Production of p-process governed by the s-process in Type Ia SNe

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Collaborators:

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Nucleosynthesis in Asymptotic Giant Branch Stars

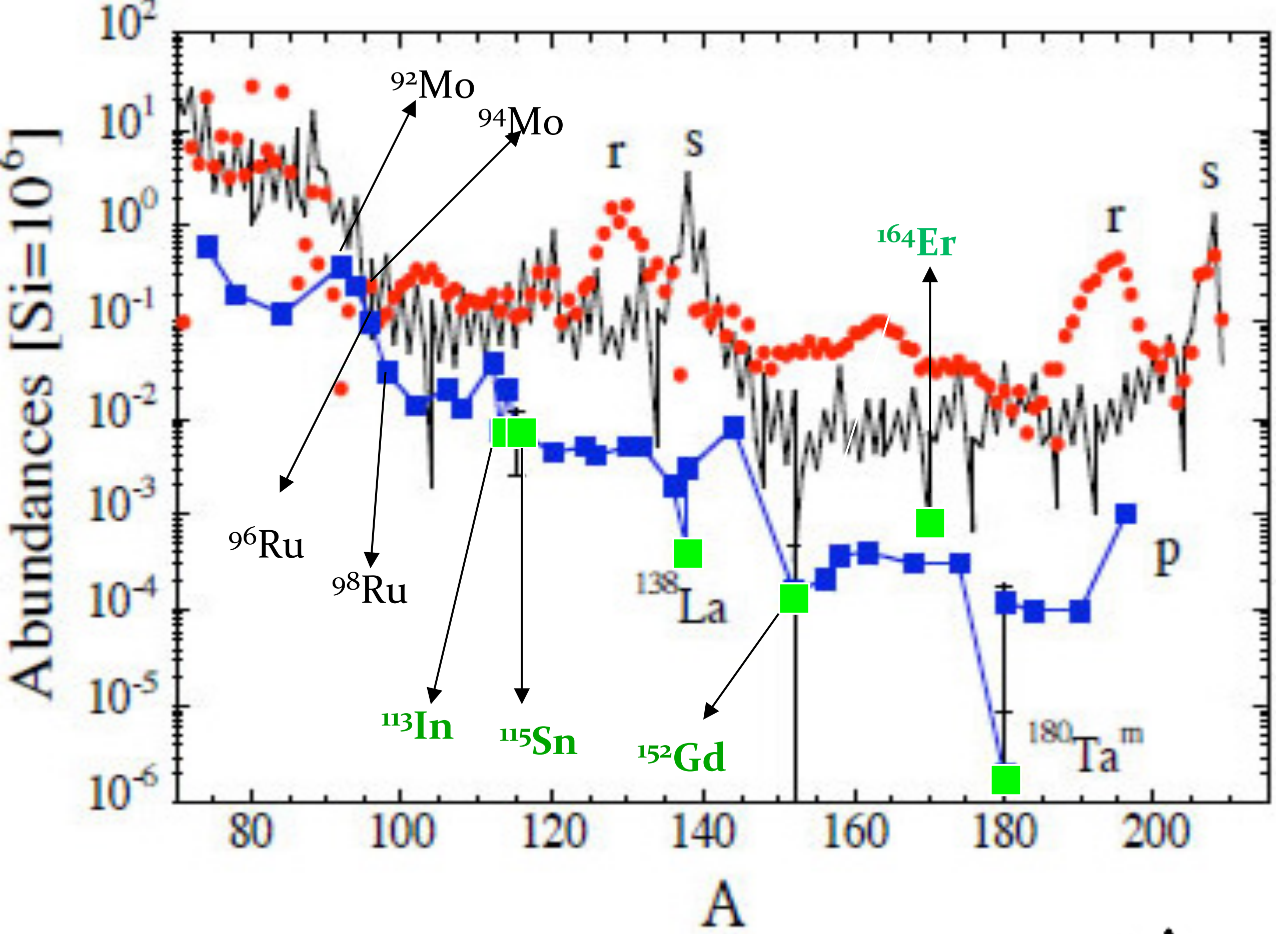
July 14-18th 2014 Bad Honnef, Germany

Abstract

I discuss the possibility that single degenerate WDs accreting mass from a Giant companion up to the Chandrasekhar mass limit, and exploding as Type Ia SNe, provide a substantial contribution to Galactic p-nuclei, including the very debated pairs ^{92}Mo--^{94}Mo and ^{96}Ru--^{98}Ru.

In the Galactic chemical evolution scenario, also the two short-lived p-only nuclides, ^{92}Nb, ^{146}Sm, whose presence in the early solar system have been ascertained, can be reconciled.

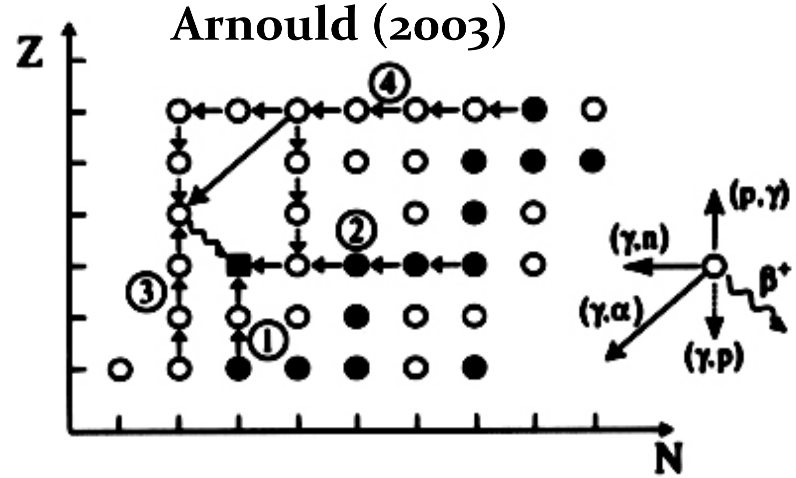
So to say, the mistery of the ^{13}C-pocket formation in TDU-TPAGB translates to an even double mistery for making the p-process.



Are p-only 35 nuclides?

Likely 29!

Arnould (2003)



Nucleosynthesis in Asymptotic Giant Branch Stars

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

NO p-only nuclei

^{138}La produced by neutrino interaction on ^{139}La (Woosley et al. 1990)

