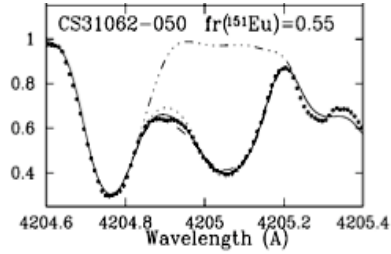
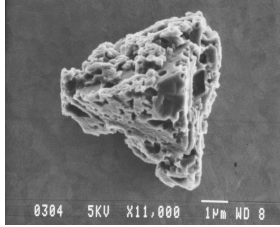


Why NUGRID?

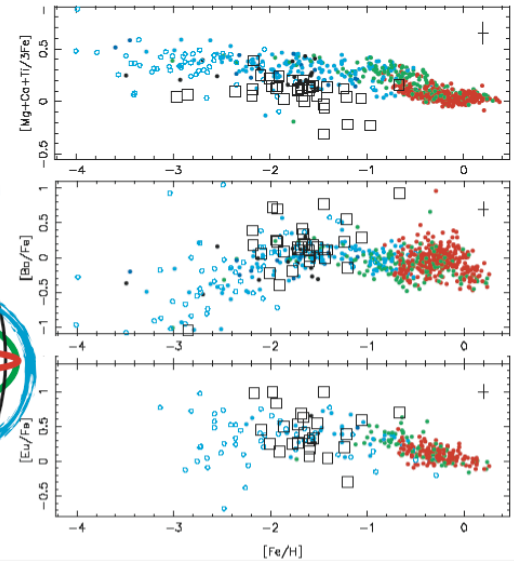
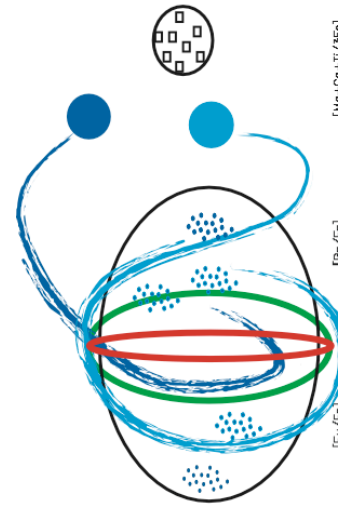
- Fundamentally improve our understanding of the physics for the origin of the elements in order to address a wide range of astronomical problems.

• For example:

pre-solar grains

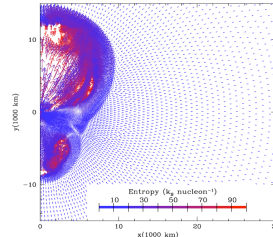
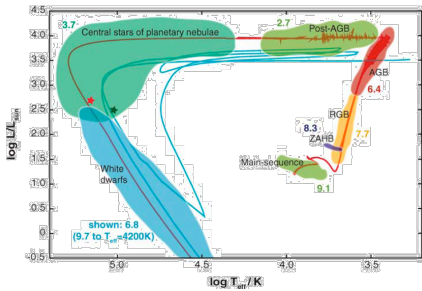


Stellar explosions

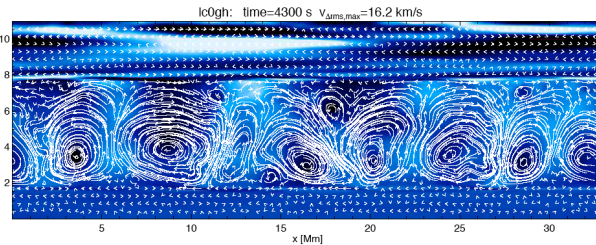


Near-field cosmology

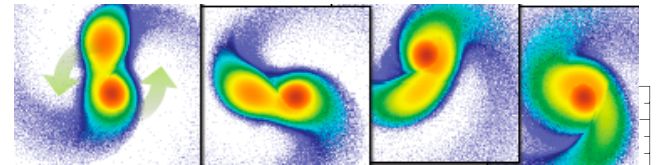
Stellar evolution



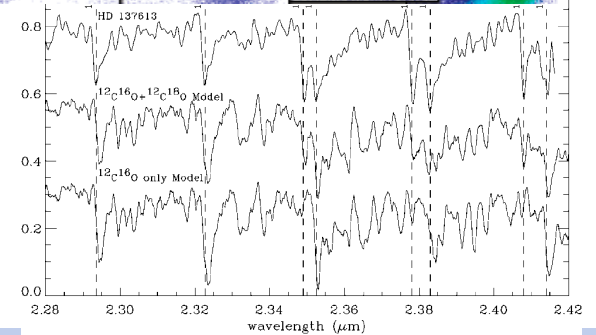
Stellar hydrodynamics



DD merger



Observations



Why NuGrid?

- Create a framework that allows to process large, internally consistent and comprehensive yield sets:
 - ♦ include low-mass and massive stars
 - ♦ include all possible nuclear processes
 - ♦ (eventually, include explosive yields)
- facilitate easy and routine production of large sets of observables that allow simultaneous validation of stellar physics in a wide range of situations
- detach (as far as possible) stellar evolution and explosion (SEE library) business from nucleosynthesis business (PPN - post-processing network code suite)

The **NUGRID** (Nucleosynthesis Grid) collaboration has three goals:

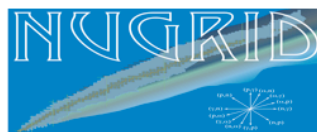
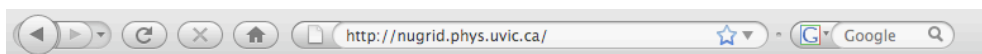
1. Develop and maintain a new code that can compute the nucleosynthesis in all nuclear production regimes: PPN code suite
2. Create an up-to-date library of stellar evolution and explosion simulation data.
3. Apply the PPN code to SEE library to generate a comprehensive yield set.

Marco Pignatari

Gabriel Rockefeller



<http://nugrid.phys.uvic.ca>



[Introduction](#)
[The NuGrid Web Page](#)
[The NuGrid SEE library](#)
[The NuGrid mailing lists](#)
[Links related to the NuGrid collaboration](#)

Michael Bennett



Introduction

The NuGrid collaboration works on Computational Nuclear Astrophysics and Stellar Physics to characterize the Origin of the Elements for a wide range of conditions.

The NuGrid Web Page

Please visit the [NuGrid web site](#), which is a wiki-like Plone page. We use it for our regular collaborative exchange. The internal pages require login password. But there is already some public information.

The NuGrid SEE library

We are in the process of building up the NuGrid stellar evolution and explosion [SEE library](#). The library already contains a large number of low-mass and massive stellar evolution tracks. Since we are still in the process of working on the publication the library is still password protected. However, please contact us if you would like to have pre-release access to the library.

The NuGrid mailing lists

We have two mailing lists:

- [NuGrid list](#): please sign up to this list. It is meant to inform anyone interested about the progress and development of the NuGrid project. You will receive the occasional message about new data releases, releases of public codes, etc. We will at some point make the archive publicly available. So, we hope that over time this will develop into a great place to ask questions, and search for answers.
- [NuGrid-team list](#): This is a list only for internal collaboration use.

