LA-UR-23-29659

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Title:	Preliminary results of lead shielding effects on neutron assay of 233U contain items
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Intended for:	I will be presenting this as part of a independent review (Schubert Review) for the Thorium Fuel Safeguards project.
Issued:	2023-08-31 (rev.1)

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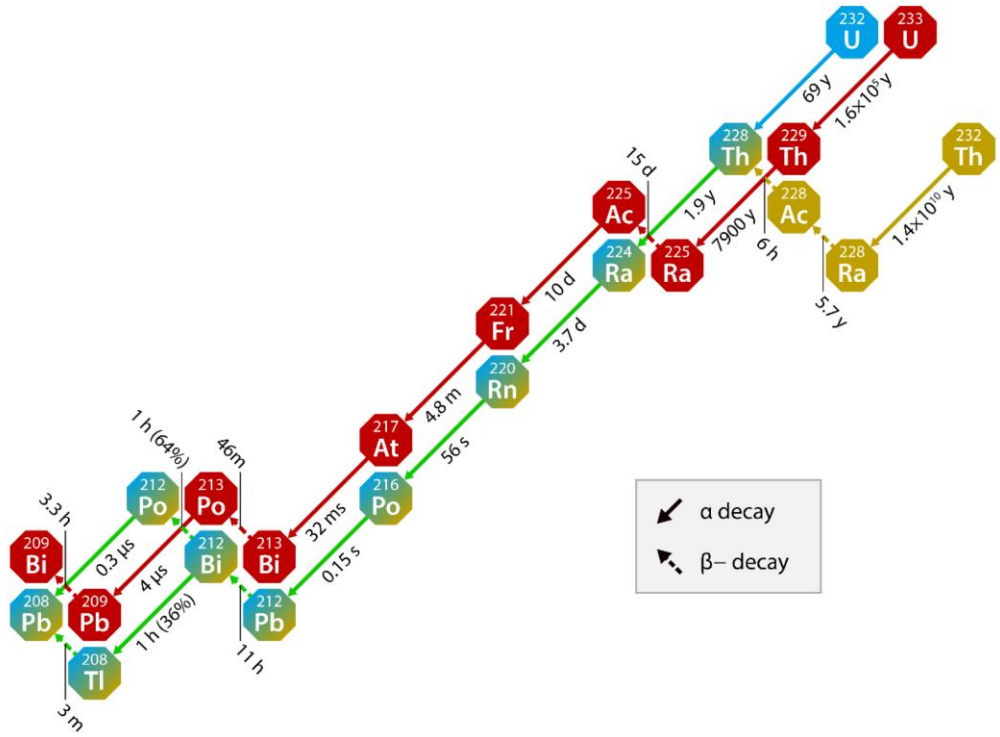
Preliminary results of lead shielding effects on neutron assay of 233U containing items.

Daniel Jackson, Madeline Lockhart, Vlad Henzl

8/15/2023

Lead Shielding and ^{233}U containing items

- 232U impurity causes a build of of 208Ti in the material
- 208Ti has a 2614 keV gamma ray associated with its decay
- Lead shielding necessary to protect workers

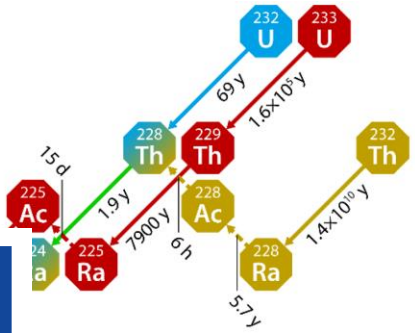


Safeguards Technology for Thorium Fuel Cycles: Research and Development Needs Assessment and Recommendations (2021)

Lead Shielding and ^{233}U containing items

- 232U impurity causes a build of of 208Ti in the material
- 208Ti has a
  associated
- Lead shield
  workers

Metal	Dose Rate (rem/hr)	Hours
Weapon-grade plutonium	0.0013	3800
Reactor-grade plutonium	0.0082	610
^{233}U containing 1 ppm ^{232}U	0.013	380
^{233}U containing 5 ppm ^{232}U	0.059	80
^{233}U containing 100 ppm ^{232}U	1.27	4
^{233}U containing 1% ^{232}U	127	0.04



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Possible effects of lead shielding

