Analysis of CDMSlite Run 3

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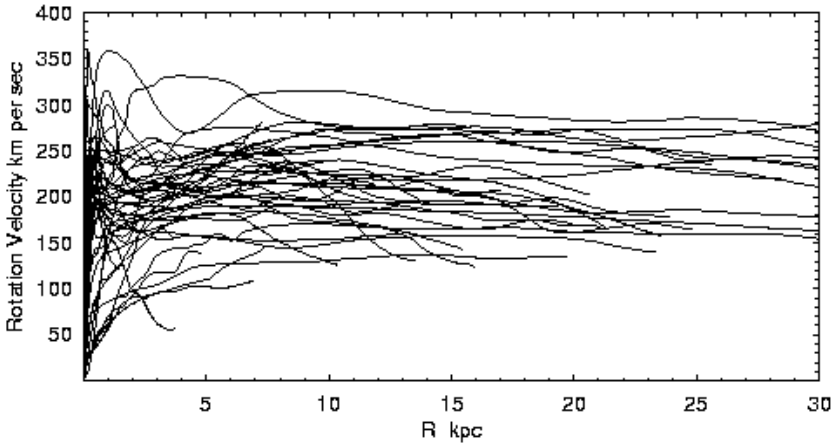
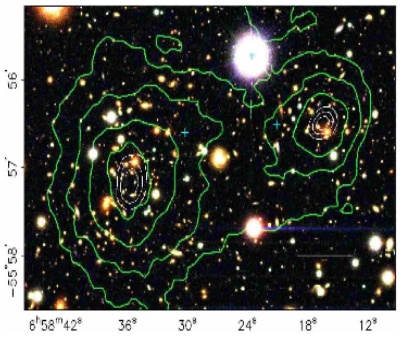
SuperCDMS

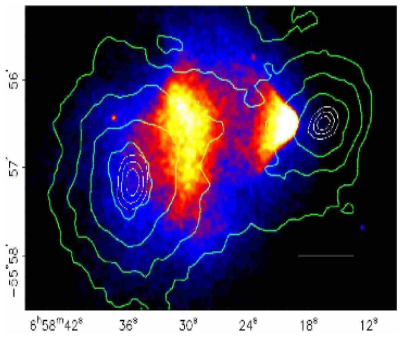
CAP 2018

WIMP Dark Matter

- Strong evidence for a non-luminous, gravitationally interacting kind of matter; "Dark Matter"
- A favoured candidate for dark matter is a Weakly Interacting Massive Particle (WIMP)
- May interact with normal matter through weak-scale force which could be detectable through energy deposits from nuclear recoils

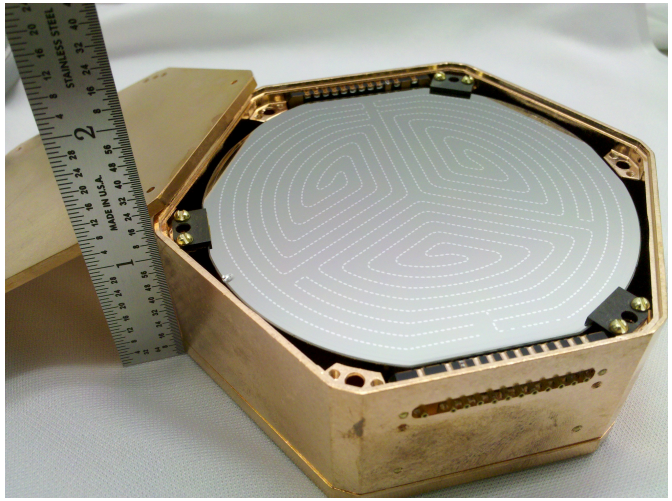






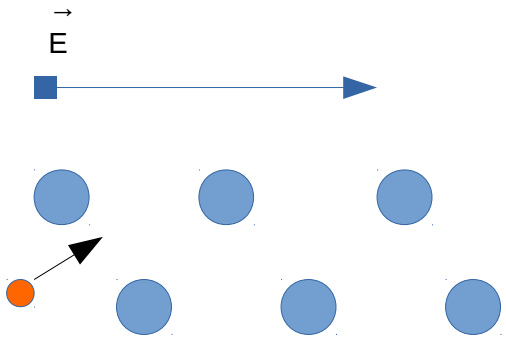
Super Cryogenic Dark Matter Search (SuperCDMS)

