Target performance under beam influence: Comparison of different production methods and different incident projectiles

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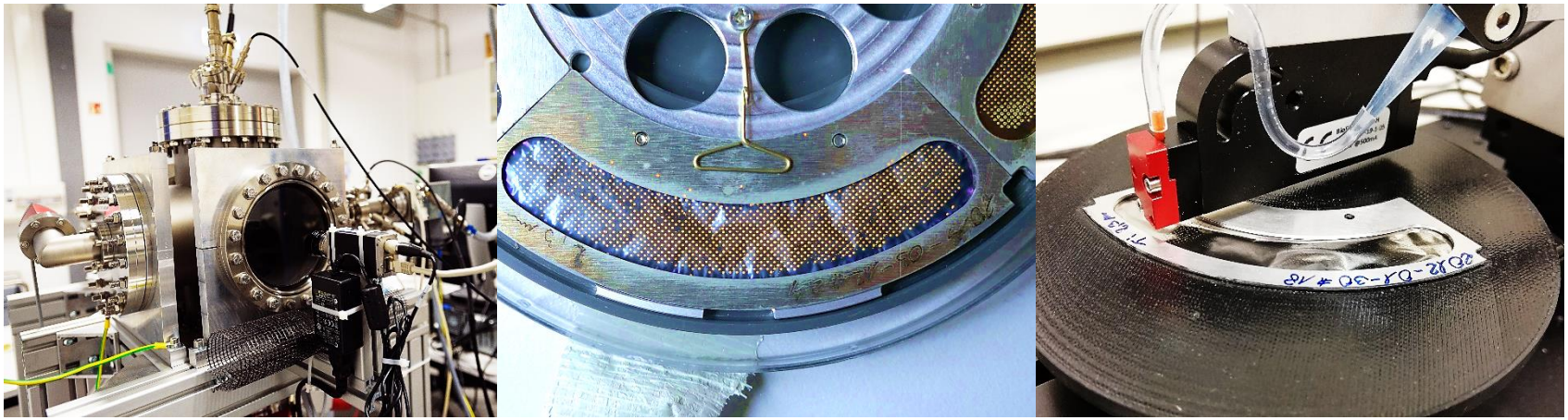

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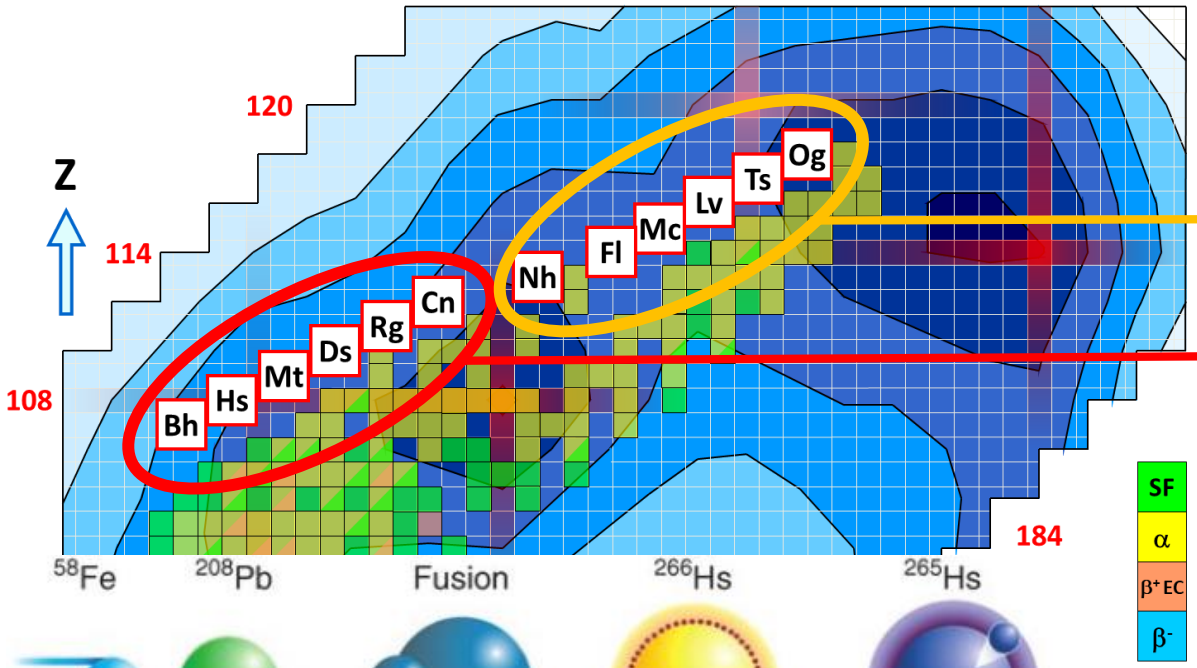
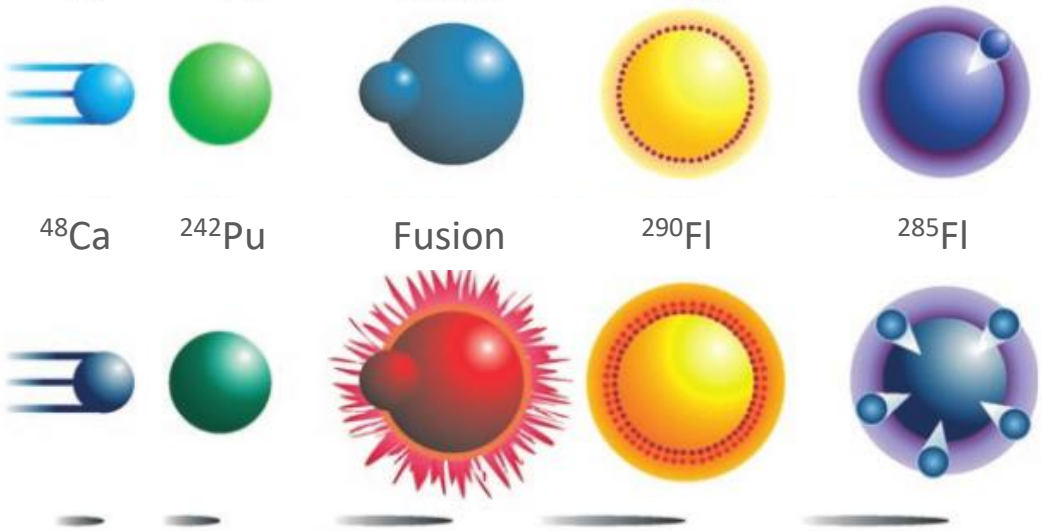
Introduction



