The new 1MV AMS facility HAMSTER at HZDR

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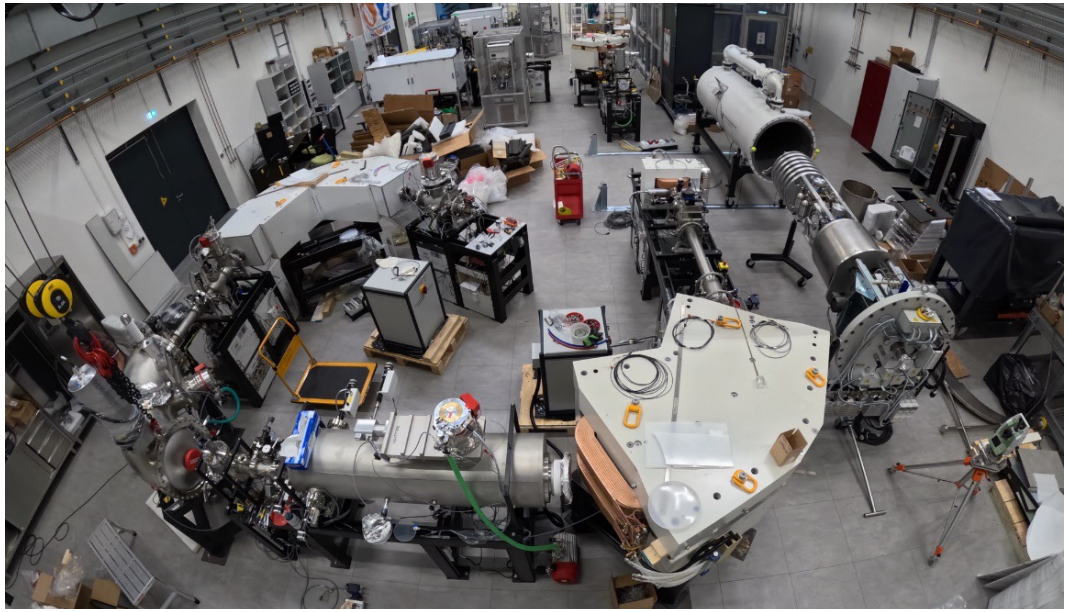
Accelerator Mass Spectrometry & Isotope Research

Helmholtz-Zentrum Dresden-Rossendorf

www.hzdr.de/ams



Live radioactivities – fingerprints of ongoing nucleosynthesis from satellite observations

Superposition of the two ^{60}Fe emission lines (1173 keV & 1333 keV) recorded on board INTEGRAL

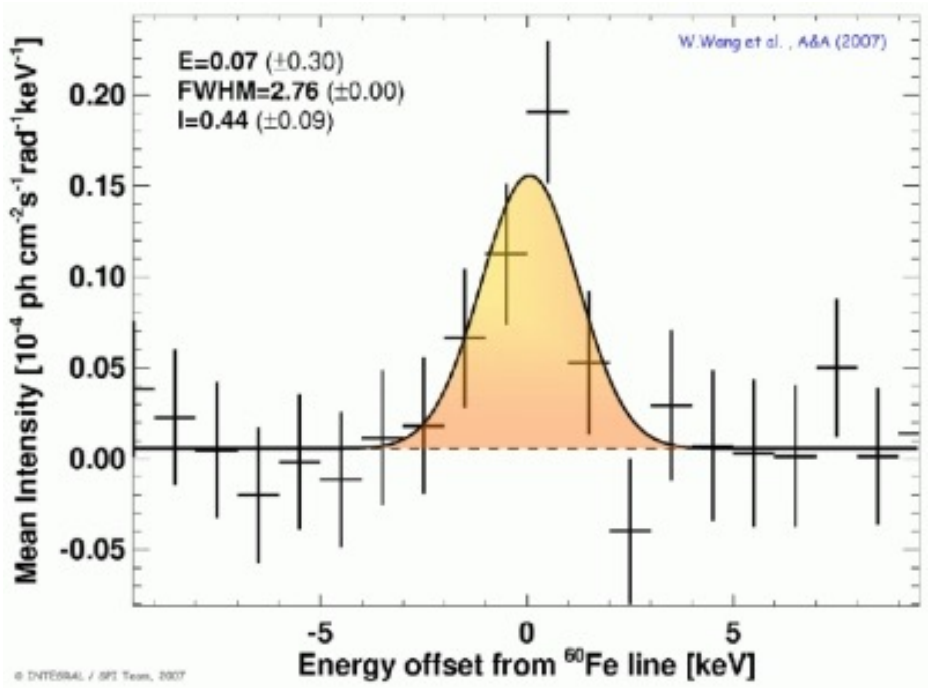
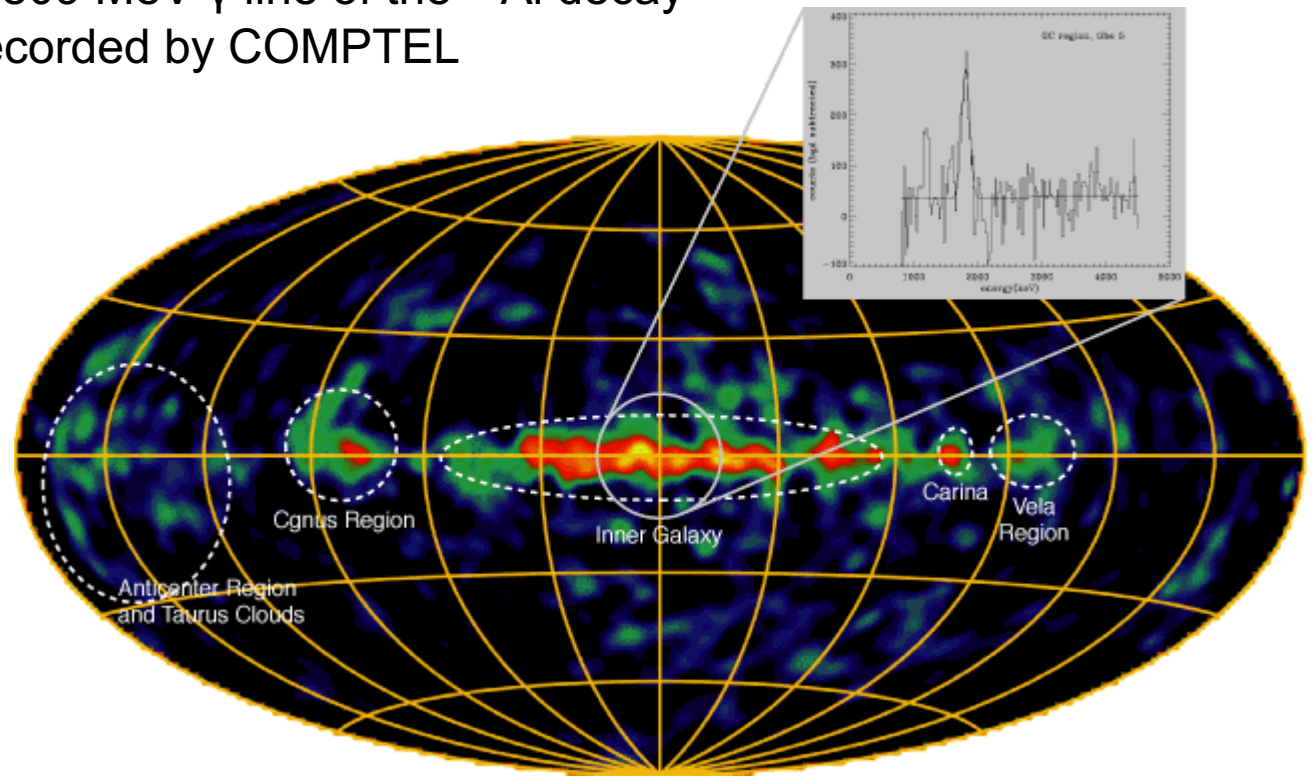
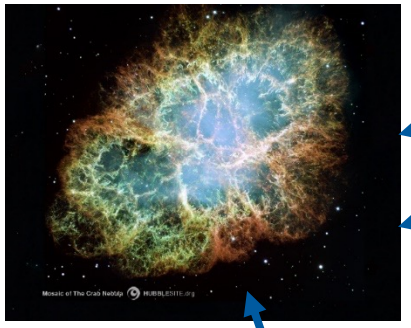


