The LUX Dark Matter Detector

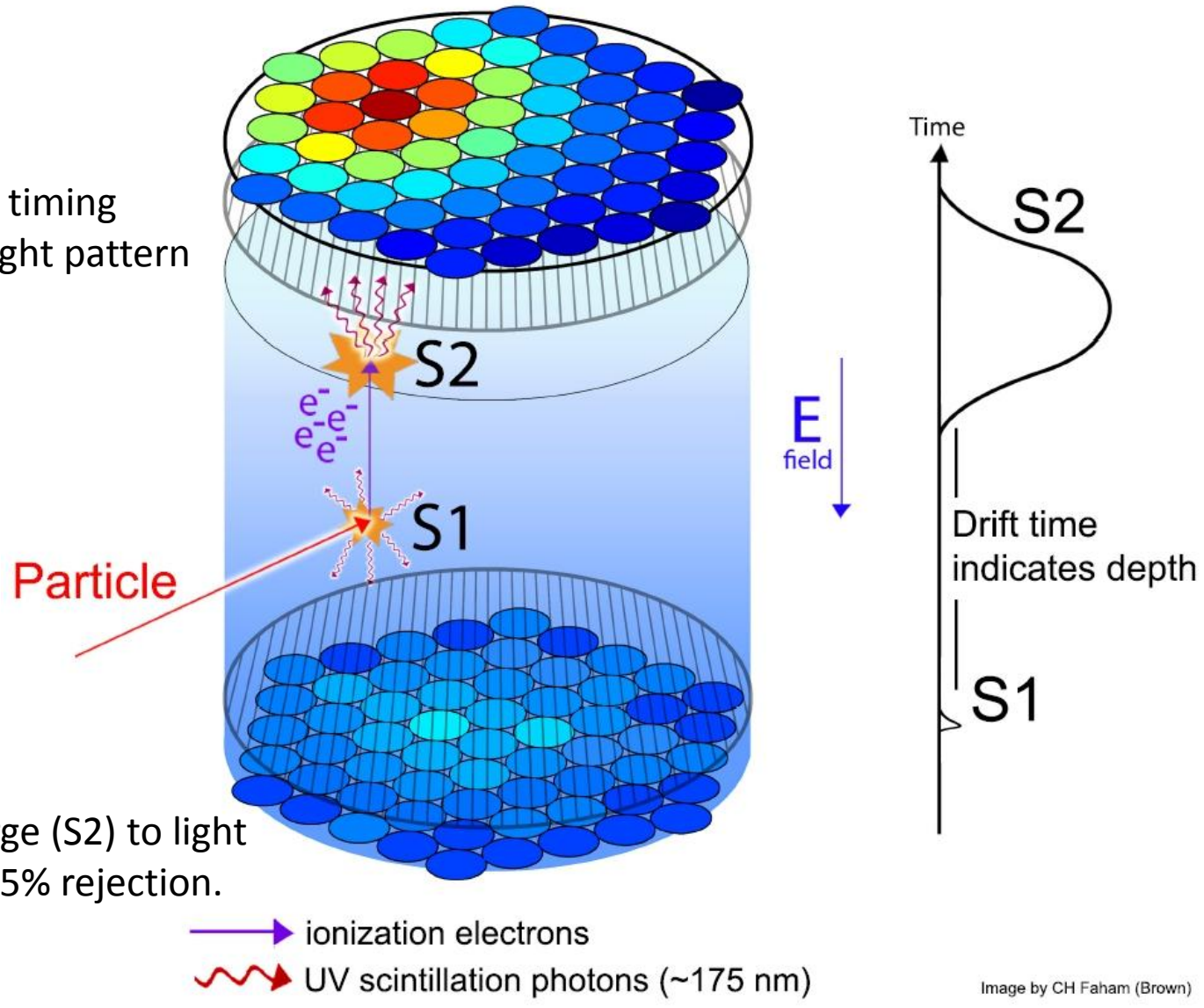
Nov 2011 – Feb 2012 Surface run

Ethan Bernard, Yale University

February 24th, 2012 – Dark Matter 2012

LUX is a two-phase liquid xenon WIMP detector

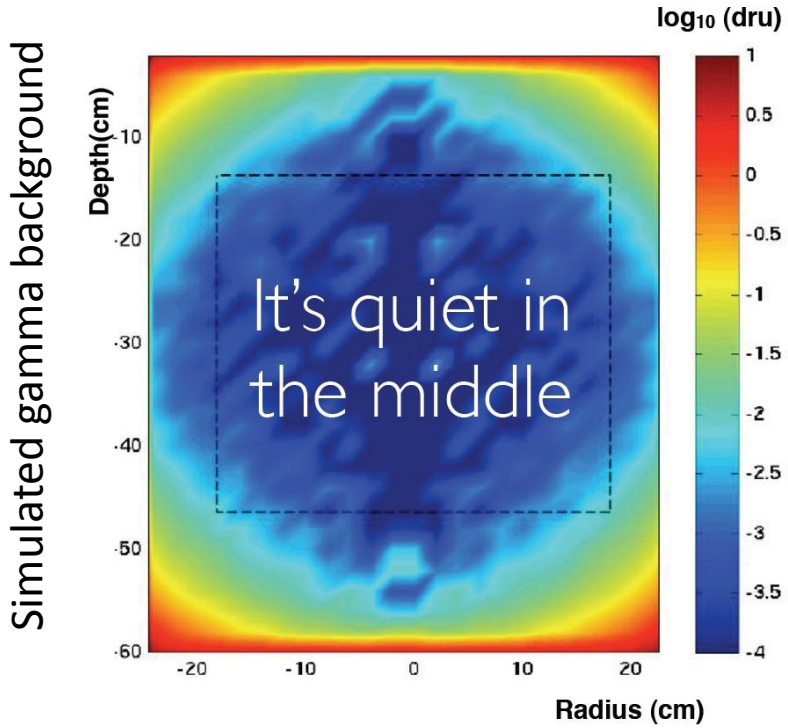
Z position from S1 – S2 timing
X-Y positions from S2 light pattern



Reject gammas by charge (S2) to light (S1) ratio. Expect > 99.5% rejection.

