Nucleosynthesis in Surface Detonation Models of Type Ia Supernovae

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Very off center

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U.S. DEPARTMENT OF ENERGY

Collaborators

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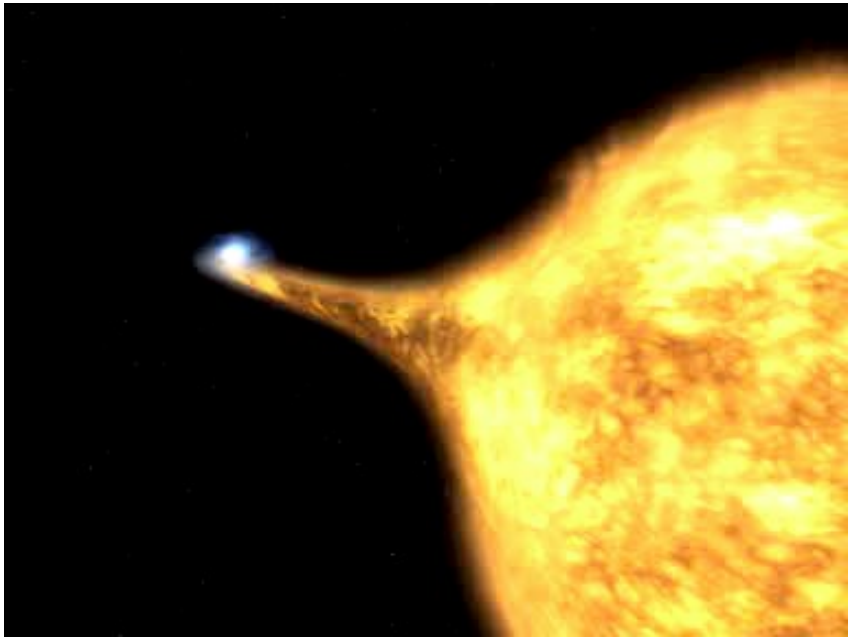
Type Ia Supernovae



[NASA]

Stars with a main sequence mass between 0.85 and 8 solar masses form C/O white dwarf.

A single degenerate binary system where the non-degenerate star accretes onto the white dwarf.

Thermonuclear incineration of a C/O white dwarf near the Chandrasekhar limit (1.4 Solar Masses). [see Hillebrandt & Niemeyer 2000]

Detonation

It is necessary to invoke a detonation in models of Type Ia supernovae. (Gamezo et al. 2004; Reinecke et al. 2002;Ropke et al. 2007a)

There are different prescriptions for how to do this. (Gamezo et al. 2004; Plewa 2007; Plewa et al. 2004; Ropke et al. 2007b,Fink et al. 2010)