image of the galaxy in intensity of the 1.809 MeV γ line of the ^{26}Al decay recorded by COMPTEL



Interstellar radionuclides constrain site of the *r*-process

production in massive stars
Core collapse supernova



Number of protons Z

Number of neutrons N

$_{82}$Pb

$_{50}$Sn

$_{28}$Ni

$_{20}$Ca

$_{8}$O

$_{2}$He

?

?

?

Cm 247
15.6 Myr

Pu 244
81.3 Myr

Hf 182
8.90 Myr

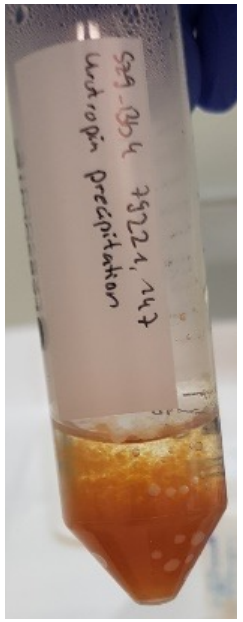
Fe 60
2.6 Myr

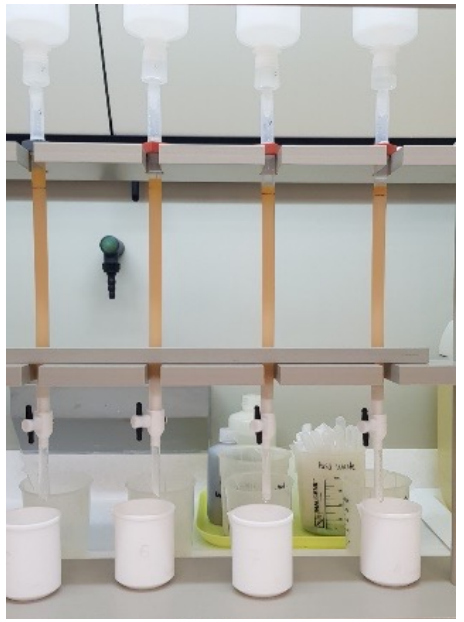
r-process production at
yet unknown site(s)
Neutron star merger ?

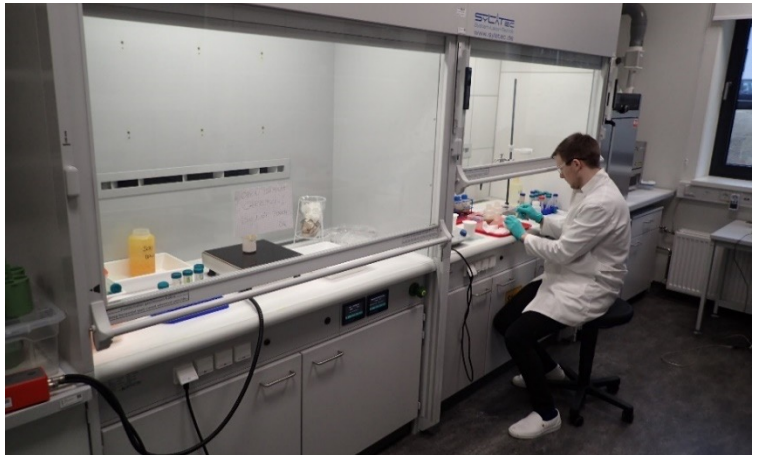
Artistic illustration, GSI Frankfurt

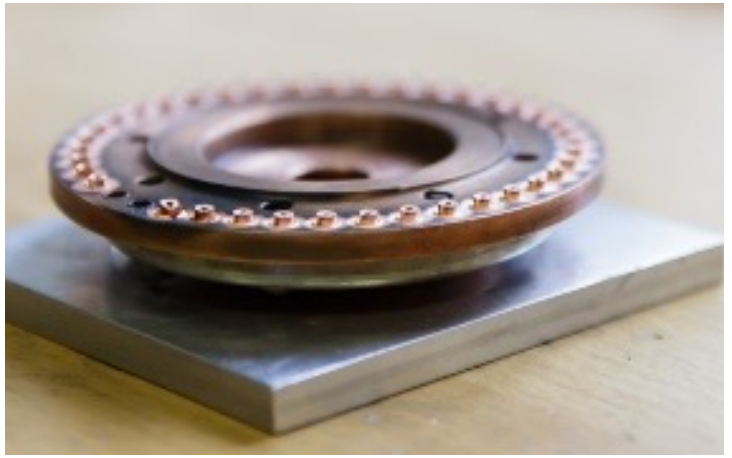
Connect supernova ^{60}Fe with nuclides from *r*-process (e.g. ^{244}Pu & ^{247}Cm) or potentially other scenarios (^{182}Hf)

