S10-O2
Design Principles of Enhanced Dose Rate Monitoring Network

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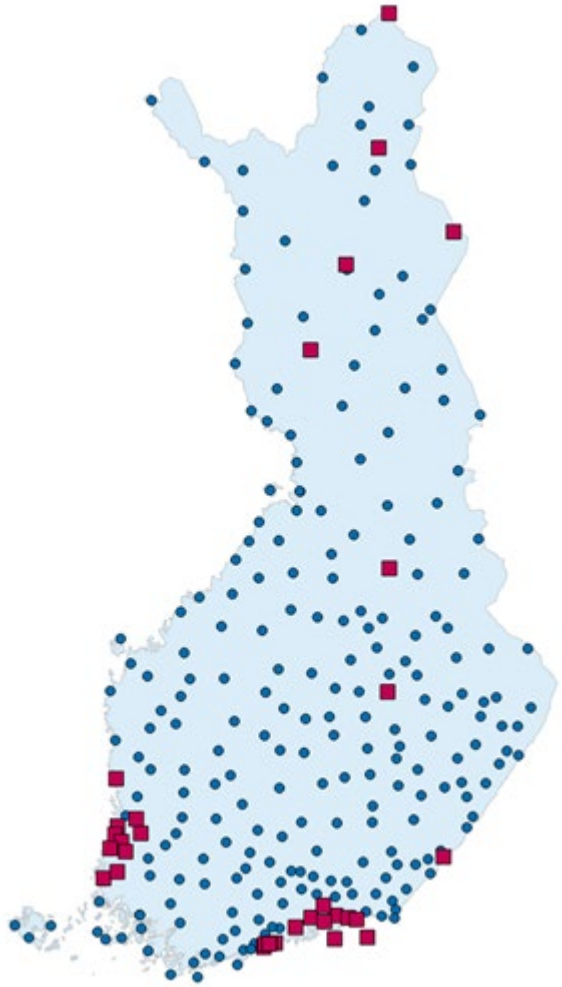
Outline

- Introduction
- Current state of the monitoring network
- Purpose of enhanging of network
- Methods
- Results and discussion
- Conclusions

Introduction

- The Finnish dose rate monitoring network consists of about 260 stations equipped with Geiger-Műller (GM) tubes
  - Marked as blue circles on the map.
- Additionally, over 25 are equipped with LaBr3 spectrometers adapted for environmental monitoring.
  - Marked as red squares on the map.
- The existing network ”ULJAS” has been in use since about 2005.
- The current network has been very robust so far. However, some of its components are at the end of their life cycle.
- STUK decided two years ago to establish a project on the renewal of the network.

