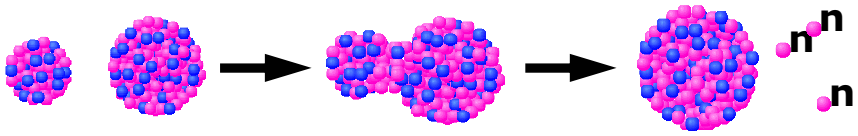
Targets for SHE experiments with intense beams

GSI Nuclear Chemistry Group □ GSI Target Laboratory
Workshops GSI + JGU □ JGU Nuclear Chemistry

- SHE production with actinide targets
- Target production - Molecular Plating
- New (100-mm) target wheel @ TASCA
- Target development

SHE production with actinide targets



- E114 ^{244}Pu(^{48}Ca,xn)
- E115 ^{243}Am(^{48}Ca,xn)
- E116 ^{248}Cm(^{48}Ca,xn)
- E117 ^{249}Bk(^{48}Ca,xn)
- E119 ^{249}Bk(^{50}Ti,xn)
- E120 ^{248}Cm(^{54}Cr,xn)
- E120 ^{249}Cf(^{50}Ti,xn)

Target thickness:…...500 µg/cm^2

Target production technique:

- Chemical purification prior to deposition
- Recovery and chemical purification of used target material
- Small and simple set-up
- Components easy to replace in order to avoid cross-contamination

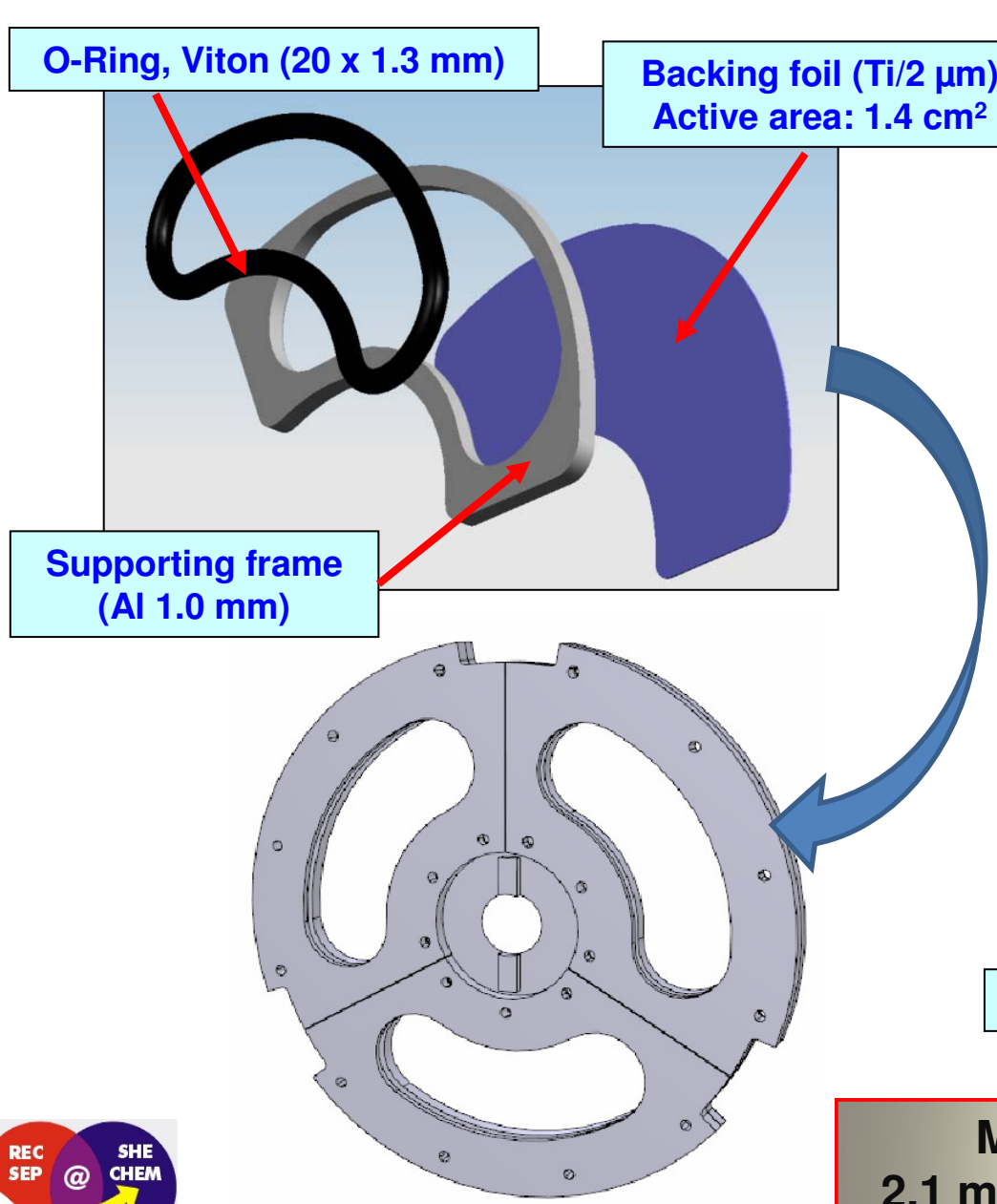
Electrochemical deposition:

