CTBTO PREPARATORY COMMISSION | PUTTING AN END TO NUCLEAR EXPLOSIONS

Updates on IMS noble gas systems and IDC analysis software

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Introduction

Major achievements over the recent years in the area of CTBTO radionuclide monitoring technology:

- Significant progress in acceptance testing of next generation noble gas systems for the International Monitoring System (IMS).

- Development, testing and deployment of novel software applications for ensuring smooth integration of next generation noble gas systems into IDC operation.
- Integration of new analysis methods.
- Migrating Monte Carlo to open source.
- Modernization of NDC-in-a-Box package.

Scope

- Next generation systems
- Novel processing pipeline
- RNToolkit
- NDC-in-a-Box package
- IDC products
- Monte Carlo simulation
- Summary

Next Generation systems (1/4)
SAUNA III (Sweden)

Detection system	2 x NaI + plastic scintillator
Sampling cycle	6 h (4 samples/day)
Processing time	
Sample measurement time	6 h
Gas background measurement time	6 h

Status:

- **1st SAUNA III deployed at RN63 – Q2 2021**
- **admitted into IDC operation – Q3 2021**

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Next Generation systems (2/4)
SPALAX NG (France)

Detection system	1 x HpGe + SiPIN
Sampling cycle	8 h (3 samples/day)
Processing time	
Sample measurement time	6.5 h
Gas background measurement time	not applicable

CTBTO acceptance testing:

- SPALAX NG accepted in Q3 2021

Next Generation systems (3/4)
Xenon International (USA)

Detection system	4 x NaI + plastic scintillator
Sampling cycle	6 h (4 samples/day)
Processing time	
Sample measurement time	12 h
Gas background measurement time	12 h

Status:

- **Xenon International completed phase 2 of CTBTO acceptance testing at RN33 – Q1 2022**

Next Generation systems (4/4)
MIKS (Russian Federation)

Detection system	2 x NaI + plastic scintillator
Sampling cycle	12 h (2 samples/day)
Processing time	
Sample measurement time	14 h
Gas background measurement time	6 h

Status:

- **MIKS is under CTBTO acceptance testing**

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IMS noble gas systems in IDC operation

Out of the 40 IMS noble gas systems, **26 are currently certified and sending data to IDC operations**

Latest: MRX43, April 2022

Operational technologies:

SAUNA II: 15
SAUNA III: 1

HPGe *SPALAX:*

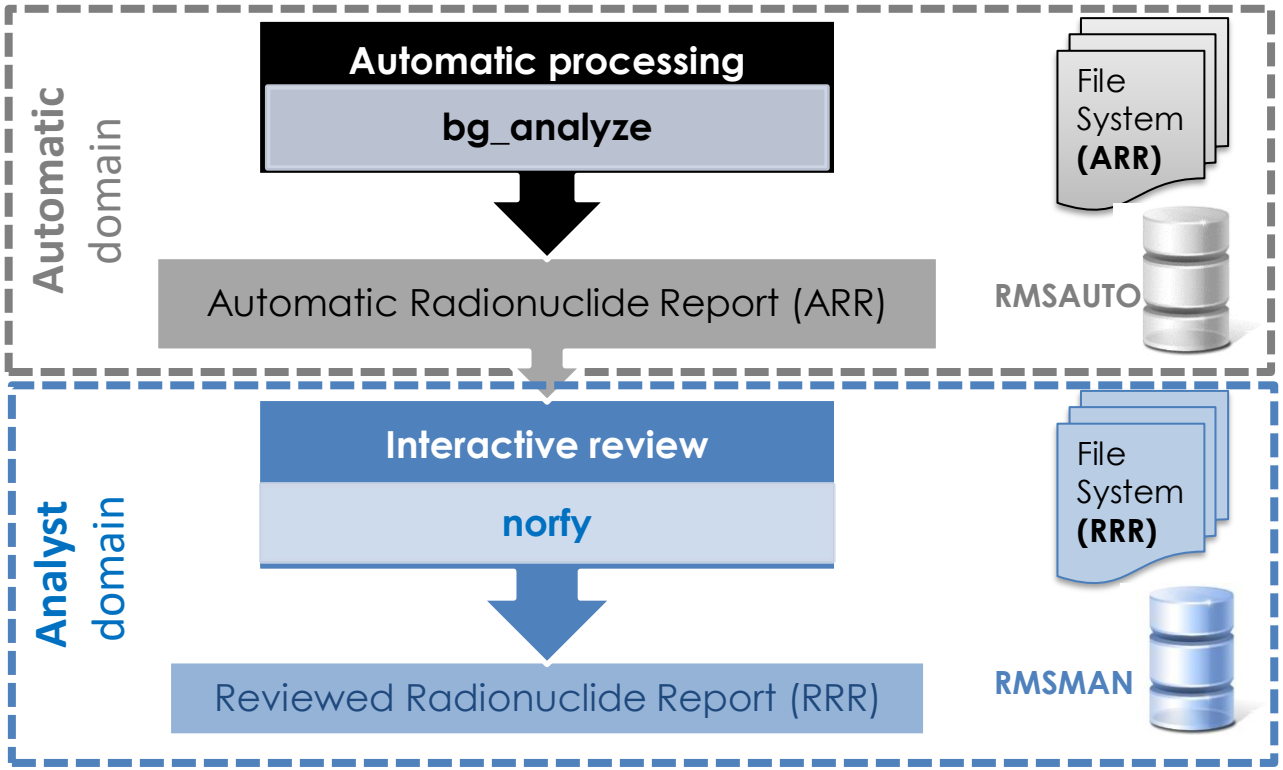
Former processing pipeline for noble gas

Algorithm:
- **NCC**

NG technology:
- **SAUNA II**

Database schema:
- **RMSAUTO**
- **RMSMAN**

IDC product:
- **ARR**
- **RRR**



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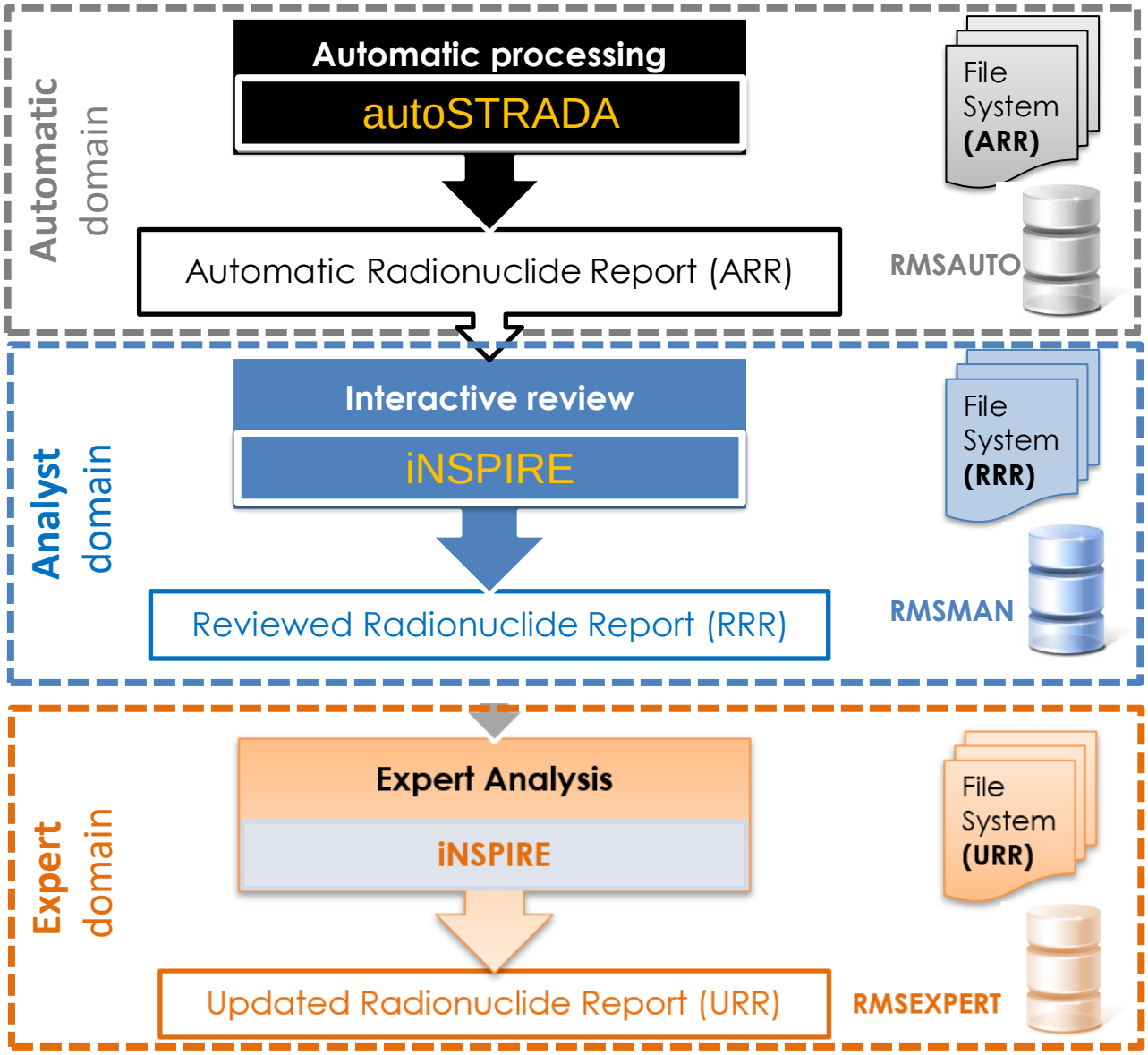
Novel processing pipeline
for noble gas (since Aug. 2021)

