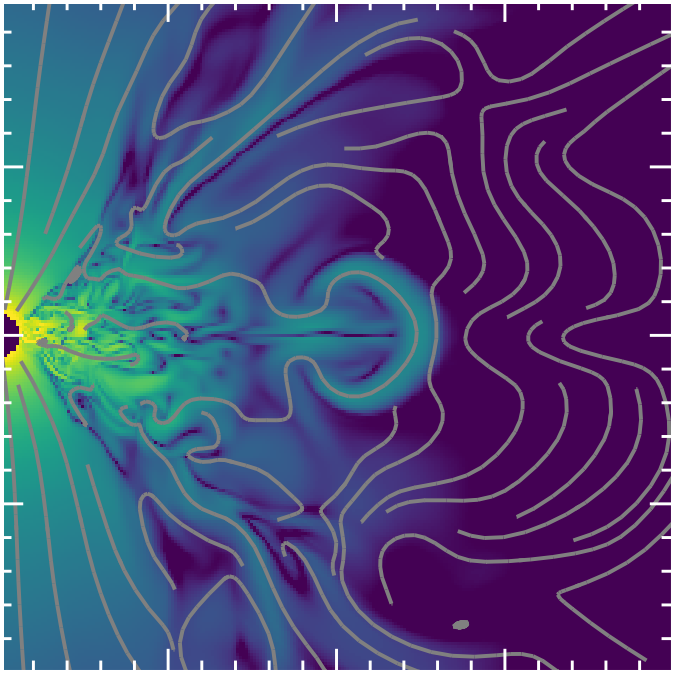
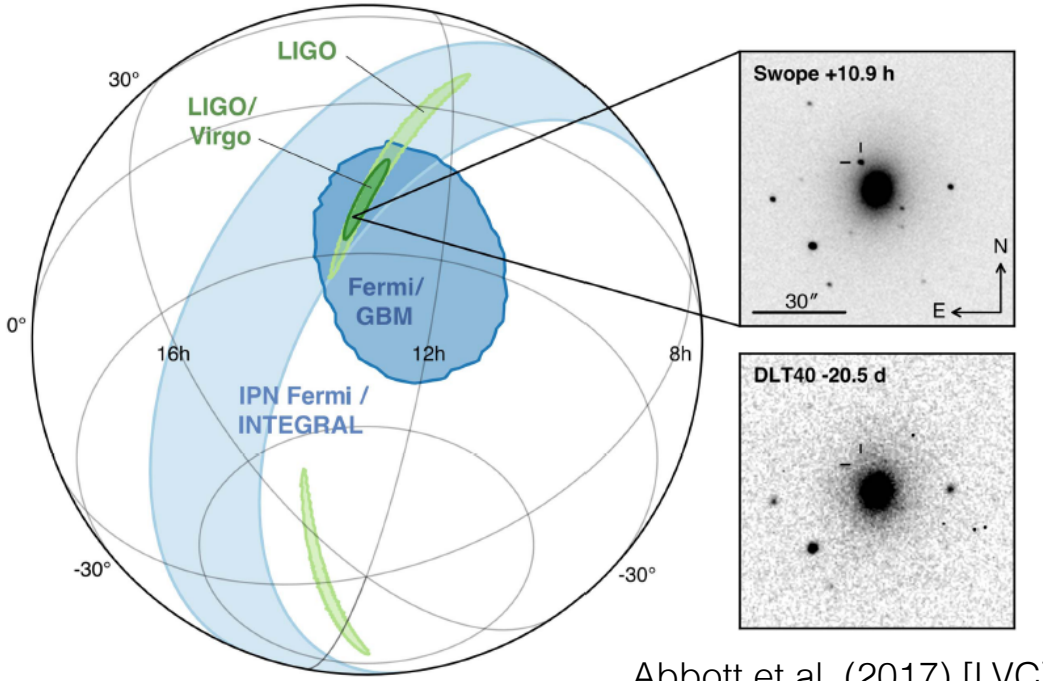




