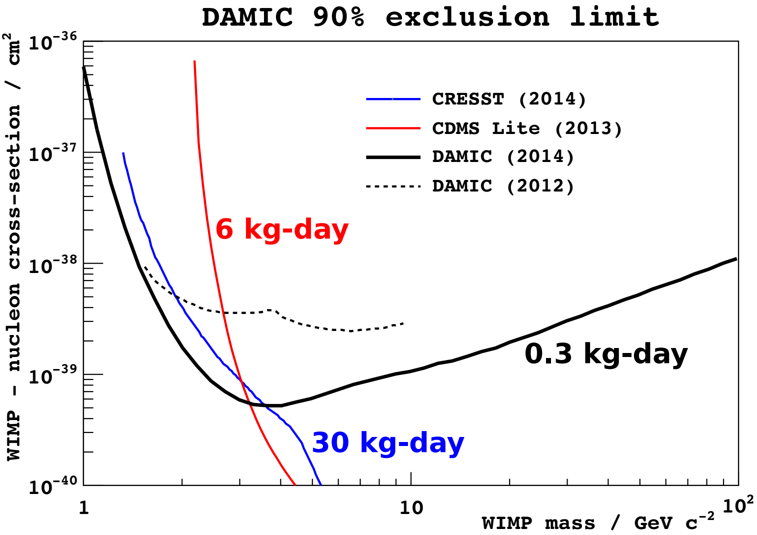
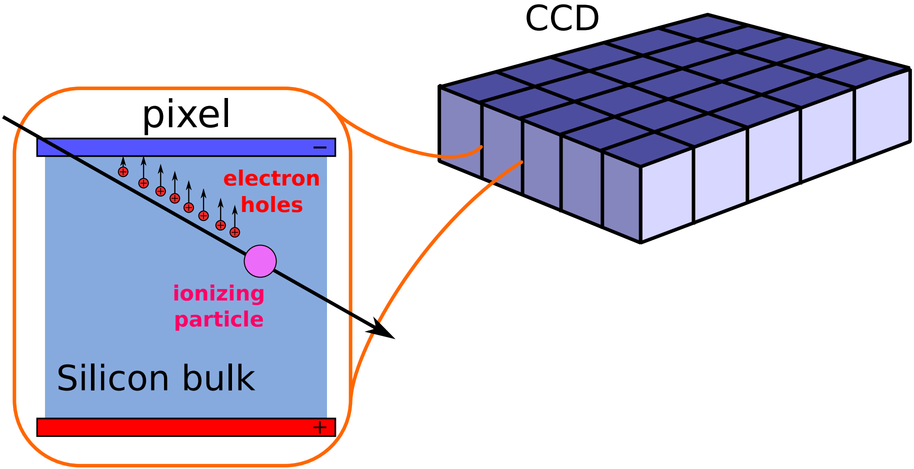
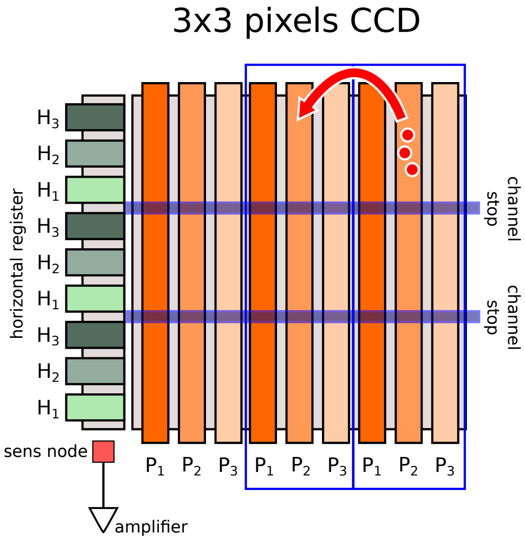
DAMIC Preliminary result – Best world limit @ low mass

