



Novel IDC software applications for Radionuclide data analysis

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The CTBTO International Data Centre (IDC) is developing **novel software applications for modernizing automatic processing and interactive analysis of radionuclide data** from the International Monitoring System (IMS).

The projects aim at **completing the migration to open source** license free software, **unifying the processing tools** for particulates and noble gas, **integrating new technologies** and **analysis methods** as well as **enhancing the IDC products** and dissemination tools for National Data Centers (NDCs).

The presentation will provide updated status and future plans on ongoing projects:

- (a) iNtegrated Software Platform for Interactive Radionuclide rEview (**iNSPIRE**),
- (b) automatic Software Tool for RAdionuclide Data Analysis (**autoSTRADA**),
- (c) Geant4 based RAdioNuclide Detector Simulation (**GRANDSim**)
- (d) The new web based application (**RNToolkit**).



iNSPIRE

for interactive analysis

iNSPIRE is intended for the interactive review of automatic processing results as generated by automatic software applications of the Radionuclide pipeline.

iNSPIRE provides relevant features and dedicated functionalities to Analysts **for checking the data quality, performing the standard interactive review and introducing necessary corrections to automatic processing results** as appropriate.

In addition to sample spectra analysis, the GUI is also used to interactively check all auxiliary spectral data (gas and detector backgrounds, Quality Control and spike spectra).

iNSPIRE software allows assignment of spectra to individual users with required roles and permissions as configured in the database. Interactive changes are only allowed when the spectrum is assigned to the current user.

iNSPIRE is a python language/ Qt framework as a widget toolkit based license-free application.

It runs on Linux Operating System under the standard configuration IDC environment (file system structure and database schema of the Radionuclide pipeline).

In routine analysis mode, iNSPIRE runs in RMSMAN schema **for releasing RRR** (Reviewed Radionuclide Report).

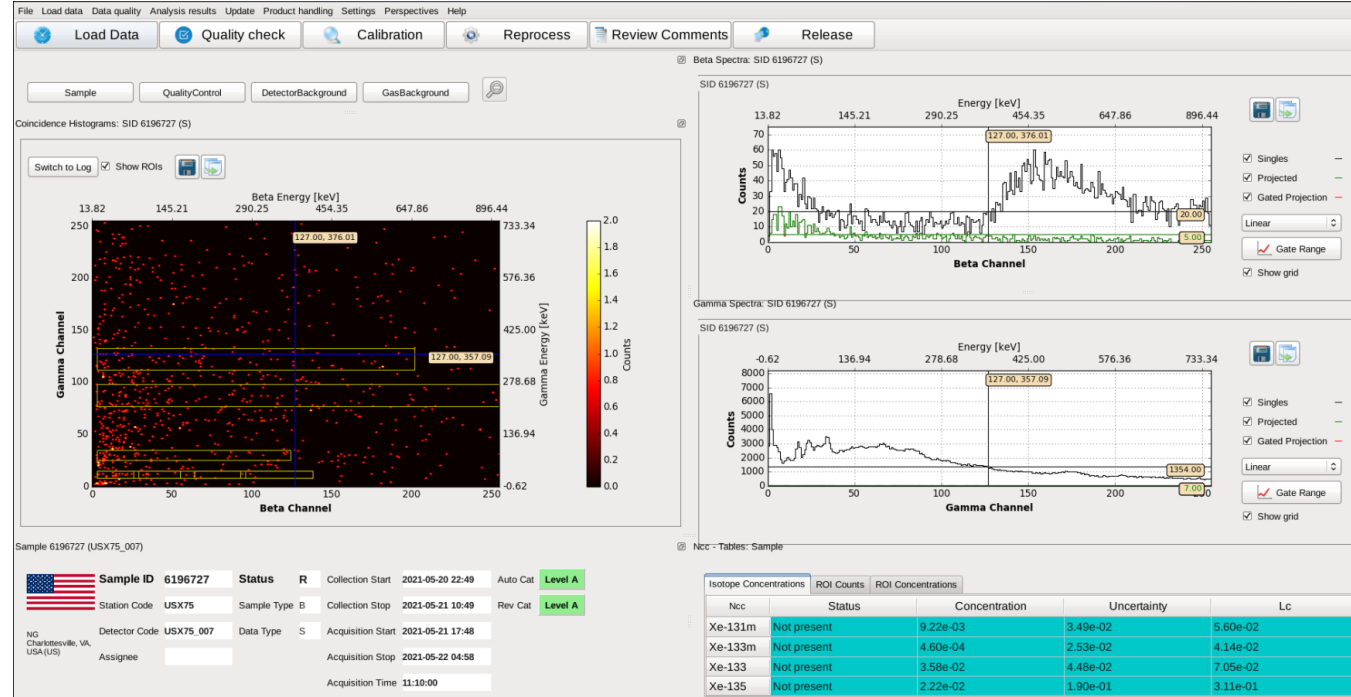
iNSPIRE also handles additional use cases in the context of special studies and expert technical analysis. It runs then in the new database schema RMSExpert **for creating the new IDC product URR** (Updated Radionuclide Report).

