

Start of commissioning of UniCell – A new fast and highly efficient buffer-gas stopping cell for superheavy element chemistry

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SHE chemistry experiments

1 IA H Hydrogen																	18 VIIIA He Helium						
3 Li Lithium	4 IIA Be Beryllium																	5 IIIA B Boron	6 IVA C Carbon	7 VA N Nitrogen	8 VIA O Oxygen	9 VIIA F Fluorine	10 VIIIA Ne Neon
11 Na Sodium	12 IIA Mg Magnesium	3 IIIB Sc Scandium	4 IVB Ti Titanium	5 VB V Vanadium	6 VIB Cr Chromium	7 VIIB Mn Manganese	8 VIIB Fe Iron	9 VIIB Co Cobalt	10 VIIB Ni Nickel	11 IB Cu Copper	12 IIB Zn Zinc	13 IIIA Al Aluminium	14 IIIA Si Silicon	15 VA P Phosphorus	16 VIA S Sulfur	17 VIIA Cl Chlorine	18 VIIIA Ar Argon						
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton						
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon						
55 Cs Caesium	56 Ba Barium	57-71 *La-Lu Lanthanides	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon						
87 Fr Francium	88 Ra Radium	89-103 **Ac-Lr Actinides	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson						

Chemically investigated SHE

115
Mc
Moscovium

Heaviest chemically investigated element

Yakushev *et al.*, Front. Chem. 12 (2024) 1474820

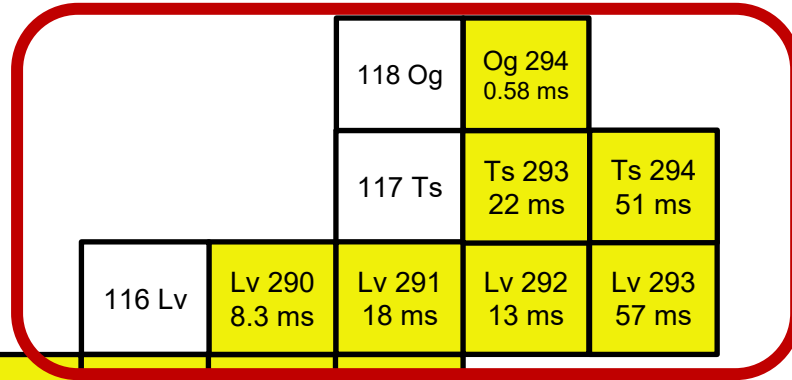
Superheavy elements (SHE)

*Lanthanides	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
**Actinides	89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Challenges for Lv, Ts, and Og studies

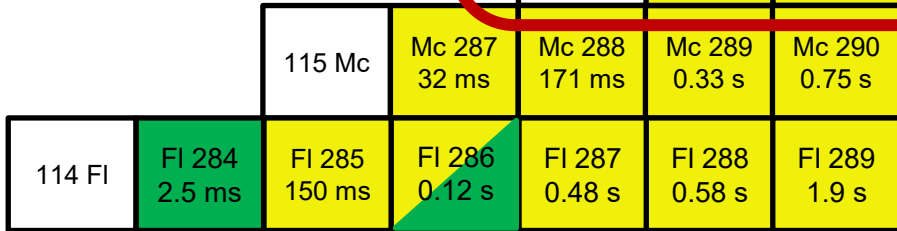
α-decay

spontaneous fission

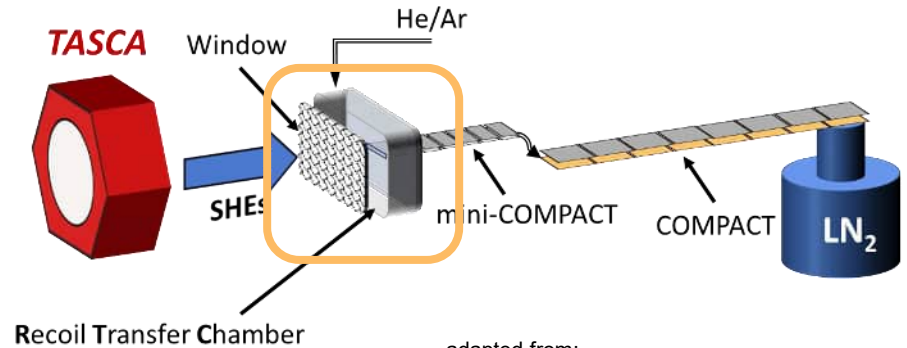


Extraction time:
several hundred ms
→ Too slow!

