COMPUTATIONAL ASTROPHYSICS CONSORTIUM

TEAM MEETING 2010

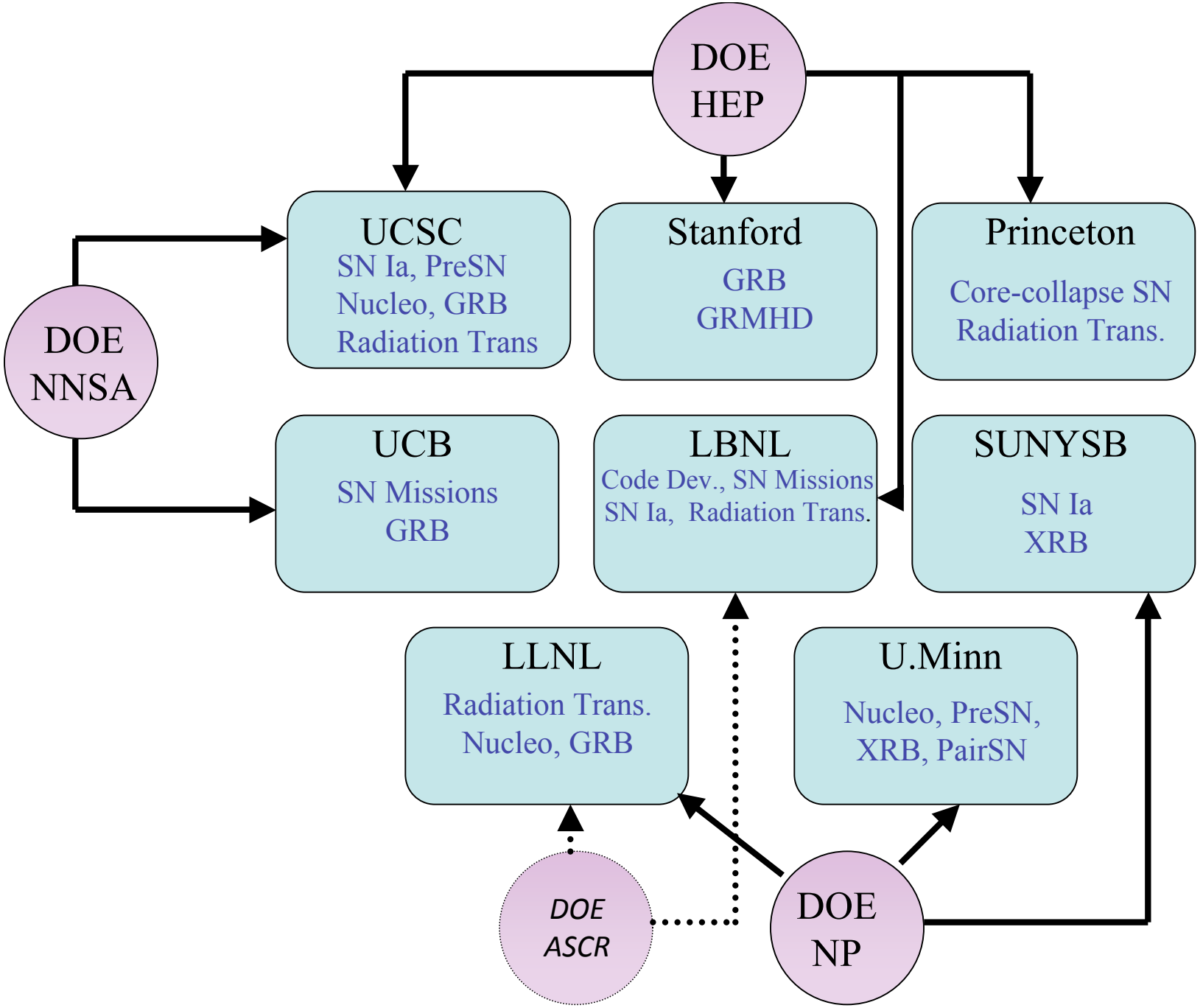
KIPAC - Stanford
May 19, 2010

- Stan Woosley,
- John Bell

COMPUTATIONAL ASTROPHYSICS CONSORTIUM

Purpose:

