The LZ Experiment

A Mechanical Designer's Perspective

Donuts Talk Matt Hoff LBNL August 12, 2014

LZ Quick Start Guide

Became an official DOE project July 7, 2014

The experiment is a dark matter detector. Looking for WIMP's (weak interacting massive particles)

The name LZ comes from combining two previous projects LUX (Large Underground Xenon) and ZEPLIN (ZonEd Proportional scintillation Nobel gases).

Approximately $60 million project cost, 29 institutions and 140 engineers and scientist. The cost of the Xenon alone is approximately $19 million

The experiment will be located below ground in the Davis Campus at SURF in South Dakota

This project will not generate a lot of work for Building 77. Some, but not a lot.

http://lz.lbl.gov/

www.lzdarkmatter.org

An over view of the Davis Cavern

60 x 30 x 40 ft high

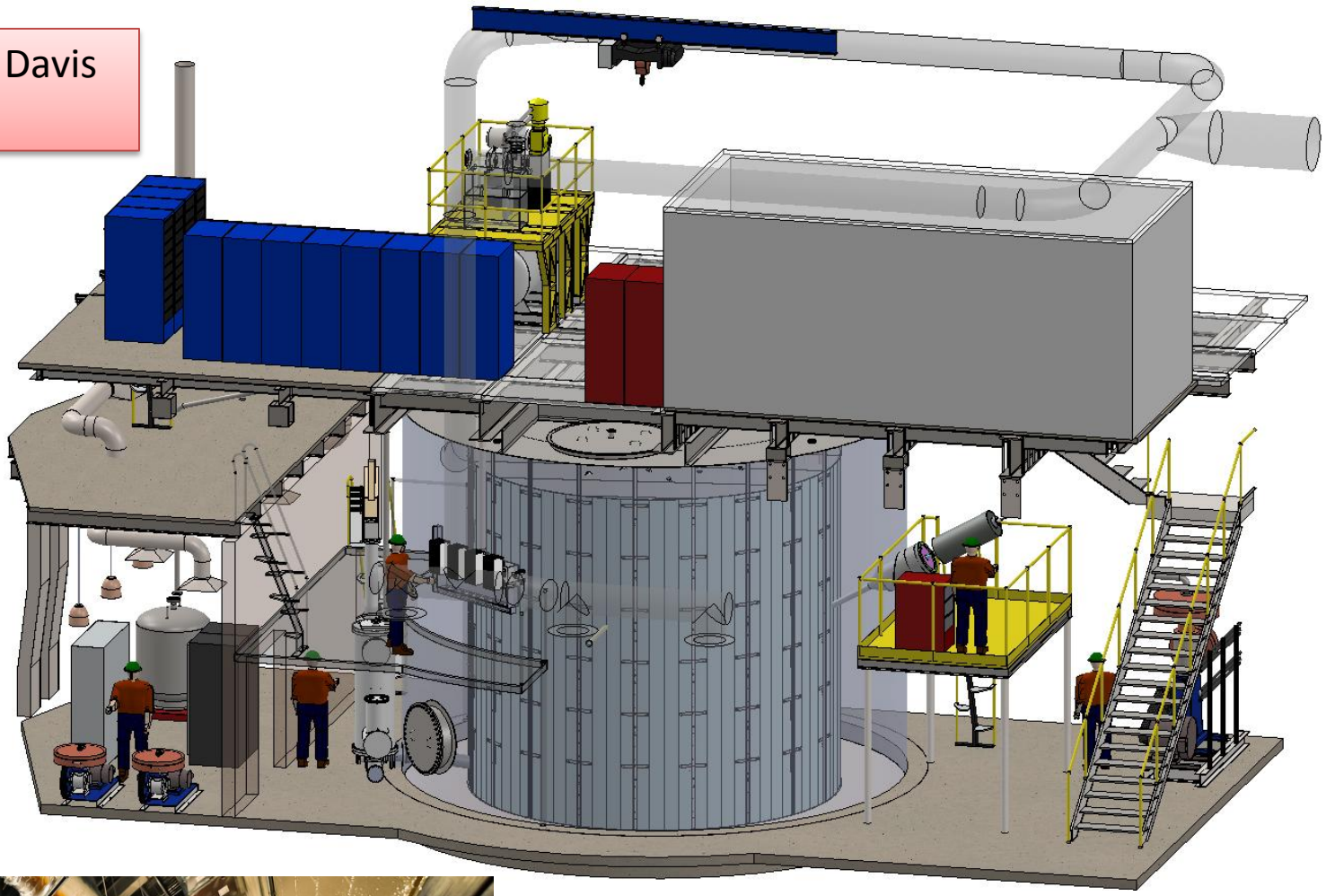
4850 feet underground

Currently holds the LUX Experiment

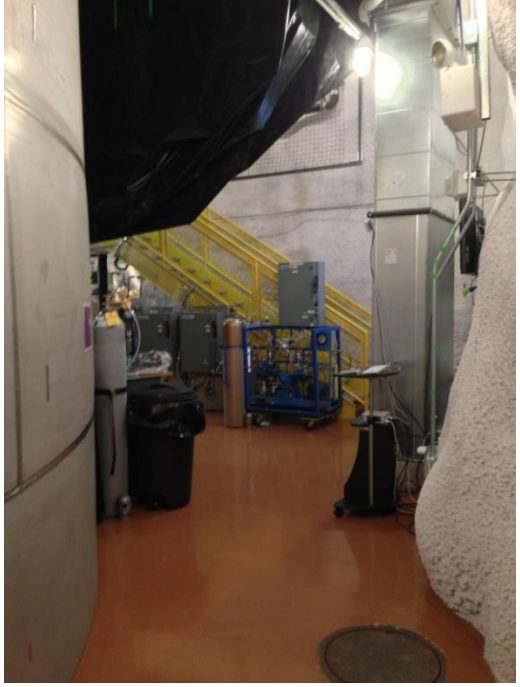
The elevator ride takes 12 minutes

Free wi-fi

No flush toilets

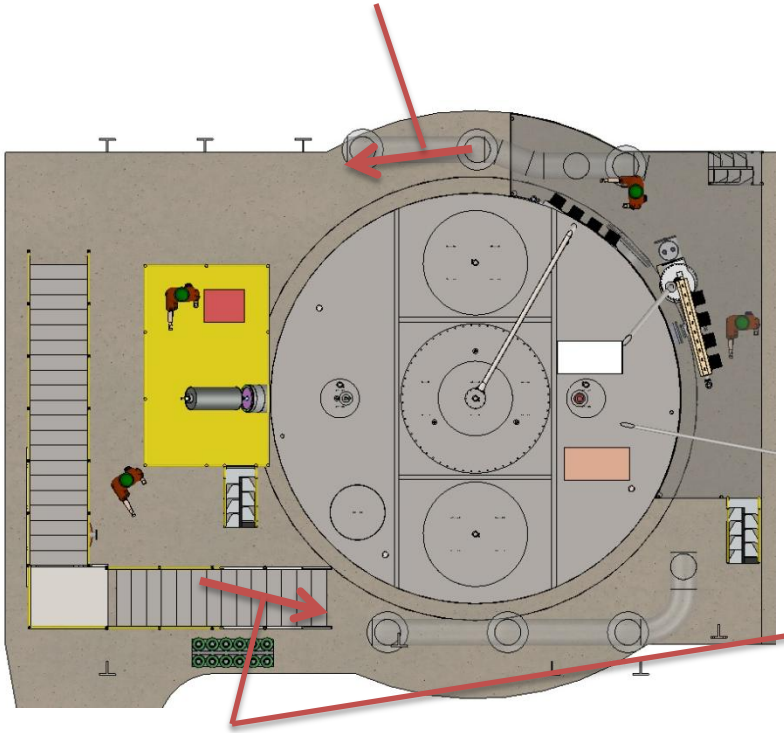


Named for Ray Davis who shared the 2002 Nobel Physics Prize for a neutrino experiment in this cavern / water tank in the mid 1960s