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

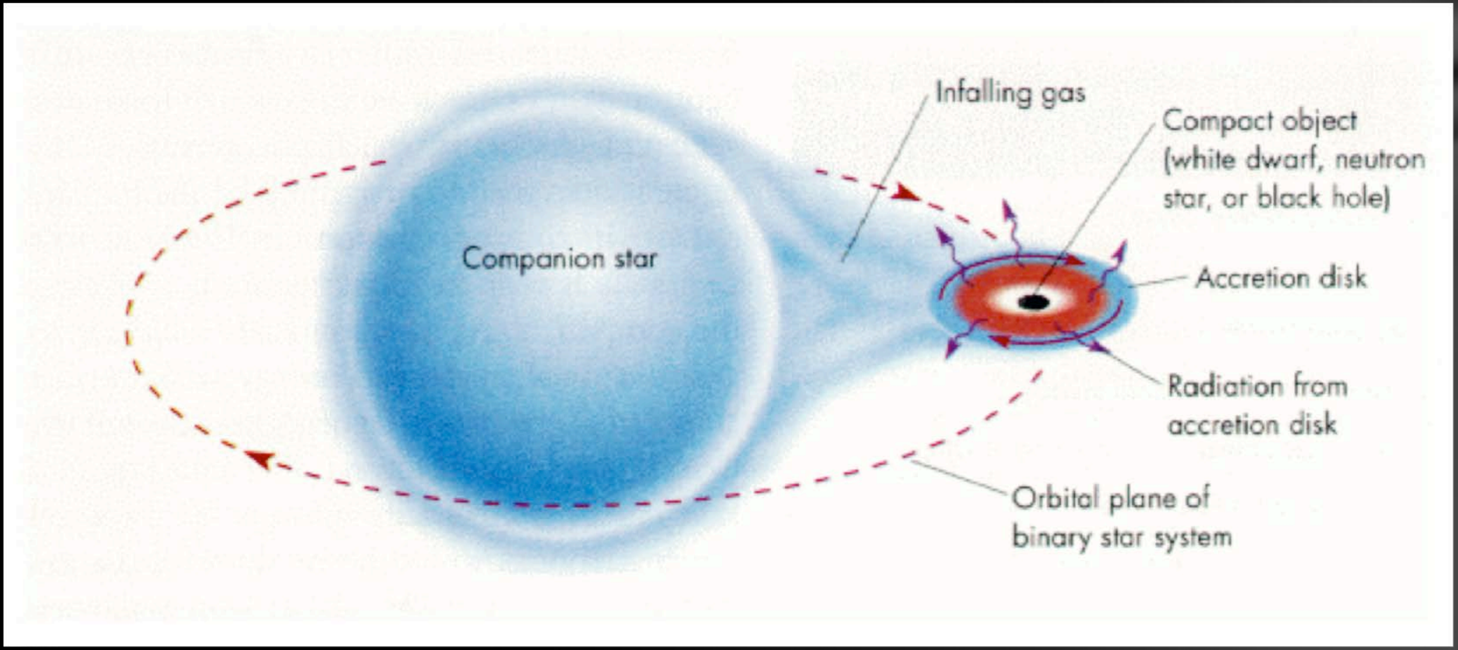
^{164}Er at least 50% contribution by s-process (Jaag & Kaeppeler 1996)

^{180}Ta at least 50% by the s-process and 40% by neutrino interaction on ^{181}Ta (Mohr et al. 2007)

Travaglio et al. (2011)

s-nucleosynthesis during accretion phase

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



Previous Attempts

Howard,W.M., &Meyer, B. S. 1993, in Proc. 2nd International Symposium on Nuclear Astrophysics, Karlsruhe, Germany, ed. F. K¨appeler & K. Wisshak (Bristol: Institute of Physics Publishing), 575

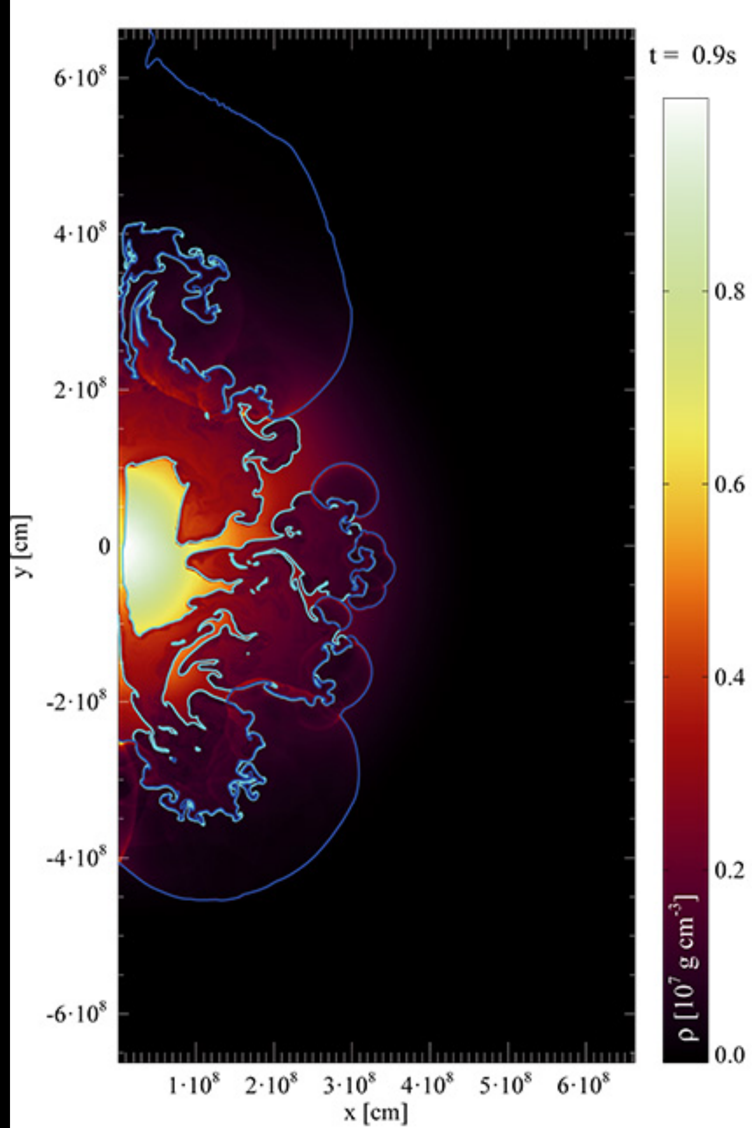
Howard, W. M., Meyer, B. S., & Woosley, S. E. 1991, ApJ, 373, L5

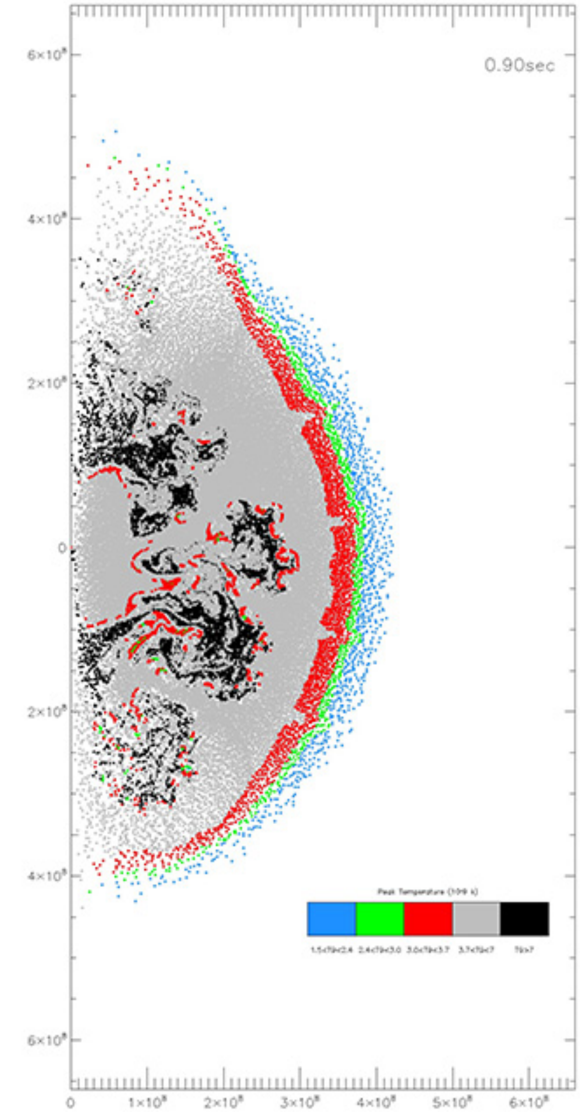
Kusakabe, M., Iwamoto, N., & Nomoto, K. 2005, Nucl. Phys. A, 758, 459

