

## Practical Use of the Mobile Radiological Laboratory to Support the Nuclear Regulatory Authority of Ukraine

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### **Abstract:**

The State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) is the technical support organization providing expert support to the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). Technical means of SSTC NRS include, among others, mobile radiological laboratory RanidSONNI. This paper describes equipment of the mobile laboratory, tasks to be accomplished by using it, experiences in using RanidSONNI, in particular, during the UEFA Championship EURO-2012 and survey of an oncological center (National Institute of Cancer), analysis of capabilities of the mobile laboratory in undertaking certain tasks.

In the framework of the IAEA project UKR/9/028 "Strengthening of nuclear and radiation safety infrastructure" SNRIU, being the nuclear and radiation safety regulatory authority, received a mobile radiological laboratory (radiation reconnaissance vehicle) RanidSONNI at the end of 2010 (Fig. 1.1). The mobile laboratory was developed and manufactured in Finland by the Environics Company. The delivery was done via IAEA in cooperation with the nuclear and radiation safety regulatory authority of Finland (STUK). Since 2011 the mobile laboratory RanidSONNI is on the balance of SSTC NRS and is used by its personnel.

## 1 MOBILE RADIOLOGICAL LABORATORY RanidSONNI EQUIPMENT



Fig. 1.1 – Mobile radiological laboratory RanidSONNI

### 1.1 Stationary equipment

The measurement system has two large NaI(Tl) scintillation detectors which are mounted on the opposite walls facing the sides of the RanidSONNI. Steel shields of 10 mm around the detectors create 180° fields of view opening outwards. This type of configuration enables good detection and localization of radiation sources.



Fig.1.2 – Scintillation detectors NaI (Tl)

RanidPro100 LaBr3 detector (Fig.1.3) is mounted in front of the vehicle. It is located above and in between driver and the co-drivers' seat. It is installed inside 10 mm thick background radiation shield tube opening in the direction of travel. This type of collimation makes it possible to make a spatial scan of the incident site from a distance. In addition, it gives a capability to pinpoint target vehicles among the traffic

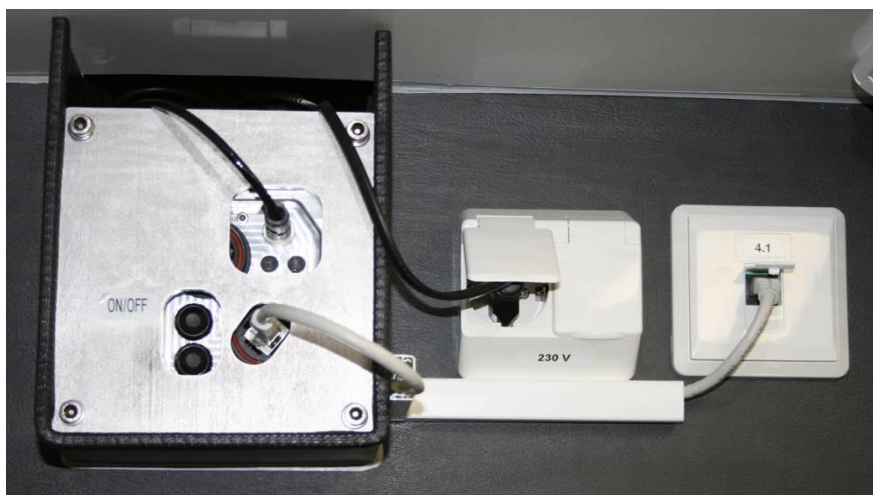


Fig. 1.3 – RanidPro100 LaBr3 detector

The mobile laboratory is equipped with two fixed air samplers (Fig.1.4). The filters are laminated into a plastic cassette, which make sample handling easy in the moving vehicle. Sample preparation is not needed before measurement because of the design of the filter cassette.

The main features of the system are as follows:

- two collection lines for air sample collection;
- adjustable air flow from 10 - 40 m<sup>3</sup> per hour, with possibility of stepwise adjustment;
- filter holder cassettes to facilitate easy sample handling;
- possibility to use glass fiber and membrane filters;
- collection areas compatible with 76 mm diameter gamma spectrometer end cap.



