O3.2-362

Laboratory measurements of radioxenon samples from an IMS station

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FOI, Swedish Defence Research Agency

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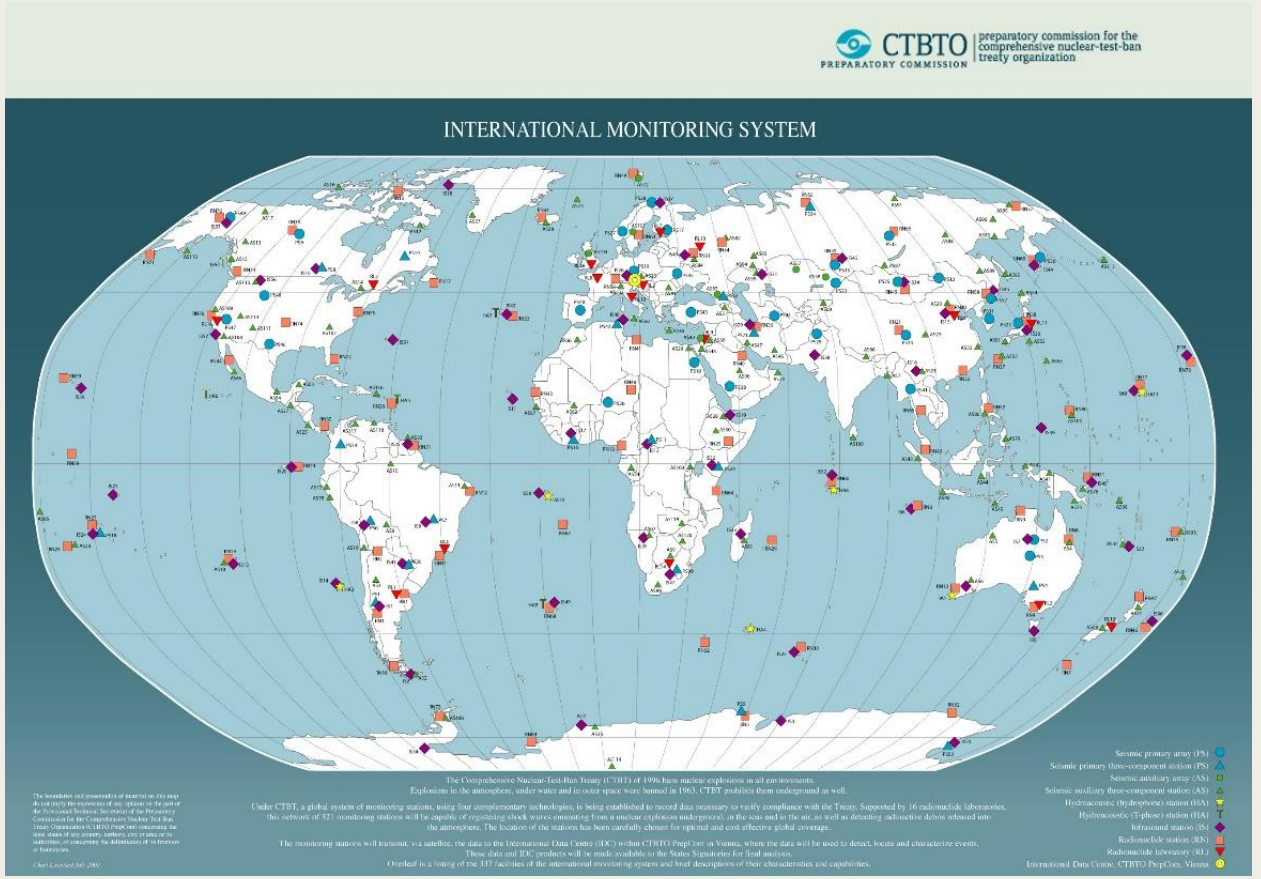
O3.2-362

Objectives

- How can laboratory measurements be used to improve analysis of radioxenon detections?
- Evaluate IMS system performance using a laboratory system.
- Quality control of the IMS systems.
- Optimize laboratory measurements.
- Further improve calibration and analysis routines.
- Strengthen the role of the RN labs with Xenon capacity in the IMS.



