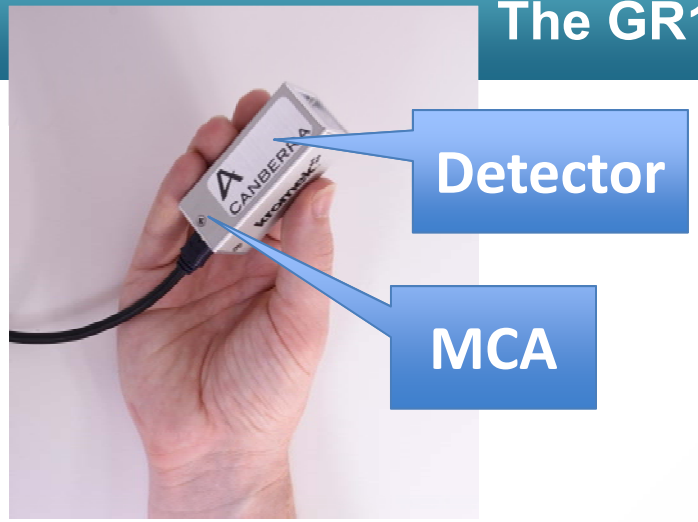
MIRION TECHNOLOGIES

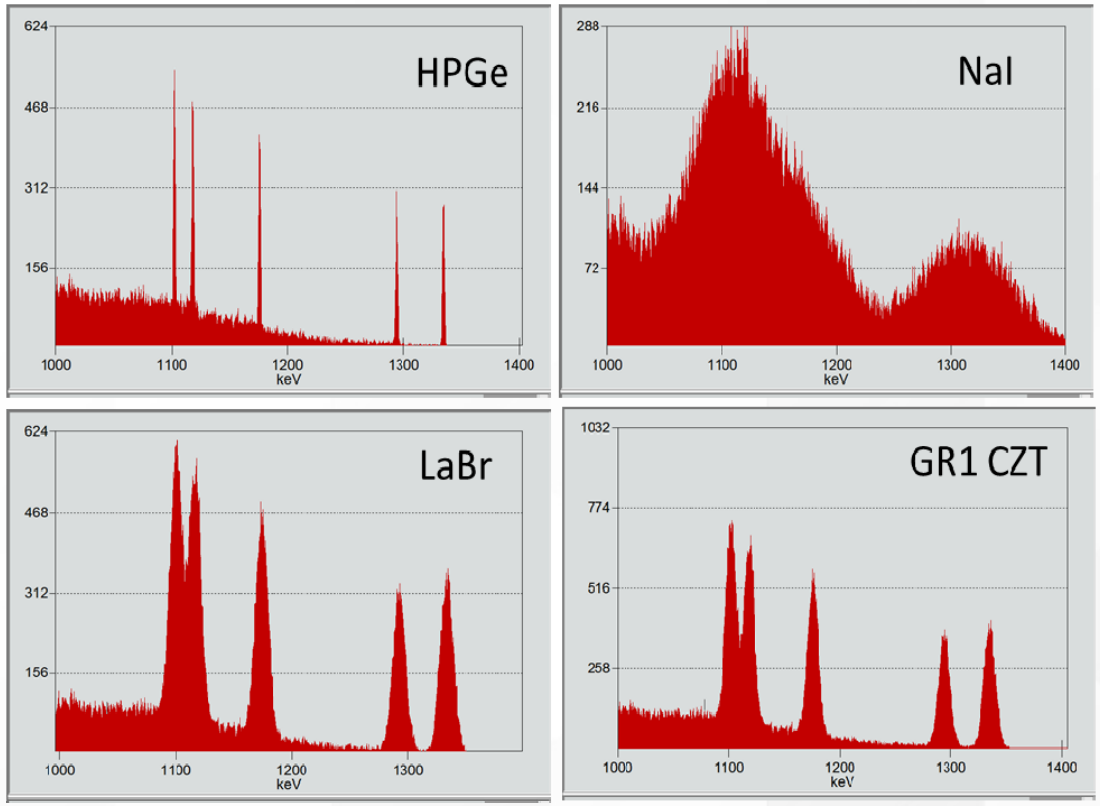
Radiation Safety. Amplified.

Portable Gamma Spectroscopy System for In-Situ Measurements and Examples of its Use for Continuous On-Line Assay of Primary Coolant.

