Instrumental and Methodical Improvements for Chemistry Experiments at the Berkeley Gas-filled Separator

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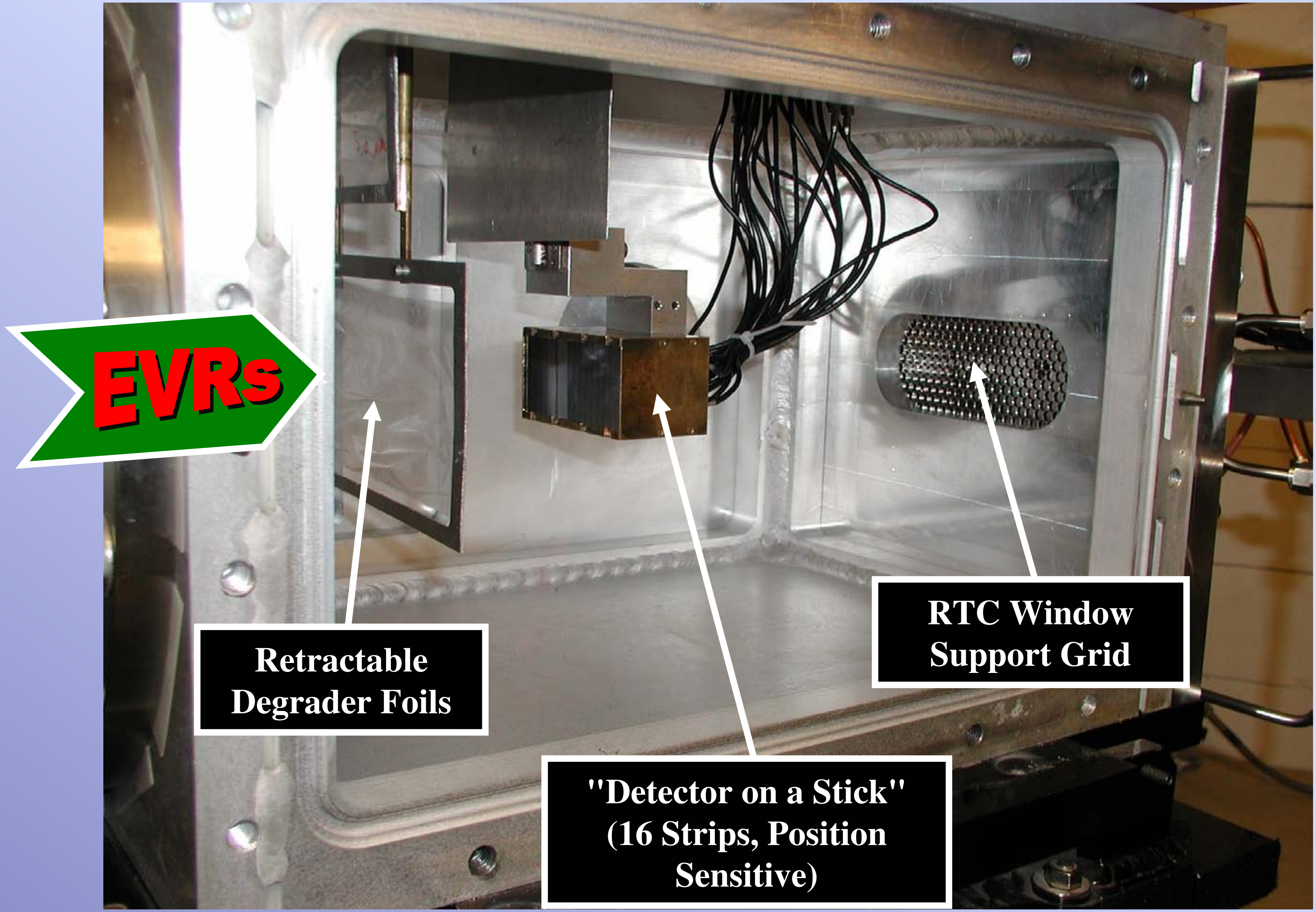
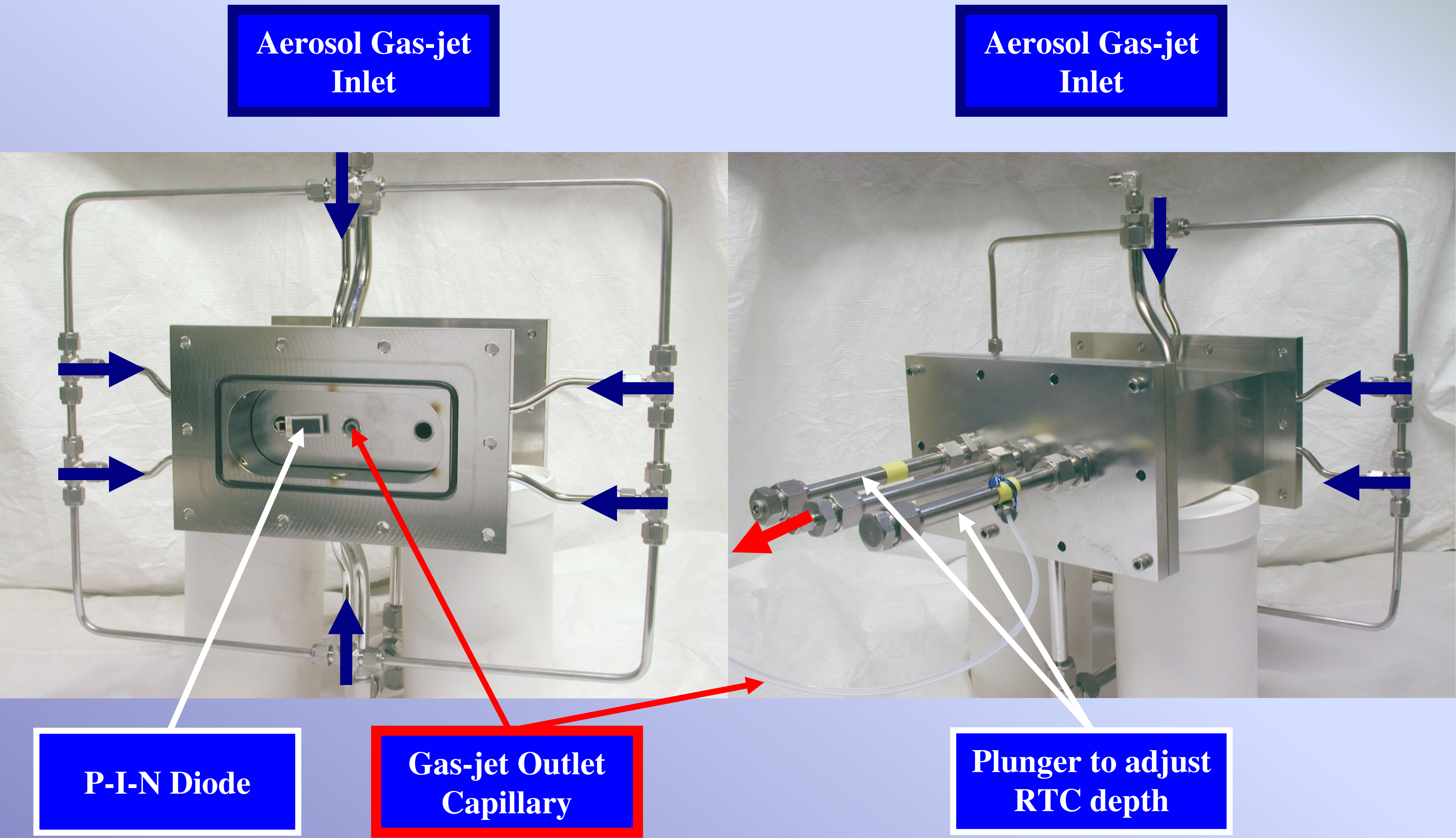
Recoil Transfer Chamber

