The LUX Dark Matter Search Experiment

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PASCOS
Merida, Mexico
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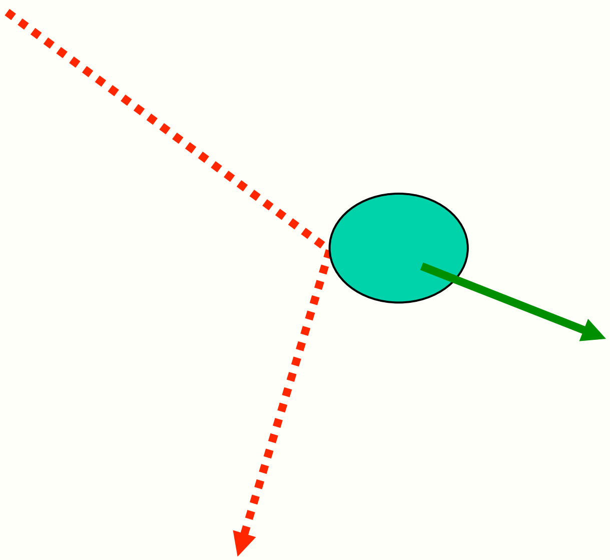
A direct detection experiment



- Elastic scattering: DM + Xe → DM + Xe

- Measure recoil energies in the 5 – 25 keV range.

- Simple dynamics. Cross section α (form factor)^2

- Spin-independent: Nuclear form factor gives rise to A^2 enhancement to the cross section due to coherence.

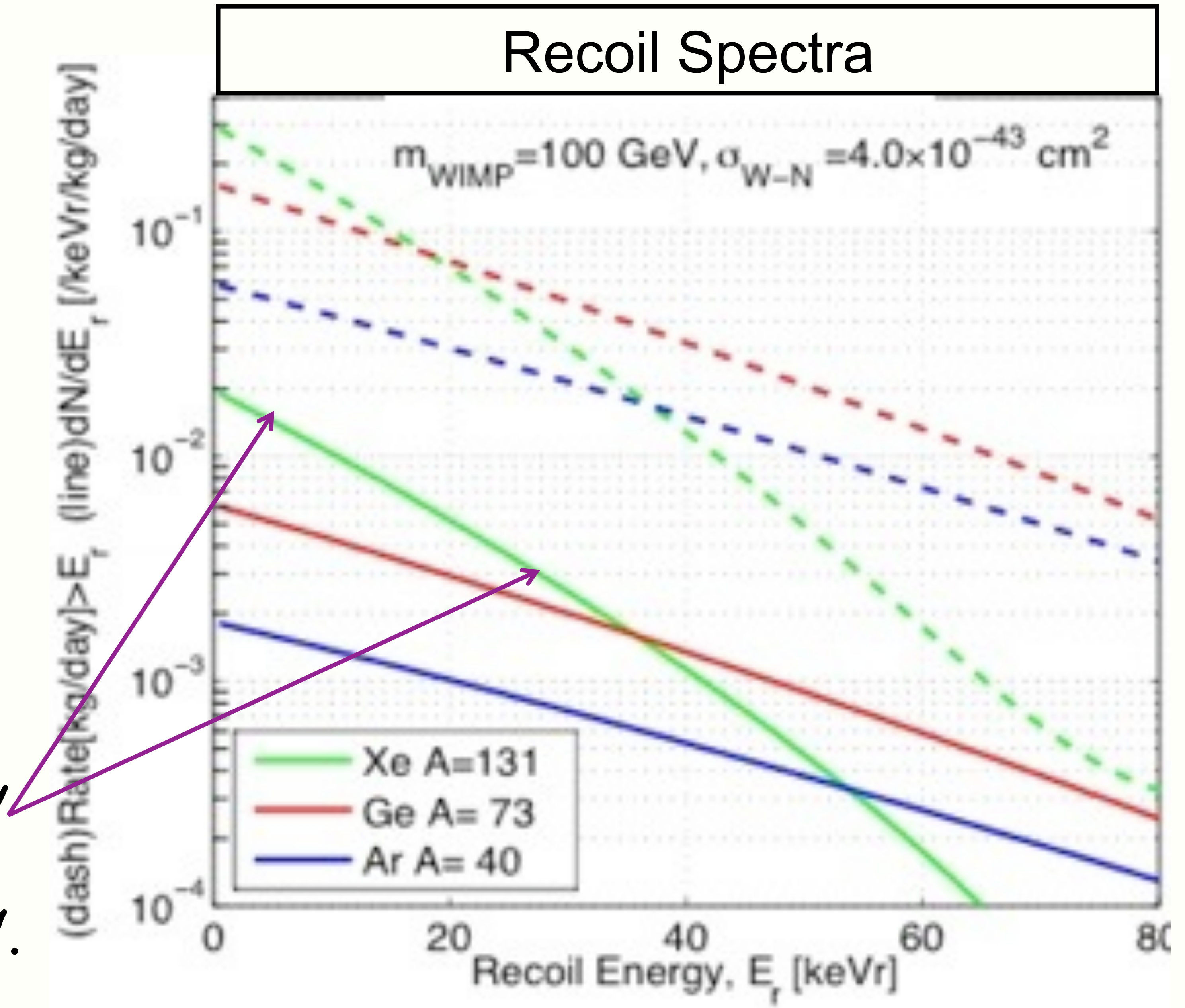
Why Xenon?

Nobel element
=> Inert. Can be purified.

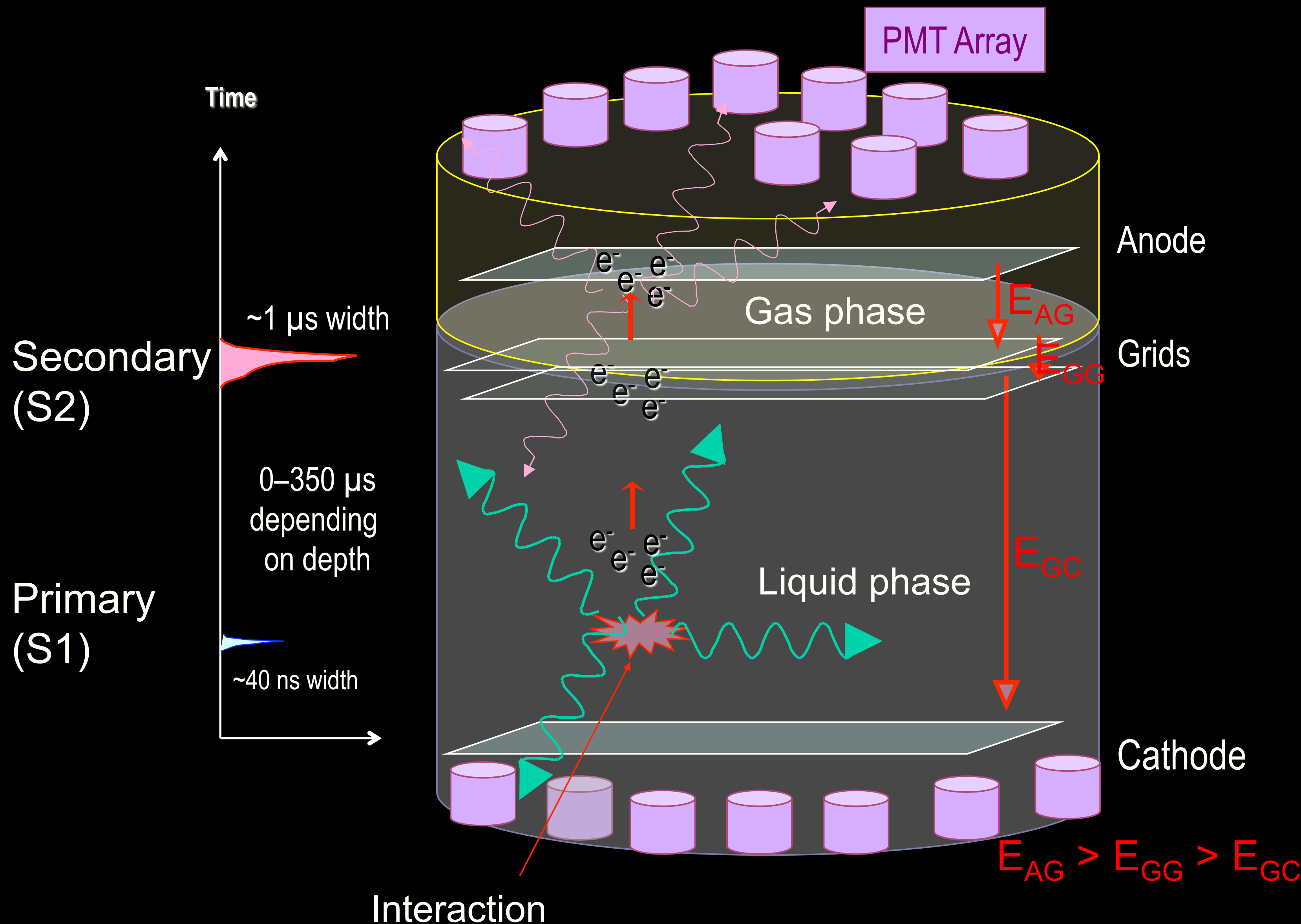
High density ($\sim 3 g/cm^3$)
=> Very powerful Self-shielding.

High A (131)
=> Large elastic σ

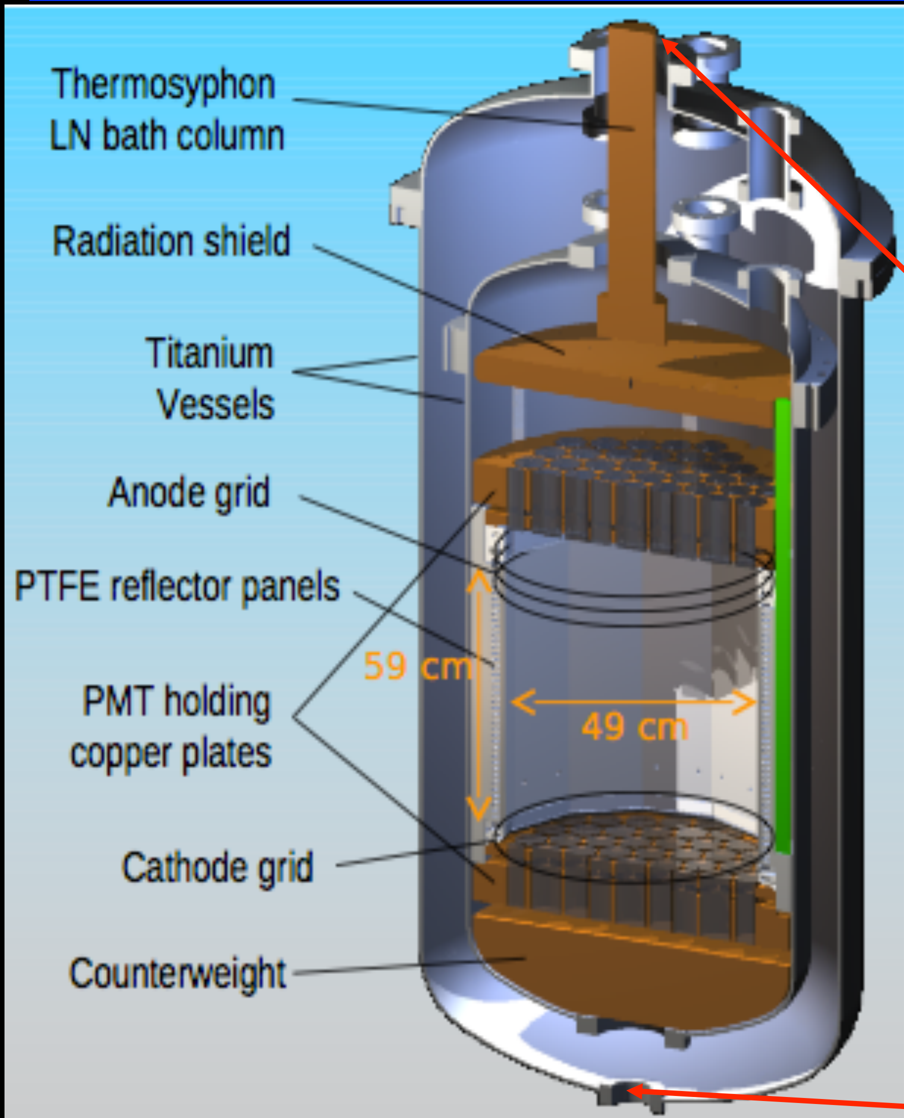
Higher Sensitivity in the range
5 keV < E < 25 keV.



