2011 HASP February Status Report
UA Maple Leaf Cosmic Ray Detector

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Revision: 1.0

1 Activities

February was a very busy month for our team: The team worked on defining the new design and investigating the new detector's components. Also, improvements were made in the team's organization and structure to improve the communication and definitions of each team members roles and responsibilities.

1.1 Detectors

A scintillator design was initially considered by the team. With the help of, with the help of Richard Soluk (Detector Technologist at the UofA Department of Physics High energy particle physics), three options were considered for transmitting light from the scintillating material to a photomultiplier tube, giving a voltage of the reading with a measurement of the energy of the incident particle. The first design involved a light guide directly below the scintillator, with an equal surface area as the scintillator to channel light into the PMT. The second design involved wavelength-shifting fiber, which would be embedded into the scintillator material and run into the PMT to give us a voltage and energy reading. Finally, a light guide parallel to the scintillator was considered. After fully researching each option based on previous papers, advice from Richard Soluk (Detector Technologist at the UofA Department of Physics High energy particle physics) and the UofA Machine and Electronics Shops personnel we found that the first light guide would be both too heavy for our weight budget, and expensive to manufacture. Further, using a formula found in in Spieler (1999)[i], we calculated as stated the angle at which the light guide could shrink to fit the PMT, and this required very long light guides, which added to the bulk and limitations of this design. The second option was much better, since wavelength shifting fiber is light, and compared to the first option, there would only be a 10% efficiency loss between the scintillator and the PMT (Moiseev et al (2007)[ii]). This allowed us to consider multi-layer scintillator designs. The final design was also an option, since it's volume is greatly reduce, however it again ran into an efficiency loss. At this point, we had tentatively decided on a multi-layer design with wavelength shifting fibers analogous to a design found in a paper we came upon while researching the project.

Due to time restrictions (design and manufacture of detector before April 30th to allow testing at CSA David Florida Laboratories), these designs had to be put aside for a number of reasons: For example, the delivery time of the light guides are above 8 weeks and would never reach UofA in time for manufacture. Moreover, the UofA Department of Physics is moving to a new building during the months of March-May, which limits the access to electronic and machinery workshops. Therefore, the team had to revise their plans again and consider a compromise design of more 'off the shelf' detector design that could be modified by the team in a realistic time frame.

Dr. Pinfold, a faculty at the UA Department of Physics, Particle Physics group advised us on a design that included medipix chips used in CERN to detect particles which he had access to through a collaboration with Dr. Stanislav in the Czech Republic. The team set to work investigating the characteristics of these medipix chips, whilst also considering fallback options for the revised design. Potential problems by using the medipix detector included that the team had very little information on their design and very little information available to them online, so we were reliant on Dr. Pinfold contacting a Dr. Stanislav in the Czech Republic for specifics on the detector design. Each medipix chip is a 256x256 pixel chip, with about two square centimeters of detection area. The events recorded on the chip as a function of time could be loaded into a software to be provided by Dr. Stanislav to produce a video on the incident events and allow us to determine the particles that contacted it (see appendix 1, BEXUS balloon flight paper). One version of the medipix chips called timepix would give us both an energy resolution of the particle, directionality based on pixels crossed, and a time stamp on the event. The detector design using medipix would include one medipix on the top of the detector stack to detect low-energy solar proton events (energies 1MeV-100Mev) of particular interest for the Space Physics members of the team (L-shell 2, at the heart of the inner proton radiation belt), and using an absorber material with increment of 500MeV per layers to be recorded by other chips within the detector stack. Simulations were run to determine the thickness of materials required for certain energies of cosmic rays.

Multiple designs with the chips were considered. The first was a stack, similar to the photo paper stack of our original proposal with Lexan Makrofol and Cr-39 plastics added in, along with the medipix chips. The whole stack was then to be enclosed in a box to block out lower energy cosmic rays. The plastics, when hit by a particle would decay producing a trace on the plastics; when emulsified in a special mixture, through a rigorous process developed by Dr. Pinfold?s collaborators in Italy (basically stirring sodium hydroxide over the plastic evenly) we would learn about the incident particles. Difficulties on the plastic portion of the design include limitations place to be developed as well as time frame compatible with Canadian Space Agency fiscal year. A final design was considered involving medipix and x-ray film combination embedding into an iron structure that would define energy channels was considered. The choice of iron relies on it's absorption properties and interaction length, and the fact that it's much cheaper than tungsten. Our fall back should we not get the chips would therefore be our design submitted with the original proposal, however we also looked into alternatives.

Unfortunately, given the time line for the revised proposal, the specific Medipix technical information did not arrive in time to UofA to finalize the preliminary design. Therefore, a final design was considered. and the team is finalizing the new proposal based upon this design only.

The team decided on designing a detector using Geiger Muller counters in replacement of the medipix. Geiger Muller counters were considered since they can be bought off the shelf for a price within our budget, could be delivered within the time frame established by CSA fiscal budget and could easily be set up in a form of a DE/dx detector with the help of the Department of Physics Electronic shop. David Miles, from the Space Physics group, and Shengli Liu, supervisor of the Department of Physics Electronic shop helped the team to design a circuit board design to accommodate three Geiger tubes, to be placed between absorbing layers that would allow detection of solar particles between 50MeV-100MeV, and cosmic rays of energies 100MeV-250 MeV and 250-500MeV respectively. Simulations using Trim/Srim software were run to estimate absorbing layers thickness using iron, to estimate weight budget and define mechanical and electronics layout. A complete description on the new design can be found in the new proposal to be presented to HASP on February 28th.

