

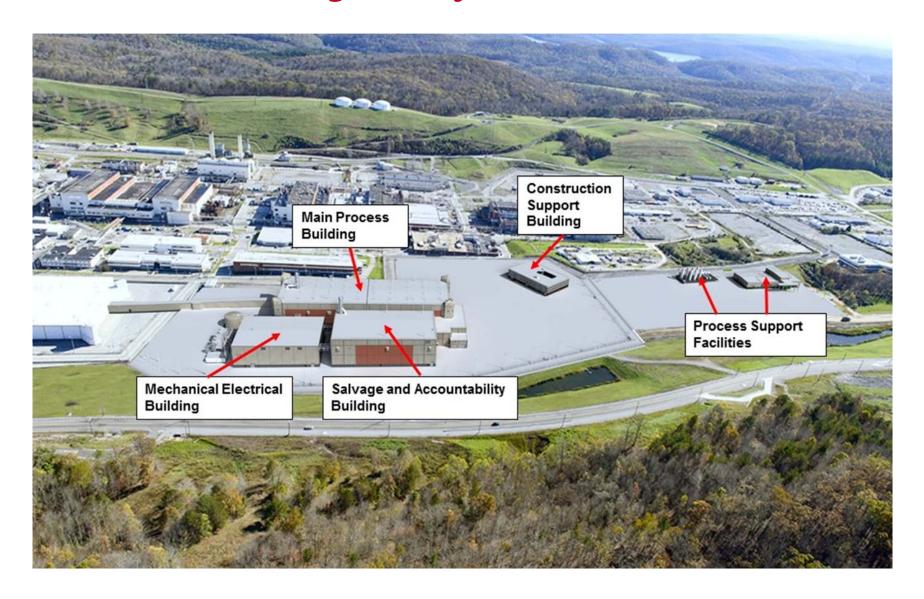


Technical Basis for the Uranium Processing Facility Criticality Accident Alarm System

Presented at the Philadelphia ANS Summer Meeting June 17-21, 2018

Kevin H. Reynolds Consolidated Nuclear Security – Y-12 National Security Complex

Uranium Processing Facility





Going VERTICAL!!





Criticality Accident Alarm System

- Fissile Operations in four Facilities
 - -Main Processing Building (MPB)
 - -Salvage and Accountability Building (SAB)
 - -Personnel Support Building (PSB)
 - -HEUMF Connector (HCON)



Evaluation Tasks:(All analyses performed in MCNP6)

- Detection of minimum accident of concern
 - -20 Rad in air at 2m
- 12-rad dose boundary
 - -design basis yield event 10¹⁸ fissions
 - -Fast spectrum
- CAAS radiation tolerance
 - Detection from alternate detector assuming burnout of detector nearest to event
 - -Evaluation of dose at CAAS control console

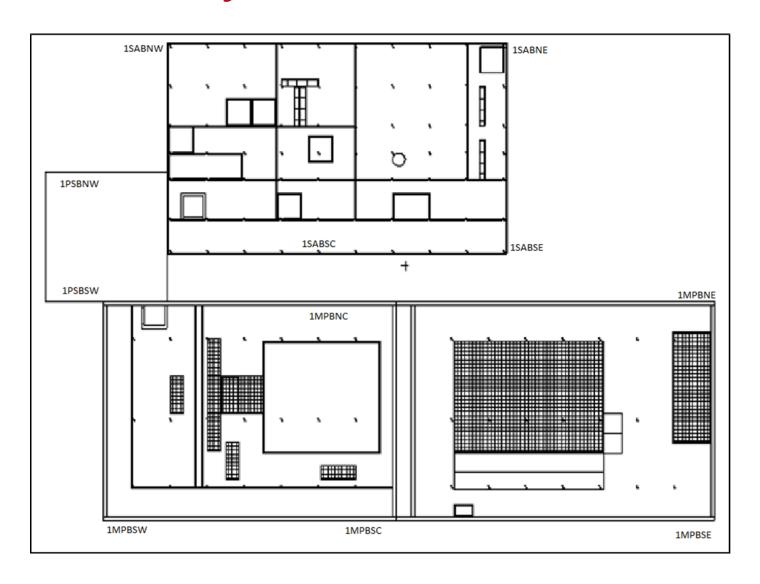


MPB: Detector Locations

- MPB is evaluated as two separate buildings: MPB West and MPB East
- Walls and columns evaluated explicitly at actual locations and thicknesses.
- Framing steel and equipment support steel evaluated using repeated structures with unit element based exact cross-cut of largest beams.
- Equipment loading evaluated in two ways:
 - -Gloveboxes modeled using a repeated lattice cell that accounts for glovebox floors, walls, and ceiling (more steel than actual per unit).
 - -Other equipment modeled using a homogeneous "smear" in the lower ~ 10 ft of each floor based on the seismic loading analyses for each area (loading per $\rm ft^2$)

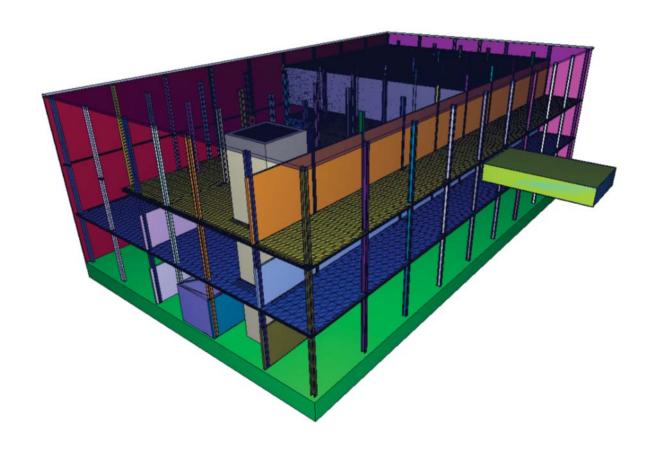


Overall Model Layout (First Level)





