Next Generation Dynamic Contamination Monitoring based on the FastTrack Technology

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Many colleagues at Mirion Technologies have been involved in the development of the FastTrack Technology and its implementation in various products. Their contribution is greatly appreciated.

1. Introduction

Dynamic contamination measurement approaches are widely used, for example by portal monitors to scan vehicles and pedestrians for ionizing gamma radiation, among others in the nuclear industry and nuclear decommissioning, in homeland/event security applications or in radiological emergency scenarios.

Typical portal monitors however require a significant slowing down of the person or object to be measured or even a static measurement in order to reach the required detection limits. At the same time, conventional monitors have a hard time distinguishing between radioactive materials passing through the portal, and dynamic background fluctuations, for example due to nearby radioactive materials. Radiation detectors measure a response regardless of where the radiation originates. This fact leads to the potential for numerous false alarm conditions in the course of normal operation, which erodes confidence in the product. This can create either confusion or complacency for operators of a radiation security checkpoint.

In the following, a novel method – Mirion Technologies' patented FastTrack Technology – is presented which, amongst other positive features:

- Allows a fast movement of the measurement object during the measurement process – without slowing down
- Is able to clearly distinguish between sources moving through a portal monitor and dynamic background fluctuation, such as sources or contaminations being located/moved nearby but outside the monitor
- Features exceptionally low false alarm rates
- Features beyond standard detection limits (MDAs)

The FastTrack Technology is therefore particularly useful in challenging background conditions or when a high throughput is required. This may involve outages of NPPs, decommissioning activities, radiological terror prevention at airports/customs or large scale events/venues. After having explained the basics of FastTrack Technology, examples of real life applications are presented.

Mirion Technologies (Rados) GmbH (2012). U.S. Patent 8,119,993 B2. Hamburg, DE: U.S. Patent and Trademark Office.

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2. Basics of FastTrack Technology

The basic idea of the FastTrack Technology is both very simple and very effective: In contrast to common portal monitors which are composed of a single detector per pillar, the FastTrack Technology is based on three (or more) horizontally arranged detectors per pillar as illustrated in Figure 1.

Depending on the direction in which a source is moving through the monitor, the detector electronics responds in a different way: given a source approaches from the left, the "black" detector responds first whereas the "green" detector responds last. Furthermore, the sequence of the signals peak amplitudes in this example is black → red → green. A source approaching from the right would reverse the sequence into green → red → black. Any movement in between these two initial positions would cause a smooth transition in-between the signal sequences and amplitudes.

As shown in this simplified example, the direction of movement of the source can be determined based on the temporal profile of the measurement signals from all three detector arrays. Mirion Technologies' FastTrack Technology compares this information to the direction and speed of movement of the object or person currently being measured (which is independently determined by multiple light barriers). This allows a reliable distinction of sources being carried inside/through the monitor from sources and dynamic background fluctuations originating from outside the monitor.

Limitations to this approach are mainly given by electronics noise, geometrical imperfections, and complex source geometries. Thus, a down to the "degree" resolution of the source's direction of movement is not possible today.

Successful measurement operation of the FastTrack Technology is not limited to sources or contamination being moved but can also handle staircase signal shapes which e.g. occur when doors to a close-by radiologically controlled area are opened. In this case all detectors would respond with an identically temporal staircase signal profile which can be clearly distinguished from the specific profile of a source/contamination being carried through the monitor (sinusoidal shape).

In this way the main reason of false alarms in portal monitors is eliminated both for moving sources as well as static ones. At the same time, this allows particularly high measurement frequencies.

Furthermore, the FastTrack Technology ensures measurements without waiting times. In this "walk-through" mode, vehicles or pedestrians can simply pass through the portal at relatively high speeds without having to stop. This functionality is available without compromising MDA (Minimum Detectable Activity) levels.

