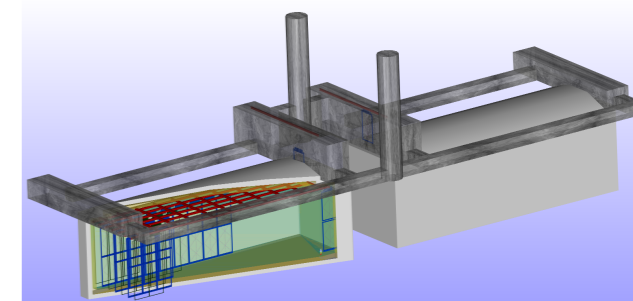


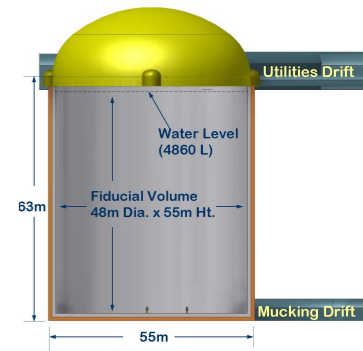
# Status of LBNE at DUSEL

Milind V. Diwan  
Laguna General Meeting  
March 3-4, 2011

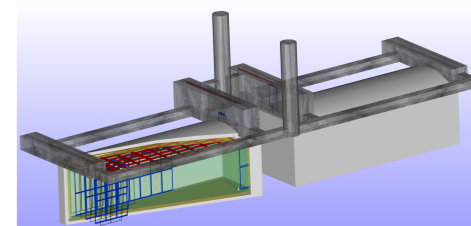
LBNE: Long-Baseline Neutrino Experiment  
DUSEL: Deep Underground Science and Engineering Laboratory.



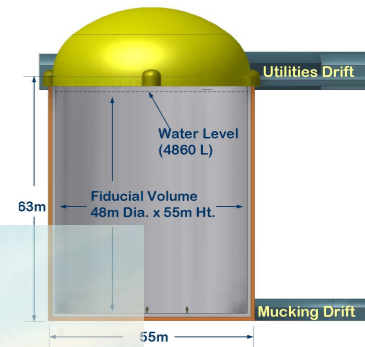
# Outline



- Summary of recent news and collaboration status.
- Status of the Homestake/DUSEL site.
- Summary progress on Water Cherenkov and Liquid Argon detectors at Homestake.
- Timetable over the next few months.



# Long-Baseline Neutrino Experiment Collaboration



**Alabama:** J. Goon, I Stancu

**Argonne:** M. D'Agostino, G. Drake, Z. Djurcic, M. Goodman, X. Huang, V. Guarino, J. Paley, R. Talaga, M. Wetstein

**Boston:** E. Hazen, E. Kearns, J. Raaf, J. Stone

**Brookhaven:** M. Bishai, R. Brown, H. Chen, M. Diwan, J. Dolph, G. Geronimo, R. Gill, R. Hackenberg, R. Hahn, S. Hans, D. Jaffe, S. Junnarkar, J.S. Kettell, F. Lanni, L. Littenberg, J. Ling, D. Makowiecki, W. Marciano, W. Morse, Z. Parsa, C. Pearson, V. Radeka, S. Rescia, T. Russo, N. Samios, R. Sharma, N. Simos, J. Sondericker, J. Stewart, H. Tanaka, C. Thorn, B. Viren, Z. Wang, S. White, L. Whitehead, M. Yeh, B. Yu

**Caltech:** R. McKeown, X. Qian, C. Zhang

**Cambridge:** A. Blake, M. Thomson

**Catania/INFN:** V. Bellini, G. Garilli, R. Potenza, M. Trovato

**Chicago:** E. Blucher

**Colorado:** R. Johnson, A. Marino, M. Tzanov, E. Zimmerman

**Colorado State:** M. Bass, B. Berger, J. Brack, N. Buchanan, J. Harton, V. Kravtsov, W. Toki, D. Warner, R. Wilson

**Columbia:** R. Carr, L. Camillieri, C.Y. Chi, G. Karagiorgi, C. Mariani, M. Shaevitz, W. Sippach, W. Willis

**Crookston:** D. Demuth

**Dakota State:** B. Szczerbinska

**Davis:** R. Breedon, T. Classen, J. Felde, P. Gupta, M. Tripanthi, R. Svoboda

**Drexel:** C. Lane, J. Maricic, R. Milincic, K. Zbiri

**Duke:** J. Fowler, J. Prendki, K. Scholberg, C. Walter, R. Wendell

**Duluth:** R. Gran, A. Habig

**Fermilab:** D. Allspach, M. Andrews, B. Baller, D. Boehnlein, M. Campbell, A. Chen, S. Childress, B. DeMaat, A. Drozhdin, T. Dykhuis, A. Hahn, S. Hays, J. Howell, P. Huhr, J. Hulen, M. Johnson, J. Johnstone, T. Junk, B. Kayser, G. Koizumi, T. Lackowski, P. Lucas, B. Lundberg, T. Lundin, P. Mantsch, N. Mokhov, C. Moore, J. Morfin, B. Norris, V. Papadimitriou, R. Plunkett, C. Polly, S. Pordes, O. Prokofiev, G. Rameika, B. Rebel, D. Reitzner, K. Riesselmann, R. Rucinski, R. Schmidt, D. Schmitz, P. Shanahan, J. Strait, S. Striganov, K. Vaziri, G. Velev, G. Zeller, R. Zwaska

**Hawaii:** S. Dye, J. Kumar, J. Learned, S. Matsuno, S. Pakvasa, M. Rosen, G. Varner

**Indian Universities:** V. Singh (BHU); B. Choudhary, S. Mandal (DU); B. Bhuyan [IIT(G)]; V. Bhatnagar, A. Kumar, S. Sahijpal (PU)

**Indiana:** W. Fox, C. Johnson, M. Messier, S. Mufson, J. Musser, R. Tayloe, J. Urheim

**Iowa State:** M. Sanchez

**IPMU/Tokyo:** M. Vagins

**Irvine:** G. Carminati, W. Kropp, M. Smy, H. Sobel

**Kansas State:** T. Bolton, G. Horton-Smith

**LBL:** R. Kadel, B. Fujikawa, D. Taylor

**Livermore:** A. Bernstein, R. Bionta, S. Dazeley, S. Ouedraogo

**London-UCL:** J. Thomas

**Los Alamos:** S. Elliott, A. Friedland, V. Gehman, G. Garvey, T. Haines, D. Lee, W. Louis, C. Mauger, G. Mills, A. Norrick, Z. Pavlovic, G. Sinnis, W. Sondheim, R. Van de Water, H. White

**Louisiana State:** W. Coleman, T. Kutter, W. Metcalf, M. Tzanov

**Maryland:** E. Blaufuss, R. Hellauer, T. Straszheim, G. Sullivan

**Michigan State:** E. Arrieta-Diaz, C. Bromberg, D. Edmunds, J. Huston, B. Page

**Minnesota:** M. Marshak, W. Miller

**MIT:** W. Barletta, J. Conrad, T. Katori, R. Lanza, L. Winslow

**NGA:** S. Malys, S. Usman

**New Mexico:** B. Becker, J. Mathews

**Notre Dame:** J. Losecco

**Oxford:** G. Barr, J. DeJong, A. Weber

**Pennsylvania:** J. Klein, K. Lande, A. Mann, M. Newcomer, R. vanBerg

**Pittsburgh:** D. Naples, V. Paolone

**Princeton:** Q. He, K. McDonald

**Rensselaer:** D. Kaminski, J. Napolitano, S. Salon, P. Stoler

**Rochester:** R. Bradford, K. McFarland

**SDMST:** X. Bai, R. Corey

**SMU:** T. Liu, J. Ye

**South Carolina:** H. Duyang, S. Mishra, R. Petti, C. Rosenfeld

**South Dakota State:** B. Bleakley, K. McTaggart

**Syracuse:** M. Artuso, S. Blusk, T. Skwarnicki, M. Soderberg, S. Stone

**Texas:** S. Kopp, K. Lang, R. Mehdiyev

**Tufts:** H. Gallagher, T. Kafka, W. Mann, J. Schnepps

**UCLA:** K. Arisaka, D. Cline, K. Lee, Y. Meng, F. Sergiampietri, H. Wang

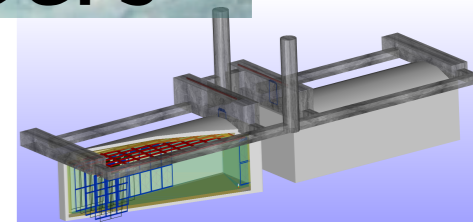
**Virginia Tech:** E. Guarnaccia, J. Link, D. Mohapatra, R. Raghavan

**Washington:** S. Enomoto, J. Kaspar, N. Tolich, H.K. Tseung

**Wisconsin:** B. Balantekin, F. Feyzi, K. Heeger, A. Karle, R. Maruyama, D. Webber, C. Wendt

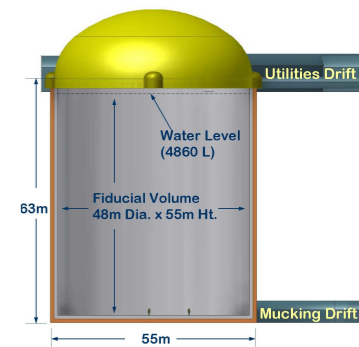
**Yale:** E. Church, B. Fleming, R. Guenette, J. Spitz