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O3.2-362

SAUNA systems at FOI

- SAUNA III IMS station (SEX63)
  - 6 hours collection time
  - 6 hours measuring time
  - Sample volume about 40 m^3
  - Beta-gamma coincidence detectors

- SAUNA Laboratory system (SEL)
  - Not an IMS RN laboratory
  - Participates in PTE's run by CTBTO
  - Improved GC calibration accuracy
  - 10 cm thick (low activity) lead shield
  - Manually chosen measurement times

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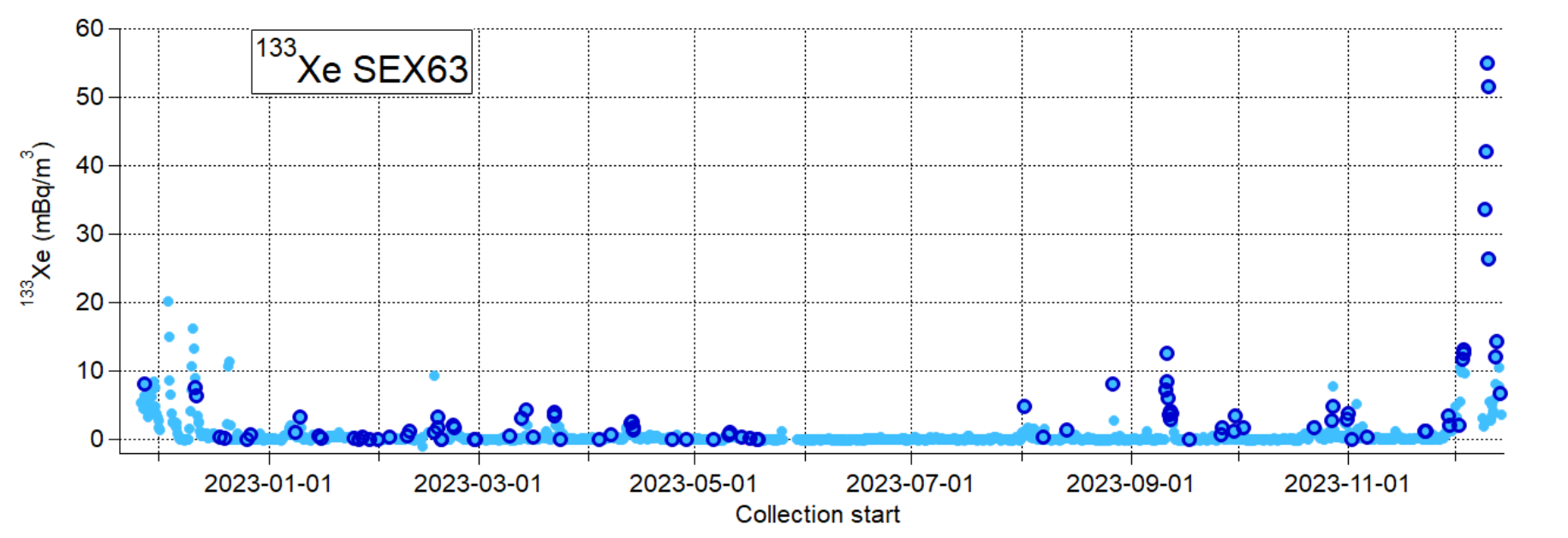
O3.2-362

Comparative study between SEX63 and SEL

- 91 samples from SEX63 re-measured at the SEL laboratory
- Laboratory measurement times typically 11 hours
- Comparison of xenon volume determinations and activity concentrations



