^{44}Ti and ^{56}Ni from Type II supernova explosions

G. Magkotsios (ND), A. Hungerford (LANL), C. Fryer (LANL), P. Young (ASU), F.X. Timmes (LANL, ASU)

A JINA – LANL collaboration

Los Alamos
NATIONAL LABORATORY

Motivation

- Both are supernovae diagnostic
- $^{44}Ti \rightarrow {}^{44}Sc \rightarrow {}^{44}Ca$
  - Primary channel for ^{44}Ca synthesis
  - Observational constraints in Cassiopeia A
    - COMPTEL for ^{44}Ti γ -rays, BeppoSAX PDS for ^{44}Sc ones
- $^{56}Ni \rightarrow {}^{56}Co \rightarrow {}^{56}Fe$
  - ^{56}Fe X-ray lines observed
  - Large fraction of ^{56}Ni expected
  - Restrict upper/lower limits
    - Recent *Chandra* data (1 Ms X-ray observation)

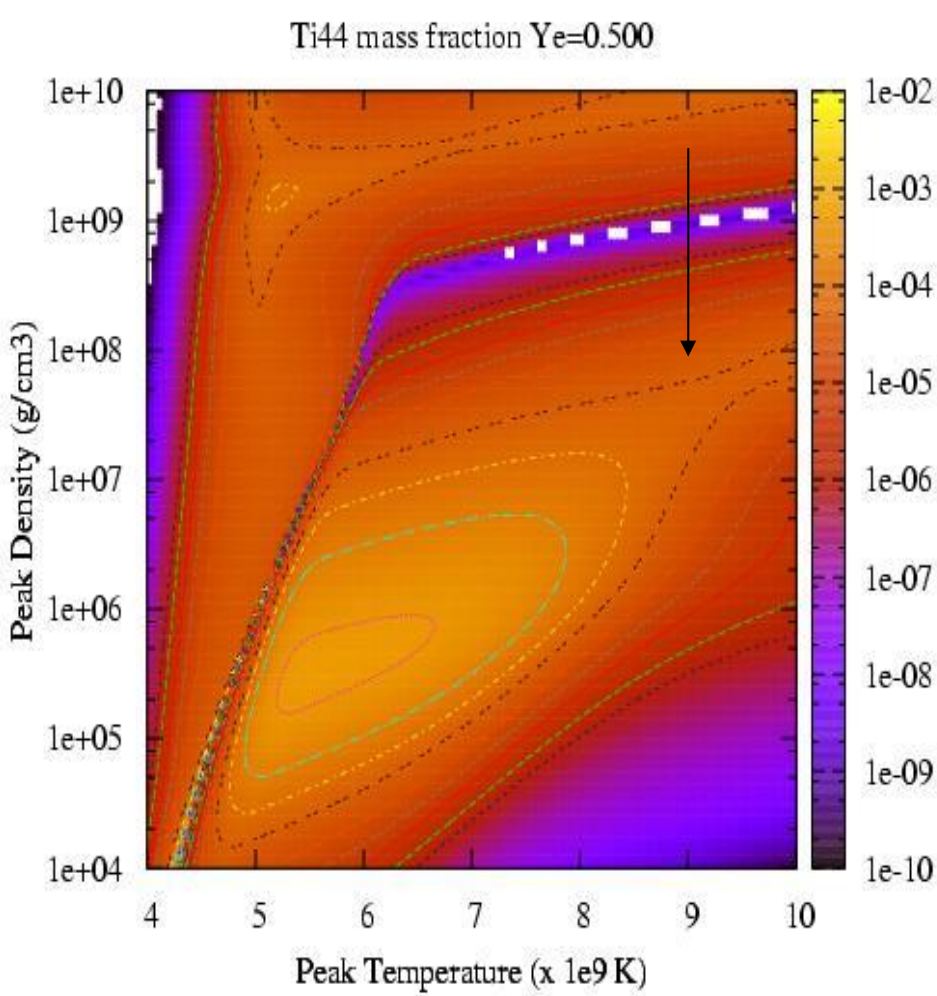
Terminology

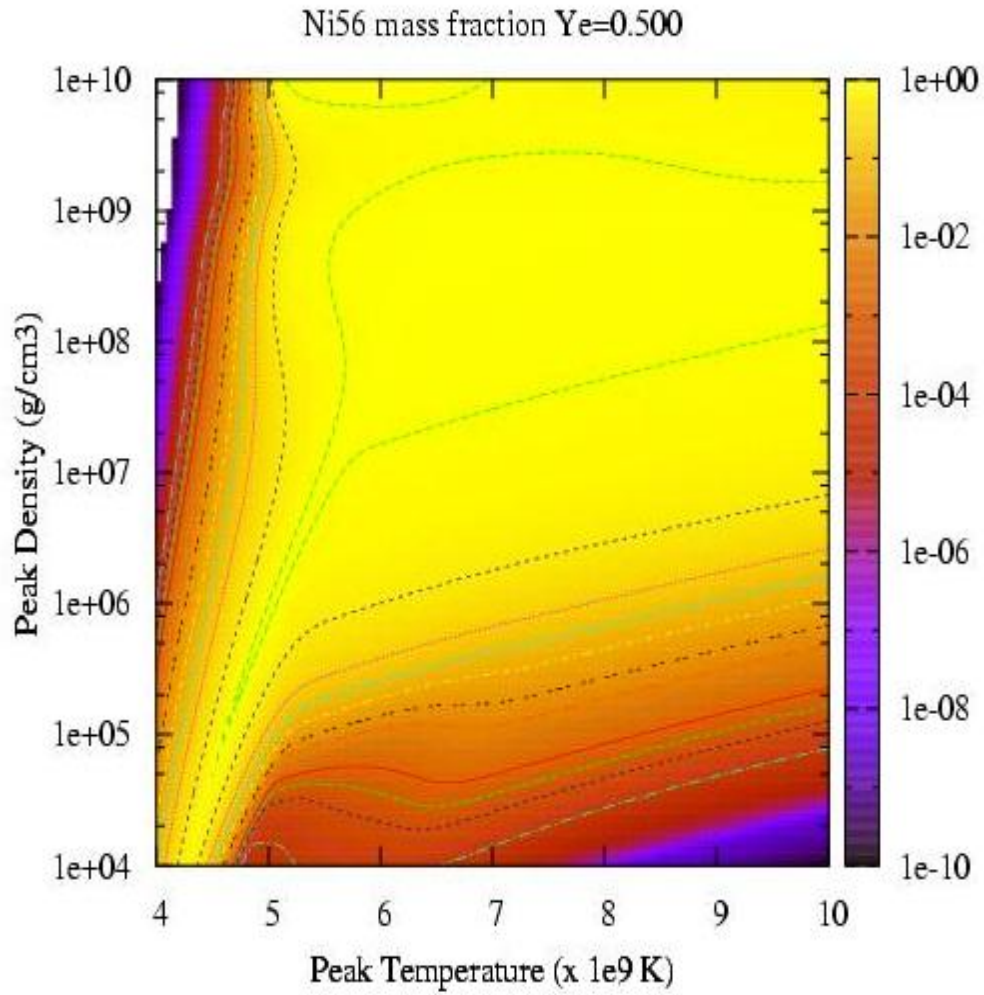
- Burning regimes
  - Nuclear Statistic Equilibrium (NSE)
  - Quasi Static Equilibrium (QSE)
- Hydrodynamic simulations
  - Parameterized post-shock analysis (freeze-out)

$$\frac{dT}{dt} = -\eta \frac{T}{\tau_T} \qquad \frac{d\rho}{dt} = -\eta \frac{\rho}{\tau_\rho}$$

