

The Mirion Spectroscopic Stack Monitor Installations and data comparisons

WOSMIP 2021

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MIRION
TECHNOLOGIES

Outline

- System overview
- System performance
- System data

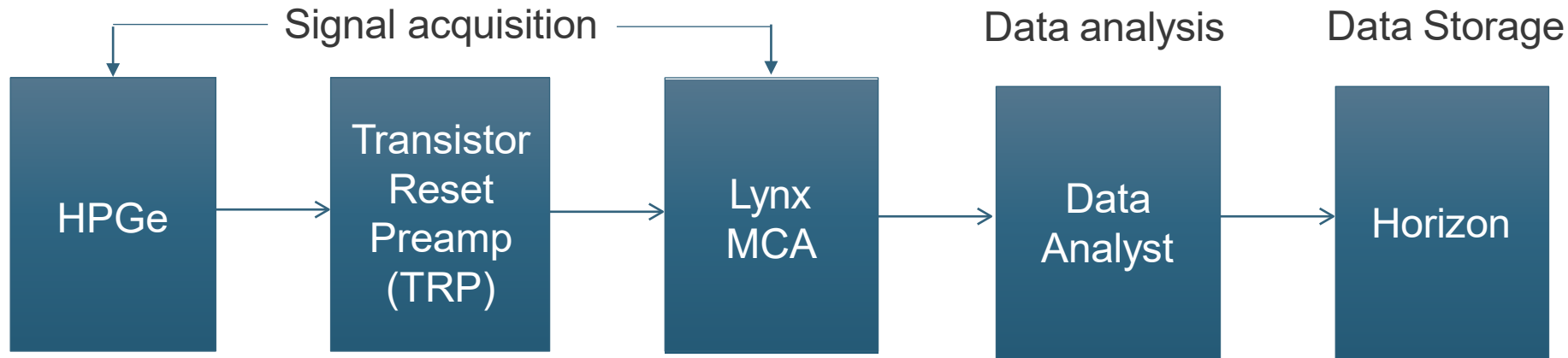


System Overview

- Designed to measure stack releases of noble gases e.g.:
 - Xe-131m
 - Xe-133
 - Xe-133m
 - Xe-135
 - Xe-135m
- Designed specifically for the STAX project
- Uses existing Canberra/Mirion standard products
- 5 systems running at different installations
 - IRE – 3.5 years
 - ANSTO – 2.5 years
 - Research Reactors (2 systems) – 1.5 years
 - Niowave – 0.5 years



System overview - Signal Chain



- The system is built with Mirion standard products – limits downtime during maintenance
- Large dynamic range is possible with TRP/Lynx signal chain
- Automated acquisition and analysis with the Data Analyst
- Horizon provides permanent local storage of data and data review interface

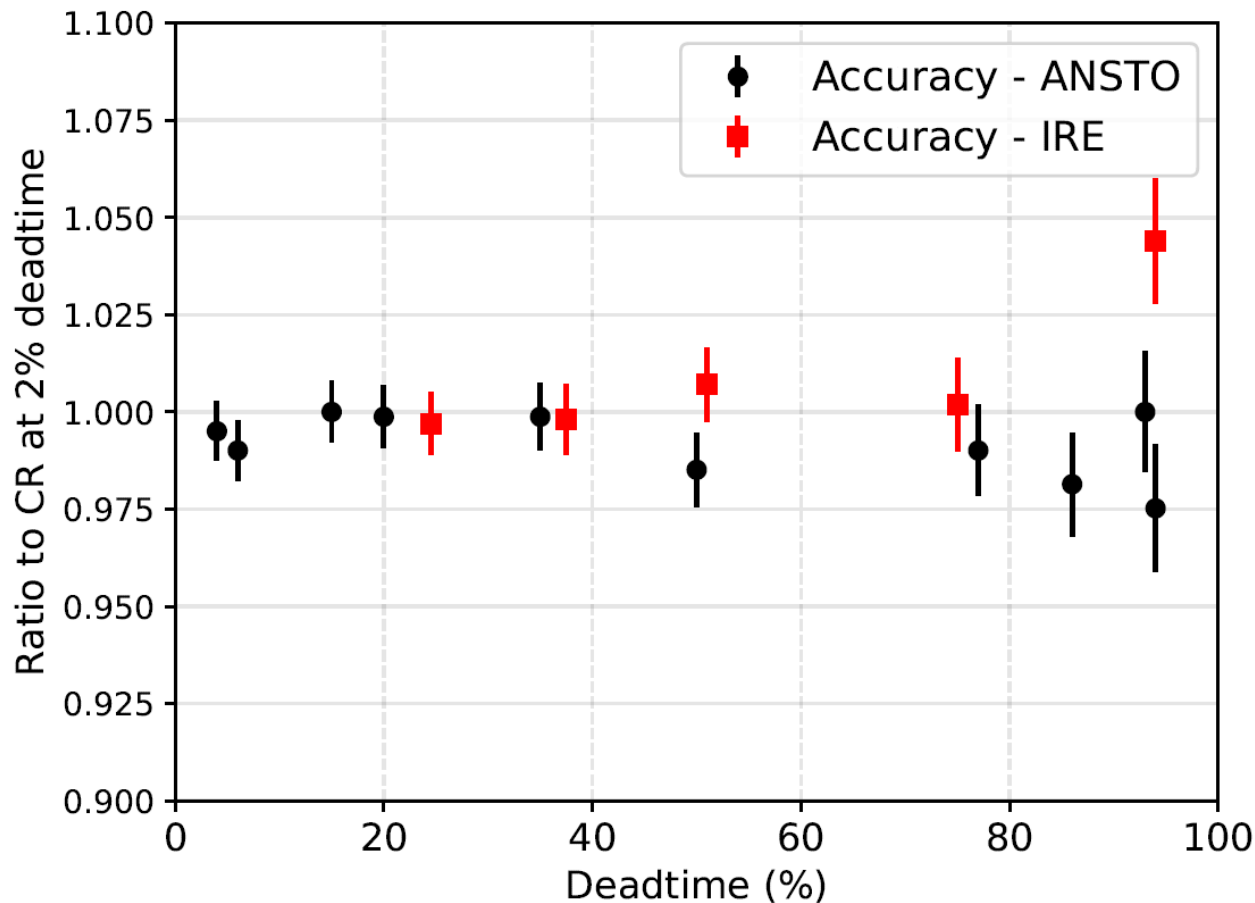
System Performance - MDC

- Using the simple Currie formalism at the 95% confidence level
- MDC for various averaging times (they are all run in parallel)
- BKGD rates for closed shield in ~100 nSv/hr ambient field

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

System Performance – High count rates

- The Lynx deadtime correction was tested with a dual source method
- Less than 5% error at 500,000 cps
- Actual deadtime is dependent on shaping parameters
- System specified top end count rate is 500,000 cps but will measure well beyond that