From the cosmos to the lab



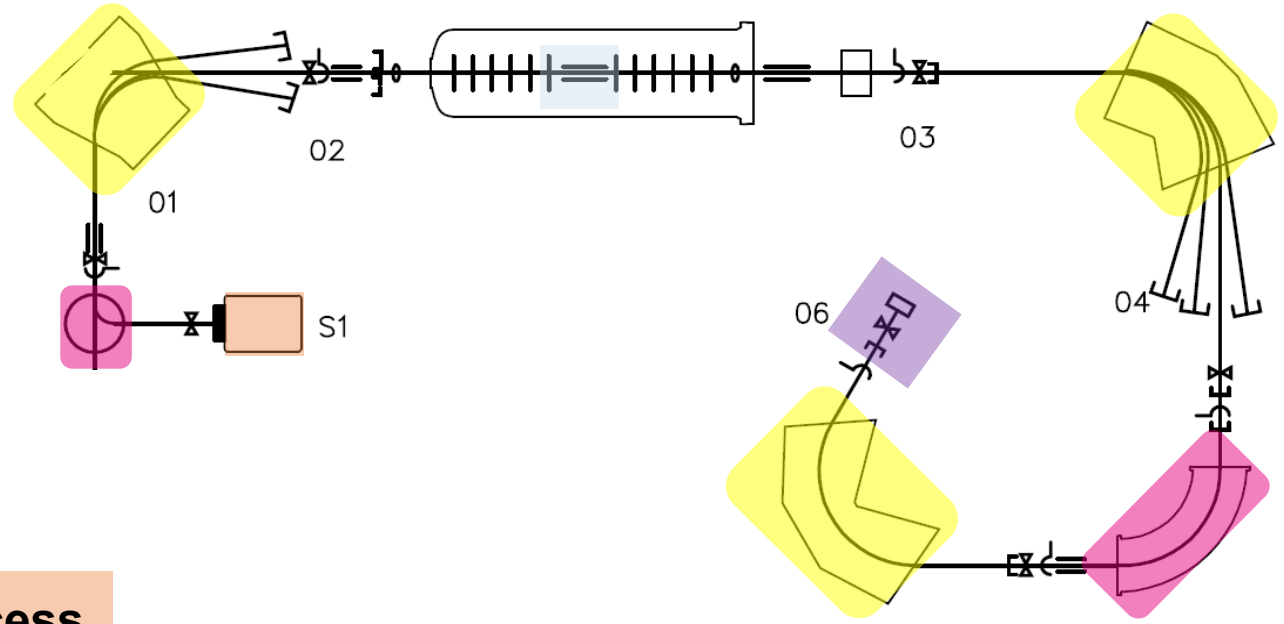






Technique: Accelerator Mass Spectrometry

- ✓ generate, transport and detect many ions of the isotope of interest
  → efficiency typically 0.01-1%
- ✓ suppress molecular and atomic isobars
  → efficiency typically >99.99999%
- ✓ essentially background-free detection at concentrations of 10^{-21} at/g,



The classic AMS toolbox:

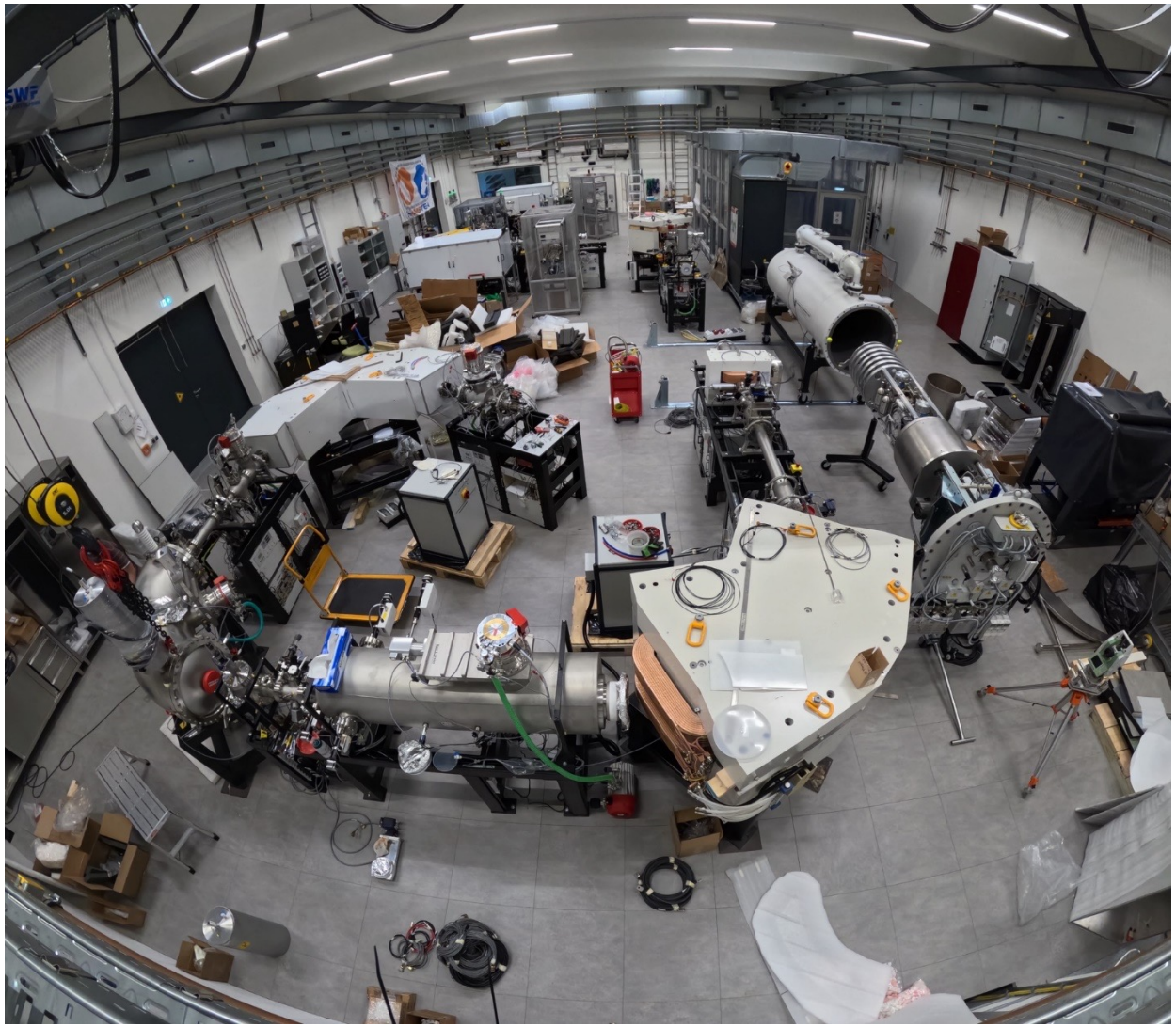
- **element selective negative ionization process**
- **stripping process**
- **mass selection with magnetic and electrostatic filters: isotope ratios in range 10^{-10} to 10^{-17}**
- **single ion identification at increased beam energies: single atom counting**

since 2011: DREAMS = DREsden AMS

- 1 week beamtime per month
- mostly ^{10}Be and ^{26}Al
- presence during night-shifts required
- limited access outside of beamtimes – hardly any technical development possible

