SOCIETY OF PHYSICS STUDENTS
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SPS Chapter Research Award Proposal

Project Proposal Title	Neutron Energy Distribution of an AmBe Source at the MGH Proton Center
Name of School	Suffolk University
SPS Chapter Number	6917
Total Amount Requested	$2000.00

Abstract

Bubble detectors are useful tools for determining neutron radiation of both an AmBe source and a 15 MV medical linear accelerator (LINAC). In order to determine the energy distribution of the sources, a more sophisticated system of bubble detectors is necessary. In particular this requires an external compression system (rather than the screw system used on each detector). A system of a multiple energy dependent bubble detectors and the recompression system will allow a variety of experiments for energy determination of the neutron spectrum. This will be used for determining the effectiveness of different thicknesses of polyethylene for different neutron energies.

Proposal Statement

Overview of Proposed Project

We would like to determine the energy distribution of the AmBe source and can do that if we use a more sophisticated system of bubble detectors. In particular this requires an external compression system (rather than the screw system used on each detector). It makes use of different types of detectors made to have different neutron energy thresholds so that they do not respond to neutrons below the threshold. Such a system of a multiple energy dependent bubble detectors and the recompression system will allow a variety of experiments for energy determination of the neutron spectrum. This will be used for determining the effectiveness of different thicknesses of polyethylene for different neutron energies.

The entirety of the SPS chapter takes part in the research project, about a dozen students. In addition to the SPS members, Tara Medich, the Director of Radiation Safety at MGH, Joe McCormac, cyclotron operator at MGH, Jacqueline Nyamwanda, Educational Coordinator for Medical Dosimetry at Suffolk University, Dr. Walter Johnson, Physics Program Director at Suffolk University and project leader, also participate in the research.

This project allows students to get experience working as part of a research team. The team is structured so that the upperclassmen are well versed with all experimental components, with a specific area of expertise. They are responsible for educating and training the underclassmen in all aspects of the project, so that the information is passed down and research will perpetuate after students graduate. Students beginning on the project will attend project meeting and experiments, primarily as documentors, and as they learn more about the project, new students participate more in the experimental planning and design as they learn more about the particulars of the project.

Background for Proposed Project

We have been studying the neutrons emitted by an Americium- Berylium (AmBe) source made available to us at the Proton Center at Massachusetts General Hospital (MGH). Part of our effort has been to measure the absorption of neutrons by different thicknesses of polyethylene which is of importance for shielding studies both near reactors and onboard spacecraft (such as the International Space Station or a ship carrying people to Mars as planned by many countries about a decade from now). The absorption of neutrons depends on the energy of the incoming neutron flux and this energy distribution varies from one Am Be source to the next. The distribution for the source at MGH is not known.

There are bubble detectors made by BubbleTech in Canada which are transparent tubes about the size of a test tube and they are filled with a gel which has the property of producing bubbles when a particular number of neutrons pass through. The calibration by the company lets us know the dose in mrem received by the detector as some number of bubbles/mrem. From known activity of the neutron source we can convert that to neutron intensity in n/(cm2 sec). Our detectors to this point have been general in that they respond to all neutrons above an energy of 200 Kev. They are reusable by means of a screw type plunger at the base of the detector which compresses the gel and eliminates the bubbles after pictures have been taken for bubble counting and analysis.

Expected Results

For this research, our main goal is to determine the energy distribution of an AmBe neutron source and 15 megavolt linear accelerator (LINAC) as well as characterize the level of energy in analyzing the effect of polyethylene's thickness on the method of shielding scattering neutrons.

For obtaining the energy distribution of flux coming out of the AmBe source and the 15 megavolt LINAC, we expect that we can make measurements with energy dependent bubble detectors. The energy distribution of both AmBe source and the LINAC are unknown to MGH. With each bubble detector set up with distinct neutron energy thresholds, we can obtain different number of bubbles appearing in each individual bubble detector. By tracing back the number of bubbles in each detector to the number of neutrons passing through the detector in different levels of thresholds, we can estimate and calculate the energy of flux coming out of the sources. The result is including the calculated value with an estimated error since it takes many different bubble detectors with different thresholds value to estimate the source energy

The result of energy distribution from AmBe source and 15 megavolt LINAC will be used in continuing finding the linear attenuation coefficient of the polyethylene sheet. Since the energy distribution has been known, we can use it to optimize the ability of blocking neutrons of this material. With different neutron energies, we can arrange different ways of shielding the bubble detectors with polyethylene sheets.