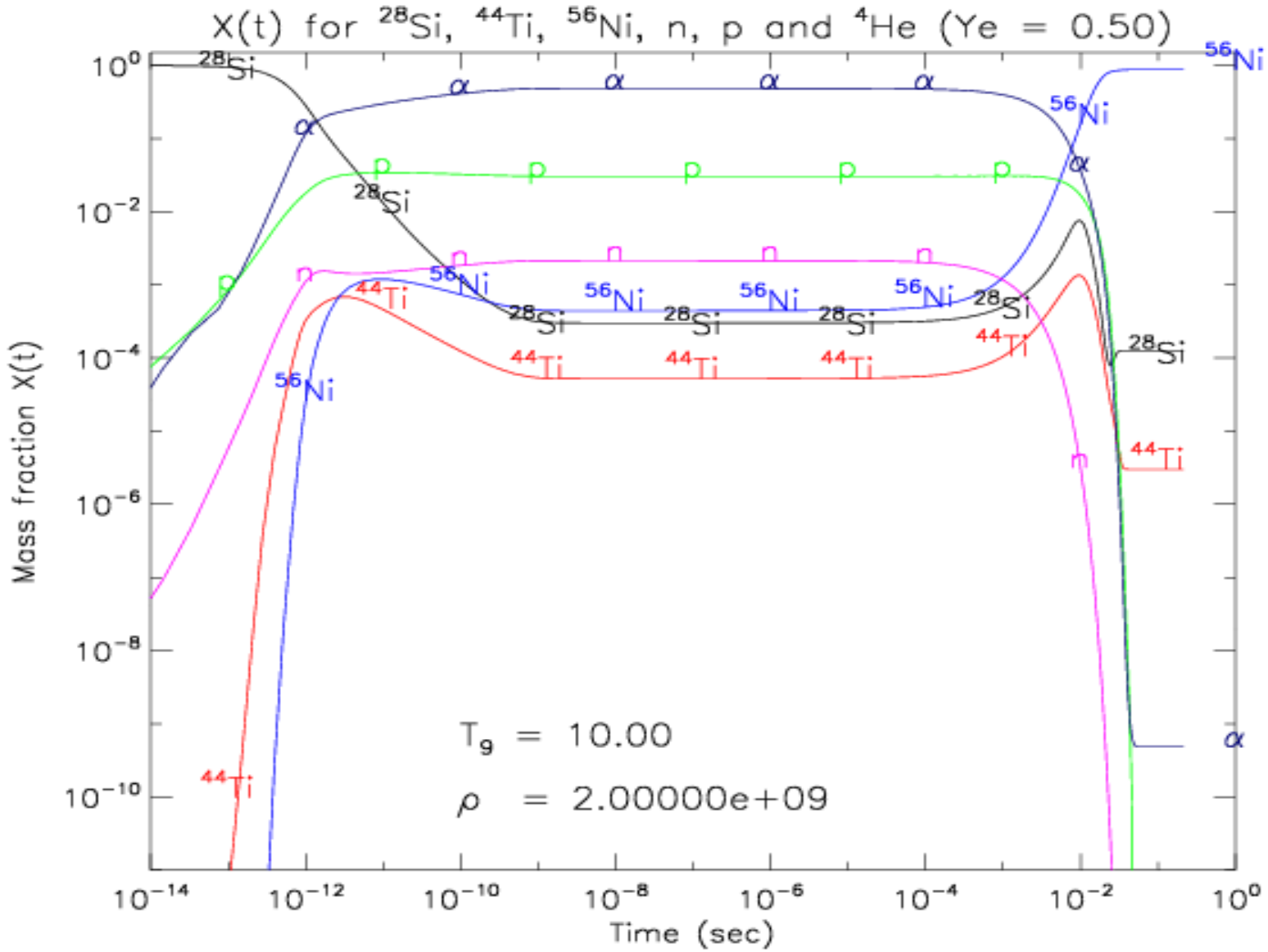
  - 2D & 3D Smooth Particle Hydrodynamics (SPH) of core collapse supernovae

