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Connecting Visionaries in Radiation Safety, Science and Industry

MIRION Connect 24

Annual Users' Conference

July 29 - August 2 | Omni Dallas Hotel, Dallas, TX

MIRION TECHNOLOGIES

Workshop and Demonstration of the Data Analyst

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Mirion Technologies – Canberra
Meriden CT USA

Agenda

Power Point

- Presentation of the Agenda
- Introduction to the Data Analyst
- Software support tools
- Examples of applications
- TouchPanel for simplified Gamma Spec operations
- Continuous QC operations

Live Action

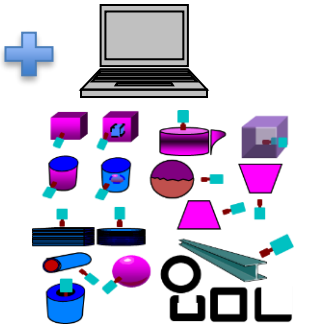
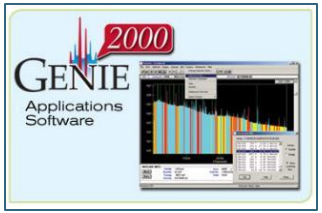
- Show-N-Tell of the Data Analyst
- Show-N-Tell using DAProspector
- Q&A

Tools to build continuous or triggered assay systems

Building Blocks:
Detector
MCA
Data Analyst
Shielding
Support Tools:
ISOCS
Genie
Display software
Viewing software
Reanalysis software




NEW TOOL

The Data Analyst provides unattended continuous sequence of quantitative gamma assays
OR remotely triggered spectral acquisition and analysis
OR both simultaneously

- Works with various detector/MCAs
  - **CZT** with internal MCA
  - **Scintillation** detectors with Osprey MCA
  - **HPGe** detectors with Lynx MCA
- Autonomous – apply power and immediately starts running; PC only for setup and data readout
- Runs standard Genie inside the box
- Wi-Fi, or Ethernet communications
- Includes GPS to correlate nuclide activity with location
- Compatible with EcoGamma for concurrent doserates
- Includes remote temperature sensor

Conventional sample assay

Data Analyst

Power On starts these processes

Preliminary Analysis

Repeating process
e.g. 5 min,
Stores ancillary data
cps, doserate, temp & pressure, raw spectrum
Alarms as they happen
cps, doserate, …

Continuous mode

Continuously repeated assays

Workflow 1
5 minutes

Wf 2
30 m

Wf 3
4 hr

Count stopped at preset time

Std Genie Analysis

Post NID functions

Data stored

Outside world communication

Same process. Can have different analysis parameters

Triggered mode

External signal starts count

Count stopped at preset time

Std Genie Analysis

Post NID Fx

Data stored

Outside world comm'n

User starts count

Count stopped at preset time, or by user

Std Genie Analysis

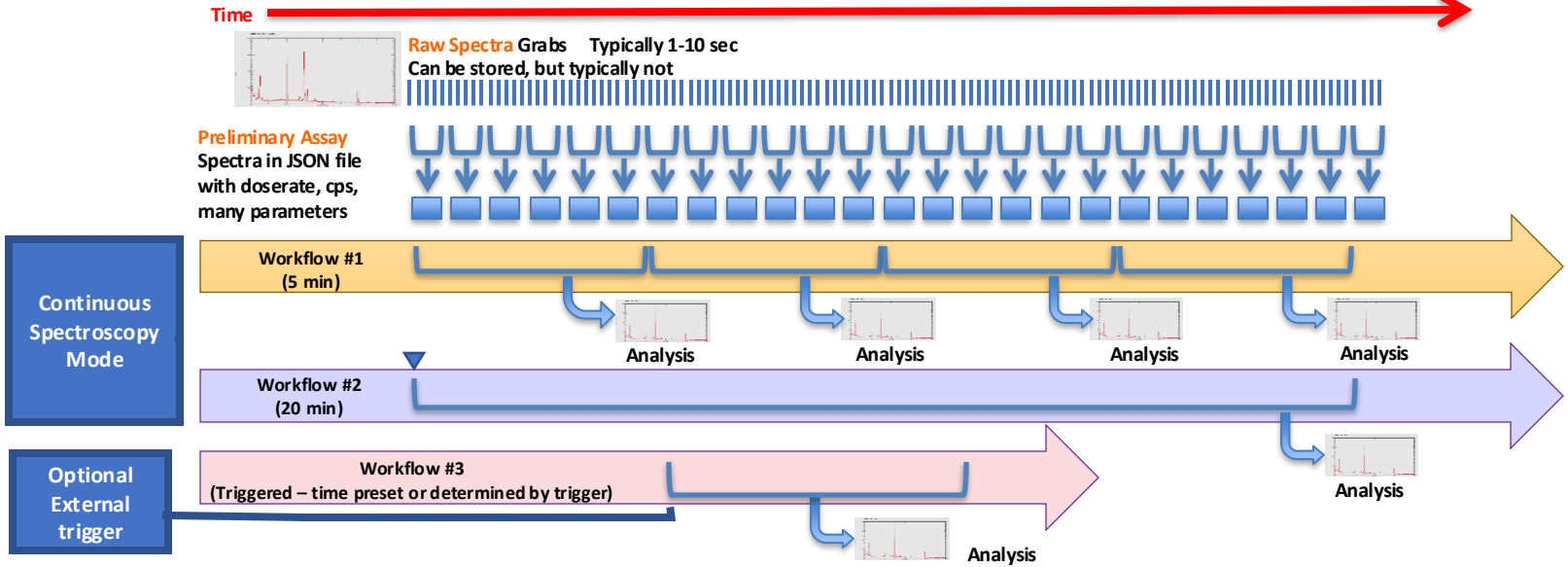
Post NID functions

Data stored

NID alarms, Custom script calculations, ..

FTP results to server
Alarm status on GPIOs
data to Horizon

Data Analyst Key Features

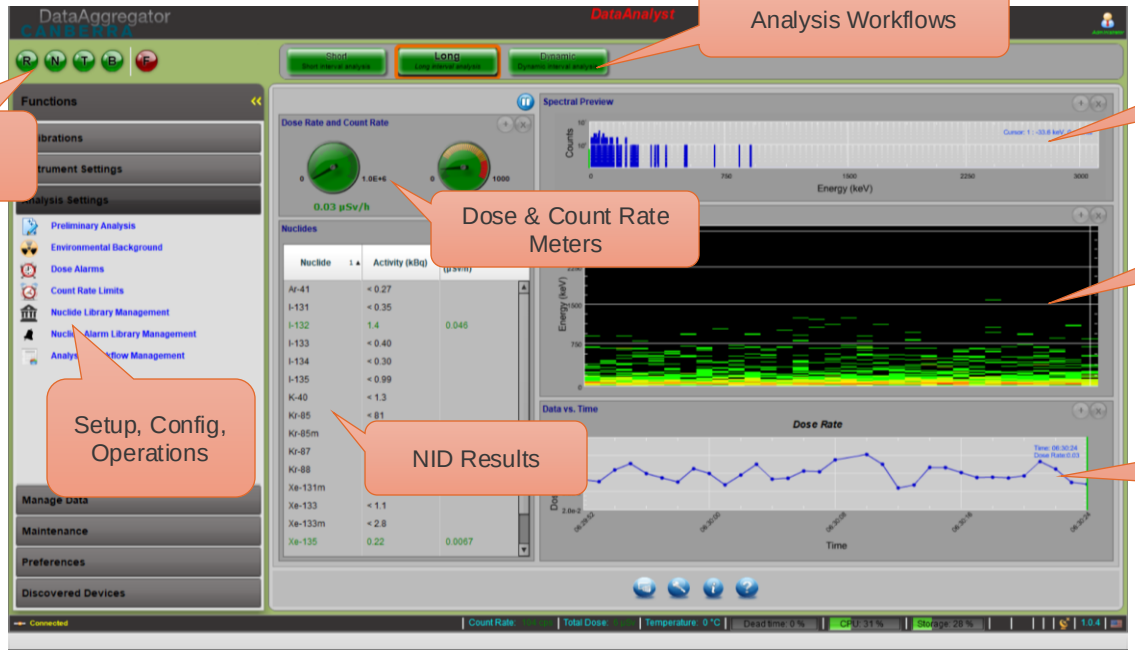


- **Workflow: Assay processing procedure:**
  Each with own Count time, Libraries, Analysis parameters
- Multiple workflows can operate at the same time:
  e.g. short sample, long sample, very long QC
- Continuous Spectroscopy Mode; Triggered Mode; or Both
- Alarm outputs: based upon nuclide-specific assay results

- **Process monitors:**
  - Generally Continuous Mode
  - Short count workflow for quick response
  - Long count workflow to detect low activity nuclides
  - Longer count time for continuous QC assay

- **Sample assay systems**
  - Triggered for sample type 1
  - Triggered for sample type 2
  - Triggered for sample type n
  - Continuous mode long count time for QC assay

Data Analyst Dashboard primary screen



Analysis Workflows

Alarm, Fault indicators

Spectrum Display

Dose & Count Rate Meters

Waterfall Display

Setup, Config, Operations

NID Results

Data Time Plot for Dose, and Nuclide Activity

- Connects to PC via supplied Dashboard tool – based upon Adobe-AIR
- PC for setup and viewing of operations; not required for data collection and analysis
- This viewing tool might be suitable for simple short applications.

