# INTERACTION

# HI

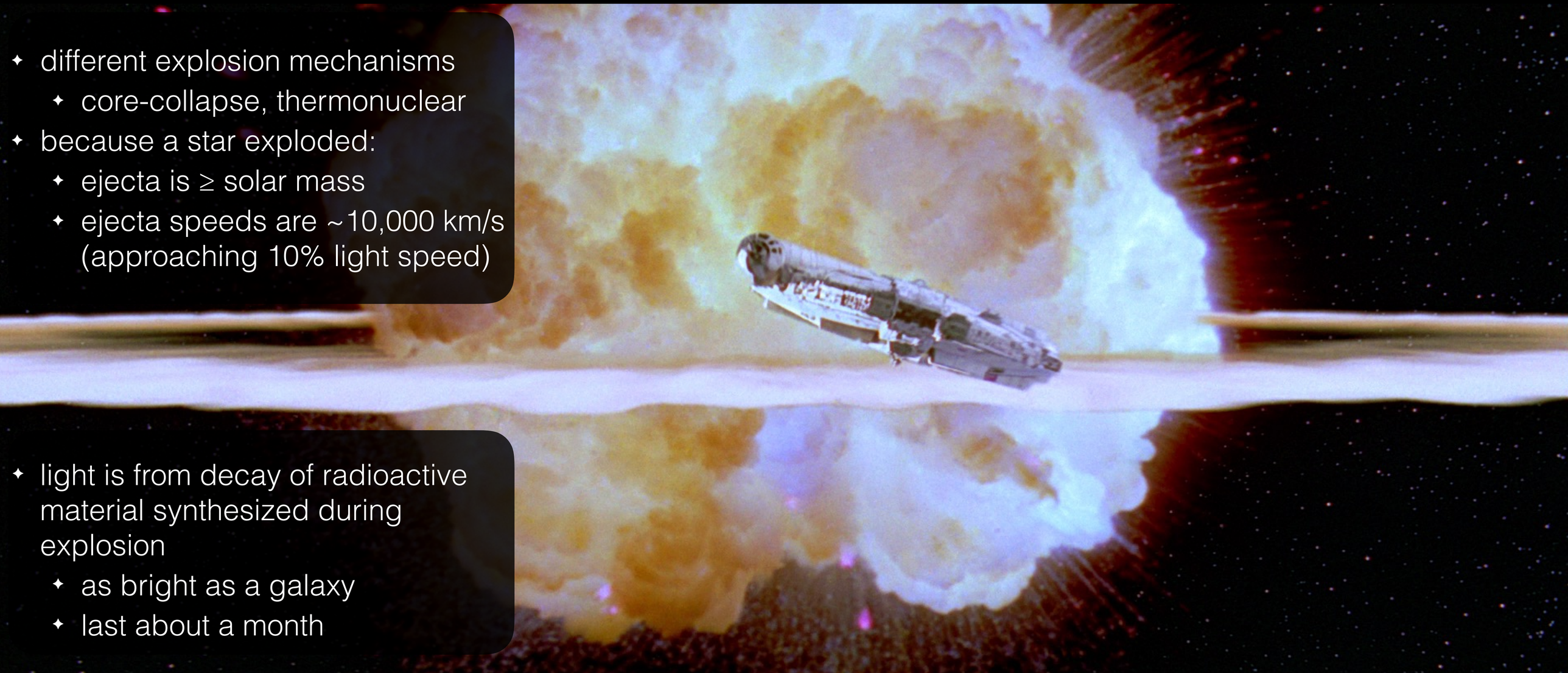
OR: HOW I LEARNED TO STOP WORRYING AND LOVE THE STELLAR BOMB

# M

CHELSEA HARRIS

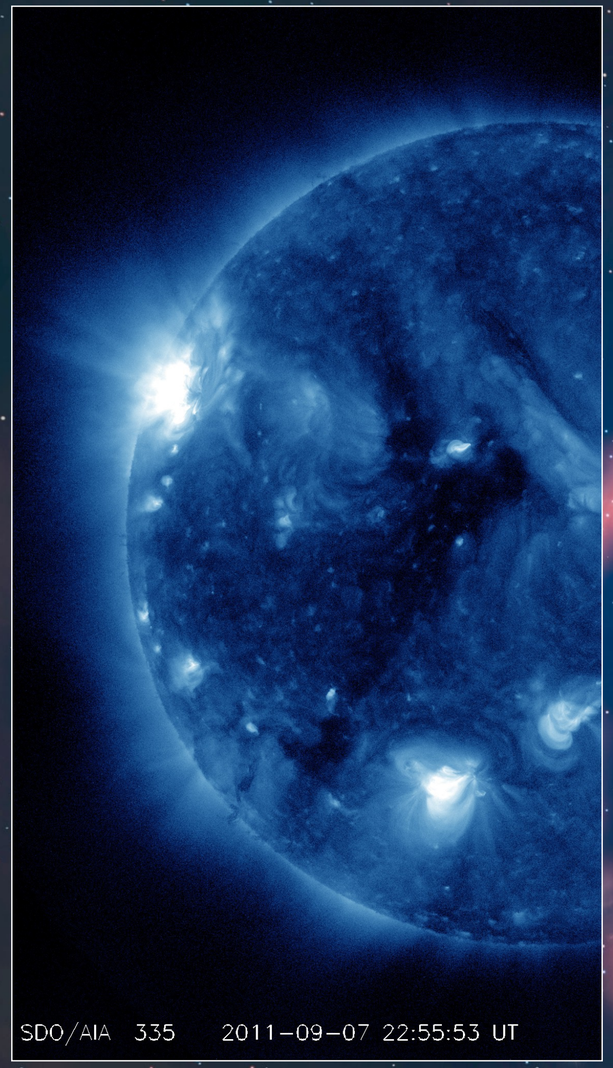
U C BERKELEY

# supernovae: stellar explosions



- different explosion mechanisms
  - core-collapse, thermonuclear
- because a star exploded:
  - ejecta is ≥ solar mass
  - ejecta speeds are ~10,000 km/s (approaching 10% light speed)