Links related to the NuGrid collaboration

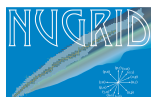
- [Joint Institute for Nuclear Astrophysics - an NSF Physics Frontier Center](#)
- [MESA stellar evolution and MESA plone](#)
- [LCSE at the University of Minnesota](#)
- [Raphael Hirschi's home page and his group](#)
- [Claudia Travaglio and B²FH in Italy](#)
- [Frank Timmes' cococubed](#)
- [Falk Herwig's web page](#)
- [NuGrid on ADS](#)

NuGrid Collaboration, Last update: Sat Nov 21 11:55:57 PST 2009, [Back to NuGrid web page](#)

2009: Claudia Travaglio, Aaron Dotter, Aaron Courture

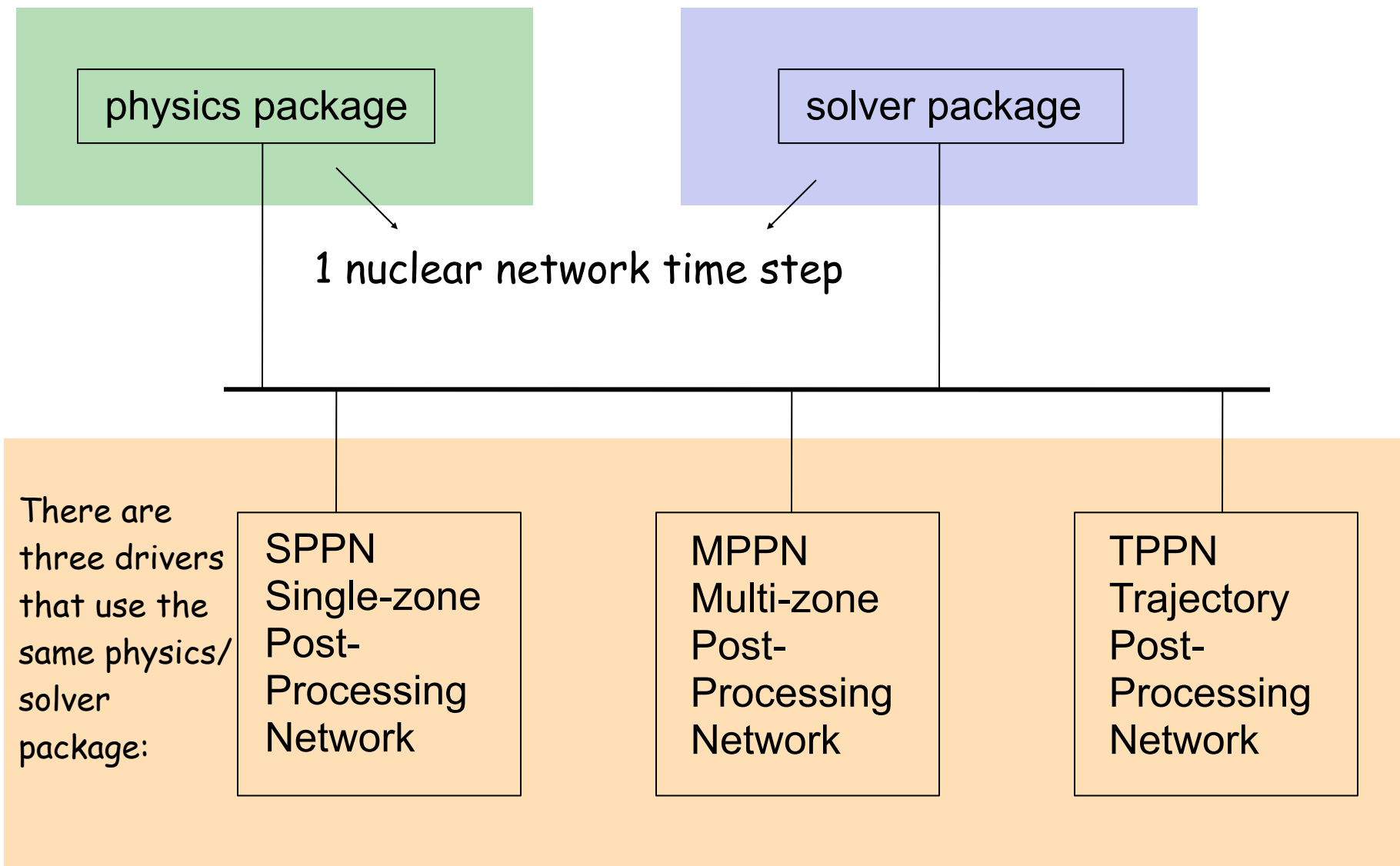


University of Victoria



Friday, April 30, 2010

The PPN code suite



Drivers:

- SPPN: single zones, trajectories, analytic prescriptions

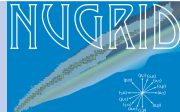
- TPPN (->BMPPN):
TBD

MPPNP (multi-zone PPN)

- MPI-parallel (typical runs on 50-80 procs)
- USEEPP (Unified Stellar Evolution and Explosion Post-processing) IO hdf5 library
- grid options:
 - ✓ Static
 - ✓ Input
 - ✓ AMR
- Flexible restart and re-grid options (batch queuing system enabled)

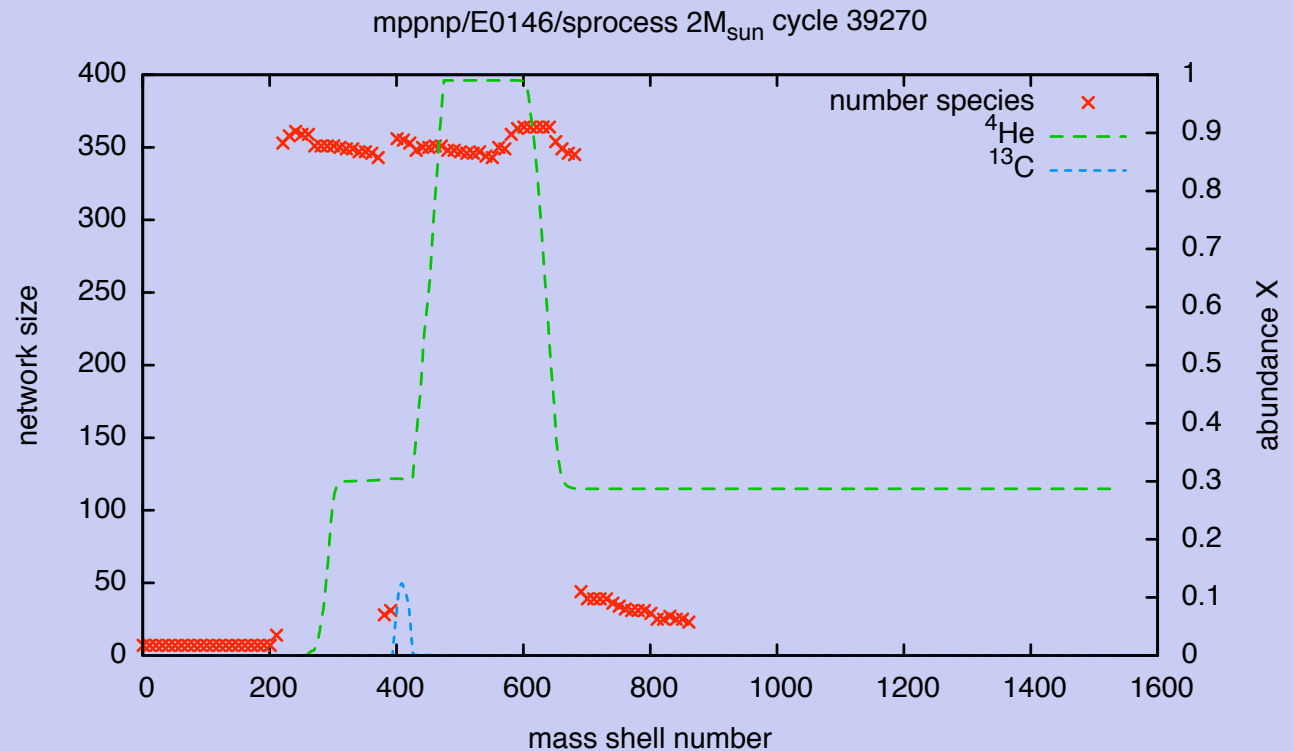
Physics package:

- < 5170 isotopes
 - Reaction rate libraries:
 - ✓ Basel reaclib
 - ✓ JINA reaclib
 - ✓ Dillmann et al. 2006 (Kadonis)
 - ✓ Angulo et al. 1999 (NACRE)
 - ✓ Iliadis et al. 2001
 - ✓ Caughlan & Fowler 1988
 - ✓ Aikawa et al. (BRUSLIB)
 - ✓ Oda et al. 1994.
 - ✓ Fuller & Fowler, 1985
 - NSE:
 - ✓ T-dependent partition function & mass excess (reaclib)
 - ✓ Coulomb screening (Calder et al. 2007)
 - Sandbox e.g. Luna N14(p,g), 3a Fynbo 2005, Kunz 2002 C12(a,g) etc
 - isomeric states framework Al26, Kr85, Sn115
- * NETGEN interface

