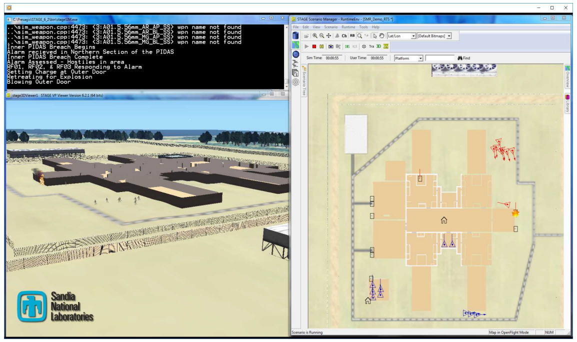
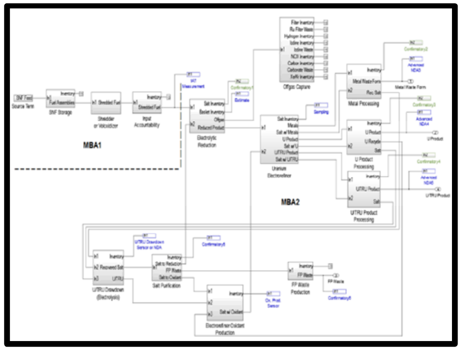
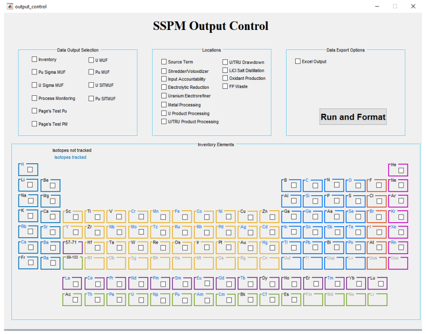
SAND2017-8421PE







SNL Capabilities Update and Integration with the Implementation Plan

Ben Cipiti, Nathan Shoman, Sam Durbin, Eric Lindgren, Jordan Parks

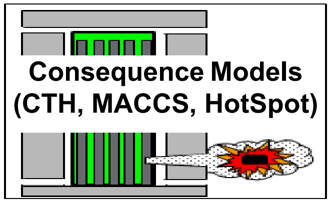
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Overview

- Sandia's focus in the MPACT program is in the areas of Safeguards, Security, and Consequence Modeling.
- In FY17, the modeling capabilities have been refined to prepare for integration with other MPACT capabilities in order to meet the Virtual Facility Distributed Test Bed 2020 Milestone.
- Deliverables:
  - M4 Contribution to Implementation Plan (Submitted in June)
  - M4 Spent Fuel Ratio Grid Refinement (Submitted in July)
  - M3 Integration of SSPM and STAGE in the Virtual Facility Distributed Test Bed (Due in September)

Virtual Facility Distributed Test Bed

High Fidelity Capabilities

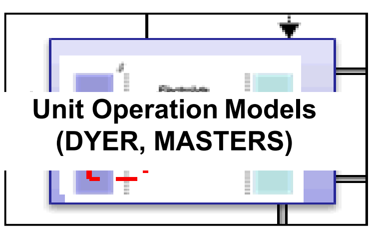


Measurement Technologies (Bubbler, Voltammetry, Microfluidic Sampler, Microcal, High Dose Neutron, Electrochemical Sensor)

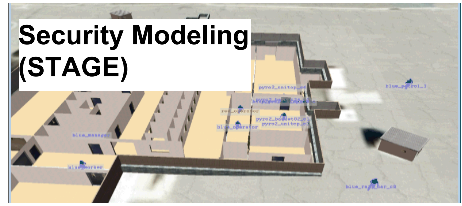
Measurement Models (NDA, MIP, etc.)