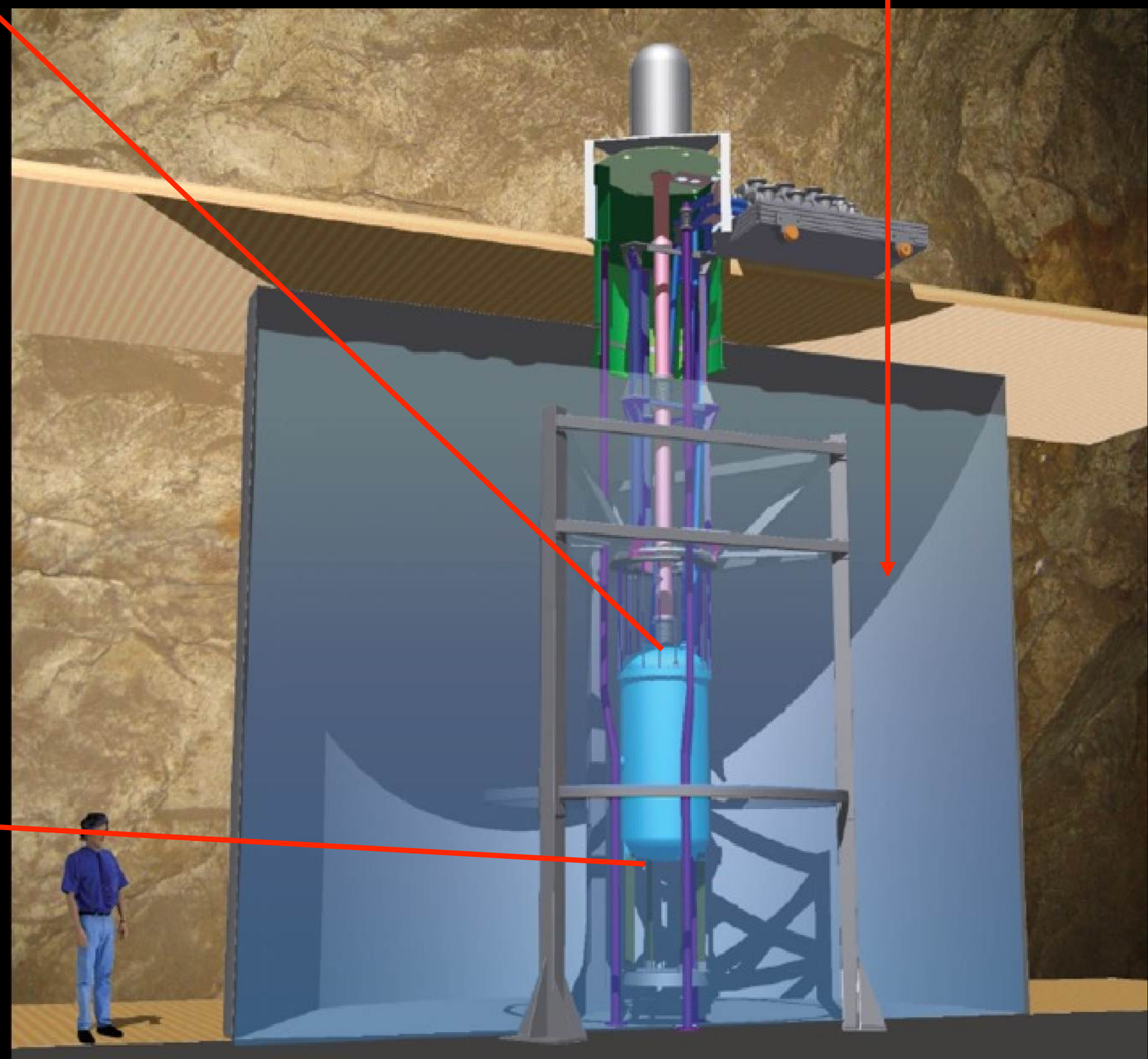
Two Signal Technique



The LUX detector

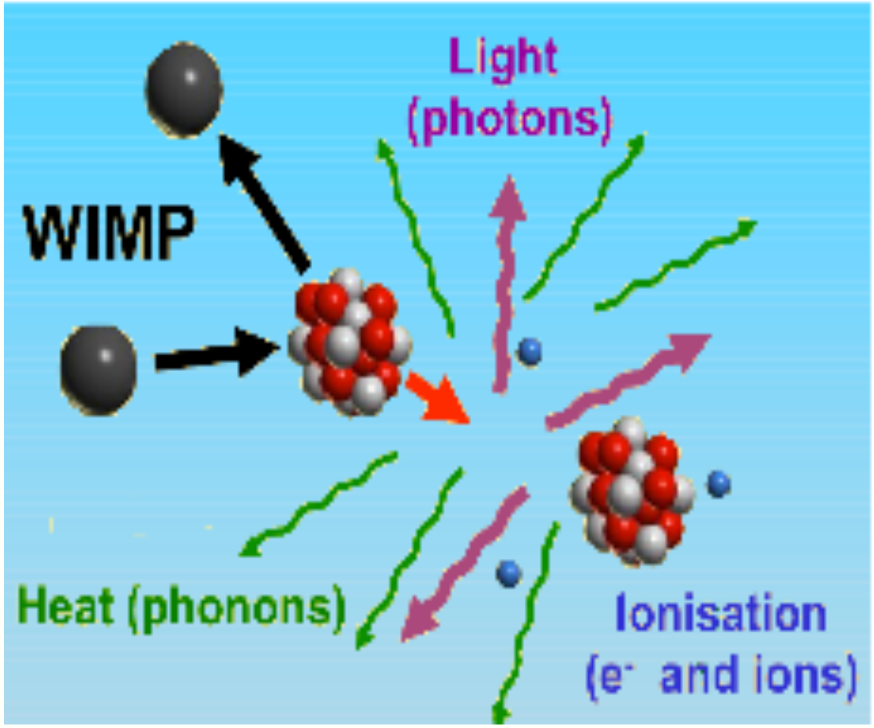


~ 7m diameter Water Cerenkov Shield.

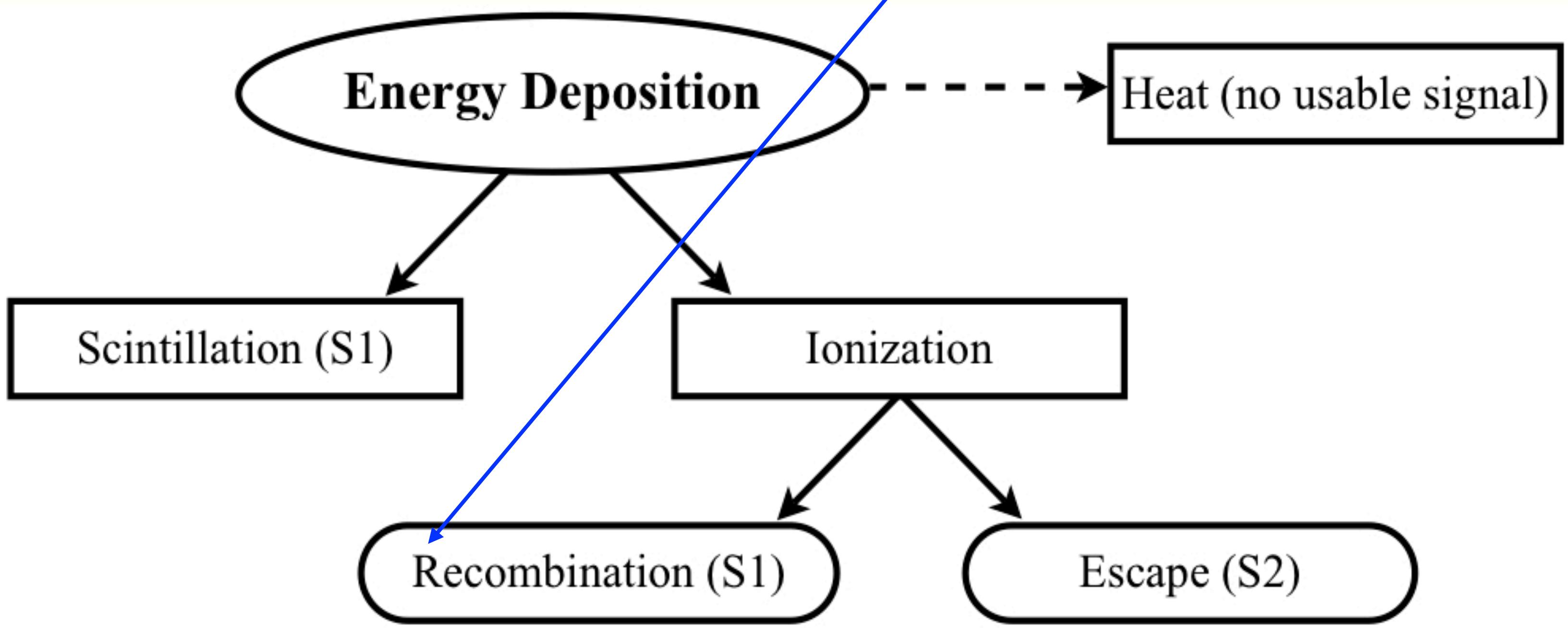


- 350 kg of Lxe
- 122 photomultiplier tubes (top plus bottom)

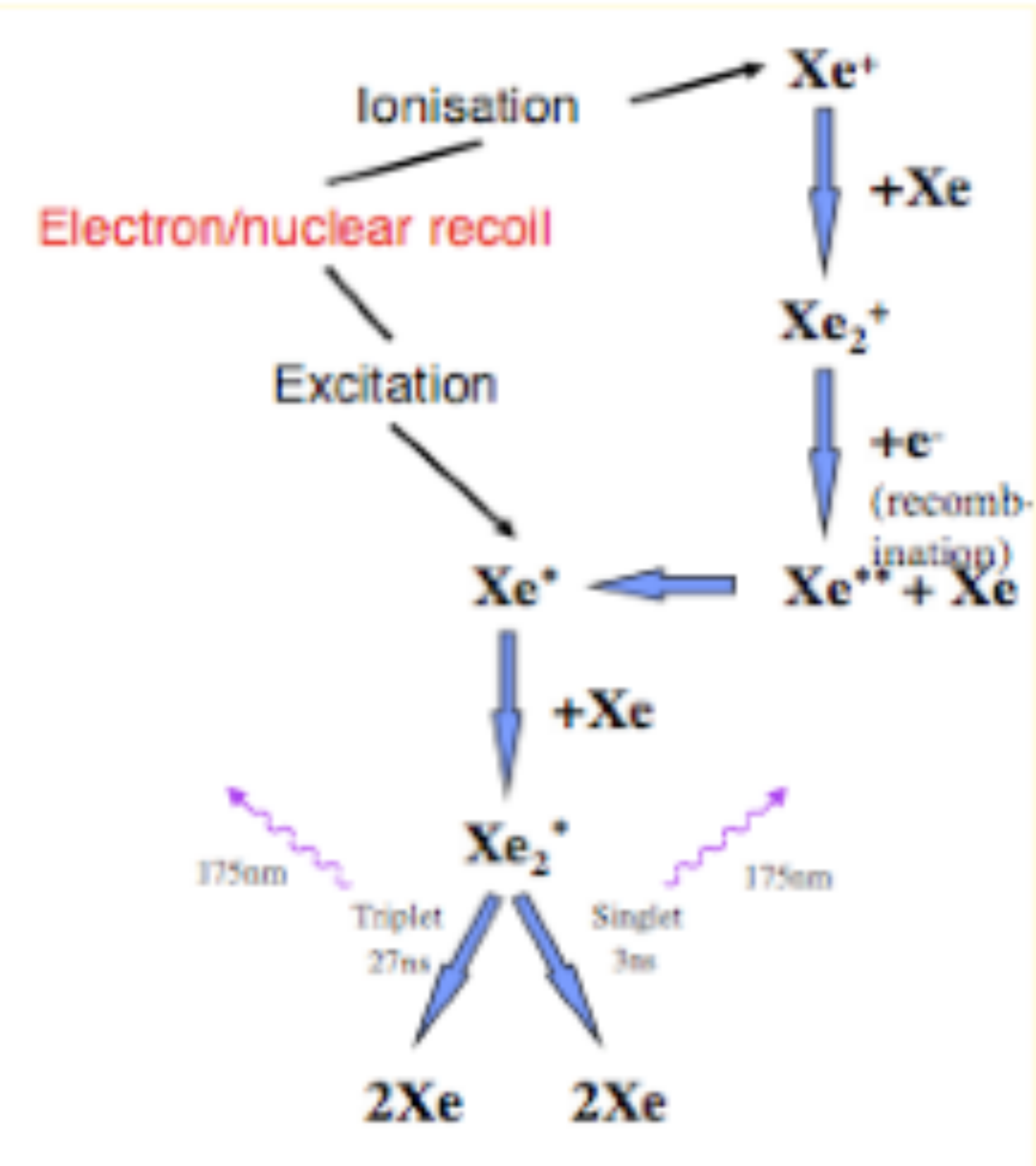
Scintillation process in LXe



- Difference in recombination efficiency is exploited to discriminate between electron and nuclear recoils



γ/neutron Discrimination



Xenon is transparent to its own scintillation light !

