Gruppi Italiani di Astrofisica Nucleare Teorica e Sperimentale XII

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Carbon-Oxygen Shell Interactions in Massive Stars: Nucleosynthesis and Implications

Lorenzo Roberti, INFN – Laboratori Nazionali del Sud, Catania, Italy

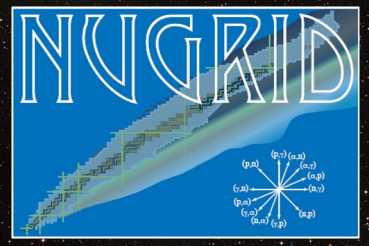
Main collaborations:

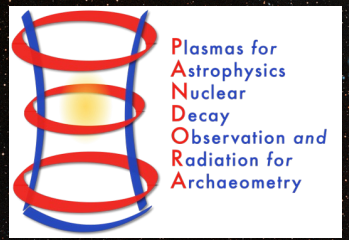
Pandora + AsFiN

Budapest group: M. Pignatari, M. Lugaro

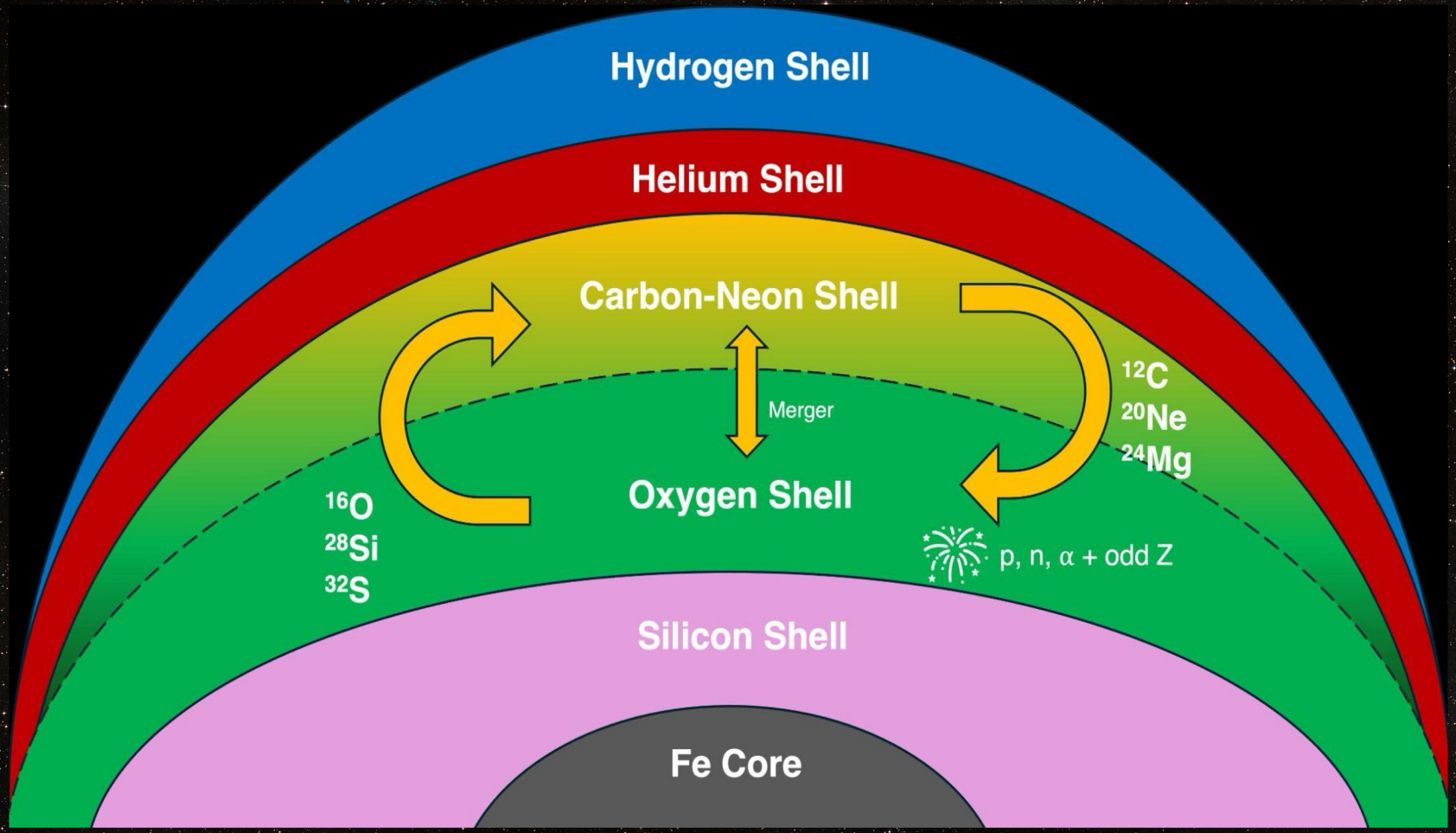
Rome + Berkeley group: M. Limongi, A. Chieffi, A. Falla, L. Boccioli

NuGriD collaboration





Carbon-oxygen shell mergers in massive stars



- Ingestion of some C (and Ne) in the O burning shell during late stages of the evolution;
- Convective-reactive event →Formation of an extended mixed convective zone;
- Peculiar **nucleosynthesis** and impact on the **explodability**;
- Found often in 1D stellar models with $M_{ini} \leq 25\ M_{\odot}$;
- Confirmed by 3D simulations (e.g., Rizzuti+24).

