

# Update MIRP Cyclotron & Ac-225 production

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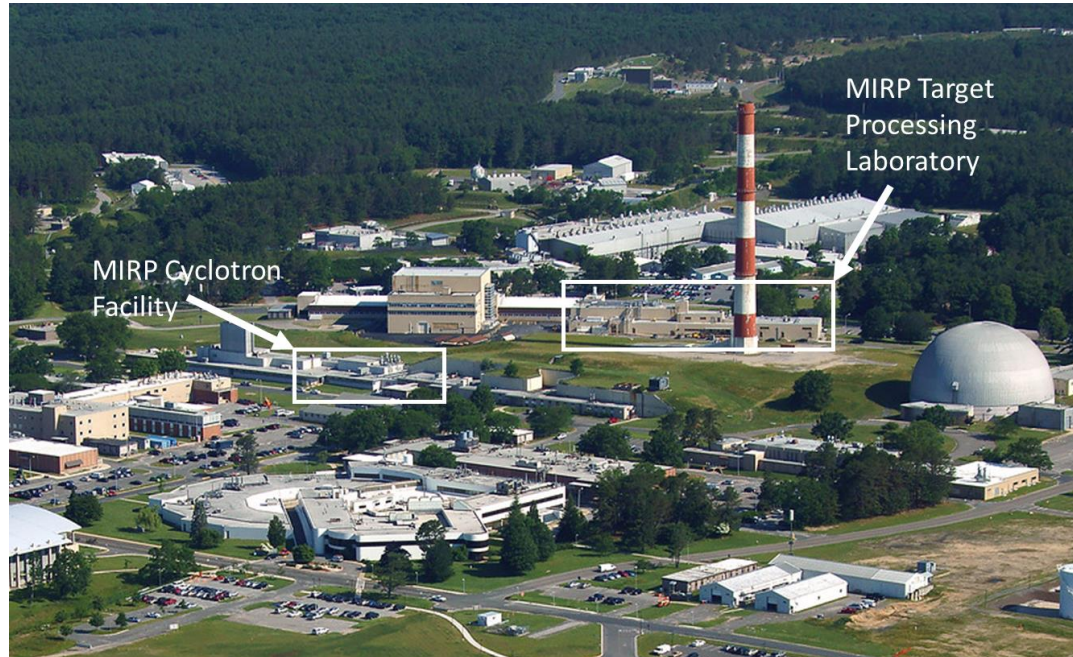
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# Outline

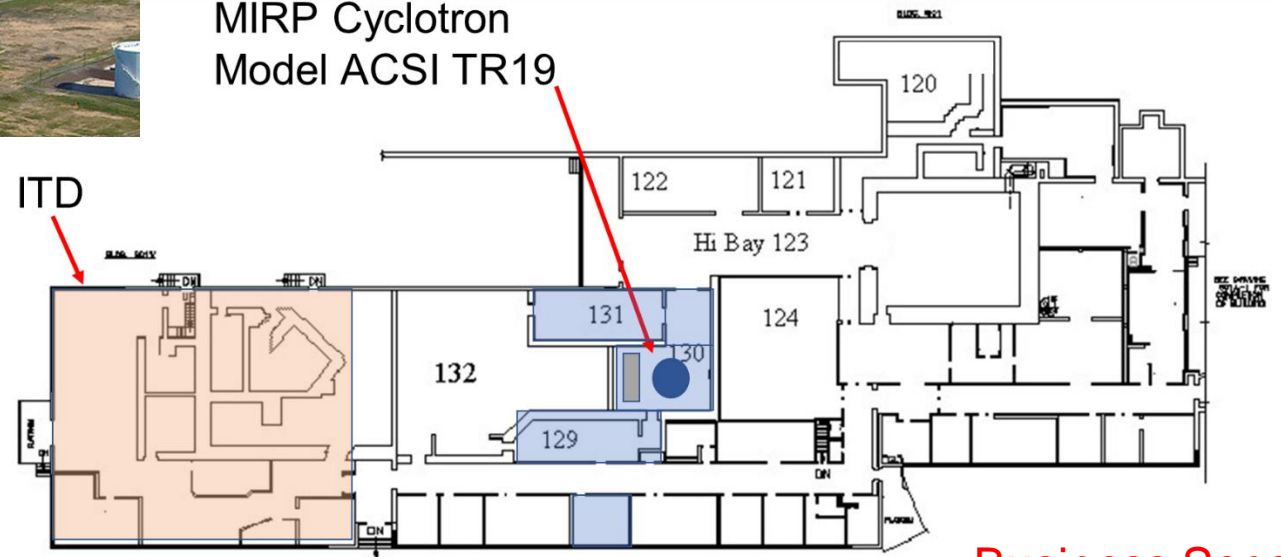
- MIRP Cyclotron
- Target holders design
- FLUKA results
- Target Development
- Target Separation
- Target Recycling



# MIRP Cyclotron



MIRP Cyclotron  
Model ACSI TR19



# MIRP Cyclotron

- Beam Energy: 13 ~ 19 MeV      Beam Current: 200uA
- Refurbished
  - Ion Source Injection System and all the Lenses
  - RF Tuner and High voltage
  - Chilled water system
  - Vacuum (  $0.27 \times 10^{-6}$  Torr) and Cryo systems
  - PLC system, power supplies and controlling PC
  - Target selection station
  - Shielding
  - Interlocks