- Improve our understanding of supernovae of all types through the use of large scale computing.
- Design codes for the efficient study of hydrodynamics and radiation transport on the largest, fastest available machines.
- Train postdocs and graduate students in computational physics.
- Optimize and enhance the scientific return from astronomical missions - including JDEM, LSST, and ground-based supernova searches.


DOE
HEP
DOE
NNSA
UCSC
SN Ia, PreSN
Nucleo, GRB
Radiation Trans
Stanford
GRB
GRMHD
Princeton
Core-collapse SN
Radiation Trans.
UCB
SN Missions
GRB
LBNL
Code Dev., SN Missions
SN Ia, Radiation Trans.
SUNYSB
SN Ia
XRB
LLNL
Radiation Trans.
Nucleo, GRB
U.Minn
Nucleo, PreSN,
XRB, PairSN
DOE
ASCR
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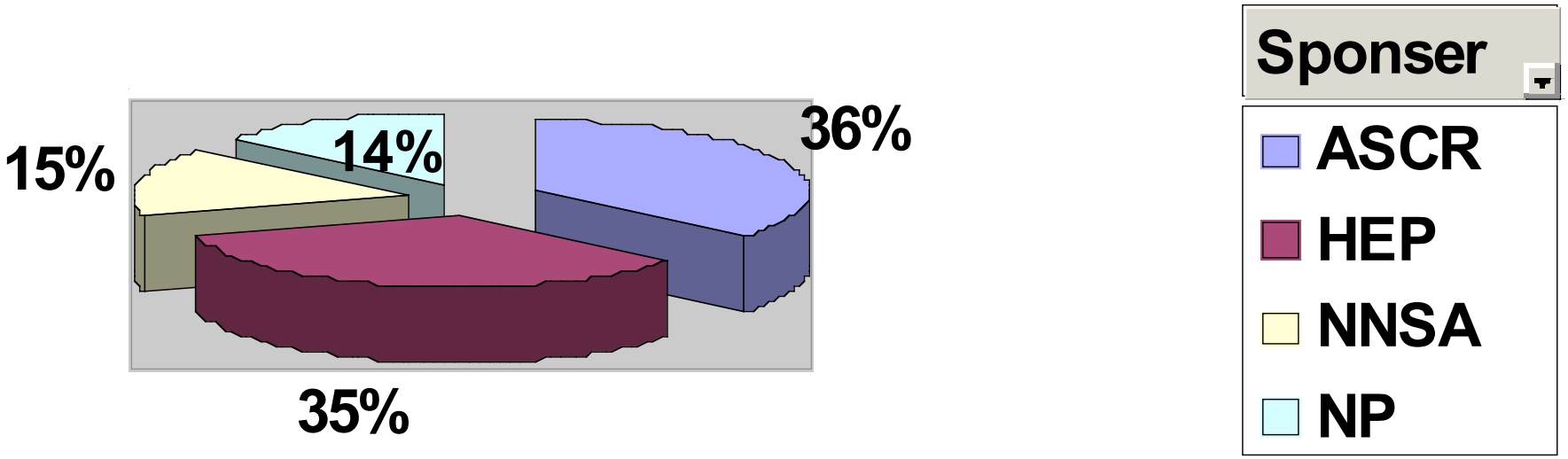
NP