The first release of iNSPIRE is used in IDC Operations since late May 2021.

This covers the functionalities for beta-gamma noble gas data analysis.

The new version was also delivered to NDCs in November 2020 (Centos 7, Virtual Machine + rpm packages)

The integrated set of iNSPIRE functionalities will further boost the quality of the IDC reviewed products.



In addition to handling currently operated noble gas systems, **iNSPIRE** will also process next generation-noble gas technologies.

The version of iNSPIRE in NDC-in-a-Box offers features for downloading IMS data and performing the automatic processing from within iNSPIRE GUI

iNSPIRE 1.10.1 - connected to manalyst@localhost/ndcrn - 89

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

Load Data Quality check Calibration Reprocess Review Comments Release

Sample: 89 (AUX04_004)

Login Assigned Queue Load Sample ID Spectra Handling NMS Client NMS Scheduled Jobs Current Data

From: 6/6/21 Till: 6/13/21

Data Types:

- ☒ FULL SAMPLEPHD
- ☐ PREL SAMPLEPHD
- ☐ DETBKPHD
- ☒ QCPhD
- ☐ GASBKPHD
- ☐ BLANKPHD
- ☐ CALIBPHD

Stations:

- ARL01
- ARP01
- ARP03
- ATL03
- AUL02
- AUP04
- AUP05
- AUP06
- AUP07


Folder name: <timestamp>

NMS Client credentials:

User ID: gheddou

Password: *****

☒ Remember credentials


 Download data

Name Date Modified

- PTE_spectra 3/15/21 8:30 PM

Name Size Type Date Modified

- 2020-11-24_21:11:13 Folder 11/24/20 9:11 PM
- 2020-11-24_21:12:08 Folder 11/24/20 9:12 PM
- 2020-11-24_21:20:42 Folder 11/24/20 9:23 PM
- 2020-11-25_14:43:02 Folder 11/25/20 2:55 PM
- 2020-12-01_14:32:48 Folder 12/1/20 2:34 PM
- 2020-12-01_14:37:54 Folder 12/1/20 2:40 PM
- 2020-12-03_14:29:46 Folder 12/3/20 2:30 PM
- 2020-12-03_15:05:55 Folder 12/3/20 3:06 PM
- 2020-12-07_11:51:12 Folder 12/7/20 11:57 AM
- 2020-12-07_12:00:35 Folder 12/7/20 12:01 PM
- 2020-12-07_12:22:37 Folder 12/7/20 12:23 PM
- 2020-12-07_12:57:02 Folder 12/7/20 1:07 PM
- 2021-01-25_14:05:20 Folder 1/25/21 2:05 PM
- 2021-01-25_14:11:39 Folder 1/25/21 2:12 PM
- 2021-03-02_14:12:39 Folder 3/2/21 2:25 PM
- 2021-04-12_20:24:09 Folder 4/12/21 8:25 PM
- 2021-04-16_03:12:32 Folder 4/16/21 3:37 AM
- arp01_tst3 Folder 12/3/20 11:50 AM
- aux04_1weekOFData Folder 3/3/21 2:53 PM
- aux04_detBkgnd Folder 3/3/21 2:43 PM
- calib_FRP28 Folder 12/3/20 11:41 AM
- cap14_extra Folder 12/2/20 6:01 PM
- CAP17 Folder 12/3/20 11:49 AM
- myData Folder 3/12/21 3:04 PM
- RUP54 Folder 12/3/20 11:49 AM
- spikephd Folder 12/2/20 5:49 PM
- ZAI14 Folder 3/14/21 5:35 PM

 Process data

autoSTRADA

for automatic processing

In order **to ensure smooth integration of next generation noble gas systems**, the CTBTO IDC developed a new software tool dubbed **autoSTRADA** (automatic Software Tool for RAdionuclide Data Analysis).

Both currently operated **SAUNA II** systems and next generation technologies (**SPALAX NG**, **Xenon International**, **MIKS** and **SAUNA III**) **will be handled by autoSTRADA**. The implementation allows data from all systems to be automatically processed using the same software tool, taking into account their inherent specificities.

In addition to the already implemented Net Count Calculation (**NCC**) method, autoSTRADA modular design will **also support new analysis methods** of the four CTBT relevant radioxenon isotopes (Xe-131m, Xe-133, Xe-133m and Xe-135) in IMS spectral data of noble gas systems.

The software runs completely automatically without human intervention. The user will control the software through command line parameters.

