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Fast Neutron Imaging for Materials Accountancy of Uranium Hexafluoride

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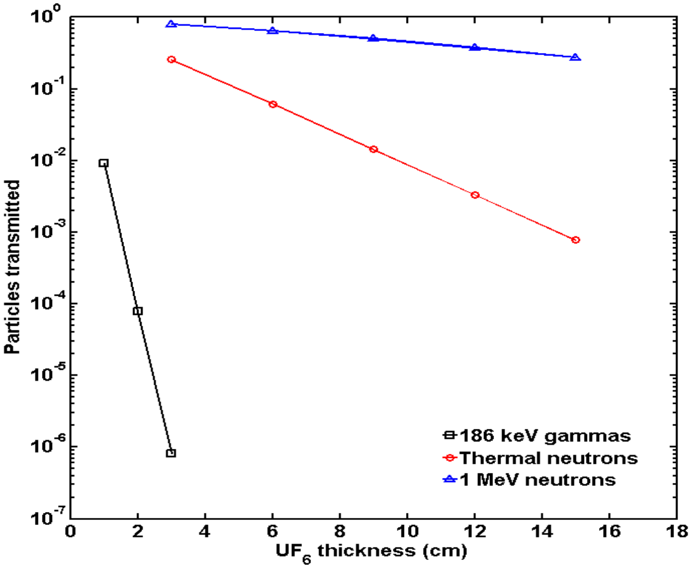
Introduction

- Monitoring and accountancy of declared UF_6 enrichment and mass in storage cylinders are crucial.
- Neutron and gamma detection are used for monitoring UF_6 enrichment and mass.
  - U-238 Spontaneous fission and (α,n) neutrons
  - 186 keV gamma from U-235
- Gamma radiation has short mean free path and can not be used to assay inner regions of UF_6 cylinders.
- Neutrons are more penetrating and enable assaying inner regions of UF_6 cylinders.

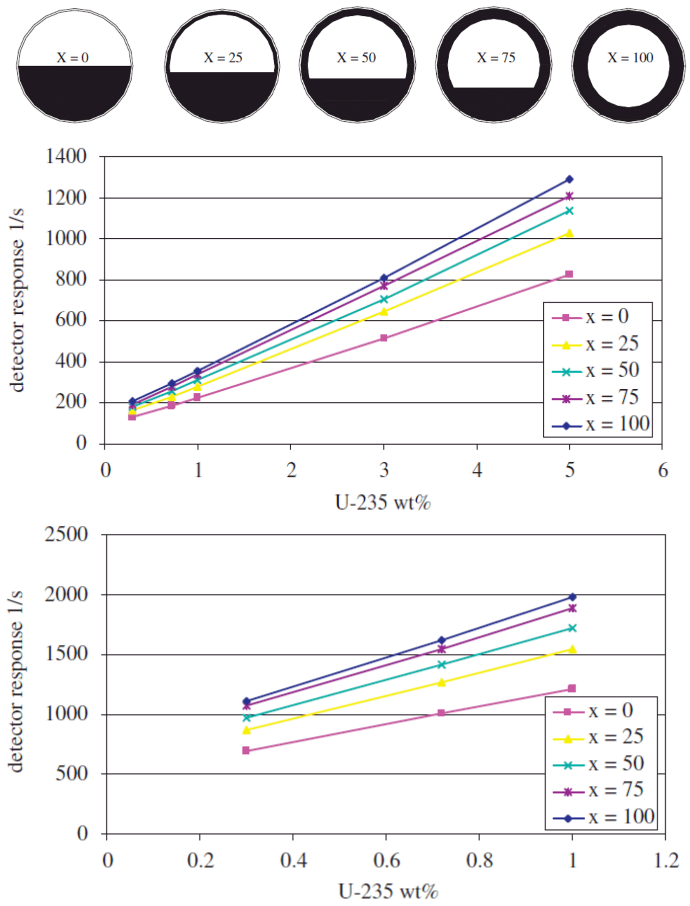


Introduction Cont.

- Neutron techniques has shown strong dependence of detector response on UF_6 filling profile.

- Discriminating UF_6 level of enrichment is difficult if UF_6 filling profile is unknown.

