DAMIC Results and its Current Status

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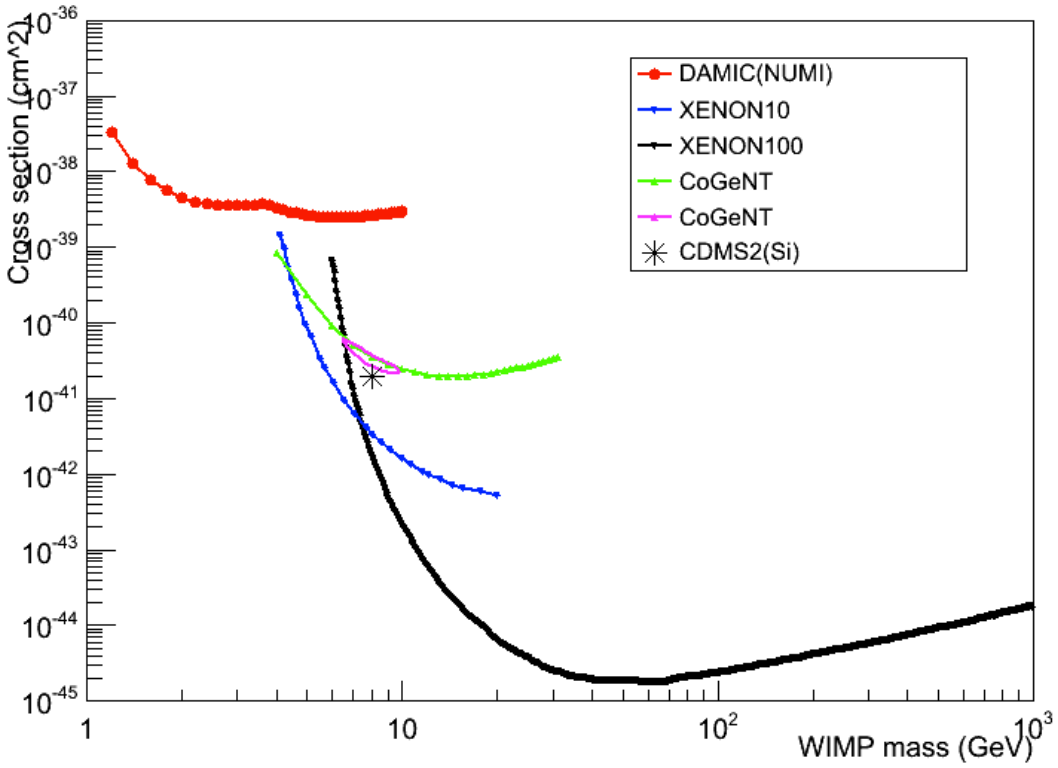
- DAMIC setup at SNOLAB
- Current status of DAMIC
- Comparison of MCNPX simulation with data collected by DAMIC at SNOLAB
- DAMIC100

DAMIC (Dark Matter in CCDs)



90% C.L. cross section upper limit with 0.5 g prototype DAMIC at Fermilab (red).
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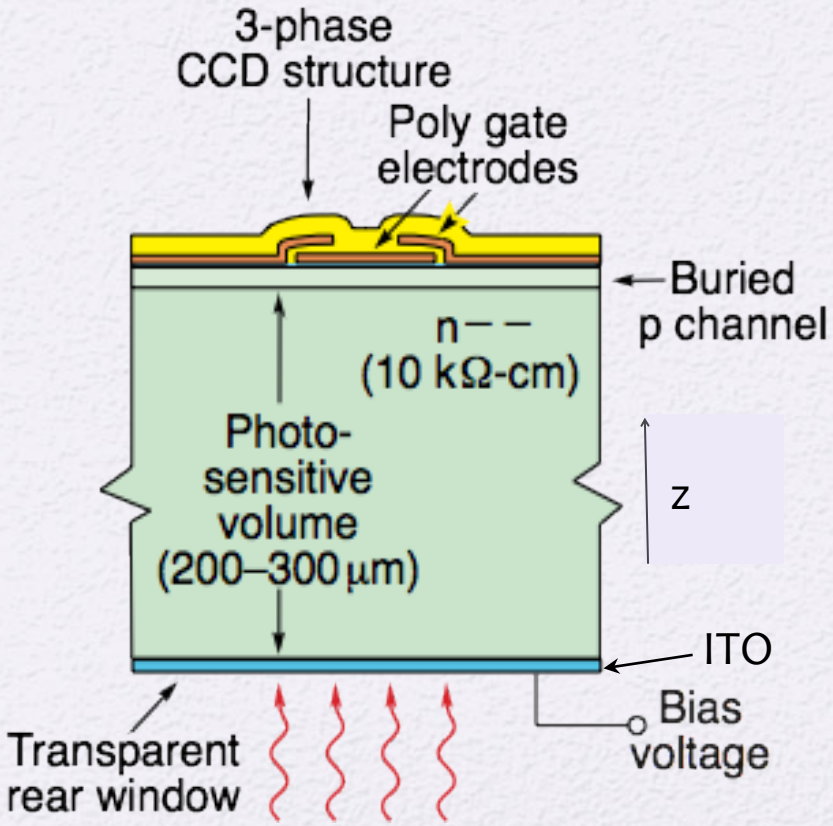
- DAMIC (Dark Matter in CCDs) is a direct dark matter detection experiment, which focuses on low mass(<10 GeV) DM
- Silicon in CCD as WIMP target
- Progressive program with increasing target mass (currently ~5 g)
- Sub-keVr threshold
- Energy reconstruction
- Position reconstruction
- Signal/background characterization based on patterns of charge collected on CCD plane.

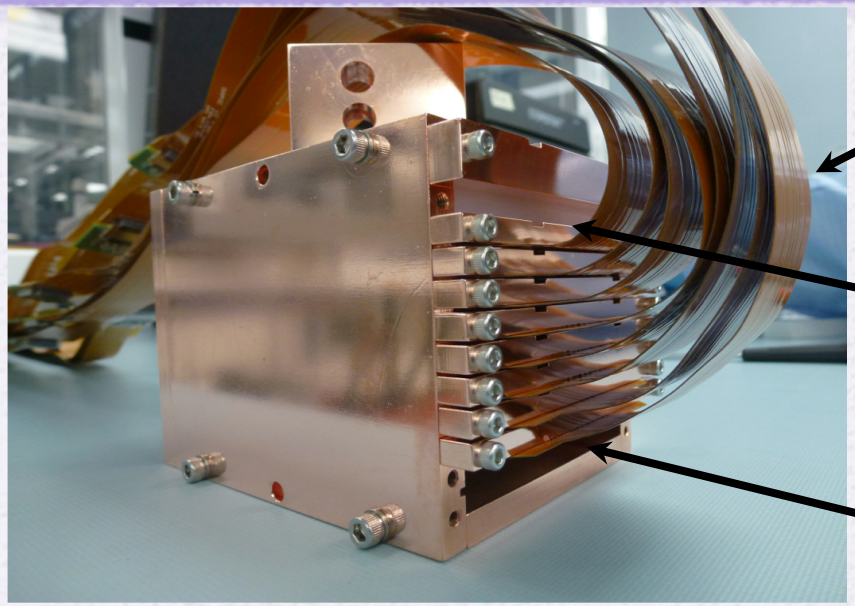
CCD for ionization detection

a CCD pixel



- Electrons / Nuclear recoils deposit energy in the CCD bulk
- Ionized electrons promoted to conduction band (3.62 eV per e^-h pair)
- Electrons collected and held at the gates
- Charge read out after some exposure time (typically several hours for DAMIC)
- Read out noise level of $2e^-$ RMS, equivalent to 7.2 eV of ionizing energy in silicon

