CDMSlite Run 2 Results

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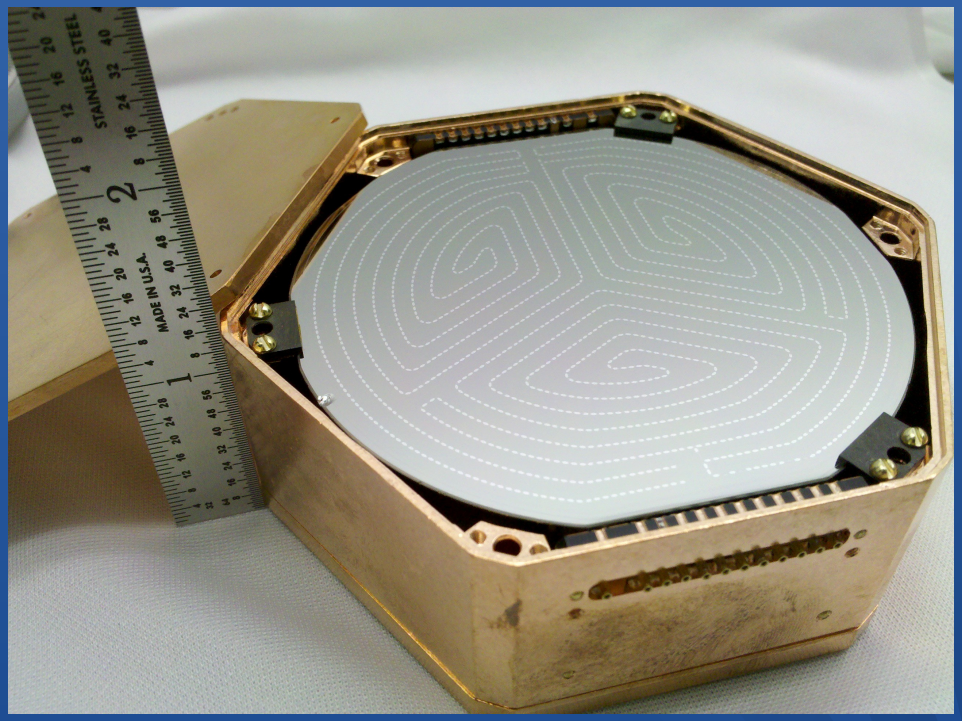
CAP 2016

SuperCDMS Experiment

- Super Cryogenic Dark Matter Search
- 15 Germanium crystals (0.6 kg each)
- Particle interactions with Ge measured through heat (phonon) and charge signals



CDMSlite

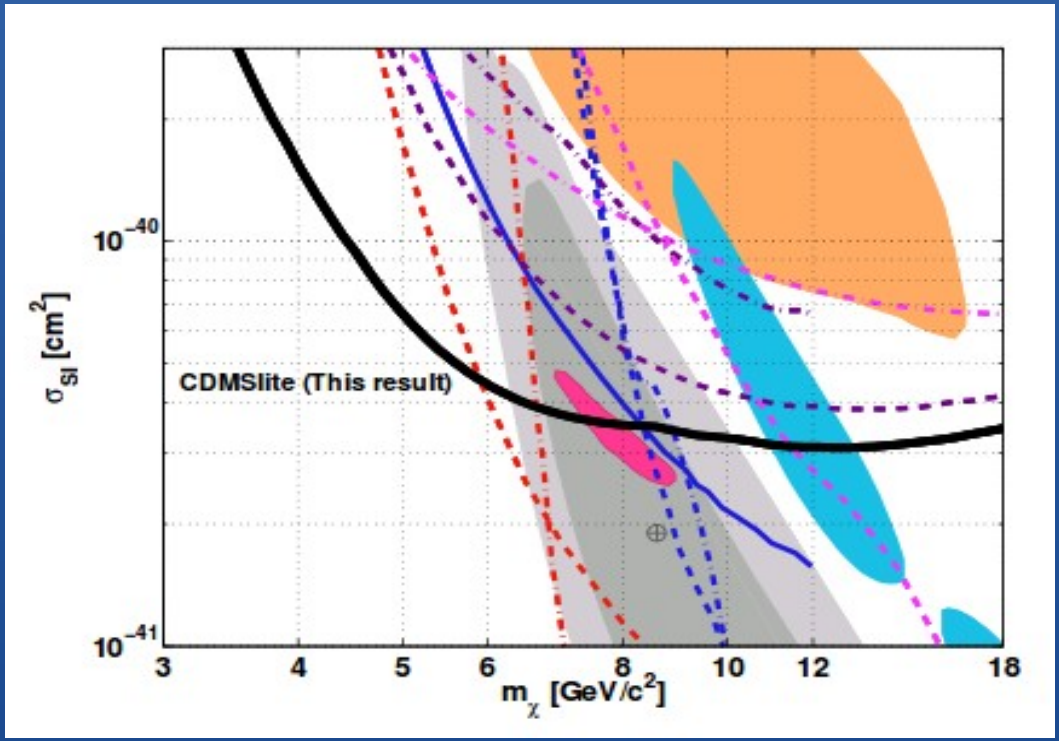
- One of the detectors has been operated in a “high voltage” (-70 V) mode.

