Radiation Measurements Using a Wireless Robot

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Abstract

This paper presents preliminary measurement results using a wireless robot. Our objective is to measure detector response for moving source-detector configurations. The measurements are performed in two different modes i.e. manual (v= 0 m/s) and robot running at 1.22m/s; for two different configurations: in the first, a detector is placed on a moving robot and in the other, the source is placed on a moving robot. Count rates are recorded as a function of position data, and then peak count rate is determined, which indicates the presence of radiation source. Due to the speed of the robot the peak count rate decreased by 250 times of the theoretical cps. If the survey meter detector and the source are facing each other then we get good count rate. This method is appropriate for the sources having activity above thousand cps. The robot has a wireless range limited to 30 feet. Thus, this method is an economic setup suitable for indicating low radiation in small campuses.

1. Introduction

In case of Fukushima nuclear accident, Packbots (iRobot) were used for post disaster analysis (detect temperature, gamma radiation, explosive gases and vapours and toxic chemicals etc.) and cleaning up wreckages. These robots are highly specialized and are designed to work in rugged and high level radiation areas [1, 2]. However, these robots are very expensive (as much as USD 120,000 [1]). It is not feasible to deploy such expensive and highly specialized robots in all radiation fields, especially not in areas with low levels of radiation. Nuclear and Radiological threats have induced the needs of robotic systems.

Nonetheless, even in low radiation areas (such as universities, medical centres etc.), it is important to continuously monitor and safeguard radiation sources. It is important to detect subtle indication of radiation in early stage by means of daily inspection and take measures before occurrence of unusual event in addition to a periodic examination [3]. Since this work is repetitive and involves radioactivity, robots may be used to automate the process. This paper presents a robot-survey meter setup and its verification. This paper analyses the variation in detector behaviour when it is moving or stationary with respect to source because detector may behave differently in different situation. The method presented here is a single detector approach. Such measurements can be useful for improving automated radiation detection capabilities. These measurements can also be useful in improving detection capabilities of moving sources such as sources placed over automobiles.

2. Experimental setup

This paper details a wireless robot that works as a vehicle carrying scintillation survey meter or source over it. This can easily move over the plane areas of universities & medical centres in low radiation level environments. The wireless robot is running at constant speed.

Fig. 2.1 showing robot with its remote controller and radiation survey meter

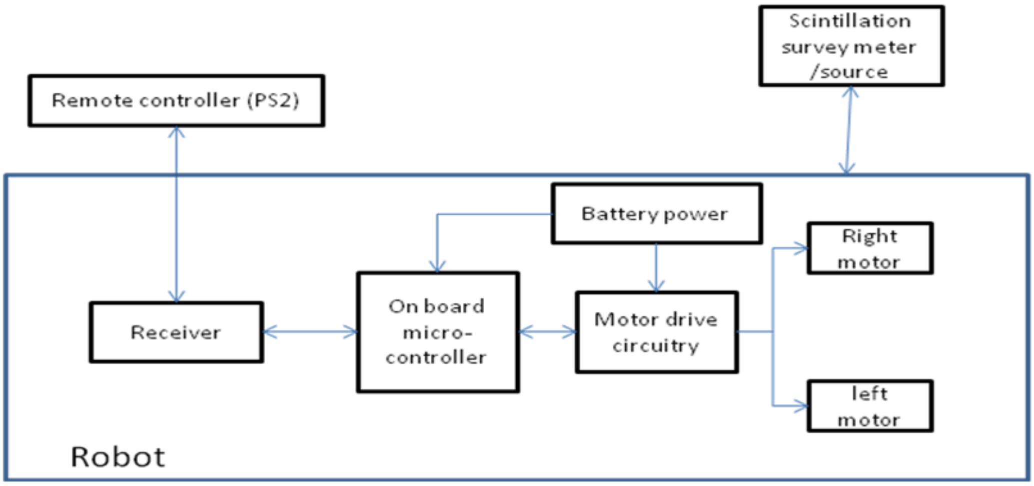

Fig. 2.2.Robot-survey meter setup

2.1. Equipment

Radiation survey meter used is a scintillation counter whose specifications are shown in Table 1. Geiger-Muller counter is usually used for radiation dose rate. In this study, however, the scintillation counter was applied because it is able to detect small gamma radiations(due to its amplification property)[4].Radiation survey meter used in this paper is a LB125 g-Analyzer (Berthold) [5], a portable radiation measuring device; it serves as an investigator for hidden and/or unknown radioactive sources. The instrument integrates in a small volume a large NaI crystal with photo multiplier tube, a preamplifier and multichannel analyzer, with a high voltage unit and memory for many spectra. It combines portable gamma spectroscopy, nuclide identification, search mode and dose rate measurements. It has an auto save property by which it can automatically save cps readings and its interval can be set by using ‘measuring time’ command [5]. Its specifications are shown in Table 2.1.1. Cs-137 and Ba-

133 are used as radiation sources, placed on 2cm height plastic box. And the activities of sources at the time of experiment calculated theoretically are shown in the Table 2.1.2.

