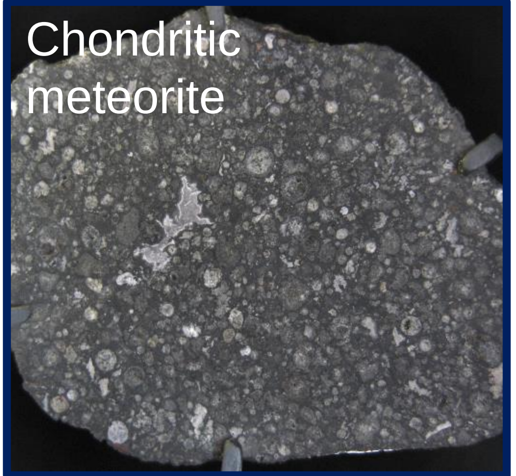
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101008324 (ChETEC-INFRA).

NA4 Mass Spectrometry Network

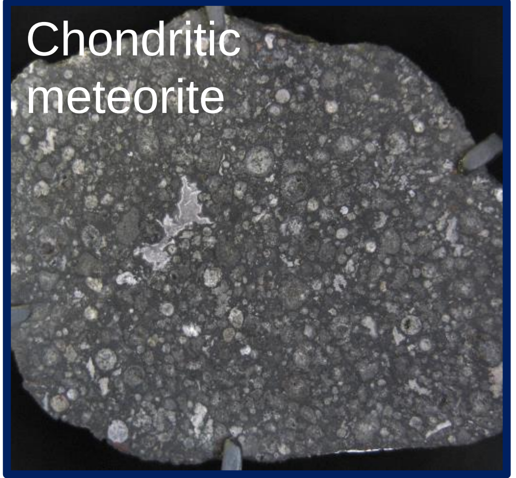
Maria Lugaro (Konkoly Observatory, HU)

NA4 Mass Spectrometry Network: Introduction



Mass Spectrometry analysis of different types of meteorites has revealed **isotopic variations** due to the presence of material (e.g., *stardust*) that preserved the signature of **nuclear reactions** occurring in specific stars.

NA4 Mass Spectrometry Network: Introduction


Chondritic meteorite


Iron meteorite

Mass Spectrometry analysis of different types of meteorites has revealed **isotopic variations** due to the presence of material (e.g., *stardust*) that preserved the signature of **nuclear reactions** occurring in specific stars.

The interpretation of such variations provides evidence for

- the environment of the birth of the Sun,
- the accretion process,
- the evolution of the proto-planetary disk, and
- the formation of the planets.