The software will be used for **automatic processing** when connected to the **RMSAUTO** database and as part of the **interactive analysis** when connected to the **RMSMAN** database. It also supports the new database schema **RMSEXPERT for the new IDC product URR** (Updated Radionuclide Report).

autoSTRADA code uses open source license free modern software development framework technology and shares libraries with INSPIRE.

autoSTRADA status

- ✓ Compared with CEA software for SPALAX NG.
- ✓ Compared with PNNL software for Xenon International.
- ✓ Tested with one year of data from SAUNA; benchmarked with bg_analyze.
- ✓ Integrated BGM module (FOI software delivered within SAUNA III acceptance testing).
- ✓ **autoSTRADA supports now both standard NCC and BGM analysis algorithms.**
- ✓ Under final pre-release testing on IDC testbed.
- Will be promoted to IDC operations for replacing bg_analyze.
- Will be integrated in upcoming release of NDC-in-a-Box.

optional arguments:

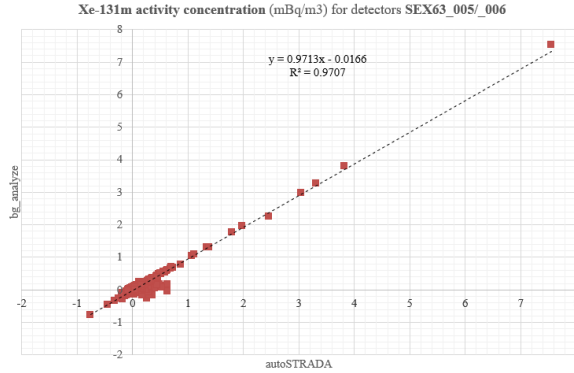
```
-h, --help           show this help message and exit
-s SID, --sid SID    sample identifier
-u USER, --user USER database user
-p PASSWORD, --password PASSWORD
                      database password
--gamma-energy-coefficients GAMMA GAMMA GAMMA
                      gamma energy coefficients
--beta-energy-coefficients BETA BETA BETA
                      beta energy coefficients
--det-bkgnd-used {0,1}
                      detector background used
--gas-bkgnd-used {0,1}
                      gas background used
--interference-used {0,1,2}
                      interference used
--det-bkgnd-id DETBKGNDID
                      detector background sample ID
--gas-bkgnd-id GASBKGNDID
                      gas background sample ID
--qc-id QCID         QC sample ID
--ingrowth-used {0,1}
                      ingrowth used
--auto              use auto schema
--expert            use expert schema
--bgm              try bgm method first
```

Xe-131m

Xe-133m

Xe-135

Xe-133

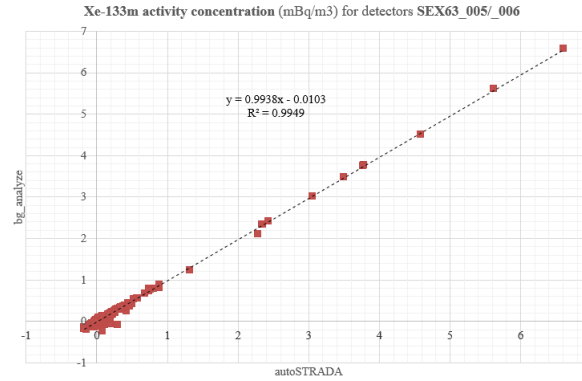


Xe-131m

Xe-133m

Xe-135

Xe-133

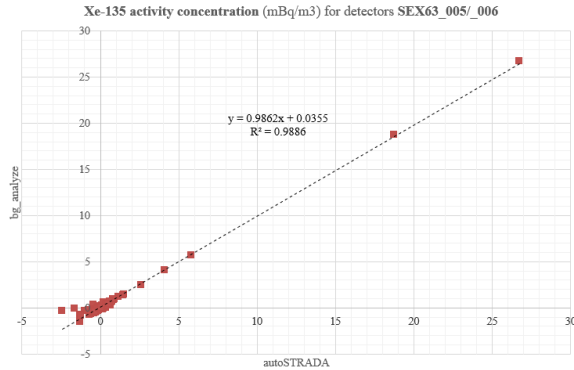


Xe-131m

Xe-133m

Xe-135

Xe-133

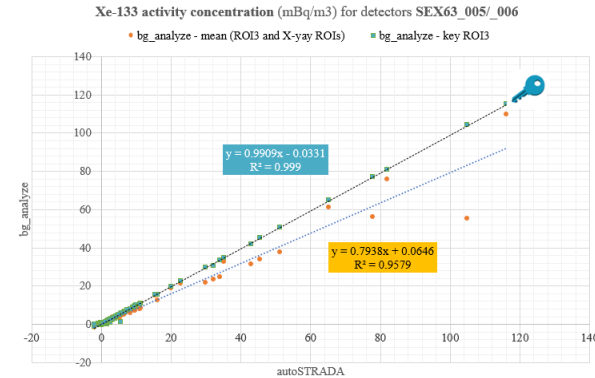


Xe-131m

Xe-133m

Xe-135

Xe-133



- Xe-131m, Xe-133m and Xe-135: excellent agreement
- Xe-133: bg_analyze **key ROI 3 in excellent agreement** with autoSTRADA (ROI 3 based)

GRANDSim

for Monte Carlo simulation

Monte Carlo simulation (MC) produces output parameters which allow:

- ❖ **Improving the efficiency calibration** data quality (by including coincidence summing corrections);
- ❖ **Enhancing nuclide identification** results (by including summation peaks) which reduces the Analysts workload in interactive mode;
- ❖ **Ensuring reliable activity concentration** results by including required coincidence summing corrections when applicable.

