Delivery of SN material to the ISM through ejecta knots

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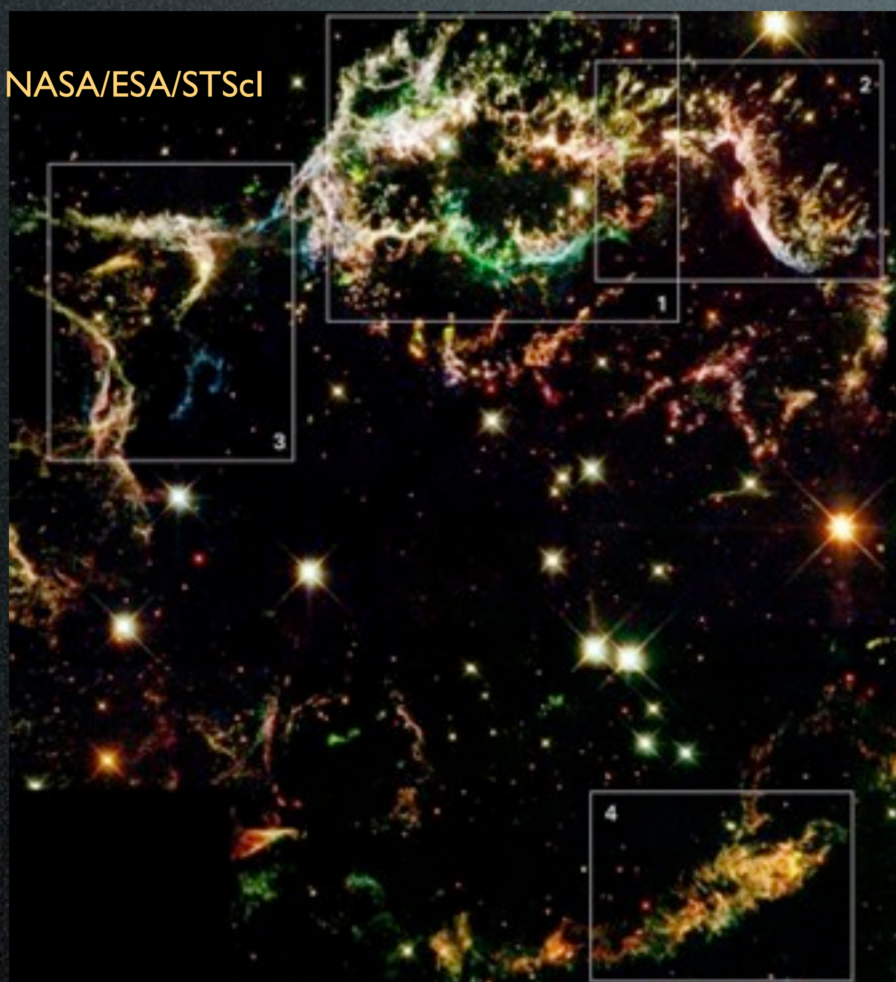
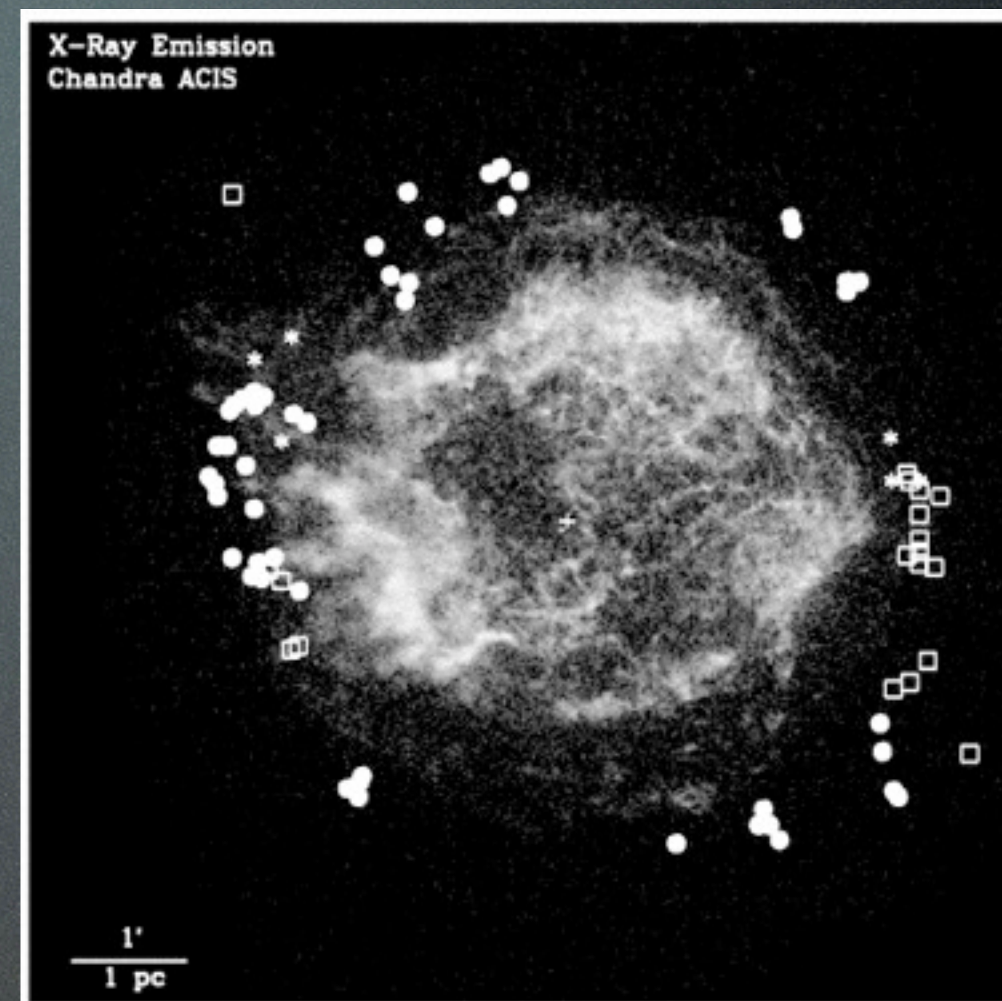
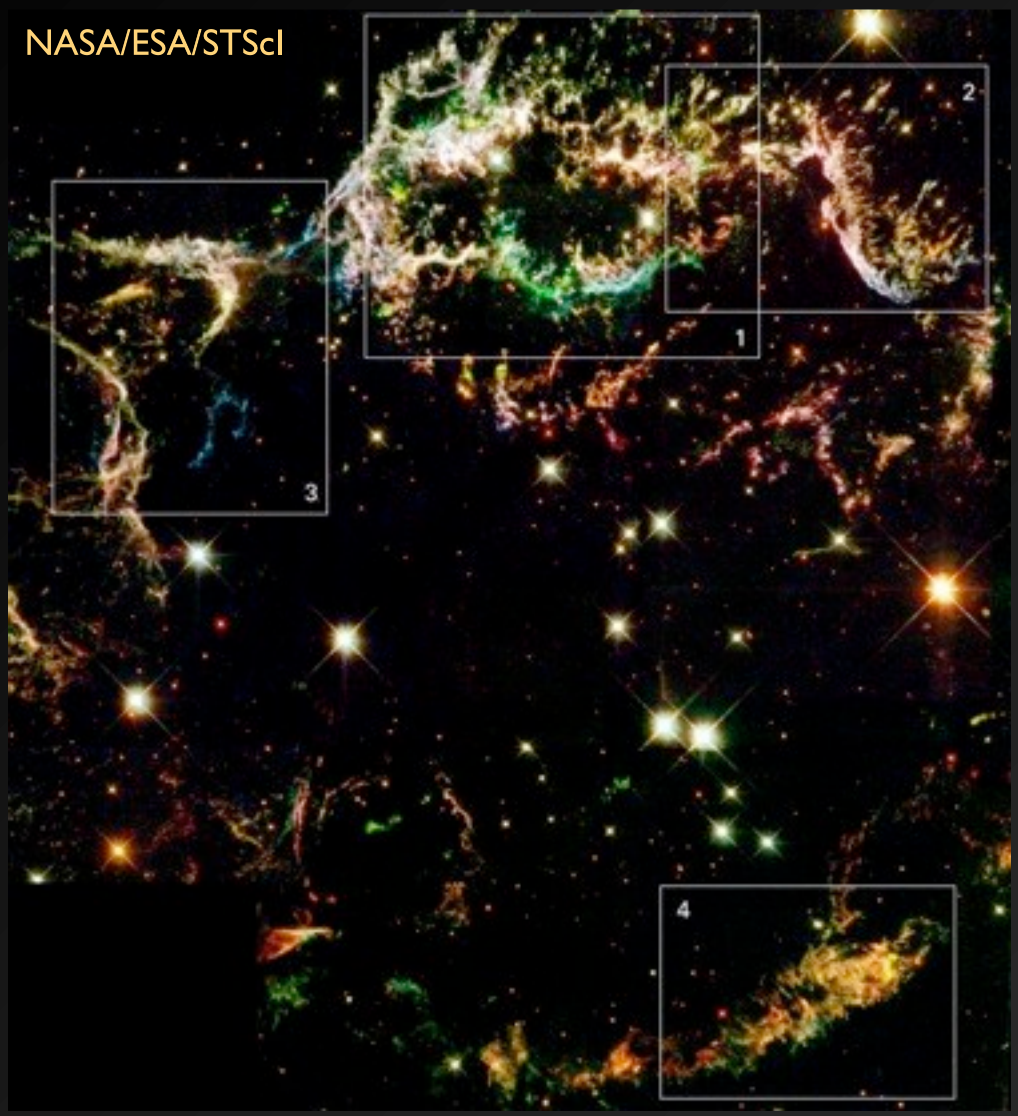
Introduction