Yakushev *et al.*, Front. Chem. 9 (2021) 753738



All known ¹¹⁶Lv, ¹¹⁷Ts and ¹¹⁸Og isotopes have half-lives below 60 ms



adapted from:

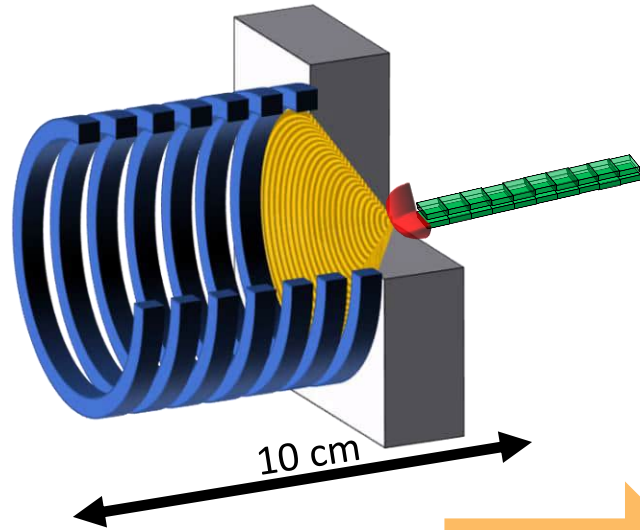
Yakushev *et al.*, Front. Chem. 12 (2024) 1474820

Fast extraction

Compact design

High efficiency

UniCell – compact, atmospheric pressure, gas buffer cell



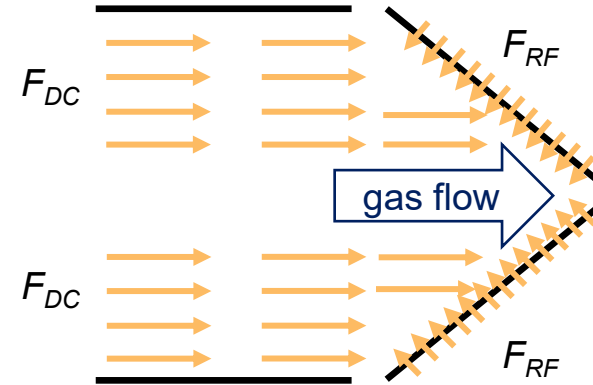
Stopping of all ions with high efficiency at 1 bar in helium

