Upgrading the neutron-capture and decay rates of Monash nucleosynthesis code

18th Russbach School on Nuclear Astrophysics

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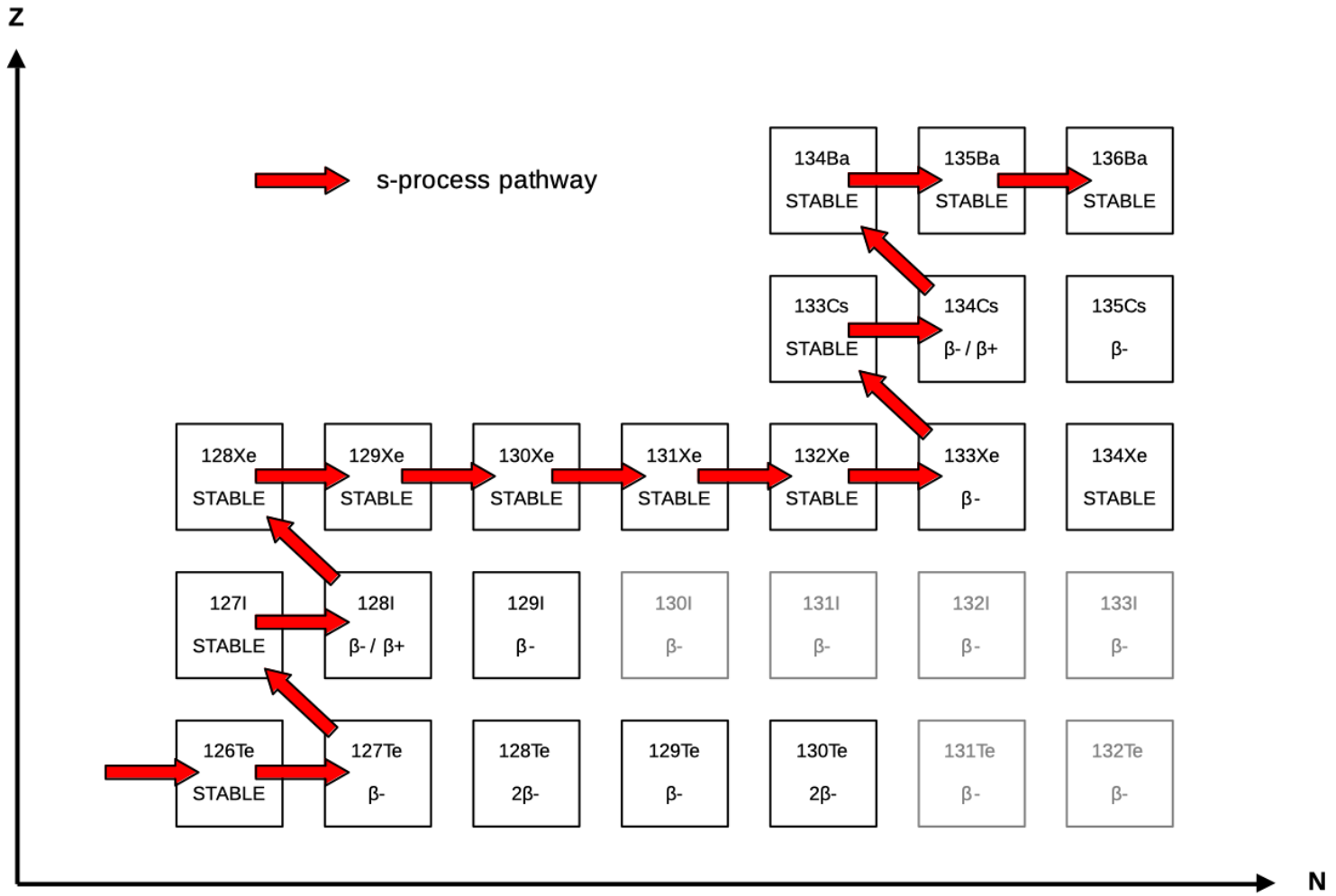
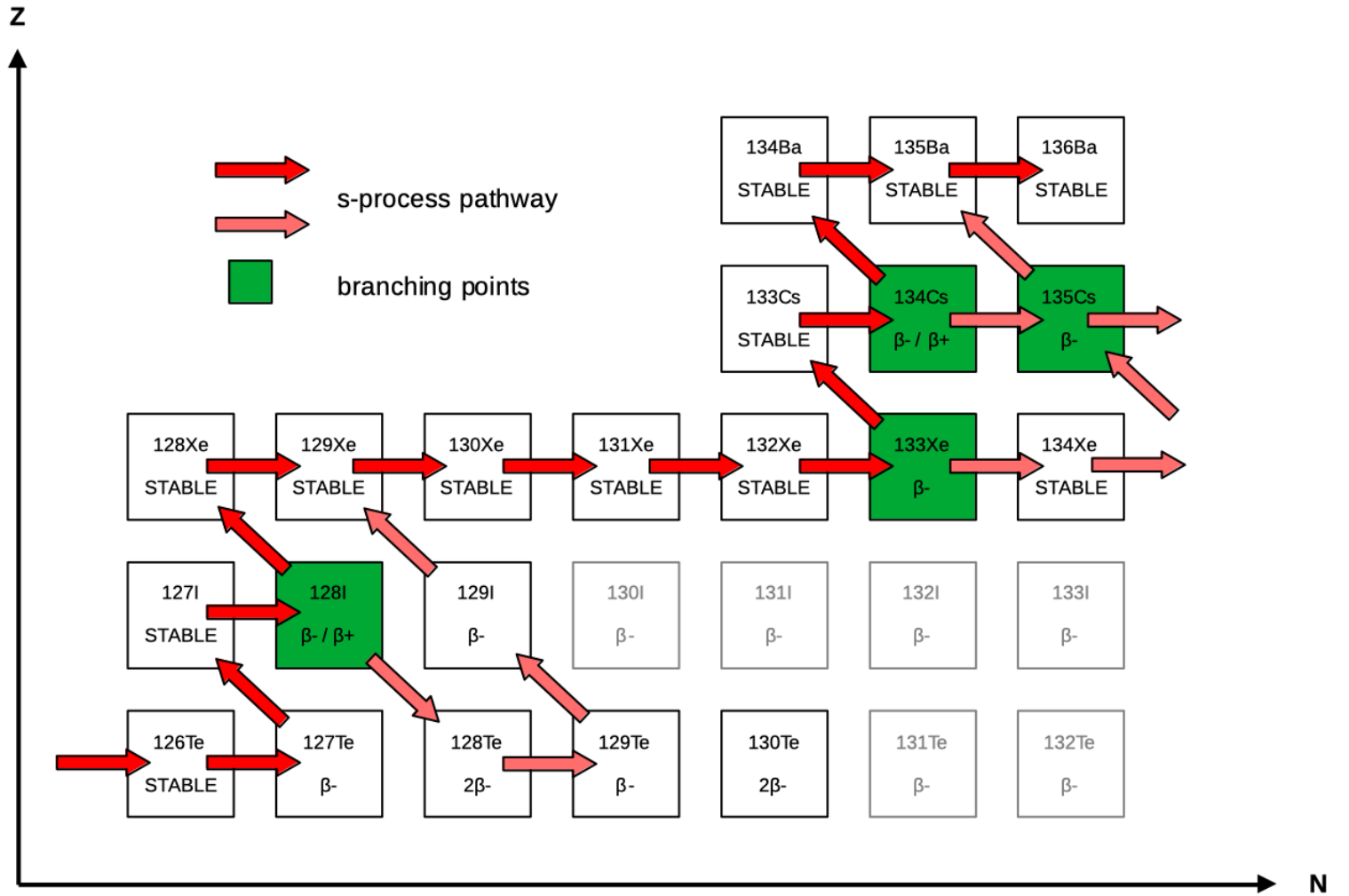
s process