## 55 inst., ~280 members



# DUSEL's Scientific Goals have been Extensively Reviewed and Documented

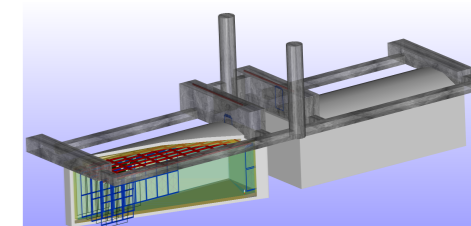
- Bahcall Committee Report 2001
- Nuclear Physics Long Range Plan 2002
- Connecting Quarks to the Cosmos
- HEPAP Long Range Plan 2003
- Neutrinos and Beyond
- EarthLab
- Physics of the Universe
- The Neutrino Matrix
- Discovering the Quantum Universe
- Deep Science
- Nuclear Physics Long Range Plan 2007
- 2008 P5 Report (also 2010 update of P5)
- 2009 PASAG
- 2010 NRC Study now underway



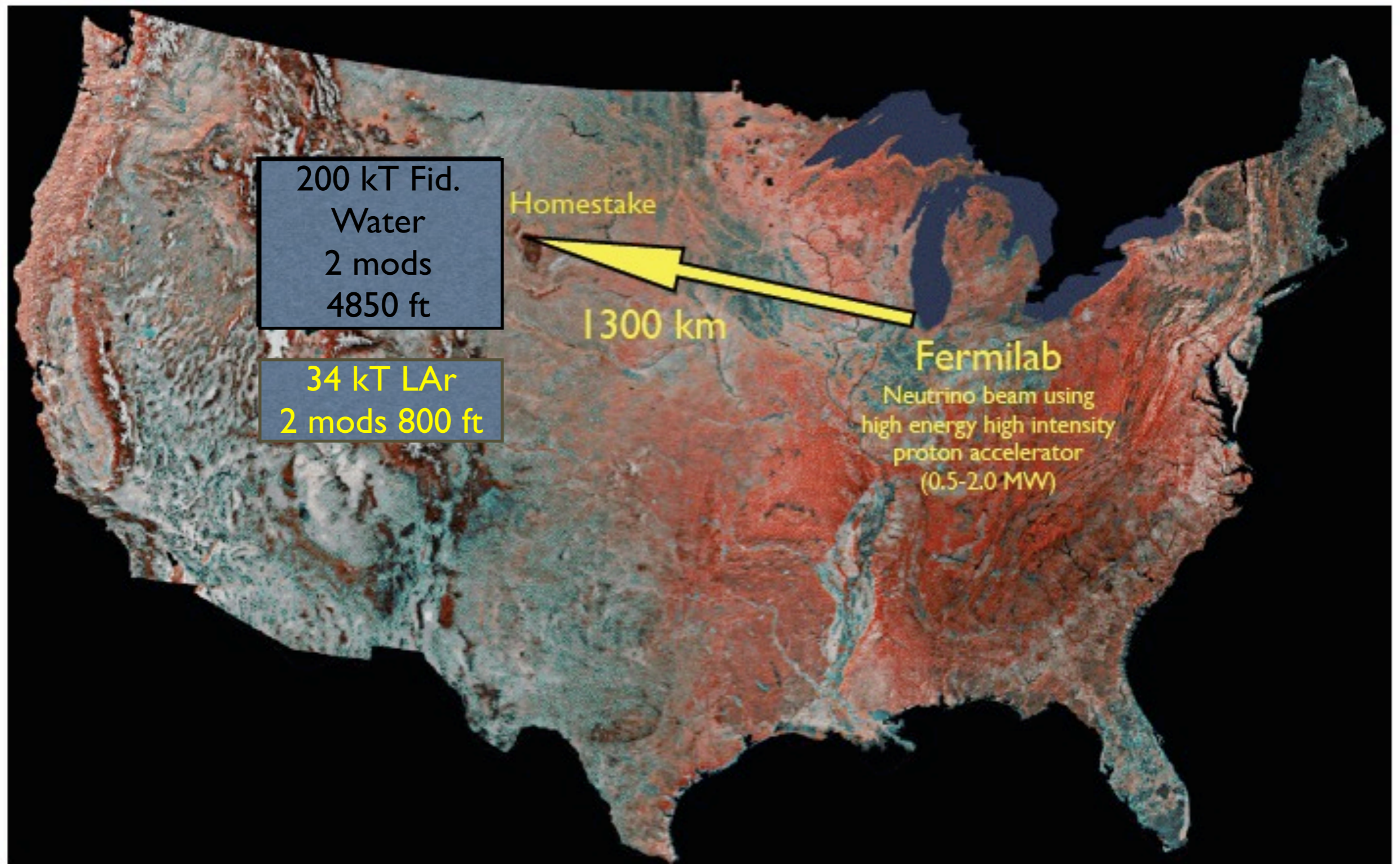
Site selection was with open competition in 2007 out of 8 sites

Slide from K. Lesko on how the LBNE/DUSEL plans evolved.

LBNE is a central part of DUSEL and the joint planning has been open, detailed, and deliberate with help from US and world science community.

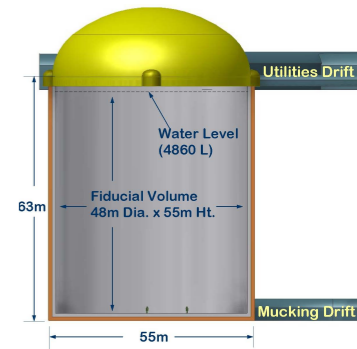
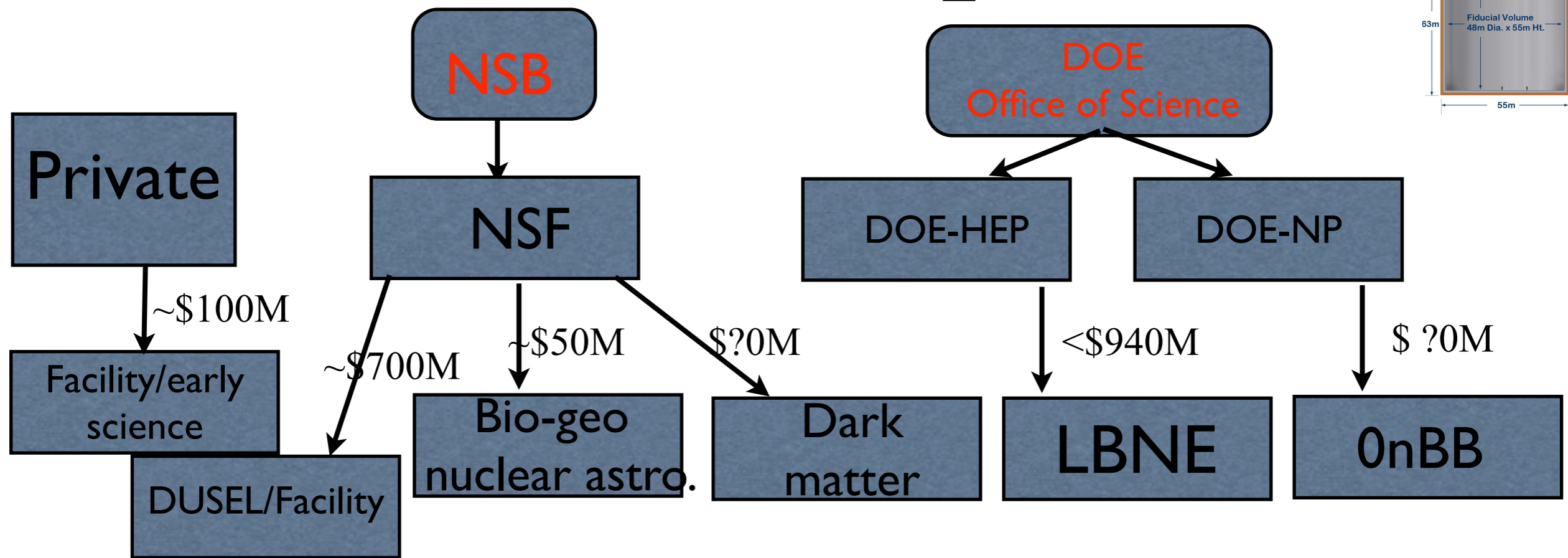


# Long-Baseline Neutrino Experiment



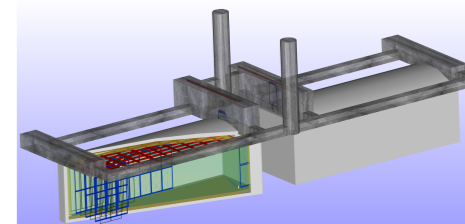
There are no plans to move the arrow, yet.

