

# Study of the Dead Layer in Ge Detectors for the CDMS Experiment

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# Overview

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- Motivation
- The experimental setup
- The dead layer - Asymmetric performance
- Systematics of a collimated source - Position dependence
- Possible rejection - Risetime

# Motivation

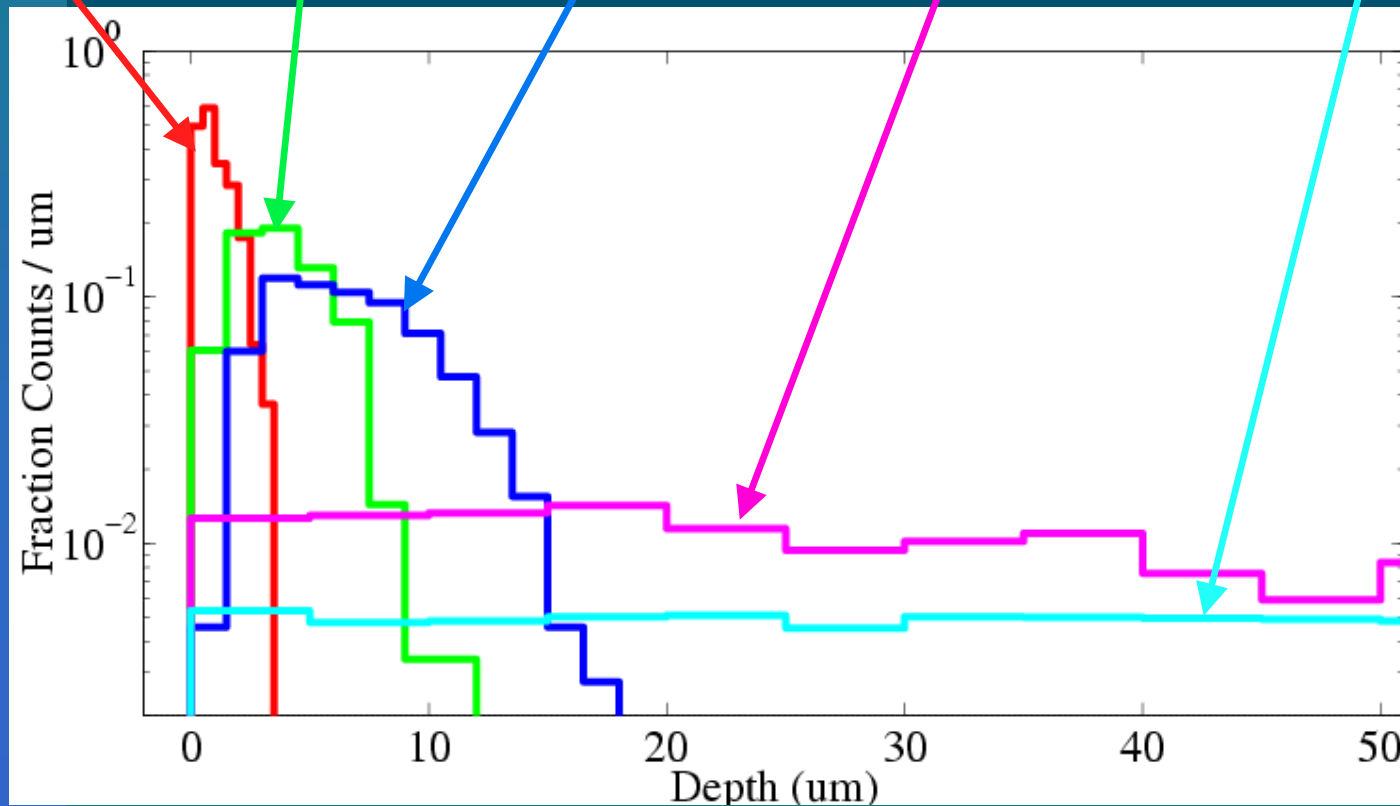


- Detectors that measure the ionization from low energy interactions are known to have a region of poor charge collection
- CDMS uses the ratio of ionization to phonon energy (yield) to discriminate electron recoils from nuclear recoils, thus, events with poor ionization can be misidentified.
- Use a beta calibration source as a way of studying the dead layer