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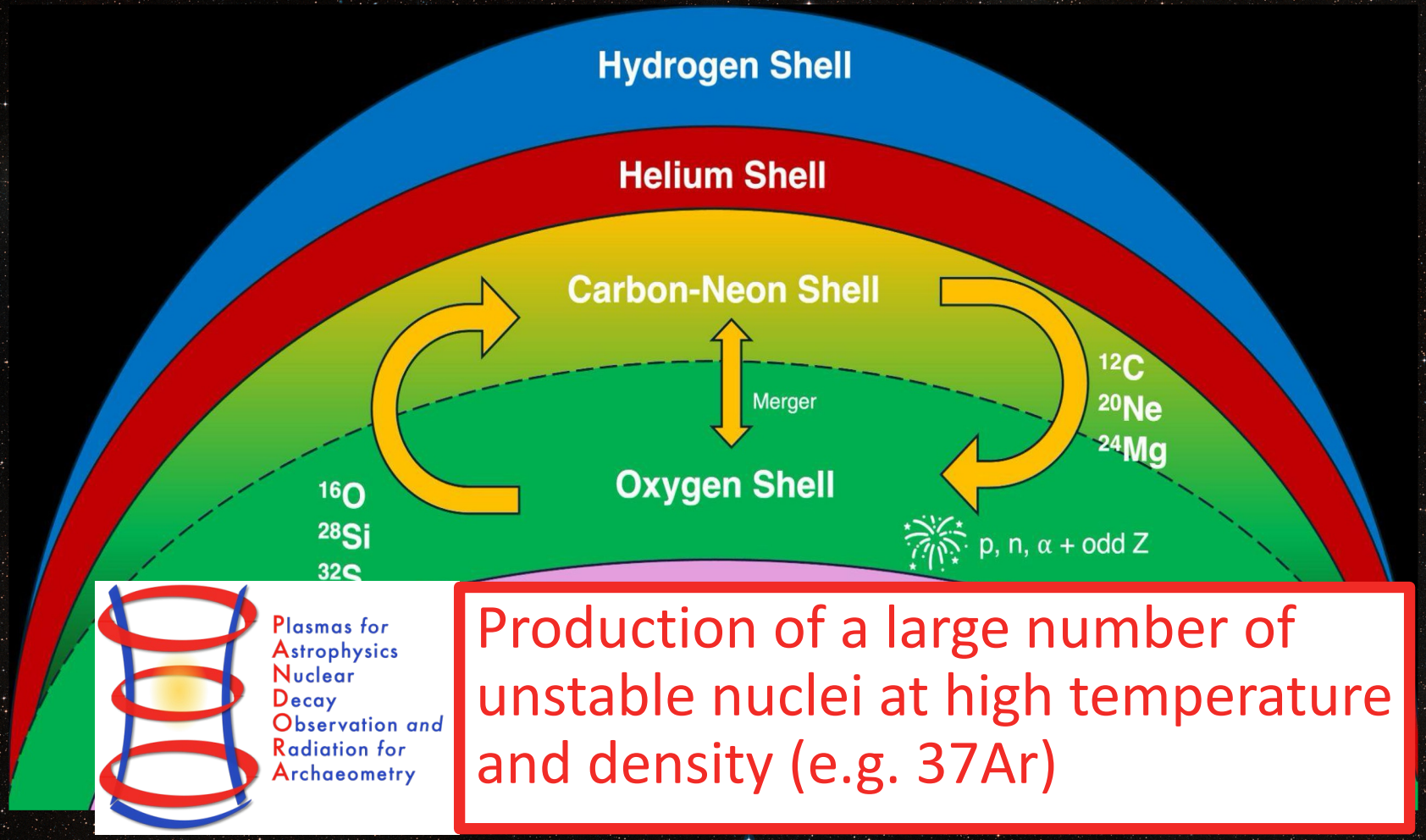

Plasmas for Astrophysics Nuclear Decay Observation and Radiation for Archaeometry

Production of a large number of unstable nuclei at high temperature and density (e.g. 37Ar)

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The occurrence and impact of carbon-oxygen shell mergers in massive stars

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Nucleosynthesis in a C-O shell merger

- Enhanced O-burning products and production of odd-Z elements (P, Cl, K, Sc);

- Efficient photodisintegration of heavy elements: production of the weak s-process and γ-process nuclei.

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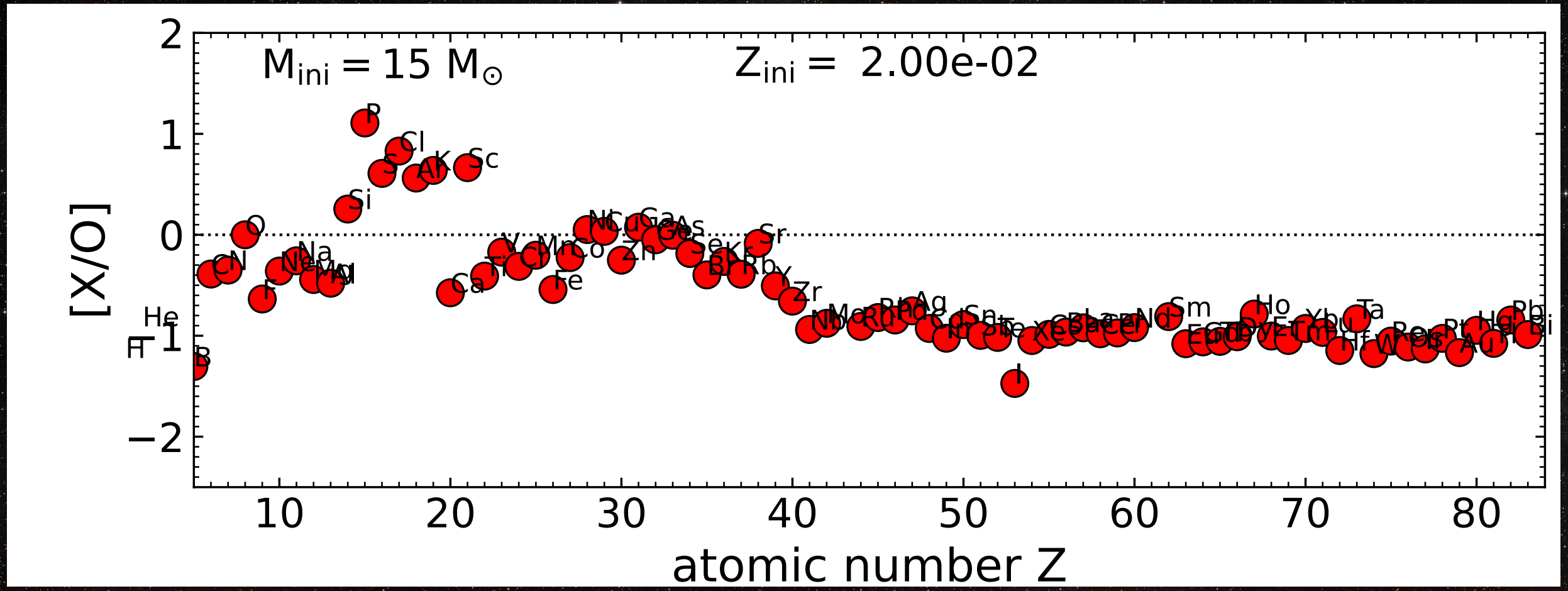