Kusakabe, M., Iwamoto, N., & Nomoto, K. 2011, ApJ, 726, 25

2D model DDT-a, 51200 tracers

Travaglio et al. 2011

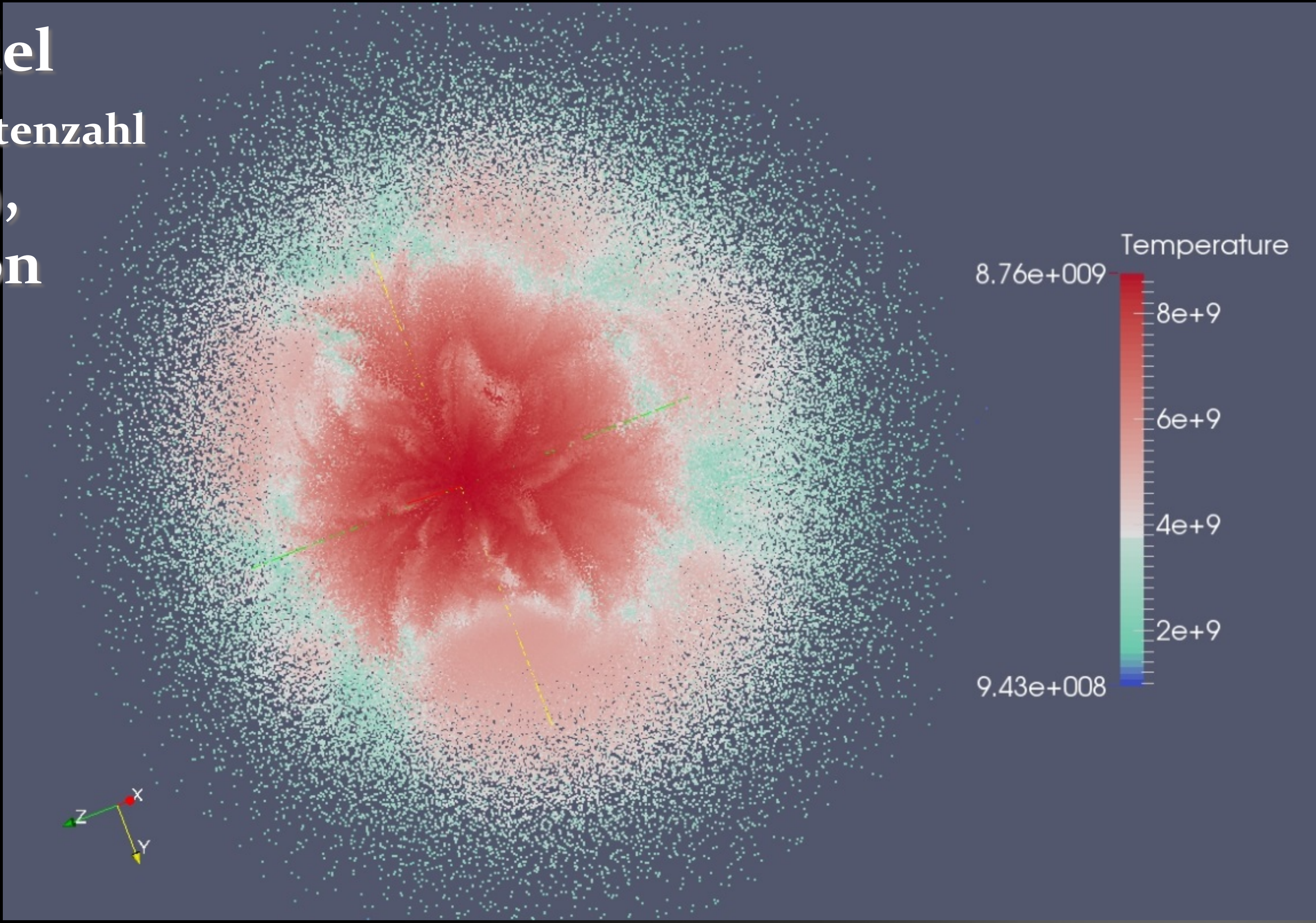




3D model

(N100, Seitenzahl et al. 2013),

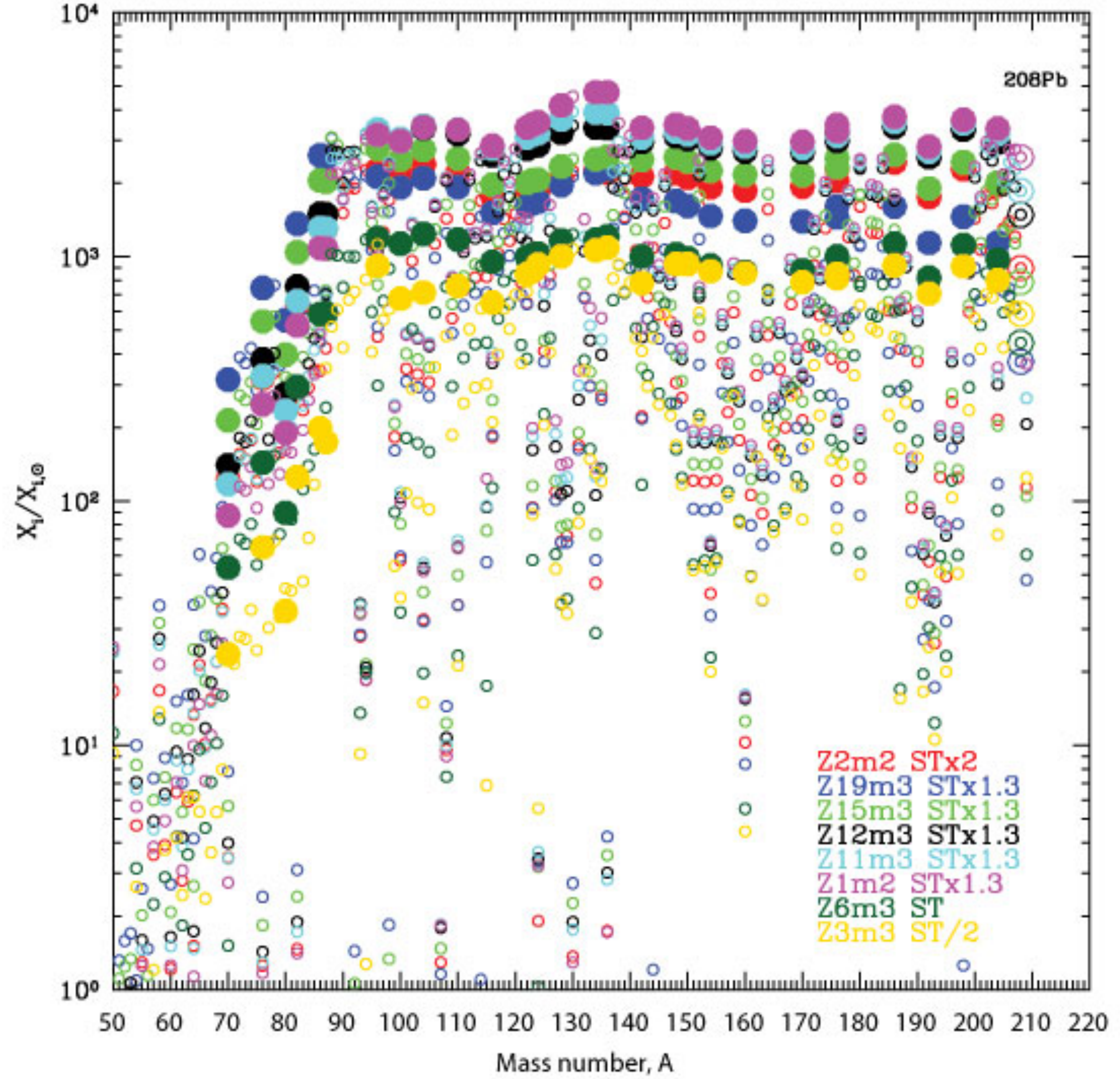