# Financial plan

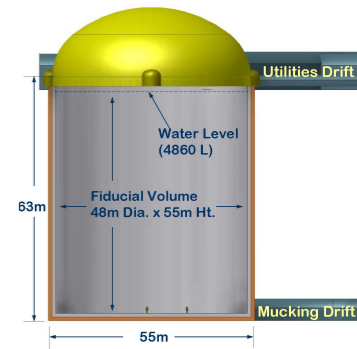
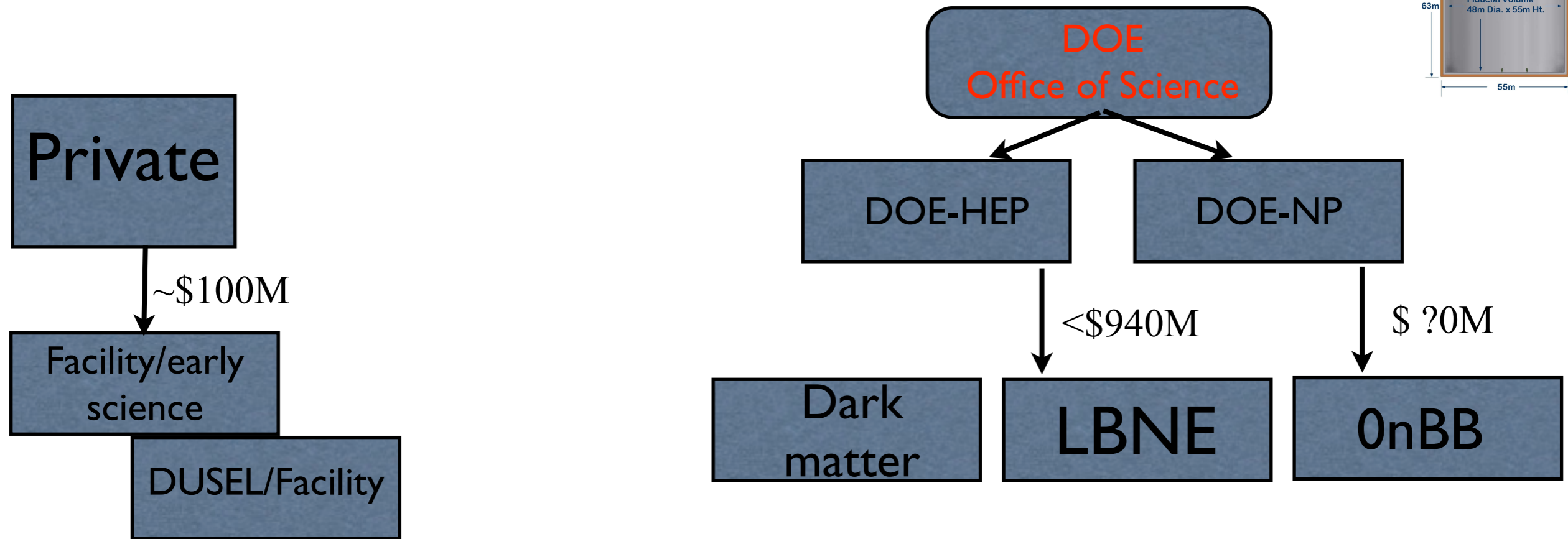


NSF: US National Science Foundation, NSB: National Science Board  
 DOE: US department of energy, HEP: High Energy, NP: Nuclear Physics

- Committee on Plans and Programs of the National Science Board did not recommend an additional \$19M this year for design funding for DUSEL-Facility.
- They dislike the above model in which NSF handles the facility.

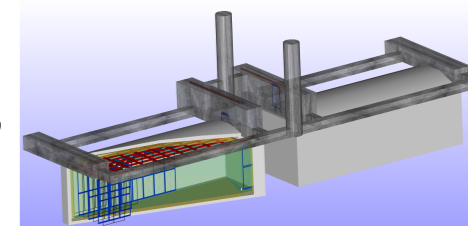


# Financial plan

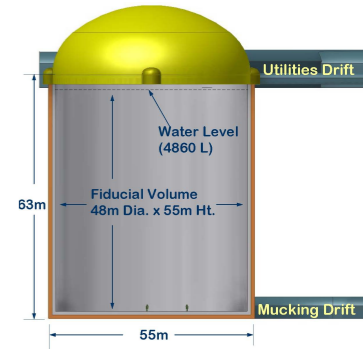
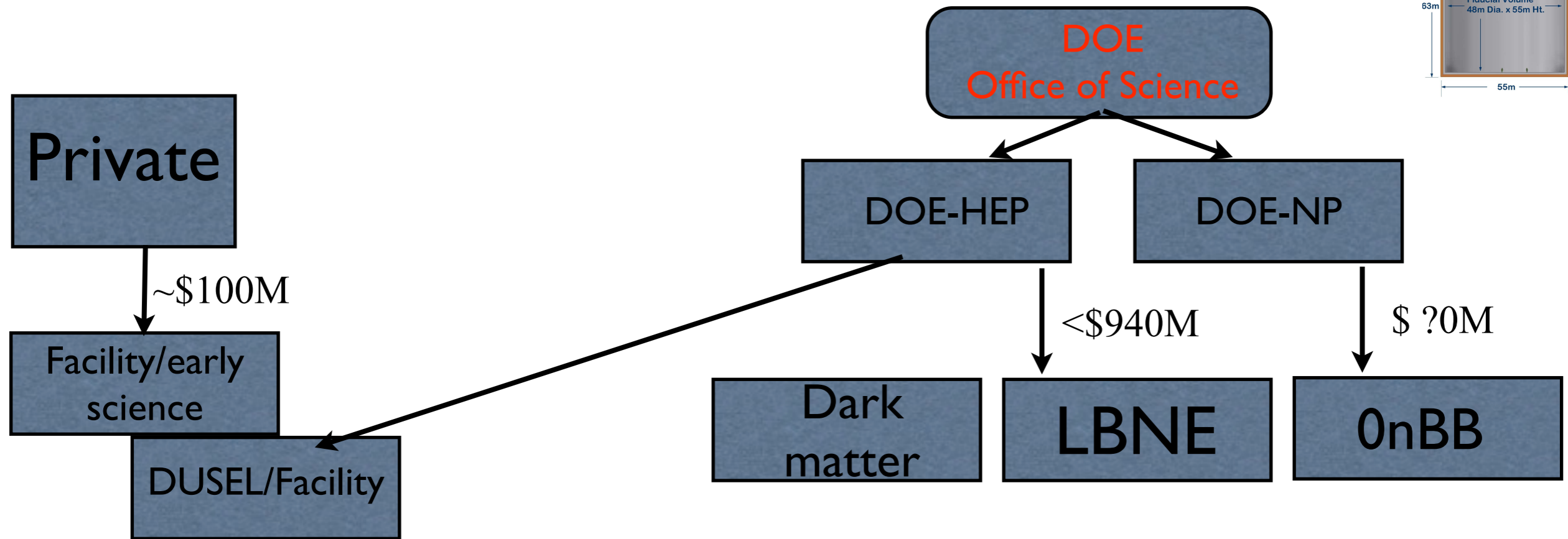


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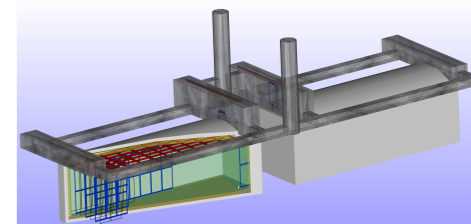


# Financial plan



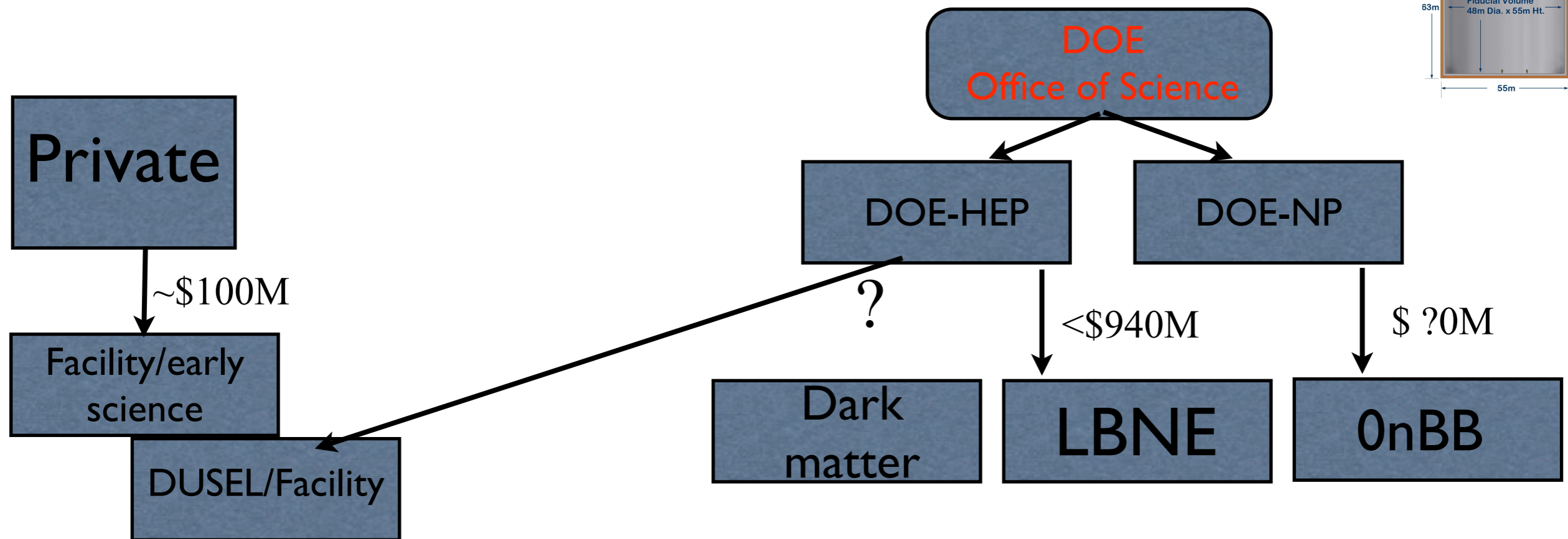
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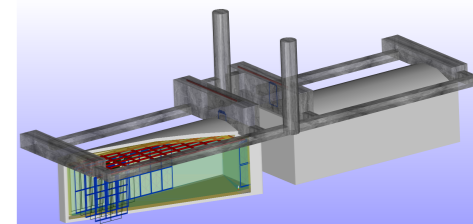