- Previous generation of experiment located at Soudan Underground lab; used 15 cryogenic germanium detectors (~9 kg)
- Searches for evidence of WIMPs through nuclear recoils in well shielded environment
- Particle interactions deposit energy in the form of heat (phonons) and electron-hole pairs



SuperCDMS

- Electron-hole pairs are drifted through the detector by means of an electric potential; V_b
- Electric Potential Energy ($e \times V_b$) is converted to phonons
- Creates a phonon amplification of charge signal "Neganov-Trofimov-Luke (NTL) Amplification"
- $E_T = E_{recoil} + E_{luke}$; $E_{luke} = N_{e/h} \times eV_b$



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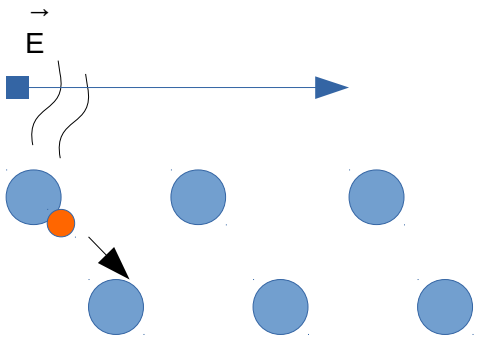

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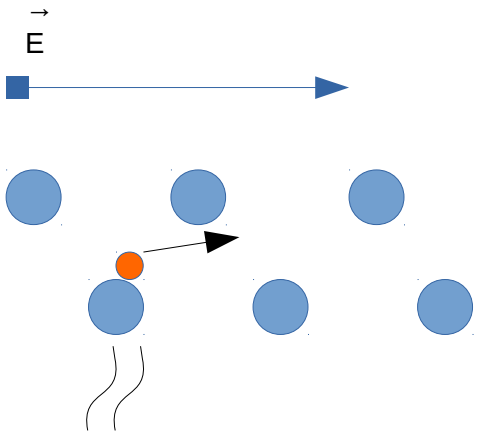
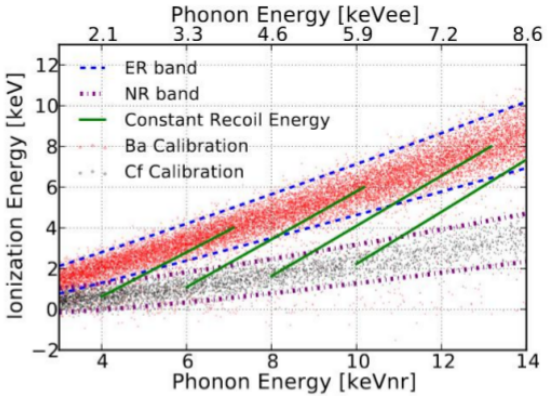
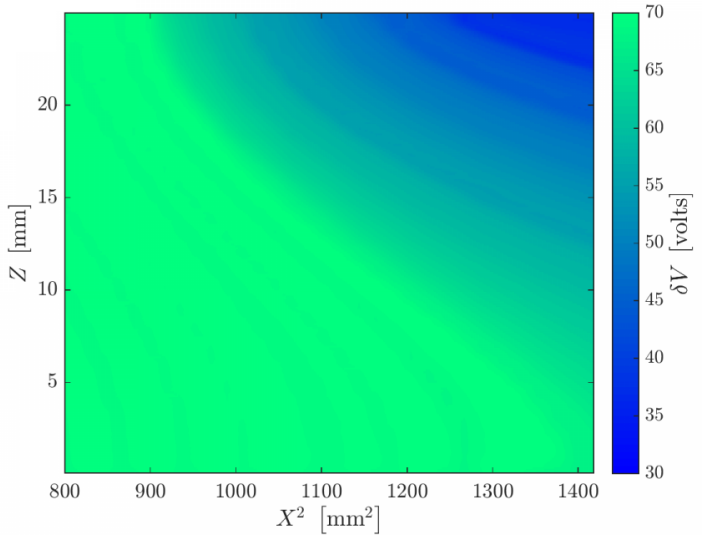