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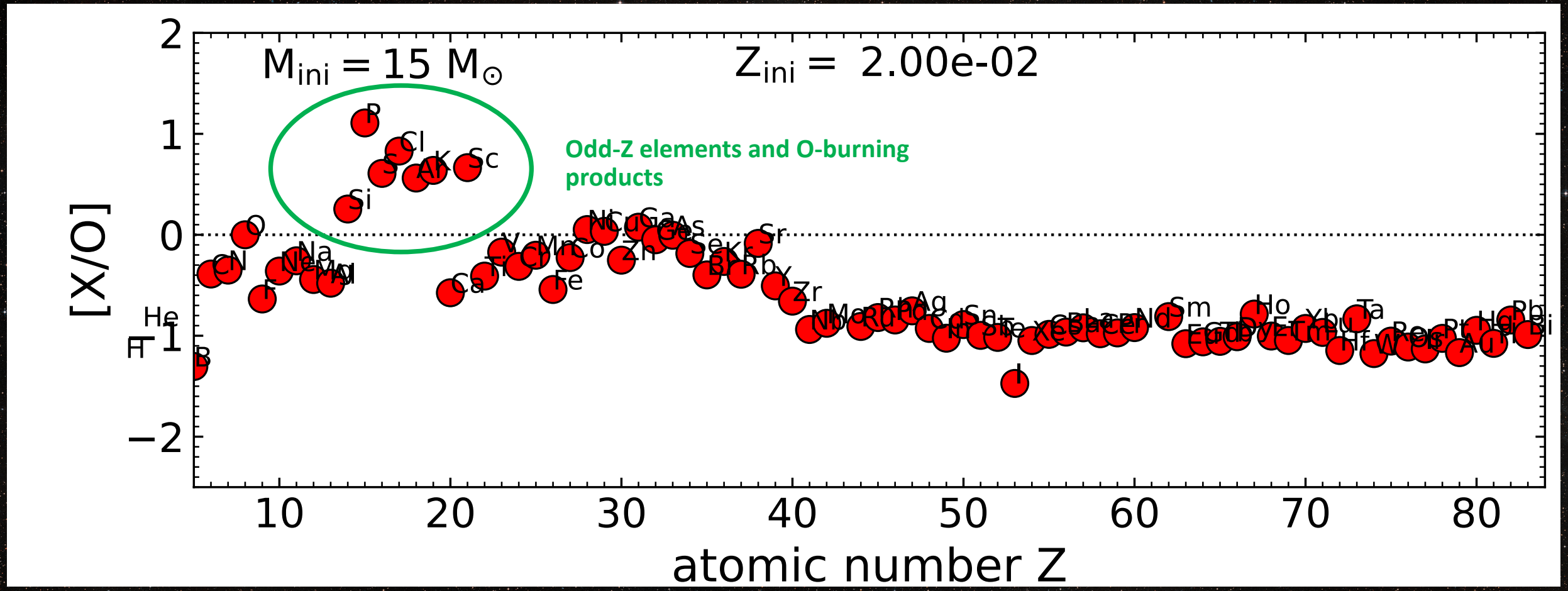

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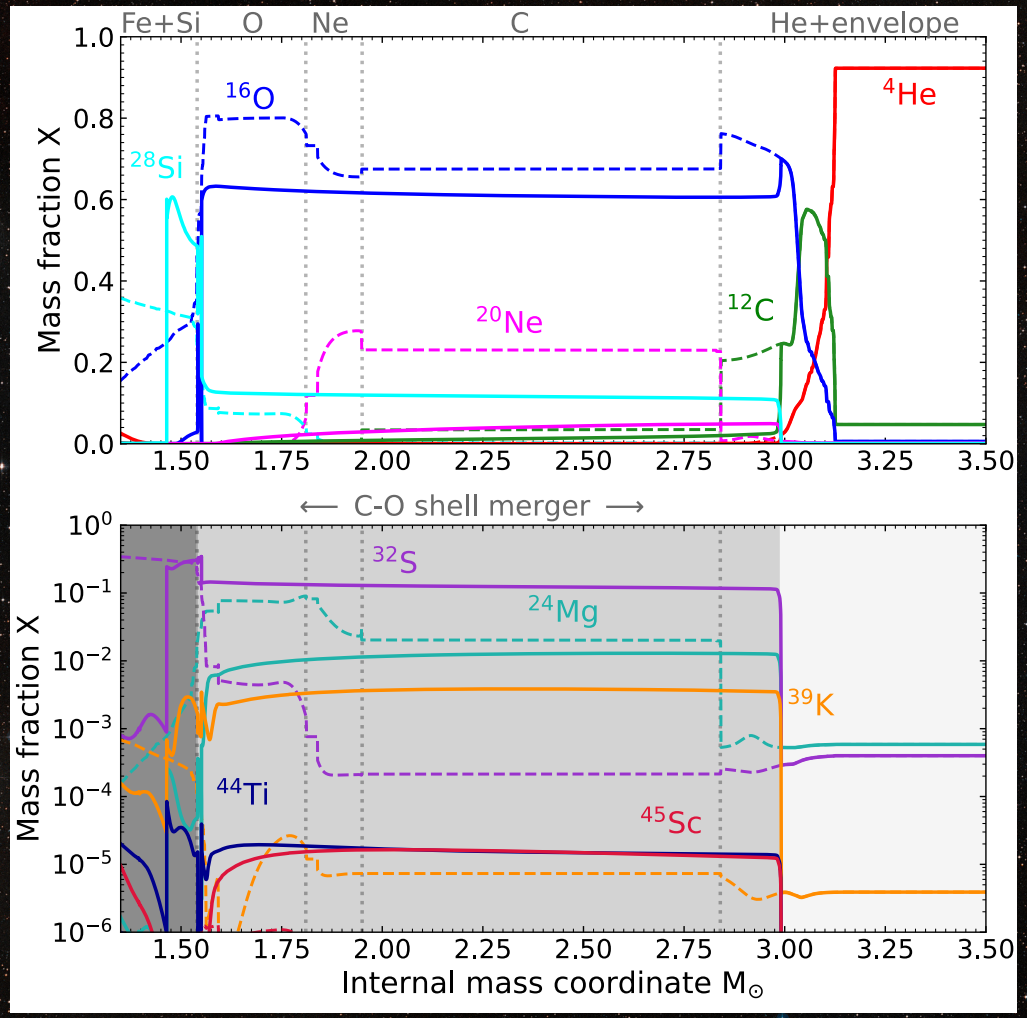

