Enhanced portal-scanning of humans for detecting illicit radioactive material

Elia Sciama Bandel, Peter G. Martin, Yannick Verbelen, Thomas B. Scott
University of Bristol, HH Wills Physics Laboratory, Tyndall Avenue, Bristol, BS8 1TL

University of Bristol

SOUTH WEST NUCLEAR HUB

The monitoring of people to detect illicit radioactive material has now become a core aspect of national and international nuclear security and nuclear non-proliferation. With large public activities such as sports fixtures, music concerns and airports seeing increased security to prevent against conventional weapons and explosives being used, attention is shifting to detecting material that could be used as a component of a dirty-bomb or radiological dispersion device.

This project sought to develop a radiation detection "portal" capable of performing rapid human-source radiation detection, identification and localisation. The system was designed, modelled and tested during this project – and now comprises a fully-functioning custom-built low-cost sensor and electronics package embedded within a standard Gunnebo SpeedGate. The add-on developed integrates fully into the current gate infrastructure without costly modifications.

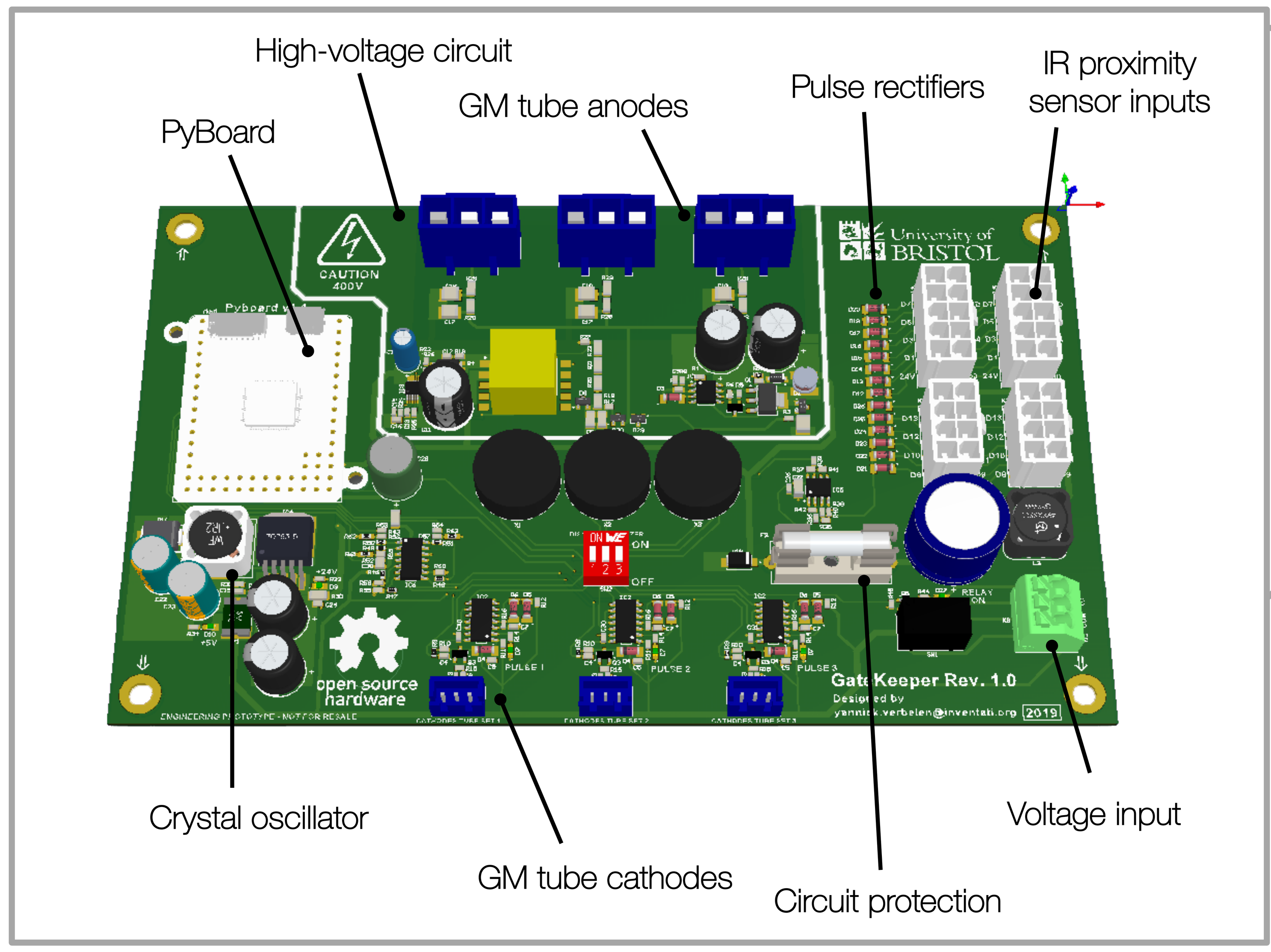
Hardware Developments

To decrease the cost of a final end product by reducing the number of expensive solid-state devices, this project elected to use arrays of gaseous GM tubes positioned around the enclosure provided by the barrier. For spectroscopic information of any radioactive source introduced into the barrier system to be determined (if required by an end-user), a single NaI(Tl) scintillator detector was mounted away from the three GM arrays.

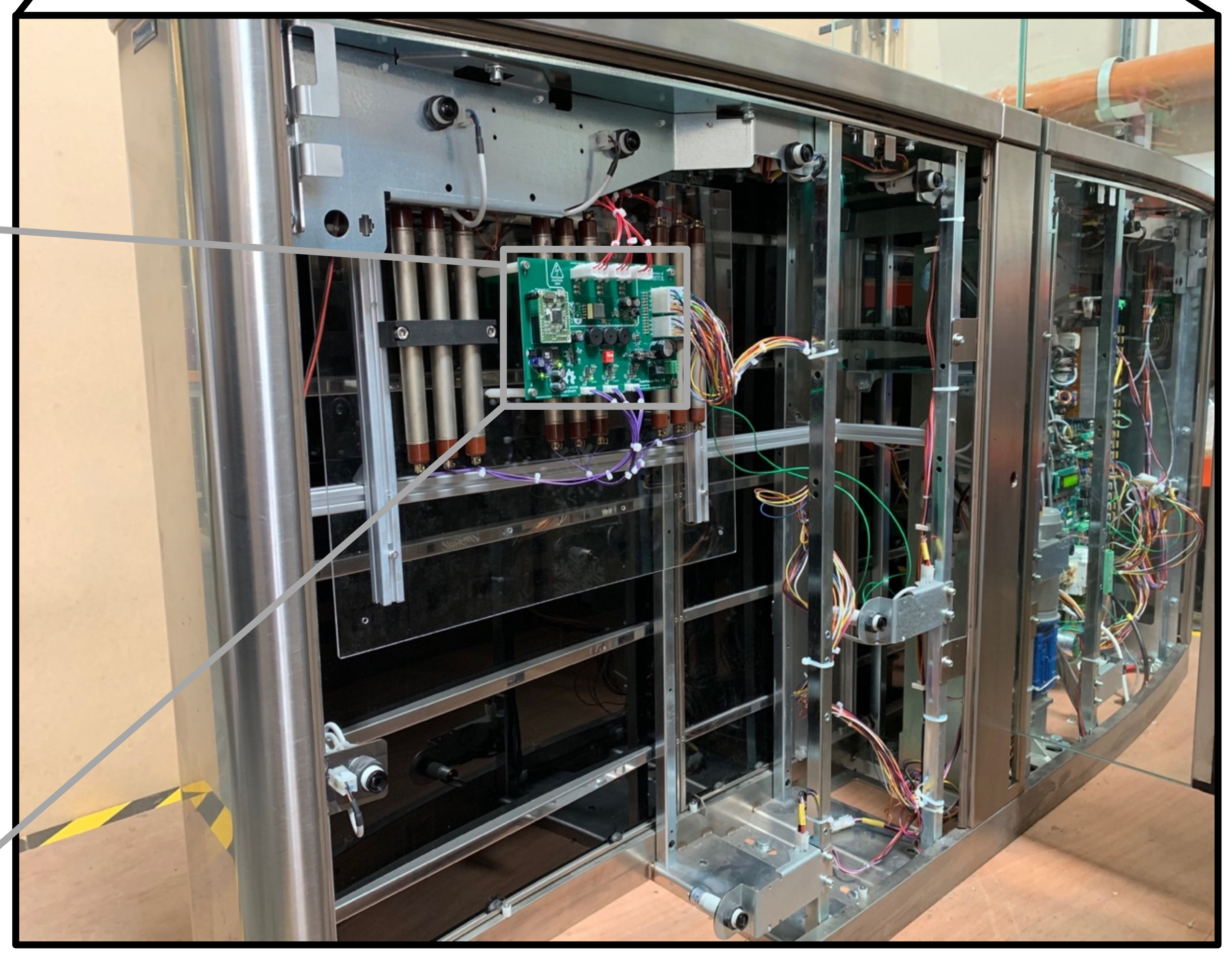
(i) Detector Arrays: To enhance the detection sensitivity of the SpeedGate system, it was determined that single high-volume GM tubes positioned around the enclosure would not possess the required sensitivity for the required low limits of detection. In order to compensate for this, arrays of three high-volume GM tubes (SI-22G type) were connected in parallel at positions around the gate.

