Fabrication of Carbon-Backed Thin ^{94,100}Mo Isotopic Targets

Presented by

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Outline

1. Introduction
2. Experimental: carbon backing, Mo deposition, floating and mounting
3. Characterisation: thickness, morphology and composition
4. Summary and conclusion

Introduction

- Target quality is vital in nuclear reaction experiments.
- A stable, uniform target with a known composition is needed to study nuclear structure and reaction mechanisms.
- A thin target limits beam energy loss, so the reaction energy stays well defined.
- Enriched isotopes reduce contributions from other isotopes.
- The target must withstand heavy-ion irradiation and have a well-defined areal density.
- This work: ^{94}Mo and ^{100}Mo targets on carbon backing, made by electron-gun evaporation.

Challenges and approach

Challenges

- Ultra-thin self-supporting targets are fragile.
- Mo melts at about 2623 °C, so thin uniform targets are hard to make by resistive evaporation.
- Poor adhesion, trapped gas and contamination affect target quality.

Approach

- Electron-gun evaporation to deposit Mo.
- Thin carbon backing to support the target. Its low atomic number adds little energy loss.
- $BaCl_2$ release layer so the film can be floated off the glass.

Fabrication steps

1. $BaCl_2$ release layer deposited on glass
2. Natural carbon backing deposited by e-gun
3. Carbon annealed in argon
4. Enriched Mo deposited by e-gun
5. Film floated off in warm water
6. Film mounted on a stainless-steel frame

Natural Mo was used for trial runs first, to set the evaporation conditions before using the enriched isotopes.

Deposition facility at IUAC



Set-up 1: $BaCl_2$ and carbon



Set-up 2: molybdenum

- Deposition pressure was about 2×10^{-6} mbar.
- The thickness is monitored with a quartz crystal monitor (QCM).

Carbon backing



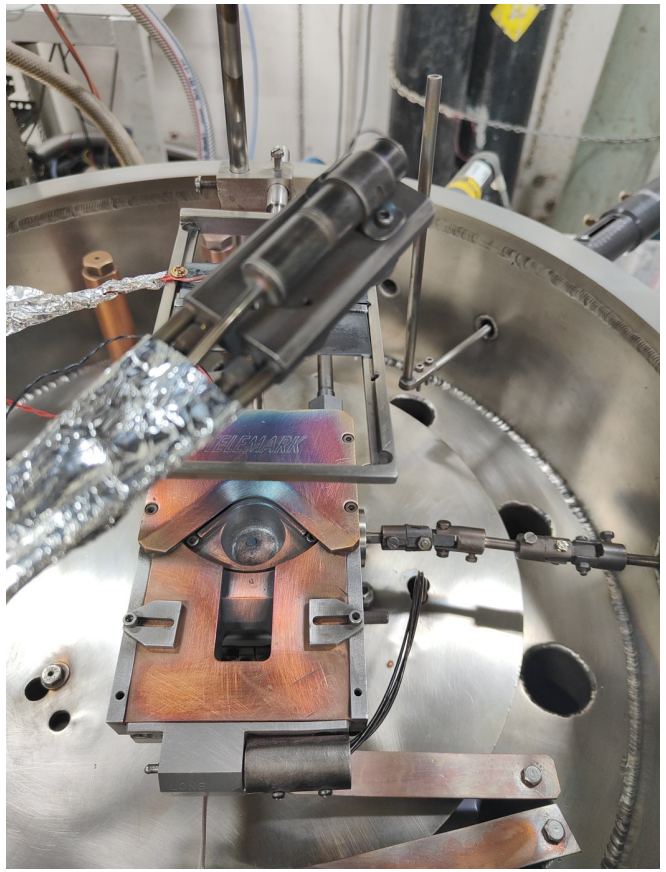
Hydraulic pellet press



Tube furnace

- $BaCl_2$ powder pressed into pellets, then deposited on glass as a release layer.
- Natural carbon, about 40 µg/cm², deposited on top by e-gun evaporation.
- Annealed in argon at about 300 °C for 30 minutes to relieve stress.
- Furnace cooled slowly to avoid thermal shock.