# Using $^{109}\text{Cd}$ electrons & gammas to probe the dead layer



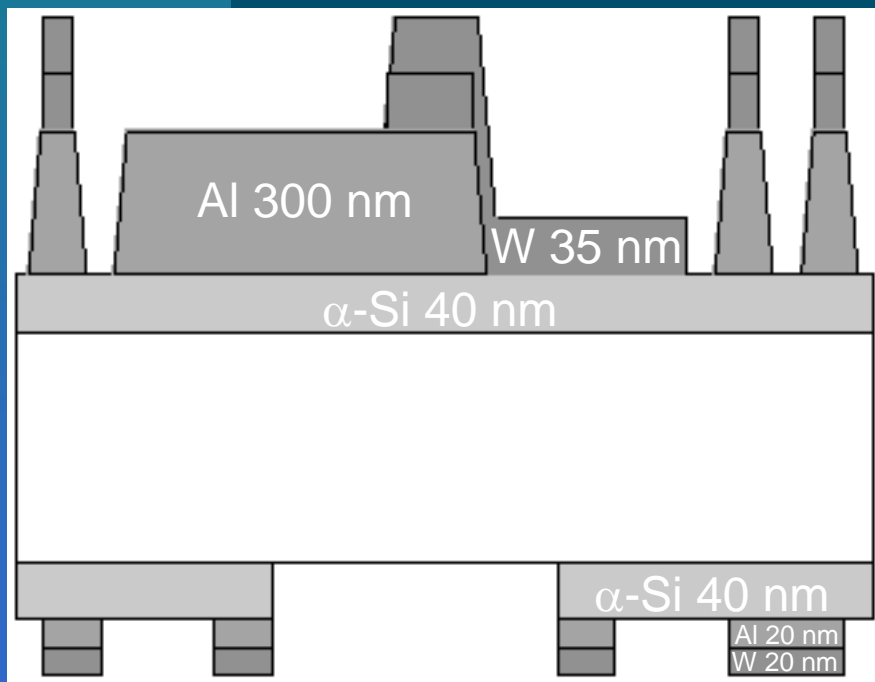
22 keV  $e^-$     63 keV  $e^-$     85 keV  $e^-$     22 keV x-ray    88 keV  $\gamma$



# Experimental Setup - the detector



Phonon side

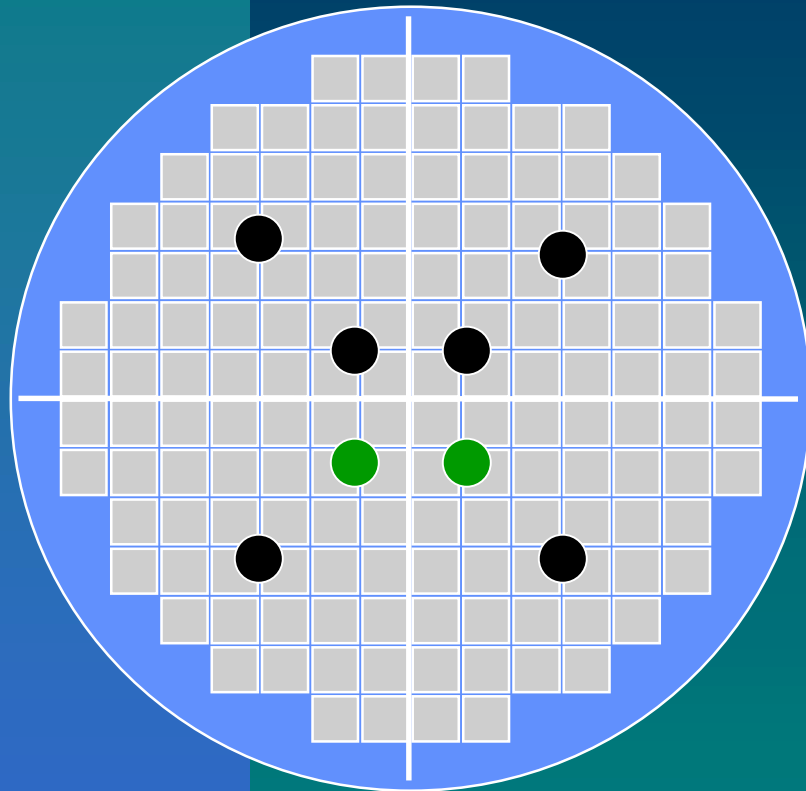


Charge side

- Amorphous Si is patterned on both sides. This reduces the thickness of the dead layer
- Phonon sensors and electrode thickness make the detector asymmetric



# Experimental Setup - the $^{109}\text{Cd}$ source



- 8 collimated holes
- 2 holes (green) covered with Al tape to stop the electrons to stop the electrons

Electrons	$\gamma$ / x-rays
18-22 keV (20%)	22 keV (84%)
63 keV (41%)	25 keV (16%)
85 keV (45%)	88 keV (4%)
87 keV (9%)	

Backscattering of electrons from radioactive source substrate & detector surface also creates sub-dominant continuum of electron events

# Experimental Setup - Run configurations



- Varied position of  $^{109}\text{Cd}$  (charge side vs phonon side)
- Varied charge bias ( $\pm 3\text{ V}$   $\pm 6\text{ V}$ )
- Data from 3 different sources
  - external  $^{252}\text{Cf}$  (neutrons) and  $^{109}\text{Cd}$
  - an external  $^{60}\text{Co}$  (gammas) and  $^{109}\text{Cd}$
  - $^{109}\text{Cd}$  only



# Preliminary

QuickTime™ and a  
Photo - JPEG decompressor  
are needed to see this picture.



