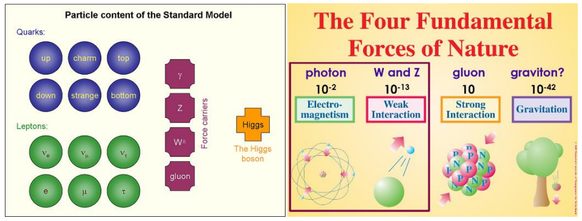
COLLEGE OF ARTS AND SCIENCES - DEPARTMENT OF PHYSICS

ANTARCTIC IMPULSIVE TRANSIENT ANTENNA

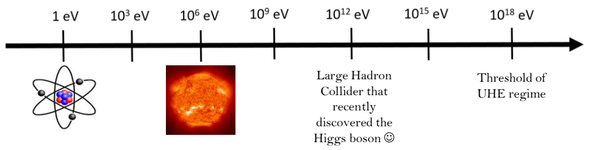
Oindree Banerjee, Brian Clark, Dr. Patrick Allison, Prof. Amy Connolly

Standard Model and the Four Forces



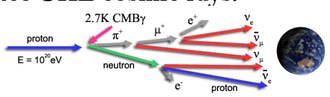
A New Frontier in Particle Astronomy

Traditionally, astronomers have relied on visible light to study the universe. Then they started looking at light outside the visible spectrum. At around the same time, cosmic rays were discovered. These were charged nuclei bombarding the Earth. Then neutrinos from the Sun were discovered. This opened up a new frontier in Particle Astronomy.



Ultra-high energy neutrinos

How energetic *can* a particle in the universe get? We don't know. Ultra-high energy (UHE) refers to energies above 10^{18} eV. In the UHE regime, specifically at energies above the GZK threshold of $10^{19.5}$ eV, the neutrino is the *only* particle that can travel large cosmic distances. Also, by virtue of its neutral charge, the neutrino points straight back to its source. With UHE neutrino astronomy, we hope to learn more about the mysterious and distant universe. What are possible sources of UHE neutrinos? The GZK process (picture below) and events in the sky that also produce UHE cosmic rays.

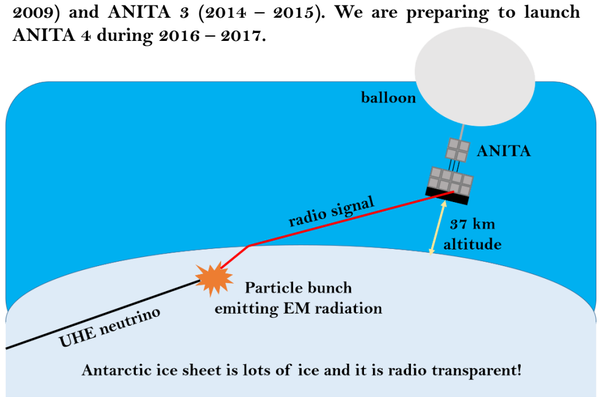


Antarctic Impulsive Transient Antenna

What is ANITA?

- ✓ balloon-borne
- ✓ array of 48 total radio antennas
- ✓ observing Antarctic ice sheet
- ✓ searching for impulsive radio emission
- ✓ in frequency range 200 – 1200 MHz
- ✓ due to the Askaryan effect
- ✓ caused by UHE neutrinos interacting in ice

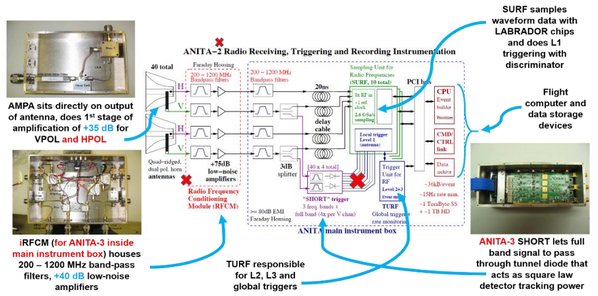
ANITA is a long duration balloon project launched with the help of NASA during the Antarctic summers. Utilizing polar winds, it circles over the continent for 20 – 40 days at a time. So far, we have had 3 flights: ANITA 1 (2006 – 2007), ANITA 2 (2008 – 2009) and ANITA 3 (2014 – 2015). We are preparing to launch ANITA 4 during 2016 – 2017.



