HPLC Radiation Detector

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UW BME Design

ABSTRACT

Our client, Dr. Jerry Nickles, has requested a method for continuously detecting the position of a gamma-emitting radioactive species, produced by a cyclotron, while passing through a high performance liquid chromatography (HPLC) column. In current methods, the only detection unit is mounted at the end of the column and only detects once the species has reached the end. We have designed a prototype in which a Si photodiode is mounted to a linear actuator. This system moves the detector linearly, directly parallel to the HPLC column, and reports position and radioactivity data to a computer using a LabVIEW interface for use by the members of the Cyclotron lab.

INTRODUCTION

Client: Dr. Jerry Nickles, UW-Madison
•Departments: Medical Physics
•Research: PET Imaging and Cyclotron
•Project proposal: A gamma radiation detector for HPLC

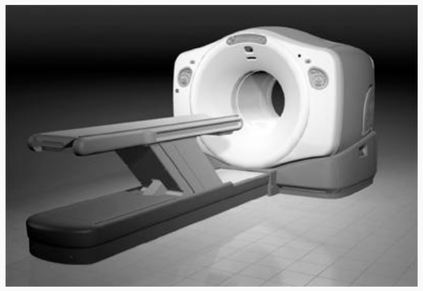

Figure 1: A PET Imaging Scanner[2]

Positron Emission Tomography (PET) Imaging is an imaging modality that utilizes radioactive drugs, injected into patient, and tracks the movement of the drugs throughout the body. This is used to diagnose many conditions that are dependent on metabolic processes[1].

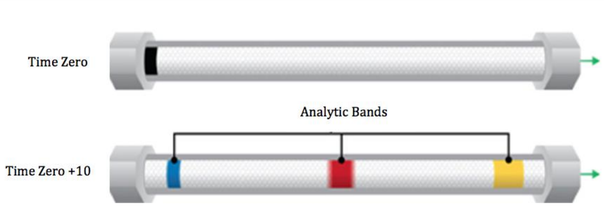

Figure 2: A typical HPLC column[3]

- HPLC is used to separate radioactive products produced by a Cyclotron
- The separated bands travel at different speeds through the column
- Currently, few products can detect the position of the radioactive band

DESIGN CRITERIA

A device that will continually track the position of the radioactive band's passage through the column

Hardware
•Must have a 2 mm position accuracy
•Must have a 10 milliCurie minimum threshold
•The irradiation time of the detector must be more than 1200 seconds

Software
•Must be able to record the data in real time and save as a file
•Must a LabVIEW interface

Must be cost efficient (target cost: $500)

TESTING

Linear Actuation Accuracy

Desired Distance	Actual Distance 1	Actual Distance 2	Actual Distance 3	Actual Distance 4	Actual Distance 5
40 mm	44.5 mm	45.5 mm	38.0 mm	38.5 mm	38.0 mm
80 mm	81.5 mm	81.0 mm	81.0 mm	81.0 mm	81.0 mm
120 mm	123.0 mm	123.0 mm	123.0 mm	123.0 mm	123.0 mm
160 mm	164.0 mm	164.0 mm	164.0 mm	164.0 mm	165.5 mm

Average Errors			
40 mm	80 mm	120 mm	160 mm
2.25 %	1.38%	2.50%	2.69%

Figure 3: Tables with the actuation testing data and estimated error.

Linear Speed Accuracy

Desired Speed	Actual Speed 1	Actual Speed 2	Actual Speed 3	Actual Speed 4	Actual Speed 5
10 mm/sec	12.5 mm/sec	9.7 mm/sec	11.1 mm/sec	11.1 mm/sec	11.6 mm/sec
20 mm/sec	21.7 mm/sec	19.6 mm/sec	21.7 mm/sec	22.2 mm/sec	17.9 mm/sec
30 mm/sec	FAILED	FAILED	FAILED	FAILED	FAILED
50.8 mm/sec	FAILED	FAILED	FAILED	FAILED	FAILED

Average Errors			
10 mm/s	20 mm/s	30 mm/s	50.8 mm/s
12.00%	3.10%	N/A	N/A

Figure 4: A table with the speed testing data and estimated error.