Computational Astrophysics Consortium
FY08 Funding by Source



ASCR funding = $700 K/yr now expired

HEP+NP+NNSA = $1239 K/yr

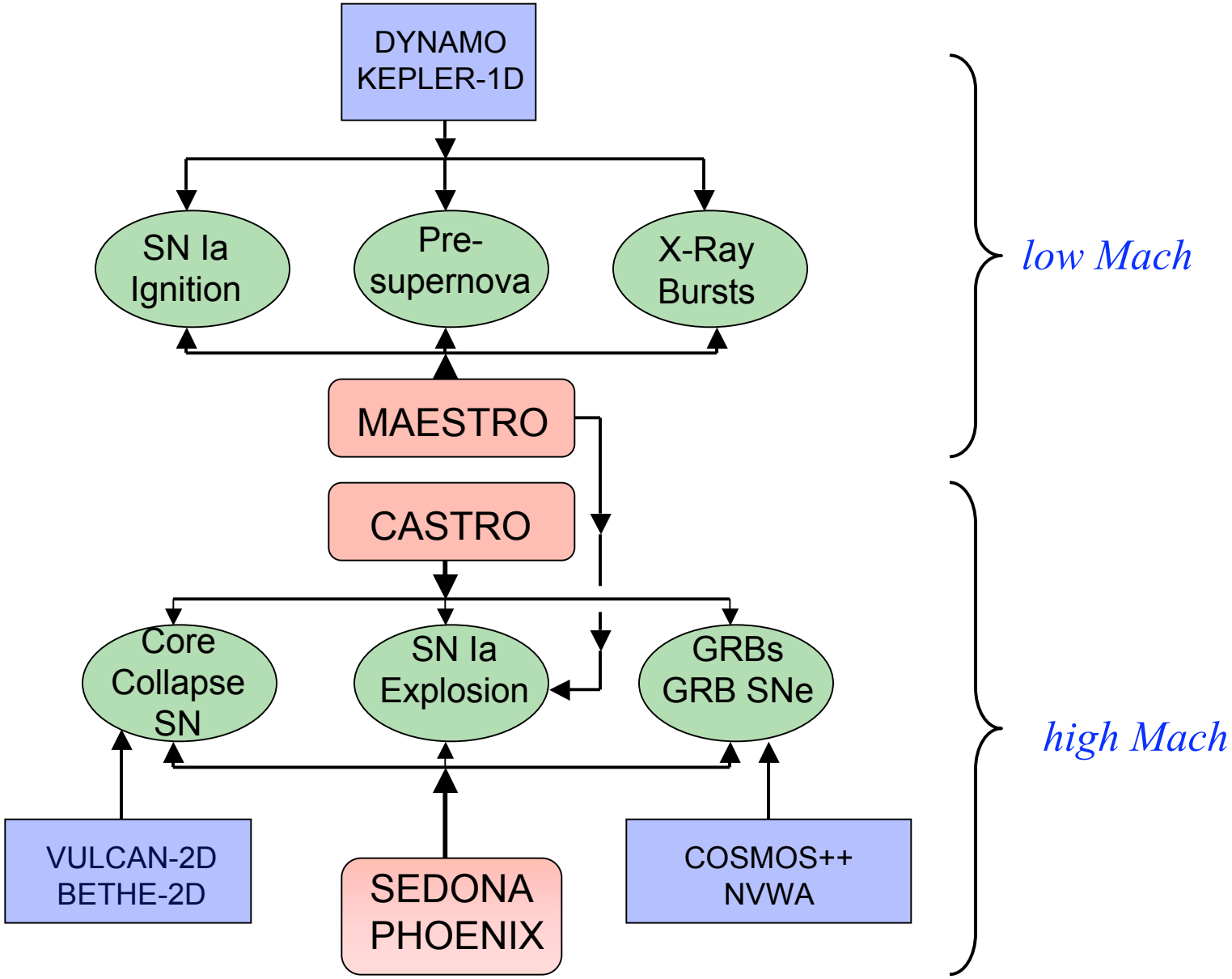
HEP one time only 2010 - $500 K

Institution		FTE	Postdoc	Grad	FTE	Postdoc	Grad
		(co-I and/or paid)	(paid)	(paid)	(leveraged)	(leveraged)	(leveraged)
UCSC		Woosley Ramirez-Ruiz Glatzmaier Dong	Kasen TBD	Ma Joggerst			Roberts
LBNL		Bell Almgren Nugent Lijewski	Nonaka	Gilet	Day Beckner Baron Thomas	Aspden	
UCB		Perlmutter Arons McKee	Sharma Poznanski Oishi	Darbha	Quataert Bloom Filippenko	Bucciantini Chang	Childress Metzger
Stanford		Blandford	Akiyama		Abel	McKinney	Wang
LLNL		Hoffman Howell			Salmonson		
U. Minn.		Heger		Chen Hou McEachern		Keek	Vo West
Princeton		Burrows Su Fisher	Nordhaus Rantsiou TBD	Brandt	Ott Thompson Hubeny	Murphy Schnetter Abdikamlov	O'Conner
SUNYSB					Zingale		Malone

18	FTE or permanent staff supported or partly supported
10	paid or partially paid postdocs
8	graduate students
13	FTE or permanent staff leveraged
8	leveraged postdocs
8	leveraged grad students

- Main codes developed and fielded:

  - CASTRO - compressible hydro, adaptive mesh, 3D, MGFLD radiation transport - talks by Almgren and Howell
  - MAESTRO - low Mach number, adaptive mesh, 3D, radiative diffusion - talks by Nonaka and Zingale
  - SEDONA - Monte Carlo, 3D, spectral synthesis and radiation transport code - talk by Kasen
  - PHOENIX - 3D spectral synthesis code - talk by Thomas


DYNAMO
KEPLER-1D
SN Ia
Ignition
Pre-
supernova
X-Ray
Bursts
low Mach
MAESTRO
CASTRO
Core
Collapse
SN
SN Ia
Explosion
GRBs
GRB SNe
high Mach
VULCAN-2D
BETHE-2D
SEDONA
PHOENIX
COSMOS++
NVWA

There are three main variations on the supernova science theme:

- Type Ia supernovae - the thermonuclear explosion of accreting white dwarf stars in binary systems. Primary challenges are the physics of turbulent (nuclear) combustion, including the transition to detonation, and radiation transport.