Fig.1.4 – Air sampling system: 1-air collection controller, 2-filter holder, 3-air samplers

The mobile radiological laboratory RanidSONNI is equipped with a portable spectrometer “ORTEC-AMETEK” on the basis of pure germanium (with electric cooler). This allows making measurements of samples and filters directly at the sampling point. Location of the spectrometer in the vehicle is shown in Fig. 1.5.

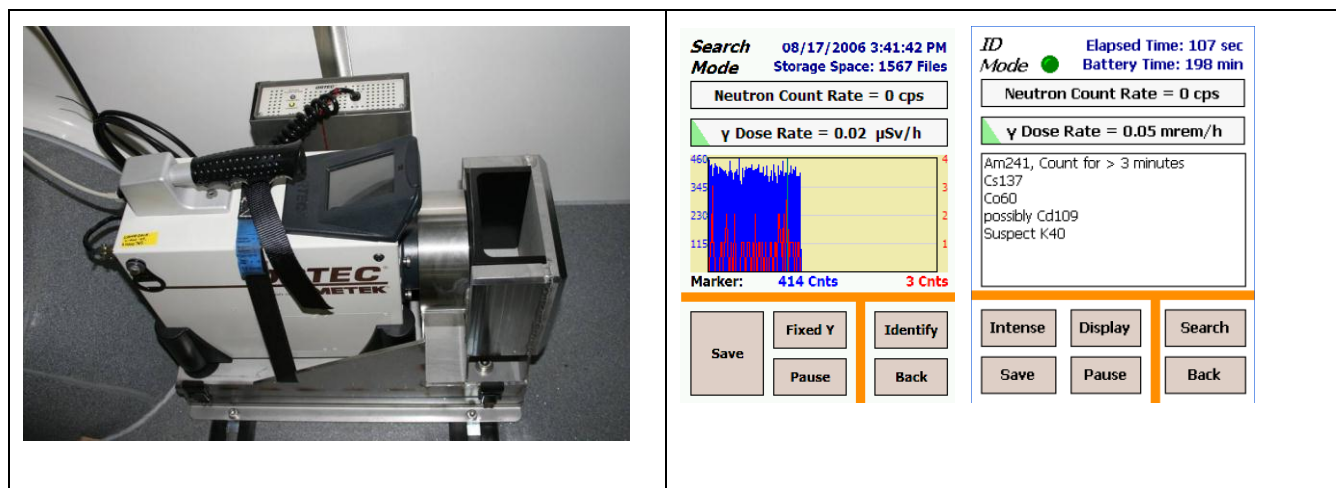


Fig. 1.5 - Ortec Portable HPGe Detector/Nuclide Identifier

## 1.2 Equipment for field measurements

The mobile laboratory RanidSONNI is also equipped with a portable measurement system Vasikka in a backpack (Fig. 1.6) used for online assessment of radiation situation.

Vasikka is a portable device for detection, identification and data collection. Vasikka is composed of a laptop, gamma and neutron detectors. For remote system control a mobile phone or palmtop can be used. Vasikka continuously collects and analyzes radiation information from detectors. All collected data are stored in a database for subsequent review or detailed analysis.



Fig.1.6 – Portable measurement system Vasikka in a backpack. 1 – neutron detector with digital multi-channel analyzer; 2 – remote control palmtop; 3 – laptop with software, GPS-receiver and database; 4 – LaBr gamma with digital multi-channel analyzer

Vasikka system is controlled by specially developed software, which ensures performance of field spectrometry, radiation monitoring in real-time mode and data transfer. The same software is installed on the server and mobile laboratory RanidSONNI workstations.

The vehicle has a portable air sampler (Fig.1.7). The stand-alone sampler is portable and battery-powered; so they can be dropped at any location for fully autonomous sampling. The filters are laminated into a plastic cassette, which make sample handling easy. Sample

preparation is not needed before measurement because of the design of the filter cassette. Air consumption is up to 12 m<sup>3</sup>/h.



Fig.1.7 – Portable air sampler

### 1.3 Peripheral systems and equipment

The vehicle is equipped with the wireless intercom system for up to 4 users (Fig.1.8). The system consists of one base unit where four handsets could be connected.