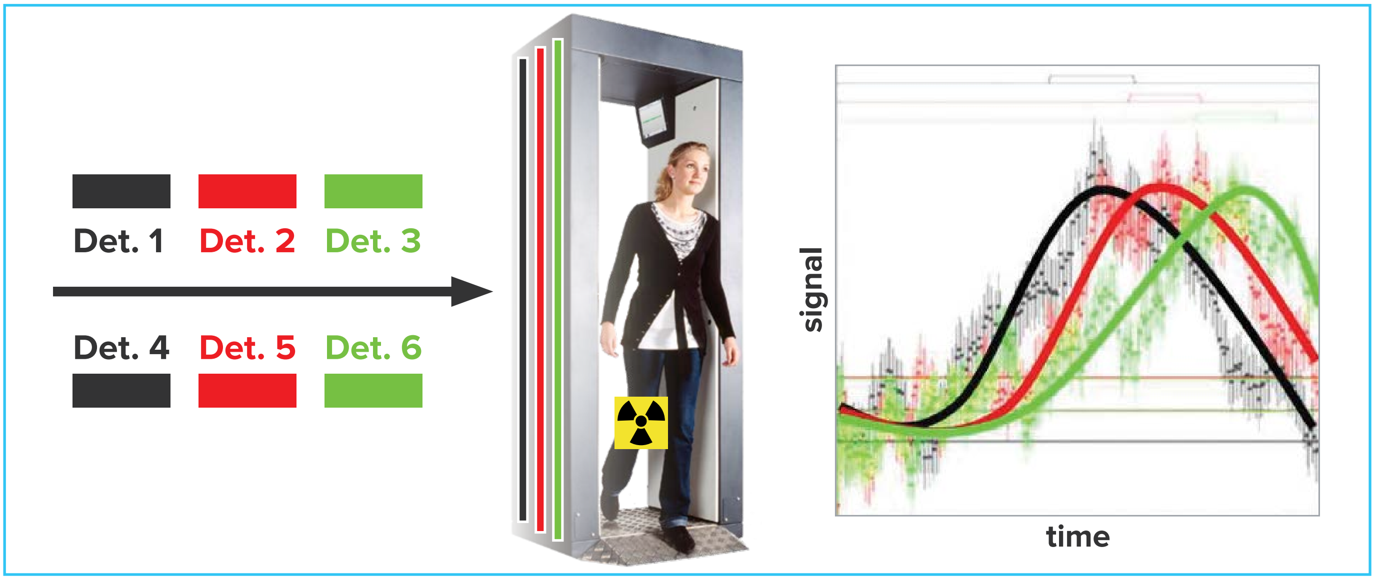

Figure 1. *Detector arrangement in FastTrack Technology; example: Mirion Technologies' FastTrack-Fibre™ Vehicle Monitor.*

3. Examples

Figures 2-4 are showing typical measuring situations in which commonplace portal monitors would respond with false alarms while the FastTrack Technology ensures trouble free operation:

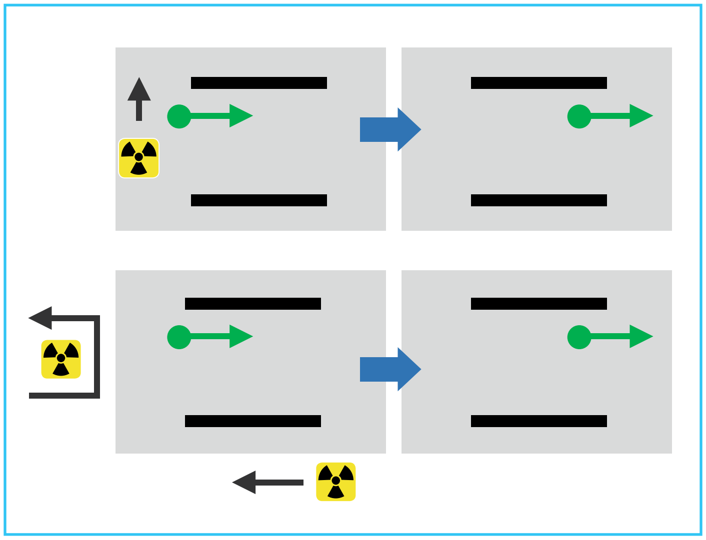

Figure 2. *Moving sources during successful operation of Mirion Technologies' FastTrack-Fibre monitor*

While sources are present in the vicinity of a FastTrack monitor during measurement operation the signals of all detectors are significantly different from each other, both in chronological order as well as in amplitudes. As explained above, the FastTrack algorithms can reliably distinguish the fraction of the signal originating "inside" the monitor from the contributions from outside sources. For the sake of precaution, the FastTrack monitors can be configured to highlight measurements where external effects are detected by descriptive indications such as "external contamination" or "non-dynamic" in order to provide additional information to the radiation protection engineer.