LUX Detector Internals

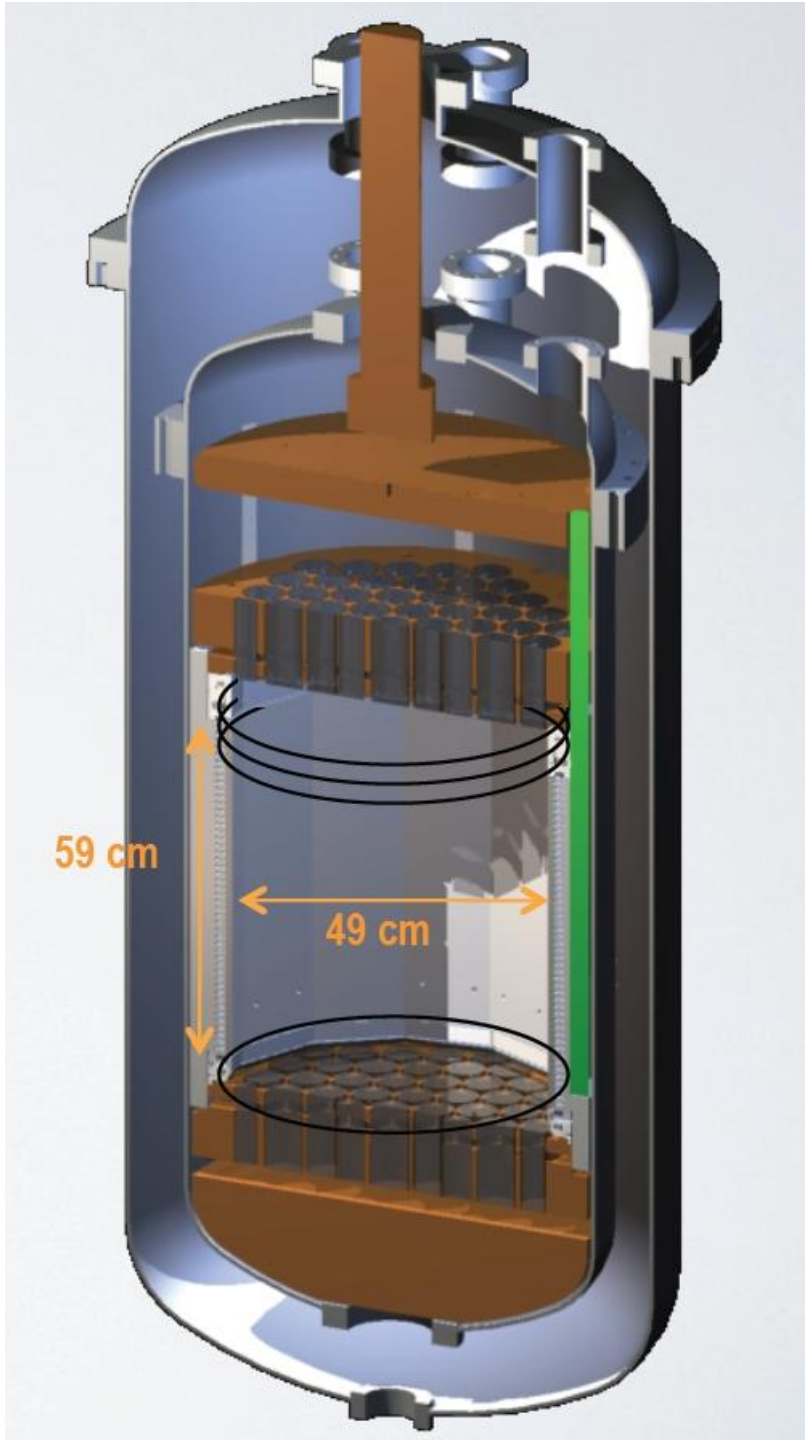
122 PMTs viewing 300 kg xenon; 100 kg fiducial



Ultra-low background PMTs and titanium cryostat[1]

Internal copper shielding

High flow plumbing and heat exchanger for rapid (>30 SLPM) circulation through external purifier



1) D.S. Akerib et al., arXiv:1112.1376

LUX Water Shield and Breakout

Water shielded with Cherenkov detection for muon veto

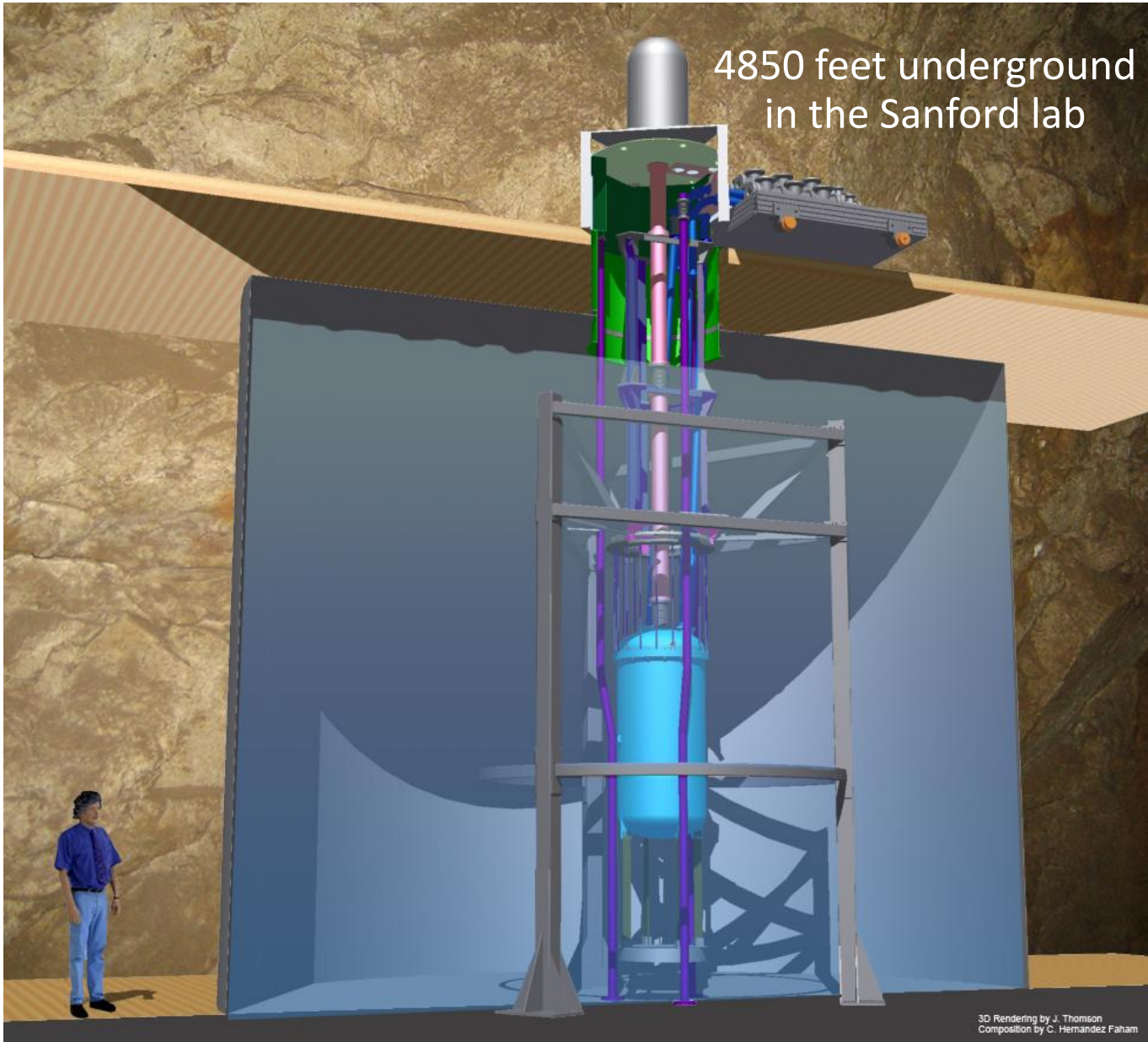
Thermosyphon cooling from above water tank