FRAZIER BRONSON CHP
MIRION-TECHNOLOGIES [CANBERRA]
MERIDEN CT USA

The GR1 – a "large" CZT detector with integrated MCA



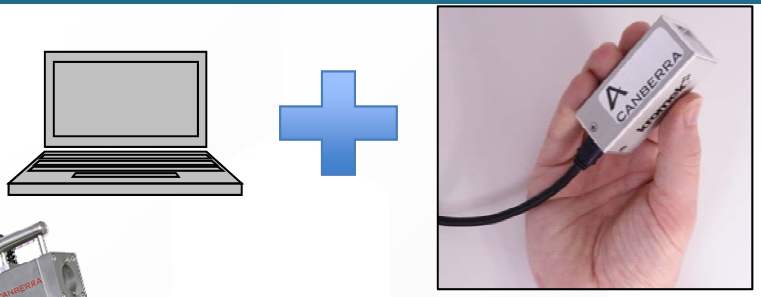


- Detector is 1 cm3
  - adequate efficiency for NPP in-plant measurements
- Small physical size
  - Lower cost/weight shield
- Good peak shape and energy resolution
  - Gaussian peak shape for good quality spectroscopy

- Energy resolution: <13 keV at Cs-137 [~2 HPGe, ~55 NaI]
- Gain stability: good up to 50 °C
- Dose rate: up to ~1 mSv/hr [100 mR/hr]; higher in shield
- Resolution stable to ~40 degC; only ~25 keV at 50 degC

Add a PC and shield to make the rest of the InSitu Measurement System

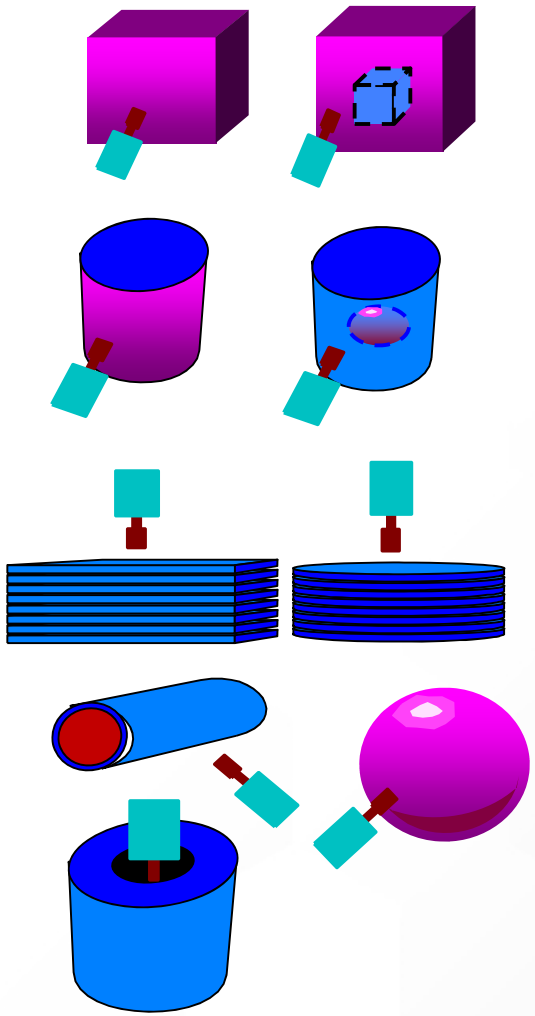
- Detector low power – runs off of PC via USB
- Small size – 2.5x2.5cm; can go in small places
  - Inside pipes
  - In holes in concrete or soil
  - Sealed in thin tubing for below-water assays
- Small Detector+MCA = small Shield
  - Unlike NaI or HPGe systems
- Versatile shield for InSitu applications
  - 2cm thickness Tungsten standard
  - Attenuation factor: 25 Co58; 6.6 Co60
  - 8.4kg (19lbs) with maximum collimator
  - 5 collimation arrangements – 9.1kg total
- More Tungsten is easy for custom units
  - 3cm = 18kg [40 lbs]; 4cm = 28 kg [70 lbs]
- Quick and easy deployment
  - Light weight, no cooling-down time
- Add efficiency calibration and get immediate quantitative results in the field,





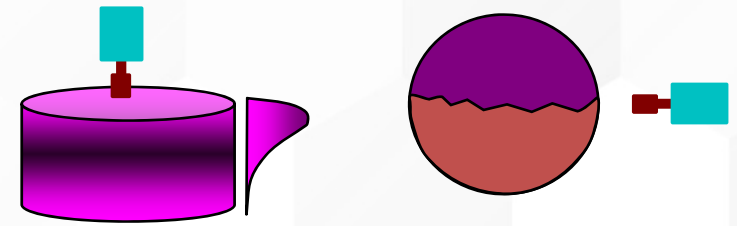


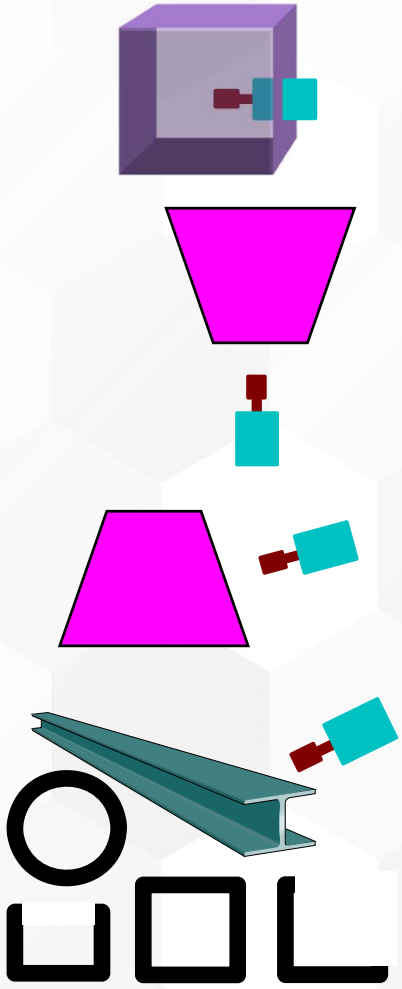
The ISOCS mathematical efficiency calibration software allows for quick and accurate Quantitative Results – by the user, in the field



