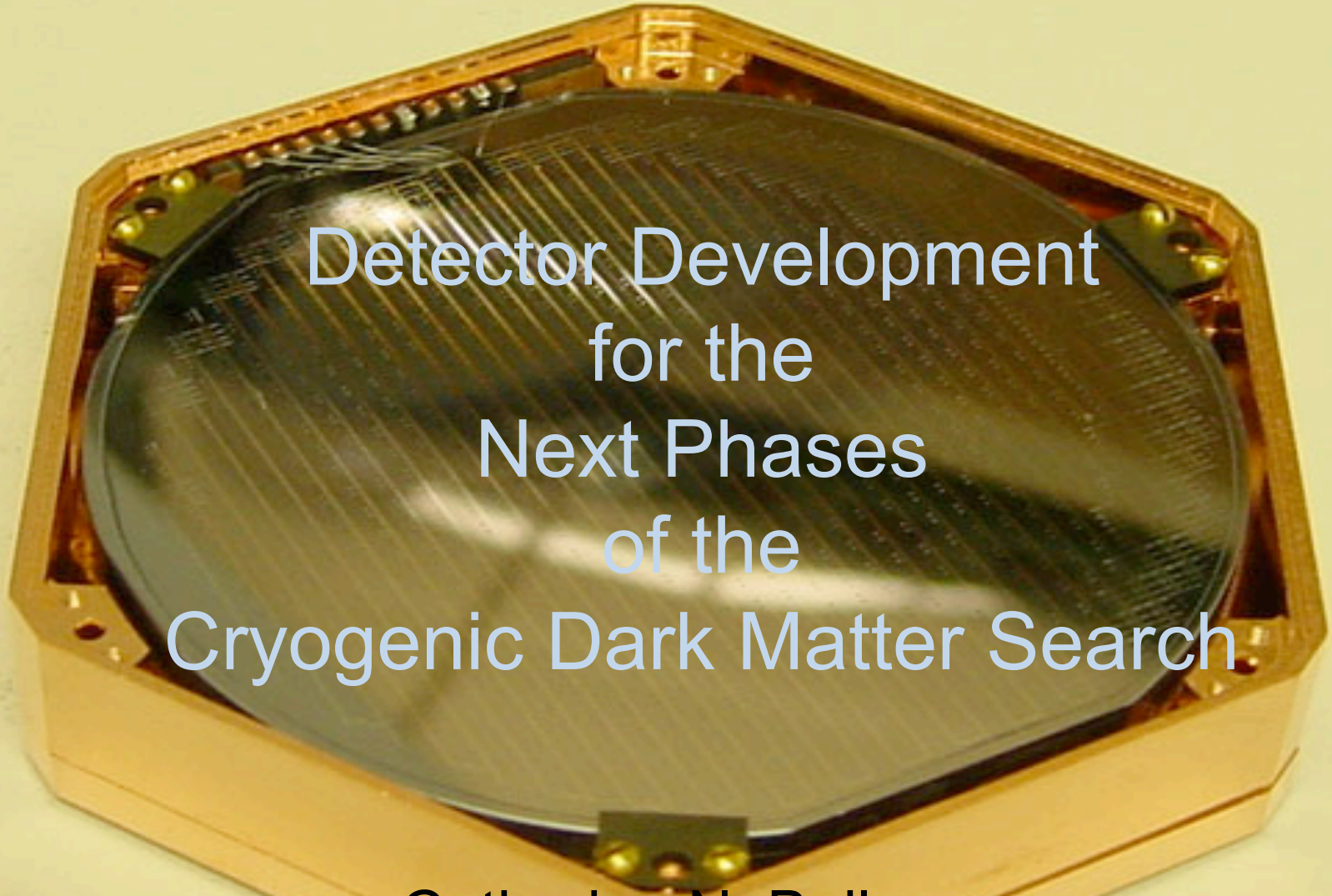


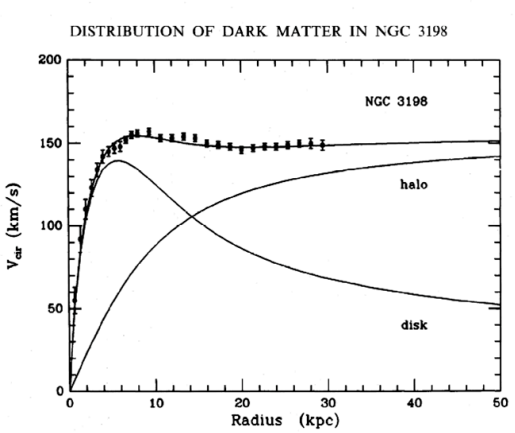
Detector Development for the Next Phases of the Cryogenic Dark Matter Search