Table 2.1.1 Specifications of scintillation survey-meter [5]

Measuring ray	γ-ray
Gamma Probe	1.5“x1.5“ NaI crystal, 1.5“ Multiplier, high gamma sensitivity
High voltage supply	Up to 1000V, microprocessor controlled
Operating temperature	-10 to 40 °C
Calibration	Requires Cs-137 source
Dose rate range	0.01 to 100 µSv/h, 25 to 2000 keV
Relative humidity	10 to 90 % , non condensing

Table 2.1.2 Present activity of Cs-137 and Ba-133 source

	Cs-137 source	Ba-133 source
Theoretical cps	63.751 Kcps	63.788 Kcps

Wireless robot is designed to withhold Survey meter and various circuitries over it, easily travel in plane areas. Its features are shown in Table 2.1.3.

Table 2.1.3: Features of wireless robot

Size	(35*50*12) in Cm
Weight	8 Kg
Payload	8 Kg
Speed	~ 1.22 m/s
Wireless module	2.4 GHz (30 feet)

2.2. Measuring mode:

Measured area was Indian Institute of Technology Kanpur Nuclear laboratory of 9m length. This 9 m length was divided into 7 parts, each 1.22 m length. In order to analyze different applications of the setup, data were taken for Cs-137 and Ba-133 sources in two different modes i.e. manual (v=0 m/s) and robot travelling at 1.22 m/s speed for different cases as shown below:

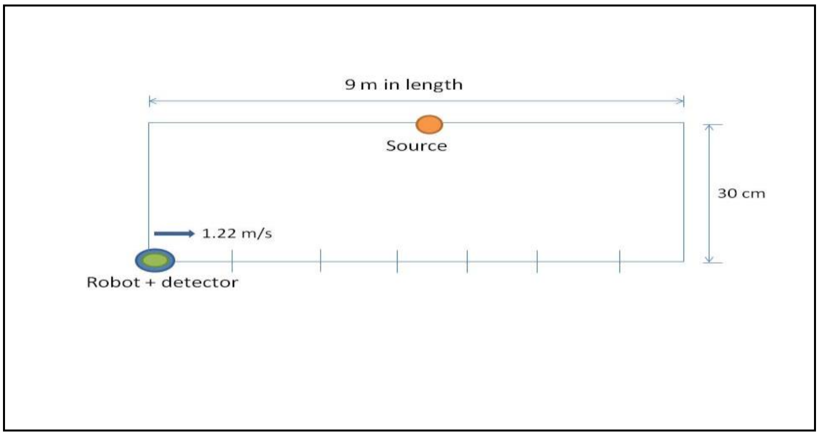

Fig. 2.2.1.Case1, Radiation survey meter was placed on the robot and the source was placed on 2cm height plastic box at 4.5 m away from the initial point.

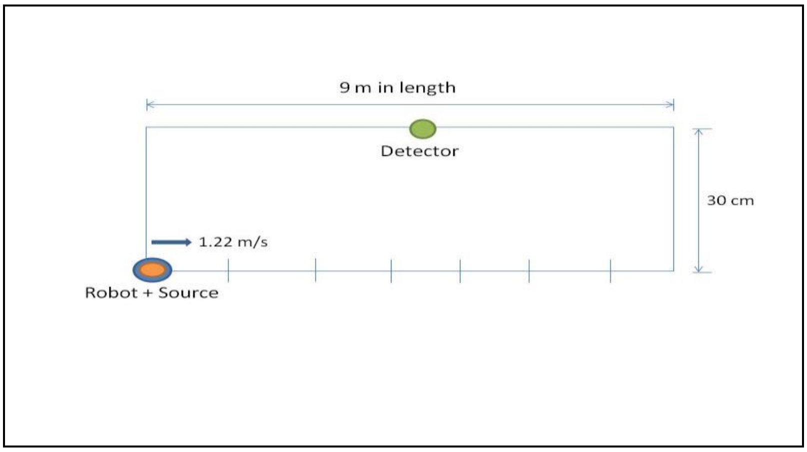

Fig. 2.2.2.Case2, Source was placed on the robot and the detector was placed at 4.5 m away from the initial point.