- Core-collapse supernovae - the outcome of iron-core instability in stars from 8 to 130 solar masses. Primary challenges are neutrino transport and high density physics. The role of rotation and magnetic fields is debated (and variable).

- Gamma-ray bursts - also produced when the cores of massive stars collapse. Challenges are the same as core-collapse supernovae but with the certain added complication of strong magnetic fields and rapid rotation. Special, and perhaps general relativistic effects are important.

Results of 2009 “Mid-term Review”, February, 2009

- Overall scientific achievement and quality of the team assembled reviewed very well (“at least a 9”). 97 refereed publications in 2.25 years considered very good. The potential for advancing the state-of-the-art in supernova modeling also ranked very highly. Training of students was lauded.

- A concern on the part of at least part of the review team though was that the CAC was not - so far - making use of petascale resources

  “Using a major fraction of 100,000 or more processor machines for scientifically relevant simulations must be a goal”

  “Should focus more on CASTRO and MAESTRO”

  “It is very unfortunate - and short sighted - that the SAP component will not be funded beyond 2009.”

- In response to the review we have refocused the project

Response

- Programmatically, top priority given to the full deployment at the "petascale" level of CASTRO and MAESTRO and their applications. Scientifically, the top application is Type Ia supernovae.

- Second highest priority is to radiation transport (CASTRO, SEDONA) and its application to core-collapse supernovae. Other research (nucleosynthesis, XRBs, GRBs, Star Formation) reduced. Observational related efforts maintained.

- AT LLNL - postdoc not rehired in nuclear astrophysics, money reassigned to CASTRO development

- Budget at UCSC reduced 100 K in 10 - 11; savings go to LBNL

- Savings from Heger move banked

- Proposal to HEP for one time stimulus funds of 500 K for code activities at LLNL approved. HEP becomes our chief sponsor. OASCR funding departs.