- Drifting charges deposits energy as phonons, proportional to voltage (Neganov-Luke effect). Allows very low threshold charge measurement

$$E_t = E_r + N_{\mathrm{eh}} e V_b$$

CDMSlite Run 1 Results

- Leading sensitivity when it was published in 2014 to WIMPs from 3-6 GeV/c^2



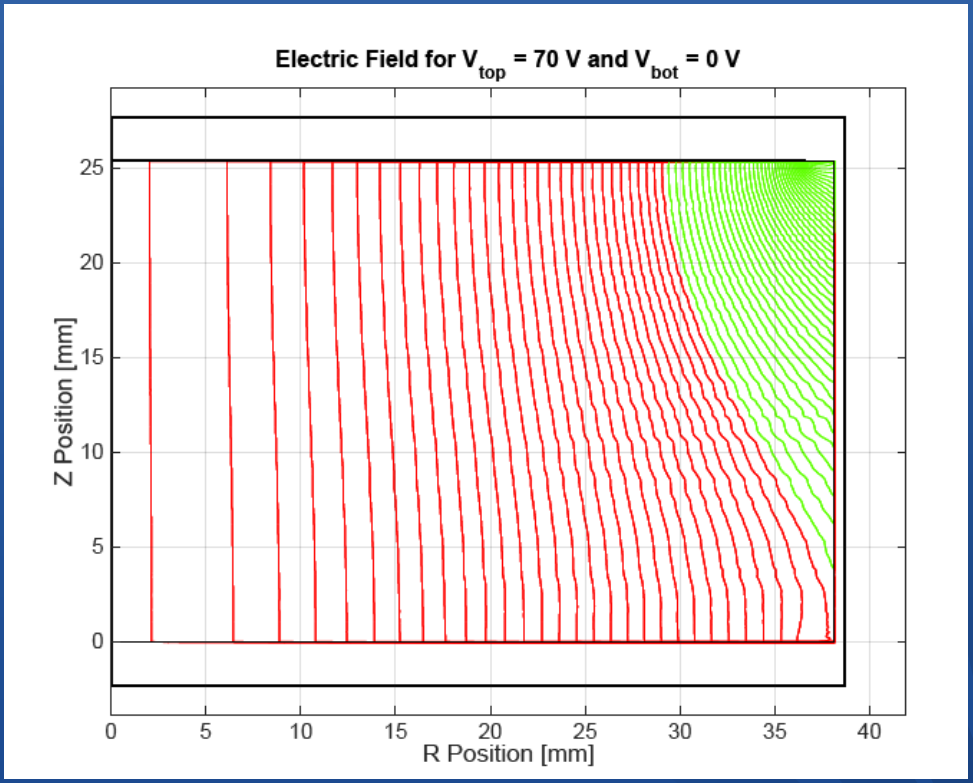
CDMSlite Run 2 Improvements

- Fluctuations in bias voltage were reduced by cleaning and sealing the high-voltage biasing-electronics board
- Noise from relocating trapped charges charges due to applying HV was observed in Run 1. Problem removed by pre-biasing at -80 V for 10 min
- Cryocooler noise better rejected with new vibrational sensor
- Most importantly, a radial cut was developed

