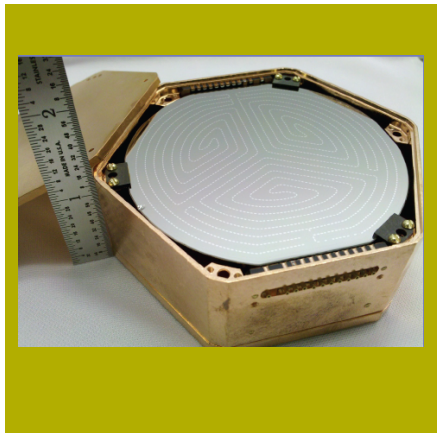
Direct Dark Matter search

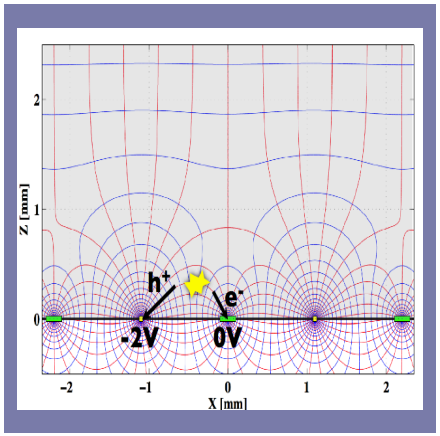
iZIP detector design

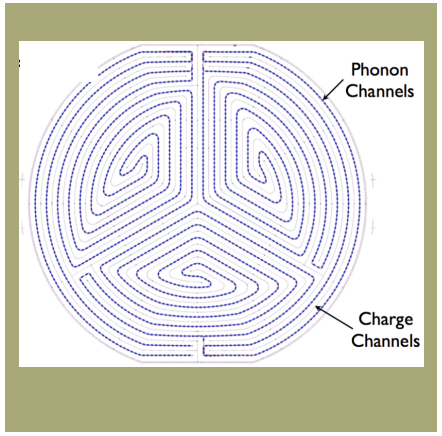
Background Rejection Power (ER/NR, NR/SE)

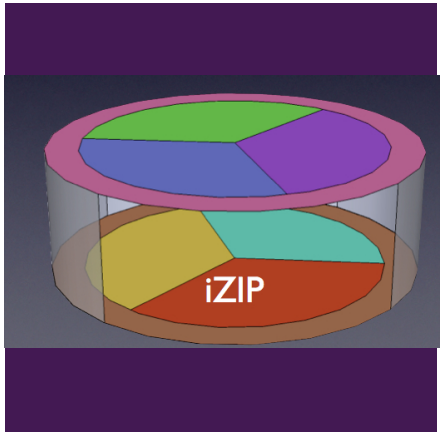
- via Charge signal
- via Phonon signal

Conclusion/Outlook









Background rejection with the SuperCDMS iZIP detector

Silvia Scorza
Southern Methodist Univeristy
SuperCDMS Collaboration

+ SuperCDMS Collaboration

California Institute of Technology
Z. Ahmed, B. Doughthery, J. Filippini, S.R. Golwala, D. Moore, R. Nelson, R.W. Ogburn

Fermi National Accelerator Laboratory
D. A. Bauer, F. DeJongh, J. Hall, S. Hansen, D. Holmgren, L. Hsu, R.L. Schmitt, R. B. Thakur, J. Yoo

Massachusetts Institute of Technology
A. Anderson, E. Figueroa-Feliciano, S. Hertel, S.W. Leman, K.A. McCarthy, P. Wikus

NIST
K. Irwin

Queen's University
C.H. Crewdson, P. Di Stefano, J. Fox , O. Kamaev, S. Liu , C. Martinez, P. Nadeau, K. Page, W. Rau, Y. Ricci, M.A. Verdier

Santa Clara University
B. A. Young

Southern Methodist University
J. Cooley, B. Karabuga, H. Qiu, S. Scorza

SLAC/KIPAC
M. Asai, A. Borgland, D. Brandt, P.L. Brink, W. Craddock, E. do Couto e Silva, G.G. Godfrey, J. Hasi, M. Kelsey, C. J. Kenney, P. C. Kim, R. Partridge, R. Resch, D. Wright

Stanford University
B. Cabrera, M. Cherry , R. Moffatt, L. Novak, M. Pyle, M. Razeti, B. Shank, A. Tomada, S. Yellin, J. Yen

Syracuse University
M. Kos, M. Kiveni, R. W. Schnee

Texas A&M
R. Harris, A. Jastram, K. Koch, R. Mahapatra, M. Platt , K. Prasad, J. Sander

University of California, Berkeley
M. Daal, T. Doughty, N. Mirabolfathi, A. Phipps, B. Sadoulet, D. Seitz, B. Serfass, D. Speller, K.M. Sundqvist

University of California, Santa Barbara
R. Bunker, D.O. Caldwell, H. Nelson

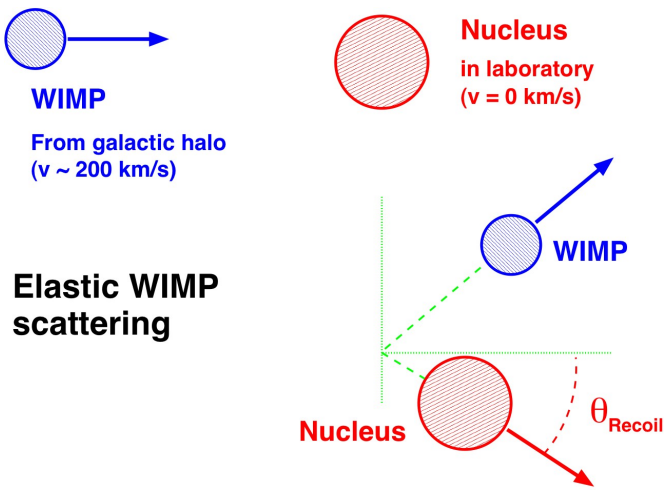
University of Colorado Denver
B.A. Hines, M.E. Huber

University of Florida
D. Balakishiyeva, T. Saab, B. Welliver

University of Minnesota
J. Beaty, H. Chagani, P. Cushman, S. Fallows, M. Fritts, T.Hoffer, V. Mandic, X. Qiu, R. Radpour, A. Reisetter, A. Villano, J. Zhang

Direct Detection of WIMPs

(Weakly Interacting Massive Particles)



- Recoil Energy ~ 10s of keV
- Interaction Rate < 1ev/kg/y
- Background Discrimination
  - α , β , γ
  - Neutrons
  - μ - induced events

Challenges

- Large Detector Mass
- Low Energy Threshold
- Excellent Resolutions
- Low radioactivity
- Powerful Rejection
- Background knowledge