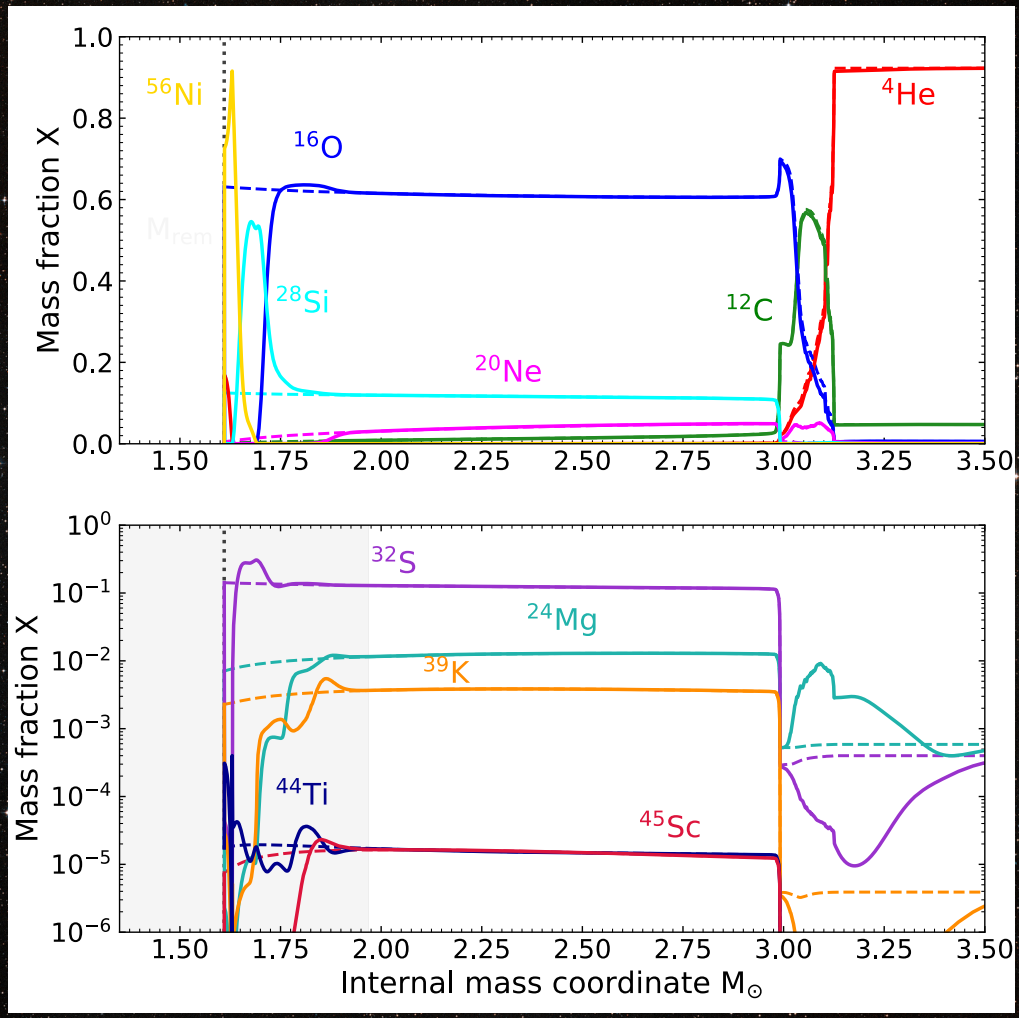

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