Development of the Sanford Laboratory at Homestake

Jose Alonso
Lab Director (‘07–’09)
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  - Sanford Lab Communications Department
- Ron Wheeler
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  - Rick Gaitskell, LUX
  - John Wilkerson, Steve Elliott, Majorana
- DUSEL leadership
  - Kevin Lesko, PI, Bill Roggenthen, Co-PI
  - Gil Gilchriese, Science Director
Where is Homestake?
Colorful Northern Black Hills

Spearfish
Deadwood
Sturgis
Lead
Lead... Old Mining Town
Yes... Lots of Snow!
Homestake Local
Modern Homestake
Aerial View of Homestake

Yates Headframe

Ross Headframe
What’s beneath Lead...
Legacy of Science at Homestake

1965

Ray Davis  John Bahcall
“Welcome to Homestake Spa!”
Stockholm, 2002
2000 Homestake announced closure
2002 NSF Process for Underground Lab starts
2006 Homestake-Barrick donates mine to State
   Formation of SDSTA
   State provides $40M, T.Denny Sanford adds $70M
2007 NSF Downselect occurs
2007 Sanford Lab startup
   Re-entry activities begin
   Early science begins
Homestake Property Donation Footprint

- Ross Complex
- Oro Hondo
- Ellison Tract
- Gold Run Park
- Yates Complex
- Shops, Warehouse
- Kirk Fans, 300L Adit

186 surface acres
7,700 underground acres
370 miles of drifts
14 shafts and winzes
Governor Mike Rounds is True Hero!
South Dakota Initiatives

SDSTA Established

Sanford Lab is Formed

SDSTA Established
NSF Selects Homestake!

July 10, 2007: Announcement!
DUSEL Plans (2007)
Re-Start Activities

- Hoist-Shaft rehab
- Inspection, safety of levels
- De-watering
- Refurbishing of 4850
  - Davis Campus
  - Ross Shops area
- Deployment of “Early Science”
  - LUX
  - Majorana Demonstrator
  - Seismometry, tiltmeters
  - Extremophile microbiology
Hoist Equipment Re-Commissioning
World’s largest single-wrap drums
Power at your fingertips!
Cage Door
Down the Shaft!
Safety Inspections

Loose rock, back (roof) integrity
Ventilation, escape routes

Iron-rich water

Don’t Go There!!
Safety is All Important!

“Tom is Back!”

Access categories
Recommissioning Pumping Chain

Water reached 4550 foot level
Recommissioning Pumping Chain

First Pump Going!

March 2008
May 13, 2009: 4850 is DRY!

Water level 3/25/11...... 5400 (feet below surface)
Installed Pump System

- 4 stations
- 2 sets of 1500 gpm pumps
- 700 hp motors
- 1250 foot pumping head
- 12” pump columns

Submersible pump at 7800 level
Not only water… it’s what’s in it!

Pooled water had leached minerals from rocks
Iron oxide must be removed!
**Mine Water Chemistry:**
Temp. = 85-90°F
pH = 7.4
Iron = 20-30 mg/l
Ammonia = 3-4 mg/l
TSS = 50-60 mg/l
Particle Size = 0.01-2.0 microns
TDS = 5000-6000 mg/l

**Tailings Dam Water Chemistry:**
Temp. = 32-65°F
pH = 8.3
Iron = 2-3 mg/l
Ammonia = 15-25 mg/l
TSS = 2.0 – 3.0 mg/l
TDS = 1500 – 2500 mg/l
Homestake Water Treatment Plant

- Dam water
- Biological Processing
- Sand Filter Polishing
- Sand Filter Fe Removal
- Mixing Station
- Outflow
- Mine water pipeline
  - From mill reservoir
- Fe Backflush Collection
- Dam water
  - From mill reservoir
Sedimentation Clarifiers

Coagulant polymers and flocculants precipitate iron
More Efficient Sand Filters

“Geotubes” collect Fe sludge (~ 2 tons/day)
RBC’s (Rotating Biological Contactors) remove Ammonia
Final Polishing Filters
Homestake Waterfall Back in Business

~ 3 M gal/day

Fish are happy
So are the Tourists
Refurbishment of 4850 L: Before

Water isn’t best housekeeper

Flat Tire!

Air bubble
Clean Room for E-Forming Copper

MAJORANA Demonstrator experiment
4850 Level
Modernization of Davis Campus

- MAJORANA Lab "Transition Space"
- LUX
- Yates shaft

Davis Campus, 4850' level, near Yates shaft

Under Excavation
Transition Cavern Excavation
Davis Cavern Expansion

Before
Shotcreting
Ridin’ High!
Early Science Deployment

- Presently ongoing
  - Geophysics/Hydrology
  - Microbiology
  - LUX
  - MAJORANA Demonstrator
Geophysics Research

- Seismometers: SDSMT, UCB, LIGO
- Tiltmeters installations: SDSMT, UCB, FNAL
- Hydrometers: SDSMT
- Radiation monitors: Regis, USD
- “Climatology”: SDSMT
Seismometer installation (LIGO)
Cynthia Anderson
(Black Hills State)
samples “interesting”
fungus at 2000 L
Geo-Bio Research

