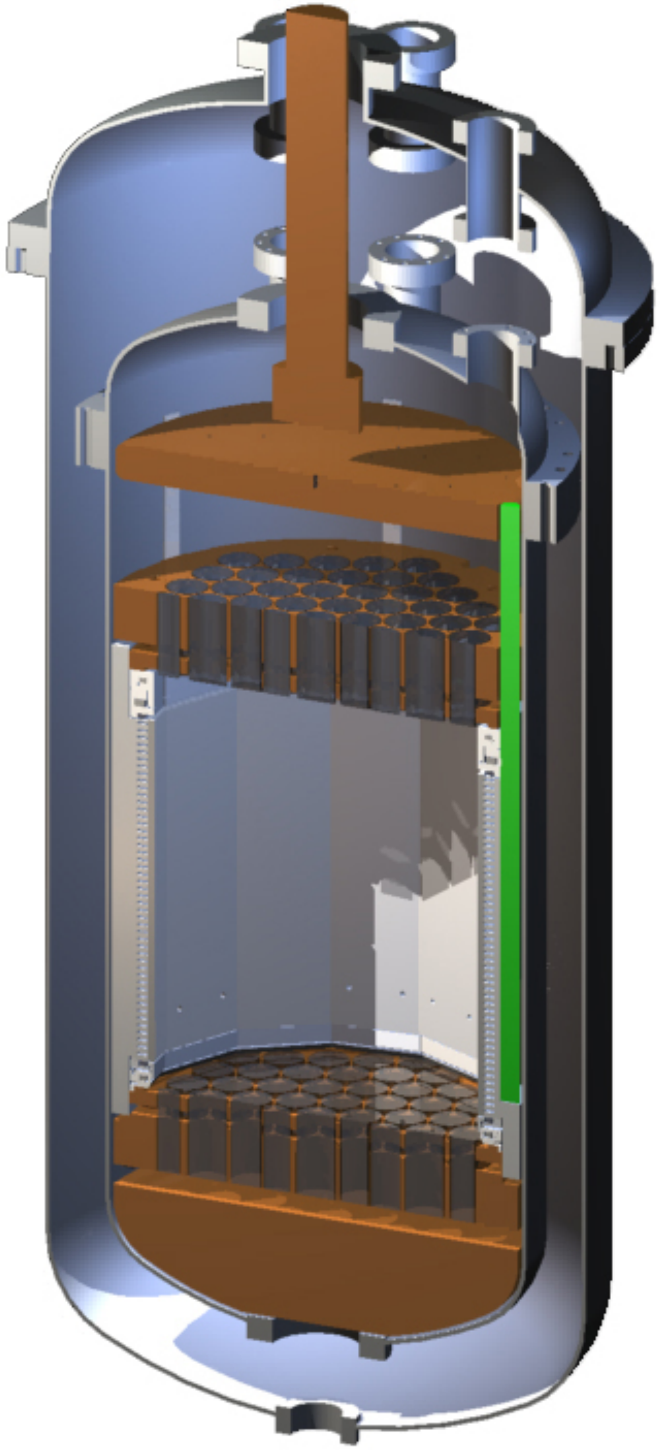
Status of the LUX Dark Matter Experiment



Jeremy Chapman
for the LUX Collaboration
-
American Physical Society, Division of Particles and Fields
Brown University August 10, 2011

LUX Collaboration

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

Brown

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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
Jim Siegrist	Professor
Bill Edwards	Engineer
Joseph Rasson	Engineer
Mia ihm	Graduate Student

Lawrence Livermore

Adam Bernstein	PI, Leader of Adv. Detectors
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
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Robert Webb	Professor
Rachel Mannino	Graduate Student
Tyana Stiegler	Graduate Student
Clement Sofka	Graduate Student

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Robert Svoboda	Professor
Richard Lander	Professor
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John Thomson	Senior Machinist
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Melinda Sweany	Graduate Student
Nick Walsh	Graduate Student
Michael Woods	Graduate Student
Sergey Uvarov	Graduate Student

University of Rochester

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Wojtek Skutski	Senior Scientist
Eryk Druszkiewicz	Graduate Student
Mongkol Moongweluwan	Graduate Student

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Chao Zhang	Postdoc
Oleg Perevozchikov	Postdoc

Yale

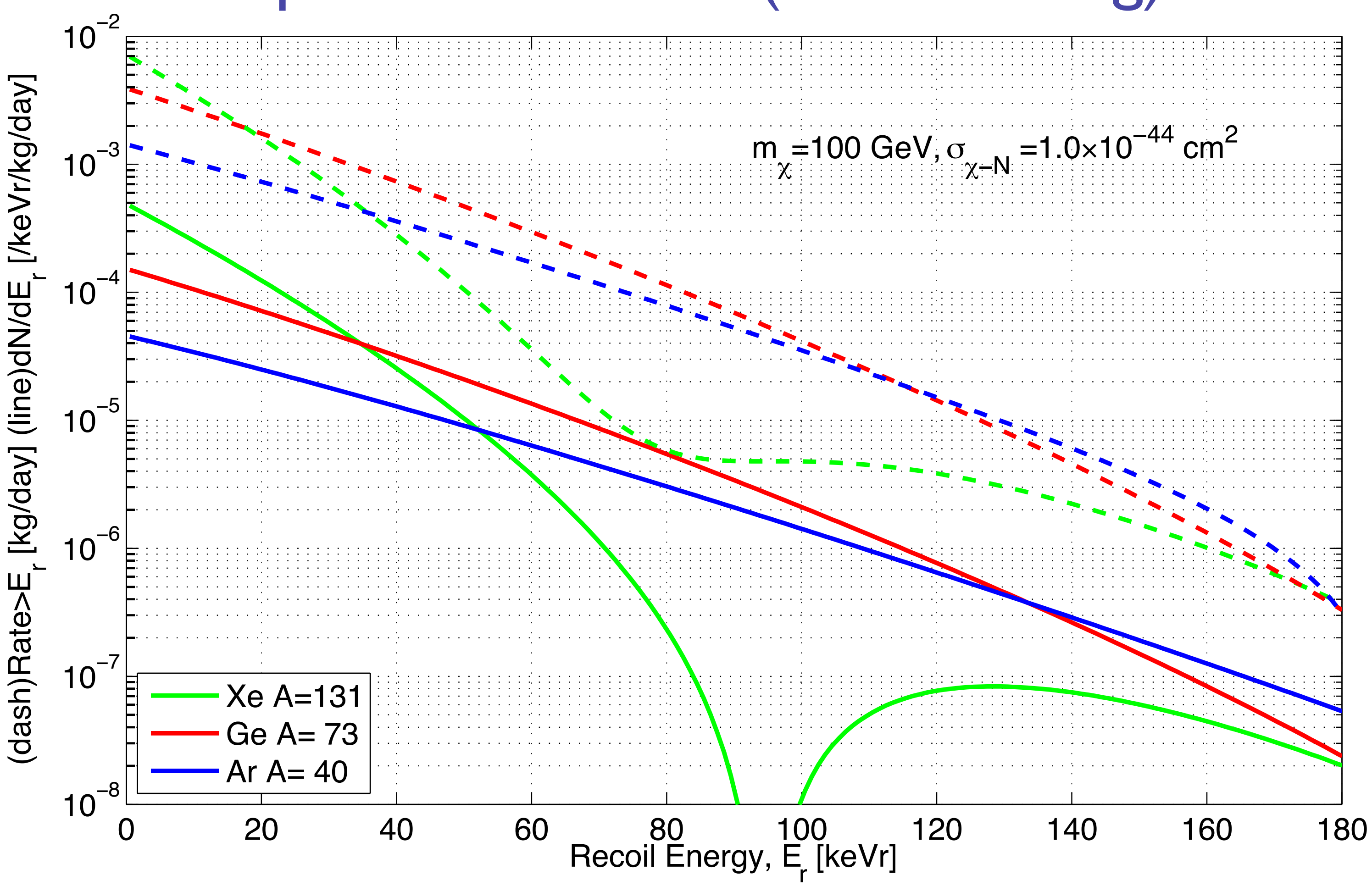
Daniel McKinsey	PI, Professor
Peter Parker	Professor
James Nikkel	Research Scientist
Sidney Cahn	Lecturer/Research Scientist
Alexey Lyashenko	Postdoc
Ethan Bernard	Postdoc
Blair Edwards	Postdoc
Louis Kastens	Graduate Student
Nicole Larsen	Graduate Student