Z
N
s-process pathway
134Ba STABLE
135Ba STABLE
136Ba STABLE
133Cs STABLE
134Cs β- / β+
135Cs β-
128Xe STABLE
129Xe STABLE
130Xe STABLE
131Xe STABLE
132Xe STABLE
133Xe β-
134Xe STABLE
127I STABLE
128I β- / β+
129I β-
130I β-
131I β-
132I β-
133I β-
126Te STABLE
127Te β-
128Te 2β-
129Te β-
130Te 2β-
131Te β-
132Te β-

Branching points



Importance of theoretical stellar nucleosynthesis calculations

- Direct comparison between predicted stellar abundances and observations
- Interpretation of chemical abundances from stellar spectra
- Interpretation of the composition of stable and radioactive isotopes in meteoric components

Monash NS code

- Developed in the 1990s by John Lattanzio and Robert Cannon
- *Monash* stellar structure evolution code $\rightarrow$ *Monash* post-processing nucleosynthesis code
- 328-species nuclear network
  - including all the isotopes on the s-process path (up to Po)
- Reaction network mostly based on the JINA REACLIB database (Set0)
  - Constant radioactive decay and electron capture rates

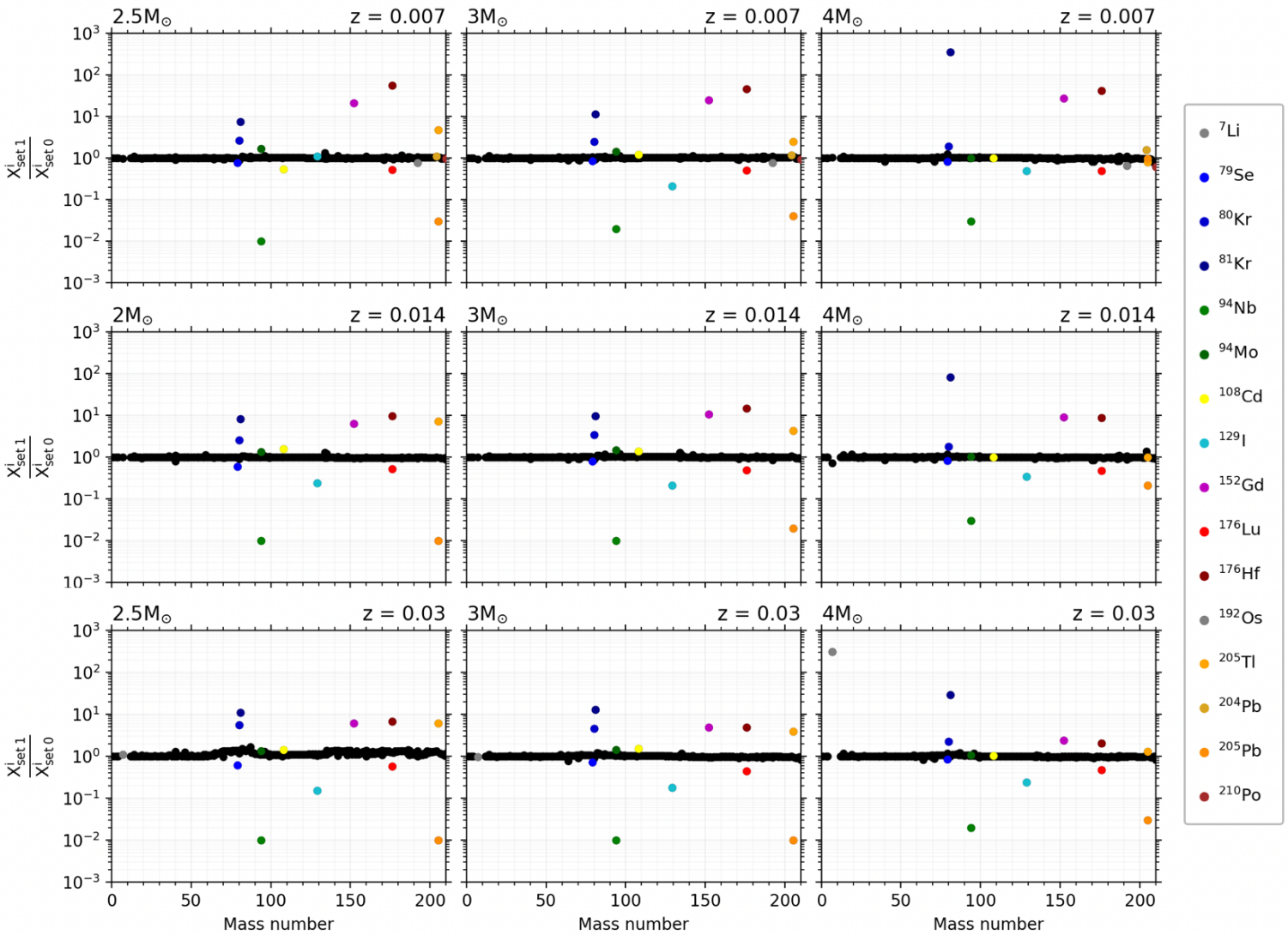
Monash NS code

- **Because of the operation of the branching points, the temperature and density-dependent decay rates are essential for the accurate study of the s-process in AGB stars**

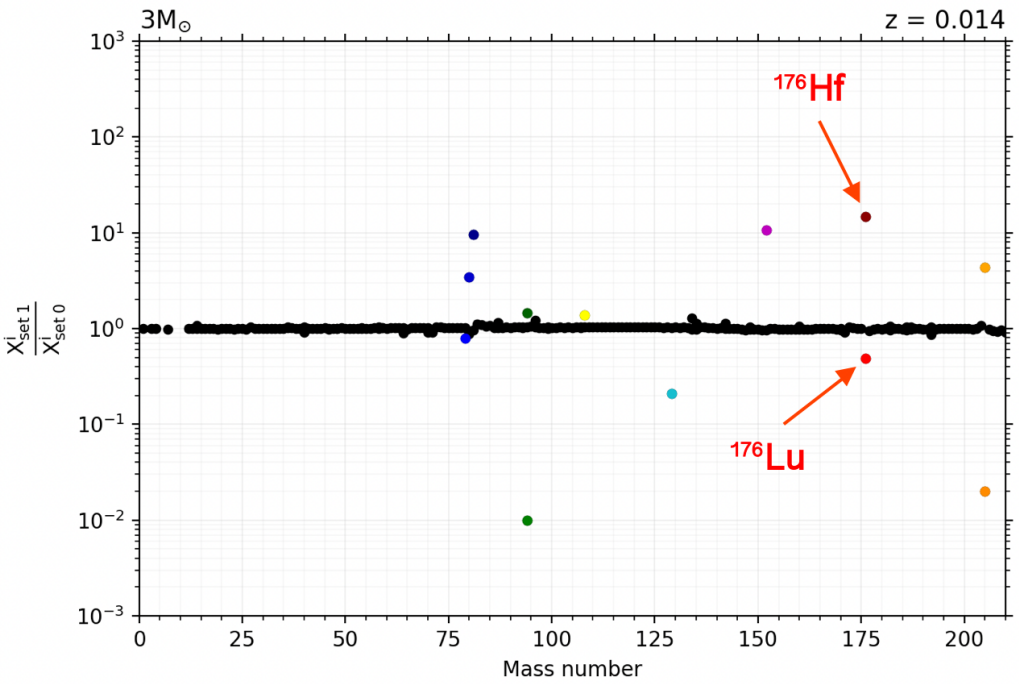
- New input physics in the code:
  - Temperature and density-dependent radioactive decay and electron captures rates from NETGEN database (Set1, 113 reactions)