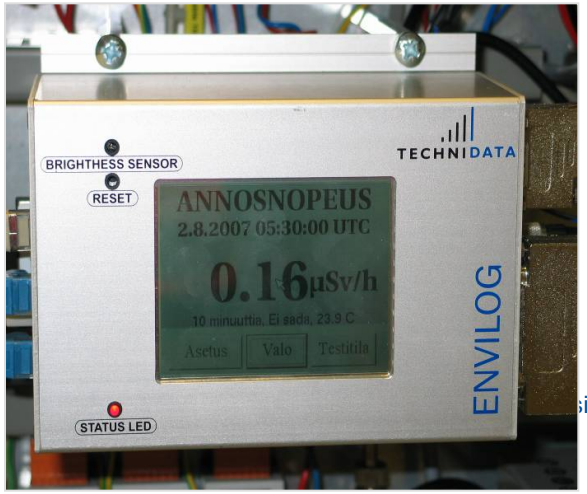


Current state of network: Capabilities

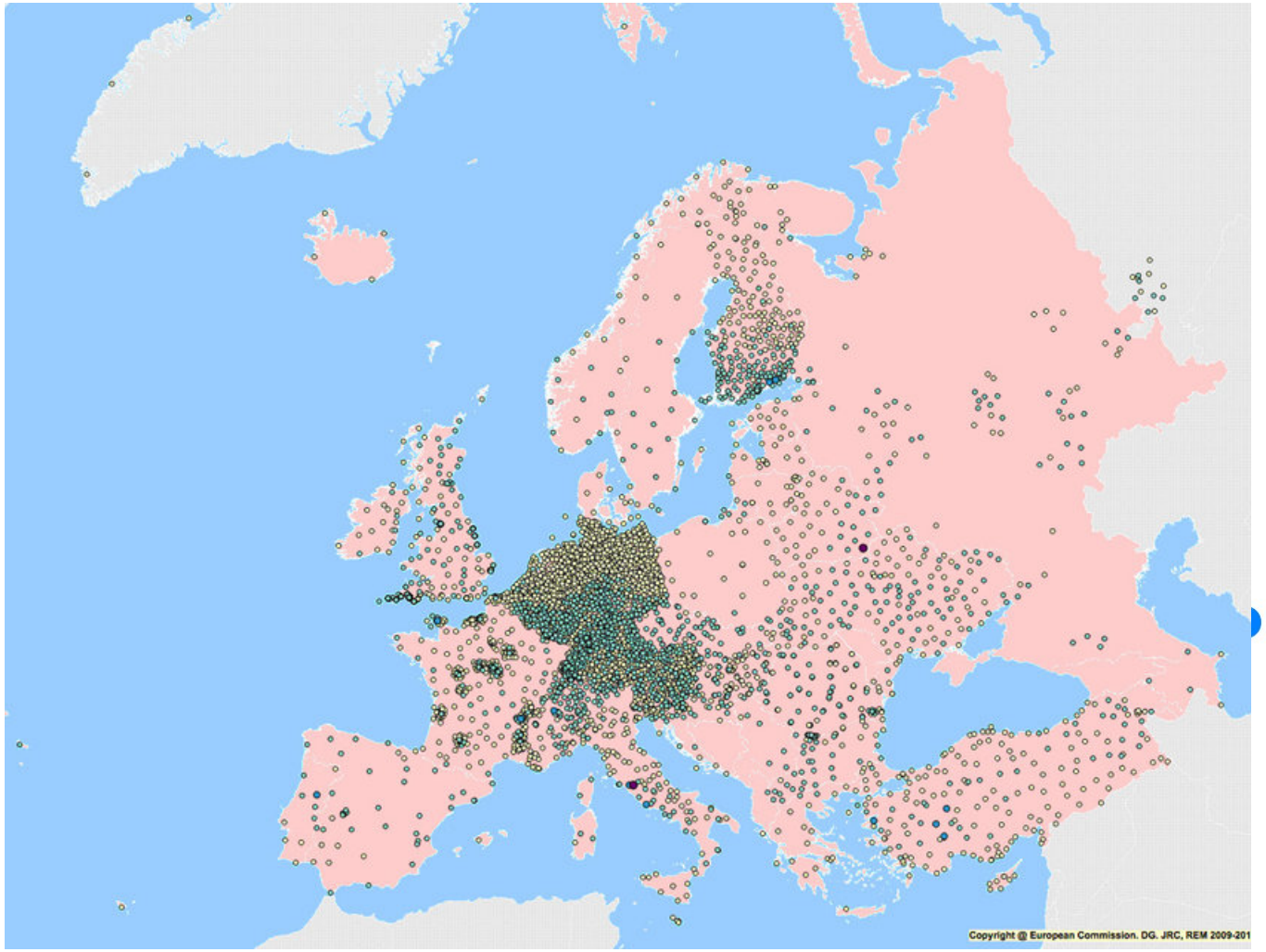
- Network of about 260 monitoring stations
- Measures dose-rate (μSv/h)
- Results transmitted at 10 min intervals to STUK → real-time radiation situation awareness
- Government Tetra radio network for data transfer
- Web-browser accessible presentation system
- Alarms: background dose-rate in Finland is between 0.05 - 0.30 μSv/h. Station-specific alarm limit set to 0.1 μSv/h increase over a 7 day smoothed average
- Regional emergency response centre (ERC) alarmed in addition to STUK's duty officer
- Monitoring results from NPP's local networks (TVO 10 stations, Fortum 15 stations)
- 25 stations equipped with a $LaBr_3$ spectrometer
- Monitoring stations run on Linux, in-house built control software, interfaces available for additional instrumentation

Current state of network: Equipment

- Embedded Intel PXA255 processor, SSD memory
- Linux OS
- In-house developed and based on free open-source software
- Secure data communication using government TETRA radio network
- Interfaces: six rs232, one rs485, Ethernet and I/O-ports
- Touch screen, local alarm
- Battery operated for 72 hours



