Calibration and Operational Data for a Compact Photodiode Detector Useful for Monitoring the Location of Moving Sources of Positron Emitting Radioisotopes

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Abstract:

D-Pace has developed a compact cost-effective gamma detector system based on technology licensed from TRIUMF. These photodiode detectors are convenient for detecting the presence of positron emitting radioisotopes, particularly for the case of transport of radioisotopes from a PET cyclotron to hotlab, or from one location to another in an automated radiochemistry processing unit. This paper describes recent calibration experiments undertaken at the Turku PET Centre for stationary and moving sources of ^{18}F and ^{11}C in standard set-ups. The practical diagnostic utility of using several of these devices to track the transport of radioisotopes from the cyclotron to hotlab is illustrated. For example, such a detector system provides: a semi-quantitative indication of total activity, speed of transport, location of any activity lost en route, and effectiveness of follow-up system flushes, a means of identifying bolus break-up, feedback useful for deciding when to change out tubing.

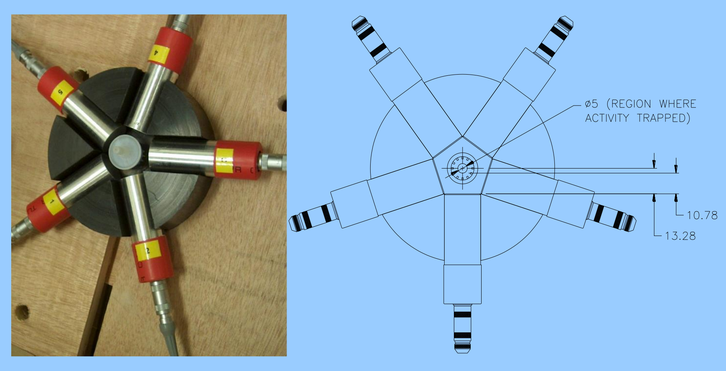

FIGURE 1. Stationary source calibration setup of five radiation detectors. Dimensions in mm. Each detector is approximately 57.5 mm in length and 19 mm in diameter. The source is centered on the detector in a Sep-Pak Cartridge and is a disk with diameter 5 ± 0.3 mm and height 3 ± 1 mm.

The stationary calibration, Figures 1 and 2, used both ^{18}F and ^{11}C. It was found that the detectors give consistent voltage responses for both positron emitting radioisotopes (refer to Table 1). In the Figure 1 setup the detectors saturate at 9.9 V, at 19 GBq of activity.

The moving source calibration test, Figures 3 and 4, used four detectors which all output a similar voltage response to a bolus of ^{18}F radioactive liquid as it passed through the PEEK tubing. For this test:

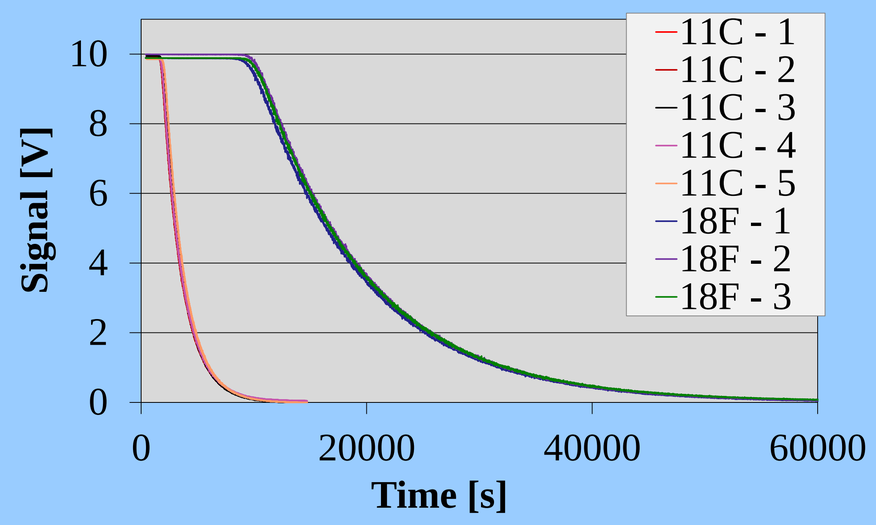

FIGURE 2. Voltage response of the radiation detectors as a function of time for the decay of 41 GBq (1.1 Ci) of ^{11}C and 51 GBq (1.4 Ci) of ^{18}F, both for Figure 1 setup.