1 Moderation – Bad moderator, still could affect the detectors efficiency.

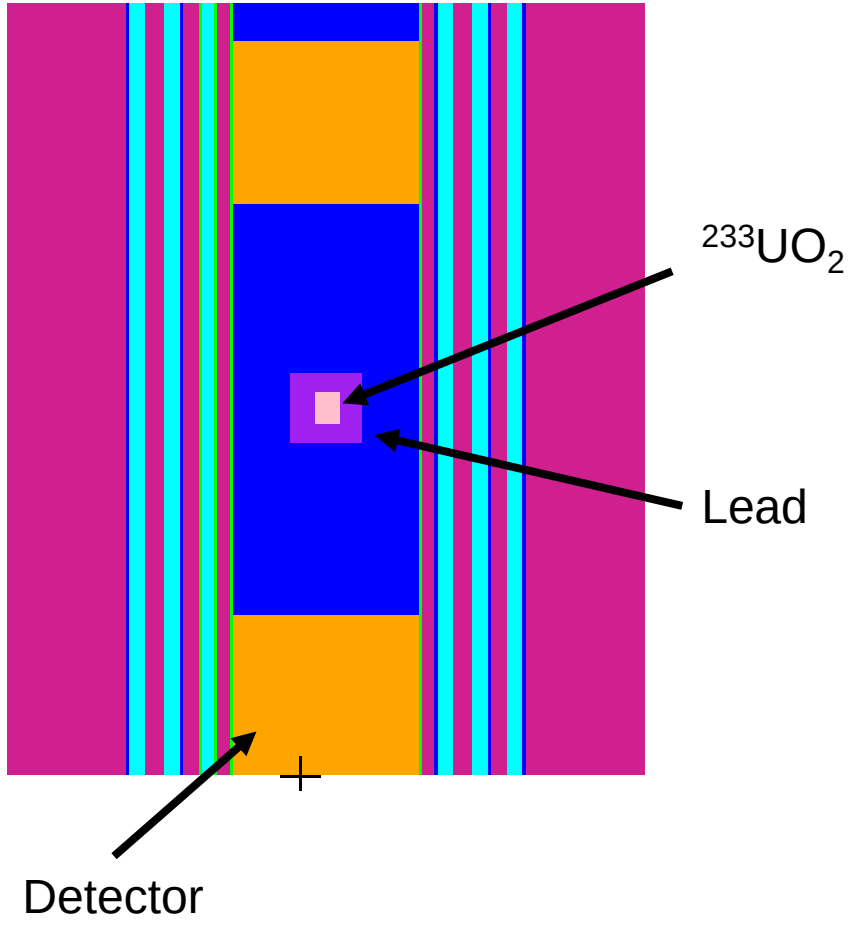
2. N-2N reactions – fission spectrums overlap with lead N-2N could cause increase in doubles.

3. Neutron Reflector – Neutrons reflected back into the sample inducing fission.

MCNP simulations of ENMC with lead shielded sources

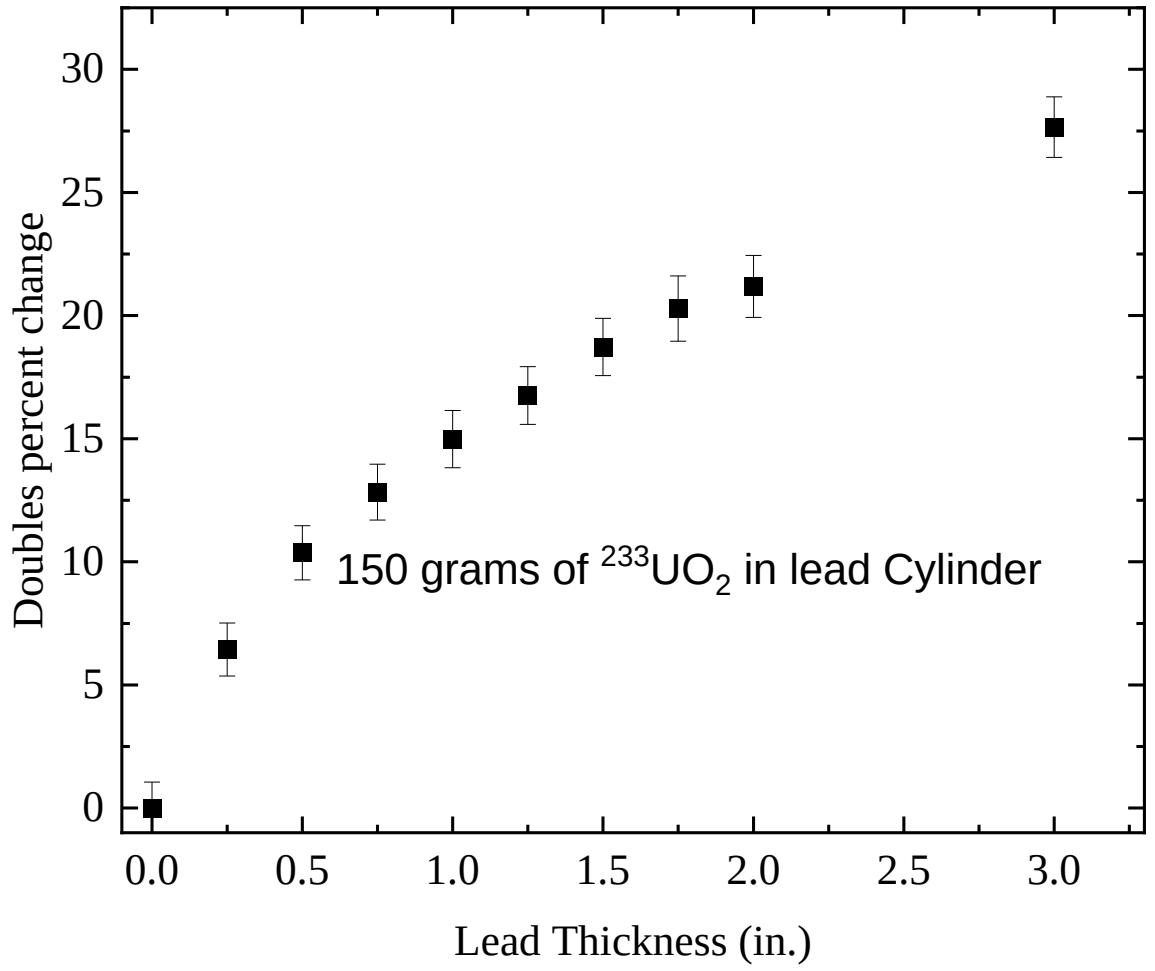
- Same mass and shape of $^{233}UO_2$
- Lead shielding thickness was changed to get trend
- Simulation results were run through in house software to generate rates based off standard gate lengths of ENMC
- High fidelity model of ENMC that has been bench marked to past experiments.

