Actinides and Rare Earths
Room Ballroom A - Session AC-ThP

Actinides and Rare Earths Poster Session

AC-ThP-1 The Application of Occam's Razor to Bremsstrahlung Isochromat Spectroscopy, ***J G Tobin,*** University of Wisconsin - Oshkosh

In philosophy and science, Occam's Razor is the problem-solving principle that recommends searching for the simplest possible explanation, consistent with the facts. [1] As put forth by Ptolemy (circa AD 90 -180): "We consider it a good principle to explain the phenomena by the simplest hypothesis possible." [2] More colloquially, "When you hear hoofbeats, think of horses not zebras," as suggested by Theodore Woodward. [3] In the case of Bremsstrahlung Isochromat Spectroscopy (BIS), [4-9] there have been many different interpretation methods based upon different theoretical models. Here, a simple picture will be presented, founded upon one underlying principle: the 5f electrons of the actinides are a slightly perturbed jj-coupled system. [10-15] This simple picture will include (1) the demonstration that many uranium systems are 5f3-localized and (2) a model for 5f mixing and delocalization. [16 -17] ACKNOWLEDGEMENTS: JGT wishes to thank the University of Wisconsin - Oshkosh for its on-going support. It is a gem set beside the Fox River and Lake Winnebago. References1.https://en.wikipedia.org/wiki/Occam%27s_razor2.Franklin, James (2001). The Science of Conjecture: Evidence and Probability before Pascal. The Johns Hopkins University Press. Chap 9. p. 2413.Sotos, John G. (2006) [1991]. Zebra Cards: An Aid to Obscure Diagnoses. Mt. Vernon, VA: Mt. Vernon Book Systems. ISBN 978-0-9818193-0-3.4.J.K. Lang and Y. Baer, Rev. Sci. Instrum. 50, 221 (1979).5.Y. Baer and J. Schoenes, Solid State Commun. 33, 885 (1980).6.Y. Baer and J.K. Lang, Phys. Rev. B 21, 2060 (1980).7.Y. Baer, Physica 102B, 104-110 (1980).8.E. Wuilloud et al., Phys. Rev. B 29, 5228 (1984).9.Y. Baer, "Electron Spectroscopy Studies," Chapter 4, "Handbook of the Physics and Chemistry of the Actinides," eds. A.J. Freeman and G.H. Lander, North Holland, Amsterdam (1984)10.J. G. Tobin et al., Phys. Rev. B 105, 125129 (2022).11.J.G. Tobin et al., Solid State Sciences 160, 107779 (2025).12.J. G. Tobin, "An Empirical Analysis of alpha-U Bremsstrahlung Isochromat Spectroscopy," MRS Advances 7, 783-788 (2022).13.J.G. Tobin et al., Phys. Rev. B 72, 085109 (2005).14.A. L. Kutepov, J. G. Tobin, S.-W. Yu, B. W. Chung and P. Roussel, J. of Phys.: Cond. Matter, 36, 045601 (2024).15.J. G. Tobin et al., MRS Bulletin 47, 1078–1083 (2022).16.J.G. Tobin, J. Vac. Sci. Technol. A 43, 063206 (2025).17.J.G. Tobin and A. Kutepov, J. Electron Spect. Rel. Phen. 284, 147577 (2026).

AC-ThP-5 5f Electronic Structure of van der Waals Uranium-Tellerium Alloys, ***Jonathan Denlinger,*** Lawrence Berkeley National Laboratory*; Christopher Broyles, Justin Shotton, Sheng Ran,* Washington University, St. Louis

Low dimensionality of magnetism and of correlated f-electron physics are current high interest research topics in condensed matter. Here, we compare and contrast the properties of two layered van der Waals uranium alloys with a focus on the diversity of their U 5f electronic structures measured by angle-resolved photoemission (ARPES), and on new f-spectroscopic features not previously reported.