Ca + U -> 112
Np -> 113
Pu -> 114
…

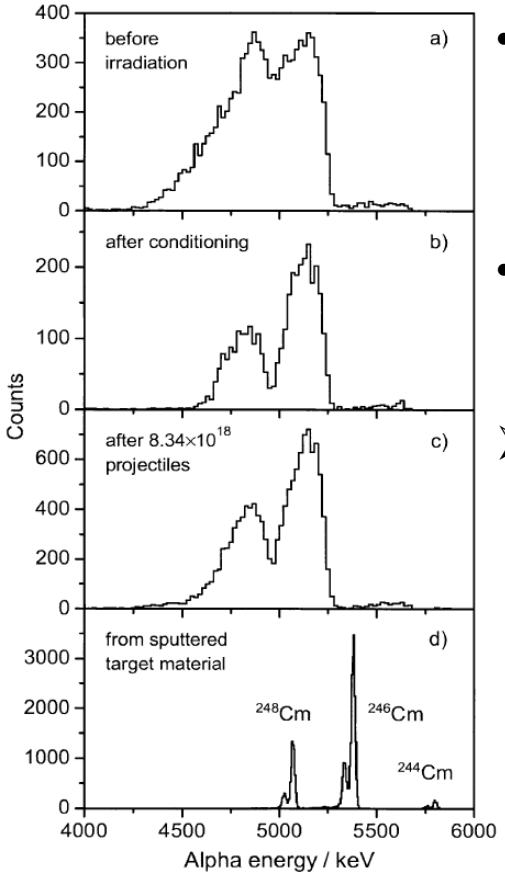
Pb + Cr -> 106
Fe -> 108
Ni -> 110
Zn -> 112



Target production well-established:
- Molecular Plating
- Evaporation

new:
- Drop-on-Demand

Motivation



- conditioning in accelerator beam „purifies“ targets as seen in α spectra
- chemical processes during irradiation still not well known

➢ Goal: accelerator independend studies on chemical processes during irradiation and development of experiment for Off-line Deposit Irradiation (ODIn)