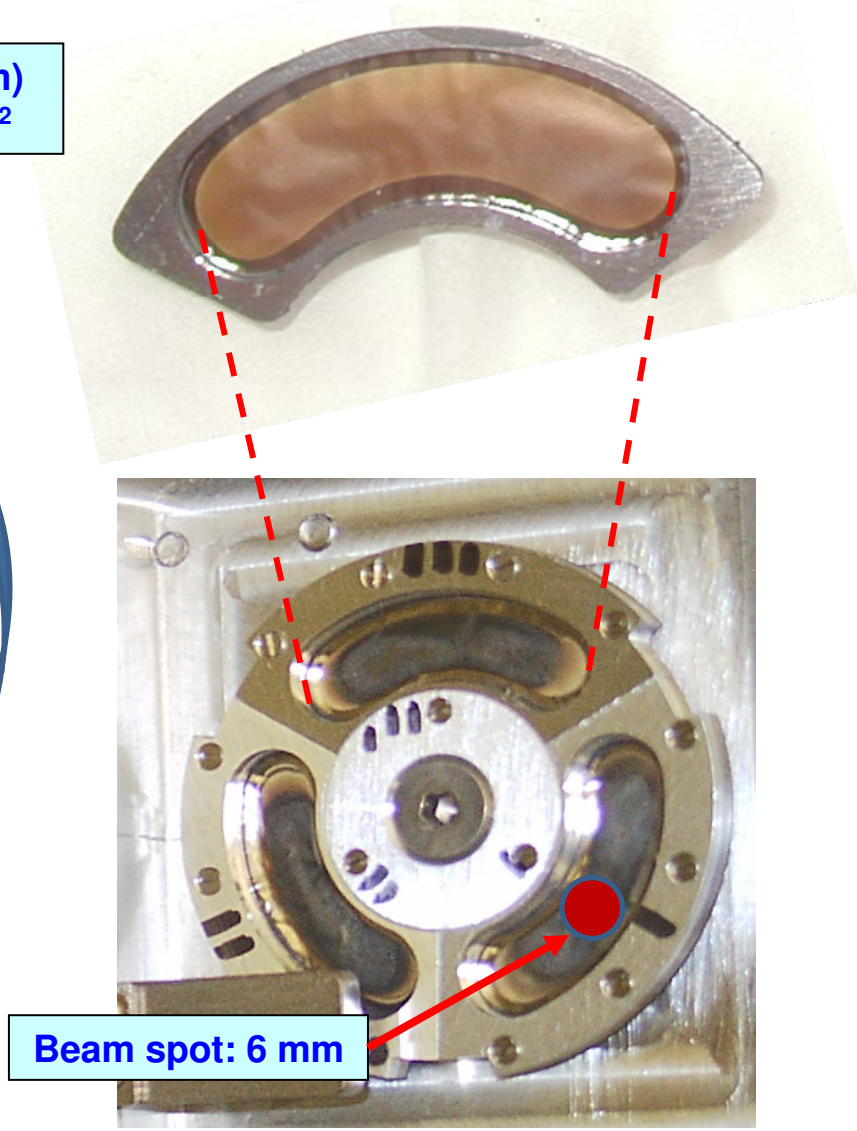
Molecular Plating

REC SEP @ SHE CHEM

JG|U

ARTESIA target wheel

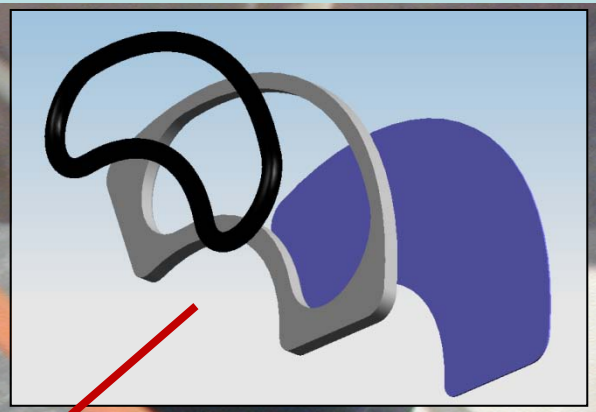




Material consumption:
2.1 mg per wheel @ 500 µg/cm²

Actinide deposition by Molecular Plating

- Simple electrochemical cell
- Material: PEEK or Teflon (for Pu)
- Volume: about 16 ml
- Solvent: isobutanol or isopropanol
- Deposition time: 0.5 h up to 6 h (Pu)
- Curren density: mA/cm^2
- Voltage: 100 V up to 1200 V



Anode (Ti)

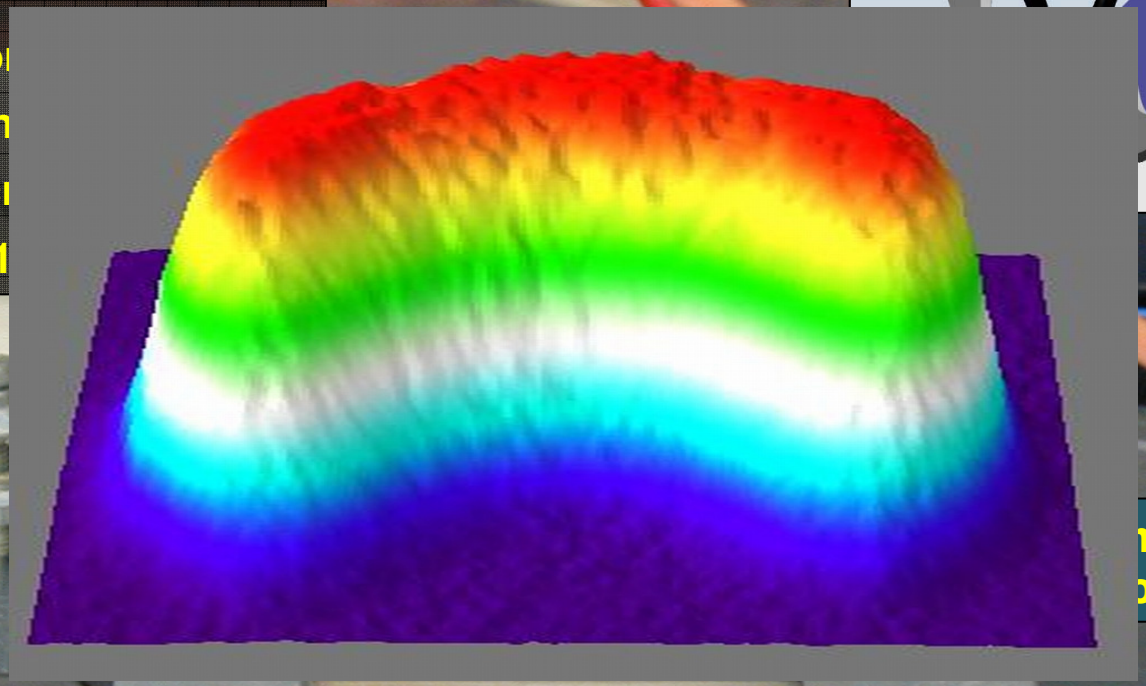
Actinide compound in isobutanol (16 ml)

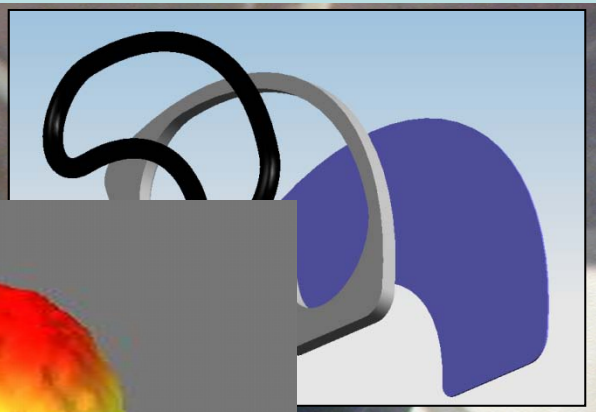
Kathode (Ti)

Cell design according to H. Haba [RIKEN], TASCA05, Oslo, Oct. 2005

Actinide deposition by Molecular Plating

- Simple electrochemical cell
- Material: PEEK or Teflon (for Pu)
- Volume: about 16 ml
- Solvent: isobutanol o
- Deposition time: 0.5 h
- Curren density: mA/c
- Voltage: 100 V up to 1





mpound
ol (16 ml)