Current state of network: EURDEP monitoring stations



Country	Representative measuring period#	Transmission interval*	Number of stations	Area	Stations per area
	hh:mm	hh:mm		km²	1/1000 km⁻²
Austria	01:00	00:30	333	83878	3.95
Azerbaijan	00:30	01:00	6	86600	0.07
Belarus	00:10	12:00	40	207595	0.19
Belgium	01:00	00:55	125	30528	4.06
Bulgaria	01:00	01:00	28	110994	0.26
Croatia	00:30	00:02	32	56542	0.58
Cyprus	01:00	00:56	8	9251	0.86
Czech Republic	01:00	01:00	64	78864	0.81
Denmark	00:17	01:36	11	43094	0.26
Estonia	00:17	00:54	18	45227	0.40
Finland	01:00	00:15	266	338432	0.79
France	01:00	00:57	852	668763	1.27
Germany	01:00	00:55	1887	357121	5.29
Greece	01:00	02:00	23	131957	0.17
Greenland	00:16	01:36	3	2166086	0.00
Hungary	01:00	00:57	120	93036	1.29
Iceland	00:10	00:10	4	103125	0.04
Ireland	01:00	01:00	15	70182	0.21
Italy	01:00	00:08	227	301338	0.75
Latvia	00:10	00:10	21	64589	0.33
Lithuania	00:10	00:10	13	65300	0.20
Luxembourg	01:00	00:30	13	2586	6.57
Macedonia	00:05	01:00	17	25713	0.47
Malta	01:00	04:48	12	316	12.66
Netherlands	01:00	00:19	168	41548	4.04
Norway	01:00	00:49	40	385199	0.10
Poland	01:00	00:53	25	312685	0.08
Portugal	00:10	01:00	13	92212	0.14
Romania	01:00	00:15	193	238391	0.96
Russia (European)	00:10	03:00	129	3960000	0.03
Serbia	00:30	01:01	8	77474	0.09
Slovenia	00:30	00:29	27	20273	3.80
Slovak Republic	01:00	01:30	134	49034	0.22
Spain	01:00	16:00	11	504645	0.09
Sweden	01:00	01:12	77	450295	0.06
Switzerland	00:59	00:58	168	41285	3.25
Turkey	01:00	01:00	191	814578	0.23
Ukraine	01:05	24:00	157	603500	0.26
United Kingdom	01:00	01:00	92	219331	0.42

*Indicated times are valid for routine operation. During an emergency all transmission intervals should be 02:00 hours or less.

#Within the harmonisation process the decision was made that all networks shall use the same representative measuring period of 1 h, i.e. 1 h data are to be send to the EURDEP database.

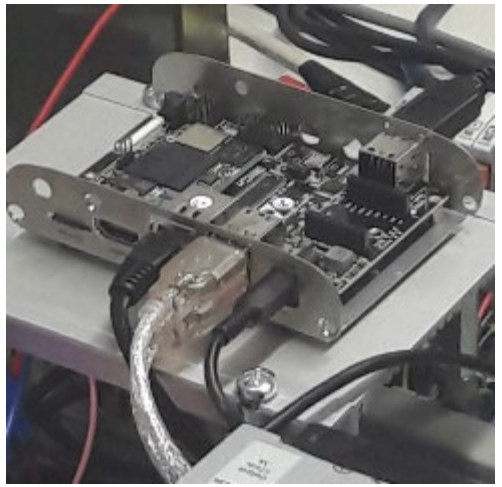
Source: Dombrowski, H & Bleher, Martin & De Cort, Marc & Dabrowski, Rafal & Neumaier, Stefan & Stöohlker, U. (2017). Recommendations to harmonize European early warning dosimetry network systems. Journal of Instrumentation. 12. P12024-P12024. 10.1088/1748-0221/12/12/P12024.

Purpose of the Enhancement

- In the beginning of the project it was decided that the network will be enhanced rather than completely renewed.
- The GM tube technology will be retained due to the good experiences with them.
- There are some disadvantages in the current software architecture that have to be fixed. This applies not only to the monitoring stations but also to the data management in the server side software.
- The purpose of the enhancement project is to extend the life-cycle of ULJAS network.
  - STUK and other authorities are currently satisfied with the density and the coverage of the network.
  - By replacing some old technology the network lifetime can be quite easily extended from 10 to 15 years.
- Some comparisons between in-house and commercially available solutions were made. It was decided that STUK will carry on with our own development of software and maintenance of hardware.

