RN SECURITY SUITE: TRAINING

DRONE

SOFTWARE FOR THE DATA VISUALIZATION AND POST-PROCESSING

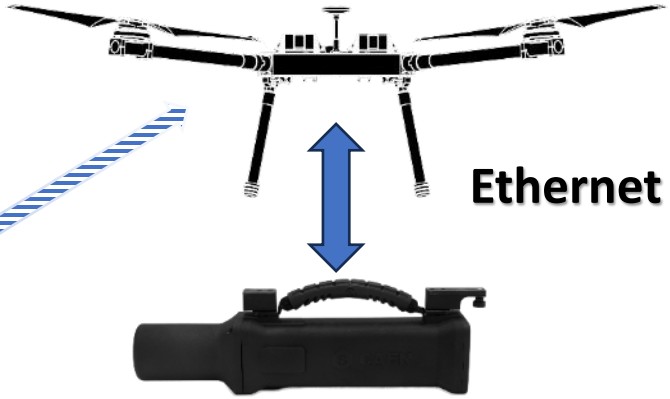
G. MANGIAGALLI

Viareggio, July 28 – August 01, 2025

Gamon-Drone UAV Mountable connection

CONNECTION SCHEME

On Flight



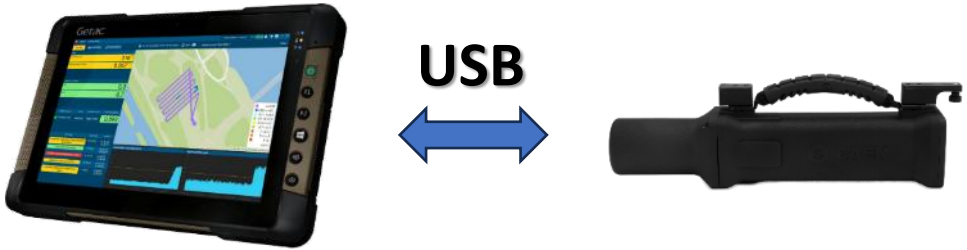
- Enable hotspot from remote
- Connect the tablet to the Wi-Fi of the remote
- Default communication link

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Gamon-Drone Portable Connection

CONNECTION SCHEME

On Laboratory



- Power Gamon-Drone by wall outlet
- Connect the USB cable from Gamon-Drone to tablet
- Modify the connection setting in the software GUI

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

UAV Gamon Drone

UAV Payload Connection - Probe

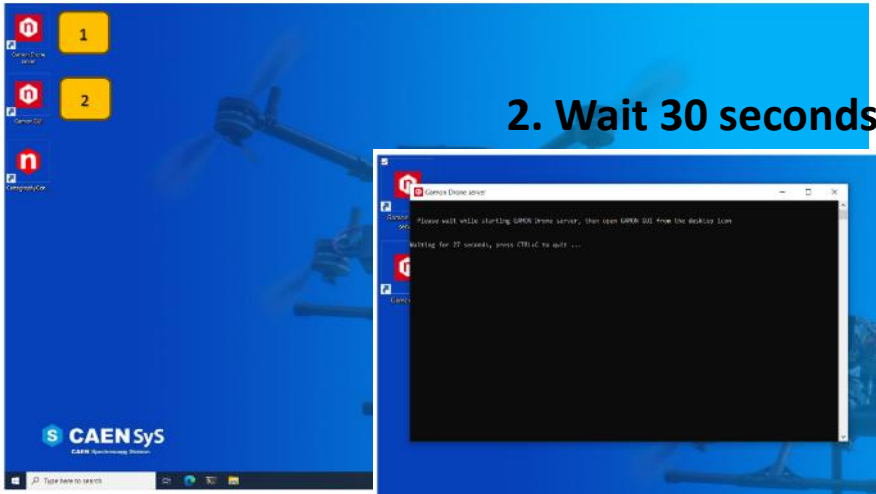
To connect the probe, insert the power and communication cable into their respective receptacles. Secure the connection by rotating the connector nut clockwise until fastened.
Follow the scheme on the images below to ensure proper connection to the Tablet **or** UAV.