Supernovae: non-uniform distribution in density and abundance

SNe have structure!



Structure in SN explosions:

- convection of post-MS star
  - ➡sets up structure before explosion
- compositional jumps + shock wave
  - ➡Rayleigh-Taylor or Richtmyer-Meshkov Instabilities
- (radiative) cooling
  - ➡rate proportional to local density/composition
- evidence for mixing/overturn
  - ➡hints at instabilities

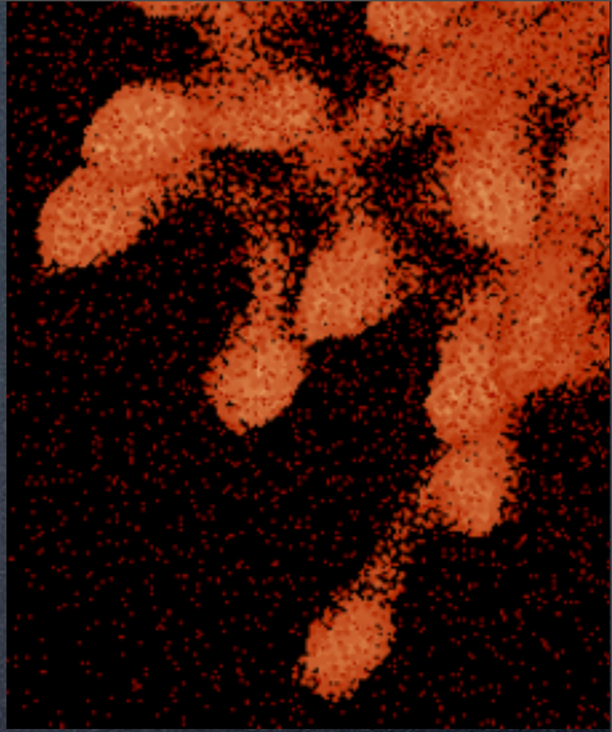
Focus: hydrodynamics + nucleosynthesis of explosion and late time evolution