UOTe crystallizes in (Te-U-O-U-Te) quintuplet layers and exhibits bilayer (uddu) antiferromagnetic ordering of local moments below 165K [1]. The U 5f states are found to be well localized at ~1 eV below E_F similar to UO_2, but with an additional weak satellite peak at -0.2 eV of unexplained origin that exhibits a Kondo-like temperature dependence. Moreover, the AFM ordering has a distinct effect on the relative energy alignment of the localized f-states between the zone center and the zone boundary. ARPES of UOTe also exhibits unusual superstructure replicas of the Fermi surface that result from an exotic incommensurate structural modulation of its vdW gap between Te layers.

The UTe_3 crystal structure contains two Te square-net planes that ubiquitously promote charge density wave (CDW) formation in the rare-earth tritellurides. Here strong U 5f character near E_F with strong temperature-dependent Kondo coherence is found in a shallow electron pocket whose high density of states is consistent with its ferromagnetic ordering below 20K [2]. The strong f-scattering dominates the otherwise delicate imperfect Fermi surface nesting of light mass Te p-bands, that results in the suppression of CDW ordering. Finally, an unusual momentum-dependent 'negative' spectral weight profile for zone-folded Te p-bands is observed and discussed as an interference phenomena.

[1] C. Broyles *et al.*, Adv. Mater. **37**, 2414966 (2025).
[2] J. Shotton *et al.*, arXiv: 2603.03509 (2026).

AC-ThP-6 Development of a Novel Aerogel-Assisted Ssntd for Automated Fissile Isotope Identification, *Rami Babayew, Yaacov Yehuda-Zada,* Nuclear Research Center Negev, Israel*; Galit Bar,* Soreq Nuclear Research Center, Israel*; Noam Elgad,* Nuclear Research Center Negev, Israel*; Danny Dayan,* Ben Gurion University Be'er Sheva, Israel*; Jan Lorincik,* Centre Řež, Czech Republic*; Itzhak Orion,* Ben Gurion University Be'er Sheva, Israel*; Shay Dadon,* Nuclear Research Center Negev, Israel*; Aryeh Weiss,* Bar Ilan University, Israel*; Galit Katarivas Levy,* ***Itzhak Halevy*** [1], Ben Gurion University Be'er Sheva, Israel

Accurate identification of fissile isotopes is a central challenge in nuclear forensics and safeguards. Fission Track Analysis (FTA) using solid-state nuclear track detectors (SSNTDs) provides high sensitivity but is limited by manual processing and restricted isotopic discrimination. This work presents an automated, physics-informed framework for fissile isotope characterization combining Monte Carlo simulations, synthetic data generation [1], and image-based analysis.

GEANT4 simulations were performed for ^{235}U, ^{233}U, and ^{229}Th to model fission fragment transport and cluster formation in LEXAN® SSNTDs with silica aerogel spacers. Synthetic track images were generated to study the effect of aerogel thickness on cluster morphology. Results show that increasing aerogel thickness enhances cluster separation and improves signal-to-noise ratio up to an optimal range, beyond which performance saturates due to pixel-resolution constraints and track truncation effects.

An automated image-processing pipeline (FTA-Finder) was developed to identify fission sites, separate overlapping clusters, and suppress background tracks. The fraction of well-resolved clusters increases with aerogel thickness, indicating improved reconstruction robustness.

Isotopic discrimination was evaluated using reconstructed track-length histograms and double-Gaussian fits for heavy and light fission fragments. A complementary analysis based on Real Flight Path (RFP) distributions showed clear isotope-dependent peak shifts. For 0.1 μm grains embedded in 50 μm aerogel (ρ = 0.033 g/cm^3), ^{235}U exhibited higher RFP peak positions than ^{233}U, while ^{229}Th showed the lowest values due to differences in fission-fragment energy and mass distributions.

Statistical analysis over 30 synthetic realizations showed significant separation between ^{235}U and ^{229}Th at ~3σ, while discrimination between ^{235}U and ^{233}U approached the resolution limit (~1σ). Peak deviations remained below 0.69%, confirming stable reconstruction performance.