21 different *ISOCS template* choices

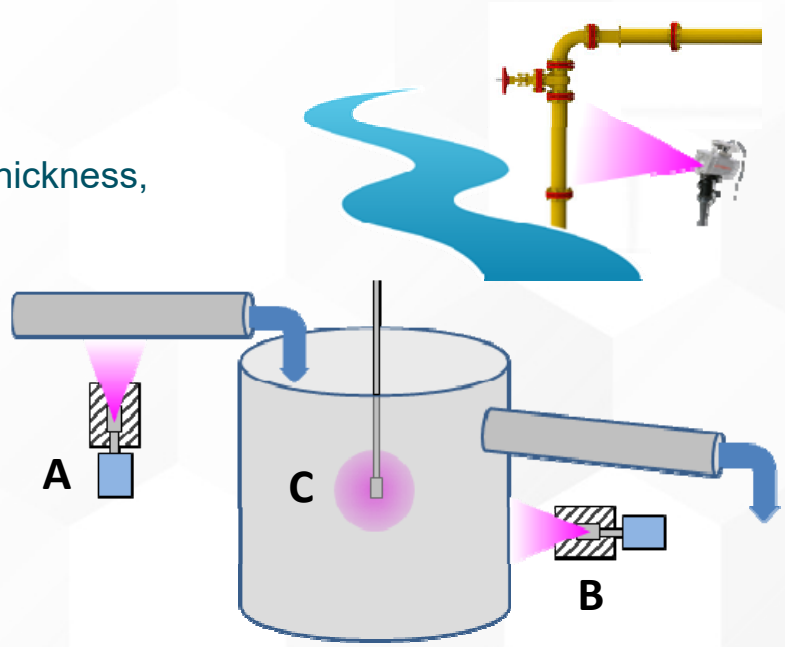
- Wide variety of sample shapes
- Multiple adjustable parameters for each sample shape
- Multiple sources & locations within each sample shape
- Sample sizes from points to VERY large
- Any location within 500 meter radius of detector
- Any energy from 45 - 7000 keV
- Collimators, both cylindrical and rectangular





Assay of Pipes, Tanks, Intake and discharges, Rad-waste processing

- In-situ assays for pipes, tanks, filters, resin columns
- A. Aim shielded detector at intake or discharge pipe
  - Detector 2cm from 15cm [6”] diameter pipe, 5mm wall thickness, 2m long [as before but detector closer]
- B. Aim shielded detector at tank
  - Tank is 2m diameter, 2m high, and filled with water
  - Tank walls are 5mm steel
- C. Insert unshielded detector into well in tank
- Detection Limit for 100% gamma yield, 15min measurement, detector at 20cm



CZT MDA 15 min

keV	60	100	300	600	1000	1500	3000
A Bq/kg	19699	424	152	272	404	542	1427
B Bq/kg	13083	270	88	136	174	203	413
C Bq/kg	61	34	25	39	52	54	104

Radioactivity in food limits:
~1000 Bq/kg in US and Europe

- Add Data Analyst for continuous assays – resin sluicing, discharges, chemical decon progress

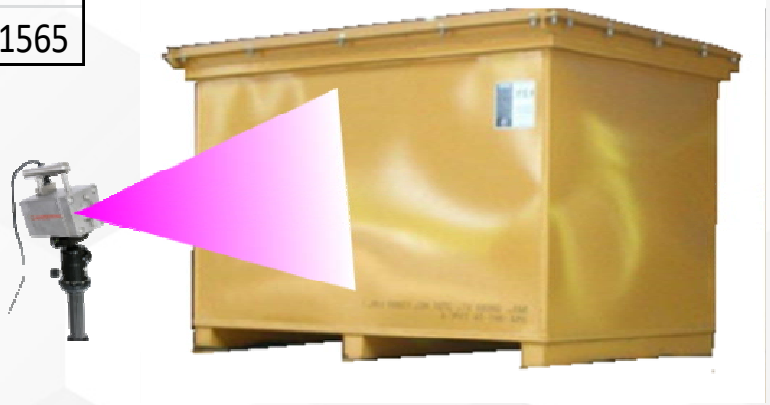
Radioactive Waste Assay – CZT detector and shield

- A. 200 liter drum filled at 0.5 g/cc density [111 kg]
  - Shielded detector at 1 meter
  - 2mm Fe walls
- B. Box [1m x 2m x 1m] at 0.5 g/cc density [1000 kg]
  - Shielded detector at 1 meter
  - 3mm Fe walls



