SuperCDMS & NEXUS

SIST Summer Research Project

Jillian Gomez

June 10, 2019

Background

The Cryogenic Dark Matter Search (SuperCDMS) is one of several collaborations performing experiments to directly detect dark matter particles with masses smaller than ten times the mass of the proton.

These dark matter particles (also known as WIMPs or "weakly interacting massive particles") could be detected directly using sensitive detectors* located in underground laboratories, to shield them from interactions of normal matter particles.

Such dark matter interactions would deposit a small, but measurable, amount of energy in an appropriately sensitive detector by elastically scattering from nuclei.
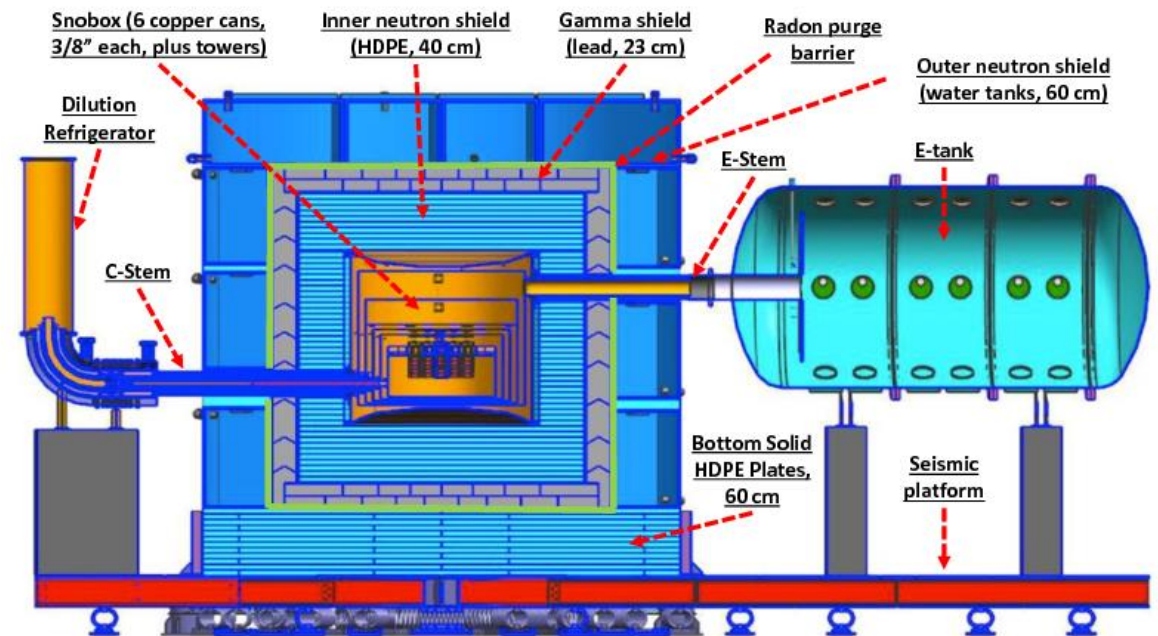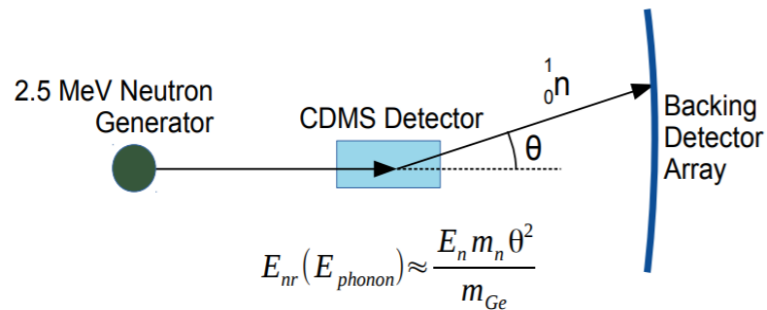
*silicon and germanium crystal detection,

in which the collisions trigger tiny vibrations

- NEXUS: Set up a clean, low-background, accessible testing facility for prototyping and testing next-generation cryogenic crystal experiments using the NuMI access tunnel at Fermilab.