The IDC was operating a MC 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 is a Geant 4 based simulation software for radionuclide detectors in use at IMS.

Status:

- Oct 2020: alpha version provided to NDCs + Webinar
- Apr – Jun 2021: pre-release testing by IDC Analysts

(a) Database mode:

- Input setup parameters (detector, sample, shielding) **from DOTS** (Database Of the Technical Secretariat) database.



Experimental calibration **from GARDS** (Global Atmospheric Radionuclide Detection System) database.

- Simulation output** (Efficiency, IRF and CSC) will be parsed **into GARDS** database.

(b) Standalone mode:



- Input will be read **from local** configuration.
- Can also be provided **from the GUI**.
- Output** (ascii files) **into filesystem**.

GRANDSim | Session: THP65-THP65_002 (on alv610.idc.ctbto.org.)

File Help

Load Input Efficiency Simulation IRF Simulation Spectrum Simulation Parse into Database

EFF
IRF
IMS

Station Code	Site Det Code	Location	Type
RUP59	RUP59_003	Zalesovo, Russian Federation.	MANUAL
RUP60	RUP60_001	Petrovsk, Russian Federation	MANUAL
RUP61	RUP61_002	Dubna, Russian Federation.	MANUAL
RUP61	RUP61_003	Dubna, Russian Federation.	MANUAL
SEP63	SEP63_001	Stockholm, Sweden	CINDER
SEP63	SEP63_002	Stockholm, Sweden	CINDER
SEP63	SEP63_003	Stockholm, Sweden	CINDER
SEP63	SEP63_004	Stockholm, Sweden	CINDER
SEP63	SEP63_005	Stockholm, Sweden	CINDER
THP65	THP65_001	Bangkok, Thailand	MANUAL
THP65	THP65_002	Bangkok, Thailand	MANUAL
TZP64	TZP64_002	Dar Es Salaam, Tanzania.	MANUAL
TZP64	TZP64_003	Dar Es Salaam, Tanzania.	MANUAL
USP70	USP70_001	Sacramento, CA, USA.	MANUAL

Site Code Detector Location Station Type Reset filters

Configure Detector System Visualize Detector System Choose Detector

Station: THP65 - THP65_002 - Bangkok, Thailand - MANUAL Calibration: 2019-11-27 - 2019-11-27 - 5394772.0

Model optimization

- GRANDSim performs **consistency check** between simulation and experimental efficiency.
- The physical model is **automatically optimized** by constraining simulation results against experimental calibration for non-summing energies.

