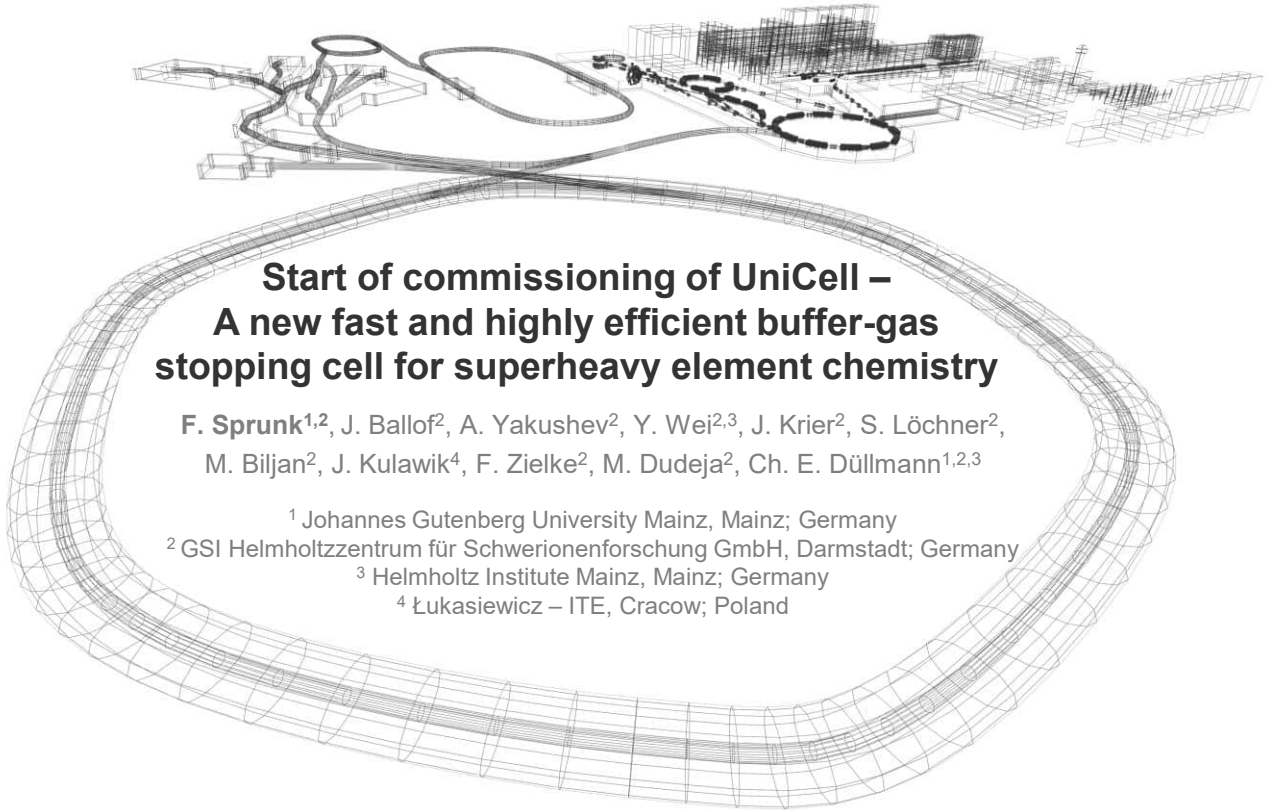
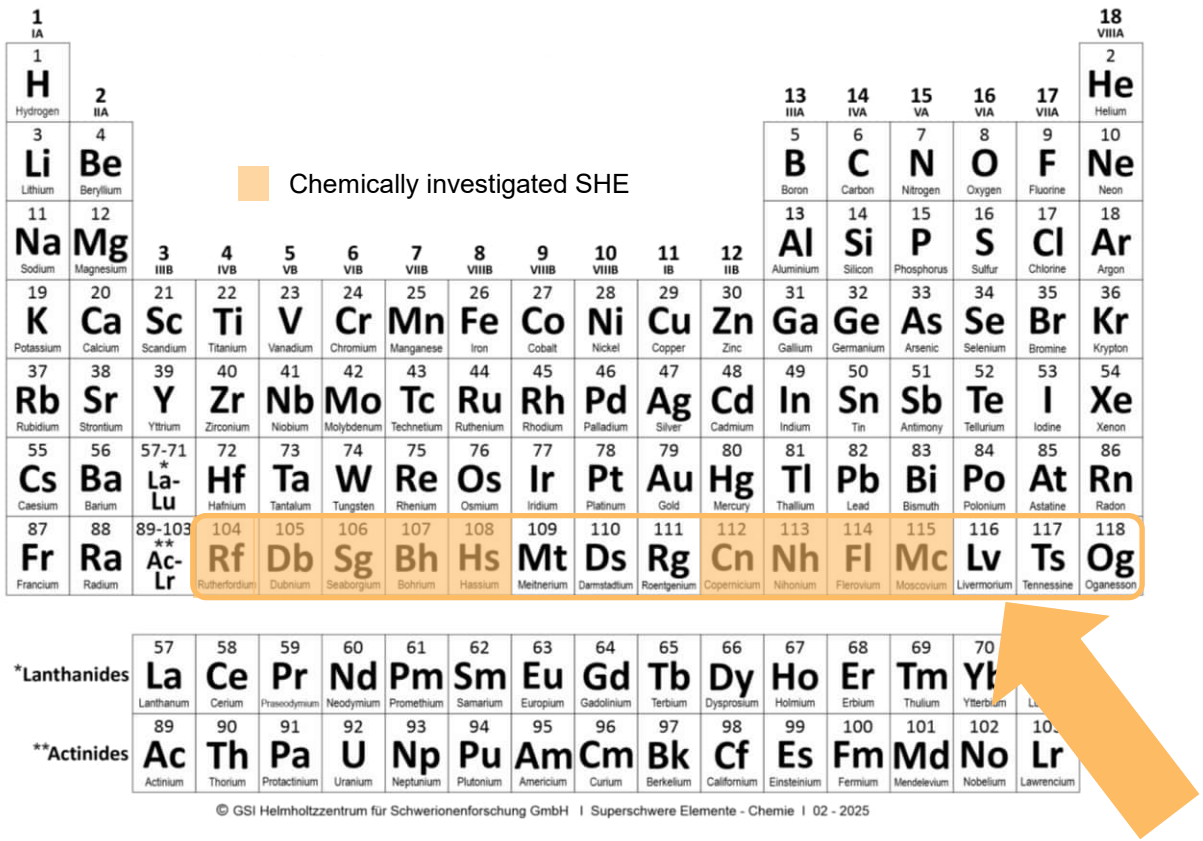