#### GPS positioning system

A combined GPS antenna & receiver is mounted on the roof of the vehicle. The vehicle location will be stored in the database.

#### Surveillance camera

The system has forward looking surveillance camera (Bosch DinionXF IP camera) with digital image storage to the commander's laptop.

### 1.4 Collection, processing and information transfer system

The system includes one main server and three working stations.

The main server uses computer hardware tools, including radionuclides identification software. The main server type is HP ML350G6 E552. It is running with Linux-based operating system, and it handles all of the measurement data from the different detectors and measurement systems. Measurement data is analyzed with Vasikka radionuclide identification software

All of the sensors are connected to the server via communication network (hardwired TCP/IP, USB).

The working stations are operating with Windows Vista operation system. The working stations are connected to the main server through local area network (LAN). All of the working stations can operate independently and manage the measurement data through local area network.

The vehicle is also equipped with a 3G-modem to transfer the measurement data (from each detector) and information on the vehicle location (GPS-coordinates) to the SSTC NRS server in automatic on-line mode.

On the SSTC NRS server the data are processed and stored in a special database which is accessible for on-line support of radiation reconnaissance as well as for subsequent, more detailed analysis of results.

## 2 MAIN TASKS FOR THE MOBILE LABORATORY

The mobile laboratory RanidSONNI is used for:

- monitoring of radiation situation around radiation-hazardous facilities (NPPs, research reactors, uranium mining and processing enterprises etc.) at all stages of their life-cycle;
- search, identification and preliminary categorization of orphan ionizing radiation sources (IRS), and IRS which can be out of regulatory control due to natural disaster, emergency situations etc.;
- radiation monitoring for early detection of IRS in places of mass events;
- support of regional state nuclear and radiation safety inspectorates under surveys of radiation-hazardous facilities.

To ensure fulfilment of the above tasks, the following has been performed:

- metrological certification of the RanidSONNI measurement equipment;
- theoretical and practical training of personnel (two crews) and equipping the crews with individual protection means;
- according to legislative procedure, permission was obtained in the State Automobile Inspectorate of the Ministry for Internal Affairs in Kyiv for operation of the RanidSONNI mobile laboratory in a Mercedes-Benz vehicle using a flashing orange light;
- equipping of the mobile laboratory with consumables.

## 3 PRACTICAL EXPERIENCES IN USE OF THE MOBILE RADIOLOGICAL LABORATORY RanidSONNI AND ITS INSTRUMENTS

### 3.1 UEFA Football Championship EURO-2012

To fulfil order of the SNRIU and to ensure systematic radiation monitoring along the perimeter and on the territory of the fanzone at the Independence Square in Kyiv during the EURO-2012 Finals, the SSTC NRS Radiation Protection Department implemented the corresponding activities.

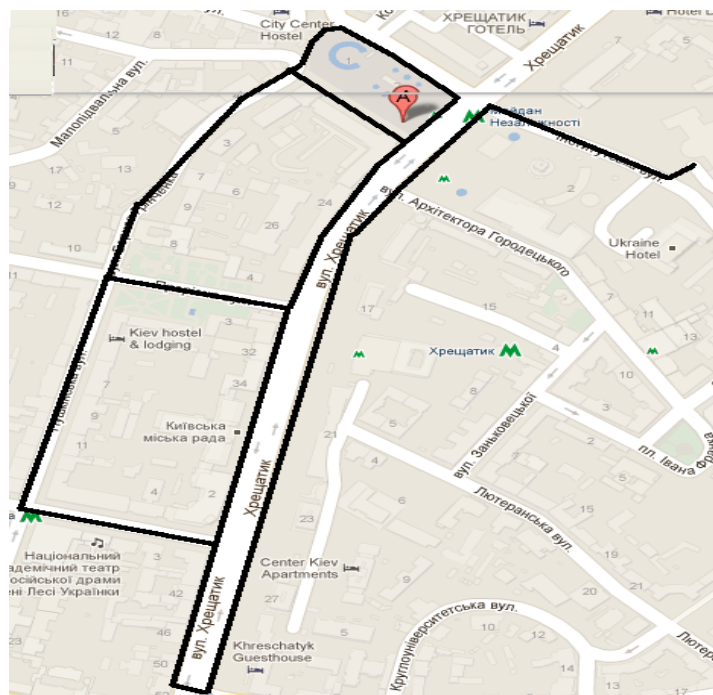
All available measurement devices were used, and, in addition, for the period of the EURO-2012, the IAEA provided search equipment such as: portable spectrometer with gamma and neutron detectors MKC-AT6101C with software "ATAS Scanner", which is similar to "Vasikka" system, and two pagers of Polimaster type with CsI detectors.