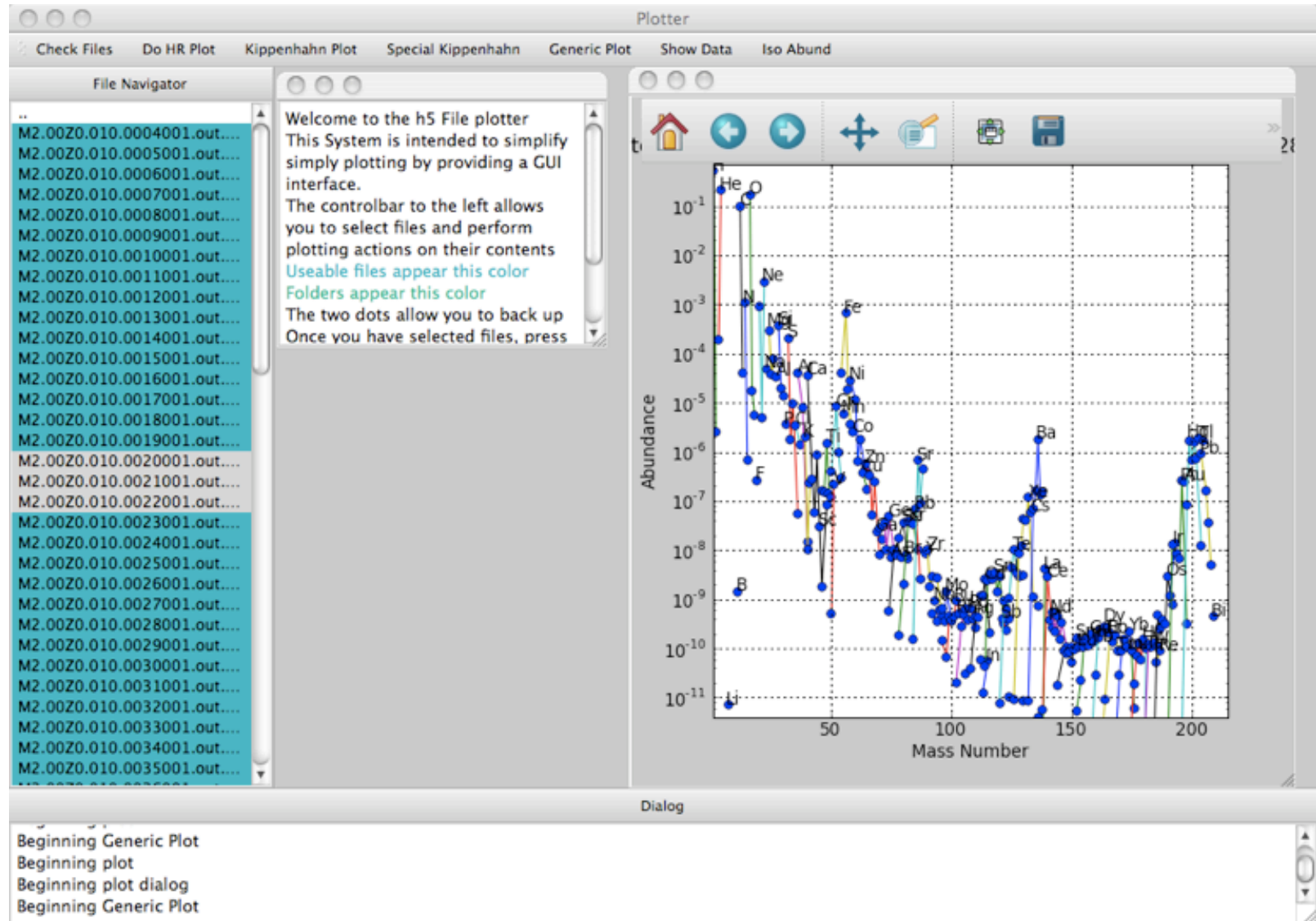


Solver package:

- Newton-Raphson, fully implicit
- Integrated dynamic network at iteration level
- Adaptive sub-time steps
- Sparse solver



SEexplorer: interactive data exploration and visualization



And the other useful things

- ★ svn, plone
- ★ python data analysis and plotting libraries
- ★ regression test system
- ★ documentation framework including the ~75 page Latex'd *NuGrid Book*
- ★ build system for wide range of platforms
- ★ regular telecons (1 per month)
- ★ annual collaboration meetings (thanks to JINA!)

Chapter 5

USEEPP: The Unified Stellar Evolution and Explosion Post-Processing library

Document name: useepp

SVN directory: <svn://forum.astro.keele.ac.uk/frames/utills/se/docs>

Contributors: GR,SD

Abstract: *USEEPP is the I/O library that the NuGrid project uses as the interface between the simulation of the thermodynamic and hydrodynamic conditions in the nuclear production site (or, in other words the output of stellar evolution or stellar explosion simulations that serve as the input for the post-processing) and the PPN code that does the nucleosynthesis post-processing. USEEPP will eventually also be used to write out PPN data and which can then be feed into a not-yet existing visualisation framework.*

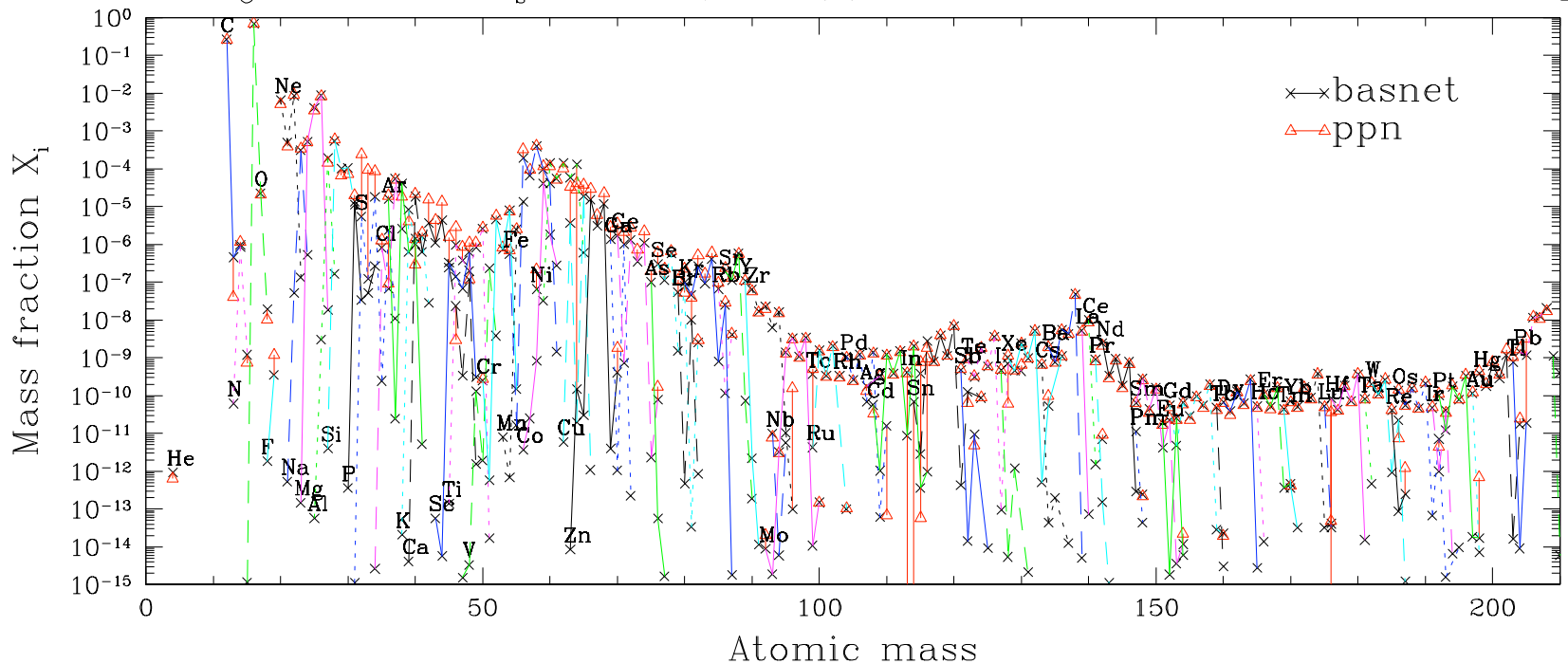
5.1 Introduction and Context

The NuGrid framework builds on two main tools, the SEE (Stellar Evolution and Explosion) database and the PPN (Post-Processing Network) codes. The SEE database contains the tracks of the Stellar Evolution and Explosion data. The PPN code performs nucleosynthesis post-processing on the data in the SEE library. We have introduced a new standard format to efficiently and accurately save stellar evolution data, the Unified Stellar Evolution and Explosion Post-Processing format, or short USEEPP. USEEPP builds on a package (the SE library) written by Steven Diehl and Gabriel Rockefeller

