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Improvement safety of population through introducing of radiation monitoring system at level of institutions, schools and citizens – project RAMESIS

Introduction

To assure and improve safety of population and to enhance efficiency in coping emergency situation caused by radiological or nuclear accident, the effectiveness of emergency preparedness and response depends to a great extent on involvement of all interested stakeholder and general public – and the level, extent and acceptance of such collaboration is significantly related to factors like their understanding to the problems of radiation protection and radiation as a whole, and their confidence of information and recommendations provided to them by the authorities. To accomplish these tasks, it is necessary to gain the participants´ confidence to information on radiation situation provided by the authorities, and consequently their confidence and understanding to recommendation on The experiences gained from the Chernobyl and Fukushima NPP accidents have shown that, especially in case of severe accident with significant consequences on large inhabited areas, the lack of public confidence to authorities originated mostly either by poor communication between the authorities and the public and stakeholders, or by restricting access to the information for them, or both. These may inevitably result into extremely negative impacts on the public and stakeholders´ understanding of actual situation and its possible risks, and on their acceptance of necessary protective measures and their participation in remediation of affected areas.

Citizen radiation monitoring, performed on a voluntary basis, may improve such a confidence significantly. Making sure, that the official results are compatible with the citizens self-measured ones, may result in gaining better confidence of the public to the authorities.

In the Czech Republic, the implementation of such an approach is investigated in the framework of security research founded by the Czech Ministry of Interior. Especially the “RAMESIS” project solved by SURO is aimed at creating tools for supporting and establishment of a citizen monitoring network based both on the network of fixed monitoring points equipped with newly developed simple and cheap fixed monitoring stations, and on mobile monitoring using the Safecast “bGeigie nano” portable devices. The project includes preparation of methods and tools for public for performing the measurements and for processing and presentation of monitoring results on both local and global levels, together with tools for utilization of these citizen networks results by the National Radiation Monitoring Network operated by the authorities. This can also improve efficiency of obtaining information needful for a fast and effective evaluation of the radiation situation in case of accident.

Experiences from severe accidents in past

Chernobyl (1986) and Fukushima (2011)

Chernobyl (1986)

Information provided by authorities to public on radiation situation anf of its possible consequences wererather limited and mostly unappropriate, not only in USSR but in most countries of the so-called Eastern block. The public has no access to any other sources of information channel and very limited possibility to obtain devices for making their own independent measurements. No social networs in today´s sence existed and communication between public was only a rather limited both due to technical means (phone, fax) and political situation in most affected countries. Public information on problematics of radiation protection was only on a rather low level. Obtaining a device at least for simple measurements of dose-rate at price acceptable for general public was hardly possible.

Fukushima (2011)

Information provided by authorities to public were often considered unadequate by the public. Nevertheless technical means for exchanging information were on much better technical levels, sharing information on social networks were common for worldwide. Soon after the accident group of active citizens formed a goup of enthusiasts (SAFECAST) who started measurements using improvised devices, and consequently designed, developed, tested and put at the market a set of devices for simple measurements of dose-rate, based on components commonly available in web e-shops and utilizing open-source hardware and software approach, requiring only a simple operation skills and for acceptable price. They also established a system for sharing results of such measurements and for presenting them in form of interactive maps on a web-based server.

Lessons learned

Both examples clearly demonstrate strong decrease of public confidence to authorities, caused poor and/or rather limited communication between official authorities and stakeholders and general public and by restricted access to information for stakeholders and general public. Such approach of authorities may have extremely negative impacts on public understanding of actual radiation situation, its possible risks and possibilities of implementing protective measures, resulting into problems with acceptance of necessary protective measures, and may lead to making participation and collaboration of stakeholders and general public in remediation of affected areas difficult.

Citizen Radiation Monitoring

Possible way to improve the situation in future can be implementation and support of citizen radiation monitoring performed on voluntary basis.

Whether the authorities like it or not, people will not only demand for information, but active try to find ways how to get information - manage for detectors and carry out measurements by themselves, especially if suitable detectors (acceptable price, simply operable) are available, and sharing data, information, meanings etc. on social networks.

Perspective of collaboration between public and authorities is aimed to making sure, that the official results are compatible with these obtained by citizens self-measured ones, so that the public may gain more confidence to official information. Another important factor is increasing capability of monitoring as a whole if citizen radioation monitoring can be implemented as supplement to monitoring performed by professional teams from authorities governed monitoring networks.

Examples of citizens initiatives in past in Czechia[1]

a) In 1987 house owner (using *a detector he borrowed from an U mine*) discovered elevated levels in his house. Further investigation shown that in some family houses built using radioactive clinker concrete panels in 1972-1983 the dose rate was up to 2 µGy/h.

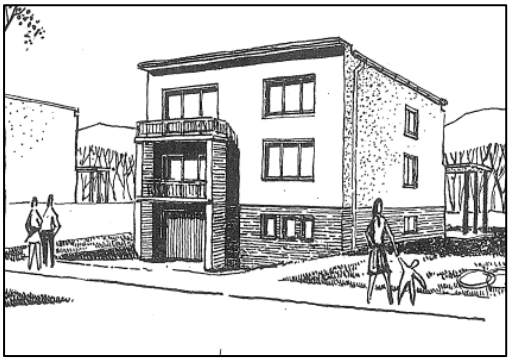


Fig. 1 Family house START where elevated levels of radiation were detected

In 29.9.2011 radiation enthusiast detected enhanced levels of dose rate near to the playground using Wrist Gamma Watch (see figure below[2]). He reported immediately the situation to authorities, further investigation proved that the source was an orphan source ^{226}Ra (700 MBq used for radiotherapy, lost before WW2 in Prague).

Fig. 2 Childern´s playground where orphan source was found by wrist detector

[1] HŮLKA, Jiří; KUČA, Petr; HELEBRANT, Jan a Zdeněk ROZLÍVKA. Citizen Measurements in Radiation Protection and Emergency Preparedness and Response - its role, pros and cons. EUROSAFE Forum 2017 Proceedings, 6-7 Nov 2017, Paris, France.

[2] All photographs included in the paper provided by SURO, if not specified otherwise.

Actual trends in devices design for citizens monitoring

Devices used for citizen monitoring can be consiedered as three types:

- Fixed stations
- Hand-held gadgets
- Mobile monitoring

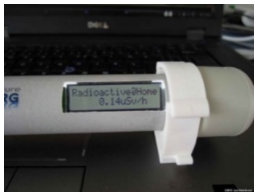
- **Devices for Fixed stations**

These devices are usually composed of detector coupled with simple processor unit providing capabilities for storing measured values together with date/time information, and for transfer data to central database via internet. Results of measerements can be seen both locally, on the device itself or using a PC, and globally on a web map-based presentation.

