



# ISOTOPIC MAPPING PROGRAM AT PRAIRIE ISLAND NUCLEAR PLANT

ISOE Summer 2018

# OVERVIEW



Prairie Island uses Cadmium Zinc Telluride (CZT) instrumentation as an important tool in managing refueling outage risk and to support the Nuclear Promise.

This presentation covers:

- CZT Introduction
- Process Monitoring Program
  - Reactor Coolant System
  - Risk Mitigation
- Questions & Answers



# CZT TECHNOLOGY



Prairie Island's CZT instruments are solid-state detectors used for gamma spectroscopy. These instruments use a 3-D position sensitive crystal and have energy resolution of less than 1.1% at 662 keV. The principle advantages of these detectors is their portability because cryogenic cooling is not required. PI uses two types of CZT instruments: process monitors and a spectroscopic imager.

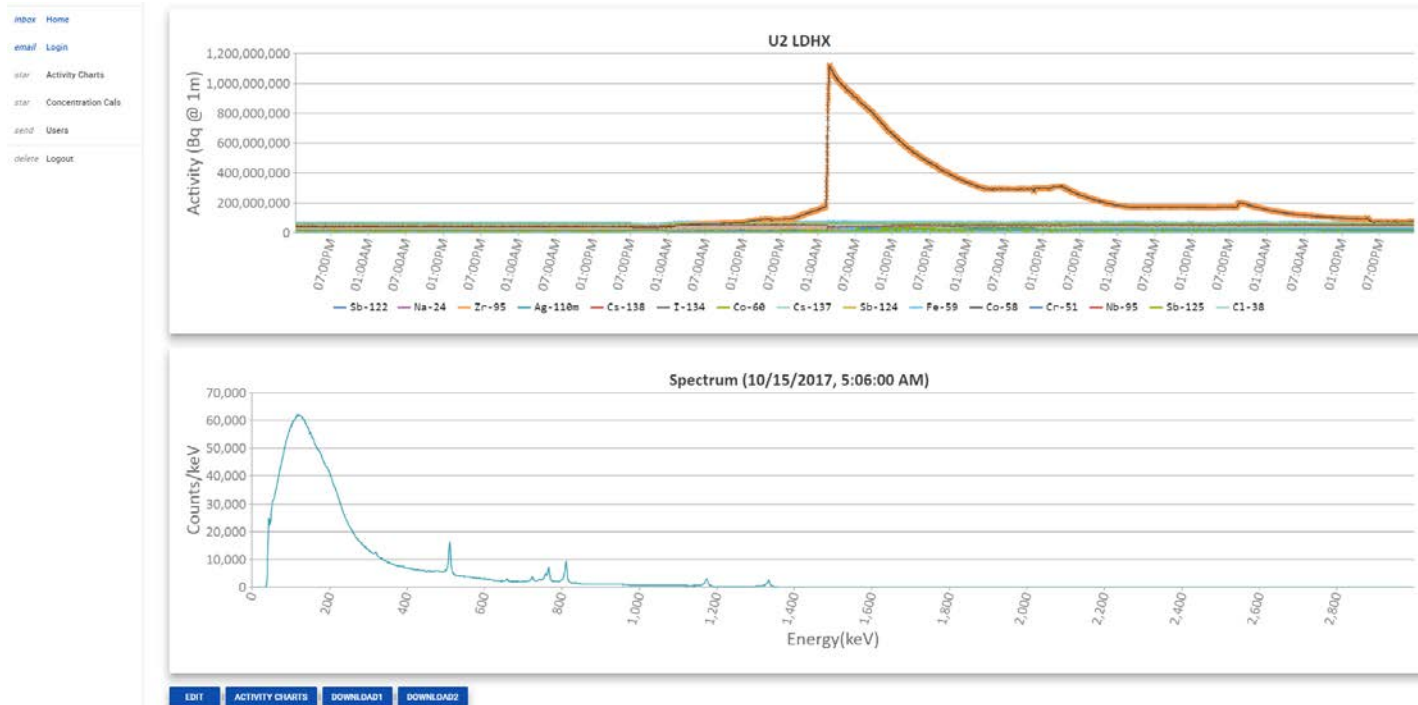




# PROCESS MONITORING INSTRUMENTS



Monitors continuously integrate spectrographic data in 1 minute intervals and upload it into a centralized database. The data is combined with efficiency curves and can be viewed in real-time. The result is a quantitative assessment of various radionuclide concentrations in process piping.

