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HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Single Atom Counting of Stellar and r-Process Nuclei in Time-Resolved Deep-Sea Archives

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Schools on Nuclear Astrophysics Questions (SNAQ)

13.10.2021


The Penguin and the Egg (NASA), my favorite pair of galaxies

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DRESDEN concept

Pioneering work

Supernova Fe-60 with AMS in Munich

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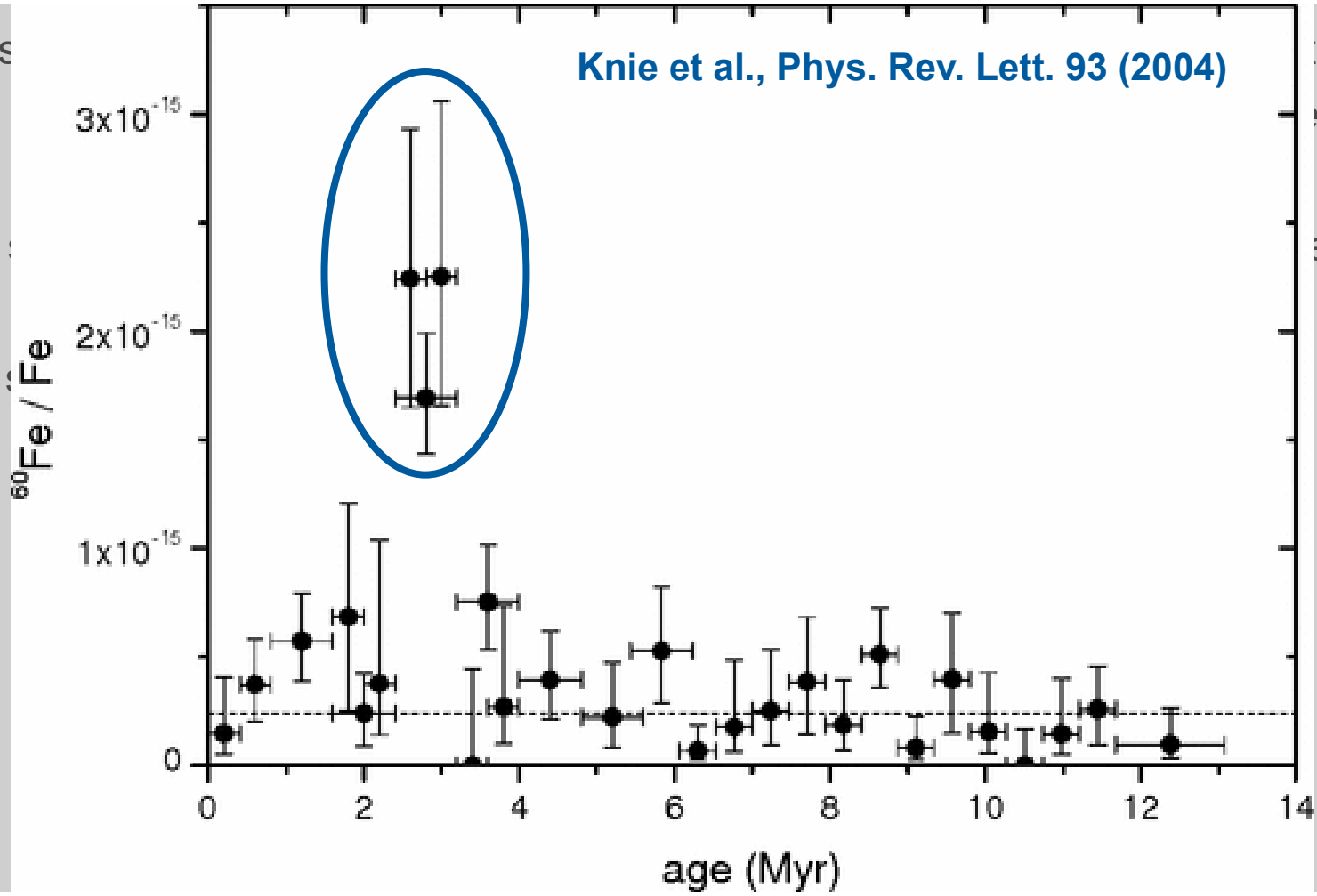

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2009-2015: Update Fe-60 $t_{1/2}$ from 1.5 Myr to 2.6 Myr (AMS groups in Munich and Canberra in collaboration with PSI)

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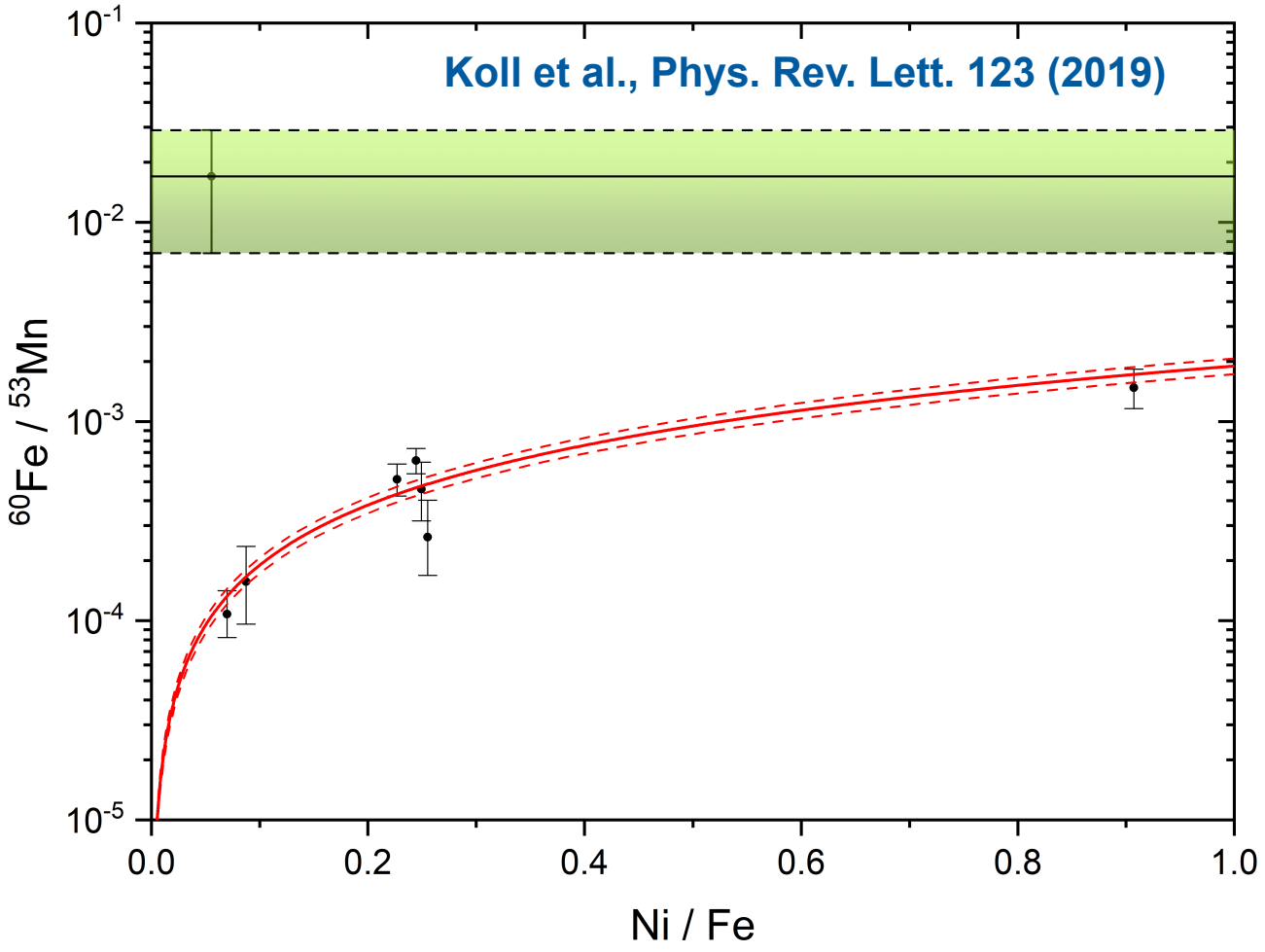