DAMIC at SNOLAB



Cu box with 8 CCDs
6 250 μm thickness
2 650 μm thickness

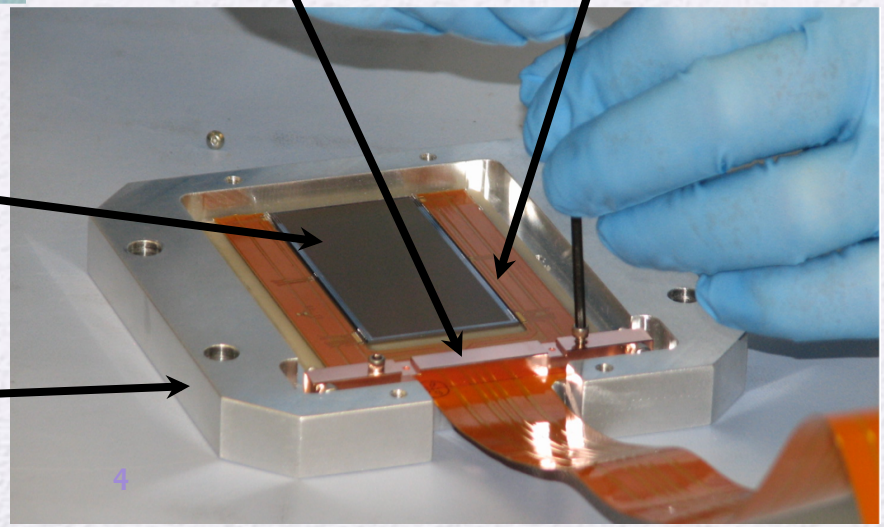
^{10}B film under poly slide to measure n background via (n,α) with CCD #1