Start of commissioning of UniCell – A new fast and highly efficient buffer-gas stopping cell for superheavy element chemistry

F. Sprunk[1,2], J. Ballof[2], A. Yakushev[2], Y. Wei[2,3], J. Krier[2], S. Löchner[2], M. Biljan[2], J. Kulawik[4], F. Zielke[2], M. Dudeja[2], Ch. E. Düllmann[1,2,3]

[1] Johannes Gutenberg University Mainz, Mainz; Germany
[2] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt; Germany
[3] Helmholtz Institute Mainz, Mainz; Germany
[4] Łukasiewicz – ITE, Cracow; Poland

SHE chemistry experiments



115
Mc
Moscovium

Heaviest chemically investigated element

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

Superheavy elements (SHE)

Challenges for Lv, Ts, and Og studies

α-decay

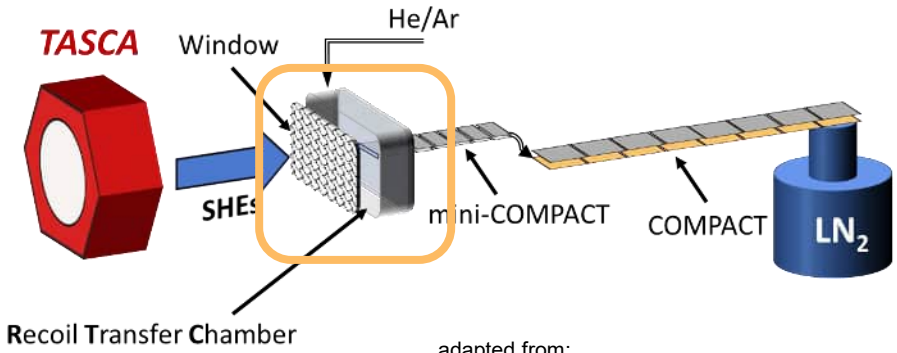
spontaneous fission

					118 Og	Og 294 0.58 ms
					117 Ts	Ts 293 22 ms	Ts 294 51 ms
				116 Lv	Lv 290 8.3 ms	Lv 291 18 ms	Lv 292 13 ms	Lv 293 57 ms
			115 Mc	Mc 287 32 ms	Mc 288 171 ms	Mc 289 0.33 s	Mc 290 0.75 s	
114 Fl	Fl 284 2.5 ms	Fl 285 150 ms	Fl 286 0.12 s	Fl 287 0.48 s	Fl 288 0.58 s	Fl 289 1.9 s		

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

Extraction time: several hundred ms → Too slow!

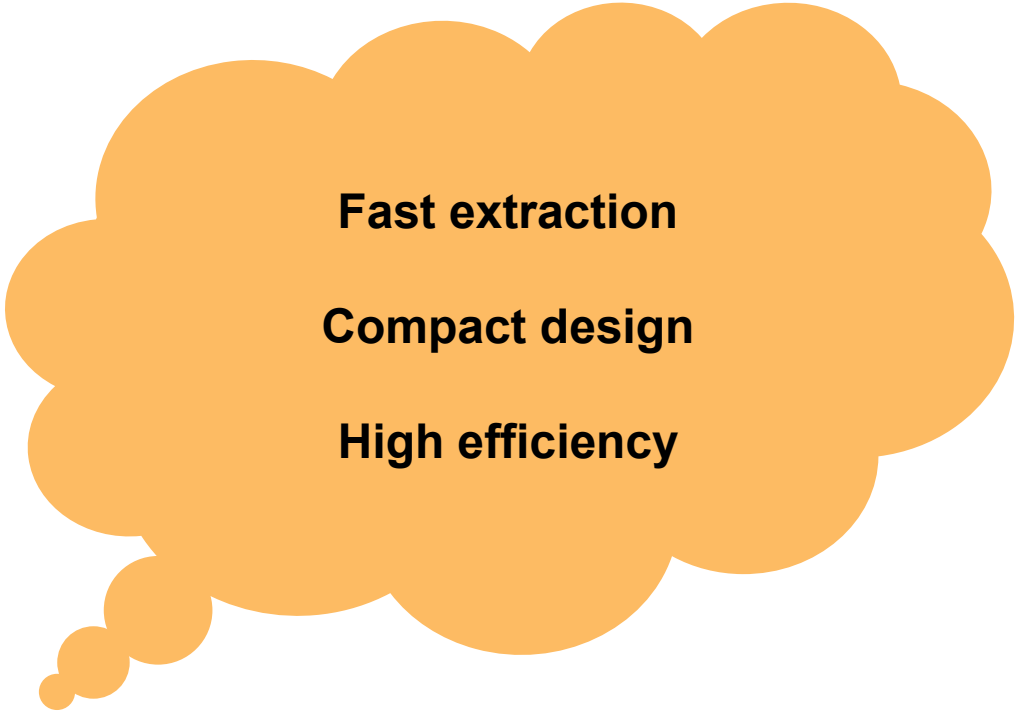
Yakushev *et al.*, Front. Chem. 9 (2021) 753738