Examples:

a) **Radioactive@Home** (scientific project - Poland)

simple device with GM detector with USB connection to PC, providing local display of actually measured value on the device itself and automatic transfer of results to central database via PC internet connection, and overal presentation on web.[1]



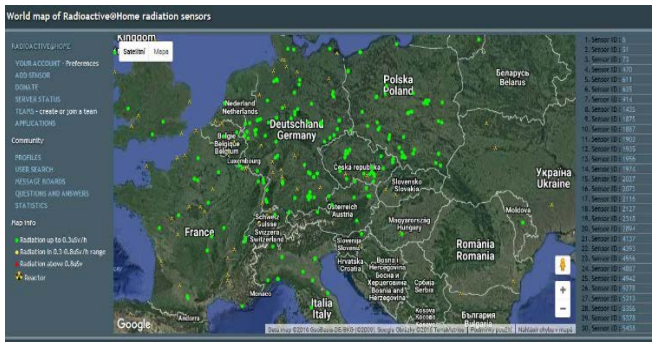


Fig. 3 Radioactive@Home project - detectors and web presentation of results

b) **MOSTAR**[2] (R&D project SURO & NUVIA – Czechia)

- sophisticated device with up to three GM* detectors (optionally), USB/LAN connection to PC, full user control of measurement parameters, off-line operation possible, automatic transfer of results to central database via PC/NB internet (standard version) or via connection or mobile networks (stand-alone version)
- capability for local display of full range of measured values and parameters on PC/NB (including history) and globally on a web map-based presentation on web ***mostar.envinet.eu*** *(registration necessary)*
- intended for municipalities, schools, youth tech-centers, local volunteer organizations (fire brigades, scouts, …)

[1] **radioactivehome.org/boinc/ (**registration necessary).

[2] Mobile and stationary radiation monitoring systems of the new generation for radiation monitoring networks (MOSTAR), ID 20122015083, research project supported by Ministry of Interior of the Czech Republic.

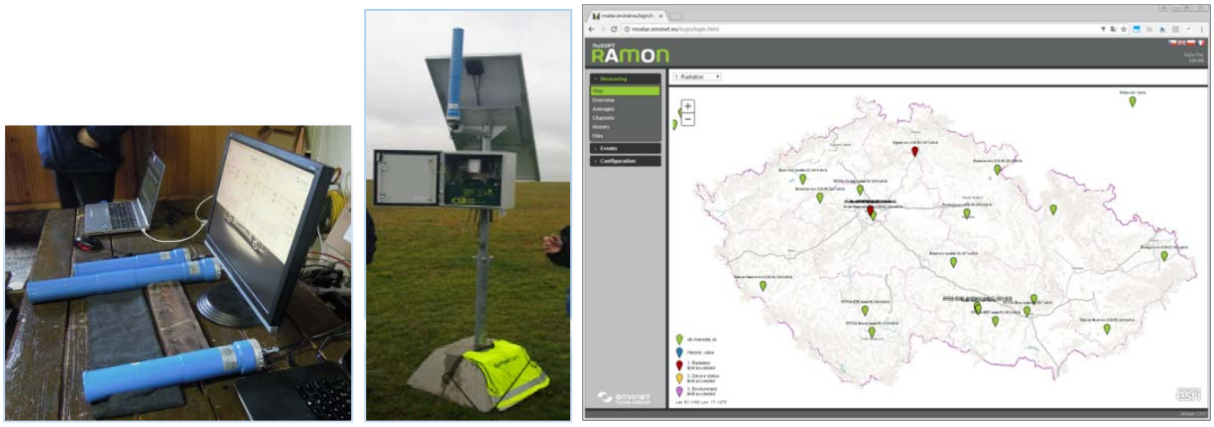


Fig. 4 MOSTAR - detectors (standard and stand-alone), web presentation of results

- **Hand-held gadgets**

These devices are battery powered, small size, ligthweighted, usually composed of detector coupled with simple processor unit providing capabilities for storing measured values together with date/time information (in some cases for transfer data to PC), measured values are displayed locally, usually an alarm fuction with presetable levels is implemented.

Price of such devices varies from some 30 USD (smartphone stick - rightmost bottom) to approx. 600 USD (Wrist Gamma Watch - lefttmost bottom).

Examples (based on study web[1] performed in SURO as a part of RAMESIS project):

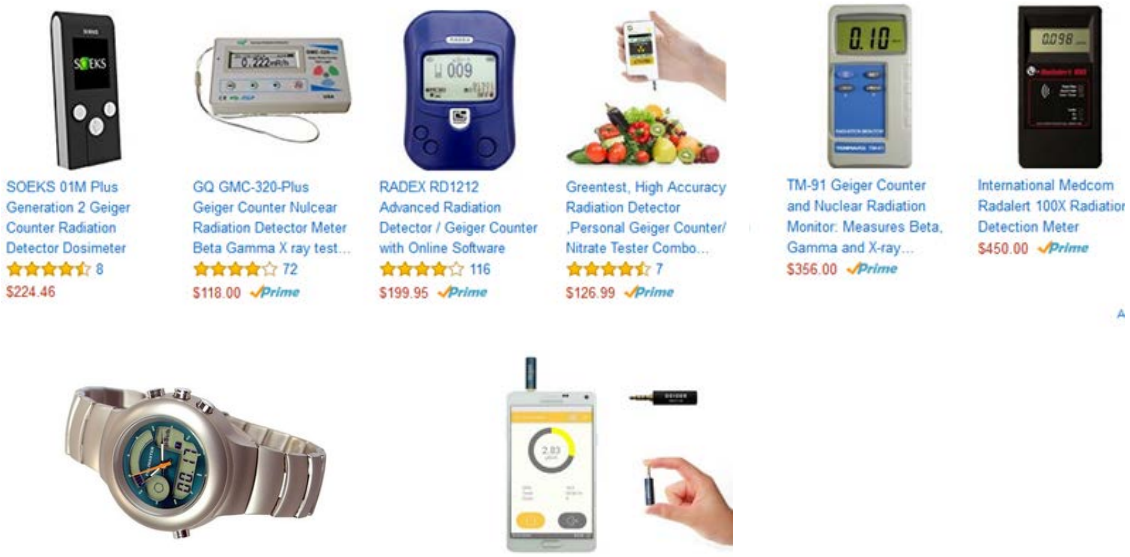


Fig. 5 Hand-held gadgets considered in RAMESIS project startup analysis

[1] Zpráva SÚRO č. 19-2015: Analýza aktuálního stavu vývoje občanských sítí ve světě, zejména detekčních sítí v projektech zahájených po nehodě JE Fukušima (in Czech).

- **Devices for mobile monitoring**

These devices are battery powered with long operation time, compact, resistant to weather and mechanical influences composed of detector coupled with processor unit and GPS module, providing storage of measured values together with date/time and geographical coordinates.

Measured values are displayed on the device, and can be tranferred both to local PC and to central server for storage, processing and web map-based presentation

Example:

Safecast bGeigie Nano (Japan/USA)

Sophisticated device equipped with GM pancake detector, Li-Ion battery charged via USB (>30h operation), display of actually measured value (CPS/µSv/h), data storage on removable SD-card (every 5 sec), data transfer to central database via PC (SD-card) or via BT coupled smartphone (on-line data transfer), price ~ 600 euro.