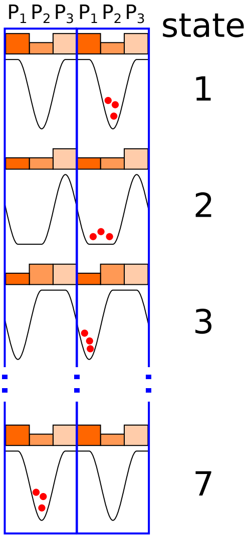


CCD: charge generation

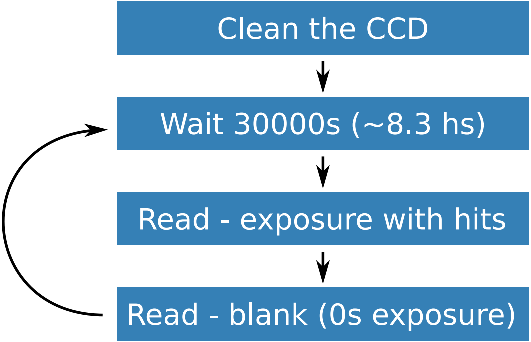


CCD: readout


3x3 pixels CCD
H3
H2
H1
H3
H2
H1
H3
H2
H1
horizontal register
channel stop
channel stop
sens node
amplifier
P1 P2 P3 P1 P2 P3 P1 P2 P3

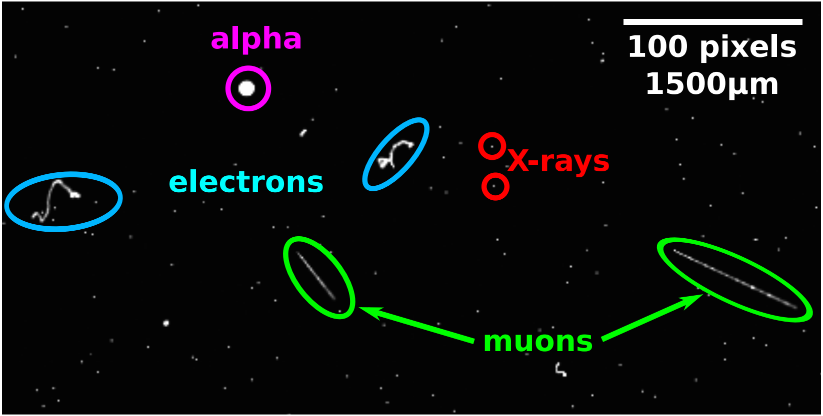

P1 P2 P3 P1 P2 P3
state
1
2
3
7

CCD: readout - typical operation at Snolab

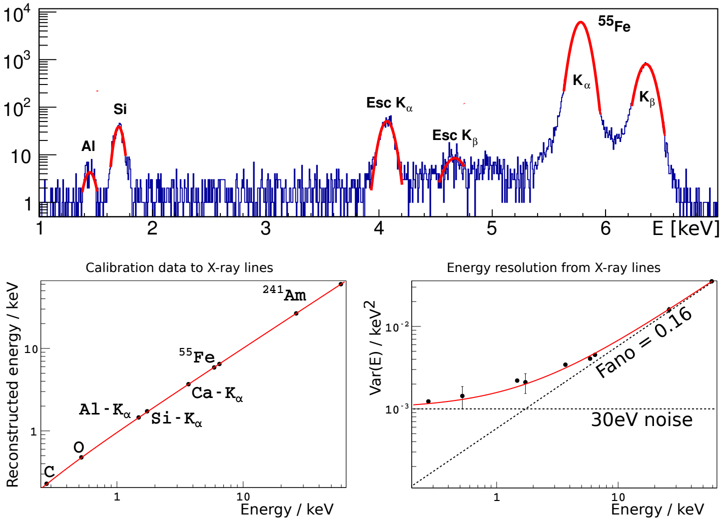


The blank images provide an excelent measurement of the background produced by readout noise