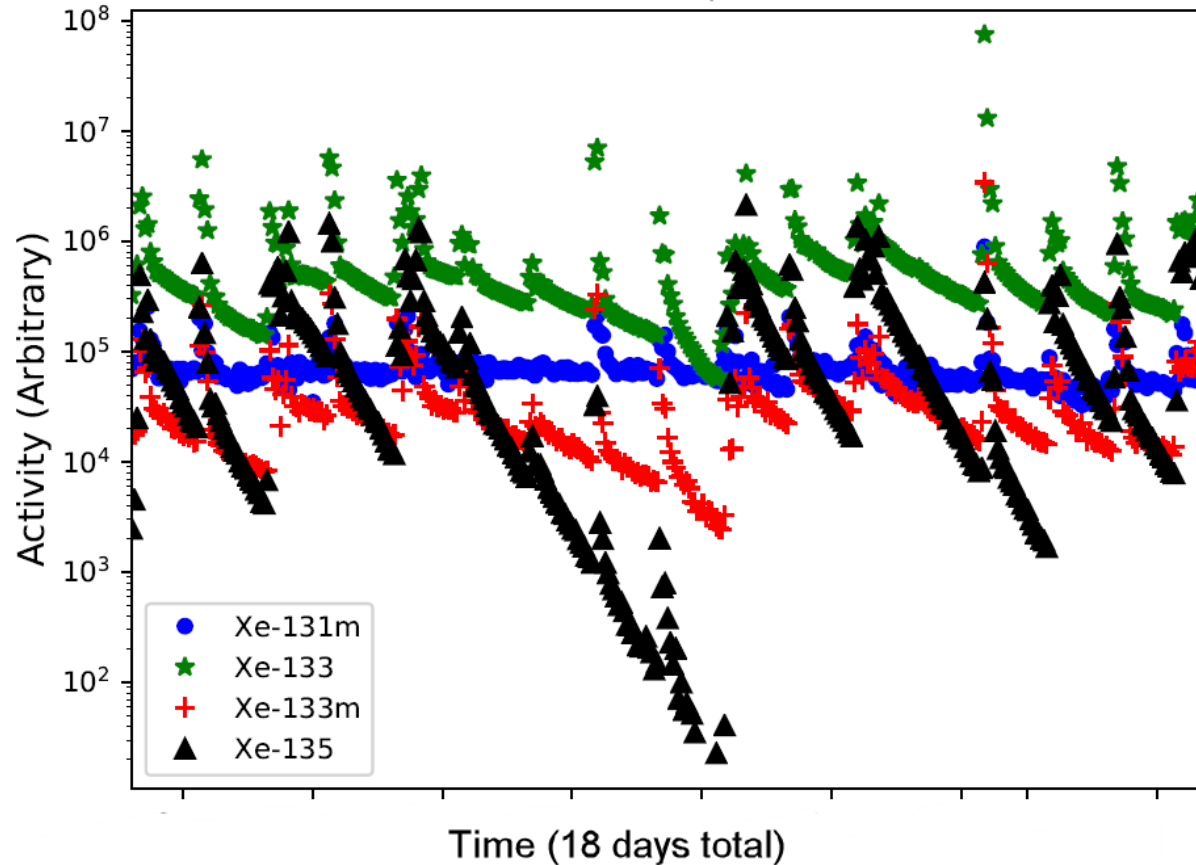


System Performance – Measurement range

- Measurable concentration range (Xe-133)
 10^2 to 6.3×10^9 Bq/m³
- Assuming 90,000 m³/h stack flow rate
- Measurable release rate range (Xe-133)
 9×10^6 to 5.7×10^{14} Bq/h

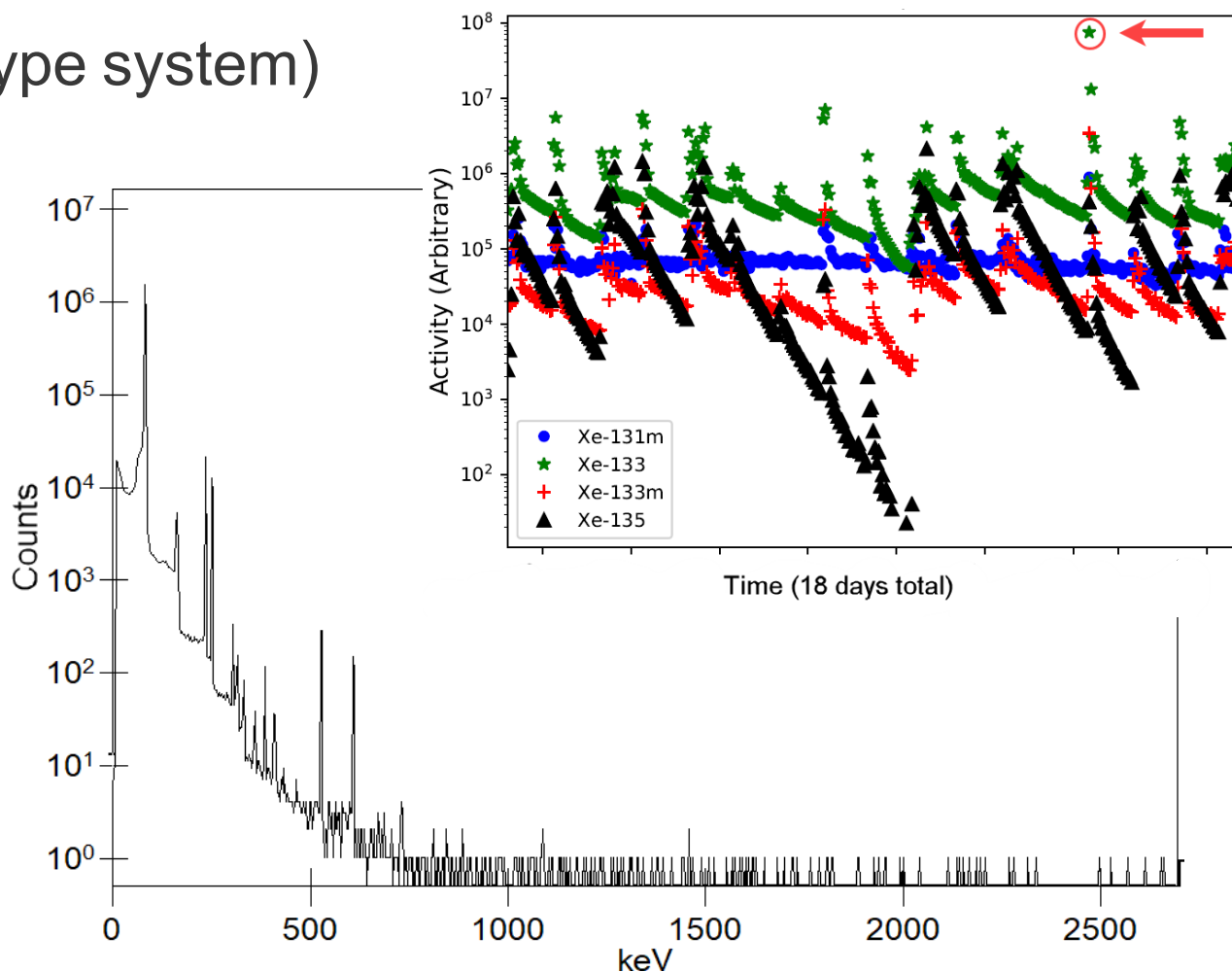
Data – IRE (prototype system)