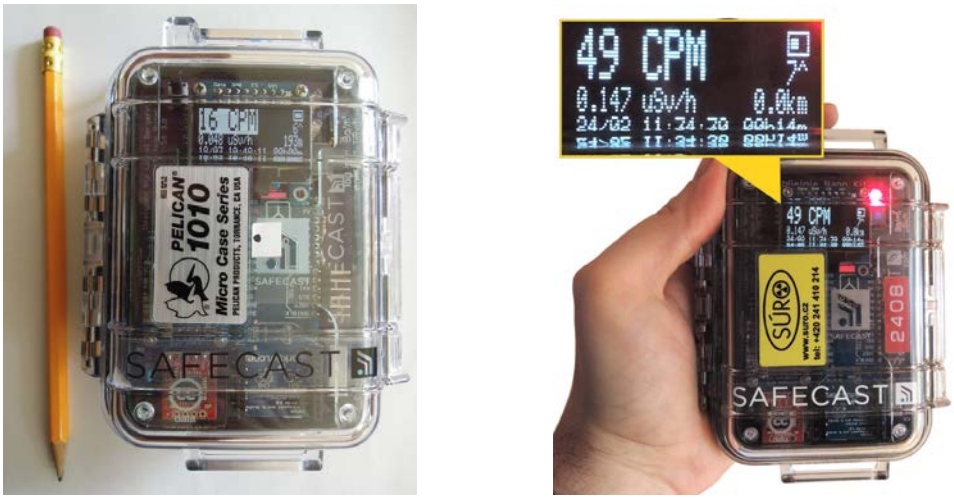


Fig 6 Safecast bGeigie Nano device suitable for mobile monitoring

Web presentations shown worldwide exploitation of the SAFECAST network.[1]

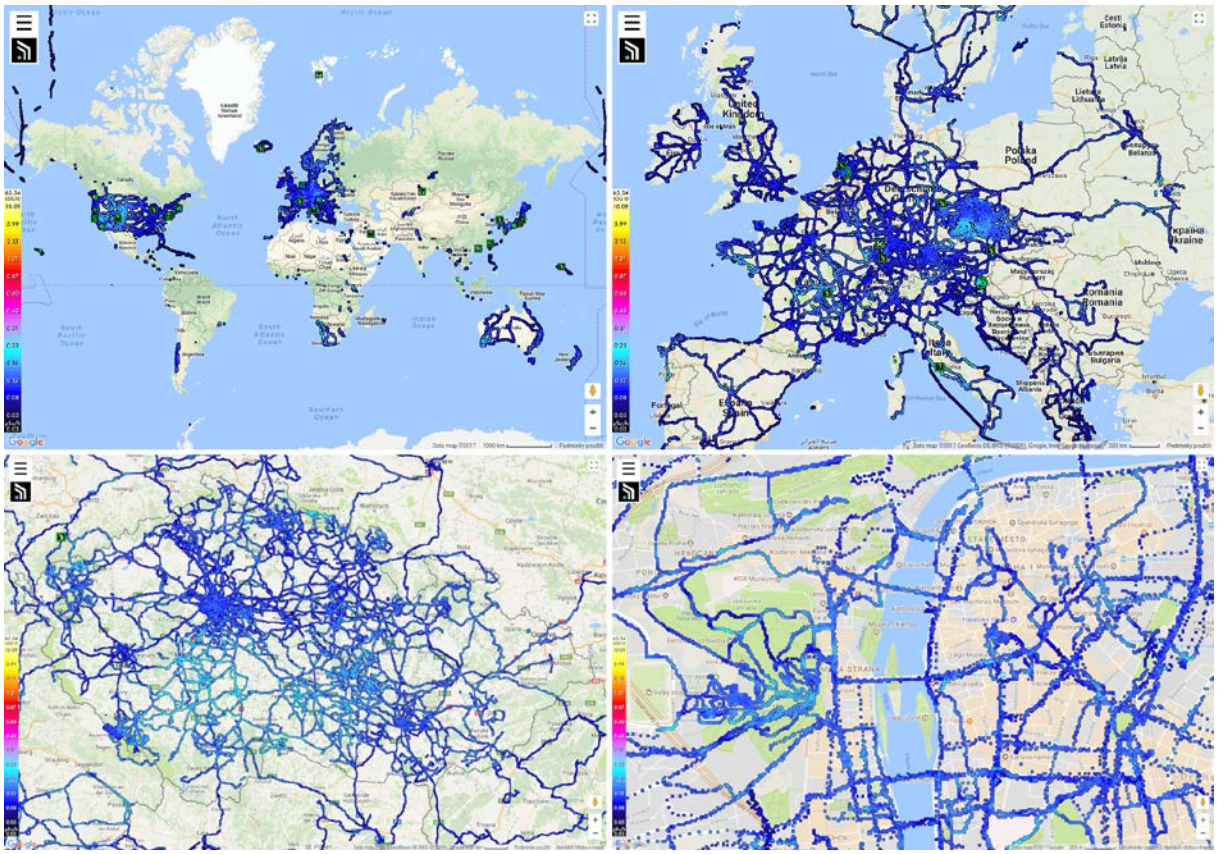


Fig. 7 Examples of web presentation of results obtained by Safecast bGeigie Nano

Czech approach – project RAMESIS

In the Czech Republic, the implementation of such an approach is investigated in the framework of security research founded by the Czech Ministry of Interior. Especially the "RAMESIS" project solved by SURO is aimed at creating tools for supporting citizen monitoring and at establishment and long-time performance of citizen monitoring network on nationwide level.

Project RAMESIS – basics

ID 20152019028 RAMESIS „Radiation Monitoring Network for institutions and schools to assure early awareness and enhancing safety of citizens" is a shared project of research (SURO & UTEF[2] CTU) and commerce (NUVIA[3]) subjects, aimed at improvement safety of population through introducing of radiation monitoring system at level of institutions, schools and citizens in accordance with current international trends. Instrumentation including central application for receipt, storage, administration and publication of monitoring results will be analyzed, projected,

[1] Available on blog.safecast.org *(registration necessary for data providers only)*.
[2] Institute of Experimental and Applied Physics Czech Technical University in Prague, Czech Republic.
[3] NUVIA, a.s. (stock company), Třebíč, Czech Republic.

developed and obtained. System will be implemented at selected institutions and schools, including training and informational materials for understanding radiation problems.

Objectives of the project are:

- design, development, operational testing and implementation of tools for supporting citizens radiation monitoring networks (detectors, communication, central database/application for local&web data presentation),
- prepare of information materials, methodics, manuals, etc. for users and public,
- prepare the system for possible future integration of results of citizens monitoring into Radiation Monitoring Network[1] operated by authorities.[2]

Roles of participants in the project are as follows:

SURO - project coordinator,

- formulation of requirements for design and parameters of detectors, monitoring network and central database/application,
- communication to public and users,
- cooperation on design and development of both detectors and central apllication for data receiving, storin, processing and presentation,
- design and development of tools for users enabling local data processing and presentation,
- preparation of inform. materials, documents, guides etc. for both users and public
- implementation of mobile monitoring,
- testing of both detectors and instrumentation in field use.

NUVIA

- design and realization of central database&applicaton for receiving, storing, processing measurement results and publication on web.

UTEF

- development of detectors
  - for fixed stations network based on Si-diode,
  - advanced detectors based on pixel Si/GaAs detectors for schools.