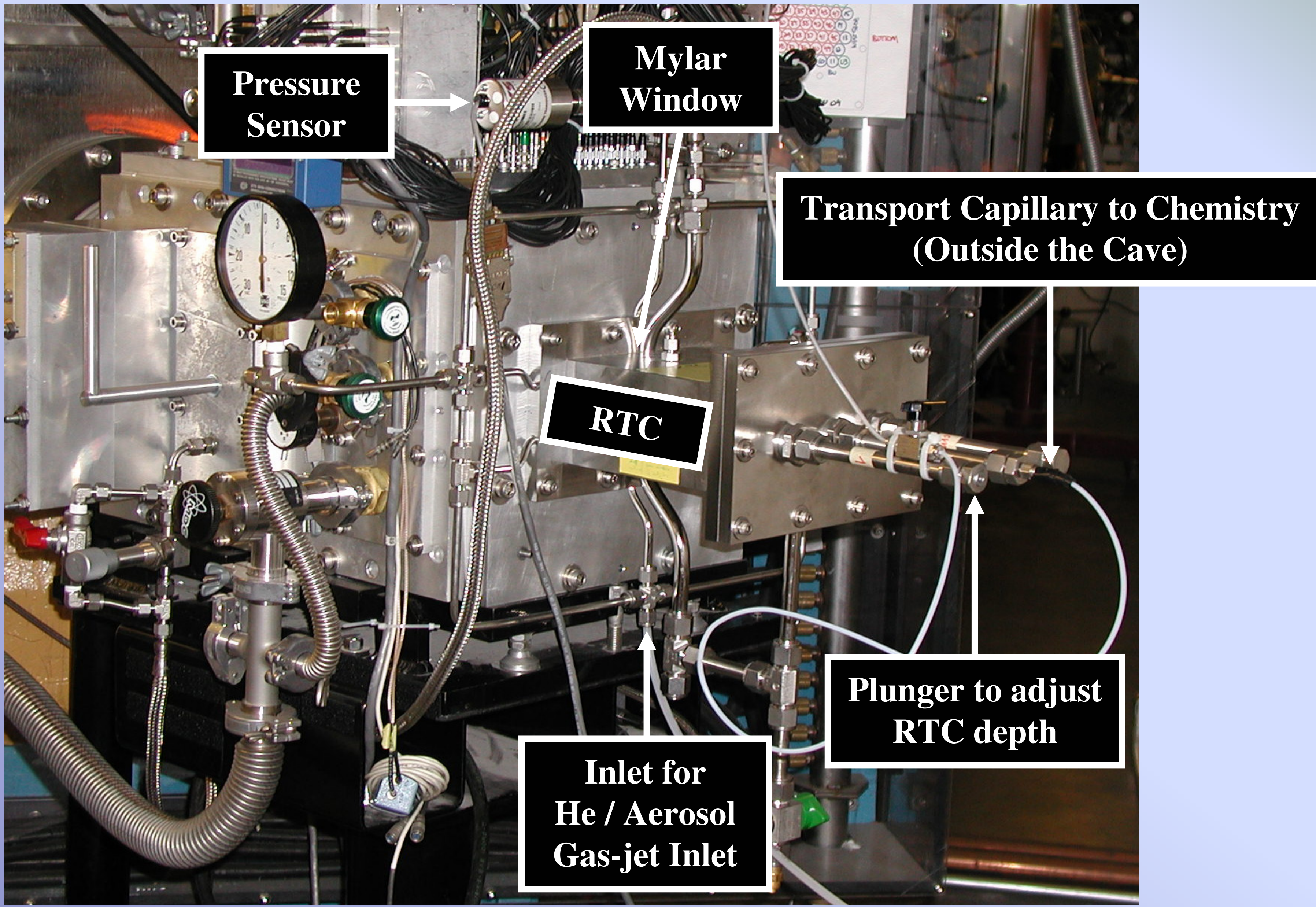
BGS Detector Setup For Chemistry



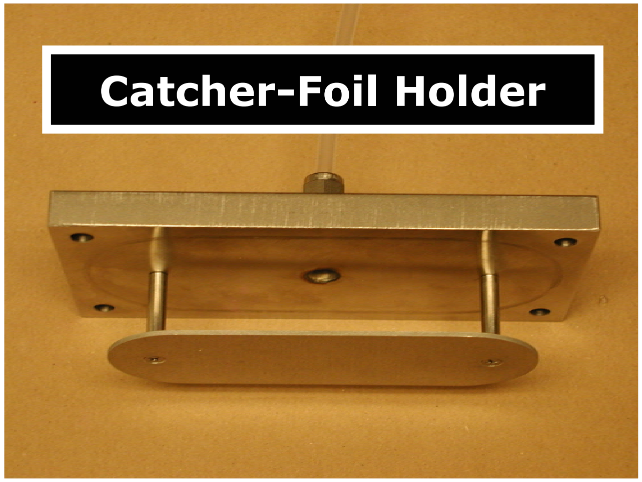
Recoil Transfer Chamber (RTC)

