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PREVENTION OF ILLICIT TRAFFICKING OF NUCLEAR AND RADIOACTIVE MATERIAL AT BORDER STATIONS BY MEANS OF HIGHLY EFFICIENT DETECTION SYSTEMS

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Abstract

In the context of the possible threat of proliferation of nuclear material by groups of terrorist and non-state actors reliable detection techniques of such material are of great importance at points of interest such as airports, harbors, railway stations, and border crossing points. The opportunity to detect nuclear material is given at border stations in particular because vehicles and pedestrians potentially carrying such material are forced to drive or walk slowly in lines, thus providing well-defined measuring conditions. Gamma and neutron detectors with a high efficiency are required for this task. As consortium leader of the current TACIS (Technical Assistance to the Commonwealth of Independent States) project "Ukrainian Border Security" of the European Union our institute is involved in setting up modern stationary portal monitor systems at selected Ukrainian border stations in order to provide adequate detection techniques for the prevention of illicit trafficking of nuclear material at these borders. The current status of the project will be presented. Furthermore, Fraunhofer-INT operates a mobile portal monitor system manufactured by Thermo based upon our institute's requirements and specifications. It comprises two pillars containing large-volume NaI crystals which can be used separately or combined, then forming a portal of variable width. Besides providing the option to localize radioactive or nuclear material, the system also allows for the discrimination between naturally occurring radiation and artificial material by means of the implemented NBR method. The measured count rate data are transferred to a PC by radio transmission. A series of measurements was performed with this portal monitor system to test its ability to detect both radioactive and nuclear material. An overview of the measurement results are presented as an example of the capabilities and performance of current portal monitor systems.

Prevention of illicit trafficking – the project "Ukrainian Border Security"

Illicit trafficking of nuclear or radioactive material (NRM) became an issue of worldwide concern in the early 1990s after a number of incidents involving the seizure of highly enriched uranium. The terroristic attacks of September 11, 2001 increased government and public concern that such material may fall into the hands of people who could use it for malicious purposes.

The project "Ukrainian border crossing station" is a task within the program TACIS of the European Commission, represented by the IPSC (Institute for the Protection and Security of the Citizens), Italy, part of the European JRC (Joint Research Centre). The overall objective of the project is the strengthening of the non-proliferation regime and the extension of the counteraction against the threat posed by illicit trafficking of NRM and its conceivable use for terrorist purpose. It is a follow-up of a former TACIS Task and is dedicated to the security situation at the borders of the Ukraine. Especially methodological and metrological support is to be provided to Ukrainian authorities, including appropriate training, to the activities of the relevant Ukrainian institutions aimed at the detection and identification of NRM at Ukrainian borders. The project is carried out by a consortium consisting of Fraunhofer-INT (Fraunhofer Institute for Technological Trend Analysis), Germany as consortium leader and BAM (Federal Institute for Materials Research and Testing), Germany and has a duration of 4 years (2009 to 2012).

Objective of the first phase of the project was to get an overview about current regulations and procedures at Ukrainian borders regarding the illicit trafficking and criminal use of NRM. By interviewing experts and literature research information was collected concerning the national situation and the procedures at the borders. Furthermore a fact finding trip to Ukraine was organized together with the Ukrainian State Border Guard Service: Three experts of the consortium visited preselected border crossing points. Border guards were interviewed to learn their needs and wishes regarding the planned technical measures and the existing procedures in combating illicit trafficking of NRM. In addition a meeting was organized with the members of the expert group for procedures of identification of seized NRM in the Institute for Nuclear Research in Kiev.

There are several reasons why illicit trafficking of NRM is probable in Ukraine: The process of political reorganization after breakdown of Soviet Union, the existence of a large amount of improperly secured nuclear material in Ukraine, the difficult economic situation and the geographical position between Asia and Europe (transit country). These national situations together with the fact of worldwide terroristic activities have caused international concern. An alarming number of cases of illicit trafficking of NRM have been observed, indeed, in the recent years in Ukraine. They include radioactive sources, which could be dispersed by a malicious act in one way or another (e.g. “dirty bomb”), and even nuclear material, which might be used to build a nuclear weapon. Therefore many national and international efforts have been made to cope with the situation. Multilateral and bilateral programs and projects have been established. Amongst others response plans were developed to define responsibilities and actions with respect to illicit trafficking of NRM, trainings were provided and border crossing stations were equipped with detection systems. The measures and provisions have to be continued and expanded.