Today

The focus on CASTRO and MAESTRO development - with a lot more help from LBNL folks and Mike Zingale than they were really paid for - has paid off. We now have three truly petascale codes - MAESTRO, CASTRO, and SEDONA - see talks by Almgren, Nonaka, and Kasen

We have - we believe - proven the viability of a new paradigm for computational science, one where applied mathematicians, application scientists and computer scientists work closely together on a problem

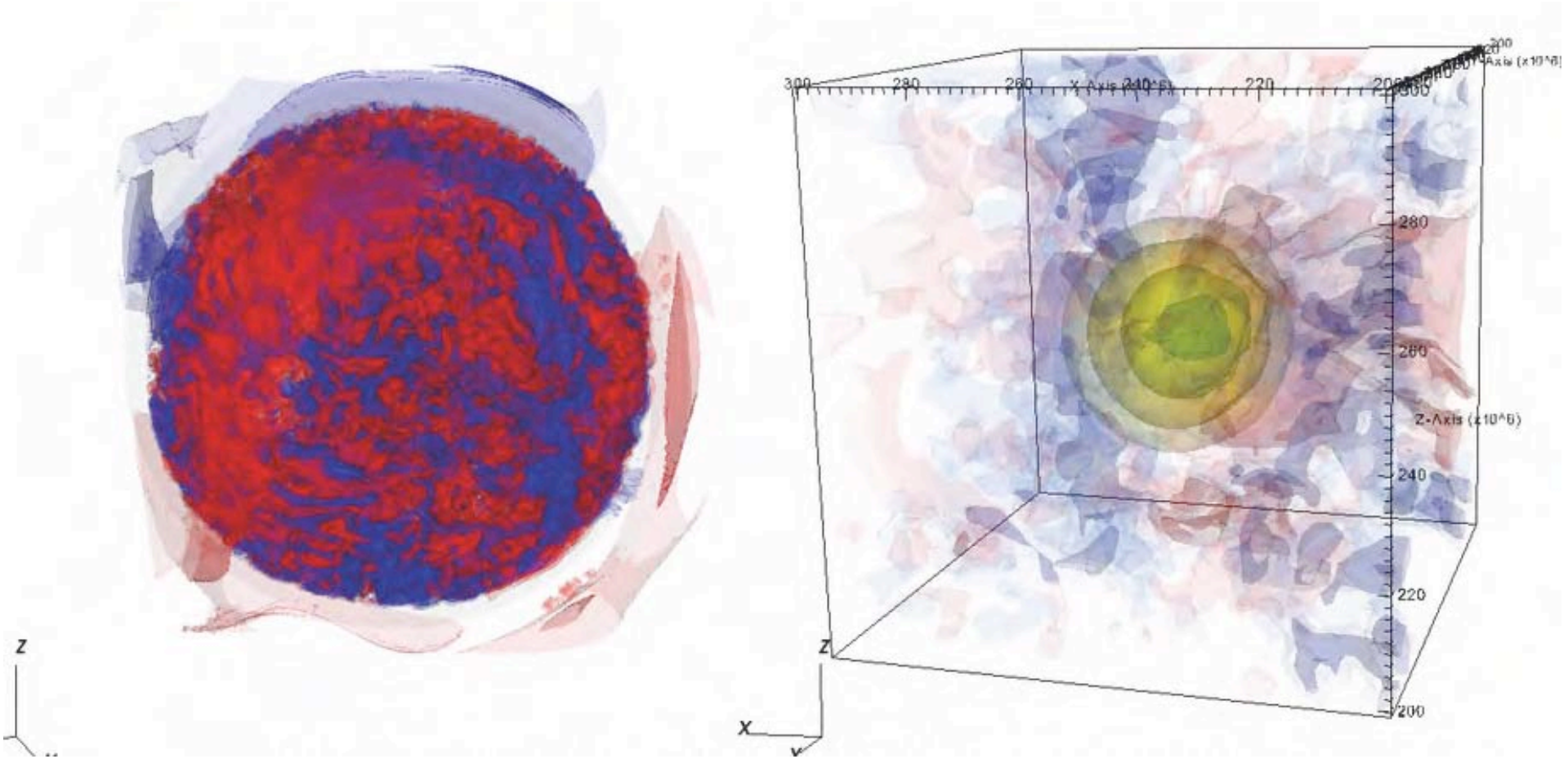
This should be a really fun year!