Askaryan effect

When an UHE neutrino interacts in ice, it produces a particle bunch ~ 10 cm in radius that propagates through ice *faster* than the speed of light in ice. It gives off EM radiation that is coherent for wavelengths longer than the 10 cm bunch size, which correspond to light of frequencies under ~ 1 GHz.

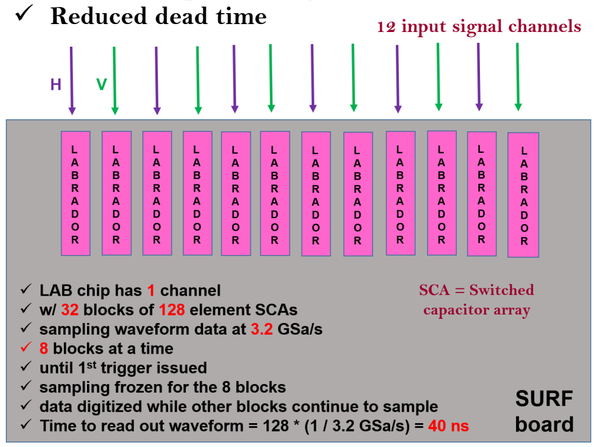
Radio Signal Chain from Antennas, through signal path, trigger logic and readout



LABRADOR (LAB)

The LAB chips on each SURF board sample waveform data so that we store data only when something interesting happens. ANITA is sensitive to both vertically (V) and horizontally (H) polarized light making for 48x2 = 96 input signal channels. In ANITA 4 there will be 8 total SURF boards with 12 LABs each to cover all 96 channels. They ensure:

- ✓ Efficient data storage on board
- ✓ Stay within power budget of ~ 1 kW
- ✓ Reduced dead time

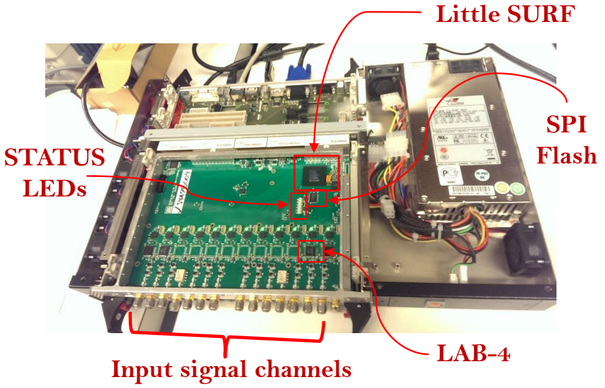


Acknowledgments

This research is supported by the NSF and NASA. Thanks to the Physics department for supporting me as a graduate research associate this summer.

Firmware for the SURF board

This summer, we worked on improving the firmware for the SURF board. The SURF board can be thought of as its own independent computer and we can communicate with and program different components of this board by writing Python programs that are then converted to firmware language. This summer, we focused on programming the 12 status LEDs on the SURF and programming a chip called the SPI Flash that can be used to then program what we call the "little SURF". The "little SURF" is a field-programmable gate array (FPGA) mounted on the SURF and it is the bridge between the SURF and the rest of the ANITA hardware. We were successful in programming and correcting the LED firmware. We have started to program parts of the SPI Flash and will continue this in the Fall.



ASPIRE 2015

The Connolly group hosts an annual summer science camp called ASPIRE. This year, we had 26 young women entering the 10th, 11th and 12th grades, participate in the camp. We organized projects, tours and talks for them. I gave a presentation introducing radio and E&M and made a "What Next" page for them suggesting follow-up activities to stay involved in STEM.