Heavy Element Research at Texas A&M University

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Current and Future History of Elements Above Oganesson ($Z = 118$)

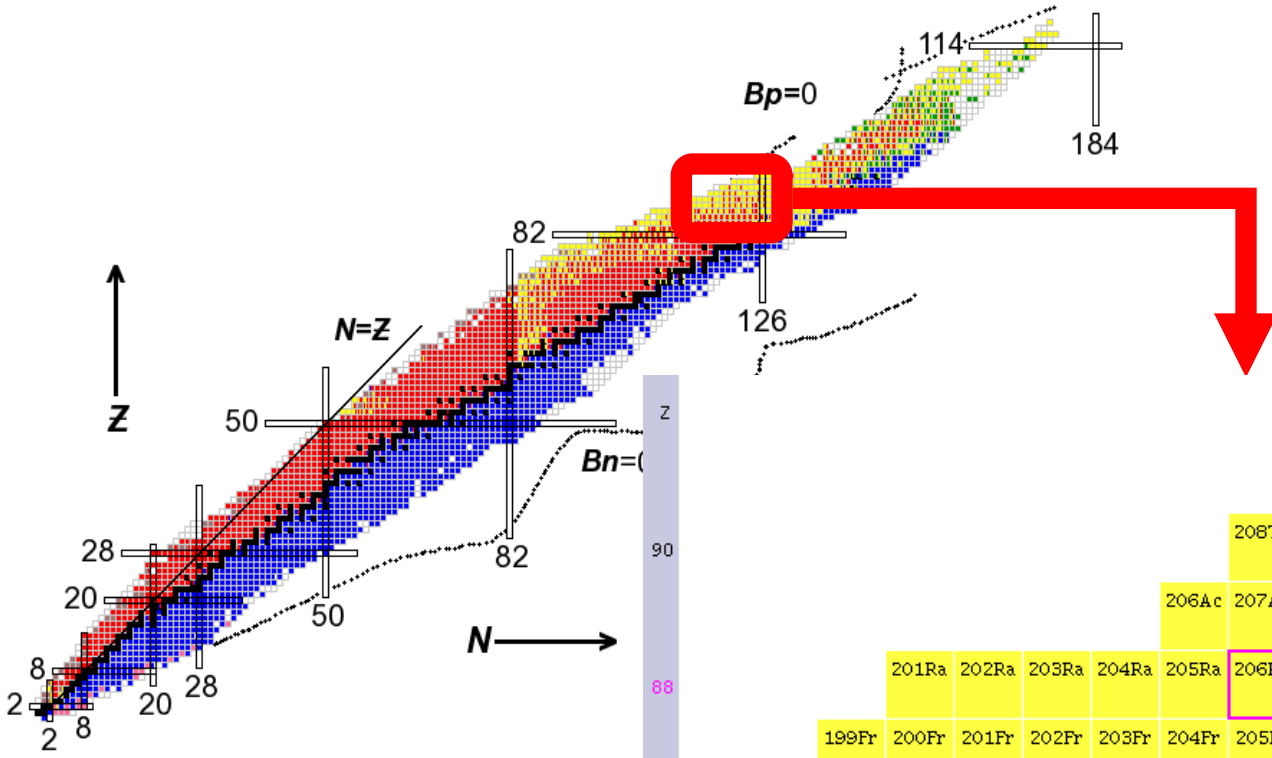
- The great question is, "What reaction is most likely to lead to the discovery of the next new element?"
- Recently, actinide elements have been irradiated with ^{48}Ca.

Lanthanides ▸	58 140.12 **Ce** Cerium	59 140.91 **Pr** Praseodymium	60 144.24 **Nd** Neodymium	61 (145) **Pm** Promethium	62 150.40 **Sm** Samarium	63 151.96 **Eu** Europium	64 157.25 **Gd** Gadolinium	65 158.93 **Tb** Terbium	66 162.50 **Dy** Dysprosium	67 164.93 **Ho** Holmium	68 167.26 **Er** Erbium	69 168.93 **Tm** Thulium	70 173.04 **Yb** Ytterbium	71 174.97 **Lu** Lutetium
Actinides ▸	90 232.04 **Th** Thorium	91 231.04 **Pa** Protactinium	92 238.03 **U** Uranium	93 237.05 **Np** Neptunium	94 (244) **Pu** Plutonium	95 (243) **Am** Americium	96 (247) **Cm** Curium	97 (247) **Bk** Berkelium	98 (251) **Cf** Californium	99 (252) **Es** Einsteinium	100 (257) **Fm** Fermium	101 (260) **Md** Mendelevium	102 (259) **No** Nobelium	103 (262) **Lr** Lawrencium