All activities involving use of the RanidSONNI mobile laboratory were coordinated with SNRIU. The following measures were implemented to fulfil the assigned tasks:

1. Theoretical and practical sessions for training of mobile laboratory staff (2 to 5 April 2012 in Kyiv) and a workshop focusing on the concept of RanidSONNI use during EURO-2012 (10 and 11 May 2012 in Kyiv), with involvement of representatives from the Radiation and Nuclear Safety Authority of Finland (STUK) and the manufacturing company Environics were conducted;

2. In cooperation with the Kyiv City Administration's Main Department in charge of preparation for EURO-2012, routes for radiation surveys around the fanzone and parking

spot for the vehicle were identified. Permission was obtained for location of the RanidSONNI mobile laboratory by the International Center of Culture and Arts of Ukrainian Trade Unions. The staff involved into EURO-2012 activities was appropriately certified;

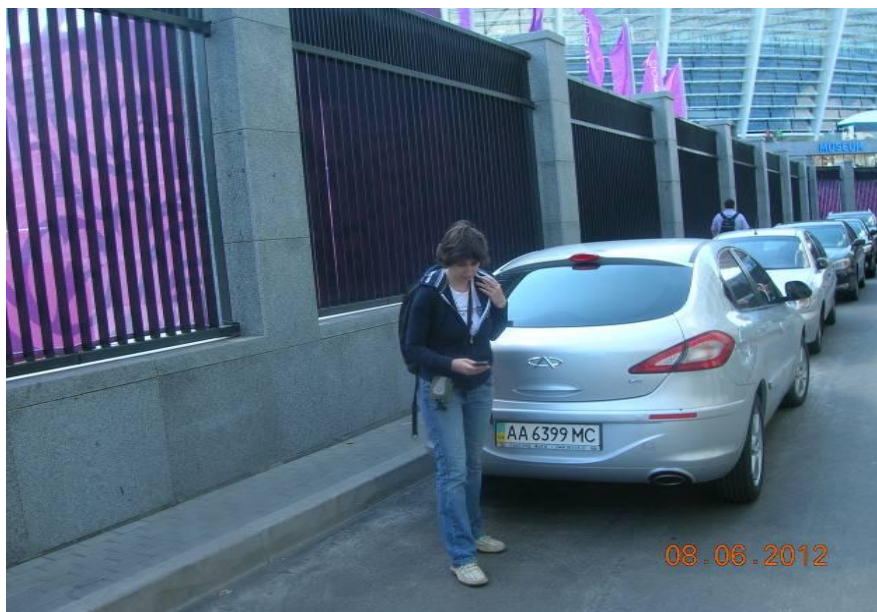


**Route for monitoring of the fanzone in Kreschatik, Pushkinska, Grinchenko Streets and Independence Square**

3. On the opening day of EURO-2012 Finals, 8 June 2012, background level was measured around the Olimpiysky Stadium, fanzone and adjacent streets using RanidSONNI stationary (on-board) equipment and portable devices;



**Measuring background level prior to opening of EURO-2012**



Survey of cars parked by the “Olimpiysky” Stadium

4. At the preparatory stage, crews were staffed with experts of the SSTC NRS Radiation Protection Department and SNRIU Radiation Safety Department and procedures were developed for operation of the RanidSONNI mobile laboratory from 7 June to 2 July 2012.



Crew briefing



**RanidSONNI crew prior to survey mission**

5. Radiation surveys were conducted on a daily basis, including weekends and holidays, twice a day. In the morning, the fanzone was checked using portable spectrometers to monitor potential locations of radiation sources (cars parked nearby, trash containers etc.). In the afternoon, the fanzone territory was checked after its opening using pagers.



