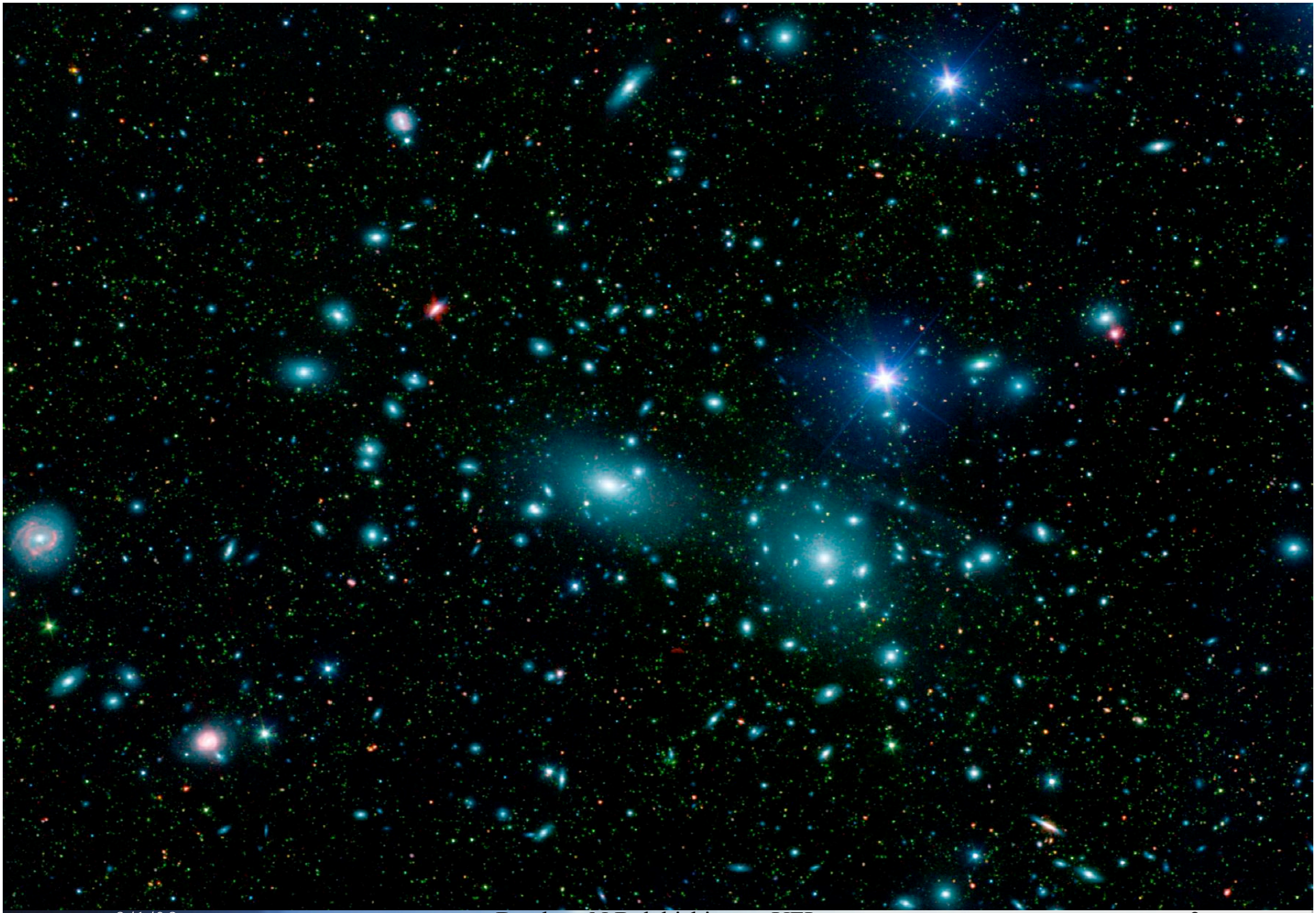
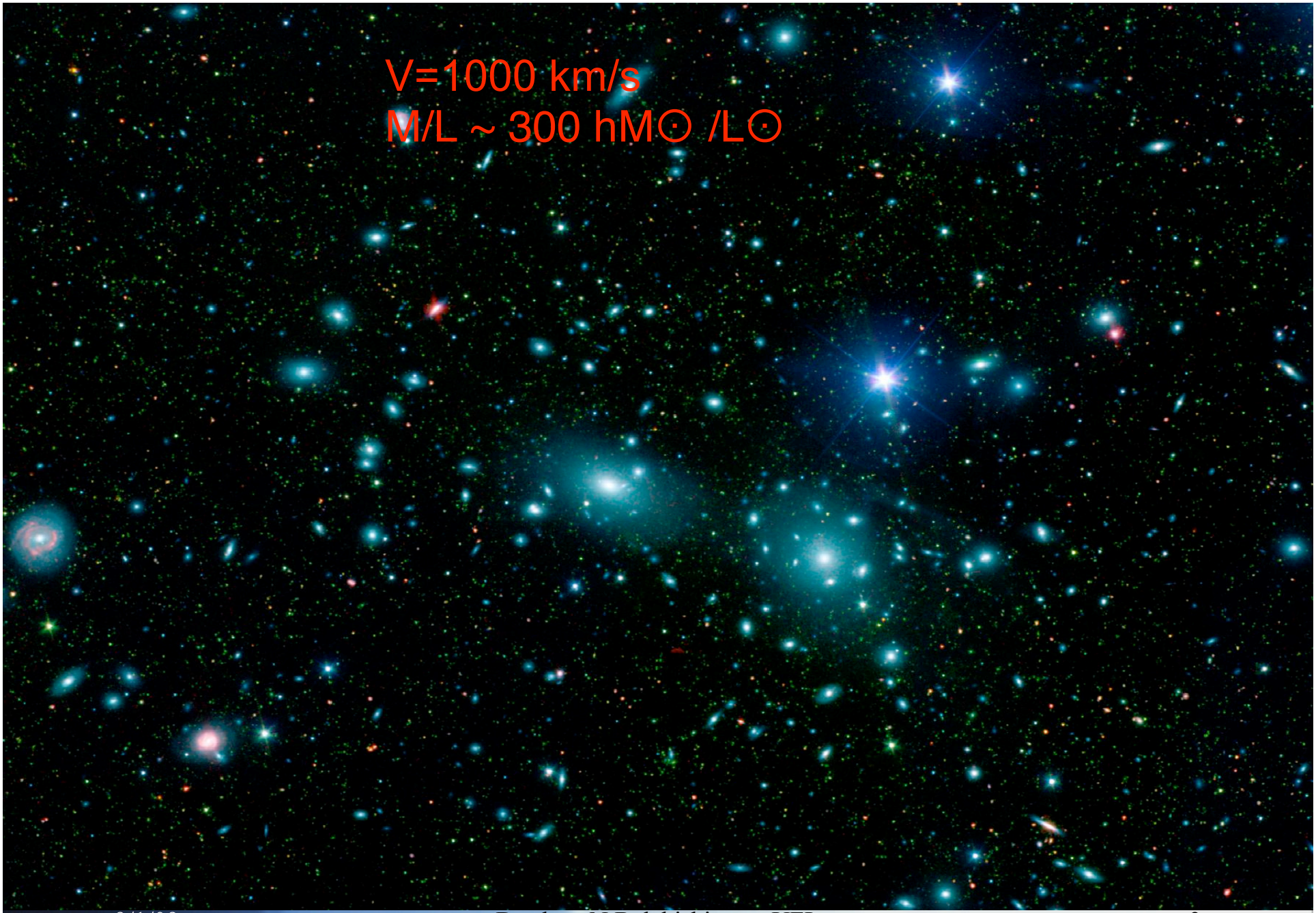
CDMS