Tablet connection

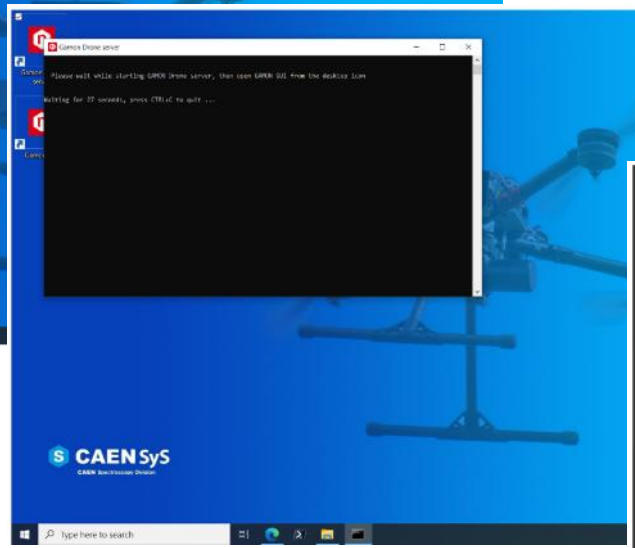
Drone connection

GUI start-up

1. Start the server



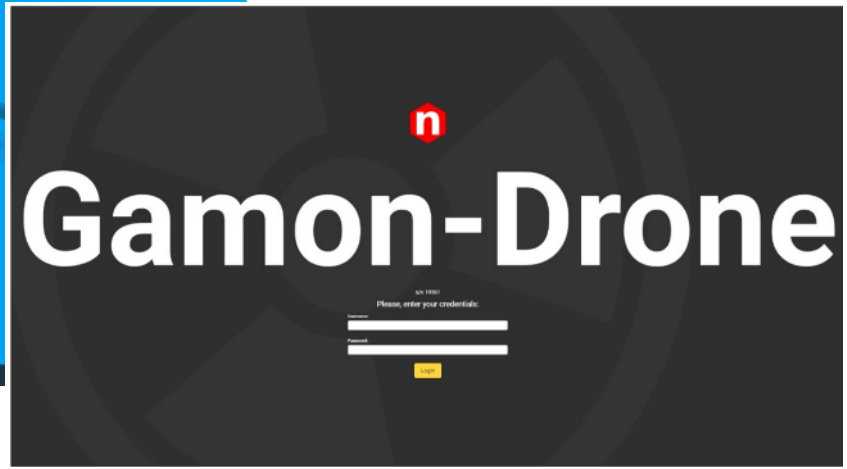
2. Wait 30 seconds



3. Open the Gamon-Drone GUI

Login: admin

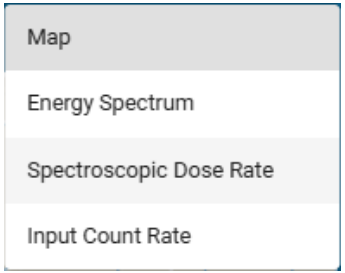
PWD: admin



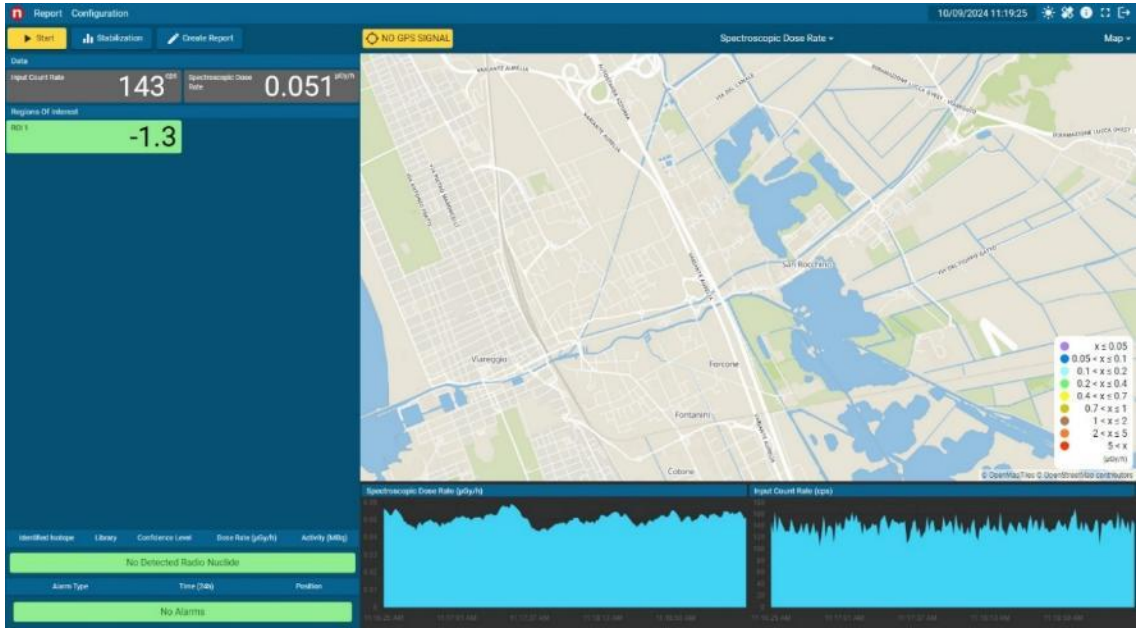
Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Main Page

1. Default visualization of the **map** with GPS position of the probe
   - Spectroscopic Dose Rate and Input Count Rate (ICR)
2. Other selections:



3. **Flow chart** of Spectroscopy Dose Rate and Input Count Rate

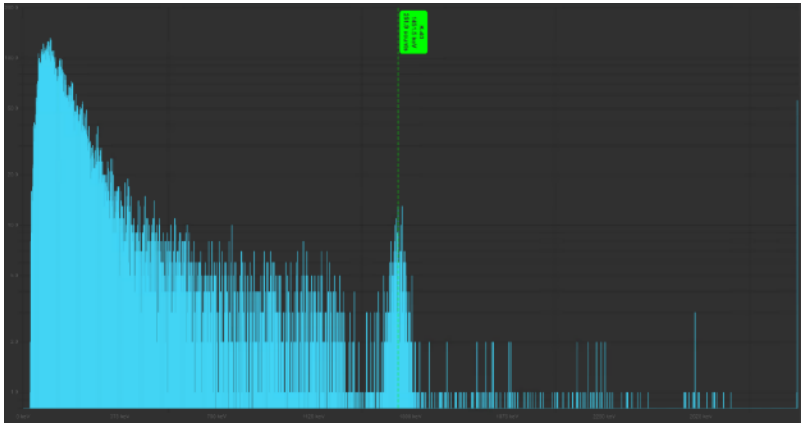


Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Spectrum Stabilization

1. At the start up, the software performs the **gain stabilization** of the detector, adjusting the energy spectrum according to the position of the peak of the K-40

2. The stabilization is performed during the overall acquisition automatically every time there is a **temperature variation of 2°C**.

