Dark Matter Direct Detection
Who will win the race?

Prof. Rupak Mahapatra

Texas A&M University

COSMO/CosPA, 2010

TEXAS A&M UNIVERSITY

Dark Matter Direct Detection
Anyone can win the race!

Prof. Rupak Mahapatra
Texas A&M University

COSMO/CosPA, 2010

TEXAS A&M UNIVERSITY

CDMS

The New York Times

Space & Cosmos

At a Mine's Bottom, Hints of Dark Matter

By DENNIS OVERBYE
Published: December 17, 2009

An international team of physicists working in the bottom of an old iron mine in Minnesota said Thursday that they might have registered the first faint hints of a ghostly sea of subatomic particles known as dark matter long thought to permeate the cosmos.

Enlarge This Image

Fermilab

The particles showed as two tiny pulses of heat deposited over the course of two years in chunks of germanium and silicon that had been cooled to a temperature near absolute zero. But, the scientists said, there was more than a 20 percent chance that the pulses were caused by fluctuations in the background radioactivity of their cavern, so the results were tantalizing, but not definitive.

Gordon Kane, a physicist from the University of Michigan, called the results "inconclusive, sadly," adding, "It seems likely it is dark matter detection, but no proof."

Dr. Kane said results from bigger and thus more sensitive

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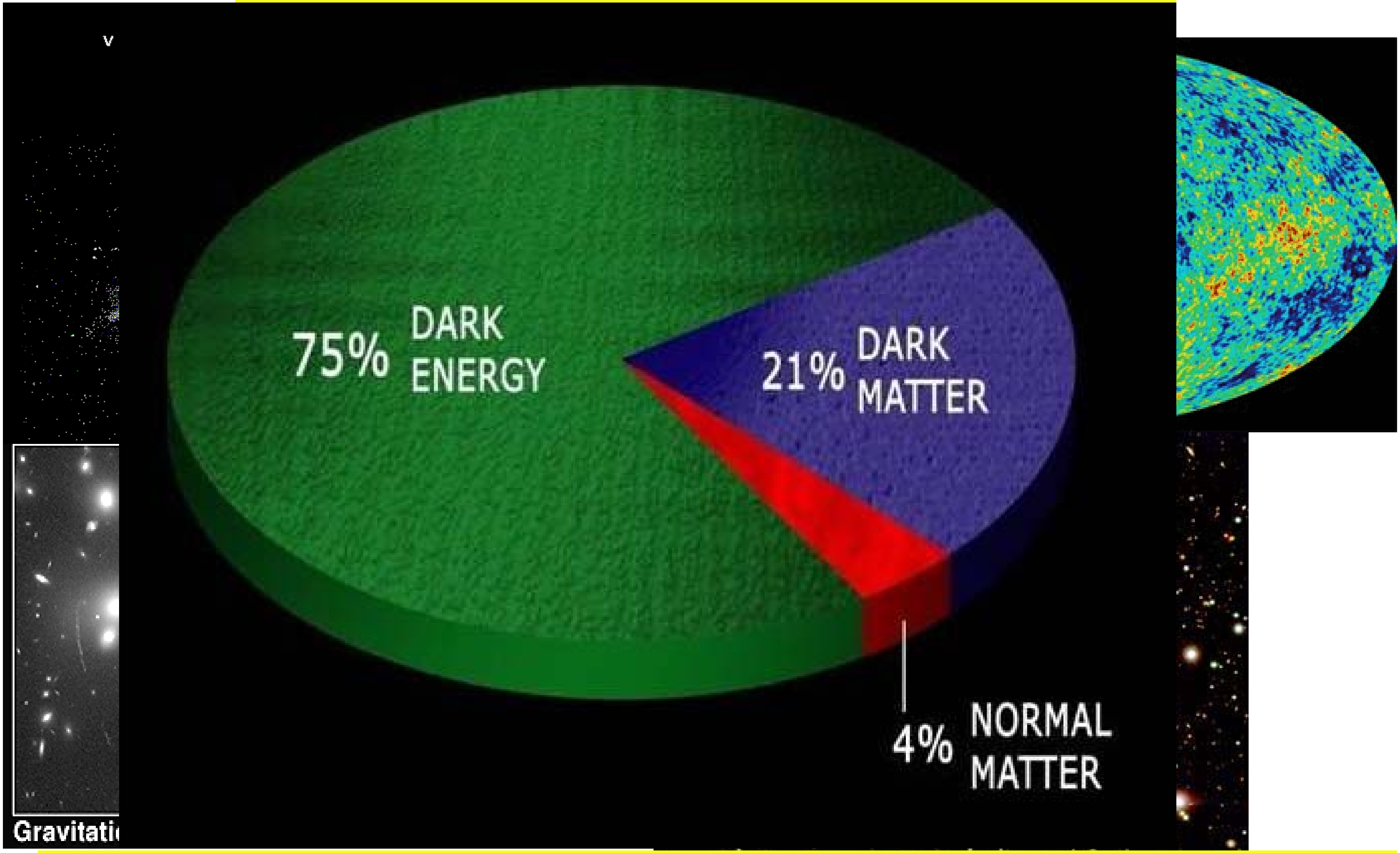
Outline

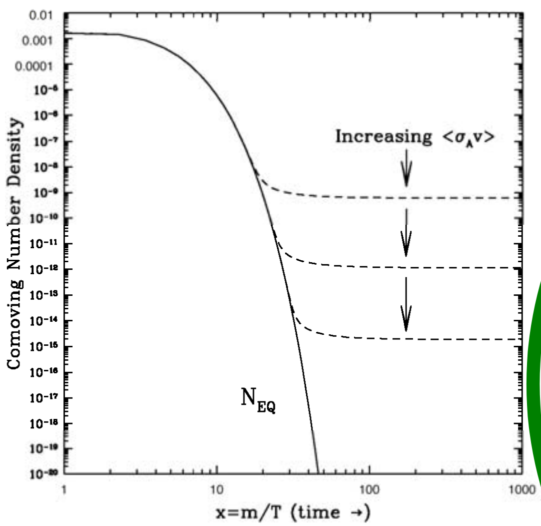
- **Dark Matter Direct Detection General Technique**
- **Cryogenic Dark Matter Search (CDMS)**
- **G2 ($10^{-46}cm^2$) 100kg SuperCDMS, G3 1.5ton GEODM**
- **Other Technologies: Noble liquid, Bubble Ch**
- **The Technical/Funding Landscape and future**

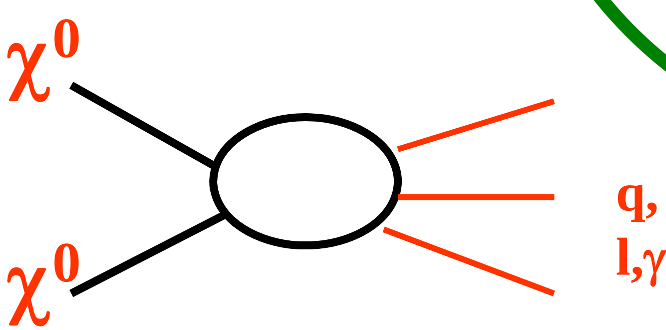
Dark Matter exists …



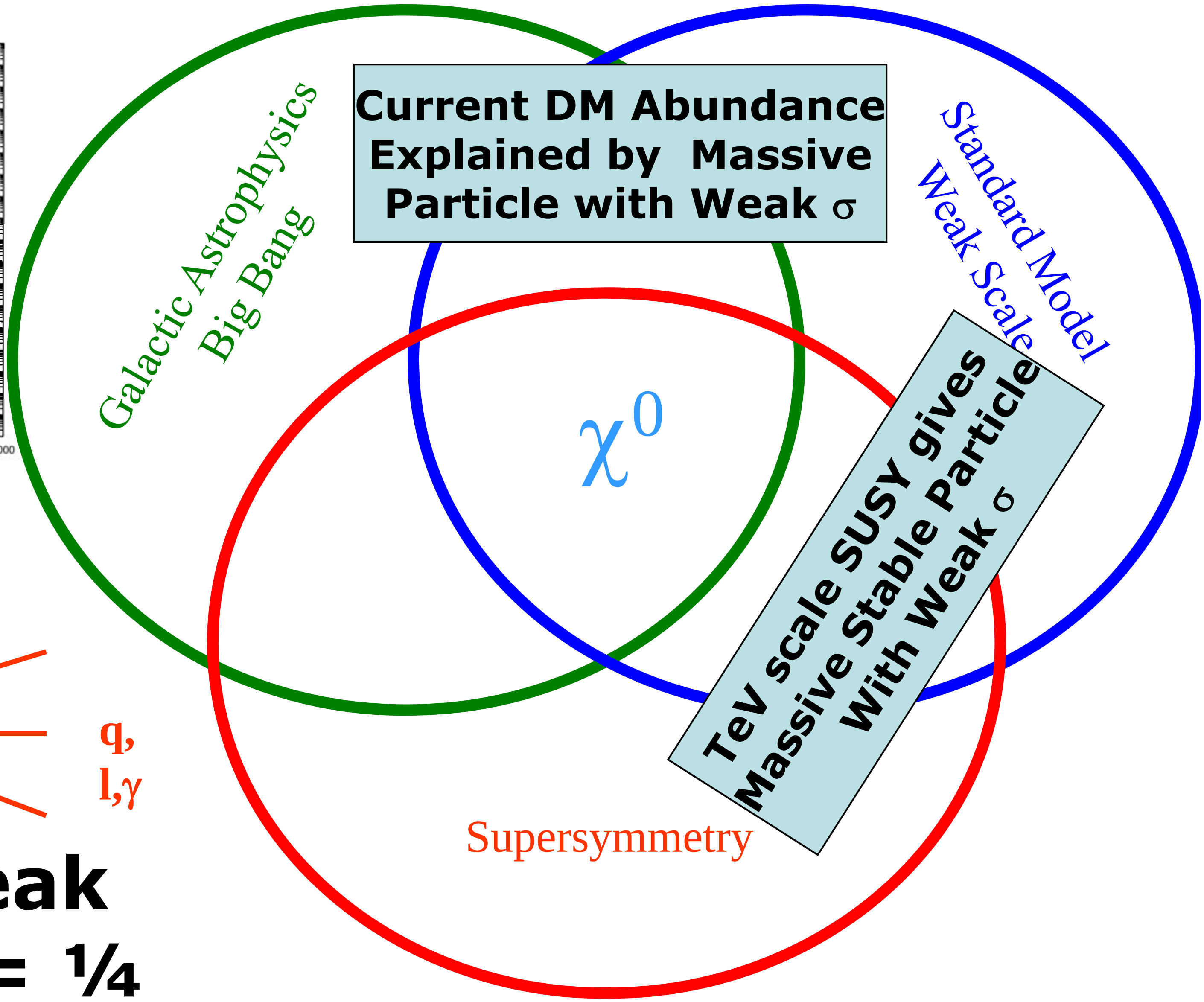
What is it made of? Can we detect it?

Coincidence or Clue? A Convergence





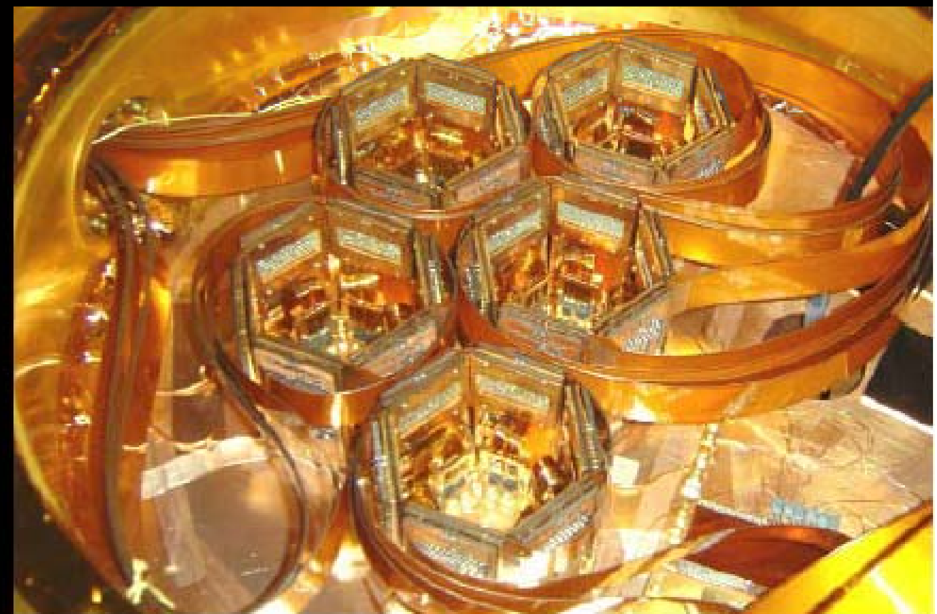
σ_{ann} ~ weak
gives Ω_χ = ¼



Compelling evidence to suspect LSP χ0 as the WIMP

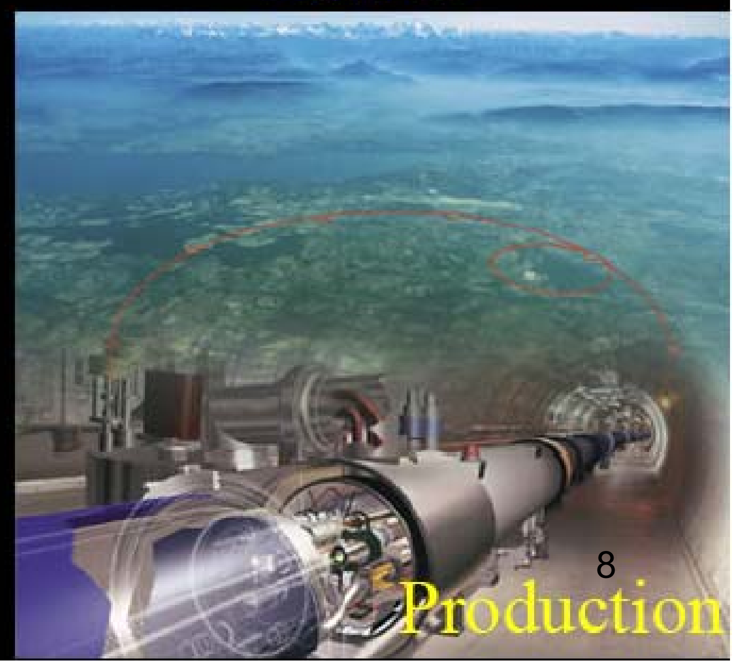
Four roads to dark matter:

Gravitational



Direct

Indirect



Production

Direct Detection

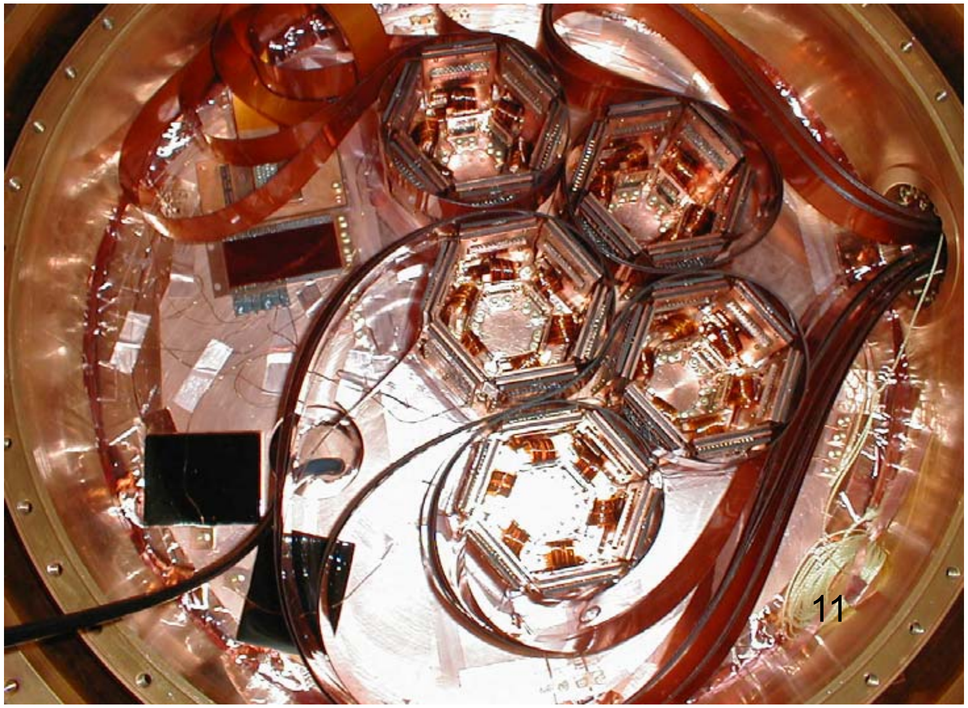
Goals:

- Directly Detect WIMPs as Earth Ploughs through the DM Halo
- Measure Mass and Scattering cross-section

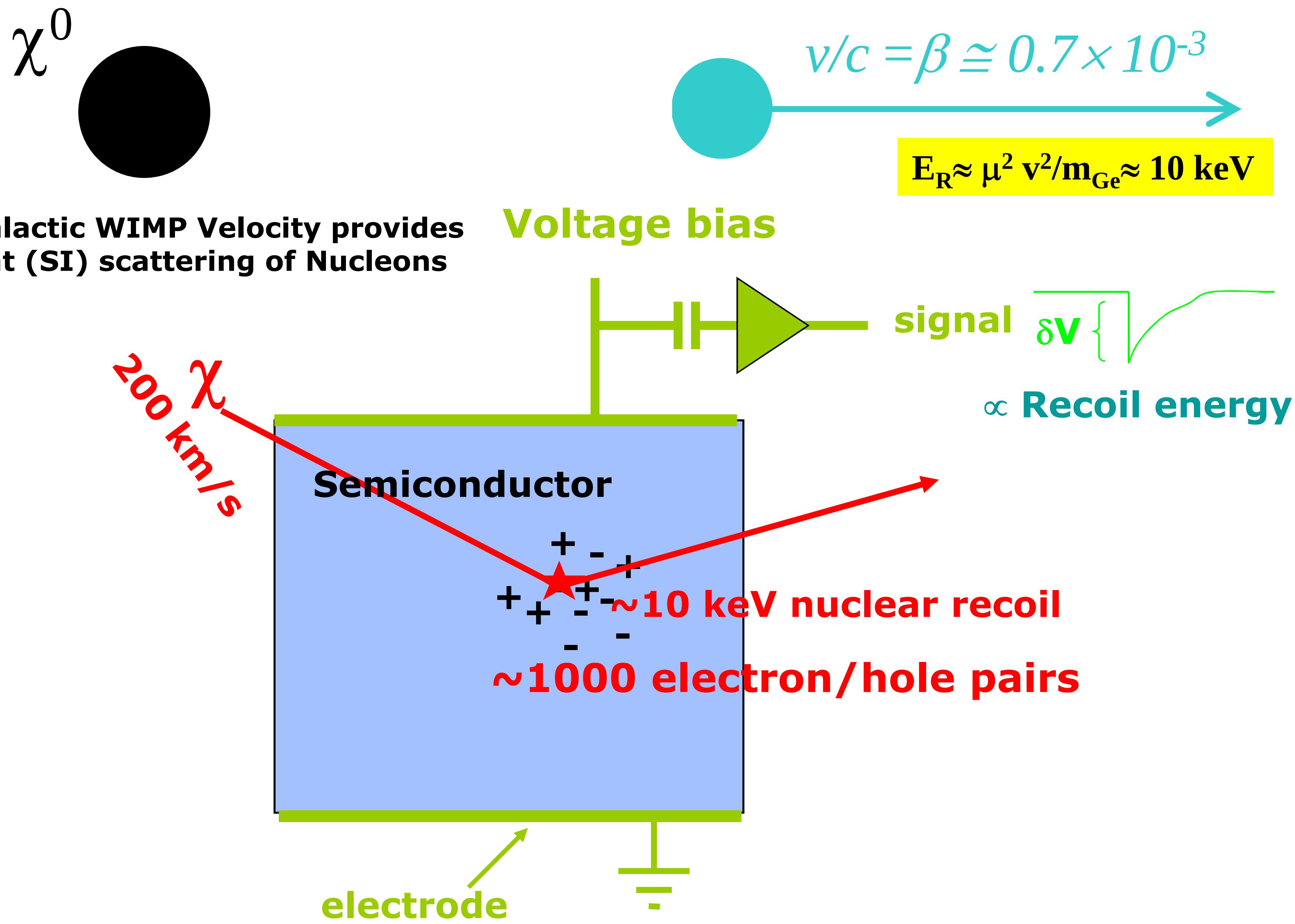
Challenges:

- Very low flux & rate
- Must maintain ultra low background < few events/year

Out there & may interact on earth!



Modern Chadwick Experiment

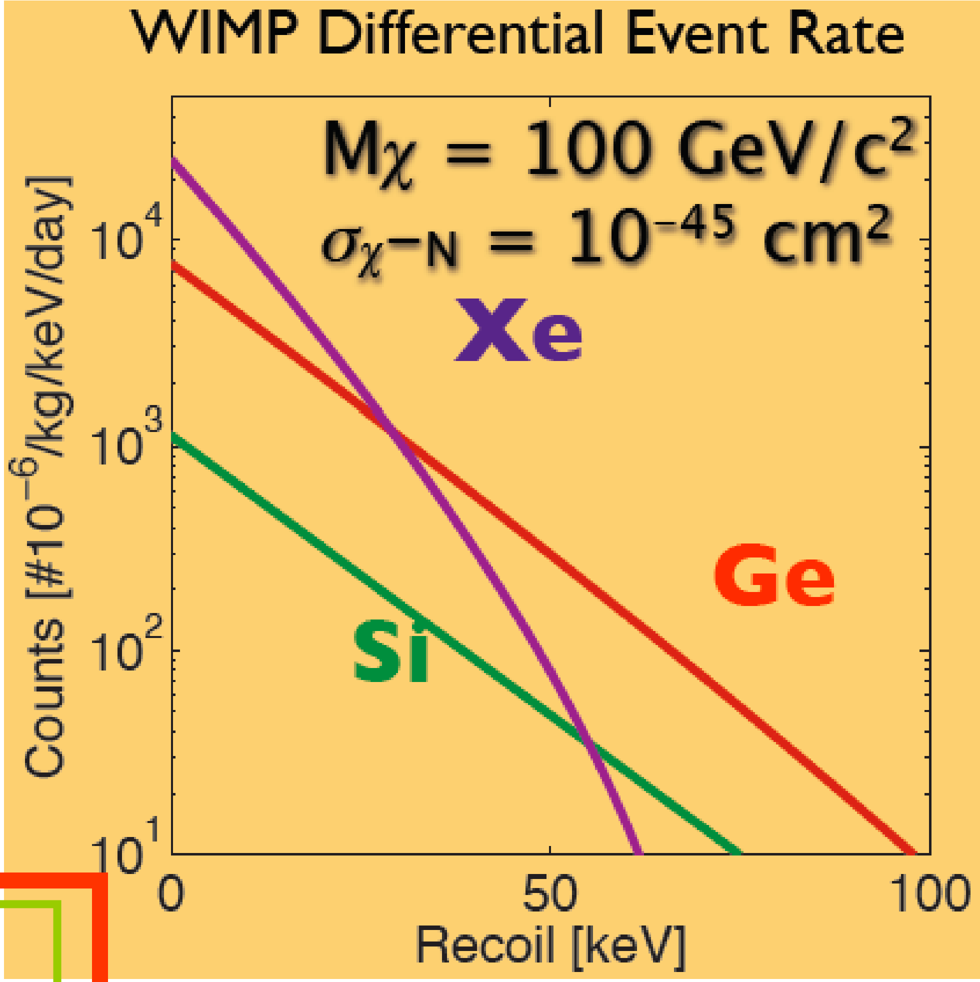


Slow Galactic WIMP Velocity provides coherent (SI) scattering of Nucleons

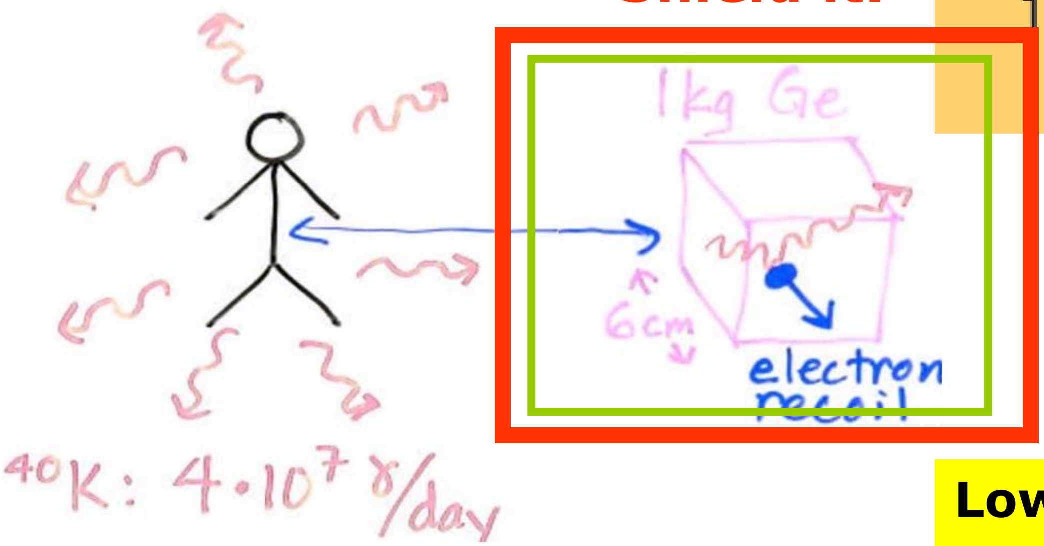
WIMP Hunting

Rate = N ϕ σ

- Weak Interaction $\sigma \sim 10^{-43} cm^2$
- Local halo density: $0.3 GeV/cm^3$
- Spin-Ind. Coherence: A^2 boost
- Expected rate <.01/kg-day



Shield it!

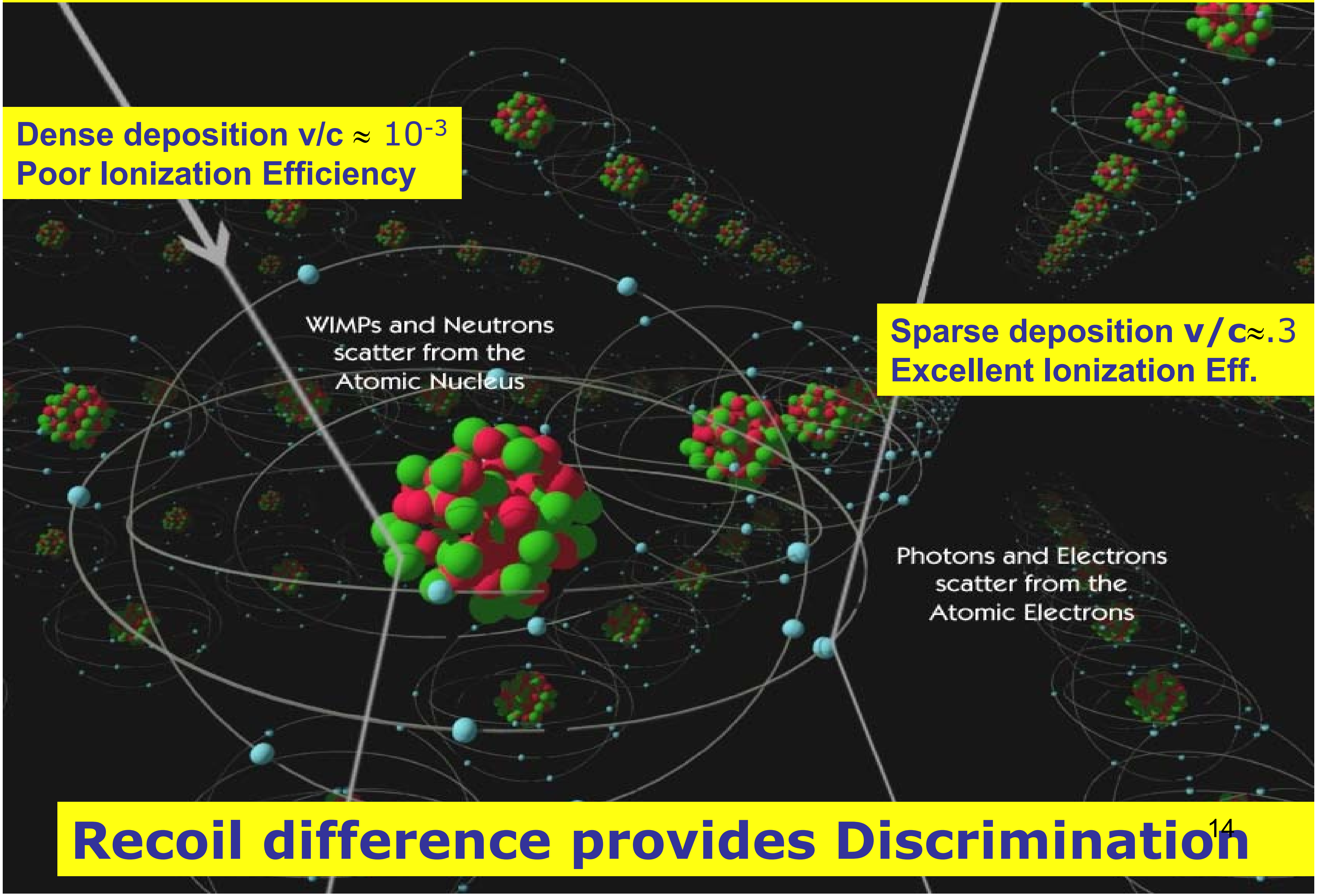


Background million X bigger

Low Background &Low Threshold essential for believable Discovery

Different Particles, Different Interactions

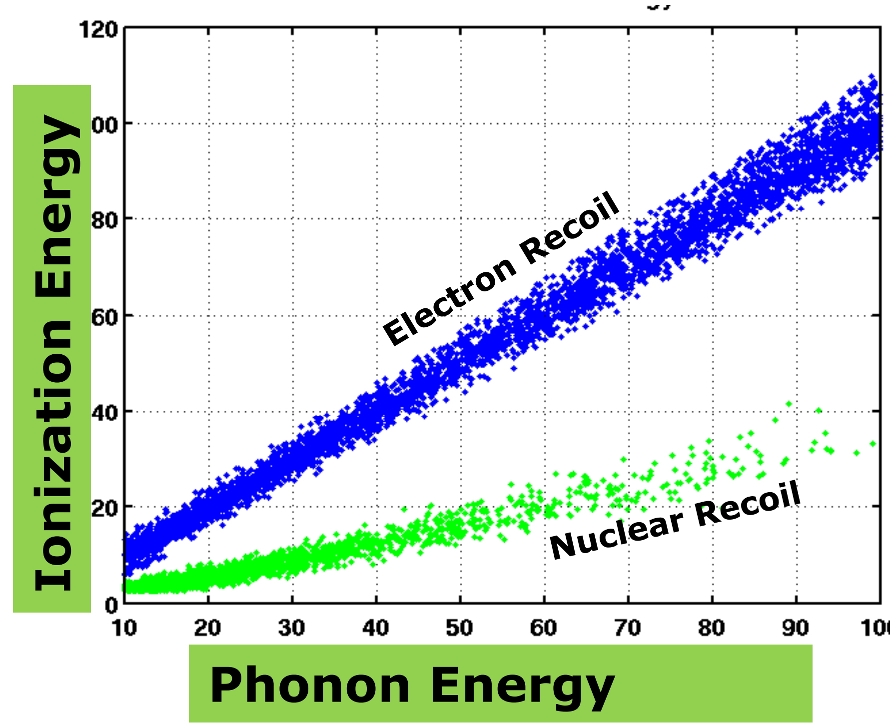
Dense deposition v/c ≈ 10^{-3}
Poor Ionization Efficiency

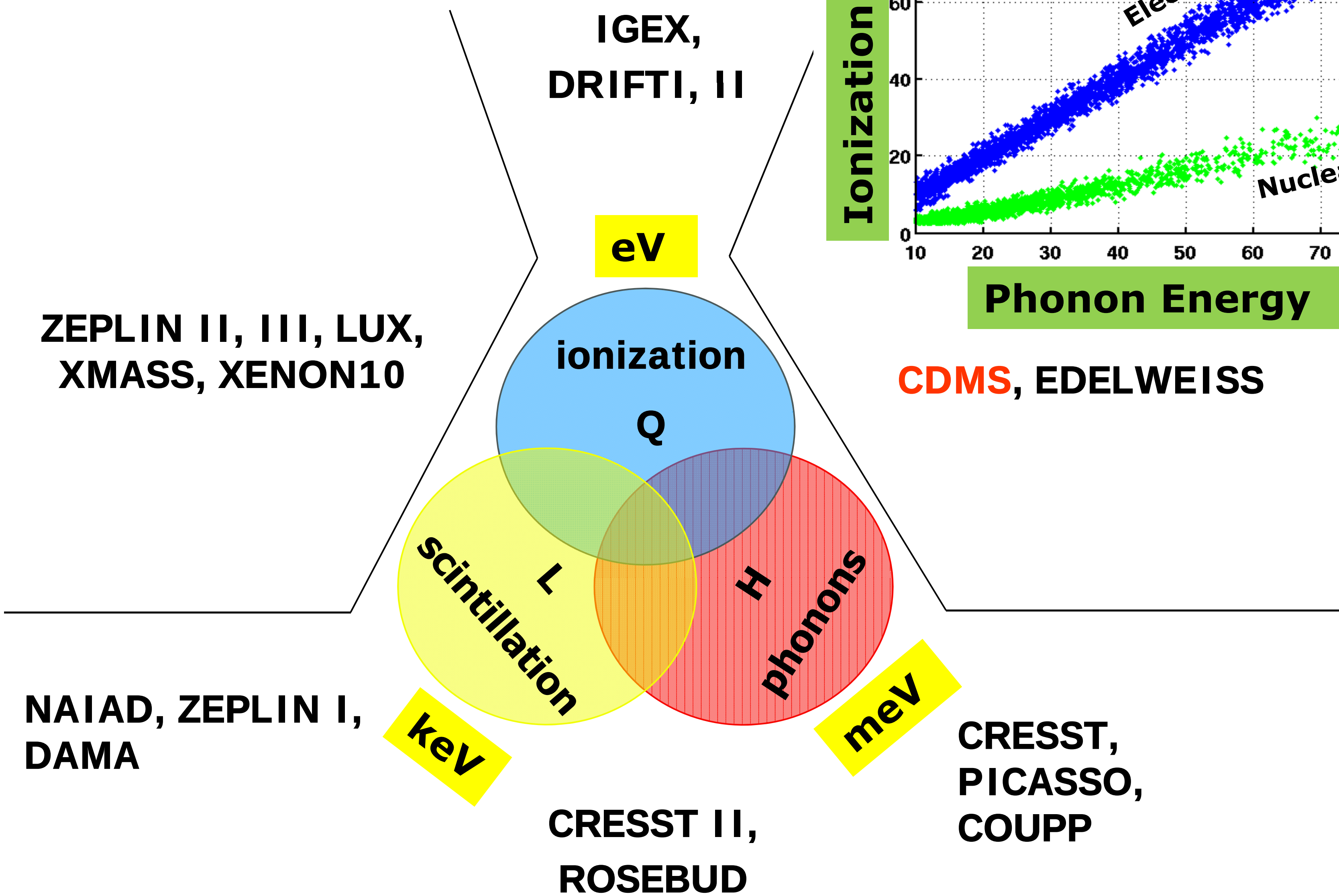


Sparse deposition v/c≈.3
Excellent Ionization Eff.

