LUX Dark Matter Experiment @ Sanford Lab

Rick Gaitskell,
Joint Spokesperson, LUX Collaboration
Spokesperson, LZ-DUSEL Collaboration
Particle Astrophysics Group, Brown University, Department of Physics

(Supported by US DOE HEP)

see information at
http://luxdarkmatter.org
http://particleastro.brown.edu/

Experiment vs Project

- LUX allows us to directly test many of the critical technologies for large Xe detectors
- The methods used are “industrial” scale
  - Necessary for multi-tonne scale aimed DUSEL
- We are aiming to reduce PROJECT RISKS
  - Not looking to introduce fundamentally new tech.
  - Necessary evil - caused by large scale/$ deployment
  - Counter cultural

The LUX Collaboration

Brown — Xenon10, CDMS

Richard Gaitskell	PI, Professor
Simon Fiorucci	Postdoc
Luiz de Viveiros	Graduate student
Jeremy Chapman	Graduate student
Carlos Hernandez Faham	Graduate student
David Malling	Graduate student
Robert Lanou	Observer (Not formal collaborator)

Case Western — SNO, Borexino, Xenon10, CDMS

Thomas Shutt	PI, Professor
Dan Akerib	Professor
Alexander Bolozdynya	Senior Scientist
Mike Dragowsky	Senior Research Associate
Ken Clark	Postdoc
John Kwong	Graduate student
Adam Bradley	Graduate student
Patrick Phelps	Graduate student
Ryan Sacks	Undergraduate student

Lawrence Berkeley — SNO, KamLAND

Kevin Lesko	Senior Physicist
Yuen-Dat Chan	Scientist
Brian Fujikawa	Scientist
Bob Jacobsen	Professor

Lawrence Livermore — Xenon10

Adam Bernstein	PI, Leader of Advanced Detectors Group
Dennis Carr	Eng. Mech. Assoc.
Steven Dazeley	Physicist
Peter Sorensen	Postdoc
Kareem Kazkaz	Postdoc

University of Maryland (College Park) — EXO

Carter Hall	Professor
Douglas Leonard	Postdoc

Harvard (June 2009)

Masahiro Morii

Texas A&M — Zeplin II

James White	Professor
Robert Webb	Professor
Tyana Stiegler	Graduate student
Rachel Mannino	Graduate student

UC Davis — Double Chooz, CDF

Mani Tripathi	Professor
Robert Svoboda	Professor
Richard Lander	Professor
Britt Holbrook	Senior Engineer
John Thomson	Engineer
Tim Classen	Postdoc
John Felde	Graduate student
Melinda Sweany	Graduate student
Nick Walsh	Graduate student
Hengkui Wu	Graduate student
Ronald Bybee	Undergraduate student

South Dakota School of Mines and Technology (August 2009)

Xinhua Bai
Mark Hanardt

University of Rochester — Zeplin II

Frank Wolfs	Professor
Udo Schroeder	Professor
Wojtek Skulski	Senior scientist
Jan Toke	Senior scientist
Eryk Druszkiewicz	Graduate student

University of South Dakota — Majorana, CLEAN-DEAP

Dongming Mei	Professor

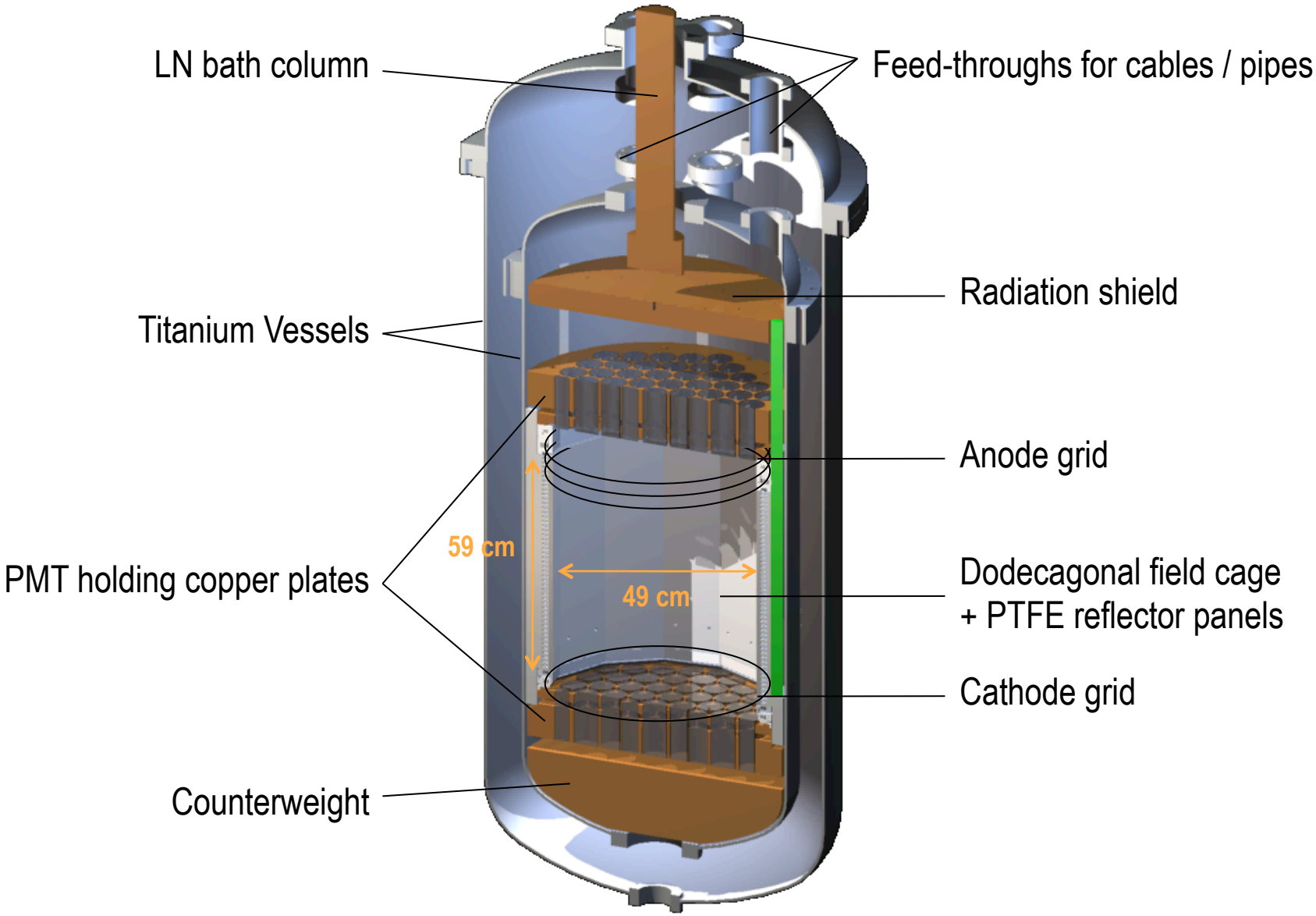
Yale — Xenon10, CLEAN-DEAP

Daniel McKinsey	Professor
James Nikkel	Research scientist
Sidney Cahn	Lecturer/Research scientist
Alessandro Curioni	Postdoc
Louis Kastens	Graduate student
Susie Bedikian	Graduate student

Sanford Lab – Davis Laboratory Design Team

- **SDSTA**
  - **Executive Director:** Ron Wheeler
  - **Project Mgr. Surface Facility:** Bob Kaufman
  - **Project Manager Davis Lab:** William McElroy
  - **Project Manager DUSEL:** Mike Headley
  - **Underground Ops:** Mike Johnson
- **Engineering Consultants**
  - **Project Lead / Civil / Layout:** CNA Consulting Eng.
    - L. Petersen, B. Wagener, R. Peterson, M. Davis
  - **Architects, FLS, Outfitting:** Miller-Dunwiddie
    - G. Hulne, A. Skow, K. Mastin, J. Tonkin
  - **Lab Science Director:** Jose Alonso
  - **Director of Engineering:** Chris Zimmer
  - **Science Liaison Director:** Jaret Heise
  - **Risk Manager:** Susan Von Stein
  - **Safety Officer**: Tom Regan
  - **Mechanical / Electrical:** Dunham Associates
    - D. Holland, M. Oldyn, S. Riegler
  - **Structural Engineers:** Hermanson-Egge Eng.
    - L. Hermanson, M. Schon, R. Venkatesh

