SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

CTBTO
PREPARATORY COMMISSION

Xenon International Acceptance Test Phase 1

James Hayes[1], Matthew Cooper[1], James Ely[1], Warren Harper[1], Michael Mayer[1], Mark Panisko[1], Michael Howard[2], Kevin Carter[2], Tricia Gomulinski[2], Robert Mikulyak[2], Aaron Orr[2]; Ryan Sayne[2]

[1] Pacific Northwest National Laboratory [2] Teledyne Brown Engineering

P3.1–616

POSTER

Funding for this research effort was provided by the Defense Threat Reduction Agency, USA.
Cleared for Release

Pacific Northwest
NATIONAL LABORATORY

PNNL-SA-163172

SnT 2021
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE
Poster No.: P3.1-616

Xenon International Acceptance Test Phase 1

James Hayes[1], Matthew Cooper[1], James Ely[1], Warren Harper[1], Michael Mayer[1], Mark Panisko[1], Michael Howard[2], Kevin Carter[2], Tricia Gomulinski[2], Robert Mikulyak[2], Aaron Orr[2]; Ryan Sayne[2]
[1] Pacific Northwest National Laboratory, [2] Teledyne Brown Engineering

CTBTO PREPARATORY COMMISSION

ABSTRACT

Xenon International is a next generation radioxenon monitoring system that was developed at PNNL and being manufactured at Teledyne Brown Engineering (TBE) to strengthen nuclear test monitoring and has recently completed phase-1 testing for acceptance as a qualified system for the International Monitoring System (IMS). Xenon International processes samples every 6 hours generating over 2.5 cc of xenon gas that is counted in a beta-gamma coincidence detector for 12 hours resulting in unprecedented detection limits for radioxenon isotopes. Phase 1 testing was conducted at TBE and consisted of a PTS acceptance visit, radioxenon spikes processed on Xenon International, and 6 months of uninterrupted automated sampling and analysis. Radioxenon analysis data was automatically sent to the PTS after the finish of each count. Xenon International completed phase 1 testing with >98% uptime, and routinely detected never-before seen radioxenon isotopes in an IMS station including ^{125}Xe, ^{127}Xe, and ^{129m}Xe. This talk will discuss Xenon International performance during phase-1 testing and will discuss the impact of unexpected radioxenon isotopes on detection of treaty verification radioxenon radionuclides.

Xenon International Acceptance Test Phase 1
First 6 months

INTRODUCTION

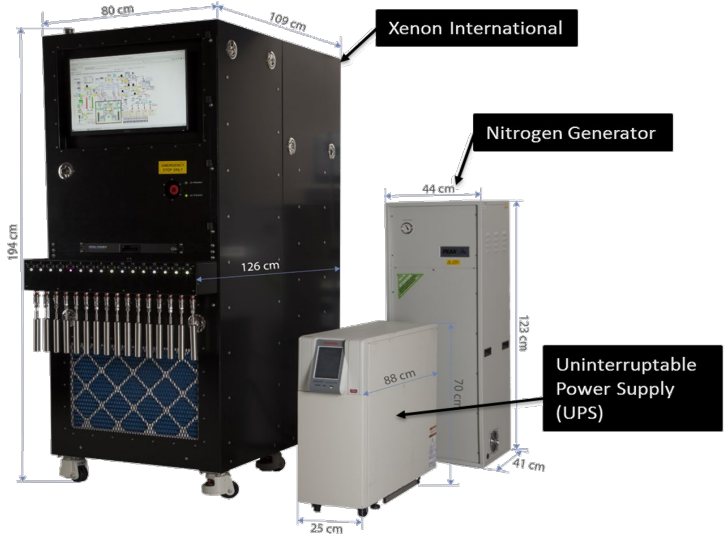
- The Xenon International (XIX81) has completed the first 6 – months of the PTS acceptance test at Teledyne Brown Engineering (TBE), located in Knoxville Tennessee.
- The Phase-1 test period included samples, identified by collection stop date/time in UTC, from April 18, 2020, 00:59:34 through October 18, 2020, 04:52:39.
- The acceptance test began prior to the PTS acceptance test visit where PNNL supplied the PTS with familiarization documents describing the Xenon International operations, measurements, calculations, and calibration methods.
- The team at TBE and PNNL attended the acceptance test visit where the PTS reviewed the Xenon International operations against the acceptance test visit requirements.
- During the visit, the PTS injected a spike sample and performed several tests on the system.
- For the following 6 months, the Xenon International operated unattended and reported data directly to the PTS.
- After the 6-month operations, another spike test was performed and evaluated by GBL15 in the UK.
- This poster highlights the first 6 months of operation and the results of the spike test and an unusual signature observation during the test.