- light is from decay of radioactive material synthesized during explosion
  - as bright as a galaxy
  - last about a month



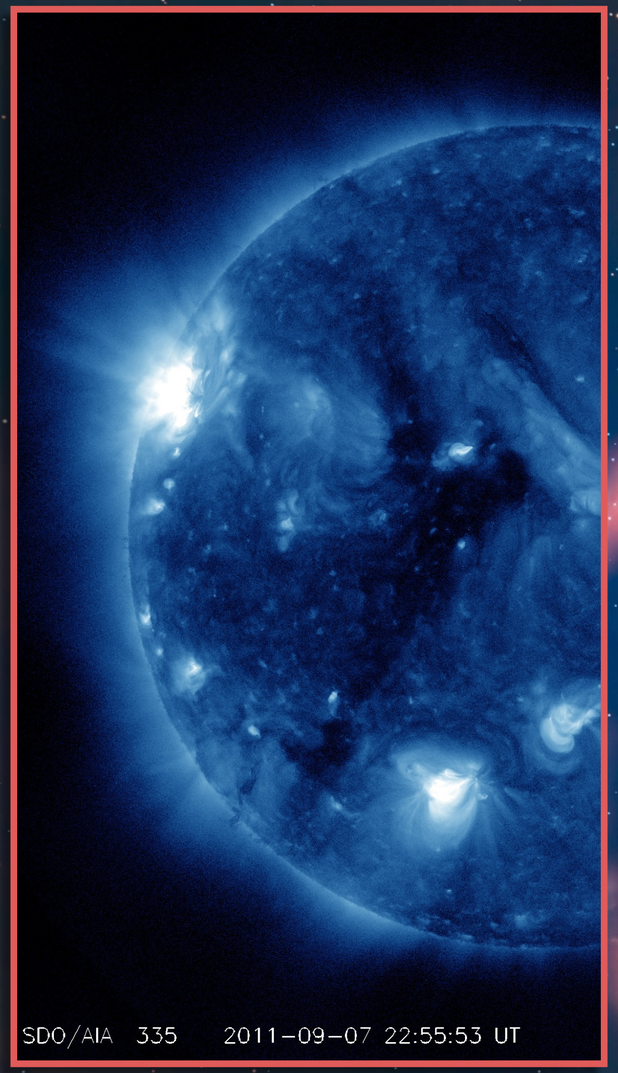

endpoints of stellar evolution

create & disperse heavy elements

energize galaxies

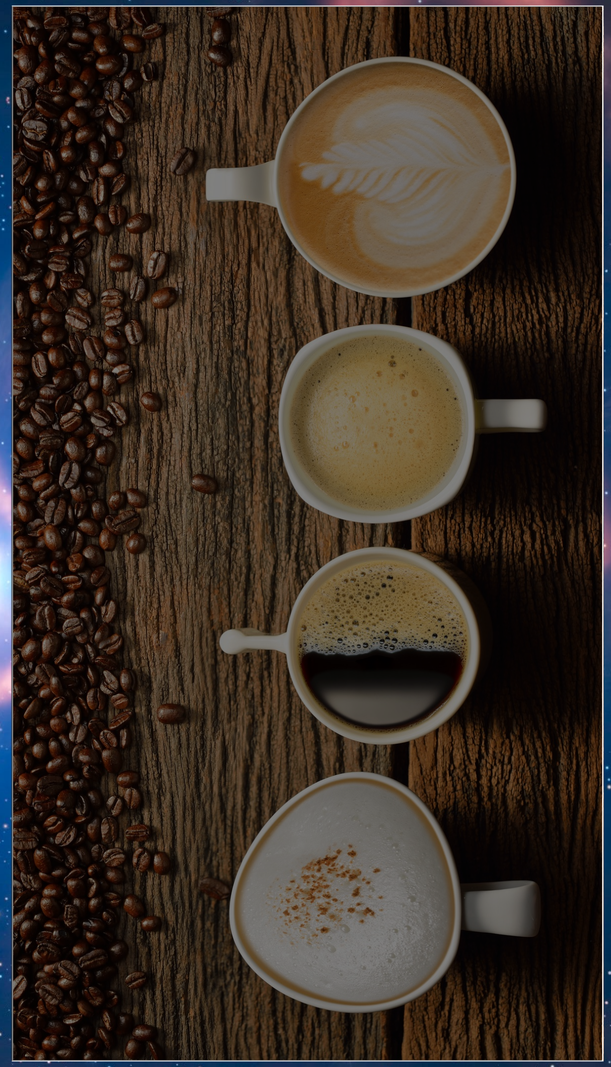
cosmological tools

# “progenitor problem”

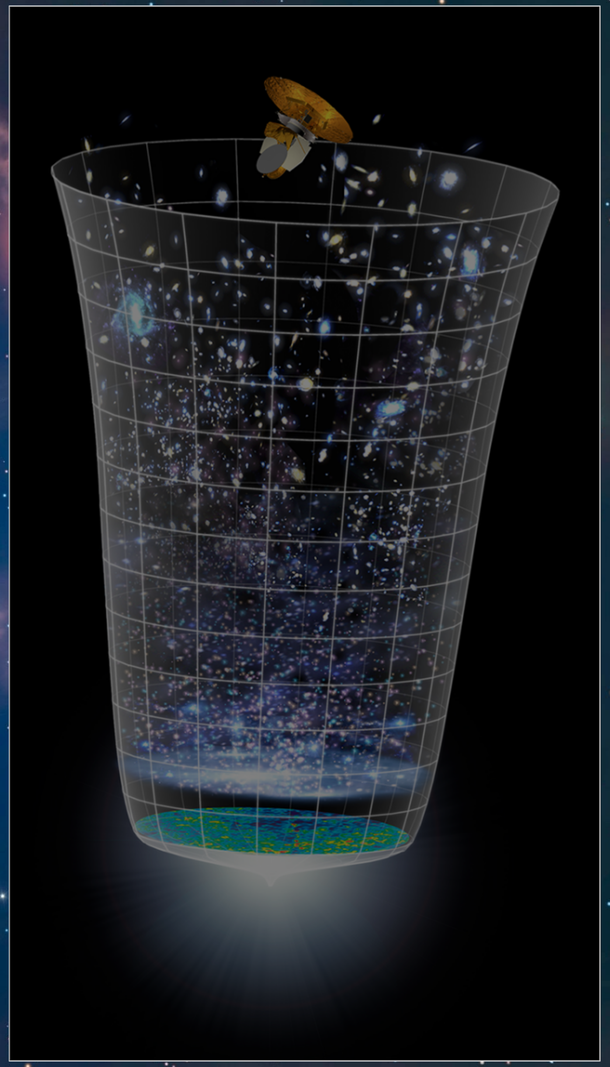