[1] S. Hofmann et al., Eur. Phys. J. A 48 (2012) 62

Target preparation

Colorful lead compounds

Lead sub oxide
Pb_2O

Lead dioxide
PbO_2

Lead oxide
PbO

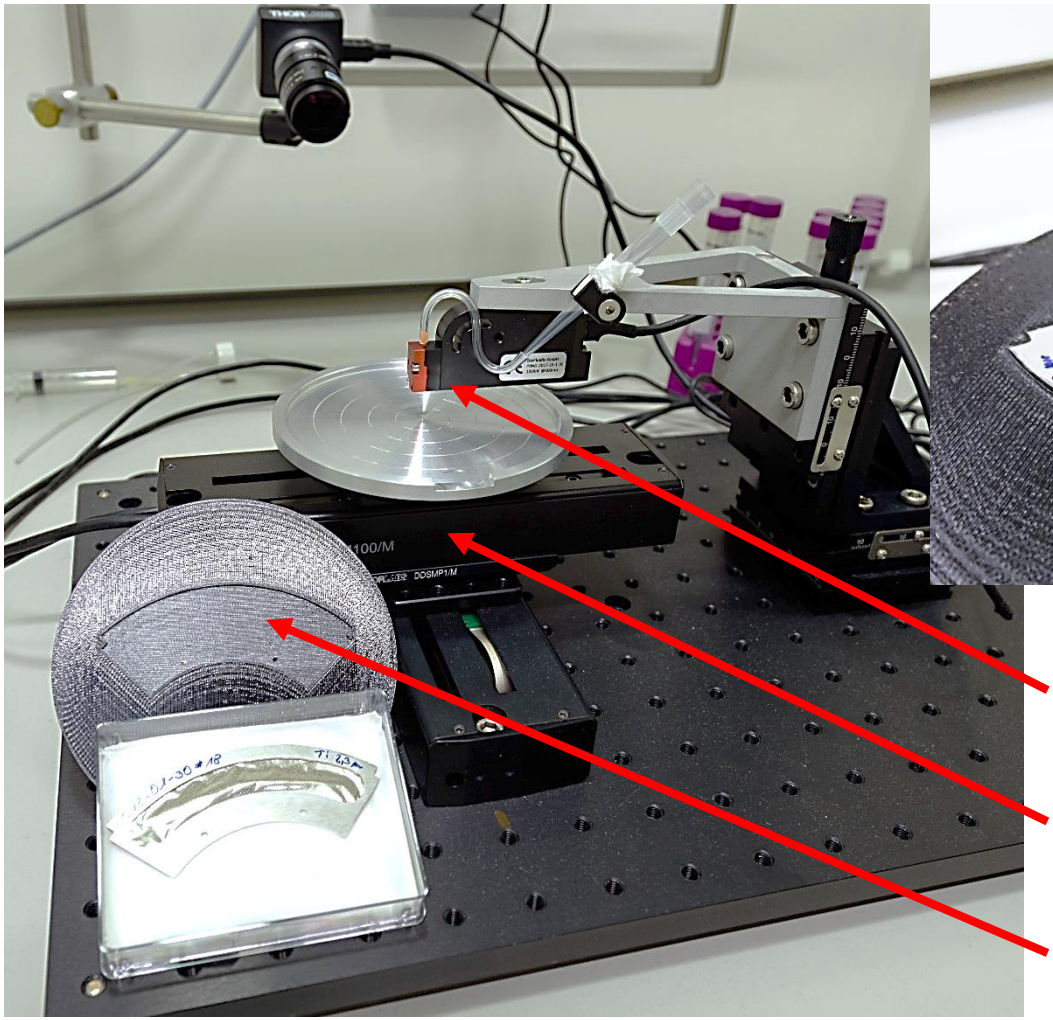
Lead nitrate
$Pb(NO_3)_2$

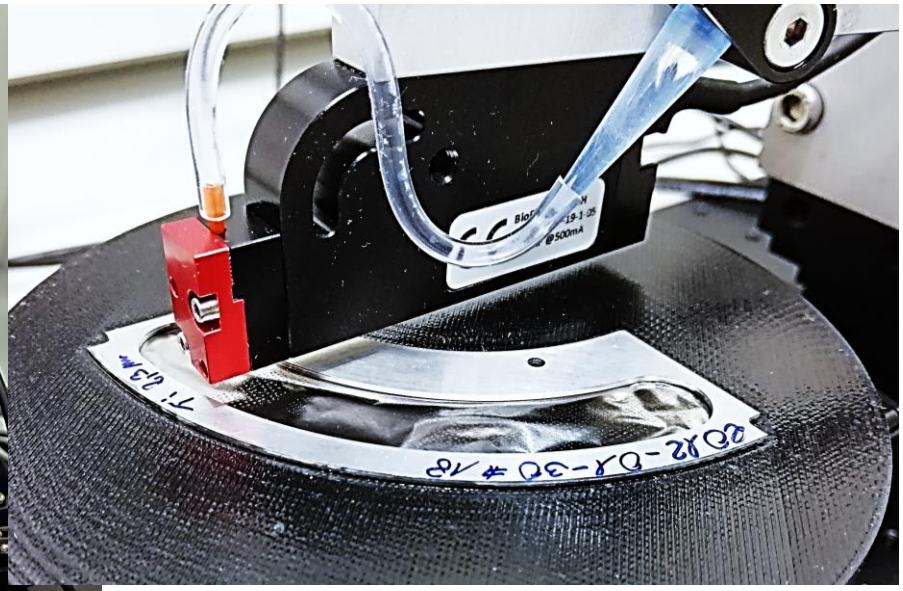
Lead tetroxide
Pb_3O_4

Reasons for lead as target material:

- good cross sections for production of No
- well known target material
- easy to transform into the oxide by tempering
- many compounds in different colors

Drop-on-Demand printer setup





PipeJet® P9 NanoDispenser
with 200 µm tip (BioFluidix)

motorized translation stage 100 mm
DDSM100/M (Thorlabs)

3D printed plate for TASCA
segments

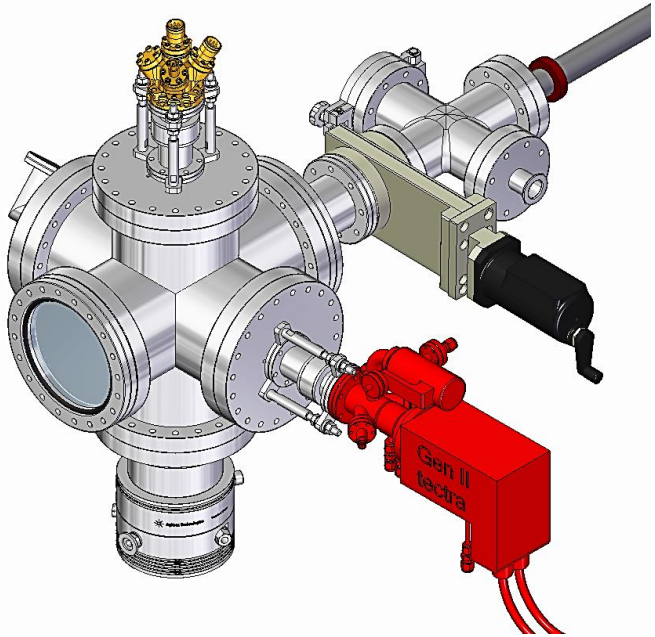
Irradiation of Pb targets

GSI - UNILAC:

^{50}Ti	~ 5 MeV/u
^{40}Ar	~ 6 MeV/u

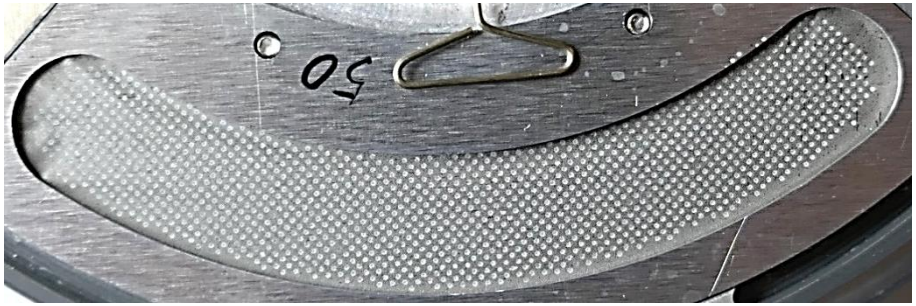
Mainz - ODIn (Off-line Deposit Irradiation):