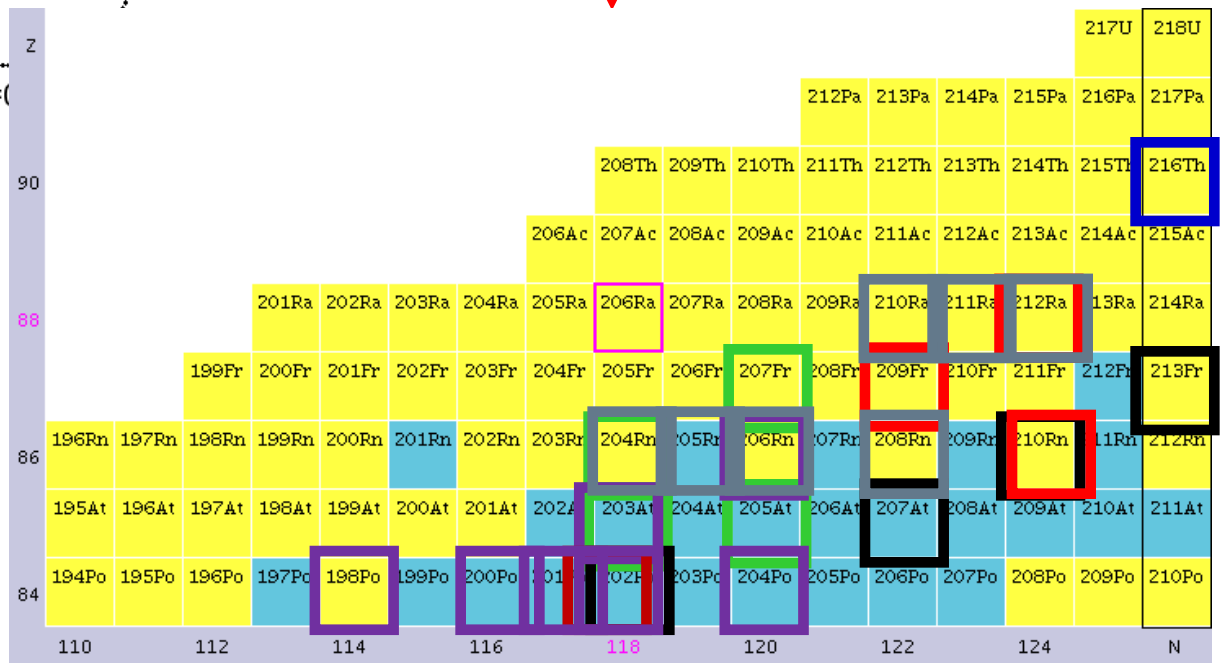
- A number of reactions have been studied using projectiles heavier than ^{48}Ca, but none have succeeded:

- $^{58}Fe + {}^{244}Pu \rightarrow {}^{298}120 + 4n$
- $^{54}Cr + {}^{248}Cm \rightarrow {}^{298}120 + 4n$
- $^{50}Ti + {}^{249}Cf \rightarrow {}^{295}120 + 4n$
- $^{64}Ni + {}^{238}U \rightarrow {}^{298}120 + 4n$
- $^{50}Ti + {}^{249}Bk \rightarrow {}^{295}119 + 4n$
- $^{51}V + {}^{248}Cm \rightarrow {}^{295}119 + 4n$

Projectiles with $Z \geq 20$ Reacting with Lanthanide Targets



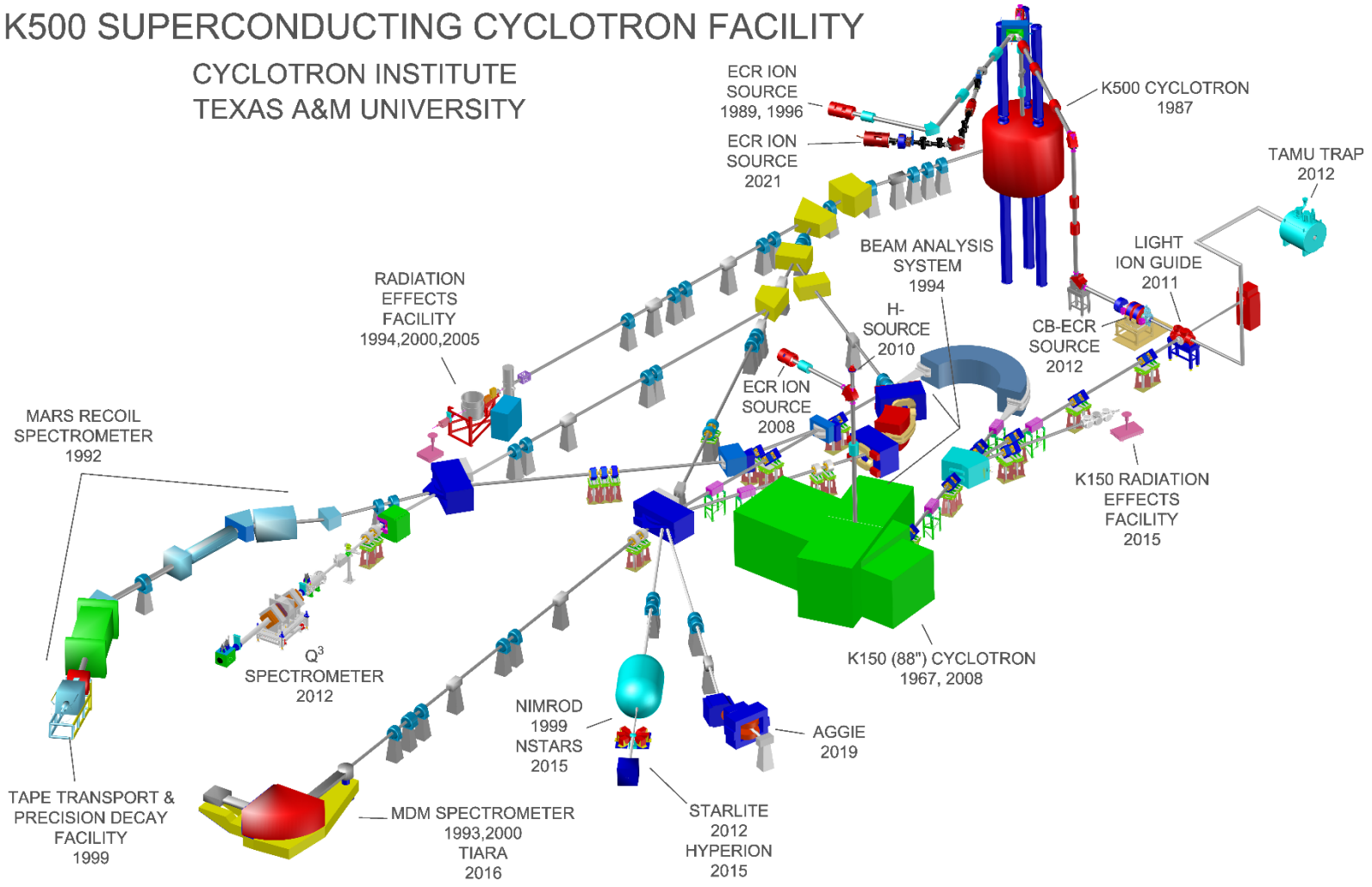
MOTIVATION:
Prospects of SHE Synthesis with $Z_p > 20$



