Experimental Detection of Charged Fusion Products in a Compact Electron-Catalyzed Fusion Sytem Using Calibrated CR-39

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Abstract

This work presents the experimental detection of charged fusion products in a compact electron-catalyzed fusion (ECF) system. Using calibrated CR-39 solid-state nuclear track detectors, we performed a large-scale study combining ^{241}Am alpha calibration, angle-of-incidence tests, and Alpha-E beam–target fusion benchmarks. Tracks recorded in plasma experiments exhibited morphology, diameter, and depth, confirming the presence of energetic charged products. Through rigorous controls and cross-validation, we established a quantitative diagnostic framework for distinguishing fusion-related signatures from background, providing reproducible evidence of charged-particle emission under mild plasma conditions.

Background

Electron-catalyzed fusion (ECF) proposes that dense electron populations can lower the Coulomb barrier and enhance fusion probability through electron screening. While this mechanism has long been hypothesized, direct experimental validation remains challenging. In this study, systematic calibration and over 6,000 controlled plasma runs using 1,400 CR-39 detectors yielded consistent charged-particle signals and several plausible mechanisms, including enhanced screening and collisional re-acceleration. These results highlight both the potential and diagnostic complexity of compact fusion systems and support ongoing efforts to develop aneutronic fusion platforms and standardized diagnostic protocols relevant to international verification and safeguards.

Methods

Detector and Calibration

ASL CR-39 detectors (2.0 × 2.5 cm) were calibrated under ~10^{-5} Torr using ^{241}Am α-sources (5.486 MeV) and Al attenuators (1.4 - 5.5 MeV). Incidence angles of 0° - 75° established depth–diameter baselines for oblique tracks.

Etching and Verification

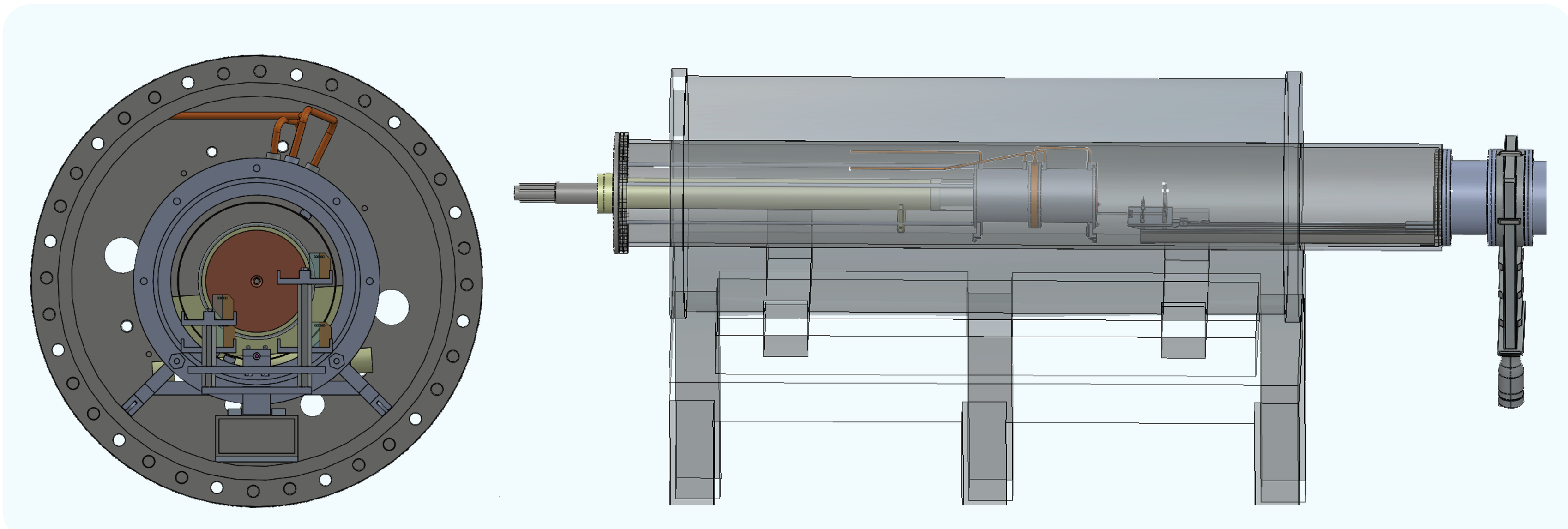
Etching was performed in 6 M NaOH at 90 °C for 3 hours. Pre- and post-exposure ^{241}Am irradiations verified detector response stability and ensured no etch-rate deviation under experimental conditions.

