Characterizing Activated Materials for Free Release at a Low-Energy Heavy-Ion Accelerator Facility

Jordan D. Noey
Ph.D. Candidate, University of Michigan
Sunil Chitra[1], Kimberlee J. Kearfott[2]
1. Argonne National Lab, 2. University of Michigan

Introduction and Motivation

Classify accelerator waste for unrestricted release

- Many materials subject to potential activation
- Provide cost-efficient option for waste disposal
- Lower the overall dose within facility

Mission Relevance

Support accelerator operations in safeguards research

- Effective waste management within facilities
- Compare physics in radiation transport codes
- Knowledge of measurement environments

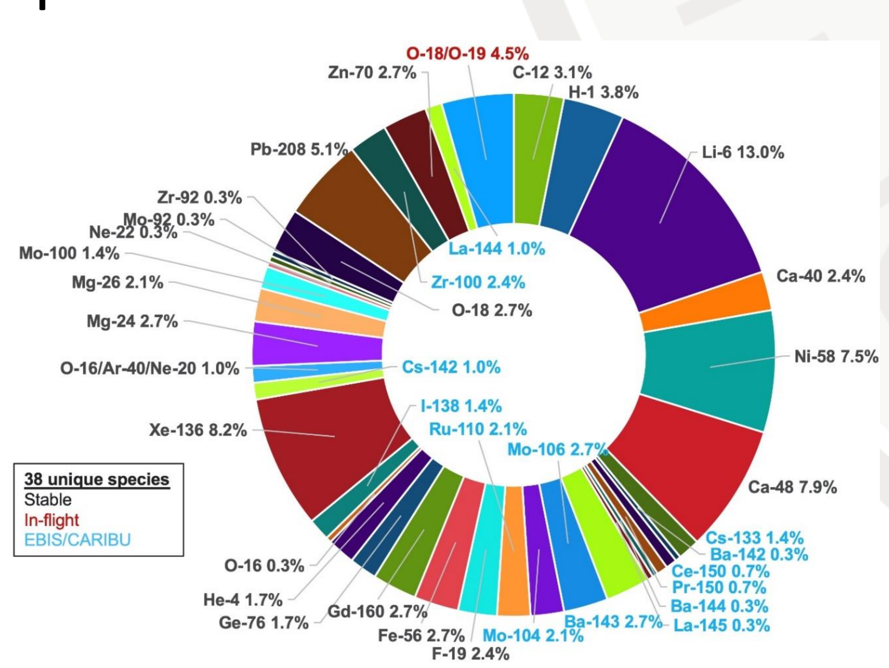
Technical Approach

1. Find target thickness using ion range code SRIM
2. Simulate various source-target configurations to get neutron yields from PHITS, FLUKA, and MCNP
3. Obtain activation profiles with each code using beam current of 10 pnA and irradiation time of 1,000 hours and compare to ANSI N13.12 limits

PHITS:
Physics: JQMD + GEM
Yields Tally: T-Cross, normalize by r^2
Activation Tally: T-DChain

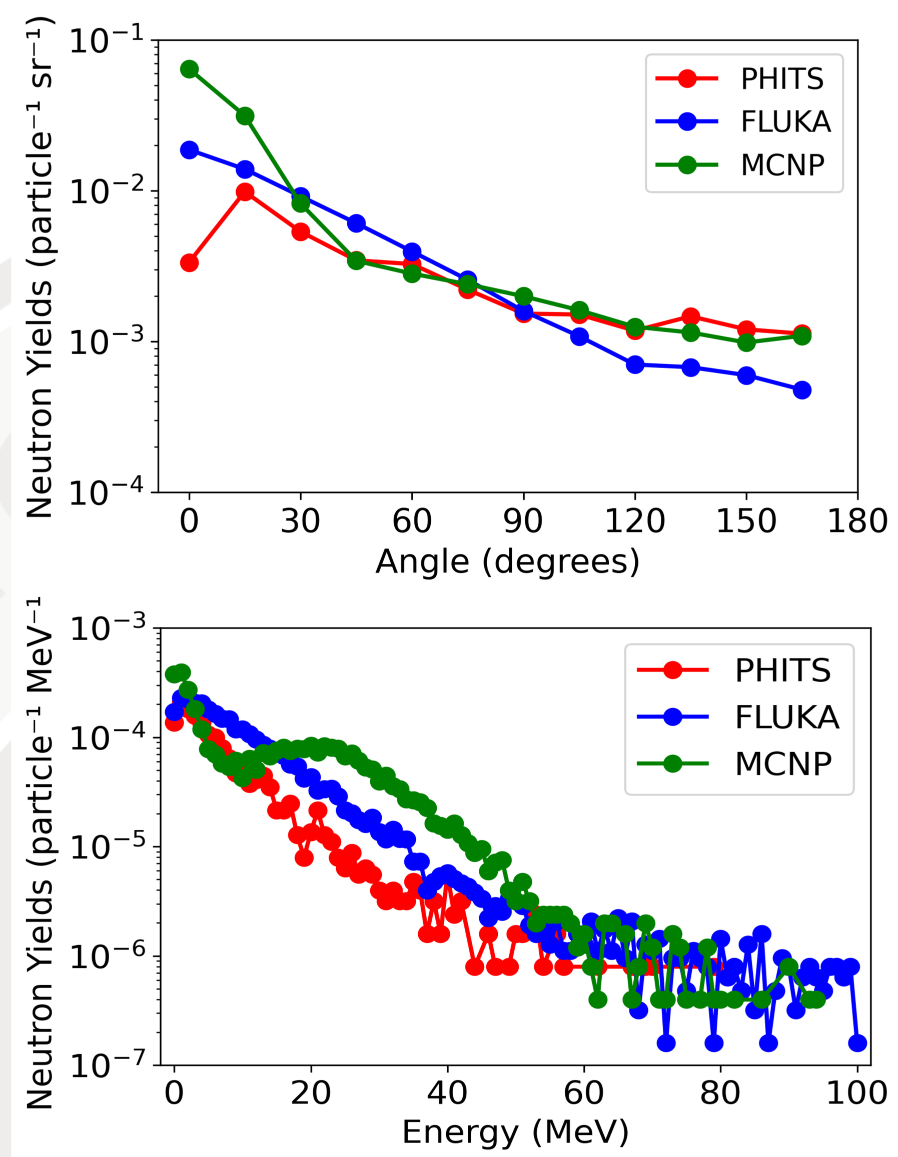
FLUKA:
Physics: BME (PHYSICS 1.0 & 3.0)
Yields Tally: USRYIELD
Activation Tally: RADDECAY, IRRPROFI, DCYTIMES, RESNUCLEI, DCYSCORE