# Modeling the Dead Layer



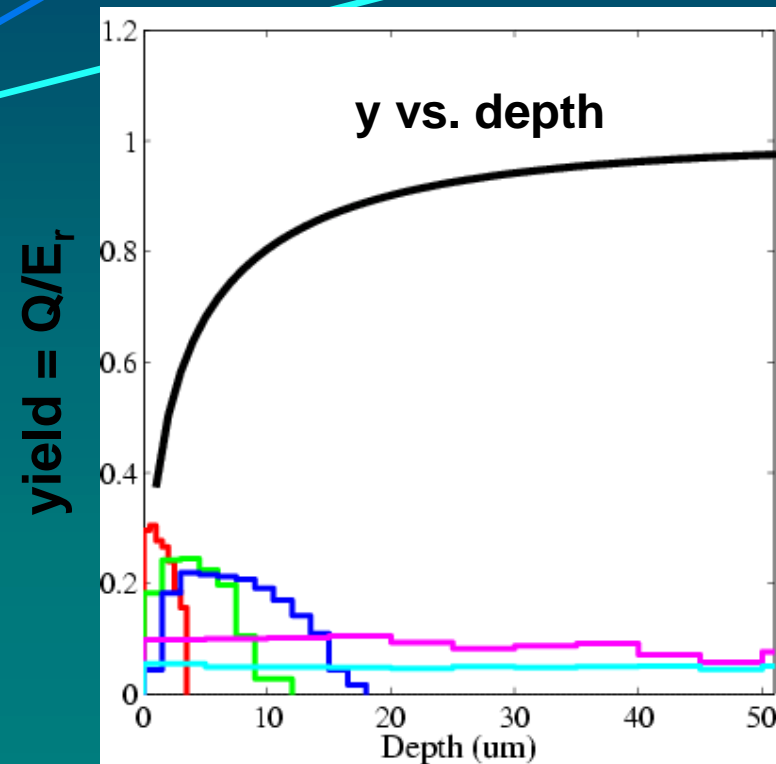
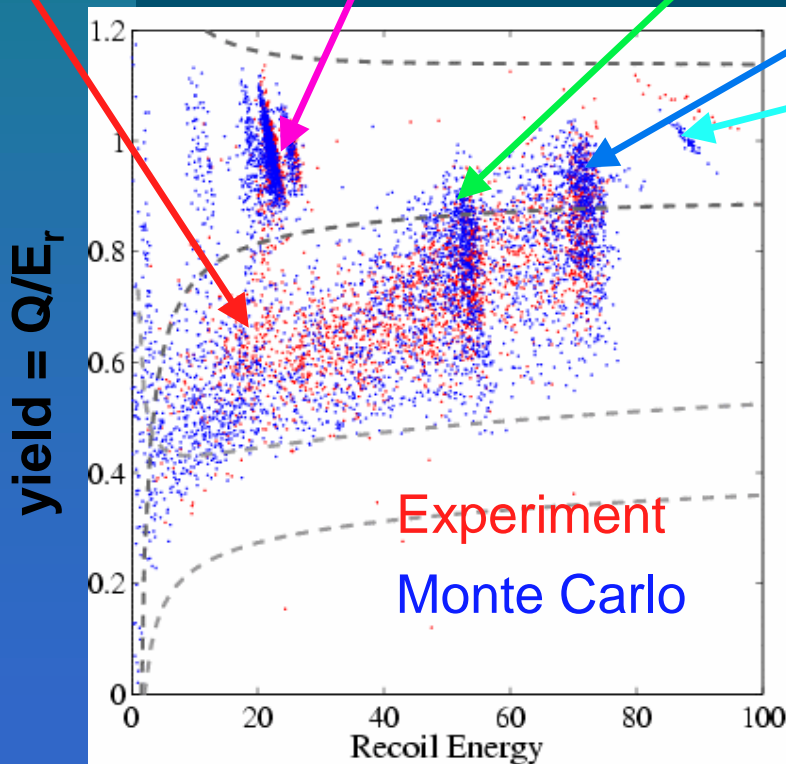
22 keV e<sup>-</sup>