Cu frame

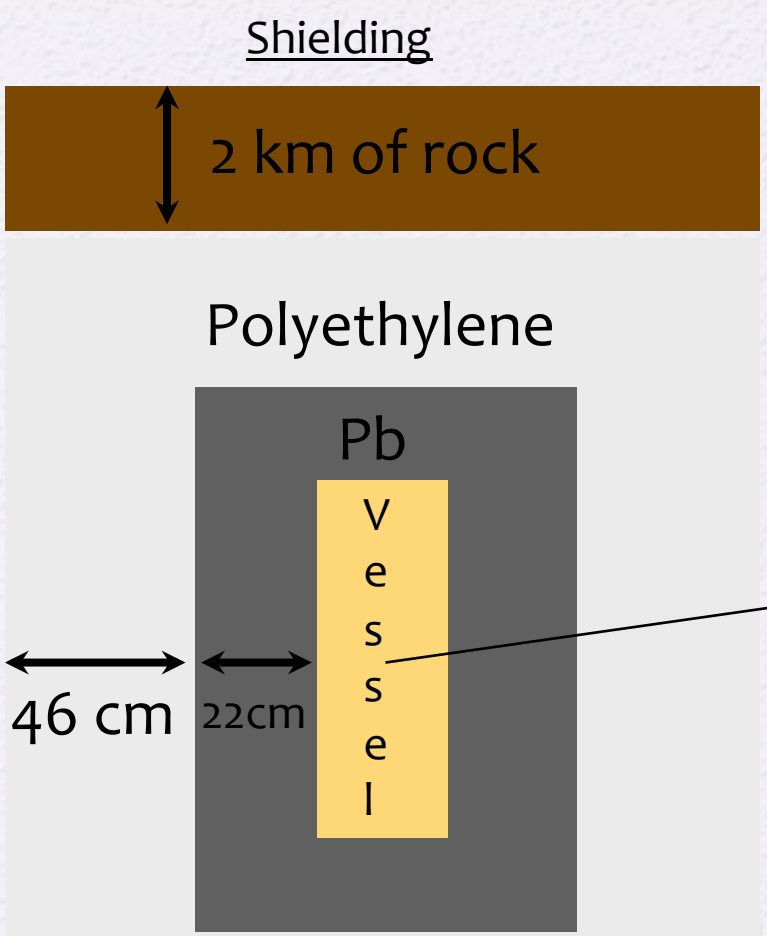
Kapton cable

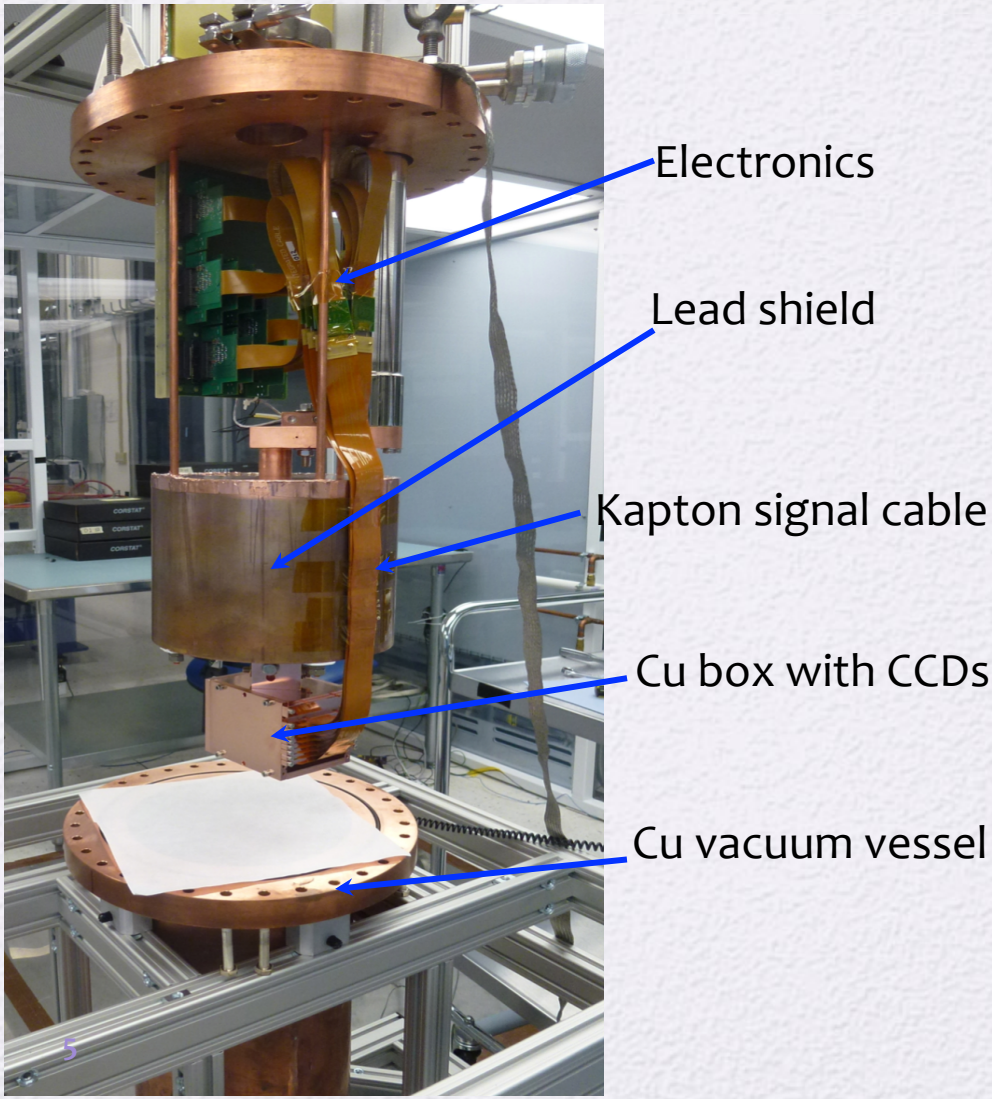
CCD on AlN support

Holder for assembly

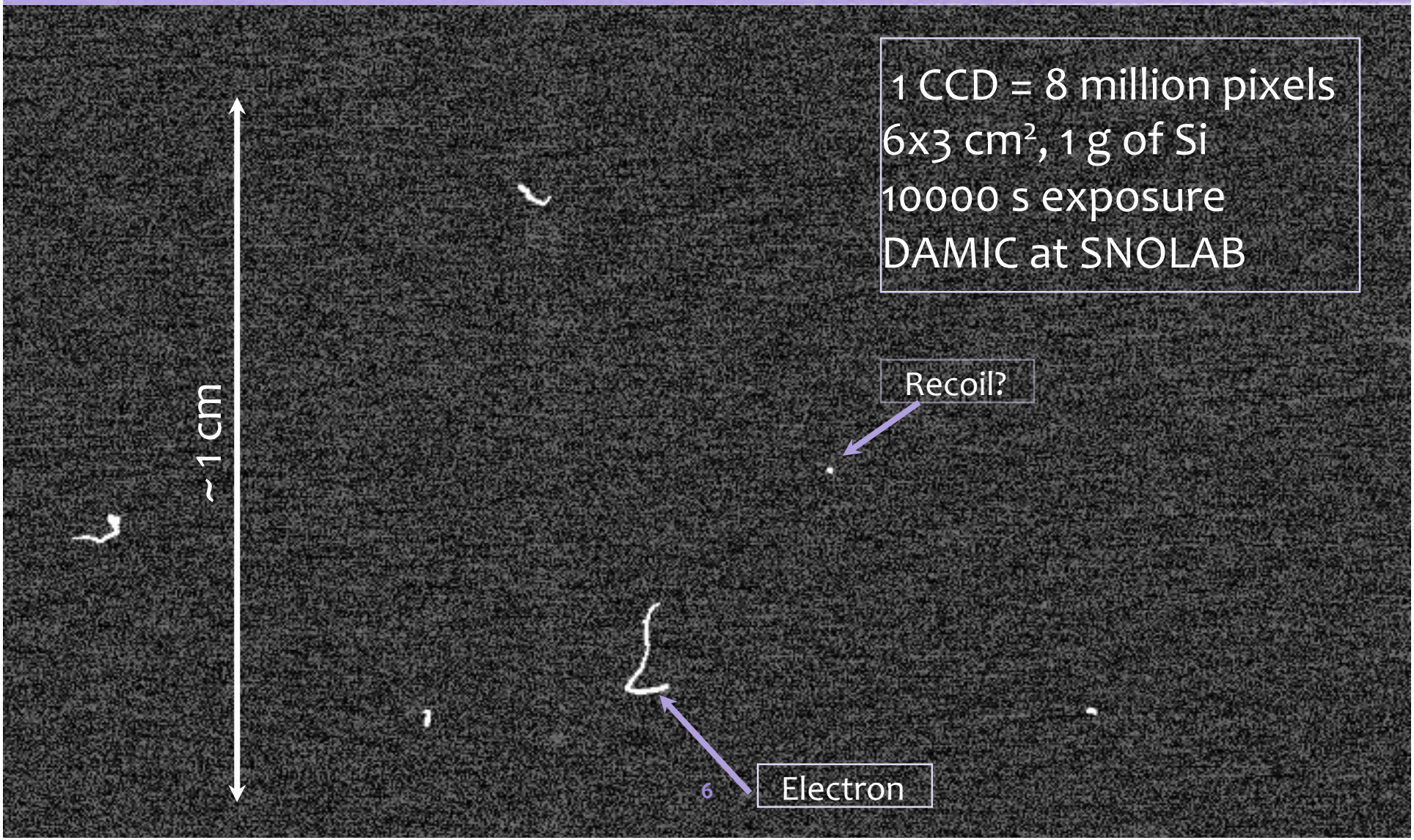


DAMIC at SNOLAB

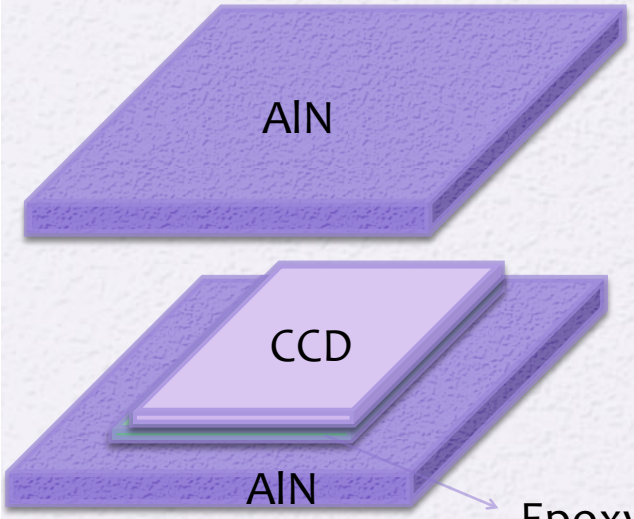




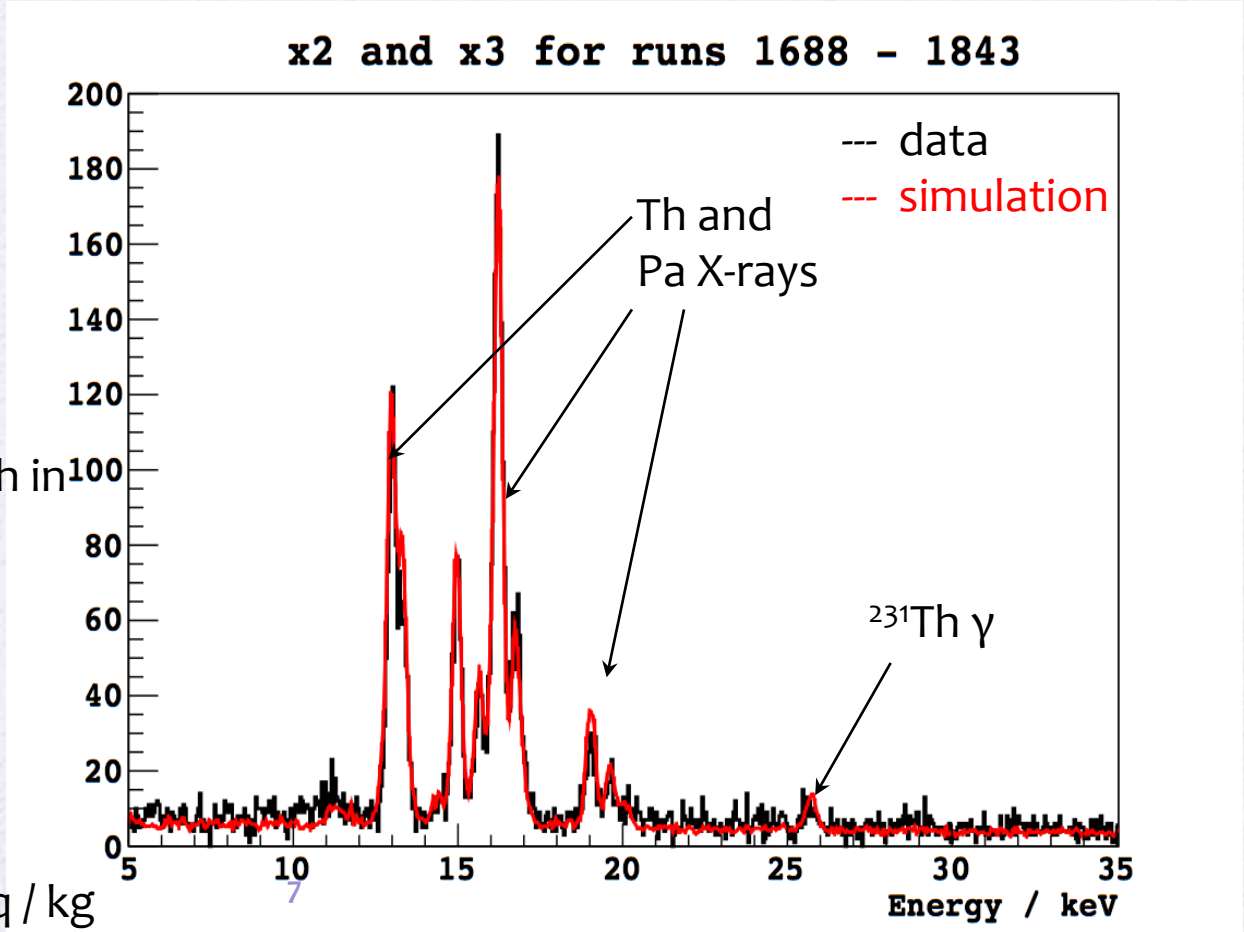
A Typical CCD image



Background in current DAMIC at SNOLAB



Use MCNPX to simulate backgrounds



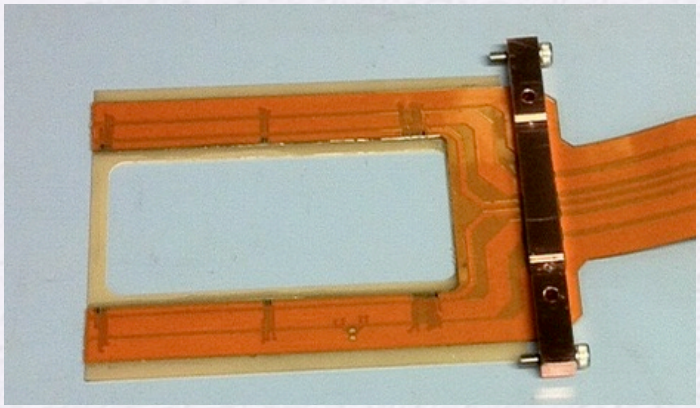