150 grams $^{233}UO_2$ inside of lead shielding



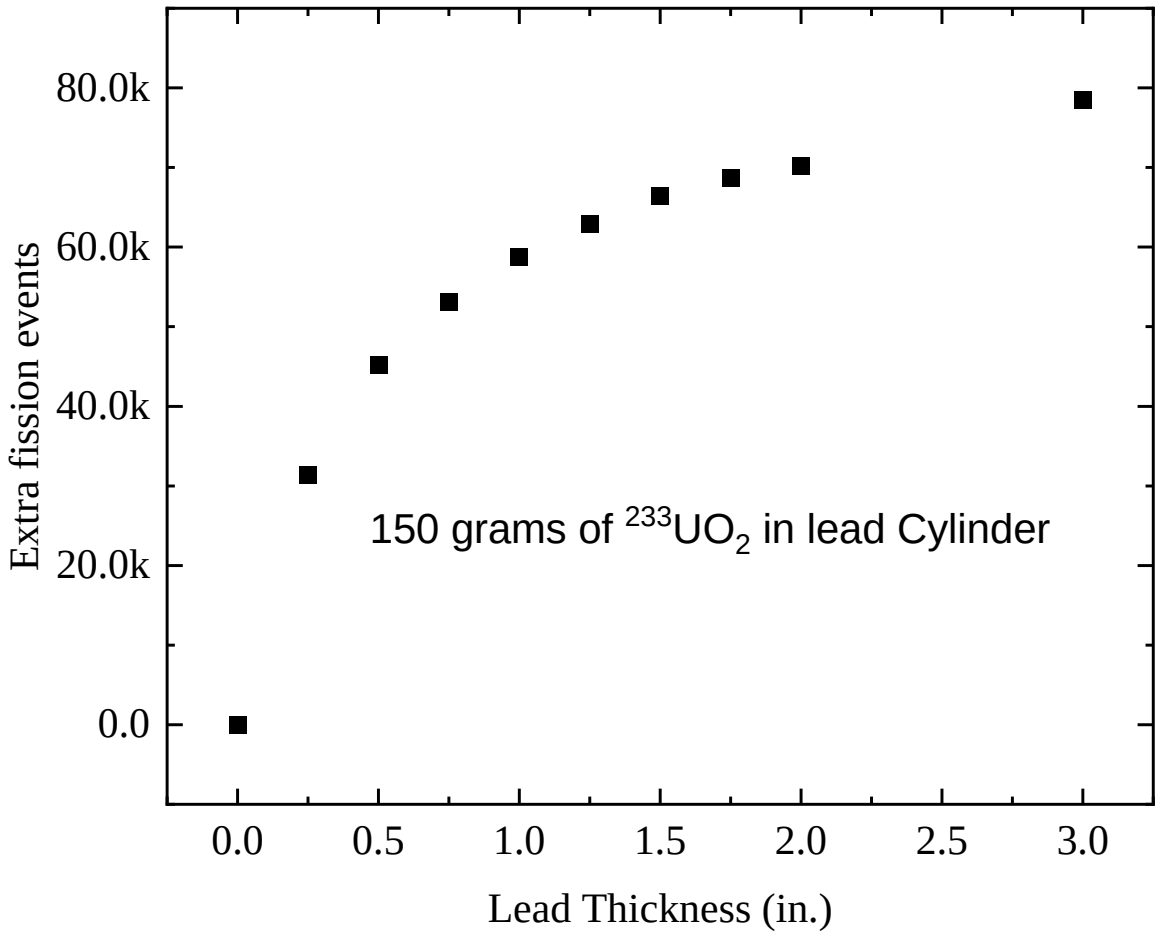
MCNP Simulations of $^{233}UO_2$ in lead shielding

- Lead shielding resulted in a significant increase in the doubles rate
- 3 inches is the maximum lead shielding fitting in ENMC