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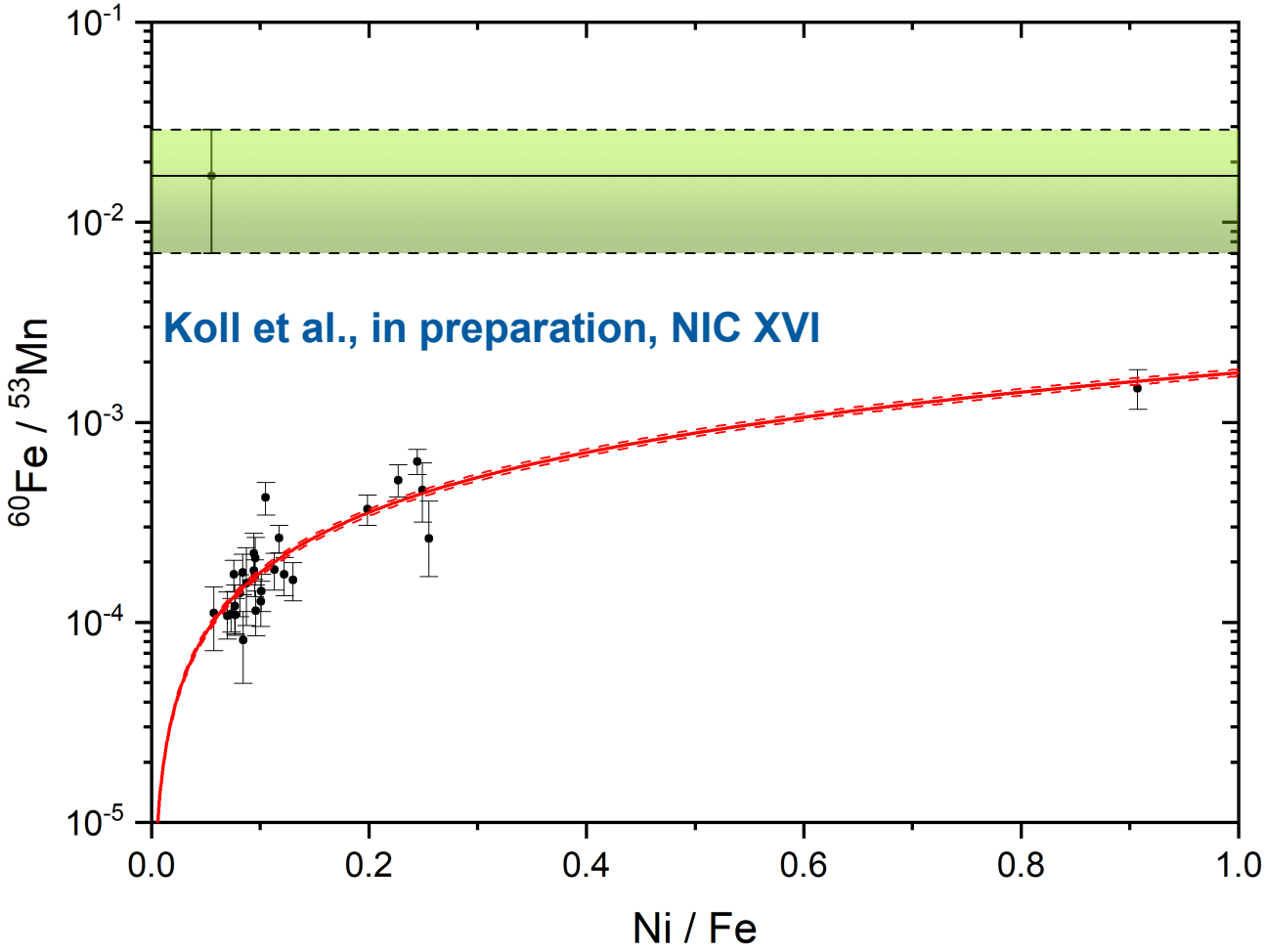

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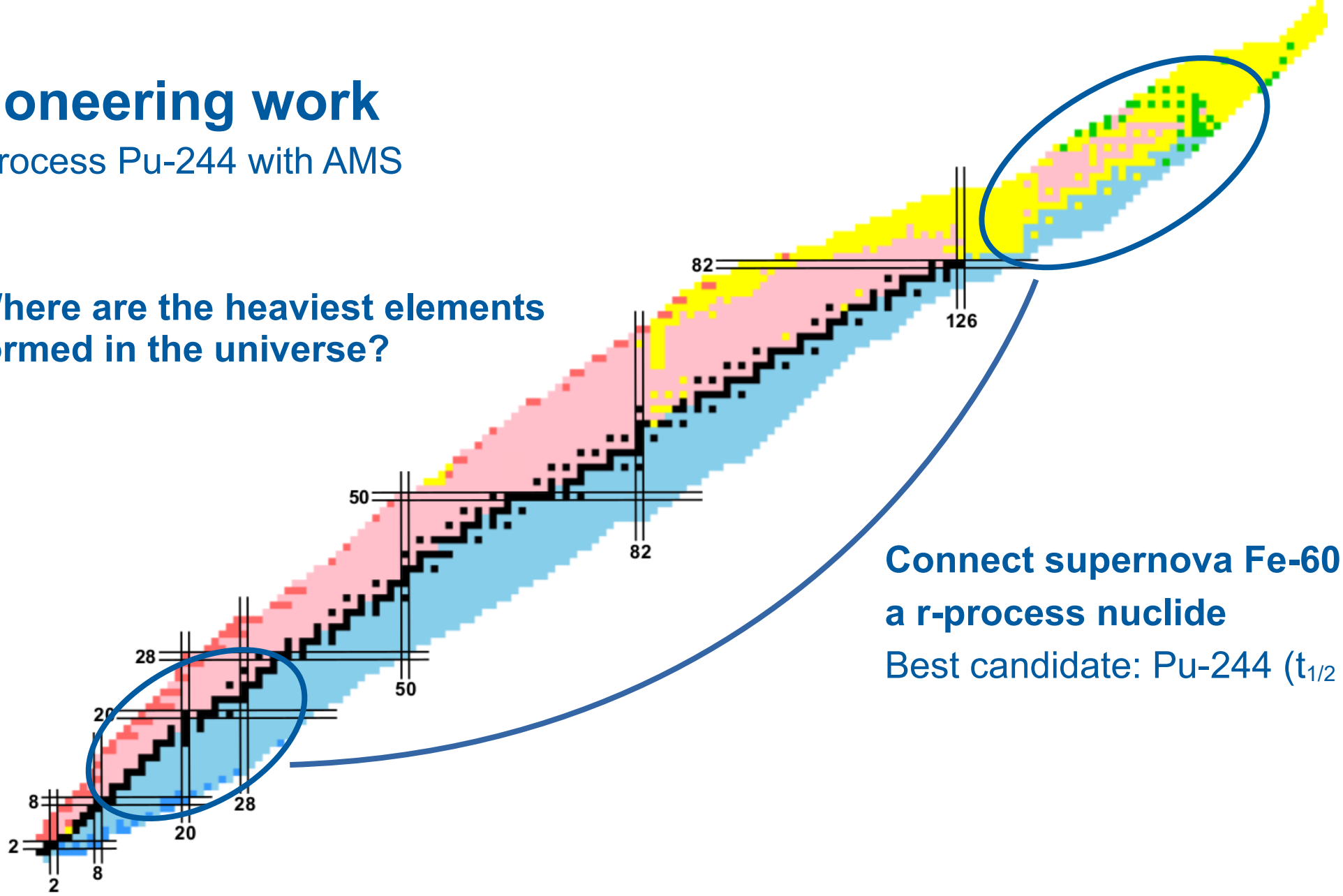
2020: Confirmation of recent Fe-60 in deep-sea sediments [9]

Pioneering work

r-process Pu-244 with AMS

Where are the heaviest elements formed in the universe?