Recoil difference provides Discrimination

Discrimination: Detect More Than 1 Signal

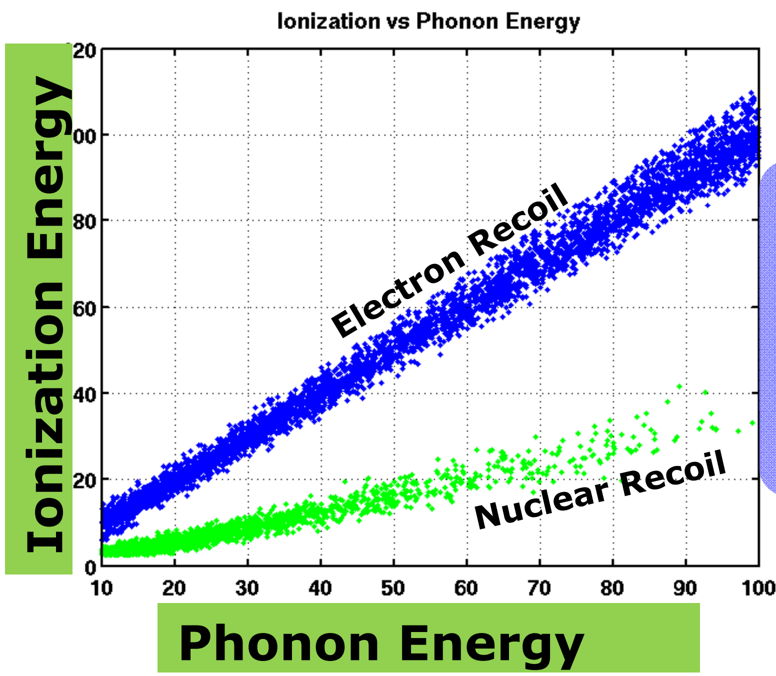




Experimental Techniques (alphabetic ordering)

- Ge detectors
  - CDMS
  - CoGeNT
  - Edelweiss
- Superheated Bubble Technology
  - COUPP
  - PICASO
- Single Phase Noble liquid Detectors
  - DEAP/CLEAN
  - XMASS
- Two Phase Noble Liquid Detectors
  - XENON/LUX
  - WARP/ArDM

CDMS: The Big Picture

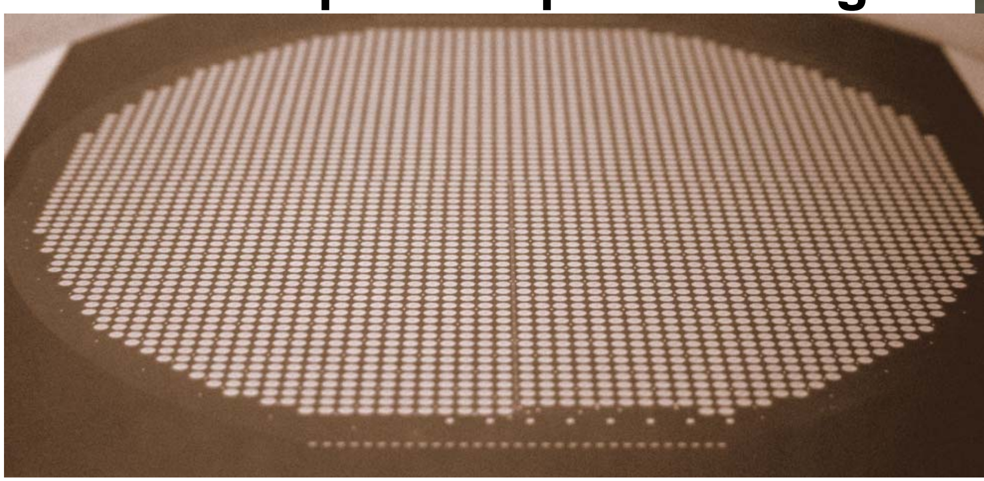


Discrimination & shielding for a zero background experiment with cryogenic Ge detectors with photo lithographically patterned sensors

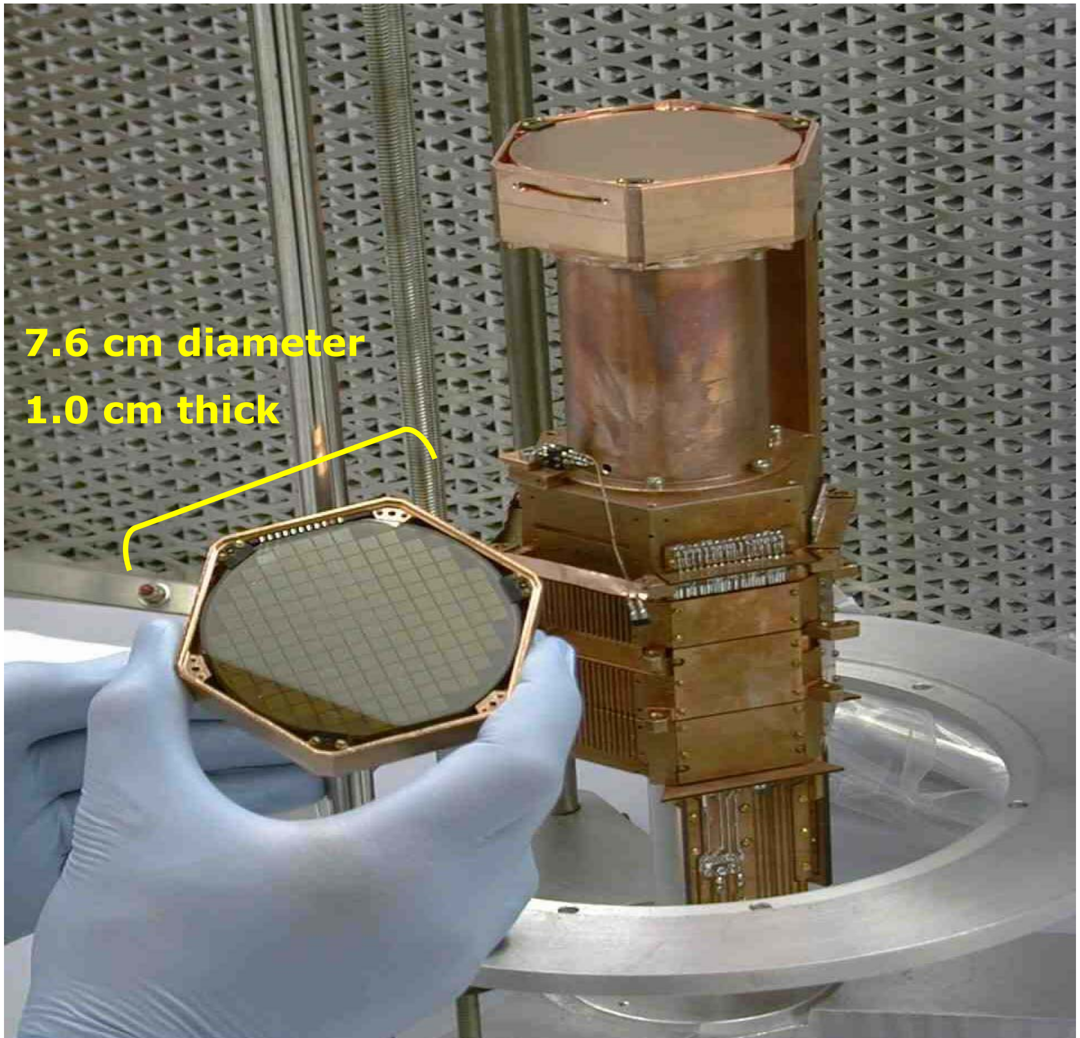
Shielding
- **Passive (Pb, poly, *depth*)**
- **Active (muon veto shield)**

Energy Measurement
- **Phonon & Charge**

Position measurement X-Y-Z
- **From phonon pulse timing**



ZIP Detectors



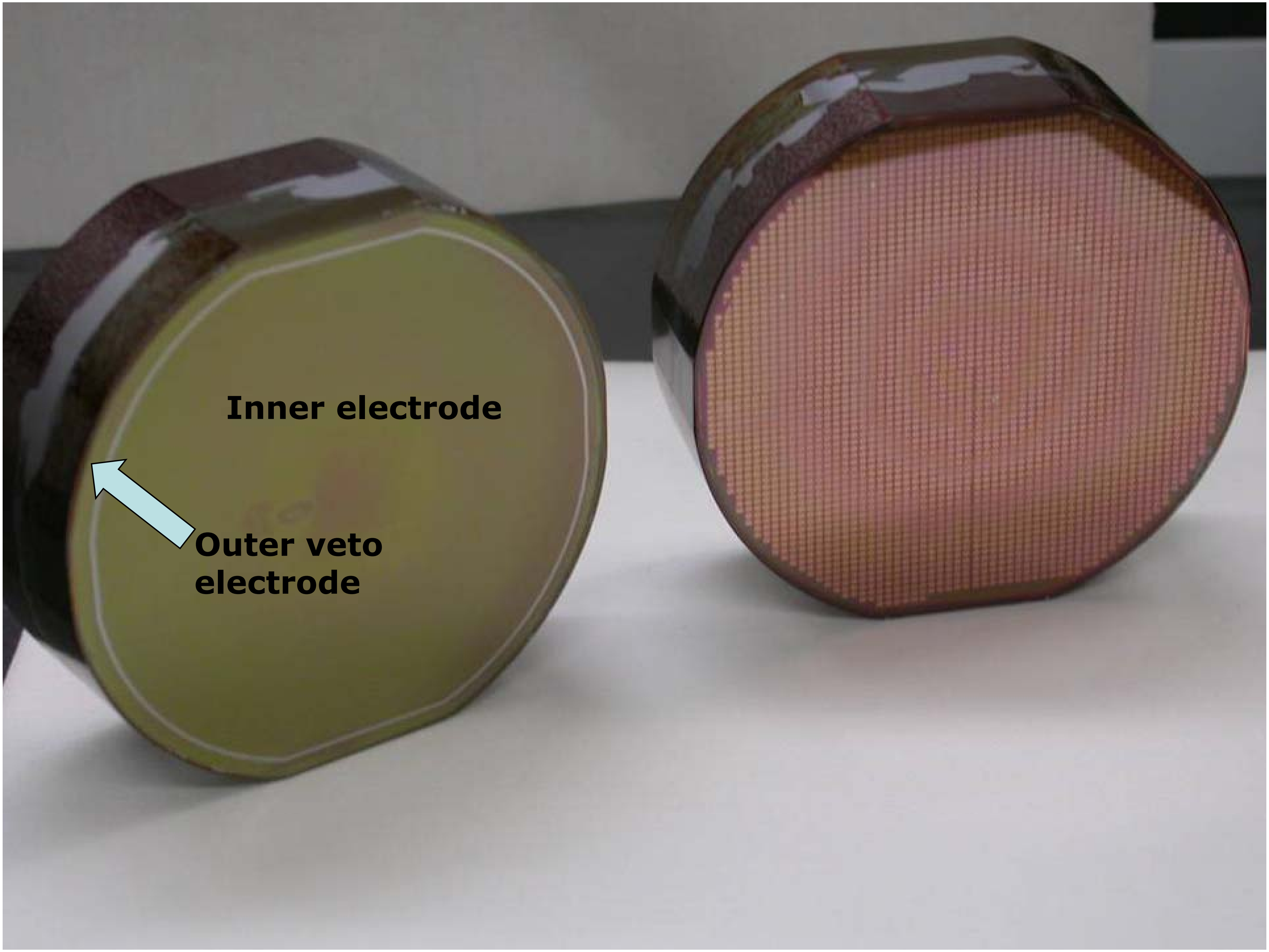
Ge: 640 gm,
3"dia x1" thick

Operated at **~40 mK** for good phonon signal-to-noise

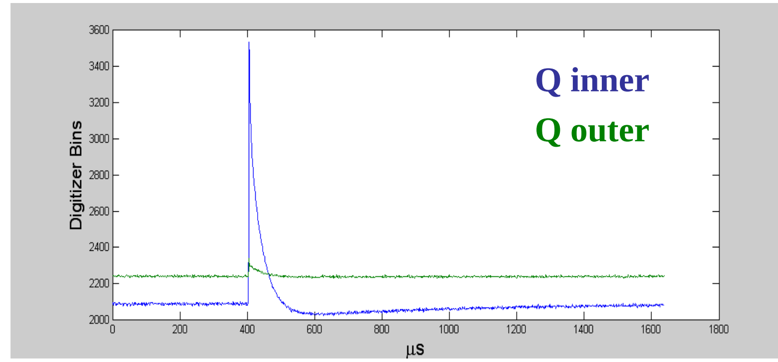
(Z-sensitive Ionization and Phonon)

Phonon side: 4 quadrants of athermal phonon sensors
Energy & Position (Timing)

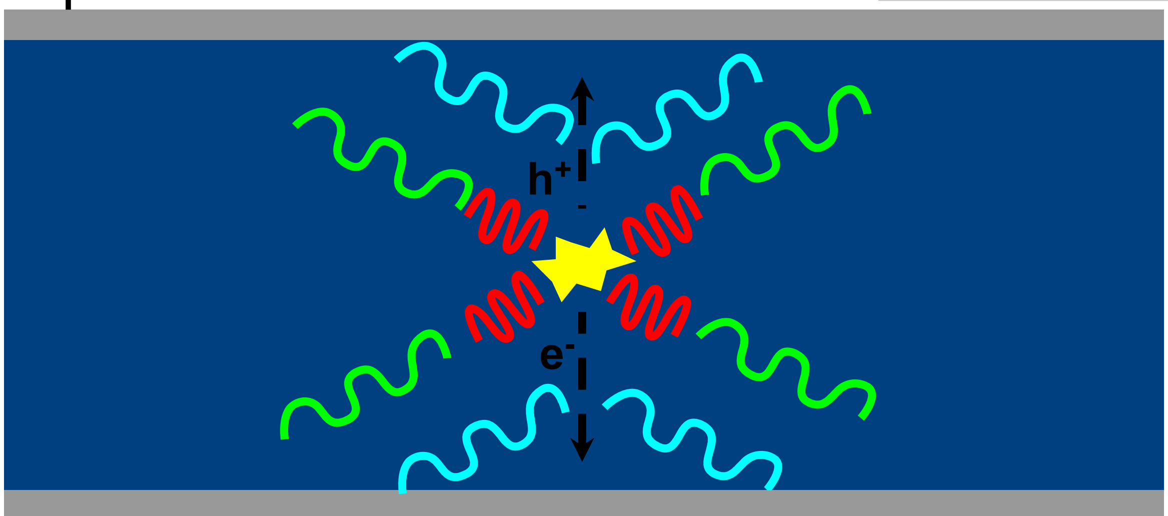
Charge side: 2 concentric electrodes (Inner & Outer)
Energy (& Veto)

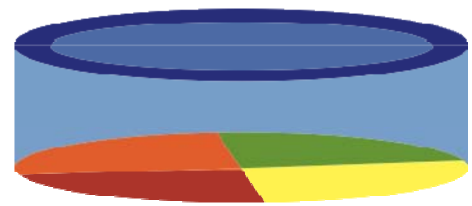

Inner electrode
Outer veto
electrode

Anatomy of an event



-3V Hot charge carriers (3eV/pair)

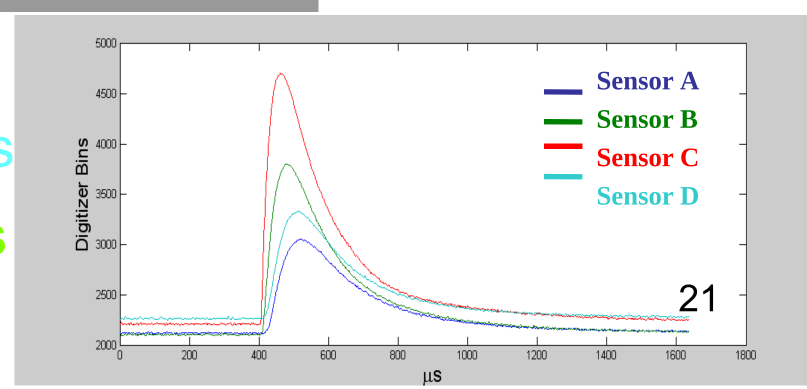




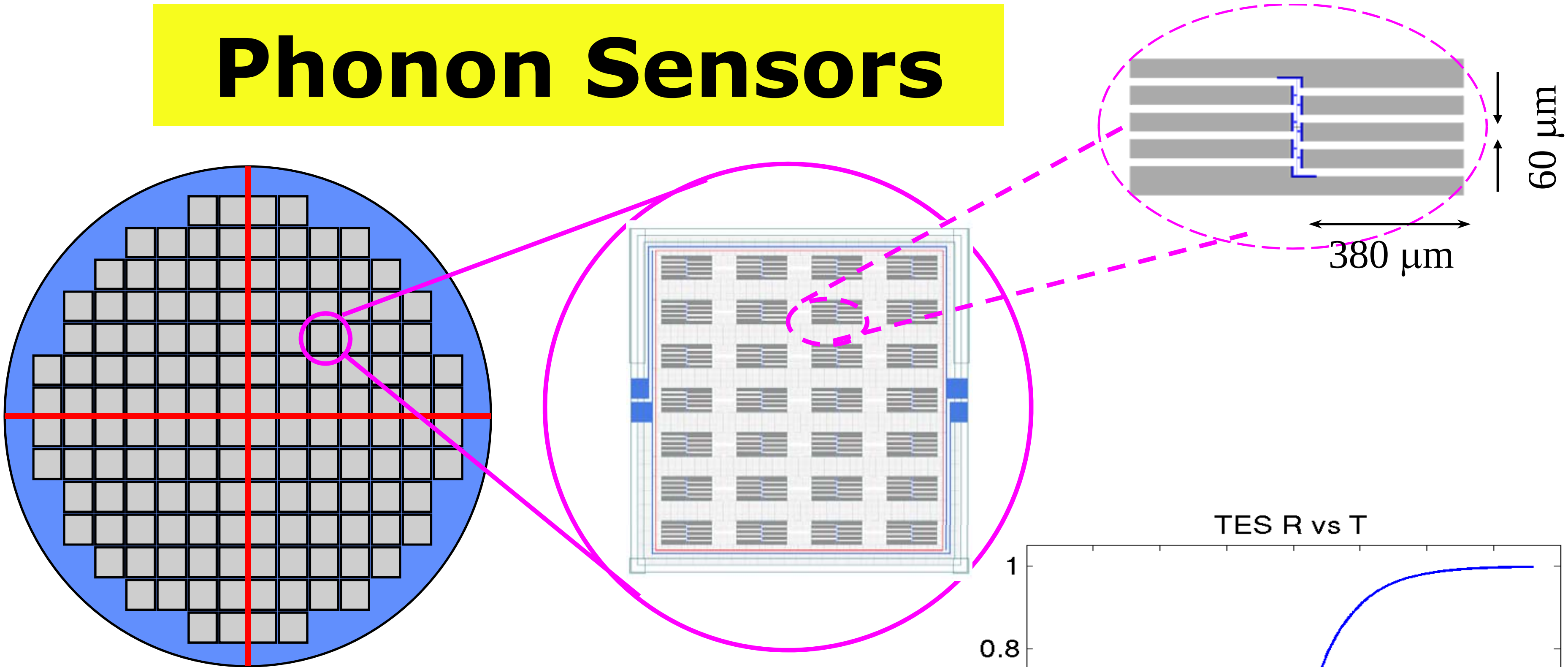
0V Quasi-diffusive THz phonons

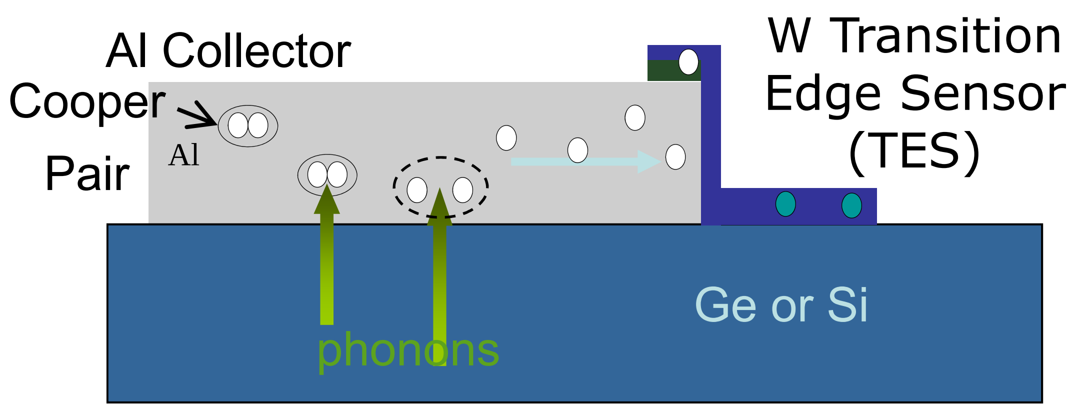
Ballistic Neganov-Luke phonons

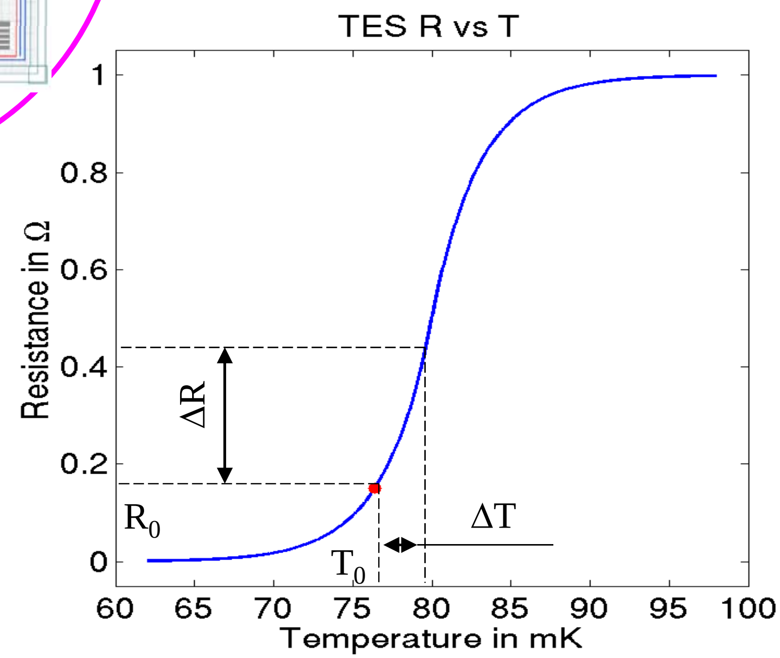
Ballistic low-frequency phonons



Phonon Sensors



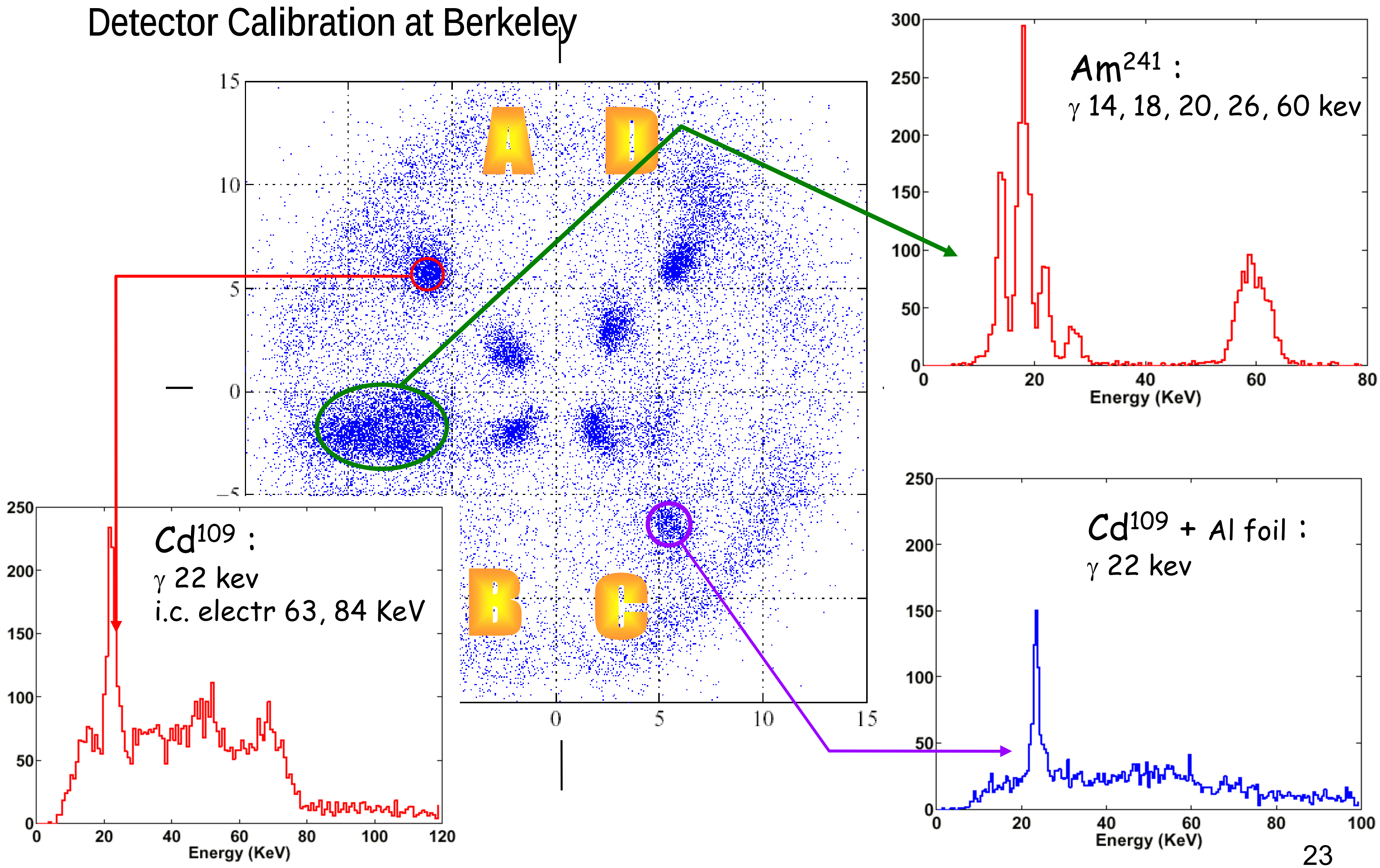




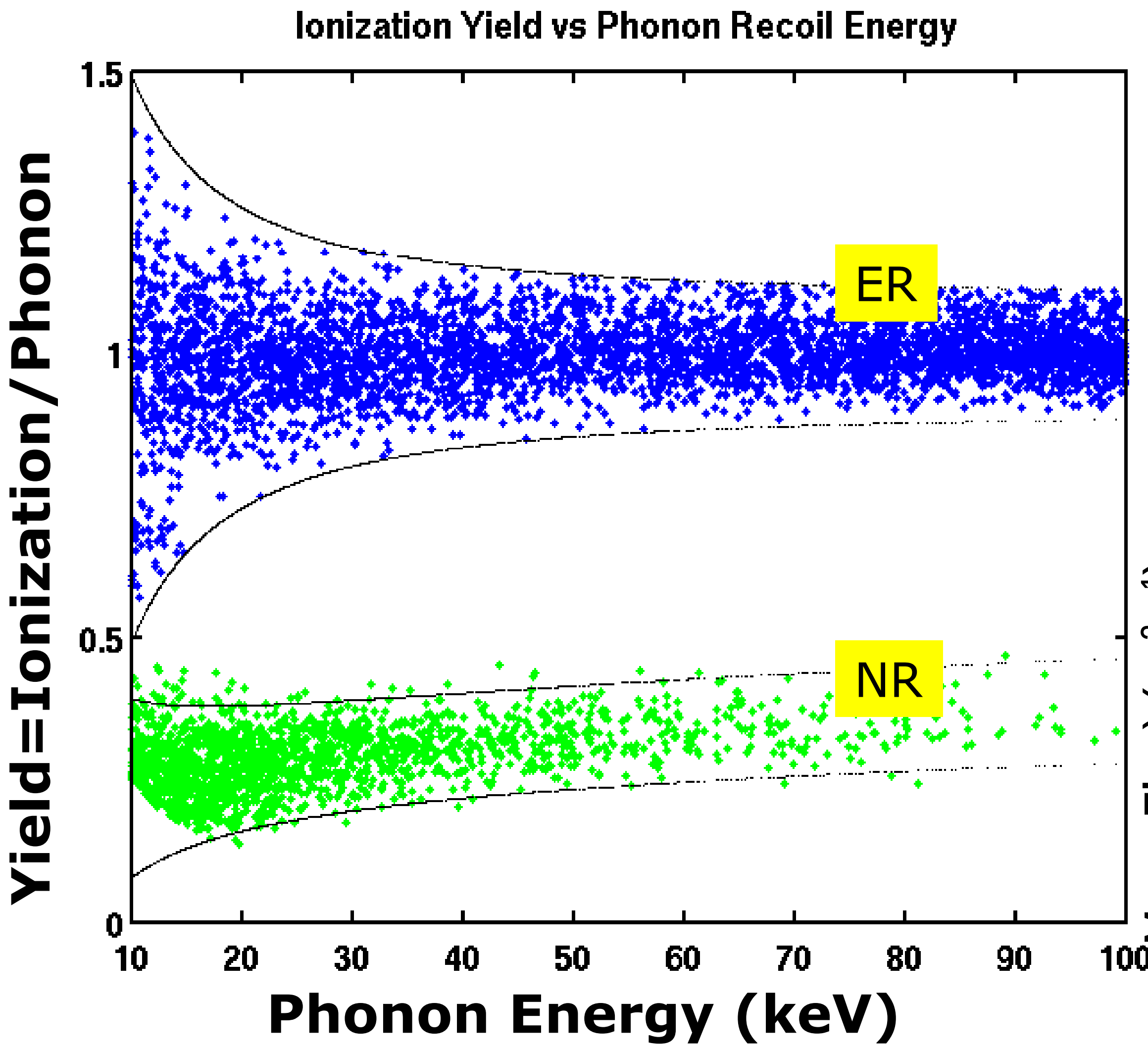
Sensors held in equilibrium between Normal and Super Conducting. Highly sensitive to small energy deposit. Fast signal. SQUID Readout

Excellent Energy, Position Resolution

Detector Calibration at Berkeley



Excellent Primary (γ) Background Rejection

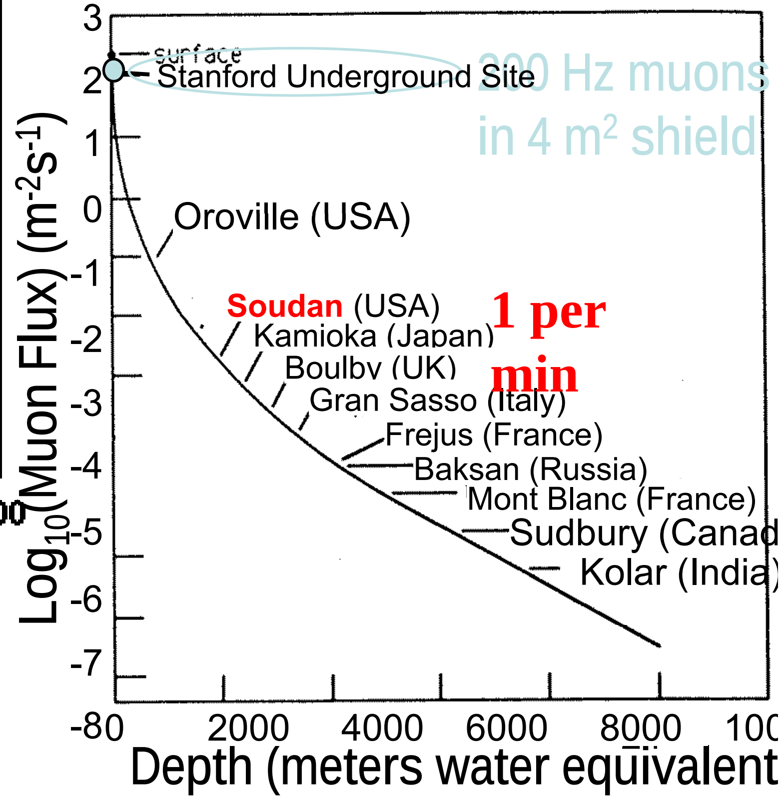


Radioactive source data define signal/background

Yield = Ionization/Phonon

> 1:10^4 rejection here

Neutrons cause nuclear recoils too!