Beams:

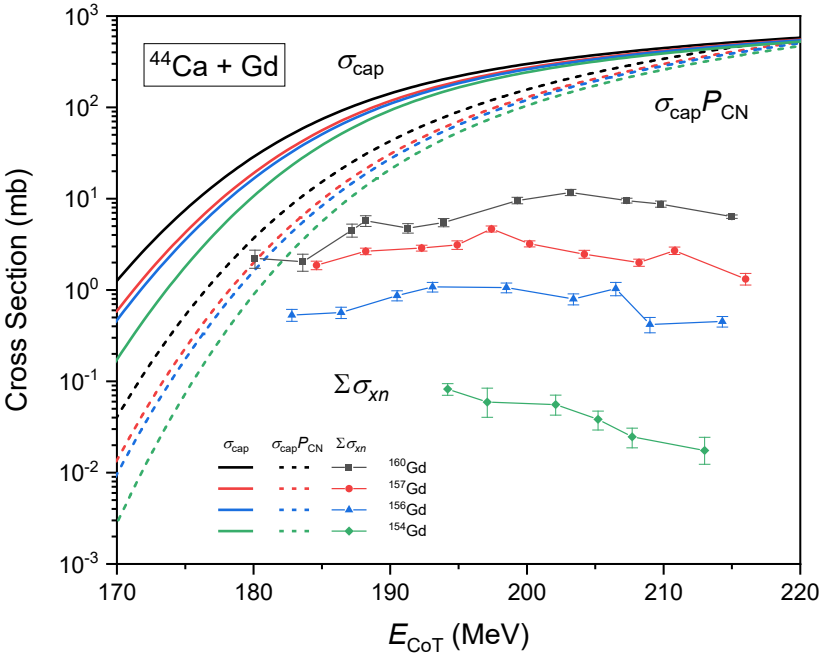
^{40}Ar CN	^{45}Sc CN
^{44}Ca CN	^{48}Ti CN
^{48}Ca CN	^{50}Ti CN
	^{54}Cr CN