Strong DC field accelerates ions
→ faster extraction

Strong RF field prevents wall encounters

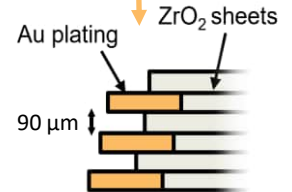


Compact design, assumed fast extraction and high efficiency



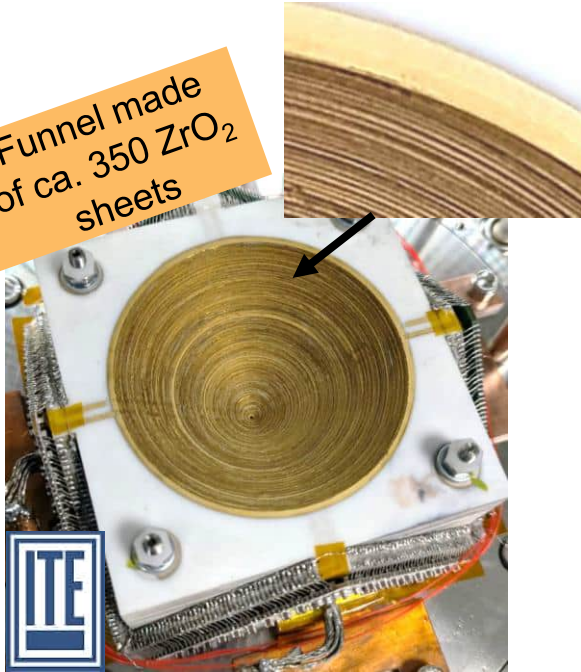
Limited by discharge voltage

$$F_{RF} = mK^2 \frac{V_{pp}^2}{4r^3}$$



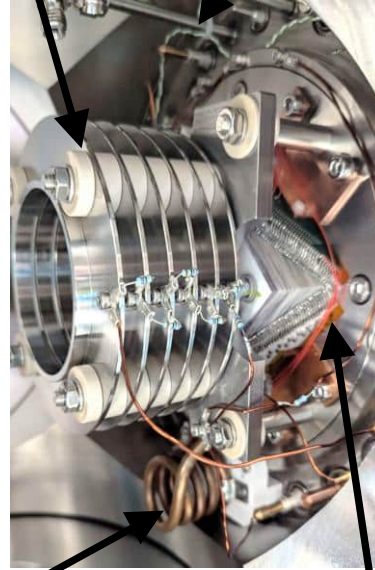
UniCell – Current status

Funnel made
of ca. 350 ZrO₂
sheets



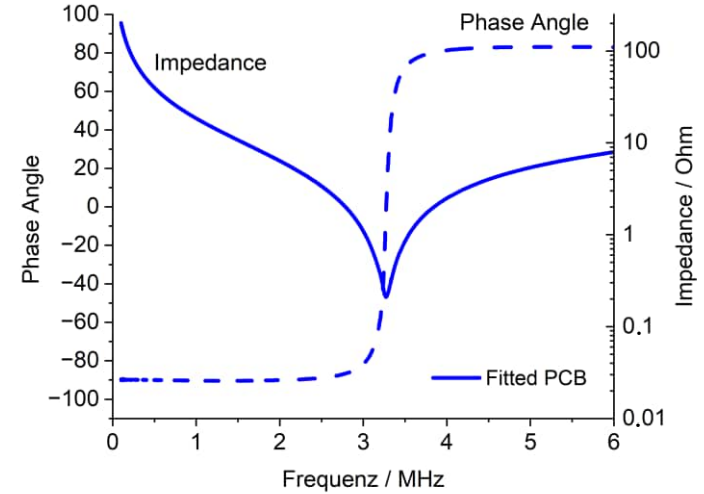
DC cage

Gas inlet

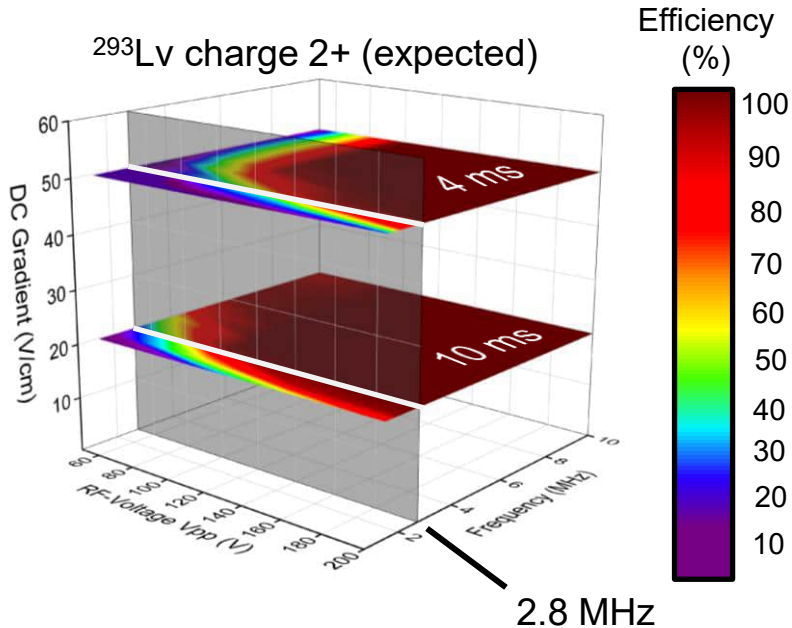


Copper coil

RF + DC funnel

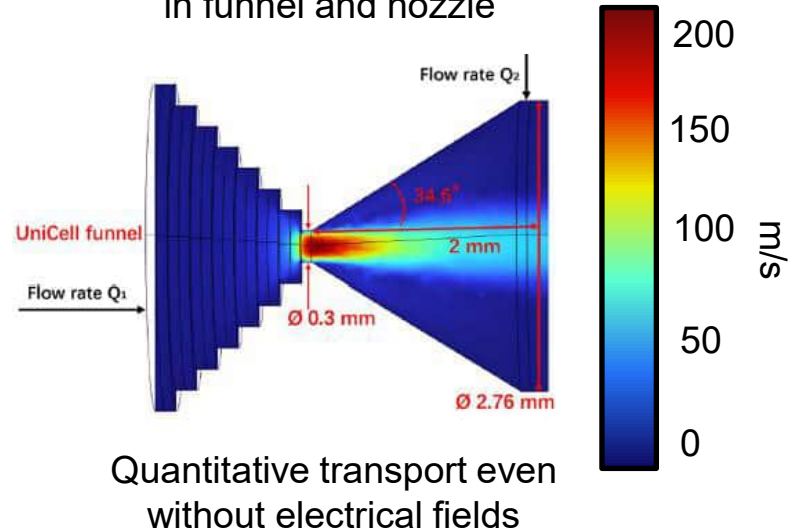


SIMION simulations: extraction time and efficiency depends on DC-gradient, RF-Voltage and frequency



