Electron Capture Supernovae
& Super-AGB Star Workshop
Monash University, February 2016

KEY ROLE OF SNIA & SNII FOR GALACTIC CHEMICAL EVOLUTION OF *P*-NUCLEI

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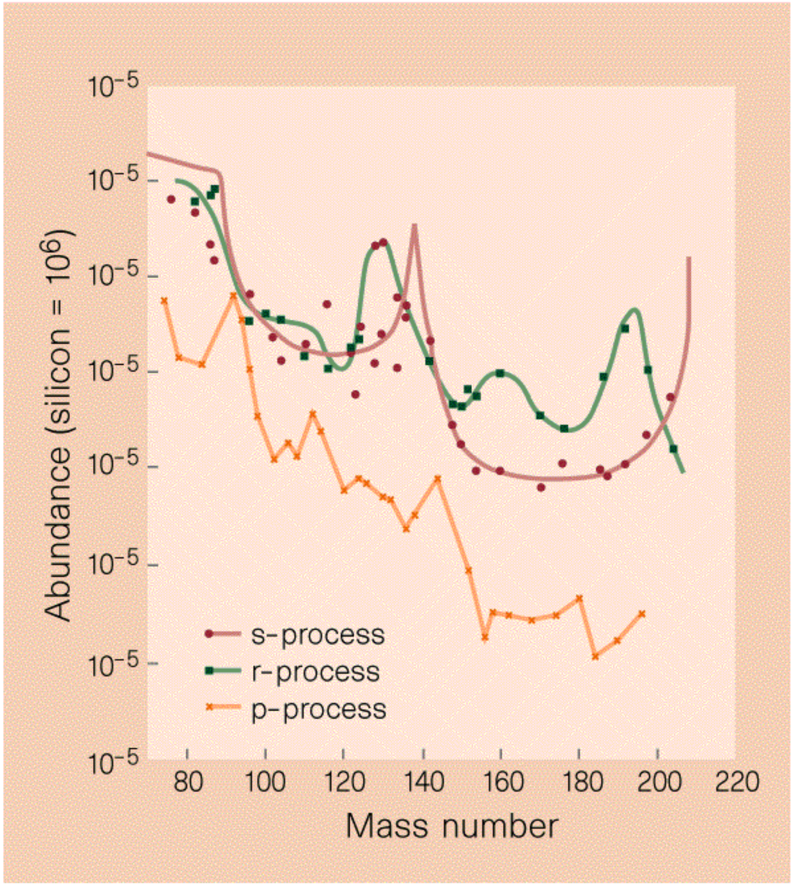
Bisterzo S.

Computer resources

B2FH Ricerca per l'Astrofisica Nucleare
WestGrid
GOETHE UNIVERSITÄT FRANKFURT AM MAIN

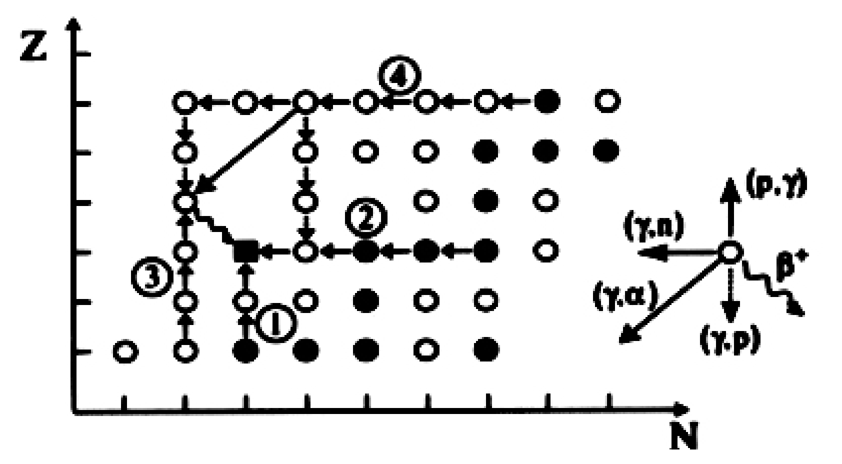


The solar abundances of the nuclides, as a function of mass number, showing the p-, s- and r-process contributions. Cameron 1998

“The first remarkable feature of the p-process is the scarcity of the efforts devoted to its understanding. Although about 50 years of nuclear astrophysics research, the number of articles devoted to their understanding remains inferior to the 35 nuclides tradionally classified as p-nuclides”

(Arnould & Goriely 2003)

γ-process



νp-process

(Wanajo et al. 2011; Arcones et al. 2012)

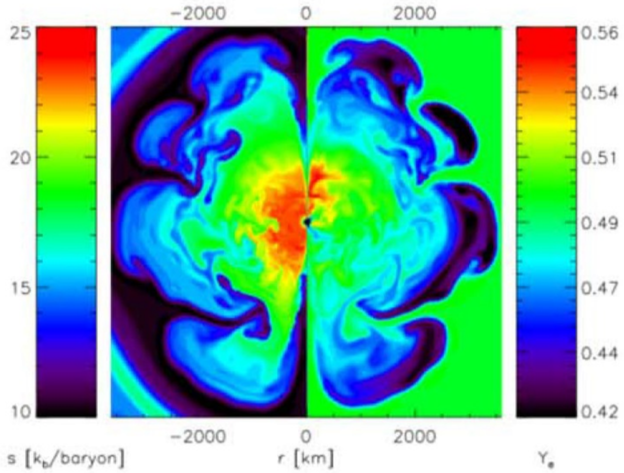


Figure 1. Snapshot of the convective region of the 2D simulation of an ECSN at 262 ms after core bounce with entropy per nucleon (s; left) and Y_e (right).

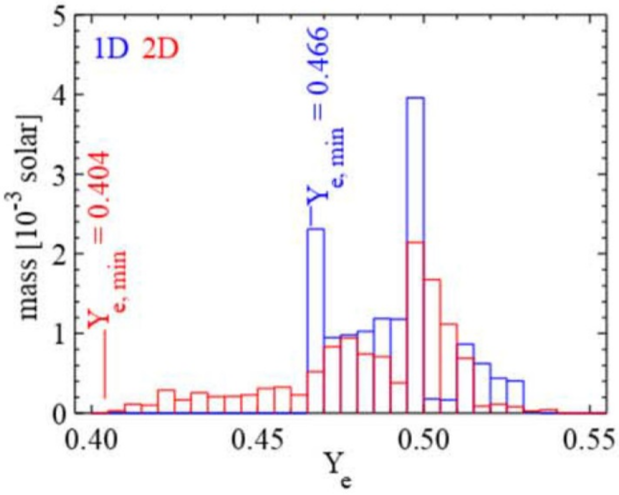
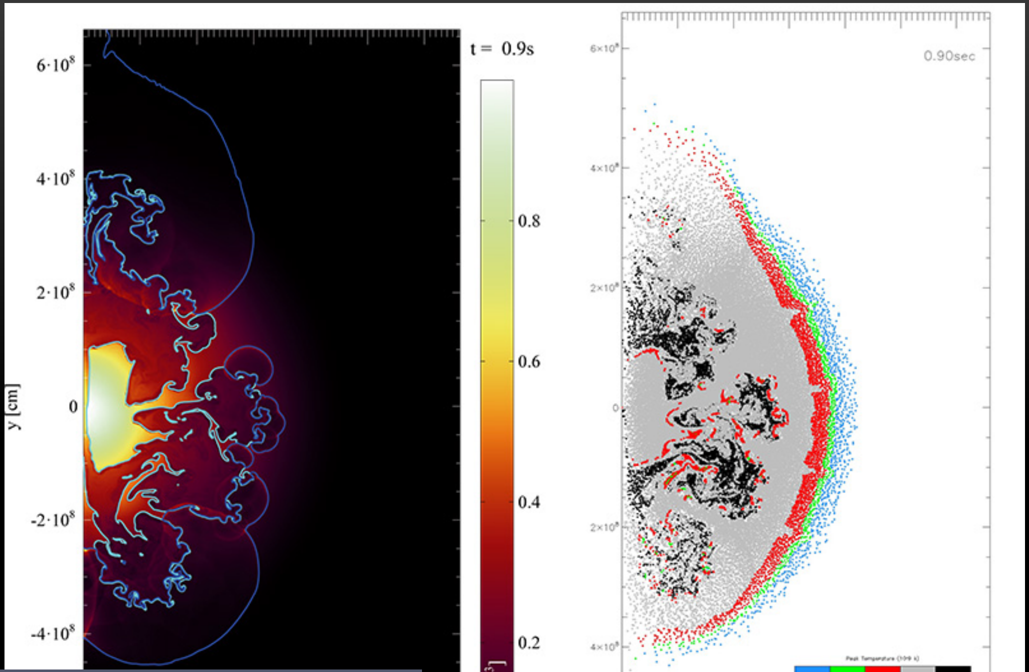