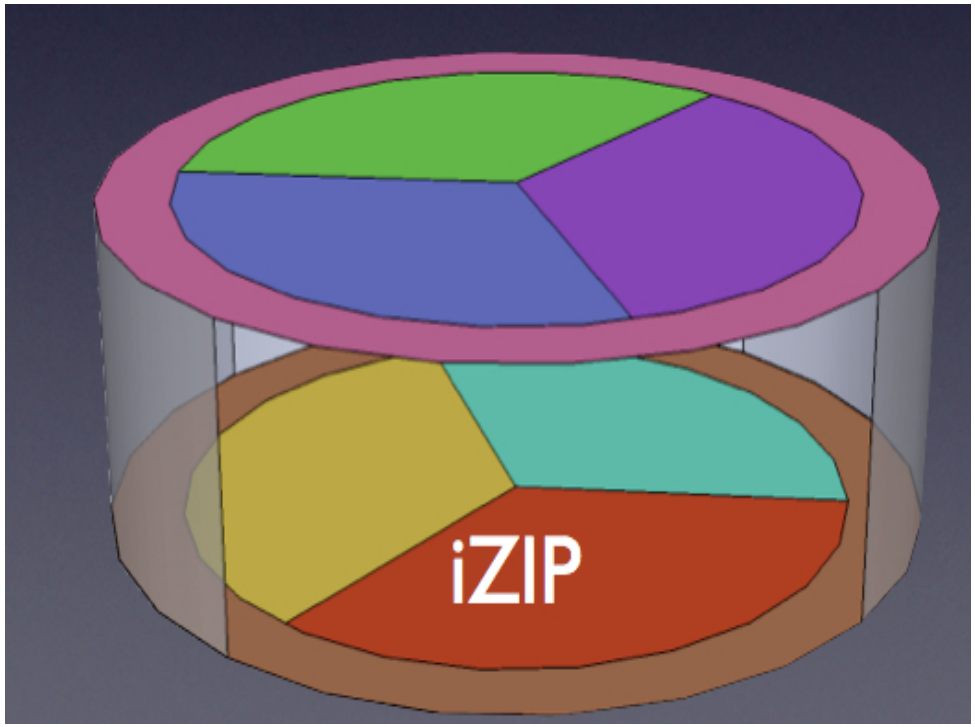
iZIP detector design - I

(interleaved Z-measuring Ionization and Phonon)

New Layout Phonon Sensors

Three inner phonon channels and one outer phonon "ring" channel to provide better radius determination in the phonon signal.

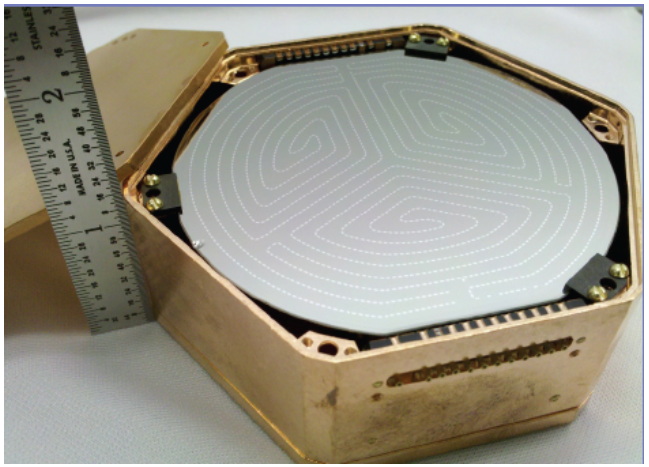
Bottom channels are rotated 60 degrees from top channels