Particle ID

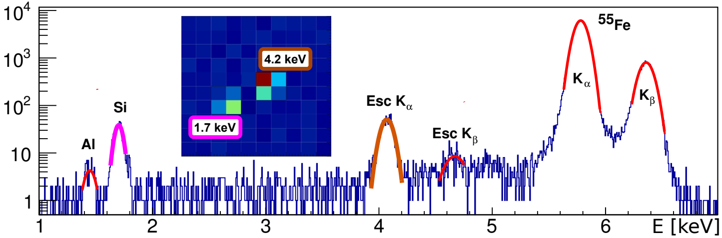


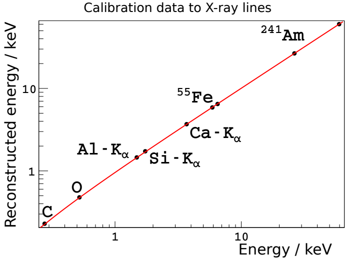
Energy calibration using X-rays

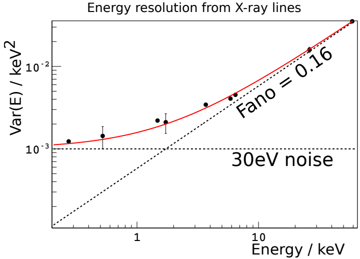


Electron energy scale calibrated down to 280eV, 63eV RMS @6keV

Energy calibration using X-rays

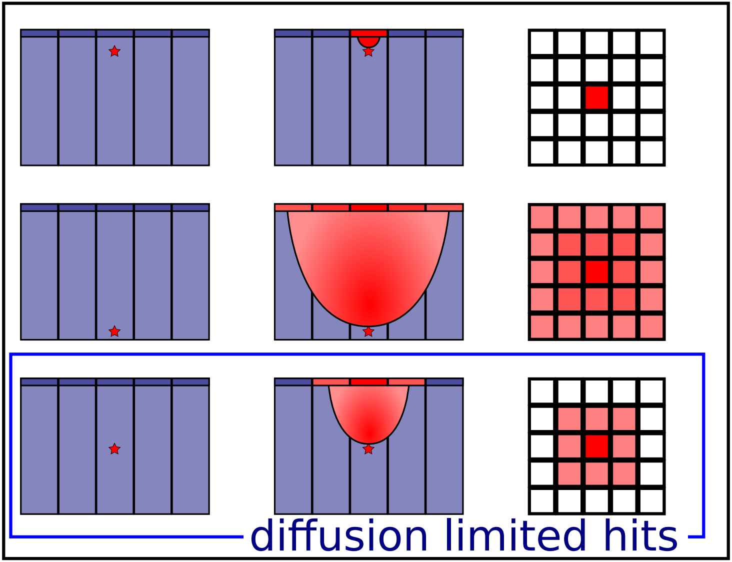




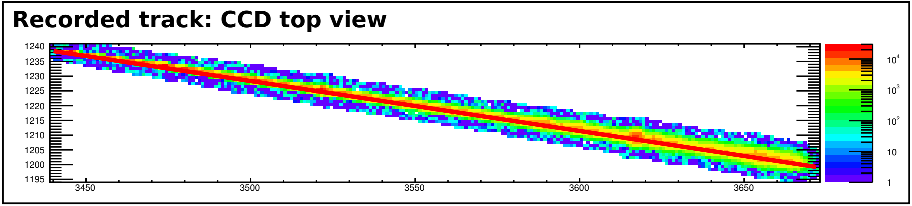


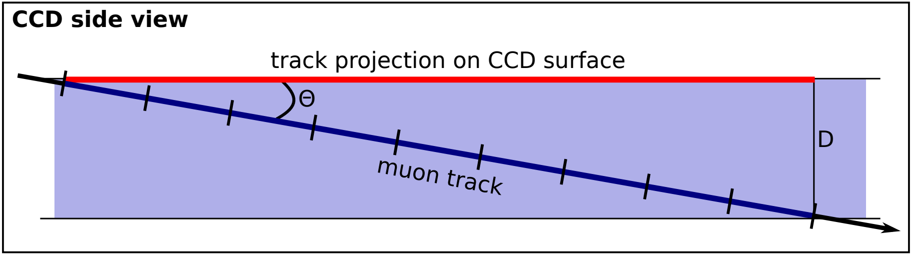
Electron energy scale calibrated down to 280eV, 63eV RMS @6keV