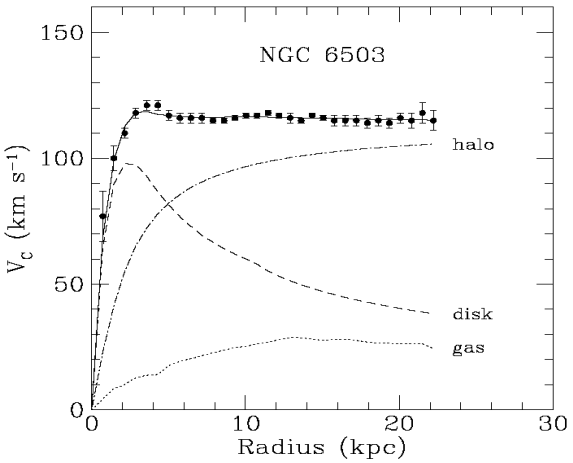
Past , Present and Future



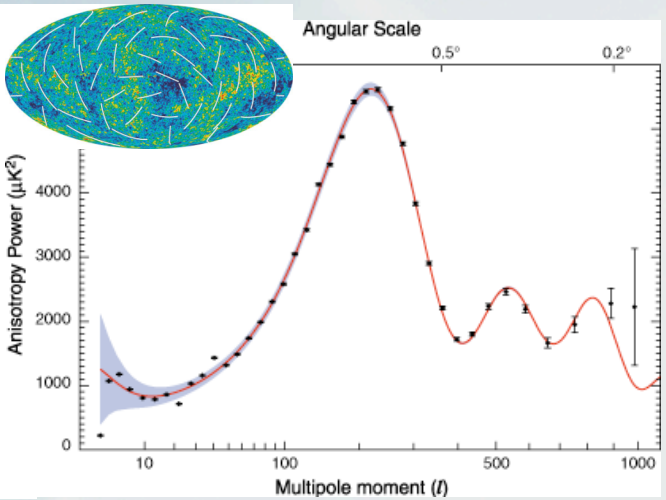

V=1000 km/s
M/L ~ 300 hM⊙ /L⊙

The Dark Side of The Universe

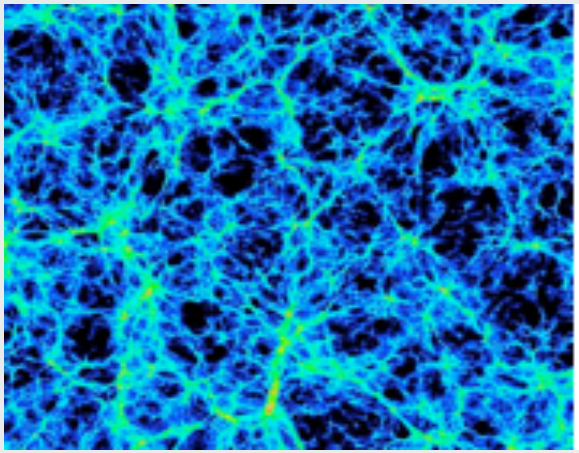
Rotation Curves of Galaxies



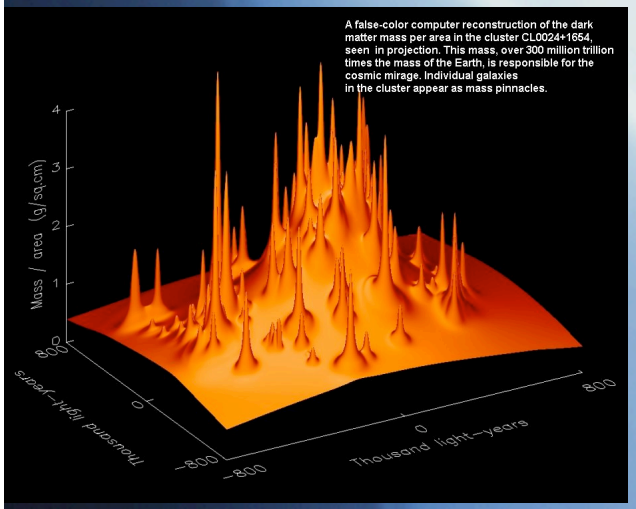
CMB



Large Scale Structure

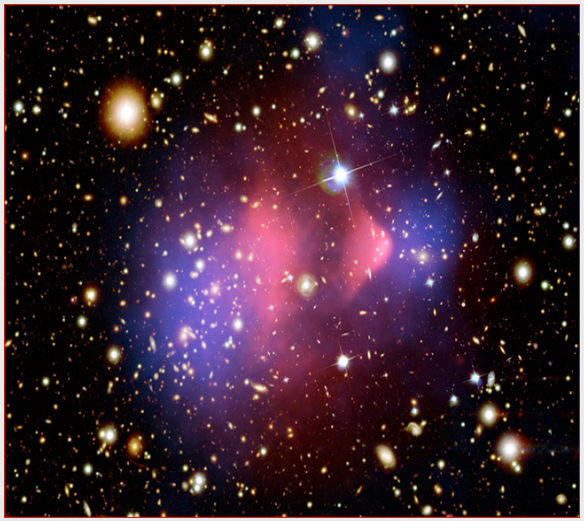


Galaxy Cluster



Dark Matter Ring

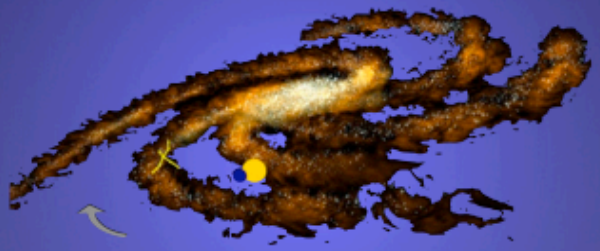
Bullet Cluster



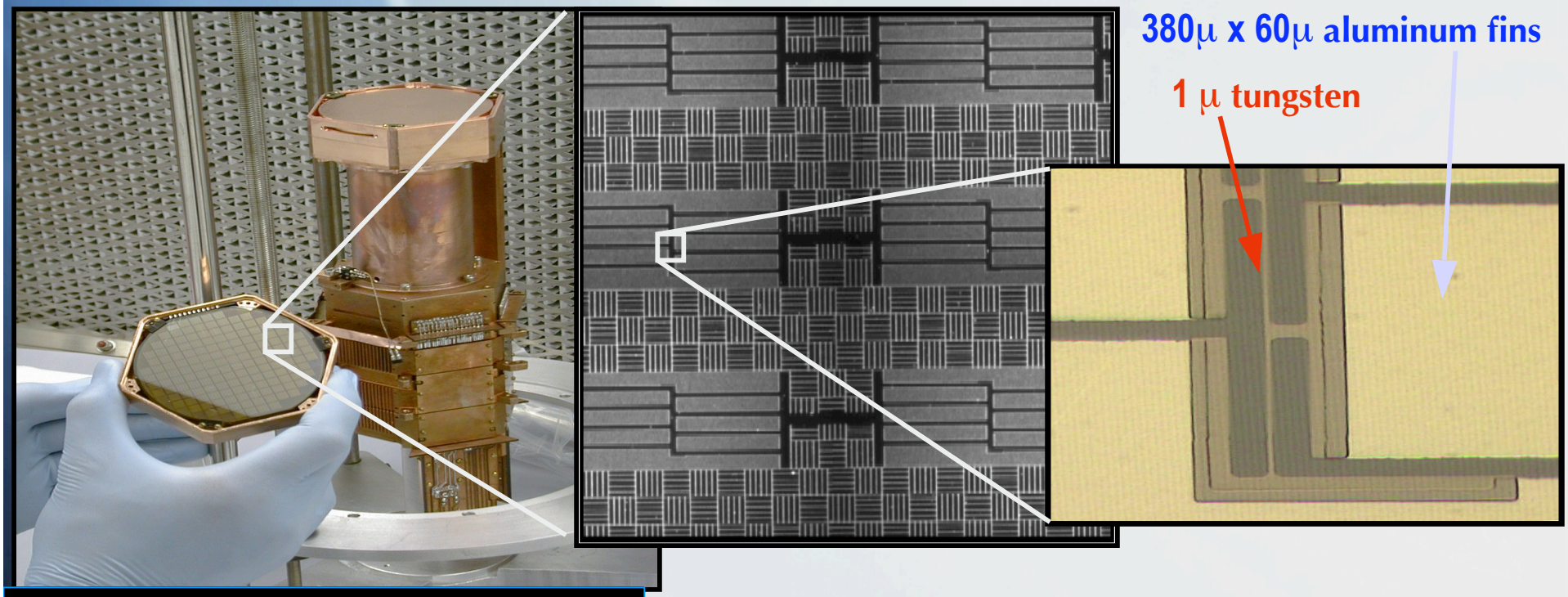
The Dark Matter Wind

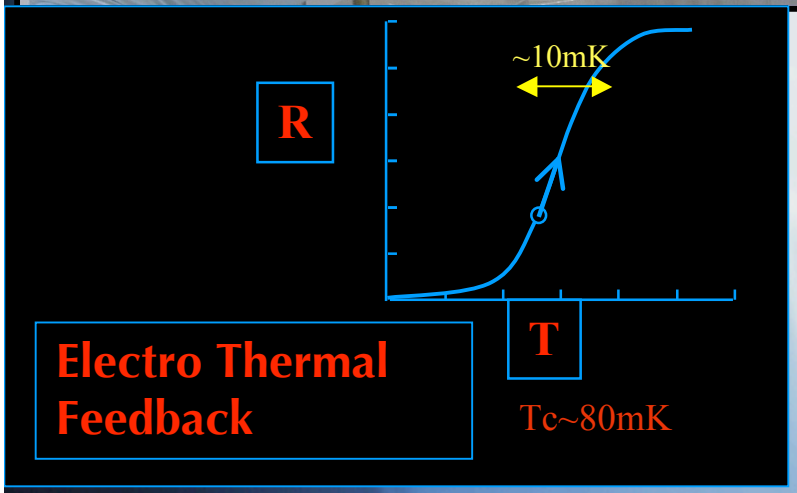
apparently "blows" from Cygnus

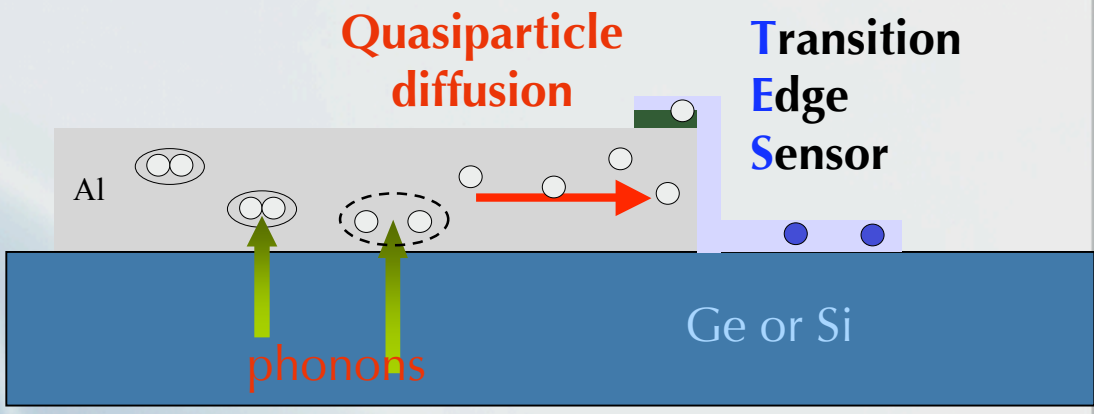
Our speed relative to the halo is ~220 km/s

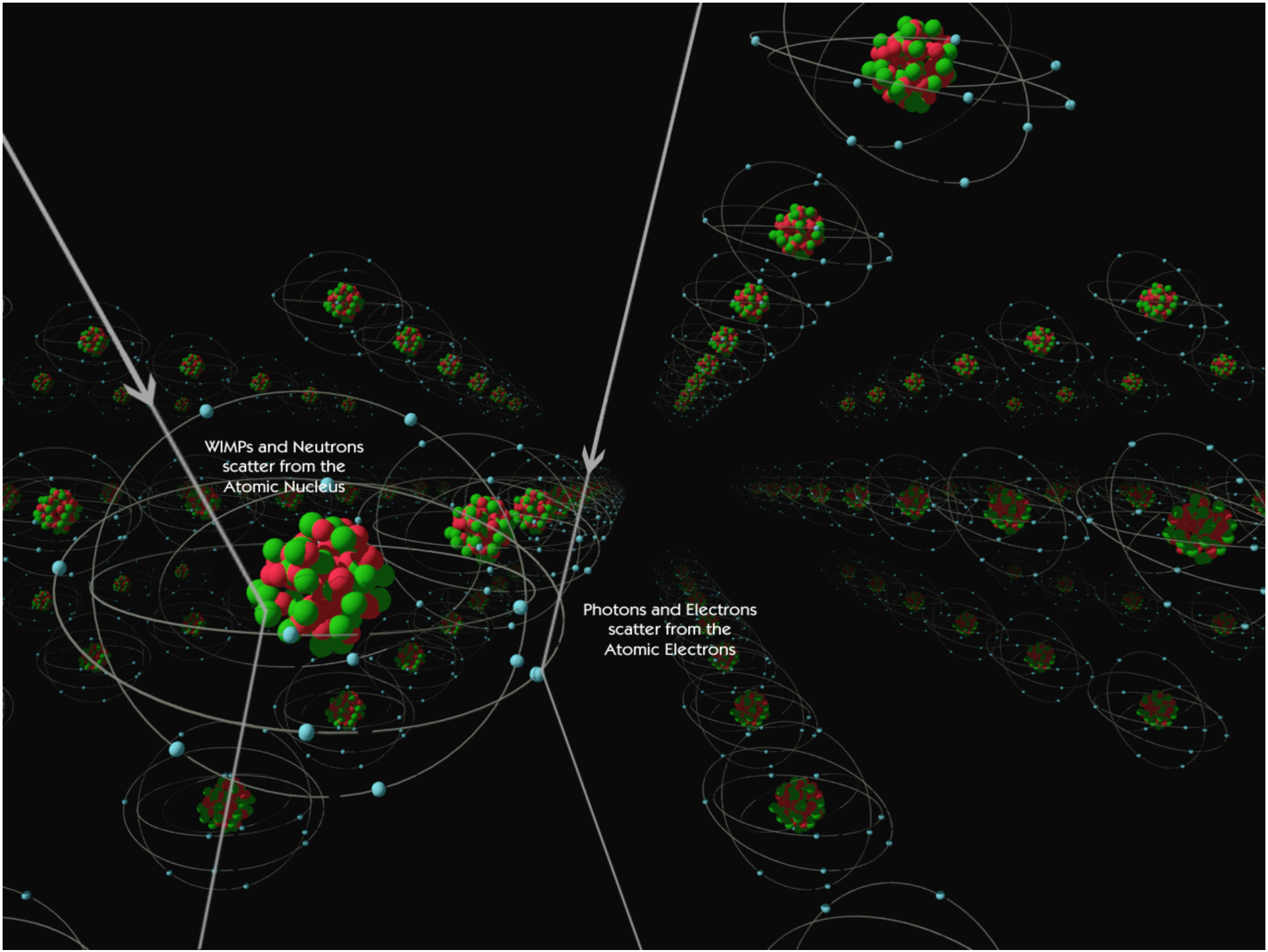


CDMS Detector





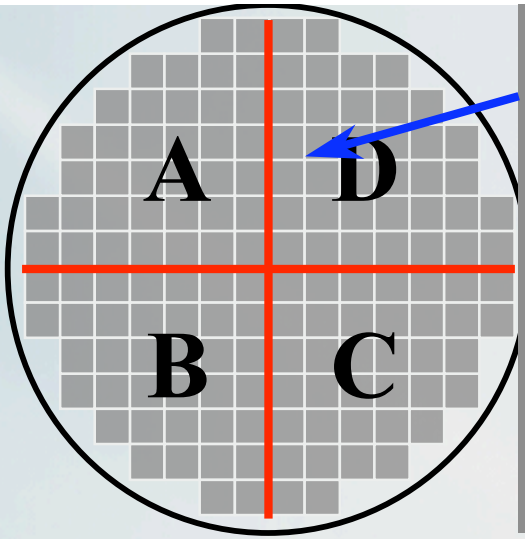


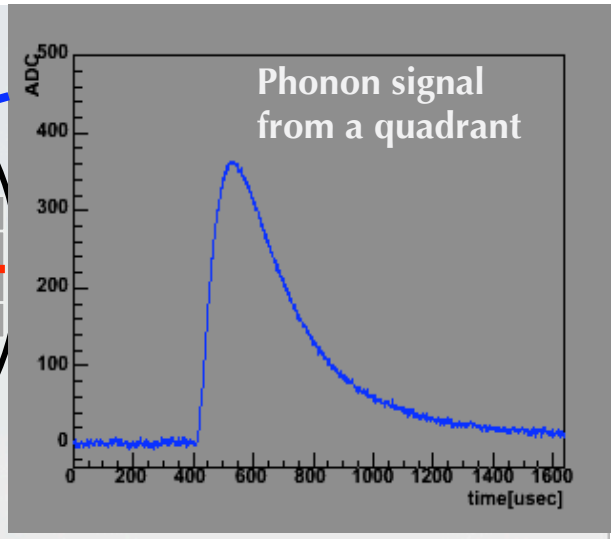

WIMPs and Neutrons
scatter from the
Atomic Nucleus
Photons and Electrons
scatter from the
Atomic Electrons