CPU Resources

One message from the review was that we should seek more computer time (one OASCR representative even said that awards were generally a percentage of what was asked for - so …)

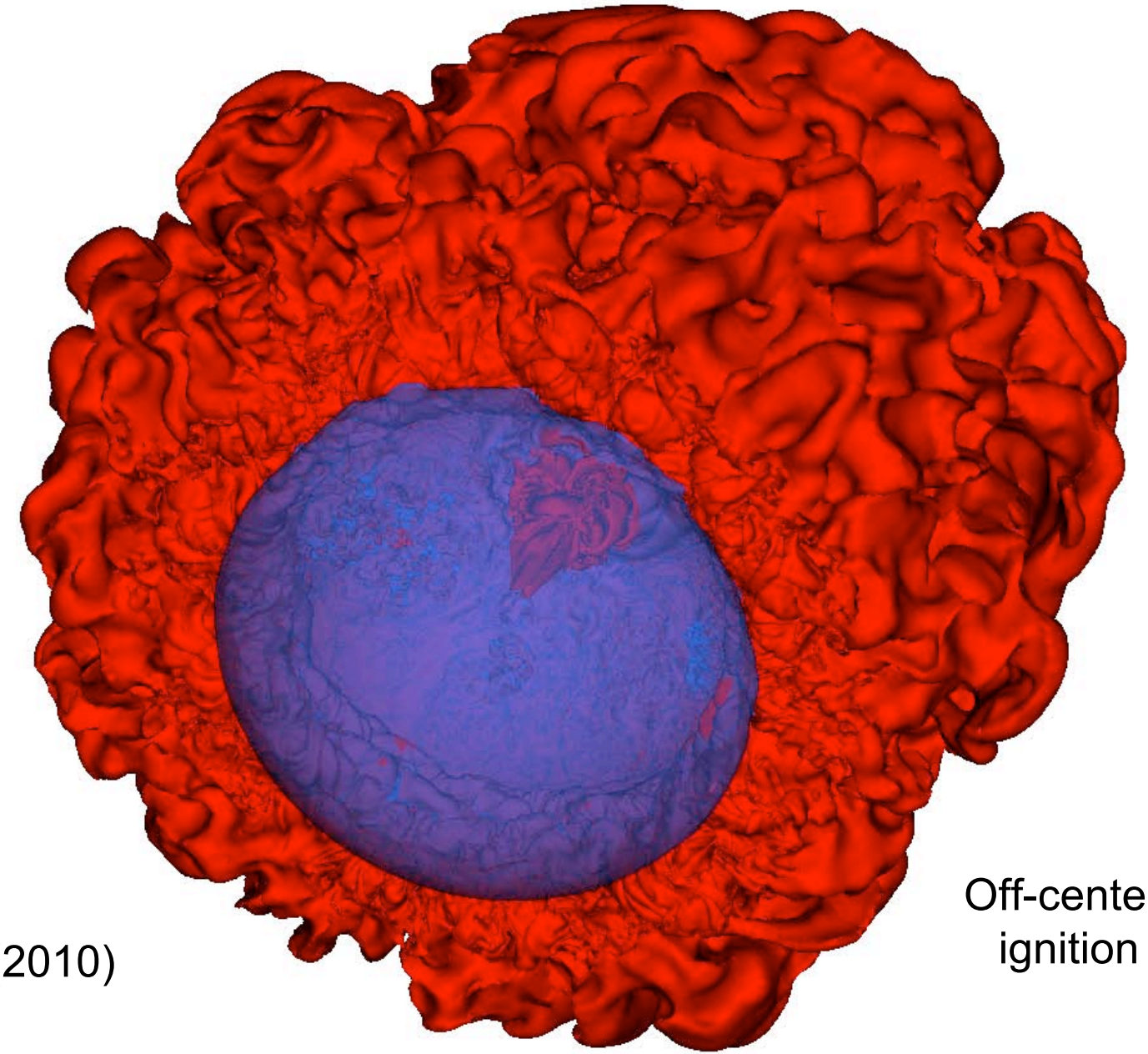
- Two proposals to NERSC requested 20 MCPU hr. 7.5 M granted in January, 2010. 5M more in February, and 2.5 M more in April, 2010 (+ Hopper time later).
- Request substantial augmentation at ATLAS/LLNL - awarded the equivalent of 10 M hrs, but have so far having trouble using it
- Two INCITE proposals request 70 M each (SN Ia and core-collapse). Total funding awarded 5 M. Bummer.
- Blue Waters proposal - early access - 200 M hrs requested- pending
- ALCC proposal - 75 M hrs - pending
- New INCITE proposals due next month