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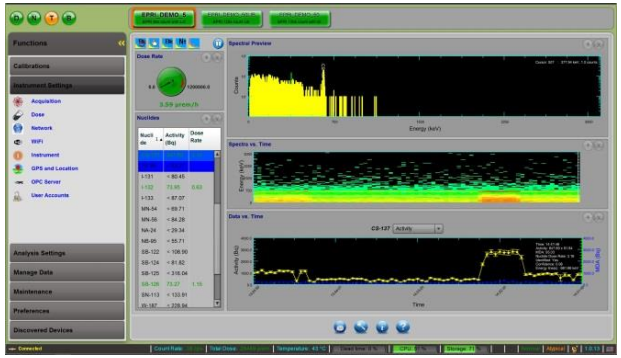
Demonstration

- Explain hardware
- Show User Interface
- Show Continuous count operation short, long
- Show Triggered count operation

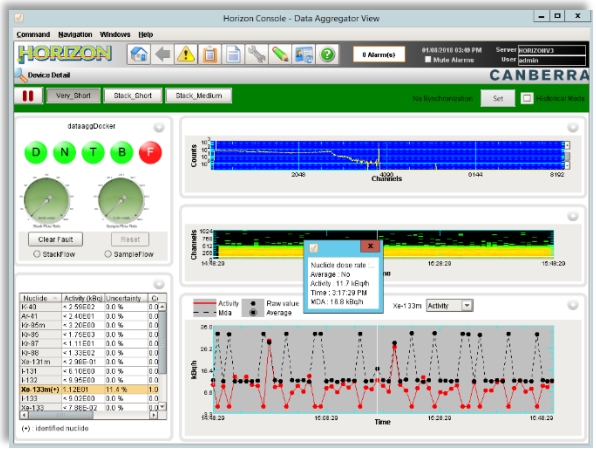
Operational and Support Tools to work with Thousands of Spectra

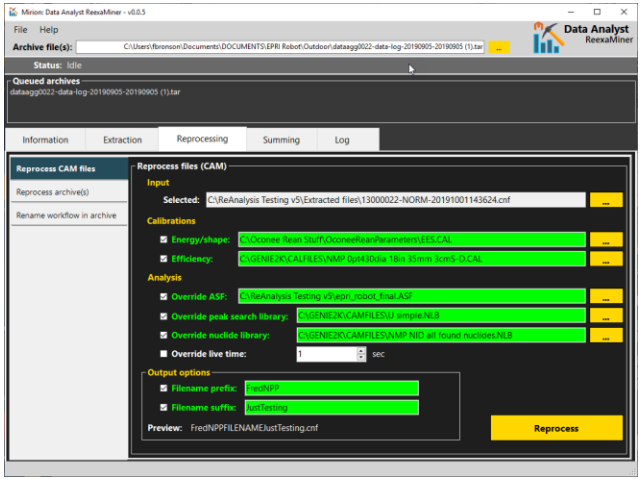
Main Screen of Data Analyst User Interface for viewing with connected PC



DA Prospector: Grouped Nuclide viewing and live data export to remote PC

Horizon: Relational Database and Central Supervisory display





ReexaMiner: Batch reanalysis tool allowing parameter changes

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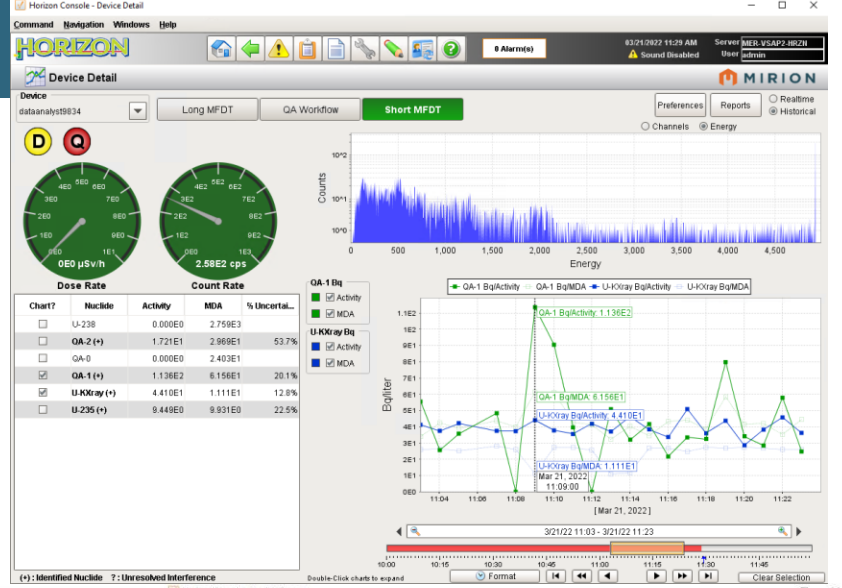
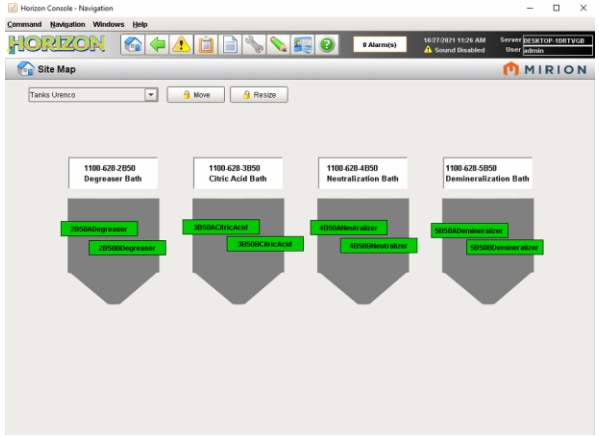
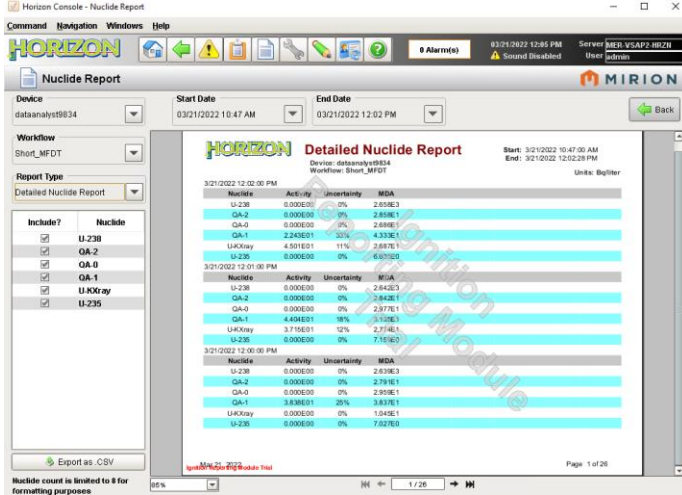
Horizon - Spectroscopy version

- Supervisory system to monitor live data
- Single or Multiple Data Analyst inputs
- Records / displays Historical data for Review
- Displays faults/warnings/alarms from DA
- Detailed nuclide reports
- View analyzed spectra
- QA workflow monitor
  - Activity, FWHM, centroid
  - Alarms, text messages
- Custom calculations and screens

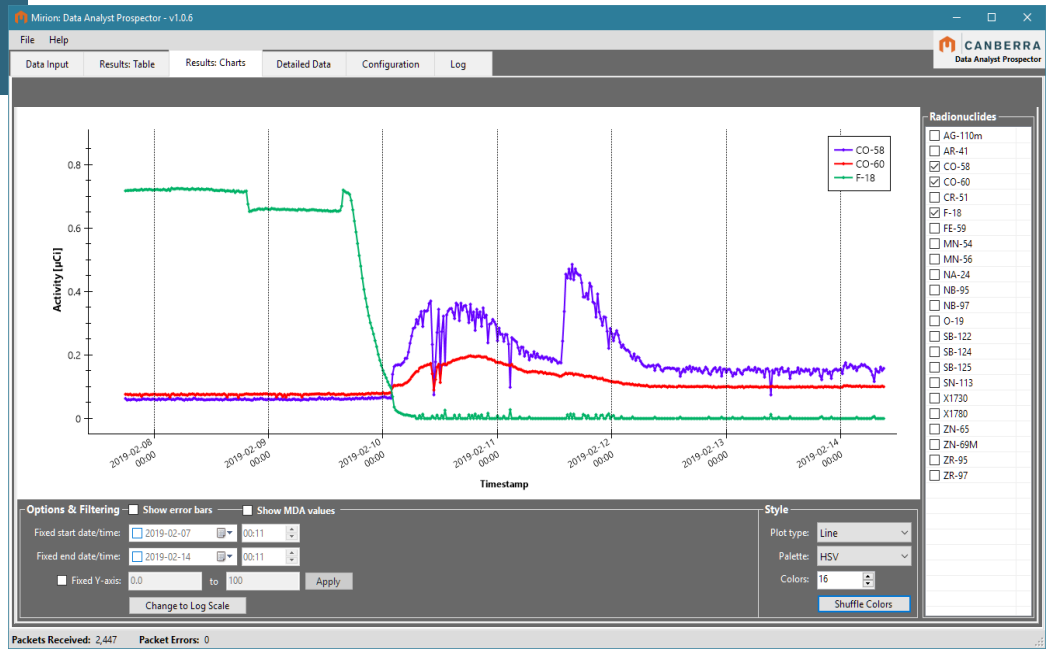


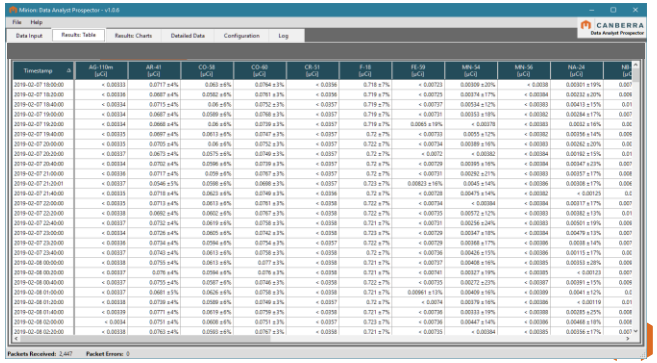




DA Prospector

- **Powerful Visualization of DA Archive file**
  - Individual nuclide activity vs. time
  - Simultaneous viewing of multiple nuclides
  - CPS and doserate vs. time
  - Identifies trends and anomalies for further investigation
  - Graphs can be exported for input into reports
- **For In-Depth Analysis of Spectra**
  - Tabular view give exact results of all nuclides
  - Tabular data can be extracted to Excel for further analysis
  - Clicking on interesting datapoint in table launches Genie for more detailed review and reanalysis
- **FTP Server for Live Updates of Data**
  - DA will hold un-transmitted files if connection interrupted
  - DA always stores and retains the full dataset