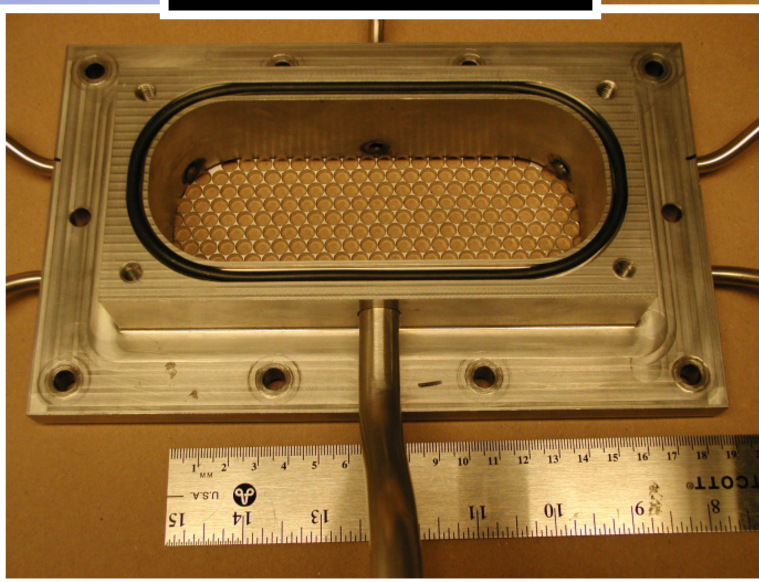


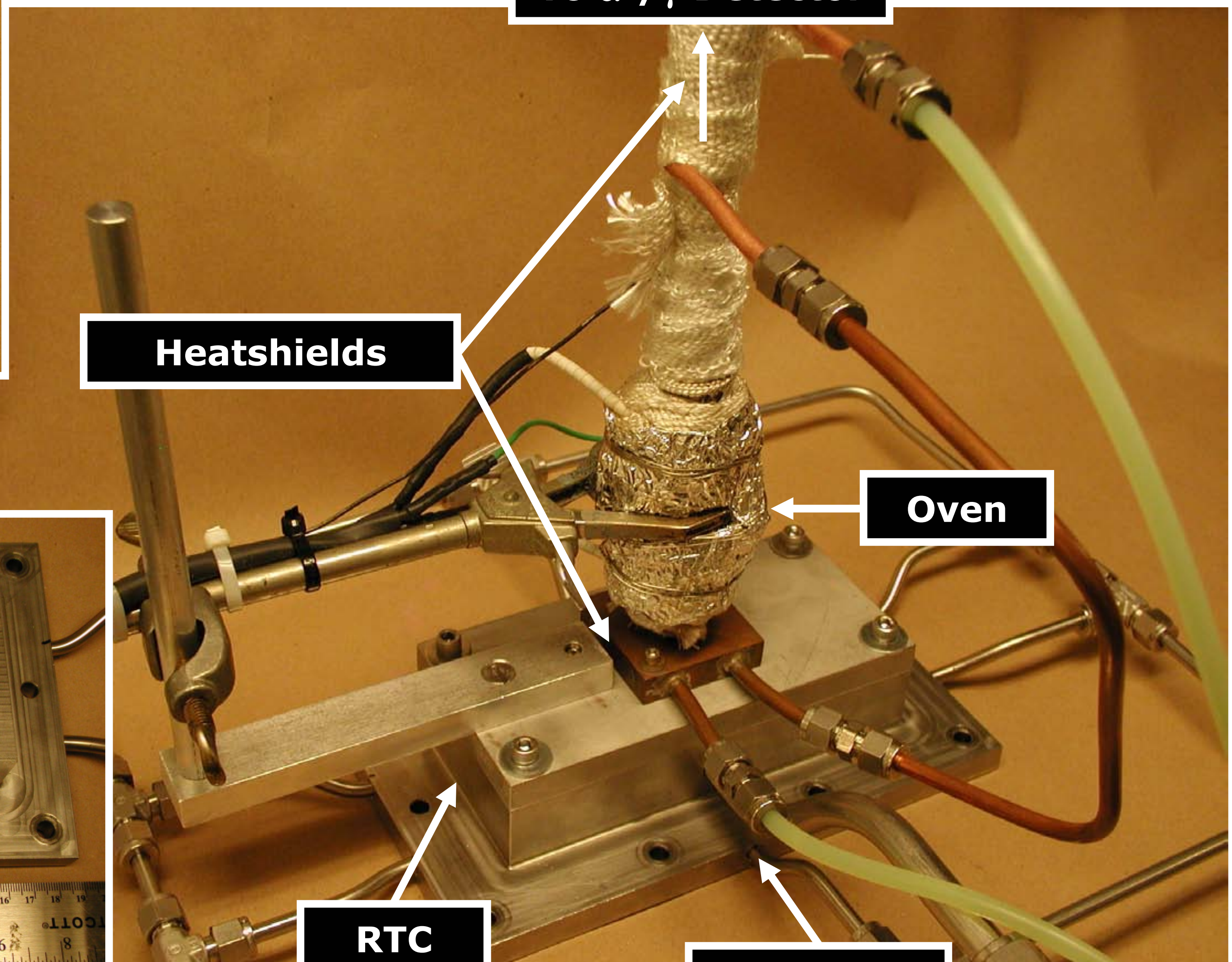
BGS / RTC Setup For Aerosol Transport



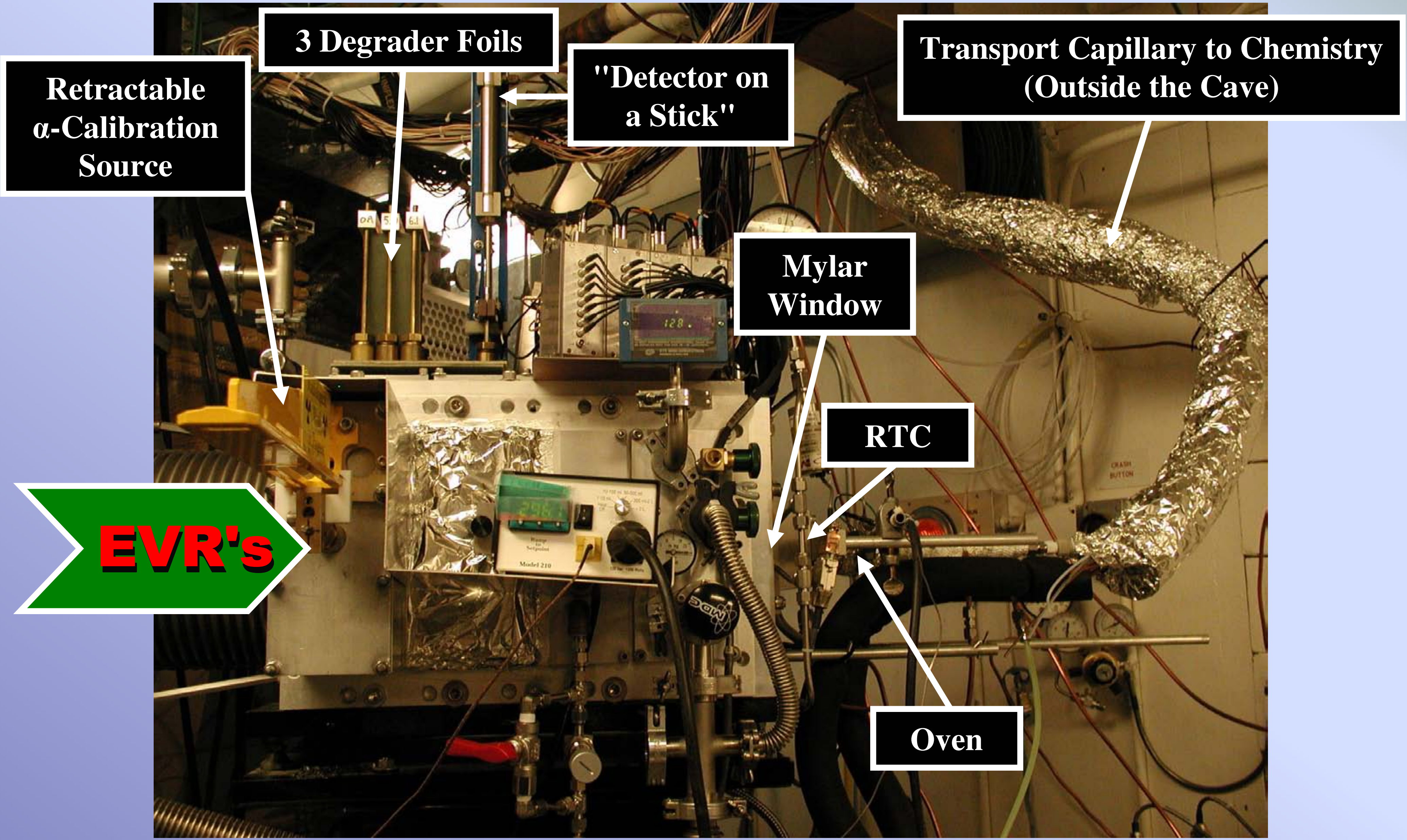
RTC : The Next Generation



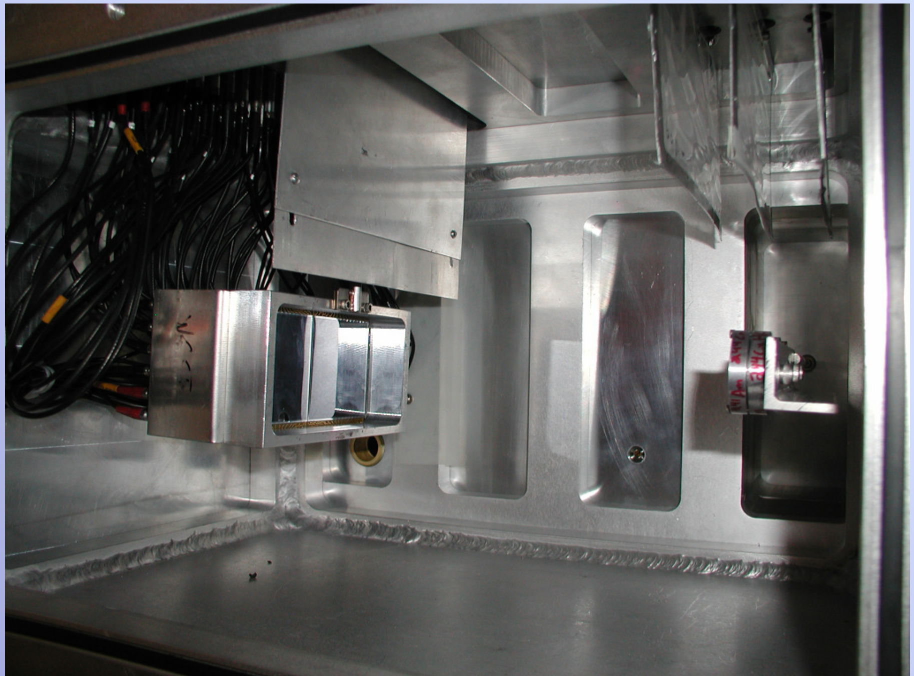