22 keV x-ray

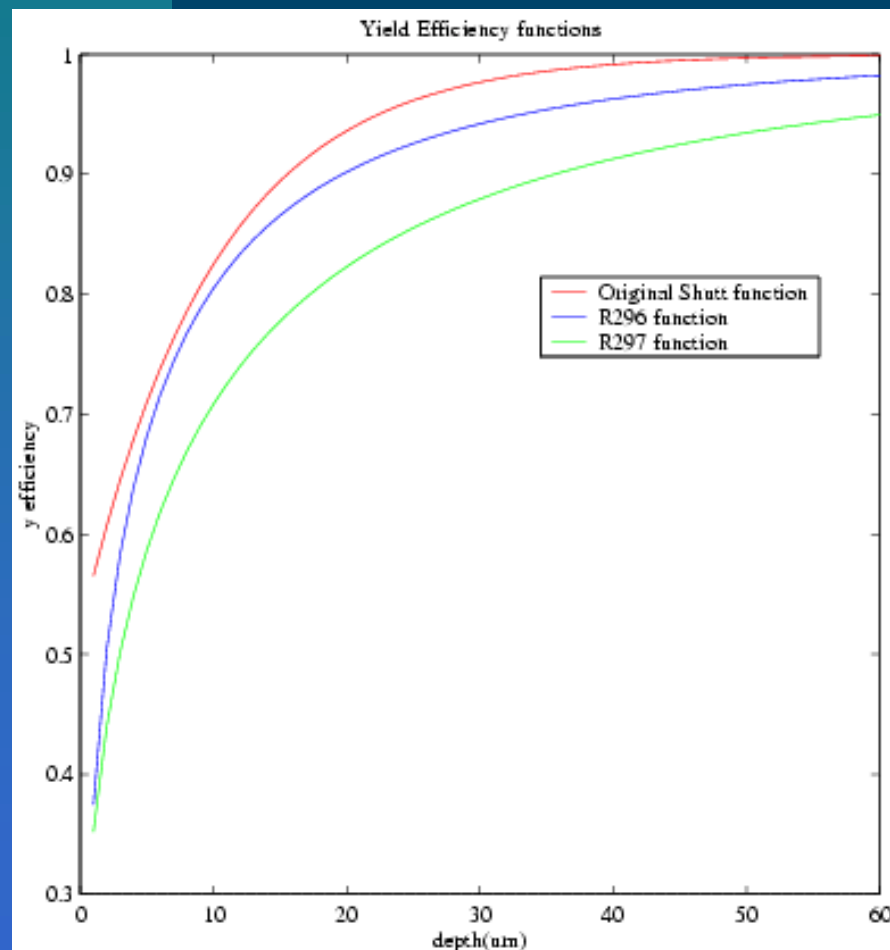
63 keV e<sup>-</sup>

85 keV e<sup>-</sup>

88 keV  $\gamma$

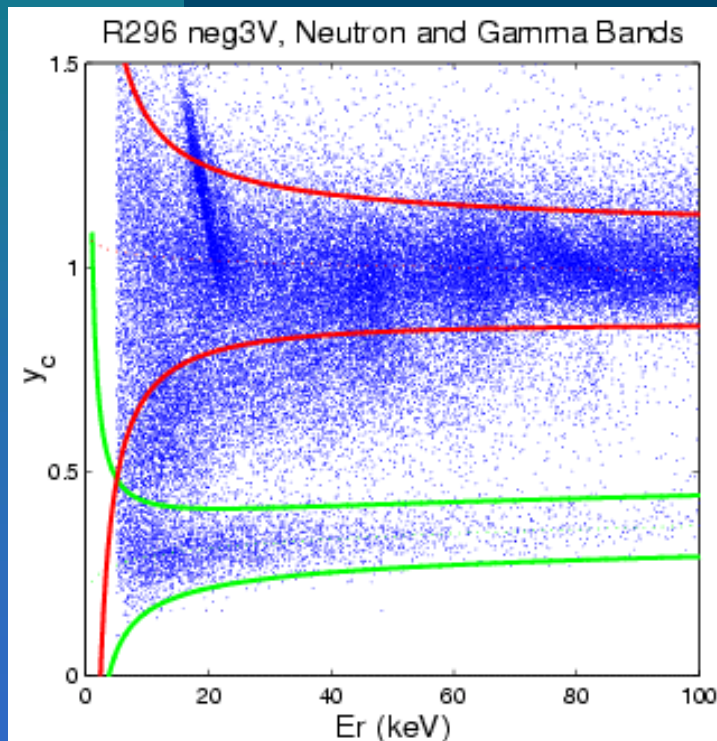


# The Dead Layer - Monte Carlo Studies

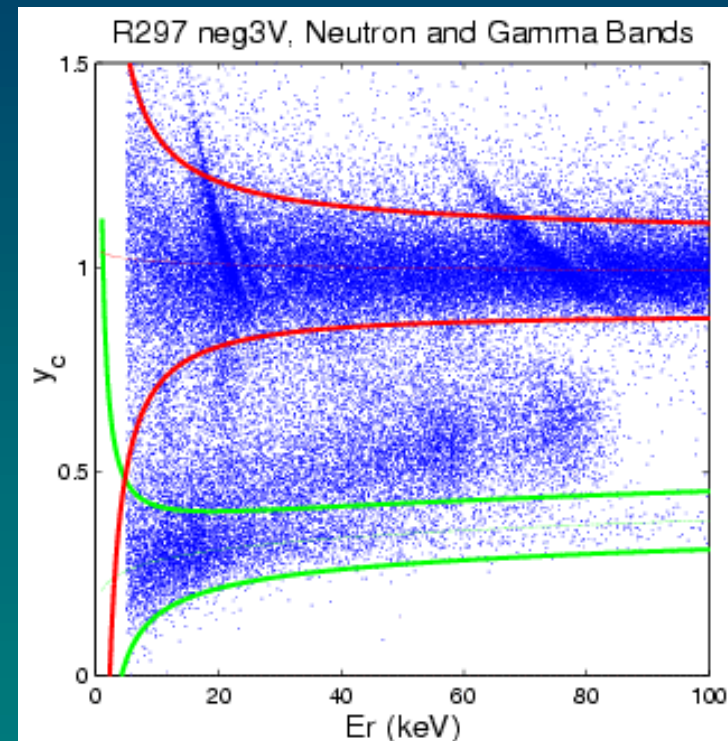


Extracted yield vs. depth relations. The charge collection is worse for events on the phonon side