LUX Detector - Overview

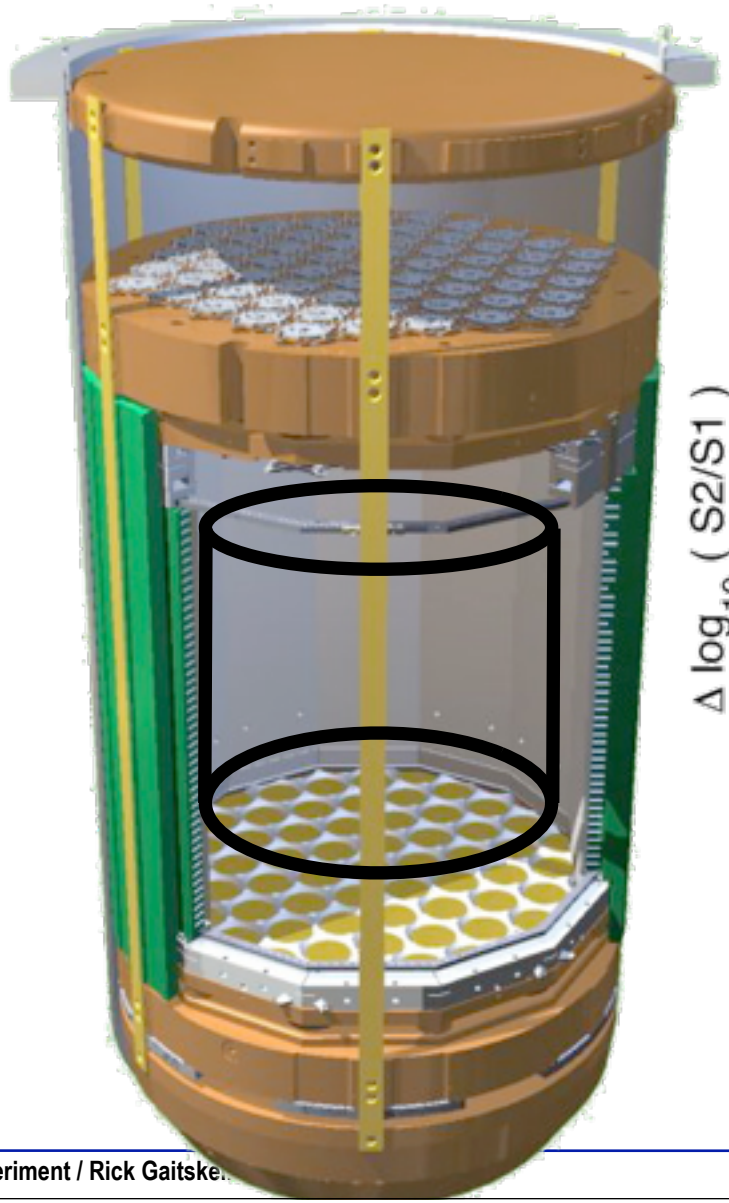


WIMP Sensitivity

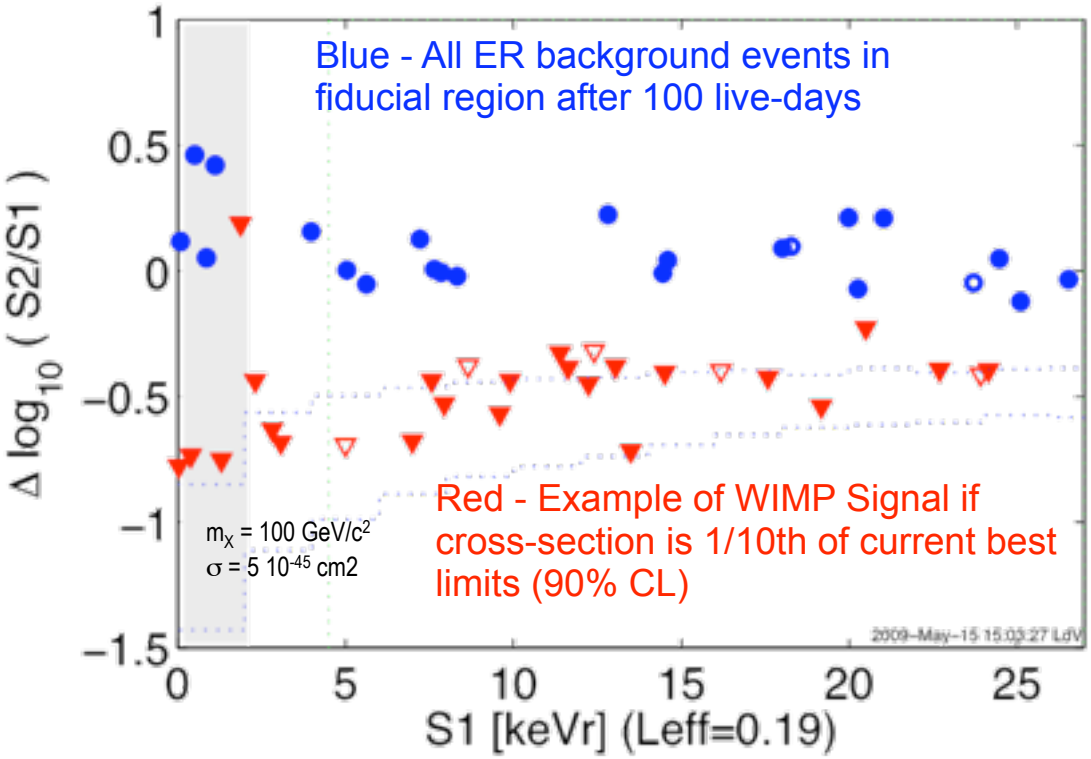
In < 2 live days we will surpass sensitivity of all existing results for dark matter direct detection experiments

Focus on discovery ... if dark matter cross section is factor 10 below current best 90% CL search limits ...

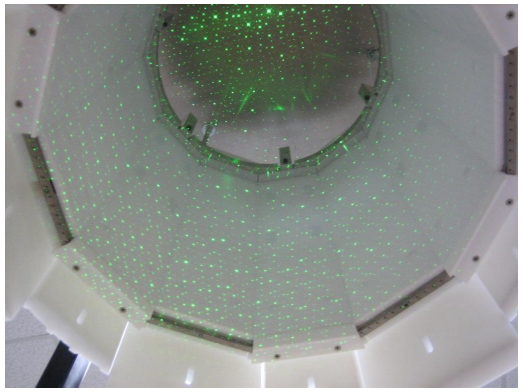
LUX 350 kg / 100 kg Fiducial 100 days / WIMP Discovery



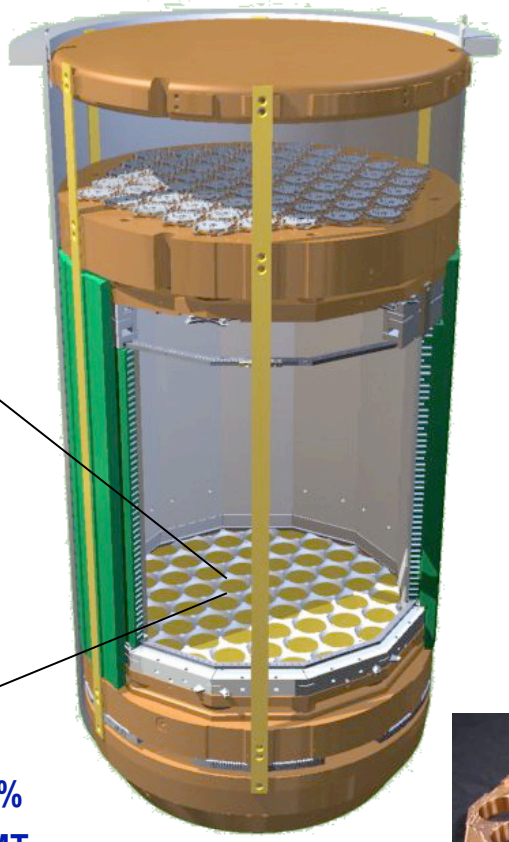
Simulated LUX data
(100 kg fiducial, 100 days)

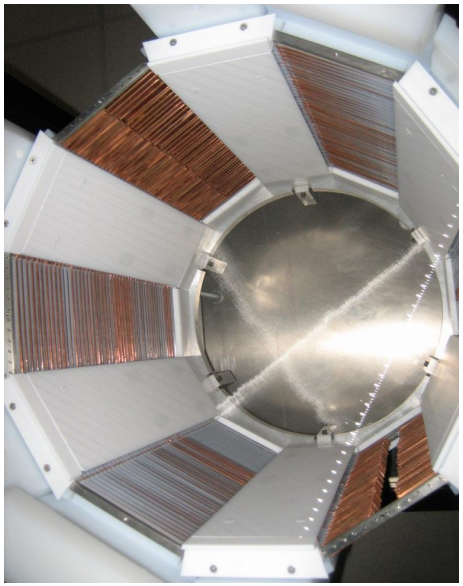


LUX Detector - Internals



- HV Grids in place and tested

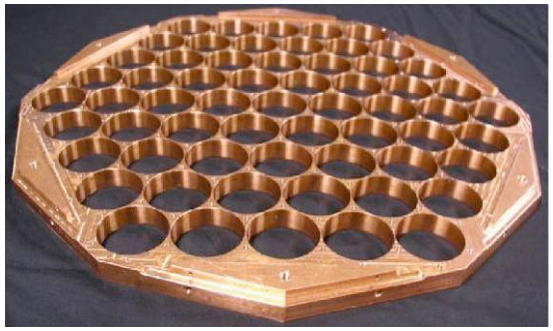




- Dodecagonal field cage + PTFE reflector panels

- 122 2" PMT R8778
  - 175 nm, QE > ~30%
  - U/Th ~9/3 mBq/PMT
  - All tested in LUX 0.1 program