BGS / RTC Setup For Gas Chemistry



New Detector-On-A-Stick



- ☑ 32 Position-Sensitive Si Strips
- ☑ 12 cm x 6 cm x 6 cm
- ☑ Covers 6.3% in Bρ
- ☑ ~50% Geometric Efficiency

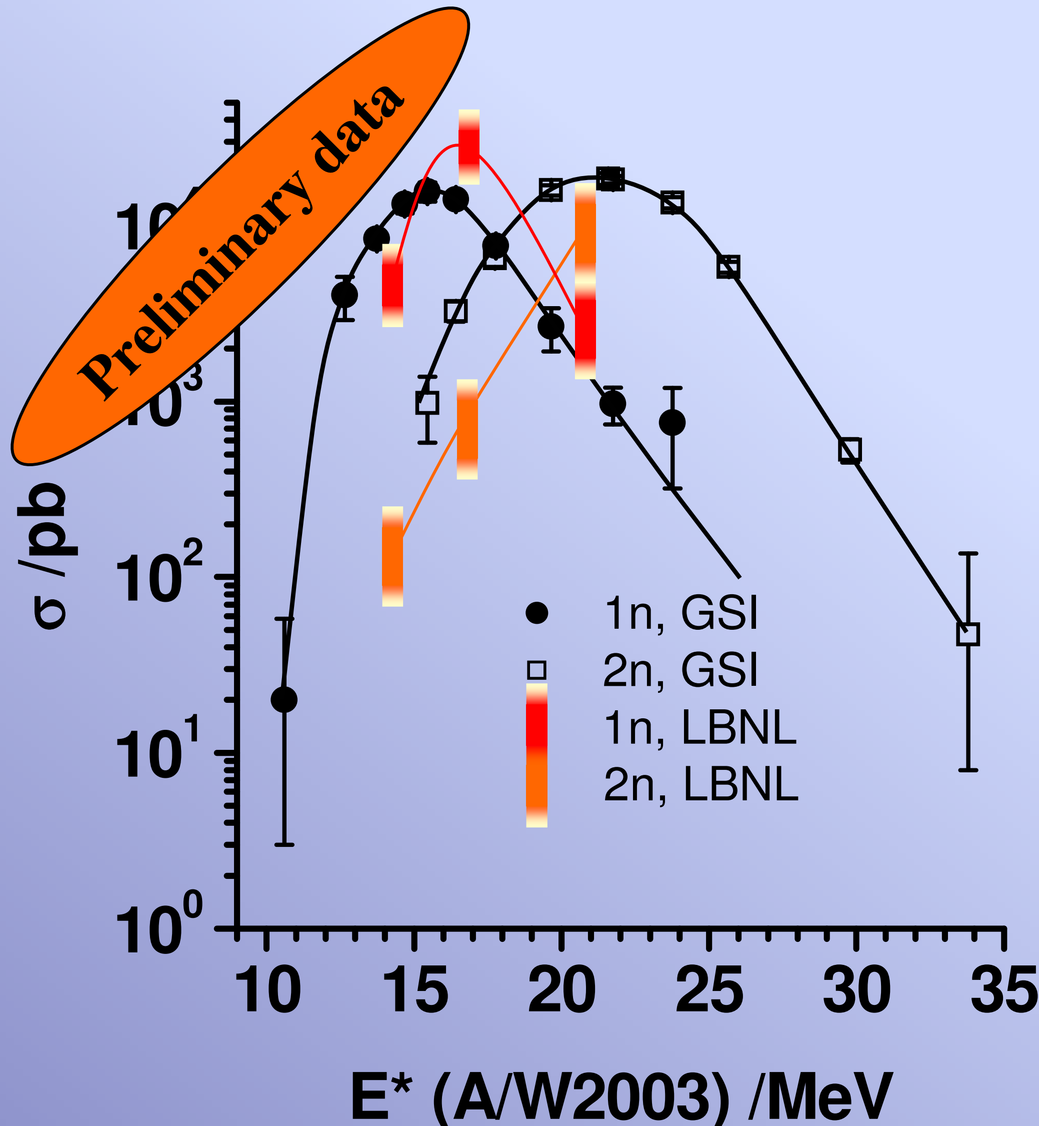
Remember:

Always retract the detector!