Abbott et al. (2017) [LVC]

Multi-messenger Transient Theory in Canada

Rodrigo Fernández (University of Alberta)

Overview

1. Science questions

2. MM transient theoretical activity in Canada

3. Future directions and opportunities

Time-domain Astronomy

Motivation:

- Transient surveys

- GW source follow up

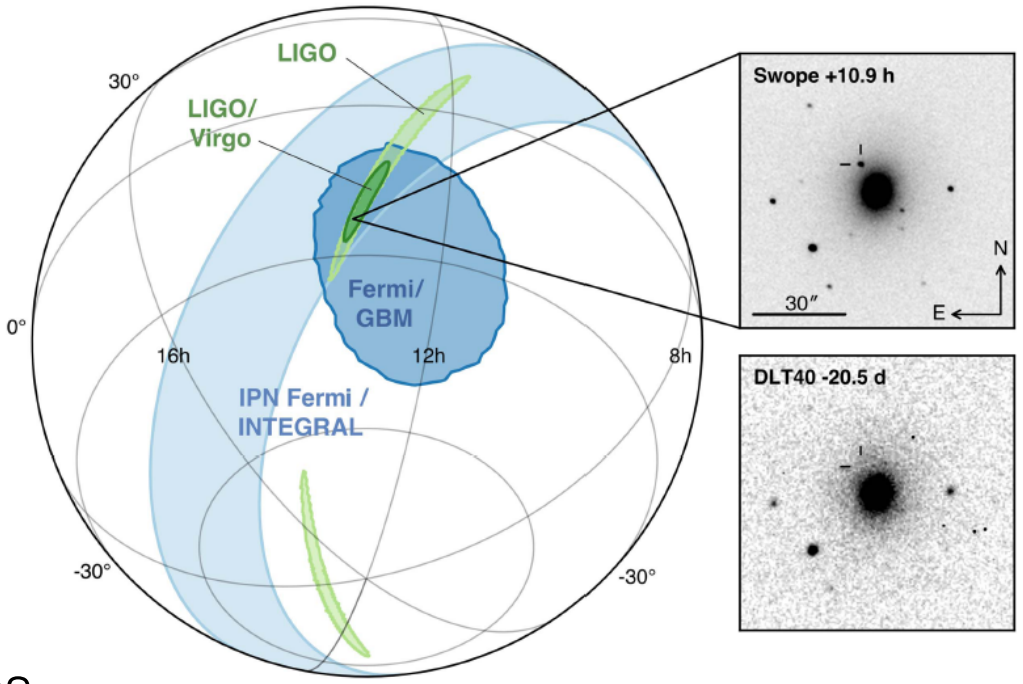
Science:

- origin of elements

- probes of fundamental physics

- compact object formation

- other astrophysics



Abbott et al. (2017) [LVC]

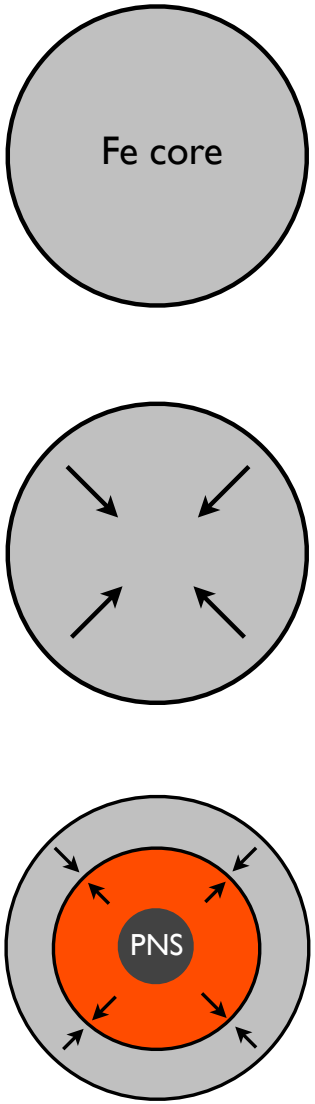
Transients

1) Galactic CCSNe:
- MeV neutrinos (if star not too massive)
- GW (if not too far & stochastic)
- EM (if bright & not too obscured by dust)
- progenitor & remnant (maybe)