**Survey along the fanzone perimeter**



Radiation survey of suspicious spots (dose rate to 2  $\mu\text{Sv/h}$ )



Radiation survey of underground passages



**Radiation survey of trash canisters**



**Radiation survey of parked cars**

In addition, radiation survey of city streets on the vehicle route using stationary devices was conducted. The routes were chosen in advance to cover as many city streets and squares as possible. The spectral data and results were remotely transmitted to the SSTC NRS server to a specially developed database (LINSSI), which facilitated subsequent

analysis at the SSTC NRS headquarters and thus enabled real-time supervision and guidance of the field performance.



**GPS route of the mobile laboratory introduced into the SSTC NRS server**

6. Radiation monitoring was conducted independently. The STUK and Environics (equipment manufacturer) experts were on call, should a need for support arise.

7. Measurement results were reported to the Head of SNRIU Radiation Safety Department on a daily basis.

## Results

Based on results of the performed measurements, the RanidSONNI crew on duty concluded that there were no incidents involving radiation sources, and dose rates on the routes remained at background level.

Radiation sources were revealed twice by means of portable devices: “medical source” (a patient) and “commercial source” (used in various devices, such as chemical detectors). The source was detected in a special-purpose vehicle of the Ministry of Emergencies of Ukraine. Both sources were detected owing to high sensitivity of the detectors, the dose rate remaining at background level.

Further to the positive experiences and outcomes, it is worth to take note of the following:

- professional training and well-defined operation of personnel of the mobile laboratory RanidSONNI were proven;
- reliable operation of the hardware complex, on-board equipment as well as portable equipment was confirmed;
- optimal planning of activities according to available human and equipment resources was accomplished;
- during survey of the downtown area, local spots (granite plates) were detected and identified, dose rate of which exceeded 2  $\mu\text{Sv/h}$ . If people stay near this spot during 2000 hours (number of working hours per year), exposure dose obtained may be 4 mSv (under permissible limit 1 mSv).

As a result of the activities performed and the analysis carried out, it can be concluded the objective to ensure systematic radiation monitoring of the assigned zones in Kiev during the EURO 2012 Championships was fully met.

Some lessons were also learned. Participation in radiation protection survey measures during mass events requires also financial support. Due to lack of financing, radiation survey of three other cities (Lviv, Donetsk, Kharkiv) of the EURO-2012 Finals using the RanidSONNI was not performed.

For efficient response to possible radiation incidents, even more close cooperation of executive power authorities is needed. As Finnish experience demonstrates, the cooperation with other authorities, such as police, border and customs, in conducting radiation surveys enhances efficiency and effectiveness of the security operations.

It would be reasonable to develop a specific program of the Kyiv city survey to detect “hot spots” of man-induced origin with the subsequent development of a program of corrective measures.

### 3.2 Survey of medical institutions

At the stage of the mobile laboratory RanidSONNI commissioning, a number of pilot surveys were conducted, in particular, radiological survey of the National Institute of Cancer territory (33/43, Lomonosova St., Kyiv). The National Institute of Cancer is a big oncological center possessing a considerable number of sealed IRS, radiopharmaceuticals, generating devices.

The measurement of the radiation situation using stationary detectors was conducted along the entire route from the moment of the departure of the mobile laboratory RanidSONNI until its return to SSTC NRS.

Continuous measurements using mobile laboratory detectors of the following areas of the National Institute of Cancer were conducted:

- parking lot near the administrative building of the Institute.
- at the entrance to the open-source department.
- on the run close to a spent materials settling tank of the open-source department.

Measurements using portable kit Vasikka and Detective-EX were conducted in the following places:

1. In premises of open-source department of the Institute:
  - brachytherapy premises (source Co-60 in container);
  - patients' waiting room after medical procedures with I-131;
  - under radiation source Co-60 in Rokus AM installation (6000 Ki) at closed gate;
  - close to operating tomograph;
  - close to empty transport container made of depleted uranium.
2. Above special drainage system of open-source department.