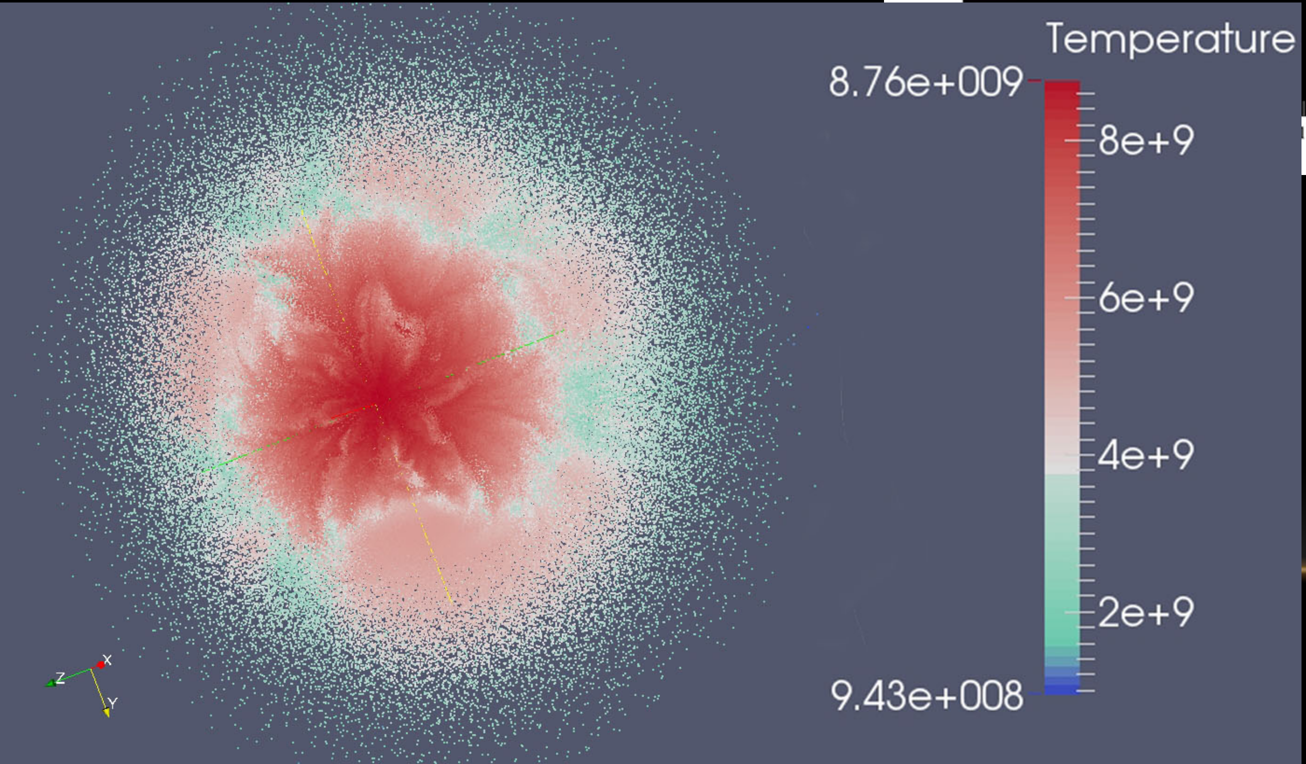
Figure 2. Ejecta masses vs. Y_e for the 1D (blue) and 2D (red) explosion models. The width of a Y_e-bin is chosen to be $\Delta Y_e = 0.005$.

- SNIa: the role of ɣ-process in multi-D (comparison between 2D and 3D)
- SNII+ECSN: the role of ɣ-process and what is predicted by νp-process
- Interplay of different sources in galactic chemical evolution

2D model DDT-a, 51200 tracers

(Travaglio et al. 2011)