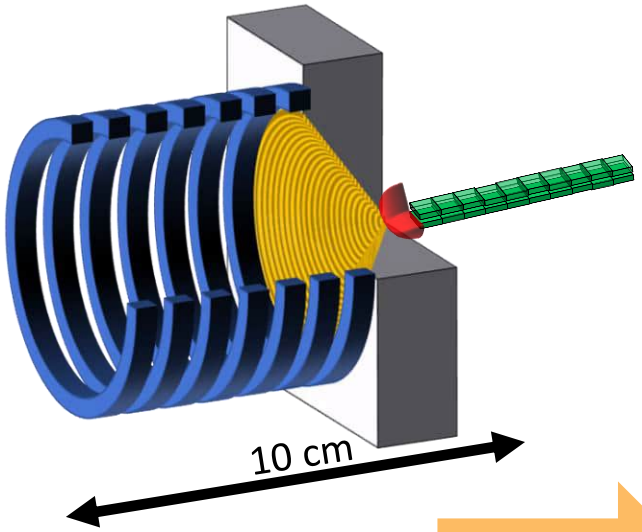
adapted from:

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

Requirements for experiments beyond Mc



UniCell – compact, atmospheric pressure, gas buffer cell

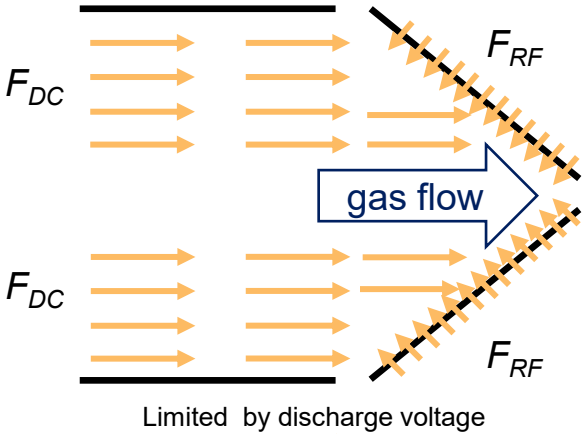


Stopping of all ions with high efficiency at 1 bar in helium

Strong DC field accelerates ions
→ faster extraction

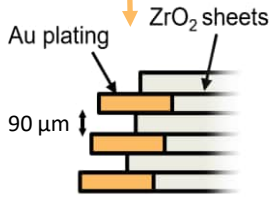
Strong RF field prevents wall encounters