M. Dudeja, Summer Student (2025)

COMSOL simulations: gas-flow in funnel and nozzle

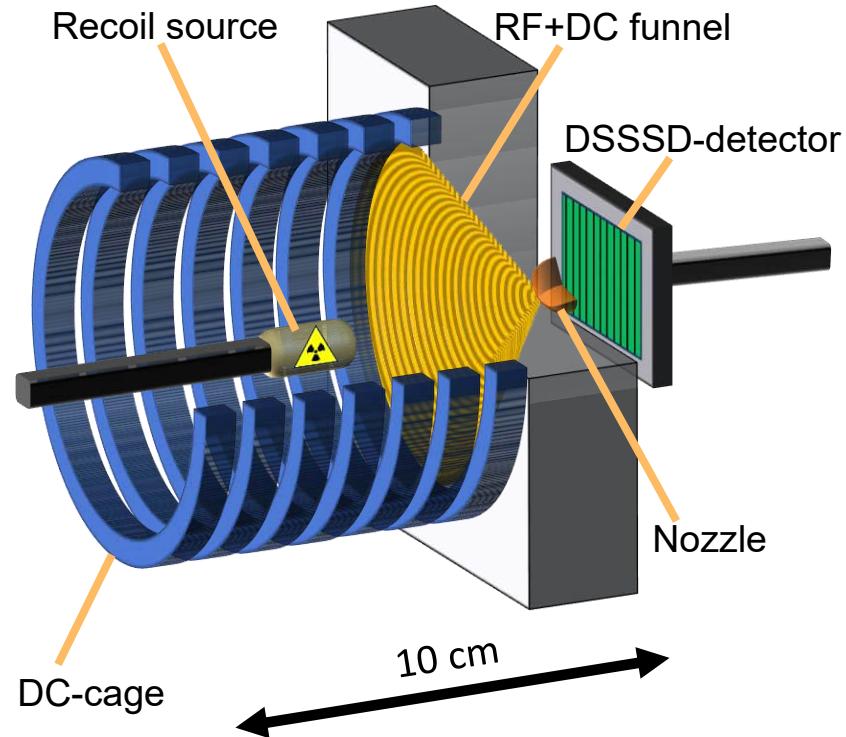
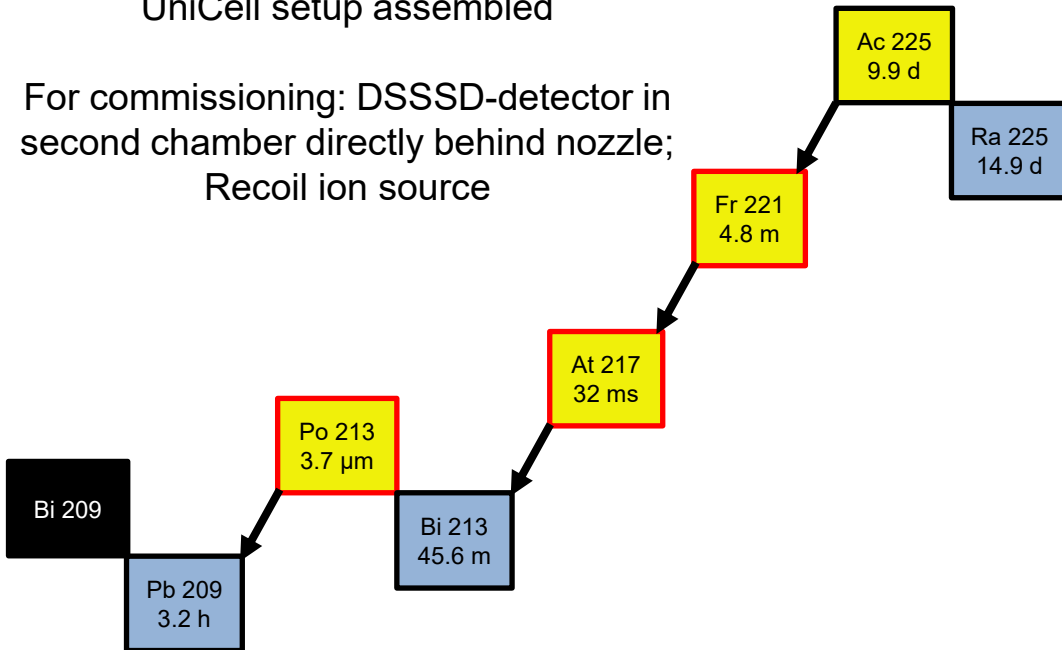