1 million tracers



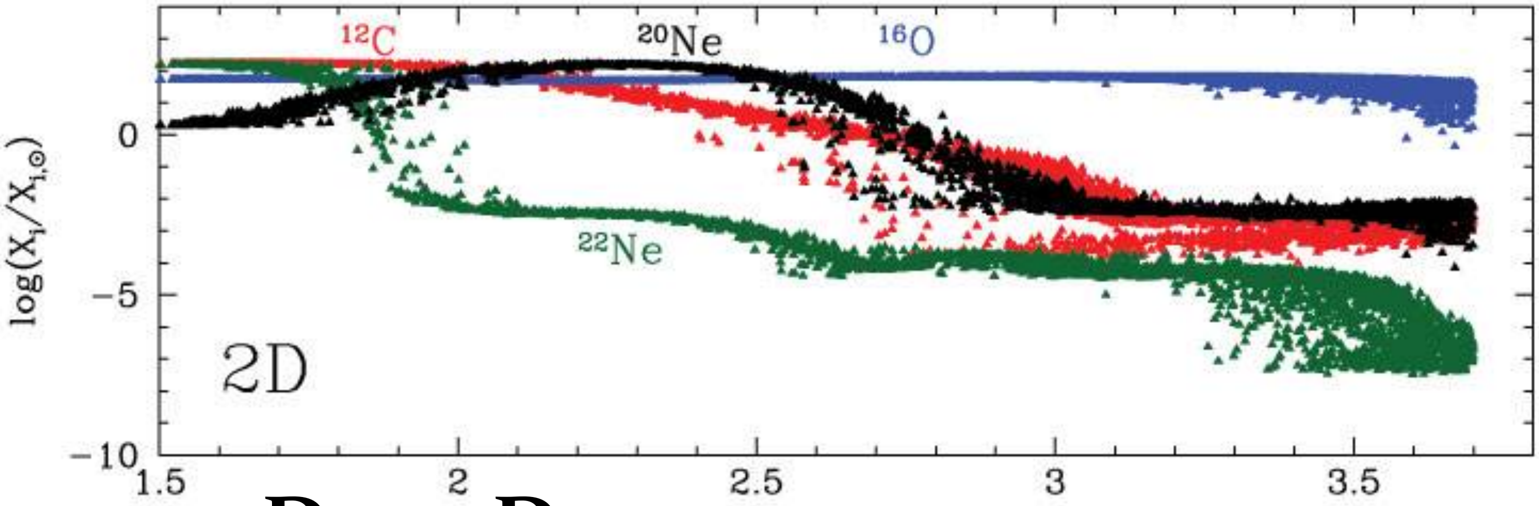
s-seeds

and

metallicity

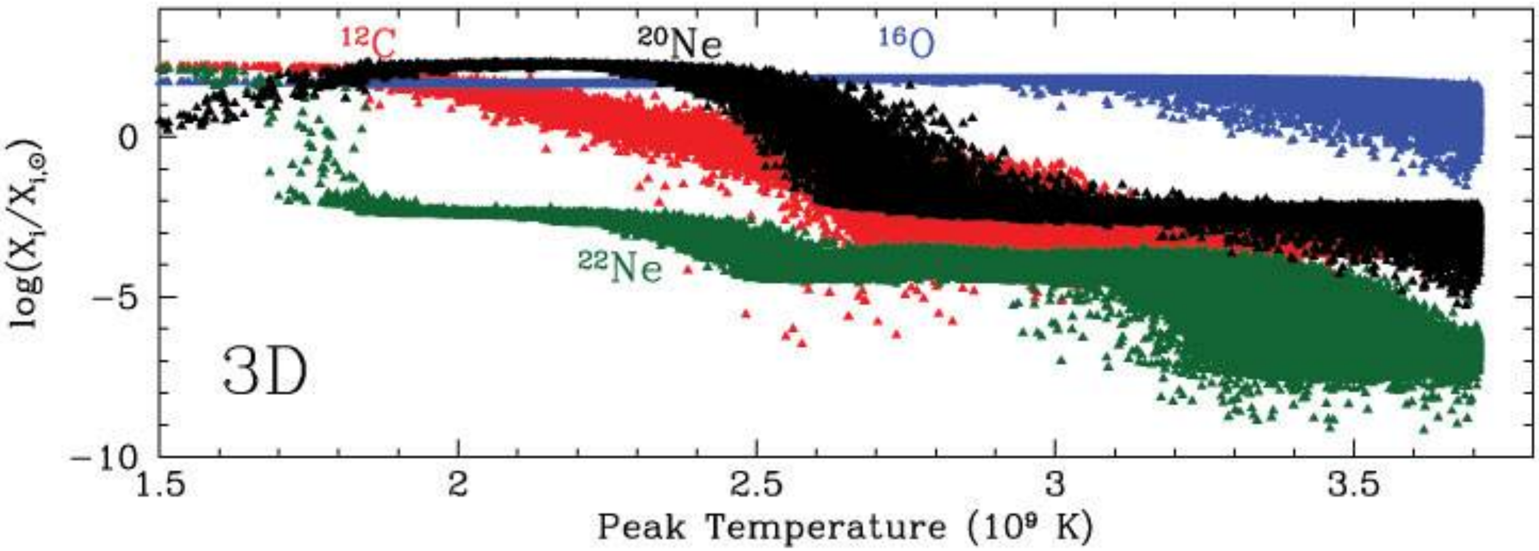


Travaglio et al. 2014, in prep.



^{12}C
^{20}Ne
^{16}O
^{22}Ne
2D
$\log(X_i/X_{i,\odot})$
0
−5
−10
1.5
2
2.5
3
3.5