Mo deposition

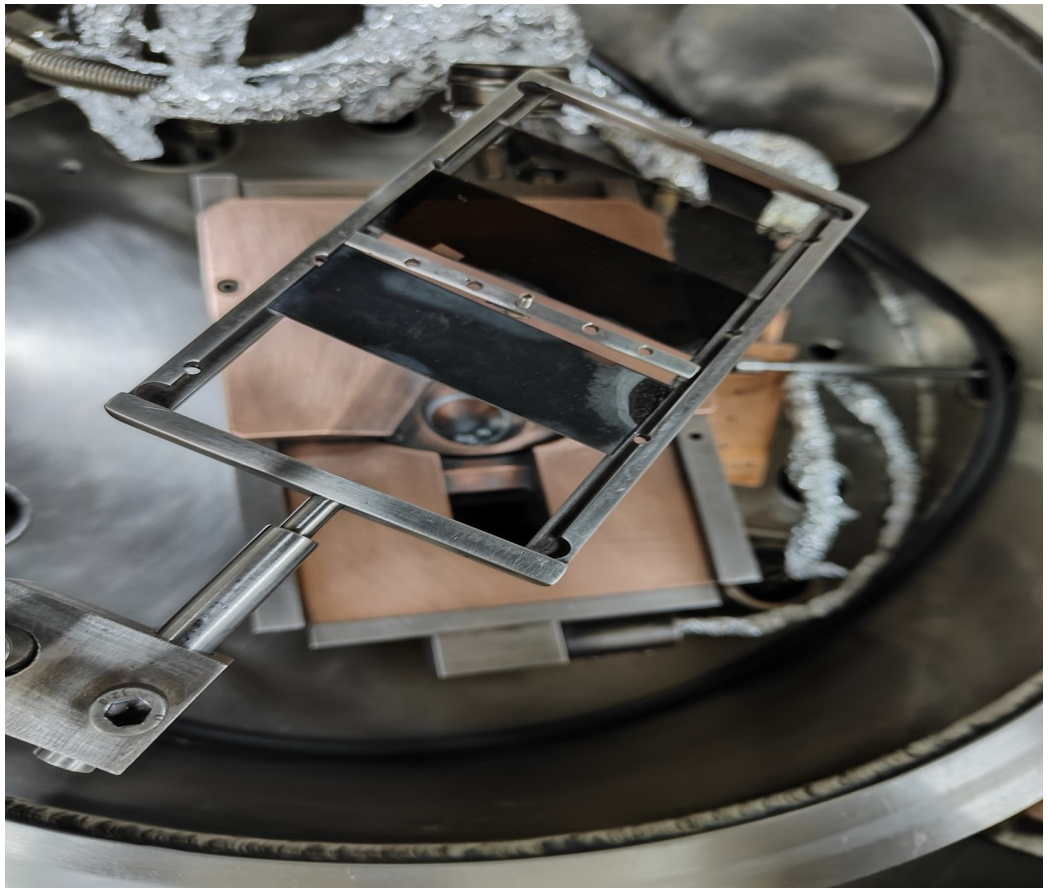


	^{94}Mo	^{100}Mo
Areal density	≈162 µg/cm²	≈154 µg/cm²
Isotopic enrichment	98.97 %(Isoflex)	99.05 %(Isoflex)
Pellet mass before	97.8 mg	99.2 mg
Pellet mass after	27.5 mg	28.1 mg

- Glass substrates placed at different distances from the source, so several targets form in one run.
- Few Silicon wafers are also placed to help in characterization .
- Source-to-frame distance: 9 cm.
- Source-to-QCM distance: 15 cm.