Y. Wei *et al.*, Nucl. Sci. Tech. 36 (2025) 187

UniCell – Commissioning

UniCell setup assembled

For commissioning: DSSSD-detector in
second chamber directly behind nozzle;
Recoil ion source



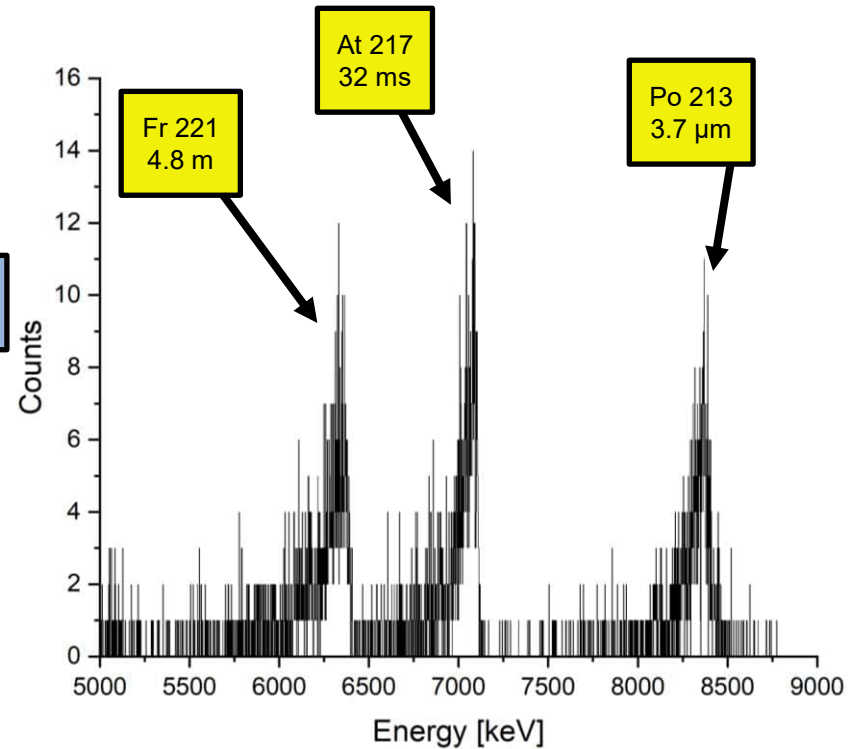
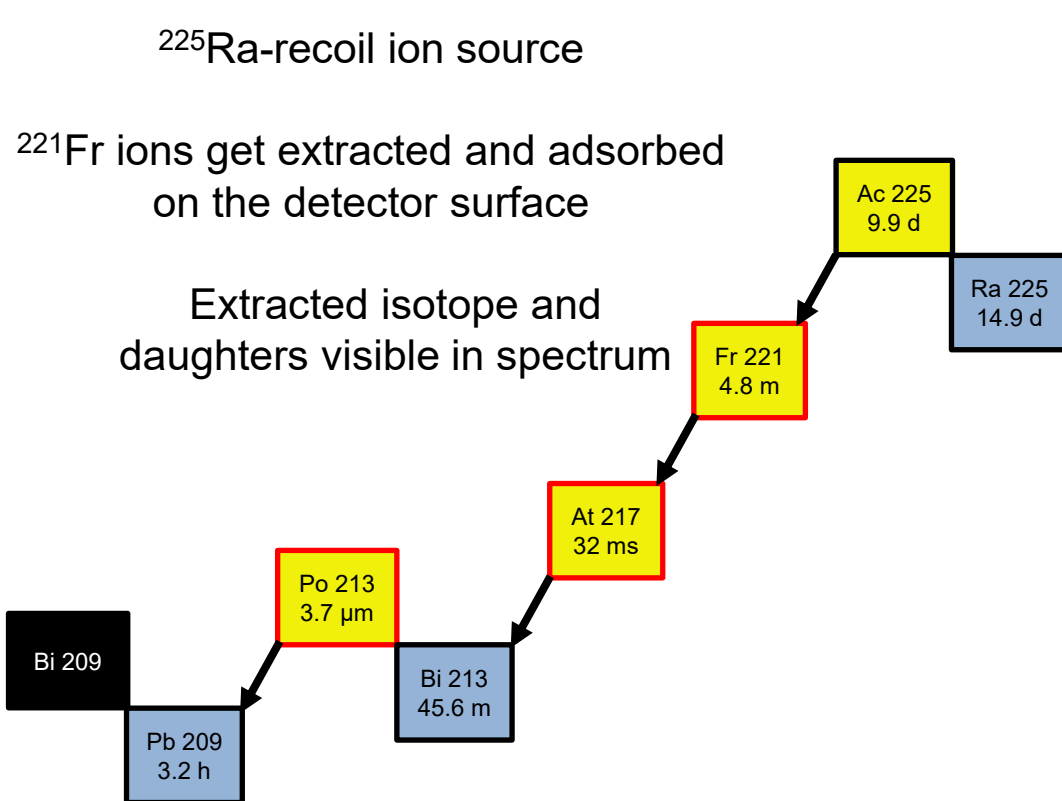
adapted from Y. Wei *et al.*, Nucl. Sci. Tech. 36 (2025) 187