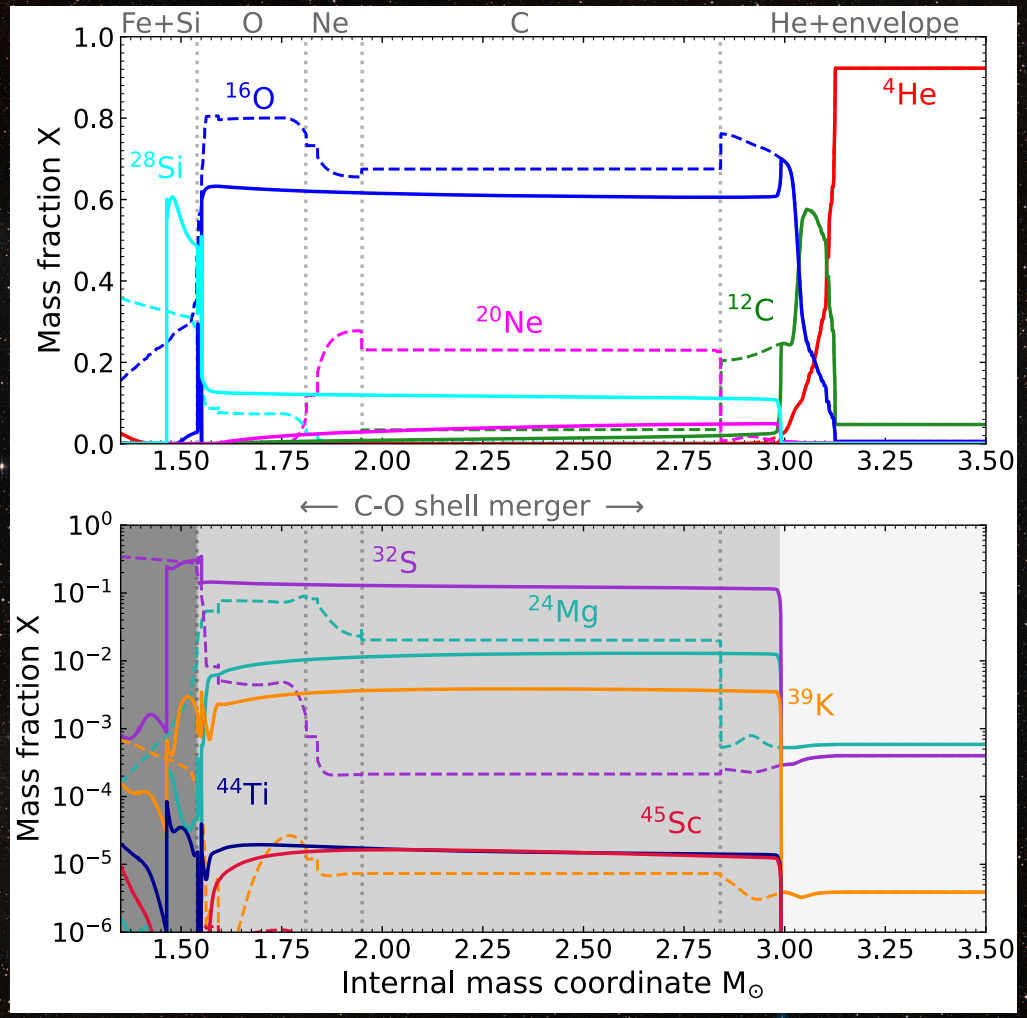
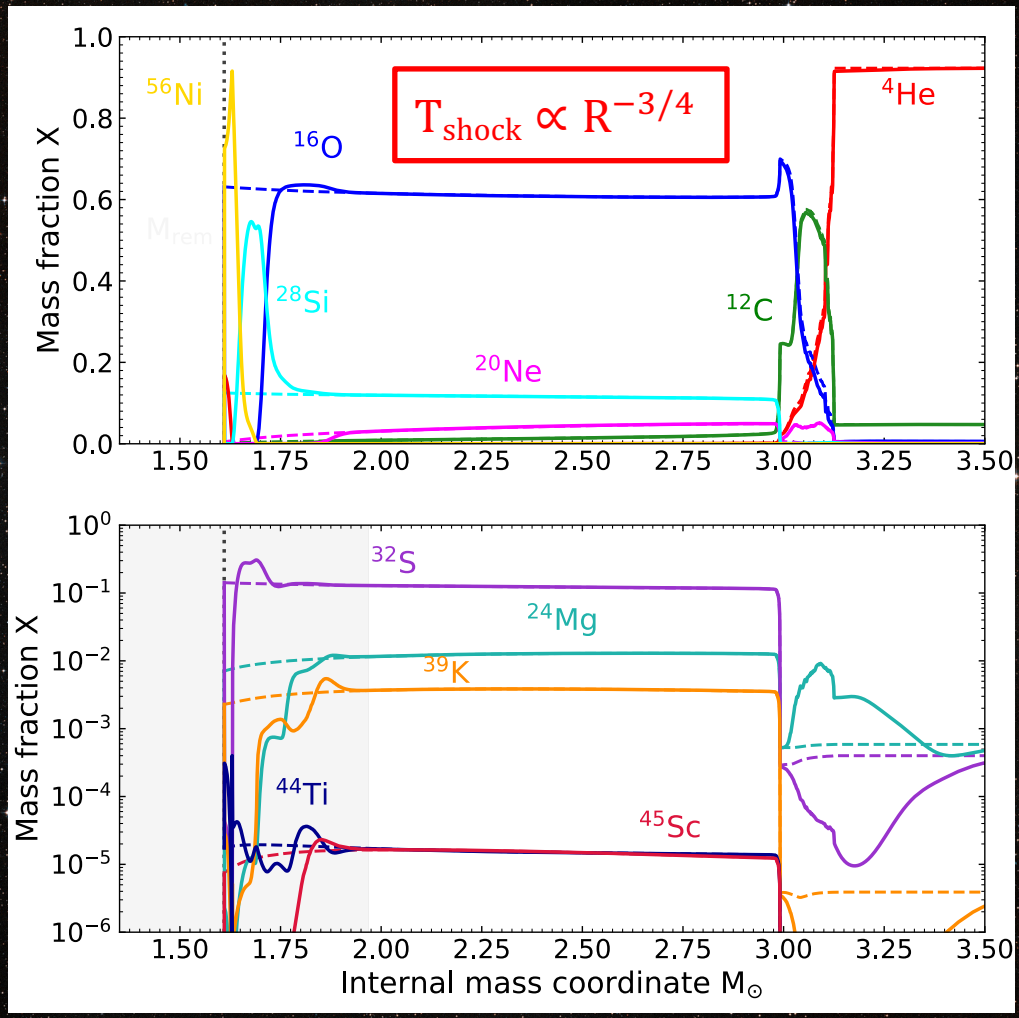
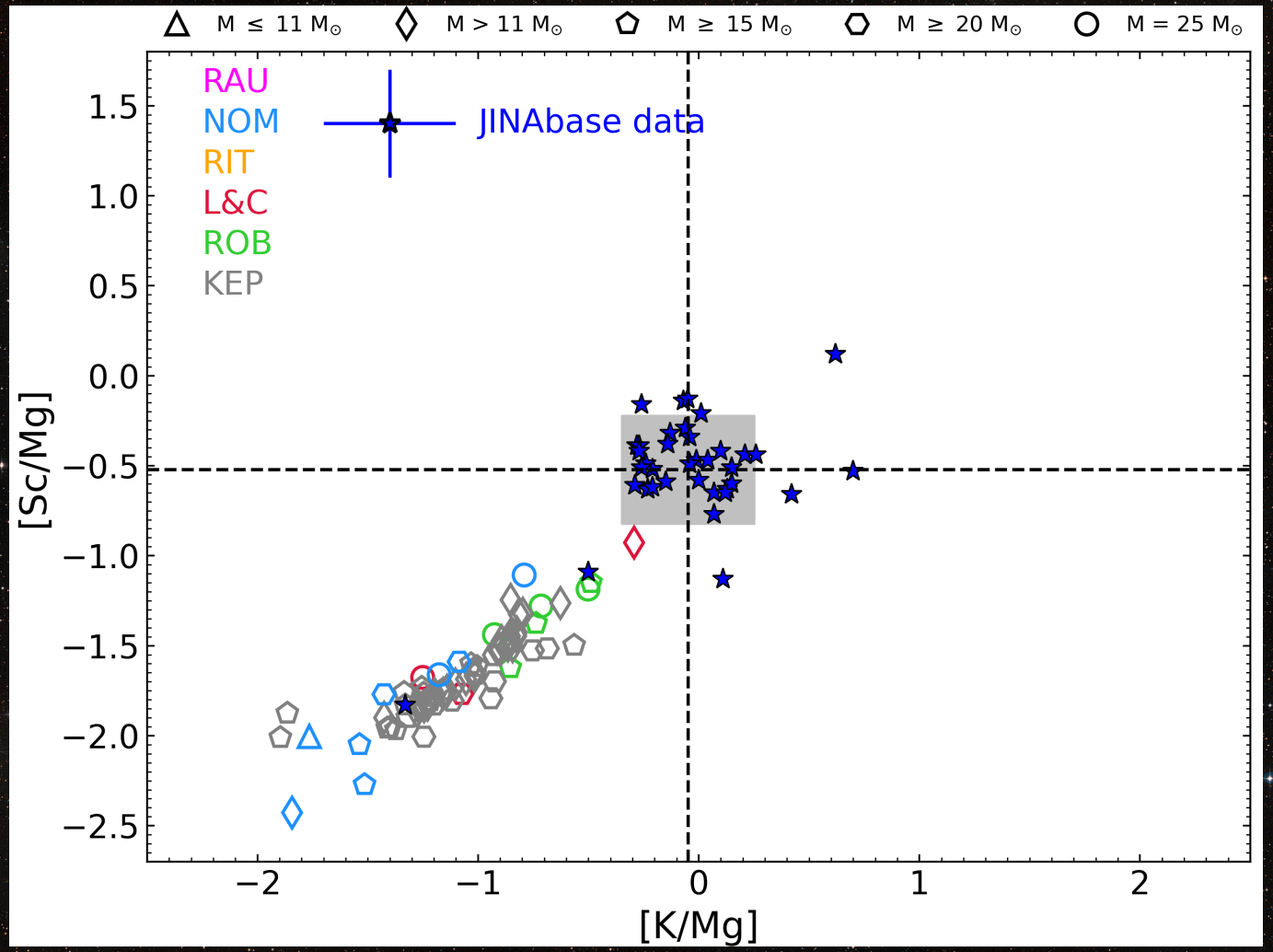