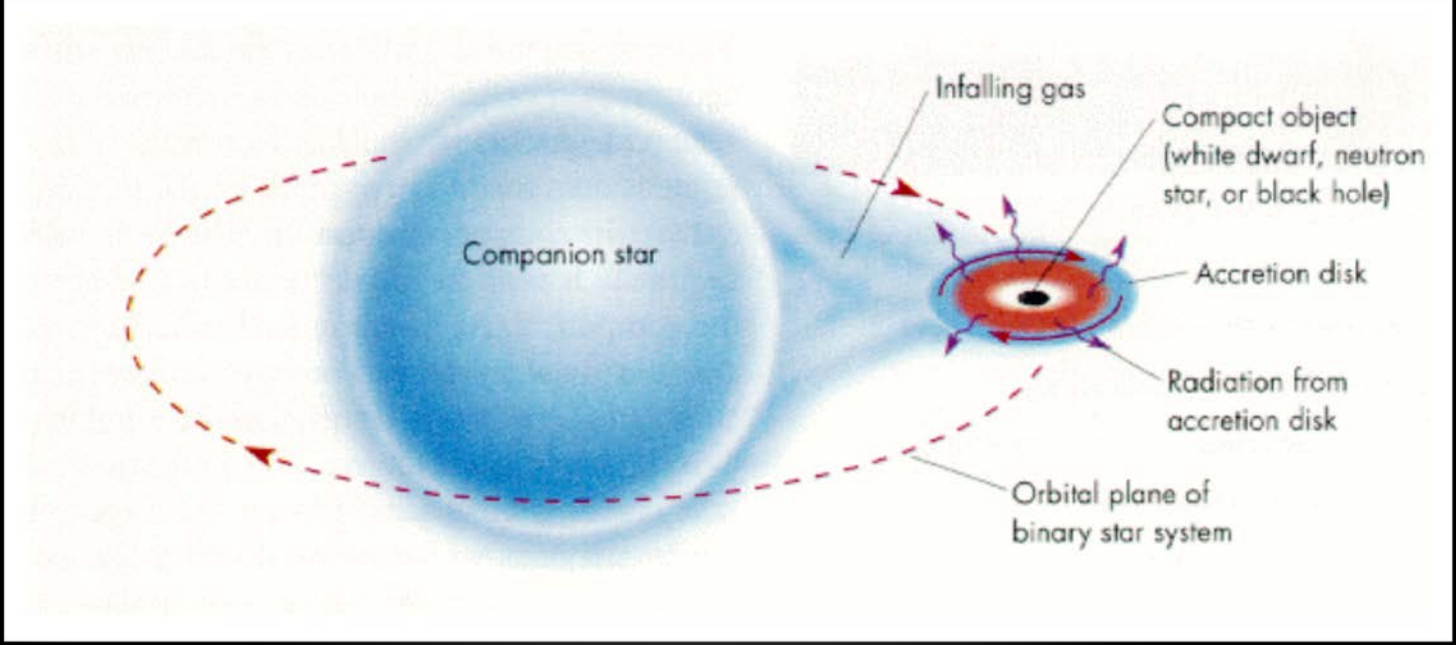


3D N100, 1 million tracers

(Seitenzahl et al. 2013)

s-process nucleosynthesis during accretion phase

“Accreting white dwarfs as an alternate or additional source of s-process isotopes” (Iben, ApJ 243, 1981)



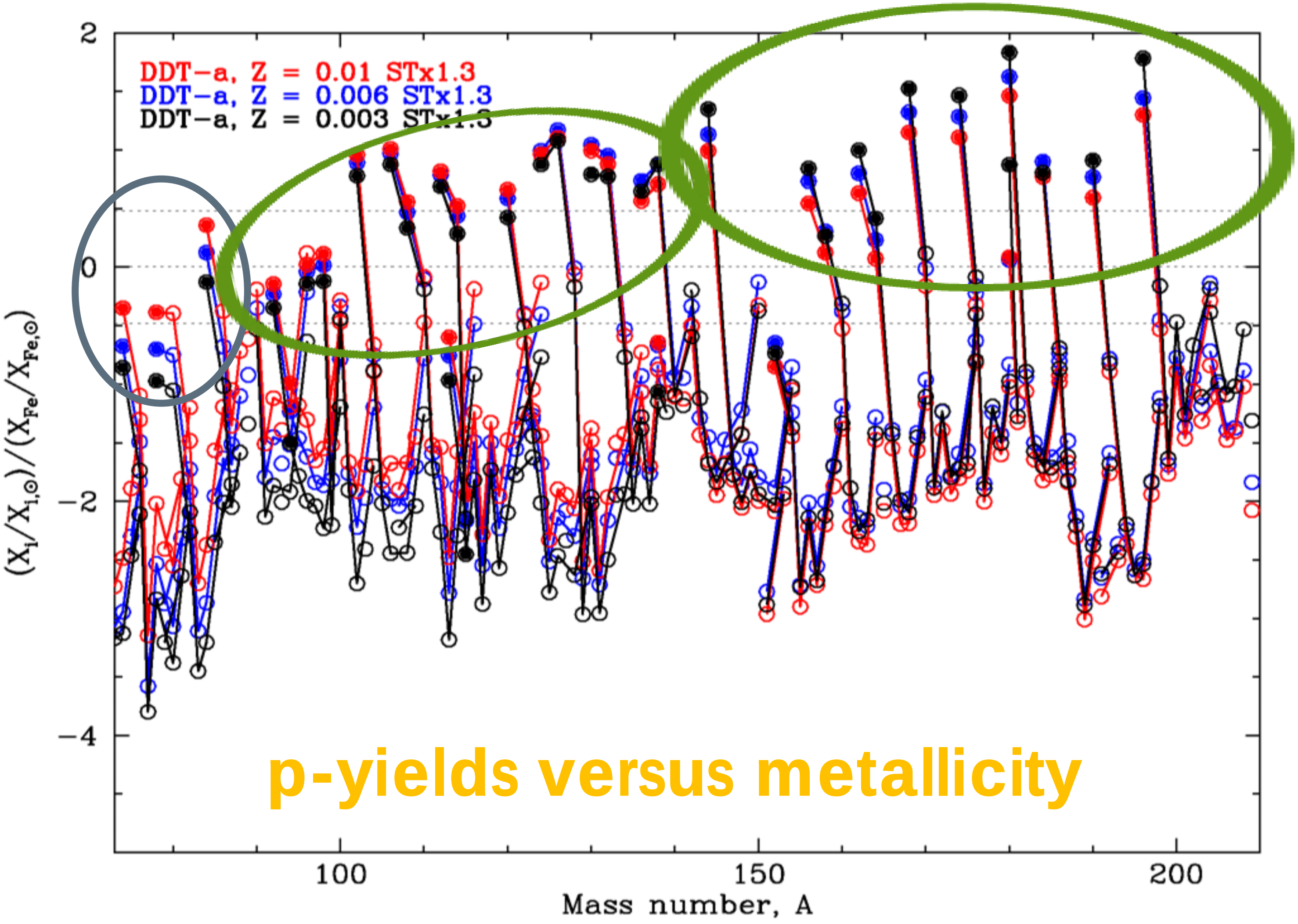
^{113}In, ^{115}Sn are p-only isotopes?
r-process contribution
(Dillmann et al. 2008, Nemeth et al. 1994)?

^{138}La produced by neutrino
(Woosley et al. 1990)

^{152}Gd has large s-process contribution
at solar composition
(Arlandini et al. 1999, Käppeler et al. 2011)