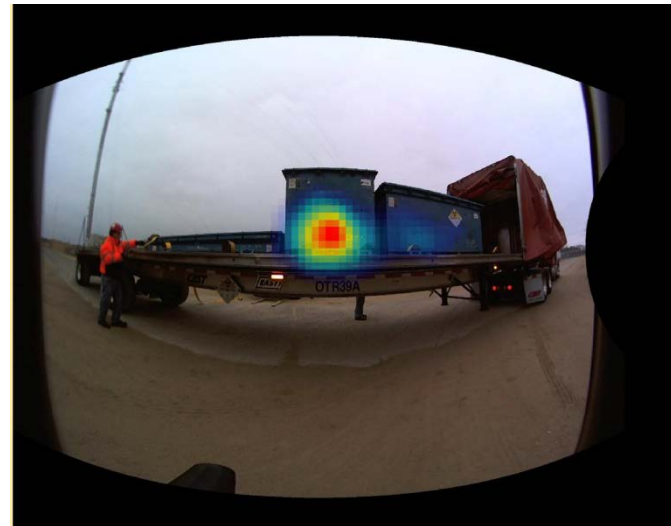
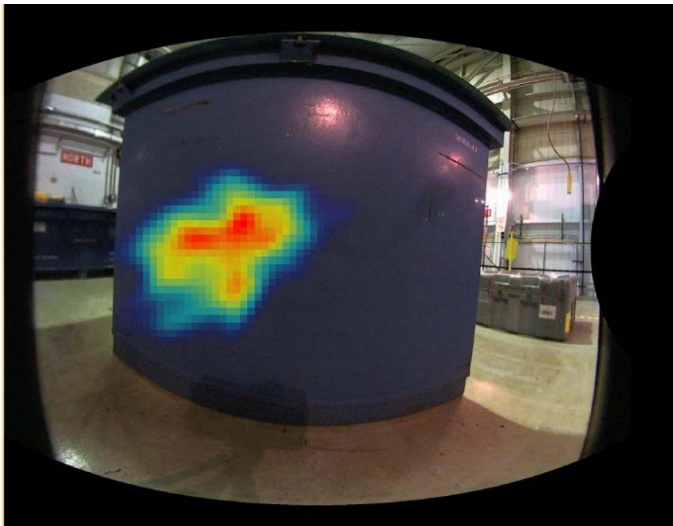


# SPECTROSCOPIC IMAGER



The instrument takes a visual image and overlays it with radionuclide specific heat maps to provide a visual means of communicating radiation fields. It is used for hot particle identification, temporary shielding validation, and shipping survey verification.

## Co-60 Images of Westinghouse Refueling Equipment

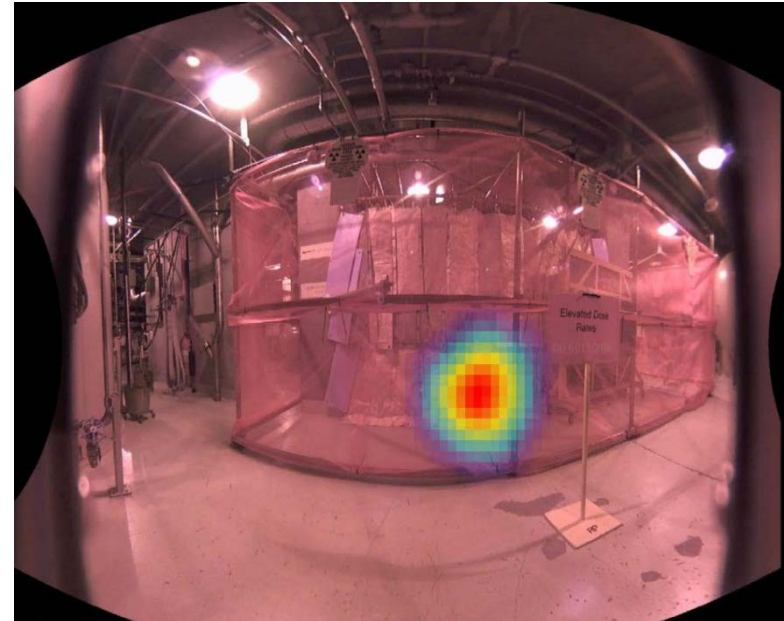
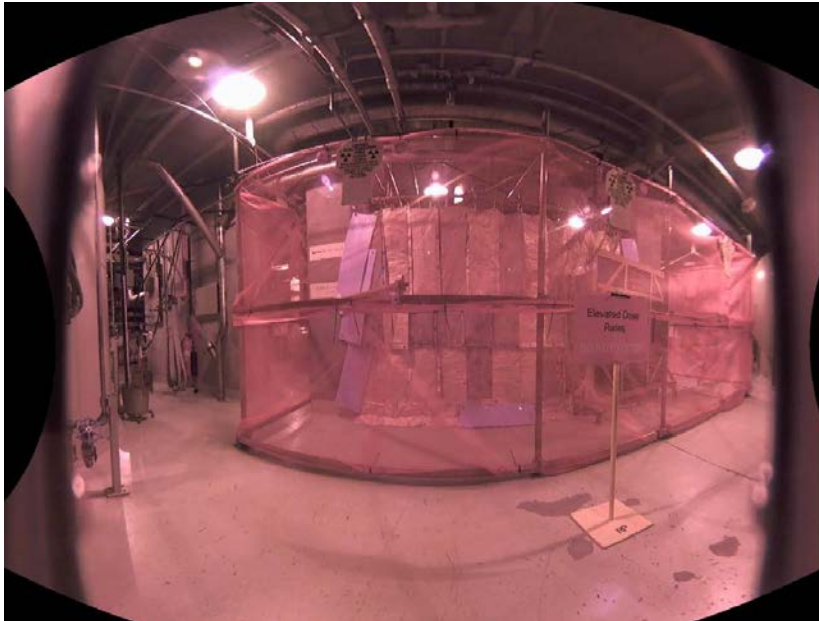