Catherine N. Bailey

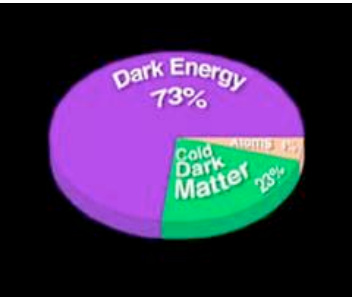
Case Western Reserve University

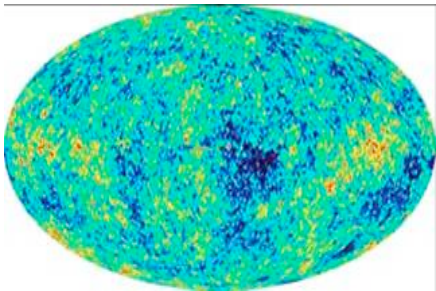
TESIII Conference

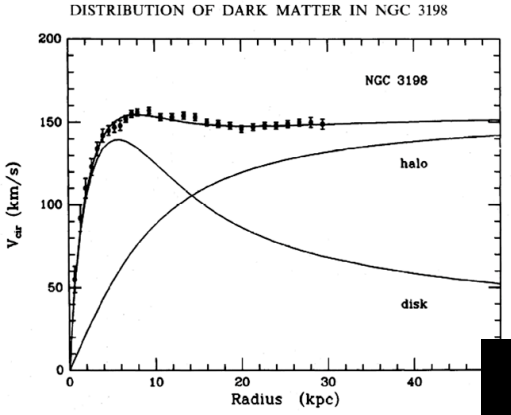
August 18, 2006



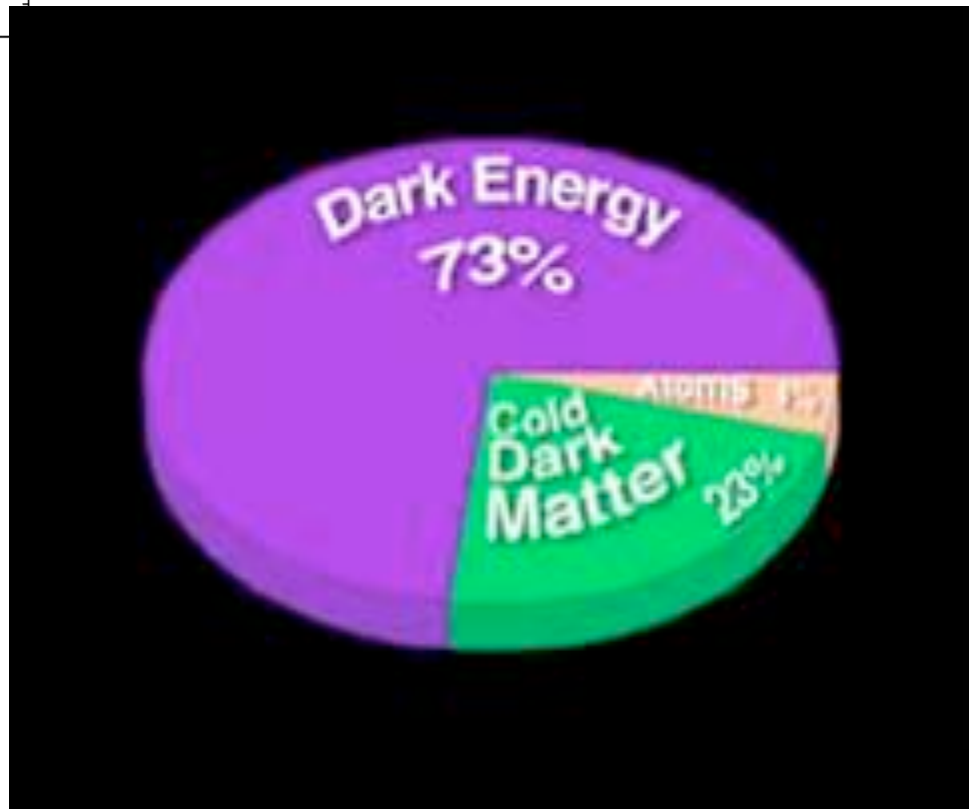
Dark Matter Evidence

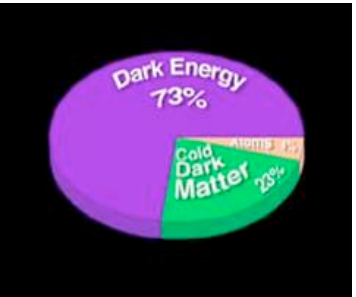


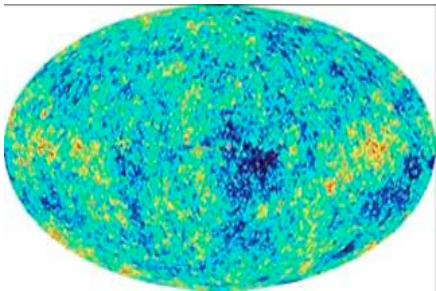




Dark Matter Evidence







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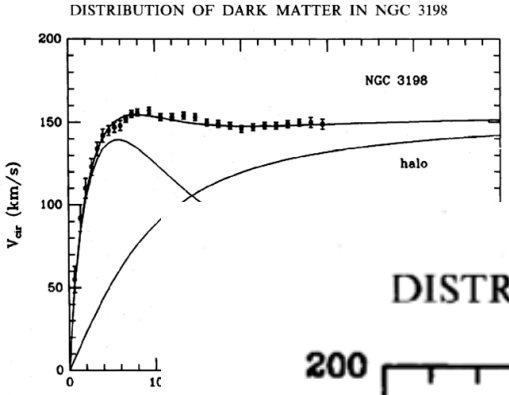
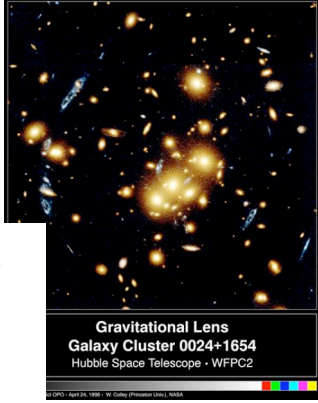
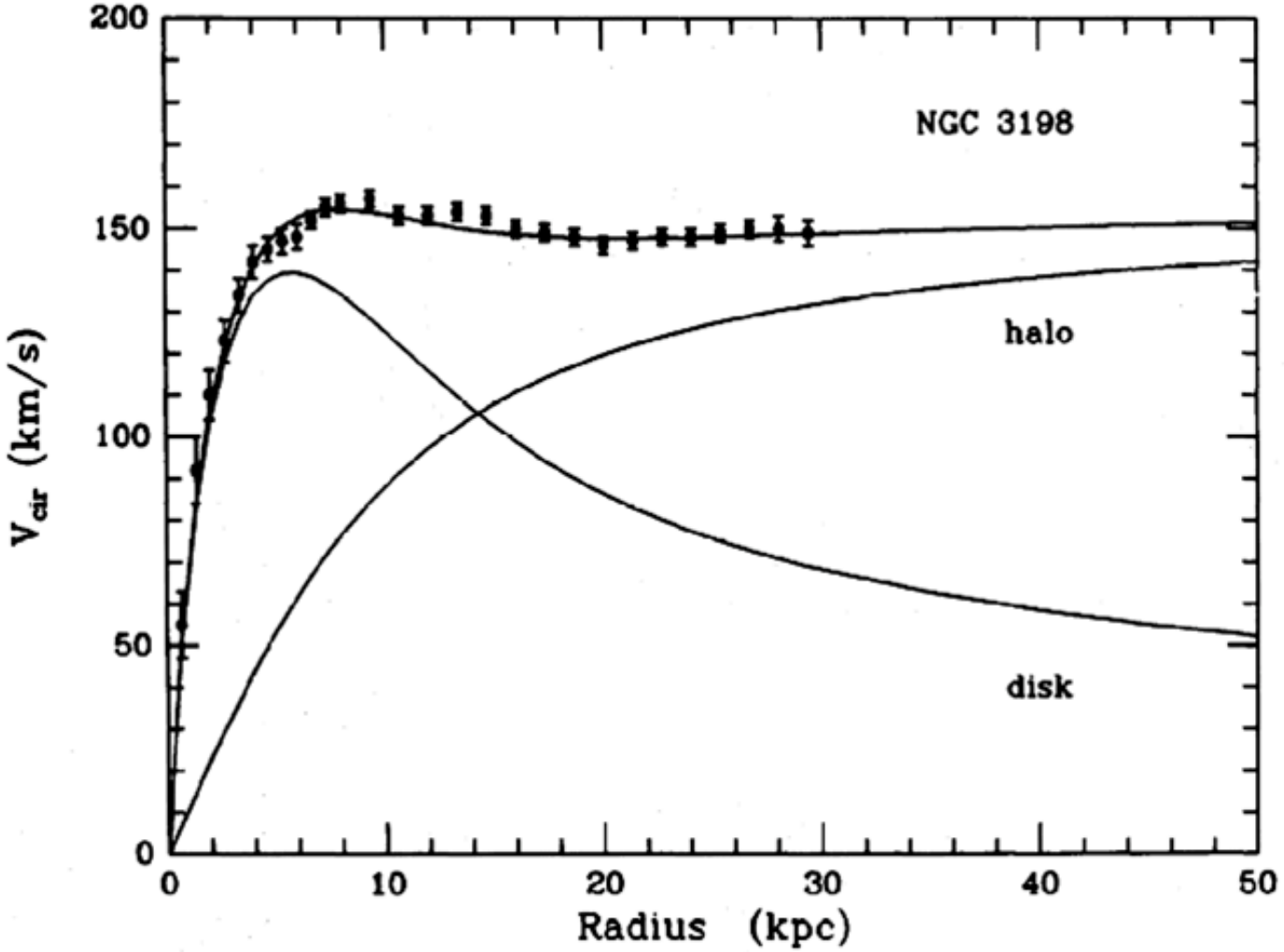
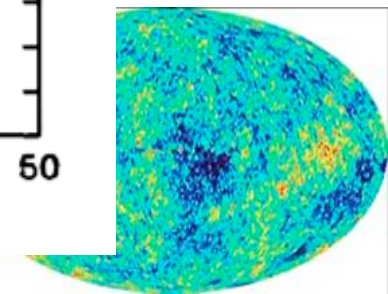