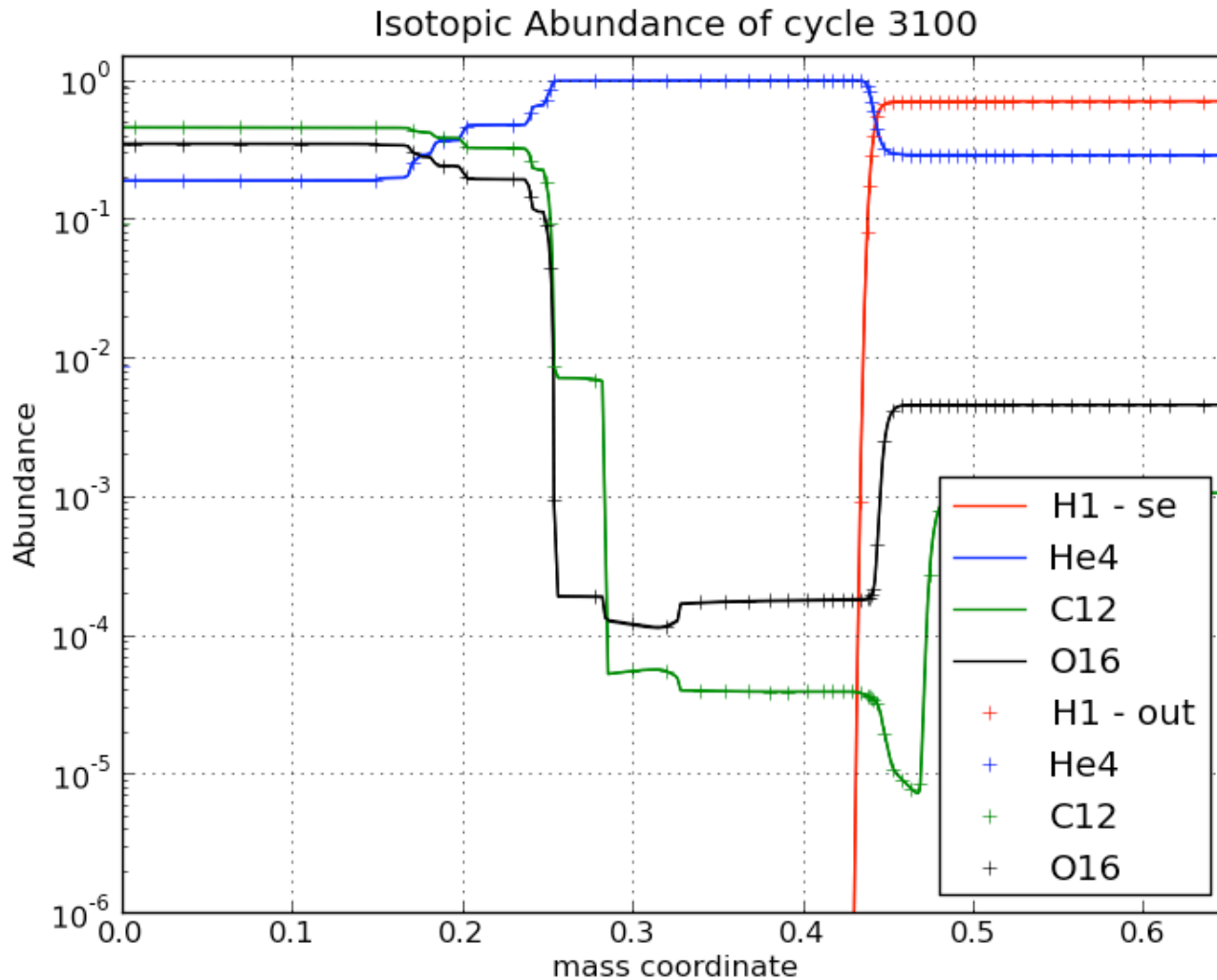
Code comparison:

- * basel network (Friedel Thielemann)
- * torch (Frank Timmes)
- * Gallino s-process code
- * various networks inside stellar evolution codes, incl. MESA nets, EVOL, Geneva code

25 M_{\odot} , $Z=2 \cdot 10^{-2}$, $v_s=000$ km/s, $m(r)=$ mixed, end of central He burning



Does the post-processing work?



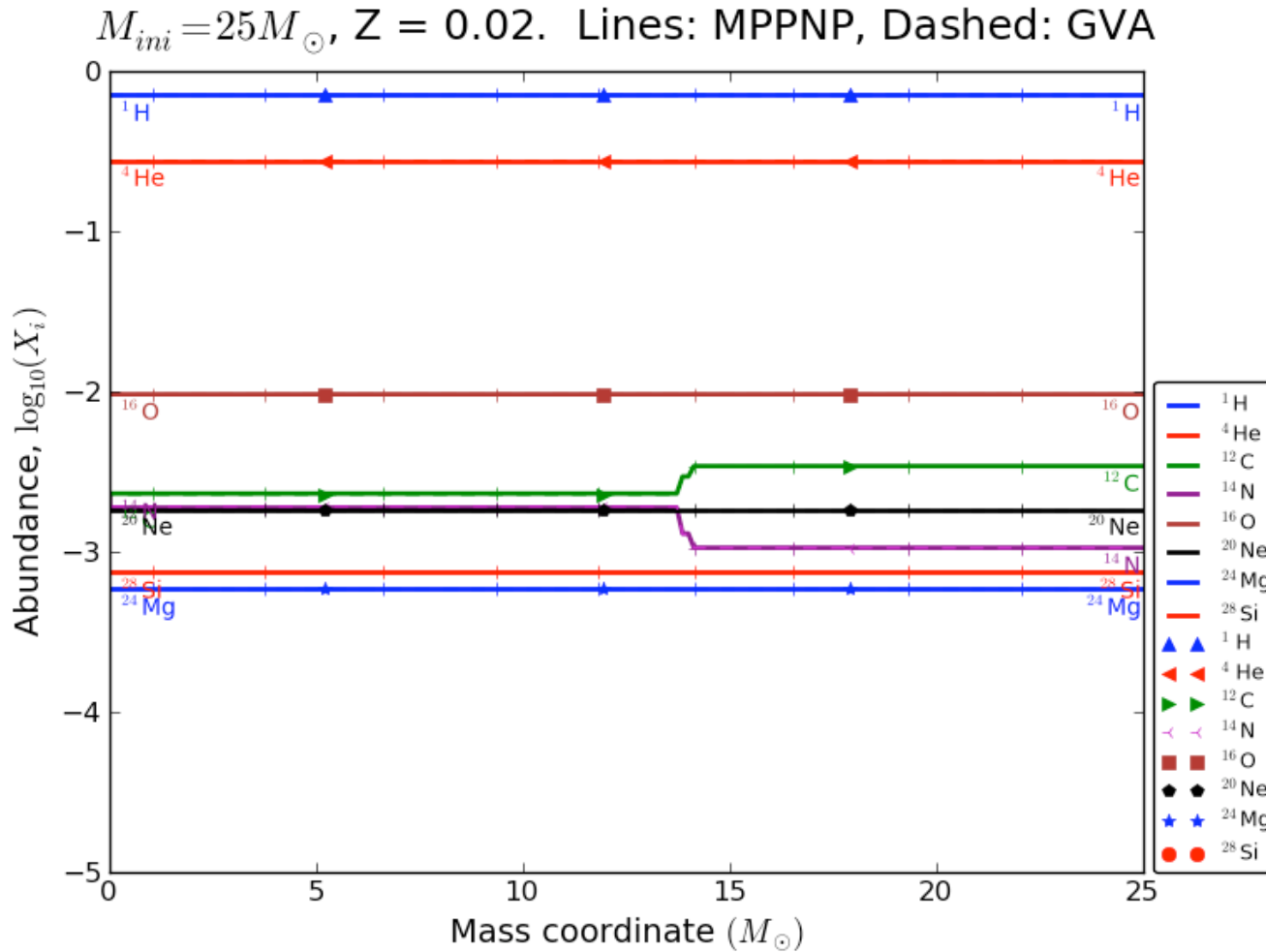
$2M_{\text{sun}}$ He-core
burning to TP-
AGB:

se: EVOL
stellar
evolution code

out: mppnp
post-
processing

YES!