- All data are scaled by the same factor
 - ▢ Relative activities are preserved
 - ▢ Absolute activities or activity concentrations are washed out
- 1 hr acquisitions over 18 days time
- Xe isotopes have the same general behavior
- ~7 orders of magnitude covered during this single period



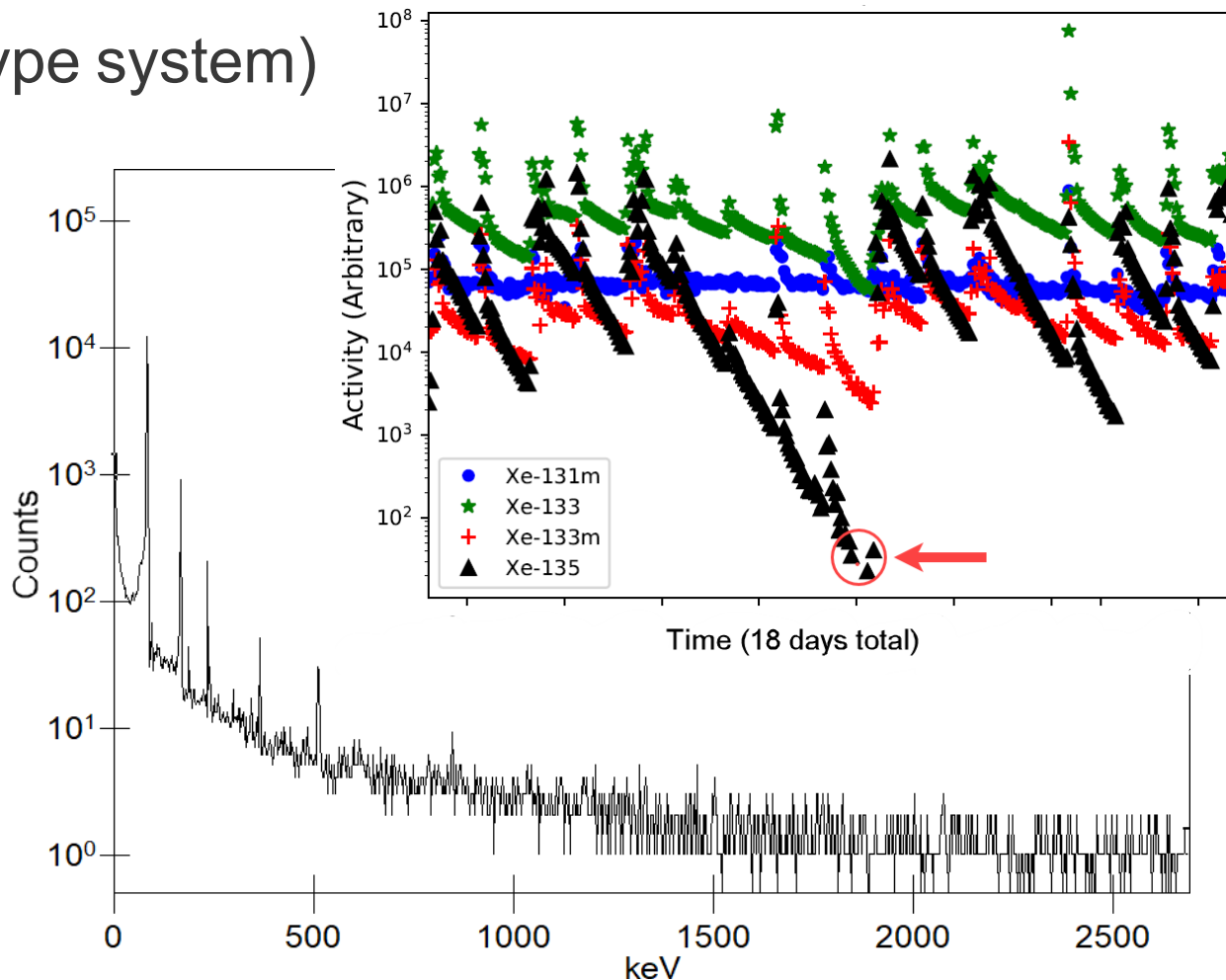
Data – IRE (prototype system)

- Spectrum from high activity period
- 8% deadtime
- 11 kcps full spectrum
- 0.99 keV FWHM @ 81 keV
- 15 minute acquisition in the spectrum
- Quite a bit more Xe-133 in this high activity case compared to the “typical” spectrum
 - ▣ Other nuclides contributing significantly less to the overall count rate



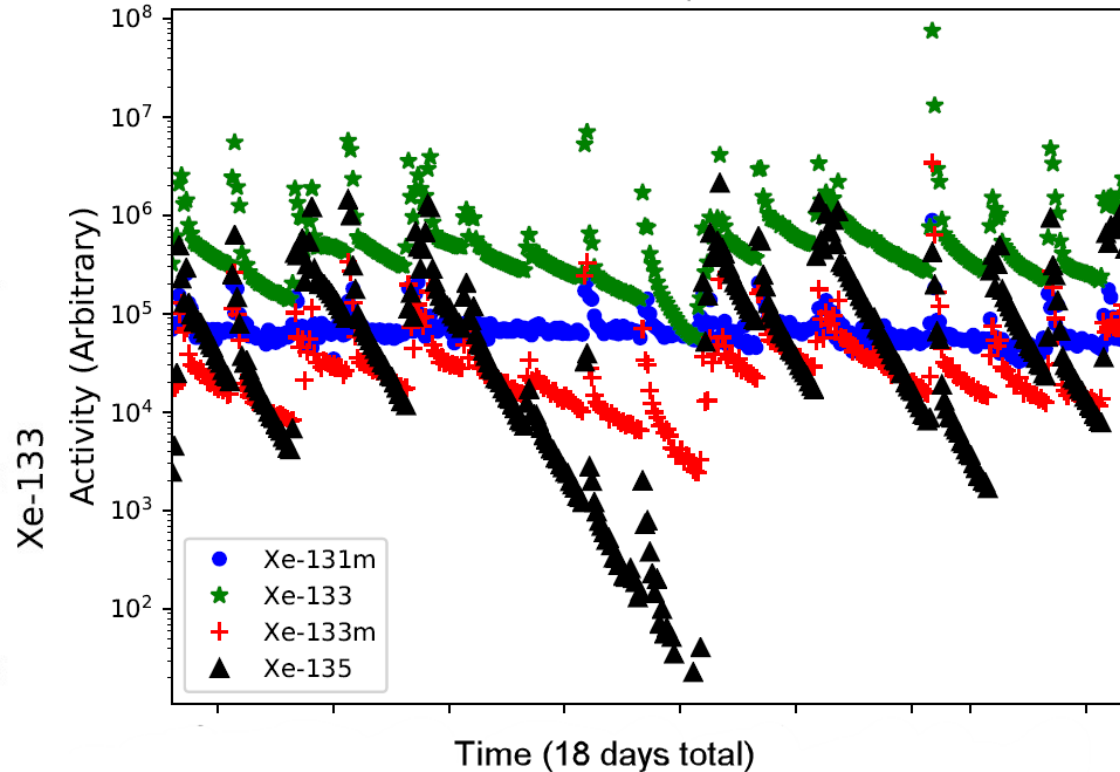
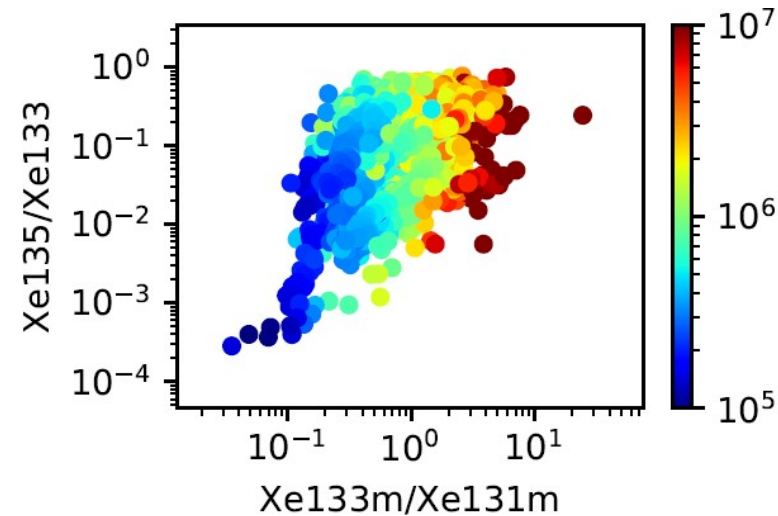
Data – IRE (prototype system)