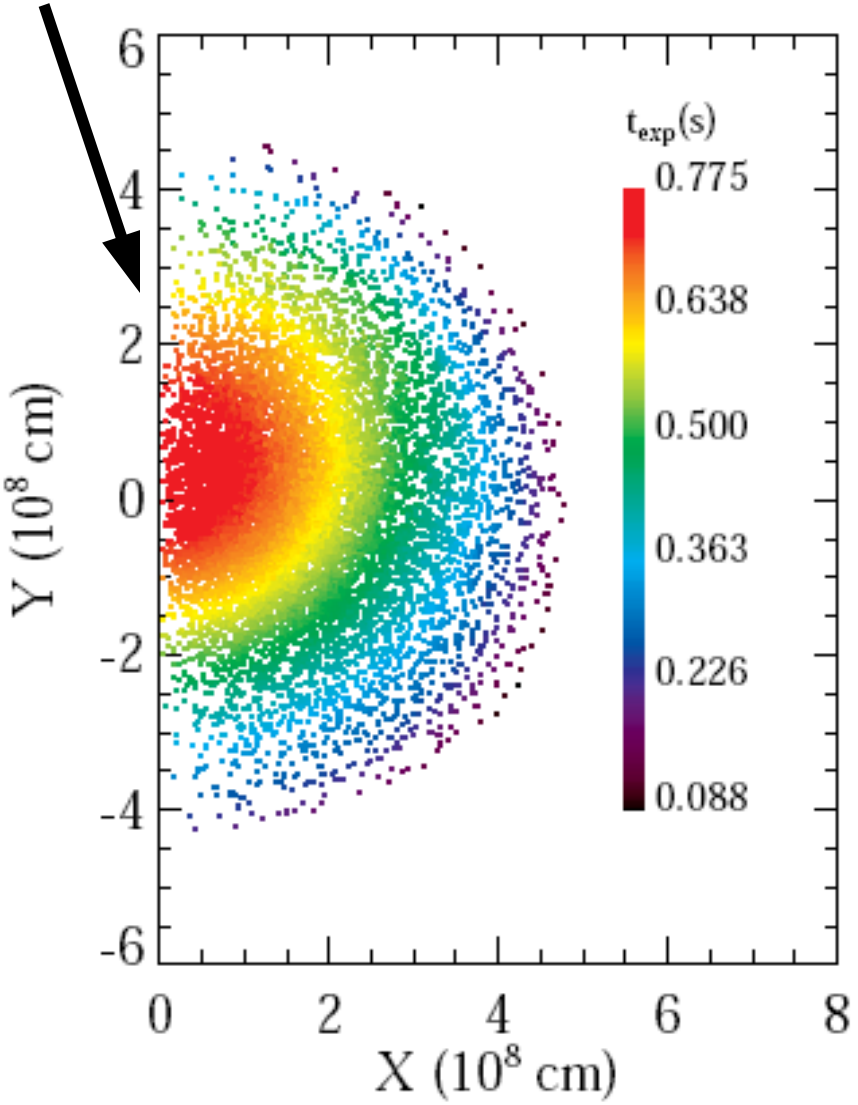
We have chosen to model a SN Ia where very little carbon has burned prior to a very off center detonation

FLASH

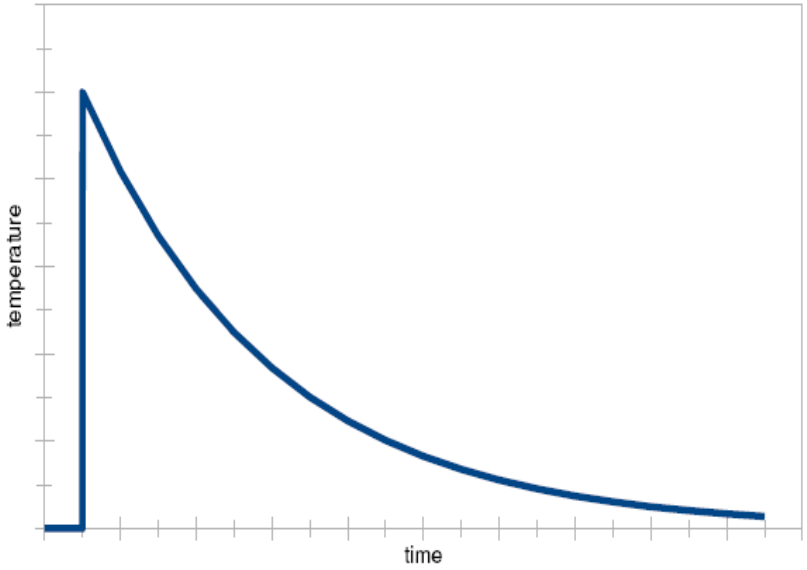
- Developed by the ASC Flash center at the University of Chicago
- Eulerian compressible hydrodynamics code
- Capable of doing hydrodynamics in 1-D, 2-D or even 3-D
- Free to download off the web.

