Research Statement

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Overview of Research Interests

My research interests are to test the standard models of particle physics and cosmology by searching for new phenomena. These paradigms are intricately linked, and there has been tantalizing evidence of new physics with exciting experiments in the areas of neutrinos, dark matter, and cosmic rays. The large scientific interest in these experiments leads me to believe that the fields of high-energy particle physics and cosmology are on the verge of a new period of discovery. To meet this great potential, I have chosen to pursue anomalies in the cosmic ray sector and in cosmology through new physics searches. I believe progress in these areas will depend critically on higher precision measurements and global collaboration between experiments.

Research on sFLASH Experiment

As an undergraduate working with The Telescope Array Project (TA), I was given the opportunity to work on the sFLASH experiment at SLAC National Accelerator Laboratory in Menlo Park, USA. The primary goals of the Super Fluorescence AirSHower experiment, sFLASH, are to reduce the systematic uncertainty on the air fluorescence measurement and to study the air fluorescence yield dependence on the shower development. To achieve these goals, we conducted two experiments. During the 2016 experiment we measured the absolute air fluorescence yield. We used this result to normalize the results of the second experiment, conducted in 2018, and we aimed to study the air fluorescence yield dependence on the shower development stage.

In our group, I lead the quality check of the data, ensuring that the beam energy was stable throughout the run. I worked with colleagues on the photo-multiplier calibration both before the experiments and *in situ*. There has been a delay in sFLASH's analyses due to the COVID-19 outbreak and anomalies within the second 2018 experiment, but we are actively working through it and plan to publish our findings soon [2].

Research on Telescope Array Experiment

As one of the first graduate students to work on TAx4, I had the opportunity to contribute to the experiment at almost every stage. The hardware expertise I gained was quite varied, and I participated in running and analysis of the TA detectors. My analysis centered on the monocular and hybrid energy spectrum measurements for the TAx4 detector. This is a compelling topic because a precise measurement of the ultrahigh-energy cosmic ray energy spectrum can help us understand the mechanism of particle acceleration and point out the sources of these extremely energetic particles. TAx4 is the newest detector at TA, and understanding the energy spectrum is a crucial first step to performing composition and anisotropy analyses. I used my programming experience in C, C++, Python, and ROOT to interpret and analyze the data. In addition to data analysis, I worked with Monte Carlo simulations to interpret detector resolutions and performance. I showed that the monocular and hybrid energy spectra agree with the previously published TA combined energy spectrum [3, 4].

Throughout my time at TA, I helped in the development of both hardware and software. With the help of Prof. Charles Jui, I set up and maintained a computer cluster and data storage server. I created an automated pipeline for the data to flow from the detector through the event reconstruction process, on the cluster, to the data storage server. A colleague and I created a ETL program that optimized the diagnosing and checking of Surface Detector (SD) errors.

Part of my duties was the operation, maintaining, and calibration of the instrumentation. On clear moonless nights, I ran the Fluorescence Detectors (FDs). The runner was responsible for diagnosing errors in real time, working with the FD hardware, recording seeing conditions onsite, and monthly calibrations using a Xenon flasher. During the day I would visit problematic SDs, in the field, and fix them by replacing damage or faulty electrical components.

It is important to me to help other graduates and undergraduates. I answer their questions about the detector and about the physics of cosmic rays. I like working as a team, and I lead the team meetings every week to discuss hardware and software developments.

Future Research

I have always sought to understand the fundamental properties of matter, whether it be through cosmic rays or accelerator research. Indeed, I think a broad program of experiments is the best way to address the physics problems of today. I bring expertise in air-shower detection and data analysis techniques, along with a curious mind to the challenges we will face. I believe that I can make a significant impact with a strong collaborative group.

References

[1] S. Atwood *et al.* (sFLASH Collaboration) The instruments of sFLASH experiment. *Proceeding of Science* (2017) 407.

[2] S. Atwood *et al.* (sFLASH Collaboration) Air fluorescence yield measurement at SLAC National Laboratory: sFLASH experiment. To be published in the Physical Review Letters pending our results from our analysis of the data gathered at SLAC.

[3] M. Potts and C. Jui (TA Collaboration) Monocular Energy Spectrum using the TAx4 Fluorescence Detector. *Proceedings of Science* (2021) 343.

[4] M. Potts (TA Collaboration) Ultra High Energy Cosmic Ray Energy Spectrum Using Hybrid Analysis with TAx4. Currently writing.

[5] D. Ivanov (TA Collaboration) Energy Spectrum Measured by the Telescope Array Experiment. *Proceedings of Science* (2019) 298.