Development of a Miniature Giga-Becqerel Gamma Detector for Liquid Chromatography

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Problem Statement:

The Cyclotron Group in the Medical Physics department at the University of Wisconsin - Madison lab routinely uses high-pressure liquid chromatography (HPLC) on cyclotron-irradiated materials in order to separate the radioactive product from the target stock. During this process, it is important to know when the radioactive band is passing through the column. Various systems are in place to do this currently, but the client requests a device that will detect the passage of the gamma-emitting product through the column, record its passage digitally, and send out either an audio or visual cue to indicate the product's progress before leaving the column.

Client requirements:

- Hardware:
    - The device should detect the peak wave at around 500 um, green area.
    - The device should give simple, reliable readouts, and either an audio or visual cue when it detects an amount of radiation at the peak wave that surpasses the threshold level of 10 milli-curie.
    - The device should be able to measure the movement of the radioactive components in real time and the position of the components within 2 mm of tolerance.
    - Three functional parts are required: detector, transducer, a cue (audio or visual), and software for observing and recording the data. The first three will be purchased, and the last will be coded using LabView (see below).
    - The irradiation time of the detector should be more than 1200 seconds so that it can cover the length of time necessary for completion of the high-pressure liquid chromatography process.
- Software:
    - A software component corresponding to the hardware should be programmed which shows the amount of radiation in real time.
    - The software should be able to record the data in real time and save as a file.
    - The software should also activate the cue device when the radiation level surpasses the threshold.

Design requirements:

- 1. Physical and Operational Characteristics

- Performance requirements: The device must consist of a detector, a transducer, and a cue device that sense and alert the researcher to the passage of a radioactive band in a chromatographic tube and report this reading to a computer.
- Safety: It is possible that the components of the device could absorb radiation. Care should be taken to minimize exposure to both the device and the chromatographic tube it is attached to.
- Accuracy and Reliability: The device should be sensitive enough to detect low level radiation as little as several milli-curie,
- Being used for scientific purposes, the data acquired from the device must be highly reliable. Specifically, the measurement of the band's position should be exact to within 2 mm and should have a resolution better than 1 second.
- Life in Service: at least 5 years
- Shelf Life: N/A
- Operating Environment: The device will be attached to a chromatographic tube in a research lab and will be subject to potentially high amounts of radiation.
- Ergonomics: The device should be easy to implement and use. The accompanying software should be easy to understand and learn.
- Size: the device must fit around the 10 mm diameter column and together with this column, fit into a shell of 5.08 cm inner diameter.
- Weight: less than 0.5 lb.
- Materials: detector, transducer, cue device (optical or visual), possibly a linear motor, attachment device.
- Aesthetics: The device must look professional and simple. It is being used in a research lab so it has to look like what it is: a scientific piece of equipment.

- 2. Production Characteristics
  - a. Quantity: 2
  - b. Target Product Cost: $500

- 3. Miscellaneous
  - a. Standards and Specifications: N/A
  - b. Customer: The client stressed the use of a cueing device to alert the researcher to the passage of the radioactive band. The client also stressed the necessity of a simple readout in real time.
  - c. Patient-related concerns: N/A
  - d. Competition: The sensors currently used by the lab only detect the radioactive band at one point. They do not track the passage of the band. Products that do this are available, but lack a cue to notify the researcher of the band passage. Current devices that are available and fulfill the functions needed are too expensive and have features not necessary for the clients' purposes.