Source(top-of-the-chain ^{238}U + ^{235}U) uniformly distributed both in the top and bottom AlN

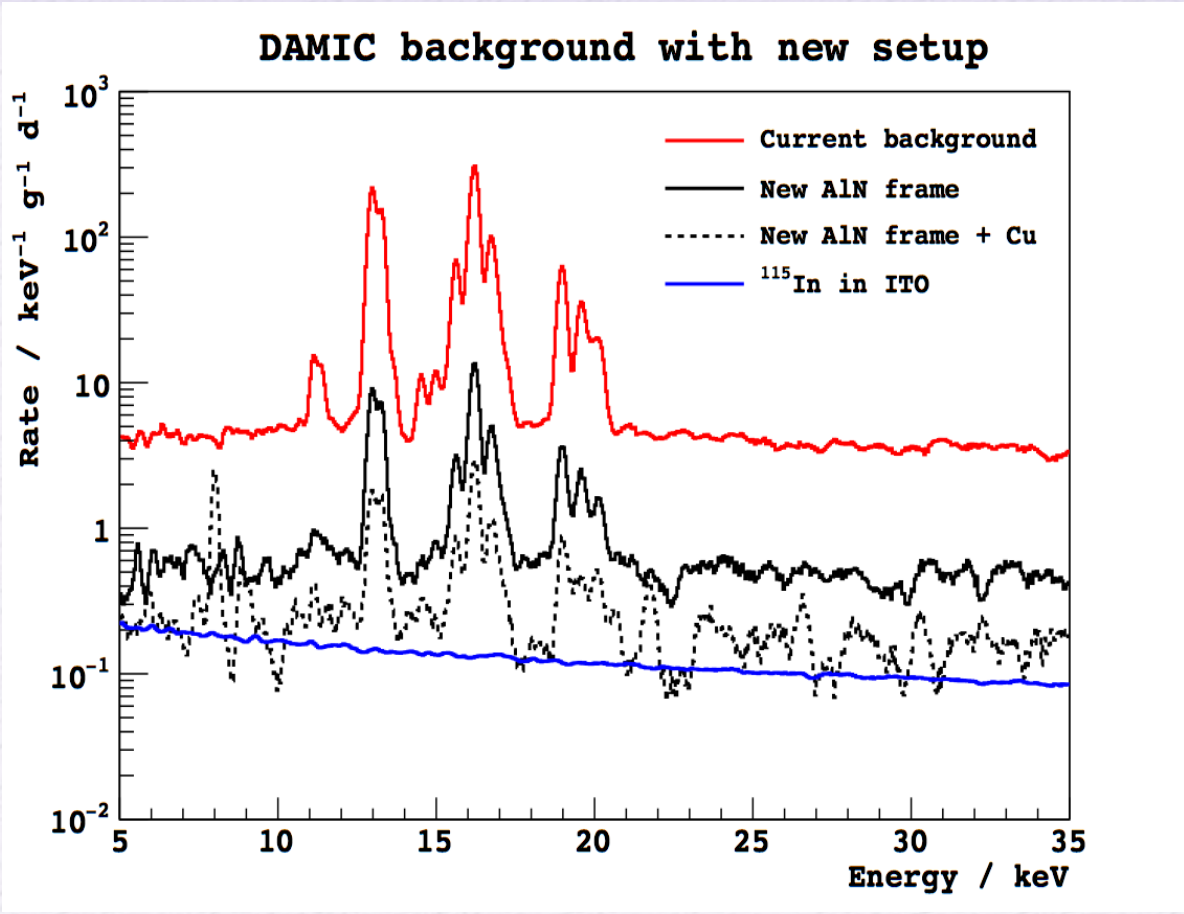
^{235}U	330 ± 30
^{238}U	4110 ± 530
^{226}Ra	42 ± 9
^{232}Th	32 ± 8

mBq / kg

New AlN frame

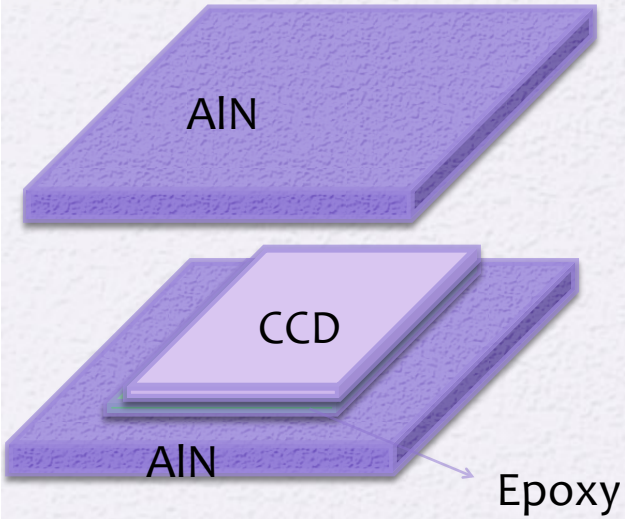
- AlN is needed to support the current 250µm CCD (too thin)
- Temporary solution: Cut a hole in the AlN
- Unnecessary with the next generation 1mm thick CCDs