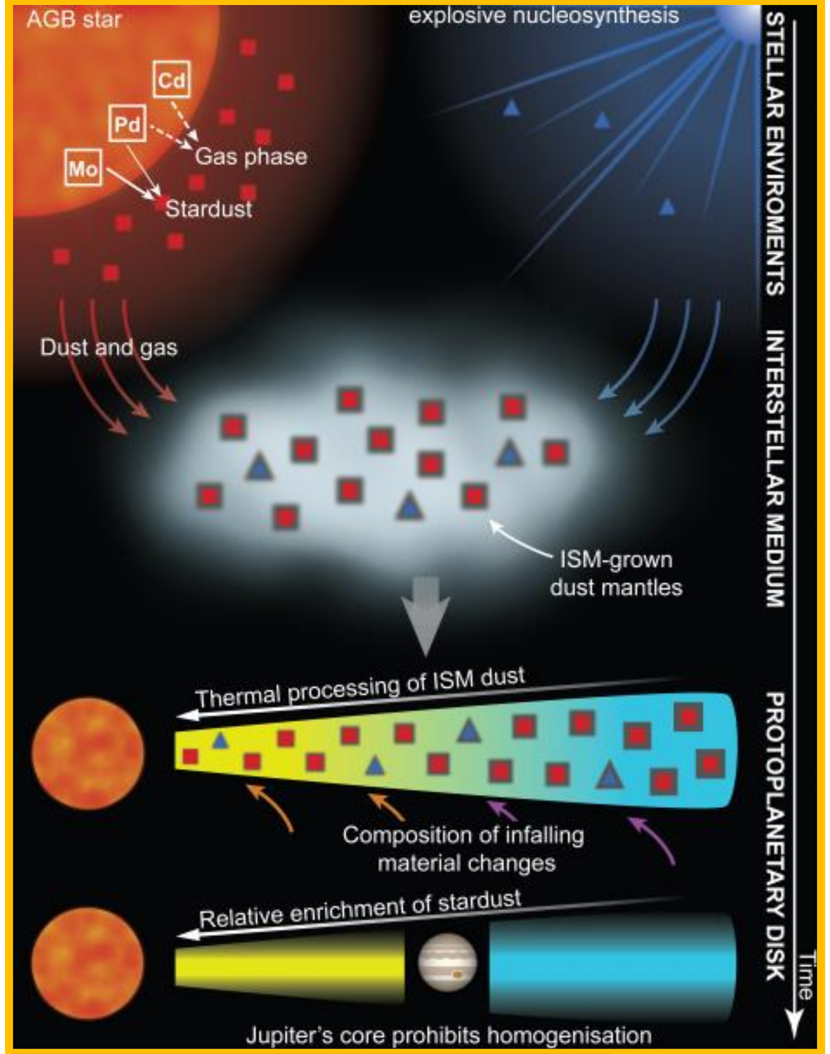


Figure from Ek et al. 2020

NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

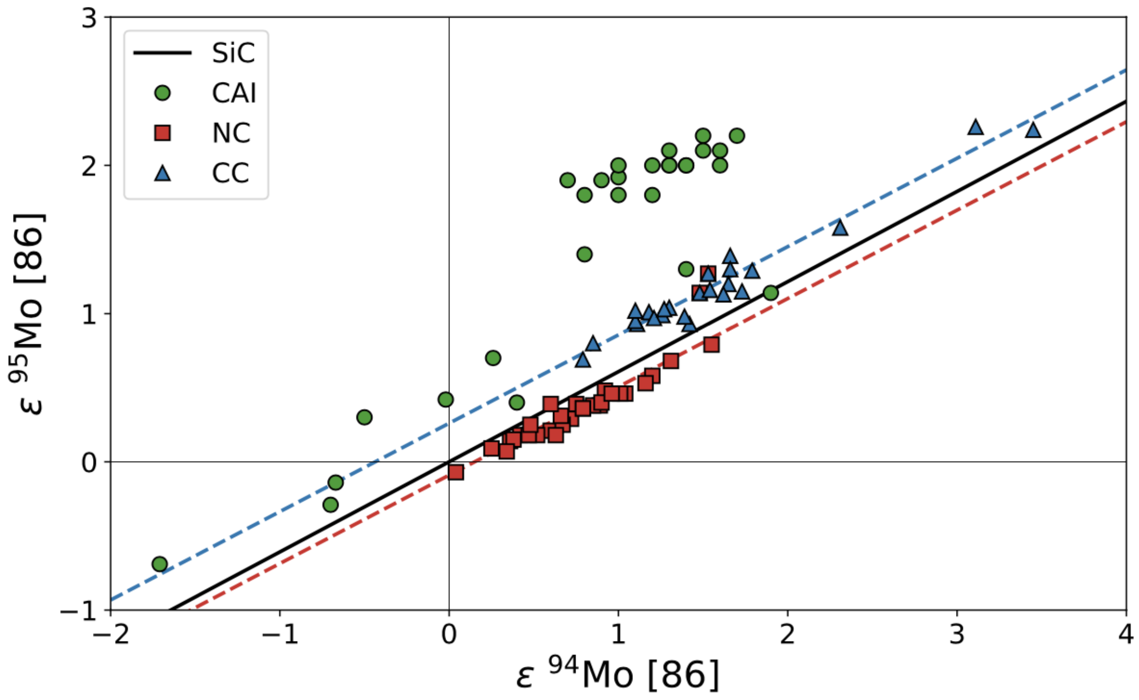
(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.

NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.

- Isotopic ratios are *internally normalized,* to avoid the problem of mass-depended fractionation
- Variations are in parts per 10^{-4}: stellar signatures are *strongly diluted*
- Chemistry effects



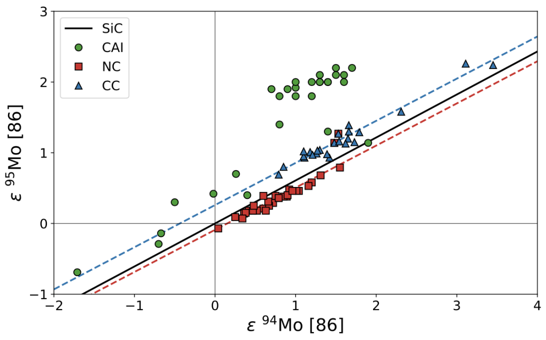
See Mattias Ek's talk

NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.

