Criticality Accident Analysis for INL Shielded Hot Cells

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Fuel Conditioning Facility

Outline

- Requirements
- Fuel Conditioning Facility
- Hot Cell Windows
- MCNP Calculation
- Results
- Conclusion

Requirements

ANSI/ANS 8.3, "Criticality Accident Alarm Systems"

4.2.1 *The need for a criticality alarm system shall be evaluated for all activities in which the inventory of fissionable material in individual unrelated areas exceeds 700 grams of U-235, 500 grams of U-233, 450 grams of Pu-239, or 450 grams of any combination of these three isotopes….*

4.2.2 *A criticality alarm system meeting the requirements of this standard shall be installed in areas where personnel would be subject to an excessive dose….*

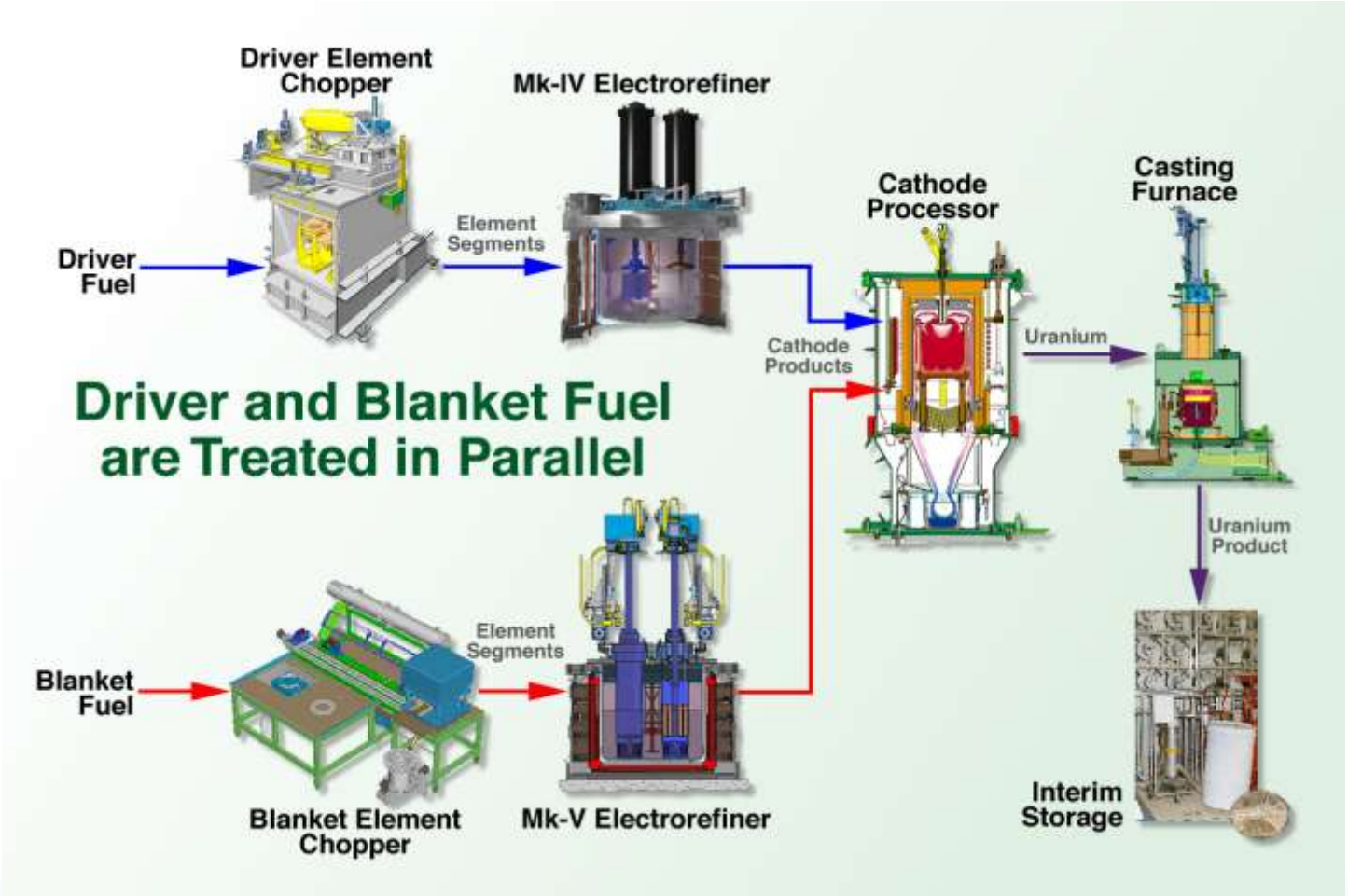
Excessive Radiation Dose **-** *Any dose to personnel corresponding to an absorbed dose from neutrons and gamma rays equal to or greater than 12 Rad in free air.*