  - Upgraded neutron-capture network with re-evaluated experimental MACS from ASTRAL database (Set2, 94 reactions)

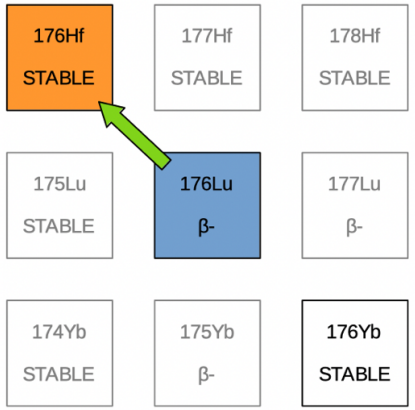
Set1 vs Set0

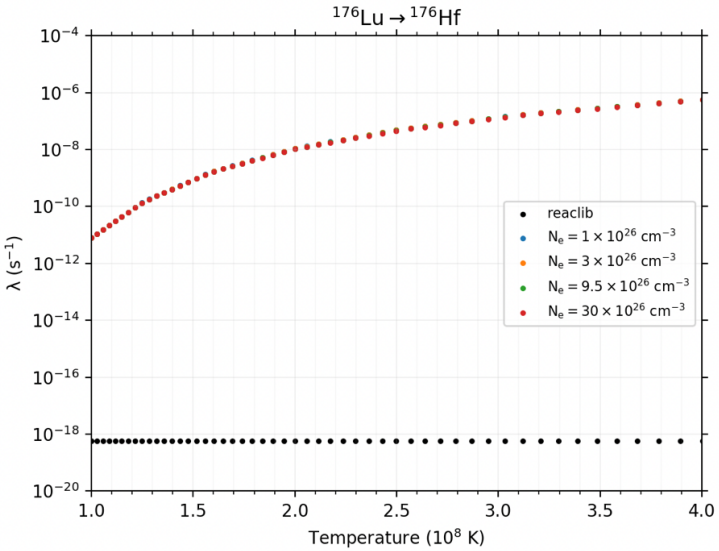

2.5M⊙ z = 0.007
3M⊙ z = 0.007
4M⊙ z = 0.007
2M⊙ z = 0.014
3M⊙ z = 0.014
4M⊙ z = 0.014
2.5M⊙ z = 0.03
3M⊙ z = 0.03
4M⊙ z = 0.03
$X^i_{set\,1} / X^i_{set\,0}$
Mass number
^{7}Li
^{79}Se
^{80}Kr
^{81}Kr
^{94}Nb
^{94}Mo
^{108}Cd
^{129}I
^{152}Gd
^{176}Lu
^{176}Hf
^{192}Os
^{205}Tl
^{204}Pb
^{205}Pb
^{210}Po