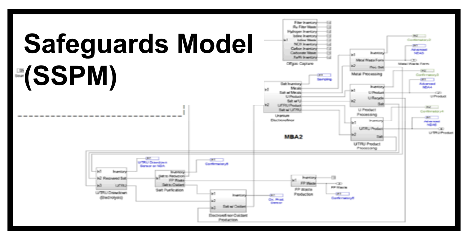
Experimental Data (IRT, Laboratory Research)

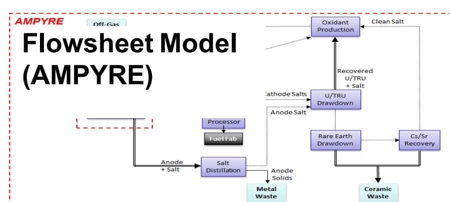
Statistical Methods (Page, Multivariate, Pattern Recognition)



Systems Level Models







Key Metrics

Probability of Success
Timeliness
Consequence

Facility Layout
Batch Timing

Sigma MUF
Probability of Detection
Timeliness

Flowrates
Inventories
Separation Efficiencies

Potential Future Directions

- **Pyro Demo**: Demonstrate the test bed concept with a complete Safeguards and Security System Design for a Pyroprocessing plant.
- **CoDCon Demo**: Develop a similar approach for aqueous reprocessing capabilities/technologies and demonstrate the concept for a CoDCon plant.
- **Expand Capabilities**: Expand the MPACT capabilities in different directions—liquid fueled molten salt reactors for example.

CAPABILITY UPDATES

SSPM Updates

- Updates to the SSPM have focused on enabling integration with other MPACT capabilities
- The following updates will be described in the following slides:
  - Source Term Improvement
  - Addition of a GUI
  - Addition of Output Control
  - Isotopic Tracking

Source Term Update

- The original source terms were generated from ORIGEN2 with older ENDF/B-V cross-sections, and read from excel sheets.
  - There were some minor errors in some of the less important fission products.
- These have been updated using ORIGEN with ENDF/B-VII cross-sections, and now stored in an HDF5 database.
  - Addition fuel types can be quickly added in the future.
- The GUI also allows for fuel swapping now to model more realistic plant conditions.

Type	Burnup (GWd/MTU)	Enrichment (wt% u235)	Discharge Options (yr)
Westinghouse 17x17	33	2.6/3.3/4.0	1,5,10,25,50
Westinghouse 17x17	45	3.3/4.0/4.7	1,5,10,25,50
Westinghouse 17x17	60	4.03/4.73/5.43	1,5,10,25,50

Addition of a GUI

Sandia National Laboratories

Separation and Safeguards Performance Model

Required Input Parameters

Select a burnup and enrichment value: Select from below

Select a time since discharge: Select from below

Enter Duration in Hours of Each Simulation:

Diversion Scenario Parameters

Diversion Simulation OFF

Select the diversion location: Select from below

Enter diversion start time (hours):

Enter diversion end time (hours):

Enter diversion fraction (%):

Select the diversion type: Select from below

Single Model Run

Generate Single Run Parameters

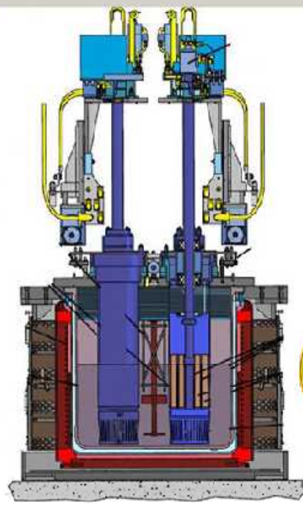
Parallel Processing Parameters

Enter Number of Simulations Per Run:

Number of Cores for Parallel Pool:

Push Run Onto Queue

Submit All SSPM Runs In Queue!



Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

	U Random Error	U Systematic Error	Pu Random Error	Pu Systematic Error
IAT	0.0500	0.0500	0.0500	0.0500
Hulls	0.0500	0.0500	0.0500	0.0500
Oxide Basket	0.0100	0.0100	0.0100	0.0100
Salt Distillation	0.0100	0.0100	0.0100	0.0100
ER Salt Sample	0.0500	0.0500	0.0500	0.0500
ER LCC	0.0500	0.0500	0.0500	0.0500
ER Double Bubbler	0.0050	0.0050	0.0050	0.0050
Metal Processing	0.0500	0.0500	0.0500	0.0500
U Product	0.0500	0.0500	0.0500	0.0500
U/TRU Product	0.0500	0.0500	0.0500	0.0500
Oxidant Production	0.0500	0.0500	0.0500	0.0500
U/TRU Drawdown	0.0500	0.0500	0.0500	0.0500
FP Waste	0.0500	0.0500	0.0500	0.0500