ANSI/ANS 8.23, "Nuclear Criticality Accident Emergency Planning and Response"

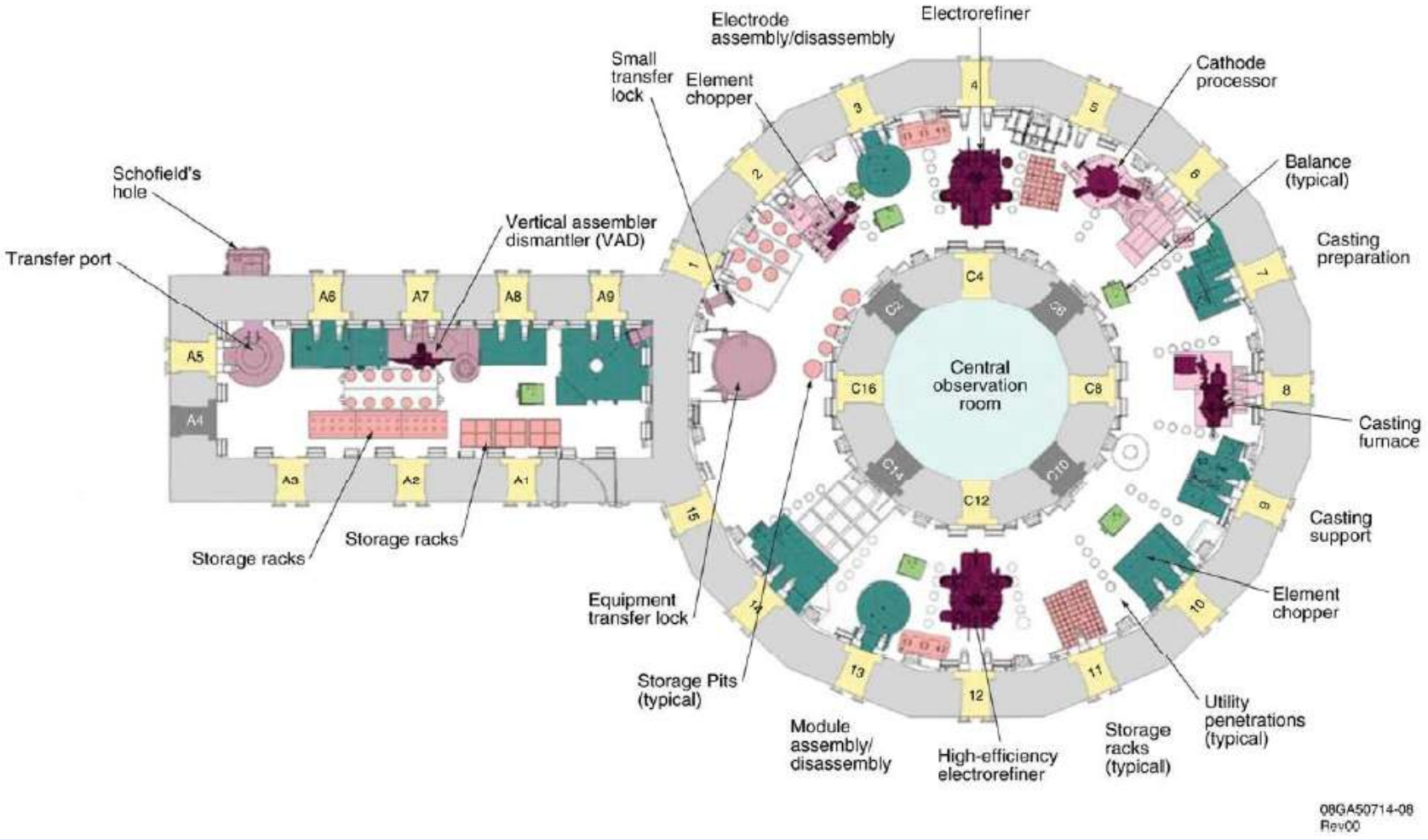
5.1.1 *An evaluation shall be conducted and documented to identify potential criticality accident locations.*

5.1.2 *If the above evaluation indicates that a criticality accident is credible, the evaluation shall describe the bounding accident. This description may be based on professional judgment or a more detailed analysis. The description should include the estimated fission yield...*

Pyrometelurgical Processing (1990's)



Fissile Materials in Hot Cells



Where could an excursion occur?