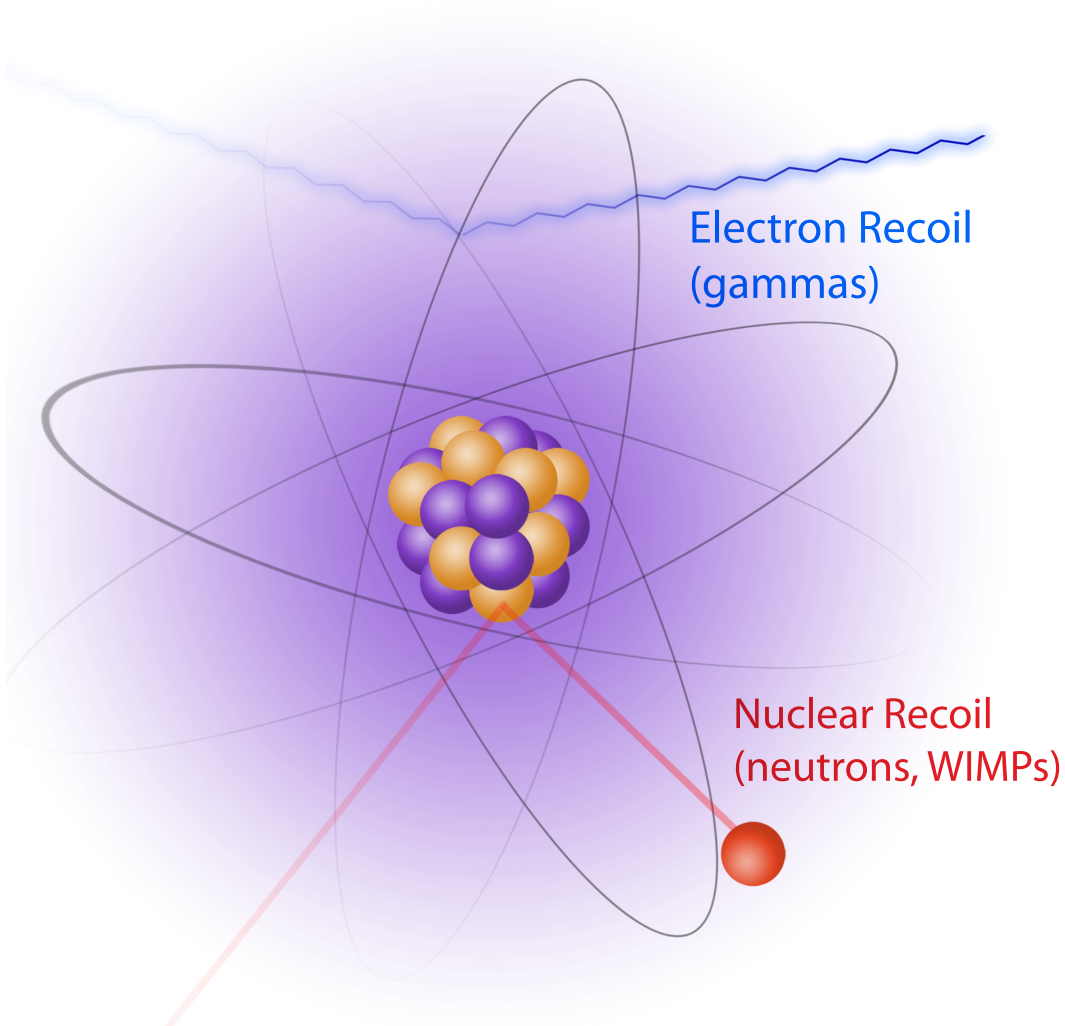
Xenon

- Large Z (large cross-section), high density (3 g/cc for liquid)
- Transparent to own scintillation photons
- Low background (no long-lived radioactive isotopes)
- Odd isotope A = 131 (needed for spin-dependent interactions)
- Boiling point = -100C (easy cryogenics using LN)
- High scintillation and ionization yield (low threshold)
- Scintillation/Ionization yield dependent on type of interaction

(good discrimination between electron and nuclear recoils ~99.8%)

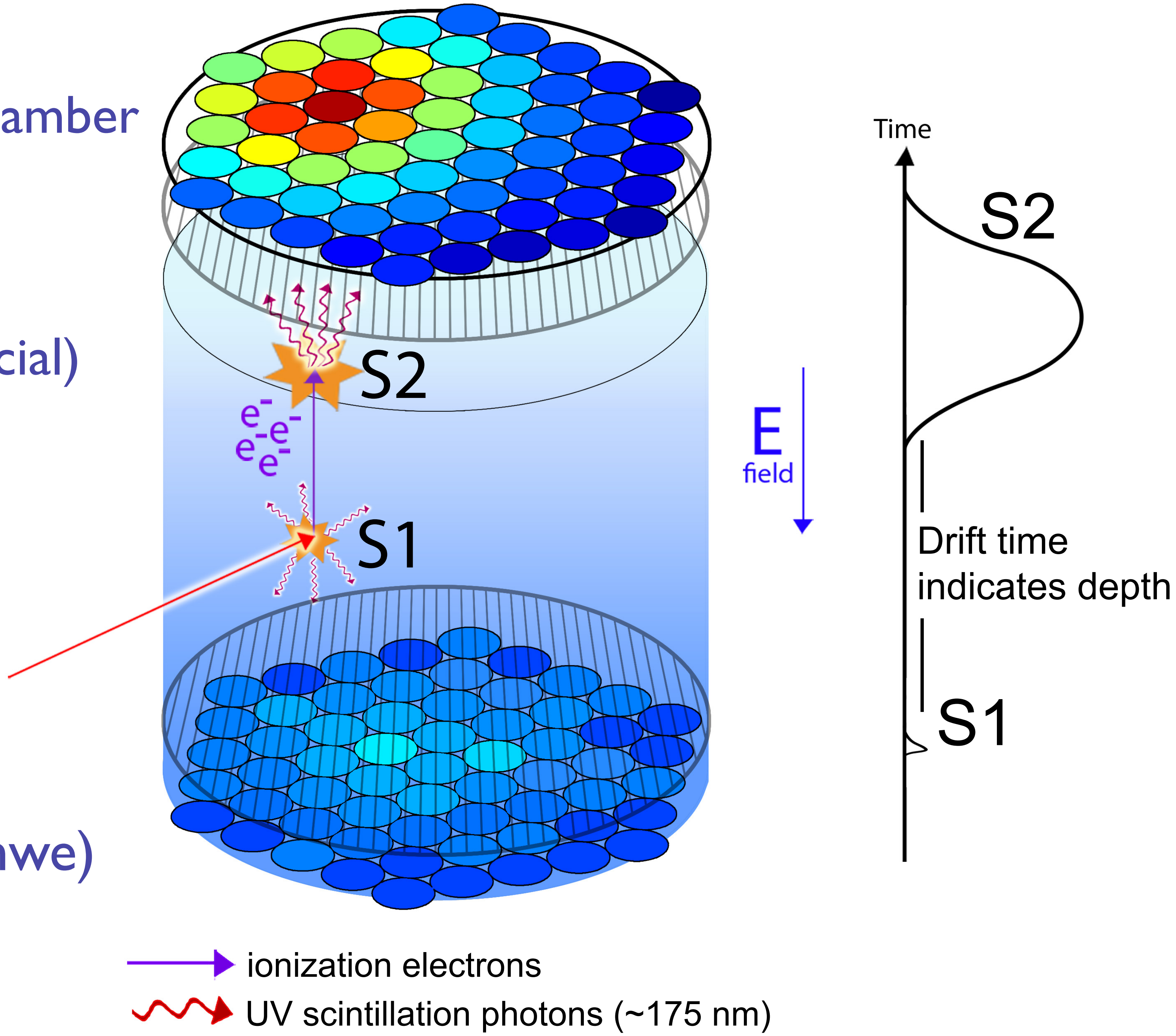
- Good spatial resolution (self-shielding)