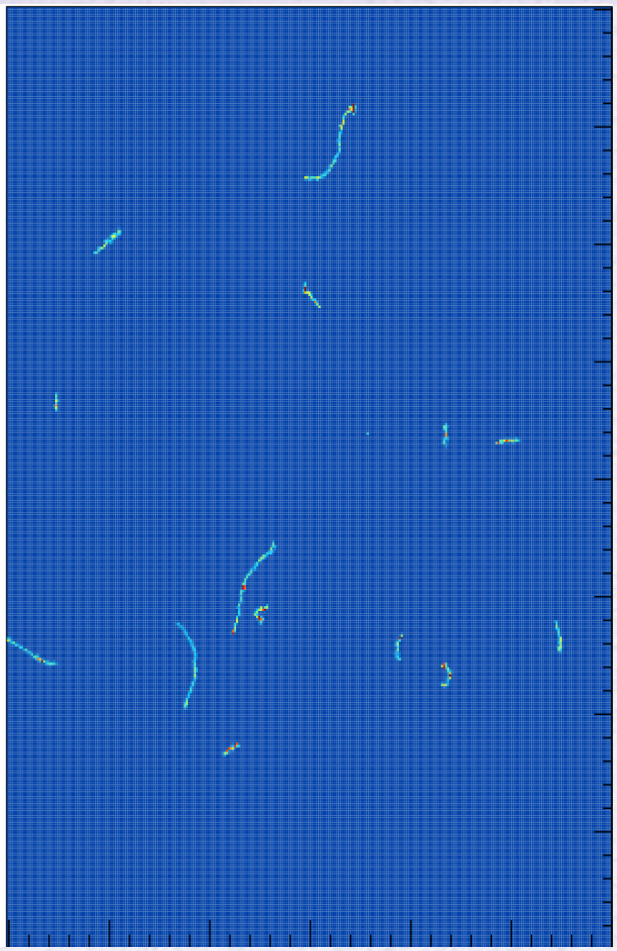


10 times less background

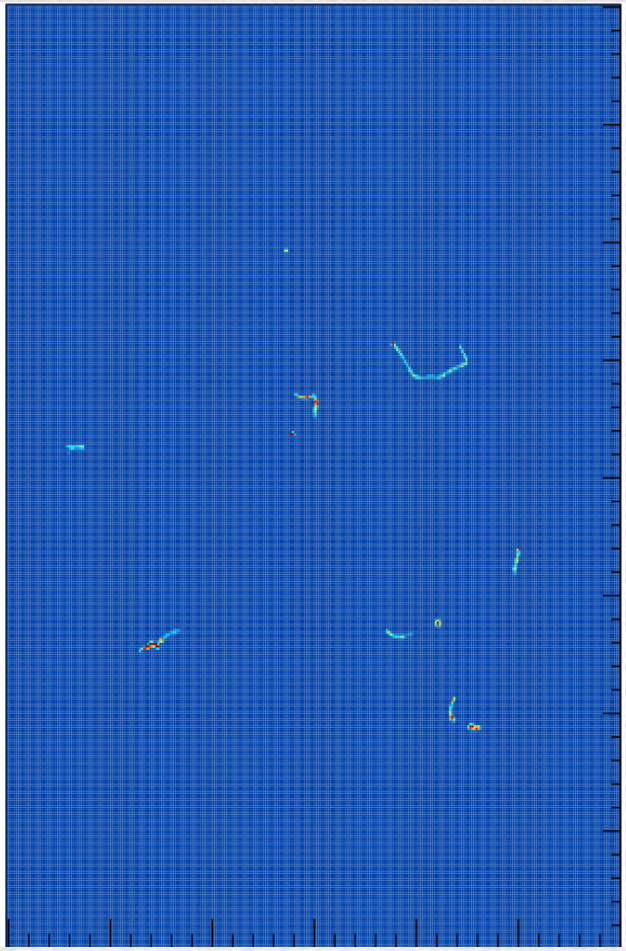
MCNPX Simulation



- Given a source, we get energy deposits in the CCD.
- We also store the mean *x*, *y* and *z* positions of the deposits.
- We use this information with noise + charge diffusion models to construct simulated image.

