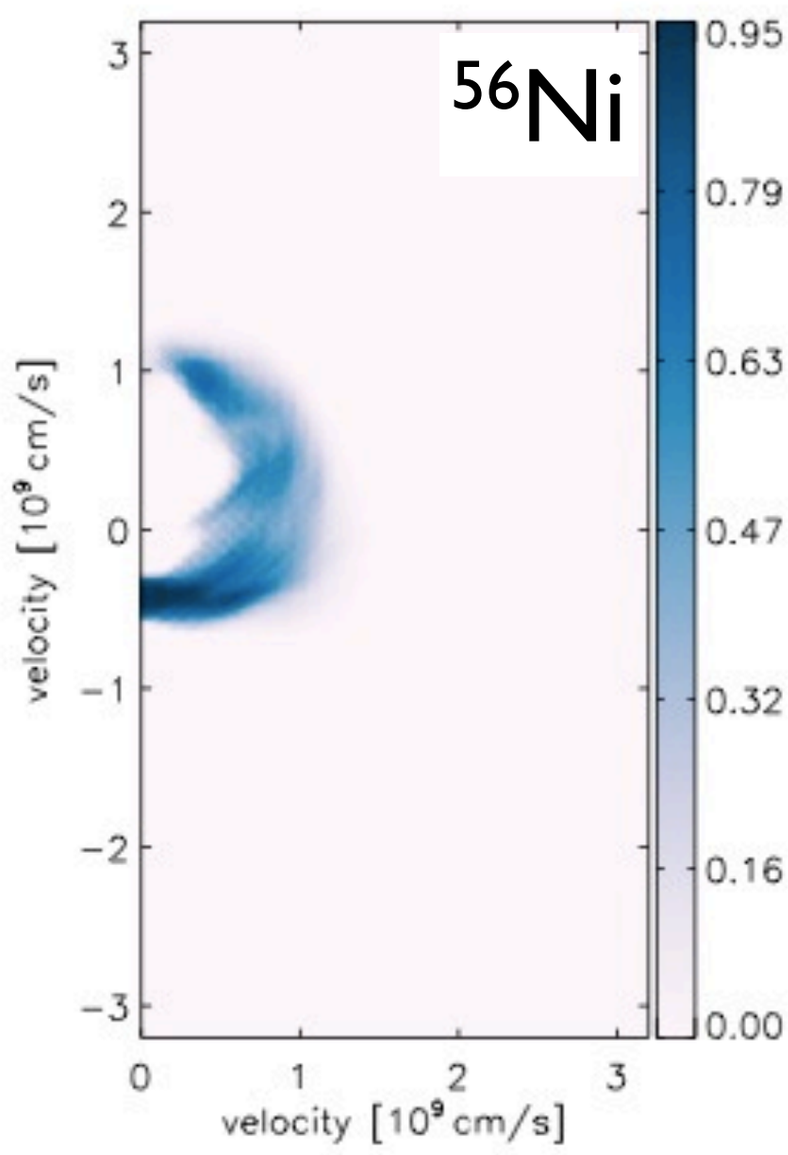
moll, raskin, kasen, woosley (2014)