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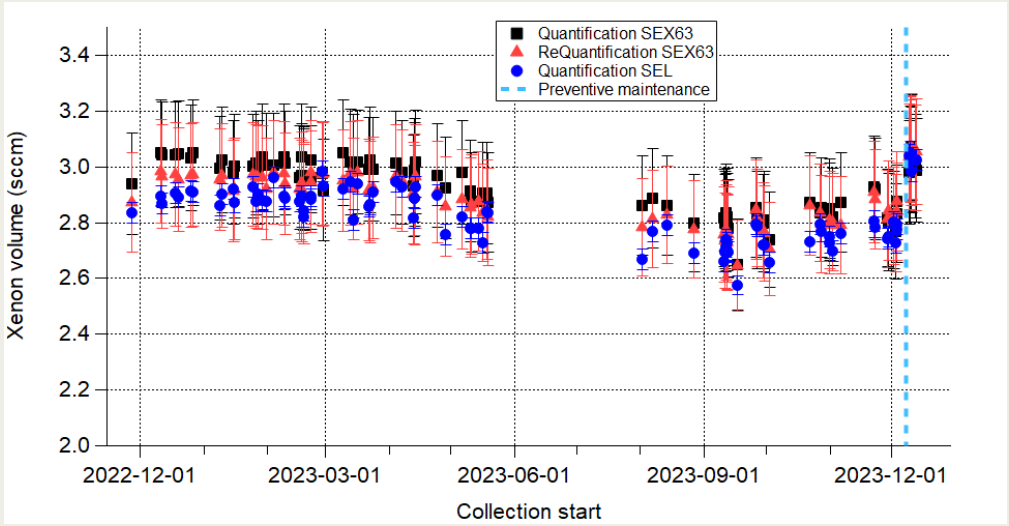
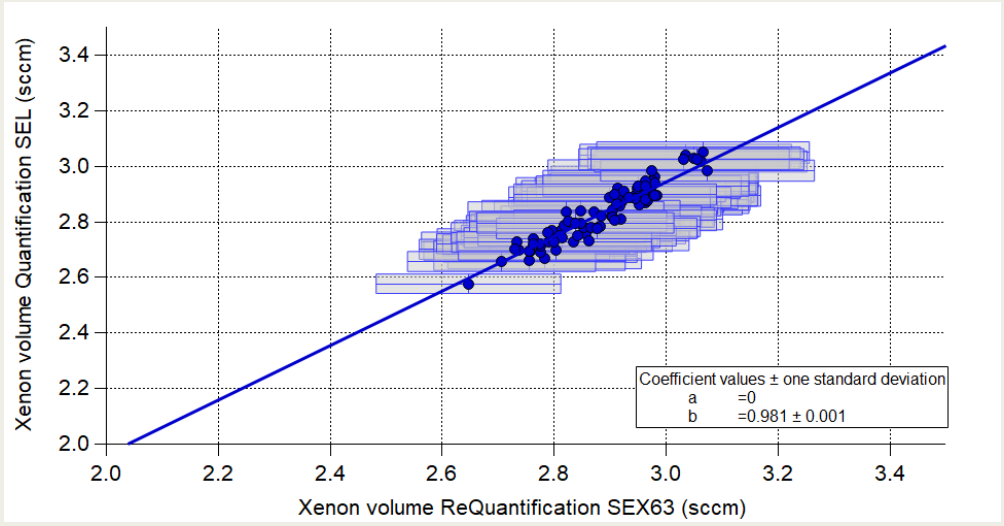
O3.2-362

Xenon volume measurements

- Good agreement between the systems.
- Volume decrease indicates wear and tear of the pumps.
- Xenon volume ratio between SEX63 and SEL is constant.
- Xenon loss between the two systems is about 2%.





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O3.2-362

Radioxenon detections

- For ^{133}Xe > 90% of the detections were above MDC.
- For ^{131m}Xe ~ 50% of the detections were above MDC.
- For ^{133m}Xe and ^{135}Xe no detection was above MDC in either systems.