Fiducial Volume Cut

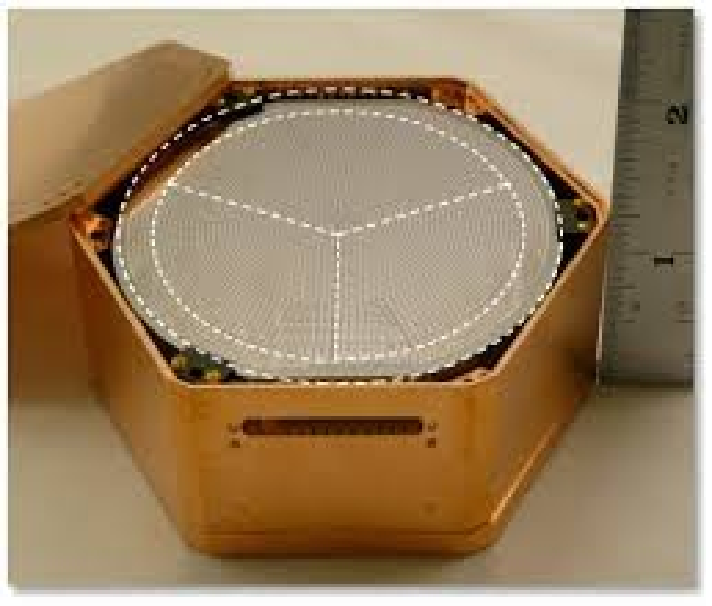
- Non-uniform E-field leads to reduced Luke Gain at the edge (lower apparent energy)

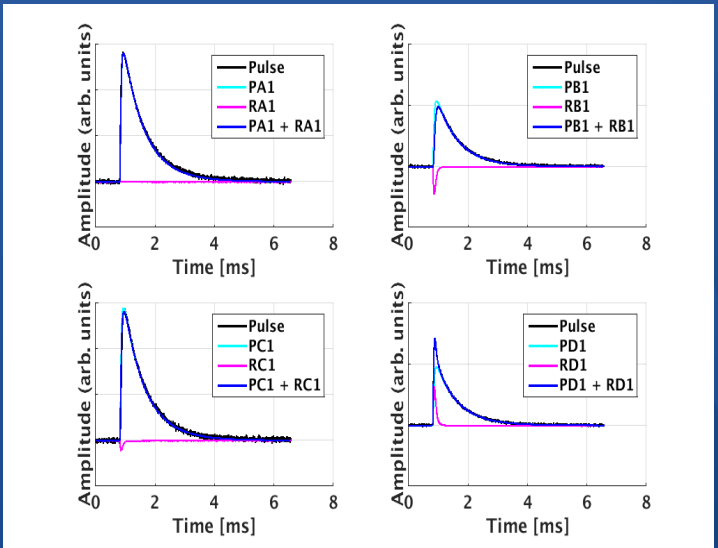
- Need to develop radial parameter to identify and exclude these events



Fiducial cut 2

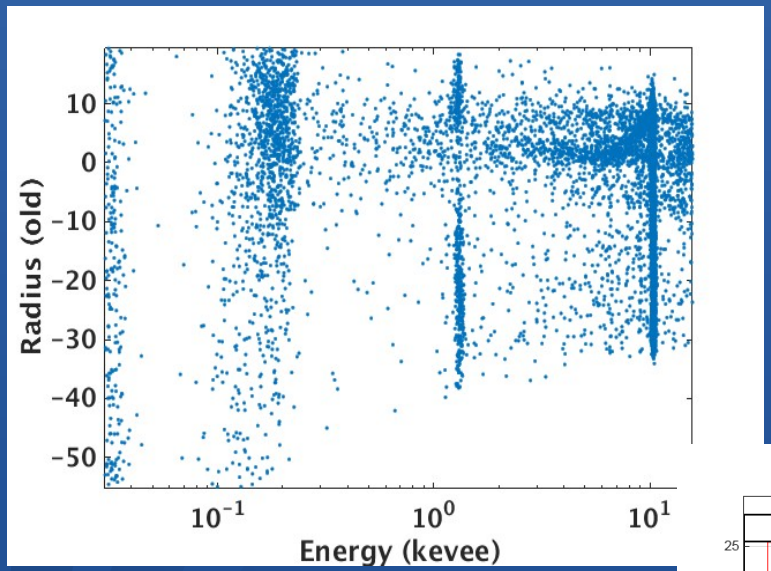
- A new radial parameter
  - Detector has 4 channels: 3 inner (pie wedge shaped) + 1 outer (annulus)
  - Pulse shapes well described by combination of two templates: a slow one (average pulse shape) and a fast one (average difference between pulses and slow template).
  - Slow template gives energy, fast template holds position information
  - Radial parameter: difference between fast template of outer and inner channels combined with pulse onset time difference