Set1 vs Set0

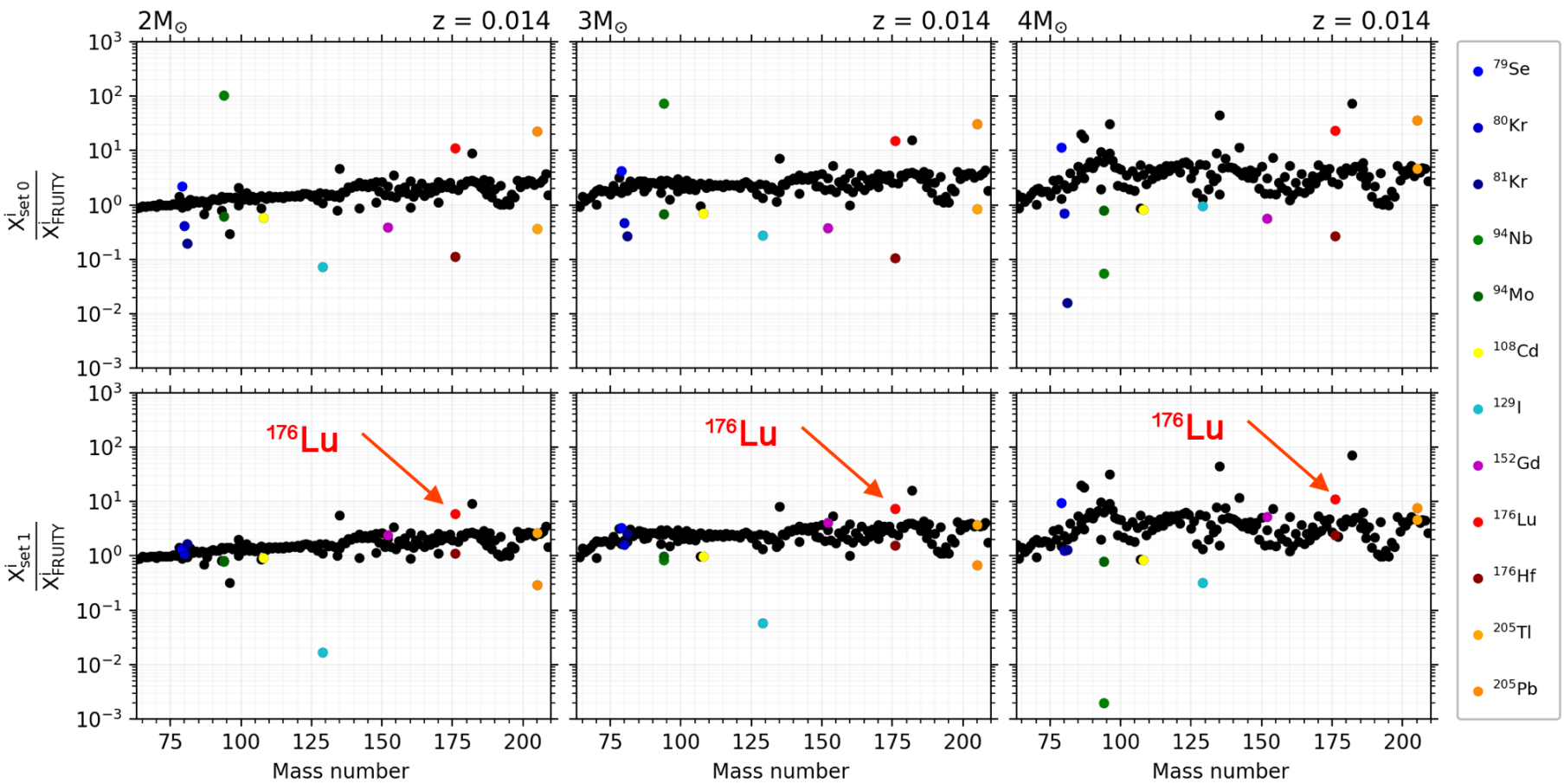


Abundance	solar	set0	set1
^{176}Lu	2.695E-14	3.456E-12	1.695E-12
^{176}Hf	1.889E-13	1.807E-13	2.660E-12
^{176}Lu/^{176}Hf	0.14	19.12	0.64