# SPECTROSCOPIC IMAGER



The instrument can be used to optimize temporary shielding installation by identifying either radiation streaming or areas where additional shielding should be placed.

## Co-60 Images of Sump-C Shielding Package Co-60





# CZT WORKING GROUP



In January 2015 a CZT Working Group was established through the North American Technical Center (NATC). The group meets on periodic conference calls to discuss site experiences with CZT monitoring, mapping of in-plant radiation fields, and the future of CZT technology.

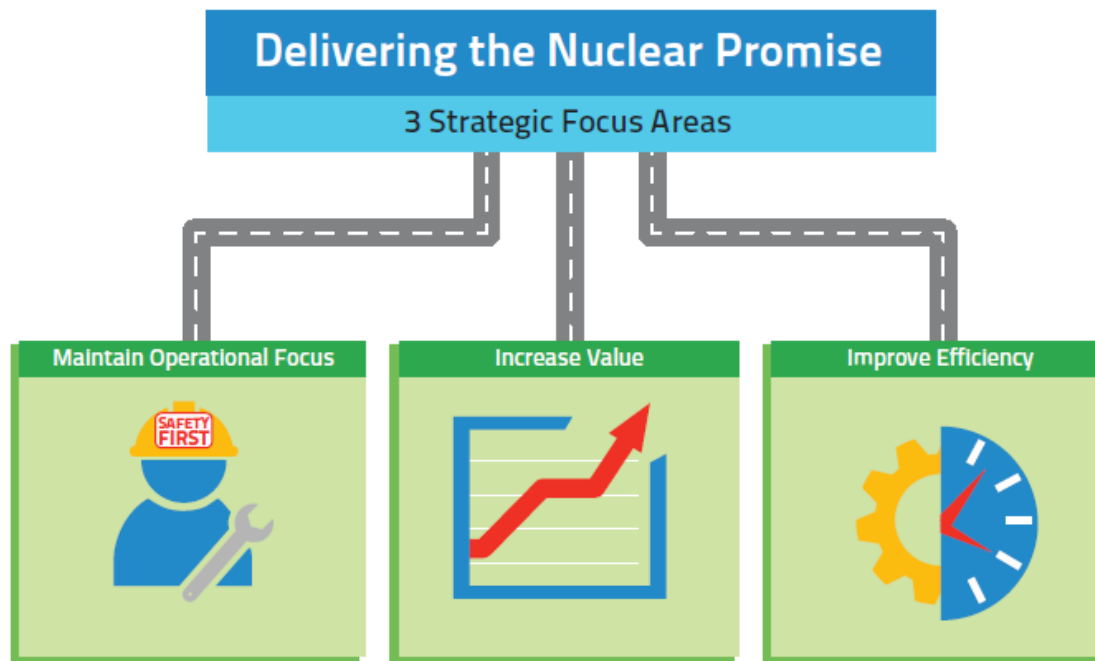
The group has also established a set of guidelines for utilization of spectroscopic imaging detectors to assist in the setup of new monitoring programs.