**endpoints of stellar evolution**

create & disperse heavy elements



energize galaxies



cosmological tools

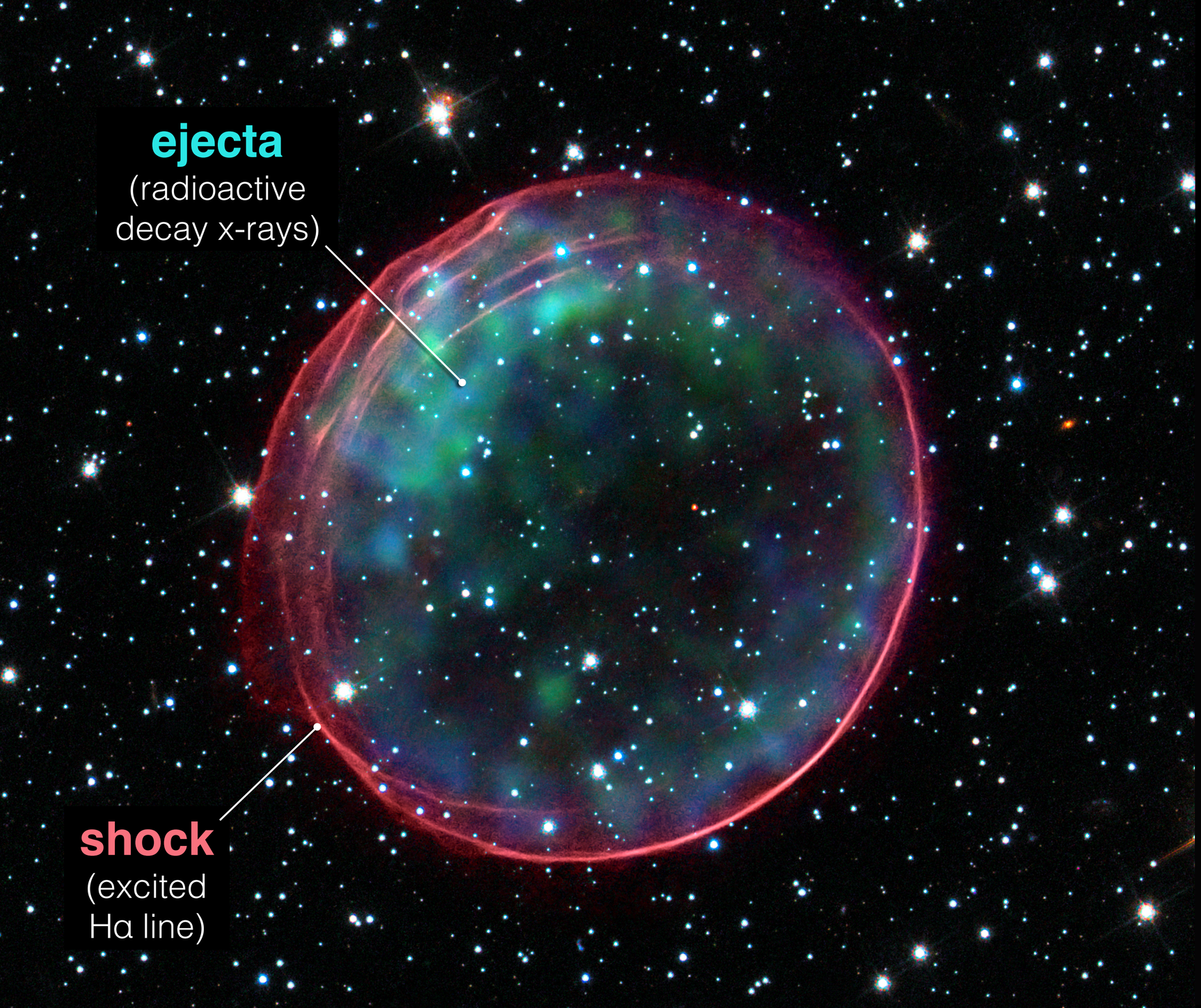
# supernova forensics

look for indirect evidence of what caused explosion, compare to theory

# circumstellar environments

auroras created by Sun’s puny wind interacting with Earth’s magnetic field and atmosphere