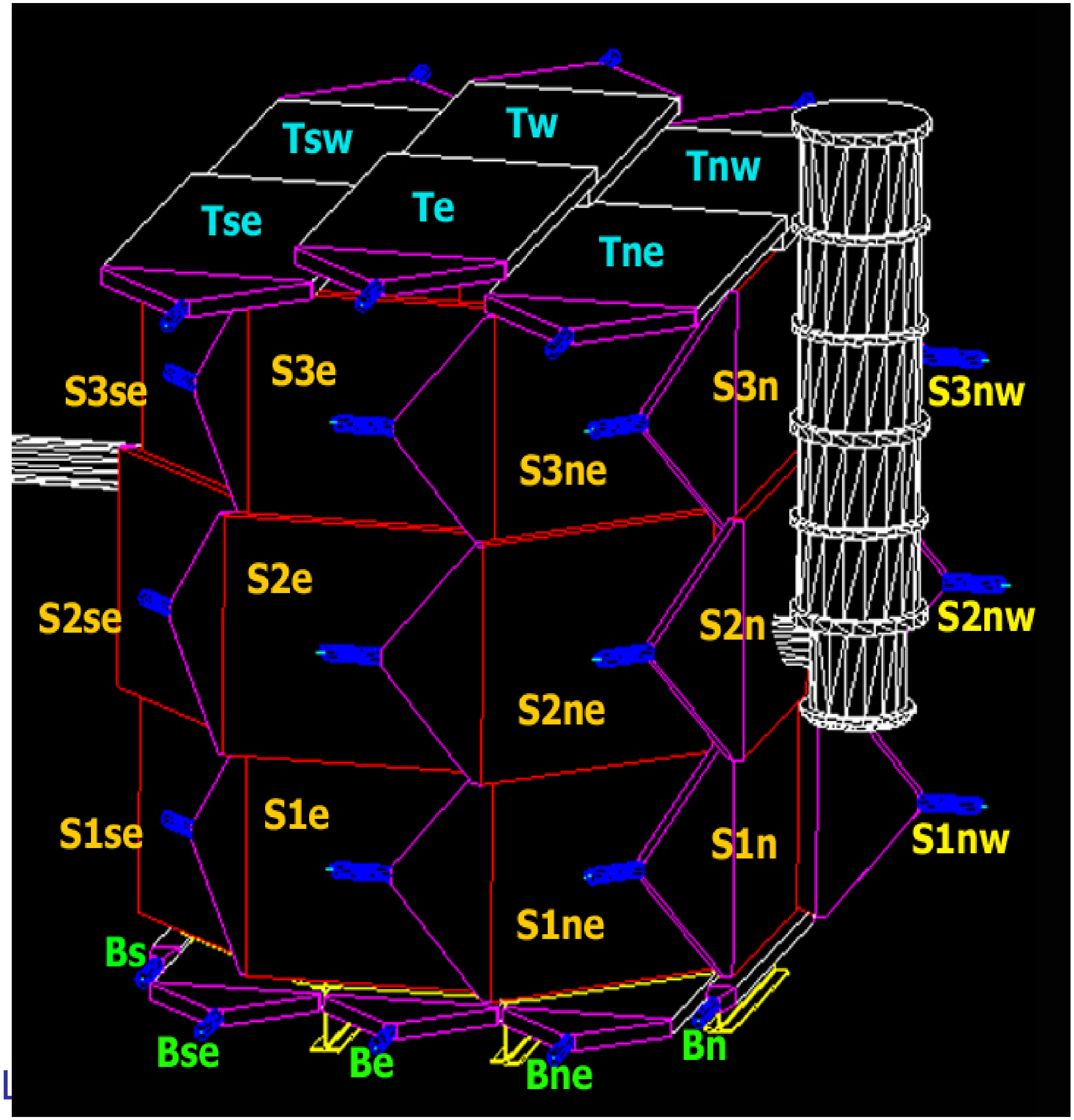
CDMS Apparatus Outside In

Surround detectors with active muon veto

Use passive shielding to reduce γ/Neutrons

- **Lead and Copper for photon**
- **Polyethylene for low-energy neutron**

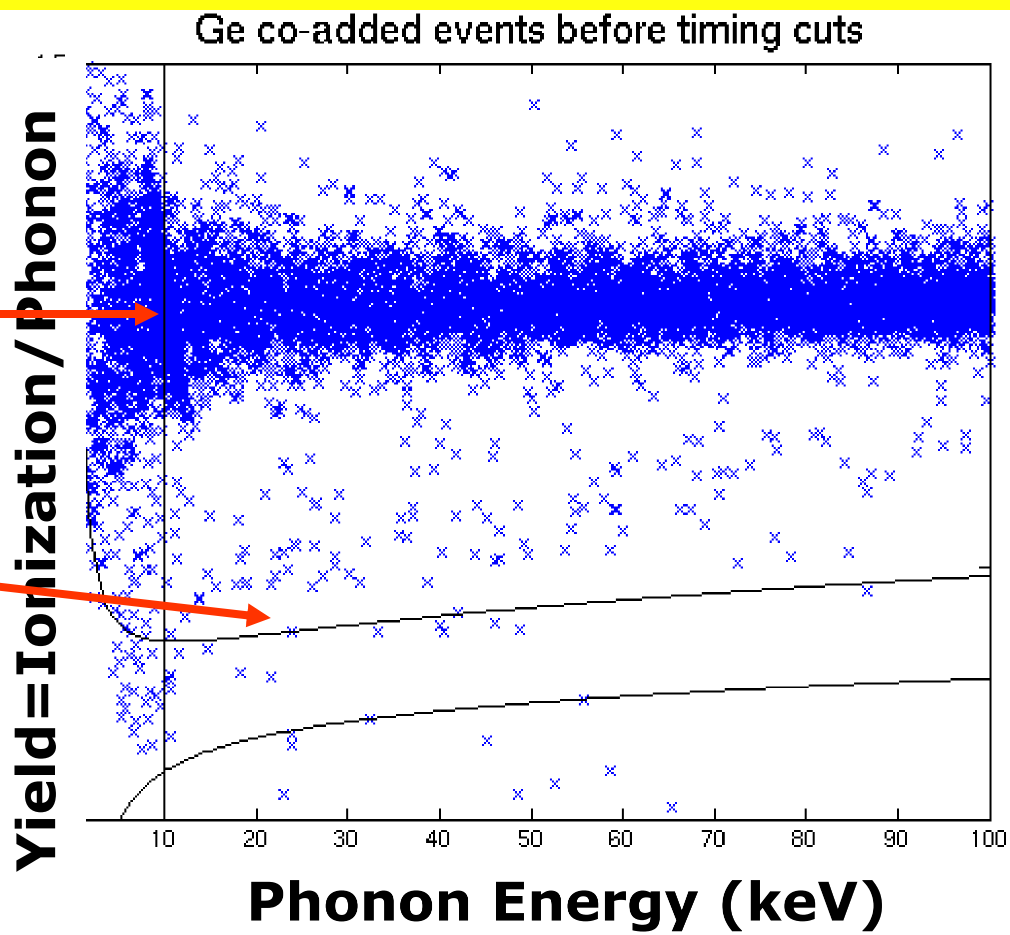
Neutron background negligible in Soudan, for recent runs



What Does WIMP Search Data Look Like?

Yield rejects most γ
Background ~ 1 M events

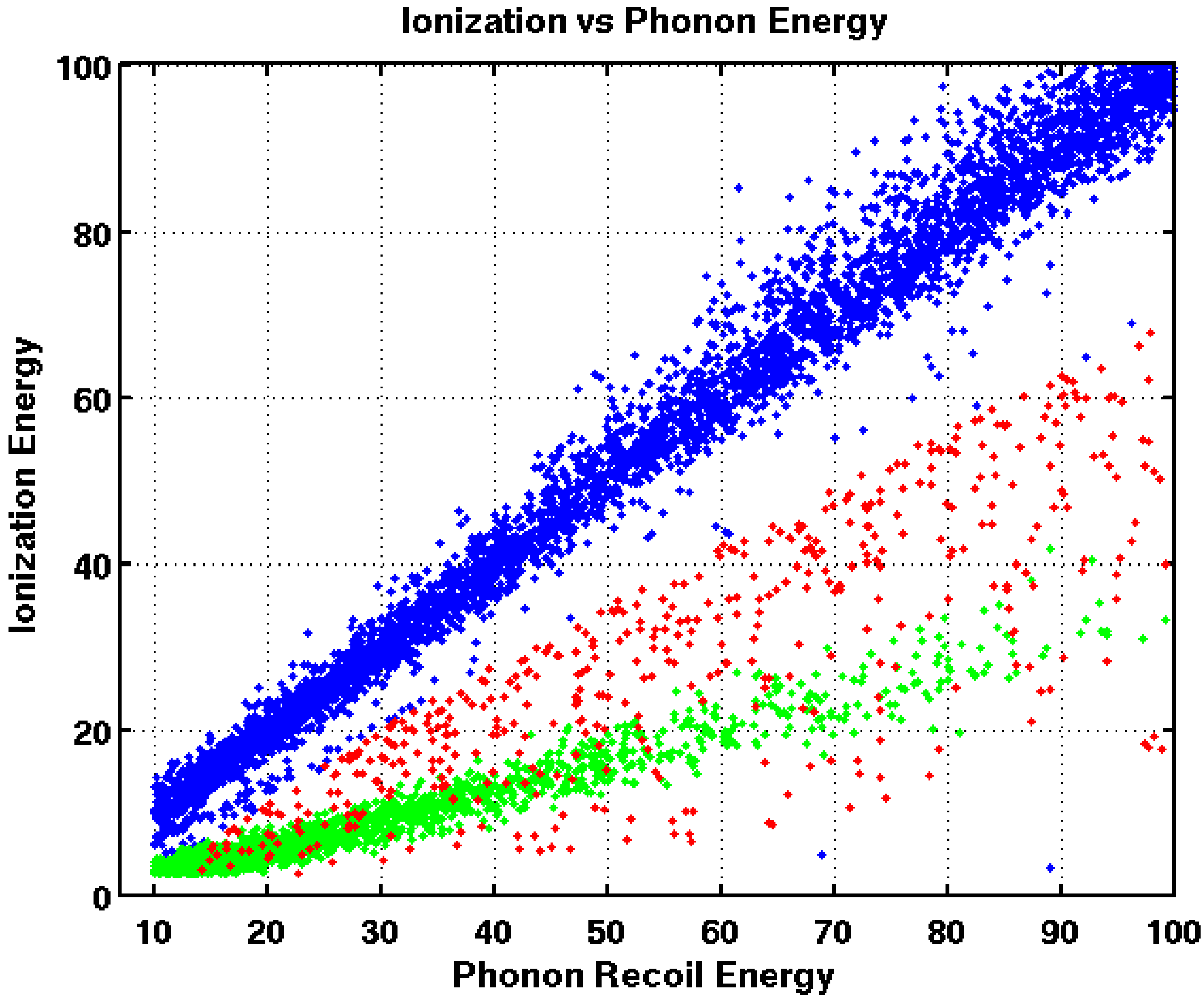
Few events in or near signal region.



Ionization collection incomplete for surface β. Low E-field at surface: e/h can travel to wrong electrode

⇒ **It can appear in low yield signal region (Yield=Ion/Phonon)**

We see it in Calibration Too!

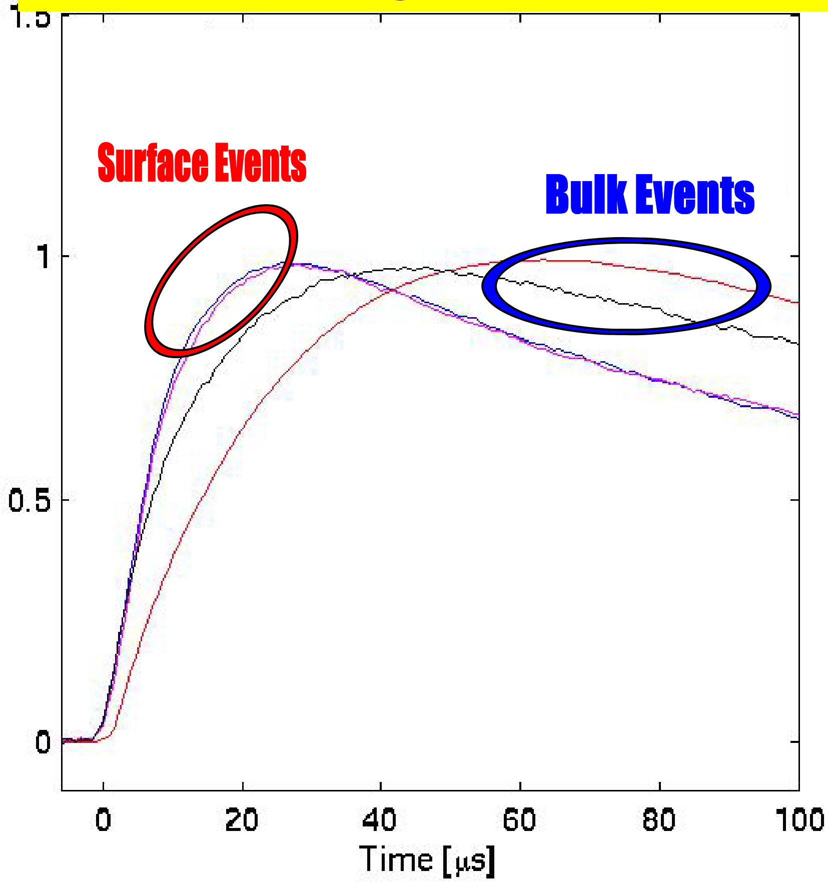


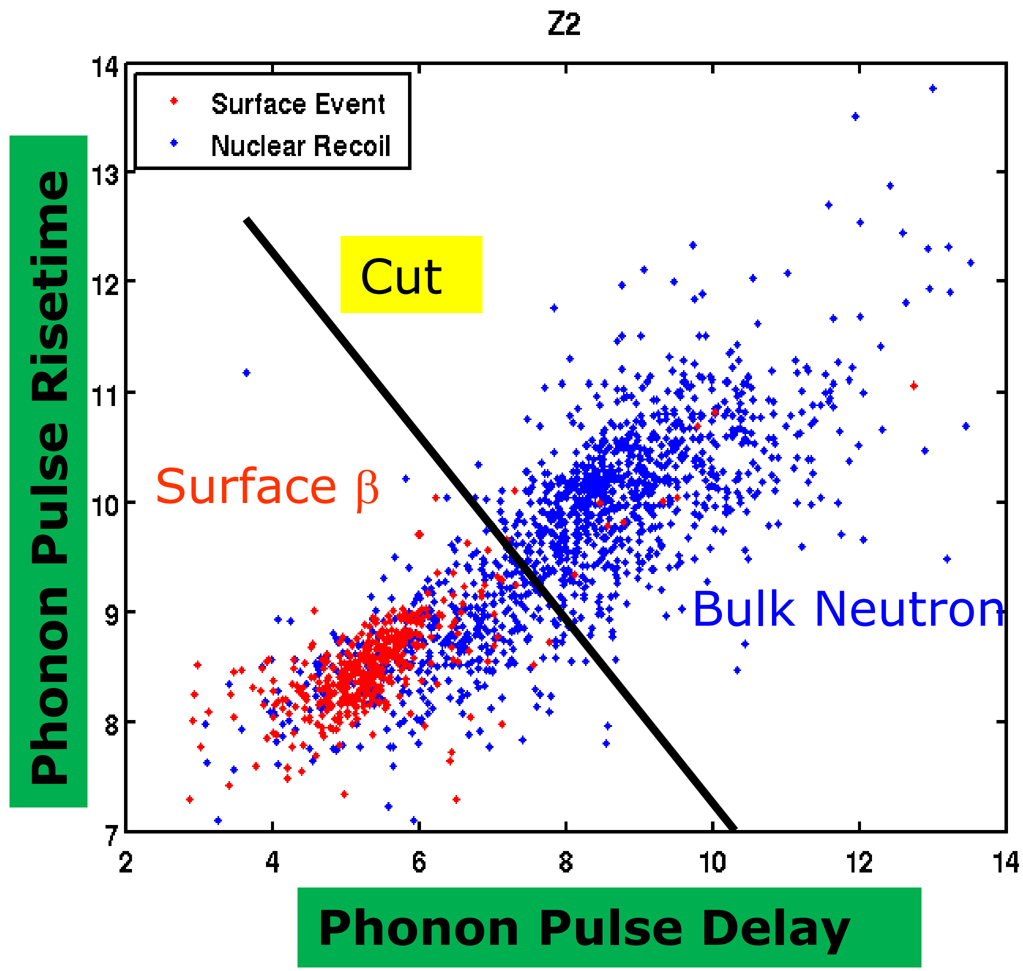
Compton scattered electrons provide us with calibration sample

β Rejection: Phonon Pulse Timing

- Surface events (β) have fast arriving and fast rising pulses
- Use both delay and risetime to discriminate signal/background

Phonon Timing: Bulk & Surface

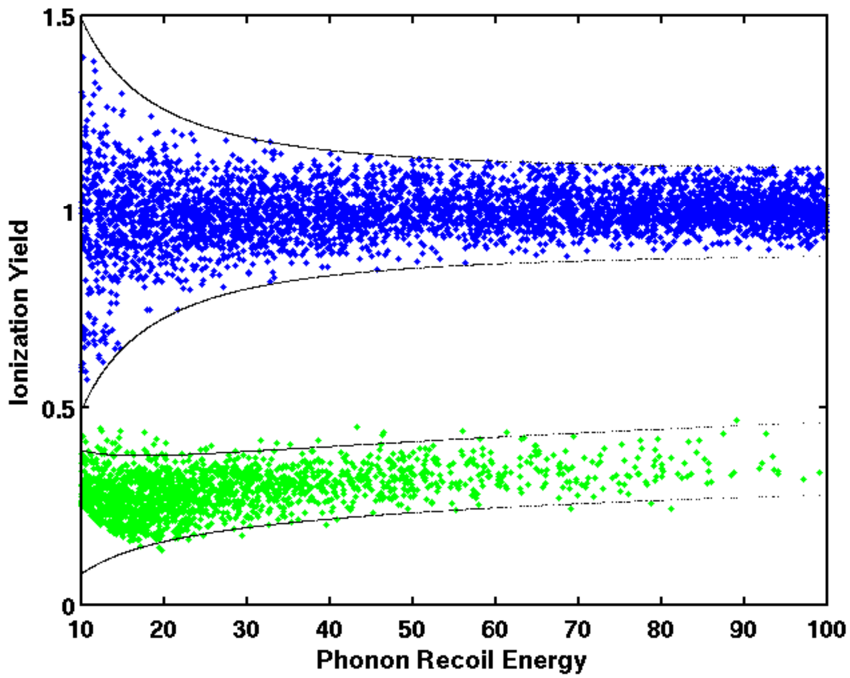


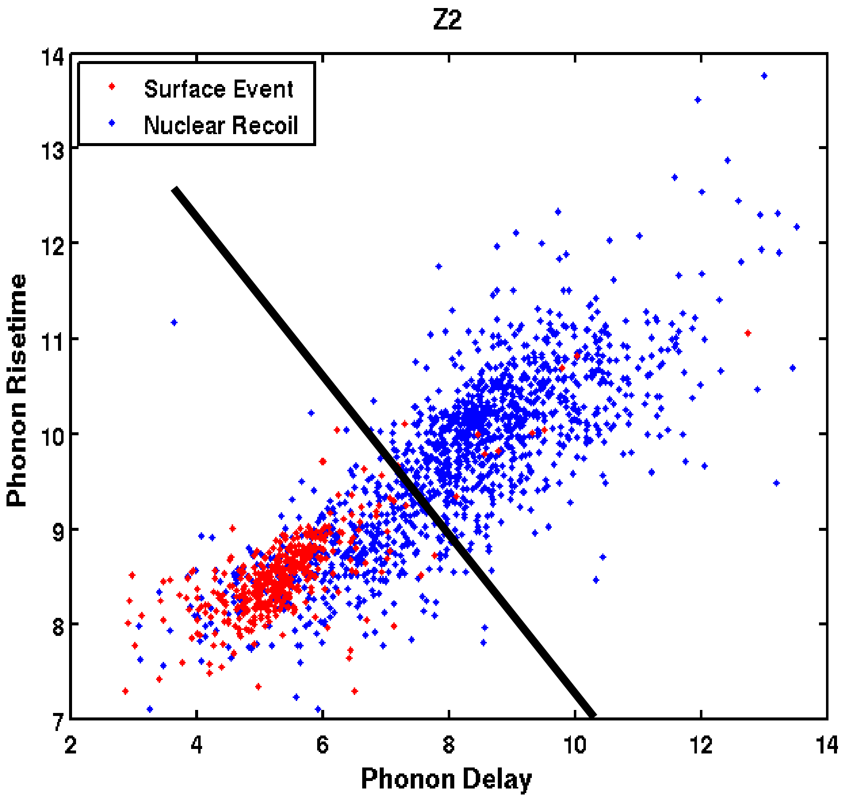


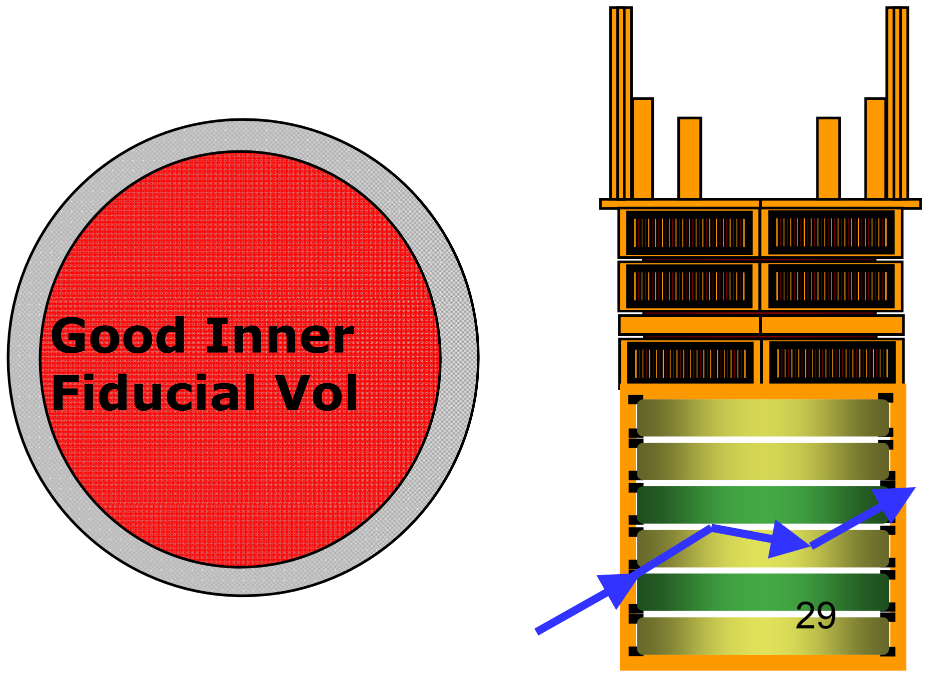
WIMP Candidate: Blind Analysis

All cuts set blind, using calibration data only

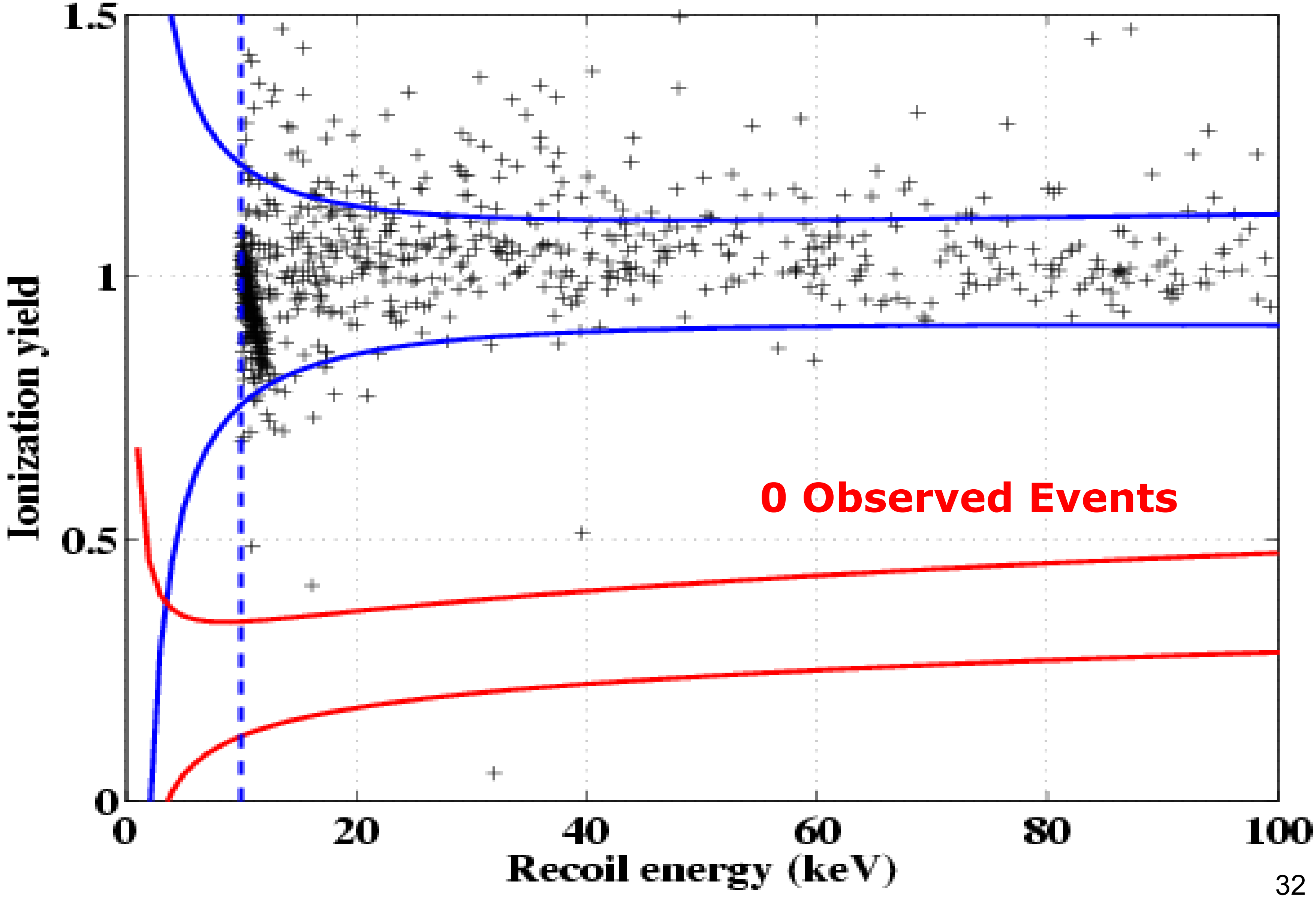
- In good Fiducial Volume
- In the Nuclear Recoil Band
- Not surface event: phonon timing cut
- Not a Multiple Scatter







2007: 0 Observed events

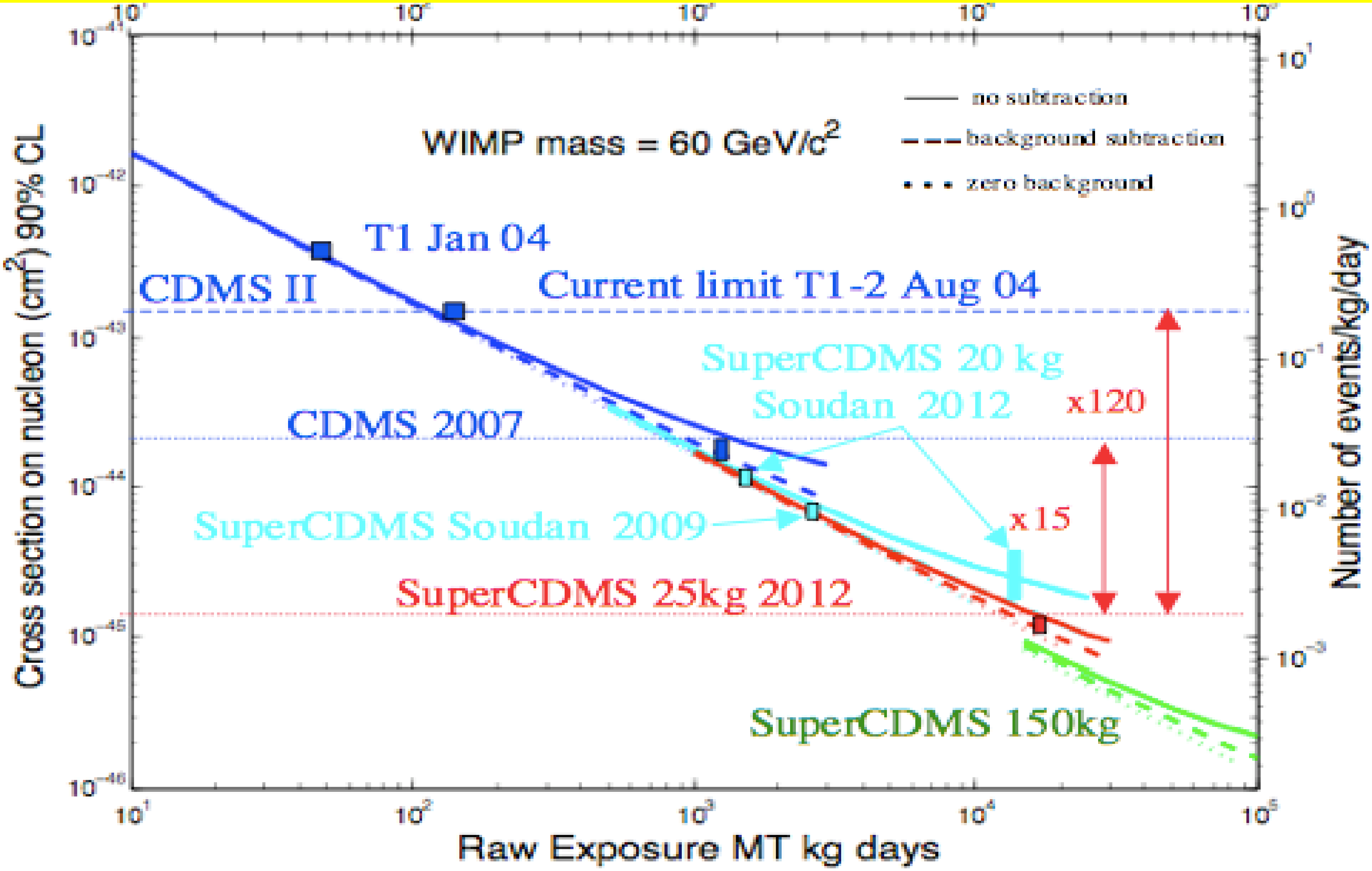


Expected Background: 0.6 ± 0.5 surface events and < 0.2 neutrons

No background in Last Few Runs

- Zero observed events in 2005 and 2007 results
- CDMS strives hard to keep almost zero background, independent of the exposure, by tightening and improving the rejection criteria
- Always keep expected background to ~.5 events to maximize discovery potential

Future: Stay Background Free

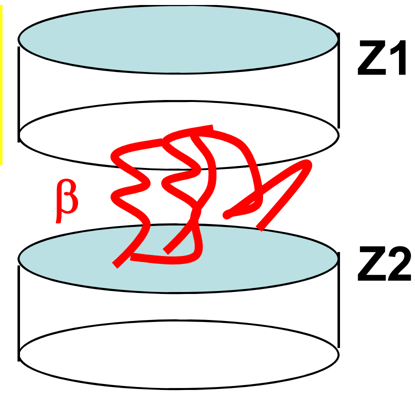


Takes years for detector technology to mature!

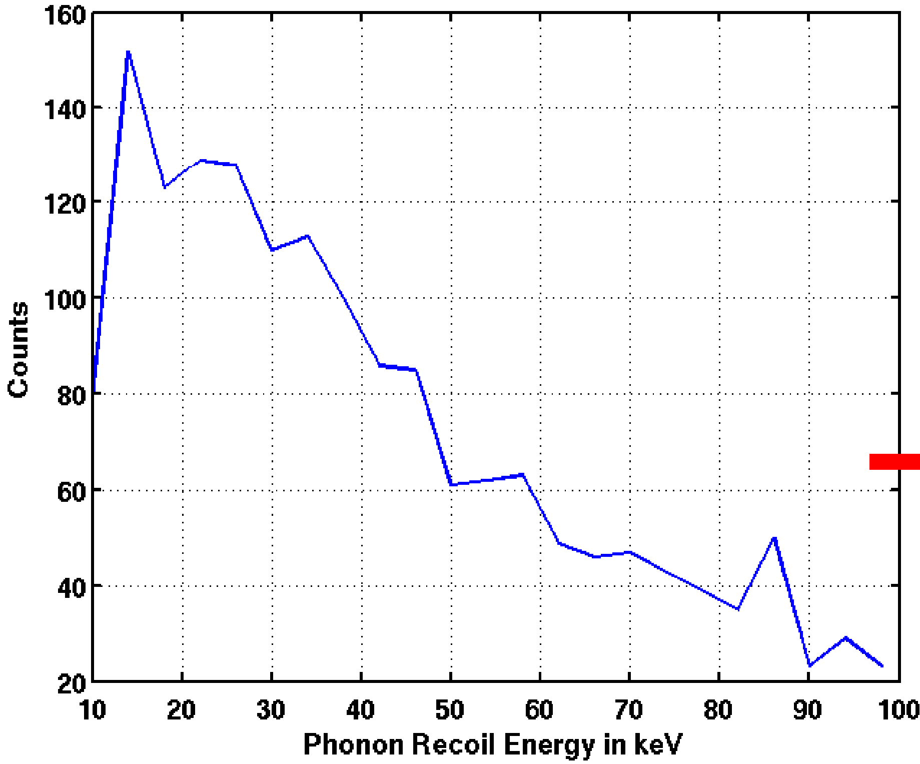
Background Identification

CDMS detectors stacked with no spacing. β multiple scatters.