2D vs 3D



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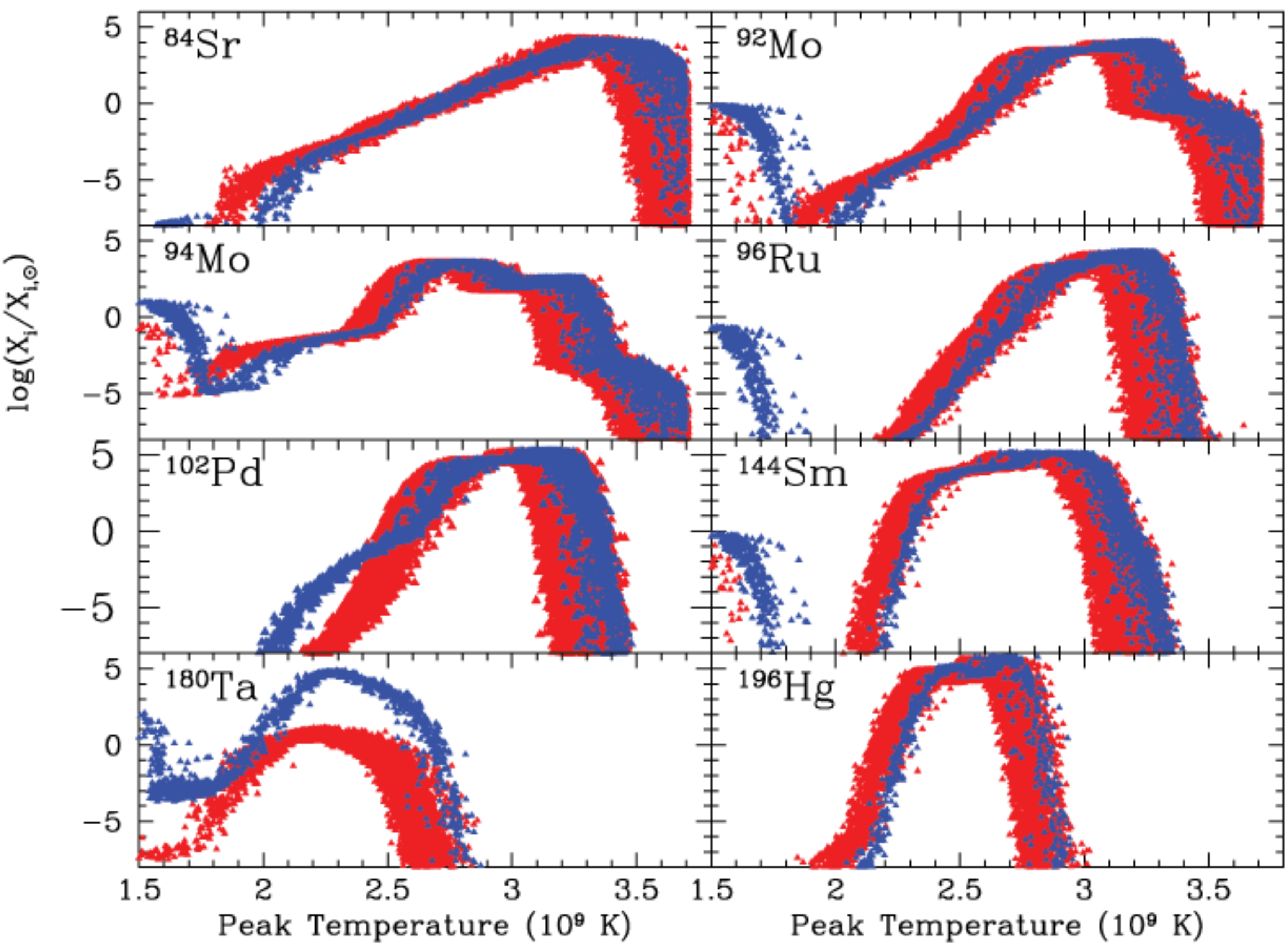
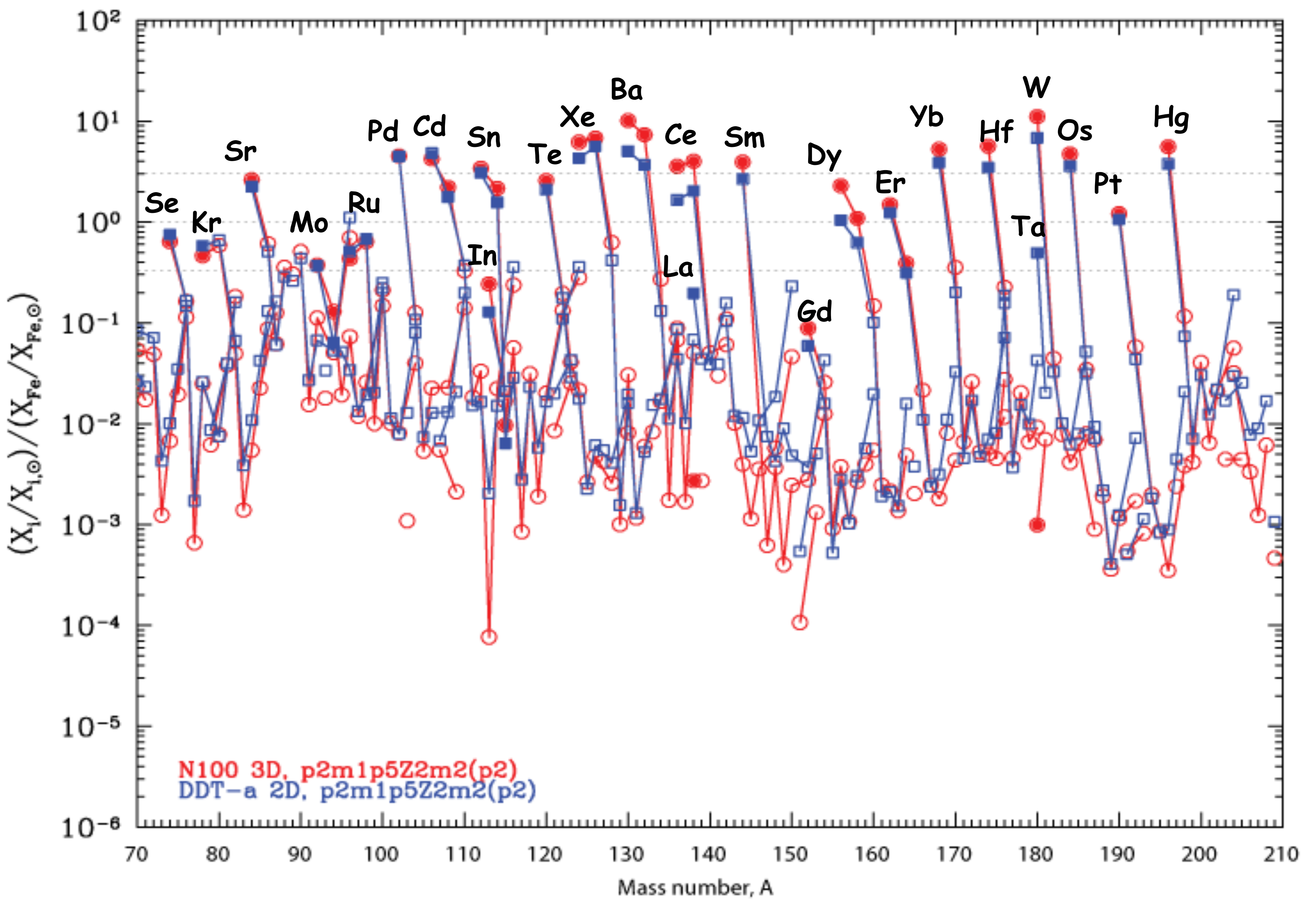
Peak Temperature (10^9 K)