- The NEXUS experiment will be focusing on cryogenics and detector shielding.
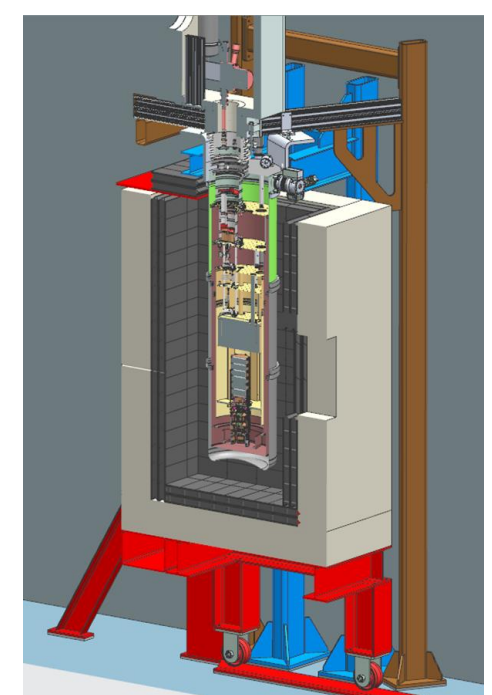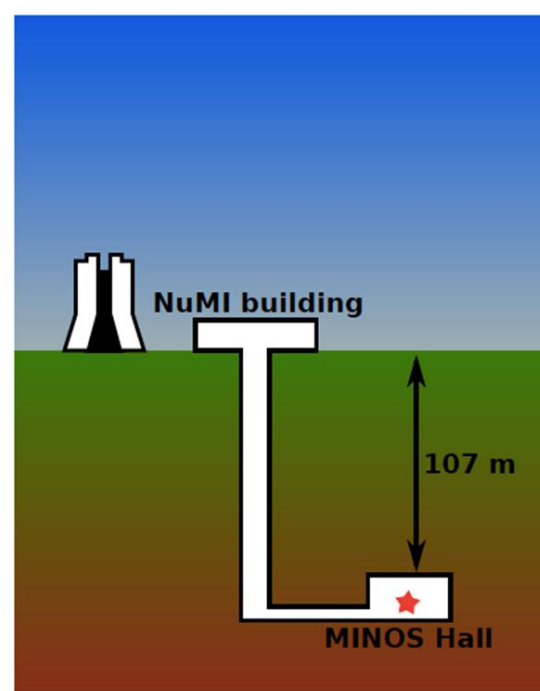
Neutron Scattering

- Neutrons
  - Penetrating radiation producing nuclear recoils.
  - Measure single scatter recoils in coincidence with a backing detector array.
    - Background discrimination with time-of-flight.
  - Needs a low-background environment.

$$E_{nr}(E_{phonon}) \approx \frac{E_n m_n \theta^2}{m_{Ge}}$$

‡ Fermilab

13   17 Oct 2016   Alan E. Robinson | Energy scale calibrations for SuperCDMS SNOLAB

My Task:

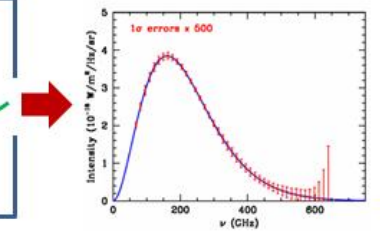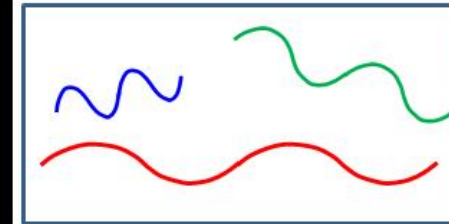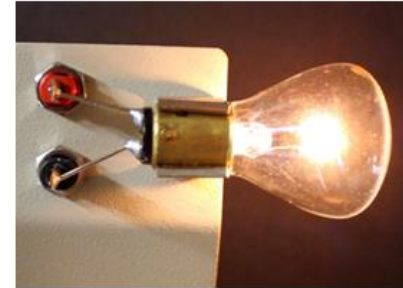***Find a way to reduce the amount of light leakage in the detector system.***

There is dark matter data being analyzed now that will be used in the model I create as soon as it is finished.

