UNIVERSITY COLLEGE LONDON VISIT REPORT

COSMOLOGY AND ASTROPARTICLE STUDENT AND POSTDOC EXCHANGE NETWORK

VISIT DURATION: APRIL 20 – MAY 3, 2017

STUDENT: OINDREE BANERJEE

ADVISOR: PROF. AMY CONNOLLY

HOME INSTITUTION: THE OHIO STATE UNIVERSITY

Introduction

I am a 4th year PhD student at The Ohio State University (OSU), working on the Antarctic Impulsive Transient Antenna (ANITA) experiment. The primary goal of this experiment is to discover ultra-high-energy (> 10^{18} eV) neutrinos via their interaction in the Antarctic ice. I was deployed in Antarctica for two months in 2016 to launch and support the ANITA-IV mission. After a successful launch and flight of the ANITA-IV mission, I am focusing on simulation and analysis work this year, including an analysis to search for Gamma Ray Burst neutrinos, that is constrained in both time and direction.

Visiting University College London (UCL) was, therefore, a unique opportunity as it is a leading institution for ANITA simulation and analysis, as well as for the Swift Gamma Ray Burst Mission. During my visit, I worked on ANITA simulation and analysis, I learned about Long Baseline Neutrino Physics experiments and I toured the Mullard Space Science Laboratory (MSSL) to incorporate into my analysis the vast knowledge and unique perspective of the Gamma Ray Burst observers there. I made progress on all aspects of my proposed work at UCL as I focused on collaborative tasks, specific to UCL expertise, that are most efficiently completed in person, if not impossible to accomplish over the phone.

My hosts at UCL Bloomsbury campus

At UCL, I mainly worked with Prof. Ryan Nichol, Dr. Linda Cremonesi (postdoc) and Mr. Luke Batten (PhD student). Prof. Nichol is a pioneering contributor to ANITA flight and analysis software. Dr. Cremonesi is currently the most active contributor to the ANITA simulation software known as “icemc”. Mr. Batten is a fellow PhD student, currently focusing on analysis techniques that are complimentary to those being developed at OSU.

ANITA analysis work

At UCL, my analysis work mainly focused on eliminating anomalous events, specifically, “payload blast” events, from the ANITA-IV dataset. This is an important early step necessary for all analyses of the data. These events are thought to be caused by the photovoltaic cells of the payload, although we are not certain of their origin. I have been doing studies to characterize these events and to come up with appropriate cuts to eliminate them while maintaining near 100% efficiency for retaining calibration pulser events.

During Dr. Nichol’s local ANITA group meetings on Tuesdays, I was able to share results from these studies and receive feedback that was critical to my progress. Dr. Nichol’s comments helped me understand the problem I was trying to solve much better. He also helped bridge gaps in my knowledge about our digitization system and prioritizer program (a program that assigns every event a priority from 1 through 9), the software for both of which were developed at UCL. The assimilation of such UCL-specific knowledge would not have been possible over the phone. Working closely with Dr. Nichol’s group is enabling me to finish this task independently and submit a report on it to the collaboration.

ANITA simulation work

My simulation work at UCL mainly focused on creating ANITA-IV inputs databases for the simulation program icemc. This is a necessary step in the development of the simulation of the ANITA-IV flight, which is critical to analyzing ANITA-IV data. These inputs are recorded during the ANITA-IV flight, for example, altitude of the payload during the flight. Complications in the dataset such as missing data can make this task challenging.

I worked on this project under the direct supervision of Dr. Cremonesi. Dr. Cremonesi’s in-person guidance and help with troubleshooting is enabling me to finish this project independently at OSU, and move on to the next steps of ANITA-IV simulation development.

Complimentary analyses

Mr. Luke Batten was one of my office-mates, and we had productive discussions on the analysis techniques he is currently implementing for ANITA-III and ANITA-IV. The technique he is working on improving is known as “clustering” which is a way to eliminate events that have temporal and/or spatial proximity to other events or Antarctic bases.

