**SLIDE 1**

Hi, my name is Matt Anthony and I will be presenting on the upcoming results of an experiment performed at Columbia University’s Nevis Labs measuring the light and charge yield of electronic recoils in LXe at low energies and at different electric fields.

**SLIDE 2**

* Dual-phase detectors
  + Particle interacts and excites and ionizes – different amount depending on type of particle
  + Excitation + recombination lead to prompt scintillation, S1
  + Free electrons drifted to gas layer lead to proportional scintillation, S2

**SLIDE 3**

* Improve understanding of interactions in LXe by characterizing light and charge yield at lw energies and different fields
  + Explain light and charge yield
* Plot on left
  + Charge and light, relative to zero field, as a function of different fields for different particles
  + Notice anti-correlation in light and charge - influenced by field dependence of recombination
    - High fields you lower recombination probability and increase number of free electrons and hence S2 while reducing S1

**SLIDE 4**

* Large detectors ideal for DM detection, but strengths are weakness for measuring low energy yields
* Constructed “shrunken-down” version called neriX
  + Much smaller in size (2 kg) and does not have shielding or extra materials around TPC
  + Dual-phase => measure light and charge yield simultaneously
* neriX is almost unique – can measure light yield as a function of energy and drift field
  + Extremely important given that larger detectors are operated with an applied electric field and given the quenching of S1 discussed earleir

**SLIDE 5**

* As mentioned before, dual-phase
  + Hand-in-hand with dual phase is 3D position reconstruction
* On the right is a schematic of the detector
  + Bottom: 2’’ diameter HQE PMT, used for yield analyses
  + Top: 4 1’’ square four anode PMTs – all intents and purposes are 16 separate PMTs

**SLIDE 6**

* Design of TPC very similar to other dual-phase Lxe experiments
  + Liquid level between gate and anode – electron extraction for S2
  + Cathode kept at negative HV to produce different electric fields
    - Cathode values used and corresponding fields in the table on the left
    - For reference, Xenon100 operates at drift field 500 V/cm and Xenon1T plans on using 1kV/cm

**SLIDE 7**

* Prerequisite for yield measurement is ability to detect single photoelectrons and electrons
* neriX PMTs at relatively low gain (4-7\*10^5 e-) so additional steps required to determine SPE gain
  + The final product of the SPE gain determination is located in the top right figure in blue
* Able to determine gain of single electrons
  + Large S2 events produce enough light to free electrons from the gate and cathode grid
  + These electrons are drifted through the TPC and create additional S2 signals after the main S2
    - In the bottom center plot, you can see the peaks in time after the main S2

**SLIDE 8**

* neriX is able to reconstruct position in three dimensions
* Use FANN open source library to train neural network on simulated S2 events
* FANN acts like a black box during processing – takes in normalized amount of proportional light seen by each PMT and outputs an XY position
* Center plot is a test of the FANN reconstruction
  + X-axis is the simulated radius and y-axis is reconstructed radius
  + Very good agreement up to 18 mm and in fact an average error of 0.5 mm
  + Radius of detector is 21 mm
* On the right is an actual XY map for a Co-57 calibration
  + Can actually see the pattern of the gate mesh since the field is slightly stronger at those locations

**SLIDE 9**

* Heard me repeat how neriX’s small size is ideal for this type of measurement – hopefully after this slide it will be clear why!
* To determine light yield, we must know S1, S2, the field, and the energy
  + Already discussed how to find the first three, so all that remains is determining the energy
  + Will do this via the Compton coincidence technique
* Place Cs-137 source on one side of detector and HPGe on the other
  + HPGe has extremely good resolution around 662 keV line
* Idea is that photons will leave the source, interact once in the xenon via a Compton scatter, creating an S1 and an S2, and then be fully absorbed in the Ge
  + Thus, to find energy just subtract energy deposited in Ge from starting photon energy
* Use coincidence trigger between Lxe, specifically the S2, and Ge to cut on good events
* Why is neriX’s small size so important?
  + Reduced double scatters since less liquid xenon
  + Reduced accidental scatters with external materials given minimalistic design

**SLIDE 10**

* Before continuing, I would like to note that ALL DATA ARE PRELIMINARY
* Shown here are our two coincidence spectra at a single drift field
* On the y-axis of each is the energy deposited in the Ge subtracted from the starting energy of the photon
* X-axis on the left plot is S1 and x-axis on right plot is S2 signal
* We project this spectra into S1 and S2 space after making energy cuts and the resulting plot can be seen below each spectrum
* Finally, to determine the yield, we fit these final spectra with a Gaussian
  + This procedure continued down to 1 keV

**SLIDE 11**

* By looking at each energy slice at each field, you produce the following light and charge yield plots
  + Again, THESE RESULTS ARE PRELIMINARY AND SUBJECT TO CHANGE
* On the x-axis for each plot is the recoil energy and on the y-axis of the left plot is the light yield and on the y-axis of the right plot is the charge yield
* The different color marks represent the different drift fields used
* While these plots only go down to 3 keV, we did measure down to 1 keV
* We are still working on finalizing our low energy analysis and our absolute yield determination

**SLIDE 12**

* A few important trends to notice
  + S1 and S2 anti-correlated with respect to field – as you increase the drift in Lxe, the S1 signal is reduced but the charge yield increases
    - Good agreement with the previous results mentioned earlier at a single energy
  + Below 10 keV, light yield increases with energy while charge yield decreases with energy
* Again, we are still working on finalizing our low energy analysis and our absolute yield determination so please stay tuned for the final results!

**SLIDE 13**

* I wanted to take a little time to mention our upcoming measurement of the light and charge yield for nuclear recoils
  + We are in the process of preparing neriX for this run and hopefully will begin soon
  + Measurement will be similar to electronic recoil measurement but with Cs source replaced by a neutron generator and the Ge replaced by multiple liquid scintillators
* Thank you for your time.