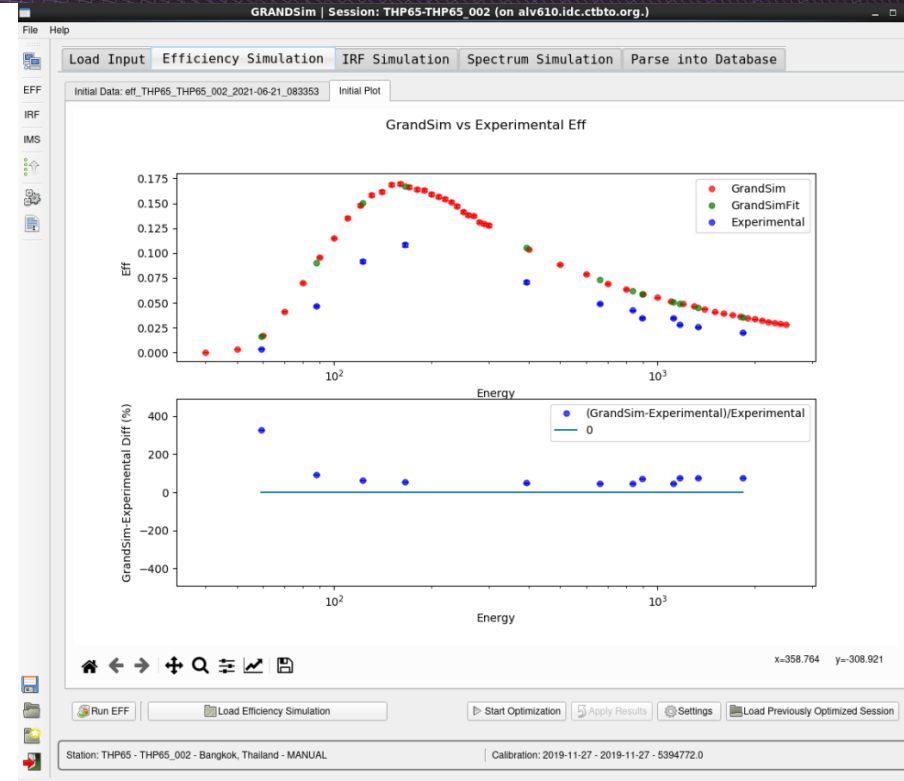
Optimized parameters

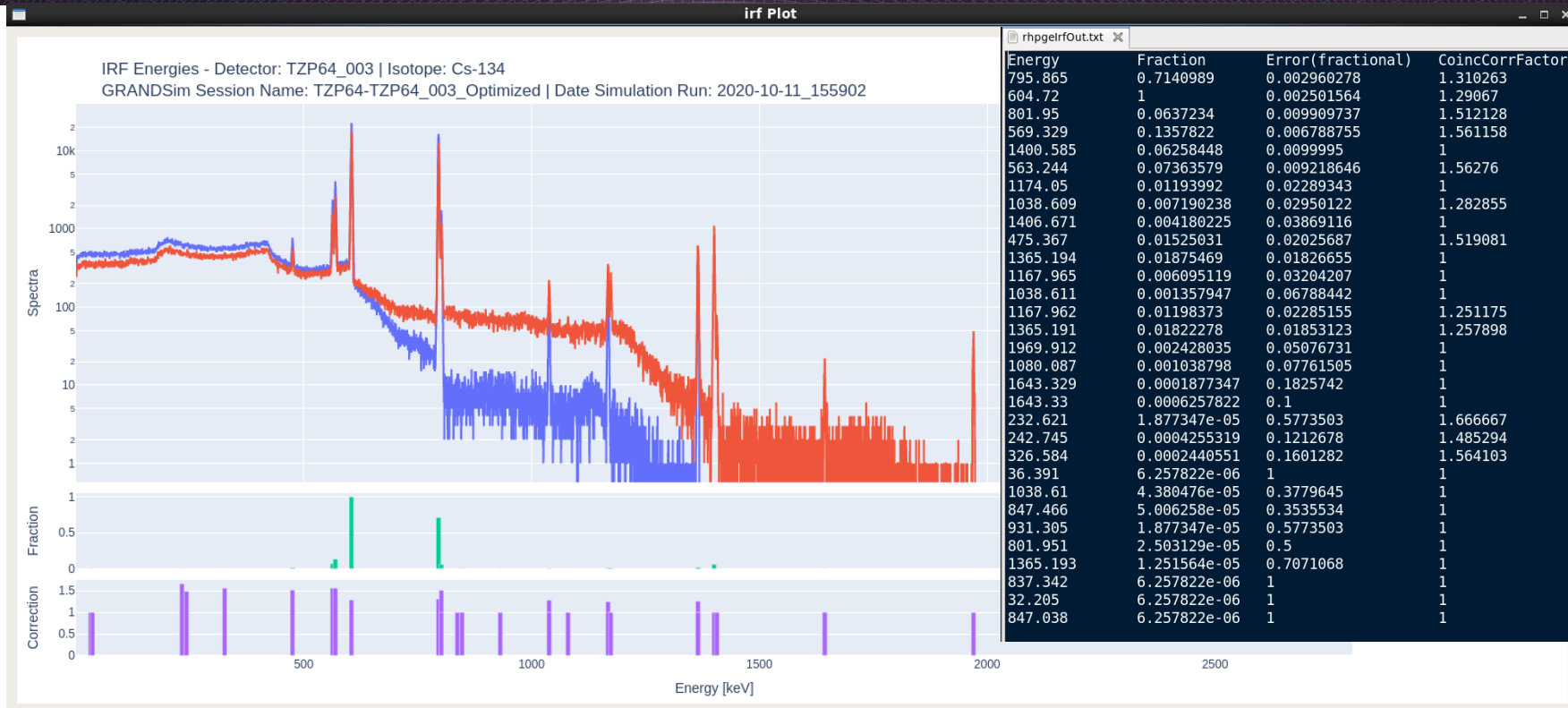
- Manual and Cinderella stations:

- thickness of detector top dead layer
- distance crystal to end-cap

- RASA stations:

- thickness of side dead layer
- sample holder diameter





Simulation of sample spectra for any source term. Output in IMS2.0 format

GRANDSim | Session: THP65-THP65_002 (on alv610.idc.ctbto.org.)