*Activity[GBq]=(13.7) Signal Voltage [V] * Volume [mL]*

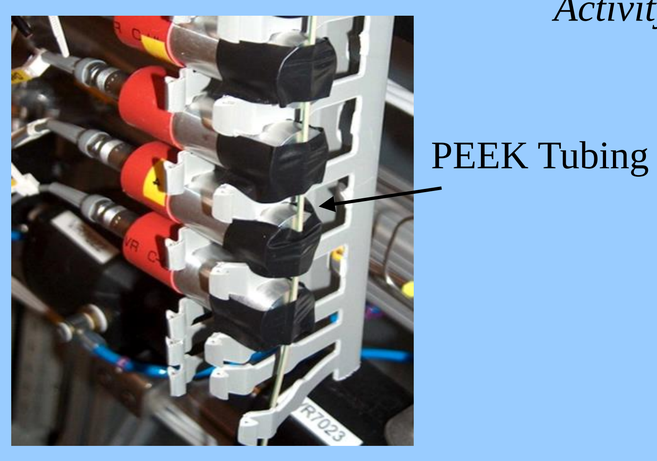

FIGURE 3. Moving source calibration setup of four radiation detectors mounted on PEEK tubing (inner diameter 1 mm, wall thickness 0.59 mm).

Signal [V]	Activity of ^{18}F [GBq]	Activity of ^{11}C [GBq]
9.9	18.6 ± 0.2	18.7 ± 0.5
8	14.2 ± 0.2	14.7 ± 0.4
6	10.6 ± 0.1	11.0 ± 0.3
4	7.0 ± 0.1	7.4 ± 0.2
2	3.5 ± 0.1	3.7 ± 0.1

TABLE 1. Voltage response of the detector as a function of ^{18}F and ^{11}C activity in Figure 1 setup.

The final test was a transfer of ^{18}F from cyclotron to hotcell, Figures 5 and 6. The five detectors each output a voltage response as the activity passed, allowing for monitoring of the location and state of the bolus throughout the transfer. Though not noted in data presented here, bolus break up can be observed if a single bolus push has two or more distinct voltage peaks. The length of the bolus is 2.25 m and its speed can be determined from the distance and time between two detectors. For example, the bolus moves at 0.097 m/s between detectors 2 and 3. The decision of when to replace degraded tubing can be made by selecting a transfer time threshold between two detectors. For example, if the transfer time is greater than 1.5 times the 59 seconds between detector 2 and 3: change tubing.

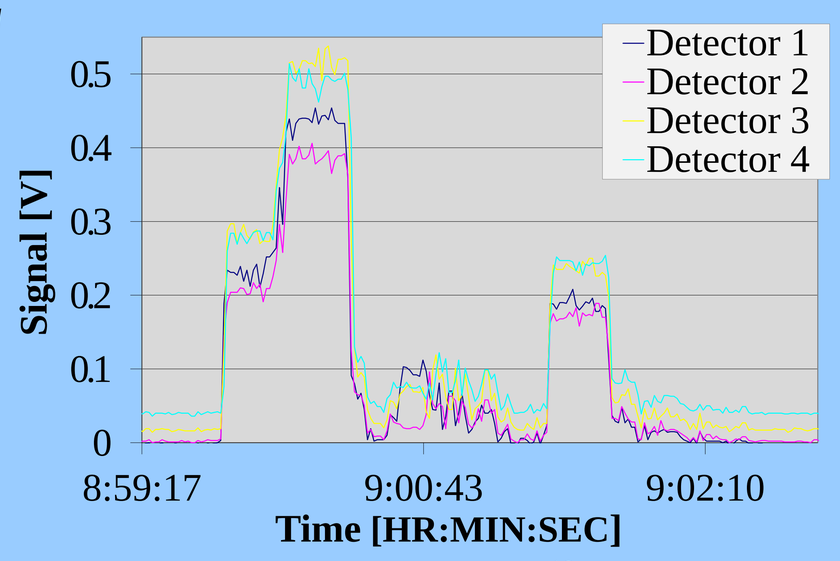

FIGURE 4. 2 mL of 12 GBq ^{18}F radioactive liquid transport with a 2 mL flush, for Figure 3 setup. Note presence of remaining activity after initial bolus push. Significant remaining activity is a clear indicator that a flush is necessary and may indicate that tube routing should be altered. The second pulse shows the flush recovering the activity.