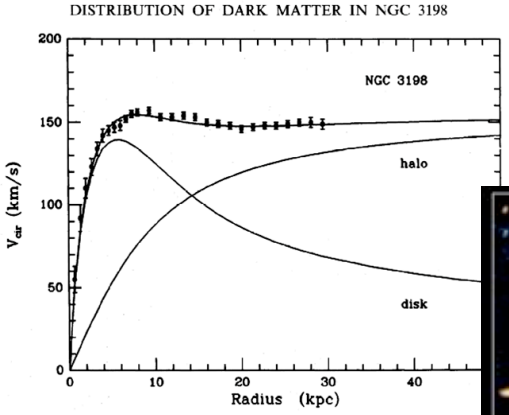


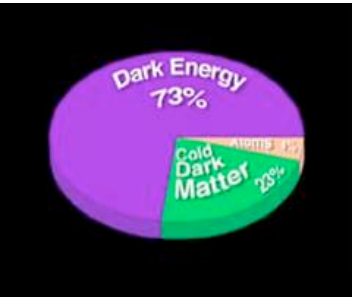
DISTRIBUTION OF DARK MATTER IN NGC 3198

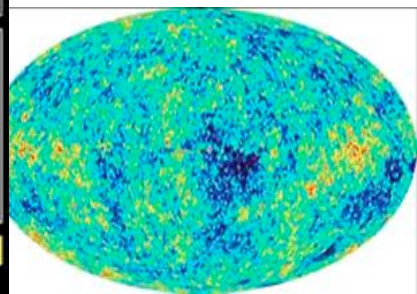


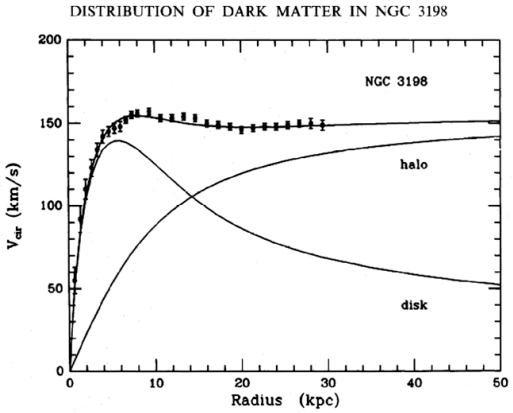


Dark Matter Evidence

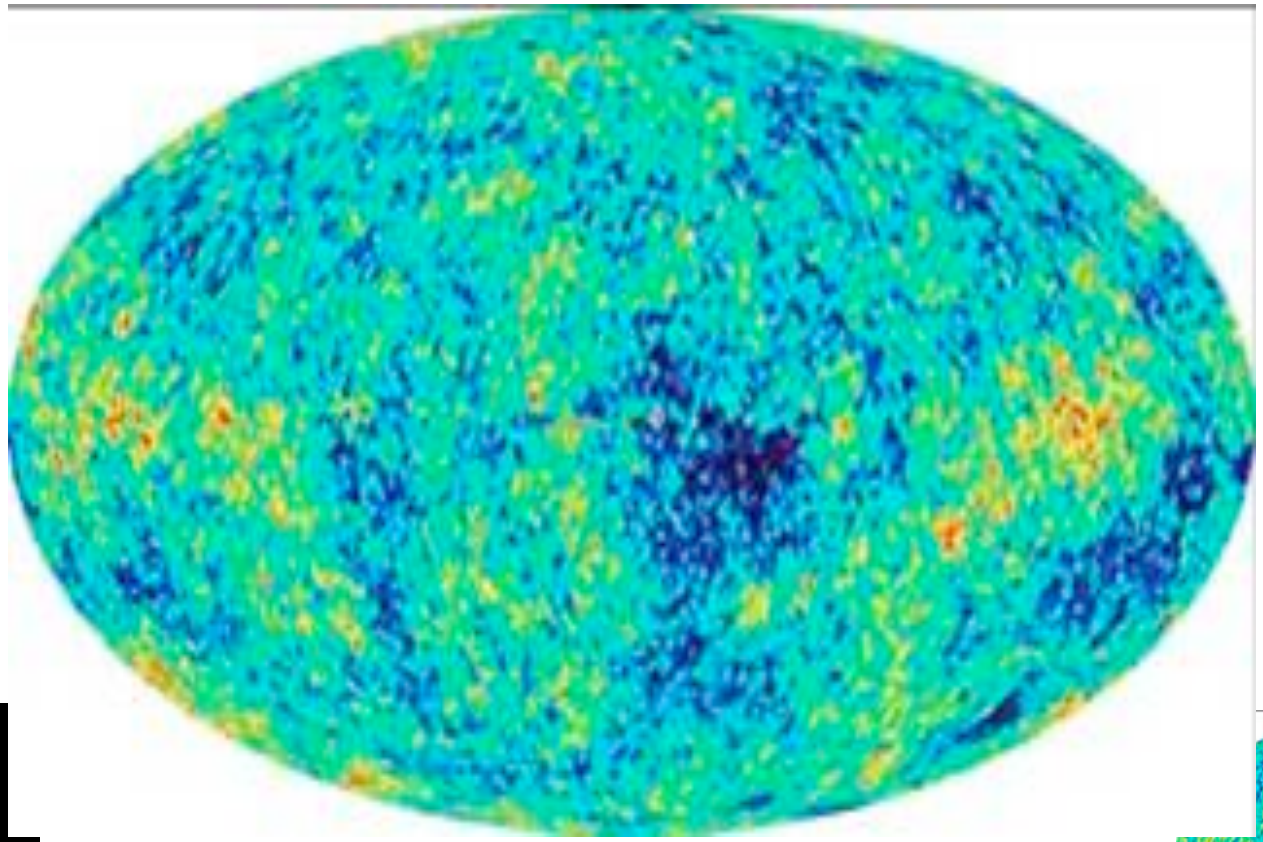


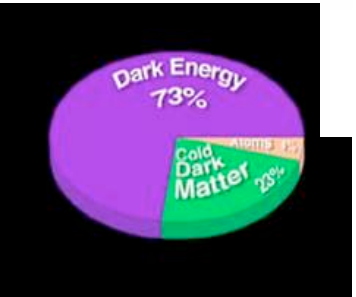


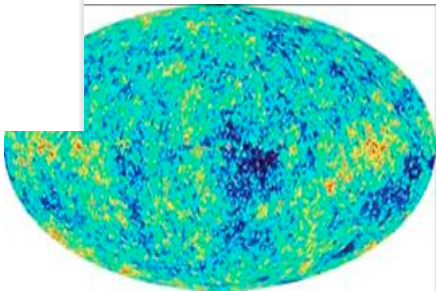




Dark Matter Evidence

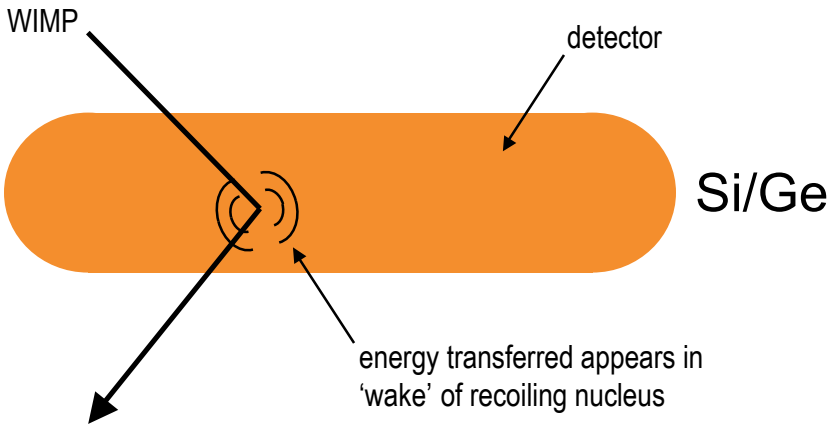




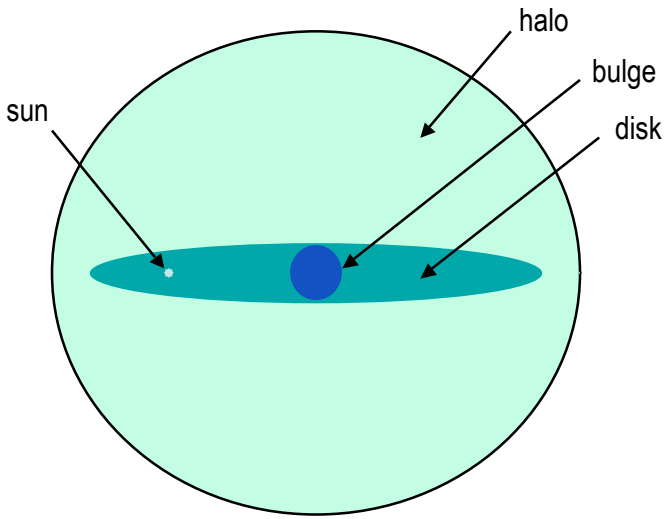


WIMPs in the Galactic Halo

WIMPs – the source of Mass in the Rotation Curves?



WIMP-Nucleus Scattering

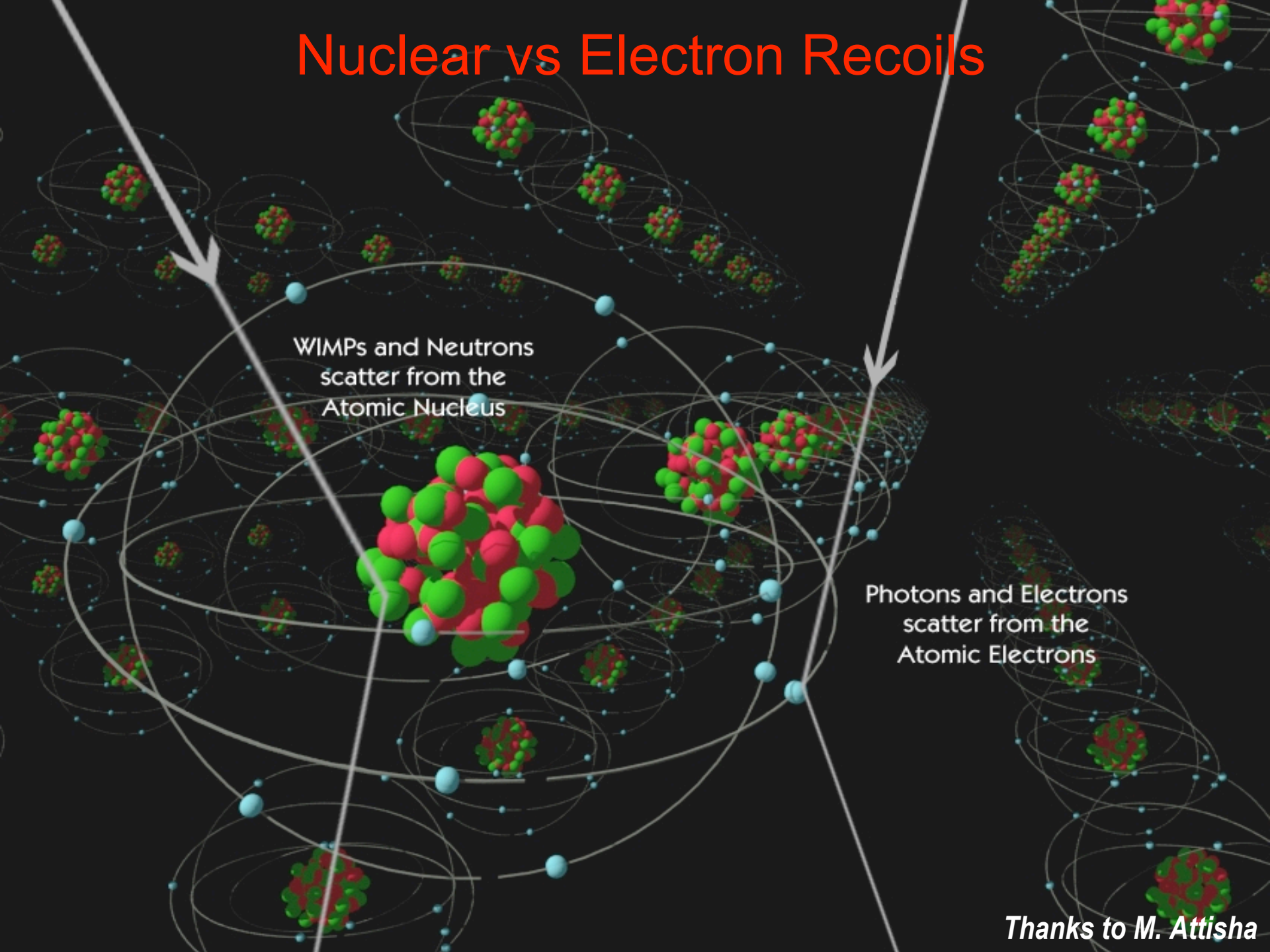


The Milky Way

Scatter from a Nucleus in a Terrestrial Particle Detector

Challenge: weakly interacting.
Expect less than one-a-day in a kilogram detector with E~10keV