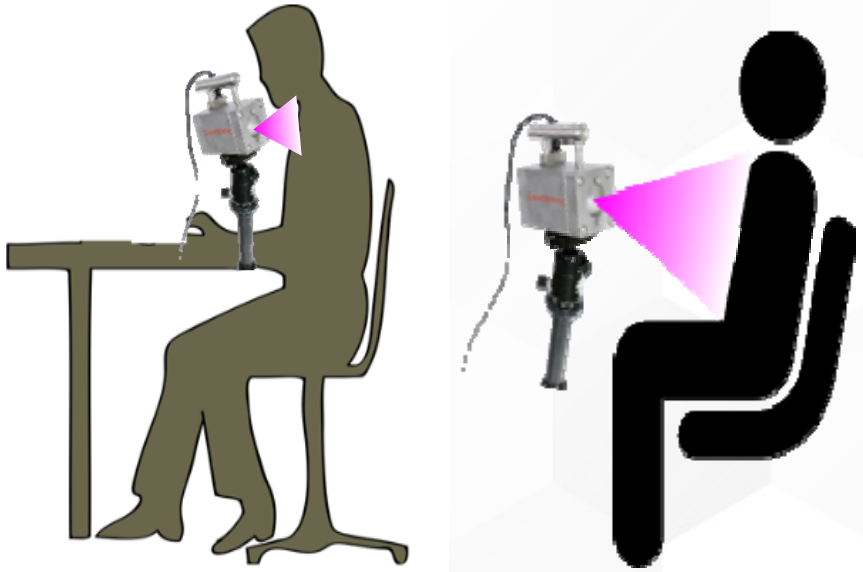
CZT MDA 15 min

keV	60	100	300	600	1000	1500	3000
A Bq/kg	6183	859	562	1157	1881	2599	7334
B Bq/kg	3563	276	152	293	449	601	1565



In-Vivo Measurements, when a "Real" Whole Body Counter isn't around

- A. Thyroid counting
  - Shielded detector at 5cm
- B. Lung deposition
  - Shielded detector at 10cm
- C. Total Body deposition
  - Shielded detector at 10cm
- D. Skin contamination – 10 cm^2 contamination area
  - Shielded detector 1cm from skin



CZT MDA 15 min

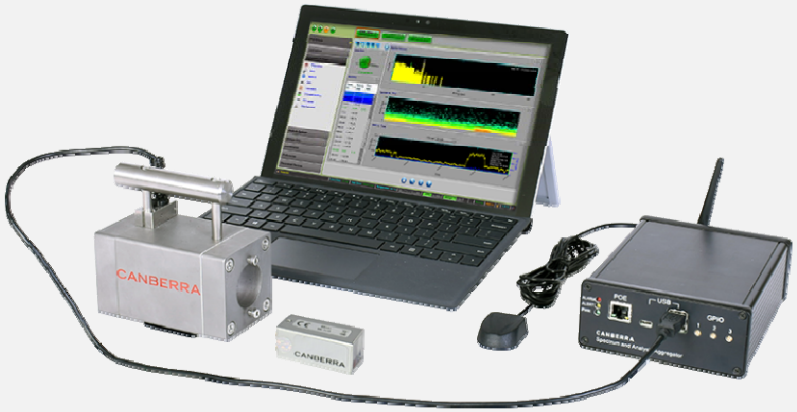
keV	60	100	300	600	1000	1500	3000
A Bq	89	75	104	257	476	742	2374
B Bq	652	514	651	1541	2767	4209	13010
C Bq	10987	8086	8226	16246	25298	34614	92670
D Bq	4	3	6	15	28	45	151

Dose Assay Capabilities

Reference: US General public limit: 1mSv/yr

- Thyroid: I-131 MDA is 160 Bq
  = 0.02 mSv at 10d after intake
- Lung: Co-60 MDA is 3500 Bq
  = 1.6 mSv CEDE at 10d after intake
- Total Body: Cs-137 MDA is 17600 Bq
  = 0.49 mSv at 10d after intake
- Skin Bq/10cm2: 300 Co-58; 100 Co-60; 400 Cs-137; = < 25% of Derived occupational limits

Add *Data Analyst* to Detector+MCA for Continuous Repeating Quantitative Assays



Works with wide variety of detectors

- Germanium for best quality
- NaI LaBr and CeBr scintillation for good sensitivity and low cost
- CZT for low cost and maximum portability