File Help

Load Input Efficiency Simulation IRF Simulation Spectrum Simulation Parse into Database

EFF Select Isotope(s) & Activity Concentration

IRF

IMS

Isotope	Activity	Mode	BeamOn
1 Nb-95	1*10**3	No Decay Product	996559
2 Zr-95	1*10**3	Full	95778186

Activity Concentration (Bq/m3)

1*10**3

Mode Full

Airflow (m3/h) 500.00

Sampling Time Start 2021-05-31 00:00:00 End 2021-06-01 00:00:00 24.00

Processing Time Start 2021-06-01 00:00:00 End 2021-06-02 00:00:00 24.00

Acquisition Time Start 2021-06-02 00:00:00 End 2021-06-03 00:00:00 24.00

IMS Comment

GrandSim

Efficiency for IMS2.0

eff_THP65_THP65_002_2021-06-01_144050

Station: THP65 - THP65_002 - Bangkok, Thailand - MANUAL Calibration: 2019-11-27 - 2019-11-27 - 5394772.0

Processing (on alv610.idc.ctbto.org.)

THP65_THP65_002_2021-06-21_083353: COMPLETE IRF If_C6-134_THP65_002_2021-06-21_083730: I

Lab Setup:

StationCode: THP65

DetectorCode: THP65_002

Acquisition Start: 2019-11-27 12:28

Run Setup:

Isotope 1: Nb-95 | activityConcentration 1*10**3 | simulationMode No Decay Product | beamOn 996559

Isotope 2: Zr-95 | activityConcentration 1*10**3 | simulationMode Full | beamOn 95778186

Execution Start: 2021-06-21_084025

Nb-95 + Zr-95

Plot Raw

BEGIN IMS2.0

MSG TYPE DATA

MSG ID 0000

DATA TYPE SAMPLEPHD

#Header 3

THP65 THP65_002 P Disk FULL

65202105310011

THP65_002_2021/06/03:00:00:00 0 0

2021/06/03 00:00:00

#Comment

GrandSim

#Collection

2021/05/31 00:00:00.0 2021/06/01 00:00:00 12000.0

#Sample

50.0 4.5

#Acquisition

2021/06/02 00:00:00.0 86400.0 86400.0

#Calibration

2021/06/21 08:40:29

#g Energy

59.54	173.612	0.0
88.03	256.913	0.0
122.06	356.269	0.0
136.47	398.408	0.0
165.86	484.235	0.0
255.13	745.667	0.0
391.7	1145.309	0.0
661.66	1935.407	0.0
834.84	2442.343	0.0
898.84	2627.291	0.0
1115.54	3263.9861	0.0
1173.23	3432.8259	0.0
1332.49	3898.961	0.0
1836.05	5373.0371	0.0

#g Resolution

59.54	0.7429	0.0
88.03	0.7367	0.0
122.06	0.8104	0.0
136.47	0.8388	0.0
165.86	0.8457	0.0
255.13	0.8457	0.0
391.7	1.1078	0.0

Spectra

Energy

Close window

RNToolkit

web-based application

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**, for **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.

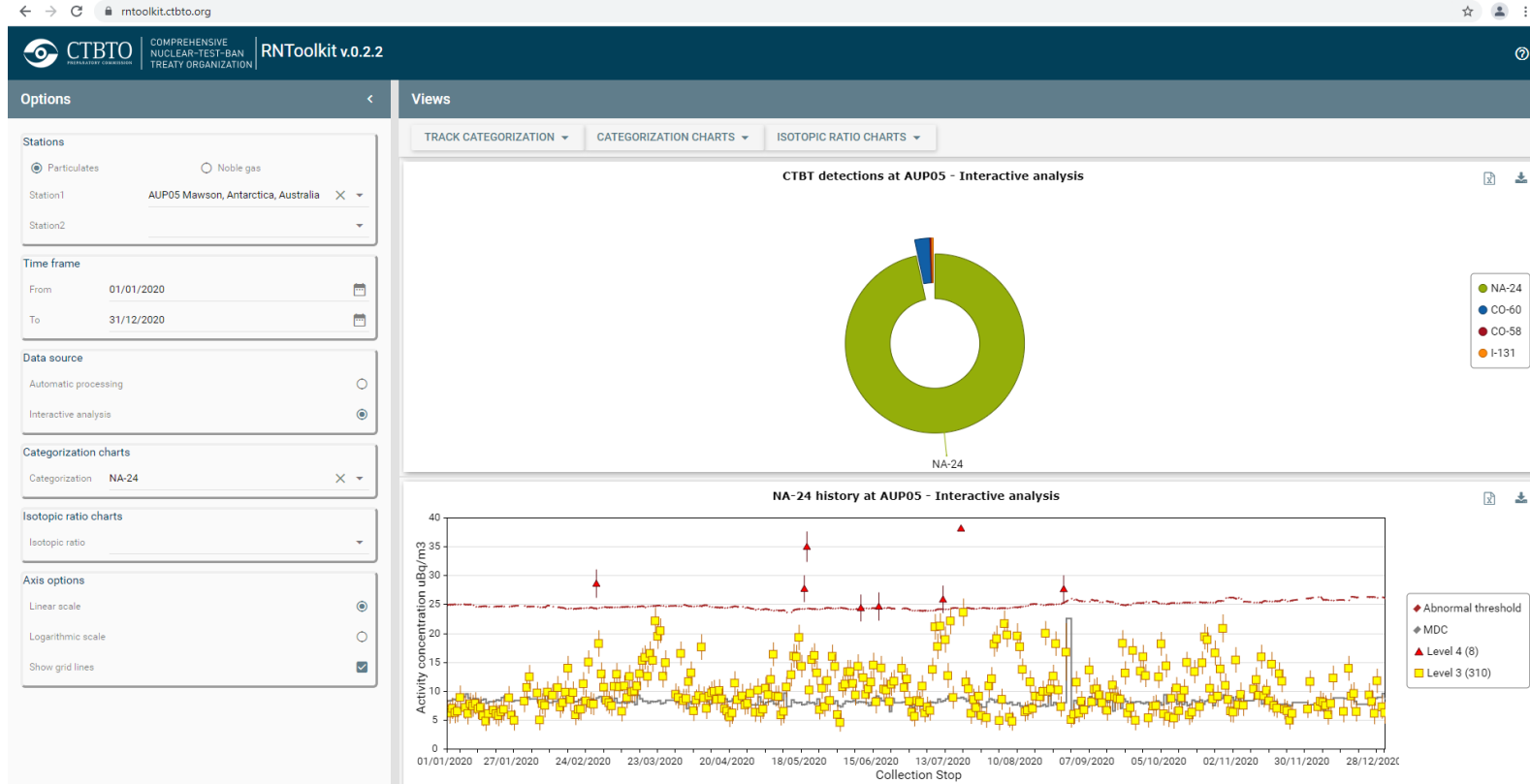
In addition to CTBT verification related activities as a main application domain, RNToolkit also constitutes a powerful resource for the purposes of radiological impact assessment studies, namely in the case of a major nuclear accident.