Assembly taking place at Texas A&M since early 2009



- Copper PMT holding plate

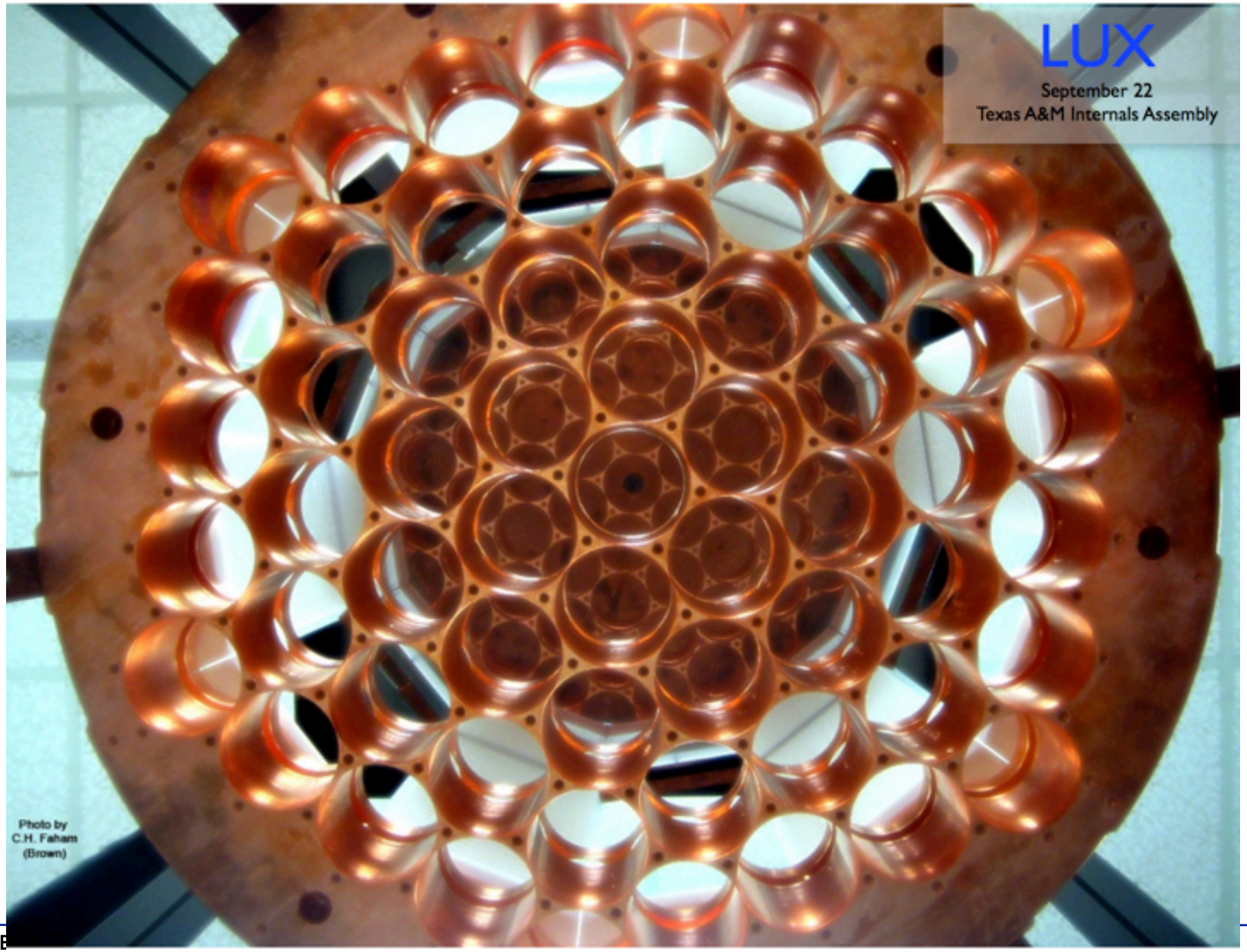

LUX
September 22
Texas A&M Internals Assembly
Photo by
C.H. Faham
(Brown)


Photo by
C.H. Faham
(brown)

LUX0.1 Overview

- Surface run at Case Western Reserve University
- Full assembly of LUX subsystems:
  - Cryogenics
  - Recirculation
  - Slow control & safety systems
  - Electronics chain
  - PMT mounts and resistor-chain bases
  - Analysis software

- 60 kg Xe total mass (260 kg Aluminum filler displacer)
- 4 PMT operation, 5 cm active Xe region

Instrumentation Overview

- **Thermosyphon:**
  - > 1 kW cooling power
  - Can cool LUX0.1's 580 kg in 12 hrs
  - > x10 more cooling power than XENON10
  - Usable for larger detectors

- **Gas panel and recirculation:**

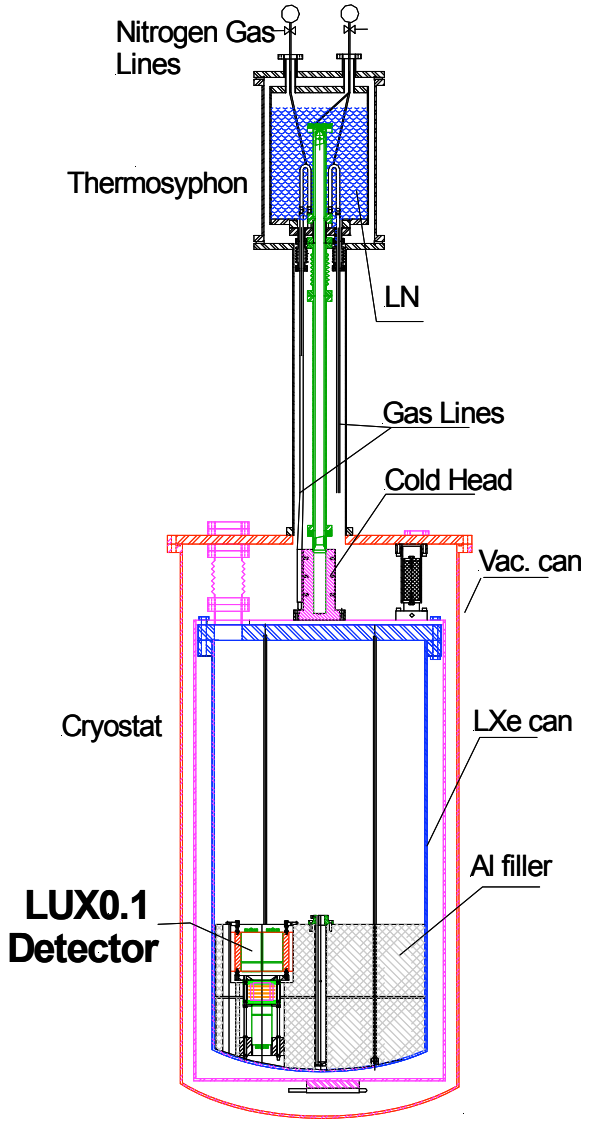
Recirculation at 50 slpm of Xe
(All LUX 350 kg recirculated in 20 hrs)