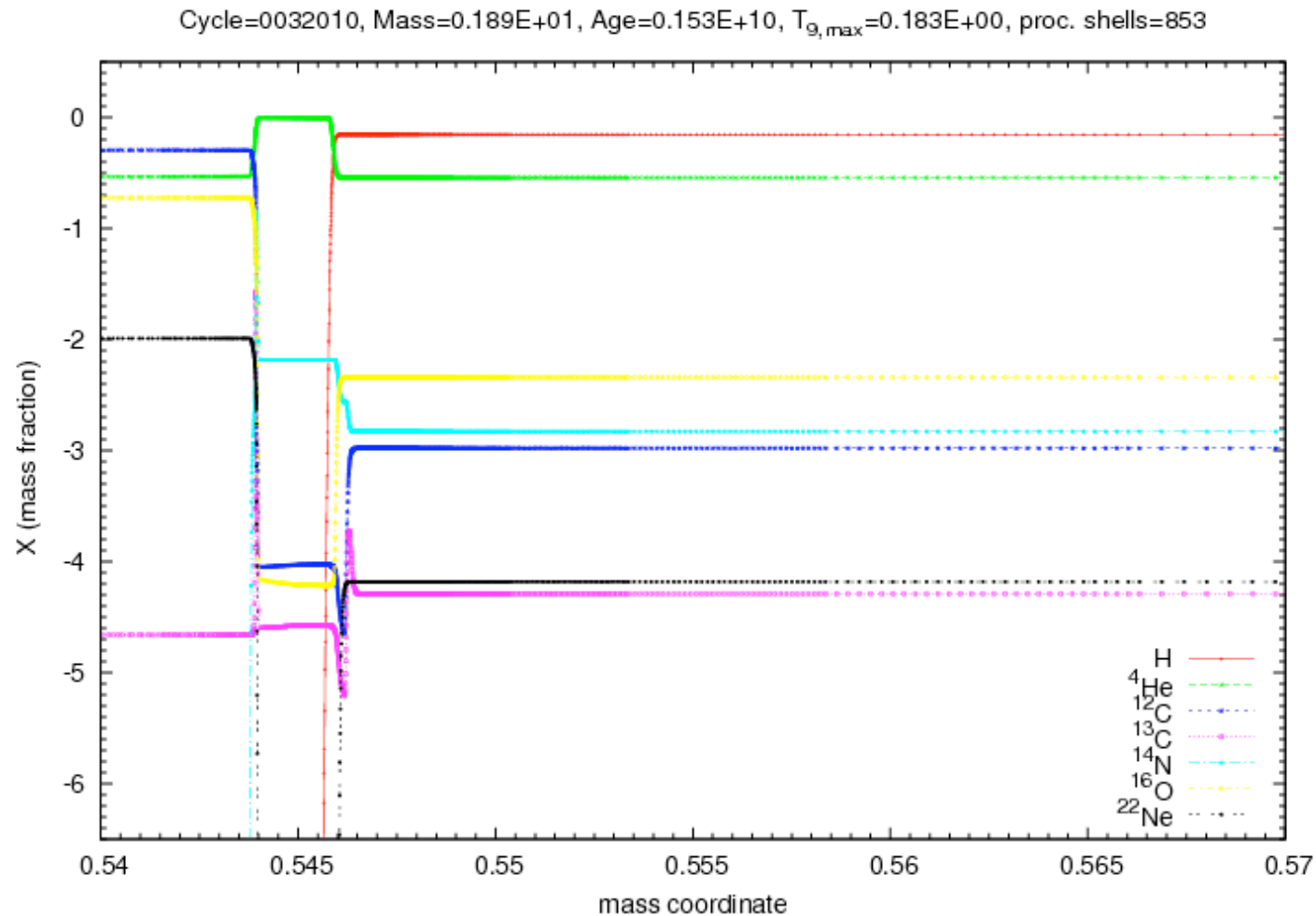
Does the post-processing work?