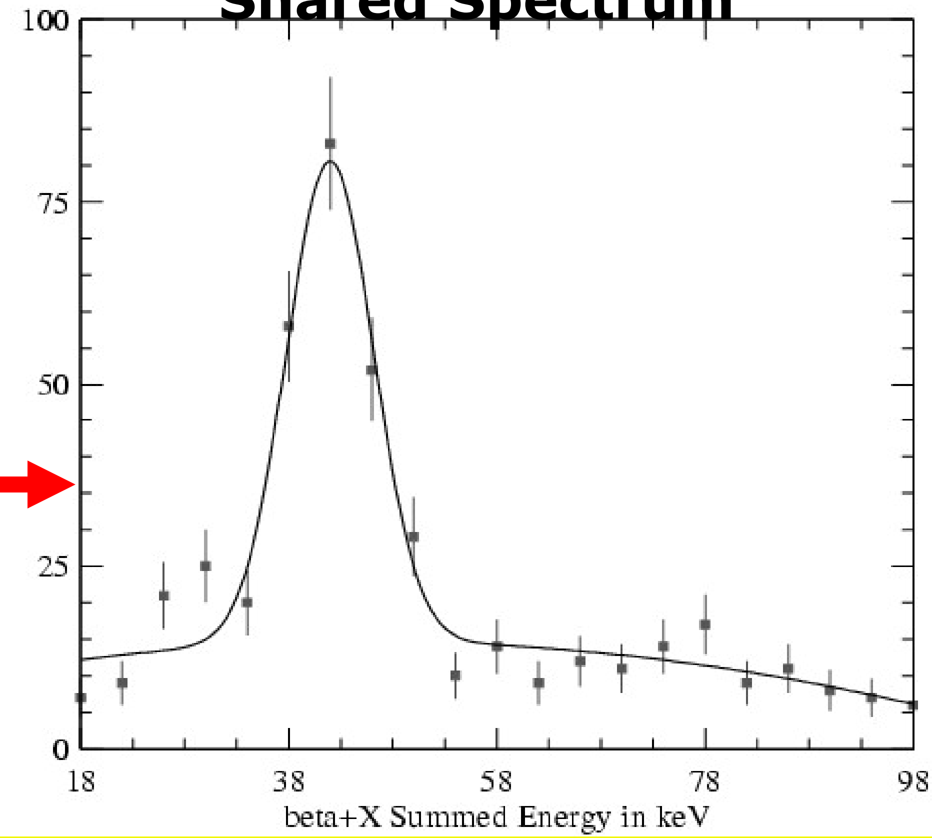
- **Check shared energy! Dramatically reduces combinatorics.**



Individual Spectrum

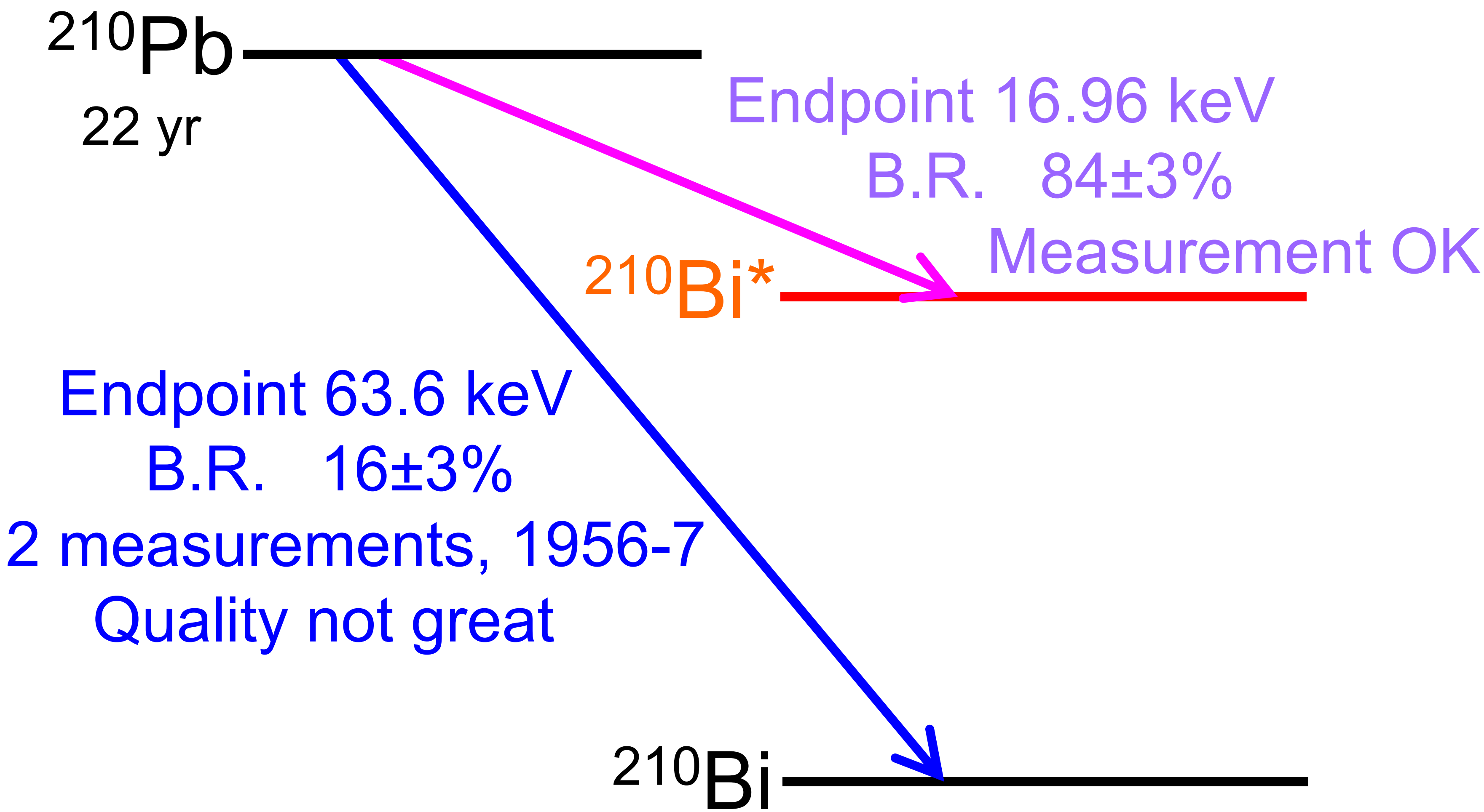


Shared Spectrum

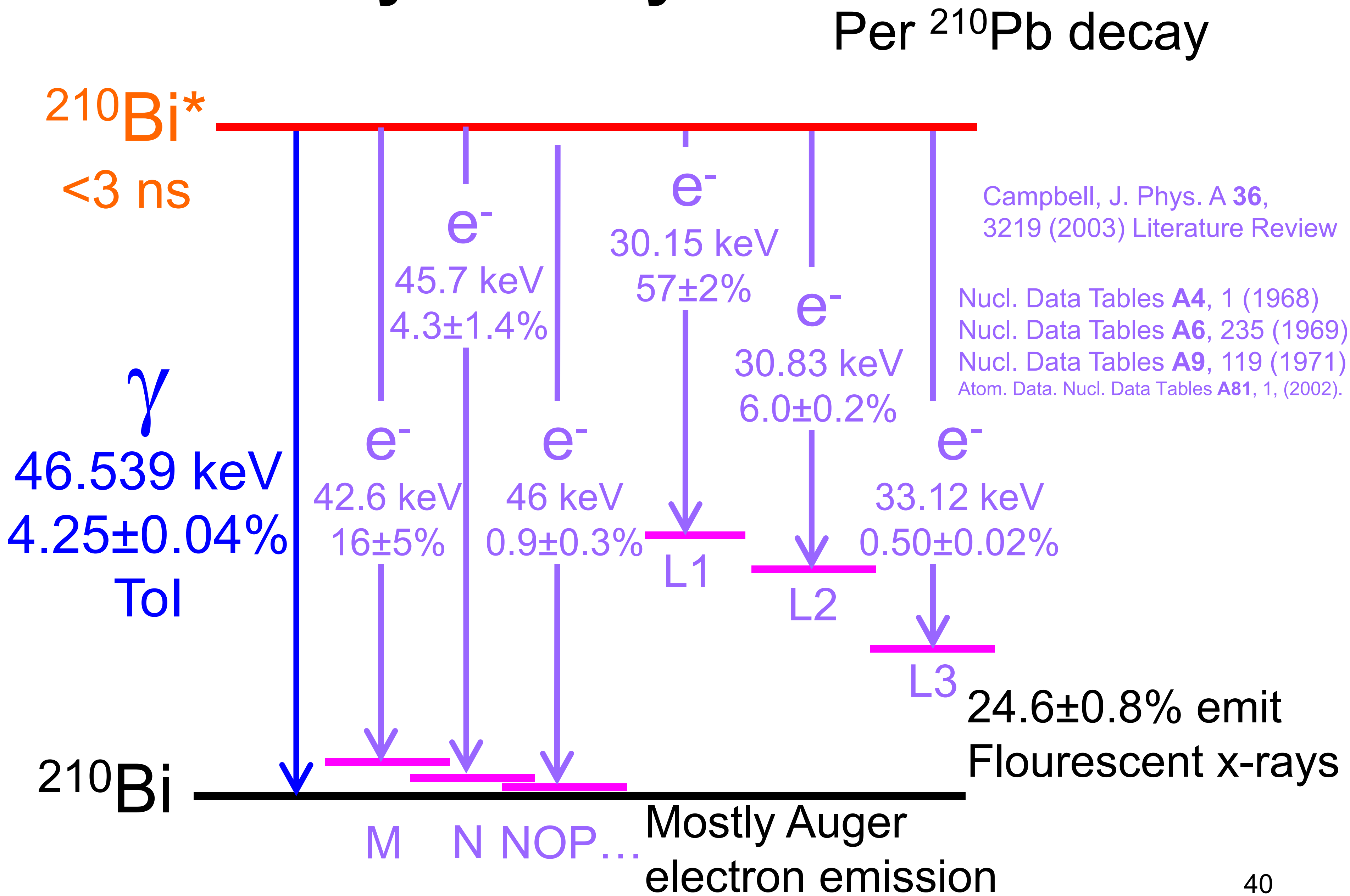


Peak in Spectrum! Find radioactive source to be ^{210}Pb from Radon Decay

^{210}Pb β^- decay



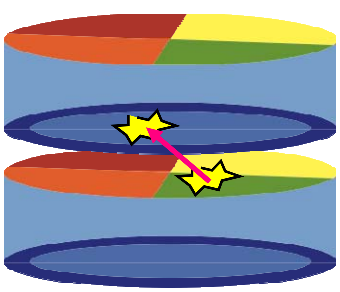
^{210}Bi* decay: mostly Internal Conversion

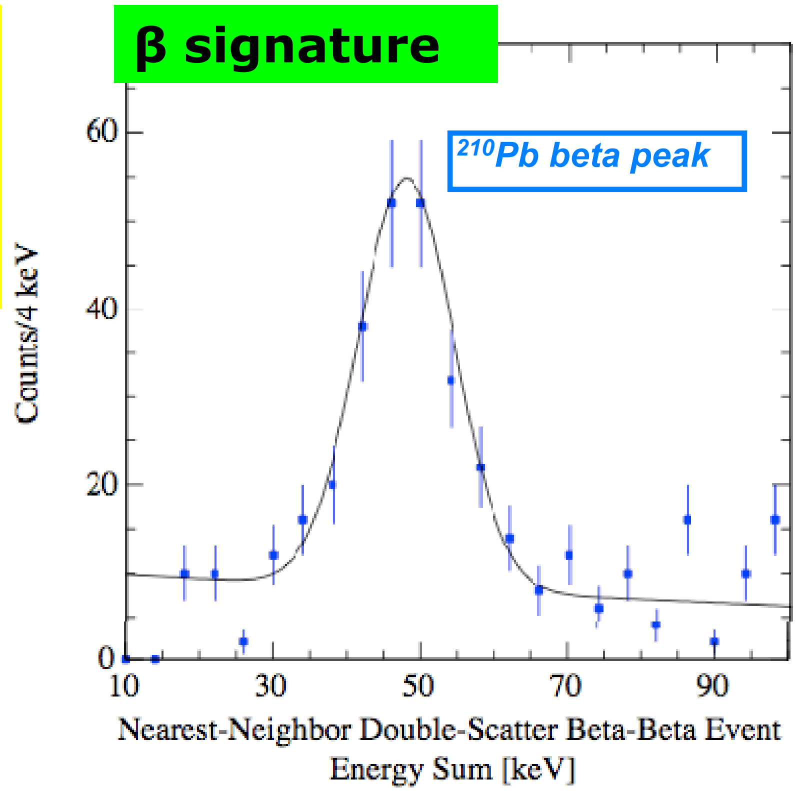


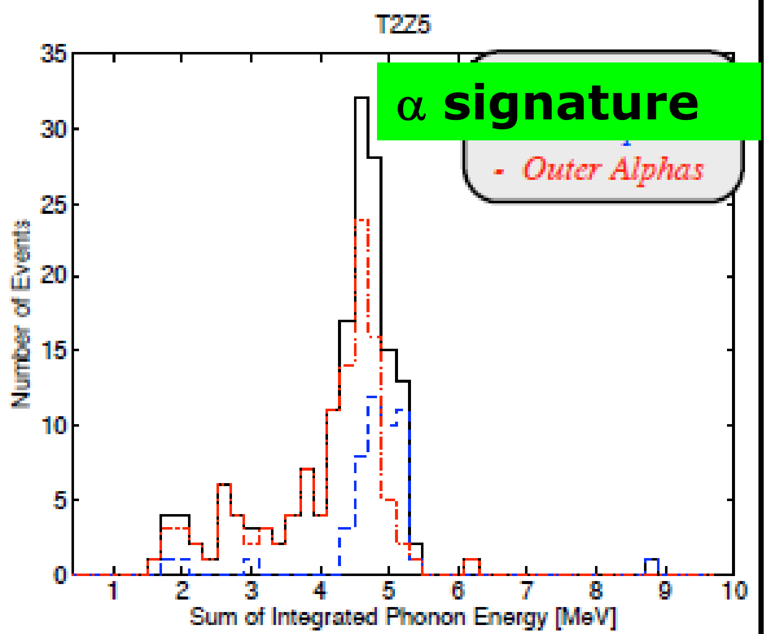
Background Identification

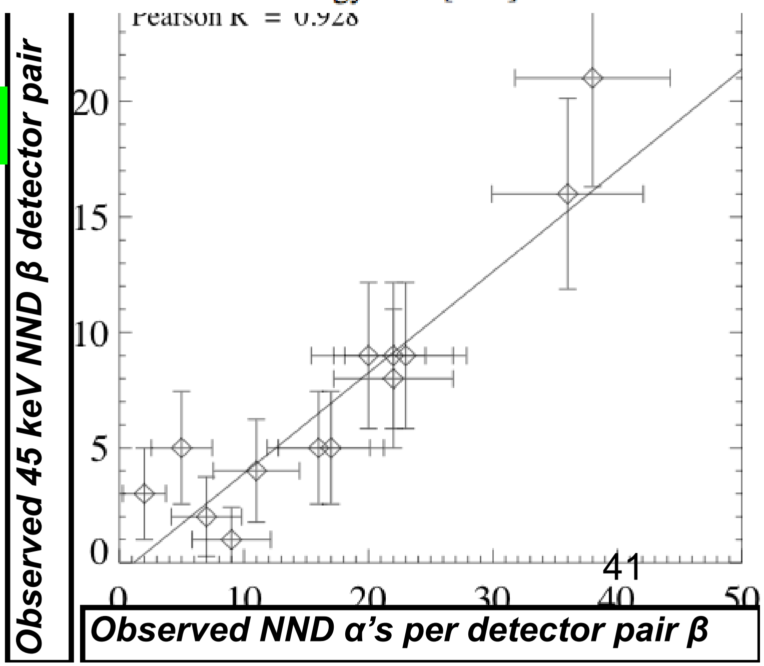
Major success with correlating α and β rates, nearest neighbor double scatters

~75% of our contamination is ^{210}Pb (Rn daughters)
=> Already reduced by improved handling. 3X lower background



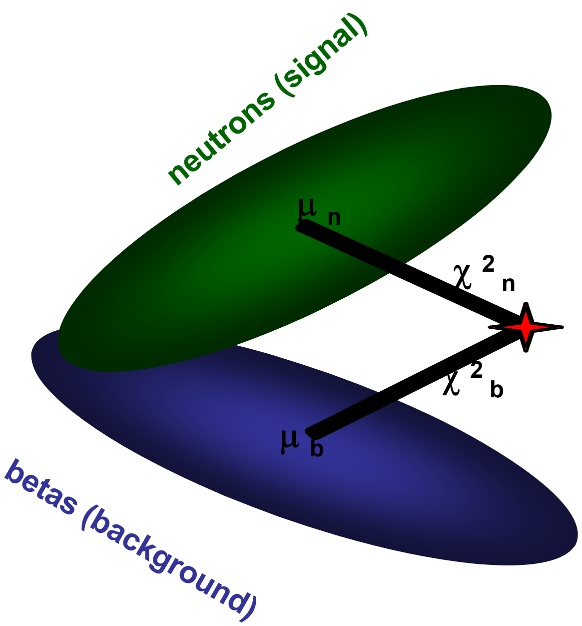


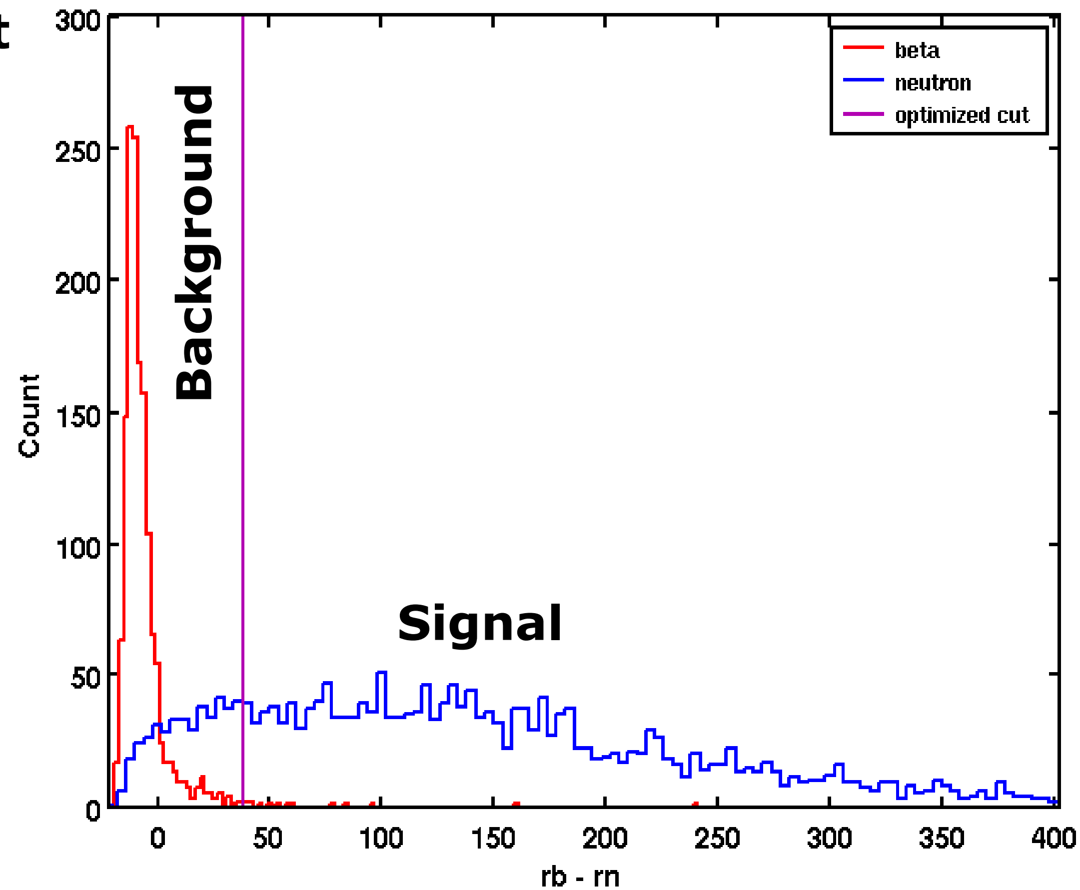




Rejecting Remaining β background

Improved surface event cut assigns a probability of an event being like a signal or background, based on χ^2





$\chi_b^2 - \chi_n^2$

Signal Likelihood increases →

We can tell how likely the candidates are to be WIMPs

Recent Result!

Surface Event "Leakage"

3 independent sidebands for estimating the passing/failing ratio

SIDEBAND 1

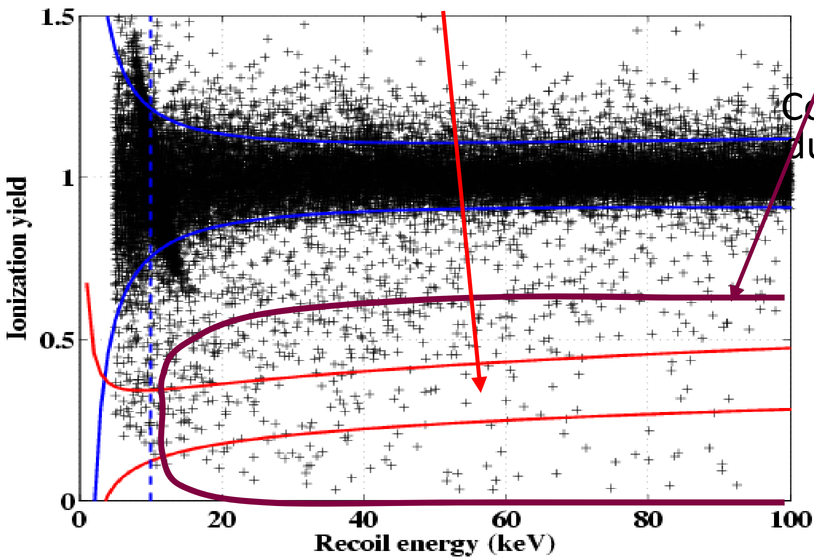
Use multiple-scatters in NR band

SIDEBAND 2

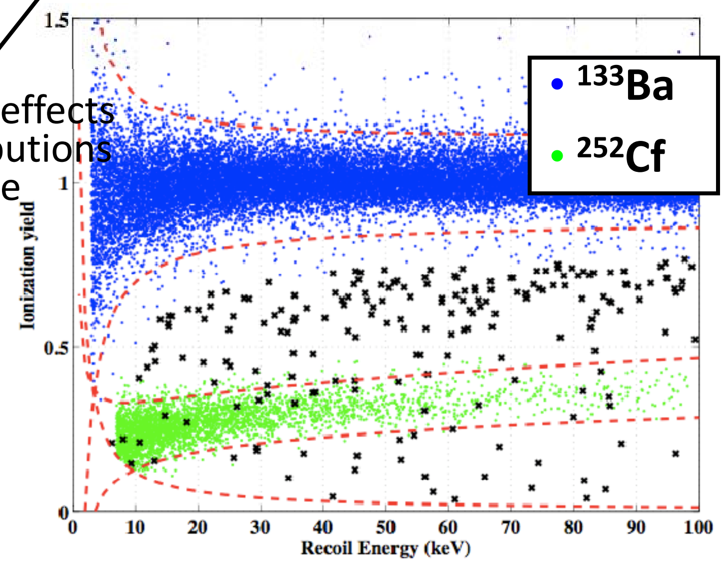
Use singles and multiples just outside NR band

SIDEBAND 3

Use singles and multiples from Ba calibration in wide region



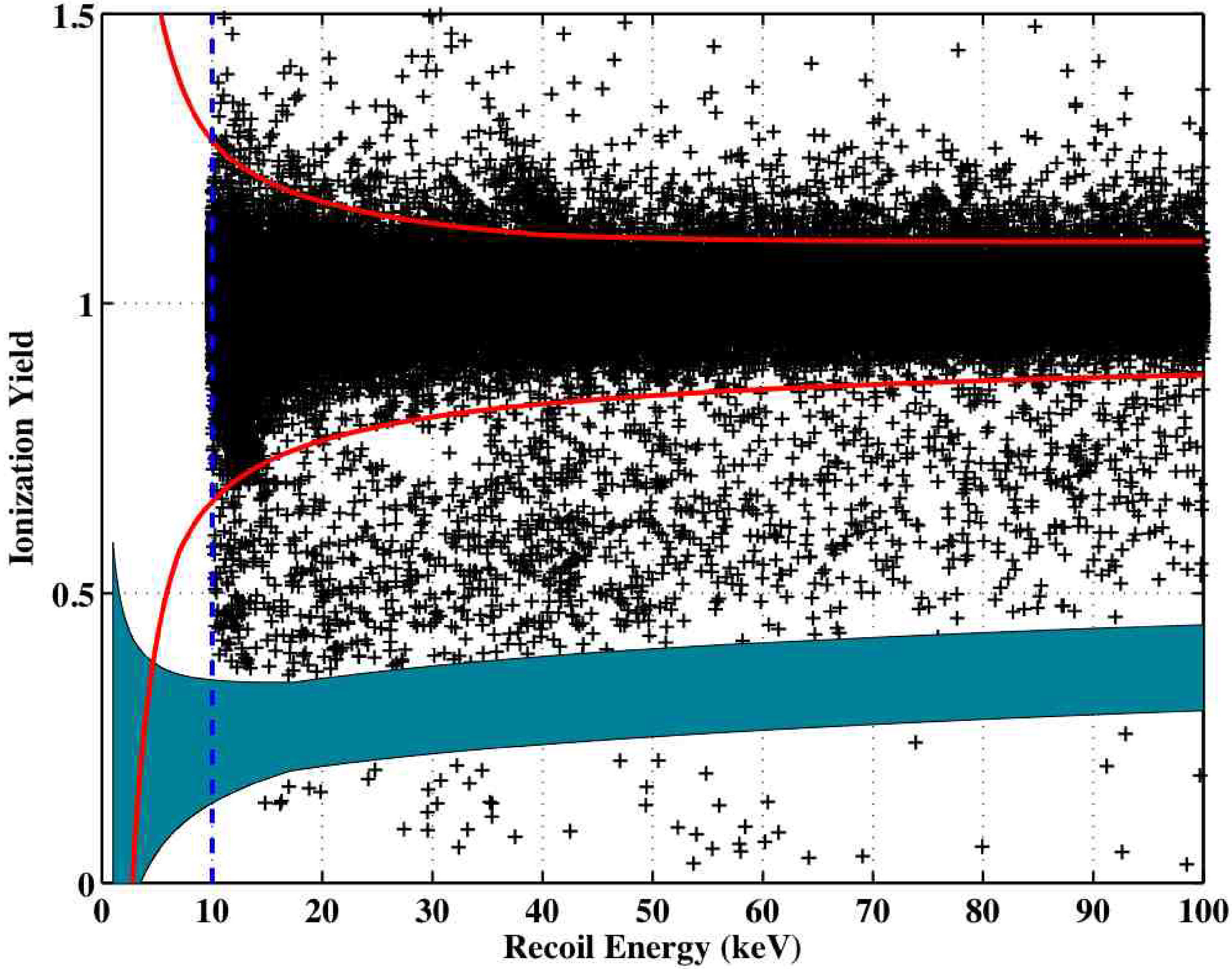
Correct for systematic effects due to different distributions in energy and face



All 3 consistent, leakage = 0.6 ± 0.1 (stat.) ± 0.2 (syst.)

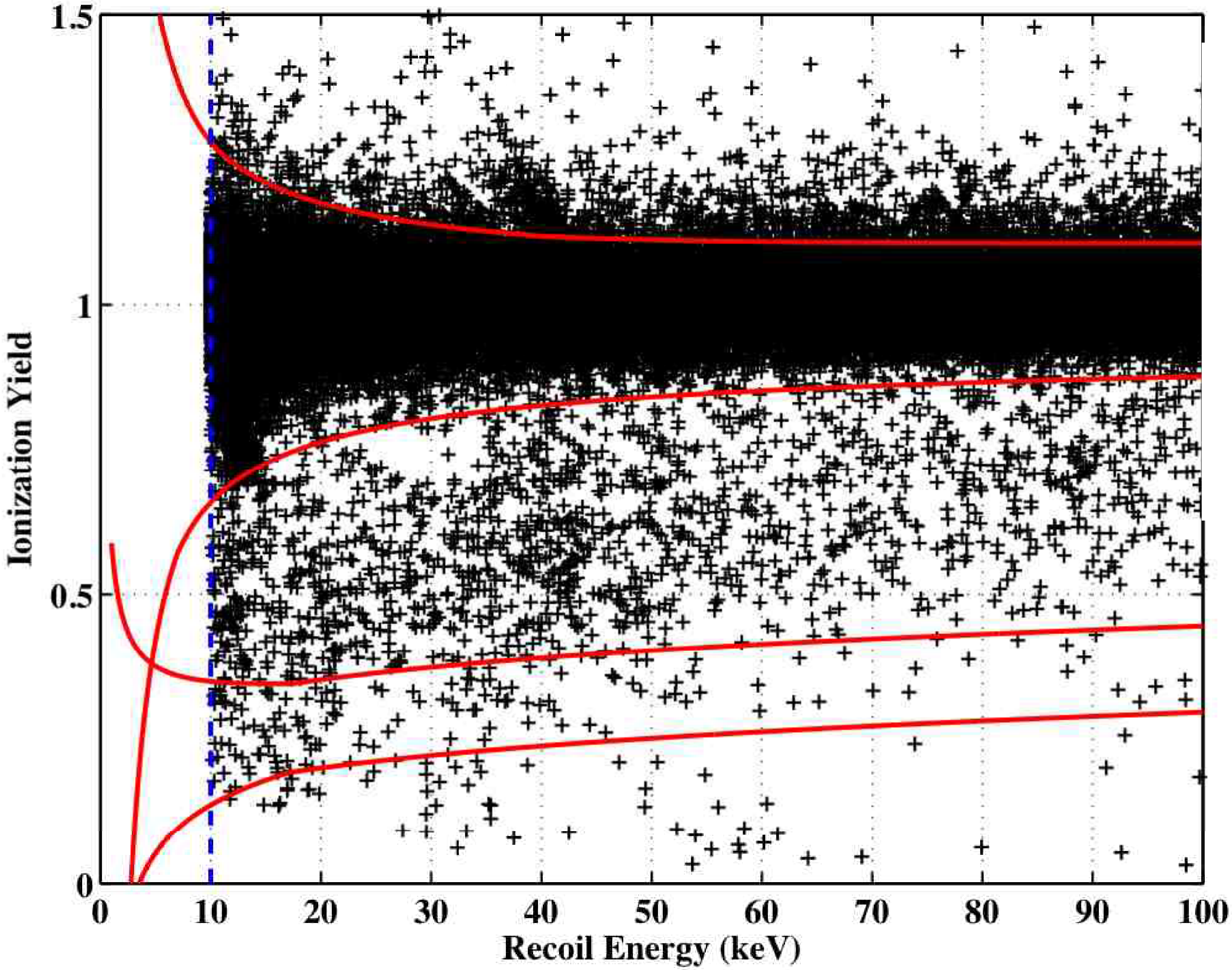
Open the Box: Look at blinded region

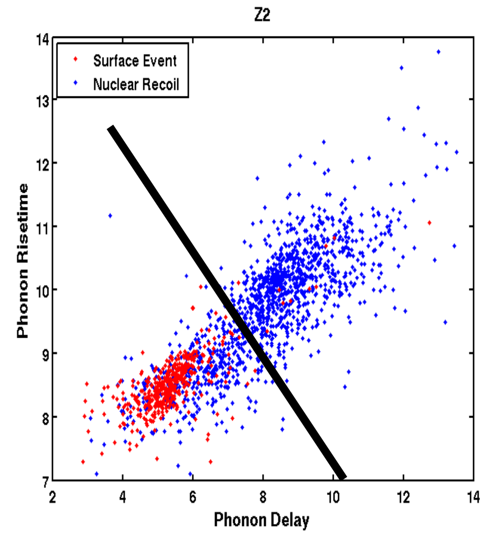
We unblinded the signal region November 5, 2009



Open the Box: Before Timing Cut

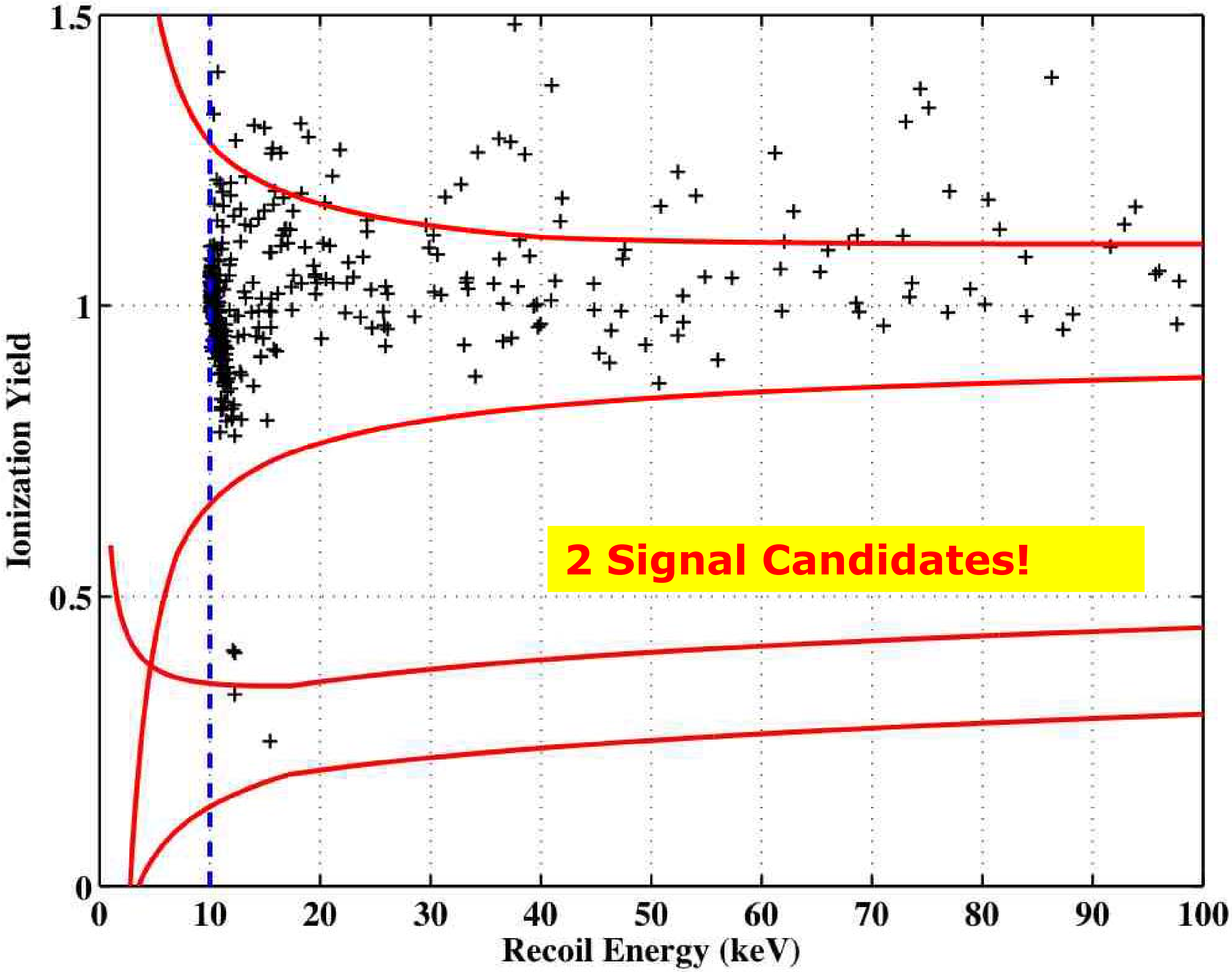
We unblinded the signal region November 5, 2009





Open the Box: After Timing Cut

We unblinded the signal region November 5, 2009



Comments

The poisson probability to have observed 2 or more surface events with an expection of 0.6 (not accounting for uncertainty) is:

12%

The observation of 2 events is consistent with background estimates made before unblinding.

However, our detectors provide numerous info on each event which can provide detailed likelihood of each event being a signal or background like

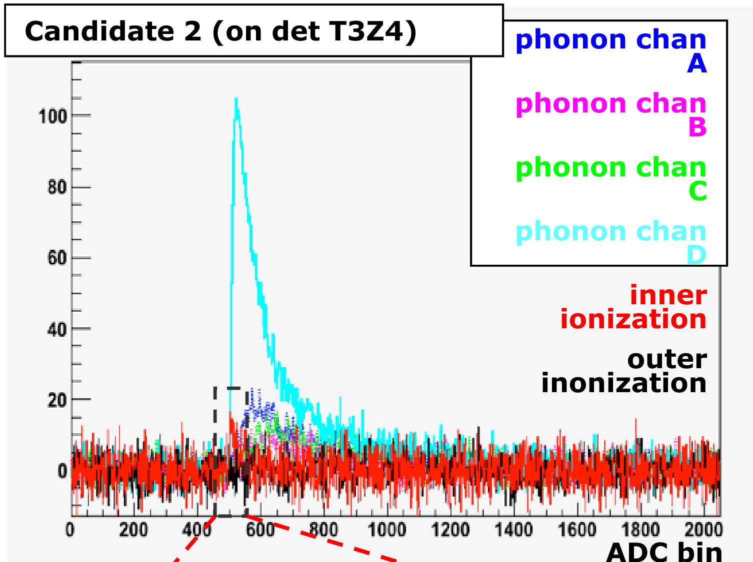
Not just a binary answer, actual prob for each event

Data Quality Re-checks

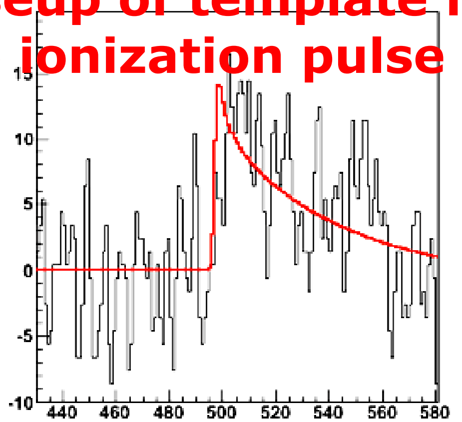
experimental performance was excellent at the time of both observed events

Data Quality Item	Result
muon veto performance	✓ *good*
neutralization	✓ *good*
KS tests	✓ *normal*
noise levels	✓ *typical*
pre-pulse baseline rms	✓ *typical*
background electron-recoil rate	✓ *typical*
surface event rate	✓ *typical*
radial position	✓ *well-contained*
single-scatter identification	✓ *good*
special running conditions	✓ *no*
operator recorded issues	✓ *no*

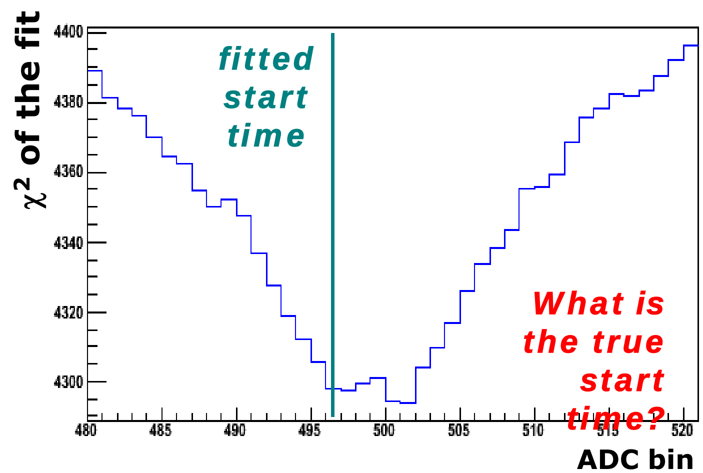
Reconstruction Checks



Closeup of template fit to ionization pulse



ionization and phonon energies look good, phonon timing looks good…

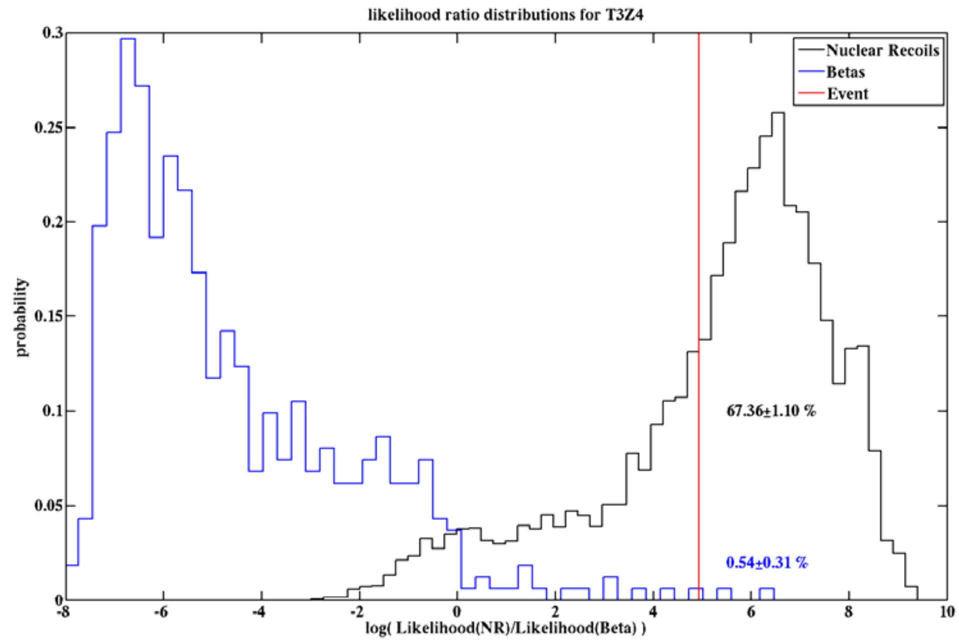


Could there be a problem with the start time of the charge pulse?