Algorithm:
- **NCC**
- **+ BGM**

NG technology:
- **SAUNA II**
- **+ SAUNA III**
- **+ SPALAX NG**
- **+ Xenon International**
- **+ MIKS**

Database schema:
- **RMSAUTO**
- **RMSMAN**
- **+ RMSEXPERT**

IDC product:
- **ARR**
- **RRR**
- **+ URR**



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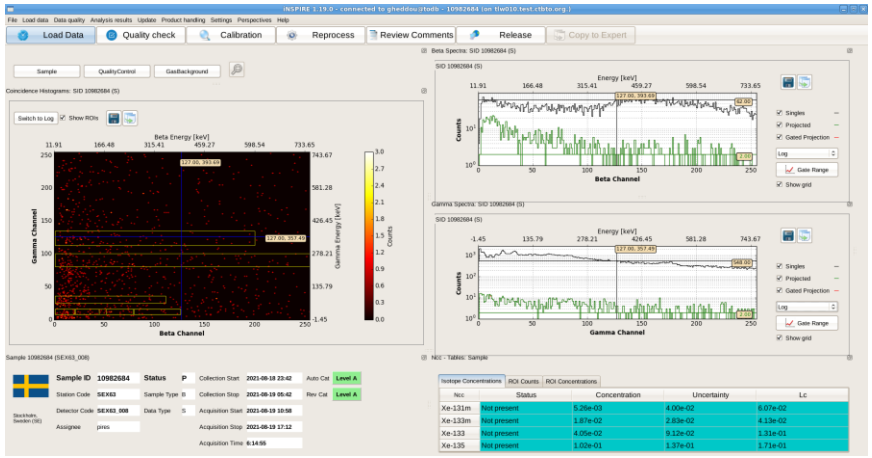
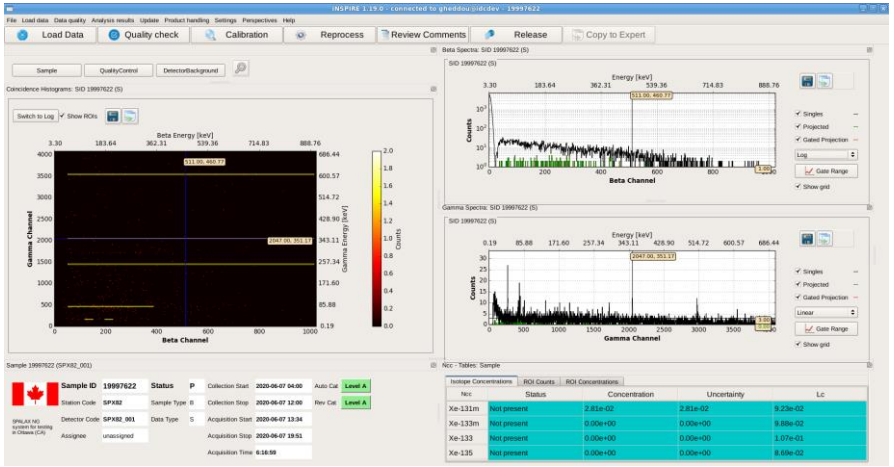
autoSTRADA and iNSPIRE handle all noble gas systems

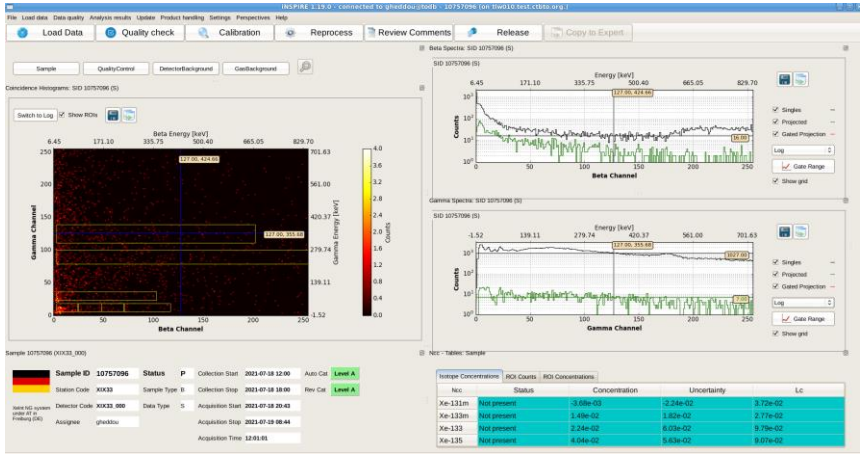
SAUNA II/III



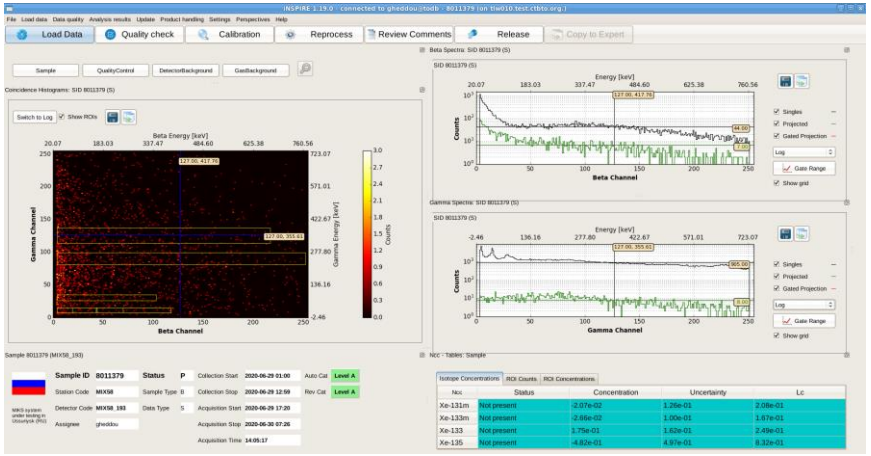
SPALAX NG



Xenon International



MIKS



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RNToolkit
web-based application (1/5)

With the aim of **further empowering National Data Centres (CND)**, the IDC developed a novel web-based application, dubbed RNToolkit.

RNToolkit offers several options that the user can customize for **accommodating specific needs**, allowing **in-depth** spatial-temporal **analysis** of anthropogenic activity concentrations that might be released into the air by a nuclear test.

Main functionalities include **time development of detected nuclides, activity concentration, categorization parameters and isotopic ratios**. It also provides contextual **access to IDC products** for any sample.

Among the key features, **detections at different stations can be compared** for any CTBT radionuclide.