Xenon International Acceptance Test Phase 1

Xenon International Technical Goals and Specifications

INTRODUCTION

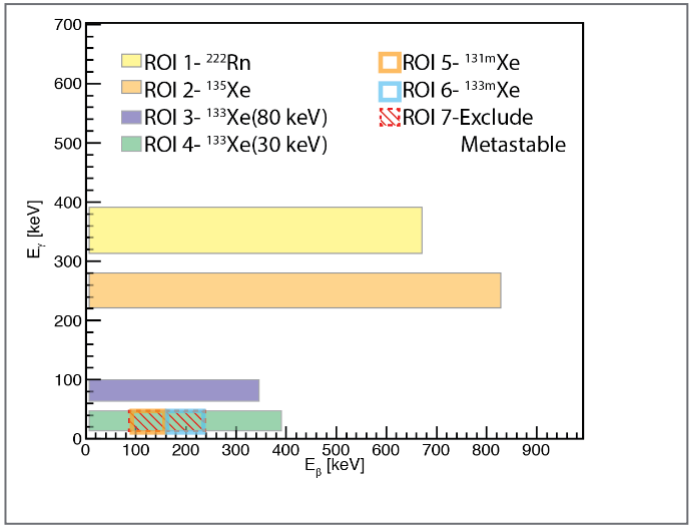
- **High sensitivity**
  - 6-hour collection, 4 samples per day, continuous sampling 24/7, 100% duty cycle
- **High flow rate** 100 L/min (stp; 0°C, 760 torr)
  - MDCs: ^{133}Xe: 0.15 mBq/m^3,^{135}Xe: 0.5 mBq/m^3, ^{131m}Xe: 0.15 mBq/m^3, ^{133m}Xe: 0.15 mBq/m^3
- **High reliability and uptime**
  - PNNL software and hardware control
  - Included manufacturer in design phase
  - 2-years of testing during development
  - Demonstrated combined uptime 97.8%
- **Reduce/eliminate consumables**
  - Nitrogen carrier gas (nitrogen generator on-site)
- **Small weight and size** of the system over currently deployed systems
  - 1240 kg, 80 cm X 109 cm X 194 cm
- **Low power and heat load** compared to current IMS xenon systems
  - 208 VAC (160-275 volt), 50/60 Hz, 30 amp circuit, 4kW (3.5 kW for Xenon International without nitrogen generator)



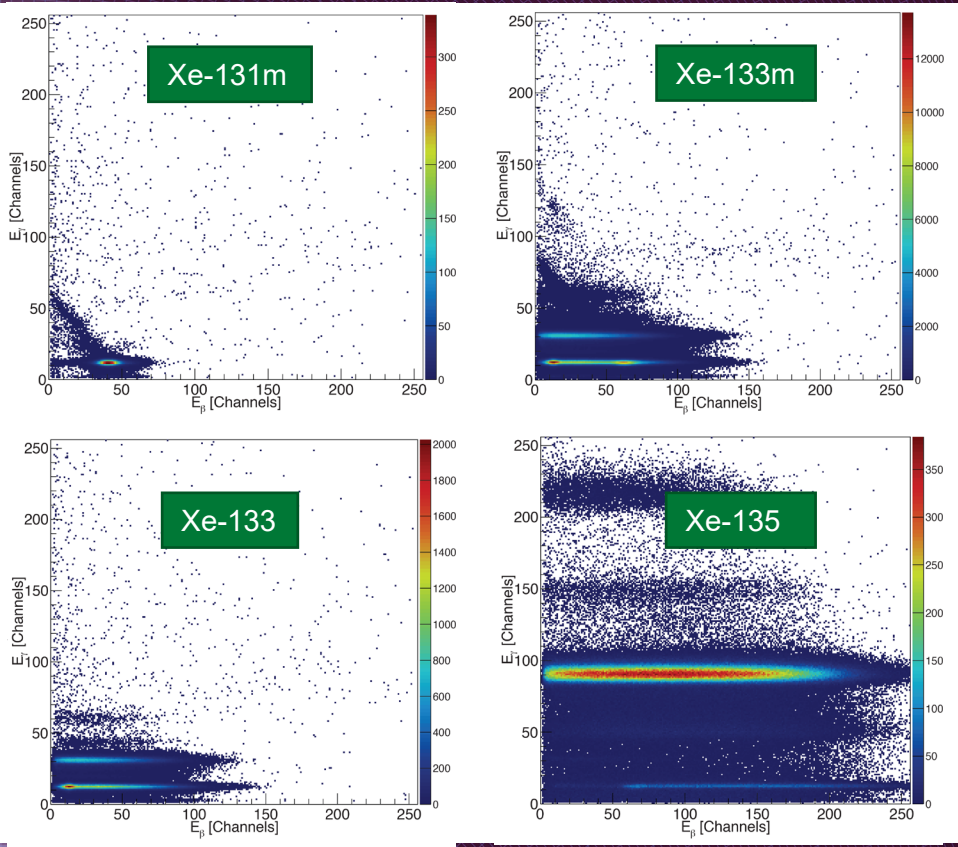
Xenon International Acceptance Test Phase 1 Expected Signatures