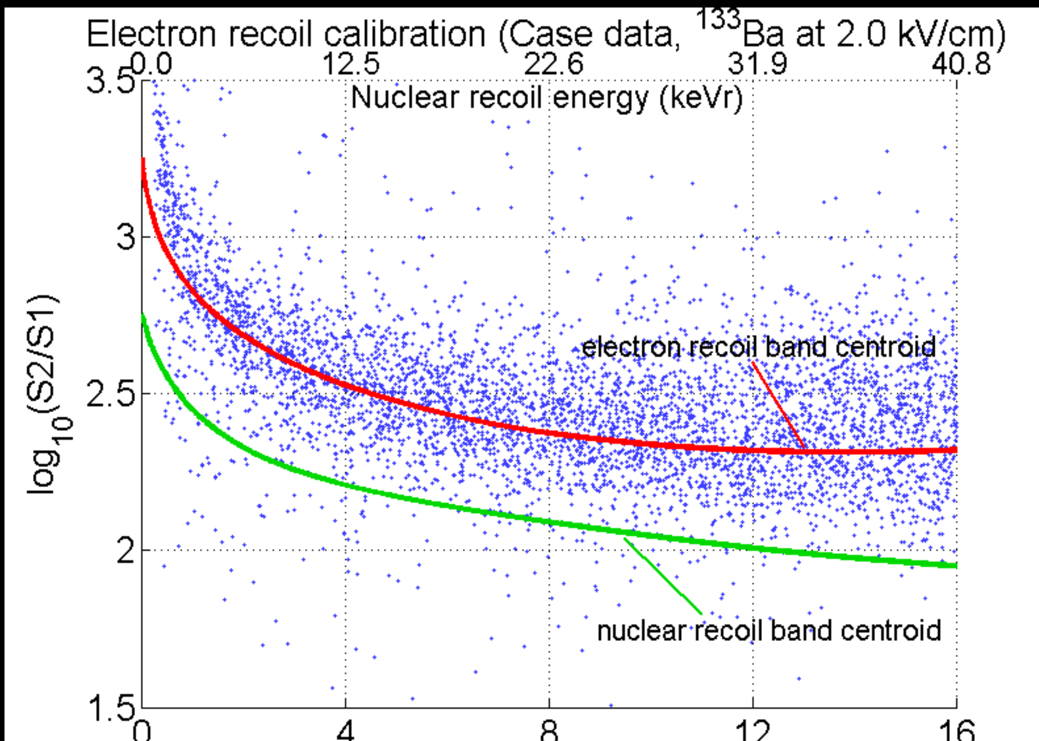
Figure of merit derived from plots of:

Log (charge escaping recombination/total primary light produced)

… Next slide.

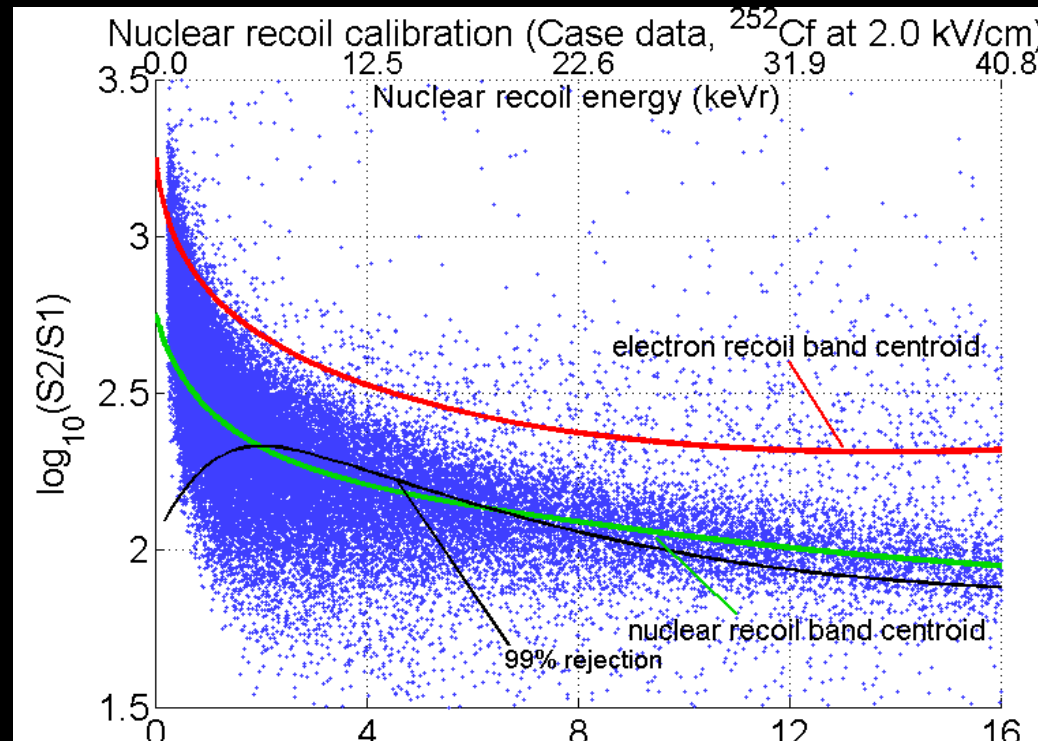
Calibration Data

^{133}Ba Electrons



Recoil Energy (keVr)

^{252}Cf Neutrons



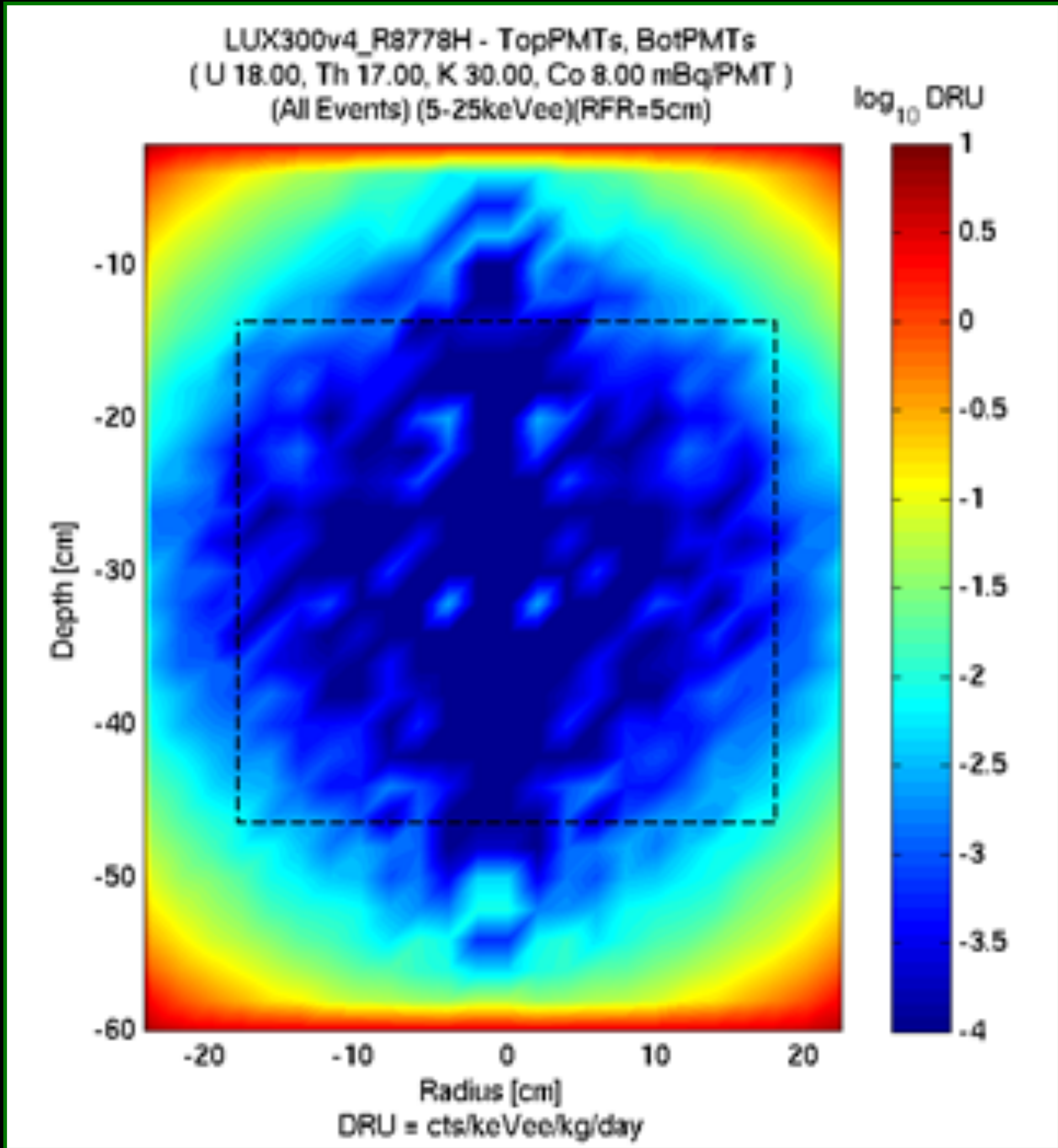
Recoil Energy (keVr)

These measurements were made using a test-cell at Case Western University. Our simulations of LXe response are tuned to these data.

Backgrounds (Gamma)

- <u>Internal</u> strong self-shielding against PMT activity (main source of background events). Double Compton scatters are rejected.

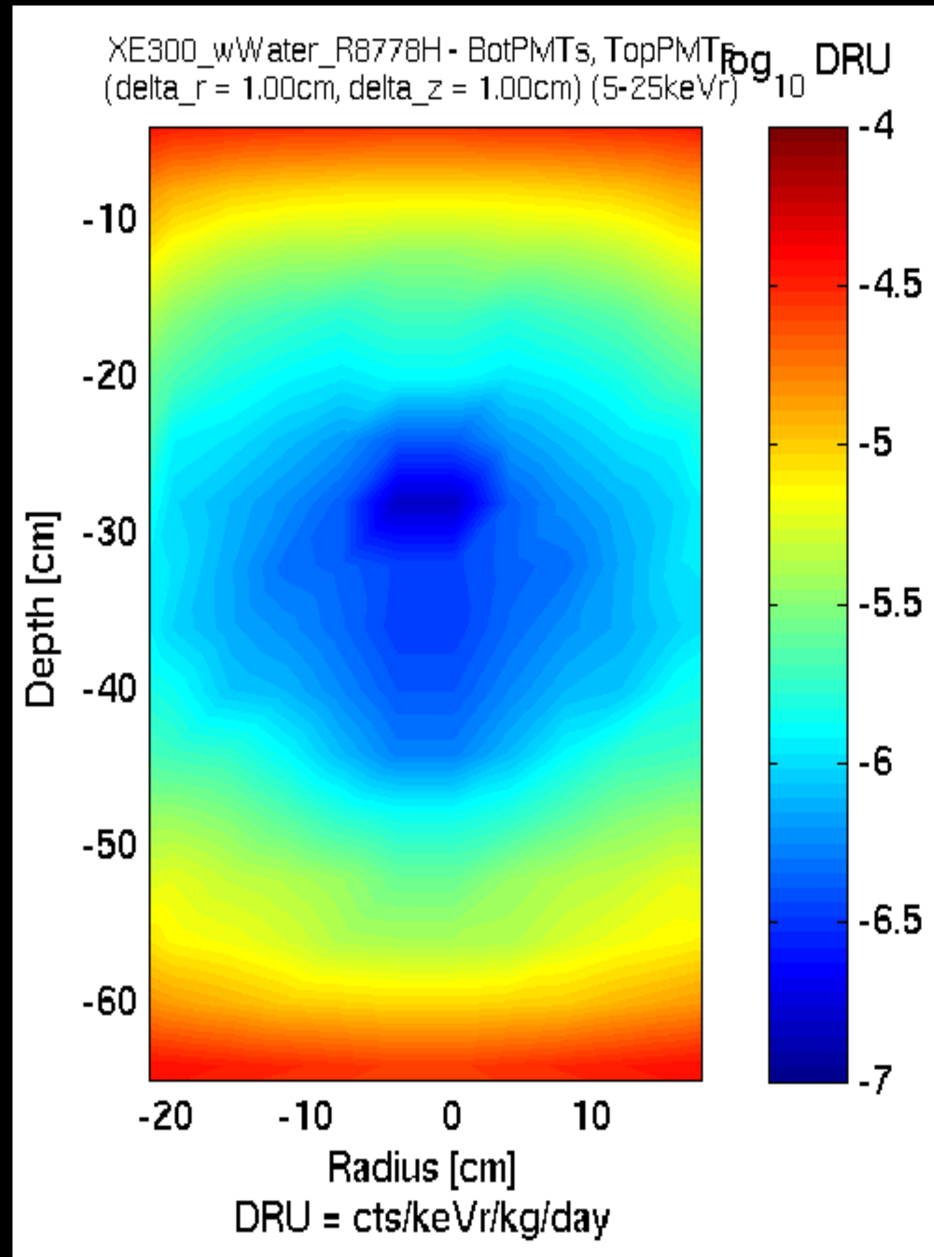
- <u>External</u> large water shield. Very effective for γ from cavern walls.



Backgrounds (Neutrons)

- Internal
  Neutrons (α,n) & fission << $\gamma + \beta$.
  ~65% double scatter.
  (PMTs are the main source)

- External large water shield.
  - Very effective for cavern n,
  - High energy neutrons from cosmic muons -> muon veto
  - Possible upgrade of adding Gd to the water.