2D vs 3D

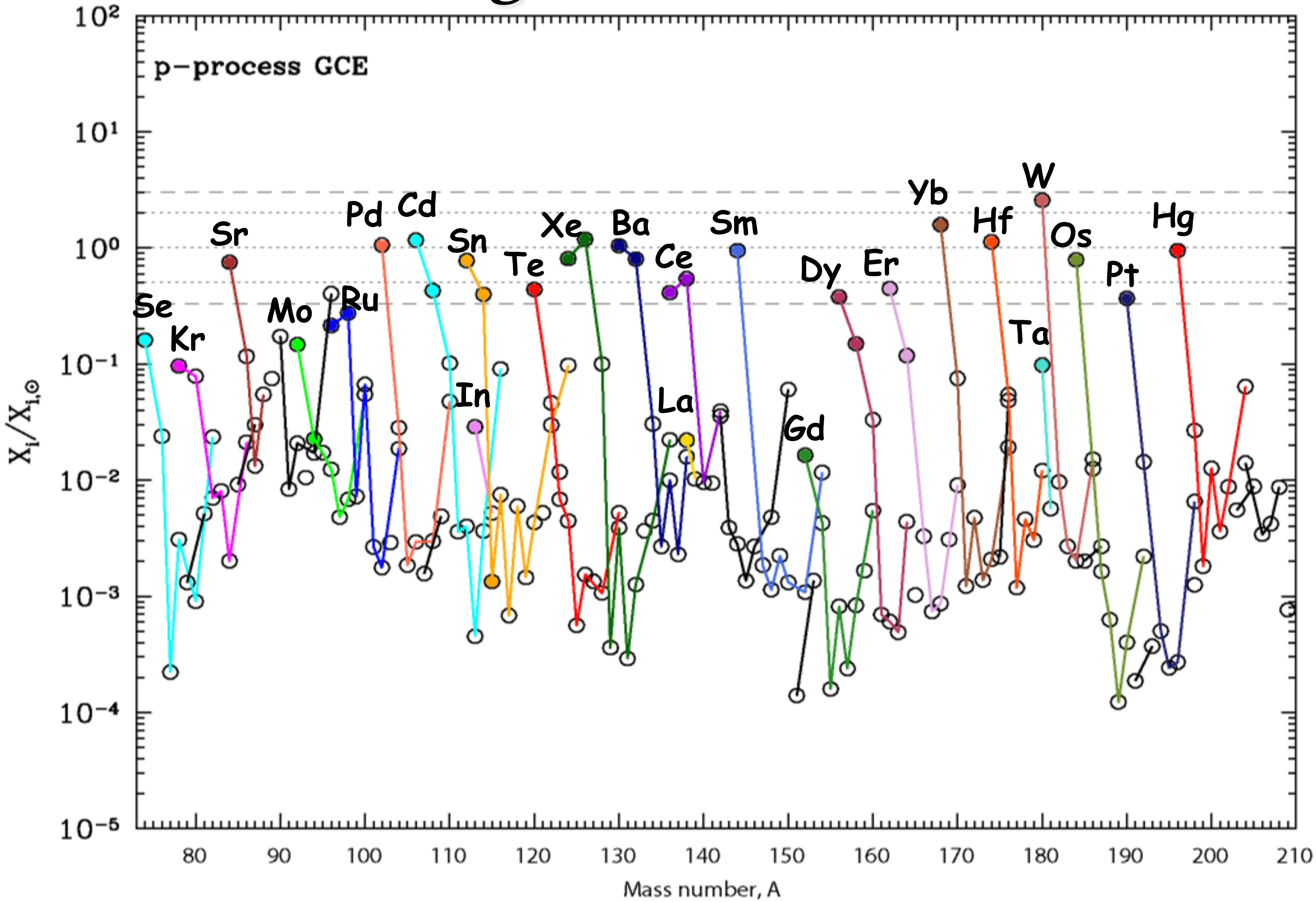


84Sr
92Mo
94Mo
96Ru
102Pd
144Sm
180Ta
196Hg
log(X_i/X_i,⊙)
Peak Temperature (10⁹ K)
Peak Temperature (10⁹ K)



p-yields 2D vs 3D, solar Z

Galactic chemical evolution with a grid of 8 metallicities



Travaglio et al. (2014, in prep.)

Radiogenic p-nuclei

^{146}Sm ($t_{1/2}$=68 Myr, old 103 Myr)

The most important development with
^{146}Sm in the past several years with respect to p-nucleosynthesis is a drastic revision of its half-life from 103 Myr to 68 Myr. Using this new half-life and the most up-to-date meteorite measurements, the initial ^{146}Sm/^{144}Sm ratio at CAI formation is $(9.4 \pm 0.5)\times 10^{-3}$

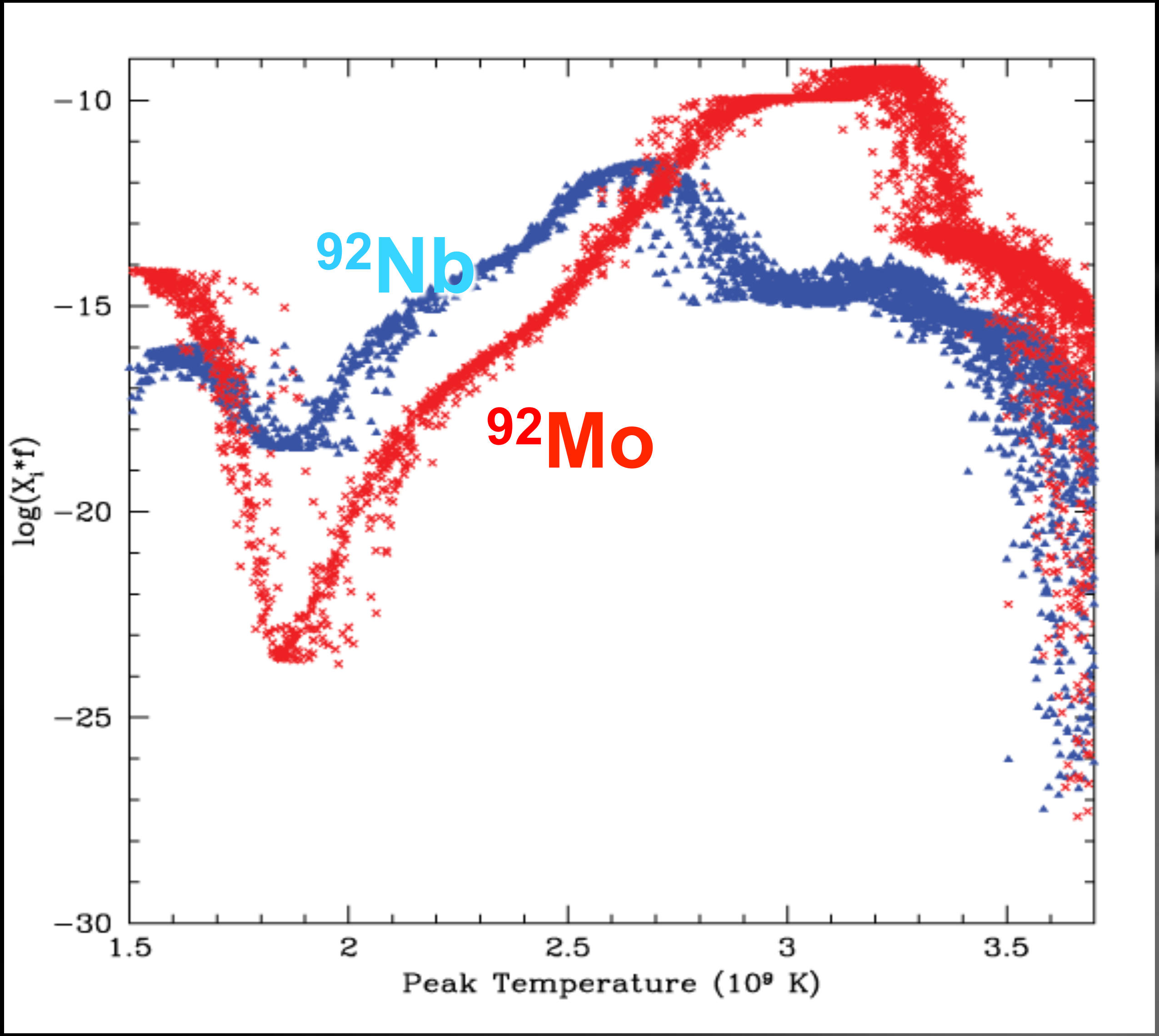
^{92}Nb ($t_{1/2}$ = 34.7 Myr)

^{93}Nb (a pure s-process nuclide) for ^{92}Nb. For the purpose of examining p-nucleosynthesis and comparing meteoritic abundances with predictions from GCE, it is more useful to normalize ^{92}Nb to a neighbour p-nuclide such as ^{92}Mo. The early solar system ^{92}Nb/^{92}Mo ratio is $(2.8 \pm 0.5) \times 10^{-5}$

Also and ^{97}**Tc** and ^{98}**Tc** radiogenic p-isotopes are included in our network but only upper limits are measured in CAI. Our predictions are consistent