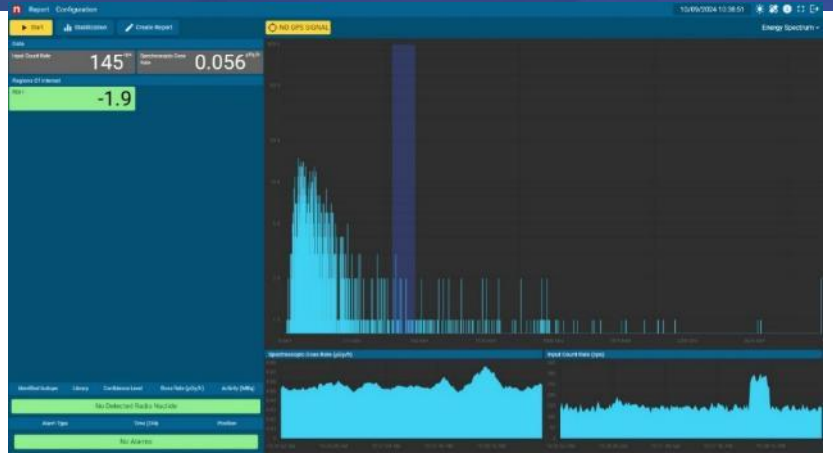


3. The user can change the reference peak and stabilization time in the configuration settings.

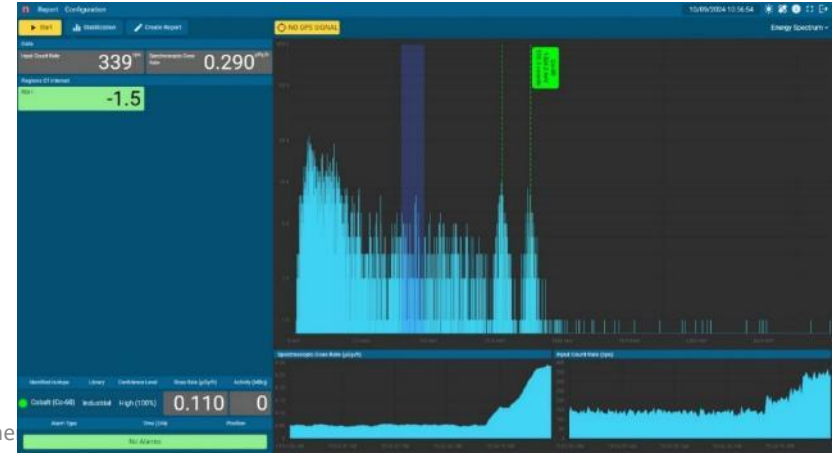
Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Acquisition modes

1. **Operation** mode:
   - typical survey mode
   - spectrum integration over 10 sec
   - moving window first in/first out



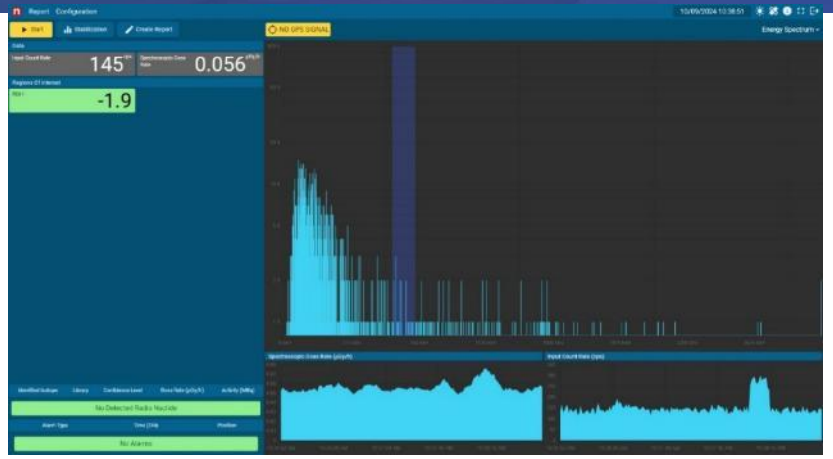
2. **Investigation** mode:
   - typical mode for source identification
   - spectrum accumulation from start to stop acquisition
   - activity calculation

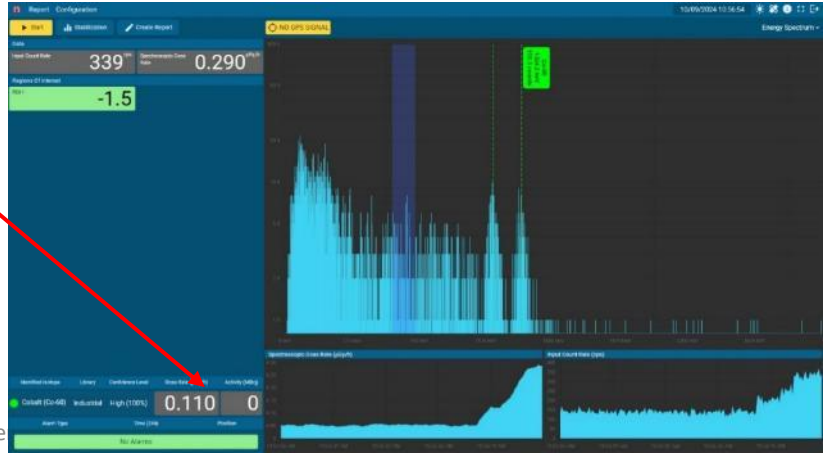


Reproduction, transfer, distribution of part or all of the contents in this docume

Special feature

1. **For each single isotope identified**:
   - real time dose rate
   - real time activity of the source (MBq)
2. *The soruce activity estimation makes the following assumption*
   - drone in a static position and a fixed height over the detected hot spot
   - source is supposed to be a point source (not a spread source over surface)

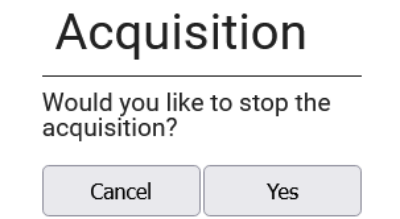




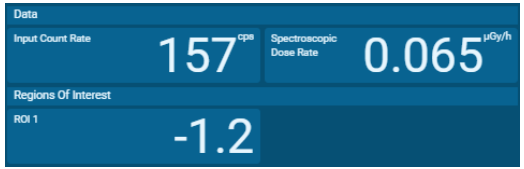
Reproduction, transfer, distribution of part or all of the contents in this docume

Toolbar and Main Data Display

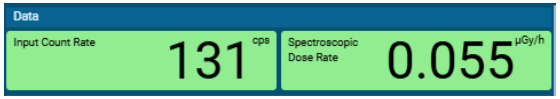
1. **Start mission**:
   - the time counter starts counting
   - the mission will be saved with an ID number and the name set by the user in the configuration
2. **Stop mission**:
   - confirmation message
3. **Create Report**:
   - to save data into the report