In principle Ukrainian border crossing stations are very well suited for implementation of portal monitors because there are only a few, often only one, entry and exit line, where the vehicles have to stop until a checklist is handed out to the driver. This means that relatively few portal monitors are necessary to check all vehicles (or pedestrians) and low speed of the vehicles is given. In a suspicious case the border officers have time to react and check carefully the car or person at an isolated place. The backup by the Institute of Nuclear Research in Kiev seems good and the personal at the border crossing stations seems to be very motivated so that the installation of portal monitors is obviously welcomed and useful.

Portal Monitor Measurements

The portal monitor system described below was designed by Thermo Scientific in cooperation with the Fraunhofer-INT based upon our institute’s experience, requirements and specifications. The system comprises two pillars which are equipped with NaI plastic scintillator with a volume of 6 litres each. The pillars can be operated separately or together with internal power supply and feature modules for the radio transmission of the measured signals. The intensity values are indicated by LEDs as well as acoustically. The measured data are transferred via radio link to a PC where they are computed and finally displayed.

The radio connection covers a maximum distance of 1 km without obstacles; otherwise the range is reduced accordingly.

We have performed experiments including a car driving through the portal monitor system or a pedestrian walking through it as well as measurements during which the sources were placed on a stand. Figure 1 illustrates the situation of a car passing between the pillars of the portal monitor system. The sources placed inside the car were located either in the passenger cabin (close to the window) or in the boot.

Fig. 1. Car with source inside driving through the portal monitor system.

Figure 2 shows an example of the feasibility of detecting radioactive or fissile material. It depicts the chronological sequence of the measured gamma dose rate for a case of two sources located both at the same time in the car within shielded boxes, a ^{137}Cs source with an activity of 265 MBq and a ^{252}Cf neutron source with an activity of 3.5 MBq. The latter contained a high fraction of ^{137}Cs because of its age (as a product of the fission chain). The passage was performed across a central position between the pillars in one case and outside the portal on both sides in other cases (see the sketches in figure 2). The car was driven at walking speed in these cases, as it is typical for an entrance area. The increase of the dose rate during the passage of the car is obvious. The figure also indicates the car's position during passage.

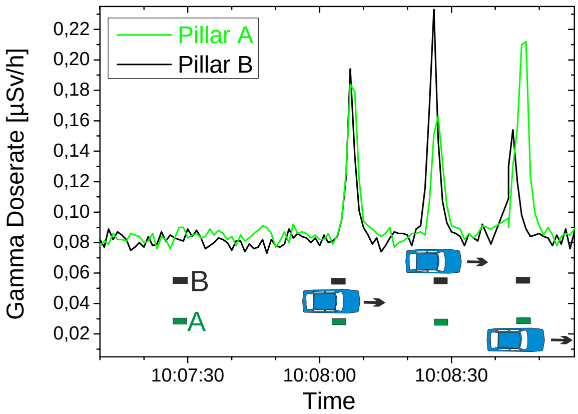

Fig. 2. Drive at walking speed through the portal monitor system with two sources (^{252}Cf and ^{137}Cs) in shielded boxes inside the car.

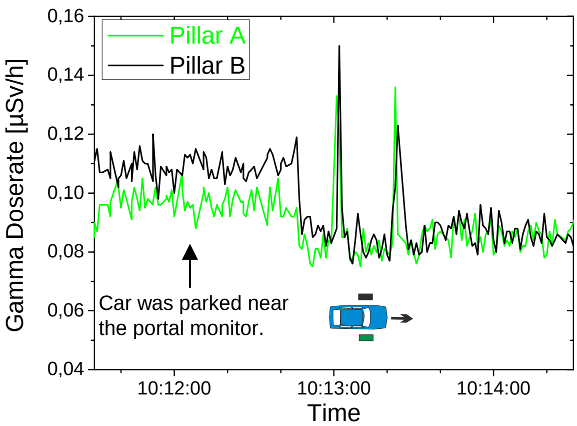

Fig. 3. Experiment identical to the one shown in figure 2, except the car was driven at approximately 45 km/h.

Figure 3 illustrates the chronological sequence of the gamma dose rate for an experiment similar to the one shown in figure 2 except for the car's speed which was 45 km/h in this case. The rise of the gamma dose rate can be seen very clearly. The higher radiation level prior to the rise because of the passage of the car was due to the car parked close to the portal monitor. The radioactive or nuclear material concealed in the car could be detected in both cases despite the presence of shielding material.