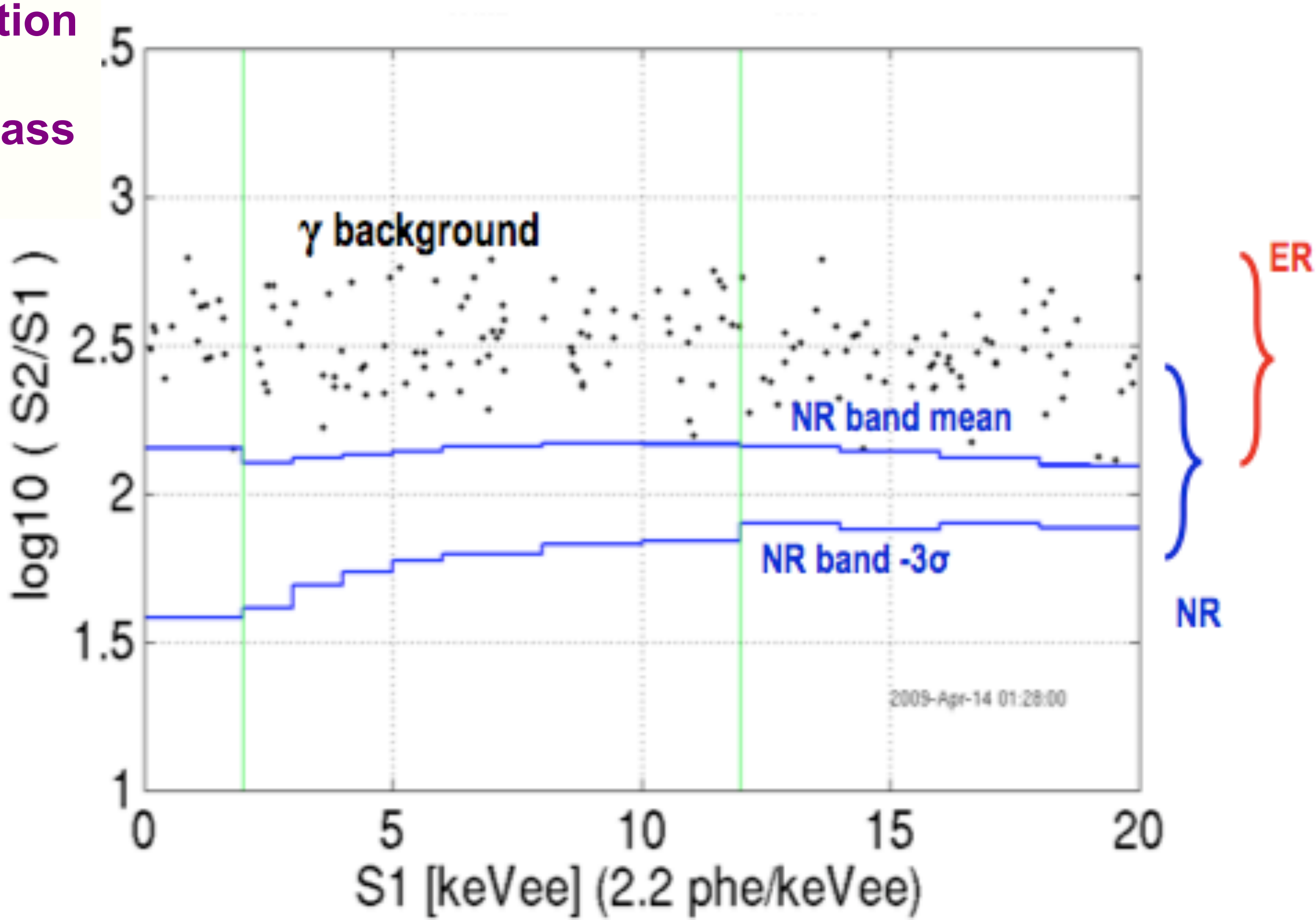


Simulated Signal in LUX

Electron recoil background ~2.6×10^{-4} dru (based on screening of materials)

300 days acquisition

100 kg fiducial mass

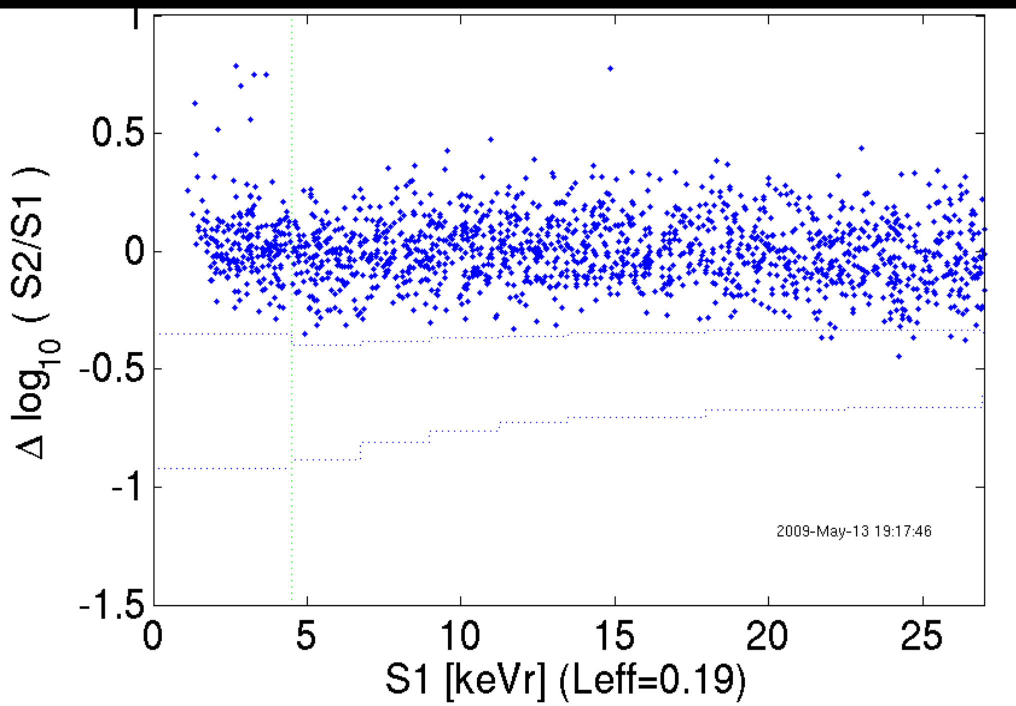


$L_{eff} = 0.19$

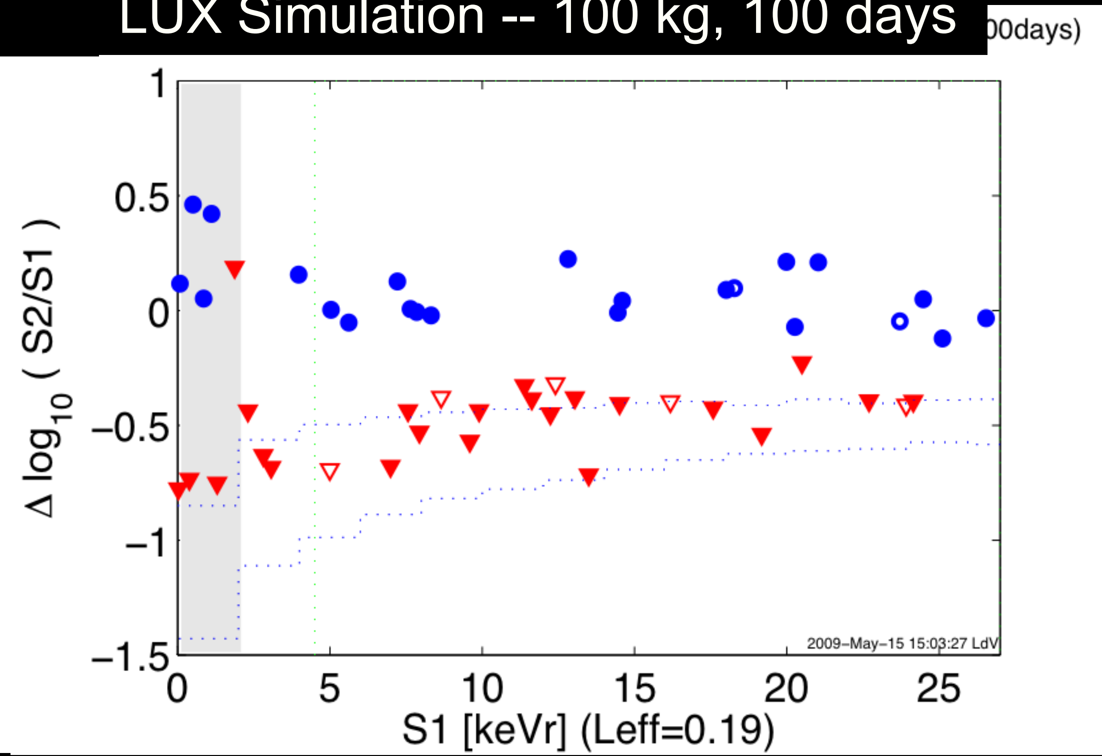
Using same ER and NR bands as XENON10

Power of self-shielding

XENON10 Data -- 5.4 kg, 59 days



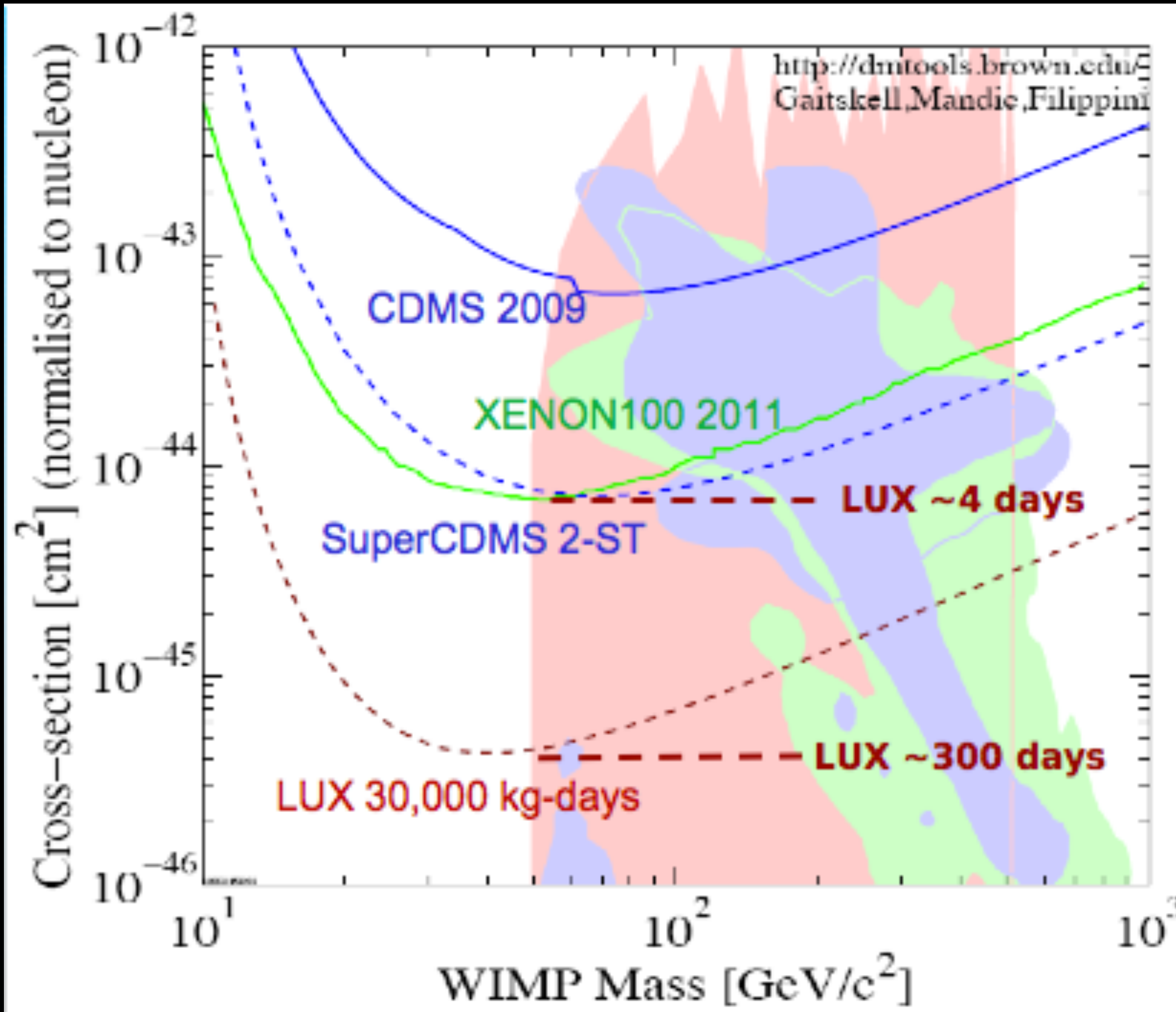
LUX Simulation -- 100 kg, 100 days



Red points are for a simulated signal of 100 GeV WIMP and a cross section $5x10^{-45}$ cm^2

Open points are for 25 kg fiducial.