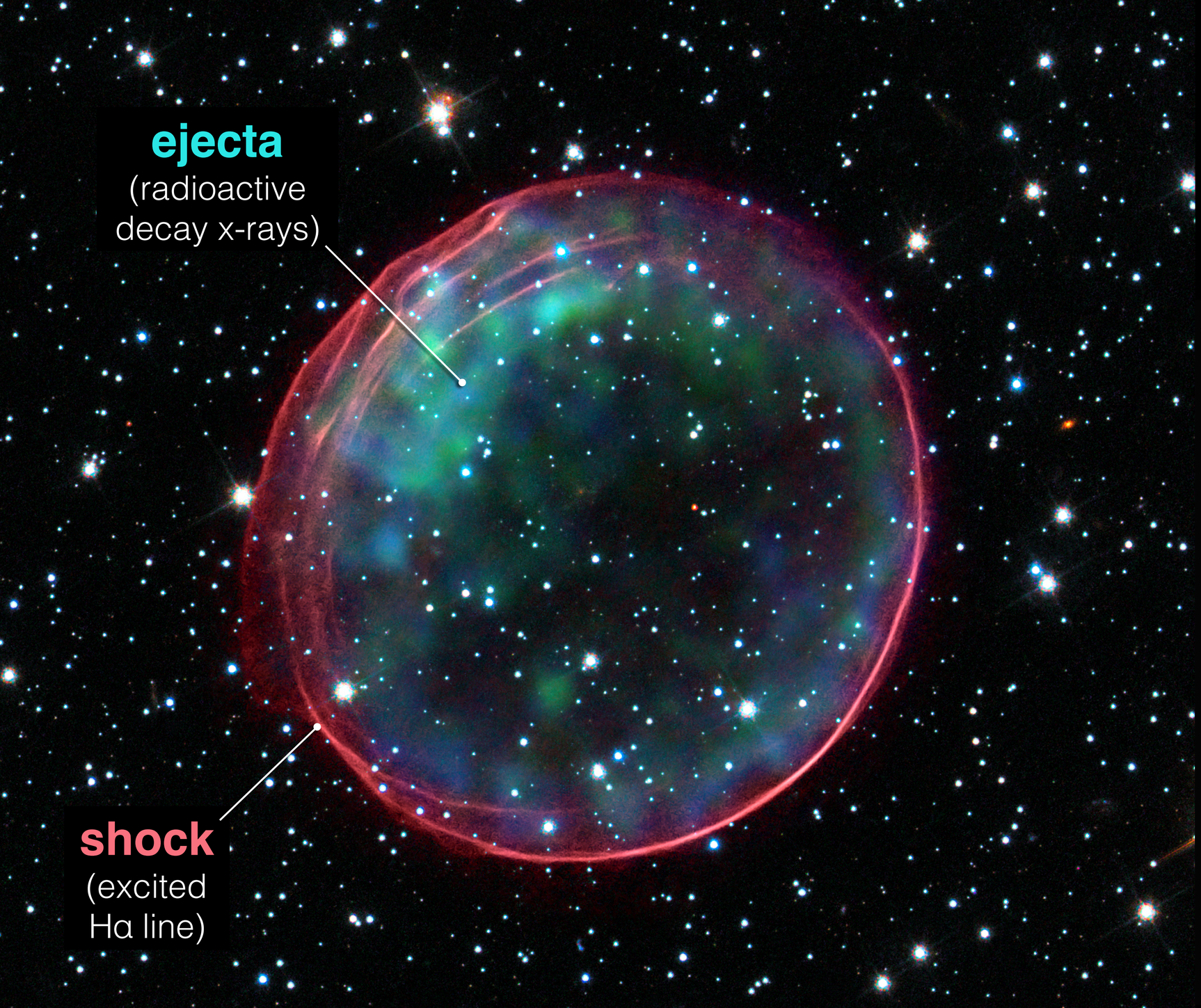
nebulae created from envelope ejection




# circumstellar interaction

(illustrated by a supernova interacting with the *inter*-stellar medium)

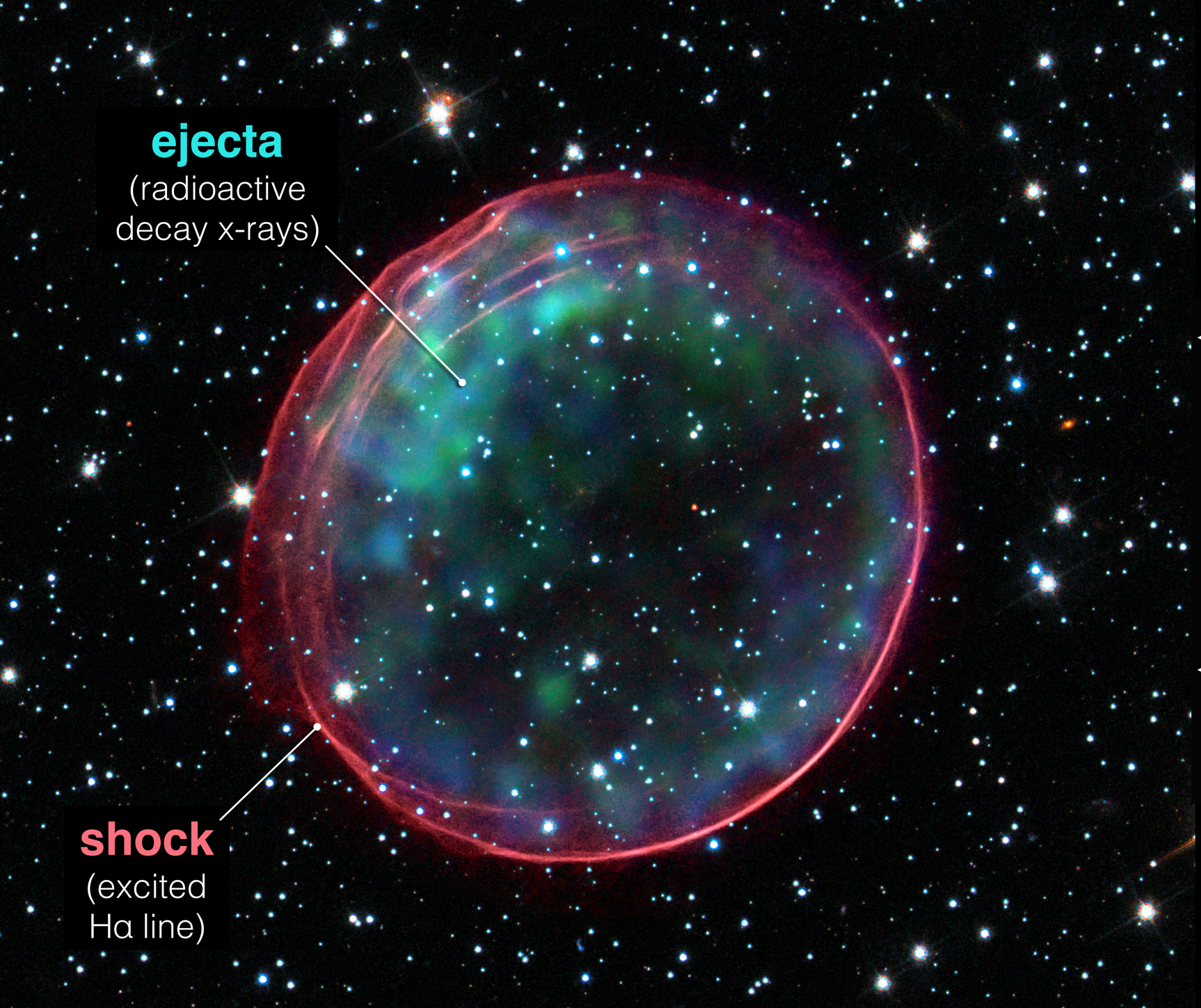
- ejecta moving ≥100× faster than CSM, sweeps over millennia of evolution history in just years
- rare to see because needs dense CSM (e.g., a million times higher mass loss rate than the solar wind)
- because CSM can be from binary processes, there is a lot to be learned!