#### ***Survey results obtained during movement along Kyiv streets***

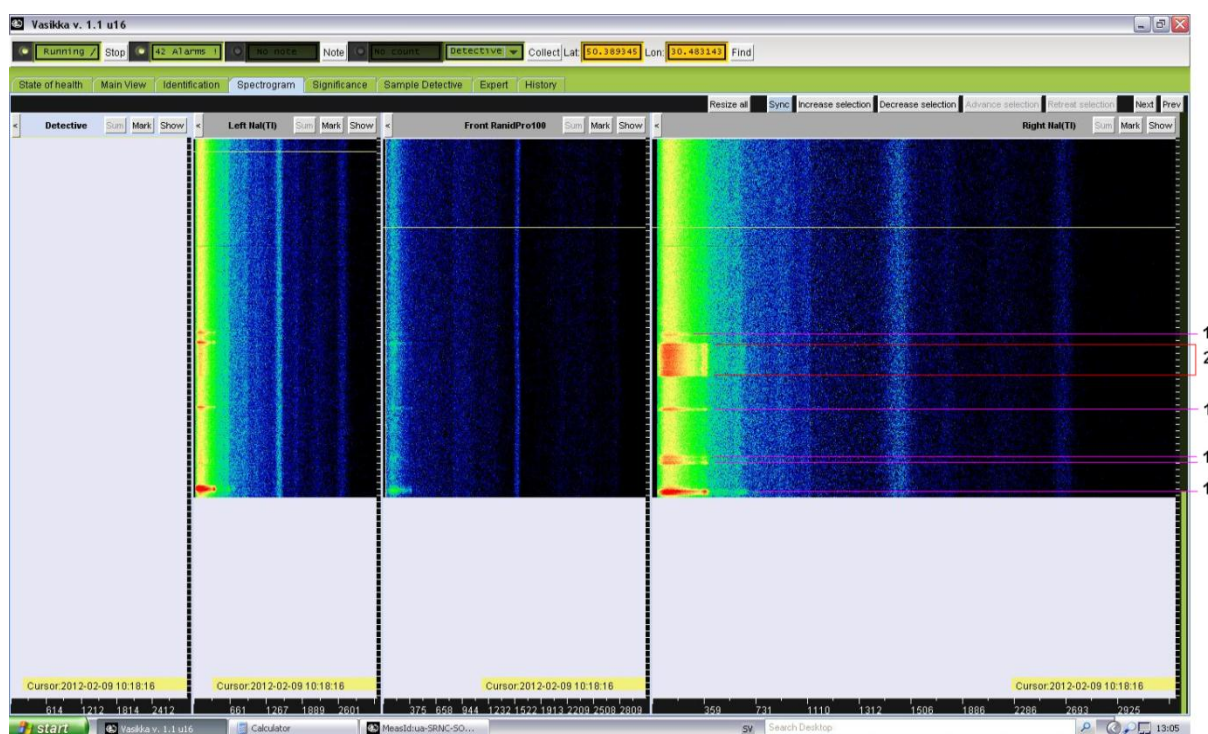
1. No radiation anomalies were detected during continuous monitoring on the route in Kyiv streets using stationary equipment of the mobile laboratory.

2. Spectrometric measurements have identified gamma-radiation sources – those were natural sources  $^{40}\text{K}$ ,  $^{232}\text{Th}$  in balance with daughter decay products.

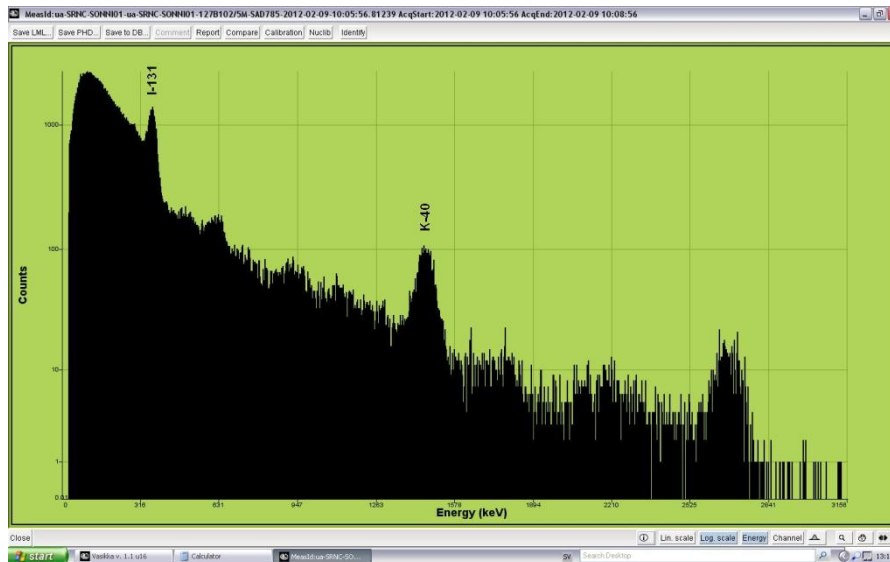
### ***Survey results using detectors of the mobile laboratory on the territory of the National Institute of Cancer***