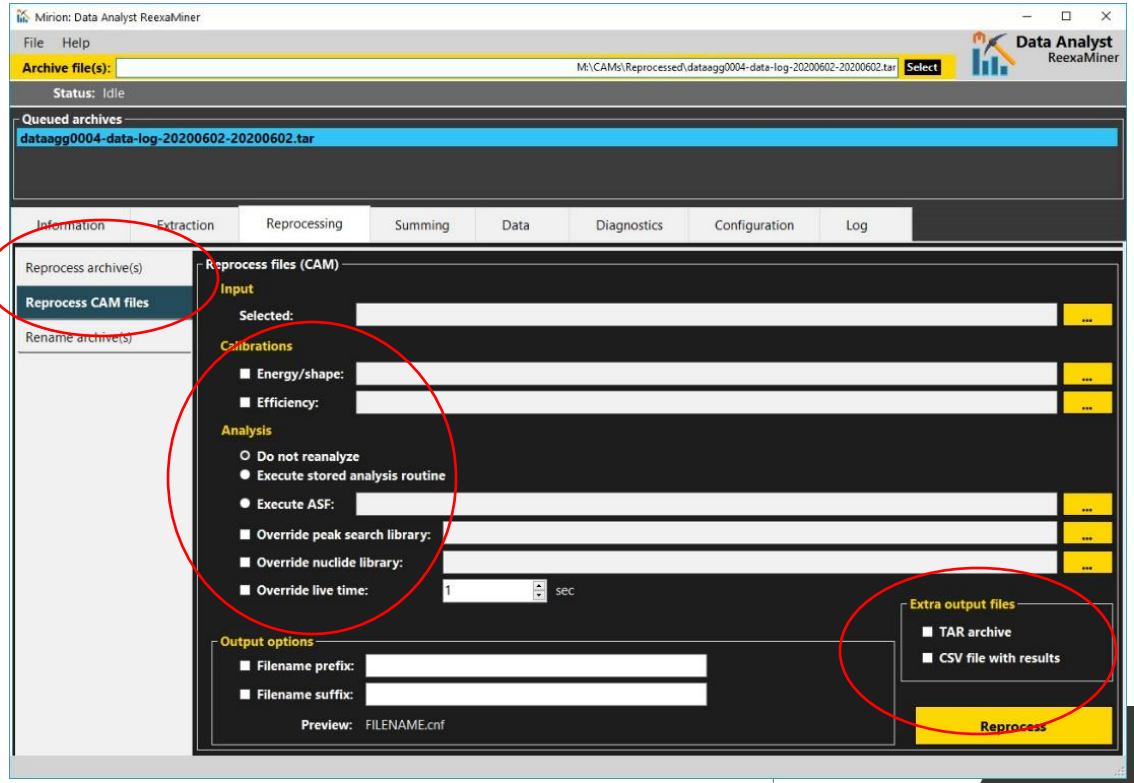




DA ReexaMiner – Batch ReAnalysis Tool

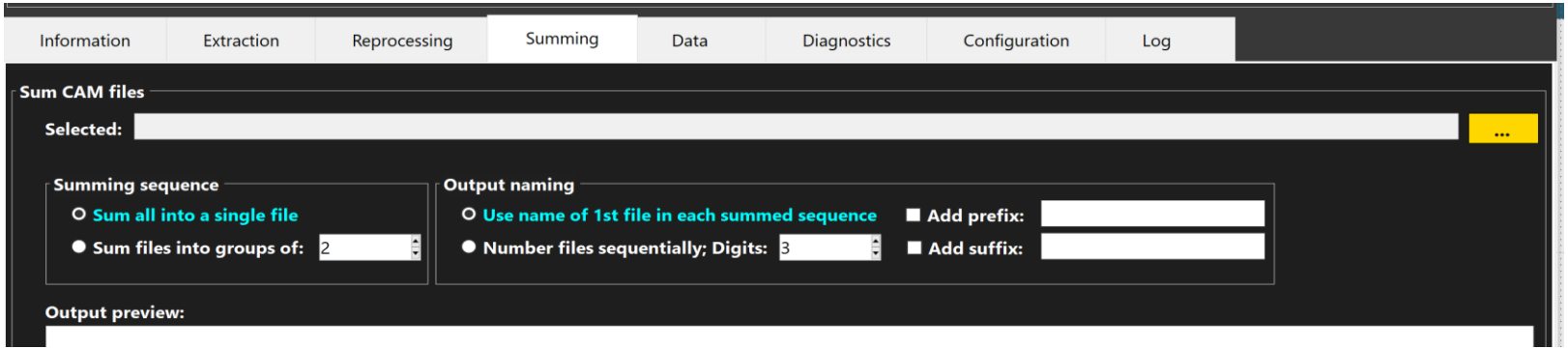
- Primary purpose - to improve Data Analyst data with a better reanalysis
- Can also be used on groups of standard Genie spectral assays.

- Inputs:
  - Data Analyst archive files
  - Groups of Genie CNF files
- Change calibrations, nuclide library, analysis parameters
  - Adjust ISOCS geometry & efficiency calibration
  - Add or remove nuclides in library
  - Reanalyze any subset of data
  - For all workflows or individual ones
- Outputs
  - File format that DA Prospector can read for visualization
  - CSV file of all nuclide results

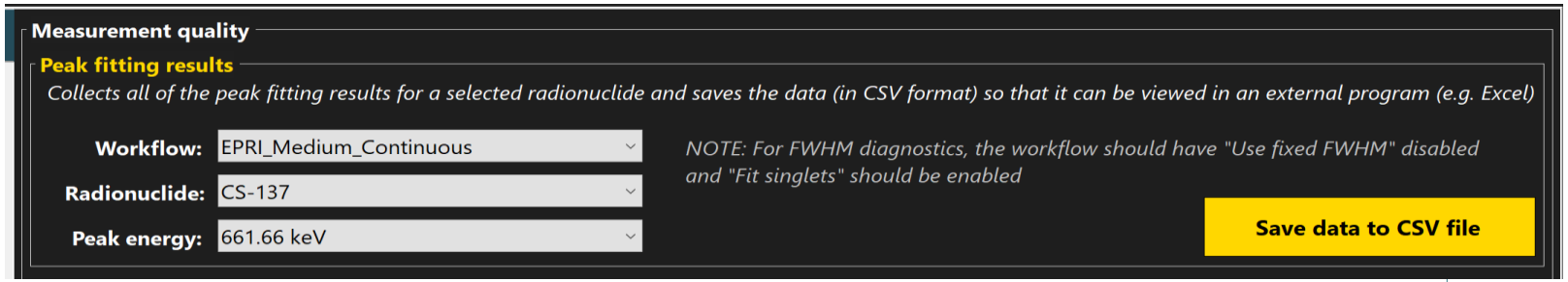


More tools within ReexaMiner for “normal” Genie users

- Sum individual CNF files



- Extract from above packaged files Quality testing data for a single nuclide and energy
  - Activity, FWHM, Centroid into CSV file for analysis and plotting with Excel



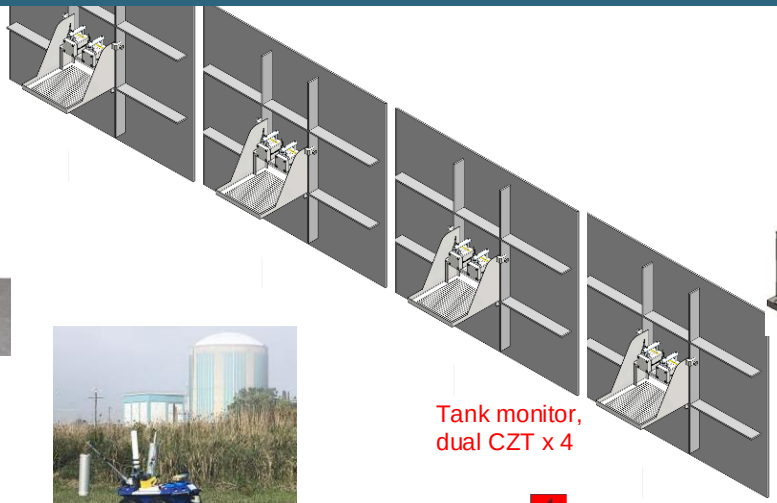
Demonstration

- Demo DAProspector
  - Nuclide Graphical data
  - Countrate
  - Tabular
  - Spawn to Genie
  - FTP Import

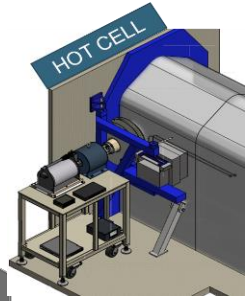
Continuous or Triggered Spectroscopy in recent Mirion projects using the Data Analyst

Stack Gas Monitor HPGe

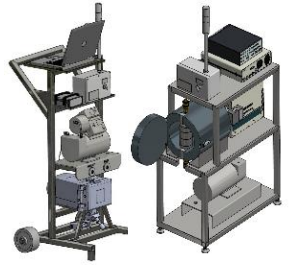
HPGe Primary Coolant Monitor



Tank monitor, dual CZT x 4

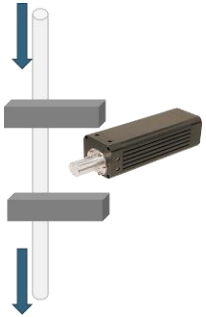


Fuel Rod Scanner HPGe



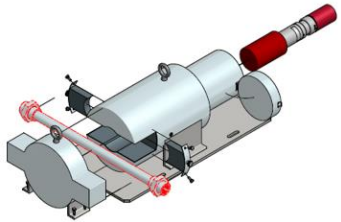
Particulate, Iodine, Gas monitor
CZT [left] HPGe [right]