A non-symmetric expansion

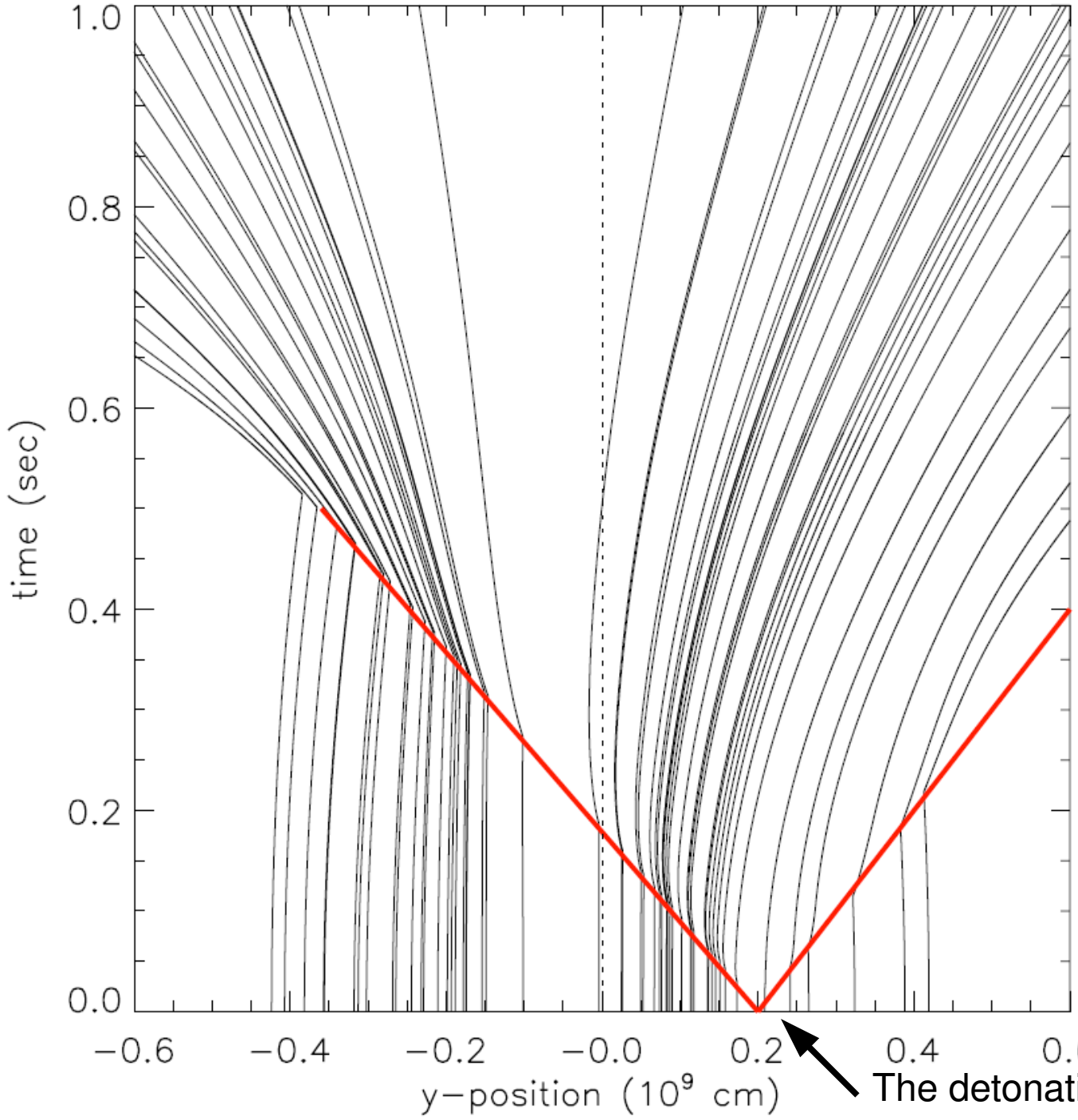
The detonation was started here.



The thermal profile is an exponential decay over a characteristic time scale.