Detector Readout

Phonon sensor

Recoil Energy

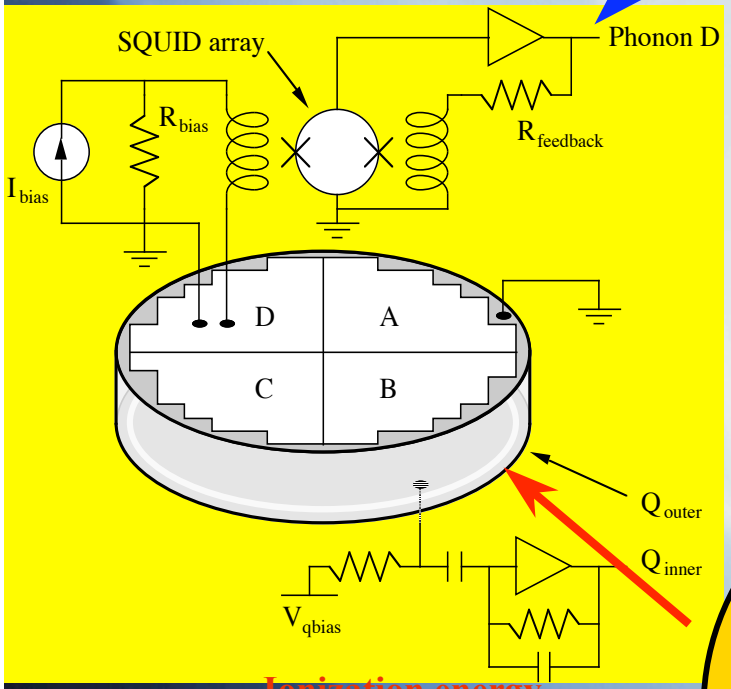




19 Ge zips (250 g each)

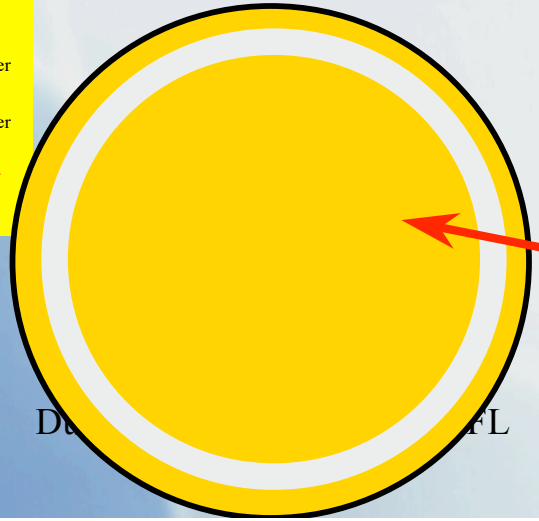
11 Si zips (100 g each)

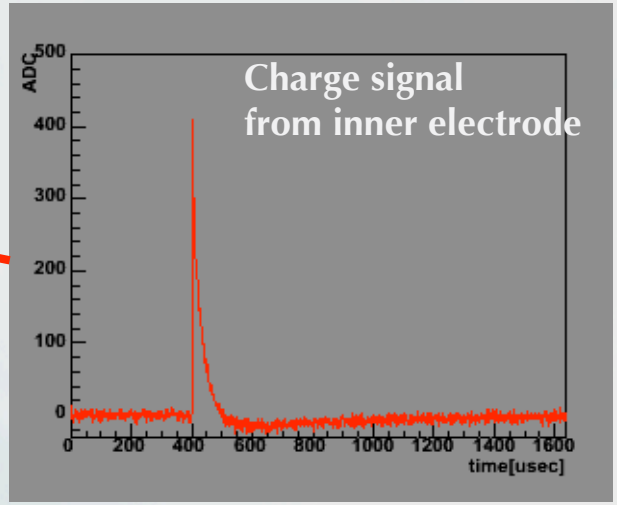
1 cm thick crystals



Ionization energy

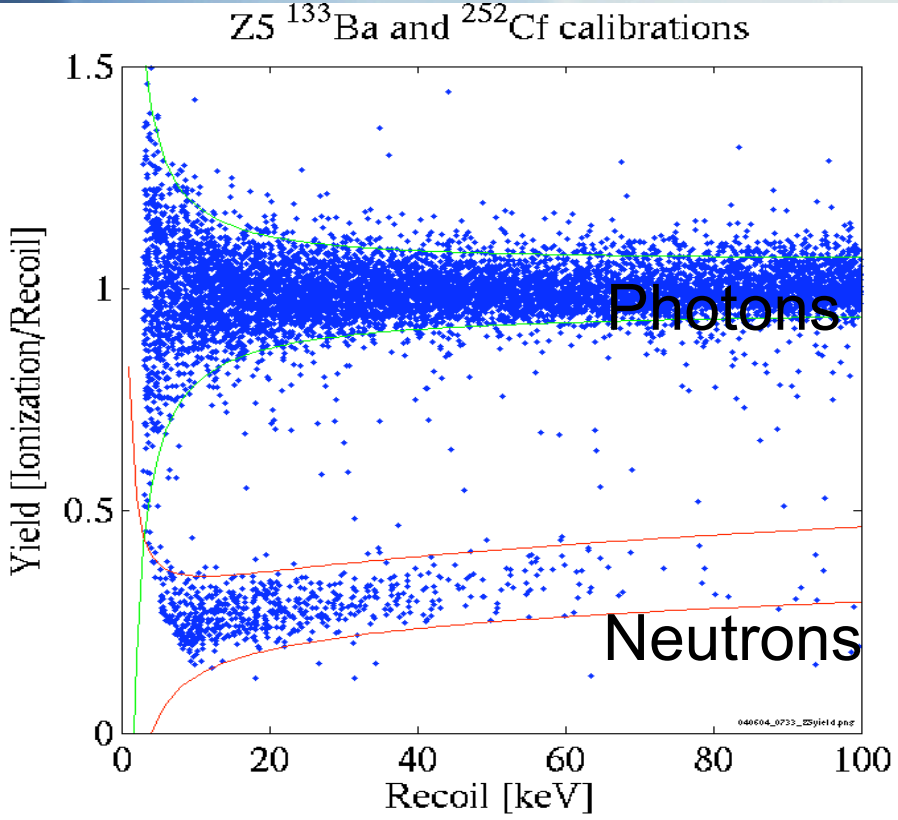
Charge Sensor

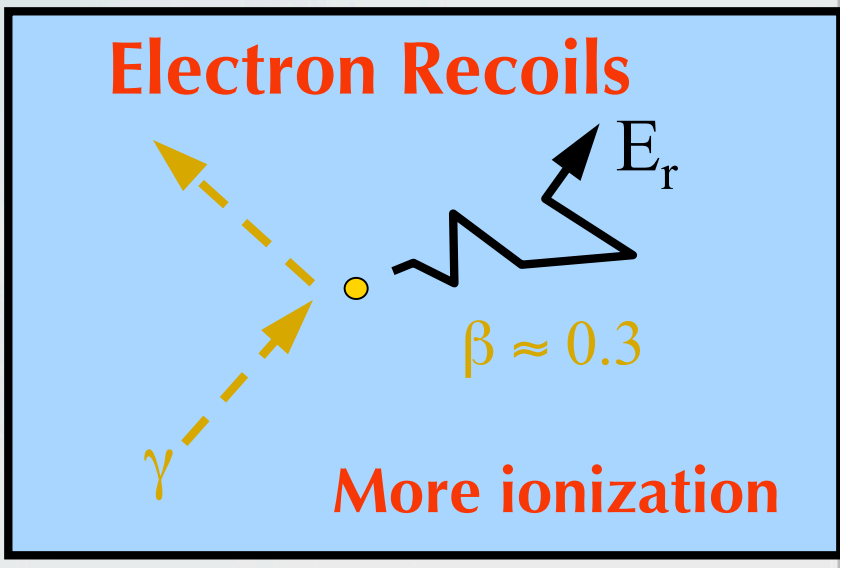


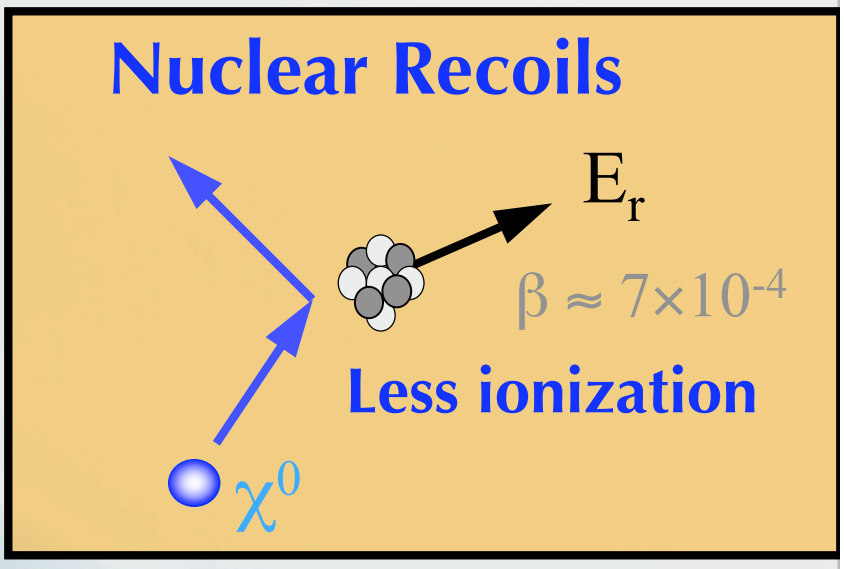


- Reduced Ionization for Nuclear Recoils

Yield = E(ionization) / E(recoil)

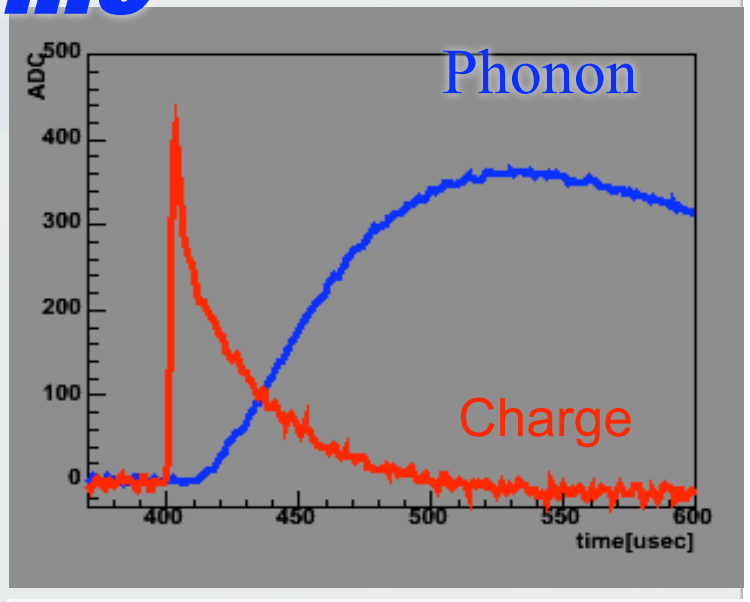


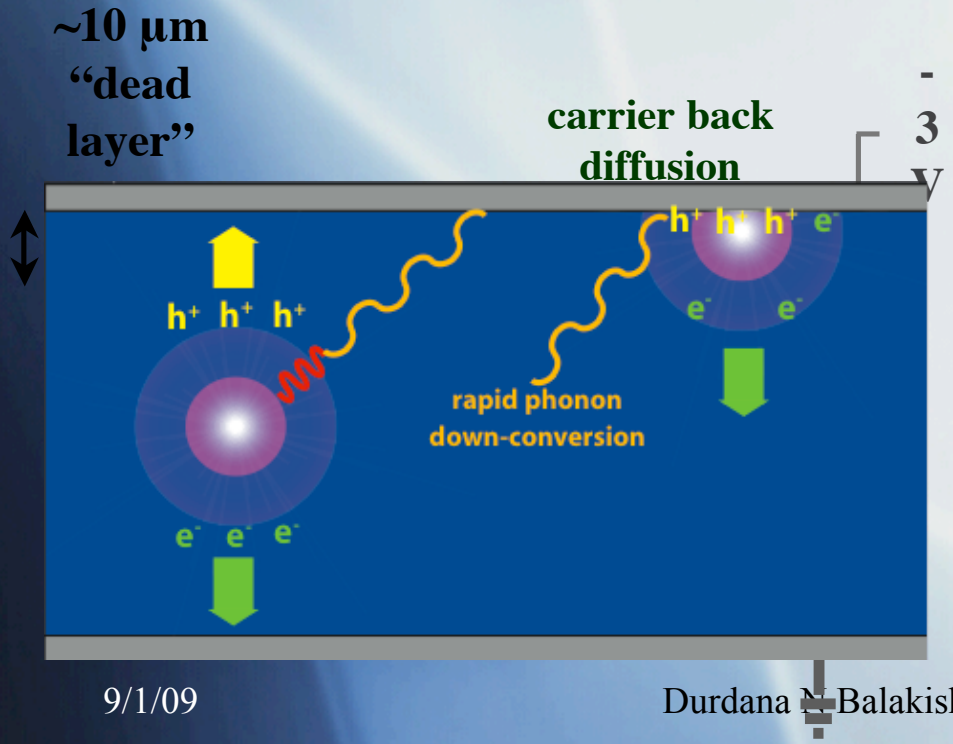


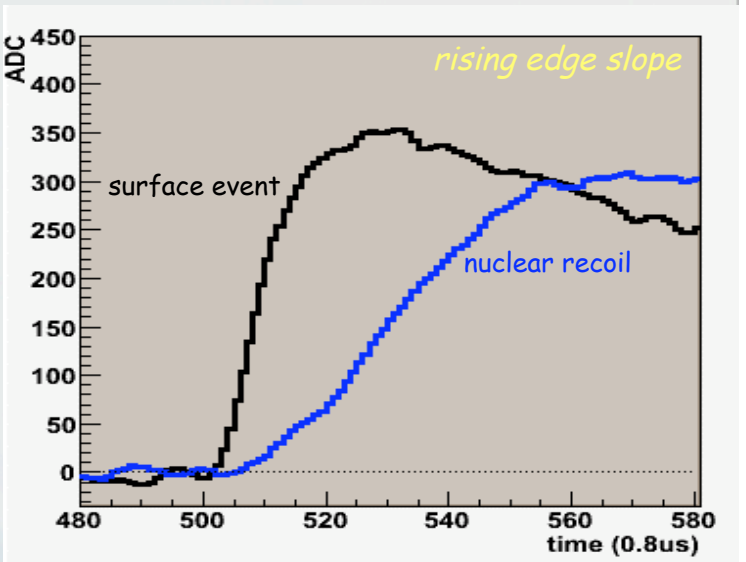


Delay and Rise Time

- Clear distinction in pulse shape and rise time
- Surface Events due to reduced ionization by a dead layer
- Yield and Timing Parameter reject surface events