LUX Goal



http://dmtools.brown.edu/
Gaitskell,Mandic,Filippini
CDMS 2009
XENON100 2011
LUX ~4 days
SuperCDMS 2-ST
LUX ~300 days
LUX 30,000 kg-days
Cross-section [cm^2] (normalised to nucleon)
WIMP Mass [GeV/c^2]
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^1
10^2
10^3

The LUX Collaboration

Brown

Richard Gaitskell	PI, Professor
Simon Fiorucci	Research Associate
Monica Pangilinan	Postdoc
Jeremy Chapman	Graduate Student
Carlos Hernandez Faham	Graduate Student
David Malling	Graduate Student
James Verbus	Graduate Student

Case Western

Thomas Shutt	PI, Professor
Dan Akerib	PI, Professor
Mike Dragowsky	Research Associate Professor
Tom Coffey	Research Associate
Carmen Carmona	Postdoc
Karen Gibson	Postdoc
Adam Bradley	Graduate Student
Patrick Phelps	Graduate Student
Chang Lee	Graduate Student
Kati Pech	Graduate Student
Tim Ivancic	Graduate Student

University of Rochester

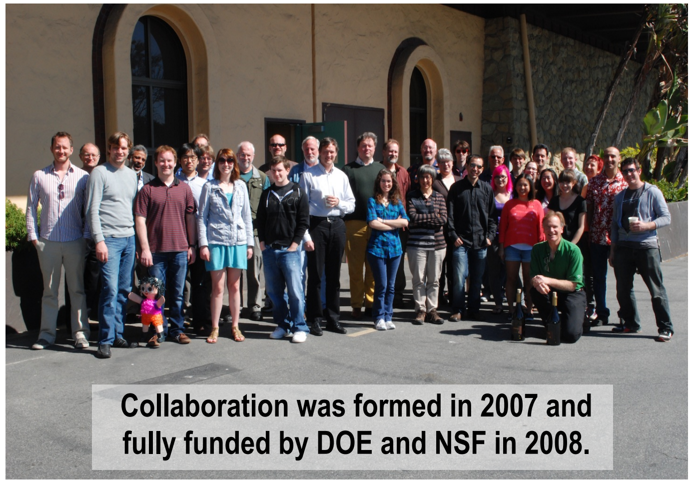
Frank Wolfs	PI, Professor
Wojtek Skutski	Senior Scientist
Eryk Druszkiewicz	Graduate Student
Mongkol Moongweluwan	Graduate Student

Lawrence Livermore

Adam Bernstein	PI, Leader of Adv. Detectors Group
Dennis Carr	Mechanical Technician
Kareem Kazkaz	Staff Physicist
Peter Sorensen	Staff Physicist
John Bower	Engineer

SD School of Mines

Xinhua Bai	PI, Professor



University of Maryland

Carter Hall	PI, Professor
Attila Dobi	Graduate Student
Richard Knoche	Graduate Student

Texas A&M

James White	PI, Professor
Robert Webb	Professor
Rachel Mannino	Graduate Student
Clement Sofka	Graduate Student

UC Davis

Mani Tripathi	PI, Professor
Robert Svoboda	Professor
Richard Lander	Professor
Britt Hollbrook	Senior Engineer
John Thomson	Senior Machinist
Matthew Szydagis	Postdoc
Richard Ott	Postdoc
Jeremy Mock	Graduate Student
James Morad	Graduate Student
Nick Walsh	Graduate Student
Michael Woods	Graduate Student
Sergey Uvarov	Graduate Student

LIP Coimbra

Isabel Lopes	PI, Professor
Jose Pinto da Cunha	Assistant Professor
Vladimir Solovov	Senior Researcher
Luiz de Viveiros	Postdoc
Alexander Lindote	Postdoc
Francisco Neves	Postdoc
Claudio Silva	Postdoc

University of South Dakota

Dongming Mei	PI, Professor
Chao Zhang	Postdoc
Dana Byram	Graduate Student
Chris Chiller	Graduate Student
Angela Chiller	Graduate Student

Lawrence Berkeley + UC Berkeley

Bob Jacobsen	PI, Professor
David Taylor	Engineer
Mia ihm	Graduate Student

UC Santa Barbara

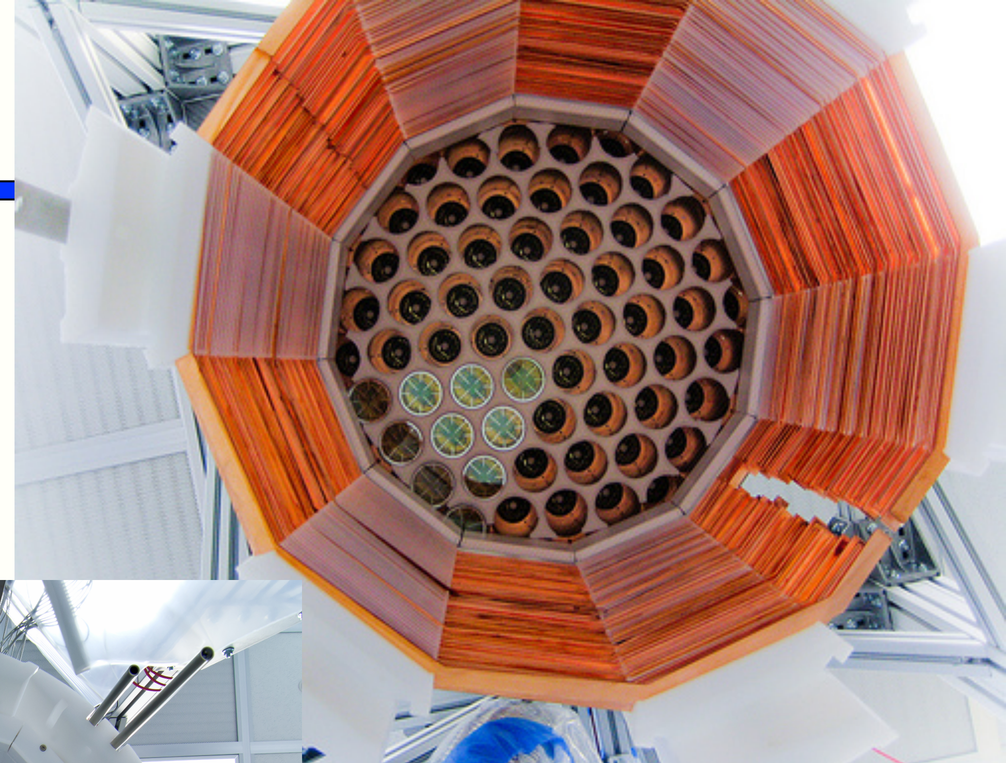
Harry Nelson	PI, Professor
Mike Witherell	Professor
Dean White	Engineer
Susanne Kyre	Engineer

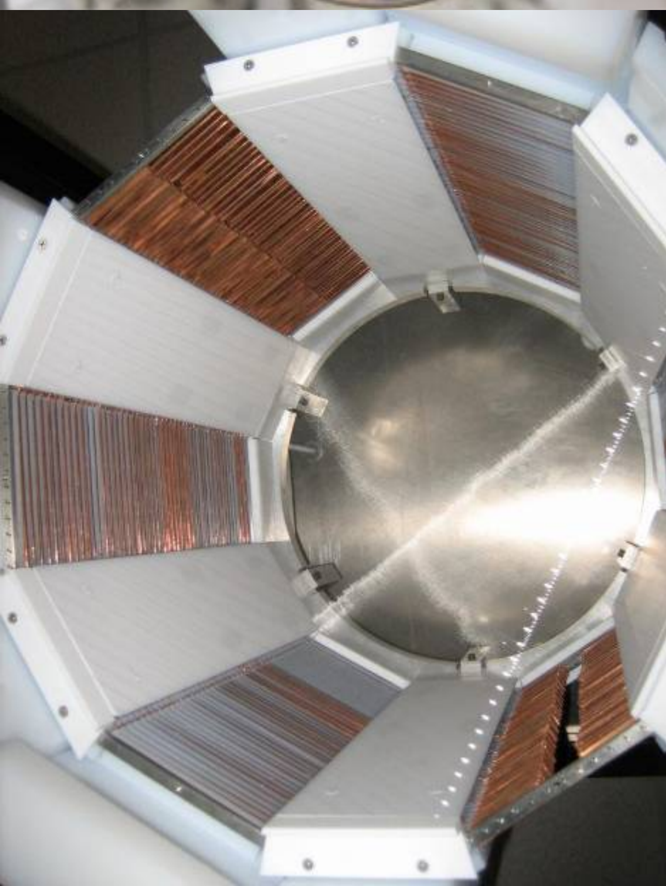
Yale

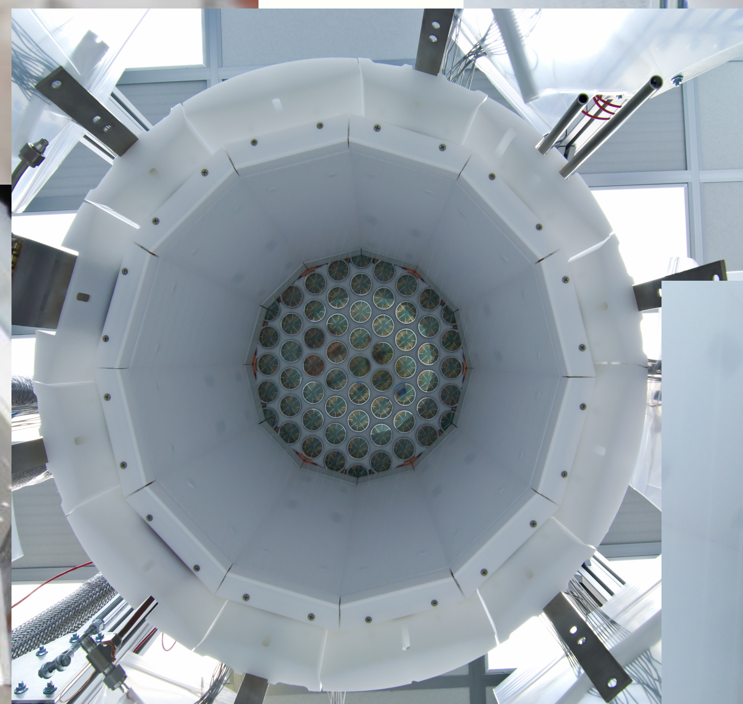
Daniel McKinsey	PI, Professor
Peter Parker	Professor
James Nikkel	Research Scientist
Sidney Cahn	Lecturer/Research Scientist
Alexey Lyashenko	Postdoc
Ethan Bernard	Postdoc
Markus Horn	Postdoc
Blair Edwards	Postdoc
Louis Kastens	Graduate Student
Nicole Larsen	Graduate Student
Evan Pease	Graduate Student

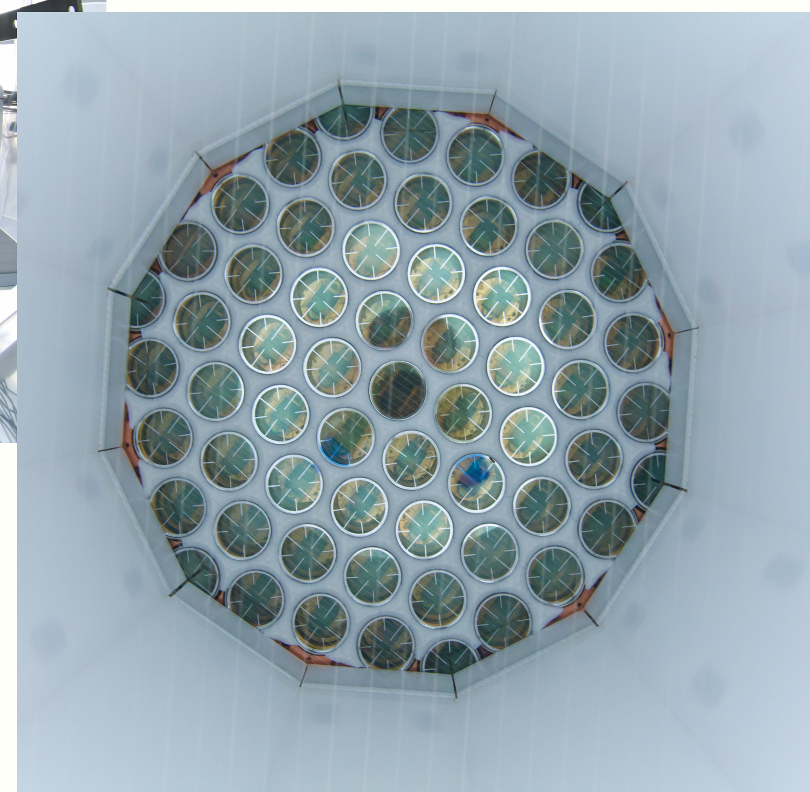
Assembly and Commissioning of LUX in a Surface Lab