Connect supernova Fe-60 with a r-process nuclide

Best candidate: Pu-244 ($t_{1/2}$ = 80 Myr)

Pioneering work

r-process Pu-244 with AMS

2015: First large investigation with small AMS in Vienna, upper limit [10]

- Time resolution only an integral over 25 Myr
- Sensitivity 1:10,000 atoms

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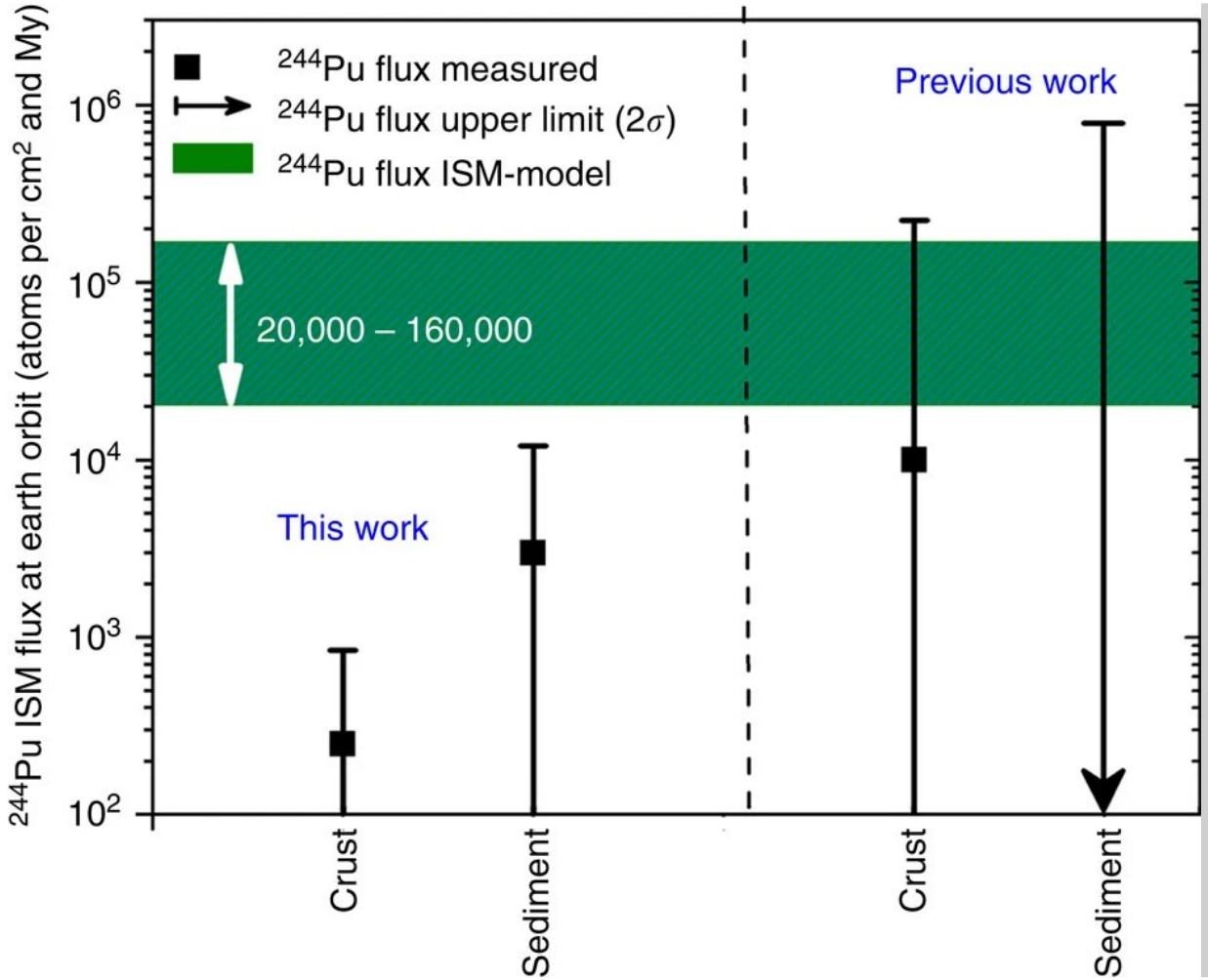
Wallner et al., Nat. Comm. 6 (2015)



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2021: First detection of interstellar Pu-244 in ferromanganese crust [12]

- Time resolution : 4.5 Myr, integral over Fe-60 influx
- Sensitivity 1:200 atoms
- Fe-60 influx between 6-7 Myr (previously 7-8 Myr)

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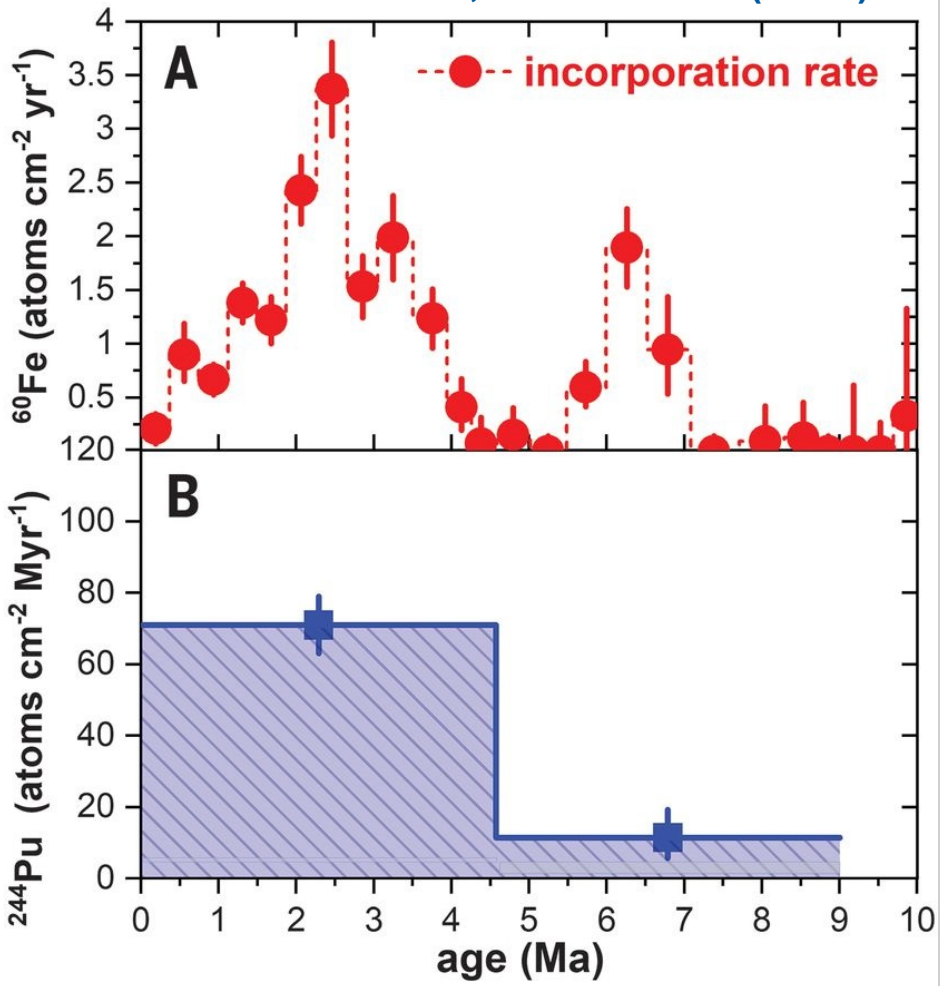