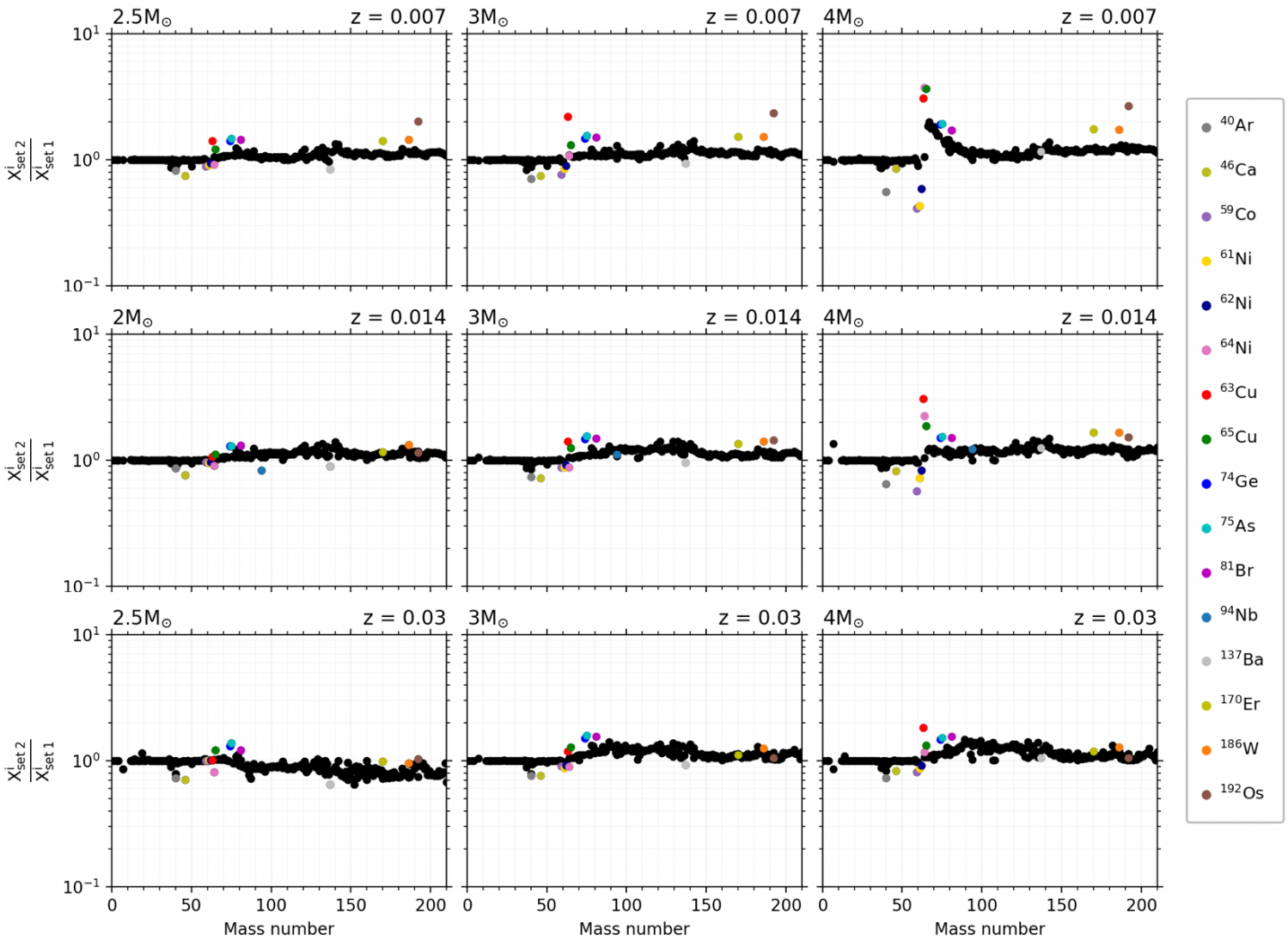




Set1 and Set0 vs FRUITY



Set2 vs Set1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2M⊙ z = 0.014
3M⊙ z = 0.014
4M⊙ z = 0.014
2.5M⊙ z = 0.03
3M⊙ z = 0.03
4M⊙ z = 0.03
$\frac{X^i_{set\,2}}{X^i_{set\,1}}$
Mass number
^{40}Ar
^{46}Ca
^{59}Co
^{61}Ni
^{62}Ni
^{64}Ni
^{63}Cu
^{65}Cu
^{74}Ge
^{75}As
^{81}Br
^{94}Nb
^{137}Ba
^{170}Er
^{186}W
^{192}Os

Future plans

- Interpreting the results of Set2
- Comparing the predictions of the upgraded code with stardust grains measurements
- Continuous updating of the network based on new research results

Thank you for your attention!