METHODS

- Xenon International uses 7 Region of Interest analysis method
- Monitored radioxenon isotopes: ^{133}Xe, ^{133m}Xe, ^{131m}Xe, ^{135}Xe



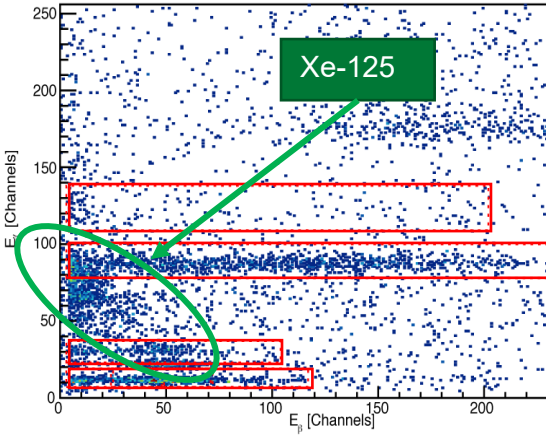
The seven ROI analysis approach provided as a two-dimensional (2D) electron- photon (beta-gamma) plot [2].



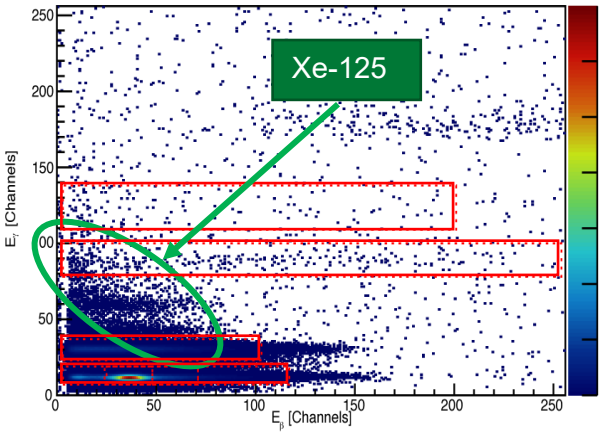
Xenon International Acceptance Test Phase 1
Unexpected Signatures

RESULTS

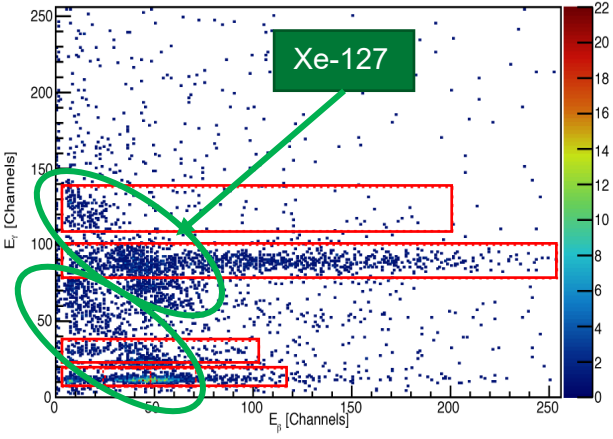
- During the 6-month test, the Xenon International unusual signatures observed which interfered with analysis by overlapping with regions of interest
- See: **James Ely - O2.4-138, First observations of environmental ^{125}Xe, ^{127}Xe, and ^{129m}Xe.**