- Work Stations
- Process Equipment
- Fissile Material Storage Areas

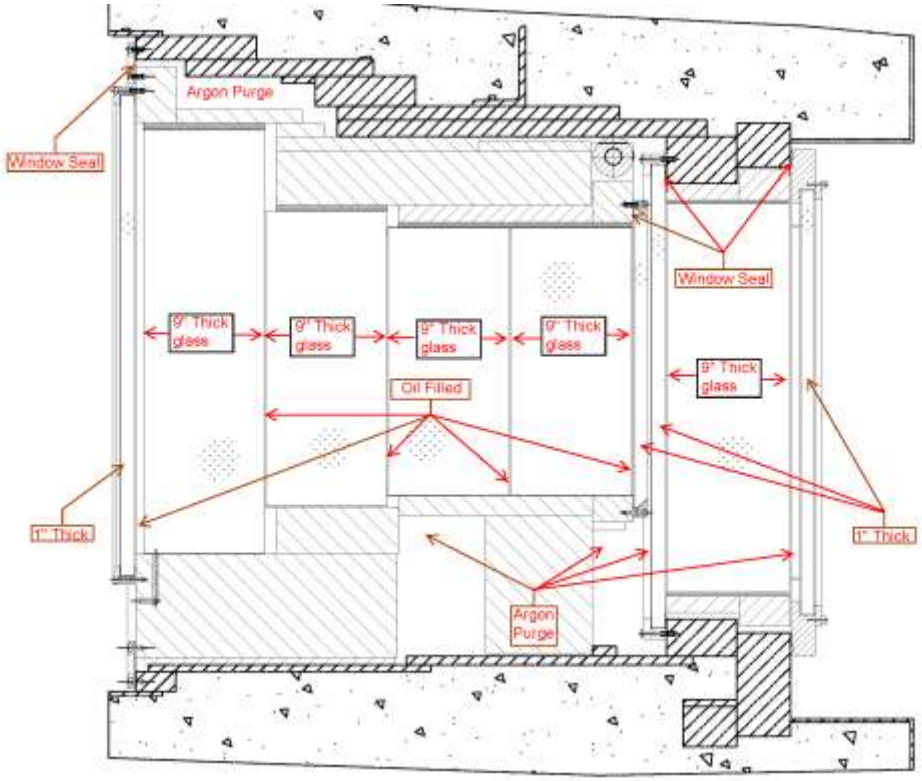
Where type of excursion?

- Dry
- Metal

Hot Cell Shielding

Hot Cell Window

Slab Identifier (right-to-left)	Thickness (inches)	Density (g/cm^3)
A (hot)	1	2.7
B	9-1/16	3.3
C	1	2.7
D	1	2.7
E	9-1/16	3.3
F	9-1/16	3.3
G	9-1/16	3.3
H	9-1/16	3.3
J (cold)	1	2.5