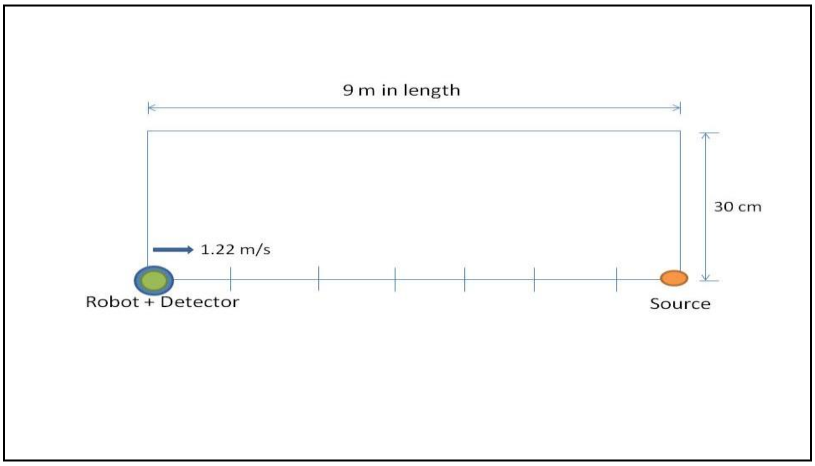

Fig. 2.2.3.Special Case, detector was placed over the robot and the source was placed in front of the detector at 9 m away from the initial point.

3. Results and Analysis

In order to get better results we have used two sources Cs -137 and Ba-133 of comparable atomic masses, comparable present activities; so the variation of activity with respect to position should be similar but here we are not getting similar variation. In case of Ba-133 peak count rate is at 6 m whereas in case of Cs-137 at 5 m (From Fig. 3.1). These results are not symmetric (i.e. cps at 4 m and at 5 m are not same) because of presence of other objects in the surrounding of the setup.

Evident from Fig. 3.1, 3.2, 3.3 when robot is travelling at 1.22 m/s count rate peak decreases, in comparison with the manual mode. As the source actual activity was in the range of Kcps but when the survey meter was placed on the robot (case 1), detector direction was in the forward direction then the count rate was in the range of cps (250 times lower than the actual theoretical activity); this is mainly due to the speed of robot and detector-source direction. As a consequence of this we are unable to detect very weak sources (~hundred of cps). Relative percentage error due to the speed of robot was investigated as 6%.