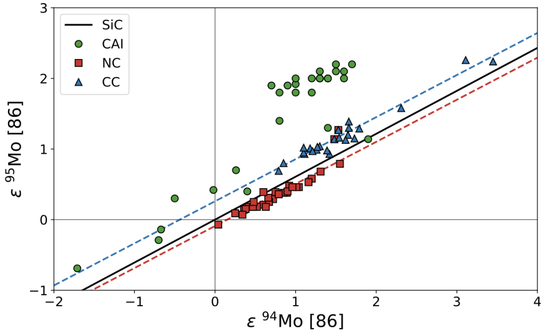
(II) the stellar models are not fully available to/manageable by cosmochemists and planetary science researchers.

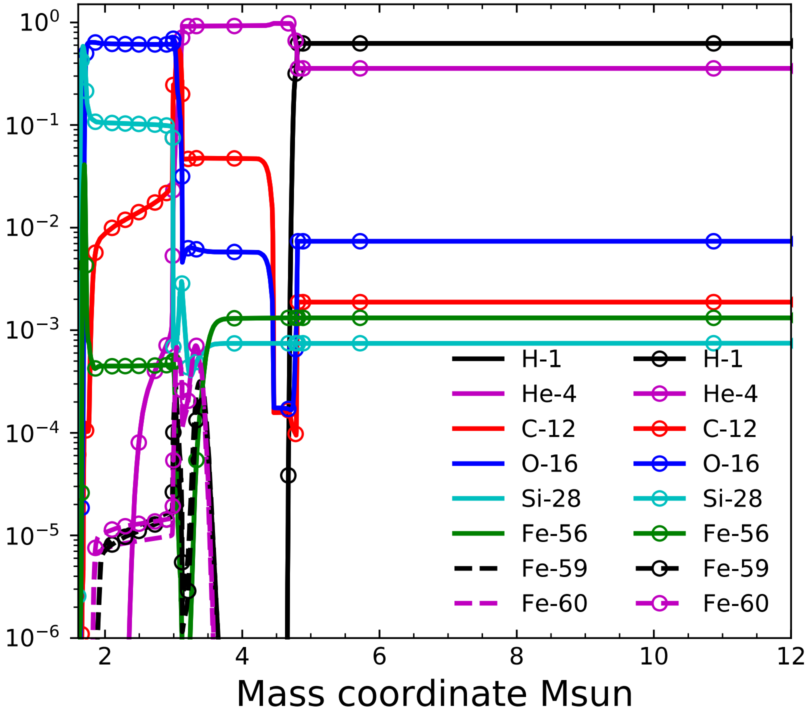


NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.





Abundance profiles in the ejecta of a core-collapse supernova (Marco Pignatari)

(II) the stellar models are not fully available to/manageable by cosmochemists and planetary science researchers.

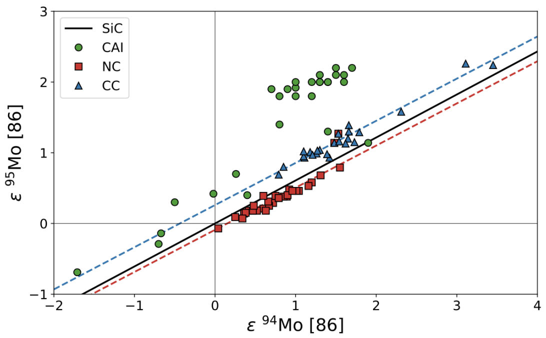
- *Abundances* (not yields) are need – often these are not even published!
- Radioactive contributions depends on time scale relative to dust formation and chemistry
- Mixing of nearby layers?

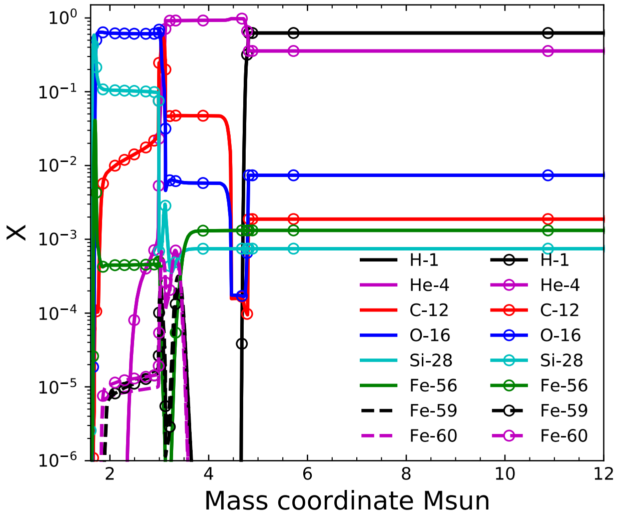
NA4 Mass Spectrometry Network: Introduction

The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.