Deposition yield: up to 90%

Target thickness: mg/cm^2 possible

Target homogeneity: radiographic imaging

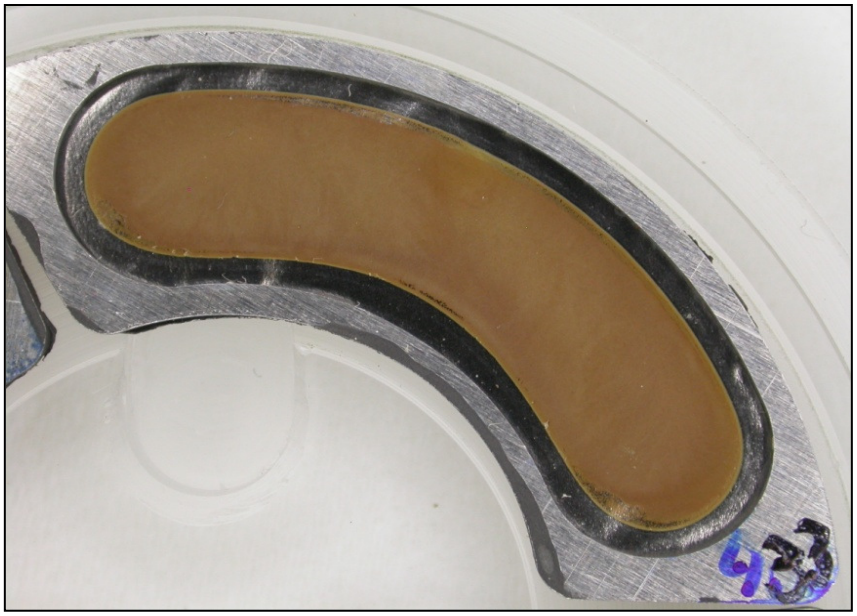
Cell design according to H. Haba [RIKEN], TASCA05, Oslo, Oct. 2005

Deposition of Pu and Cm by Molecular Plating

Deposition conditions for Pu:

Solvent……Isobutanol
Plating time……6 h
Voltage……150 – 200 V
Current density…..1.4 mA/cm²
Stirring at……1200 U/min
Temperature……15 ℃

E114 □ ^{244}Pu(^{48}Ca,xn)

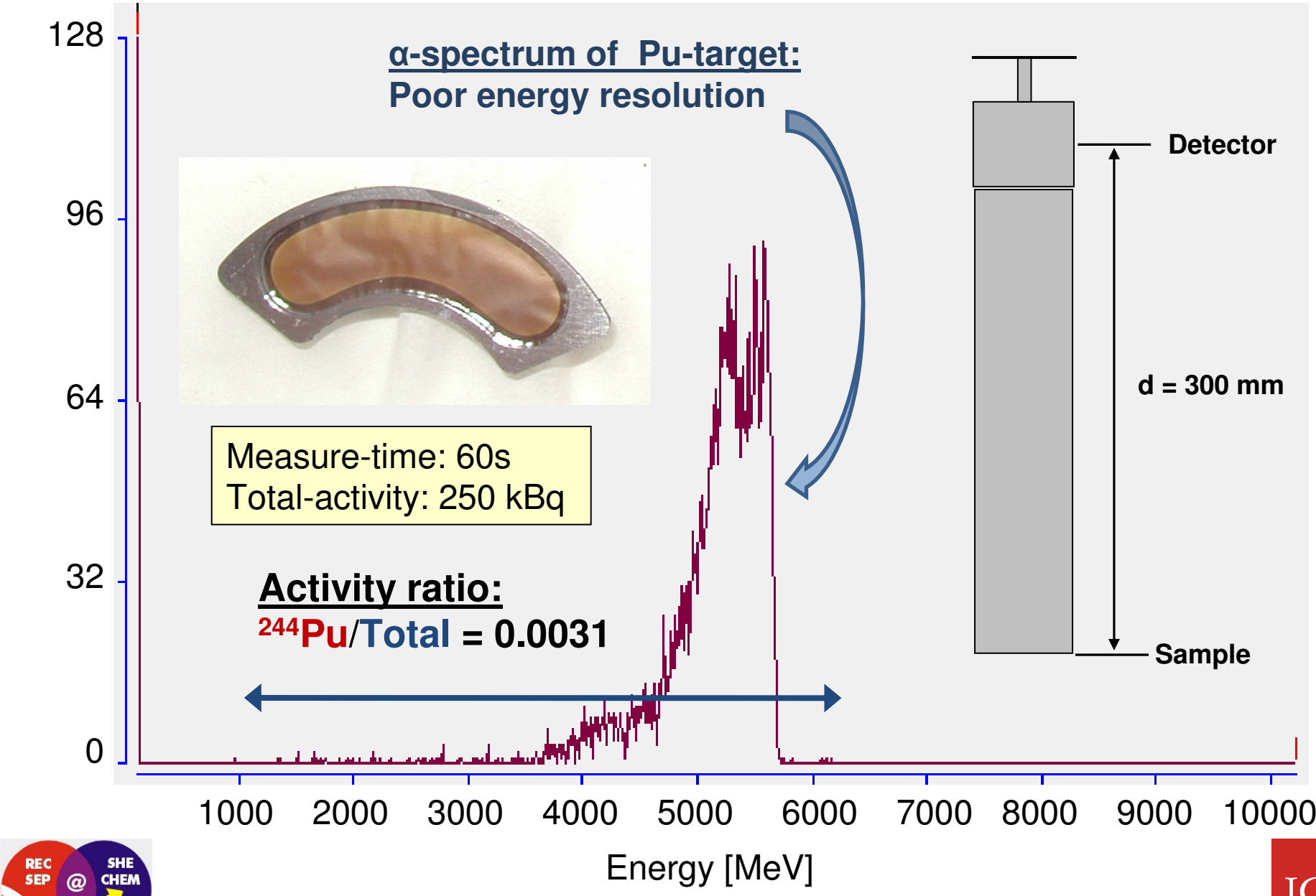


Deposition conditions for Cm:

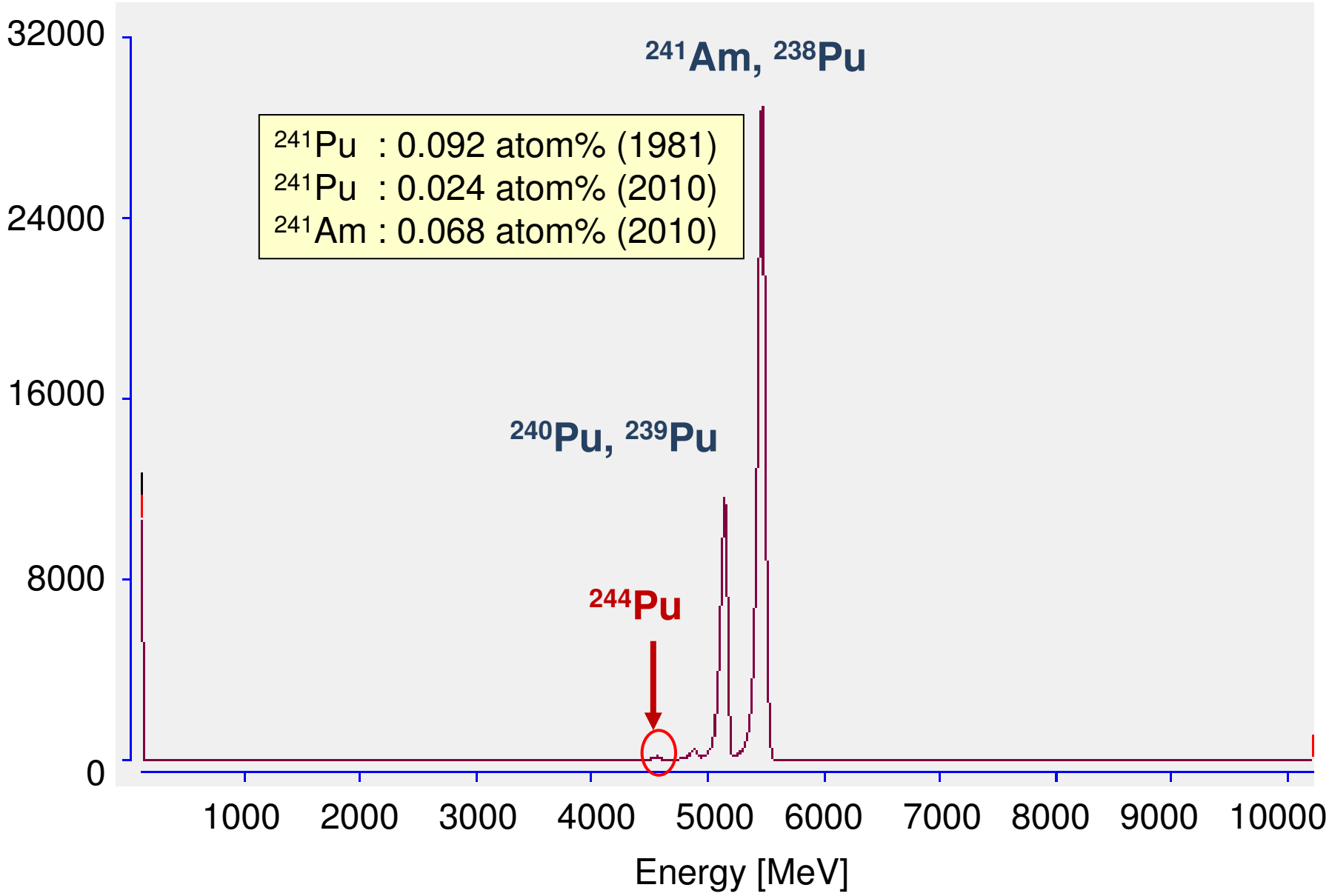
Solvent……Isobutanol
Plating time……3 h
Voltage……150 – 300 V
Current density…..0.7 mA/cm²
Stirring at……1200 U/min
Temperature……15 ℃

E116 □ ^{248}Cm(^{48}Ca,xn)

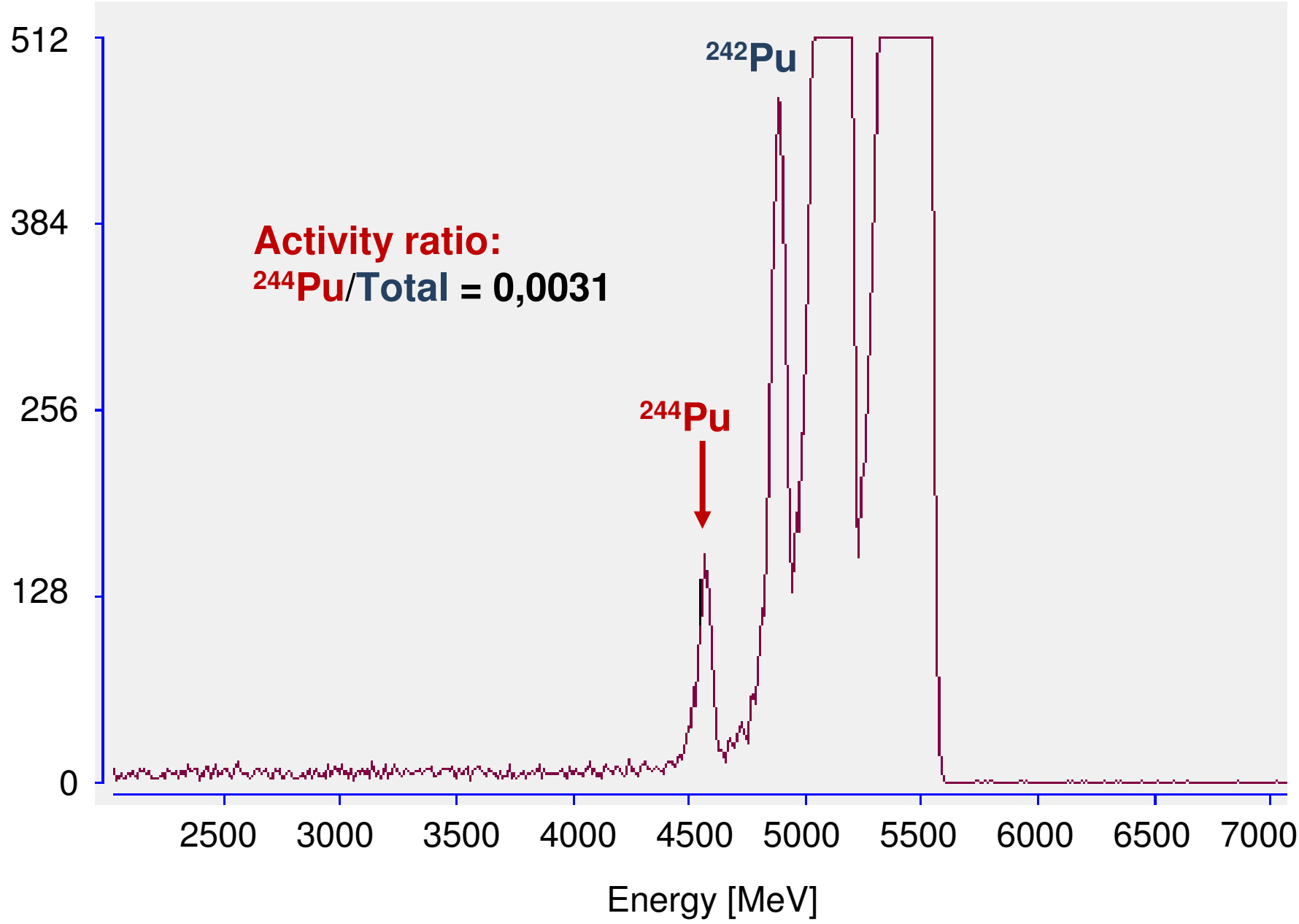
Direct yield measurement: α-particle spectroscopy