Compact design, assumed fast extraction and high efficiency



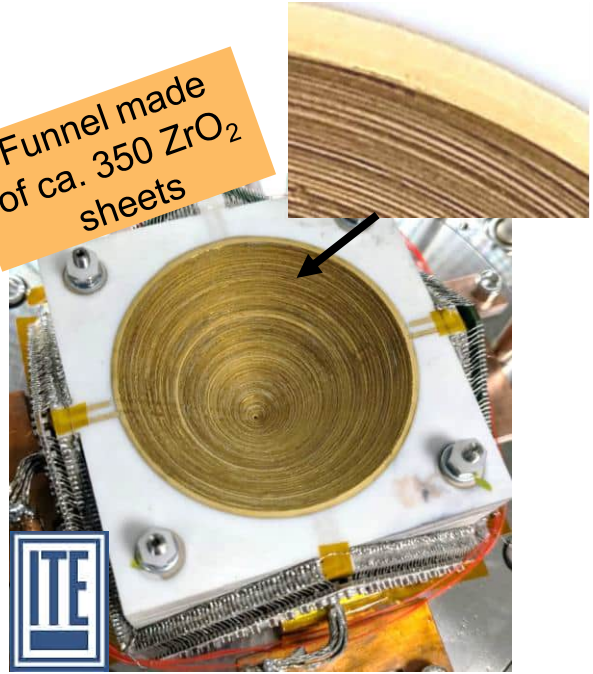
Limited by discharge voltage

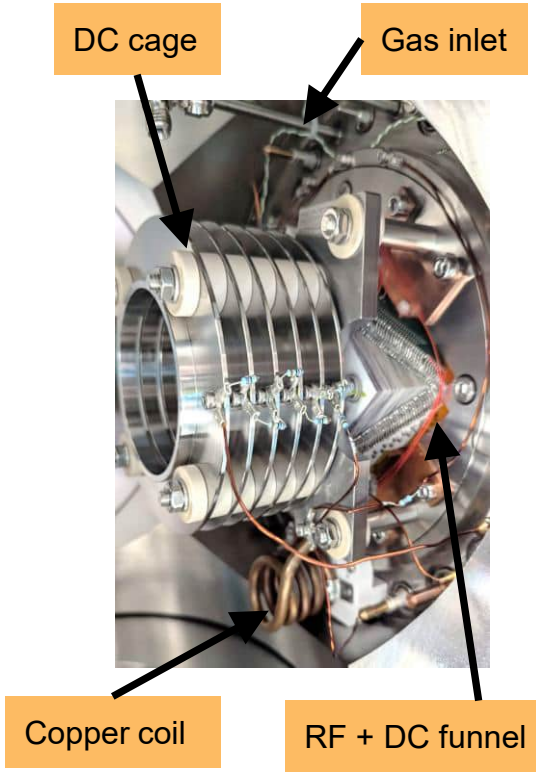
$$F_{RF} = mK^2 \frac{V_{pp}^2}{4r^3}$$

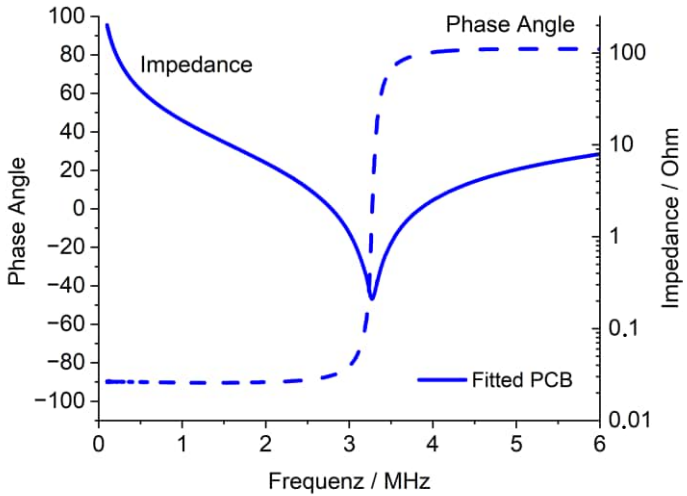


V. Varentsov, A. Yakushev, NIM A 940 (2019) 206
Y. Wei *et al.*, Nucl. Sci. Tech. 36 (2025) 187

UniCell – Current status



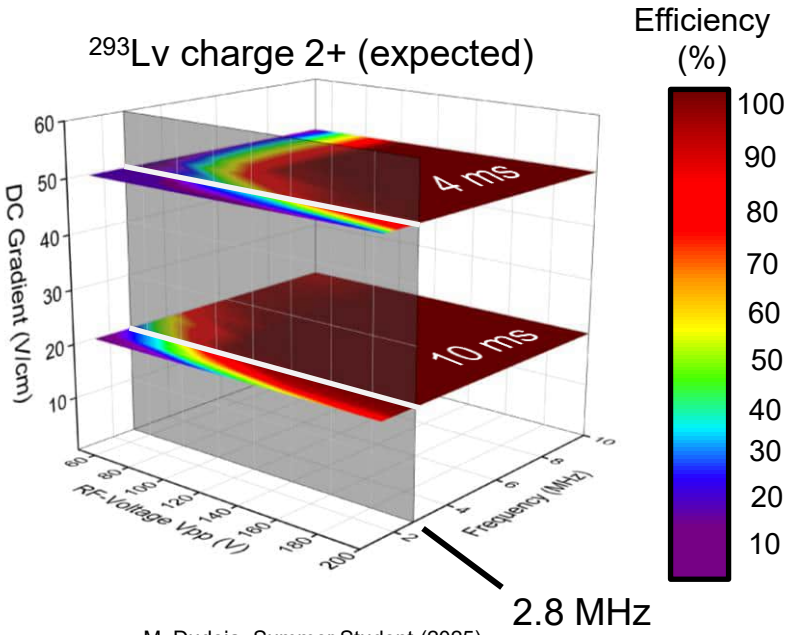




UniCell – Simulations

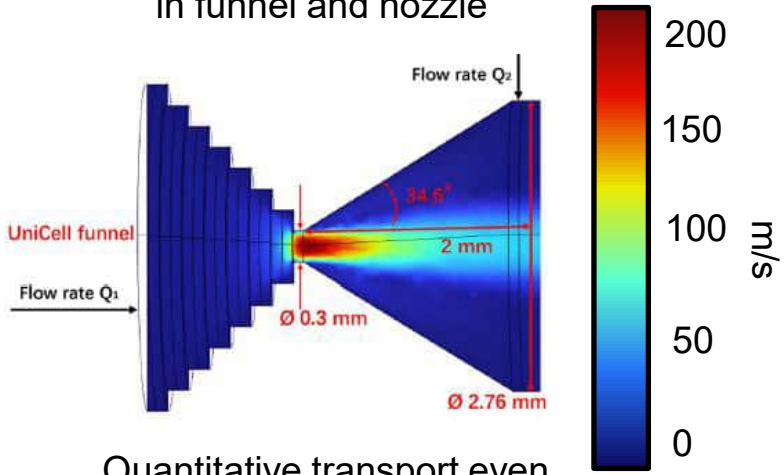
SIMION simulations: extraction time and efficiency depends on DC-gradient, RF-Voltage and frequency

^{293}Lv charge 2+ (expected)