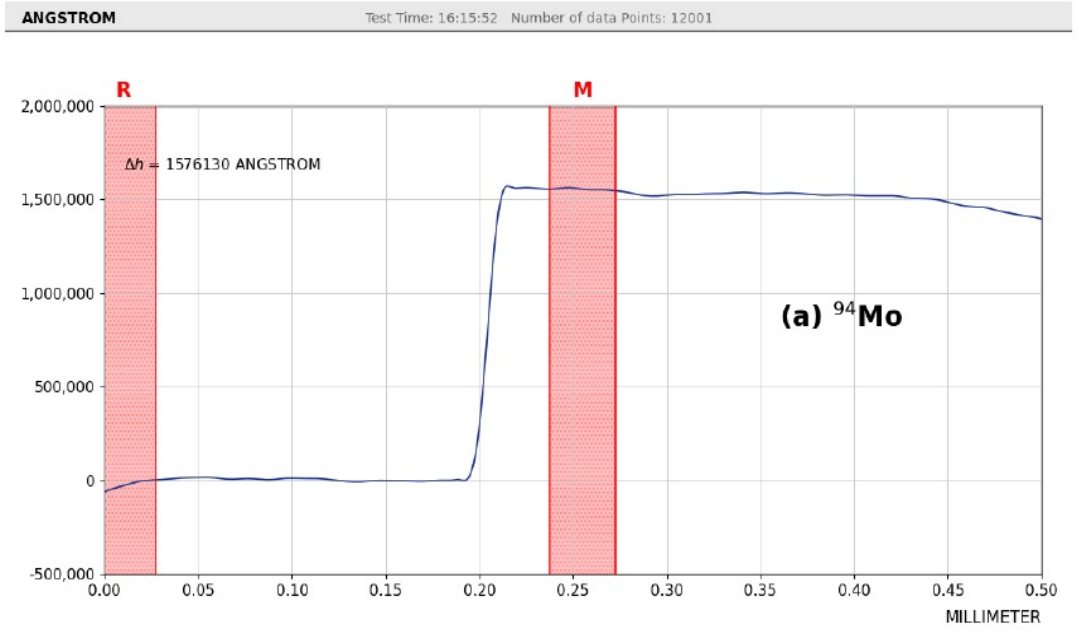
Floating and mounting

- The coated slide is placed in warm water (35–40 °C), and the film separates from the glass.
- The floating film is transferred onto a stainless-steel target frame.
- The mounted target is dried and handled with care.