View above the water tank

Davis Cavern is crowded

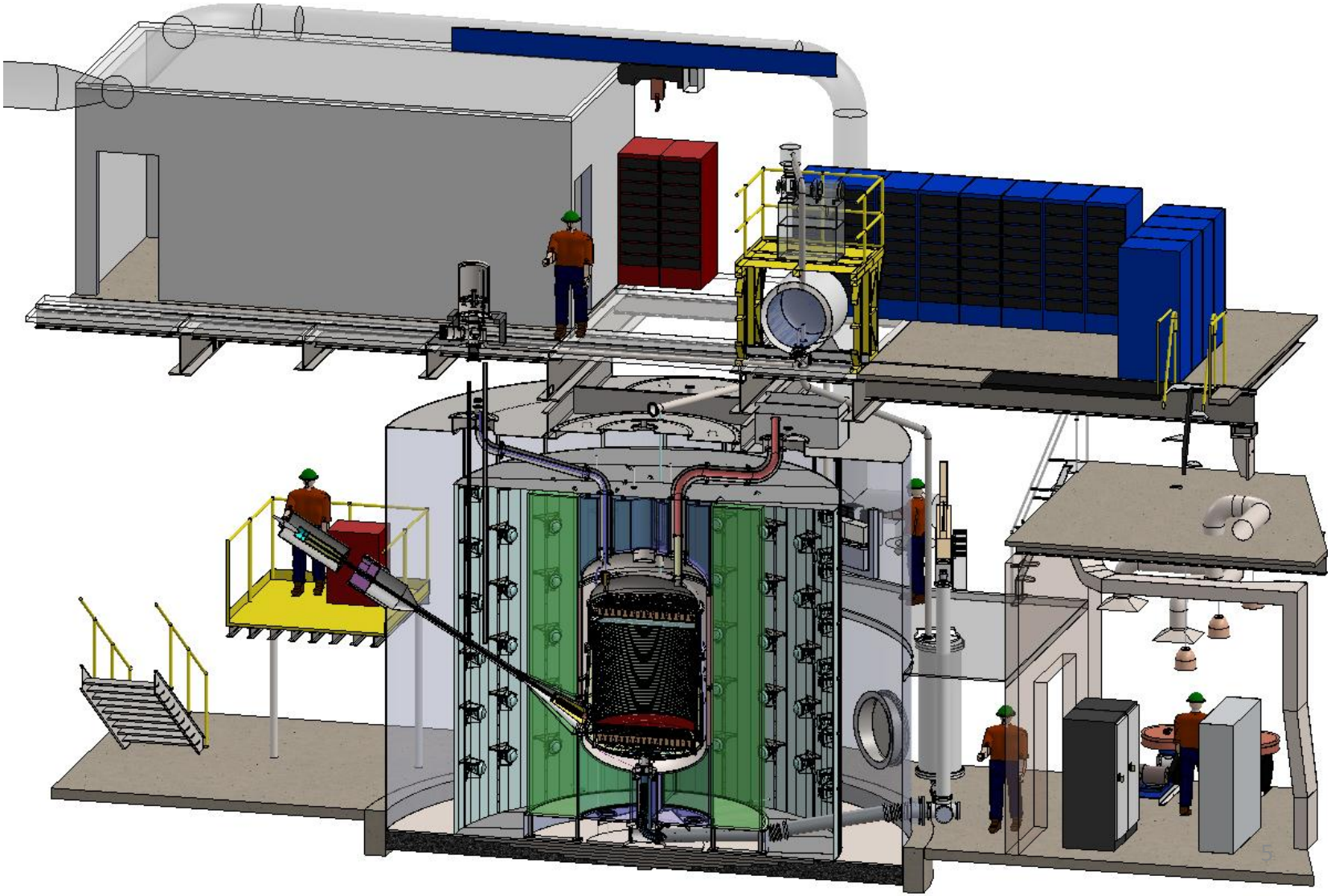


The proposed LZ experiment

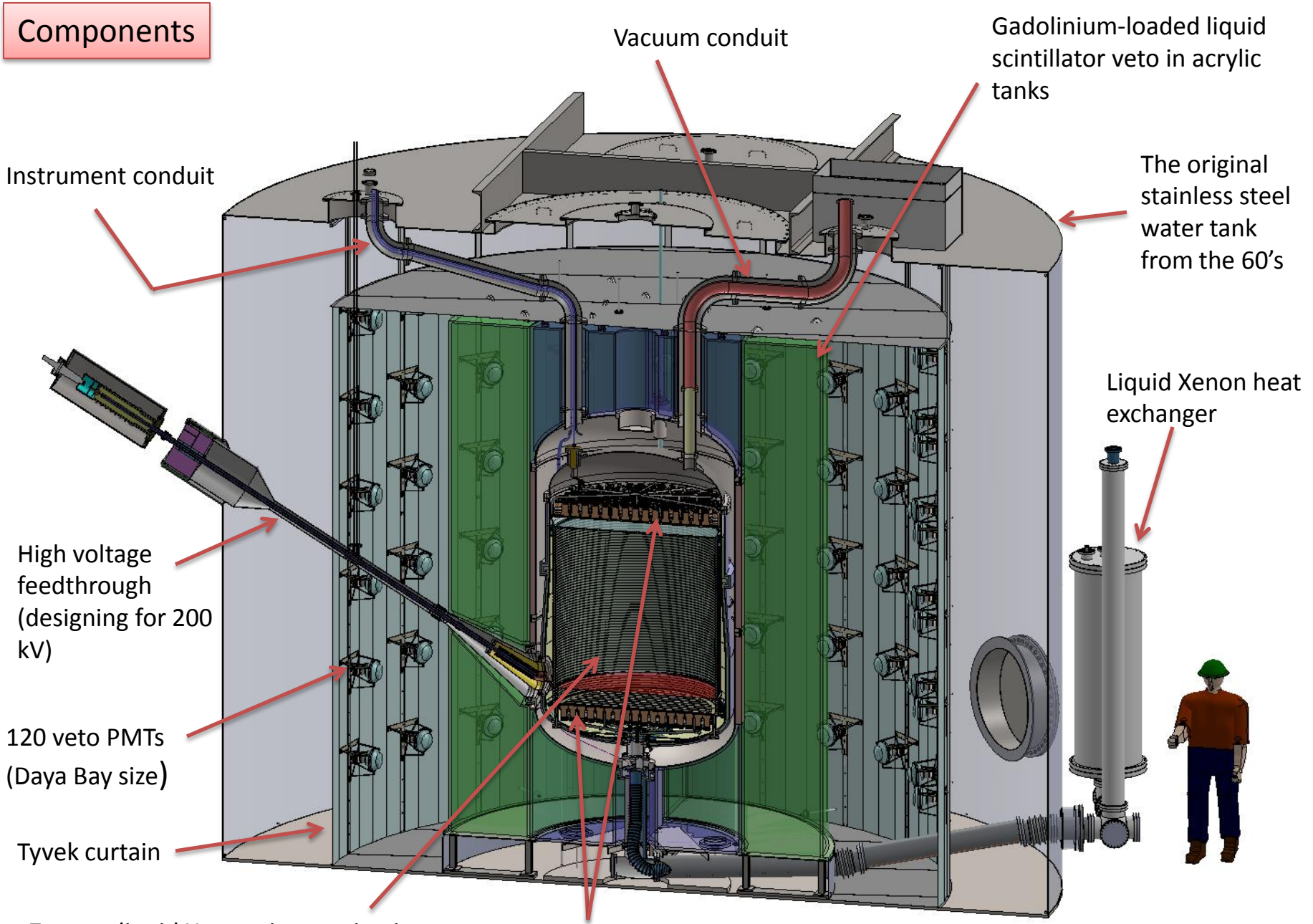
Replaces the LUX experiment

Uses the original Stainless steel water tank

All design work is to be done in SolidWorks software

