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SIMPLE: a new tool to study isotopic anomalies in meteorites

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What is SIMPLE

- Stellar Interpretation of Meteoritic Data and PLotting for Everyone (SIMPLE)
- Supported by ChETEC INFRA and developed by M. Pignatari, G. Makhatadze, M. Ek, G. Balázs and WP9 Budapest team
- Motivation: provide a tool for comparing meteoritic data with theoretical CCSNe models
- Several capabilities: abundance plots, isotopic ratios etc.

HAA-SÜLYSAP Ex-Konkoly Observatory 0.5 m astrograph

NWA 14150 from Tamás Szklenár

What are inside?

- In SIMPLE we use 6 model sets with 15, 20 and 25 $M_{\odot}$& Z=0.02 and non rotating stars

- The model sets are:
  - Rauscher et al. 2002, ApJ, 576, 323 – Ra02
  - Pignatari et al. 2016b, ApJS, 225, 24 – Pi16
  - Ritter et al. 2018b, MNRAS, 480, 538 – Ri18
  - Sieverding et al. 2018, ApJ, 865, 143 – Si18
  - Limongi, M., Chieffi, A., 2018, ApJS, 237,13L – LC18
  - Lawson et al. 2022, MNRAS, 511, 886 – La22

Structure of the ejecta

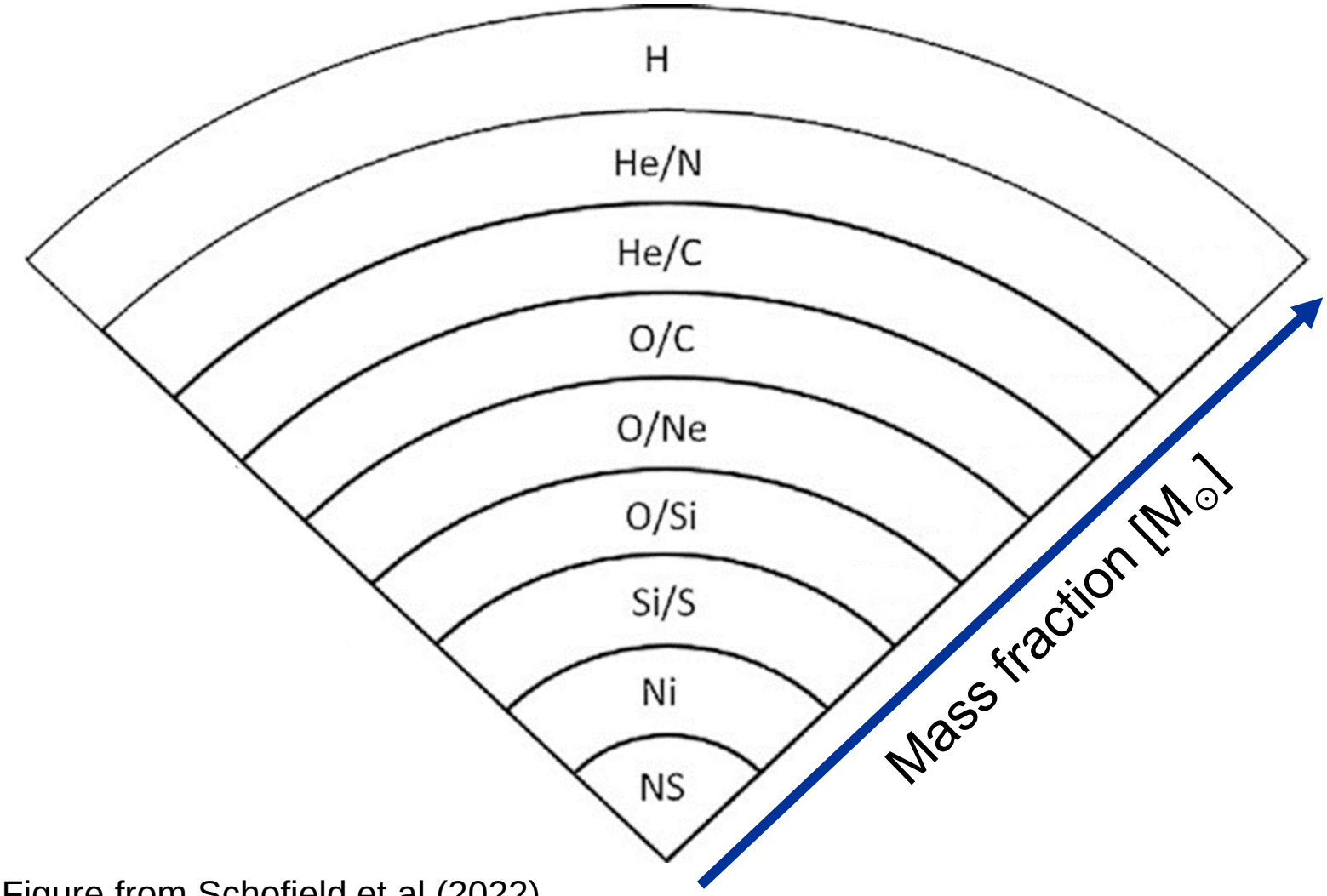


Figure from Schofield et al.(2022)

Structure of the ejecta identified by the one or two most dominant nuclear species in each layer

Not necessarily corresponding to the nuclear burning shells of the progenitor star