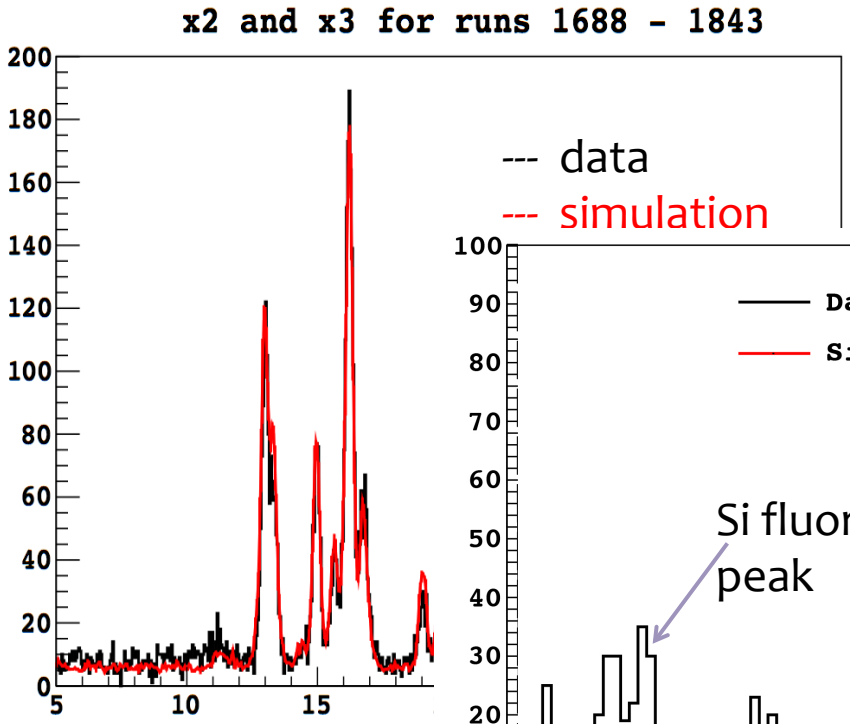


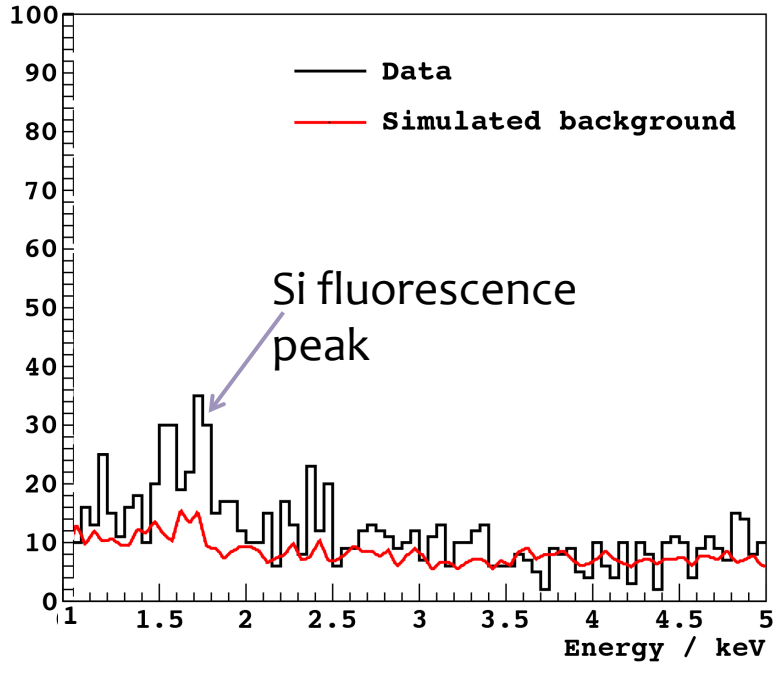
Simulated βs

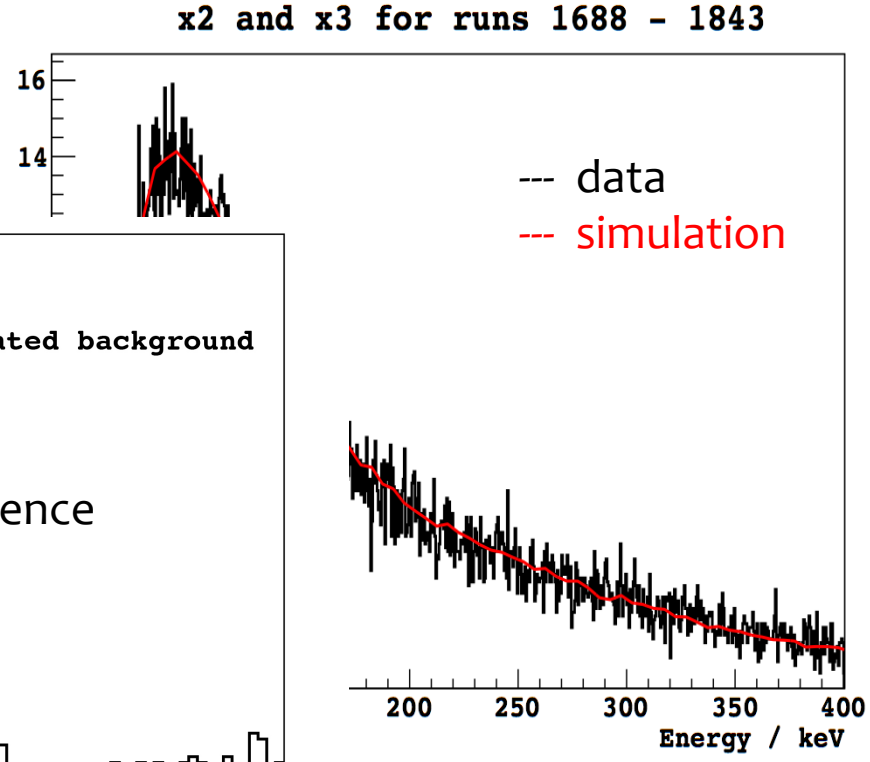


Data

Comparison between data and simulation



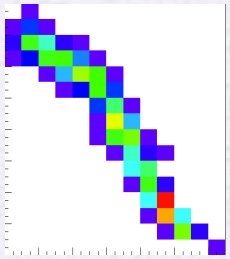




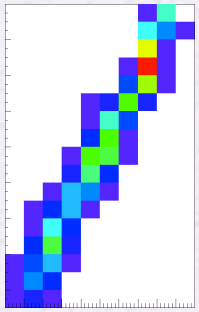
37.2 CCD days,

Energy Spectrum

Energy Spectrum



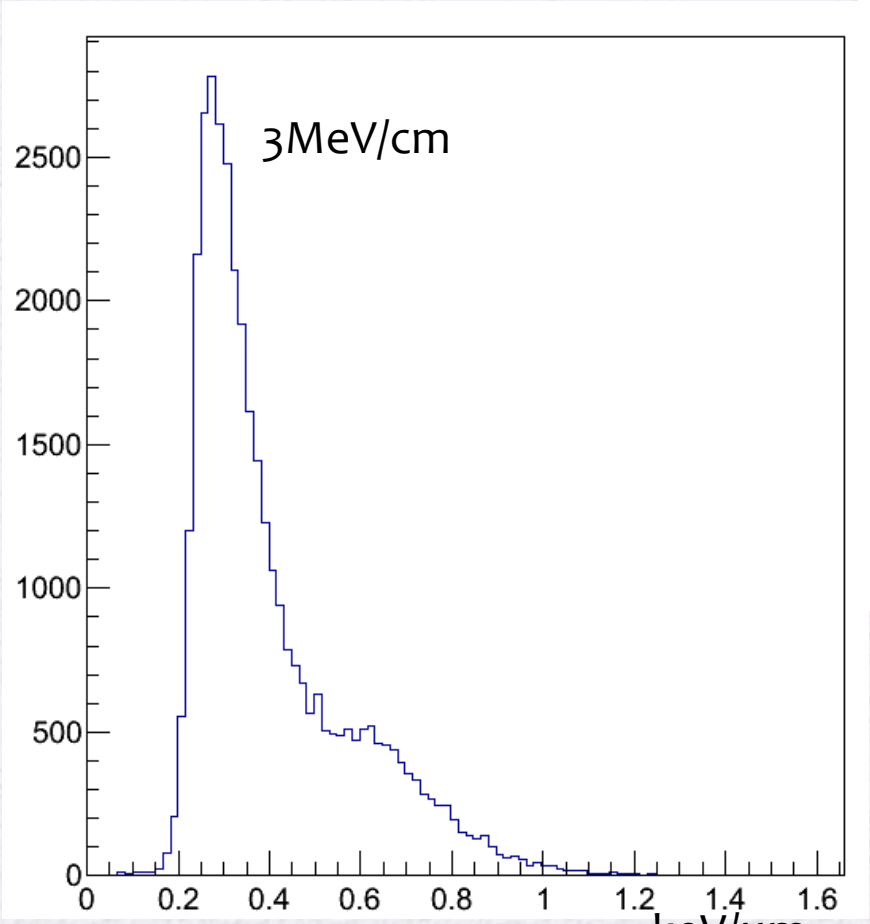
102.4keV

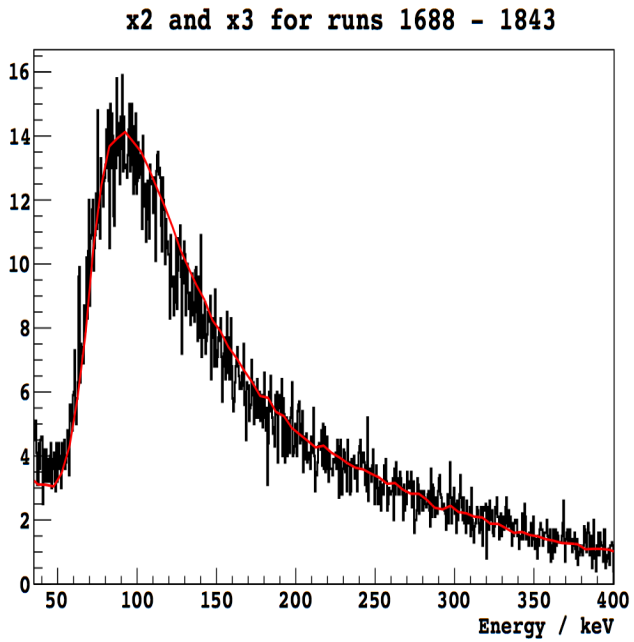


101.2keV

electrons

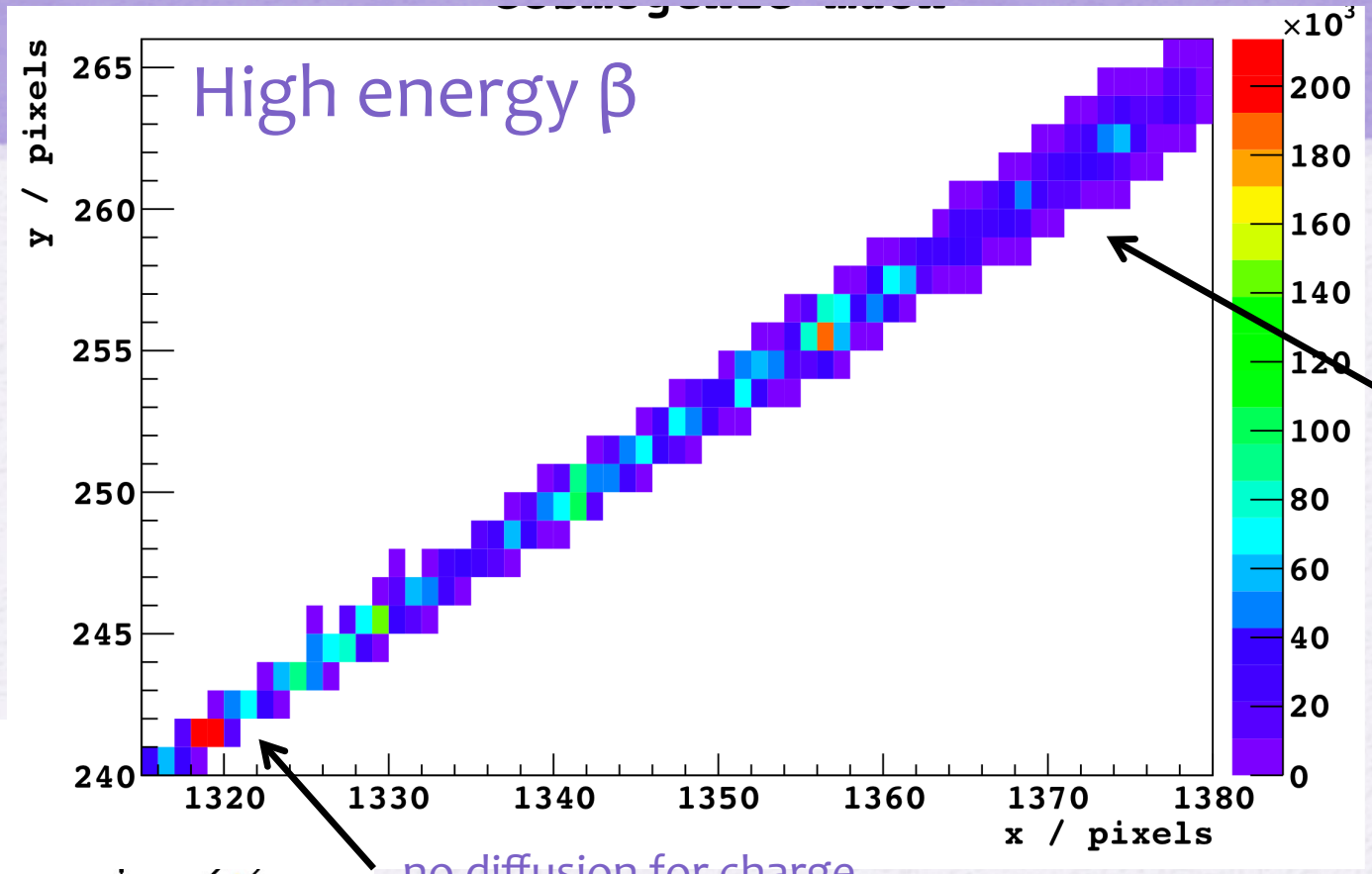
dE/dx of the events with energy between 60keV and 400keV

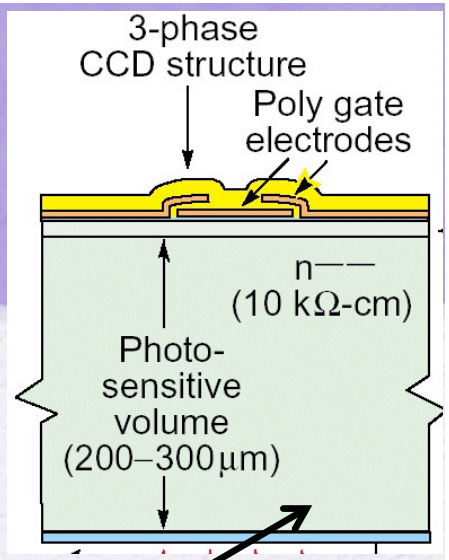




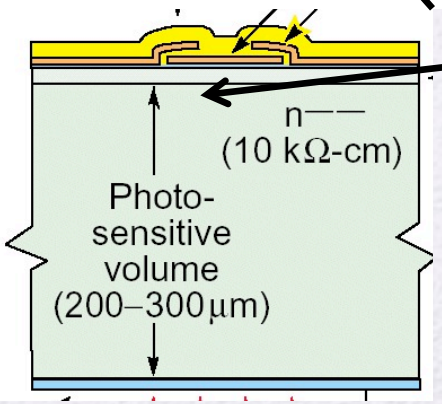