white dwarf mergers as Type Ia supernovae

compositional structure of remnant

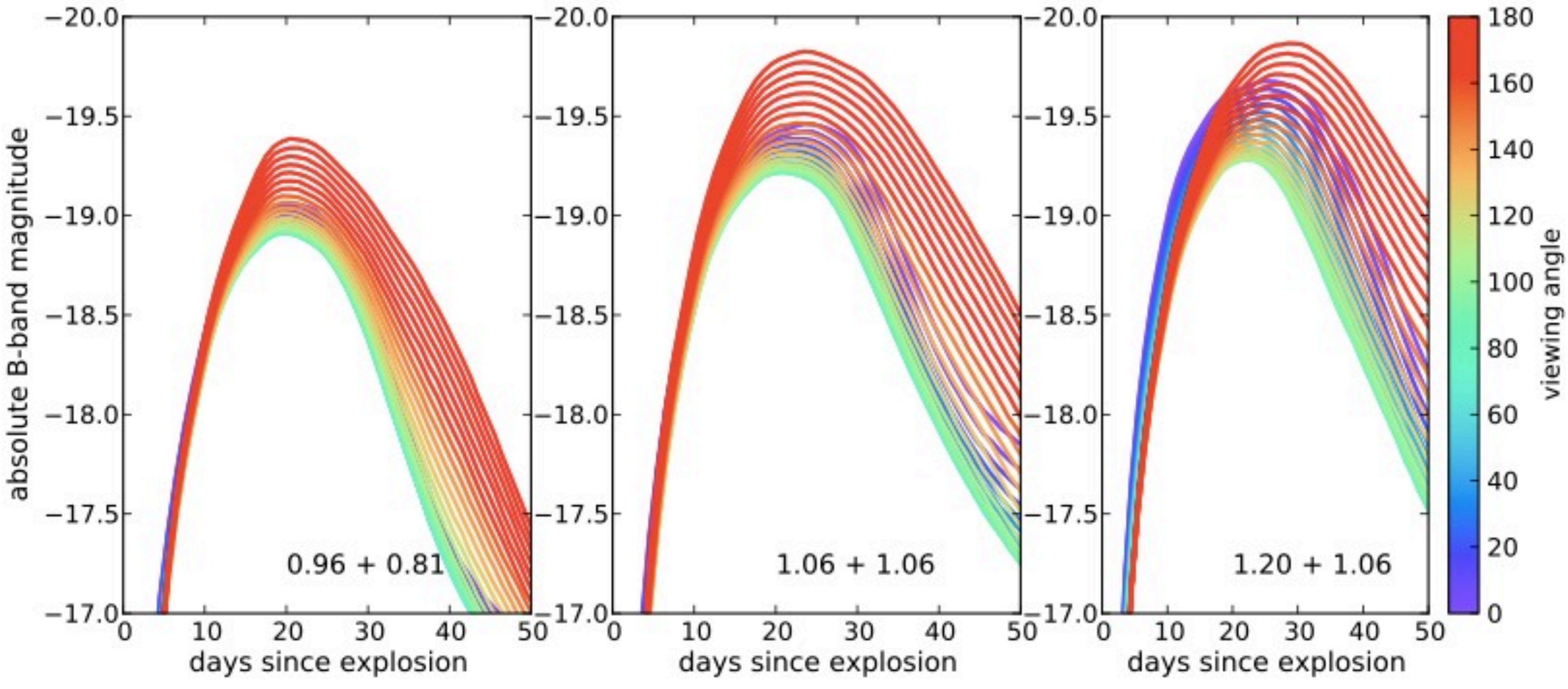




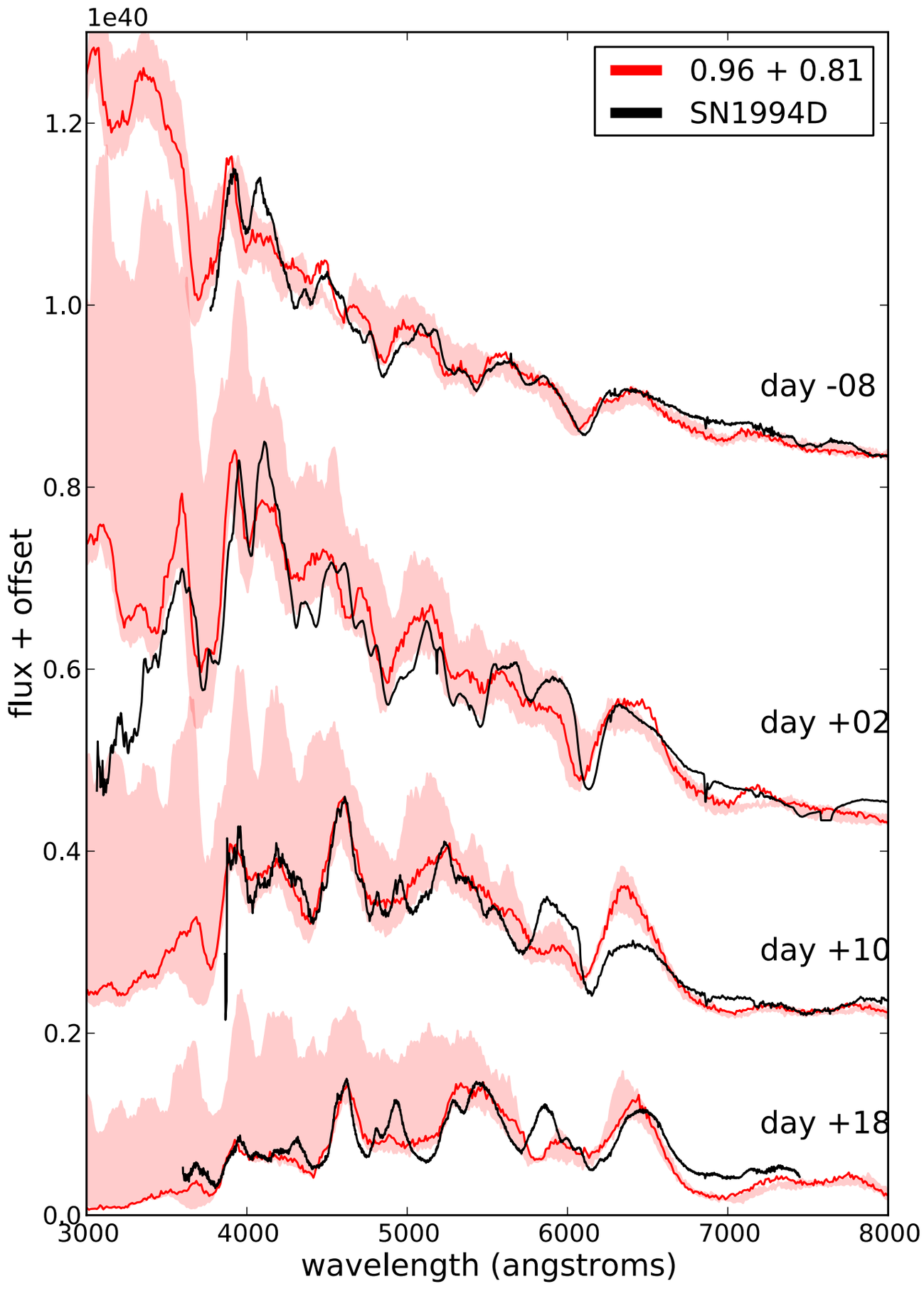


white dwarf merger as Type Ia supernovae

synthetic B-band light curves



moll, raskin, kasen, woosley (2014)