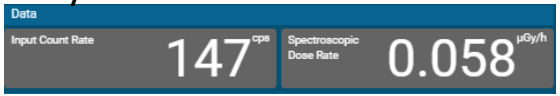
Blue->Stabilization



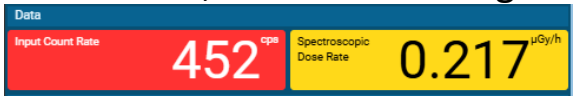
Green->Values below the threshold



Grey->Alarm not enabled

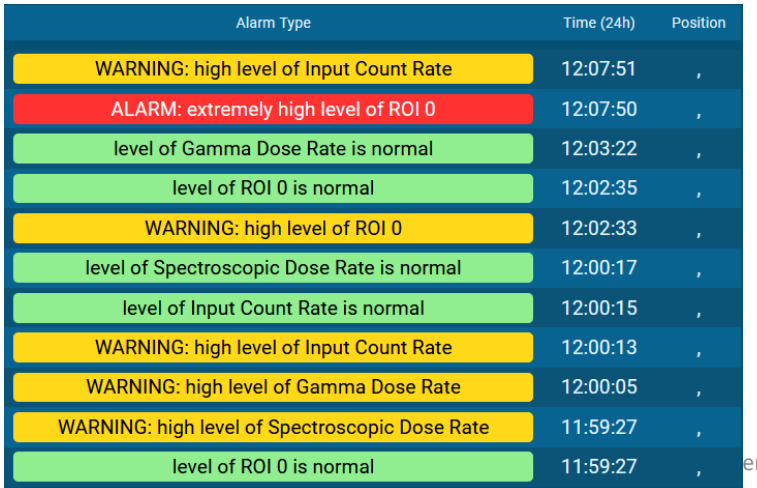


Red->Alarm, Yellow->Warning



Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Region of Interests and List of Radionuclides



Alarm Type	Time (24h)	Position
WARNING: high level of Input Count Rate	12:07:51	,
ALARM: extremely high level of ROI 0	12:07:50	,
level of Gamma Dose Rate is normal	12:03:22	,
level of ROI 0 is normal	12:02:35	,
WARNING: high level of ROI 0	12:02:33	,
level of Spectroscopic Dose Rate is normal	12:00:17	,
level of Input Count Rate is normal	12:00:15	,
WARNING: high level of Input Count Rate	12:00:13	,
WARNING: high level of Gamma Dose Rate	12:00:05	,
WARNING: high level of Spectroscopic Dose Rate	11:59:27	,
level of ROI 0 is normal	11:59:27	,

ROI value corresponds to the ratios between the slope of the count rates in the ROIs in the last 5 counting samples divided by the statistical uncertainty of the slope itself.
- Warning -> the slope is more than 4 times its statistical uncertainty
- Alarm -> the slope is more than 5 times its statistical uncertainty

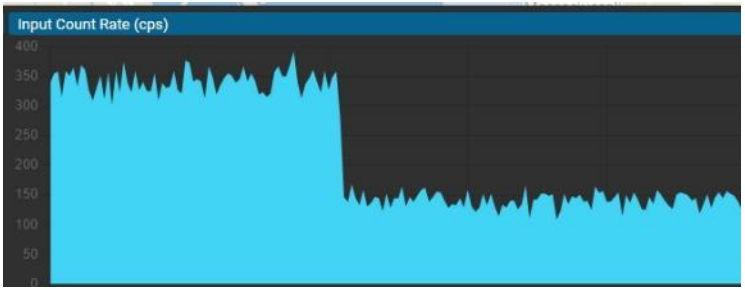
List of Identified radionuclides
The element must be added in the library

List of Warning and Alarms
with the time and position during the acquisition

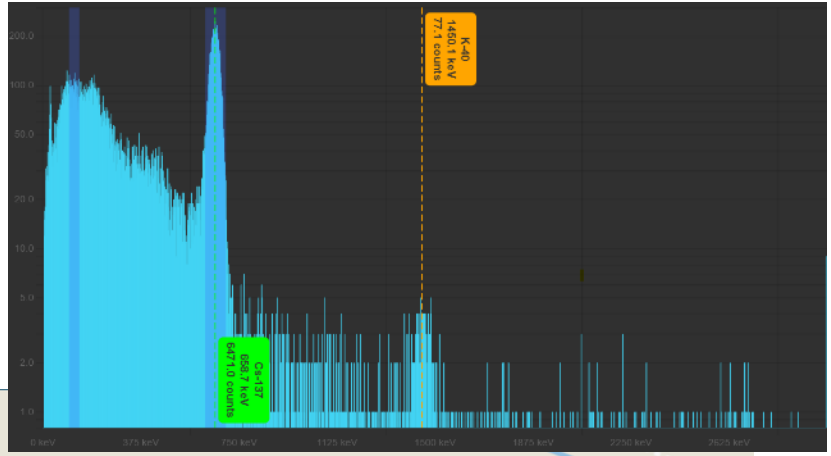
ents in this document in any form without prior written permission of CAEN SpA is prohibited

Main Page plots

Flow charts



Energy spectrum



Map with measured points

Reproduction, transfer, distribution of part or all of the co

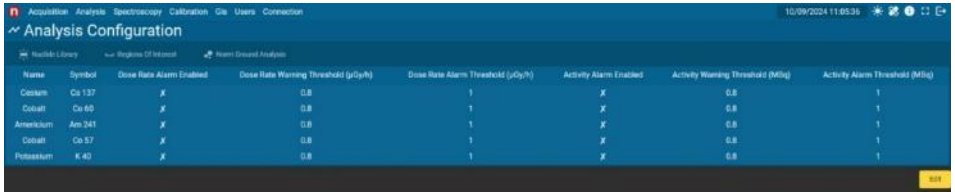
Configuration -> Acquisition

- **Notes** are an editable field that is recorded in the data reports.
- **Enable Report Data Saving**, that must be checked to save spectrum data into the report.
- **Decimation Period** sets the time granularity of the data saving. For example, if 10 seconds is selected, the system will save the integrated data each 10 seconds.
- **Saved Spectrum Bin Count** indicates the depth of the spectrometer spectrum

- **Acquisition Mode**. The option Operation sets the system for calculating real time data as moving widows for the use of the system in mobile surveys. The option Investigation sets data acquisition such that the calculated quantities are referred to the integrated data, suited for static measurements in areas of interest.
- **Alarm Mode** enables or disables the notification of the warning and alarms. The standard configuration is “Online Acquisition Only”, that allows the alarm to be visualized when the system is running the data acquisition.
- **Mission** is an editable field that is used to label the reports generated automatically by the system after the data acquisition.

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Configuration -> Analysis



- **Nuclear Library**. The algorithm will search and identify online radionuclides added in the library.
  Enable alarm and warning values.