CDMS low ionization threshold experiment (CDMSlite)

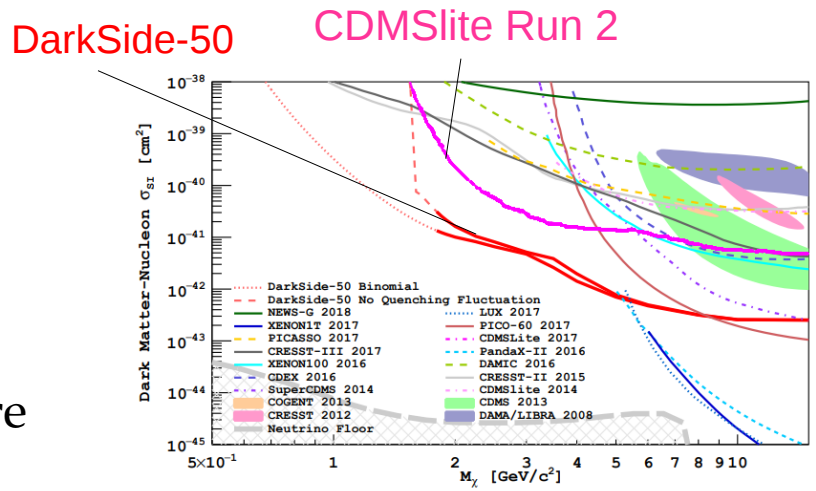
- Employs high voltage (~75 V) to create a large NTL amplification
- Great for low mass WIMP searches! But...
- Lose discrimination between nuclear and electron recoils
- Non-flat electric field means some events receive reduced NTL amplification
- Events at high radius receive reduced NTL amplification, are reconstructed at lower energy
- We need to understand and reduce this background





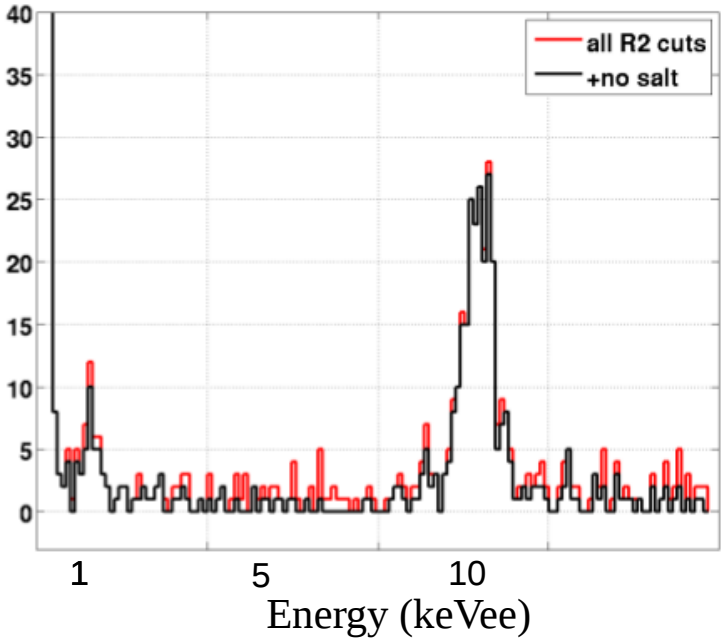
CDMSlite

- CDMSlite Run 1 (2012): Proof of principle
- CDMSlite Run 2 (2014):
  World leading result for WIMPs from ~2-6 GeV (surpassed by DarkSide-50 in early 2018)
- CDMSlite R3 (2015):
  - Different detector with lower hardware threshold and higher nominal voltage (75 vs 70 V), but lower exposure than Run 2
  - New analysis tools for use at SuperCDMS SNOLAB developed



