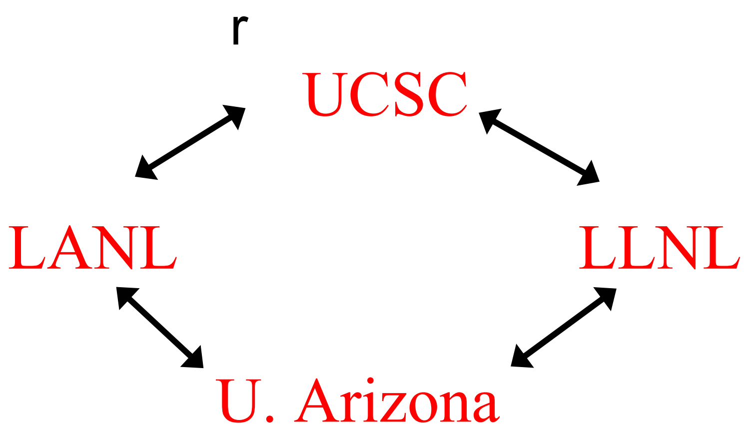
SciDAC Supernova Science Center



Primary Goal:

A full understanding, achieved through numerical simulation, of how supernovae of all types explode and how the elements have been created in nature. Comparison of these results with astronomical observations and the abundance pattern seen in the sun.

Major Challenges

- *For gravitational collapse supernovae –*
  Three-dimensional hydrodynamics coupled to radiation transport including regions that are optically gray

- *For thermonuclear supernovae –*
  Turbulent combustion at low Prandtl number and very high Rayleigh number

- *For nucleosynthesis –*
  Standardized nuclear data in a machine-friendly format

- *Computational -*
  Optimization of codes on parallel computers. Manipulation and visualization of large data sets. Development of novel approaches to radiation transport and hydrodynamics on a grid

General Approach

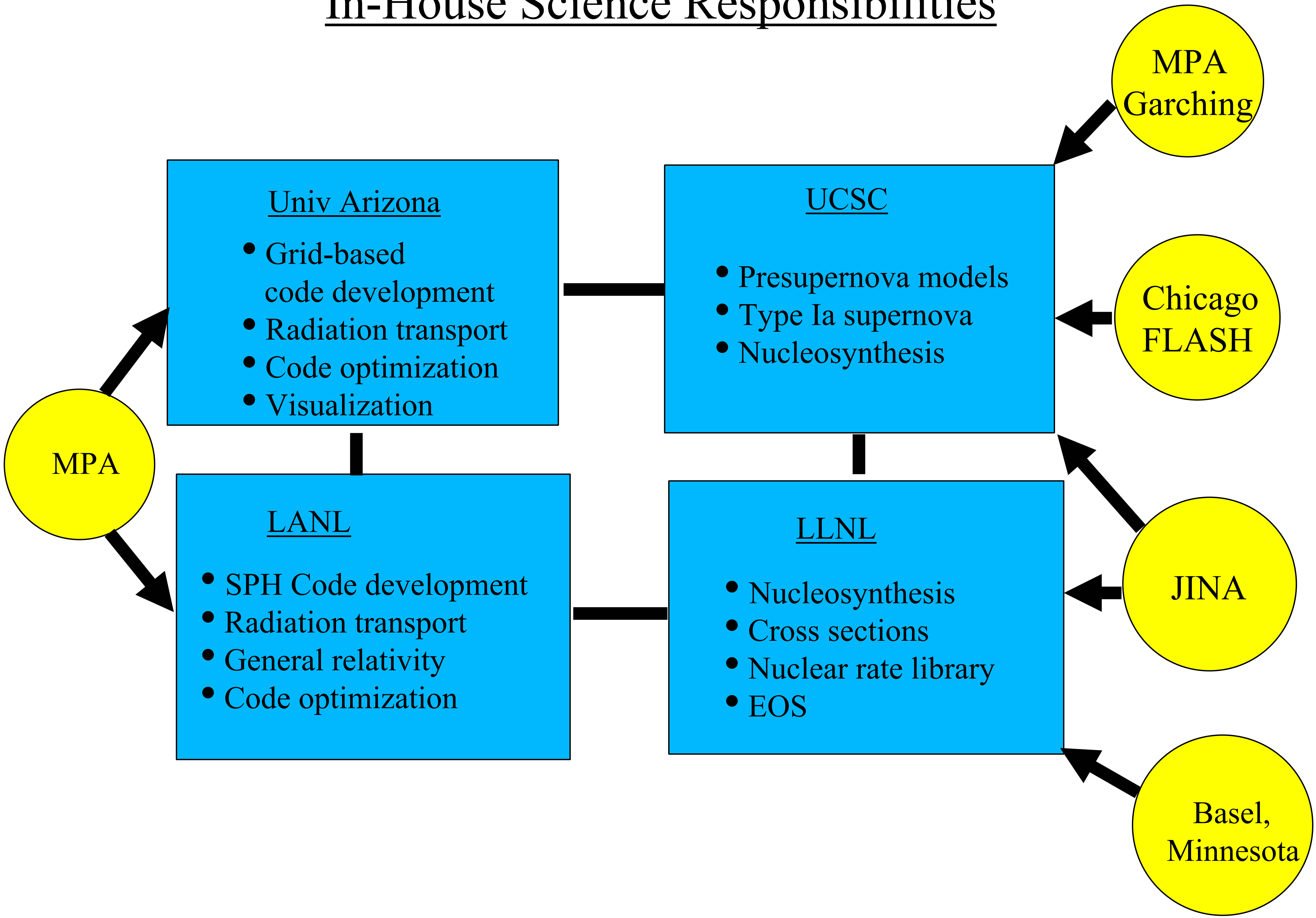
- ***Develop an ensemble of appropriate codes*** –
  We are exploring several approaches to hydrodynamics, at both high and low Mach numbers. Monte Carlo transport will serve to test and validate other approaches

