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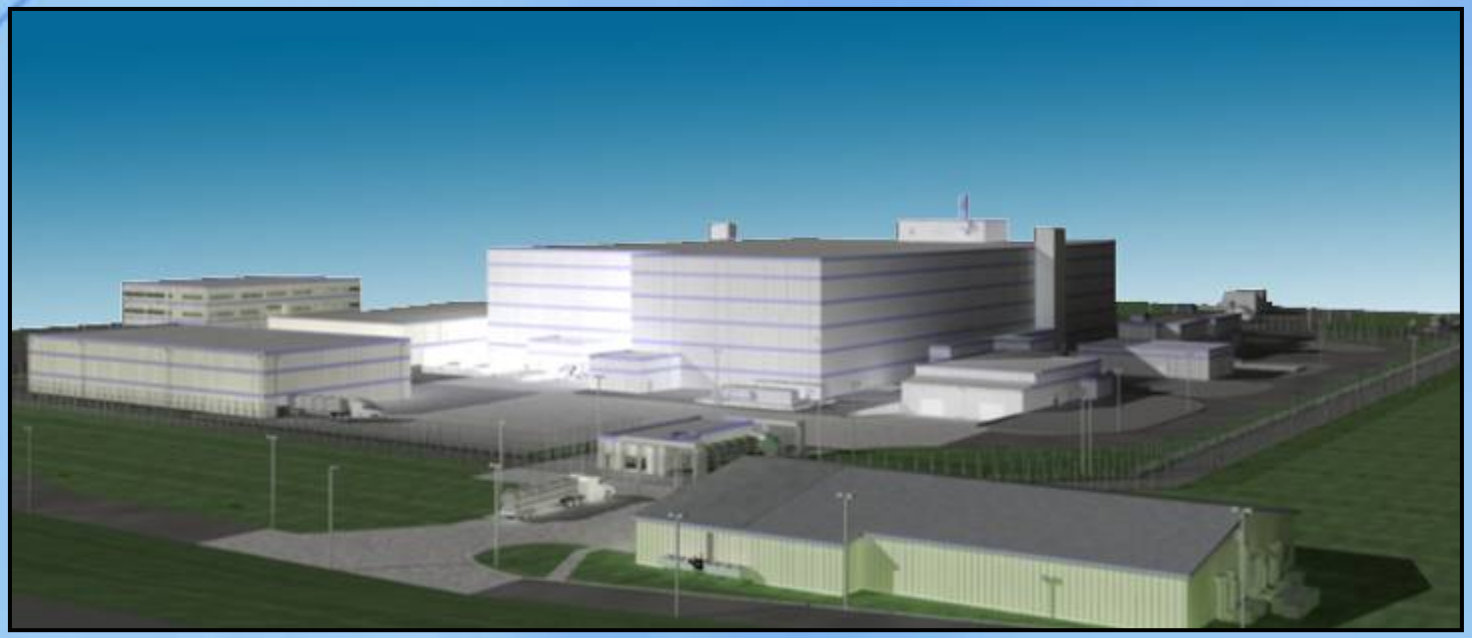
In-Line Neutron Detection in High Background



Derrick Faunce Nuclear Safety Engineer I
Robert Eble Nuclear Safety Lead, Radiation Protection

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Bio of Authors

- Robert Eble-Nuclear safety manager for the Mixed Oxide Fuel Fabrication Facility. He has worked in the nuclear industry for 32 years in design engineering at Duke Power company, on the high level waste contract for spent fuel storage and with AREVA on MOX. He is a graduate of LSU with a masters degree in nuclear engineering. He has been a member of the American Nuclear Society for 33 years. He has been married to his wife Melanie for 32 years, he has 4 children.

- Derrick Faunce- is a recent graduate of Georgia Institute of Technology, BSNRE 08. He is a Nuclear Safety Engineer at the Savannah River Site on the MOX Project and has been a member of the American Nuclear Society since 2004. He was recently married on Aug 7th, 2010 to his wife Jasmin.