- **Slow Control**

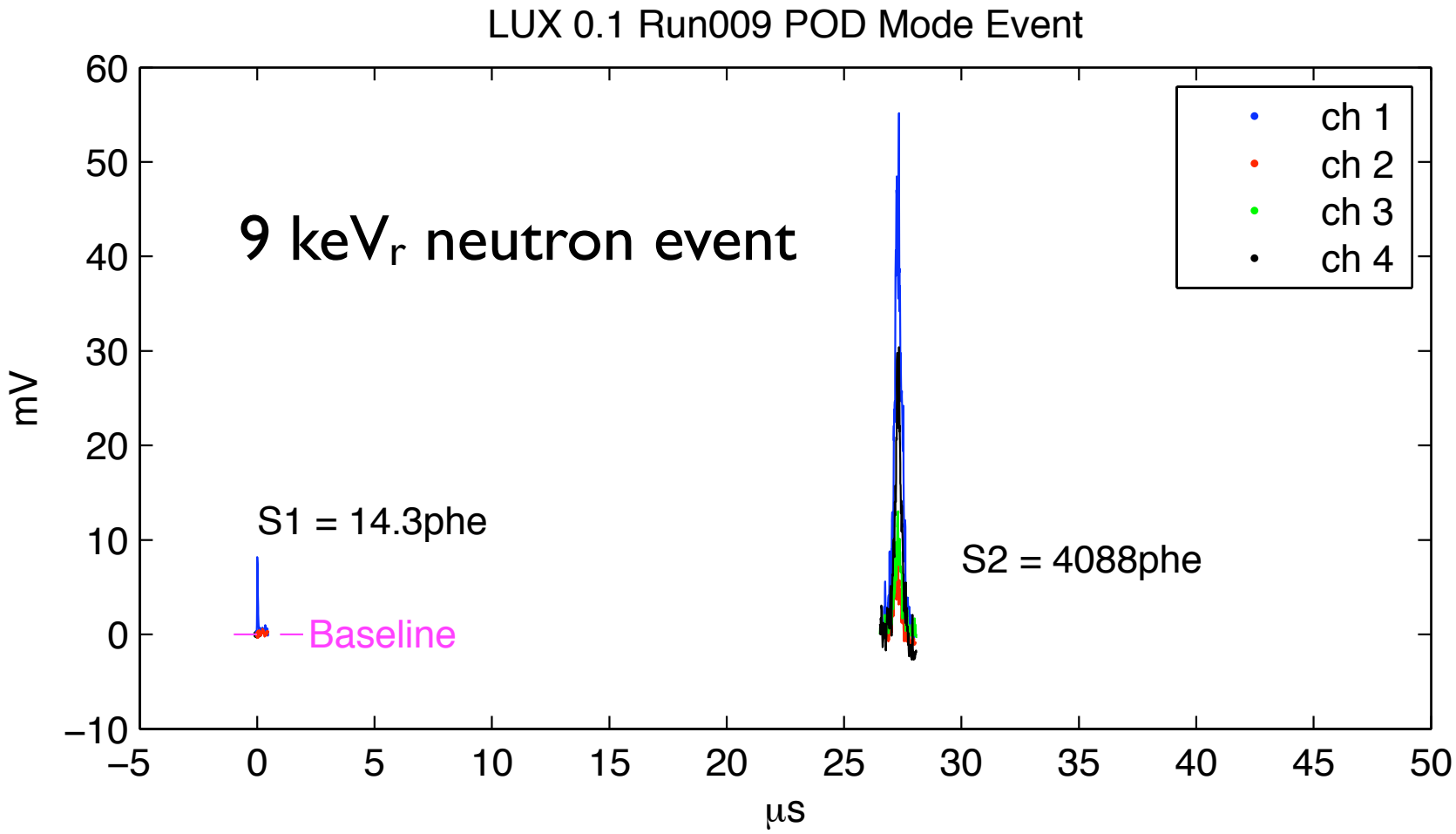
Thermometry, liquid level meters, pressure sensors, LN filling, etc.

- **Safety Systems**

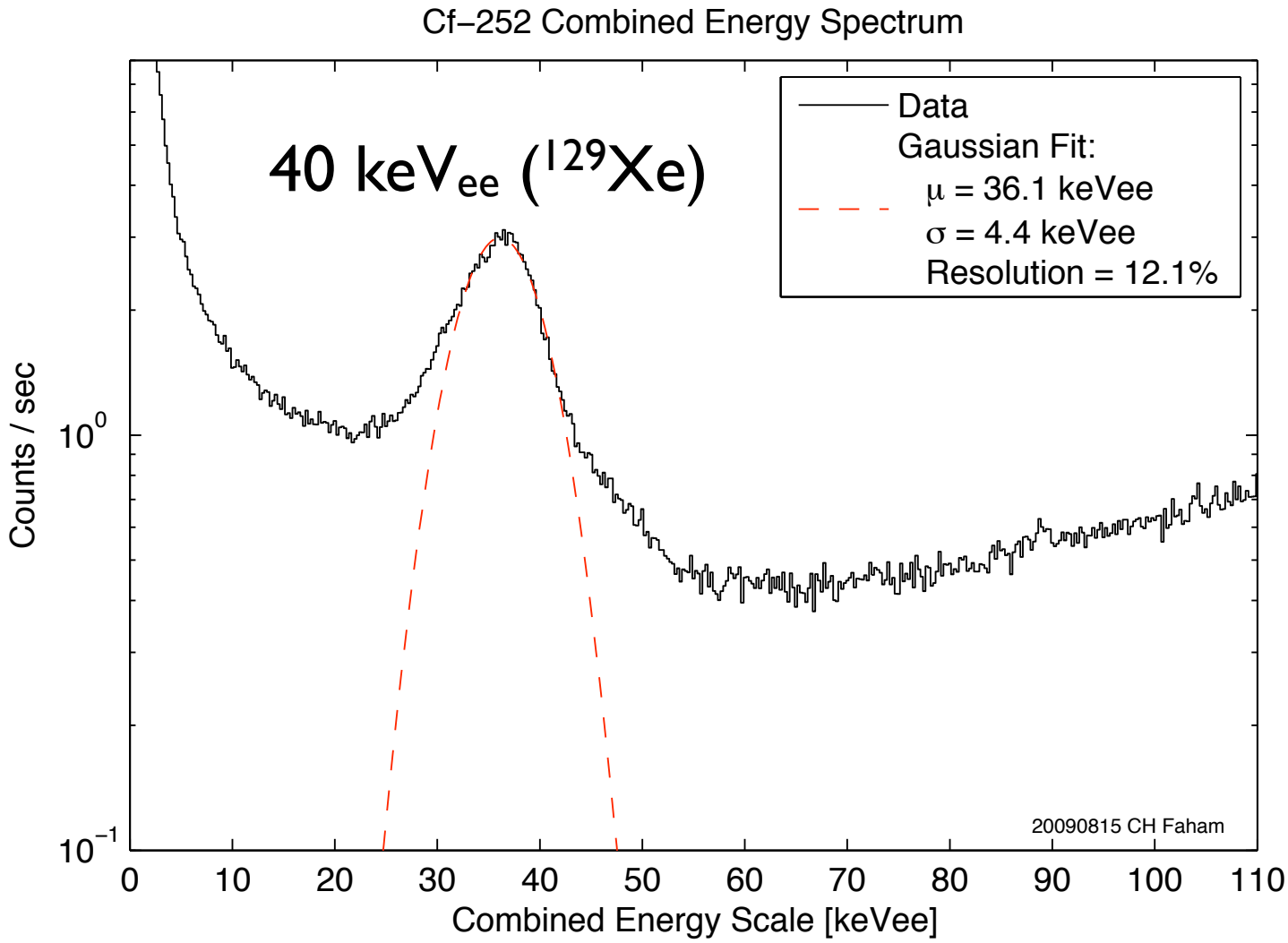
Emergency recuperation, alarm system.



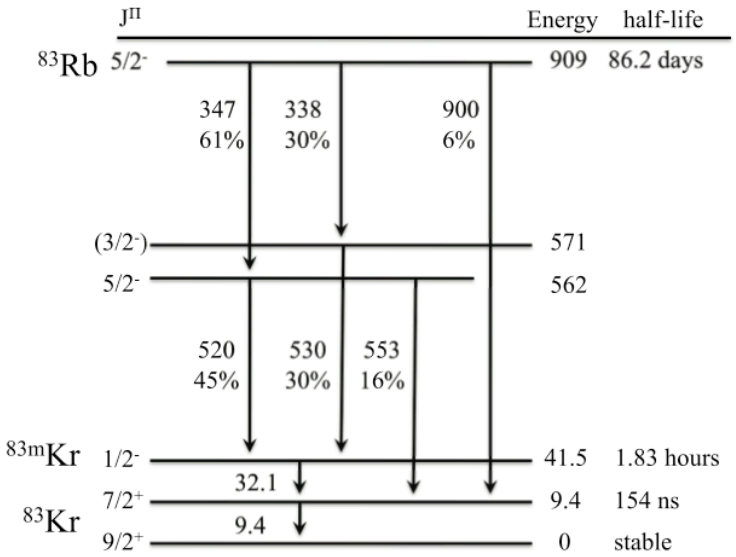
Events

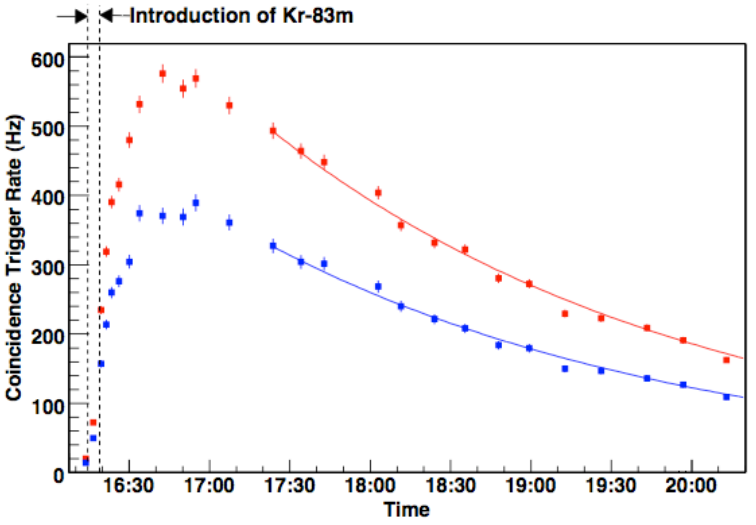

LUX 0.1 Run009 POD Mode Event
9 keVr neutron event
S1 = 14.3phe
S2 = 4088phe
Baseline
ch 1
ch 2
ch 3
ch 4
mV
μs
60
50
40
30
20
10
0
−10
−5
0
5
10
15
20
25
30
35
40
45
50