# Financial plan

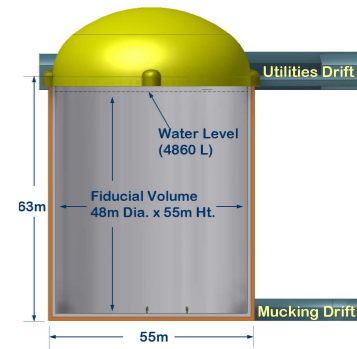
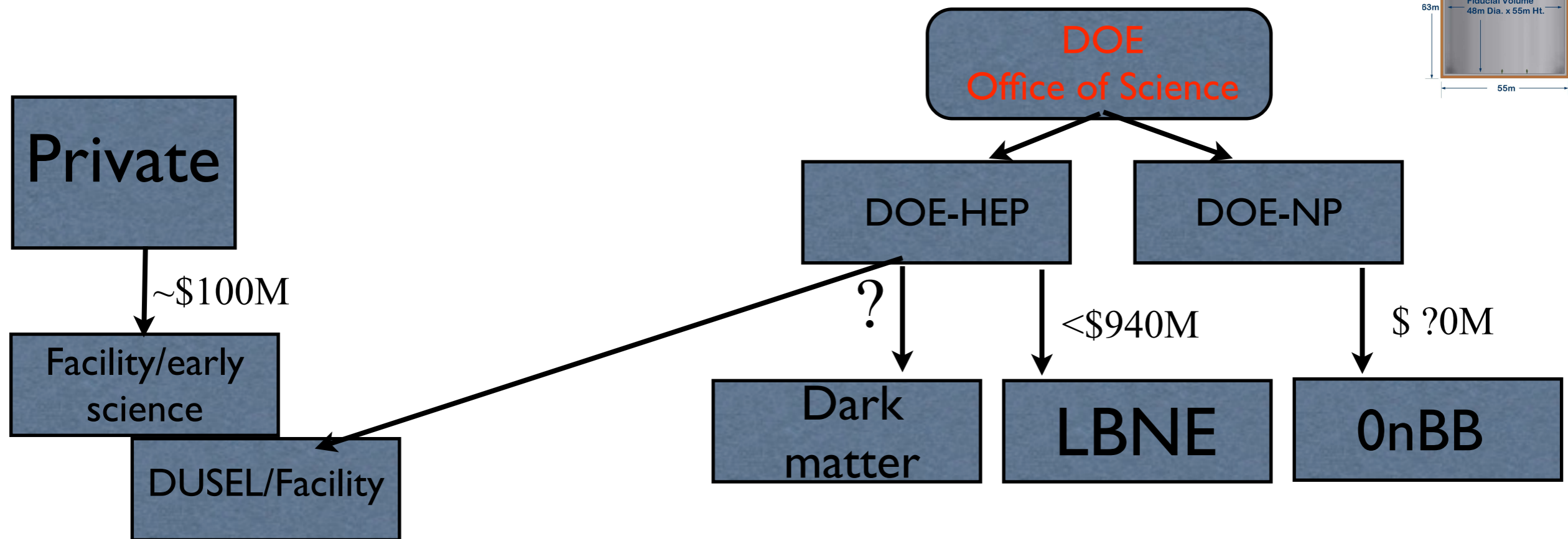


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- Committee on Plans and Programs of the National Science Board did not recommend an additional \$19M this year for design funding for DUSEL-Facility.
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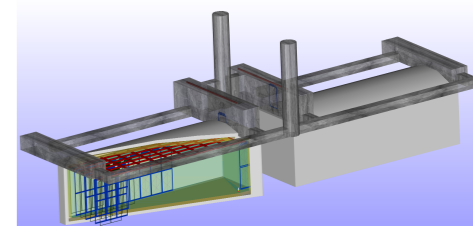


# Financial plan



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- Committee on Plans and Programs of the National Science Board did not recommend an additional \$19M this year for design funding for DUSEL-Facility.
- They dislike the above model in which NSF handles the facility.



# Message from US DOE

## DOE Perspective

**Summary: DOE HEP is continuing to pursue LBNE independent of the current DUSEL situation**

- Deputy Secretary of Energy Approved Mission Need for LBNE (CD-0) on January 8, 2010
  - The location of the far detector at DUSEL and a partnership with NSF was a possibility not a necessity
  - **The Mission Need was independent of whether or not the NSF was constructing DUSEL**
  - Our LBNE project is going forward and locating the far detector at Homestake with or without DUSEL remains a possibility
- Consistent with this we have tasked the project team with estimating the cost of two options (water Cherenkov at 4850 ft or LAr at 800 ft) including the minimal infrastructure assuming DOE bears the full cost



**There will be delays ...**

E. Rosenberg

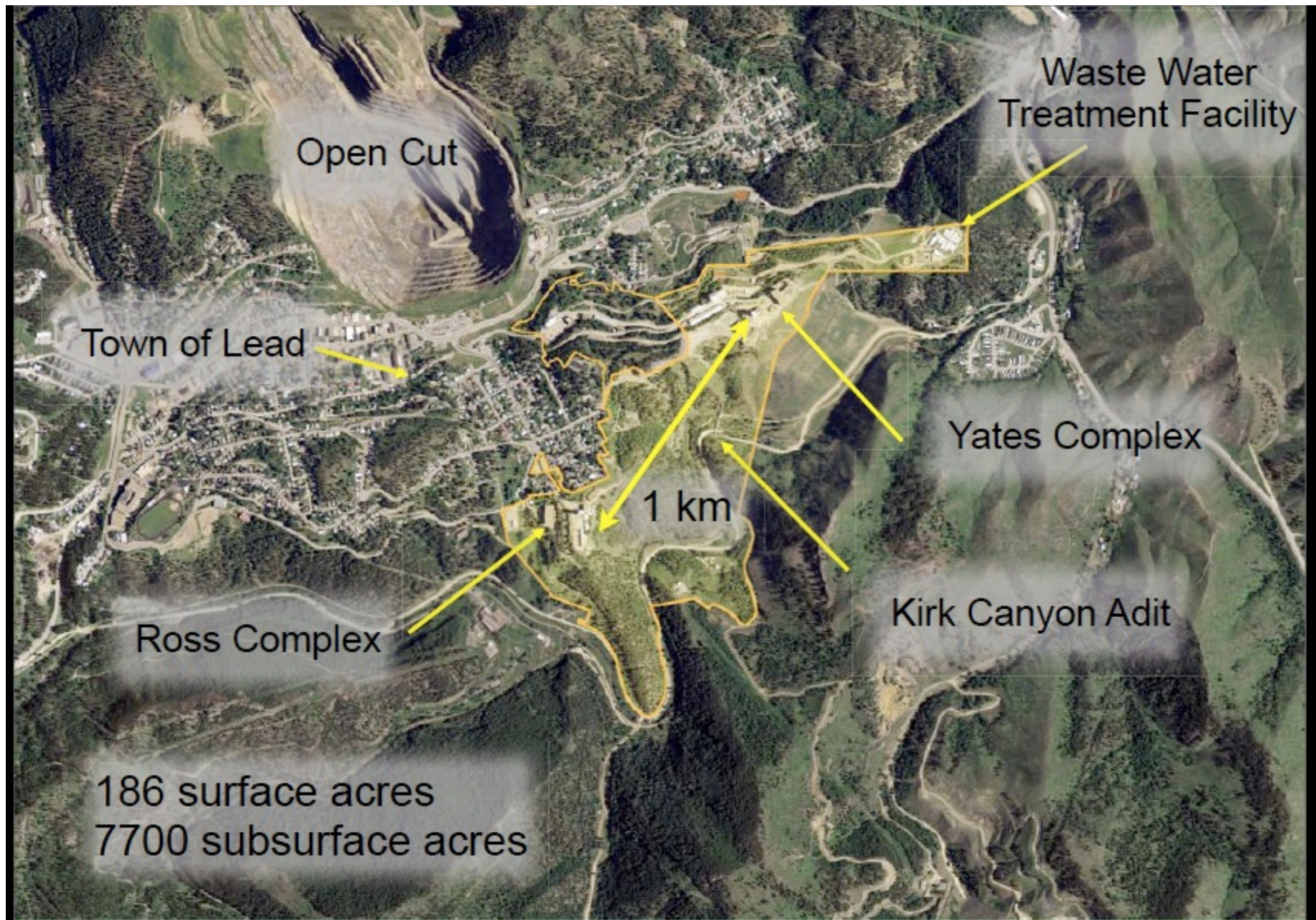
# Next steps

- A committee has been formed with Dr. Jay Marx as chair.
- They will recommend to the DOE a plan that can be carried out with known budget projections.
- Committee must report by end of May so that budgets for 2013 can be influenced.
- Money has been set aside to continue dewatering and safety operations at Homestake.
- A second committee (with chair as Prof. Lankford (UC/Irvine)) has been asked to recommend on science.