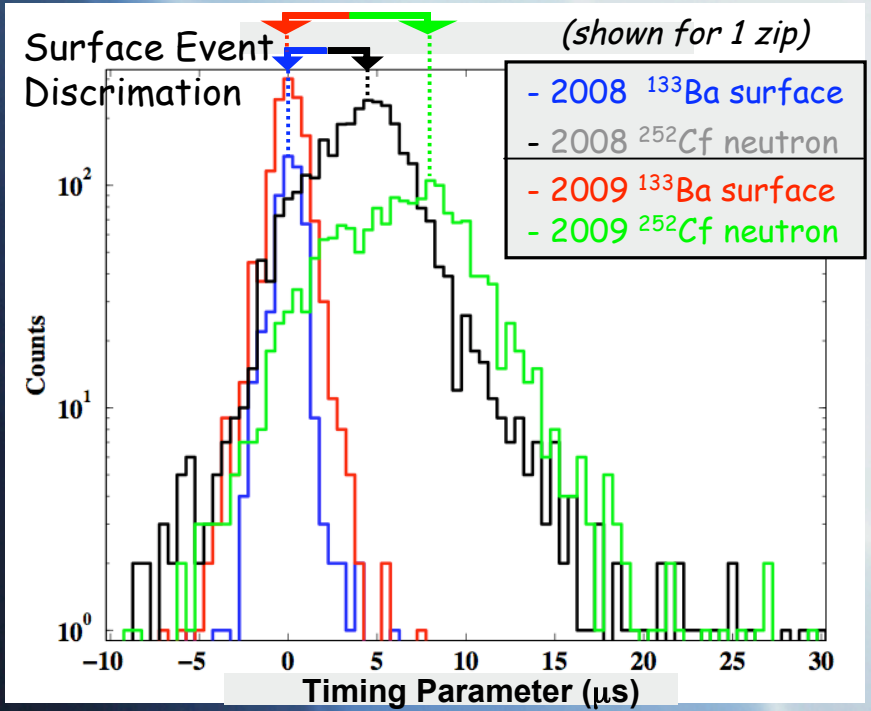


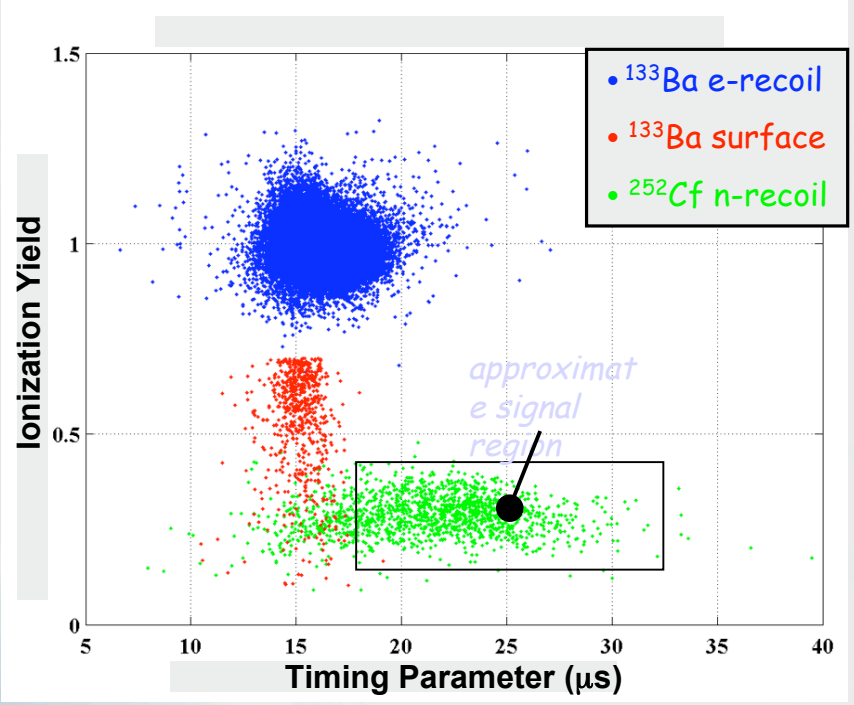




Discrimination power of Timing Parameter

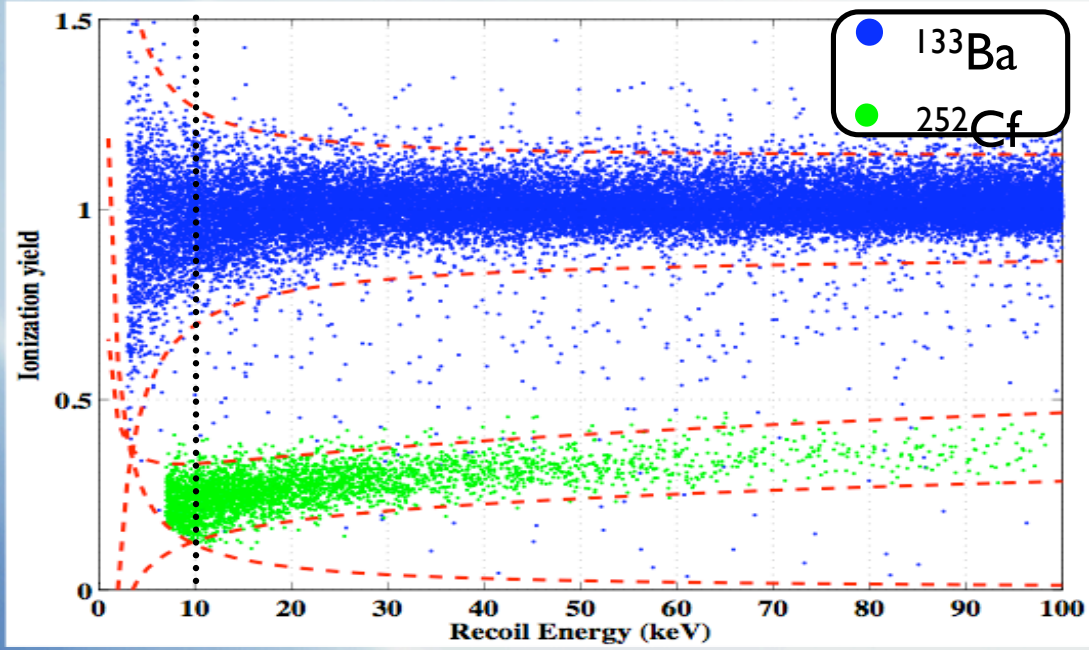
- Improvement of Surface Event Discrimination since 2008





Detector Calibration

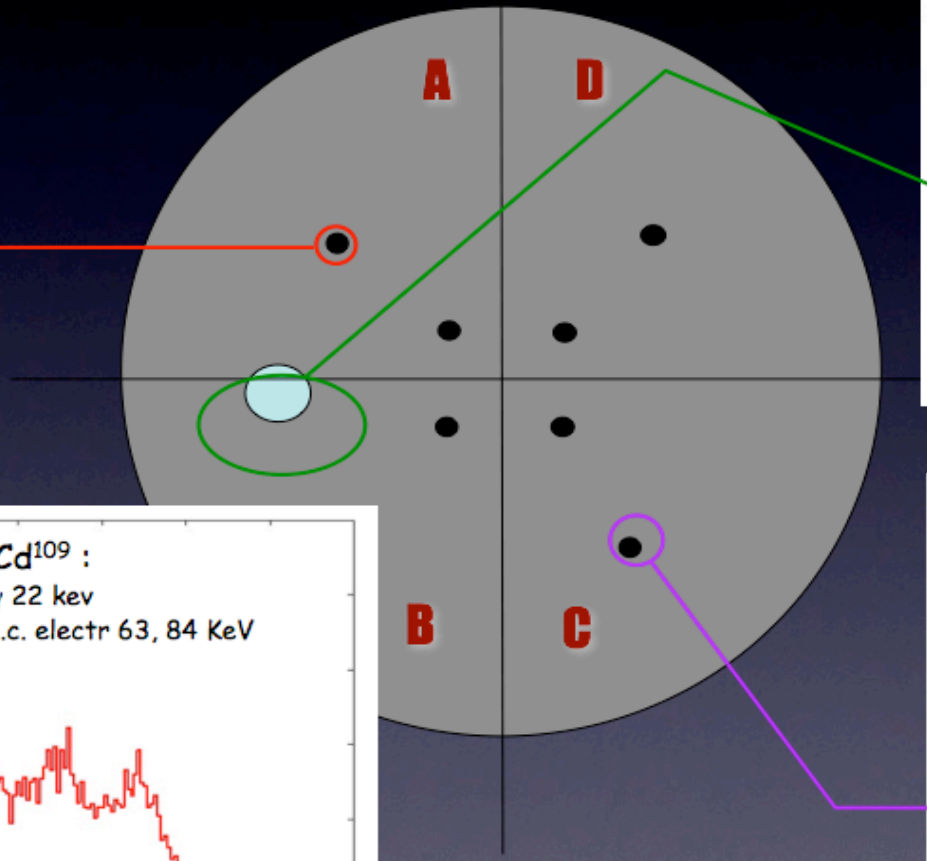
- Gammas and Betas as electron recoils

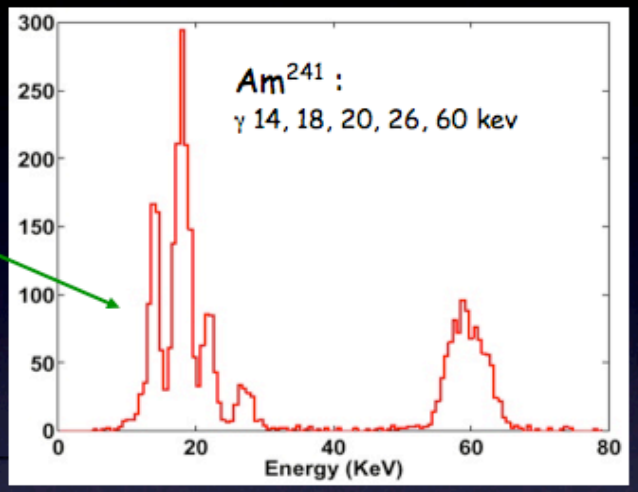


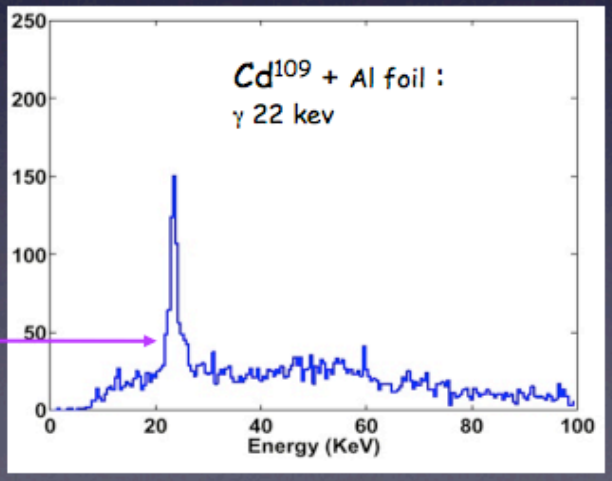
- Ionization Yield Analysis alone gives 1:10^4 rejection of gammas
- Detectors need to be properly neutralized