Fuel Swapping

Isotopic Tracking OFF

Select Source

Select Discharge Time

Start 0

End

Randomize Source (Off)

Submit Fuel Swap Card

Check Cards

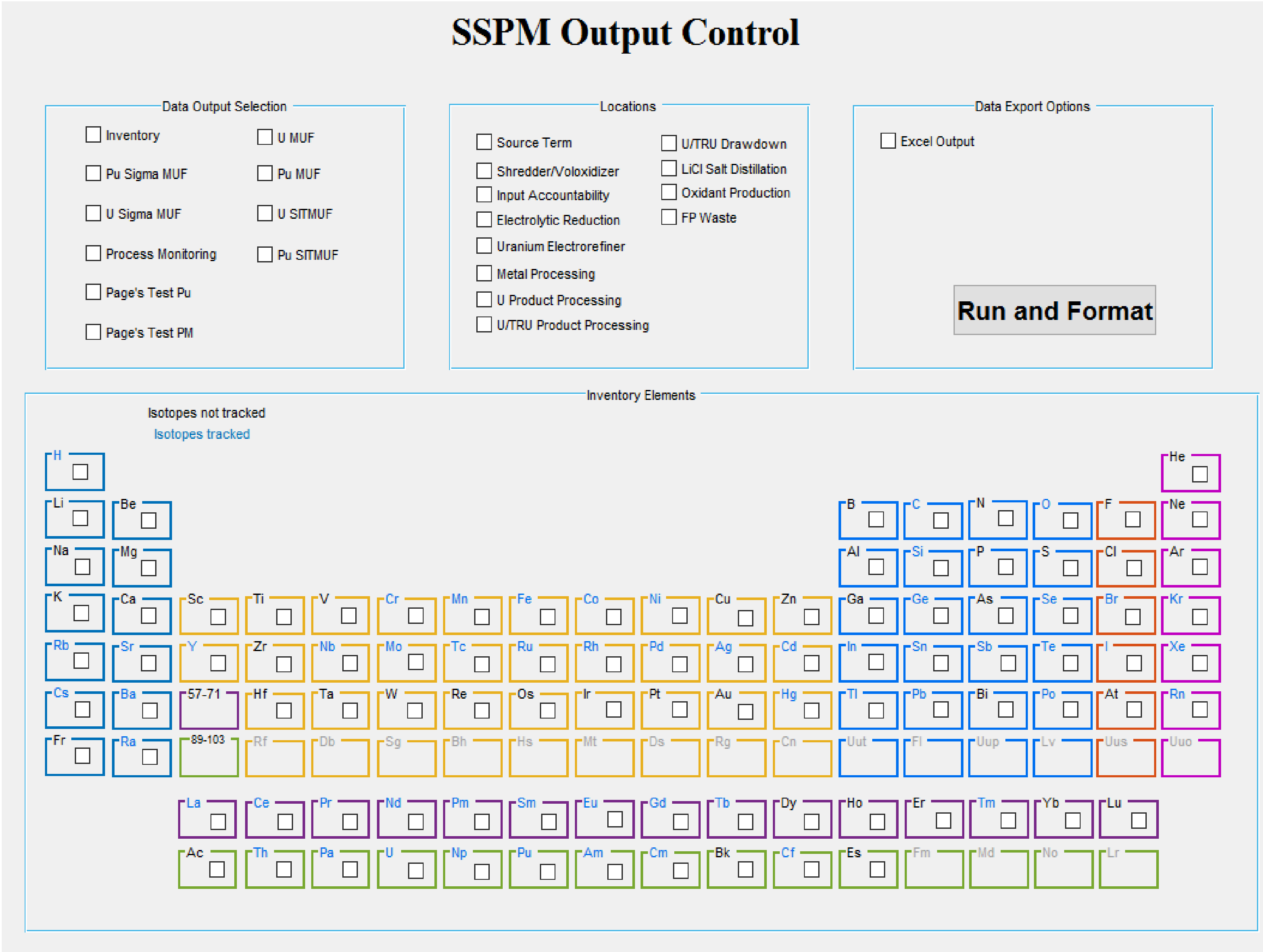
Reset

Ben Cipiti, Nathan Shoman
bbcipit@sandia.gov, nshoman@sandia.gov
505-284-8757, 505-844-1860

Serial Usage: Enter required parameter data and push "Generate Single Run Parameters". Parameters will be exported to the base workspace. The model must then be run manually from the model file.