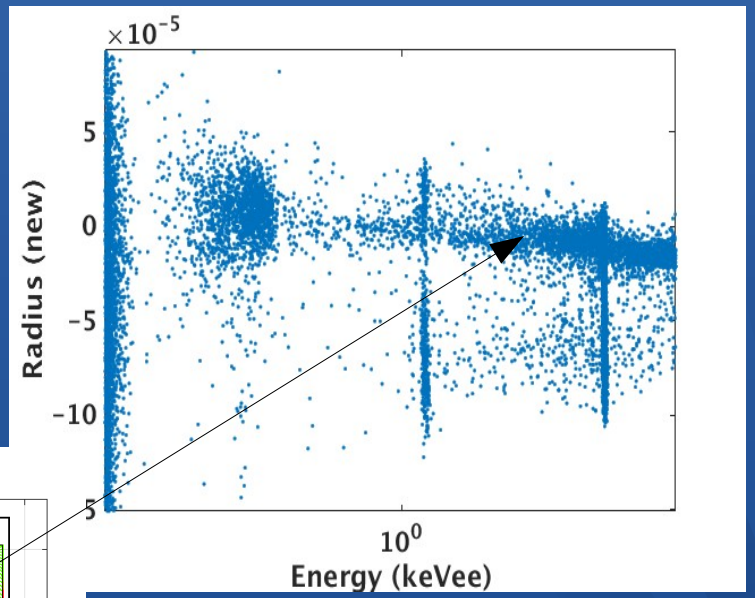


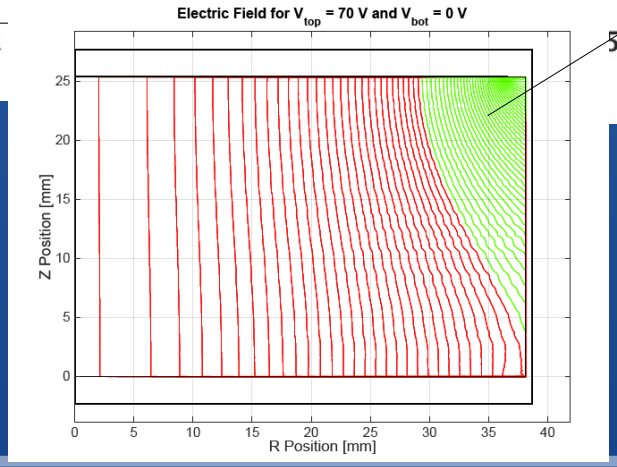


Fiducial Cut 3

- The new radial parameter allows much better inner and outer separation than old radial parameter which used just rise time in two channels, and eliminates two of our most problematic backgrounds, especially at lower energy