# The Dead Layer - Betas



Source on Charge side



Source on Phonon side

# Systematics of Collimation - Position Dependence



- We want to determine the properties of the dead layer over the entire detector surface
- Problem - the detector (phonon) response varies over the surface

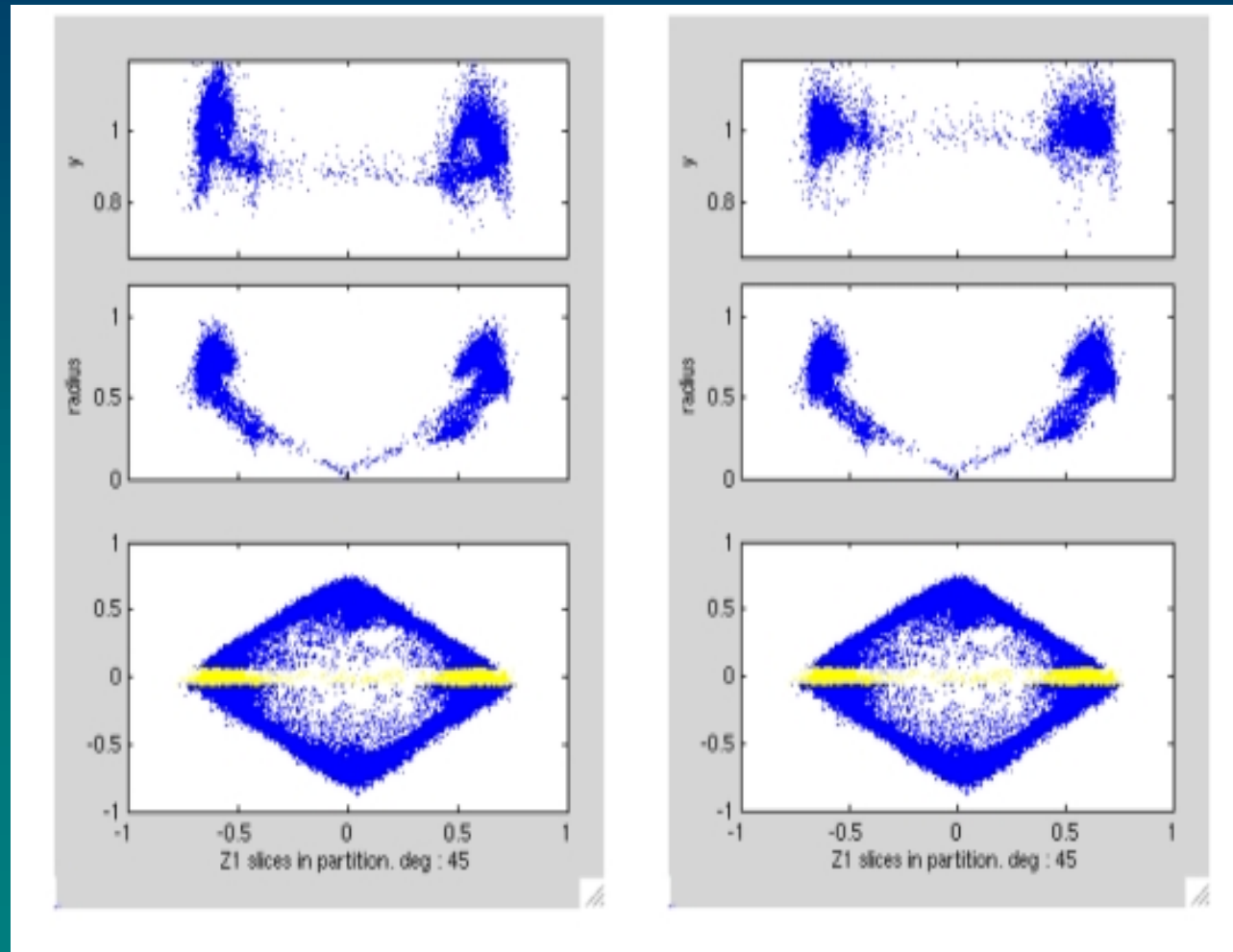
# Constructing a New Position Parameter



- The Event position can be uniquely reconstructed from a combination of delay and energy partition
- The fold back of the delay and partition is clear
- The position dependence of  $Y$  is also clear

QuickTime™ and a Video decompressor are needed to see this picture.