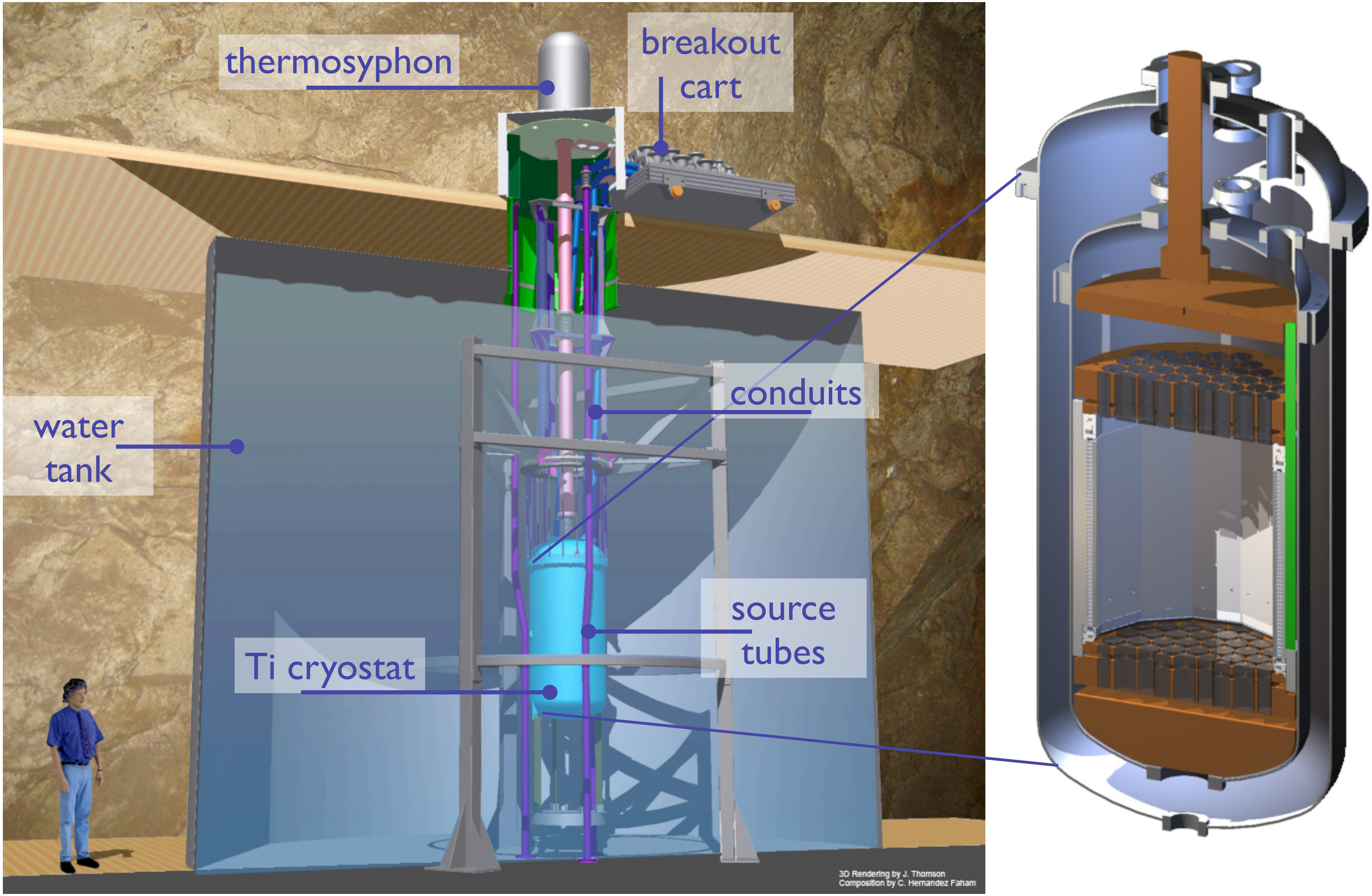


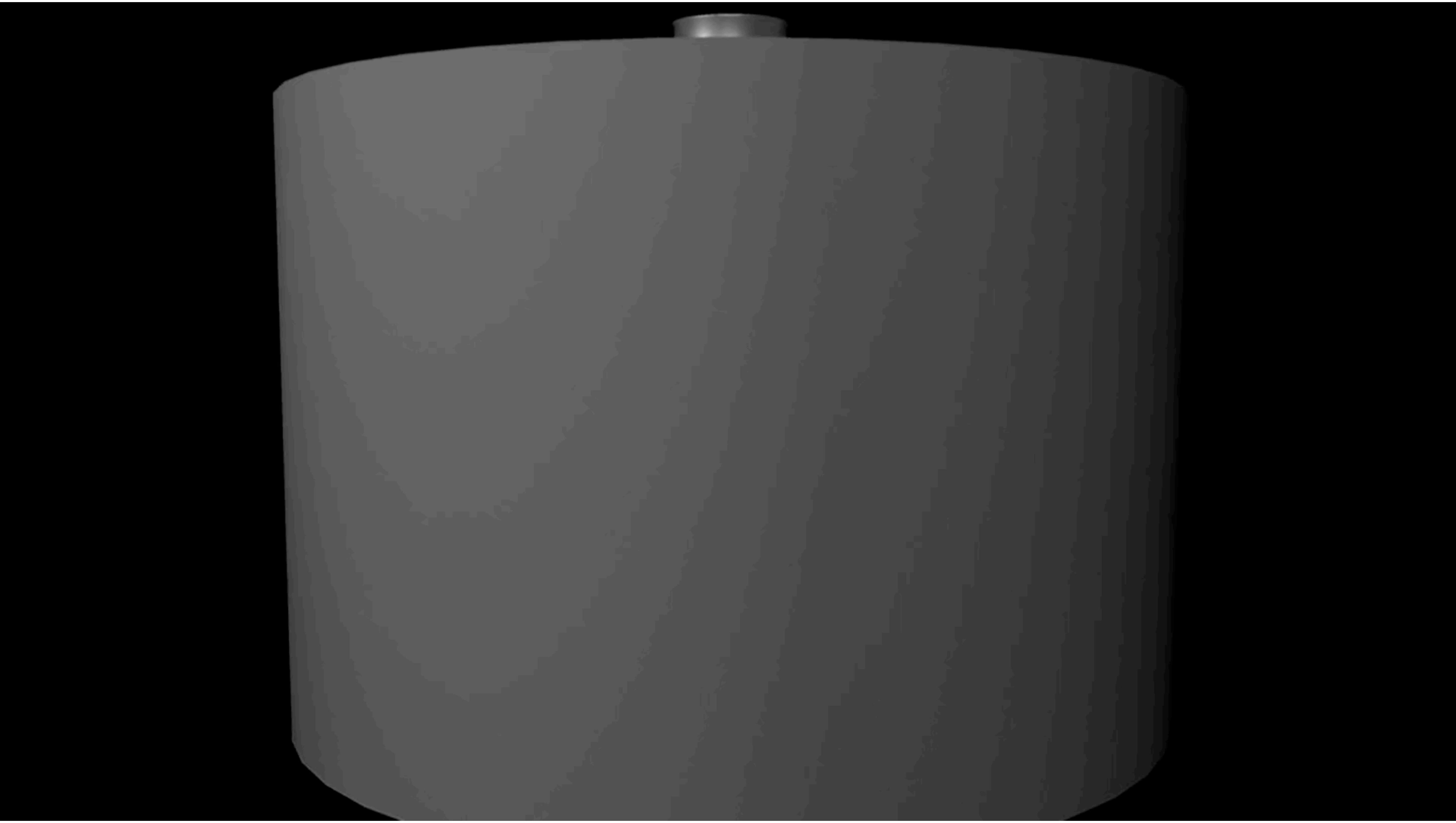
LUX Program

- Two-phase xenon time projection chamber (TPC)
- 122 Photomultiplier Tubes
- 350kg LXe (300kg active, 100kg fiducial)
- 49cm diameter, 55cm height
- Walled by PTFE (>6 phe/keVee)
- 250us max drift distance
- 2kV/cm drift field
- 8m diameter water tank
- 4850' level of Sanford Lab (4300mwe)

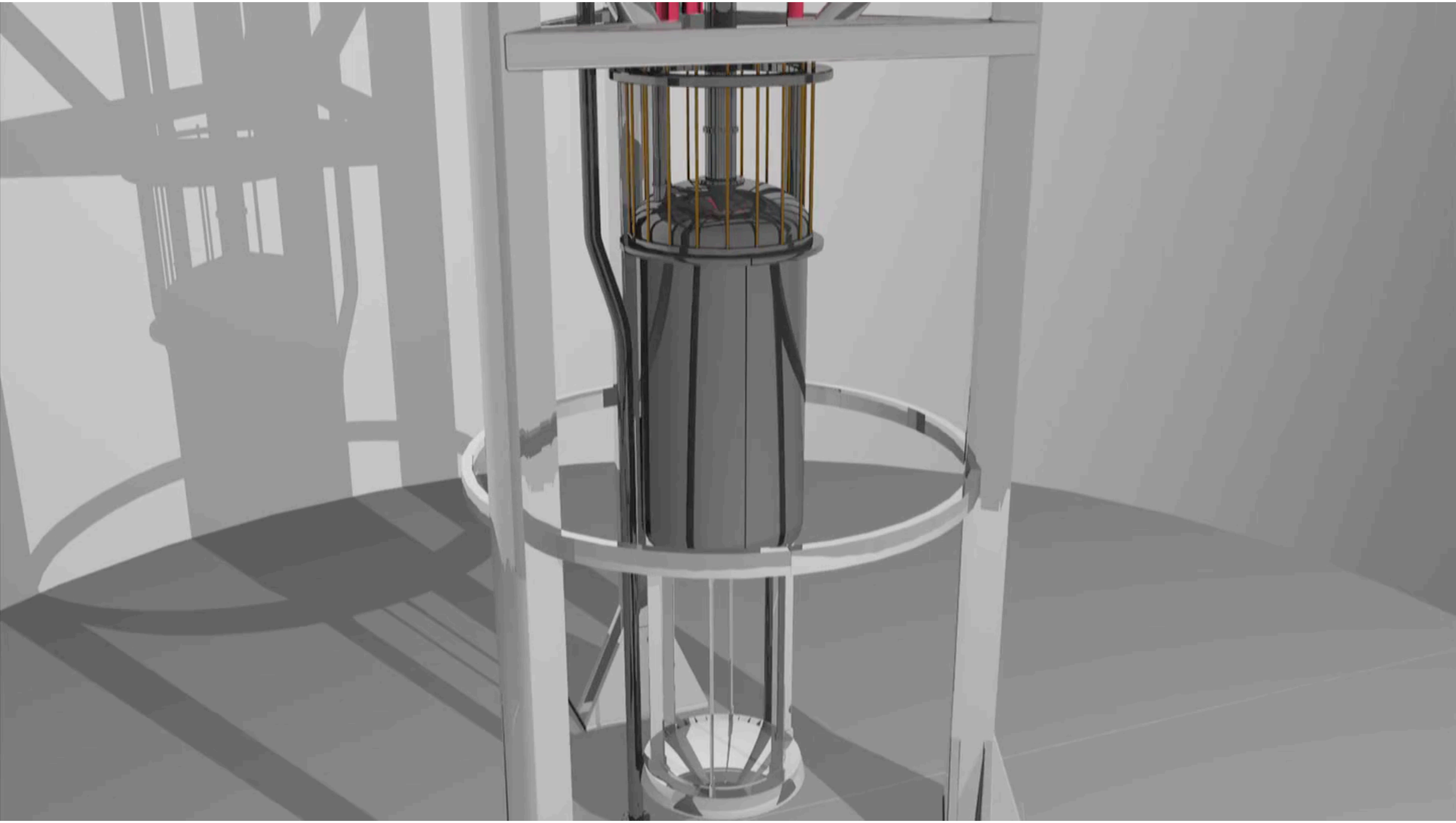


LUX Program


thermosyphon
breakout cart
conduits
water tank
source tubes
Ti cryostat
3D Rendering by J. Thomson
Composition by C. Hernandez Faham