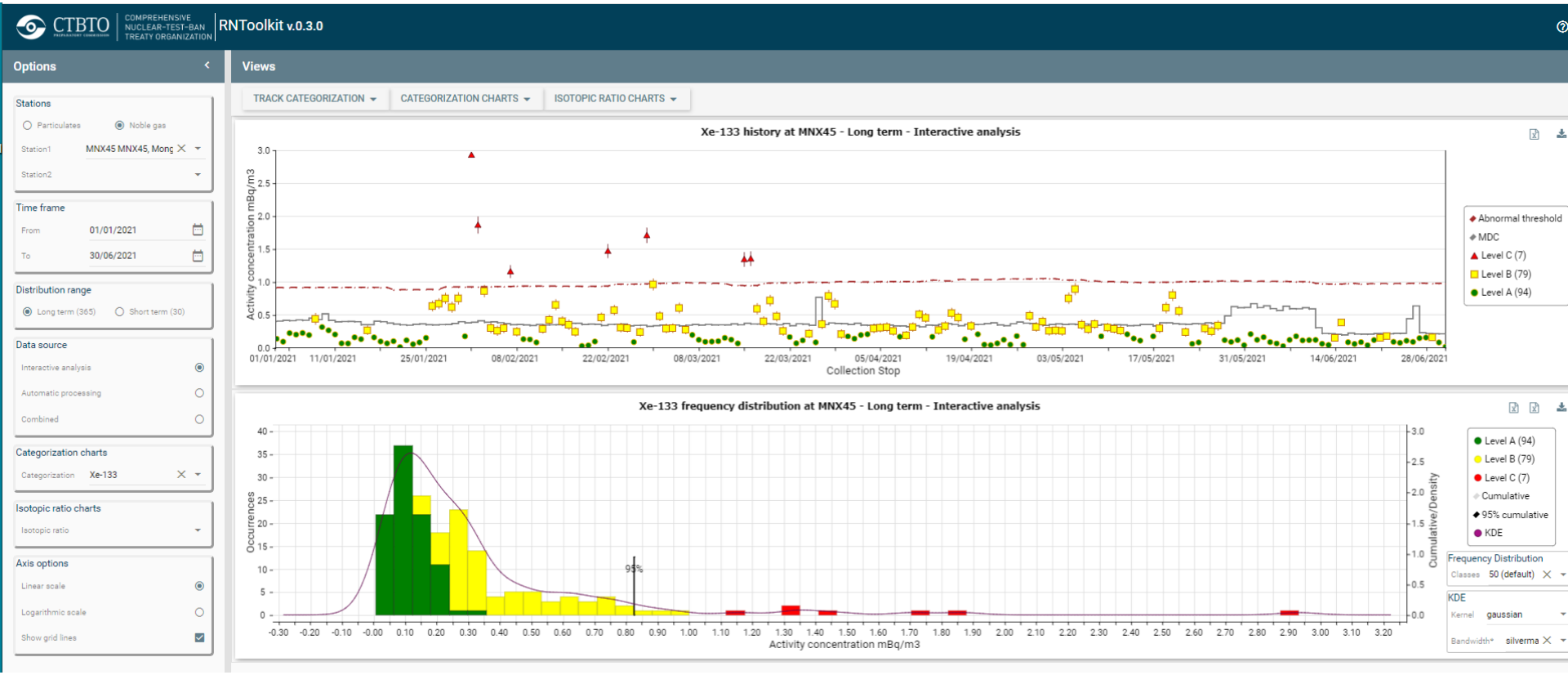
Furthermore, RNToolkit allows **tracking of detections on IMS map** for targeted days and in animated mode for a time frame of interest.

In addition to CTBT verification related activities as a main application domain, RNToolkit also constitutes a powerful resource for the purposes of radiological impact assessment studies, namely in the case of a major nuclear accident.

Status:
- Delivered to NDCs in March 2021
- Accessible with SSO credentials on https://rntoolkit.ctbto.org

RNToolkit
web-based application (2/5)

Time development of detected radioxenon isotopes, activity concentration, categorization parameters



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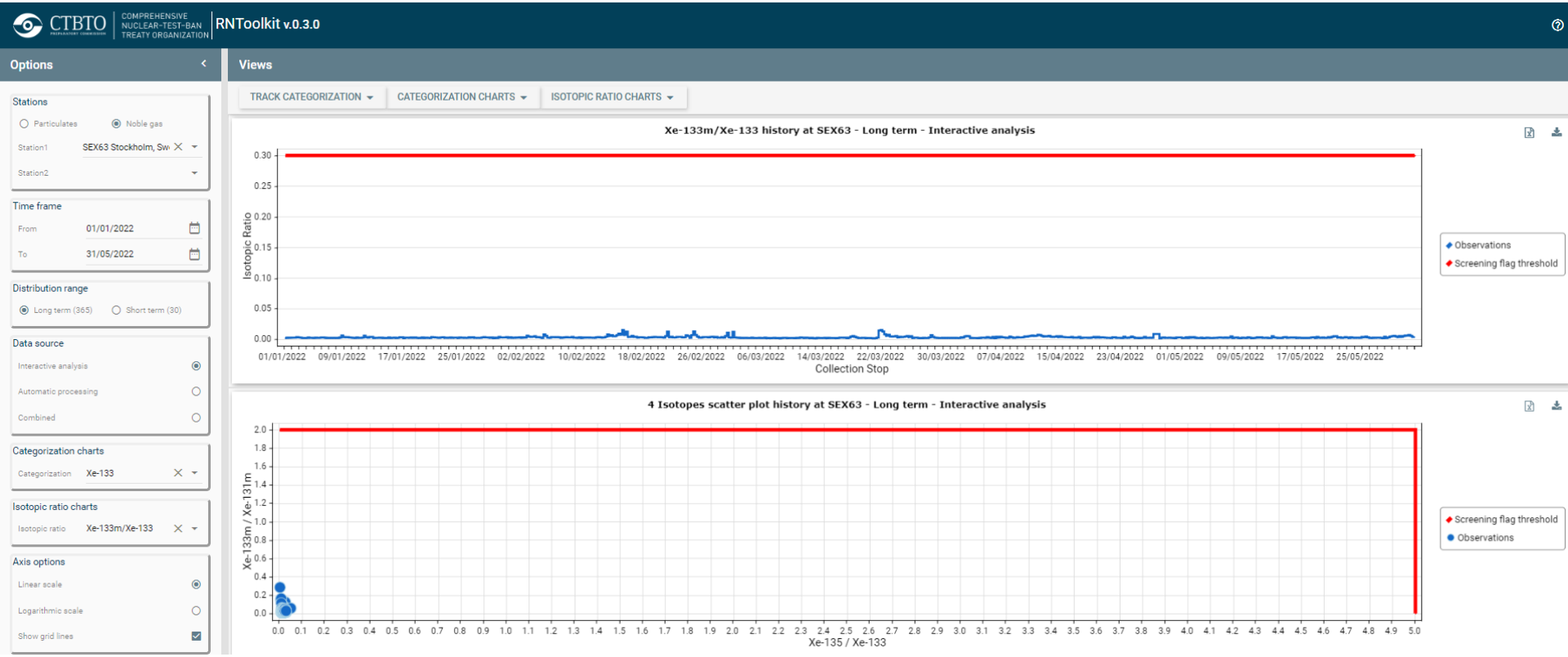
RNToolkit
web-based application (3/5)

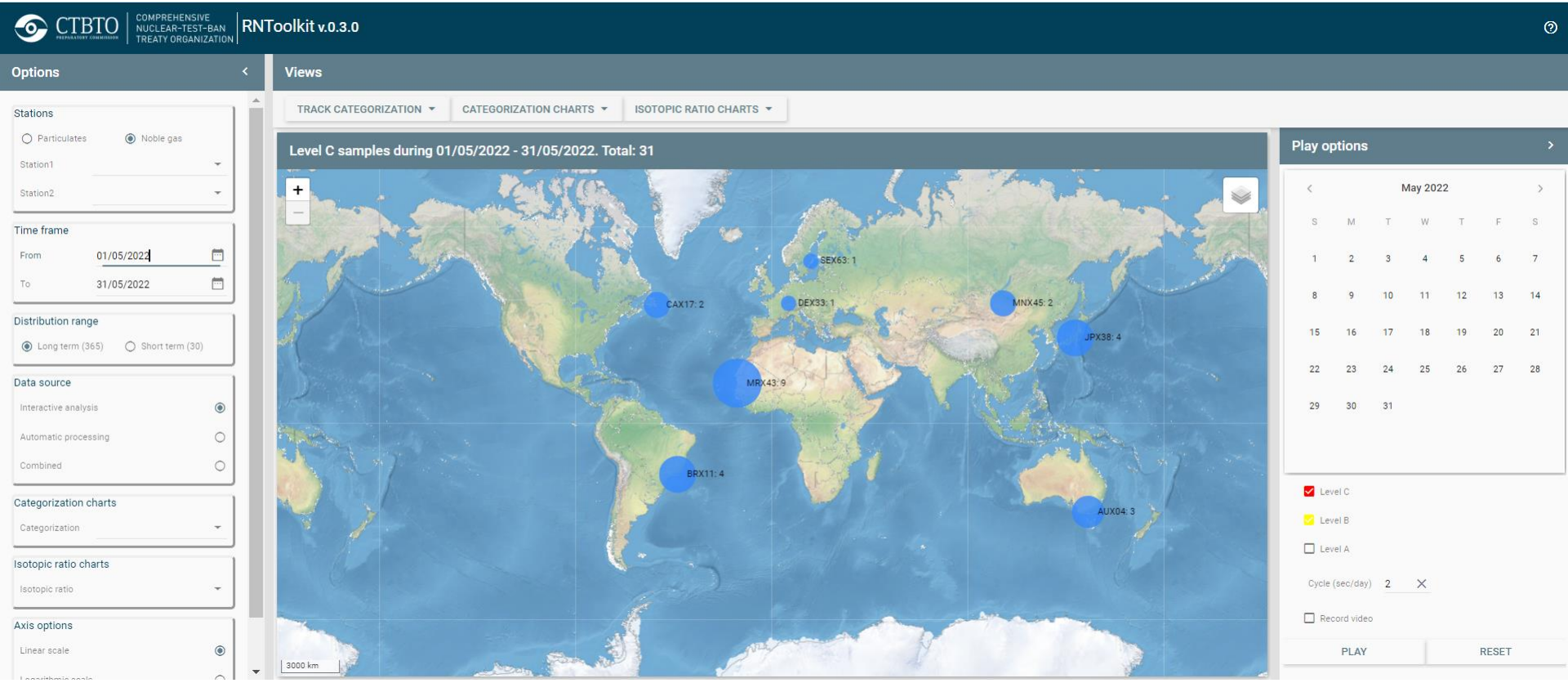
Radioxenon isotopic ratios plots with screening flag threshold lines:

- Two isotopes (Xe-133m/Xe-131m, Xe-135/Xe-133, Xe-133m/Xe-133, Xe-133/Xe-131m)
- Four isotopes (Xe-133m/Xe-131m vs. Xe-135/Xe-133)



RNToolkit
web-based application (4/5)

Total number of Level C samples for (any) specified time period



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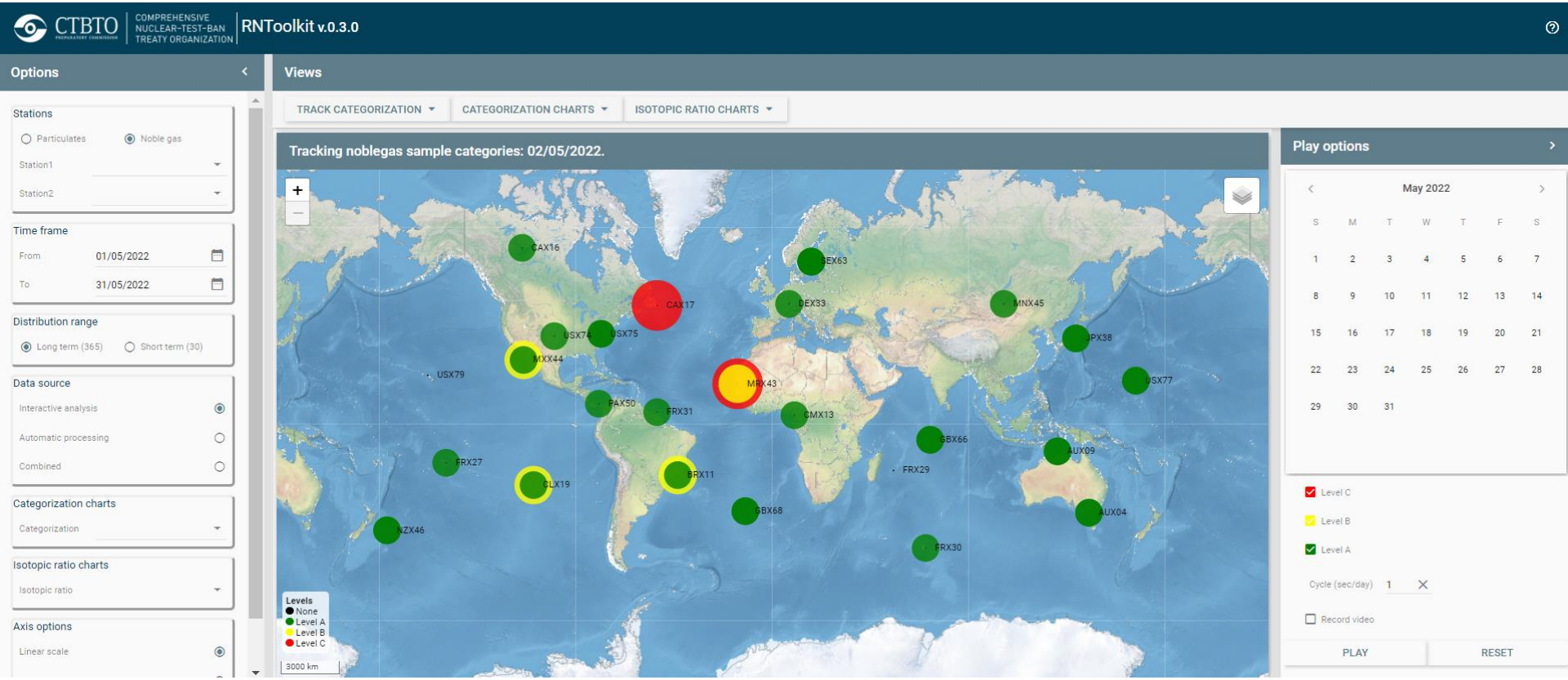
RNToolkit
web-based application (5/5)

Tacking of detections on IMS map for targeted days and in animated mode for a time frame of interest.



Enhancements to NG products (1/2)

As recommended at INGE 2021, NG products (ARR, RRR, URR) template was enhanced for:

- **Extending reported activity/concentration to non-detections (below LC)**
- **Specifying the analysis method (NCC, BGM)**
- **Reporting statistical and systematic uncertainty components, separately**

Isotope category

Isotope	Nuclide detected	Abnormal_limit *(mBq/m3)*	Category
Xe-131m	NO	1.52E-01	A
Xe-133m	NO	1.15E-01	A
Xe-133	YES	5.32E-01	B
Xe-135	NO	8.40E-01	A

Spectrum Category: B - Xenon detection within the typical range for the station

Activity Summary and Minimum Detectable Concentration for Xenon Isotopes

Radon counts in Xenon sample: 97

Xenon isotopes - Beta gamma matrix (BGM) analysis method

Nuclide	Half-Life	Activity (mBq)	RelErr (%)	Conc (mBq/m3)	RelErr (%)	LC (mBq/m3)	MDC (mBq/m3)
XE-131M	11.962 D	-1.54E-01	357.98	-1.35E-02	360.54	8.12E-02	1.79E-01
XE-133M	2.198 D	1.87E-01	210.49	1.88E-02	211.68	6.23E-02	1.44E-01
XE-133	5.2441 D	5.35E+00	21.92	4.89E-01	24.25	1.39E-01	3.02E-01
XE-135	9.143 H	-7.36E-01	125.39	-1.62E-01	126.02	3.44E-01	7.28E-01

Processing Specific Parameters and Results

Beta gamma matrix (BGM) analysis method

ROI Net Count Results

ROI	Nuclide	Net Counts	Abs Net Error	LC	Efficiency	Abs Eff Error
1	PB-214	37.92	3.57	18.41	N/A	N/A
2	XE-135	-10.80	3.68	22.91	0.60	0.01
3	XE-133	54.38	3.45	15.41	0.70	0.01
4	XE-133	67.38	3.50	22.11	0.71	0.01
5	XE-131M	-2.23	2.82	13.35	0.67	0.01
6	XE-133M	2.59	2.34	8.57	0.67	0.01

ROI Limits (channels)

ROI	BetaLow *(channels)*	BetaHigh *(channels)*	GammaLow *(channels)*	GammaHigh *(channels)*
1	1	198	114	135
2	1	255	78	100
3	1	124	26	36
4	1	138	8	16
5	28	55	8	16
6	64	93	8	16
7	1	25	8	16
8	96	138	8	16
9	64	138	8	16
10	1	55	8	16

Processing Parameters

Risk level k:	1.6449
Gas background used:	NO
Detector background used:	YES
Interference corrections:	YES
Analysis method:	BGM

Enhancements to NG products (2/2)

In addition to initial html/xml format, **NG products** (ARR, RRR, URR) **will also be available in ascii format.** (this addresses feedback from NDCs).