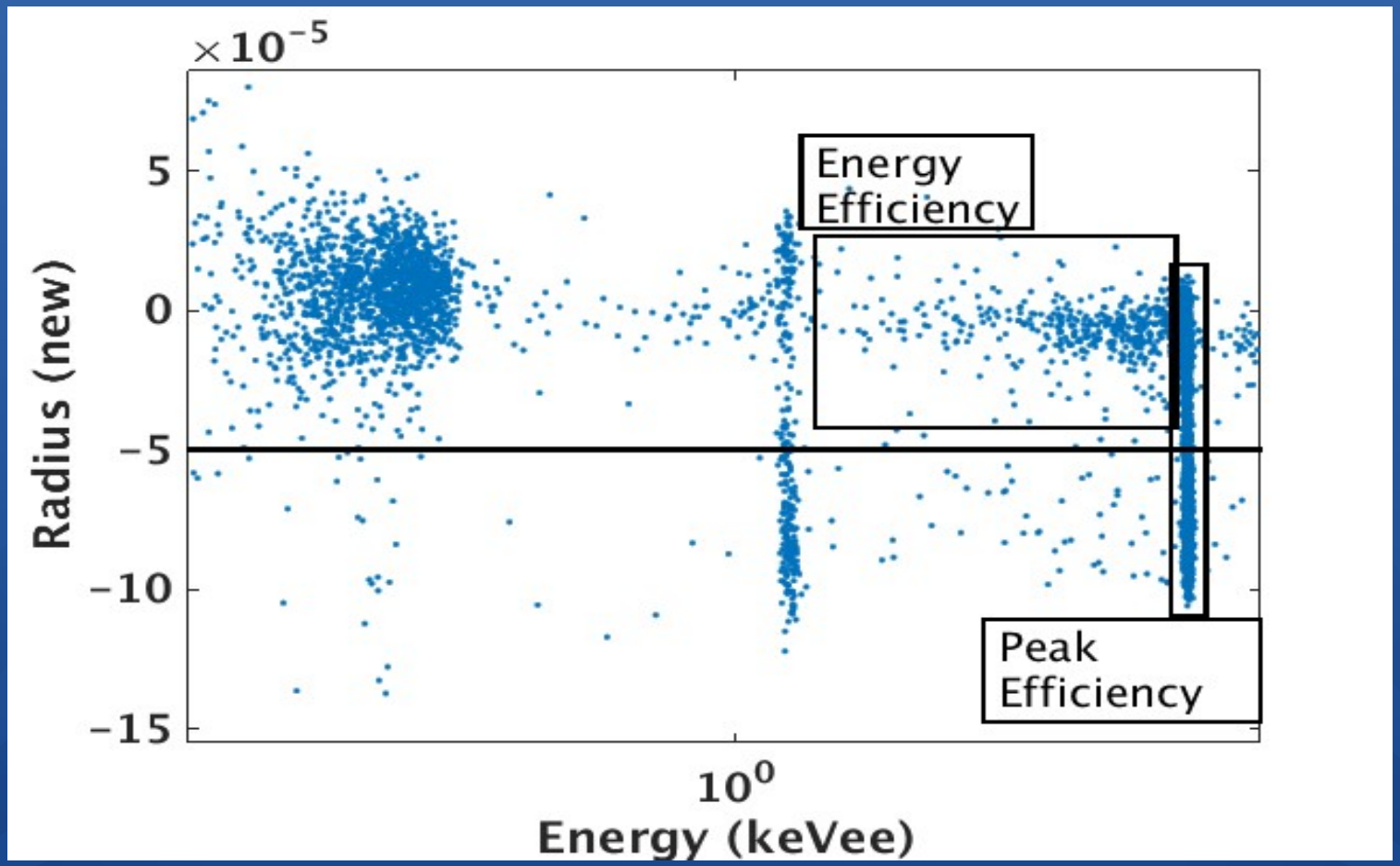






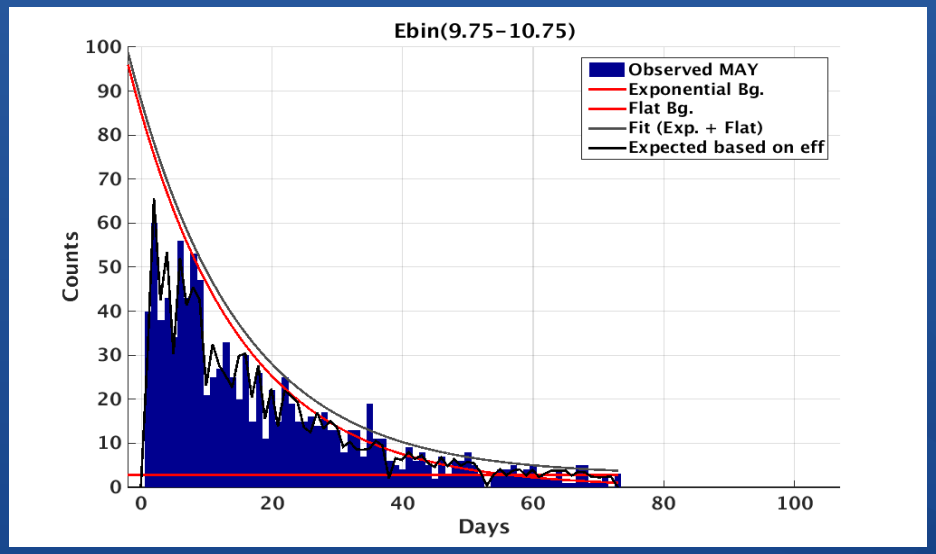
Fiducial Cut 4

- Must set a cut and check efficiency
  - Total Efficiency = Peak Eff X Energy Eff



Energy Efficiency

- Neutron Calibrations produce ^{71}Ge in the detector
- ^{71}Ge K- shell and L-shell electron capture lines (10.37 keV and 1.3 keV), are used for energy calibration and cut efficiency
- Fit time distribution of events in different regions of the R-vs-E plane with exponential (^{71}Ge life time, ~11 days) + constant background to locate ^{71}Ge events with reduced Luke gain
- Energy efficiency is fraction of ^{71}Ge events that shows up at the correct energy