Animations: Harvard-Smithsonian Center for Astrophysics, Annenberg Media

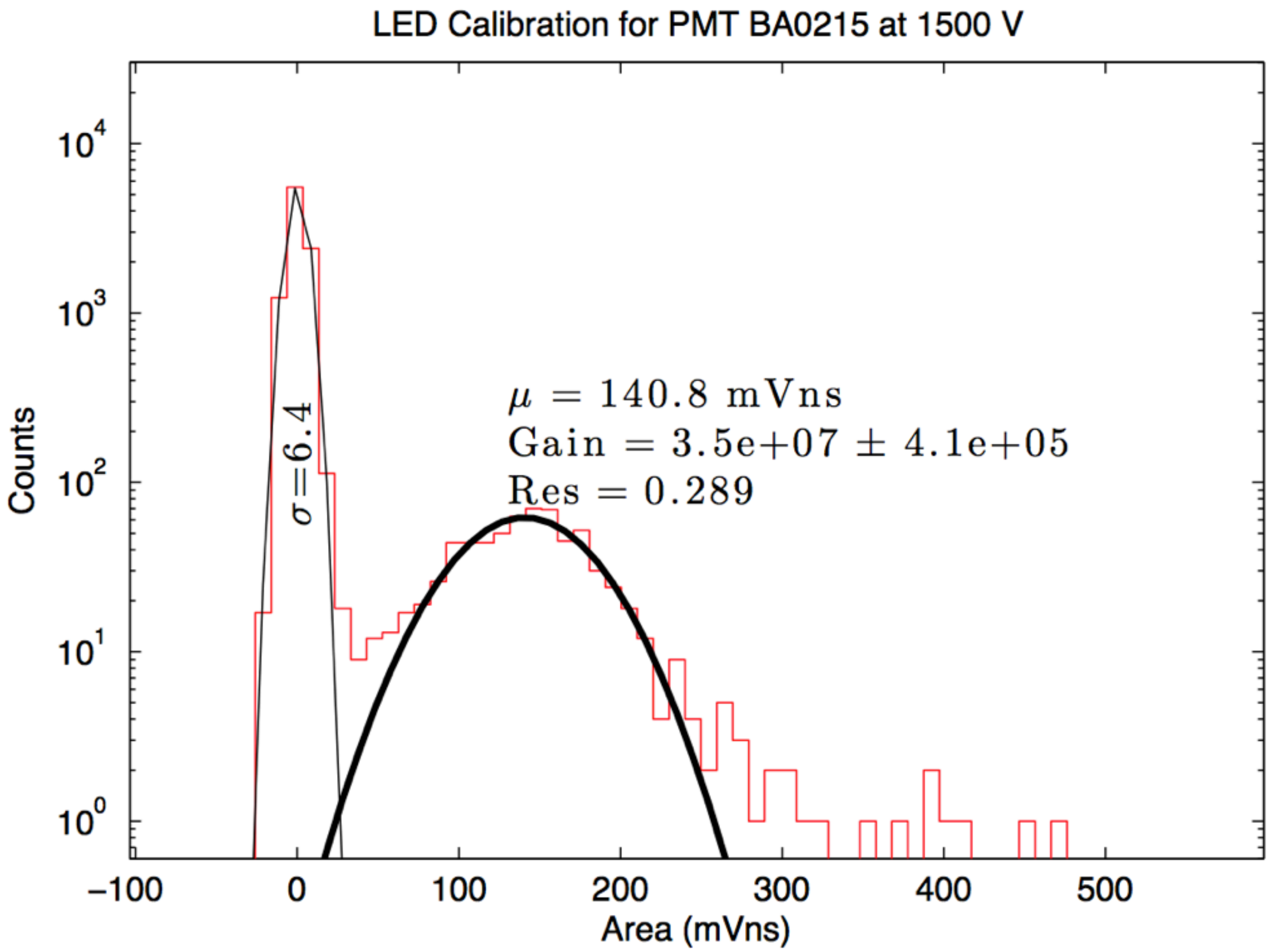


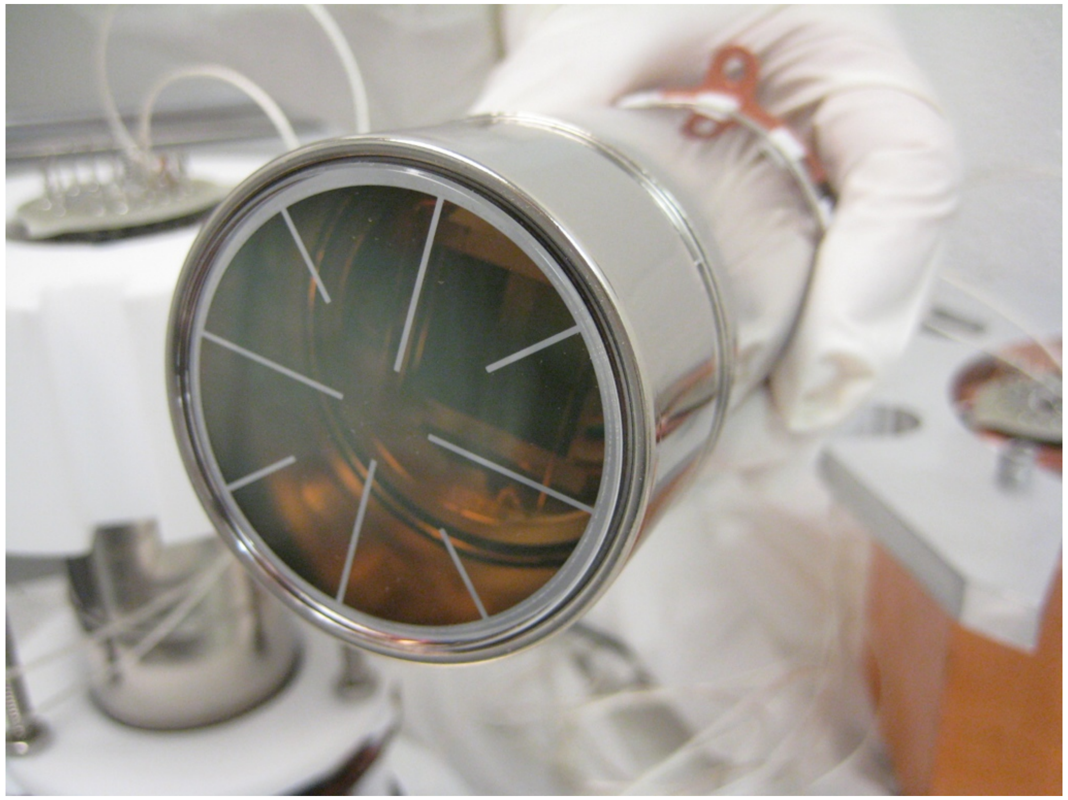
Animations: Harvard-Smithsonian Center for Astrophysics, Annenberg Media

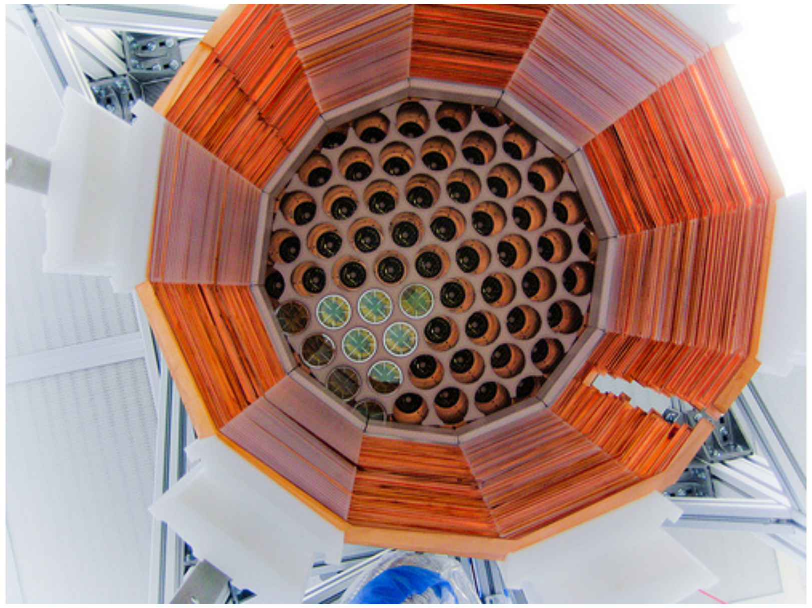
PMTs and Signals

PMTs

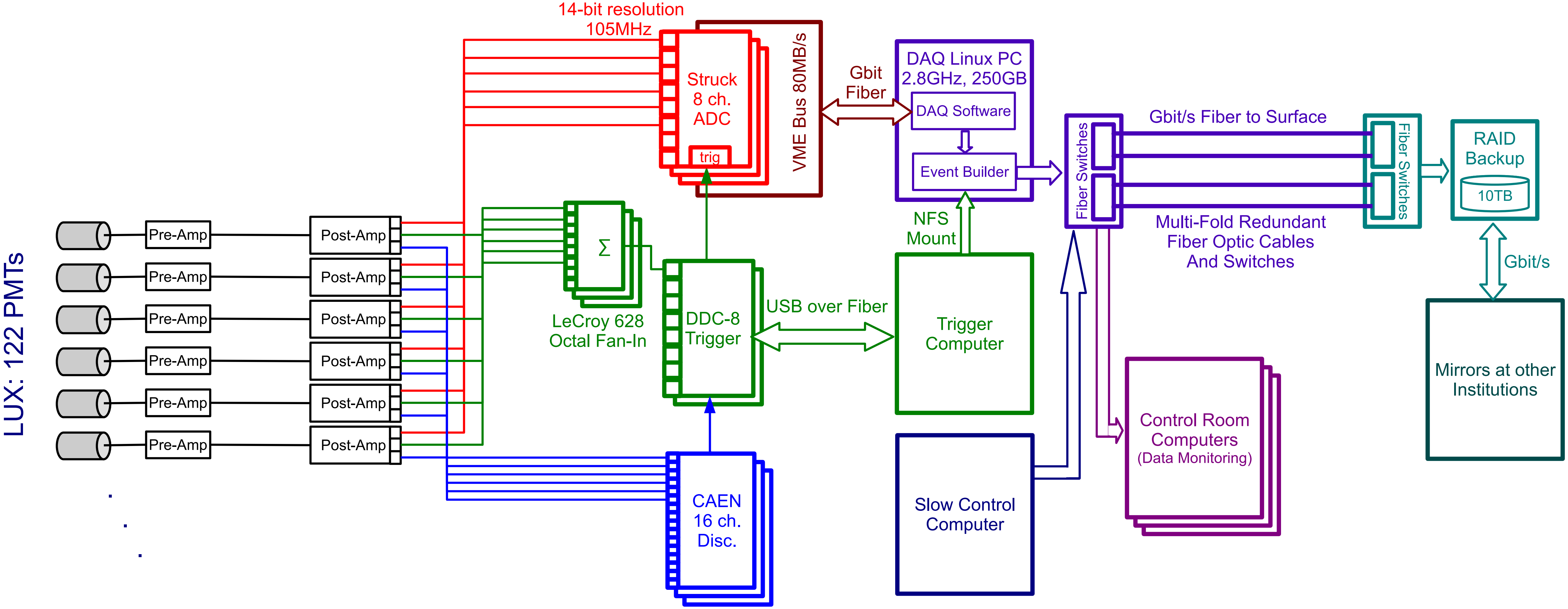
- Hamamatsu R8778
- 2 inch diameter
- Average QE of 33%
- Gain of 3.3e6
- Average DE of 30% (with 90% CE)