1. Measurements made on the parking lot and on the territory of the Institute on the run have demonstrated that there were no radiation anomalies in the public places and radiation background sources were natural radioactive materials typical for Kyiv.

2. On the parking lot near an open-source department radiation anomalies relating to patients going out of the department after medical procedures were detected. Fig. 3.1 representing change of radiation situation with the course of time clearly shows increase of the background induced by some patients and a group of patients. Spectrometric analysis of radiation identified its origin – I-131 used in the department for treatment. Fig. 3.2 represents radiation spectrum for an individual patient. At the same time, in accordance with the Main Health and Safety Rules, it is necessary to point out that patients are allowed to leave the premise only under condition that the dose rate from a patient does not exceed 10  $\mu\text{Sv/h}$  at 1 m distance.

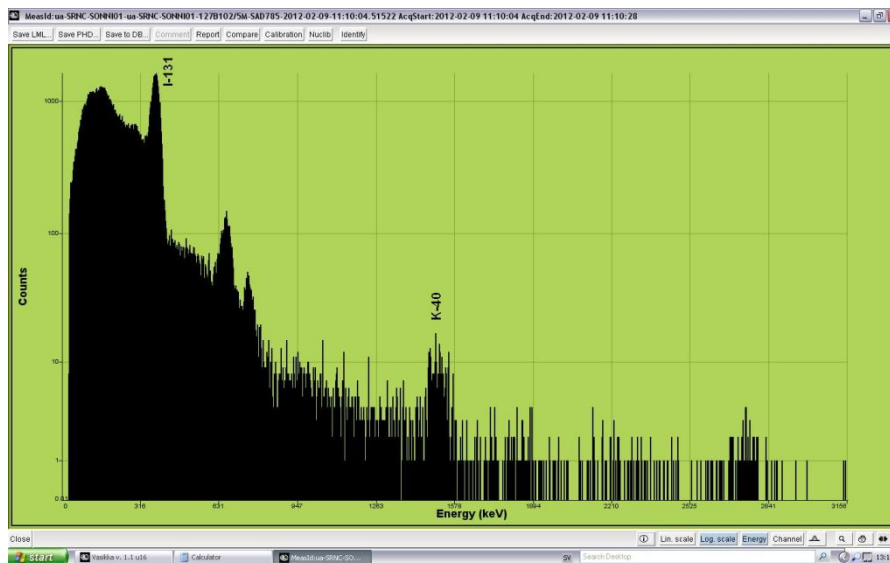


**Fig.3.1. Change of radiation situation when patients leave open-source department: 1 – for an individual patient, 2 – for a group of patients**



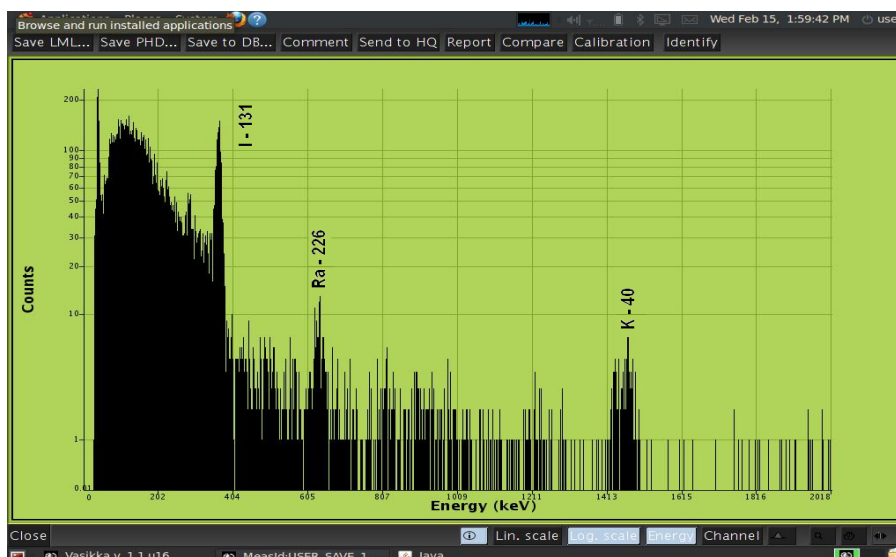
**Fig.3.2. Radiation spectrum of a patient leaving open-source department**