Project RAMESIS – main results achieved

Citizen monitoring network for mobile monitoring:

- **implementation of mobile monitoring** using SAFECAST bGeigie nano devices

[1] State Office for Nuclear Safety (SUJB), www.sujb.cz/en/
[2] www.sujb.cz/en/radiation-situation-monitoring/

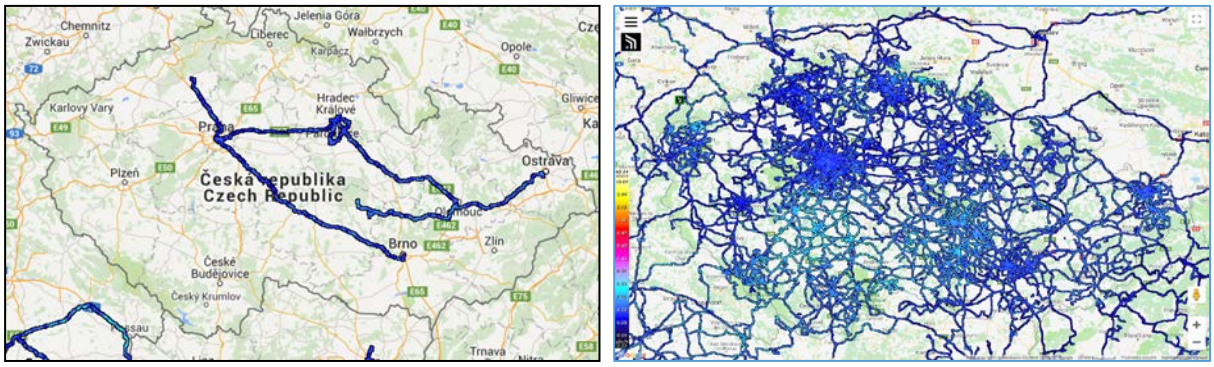


Fig. 8 Coverage of Czechia by Safecast mobile monitoring - July 2017 to June 2019

- **preparation of tools for supporting users** based on Open-source[1] solutions QGIS[2] and OpenStreetMap, including providing of vector off-line maps available for download for Czech Republic and for other regions (on demand)
  - tool for off-line maps generation using OpenStreetMap source data
  - tool for local (on PC/NB) processing and presentation of results with automatic choce of display parametrs and showing basic statistic parameters.

QGIS presentation of mobile monitoring results using RAMESIS/Safecast plugin on map background using on-line and off-line backgroud maps:

a) using on-line maps - OpenStreetMap, (GoogleMaps, Bing, … also available)

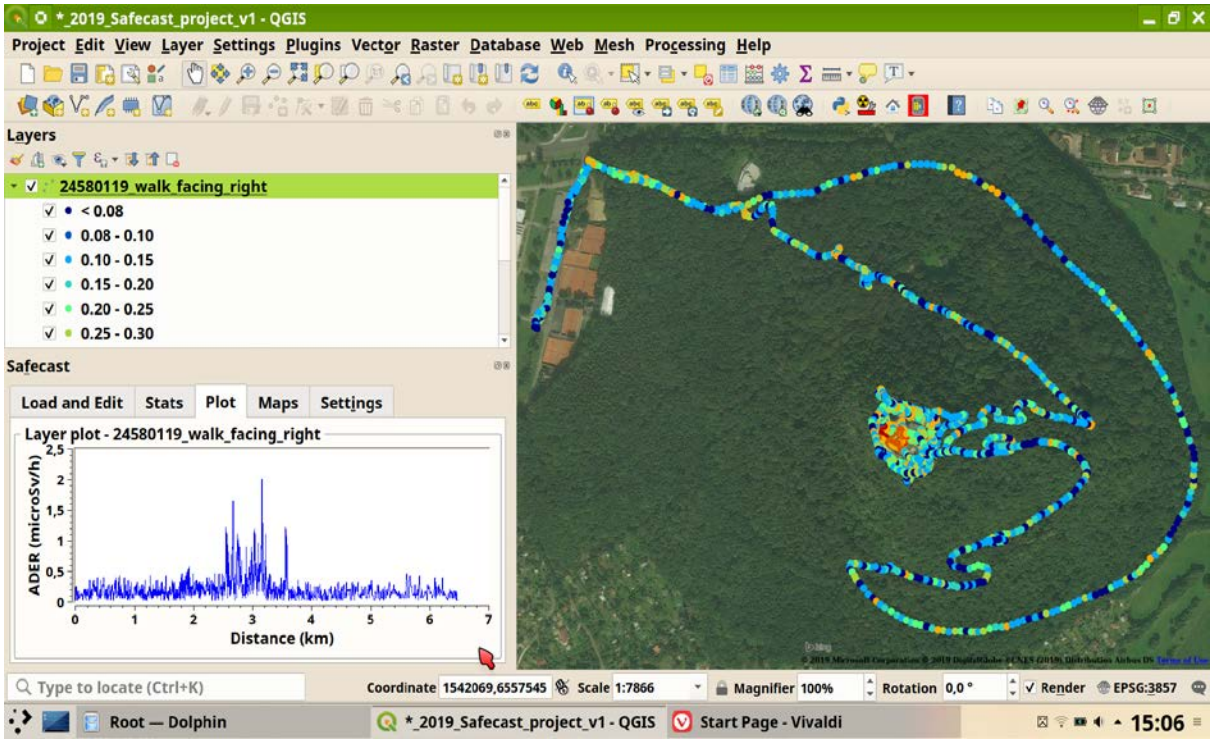


Fig. 9a Presentation of mobile monitoring results using on-line maps

[1] Open Source Organization, web opensource.com
[2] QGIS – A Free and Open Source Geographic Information System, web QGIS.org

b) using off-line maps generated by SURO(based on OpenStreetMap sources)