Status:

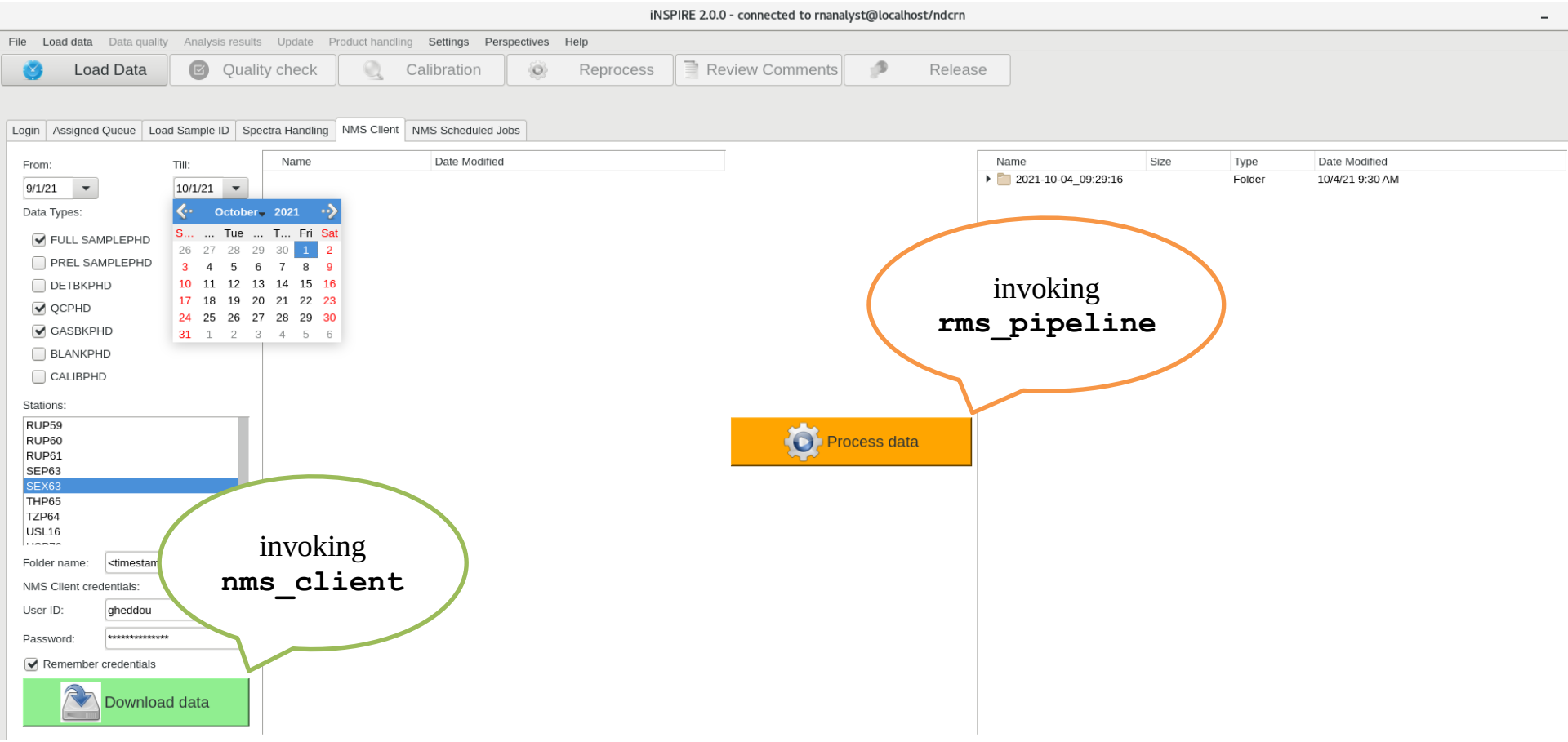
- Deployed in IDC operation (late May 2022)
- VDMS supports the new format (the user can request html or ascii, depending on specific needs).
- SWP is being enhanced for supporting the new changes.

```
IDC Generated Report
Reviewed Radionuclide Report
Noble Gas Version

Creation Date: 2021-11-05 10:36:28
Sample Arrival Time: 2021-11-02 17:33:12
Time difference from receipt of raw data to report creation: 2 d 17 h 3 m 16.0 s

Sample Information
--------------------------------------------------------------------------------

Station ID:     NZX46   Detector Code: NZX46_005
Authenticated:  YES

Station Location:       Noble Gas Christchurch, New Zealand
Detector Description:   Detector #5
System Technology:      SAUNA

Sample Reference ID:    46202111011111X
Sample ID:              56953609
Stable Xe Volume:       1.03 ml         Sample Type:    Gas

Collection Start:       2021-11-01 11:14:01     Sampling Time:          12 h  1 s
Collection Stop:        2021-11-01 23:14:02     Processing Time:        7 h 6 m
Acquisition Start:      2021-11-02 06:20:02     Acquisition Time:       11 h 10 m 2 s
Acquisition Stop:       2021-11-02 17:30:04

IDC Analysis General Comments:b'None
None
'

Measurement Categorization
--------------------------------------------------------------------------------

Categorization Legend

Level A         Clean spectrum - No Xenon is present in the sample.
Level B         Xenon detection within the typical range for the station.
Level C         Anomalous Xenon detection.

Isotope category
Isotope         Nuclide detected        Abnormal_limit (mBq/m3) Category
Xe-131m         NO                      9.91E-02        A
Xe-133m         NO                      9.42E-02        A
Xe-133          NO                      2.34E-01        A
Xe-135          NO                      1.04E+00        A

Spectrum Category: None

Activity Summary and Minimum Detectable Concentration for Xenon Isotopes
--------------------------------------------------------------------------------

Radon counts in Xenon sample: 68
```

NDC-in-a-Box (1/2)

RN NDC-in-a-Box 4.0, Nov. 2020

Data downloading and processing can be performed from with dedicated functionalities on iNSPIRE GUI



NDC-in-a-Box (2/2)

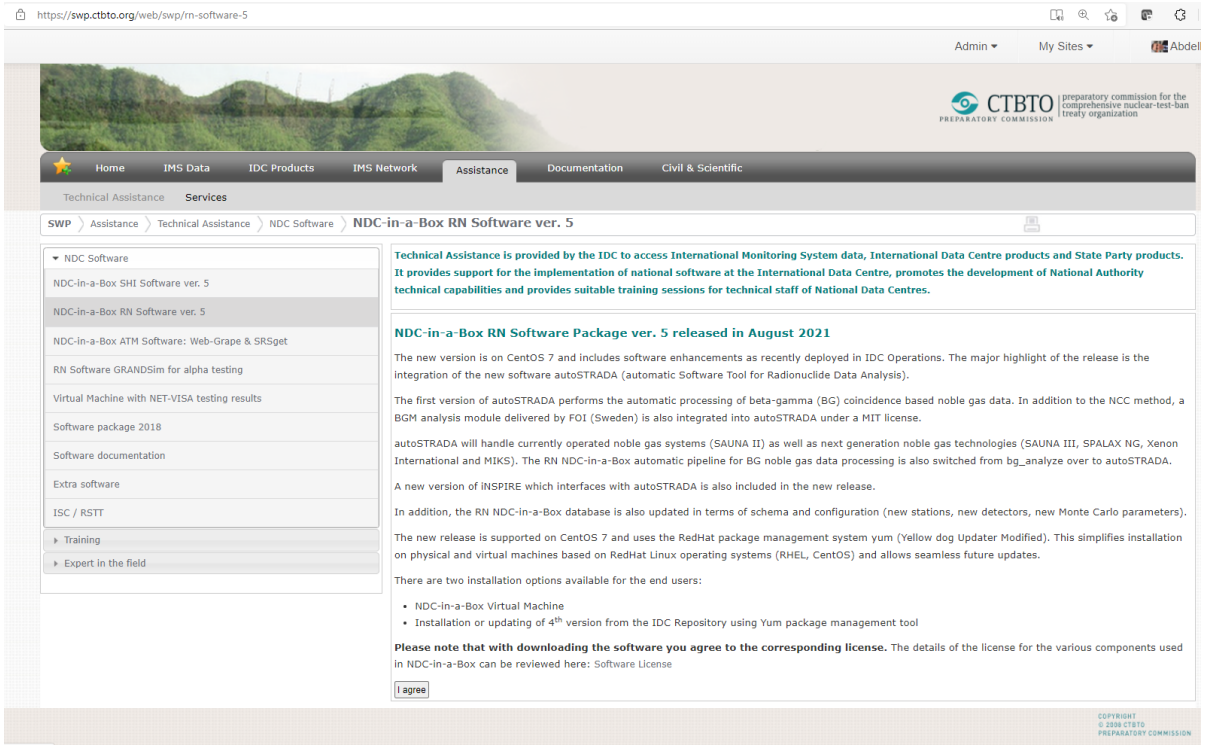
RN NDC-in-a-Box 5.0, Aug. 2021

- **Integration of the new software autoSTRADA** for automatic processing of beta-gamma (BG) coincidence based noble gas data
- A **new version of iNSPIRE** which interfaces with autoSTRADA is also included.