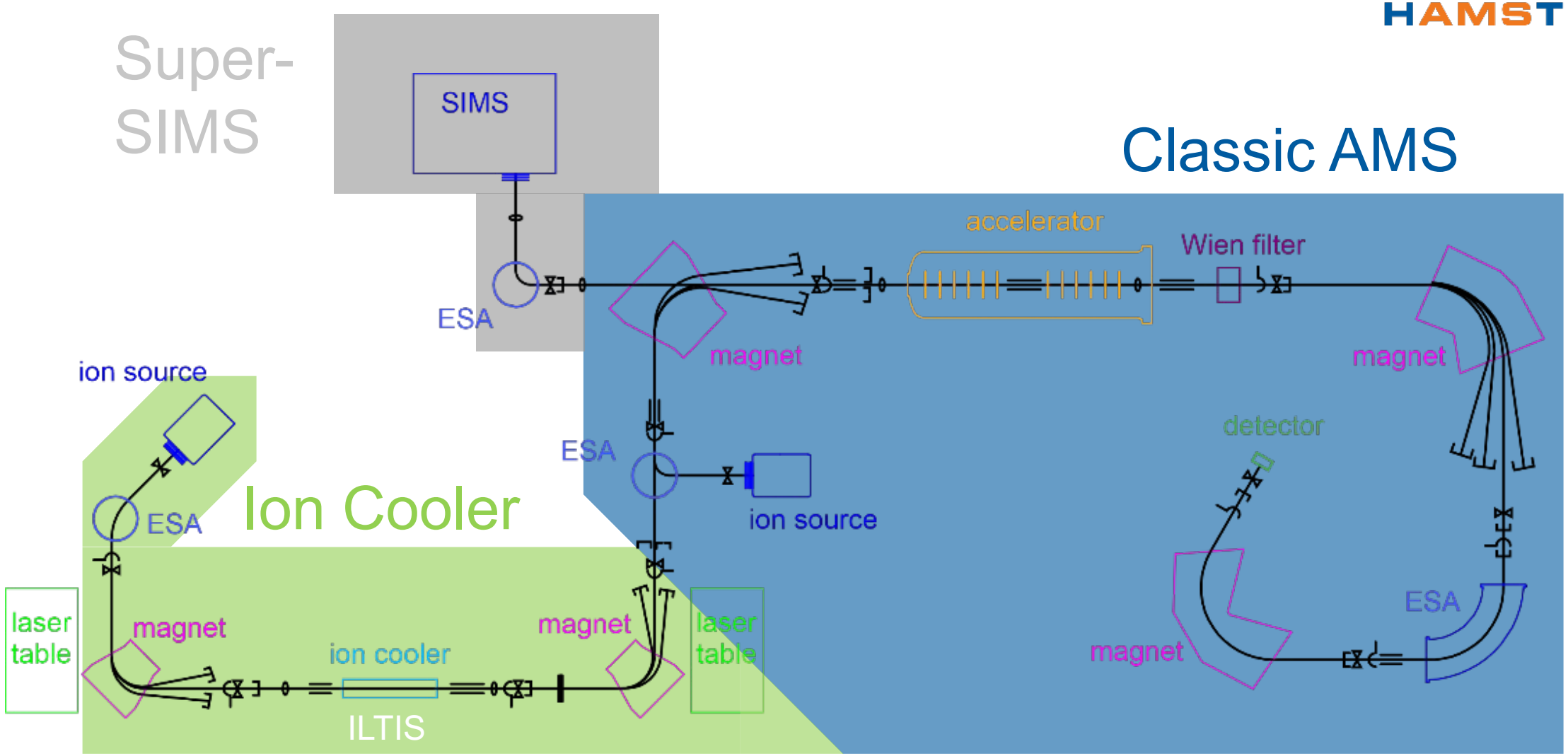
Recent setup of HAMSTER‘s main AMS system

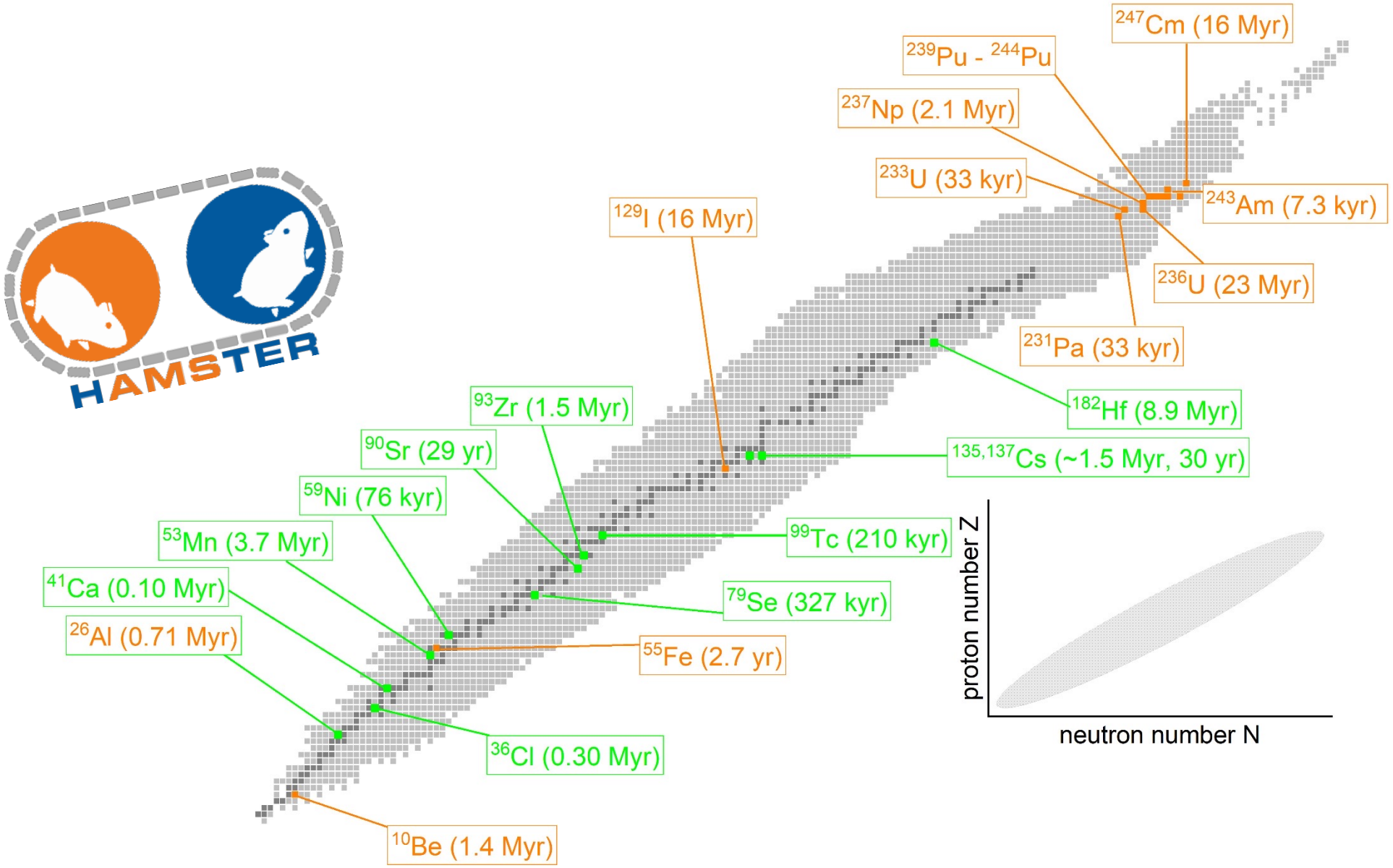
- delivery mid-August 2025
- installation largely finished
- operational by next week