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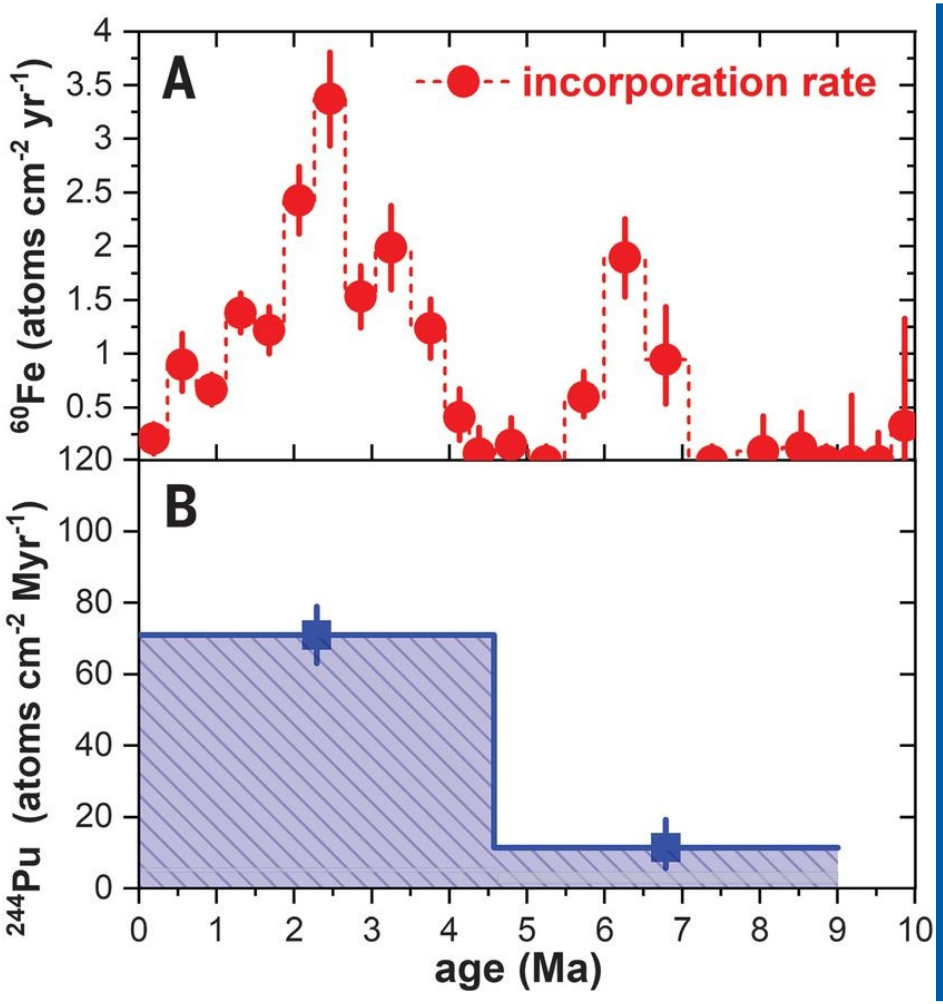

- Two supernova Fe-60 influxes and recent influx
- Pu-244 detected, but only integral over Fe-60
- AMS at ANU for Fe-60, only facility, $^{60}Fe/Fe = 2x10^{-17}$
- AMS at ANSTO for Pu-244, only facility, $\varepsilon_{Pu} = 1 / 200$ at

The goal:

Time resolved influx of Fe-60 AND Pu-244

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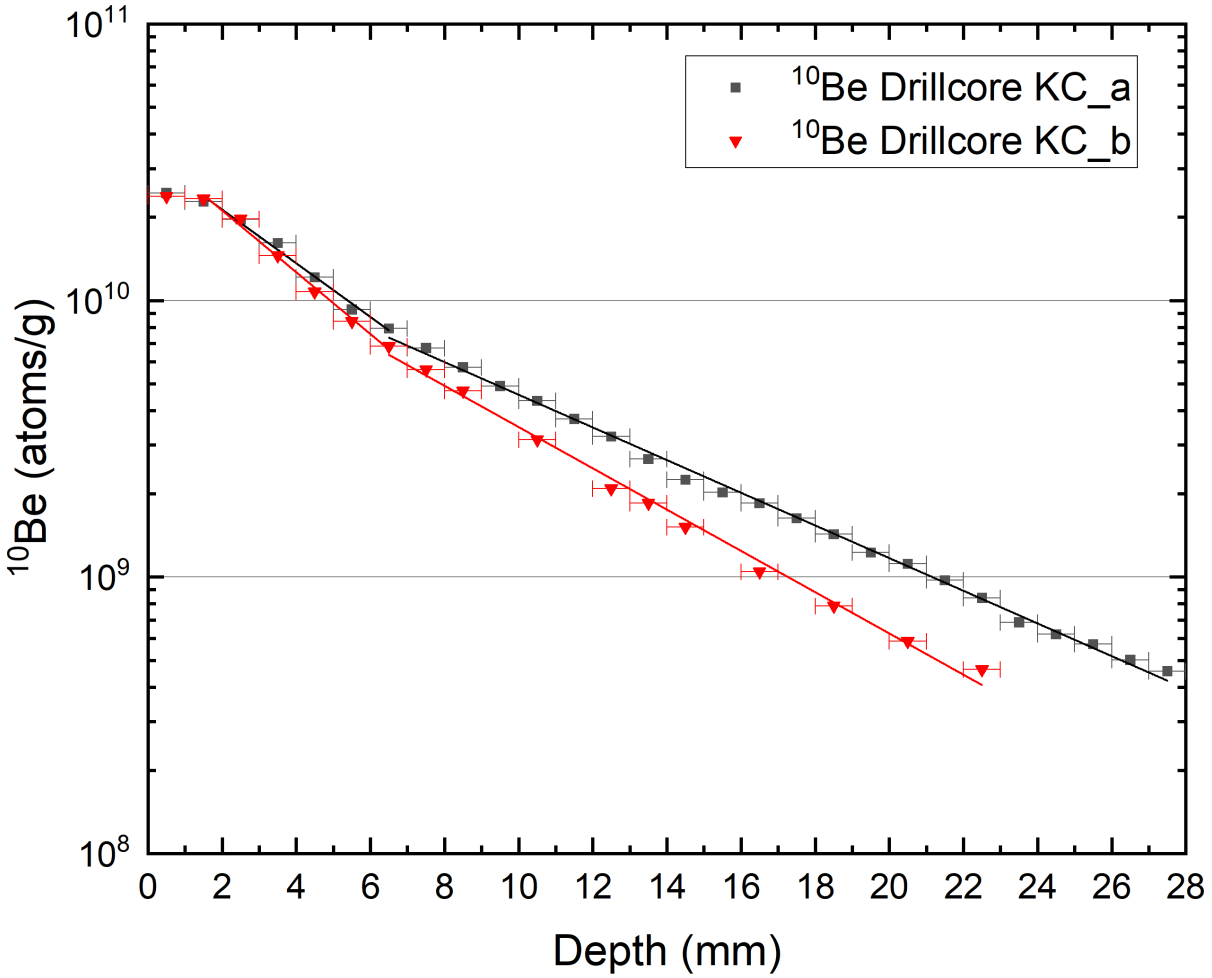
10 Myr time profile of Fe-60 and Pu-244