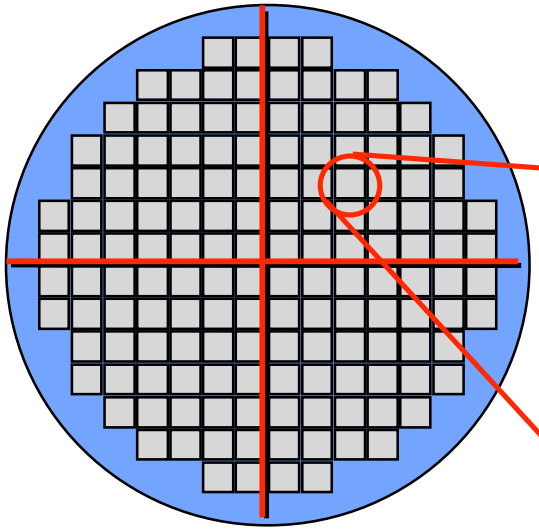
Nuclear vs Electron Recoils



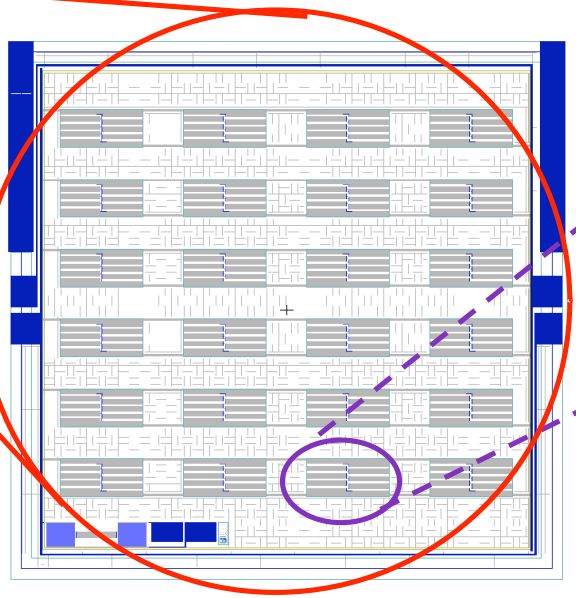
Thanks to M. Attisha

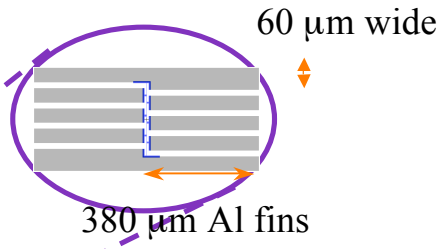
Phonon + Ionization – CDMS II ZIP Detectors

Detectors
- 250 g Ge or 100 g Si crystal
- 1 cm thick x 7.5 cm diameter



Phonon Sensors
- Photolithographic patterning
- 4 quadrants
- 37 cells per quadrant
- 6x4 array of 250μm by 1μm W TES per cell
- Each W sensor "fed" by 8 Al fins

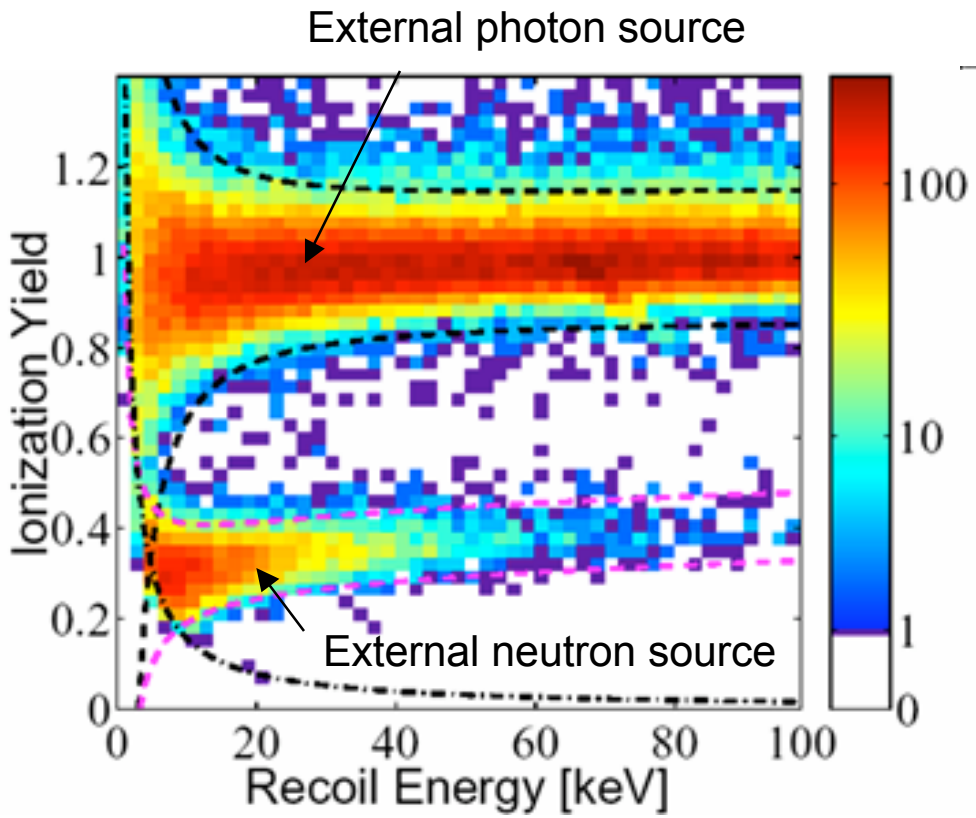


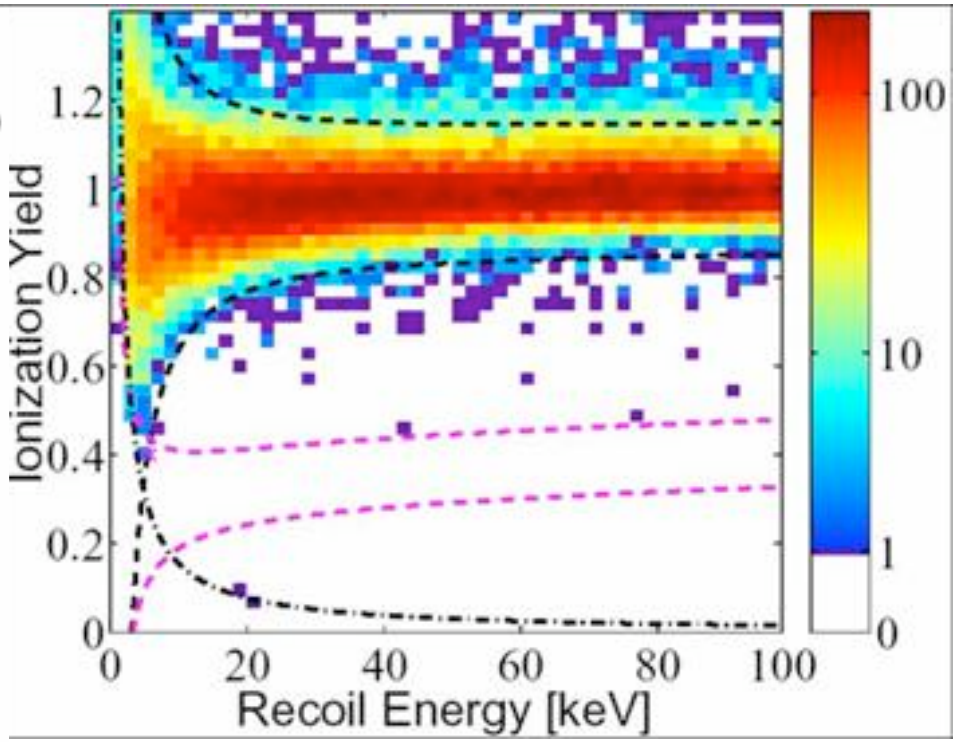


Ionization Sensors
- 2 electrodes (+ ground)
- Allow rejection of events near outer edge