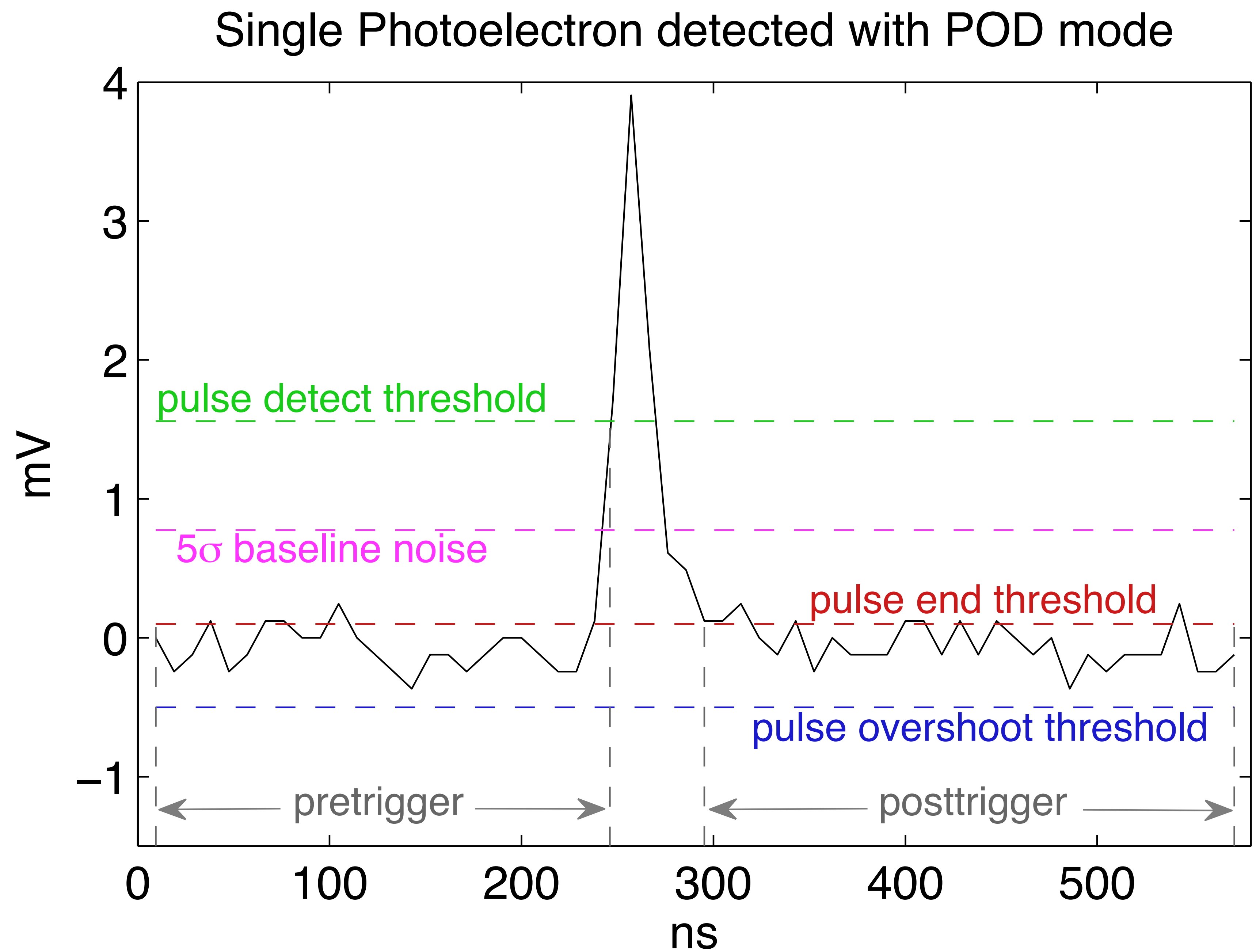
Data Acquisition and Readout



- Custom-built analog electronics
- Specially shaped signals for the digitizer, digital trigger, and analog trigger
- 1.5kHz acquisition rate w/o deadtime = dark matter calibrations w/ zero deadtime
- >99.99% zero suppression
- 95% single photoelectrons > 5σ upward fluctuation in baseline noise
- 120 keV_{ee} dynamic range with dark matter search gains

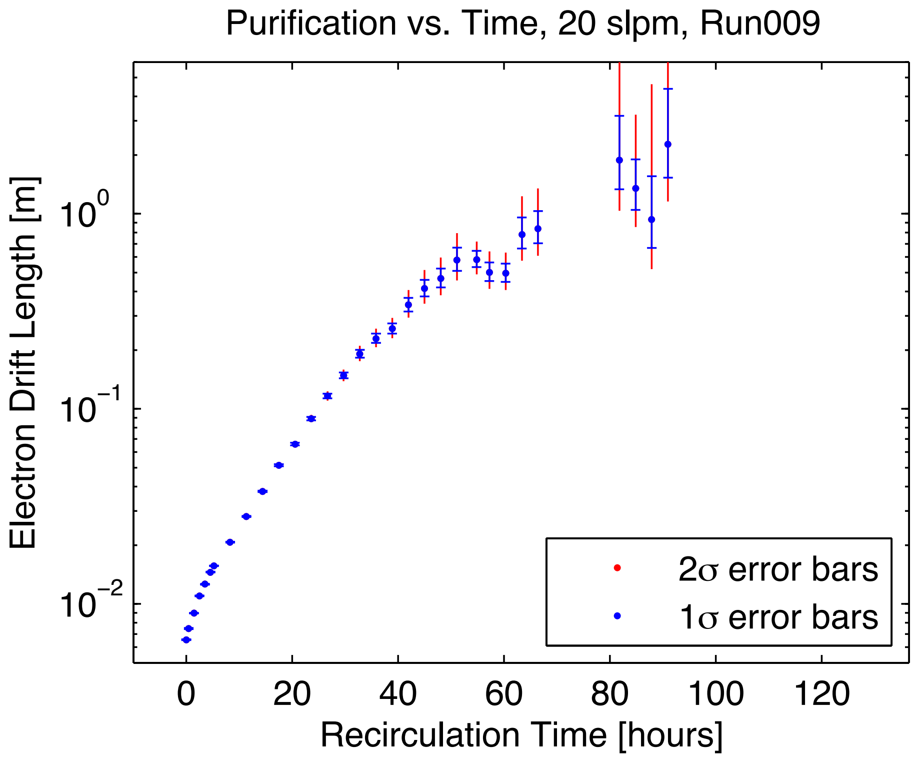
Pulse Only Digitization

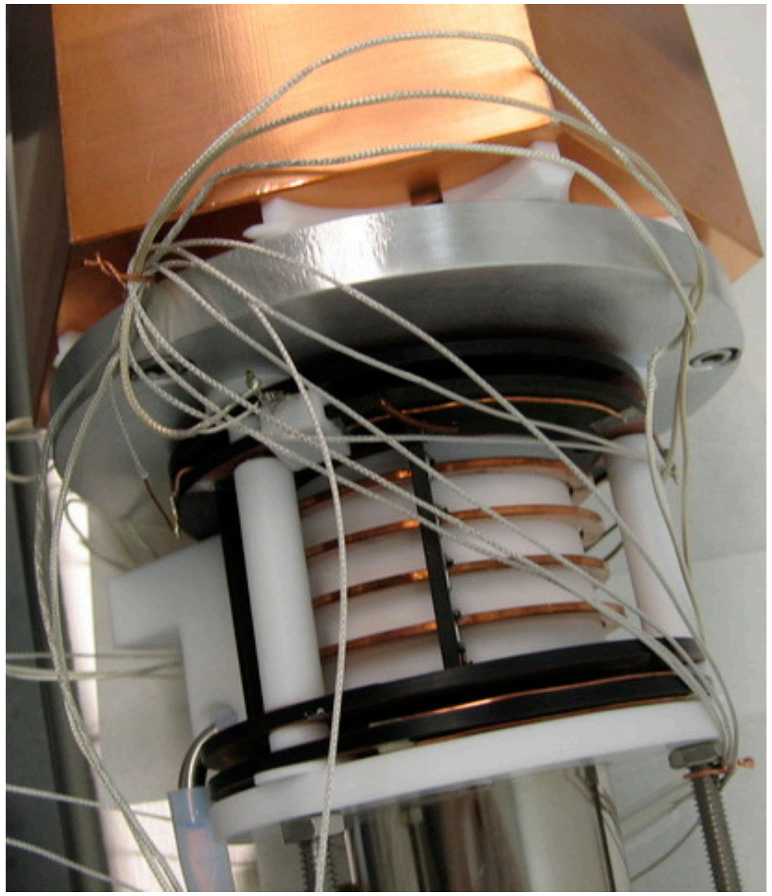
- Threshold Logic
- 24 samples pretrigger
- 31 samples posttrigger
- Rolling average of baseline recorded with each pulse (16, 32, 64, or 128 samples)