Excellent Energy and Position Resolution

Detector Calibration at Berkeley

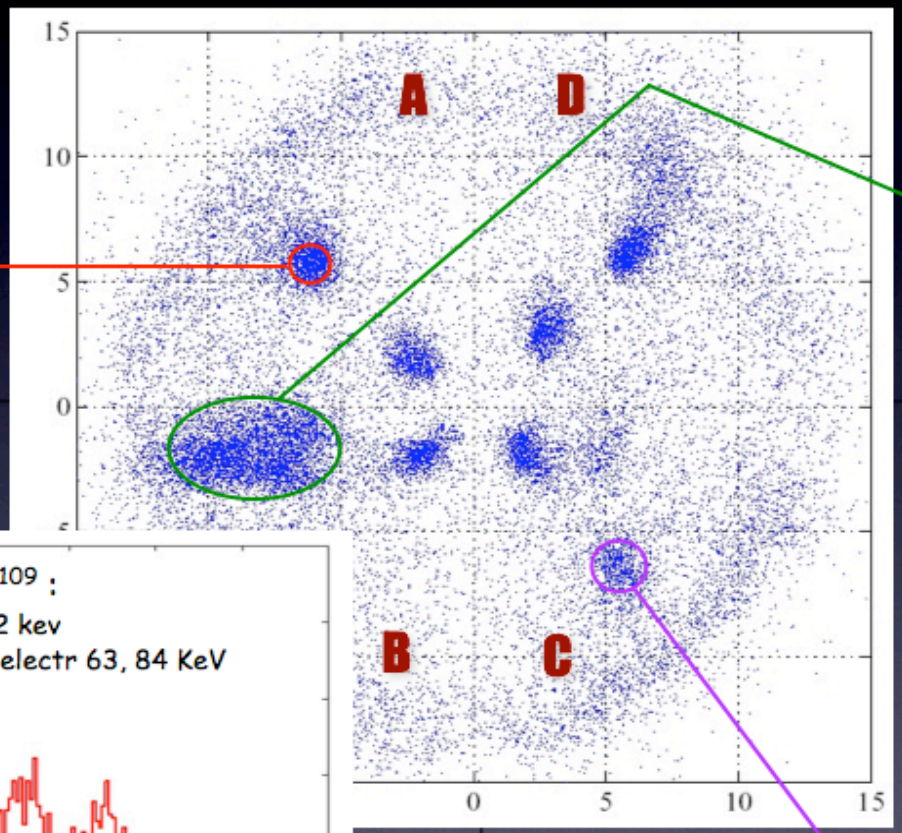


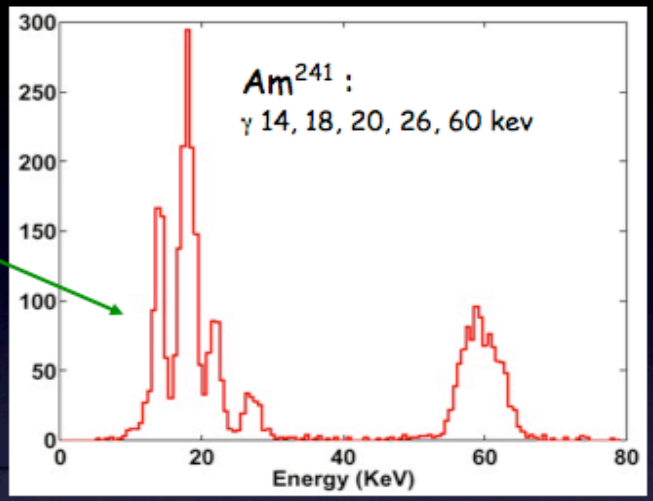


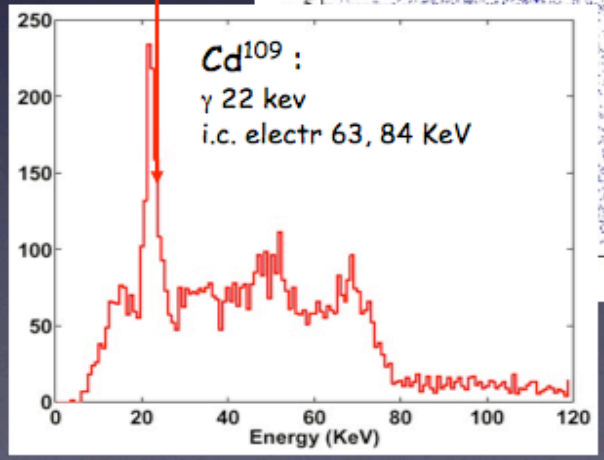


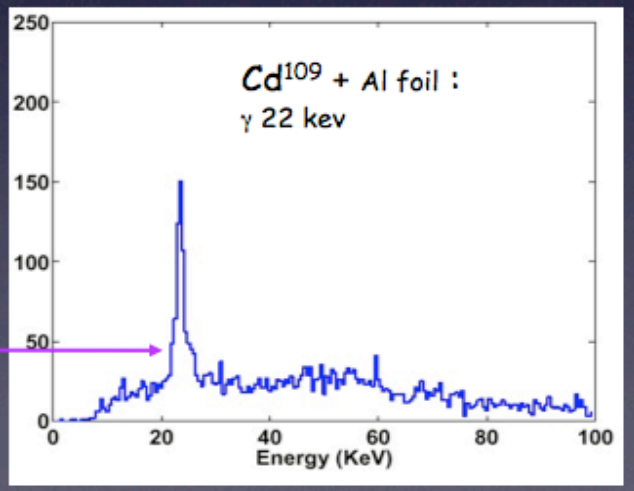
Excellent Energy and Position Resolution

Detector Calibration at Berkeley







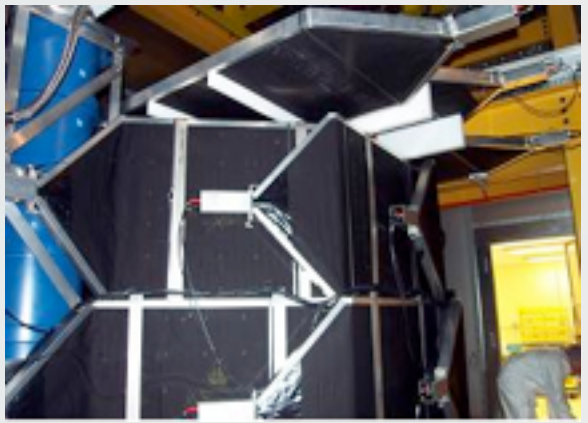


Backgrounds

- "Cosmogenic"Neutrons from Muon spallation give low ionization like WIMP's :use muon veto and go deep underground
- Poly shielding stops low energy neutrons
- Copper and Lead for gammas
- Underground Mine + Shielding + Computer Simulation=Neutron Bkgd Rejection

Passive shielding: Pb shielding

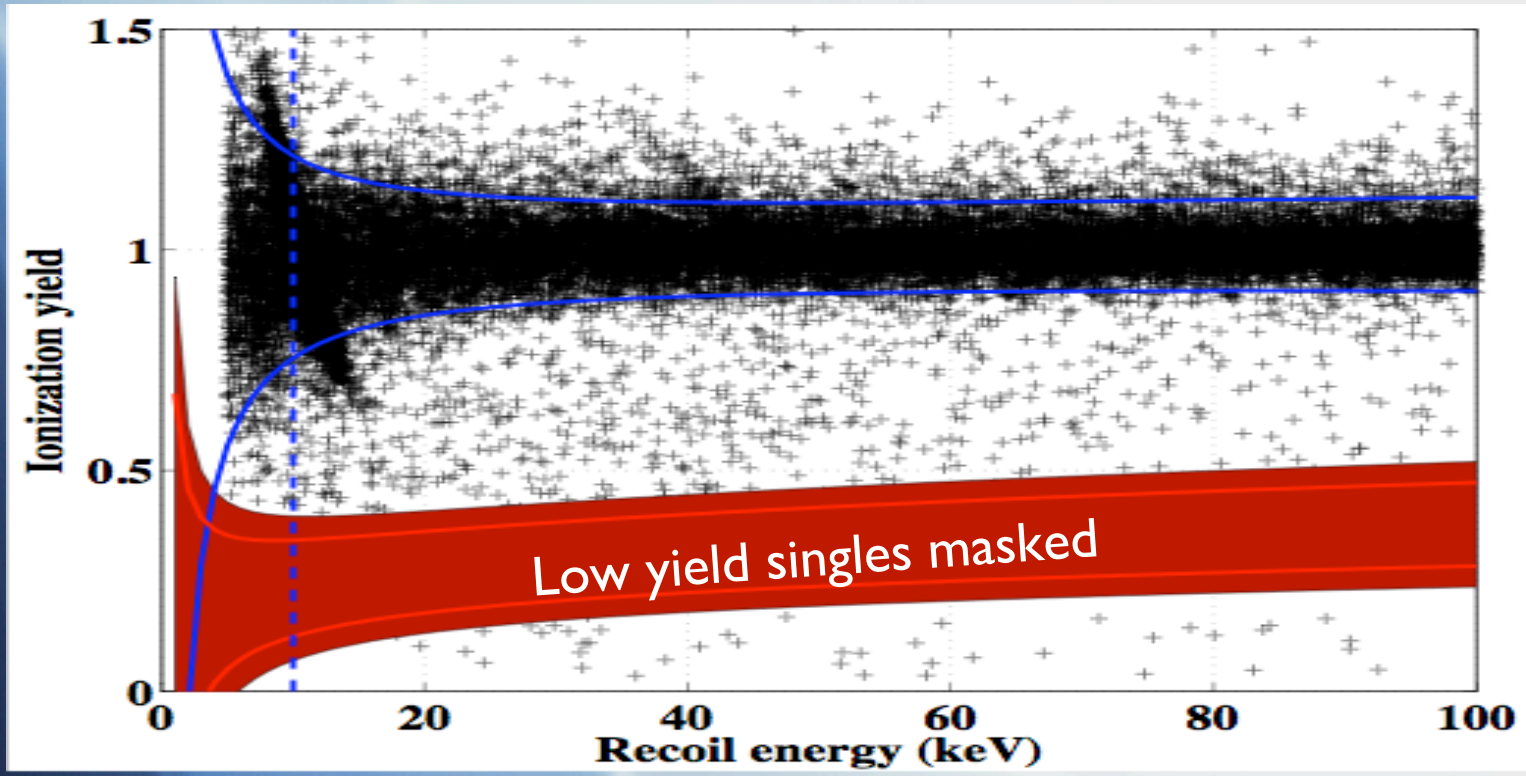
Passive shielding: Polyethylene



Active shielding: Muon veto

Analysis Routine

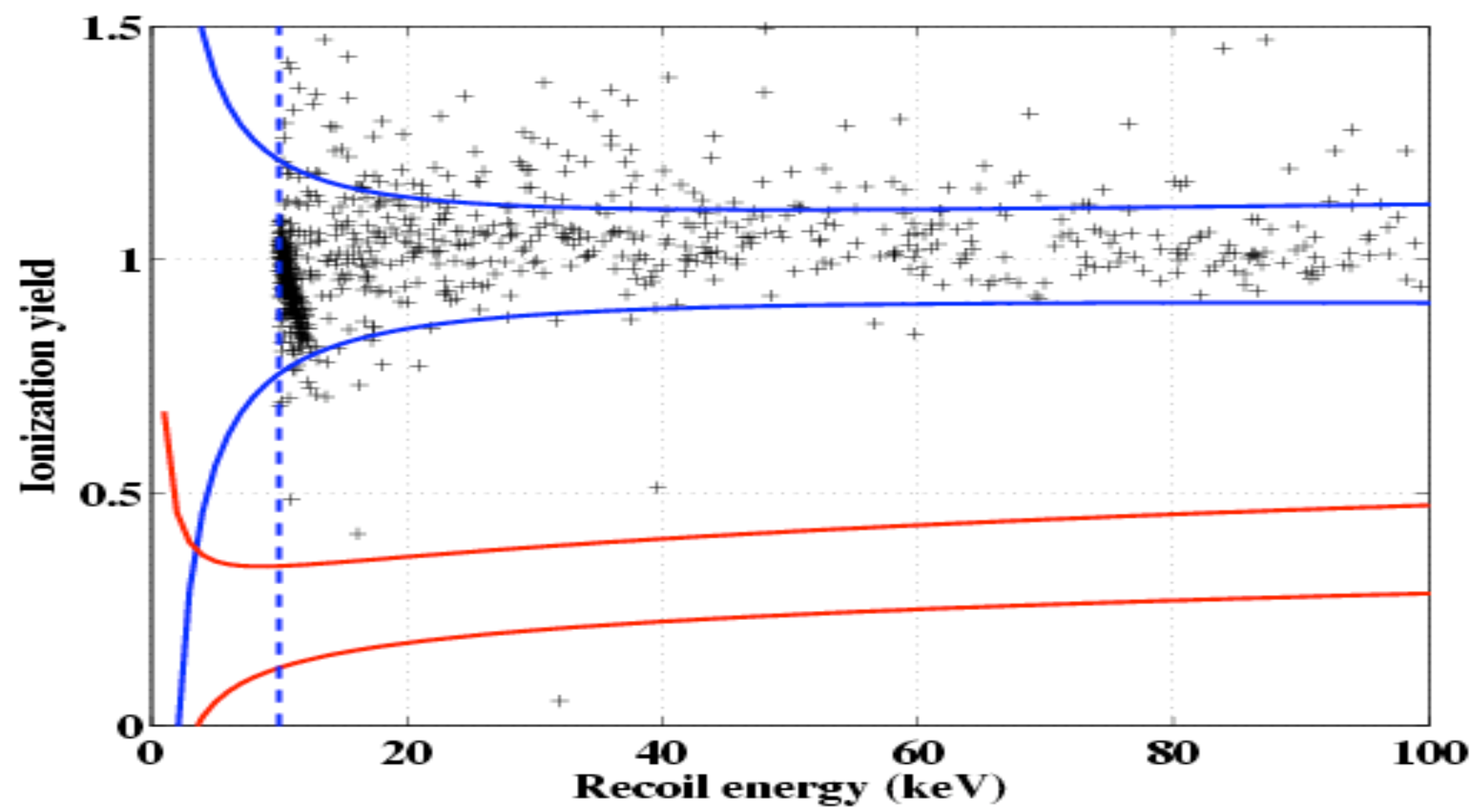
- Blind the potential WIMP signal region
- Establish all the "cuts" to be applied before unblinding