Stellar Archaeology: odd-Z elements



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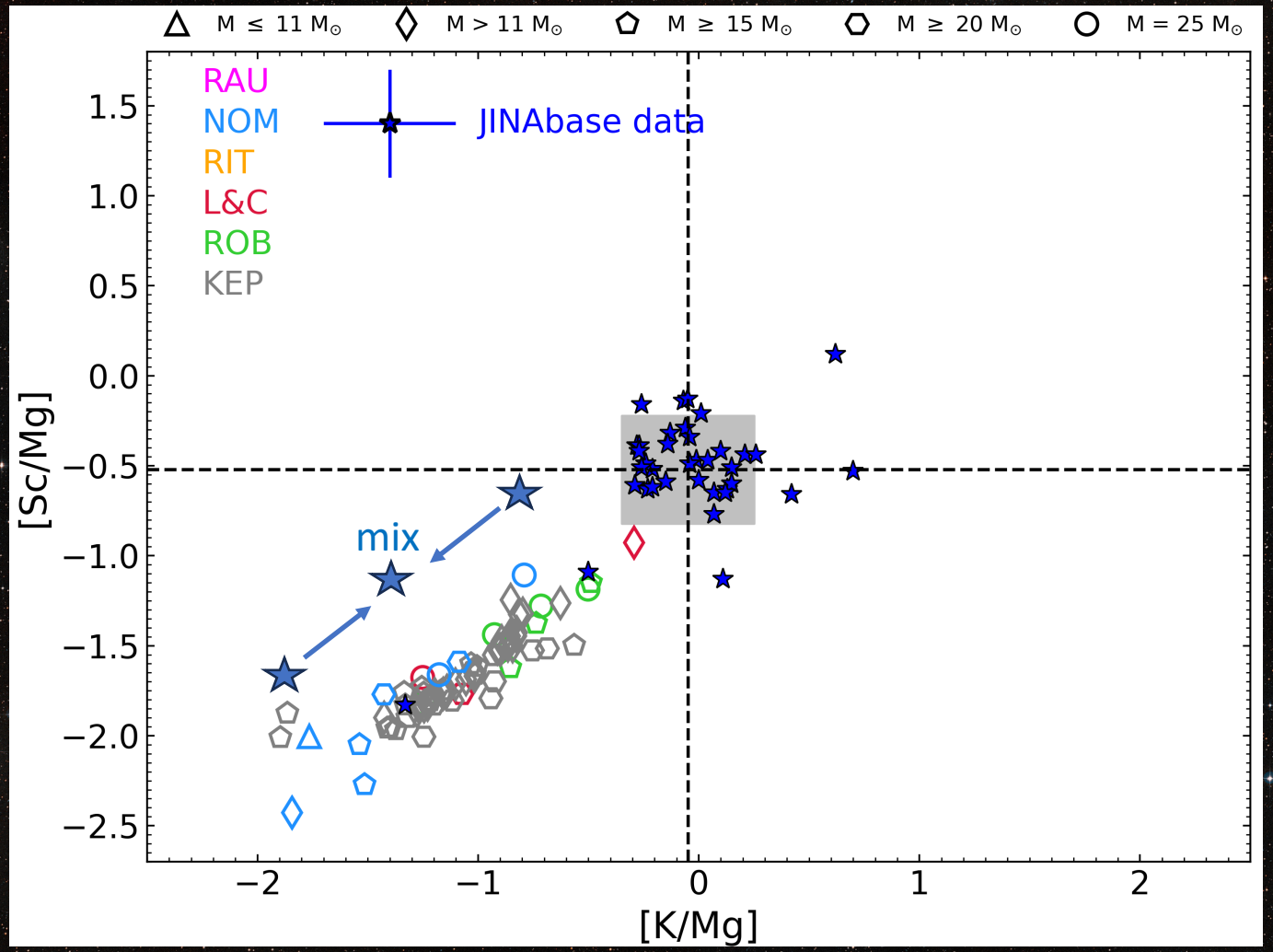