Parallel Usage: Select number of iterations per run and number of cores you would like to use. Once ready push the run onto the queue. If you have other model runs you would like to run push those onto the queue. If not, submit all runs for automated simulation.

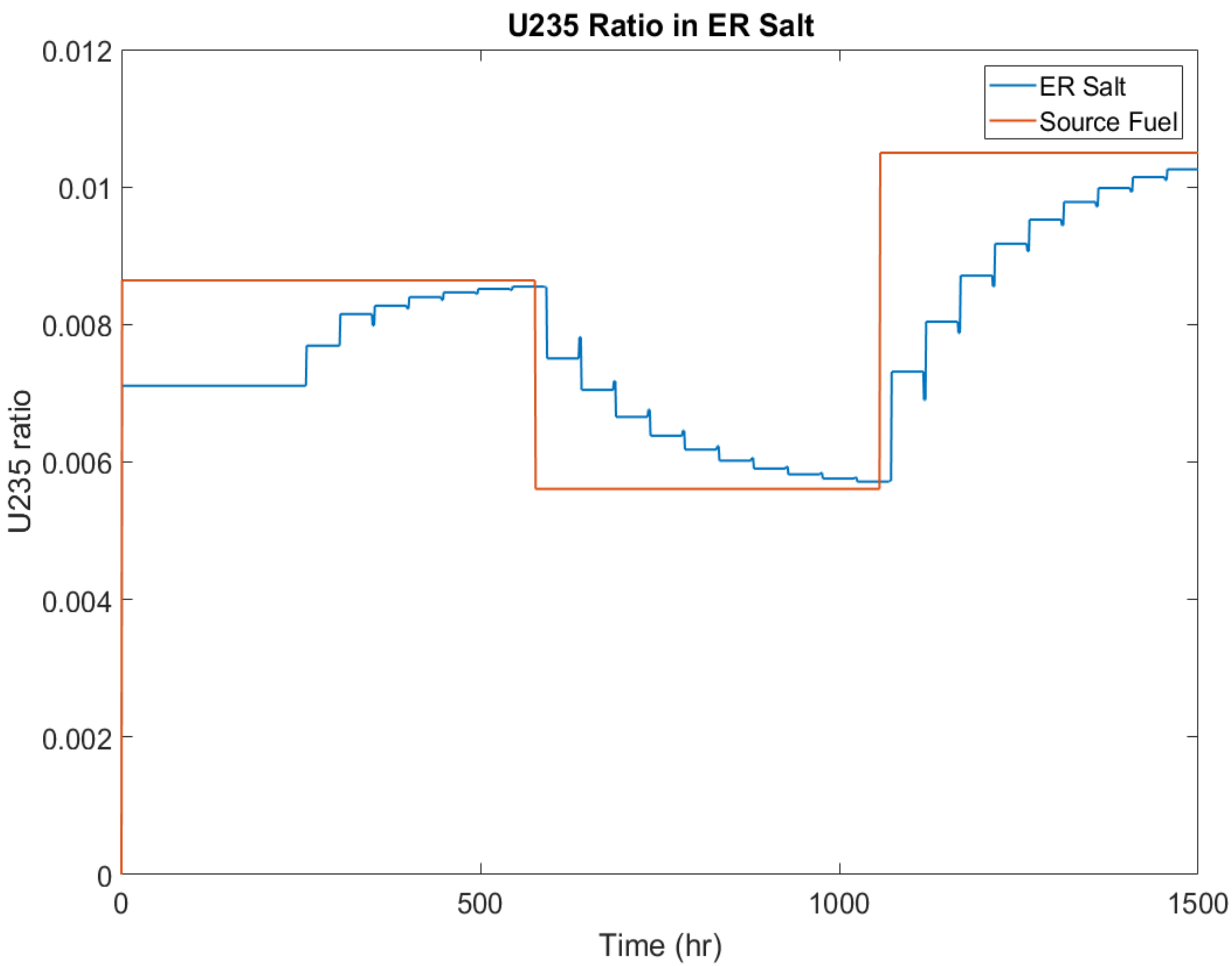
Output Control



Isotopic Tracking

- The SSPM has been updated to track 266 isotopes within 57 element groups. (ORIGEN tracks 1500 isotopes, but this number was reduced in order to optimize computational time.)
  - Isotopes were eliminated unless mass was greater than 0.1 grams/MT, activity greater than 1e-5 Ci/MT, or heat generation greater than 1e-5 W/MT
- Isotopes are tracked in 39 locations.
- This data, along with the elemental masses, can be used to generate gamma or neutron spectra for simulation of NDA measurements.

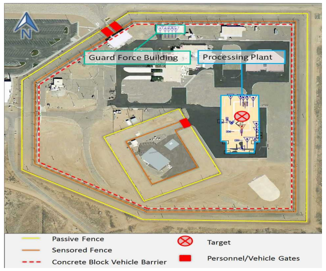
Example U-235 Ratio Change