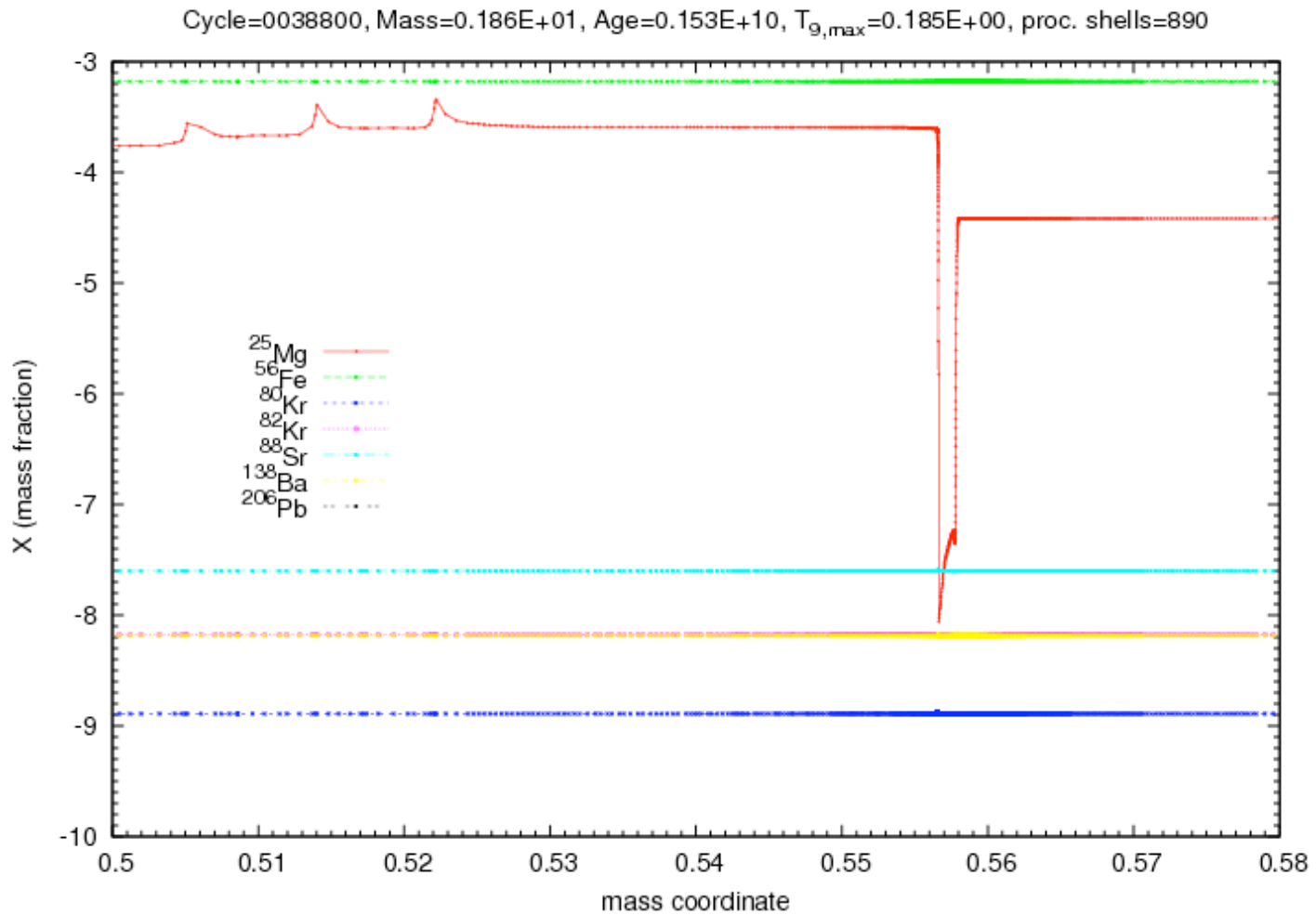
25 M_{sun}
main-
sequence to O
burning

Geneva code
vs. mppnp

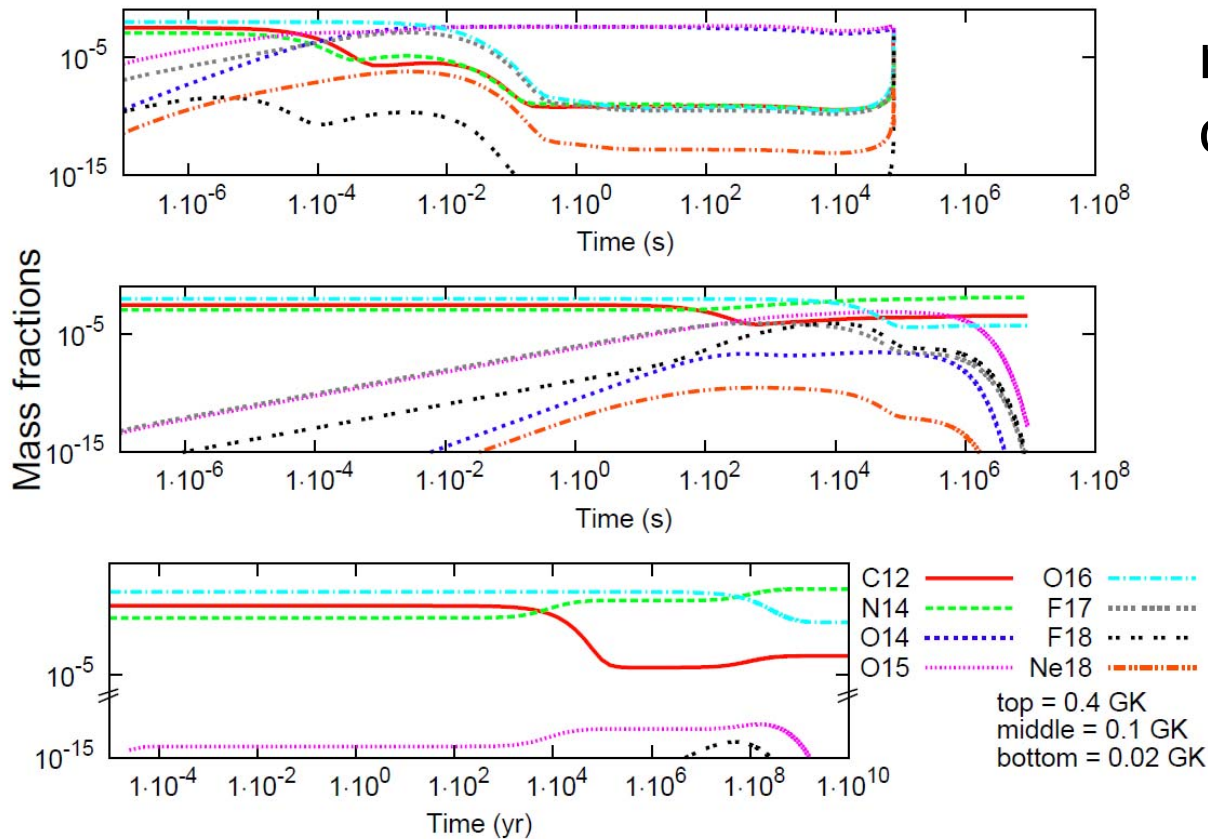
Applications: 2Msun star - light elements



Applications: 2Msun star - heavy elements



Applications: H-burning



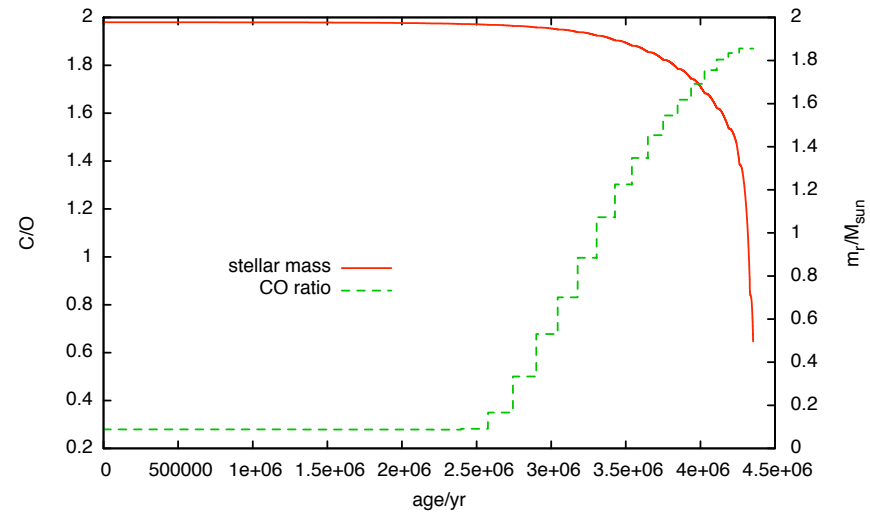
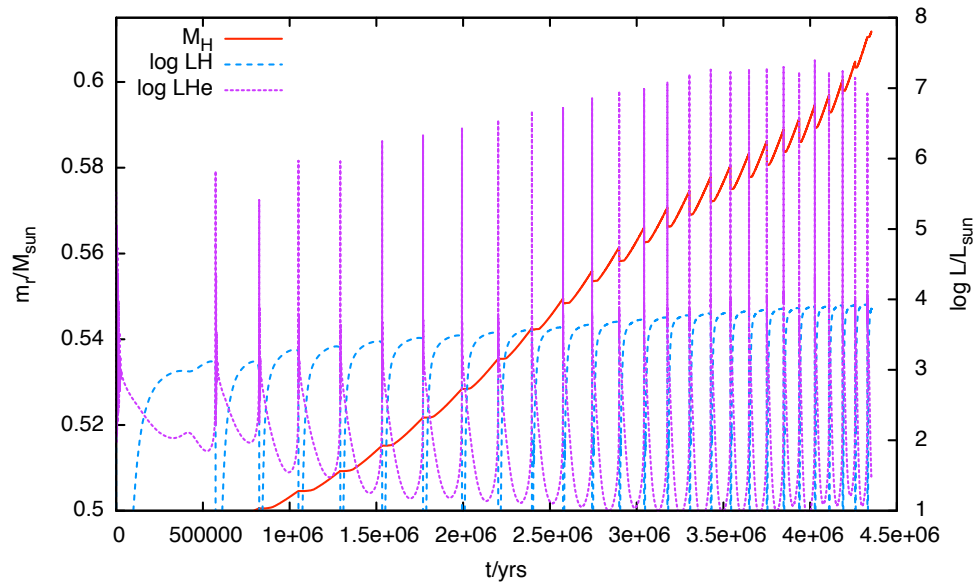
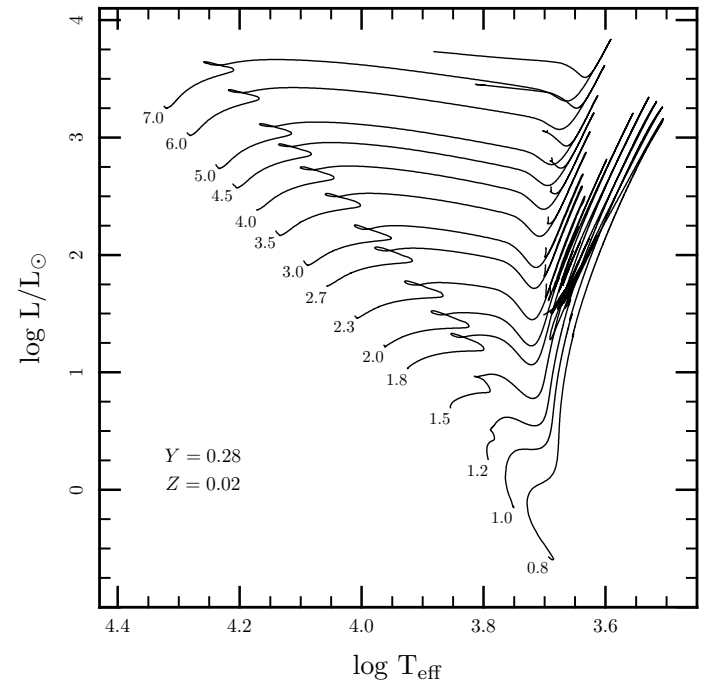
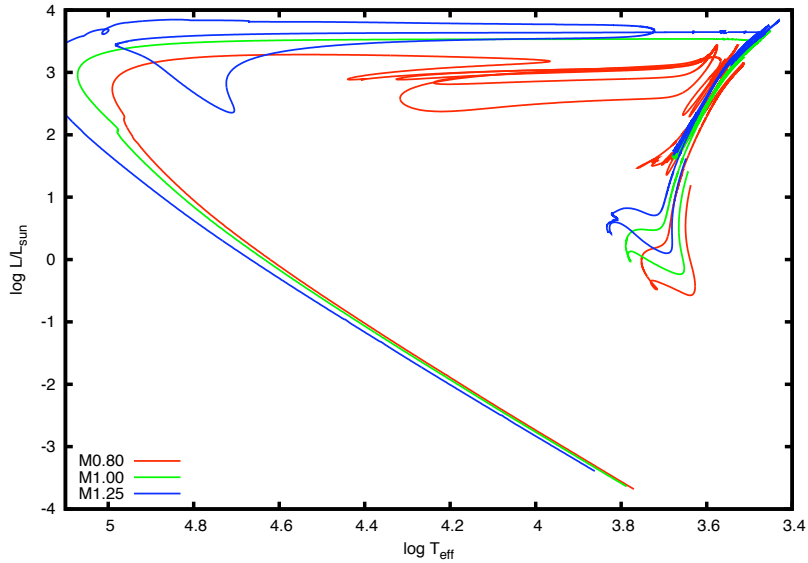
nova X-ray burst conditions