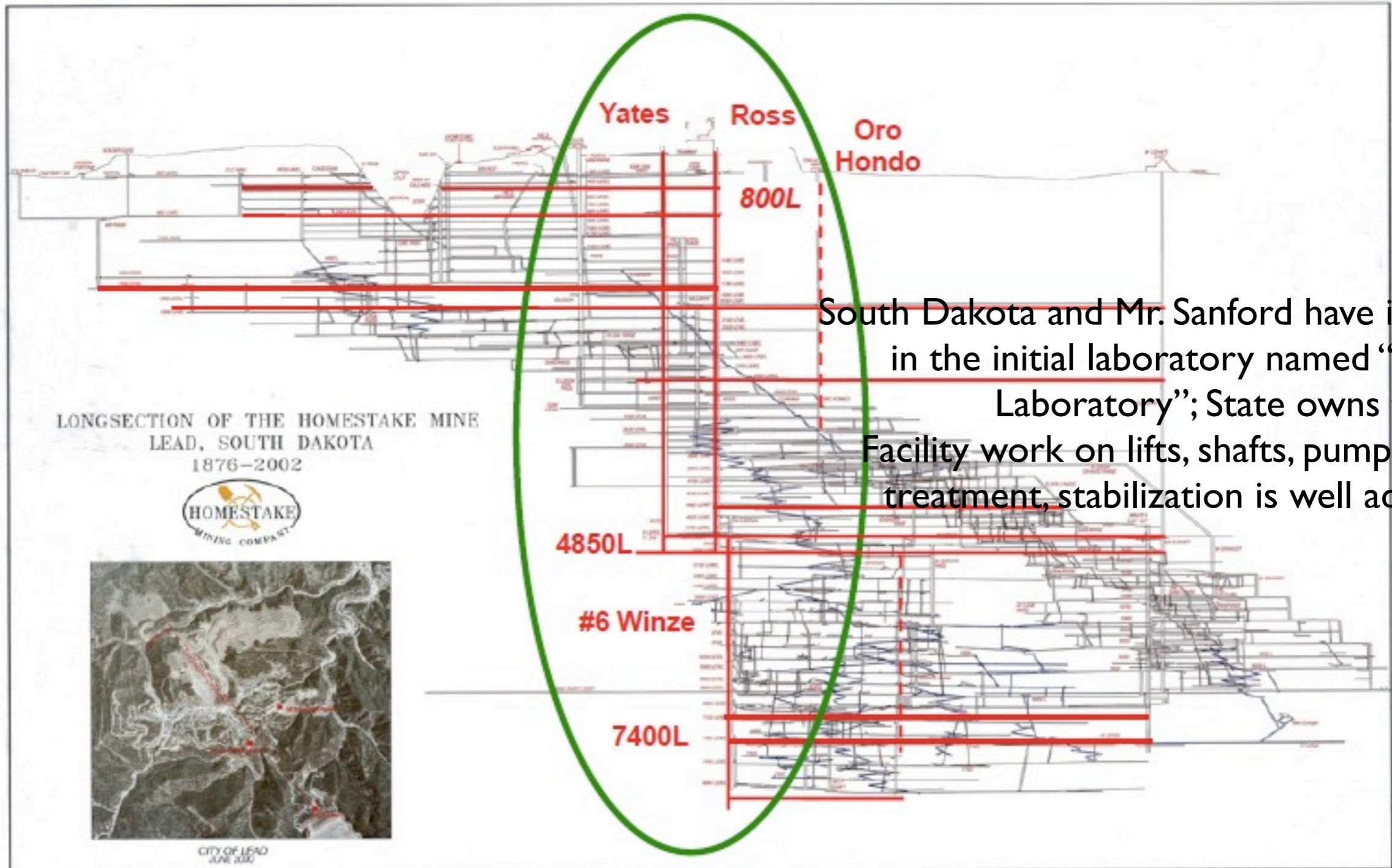
It is very important for the US physics community that we get support from the international community: specifically that LBNE/DUSEL is worth doing in the US.



# Status of the Homestake site



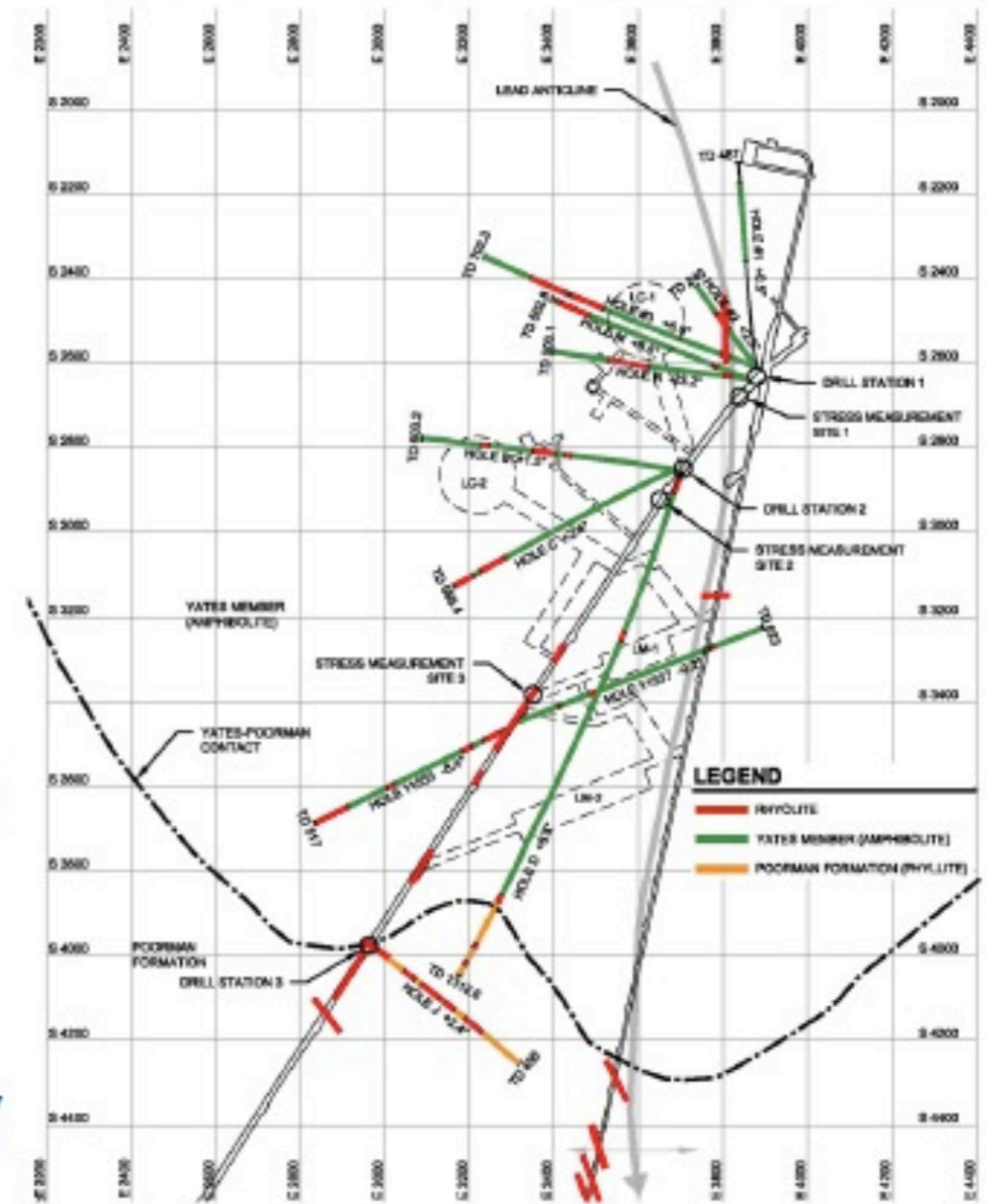
# Cross Section of the Homestake Site



South Dakota and Mr. Sanford have invested in the initial laboratory named “Sanford Laboratory”; State owns the site. Facility work on lifts, shafts, pumps, water treatment, stabilization is well advanced.