1.2 Team Organization

The team's organizational structure has greatly improved over the last month. Firstly, we changed the team structure (see "Team Structure" below) for more effective communication, and well-defined roles. Secondly, we created a "to-do" list with short descriptions of tasks and those responsible for completing them. In addition to our weekly meetings with the entire team and advisers on Monday, meetings between team members (undergraduates and team leader) have been added on

Wednesdays. Undergraduate team members also schedule meetings on Sundays to coordinate tasks and communicate among themselves. This new meeting structure has been effective on keeping everyone more up to date on what is going on and will continue to do so in the future.

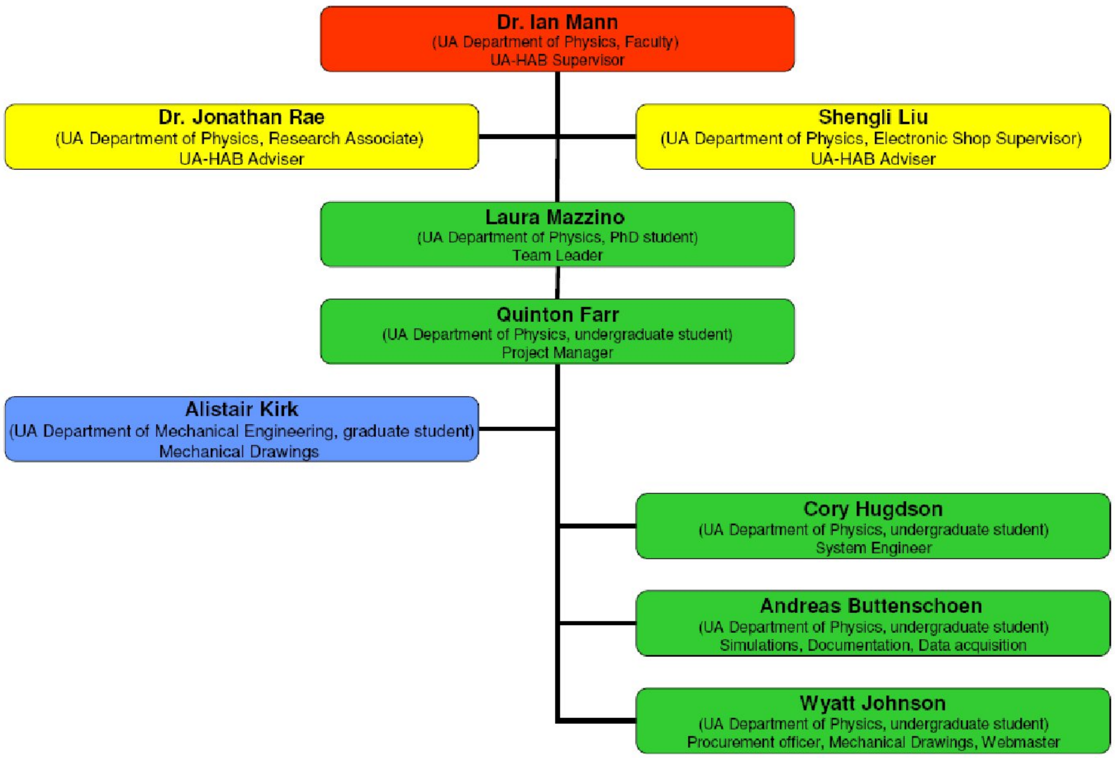

Figure 1: New Team Structure

2 Design / Development Issues

As described above, the scintillator design propose complicated electronics beyond the scope that the team members could learn in the duration of the project and the PMT required a high voltage that might have proposed problems when operated in a vacuum. The medipix design proposed challenge on getting the chips in time. Other issues were described in Activities (section 1) since they led to action immediately after they were discovered. The most significant issue was choosing a practical, realistic design that provides the necessary measurements required for our proposal, whilst also posing a challenge for the UofA team.

3 Milestones

We have chosen to go pursue the Geiger tube detector which we can finally get to work on, and we are confident, given our research and the personnel available to help us in the UofA Department of Physics, that it is the best option possible.

4 Personnel

There has been no change in personnel, however roles have changed (as seen in "team structure" (figure 1) of the new proposal). It has changed to the following:

Project Supervisor: Dr. Ian Mann (same as before)

Project Advisor: Dr. Jonathan Rae (same as before)

Project Advisor: Shengli Liu (UofA Department of Physics, Electronic Shop Supervisor)

Project Leader: Laura Mazzino (same as before)

Project Manager: Quinton Farr (already member, revised role)

Systems Engineer: Cory Hodgson(already member, revised role)

Data Storage / Documentation/Simulations: Andreas Buttenschoen(already member, revised role)

Procurement Officer/webmaster: Wyatt Johnson(already member, revised role)

Project Consultant (Electronics, general design): David Miles (UofA Department of Physics, Graduate Student)

Project Consultant (Mechanical Drawings): Alistair Kirk (UofA Department of Mechanical Engineering, graduate student)

5 References

i A.A. Moiseeva, P.L. Deering, R.C. Hartman, T.E. Johnson, T.R. Nebel, High efficiency plastic scintillator detector with wavelength-shifting fiber readout for the GLAST Large Area Telescope, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment Volume 583, Issues 2-3, 21 December 2007, Pages 372-381

ii Helmuth Spieler. IV. Scintillation Detectors - 3 LBNL Introduction to Radiation Detectors and Electronics, 02-Feb-99