AGB shell burning

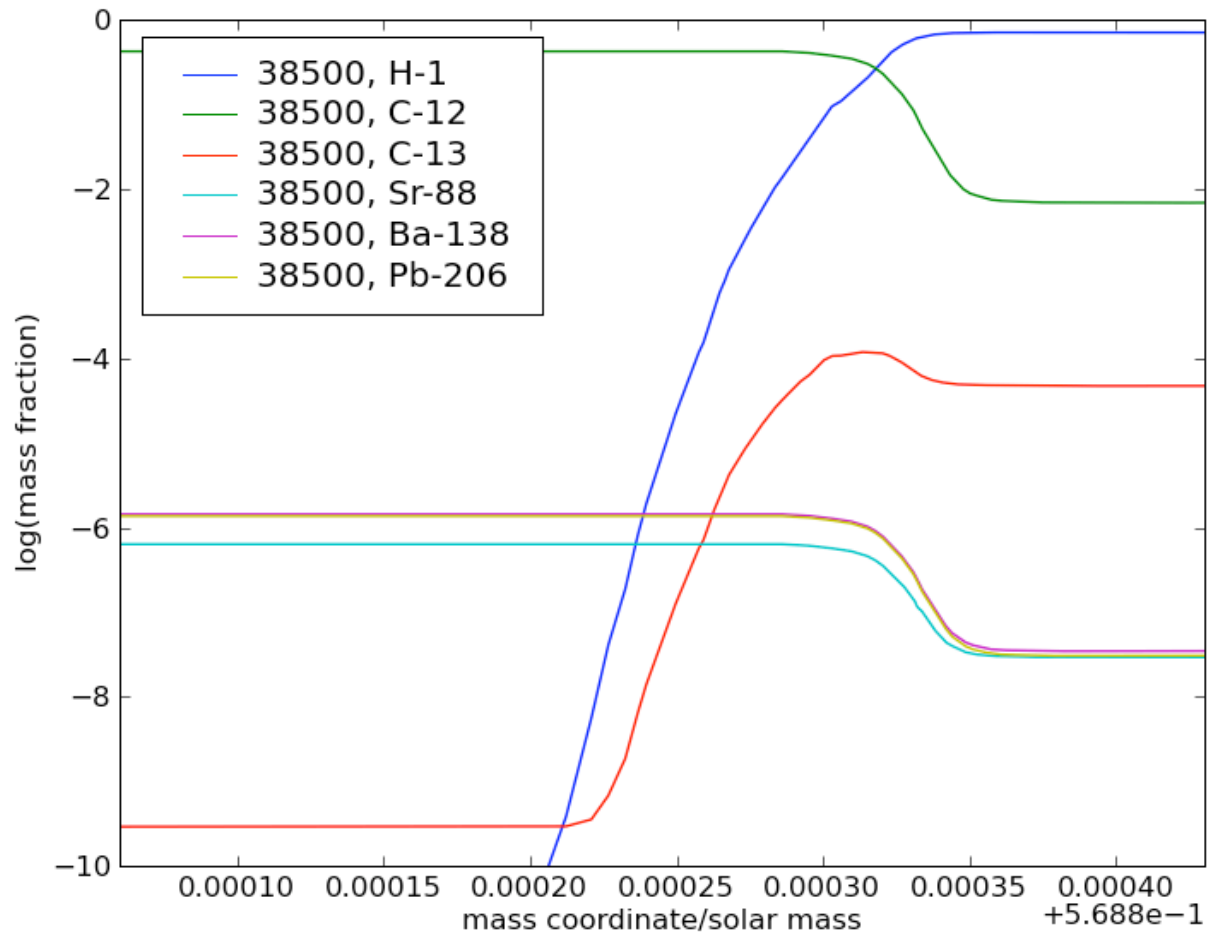
low-mass MS

Wiescher etal 2010

MESA stellar evolution



Applications: MESA post-processing, e.g. the C13-pocket



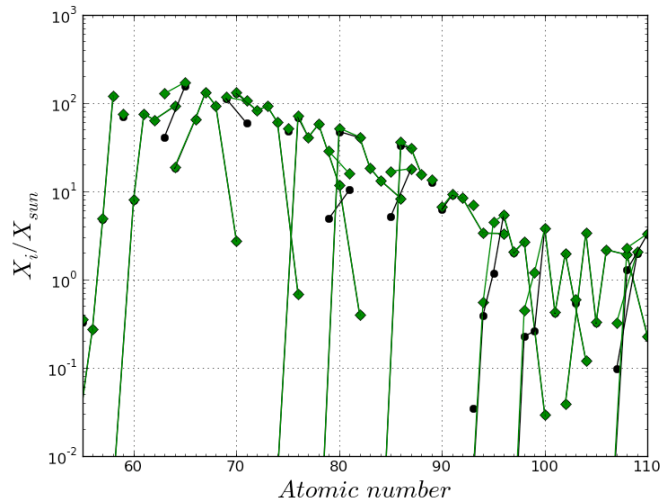
Science projects:

1. Comprehensive wind yield sets (this summer $Z=0.02, 0.01$)
2. Combustion nucleosynthesis in post-AGB flashers (ApJ subm., [arXiv:1002.2241](https://arxiv.org/abs/1002.2241))
3. C12+C12 (conf proc, [arXiv:1002.2788](https://arxiv.org/abs/1002.2788))
4. explosive He-shell burning