"Black-Body Radiation"

Absorbs all colors

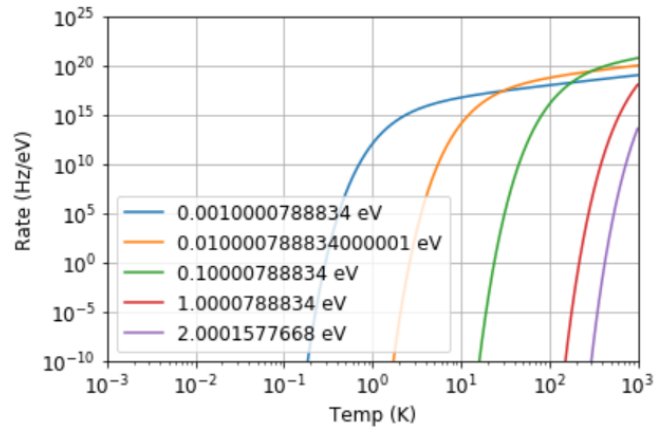Model: Box with hole

Tiny leak of light from inside

$$\frac{d\Gamma}{dE} \approx \frac{\pi r_{rad}^2 r_{abs}}{\sqrt{r_{abs}^2 + d^2}} \frac{8\pi E^2}{h^3 c^2} \frac{1}{\exp E/(k_B T) - 1}$$
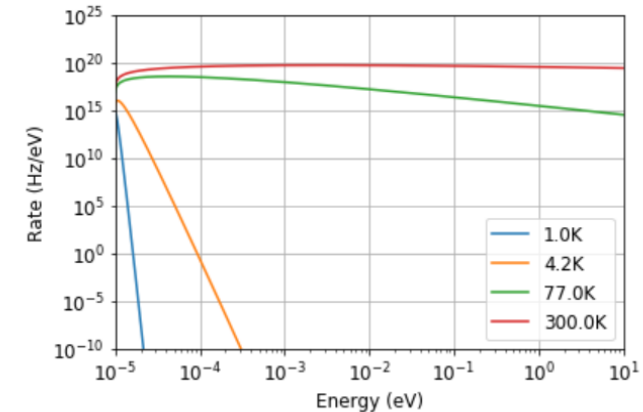
What I have been doing:

Left panel (Jupyter notebook — Blackbody2):

```
ylabel( Rate (Hz/eV) )
ylim(1e-10, 1e25)
xlim(min(T),max(T))
legend()
grid()
show()

#plt.show()
```

C:\Users\jillg\JupyterFiles\lib\site-packages\ipykernel_launcher.py:1
  if sys.path[0] == '':

Left plot legend:
- 0.0010000788834 eV
- 0.010000788834000001 eV
- 0.10000788834 eV
- 1.0000788834 eV
- 2.0001577668 eV

x-axis: Temp (K) y-axis: Rate (Hz/eV)

Here we can see the rate of various energies as a function of temperature. There is a lower rate of the higher energies (1-2eV) at around 100 K whereas there is a lower rate of the lower energies (0.001 eV) around 0.1 K. The rates of the energies seem to increase and then level off as the temperature increases.

Right panel (Jupyter notebook — Blackbody2):

```
loglog(np.array(energy),np.array(planck(T))/6242e15,label=str(T)+'K')

xlabel('Energy (eV)')
ylabel('Rate (Hz/eV)')
ylim(1e-10,1e25)
xlim(min(energy),max(energy))
legend()
grid()
show()
```

C:\Users\jillg\JupyterFiles\lib\site-packages\ipykernel_launcher.py:45: R

Right plot legend:
- 1.0K
- 4.2K
- 77.0K
- 300.0K

x-axis: Energy (eV) y-axis: Rate (Hz/eV)

Here we can see the rate of various temperatures as a function of energy. The rate of all temperatures seem to be higher at lower energies (around 0.00001 eV). The higher temperatures (77-100K) tend to have consistently higher rates at most energies whereas the lower temperatures' (1-4.2 K) rates drop drastically as the energies increase.