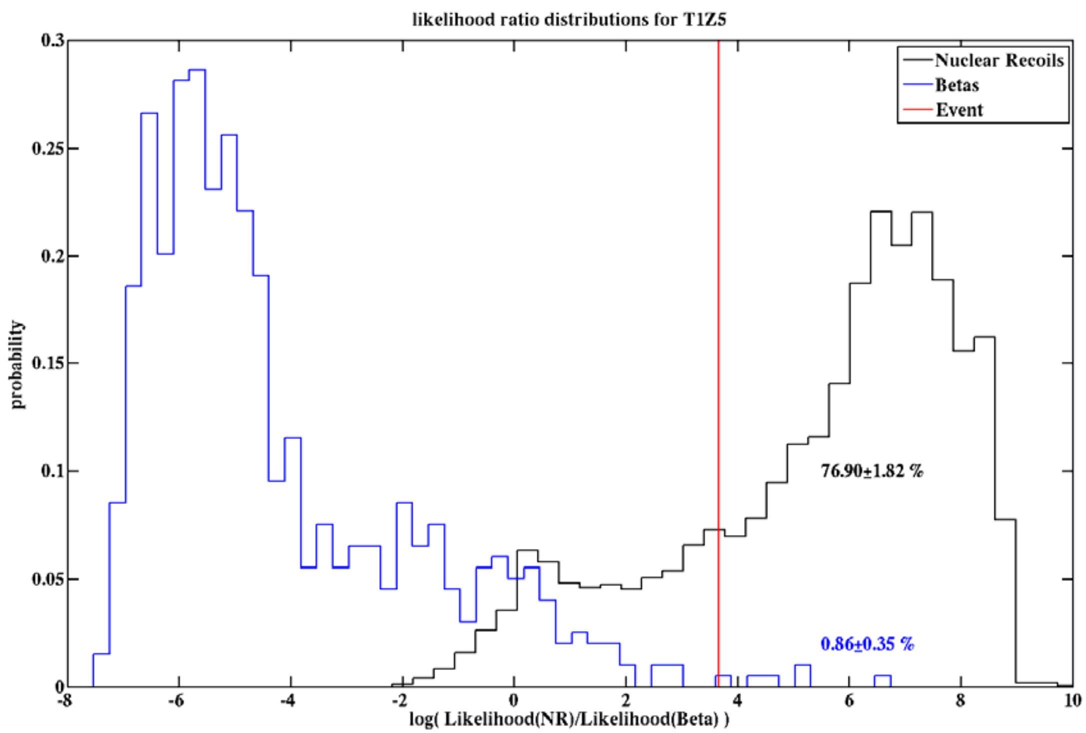
Effect included in expected leakage

But, we add additional 0.2 events systematic uncertainty post unblinding

Detailed Timing, Charge, Phonon Energy Likelihood



Candidate in T1Z5
77% probability of NR
<.9% probability of ER



Candidate in T3Z4
68% probability of NR
<.5% probability of ER

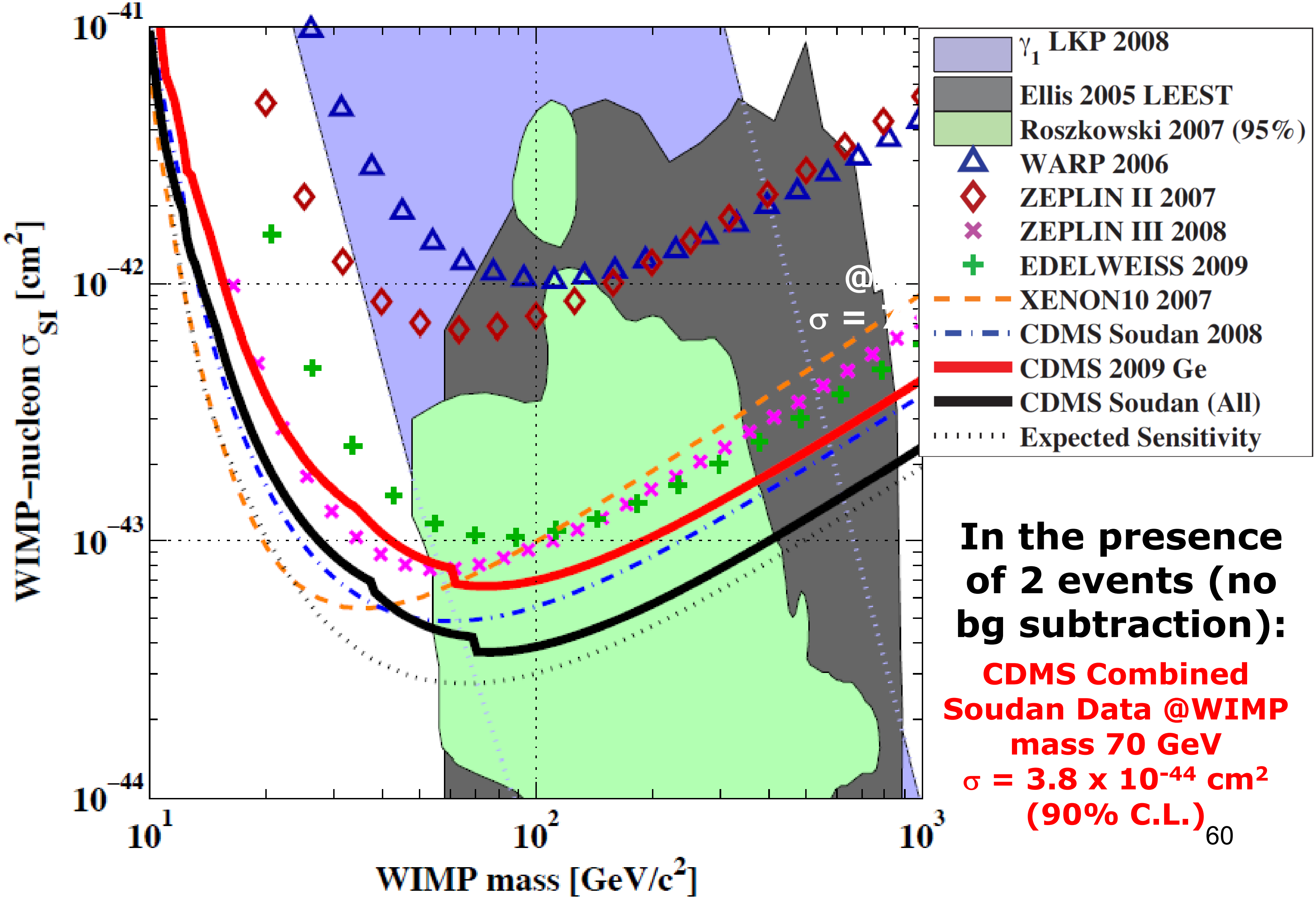
Final Comments on the 2 Events

We can not exclude possibility that these 2 events may be part of a signal

At the same time, the significance of 2 events on top of half event expected background is not high.

Need more events to confirm! Look at the Future!

90% C.L. Spin-Independent Limit



In the presence of 2 events (no bg subtraction):

CDMS Combined Soudan Data @WIMP mass 70 GeV
$\sigma = 3.8 \times 10^{-44}$ cm^2 (90% C.L.)

Future: More Data, More Detectors

CDMS R/Evolution

CDMS, Soudan (4kg)

3”x 1 cm 0.25kg
2 Yrs, 16 dets=1700kg-d

SuperCDMS, Soudan (15kg)

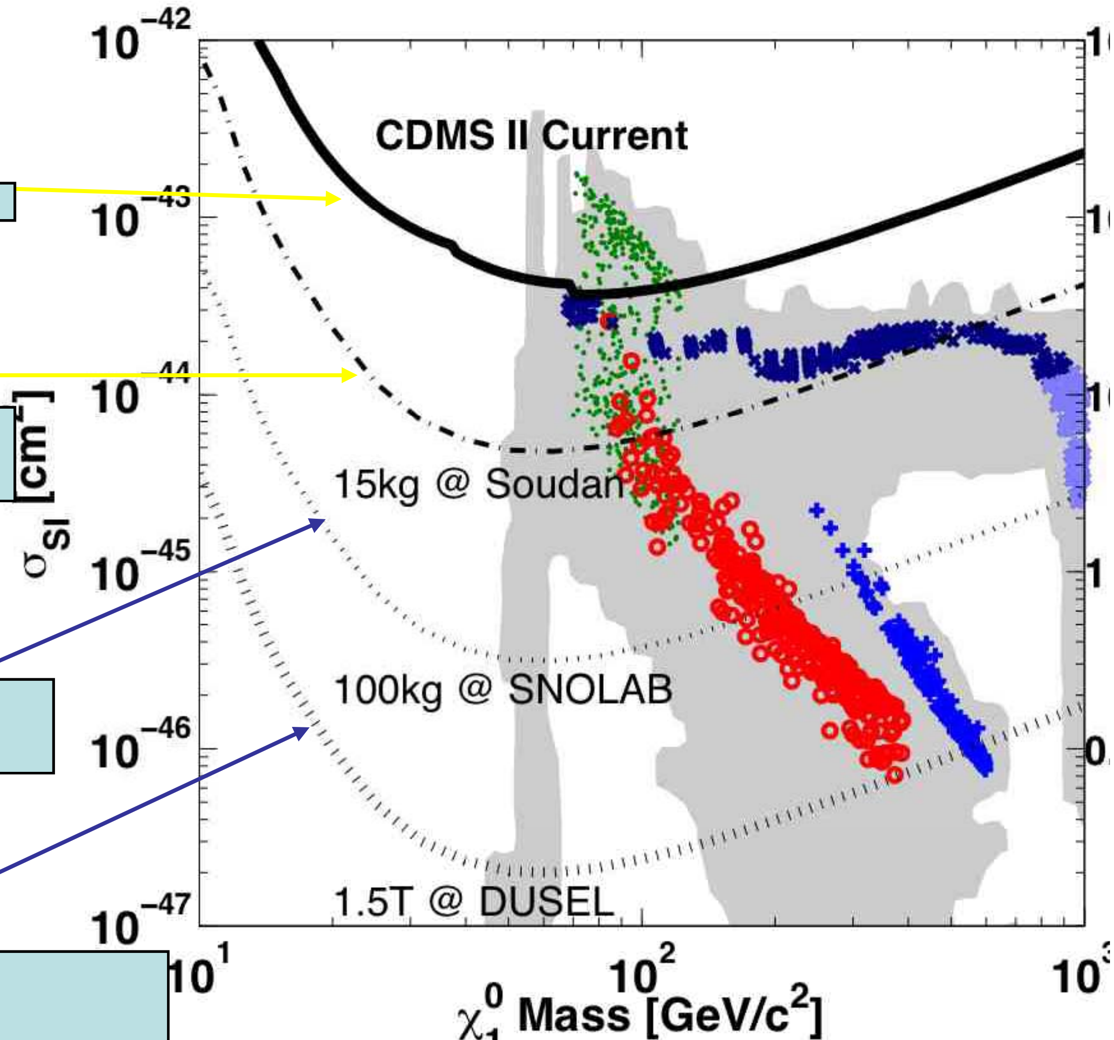
3”x 1” iZIP 0.64kg
2 Yrs, 25dets=8000kg-d

SuperCDMS, SNOLab (100kg)

4”x 1.33” iZIP 1.5kg
2 Yrs, 70dets=100000kg-d

GEODM, DUSEL (1500kg)

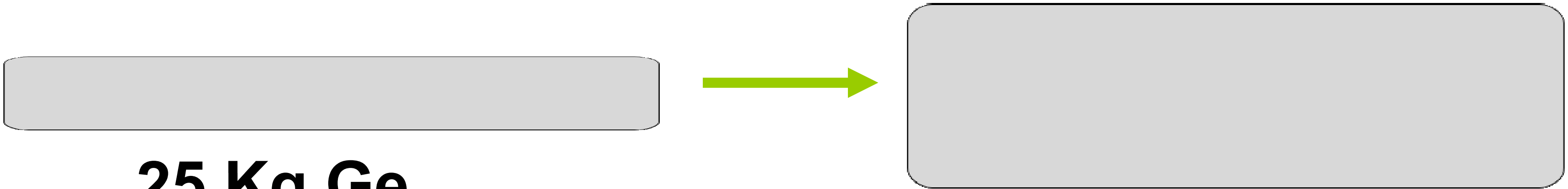
6”x 2” iZIP 5kg
2 Yrs, 300dets=1.5M kg-d



To reach the goals :

- **increase mass**
- **decrease background leakage**

SuperCDMS Detector: Bigger is Better



.25 Kg Ge

.64 Kg Ge

- Cost of production/testing
  - 1/3 less per Kg. mass

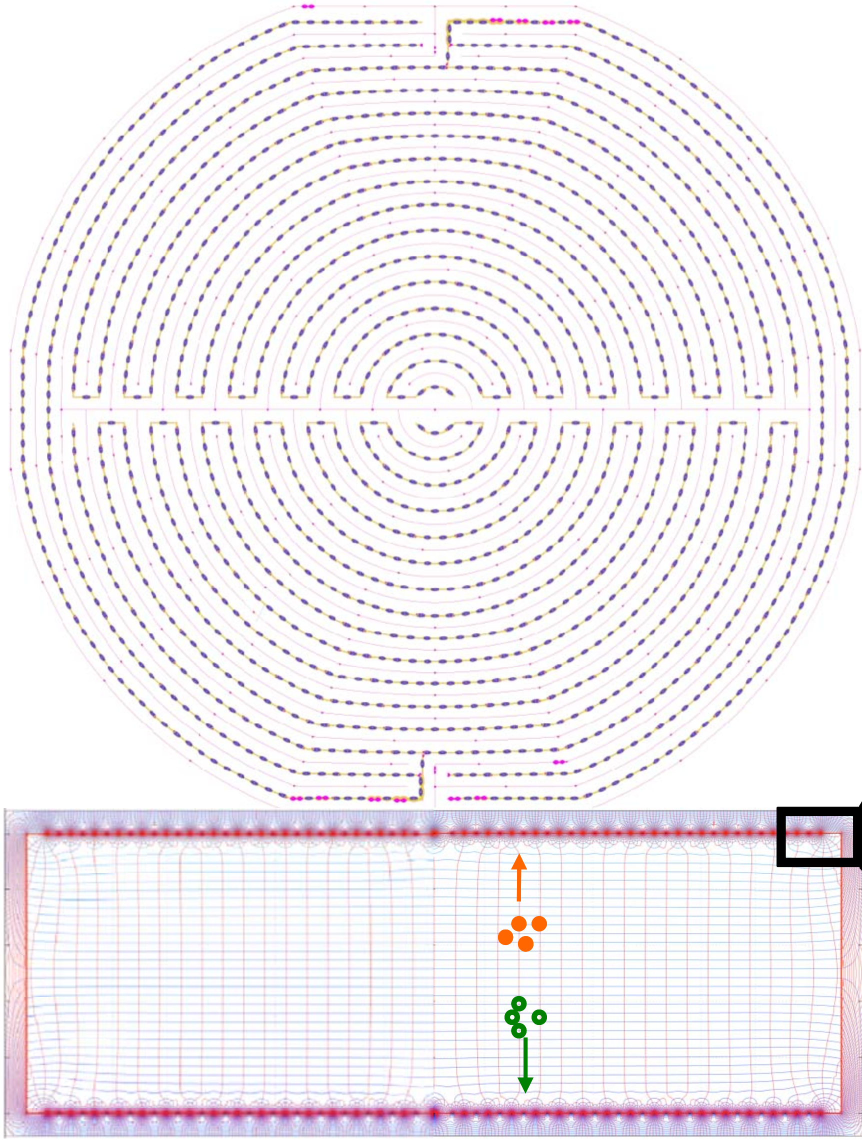
- Background dominated by surface β. Reduce surface/volume
  - 1/3 less per Kg. mass

- **One SuperTower taking data**
- **Two more to be installed soon**

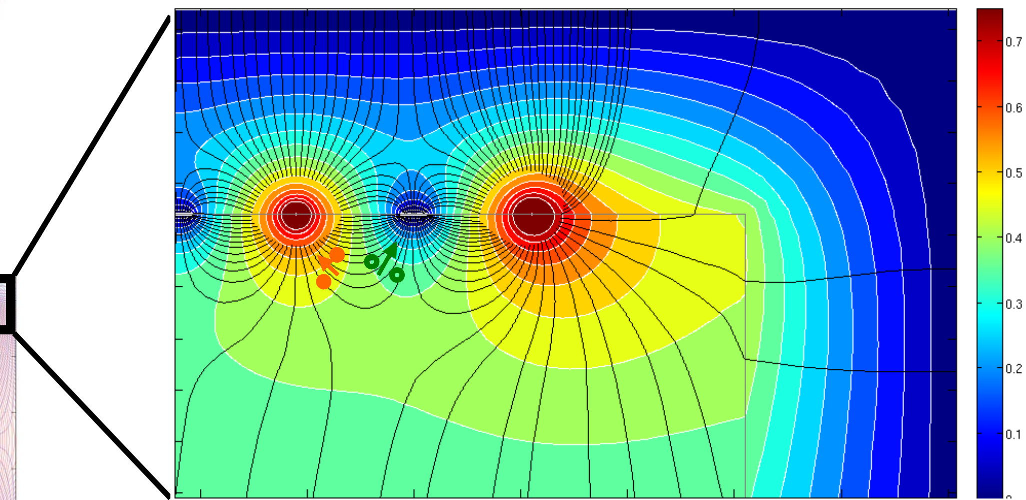
Dark Matter sensitivity scales as mass. Problems scale as surface area

Detector Revolution: iZIP

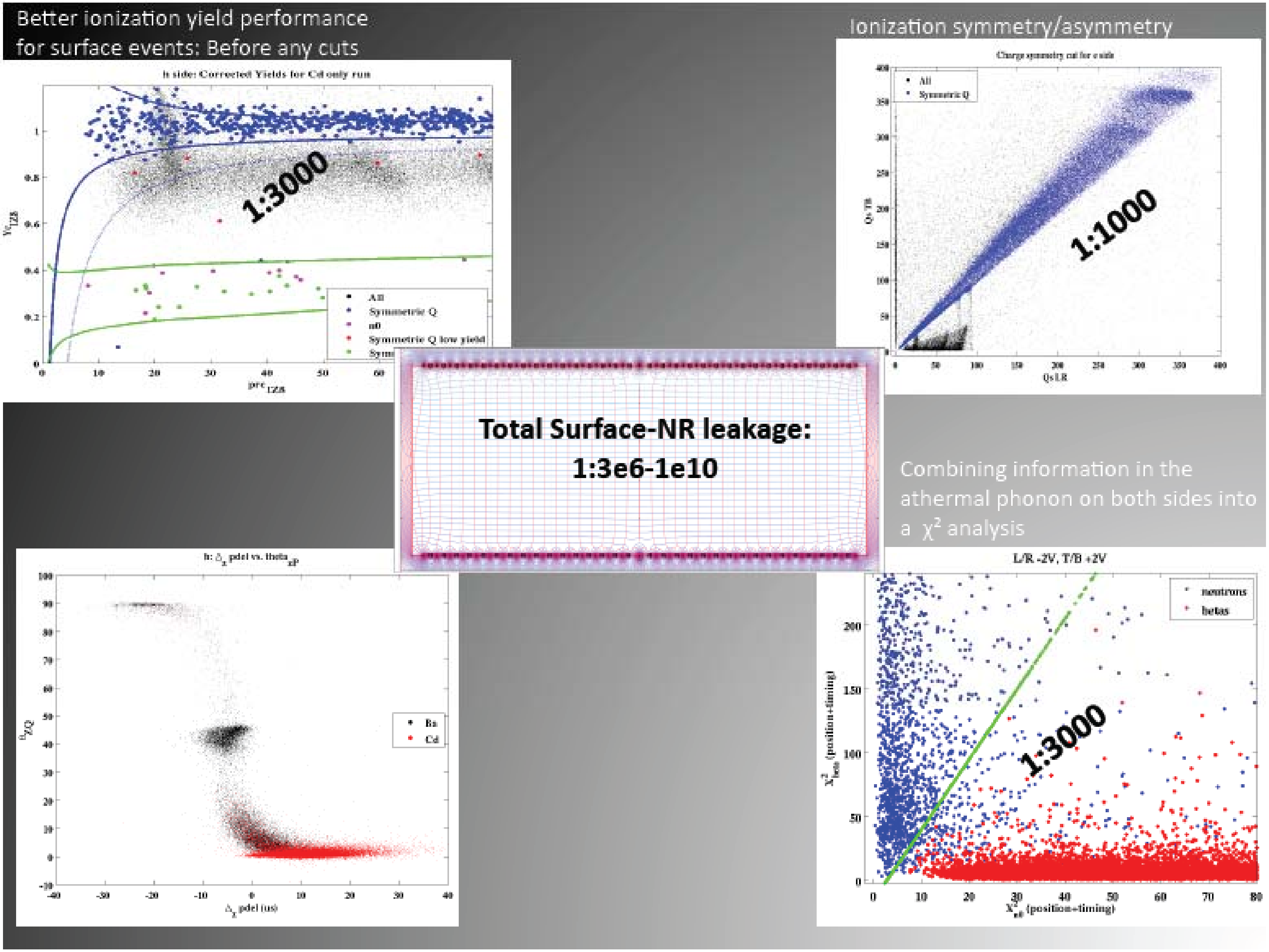
- Complex E-fields encode Position information. High field at surface improves ionization collection of β
- Alternating Lines at Different Potentials (±2V/0V)



Background rejection ~ an order of magnitude better than needed
Already good enough for ton-scale!



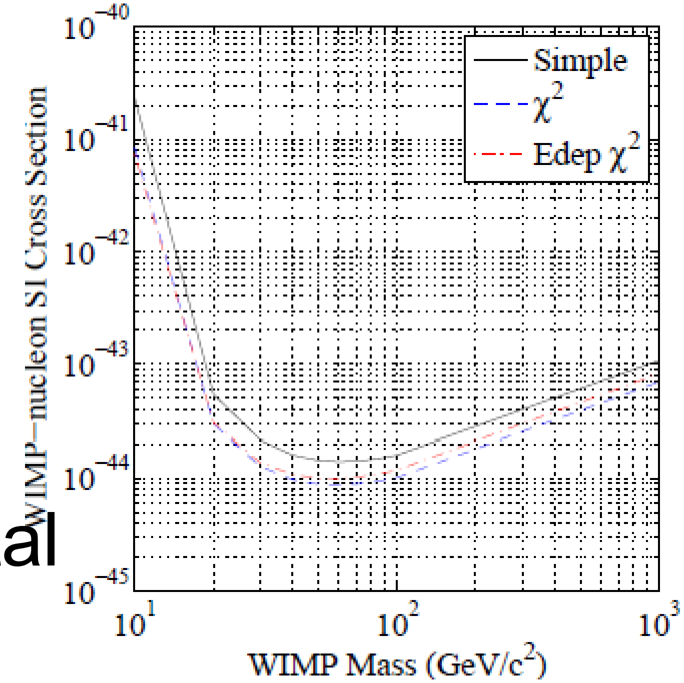
surface and bulk events experience different electric fields



Better ionization yield performance
for surface events: Before any cuts
h side: Corrected Yields for Cd only run
1:3000
All
Symmetric Q
n0
Symmetric Q low yield
Ionization symmetry/asymmetry
Charge symmetry cut for e side
All
Symmetric Q
1:1000
Total Surface-NR leakage:
1:3e6-1e10
Combining information in the
athermal phonon on both sides into
a χ² analysis
Ba
Cd
L/R -2V, T/B +2V
neutrons
betas
1:3000

SuperCDMS Soudan with iZIP

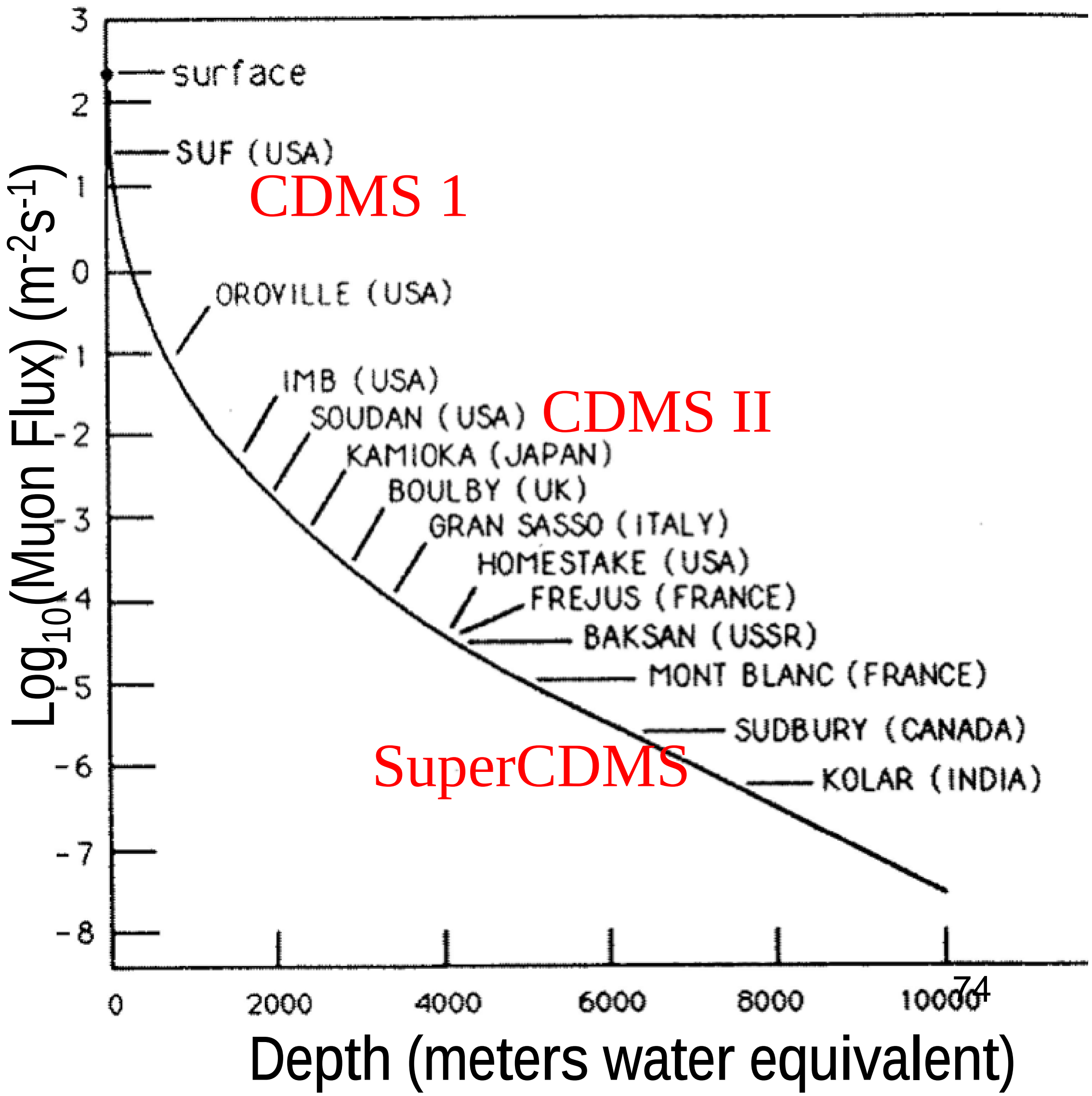
- Fabricating 5 towers of 5 iZIPs (640gm each detector) for Soudan
  - All 5 will be installed by end of summer 2011
- Installation of 2 regular ZIP towers (already built) and 1 iZIP tower (total 10kg) end of year
  - Phasing out CDMSII towers (250g)
- Exciting results next year
  - Extremely low β background
  - Probably limited by neutrons in 2 yr
  - **Go to SNOLab**



SuperCDMS 100 kg: SNOLab

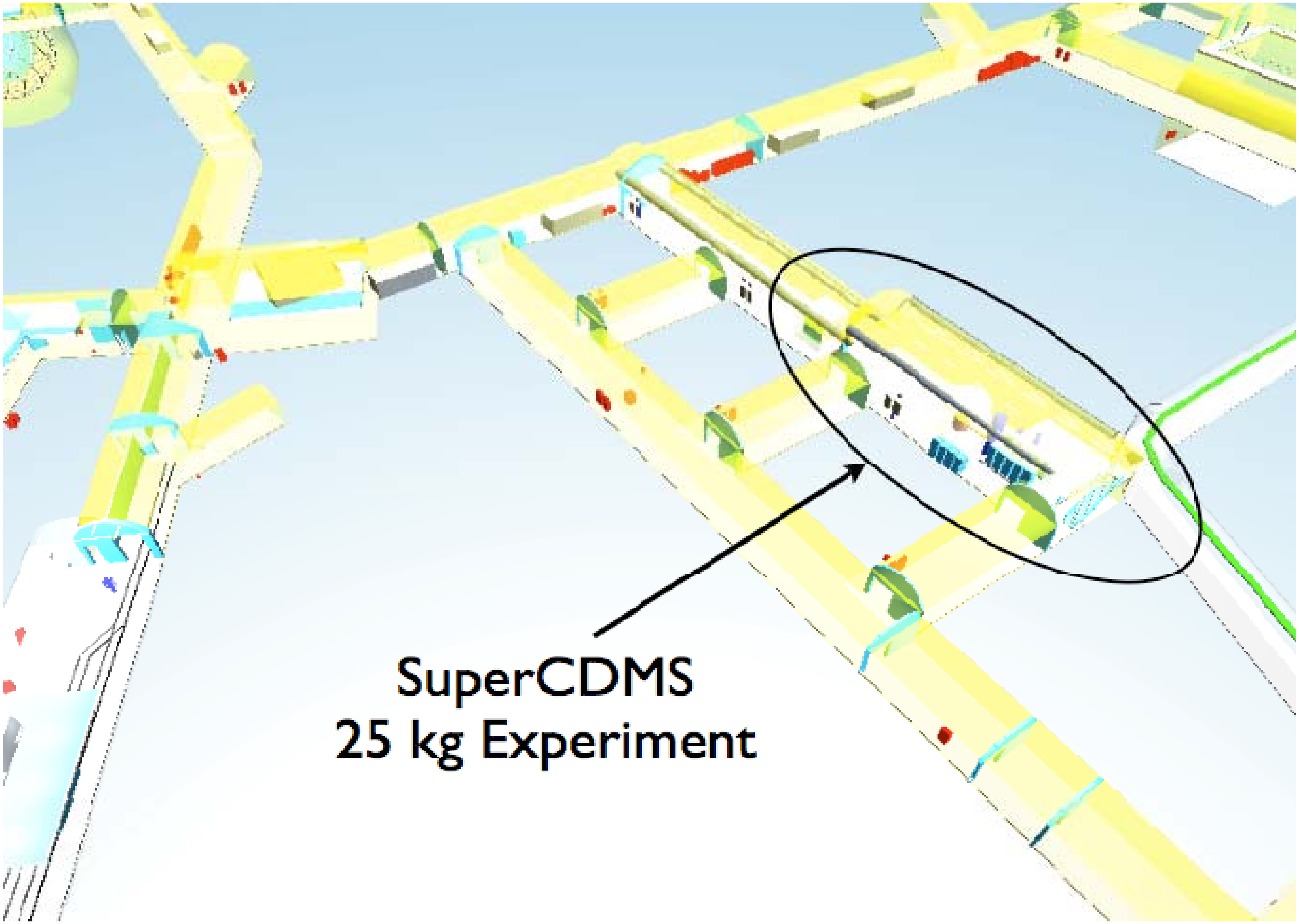
Strong endorsement by Part. Astroph. Sc. Adv. Group (PASAG) 2009

- **100kg total mass: bigger iZIP (4"x1.33", 1.5kg)**
- **Negligible radioactive & cosmogenic background**

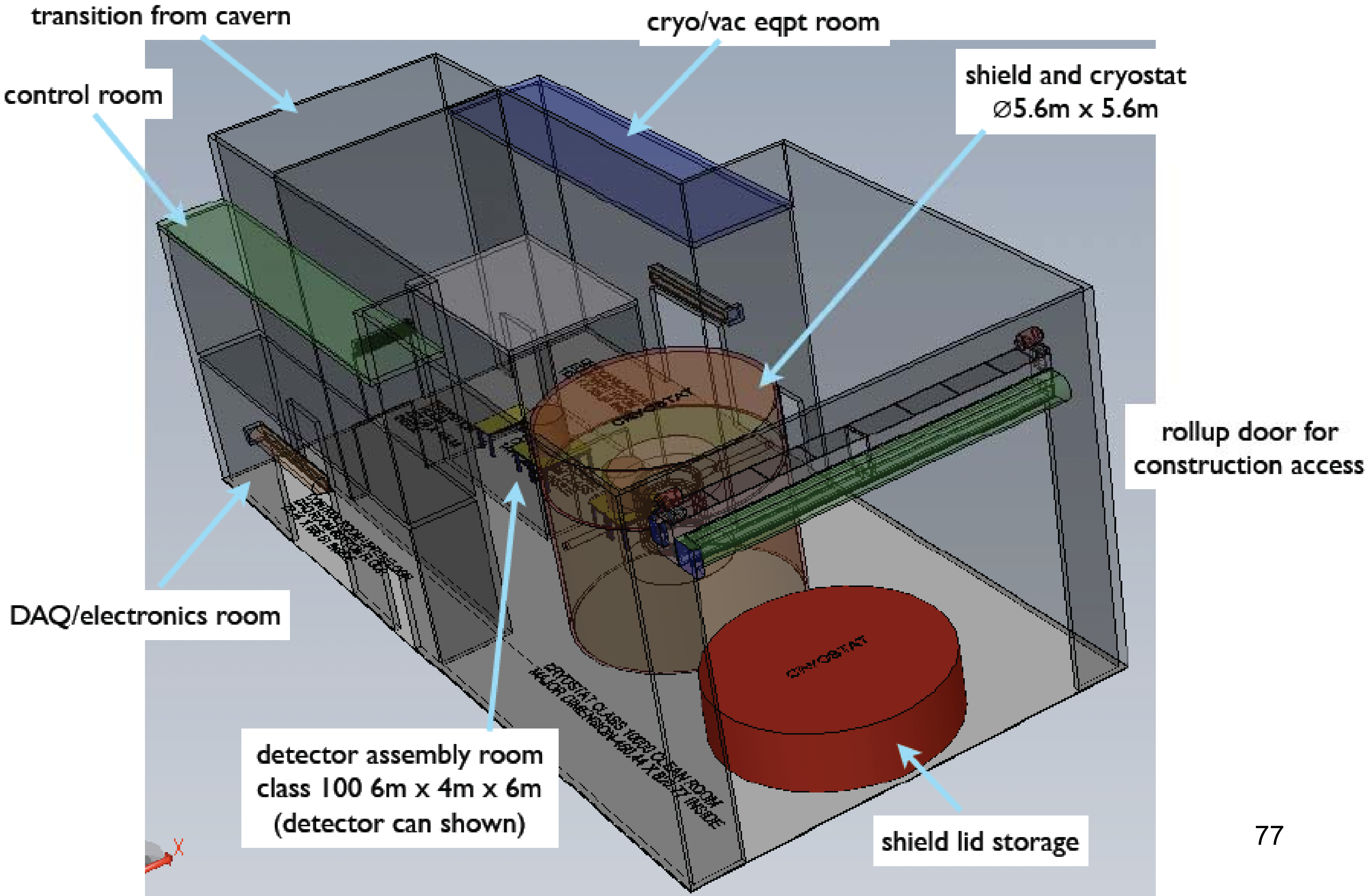


- **Sensitivity reach 10^-46**

SuperCDMS in SNO Lab



GEODM AT DUSEL (7400)