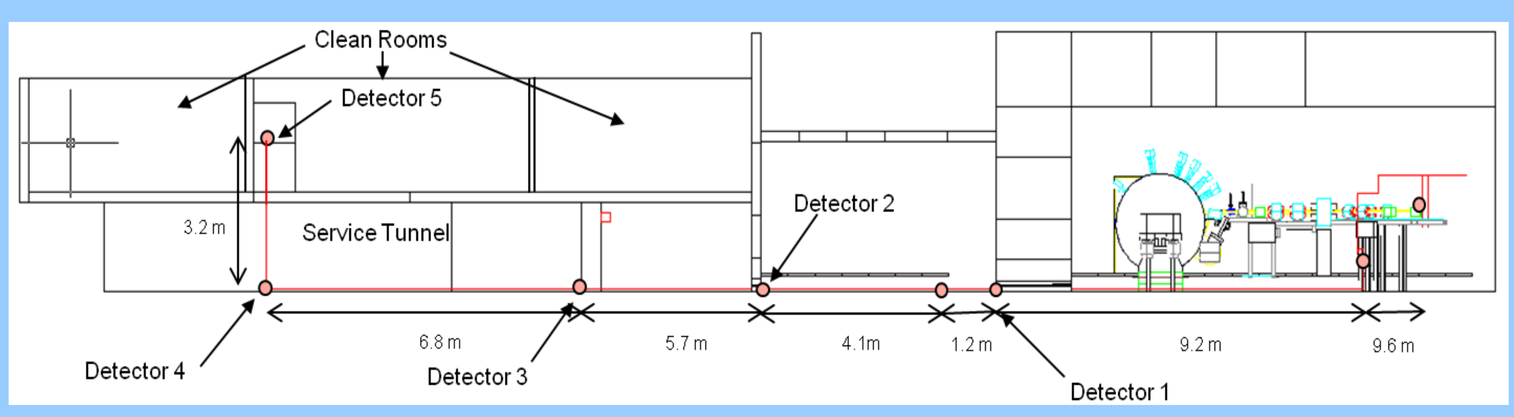

FIGURE 5. Locations of 5 TRIUMF licensed radiation detectors along transfer line from target to hotcell at Turku PET Centre.

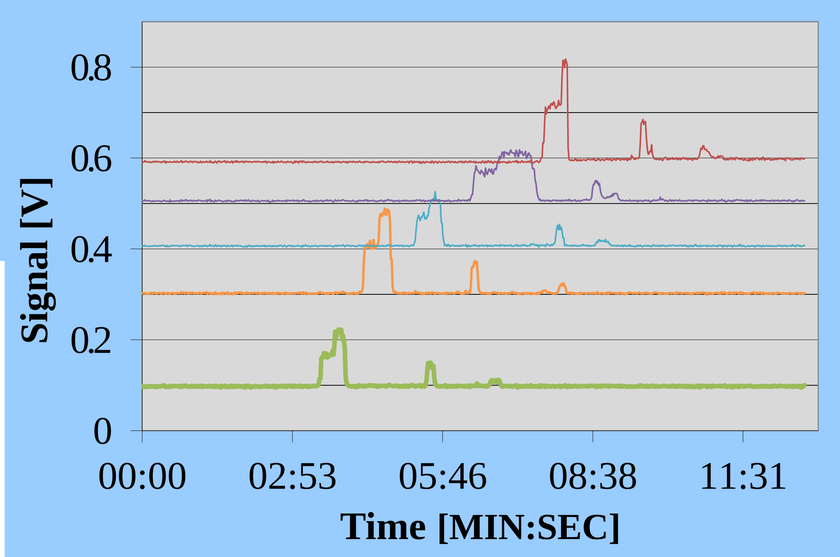

FIGURE 6. Voltage response of 5 detectors, along transfer line from cyclotron, for 19.2 GBq (0.51 Ci) of ^{18}F liquid transfer. Detectors in numerical order from lowest to highest.