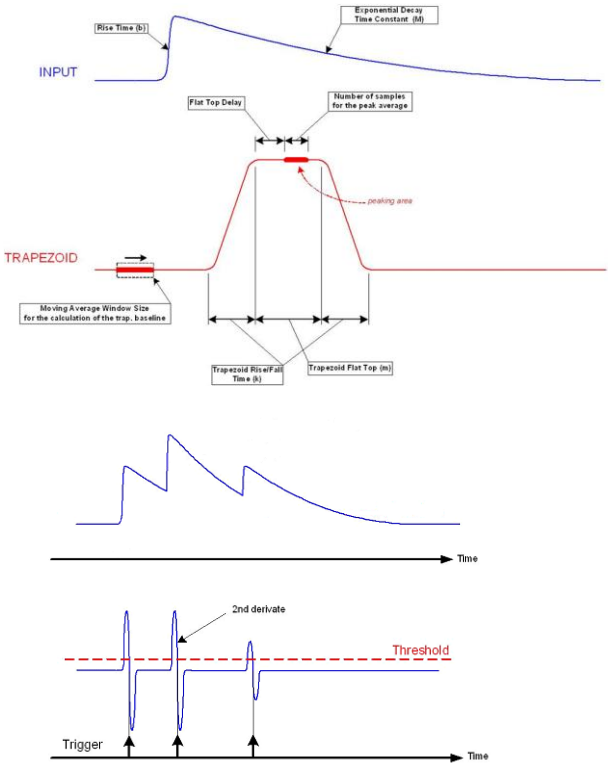
- **Regions of Interest**. Enable/disable region of interest ranges and alarm in the ROI of the spectrum

- **NORM Ground Analysis**. Set the integration time of spectrum acquisition for the NORM analysis

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Configuration -> Spectroscopy

WARNING: Modifications in the parameters contained in the page may result in system malfunctioning.

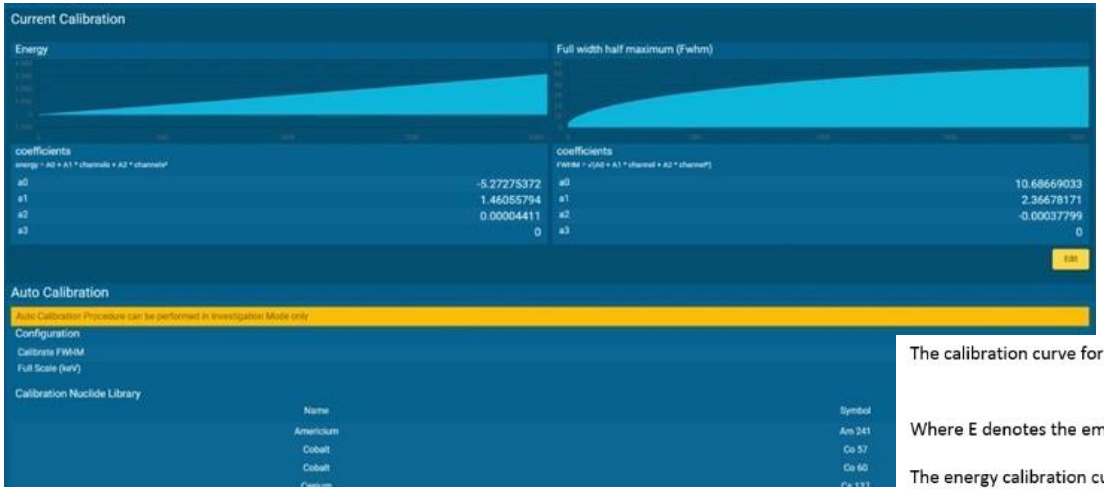


- **Temperature Stabilization**. Set the reference peak and the time for acquiring statistics

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Configuration -> Calibration

WARNING: Modifications in the parameters contained in the page may result in system malfunctioning.



The calibration curve for the FWHM is of the type:

$$FWHM = \sqrt{a_0 + a_1 * E + a_2 * E^2}$$

Where E denotes the emission line energy of a given isotope and FWHM the resolution to that specific energy

The energy calibration curve, on the other hand, is of the type:

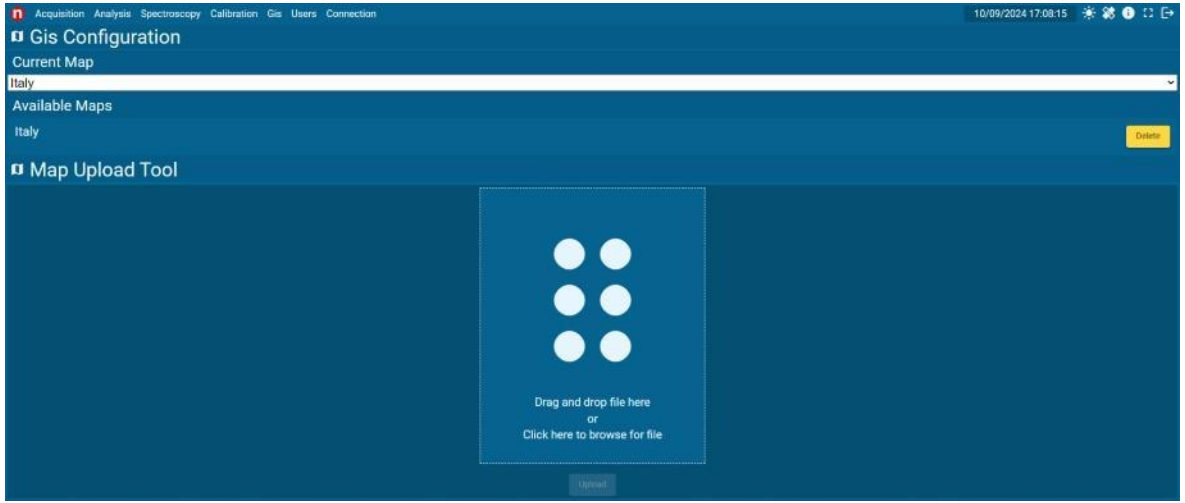
$$E = a_0 + a_1 * ch + a_2 * ch^2$$

Where E indicates the energy of the emission line of a given isotope and ch the channel corresponding to the centroid of that line.

- a0 indicates the term of degree 0
- a1 indicates the term of grade 1
- a2 indicates the term of grade 2

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Configuration -> GIS



Upload the vectorial data that allows the web interface to generate the georeferenced maps for the data point display.
As a default, CAEN provides the GAMON-Drone with the map data relative to geographical area of end user.
Additional maps can be requested to CAEN by the end user.

