THE NATION'S
URANIUM PROCESSING FACILITY

Technical Basis for the Uranium Processing Facility Criticality Accident Alarm System

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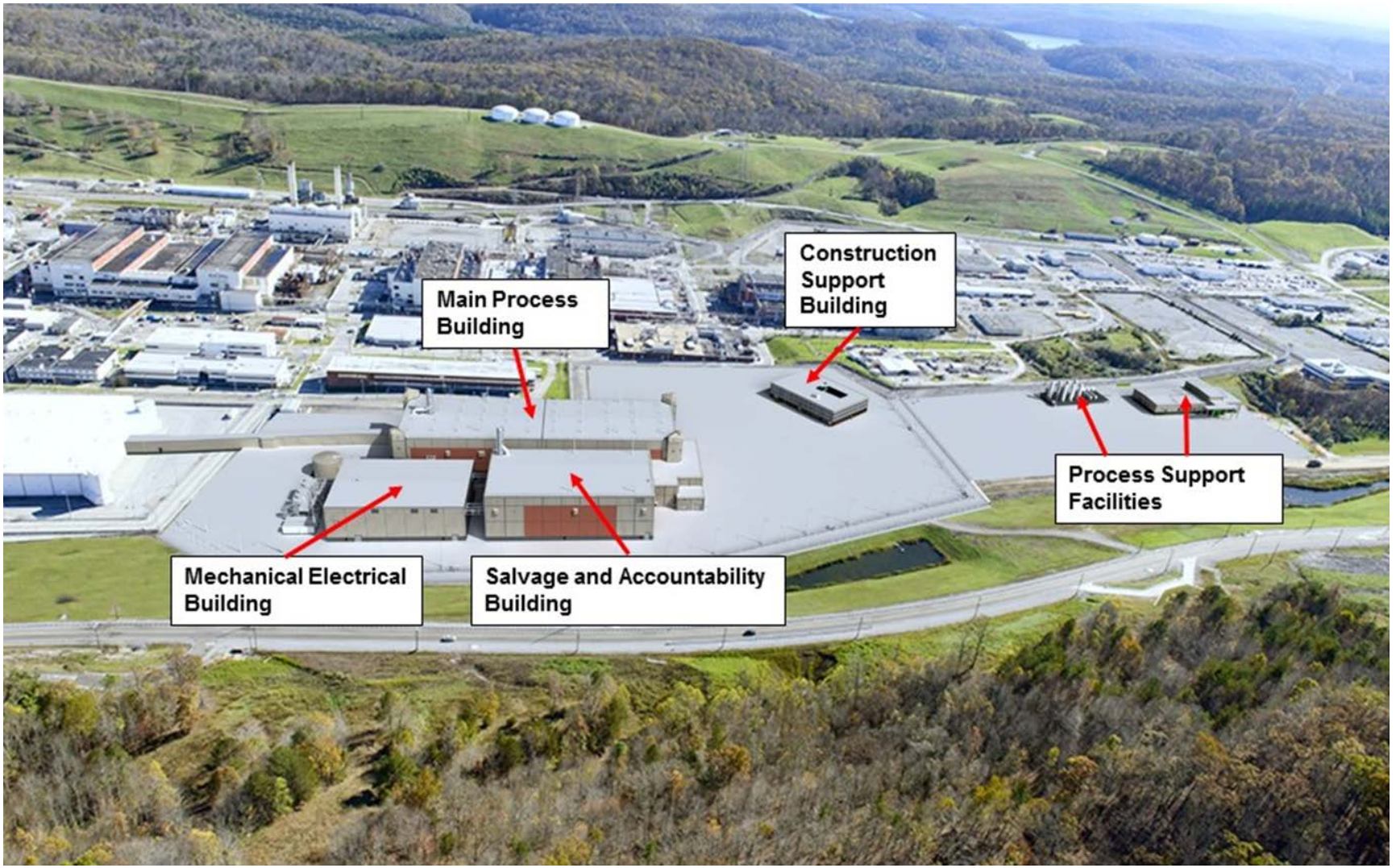
Uranium Processing Facility



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)