Structure of the ejecta

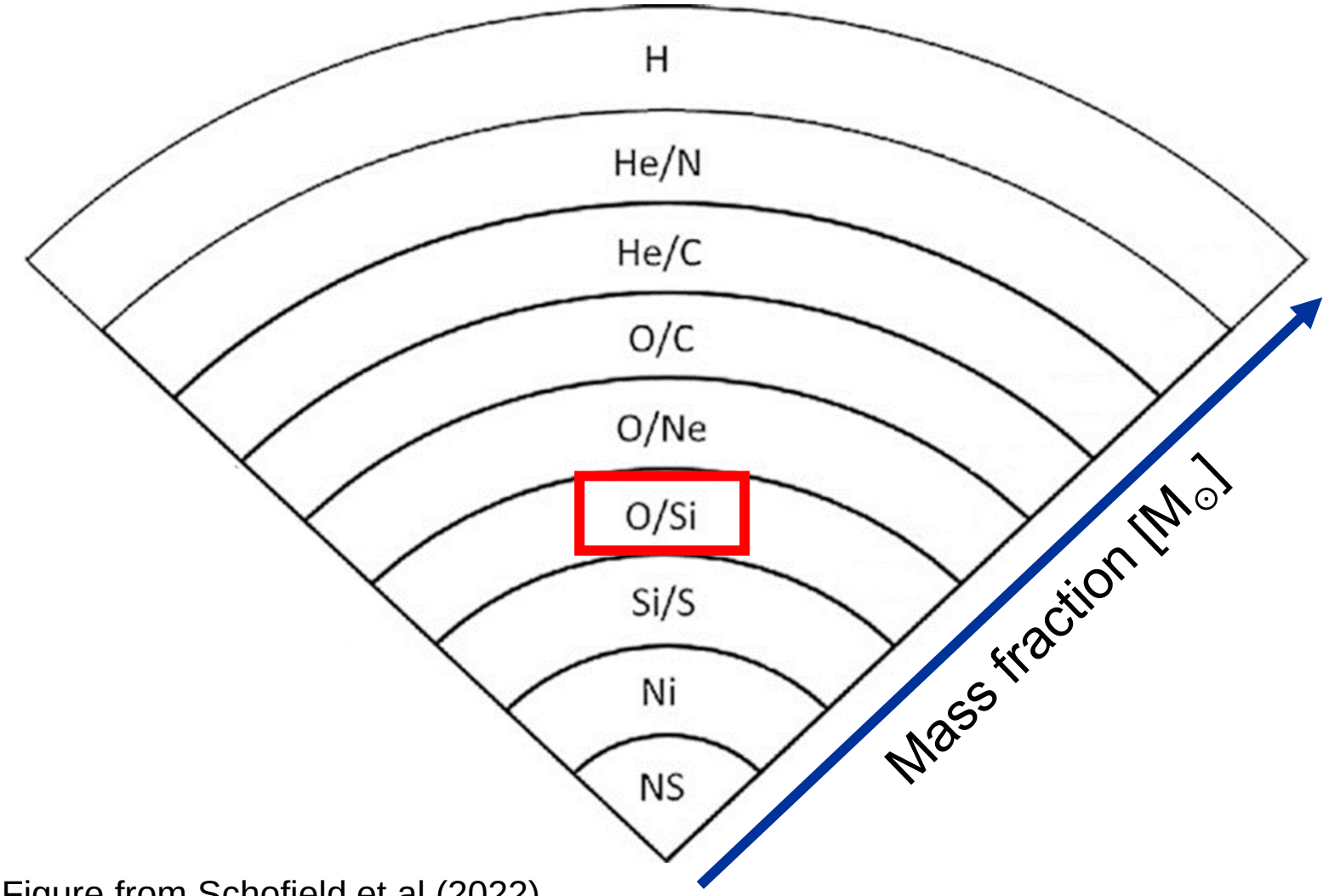


Figure from Schofield et al.(2022)