SN Ia Ignition with MAESTRO



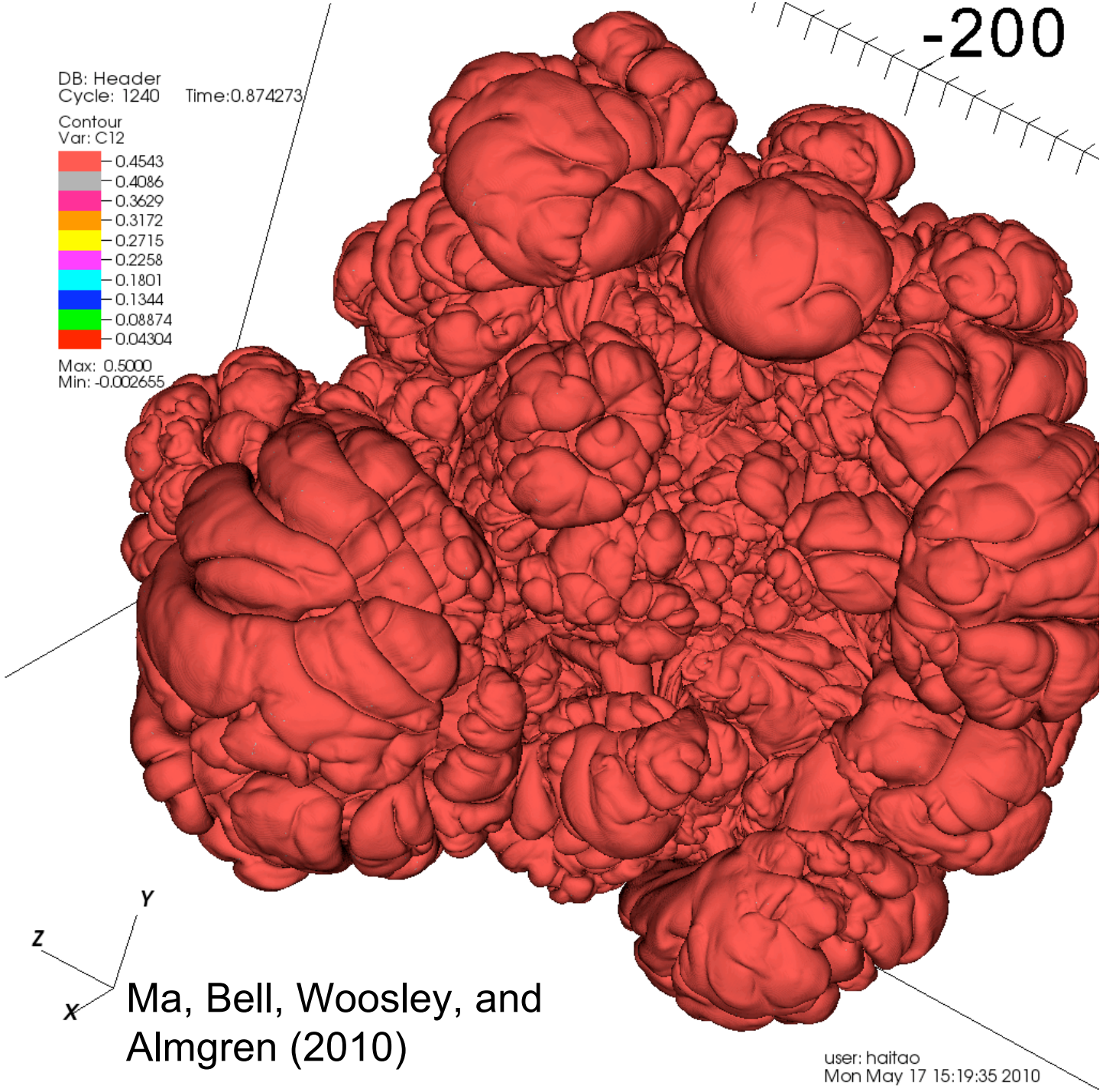
Zingale et al (2010)