M. Dudeja, Summer Student (2025)

COMSOL simulations: gas-flow in funnel and nozzle



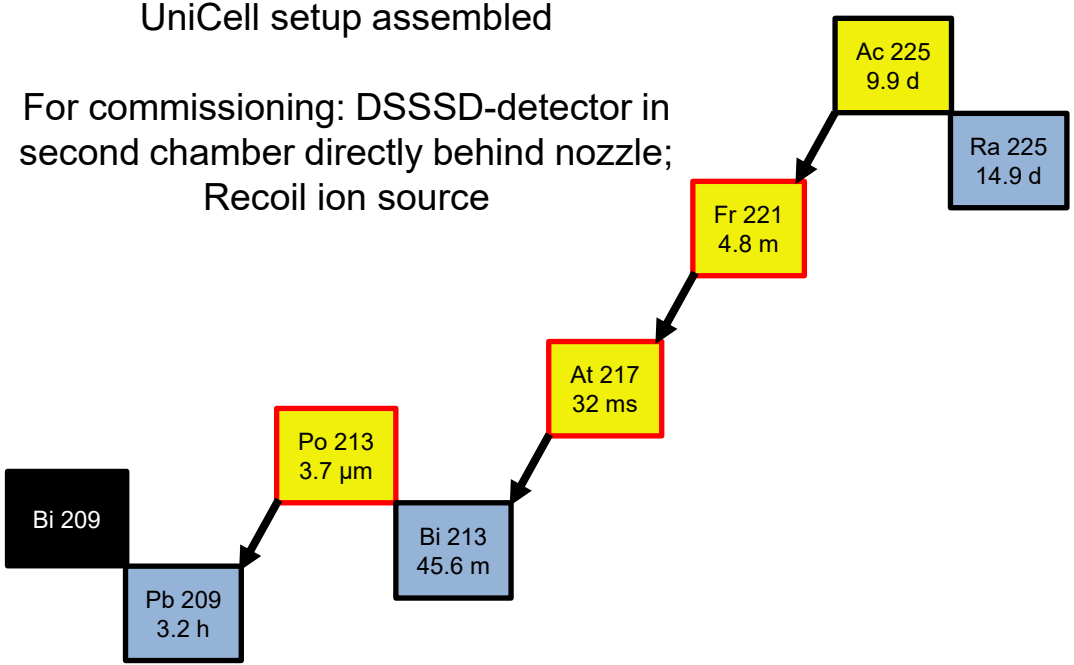
Quantitative transport even without electrical fields

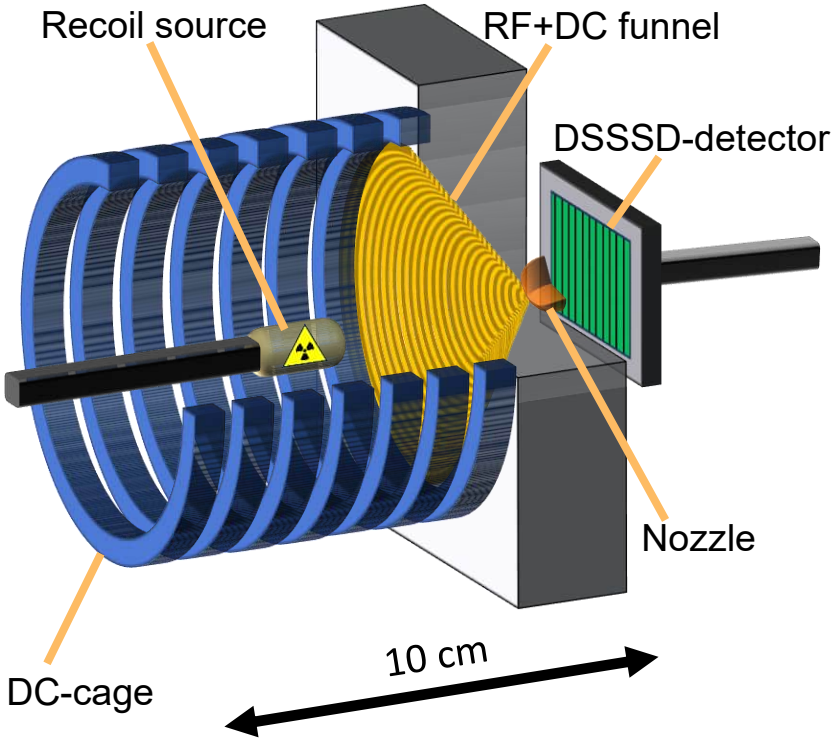
Y. Wei *et al.*, Nucl. Sci. Tech. 36 (2025) 187