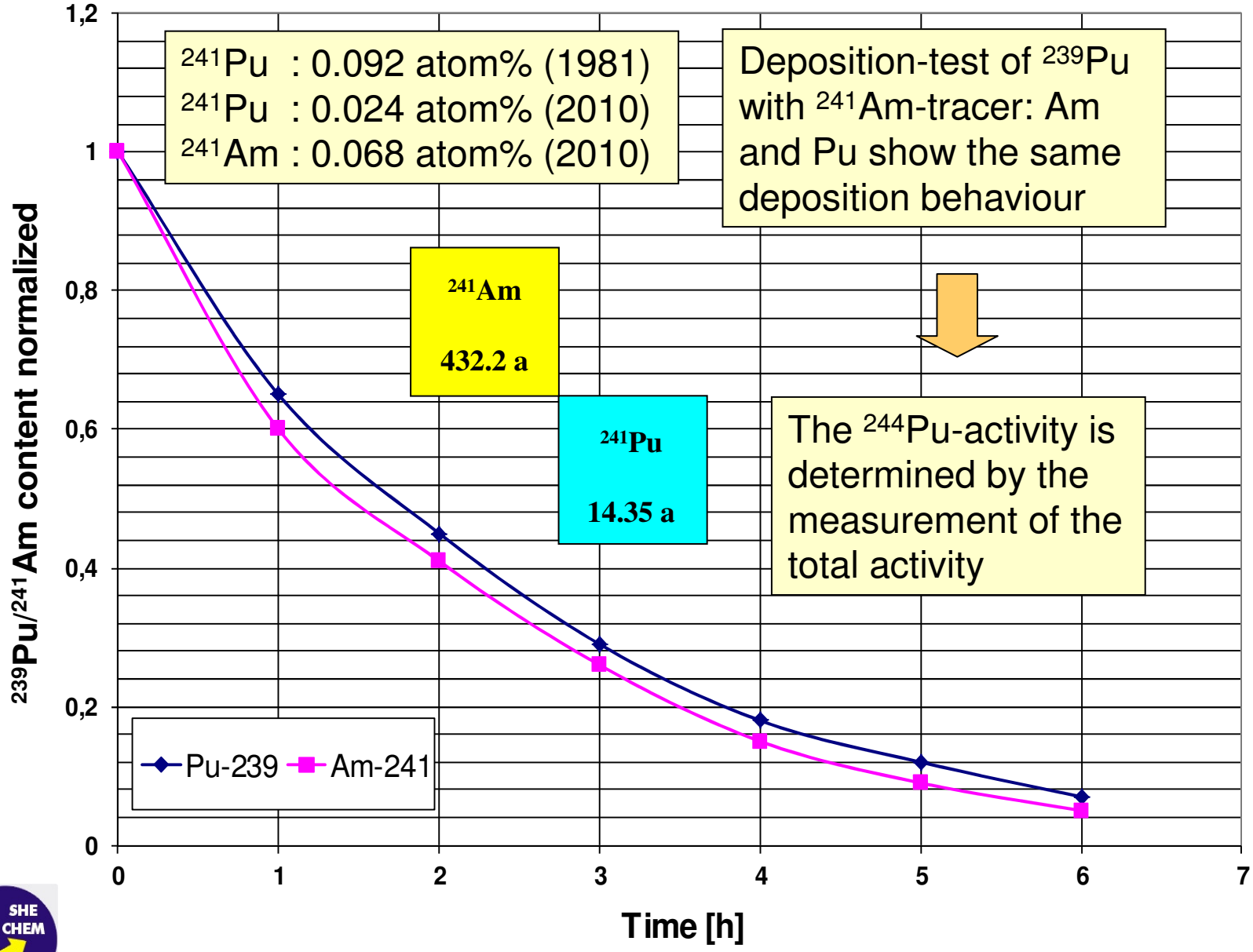
^{244}Pu stock solution



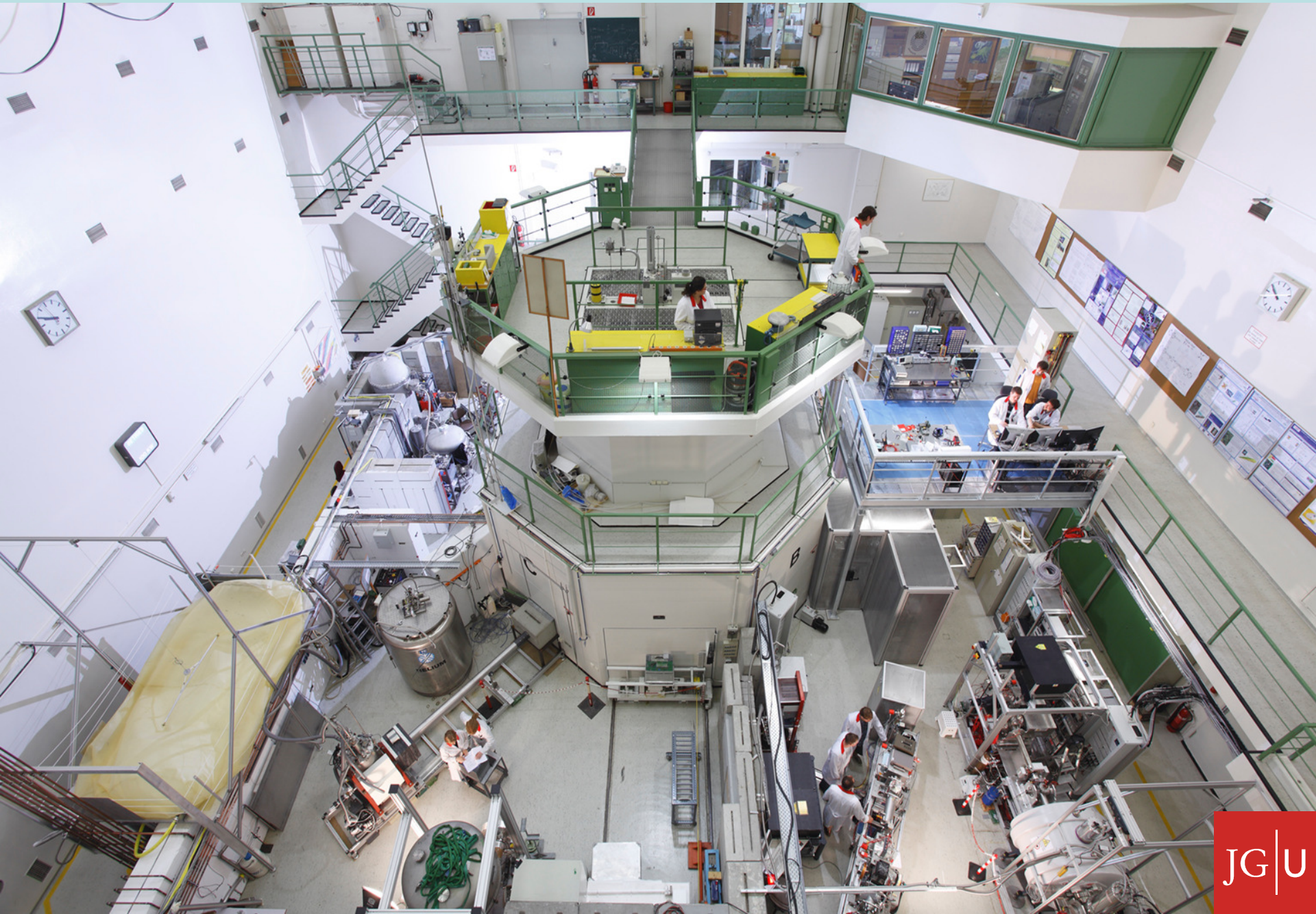
^{244}Pu stock solution



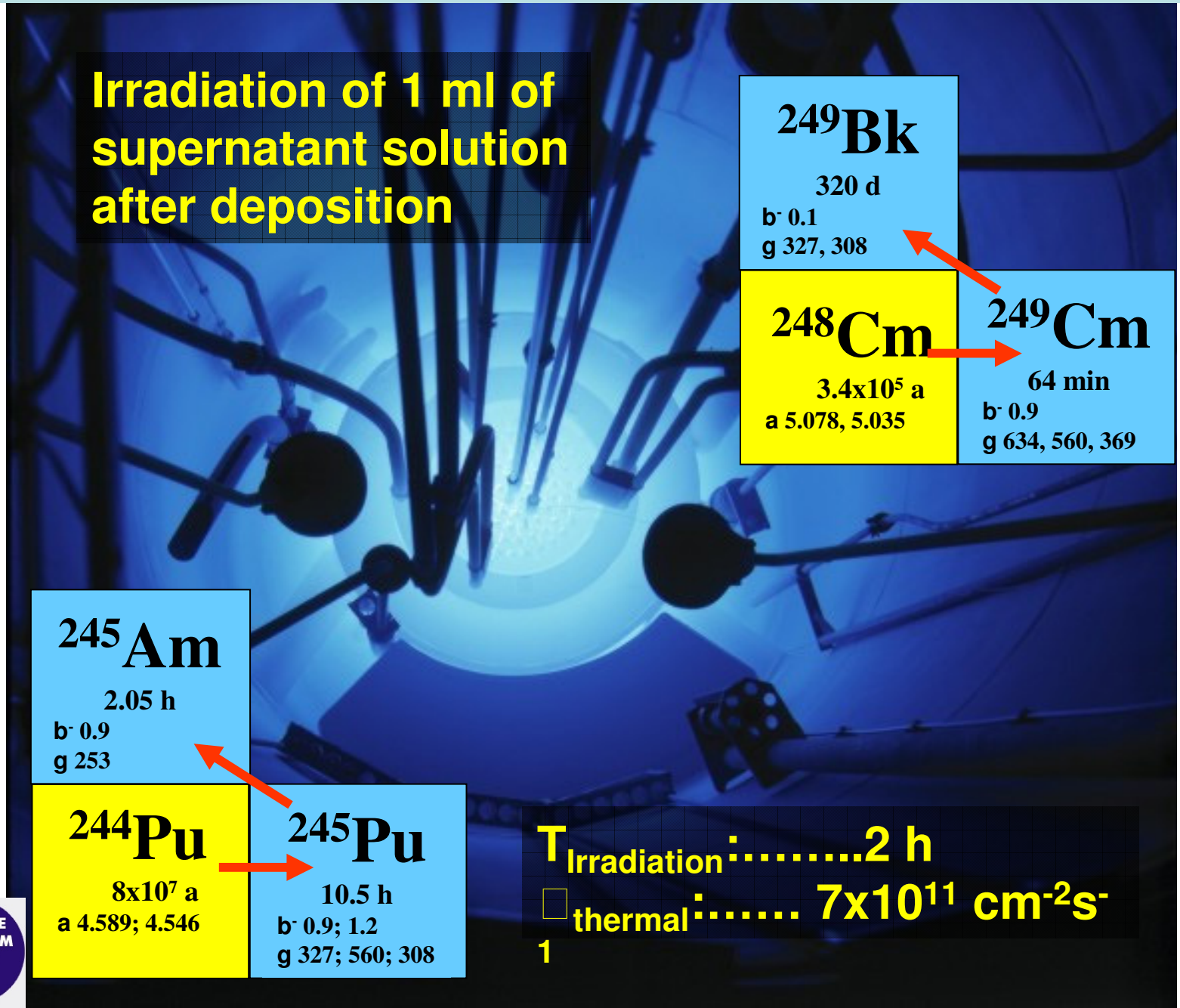