3D Vised™ View of SAB MCNP Model





Detector Summary

- MPB East First Floor: 6 cluster locations
- MPB East Second Floor: 4 cluster locations
- MPB East Third Floor: 2 cluster locations
- MPB West First Floor: 6 cluster locations
- MPB West Second Floor: 2 cluster locations
- MPB West Third Floor: 3 cluster locations
- SAB First Floor: 4 cluster locations
- SAB Second Floor: 3 cluster locations
- SAB Third Floor: 3 cluster locations
- HEUMF Connector: 3 cluster locations
- PSB: 1 cluster location
- Total: 37 cluster locations for entire facility



Accident Evaluation Basics

- All final calculations based on forward MCNP calculations
- Source term established using KCODE runs for varying materials and varying energy spectra (well moderated source most difficult to detect for Minimum Accident Analyses)
- Converge KCODE neutron and photon energy and special source distribution saved using the Surface Source Write (SSW) option in MCNP.
- Transport runs used either point source or Surface Source Read (SSR).
- Worst-case accident locations for detection by each detector cluster confirmed using "swapped source" method.
 - Swapped Source involved placing the source at each detector position
 - FMESH used to observe the flux distribution near the floor from sources placed at each detector location (using the source in a manner akin to "turning the lights on and looking for shadows).



Swapped-source example

1000000

```
probid = 01/12/17 17:21:52
basis: XY
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
( 3700.00, -2500.00, 30.48)
extent = ( 3800.00, 3800.00)
```

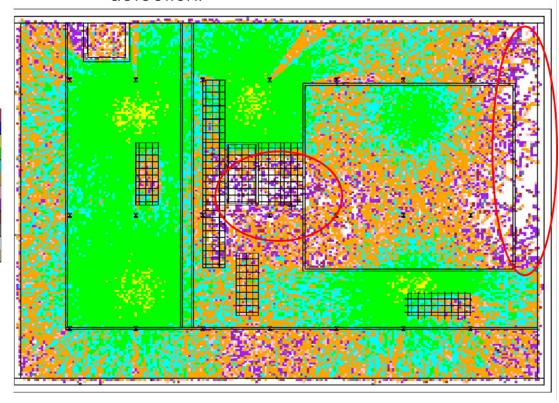
MPB West Prompt Gamma Model

Mesh Tally 14
nps 1000000
runtpe = caasrun
dump 1

01/12/17 17:41:01

Sources placed at each detector location. Map is composite near the floor.

- Circled regions near center and right side show areas most difficult to detect.
- Those are worst-case accident locations for detection.



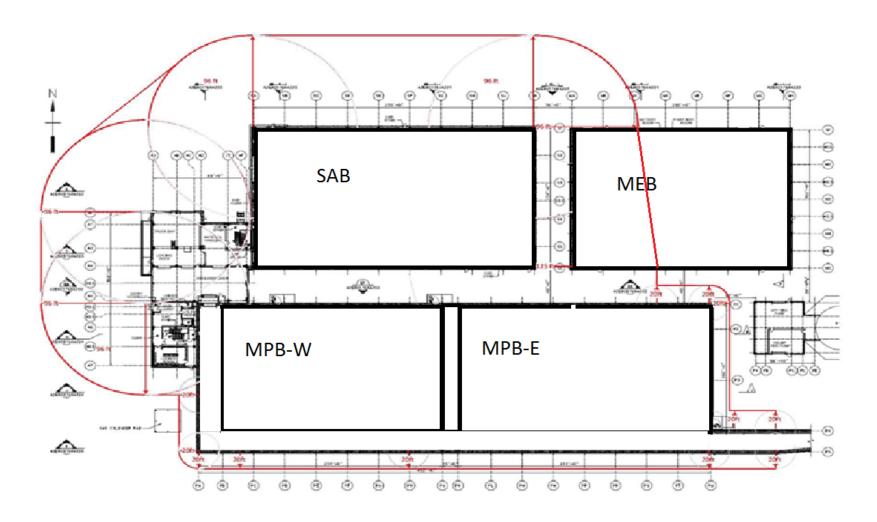


12-Rad Boundary(various locations)





12-rad Dose Line (in air)





Detector System Radiation Tolerance

- Performed calculations with accident located immediately below each detector location.
- Scaled yield to reach vendor specified failure dose at detector.
- Demonstrated that at least one additional detector would reach alarm point assuming nearest detector fails before alarming.
- Evaluated dose and dose rate at control cabinets
 - Led to relocation of control cabinet from center of SAB/MPB to a remote facility basement.
 - Discovered scarcity of vendor data on control system components and need for additional testing to prove safety function reliability.



Summary of Effort

- Three separate calculation documents totaling about 700 pages
- Thousands of iterative calculations to work through variance reduction progressions.
- Roughly 50,000 hours of calculation time on clusters
- Entire analysis effort completed in ~ 8 months by 1 engineer/1 reviewer



Disclaimer

This work of authorship and those incorporated herein were prepared by Consolidated Nuclear Security, LLC (CNS) as accounts of work sponsored by an agency of the United States Government under Contract DE-NA0001942. Neither the United States Government nor any agency thereof, nor CNS, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility to any non-governmental recipient hereof for the accuracy, completeness, use made, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency or contractor thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency or contractor (other than the authors) thereof.