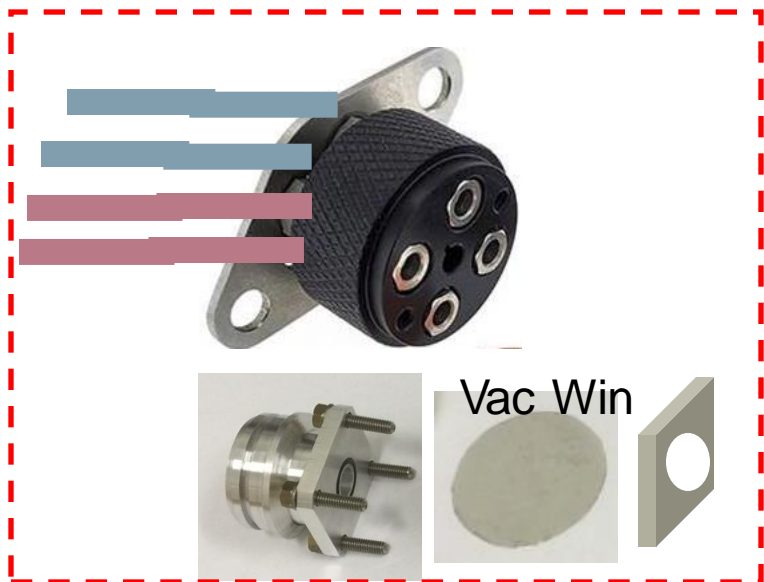


Business Sensitive

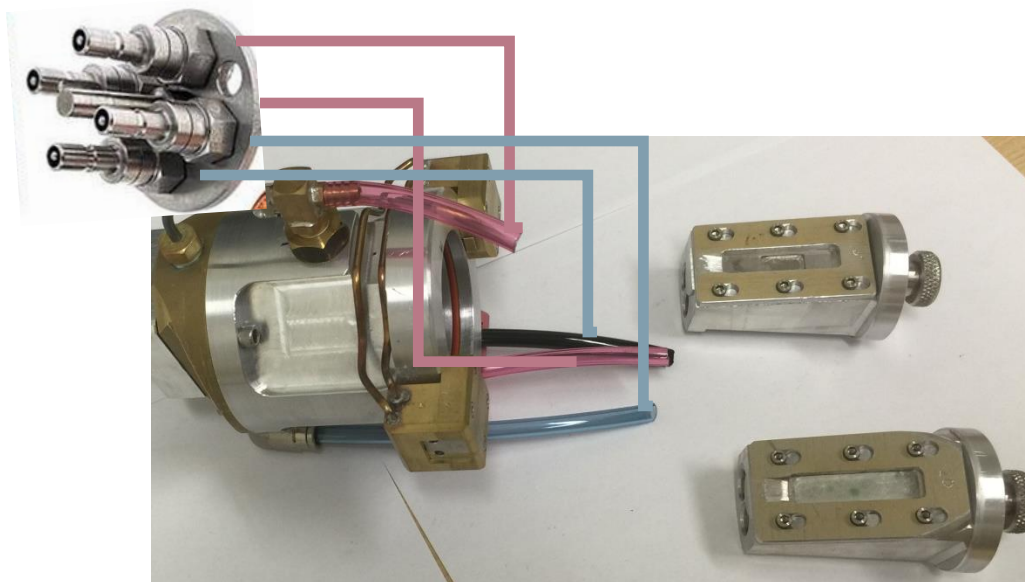
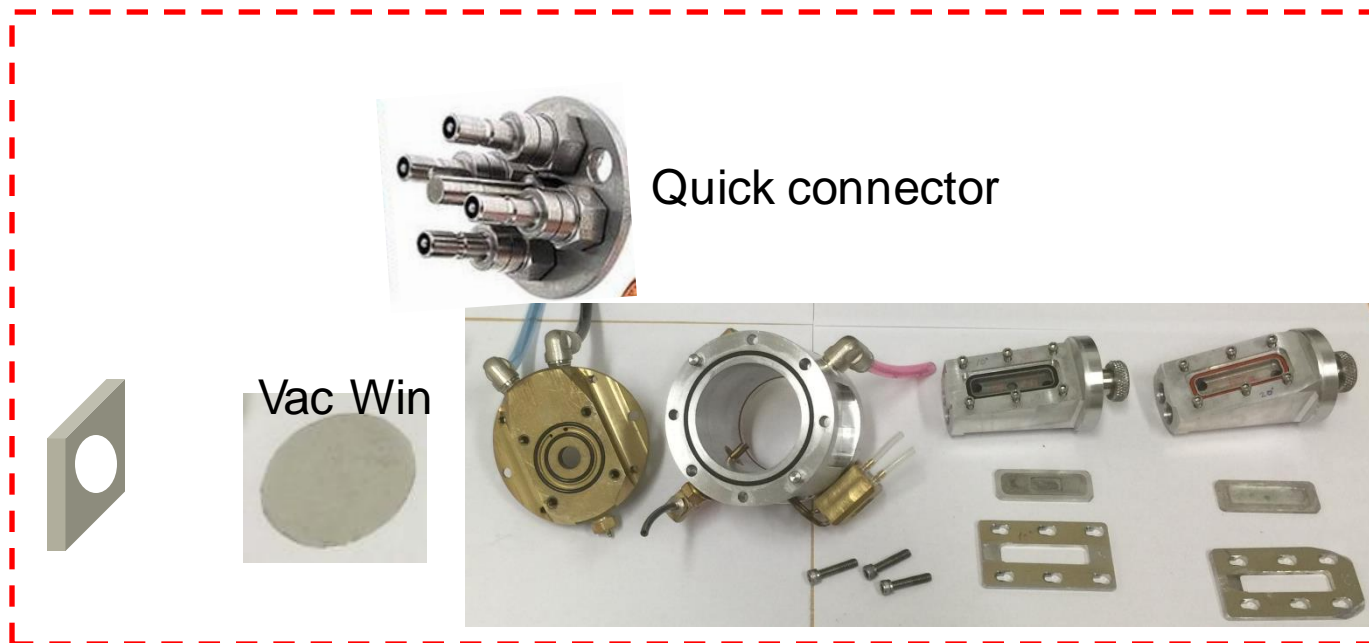