# PROCESS MONITORING PROGRAM



Real time radionuclide monitoring of the Reactor Coolant System (RCS) supports the Nuclear Promise by providing station leadership with a clear picture of plant conditions during transients and forced oxidation. The program at Prairie Island leverages this information to reduce nuclear and radiological risk.





# PROCESS MONITORING PROGRAM

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Monitors are stationed year round at near the Unit 1 and Unit 2 Letdown heat exchangers and continuously analyze plant conditions. During refueling outages, additional monitors are placed throughout the station:

- RCS Letdown
- Residual Heat Removal (RHR)
- Mixed Bed Ion Exchanger
- High Traffic Step-Off Pads

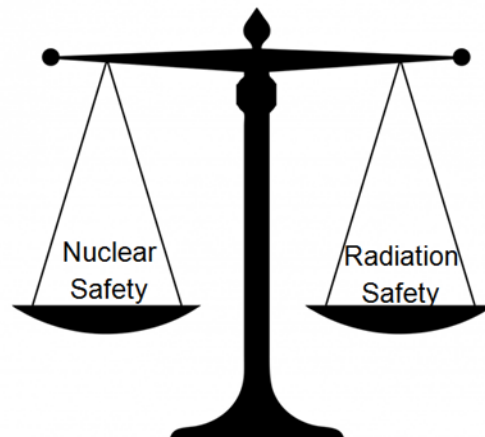
The system was piloted in 2016 and demonstrated excellent correlation between it and chemistry sampling. The system was upgraded and deployed prior to the 2017 2R30 refueling outage.

# PROCESS MONITORING PROGRAM



The monitoring system provided key radiological information that allowed the station to balance nuclear and radiological risk during the 2R30 refueling outage.

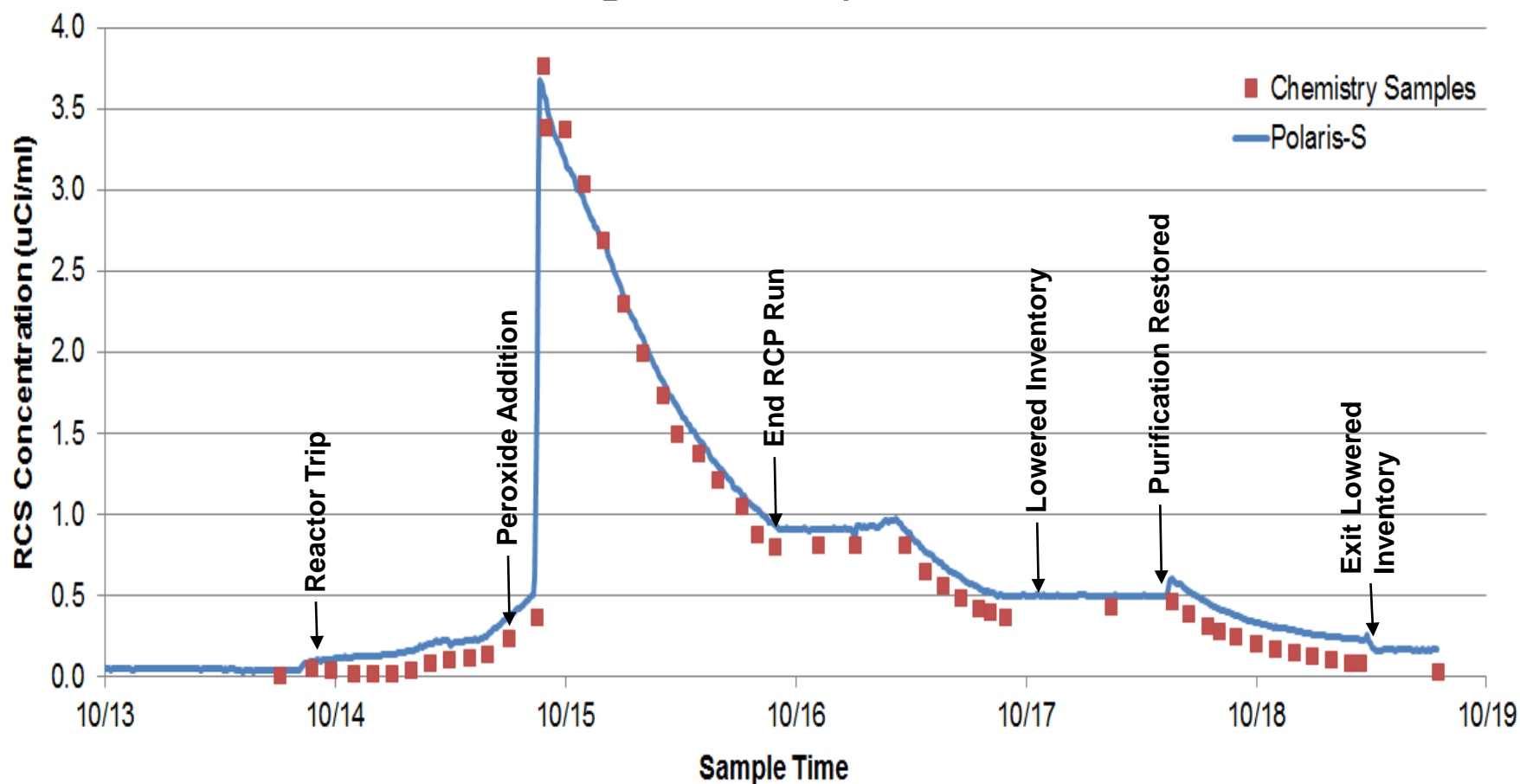
The planned window for the RCS to be in lowered inventory was 32 hours; however real-time purification forecasting showed that the RCS hard gamma emitter concentration target of 0.05 uCi/ml would require 40 hours.