# circumstellar interaction

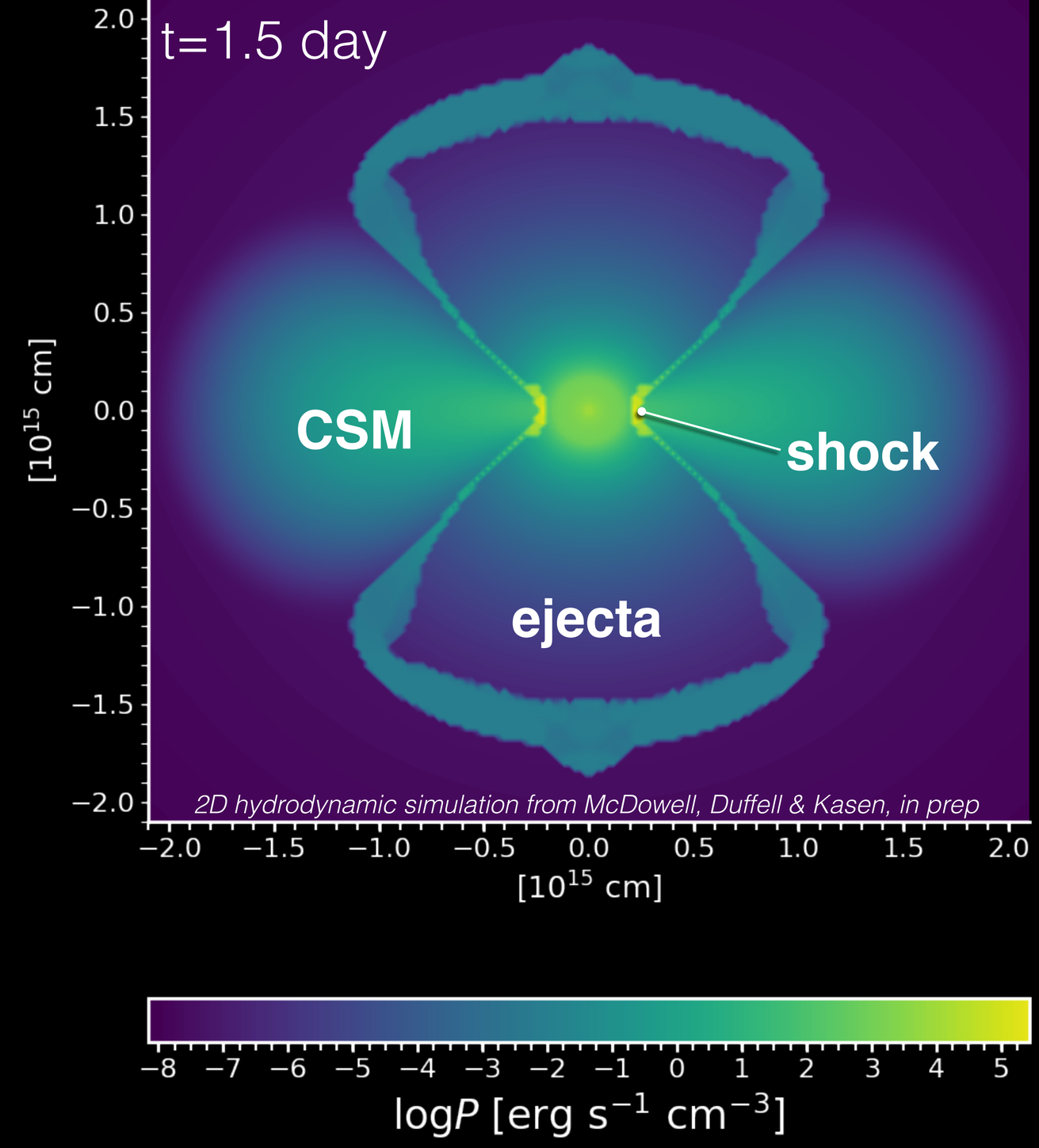
(illustrated by a supernova interacting with the *inter*-stellar medium)

- impact of fast ejecta with slow surrounding gas drives a shock
- in shock region there are magnetic fields and (thus) relativistic electrons
- emits at many wavelengths:
  - x-ray (free-free, inverse compton, synchrotron, lines)
  - optical/uv (lines, thermal continuum)
  - infrared (if dust formed)
  - radio (synchrotron)