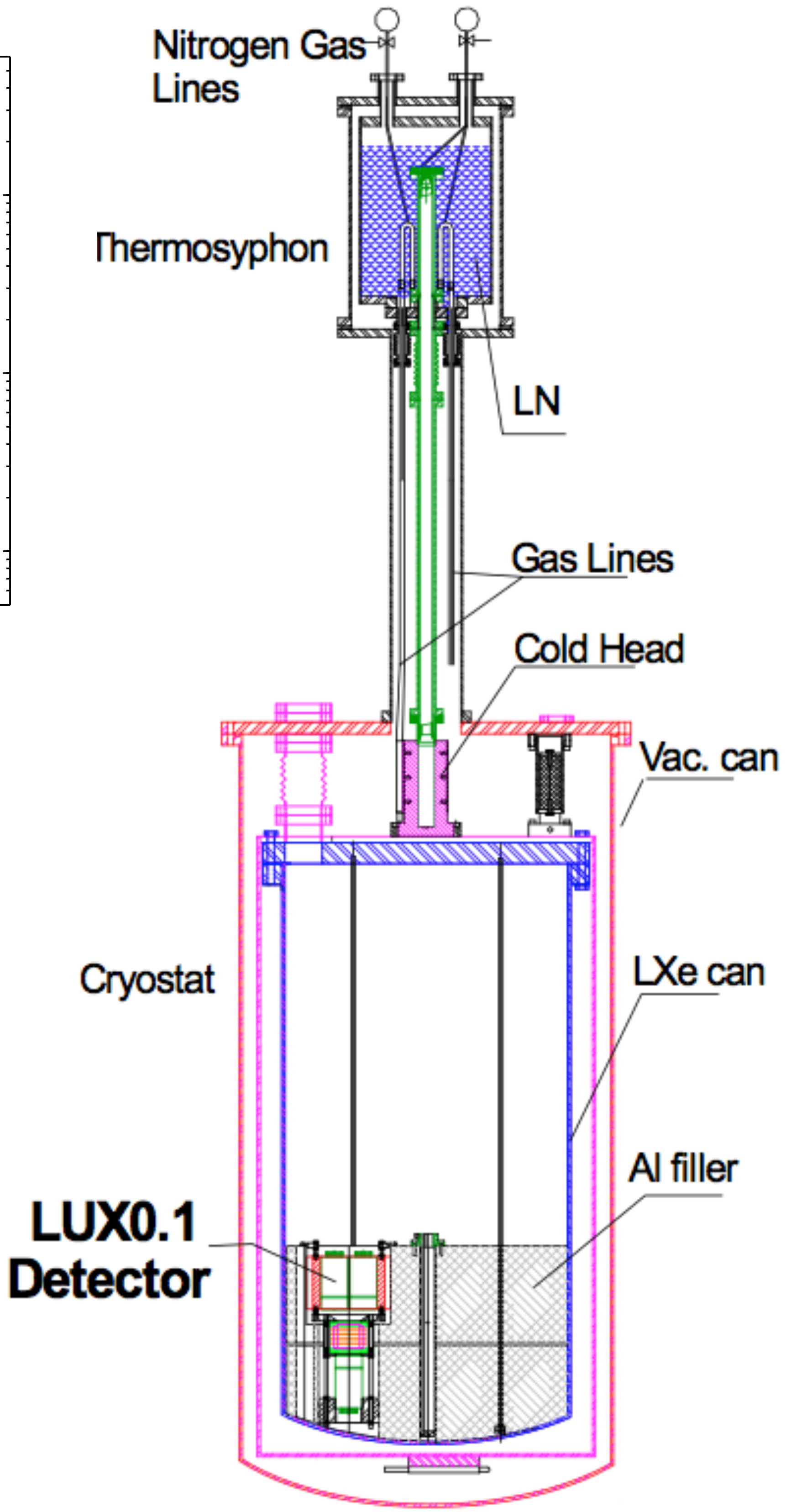


LUX 0.1 2007-2009

- Full integration of all LUX subsystems
- 60kg xenon
- 4 PMTs
- Thermosyphon
- Gas handling, circulation
- Electronics chain, DAQ, analysis
- Full test of LUX personnel (postdocs and graduate students)





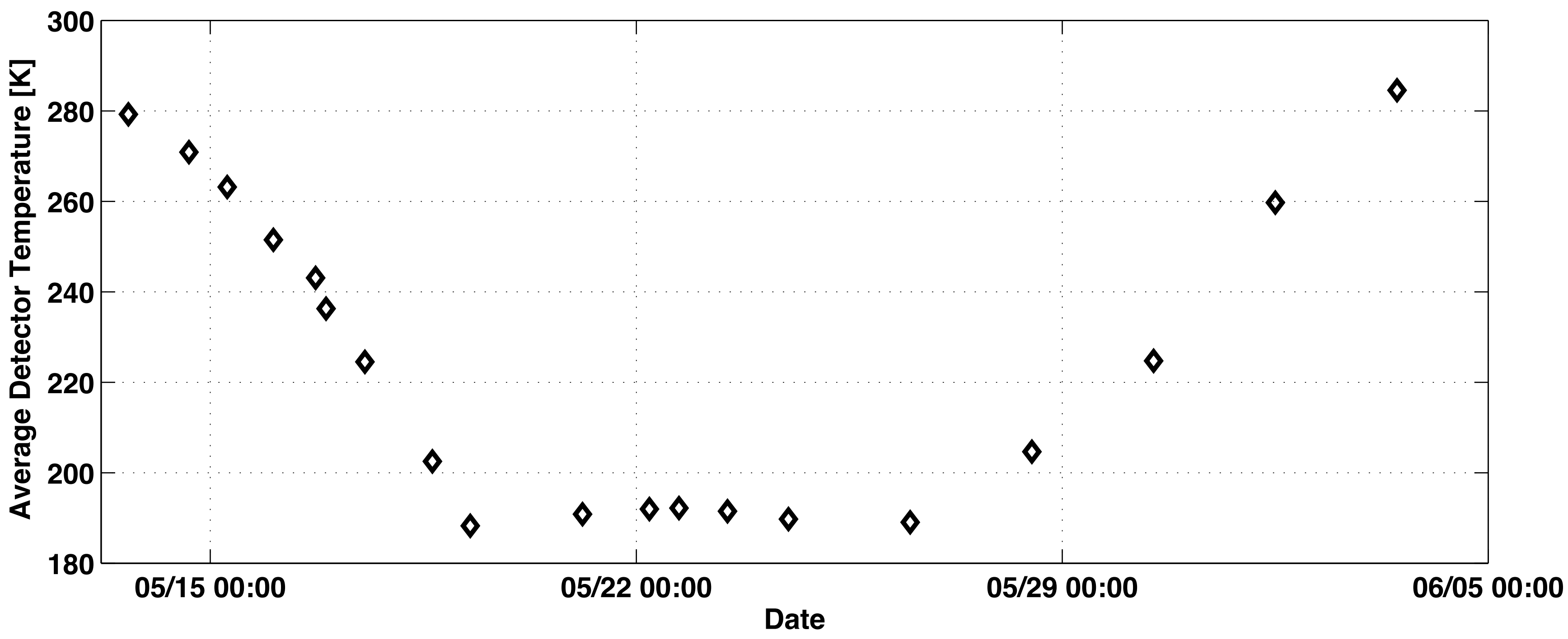


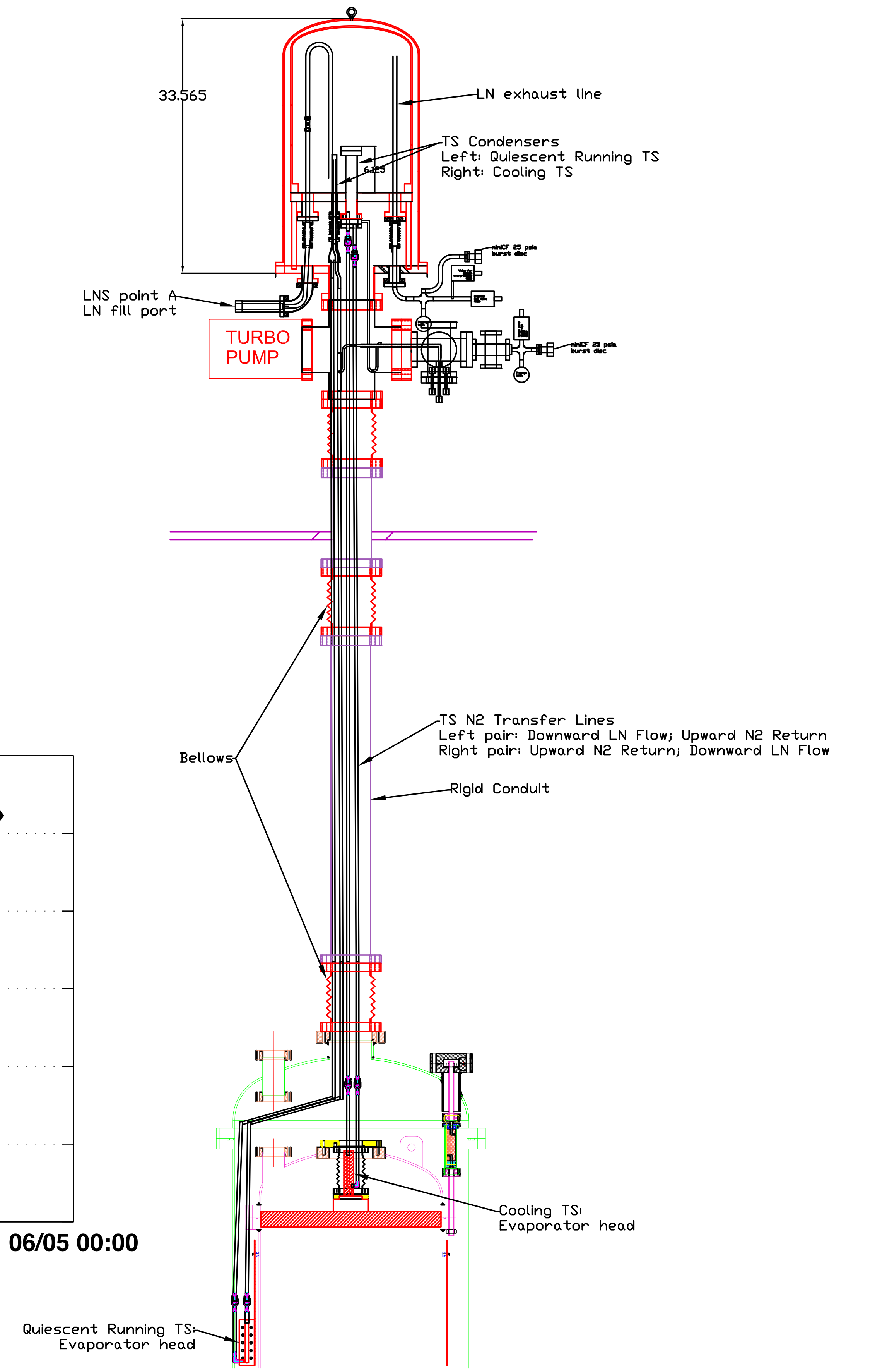
LUX @ Sanford Surface Lab

- Surface lab = Underground lab + windows
- Fully implement, test, calibrate all of LUX
- Develop new laboratory infrastructure