Objective

- Determine response of He-3 neutron detector to low concentrations of Pu in a laboratory waste tank in a high background environment
- Detect concentrations appropriately above background levels (>200% background)
- Prevent down-stream criticality

Assumptions

- 10 min count time
- Dead zone size of detector (as guided by vendor)
- Background level depending on materials in process cell

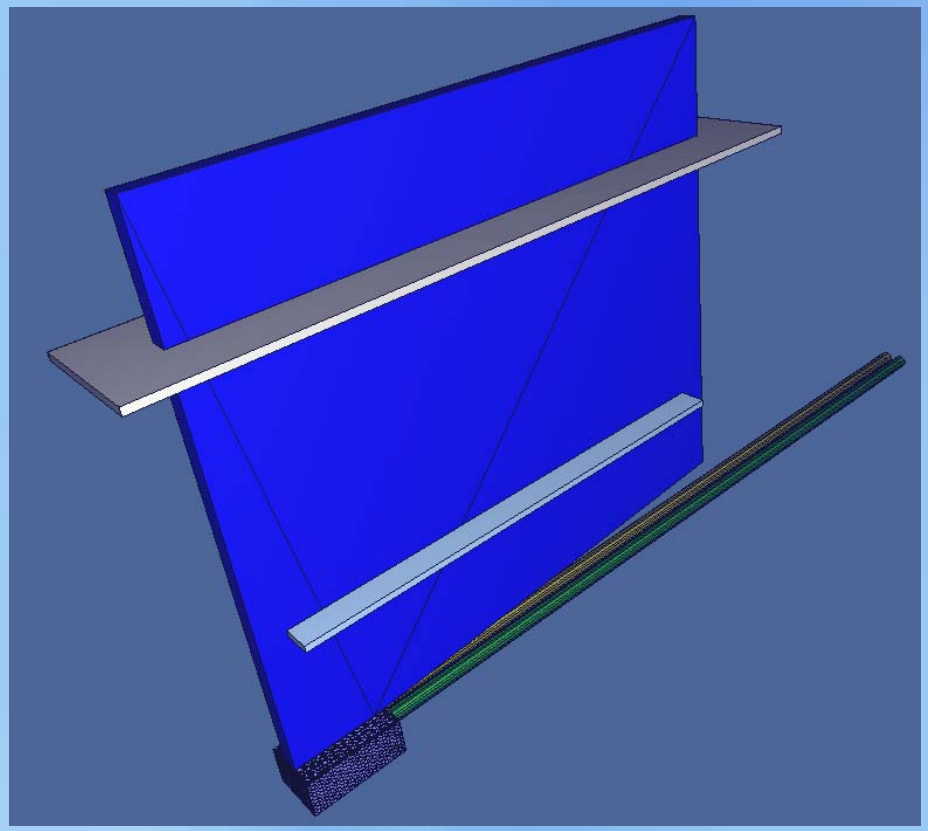
Approach

- Determine detector count time from fill rates
  - Sampling time is defined by the number of samples taken during tank fill (around 5-10)
    - 82 min. max fill time →10 min. sampling time
  - The count time is not too long. Limit mass of Pu during filling to below the allowable limit during a counting sequence

Modeling Code

- MCNP5
  - Model Tank and associated components, HDPE Block, 15cm He-3 Detector, and Pu nitrate source
  - Tally the He^3 (n,p) H^3 reaction rate within the He-3 detector volume