UniCell – Commissioning

^{225}Ra -recoil ion source

^{221}Fr ions get extracted and adsorbed on the detector surface

Extracted isotope and daughters visible in spectrum



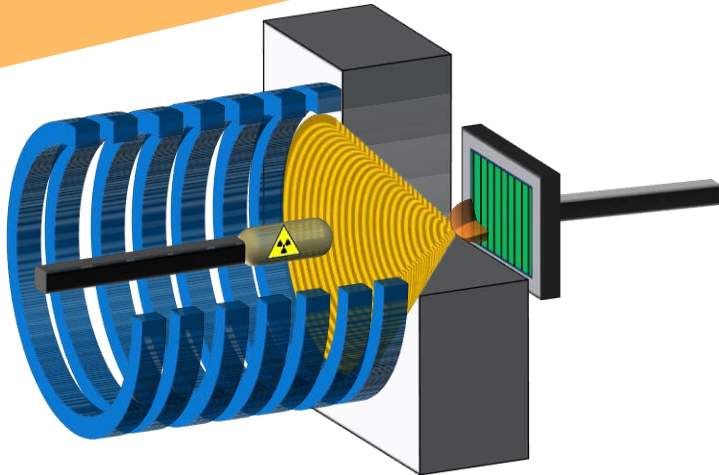
UniCell – Commissioning



- Goal:**
- Investigate parameter influence
 - Find optimal parameters

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gas flow

DC
gradient

gas
pressure

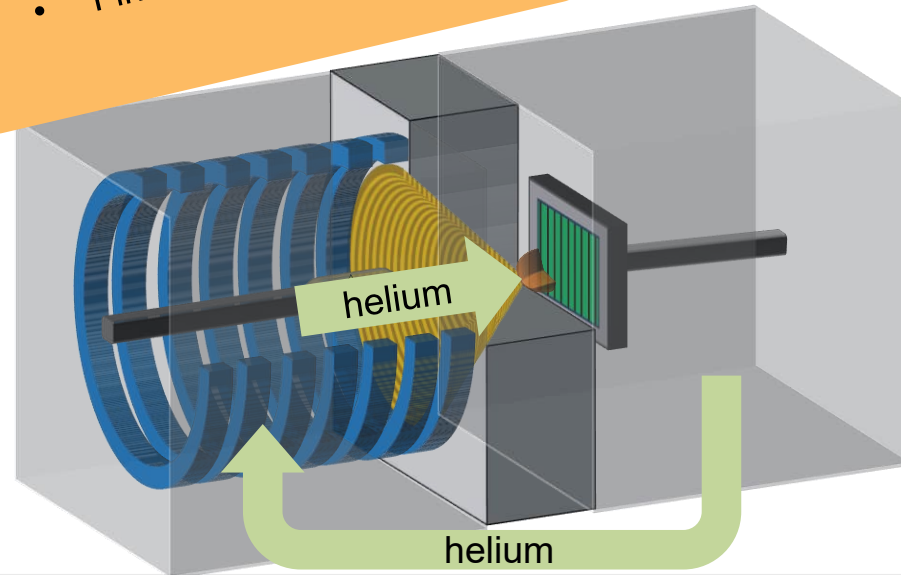
RF
voltage

bias
voltage

nozzle
voltage

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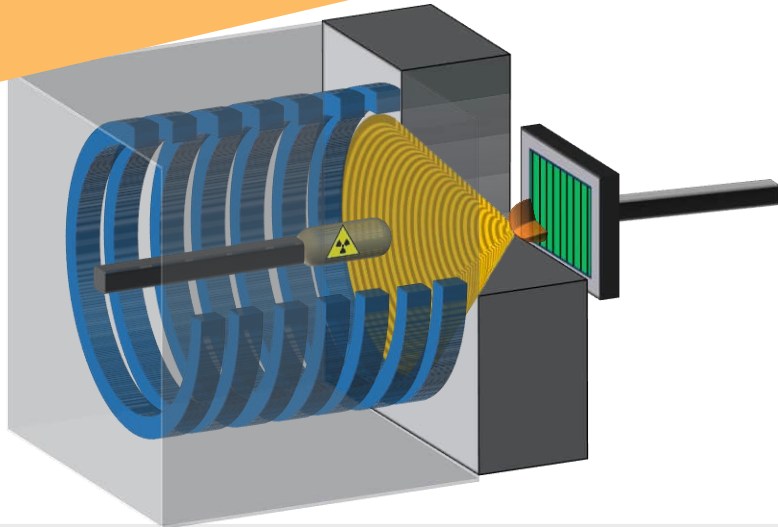
