Neutron Activation Analysis for Flux Measurements in Active Interrogation

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Introduction and Motivation

- Active interrogation (AI) induces photonuclear reactions in SNM, making energy signatures more easily detected
- Detectors desirable in AI are susceptible to pileup from intense photon flux;[1] we are using an ANN to classify particles more accurately than charge integration[2]
- Neutron activation analysis (NAA) determines neutron flux emitted by a target like HEU with no photon sensitivity, providing ANN validation

Mission Relevance

- AI increases the accuracy of SNM detection, reducing dangerous transportation of illicit materials
- This work addresses signals and source terms for nonproliferation, an MTV thrust area
- **Expected Impact**: This project seeks to solidify NAA as validation for AI detection, combatting nuclear terrorism

Technical Approach

- Al and Fe were used as foil materials for fast neutron energy (n,p) thresholds, at 1.9 and 3.0 MeV, respectively
- DU is our SNM target; Pb is a control target whose photoneutron spectrum has little to no overlap with the Al and Fe cross-sections due to their (n,p) thresholds

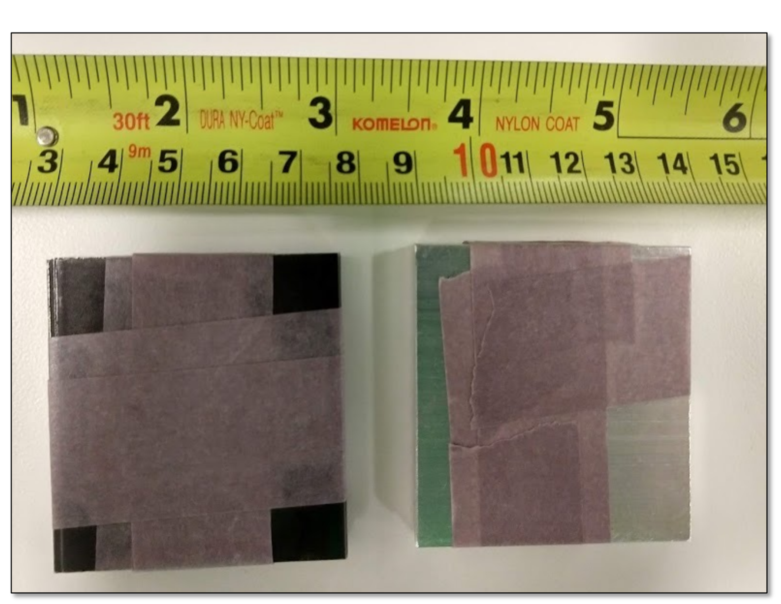

Fig. 1: Fe (Left) and Al (Right) foils

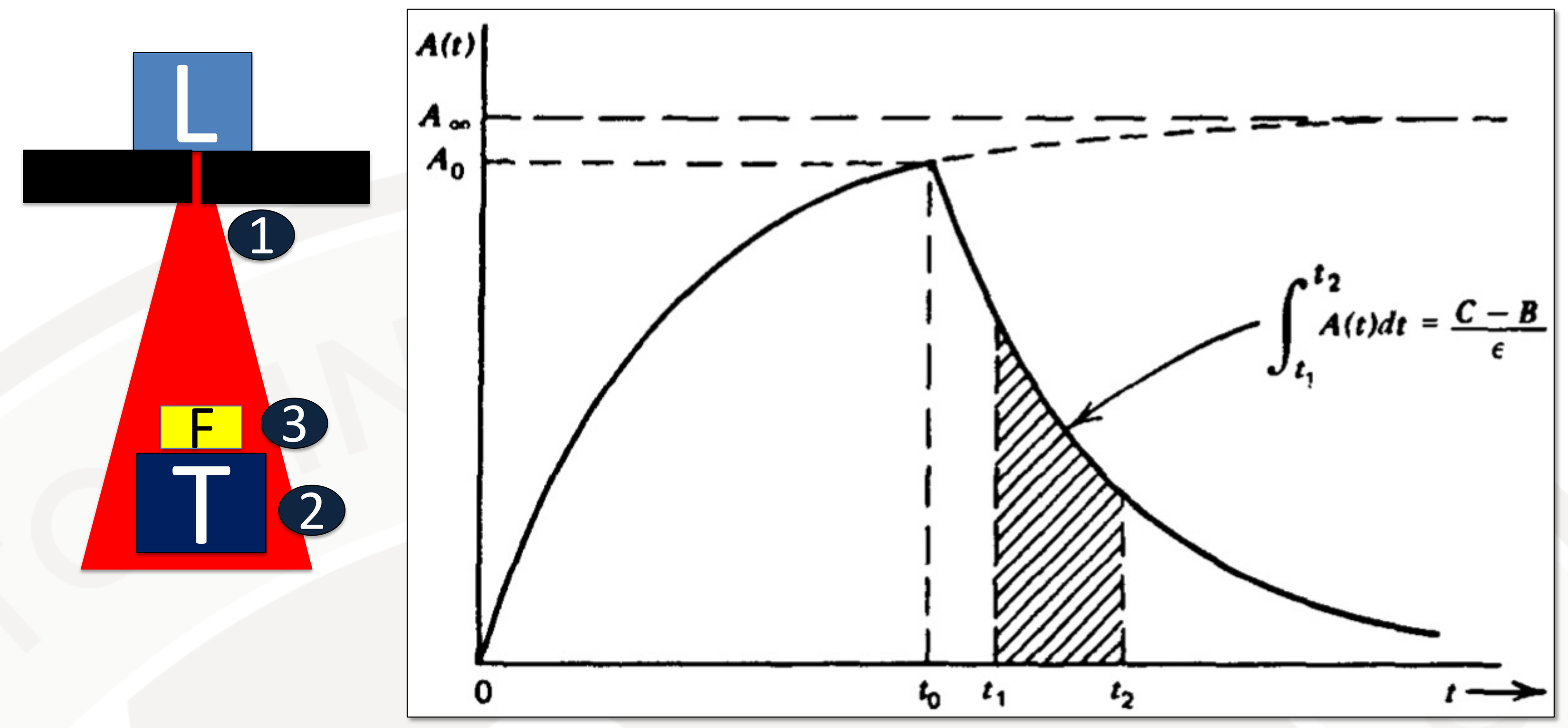

Fig. 2: Irradiation diagram (Left): (1) linac → photon beam, (2) → target photonuclear reactions, (3) → foil activation. Activation graph (Right).[3] Irradiation: $t = [0, t_0]$; counting: $t = [t_1, t_2]$.

Results

- AI: comparisons between active background, Pb activation, and DU activation show a reliable energy threshold and photon insensitivity. (Figure 4L)
- Fe: significant activation in DU case, but also some activation in active background. (Figure 4R)

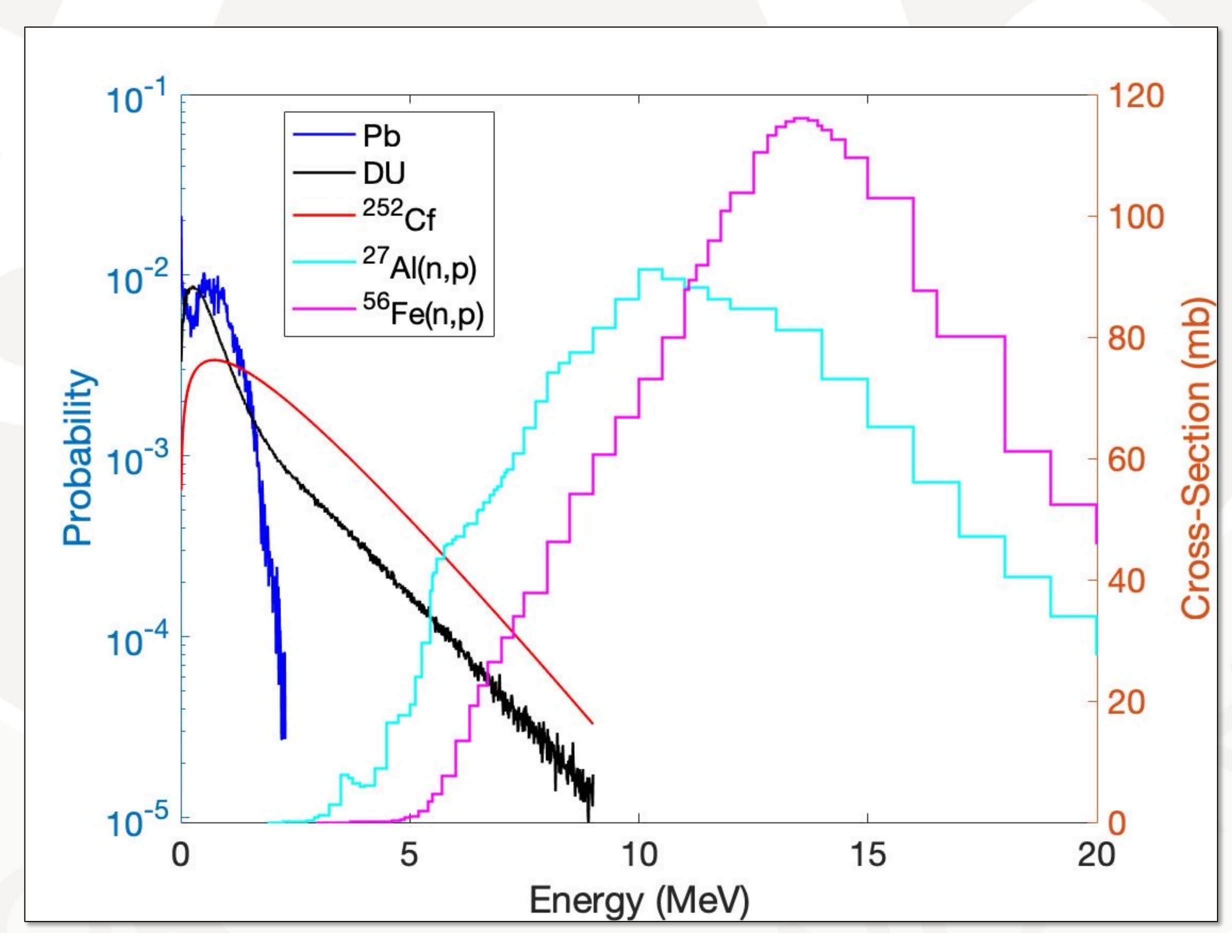

Fig. 3: ^{252}Cf, Pb, and DU neutron spectra vs. ^{27}Al(n, p)^{27}Mg and ^{56}Fe(n, p)^{56}Mn cross-sections