Science questions (for Astrophysics):

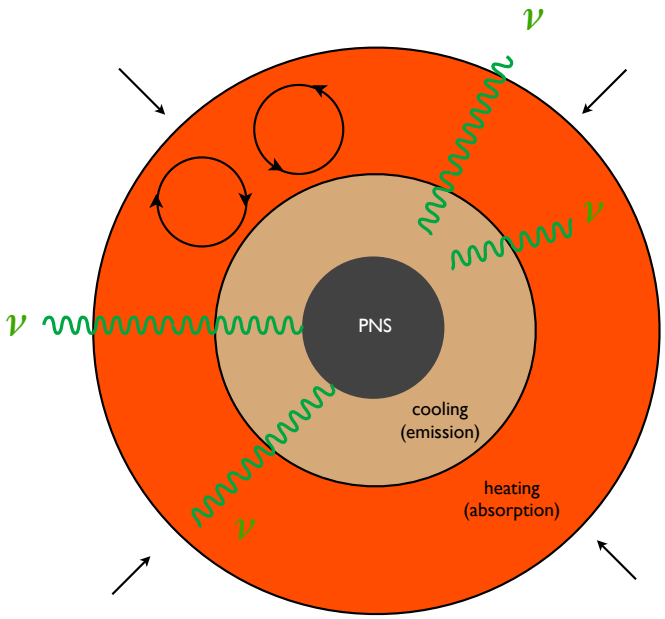
- explosion mechanism (neutrinos crucial), energy & yield
- progenitor / remnant connection
- compact object birth properties
- EOS of dense matter
- neutrino physics: flavor transformation, exotic species, etc

Core-Collapse Supernovae



Bounce shock stalls: must be revived for a successful explosion.

Neutrino mechanism: absorption of energy in a layer inside the shock fills the gap