GE Observatory for Dark Matter GEODM Ton Scale DUSEL

- Current mass of detectors : 5 Kg. Need 1500 kg!
  - Current production rate is 1 detector/month. Improve by 10X
  - The responsibilities are with Texas A&M and SLAC/Stanford

- Streamline detector fabrication (remove need for individ
  - Testing is more expensive (time wise, marching ion,. Only random sample testing if variability i

- Mass production with industrial y.
  - Already demonstrated deposition at TAMU

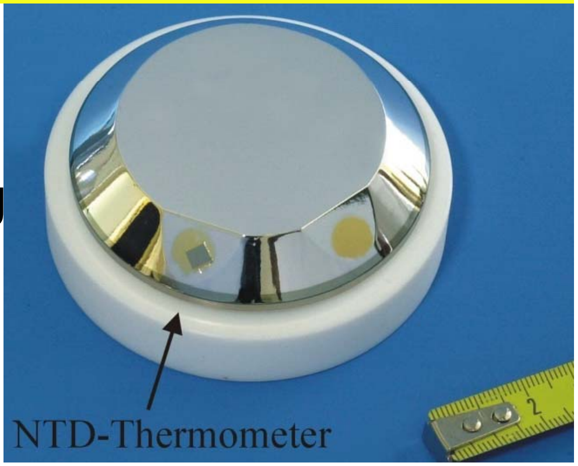
- Increase detector size. Few make and test. Economy of scale
  - Berkeley/Minnesota ex gger wafer procurement and testing

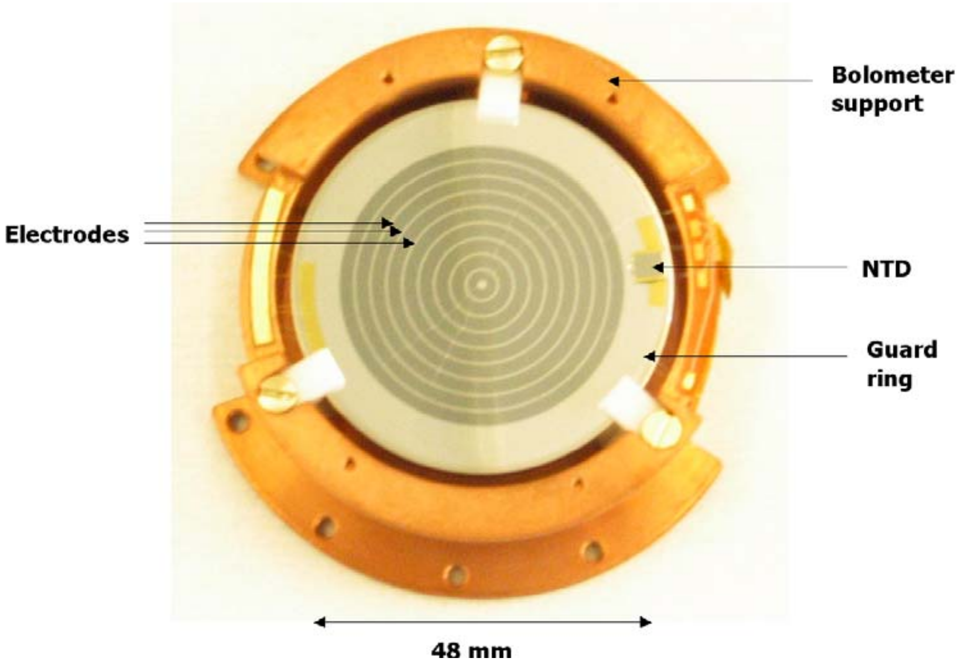
Critical issue is manufacturability

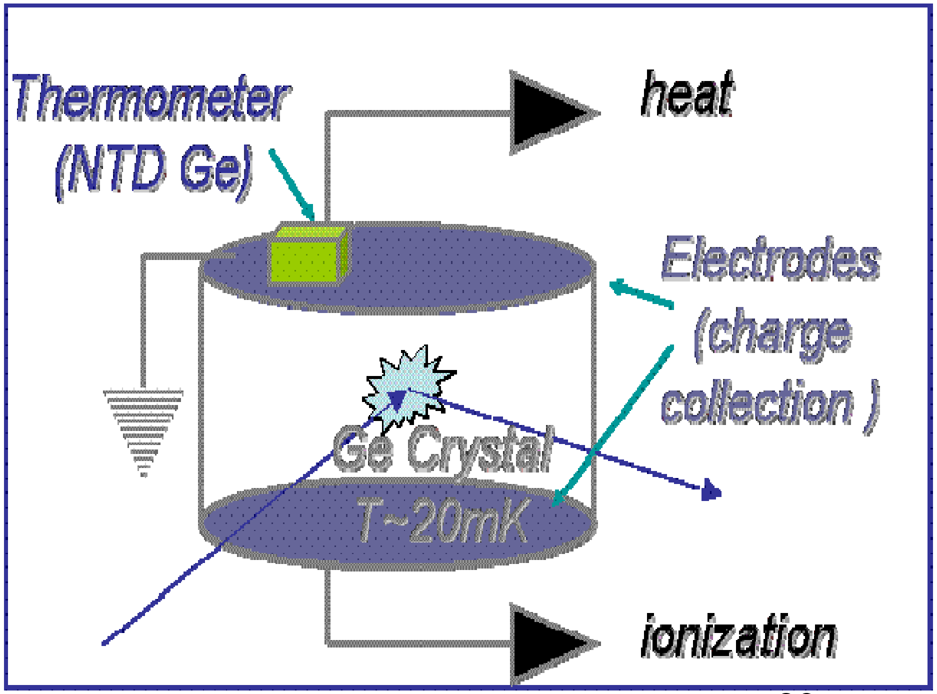
Other Direct Detection Technologies

EDELWEISS: Ge with Thermal Phonons

- Thermal Phonons with ms timing (unlike μs CDMS)
- Easier to fabricate than CDMS detectors
- New detectors interleaved electrodes for alternating electric field for better surface charge collection
- 5kg total mass (400gm detectors in latest batch)

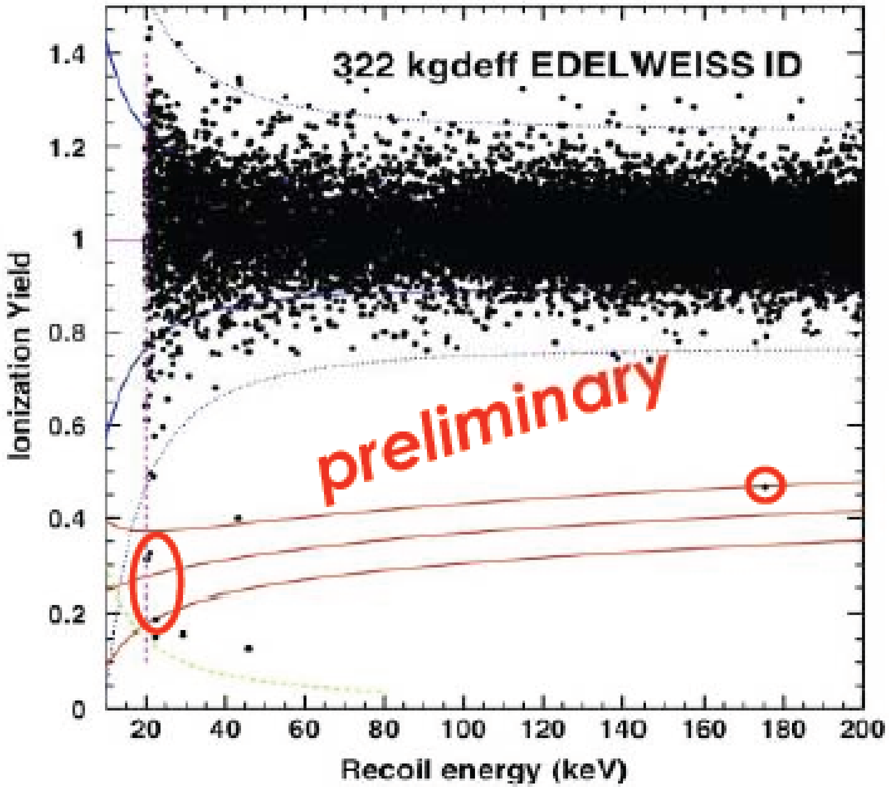


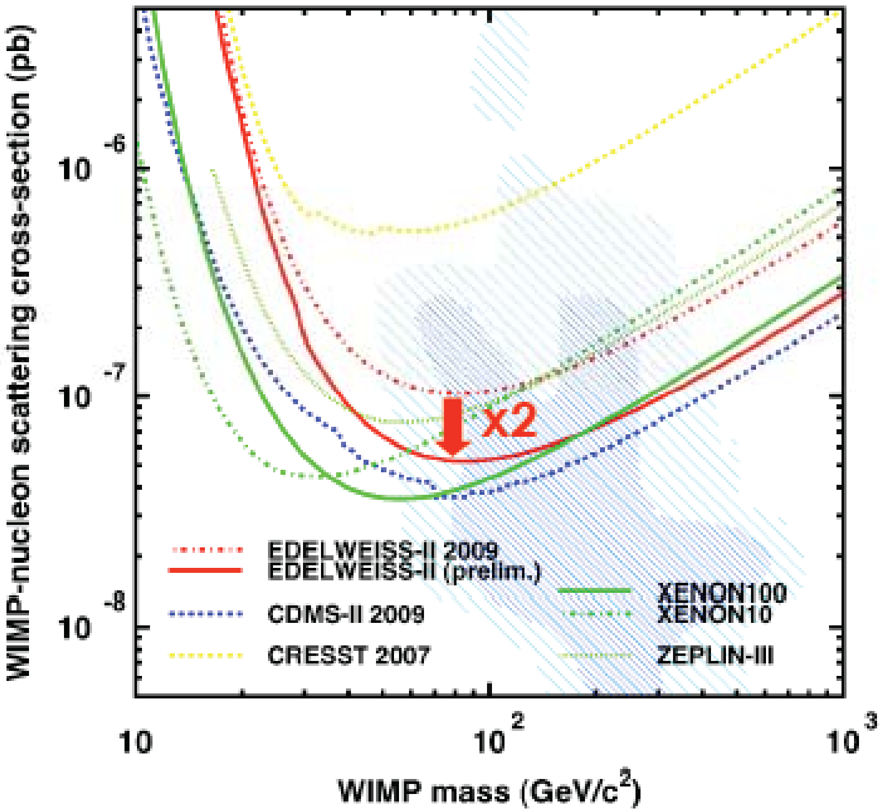




EDELWEISS & CRESST ($CaWO_4$) merge as EURECA collab.

WIMP search last results (May 2010)





- Preliminary result : 1st analysis with same cuts as first 6 months; 2nd analysis ongoing
- x2 improved sensitivity in σ_{SI} (scale with stat): best limit 5×10^{-8} pb at $M_\chi \sim 80$ GeV
- 3 evts near threshold in NR band, 2 outliers (1 @ 175 keV in NR band)

  ...background starts to appear ?

A. S. Torrentó - CEA/IRFU

Noble Liquid Status

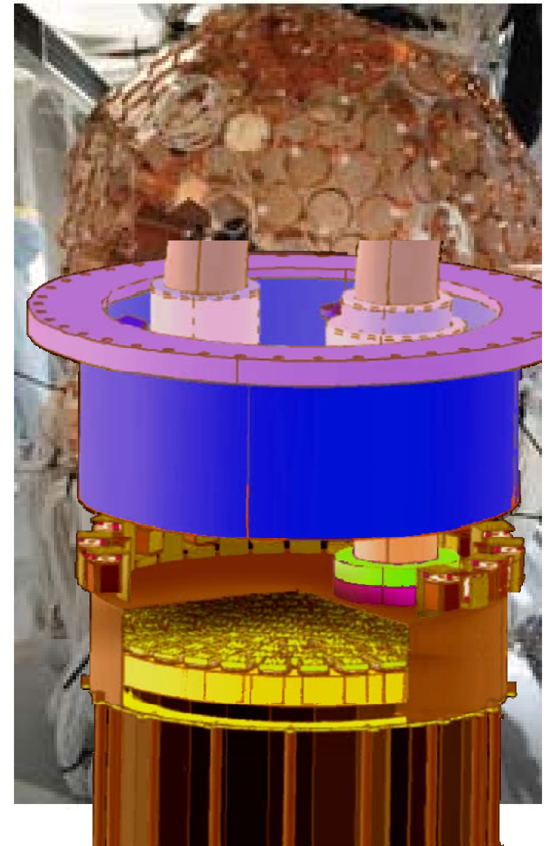
- **Single Phase Detectors: Rely on self shielding + position reconstruction/pulse shape discrimination (Ar):**
  - **No event by event discrimination (somewhat in Ar)**
  - XMASS (Xe): 100kg fiducial (Japan)
  - MiniClean (Ar): 150kg fiducial (Construction in SNOLab)
  - DEAP-3600 : 1ton fiducial (Approved)
- **Dual Phase Xenon: Self shielding + S2/S1**
  - **85Kr (β source) + diffusive background such as Rn**
  - Event by event NR/ER discrimination
  - **Light collection efficiency at low energy is uncertain**
  - Xenon100: 30 kg fiducial (Operating in Gran Sasso)
  - LUX: 100kg fiducial (construction in Home stake in 2011)

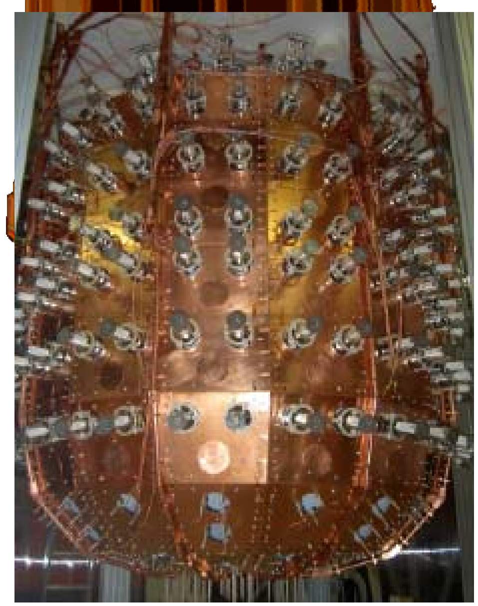
•**Dual Phase Argon: Self shielding + S2/S1**

•**39Ar is a major issue. Last run limited by background**

•**WARP: 140kg fiducial (commissioning in Gran Sasso)**

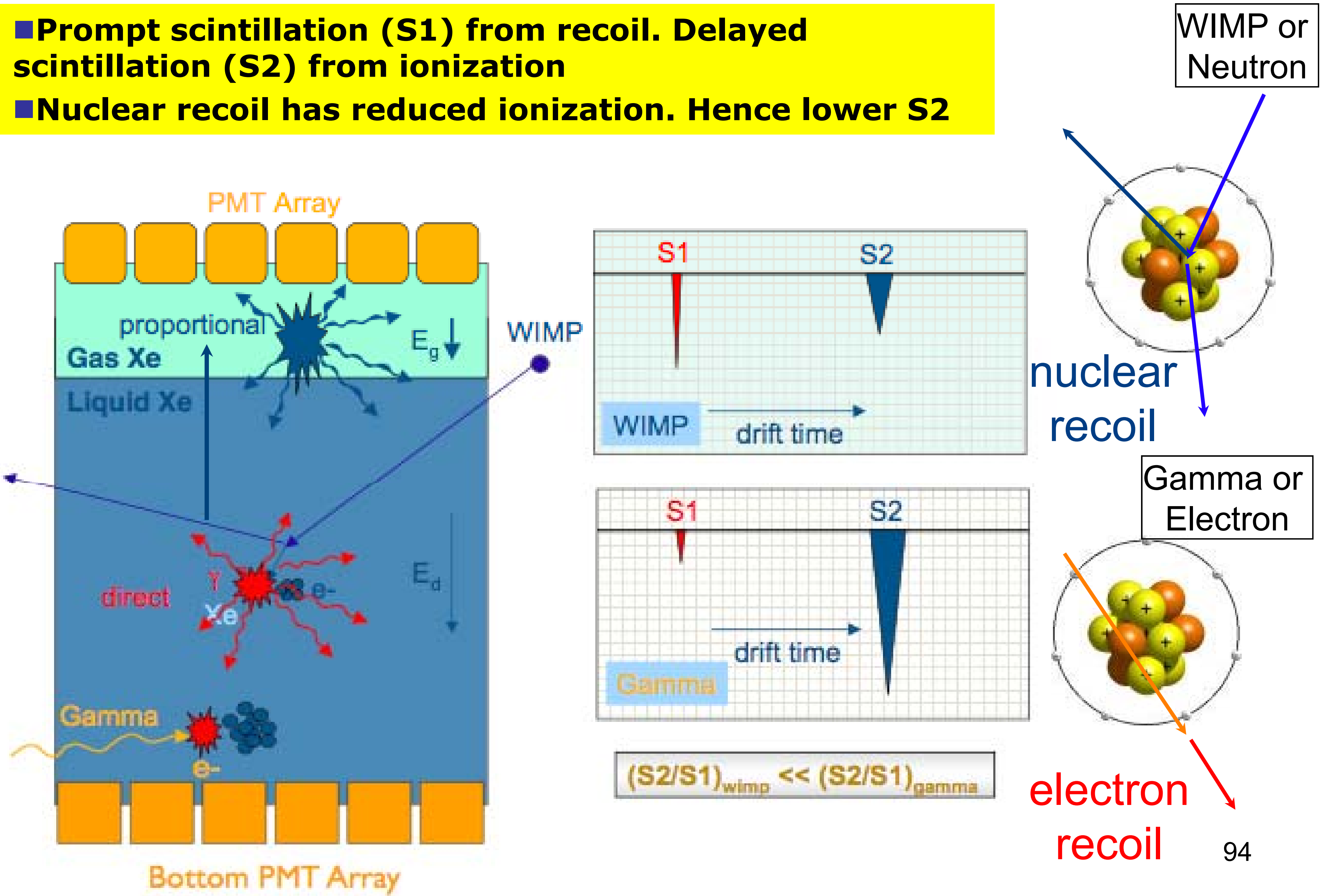
•**ArDM: 500kg fiducial (commissioning at CERN)**





Dual Phase Noble Liquid (Xenon/Ar)

- **Prompt scintillation (S1) from recoil. Delayed scintillation (S2) from ionization**
- **Nuclear recoil has reduced ionization. Hence lower S2**

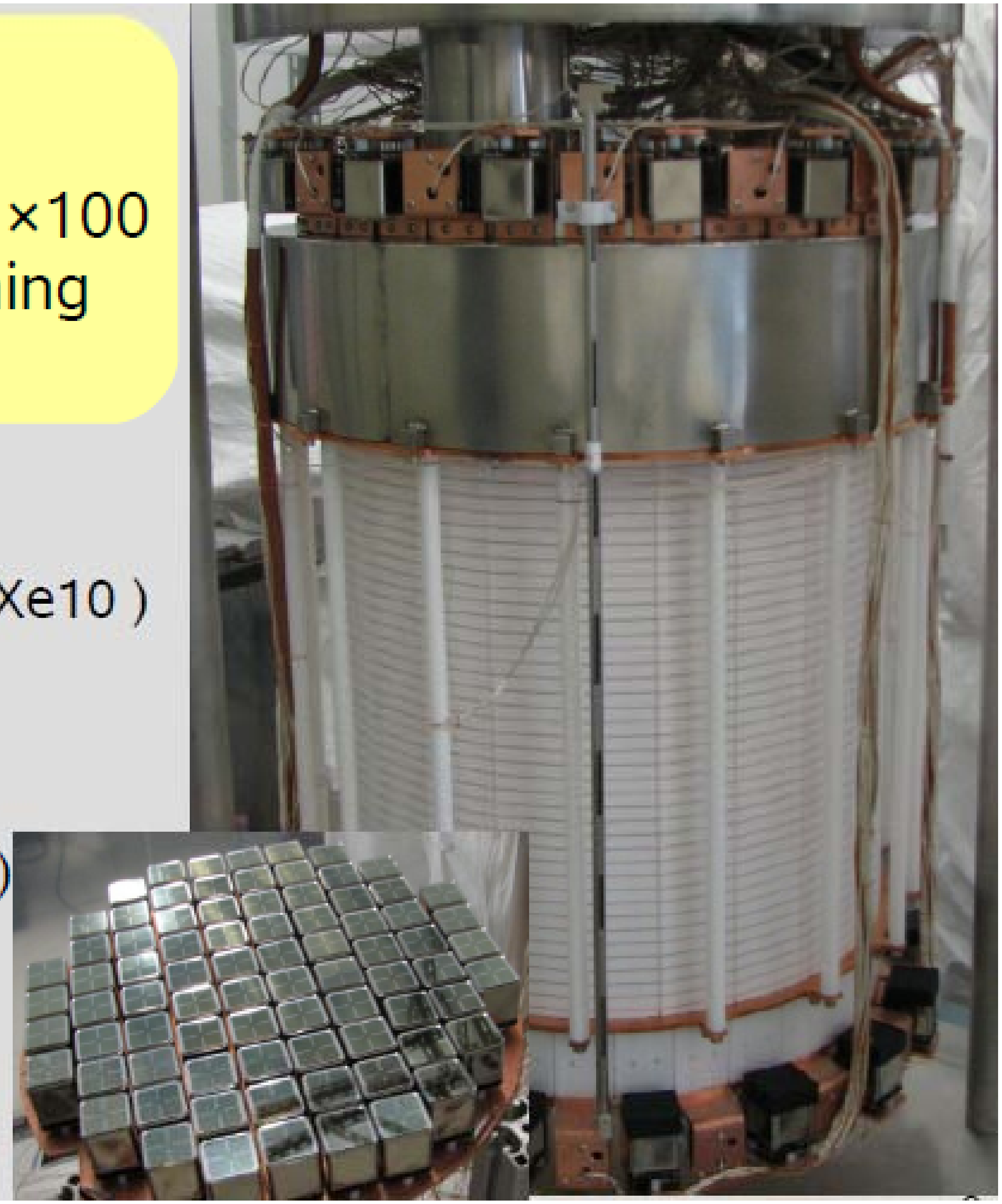


XENON100

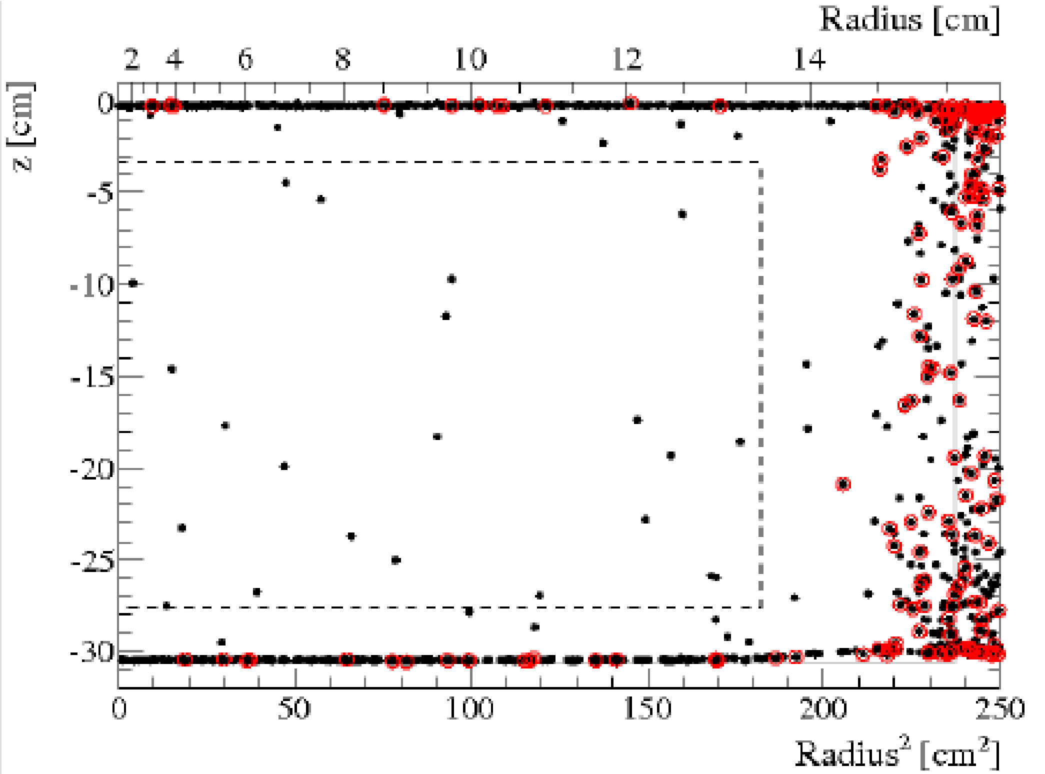
Goal (compared to XENON10):
- increase target ×10
- reduce gamma background ×100

→ material selection & screening
→ detector design

Quick Facts:
- 161 kg LXe TPC (mass: 10 × Xe10)
- 62 kg in target volume
- active LXe veto (≥4 cm)
- 242 PMTs (Hamamatsu R8520)
- improved Xe10 shield
  (Pb, Poly, Cu, H_2O, N_2 purge)



First XENON100 Nonblind Data



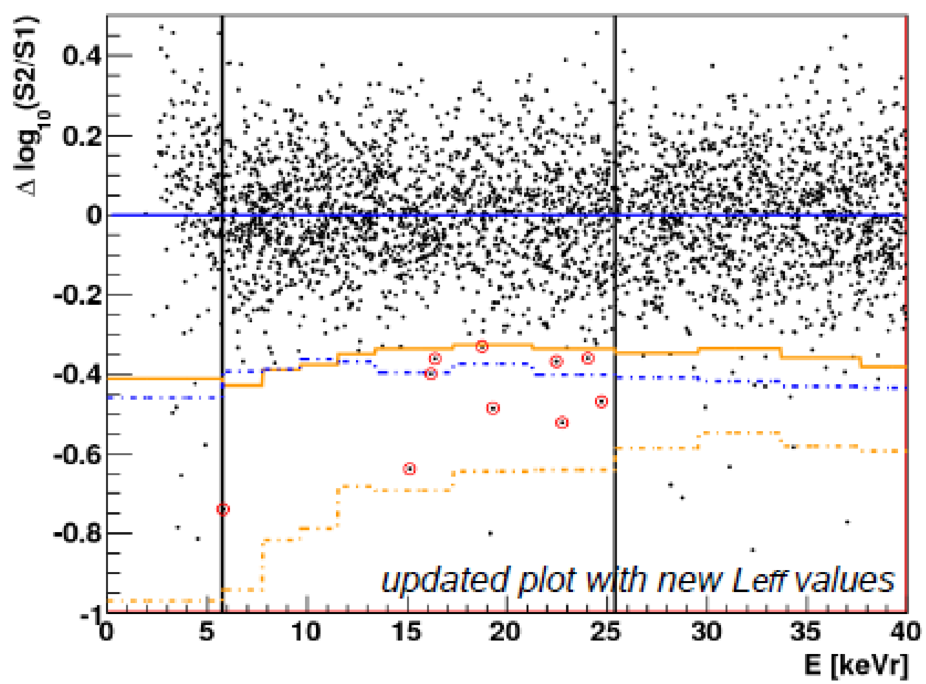
- Energy cut: <30 keVnr
- make use of excellent self-shielding capability of LXe
- **30 Kg Fiducial Mass**

- Background data taken in stable conditions Oct-Nov 2009
- 11.2 life days
- Data was not blinded
- But: Cuts developed and optimized on calibration data only
- accepted by PRL *arXiv:1005.0380*

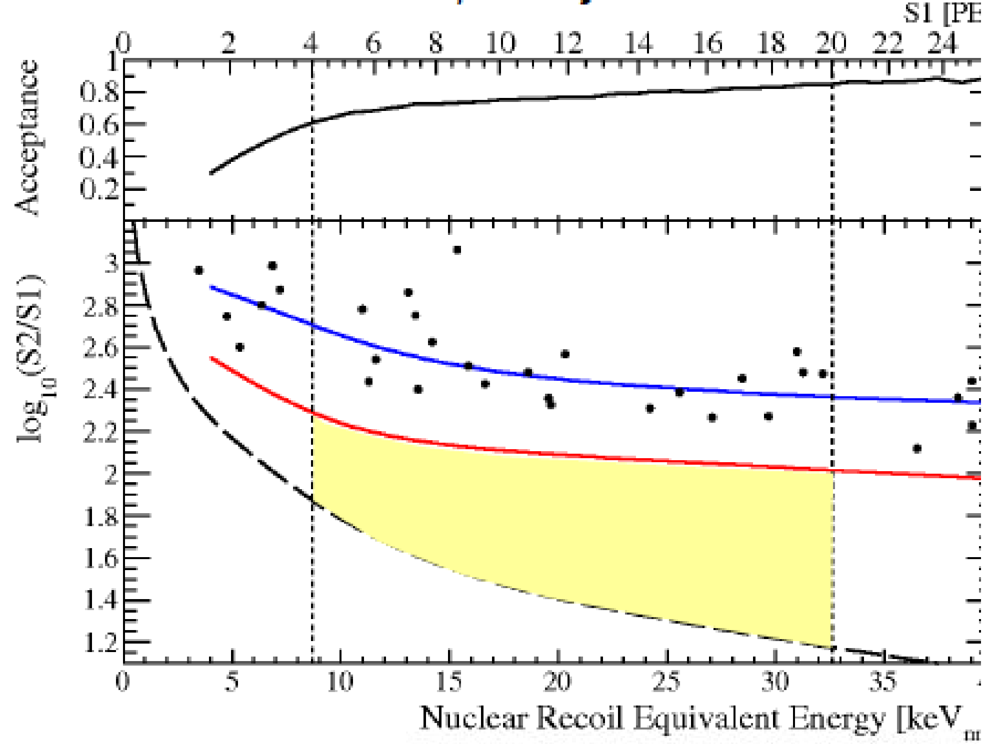
Marc Schumann, UZH

XENON10 vs XENON100

XENON10 *PRL 100, 021303 (2008)*



XENON100 *accepted by PRL, arXiv:1005.038*

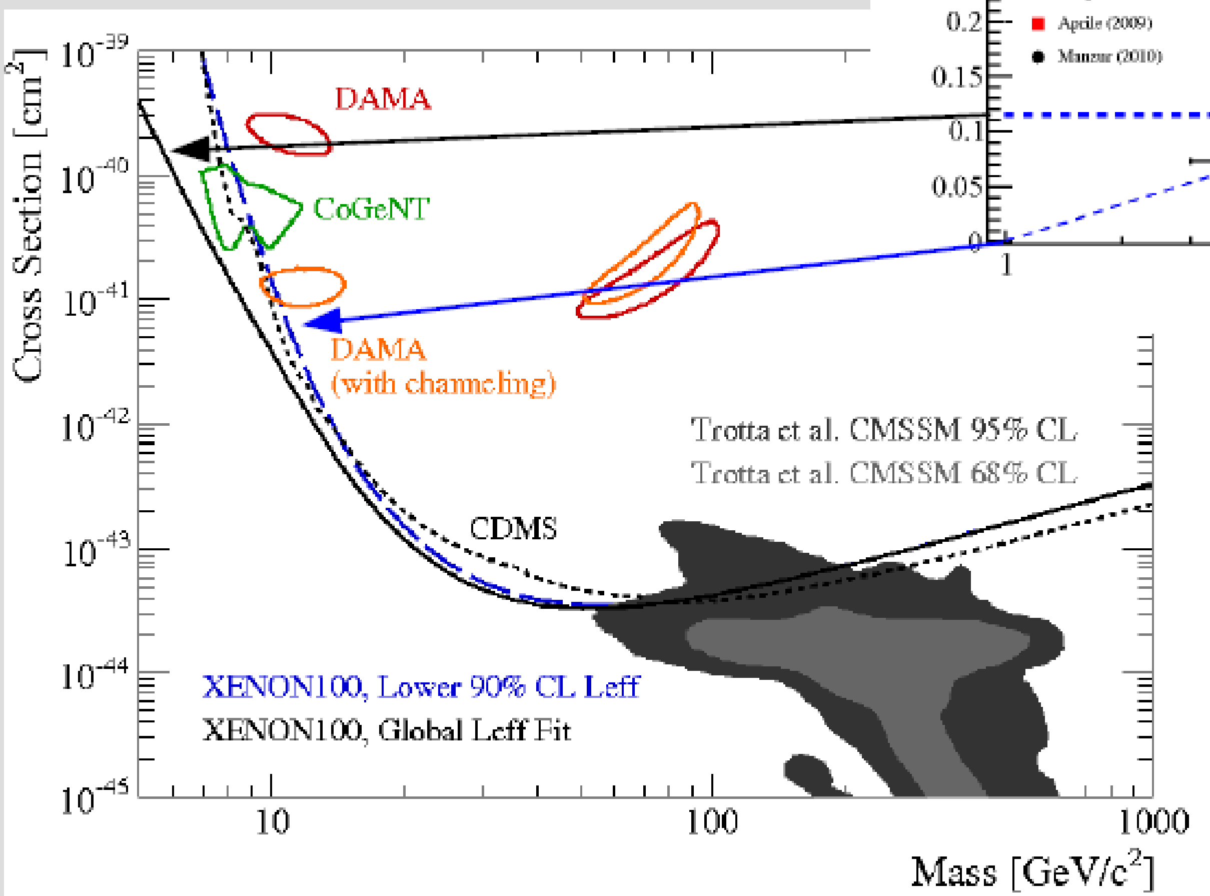


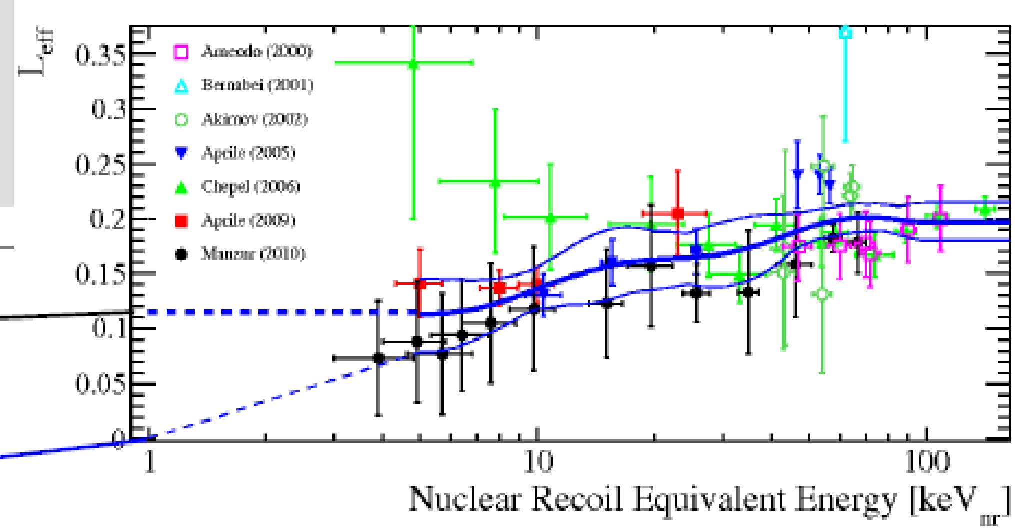
- Background free in 11.2 days after S2/S1 discimination
- Both plots show similar exposure

NR acceptance = 50%
cut efficiency ~ 60-85 % (conservative)
Background expectation ≪1

Marc Schumann, UZH

Limit (Not Blind)





spectrum averaged exposure: 170 kg days

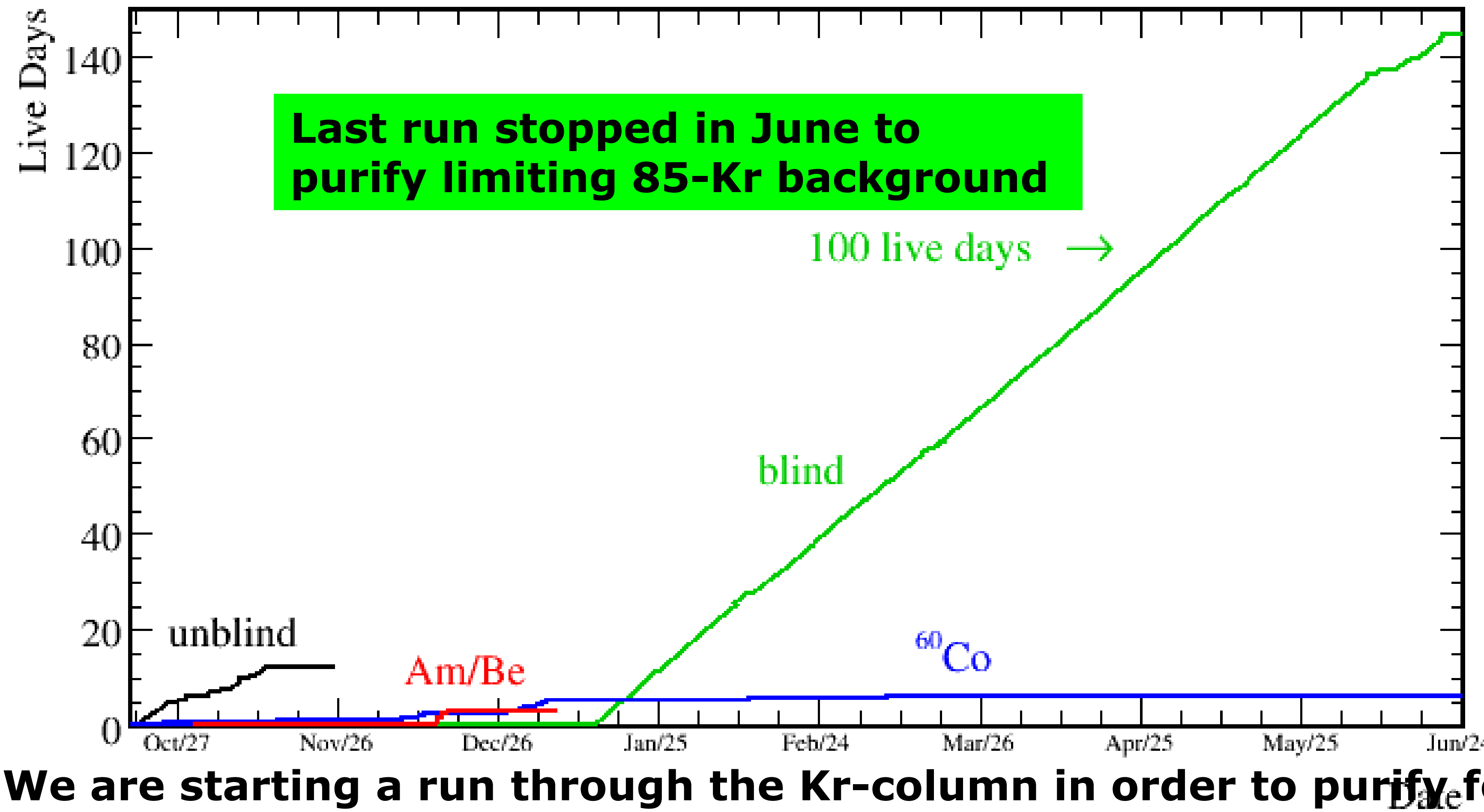
XENON100 is working extremely well and is back at the sensitivity frontier.