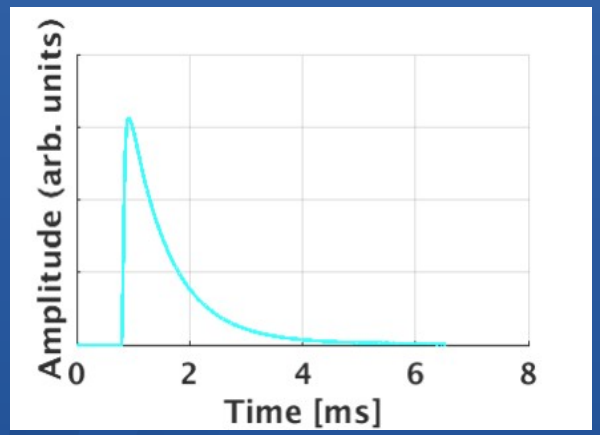


Peak Efficiency

- Peak efficiency: Fraction of events which pass radial cut
- This is a function of energy, due to the radial resolution

Simulation Event

Slow Template + Fast Template + Noise



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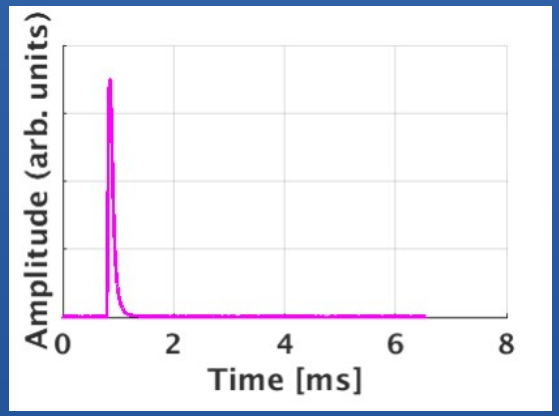

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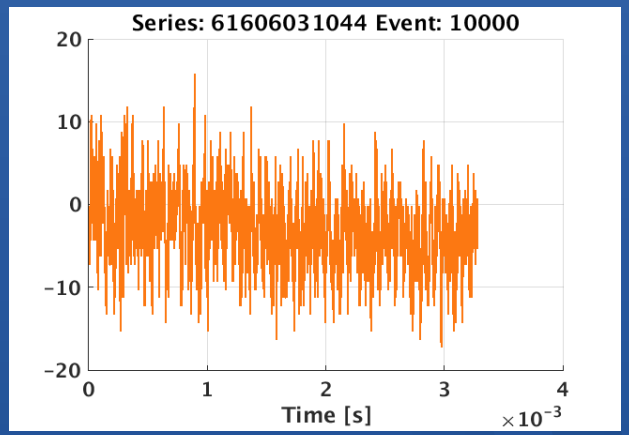
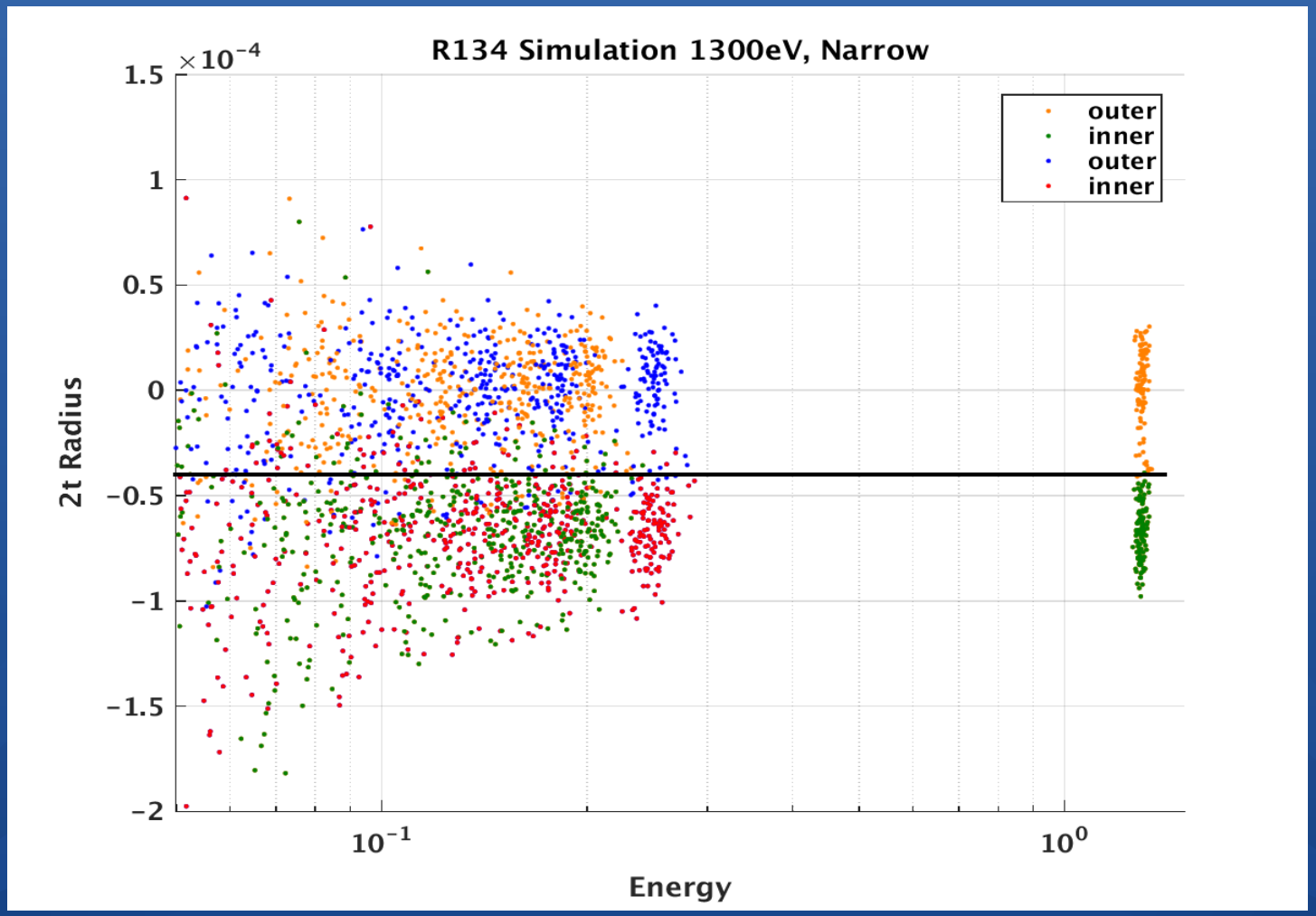