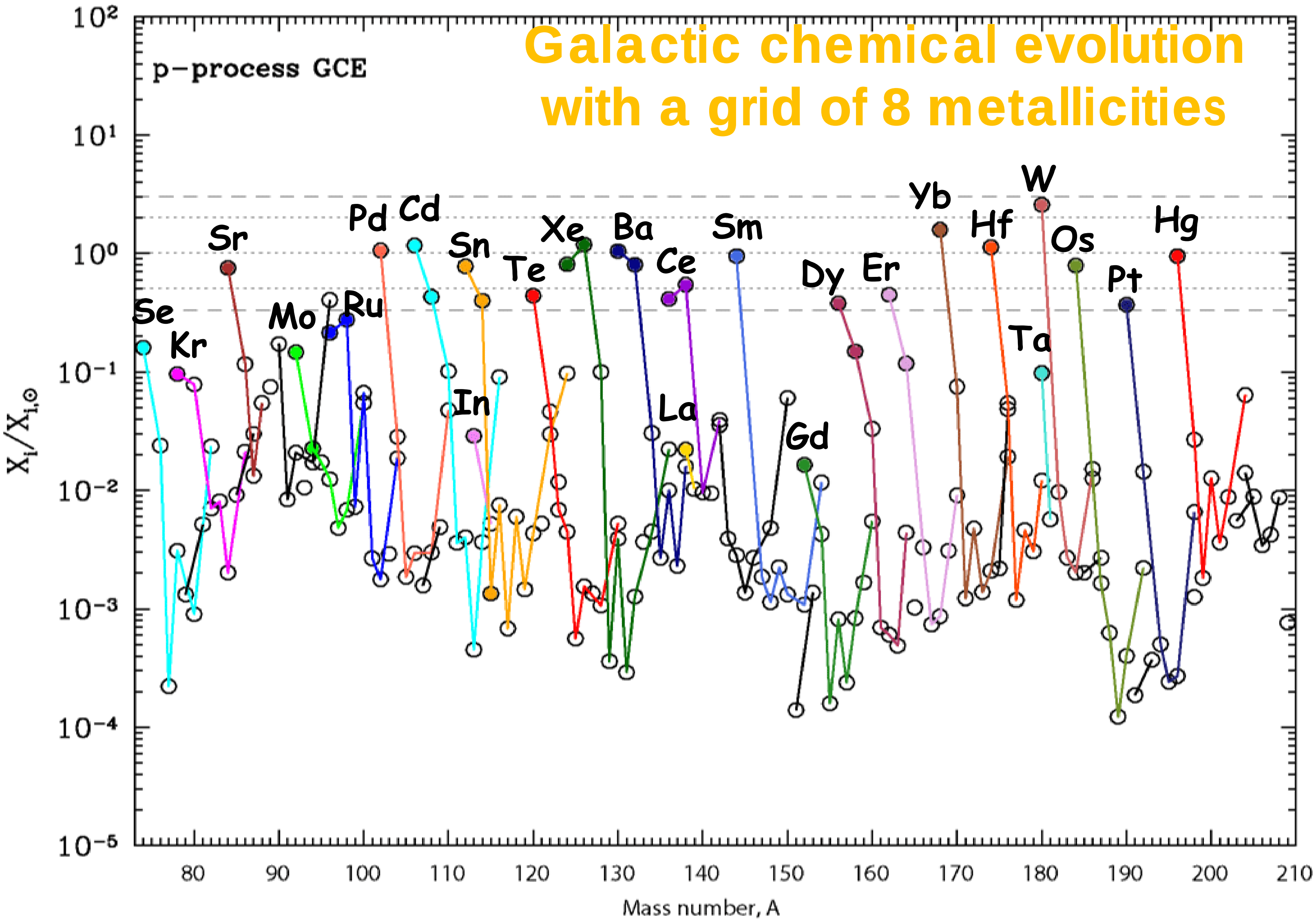
^{180}Ta at least 50% contribution from s-process
at solar composition (Mohr et al. 2007), plus
contribution from neutrino in SNII (Heger et al. 2005)

Travaglio et al. 2011, ApJ, 739, 93



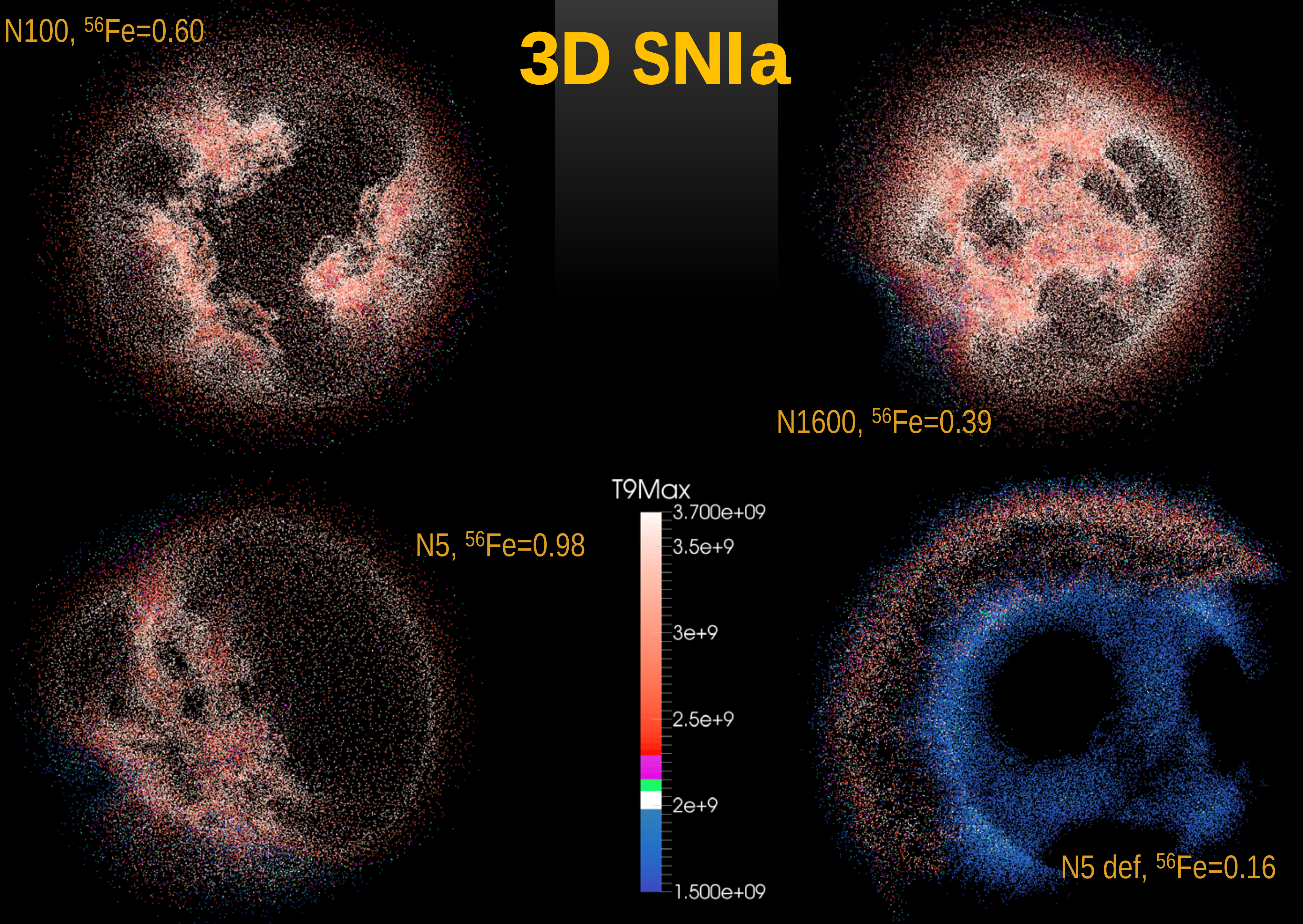
p-yields versus metallicity

Galactic chemical evolution with a grid of 8 metallicities



Travaglio et al. (2015, ApJ, 799, 54)