This is just a first glimpse! We have much more (blinded) data waiting to be analyzed.

Results accepted by PRL.
arXiv: 1005.0380

Marc Schumann, UZH

Xenon100 Current Status



We are starting a run through the Kr-column in order to purify for 85-Kr, which dominates our background (after the active veto cut). We hope to start the next run, with lower backgrounds, by the end of October or beginning Nov - Laura Baudis

The XENON Program

XENON R&D

ongoing

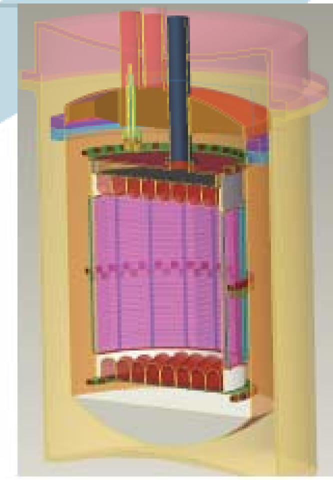
XENON10

2005-2007

XENON100

2008-2011
taking science data

XENON1t



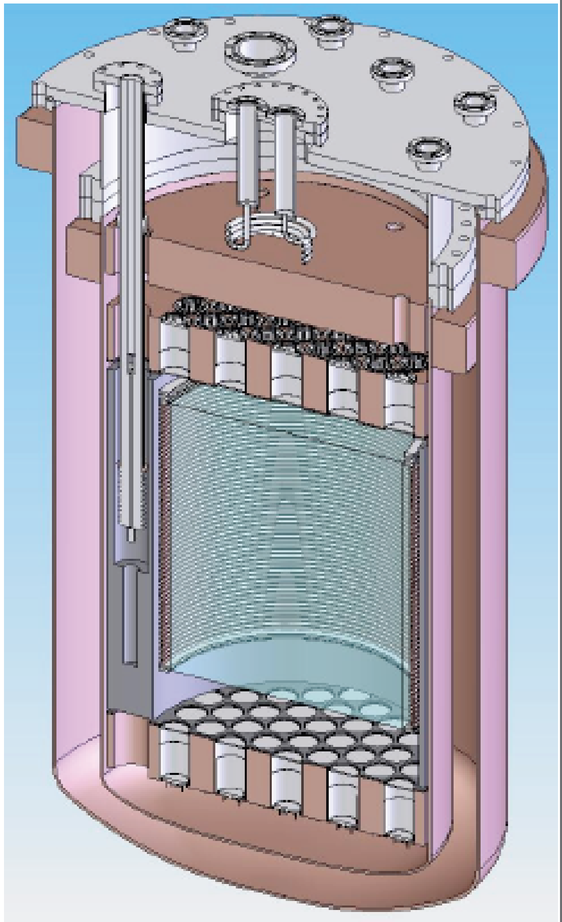
2011-2015
studies in progress
technical proposal
submitted to LNGS
end of April, 2010

Columbia, Zürich, Coimbra, Rice (Mainz), LNGS, Münster, MPIK, Subatech, SJTU, UCLA, Bologna, Torino, Nikhef

Surface assembly ongoing, Underground assembly in 2011

LUX Dark Matter Experiment - Summary

- Brown [Gaitskell], Case [Shutt], LBNL [Lesko] , LLNL [Bernstein], Maryland [Hall], Rochester [Wolfs], Texas A&M [White], UC Davis [Svoboda/Tripathi], U South Dakota [Mei] , Yale [McKinsey]
  - XENON10,ZEPLIN II (US),CDMS; ν Detectors (Kamland/SuperK/SNO/Borexino); HEP/γ-ray astro
  - Also ZEPLIN III Groups in next phase
  - Co-spokespersons: Gaitskell (Brown) / Shutt (Case)
- 300 kg Dual Phase liquid Xe TPC with 100 kg fiducial
  - Using conservative assumptions: >99.4% ER background rejection for 50% NR acceptance, E>5 keVr (ER rejection is energy dependent)
    (Case+Columbia/Brown Prototypes + XENON10 + ZEPLIN II)
  - 3D-imaging TPC eliminates surface activity, defines fiducial
- Backgrounds:
  - Internal: strong self-shielding of PMT activity
    - Can achieve BG $\gamma+\beta < 8\times10^{-4}$ /keVee/kg/day, dominated by PMTs (Hamamatsu R8778).
    - Neutrons (α,n) & fission subdominant
  - External: large water shield with muon veto.
    - Very effective for cavern γ+n, and HE n from muons
    - Very low gamma backgrounds with readily achievable $<10^{-11}$ g/g purity.
- DM reach: 7×10^{-46} cm^2 in 10 months



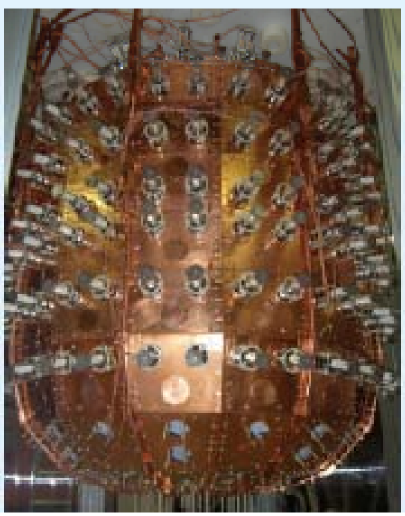
http://www.luxdarkmatter.org

Two-phase Argon Detectors

WARP at LNGS

WIMP target: 140 kg LAr
- S1 and S2 read-out with 41 x 3" PMTs
- active LAr shield: ~ 8t, viewed by 300 PMTs

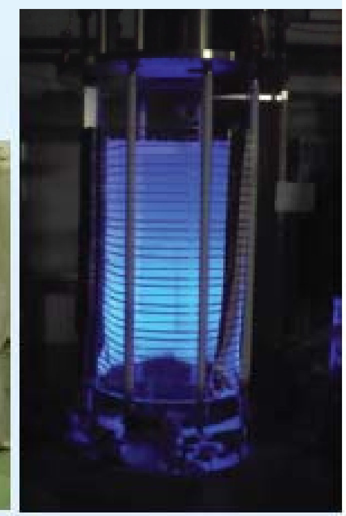
Detector had been installed in December 08
Some technical problems with HV
Now again under commissioning at LNGS

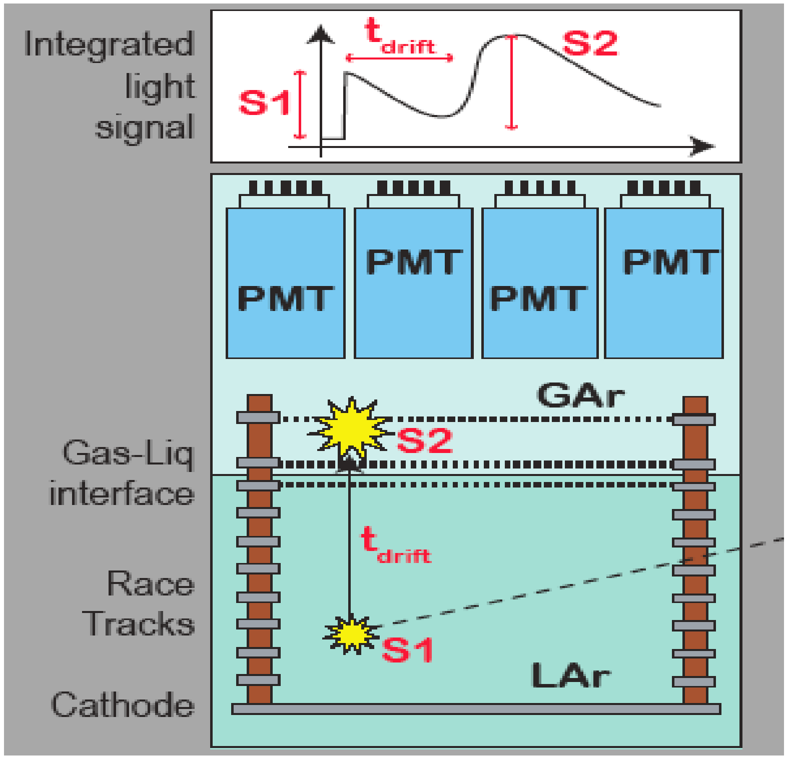


ArDM at CERN

WIMP target: ~1 ton LAr
- S1 read-out with 14 x 8" PMTs
- direct electron readout via LEMs (thick macroscopic GEM)

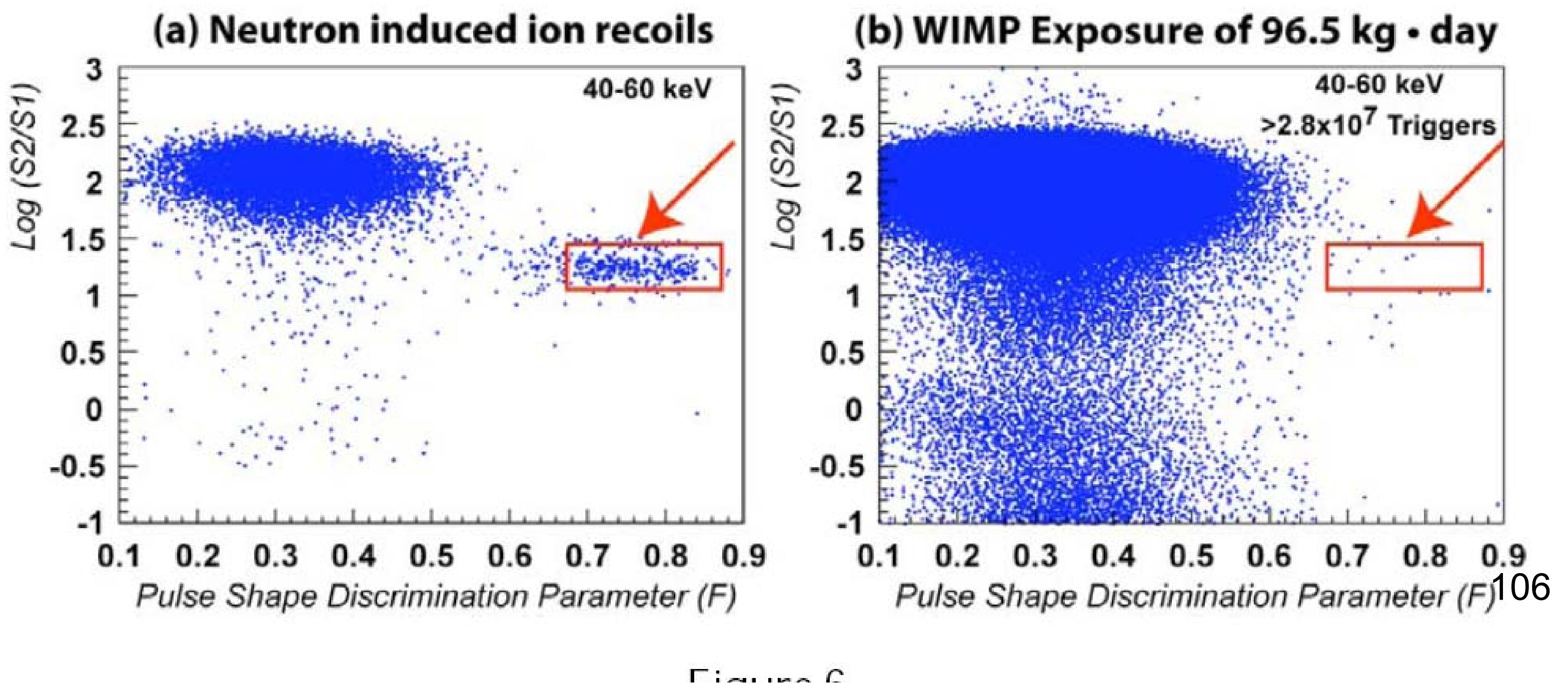
Detector is being commissioned at CERN
Underground operation: LS Canfranc in 2011





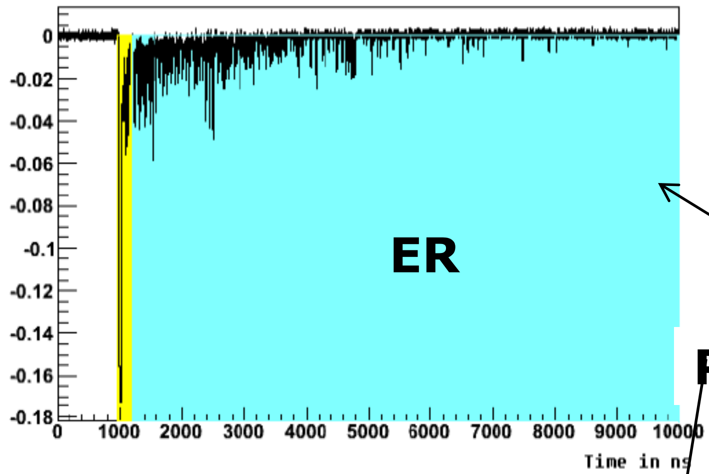
WARP: Liquid Argon

- Similar technique as Xe: Prompt and Delayed Scintillation
- Already hit background with less exposure than CDMS
- Energy scale has a 3x uncertainty! Need to address this

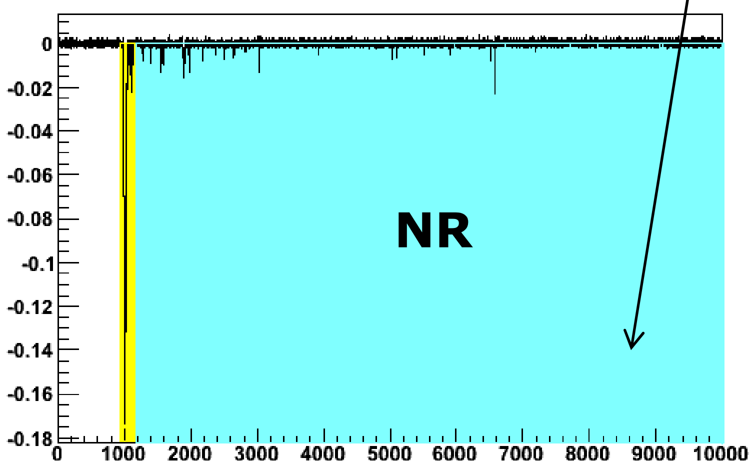


Single Phase Liquid Noble Expts

DEAP (LAr) Pulse Shape Discrmination

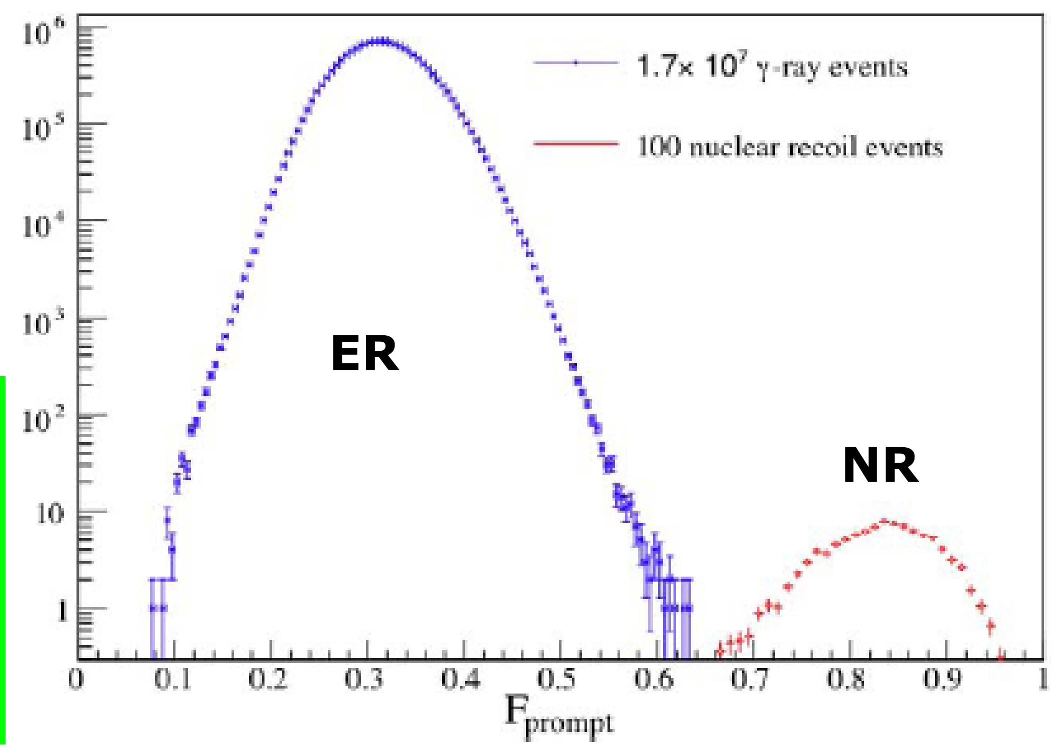


PMT Signals



$$F_{prompt} = \frac{\text{PromptPE}\ (150ns)}{\text{TotalPE}\ (9\mu s)}$$

Yellow: Prompt Light
Blue: Late light



- **Single phase detectors are simpler, but have mostly self shielding to protect them**
- **Diffusive background can be a dangerous problem (Rn?)**

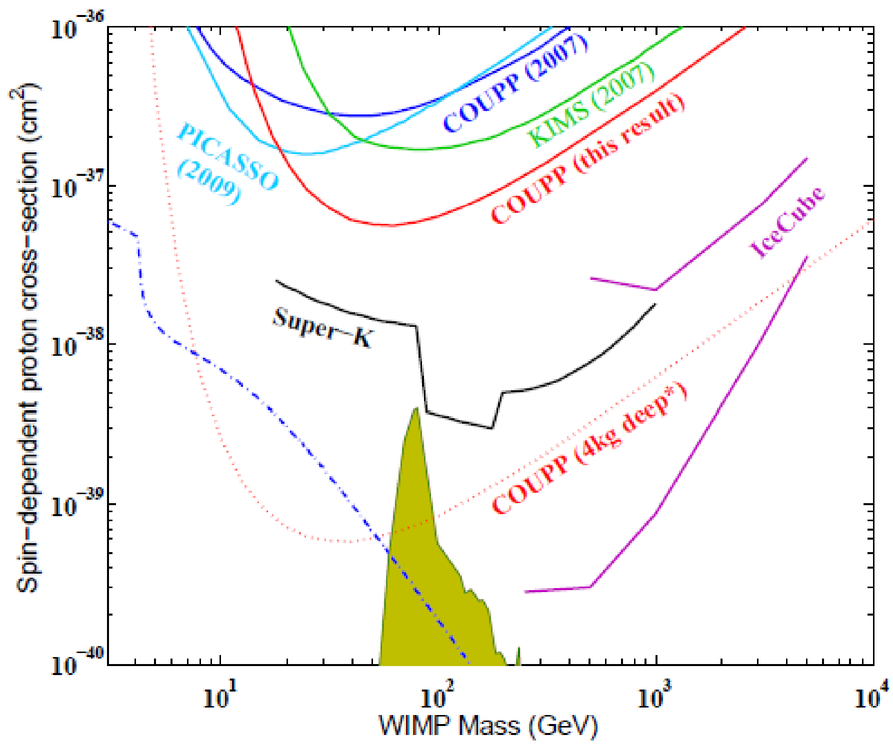
XMASS (Lxe) mini-Clean (LAr)

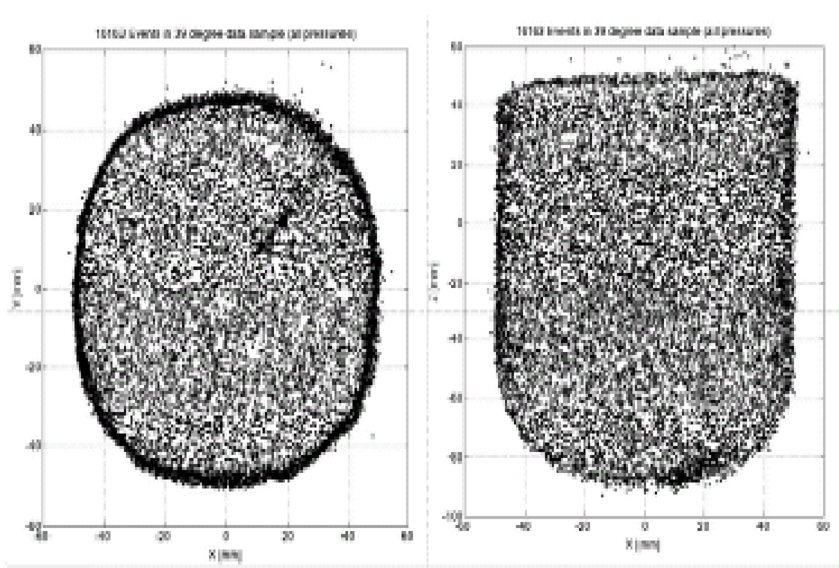
- XMASS in Japan
  - 800kg LXe single phase
  - 100kg fiducial

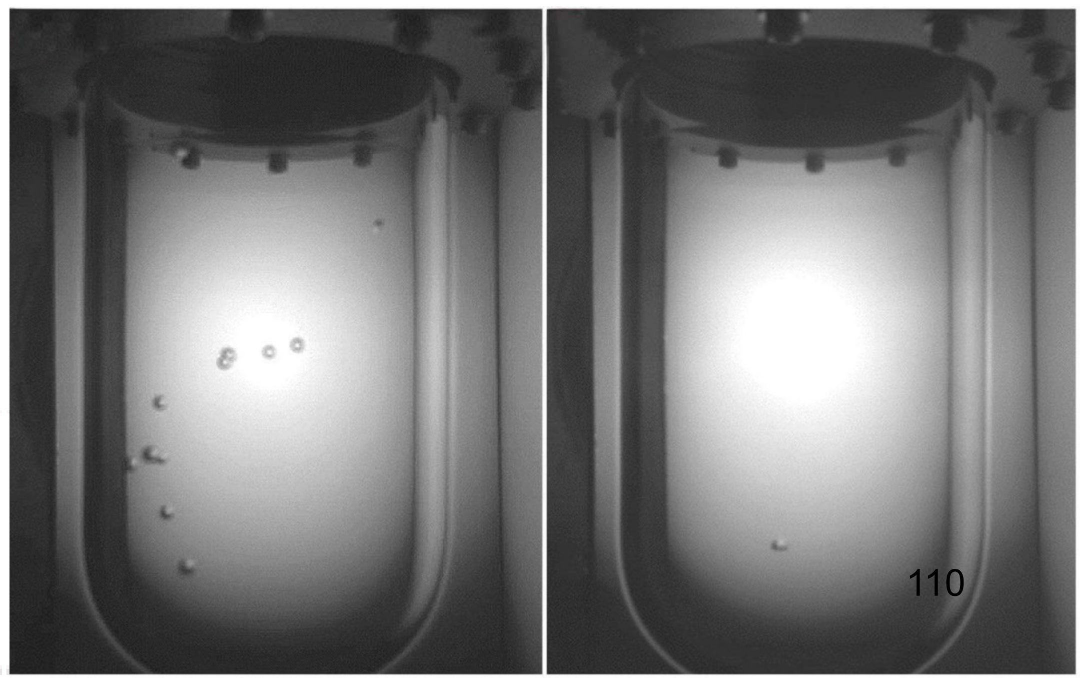
- Mini-CLEAN in SNOLab
  - 500kg LAr single phase
  - 150 kg fiducial

COUPP Bubble Chamber

- Detection of bubble(s) induced by high dE/dx nuclear recoils
- Set threshold to be insensitive to ER
- Low cost room temperature
- Currently limited by Radon
- Recent acoustic rejection of α is very promising

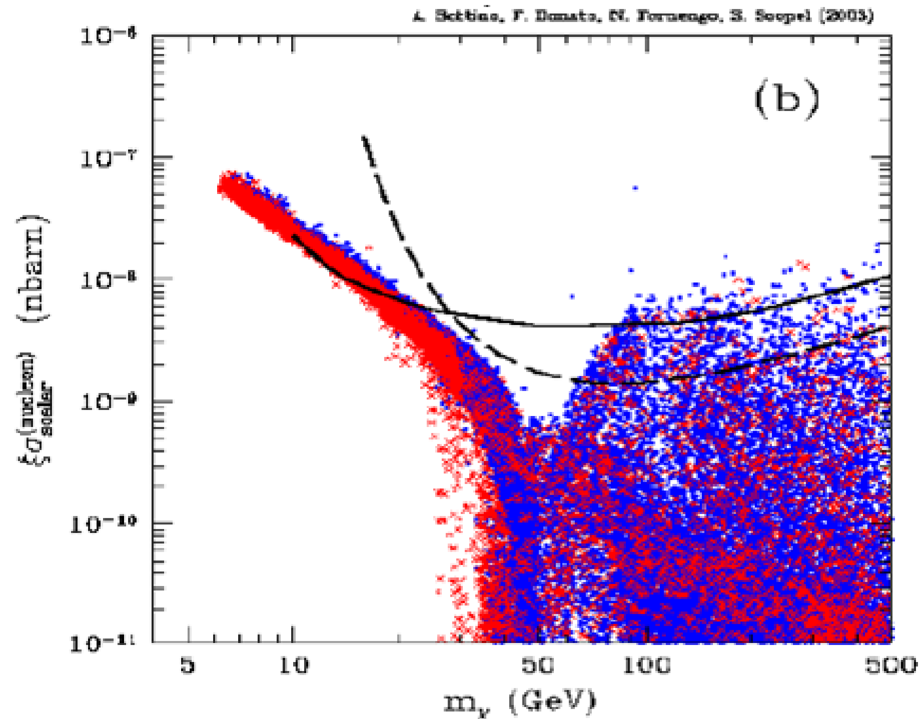


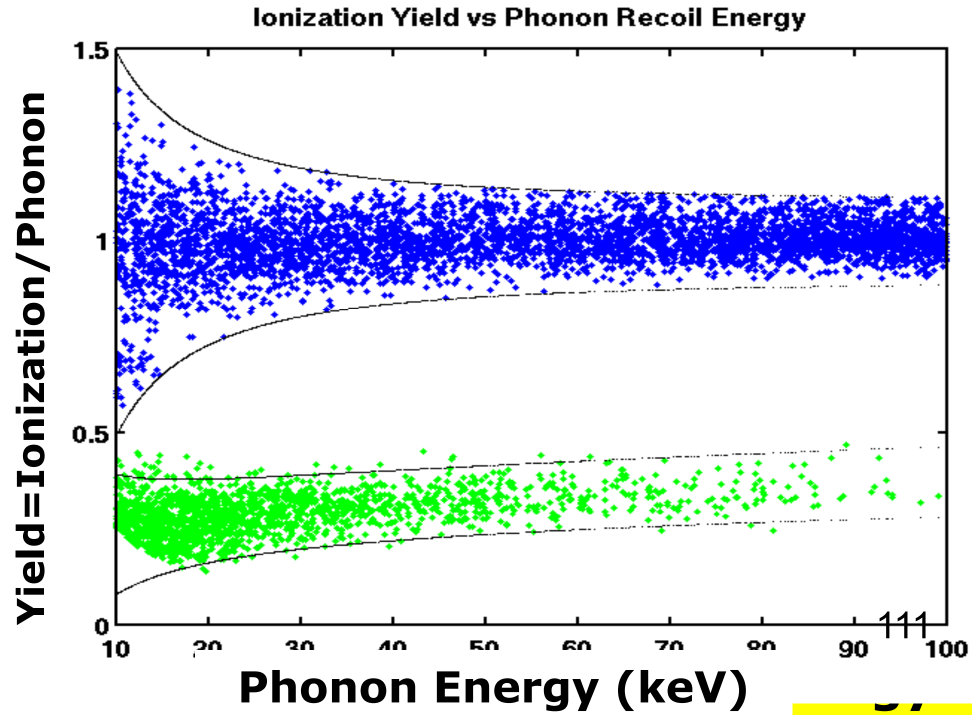




Low Mass WIMPs?