^{125}Xe observed with ^{135}Xe



^{125}Xe observed with ^{135}Xe, ^{133}Xe, and ^{131m}Xe

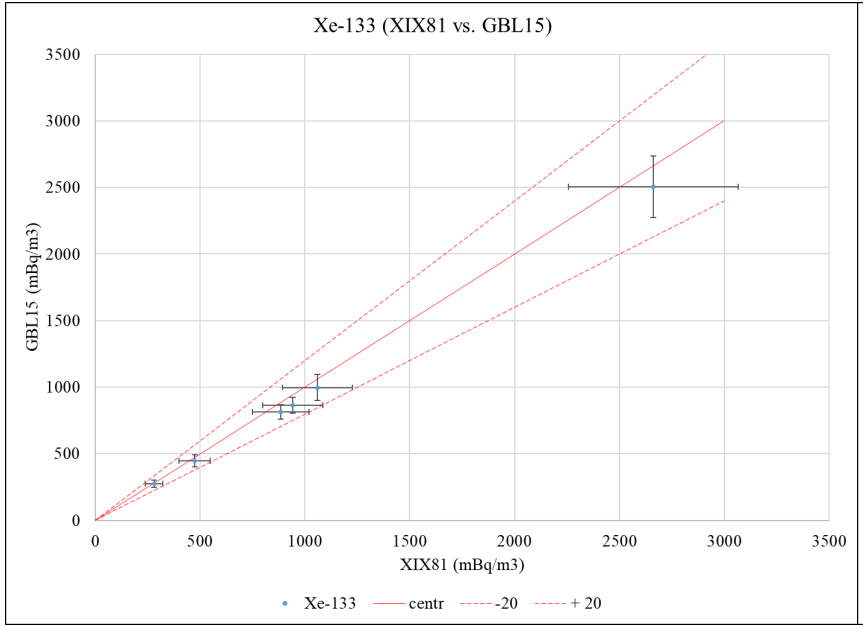


^{127}Xe observed with ^{135}Xe

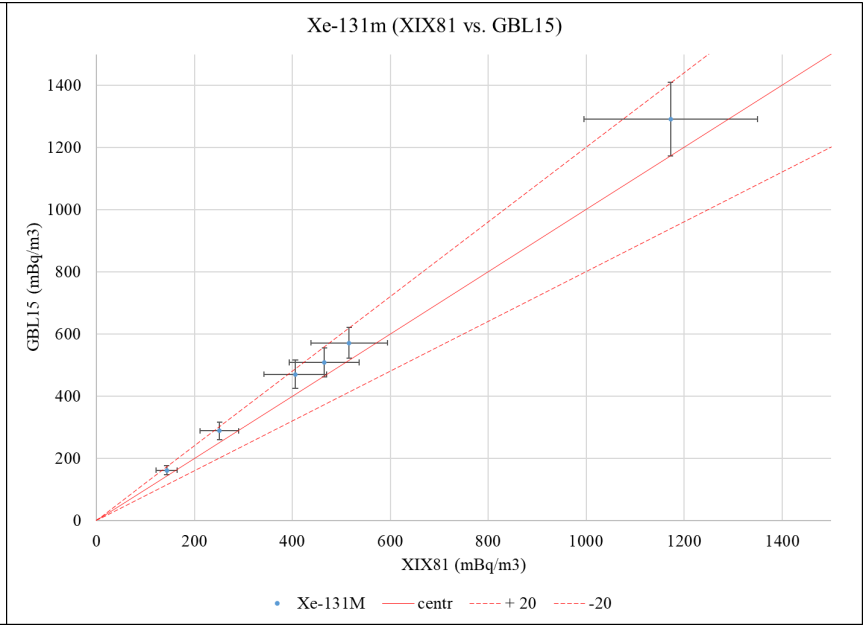
Xenon International Acceptance Test Phase 1
GBL15 Analysis of Xenon International Spike Test

RESULTS

- XIX81 Xenon International archive bottles sent to UK for analysis of acceptance test performance samples