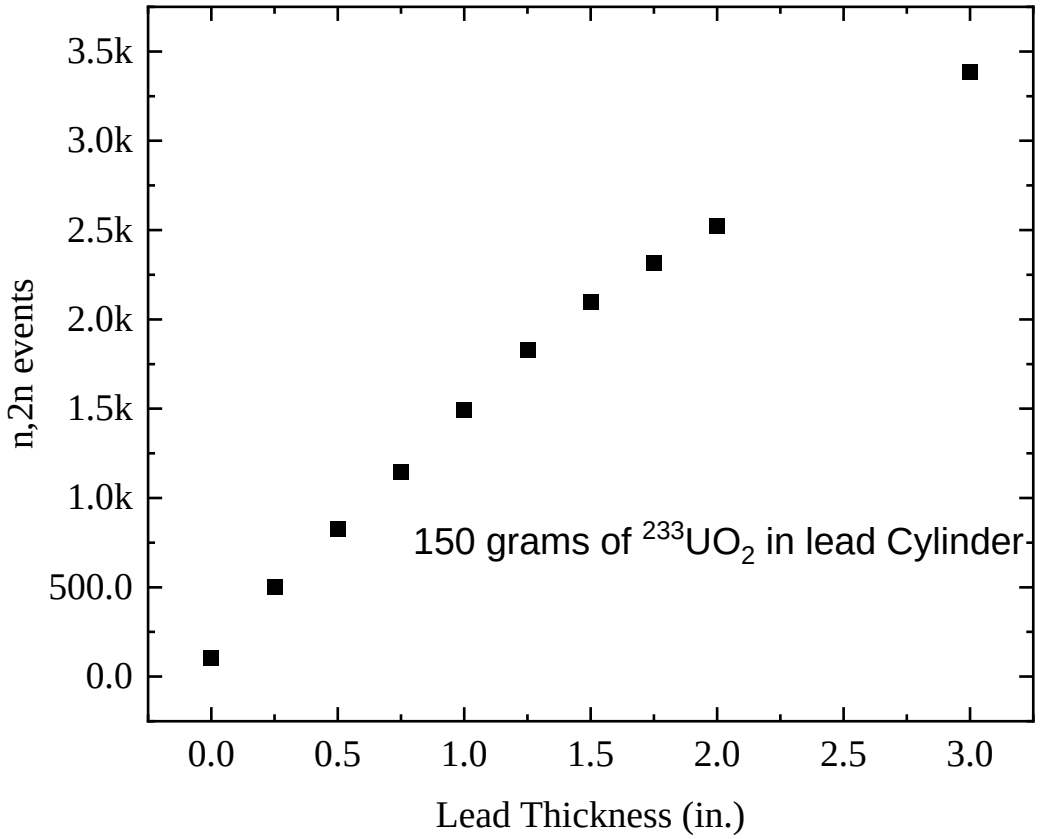


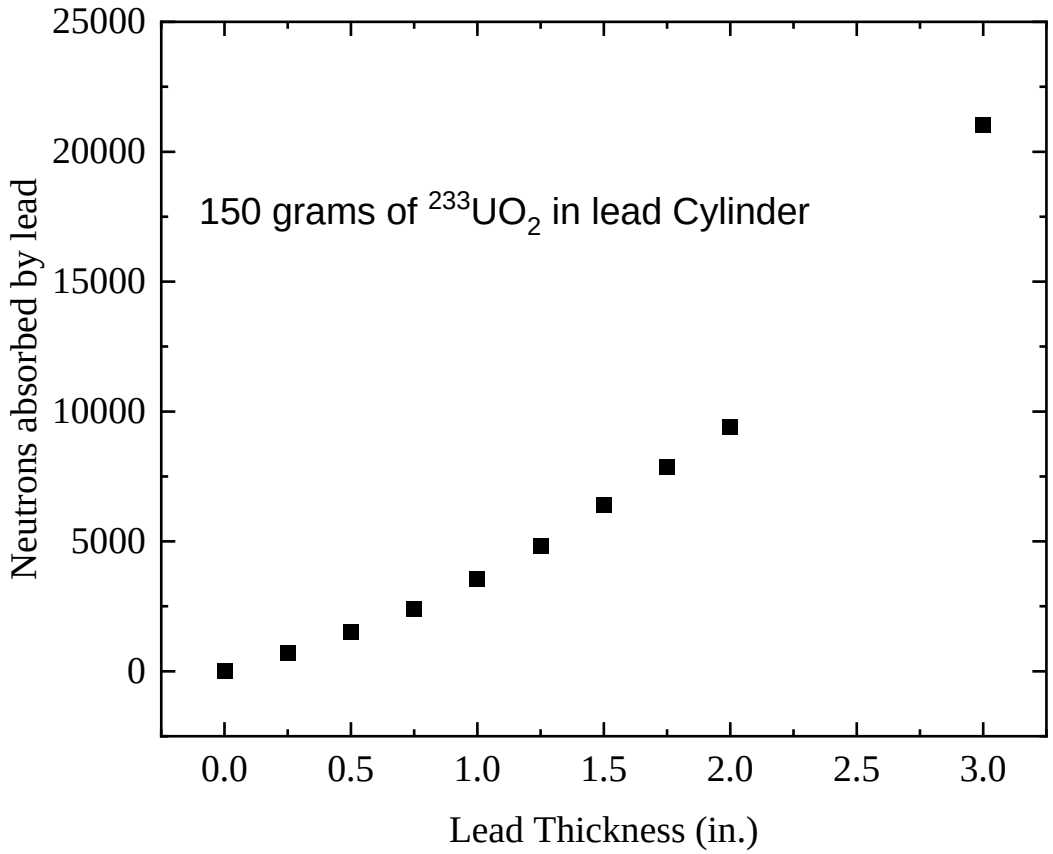
MCNP Simulations of $^{233}UO_2$ in lead shielding

- MCNP simulation reports number of fission events
- Lead increased number of fission events by 80,000 at 3 inches of lead.
- Neutron reflection strong effect on $^{233}UO_2$