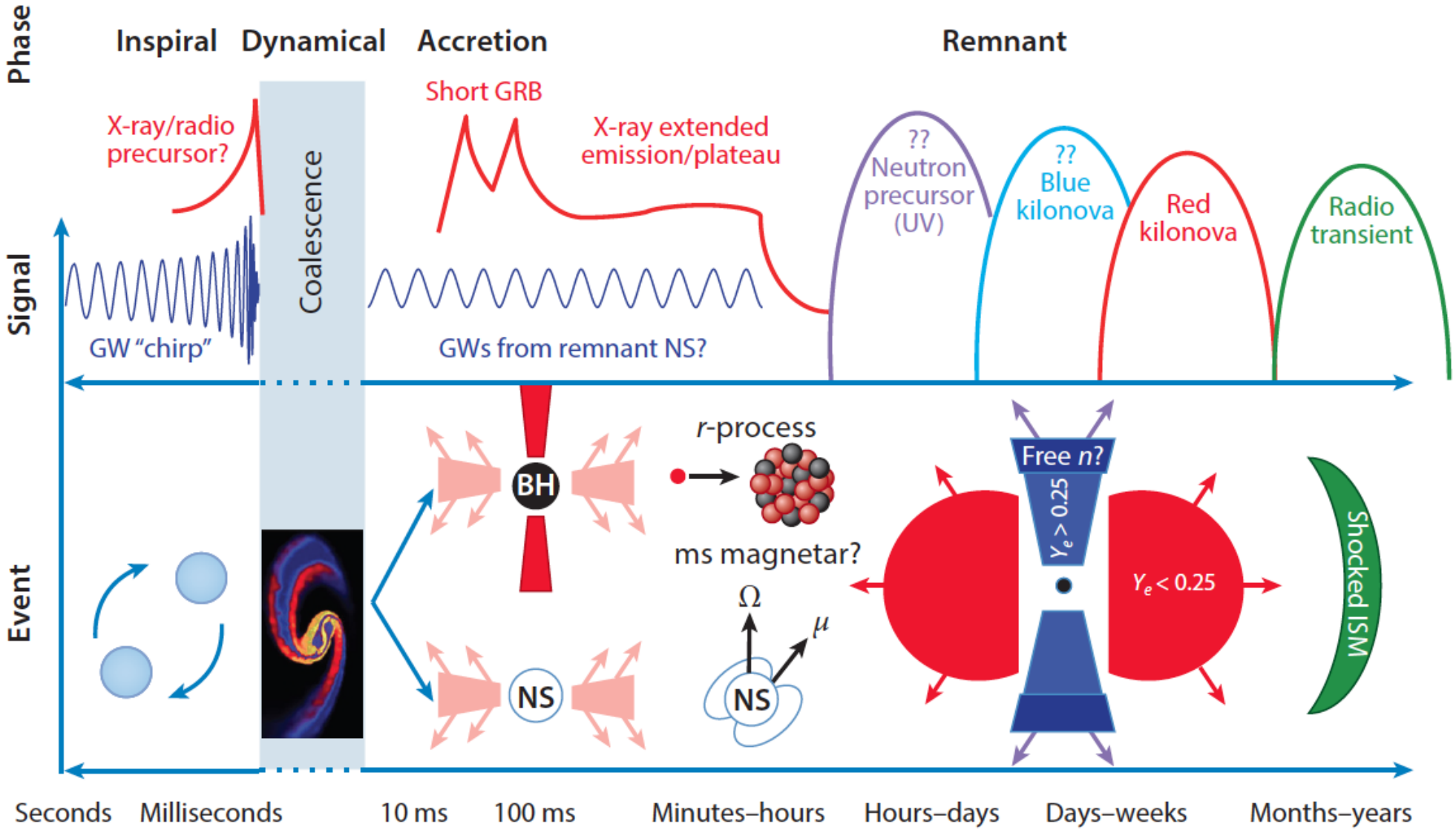
Transients

1) NS / BH mergers
- GW (if not too far)
- EM (if not too far or obscured by dust)
- HE neutrinos (maybe, if jet on-axis: sGRB)
- MeV neutrinos (unlikely, < 10^{-2} of SN rate)

Science questions (for Astrophysics):

- nucleosynthesis yield (neutrinos crucial)
- binary stellar evolution
- progenitors of high-energy transients
- tests of fundamental physics: EOS, Hubble constant, etc.

Neutron Star Mergers



RF & Metzger (2016)

MM Transient Theory in Canada

(partial list)

1) Perimeter / Waterloo / Guelph:

Lehner, East: Numerical Relativity, GW

Siegel: GRMHD, merger remnants, outflows

Caballero: Nucleosynthesis

2) UToronto / CITA:

Matzner: Shock breakout, supernovae

Thompson: Neutron star formation

Gossan: CCSN explosion mechanism

Yalinevich: Shock physics, thermonuclear transients

MM Transient Theory in Canada

(partial list)

3) UAlberta:

Ivanova: Binary evolution, stellar mergers

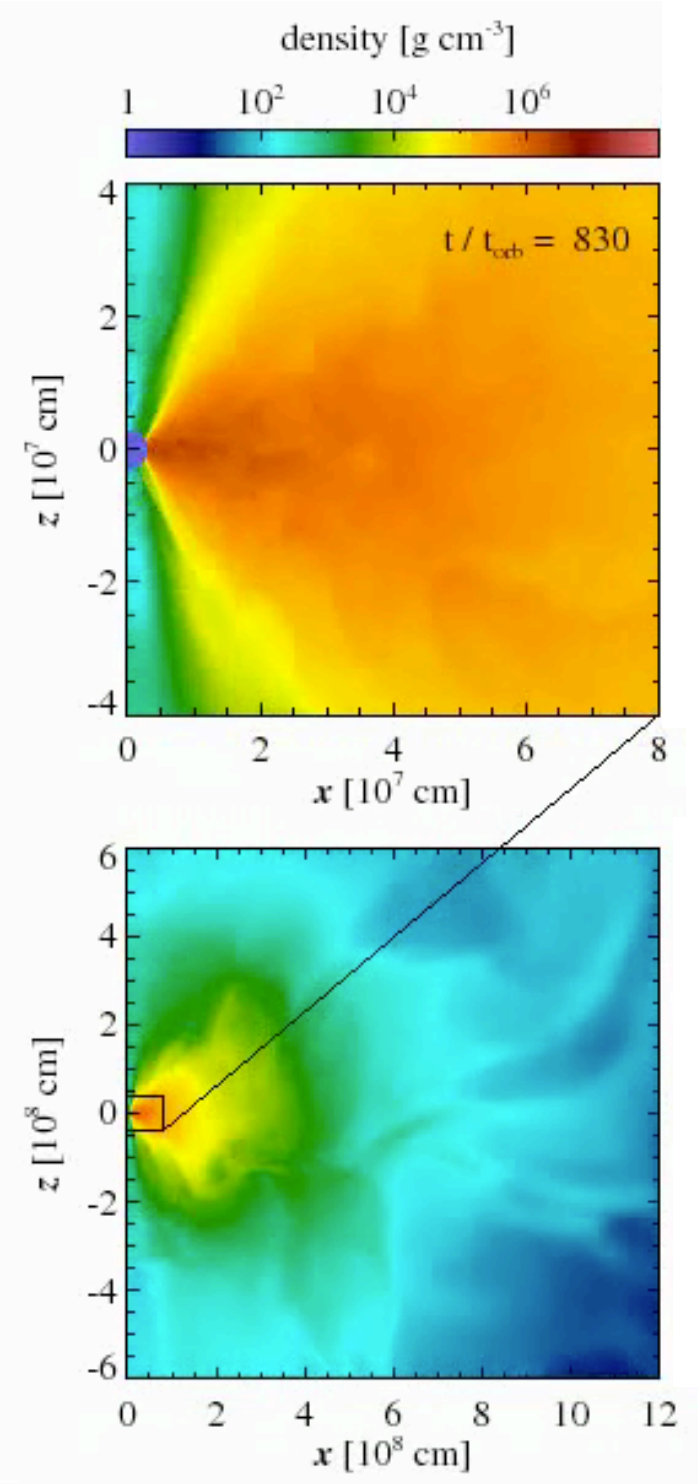
Fernandez: Mass ejection in transients

4) UCalgary:

Ouyed: Quark EOS and supernova explosions

5) UVic:

Herwig: Nucleosynthesis, supernova progenitors



Wind from remnant accretion disk

- Neutrino cooling shuts down as disk spreads on accretion timescale (~300ms)
- Viscous heating & nuclear recombination are unbalanced
- If BH-disk, eject fraction ~10-20% of initial disk mass, more if HMNS-disk
- Material is neutron-rich (Ye ~ 0.2-0.4), mostly light r-process, some light dep. on parameters
- Mass-averaged wind speed (~0.05c) is slower than dynamical ejecta (~0.1-0.3c)