Calculations

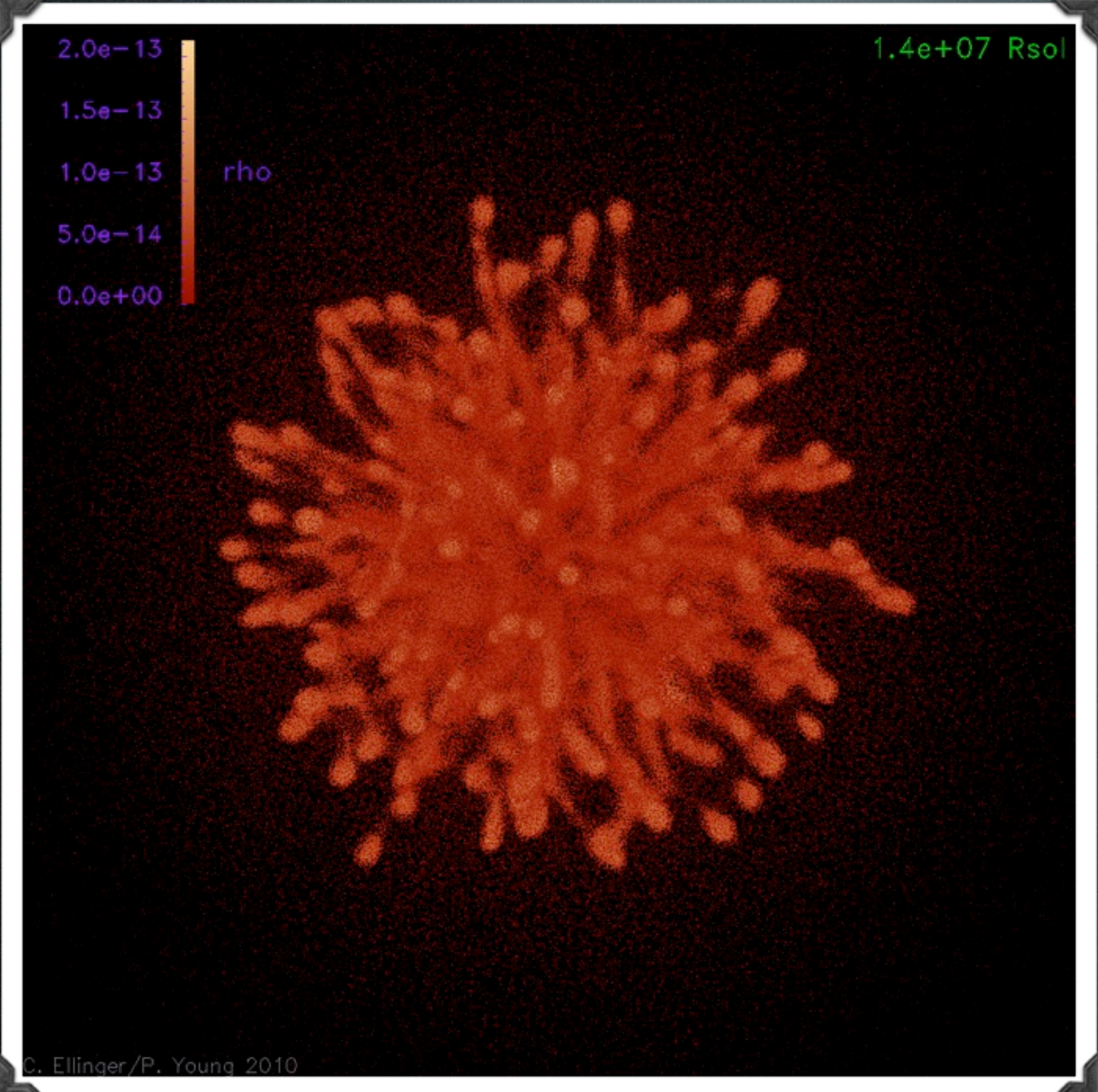
- 3D SPH simulation
- built-in radiative cooling routine
- built-in small network
- up to 3300 isotope reaction network for post processing
- follow star self-consistently from core collapse, to years after explosion

Focus: hydrodynamics + nucleosynthesis of explosion and late time evolution

Calculations



- 15 Msol star, 1 million SPH particles
- collapse + launch of shock in 1D, then mapped to 3D
  - control run: just star; to 20yrs +
  - cooling run: control run + cooling turned on
  - burning run: network turned on
  - CSM/ISM: started adding medium around star



Clumps:

t = 20 yrs

density ~ 10^{-18} $^{g}/_{cm^3}$

size ~ 1000- 1500 AU

density:
1 code unit = 0.6×10^{-5} $^{g}/_{cm^3}$

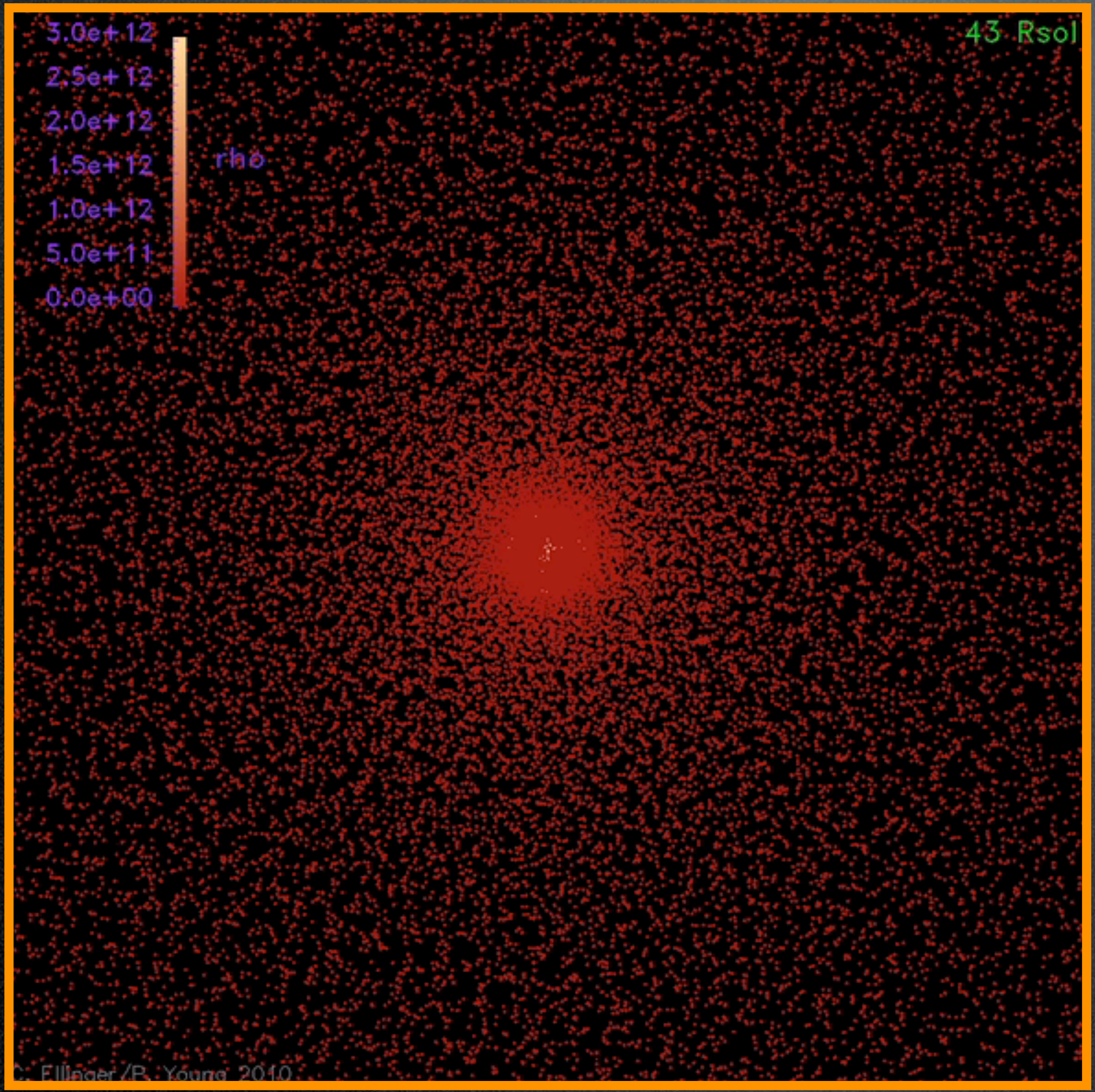
$43\ R_{sun} = 0.2$ AU