Run01

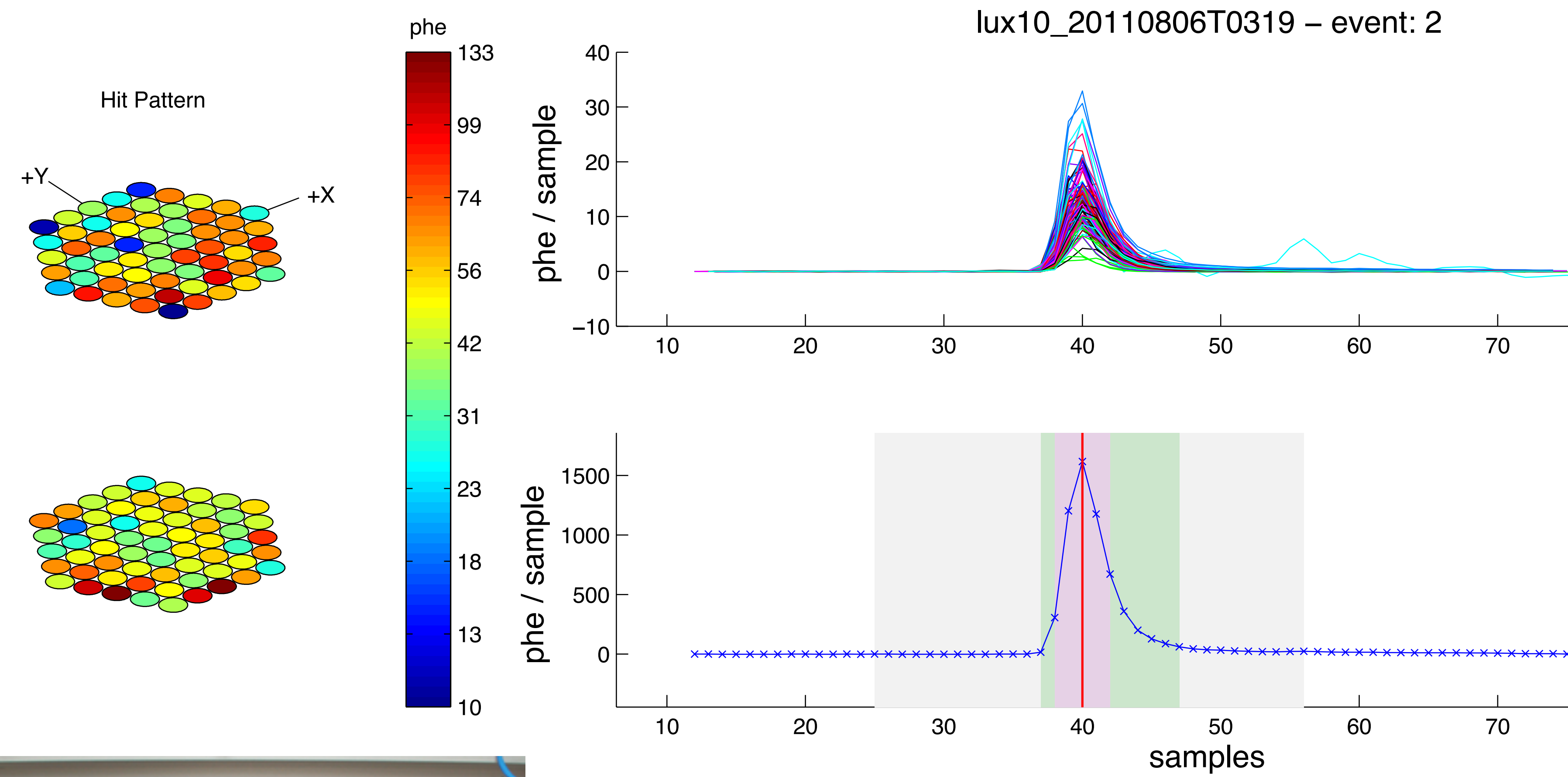
- Test LUX deployment, cooldown
- 20 PMTs (10 top, 10 bottom)
- First LUX cooldown - test of cryogenic system
- 1 atm Ar exchange gas
- ~70 thermometers in the detector and thermosyphon systems
- Goal: Avoid gradients in HDPE and PTFE panes >10K vertically, >5K radially

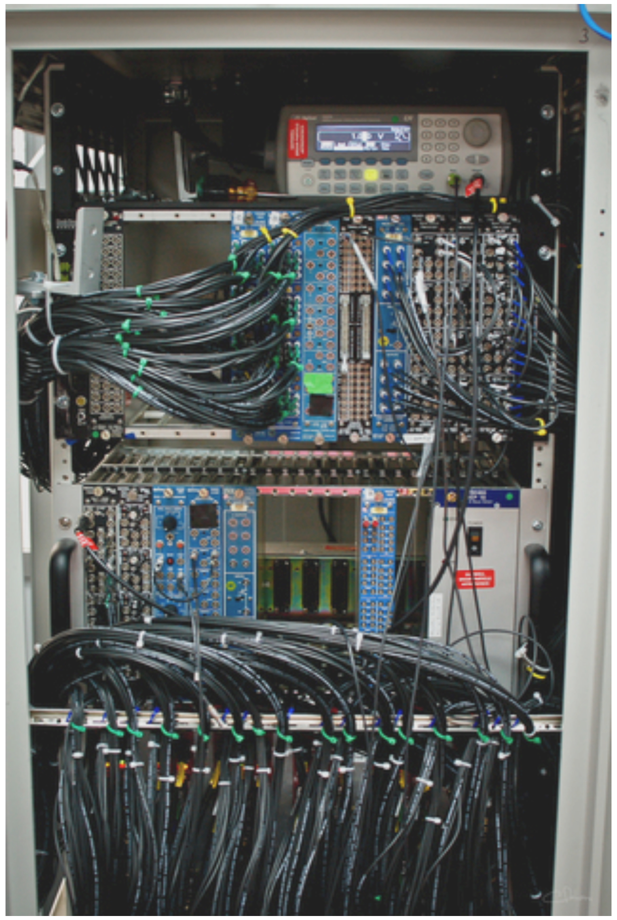




Run02

- Full LUX run
- full signal readout
  - 122 PMTs
  - Charge sensitive preamplifier
  - 122 channel DAQ electronics
  - analysis chain
- 350kg LXe
  - storage and recovery vessel
  - xenon circulation (50slpm)
  - purification system
- Water tank
- Calibration system
  - radioactive source delivery tubes
  - krypton-83m internal source





Davis Cavern - 4850ft Level

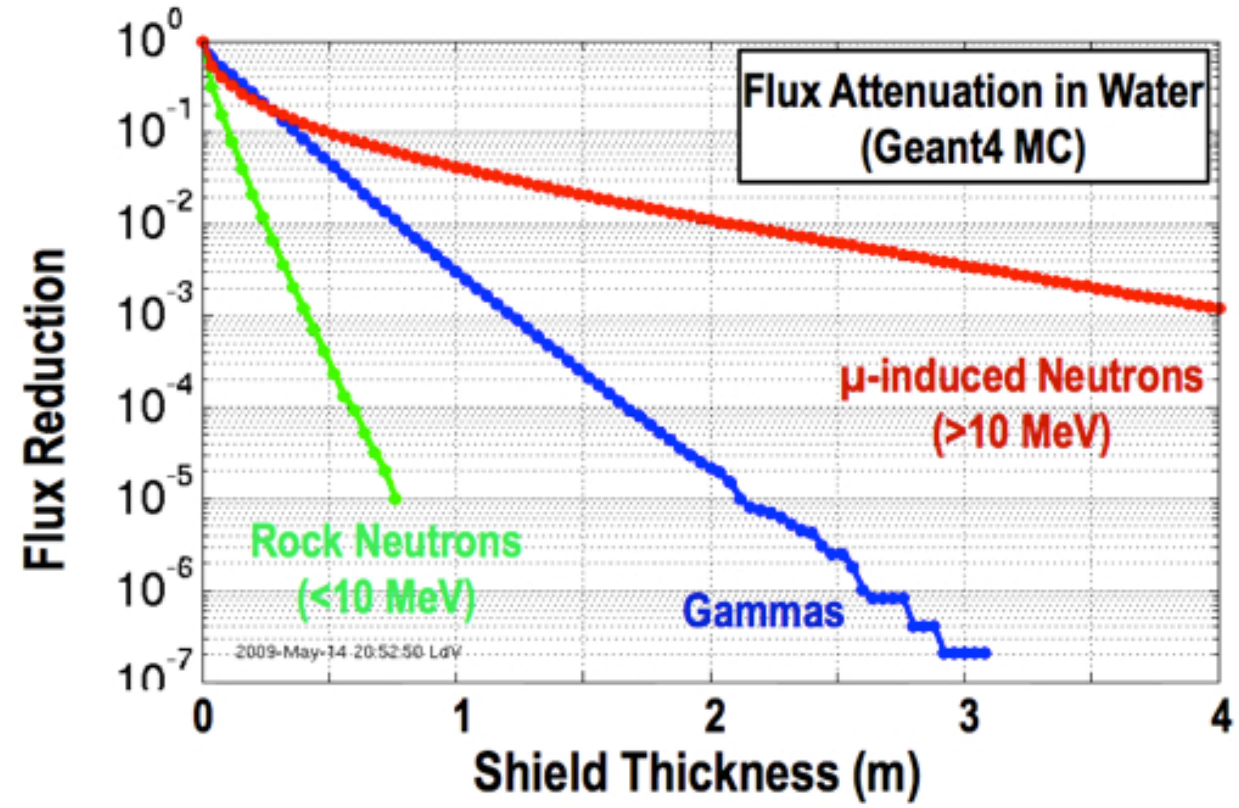
- Laboratory construction underway

Davis Cavern - 4850ft Level

- Laboratory construction underway

LUX Backgrounds

- Background dominated by PMTs
- Rn exposure limited by purging internals
- Kr removed using charcoal column separation
- Self-shielding
- Water tank
- NR/ER discrimination
- Multiple scatter cut

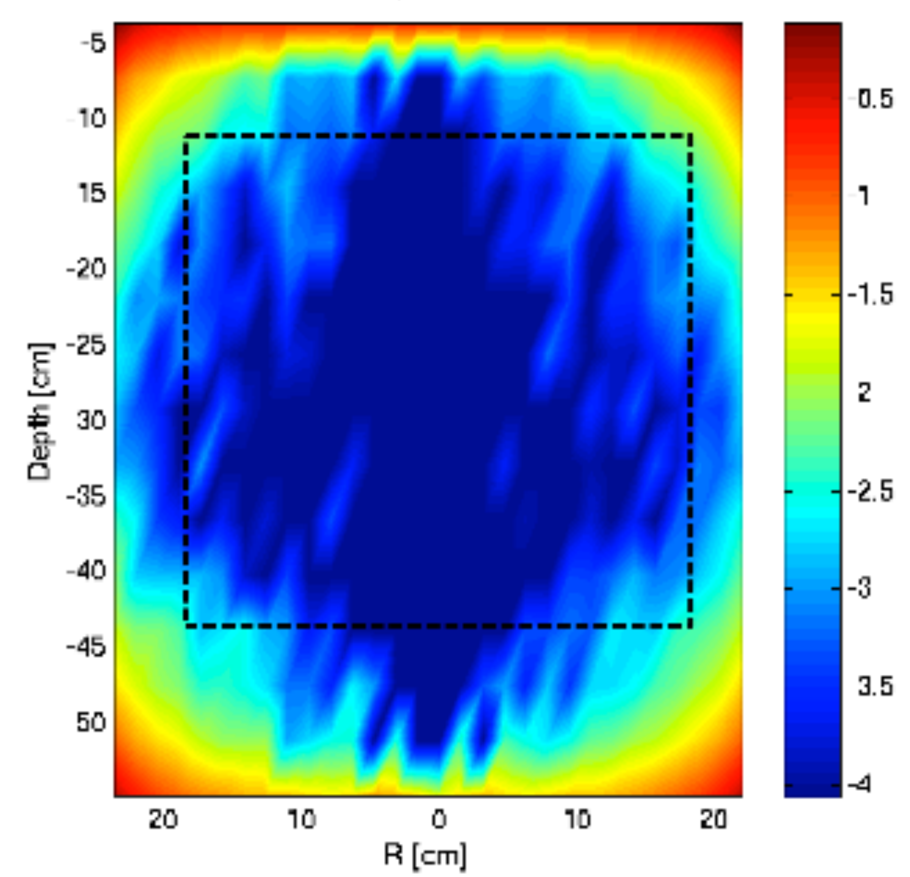


	Unit	Screening Result				
		U238	Th232	Co60	K40	Sc46
PMTs	mBq/PMT	9.5±0.6	2.7±0.3	2.6±0.1	66±2	
Ti	mBq/kg	<0.18	<0.25			4.4±0.3*
Cu	mBq/kg			2.1±0.19*		
PTFE	mBq/kg	<3	<1			
HDPE	mBq/kg	<0.5	<0.35			
Stainless steel**	mBq/kg			19±1		