A new 1 MV AMS facility at HZDR: HAMSTER

Helmholtz Accelerator Mass Spectrometer Tracing Environmental Radionuclides

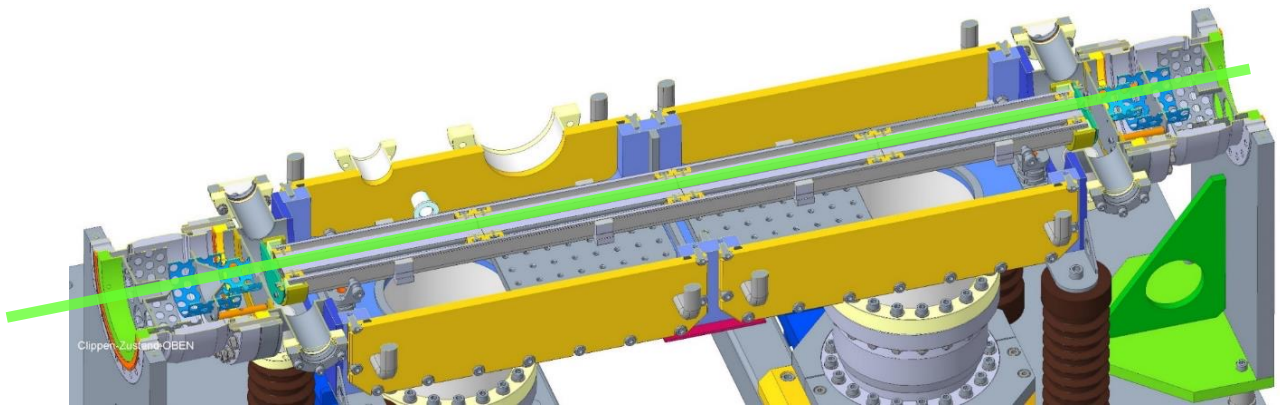


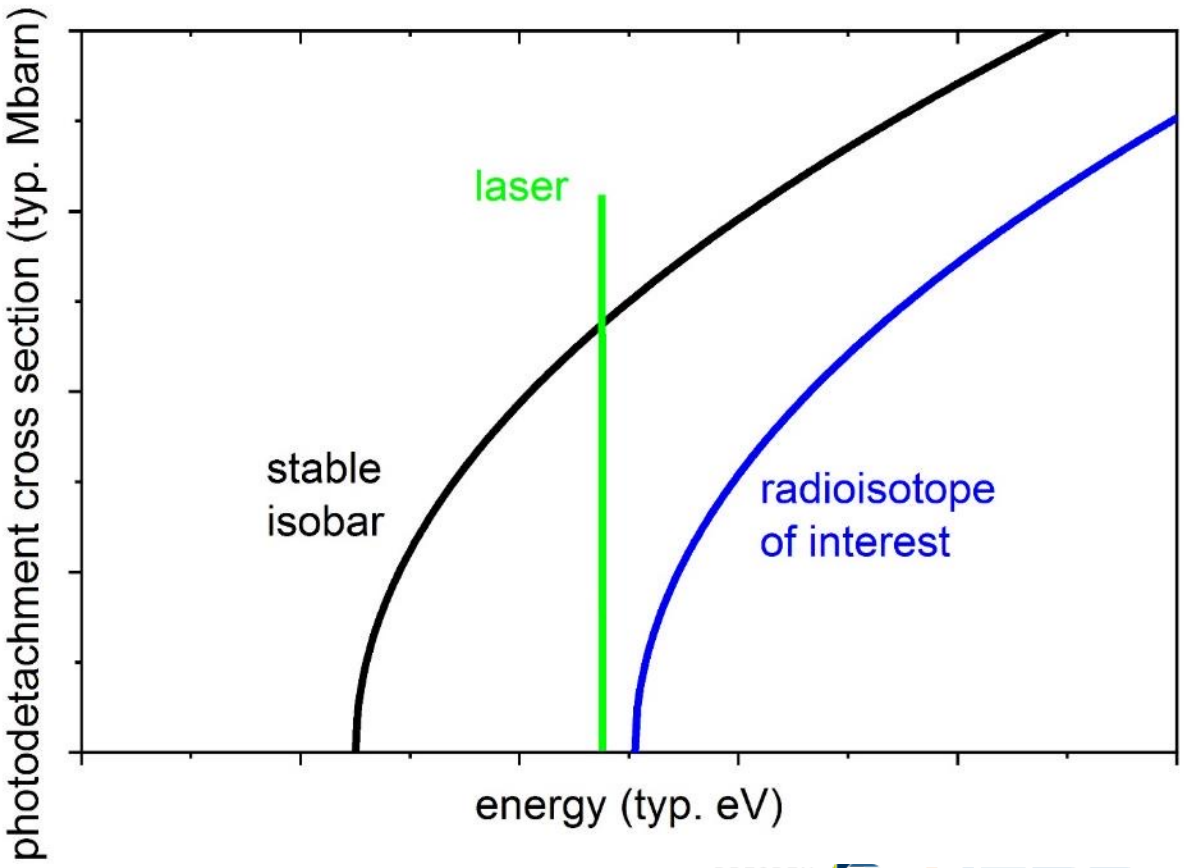

HAMSTER
247Cm (16 Myr)
239Pu - 244Pu
237Np (2.1 Myr)
233U (33 kyr)
243Am (7.3 kyr)
129I (16 Myr)
236U (23 Myr)
231Pa (33 kyr)
182Hf (8.9 Myr)
93Zr (1.5 Myr)
90Sr (29 yr)
135,137Cs (~1.5 Myr, 30 yr)
59Ni (76 kyr)
53Mn (3.7 Myr)
99Tc (210 kyr)
41Ca (0.10 Myr)
79Se (327 kyr)
26Al (0.71 Myr)
55Fe (2.7 yr)
36Cl (0.30 Myr)
10Be (1.4 Myr)
proton number Z
neutron number N

What about ^{182}Hf? AMS 2.0

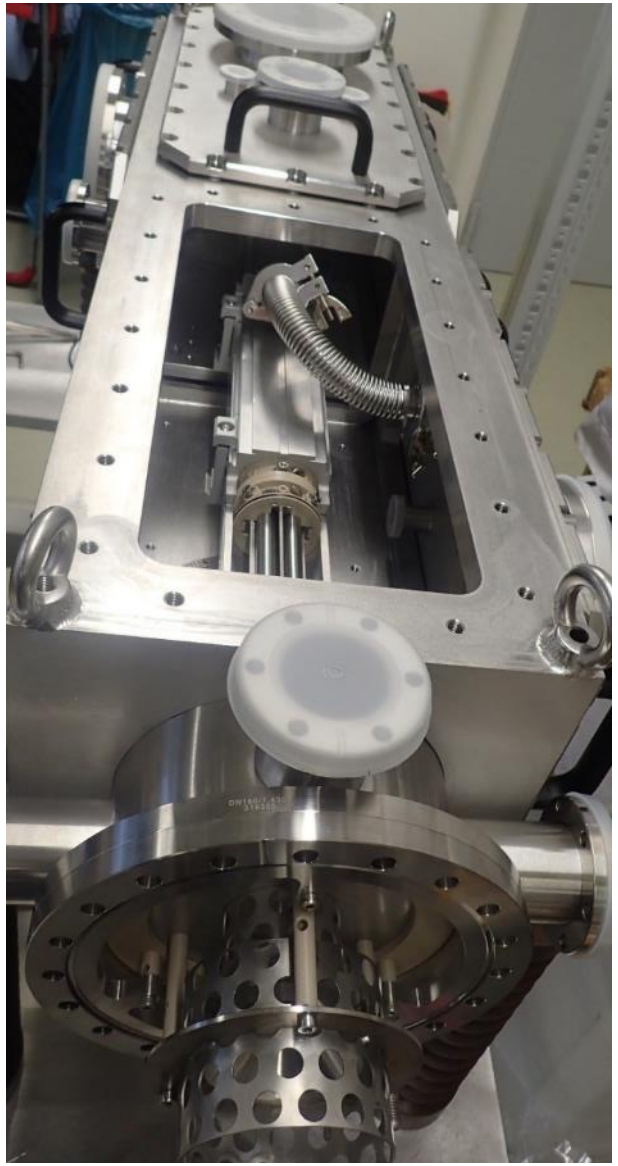
- new isobar suppression techniques
- add more element selective processes for negative ions before the accelerator: interactions of slow ions with gas and laser light
- promising results for ^{182}Hf (Martschini et al., 2020)