3. Survey of the road on the territory of the Institute, near which a settling tank of spent materials coming from the open-source department is located, was conducted to verify detection capability of the mobile laboratory. A diagram of the radiation situation change is similar to the one made at the exit from the open-source department. The spectrum (Fig. 3.3) clearly demonstrates the peak of I-131.



**Fig.3.3. Spectrum of a spent materials settling tank of the open-source department measured by the vehicle detectors**

Along with that, two unidentified peaks (Fig. 3.34) attract attention. To check and identify the origin of radiation from the container, the data were analyzed and measurements using portable device Vasikka were taken (Fig. 3.4). It is clearly seen that the origin of settling tank radiation is I-131 only.



**Fig.3.4. Measurement spectrum of the settling tank measured by Vasikka with higher resolution LaBr detector**

High resolution of the detector allowed to confidently identify the main source and origin of unknown peaks in the spectrum – natural Ra-226.

### Measurement results of premises of the open-source department

1. Measurements in the brachytherapy premise. Source- Co-60 in a container. Both devices – Vasikka and Detective-EX registered higher level of radiation, but not determined the source type (did not identify radionuclide).

2. Measurements in patients' recreation room. Vasikka confidently located this room even with the door closed and without preliminary information from the department staff. Measurements during 100 sec identified the source type – I-131. The dose rate in the room constituted about 200 nSv/h.

3. Measurements at "Rokus AM" installation at closed gate. Both portable devices detected radiation anomaly, but did not identify the source type. Along with that, after having analyzed the spectrum, Co-60 was identified.

4. Under measurements near the operating tomography, higher radiation background was registered, but both devices did not identify the source automatically.

5. Measurements of empty transportation containers made of depleted uranium represent special interest for the future. Both devices detected anomaly even under higher radiation background in the premise. At the same time, Detective-EX automatically identified presence of uranium.

6. Measurements above the special drainage system of the open-source department did not detect presence of artificial isotopes.

### 3.3 Inspection

Portable equipment of the mobile laboratory RanidSONNI was used during the pre-licensing inspection of the Kyiv oncological hospital with the involvement of the SSTC NRS experts. The following was surveyed:

- open-source department,
- sealed isotopes department,

- nuclear medicine Center (PET-technologies), radiopharmaceuticals cyclotron.

Use of measurement tools brought positive experience, provided possibility to observe actual levels of radiation exposure, detect radiation sources, identify them, and thus, assess radiation state of the facility, sufficiency of shielding and other protective measures and means.

It is planned to involve the mobile laboratory RanidSONNI in inspections at NPPs of Ukraine, corresponding regulations are currently under development.

Radiation surveys of territories of medical institutions and around uranium mining and milling enterprises using the mobile laboratory RanidSONNI will be conducted in the near future in the framework of international cooperation with the European Commission (project U3.01/11 Component C) with participation of the regulatory authority of Finland.

## Conclusions

1. SNRIU received possibility to conduct independent monitoring according to the IAEA requirements. This enhanced capacity resulted from good cooperation of the involved States, EU and IAEA.

2. Mobile nature of the laboratory provides possibility to use it for different tasks regardless of location of the objects to be surveyed.

3. Technical means of the laboratory allow clear identification of radiation anomalies in parked position and during movement. Portable tools allow determining location and identifying type of radiation sources.

4. Taking into account that SNRIU has the intention to use the mobile laboratory RanidSONNI for a wider range of objectives than it was initially designed for, it requires additional equipping and further upgrading.