Background and Artifact Exclusion

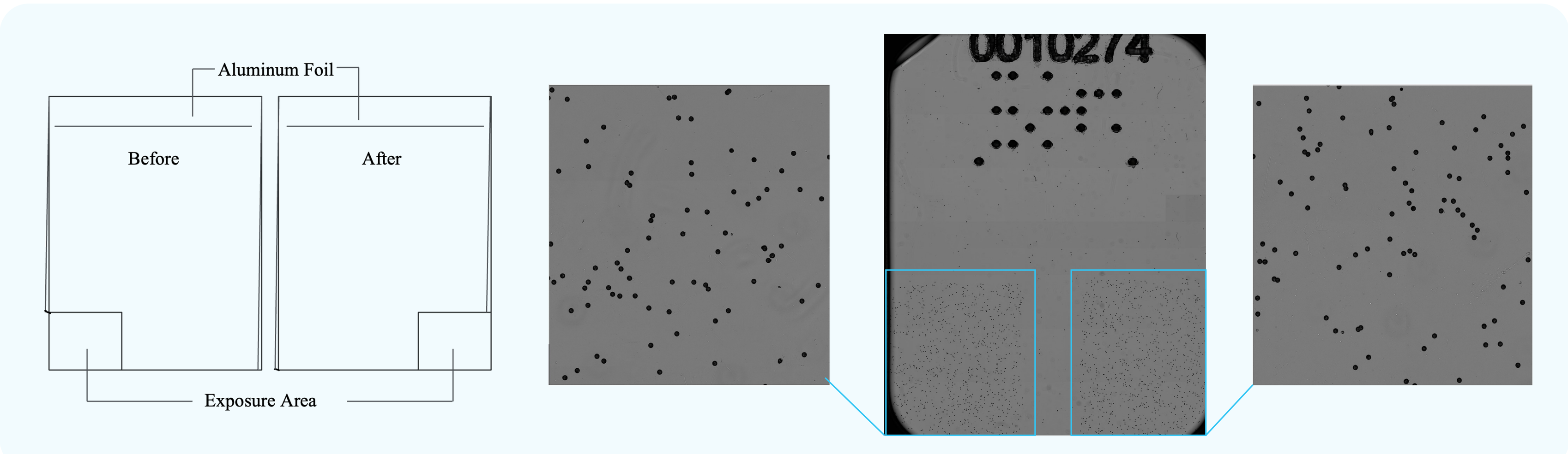
Blank, Kapton-shielded, and vacuum-only runs verified that observed pits were not from thermal, vacuum, or surface artifacts. Thermal monitoring showed < 5 °C temperature rise during discharges.