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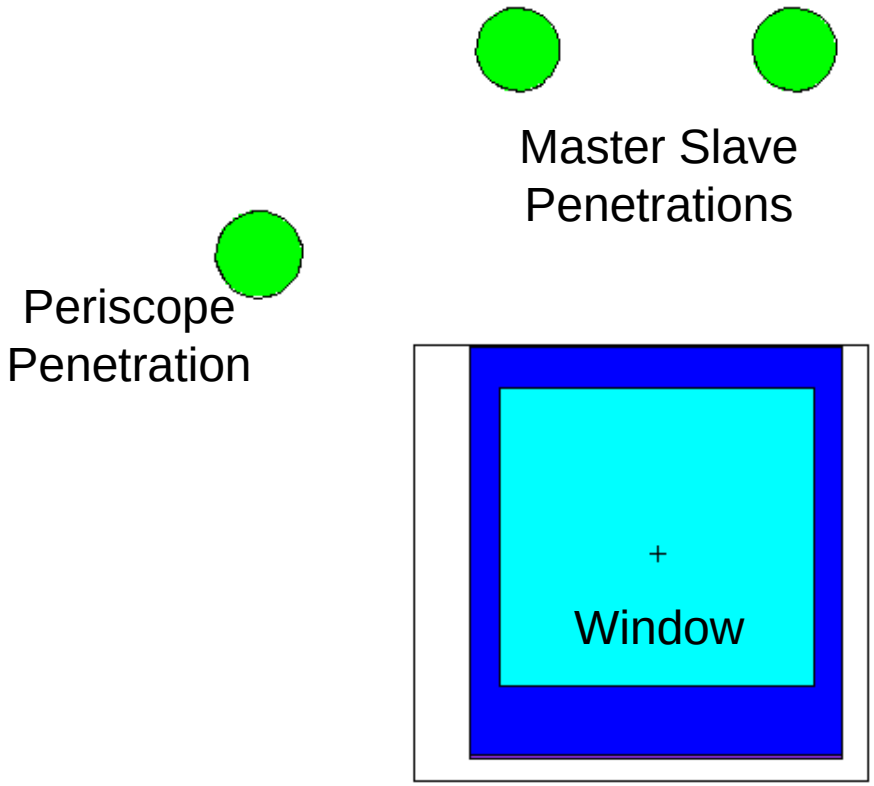
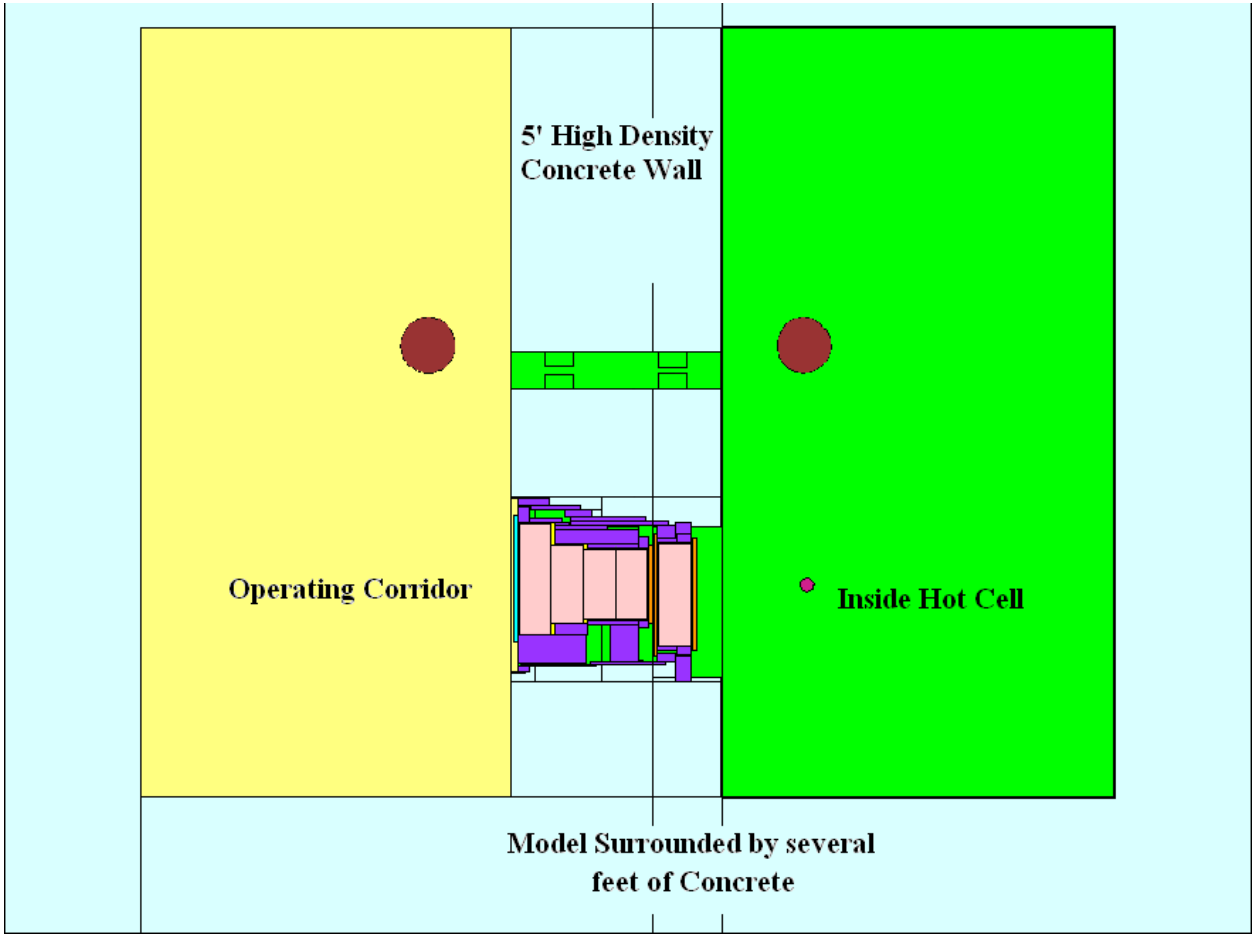
Hot Cell Primary Shielding Components