# Position Correction - Removing the dependence of Y



Uncorrected

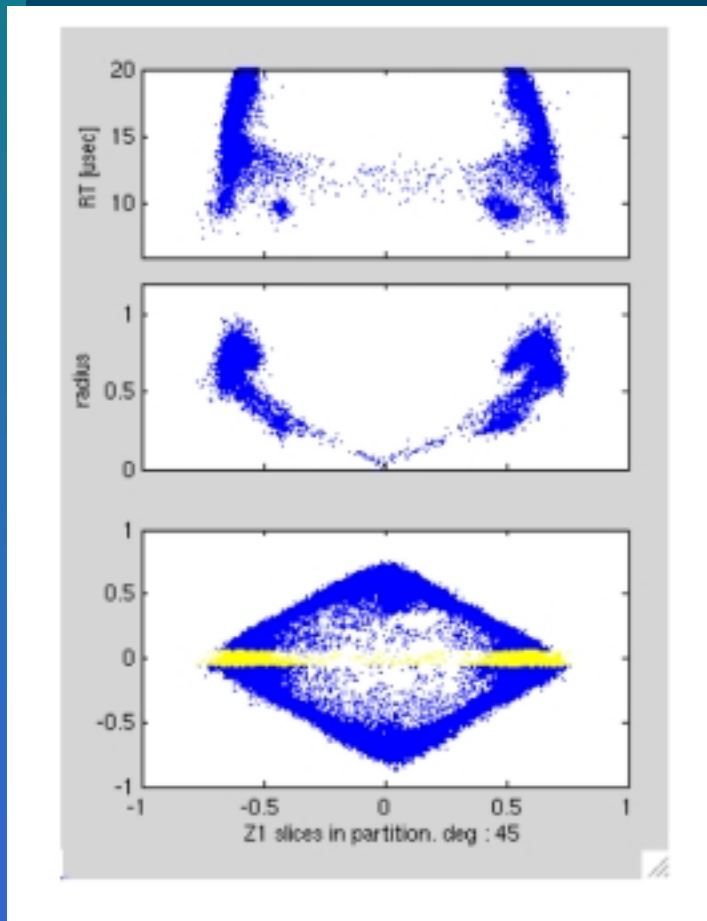
Corrected

# Position Correction - Removing the dependence of $Y$



- Correction is pretty good at removing the position dependence
- Should be able to do better

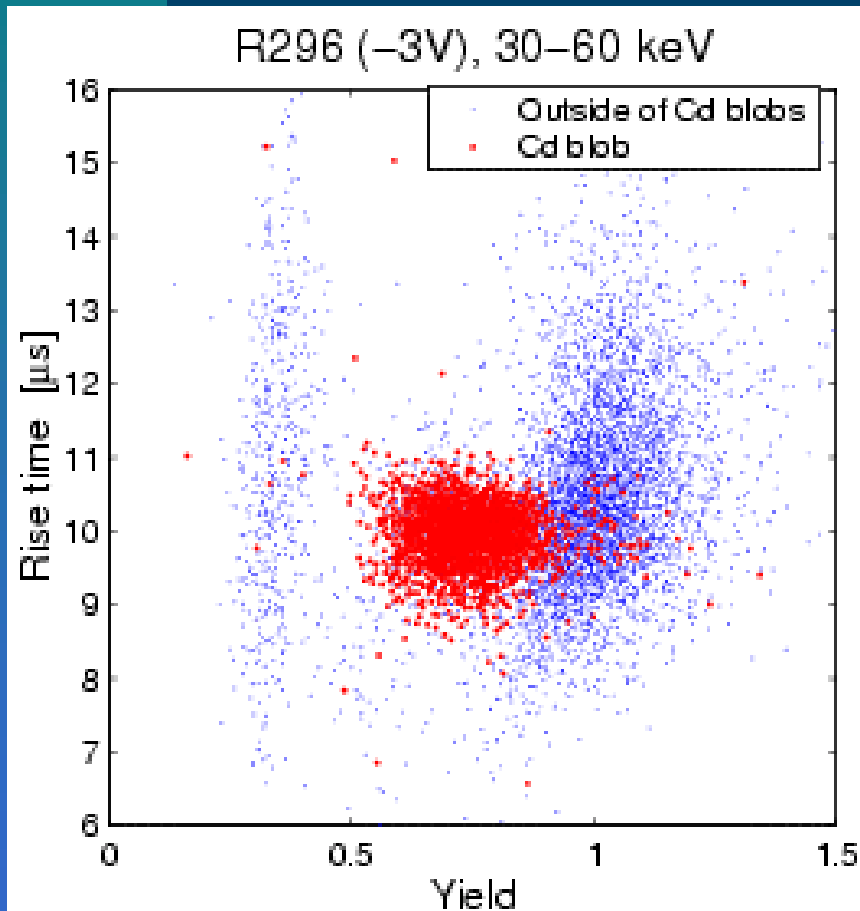
# Risetime - correction and discrimination