- ☑ Allows for nuclide identification by decay correlation while the RTC is in place.
- ☒ Does not work well when bombarded with 3.4×10^{10} atoms of O^{4+}

Nuclear Reaction Studies for Chemistry

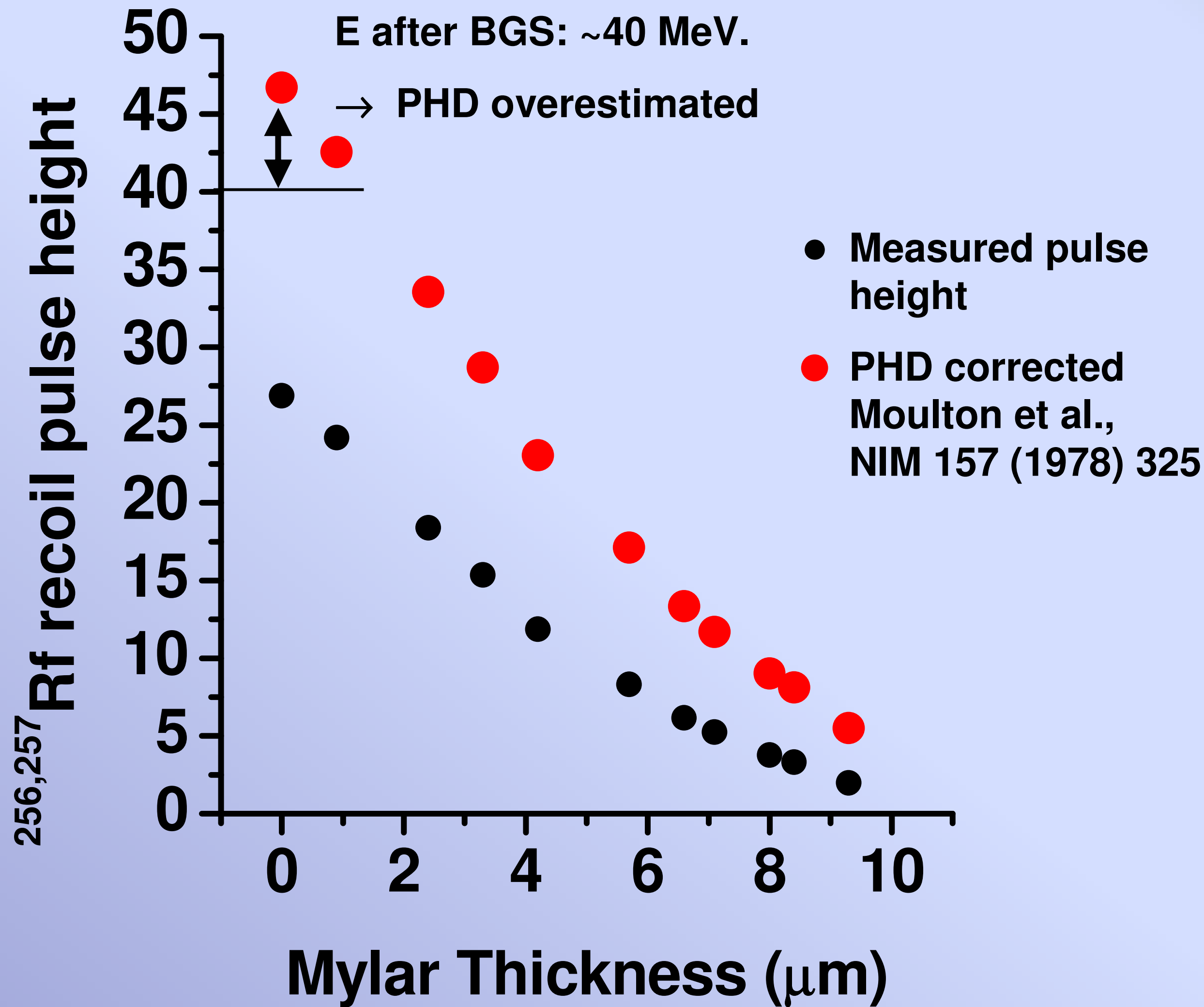
Excitation Function $^{208}Pb(^{50}Ti,xn)^{258-x}Rf$