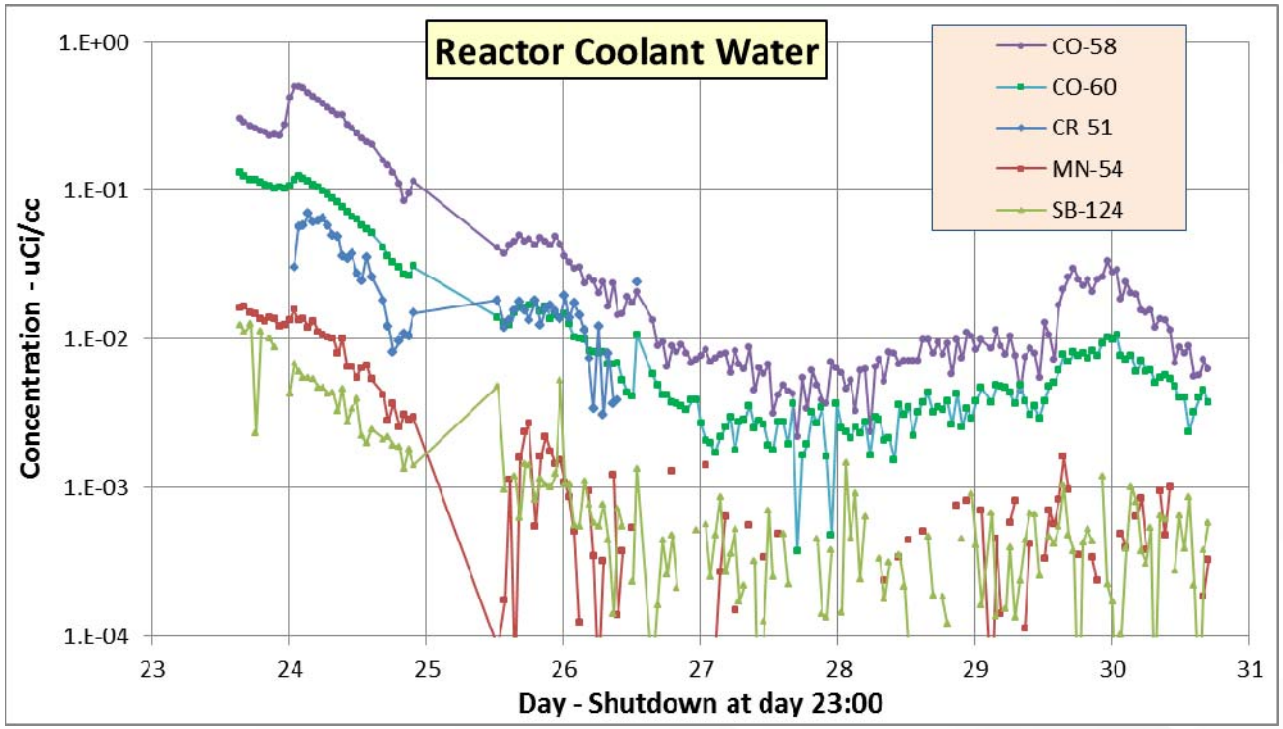
Specifications

- Power via POE
- 3 watts
- 13 x 6 x 17cm
- Integral SoM computer
- WiFi, Ethernet, and USB communications
- Integral GPS receiver
- Autonomous operation
- Full standard Genie spectral analysis
- Runs multiple simultaneous Workflows; each can have different count times, libraries, and analysis parameters
- Generates nuclide-specific alarms
- Local LED alarm lights
- External start/stop inputs
- External Alarm signal outputs
- External PC for setup and readout