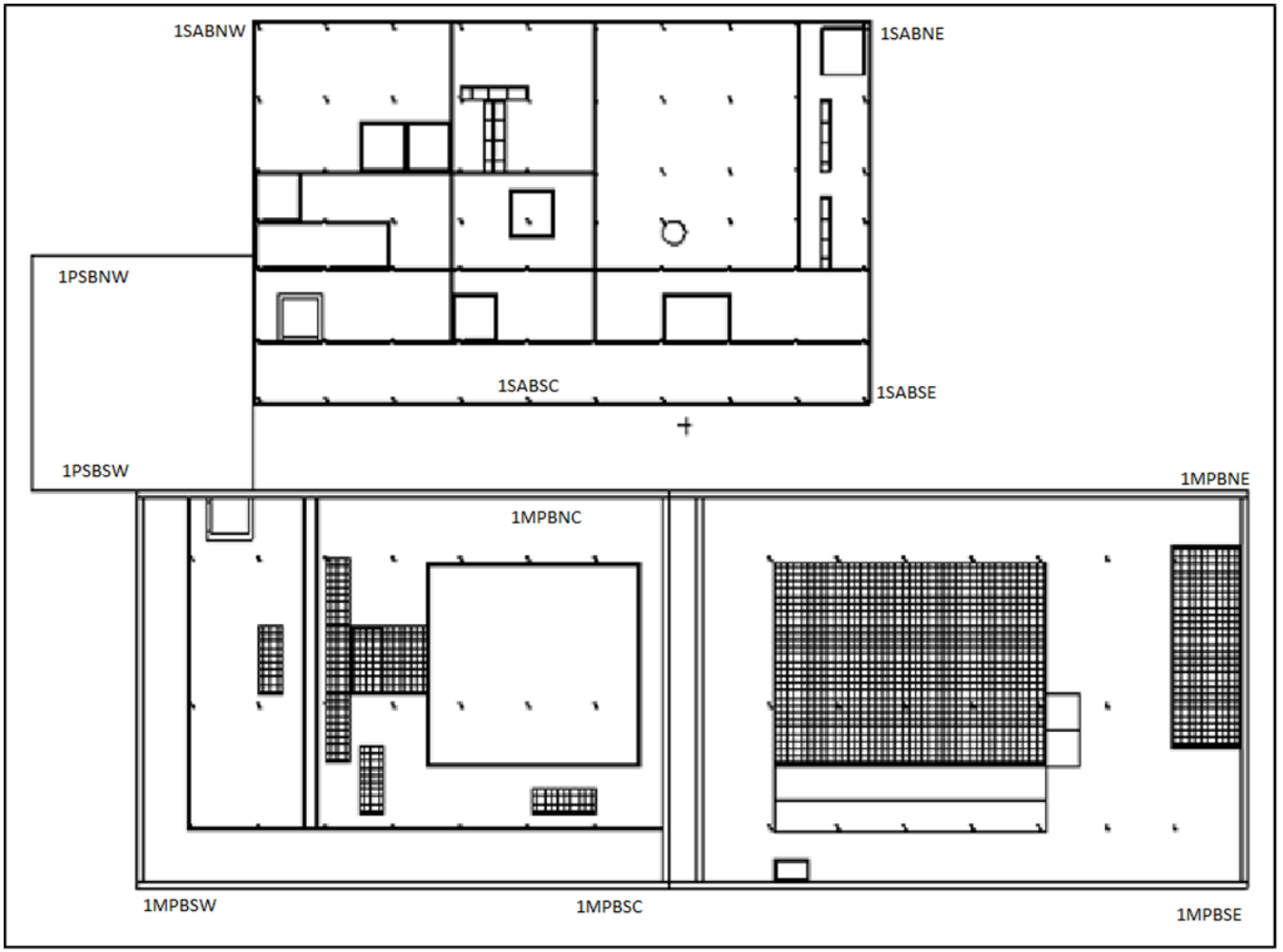
Evaluation Tasks:
(All analyses performed in MCNP6)

- Detection of minimum accident of concern
  - –20 Rad in air at 2m
- 12-rad dose boundary
  - –design basis yield event – 10^{18} fissions
  - –Fast spectrum
- CAAS radiation tolerance
  - –Detection from alternate detector assuming burnout of detector nearest to event
  - –Evaluation of dose at CAAS control console