UniCell – Commissioning

UniCell setup assembled

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





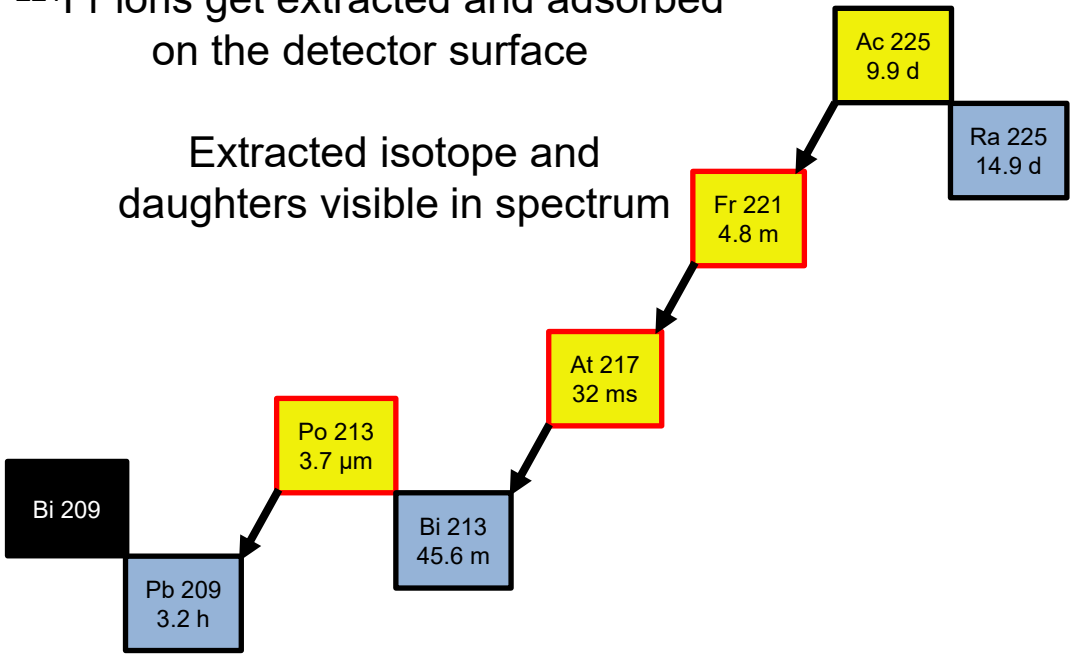
adapted from Y. Wei *et al.*, Nucl. Sci. Tech. 36 (2025) 187

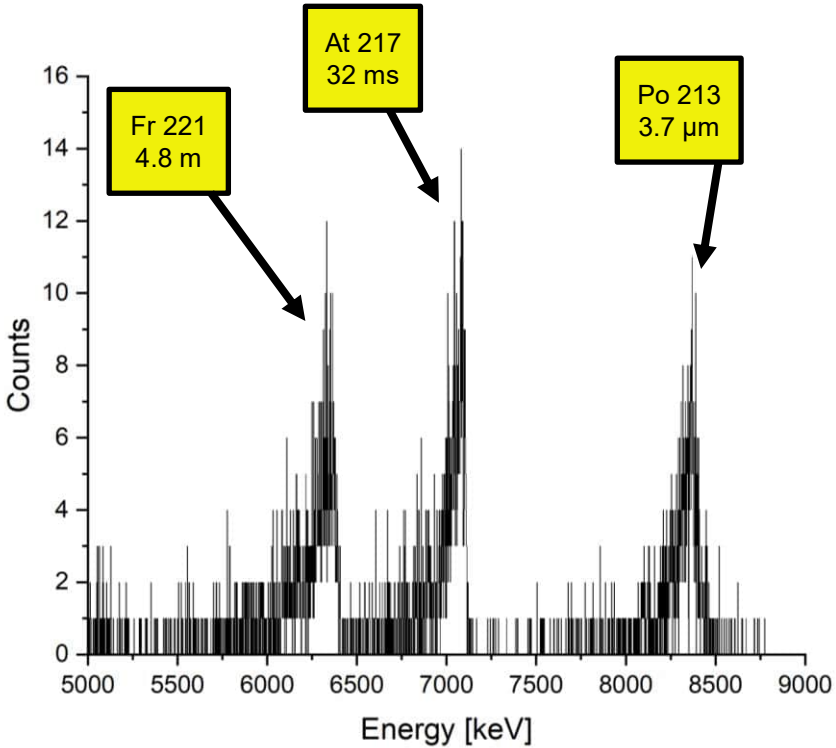
UniCell – Commissioning

^{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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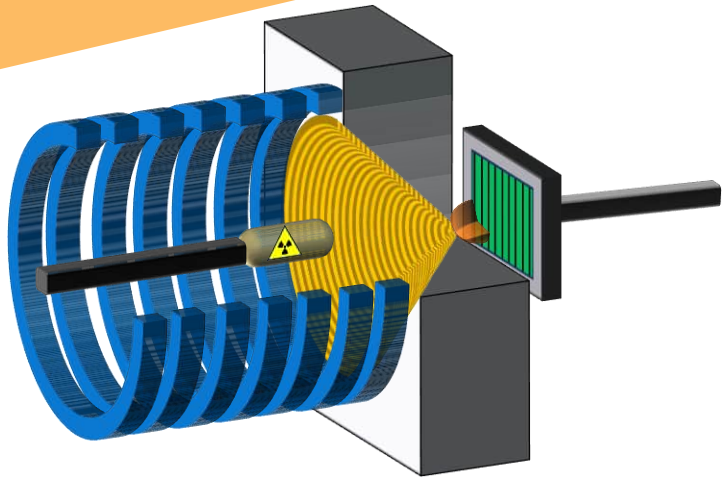

