Talk “Transcript”:

Slide 2: Dark Matter

So to start, i am gonna say a little about dark matter and its expected mass range, as well as some current experimental thresholds.
For the last (x amount of years) a popular theory for Dark matter is that it is to be a light supersymmetric particle (with respect to other SUSY particles) with a mass on the order of a GeV/c^2 to a few TeV/ c^2. With no evidence of SUSY from the LHC, and no direct detection in the current theorized mass range. The mass of Dark matter is somewhat up in the air, but there is still considerable interest in particles that interact with the nuclei of the target. There are several theories, like axions, in which dark matter would interact with a target. For this reason, experiments like CDMS, LUX, and and Edelweiss are currently trying to push their experimental thresholds lower in order to search for lower mass dark matter candidates.

Silde 3:

For the following discussion i am going to specially refer to solid state detectors with a voltage across them that specifically measure total phonon energy (number of electron-hole pairs created). (reword)

When dark matter interacts with a solid, it scatters off a nuclei creating primary phonons and liberating charge with some ratio. By measuring the total phonon energy we are actually measuring the amount of electron hole pairs that are created. The moving charge creates secondary phonons called Luke phonons. This process is called Luke gain and is created by the high voltage applied to the detector. The Luke gain acts as an internal amplifier . For the purposes of this talk, we will assume that the detectors of interest are of this type. An example would be the HVeV detector.
Detector has a 14eV resolution.

Slide 4:

Here we see the expected spectrum for 1 Er in the Hvev detector. Since we are looking at nuclear recoils, the peaks are shifter to the right, as some of the energy is put into the phonon system. To determine what the recoil energy is, you can subtract the energy difference from where the peak is from were it would appear for an electron recoil. The many peaks appear due to the internal amplification cause by the Luke effect. If we imagine that there is no voltage applied, we would only see this one peak. So even though these detectors are extremely sensitive, they are subject to the randomness in the amount of electron hole pairs create.

Slide 5:

Here, we can see that the relationship between the number of electron hold pairs produced is dependent upon the ionization efficiency and the recoil energy. For electron recoils virtually all of the energy is used to create electron hole pairs. For nuclear recoils, a significant fraction of the energy goes into the phonon system. (Need to say where some of this energy goes, energy given to the motion of the nucleus etc) We call this fraction of energy that goes into the electronic system the yield. If we could measure phonons and charge at these energies, it would be a great means of discrimination, far better than PSD and liquid scintillation. But at this low energy scale it is hard to calibrate for nuclear recoils and the relationship between the number of electron hole pairs and the recoil energy is nonlinear.

The interesting part is that for both electron and nuclear recoils, given one recoil energy, you do not get the same amount electron hole pairs produced every time.

Slide 6:

Here i am showing one of the few existing measurements for how much the number of electron hole pairs produced vary for a given Er. This variation in electron - hole pair creation is something that hasn't been accounted for. The main reason is that until recently, experiments have not been sensitive to recoil energies this low. When you have ten thousands electron hole pairs created, a variation of a few hundred doesn't effect the energy reconstruction very much. With current technology, as the HVeV detector mentioned previously, this variation may be a significant problem. For electron recoils, this variation is sometimes parameterized by the "Fano Factor" We call the paramerterization " NR fano factor" for nuclear recoils.

Slide 7:

Show here is a plot of the expected spectrum for a 1 GeV WIMP.   The F is referring to the added width due to the variation electron hole pair production. When looking at the spectrum for F = 0.1 We can see a shift in the spectrum as we move to a higher amount of electron hole pairs produced. The shift is due to.. Looking at the spectrum for F = 1. Is can bee seen that the shift is less dramatic. Though the probability decreases as the number of electron hole pairs increases, there now exists more ambiguity in what recoil energy created the e-h pairs.
An important observation from this plot is the difference in spectrums between the F =- 0.1 and 1. For example, say that we get a count during an experiment that is at 3.4 electron hole pairs. If we use the spectrum for F = 0.1, we would expect that the signal was from a wimp. If we were using the spectrum for F = 1. We would not expect the signal be from a WIMP and be only from background.

Slide 8:

What i have mentioned previously is the motivation behind wanting to understand the variation in electron hole pair production. To understand this, i first need to be able to quantify the this variation. Shown here is a plot by Edelweiss. Because they measure the phonon energy and charge energy, with their current detectors they can directly measure the ionization efficiency as shown by the nice separation between the electron and nuclear recoil bands. This is useful because the width of the NR band is sensitive to the variance in Ne/h , the variance in electron - hole pair production is something i should be able to extract. It is important to note that this is for a higher energy range that i have mentioned before. Being able to extract and quantify this variance will allow me to understand its impact when dealing with lower threshold detectors.

(Slide 9 and 10 i have purposely left short, as i am not sure how much detail i should go into when talking about where these plots come from.. and how and why I am adding in the constant variance they way I do.

Slide 9:

Show here is a simulation that takes into account instrumental resolutions only. It can be seen that theses resolutions do not explain the width in the nuclear recoil band.

Slide 10:

In this plot, i am accounting for the variation in electron hole pair production by adding in a constant variance. As we can see there is an improvement in the nuclear recoil band. Using this method, i should be able to get a bound on what the added ionization variance should be.