RF & Metzger (2013), MNRAS

Just et al. (2015), MNRAS

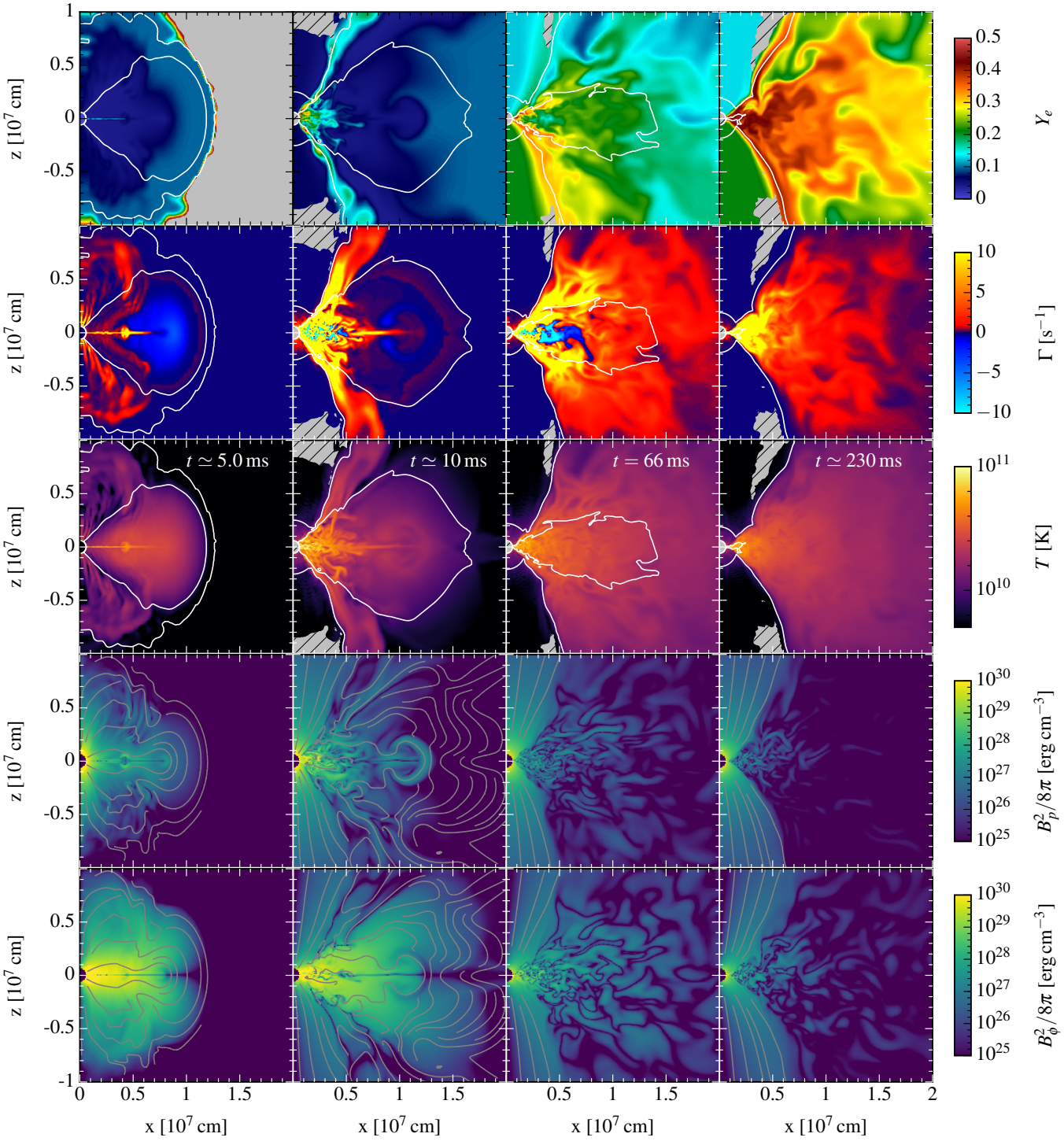
Perego+(2014)

Fujibayashi+(2017)

Setiawan et al. (2005)

Lee, Ramirez-Ruiz, & Lopez-Camara (2009)

Metzger (2009)