Investigation of Track Morphology

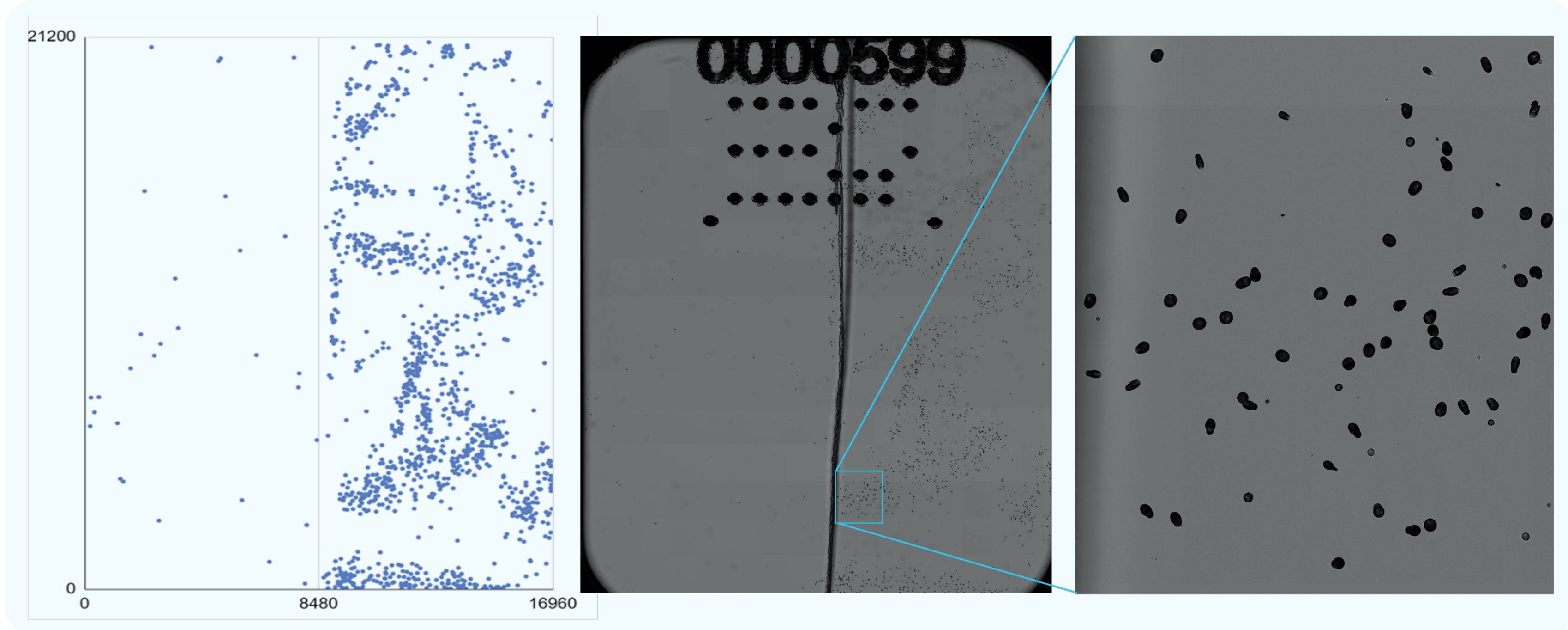
Systematic variation of incidence angle and etching duration was conducted to study the formation of oblique and asymmetric tracks. Comparative analyses with Alpha-E beam–target fusion experiments provided reference datasets for identifying fusion-generated α-particles and evaluating angular dependence.



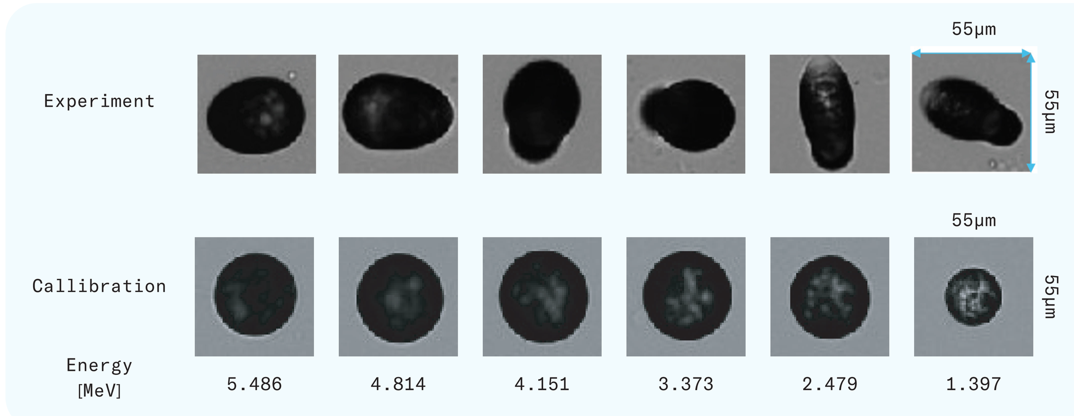
Schematic of the ECF reactor showing plasma region, electrodes, and CR-39 detector placement