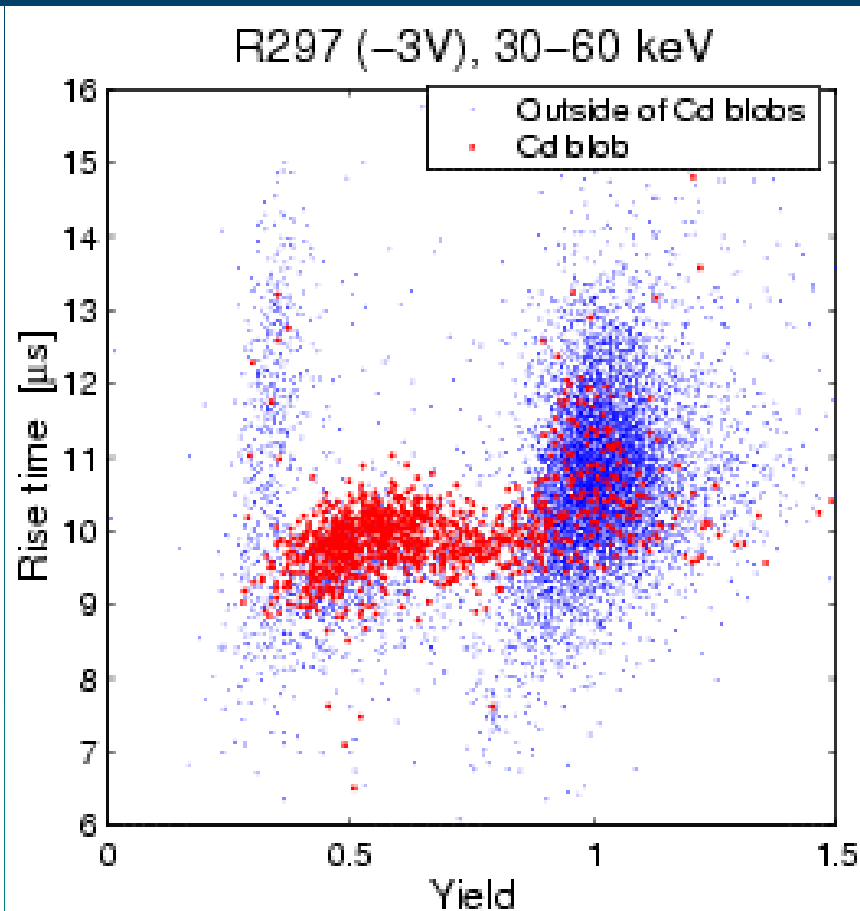
- The risetime is also dependent on position
- The dependence looks like it can be corrected by the same algorithm used for Y
- It looks like the risetime provides additional discrimination for betas



# Risetime Discrimination - preliminary



Charge side



Phonon side

# Conclusions



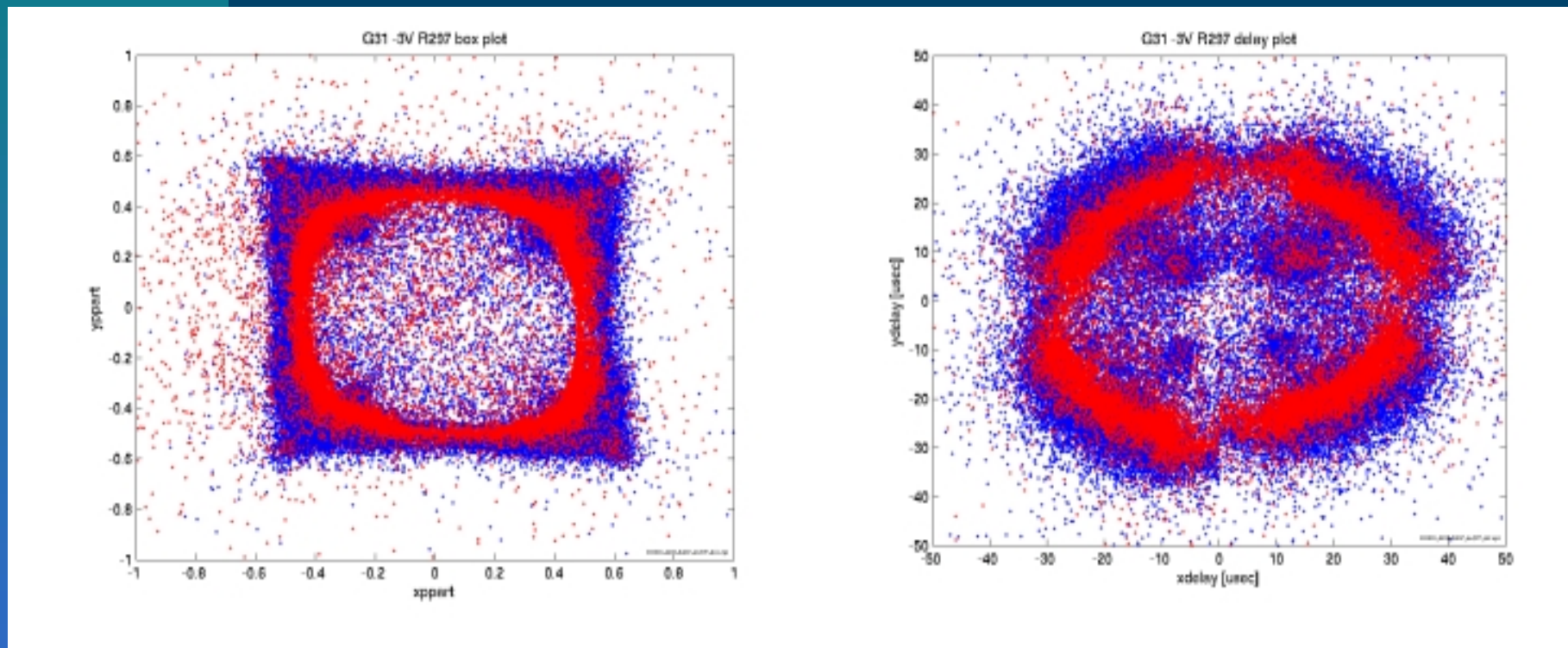
- A collimated  $^{109}\text{Cd}$  source provides good data for the study of the dead layer
- The dead layer for CDMS ZIP detectors appears to be asymmetric
- An algorithm has been developed that makes it possible to globalize the response of the detector to a collimated source
- Risetime looks like a promising parameter for rejecting of dead layer events