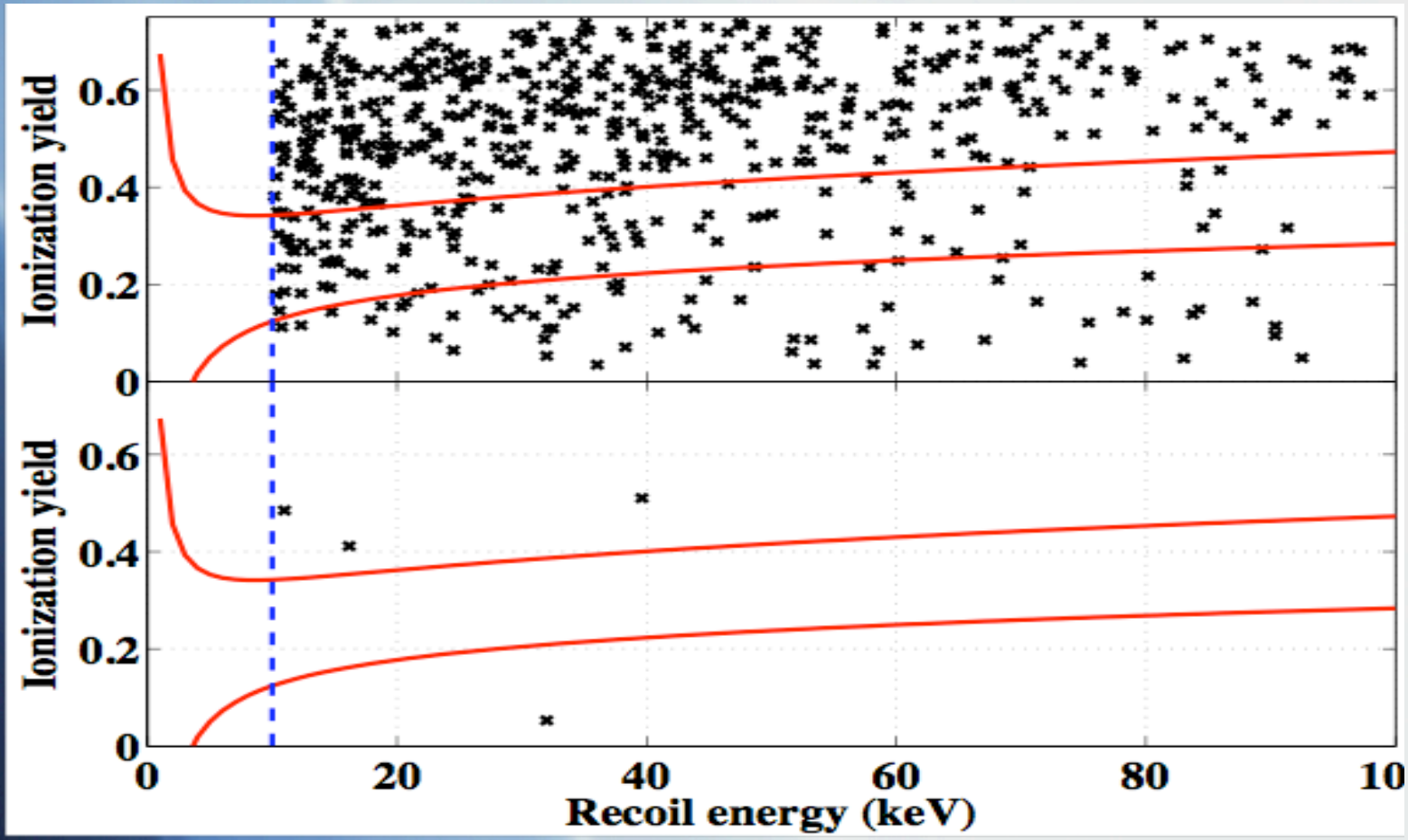
Analysis Routine

- KS test
- Fiducial Volume
- Muon Scintillator Veto:no event within 200 μs window around the trigger
- Single Detector Event with Energy deposition with >4σ above mean noise
- 2σ nuclear recoil band
- Phonon Timing/Surface Events cut
- Expected Electron Bkgd 0.6±0.5 events
- Expected neutron <0.2 events
- Gammas rejected>10^6

Analysis Routine

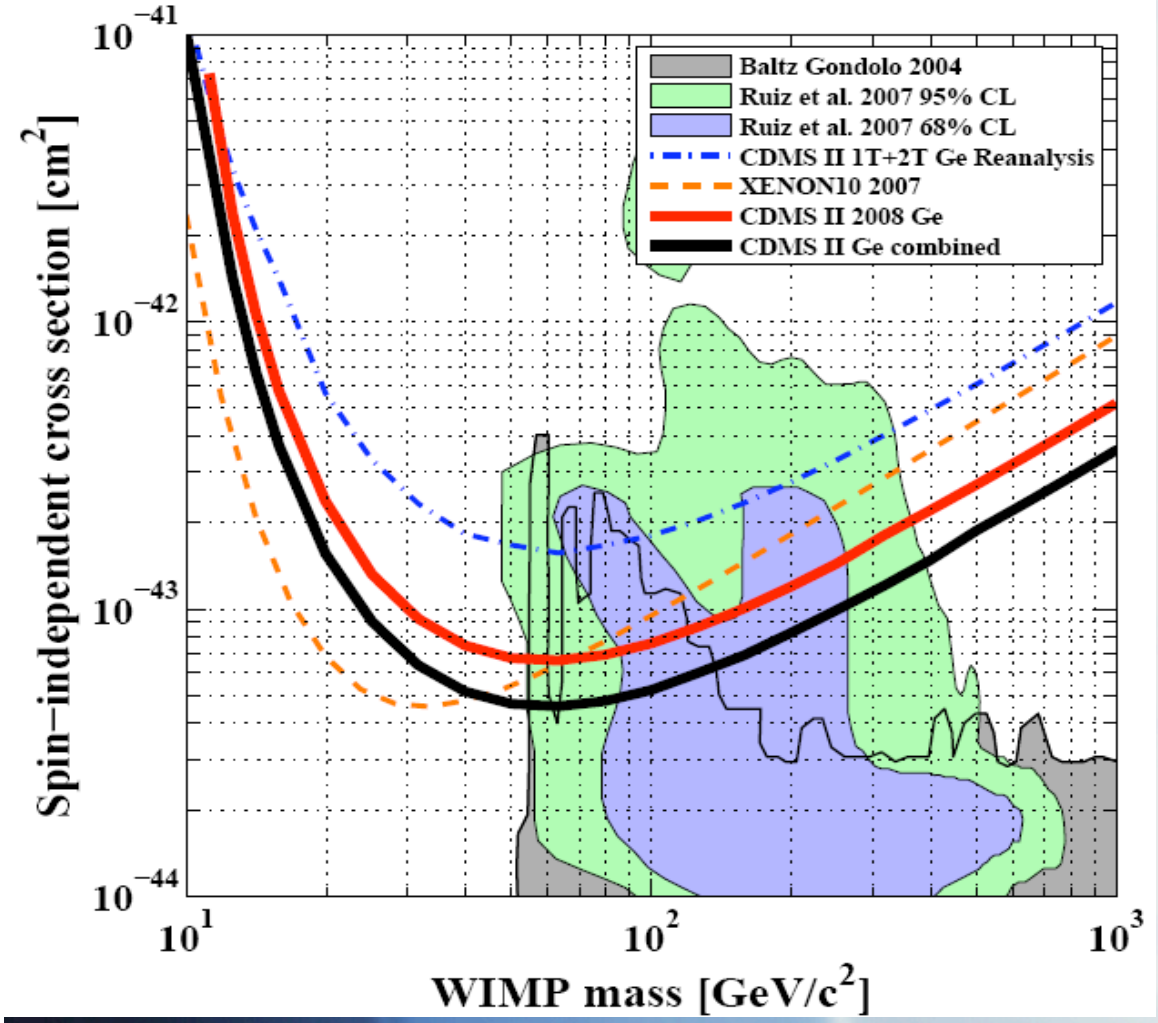


With and Without Timing Cut



PRL 102, 011301 (2009)

Spin Independent Limit



- No events observed
  "Zero" background
- CDMSII 2008 @60GeV:
  $\sigma=6.6\times10^{-44}$cm^2 (90%CL)

- CDMSII Combined
  (add data collected during Oct. 2006 - July 2007)
  @60GeV:
  $\sigma=4.6\times10^{-44}$cm^2 (90%CL)

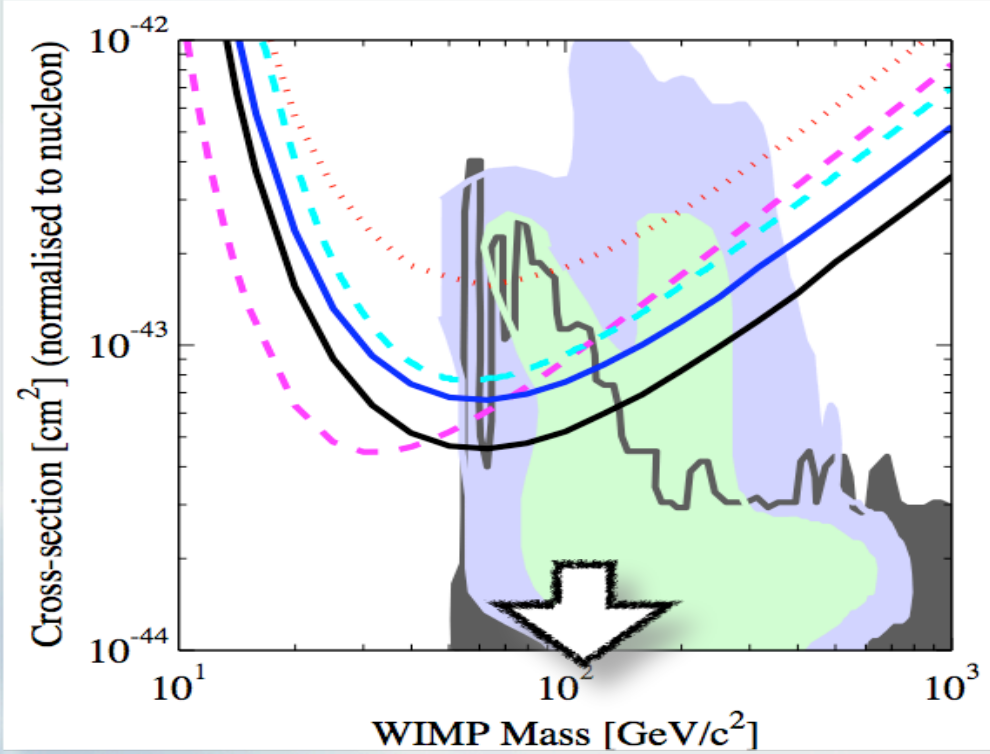
Push the Current Limit

- CDMS II 2008 398 kg/day raw data;121 kg/day after "cuts"
- CDMS II 2009 close to 750 kg/day before "cuts"
- Ongoing Analysis

of Remaining Data

End Run March 18

2009



Five Tower Runs (2006-8)

30 ZIPs (5 Towers) installed in Soudan icebox:

4.75 kg Ge, 1.1 kg Si

	T1	T2	T3	T4	T5
Z1	G6	S14	S17	S12	G7
Z2	G11	S28	G25	G37	G36
Z3	G8	G13	S30	S10	S29
Z4	S3	S25	G33	G35	G26
Z5	G9	G31	G32	G34	G39
Z6	S1	S26	G29	G38	G24