NPP in-situ CZT system

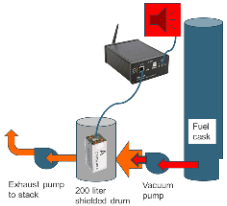


Plutonium chromatography system, uGe

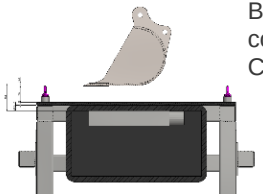
Robot ground and floor, dual



Pipe process monitor NaI

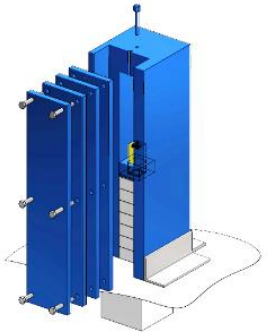


Fuel cask monitor CZT detector



Excavation bucket monitor

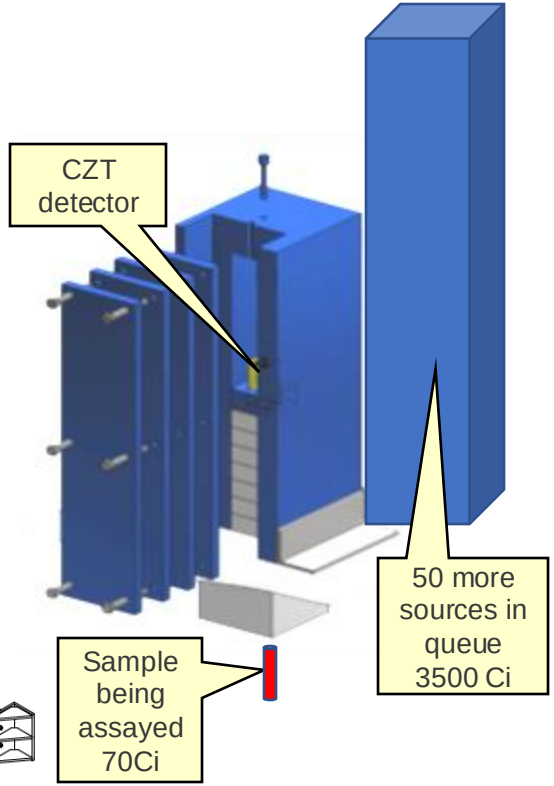
BWR primary coolant monitor, CZT

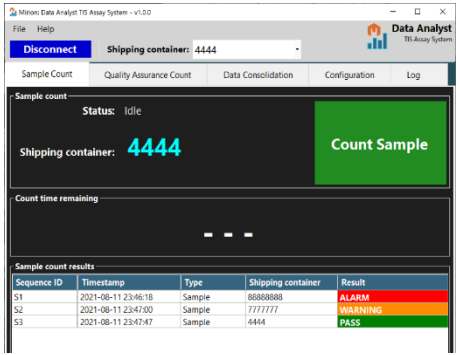


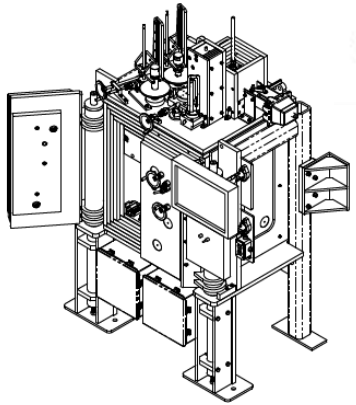
Lu177 assay, CZT

Lu-177 assay system at Bruce Power

- Targets containing enriched Yb-176 are irradiated in the Bruce Power reactors
  - Yb-177 [T½ = 1.9hr] produced; decays to Lu-177 [T½ = 6.7d]
  - Irradiated ~1 week; decayed ~24 hours before assay
- Sample assayed at 40cm away inside 15cm thick tungsten box
  - Estimated activity at time of measurement is ~70 Ci [3E12 Bq]
  - About 50 more samples of similar activity are waiting in the queue only 20 cm and away behind 15cm of Tungsten
- Heavily attenuated CZT detector will be used
  - MicroGe detector recommended, but too “complicated”
- New feature on DA allows custom dead-time for CZT which extends accurate counting range
- Touch screen PC for operator
  - 2 Software-Triggered Workflows
  - One for QC source
  - One for Targets
- Custom software consolidates all the data, loads into database, and generates shipping document



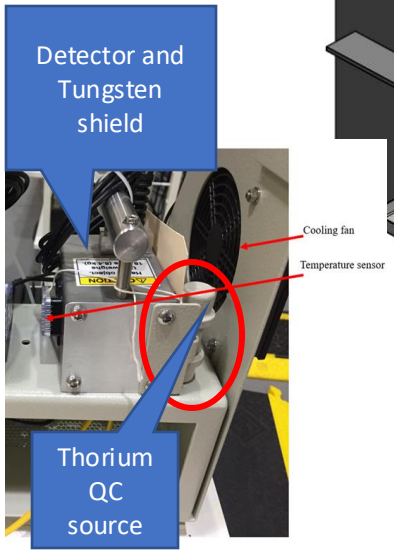


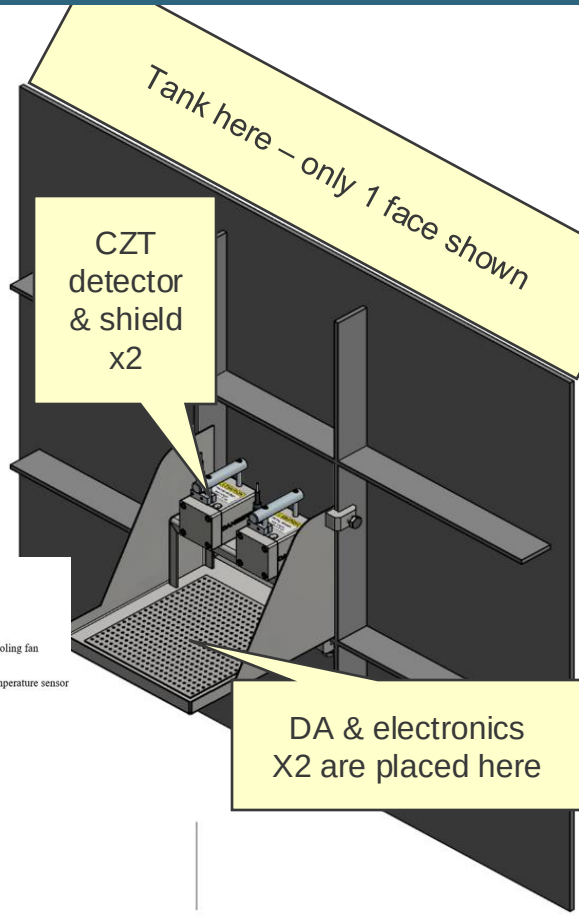


MIRION TECHNOLOGIES

URENCO MFDT Assay and Release System

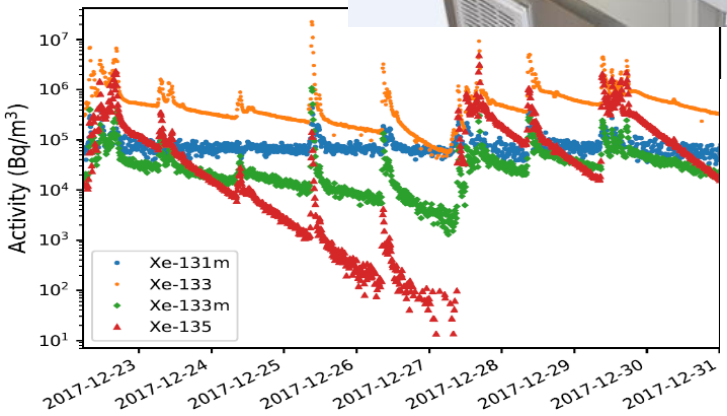
- URENCO is a Uranium Enrichment facility
- Components are cleaned in the 4 Multi Functional Decontamination Tanks - MFDT
  - All identical in size – about 1x1x1 meter
- Before discharging fluid from the tanks, a Dual Independent assay is required to assure no downstream criticality
- Dual independent shielded CZT detectors aimed at each tank
- Shield has embedded Thorium source for continuous QC for continuous QA
- Continuous Spectroscopy Workflows used
  - Short [4 hour] and Long [12 hour] for Uranium
  - Very long [1-2 days] for very low level Thorium QC source
- Horizon software continuously collects data from all systems for remote viewing and database storage
- Special Tank Release report
  - Time history of the QC results for each group of 4 detectors
  - Time history of the Tank Assay results for each group of 4 detectors
  - Comparison between the two assays and to the release limit





Stack Gas Monitor – 4 similar units

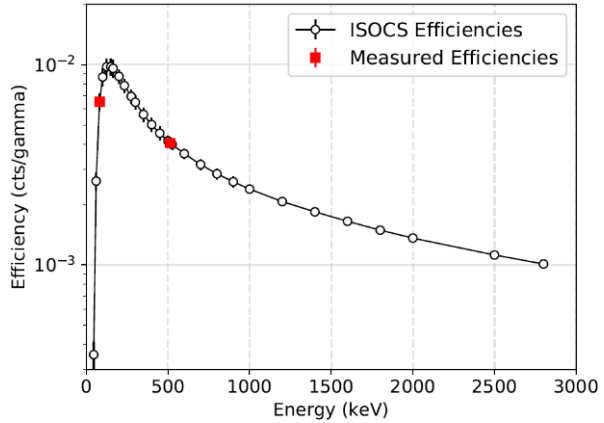
- Earliest large system use of the Data Analyst
  - 2017, 2018, 2019, 2020
- Pump pulls sample from stack
- Pre-filter to remove particulates and Iodine
  - Could be monitored separately for P-I-NG
- Assay container 17 Liter Marinelli Beaker
  - Inside modified 747 shield
- HPGe detector [30% RE] and Lynx MCA
  - Electrically cooled with CP-5
- Lynx MCA and Data Analyst
- 8 decade dynamic range
- Temperature and pressure corrections to concentration
- Stack flow input to convert results to effluent rate
- Horizon for remote display and data archive

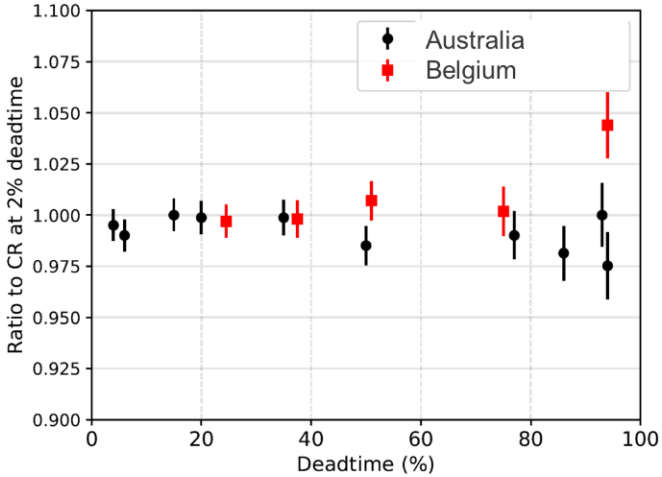


MDC (Bq/m³)			
Nuclide	600 sec acquisition	3600 sec acquisition	14400 sec acquisition
Kr-85	6.91E+04	2.50E+04	1.19E+04
Kr-85m	1.85E+02	6.77E+01	3.25E+01
I-131	2.20E+02	7.67E+01	3.61E+01
Xe-131m	7.41E+03	2.72E+03	1.31E+03
Xe-133	5.74E+02	2.10E+02	1.01E+02
Xe-133m	1.56E+03	5.66E+02	2.70E+02
Xe-135	1.87E+02	6.77E+01	3.24E+01
Xe-135m	2.46E+02	8.25E+01	3.82E+01