Current status:

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

Time development of detected nuclides,
activity concentration, categorization
parameters



Disclaimer: The views expressed on this presentation are those of the author and do not necessarily reflect the view of the CTBTO

← → ↺ 🔒 rntoolkit.ctbto.org



COMPREHENSIVE
NUCLEAR-TEST-BAN
TREATY ORGANIZATION

RNToolkit v0.2.2

Options

Stations

☐ Particulates

☒ Noble gas

Station1 USX75 NG Charlottesville, VA, USA

Station2

Time frame

From 01/01/2020

To 31/12/2020

Distribution range

☒ Long term (365)

☐ Short term (30)

Data source

Automatic processing

Interactive analysis

Categorization charts

Categorization Xe-133

Isotopic ratio charts

Isotopic ratio

Axis options

Linear scale

Logarithmic scale

Show grid lines

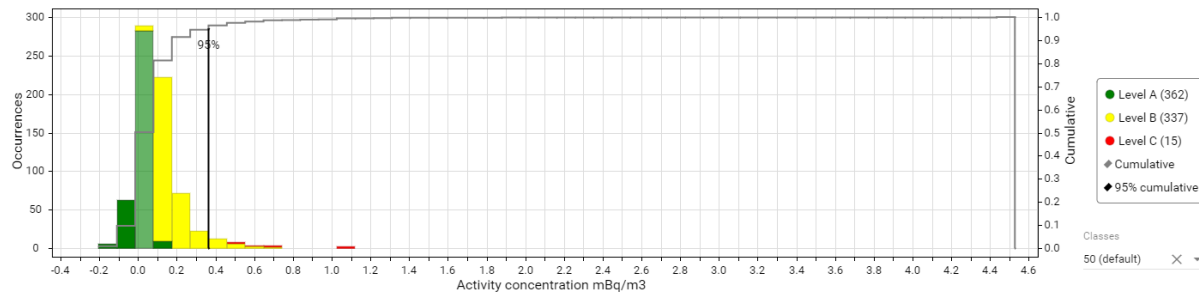
Views

TRACK CATEGORIZATION

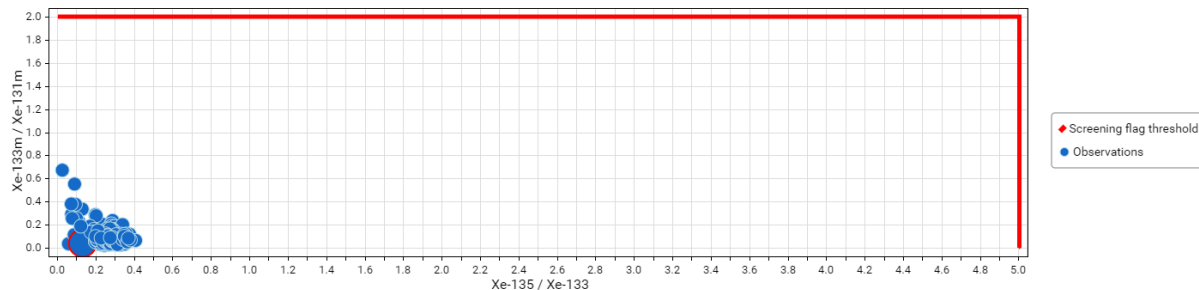