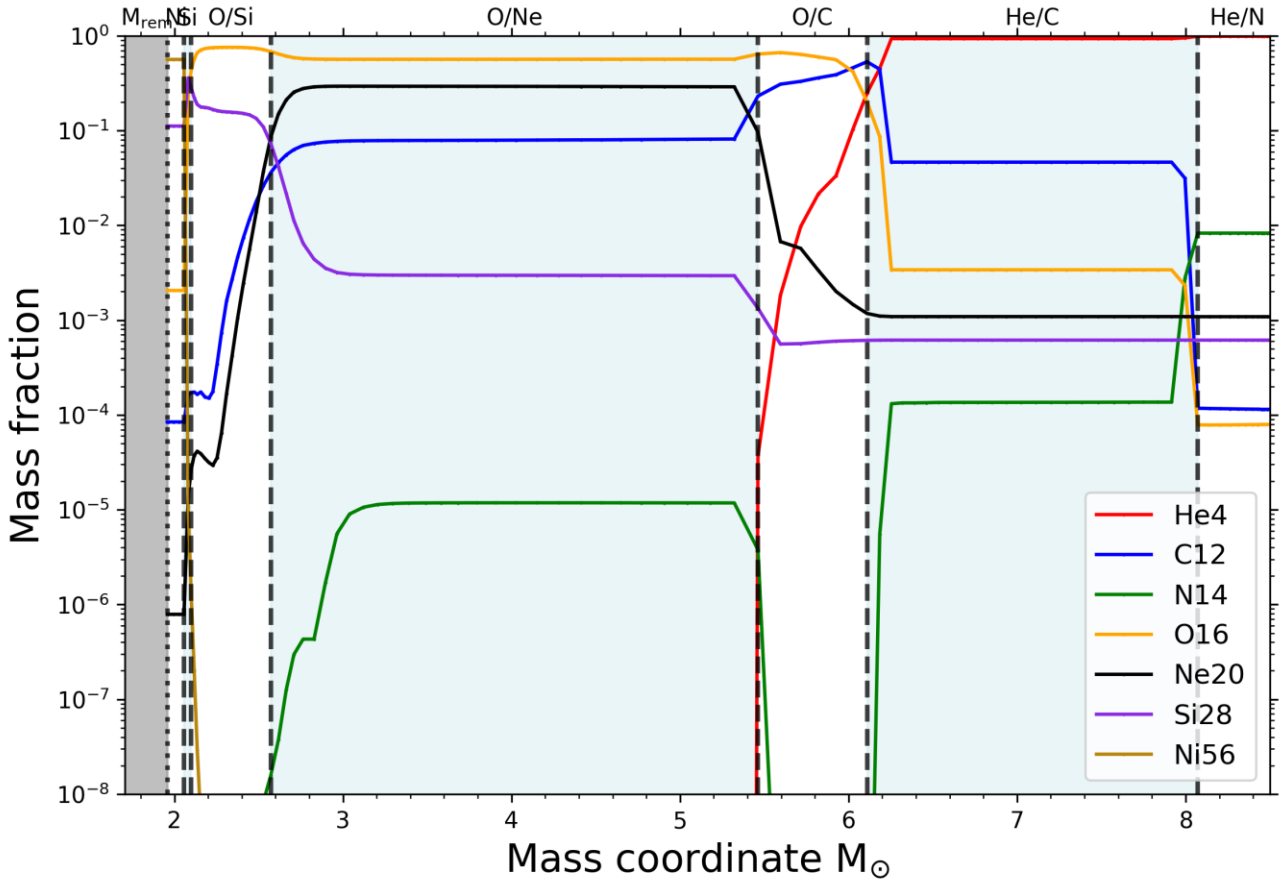
Structure of the ejecta identified by the one or two most dominant nuclear species in each layer