Diffusion

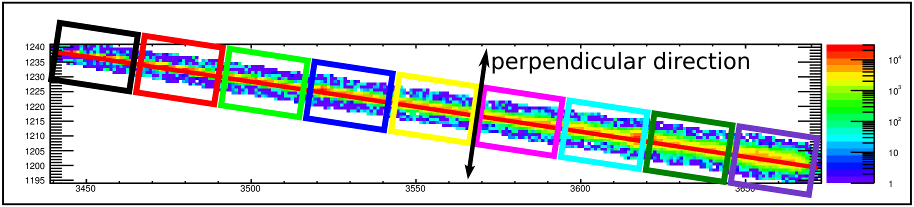


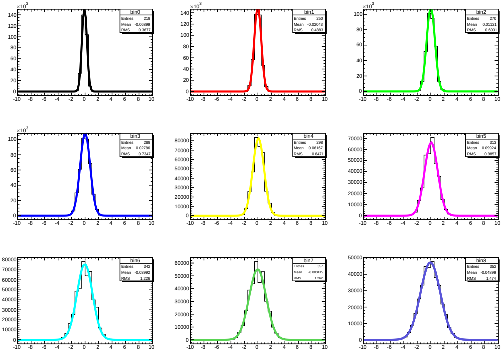
Measuring diffusion



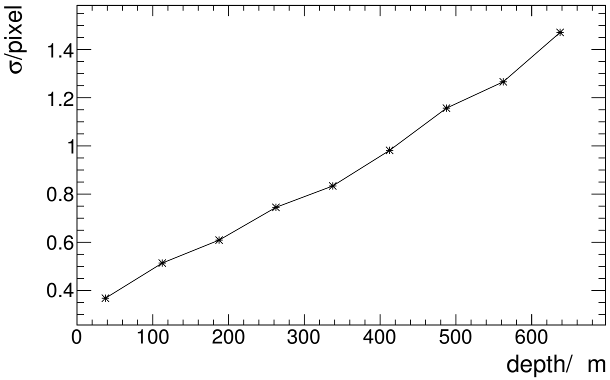


Measuring diffusion





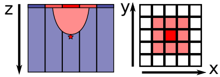
Measuring diffusion

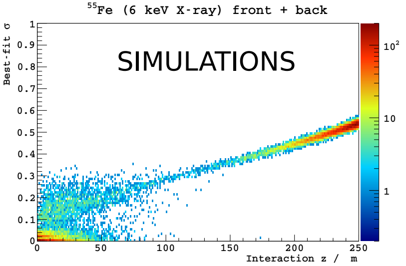


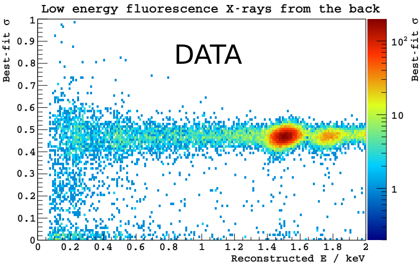
Diffusion can be measured as a function of the interaction depth.
No need to rely on models.

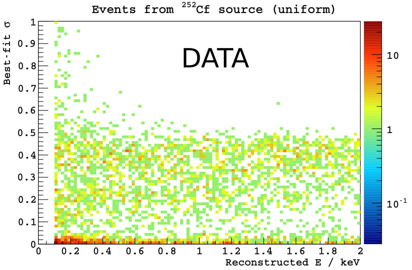
3D reconstruction of low energy (point like) like events

We fit to the radial spread of the cluster to estimate its position in z within the CCD bulk