In addition, the FastTrack Technology prevents an (un-)intentional extraction of sources from controlled areas, as depicted in Figure 3 and Figure 4: when a source is carried into the monitor and remains inside, the rising edge of the detector's signal will not proceed to a trailing edge when the person leaves the monitor without the source. A corresponding alarm is given by the FastTrack monitor.

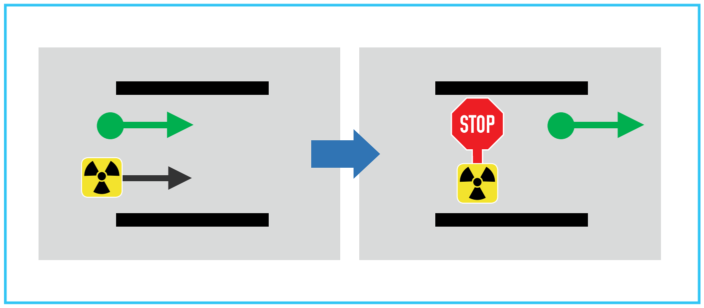

Figure 3. *Source remaining inside the monitor*

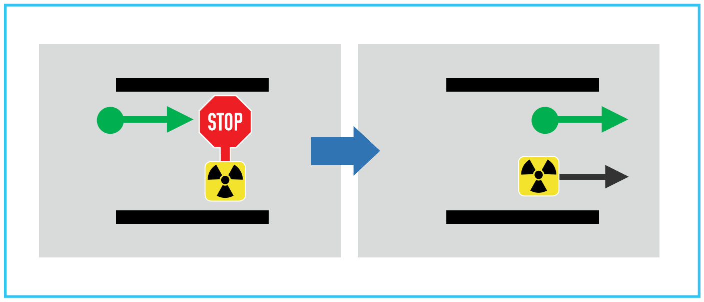

Figure 4. *Source taken away from inside the monitor*

Similarly, when a stationary source inside the monitor is extracted from the monitor, a trailing edge of the detector's signal is detected without rising edge in the beginning of the measurement. The FastTrack monitor will give a corresponding alarm.

Nevertheless, all "true" contaminations are detected by the FastTrack Technology – independent from any additional sources inside or outside the monitor.

3.1 FastTrack-Vehicle™ monitor in Fukushima

Mirion Technologies' patented FastTrack Technology has been invited for a test of vehicle monitors nearby Fukushima, Japan for demonstrating its efficiency. Measurements of all vehicles leaving the 30 km area around Fukushima have been performed with an MDA of 4 Bq/cm^2 Cs-134 at walking speed. Mirion Technologies' FastTrack-Vehicle monitor has been chosen for this test. The two pillars where placed at a distance of 6 m clear width, as illustrated in Figure 5.

For the project team it was of particular interest how the FastTrack Technology would perform in high backgrounds of about 1-2 µSv/h due to contaminated soil. All measurements have been carried out over a period of three weeks. In the very beginning, additional steel plates had been mounted above the soil to artificially decrease the background, Figure 6. However, this countermeasure proved to be unnecessary as the FastTrack-Vehicle monitor could fulfill all requirements without these additional means.

Figure 5. *FastTrack-Vehicle monitor in operation nearby Fukushima*

Figure 6. *FastTrack-Vehicle monitor in operation nearby Fukushima*

3.2 FastTrack-Fibre pedestrian monitor at major sporting event

As a counter terror measure during a major sporting event it was of the highest importance to scan all (100%) of the approximately 4.1 million spectators, attendees, politicians, security personnel, etc. for radiological threats when entering the arenas. Due to the anticipated large number of attendance at each access point, the organizers expected an uninterrupted passage of pedestrians into the arenas, i.e. no tailbacks were allowed, but people should be able to move more or less “as they like”. As a solution to these challenging requirements each access point was equipped with a dedicated FastTrack-Fibre portal monitor, as shown in Figure 7.