Tank View



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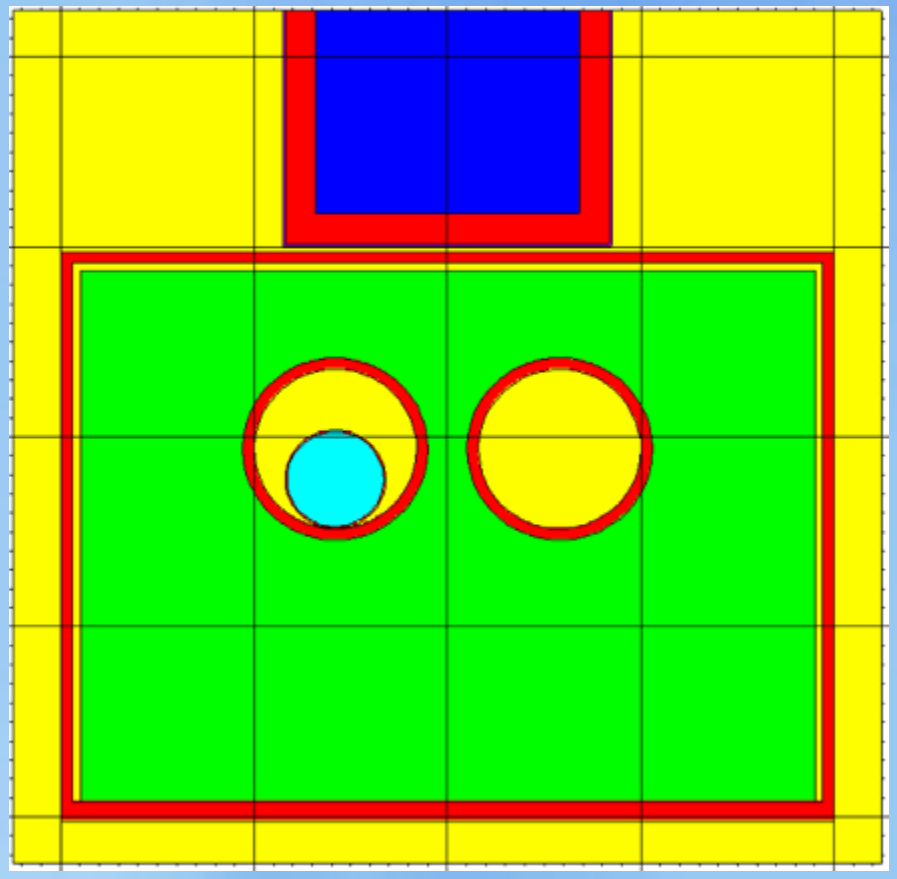
Detector View



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Determination of Alarm Threshold

- Neutron Counting Normal Statistical Process
- Comply with Max Spurious Alarm Probability, threshold set at 5σ above background level.
  - For safety considerations, background is considered an effective signal:

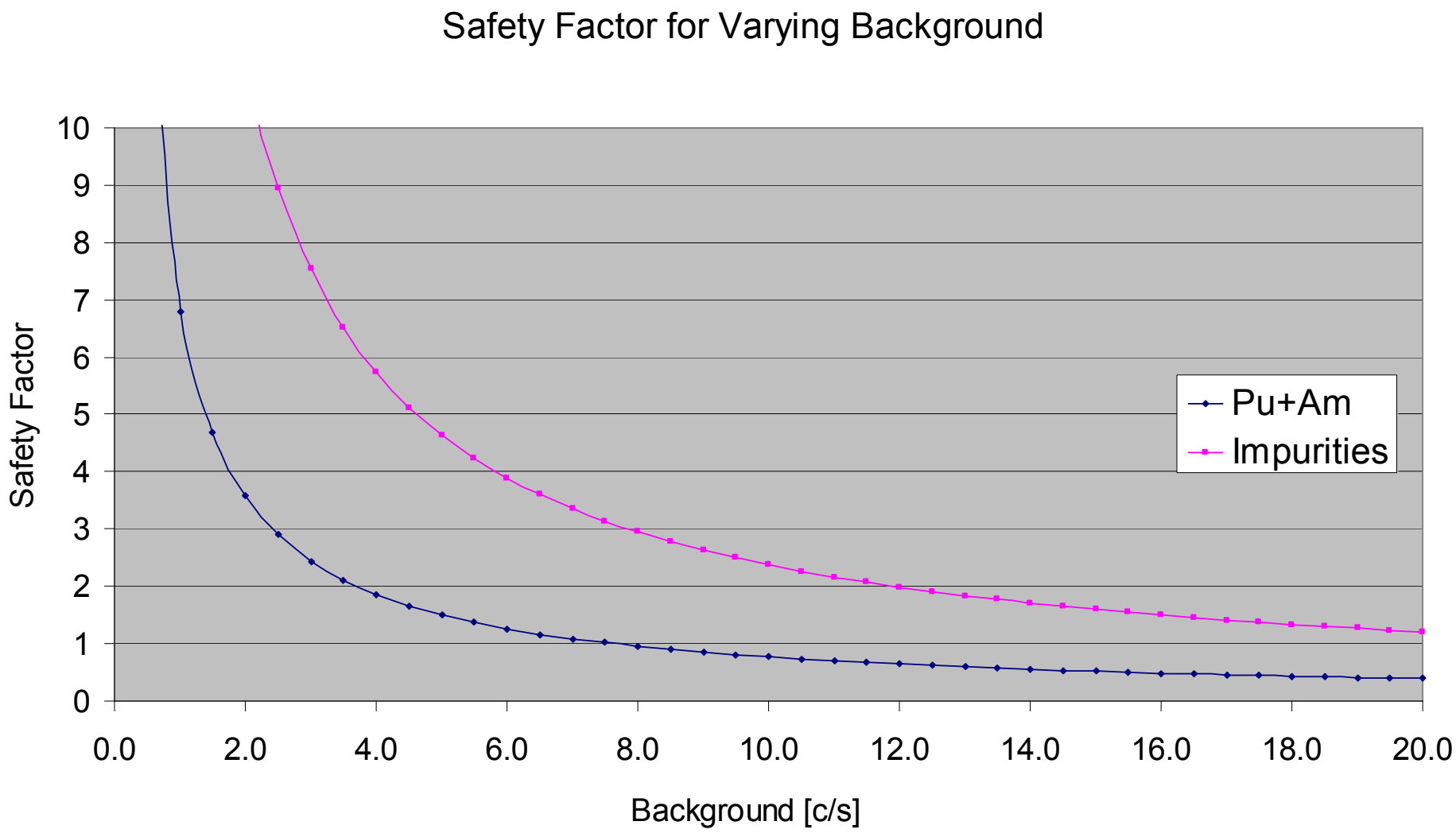
$$T_A = \frac{bg + 5\sqrt{bg}}{eff_d \times t}$$

High Background Scenarios

- High concentration tanks in the process cell with the lab waste tank
  - Background level ~20 c/s when tanks full
  - When tanks empty ~1.5 c/s
- Consider both cases for feasibility of detector response

Results

- As expected, detector response is highly sensitive to background
- For the limiting case, Pu+Am composition, the detector cannot perform to an acceptable safety factor at background levels above 4 c/s



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Conclusions

- Pu+Am the restricting case for neutron sensitivity
- When other high concentration tanks are full, the detector cannot perform with an acceptable safety factor due to high background levels
- The detector system can perform as long as the background level is <4 c/s (empty tanks)

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Alternative Solutions

1. Use multiple/more sensitive detectors
2. Increase shielding around detector
   - Additional 30cm HDPE gives background of ~0.7 c/s, which is acceptable
3. Alternative Criticality Safety Strategy to avoid reliance on detector. Use detector as defense-in-depth.

- Solutions 1 & 2 can be cost prohibitive due to design change and delivery schedules.

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Contact Information

Derrick Faunce
803.819.2090
DTFaunce@moxproject.com

Robert Eble
803.819.2255
RGEble@moxproject.com

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