## On the target station

## Target holder and target

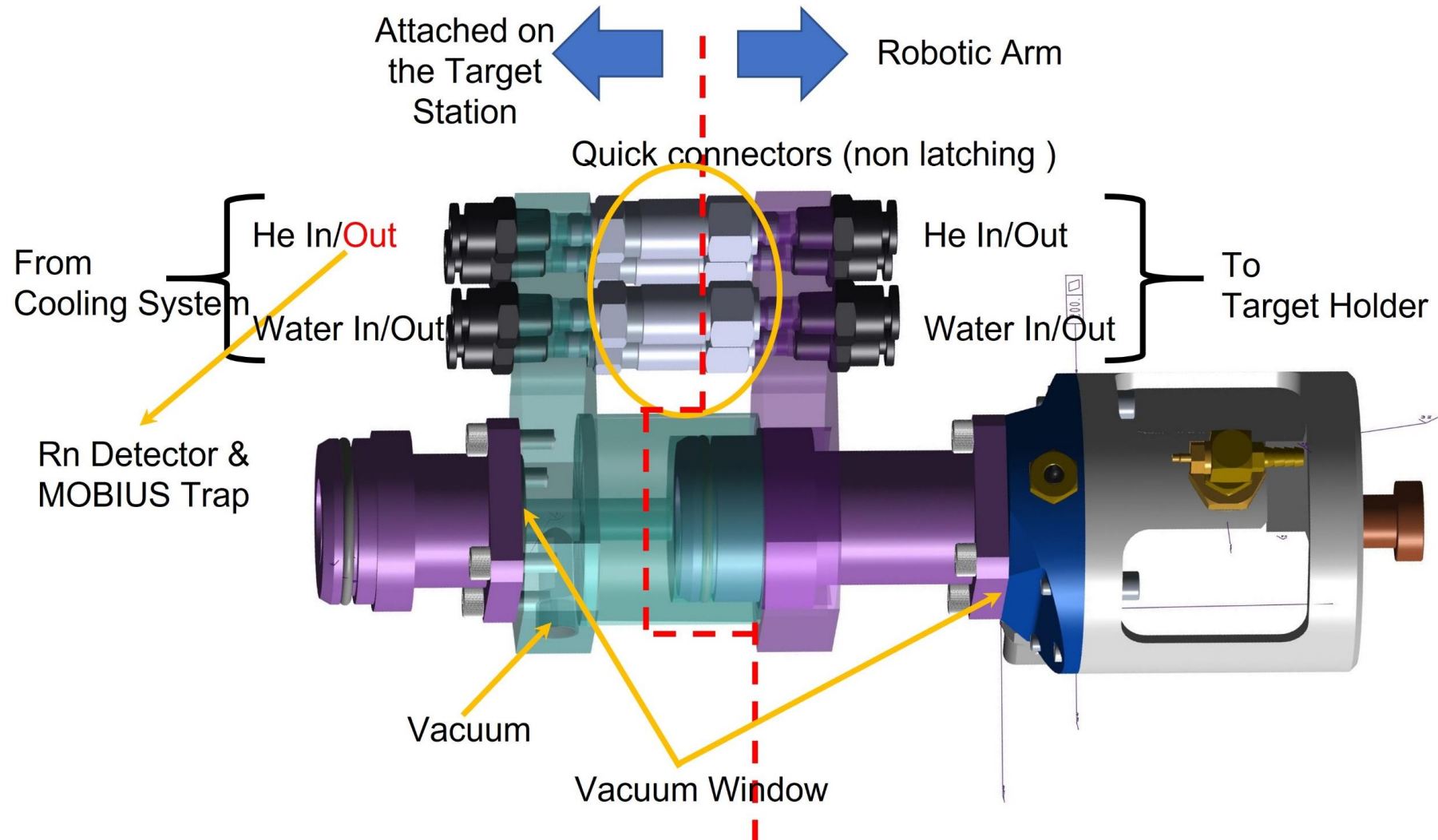


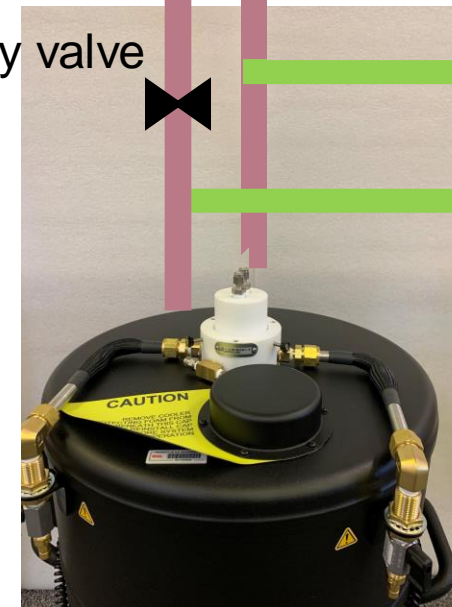
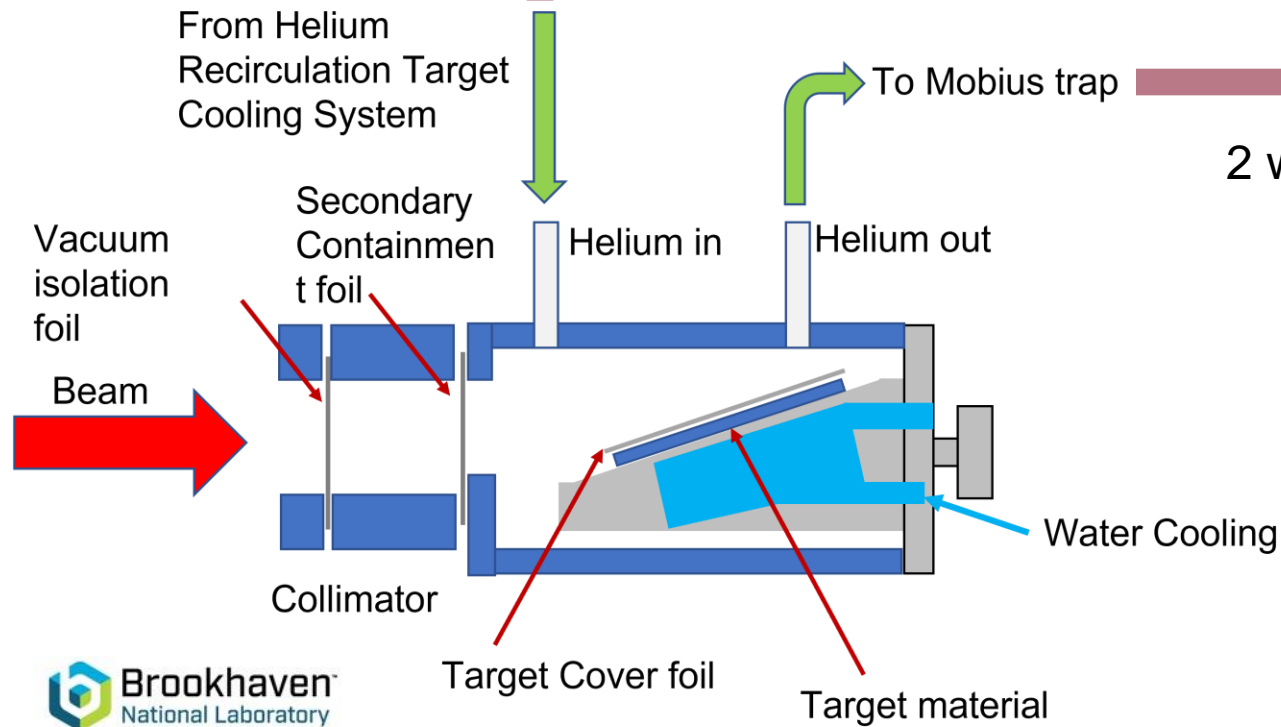
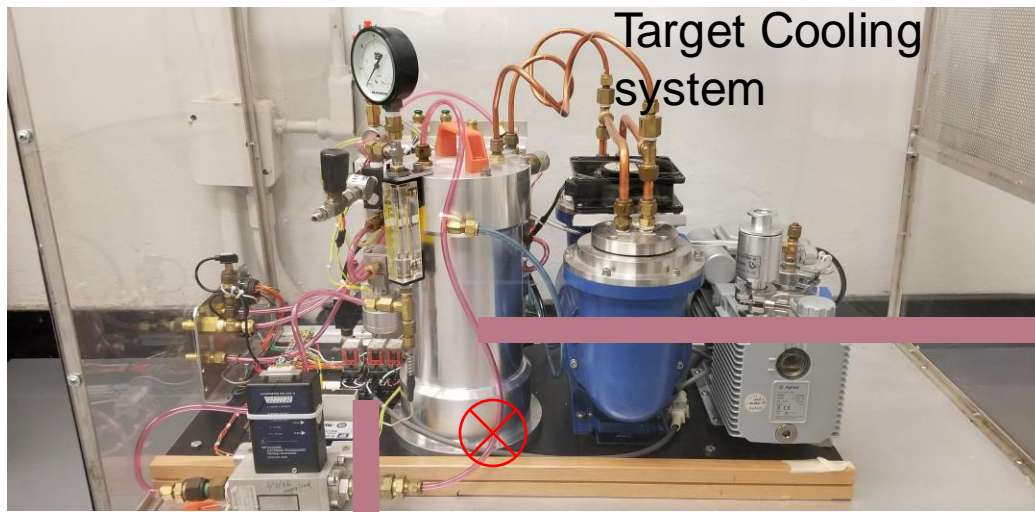
Vacuum tight