Accuracy tests: Efficiency calibration & Deadtime correction

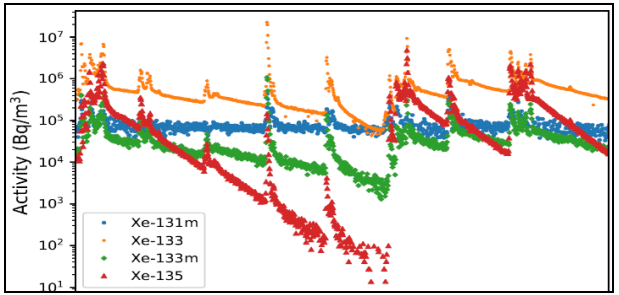
- Efficiency Validation of ISOCS calibration for Australia and Belgium systems
  - Calibrated Xe133 and Kr85 injected into system
  - Both energies on Both systems were within 2% of the calibrated efficiency
- Deadtime correction
  - 30% REGe detector with Transistor Reset Preamplifier and Lynx MCA
  - Cs-137 source held at a fixed distance (fixed count rate)
  - Eu-152 source moved to increase total count rate
  - Peak analysis settings remained constant during testing
  - No change in net peak area up to 75% dead time
  - Only 4.4% change in net peak area at 94% dead time (510,000 cps)





Recent request – add High Range channel

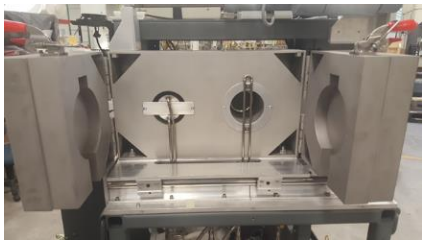
- Accident scenario indicated very high potential gas releases
  - 11 different gas nuclides with concentrations 10,000x – 100,000x higher than installed system can handle
- Regulator requires accident range system
- Customer proposed using Mirion microGe detector to look at inlet pipe of existing gas monitor
  - 1 cc HPGe with electric cooler
  - Lynx MCA
  - Data Analyst
  - Horizon user display
- Discussions in progress



These duplicate existing system

EPRI HPGe NPP Primary Coolant Monitor

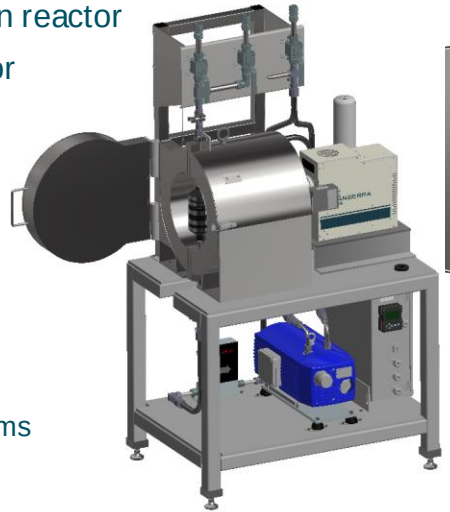
- Primary coolant externally reduced in pressure and temperature
- HPGe detector with dual counting chambers
- Sliding backshield exposes proper chamber to detector
- Chamber 1 for **continuous** flow measurements
- Chamber 2 for **sample - decay** - **count** measurements
- Embedded Thorium source for continuous QA
- Top of unit houses the detector, cooler, and electronics
  - Enclosed in insulated chamber with HVAC to regulate temperature
- Plumbing system at bottom
  - ► Controls chambers
  - ► Chambers can be filled with other fluid for background measurements and for cleaning
- Horizon for remote data viewing and historical records
- Installed and operated at Monticello NPP for 7 months – no failures !!

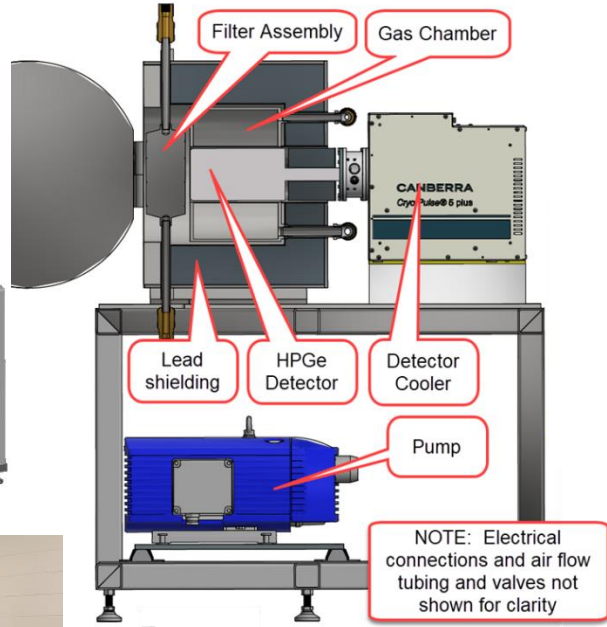


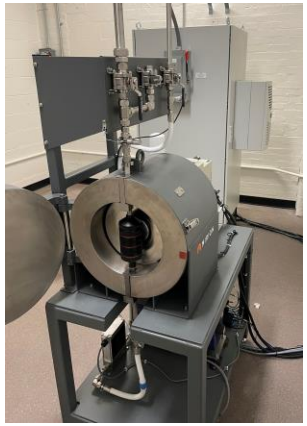
Spectroscopy Particulate Iodine and Noble Gas Monitor

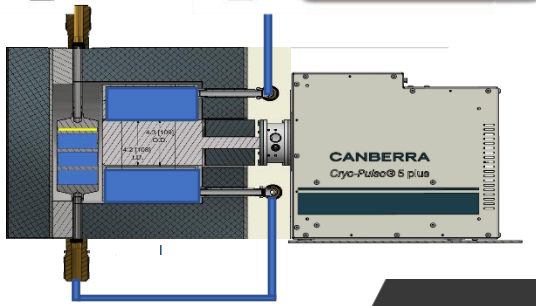
- Now starting initial operation at ORNL isotope production reactor
- Particulate and Iodine** filter cartridge in front of detector
- Gas chamber around side of detector
- Can be configured for:
  - Particulate only; Iodine only; Gas only
  - Any combination of the above
- Filter exchange by replacing cartridge assembly
- Electronics in separate cabinet
  - Local Horizon display; Networked display of multiple systems
- Separate Continuous Workflows for Particulate, Iodine, and Noble Gas
  - Each workflow has separate efficiency calibration and separate nuclide library
- Thorium source in shield for Continuous QC
  - Separate Continuous QC Workflow
- New: Differentiation software for filter assays

** ORNL application is also for other nuclides [e.g. Os-191] that accumulate on charcoal cartridges





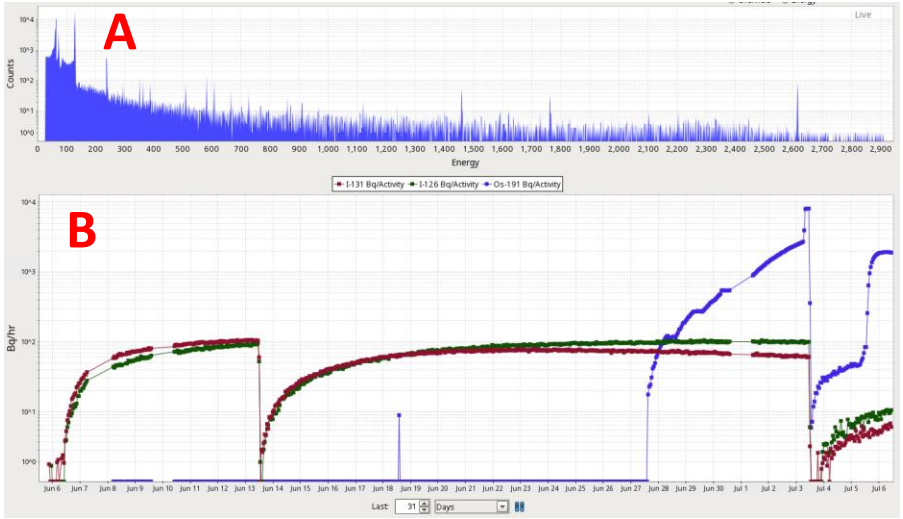


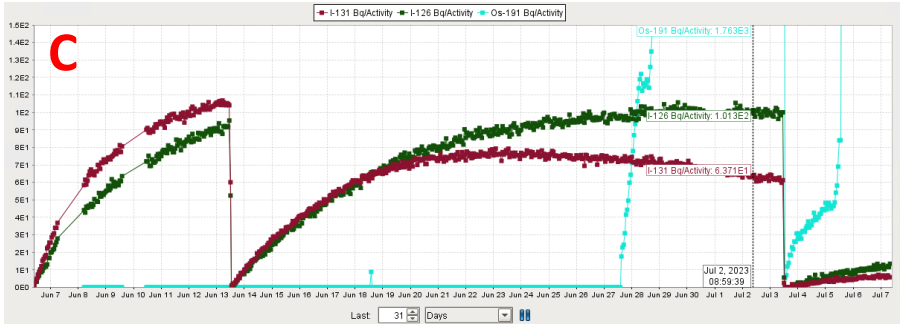


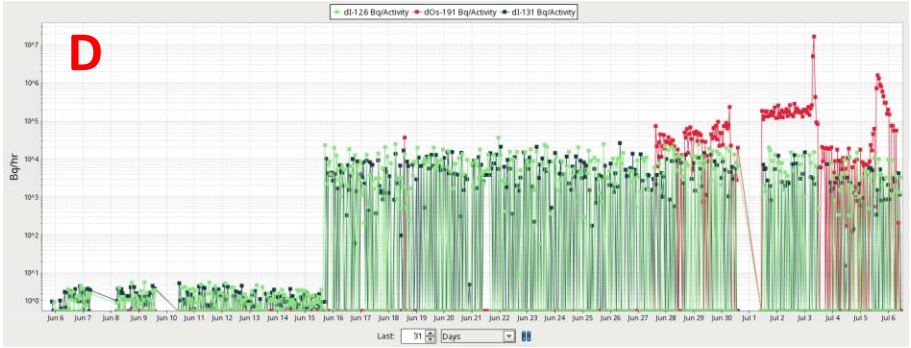
Special Differential Activity Assay feature