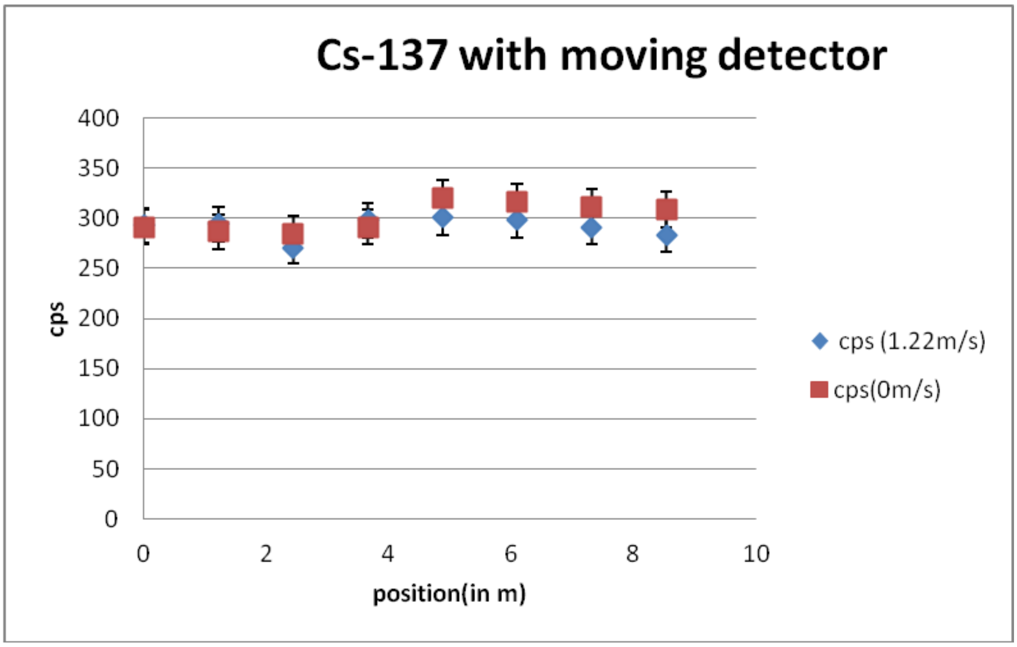

Fig. 3.1.a.Case 1, position v/s cps plot for Cs-137 source

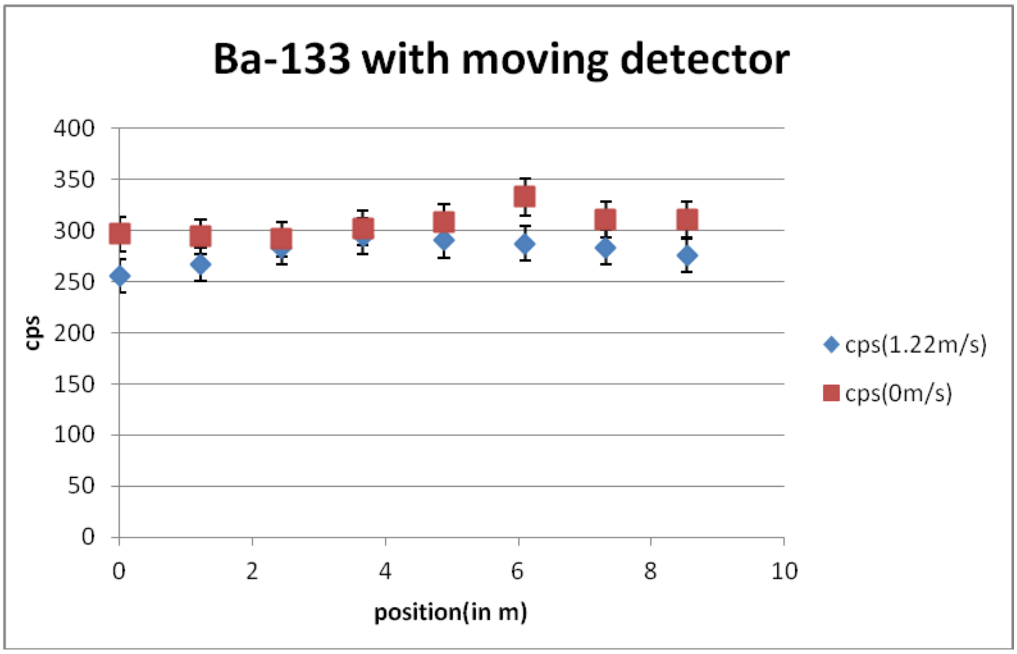

Fig. 3.1.b.Case 1, position v/s cps plot for Ba-133 source

In case 1 and 2 relative speed of the robot with respect to source or detector is always same but we are not getting exactly similar variations in both the cases. But in both the case we are getting count rate peak that means this method can be employed for the detecting source placed over automobile.