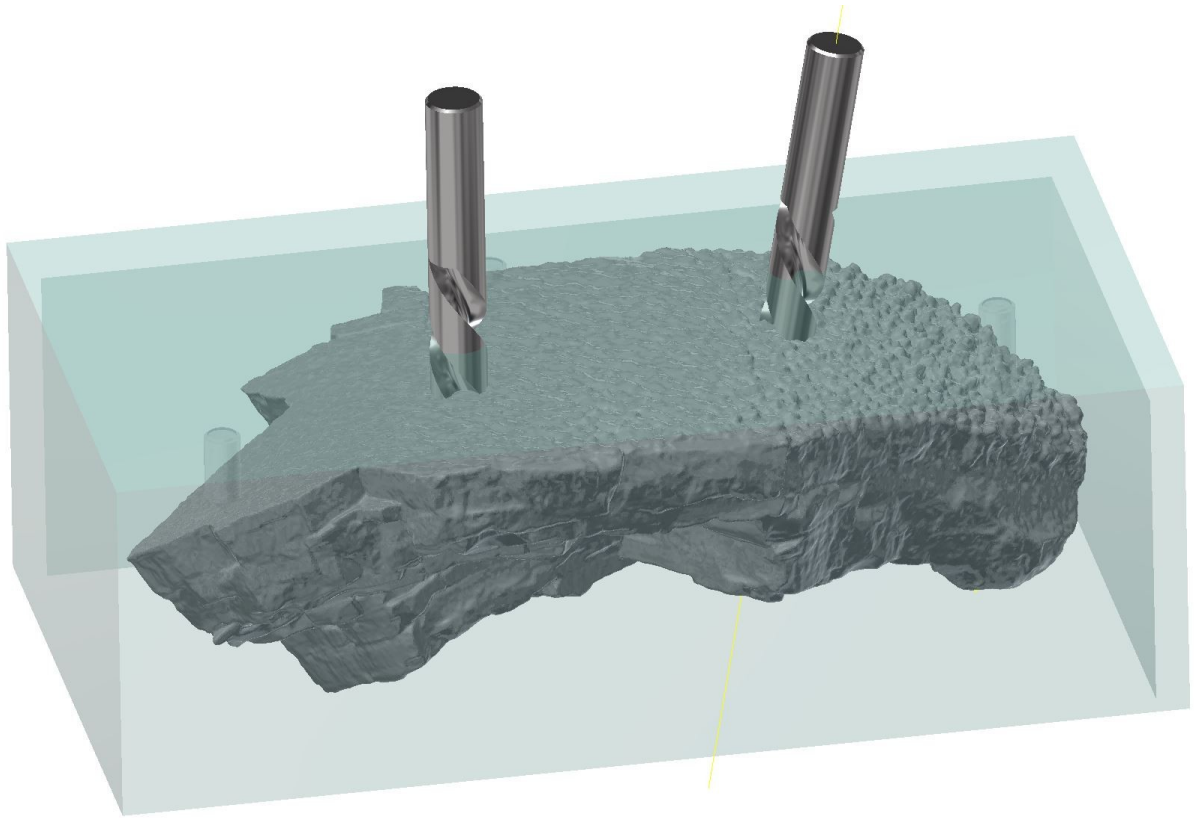
Characterization of the crust

- VA13-237KD
- 3.7 kg
- 2 drillcores for Be-10 dating
- 1 drillcore for Fe-60 profile
- Layers for Pu-244
- Characterization with
  3D optical scan
  3D x-ray scan
  3D CNC model and print

10 Myr time profile of Fe-60 and Pu-244

Characterization of the crust





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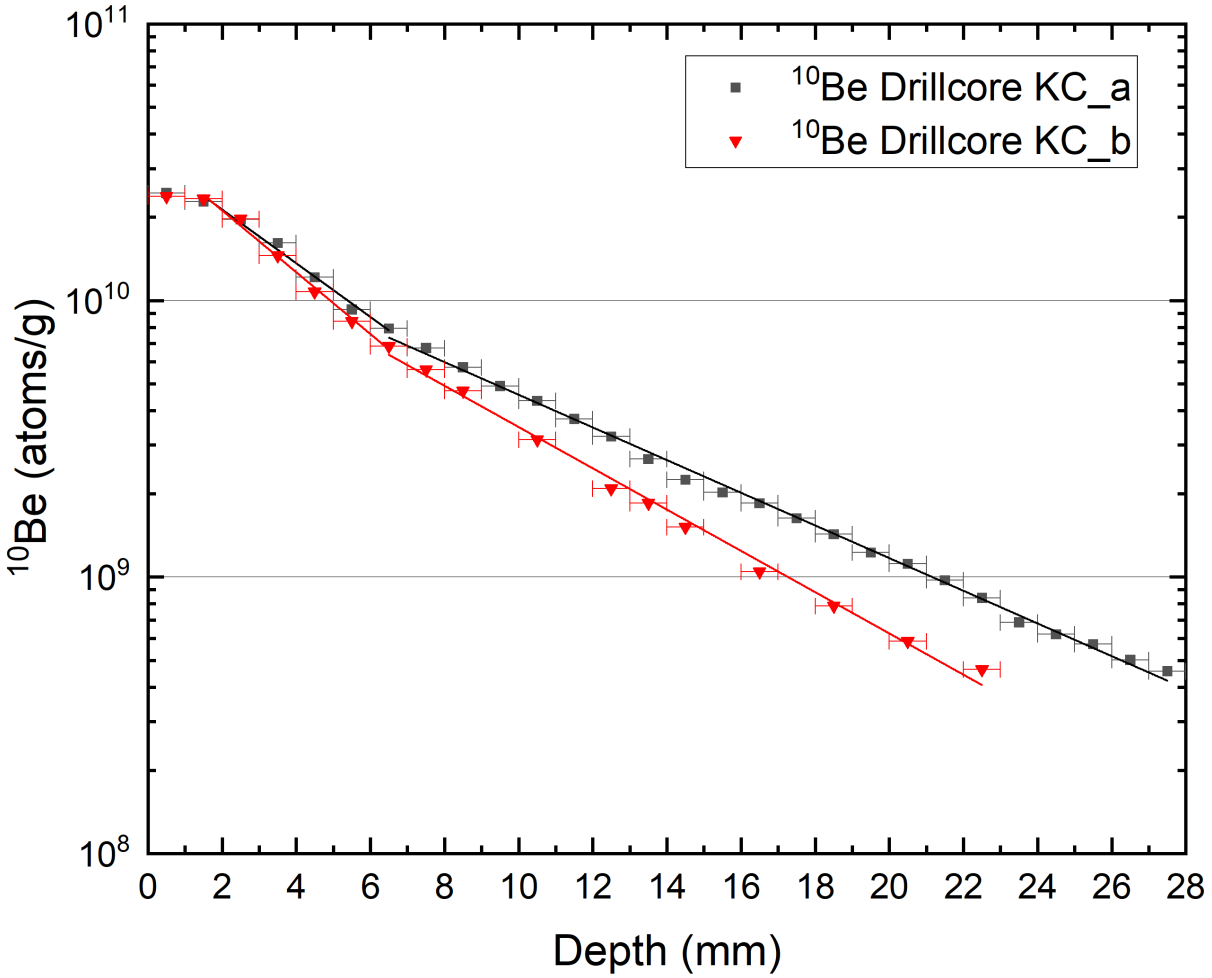