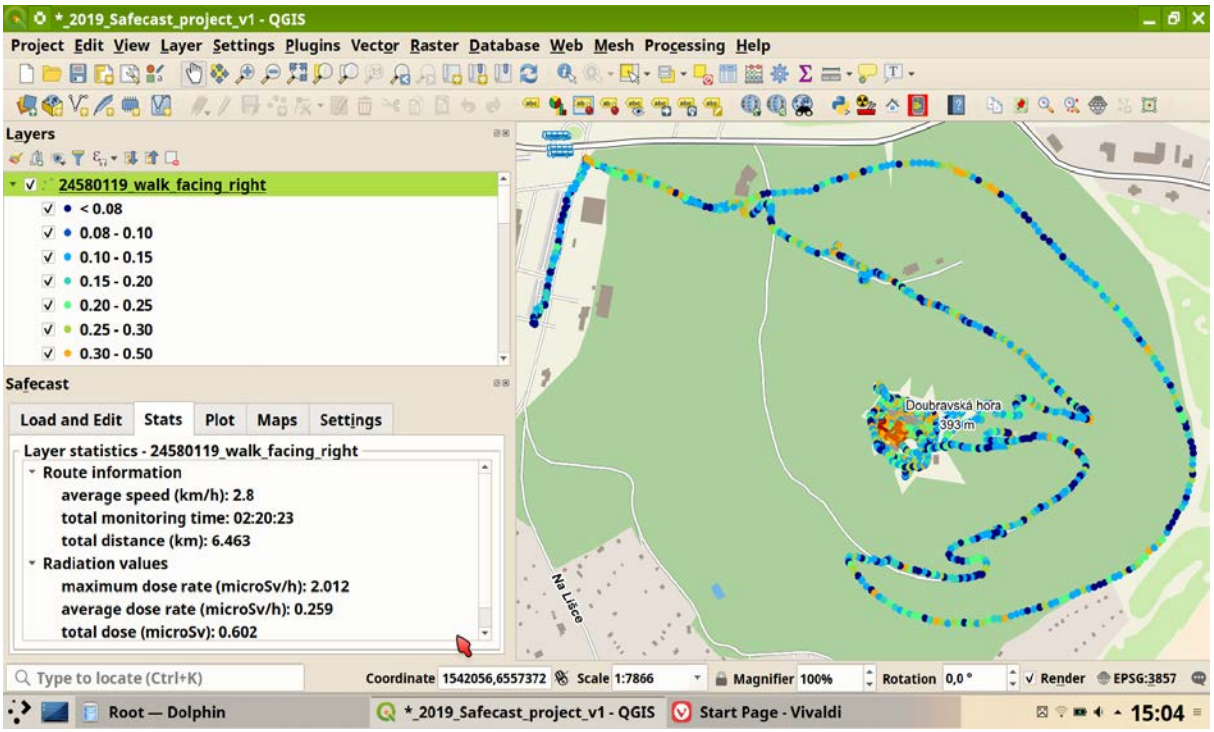


Fig. 9b Presentation of mobile monitoring results using off-line maps

Citizen monitoring network for fixed-stations monitoring:

- development of detectors for fixed stations network (based on Si-diode)

prototypes final version final version - detail

Fig. 10 Detector for fix-monitoring network

Instrumentation for Citizen monitoring network
(accessible on www.suro.cz/aplikace/ramesis/)

- RAMESIS server application for the citizen monitoring network, including central database and applicaton for receiving, storing and processing measurement results, and their publication on web – covering both mobile and fixed-stations monitoring

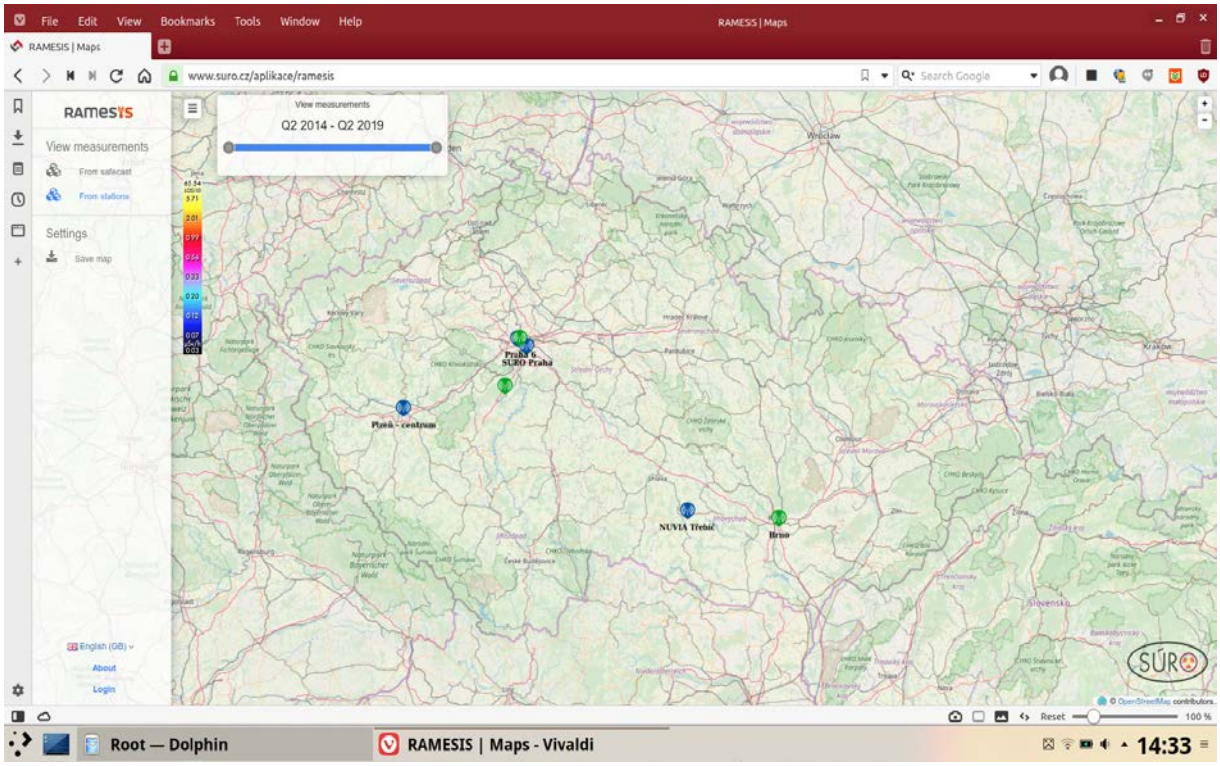
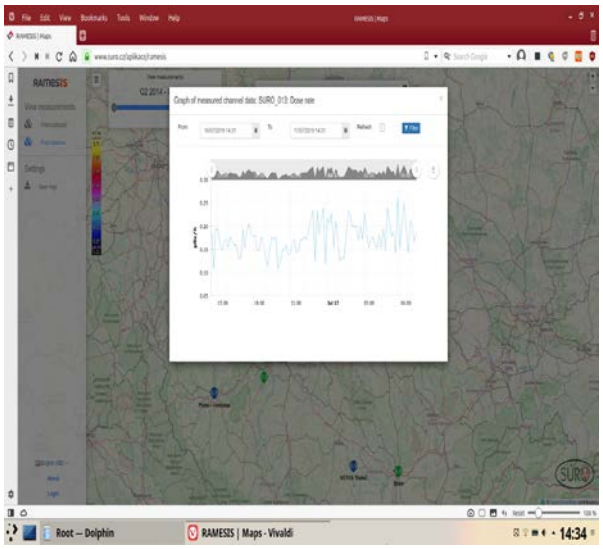
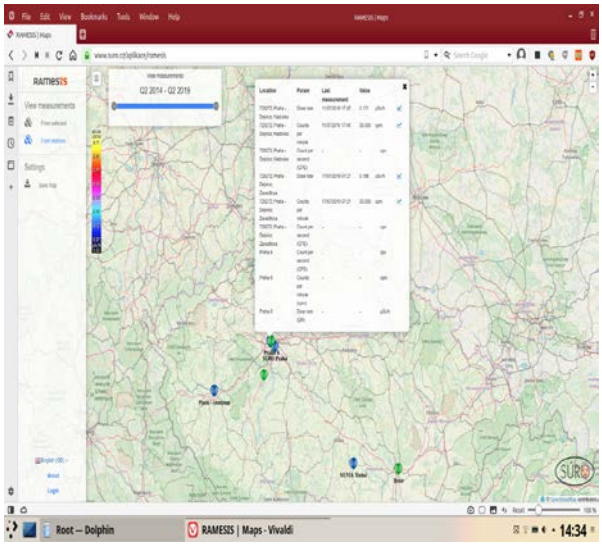