The new release is supported on **CentOS 7.**

Two options are available to end users for installing the new RN software package:

- NDC-in-a-Box **Virtual Machine**
- **Installation** from the IDC repository **using** `yum` package management tool



The software package can be downloaded as described on https://swp.ctbto.org/web/swp/rn-software-5

Integration of calibration validation tool (ongoing)

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iNSPIRE 2.0.0dev - connected to gheddou@idcdev (on dlvw003.idc.ctbto.org)

File Load data Data quality Analysis results Update Product handling Settings Perspectives Help

Load Data | Quality check | Calibration | Reprocess | Review Comments | Release | Copy to Expert

Calibration report for XIX33_003 - Generated 2021-11-24T07:24:25Z - Konqueror

File Edit View Go Bookmarks Tools Settings Window Help

/dvl/products/rn/bg_ca

Google

Calibration report for XIX33_003

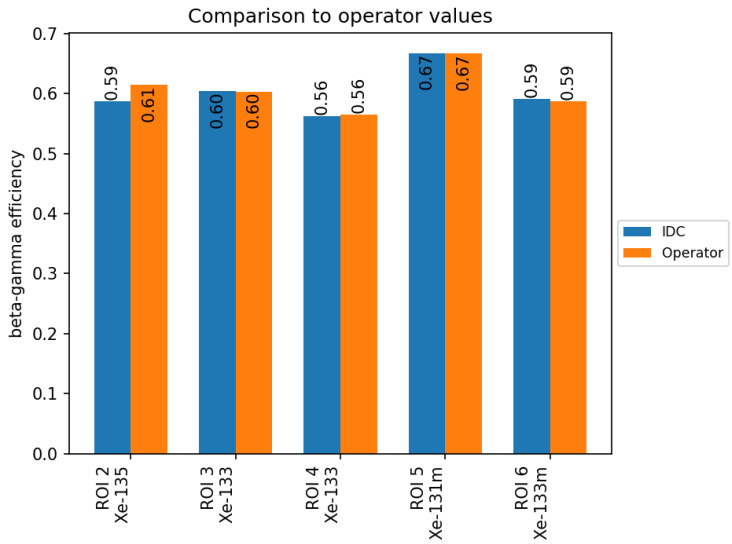
Generated 2021-11-24T07:24:25Z.

Table of Contents

tector Code | From | To | Assignee

X33_003 | 2020-12-01 | 2021-01-31 | Any | Assigned to me

p Time [h]	Acq Start	Acq Time [h]	Transm Date	Sample Id	Auto Category	Category	Assignee
	2021-01-08 17:11	12	2021-01-09	54346616	-	-	unassigned
	2021-01-06 17:28	12	2021-01-07	54346617	-	-	unassigned
	2021-01-27 17:12	12	2021-01-28	54346618	-	-	unassigned
	2021-01-20 11:51	21	2021-01-21	54346619	-	-	unassigned
	2021-01-29 17:10	1	2021-01-29	54403629	-	-	unassigned



Spectra Handling

Query | Load

5 rows returned

bg_calval | Detect

Cs-137	Load
Xe-131m: sid 54346616	Load
Xe-131m Gas: sid 54346622	Load
Xe-133: sid 54346617	Load
Xe-133 Gas	Load
Xe-133m: sid 54346618	Load
Xe-133m Gas: sid 54346624	Load
Xe-135: sid 54346619	Load
Xe-135 Gas: sid 54346625	Load
Rn: sid 54403629	Load
Rn Gas: sid 54346621	Load
Reference	Load

HTML output

Don't Use Reference

Skip Configuration Parameters

Skip ROI Limits

Execute

- ✓ Supports the different calibration approaches as currently used for the different NG technologies.
- ➢ Will be used at IDC for validation of operator calibration.

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Integration of sample metrics assessment tool (ongoing)

Station: JPX38 - Mozilla Firefox (on dlw084.idc.ctbto.org.)

Station: JPX38 | Station: MXX44

file:///home/rsmon/gheddou/metricsPrototype/JPX38_01-OCT-2021_01-NOV-2021_01-OCT-2021_01-NOV-2021sampleMetricsReport.html

- ✓ Supports the different NG technologies.
- ✓ Checks sample metrics against system specific thresholds for certification/ data availability.
- ➢ Will be used at IDC for new stations/detectors testing .

Data quality assessment report

Station: JPX38

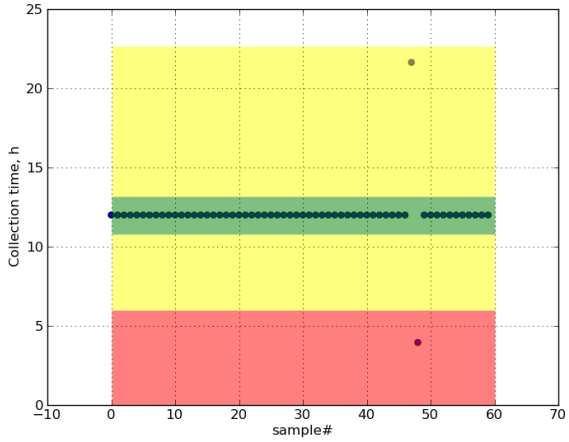
Collection stop period: 01-OCT-2021 - 01-NOV-2021

by gheddou on 09 November 2021 01:42PM

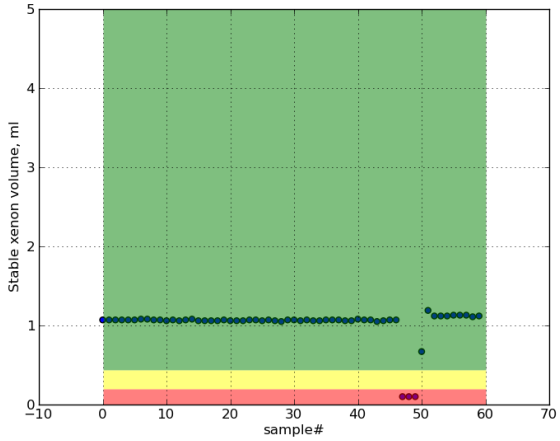
Sample metrics matrix

SRID	DETECTOR_CODE	COLL_STOP	ACQ_START	COLL_TIME, h	ACQ_TIME, h	REPORTING_TIME, h	XE_VOLUME, ml	XE133_MDC, mBq/m3	XE_YIELD	RADON
38202109301811X	JPX38_004	01-OCT-2021 06:37	01-OCT-2021 13:45	12	11.17	30.3	1.07	0.33	0.92	99
38202110010611X	JPX38_003	01-OCT-2021 18:37	02-OCT-2021 01:45	12	11.17	30.3	1.07	0.33	0.92	129
38202110011811X	JPX38_004	02-OCT-2021 06:37	02-OCT-2021 13:45	12	11.17	30.3	1.07	0.33	0.91	115
38202110020611X	JPX38_003	02-OCT-2021 18:37	03-OCT-2021 01:45	12	11.17	30.3	1.07	0.32	0.92	120
38202110021811X	JPX38_004	03-OCT-2021 06:37	03-OCT-2021 13:45	12	11.17	30.3	1.07	0.34	0.91	128
38202110030611X	JPX38_003	03-OCT-2021 18:37	04-OCT-2021 06:21	12	6.58	30.3	1.07	0.37	0.91	69
38202110031811X	JPX38_004	04-OCT-2021 06:37	04-OCT-2021 13:45	12	11.17	30.3	1.08	0.34	0.92	115
38202110040611X	JPX38_003	04-OCT-2021 18:37	05-OCT-2021 01:45	12	11.17	30.3	1.08	0.33	0.92	133

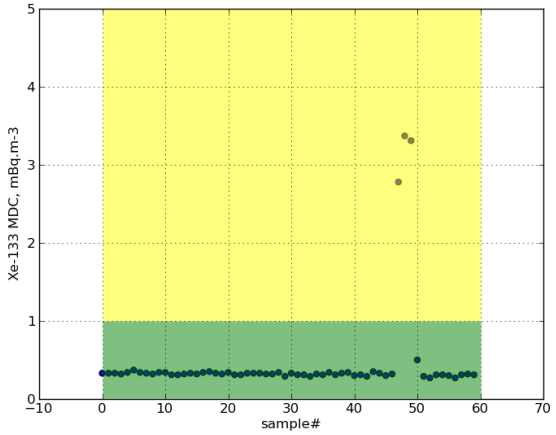
Collection time



Stable xenon volume



Xe-133 MDC



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GRANDSim (1/5)
The project

Background

The IDC was operating a Monte Carlo simulation tool ***limited to*** *HPGe gamma detector systems in use at IMS* ***particulate stations****.*

The tool called ***VGSL*** *(Virtual Gamma Spectroscopy Laboratory)* ***uses MCNP license*** *dependent code.*