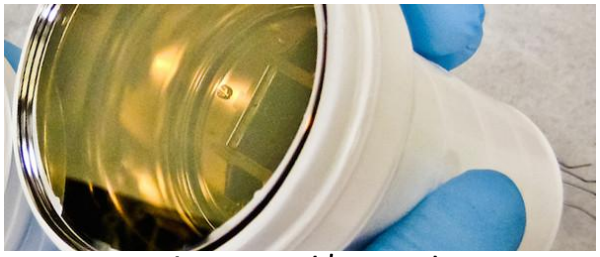


Components


Vacuum conduit
Gadolinium-loaded liquid scintillator veto in acrylic tanks
Instrument conduit
The original stainless steel water tank from the 60's
Liquid Xenon heat exchanger
High voltage feedthrough (designing for 200 kV)
120 veto PMTs (Daya Bay size)
Tyvek curtain
7 tonne liquid Xenon time projection chamber (TPC)
488 photomultiplier tubes (PMTs) with an additional 120 smaller "skin" PMTs

LZ Time Projection Chamber (TPC)

62 inch diameter x 87 inch high



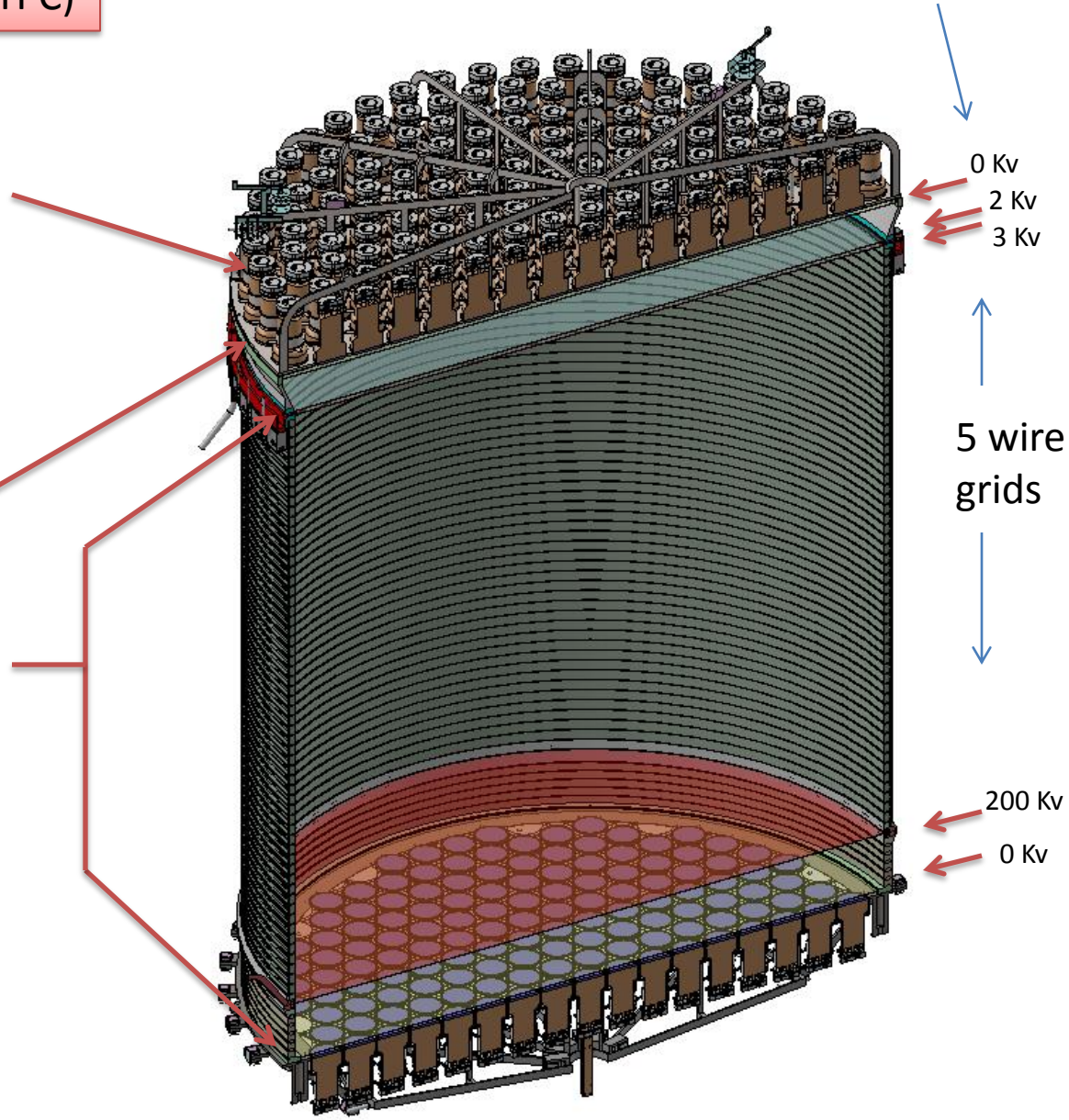
488 3 inch PMTs ($2.5M)