FINAL DESIGN

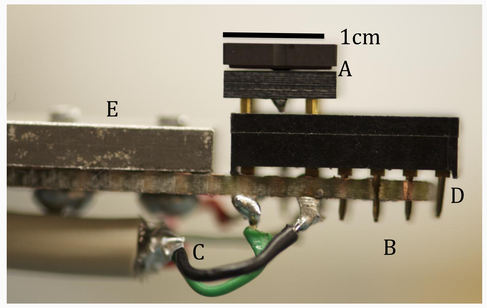

Figure 5: The detection unit
A)The Si pin diode
B)A socket was used to secure the pin diode and connect in the input and output wires
C)The wires collected at the back of the steel bar
D)The bread board type surface connects the steel arm to the detector
E)This steel arm is attached to the detection unit and the linear actuator by the bridge

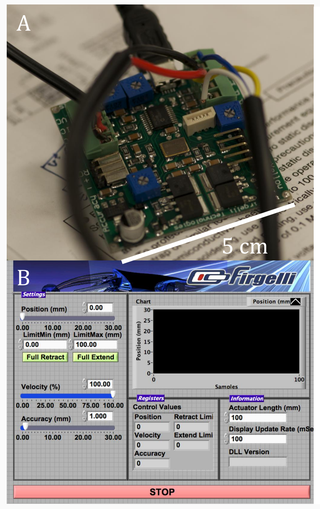

Figure 6: The control unit
A) The fully operational linear control board
B) The LabVIEW UI for position

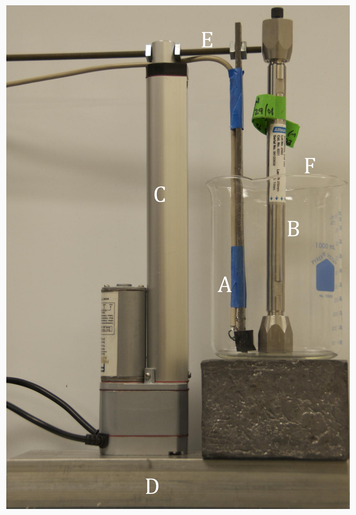

Figure 7: The final functional prototype.
A)The detection unit , B) The HPLC Column, C) The linear actuator, D) The aluminum base unit, E) The steel bridge F) Beaker represents lead shield

- The linear actuator is a Firgelli Motor (FA-PO-35-12-08") used in combination with a Firgelli Linear Actuator Control Board[4].
- The detector is a Hamamatsu Si Pin Photodiode (S9269)[5]
- The software interface utilizes LabVIEW sample code provided by Firgelli Automation[6]

FUTURE WORK

- Conduct combined radioactivity detection and distance-threshold testing with the linear actuator in order to confirm both are performing in parallel.

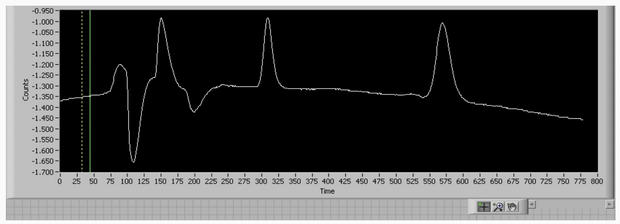

Figure 8: A graph of radioactivity vs. time passing through an HPLC column

- Include a remote controlled system so that the HPLC can be monitored from anywhere in the lab
- Consolidate the design so that it can be manufactured *en mass* for multiple HLPC columns in the lab
- Improve the software user interface in order to simplify the data output and improve usability

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REFERENCES

[1] *Advances in PET Scanning*. Diagnostic Imaging, n.d. Web. 21 Oct. 2012. <http://www.diagnosticimaging.com/pet-mr/content/article/113619/1877446>.
[2] < http://pubs.niaaa.nih.gov/publications/arh27-2/161-173.htm>
[3] *How Does High Performance Liquid Chromatography Work? Waters HPLC, n.d. Web. 16 Oct. 2012.* <http://www.waters.com/waters/nav.htm?cid=10049055&locale=en_US>.
[4] <http://www.firgelliauto.com/product_info.php?cPath=109&products_id=161>
[5] <http://sales.hamamatsu.com/en/products/solid-state-division/si-photodiode-series/with-preamp-cooler/part-s9269.php>
[6] <ni.com>