

Summary of Work Done During Summer of 2004

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1 Introduction

This report outlines the projects that I worked on from May 1 to August 31, 2004. This work was done for the Subatomic Physics group at the University of Saskatchewan during the tenure of my NSERC Undergraduate Student Research Award. Each project is described briefly below, with reference to additional reports for the larger projects. The projects are listed in approximately chronological order.

2 Projects

2.1 GEANT 3 Exercises

My first project was to familiarize myself with the GEANT 3 particle simulation software. This was done by completing the set of exercises written by Ru Igarashi and located on the website <http://nucleus.usask.ca/Geant/Exercises>. This experience also introduced me to Fortran, which would be useful in my work on pion production near threshold later in the summer. No formal report was prepared from the results of these exercises, but the results were recorded in my logbook and in several graphs in the directory `/home/barnett/geant_sim/`.

2.2 Blowfish Detector Upgrades at Duke University

From May 9 to May 24, 2004, a group consisting of Jennifer Robb, Brian Bewer, Ru Igarashi and myself travelled to Duke University to complete upgrades on the Blowfish detector at the High Energy Gamma Source. The work consisted of replacing the photomultiplier tubes and electronics for 61 of the 88 detectors on the Blowfish array. As well, optical fibres were installed into the

detectors to allow light from a flasher to be piped directly into the scintillator box of the detector. Later in the summer, Brian Bewer returned to Duke and installed the flasher system which will be used to monitor gain drift in the detectors over time. The design and implementation of this system was Brian's master's thesis. The detector upgrade manual [1] describes the procedures used in performing these upgrades.

2.3 Measurements of Blowfish Geometry and Attempts to Improve Blowfish Detector Mounting Method

While at Duke, measurements were taken of the detectors, mounts and frame of the Blowfish array. These measures were checked against the GEANT 4 model of Blowfish used by the group, and checked out reasonably well. The measures were collected into a set of CAD drawings created with QCAD and saved in .eps format, and are located at /home/barnett/final_reports/schematics.

The other purpose for these measurements is for use in designing better mounts for the detectors on the Blowfish array. Due to time constraints on my part, this work is still unfinished. Preliminary sketches and the results of several discussions with Ru Igarashi about possible mount designs are recorded in my logbooks. As only preliminary work was done on this topic, no formal report was prepared for it, other than the set of CAD drawings of the detectors and the Blowfish arms.

2.4 Cosmic Ray Muon Detector

During the 2003-2004 school year, a cosmic ray detector was designed and partially built by Janelle McKenzie, Amanda Gerbrandt and Nolan Dougherty for their Capstone Design Project[2]. Completing work on the detector and its software was an ongoing side project for Ward Wurtz, Jennifer Robb and myself this summer.

My largest contribution to the detector consisted of a high voltage distribution box for powering the 8 photomultiplier tubes in the detector; this is described in more detail in [3].

I also assisted in the optimization of the circuit layout needed to reduce the total number of components needed, and to make the circuit fast enough to be responsive to the 7ns pulses the muons produce in the detector. The final circuit designs are described, along with the huge body of work done on the detector by Jennifer Robb and Ward Wurtz, in the final report for the detector [4].

2.5 Pion Production Near Threshold

This was the largest portion of my work this summer, and the majority of my time at work was devoted to it. The object of this work was to refine earlier methods of extracting p_3 amplitudes near threshold for pion production from larger nuclei. The earlier methods were developed by Ru Igarashi and Jack Bergstrom, and their original results are contained in a series of papers [5]. The methods that I developed involved a set of scripts and C programs contained in the directory /home/barnett/pion_analysis on the gamma computer. I applied the methods to carbon, refining previous results, and to helium, a target which had not been previously analyzed. The full details of this work may be found in [6].

The theoretical cross sections (less a factor of $(p_3)^2$) may be found in the files

/home/barnett/pion_analysis/xs_files/xs.theor.<target>,

where <target> is "c" for carbon or "he" for helium. The experimental cross sections with the energy shifts applied are collected into two files:

/home/barnett/pion_analysis/xs_files/xs.shifted.c1to5,
/home/barnett/pion_analysis/xs_files/xs.shifted.he1to4.

for the carbon and helium data respectively.

2.6 Light Pipe for Active Target in Blowfish Detector

In order to detect light from a scintillating target placed inside the Blowfish array, the light must be passed into a photomultiplier tube. To avoid placing a tube within Blowfish and thus destroying its spherical symmetry, it is desirable to design a "light pipe" (affectionately called a periscope) to direct the light to a photomultiplier tube located just outside of the array. A proof of concept was prepared by Jennifer Robb and myself consisting of plastic tubes coated with aluminized mylar. This work remains unfinished, but its progress so far is described in [7].

2.7 Poster for NSERC Poster Session

As part of my NSERC grant, I prepared a poster of one aspect of my research this summer and presented it at the NSERC poster session on August 25, 2004. The poster focussed on the pion production work that I had done, as it produced the most concrete results. The poster can be found in pdf format at /home/barnett/final_reports/poster/michael_barnett_NSERC-poster.pdf.

References

- [1] Barnett, Michael, Brian Bewer, Jennifer Robb & Ward Wurtz. *Blowfish Detector Upgrades Manual, Version 2*. Internal Report SPIR-124, 2004.
- [2] Dougherty, Nolan, Amanda Gerbrandt & Janelle McKenzie. *4th Year Engineering Physics Design Project: Cosmic Ray Detector*. April, 2004.
- [3] Barnett, Michael. *Design and Fabrication of a High Voltage Distribution Box*. Internal Report SPIR-126, 2004.
- [4] Robb, Jennifer, Michael Barnett, Ward Wurtz. *Cosmic Ray Detector - Redesign and Fabrication*. Internal Report SPIR-125, 2004.
- [5] Bergstrom, Jack, Ru Igarashi, J. M. Vogt. *Measurement of the $^{12}\text{C}(\gamma, \pi^0)$ Reaction Near Threshold*. Phys. Rev. C. **55** 2923 (1997).
- [6] Barnett, Michael. *Analysis of Pion Production Near Threshold for Carbon and Helium*. Internal Report SPIR-127, 2004.
- [7] Barnett, Michael, Jennifer Robb. *Design of Light Pipe for an Active Target in the Blowfish Detector Array*. Internal Report SPIR-128, 2004.