Simultaneous deposition of ^{239}Pu and ^{241}Am



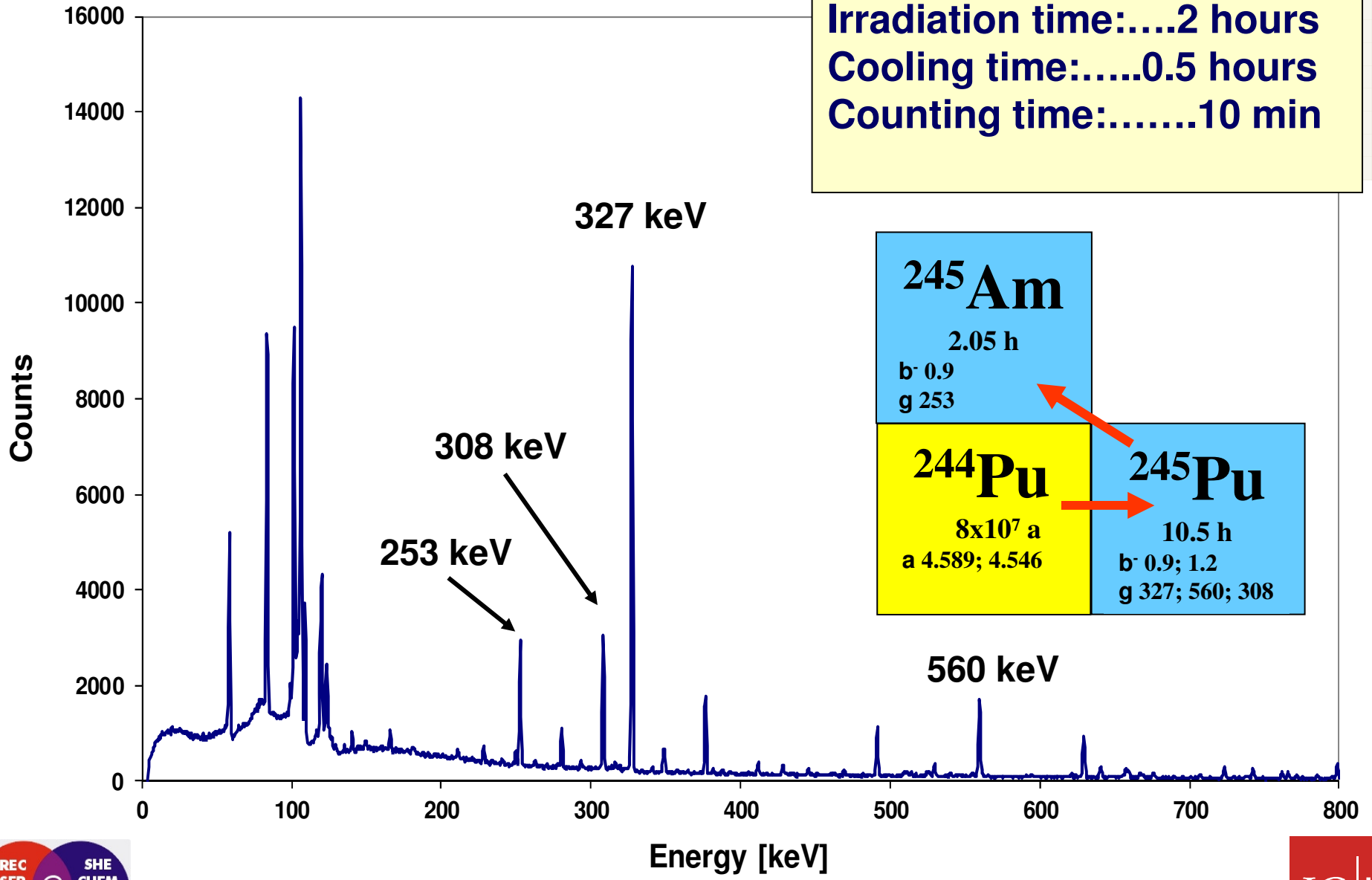
Indirect yield measurement: NAA @ TRIGA Mainz