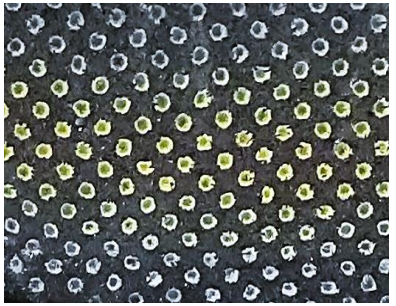
e^-	max. 1.5 keV
H_2, N_2, O_2, He, Ne, Ar, CO	max. 5 keV



Irradiation tests at TASCA

First irradiation with ^{50}Ti beam





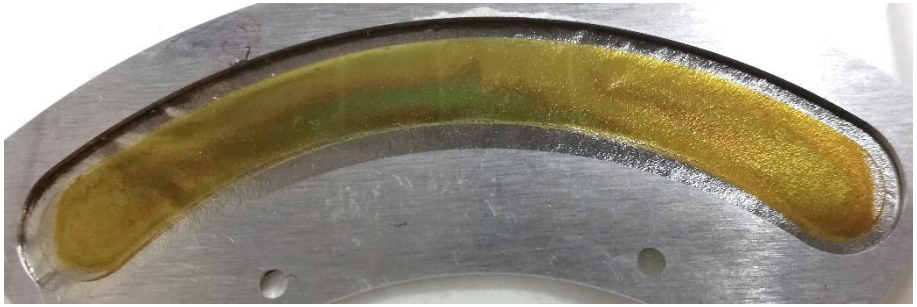
Lead nitrate (2.1 mg Pb) on carbon foil

Lead nitrate (2.1 mg Pb) on Ti foil (2.3 µm), tempered at 500°C for 30 min

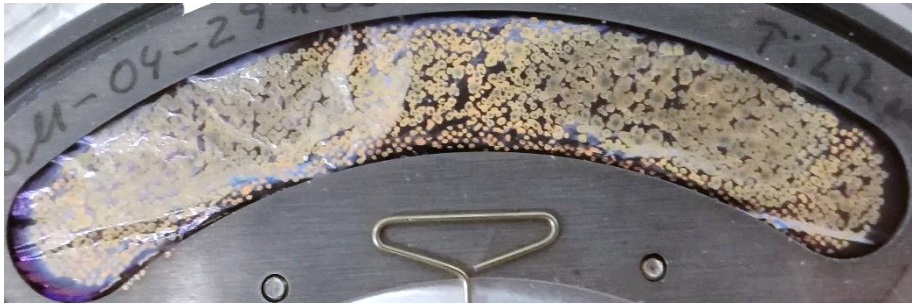
Before irradiation

After irradiation with 4.85 MeV/u ^{50}Ti with 6.8 µA, 14 µA, 25 µA and 44 µA for 5 min each