Xenon space extends through flexible umbilicals to electrical breakouts

In the 100 kg fiducial region over the energy range of interest:

Only 2 gamma events per week

Less than 0.08 neutron events per year

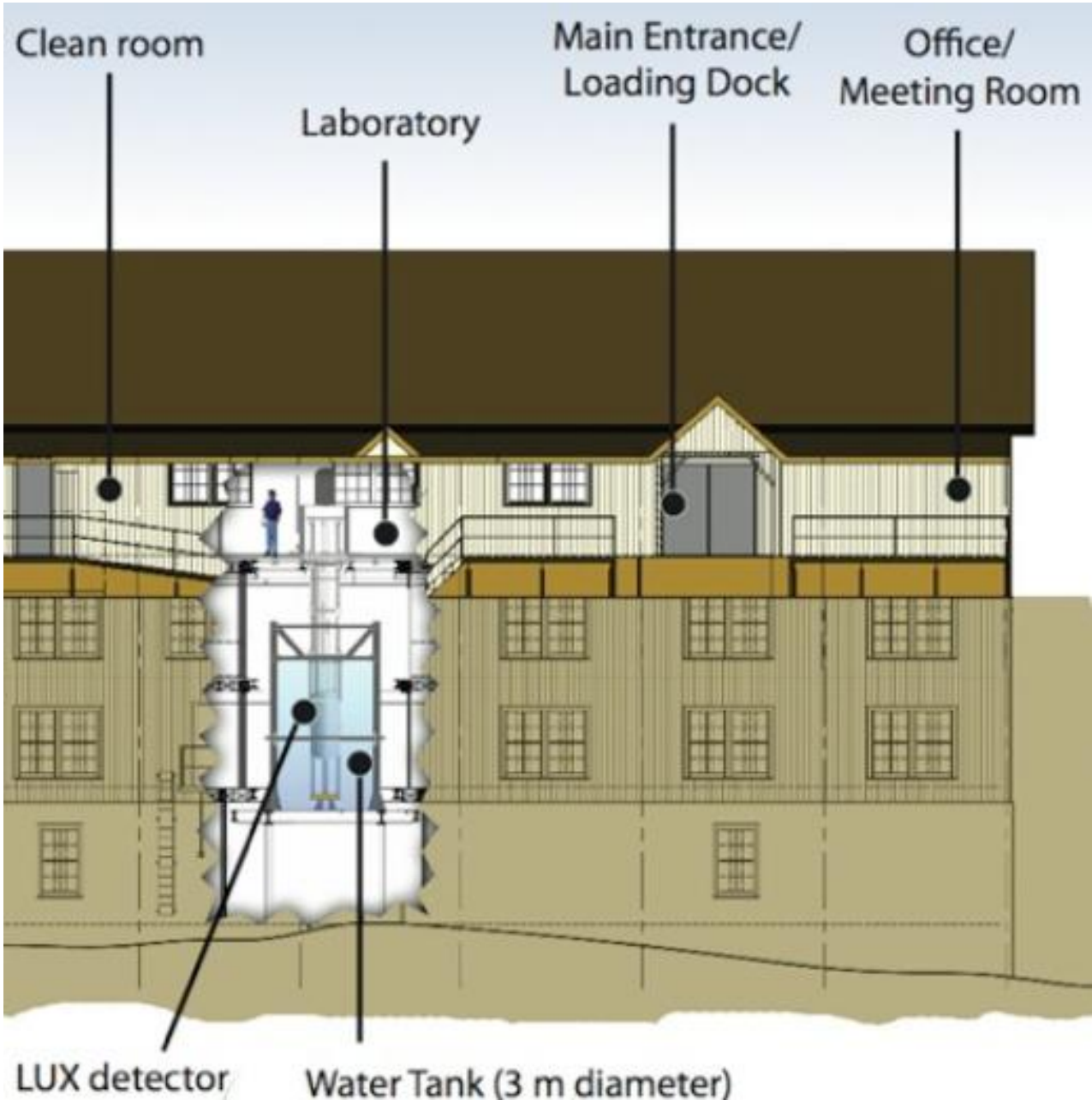


Nov 2011 – Feb 2012 Surface Run

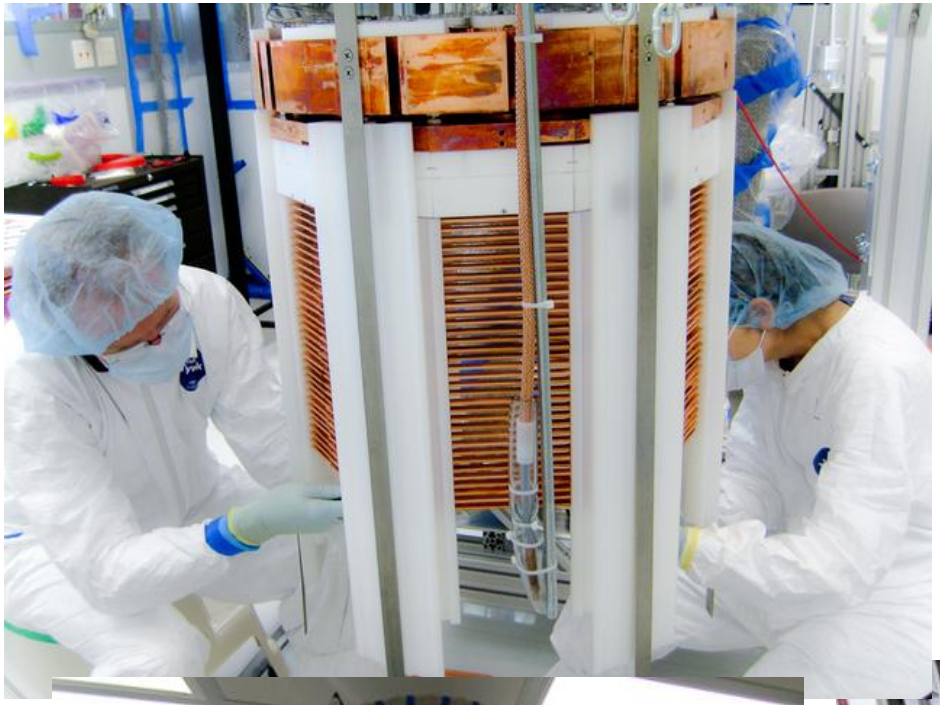
Surface run:

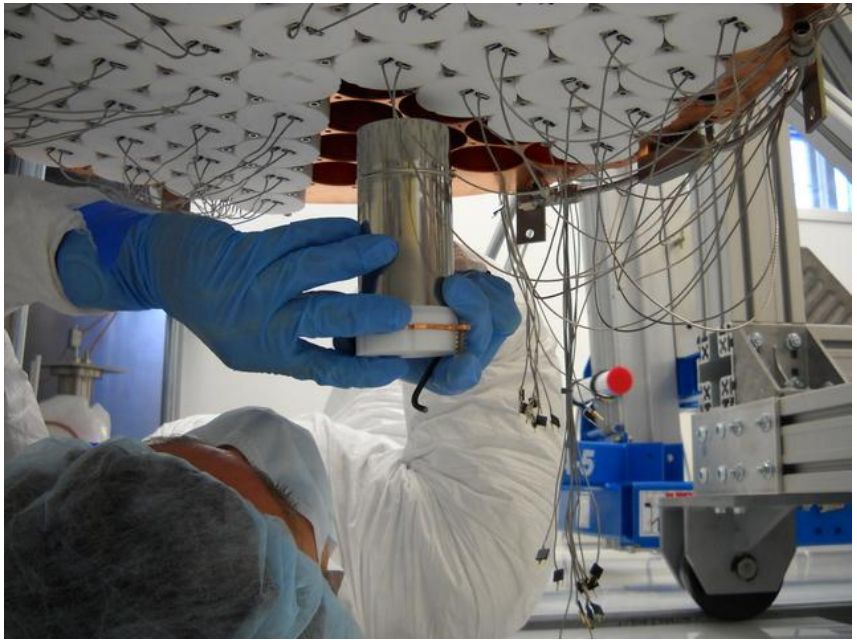
Deploy the detector in a water shield at the surface.

Test everything that can be tested!