Different neutron energies passing through the same bubble detector with fixed threshold gives out different number of bubbles. From the number of counted bubbles, we can calculate the number of neutrons passing through each detector, then comparing those that are shielded and those that are unshielded to find the number of neutrons or radiation intensity has been lost due to this method of shielding. From this result, we can determine the linear attenuation coefficient (unit: 1/cm) of the polyethylene on blocking neutron scattering from this radiation source, which can also be explained as how much in the unit of radiation intensity is lost during one centimeter of polyethylene thickness.

Description of Proposed Research - Methods, Design, and Procedures

We would like to determine the energy distribution of the AmBe source and can do that if we use a more sophisticated system of bubble detectors. In particular this requires an external compression system (rather than the screw type system on each detector). It makes use of different types of detectors made to have different neutron energy thresholds so that they do not respond to neutrons below the threshold. Such a system of multiple energy dependent bubble detectors and the recompression system will allow a variety of experiments for energy determination of the neutron spectrum.

This will be useful for determining the effectiveness of different thicknesses of polyethylene for different neutron energies. In addition we have access in the evenings to a 15 megavolt linear accelerator (LINAC) at MGH which produces neutrons when operating. These are an inadvertent by-product of focusing the photon beam used for treating cancer patients and it is of interest to determine the energy spectrum of the neutrons produced by the LINAC.

Each of the bubble detectors provided by BubbleTech in Canada designed with the compression system allows the users to choose the level of neutron energy threshold, so it only identifies the neutrons at a specific level of energy. Therefore, we will set up multiple detectors, each with different thresholds so that they are all used in the same experiment and give out different number of bubbles in each individual detector. With different number of bubbles in different tubes with known thresholds, we can calculate the radiation energy from the flux coming out of the source. The result will be estimated close to the threshold of the detector containing the least number of bubbles. These bubble detectors will be placed on the detector stand, which has been designed on earlier experiment, with the same distance to the source. Each detector will be marked and noted carefully with the threshold number. After an amount of time, the source will be taken away, and all of the detectors will be treated carefully and photographed for the students to count the bubbles. From the number of bubbles, we can obtain the energy distribution of the source. This same procedure is used for both AmBe source and 15 megavolt LINAC at MGH at night to identify neutron energy distribution.

Plan for Carrying Out Proposed Project

The entirety of the SPS chapter takes part in the research project, about a dozen students. About 4 or 5 of the students are juniors and seniors and have been working on this project since they came to Suffolk freshman year, they give the team the advantage of seeing the project in all iterations it has been through. All upper level students have been trained on all aspects of the project, including instrumentation, data analysis, execution of experiments, and how to write research reports and posters.

This project takes place at the Proton Center at Mass General hospital, that is where the neutron and proton sources are located that we use for collecting data. Typically, data analysis is done together in our physics lounge. In addition to the SPS members, Tara Medich, the Director of Radiation Safety at MGH, Joe McCormac, cyclotron operator at MGH, Jacqueline Nyamwanda, Educational Coordinator for Medical Dosimetry at Suffolk University, Dr. Walter Johnson, Physics Program Director at Suffolk University and project leader, also participate in the research.

Project Timeline

January 2020

- Begin planning for experiment execution, order detectors and compression system

February 2020 - March 2020

- Conduct several experiments at Mass General using the new detectors and compression system
- Submit results to JURP on March 15

April 2020

- Present at APS April, April 18-21, 2020. Washington, D.C

May 2020

- Submit interim report due May 31

June 2020 - August 2020

- Typically there is no activity during the summer months

September 2020

- Train new students
- Begin planning for experiment execution

October 2020 - December 2020

- Plan for several experiments using detectors and compression system
- Submit final report on December 31

Budget Justification

The bubble detectors are individually not very expensive (about $160- see attached quote) but the recompression system is a little over $3600. The department has agreed to provide the excess needed about the $2000 SPS grant in order to allow us to obtain the recompression system and the detectors. The quote for the recompression system is attached. The SPS grant would cover $984 of the recompression system and the department would cover the rest. The SPS grant would also allow us to obtain a new set of six bubble detectors. Mass General Hospital allows us to use their beta decay detector, neutron and proton sources.

Bibliography