SN Ia Full Star Explosions with CASTRO



Ma et al (2010)

Off-center ignition



Central ignition

Ma, Bell, Woosley, and Almgren (2010)

HIGH PRIORITY PLANS FOR THE NEXT YEAR

- Complete the development of CASTRO as a SN Ia code - level set, subgrid turbulence model, detonation physics

- Complete exploratory studies with CASTRO, of full star SN Ia models ignited both centrally and off-center

- Further studies in 3D at higher resolution of SN Ia ignition using MAESTRO

- Complete first generation neutrino transport in CASTRO.
  A realistic 3D calculation of a 15 solar mass core-collapse supernova (without magnetic fields and rotation)

- Spectra and light curves of all models with SEDONA; complete 3D survey with (or without) MPA.

- Respond to new funding and CPU opportunities. Prepare successful INCITE proposal.

OTHER GOALS FOR THE NEXT YEAR

- SN Ia small scale flame studies. Detonation transition physics
- Pair-instability supernovae with CASTRO. SN mixing with CASTRO
- Massive star convection study, with and without rotation, using MAESTRO
- A GR MHD simulation of core collapse using COSMOS++
- Apply spectral synthesis and matching code SYNAPPS to 150 time series for observed spectra and SEDONA models
- Time-dependent spectropolarimetry for several 3D models on > 10,000 CPU
- Develop nucleosynthetic post-processing ability
- Greater interaction with VACET - data analysis and visualization

OTHER GOALS FOR 1 to 2+ YEARS

- Radiation (i.e., photons) transport in CASTRO. Shock break out
- Implement GR, SR and MHD in CASTRO. Study rotating magnetic supernovae and GRBs
- Couple Monte Carlo to hydro in CASTRO
- Increased coordination with supernova mission planners and observers
- Depending on available funding, make CASTRO and MAESTRO public codes
- Study other models for SN Ia besides the standard Chndrasekhar Mass Model
- Surveys of core-collapse supernovae with various masses, rotation rates, metallicities, etc.

SciDAC 3 ??

Plans for 2011

HEP is in discussion with NP and NNSA concerning the possibility of extending the SciDAC II CAC project for a sixth year.

The offices are in the process of finalizing FY11 budgets and there is no final decision as yet.Procedurally, such an extension would require a proposal from CAC outlining the activities for that year.

Planning for the next SciDAC competition is in progress with discussions and meetings scheduled.

Plans for closing out SciDAC II

We anticipate needing final reports to close out the grants.

We are planning no future reviews at this time.