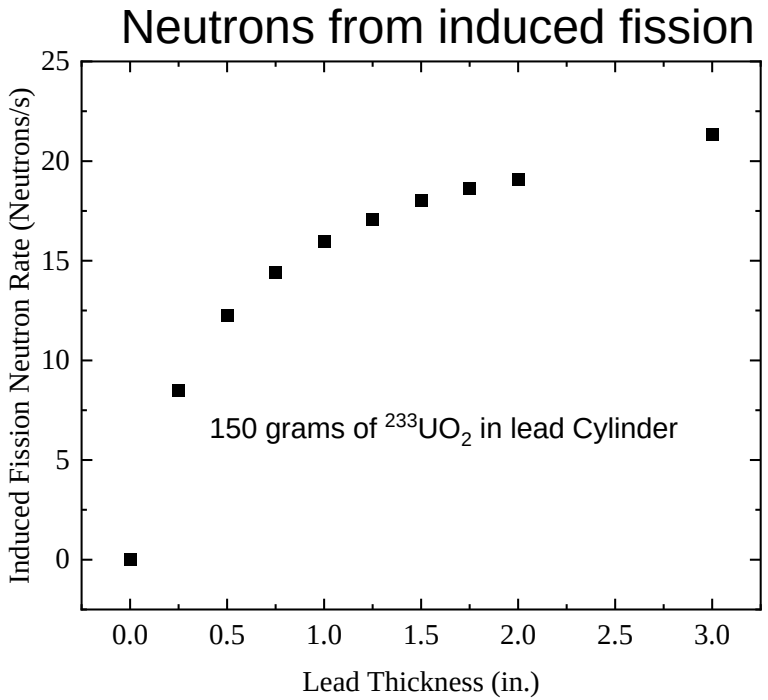
N-2N and lead absorption of neutrons

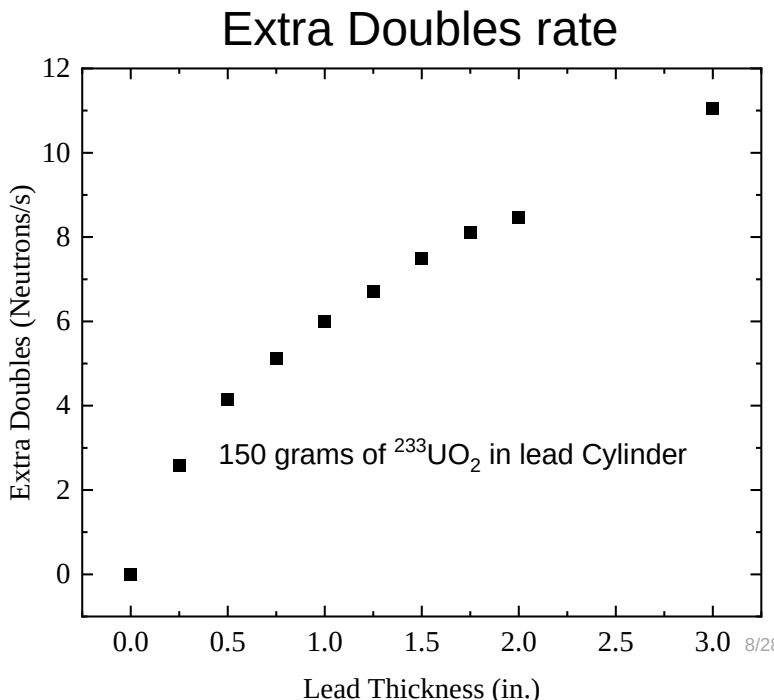




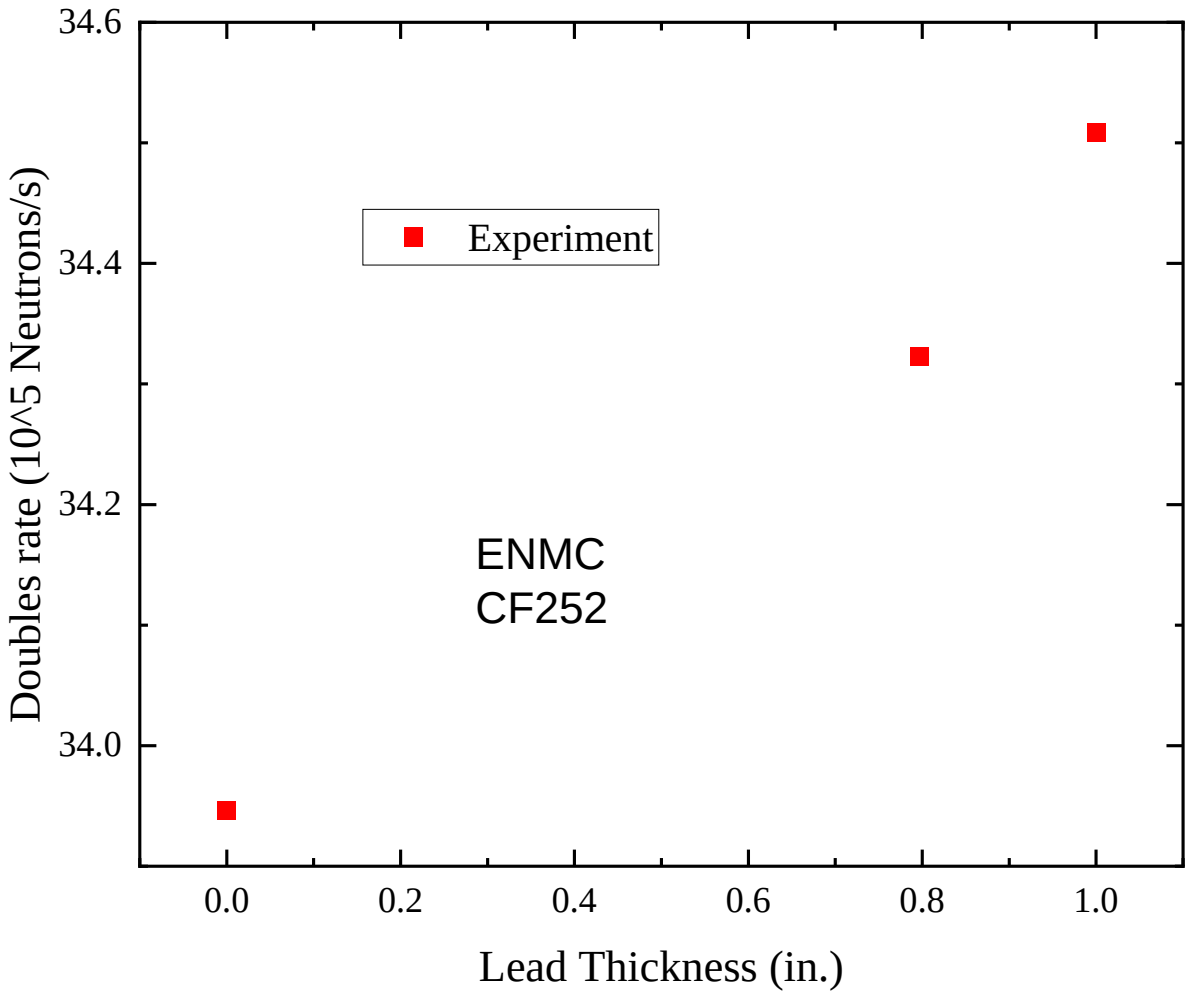
Induced fission drives the increase in doubles rate