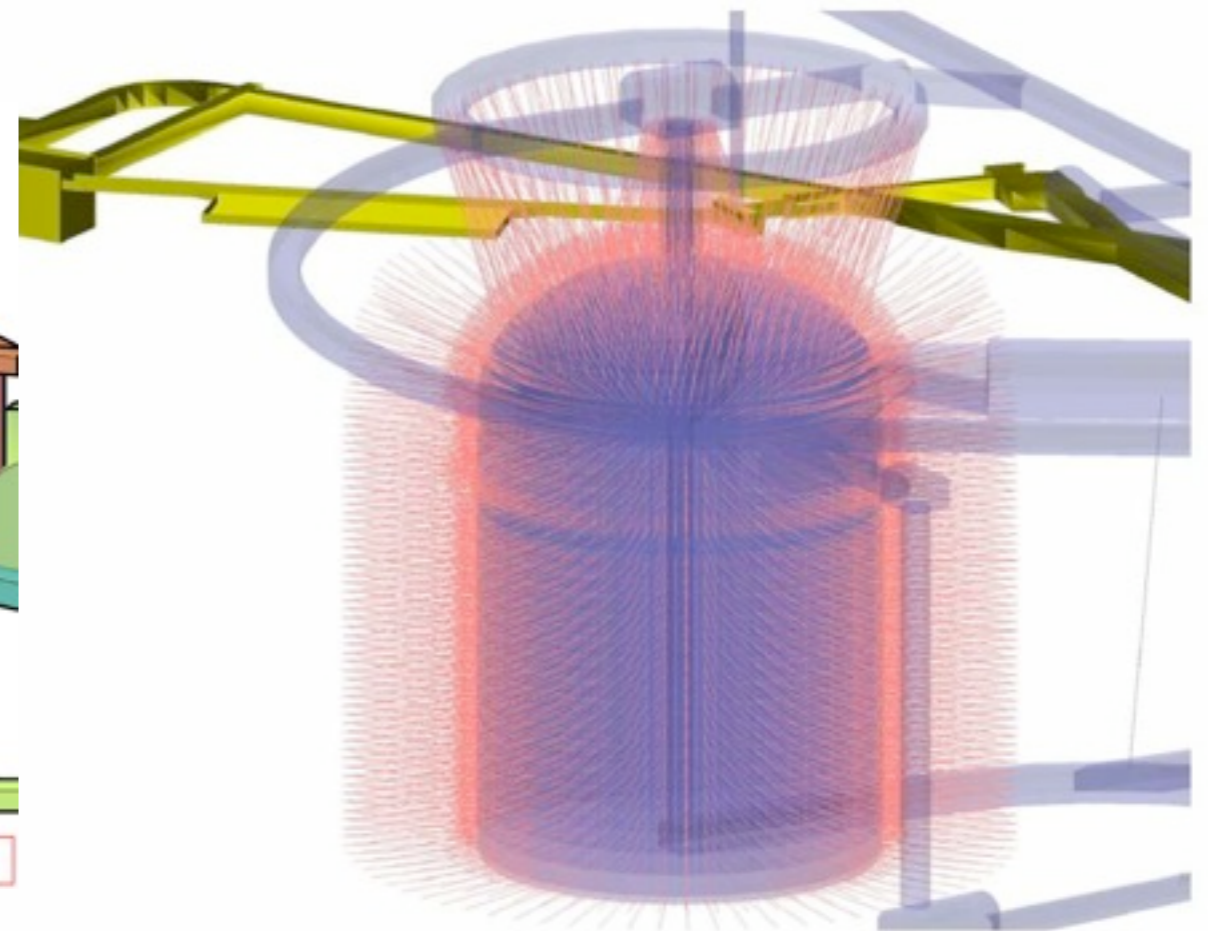
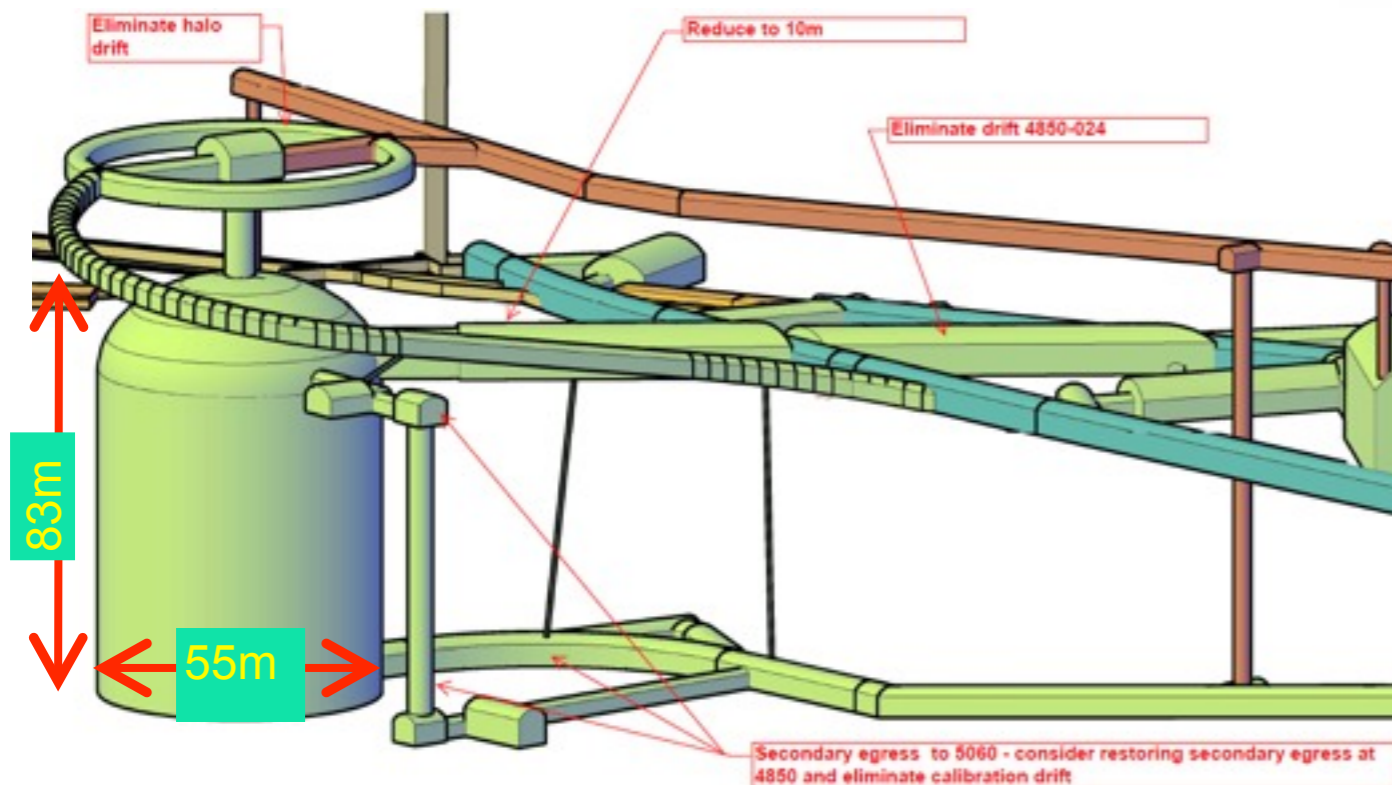
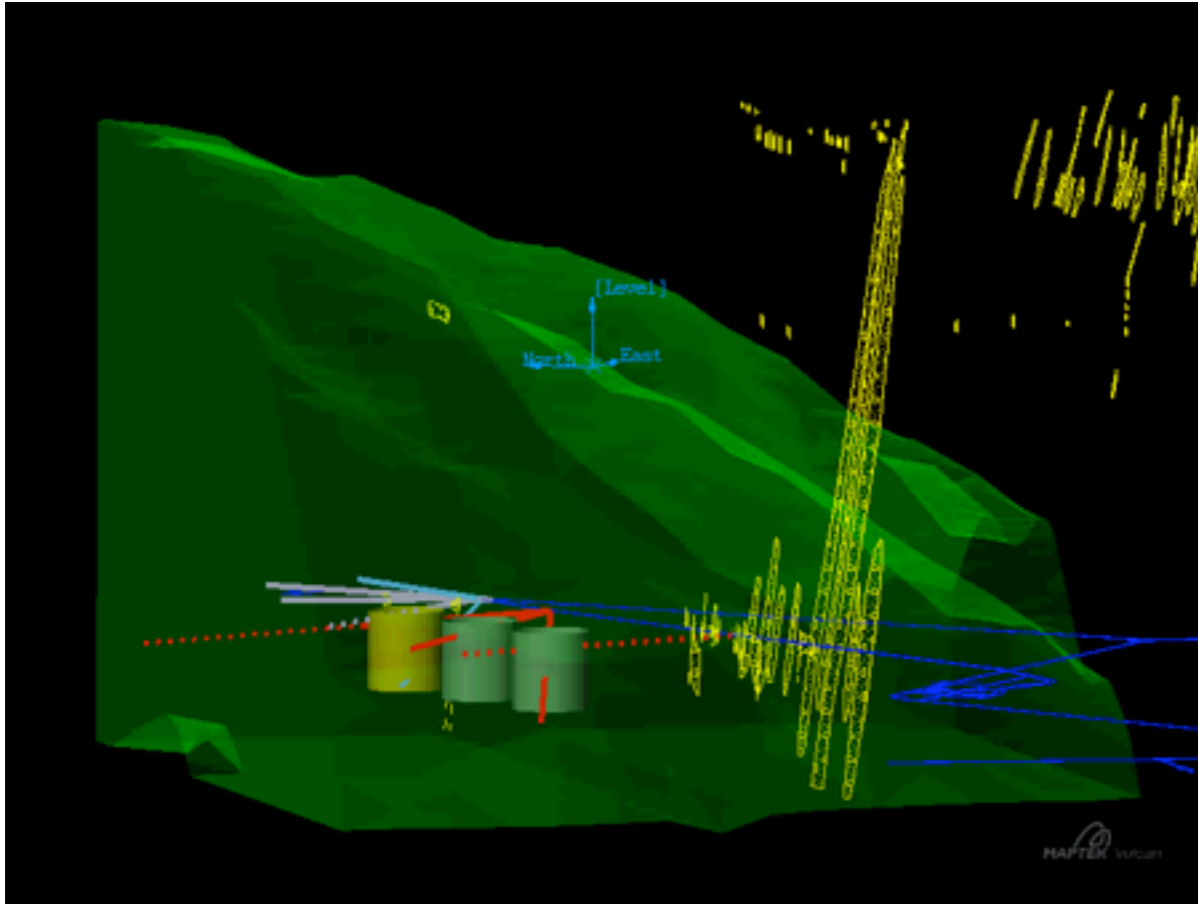
# Completed Critical Geotechnical Investigations