Second irradiation with ^{40}Ar beam

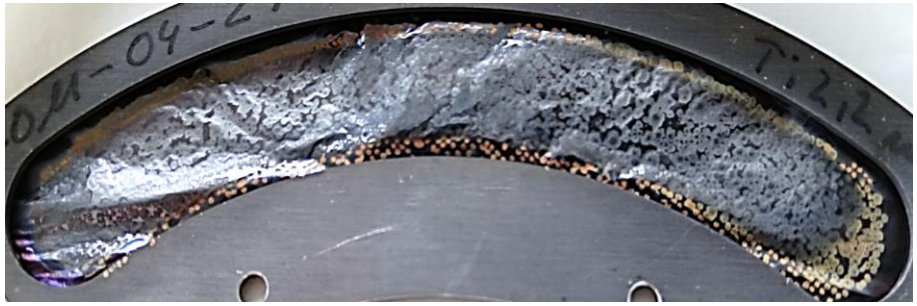


0.42 mg/cm² Pb on 2.2 µm Ti foil



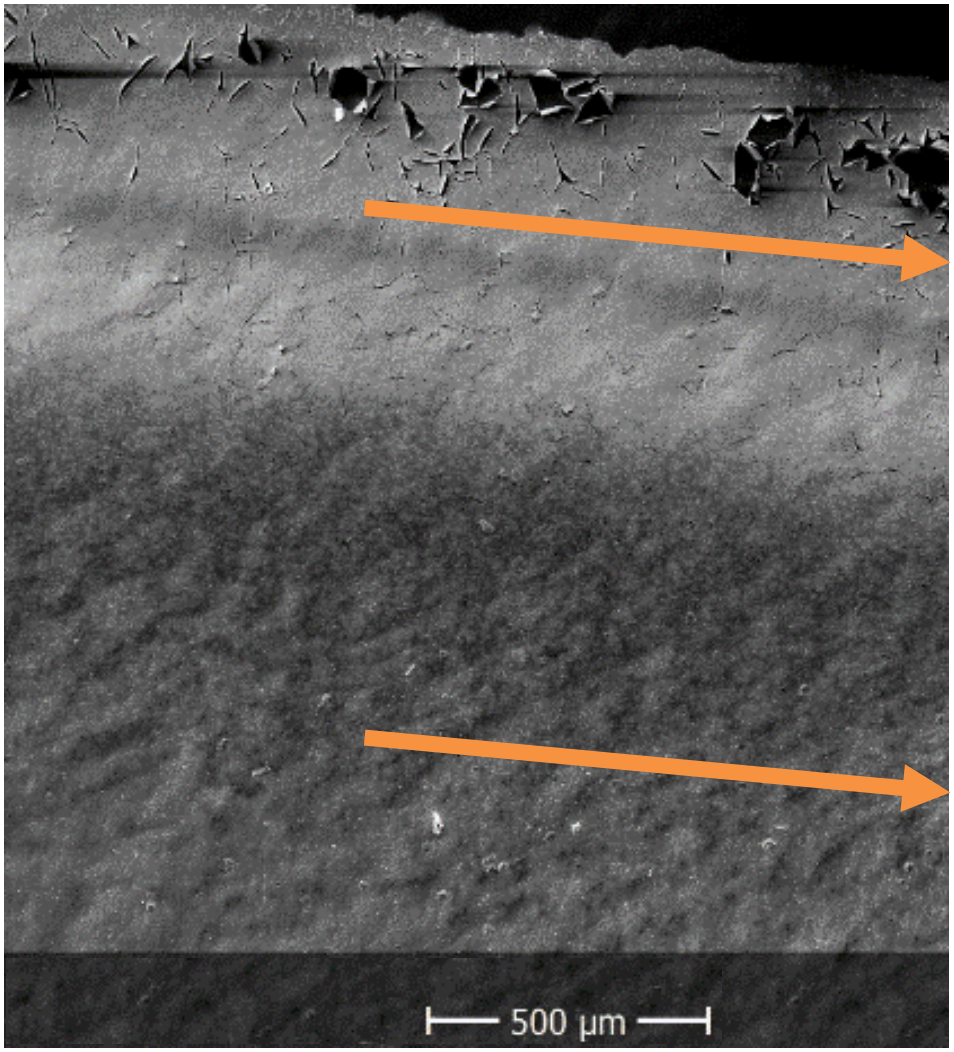
0.85 mg/cm² Pb on 2.4 µm Ti foil

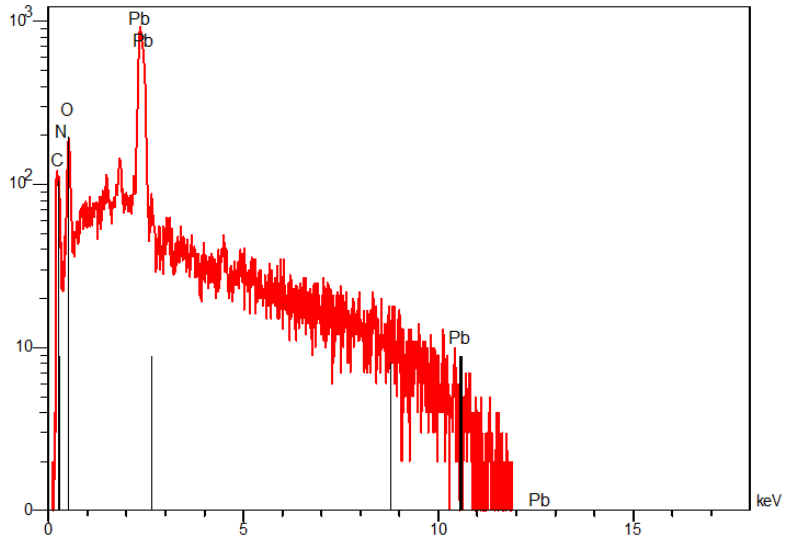
Before irradiation

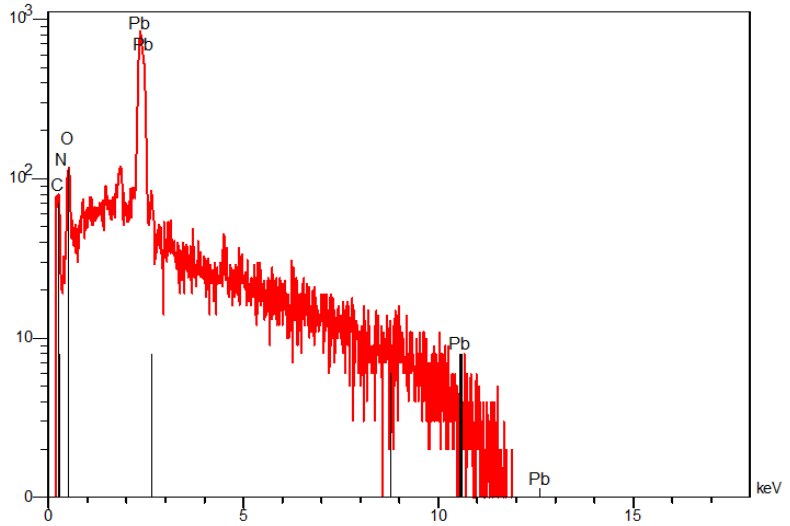