ZIP: Z-sensitive Ionization and Phonon Detector

CDMS II

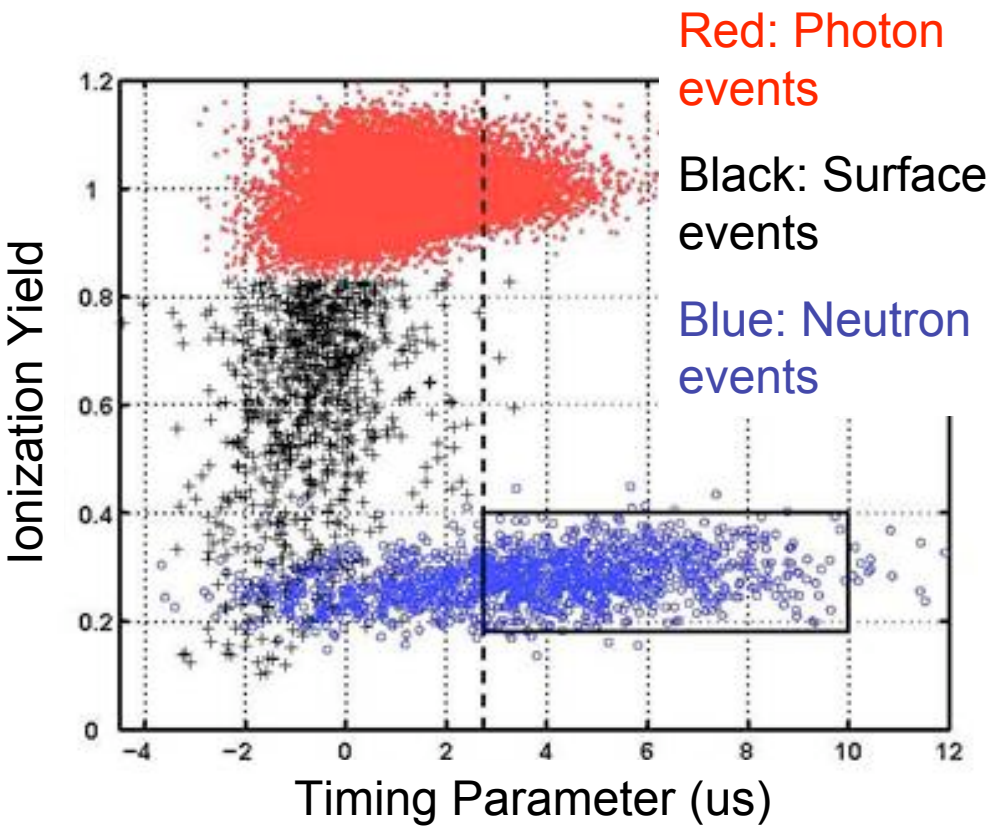




Ionization Yield = Ionization / phonon energy

Better than 10,000 : 1 rejection

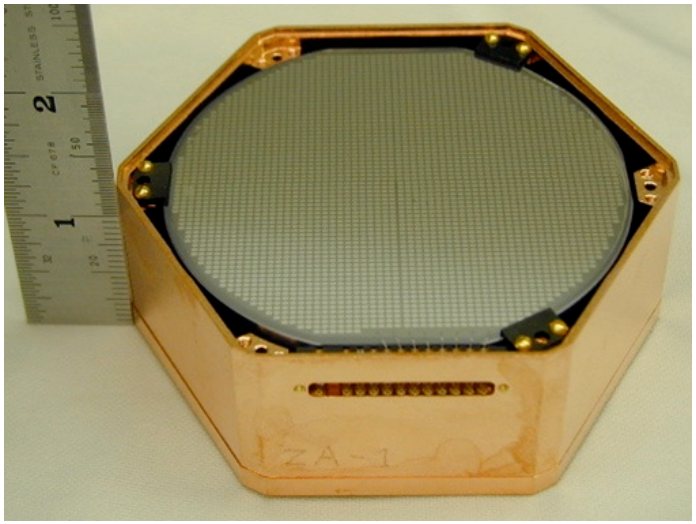
Discriminating Signal from Backgrounds



- Types of Phonons
  - Bulk phonons (diffusive)
  - Recombination (ballistic)
  - Luke
- Gives faster timing parameter profiles for electron recoil events

SuperCDMS – phased approach toward a larger scale experiment

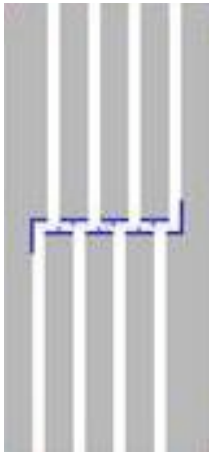
- Improve Discrimination
- Increase Mass



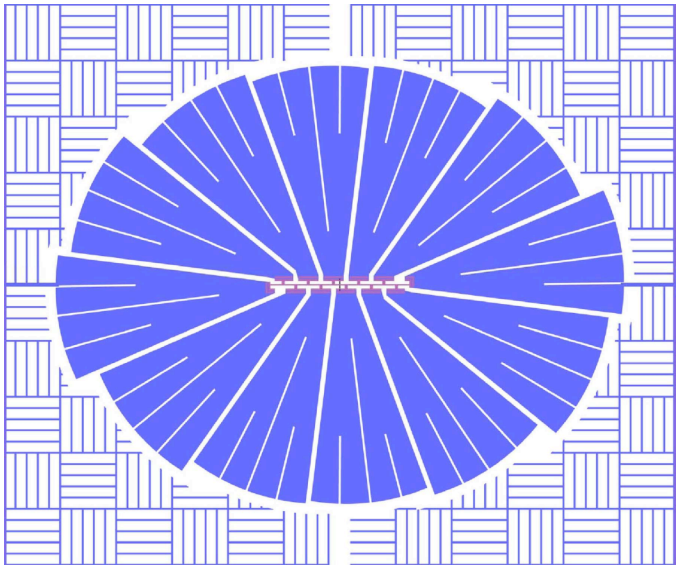
- 25kg baseline design
  - Modified ZIP mask
    - Improve discrimination through phonon timing
  - 1 inch thick detectors
    - Increase mass & improve background rejection
- Larger scale
  - Crystal structure
    - Improve phonon collection
  - Interleaved ZIP
    - Improve discrimination through Ionization readout
  - Ionization readout

SuperCDMS – 25kg modified ZIP

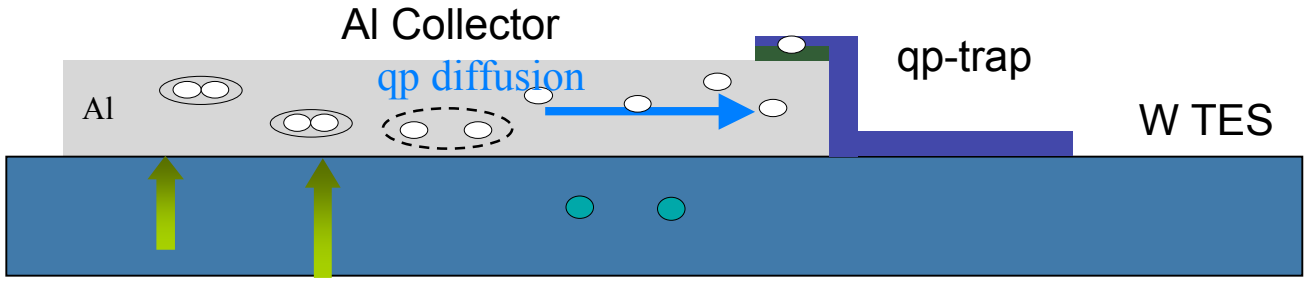
- x2 phonon coverage with the new wafer mask
- Improved risetime discrimination
- decreased passive Al → more phonons collected by active Al