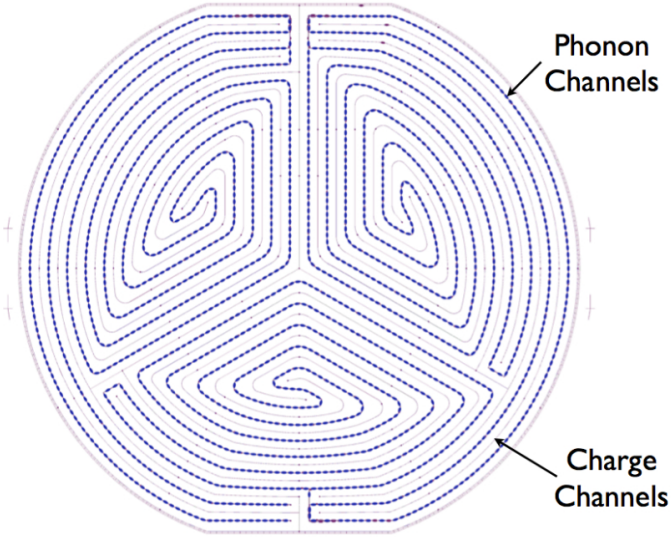


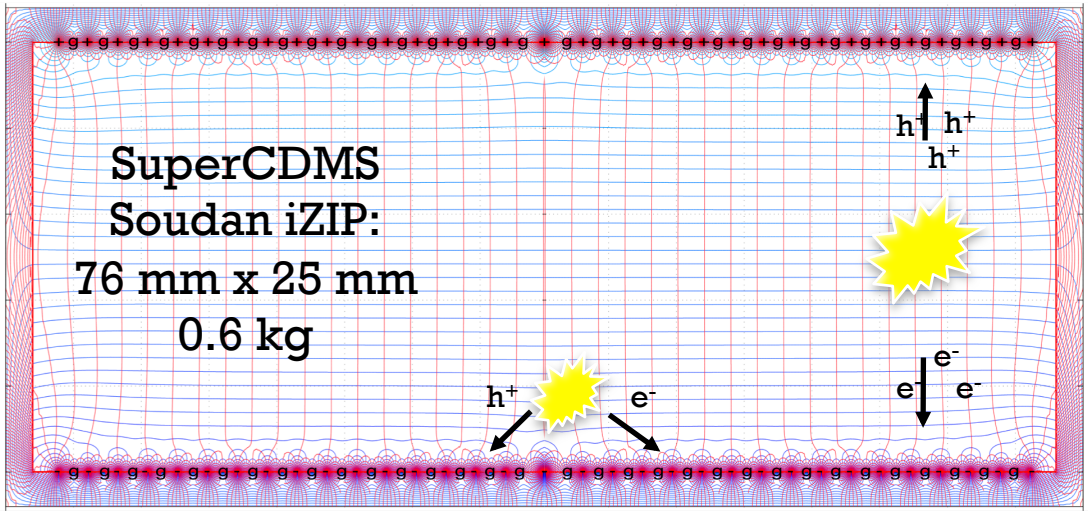
iZIP detector design - II

Electrode Scheme

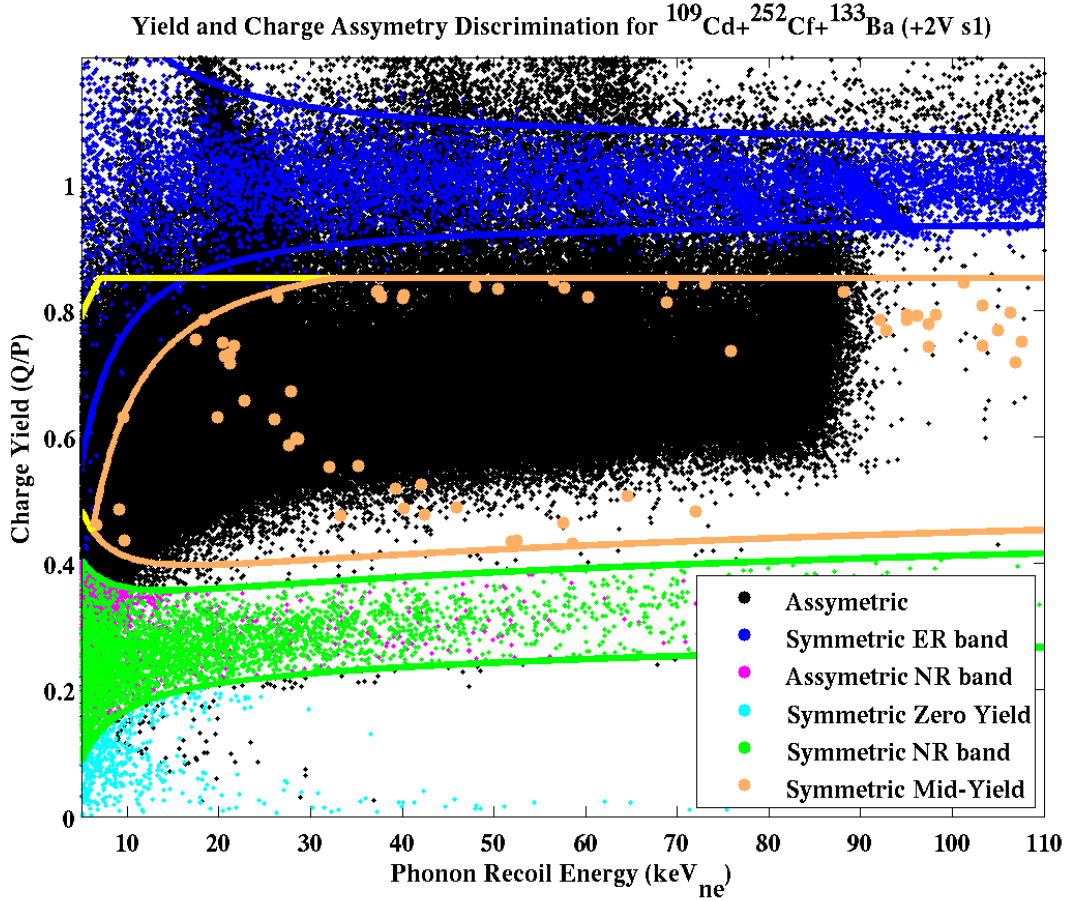
- NEW interleaved layout of ionization and phonon sensors
- We now have phonon sensors and ionization sensors on BOTH the top and bottom of the detector
- Major improvements in discrimination from this new technology



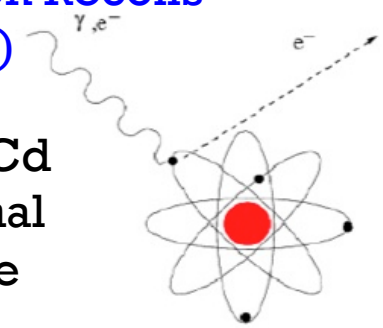




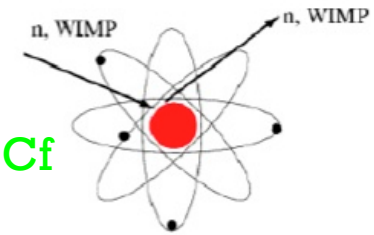
+ Primary Background (γ) Rejection



Electron Recoils (133Ba)



β ^{109}Cd Internal source



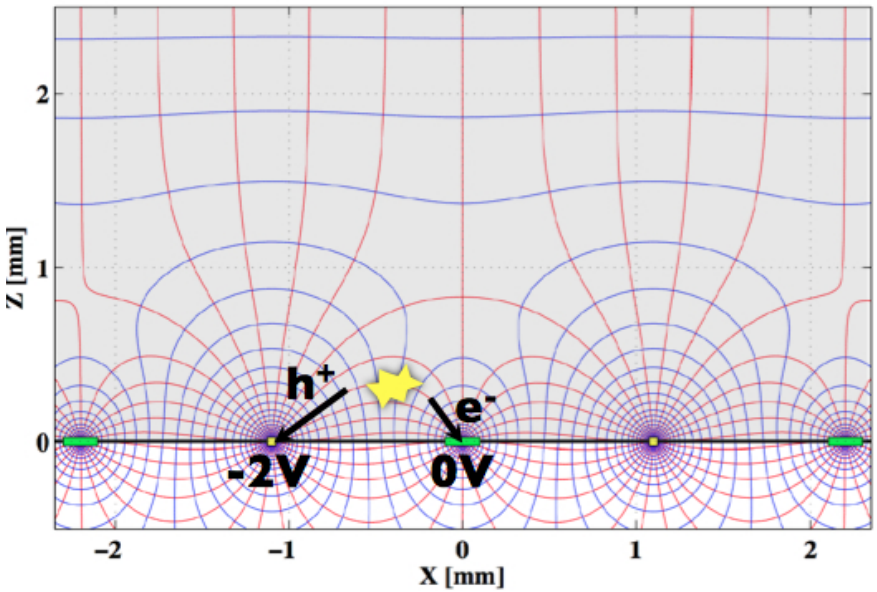
Nuclear Recoils (252Cf source (external) + **7evt/hr background)**

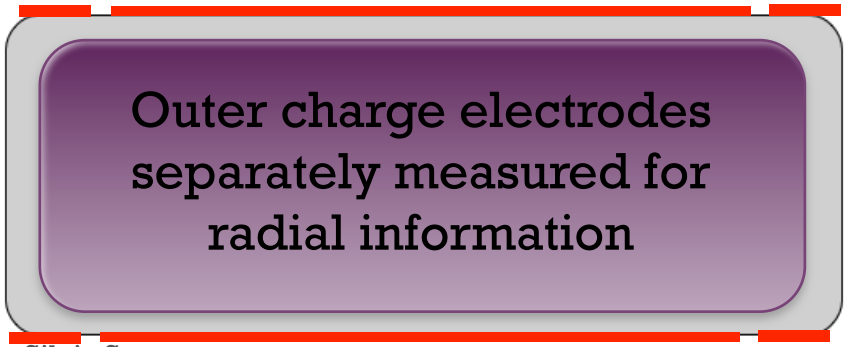
- Radioactive source data defines the signal (NR) and background (ER)
- The simultaneous measurement of phonon and charge signals allows an event by event identification by Yield = Ionization/Phonon