Isotope	SEX63 AC > LC	SEL AC > LC
^{133}Xe	82	85
^{131m}Xe	27	44
^{133m}Xe	21	9
^{135}Xe	11	15

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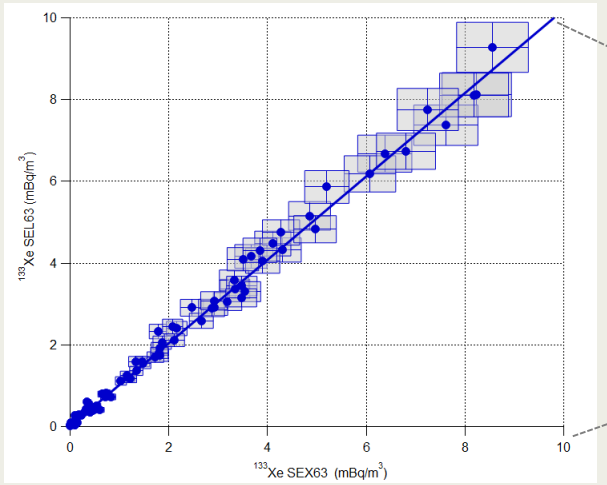
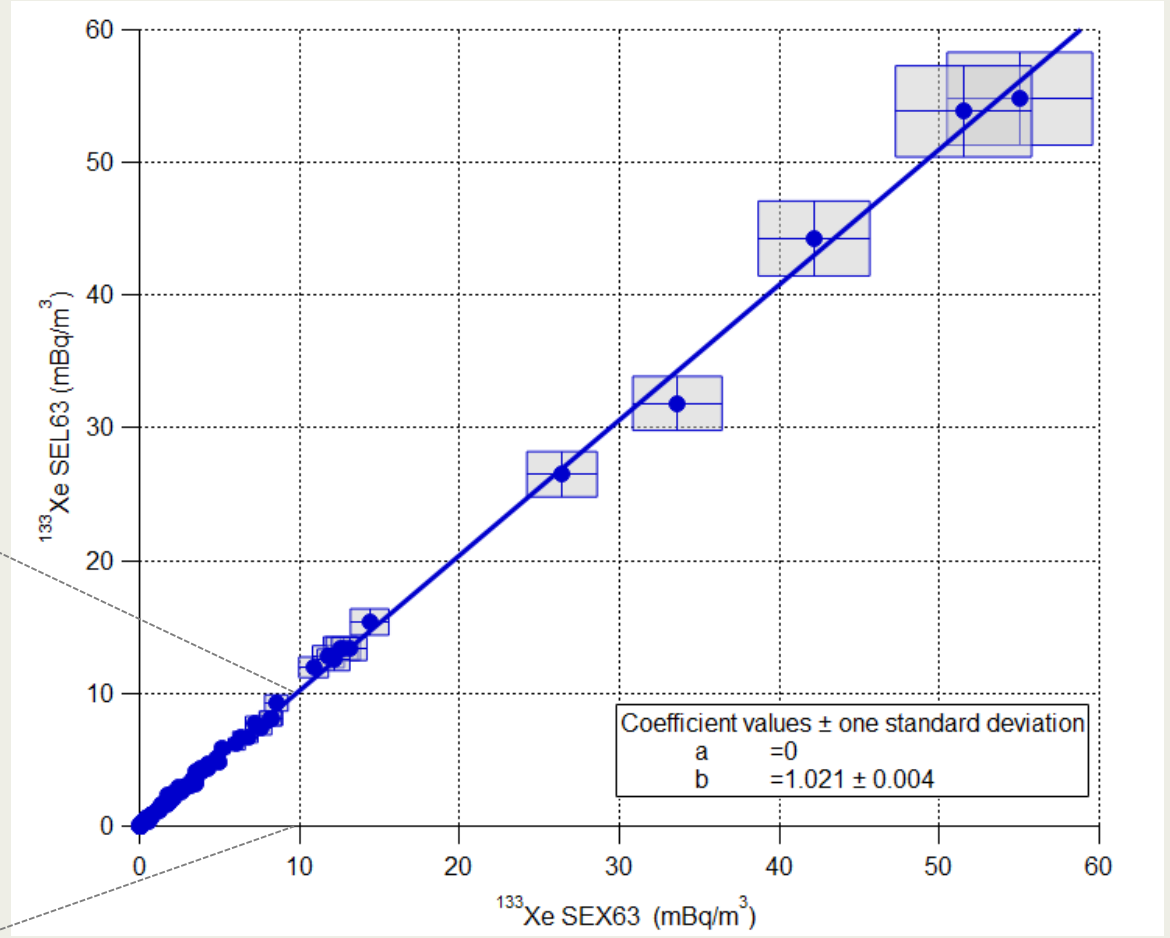
O3.2-362

Results ^{133}Xe

- Linear over measured activity span.
- 2% higher for SEL, within uncertainty.