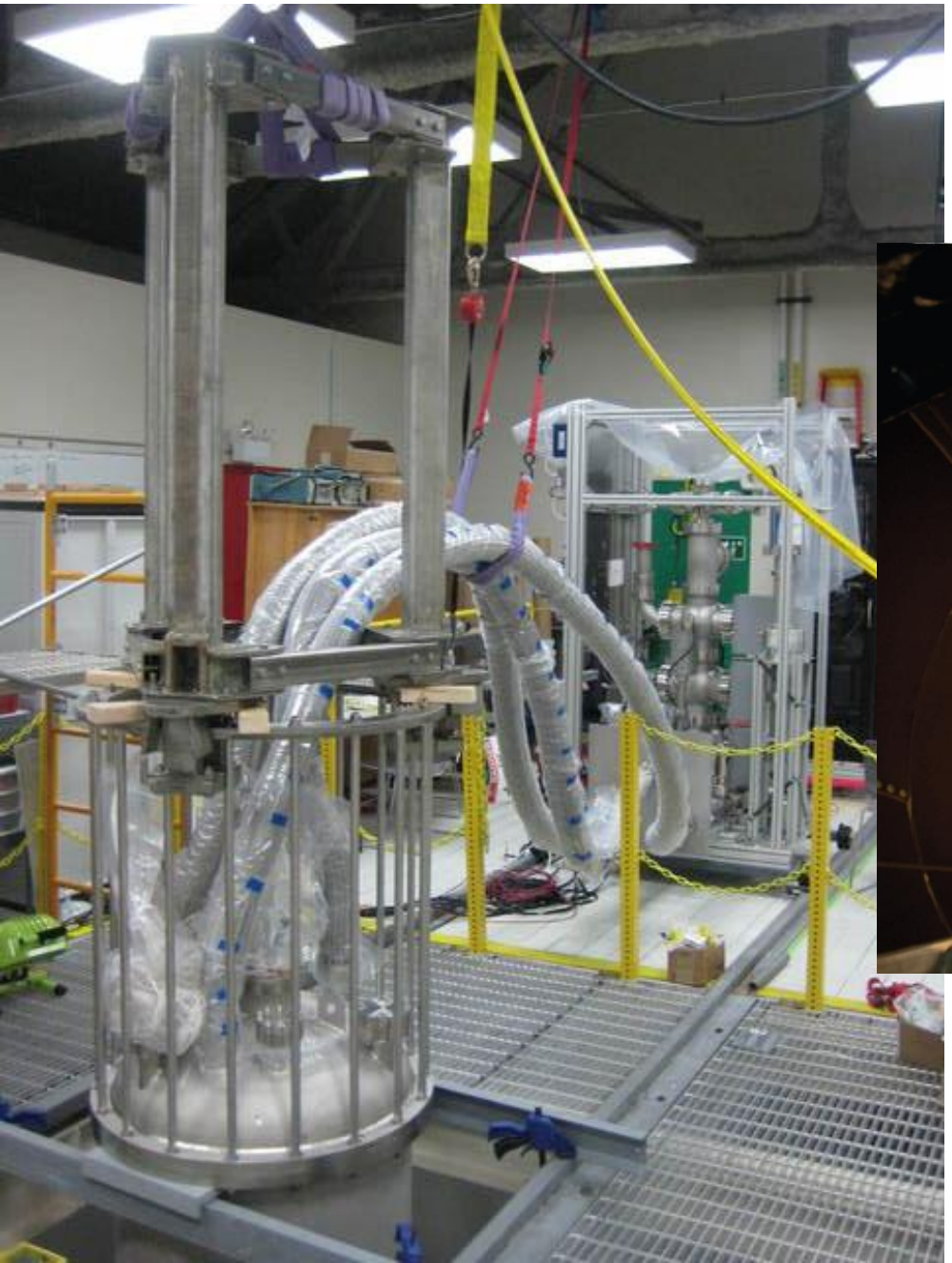


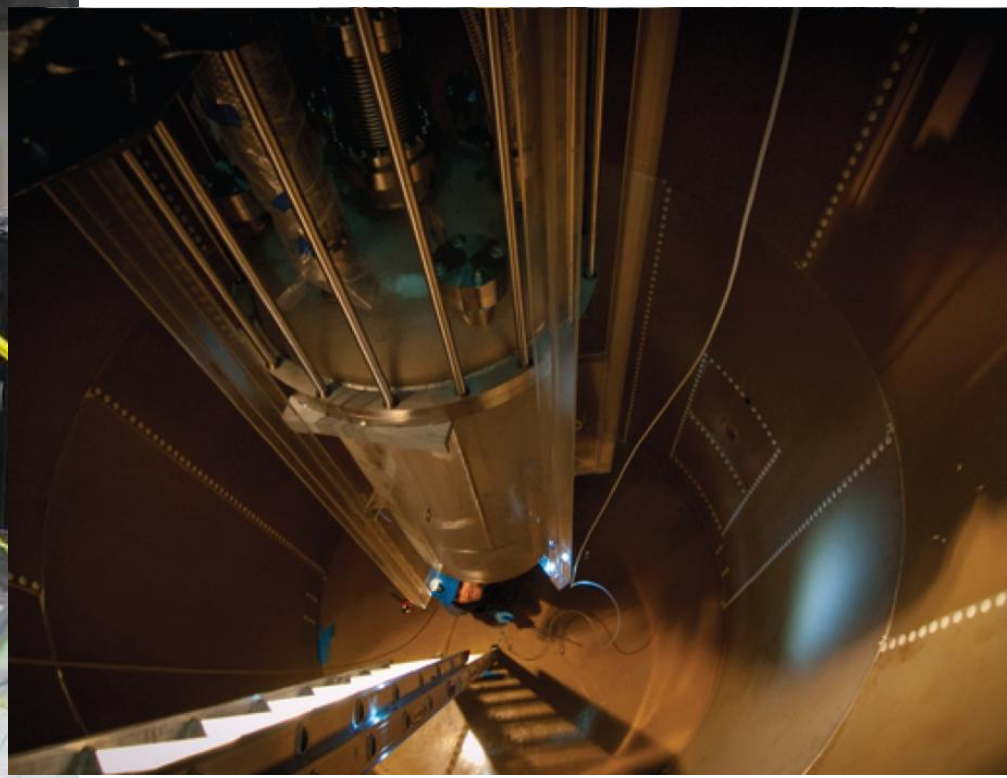
Construction





Deployment

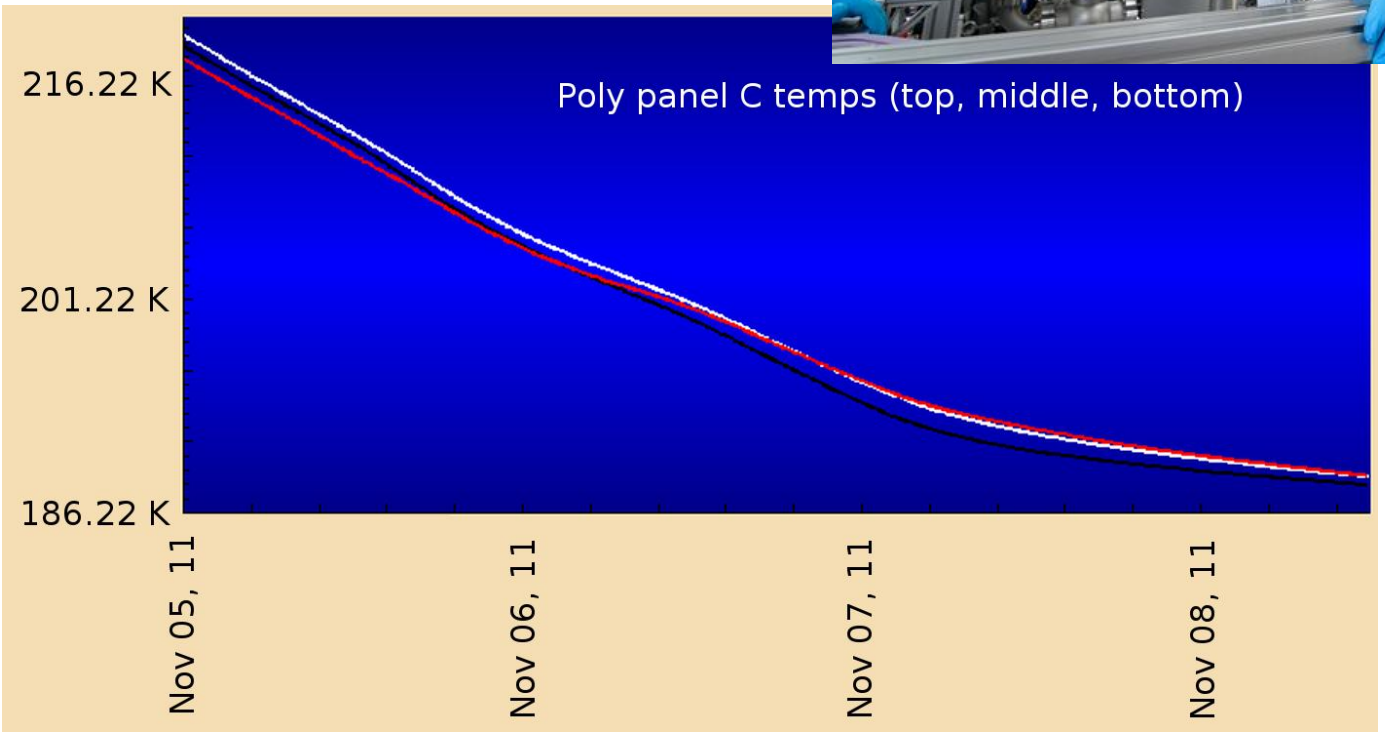




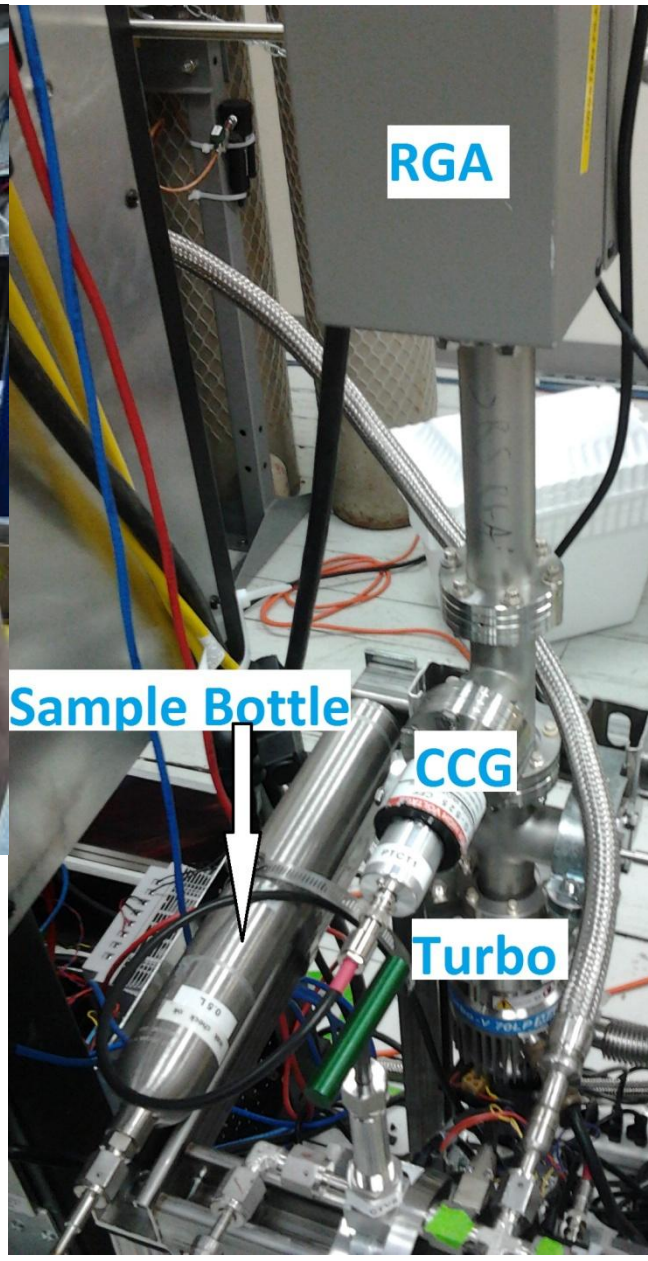
Collimated sources for external calibration

