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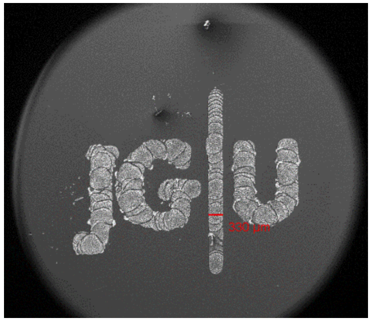
Developments on a Drop-on-Demand System for Actinide-Targets



D. Renisch[1,2], Ch. E. Düllmann[1,2,3], K. Eberhardt[1], R. Haas[1,2,3], S. Lohse[1,2], C.-C. Meyer[1,2], C. Mokry[1,2], J. Runke[1,3], P. Thörle-Pospiech[1,2]

[1]Institut für Kernchemie, Johannes Gutenberg-Universität Mainz
[2]SHE-Chemie, Helmholtz-Institut Mainz
[3]SHE Chemie, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

NUSPRASEN Workshop 2019, GSI

Requests of (Actinide)-Targets

SHE production and research

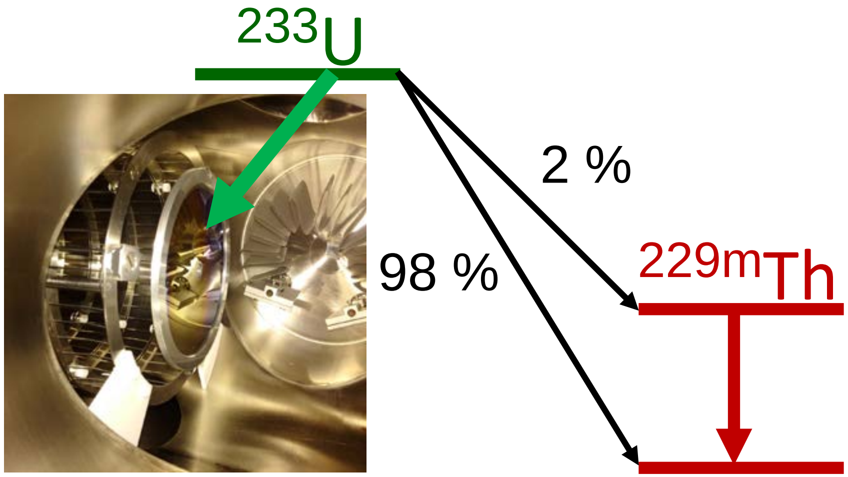
Synthesis of $_{117}$Ts; search for E119

^{249}Bk	320 d

4x 200 GBq

J. Runke *et al.*, JRNC 299 (2014) 1081

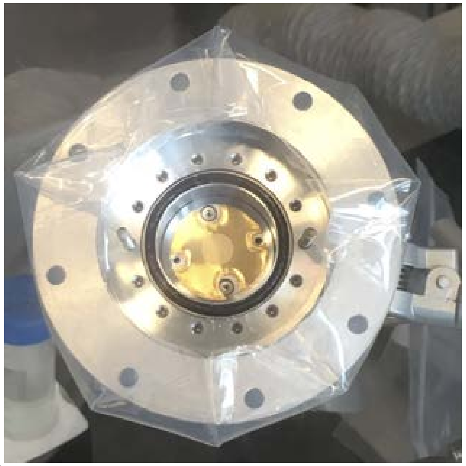
Investigations on Th-229m



^{233}U-target on Ti-coated Si-wafer

L. von der Wense *et al.*, Nature 533 (2016) 47

Muonic X-Ray spectroscopy



^{248}Cm-target on gold coated copper backing

A. Adamczak *et al.*, EPJ Web of Conferences 193, 04014 (2018)

Production of Actinide-Targets

Challenges in the production of Actinide-Targets:

- limited availability
- high specific activity (in some cases)
- material and thickness of backing
- different geometries
- layers from 10 to 1000 µg/cm^2
- high chemical purity

→ Requirements to the production technique

- high yield
- reliability / reproducibility
- control of dimension and thickness

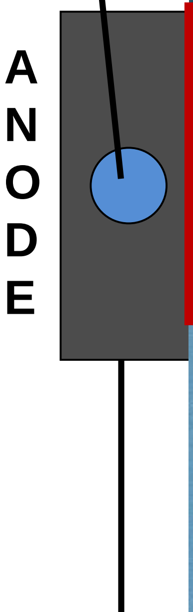
Available — **Rare / Radioactive**

89	90	91	92	93	94	95	96	97	98	99	100
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm

Actinide deposition by Molecular Plating (MP)