Assembly of Internals

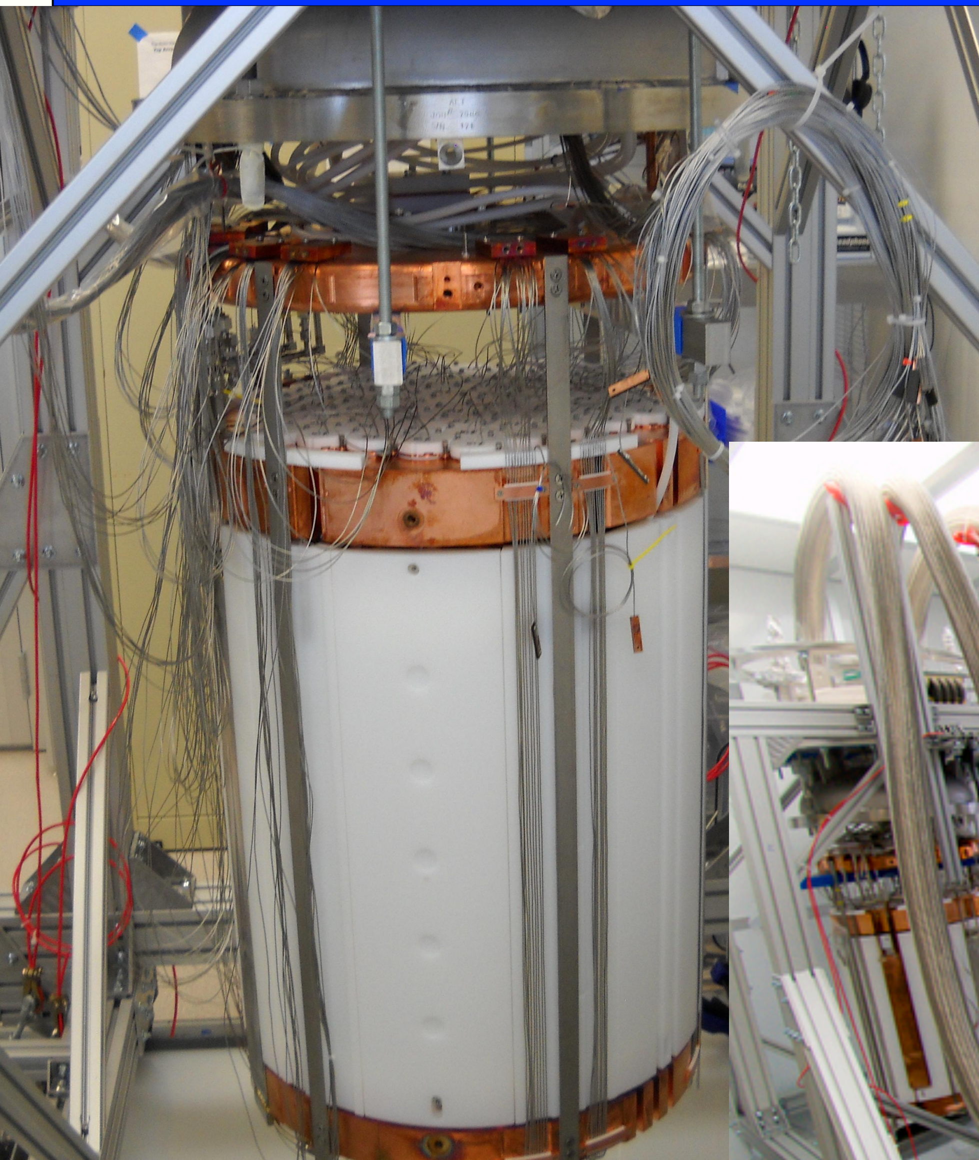




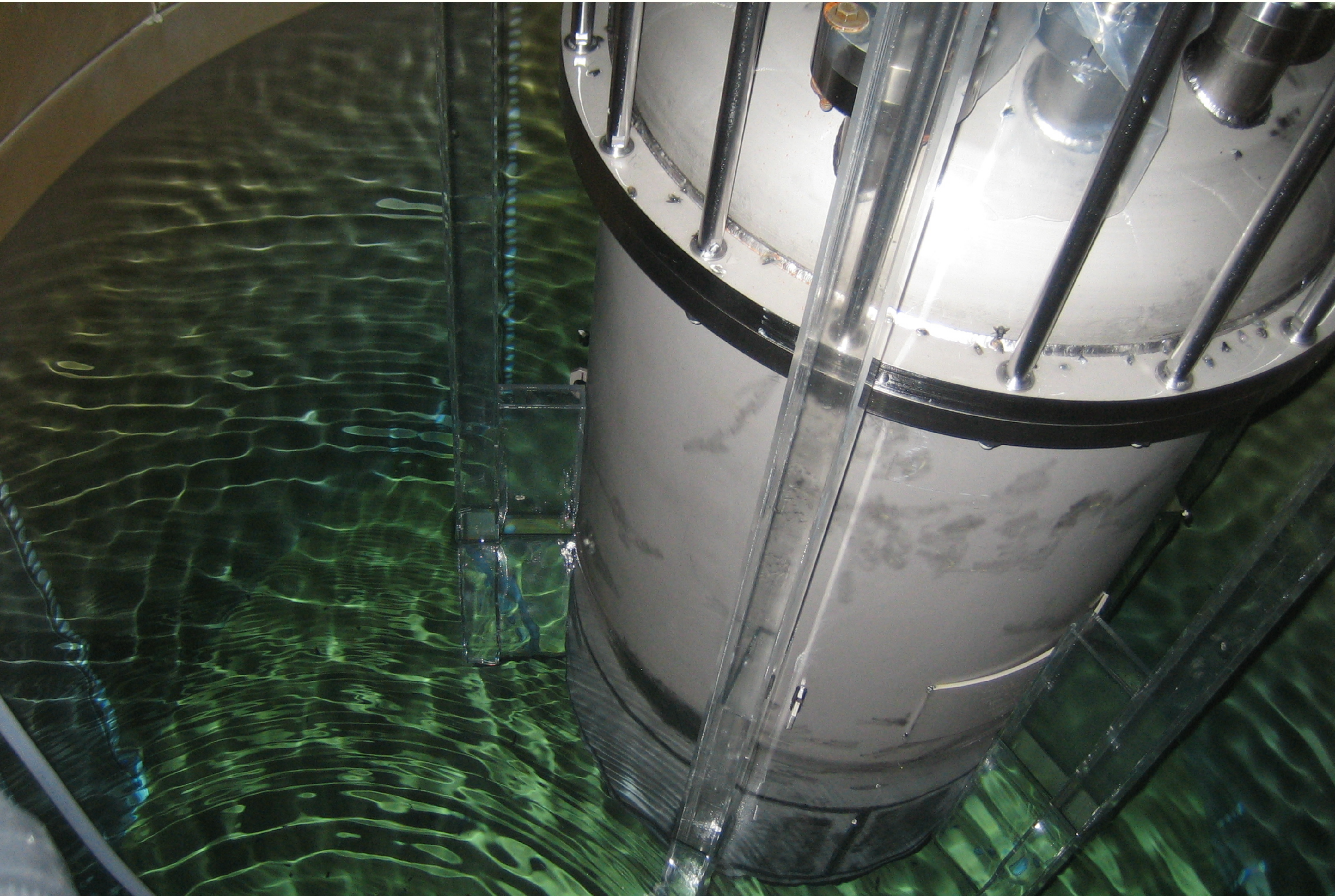




Assembled and Cabled up



LUX Deployed in a Water Tank



Calibration using a ^{137}Cs Source

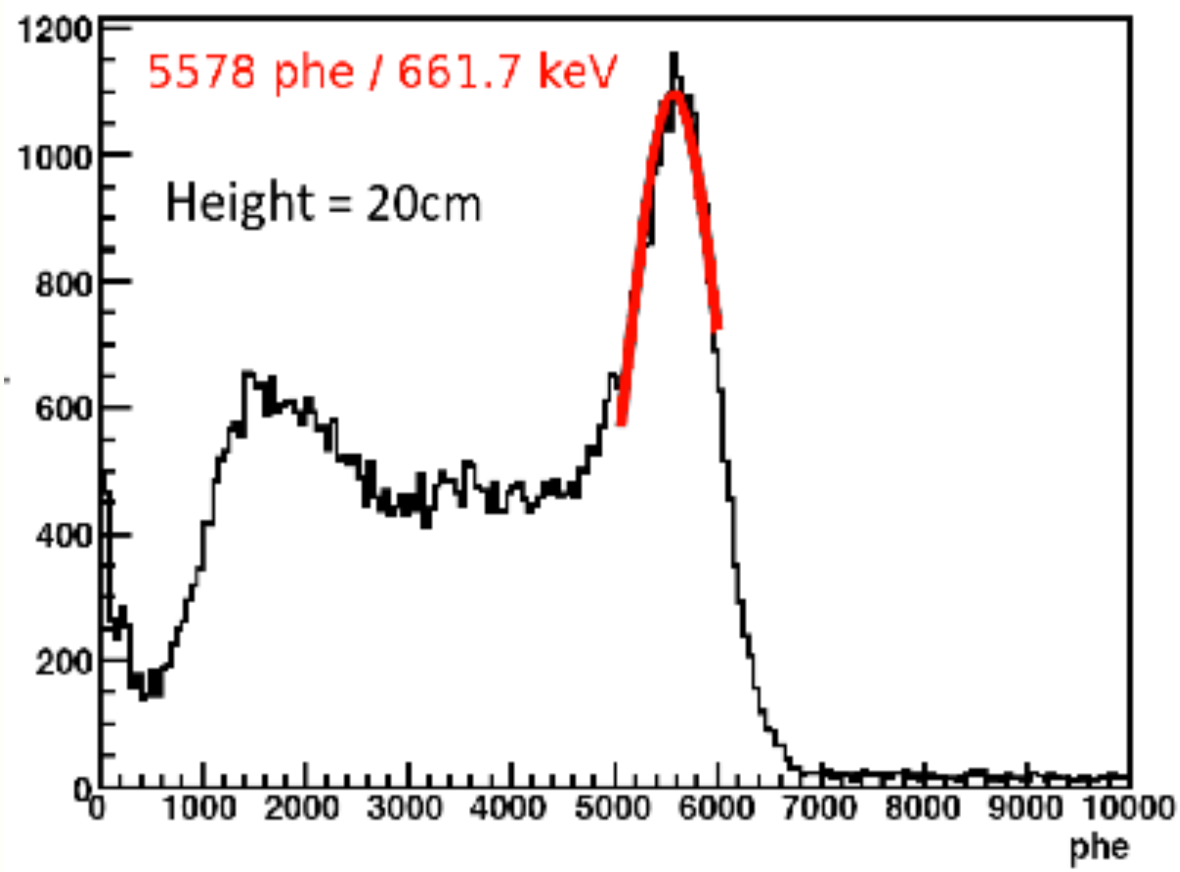
- At zero electric field, the light yield is very good for 662 keV γ:

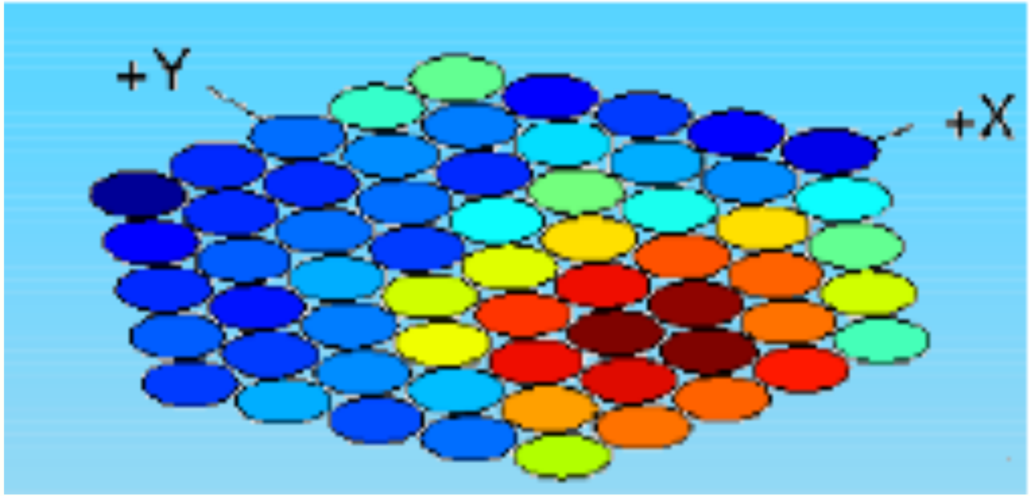
~8 photoelectrons/keV

- PTFE panels have very high reflectivity:

>95%

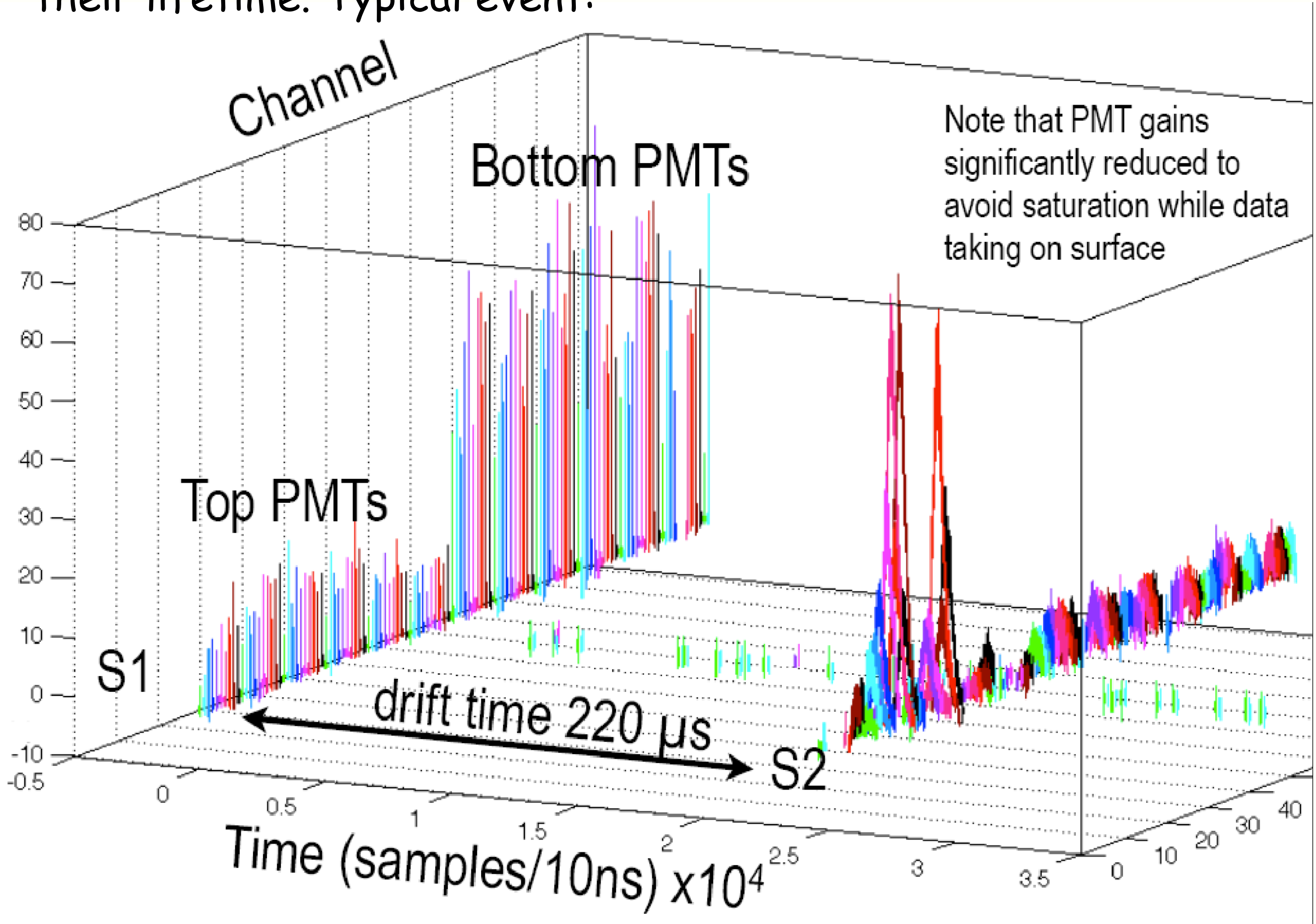
- Photon Absorption length > 5 m
  (will improve with purification)





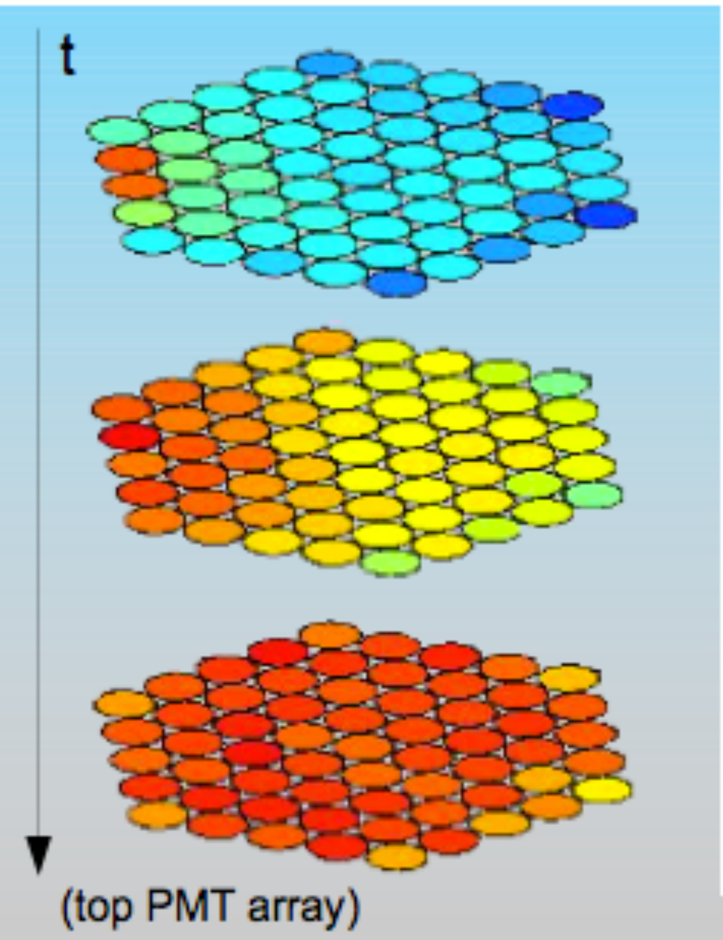
Turn on Electric Field

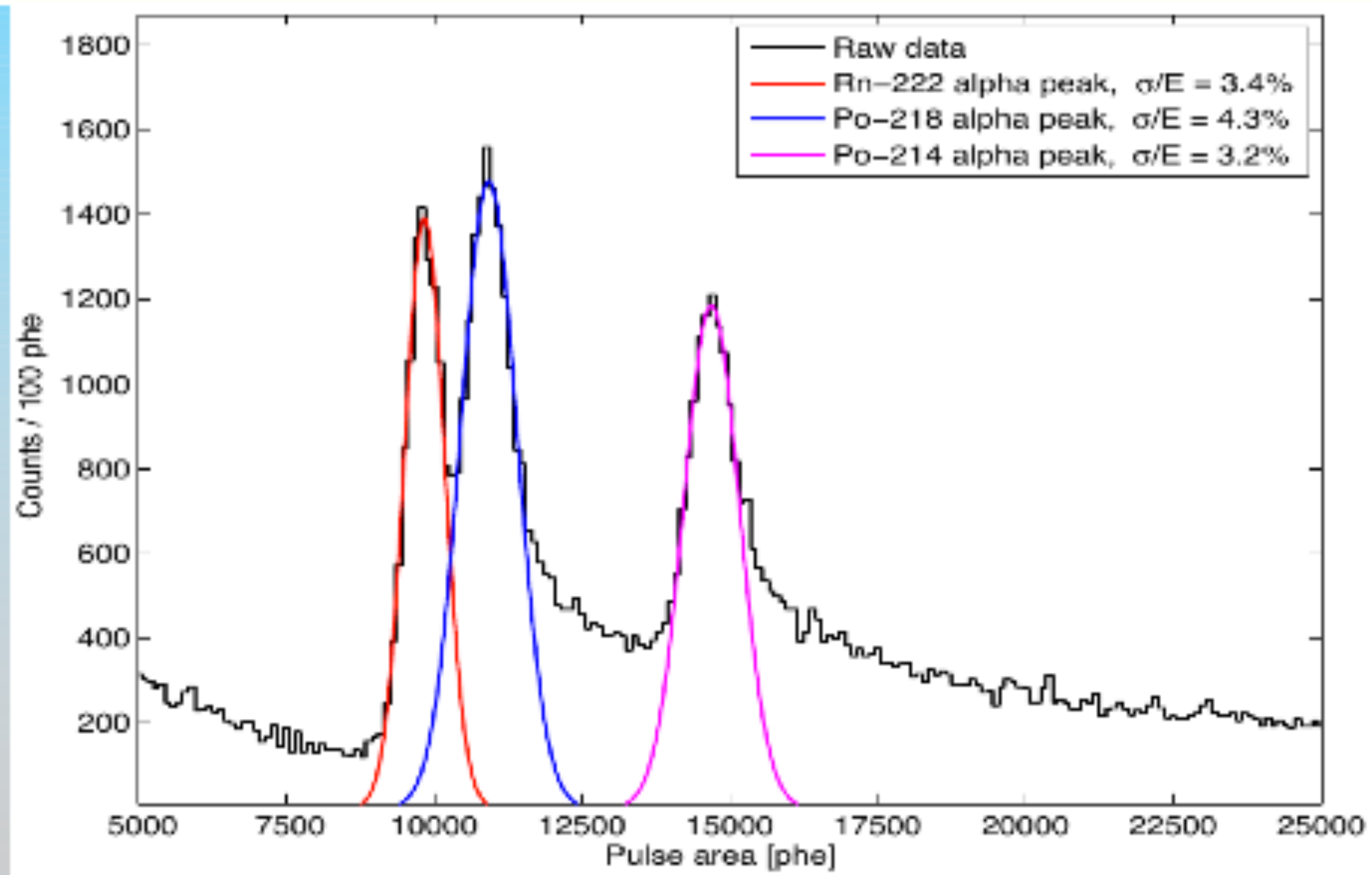
- With electric field turned on, we can drift electrons and measure their lifetime. Typical event:



Calibration by Injecting ^{222}Rn

- Due to a plumbing problem, Lxe purification was limited and the electron lifetime achieved was ~ 90 μs.
- Energy resolution from 5.5 MeV α's was ~3%.