Not necessarily corresponding to the nuclear burning shells of the progenitor star

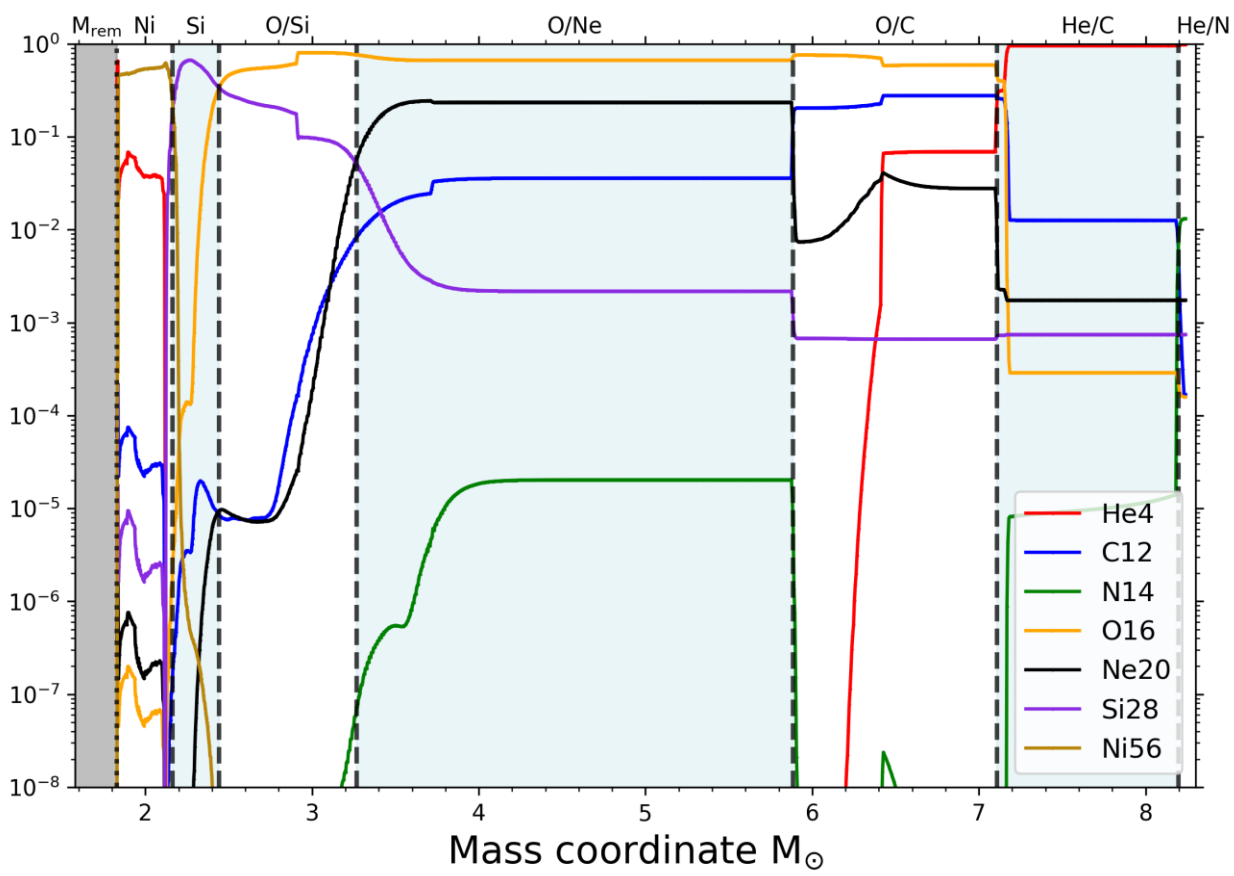
Important for the p production of the p nuclei:
O/Si ≈ explosive Ne
(T ≈ 3.3 - 2.1 GK)