After irradiation with 5.9 MeV/u ^{40}Ar with 18.5 µA for 100 min

Second irradiation with ^{40}Ar beam

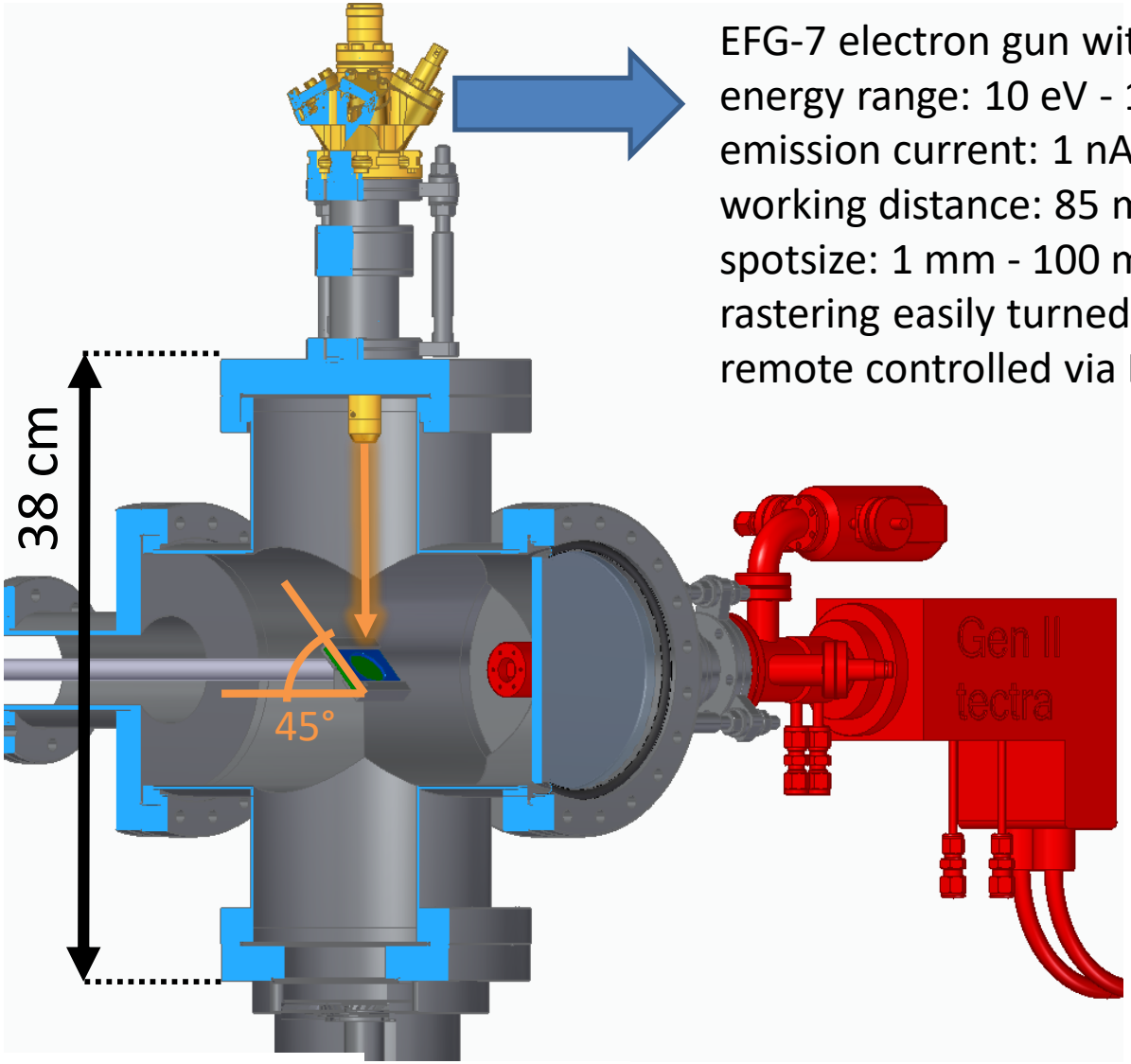






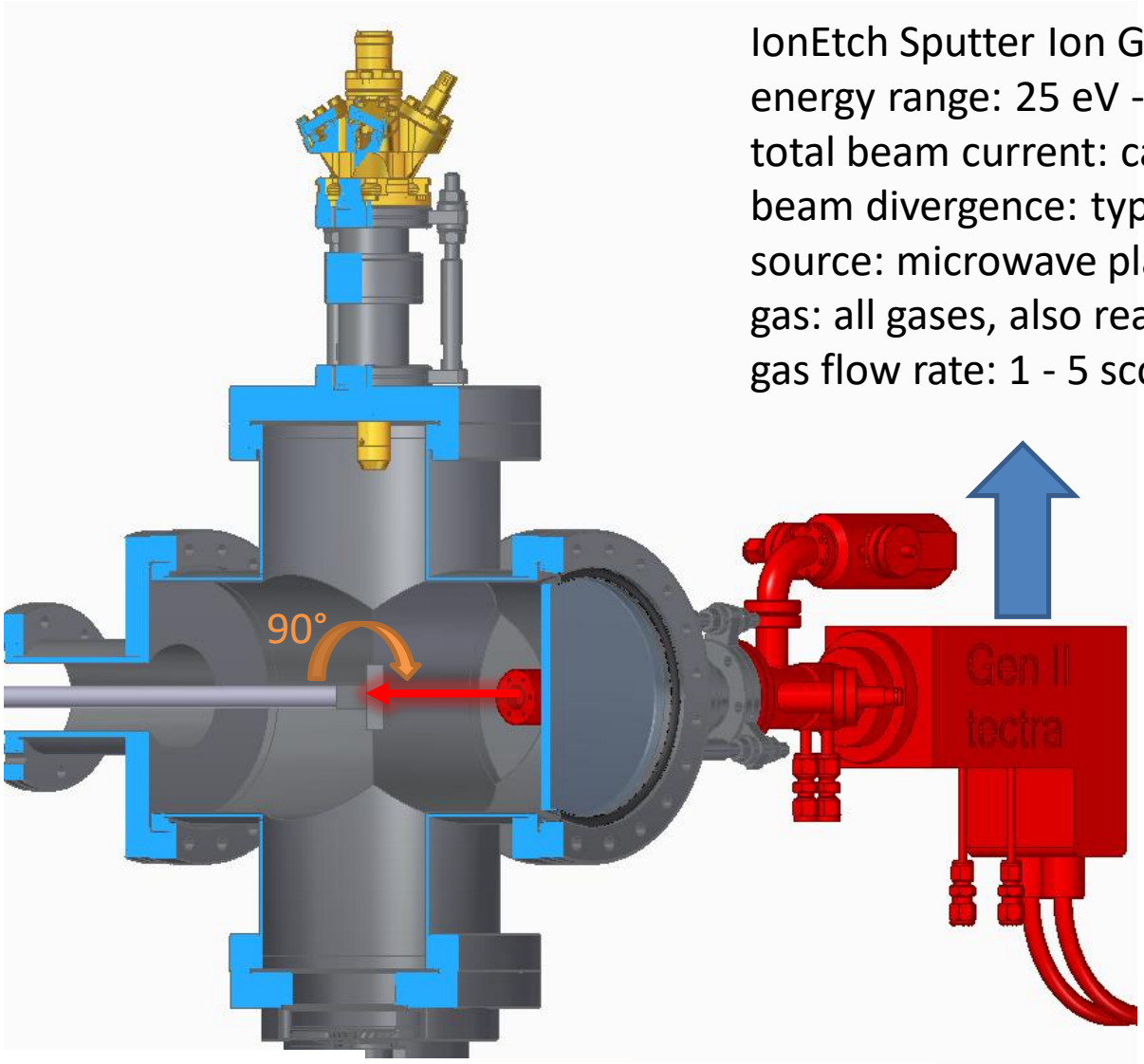
Development of an experiment for Off-line Deposit Irradiation (ODIn)