Entering the portal monitors was only possible through restricted guidance systems, Figure 8 - 10. When contamination was detected, a group of 1 - 3 persons were isolated from the crowd and each person in the group was manually checked with handheld spectroscopic devices.

Figure 7. *Mirion Technologies’ FastTrack-Fibre pedestrian monitor*

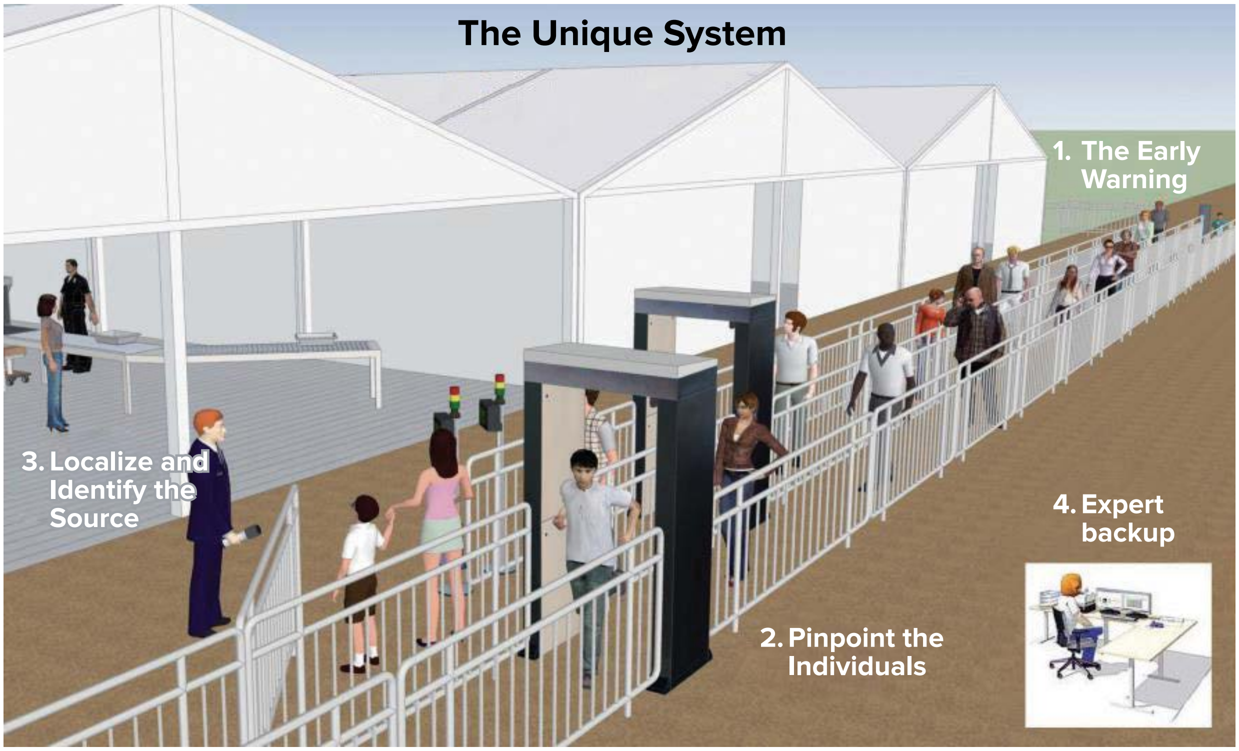

Figure 8. *Schematics of arrangement to guide visitors include radiation scan by the FastTrack-Fibre monitor*