CATEGORIZATION CHARTS

ISOTOPIC RATIO CHARTS

Xe-133 frequency distribution at USX75 - Long term - Interactive analysis

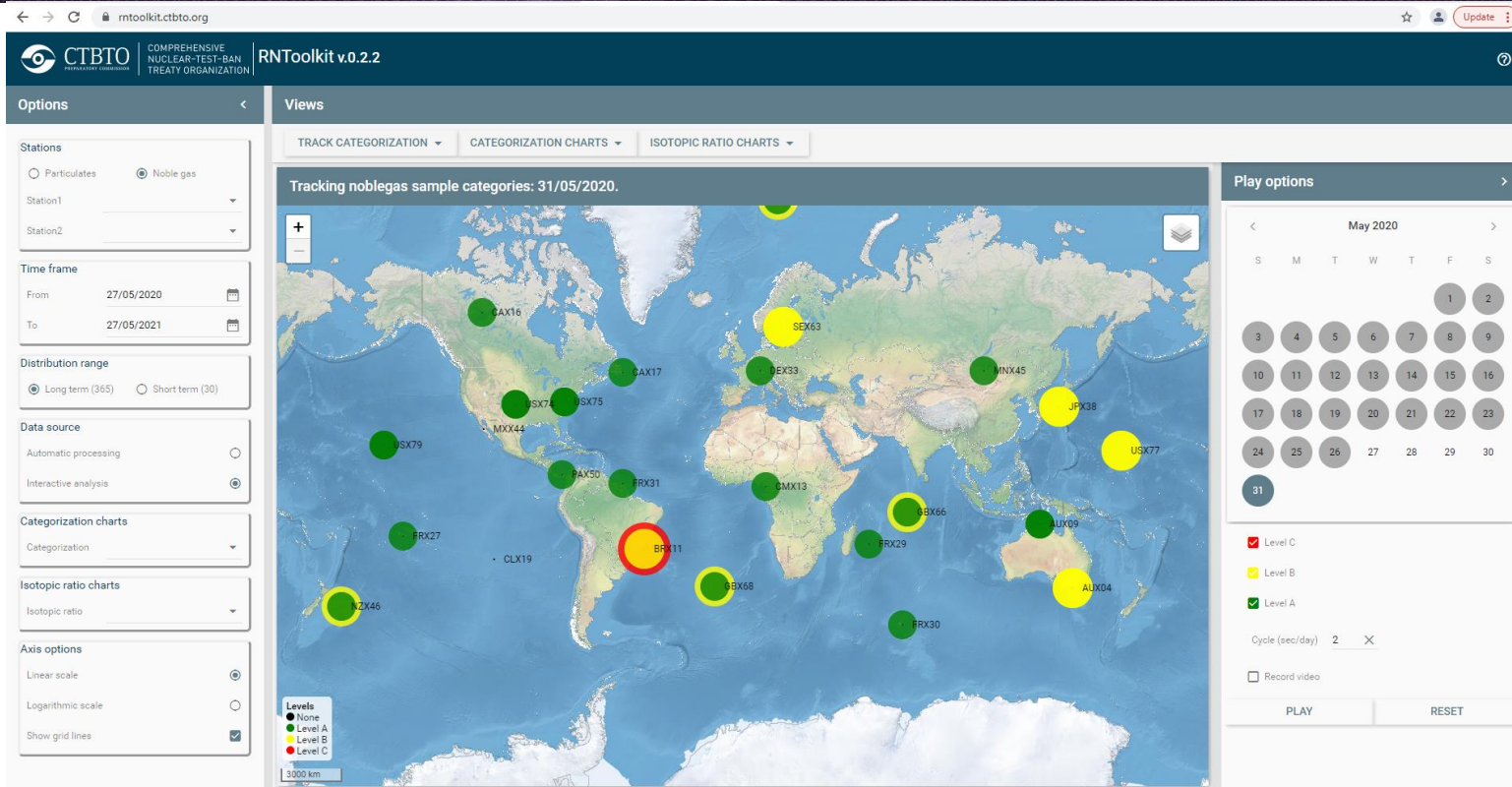


4 Isotopes scatter plot history at USX75 - Long term - Interactive analysis



Disclaimer: The views expressed on this

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



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Summary

INSPIRE (interactive analysis):

- Deployed in IDC the production
- Handles both current and next generation noble gas systems

autoSTRADA (automatic processing):

- Supports two analysis algorithms (NCC and BGM)
- Under final pre-release testing
- Will handle both current and next generation noble gas systems

GRANDSim (Monte Carlo simulation):

- Full functionality for particulates
- Under final pre-release testing

RNToolkit (radionuclide web-based “browser”):

- Particulates and noble gas
- Delivered to NDCs



Thank you!