Fig. 11a Web presentation of Citizen monitoring network results of fixed-stations monitoring: overview (above) and detail information (below)





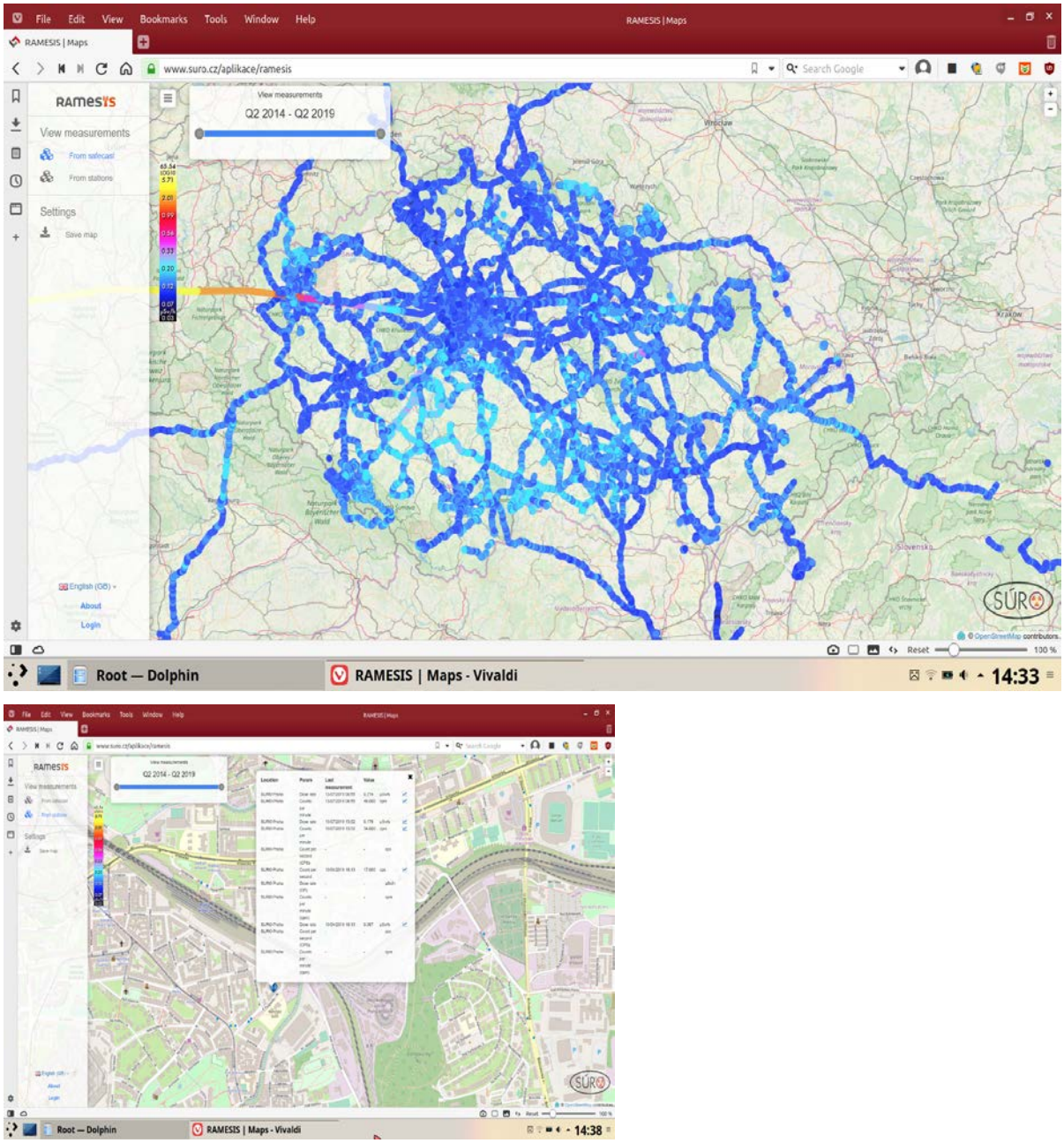


Fig. 11b Web presentation of Citizen monitoring network results of mobile monitoring: overview (above) and detail information (below)

Information materials, documents, guides etc. for users and public

Information materials prepared in the frame of RAMESIS project covering

- Information of radiation and radiation protection problems
- Guides for performing measurements and providing data to central database
- Manuals for using instrumentation and tools developed in RAMESIS project

are available on www.suro.cz/aplikace/ramesis-wiki/

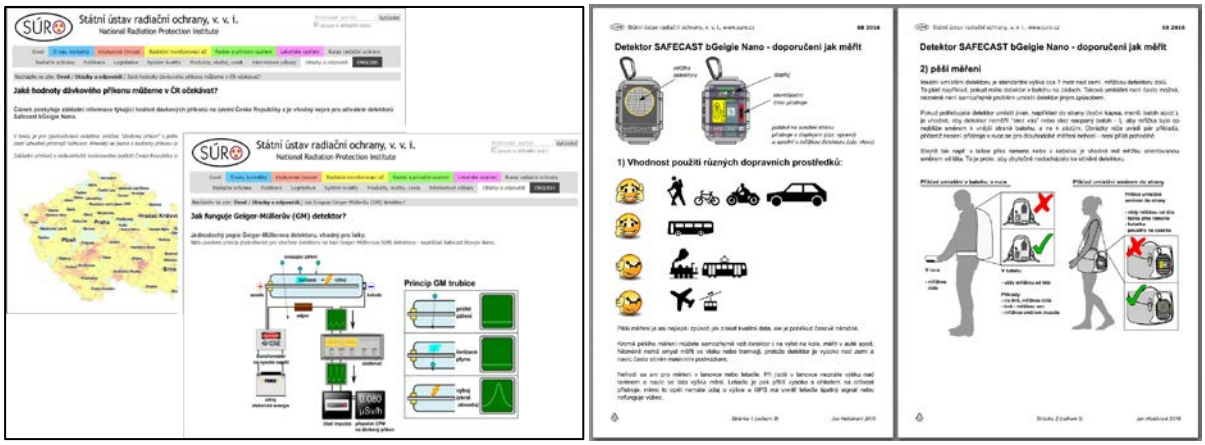


Fig. 12 Examples of information provided by the RAMESIS-wiki web pages

Advanced detector based on pixel Si/GaAs technology

Detector Medipix-type based on silicon sensor in form of 256x256 pixels of 55μm size for detection of alpha, beta, gamma, ion, neutron particles,[1] with USB connection to PC for data processing and visualization, suitable for advanced physical experiments in schools.