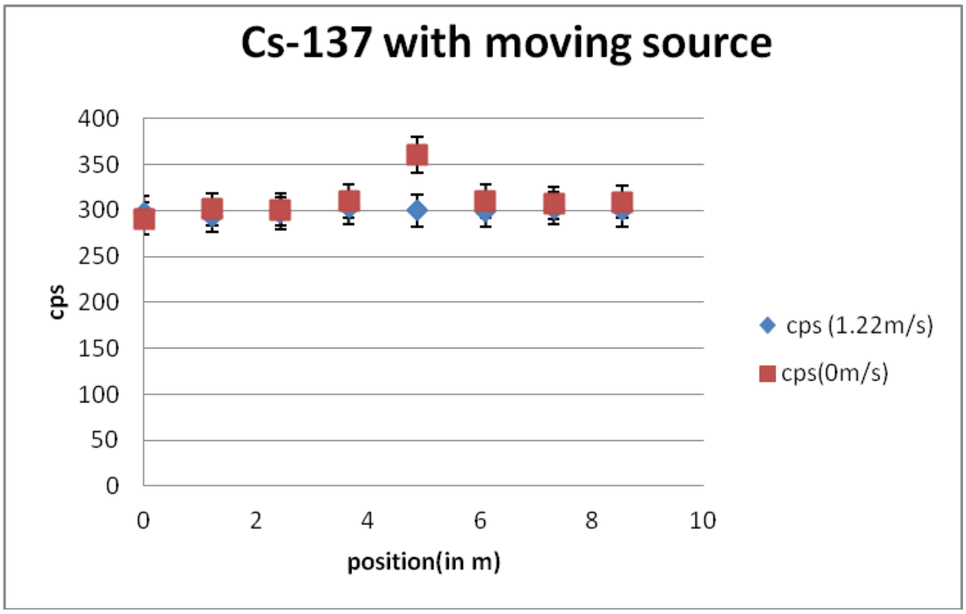

Fig. 3.2.a.Case 2, position v/s cps plot for Cs-137 source

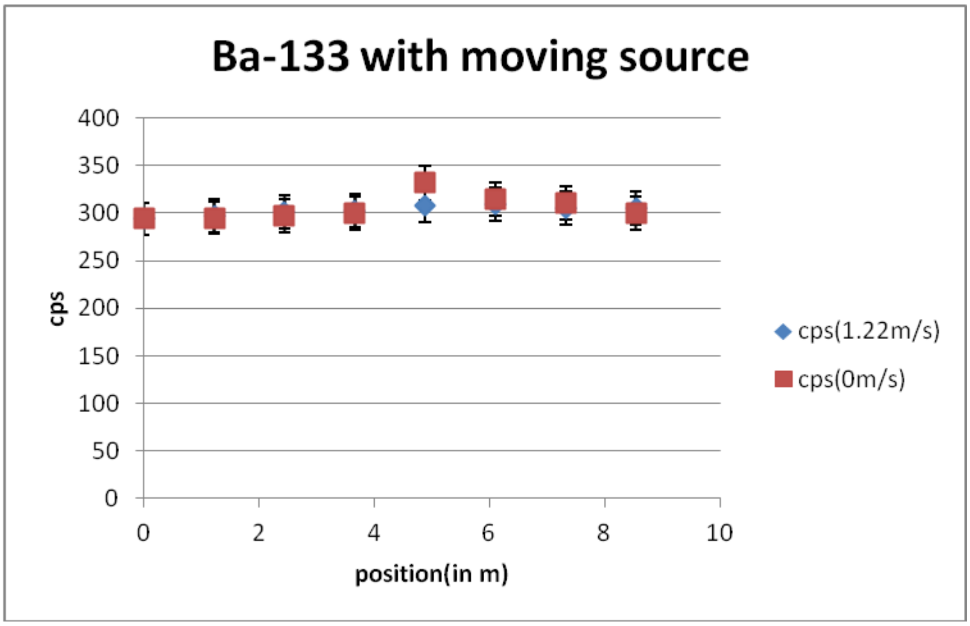

Fig. 3.2.b.Case 2, position v/s cps plot for Ba-133 source

In special case (Fig. 3.3.a & 3.3.b) when the survey-meter detector and the source were facing each other, count rate at the end of the path was in the range of Kcps. That means direction of survey-meter detector with respect to source, matters a lot in this experimental setup. Furthermore, it can be concluded that if multiple detectors in different directions with robot running at moderate speed will be considered, then it will also detect very weak sources and increases the efficiency of the setup.