3D SNIa



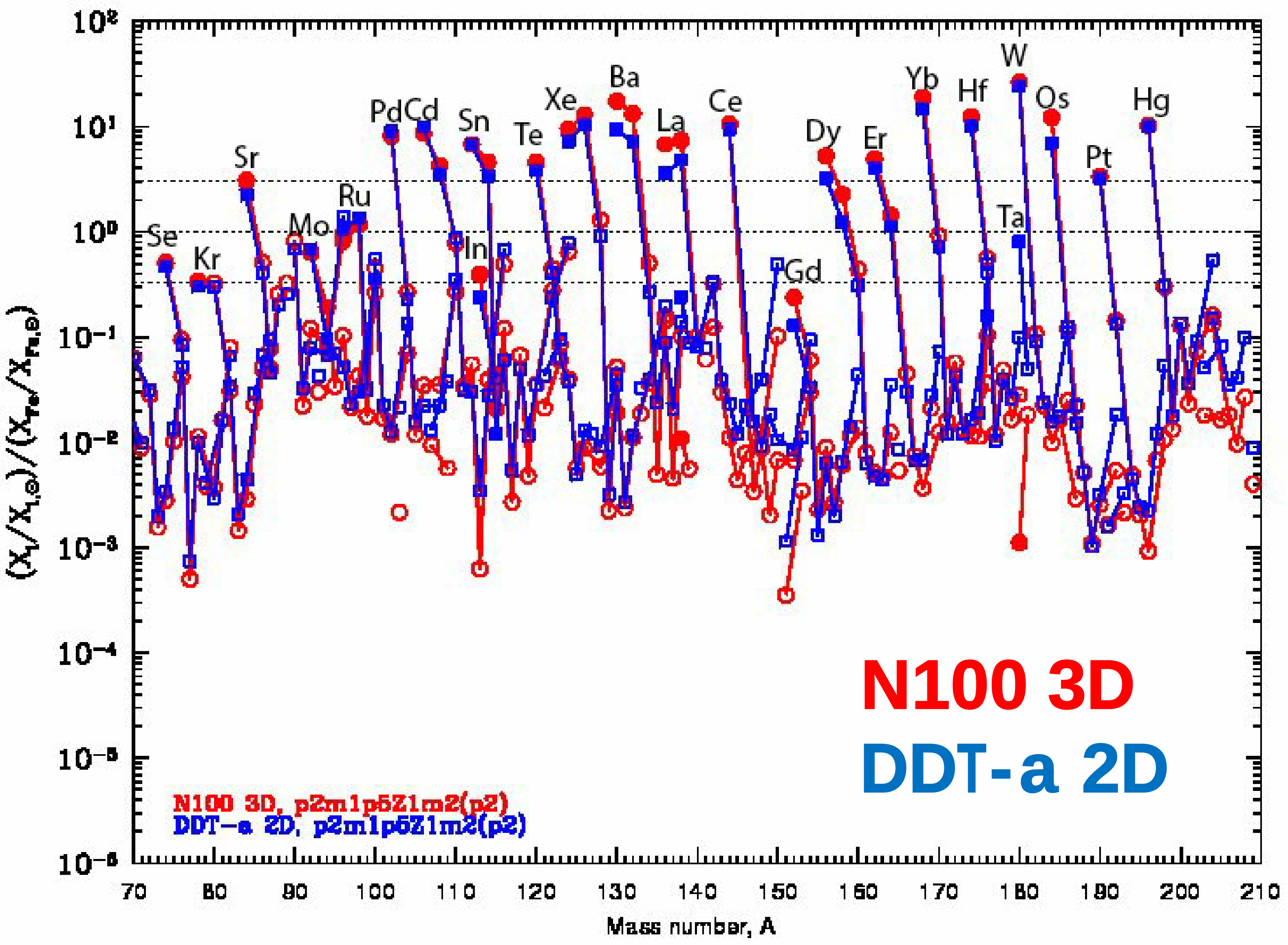
N100, ^{56}Fe=0.60

N1600, ^{56}Fe=0.39

N5, ^{56}Fe=0.98

N5 def, ^{56}Fe=0.16

Seitenzahl et al. (2013, MNRAS 429,1156; Kromer et al. (2013, MNRAS, 429, 2287)



N100 3D

DDT-a 2D

	92Mo/94MO
⊙	1.5
2D	9.0
N100	4.3
N1600	3.8
N5	3.5
N5def $(^{94}\mathrm{Mo}(\gamma,n)^{93}\mathrm{Mo}/3)$	2.7 (1.6)

^{94}Mo is a one of the isotope that particularly reflects the difference between 2D and 3D models.

In 2D it is mainly synthesized in matter that has undegone detonation, while in 3D it is also made in the later phases of deflagration. Therefore a stronger deflagration phase in DDT-3D models (that will produce less ^{56}Fe) will produce more ^{94}Mo.

SNII:

M. Pignatari & Nugrid collaboration

Set-1 (Nugrid collaboration, Pignatari et al. 2013 ApJS submitted)

- Preexplosive GENEC (no *p*-process calculations) (R. Hirschi)
- Explosion 2D (Freyer et al. 2012)

p nuclei are made via γ-process in the O-burning region, very sensitive to the explosion mechanism and fall back.

Secondary component.: from 12 $M_\odot$ to 25 $M_\odot$ carry the classical γ-process.

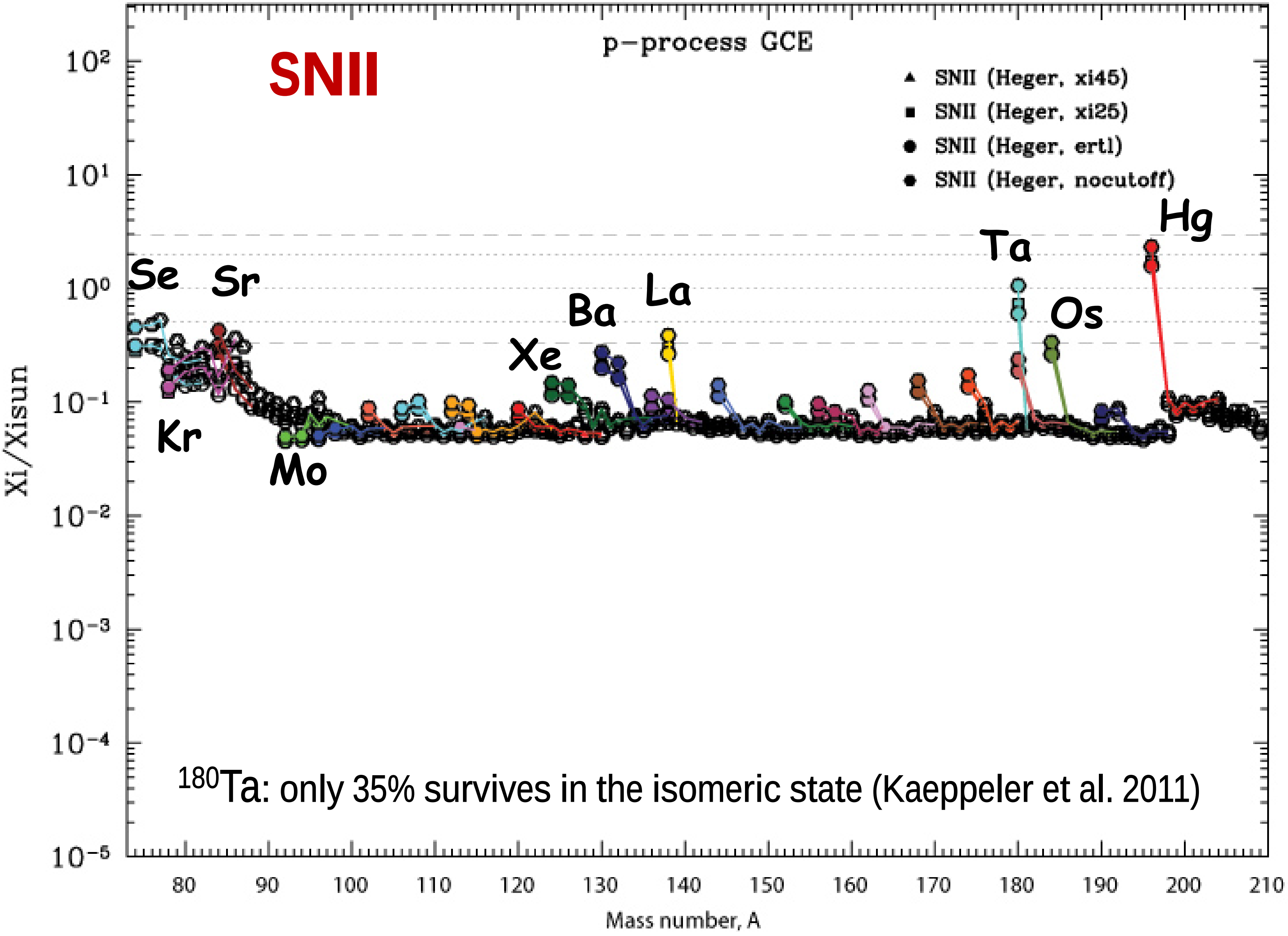
α-rich freeze out only about 10% of 15 $M_\odot$. Primary component