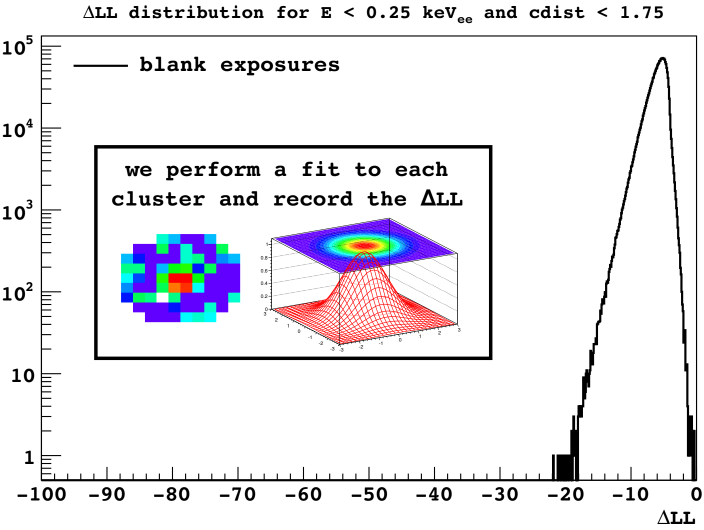




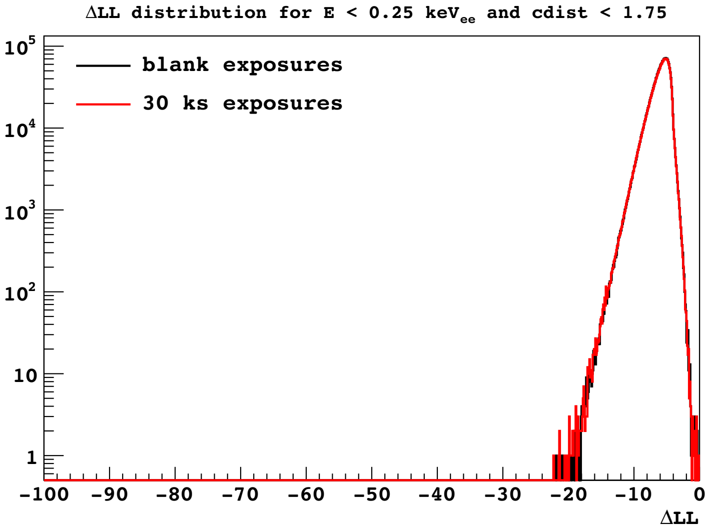




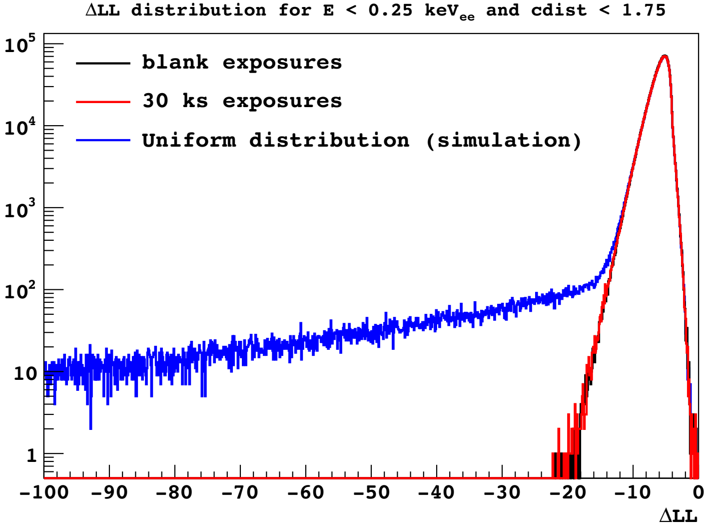
Data Analysis



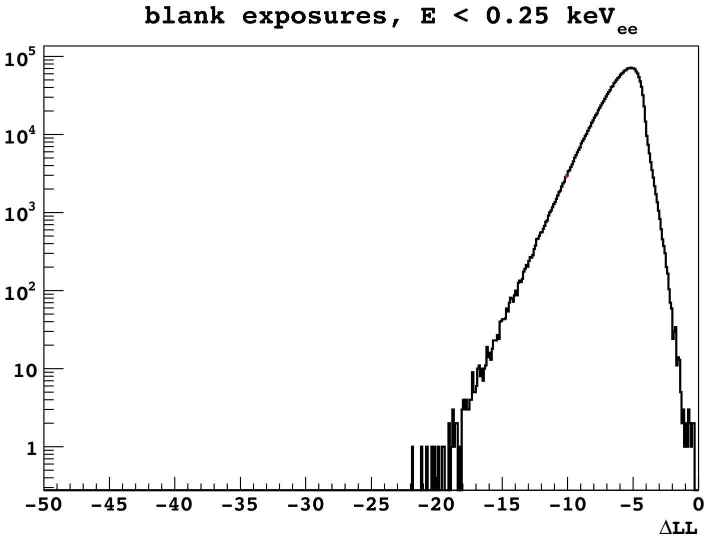
Data Analysis



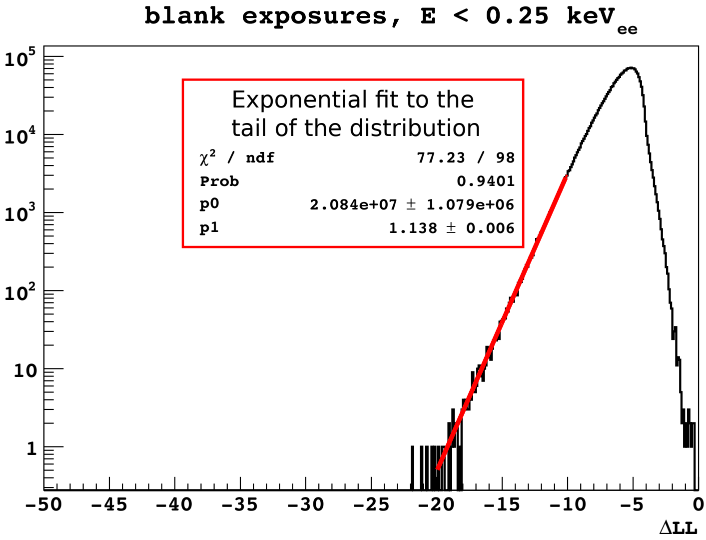
Data Analysis



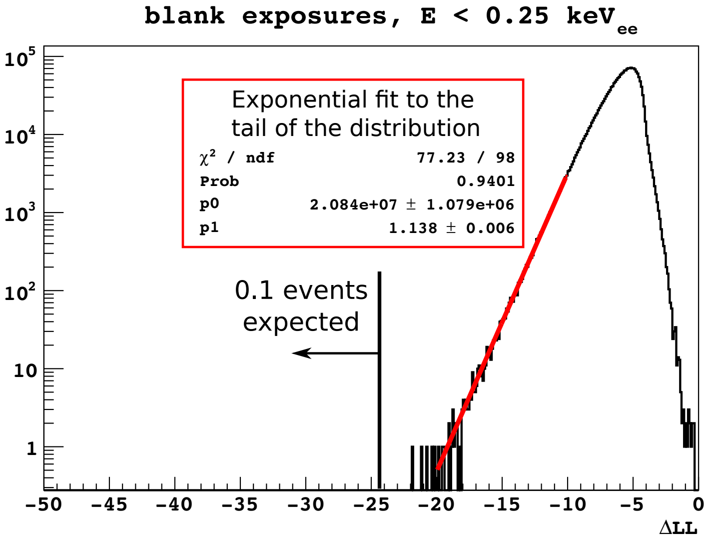
Data Analysis: events selection - quality cut



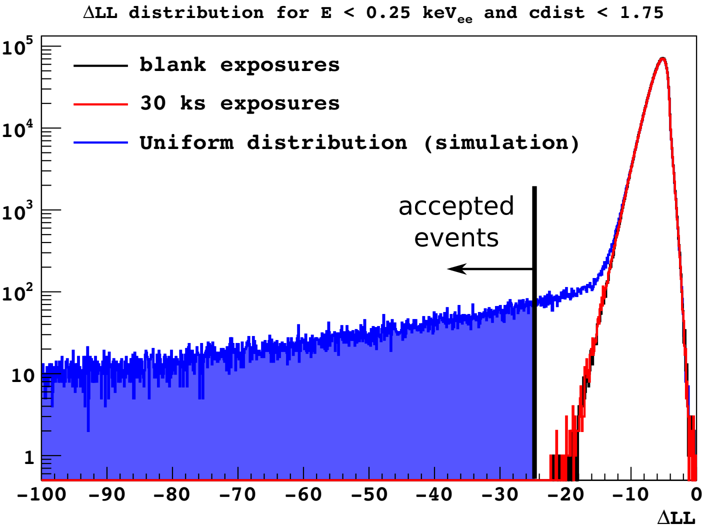