Comparison GSI ↔ LBNL

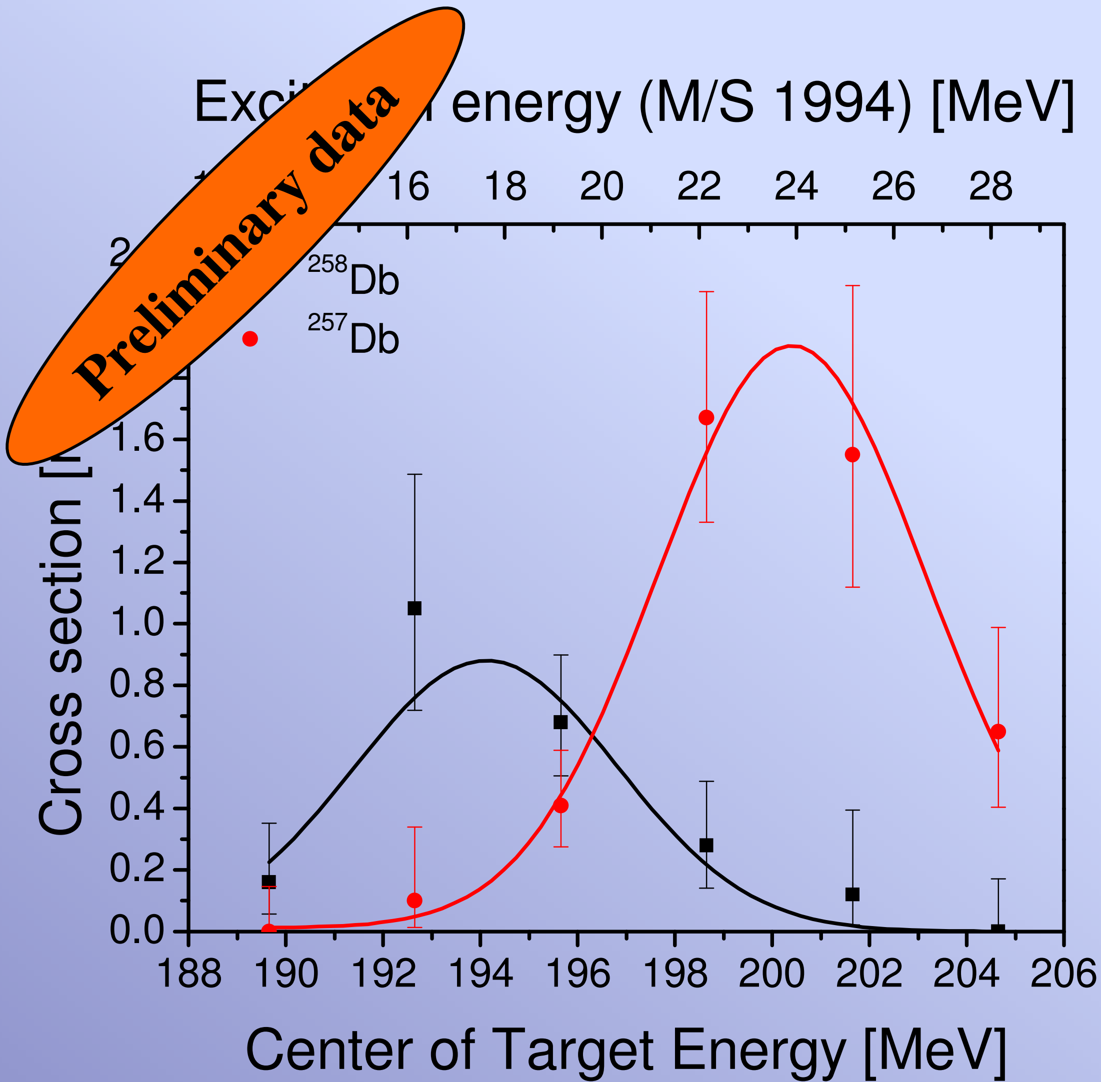
- Maximum of the excitation function seems to be shifted to slightly higher energies at LBNL. (similar to $^{64}Ni+^{208}Pb \rightarrow ^{271}Ds$)
- Maximum of the LBNL excitation function appears somewhat higher than that of the GSI function.
- Detailed analysis in progress

Recoil Ranges for Rutherfordium EVRs



Pulse height recorded for Rf recoils passing through different thicknesses of Mylar foil.

Excitation Function $^{208}Pb(^{51}V,xn)^{259-x}Db$



- Maximum cross section for the 1n reaction is ~3-4 times smaller than in the $^{209}Bi(^{50}Ti,xn)$ reaction.
- Found optimum energy for chemistry experiments to study element 105.
- Detailed data analysis in progress.

Target Development

TA Nuclides Currently Available

Rutherfordium:

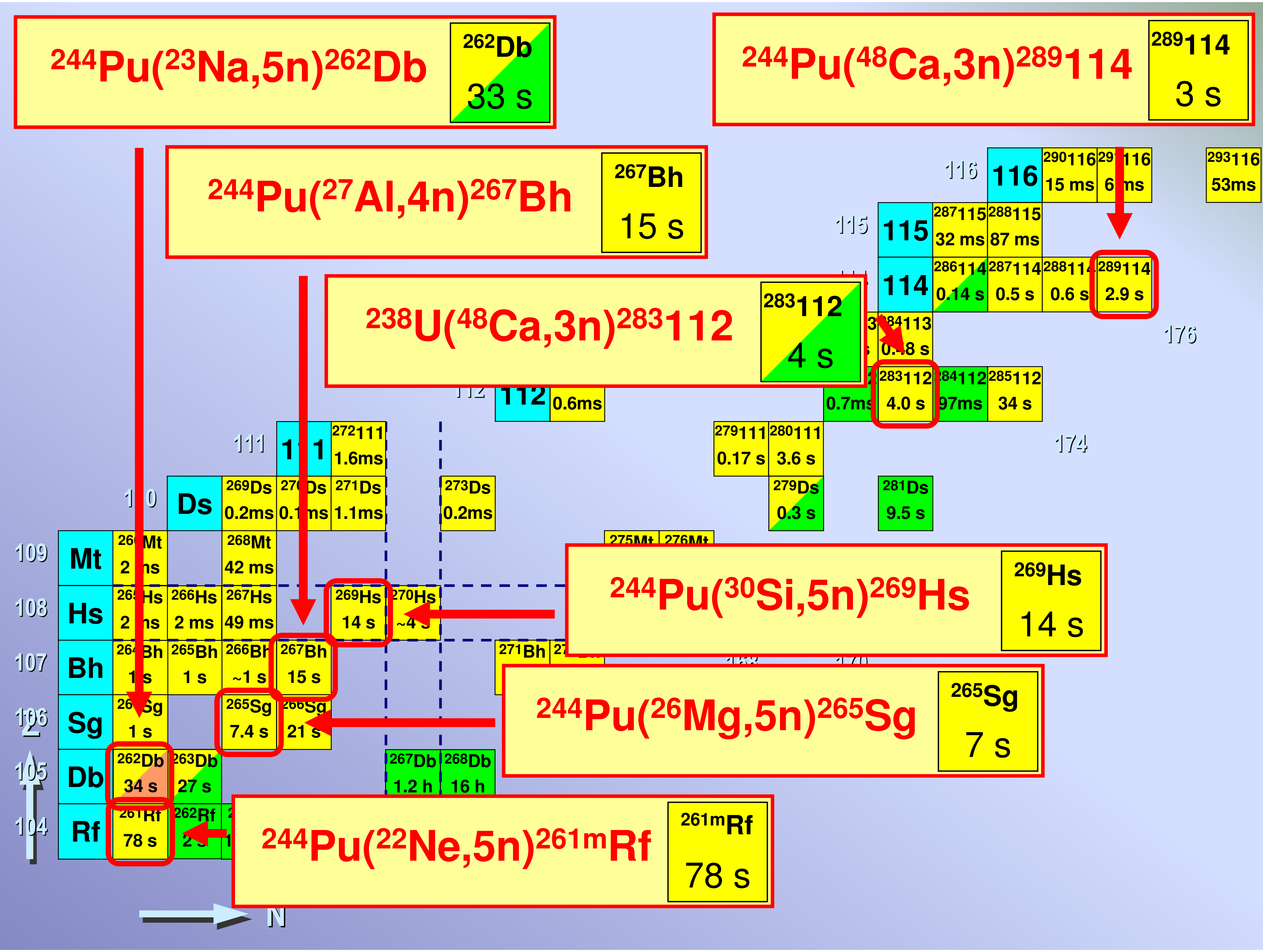
^{257}Rf ($T_{1/2}$= 4.0 s) 0.5 Atoms/min behind BGS
Reaction: ^{208}Pb(^{50}Ti, 1n)^{257}Rf, $\sigma \approx 10$ nb
Used in SISAK chemistry experiments.

