SCIPP Internship Program, 2007

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Congratulations on being selected for this year's program.
You will have the opportunity to learn a great deal about particle physics, electronics, & mathematical analysis; while working in a research lab.

You will spend one part of your time in the lab building detectors and testing them. Another will be in the research library learning more about topics that arise and a third part in colloquia meetings where you will be the expert presenting to a group of your peers as well as professors.

Following is a list of objectives and topics. It is expected that you will be working on most of these and likely others as the internship progresses.

1. Refine, test, and document techniques to measure singles rates, coincidence rates and efficiencies of these detectors.
2. Develop lab techniques for measuring muon count rates to establish exponential decay rates as a measure of the muon lifetime.
3. Design sampling plans and evaluate statistical uncertainties.
4. Statistically evaluate data: conditional probabilities, standard deviation, confidence levels, hypothesis testing.
5. Understand the sources and interactions of cosmic rays.
6. Learn to program and use FPGA devices (Field Programmable Gate Array) to measure muon lifetimes.
7. Thermodynamics experiments with Sterling engines.
8. Develop advanced atmospheric measurements for Global Warming data.
9. Learn to use research grade equipment such as digital storage oscilloscopes.
10. Keep thorough & complete lab notebooks. Write professional lab reports. Create an interesting, useful, and accurate website as a record of work accomplished and as a reference source for others.

Expected working hours and days:

You will be expected to begin work in our SCIPP office promptly at 9am each weekday morning. We will begin each morning with a briefing by each member on yesterday's accomplishments and problems and will make plans and assignments for today's work. We will break for lunch about noon and usually work will end by about 5pm. Each week at least one colloquium meeting (usually Wednesday afternoon) is planned where you will be expected to report on progress and things learned to your peers as well as graduate students and professors. In addition, we will identify areas of interest to us and invite various scientists to present these topics in informal talks each week.

Pre-Internship Research Assignments:

Our work this year will center on development and test of cosmic ray scintillation detectors. We will be using statistical analyses to measure the efficiencies of the detectors.

Before we begin, you will need to do some preliminary research on selected topics so that you can prepare a presentation for our first colloquium that week.

Each of you are assigned one of the following areas to research. You will become especially familiar with that area so that you can present and teach it to each other as well as an interested group of teachers and professors. Please refer to the reference materials at the end of this document.

Research Topics to be presented in the first week:

1. Scintillator DAQs & Quarknet Grid..... Melissa / Alex
2. Cosmic Rays ..... Nathan / Brooke
3. Statistical Analysis..... Marshall
4. Muon Lifetime experiment ..... Anna / Ben

Important Note: You will be expected to make a formal Powerpoint presentation early in the first week of the Internship.

Description of Research Assignments:

Scintillator DAQs & Quarnet Grid

Study the manuals and schematic diagrams for the electronics board (DAQ) developed by QuarkNet at Fermi National Accelerator Laboratory (FNAL) and used as part of the WAshington Large area Time coincidence

Array (WALTA) as well as the DAQ developed by the Stanford Linear Accelerator Center (SLAC) and called the Compact Cosmic Ray Telescope (CCRT) and the DAQ developed by the Lawrence-Berkeley National Lab (LBNL). Research each IC used on the board. Download and printout a copy of each ICs data sheet. Explain the operation of each stage of the electronics.
Review the animations (e.g. DAQII simulation), explanations, and example data sets in the Quarknet Grid Website (see Resources page 5) as it is used for collaboration.

FPGA programming and design

Locate all reference materials to the Xilinx FPGA board that we have. Get copies of all specifications, diagrams, and manuals. Assemble these into an indexed binder for reference by all interns this year and next.
Assemble a complete set of necessary software and make it available to each intern for loading on various lab computers. Find the programming written for our Muon lifetime experiment last year. Make copies, print out and annotate for full understanding by all interns. Fully explain the logic and operation of this program. Describe how correct operation of the programmed FPGA system will be tested.
Determine and list the necessary specifications for all inputs to the FPGA. What voltage levels, time durations, and current levels must the scintillator signals meet in order to be useful to the FPGA. How can we make sure that our signals meet these requirements.

Cosmic Rays

Research cosmic rays; their origin, make-up, energies, interactions, decay products, and lifetimes. Learn about strong force & ionization interactions; quarks, baryons (e.g. proton, neutron), mesons (e.g. pion & kaon), leptons (e.g. electron, positron, & muon). Learn about Interaction depth and air showers. Research scintillator materials and explain their function, efficiency, and limitations.

Statistical Analysis

Statistically evaluate data: conditional probabilities, standard deviation, confidence levels, hypothesis testing. Compare binomial, Poisson, & Normal distributions. Use probability models to determine confidence levels and test hypotheses. Analyze data sets for mean, mode, & variance using non-parametric statistics.

SCIPP Internship Website design and documentation

Research the existing website. Fully understand the layout of graphics, links and files. Plan a structure and procedure to publish all of this year's resource materials, presentations, and documentation. This should be exciting, interesting, useful and easy to use. It should be a resource both for you and later interns as well as other researchers and curious people. This should be considered a day-to-day resource for each member and must be updated frequently. Documents published on this site must be complete with appropriate titles, abstracts, authors, dates, and must reference sources and link to other documents.

Muon Lifetime experiment

Understand the sources and interactions of cosmic rays. Study the Standard Model of Fundamental Particles and Interactions. Understand exponential decay of muon particles. Measure muon lifetimes.