Data Analysis: events selection - quality cut



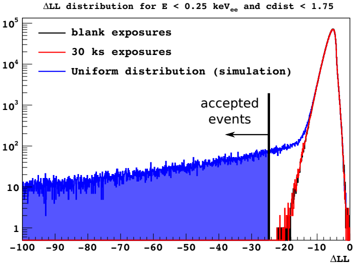
Data Analysis: events selection - quality cut

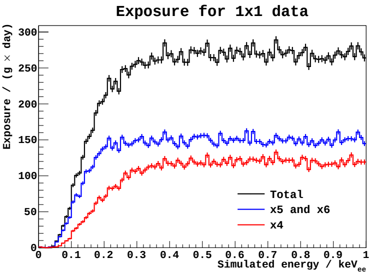


Data Analysis: events selection - quality cut



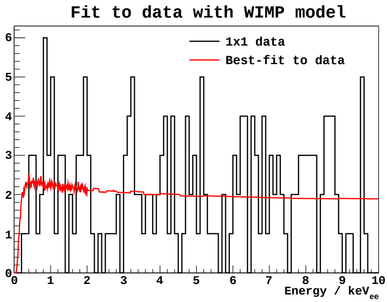
Data Analysis: exposure





Simulation used to estimate the efficiency down to threshold.
Based on this efficiency, an exposure is calculated.