Current ZIP TES

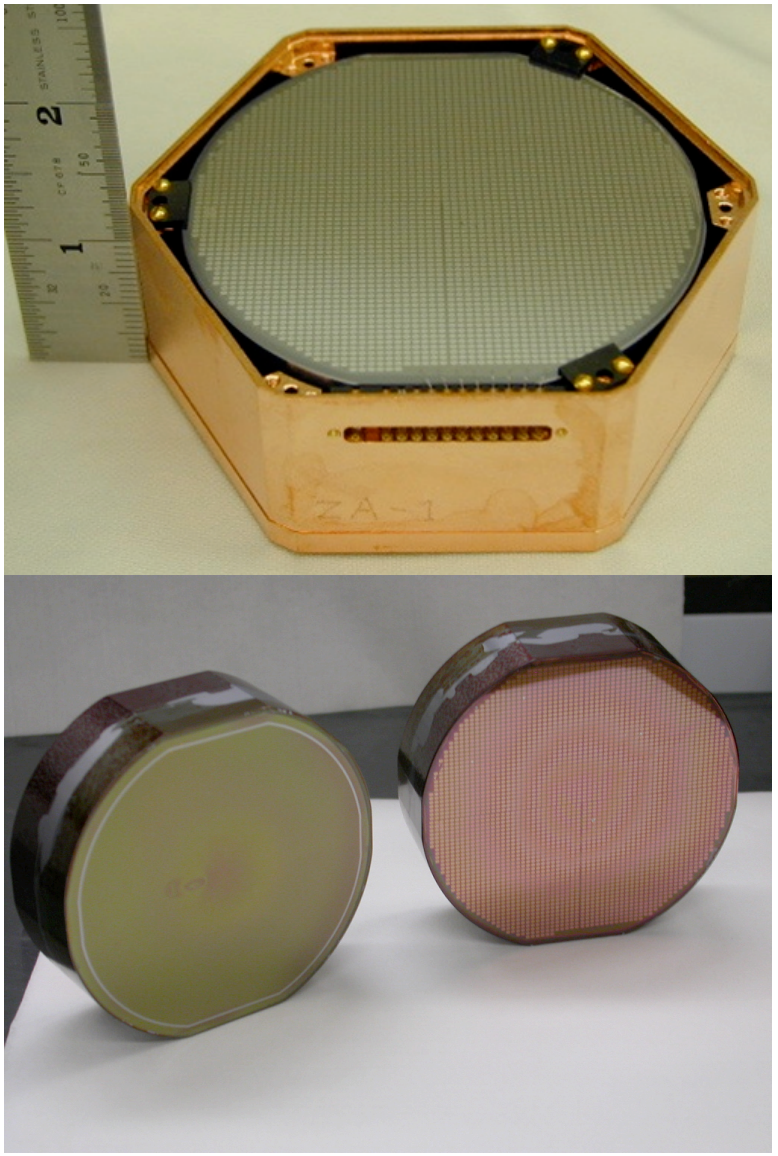


Modified ZIP TES



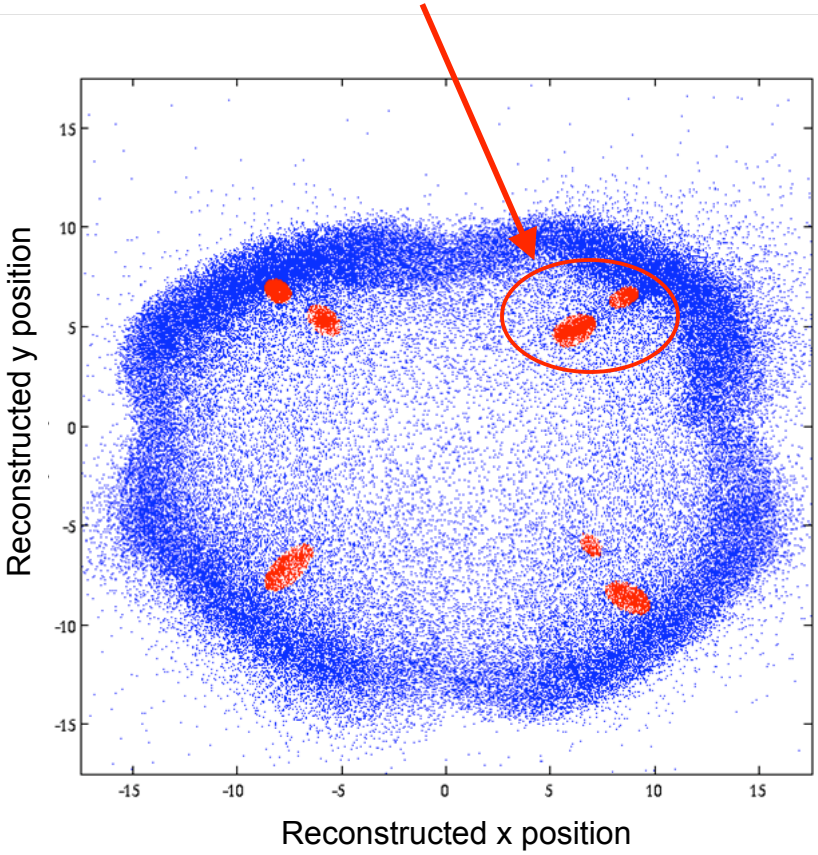
1 inch thick detectors

- Improved background rejection due to larger volume to surface ratio
- x2.5 mass per detector readout channel
- Hydrogen passivation of a-Si

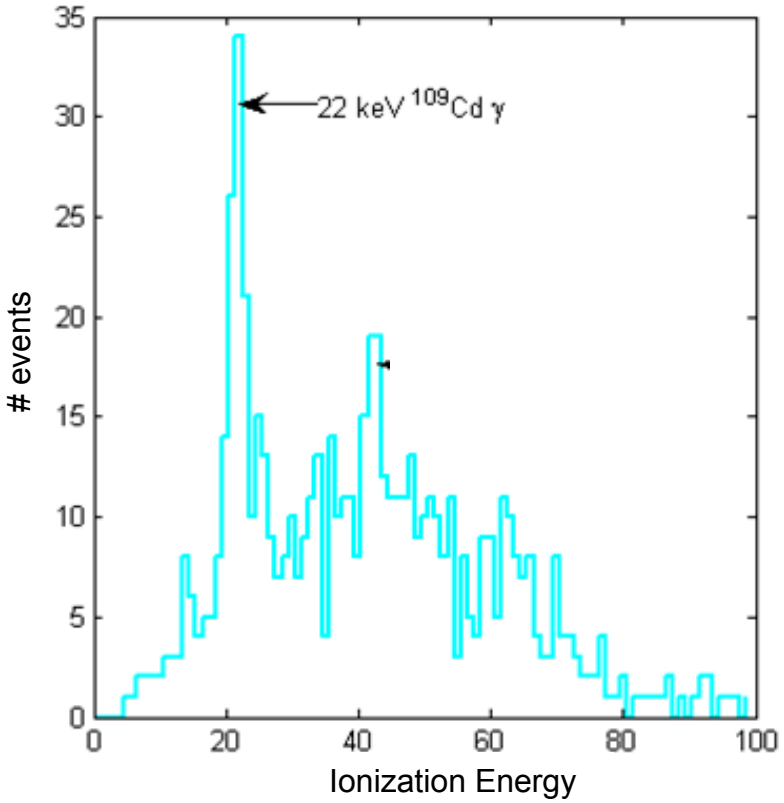


Initial 1inch detector testing

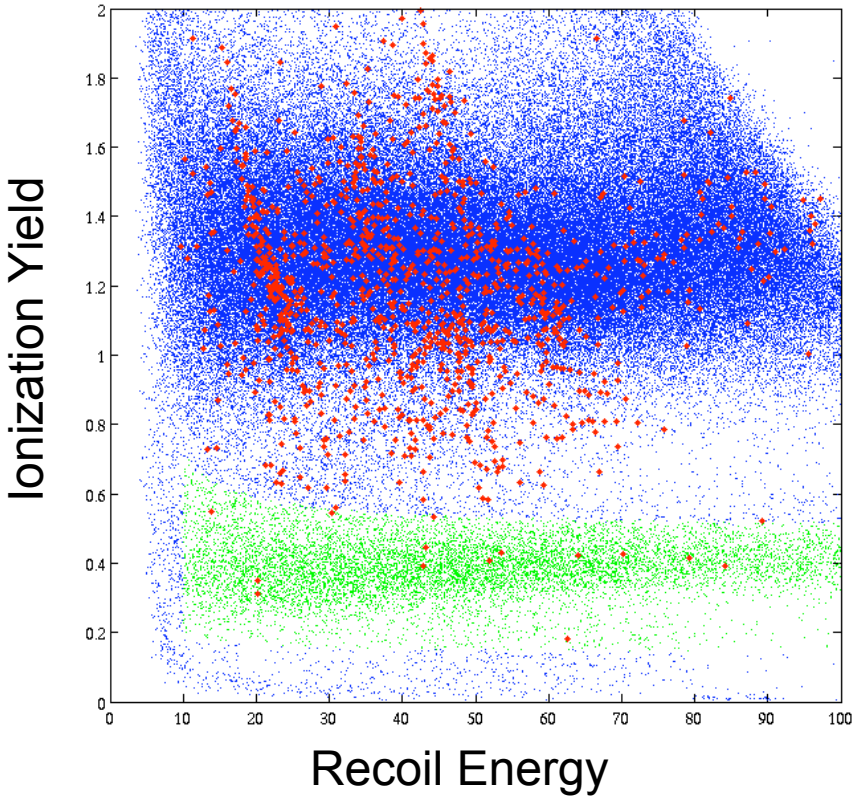
Reconstructed location of ^{109}Cd events