(ii) Customised Printed Circuit Boards: Resulting from the large total volume of the gas-filled detectors, high-voltage supply electronics were required to each of the tube arrays. As this this was in excess of what commercial GM boards could provide, customised printed circuit boards (PCBs) were constructed with appropriate voltage step-up and processing electronics.

(iii) Peak Shaping, Timing and Triggers: Owing to the sensitivity of the system (arising from the large active detector volume) and the high count-rates that could occur in the presence of a radioactive source, a need was identified to refine the shape of the voltage spikes that occurred when the a GM tube was triggered by an ionisation event. This shortening of the peak width (to <10 ms), by removing the trailing (decaying) edge was achieved through the incorporation of a small high value resistor and micro-capacitor containing circuit for each of the tube arrays



[Above] Rendering of the custom-built PCB developed for the project, comprising high-voltage regulation, signal processing and CAN-bus injection.



[Top] Graphical rendering of the Gunnebo SpeedGate comprising the large upright units into which the detectors and control electronics are contained. The proximity sensors are additionally mounted within these units, behind the glass panel sides.
[Bottom] Photograph showing the radiation detection module and processing electronics mounted within one of the side units. Both 24v DC power and IR sensor information was "tapped" directly from the SpeedGate electronics.

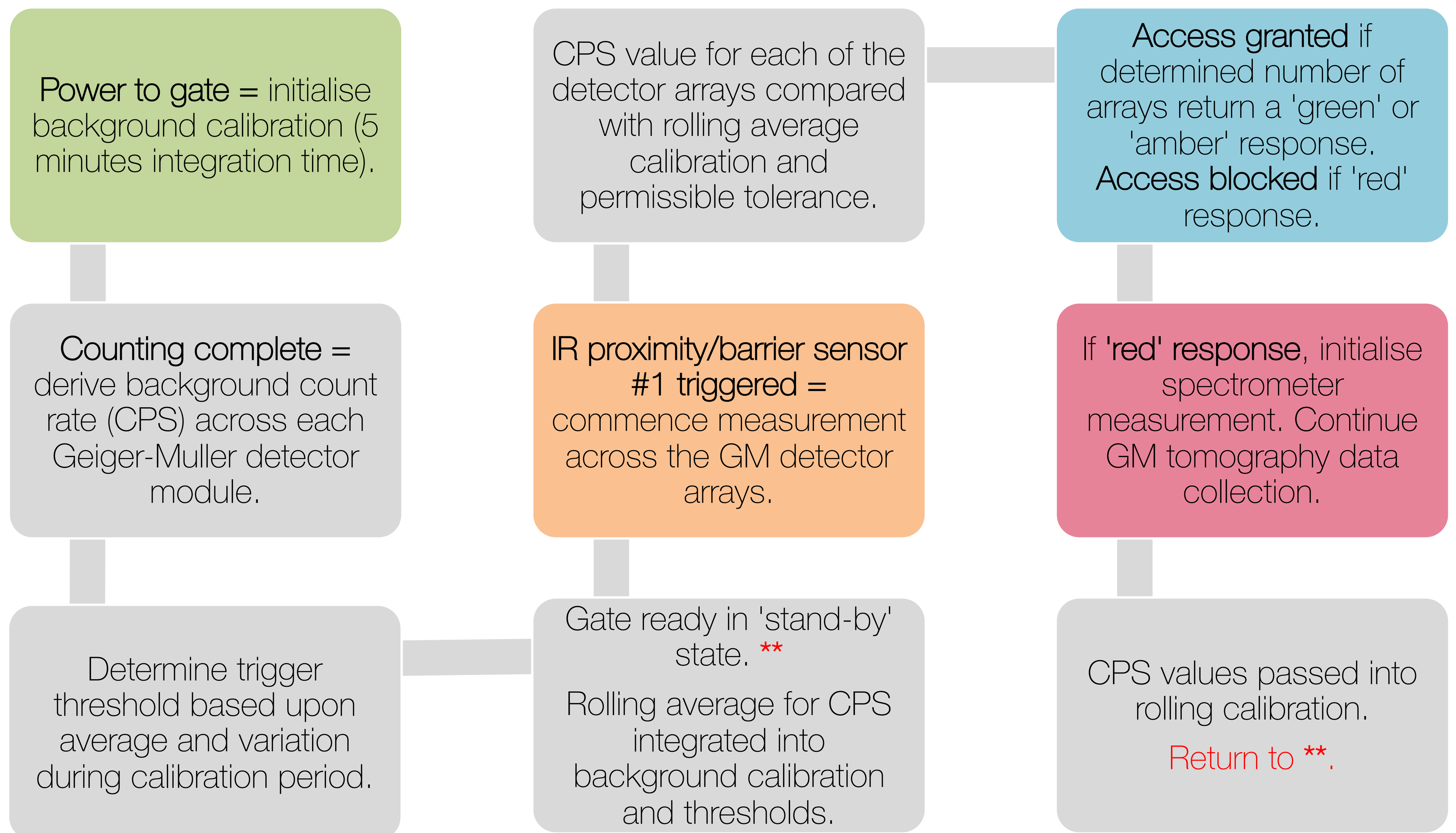
Software Developments

(i) Rolling Background Calibration: As the environments in which the SpeedGate detection systems will be installed are likely to be varied (e.g. differing construction materials), then the level of background radioactivity will consequently be highly variable and venue specific. To account for such variability, a rolling background calibration was established within the RAM memory of the algorithms control code.