(II) the stellar models are not fully available to/manageable by cosmochemists and planetary science researchers.





NA4 Mass Spectrometry Network: Introduction

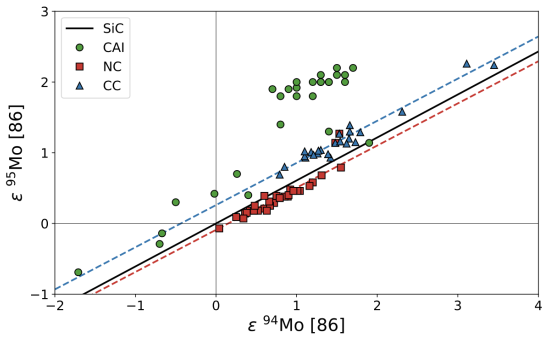
The comparison of the observed variations to predictions from models of nuclear burning in stars can help us to discover **the physical origin of the isotopic variations**. However, this comparison has been limited to a handful of model predictions because:

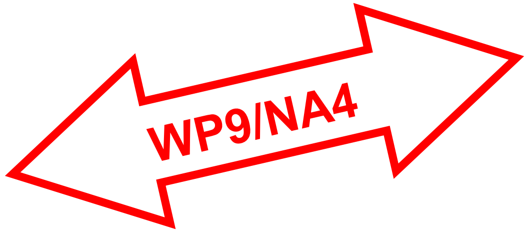
(I) the predicted stellar abundances need to be transformed into a representation that nuclear astrophysicists are unaccustomed to.

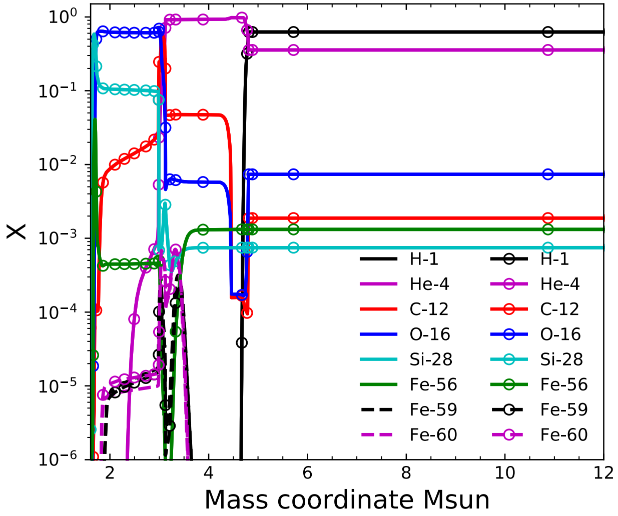
Provide Virtual Access to:

- codes/algorithms for the nuclear astrophysicists
- stellar models for the cosmochemists and planetary science researchers

(II) the stellar models are not fully available to/manageable by cosmochemists and planetary science researchers.







NA4 Mass Spectrometry Network: D9.1

- D9.1 Basic skeleton of open-source computational algorithm to translate predictions from stellar yields into units and representations from laboratory analysis of meteorites published on github or project web page (Task 9.1, Month 12)

Completed April 2022 based on Mattias Ek (ETHZ)'s python code

- Focus on *slow* neutron-capture process in AGB stars
- Code available via the ChETEC-INFRA.eu website; more AGB data to become available soon from CSFK
- Dissemination via paper (Lugaro et al. 2023, EPJA, 59, 53) and talk (Lugaro et al.) at OMEG2022 conference (October 2022)