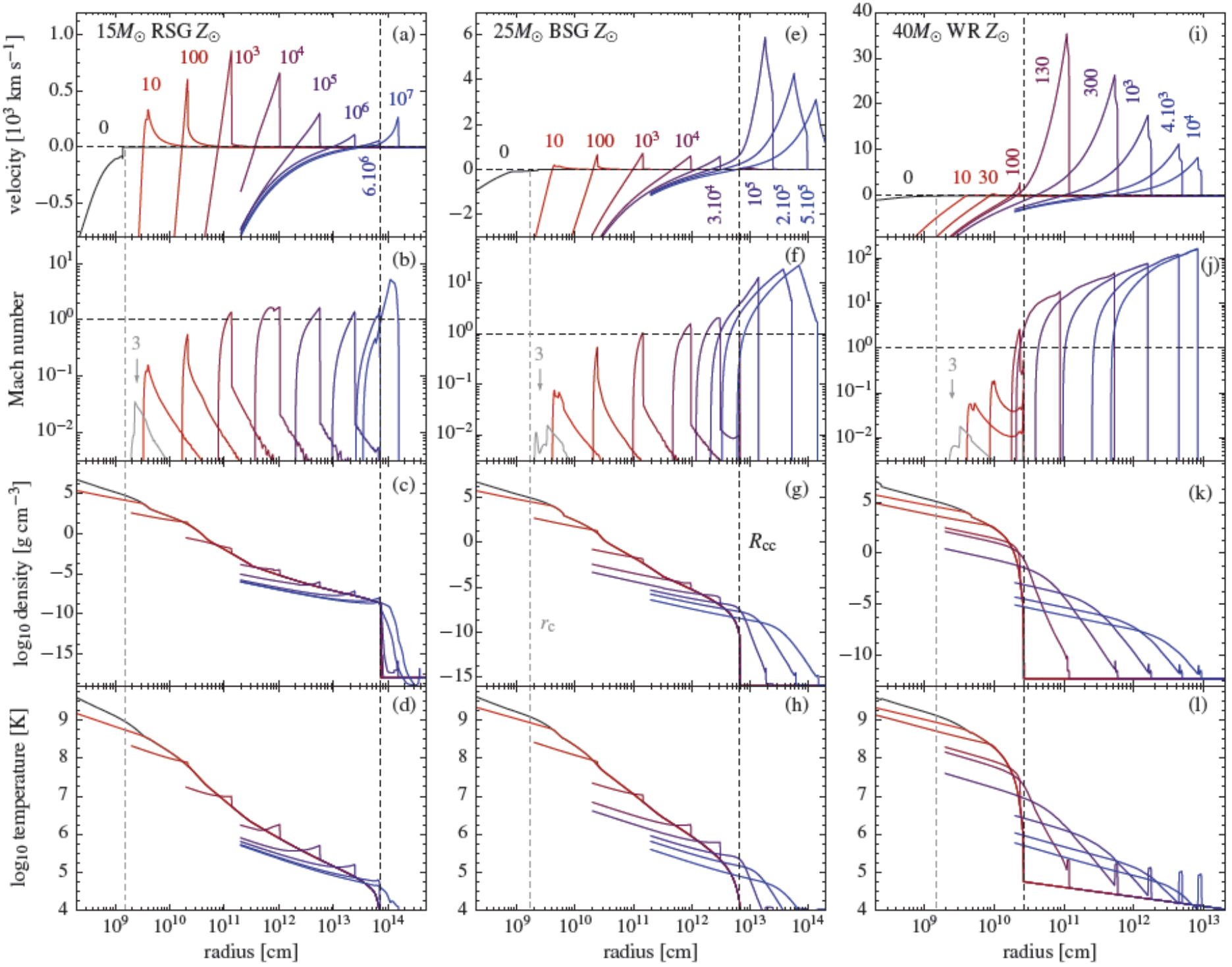
GRMHD

Development of MRI starts accretion

Magnetic field winding and amplification launch relativistic outflow over first few orbits