(ii) Localisation Algorithm: The localisation algorithm results on rapidly processing both distance readings from the numerous infra-red proximity sensors located around the internal perimeter of the SpeedGate and the radiation intensity values obtained from the arrays of high-volume GM tubes similarly located around the gates interior.

(iii) Spectrometer Integration: If the algorithm detects and locates a radioactive source within the barrier, then the spectrometer mounted towards the top of the barrier, behind the uppermost IR proximity sensor, is initialised.

(iv) CAN-BUS Injection: Resulting from the close collaboration with Gunnebo, it has been possible to inject customised code into the Controller Area Network (CAN) bus used. Therefore, is an event is detected it can be immediately passed back to the system monitoring each of the gates and determining user access.



[Above] Simplified process flow for the source detection and localisation algorithm used within the barrier.

Future Developments

This work has successfully developed a low-cost system capable of being retrofitted into existing Gunnebo access control infrastructure to detect, locate and subsequently spectrally identify radioactive material as it passes through the system. Although a highly successful product has been developed during this short pilot project, a number of areas for future work have been identified:

- Incorporation of an LCD screen on the board to allow for a visual identification of the algorithm's status (e.g. performing initial calibration, stand-by or fault condition).
- Integration of a Bluetooth link and mobile application for end-users to view the status (and detection event) associated with each gate.
- Enhance the performance and efficiency of the tomography algorithm.