Calibrated internally and with ^{83m}Kr, tritium

Thermosyphon Cooling System



Circulation, Sampling and Storage



Circulation at 35 SLPM through purifier by diaphragm pump

In-situ xenon sample RGA analysis[1] sensitivity:
0.7 ppb O_2 mol / mol
0.5 ppt Kr mol / mol

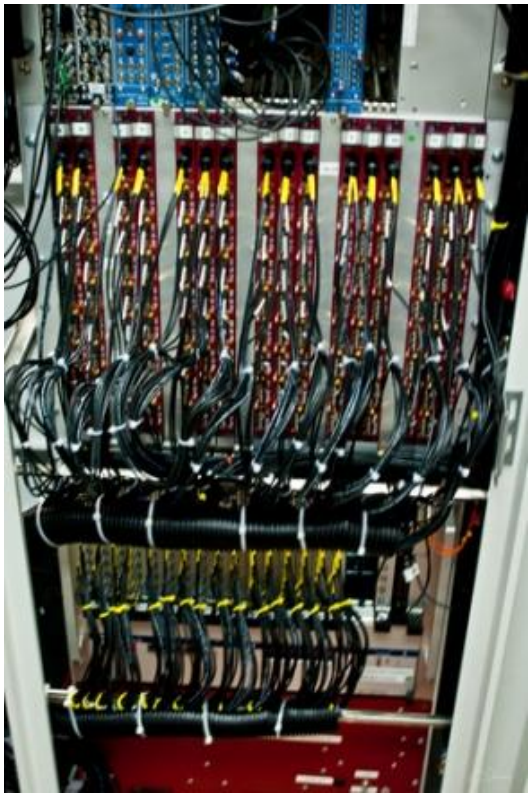
1) A. Dobi et al., NIM-A, Vol. 675, 40-46 (2012) [arXiv:1109.1046]

DAQ and Trigger

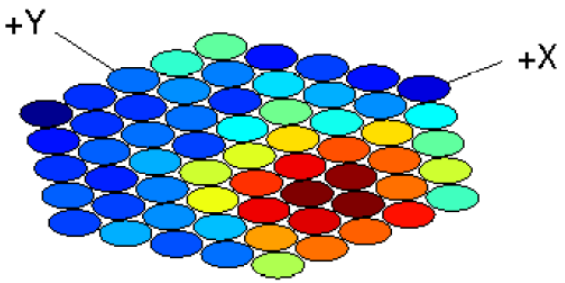
Samples at 105 MHz with 14 bit depth

All channels are working; surface run generated 3 TB of data.

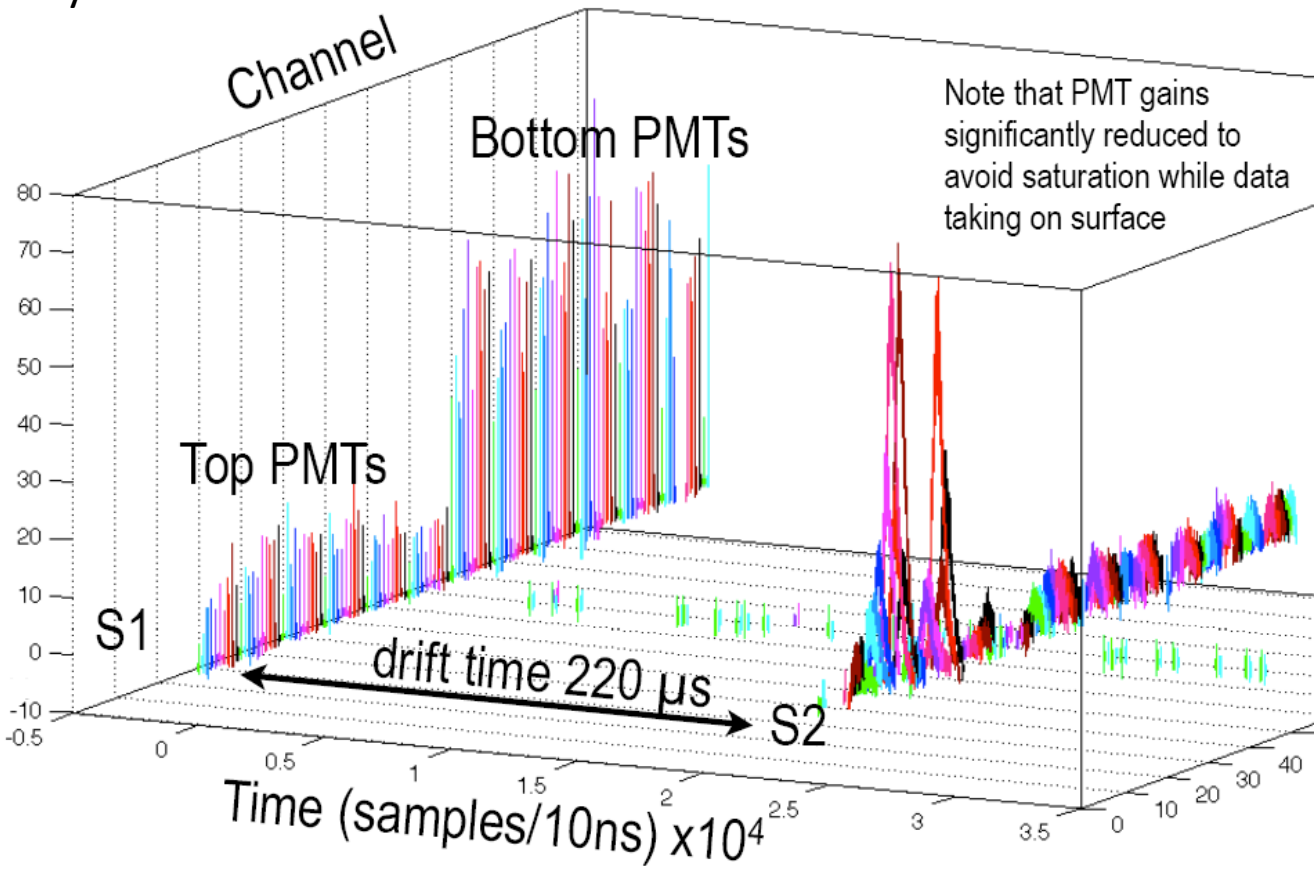
121 of 122 PMTs are working; one broken base in lower PMT array.