Comparison of ^{133}Xe results from XIX81 and GBL15

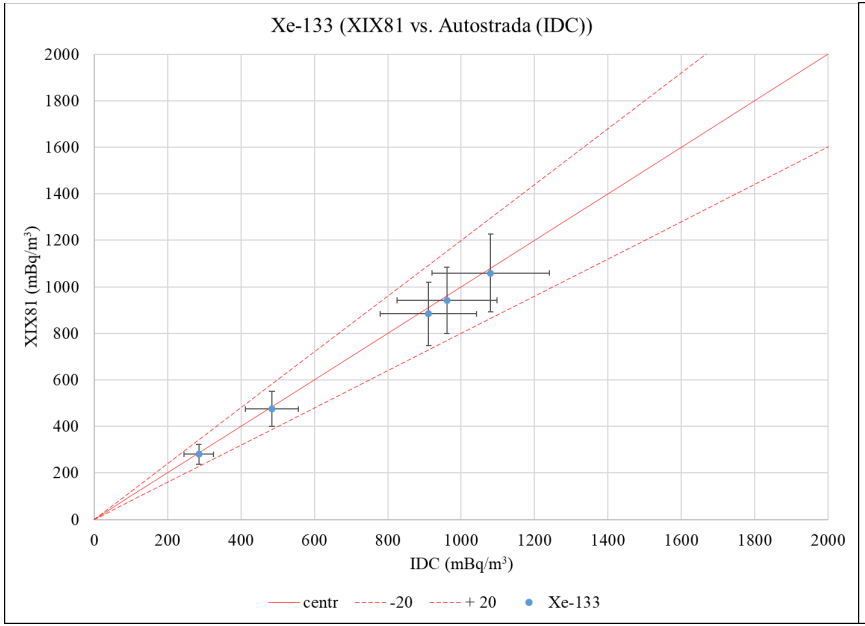


Comparison of ^{131m}Xe results from XIX81 and GBL15

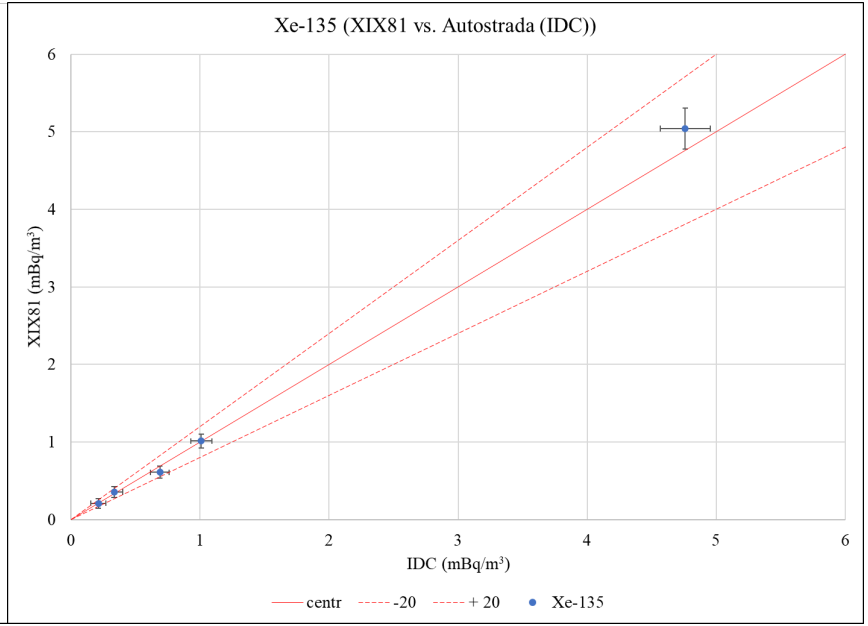
Xenon International Acceptance Test Phase 1
Comparison of Xenon International and Autostrada

RESULTS

- XIX81 Xenon International analysis results comparted to Autostrada developed by the IDC