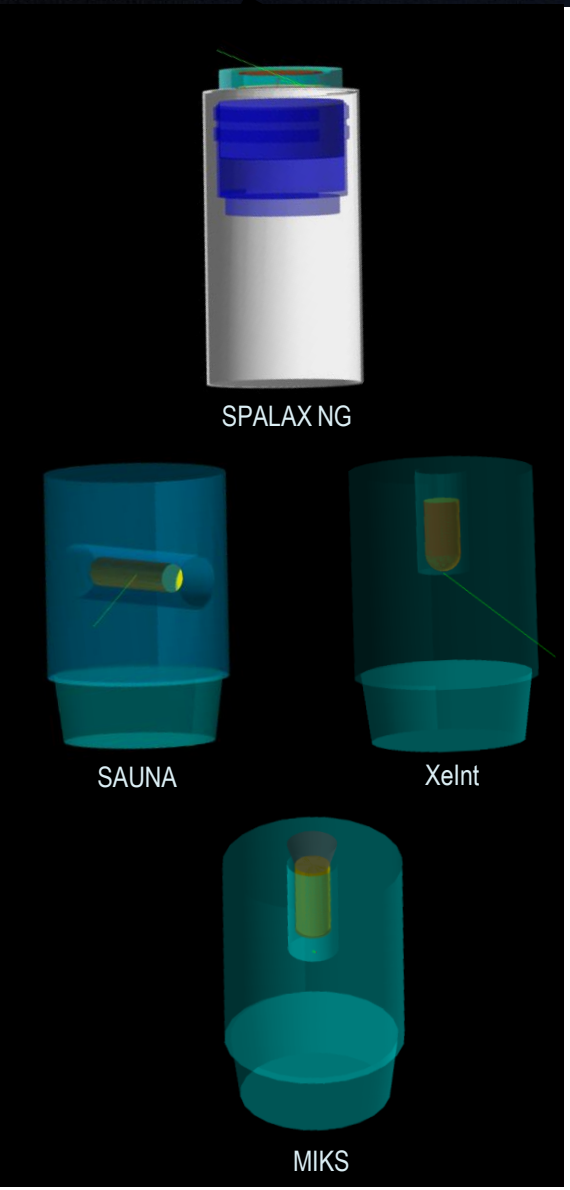
Therefore the ***IDC could not distribute VGSL*** *as part of the NDC-in-a-Box software package.*

GRANDSim (Geant 4 Radionuclide Detector Simulation) **is a novel IDC software for radionuclide detectors in use at IMS.**

Specific objectives:

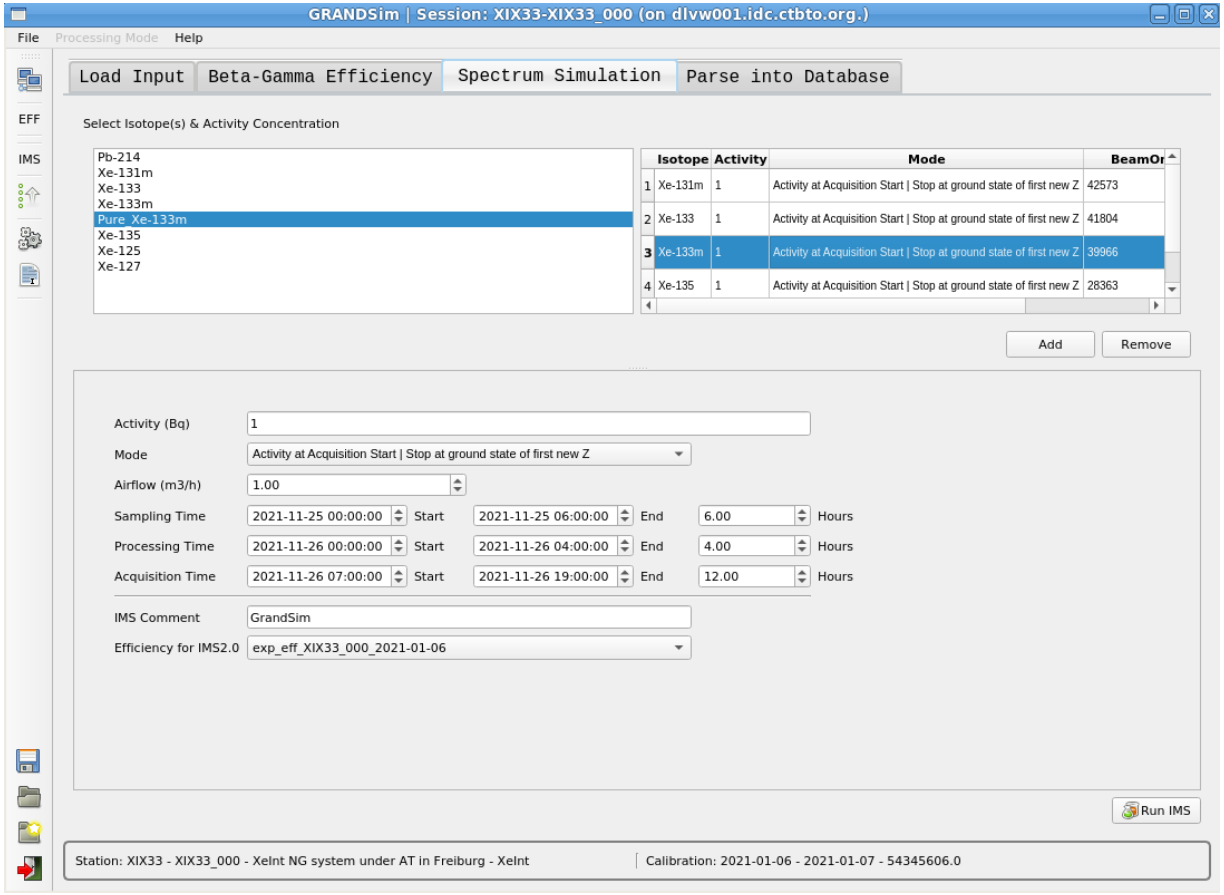
- To **complete the migration** of RN software tools to **open source** (license free).
- To further **enhance the integration level** into the RN processing pipeline for by reading the simulation input from DOTS and writing the output into GARDS database.
- To progressively **extend PTS simulation capabilities to beta-gamma** coincidence-based detection technologies of IMS noble gas systems. This will include upcoming systems making use of high-resolution beta and/or gamma detectors.
- **GRANDSim** is intended for internal use at the PTS **and distribution to NDCs** as part of the (**license free**) NDC-in-a-Box software package.

GRANDSim (2/5)
Extension to noble gas (ongoing)



GRANDSim (phase 2 of the project):

- GRANDSim is being extended to beta gamma coincidence-based detectors of all (current, new and next generations) noble gas technologies): SAUNA II/III, SPALAX NG, Xenon International and MIKS



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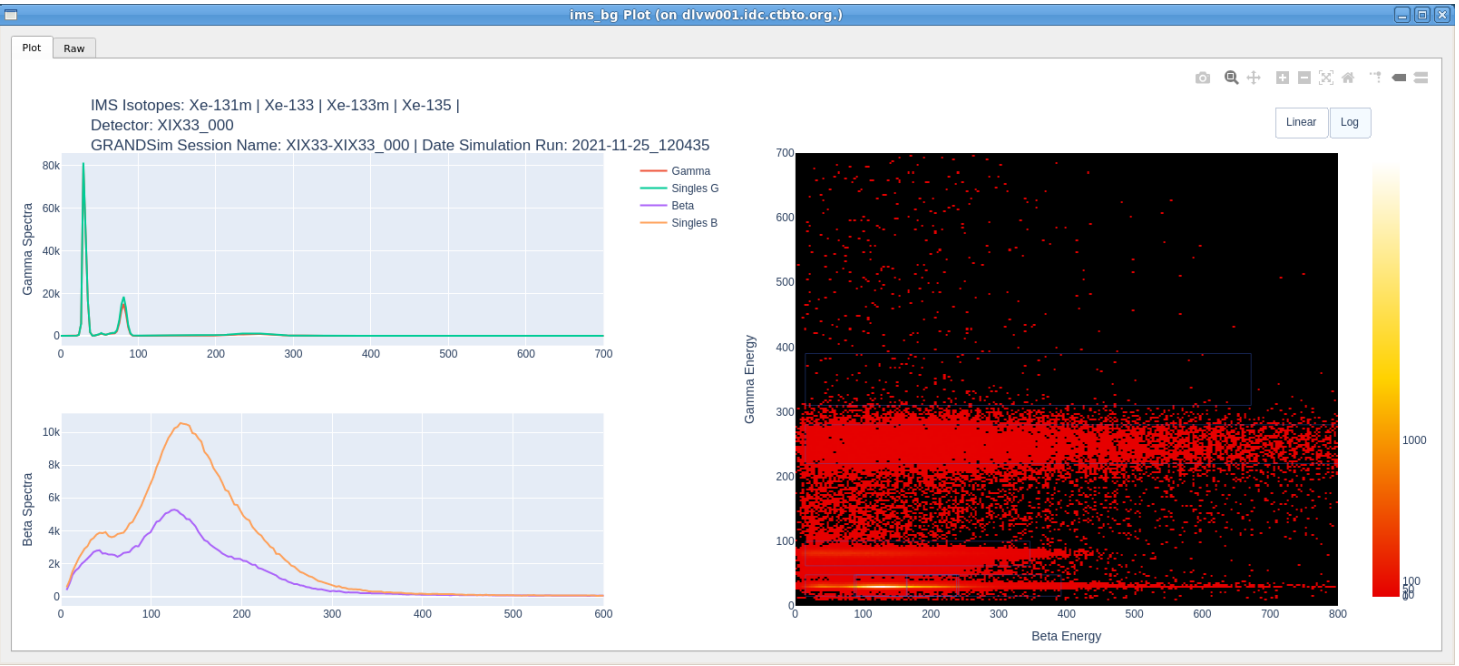
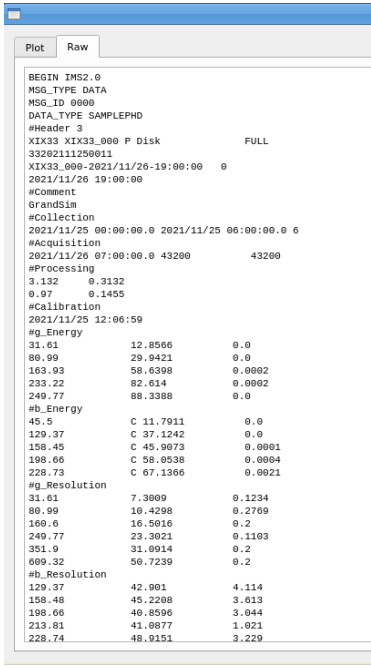
GRANDSim (3/5)
Spectra simulation