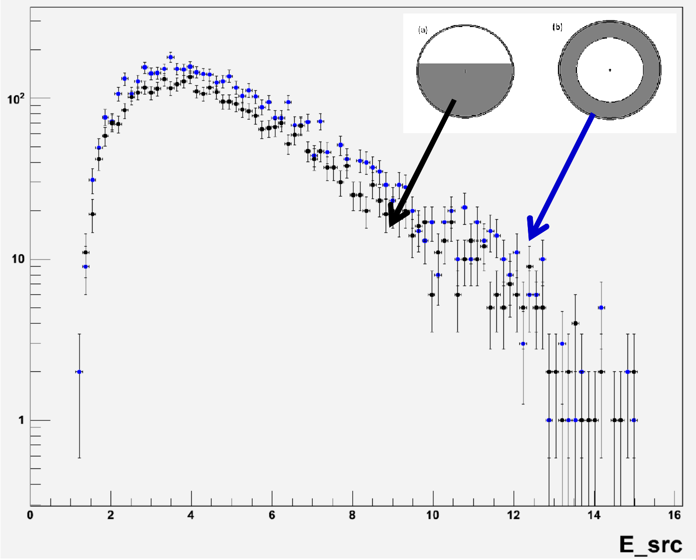
- UF_6 filling profile may not be a priori knowledge.



R. Berndt et al. NIM A612 (2010) pp. 309-319

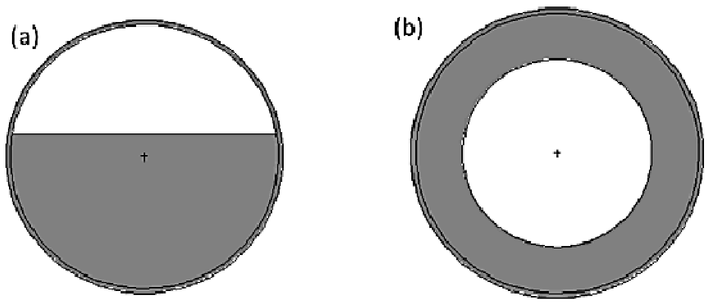
Fast Neutron Imaging

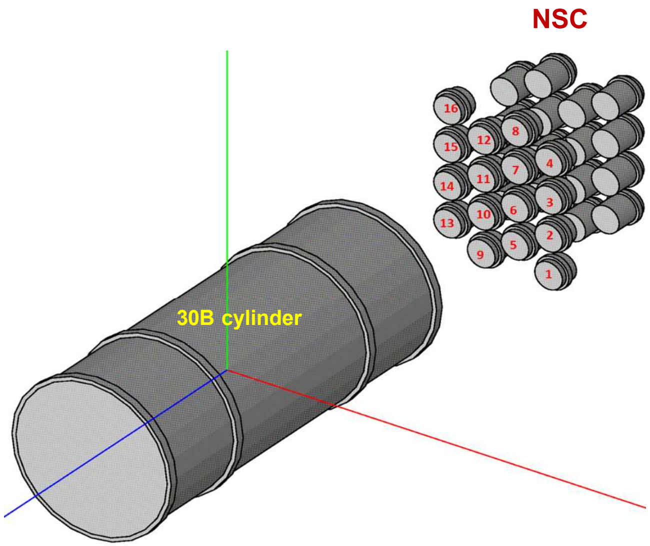
- Sandia is investigating fast neutrons spectroscopy and imaging for monitoring UF_6 in storage cylinders using a Neutron Scatter Camera (NSC).
- NSC imaging of UF_6 cylinders may support in assessing UF_6 filling profile.
- Present work is on Simulation of UF_6 30B cylinder and NSC using MCNP5/MCNPX-PoliMi to assess UF_6 filling profile through imaging.



MCNP5/MCNPX-PoliMi Modeling

- MCNPX-PoliMi used to model 30B cylinder and the NSC.
- SOURCE-4C code (RSICC, ORNL) was used to generate spontaneous fission (SF) and (α, n) neutrons spectra.
- Two distinct UF_6 filling profiles were considered; (a) Pool and (b) Shell.