Review the animations, explanations, and example data sets in the Quarknet Grid Website. Fully understand the

Reseach the construction & operation of scintillation panels. Understand the process of testing the detectors: PMT voltage, threshold voltage, singles rates, coincidence rates, & efficiencies.

Learn about the operation of digital storage oscilloscopes and FPGA devices (Field Programmable Gate Array).

Global Warming Research

Contact Dr. James Dann (jamdann@gmail.com) for further information

Internship Documentation

Purpose

You should recognize that your effort during this internship has been significant and that you have learned a great deal that will be needed by others continuing your work. However, all your efforts will be wasted if you do not fully document your work.

Continued funding for internships require providing "measurable evidence of productivity". This means that our funding agency expects to see reports documenting your progress.

Types of Reports

White Papers: document the designs, resources, techniques, processes, analyses, tips, or lessons that you have developed or learned.

Personal Reports: should detail problems encountered, resolutions, and personal growth experienced as a result of this summer's internship.

Due Date

Each intern writes, proofreads, and corrects a Personal Report.

Each intern writes one or more White Papers. Each White Paper should be reviewed by at least one other intern, proofread, and corrected.

All reports must be complete and posted in Word and PDF format on our website no later than Wednesday, 7/25/07.

Remember, you cannot be paid for your summer's work until these reports are complete, accepted and posted on the internship website.

Format

Please use the Arial 12 point font in MS Word. Include the following sections: Title (see below), By: , Reviewed by:, Abstract, Purpose, and Main Section.

Make it accurate and professional in quality.

Always fully document and explain how things were calculated and where information was derived from. Include bibliographies and references to all needed resources especially those posted on our web.

Suggested Titles ----Review titles for new year----

- Design of the Balloon Deployable Detector System
  Purpose of BDD. How the BDD was designed. What parameters were selected and why. What performance is expected. (KAO line fitting, statistical significance, weight and power budget, helium and balloon requirements, laws, etc.)

- Construction of the Balloon Deployable Detector System
  How the BDD was constructed. Engineering drawings, electronic schematics, actual weight and power, parts lists, tips and lessons learned during construction.

- Validation of the Balloon Deployable Detector System
  Actual test results during lab test of the BDD. Plateau data, efficiency, and comparison to design specifications.

- Flight Test of the Balloon Deployable Detector System
  Actual report detailing the results of the Flight Test of the BDD. Flight log, data, and analysis. Does the BDD work as planned? What needs to be fixed? What can be improved?

- How to Construct a Muon Scintillator Detector
  Beginners guide to successfully constructing a working scintillator detector. Materials list with sources, tools and supplies list, recommended construction procedure, important considerations, and tips for success.

- How to Calibrate a Muon Scintillator Detector (Plateauing)
  Theory and practice of successfully plateauing a detector. Why the process works, how to do it, sample data, analysis, and what it means. What Oscilloscope signals should look like at each stage.

- Design of the Muon Lifetime Experiment
  Theoretical background and design for our Muon Lifetime Experiment.

- Statistical Analysis of Muon Lifetime Data
  Uncertainty estimation and propagation in counting data. Frequency analysis (binning) of muon decay times. Exponential line fit with parameter error estimation. Estimation of muon lifetime with uncertainty.

- Design and Maintenance of the Outreach Website
  File structure, hyper structure, cascading style sheet design, guidelines and procedures. Where and how should future changes be made to the outreach website?

- Using the FPGA to measure the Muon Lifetime
  How to, where to find resources (software, etc.), what hardware is needed, input signal specifications, output specifications, expected resolution & accuracy.

Resources

Following is a list of useful resources. Be sure to explore each thoroughly before this summer's internship begins.

Top level Resources:

SCIPP Outreach: http://scipp.ucsc.edu/outreach/index.html
The Cosmic Ray Experiment:
http://www.lbl.gov/abc/cosmic/SKliewer/Index.htm
Particle Physics: http://www-pdg.lbl.gov/pdg.html
SLAC Virtual Visitors Center:
http://www2.slac.stanford.edu/vvc/Default.htm
APS Physics Links: http://pdg.lbl.gov/~aerzber/aps_index.html
FPGA: http://www.xilinx.com/

Products of Prior Interns:

Internship Home: http://scipp.ucsc.edu/outreach/intern.html
Resources:
http://scipp.ucsc.edu/outreach/internships/2006Internship/resources.html

Detector Designs:

CR detectors: http://quarknet.fnal.gov/toolkits/ati/crdetectors.html
SLAC CCRT detector:
http://scipp.ucsc.edu/outreach/internships/2004Internship/Resource/slac-tn-95-001.pdf
LBNL Berkeley detector: http://quarknet.fnal.gov/toolkits/ati/lbnldet.html
FNAL WALTA detector: http://neutrino.phys.washington.edu/~walta/
FNAL Grid Project: http://www11.i2u2.org:8080/elab/cosmic/project.jsp
Logon as SCIPP pass=muon

Books for loan:

"Cosmic Bullets" by Roger Clay & Bruce Dawson
"Practical Electronics for Inventors" by Paul Scherz
"Space-Time Physics" by Taylor and Wheeler
"Particle Physics" by Abe Seiden
"The Nature of Science" by James Trefil
"Teach Yourself Statistics" by Alan Graham
"The Cartoon Guide to Statistics" by Larry Gonick
"The Cartoon Guide to Physics" by Larry Gonick

Please check out these materials and websites in before beginning your internship.