SNII:
models from A.Heger

xi45,xi25,ertl,nocutoff

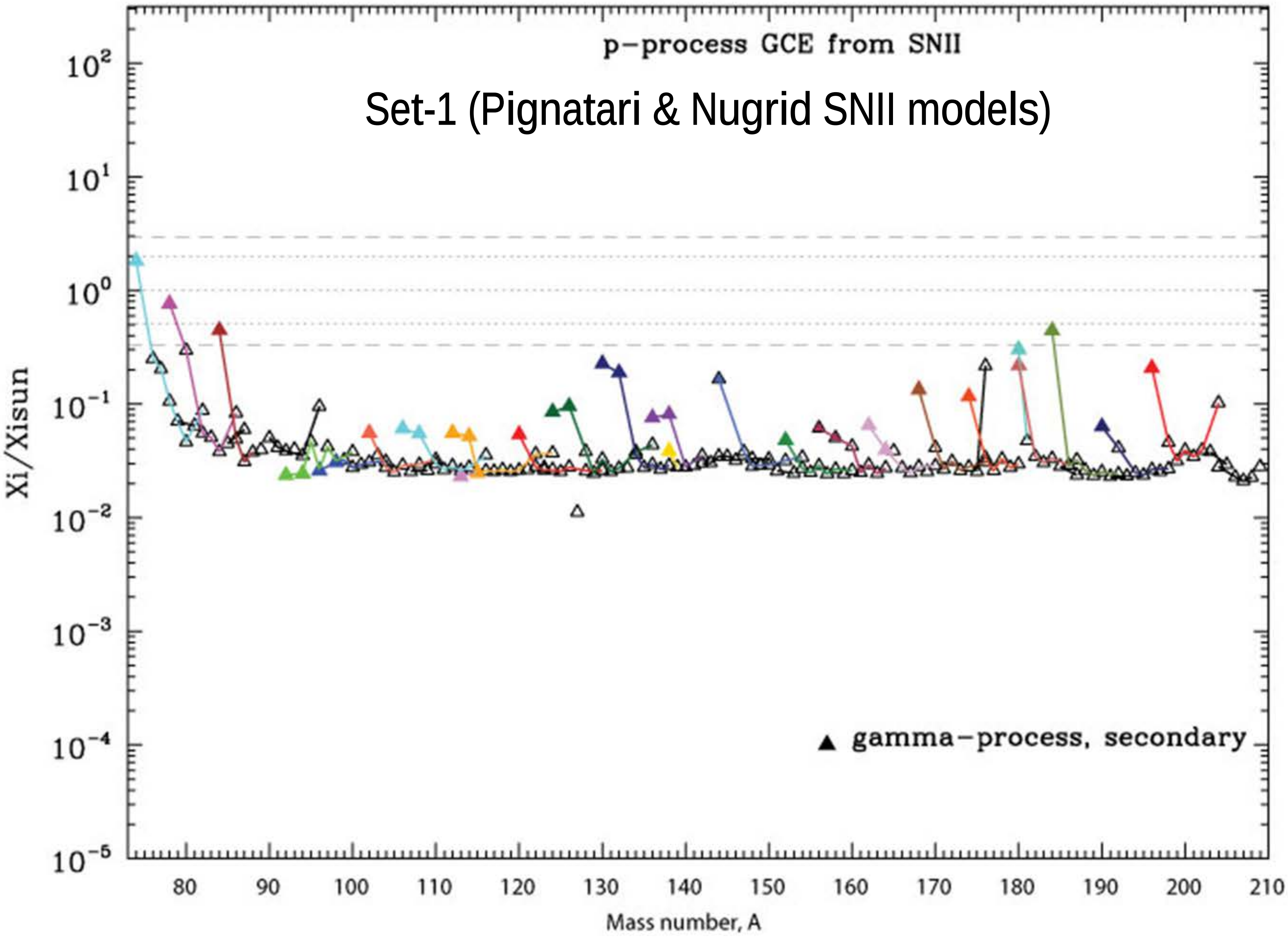
A grid of 14 metallicities has been used.

Masses included: 13$M_\odot$, 15$M_\odot$, 17$M_\odot$, 20$M_\odot$, 22$M_\odot$, 25$M_\odot$, 30$M_\odot$

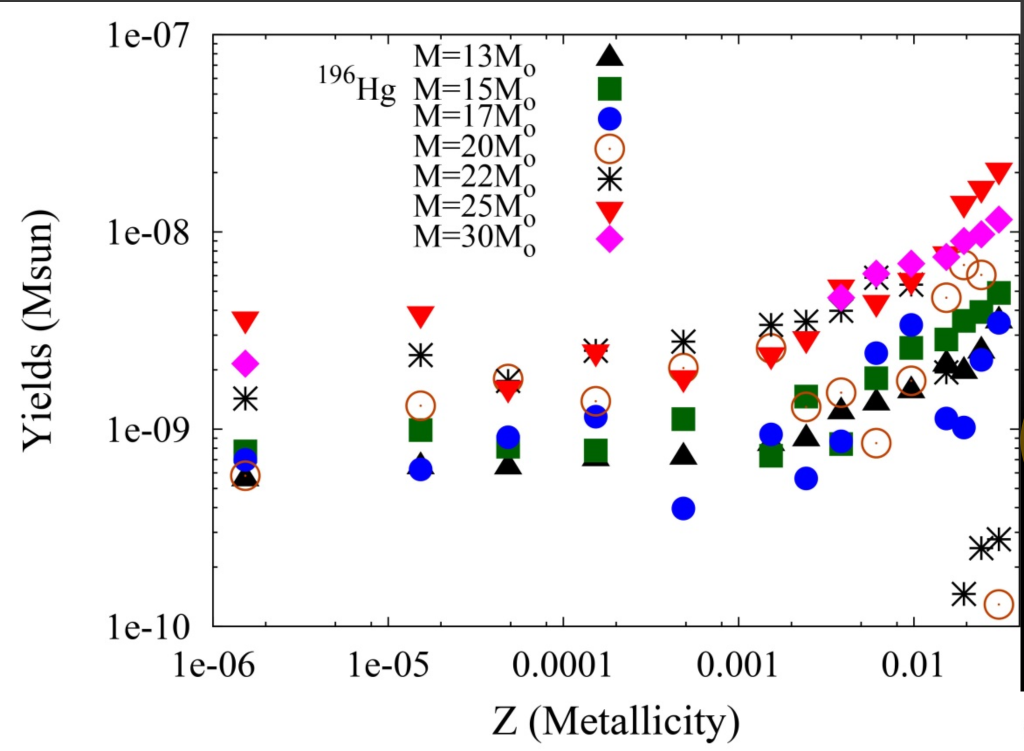


^{180}Ta: only 35% survives in the isomeric state (Kaeppeler et al. 2011)