- 300 & 4850 Level Mapping - Completed
  - Geological Model - Developed
  - Coring and Logging - Completed
    - holes 1, 2, 3: [Sanford Lab](#)
    - holes 3, M, N: [LC 1](#)
    - holes B, C: [LC 2, LC3](#)
    - holes D, J: [4850 Lab Modules](#)
    - 5,399 feet of core: logged, televue
    - “enough geotech for preliminary design” - Large Cavity Advisory Board
  - *In situ* testing - Completed
  - Laboratory testing - Completed
- Good news: Little Water, Good to Very Good Rock Quality**



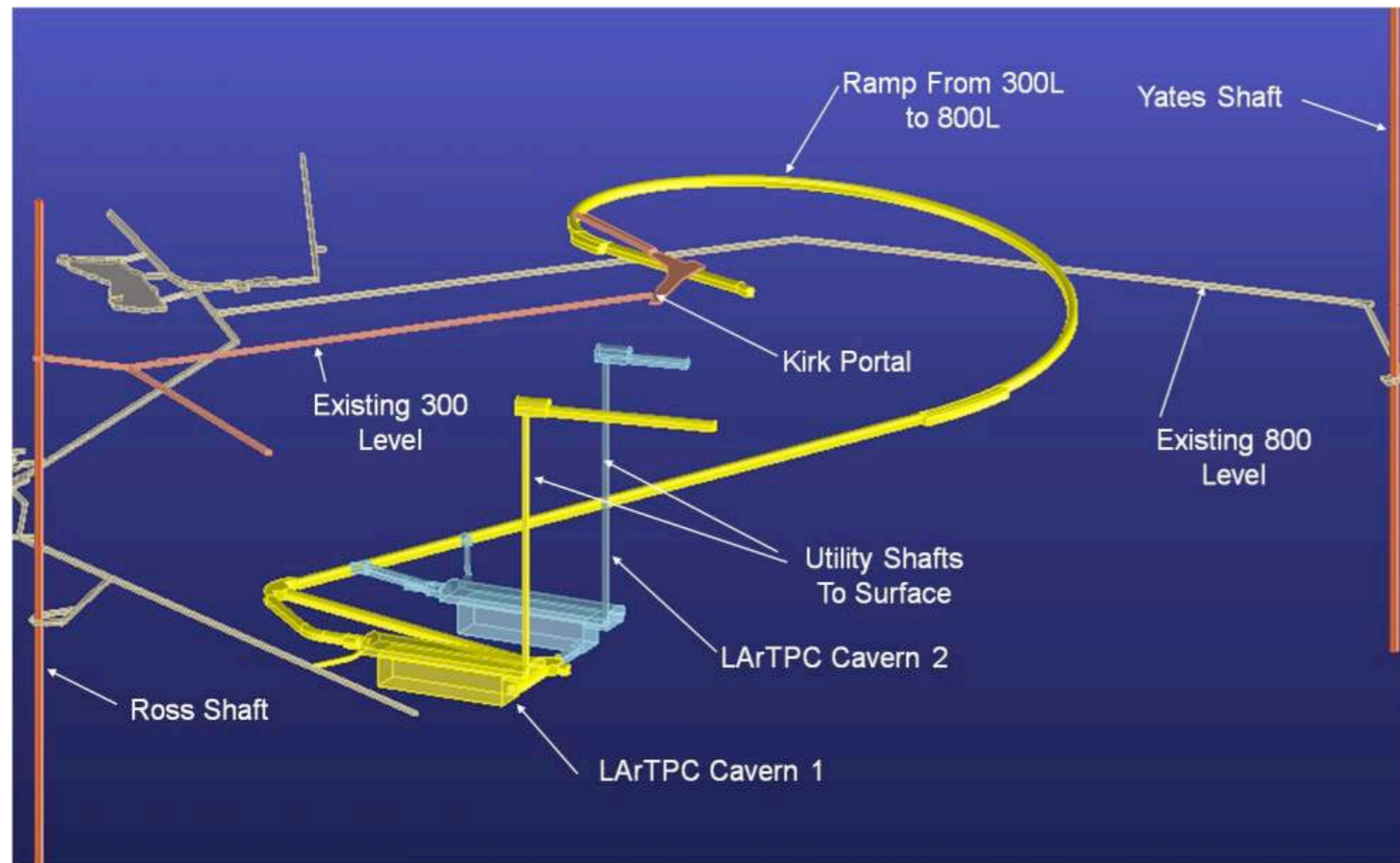
# Site investigation and preliminary design

- Confidence in 55m span WCD cavity is high after much detailed design. (100kTon)
- Initial studies show that 200kTon could be possible

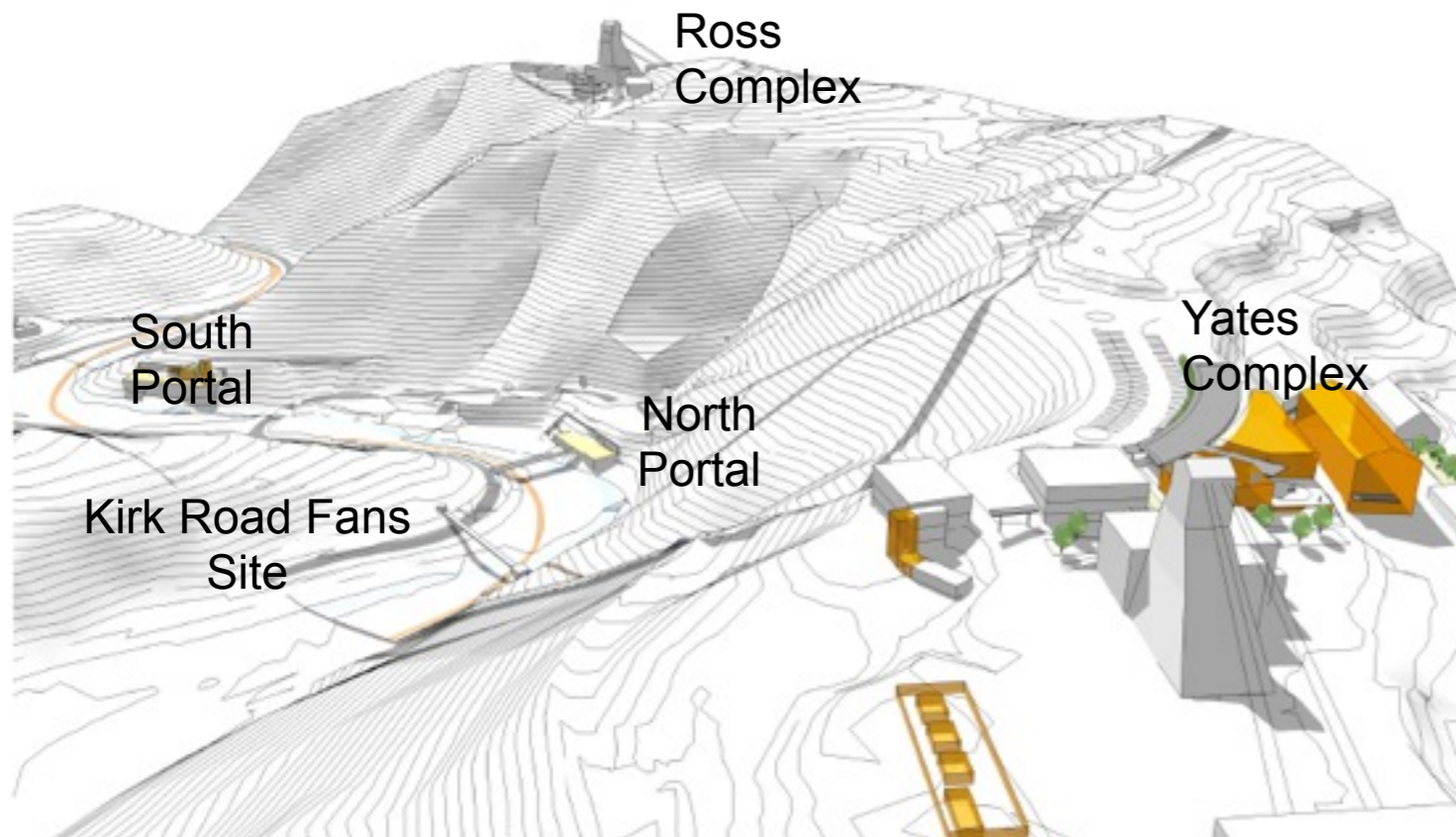




# Site proposal for 34 kTon liquid argon



- Liquid Argon development is proposed to be at 800 ft level.
- Keep separated from rest of lab.
- Allow horizontal access through tunnel.
- Rock is not fully explored, but caverns are smaller.

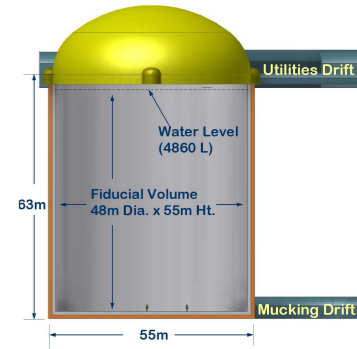


Technical progress on detectors

A quick tour through interesting work

# Long-Baseline Physics

[www.int.washington.edu/PROGRAMS/10-2b/LBNEPhysicsReport.pdf](http://www.int.washington.edu/PROGRAMS/10-2b/LBNEPhysicsReport.pdf) (Bob Wilson, et. al)



Effort into understanding and improving performance.