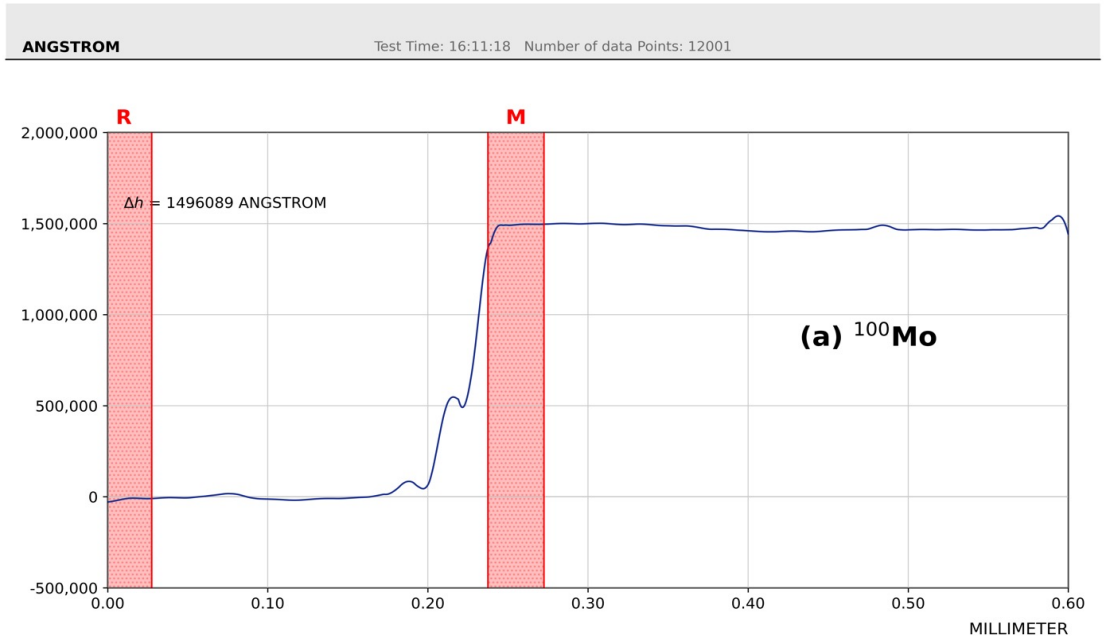


Mounted target film

Thickness: stylus profilometry



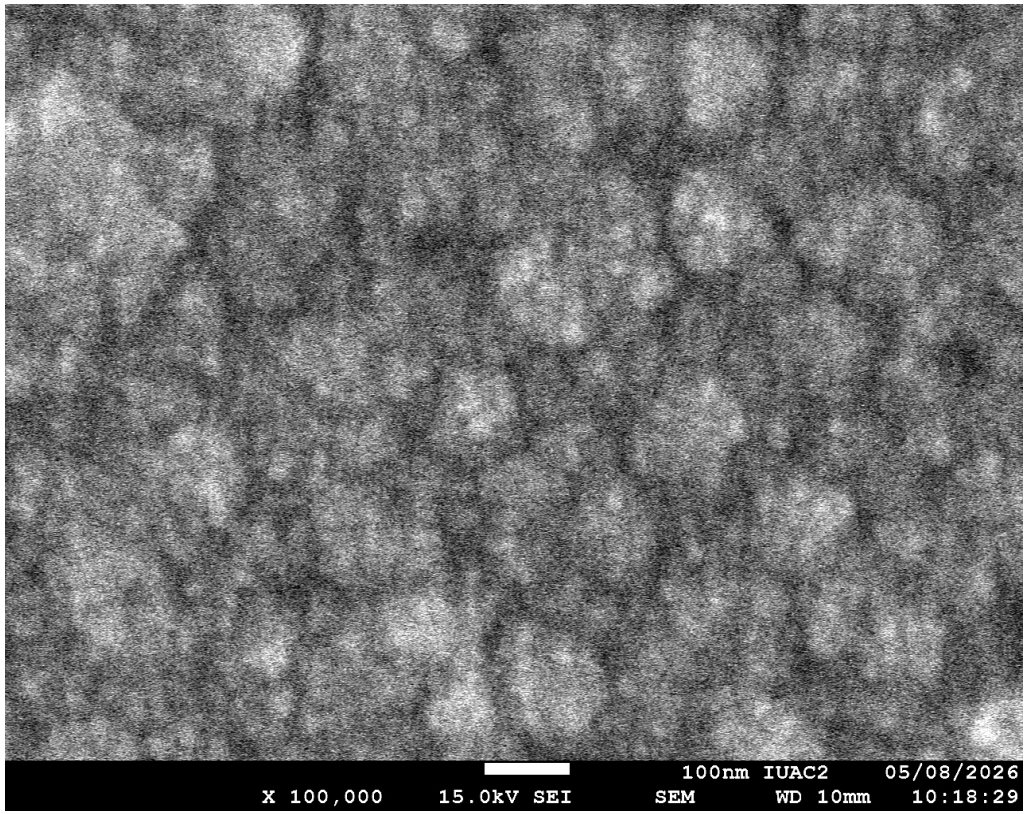
^{94}Mo: step height Δh = 157.6 nm