^{109}Cd energy spectrum



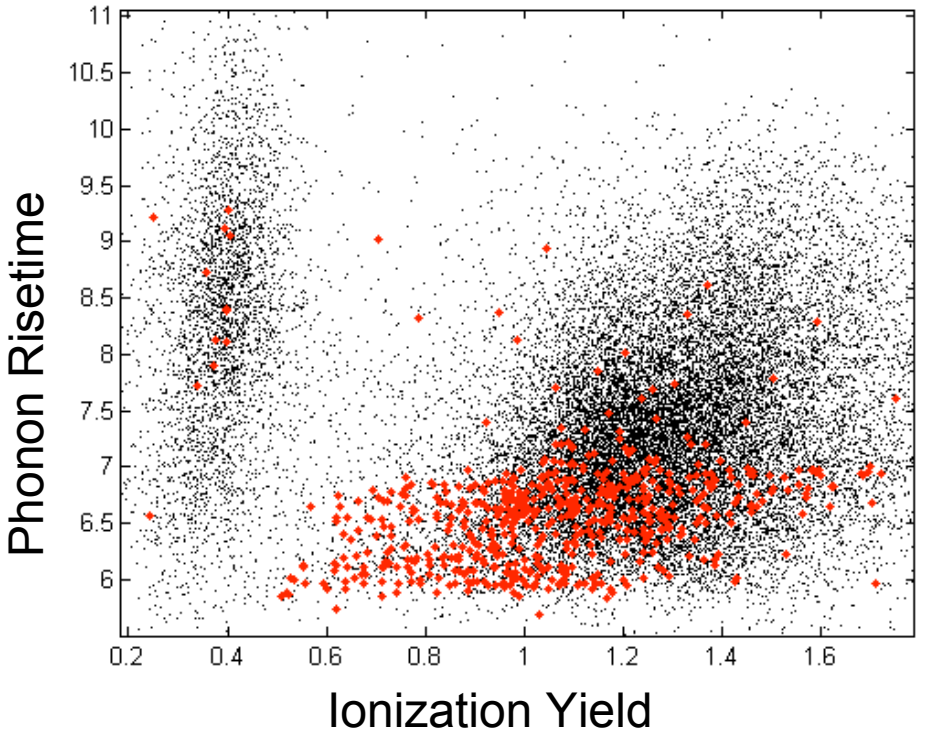
Initial 1inch detector testing



Blue – Photon Events

Red – ^{109}Cd Events

Green – Neutron Events

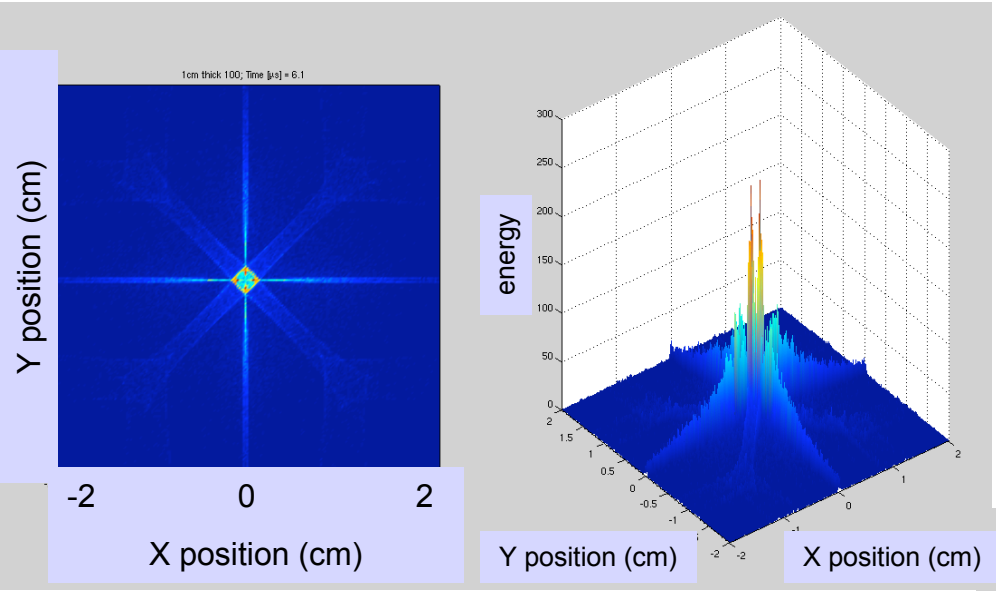


Black – all events

Red – 109Cd Events

111 Crystal

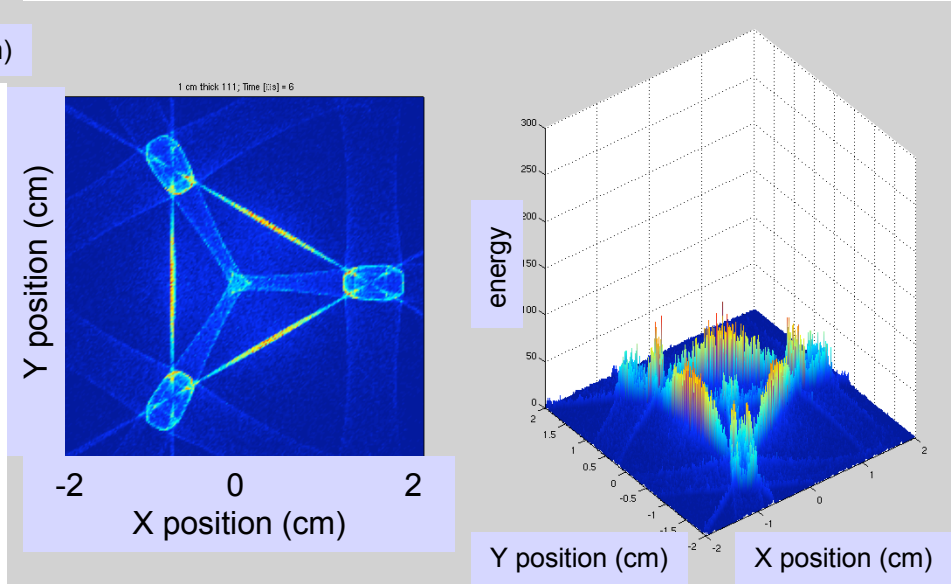
1,0,0 – current crystal orientation



phonons distribute energy more evenly

=> reduce position dependence

1,1,1 – new crystal orientation



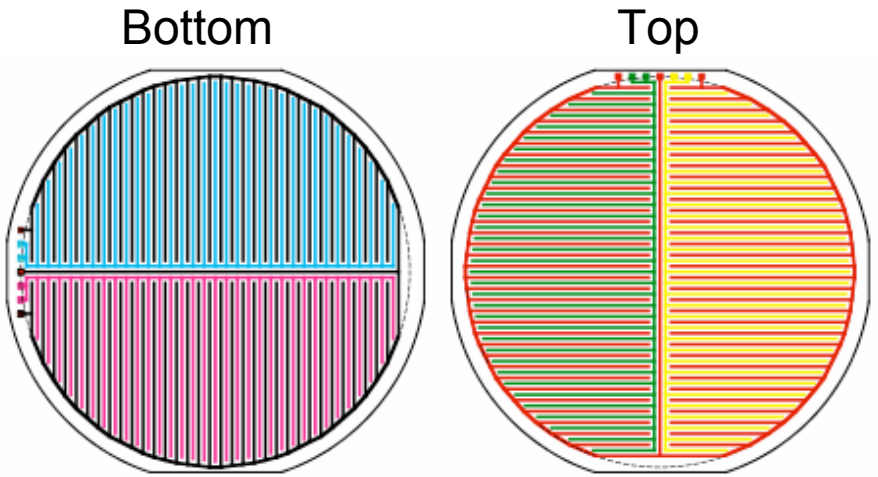
Simulations by

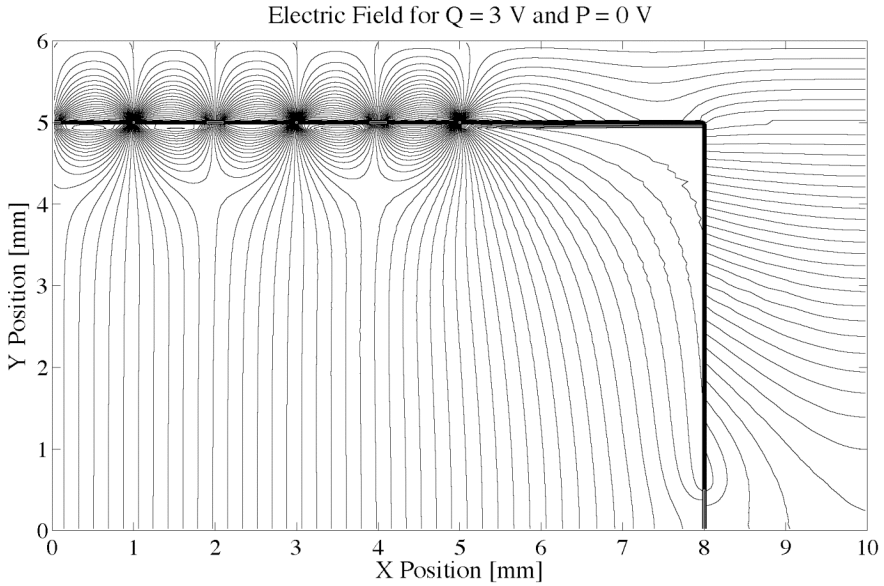
M. Pyle

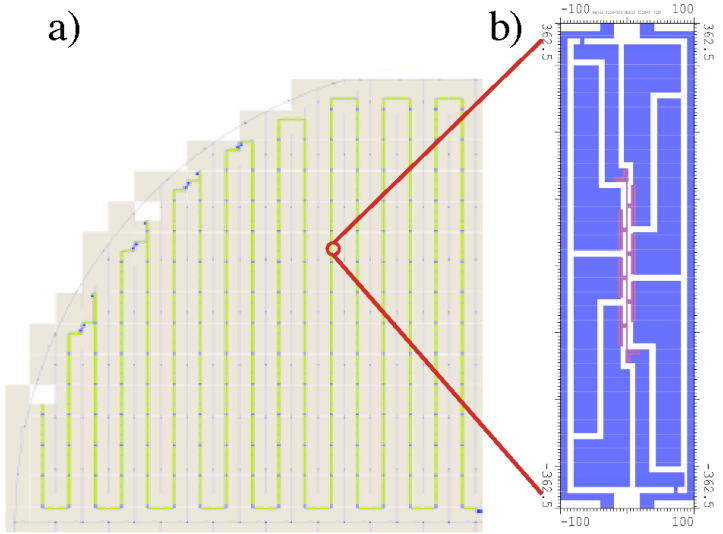
(Stanford University)