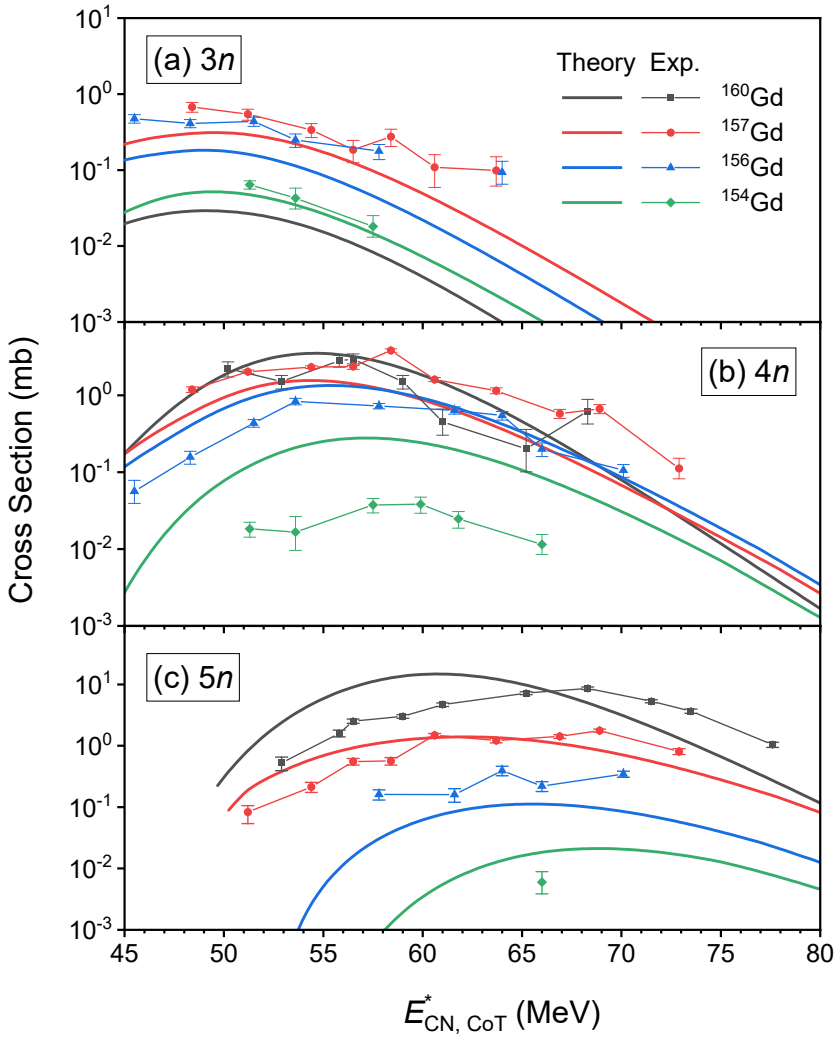
Cyclotron Institute Layout



Summary of ^{44}Ca + ^{154,156,157,160}Gd

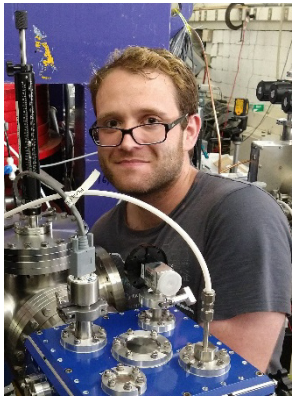
Tyler Werke





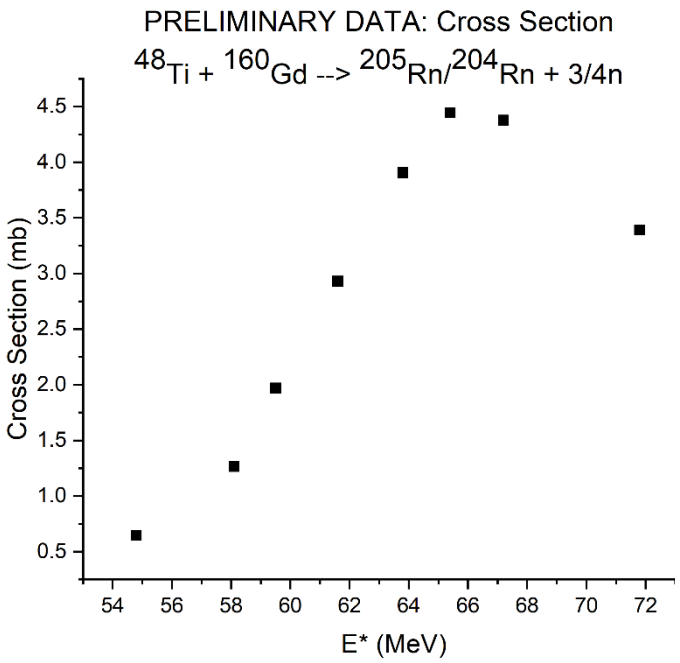
T. A. Werke *et al.*, Phys. Rev. C **106**, 054615 (2022). doi:10.1103/PhysRevC.106.054615

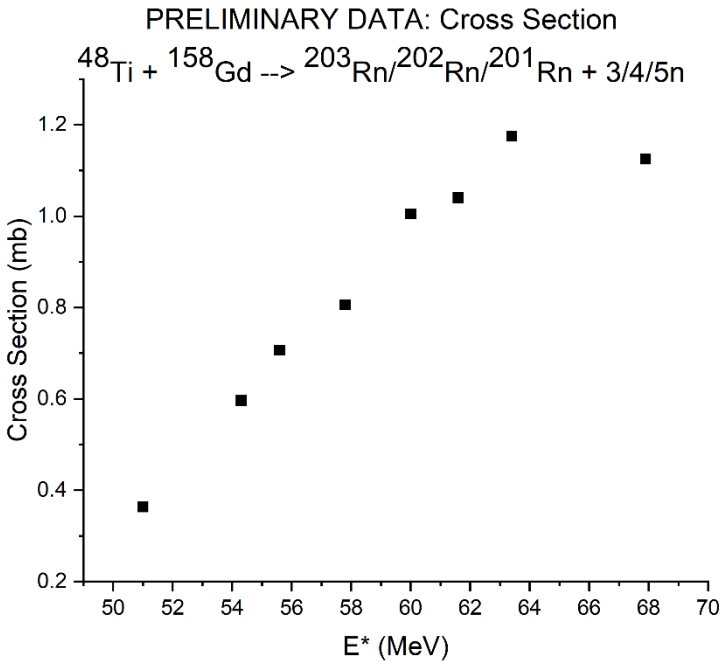
^{48}Ti + $^{156\text{-}158,160}$Gd, $^{162\text{-}164}$Dy (Preliminary Data)



Jordan Mildon

- In 2023, we studied the influence of CN deformation on survival using ^{48}Ti + $^{156\text{-}158,160}$Gd, $^{162\text{-}164}$Dy.
- First production experiment using MIVOC.