CDMSlite Run 3 improvements

- New Analysis Techniques
  - Salted dataset for removing bias
  - Profile likelihood analysis to improve sensitivity
- We used a detector we thought had a better noise environment
- Better data selection (e.g. improved radial cut, harder cut on LF noise) lead to lower background rate



Profile Likelihood

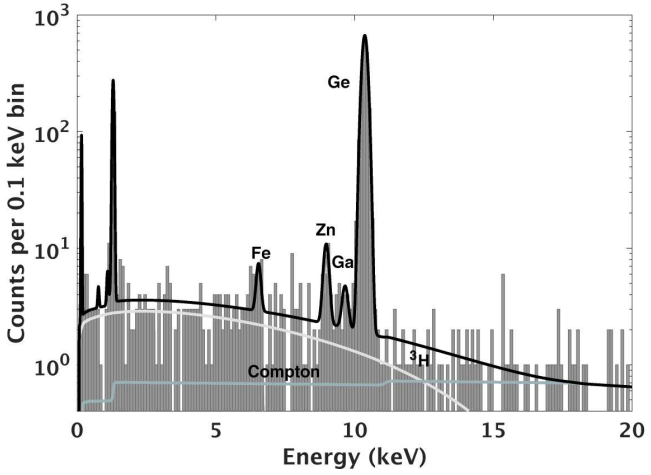
- First iteration of CDMSlite to use profile likelihood instead of optimum interval limit setting

- This means we have the possibility of making a detection versus just an exclusion