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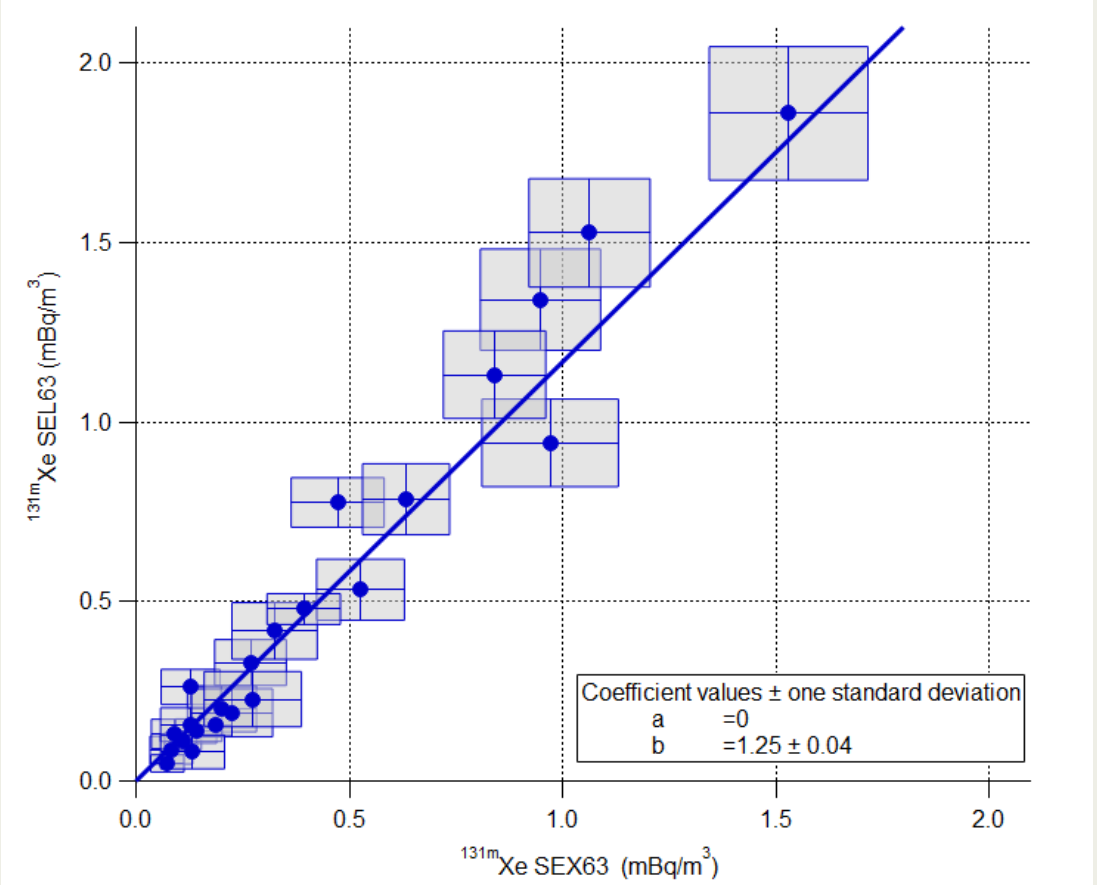
Results ^{131m}Xe

- Linear over measured activity span.
- Bias with 25% higher activities for SEL.
- Not seen in the PTE results.