Electro plated  
target holder

# Target holder





Business Sensitive

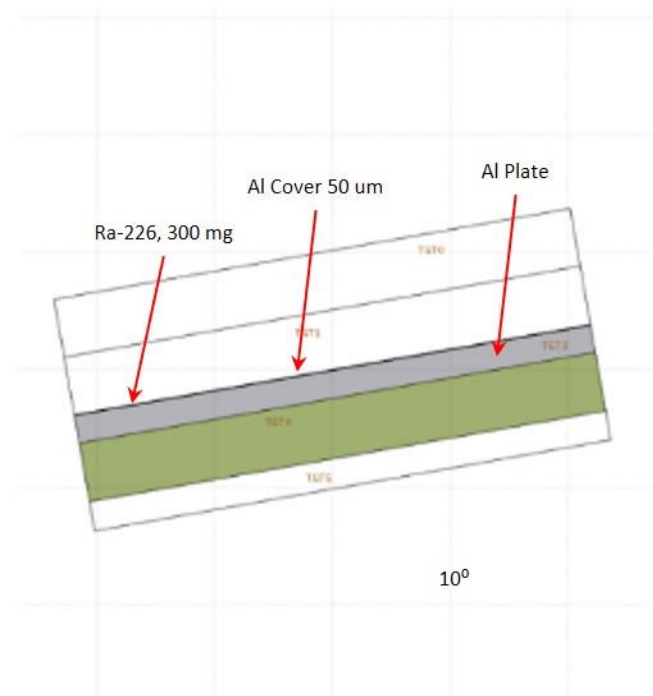
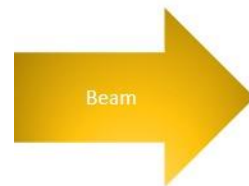


# Ra-226 Solid Target

Beam Energy: 13 to 19 MeV, Beam Current: 200  $\mu$ A, Gauss Beam X & Y FWHM: 0.3, 0.3 cm

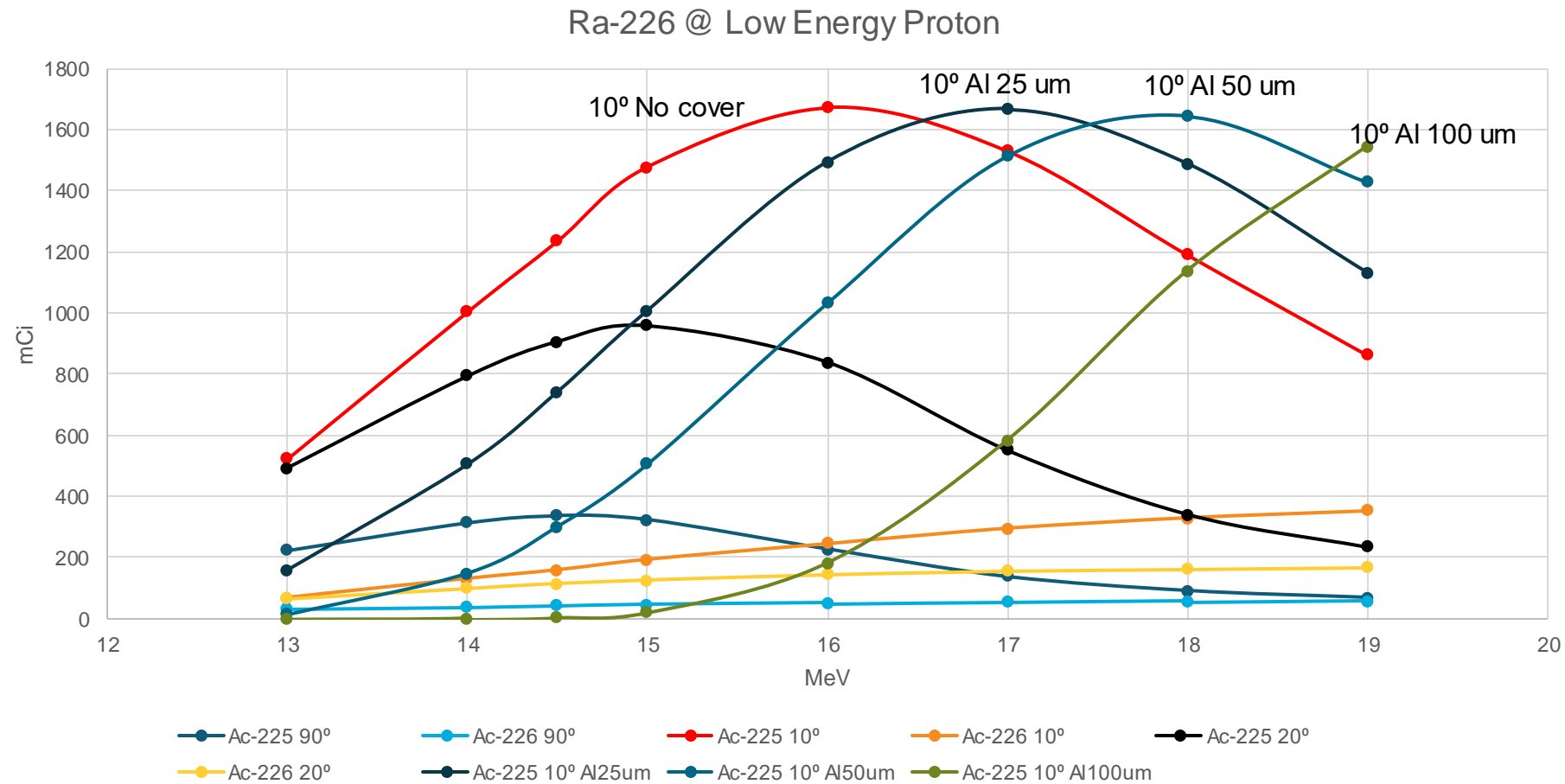
Ra226 target: 1.4 X 4.5 X 0.0086 cm (thickness) :  $7.99 \times 10^{20}$  Atoms (300 mg)

40 hours irradiation





# Ra-226 Solid Target



# Transportation Route

1. Leave from the rear loading dock of Building 901: Cyclotron
2. Turn Left onto Cornell Ave
3. Turn Left onto Renaissance Rd
4. Turn Left onto Rutherford Dr
5. Stay left on Rutherford Dr to the back loading dock of Building 801