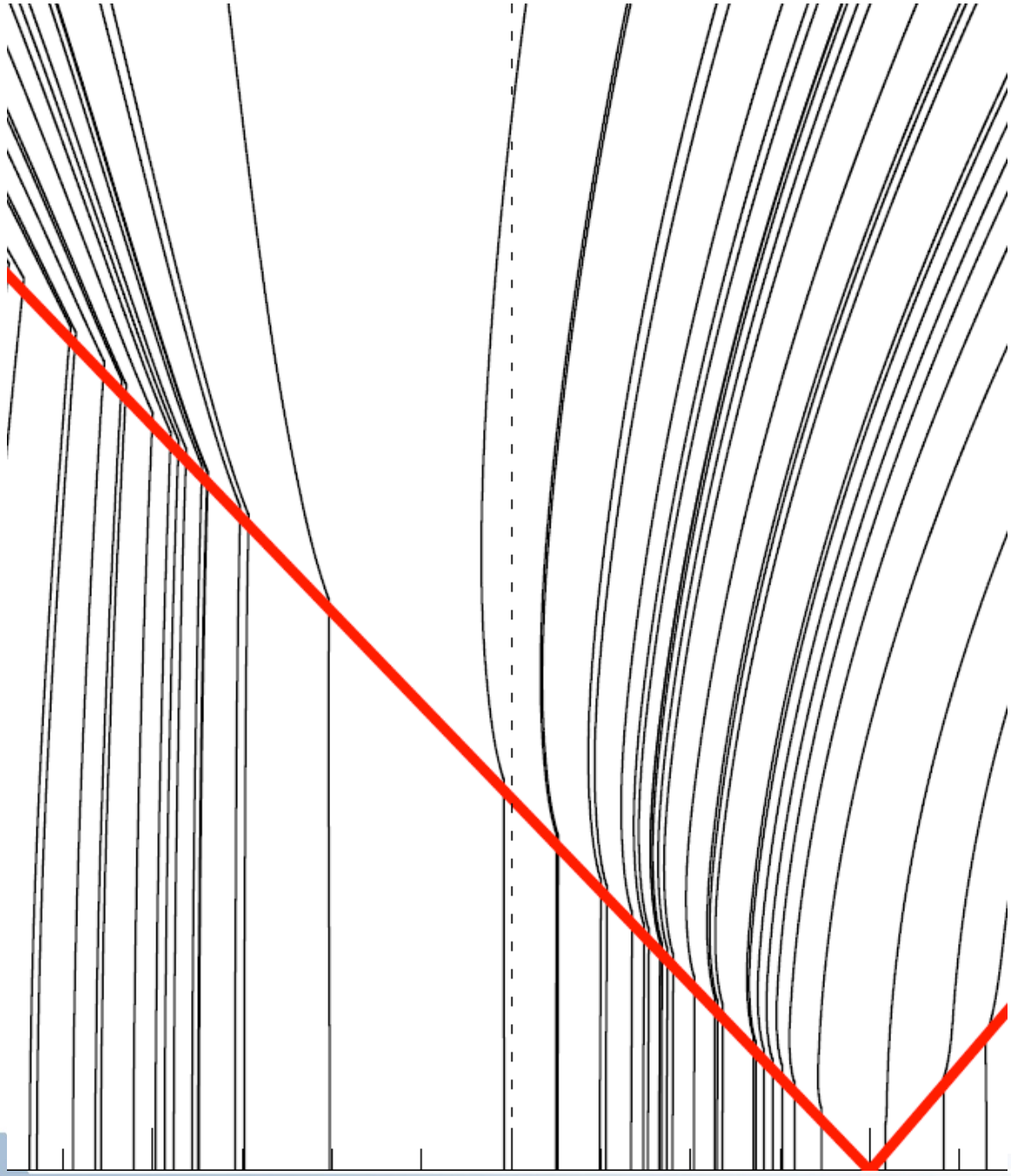


[Chamulak et al. in prep]