- Spectrum from relatively calm period
- 0.15% deadtime
- 7 cps full spectrum
 - ▢ BKGD at the factory was 2.7 cps for comparison
- 0.97 keV FWHM @ 81 keV
 - ▢ FWHM during FAT was 0.94 keV
- 4 hr acquisition



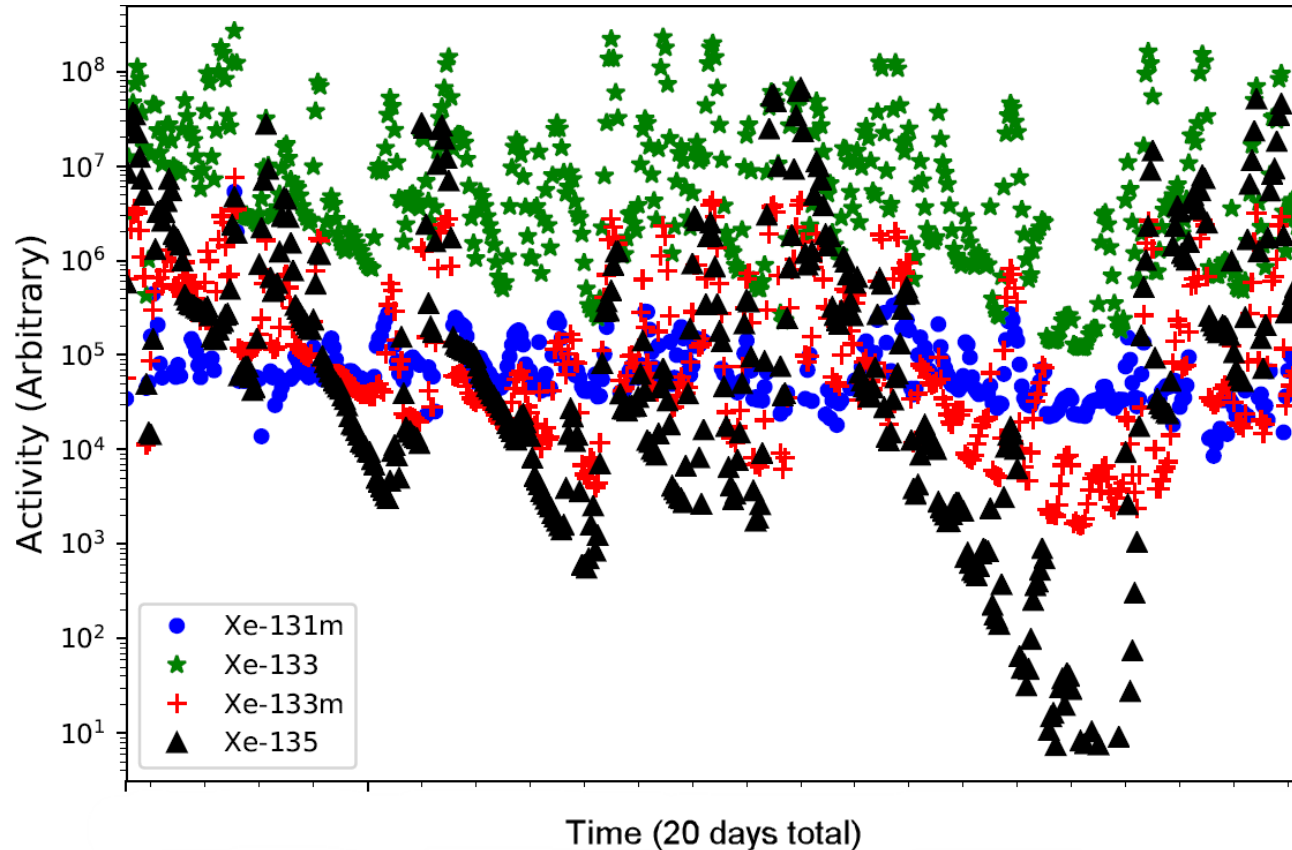
Data – IRE (prototype system)

- 1 hr acquisitions
- Some interesting correlations between Xe-133 activity and Xe ratios