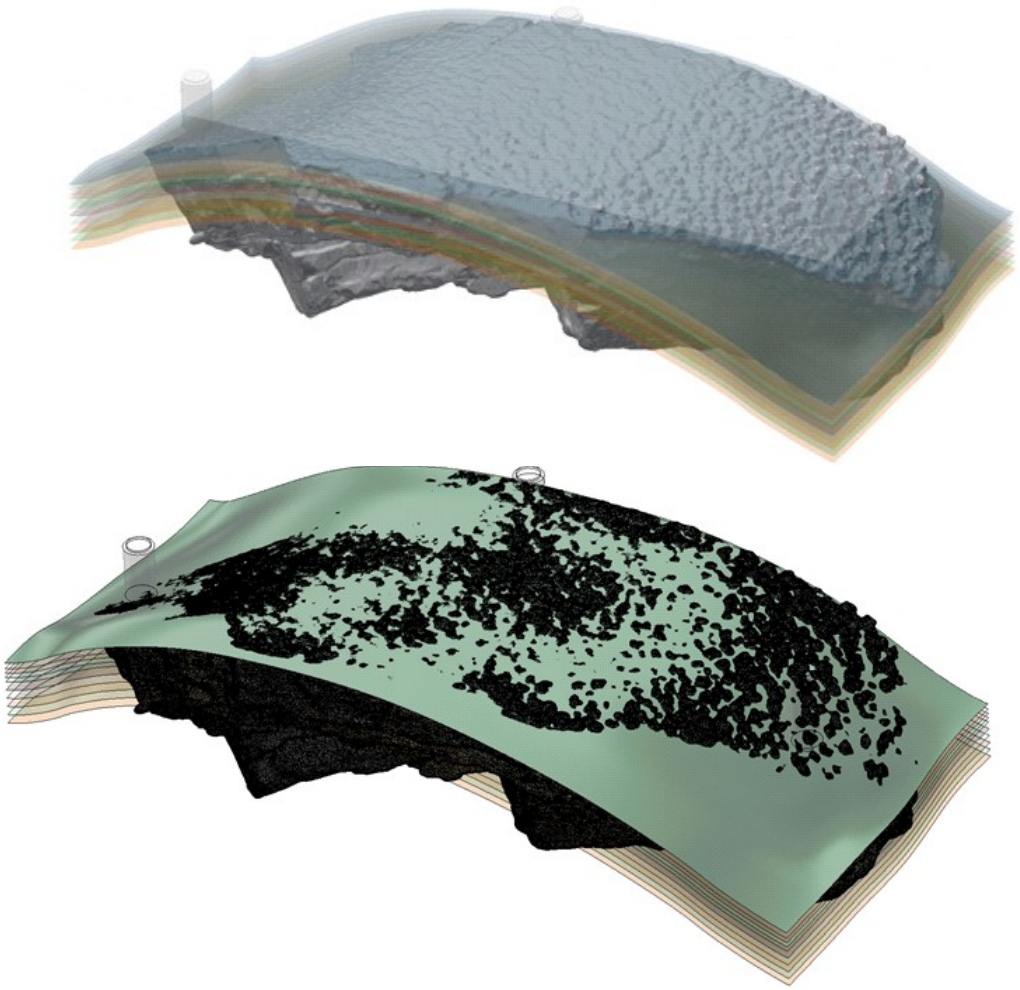

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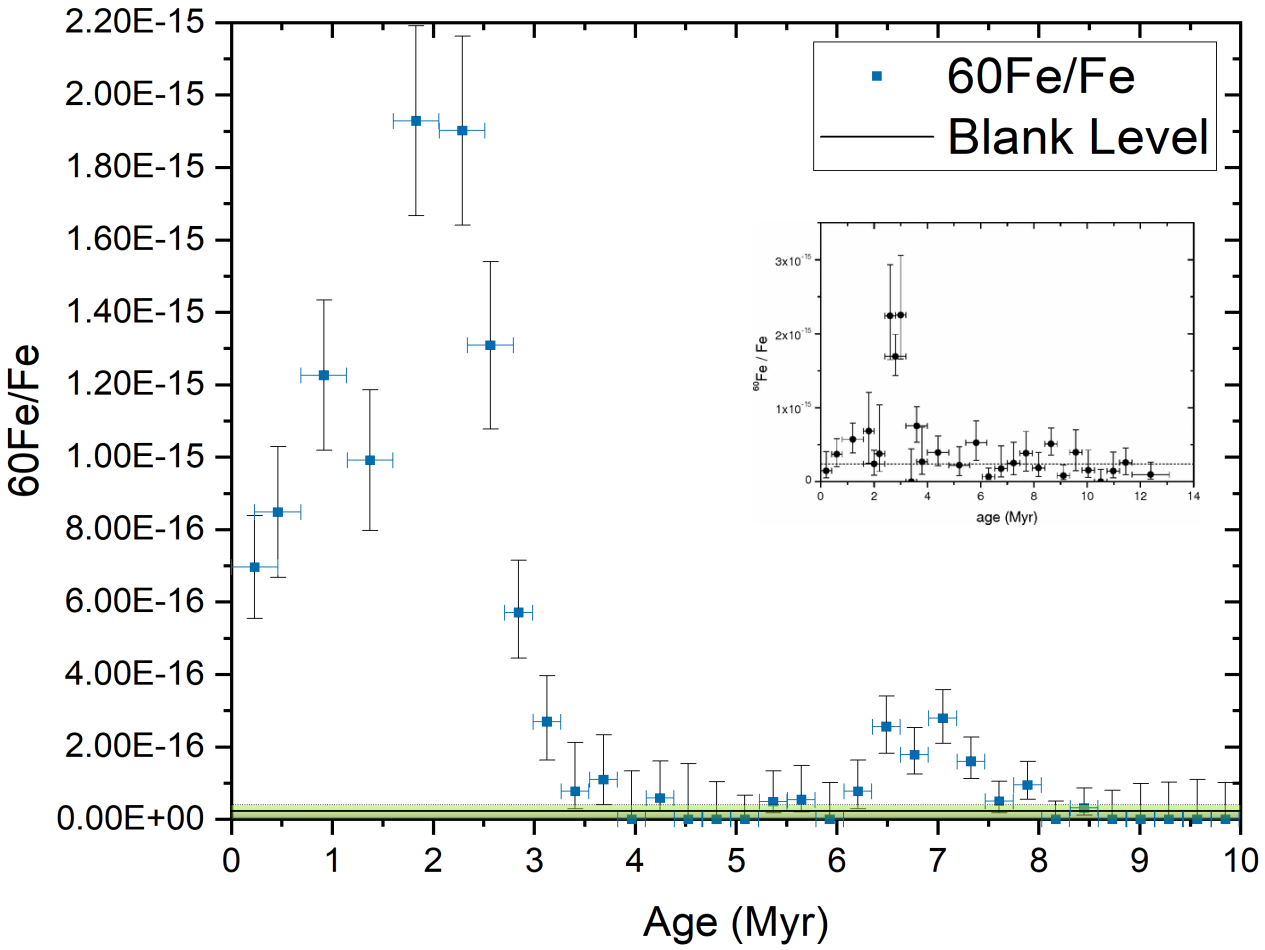
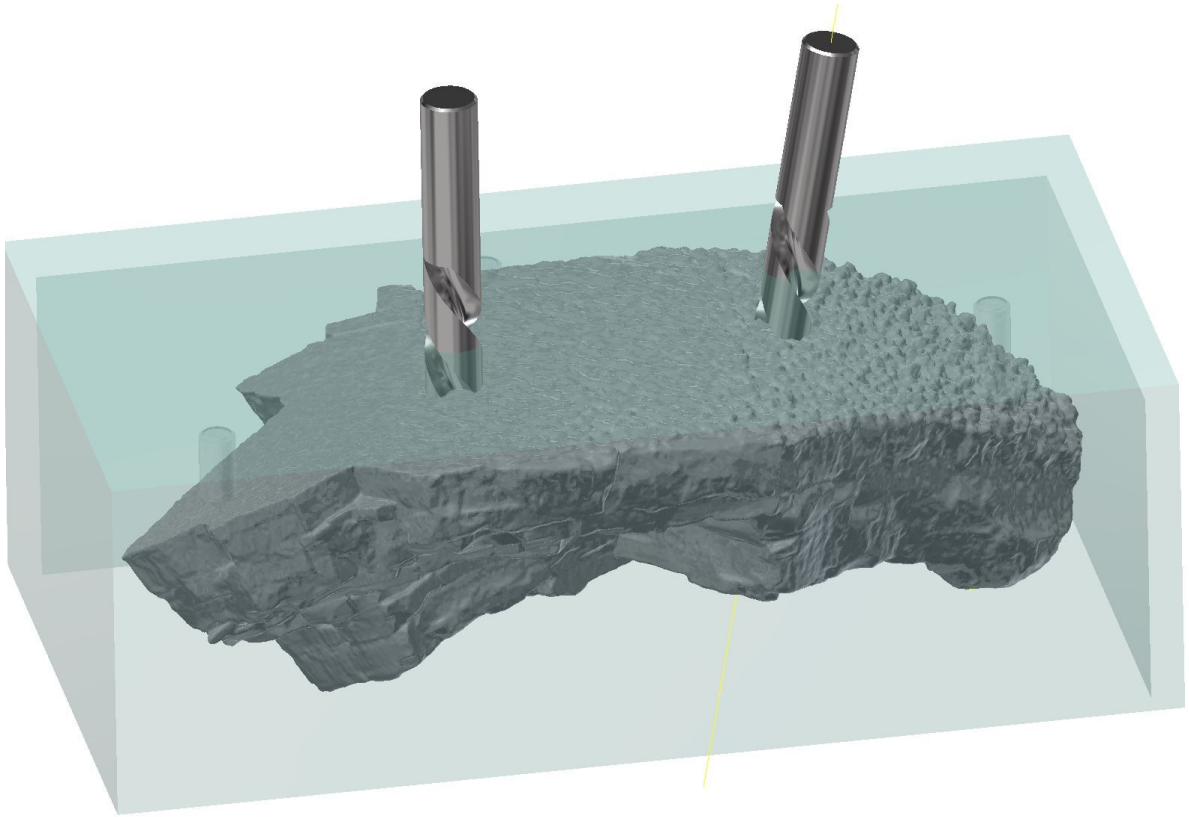
Fe-60 profile