PMT support plate and truss are titanium. Top and bottom.

Grading rings are titanium with Teflon insulating rings

The liquid Xenon is not stagnant, it has a constant flow and is cleaned during re-circulation

This entire assembly will float in the liquid Xenon, so its bolted to the bottom of the cryostat



The LZ Cryostat

Approximately $1.5 million

Made of ultra pure Titanium

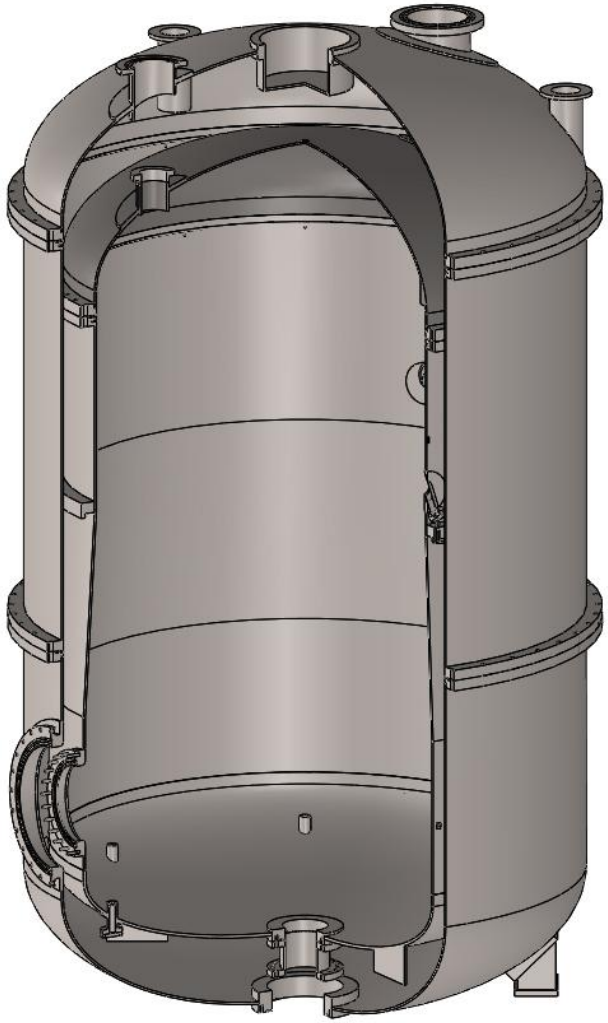
Will be designed and fabricated in Europe and shipped here

Operating temperature range -100 C to +38 C
Max inner pressure 4 bar (58 psi)
Inner and outer vessel must support vacuum