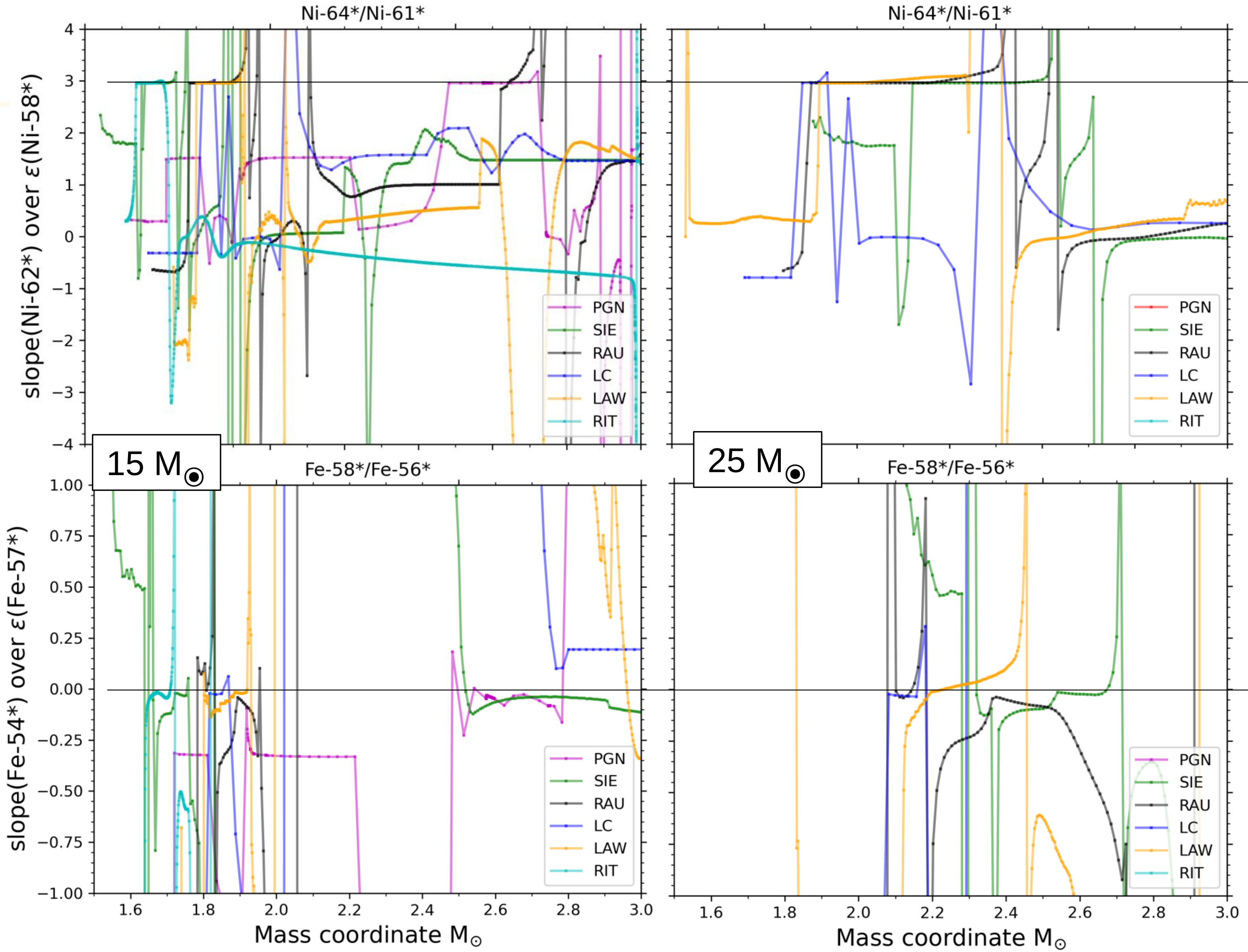
See Mattias Ek's talk

NA4 Mass Spectrometry Network: D9.2

- D9.2 Basic skeleton of open-source computational algorithm to predict expected variations to be seen in Solar System materials, as carried from stardust grains, including nucleosynthesis and dust condensation (Task 9.1, Month 24)

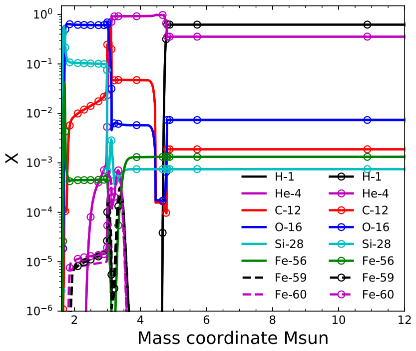
Completed: June 2023 based on Marco Pignatari (CSFK)'s python code

- Validation of the code completed using Ni isotopes, more development ongoing
- Code available via the online platform: https://astrohub.uvic.ca/chetec/
- ApJS paper (Pignatari et al., in prep) and talk (Lugaro et al.) at the Goldschmidt conference in Lyon (14^{th} July 2023)
- **Six (seven)** sets of core-collapse supernovae of masses 15, 20, 25 solar masses available to be processed (for a total of 18 models, to become 21)