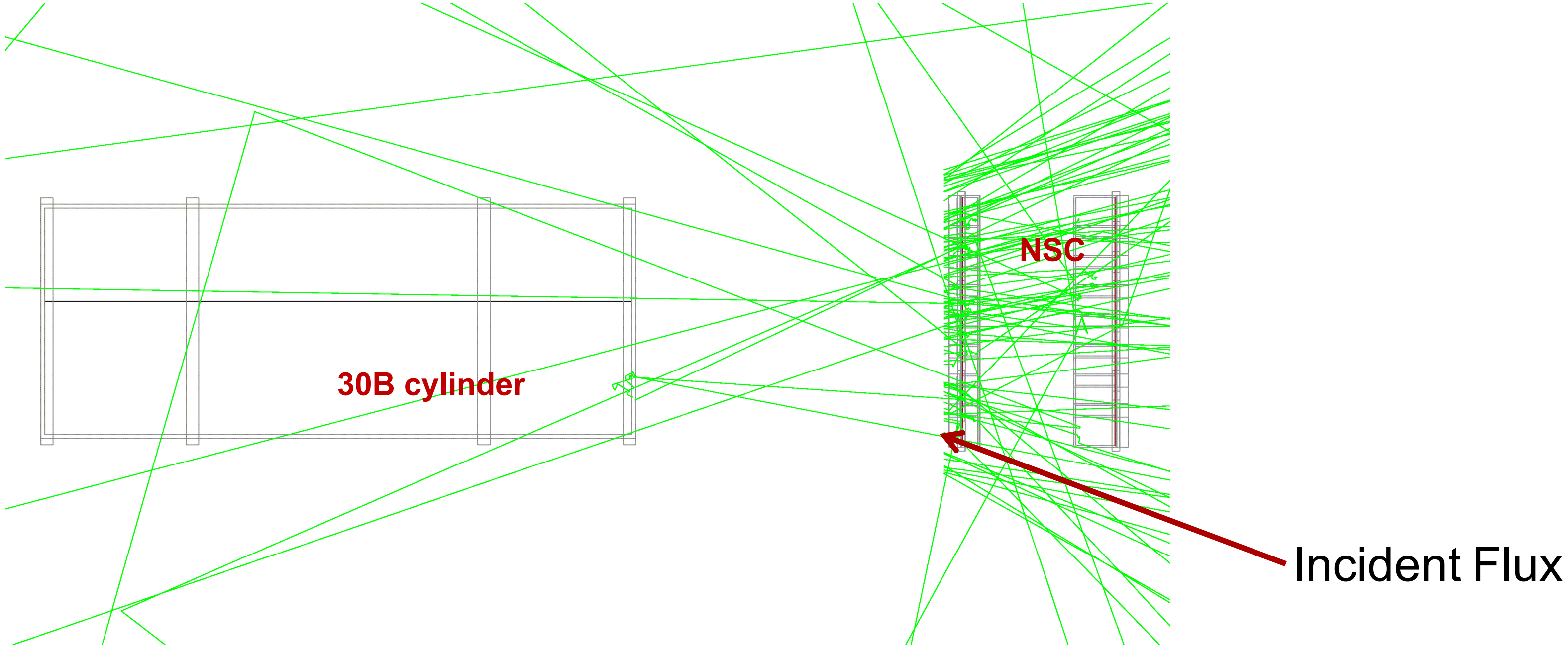


Imaging UF_6 Profile

- Is there filling profile information in the neutron flux from UF_6 cylinder?
- Is the neutron flux has volumetric information?
- Neutron flux incident on NSC was recorded using MCNP-PTRAC to ascertain the existence of filling profile information.
- Recorded flux was back projected to confirm profile information and viability of imaging before simulating NSC detector response.
- Neutron origins were tallied to assess possibility of assaying the cylinder volume.

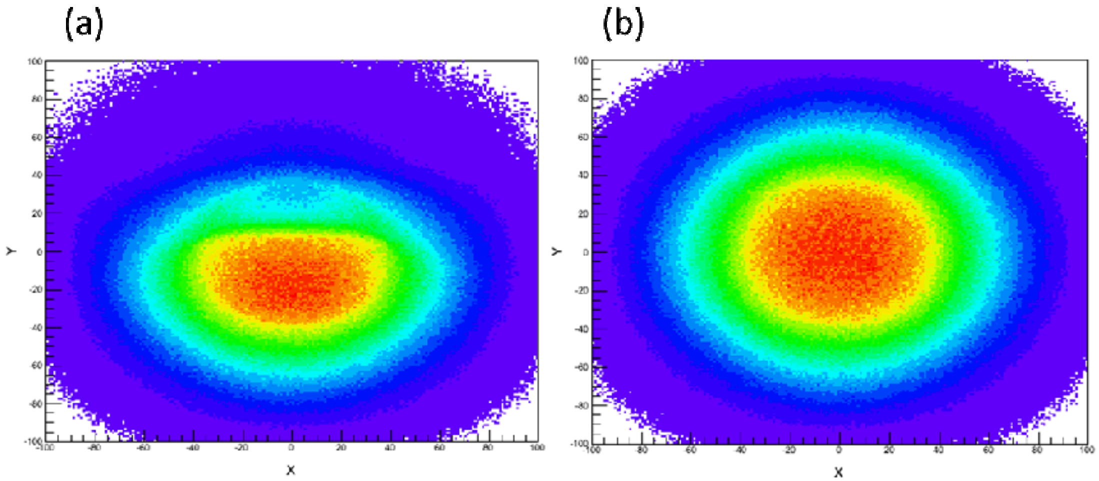
Back projecting neutron flux

- MCNP-PTRAC recorded data include position, momentum, energy, and time.
- Using the momentum and position back projected images were reconstructed for (a) pool and (b) shell profiles.