- Particulate filter and Iodine cartridge are integrating devices.
  - Activity from assay is total activity on filter since the filter was installed, not the current concentration in the fluid
- Regulatory and site control limits are concentration, not activity on filter
- Differential engine created to compute and display concentration
  - New “Nuclide” added to library; e.g. D_I-131 and paired with I-131
  - Concentration of D_I-131 determined by the difference in successive Activity values divided by the product of flowrate and count time.
- This derived concentration Nuclide can be treated just like any other nuclide
  - Stored, Plotted, Alarm settings, …
- Multiple Workflows with different times will be set up
  - Short count times for early detection and to better define the start time of the release
  - Long count times for lower detection limits and more precise results

Iodine** Cartridge Activity Time-sequence Horizon Displays







A. Spectrum of example datapoint

B. Activity of I-131 I-126 and Os-191 on filter – Log
   Two separate filter changes during time period

C. Activity of I-131 I-126 and Os-191 on filter – Linear

D. Differential activity for I-131 I-126 and Os-191 – Log

Early data in units of Bq on filter in sample flow stream

Later data in units of Bq/hr out the stack; ~4000x dilution

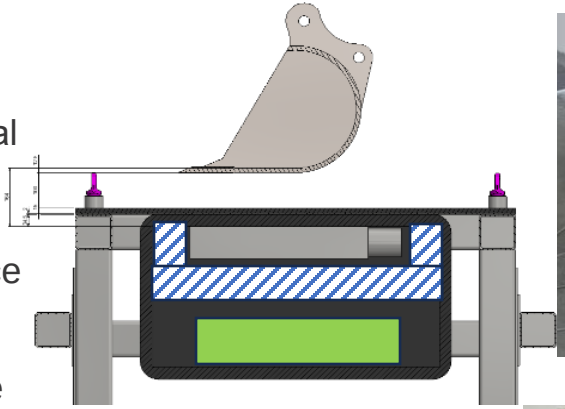
I-131 and I-126 below MDA for these “too short” count times

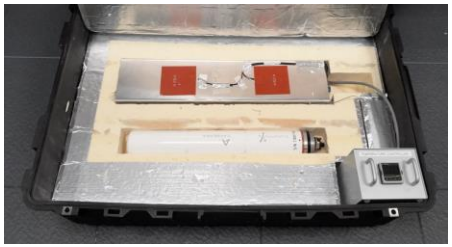
Os-191 stack release rates in red

NOTE: The Os-191 release rates are only 0.02% of the 10CFR20 App. B Environmental [yearly average] Limits

UK Service Project – Magnox site soil sorting

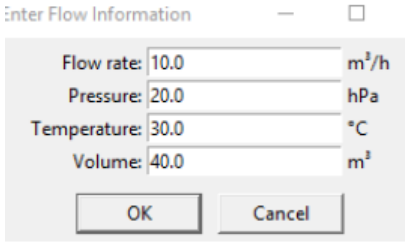
- Soil excavation and sorting project
- Each bucket assayed to separate “contaminated” material
- Soil has both Cs137, Co60, Radium, Thorium, and K-40
- Used existing equipment in UK office for this small service project
- 3x5x16 NaI detector, Osprey MCA, EcoGamma doserate
  - LED-stabilized not available; used heated blanket for stable gain
- Custom support box, with shielding from sides and bottom
- Detector and support electronics in waterproof Pelican cases
- 10 second count, triggered by the presence of the bucket
- Good / Bad separation levels:
  - 1 Bq/g Cs-137 and 0.1 Bq/g Co-60 limits
  - Sum of Fractions method Alarm calculations in DA
  - High/Low Alarm signal to Red/Green light for operator

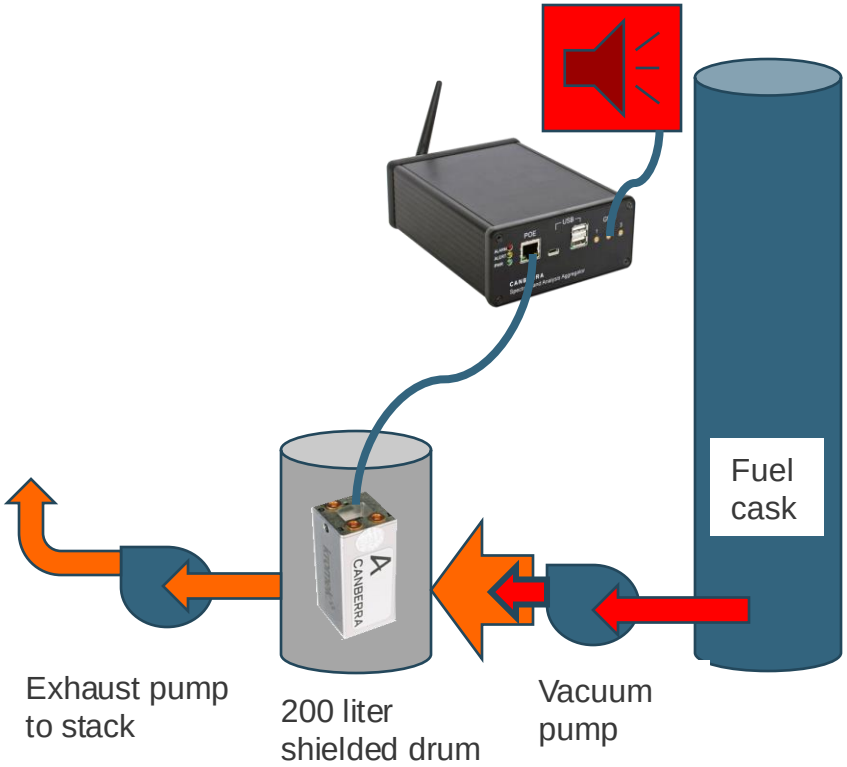


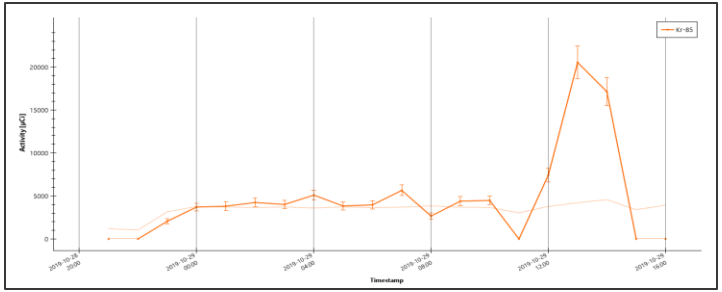


OPPD Fuel Drying Monitor

- 2018 customer bought CZT/shield/tripod kit
- NRC issued IE notice about problem at 2 other plants: Gas released unexpectedly as fuel bundles are vacuum dried in storage cask before welding cask shut.
- Want to determine nuclides and quantity of gasses released from each storage cask
- Calculation modification to compute gas release out stack
  - Corrections for chamber pressure, temperature, and flowrate
  - Results in Bq/m3 in the exhaust
- Alarm triggered if activity in gas too high







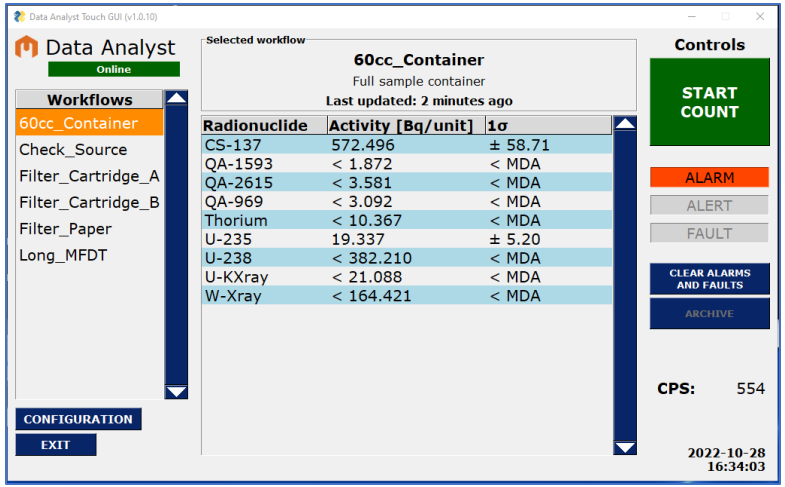
“Pushbutton” Sample Assay Application

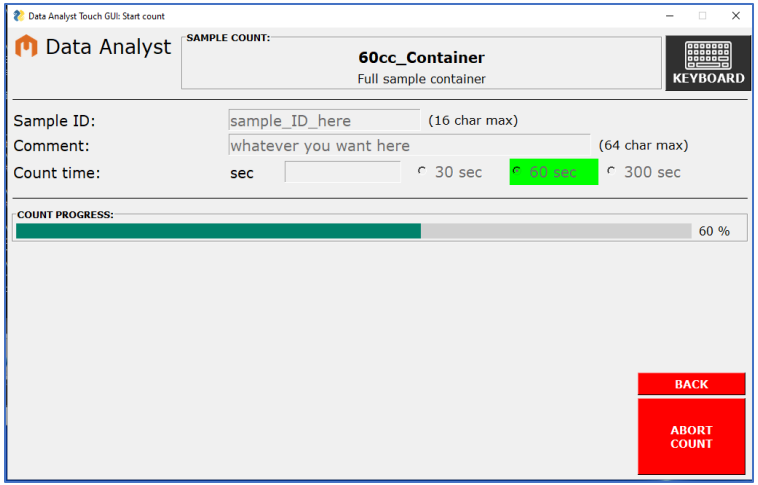
- Over the past few years had a variety of requests for a simple error-proof gamma-spec assay system for standardized operations
  - Back-shift laboratory operation without radiochemist presence
  - Ship-board 24 hr unattended operations
  - In-situ field assays
  - Emergency response field assay laboratories
  - D&D field assay operations
- Standard Data Analyst has 2 hardware trigger inputs for 2 different automated assay operations workflows
  - Each with its own library, efficiency, assay parameters, …
- Created a modified version with a large number of software-triggered workflows
  - Each with its own library, efficiency, assay parameters, …