gas flow

DC gradient

gas pressure

RF voltage

bias voltage

nozzle voltage

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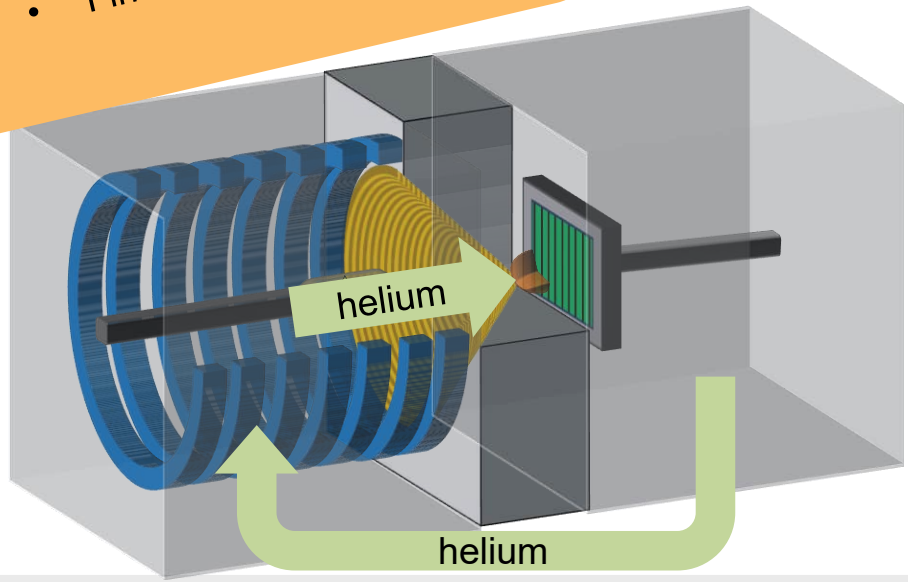

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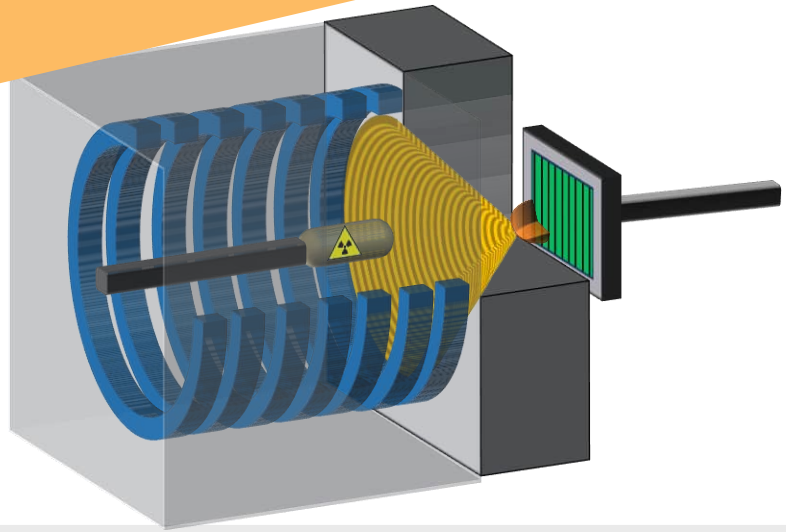

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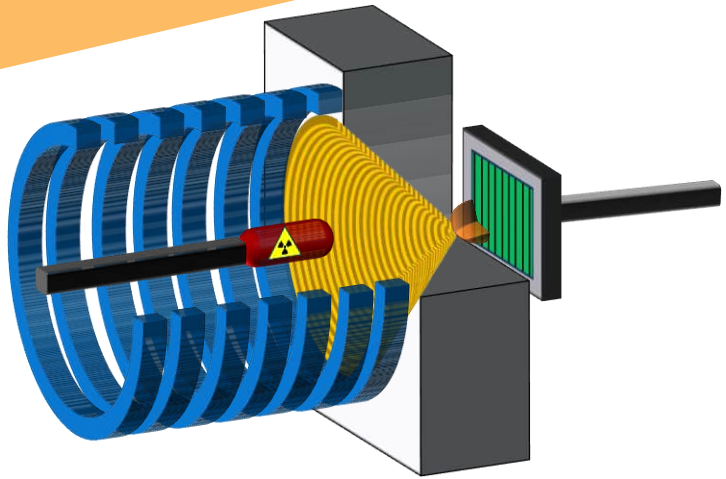

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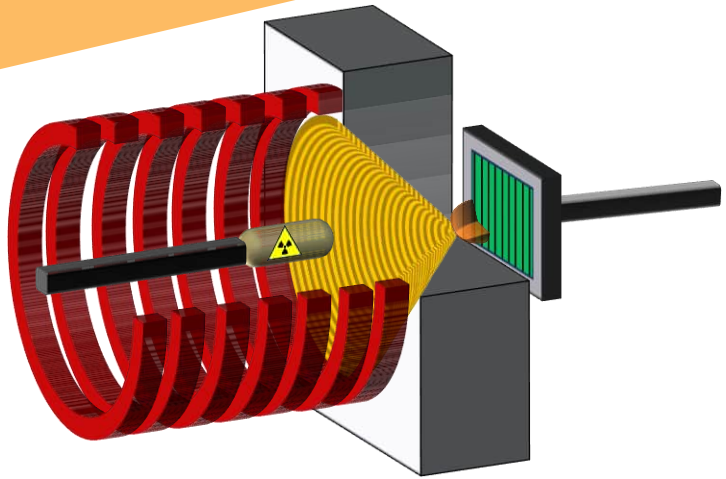