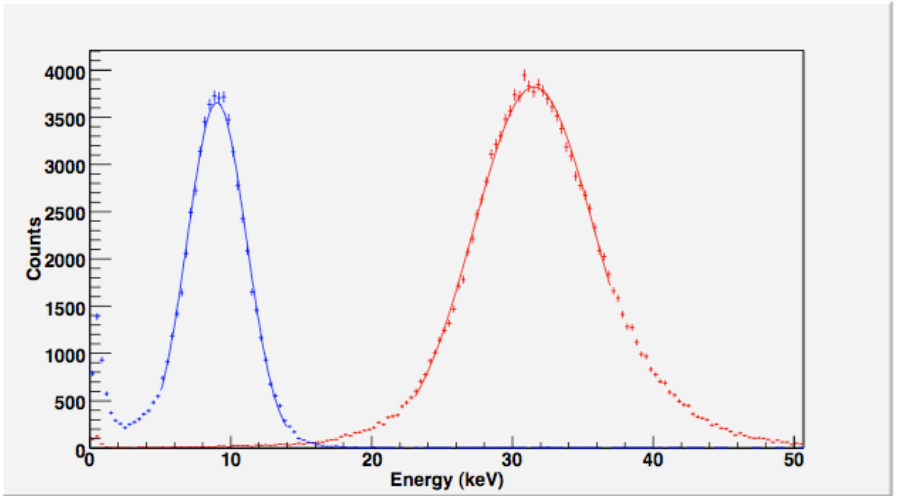
40 keVee Nuclear Recoil Inelastic Spectrum



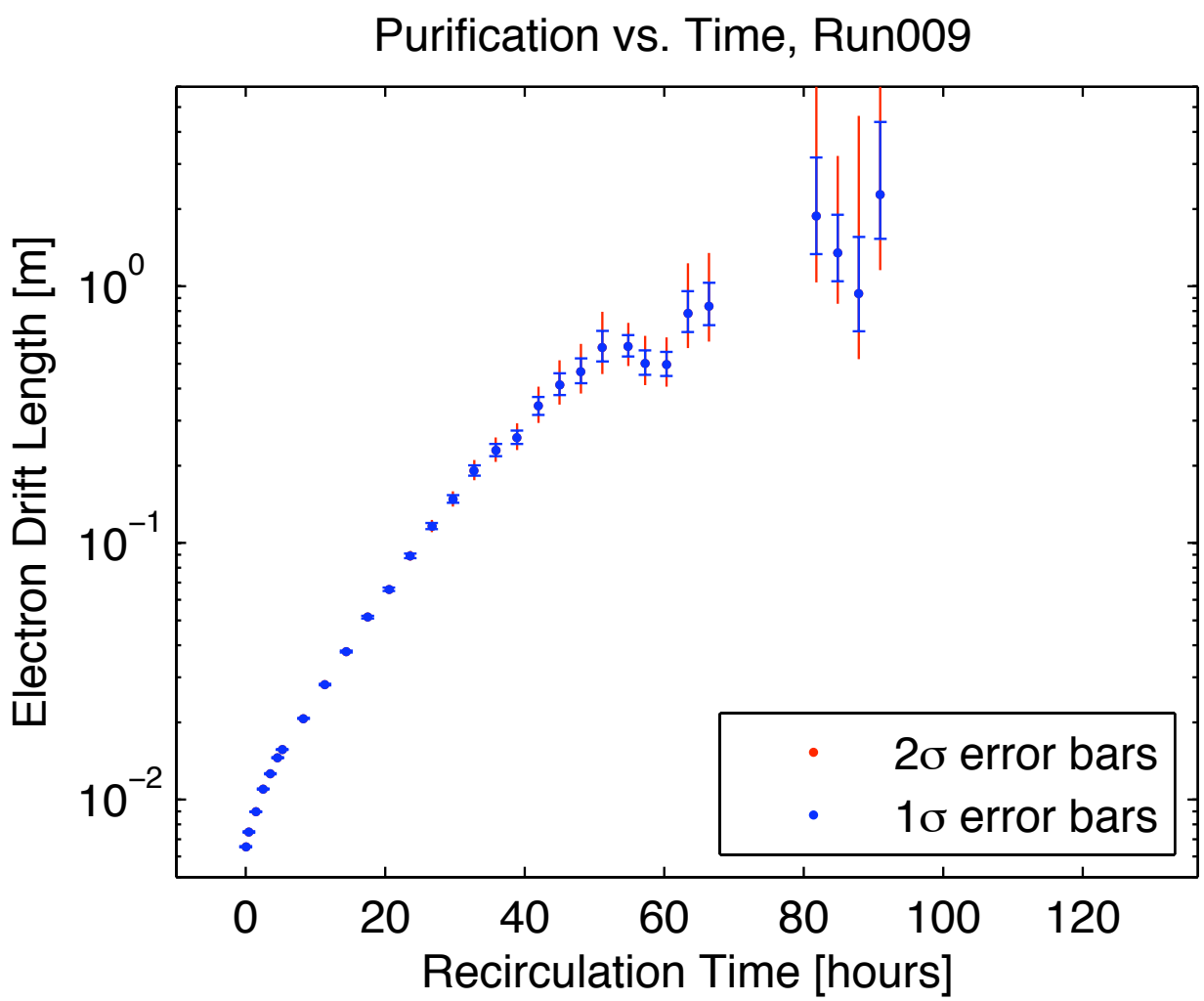
83mKr


Jπ
Energy
half-life
83Rb 5/2-
909
86.2 days
347
61%
338
30%
900
6%
(3/2-)
571
5/2-
562
520
45%
530
30%
553
16%
83mKr 1/2-
41.5
1.83 hours
32.1
7/2+
9.4
154 ns
83Kr
9.4
9/2+
0
stable


Introduction of Kr-83m
Coincidence Trigger Rate (Hz)
0
100
200
300
400
500
600
16:30
17:00
17:30
18:00
18:30
19:00
19:30
20:00
Time


Counts
0
500
1000
1500
2000
2500
3000
3500
4000
0
10
20
30
40
50
Energy (keV)