Set-1 (Pignatari & Nugrid SNII models)

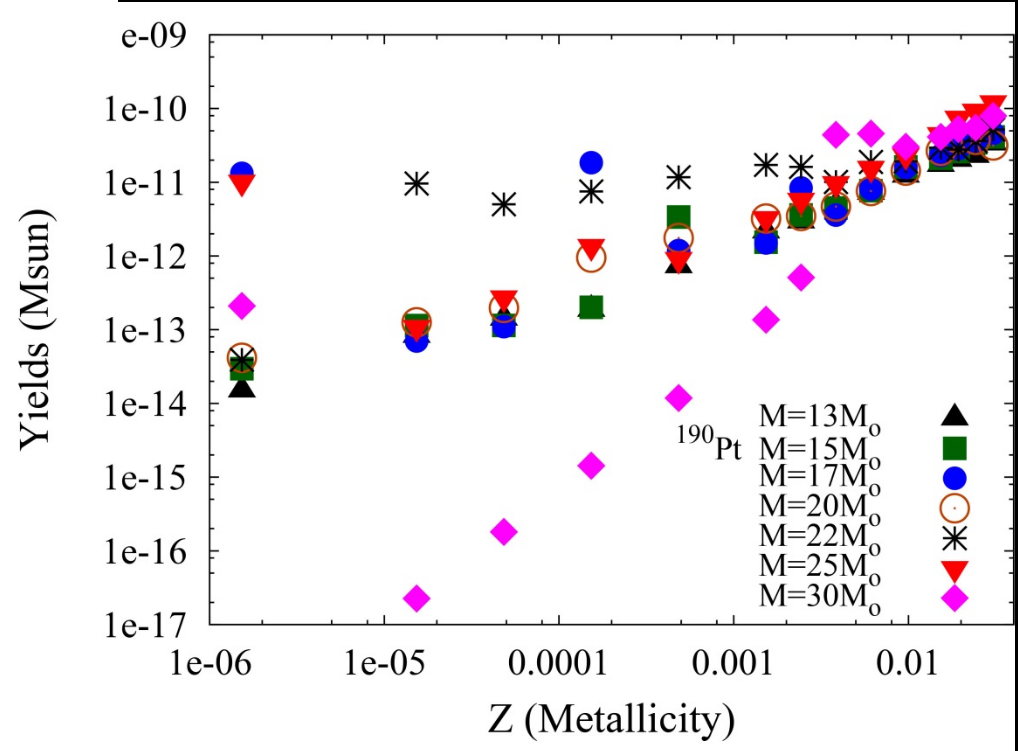


Heger xi45 models



^{196}Hg

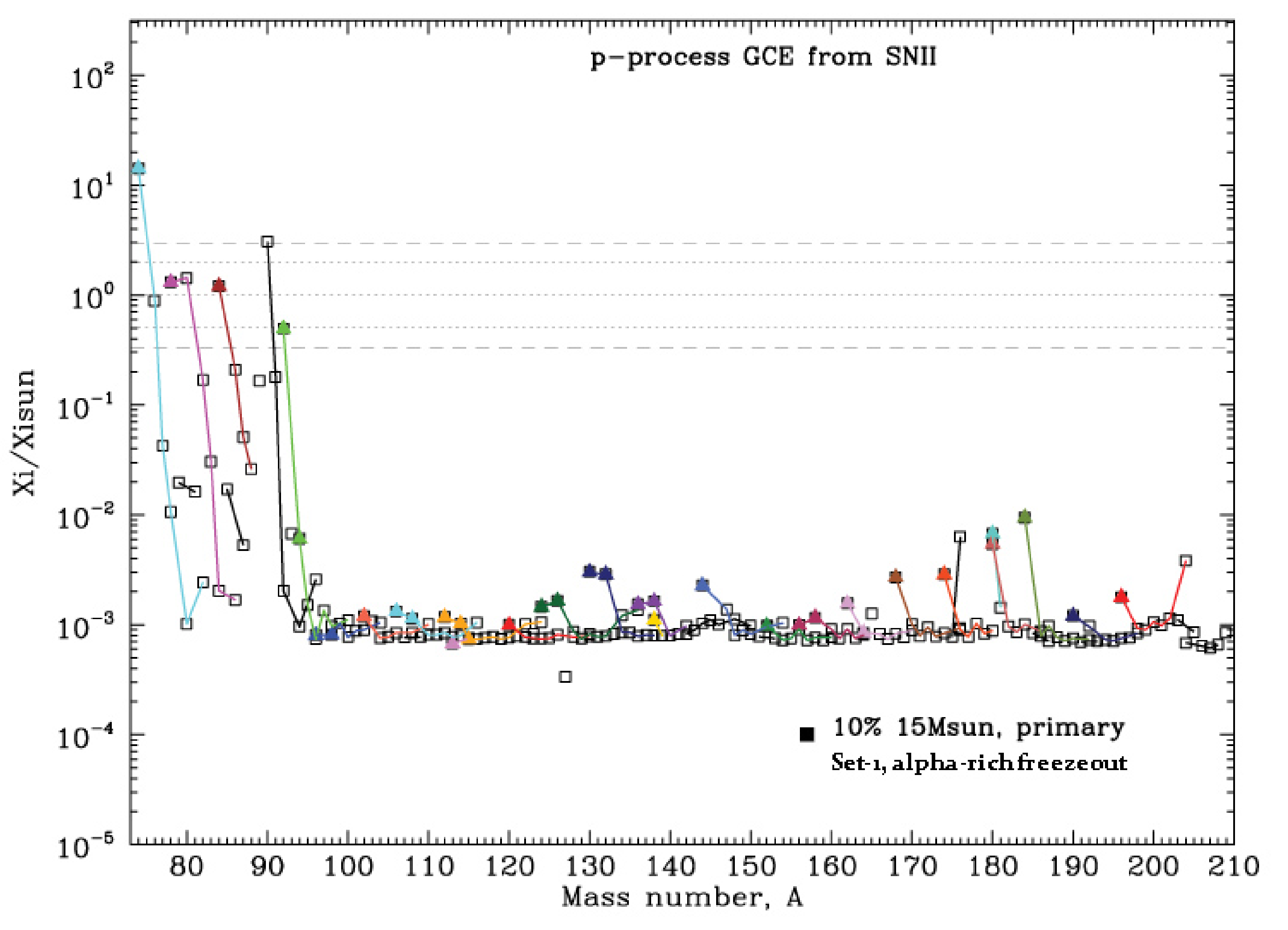
^{190}Pt



Set-1, 15M$_\odot$:

10% of primary component, from α-rich freeze-out

(Woosley & Hoffman 1992)



- Too much ^{74}Se
- Ok for ^{78}Kr, ^{84}Sr and ^{92}Mo
- Nothing from ^{94}Mo

M = 15 M$_{sun}$,
Z=0.02,
Stellar code: GENEC
SN explosion =
Fryer+ 2012
Pignatari+ 2013

If single degenerate SNIa **do exist**,

they can be important contributors to explain the abundances of *p*-nuclei in the Solar System