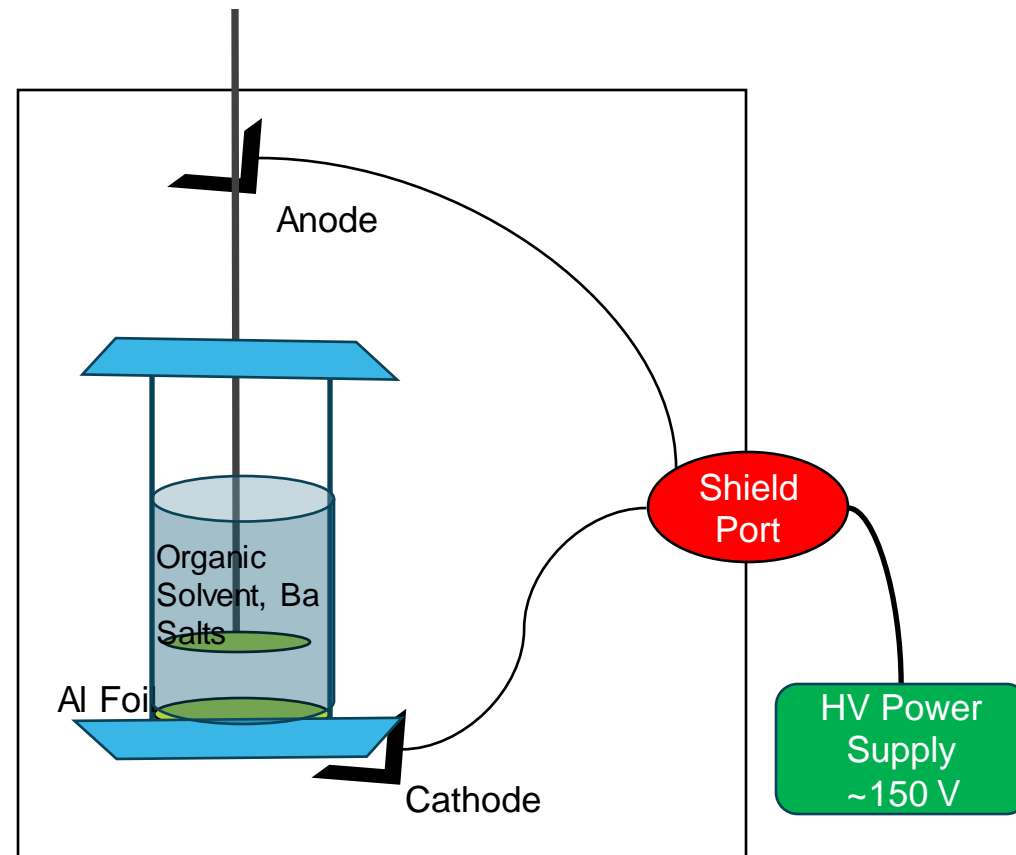


# Target Development

- $^{226}\text{Ra}(p,2n)^{225}\text{Ac}$
- We have used Ba to mimic the chemical behavior of Ra for our initial studies
- Electrodeposition technique was developed to deposit a thin layer of Ba on an Al substrate for cross-section analysis



Ba electrodeposition on Al substrate



Work performed by Jasmine Hatcher-Lamarre



# Target Development

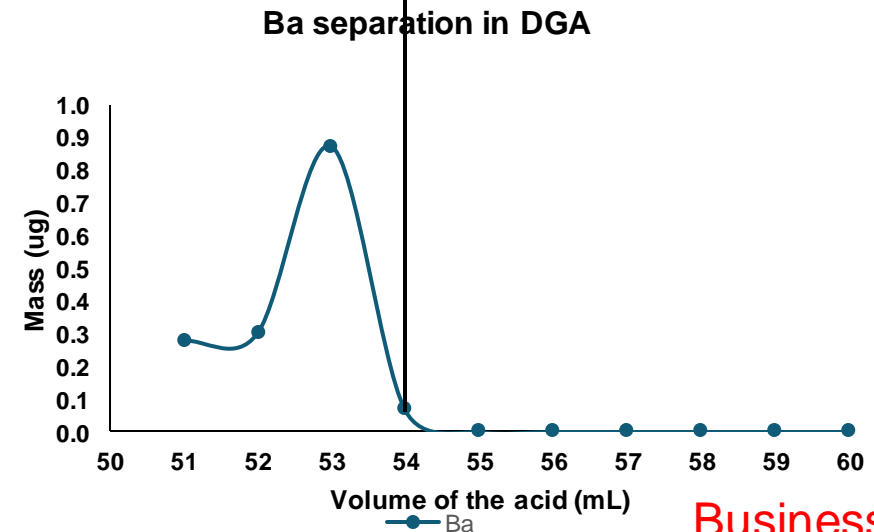
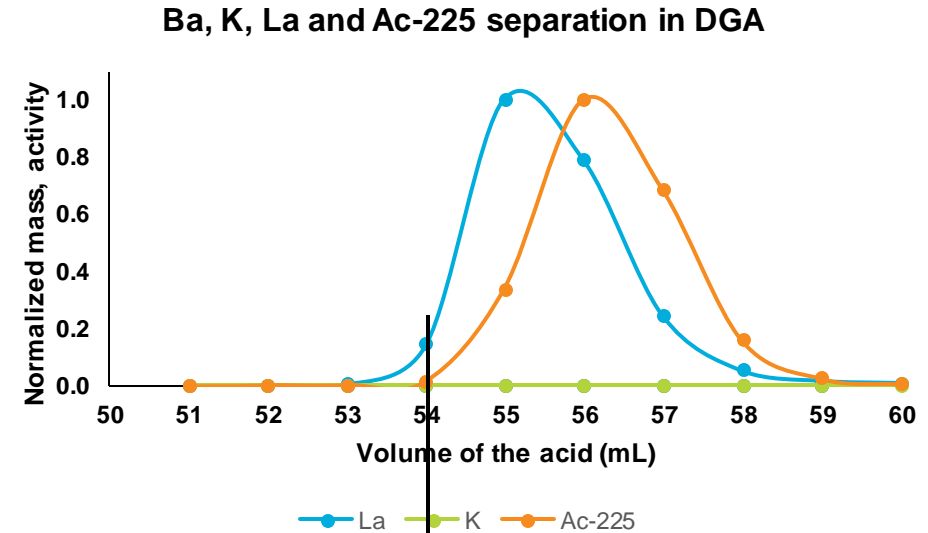
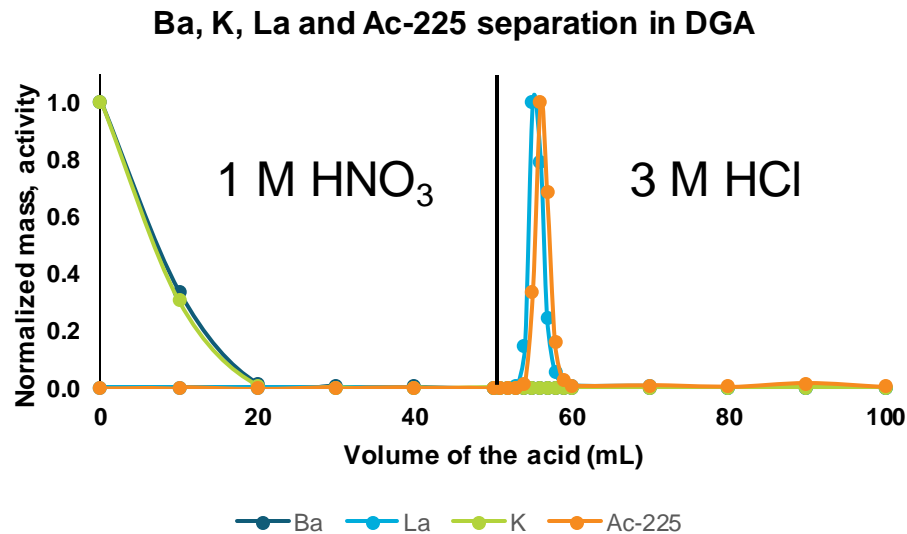
- Pellets with only Ba salts were fragile
- To improve the robustness of the target, we have added KBr as an additive.
  - This method exploits the property that alkali halides become “plastic” when subjected to pressure
- Dry KBr (308.8 mg) and  $\text{Ba}(\text{NO}_3)_2$  (20.8 mg) were ground using a motor and pestle
- 13 mm stainless steel die set was used to press the pellet
- 2.5 tons of pressure was applied for 5 min
- A robust pellet was observed