1) 5 ft thick high-density concrete walls
2) 4 ft thick concrete ceiling and floor
3) Additional ½ inch seal-welded liner in Argon Cell
4) 27 Viewing Windows
    1) 9 glass slabs ranging in density 2.5 – 3.3 g/cc
    2) ~4 ft of high density glass
    3) High Purity Mineral Oil fills 5 of the 8 gaps

Operating Corridor Shielding (Front)

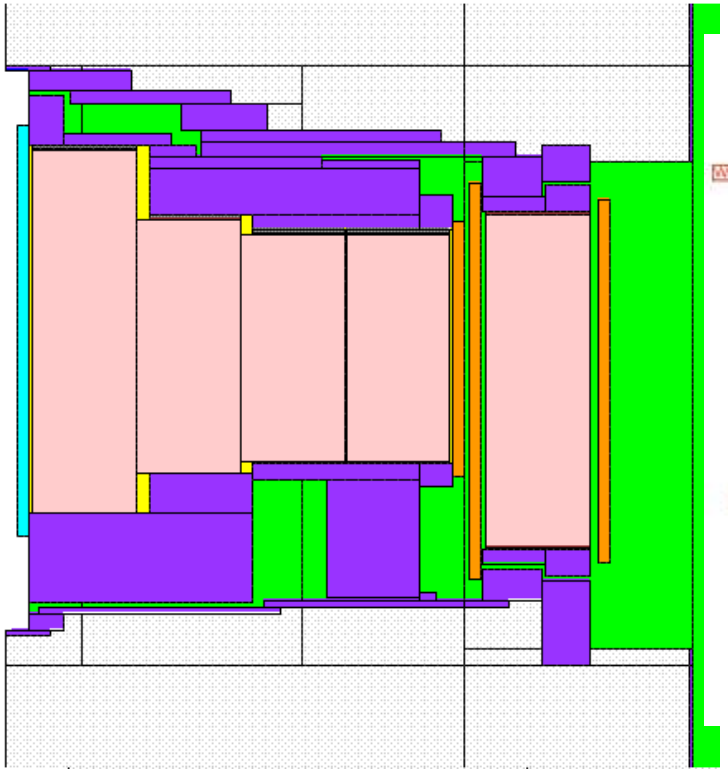


MCNP Operating Corridor Model

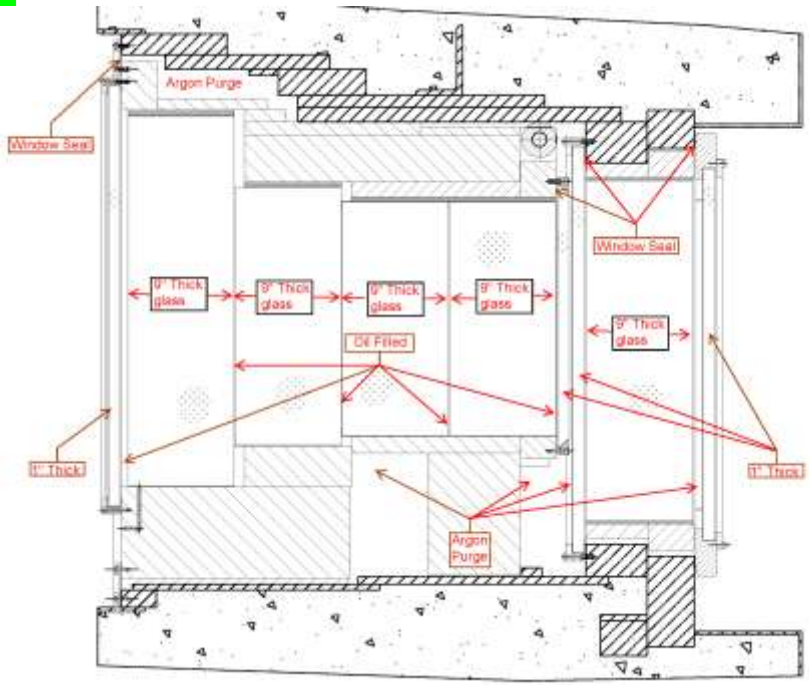


Observation Window

MCNP Model



Drawing



Dose Calculations

- **Criticality Source**