Minimum Ionization peak contributing from electrons

Charge diffusion





7 micron diffusion for charge deposited at the back side



no diffusion for charge deposited close to the gates

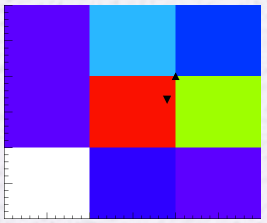
Low energy X rays stop in a few microns of Si (i.e. at the front and back surface of the CCD).

Surface background events can be eliminated by cutting the "thinner" and the "fatter" hits

Comparison between data and simulation

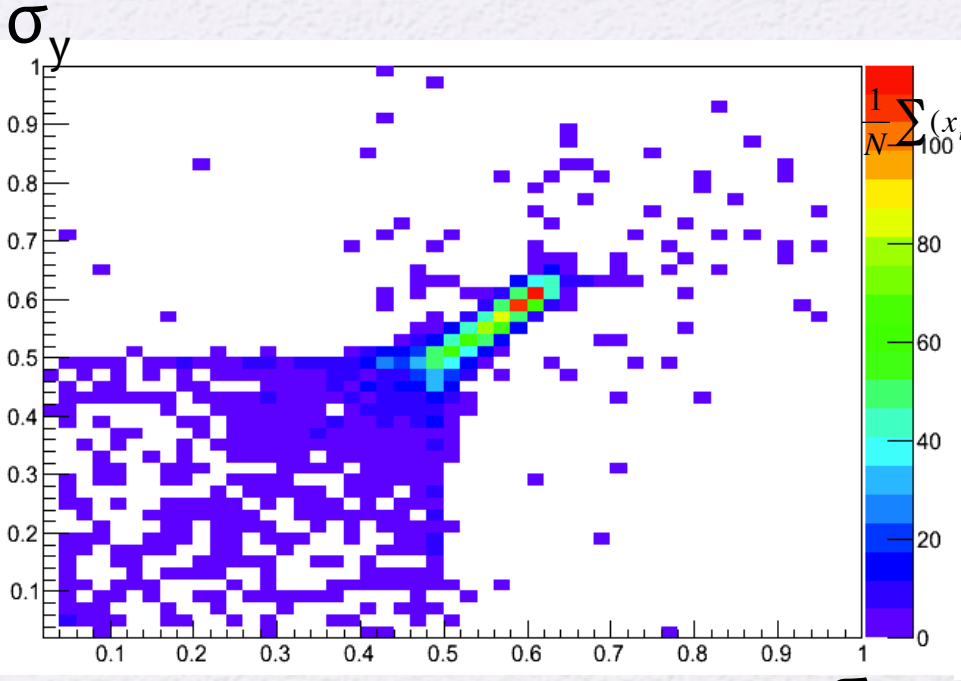
$$\sigma_x = \sqrt{\frac{1}{N}\left(\sum (x_i - \bar{x})^2\right)} \propto \sqrt{depth}$$