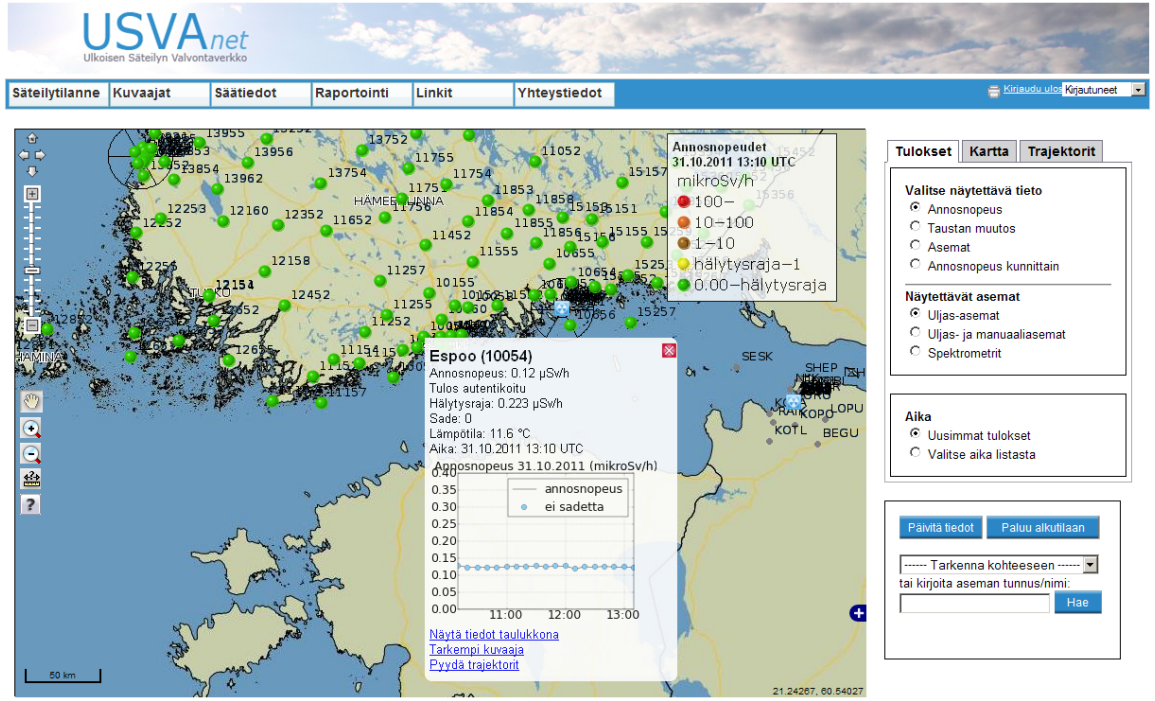
Methods: Station Computer Replacement

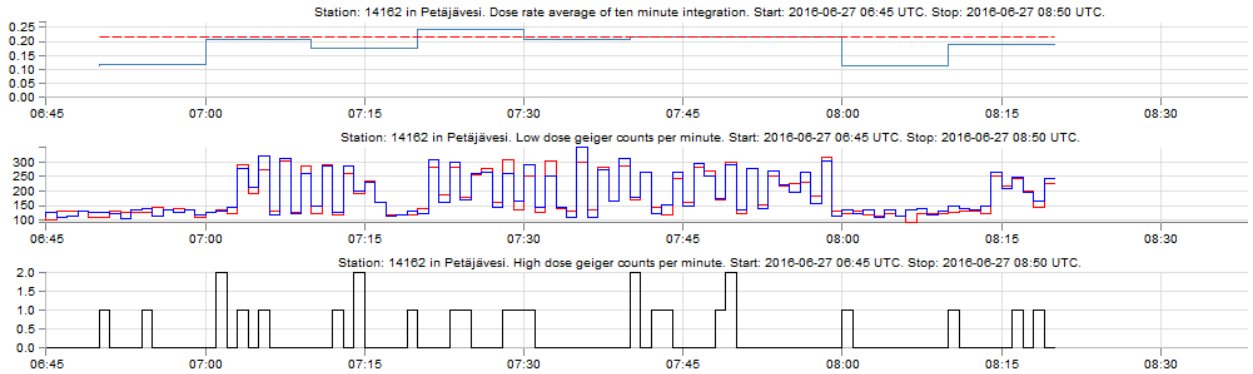
- The most critical component at the end of its life-cycle is the computer at the measurement station. It is now 15 years old and in the near future it is expected that they begin to break more frequently.
- The number of different kind of computers have already been tested at STUK. In the market there are a lot of alternatives but it is not easy to find robust computer with low power consumption in the market.
- The requirement for the station is to keep it running 3 days without external power. The testing of different computer is still in progress.
- At this point the idea is to make station software independent of computer model.