Radiogenic

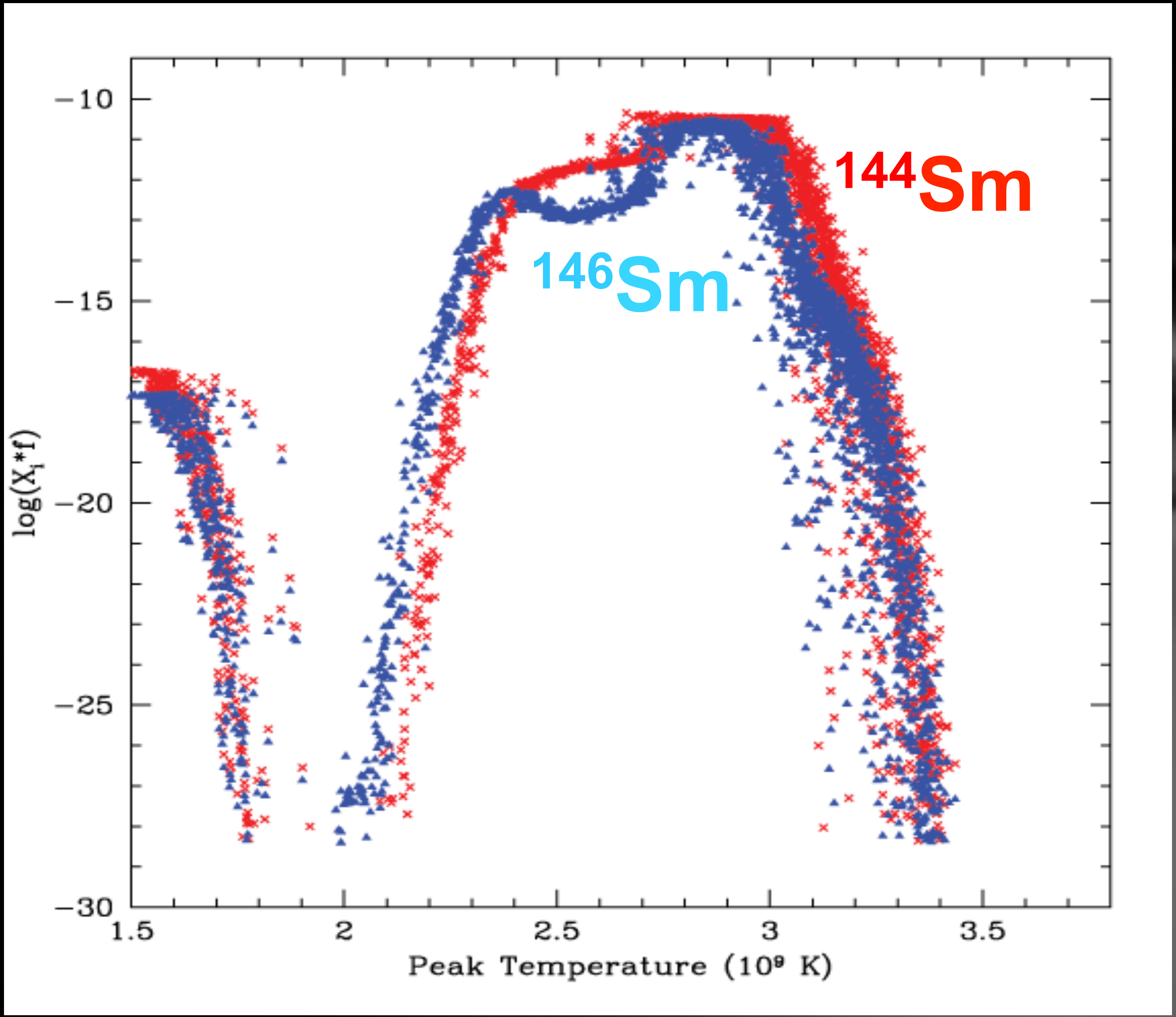
^{92}Nb



Travaglio et al. (2014, ApJ submitted)

Radiogenic

^{146}Sm



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^{92}Nb and ^{146}Sm in SNIa

	Meteorite	GCE
^{92}Nb/^{92}Mo	$(2.8 \pm 0.5)\times10^{-5}$	$1.7 - 3.1\times10^{-5}$
^{146}Sm/^{144}Sm	$(9.4 \pm 0.5)\times10^{-3}$	1.7×10^{-2}

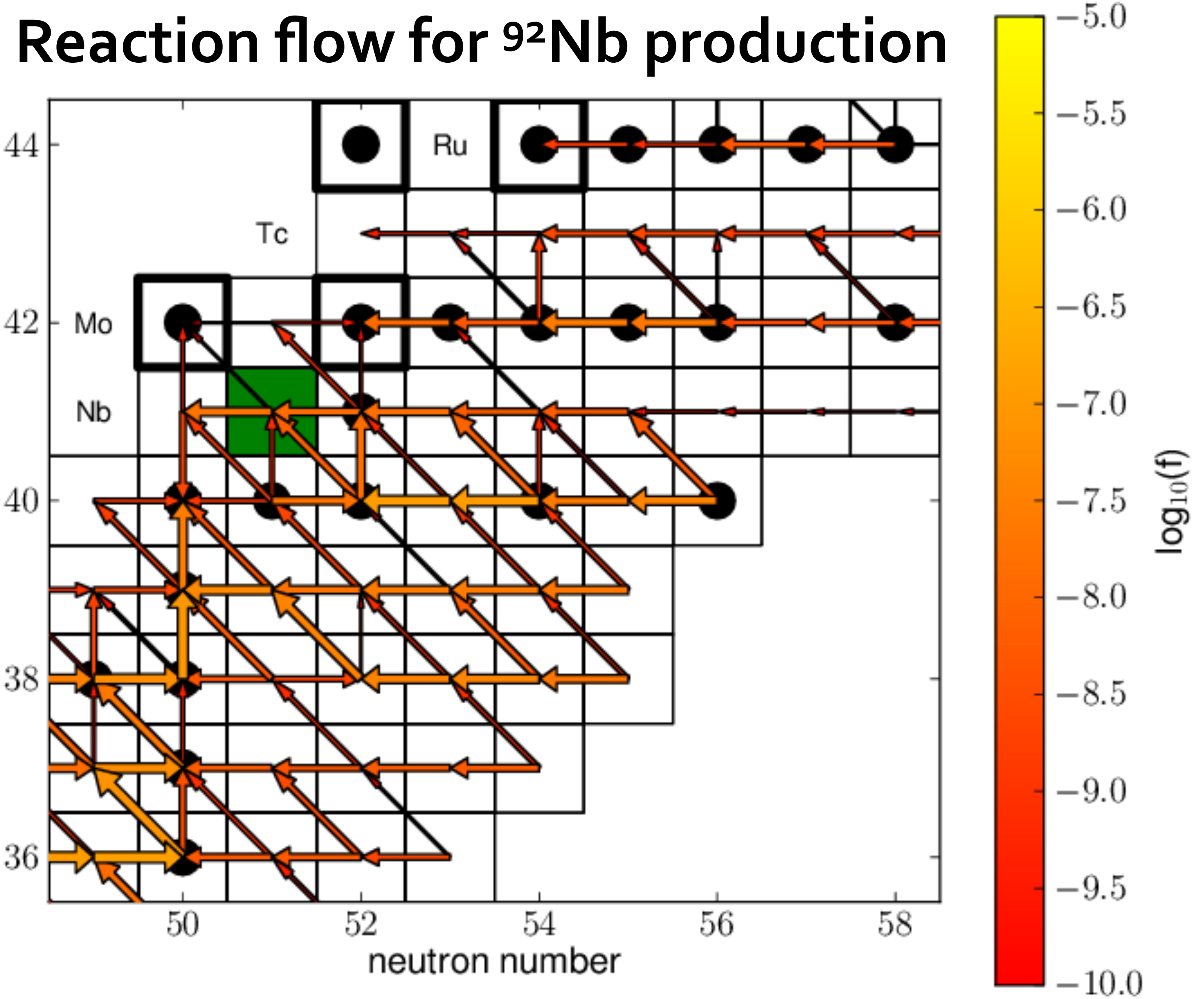
Rauscher et al. (2013),new 148Gd(γ, α)144Sm rate.

We found that the obtained ^{146}Sm/^{144}Sm ratio is compatible with the meteoritic value when using a ^{148}Gd(γ,α) rate based either on a fit to the Somorjai et al. (1998) (α,γ) cross sections or on the recent rate including an additional reaction channel as presented by Rauscher (2013). Concerning

Reactions	Rate set MIN	Rate set MAX
$^{91}Zr(p,\gamma)^{92}Nb$	↓	↑
$^{92}Zr(p,\gamma)^{93}Nb$	↓	↑
$^{92}Zr(p,n)^{92}Nb$	↓	↑
$^{91}Nb(n,\gamma)^{92}Nb$	↑	↓
$^{92}Nb(n,\gamma)^{93}Nb$	↓	↑
$^{91}Nb(p,\gamma)^{92}Mo$	↑	↓
$^{93}Nb(p,n)^{93}Mo$	↑	↓
$^{93}Mo(n,\gamma)^{94}Mo$	↑	↓
GCE	1.660×10^{-5}	3.118×10^{-5}

Travaglio et al. (2014, ApJ submitted)