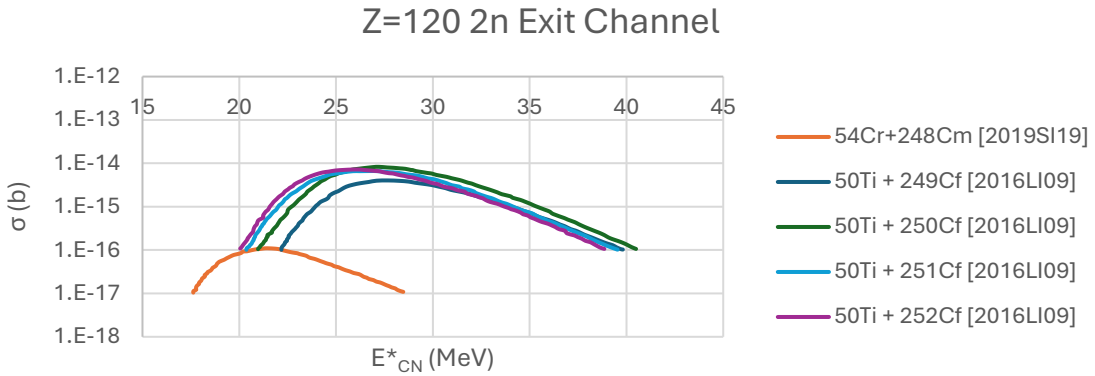


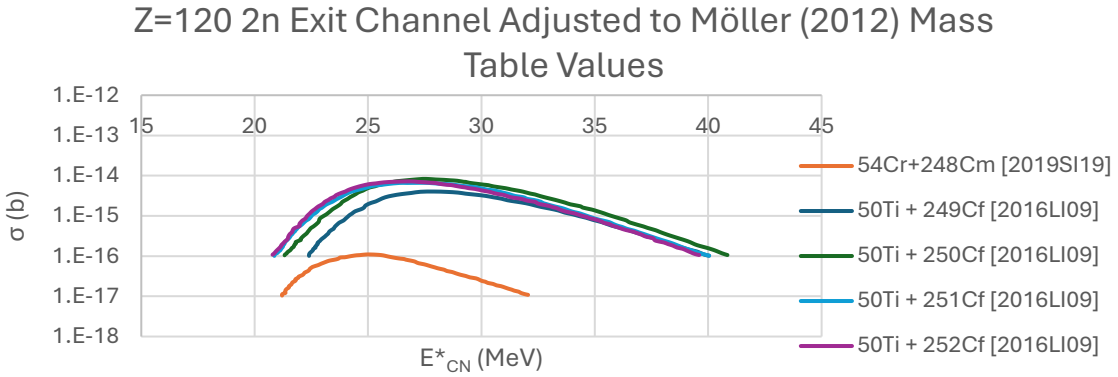


Kinetic Displacement of the Reaction (KDR, Preliminary Data)

Christa Pritchard

- Predicted excitation functions for elements 120 and 119 vary partly because of the different mass tables used.





The Most Important Questions

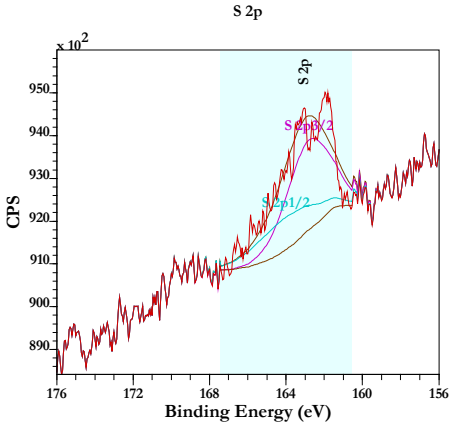
- Over one year of beamtime has been spent on discovering elements 119 and 120. No decays chains have been reported.

- Theoretical predictions show a wide variation in cross section and optimum energy.

- What are the most important questions?
  - What are the fission barriers for superheavy nuclei?
  - What is the influence of angular momentum, both in the entrance channel and on the fission barrier?
  - How does P_{CN} change with any parameter?

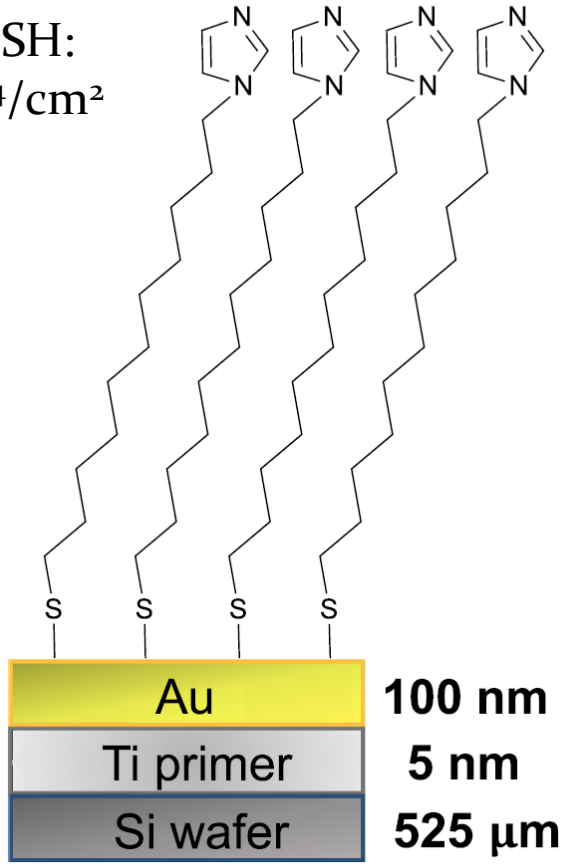
Functionalized Detector Surfaces

Vera Zakusilova



Sulfur 2p XPS for Im-C_{11}-SH SAMs Adsorbed on Au

Im-C_{11}-SH:
$4.5 \times 10^{14}/cm^2$



Self-Assembly of Im-C_{11}-SH Molecules

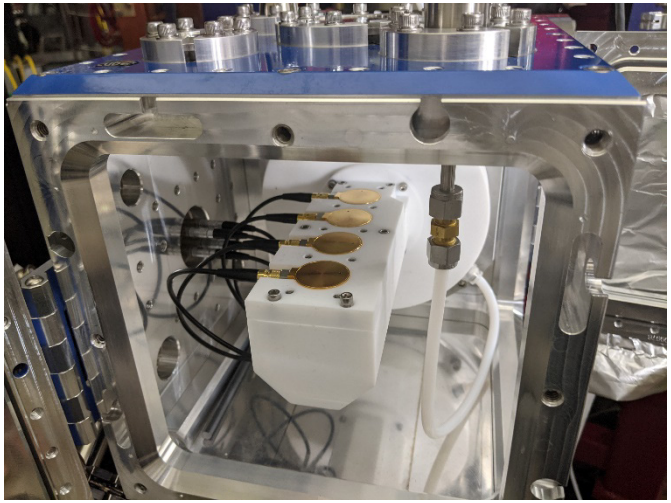
- Quantitative coverage [(99± 6)%] of Au-coated Si chips with 1-(11-mercaptoundecyl)imidazole (Im-C_{11}-SH) molecules.