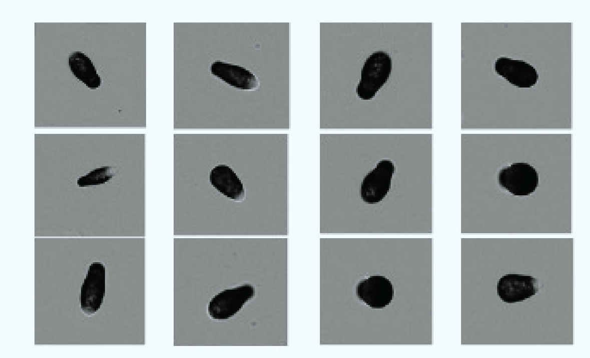
CR-39 tracks from ^{241}Am α-particles attenuated by Al foils, showing energy-dependent pit size reduction.



Typical image of an CR-39 testing coupon and track distribution map



CR-39 tracks from experiments and tracks from ^{241}Am α-particles



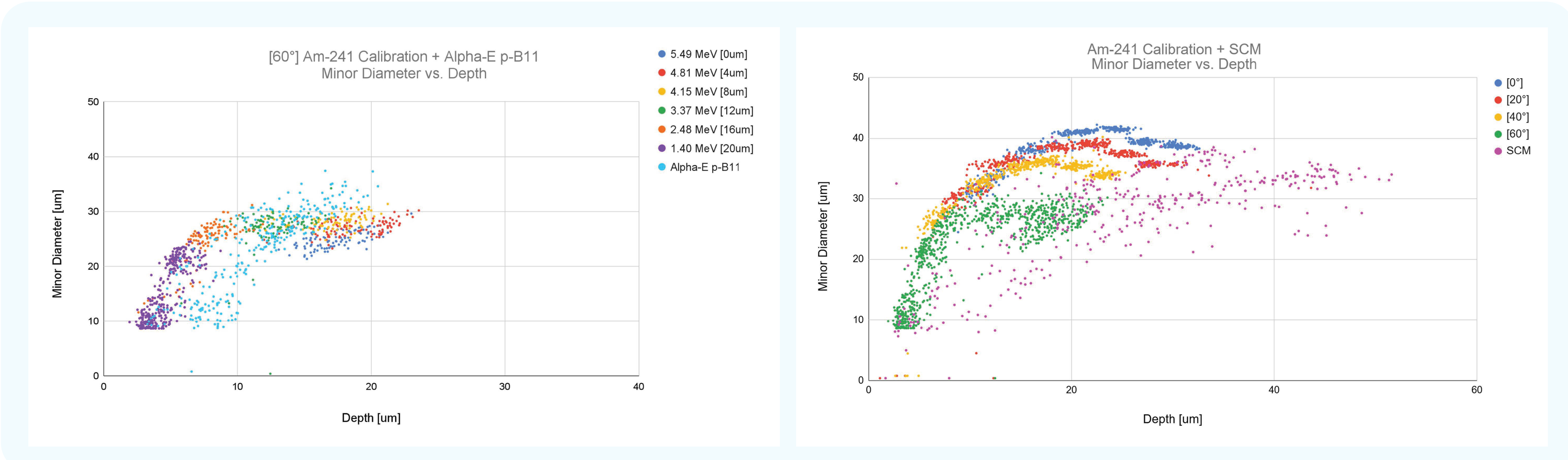
Typical image of CR-39 tracks

Outcome

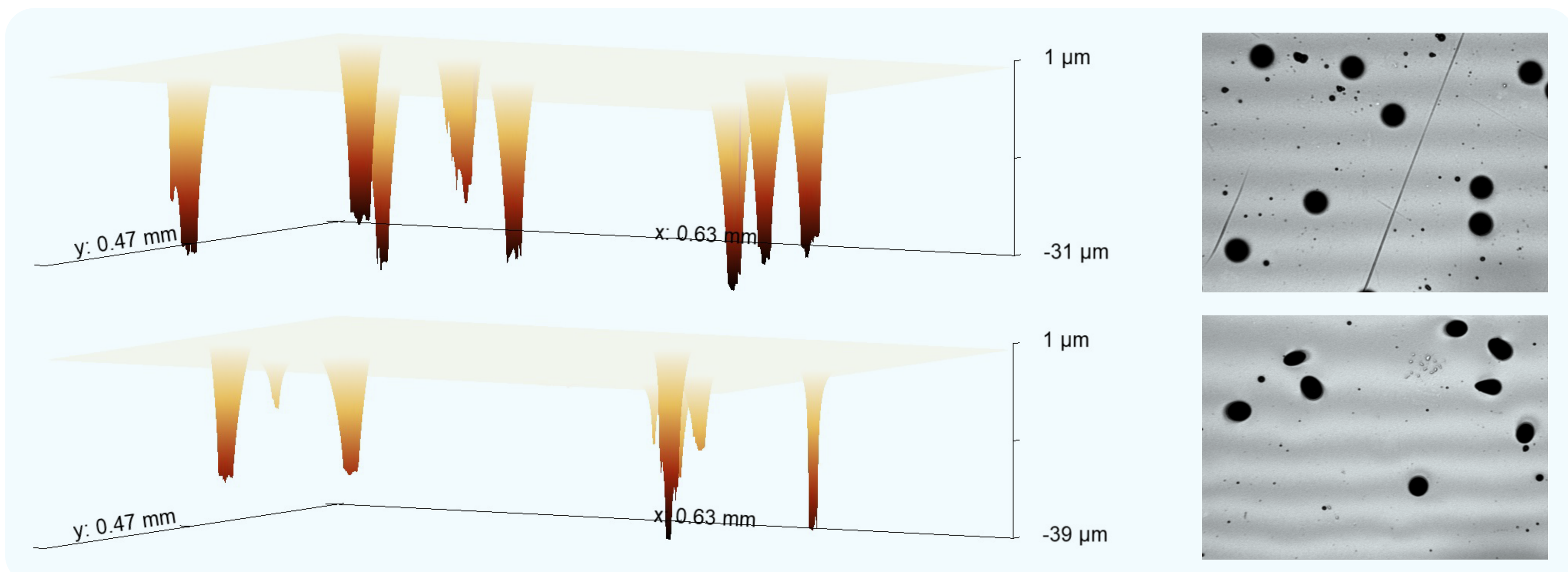
Track Morphology – Fusion-exposed CR-39 showed α-like pits matching ^{241}Am calibration in depth-diameter correlation; no comparable features in controls.

Energy Consistency – Track depths consistent with alpha particle stopping ranges

Angle-Dependent Behavior – Controlled incidence-angle studies (0°-60°) established predictable changes in pit elongation and provided calibration for non-normal fusion tracks.



Depth–diameter distributions for ^{241}Am, Alpha-E and our experiment



Confocal microscopy results showing consistent track depth range between ^{241}Am calibration and reactor plasma samples

Conclusion

- These findings provide evidence for charged-particle emission under mild plasma conditions, suggesting that fusion-related processes may occur in the electron-rich discharge environment
- The results establish a reproducible diagnostic framework for compact fusion systems and inform safeguards verification protocols.
- Further studies integrating time-resolved and spectroscopic diagnostics are needed to confirm particle origin and energy distribution.

Acknowledgements

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