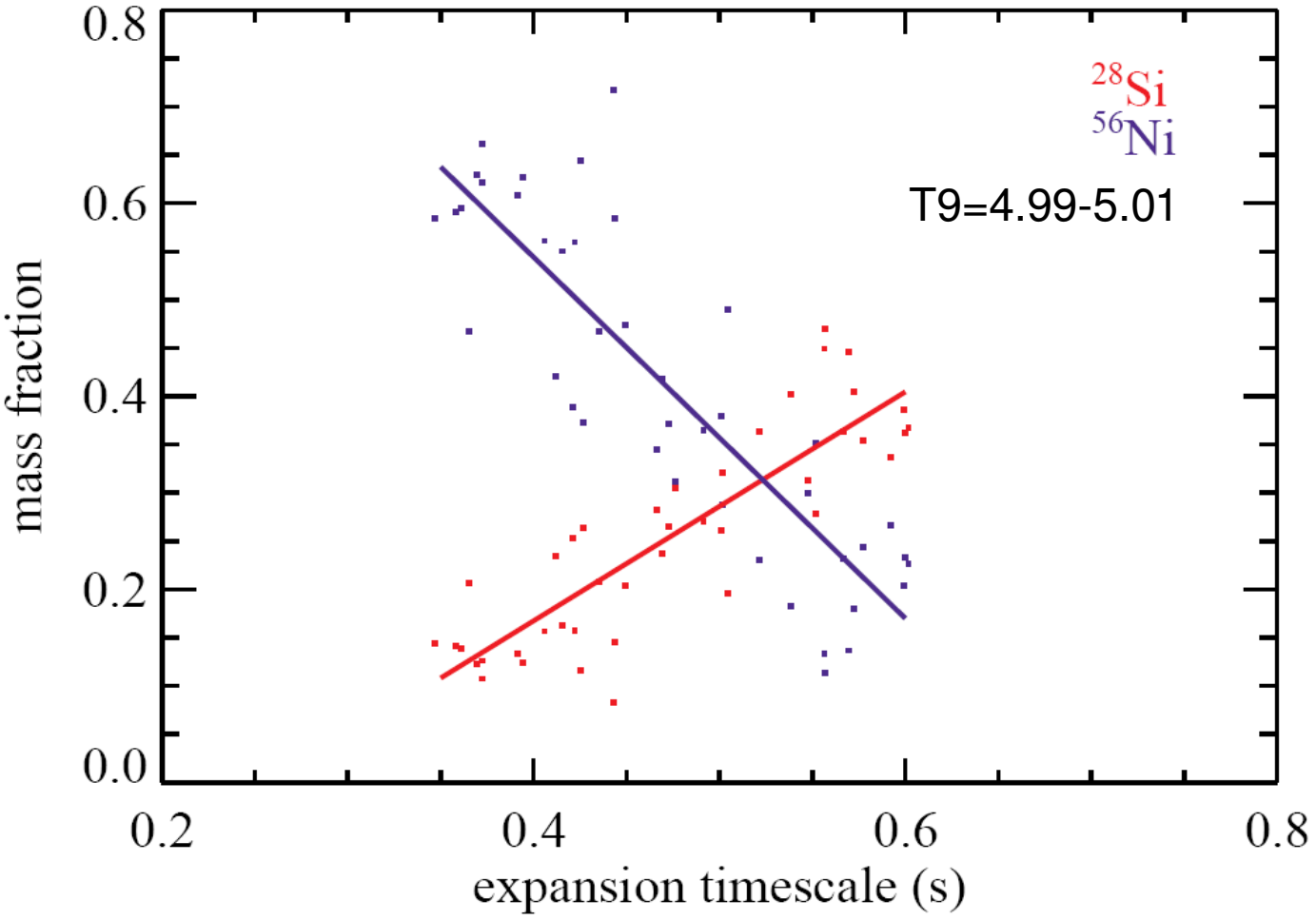
Trajectories of tracer particles along the y-axis.

The detonation was started here.