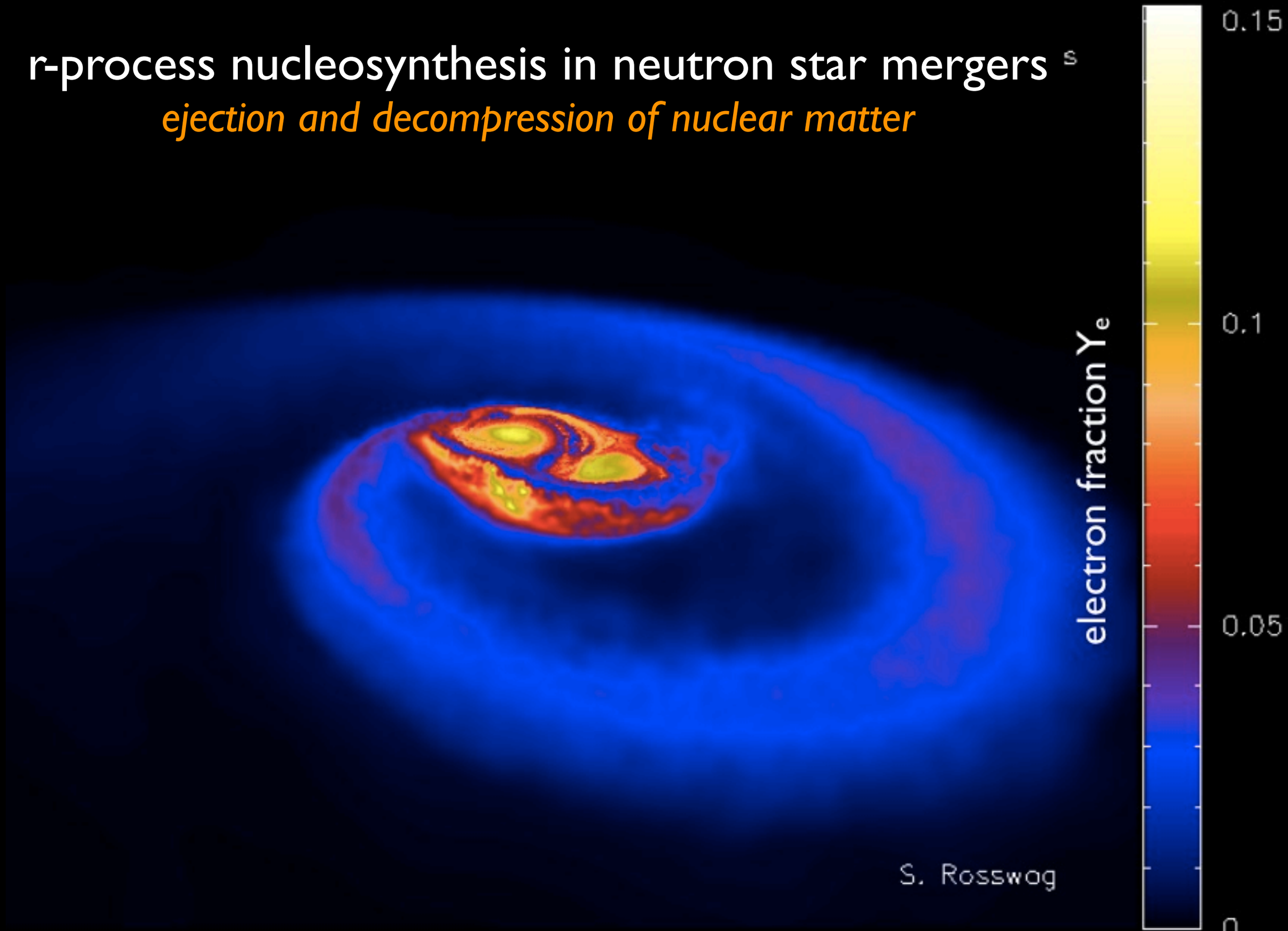


white dwarf mergers as Type Ia supernova

comparison to observed spectra

r-process nucleosynthesis in neutron star mergers [5]