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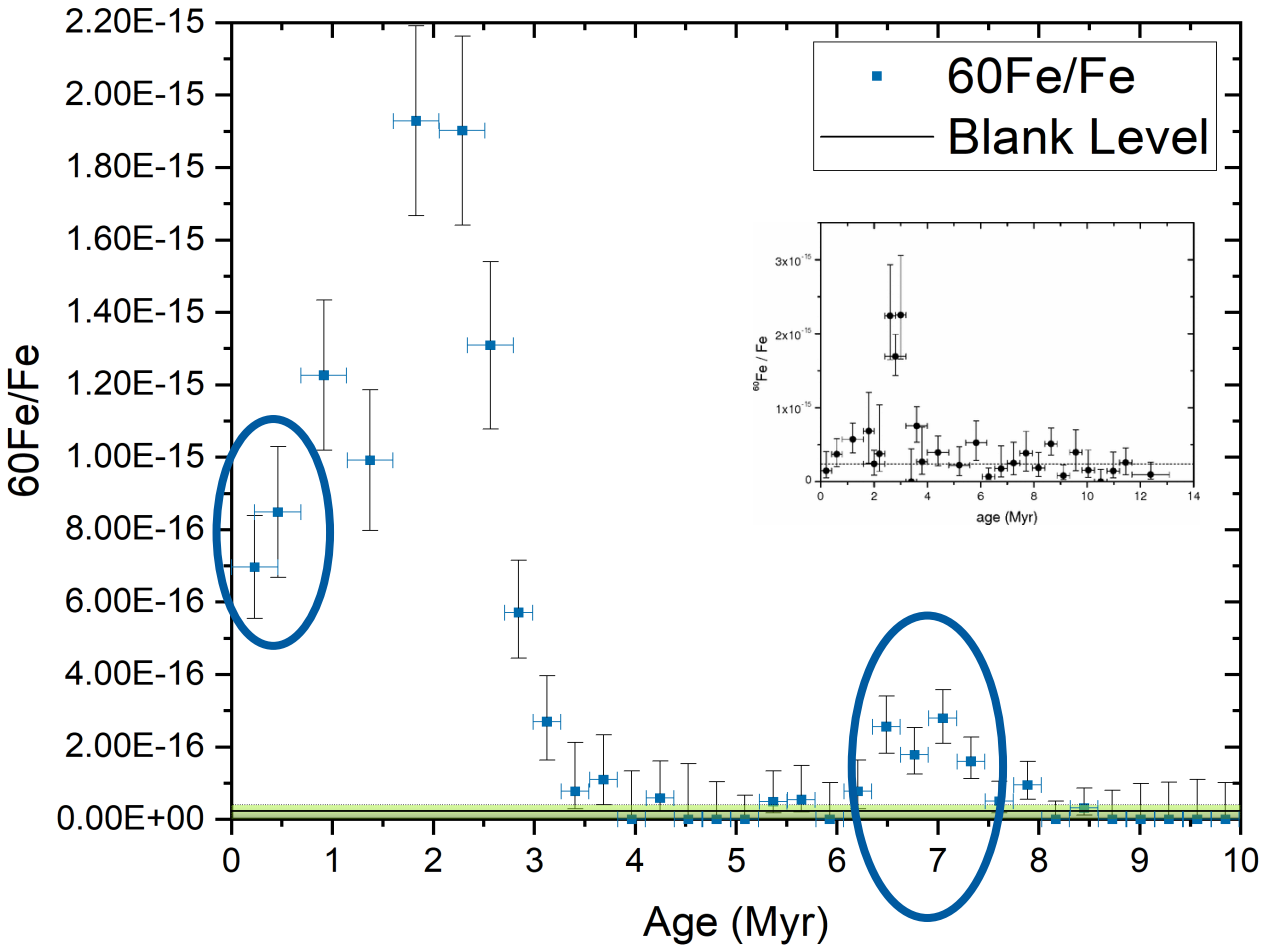
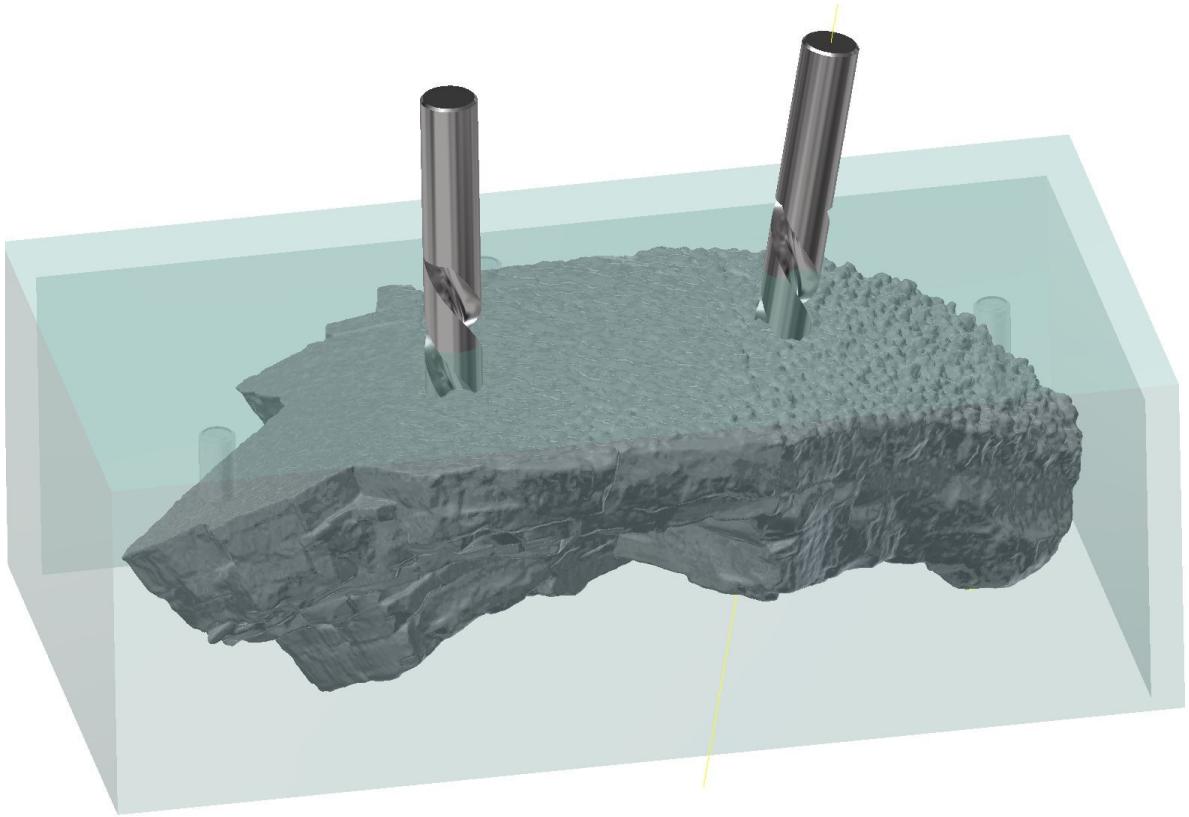