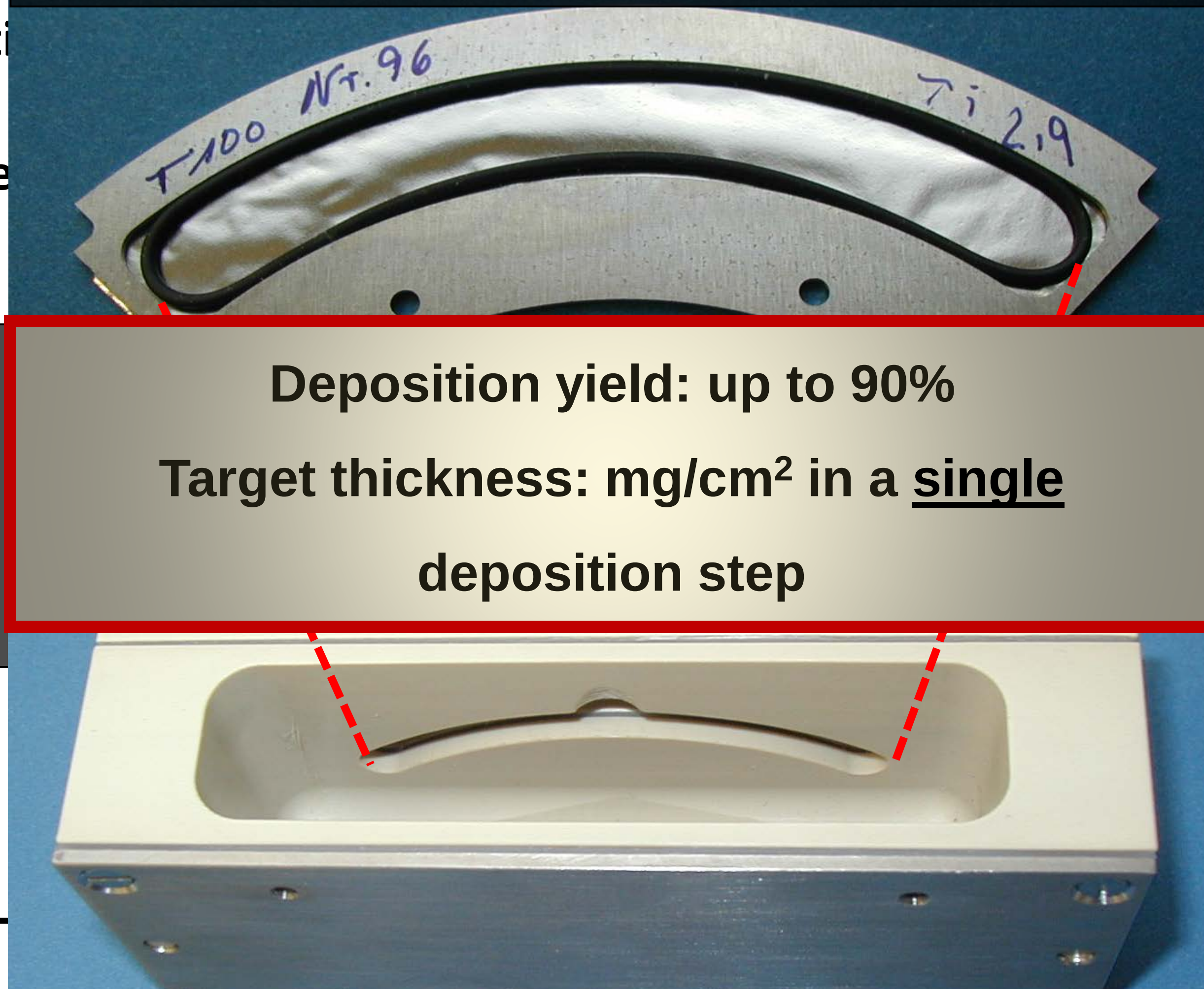
Ultrasonic sti

Cooling wate



Vo

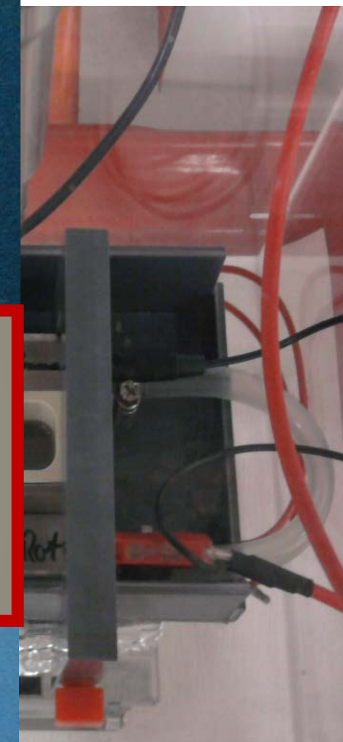
Supporting frame with Ti-backing foil (2 µm)



Deposition yield: up to 90%

Target thickness: mg/cm^2 in a <u>single</u> deposition step

Electrochemical cell assembly (26 ml)



:

Actinide deposition by Molecular Plating (MP)

Molecular Plating

+ reliable technique; long-term experience
+ high yields possible (> 90%)
+ homogeneous layers
- conductive substrate necessary
- chemical form undefined
- impurities from organic solvent