ejection and decompression of nuclear matter



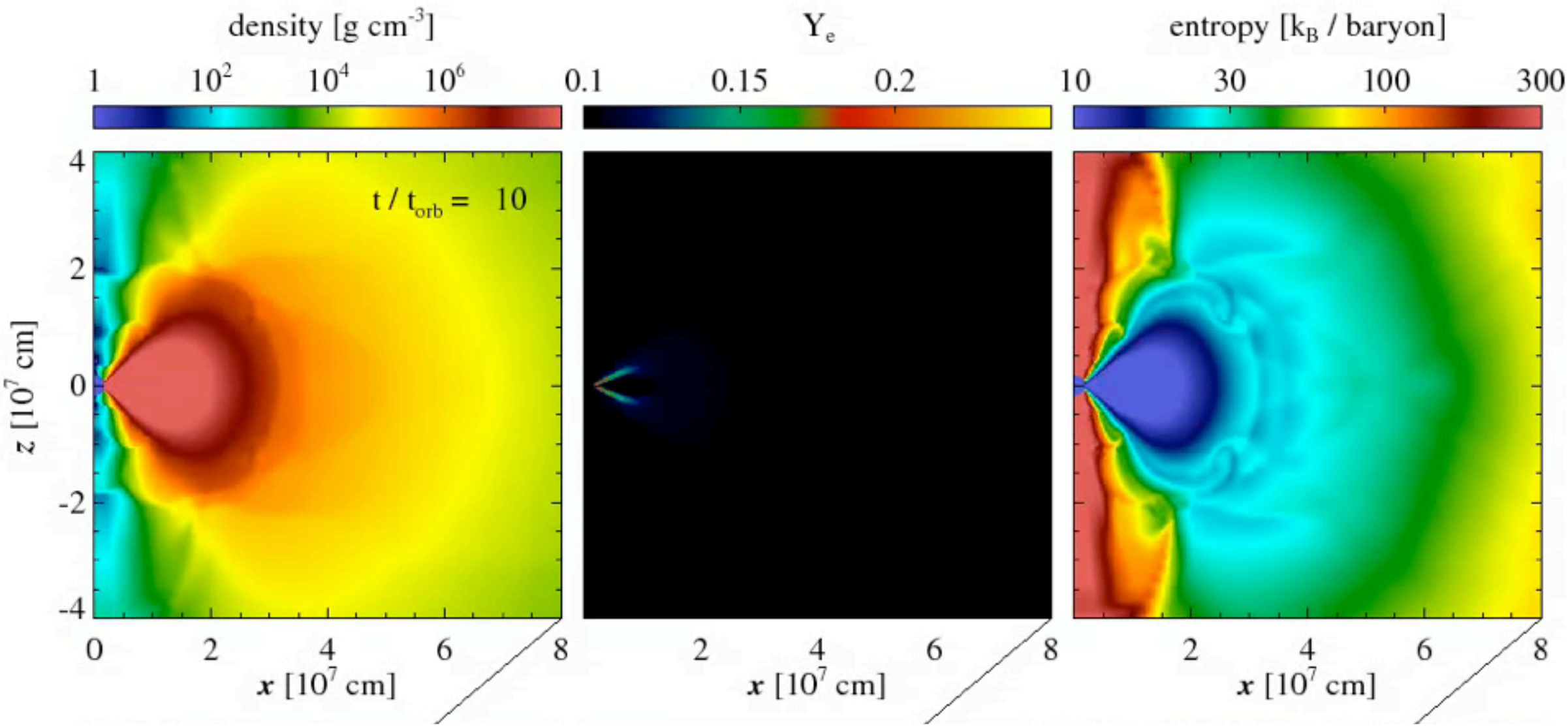
post-merger mass ejection in winds

fernandez and metzger (2013)

2D FLASH calculations

post-merger mass ejection in winds

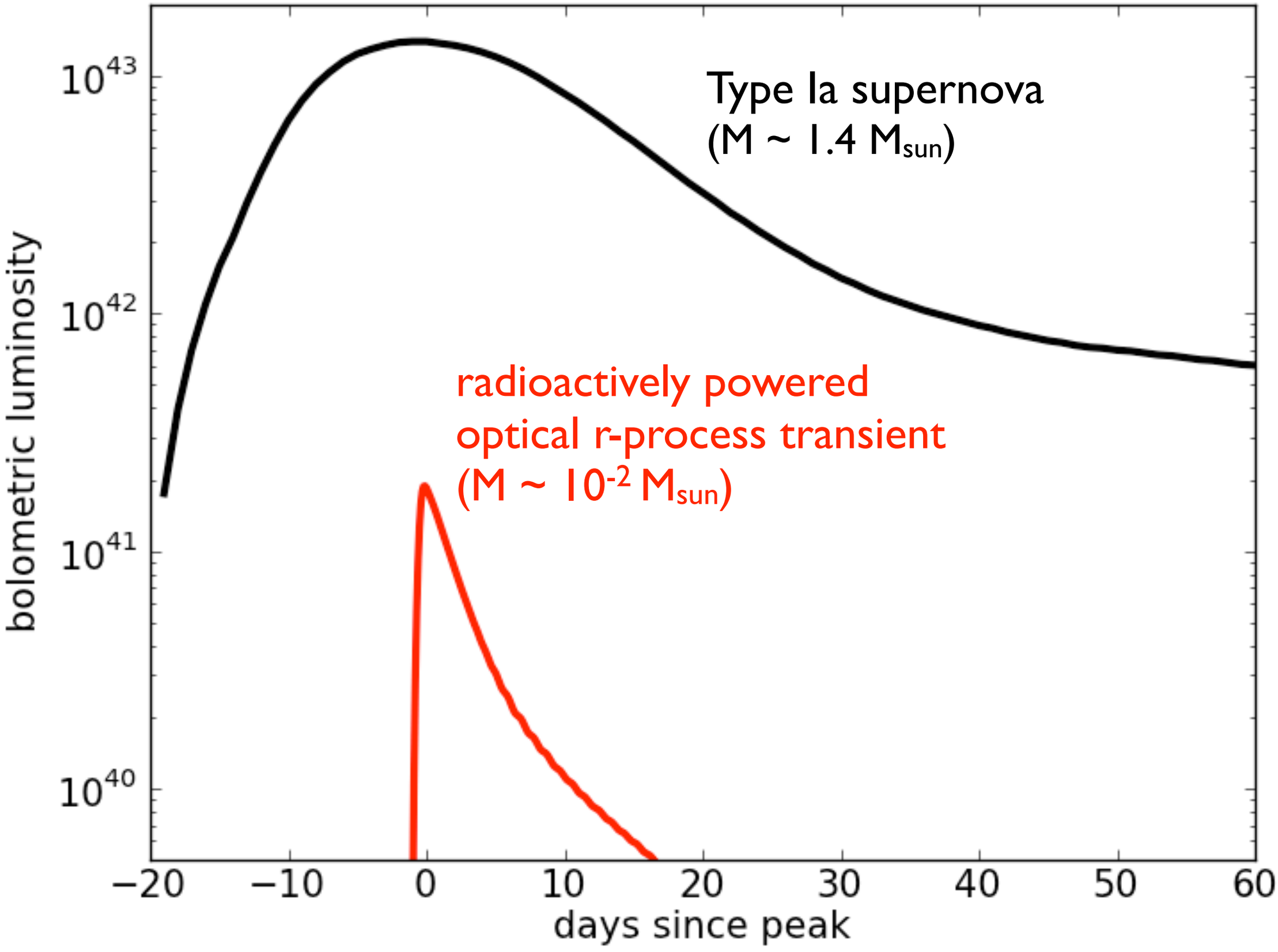
fernandez and metzger (2013)