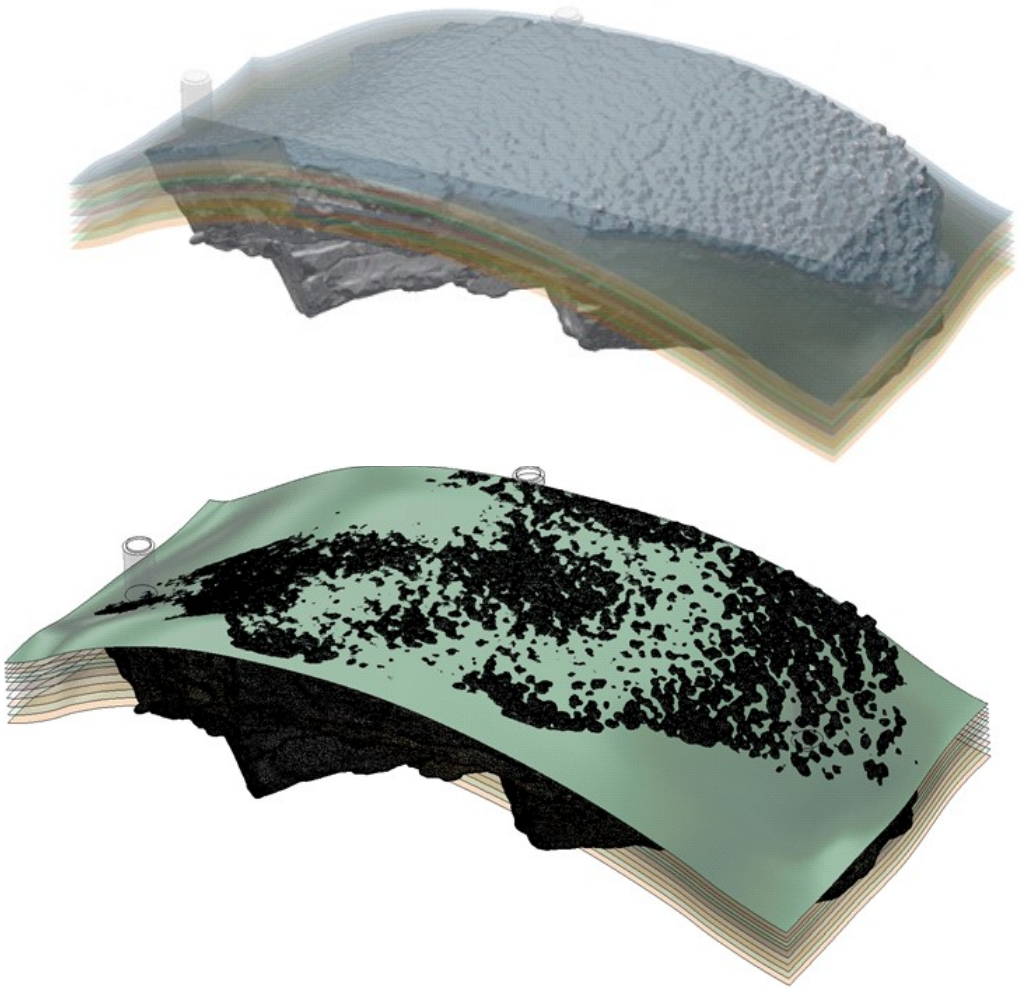


10 Myr time profile of Fe-60 and Pu-244

Pu-244 profile

Measurements finished early October 2021

- **Time resolution 1 Myr**
- **ε_{Pu} = 1 : 100 at**
- **Lower Pu-244 compared to Wallner 2021**
- **Confirm previous results, differences between samples**
- **PRELIMINARY:**
  Pu-244 follows Fe-60 for first peak
  BUT unexpected older influx pattern



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Outlook

- Analysis of Pu-244 data
- Further dating of drill cores into 10 Myr – 15 Myr region (up to 10 x $t_{1/2}$)
- Chemistry development for Cm-247 in same sample
- Chemistry development for Hf-182, lead by University of Vienna, ILIAMS
- New samples for Pu-244 investigations:
  Sediments/ice for less diffusion, crusts for statistics, lunar for nuke free integral

DRESDEN concept

Thanks to

A. Stuchbery, S. Battisson, M. Hartnett, L. K. Fifield, M. B. Fröhlich, S. Pavetich, Z. Slavkovska, S. G. Tims

A. Wallner, J. Lachner, S. Merchel, G. Rugel, R. Ziegenrücker

M. A. Hotchkis, D. Child

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[9] Wallner et al., PNAS 117 (2020)
[10] Wallner et al., Nat. Comm. 6 (2015)
[11] Hotchkis et al., NIMB 438 (2019)
[12] Wallner et al., Science 372 (2021)

AINSE Funding:
AINSE PGRA

ANSTO Proposals:
#AP12793
#AP12193

ARC Funding:
DP18100495
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Radiate Proposals:
#21002421-ST
#20002142-ST