Examples of Continuous Spectroscopy Applications at Reactors

First Field Deployment – at Nuclear Power Plant immediately after shutdown

joint project with Electric Power Research Institute, Plant, and Canberra





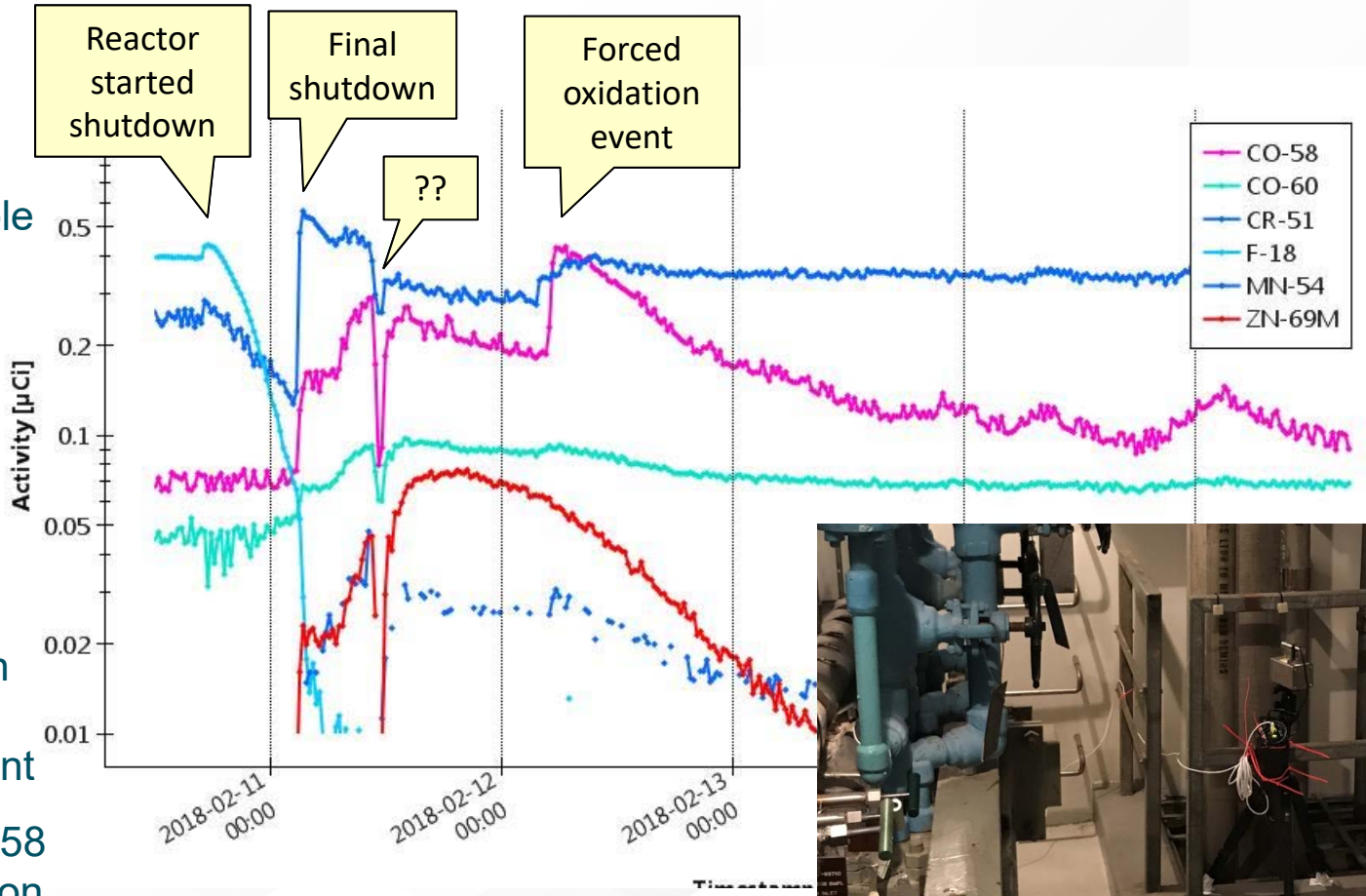


Other nuclides reported

Fe-59	Ag-110m
Sn-113	Zn-69m
Zr-95	Nb-95
A-41	Na-24

Third CZT Reactor Deployment on EPRI project – 3 units deployed

- On Primary Coolant letdown line to sample sink
- F-18 shown to illustrate reactor power ramp-down to ~20% and then rod-drop to 0%
- Immediate release of Cr-51 at shutdown and Co-58/60 and Mn-54 to lesser extent
- Major release of Co-58 during forced oxidation event, and Co-60, Cr-51, and Mn-54 to lesser extent
- Zn-69*m* behaves differently



MIRION TECHNOLOGIES

Radiation Safety. Amplified.

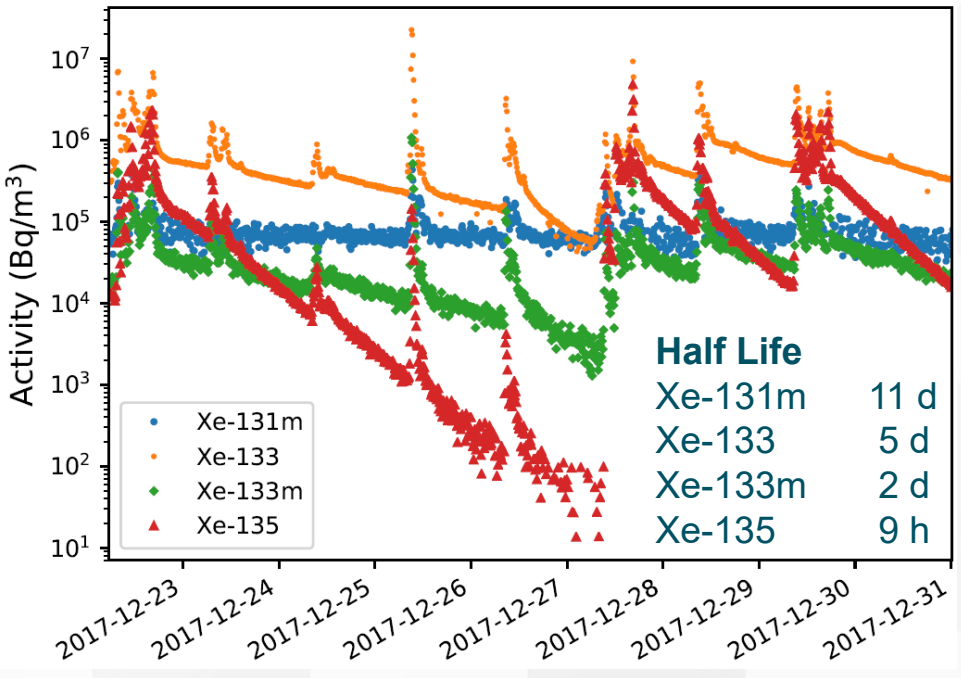
Stack gas effluent with HPGe + DA at Medical Isotope Production Rx