Measure peak event pulse shapes, rescale to lower energy and add real noise, refit energy/radius parameters to see how noise affects radial distribution at low energy

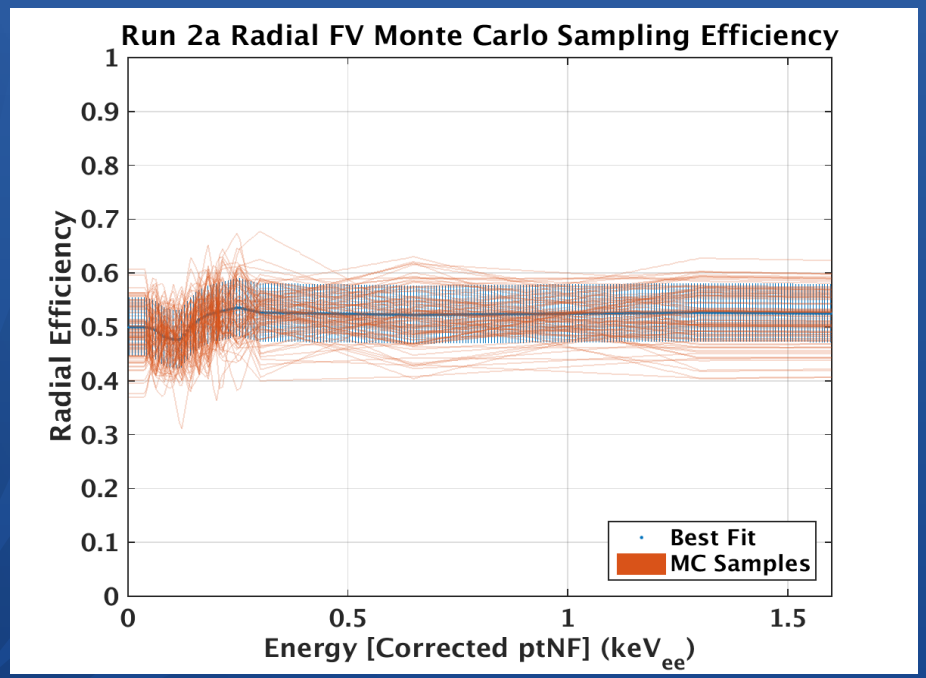
Peak Efficiency 2

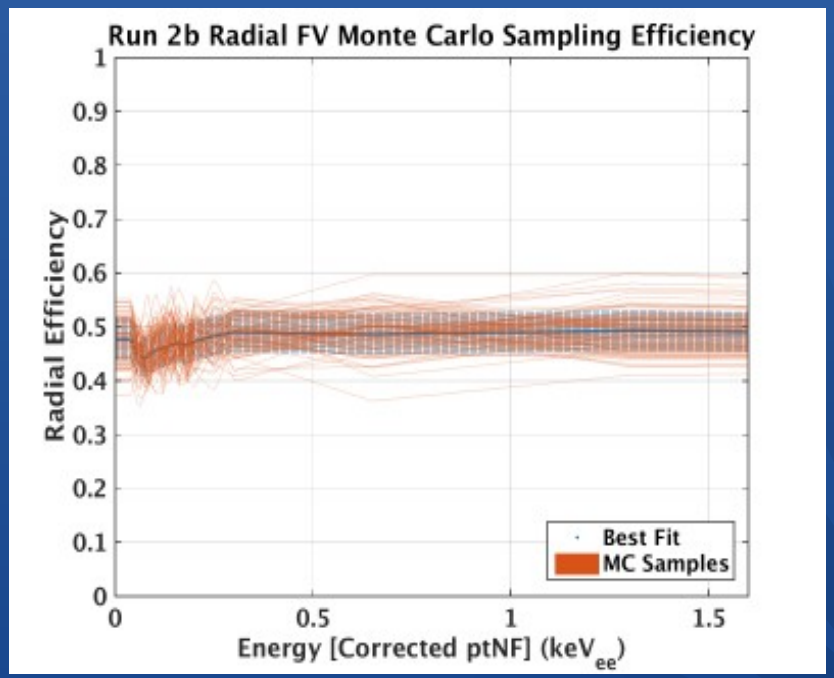
- Results of Simulation



Final Efficiency

- After taking in to account second order effects such as background in the line, efficiency as a function of energy can be calculated





Results of CDMSlite R2

- Total Exposure: 70.1 kg-days
- Threshold as low as 56 eVee
- Leading sensitivity between 2 and 6 GeV/c² for spin-independent WIMP nucleon cross section
- See: http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.116.071301