Contour plots for ^{44}Ti and ^{56}Ni yields





Changing peak density



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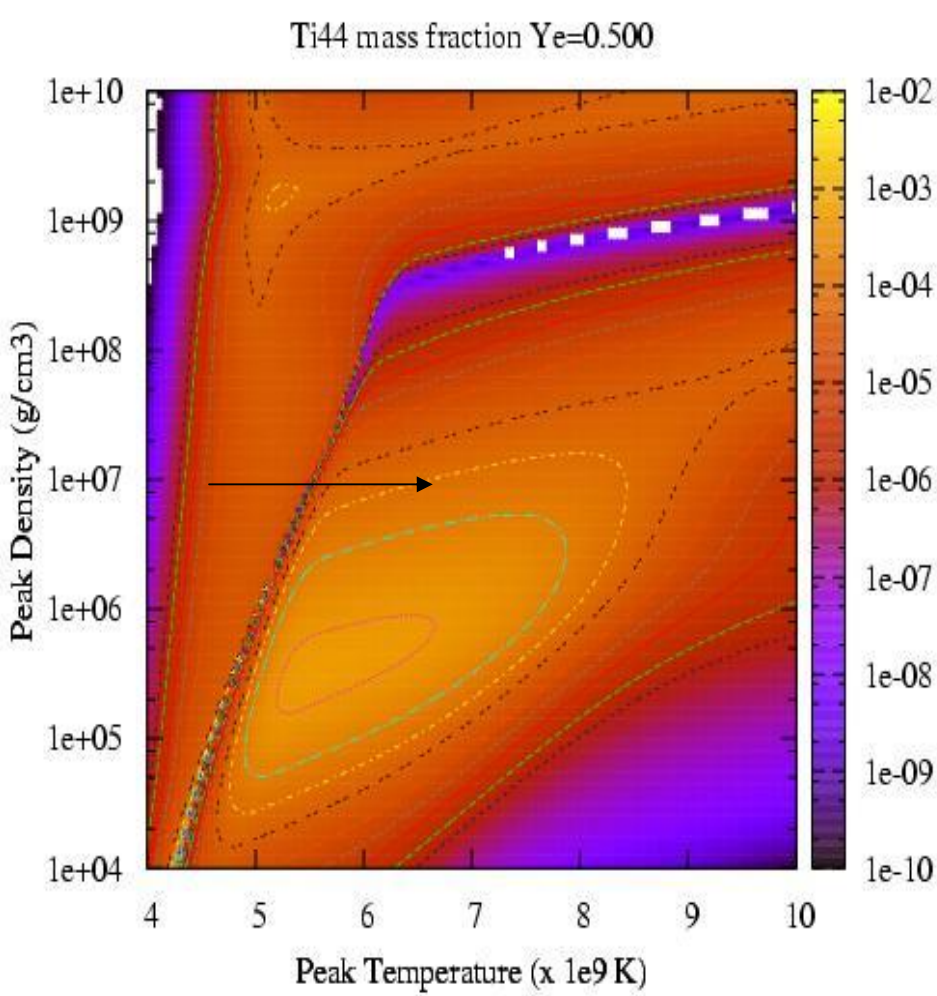
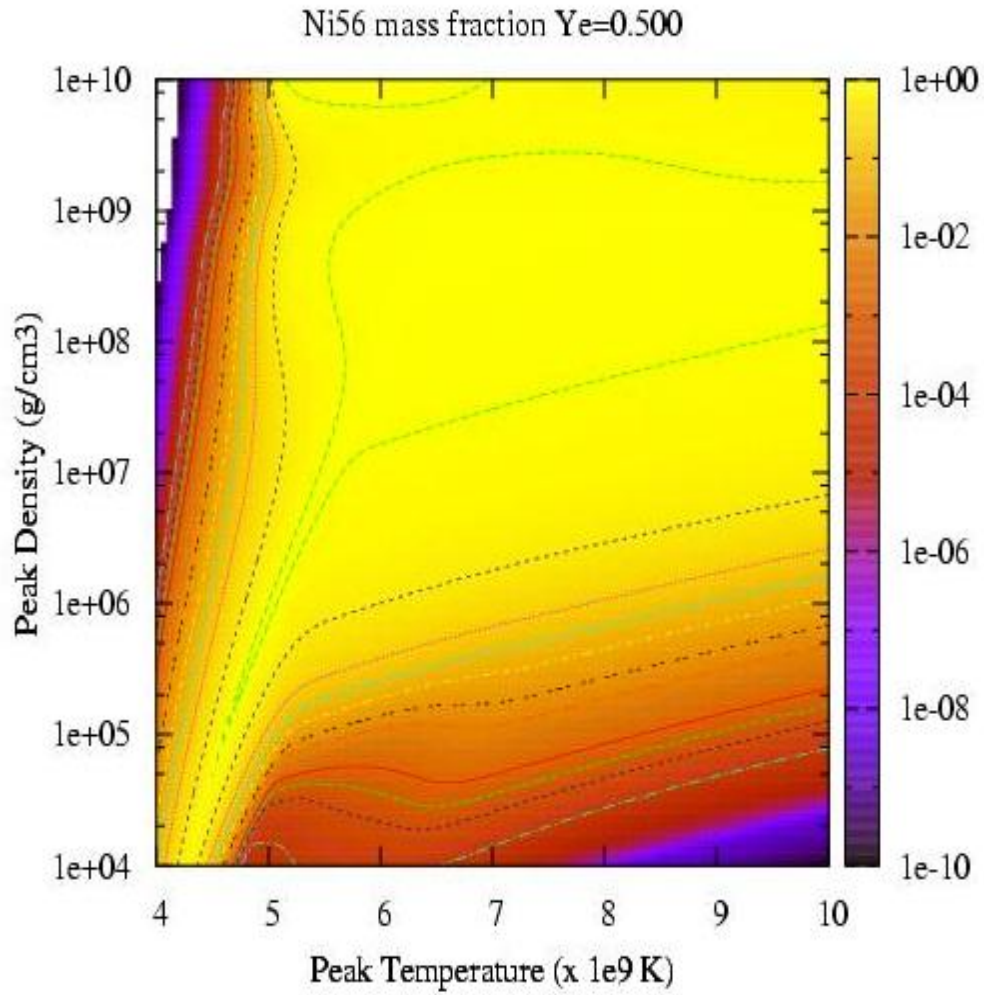