DATA

e.g., Steele et al. 2012
Nanne et al. 2019
Makhatadze et al. 2023



DATA

e.g., Hopp al. 2022

Figures by Gábor Balázs

NA4 Mass Spectrometry Network: D9.3

- D9.3 Online database of stable isotope anomalies in bulk meteoritic materials published on project web page (Task 9.2, Month 30)

In Progress: October 2023 prototype from Mattias Ek (ETHZ)

Search:

Authors	Year	Source	DOI	Sample Type	Element
Akram, W; Schonbachler, M; Bisterzo, S; Gallino, R	2015	Geochimica et Cosmochimica Acta	Link	Wholerock	Zr
Budde, G; Burkhardt, C; Kliene, T	2019	Nature Astronomy	Link	Wholerock	Mo
Ek, Mattias; Hunt, Alison; Lugaro, Maria; Schonbachler, Maria	2020	Nature Astronomy	Link	Wholerock	Pd
Ek, Mattias; Hunt, Alison; Lugaro, Maria; Schonbachler, Maria	2020	Nature Astronomy	Link	Wholerock	Pt
Fischer-Godde, M; Burkhardt, C; Kruijer, T; Kleine, T	2015	Geochimica et Cosmochimica Acta	Link	Wholerock	Ru
Fischer-Godde, M; Burkhardt, C; Kruijer, T; Kleine, T	2015	Geochimica et Cosmochimica Acta	Link	Leachate	Ru
Hunt, A; Ek, M; Schonbachler, M	2017	Geochimica et Cosmochimica Acta	Link	Wholerock	Pt
Shollenberger, Q; Borg, L; Render, J; Ebert, S; Bischoff A; Russel, S; Brennecka, G	2018	Geochimica et Cosmochimica Acta	Link	CAI	Sr
Shollenberger, Q; Borg, L; Render, J; Ebert, S; Bischoff A; Russel, S; Brennecka, G	2018	Geochimica et Cosmochimica Acta	Link	CAI	Mo
Shollenberger, Q; Borg, L; Render, J; Ebert, S; Bischoff A; Russel, S; Brennecka, G	2018	Geochimica et Cosmochimica Acta	Link	CAI	Ba
Shollenberger, Q; Borg, L; Render, J; Ebert, S; Bischoff A; Russel, S; Brennecka, G	2018	Geochimica et Cosmochimica Acta	Link	CAI	Nd
Shollenberger, Q; Borg, L; Render, J; Ebert, S; Bischoff A; Russel, S; Brennecka, G	2018	Geochimica et Cosmochimica Acta	Link	CAI	Sm
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Wholerock	Dy
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Wholerock	Er
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Wholerock	Yb
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Leachate	Dy
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Leachate	Er
Shollenberger, Q; Brennecka, G	2020	Earth and Planetary Science Letters	Link	Leachate	Yb
Shollenberger, Q; Render, J; Brennecka, G	2018	Earth and Planetary Science Letters	Link	CAI	Er
Shollenberger, Q; Render, J; Brennecka, G	2018	Earth and Planetary Science Letters	Link	CAI	Yb

Showing 1 to 20 of 25 entries

Previous 1 2 Next

NA4 Mass Spectrometry Network: Future D9.4, D9.5, D9.6

D9.4 Extension of database into implantation of ionised noble gases into dust grains (Task 9.3, Month 36) April 2024

D9.5 Online example database generated representing nuclear astrophysics models predictions of correlations between stable/stable and radioactive/stable abundances of specific isotopes. We will start considering core-collapse supernovae and selected isotopes, but the work can be extended in the future to similar databases including other elements and isotopes and other stellar sources (Task 9.4, Month 36) April 2024

D9.6 Basic skeleton of open-source computational algorithms to produce, transport and incorporate radioisotopes in Earth material (Task 9.5, Month 42) October 2024

See Benjiamin Wehmeyer’s talk

NA4 Mass Spectrometry Network

- **Bridge the gaps** between nuclear astrophysics and cosmochemistry and planetary science
- **Combine expertise** on mass spectrometry laboratory investigations and the theoretical modelling that can help to interpret the data
- **Train** a new generation of scientists who can understand both languages
- **Provide the first comprehensive framework** of Virtual Access to tools (D9.1, D9.2, D9.4, D9.6), data (D9.2), and resources (D9.3, D9.5) to the different communities