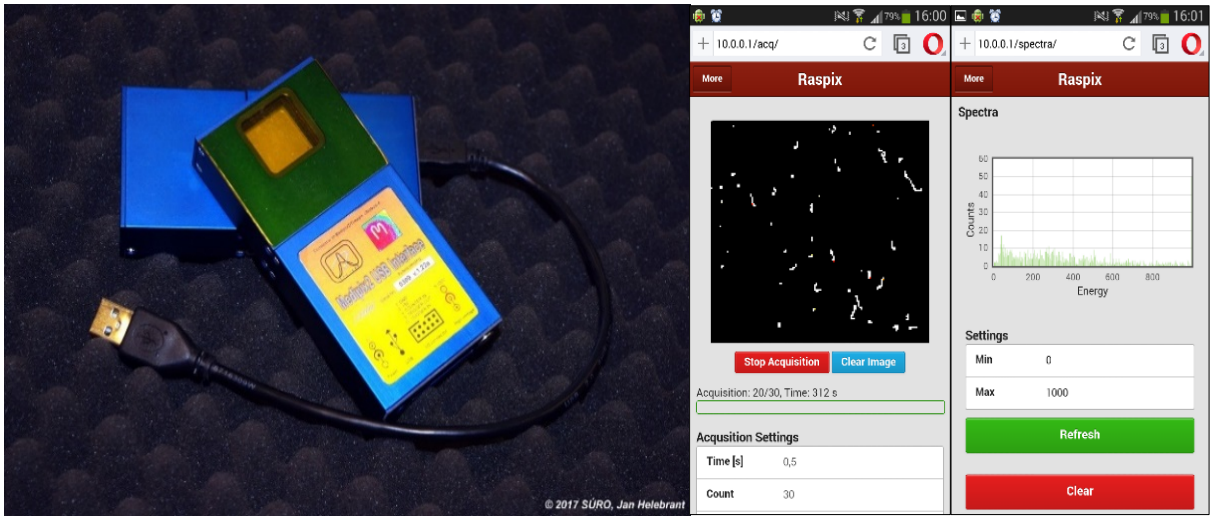


Fig. 13 Advanced detectors for school experiments

Calibration and testing of detectors in the SURO calibration laboratory

Detectors developed in the frame of RAMESIS project were tested and calibrated in the SURO calibration laboratory using gamma- and X-ray sources. Calibration covers dependence of detectors´response on dose rate, energy, direction of irradiation, and for Safecast bGeigie nano device also on ambient temperarture in the clima-box.

[1] VÍCHA, Vladimír. *Experiments using Pixel Detector in Teaching Nuclear and Particle Physics*. UTEF ČVUT, 2017. ISBN 978-80-01-06108-4.

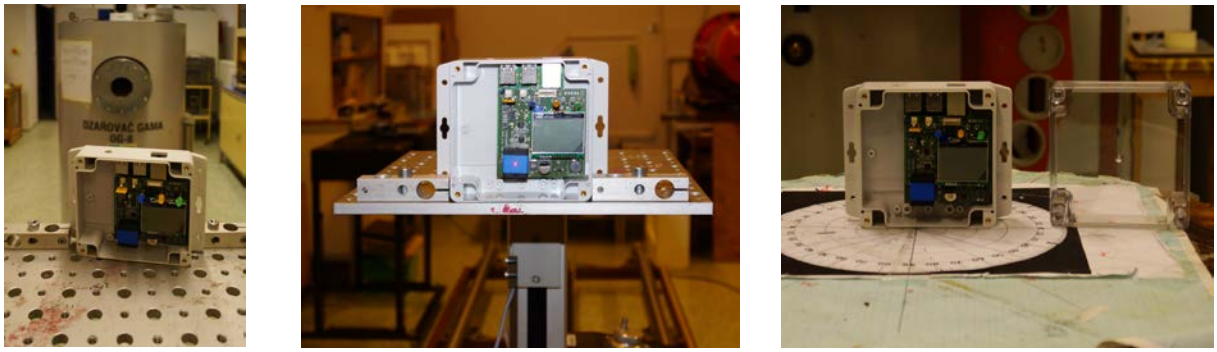


Fig. 14 Examples of detectors testing in SURO Calibration Laboratory

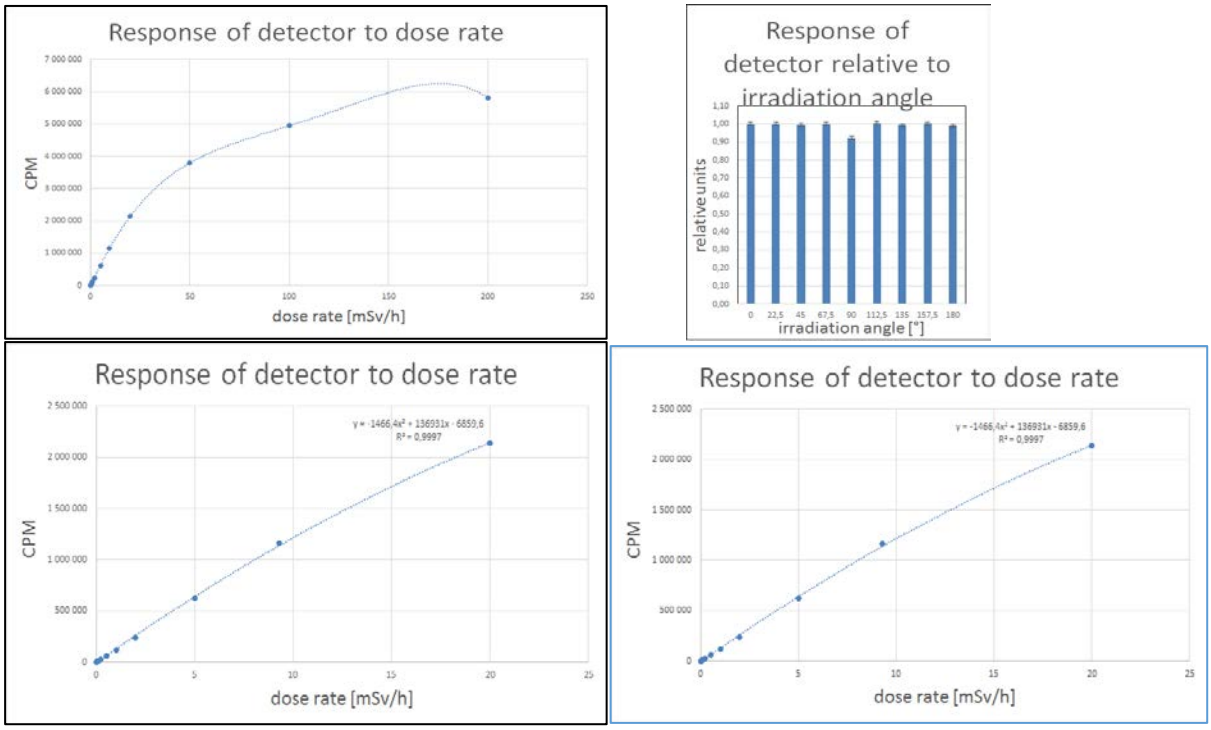


Fig. 15 Examples of detectors testing in SURO Calibration Laboratory

Discussion

RAMESIS project results

- Technical solution matching appropriate requirements was discussed, tested, optimized and verified by the project participants, considering both technical and economical aspects, to reach the level of industrial production capability and wide applicability,
- The device fox fixed-station monitoring was registered as „Industrial design“,
- System enables continuous monitoring of radiation situation by measuring gamma dose rate in range from tens of nSv/h up to tens of mSv/h, covering both monitoring of natural background in given locality and values of dose rate considered in case of emergency,

- System enables obtaining warnings in case of occurrence of higher dose rate values,
- System ensure automatic operation (24 hours per day 7 days a week) with transferring data into central database (using common internet connections),
- The device fox fixed-station can be used for performing physics experiments and demonstrations in laboratories, schools, etc..