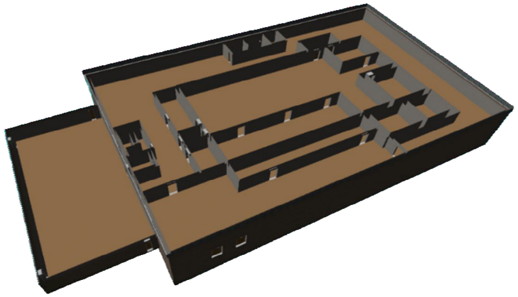


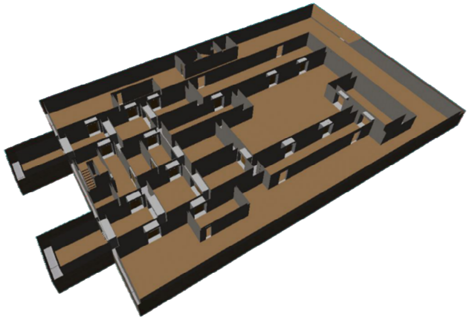
- Shows the U-235 ratio (within the U element group) in the ER salt with two step changes in the source term fuel.
- Starts at natural uranium levels for the initial loading.
- Values are updated when each new batch of fuel is processed.

STAGE Integration

- There were no updates to STAGE in FY17, but we examined how STAGE can integrate within the Test Bed.
- Modeling in STAGE first requires construction of a 3D model using the Creator tool.
  - Import of 3D CAD files is not supported because the analyst needs program in the physical protection elements (like type of barrier)
  - The easiest way to build the models is to start with 2D drawings of the site layout and floor plans.
  - The analyst will build the perimeter and then add all necessary doors, penetrations, and physical protection elements as needed