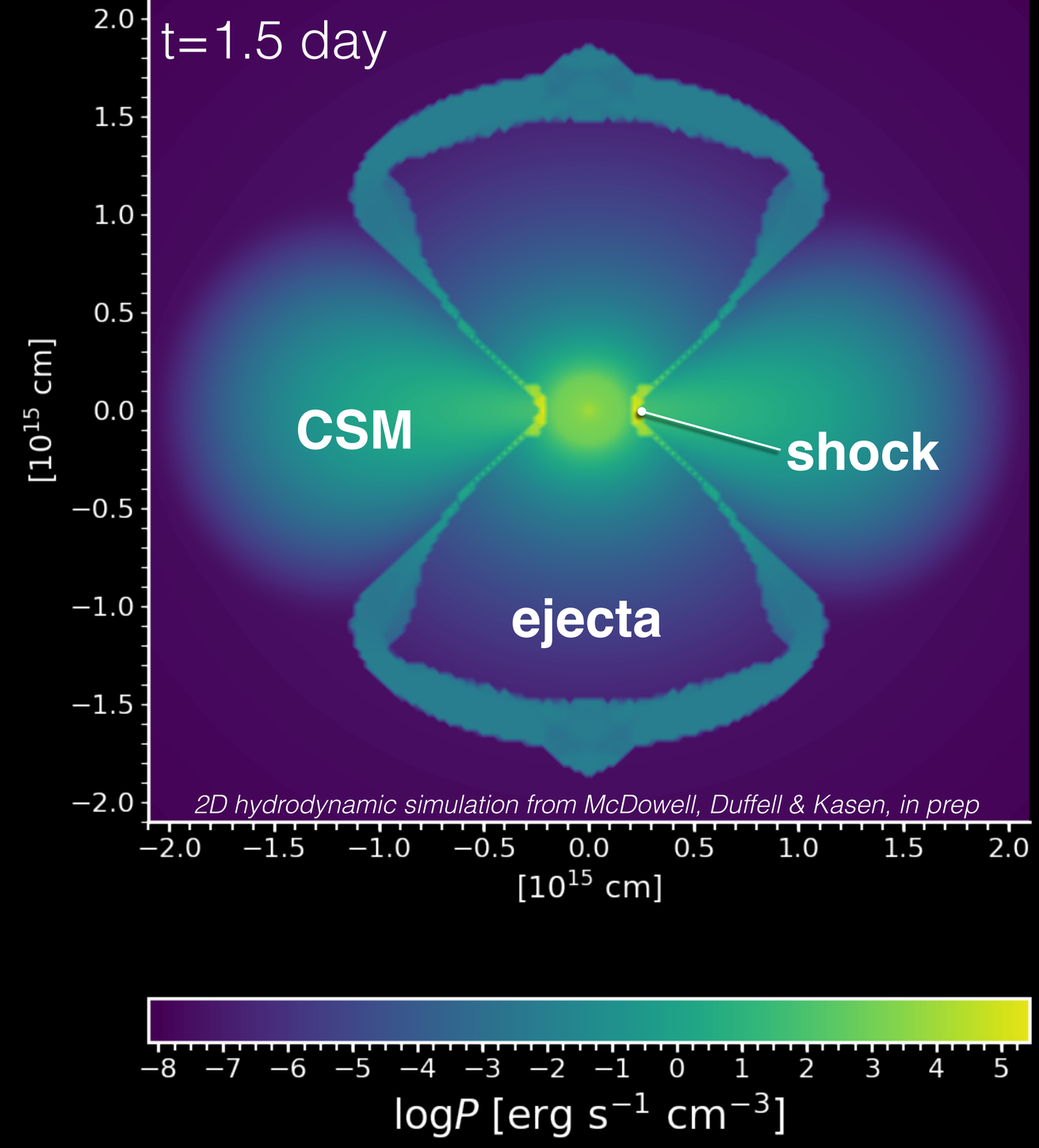

# thesis goals

- expand computational models beyond continuous, steady wind off progenitor surface
  - short-duration interaction
  - delayed interaction
  - non-spherical interaction
- predict non-thermal radiation signatures and optical line luminosities




# HPC

- hydrodynamics (solve conservation equations)
  - moving mesh (Lagrangian)
  - 3D: Rayleigh-Taylor instability, mixing




# HPC

- hydrodynamics (solve conservation equations)
  - moving mesh (Lagrangian)
  - 3D: Rayleigh-Taylor instability, mixing
- **radiation transport**
  - ionization states
  - electron (level) states
  - photon transport (monte carlo)