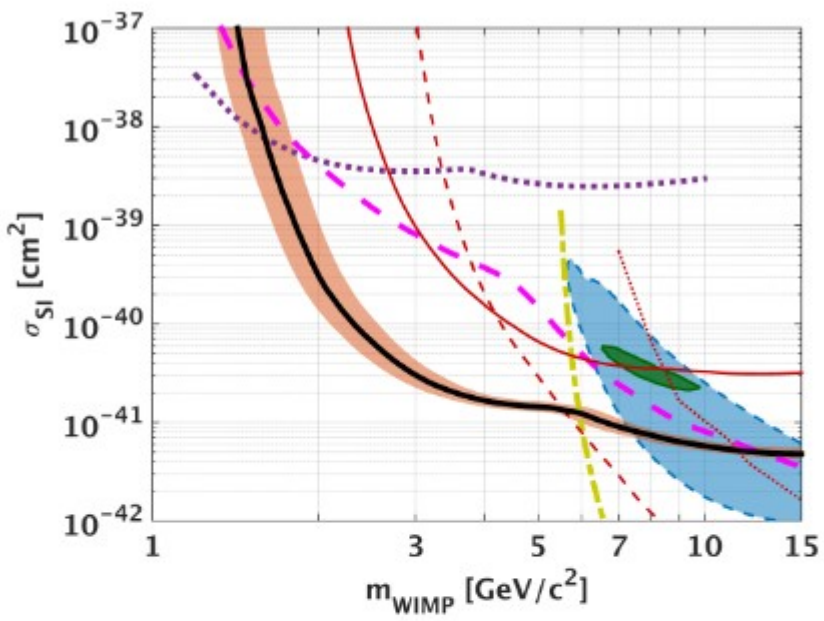


FIG. 4. (color online) Median (90 % C.L.) and 95 % interval of the WIMP limit from this analysis (black thick solid surrounded by salmon-shaded band) compared to other cryogenic experiments and the most recent LXe result. Other 90 % upper limits shown are CDMSlite first run (red thin solid) [24], SuperCDMS low threshold (red thin dashed) [41], EDELWEISS-II (red thin dotted) [42], LUX (dark-yellow thick dashed-dot) [5], CRESST (magenta thick dashed) [43], and DAMIC (purple thick dotted) [44]. Closed regions are CDMS II Si 90 % C.L. (blue dashed shaded) [17], and CoGeNT 90 % C.L. (dark-green shaded) [19].

Thank You