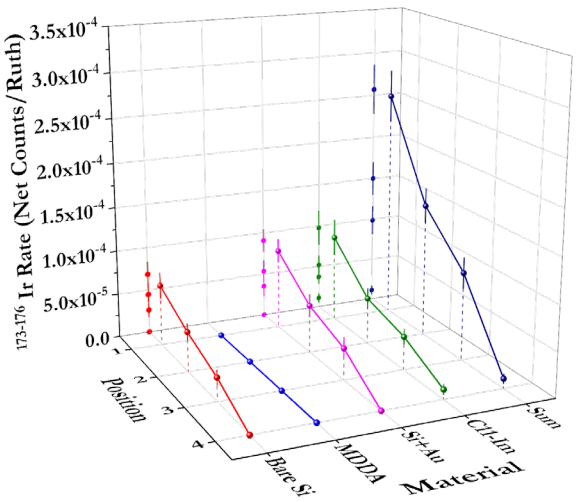
V. Zakusilova *et al.*, Appl. Surf. Sci. **642**, 158356 (2024). (link)

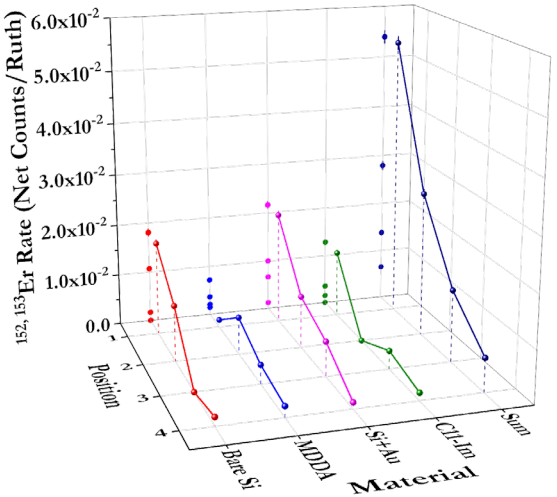
Functionalized Detector Surfaces (Preliminary Data)

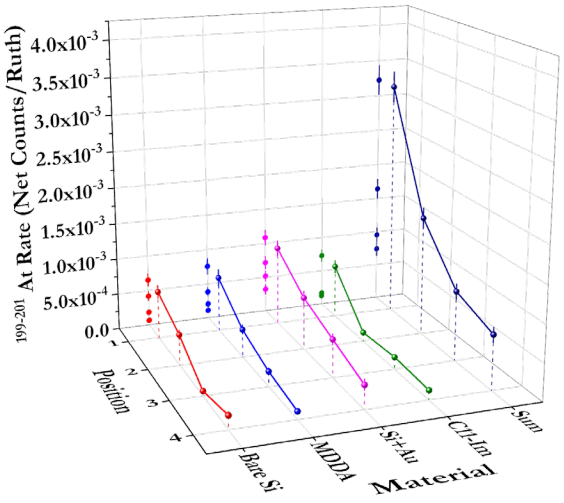
Vera Zakusilova

- We have measured the adsorption of Er, At, and Ir on functionalized Si detectors.







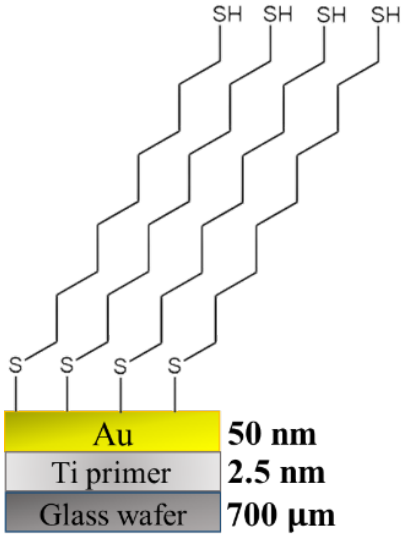


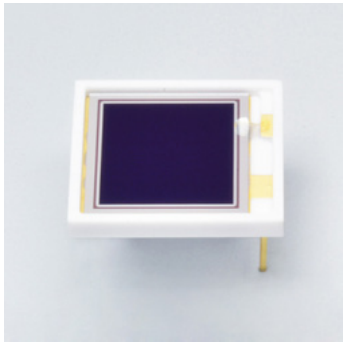
V. Zakusilova *et al.*, in preparation (2024).

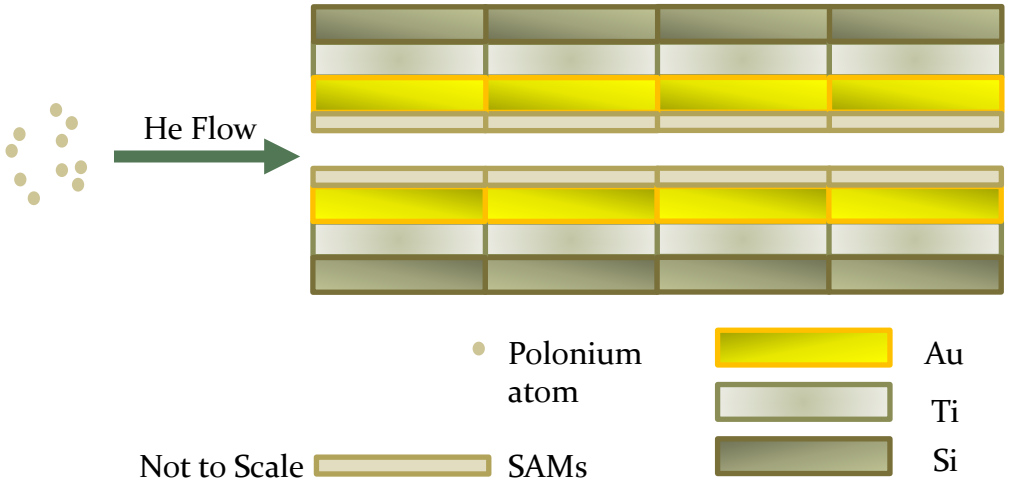
Chemically-Tunable Detectors for Chromatography of Po

Amelia Kirkland

- Self-assembled monolayers (SAMs) can be used to create chemically tunable surfaces for studying gas-solid interactions.
- Po (Z = 84), a lighter homolog of Lv (Z = 116), is being studied on a 1,9-nonanedithiol (NDT) surface.