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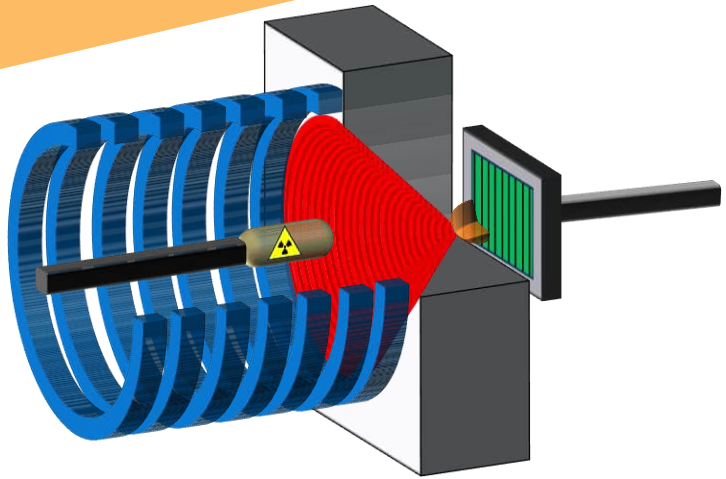

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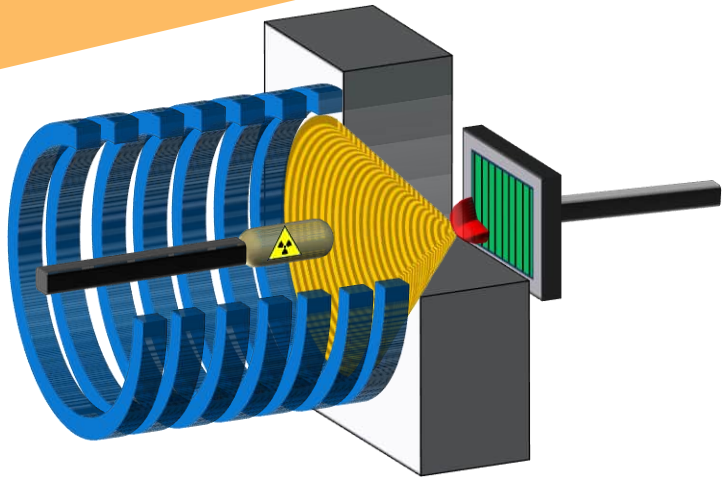

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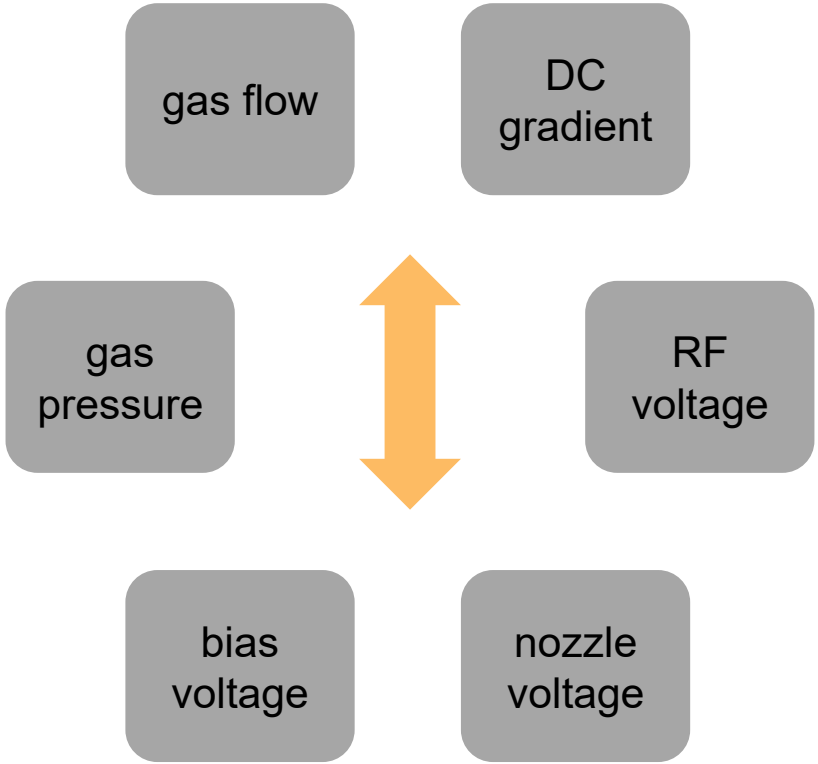


Change one parameter at a time:
Influence on the count rate

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-feuer-forschung-helmholtzzentrum-100.html (30.04.26)

Commissioning will be resumed as quickly as possible

Summary & Outlook

UniCell in commissioning phase

Setup fully assembled

First tests performed with recoil ion source

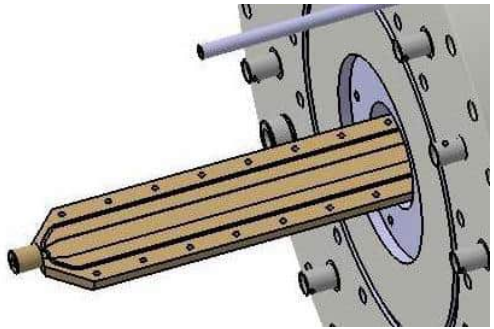
→First spectra look promising, but data set is incomplete

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)



Acknowledgments

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… the Federal Ministry of Research, Technology, and Space
Project number: 05P21UMFN2

Bundesministerium
für Forschung, Technologie
und Raumfahrt

… Dr. Dennis Renisch for the preparation of the recoil ion source

… the staff at the GSI workshop for the manufacturing of many parts of UniCell

… the rest of the working group for their support

Thank you for your attention