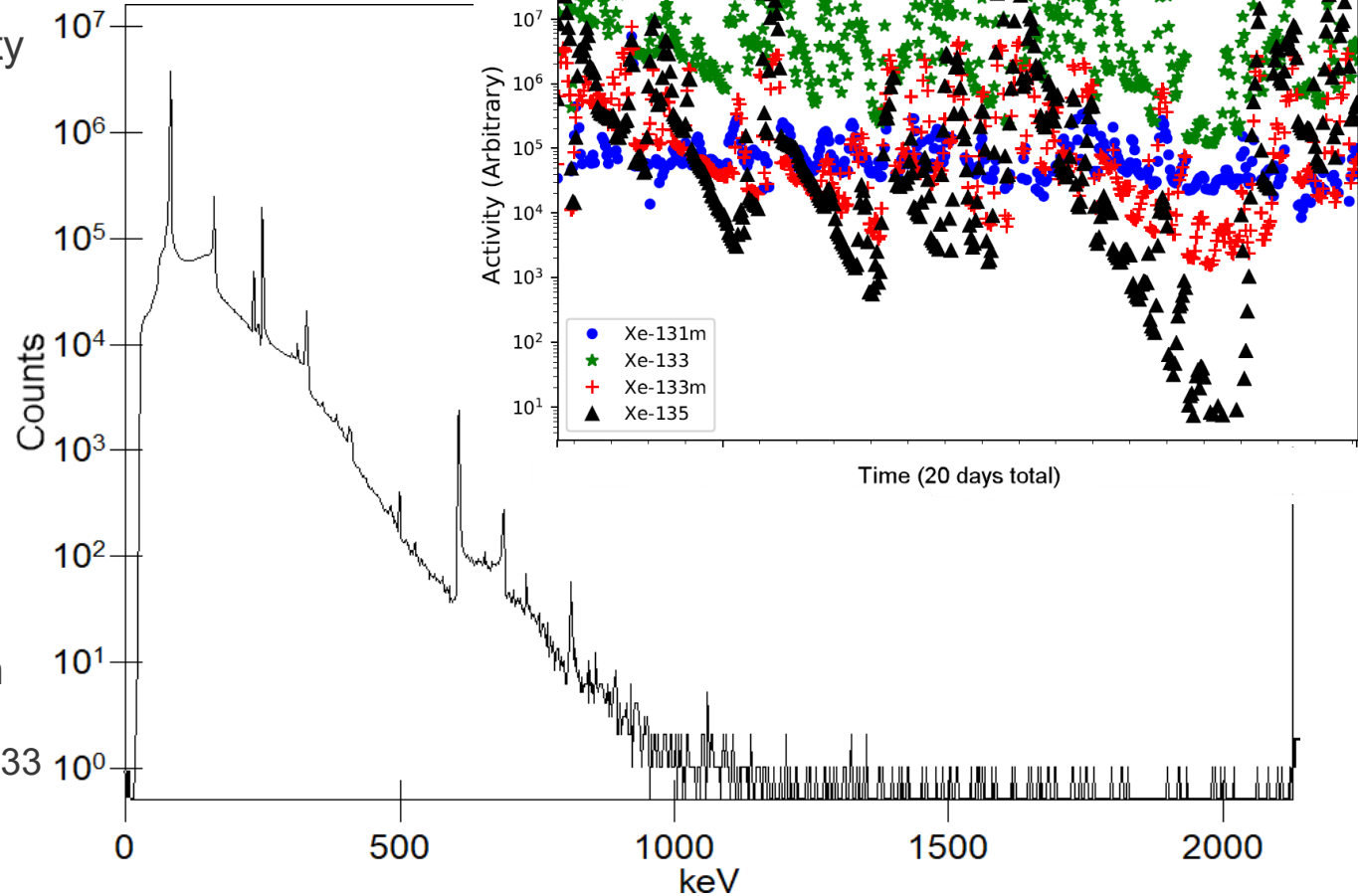
Data – ANSTO

- All data are scaled by the same factor
 - ▣ Relative activities are preserved
 - ▣ Absolute activities or activity concentration is washed out
- 1 hr acquisitions over 20 days time
- Xe isotopes have the same gross behavior but vary on small time scales
- ~7+ orders of magnitude covered during this single period



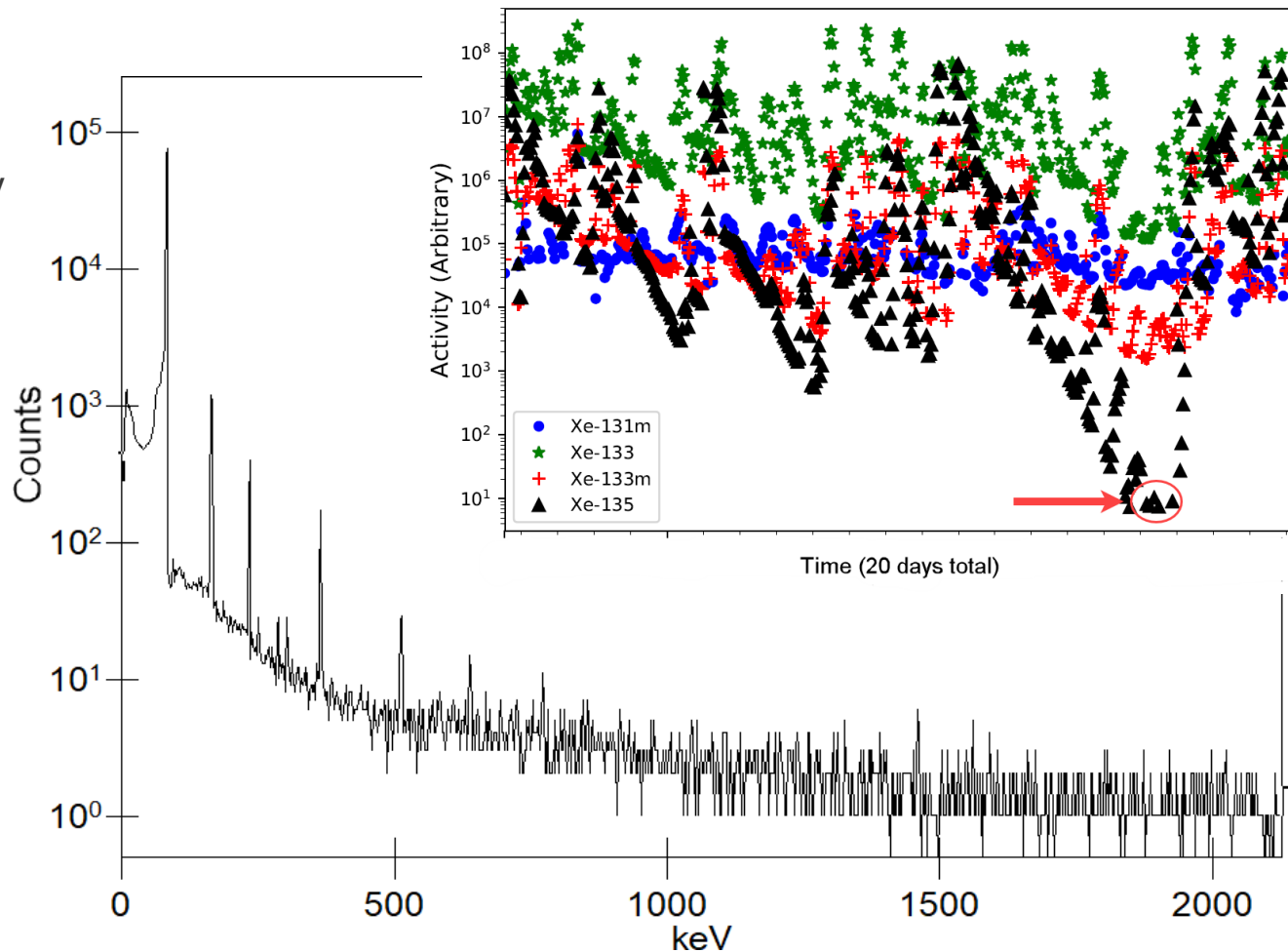
Data – ANSTO

- Spectrum of high activity period – random sum peaks!
- 62% deadtime
- 195 kcps full spectrum
- Xe-133 centroid
 - ▢ 80.1 keV (before recalibration)
 - ▢ 80.9 keV (after recalibration)
- 1.38 keV FWHM @ 81 keV
- 15 minute acquisition in the spectrum
 - ▢ Isotopes other than Xe-133 contributing significantly too