# PROCESS MONITORING PROGRAM



## 2R30 Refueling Outage - Letdown Heat Exchanger Co-58



# PROCESS MONITORING PROGRAM

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Monitoring data was used to support CRE projections and the decision to allow cavity flooding at an RCS maximum concentration 0.10 uCi/ml. Flood up occurred at 0.078 uCi/ml.

The lowered inventory window was completed in 33.5 hours, which was 1.5 hours longer than the original window, but 6.5 hours were saved.

Station leadership balanced the nuclear risk associated with lowered inventory against the radiological risks. This resulted in a CRE of 31.346 on goal of 34 person-REM, and an estimated cost savings of \$270,000.



# POLARIS-S OVERVIEW



The Polaris-S gamma spectroscopy system by H3D provides radionuclide characterization in real time to the Remote Monitoring System. These temporary monitors are installed to observe plant transients and quantitatively determine radionuclide activity in process piping.



# POLARIS-S VALUE PROPOSITION



## Short Term (< 3 yrs)

- Knowing exactly when the Reactor Coolant Systems reaches the cleanup goal saves 2 hours of critical path time.
- Staggered early release of specific containment areas based on real time monitoring and improved transport modeling of specific radionuclides to determine risk can save 2 hours of critical path time.

**\$166,666 Per Outage**

## Long Term ( 3 – 5 yrs)

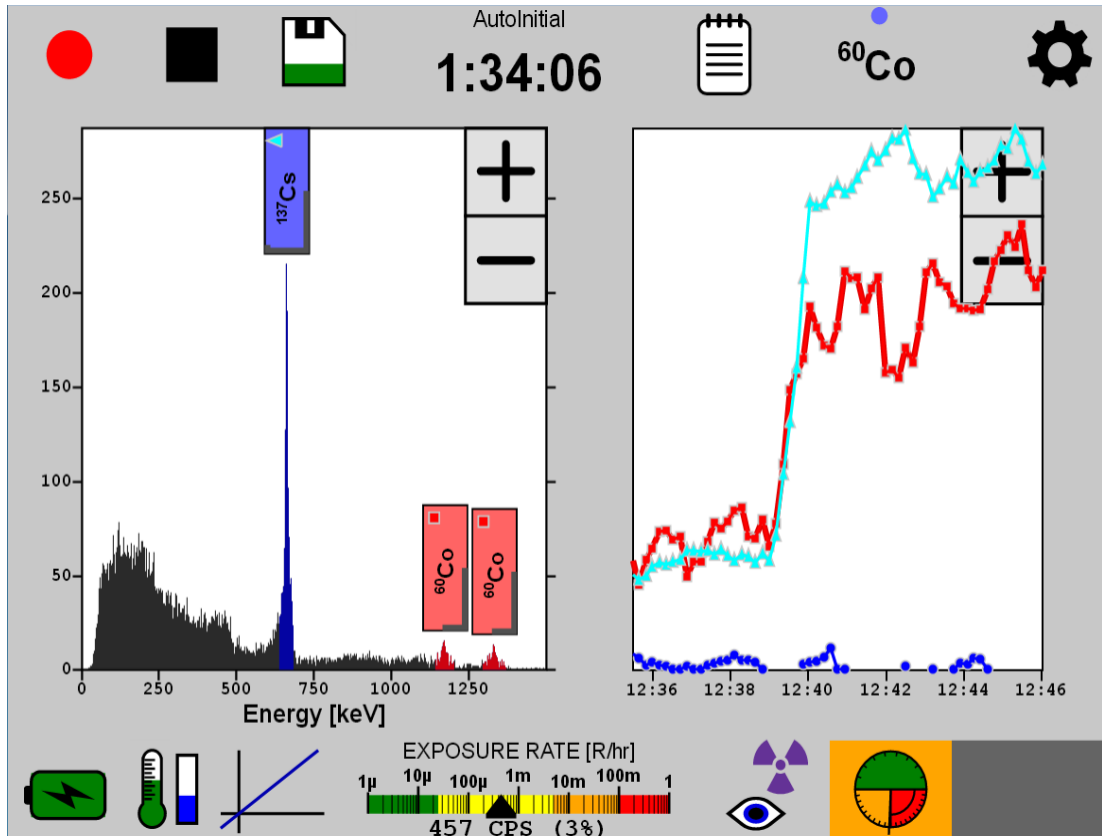
- Transient optimization will reduce RCS cleanup time by nearly 20 hours  
For example, DC Cook cleanup is 4 hours verses PI at +24 hours
- Real time isotopic process monitoring allows faster decision making, detects unmonitored plant transients, and provides state of health information for components containing activation materials