All results are based on simulation and synthetic data. Future work will focus on experimental validation using neutron irradiation in reactor environments and extension to additional detector configurations. The proposed framework provides a scalable pathway toward quantitative isotopic fingerprinting for nuclear forensic and safeguards applications.

Reference:

[1] R. Babayew, Y. Yehuda–Zada, N. Elgad, J. Lorince, I. Orion, A. Weiss, G. Katarivas Levy, I. Halevy, *Simulation tools for improvement of the fission track analysis method for nuclear forensics* (2024), JRNC, Akadémiai Kiadó, Budapest, Hungary, DOI: 10.1007/s10967-023-09313-5.

AC-ThP-7 Cross-Model Validation of Raw Stopping-Power Data forRobust Automated Fission Track Analysis, *Danny Dayan, Rami Babayew, Yaacov Yehuda-Zada,* Unit of Nuclear Engineering, Faculty of Engineering Sciences, Ben Gurion University, Israel*; Galit Bar,* Department of Solid-State Physics, Soreq Nuclear Research Center, Yavne, Israel*; Noam Elgad,* Unit of Nuclear Engineering, Faculty of Engineering Sciences, Ben Gurion University, Israel*; Jan Lorincik,* 4 Nuclear Fuel Cycle Department, Centre Řež, Hlavní 130, Řež 250 68, Husinec, Czech Republic*; Itzhak Orion,* Unit of Nuclear Engineering, Faculty of Engineering Sciences, Ben Gurion University, Israel*; Shay Dadon,* Engineering Department, Nuclear Research Center Negev, Beer-Sheva, Israel*; Aryeh Weiss,* Bar Ilan University, Ramat Gan P.O.B. 90000 5290002 Israel, Italy*; Galit Katarivas Levy,* Dept. of Biomedical Engineering, Ben-Gurion University, Beer-Sheva, Israel*;* ***Itzhak Halevy,*** Unit of Nuclear Engineering, Faculty of Engineering Sciences, Ben Gurion University, Israel

Automated fission-track analysis (FTA) frameworks such as FTA-Finder rely on Monte Carlo–generated synthetic training and validation imagery, typically produced with a single particle-transport code (GEANT4) [1]. A validation strategy built on one simulation engine cannot, by itself, show that the reconstructed forensic observables — fission-center localization, cluster-diameter reconstruction, and isotopic separability — reflect the

[1] **JVST Highlighted Poster**

physical system rather than artifacts of a particular code. This work reports a systematic cross-model assessment of the raw fission-fragment stopping-power and range data underlying FTA-Finder's synthetic imagery.

Raw range–energy data for a single representative light (^{95}Sr, 100 MeV) / heavy (^{138}Cs, 67 MeV) ^{235}U fission-fragment pair — used in place of a full isotope-resolved survey so that the raw-data source remains the only variable under comparison — were generated via five independent routes: GEANT4 Monte Carlo transport; analytical Bethe–Bloch integration; the PDG-recommended combined electronic–nuclear stopping formalism; a Bragg–Kleeman scaling integral; and the SRIM-2013 empirical database, used as reference. Each source was harmonized into a common schema and propagated, unchanged, through the existing FTA-Trainer/FTA-Finder pipeline.

Once a consistent Barkas effective-charge treatment was applied, all five methods agreed with SRIM-2013 to within ~1–9% in projected range across four detector-relevant materials (UO_2 fuel grain, aluminum catcher foil, LEXAN® SSNTD, and silica-aerogel spacer) — vs. 30–160% before correction — showing that agreement is governed by a small number of shared physical parameters rather than code-specific implementation choices.

As a first image-level demonstration, synthetic SSNTD cluster images were generated directly from the PDG-method raw data and processed with the unmodified FTA-Finder pipeline; fission-center localization and cluster-boundary reconstruction were consistent with the GEANT4-based baseline established previously [1] (Supplemental Material).

These results support the conclusion that FTA-Finder is adaptive to, and its forensic conclusions largely independent of, the specific route used to generate its raw training data — an important property for adoption across laboratories with heterogeneous simulation infrastructure. Full image-level robustness metrics for all five sources are in progress.

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