Methods: Data Collection Software Update

- Data collection and data management software is under reengineering.
- The current software is not maintainable anymore and more modern programming techniques will be used in the next version of the software.
- The principle of the software development is make the code more readable and well documented. This makes it possible to have more people familiar with the system which is crucial especially when there's misbehavior in the network.





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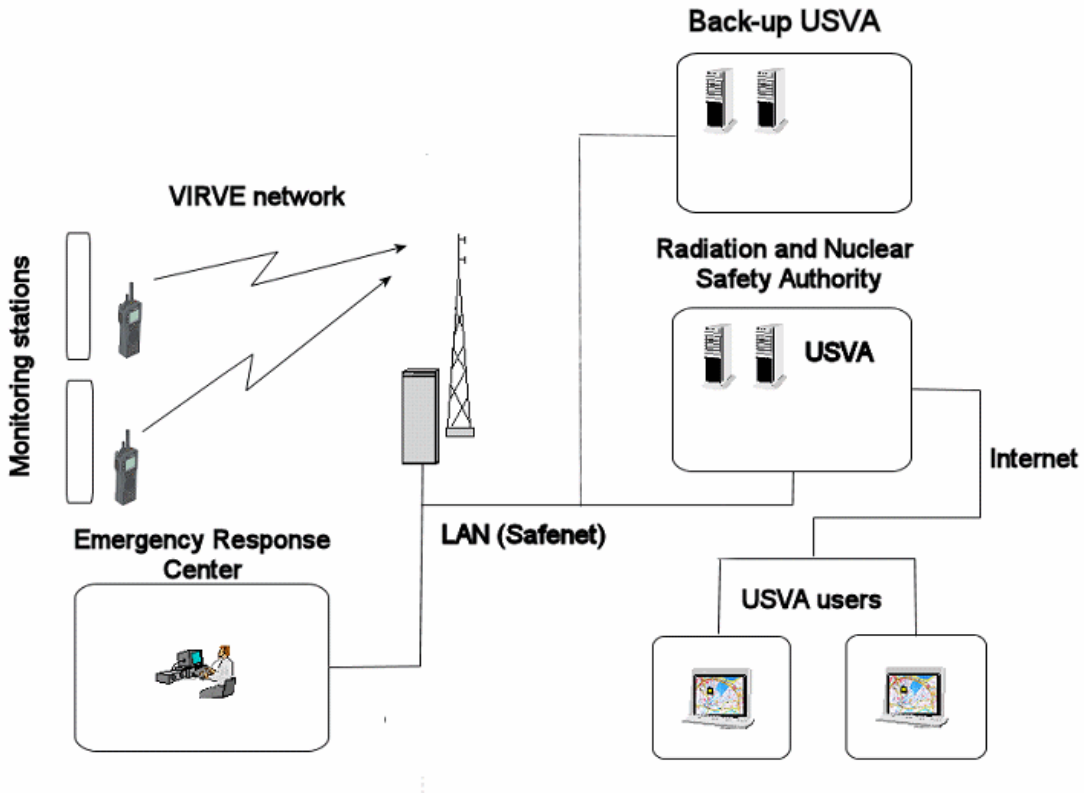
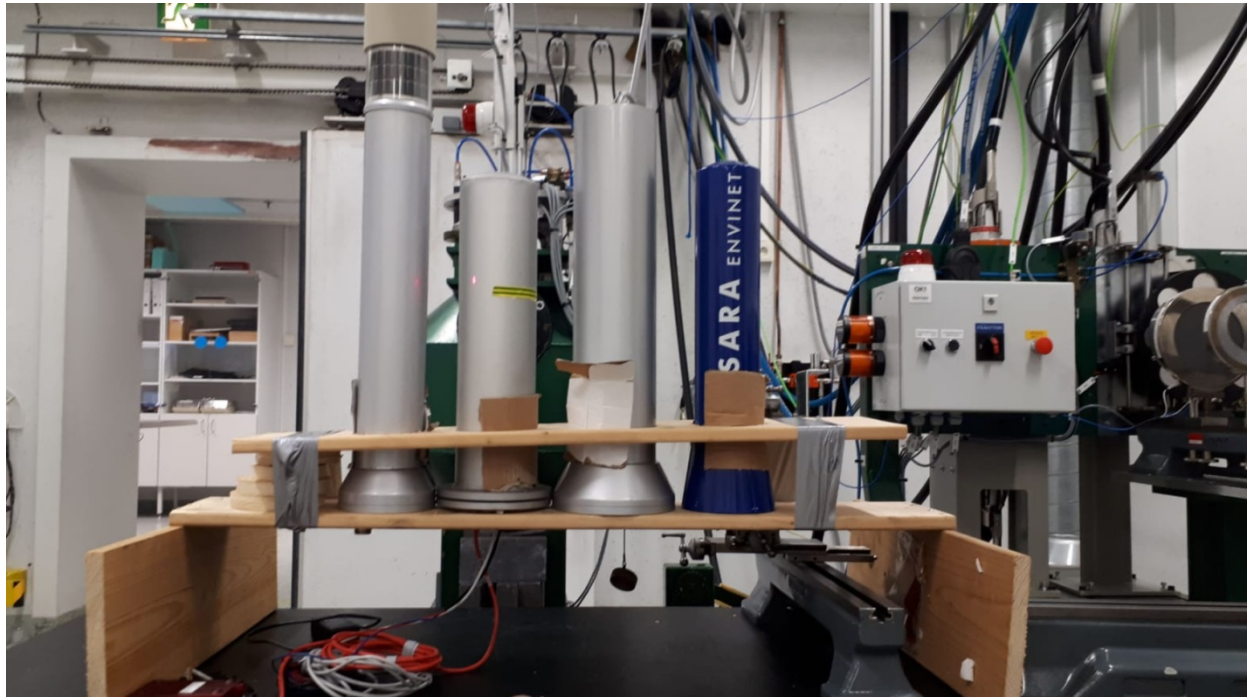
Methods: Data Communucations Update