→ **multi-band light curves, spectra**

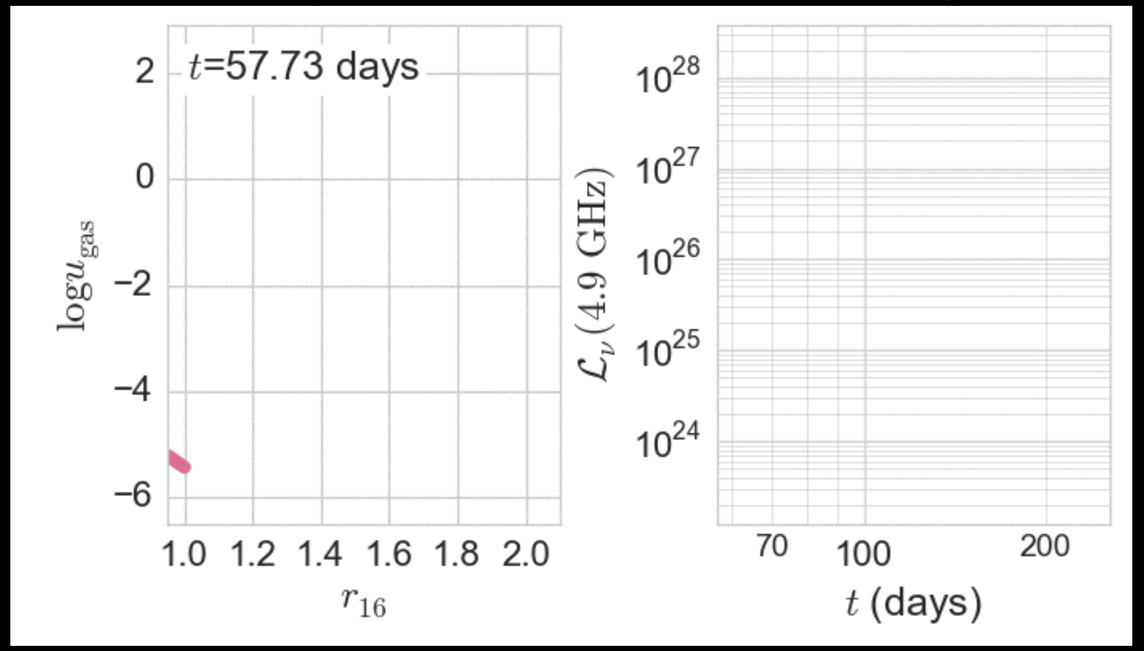
# confined circumstellar shell

1-D: explore parameterspace

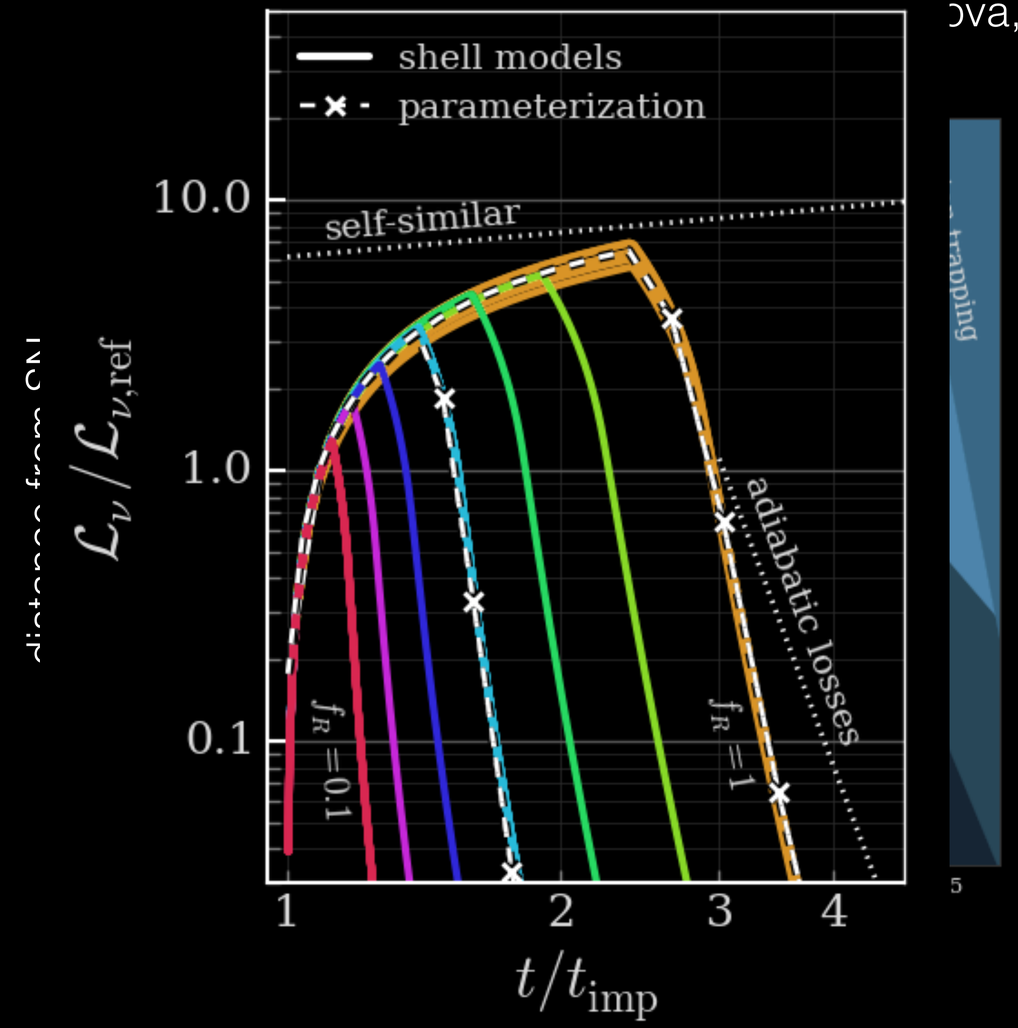
no need for more modeling!