Pressed  $\text{Ba}(\text{NO}_3)_2$  + KBr  
pellet

# Target Separation: Method 1

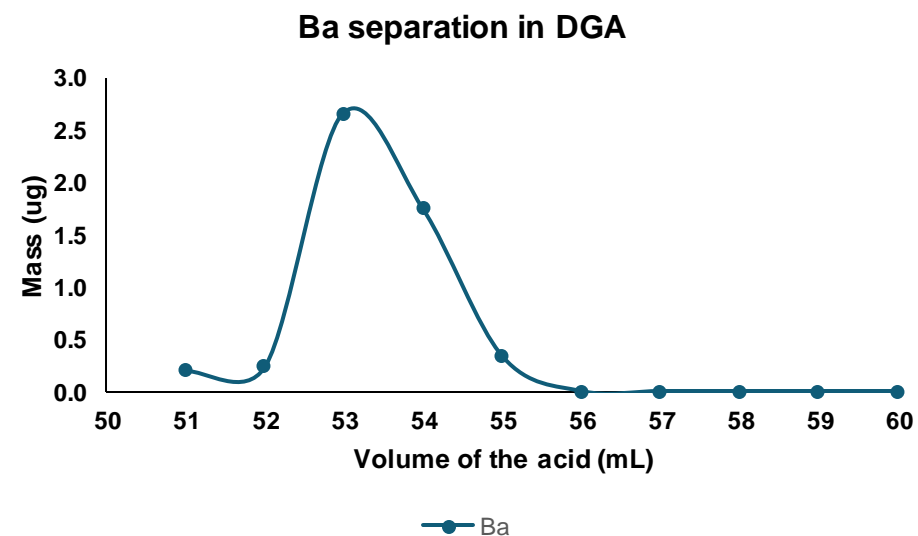
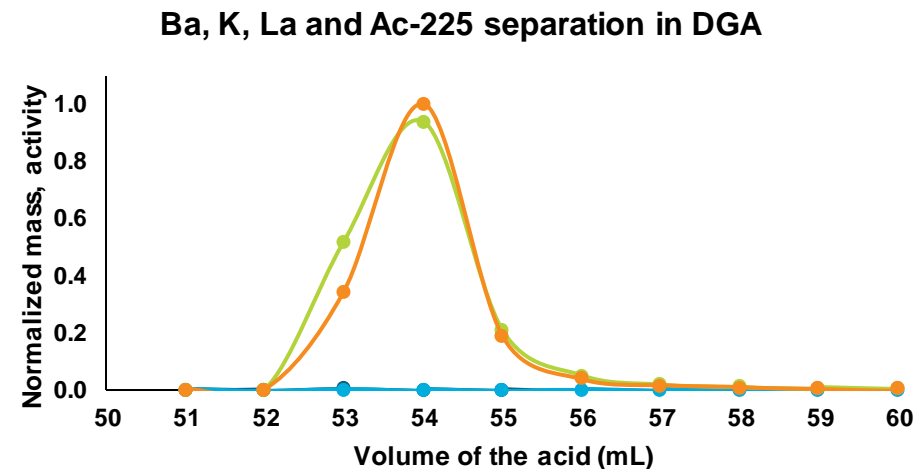
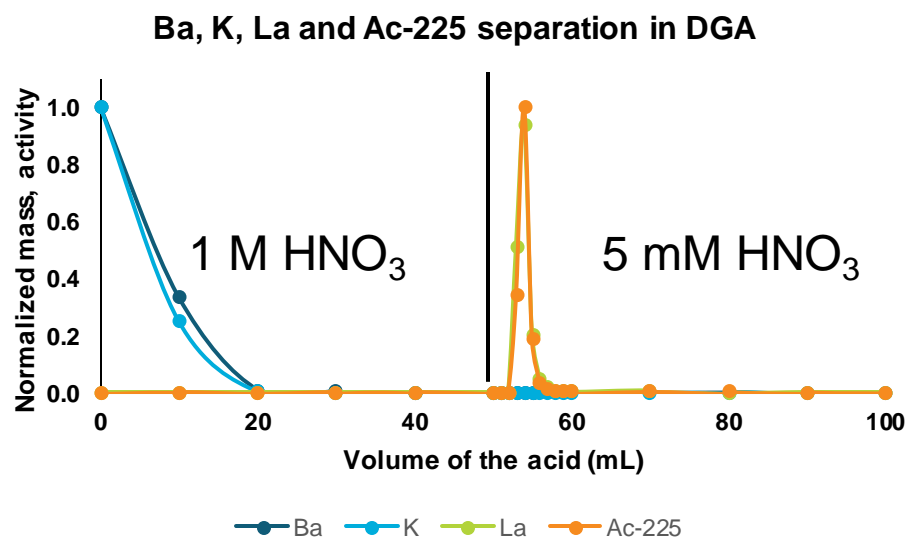
- The load solution had
  - KBr (302.8 mg),  $\text{Ba}(\text{NO}_3)_2$  (25.1 mg),  $\text{LaCl}_3$  (6.1 mg), Ac-225 (40  $\mu\text{Ci}$ )
- 2 mL DGA cartridge was used at 1 mL/min flow rate
- Yields: Ba=97%, K=98%, Ac-225=92%, La=94%