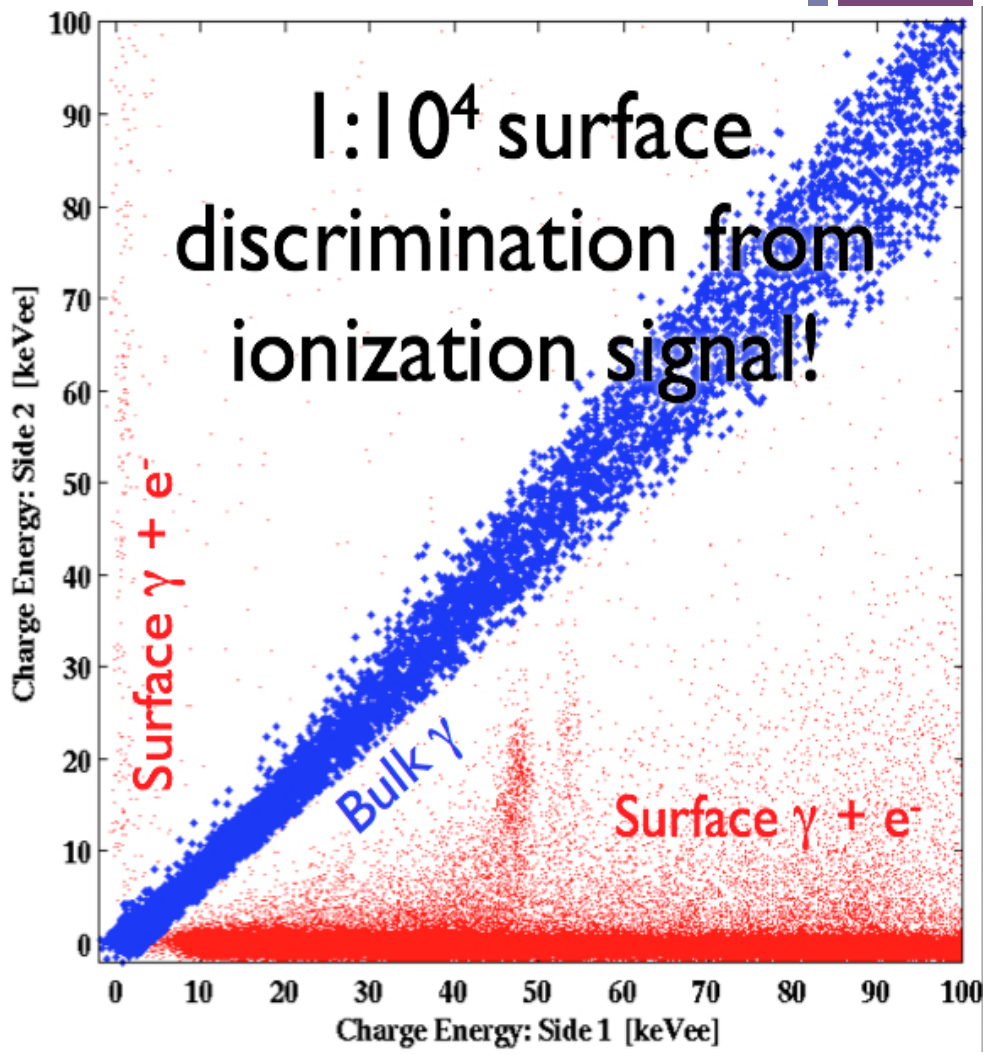
ER/NR well separated
E > 6 keV
σ_q ~ 300 eV (measured)
σ_p ~ 192 eV (measured)
-> underground σ_p ~ 72 eV

+ Charge-based Surface event rejection

Complex E-fields produced by interleaving +2V/0V electrodes encode Position Information