→ search for a complementary production method that avoids those drawbacks

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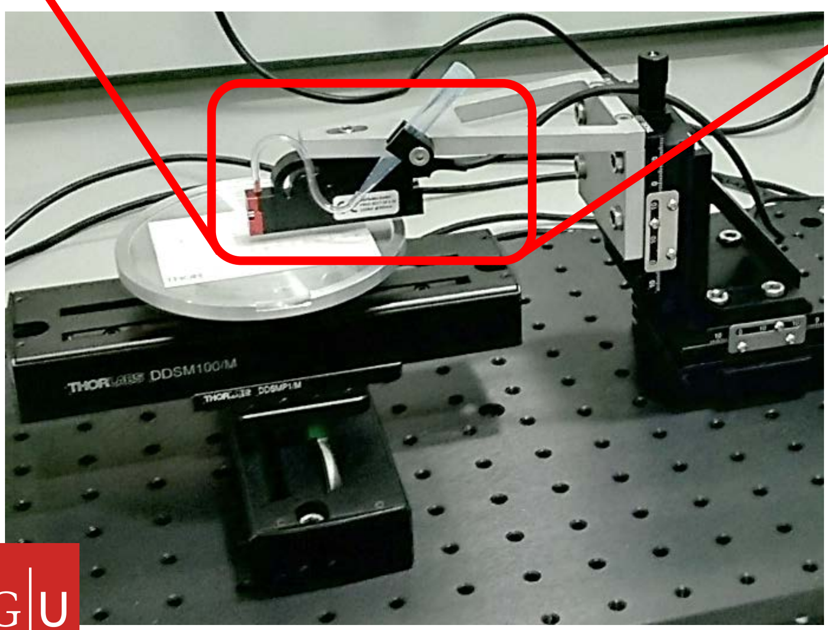
„Drop on Demand“ (DoD) target printing

BioFluidix PipeJet® P9 NanoDispenser with 200 µm tip

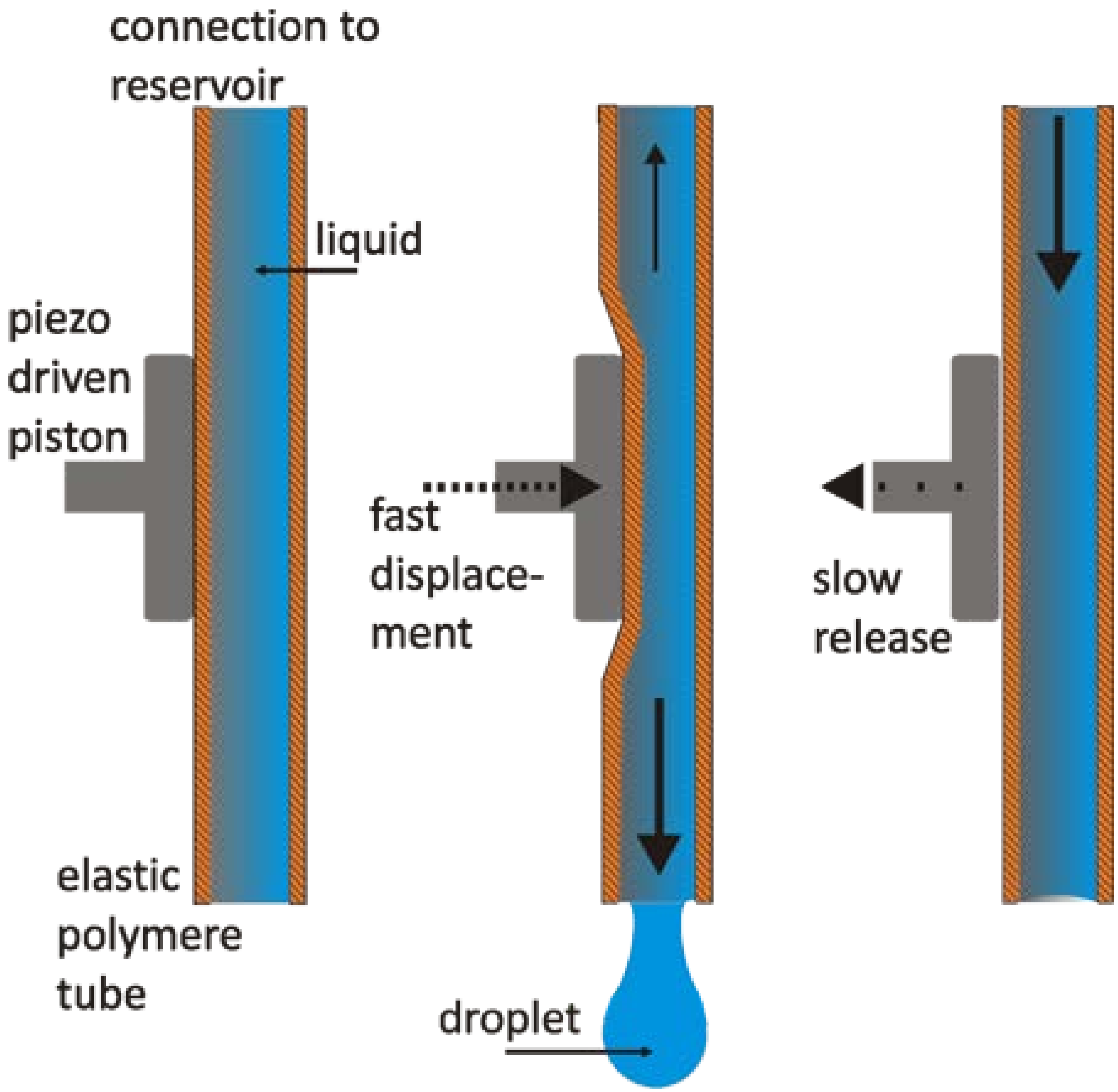
Reservoir filled with solution of target material