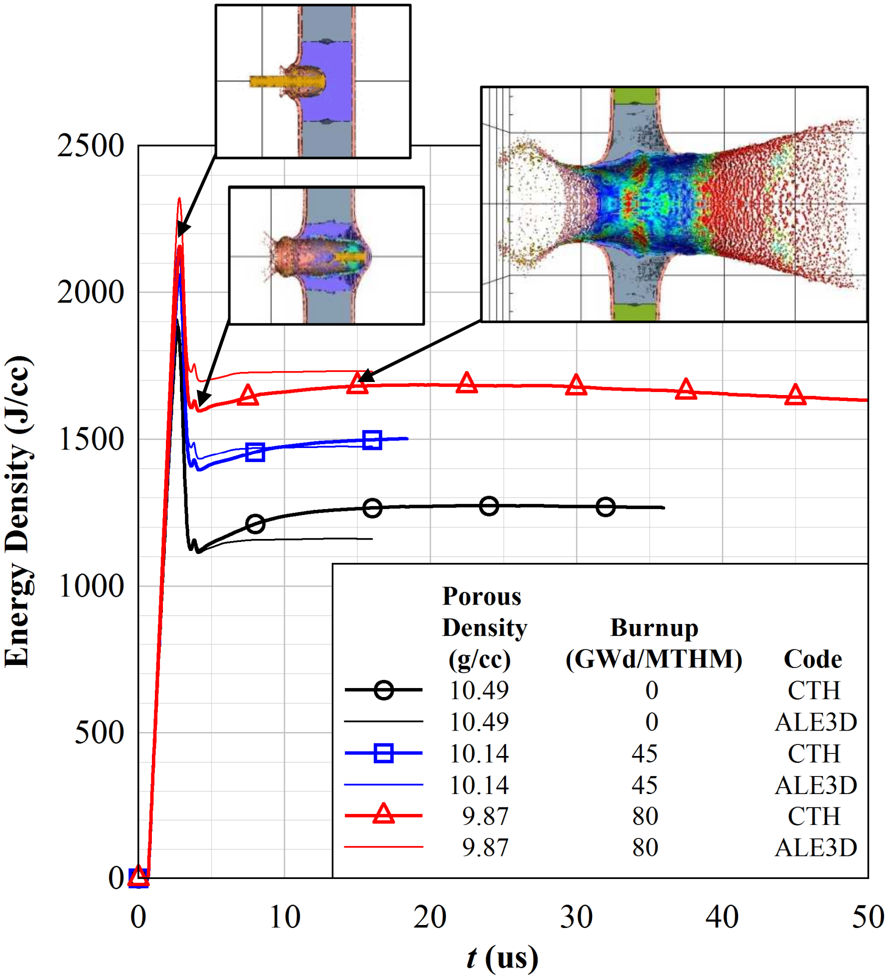
STAGE Integration (cont.)

- Physical security modeling requires a strong background in the physical protection area—all physical protection elements need to be programmed in with proper metrics, like detection probabilities. Special databases are used.
  - The work cannot be done by just anyone, so integration with other codes is not recommended.
- Past work has shown how integrating alarm data from the safeguards/process monitoring system can improve the response force effectiveness against insider threats.

Refinement to Spent Fuel Ratio

- For cask sabotage, past experiments examined respirable releases from DUO_2 assemblies.
- The Spent Fuel Ratio (SFR) is needed to scale the release fractions of the surrogate to what it would be for spent fuel.
- Calculations for Yucca Mt. assume SFR=3.
- Using shock physics modeling (CTH and ALE3D), the SFR and release fraction have been calculated for very high burnup fuel as a worst case scenario.
- The SFR was estimated to be as large as 1.3 for the worst case scenario, but 1.1 should be used for typical 45 GWD/MT spent fuel.

Shock Physics Modeling Confirmed the SFR and Release Fractions



CASE	Burnup (GWd/t)	material / vol frac / code	1 / 0.336 / Bulk Rim RF (%)	2 / 0.636 / Bulk Core RF (%)	3 / 0.003 / Jet-path Front Rim RF (%)	4 / 0.023 / Jet-path Core RF (%)	5 / 0.003 / Jet-path Back Rim RF (%)	Wt'd AVG RF (%)	SFR RF_{spent}/RF_{fresh} (-)
uniform fresh	0	CTH	1.4			2.5		1.40	-
		ALE3D	1.4			3.0		1.48	-
uniform spent	127	CTH	1.8			3.2		1.83	1.3
		ALE3D	1.9			3.5		1.90	1.3
rim fresh	0	CTH	1.4	1.3	72.5	2.1	2.4	1.56	-
		ALE3D	1.4		100	2.6	2.4	1.74	-
rim spent	127	CTH	1.8	1.7	40.8	2.8	2.8	1.85	1.2
		ALE3D	1.9		100	3.2	30.3	2.22	1.3
rim bimodal	64/223	CTH	2.0	1.8	100	2.8	31.4	2.22	1.4
		ALE3D	1.8	1.7	100	3.0	30.6	2.13	1.2

Next Steps

- If the current goal is to demo a full pyroprocessing safeguards and security design, work will need to start next year in order to be successful by 2020:
  - Develop a generic conceptual pyroprocessing plant design.
  - Modify existing SSPM to be consistent, and develop the safeguards approach.
  - Develop a more detailed STAGE model
  - Examine sabotage scenarios for various targets in the pyroprocessing plant