At OSU, we are developing a different technique that divides Antarctica in equal area bins each with its individual cut for noise events. This method is novel and promising. It was critical to obtain first-hand knowledge and explanations of the clustering methods and its limitations, in order to convince myself as well as others of the benefits of the complimentary analysis we are developing at OSU.

Increasing my breadth in the neutrino field

Along with Drs. Nichol and Cremonesi, I attended the Long Baseline Neutrino Physics combined group meeting covering experiments such as CHIPS, MINOS, NoVA and MINERvA. At this meeting, I met Prof. Jennifer Thomas who is a pioneering contributor of this field. I also heard talks by Stefano Germani (CHIPS) and Anna Holin (MINERvA).

Dr. Cremonesi introduced me to the NoVA and CREAM TEA experiments and the science behind these projects. She showed me part of a CREAM TEA detector, and also gave me a tour of the NoVA shift room during an active NoVA shift by Dr. Anna Holin. I met scientists on the SuperNEMO experiment such as Dr. Cheryl Patrick and Mr. Laurent Simard. I learned more about the ATLAS and CHIPS experiments through my office-mates Mr. Amal Vaidya (ATLAS), Mr. Vasilis Konstantinides (ATLAS) and Mr. Josh Tingey (CHIPS).

Visiting MSSL

I visited the Mullard Space Science Laboratory (MSSL) in the Surrey countryside on April 27, 2017. The main goal of my visit was to interact with scientists working on Gamma Ray Bursts (GRBs), as I am leading an analysis of the ANITA-IV data to search for ultra-high-energy neutrinos from GRB afterglows for the first time.

Thanks to my hosts Drs. Silvia Zane and Daisuke Kawata, I had the opportunity to participate in extensive discussions with the GRB team at MSSL including Drs. Mathew Page, Paul Kuin, Alice Breeveld and others. All of these scientists have first-hand knowledge of the Swift satellite.

Swift holds the premier detector for GRBs with the best pointing accuracy, thereby enabling follow-up studies in X-ray, ultra-violet and optical wavelengths. The Swift UVOT (for follow-up in ultra-violet and optical wavelengths) had been built at MSSL. Follow-up in other wavelengths is relevant to my study as ultra-high-energy neutrinos are predicted to accompany the afterglow (lower energy) photons.

My day at MSSL was a crash course, together with Dr. Page's lecture notes, on Swift GRB detection. Through multiple discussions, I obtained answers to a host of questions from clarifying what is reported in the GCN circulars to insights on GRBs with no follow-up observations in other wavelengths.

I also received an extensive tour of the MSSL facilities thanks to Dr. Kuin. Overall, the MSSL visit was not only productive but also the beginning of a long-lasting relationship with several GRB observers.

Publications

Drs. Nichol and Cremonesi gave me helpful comments on two papers I am writing at the moment. The first is a paper on hardware I built for the ANITA-IV mission, the second is a paper on simulation. The former paper will be submitted for publication in

Nuclear Instruments and Methods Section A, within the next 2 months. The UCL visit helped me get started on the latter paper. We plan to finish this paper by late 2017.

The analysis I worked on at UCL will contribute to a collaborative paper on a diffuse search for ultra-high-energy neutrinos. We plan to finish this paper by early 2018. My visit to MSSL will contribute to a paper on a search for GRB neutrinos. This will be part of my PhD dissertation, currently scheduled for May 2018. We plan to write a paper on this work for submission by the summer of 2018.

Summary

In summary, the UCL visit allowed me to efficiently learn from and work with simulation and analysis experts in ANITA, to meet scientists from other neutrino experiments, to increase the breadth of my knowledge of neutrino experiments and their underlying principles, and to meet and learn from GRB experts at MSSL. The collaborative visit helped me make progress on four future publications. The visit was critical to not only my current PhD work but also to achieving my career goal of serving as a Principal Investigator in Particle Astrophysics.

At MSSL with a British Skylark 7 Rocket