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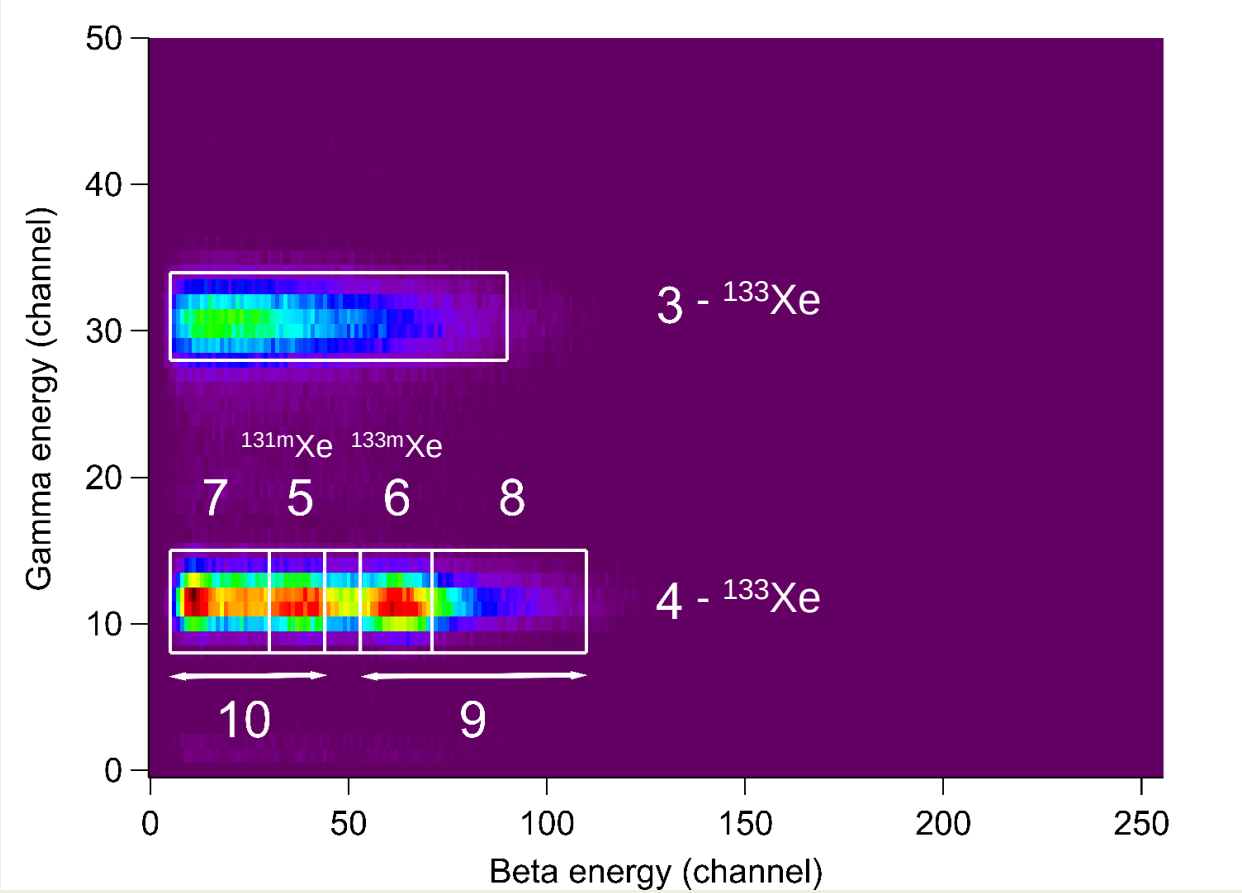
O3.2-362

Interference correction for ^{131m}Xe

- MDCs for ^{131m}Xe and ^{133m}Xe depend on ^{133}Xe activity in the sample.
- Interference correction is performed for detections of ^{131m}Xe and ^{133m}Xe (ROI 5/3 and 6/3).
- Correction factors are determined during detector calibration.
- Interference correction factor 5/3 adjusted down 6% decreases bias from 25% to 10%.
- First estimate, solution might be more complex.



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O3.2-362

Minimum detectable concentration (MDC)

- Factor affecting the MDC's are:
  - Total activity in the sample at measurement (delay)
  - Interference between ROI's for ^{133}Xe and the metastable isotopes ^{131m}Xe and ^{133m}Xe
  - Measurement times
- MDC for the IMS system is constant.