- Sample extracted from stack
- Pre-filter to remove particulates and Iodine
  - Could be monitored separately for P-I-NG
- Assay container 17 Liter Marinelli Beaker
  - Pressure sensors read by DA and used to compute sample volume
  - Stack flow rate used to compute effluent rate
- Inside modified 747 lead shield
- HPGe detector [30% RE] and Lynx MCA
  - Electrically cooled with CP-5

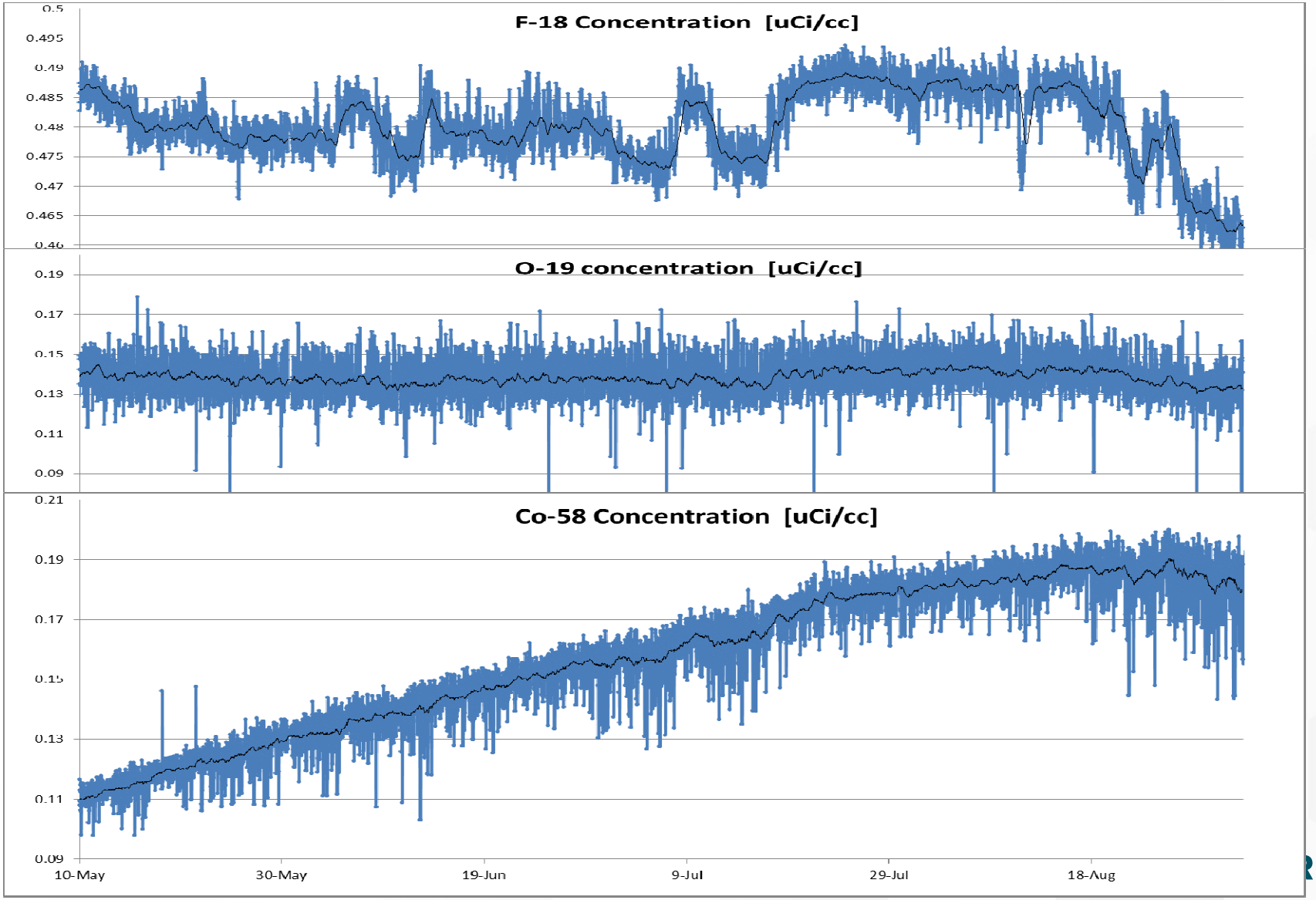
MDC (Bq/m^3)			
Nuclide	600 sec acquisition	3600 sec acquisition	14400 sec acquisition
Kr-85	6.91E+04	2.50E+04	1.19E+04
Kr-85m	1.85E+02	6.77E+01	3.25E+01
I-131	2.20E+02	7.67E+01	3.61E+01
Xe-131m	7.41E+03	2.72E+03	1.31E+03
Xe-133	5.74E+02	2.10E+02	1.01E+02
Xe-133m	1.56E+03	5.66E+02	2.70E+02
Xe-135	1.87E+02	6.77E+01	3.24E+01
Xe-135m	2.46E+02	8.25E+01	3.82E+01