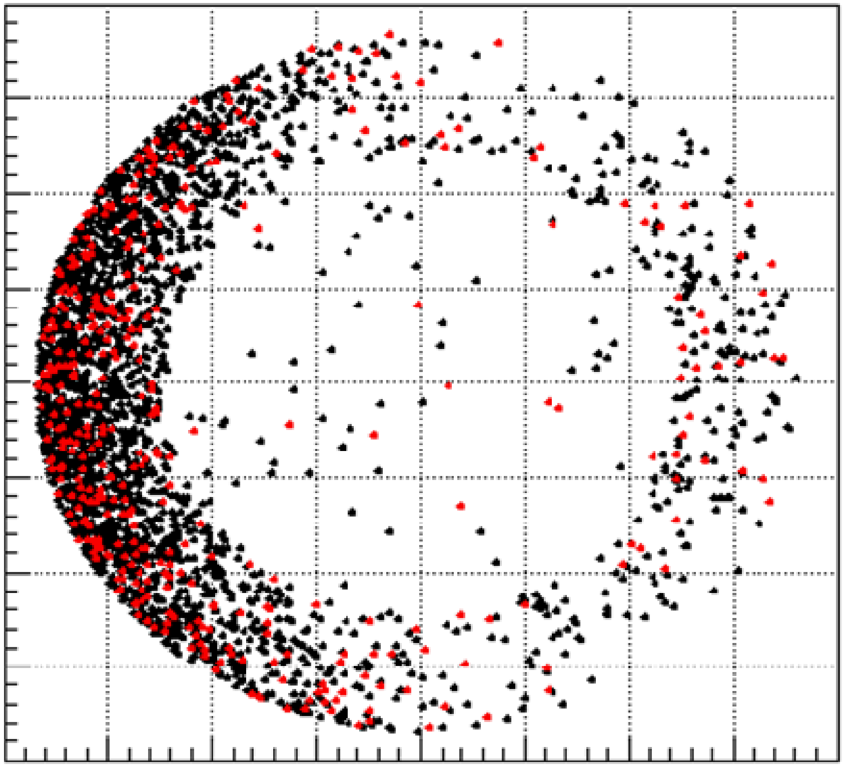
Back projecting cont.

- Reconstructed image confirmed the possibility of assaying the UF_6 filling profile through imaging.
- However simple back projection approach may not be sufficient to determine if inner cylinder is void or not.
- Image analysis is under investigation to assess inner cylinder fill pattern.



Back projecting cont.

- Simulation proved reconstructed image contains information from cylinder volume and enables assaying the whole 30B cylinder volume.



Methods

- Neutrons interacting and depositing energy in the NSC were recorded.

- Coincident neutron energies deposited in the NSC front and back detectors were folded with the NSC response function.

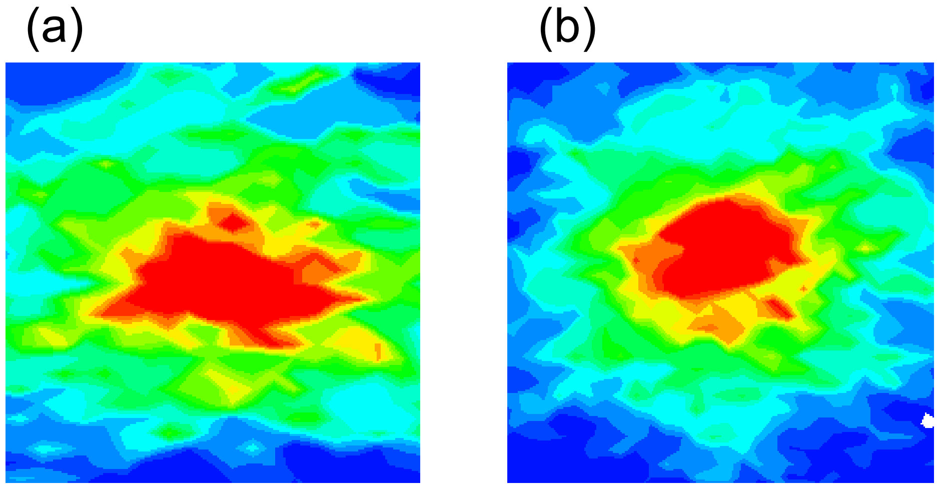
- Back projection technique was used to reconstruct the UF_6 filling profile images.

Results

- Preliminary results of reconstructed images for the two filling profiles considered have shown some differences.

- Results are for 10^9 source MCNP histories resulting few thousands NSC recorded coincident events.

- Work is in progress to improve the result:
  - Implement deconvolution using point spread functions for detector response
  - Investigate different energy cuts
  - Simulate more source histories for a better statistics



Conclusion

- Viability of fast neutrons imaging using NSC for assaying UF_6 filling profile in 30B cylinder is considered.
- Preliminary results indicate possibility of imaging to assay UF_6 filling profile.
- Imaging can eliminate uncertainties in UF_6 enrichment and mass determination.
- Future work will address:
  - Better image reconstruction and analysis for accurate assaying of UF_6 profile
  - Modeling other possible UF_6 filling profiles
  - Developing metrics for discriminating UF_6 filling profiles

Acknowledgements

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