Inner vessel fits down the Yates Shaft sealed up. 67 inch diameter vessel

Outer vessel fits down the Yates Shaft in three pieces

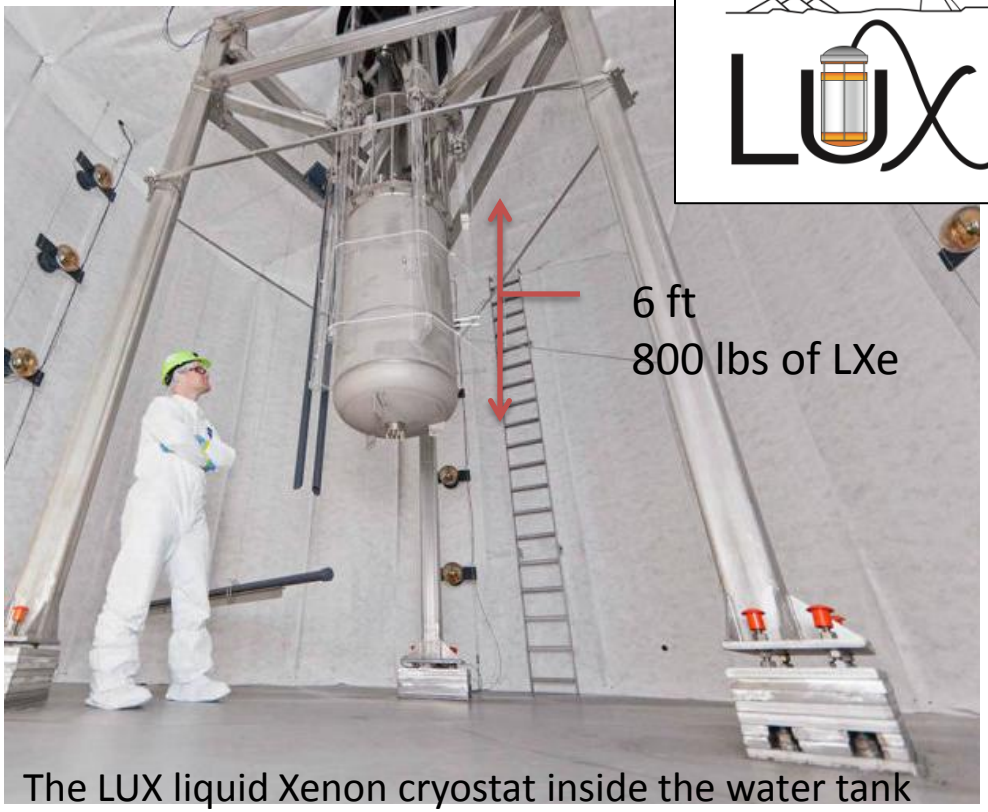
Parts that are not bagged must be re-cleaned inside the Davis Cavern after transport through the mine. That means re-cleaning the outside of the inner vessel and the inside and outside of the outer vessel.