W 182	W 183	W 184
26.50	14.31	30.64
Ta 181	Ta 182	Ta 183
99.98799	114.74 d	5.1 d
Hf 180	Hf 181	Hf 182
35.08	42.39 d	8.90 Myr

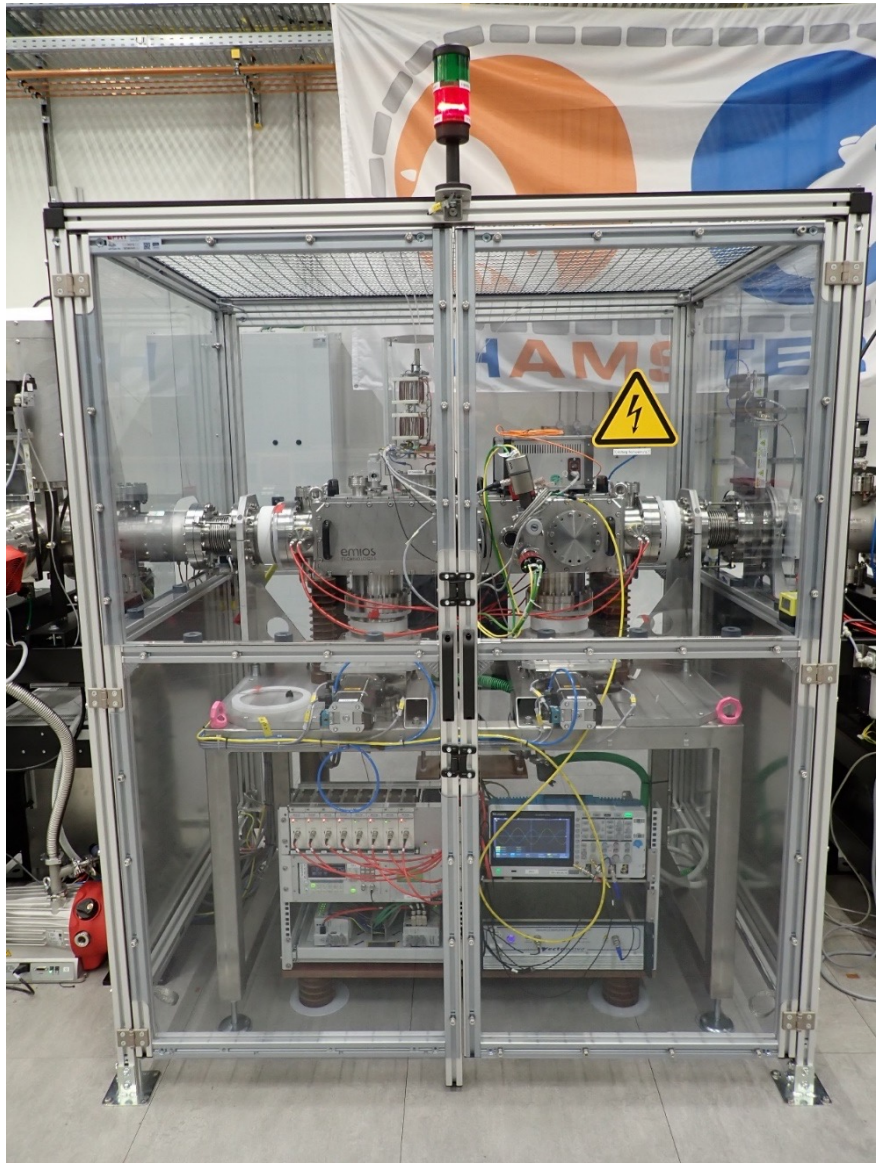




ILTIS: Ion Linear Trap for Isobar Suppression

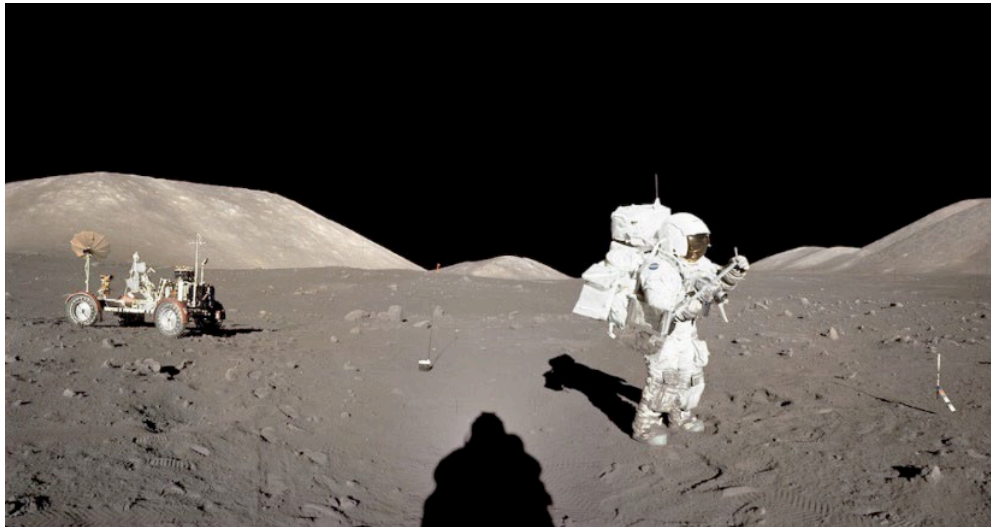


- new ion cooler designed in collaboration with the University of Vienna
- based on ILIAMS
- in operation since 11/24