- The profile likelihood requires a background model

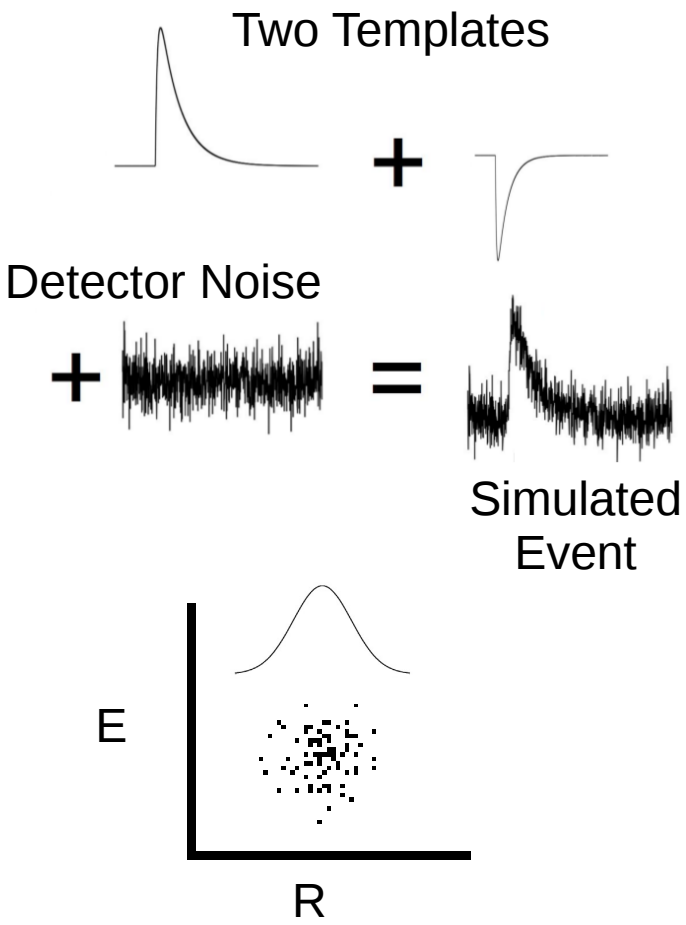
Background Model

- Energy Resolution model
  - Built from K, L, M shell electron captures on ^{71}Ge, and detector noise.
- Models for Electron capture backgrounds (^{71}Ge, ^{68}Ga, ^{65}Zn, ^{55}Fe)
- Model for β-decay of tritium
- Compton Scattering
- ^{210}Pb surface background
- Model of events with reduced NTL-gain



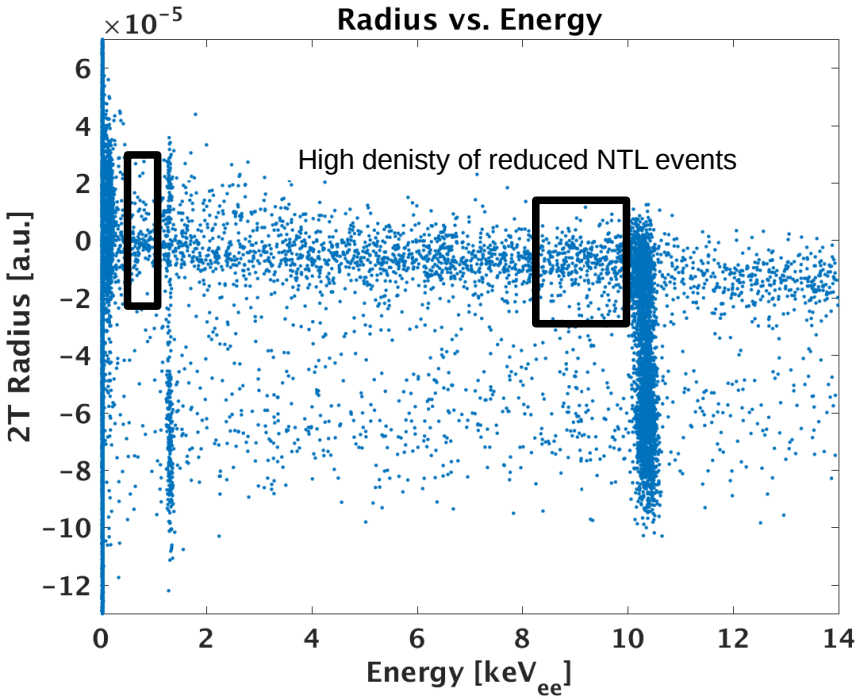
Radial Resolution Model

- Need to model reduced NTL events and make a cut to remove this background
- Simulate events
  - Fit well known pulse shapes distributed uniformly in volume (L-shell capture events) with 2 templates
  - Rescale templates from these fits to lower energies
  - Add detector noise to each event
  - Do this 100 times at many different radii and energies to build radial resolution model



Radial Resolution Model

- Model reduced NTL events' distribution in radius by looking at high reduced NTL density region right below calibration lines
- Model reduced NTL tail's distribution in energy with simulated voltage model
- Model number of reduced NTL events with simplified background model, and by knowing percentage of events constructed at correct energy (~86%)
- Use this to create a Monte Carlo of where reduced NTL events lie in E-R plane
- Design cut to remove radial regions where reduced NTL events fall



Analysis Status

- Salted dataset analysis essentially complete
- Final review of analysis underway before unsalting
- Results to be released very soon

Conclusion

- CDMSlite Run 3 improved some run conditions, but is best used as playbox for new analysis tools for SNOLAB
- Profile likelihood technique with detailed background model improves sensitivity and generates discovery potential
- My work on radial resolution allows us to model and significantly reduce the background
- Data to be unsalted and results published soon!

Thank You!

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