Liquid Xenon Detectors

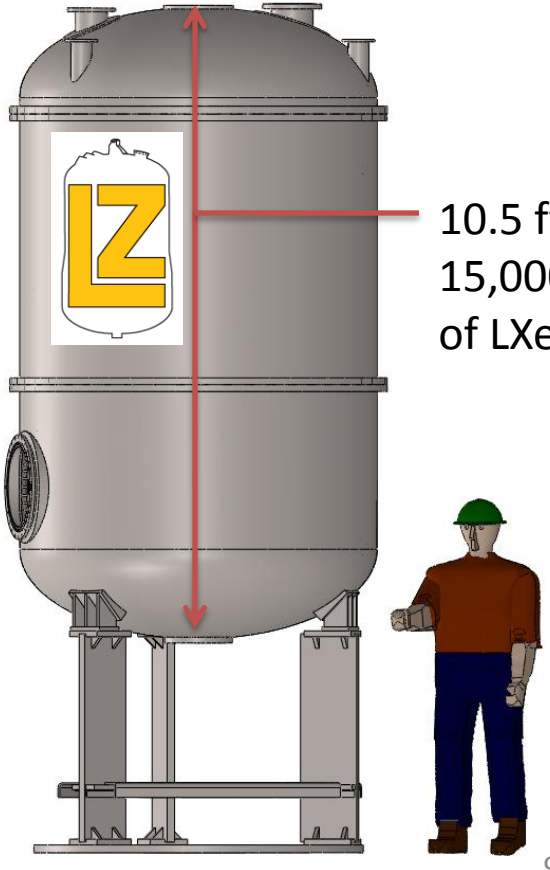
LZ is the LUX Experiment on steroids

LUX is running right now in the exact spot where LZ will be installed in the Davis Cavern.



The LUX liquid Xenon cryostat inside the water tank

http://lux.brown.edu/LUX_dark_matter/Home.html



LZ liquid Xenon cryostat CAD model

What make this experiment difficult?

The experiment must be “radio-pure” (zero radioactivity)

- No carbon steel around the detector
- Super pure titanium must be sourced
- Radon wants to attach to all the Teflon part surfaces
- Super clean assembly. No finger prints.
- Every piece must be inspected to see if its radio-pure

The design high voltages levels should be in a shipping container, not a 5.5 foot diameter vessel.

The liquid Xenon must be super clean (no Krypton) to <0.015 ppt (parts per trillion)

This experiment is using about 20% of the worlds yearly production of Xenon

The largest producer of Xenon is Russia

The experiment is being built at the bottom of a 4800 foot shaft that is has a maximum width of 63.5 inches. The Yates shaft is 63.5 x 160 inches (5.25 x 13.25 feet)

The passage from the shaft to the cavern is small too.

We are building a ship in a bottle

About SURF

Located in Lead, South Dakota
elevation 5,000 ft

Started as the Homestake gold mine in 1876.

Purchased by George Hearst in 1877. (William Randolf Hearst Father)

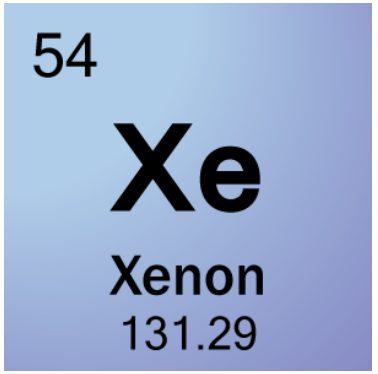
Stopped production in 2001

Became DUSEL in 2006
Deep Underground Science and Engineering Laboratory run by Kevin Lesko

2011 DUSEL morphed into SURF
(Sanford Underground Research Facility)
Helped by S.D. philanthropist Denny Sanford.

Located just up the road from Sturgis and Deadwood.

About liquid Xenon



Atomic number 54
Discovered 1898
Present in the atmosphere at about one part in 20 million
From the Greek word for stranger
Xenon gas was used as anesthesia for surgery starting in 1951.
Xenon is a byproduct of the separation of air into oxygen and nitrogen. Usually for steel production

Boiling point -108.0C (-162.4 F)
Melting point -111.9C (-169.4 F)

Only a 7^0F zone where Xenon is liquid

Solid Xenon is heavier then granite
Liquid Xenon is 3 times heaver then water
Aluminum will float in liquid Xenon

Xenon gas is commonly used in light bulbs and lighting products

Who is working on this Project

Gil Gilchriese – Lead Scientist - a long time LBNL scientist
Bill Edwards – Project Manager – a long time LBNL engineer
Kevin Lesko – Scientist
Joe Saba – Engineer – Kind of new to LBNL - Gets to the shops occasionally
Will Waldron – High voltage engineer
Tom Miller – designer – a Building 77 regular – just starting on LZ
Steve Dardin – Technical Coordinator – a Building 77 regular
Matt Hoff – Lead designer – care taker of the CAD model

There are more, but I don't think they visit Building 77 often or ever

LZ collaboration meeting
University of Maryland
March 2014