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Configuration -> User & Connection

Management of the Admin and User login and passwords

Data communication settings between the GAMON-Drone spectrometer and the relative tablet

- through the radio communication link and WiFi of the UAV and its remote;
- through the TCP/IP communication of the USB 2.0 cable adapter.

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Reports list

NOTE: In the main page, press «Create Report» button to save the report

Creation Date

Normal/Warning /Alarm status

Unique ID number

Open and Delete buttons

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Report information

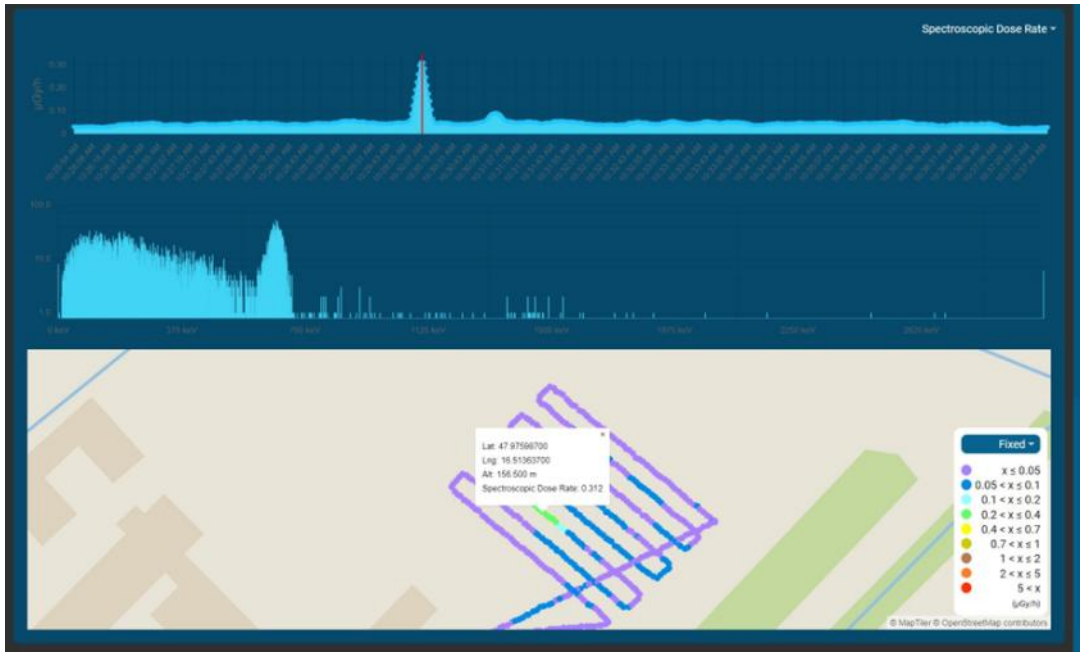
Summary
mission name/date, etc.

Device info

ICR max, min, average
Spectroscopic Dose Rate
Identified Radionuclides

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Report Information



Flow Chart with ICR or Dose Rate for each measured point

Spectrum at the selected time/position

Map with the entire path from Start to Stop Mission

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Data Saving Options

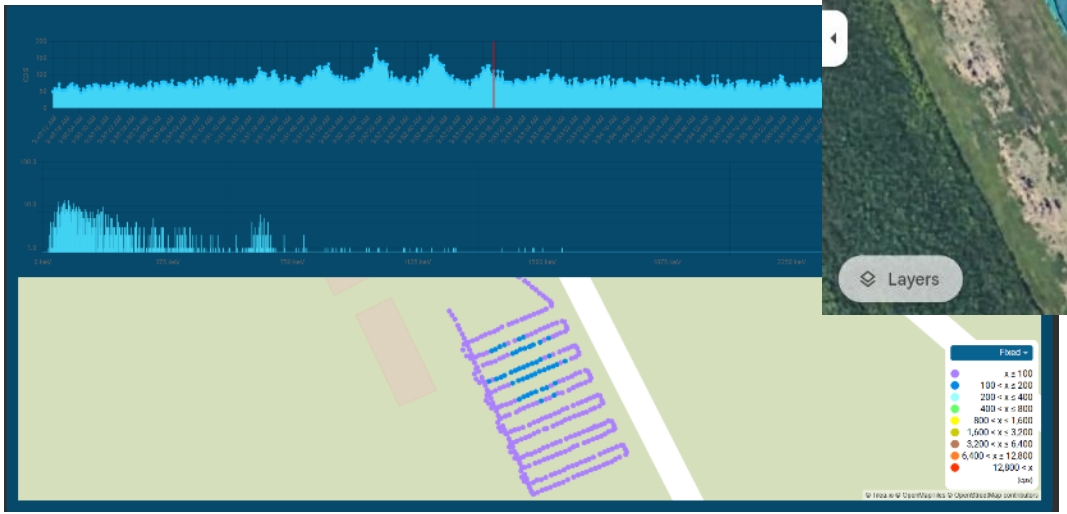
The report can be saved into multiple options:

- “Pdf file” saves the report as a pdf file.
- “Download spectra” button transfers all the spectra in the selected time window during the survey, exported in spe files.
- “csv” exports into a .csv file
- “kml” exports the file in a compressed folder where the kml files are saved
- “NORM Ground Analysis” saves the results of the NORM analysis on the acquired spectra with the time granularity defined in the Configuration -> Analysis Configuration -> NORM Ground Analysis section.

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Kml file production

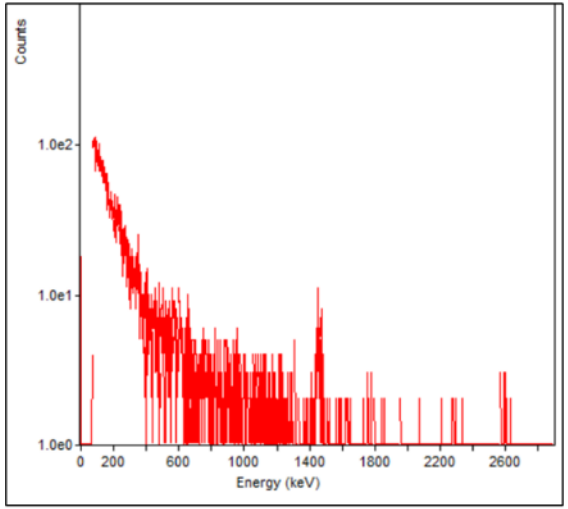
From Gamon software interface to Google Earth



Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

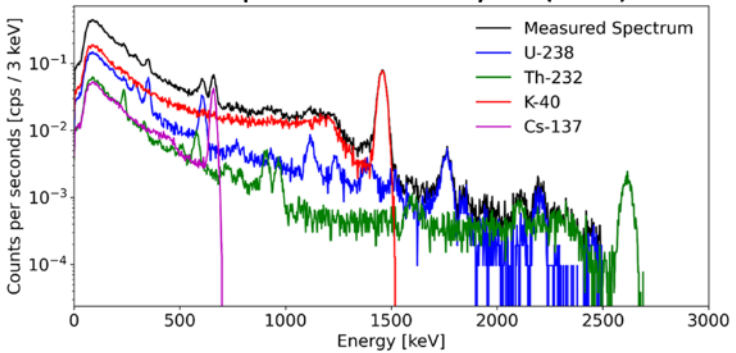
Map post-processing: spectral analysis

Geospectrum



- **Spectrum**
- **LAT**
- **LON**
- **Height**

Full Spectrum Analysis (FSA)



Estimation of the activity concentration C of natural (^{40}K, ^{232}eTh, ^{238}eU) and anthropogenic (^{137}Cs) radionuclides through full spectrum (S_K, S_U, S_{Th}, S_{Cs}) analysis:

$$M(i) = S_K(i)C_K + S_U(i)C_U + S_{Th}(i)C_{Th} + S_{Cs}(i)C_{Cs}$$

- Total spectrum: linear combination of fundamental spectra
- Fundamental spectra as a function of height obtained with Monte Carlo simulations

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Map post-processing: tabular output

ID	Date	Time	Lat	Lon	H_{GPS}[m]	H_{ALT}[m]	H_{BAR}[m]	Speed[m/s]	CPS	K [%]	σK[%]	U [ppm]	σU[ppm]	Th[ppm]	σTh[ppm]	Cs[Bq/m^2]	A_{Tot}[Bq/kg]	D_{eff}[nSv/h]
0	21/03/2023	14:17:17	47.9761	16.5125	184.9	0.1	3.9	0.0	28.3	1.40	0.08	3.3	0.2	4.3	0.3	<MDA	497	33
1	21/03/2023	14:17:22	47.9761	16.5126	194.1	8.8	13.1	1.9	28.3	1.39	0.08	3.3	0.2	4.4	0.3	<MDA	494	33
2	21/03/2023	14:17:27	47.9762	16.5125	194.1	9.3	13.2	1.1	28.4	1.40	0.07	3.2	0.2	4.6	0.3	<MDA	496	33
3	21/03/2023	14:17:32	47.9762	16.5125	193.8	9.1	13.2	0.5	28.6	1.41	0.08	3.2	0.2	4.5	0.3	<MDA	500	34
4	21/03/2023	14:17:37	47.9762	16.5125	194.3	9.9	13.8	0.8	28.6	1.41	0.07	3.2	0.2	4.7	0.3	<MDA	500	34
5	21/03/2023	14:17:42	47.9762	16.5126	194.2	10.0	13.3	1.1	28.3	1.40	0.07	3.1	0.2	4.7	0.3	<MDA	496	33
6	21/03/2023	14:17:47	47.9762	16.5126	193.5	9.6	13.0	1.0	28.4	1.37	0.07	3.1	0.2	5.0	0.3	<MDA	487	33
7	21/03/2023	14:17:52	47.9762	16.5127	193.2	9.4	12.7	1.0	28.3	1.33	0.07	3.1	0.2	5.1	0.3	<MDA	475	33
8	21/03/2023	14:17:57	47.9762	16.5128	192.9	9.2	12.6	0.9	28.3	1.34	0.07	3.1	0.2	4.8	0.3	<MDA	477	33
9	21/03/2023	14:18:02	47.9762	16.5128	192.7	9.1	12.5	1.0	28.3	1.33	0.07	3.1	0.2	4.6	0.3	<MDA	473	33
10	21/03/2023	14:18:07	47.9762	16.5129	192.2	8.7	13.1	1.0	27.6	1.30	0.08	3.0	0.2	4.5	0.3	<MDA	462	32
11	21/03/2023	14:18:12	47.9762	16.5130	191.1	7.7	12.6	0.9	27.3	1.33	0.08	3.1	0.2	4.2	0.3	<MDA	472	32
12	21/03/2023	14:18:17	47.9762	16.5130	190.8	7.4	11.1	0.9	27.6	1.37	0.08	3.1	0.2	4.4	0.3	<MDA	486	32
13	21/03/2023	14:18:22	47.9761	16.5131	191.2	8.1	11.3	1.0	27.4	1.35	0.07	3.1	0.2	4.6	0.3	<MDA	478	32
14	21/03/2023	14:18:27	47.9761	16.5131	191.0	8.0	11.2	1.0	27.1	1.33	0.07	3.0	0.2	4.4	0.3	<MDA	472	32
15	21/03/2023	14:18:32	47.9761	16.5132	191.0	7.8	11.2	1.0	26.9	1.36	0.08	3.0	0.2	4.4	0.3	<MDA	481	32
16	21/03/2023	14:18:37	47.9761	16.5133	190.6	7.6	10.8	1.0	26.6	1.28	0.08	3.1	0.2	4.2	0.3	<MDA	456	31