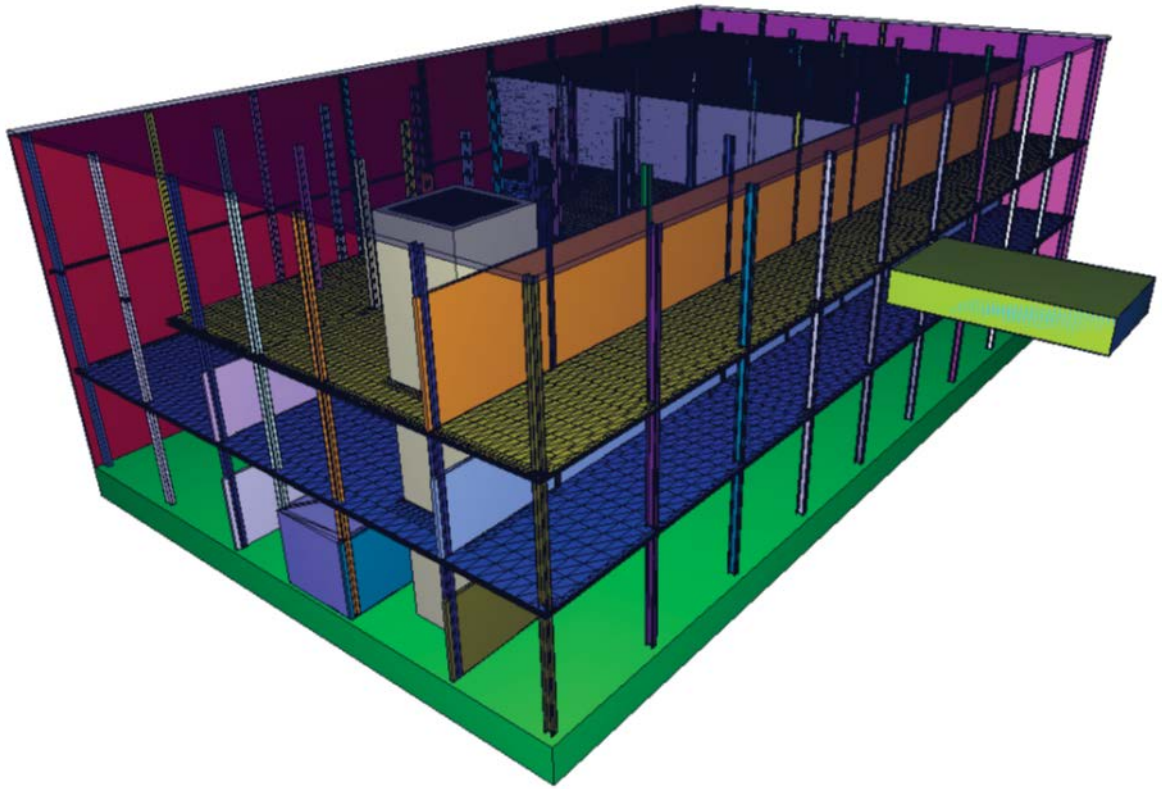
MPB: Detector Locations

- 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 ft^2)

Overall Model Layout (First Level)



3D Vised™ View of SAB MCNP Model



Detector Summary

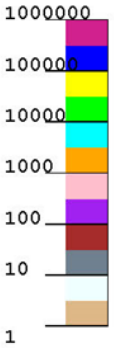
- MPB East First Floor: 6 cluster locations
- MPB East Second Floor: 4 cluster locations
- MPB East Third Floor: 2 cluster locations
- MPB West First Floor: 6 cluster locations
- MPB West Second Floor: 2 cluster locations
- MPB West Third Floor: 3 cluster locations
- SAB First Floor: 4 cluster locations
- 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).

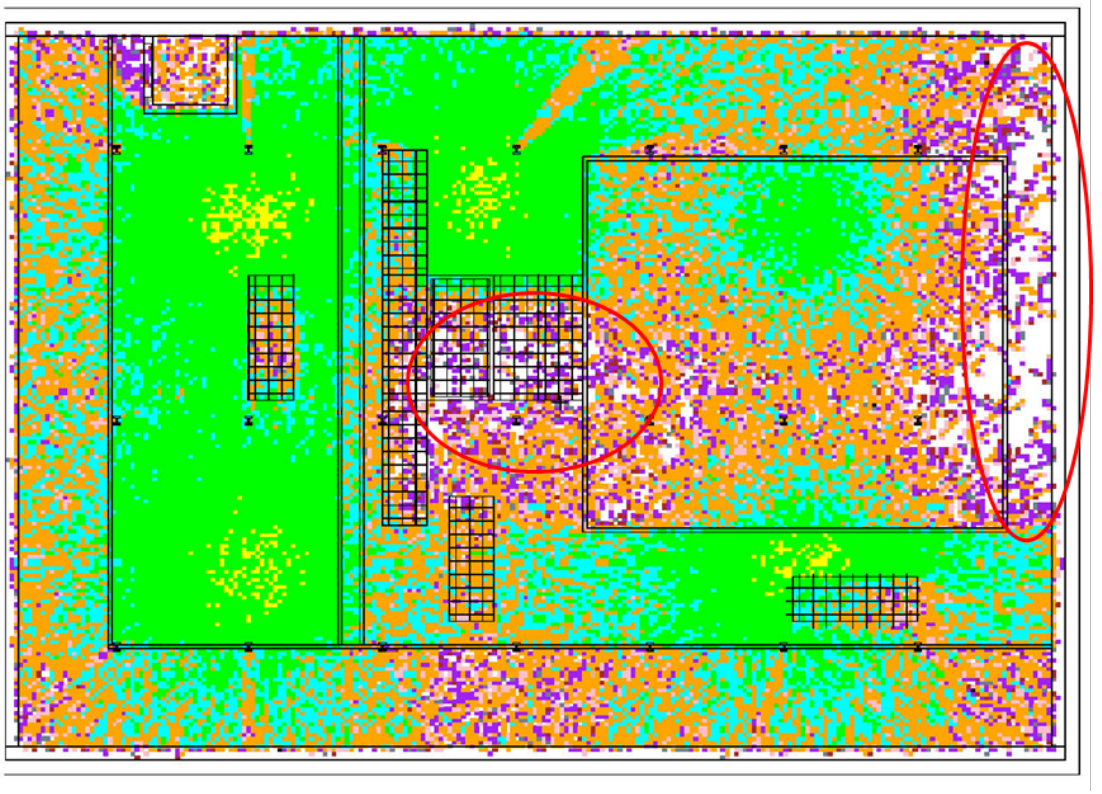
Swapped-source example

```
 01/12/17 17:41:01
MPB West Prompt Gamma Model


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)


Mesh Tally        14
nps          1000000
runtpe = caasrun
dump               1
```