Backing placed on programmable xy-translation stage

„Drop on Demand“ (DoD) target printing

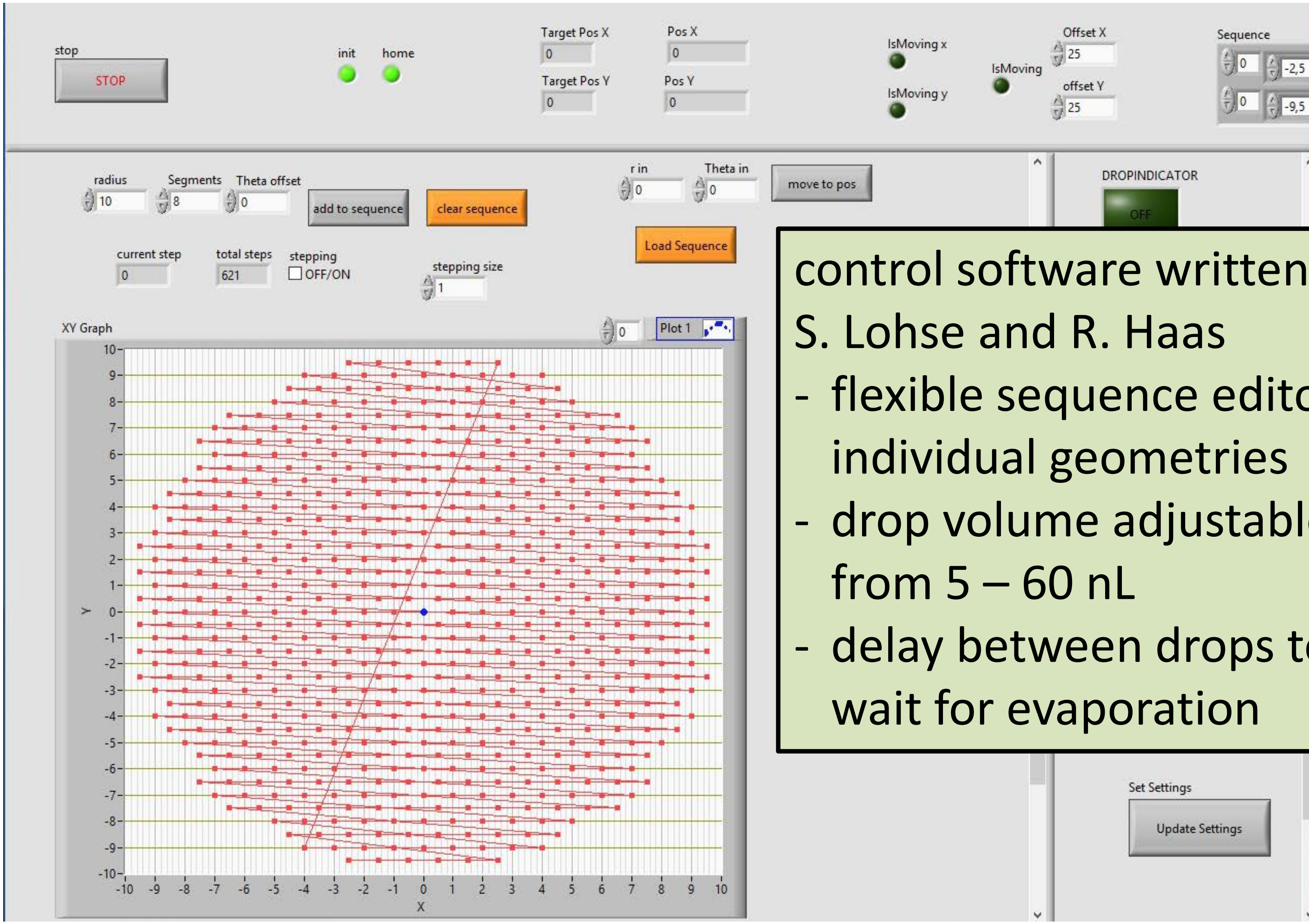
Principle of PipeJet® Nanodispenser



BioFluidix GmbH, http://www.biofluidix.com

„Drop on Demand“ (DoD) target printing

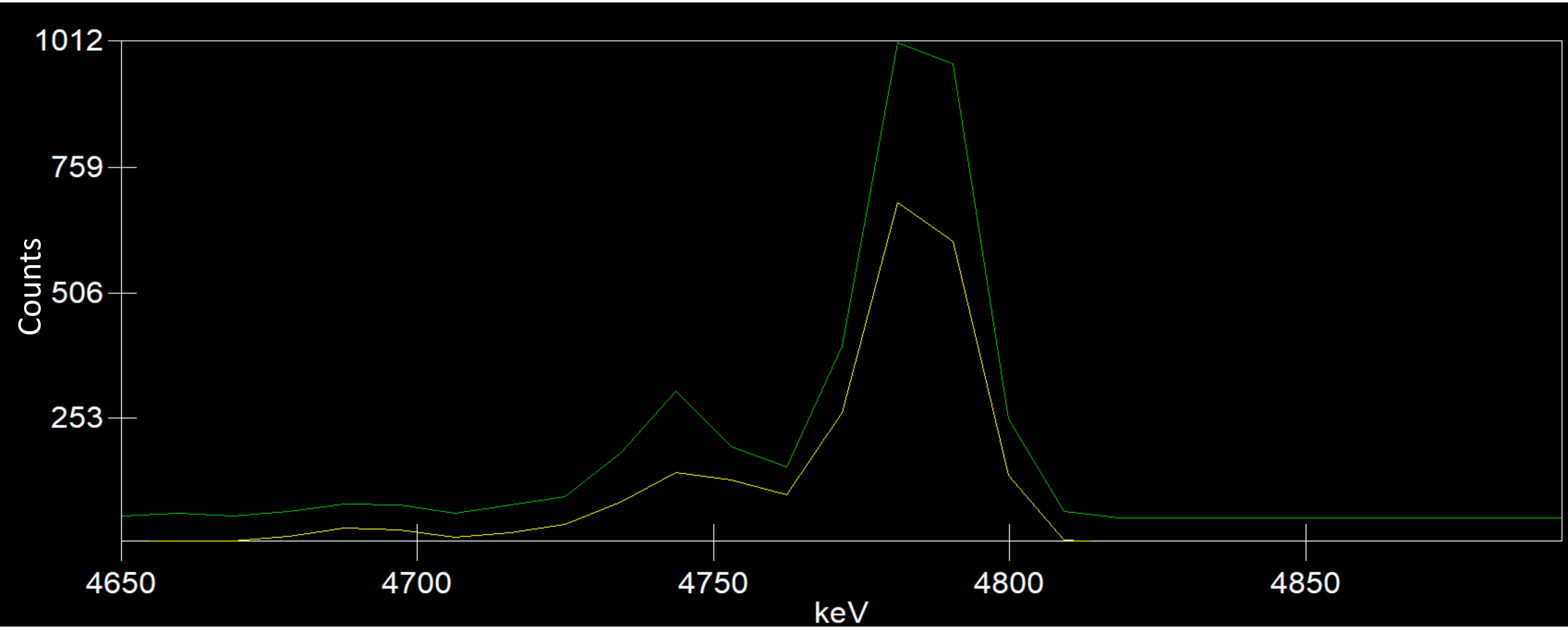
DoD control software



control software written by S. Lohse and R. Haas

- flexible sequence editor for individual geometries
- drop volume adjustable from 5 – 60 nL