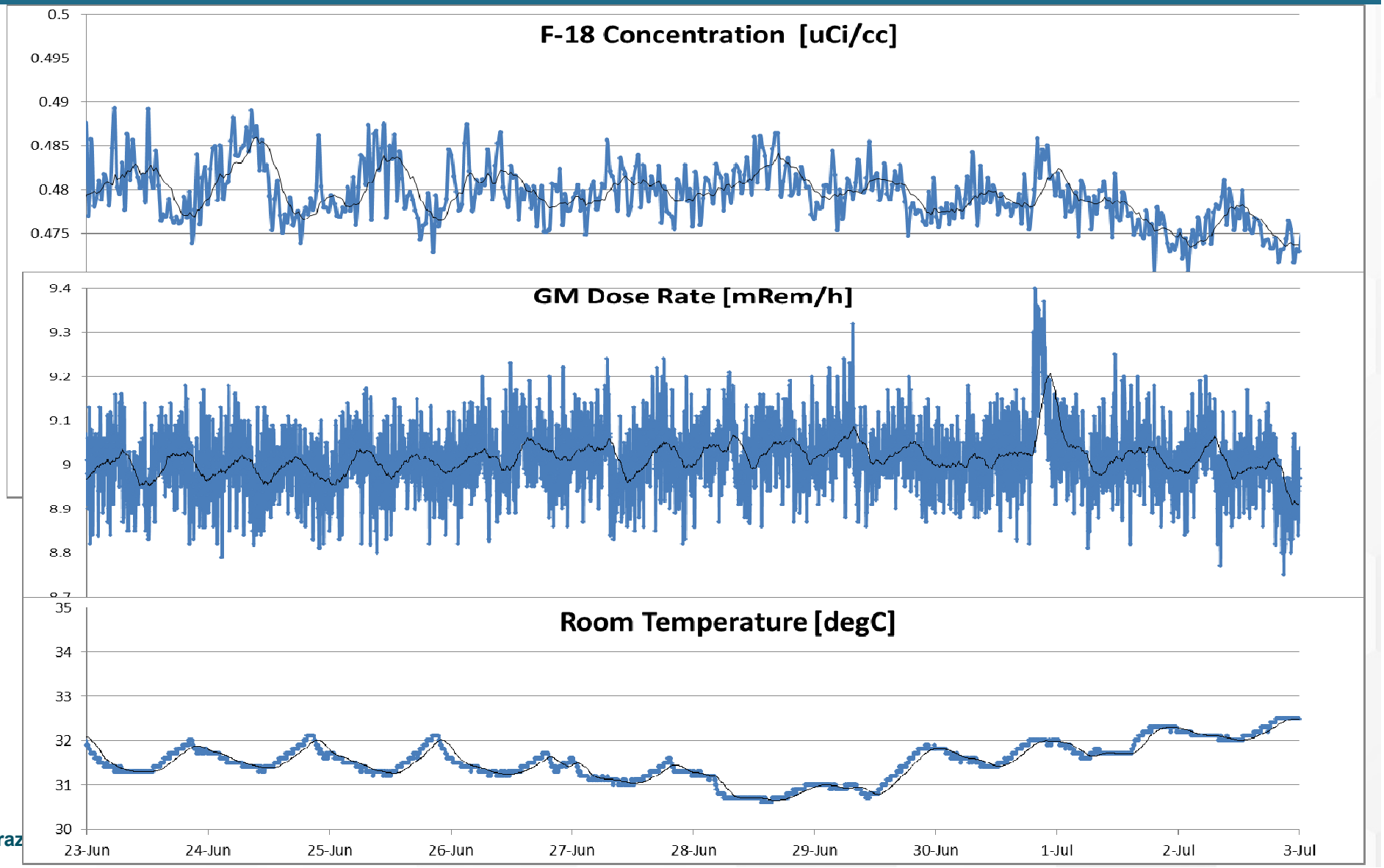




Mystery #1 Why does F-18 vary so much ? 5% Rx power adjustments ?



Mystery #2 Why a 1/day cycle in F-18 and a 2/day cycle in doserate ?



Summary and Conclusion

- The CZT detector and shield has adequate sensitivity for most HP NPP waste assay applications, and operational D&D applications
- The CZT/shield/tripod/LaptopPC highly portable for quick deployment in complicated areas
  - <20 lbs and no external power
- The addition of the ISOCS efficiency software makes quantitative results easy and accurate.
  - Calibrations can be quickly made by user for very wide range of situations
  - Calibration method acceptable by USNRC in RG 1.21
- Addition of Data Analyst turns InSitu measurement system into Continuous Spectroscopy System
  - Works with CZT detector, with HPGe detector and Lynx, and with Scintillation detectors and Osprey
  - EcoGamma probe can be added for wide-range accurate doserate measurements
- Deployment in measurement area very easy – set equipment in place and apply power; then everything happens automatically
- Results instantly available at the end of each measurement period
  - Multiple measurement periods and assay scenarios can happen simultaneously
  - Results transmitted over WiFi, Ethernet, USB, and Mirion WRM dosimetry network.


THANK
YOU!
STOP
935
Give me your card, or send me an e-mail for technical publications with this information
FBRONSON@MIRION.COM