Comparison of ^{133}Xe results from XIX81 and Autostrada

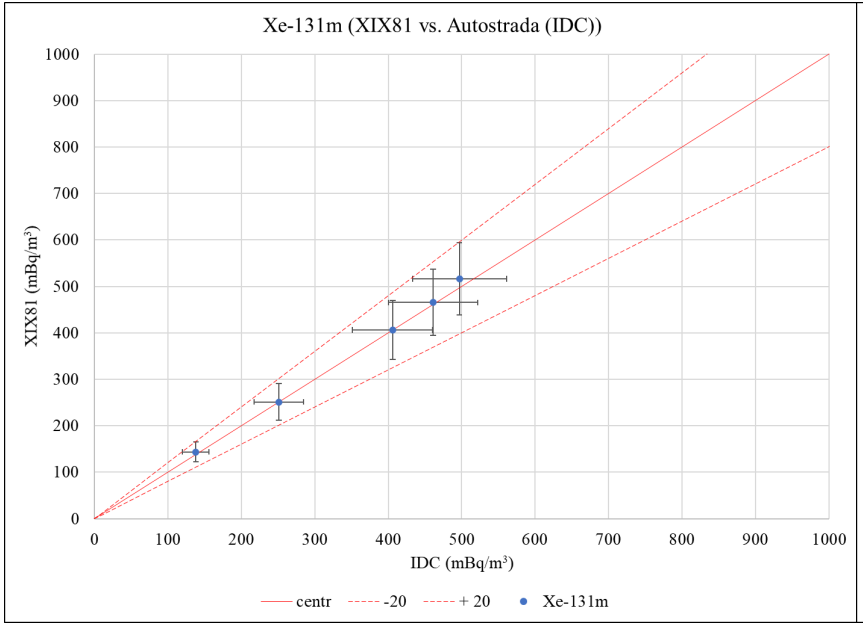


Comparison of ^{135}Xe results from XIX81 and Autostrada

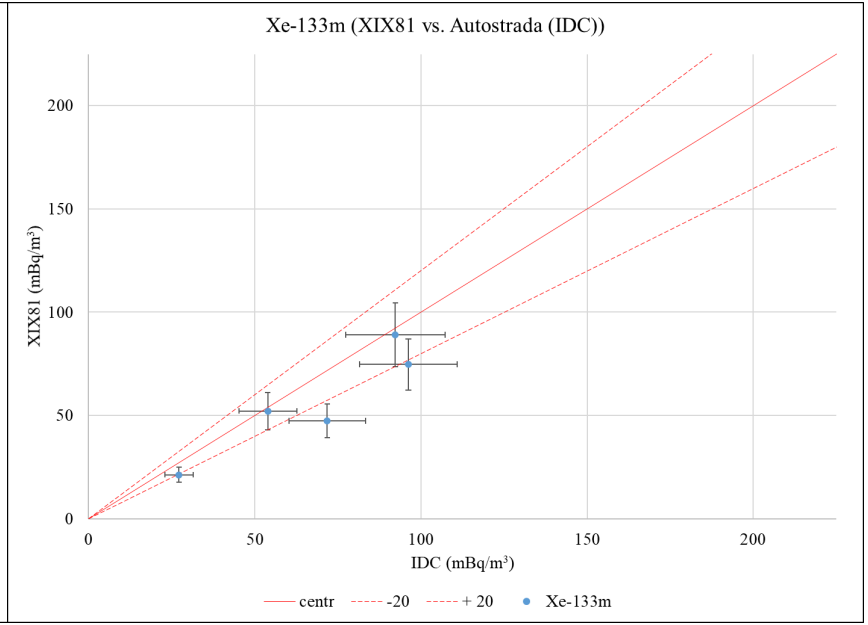
Xenon International Acceptance Test Phase 1
Comparison of Xenon International and Autostrada

RESULTS

- XIX81 Xenon International analysis results comparted to Autostrada developed by the IDC



Comparison of ^{131m}Xe results from XIX81 and Autostrada



Comparison of ^{133m}Xe results from XIX81 and Autostrada

Xenon International Acceptance Test Phase 1
System Data Availability Performance

RESULTS

- The data availability (uptime) is calculated by dividing the samples received that met the quality objectives divided by the possible samples of the test duration.
- First collection start 4/17/2020 18:59 (GMT)
- Last collection stop 10/18/2020 16:52 (GMT)
- 735 possible samples
- 12 samples were missing or did not meet quality criteria (unofficial results)
- **Uptime 98.4%**

Category		Value	Units
Xenon volume	>	0.2	cc
133 MDC	<	5	mBq/scm
Collection time	>=	3	hrs
	<=	12	hrs
Acquisition time	>=	6	hrs
	<=	24	hrs
Reporting time	<=	72	hrs

Xenon International Acceptance Test Phase 1
Upgrades and Documentation for Phase 2

RESULTS

- Additional documentation was completed for preparation for Phase 2:
  - Xenon International User Manual
  - Description of the quantification procedure
  - Limited user-maintenance manual
  - Report on stable xenon collection efficiency
  - State of Health (SoH) parameters
  - Acceptance Test Report

- Software was also updated in preparation for Phase 2:
  - Data reporting format including the collection efficiency in phd files
  - Partial SoH file during system shutdown
  - On/off alert during power outage
  - Data authentication
  - SoH 10-minute average
  - Labeling spike data

- New coated beta cells were assembled, installed and calibrated.

On to Germany for Phase 2 Acceptance Testing

CONCLUSIONS

- June 2021, TBE will train the operators from German Federal Office for Radiation Protection (BfS) via teleconference.
- Xenon International will be shipped to Germany June 11th, 2021.
- Xenon International is expected to be delivered before June 28th when TBE is scheduled to begin installation.
- On-site training is scheduled for the first week of July.
- Phase 2 testing is expected to start during the middle of July.