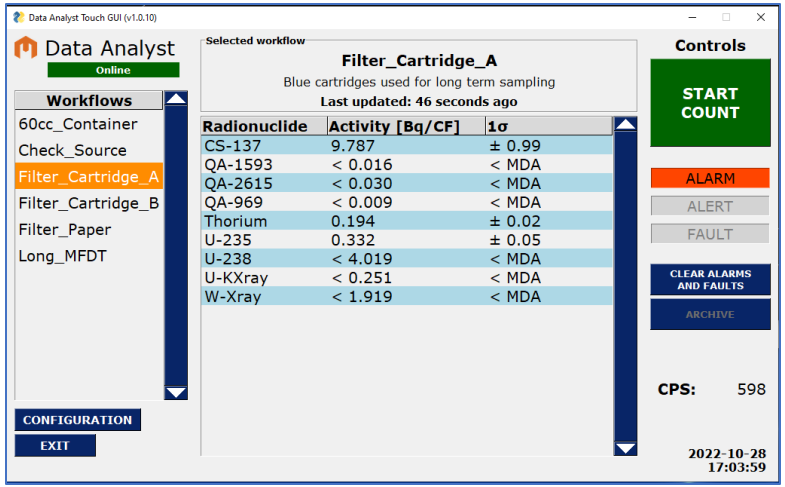
New Control Console

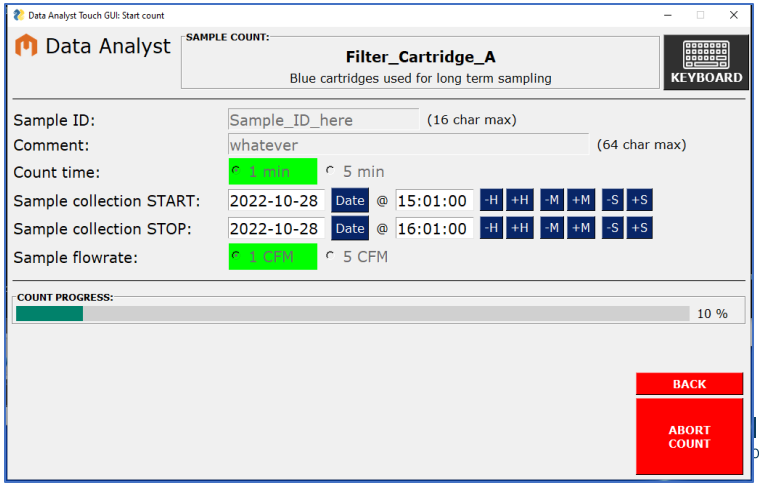
- Integrated unit for quick setup
  - Plug in detector cable & 12v power supply; then start counting.
- Touch screen panel for Operator control, result output, and Alarm annunciation
- Inside the console
  - Data Analyst
  - Temperature monitor
  - GPIO to send outputs to Optional front-panel LEDs or other
- Data Analyst pre-configured for multiple Workflows – examples:
  - QC source Iodine cartridge
  - Filter paper 60cc sample container
- Each workflow can have specific library and alarm levels
- QC workflow will evaluate/alarm on activity, peak centroid and FWHM
- Touch screen configurable for desired user input
  - Sample ID; Additional description
  - Count time – user input or select pre-defined choices
  - Sample collection time – to allow proper decay calculations
- Works with CZT or HPGE or Scintillation detectors

Example Operator Interaction Screens



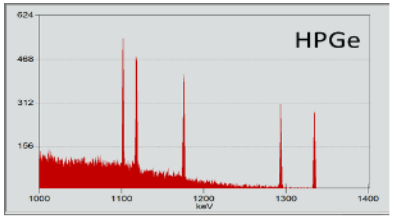


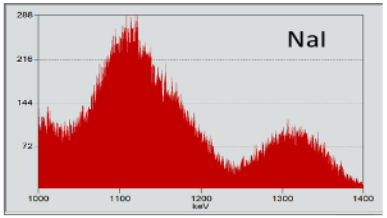


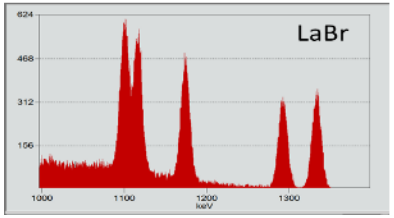


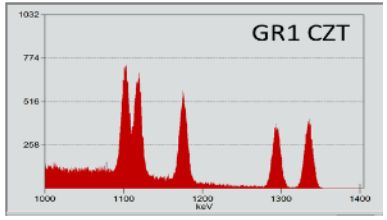
Filter and Small Sample counting application

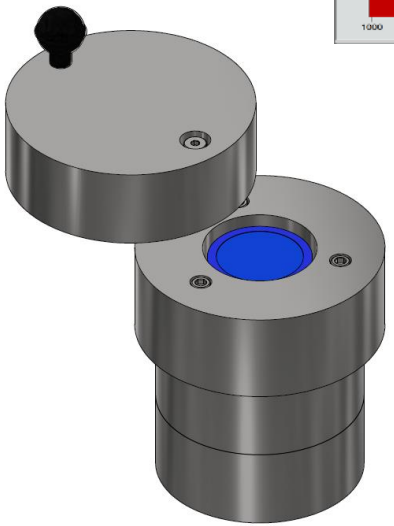
- Portable system for quantitative assay of filters at work site
  - Fresh releases therefore multiple Iodine isotopes, adsorbed gasses
  - Gamma spec is a requirement
- CZT detector and MCA
  - Small, therefore lightweight shield
  - 2% FWHM – good for fresh samples with many nuclides
  - USB powered – low power
  - Stable with temperature
  - 40 – 3000 keV energy range
- Shield – 2” steel thick
  - Sample cavity for
    - Iodine filter cartridge [primary ap]
    - Particulate filter
    - 100cc sample container

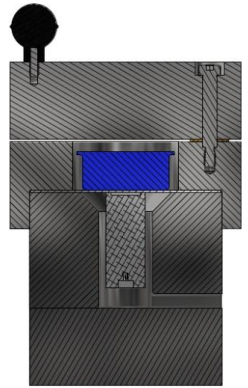










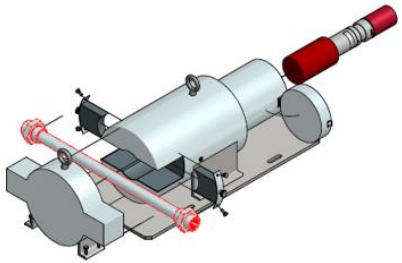


Quality Control

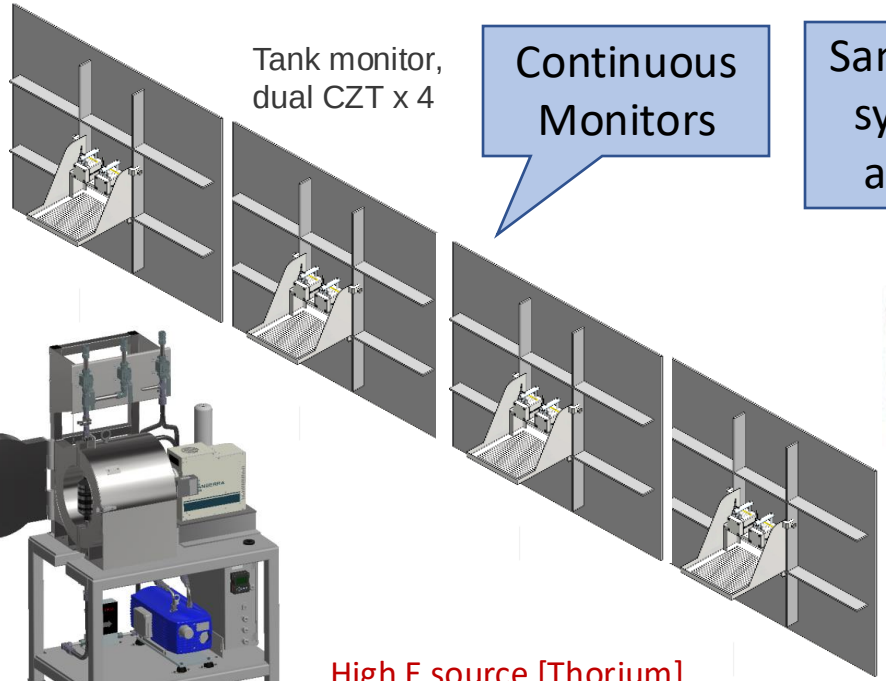
- It is important – Just Do It
- Equally important for Laboratory systems and remote Installed monitors
- For gamma spec systems, monitor for efficiency, gain, resolution
- Typical process: simple in Lab, more complicated for Installed monitors
  - Stop the sample measurement cycle
  - Bring source to instrument
  - Count long enough for good statistics
  - Put source back in storage
  - Analyze results
  - Start counting samples again
- Problems with this method of Discrete QC measurements
  - Only documents quality of operation for a short point in time with big gaps in-between
  - Interrupts sample measurement process during QC period
  - Labor-intensive for remote installed monitors
- With the Data Analyst, the user can do Continuous Quality Control
  - Permanently Installed QC source
  - Low activity, high energy, long count time, Continuously repeating Workkflow

