Detection of Dark Matter using XENON

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A little about me:

- Massachusetts College of Liberal Arts
  - BA in physics
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- Why Columbia?
Dark Matter

What we know:

• Dark Matter makes up about 85% of the matter in our universe
• We know this non luminous matter exists from different measurements such: Cosmic Microwave Background, Gravitational Lensing, and Rotation Curves of galaxies and clusters of galaxies.
• Thus far we lack any particles to explain DM. The most searched for and studied particle is currently the Weakly Interacting Major Particle or WIMP
• WIMPs have also been detected on earth through their ability to elastically scatter off atomic nuclei
This experiment is a collaboration between scientists from: China, Italy, USA, Portugal, Germany, France, Israel, Switzerland, and The Netherlands.

The XENON Dark Matter detection experiment is located inside of the Gran Sasso mountain in central Italy.

The machine is housed inside the mountain to ensure that only particles with high enough energy can penetrate the Earth’s atmosphere and reach the detector.

Source: http://www.xenon1t.org/
We like XENON for this experiment for a few reasons:

1. XENON has 9 stable isotopes in nature.
2. Xe has little radioisotopes with large lifetimes
   - The longest are (124)Xe and (136)Xe and their decays do not contribute significantly to background radiation in Xenon detectors.
   - Two of its isotopes are non-zero nuclear spins
3. It is a great scintillators in its liquid phase.
Overview:

Data collection for this system is focused on two main reactions taking place inside the time projection chamber (TPC).

WIMP\textsuperscript{s} collide with the liquid Xenon nuclei and produce recoiling Xe ions. The excited atoms emit scintillation light which is able to be detected by the photomultiplier tubes (PMTs) at the top and bottom of the chamber. This data is known as the S\textsubscript{1} signal output. Ionization produces free electrons that are able to move due to an electric field. The strong electric attraction to the anode pulls these electrons into the gaseous Xenon section where the high energy excites the Xe atoms again. The secondary excitation creates scintillation light collected by the PMTs known as S\textsubscript{2} output signal.
cryogenic camera for high voltage monitoring in liquid Xenon
Beginning Steps:

- Reading papers published on the Xenon experiment, cryogenics, experiments using cameras in cryogenic conditions, and vacuum hardware.

Calculations of:
- Heat input vs insulation thickness
- Mass of the Xenon inside of cylinders
Then we got hands on...
Wiring Practice:
Helium Leak Tests:
Experimental Tests
What’s next?

- Continued tests of the cryogenic capabilities of the vessel.
- Larger scale tests can be run using different cameras that would be able to capture interactions in the XENONnT.

Recent Issues:
Having issues with the cooling down of the entire vessel.

Overall, this project gave me great real world experience in the lab doing hands on research and has given me a lot of confidence in my ability to contribute to future employers as I move on to getting a job in a laboratory setting. This has also strengthened my appreciation for electronics and physics overall.
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