- delay between drops to wait for evaporation

Comparison of MP and DoD



alpha-spectra of a DoD and a MP target

→ 10^{16} atoms U-233 on Ti coated Si wafers

→ FWHM of 4.824 MeV peak in both cases 20.7±0.3 keV

→ thin layers comparable to MP targets are possible

Influence of the substrate

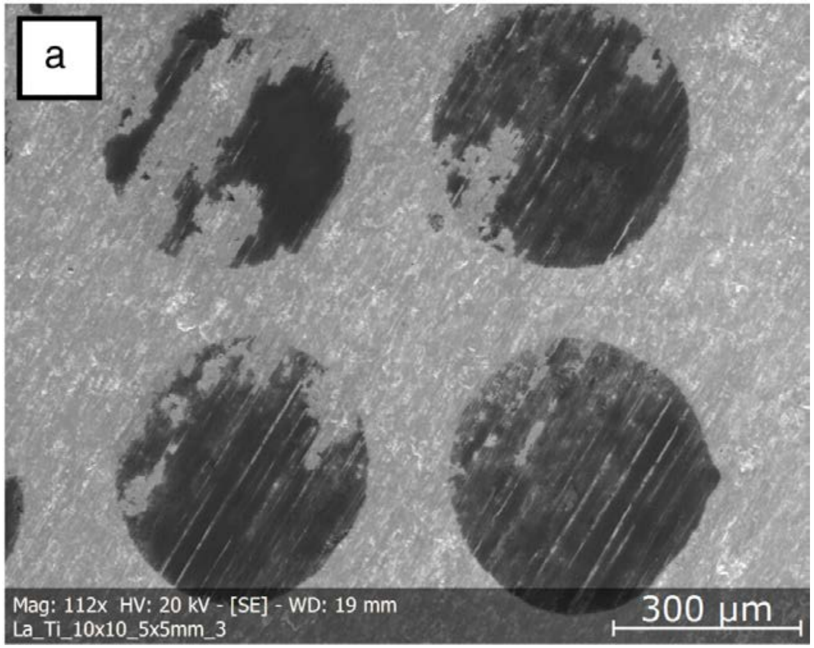
Deposition of La nitrate

8 nl drops, 2.5 mg/mL La in 0.1 M HNO_3

Substrate: Ti foil (more hydrophilic)