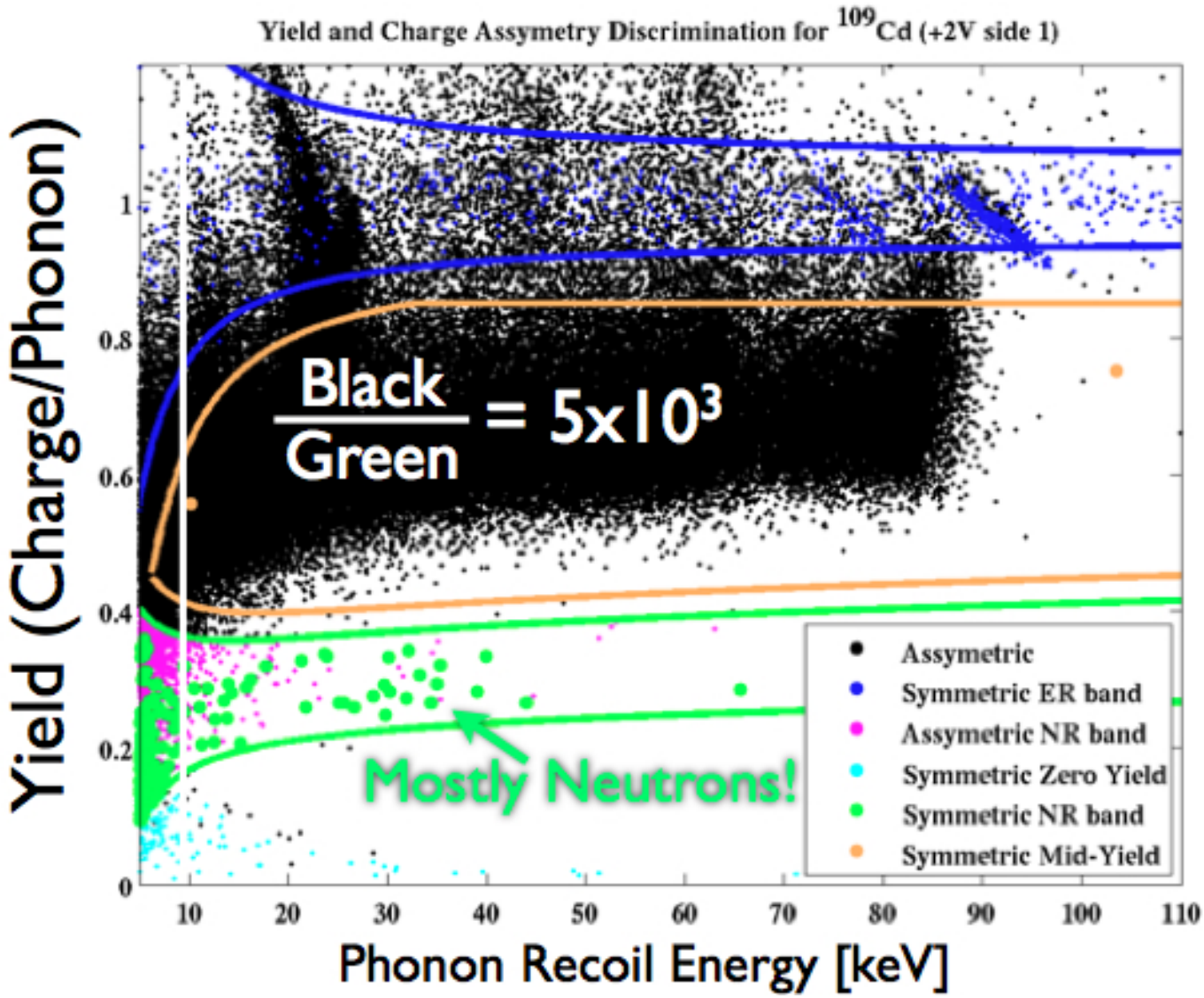


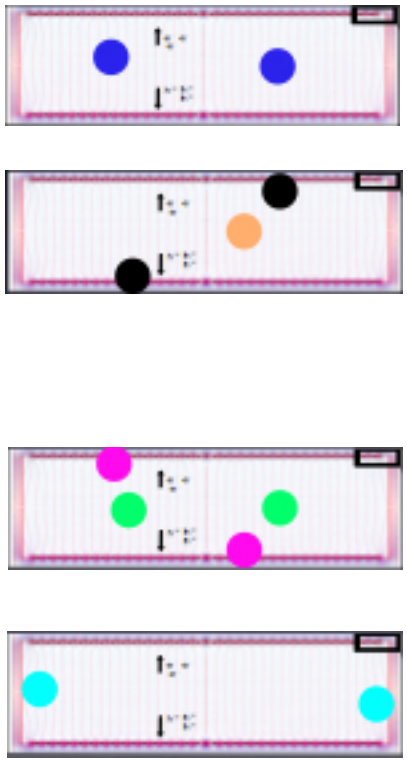




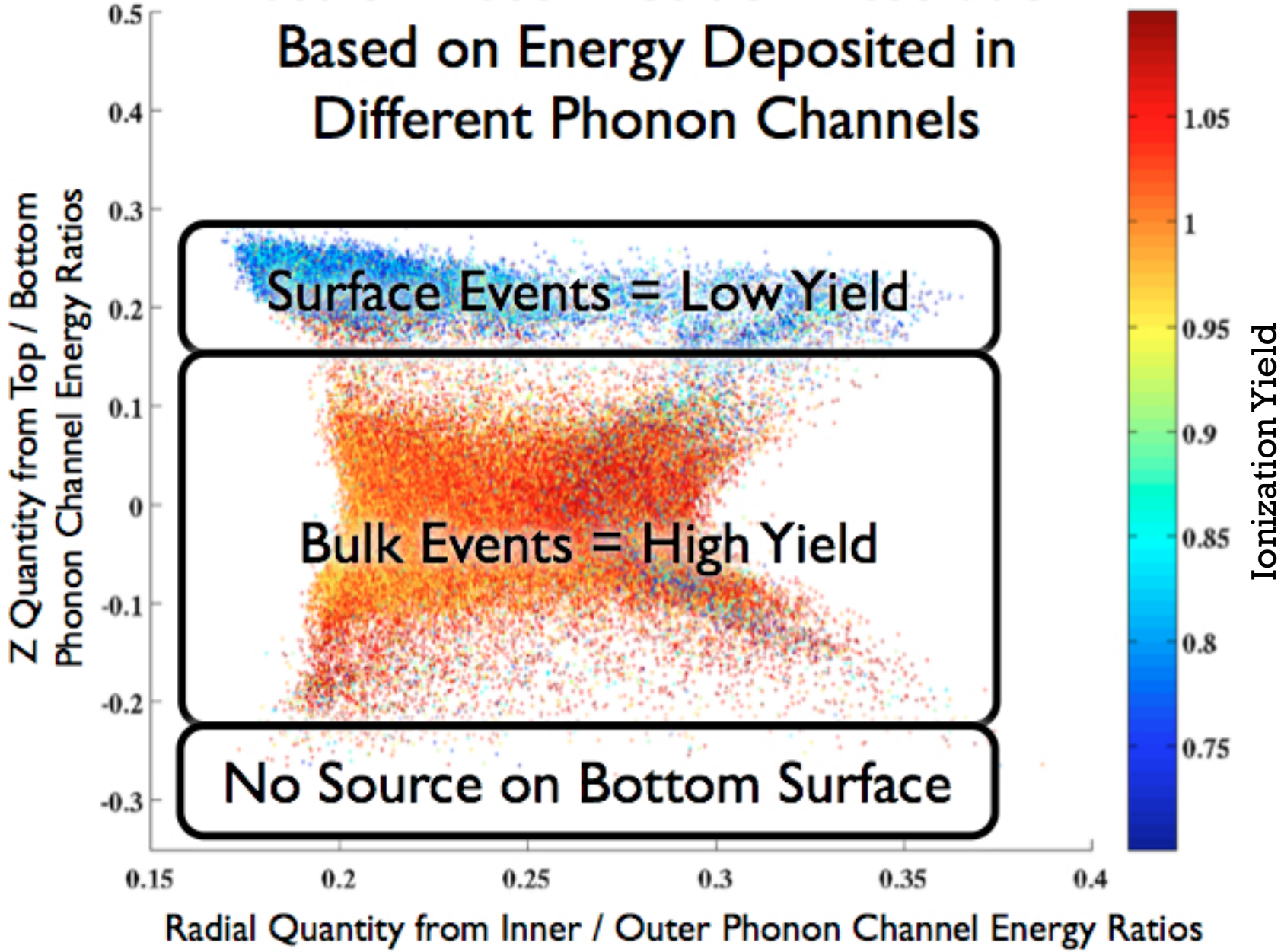
Yield-based Surface Event Rejection

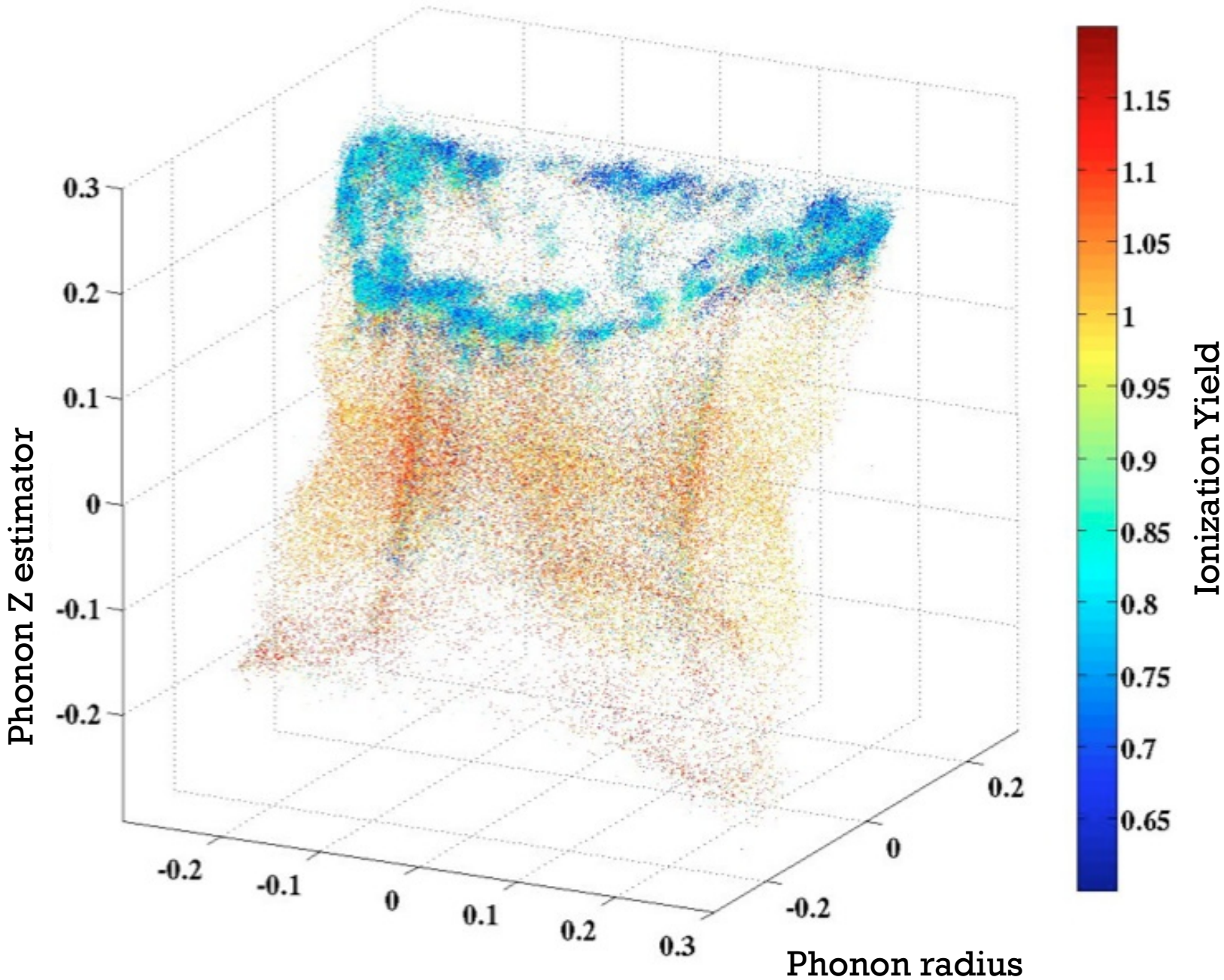
(Test Facility Data)