Setup of ODIn: electron gun



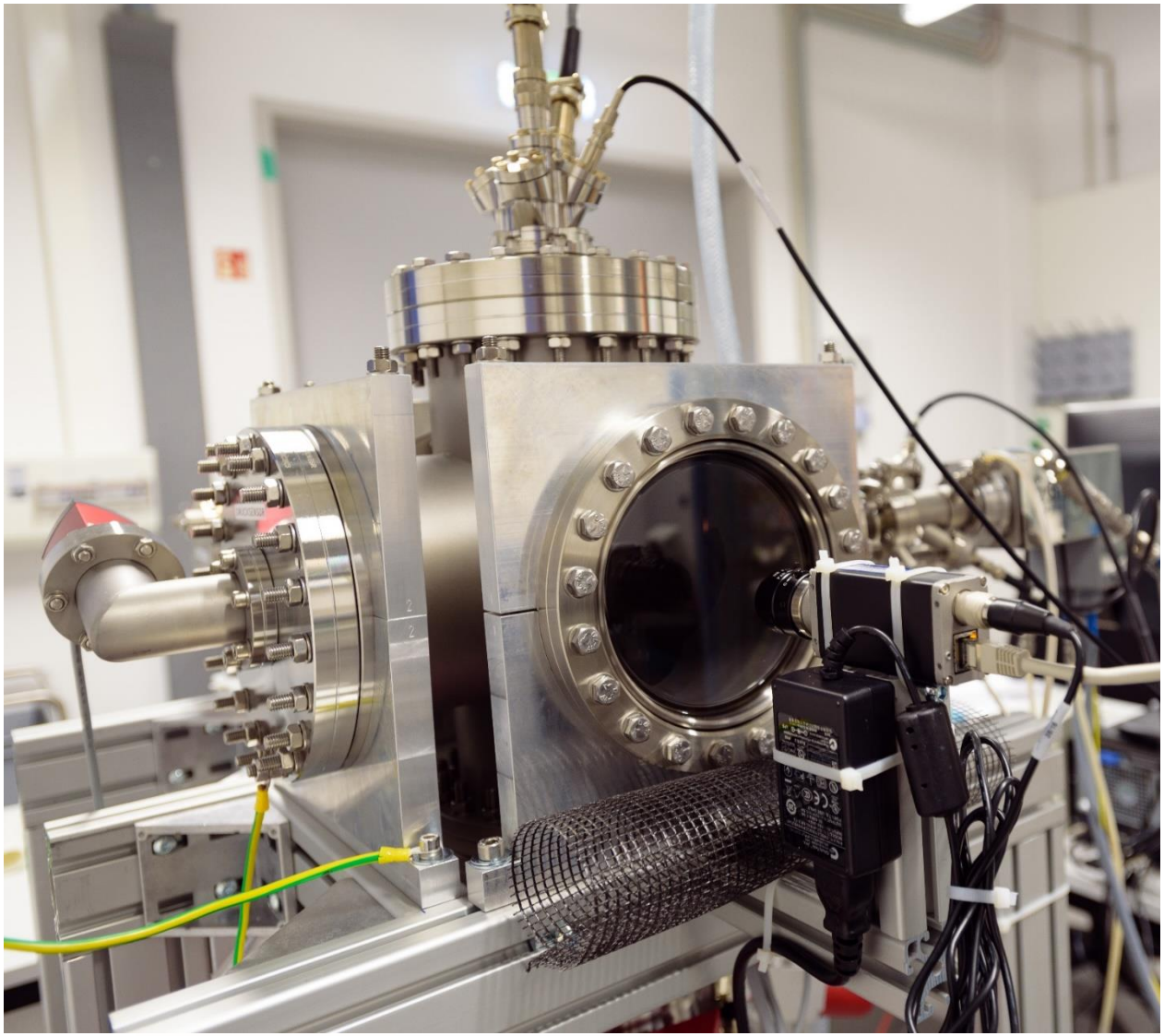
EFG-7 electron gun with deflection (Kimball Physics)
energy range: 10 eV - 1500 eV
emission current: 1 nA - 1 mA
working distance: 85 mm - 95 mm
spotsize: 1 mm - 100 mm
rastering easily turned on/off
remote controlled via LabView software