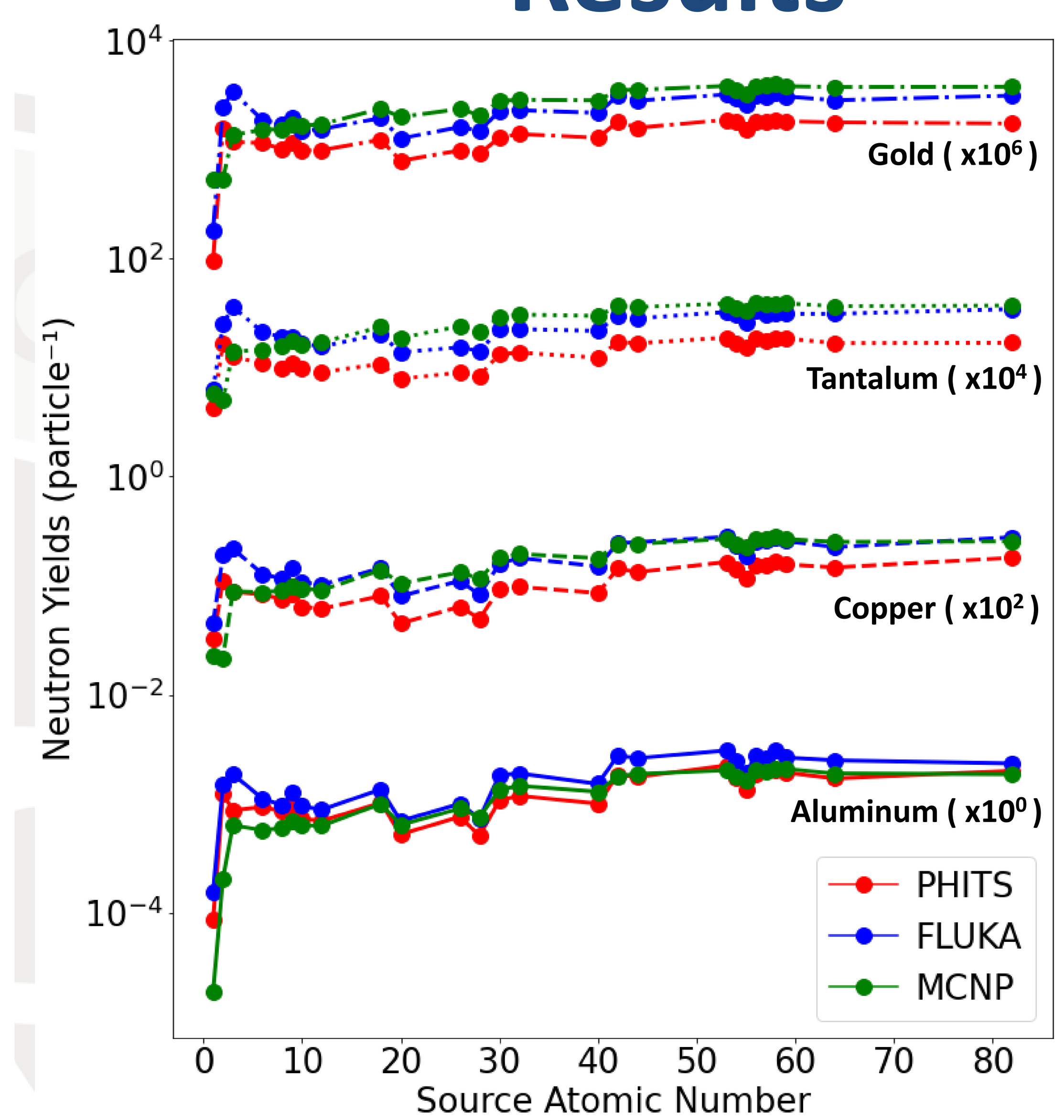
MCNP:
Physics: LAQGSM + CEM (LCA 7j -2 1 1)
Yields Tally: F2, normalize by r^2
Activation Tally: F4, execute CINDER90