**Type 304 stainless steel used in electric field grids

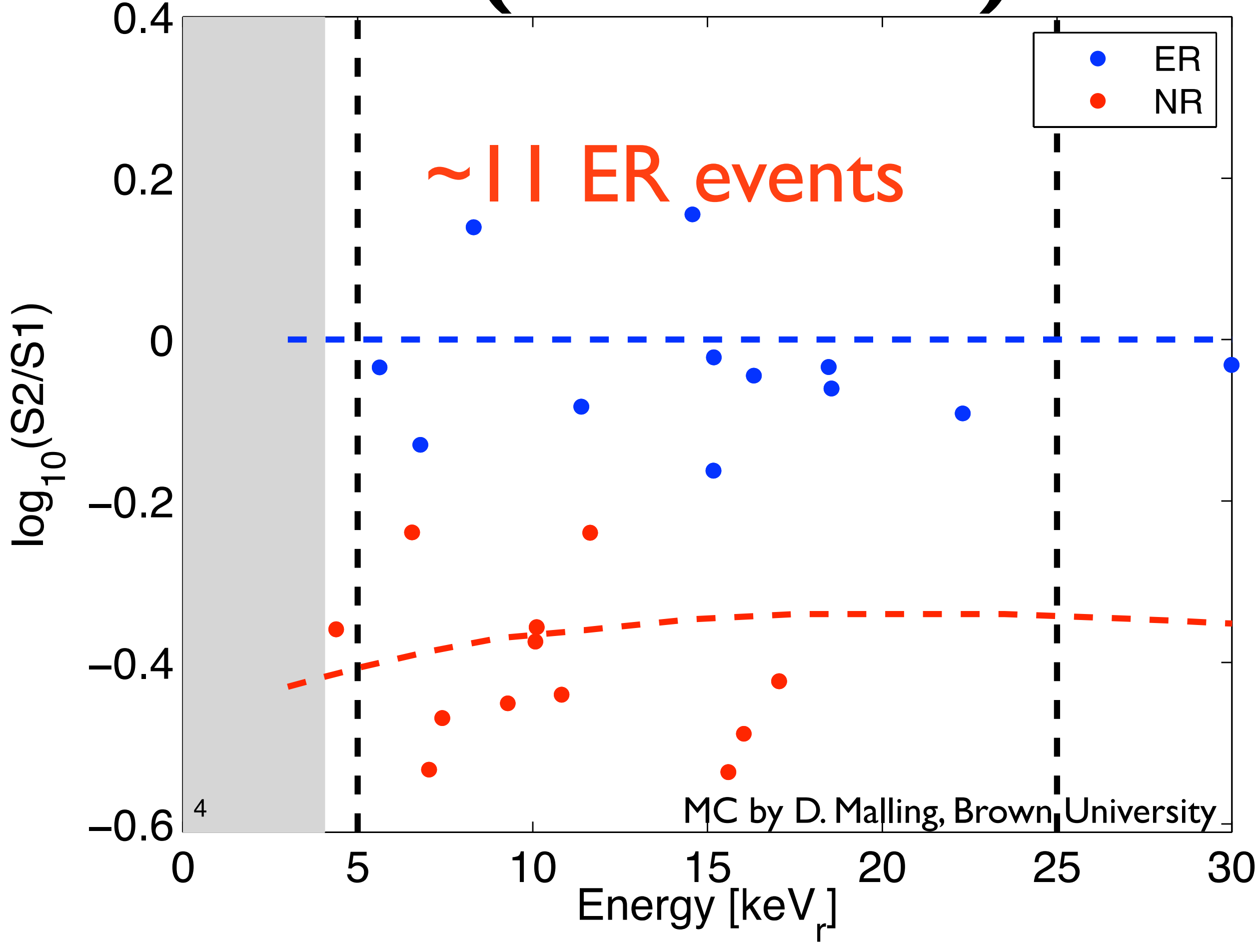
*Cosmogenic equilibrium at 1 mile above SL; decays below ground

5-25 keV_{ee} single scatter $\log_{10}(DRU_{ee})$

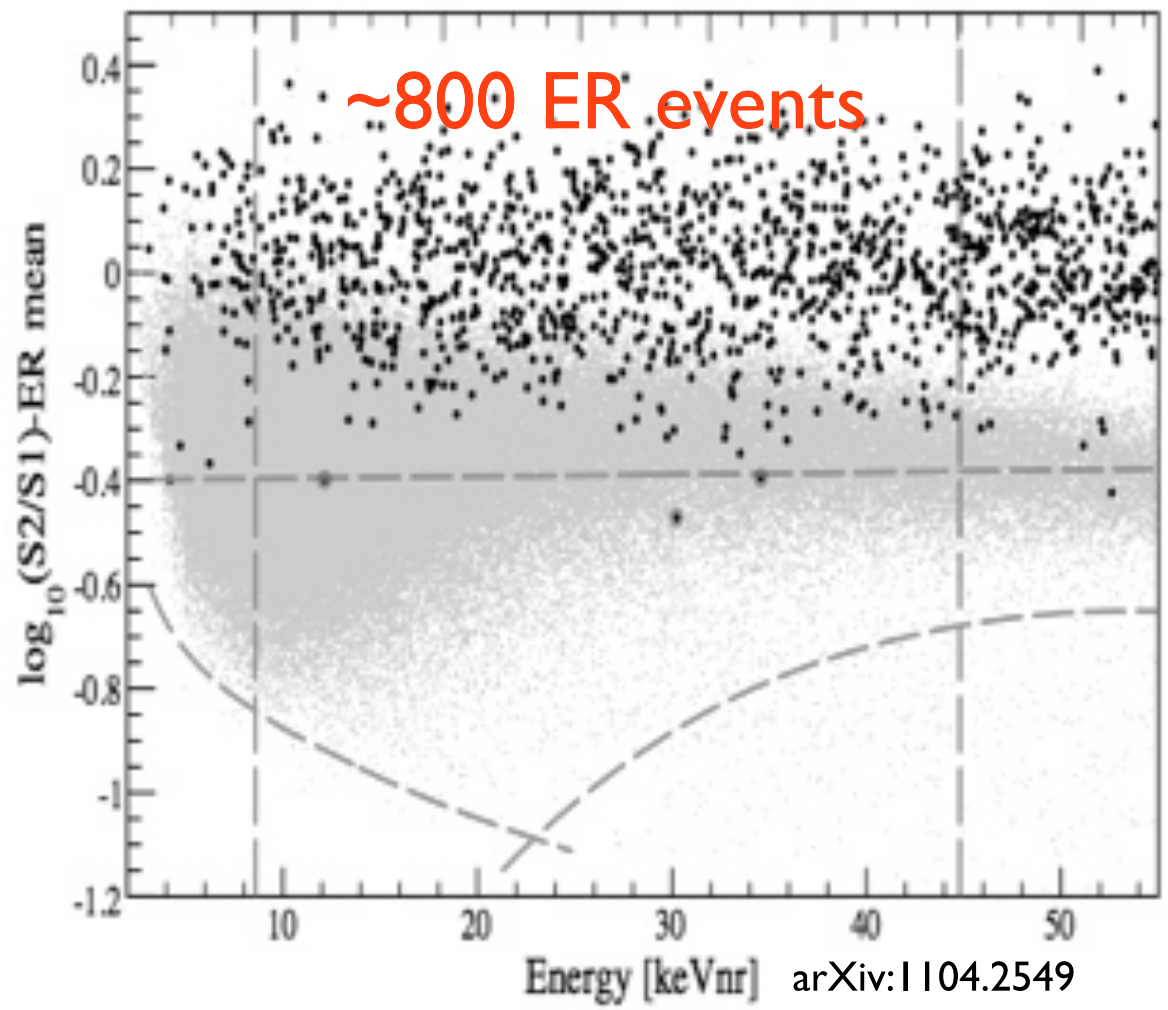


LUX: The First 40 Days

LUX (Monte Carlo) ← equivalent kg-days → XENON100



LUX signal and background expectation for 4,000 kg-days net exposure. WIMP events assume m = 100 GeV, σ = 1x10^{-44} cm^2.



arXiv:1104.2549

XENON100 4,000 kg-days result for comparison.
Note higher ER rate - ~800 events in 100 days x 40 kg fiducial
~60% due to 85Kr with remaining 40% due to Compton scattering of external gamma background

- **Red Points:** WIMP events after only 40 days (equivalent exposure to all of XENON100 run) assuming a WIMP model for mass 100 GeV at current best 90% CL Exclusion Limit
- **Blue Points:** Total # of single scatter electron recoil events in LUX (before any other cuts) after 40 days of running. Expect only 11 events in 100 kg fiducial x 40 days for a net 4,000 kg-days exposure.
- **LUX - Strong Emphasis on WIMP Discovery / Plan to run LUX for 300 days**