No WIMP detected



Best fit mass: 26±46 GeV/c^2
Best fit σ: (7±16)x10^{-39} cm^2
Best fit bkg: 67±13 dru
Min -LL: -396.5

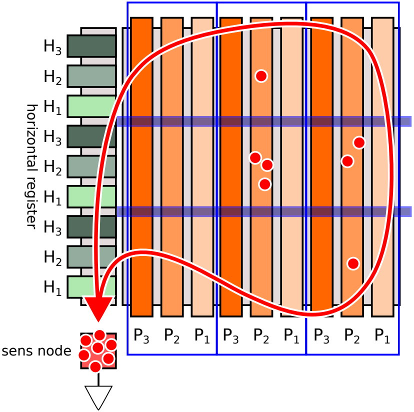
Null hypotesis bkg: 74±5 dru
Min -LL: -396.1

- Background is still high (∼74 dru)
- We associate this to Radon in the volume around the lead shield.
- We have a nitrogen gas purge, but it is not performing as it should.
- Upgrade last week to address this purge performance.

The DAMIC detector has two unique capabilities, not used for the preliminary result yet.

However, they demonstrate the flexibility of this technology.

Binning



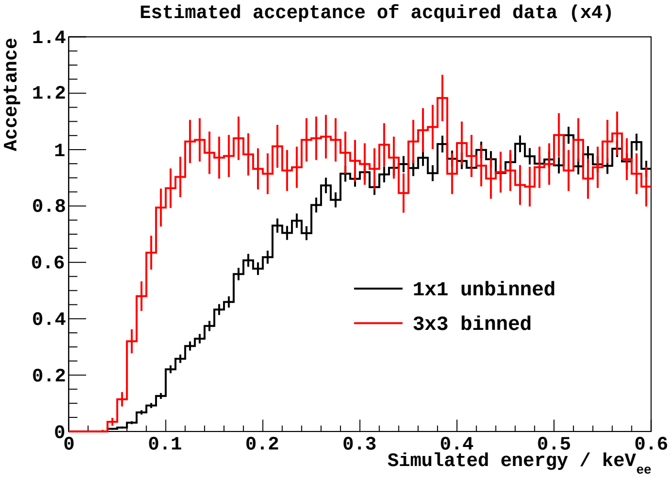
- Every readout introduces a $2e^-$ noise
- The CCD allows you to add charge in the sensor (binning) and then readout many pixels as a single one
- This improves signal to noise, effectively increasing the efficiency at low energy

$$\mathbf{S/Noise} = \frac{\mathbf{Q}}{\mathbf{N_{reads}}\sigma}$$

Reading the charge in less pixels is good!

Binning

Improves signal to noise, effectively increasing the efficiency at low energy



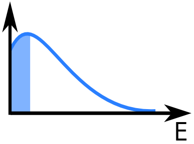
Binned data not used for preliminary result shown here

Background from Silicon: could be a limiting factor

^{32}Si → β (227.2 keV) → ^{32}P (14.2 day) → β (1.71 MeV) → ^{32}S

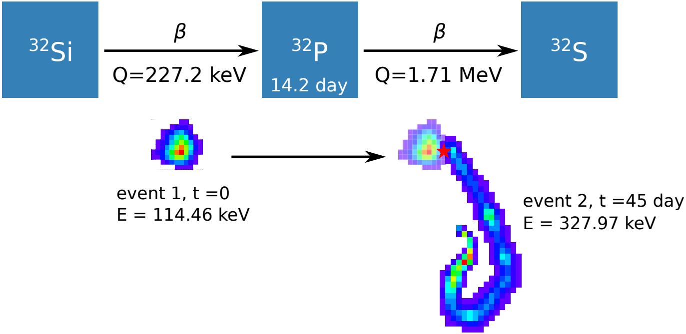
^{210}Pb → β (63.5 keV) → ^{210}Bi (5.01 day) → β (1.162 MeV) → ^{210}Po

Low energy electrons from β decays could be a significant background in silicon



Background from Silicon: candidate ^{32}Si event

The precise position reconstruction in the CCD allows the study of spatial coincidences of those decay chains to measure and veto ^{32}Si and ^{210}Pb events in the CCD



The pixilation of the DAMIC detector allows us reject this background.