- ***Obtain short term results for guidance*** –
  Useful results can be obtained in 3D using a Lagrangian particle based code (SPH) and rudimentary neutrino transport. These can guide future work.

- ***Work with in-house experts in computer science*** –
  There are experts in radiation hydro – e.g. Monte Carlo, at LANL. The University of Arizona Center for Integrative Modeling and Simulation and High Performance Distributed Computing Laboratory will help with code development and visualization.

- ***Work with other SciDAC centers*** -

In-House Science Responsibilities



Other Related SciDAC Activities

- ***Terascale Supernova Initiative*** –
  We will make our presupernova models and nuclear data libraries publicly available. We plan joint meetings with the TSI teams

- ***High Performance Data Grid Toolkit, Extreme! Computing, and DOE Science Grid*** –
  These three national co-laboratories and networking centers, working together with computer scientists on our team at Arizona, can help us optimize our codes for large scale, distributed computing environments (Grid computing). The PI's of these centers have ongoing interactions with our team members at the HPDC laboratory in Arizona

- ***Algorithmic and Software Framework for Applied Partial Differential Equations Center*** –
  Phil Collela is a co-author of one of our main codes (PPM). We are interested in learning new techniques especially for following low Mach number flows

Other Related SciDAC Activities - continued

- ***Terascale High Fidelity Simulations of Turbulent Combustion with Detailed Chemistry*** –
  Type Ia (thermonuclear) supernovae are prime examples of turbulent combustion. We have already worked with experts at the Livermore Sandia Combustion Center for years

- ***Scalable Systems Software Center and the Center for Component Technology for Terascale Simulation Software*** –
  We will collaborate with experts at these two centers to make our codes scalable, component based, and run efficiently in Grid computing environments

- ***Particle Physics Data Grid (PPDG)*** –
  Grid enabled tools for data intensive requirements. Also possible common interest in Monte Carlo and other particle transport schemes. Discussions begun with Richard Mount.