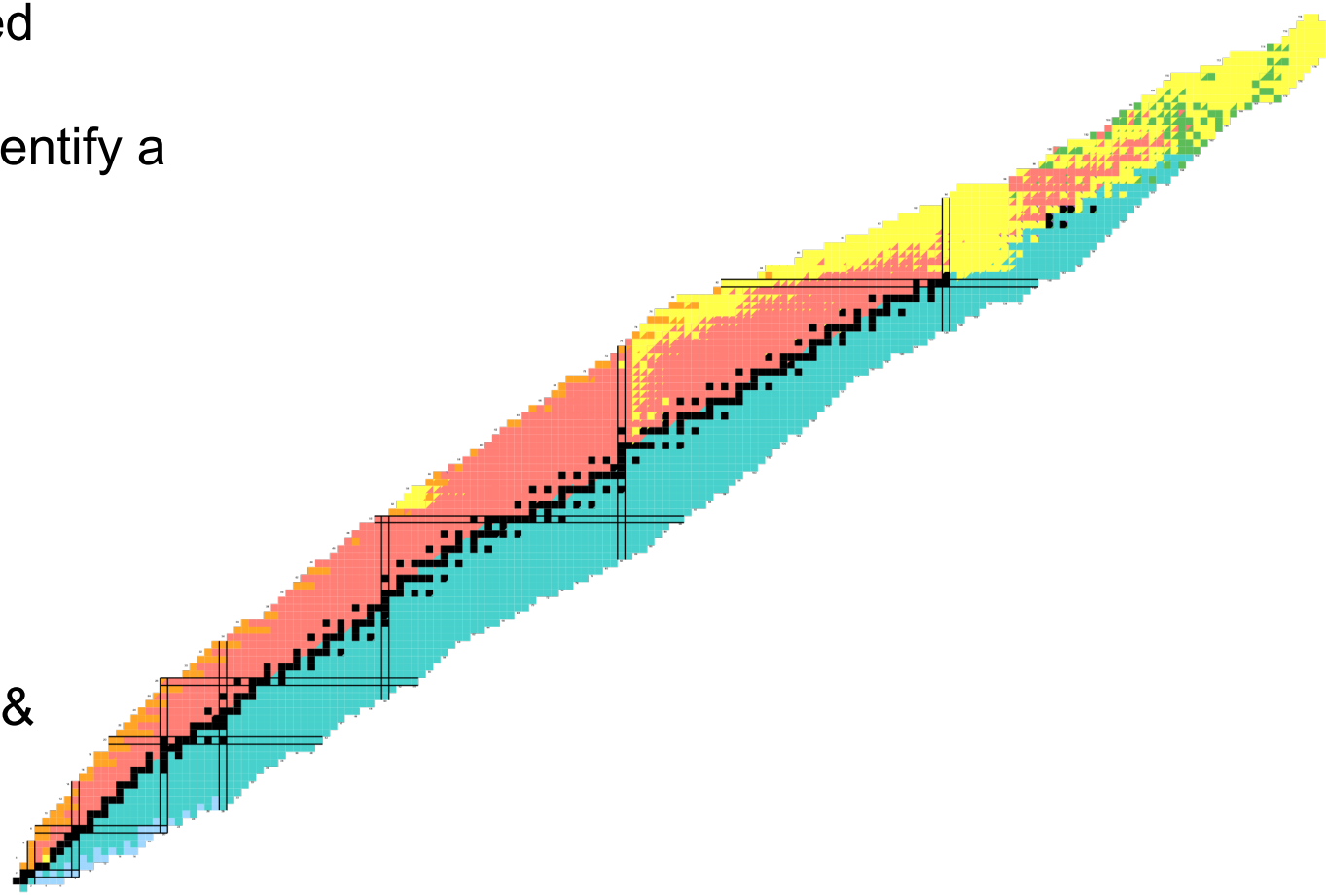
universität wien Fakultät für Physik DRESDEN concept HZDR

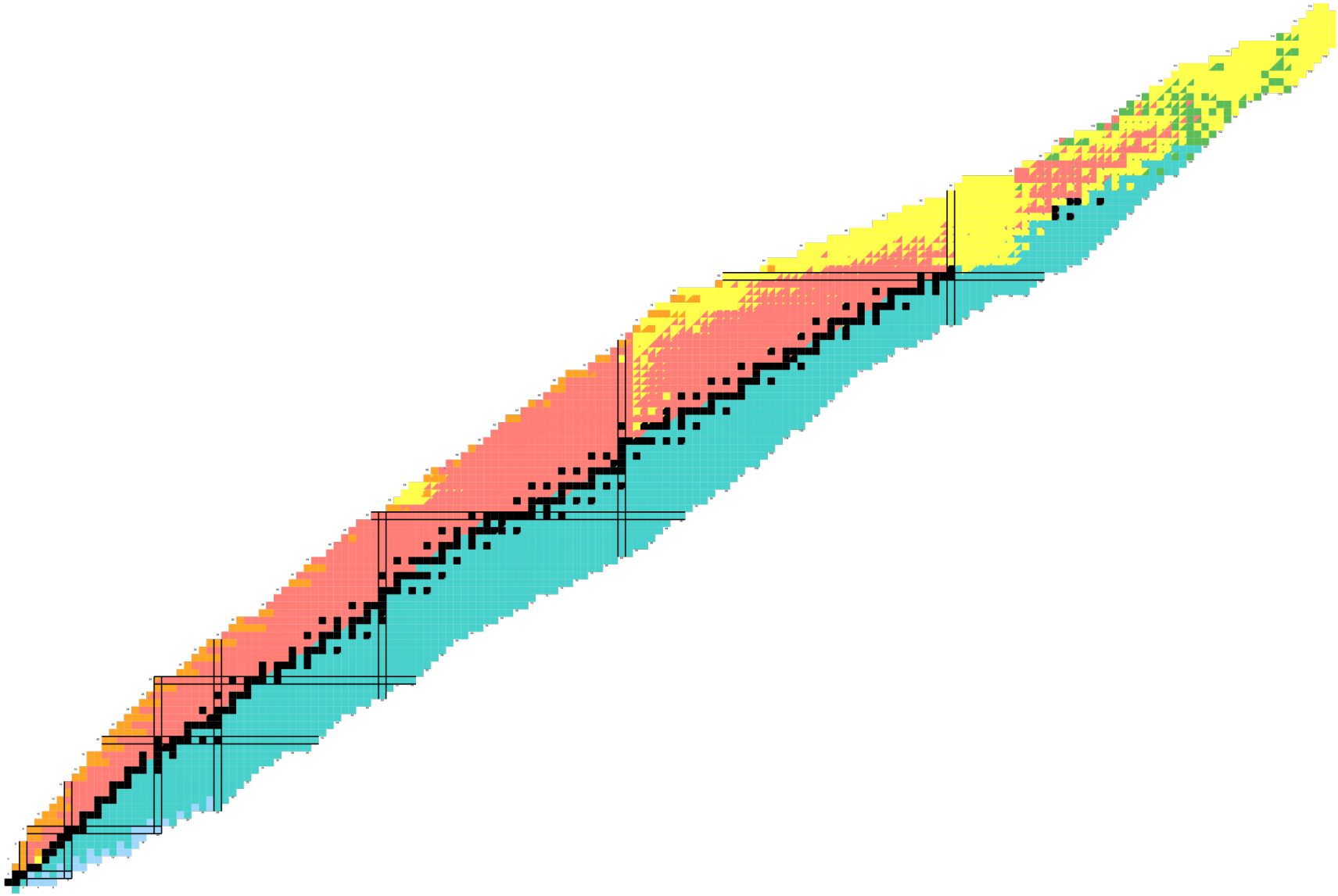
Alternatives to FeMn crusts and marine sediments