Isotope	SEX63 - 6 h MDA (mBq)	SEL - 11 h MDA (mBq)
^{133}Xe	~ 5.3	~ 2.1
^{131m}Xe	~ 3.4	~ 1.3
^{133m}Xe	~ 2.7	~ 1.2
^{135}Xe	~ 5.4	~ 2.4

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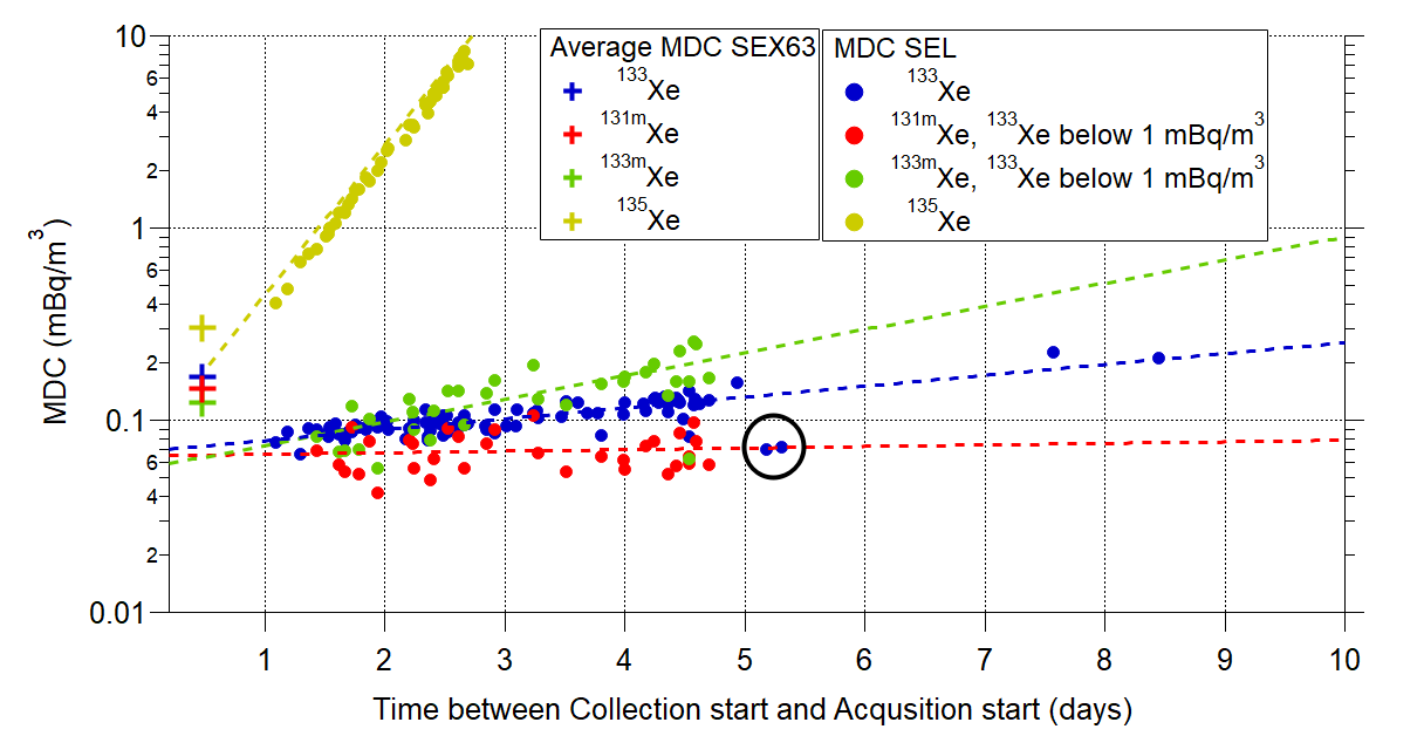
O3.2-362

MDC and delay time

- MDC for the laboratory system increases with delay due to decay.
- MDC is lower than for the IMS system up to a week after sample collection.
- Increased measurement time reduces the MDC and can compensate for a longer delay.