References

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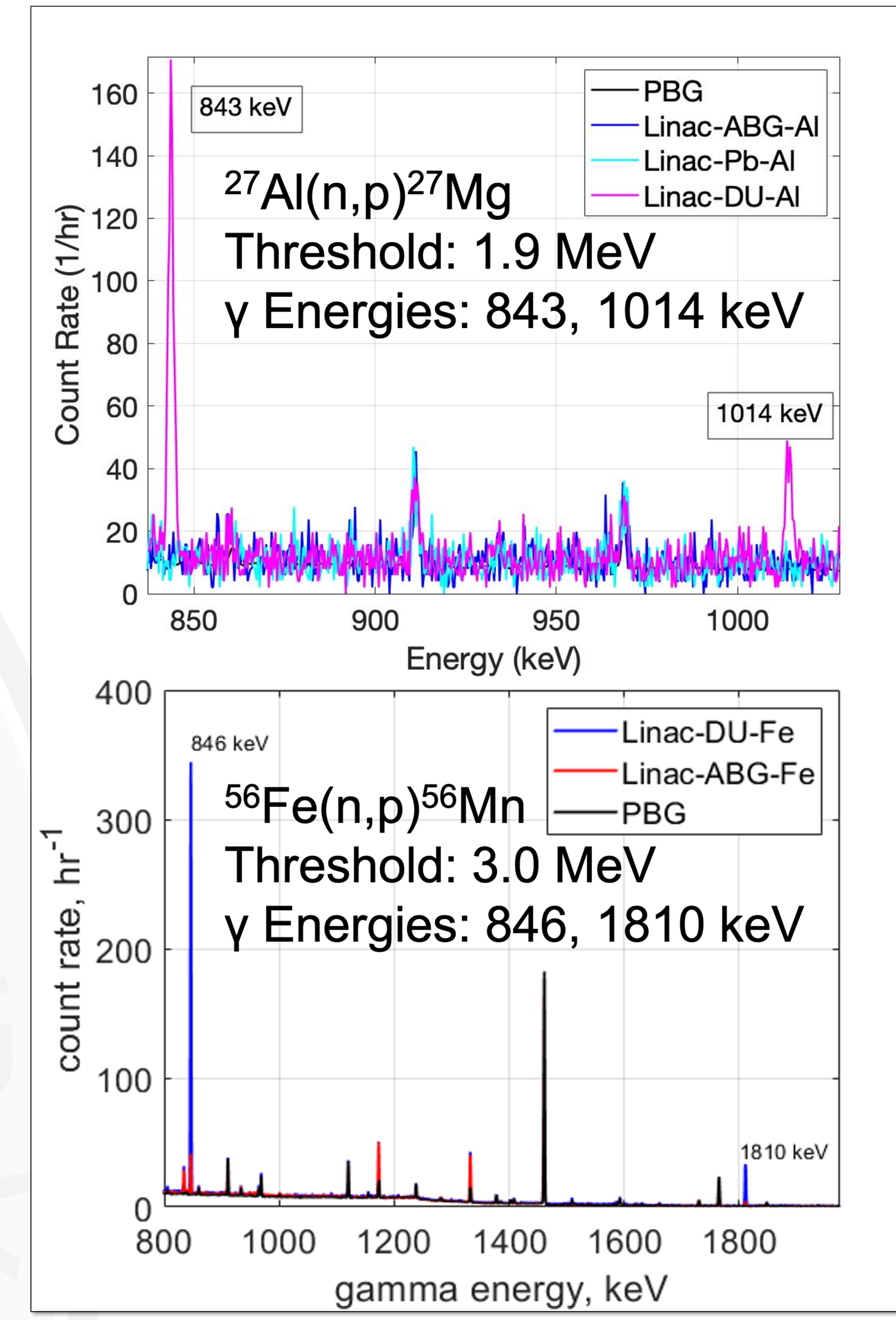

Fig. 4: Al (Top) and Fe (Bottom) activation spectra post-irradiation, collected using a mechanically-cooled HPGe detector

Conclusion

- Al has demonstrated fast neutron sensitivity without pileup, proving its usefulness in detecting fast neutron signatures
- The ^{55}Mn(n, g)^{56}Mn likely causes the Fe ABG activation, as neutrons from the linac collimator can cause this reaction. ABG subtraction can resolve this.
- **Next Steps:** Calculate flux using cross-section approximations across neutron spectrum, present on foil materials at ANS, publish paper with full results

National Nuclear Security Administration

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