Xenon Purity

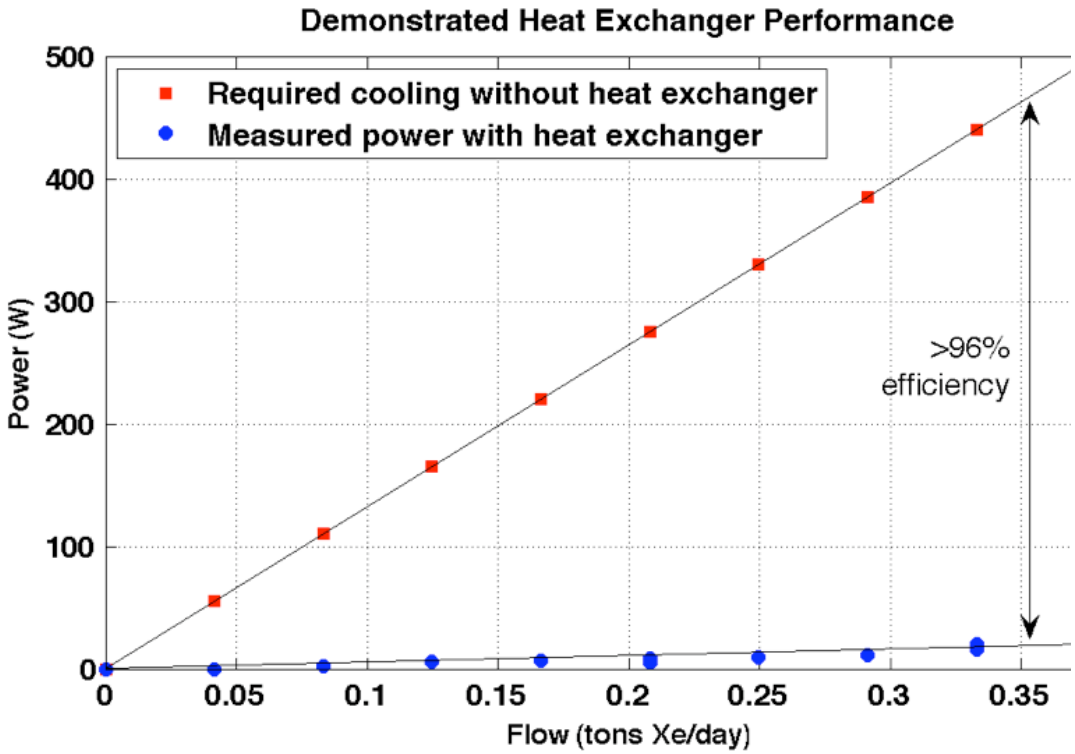


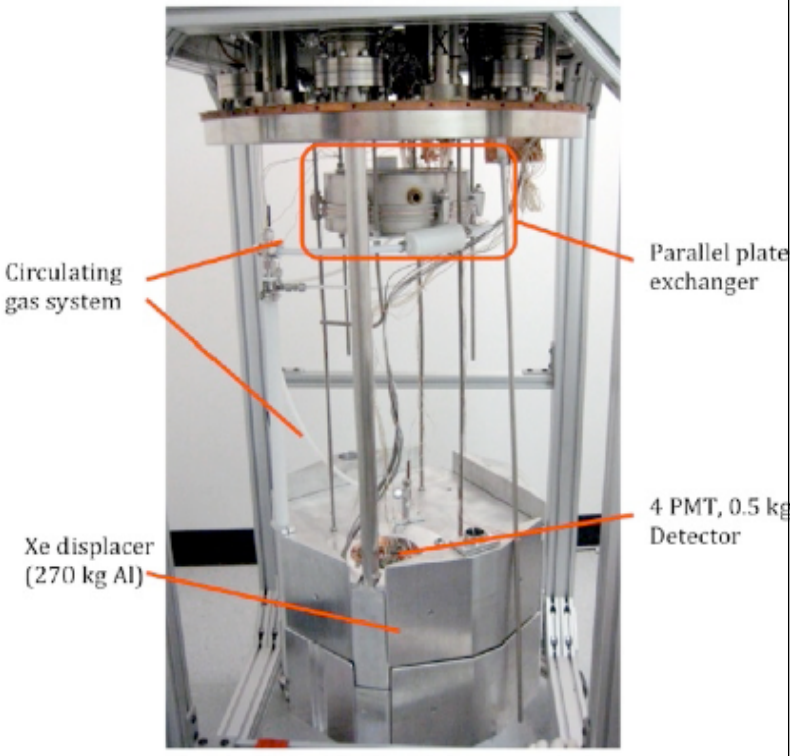
0.2 tonnes circulation per day

- ~9 hr time constant for purification
- > 2 m electron drift length achieved (> 1000 us) with 60kg target
- Errors dominated by use of 5 cm test drift

Heat Exchanger Operates >96% Efficient

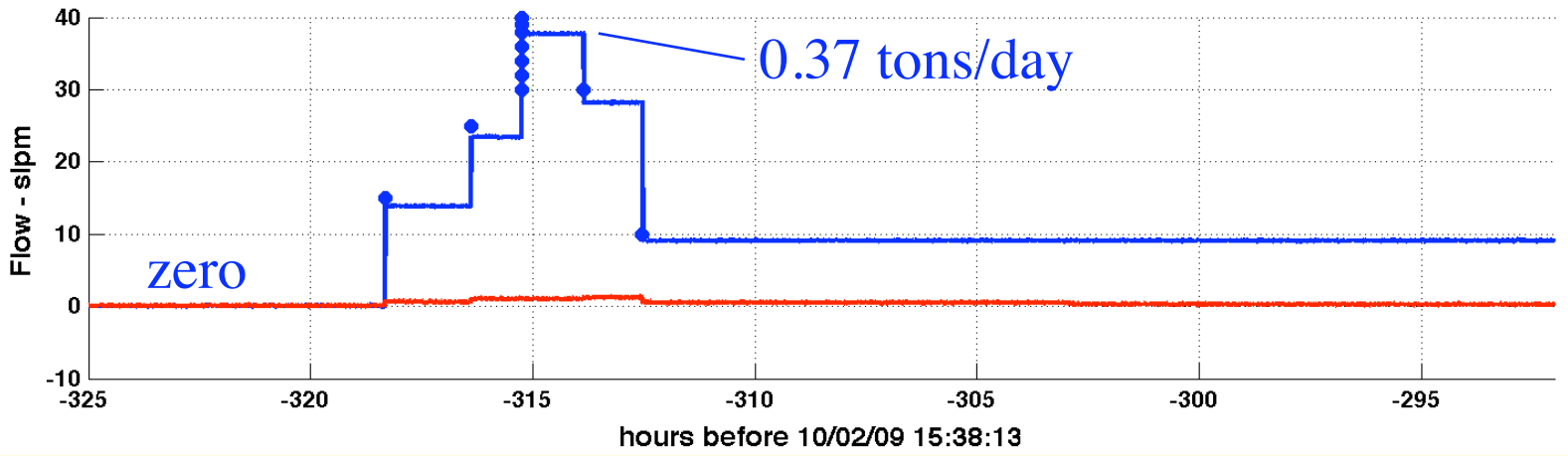
Demonstrated - 18 W required to circulate 0.4 tonnes of Xe a day
Evaporate Liquid > Gas / Purification -> Re-condense Liquid



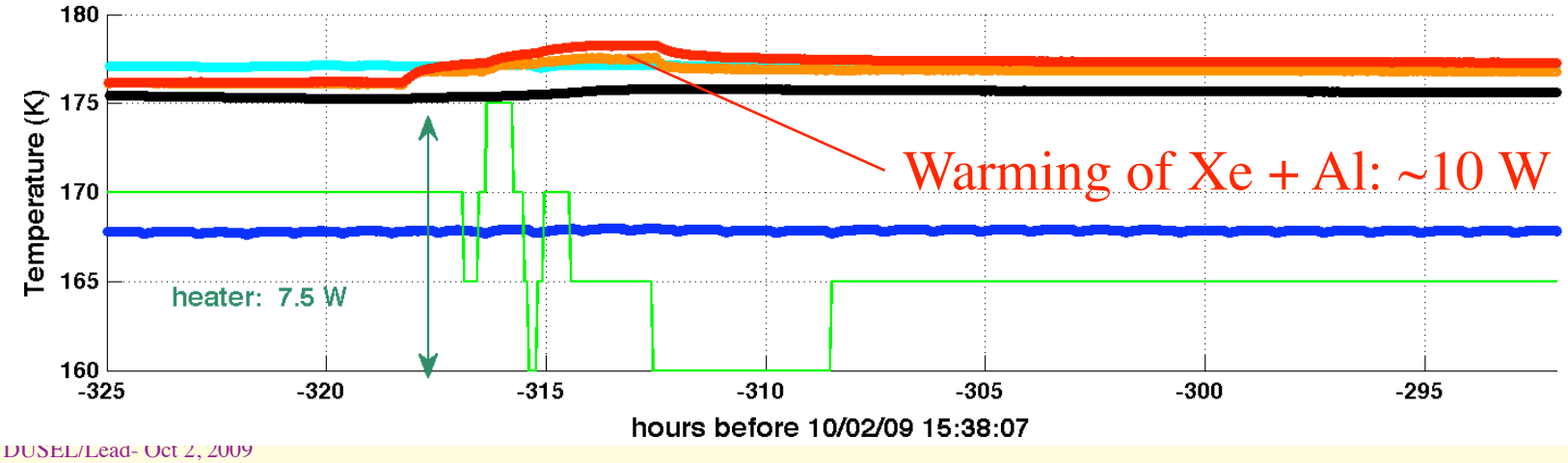


Heat Exchanger Test

Xe Circulation



Temperatures, Heater

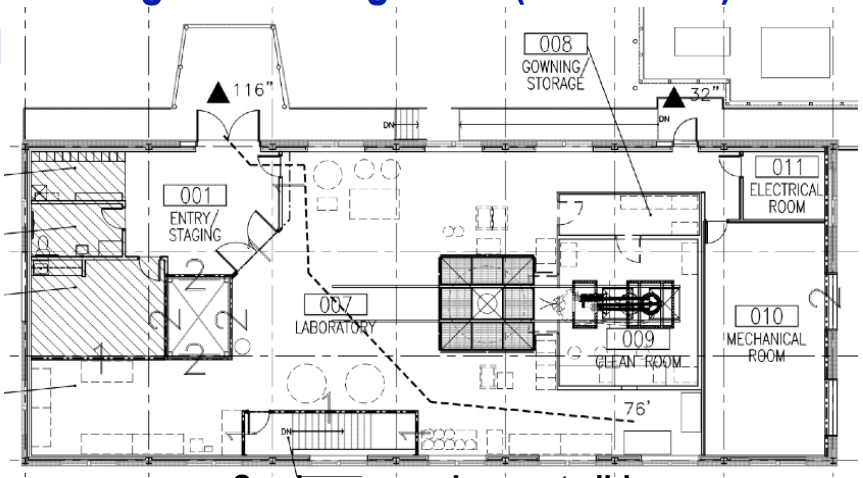


Sanford Lab
LUX Surface Facility

Sanford Lab – LUX Surface Facility

- Full-scale test of LUX assembly and deployment
  - 350 kg Xe
  - 122 PMTs
  - Titanium cryostat
  - Full DAQ system