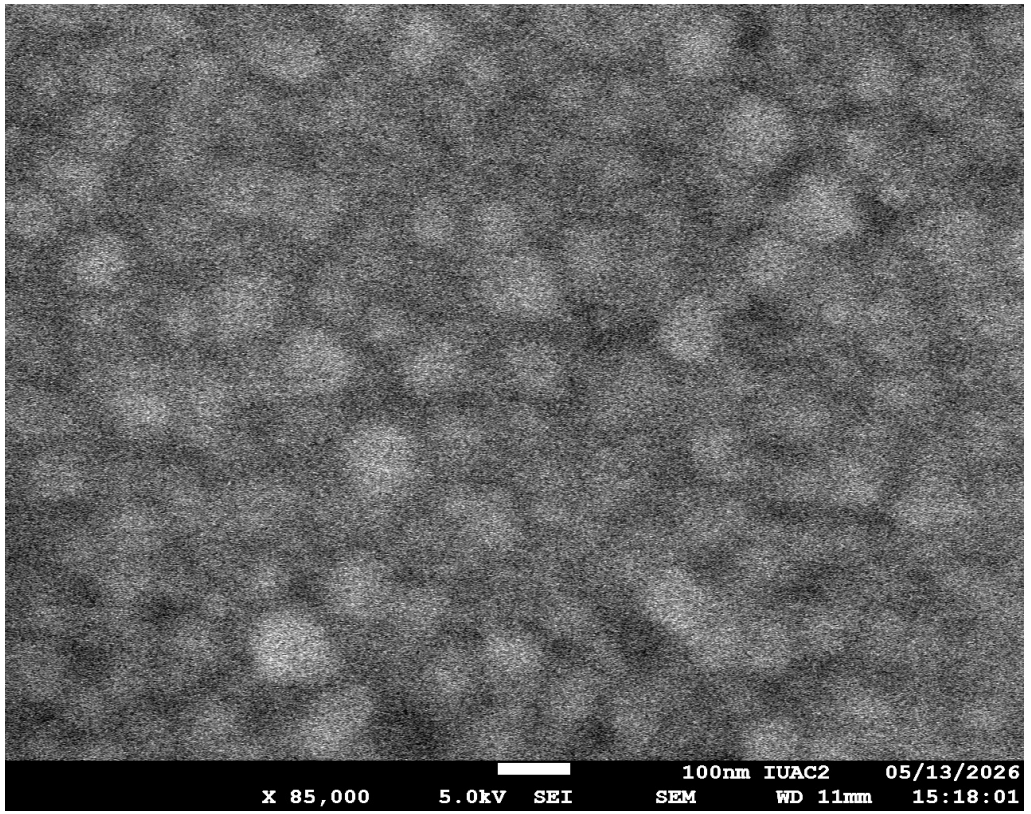
^{100}Mo: step height Δh = 149.6 nm

Step height × bulk Mo density (10.2 g/cm³) gives about 161 and 153 µg/cm², in line with the target areal densities.