hydro

radio light

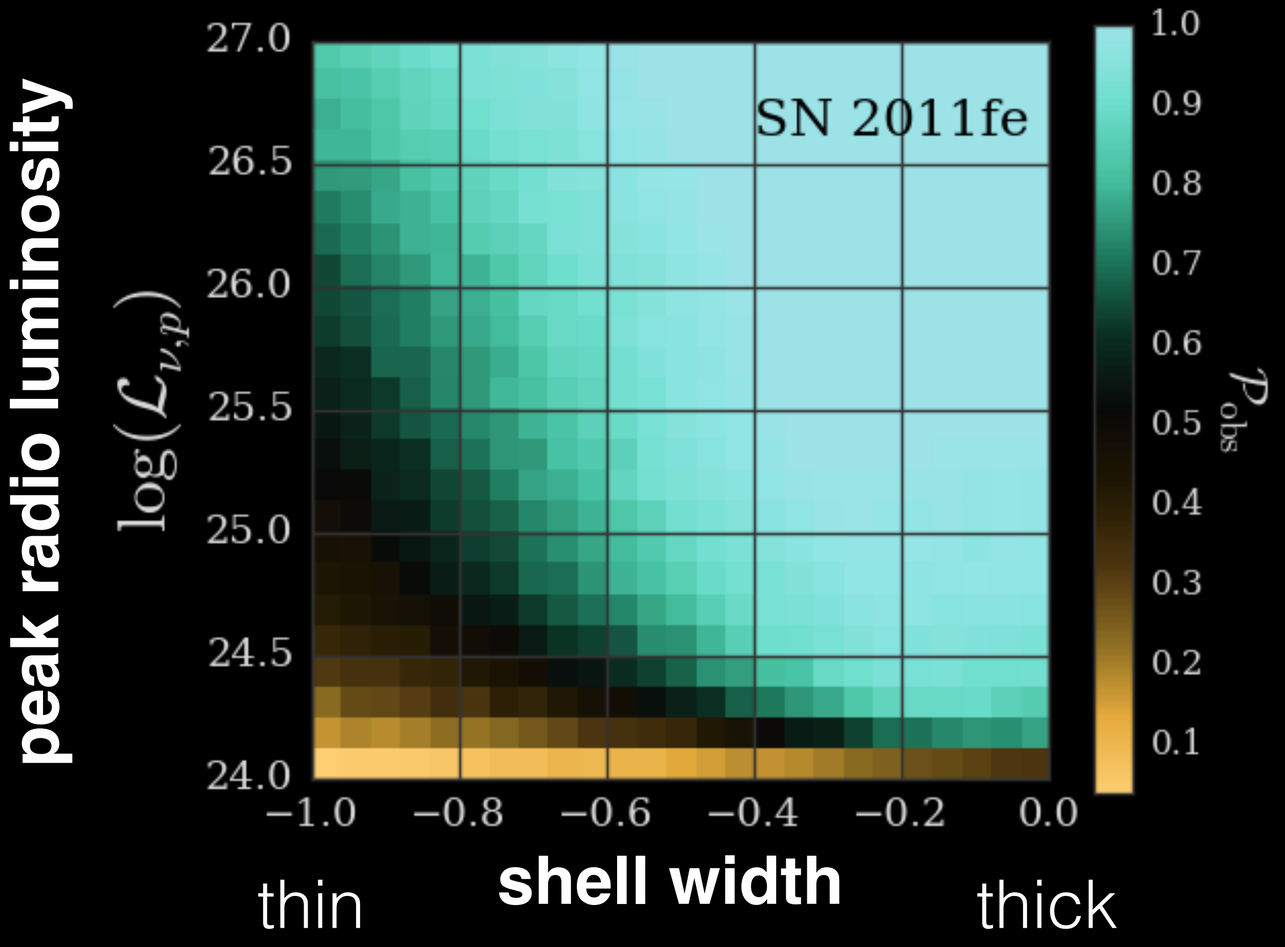



**C. Harris**, P. Nugent & D. Kasen (2016)



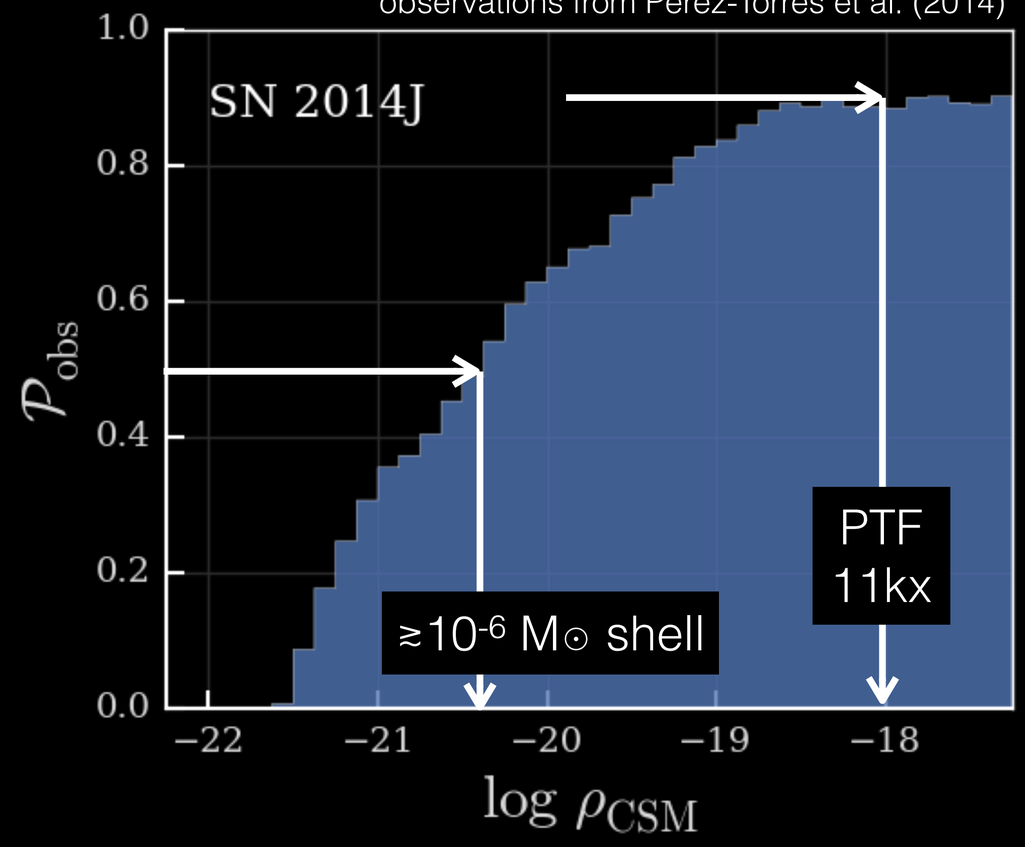
# tool for interpreting observations

observation probability
heat map




probability of observing a
thin (nova) shell collision:

observations from Pérez-Torres et al. (2014)



# thank you!

. . . **Krell** (esp. for putting up with my inability to do paperwork)

. . . **DC folks** (for funding us)

. . . **NREL** (for a great practicum)

. . . **fellows** (for being cool)

. . . **Peter** (esp. for stopping in the Alps)