Setup of ODIn: sputter ion gun



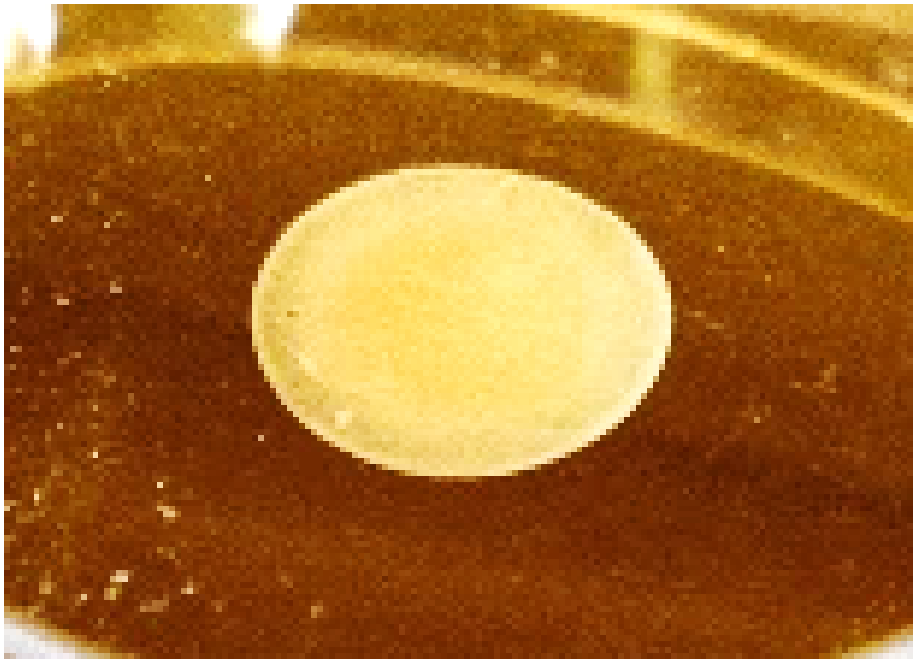
IonEtch Sputter Ion Gun GenII (Tectra)
energy range: 25 eV - 5 keV
total beam current: ca. 2 mA
beam divergence: typically 15°
source: microwave plasma induced discharge
gas: all gases, also reactive ones like H_2 and O_2
gas flow rate: 1 - 5 sccm

Setup of ODIn

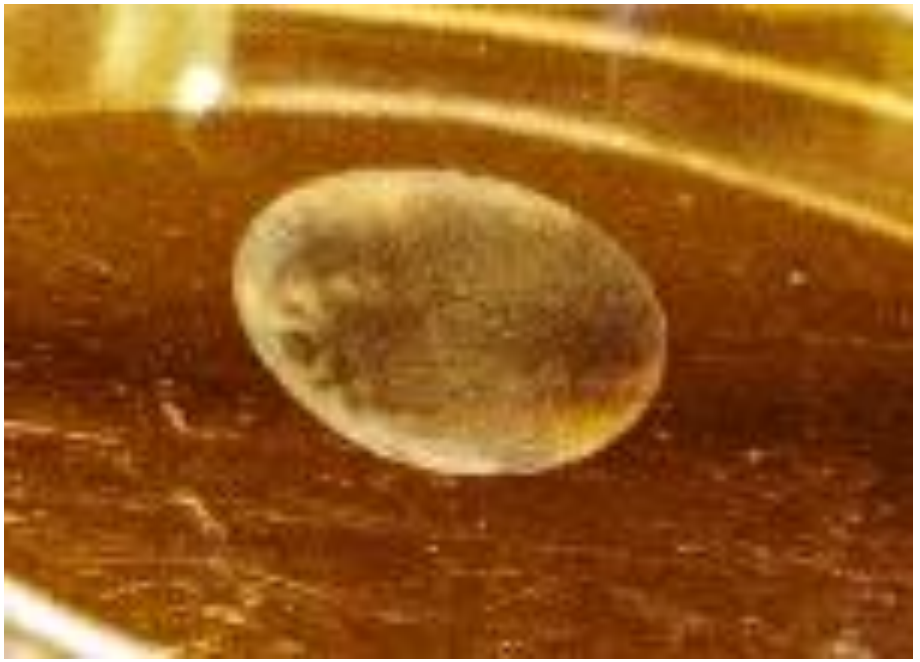


First irradiations with electrons

Molecular plated lead sample
on Kapton foil with 33 nm gold coating
deposition density: 0.36 mg/cm²



before irradiation



after irradiation with
1.5 keV and 100 µA

Summary

- First irradiation tests offered valuable clues about good DoD target preparation
- Second irradiation tests showed clearly visible transformations on both MP and DoD targets
- Off-line experiment ODIn was set up to reproduce these results with low-energy electron and ion beams
- First results of irradiation with electron beams are comparable to results of TASCA experiment

Outlook

- More analytics need to be done to identify the chemical compounds before and after irradiation
- Commissioning of ion gun at ODIn and further irradiations of lead and samarium at TASCA

Acknowledgements

- financial support of Helmholtz-Institut Mainz

- manufacturing of the TASCA segments by GSI target laboratory
- local support of the UNILAC staff
- local support of mechanical workshop at the Institut für Kernchemie Mainz