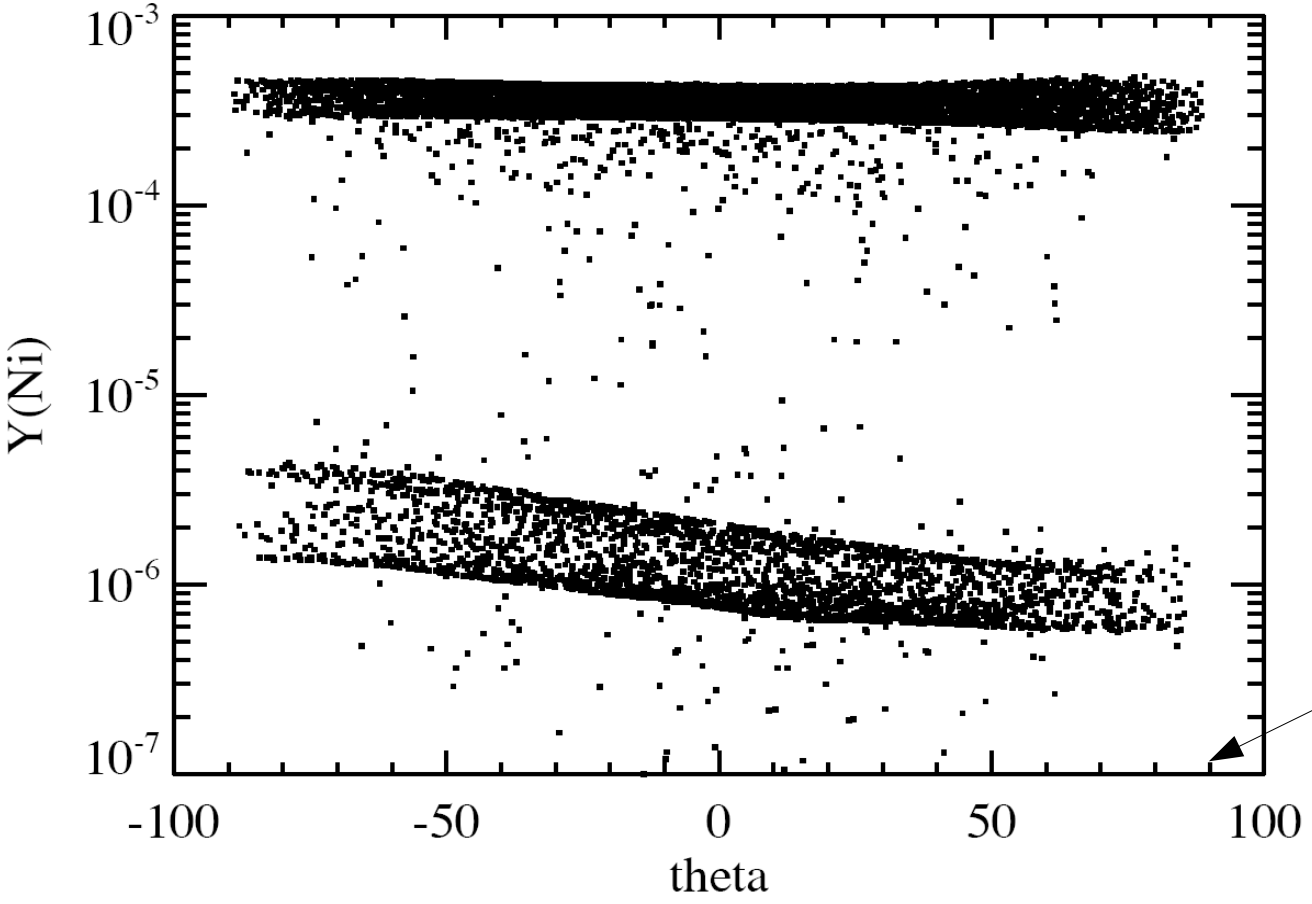


As the detonation wave passes through the star matter is compressed or pushed away from the star depending on the location..