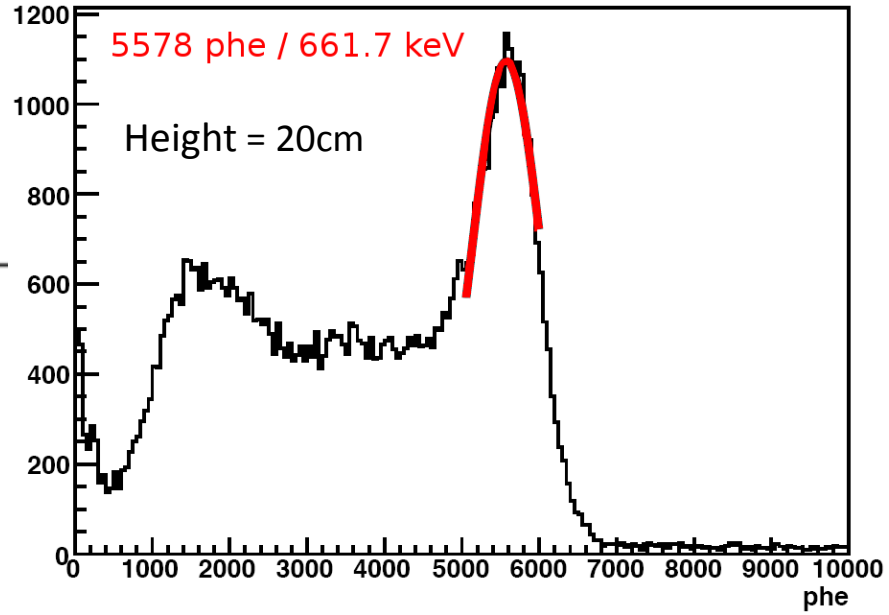
Hit Pattern

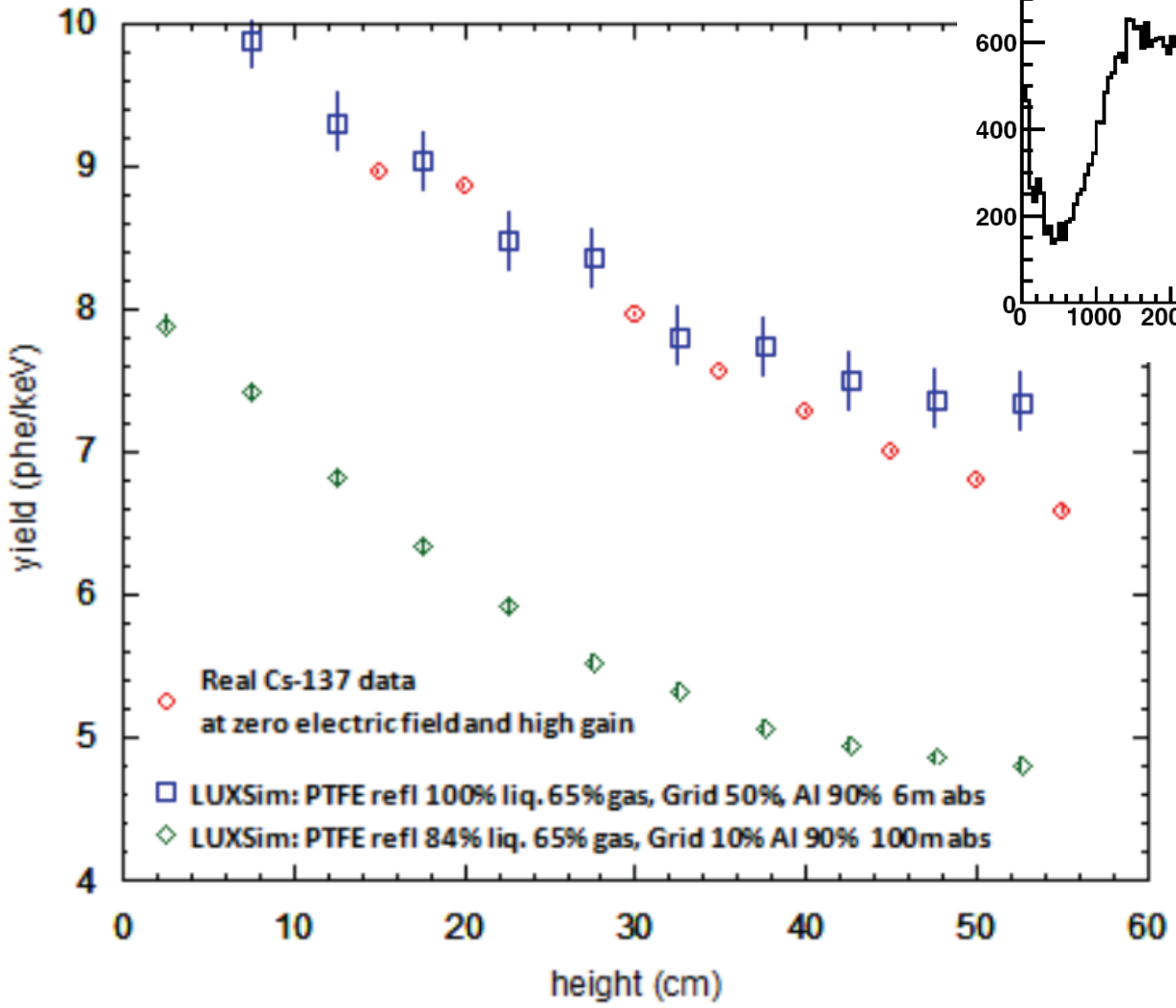


Example of alpha particle in middle of LXe detector



Light Collection





Collimated ^{137}Cs calibration:
8 phe / keVee in detector center at zero drift field

Electron lifetime

- Xenon chemical purity is monitored by sampling system.
- Electron lifetime is monitored by muon and alpha signals.
- Purification was studied in a number of modes, using purge paths and thermal gradients to manipulate circulation.
- We achieved an electron lifetime of 90 μs 1/e time (drift length ~ 11 cm).
- We believe the lifetime is limited by inefficient delivery of clean xenon to the active region, caused by a break within the detector of the plumbing designed to route the purified xenon to the active volume.