Basic structure of the CCSN ejecta

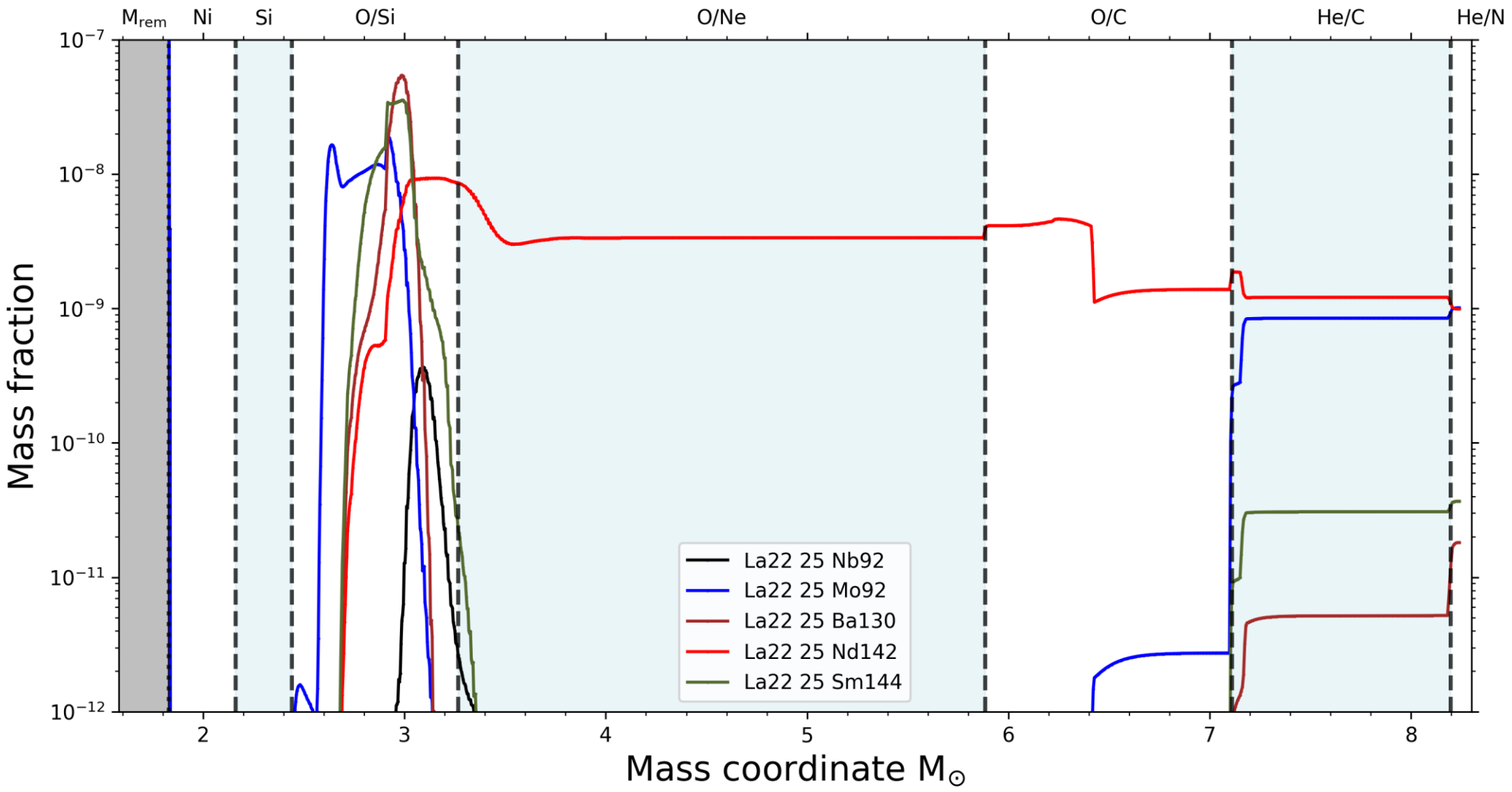
LC18 25 $M_\odot$



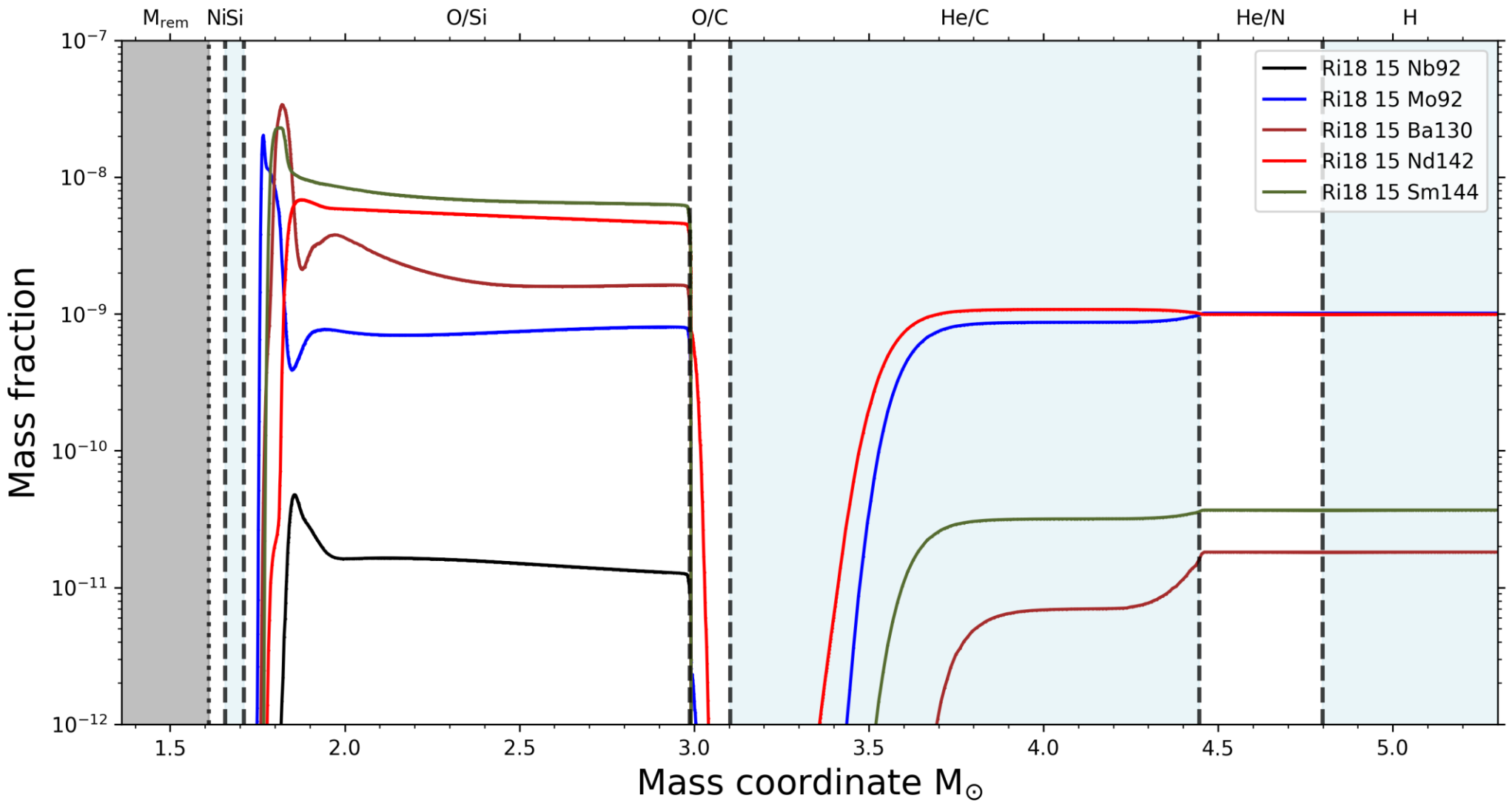
La22 25 $M_\odot$



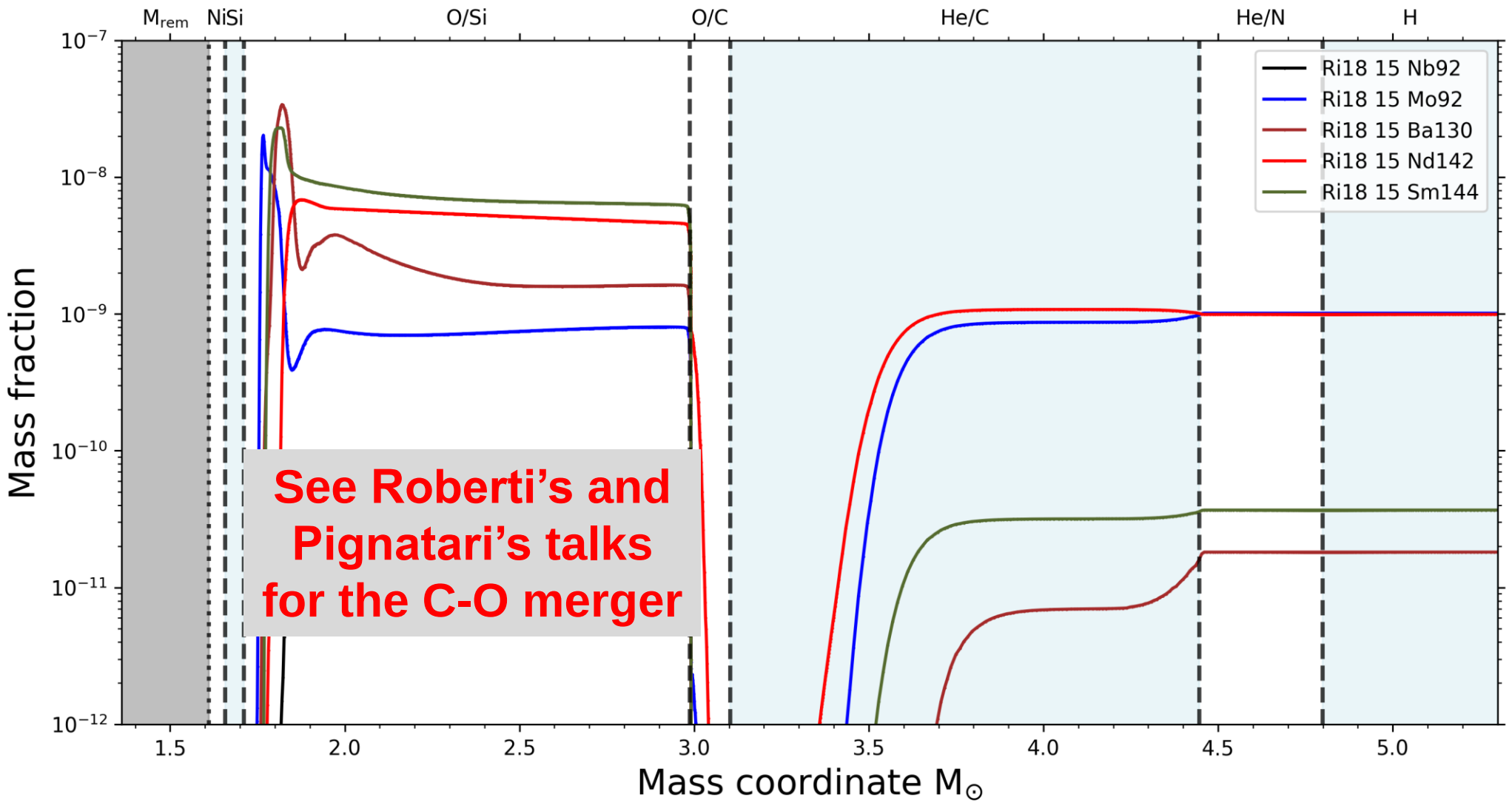
The p nuclei


M_rem
Ni
Si
O/Si
O/Ne
O/C
He/C
He/N
Mass fraction
Mass coordinate M⊙
La22 25 Nb92
La22 25 Mo92
La22 25 Ba130
La22 25 Nd142
La22 25 Sm144

The p nuclei


M_rem
NiSi
O/Si
O/C
He/C
He/N
H
Ri18 15 Nb92
Ri18 15 Mo92
Ri18 15 Ba130
Ri18 15 Nd142
Ri18 15 Sm144
Mass fraction
Mass coordinate M⊙

The p nuclei


M_rem
NiSi
O/Si
O/C
He/C
He/N
H
Ri18 15 Nb92
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Mass fraction
Mass coordinate M⊙
See Roberti's and Pignatari's talks for the C-O merger

Conclusion

- The SIMPLE code is a tool to examine the CCSN yields and compare these data with meteoritic measurements
- SIMPLE will be released soon as an open access code with a basic description of its capabilities available in a reference publication in preparation
- A preliminary version is available on the ChETEC INFRA website
- One of its application will be to examine p-process anomalies in meteorites
- The p-process abundance signatures can change significantly between different CCSN models