<table>
<thead>
<tr>
<th>L</th>
<th>Description</th>
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<tbody>
<tr>
<td>300 L</td>
<td>LIGO – Low-frequency seismometer</td>
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<tr>
<td>800 L</td>
<td>LIGO</td>
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<td></td>
<td>USD – Background measurements</td>
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<tr>
<td>1250 L</td>
<td>SDSMT – Climate station</td>
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<tr>
<td>2000 L</td>
<td>SDSMT – Climate stations (2)</td>
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<tr>
<td></td>
<td>SDSMT/FNAL – HLS Tiltmeters (2)</td>
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<td>Regis – Muon/neutron monitoring</td>
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<td></td>
<td>SDSMT/UCB – Seismometers/tiltmeters (2)</td>
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<td>LIGO – Seismometer</td>
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<tr>
<td></td>
<td>BHSU – Bio characterization of fungus colonies</td>
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<tr>
<td>2600 L</td>
<td>SDSMT – Climate stations (2)</td>
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<tr>
<td>3350 L</td>
<td>Utah – Extensometers</td>
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<tr>
<td>4100 L</td>
<td>LIGO – DUGL, seismometers, laser sounding</td>
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<tr>
<td>4550 L</td>
<td>SDSMT – Hydrometry probes</td>
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Early Science at 2000 L
Major “Early” Physics Experiments

• LUX: Dark Matter search
  – Liquid Xenon TPC (350 kg)
  – Being assembled/tested in surface lab
  – To be deployed in Davis Cavern 4850 L

• MAJORANA Demonstrator: $0\nu\beta\beta$
  – E-forming lab at 4850, Ross Shops area
  – To be deployed in Davis Transition Cavern
LUX Overview

2. Thermosyphon

1. Water Shield
   In addition to liquid xenon’s self-shielding, the 8-meter diameter by 6-meter height water tank reduces gamma background by 7 orders of magnitude.

3. Photomultiplier Tubes
   Detect scintillation and ionization light of events inside the detector, they are sensitive to xenon 173 nm.

4. PMT Cu Holders
   The PMT is strongly purifying, by using a copper panel for xenon purification with a xenon-perforating panel on the right.

5. Photomultiplier Tubes (PMTs)
   Xenon is constantly being recirculated in and out of the detector for purification, shown above, with the xenon-perforating panel on the right.

6. Internal Structure
   The internal supporting frame, shown on the right, is composed of two PMT copper holder plates for the top and bottom PMT arrays and titanium struts. The materials for these components were chosen for their low radioactivity. Eikon reflects xenon.

350 kg Liquid Xenon

Anode and Electron Extraction Grids

Cathode Grid

Time Projection Chamber

Titanium Cryostats

Feedthroughs

Water Shield

Thermosyphon
LUX Deployment in Refurbished Warehouse

SANFORD Underground Science and Engineering Laboratory @ HOMESTAKE
LUX Assembly

Potential grading rings

PMT Base
Assembled Detector
Deployment
$^{76}$Ge $0\nu\beta\beta$ -decay

Background suppression goal:
>
1 count/ton-year in region of interest
(\sim 4$^{\text{keV}}$ around 2039$^{\text{keV}}$)

Endpoint Energy (2039 keV)
Plans for Deployment

Low background cryostats and shields:
- Develop electroforming techniques in underground environment
- Ultra clean assembly techniques
Germanium Detectors

~40 kg Ge (>50% enriched $^{76}\text{Ge}$)
- Crystal growth, detector manufacture
- Optimized mounting supports
Plans for Deployment

Electroforming lab in Ross Shops area of 4850L

Assembly and counting area in Davis Campus 4850 L
Electroplating Systems

Copper plating bath

Mandrel
Current Status

• All funding for Sanford Lab activities provided by:
  – State of South Dakota
  – Donations by T. Denny Sanford

• DUSEL PDR (Preliminary Design Report) has been completed
  – Passed internal reviews with high marks
  – Will be delivered to NSF
  – Serves as a “catalog” of options for future lab
Current Status

- NSF has withdrawn support for DUSEL
  - NSB (National Science Board) refused to authorize any further funding
  - Fiscal climate made cutting easy
- DOE will support “its experiments”
  - Long Baseline (LBNE) from Fermilab
  - Majorana
  - Dark matter (?)
Personal Perspective

- Laboratory will continue
  - DOE will manage and operate
- It will be substantially smaller than originally envisioned
- NSF will participate, supporting experiments and programs DOE not interested in
  - Bio, Geo, Engineering
  - Education, Outreach
- It will take several years to sort things out
Near Term

- Sanford Laboratory has great momentum
- Infrastructure rehabilitation and setup of Davis Campus will continue
- “Early Science” program will continue and thrive
  - Small geoscience experiments
  - Microbiological characterization
  - LUX
  - Majorana Demonstrator
There’s real gold at the end of this rainbow!
Long Baseline Neutrino Experiment

Homestake

900 Miles

Fermilab

SANFORD Underground Science and Engineering Laboratory  @ HOMESTAKE
Long Baseline Neutrino Experiment (LBNE)

**Anti-Neutrino Mode**
- Protons \(~100\text{ GeV}\)
- Focusing Lens
- \(\pi^+\), \(\pi^-\), \(K^+\), \(K^-\)

**Focusing Lens**
- (current direction)
- Evacuated drift space \((\pi, K\text{ decay})\)

**Neutrino Mode**
- ~1 km

**Target**
- ~1000 km

**300 kTon Water Cherenkov detector**

**ROCK**
Super-Kamiokande --- Japan
50,000 tons water-Cherenkov
Rock Volume in Perspective
First inspection crew on 4850 L