Spot diameter: 400 μm

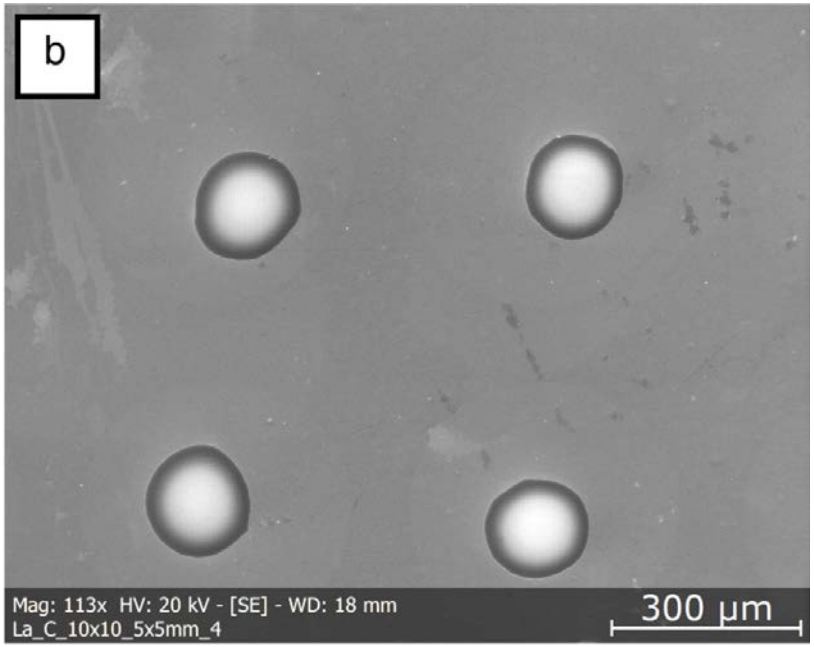
Average layer thickness: 16 μg/cm²



Substrate: polycryst. graphene foil (more hydrophobic)

Spot diameter: 170 μm

Average layer thickness: 88 μg/cm²



R. Haas *et al.*, NIMA 874 (2017) 43

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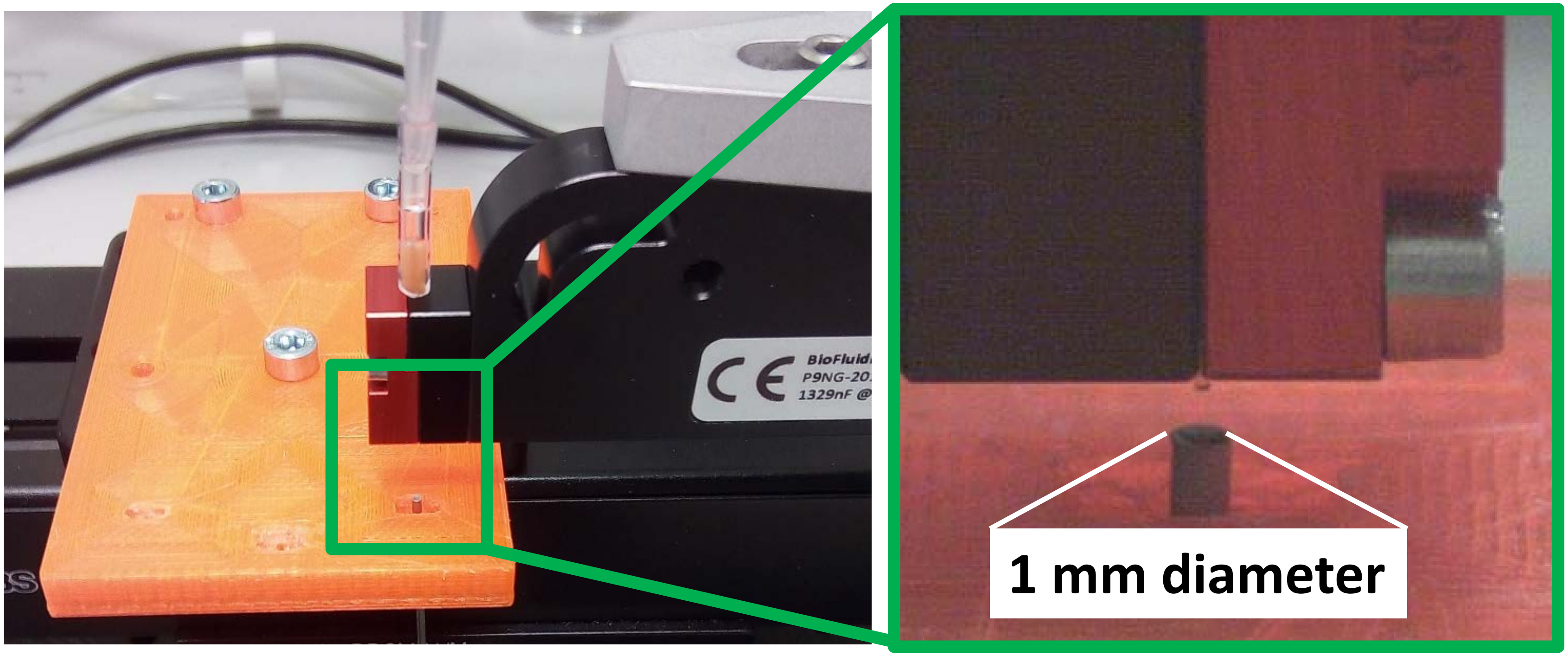
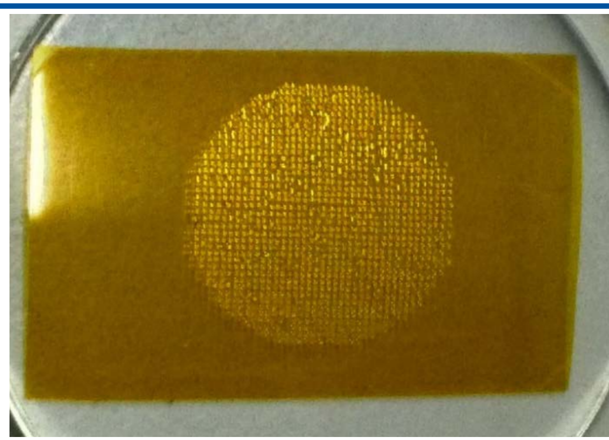
Some recent DoD targets