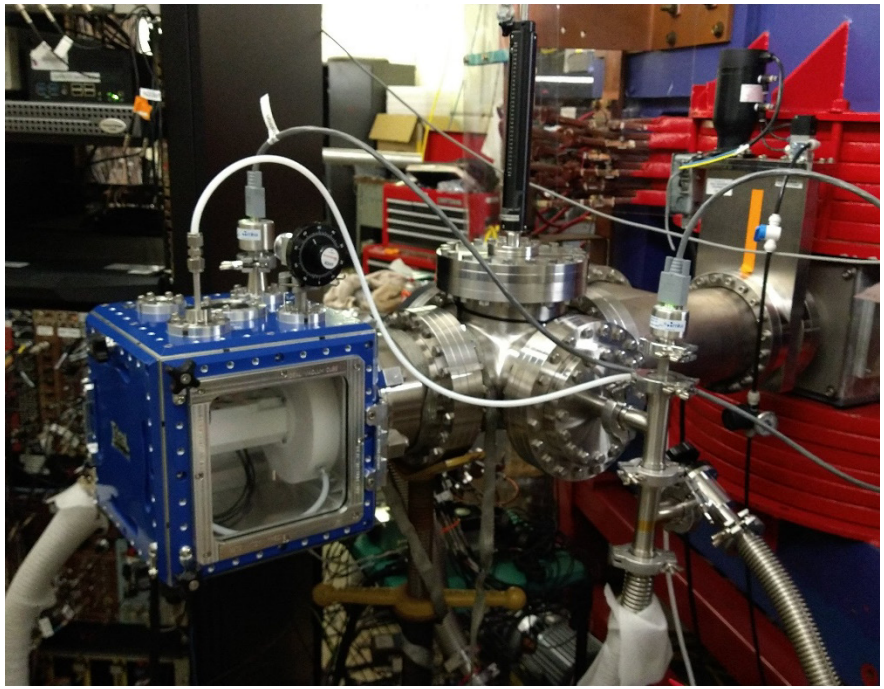


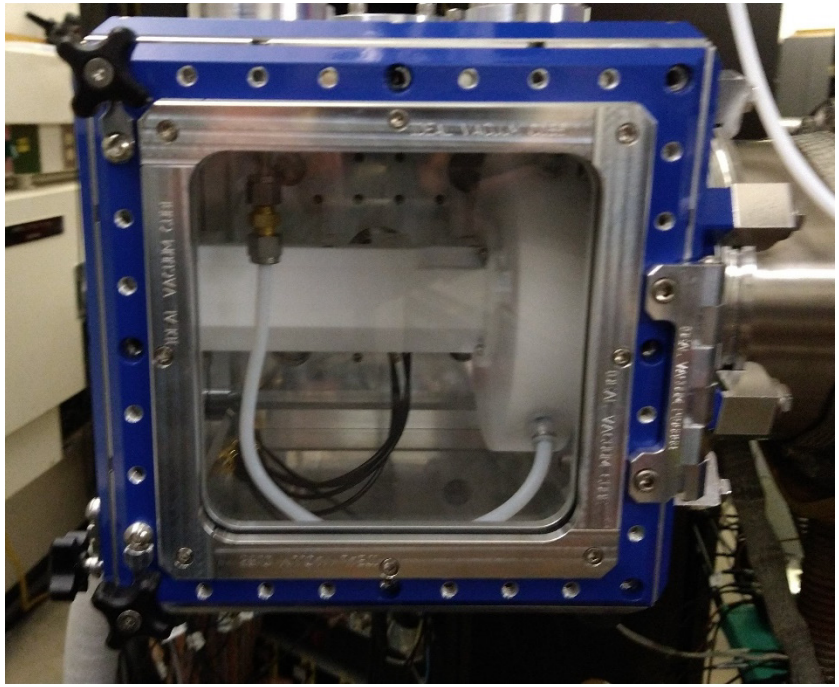




Simplified Recoil Transfer Chamber

- We have designed a new recoil transfer chamber for our functionalized detector surface experiments.
- Characterization is ongoing.