Open problems, work in progress

- A more detailed analysis of the role of **SNII** in GCE of p-nuclei:
  - grid of models at different Z with rotation
  - multi-D role in p-production
  - role of νp process in electron capture SNe (talks by Mueller, Hix)

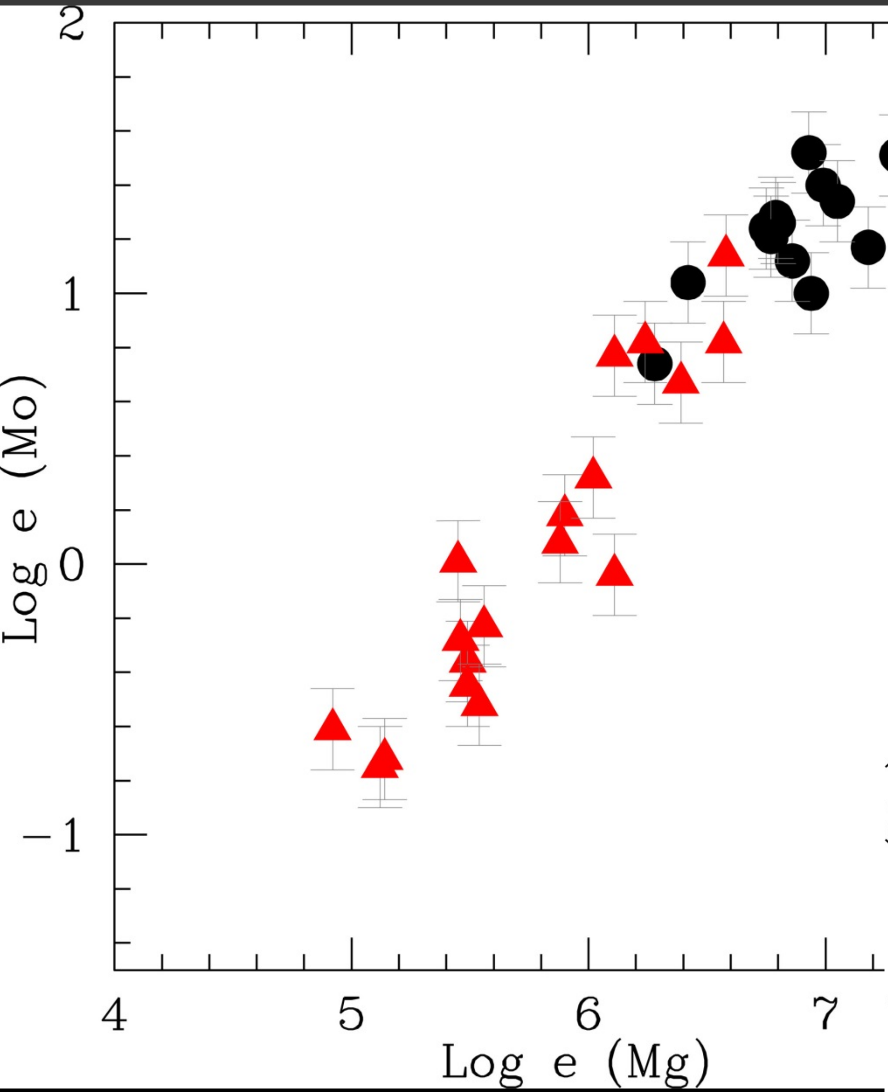
- To better understand the role of **SNIa** in GCE of p-nuclei:
  - more detailed analysis of 3D models
  - s-seeds composition
  - sub-Chadrasekhar and mergers as alternative contributors to explain the solar p-nuclei composition

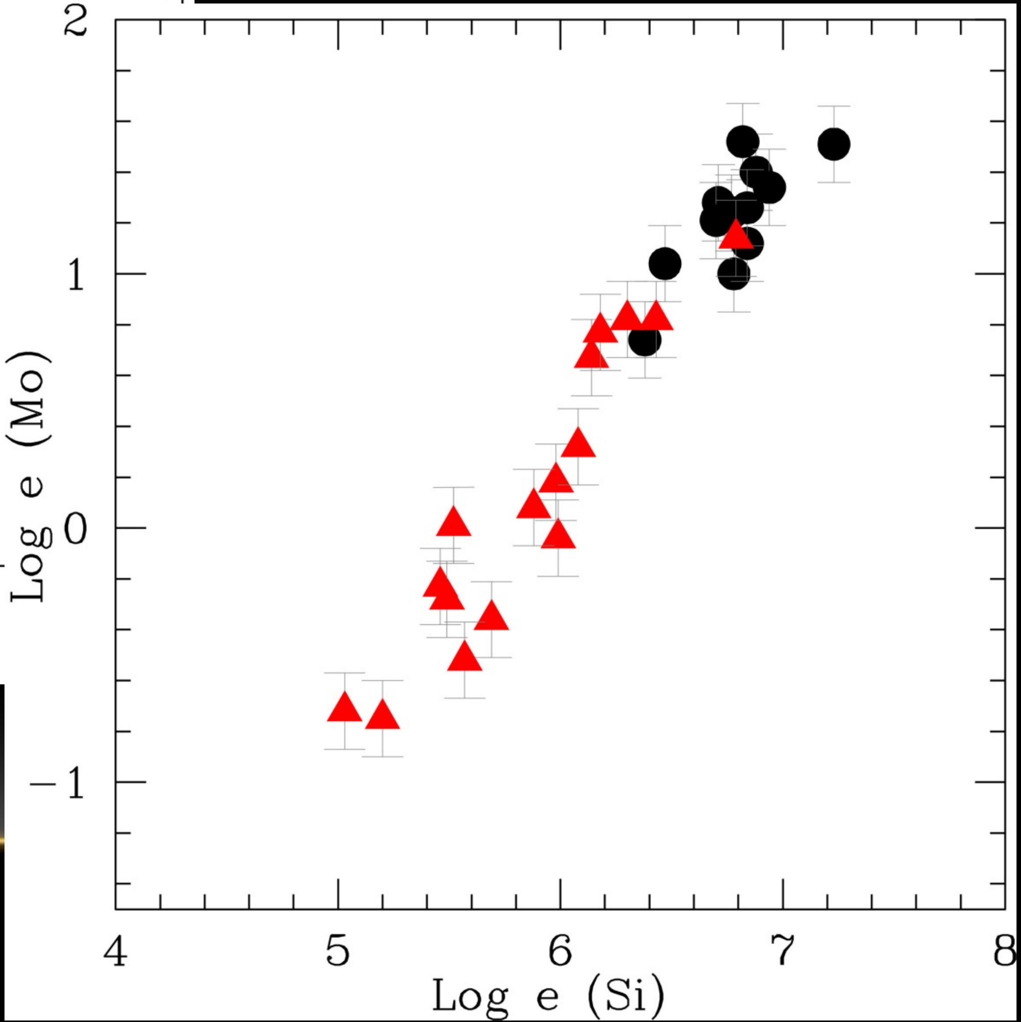
- Constraints from spectroscopic observations and meteorites measurements

Observational constraints

- Spectroscopic observations:
no way to get isotopic composition.
Search for correlations
(Hansen et al. 2014)

- Interstellar grains: CHILI
(THE CHICAGO INSTRUMENT FOR LASER IONIZATION)
is planning to measure p-isotopes
(ref. A. Davis)





Hansen et al. 2014 for Mo