MRI increases heating and equilibrium Ye

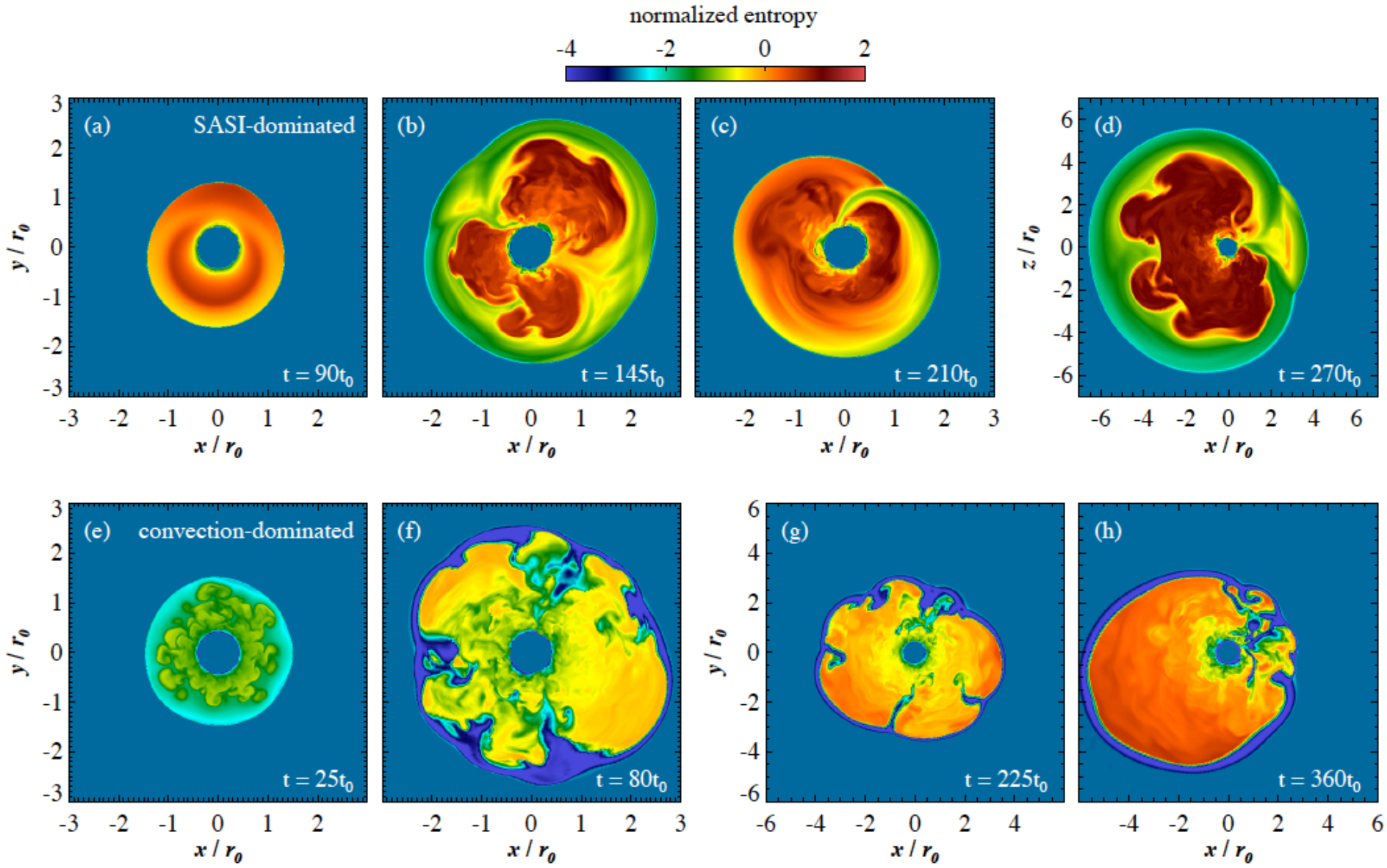
RF, Tchekhovskoy, et al. (2019)



FAILED SUPERNOVAE that form BLACK HOLES

RF, Quataert, Kashiyama, Coughlin (2018)

3D: Transition to Explosion



RF (2015)

Future Directions & Opportunities

CCSNe:

progenitors → collapse models → neutrino signal predictions

EM signal predictions

nucleosynthesis predictions

background models

NS/BH mergers:

binary populations → merger simulations → GW predictions

→ remnant evolution

→ nucleosynthesis yields

→ light curves, spectra, etc.

→ background for neutrino studies