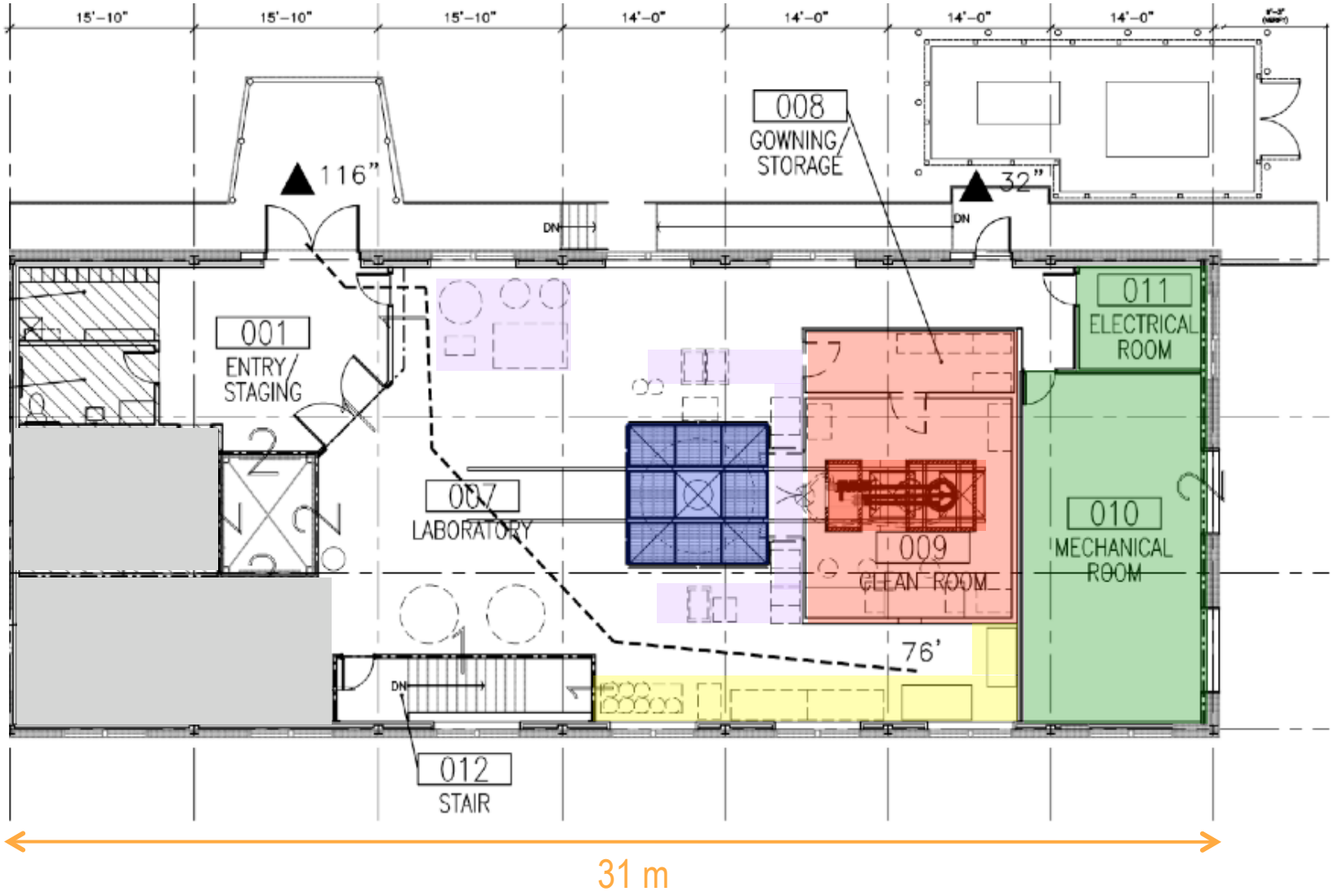
- Refurb supported entirely by SDSTA funds
- Exact duplicate of the underground layout for all major systems
  - Smaller d=3m water tank, permits data taking with manageable background (Brown MC)
  - CL 1k clean room, will be relocated underground



See larger version next slide

- Summary schedule (2009):
  - Jul 8: Began demolition / clean-up
  - Jul 14: Began new construction
  - Oct 14: Full beneficial occupancy
  - ☒ Nov 1: Start full detector assembly
  - ☒ Jan: Detector operation with full payload

Sanford Lab – LUX Surface Facility



Warehouse (This Morning)

Vertical Shaft within Surface Facility

(Site visit today)

Shaft

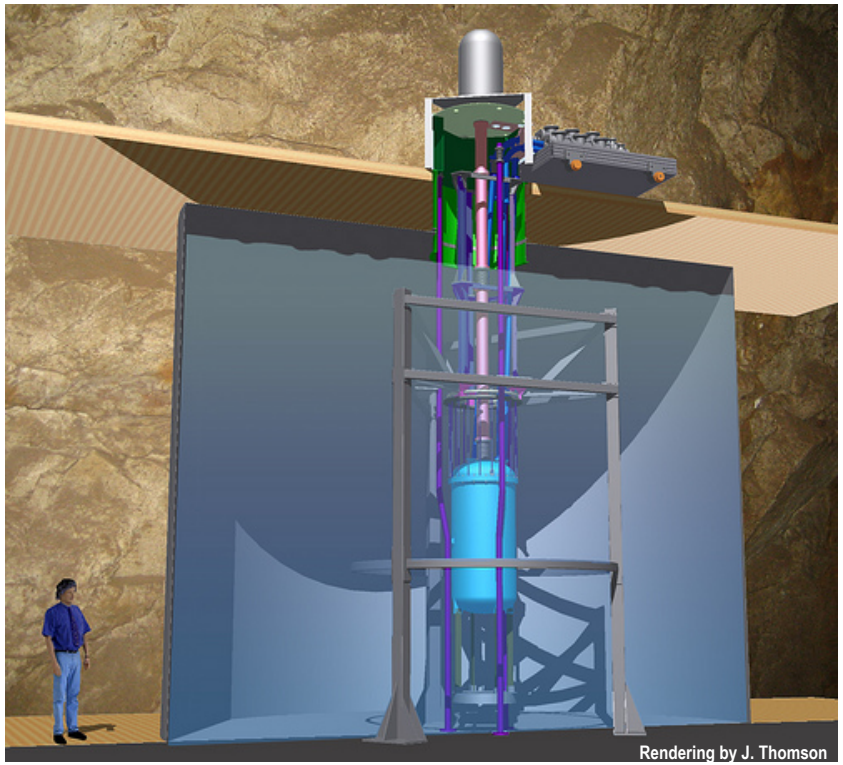
7 m depth, 4x4 m

Will contains ø3 m water tank

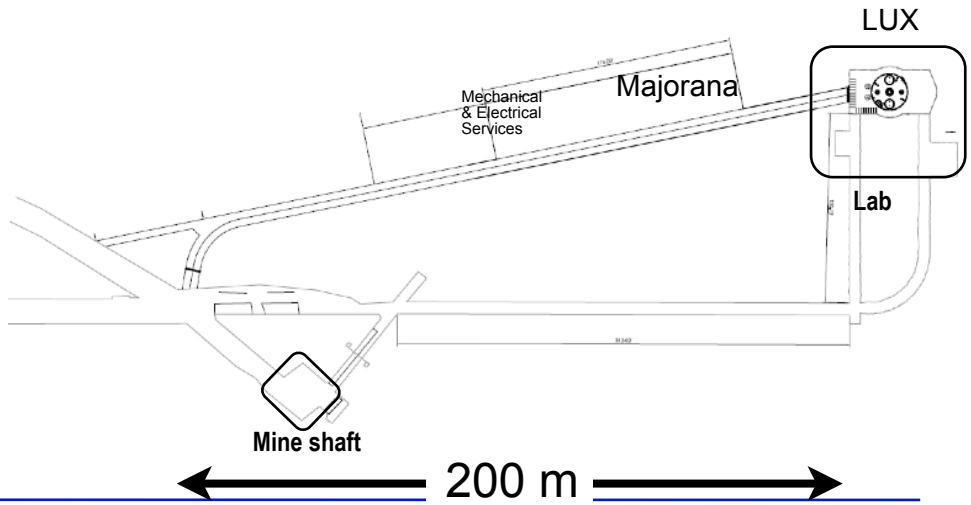
Sanford Lab
Davis Underground Laboratory