Simulation input:
- isotope(s) + activity(ies)
- Collection
- Processing
- Acquisition

Simulation output:
- Graphical
- IMS 2.0 format





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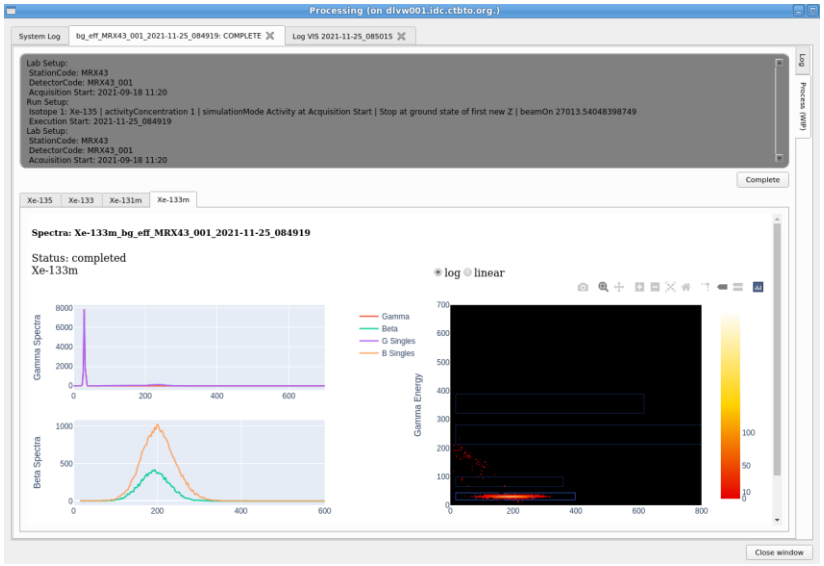
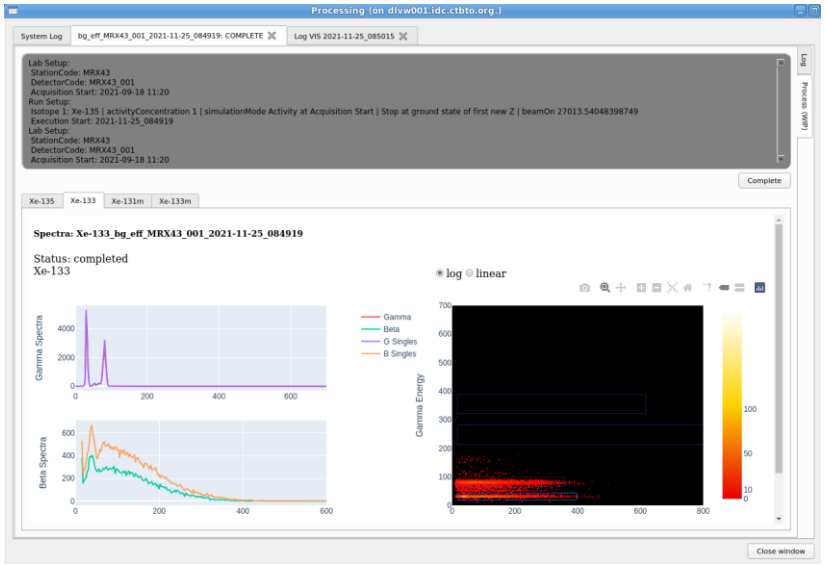
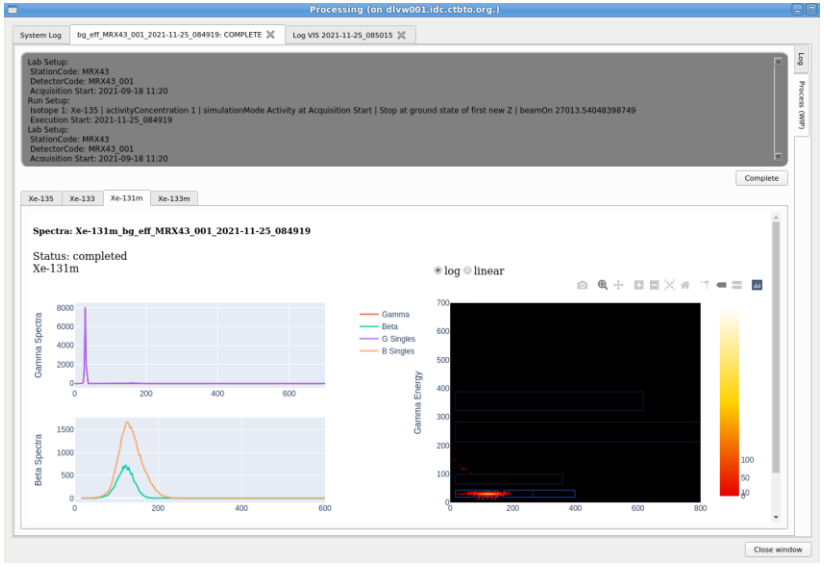
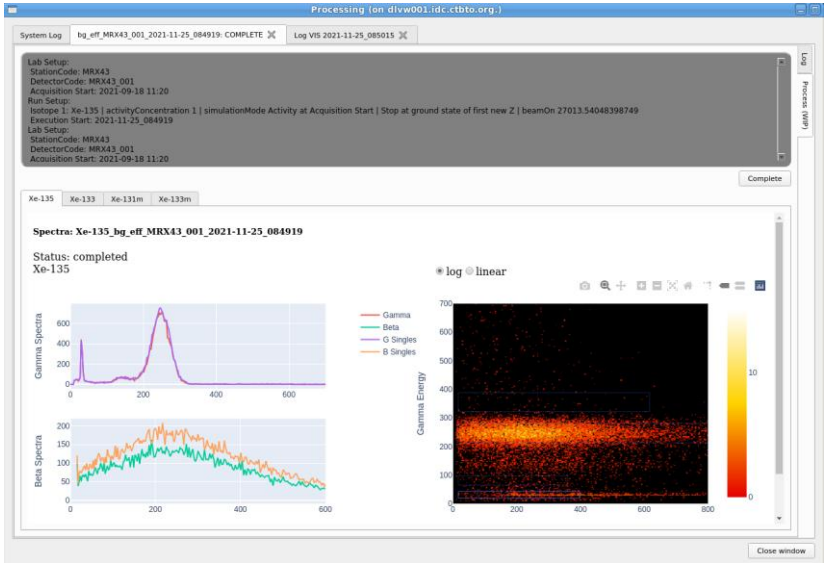
GRANDSim (4/5)
Detection efficiency check









GRANDSim (5/5)
Potential applications

GRANDSim will offer a wide range of potential applications:

- Implementing Standard Spectra Method (SSM)
- Testing new analysis methods
- Calibration in efficiency and interference ratios
- Simulating complex mixtures of CTBT relevant isotopes
- Investigating effects from non-CTBT relevant isotopes (Xe-125, Xe-127)
- Detector optimization
- NDC Preparedness Exercises (NPE)
- Proficiency Test Exercises (PTE)
- OSI exercises
- Training
- …

Summary

Significant progress was achieved in CTBTO acceptance testing of next generation noble gas systems:

- **First SAUNA III deployed at IMS station**
- **SPALAX NG accepted**
- **Xenon International completed phase 2**
- **MIKS testing is ongoing**

The IDC pipeline for noble gas was completely reengineered with novel software applications:

- **autoSTRADA** for automatic processing
- **iNSPIRE** for interactive analysis

The new analysis pipeline **handles both current, new and next generation technologies** and **supports parallel analysis methods** (currently: NCC, BGM).

The new software was **deployed in IDC operations and delivered to NDCs in a timely manner**.

Thank you !