# Pesky Questions

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# Event Position Reconstruction



- Red Events correspond to events in the outer electrode
- Each of the two position parameters are double valued

# Accounting for Position Dependence - the Algorithm



- Need a large gamma calibration
- Form a lookup table from the calibration
  - For each event in the calibration, we take the average “Y” from N nearest neighbors. The average becomes the correction value associated with the event’s “coordinate”
  - Note : this algorithm is independent of binning and naturally accounts for non-uniform (non-linear) distribution of the events in our position parameter.
- Correct data by using correction values of closest “coordinate” in the table

# Risetime movies for both sides



QuickTime™ and a Video decompressor are needed to see this picture.

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Phonon Side

Charge Side

# Movies of Y

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Charge  
side

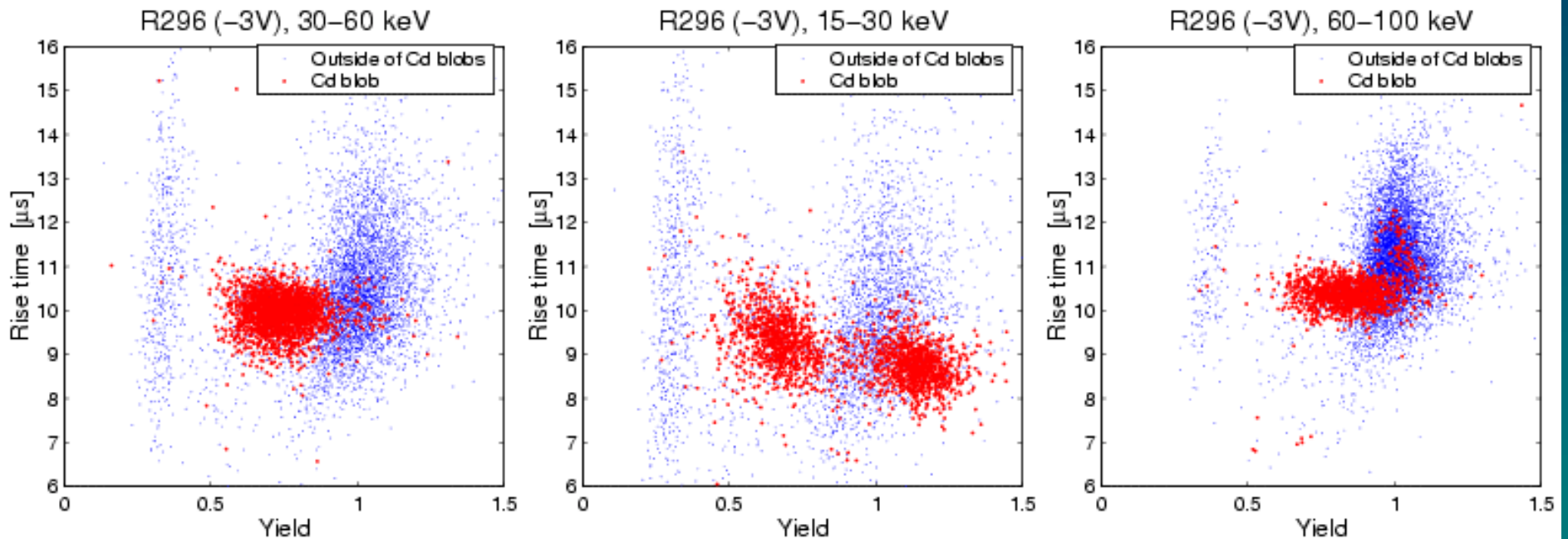
Phonon  
Side

QuickTime™ and a Video decompressor are needed to see this picture.

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# RT vs Y plots for R296



# RT vs Y plots for R297