Projects using Data Analyst with Continuous QC

Primary Coolant Monitor, HPGe



Pipe process monitor NaI

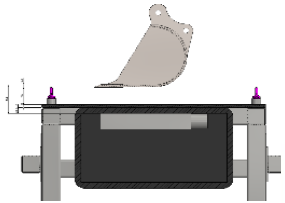


Tank monitor, dual CZT x 4

Particulate, Iodine, Noble Gas Monitor, HPGe

Continuous Monitors

Sample Assay system can also use it

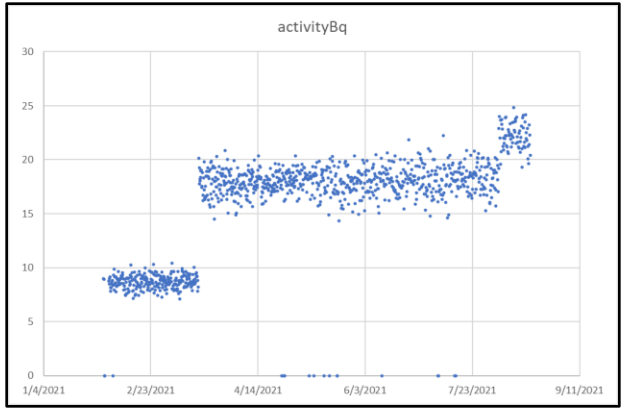


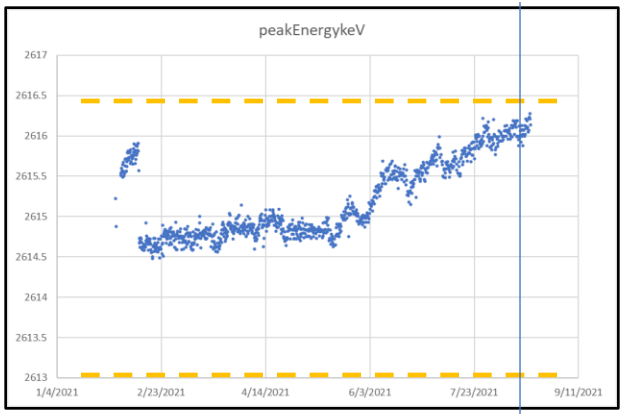
Excavation bucket monitor, NaI

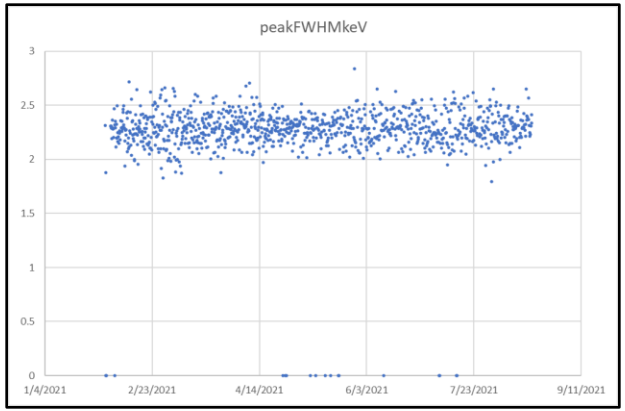
High E source [Thorium]
Behind 2-3cm W, removes low E
Continuous Workflow – always On
Monitoring Activity, FWHM, Centroid
Low activity to not interfere with sample assays
Long count Workflow – e.g. 24hr

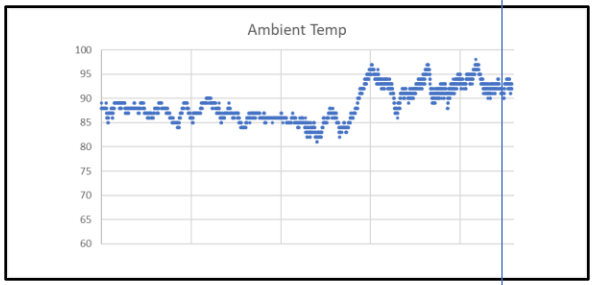
Example - QA data from Primary Coolant Monitoring system

- HPGe system in operating NPP for 6mo
- Thorium 2614 keV line used
  - Activity [efficiency]
  - Energy [gain]
  - FWHM [detector quality
- Activity stable
  - Changes are from equipment reconfiguration
  - Most important QC parameter
- FWHM stable; ~2.3 keV
  - Detector quality indicator
- Gain showed changes, but
  - Always within QC limit of 0.5 FWHM
    - Nuclide ID good until about 1.0 FWHM
  - Much of Gain changes due to temperature changes
- Under normal conditions would have adjusted gain, but this was during COVID times





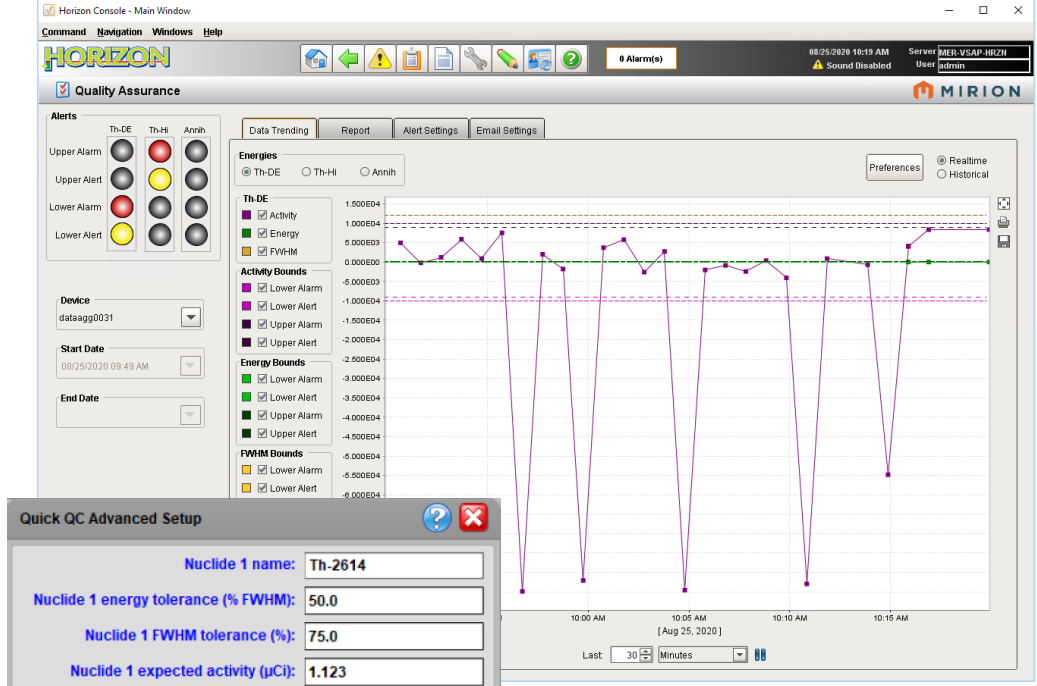


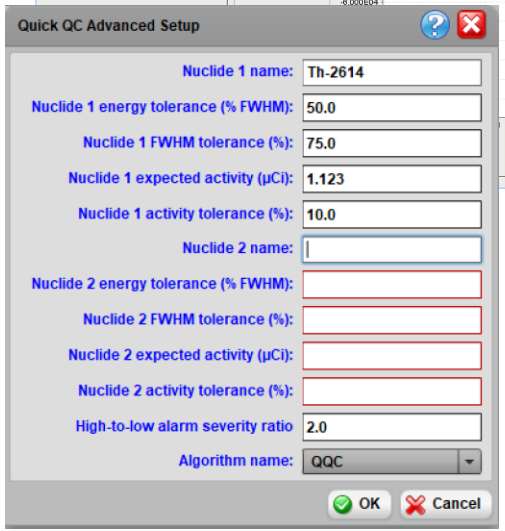


Notification to Data Analyst User for Alerts and Alarms

- Horizon Users
  - Displays live DA output
  - Tests for Hi & Lo QC Limits
  - Activity, Energy, FWHM
  - 1-3 single-line Nuclides
  - On-screen Alert & Alarms
  - Sends text messages upon Alarm

- Data Analyst users [new feature]
  - QQC – Quick Quality Control
  - Tests for Hi & Lo Limits
  - Activity, Energy, FWHM
  - 1-2 single-line Nuclides
  - Activates Alert and Alarm flags
  - LED on-screen indicators [if viewing]
  - GPIO signals for Alert and Alarm

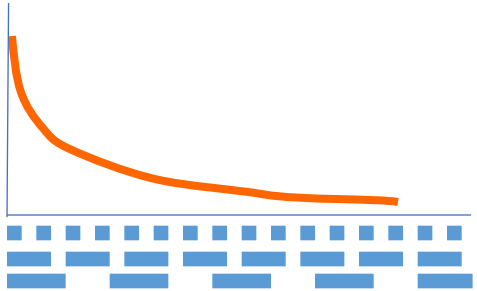




More Applications

- **InSitu Assays**
  - Add TouchPanel to ISOCS system – small 12v battery will run all day
  - No laptop needed in the field
  - Pre-defined standard procedures for semi-trained operators

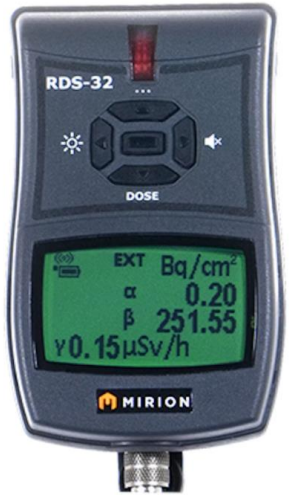
- **Gamma Counting Laboratory Applications**
  - Push-button Automated Sample Assay
    - For novice operators
    - For unattended assay system – worker measures own samples
    - For backshift operations; converts to standard system during day
  - Low level assays with very long Counting times
    - One workflow for shorter counts, one for the Very Long count time
    - Examine short counts to assure no anomalies; reject non-statistical data but keep rest
  - Neutron Activation Analysis
    - Automatic sequence with simultaneous Short, Medium, and Long counts
    - Short count Workflows for short-lived nuclides early after irradiation
      Long count Workflows for long lived nuclides later in irradiation



Predicting the Future

- Aegis next release
  - Will have the Data Analyst software embedded within it.
  - Continuous Spectroscopy without external PC or DA module
  - Genie spectral analysis within Aegis
  - Great for quick field measurements of dynamic situations

- Next release of the Data Analyst Incorporates many “Special” features we have done into the Standard software.
  - Quick Quality Control within the DA software
  - Software Trigger support for external triggers [e.g. with the Pushbutton]
  - Spir Explorer support
    - NaI or LaBr detector, 1024 ch MCA
  - RDS-32 doserate meter support
  - Aegis and DSA-LX support



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