**\$833,330 Per Outage**

**\$330,000 Per Spent Resin Bed**

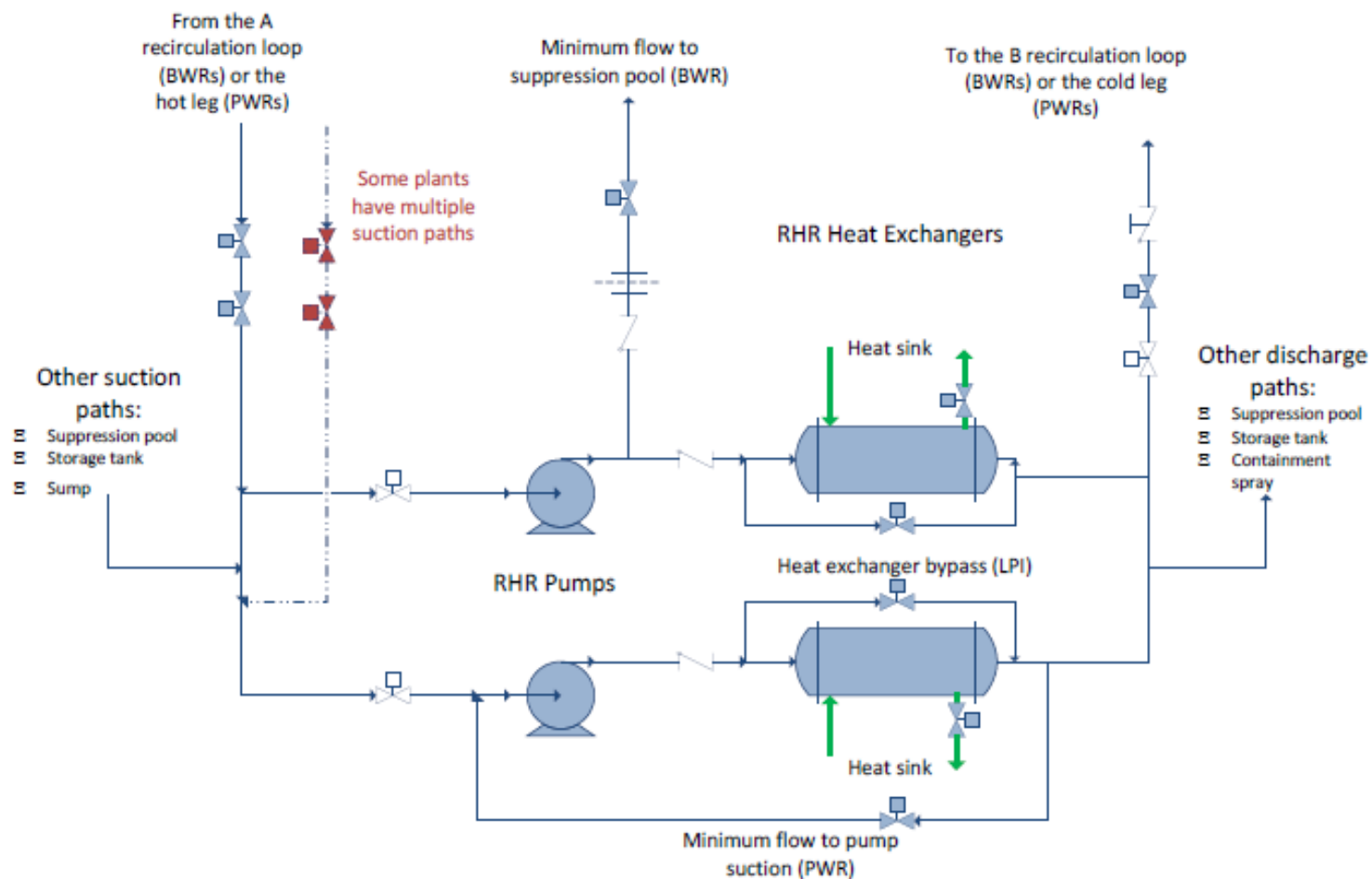
\*Savings are estimated on 18 month fuel cycle and a \$1M outage cost per day