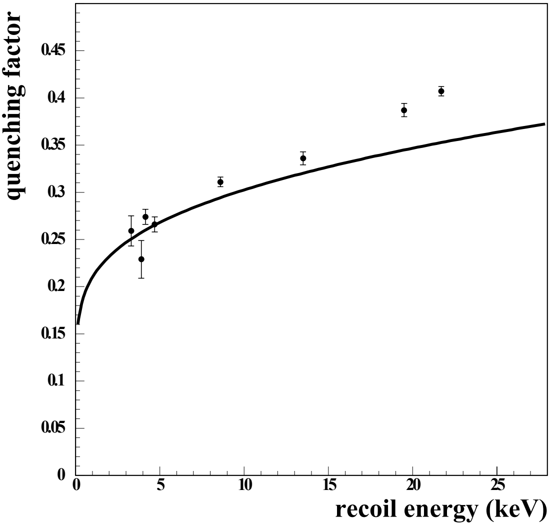
This is a unique capability of the DAMIC sensors.

Summary

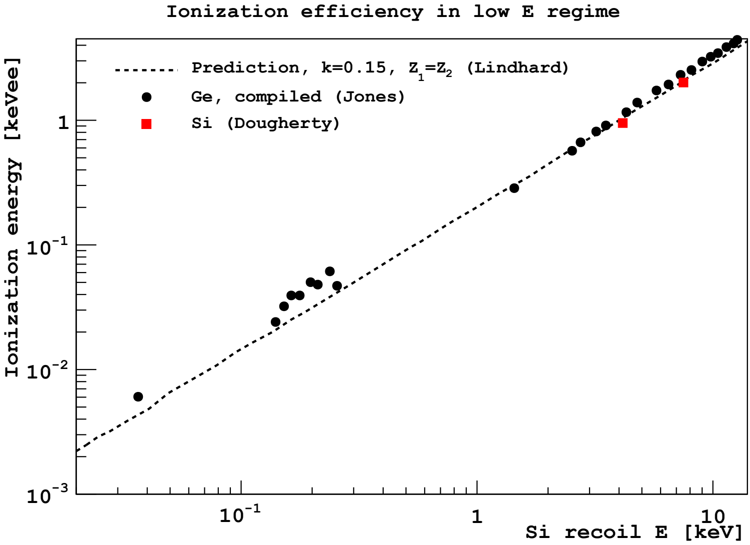
- DAMIC is now science ready, leading experiment at low mass.
- Currently upgrading to larger active mass.
  Parts available, some assembly required.
- We are asking for support to install, commission and operate this upgrade.

BACK UP SLIDES

Quenching factor.



Quenching factor: nuclear recoil ionization efficiency



Measuring Q: ongoing efforts

- Scattering experiment at a neutron beam.

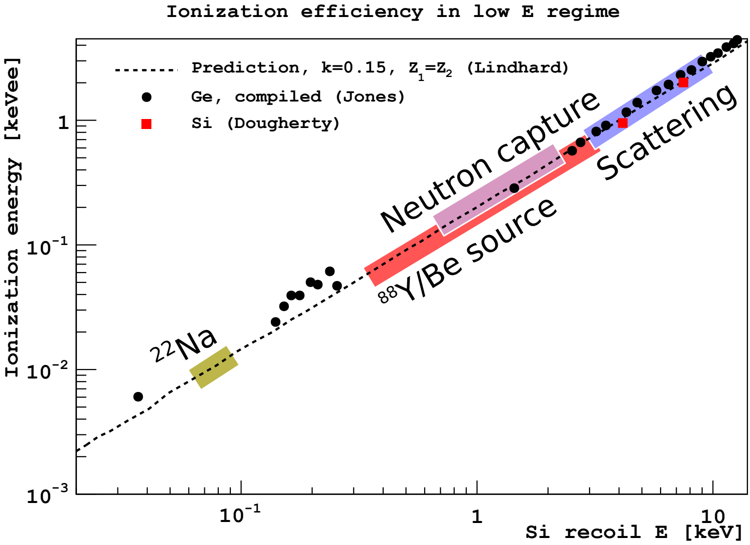
- Neutron capture: ^{28}Si+n $\rightarrow$ ^{29}Si+γ
  - Using a LAAPD + NaI detector in coincidence.
  - Using a CCD at a nuclear reactor.

- *Monochromatic* neutron exposure: ^{88}Y/Be source

- CCD activation at a proton beam:

  measure nuclear recoils after EC of ^{22}Na.

Measuring Q: ongoing efforts



hit extraction