2D FLASH calculations

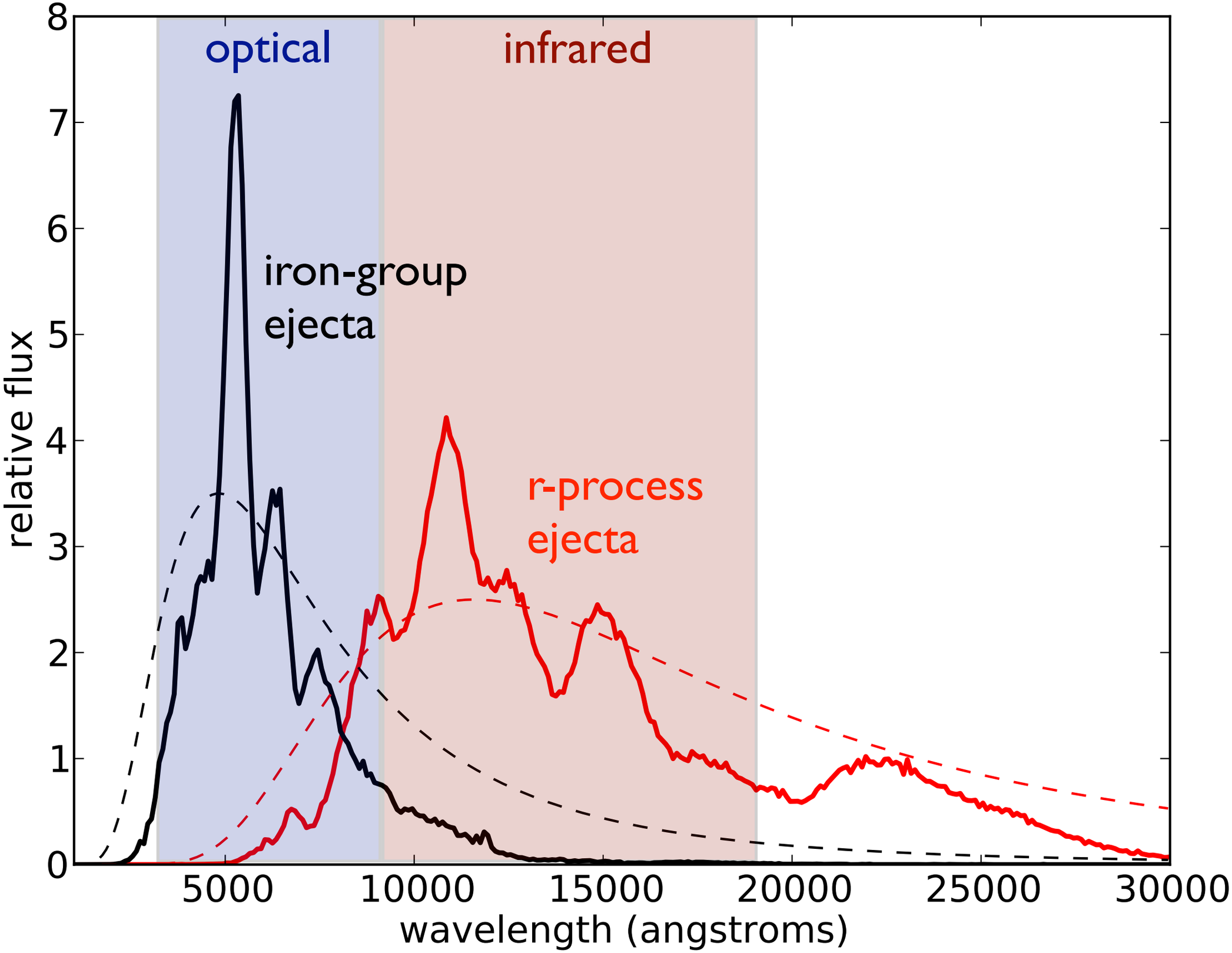
kilonovae from neutron star mergers

a direct astrophysical probe of r-process nucleosynthesis