Expansion time Scale and Nucleosynthesis



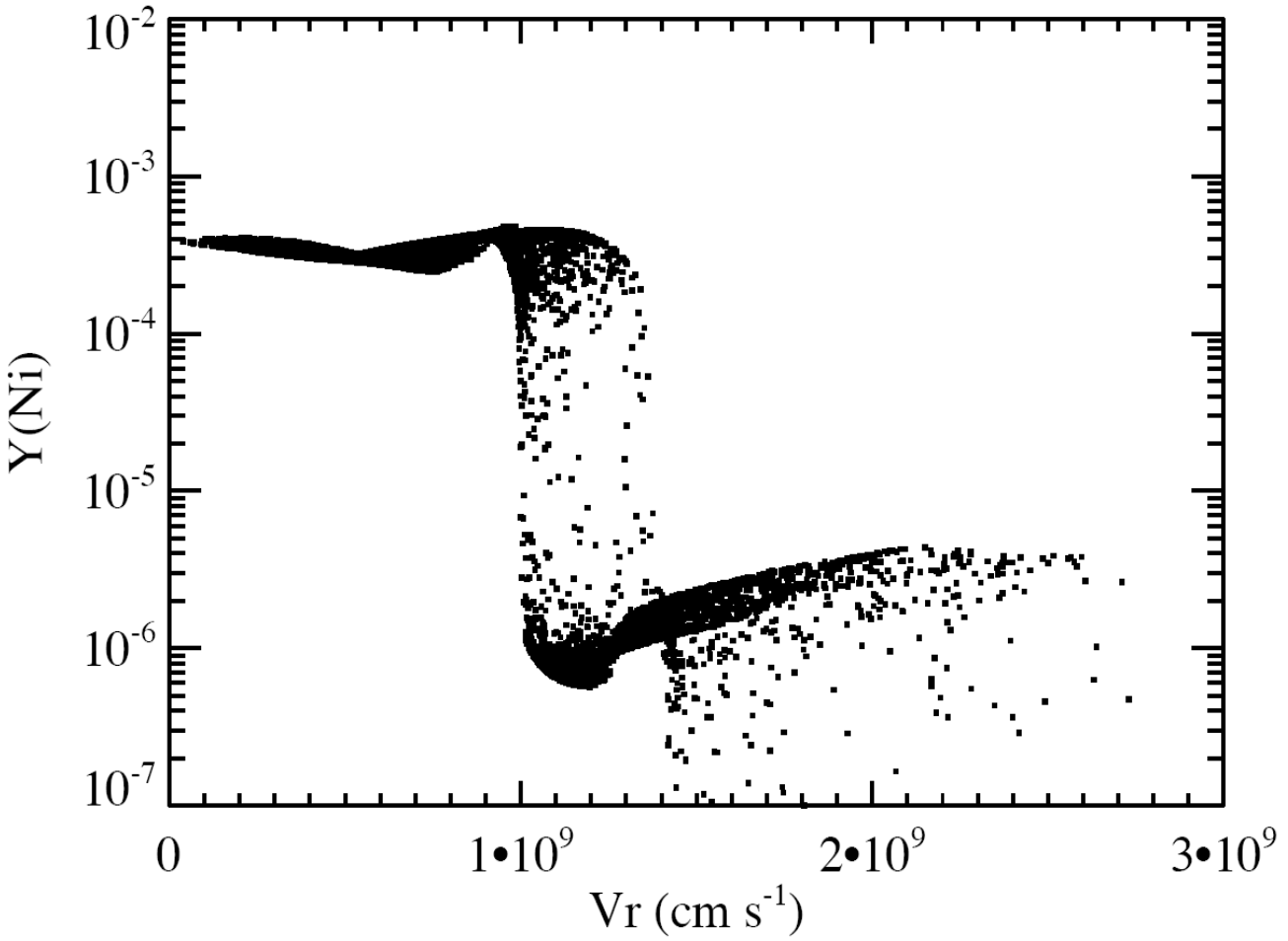
Reactions are sensitive to the thermal profile



Elemental Ni abundance shows a clear dependence on central ejection angle.

The detonation was started in this direction.

Elemental Ni abundance shows a correlation with radial velocity.



The Way Forward

We need to generate synthetic spectra/light curves so that we can compare to observation.

We need to consider other preconditions such as metallicity and central density on asymmetries. [see posters by A. Jackson and B. Krueger]

This can be made easier by using less tracer particles. [see poster by I. Seitenzahl]

Conclusions

-Material is accelerated by the detonation in the direction of the detonation.
-Because of this acceleration some material will “bounce” back resulting in the gradient in expansion time scale.
-Different expansion time scales mean different thermal trajectories and therefore different abundances produced by nucleosynthesis
-We need to generate synthetic spectra/light curves so that we can compare to observation.