Ho-165 target (10^{12} atoms) on EBIT holder for PENTATRAP

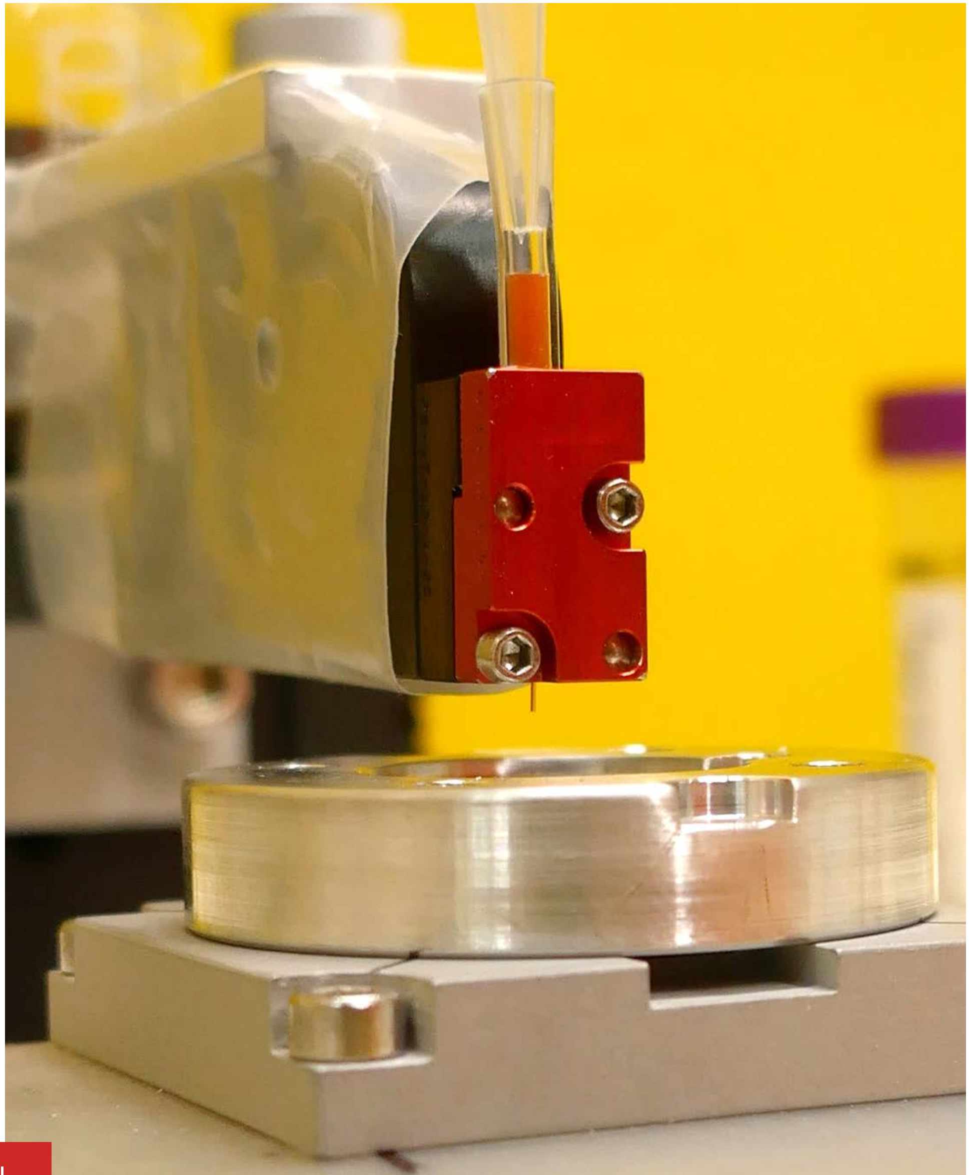
→ efficiency tests for Ho-163 targets for ECHo collaboration