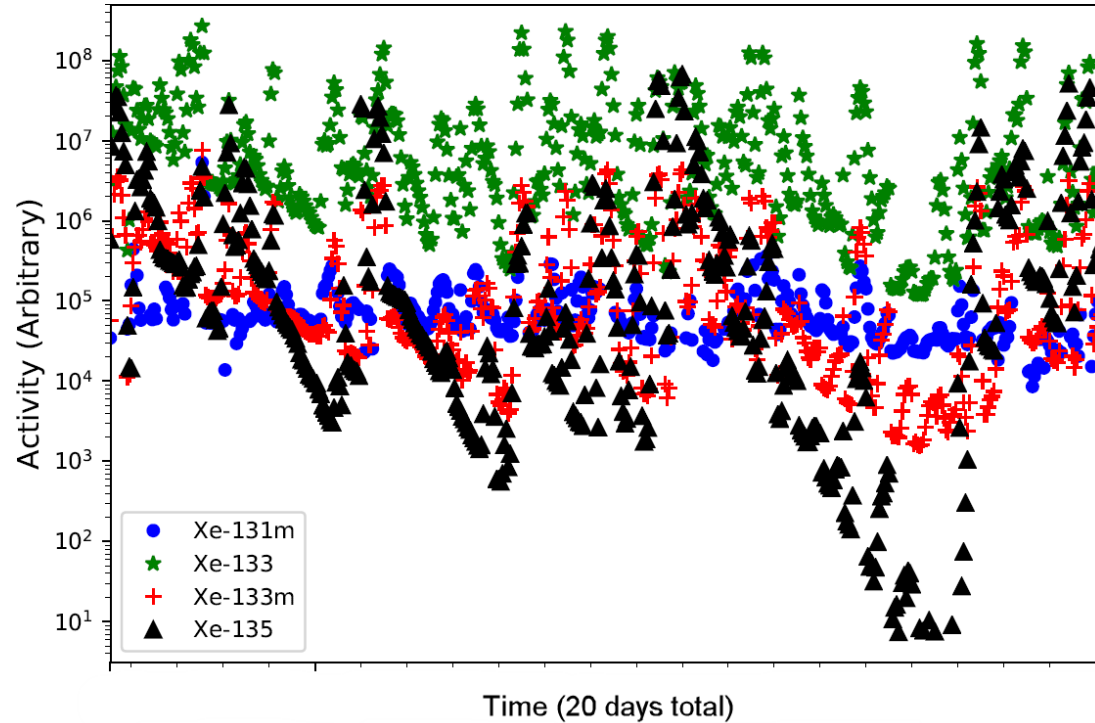
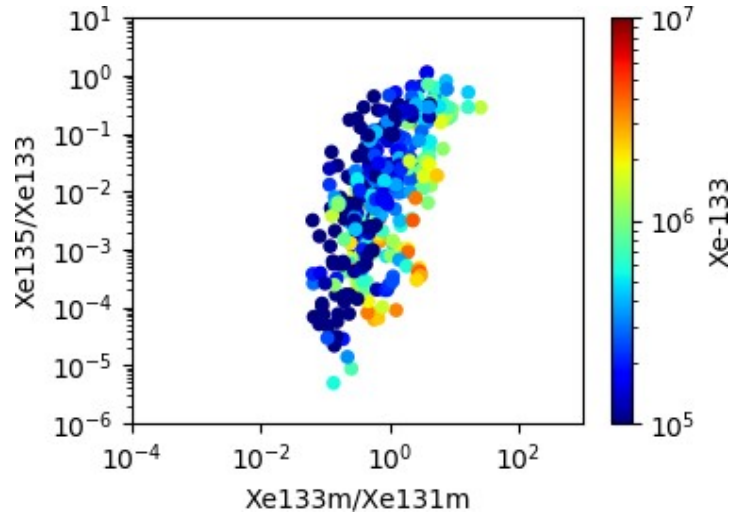
Data – ANSTO

- Spectrum from a relatively calm period
- 0.17% deadtime
- 49 cps full spectrum
 - ▣ Compare to 2.6 cps full spectrum at the factory
- 1.25 keV FWHM @ 81 keV
 - ▣ Compare to 1.0 keV at the factory
- 4 hr acquisition
 - ▣ Mostly Xe-133