Summary

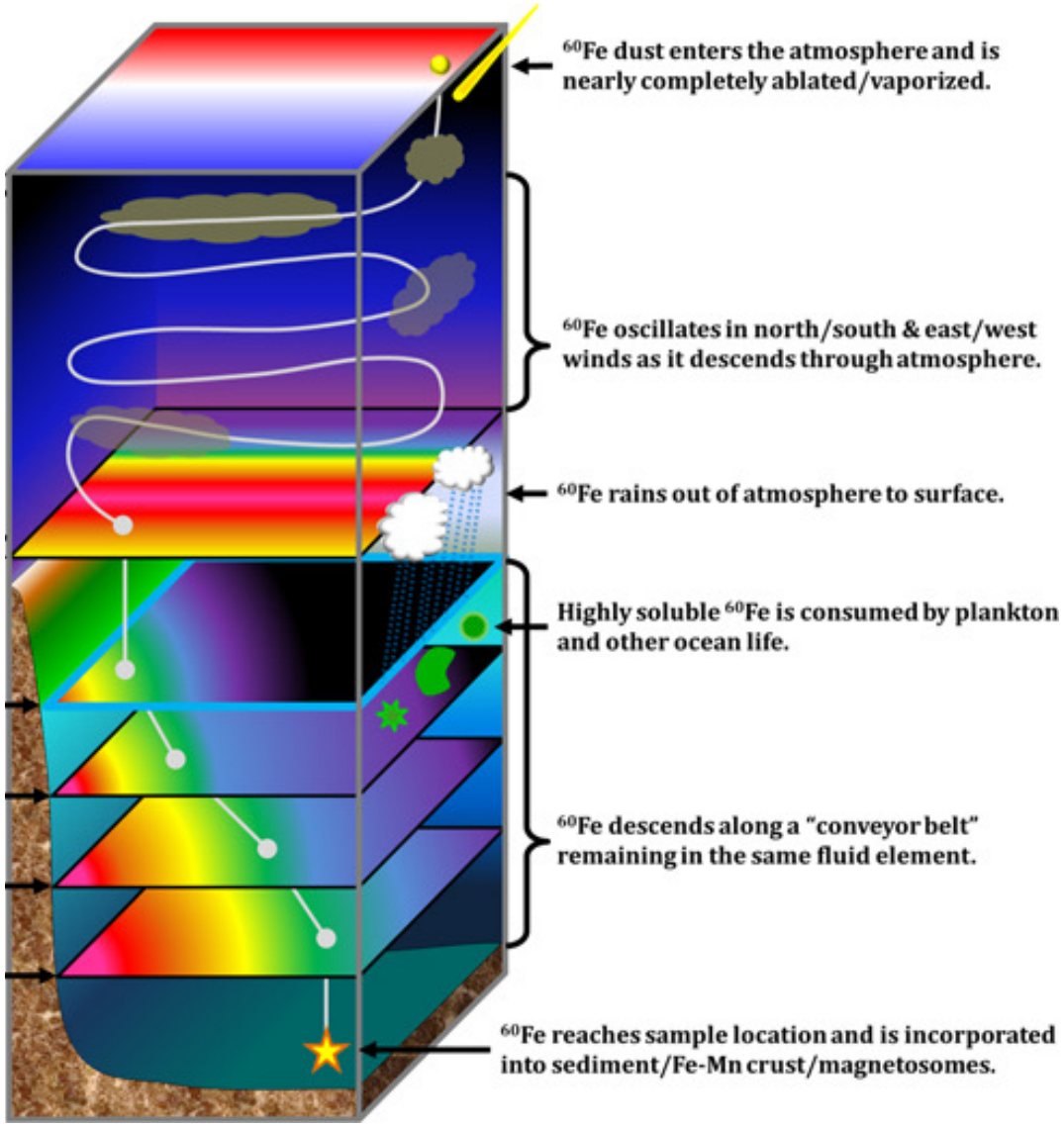
- new 1MV HAMSTER facility being installed
- few radionuclides relevant & suitable to identify a cosmic nucleosynthesis fingerprint
- different archives tell us different stories
- AMS as powerful technique to detect live radionuclides in nature
- critical to rule out input from other natural & anthropogenic sources





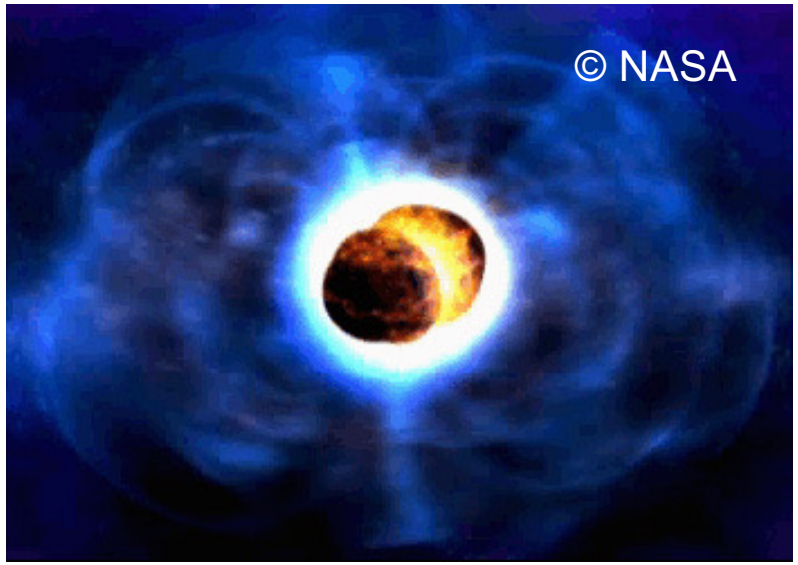
Transport processes on Earth

- dust enters atmosphere & gets vaporized
- atoms attach to particles and get rained down
- deposition on ground or in ocean
- transport through ocean currents
- deposition in sediment or other marine „archive“



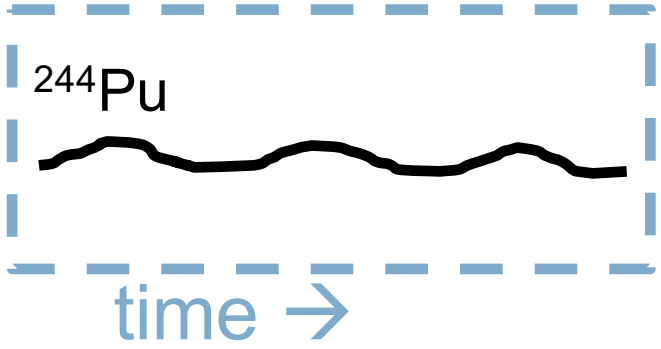
Fry, Fields & Ellis 2016

r-process sites: a matter of timing & frequency

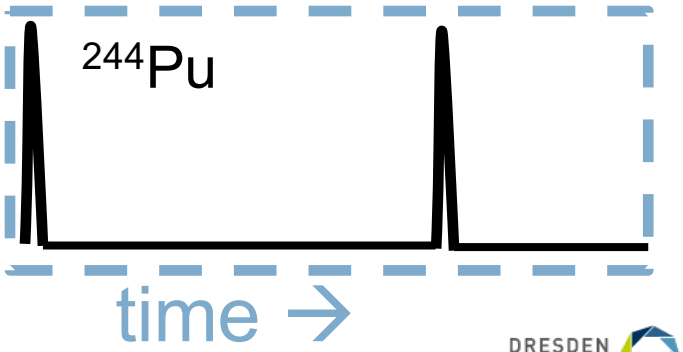


frequent events:
e.g. core collapse supernova

rare events:
e.g. neutron star mergers



rates:
~ 1000:1



New insights from a classic AMS isotope: ^{10}Be

Koll et al., Nature Comm. 2025

- significant change of otherwise long-time stable ocean transport pattern?
- increased production of ^{10}Be in atmosphere?