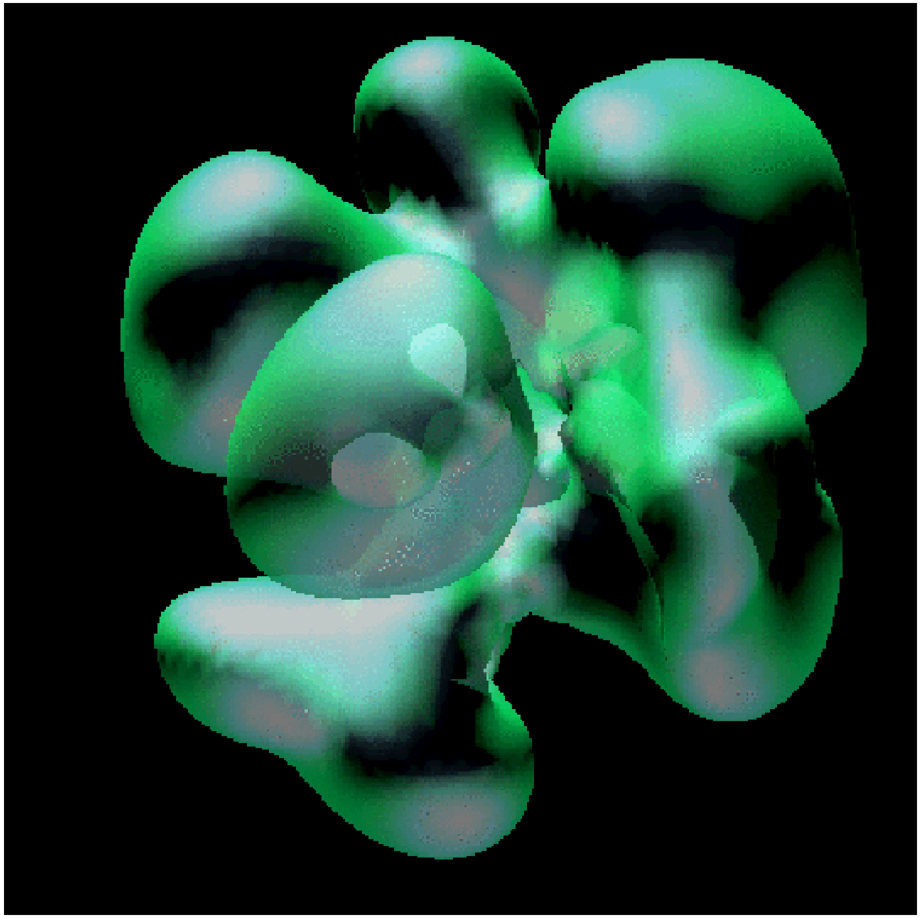
Recent Activities of the SNSC

SciDAC-SNSC Postdocs Hired:

- **UCSC – Mike Zingale** – *formerly co-author Univ Chicago FLASH code*
- **LLNL – Jason Pruet** – *expert in neutrino physics and weak interaction rates*
- **Arizona – Rolf Walder** – *formerly of Zurich. Expert in multi-D hydro and radiation transport*
- **LANL – Adrian Gentile** – *formerly of Monash . Expert in numerical relativity*

plus 13 graduate students (7 Arizona, 4 UCSC, 2 LANL)