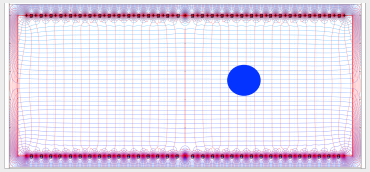
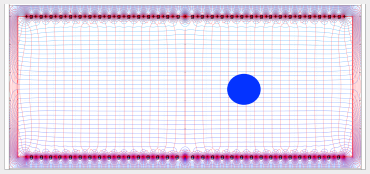


Electron Recoil Position Resolution Based on Energy Deposited in Different Phonon Channels

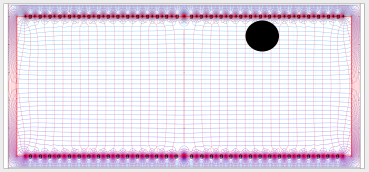
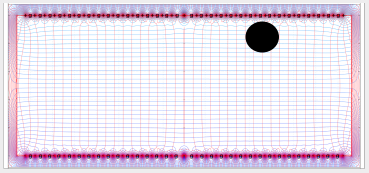
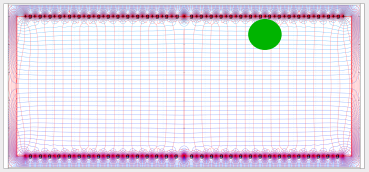



Phonon Z estimator
0.3
0.2
0.1
0
-0.1
-0.2
-0.2
-0.1
0
0.1
0.2
0.3
Phonon radius
0.2
0
-0.2
Ionization Yield
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65

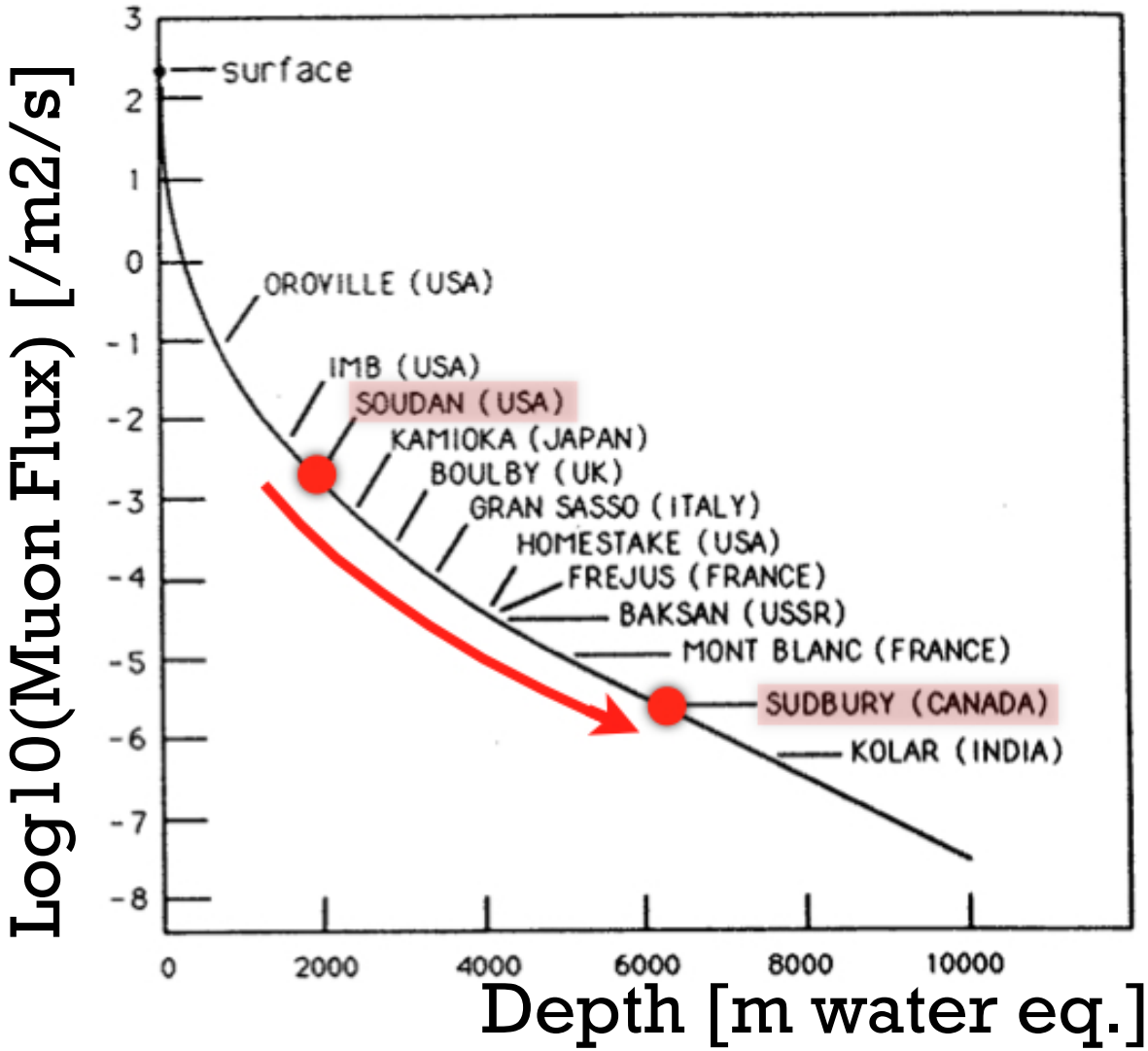
Bulk Electron Recoil Rejection

Discrimination Type	iZIP power rejection	
Yield	Expected to be the same as CDMS II (> 1:10^6)	
Phonon Pulse Shape ER/NR Discrimination	>1: 10^3 but this will improve significantly	