Example:
15.4keV

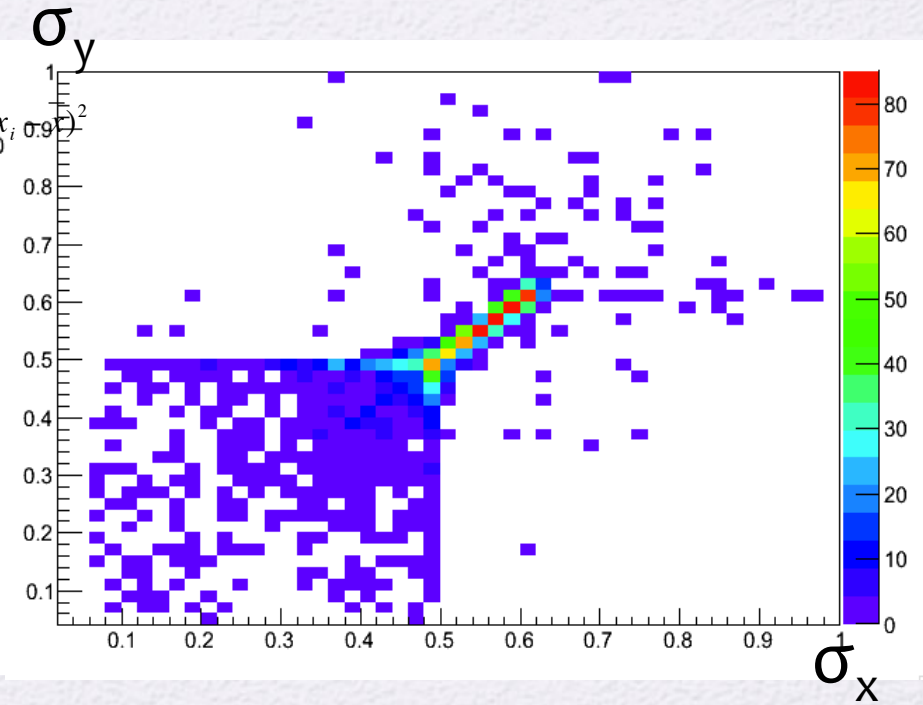


$\sigma_x = 0.5$

$\sigma_y = 0.5$



Simulation
(diffusion coefficient=0.28μm²/μm)



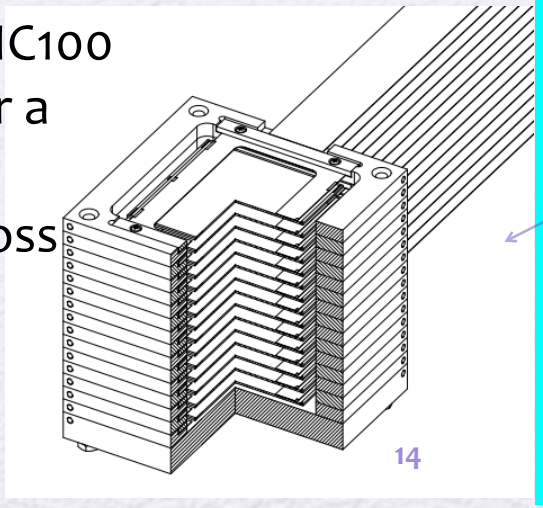
Data

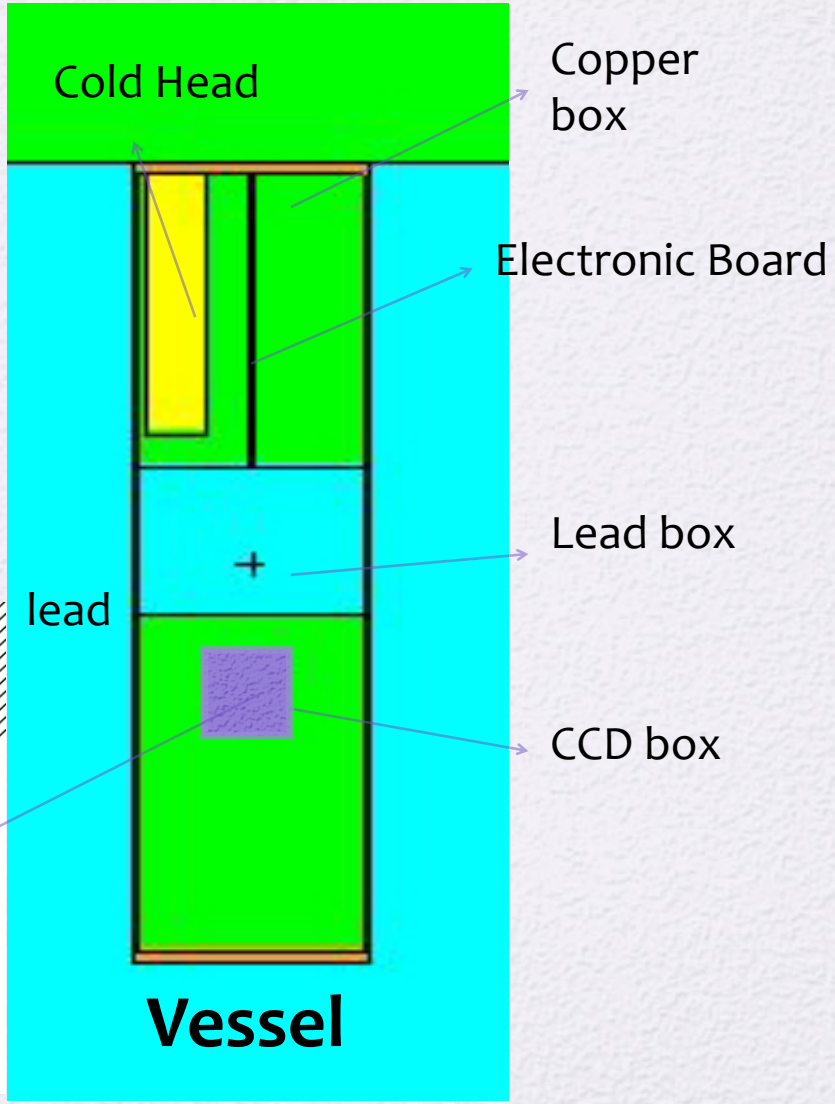
Energy [12.2 , 13.8] keV

DAMIC100

- In the next generation of DAMIC, ≈1mm thick CCDs will be used. No frame and no ITO layer will bring a great reduction of background by a factor of 1000.
- A 1mm thick CCDs (4k*4k pixels) is about 8g. DAMIC100 will have a total of 100 g target mass

We estimate for DAMIC100 O(100) events/year for a quenching factor 0.2, threshold 40 eVee, cross section 2 10^{-41} cm^2 and WIMP mass 8.6 GeV.





Conclusion

- DAMIC experiment is a direct dark matter detection experiment using CCD with sub-keV$_r$ threshold.
- DAMIC setup is now installed in SNOLAB, Canada. Background from the AlN support is understood and new AlN frame packaging is underway.
- The MCNPX simulation matches DAMIC data very well.
- DAMIC100 is well-suited to probe the low mass WIMP region hinted by several experiments (DAMA,CoGeNT, CREST, CDMS-Si).