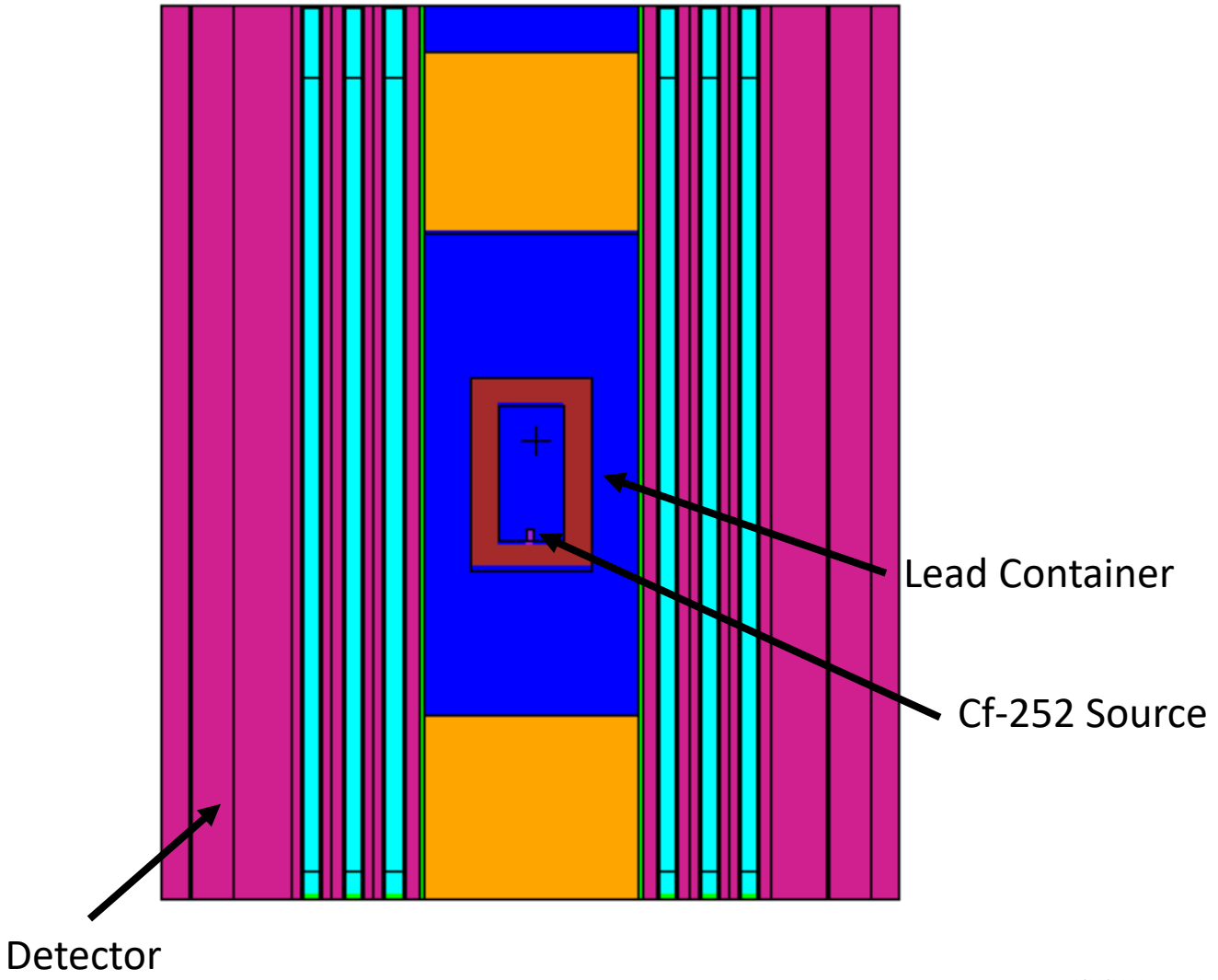
- The adding of lead shielding for 233UO2 is predicted to significantly increase the doubles rate.
- The doubles rate in neutron measurements is often used to determine the mass of material present.
- Understanding how to adjust for this increase may require using triples as the amount of lead and material may both be unknown.