Dubnium isotopes:

^{258}Db ($T_{1/2}$= 4.4 s) Reaction: ^{209}Bi(^{50}Ti,1n)^{258}Db, $\sigma \approx 3$ nb
Used in SISAK detector test experiments.

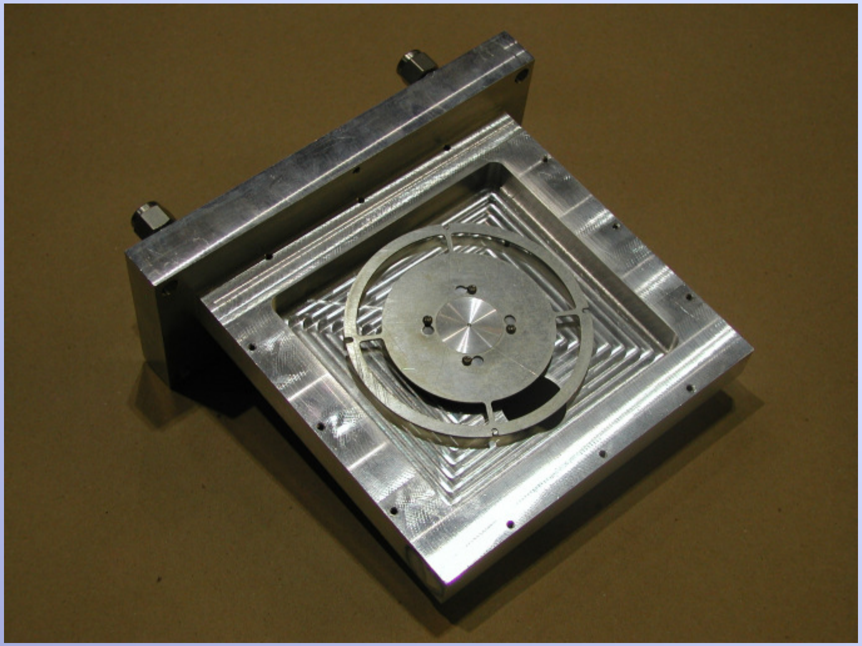
Heavier elements:

Currently no isotopes with $T_{1/2} > 0.5$ s can be produced and separated with BGS.



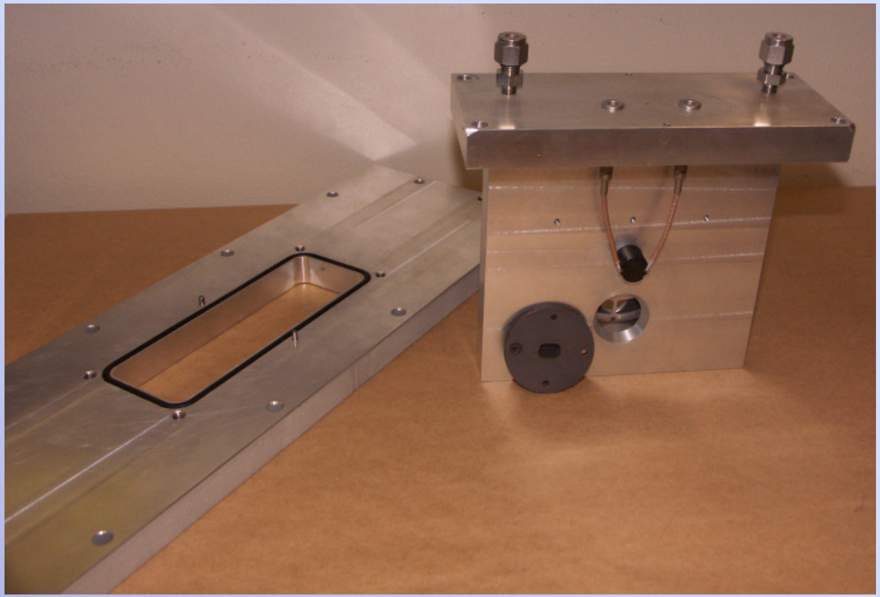
244Pu(23Na,5n)262Db
262Db 33 s
244Pu(48Ca,3n)289114
289114 3 s
244Pu(27Al,4n)267Bh
267Bh 15 s
238U(48Ca,3n)283112
283112 4 s
244Pu(30Si,5n)269Hs
269Hs 14 s
244Pu(26Mg,5n)265Sg
265Sg 7 s
244Pu(22Ne,5n)261mRf
261mRf 78 s
116
290116 15 ms
293116 53ms
115
287115 32 ms
288115 87 ms
114
286114 0.14 s
287114 0.5 s
288114 0.6 s
289114 2.9 s
283112 4.0 s
285112 34 s
0.6ms
0.7ms
97ms
279111 0.17 s
280111 3.6 s
272111 1.6ms
Ds
269Ds 0.2ms
271Ds 1.1ms
273Ds 0.2ms
279Ds 0.3 s
281Ds 9.5 s
109 Mt
268Mt 42 ms
108 Hs
266Hs 2 ms
267Hs 49 ms
269Hs 14 s
270Hs
107 Bh
265Bh 1 s
267Bh 15 s
271Bh
106 Sg
265Sg 7.4 s
21 s
105 Db
262Db 34 s
263Db 27 s
267Db 1.2 h
268Db 16 h
104 Rf
78 s
262Rf
176
174
Z
N

New Small Rotating Target Wheel



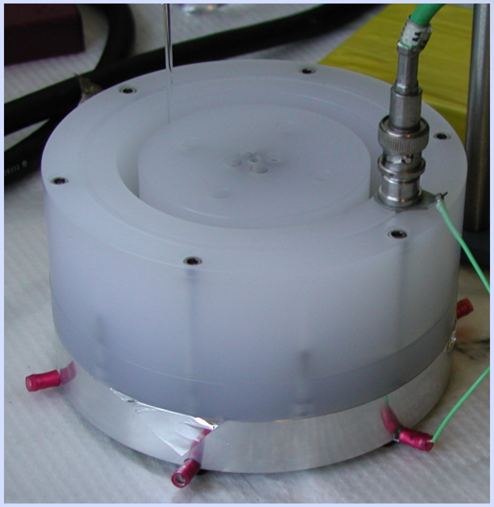
- New target chamber has been constructed to accommodate 3.5 inch diameter actinide target wheel.
- Complete target unit can be removed and transferred to a glove box.
- Housing can be water cooled.

- Motor has been successfully tested in vacuum.
- Modifications to the BGS beam line are still necessary to accommodate the new target box.
- Fast closing valves need to be installed in the beam line to protect the cyclotron.