General approach

Experience from Chernobyl and Fukushima accidents:

- public will demand information in case authorities and/or NPP operator fail in providing **complex**, **reliable** and **in-time information** they will loose credibility at all…
- public cannot be stopped or restricted
  - in attempts to obtain information, including obtaining of detectors and performing their own measurements,
  - in sharing results of monitoring, information, etc. on social networks.

CONs and Pros of engaging citizens monitoring in coping emergency

CONs – questions/risks:

- **results of citizen monitoring provide usually only a basic rough information,** total dose-rates measured by simple detectors usually used by the public may not be sufficient for proper and complex evaluation of radiation situation and for prognosis of its development, nevertheless if properly treated they can make significant contribution to overall evaluation of the radiation situation**.**
- **expert engagement is inevitable**, providing appropriate evaluation of radiation situation based on as much complex information on the situation as available to avoid misunderstandings and/or misinterpretations (e. g. noble gas release from the Fukushima NPP)**.**
- **results misinterpretation and/or hoaxes** - may cause incommensurate reactions of public and even panic behavior…

- **overwhelming of the authorities** by requests for evaluation/explanation etc., often followed by endless discussions of possible (including not reasonable) alternatives
- **demands of public for „alternative opinions“ by „independent“ experts** – but who are they?

PROs – benefits:

- **Citizen data can help in more efficient usage of response capabilities** in the event of an accident an enormous amount of data could be obtained by citizens (very quick and cheap) at the time when government could have only limited capacity of measurements – e.g. all roads on Czechia (approx. 131 000 km of national&local roads) can be measured during one day using about 333 Safecasts, assuming monitoring speed of 40-50km/h).

- **Citizens (stakeholders) involvement in measurements in advance** *(under normal circumstances yet)* can help increase their **education for better understanding** of radiation risks.
- **Increase stakeholders and general public confidence to information provided by authorities** both before and during emergency.
- **Local data** could be available even in case of a large/total blackout.

Conclusions

- **Involvement of stakeholders and general** public plays one of the key roles in the process of effective solving problems in emergency preparedness, response and remediation on affected territories. To accomplish these tasks, it is necessary to gain all the participants´ confidence - especially of stakeholders and general public - in information on radiation situation provided by the authorities.
- **Engaging public in monitoring** performed on voluntarily basis can help keeping or even **increasing credibility** of both stakeholders and general public to information and recommendation given by authorities **for proper coping the emergency.**
- For proper understanding the radiation situation and giving chance for wide adopting necessary radiation **protection measures by the stakeholders and general public**, they must get appropriate information and education **in advance.**

  Successful nationwide implementation of citizen monitoring can lead to significant increase od safety and secutiry of public in case of radiation acccident and incidents.

Literature

HŮLKA, Jiří; KUČA, Petr; HELEBRANT, Jan a Zdeněk ROZLÍVKA. Citizen Measurements in Radiation Protection and Emergency Preparedness and Response - its role, pros and cons. EUROSAFE Forum 2017 Proceedings, 6-7 Nov 2017, Paris, France.

BOINC Polska Foundation, radioactivehome.org/boinc/ (registration necessary).

Mobile and stationary radiation monitoring systems of the new generation for radiation monitoring networks (MOSTAR), ID 20122015083, research project supported by Ministry of Interior of the Czech Republic.

Zpráva SÚRO č. 19-2015: Analýza aktuálního stavu vývoje občanských sítí ve světě, zejména detekčních sítí v projektech zahájených po nehodě JE Fukušima (in Czech)

SAFECAST – OPEN DATA FOR EVERYONE. Available on blog.safecast.org *(registration necessary for data providers only)*.

State Office for Nuclear Safety (SUJB), www.sujb.cz/en/

State Office for Nuclear Safety (SUJB), www.sujb.cz/en/radiation-situation-monitoring/

Open Source Organization, web opensource.com

QGIS – A Free and Open Source Geographic Information System, web QGIS.org

VÍCHA, Vladimír. Experiments using Pixel Detector in Teaching Nuclear and Particle Physics, UTEF ČVUT 2017. ISBN 978-80-01-06108-4.

R E S U M É

KUČA, Petr; HELEBRANT, Jan; ČEŠPÍROVÁ, Irena Jiří HŮLKA: ZVÝŠENÍ BEZPEČNOSTI OBČANŮ MĚST A OBCÍ POMOCÍ IMPLEMENTACE RADIAČNÍHO MONITOROVACÍHO SYSTÉMU NA ÚROVNI INSTITUCÍ, ŠKOL A OBČANŮ – PROJEKT RAMESIS

Článek prezentuje výzkumná zjištění vědeckovýzkumného úkolu – projektu RAMESIS řešeného v rámci bezpečnostního výzkumu podporovaného Ministerstvem vnitra České republiky „Radiační měřící síť pro instituce a školy k zajištění včasné informovanosti a zvýšení bezpečnosti občanů měst a obcí“ společně SÚRO, ÚTEF ČVUT a NUVIA. Projekt je zaměřen na zvýšení bezpečnosti občanů měst a obcí pomocí implementace systému monitorování radiační situace na úrovni institucí, škol a občanů odpovídající aktuálním světovým trendům v této oblasti. Projekt této občanské měřicí sítě zahrnuje návrh, vývoj a realizaci detektorů a centrální aplikace měřicí sítě pro přenos dat a jejich ukládání, zpracování a prezentaci na webových stránkách. Systém bude implementován na úrovni vybraných institucí, škol a občanů, včetně poskytování návodů a informačních materiálů pro porozumění problematice radiační ochrany, čímž umožní včasnou detekci přítomnosti radioaktivních materiálů měřením příkonu záření gama v husté síti měřicích míst zahrnující fixních a mobilní měření. Výsledkem zvýšení a prohloubení informovanosti obyvatelstva v oblasti radiační ochrany, vedoucí ke zvýšení bezpečnosti občanů.

Klíčová slova: monitorování radiační situace, občanské měřicí sítě, dávkový příkon záření gama, radiační ochrana, bezpečnost občanů.

S U M M A R Y

The article presents findings of scientific research of the project RAMESIS in the frame of Security research supported by the Czech Ministry of interior „Radiation Monitoring Network for institutions and schools to assure early awareness and enhancing safety of citizens“ - shared project of SURO&UTEF&NUVIA, aimed at improvement safety of population through introducing of radiation monitoring system at level of institutions, schools and citizens in accordance with current international trends. Project covers design and development of detectors and of central application for receipt, storage, administration and publication of monitoring results on webpages. System will be widely implemented at selected institutions and schools, including training and informational materials for understanding radiation problems, resulting into increasing and intensifying of ability for early detection of radioactive material presence through monitoring of dose-rate using high-density network of both fixed-station and mobile monitoring, leading to increase of the level of awareness of general public in the field of radiation protection.

Keywords: Radiation situation monitoring, Citizen Monitoring Network, Gamma dose rate, Radiation Protection, Safety of Population.