$860\ R_{sun} = 4$ AU

$8600\ R_{sun} = 40$ AU

$860000\ R_{sun} = 4000$ AU

1 AU = ave. Earth-Sun distance



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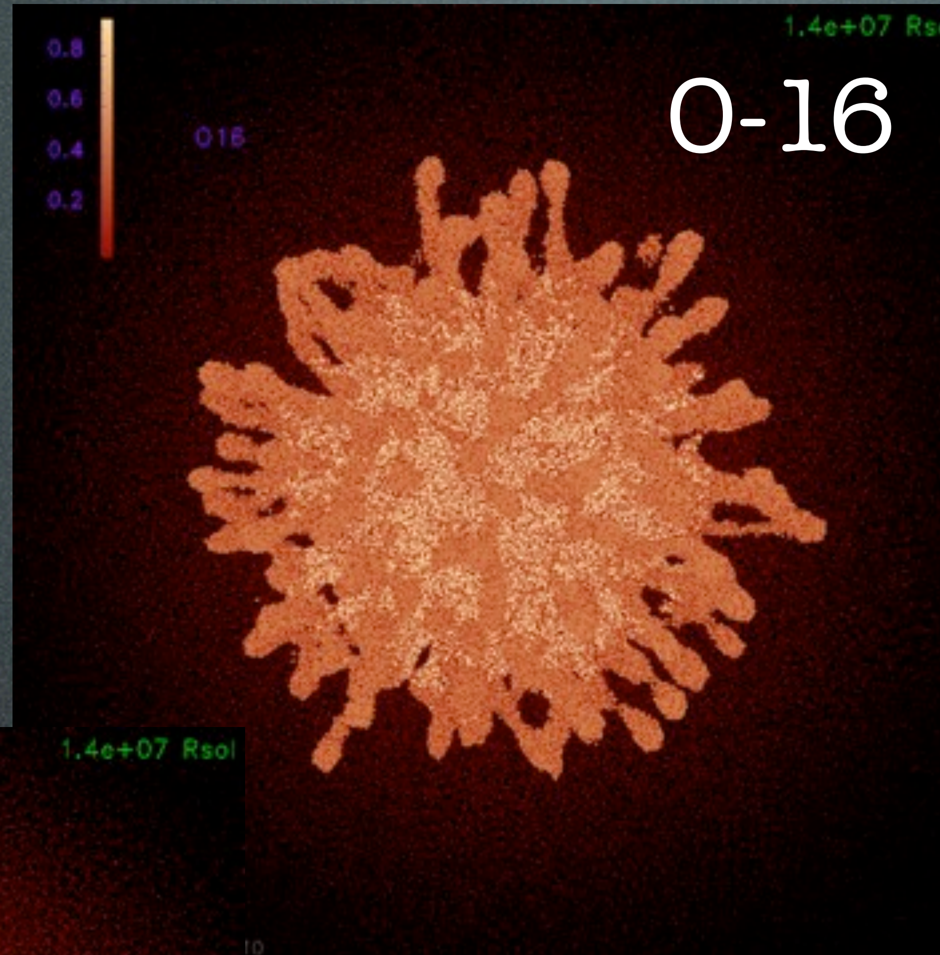
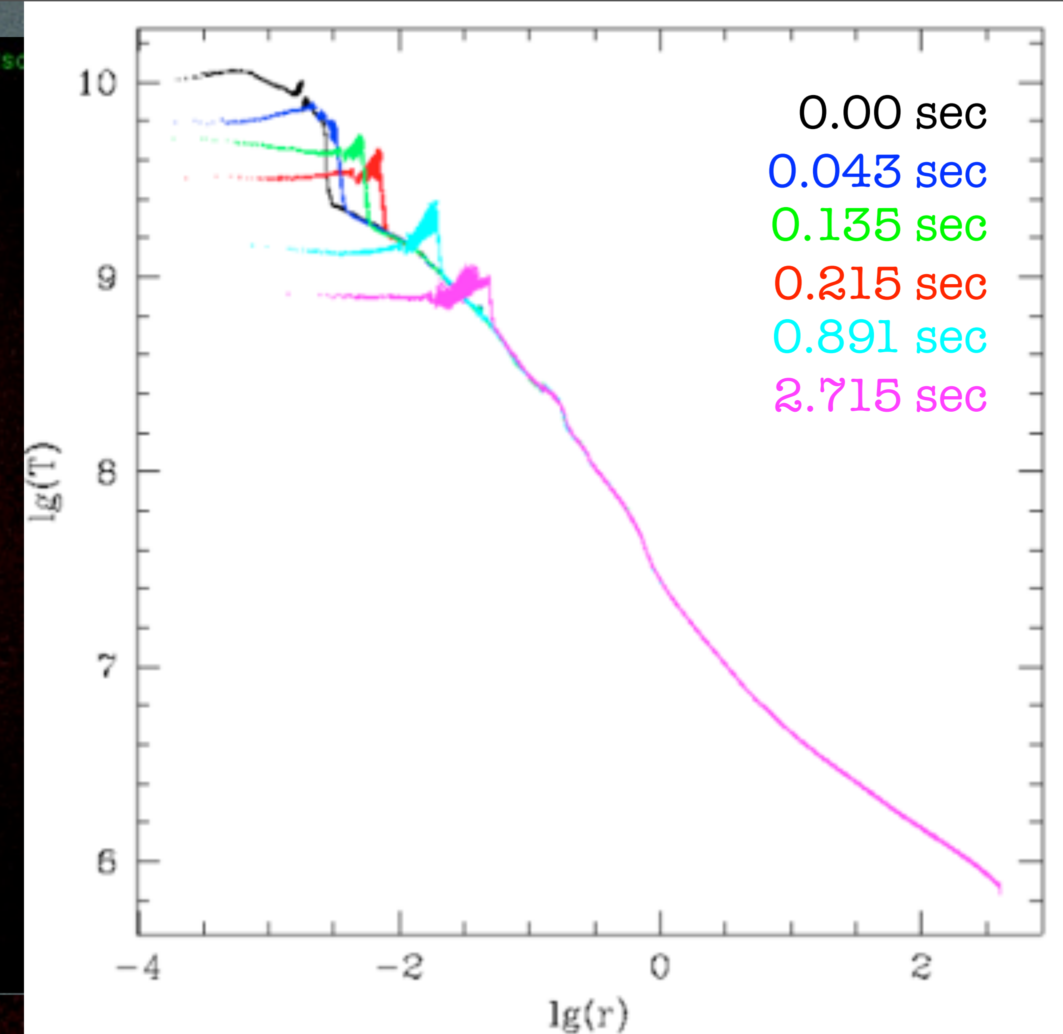
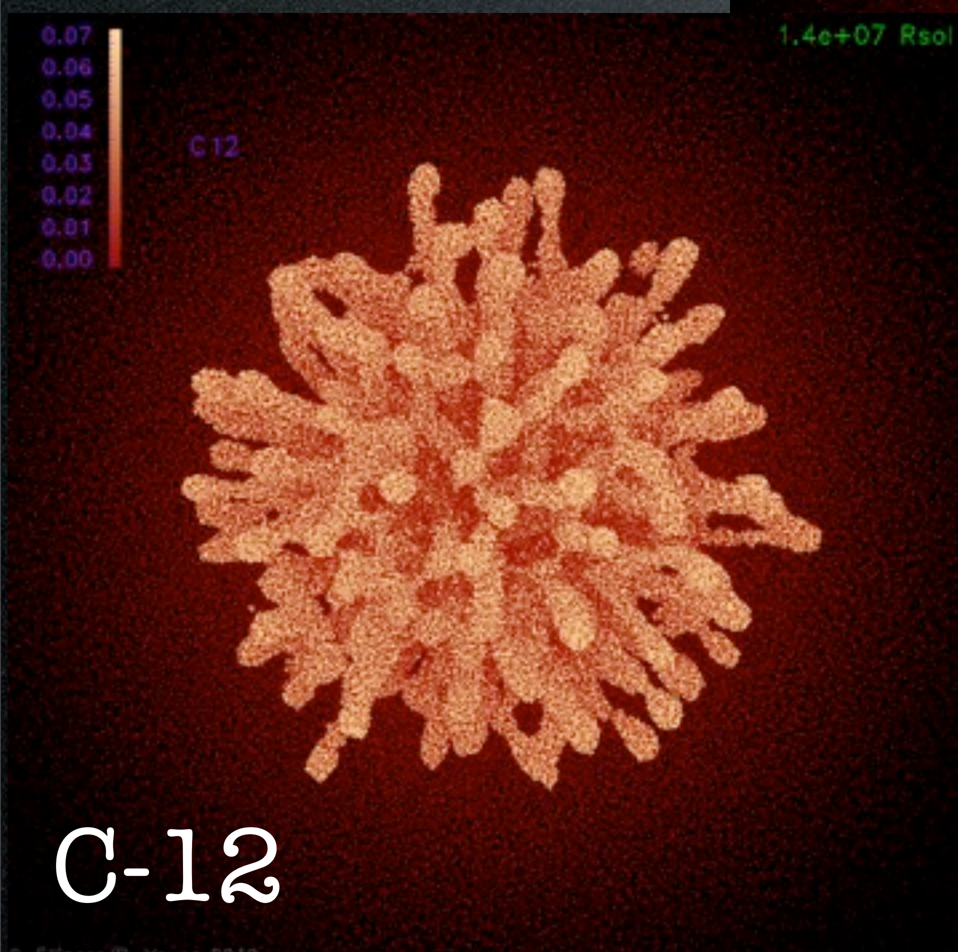
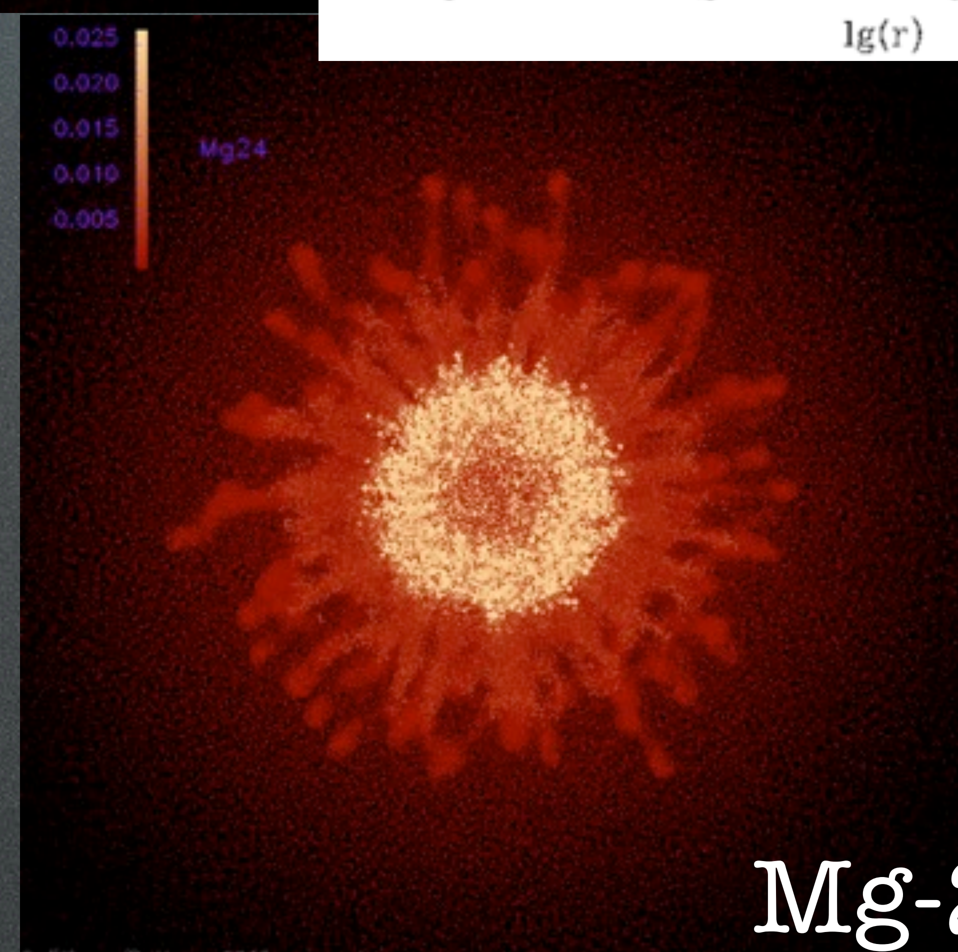
Results