Reaction flow for ^{92}Nb production



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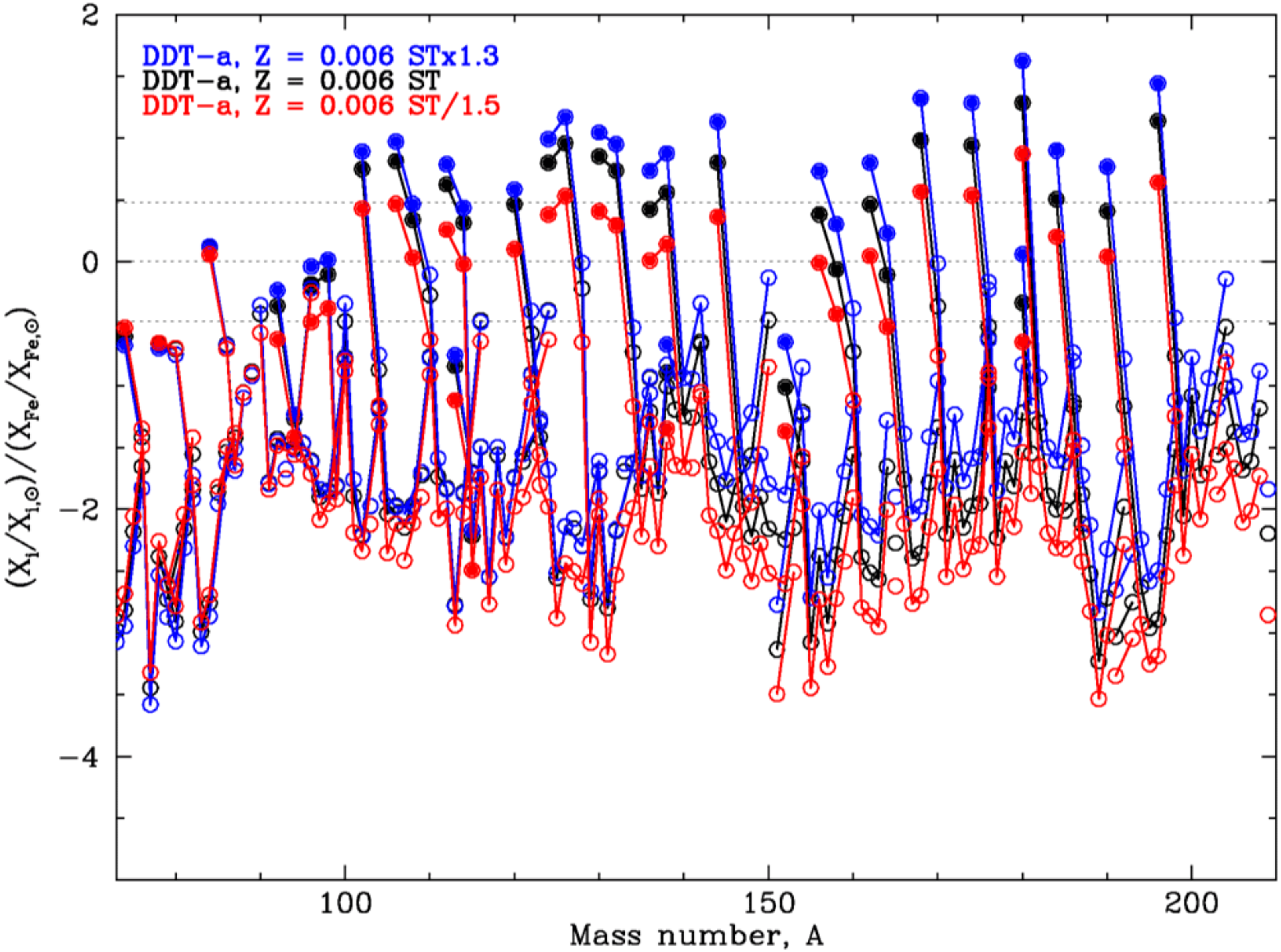
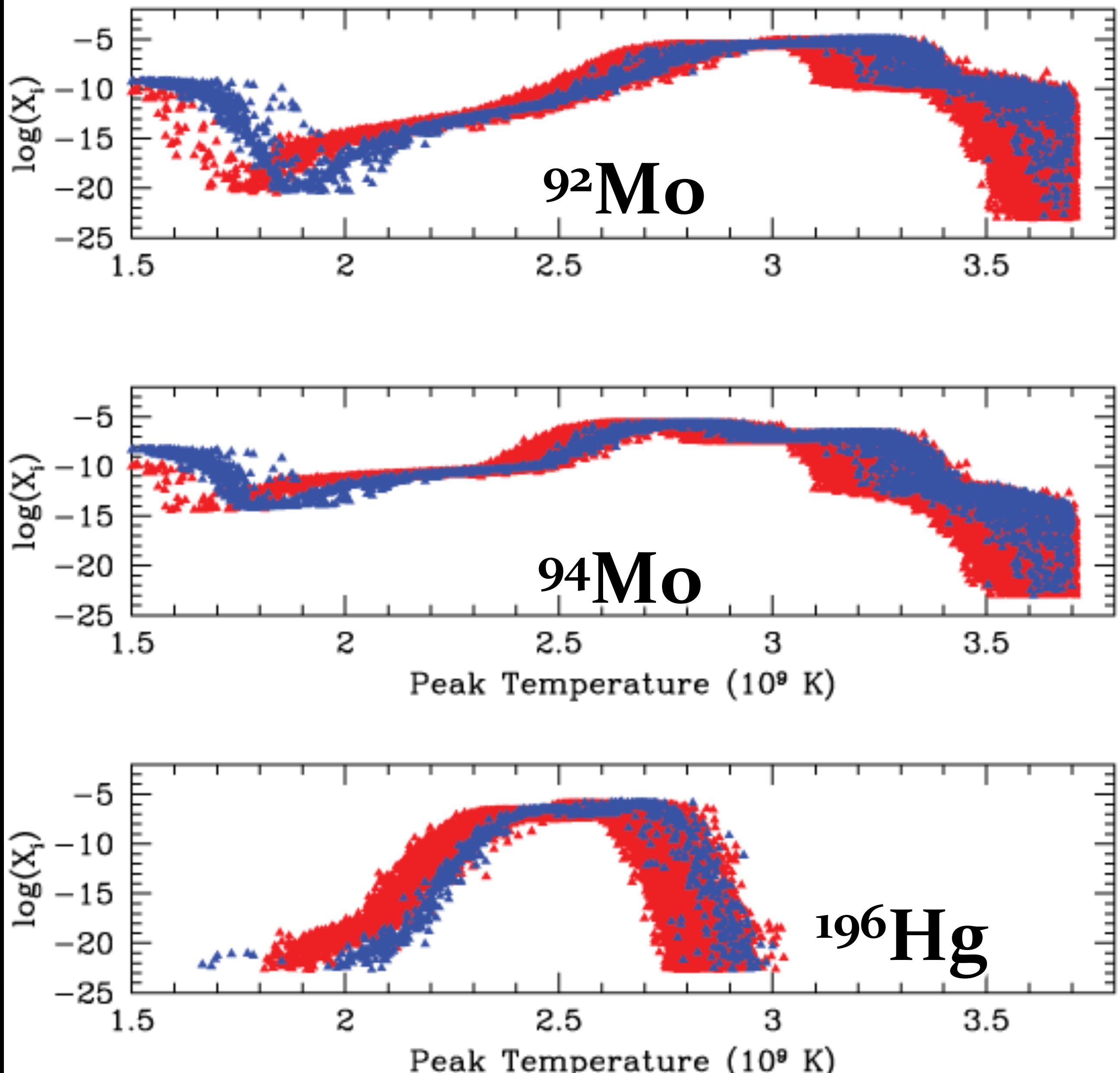


p-yields changing ^{13}C and fixing Z

2D vs 3D



^{92}Mo
^{94}Mo
^{196}Hg
log(X$_i$)
−5
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Peak Temperature (10⁹ K)