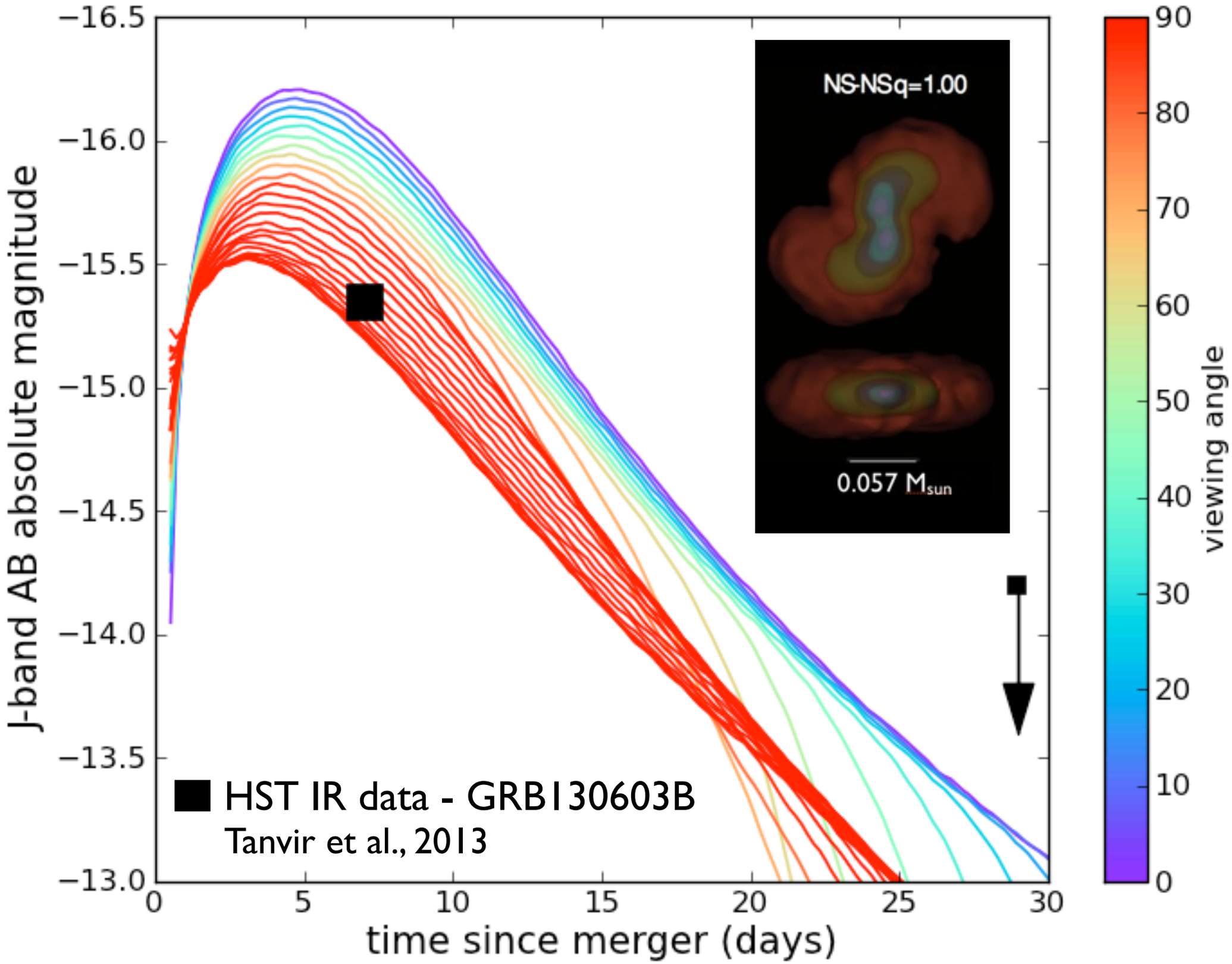


spectral signatures of r-process ejecta

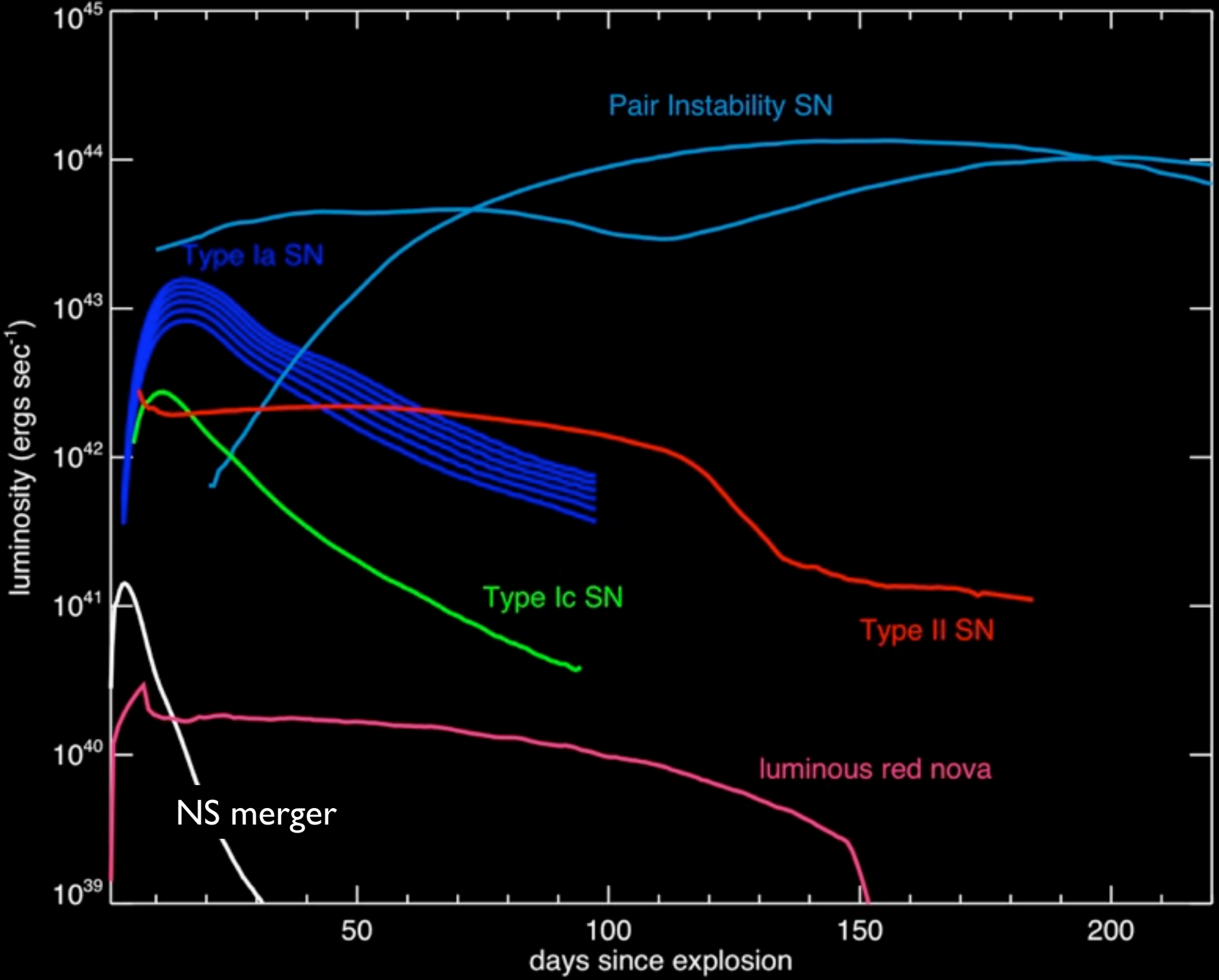
barnes & kasen 2013, kasen et al.2013