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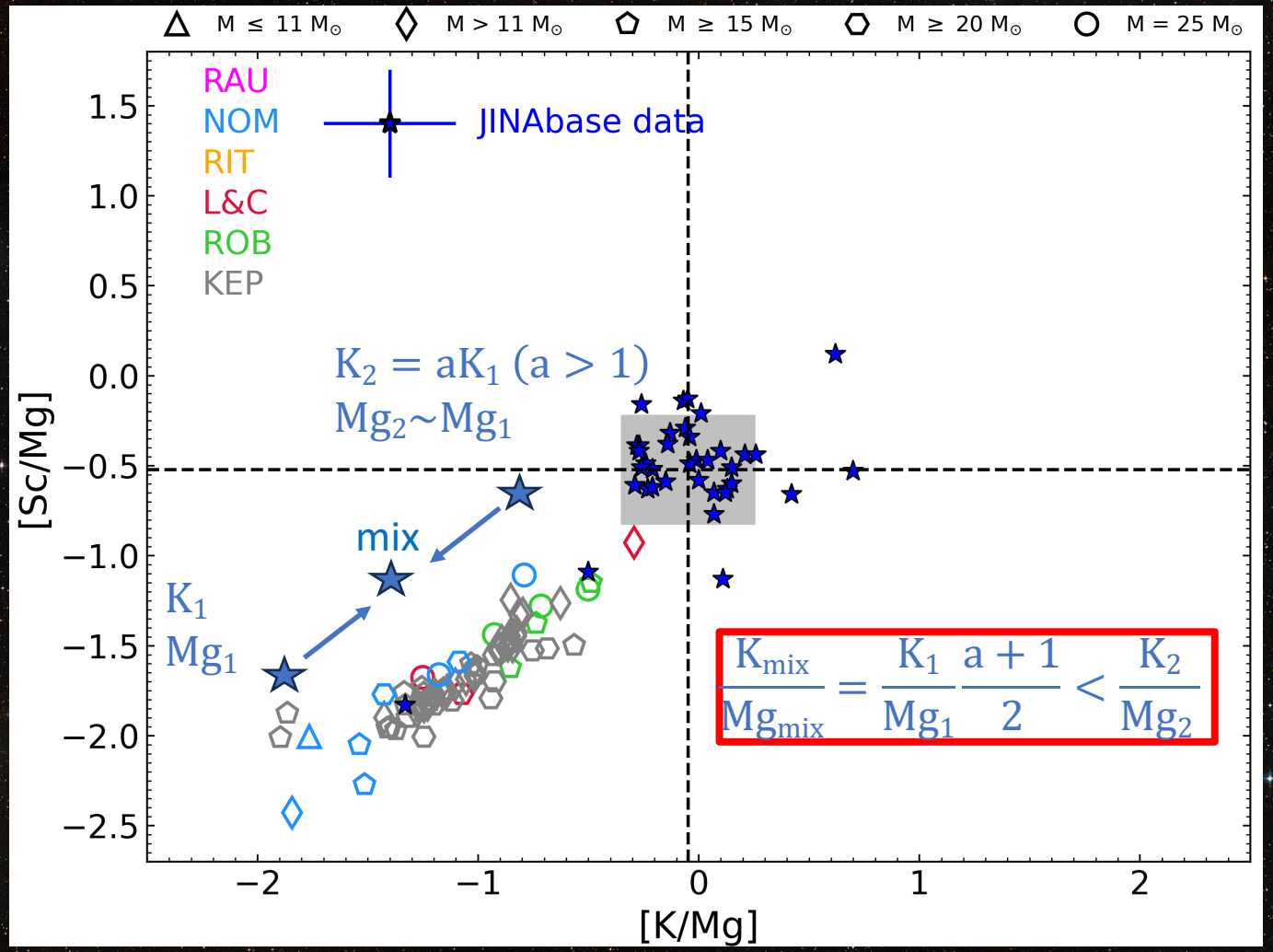

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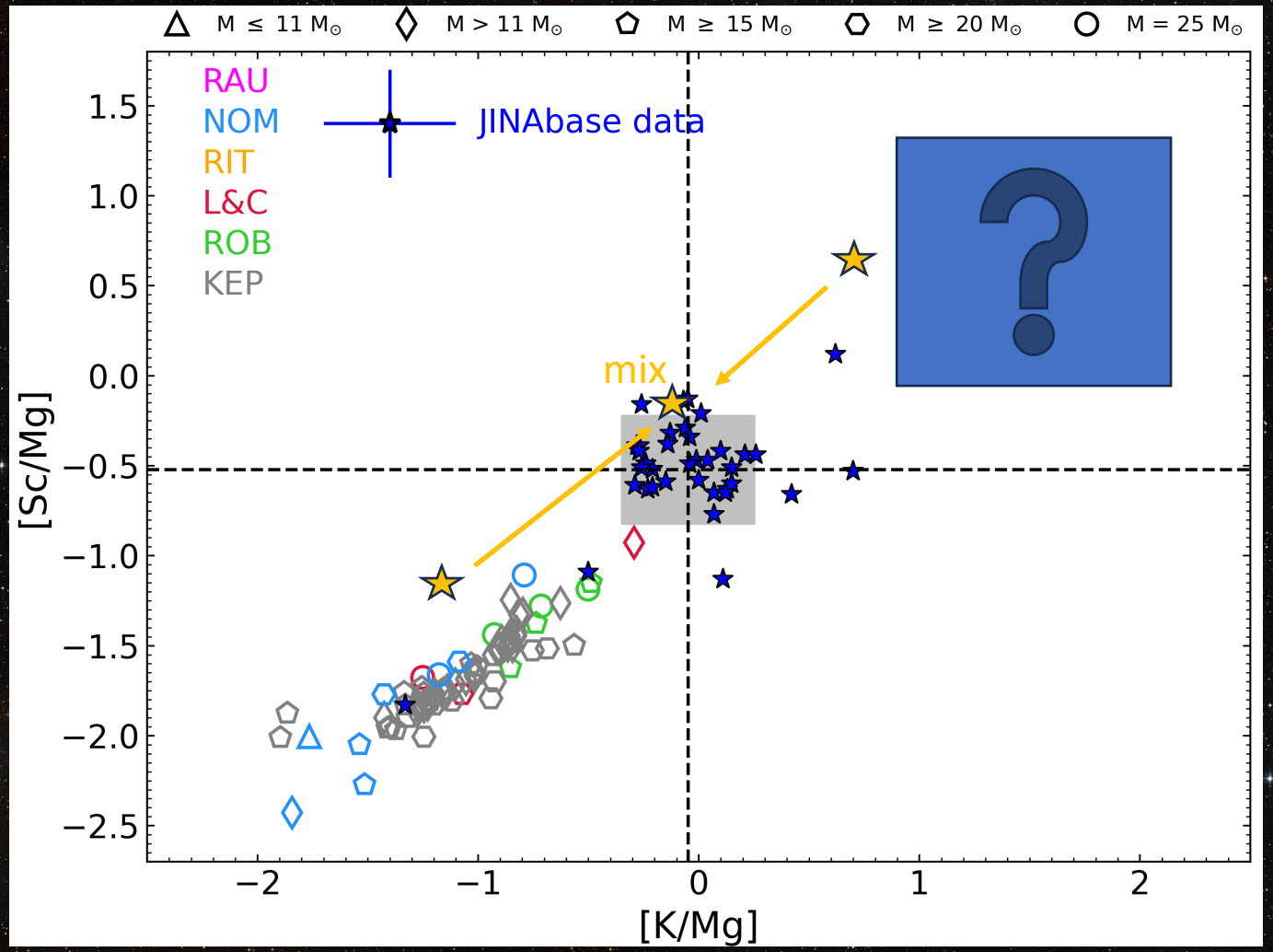