# Target Separation: Method 2

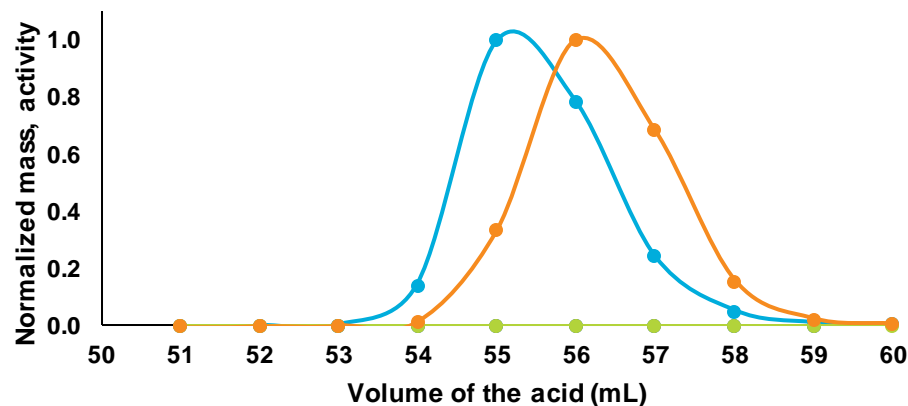
- The load solution had
  - KBr (306.4 mg), Ba(NO<sub>3</sub>)<sub>2</sub> (25.6 mg), LaCl<sub>3</sub> (6.1 mg), Ac-225 (48 µCi)
- 2 mL DGA cartridge was used at 1 mL/min flow rate
- Yields: Ba=99.7%, K=99.7%, Ac-225=92%, La=96%