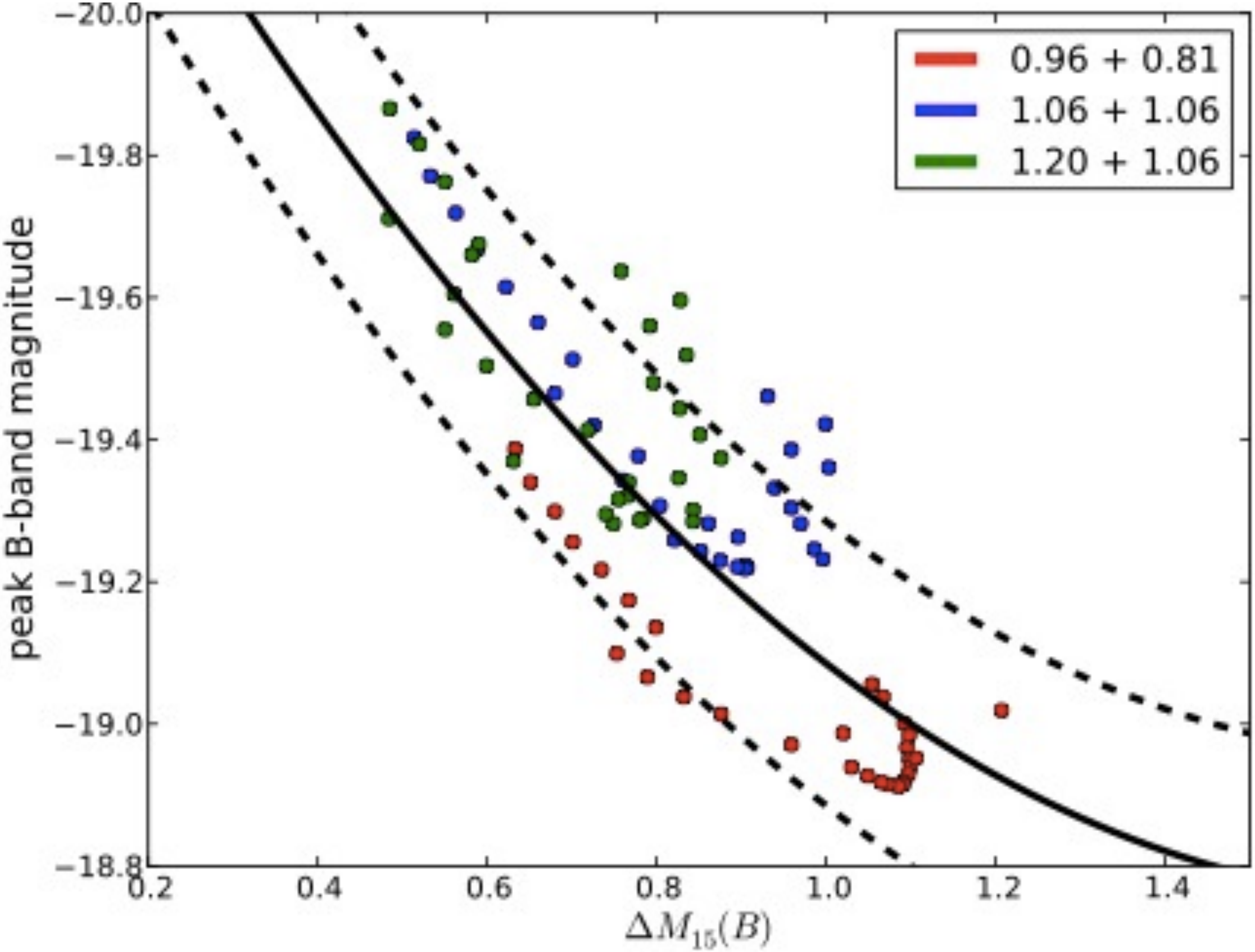


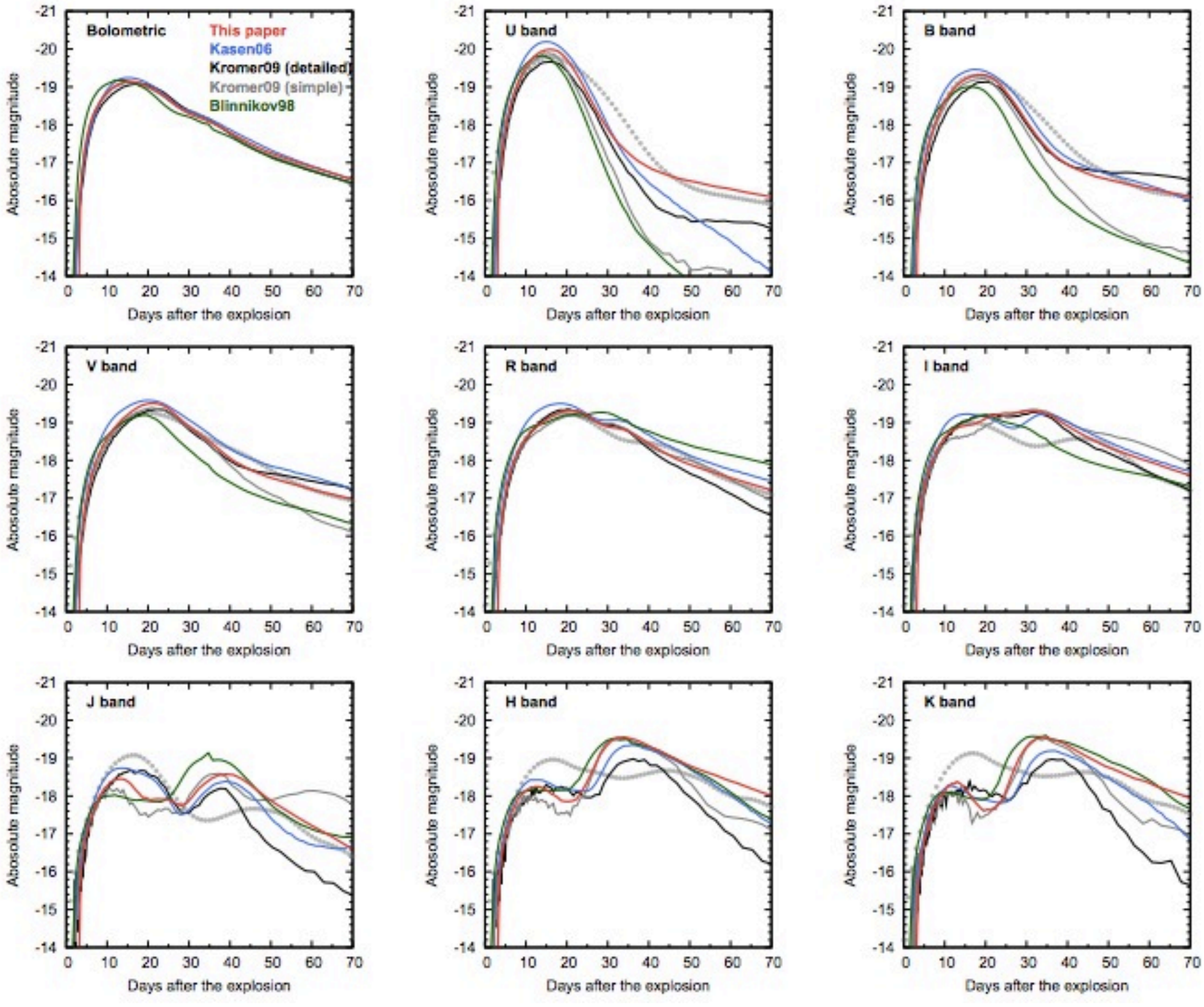
3D kilonova light curve simulation



theoretical transient universe




0.96 + 0.81
1.06 + 1.06
1.20 + 1.06
−20.0
−19.8
−19.6
−19.4
−19.2
−19.0
−18.8
peak B-band magnitude
0.2
0.4
0.6
0.8
1.0
1.2
1.4
$\Delta M_{15}(B)$



tanaka and hotokezaka 2013