Summary and Outlook

- ✓ Deployed into water tank shield
- ✓ Stable cryogenic control for ~100 days of running
- ✓ Purification at 35 SLPM
- ✓ Heat exchanger efficiency > 98%; < 5 W heat load at 300 kg/day
- ✓ In-situ xenon purity analysis
- ✓ Working PMTs, Trigger, DAQ
- ✓ Excellent light collection (8 phe / keV in center)
- ✓ Drift field to 300 V / cm (limited by provisional cathode feedthrough)
- ✓ Recovered xenon to storage vessel by cryopumping

- ❑ Did not achieve necessary purity (200 μs) for full scale drift (internal plumbing problem)

The detector will return to the cleanroom for March and April

- Plumbing repair
- PMT base replacement
- Cathode high voltage feedthrough upgrade

Meanwhile, 4850 feet underground in the Homestake mine…

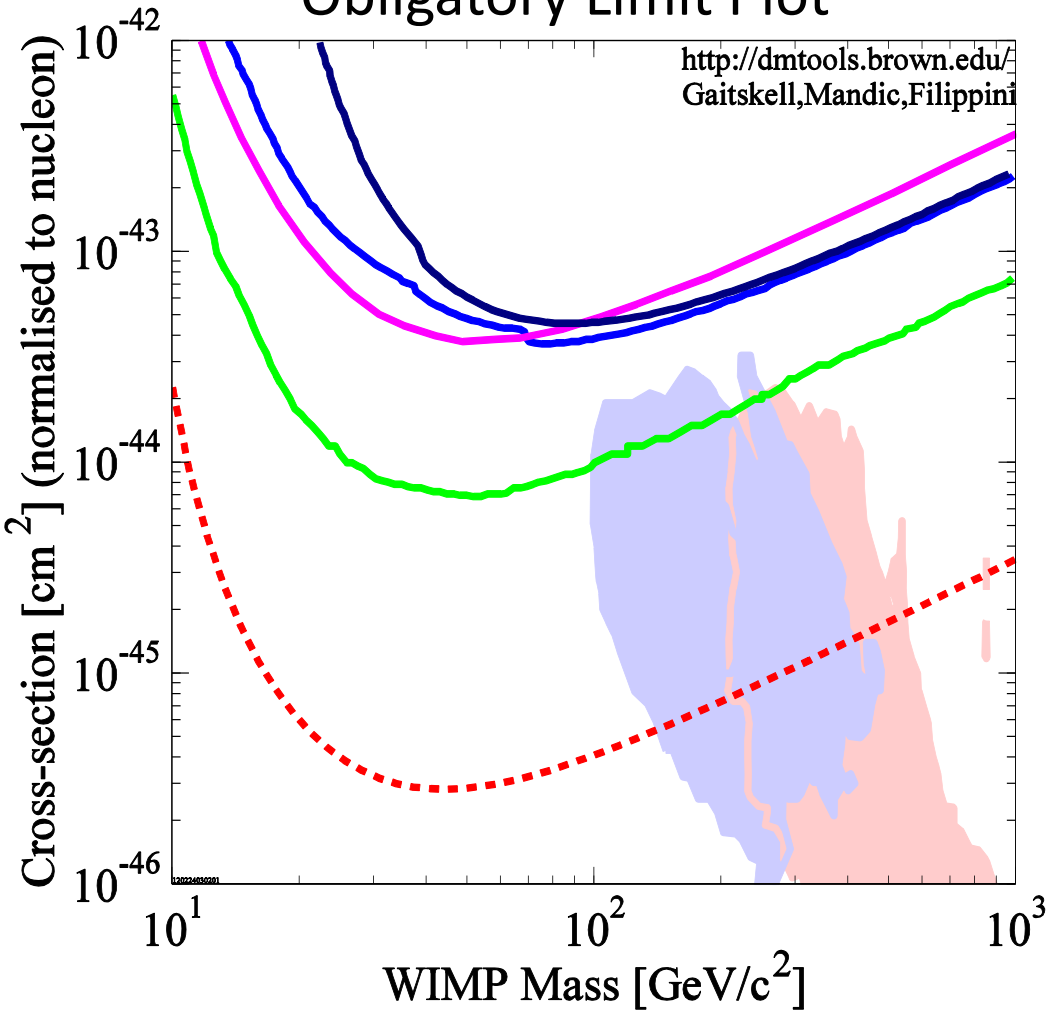
Moving begins at the end of March

Detector moves at the end of April

Xenon purification (Kr removal) during summer 2012

Underground science run begins this fall

Obligatory Limit Plot



Bob Jacobsen, LZ program, at 4:15 → → → → → →

DATA listed top to bottom on plot
Edelweiss II, 2011, Final Results, 384kg-days, SI
ZEPLIN III, 2011, second science run, 1344kg-days, SI
CDMS II (Soudan), 2010, combined 2004 to 2009, all Soudan data, SI
XENON100, 2011, 100.9 live days of data, SI
LUX 300 kg Projected Sensitivity: 30000 kg-d, 5-30 keV, 45% eff
Buchmueller et. al., 2011, LHC CMS contraints on CMMS, 68% and 95% CL, S
Buchmueller et. al., 2011, LHC & XENON100 constraints on CMSSM, (1/fb LH

120224030201

The LUX Collaboration

Collaboration was formed in 2007 and fully funded by DOE and NSF in 2008.

The most recent collaboration meeting was held in Lead, SD in March 2011.

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
Carmen Carmona	Postdoc
Ken Clark	Postdoc
Tom Coffey	Postdoc
Karen Gibson	Postdoc
Adam Bradley	Graduate Student
Patrick Phelps	Graduate Student
Chang Lee	Graduate Student
Kati Pech	Graduate Student

Harvard

Masahiro Morii	PI, Professor
Michal Wlasenko	Postdoc
John Oliver	Electronics Engineer

Lawrence Berkeley + UC Berkeley

Bob Jacobsen	Professor
David Taylor	Engineer
Mia ihm	Graduate Student

Lawrence Livermore

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

University of Maryland

Carter Hall	PI, Professor
Douglas Leonard	Postdoc

UC Santa Barbara

Harry Nelson	PI, Professor
Dean White	Engineer
Susanne Kyre	Engineer

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

SD School of Mines

Xinhua Bai	PI, Professor, Physics Group Leader
Mark Hanardt	Graduate Student

Texas A&M

James White	PI, Professor
Robert Webb	Professor
Rachel Mannino	Graduate Student
Tyana Stiegler	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
Jeremy Mock	Graduate Student
Melinda Sweany	Graduate Student
Nick Walsh	Graduate Student
Michael Woods	Graduate Student
Sergey Uvarov	Graduate Student

University of Rochester

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

U. South Dakota

Dongming Mei	PI, Professor
Wengchang Xiang	Postdoc
Chao Zhang	Postdoc
Oleg Perevozchikov	Postdoc

Yale

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