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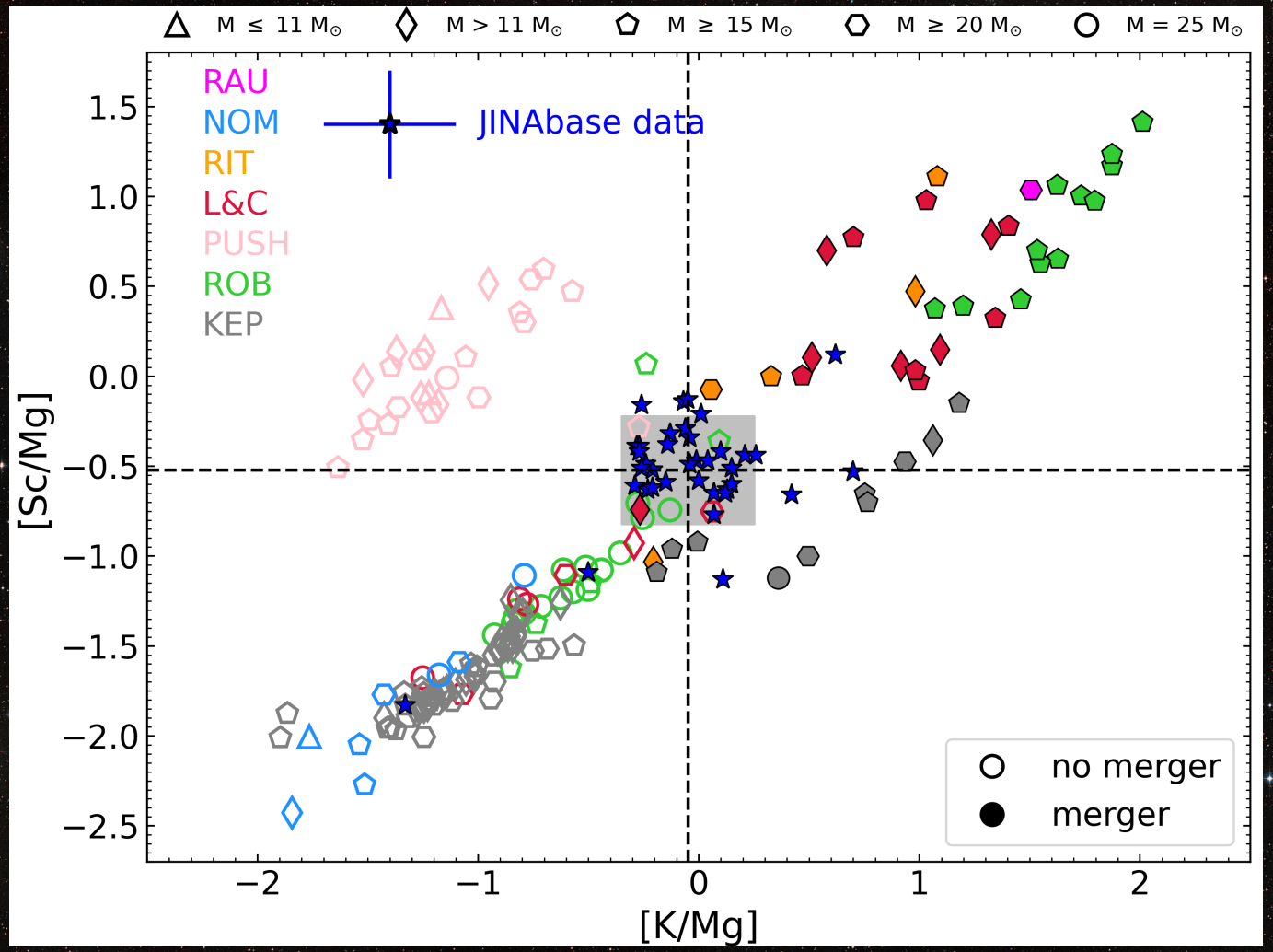

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- Mixing between more stars does not allow the ratios to move to the observations!
- An extra (super-solar) component is required;
- Models with C-O shell mergers naturally populate the required quadrant!

Summary and conclusions

- Carbon-oxygen (C-O) shell mergers in massive stars have a crucial impact on the explosion and on the ejecta composition of CCSNe;
- Indications from 3D modeling seem to confirm their existence;
- Production site for **odd-Z elements**: possible enrichment already in the early universe!
- Large density jump at the Si/O interface because of the extended mixed convective region: easier explosion? **In progress, stay tuned!**
- **Questions**: frequency? Trend with mass/metallicity/rotation? Nuclear physics?

THANK YOU!