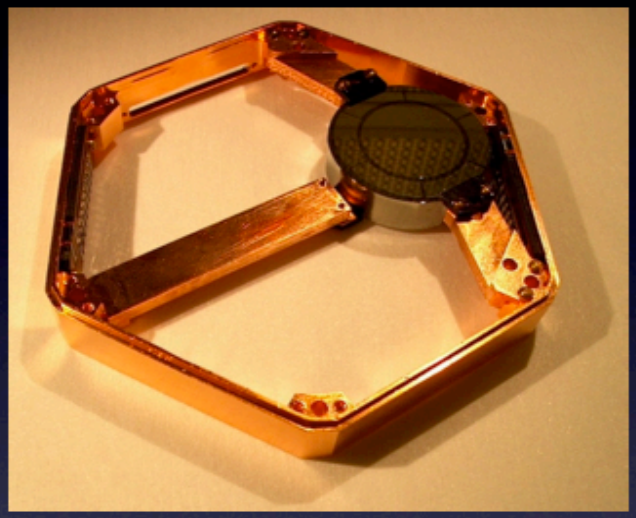
Side View

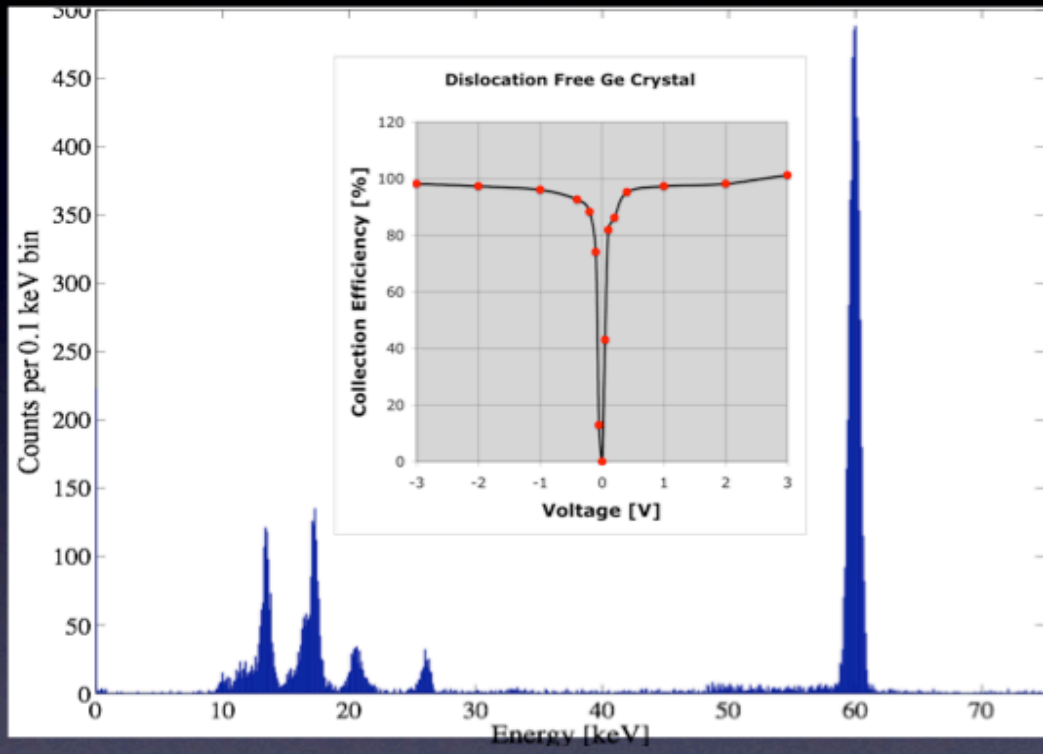
Combination of Ge and Si Detectors

- Neutron background measurement
- WIMP Mass Measurement
- Ge more sensitive to higher mass WIMPs, Si to lower mass WIMPs

Path to Large Ge Crystals - purity

Charge collection in dislocation-free Ge (Berkeley, February 2008)





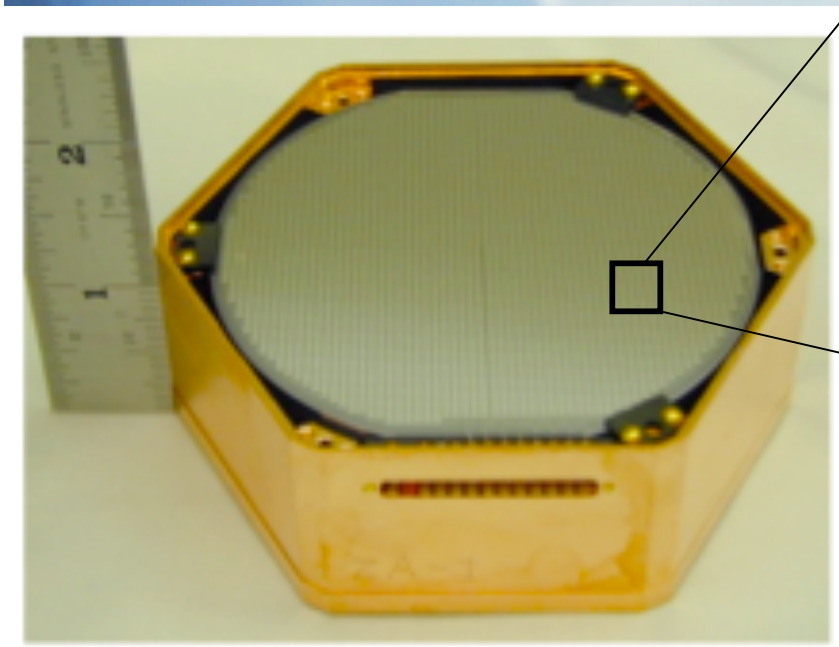
- 3cm x 1cm sample of H-grown dislocation-free Ge (E.E. Haller)
- Unusable @77K, but can be neutralized at <100mK
- Excellent charge collection @ low voltages
- *Available in >6" diameters (standard detector grade Ge limited to 3-4")*

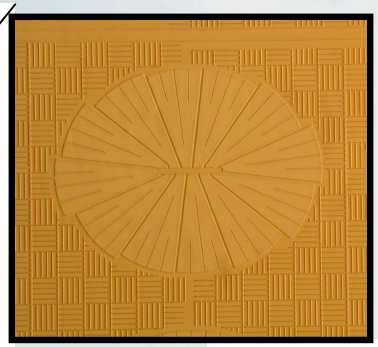
3"x1cm: 250g (CDMS II)

6"x2": 5kg?

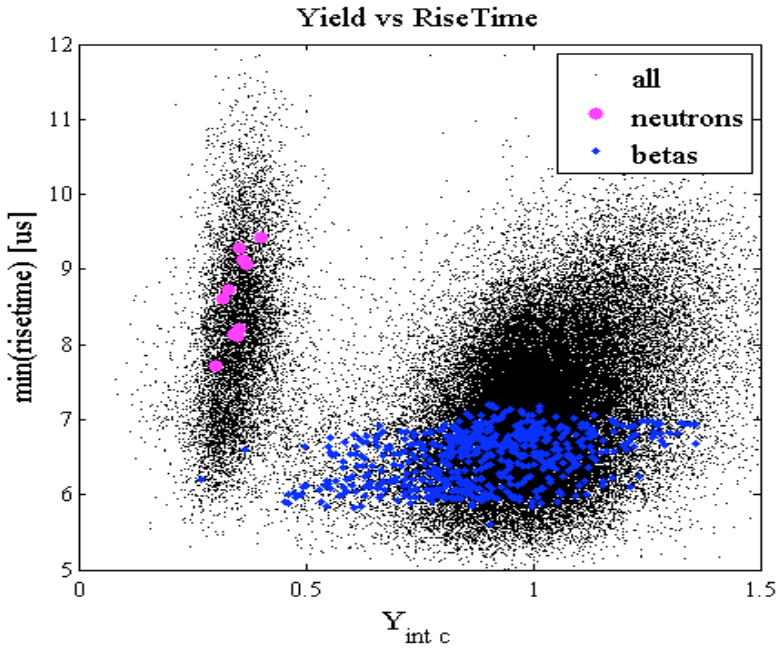
SuperCDMS at Soudan 2009

Super Tower installed. Collecting Data.
Detector 1”thick and 7 cm in diameter--> 600 grams