Surface Electron Recoil Rejection

Discrimination Type	iZIP Power rejection	
Charge-based Surface Cut	$>1:10^4$	
Phonon-based Surface Cut	$>1:10^3$	
Low Yield Surface Events	$>1:10^3$	
Total Surface Event Rejection	$>1:10^6$ EXPECTED	For 1ton scale experiment -> $2x10^5$

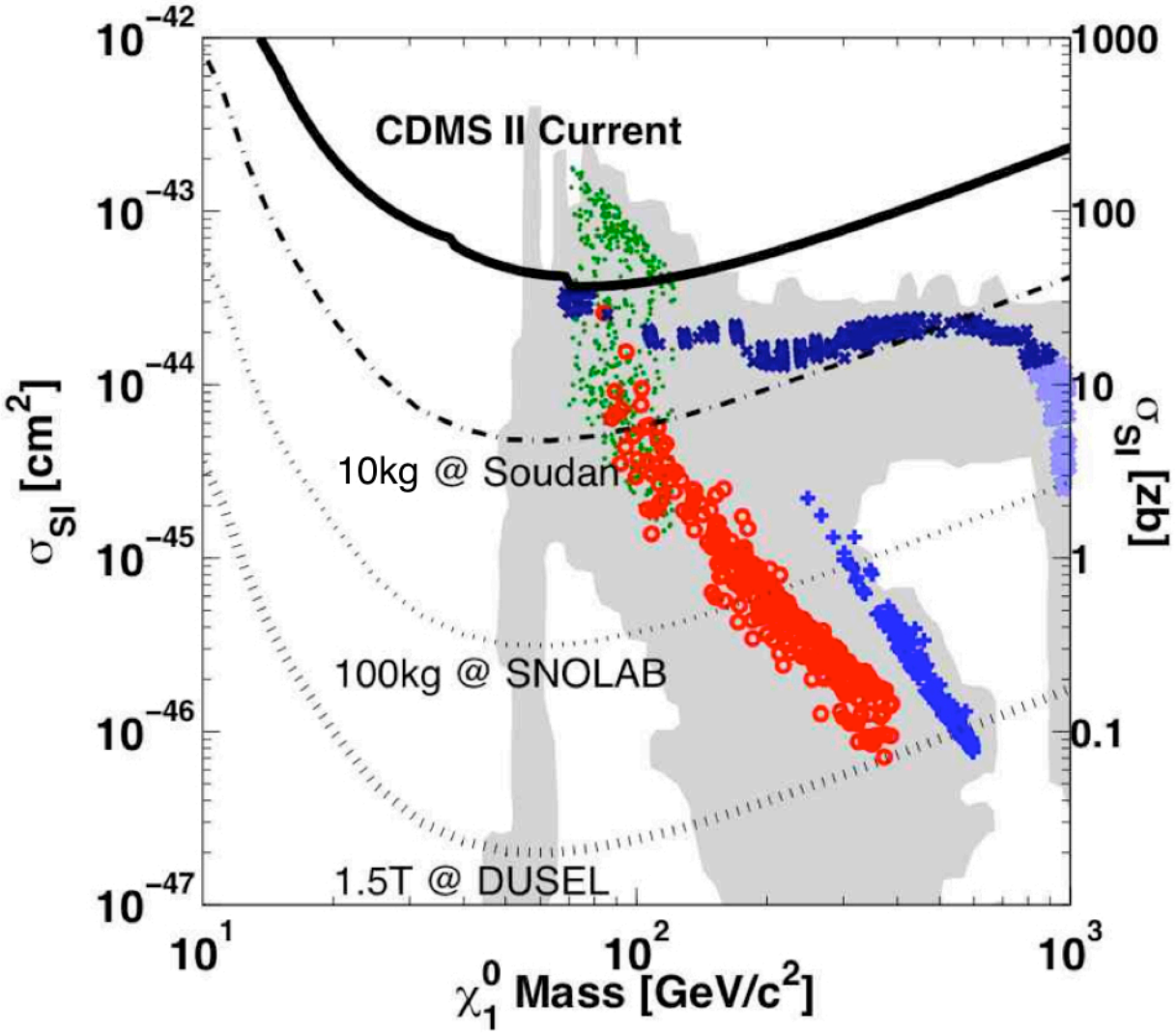
Deeper Underground
Cosmic Background



Soudan:
2090 mwe
~75 /yr/ton

SNOLAB:
6060 mwe
< 1 /yr/ton

Conclusions

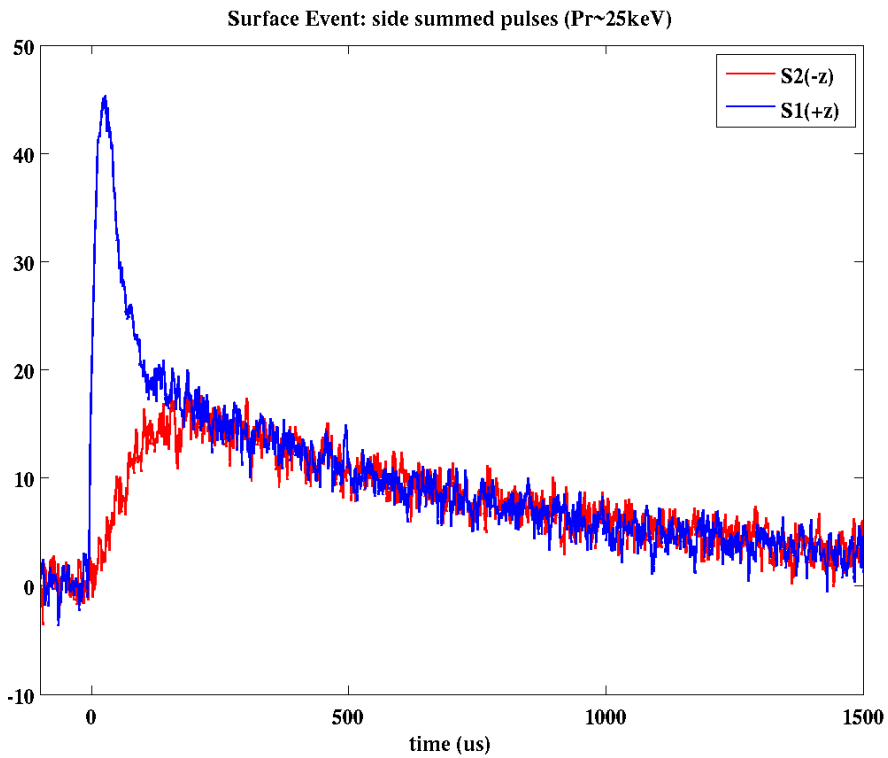


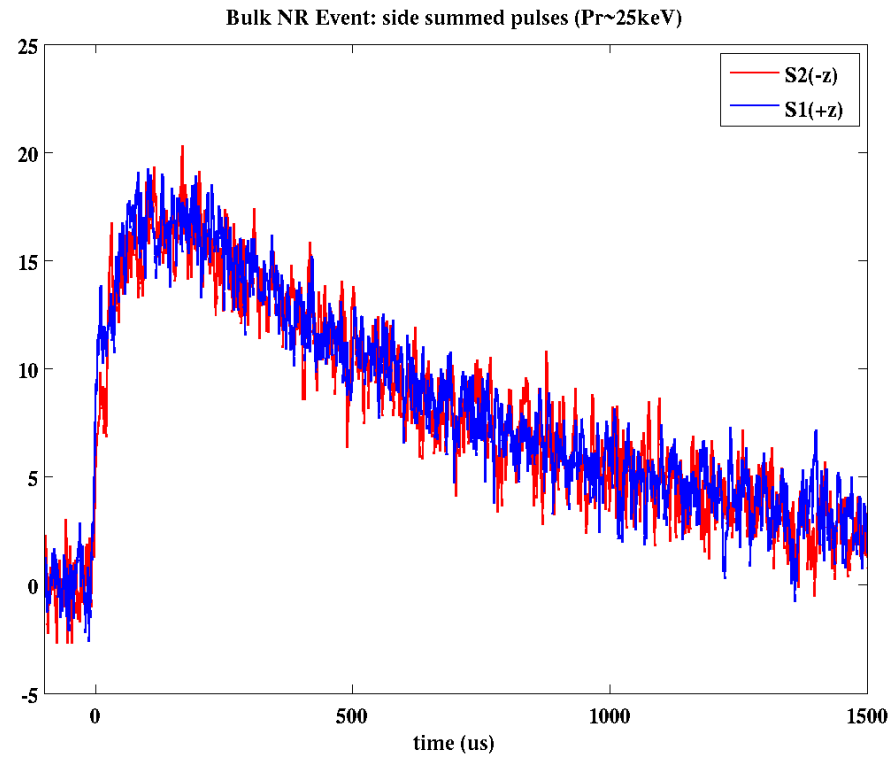
The new iZIP detector technology is vastly superior to CDMS II devices.