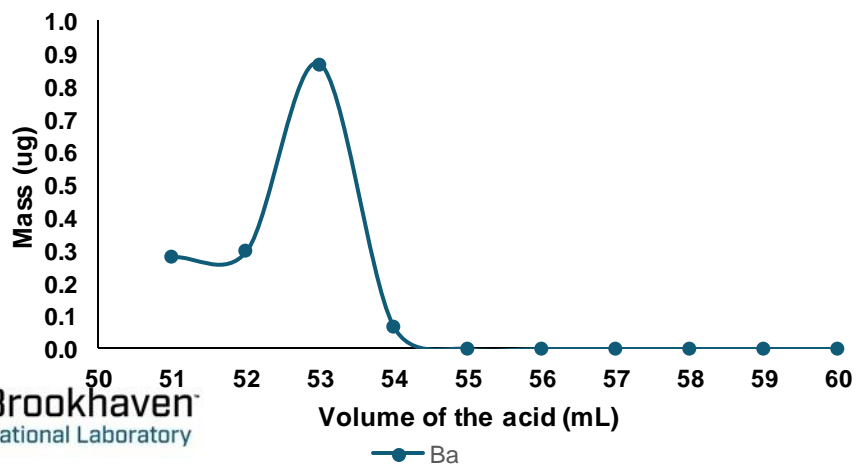
# Target Separation: Method comparison

## Method 1: 1 M HNO<sub>3</sub> and 3 M HCl

Ba, K, La and Ac-225 separation in DGA

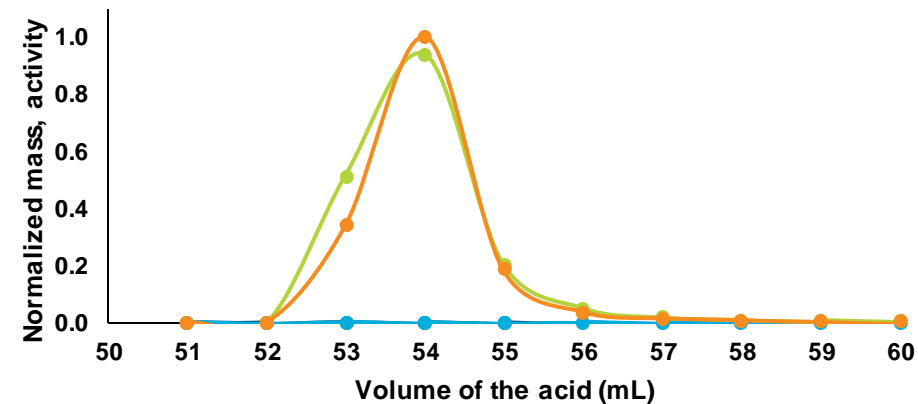


Ba separation in DGA

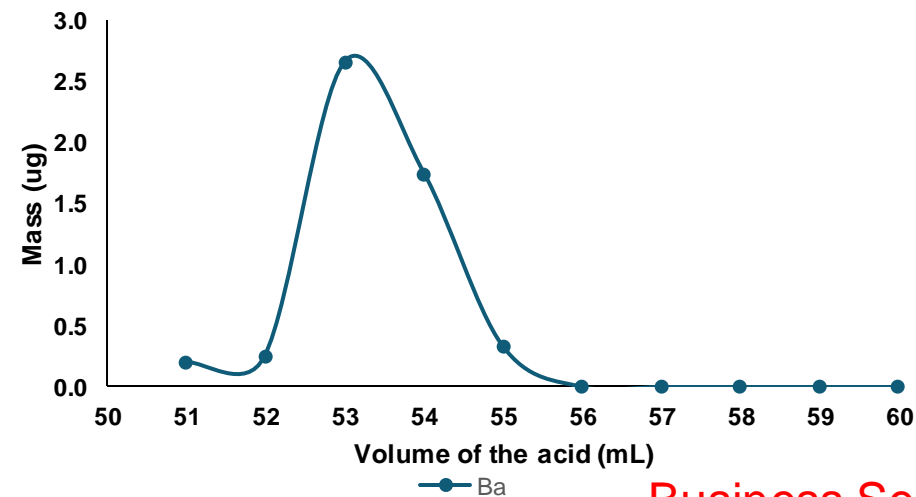


## Method 2: 1 M HNO<sub>3</sub> and 5 mM HNO<sub>3</sub>

Ba, K, La and Ac-225 separation in DGA



Ba separation in DGA

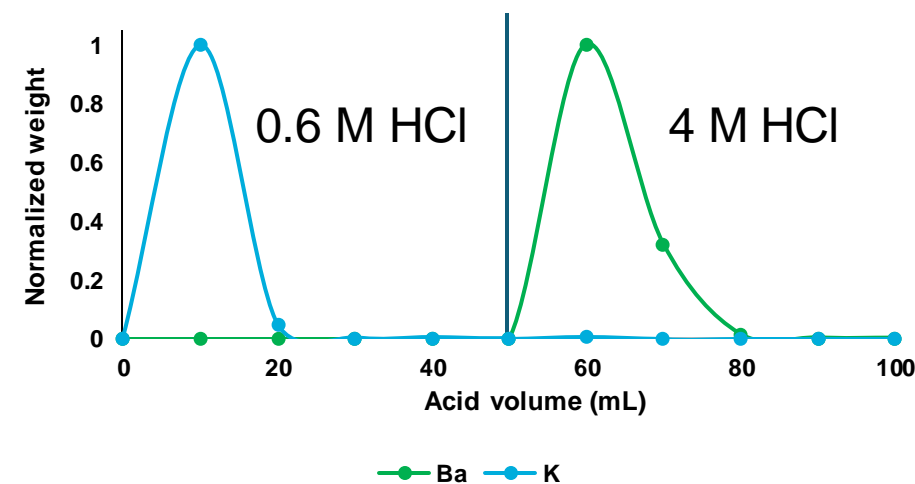




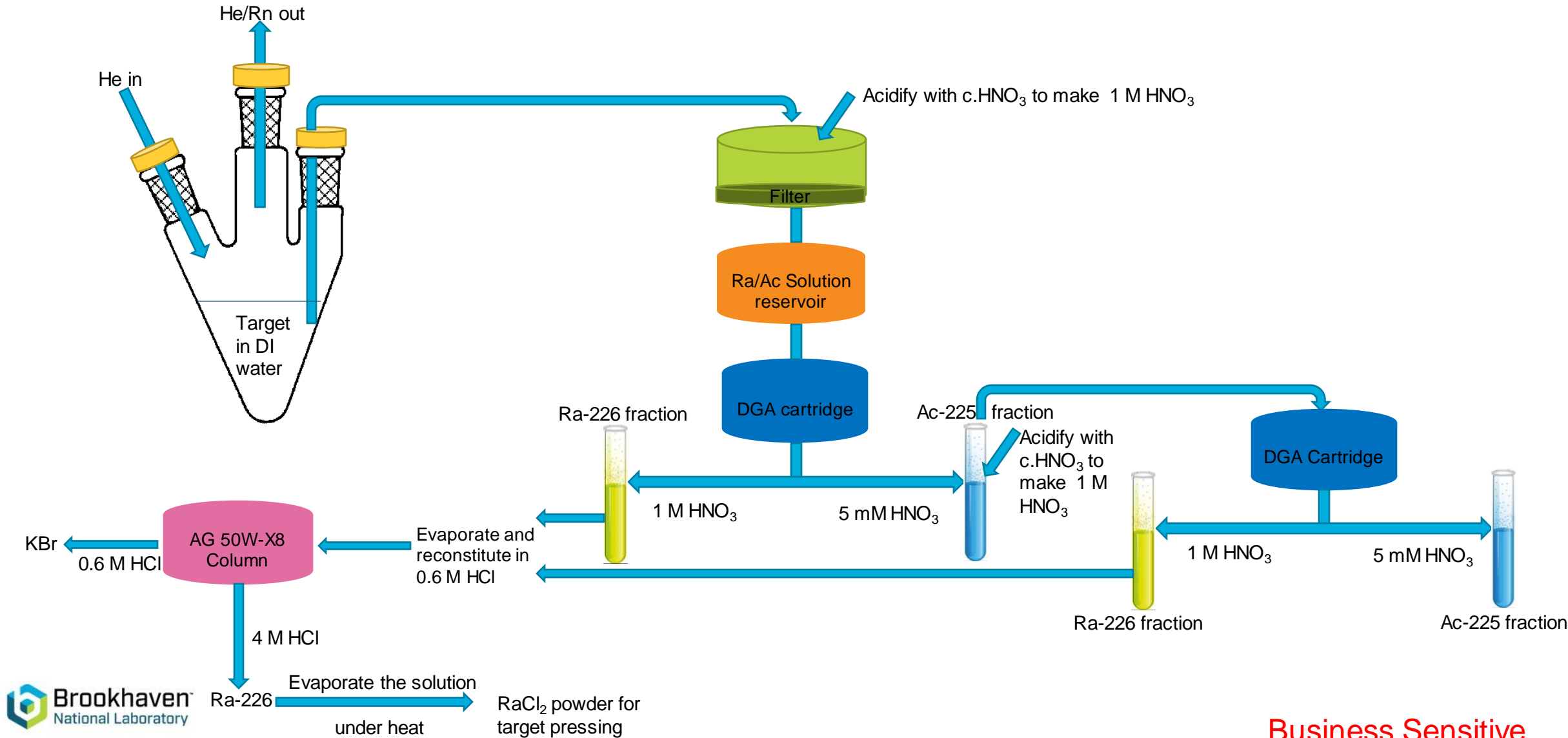
# Target Recycling

- After Ac-225 separation, the Ra-226 target needed to be recycled
- We have used Ba to mimic the chemical behavior of Ra for our initial studies
- AG 50W-X8 resin (1 g) was used for the separation.
  - Dry KBr (228.3 mg) and Ba(NO<sub>3</sub>)<sub>2</sub> (23.6 mg)
- K was eluted with 0.6 M HCl, and Ba was eluted using 4 M HCl
- Total Ba recovery in all 4 M HCl fractions is 98.7%
- All the 4 M fractions were combined and dried on a hot plate
  - A white residue was observed
  - 97.6% Ba recovery

K and Ba separation on AG50W-X8 resin



# Ra Target Processing



# Commissioning Plan - Cyclotron

- Plan is designed to exercise all key aspects associated with operation of the cyclotron, including equipment, processes, and personnel necessary to support the cyclotron operations and target handling.
- Objective is to confirm the following are in place, functioning as intended, and to address any identified refinements:
  - Physical systems - Facility and equipment are functioning as designed.
  - Credited Controls are functioning as designed and verification procedures effectively achieve objectives.
  - Procedures are in place to accurately describe and control tasks.
  - Personnel are trained to tasks and effectively perform procedures.
- Two Modules:
  - Module I – Cyclotron & Support Operational Assessments
    - System/equipment operational inspections
    - Includes access control system interlocks, shielding integral to the cyclotron, remote operated robotic arm, target cooling and trapping system, ventilation system, area radiation monitors/continuous air monitors, remote operation of shielding doors
  - Module II – Cyclotron operation activities
    - Cyclotron systems, vacuum, ion source, RF, beam extraction, radiations surveys
    - Assess beam on targets 90 degree, foils, assess beam profile
    - Perform target irradiations, barium target, irradiate metals for Co-57
    - Barium add in Ra up to 10 mg



# Summary

- Targets with  $\text{Ba}^{2+}$  to mimic  $\text{Ra}^{2+}$  have been developed for producing Ac-225 on the 19 MeV cyclotron
- The safe installation and removal of the targets have been developed using a robot arm
- The process for the separation of Ac-225 from the radium target has been developed and tested with  $\text{Ba}^{2+}$
- The method for recovery of the radium has been identified and tested with  $\text{Ba}^{2+}$