The Fraunhofer-INT also possesses small amounts of depleted and natural uranium which may serve to represent fissile material. A cube with 1.8 kg of depleted uranium was used for the measurements described below. The cube was located close to one side of the boot (see picture in figure 4). The car was repeatedly driven at approximately 10 km/h through the portal monitor. Figure 4 shows the results of theses measurements. The pillar which was closer to the source during passage (pillar B) than the other one detected the material quite clearly (at ca. 60 cm to the source) whereas the other pillar (pillar A) could not detect it at 2.4 m distance. At this distance, the gamma dose rate was within the range of the background rate.

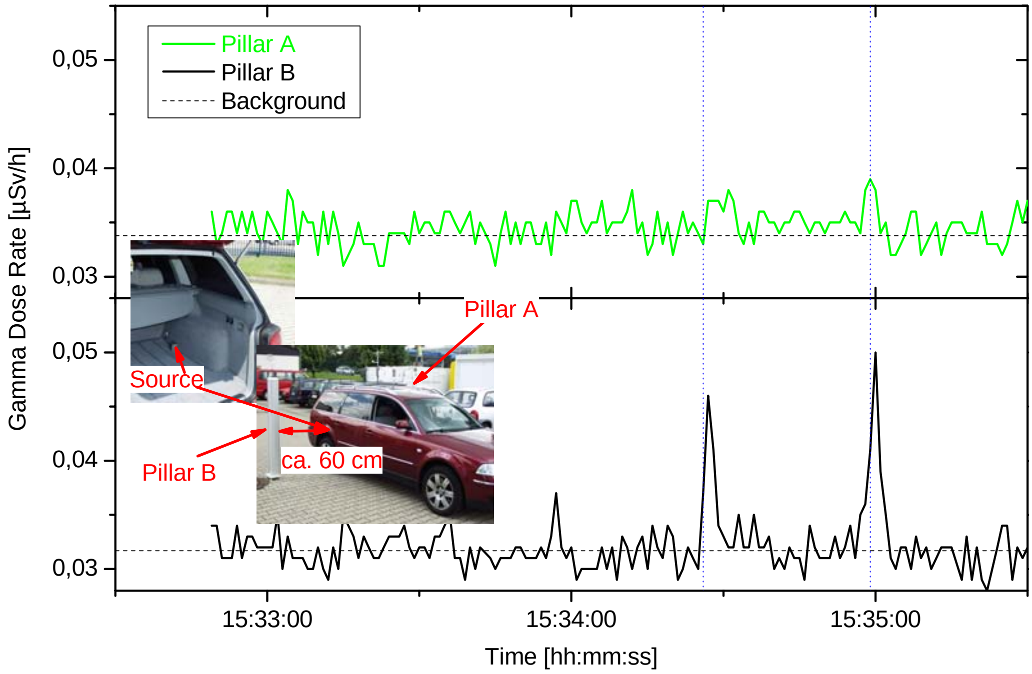

Fig. 4. Two times drive through the portal monitor system at approximately 10 km/h with 1.8 kg of depleted uranium in the car's boot (see photo on the top left). The moment of source transition is marked by the vertical dotted lines.

Aside from the experiments involving the car we also performed measurements representing the control of pedestrians with the portal monitor system. Sources were placed on a stand at a height of ca. 90 cm which is at the centre of the pillars' plastic scintillators. The stand with the sources mounted on it was then placed between the pillars at various distances. This was done to represent a scenario including a potential terrorist carrying a nuclear source through the portal, disregarding shielding effects by clothing etc. These experiments were performed with 37.5 g of depleted uranium (small metal plates in a plastic box) and 50 g of natural uranium (inside a bottle). As results of these measurements we can state that the uranium sources could be detected up to a distance of 70 cm to the pillar.

Similar measurements were performed with a ^{133}Ba source (91 kBq) in the same way. The obtained results were similar to the measurements performed with the other mentioned sources. We also simulated a portal monitor situation with one of Fraunhofer-INT's neutron detectors, the slab counter, fabricated by Canberra. The neutrons emitted by the Cf and

Uranium sources could be detected quite well. As shown above, portal monitor systems proved to be an extremely useful tool in the context of illicit trafficking of NRM.