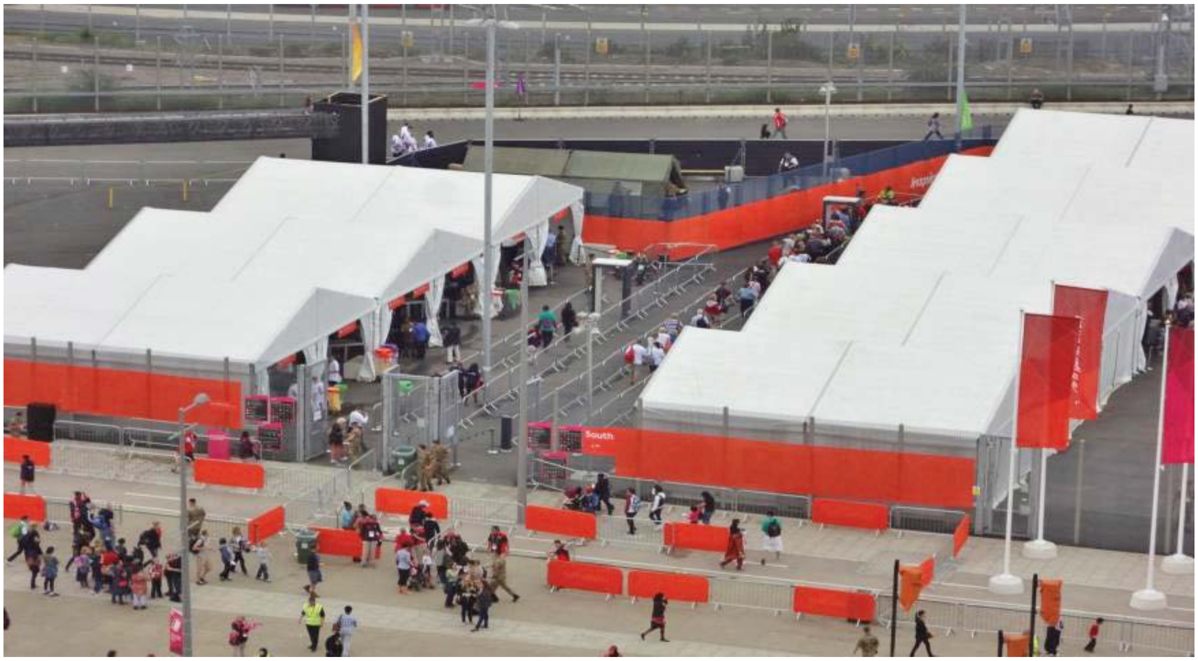

Figure 9. *Live situation of visitors entering arenas include radiation scan by the FastTrack-Fibre monitor*

Figure 10. *Live situation of visitors entering arenas include radiation scan by the FastTrack-Fibre monitor*

This measurement campaign for radiological threats has been the first of its kind and dimension, worldwide. Some impressive figures have been reported:

- 4.1 million measurements have been executed by 19 FastTrack-Fibre monitors over a period of 19 days.
- This corresponds to over 10,000 measurements per day and monitor.
- The most intensively used monitor carried out over 300,000 measurements within 19 days.
- Throughout the entire period 72 alarms were detected, all resulting from medical treatments of the corresponding persons.
- No false alarm events were generated in the 4.1 million measurements.
- Due to these impressive figures the CBRN “Counter Terror Award” has been awarded to the FastTrack-Fibre monitors.

4 Conclusion

The FastTrack Technology has been invented to reduce false alarms in portal monitoring for ionizing gamma radiation. It is based on a sequential three-detector-arrangement, which allows correlating the measurement signals to the movement of the measurement object (or person). Consequently, it can be clearly distinguished if a source of ionizing radiation is moving with the measurement object through the monitor or if it is located outside the monitor. This leads to a significant false alarm reduction with respect to conventional portal monitors, especially in challenging background conditions.

Two applications have been presented:

- Mirion Technologies’ FastTrack-Vehicle monitor has been operated near Fukushima. The test demonstrated a robust performance, even in significantly elevated gamma background of 1-2 µSv/h.
- Mirion Technologies’ FastTrack-Fibre pedestrian monitor has been used for a large-scale radiological screening at a major sports event. Throughout the event 4.1 million measurements were performed by 19 monitors. Not a single false alarm occurred.

The FastTrack Technology has been developed and patented by Mirion Technologies.

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