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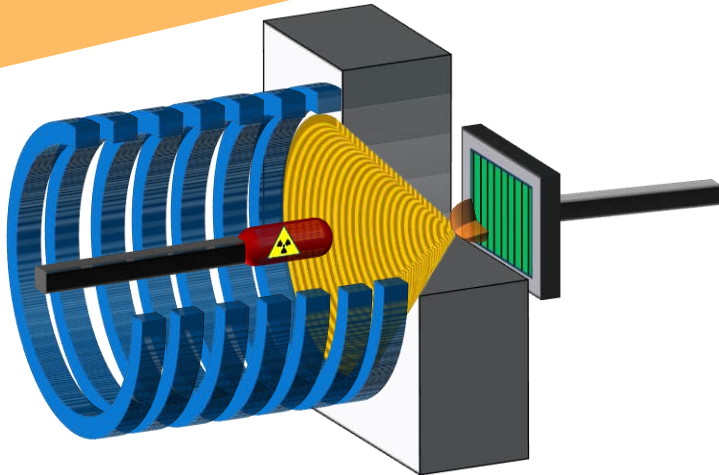
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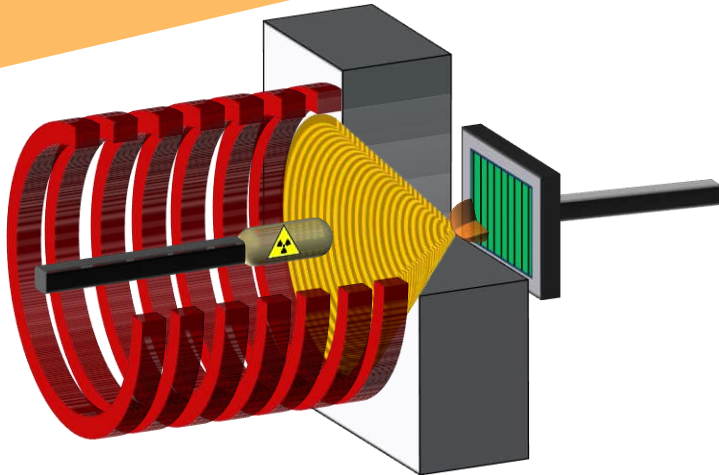
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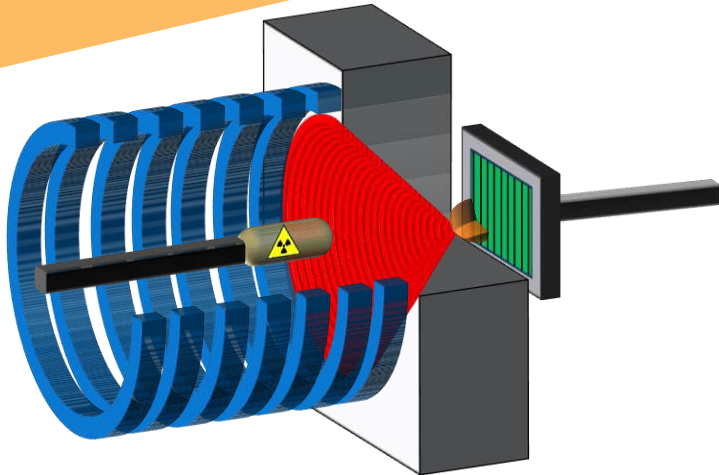
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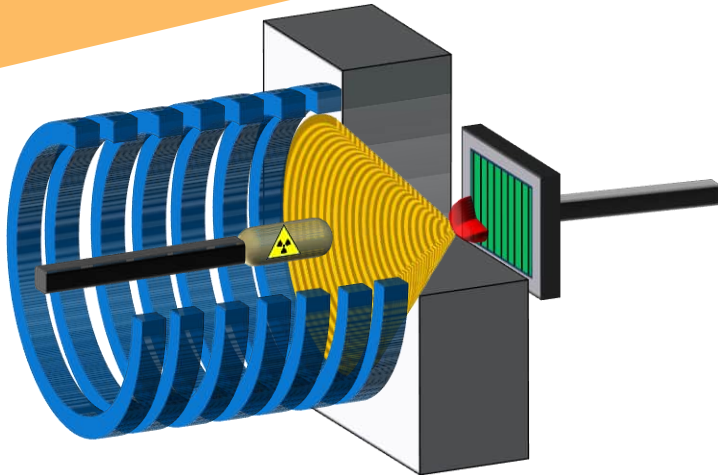
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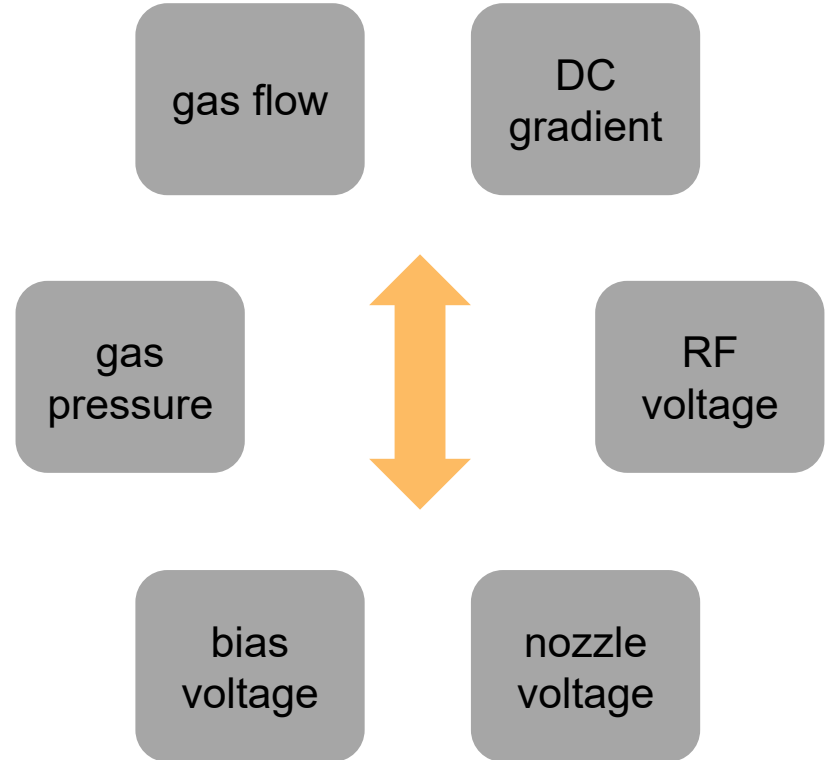
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UniCell – Commissioning