Measurement of Cf-252 to help benchmark effects of lead without access to sufficient $^{233}UO_2$ samples





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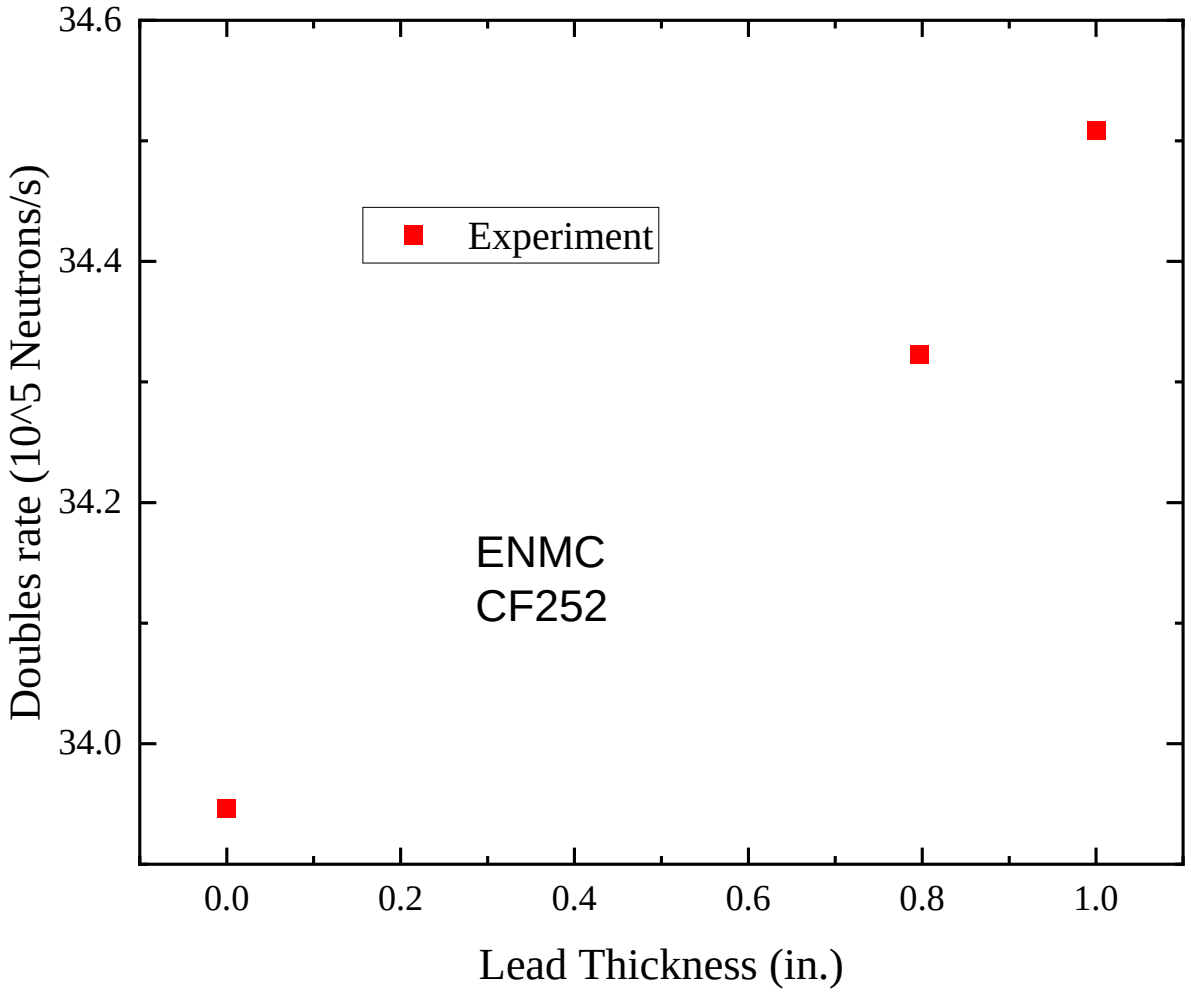
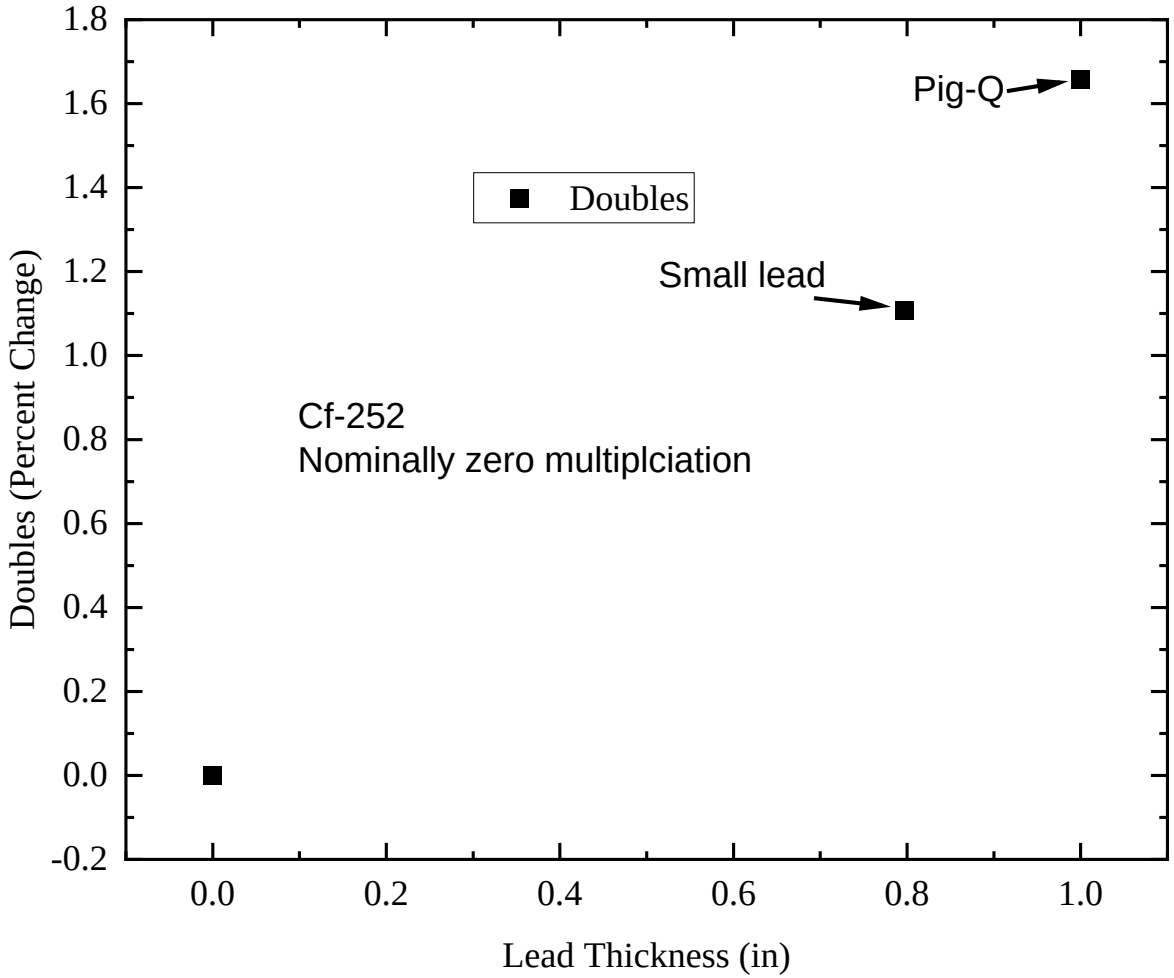
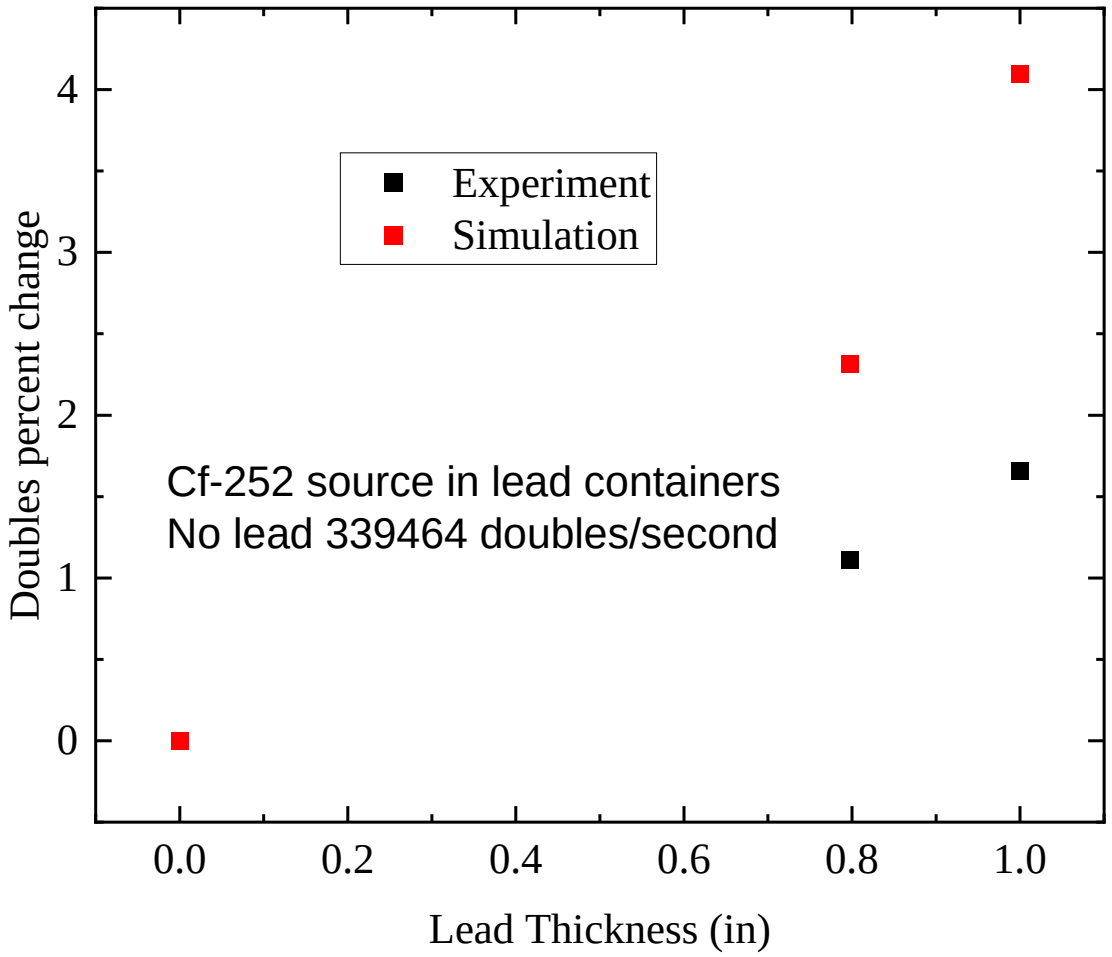




Initial simulations of Cf-252 are not completely consistent

- Rate of Cf-252 sample in experiment was 852K neutrons per second
- ENMC captures 62% of neutrons and not typically used for sources of such high intensity
- Simulation data is being run through in house software including dead time adjustments..
- Future measurement with less intense source, and with sources with higher induced fission total cross section (Pu or ^{235}U) in lead.



Future work to lock down lead effects

- Measure Cf-252 source with more similar activity to 150 grams of $^{233}UO_2$.
- Measure other materials such as plutonium in lead (large enough to get induced fission from reflection).
- Simulations of varying masses of $^{233}UO_2$ in lead.
- Experiments of samples in lead when $^{233}UO_2$ is available.