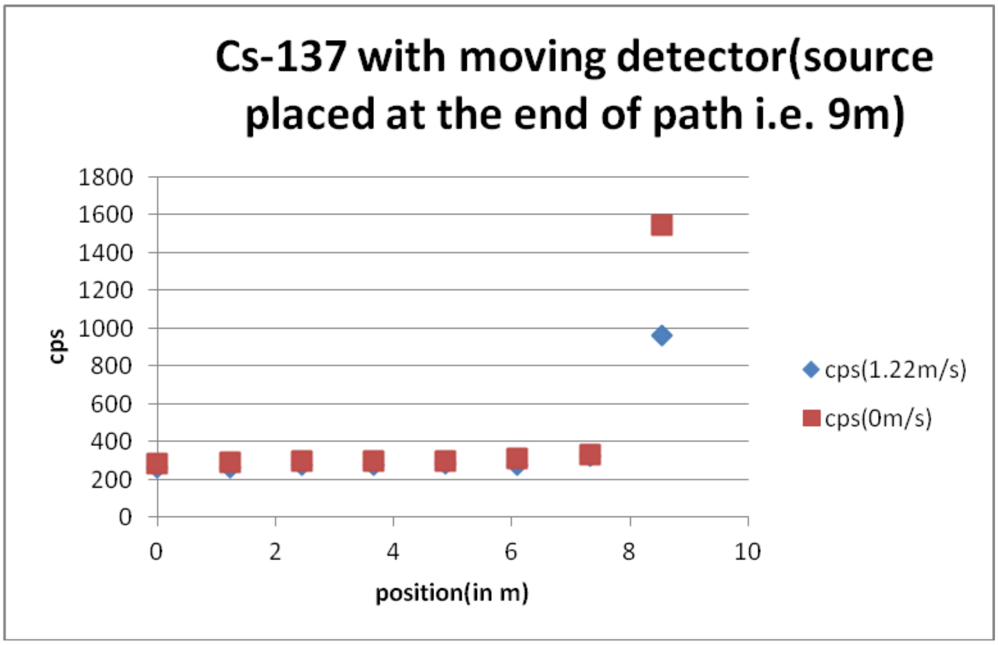

Fig. 3.3.a.Special case, position v/s cps plot for Cs-137 source

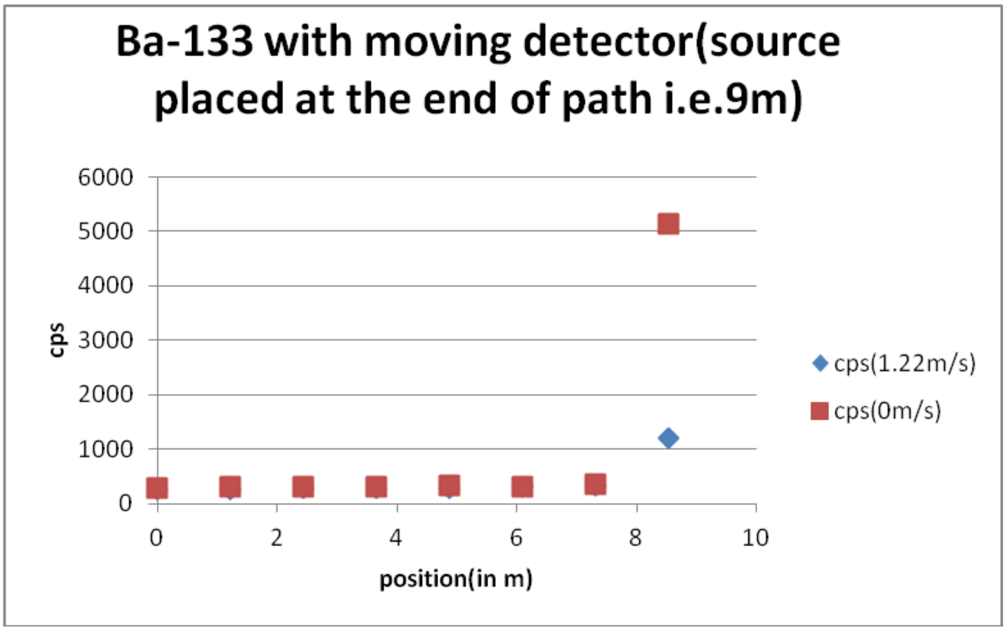

Fig. 3.3.b.Special case, position v/s cps plot for Ba-133 source

4. Conclusion

When we employ a wireless robot for activity measurements, it is important to examine detector behaviour for moving source-detector configurations. Moving detector or source configuration find out the presence of radioactive source in the detected area. If the source and the detector direction are same then the readings are more accurate. So, if we use multiple detectors in different direction we can find out exact direction of the source from the detected path. This configuration has the ability to find out activity of source placed on the vehicle, if the vehicle is moving at moderate constant speed (~1m/s). If the vehicle is moving at high constant speed then the detector doesn't give good results because detector stores two readings per second; so in this case detector is unable to discriminate activity with respect to position and it may or may not store activity at the point where the source is placed. And count rate peak decrease in detector or source moving case with respect to the manual mode.

It can be concluded that the setup cost is less (USD 10,000+ USD 1200), suitable for universities and medical centres. It will be very helpful in detecting 'orphan' sources (no longer under proper regulatory control) present in the campus. Hence, it can address the radiation hazard that area may face. It will be very useful in indicating sources placed over moving automobile.

As this analysis is based on single speed, it can be applied for multiple speeds. Especially, at slow speed to get more readings and a smooth plot of activity as a function of position. The impact of moving setup on detector resolution will be studied. The angular response of a detector is very important to get an idea of the relevance of measurements with respect of the position of the detector would be done in future. Variation of activity by moving setup in different directions (Especially in forward and backward direction) will be analysed. And in future high range wireless module will be used.

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