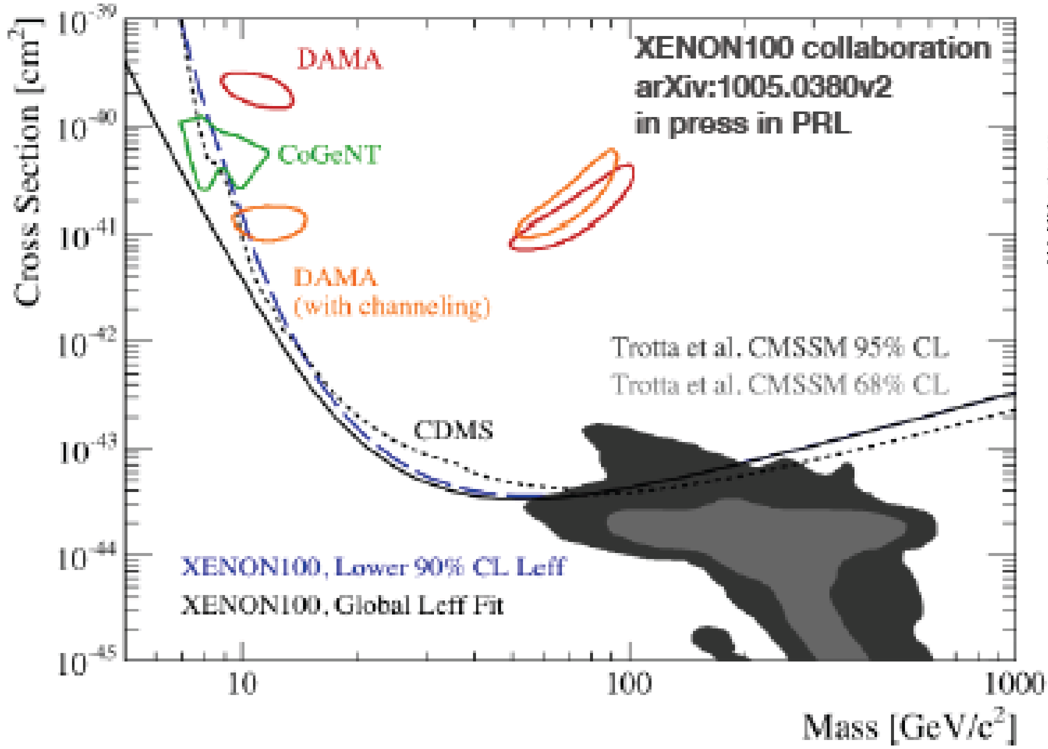
- Some models predict low mass WIMPs from relaxed GUT scale mass unification assumptions
- **Low Mass = Low Threshold!**
- Noise level at ~ .1 keV
- Well understood Background
  - 10.4 keV x-rays from ^{71}Ge
  - 1.3 keV x-rays from ^{71}Ge

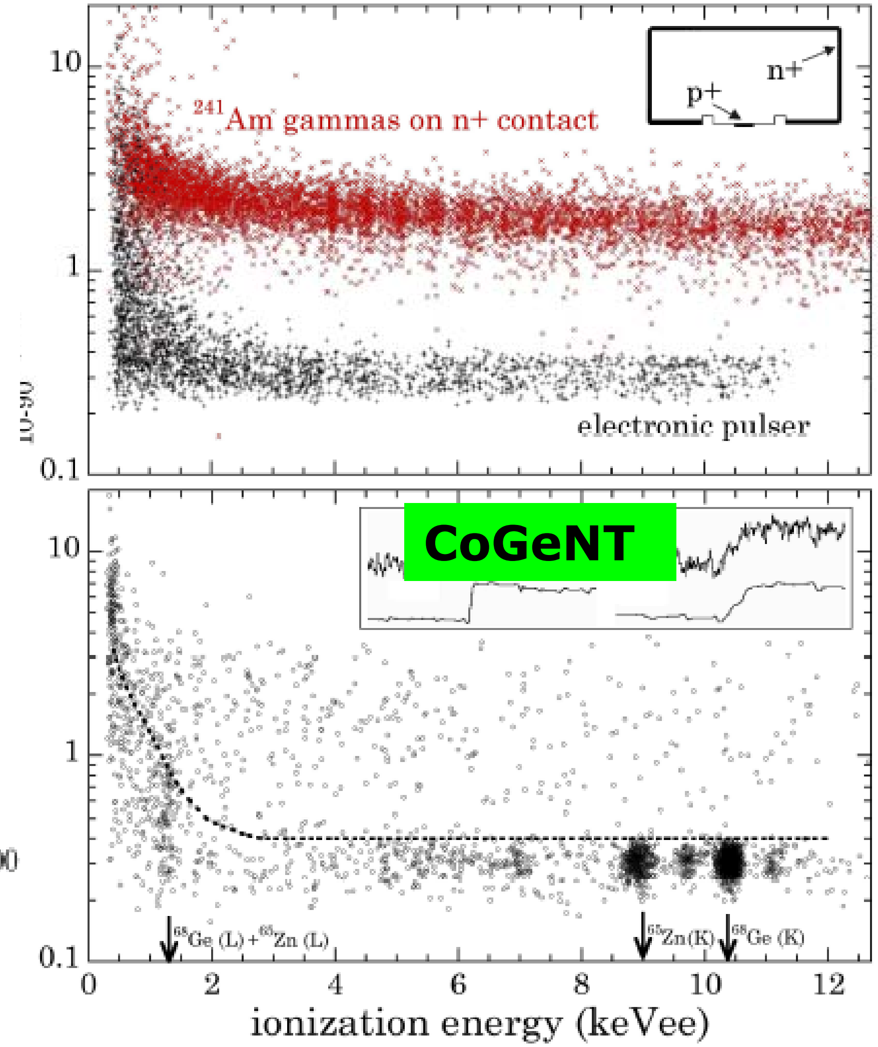


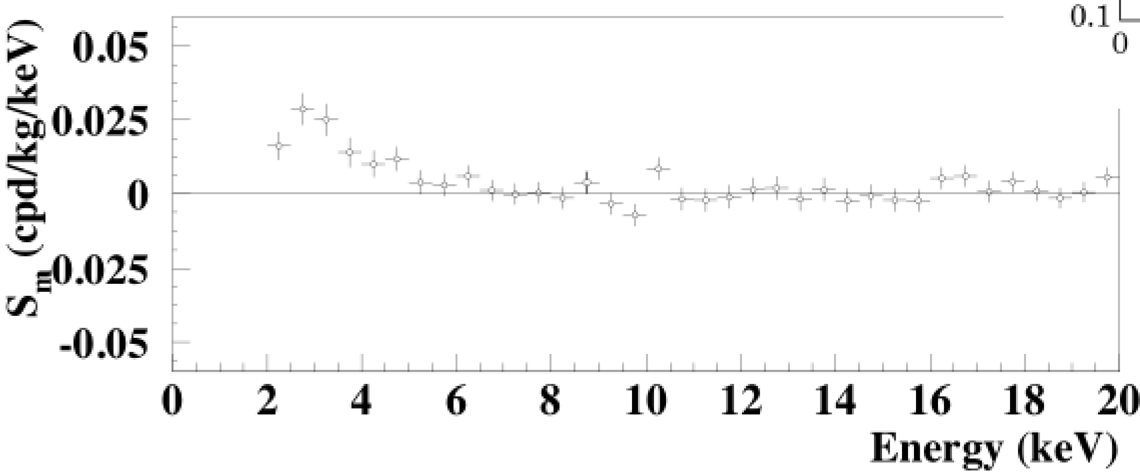


Ray Bunker, UCSB

Low Mass WIMP?

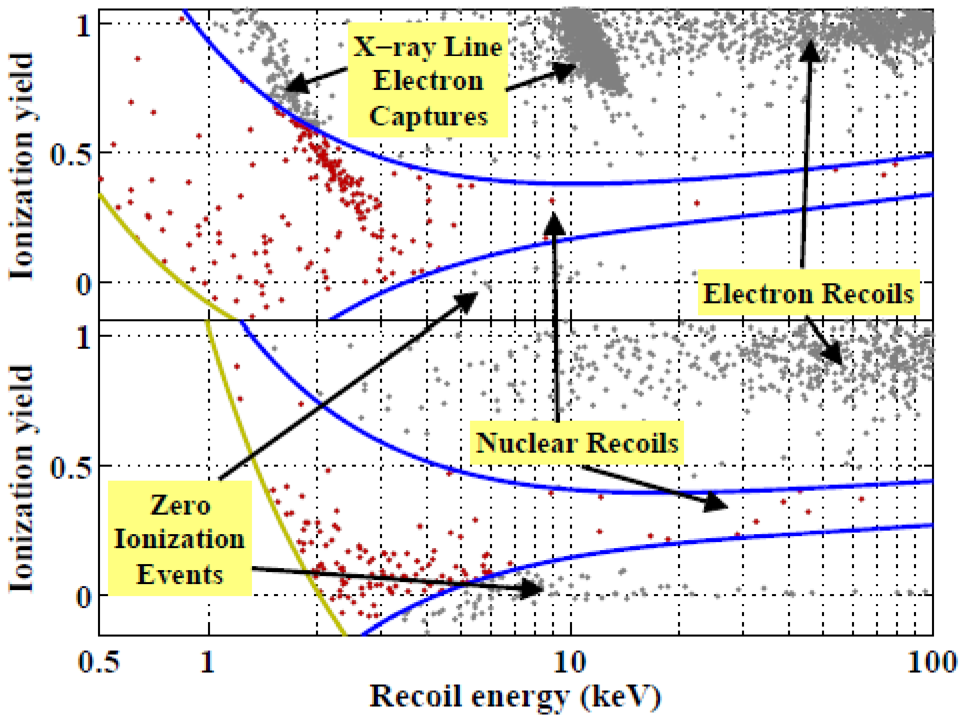


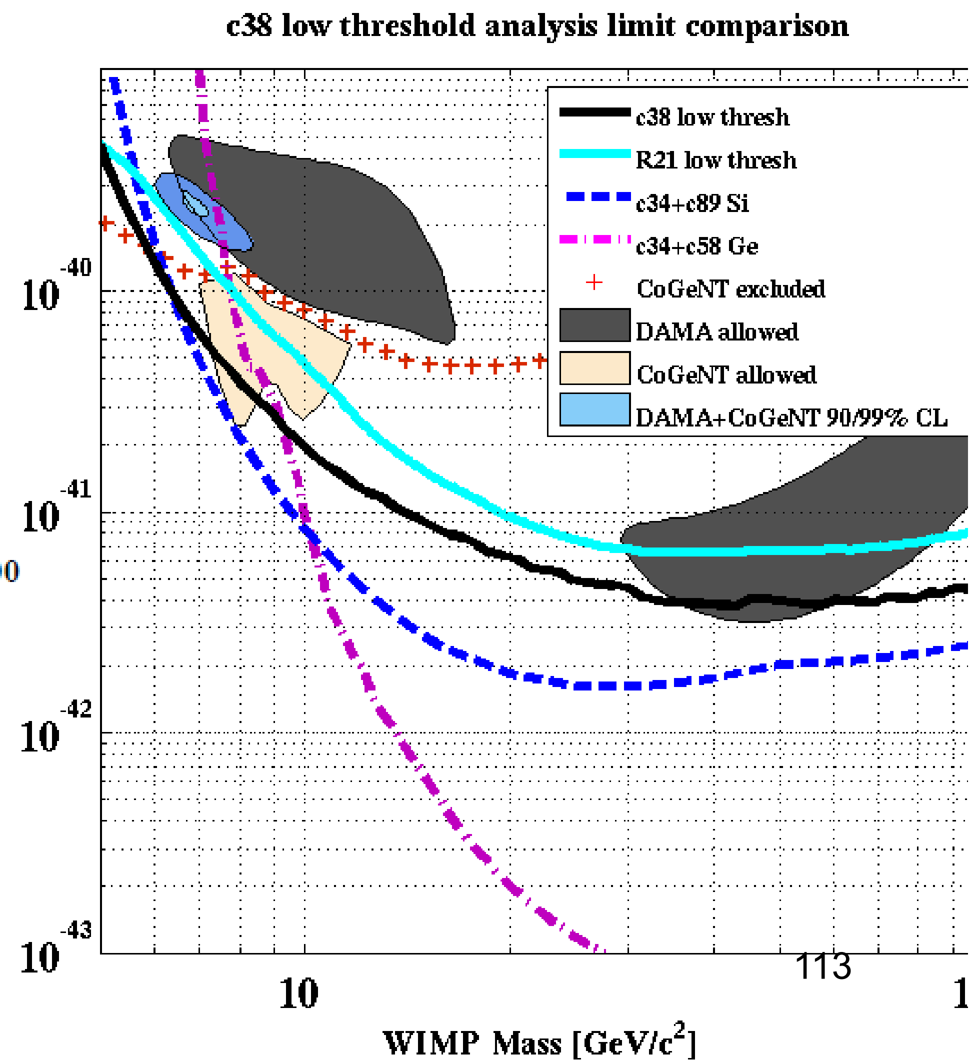




DAMA Modulation

CDMS Low Threshold & Reanalyzed Xenon 10 Reject This





- **CDMS Low threshold analysis can cleary resolve 1 keV Ge activation line!**
- **Threshold set at .5 keV**

US PASAG: SuperCDMS + 2 G2 Experiments

G2: ~100kg (10^{-46}cm2), G3~1 ton

Scenario A (constant level of effort at the FY08 level)

In dark matter, the current world-leading program is maintained, but world leadership would be lost toward the end of the decade:

- Two G2 experiments and the 100-kg SuperCDMS-SNOLA ent are supported. The technology selection for the G2 ex should occur soon enough to allow the construction of at l 2 experiment to start as early as FY13.
- No G3 experiments can be started in this d rogress will be slowed, risking loss of U.S. world leade wever, due to the risk of picking the wrong technology, this i le to descoping to only one G2 experiment.

Scenario B (constant level of e e FY09 level)

The current world-leadin in dark matter is maintained, but with some risk later in the deca

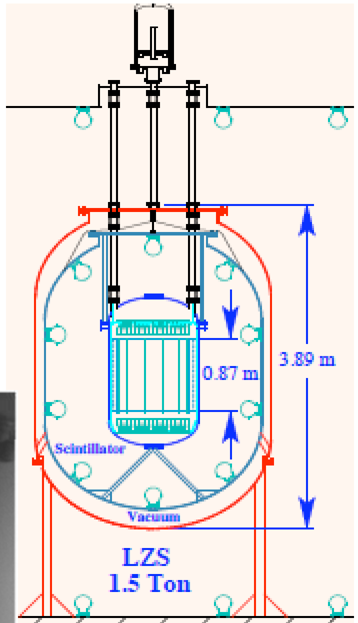
- Two G2 e s and the 100-kg SuperCDMS-SNOLAB experiment are su he technology selection for the G2 experiments should o enough to allow the construction of at least one G2 experiment as early as FY13.
- y one G3 experiment can start in this decade. Based on what is known at this time, to mitigate risk of picking the wrong technology, a broad second-generation program is a higher priority than starting a second G3 experiment.

Downselect of other 2 G2 Experiments in 2011!

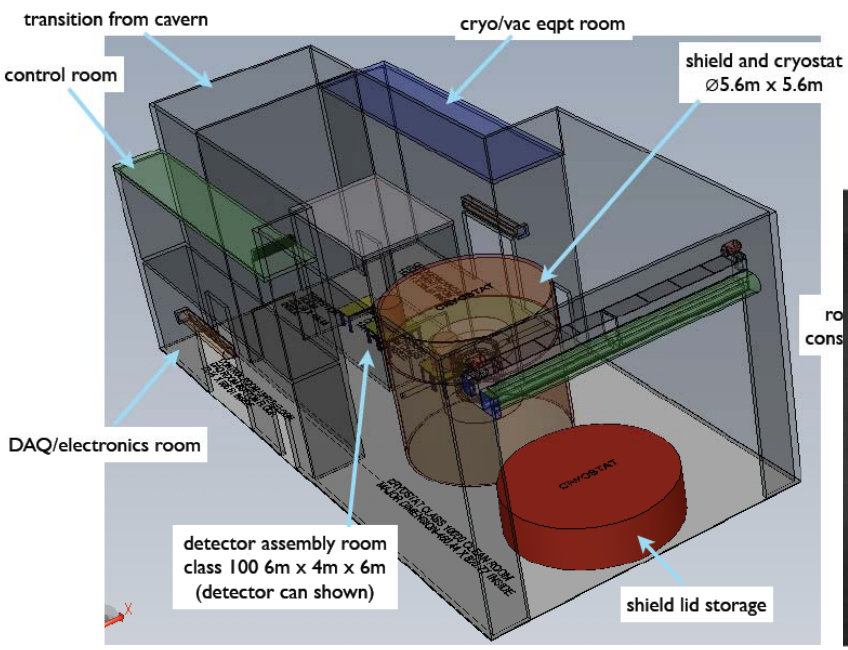
DUSEL Initial Suite of Expts. – Ton Scale

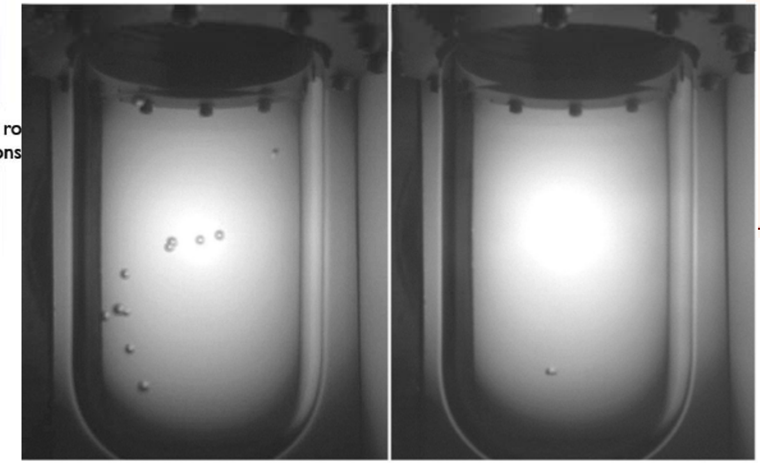
At most 1 of these G3 experiments to be funded!

- GEODM – 1.5 Ton Ge
- COUPP – Bubble Chamber
- MAX – Combination of Lxe and LAr
- LZ (LUX and ZEPLIN)– 1.5 ton LXe

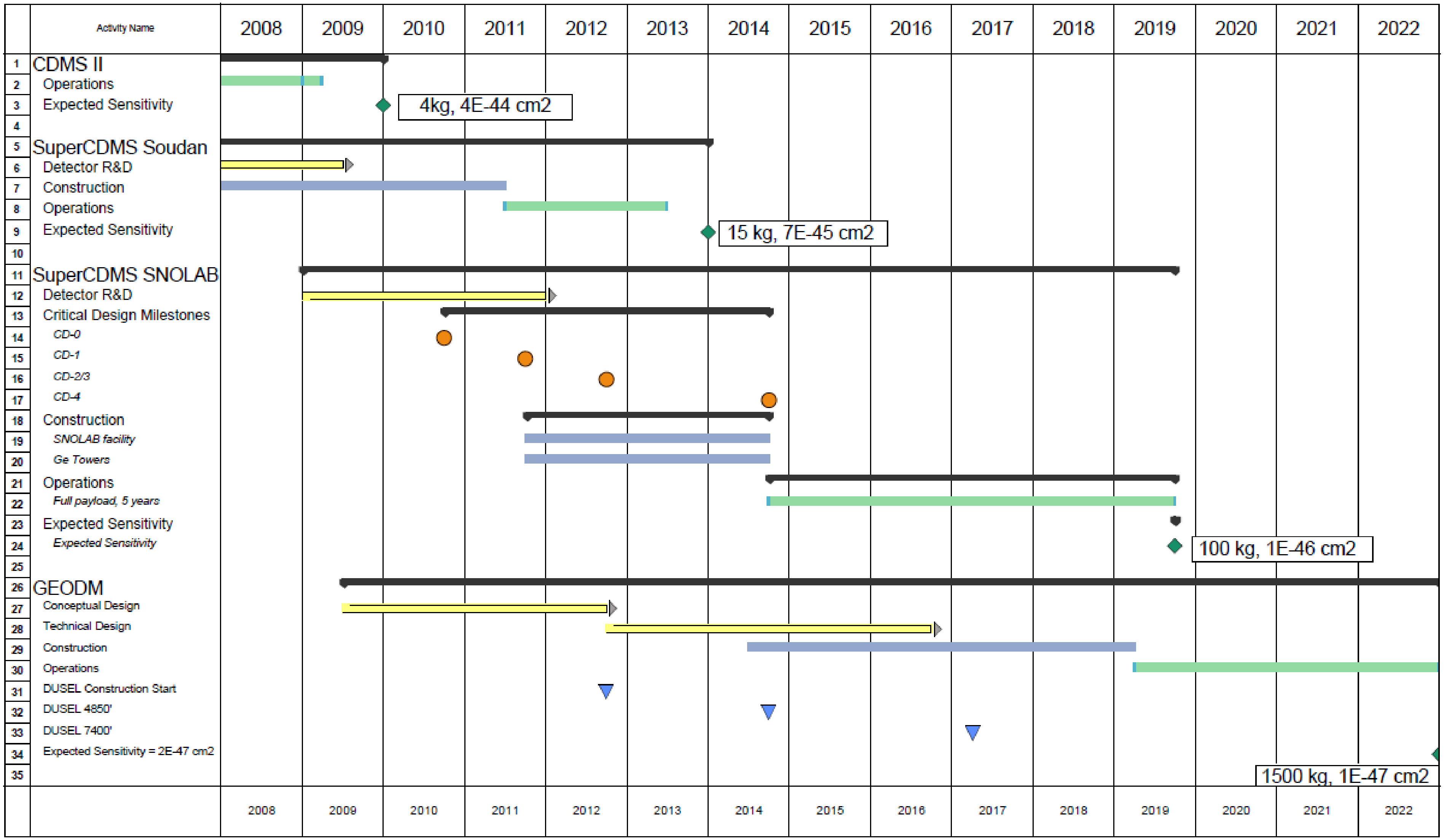


Conceptual Design for 7400 Level





SuperCDMS, GEODM Schedule



Generic G2 and G3 Sensitivity Reach

CDMS, Soudan (4kg)

3"x 1 cm 0.25kg
2 Yrs, 16 dets=1700kg-d

SuperCDMS, Soudan (15kg)

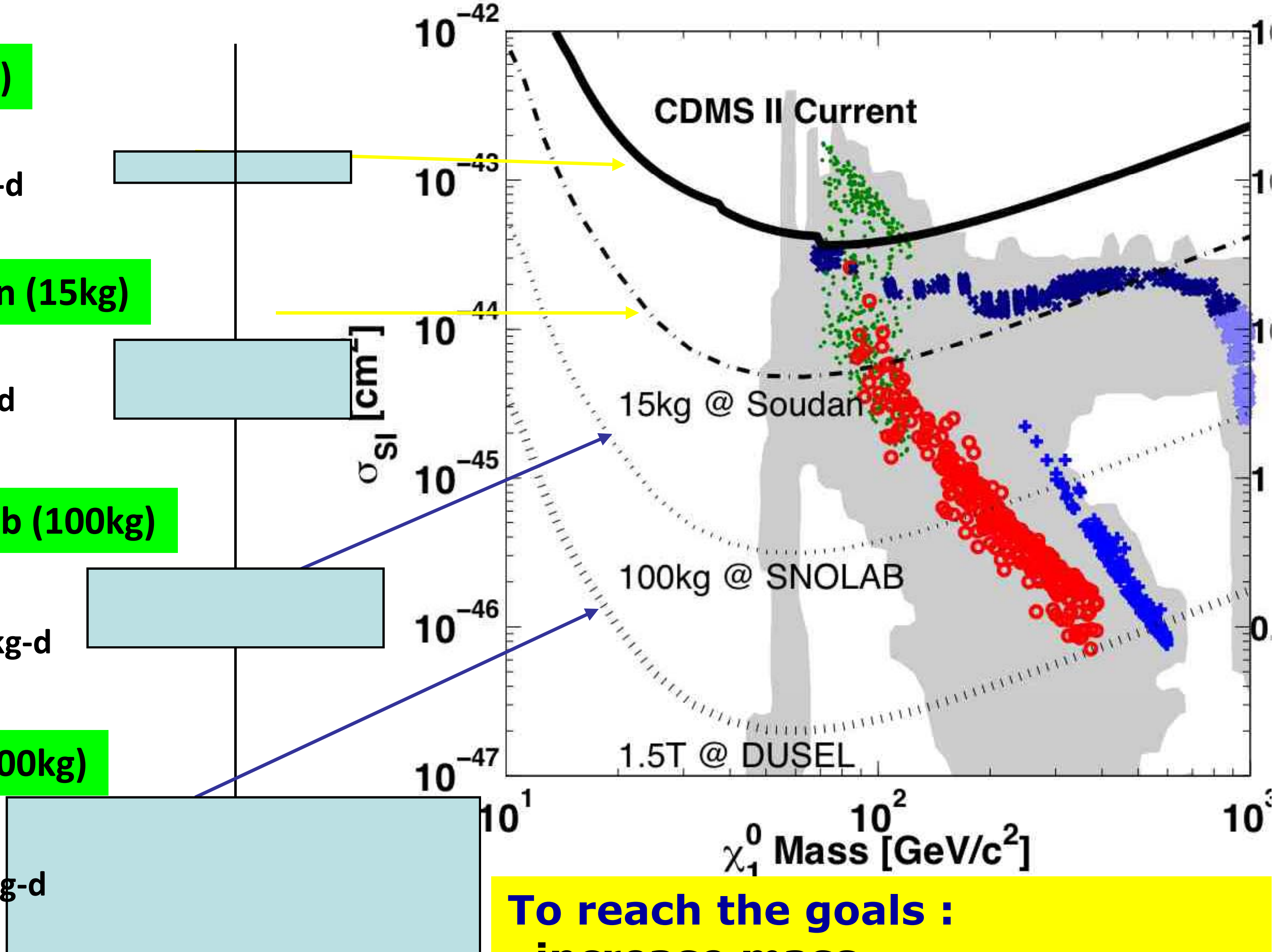
3"x 1" iZIP 0.64kg
2 Yrs, 25dets=8000kg-d

SuperCDMS, SNOLab (100kg)

4"x 1.33" iZIP 1.5kg
2 Yrs, 70dets=100000kg-d

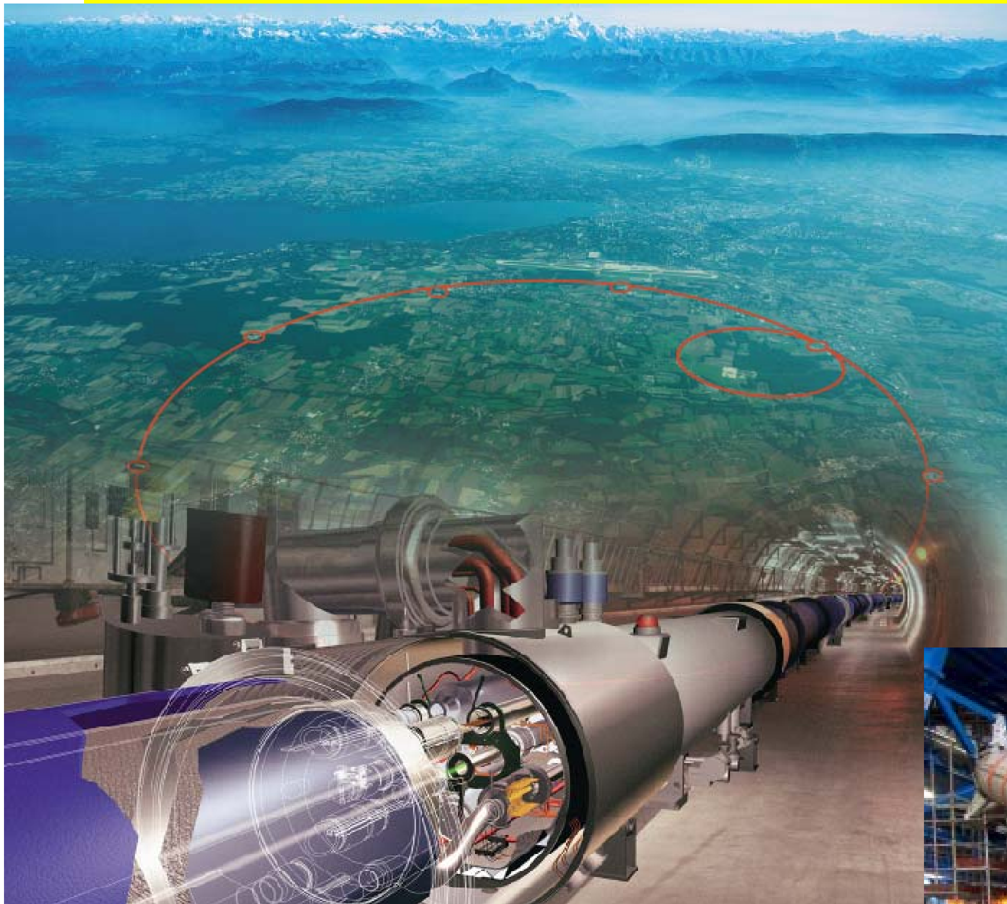
GEODM, DUSEL (1500kg)

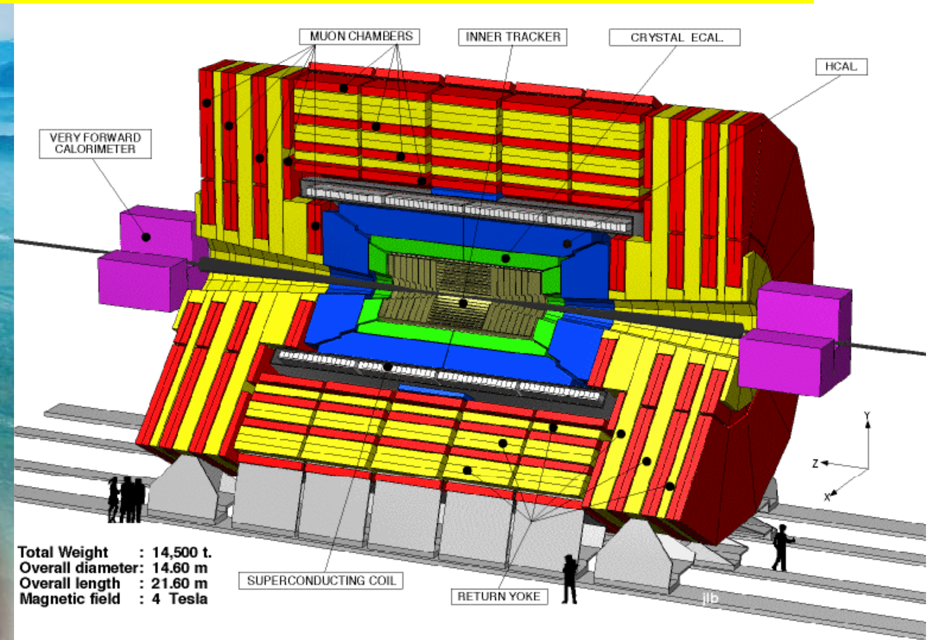
6"x 2" iZIP 5kg
2 Yrs, 300dets=1.5M kg-d

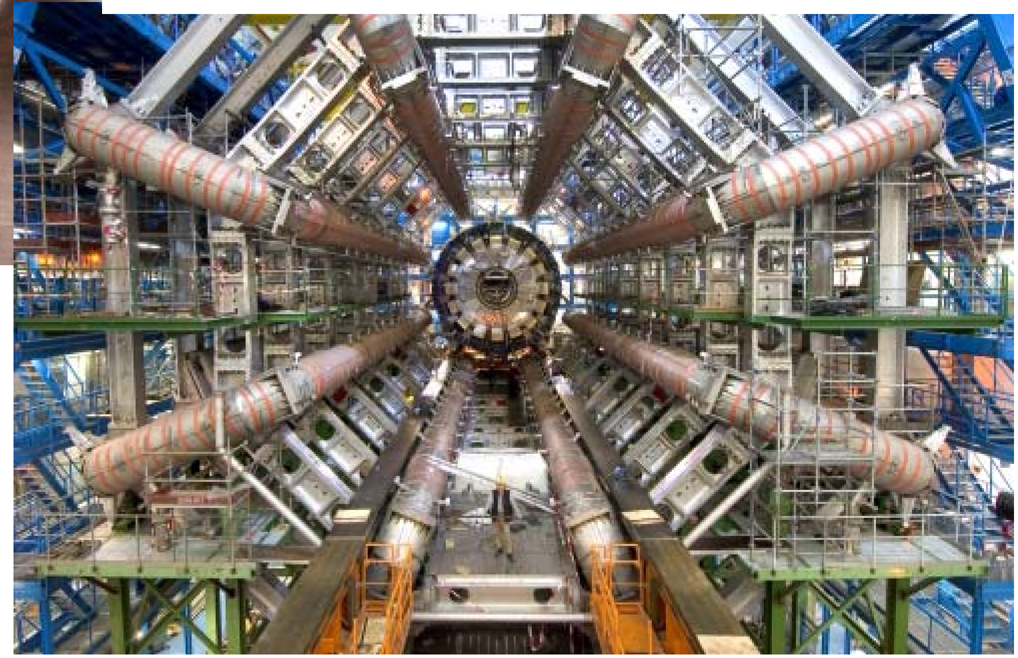


To reach the goals :
- **increase mass**
- **decrease background leakage**

LHC: The WIMP Maker

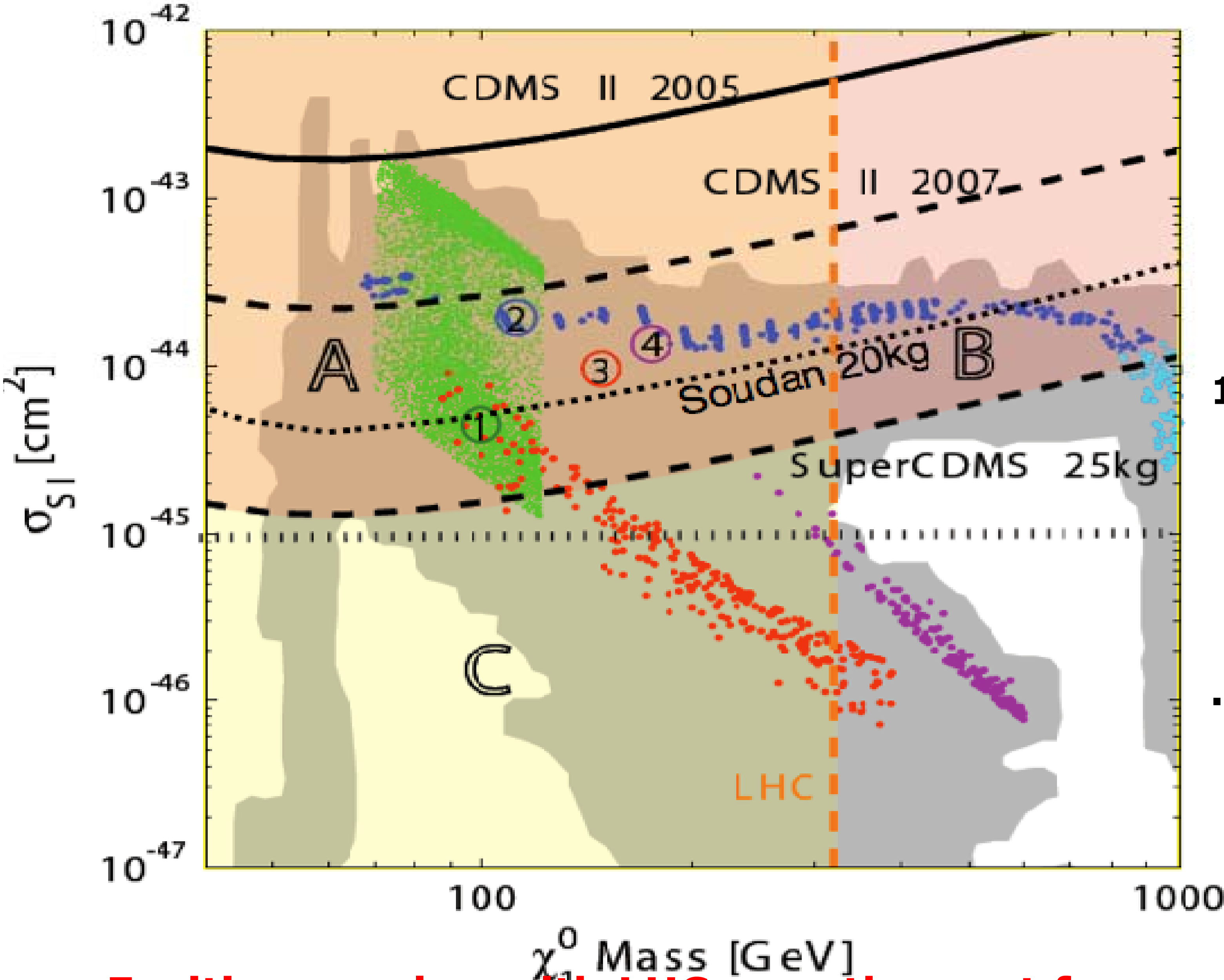






Will LHC discover SUSY before Direct Detection?

SuperCDMS Sensitivity Reach



1/kg-d

1/100 kg-d

.01/100 kg-d

Exciting overlap with LHC over the next few years

Conclusions

- **CDMS world leader in ultra low background experiment**
    - 0 events in 05, 07 and 2 Events last run (20% chance of background)
- **SuperCDMS,Soudan (16kg) and G2 SNOLab (100kg) with iZIPs**
    - β rejection >100 times better. Exciting results next year from Soudan
- **G3: Ton-scale Germanium Observatory for Dark Matter (GEODM)**
    - Funded by DUSEL Initial Suite of Experiments (ISE) engineering funds
    - Rapid progress at TAMU for automated high quality detector fabrication
- **G2 Down select in 2011: Important in limited resources**
    - PASAG endorses SuperCDMS + 2 G2 experiments (which ones?)
    - **Exciting New Technologies: Noble Liquids (Xe/Ar), Bubble Ch**
    - Background/Systematics in rare search come in surprising ways
- **There may be 0 or 1 G3 (~ton scale) experiment in DUSEL**
    - Next decade will see one technology survive (which one?)
- **Very Exciting LHC Complimentarity in next 5 Years**
    - LHC can't say SUSY particle is Dark Matter. Need DM experiments

- **All permutations/commutations proposed! Unify to win quickly?**

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** new collaborators or new institutions in SuperCDMS*

CDMS Collaboration