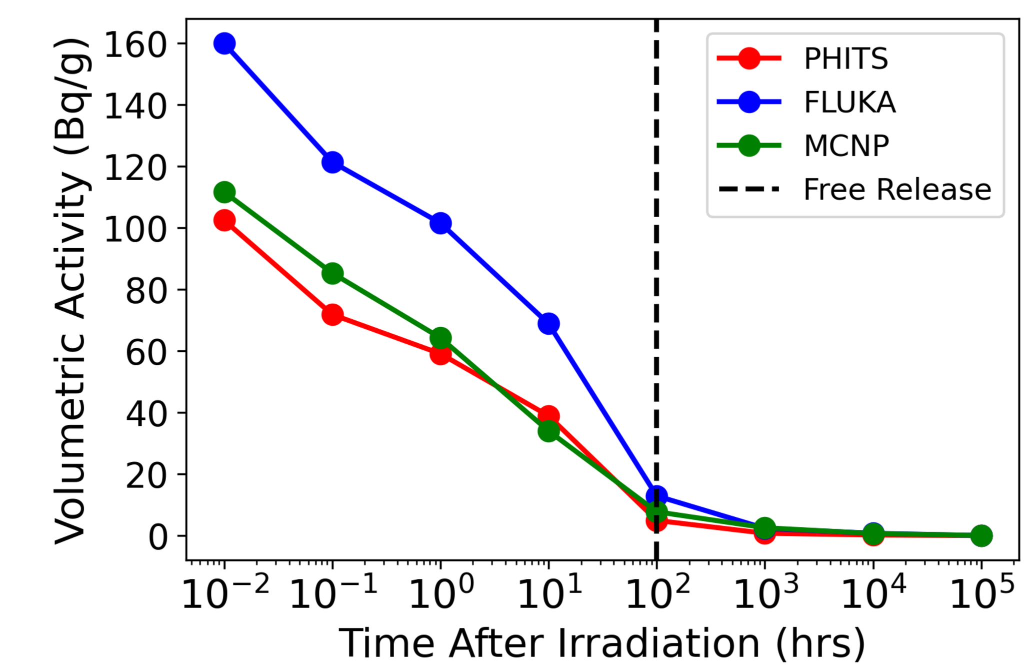


https://www.anl.gov/atlas/stable-beams

Results







Radionuclide		Dominant Radionuclides Volumetric Activity (Bq/g)			
		PHITS	FLUKA	MCNP	Limits
Mn	54	0.050	0.090	0.076	0.1
Co	60	0.008	0.013	0.011	0.1
Ag	110m	0.085	0.022	0.005	0.1
Co	57	0.059	0.103	0.088	1
Au	198	3.281	7.573	0.029	10
Cu	64	0.204	0.330	0.114	100
Fe	55	0.071	0.142	0.238	1,000

Neutron yields with varying angle for Xe-136 on tantalum (top left), and neutron yields with varying energy for Xe-136 on tantalum (bottom left), total neutron yields for different sources on multiple targets (middle), total volumetric activity concentration (Bq/g) for an electronics rack for different cooldown times using Xe-136 on tantalum (top right) and dominant radionuclides activity concentration at 100 hours cooldown time compared with ANSI N13.12 free release limits (bottom right).

Expected Impact

Allow technical basis for unrestricted release

- Bridge literature gap for low energy heavy ions
- Provide effective scripts for several simulations
- Implementation in similar accelerator facilities

Conclusion

Simulations provide validation for unrestricted release

- ANSI N13.12 limits met at 100 hours cooldown
- Good agreements between each code used
- Uncertainties and code discrepancies negligible

MTV Impact

Form connections with nuclear waste community

- Collaborations with Argonne National Lab
- Demonstrations of work at national conferences
- Applications in low-energy accelerator facilities

Next Steps

Continue to develop simulations and confirm results

- Experimentally verify with high purity germanium
- Validate neutron energies with additional runs
- Improve geometries to account for albedo

Contact email: noeyjd@umich.edu

This work was funded in-part by the Consortium for Monitoring, Technology, and Verification under Department of Energy National Nuclear Security Administration award number DE-NA0003920