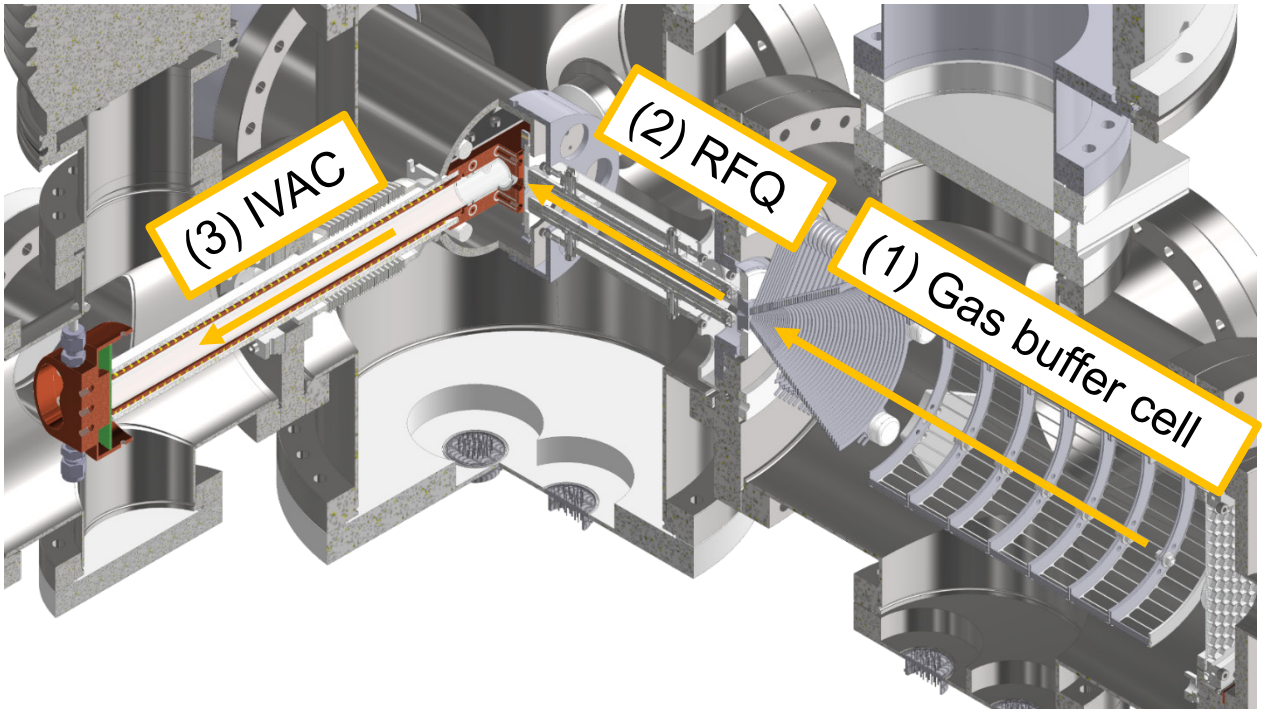


Vacuum Chromatography for Short-Lived SHE

Georg Tiebel

Isotopes of SHEs beyond Fl are in the sub-second domain → Wanted: New experiments!

Isothermal vacuum chromatography tested.



May 2024:
$^{147}Sm(^{36}Ar, 5n)^{178}Hg$
$t_{½}$ = 266 ms

Slide prepared by P. J. Steinegger.

Vacuum Chromatography for Short-Lived SHE

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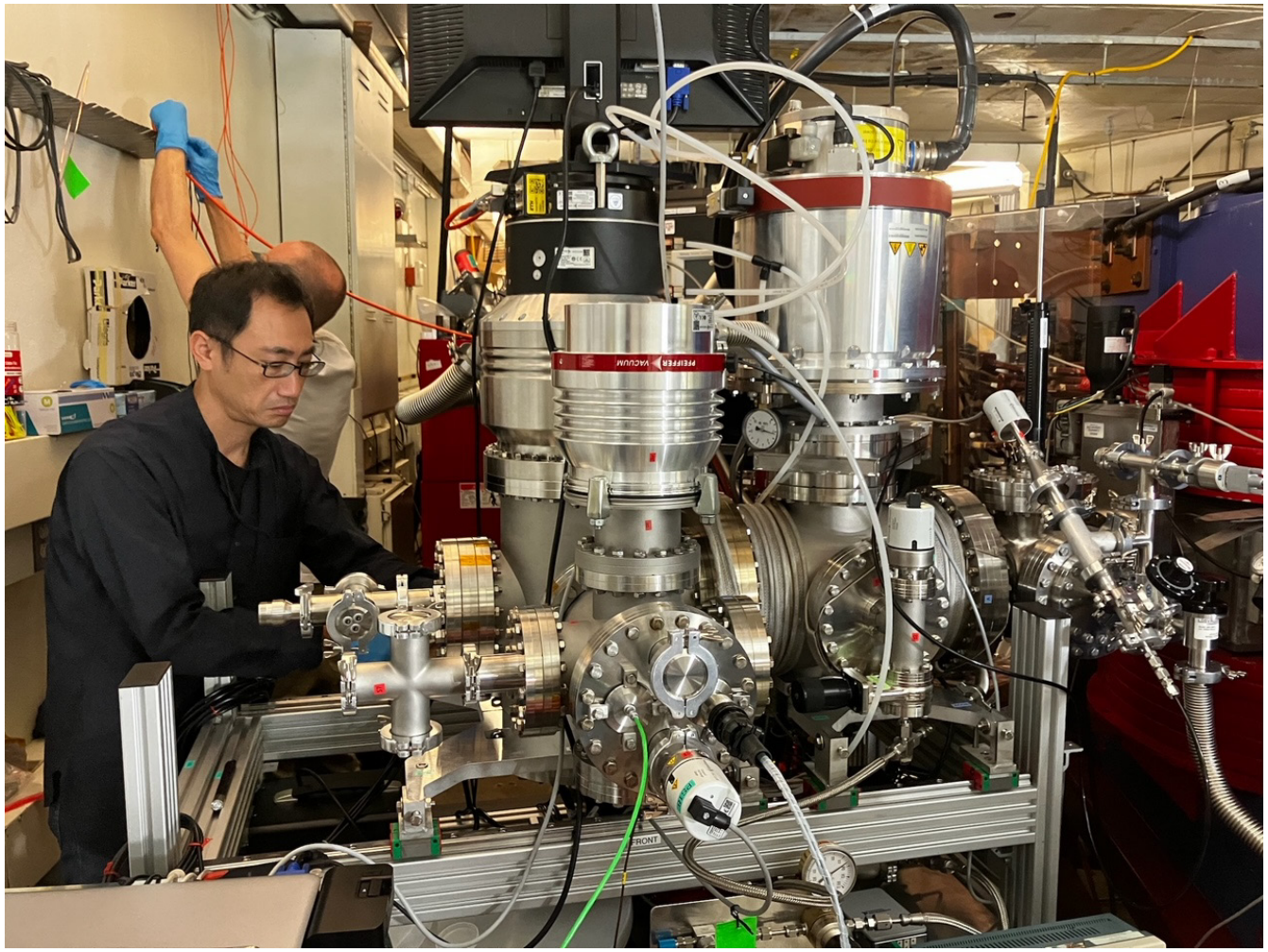

Slide prepared by P. J. Steinegger.

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