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Change one parameter at a time:
Influence on the count rate

UniCell – Next steps



Commissioning was interrupted by GSI Fire on February 5th.

→ Data set not complete

High RF-voltage interferes with detector electronics

→ Better shielding and filters needed

Gas impurities influence the efficiency of the cell

→ Purification cartridges will be used



<https://www.zdfheute.de/panorama/darmstadt-brand-feuerforschung-helmholtzzentrum-100.html> (30.04.26)



Commissioning will be resumed as quickly as possible

UniCell in commissioning phase

Setup fully assembled

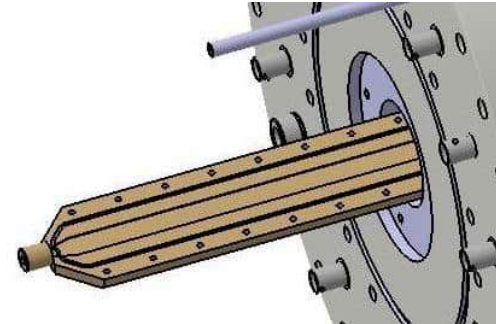
First tests performed with recoil ion source

→ **First spectra look promising, but data set is incomplete**

Next Step:

Replace DSSSD-detector with
adjusted mini-COMPACT
→ Proof of concept experiments were
already done successfully on an other
buffer gas cell

S. Götz *et al.*, NIM B 27 (2021)



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... the rest of the working group for their support



Thank you for your attention