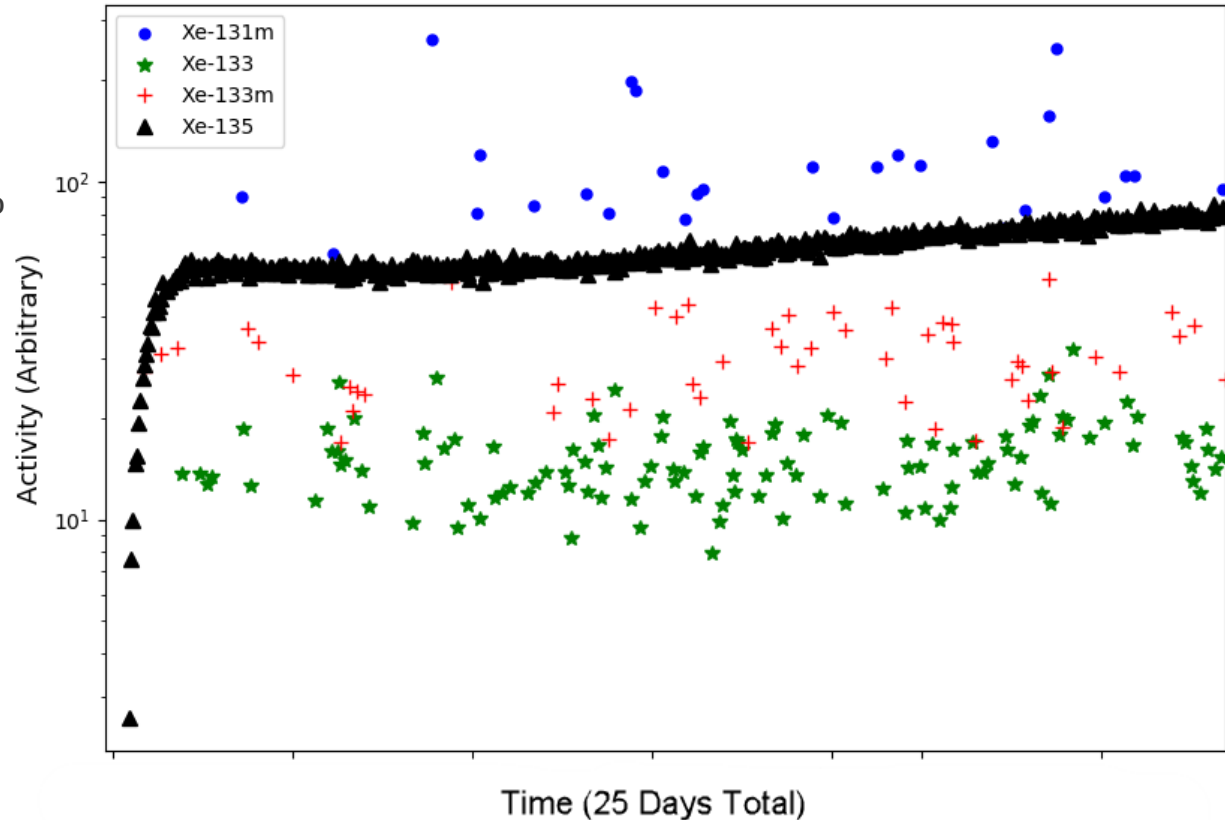
Data – ANSTO

- 1 hr acquisitions
- Some interesting correlations between Xe-133 activity and Xe ratios again
- Slightly different behavior than IRE?



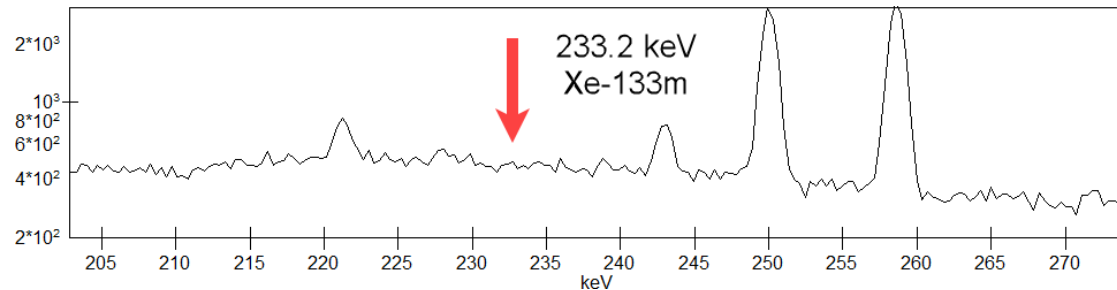
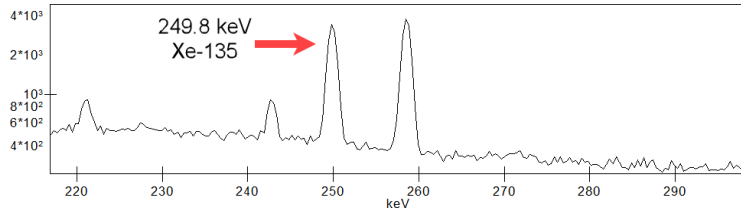
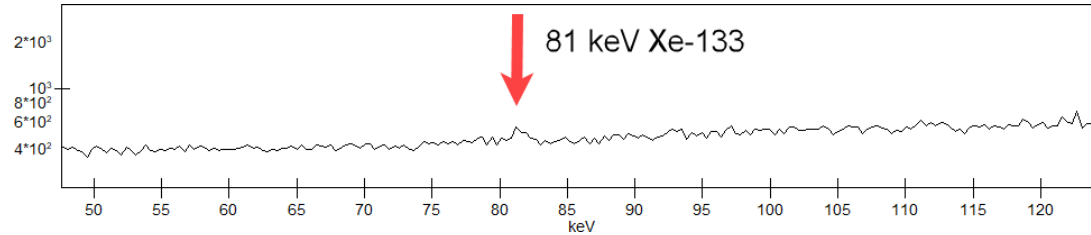
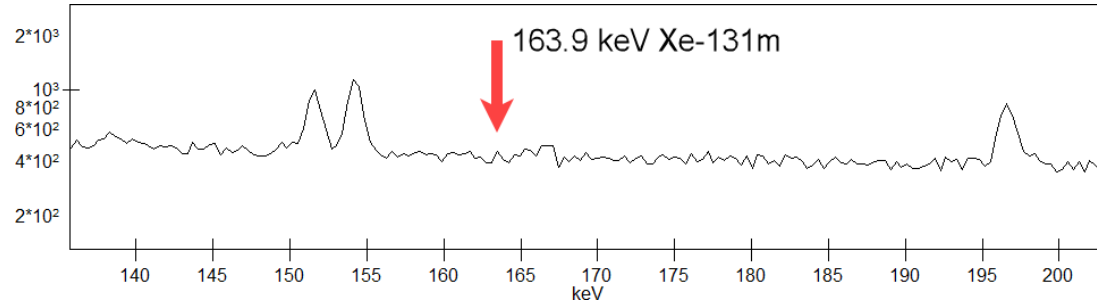
Data – Research reactor

- Location: undisclosed
- Reactor type: research reactor
- Reactor power: <100 MW
- Reactor fuel enrichment: >20%
- All data are scaled by the same factor
 - ▣ Relative activities are preserved
 - ▣ Absolute activities or activity concentration is washed out
- 1 hr acquisitions over a bit under a month time