- The current communication between stations is based on governmental TETRA technology (“VIRVE”).
- It is very secure and robust but unfortunately very slow.
- In Finland there is an ongoing project to establish a new governmental network based on LTE technology. In this network the data communications would be in regular commercially operated networks but certain traffic could be prioritized.
- The software and the hardware will be designed to support this new network technology.



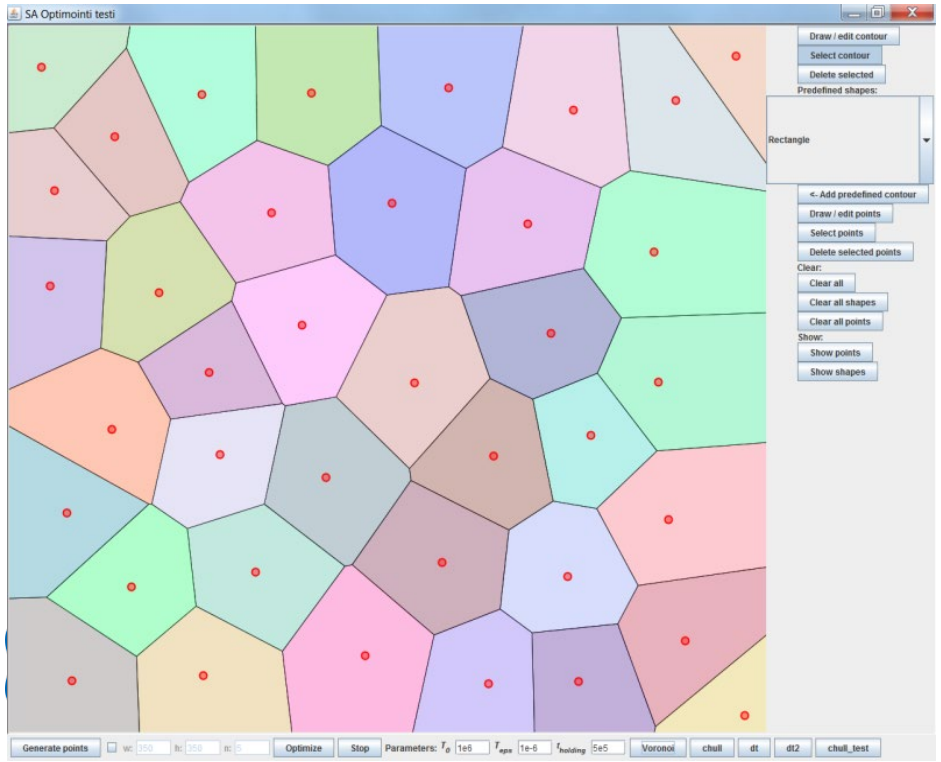
Methods: Detector Tests

- In this project the currently well working GM tubes will remain.
- However in the future the support for at least one model STUK has in use will cease.
- That's why some irradiation tests with commercially available gamma dose rate monitoring devices including $LaBr_3$ spectrometers will be tested at STUK's irradiation facilities.



Methods: Network Optimization Calculations

- To study the extent of the network some computational network optimization calculations are performed.
- The calculations are based on simulated annealing method.

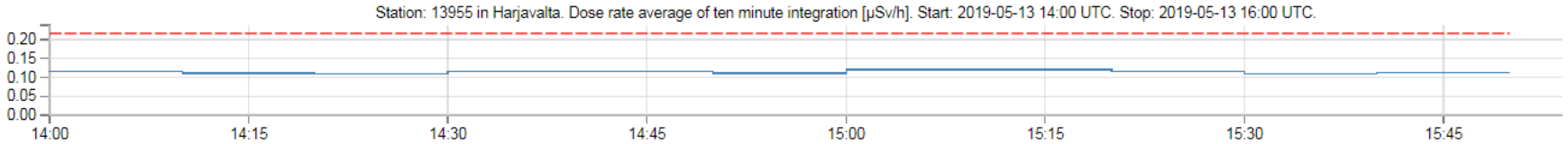


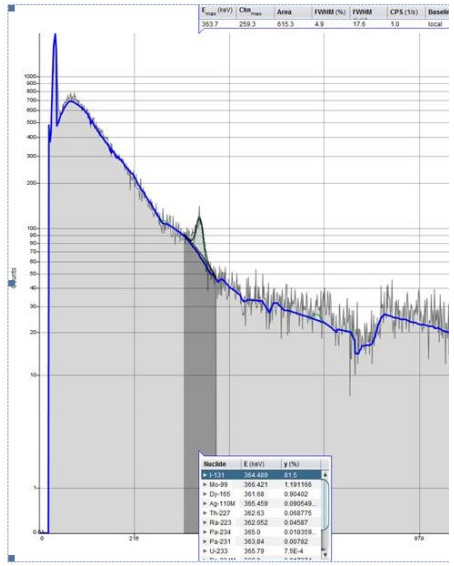
The aim is to justify the extents and density of current monitoring network.

- Is current network capable for early notification of elevated radiation levels?
- If more stations would like to be added where they should be located?
- If less stations is wanted which stations should be removed?
- Optimization criteria
  - Geographic extents
  - Affected population
  - Maintenance costs
- Simulated releases will be used in optimization
  - Using 4 year weather data, 2 releases /day (See poster Ukkonen et.al. @NSFS 2019)

Methods: Spectrometric Equipment

- Also, the spectrometric part of the network will likely be expanded.
- There is an ongoing research project in STUK on a new detector that makes it possible to separate the cloud-shine, deposition and detector contamination components of detected radiation. [Ihantola et.al.]
- A recent example of detection capabilities 9.5.2019 15.00 UTC: likely due to a patient that has been in iodine treatment.





Results and Discussion

- The current timeline is that under 2019 the software for data collection and data management is ready.
- Then STUK can begin to build a prototype of the new station and test it in a field usage for a while.
  - After some period larger amount of stations will be tested at some selected sites of the monitoring network.
  - Experiences will be collected during that period and modifications for station design can be made based on these tests.
- Another major challenge will be project management of such a big task. Due to regulations the buying of the equipment has to be put out to tender. This will require a lot of effort from project participants.

Conclusions

- Between 2017 and 2019 STUK will design the hardware and the software new external dose rate monitoring network.
- From 2020 the assembling of new equipment is made to replace the existing monitoring stations.