1. Approach: Plating a Whole Wheel

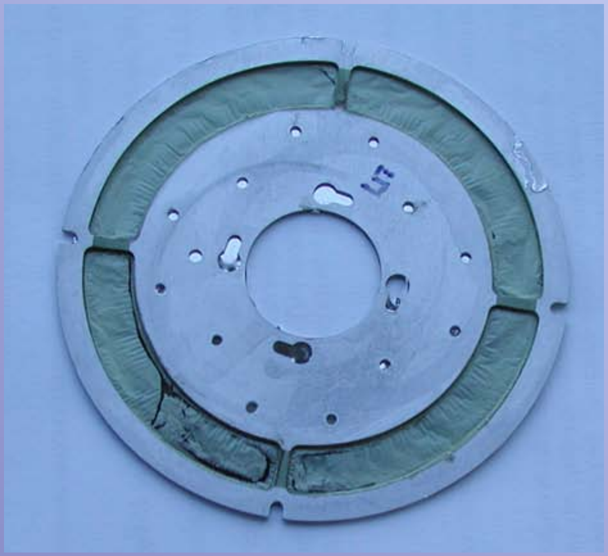
Goal: Preparation of segmented wheel targets of uranium with thickness up to 500 μg/cm^2 by electroplating.



Plating cell: Made from Teflon (Volume 40 mL)

Aluminum base plate

Ring shaped palladium anode



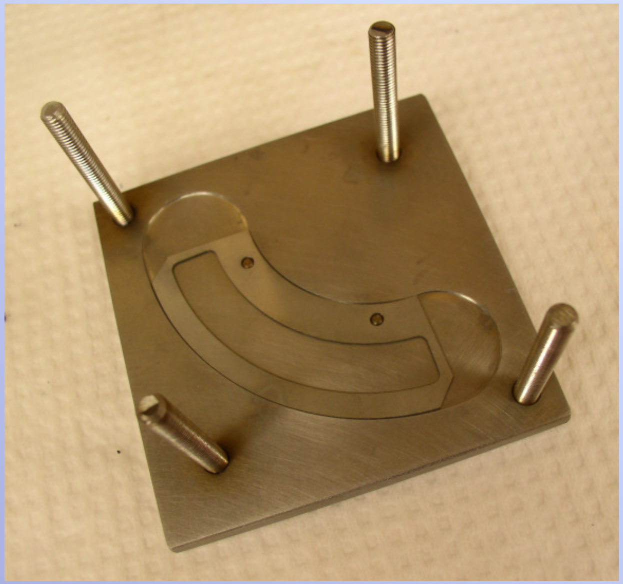
Successfully able to plate uranium up to a thickness of ~500 μg/cm^2 using ~100V.

BUT: Thermal expansion of the foil while heating.

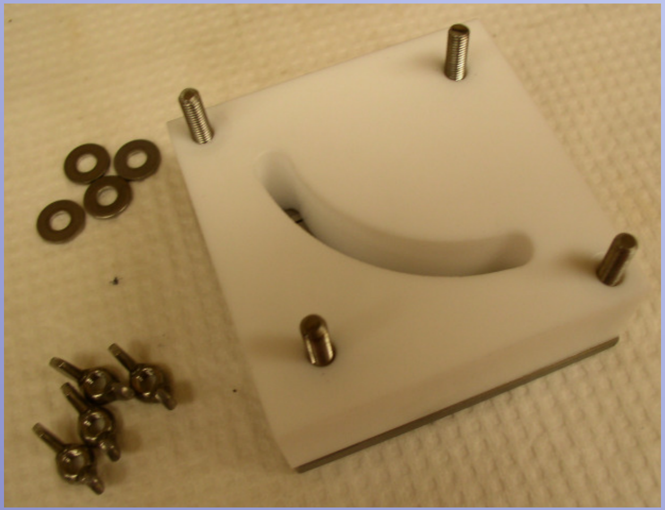
Thin Al foils are very fragile and difficult to handle!

What about rare and expensive isotopes?

2. Approach: Plating Segments



- Electroplating cell for small segments has been constructed from Teflon.
- Backing foil (Al or Ti) is attached to the frame with heat resistant glue.
- Electrode geometry needs to be optimized and target homogeneity needs to be evaluated.



But:

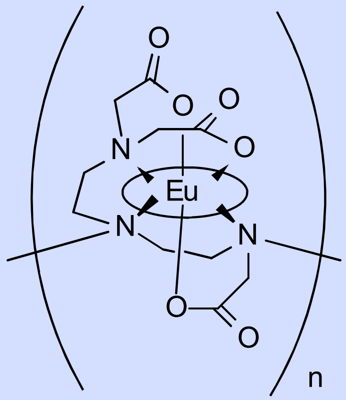
Al foil shows wrinkles when heated!

Ti may be a better choice.

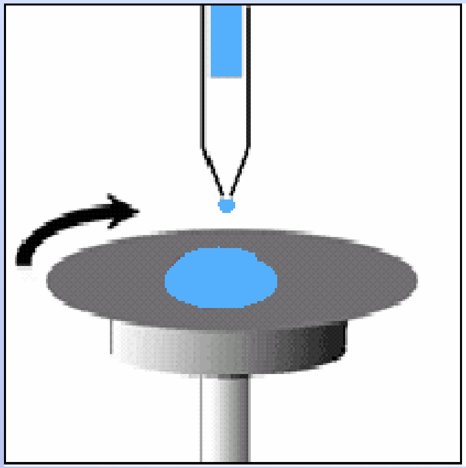
An Alternative to Electroplating?

Polymer Assisted Deposition (PDA)

Method is used to generate uniform thin metal films in microcircuit fabrication and semiconductor industry.

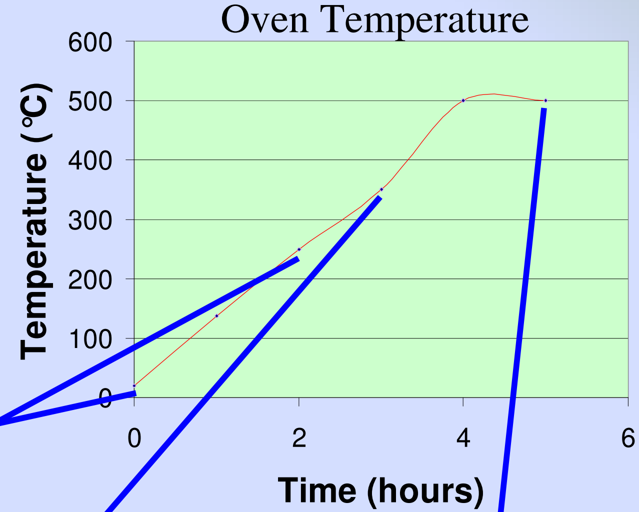


- Metal ion is coordinated to a polymer, e.g. polyethylenimine, in solution.
- Solution is spin coated onto a substrate until the desired thickness is reached.
- Substrate is baked in an oven to remove the polymer and leave the metal oxide.



First tests with Polmyer Assisted Deposition

- Solution containing Eu coordinated to a carboxylated polyethylenimine was placed onto aluminum foil.
- Solution was mechanically spread.
- Foil was baked in the oven.



0 Hours Baking

2 Hours Baking

3 Hours Baking

5 Hours Baking