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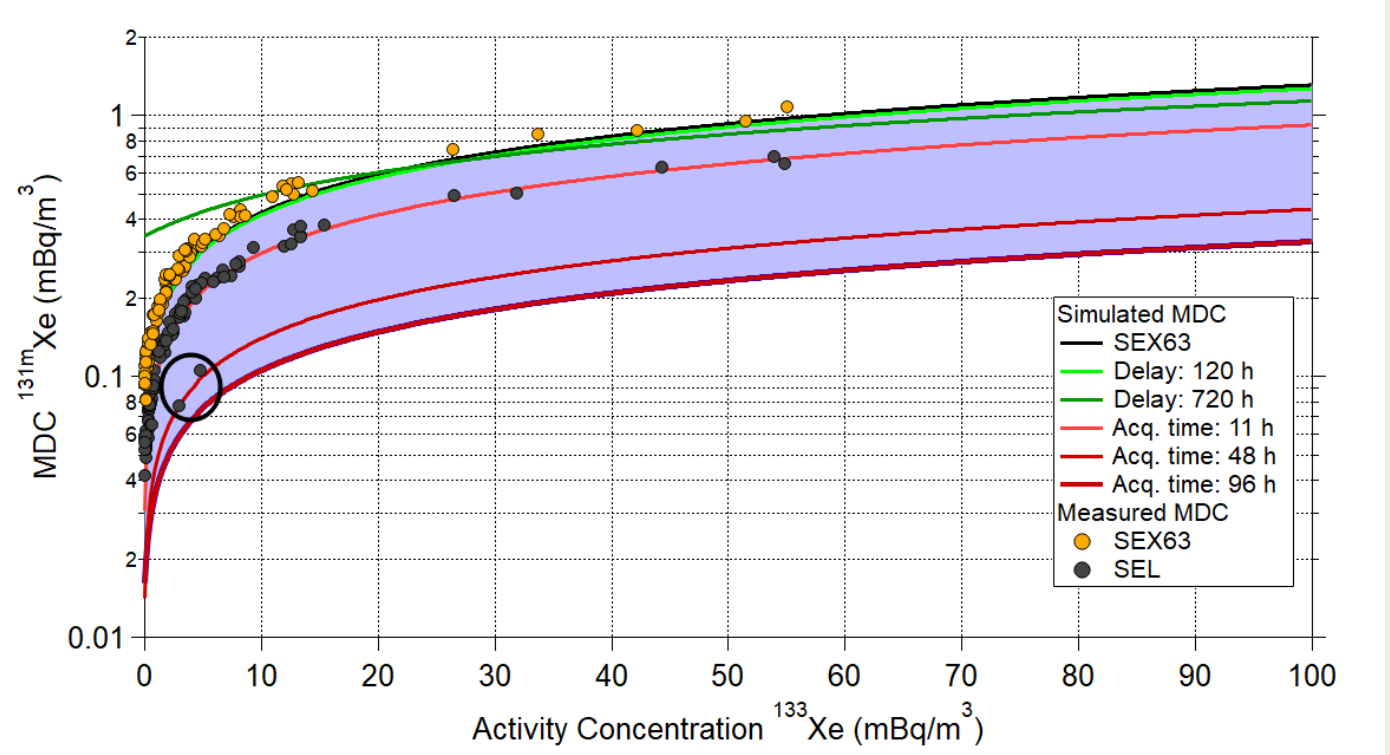
O3.2-362

MDC for ^{131m}Xe and activity concentration for ^{133}Xe

- MDC for ^{131m}Xe depends on activity concentration of ^{133}Xe.
- Longer delay (green curves) has little effect on ^{131m}Xe detectability.
- Longer measurement times (red curves) in laboratory system reduces the MDC for ^{131m}Xe substantially.



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Conclusions

- The IMS laboratories can give valuable information on overall IMS system performance.
- Calibration and interference factors for the IMS system might need adjustment.
- Detectability for three out of four of the radioxenon isotopes are good for up to a week after sample collection.
- Laboratory measurement parameters can be optimized for detectability.
- Laboratory measurements provides a possibility to enhance radioxenon detection capability and improve xenon ratio determination.