Er-170 nitrate on polyimide foil for I_γ determination of ^{171}Tm @ GUF

M. Weigand *et al.*, Phys. Rev. C 97 (2018) 035803

A Drop-on-Demand Printer for Actinides



Three printing systems for non-, medium- and highly radioactive material

First application:
Preparation of ^{252}Cf fission fragment sources for JRC Geel

High energy resolution in 4π
→ very thin backings
→ Polyimide foil (24 µg/cm²)
→ Graphite foil (10 µg/cm²)

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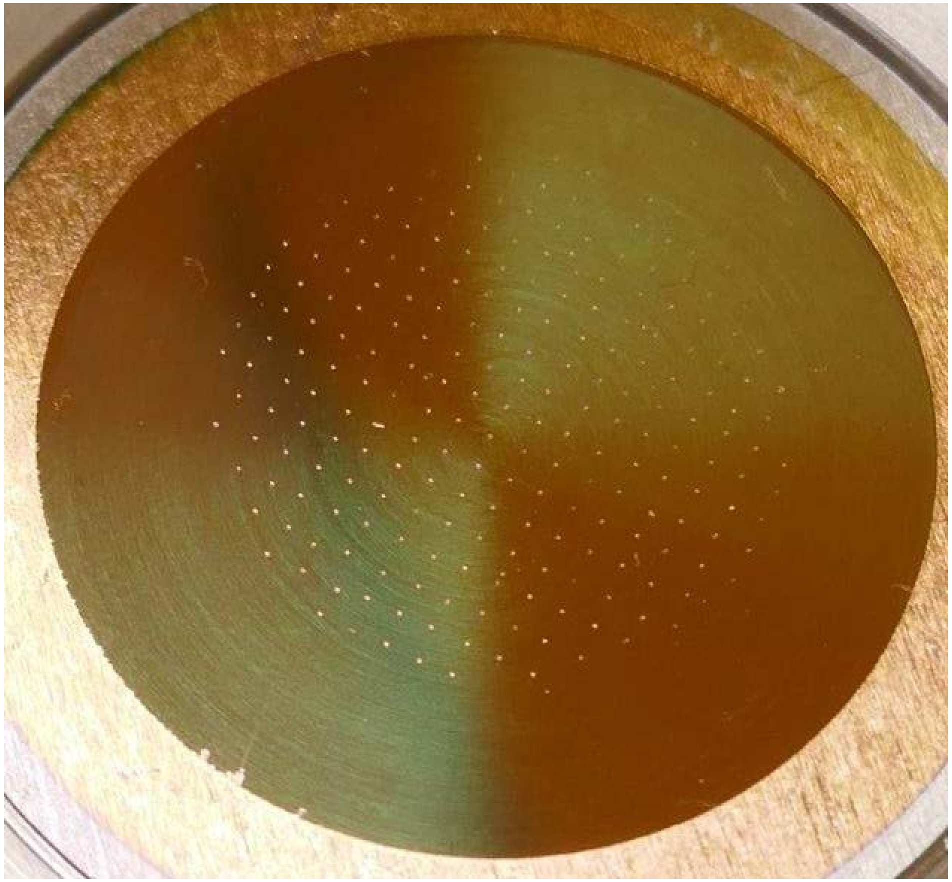
^{252}Cf fission fragment sources for JRC Geel

Sources made by depositing 221 drops à 20 nL and 109 drops à 20 nL

Drops are separated by 1 mm



Activity (221 drop sources):

Alpha: 330 kBq

SF: 10 kBq

Cf 252

2.645 a

α 6.118; 6.076..

sf(3.09%); (γ); e^-

K. Eberhardt, J. Runke, C. Mokry, D. Renisch

Comparison of MP and DoD

Molecular Plating

+ reliable technique; long-term experience
+ high yields possible (> 90%)
+ homogeneous layers
- conductive substrate necessary
- chemical form undefined
- impurities from organic solvent

Drop-on-Demand

+ no restrictions for the substrate (metal, polymer, carbon foils)
+ flexible target geometry
+ quantitative yield
+ fast method
- influence of certain parameters has to be studied (pH, viscosity, surface roughness, hydrophobicity, …)
- less homogeneous, uniform layer from aqueous solution

Conclusion

- DoD printing offers a complementary target production technique
  - superior to MP especially with non-conductive, ultra thin or small-area backings
  - potential for more chemical flexibilty by using non-aqueous solvents (e.g. ethylene glycol)
  - performance of DoD targets in accelerator beam conditions is under investigation

→ *wait for the talk by Raphael Haas*

Many thanks for the support by
… the staff of TRIGA Mainz
… the staff of UNILAC at GSI
… the GSI target laboratory
… the workshops at the JGU

Thank you for your attention!