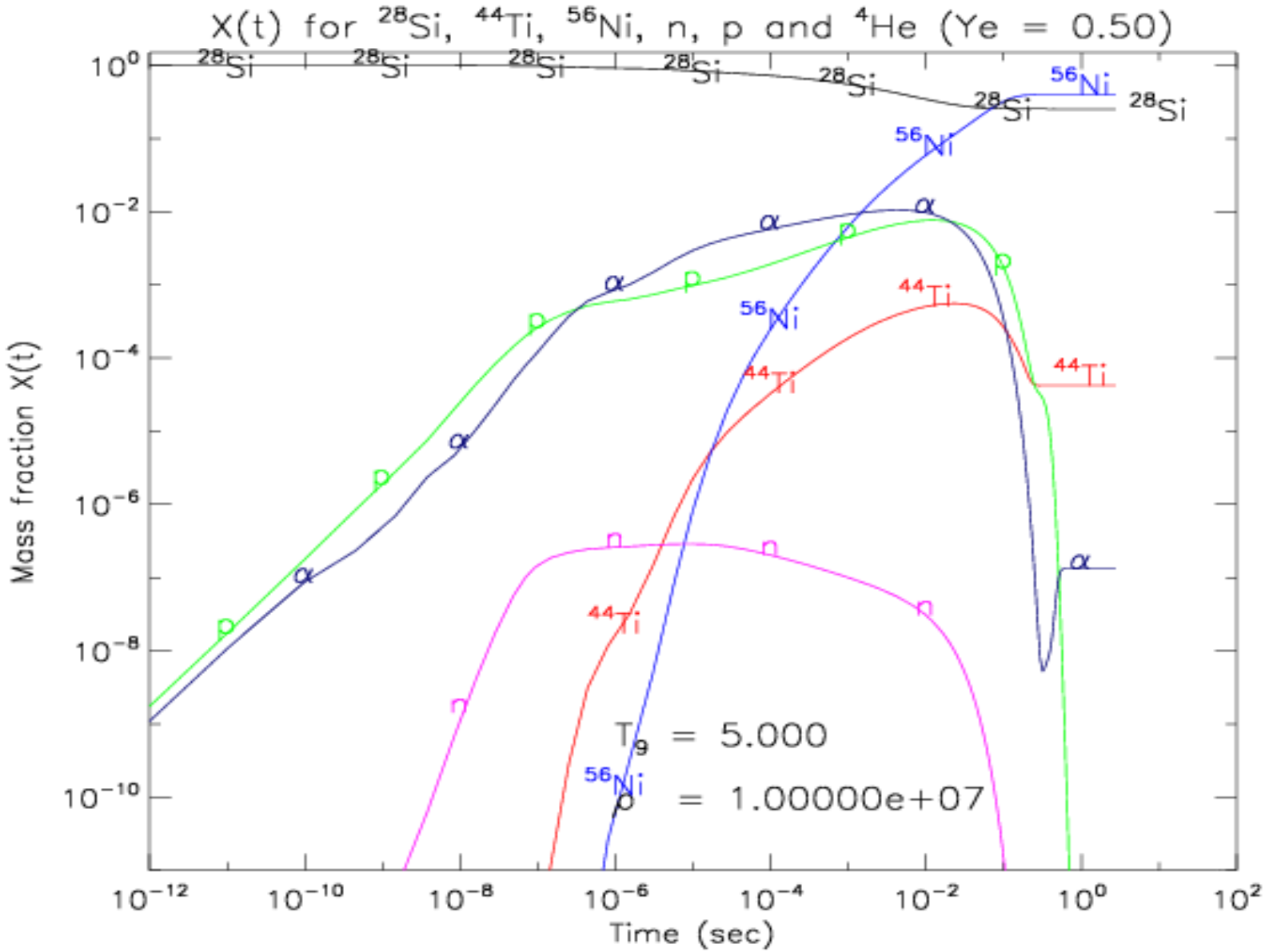
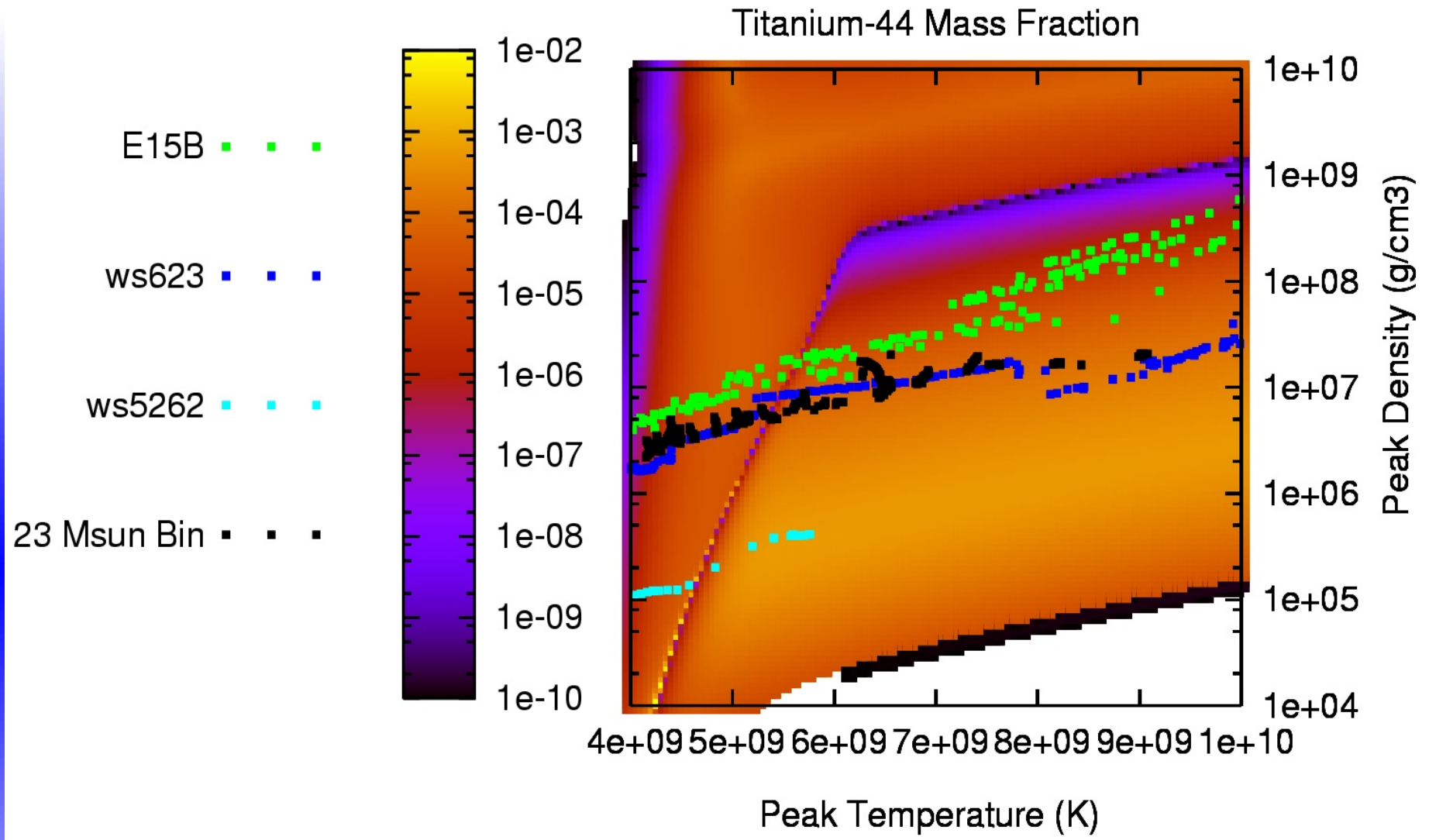