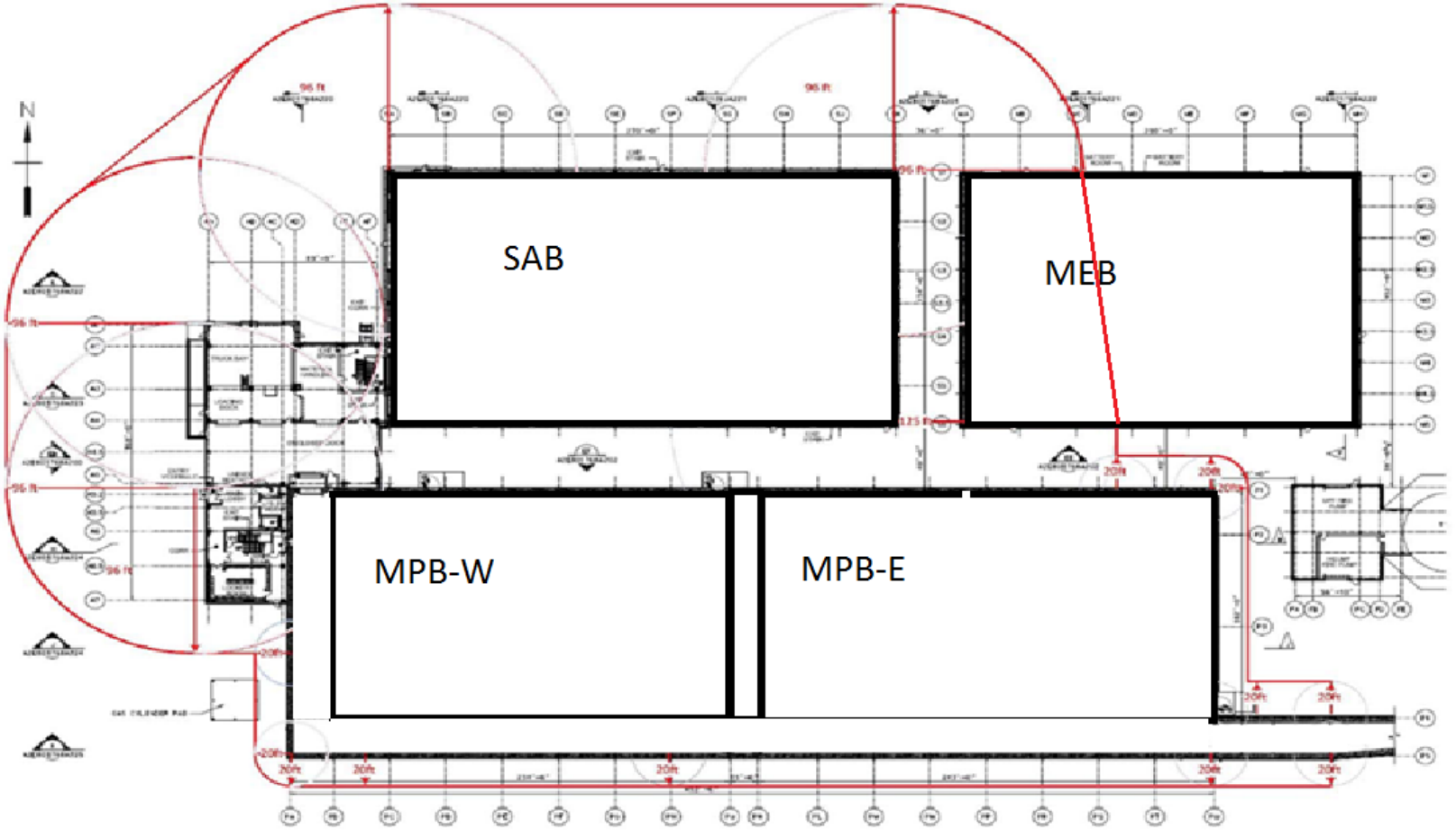
Sources placed at each detector location.
Map is composite near the floor.

- 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