Current 100 kg SuperCDMS SNOLAB and future 1.5 ton GEODM plans.

Backup Slides

NR/SE Phonon Pulse Shape Discrimination

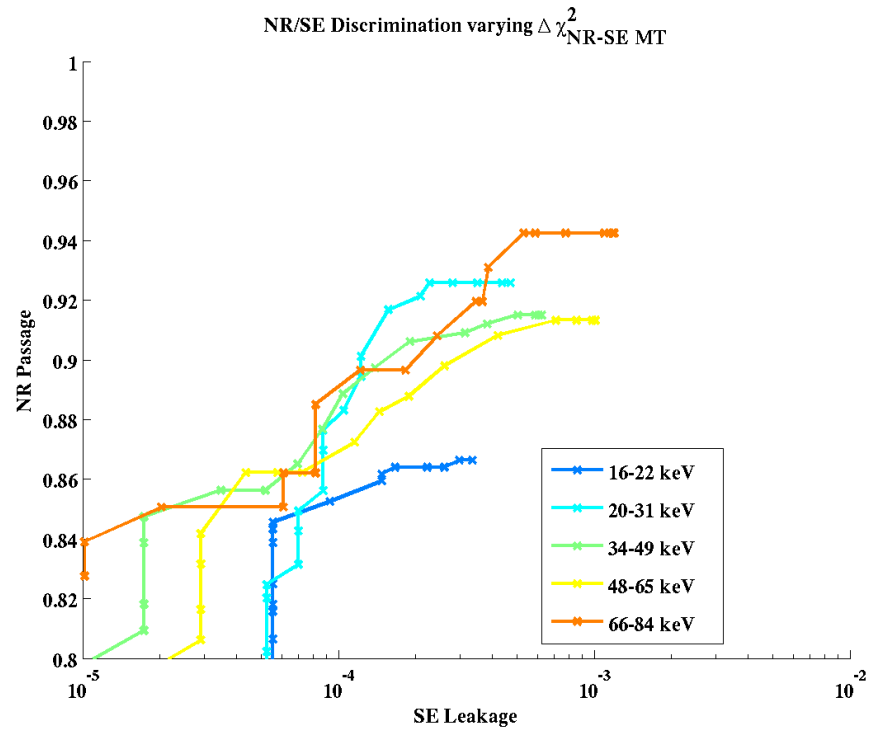


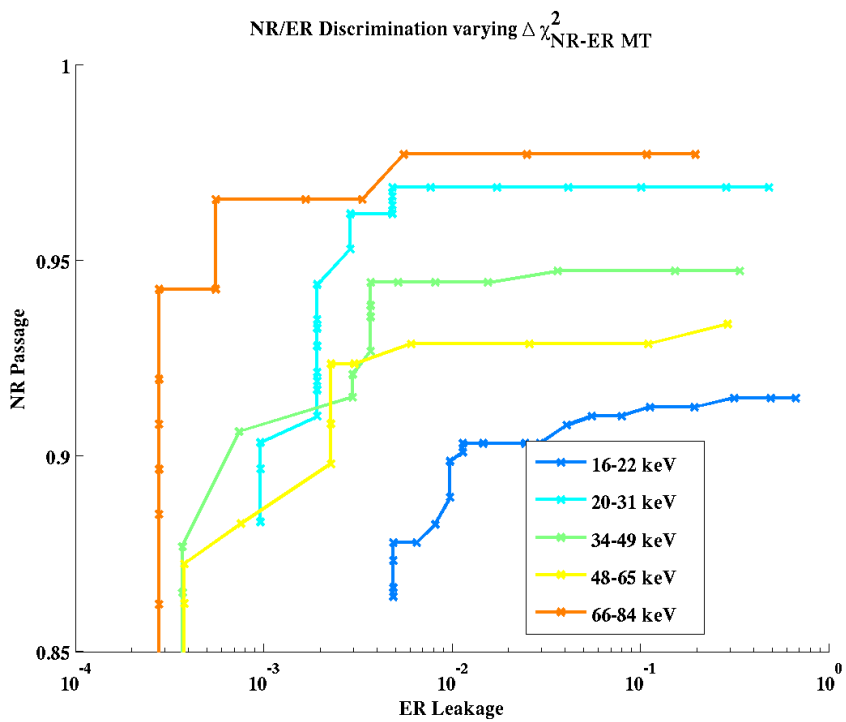


- NR/SE discrimination seen in both pulse shape differences and z partition

Phonon Pulse Shape Discrimination

- NR/SE discrimination
- 1:10^4 Rejection down to 15keV$_{ne}$ with ~60% total efficiency (15% additional loss after Q radial cut)





- NR/ER discrimination
- Current Algorithms have sizeable energy degradation
- Nonlinear pulse shape fitting currently being pursued.