  - **10 kg Pu Sphere**
  - **Maximum Fission Yield of 10^{17}**

DOE-HDBK-3010-94 (Dry Power and Metal System)

- **MCNP**
  - **KCODE**
  - **F5 point detector (dose-in-air)**
  - **Variance Reduction**

Dose Calculations (cont.)

$$D_{\max} = D_f \cdot FY_{\max}$$

Maximum Dose per excursion (D_{max})

Dose per Fission (D_f)

Maximum Fission Yield

$$D_f = \nu \cdot \left(D_n + D_\gamma \right)$$

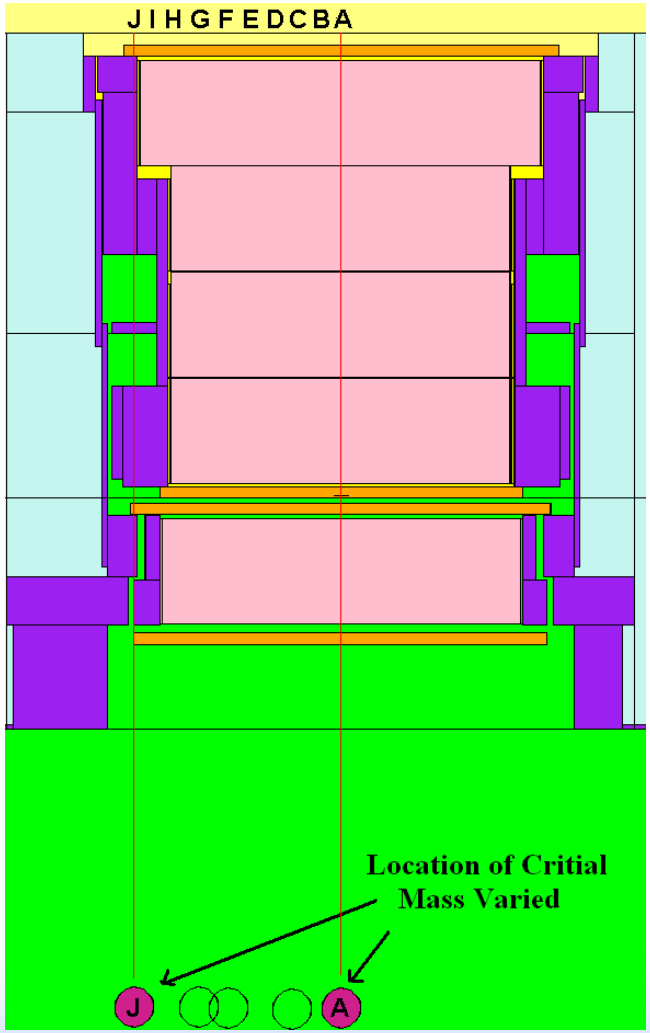
Neutrons per fission (ν)

Neutron Dose per Fission Neutron (D_n)

Photon Dose per Fission Neutron (D_γ)