# POLARIS-S REAL-TIME INTERFACE



- Initially will provide dose rate ratios graph of the different isotopes and after calibration, will provide estimate of the isotopic concentrations within process piping
- Perform activity integrations to determine deposited activity in filters, resin beds, and hold up tanks; thereby reducing Part 61 characterization costs.

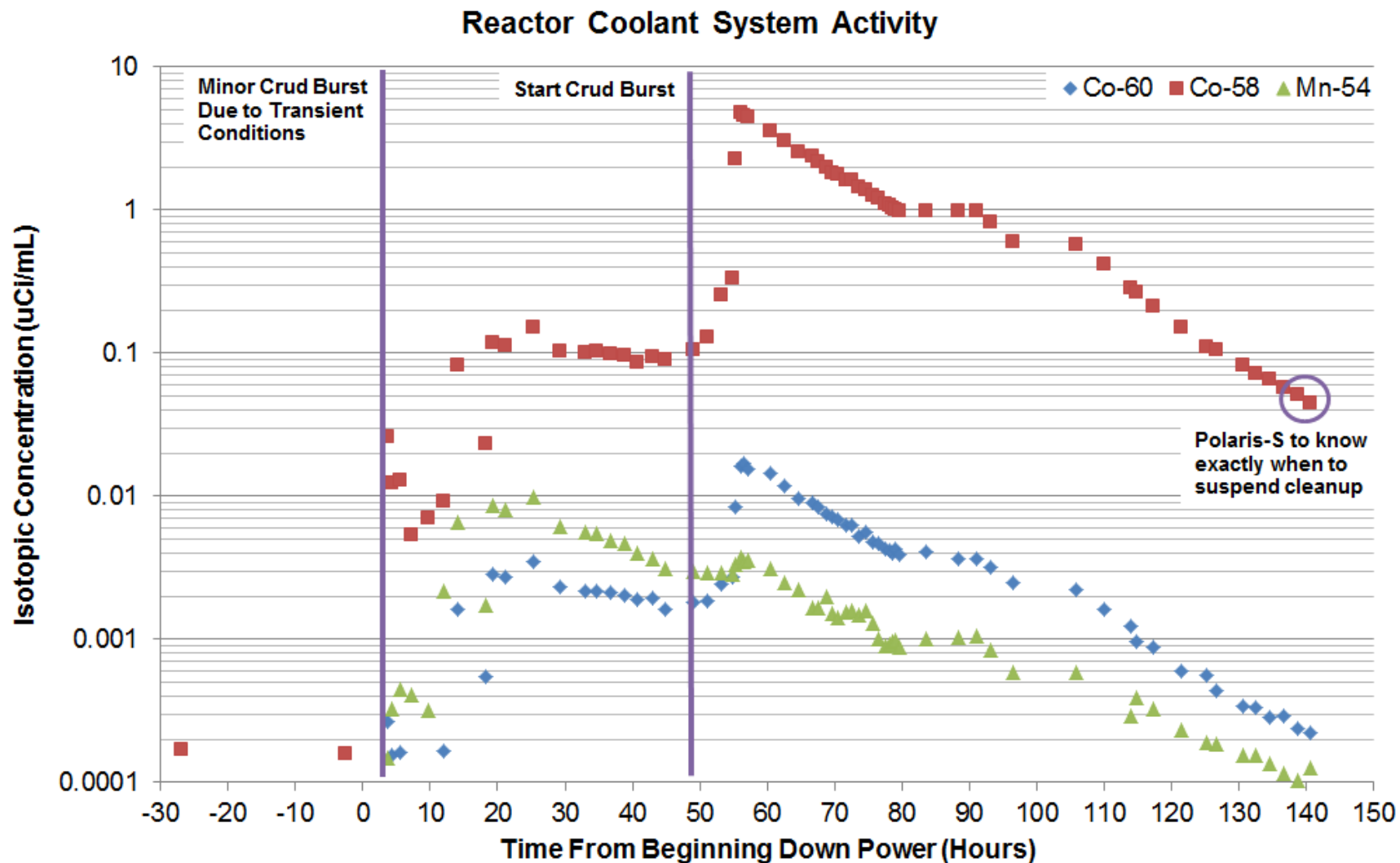
# POLARIS-S TRANSIENT MONITORING



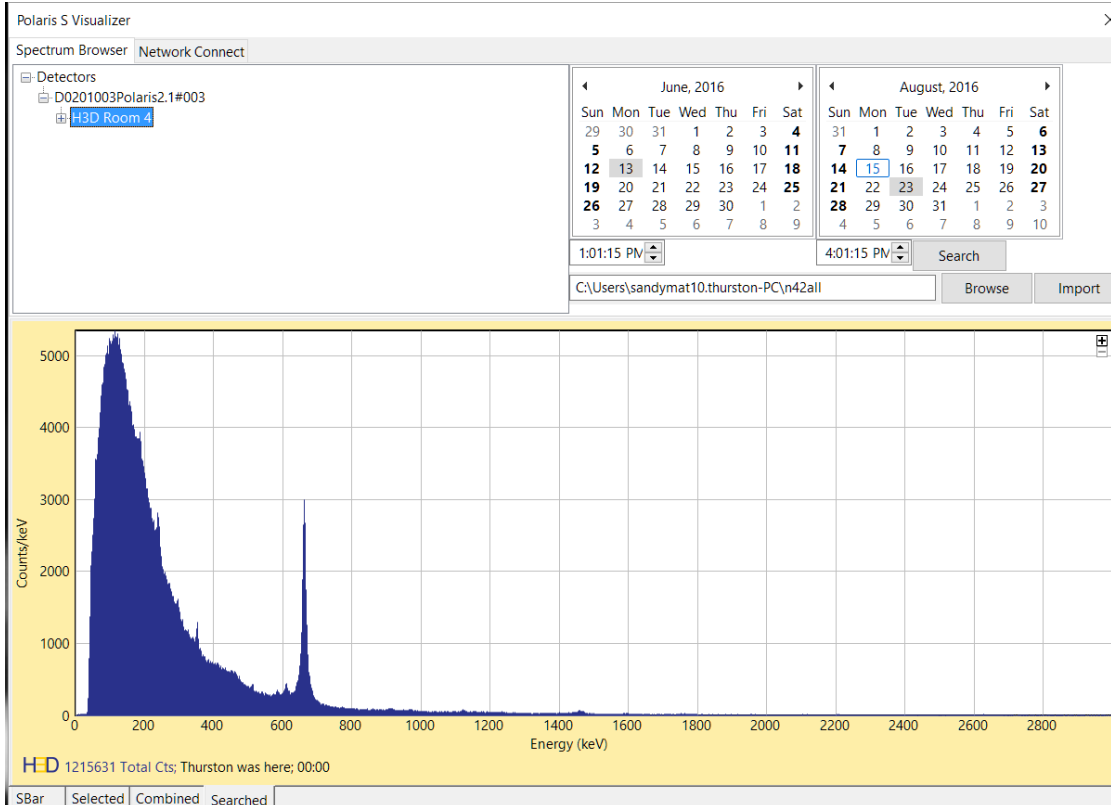
Generic RHR Diagram



# POLARIS-S CRUD BURST MONITORING



# POLARIS-S POST-PROCESSING SOFTWARE



- Allows selection of data based on date/time, monitored system and measurement location
- Performs Isotope Activity Analysis and exports data to analyze isotopic trends
- Correlation with operation logs, and other process monitors to examine cause and effect to provide evidence based optimization plans for transients

# POLARIS-S SPECIFICATIONS

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- $\leq 1.0\%$  FWHM at 662 keV
- Energy range: 50 keV – 3 MeV
- Maximum Dose Rate: 200 mRem/hr
- IP65
- Power Supply: 100-240V, 47-63 Hz
- Battery Life: >6 hours at 73°F, >3 hours at 5°F or 122°F
- Data storage on removable USB drive
- View real-time data on tablet or over network communication
- Data download via tablet or over network communication
- WiFi, Bluetooth and Ethernet compatible
- Post-processing software to analyze and compare results



**QUESTIONS**