SuperCDMS – beyond 25kg interleaved ZIP (iZIP)

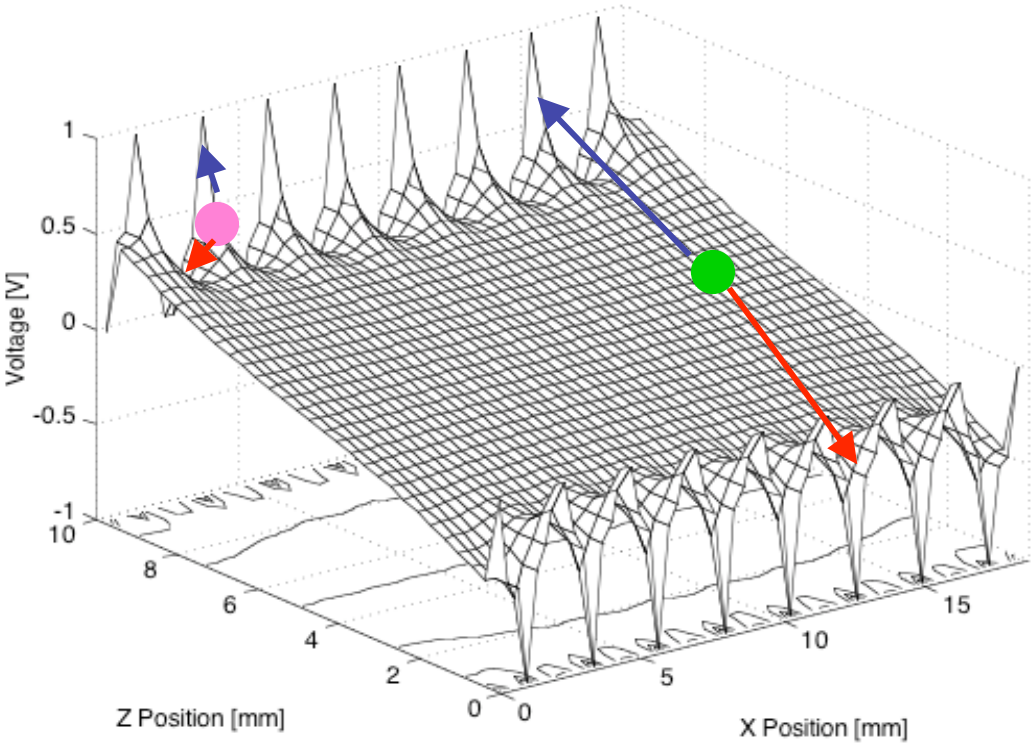
- Surface event discrimination through ionization collection
- Phonon sensors and ionization electrodes interleaved together

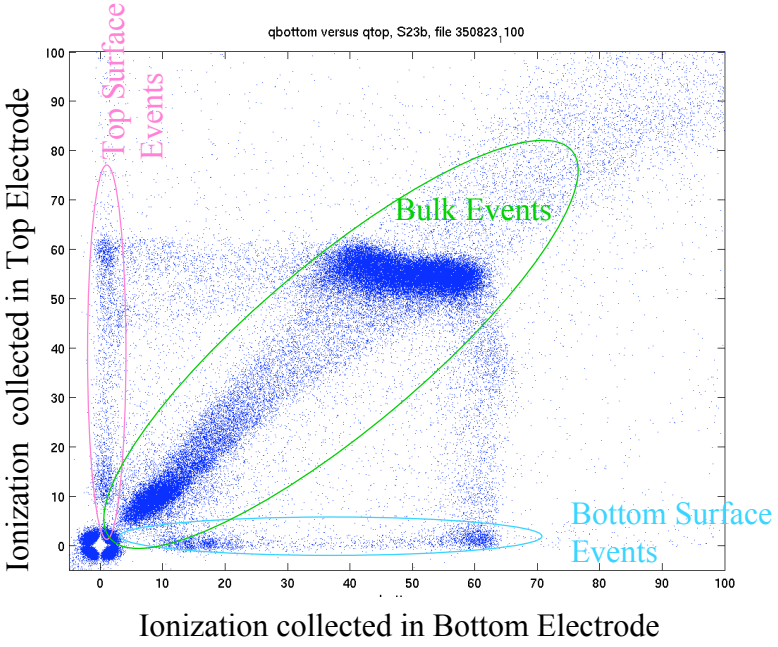


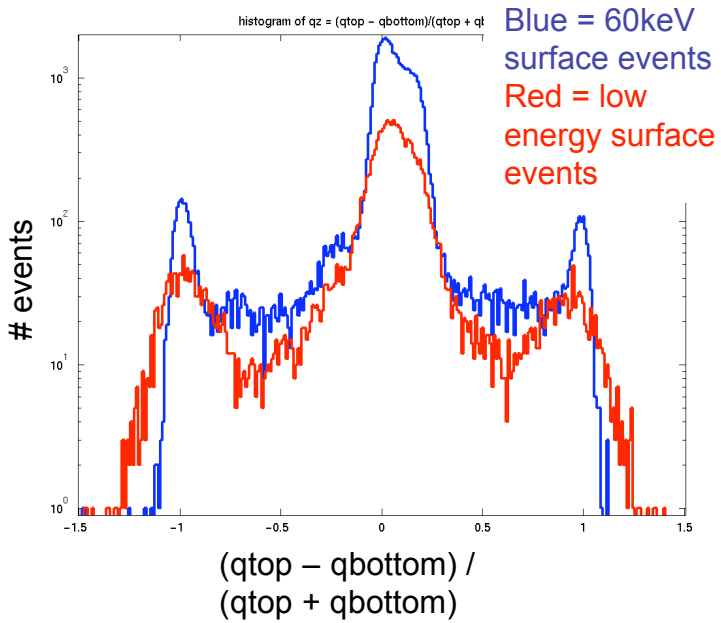




iZIP





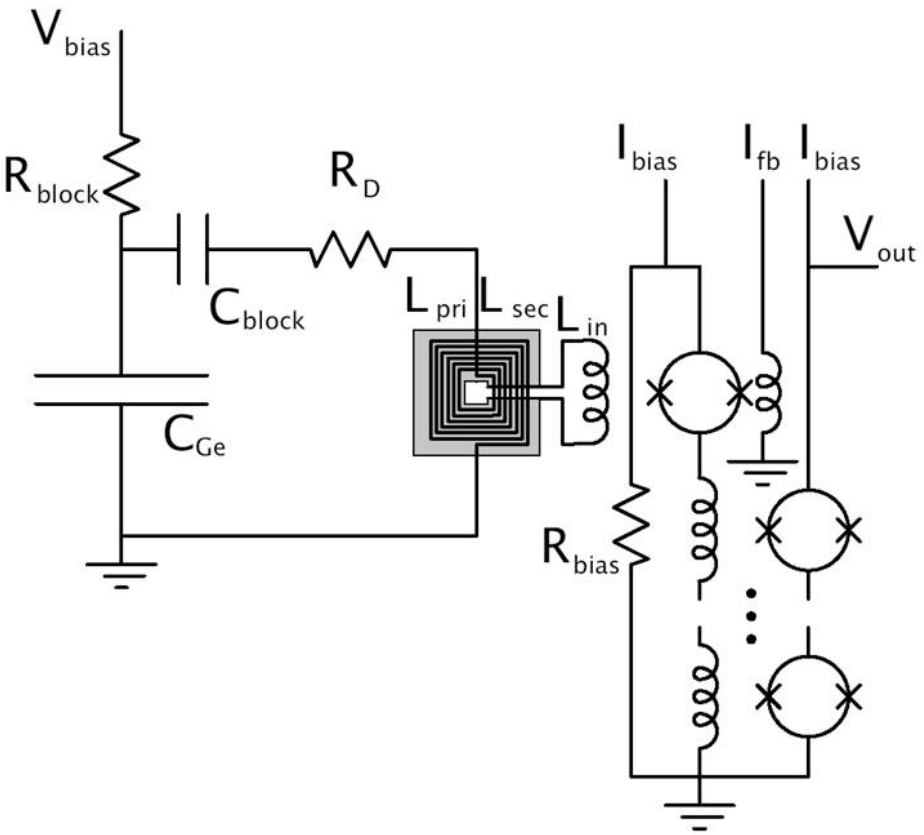


P. Luke, B. Cabrera

(Stanford University)

2-Stage SQUID Ionization readout

- Currently use FET readout
- SQUIDs would
  - significantly reduce heat loads
  - Simplify readout
  - multiplexing



K. Irwin

(NIST)

TESs at work!

- Current generation of detectors produces world's best background discrimination & dark matter results
- Next generation of detectors are being fabricated, tested, and are showing promising results
- Work on longer term scale-up has begun
- Collaboration in Growing Phase

I'd like to acknowledge

the School of Graduate Studies at Case Western Reserve University who helped make this presentation possible through their financial support

the CDMS collaboration for their continued support

The CDMS Collaboration

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