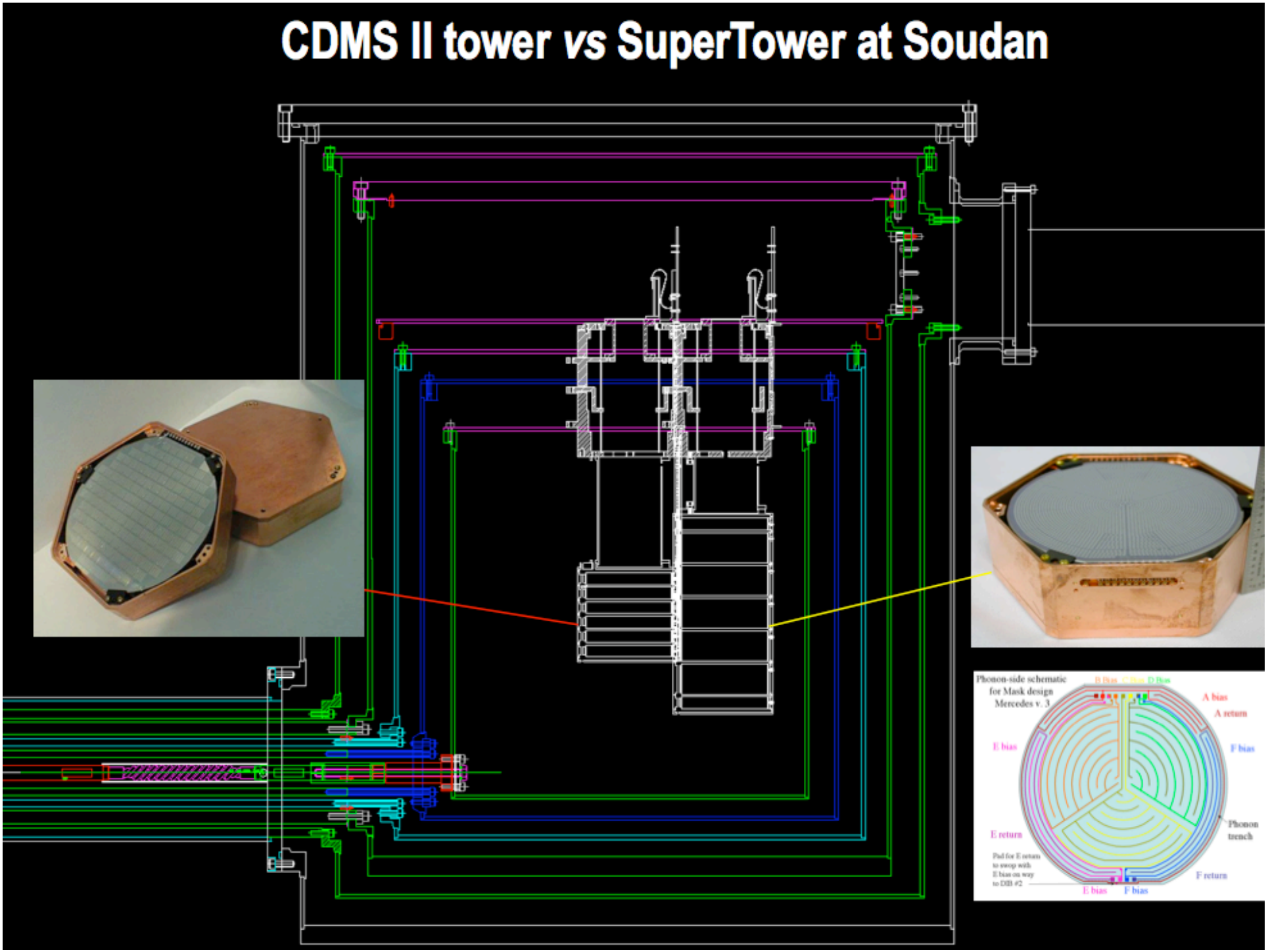




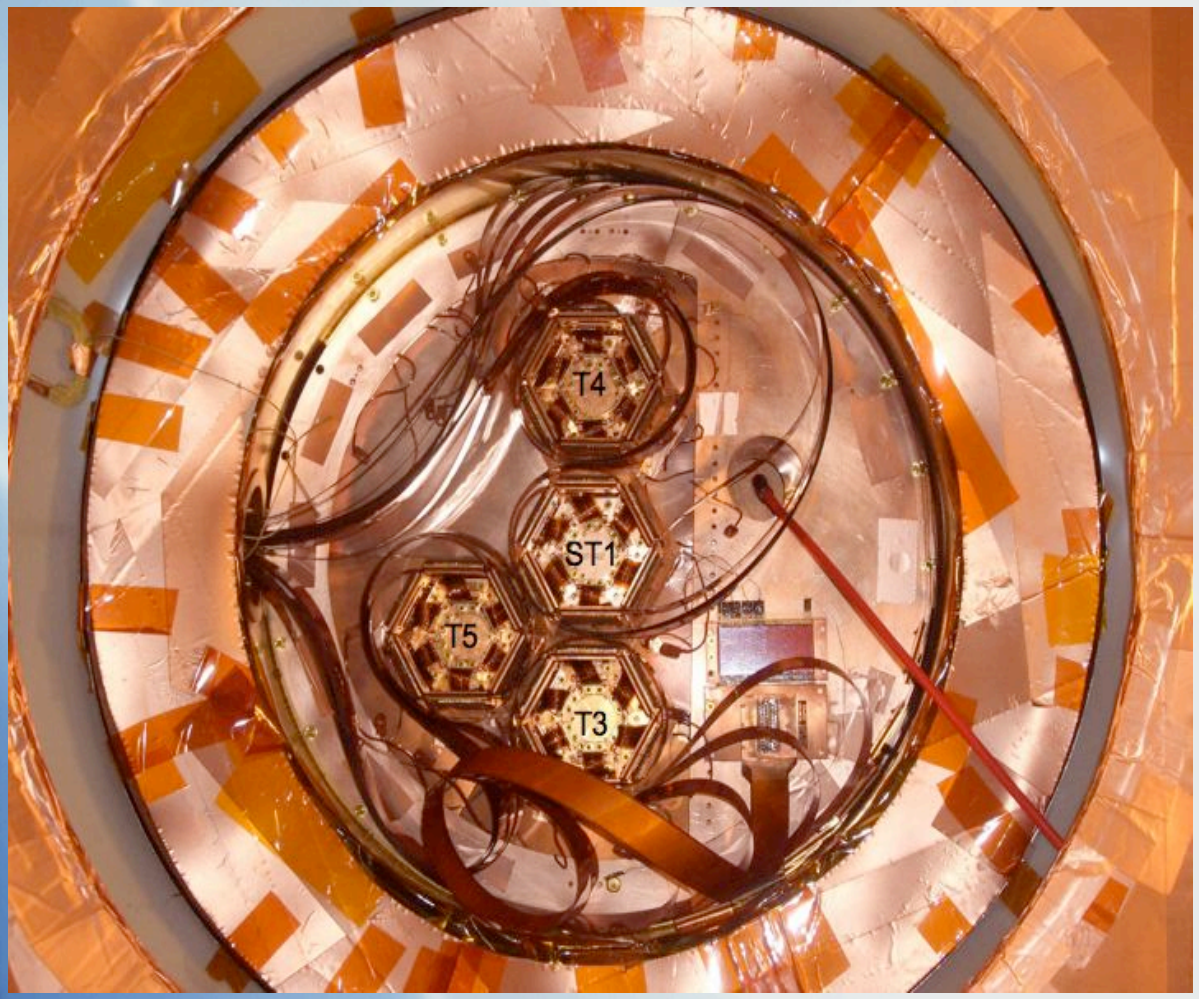
Phonon collection improved
Better background rejection



CDMS II tower *vs* SuperTower at Soudan



First Super Tower Installed



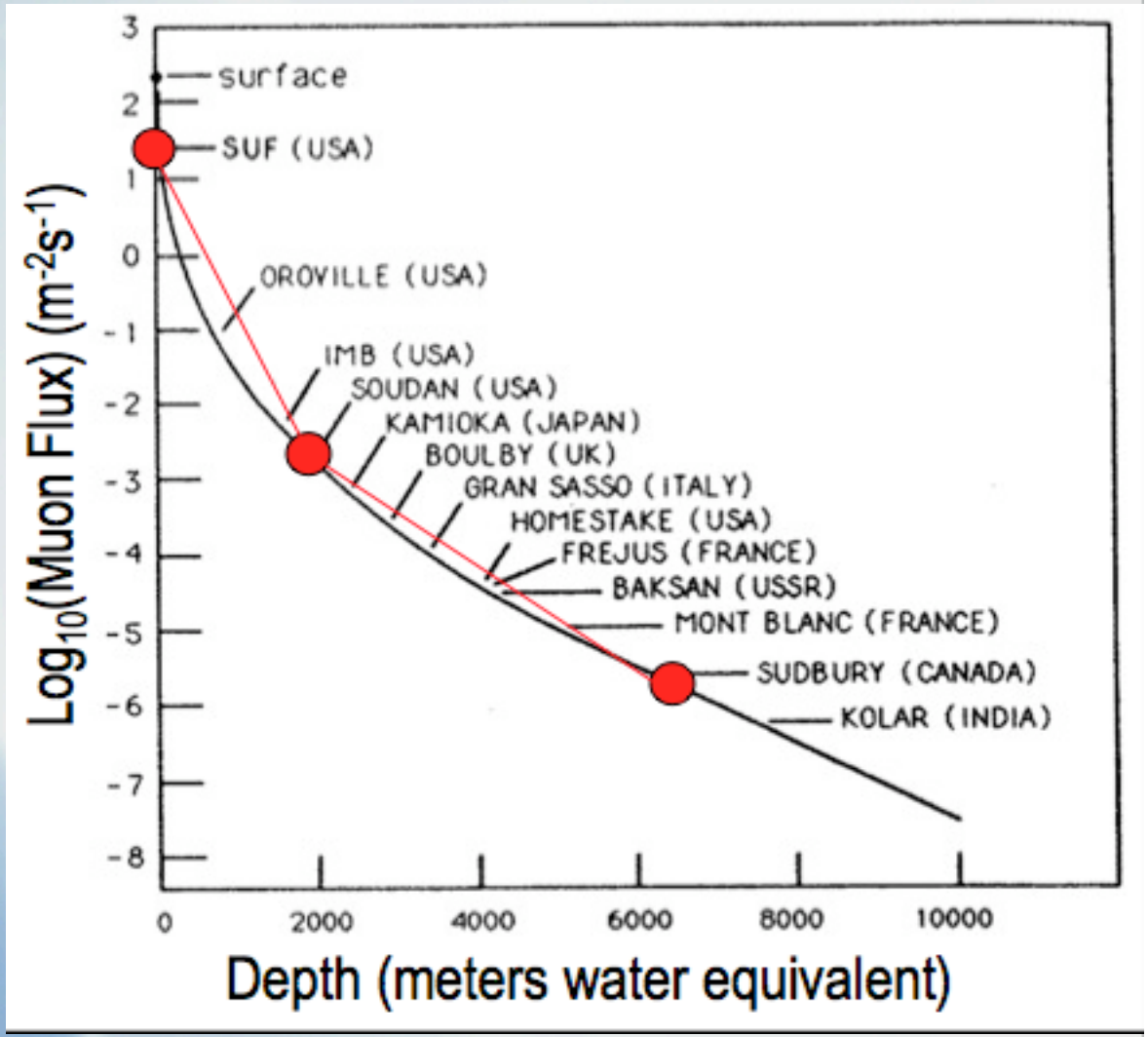
Plans

- Super Towers

Operation w/15 kg Ge for 2 years @ Soudan 2090 mwe; 0.05 n/y/kg

- Going deeper:

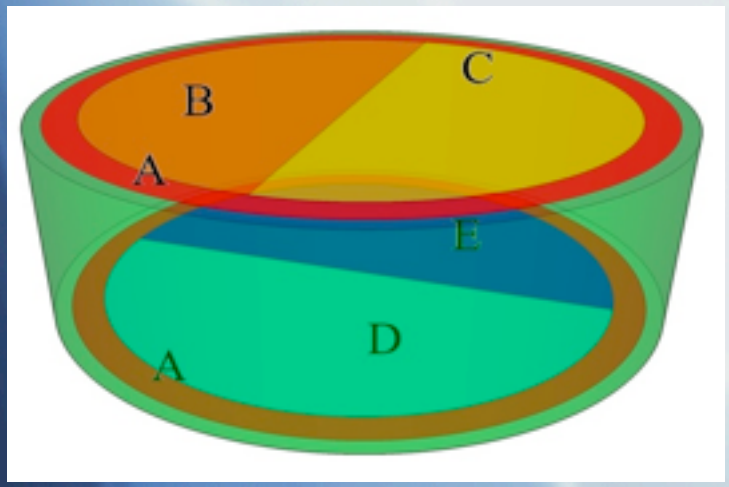
SNOLAB 100 kg Ge; 6060 mwe; 0.2 n/y/ton

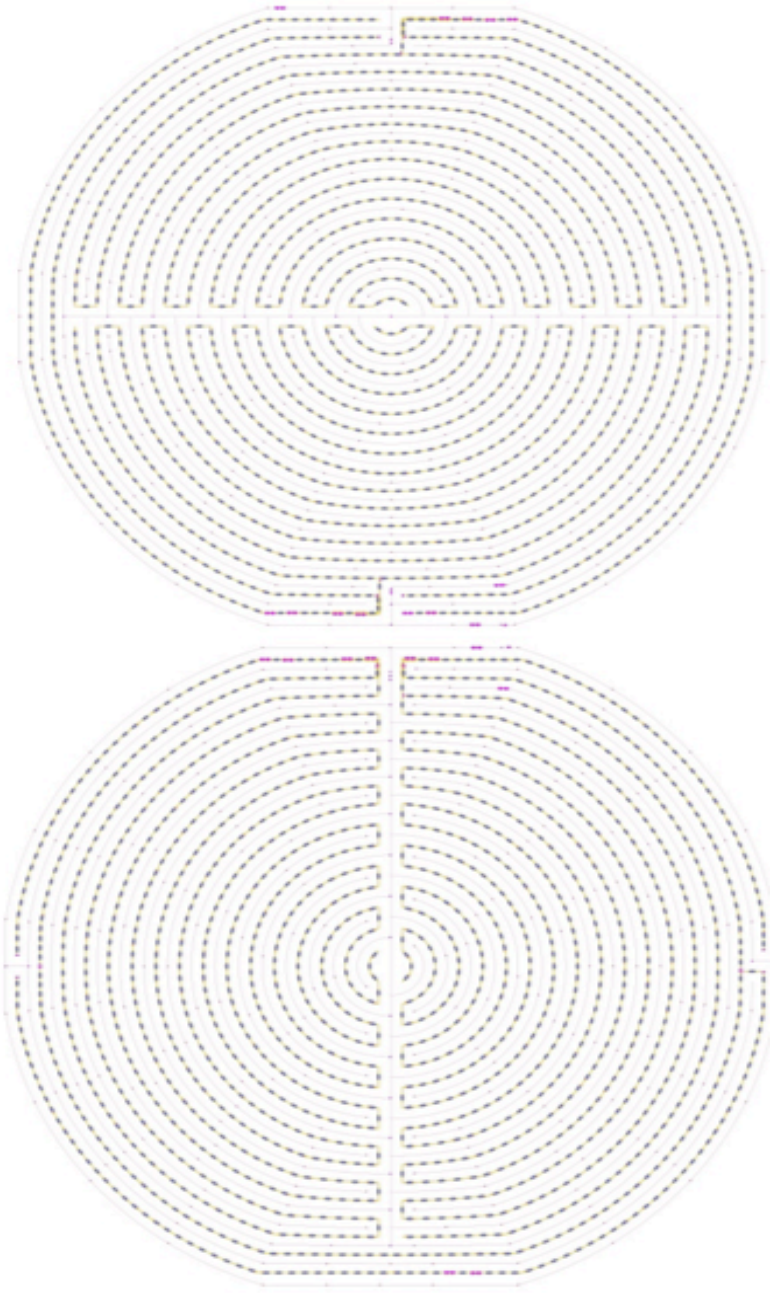


Future Detectors…

- iZIP/double-sided detectors with outer phonon channel (A) to reject perimeter events.

  iZIP charge electrodes interleaved with narrow strips occupied by phonon sensors. Less phonon timing information for surface events But now charge channels can veto surface events





Plans


Activity Name
2008
2009
2010
2011
2012
2013
2014
2015
2016
1 CDMS II
2 Operations
3 Expected Sensitivity
4kg, 2E-44 cm2
4
5 SuperCDMS Soudan
6 Detector R&D
7 Construction
8 Operations
9 Expected Sensitivity
15 kg, 5E-45 cm2
10
11 SuperCDMS SNOLAB
12 Detector R&D
13 Construction
14 SNOLAB facility
15 100 kg detector payload
16 Operations
17 100 kg detector payload
18 Expected Sensitivity
19 100 kg sensitivity
100 kg, 3E-46 cm2
20
21 GEODM...
2008
2009
2010
2011
2012
2013
2014
2015
2016

Thank You, CDMS Collaboration!!!

Brown University

M.J. Attisha, R.J. Gaitskell

Case Western Reserve University

D.S. Akerib, C. Bailey, P. Brusov, M.R. Dragowsky, D.D.Driscoll, D. Grant, R. Hennings-Yeomans, S.Kamat, T.A. Perera, R.W.Schnee, G.Wang

California Institute of Technology

S.Golwala, Z.Ahmed, J. Filippini

Fermi National Accelerator Laboratory

D.A. Bauer, M.B. Crisler, R. Dixon, F. DeJongh, D. Holmgren, L. Hsu, J.Hall, E.Ramberg, J. Yoo

Lawrence Berkeley National Laboratory

R. McDonald, R.R. Ross, A. Smith

Massachusetts Institute of Technology

E.Figueroa-Feliciano, S.Hertel, K.McCarthy

National Institute for Standards and Technology

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