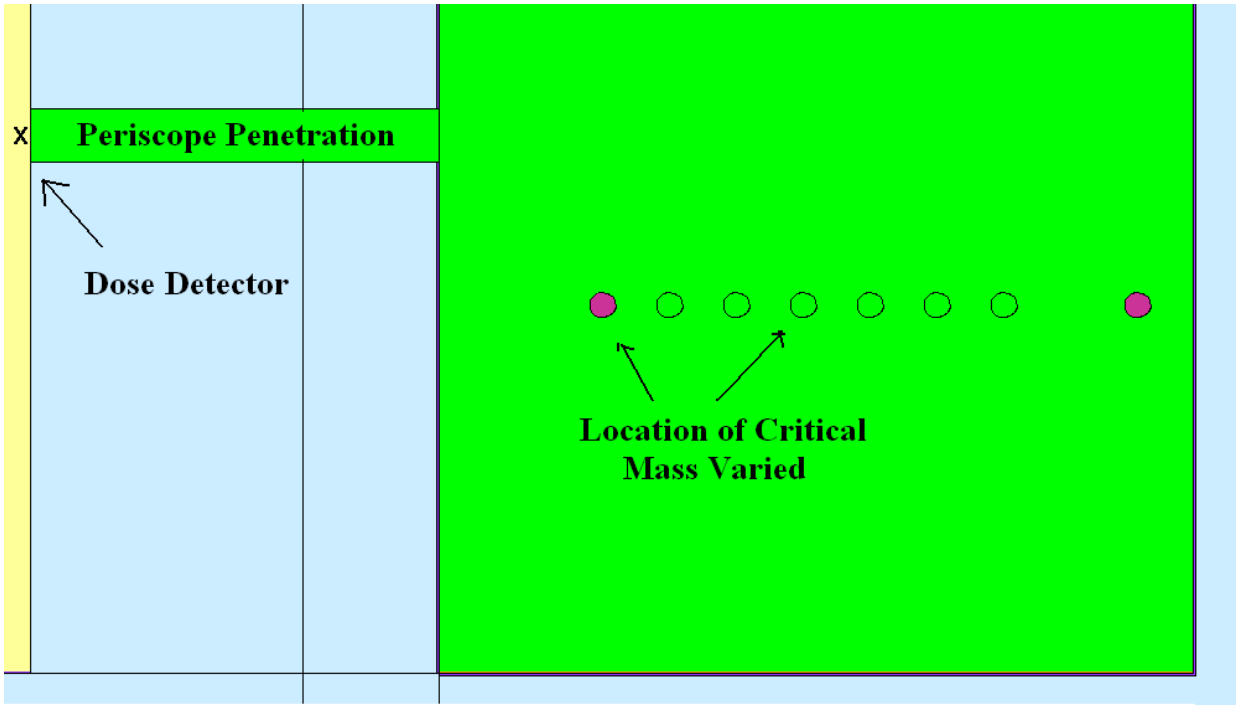
Parametric looking for Weak Points in Window

Plutonium Sphere and Detection Point in opposition through the Observation Window (y,z) (cm)			Dose	
Label	y	z	Rad-in-Air	+/-
A	0	0	2.7	2.3%
B	-5	0	2.7	1.9%
C	-10	0	2.6	2.0%
D	-15	0	2.6	2.3%
E	-20	0	2.4	2.2%
F	-25	0	2.3	2.1%
G	-30	0	2.1	2.1%
H	-35	0	1.8	2.2%
I	-40	0	1.6	2.6%
J	-45	0	1.3	6.8%



Parametric for Periscope Penetration

Pu Sphere directly below Periscope penetration, 5 feet off floor and at different distances from the wall			
Label	**Distance From cell wall (cm)**	**Rad–in-Air**	**+/-**
A	**60.69**	**6.6**	**0.6%**
B	**85.69**	**6.2**	**0.6%**
C	**110.69**	**5.9**	**0.6%**
D	**135.69**	**5.7**	**0.7%**
E	**160.69**	**5.7**	**0.7%**
F	**185.69**	**5.9**	**0.7%**
G	**210.69**	**6.4**	**0.8%**
H	**260.69**	**7.7**	**0.7%**



Results for Operating Corridor

- **Dose through intact window is 2.7 Rad-in-air.**
- **Dose at periscope penetration is 7.7 Rad-in-air**
- **Dose at master slave penetration is 3.7 Rad-in-air**

Conclusion

- **Results were better than expected**
- **No Excessive Dose to Operating Corridor**
- **Criticality Alarm System is not required**