Surface morphology: SEM

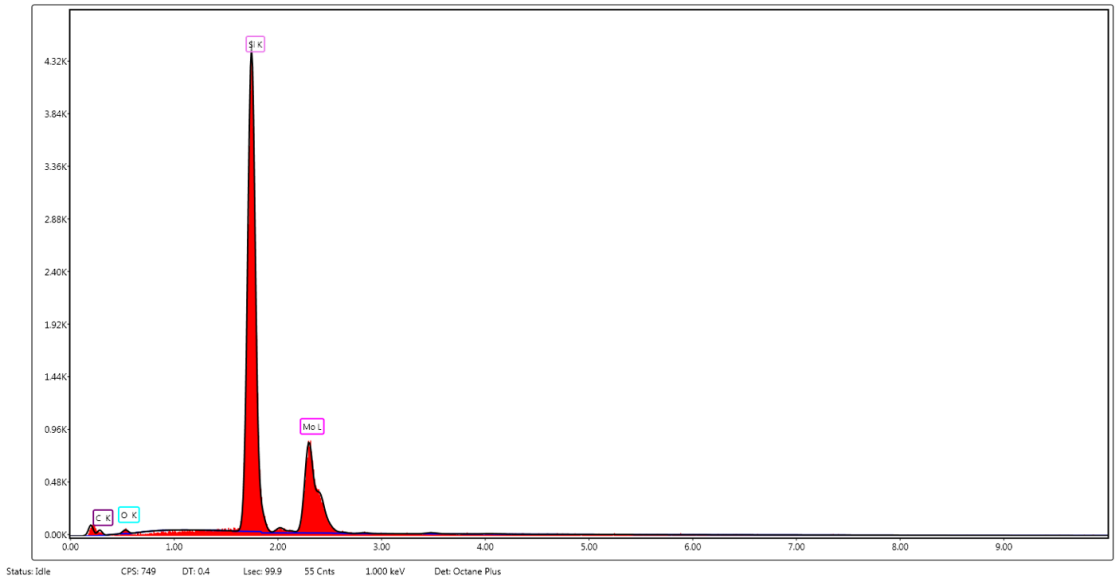


× 100,000, 15 kV

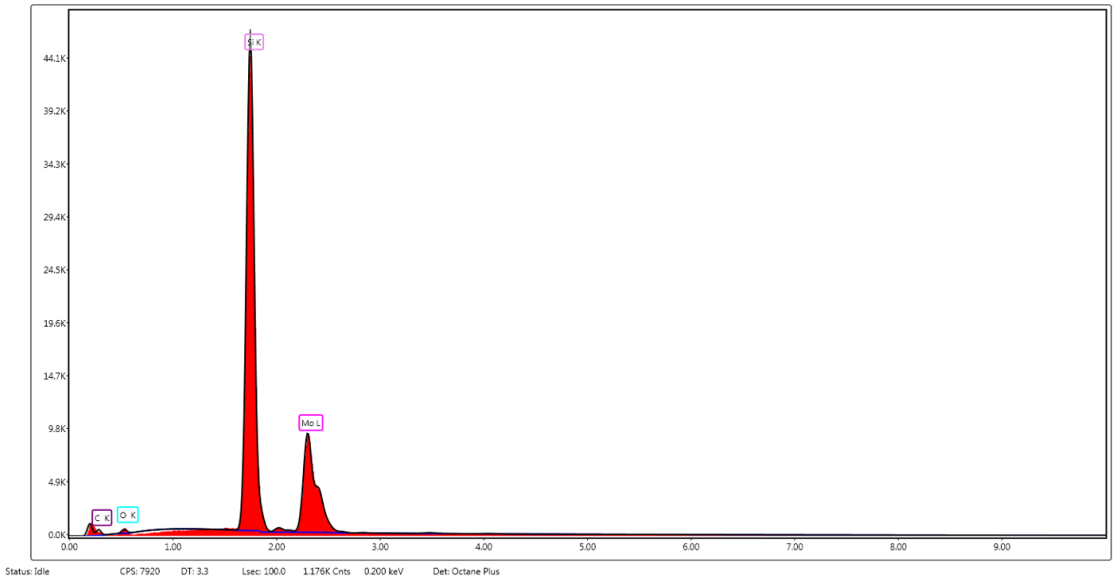


× 85,000, 5 kV

Composition: EDS

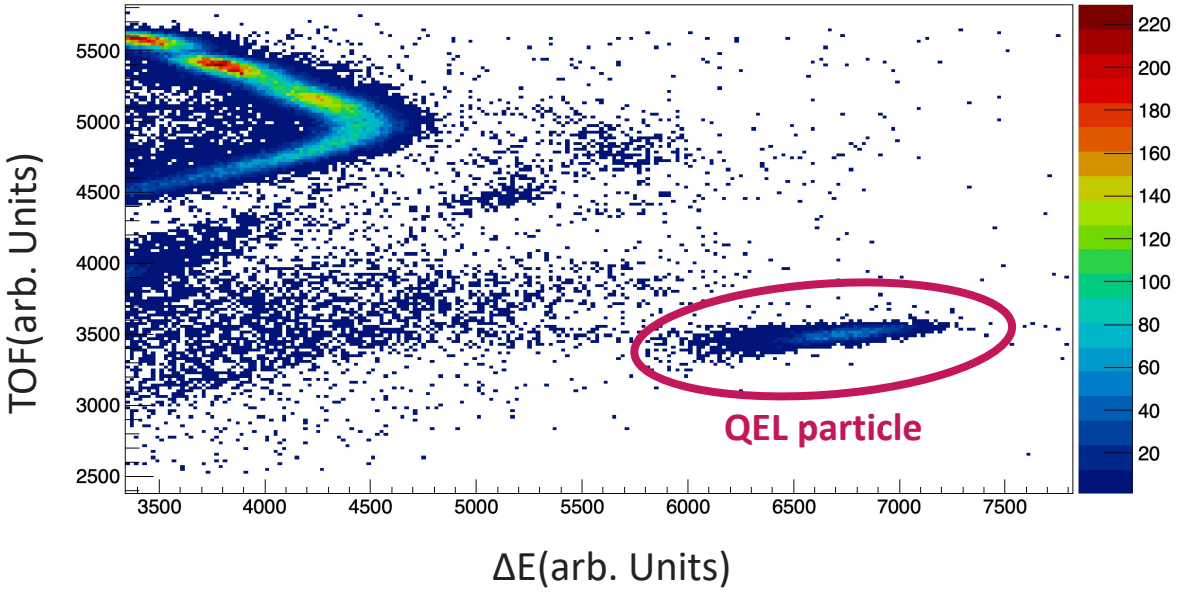


Element	Weight %	Atomic %
C	3.19	9.32
O	0.98	2.16
Si	60.32	75.50
Mo	35.51	13.01

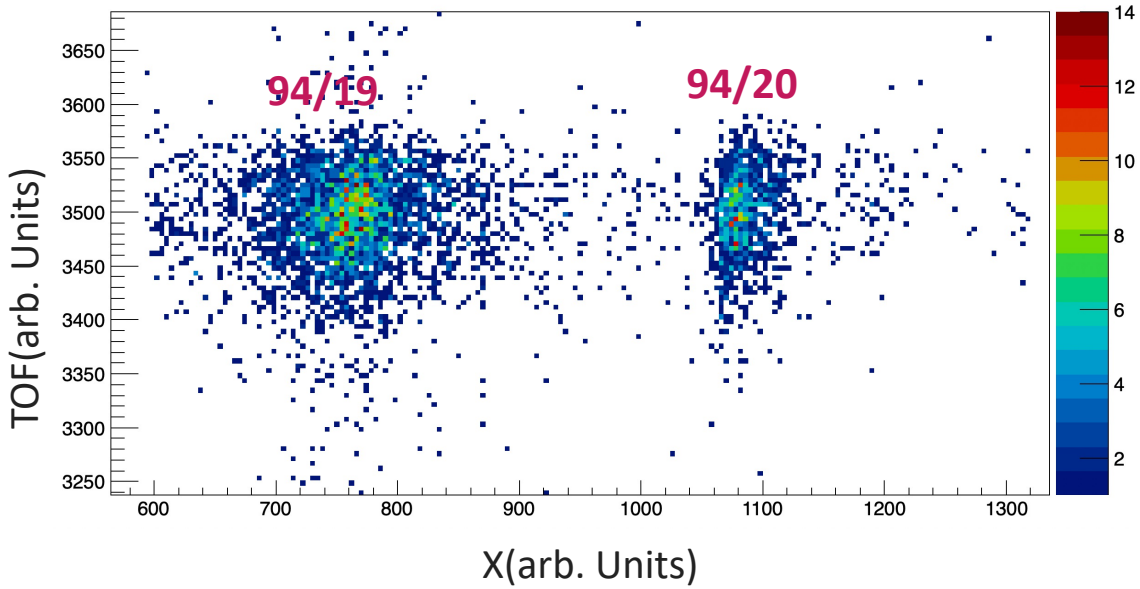


Element	Weight %	Atomic %
C	3.24	9.59
O	0.96	2.14
Si	58.89	74.59
Mo	36.90	13.68

2D spectrum of target-like particles $^{28}Si+ ^{94}Mo$