LUX 1.0 – Davis Laboratory (4850L)

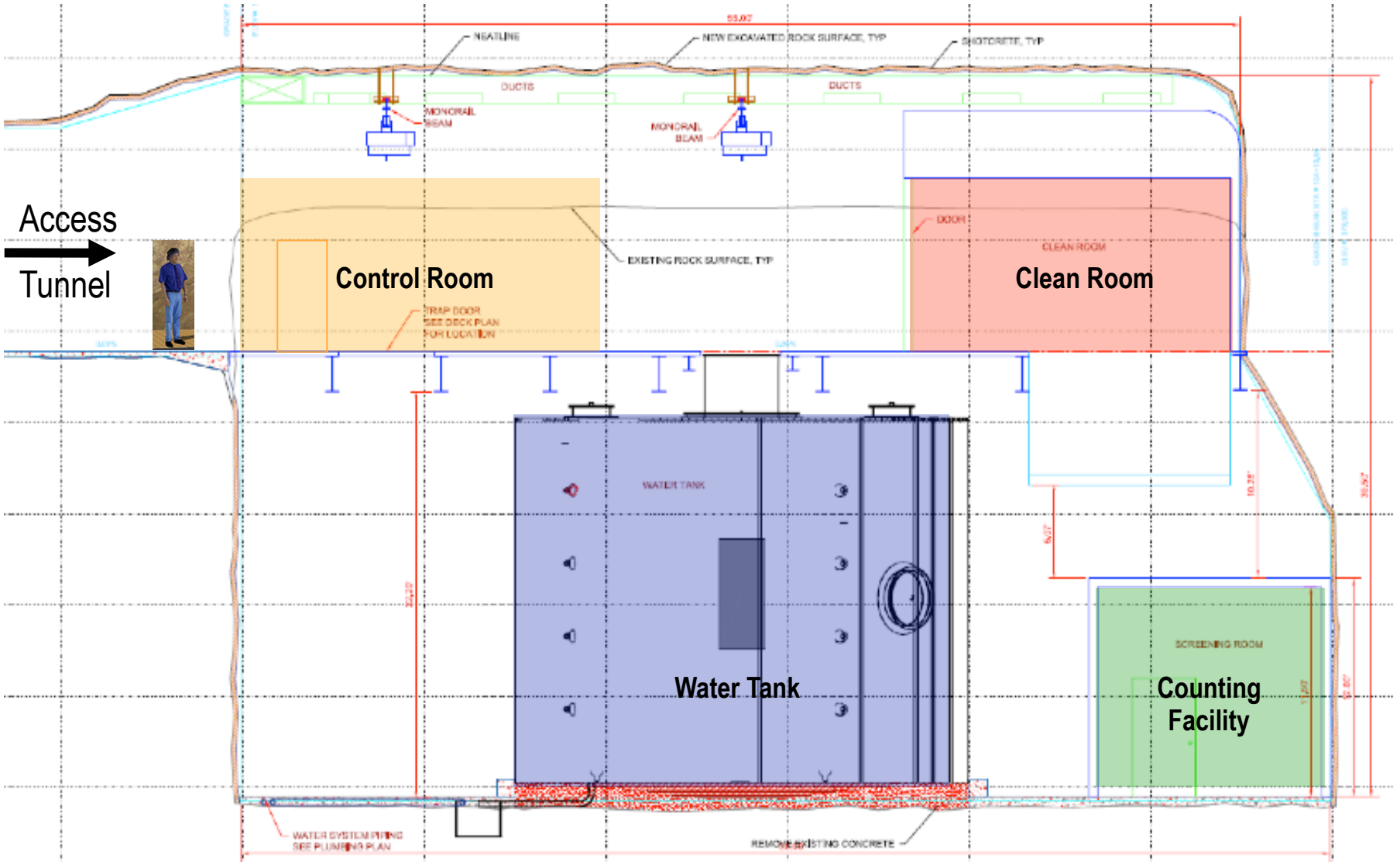
- Construction/excavation design completed
  - New 300’ access/safety tunnel to be excavated
  - Shared access with Majorana facility, also to be excavated
- Two storey, dedicated LUX 55’ x 30’ x 32’ facility, CL 100k
  - Includes CL 1k clean room, control room, counting facility

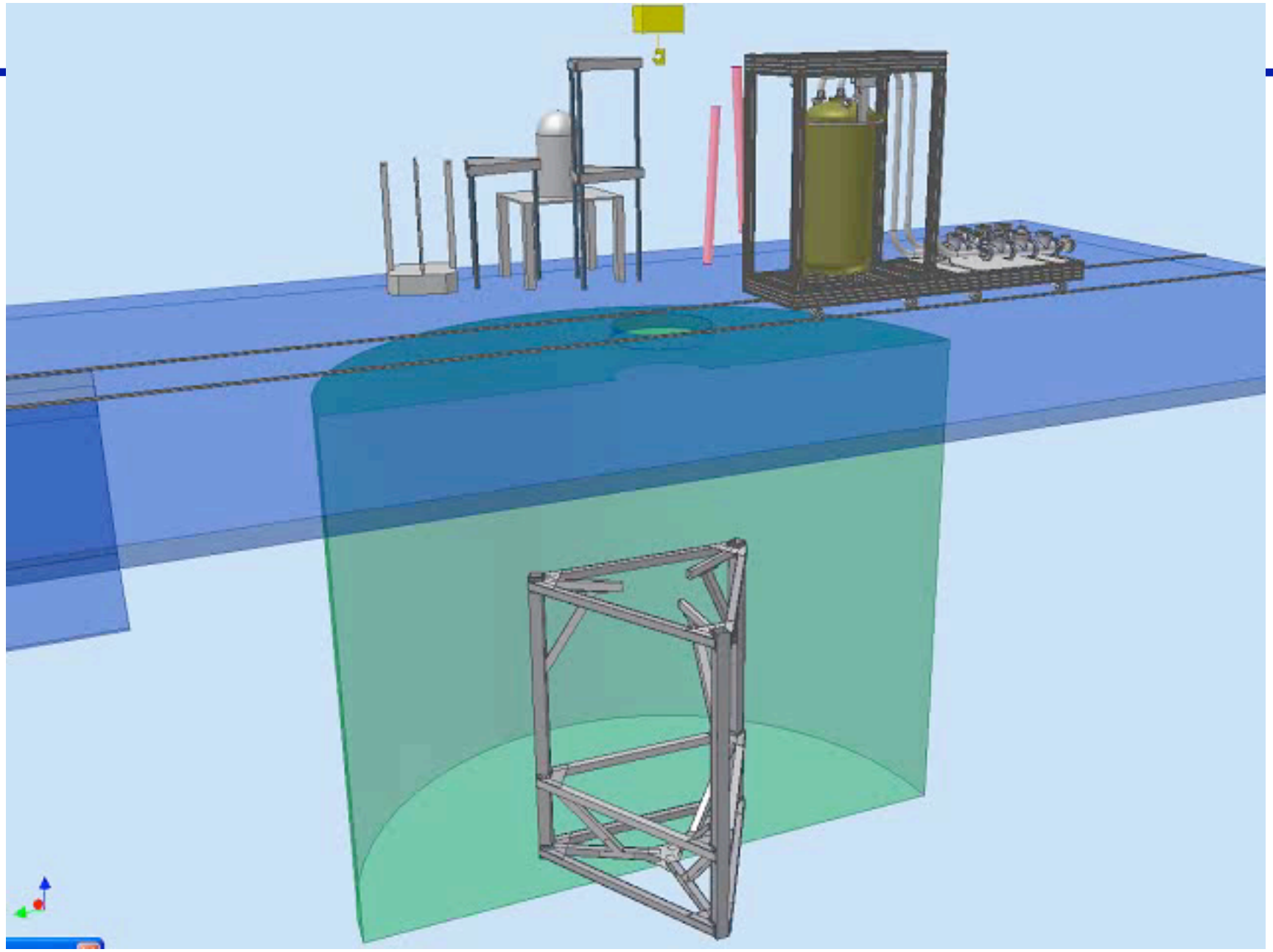


- Beneficial occupancy: May 2010



Sanford Lab – Davis Laboratory Layout (Side View)





1964 / 2009 “They want to fill the cavern with what ?*?”

Sanford Lab – State of the Davis Cavern

- Aug 24: Equipment commissioning complete
- Aug 31: Began excavation of new drift
- Sep 10: Steel structures removal complete — now
- Nov 15: Detailed Outfitting docs 100% complete
- Jan 20: Excavation complete
- Mar 25: Rock support & wall finish complete
- Mar 30: Begin Lab outfitting
- May 05: Davis cavern ready

Personal Remark

We are seeing the very best of the Sanford Lab team. We appreciate their incredible professionalism and enthusiasm for the tasks at hand.

I am confident that they will show the same dedication to making DUSEL a great lab to work at.