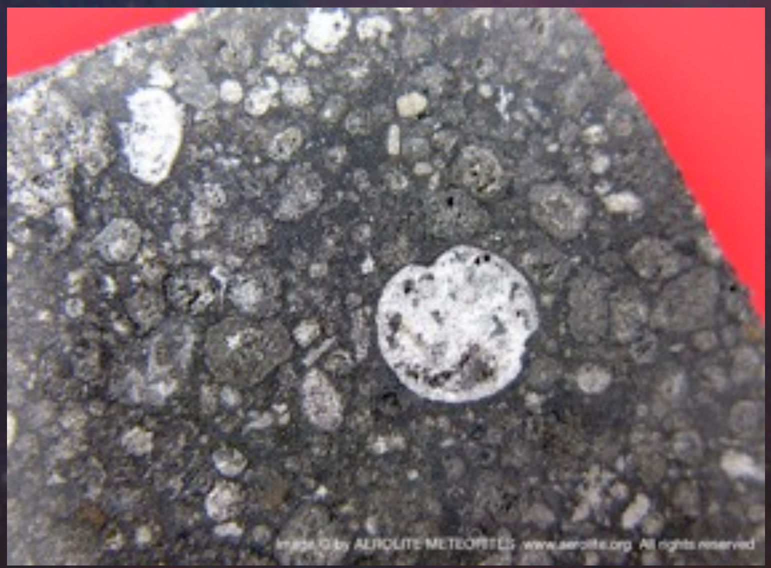


all elements shown are still from hydrostatic burning!

SN enrichment of Solar System

(Young, Ellinger, Arnett, Fryer & Rockefeller, 2009, ApJ, 699, 938;
Ellinger, Young & Desch 2010, ApJ, in revision)

- Setting: Star cluster (massive star/s + low mass stars/ planetary systems
- Injection of material (dust) from nearby SN
- Protoplanetary disk likely to encounter ~1 clump in a high mass star forming region



Proplyds in Orion: NASA, ESA, M. Robberto (Space Telescope Science Institute/ESA), the Hubble Space Telescope Orion Treasury Project Team and L. Ricci (ESO)

Summary/Conclusion

- show formation of clumps in 3D calculation
  - hydrodynamic instabilities
- formed early, persist to end of simulation
- fragmentation of clumps into knot-like features from radiative cooling.
- implications for enrichment of the forming solar system