First team meeting Tucson Feb 1,2; Second at LANL first week of June

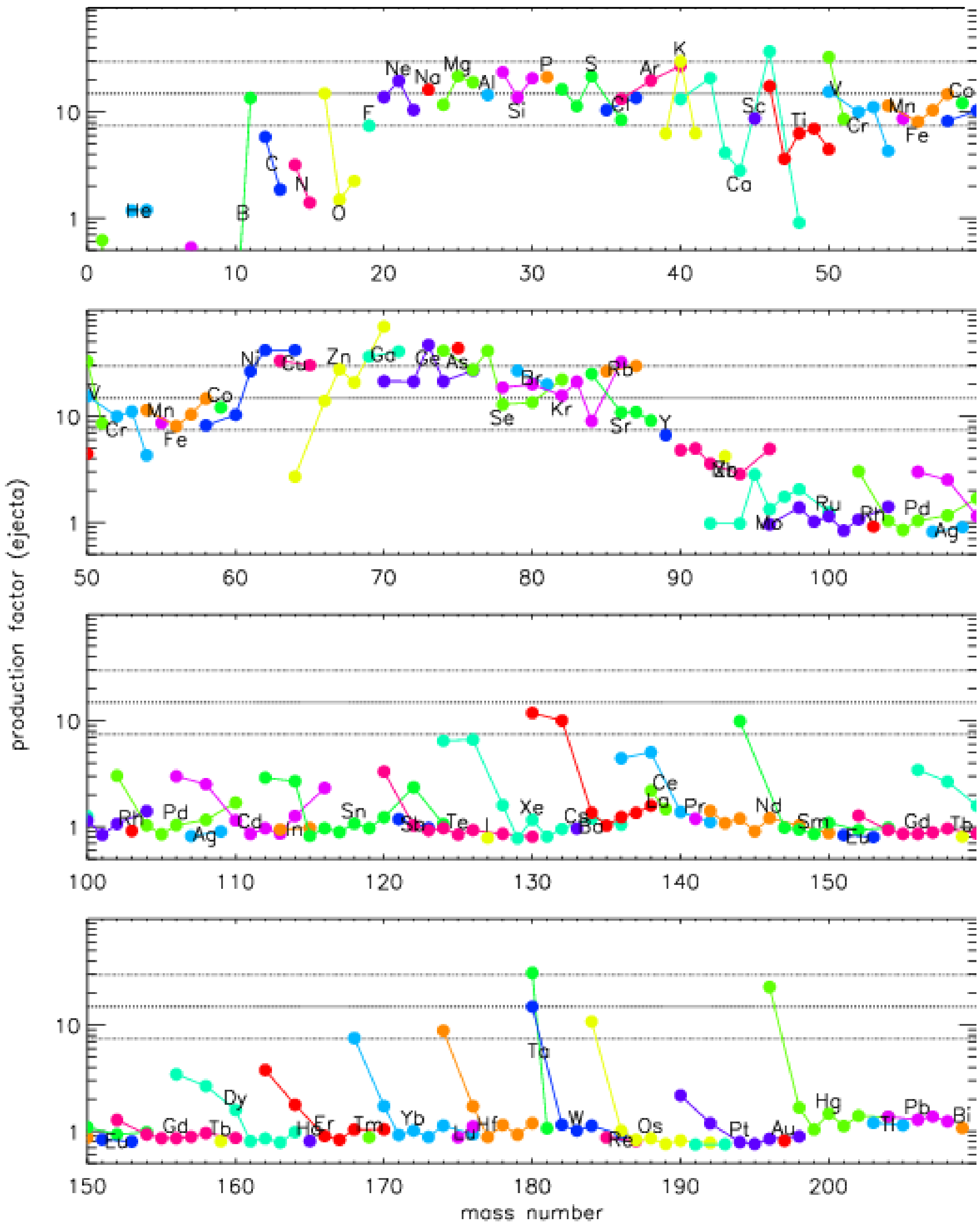


The box is 1000 km across.

First three-dimensional calculation of a core-collapse supernova.

This figure shows the iso-velocity contours (1000 km/s) 60 ms after core bounce in a collapsing massive star. Calculated by Fryer and Warren at LANL using SPH (300,000 particles).

Resolution is poor and the neutrinos were treated artificially (trapped or freely streaming, no gray region), but such calculations will be used to guide our further code development.



Nucleosynthesis in a 25 solar mass supernova compared with abundances in the sun.

Abundances for over 2000 isotopes of the elements from hydrogen through polonium were followed in each of approximately 1000 zones throughout the life of the star and its simulated explosion as a supernova. Our library will eventually include 300 such models.

A production factor of 20 for every isotope would mean that every isotope in the sun could be created if 1 gram in 20 of the primordial sun had been ejected by 25 solar mass supernovae like this one. Actually making the solar abundances requires many stars of different masses.