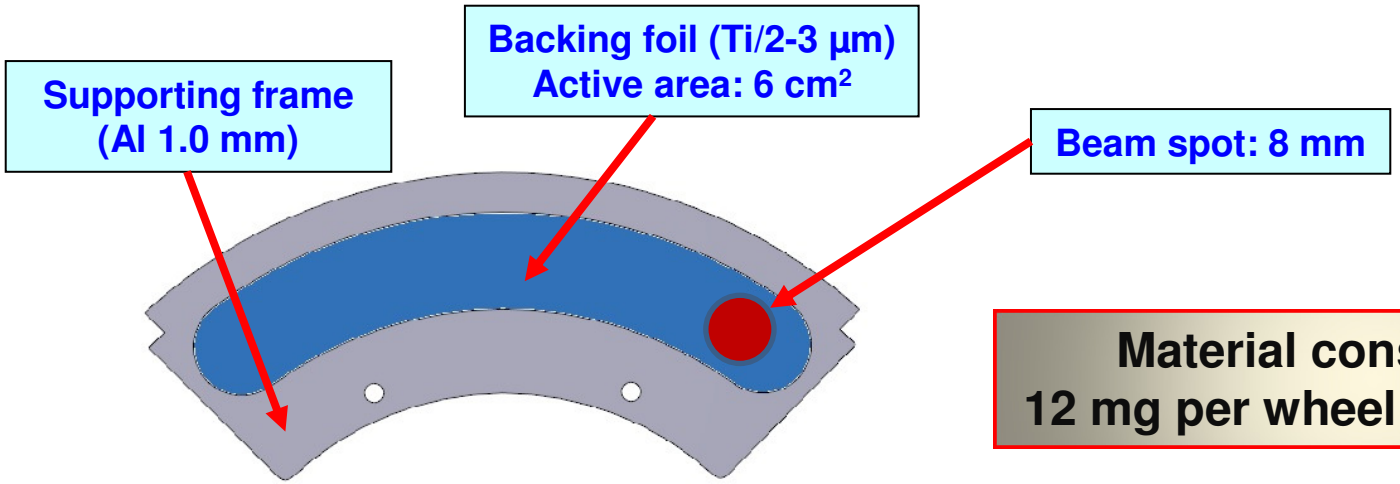
Indirect yield measurement: NAA of Pu and Cm



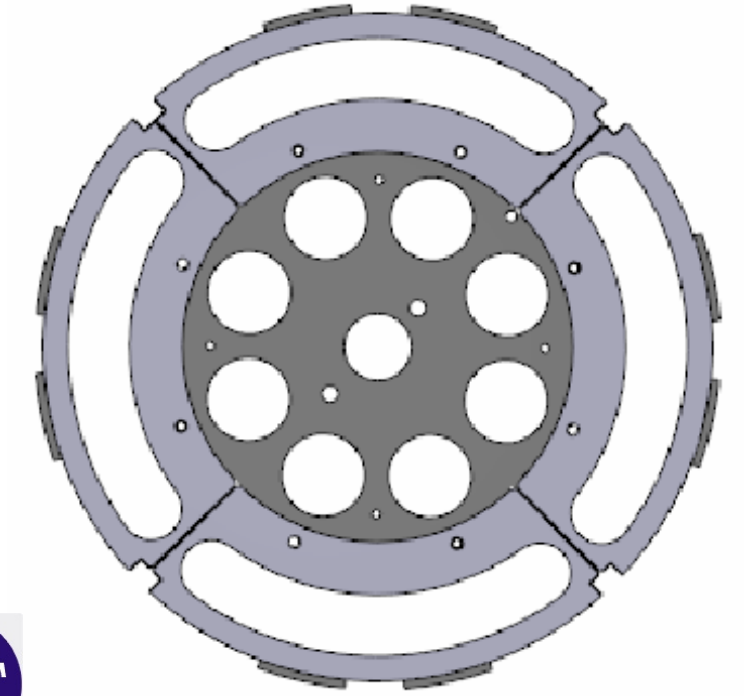
□-spectrum of irradiated ^{244}Pu solution (1 ml / 10 µg)



New (100-mm) target wheel



Material consumption:
12 mg per wheel @ 500 µg/cm²



	ARTESIA	New wheel
Material	2 mg	12 mg
Target area	1.4 cm²	6 cm²
Beam spot	6 mm	8 mm
Gain factor		**1.8**
Intensity	0.5 pµA	1.0 pµA
Gain factor		**2**

New (100-mm) target wheel

Supporting frame (Al 1.0 mm) with Ti-backing foil (2.9 µm)

Deposition of Gd tested
First targets irradiated with low beam intensity

Electrochemical cell assembly (26 ml volume)

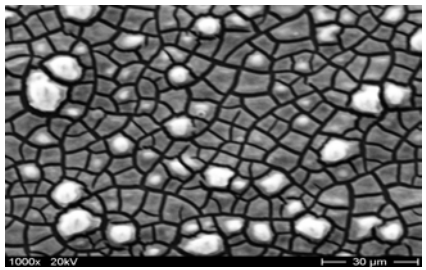
Target development

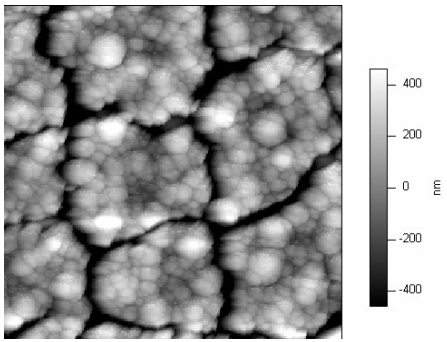
Alternative backing materials:

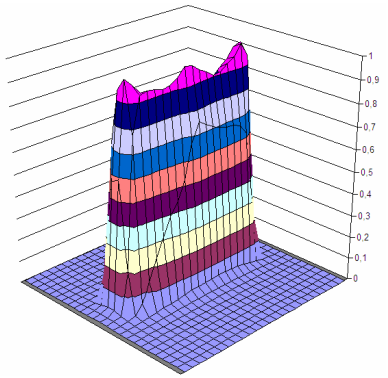
- Beryllium
- Diamond-like carbon (DLC)
- Polyimid-foil covered with metallic layer

Target layer characterization:

- Yield: α-particle spectroscopy / Neutron activation analysis
- Layer homogeneity: Radiographic imaging
- Morphology: SEM and AFM







- More detailed understanding of the deposition process

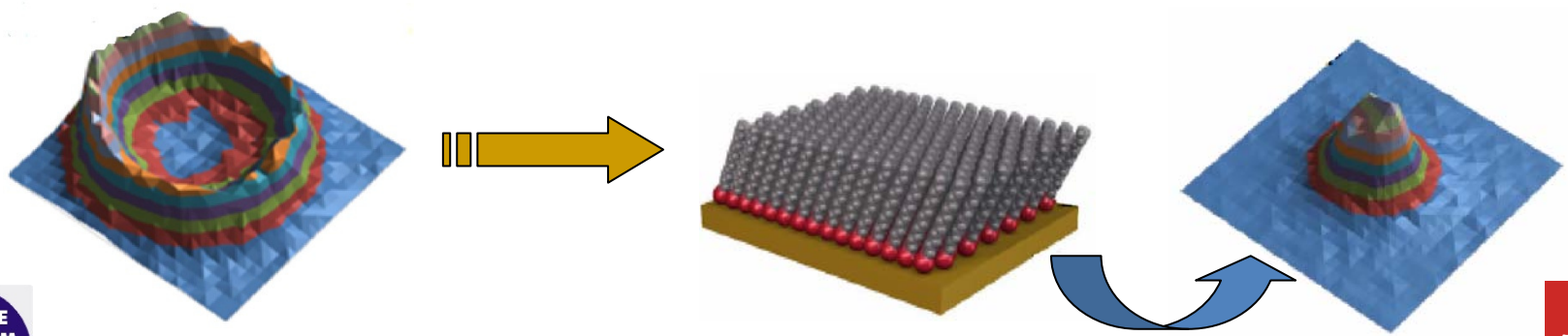
[Vascon et al., submitted to NIM A]

Target development

Alternative target production techniques

- **Polymer-assisted deposition (PAD):** Metal-oxide mixed with polymer solution. Spin-coating of silicon substrate with metal-organic film. Target thickness up to 600 µg/cm^2 possible. No irradiation tests with actinide elements so far
  [Garcia et al., Nucl. Instr. Meth. Phys. Res. A613 (2010) 396]

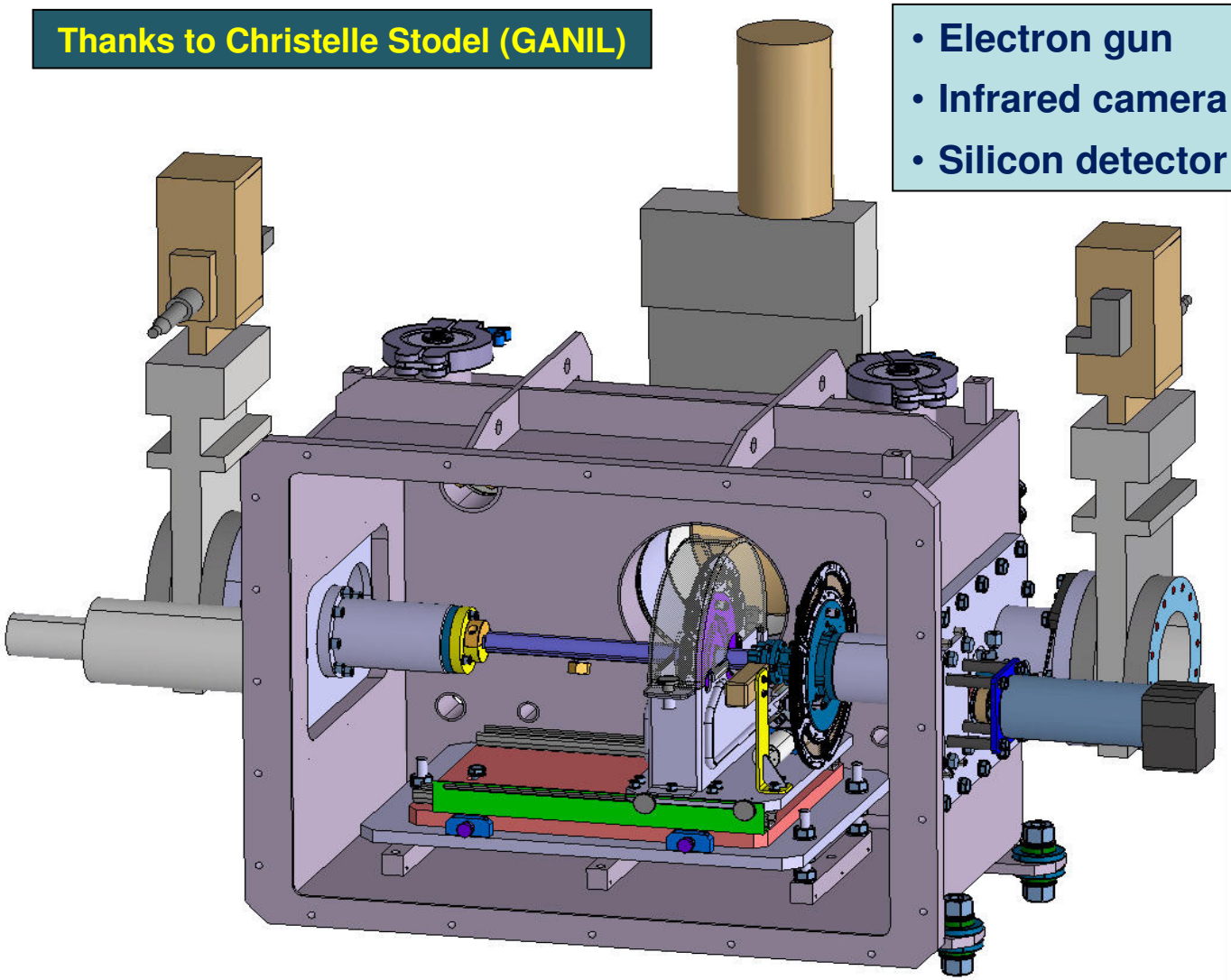
- **Superhydrophobic surfaces:** Modification of a substrate with self-assembled momolayer of alkyl chains. Homogenious deposition of metal-oxide/nitrate from aqueous solution by simple evaporation of single drops **[D. Renisch, Diploma Thesis, JGU (2010)]**



Design of the actinide prototype target chamber @ GANIL

Thanks to Christelle Stodel (GANIL)

- Electron gun
- Infrared camera
- Silicon detector



Irradiation tests with up to 1 pμA ^{48}Ca-beam possible