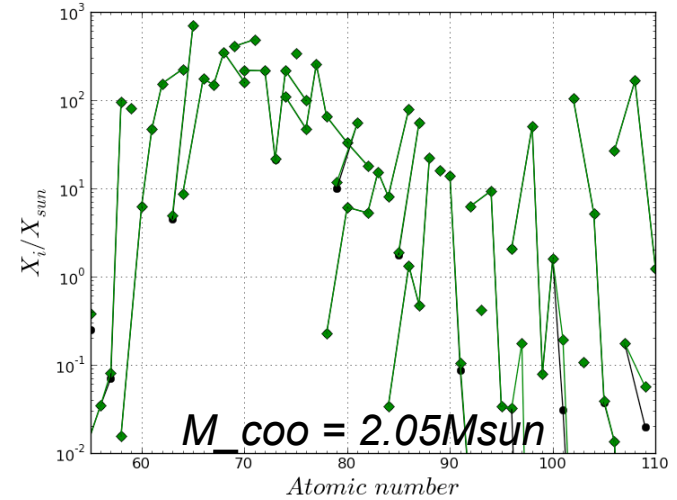
Stellar material processed by shock wave during SN explosion (temperature and density profile, e.g., Thielemann et al. 1996, 1979)

Marco Pignatari

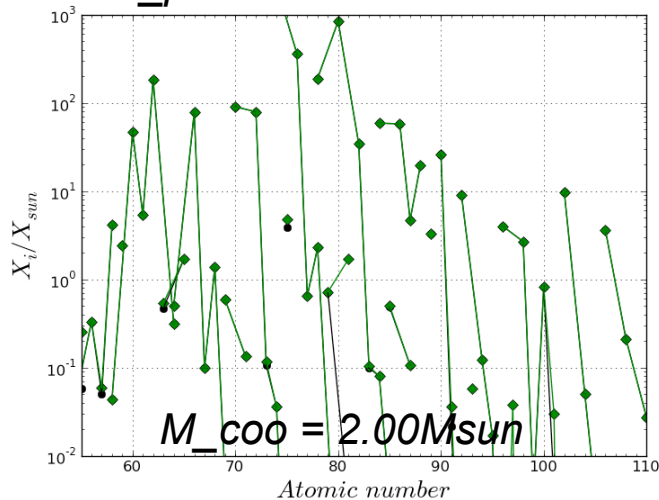
s-process seeds



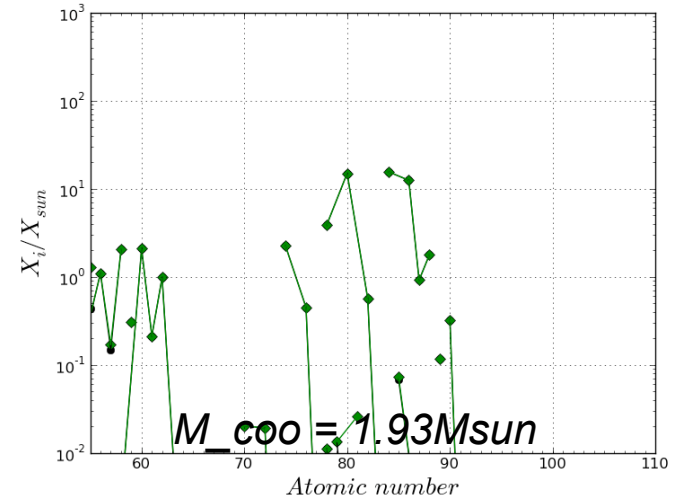
$T9_{peak} = 2.76$ $\rho_{05} = 4.82$



$T9_{peak} = 3.11$ $\rho_{05} = 6.64$



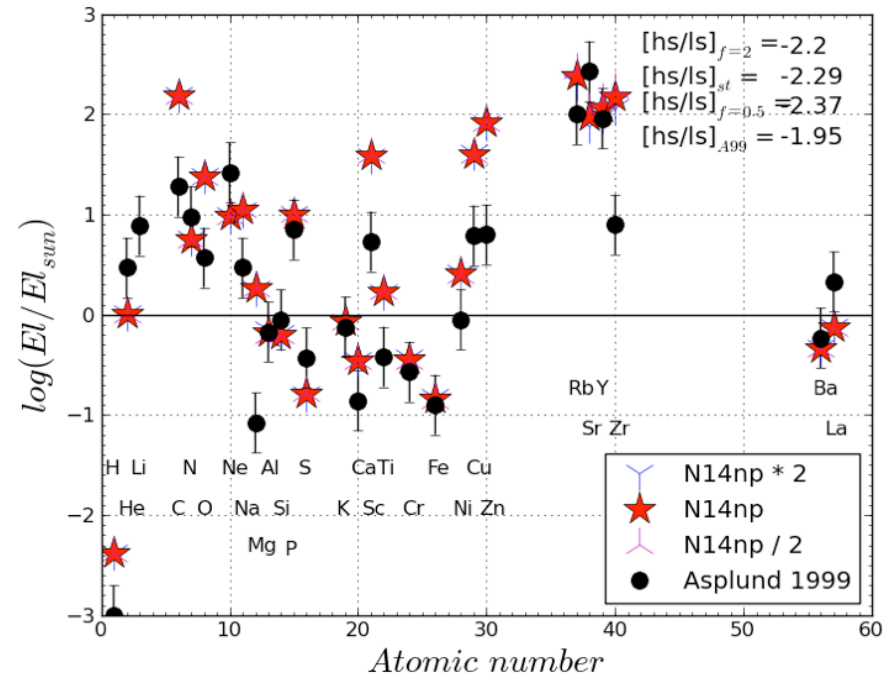
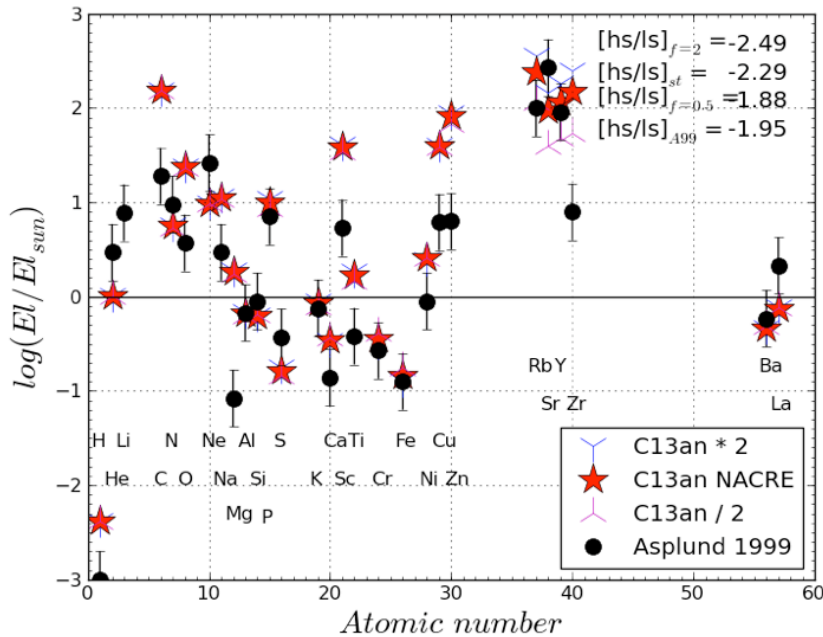
$T9_{peak} = 3.45$ $\rho_{05} = 7.85$



Temperature and density peaks for a given mass coordinate is given by Rapp et al. 2002

Science projects:

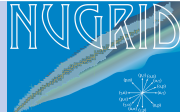
1. Comprehensive wind yield sets
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3. C12+C12 (conf proc, [arXiv:1002.2788](https://arxiv.org/abs/1002.2788))
4. explosive He-shell burning
5. reaction rate uncertainty analysis for (1)



Concluding remarks

NuGrid tool:

- ★ validate stellar physics processes
- ★ provide data needs of GCE models
- ★ connect astro nuclear physics to nuclear astrophysics
- ★ astro nuclear physics experiment support
- ★ tool box for experiments in nucleosynthesis
- ★ outreach potential
- ◆ (not yet) open source but open collaboration



Concluding remarks

Outlook:

- ★ explosive nucleosynthesis to complement the wind yields (Marco Pignatari, Frank Timmes, Claudia Travaglio, Chris Fryer)
- ★ adapt codes to hybrid architectures
- ★ enhance modularity to allow independent physics/ solver packages, improve integration with MESA
- ★ BGM driver