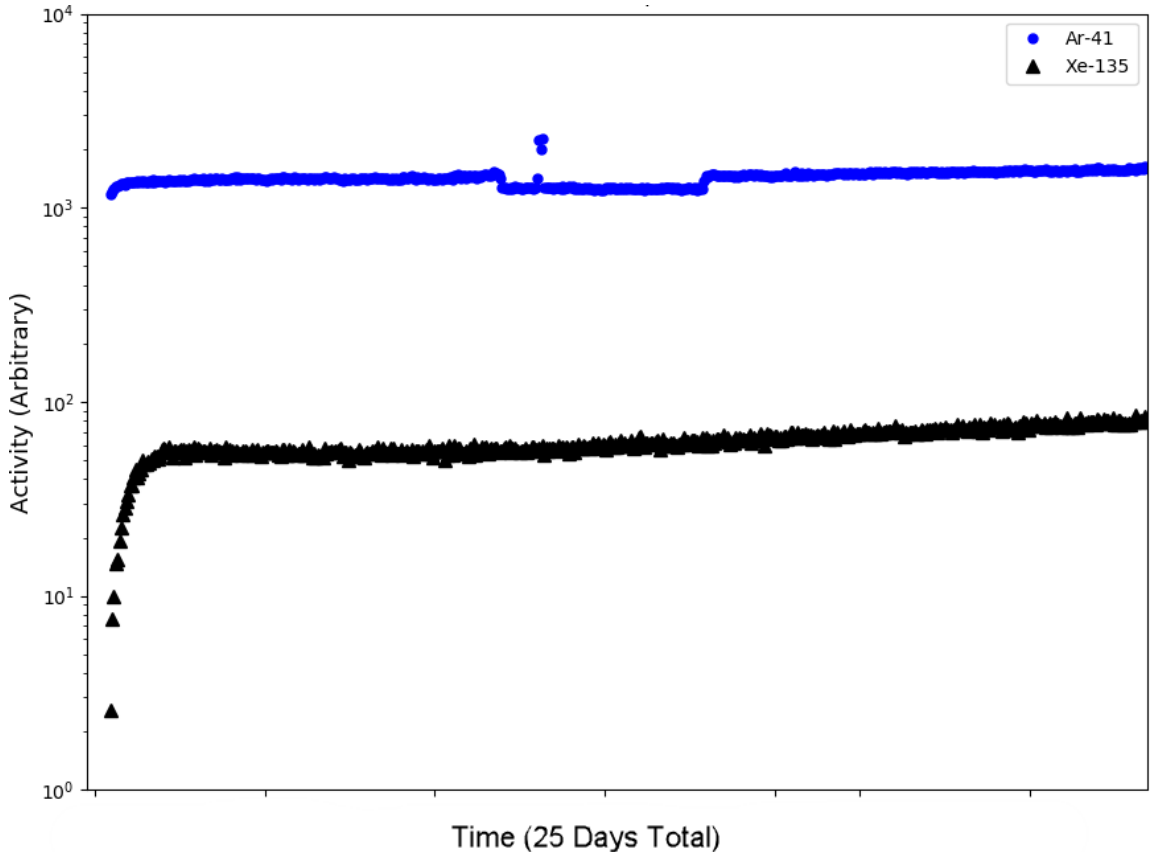
Data – Research Reactor

- Spectra show the highest activity acquisitions for each nuclide over the 25 day period
- Xe-135 is clearly present
- Xe-131m, Xe-133, and Xe-133m are either not present or only at MDA levels.



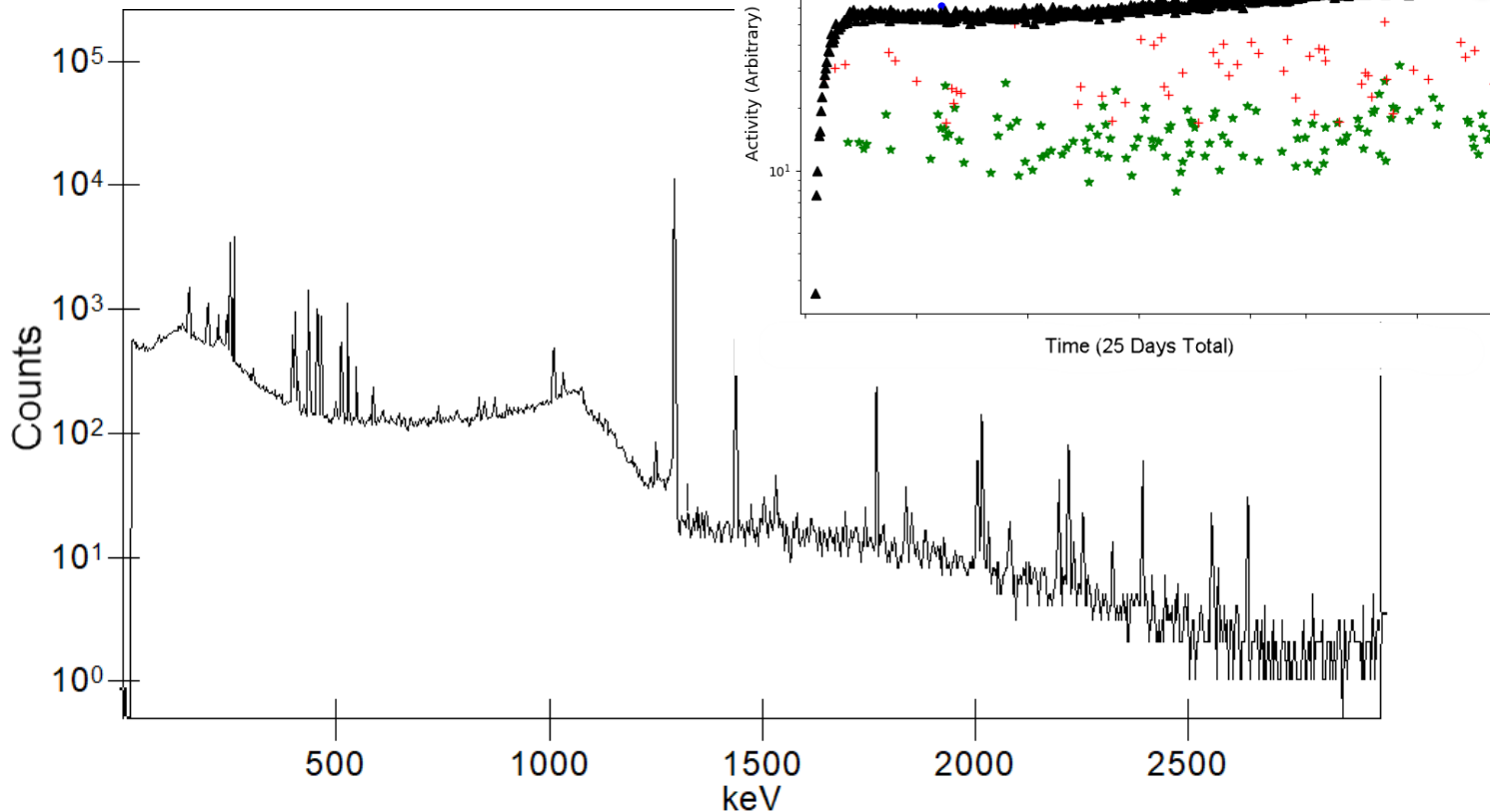
Data – Research reactor

- Xe-135 does follow gross reactor power (Ar-41) but quick variations are washed out
 - ▢ Ar-41 ~110 minutes half-life
 - ▢ Xe-135 ~ 9 hrs half-life
- Other xenons (Xe-137, Xe-138) and some kryptons (Kr-85m, Kr-87, Kr-88) also show similar behavior



Data – Research reactor

- Long count
- Resolution
 - ▢ Factory – 1.93 keV @ 1332 keV
 - ▢ Installed – 1.88 keV @ 1294 keV
- Count rate 60.5 cps
- Deadtime 0.06%
- Ar-41 is the most prominent nuclide



Conclusions

- 5 systems running at various facilities
 - ▣ 3 MIP
 - ▣ 2 Research reactor
- IRE data show clear patterns in the data
 - ▣ Peaks in activity and then slow decay away
 - ▣ Clear correlation in the 4 isotope plot with Xe-133 activity
- ANSTO data show higher frequency variations
 - ▣ Significant random summing
 - Perhaps affecting the 4 isotope plot?
- Research reactor shows little to no Xe-133
 - ▣ Xe-135 is clearly present
 - ▣ Other Xe may be present near to the MDC levels



Thank you!

Special thanks to folks at IRE, ANSTO, and the
research reactor!