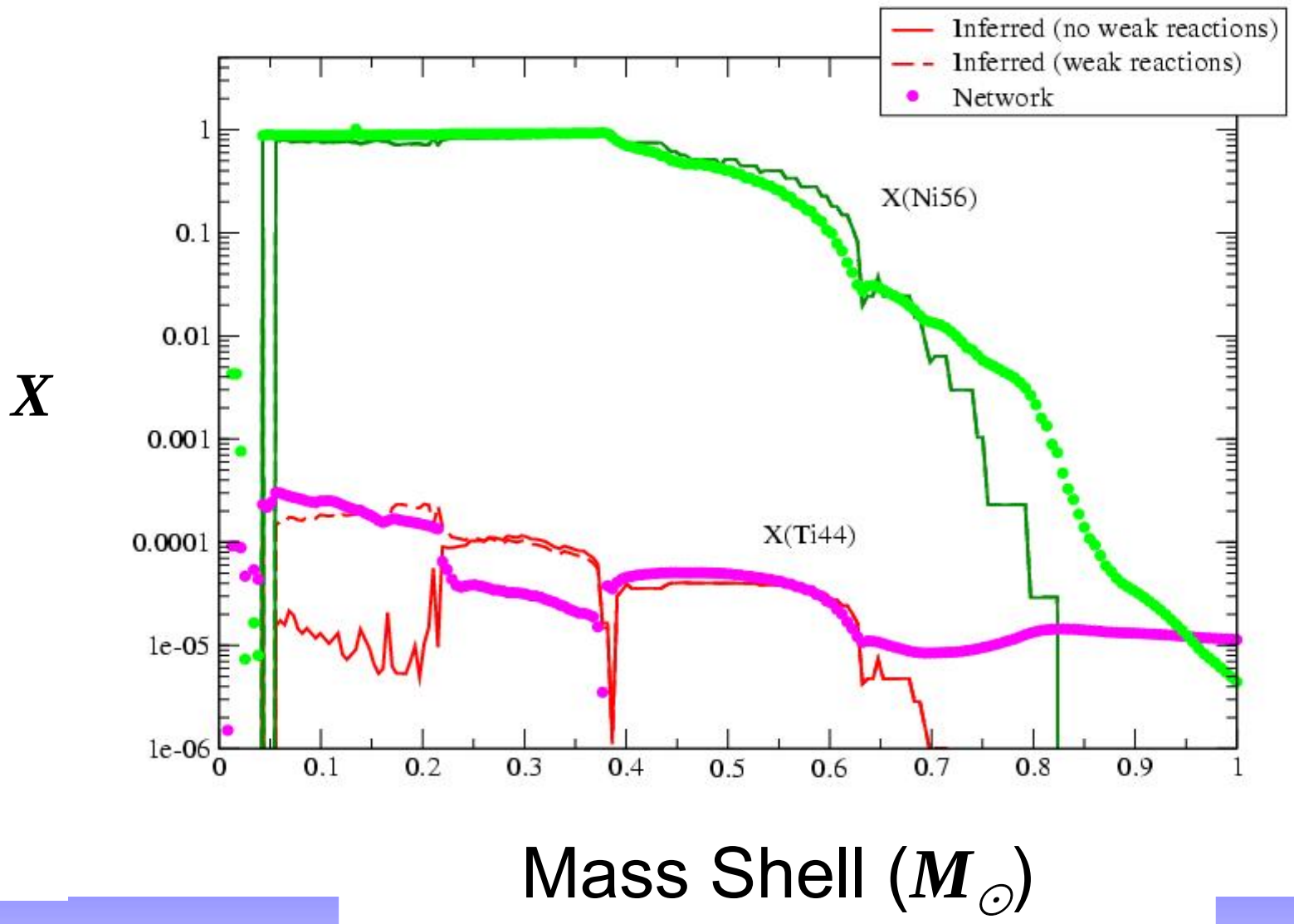
Changing peak temperature



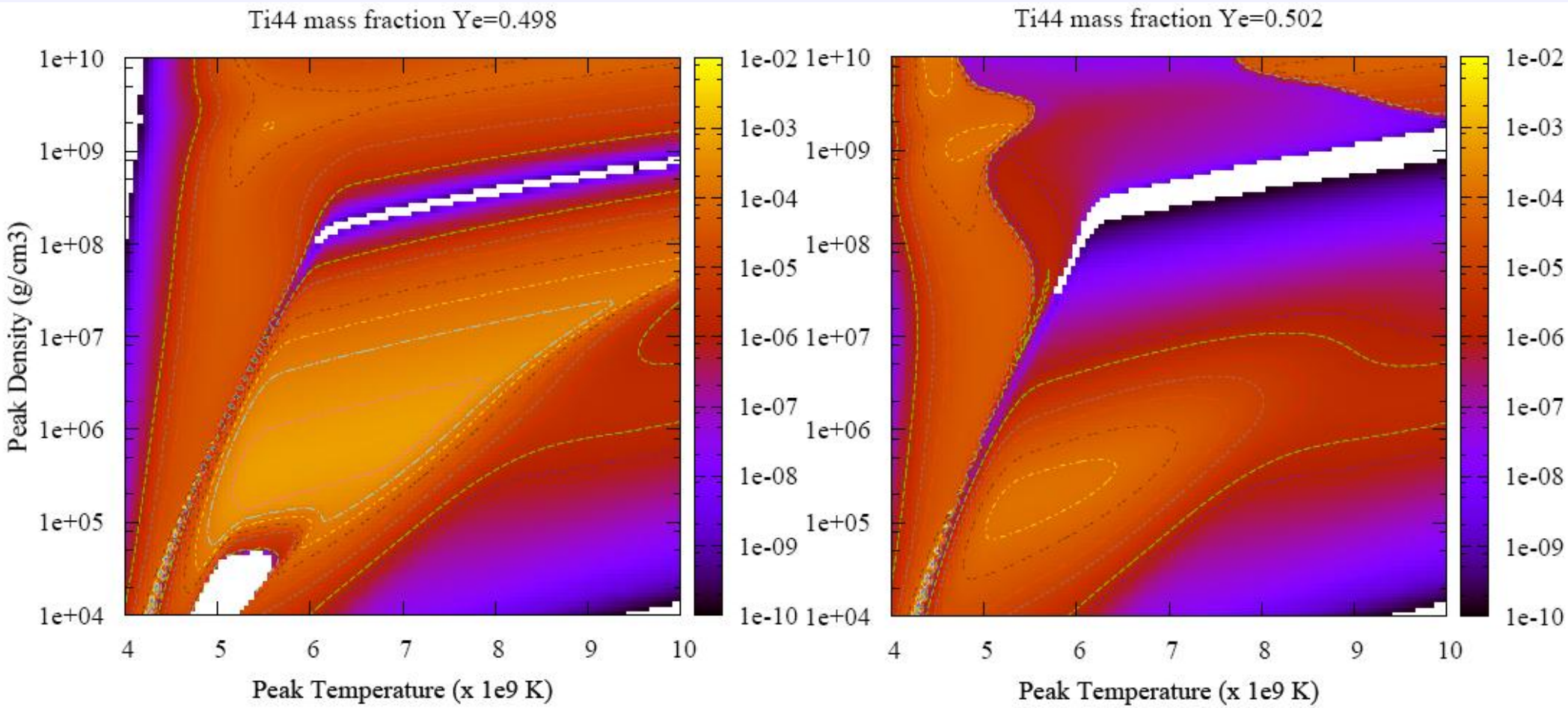
SPH contour plot for ^{44}Ti



Freeze-out vs post-processing



Yields for Y_e = 0.498 and Y_e = 0.502



Outlook

- With the parameterized shock wave approximation we may avoid the post - processing in SPH models
- For “proton - rich” matter, $^{44}\mathrm{Ti}$ abundance decreases dramatically
- More calculations to be done
  - Greater accuracy in NSE calculations
  - How much is the total mass of each isotope ?