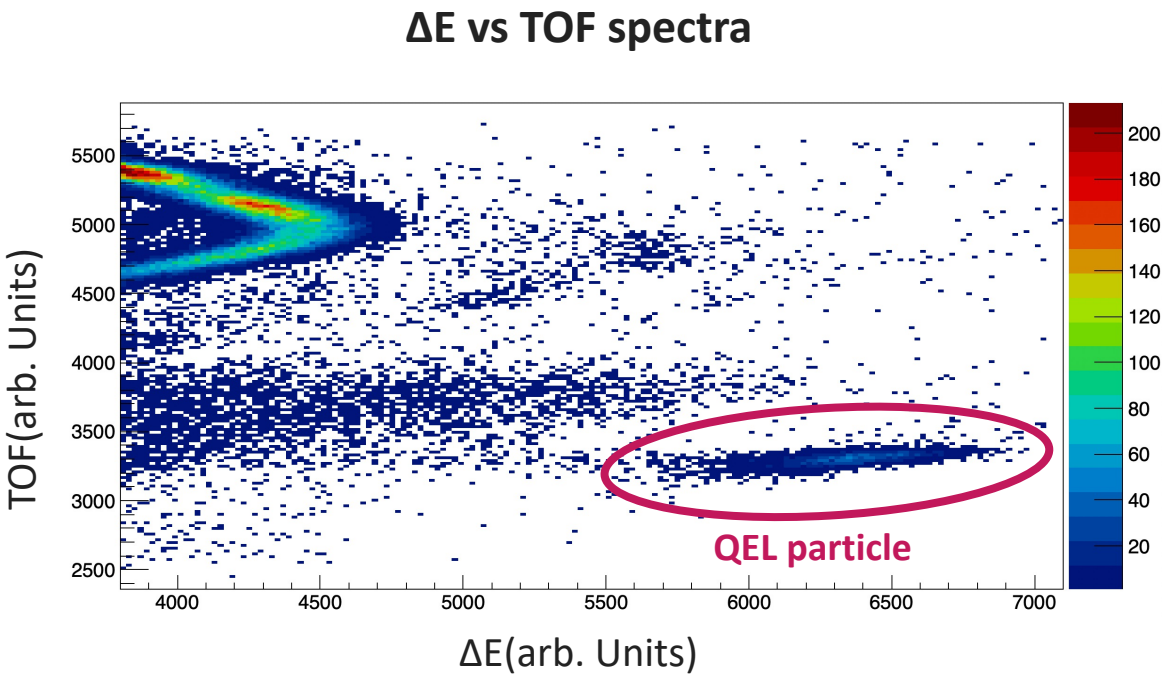


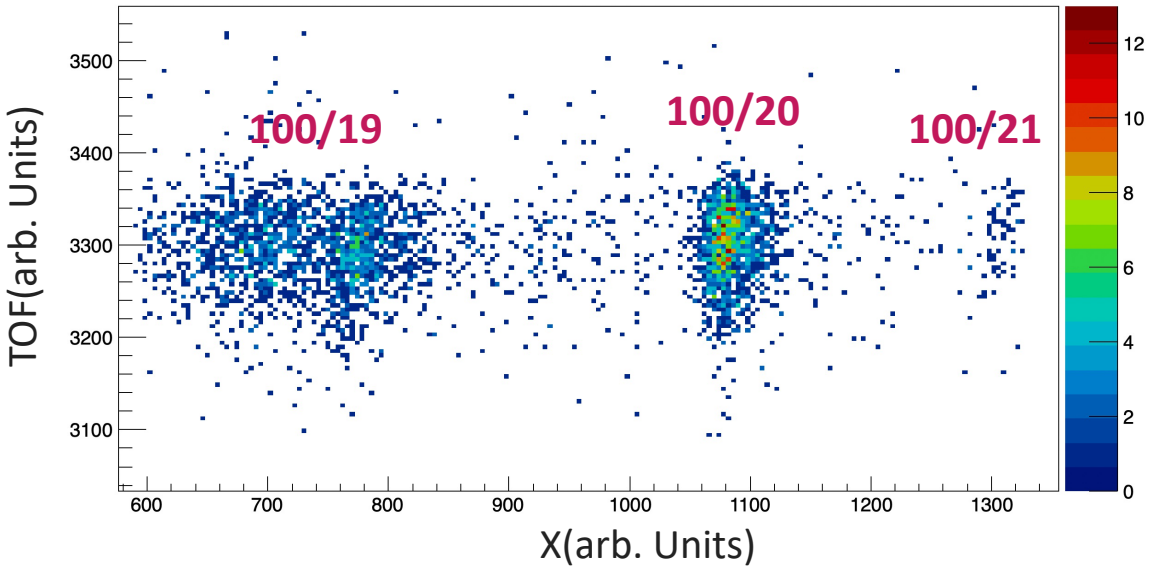
ΔE vs TOF spectra



Position vs TOF spectra

2D spectrum of target-like particles $^{28}Si+ ^{100}Mo$





Position vs TOF spectra

Summary and conclusion

- Thin ^{94}Mo and ^{100}Mo films were deposited by electron-gun evaporation.
- Both targets used a natural-carbon backing of about 40 µg/cm².
- A $BaCl_2$ release layer and floating were used to mount the films on stainless-steel frames.
- Areal densities: about 162 and 154 µg/cm². Enrichment: 98.97 % and 99.05 %.
- Step heights (profilometry), SEM and EDS were used to check thickness, morphology and composition.
- Further characterisation, including more detailed thickness, uniformity and composition studies, is planned.
- The targets are used for the quasi-elastic scattering reaction and are planned to be used in transfer-reaction measurements.

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