From abundances to activity concentration

1% K = 313 Bq/kg
1 ppm U = 12.4 Bq/kg
1 ppm Th = 4.1 Bq/kg

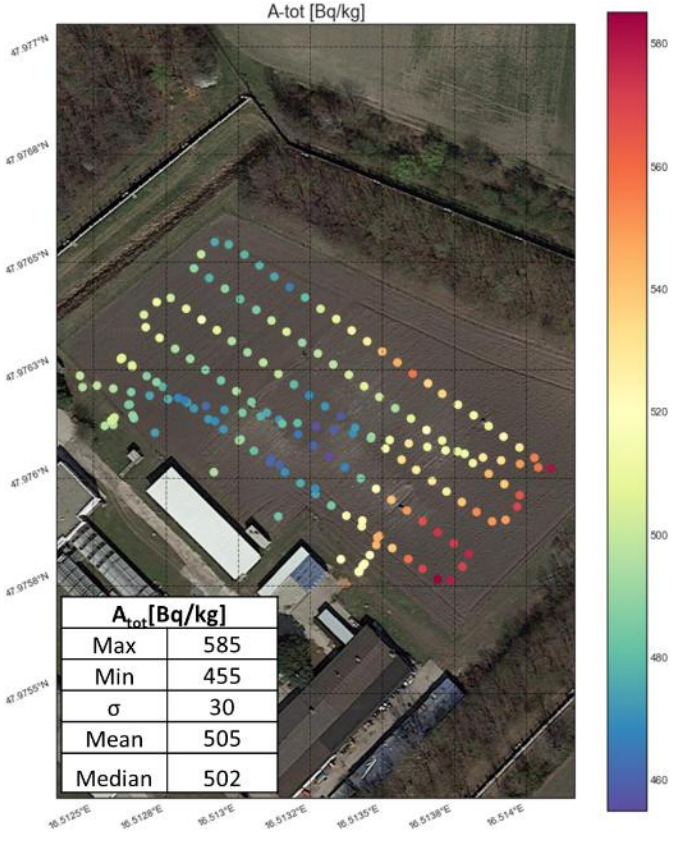
$$A_{tot}\,[Bq/kg] = 313\,C_K + 12.35\,C_U + 4.06\,C_{Th}$$

Effective dose UNSCEAR 2000 Report

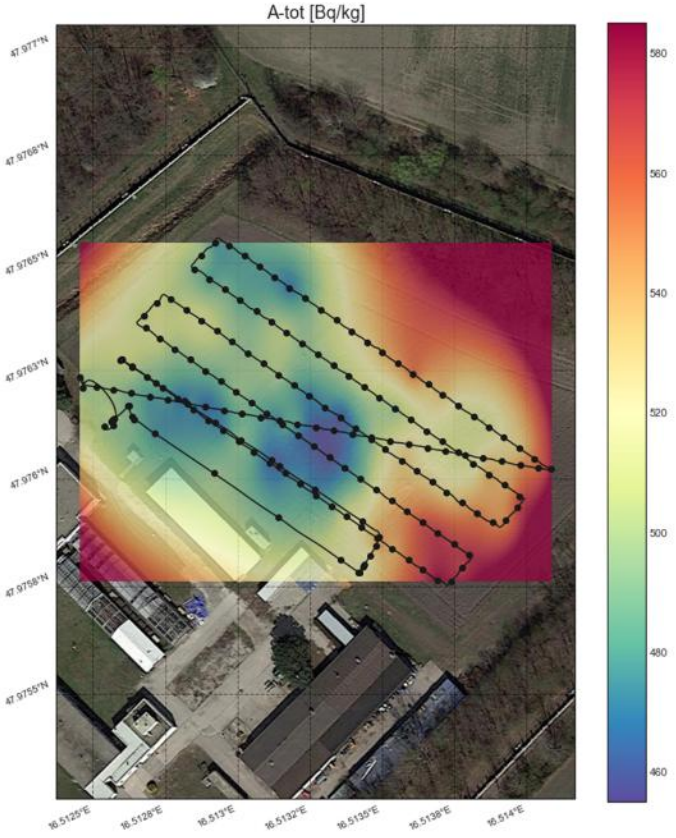
$$D_{eff}\,[nSv/h] = 0.7 \cdot (0.0417 \cdot A_{K\text{-}40}\,[Bq/kg] + 0.462 \cdot A_{U\text{-}238}\,[Bq/kg] + 0.604 \cdot A_{Th\text{-}232}\,[Bq/kg]) + 0.0303 \cdot A_{Cs\text{-}137}\,[Bq/kg])$$

Reproduction, transfer, distribution of part or all of the contents in this document in any form without prior written permission of CAEN SpA is prohibited

Map post-processing

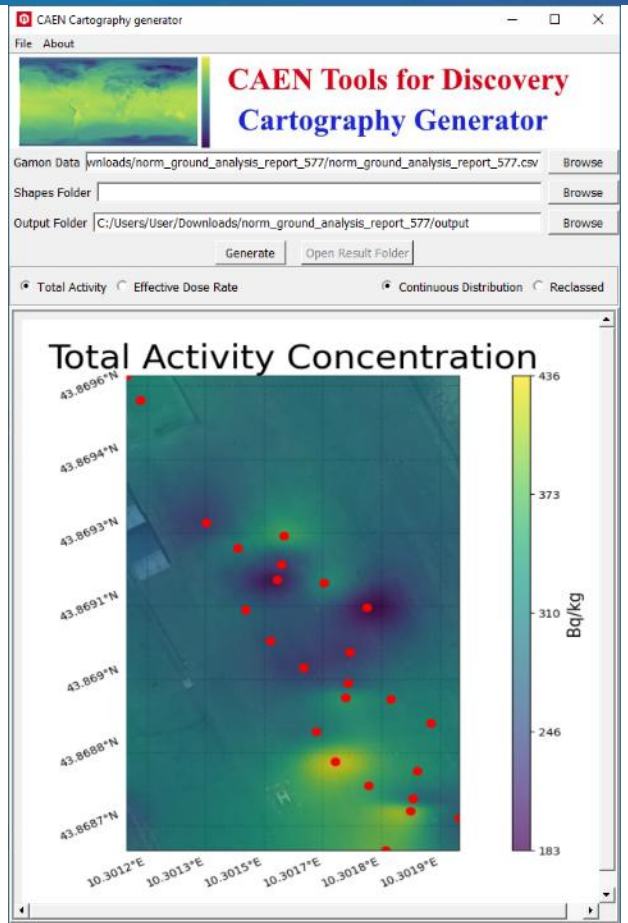


A_{tot}[Bq/kg]	
Max	585
Min	455
σ	30
Mean	505
Median	502



Inverse Distance Weighting method to create the heat map.

CAEN Cartography Generator



- Gamon Data: input csv file from NORM analysis.
- Shapes Folder: shape file (not mandatory)
- Output folder: all map plots will be saved there

- Press Generate

- Total Activity Concentration (Bq/kg) and Dose Rate (nSv/h) maps will be shown in the GUI.
- K (% and Bq/kg), eTh (ppm and Bq/kg), eU (ppm and Bq/kg) maps available in the output folder

THANK YOU!

SCAN ME

Follow us on linkedin

INTERNATIONAL SUMMER SCHOOL 2025