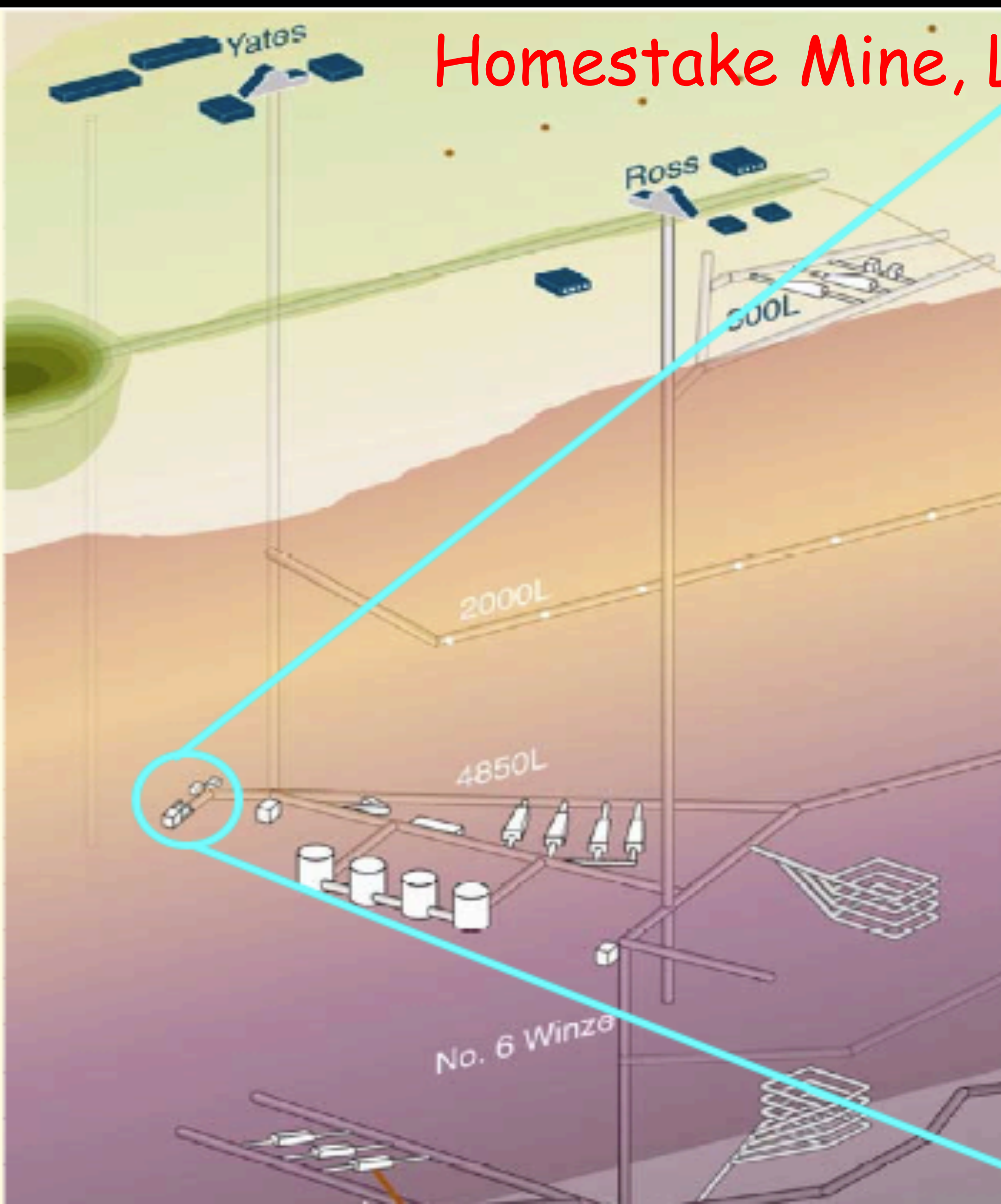


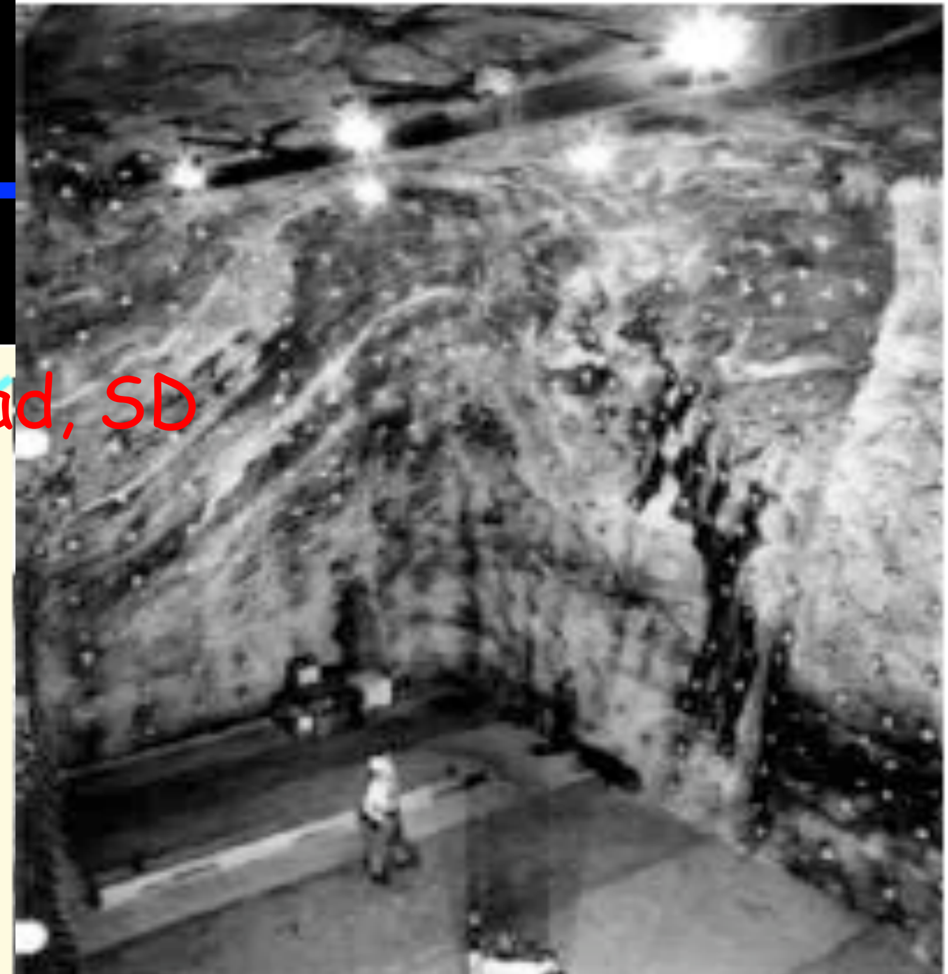



Underground Deployment:
A lab in the making

Davis Cavern

Homestake Mine, Lead, SD





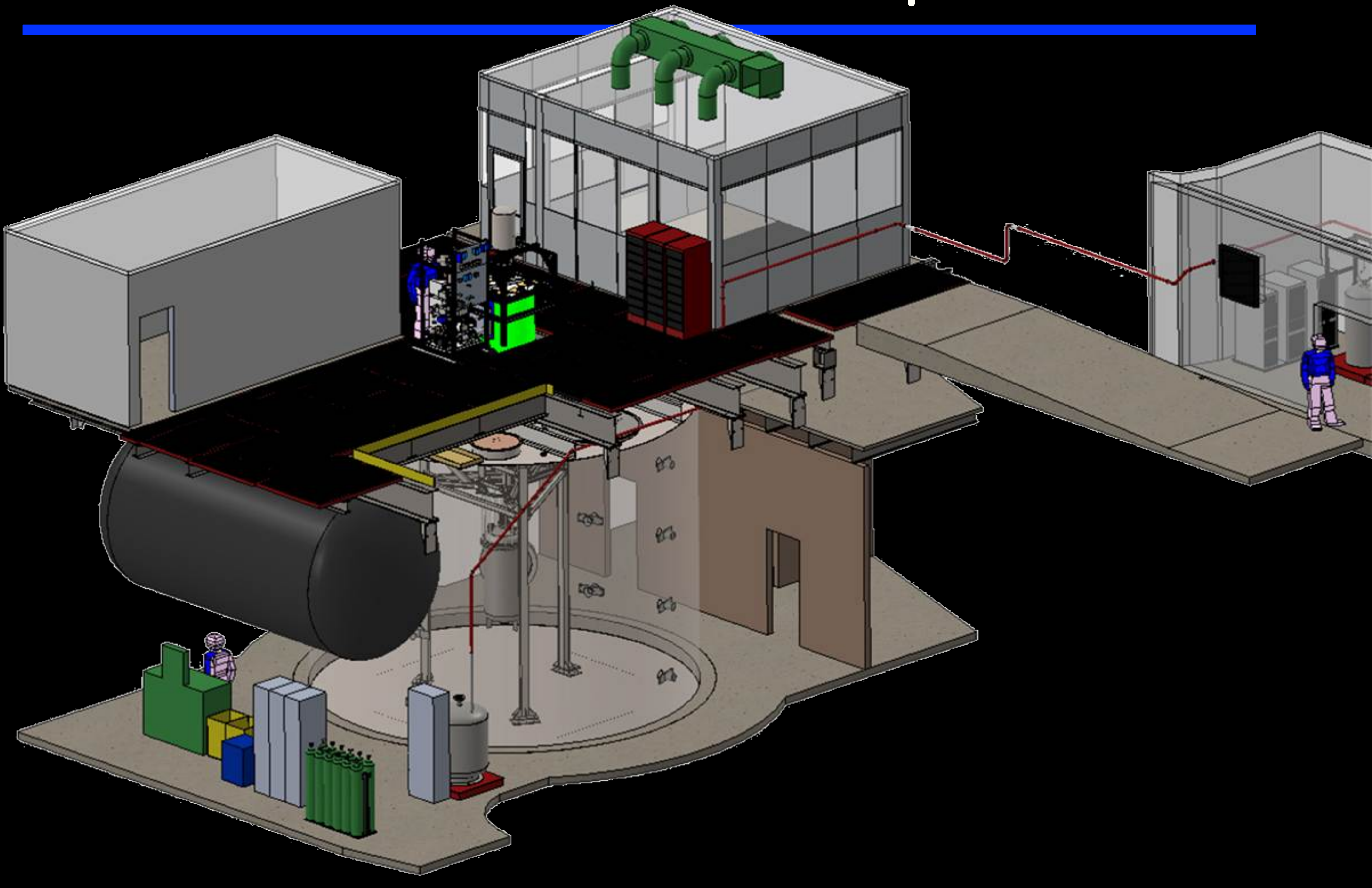
Sanford Lab

De-watering Milestone

May 22, 2009. Inspection of 4850 ft level.

Excavation Completed

Planned LUX Complex

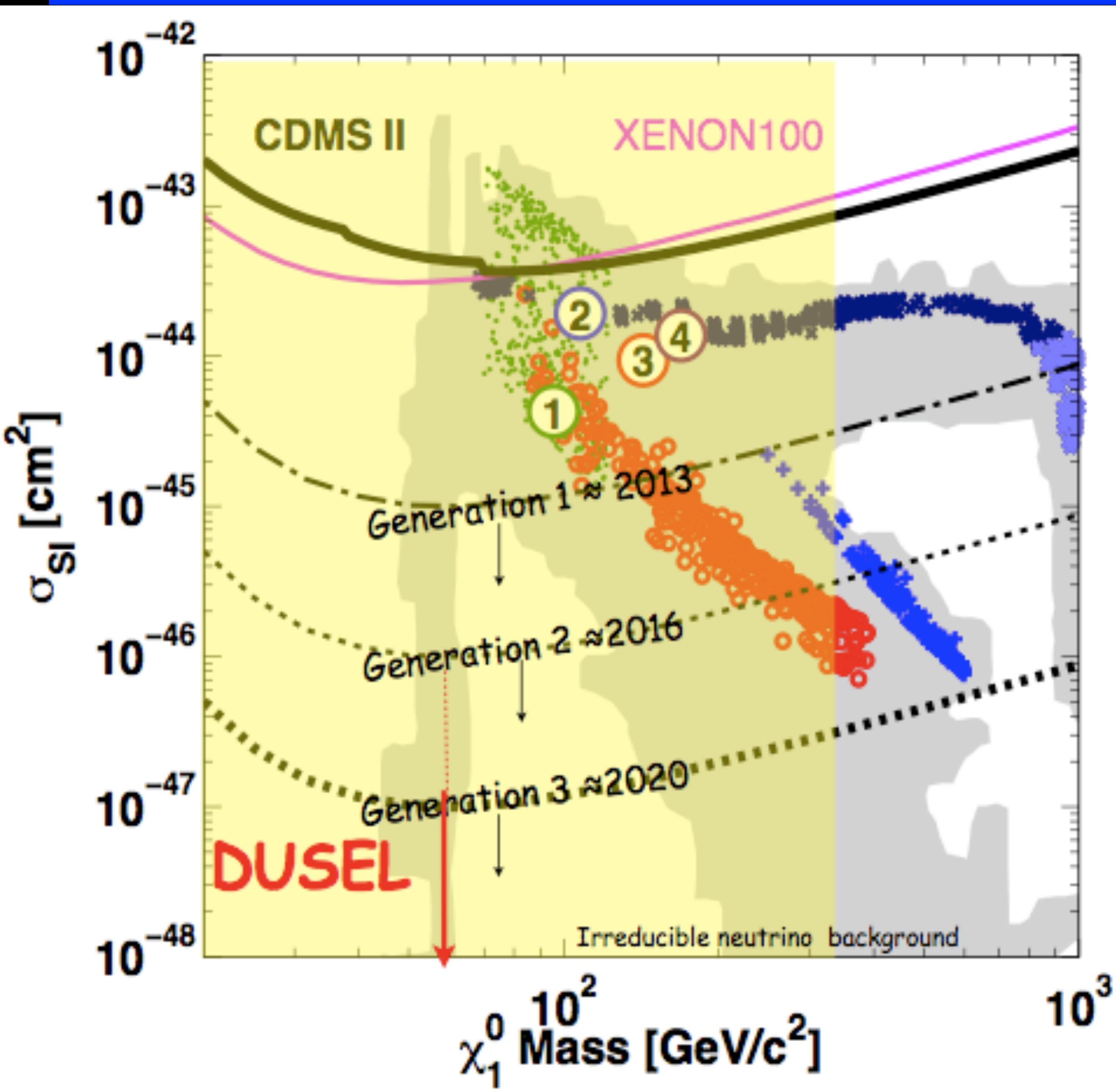


Water Shield Construction

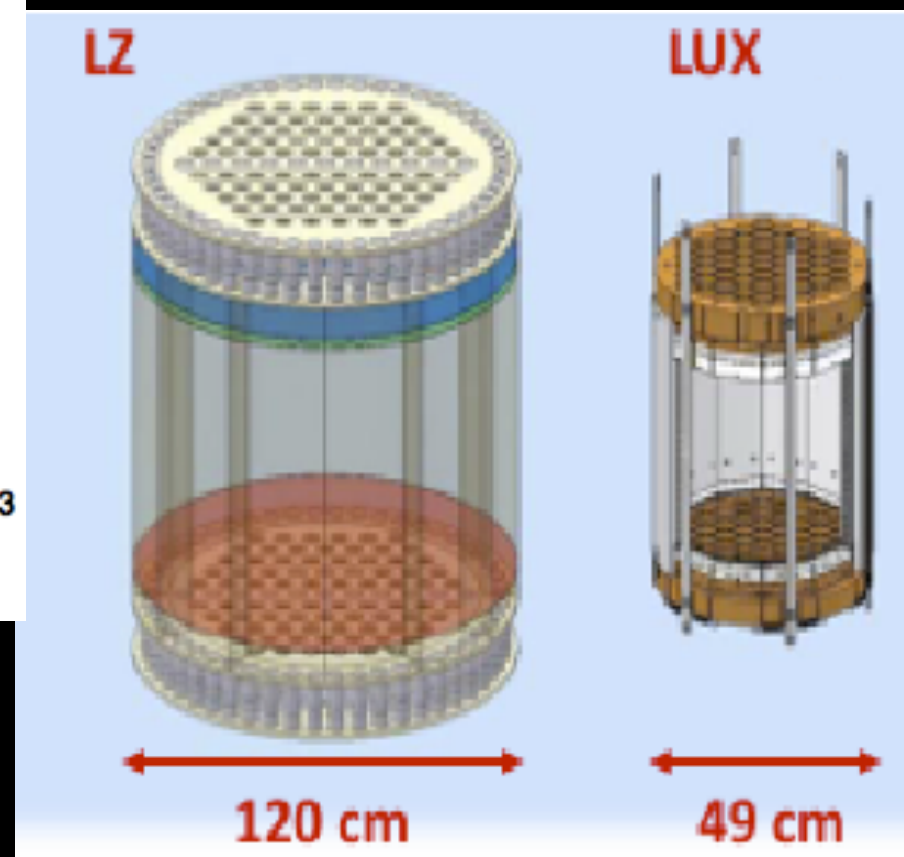
The water tank is now complete and being instrumented with PMTs.

Cavern Infrastructure

LUX → LZ (LUX-ZEPLIN)



3 Generation program being envisioned. LZ is a Generation-2 experiment.



Summary

1. Investigating the nature of Dark Matter is a leading problem of our times. The experimental program being planned for the future will provide definitive limits on whether WIMPs are the answer.

2. Liquid Xenon TPC is a highly promising technology that can be scaled to ~20 tonnes. Our understanding of LXe detectors is continually improving. More test cell data will shed light on the Lxe response in the low energy regime.

3. The LUX detector is being deployed underground. Expect to start delivering physics results in early 2013.