Physics Working Group report is public with many details.

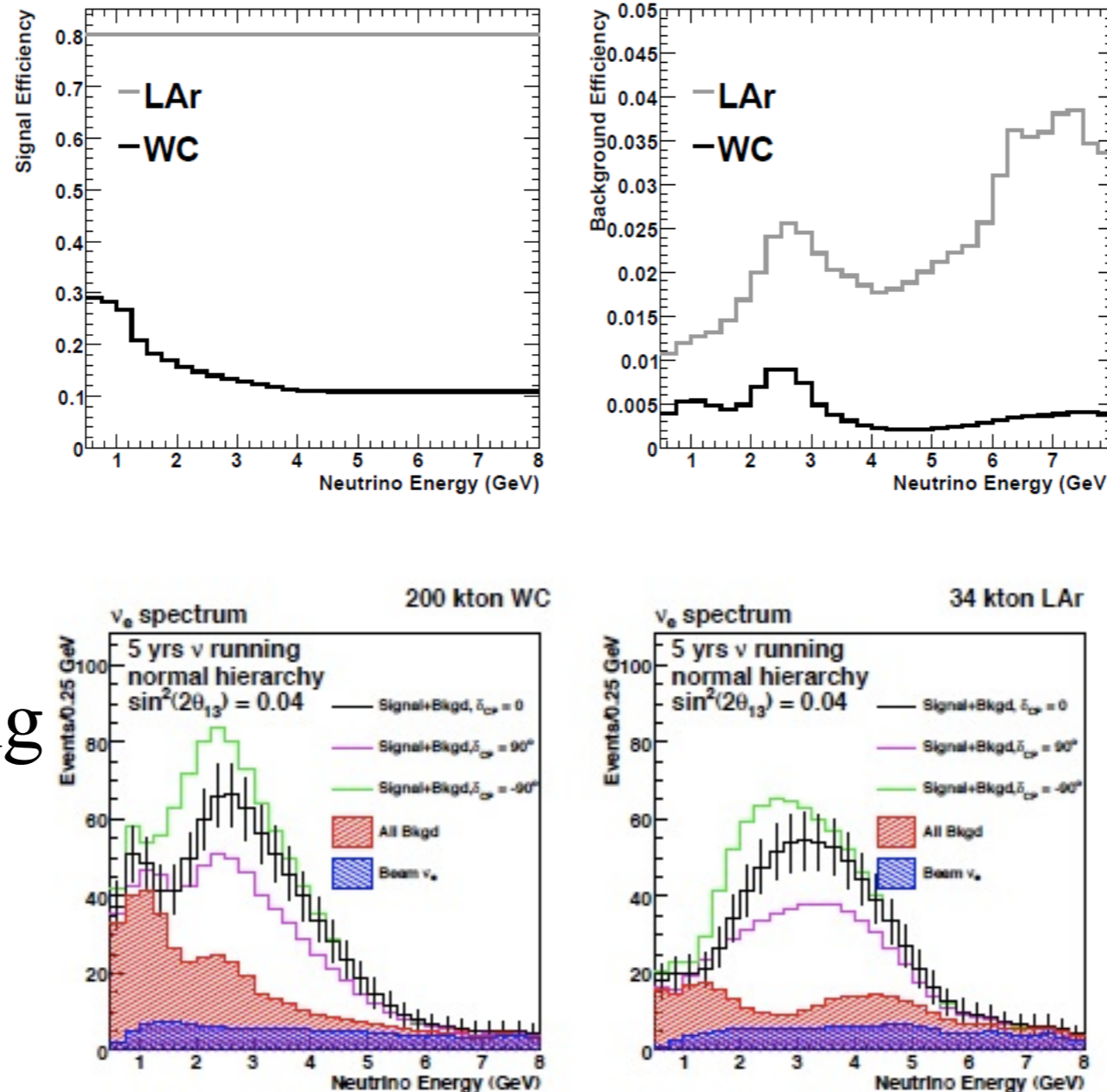
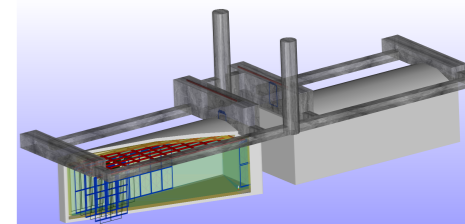


FIG. 9. The expected  $\nu_e$  appearance spectrum for a 200 kt WC (left) and 34 kt LAr (right) detector for  $\sin^2 2\theta_{13} = 0.04$  and 5 years of neutrino running in a 700 kW beam assuming a *normal* mass hierarchy. The black points assume  $\delta_{CP} = 0$  while the green and pink lines are for  $\delta_{CP} = \pm 90^\circ$ . The different background contributions are indicated by the hatched histograms.

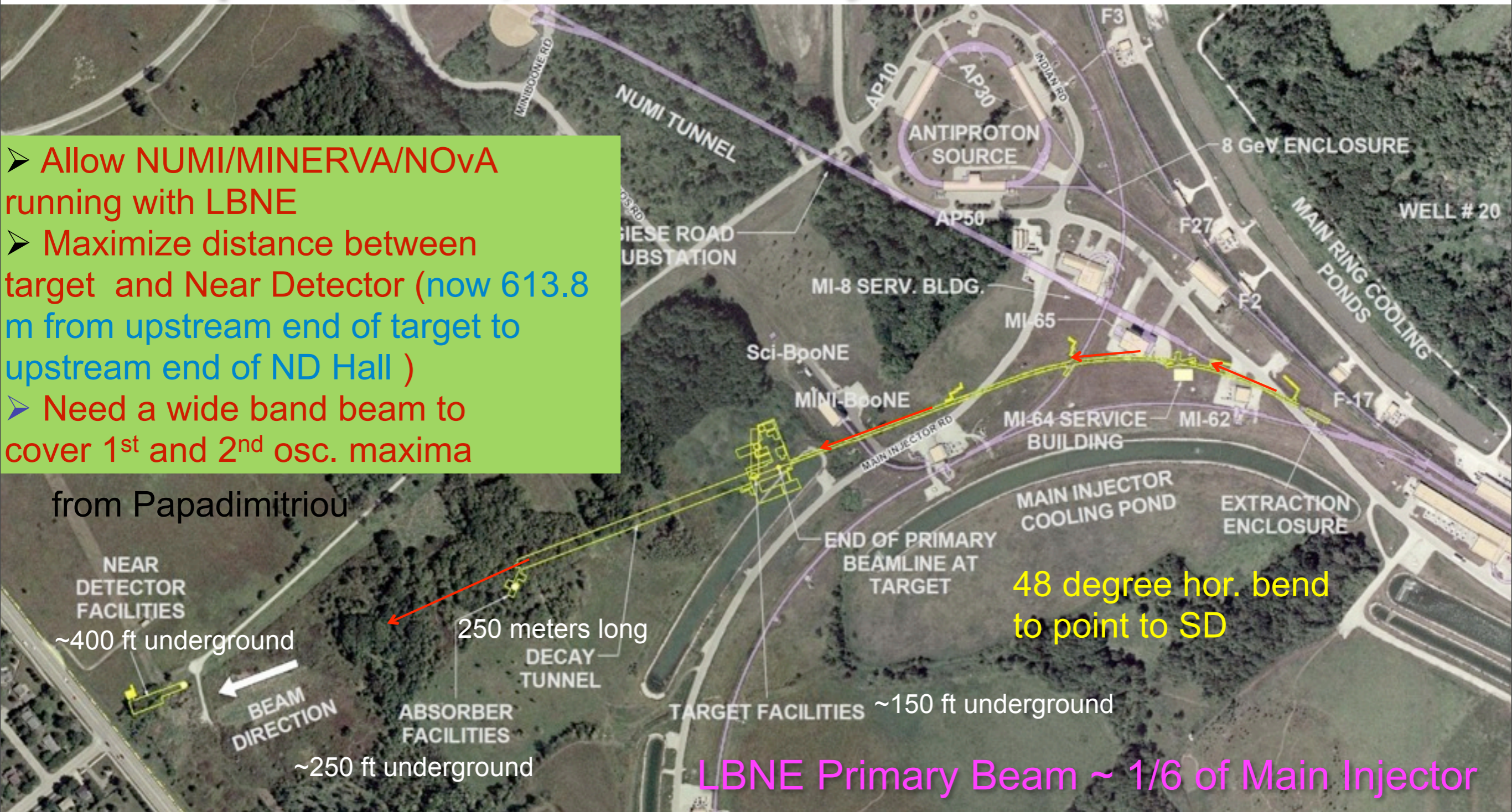
WCD performance is getting improved with new code.



# The Neutrino Beam Facility at Fermilab

Start with a 700 kW beam, and then take profit of the significantly increased beam power (2.3 MW) available with Project X

- Allow NUMI/MINERVA/NOvA running with LBNE
- Maximize distance between target and Near Detector (now 613.8 m from upstream end of target to upstream end of ND Hall)
- Need a wide band beam to cover 1<sup>st</sup> and 2<sup>nd</sup> osc. maxima



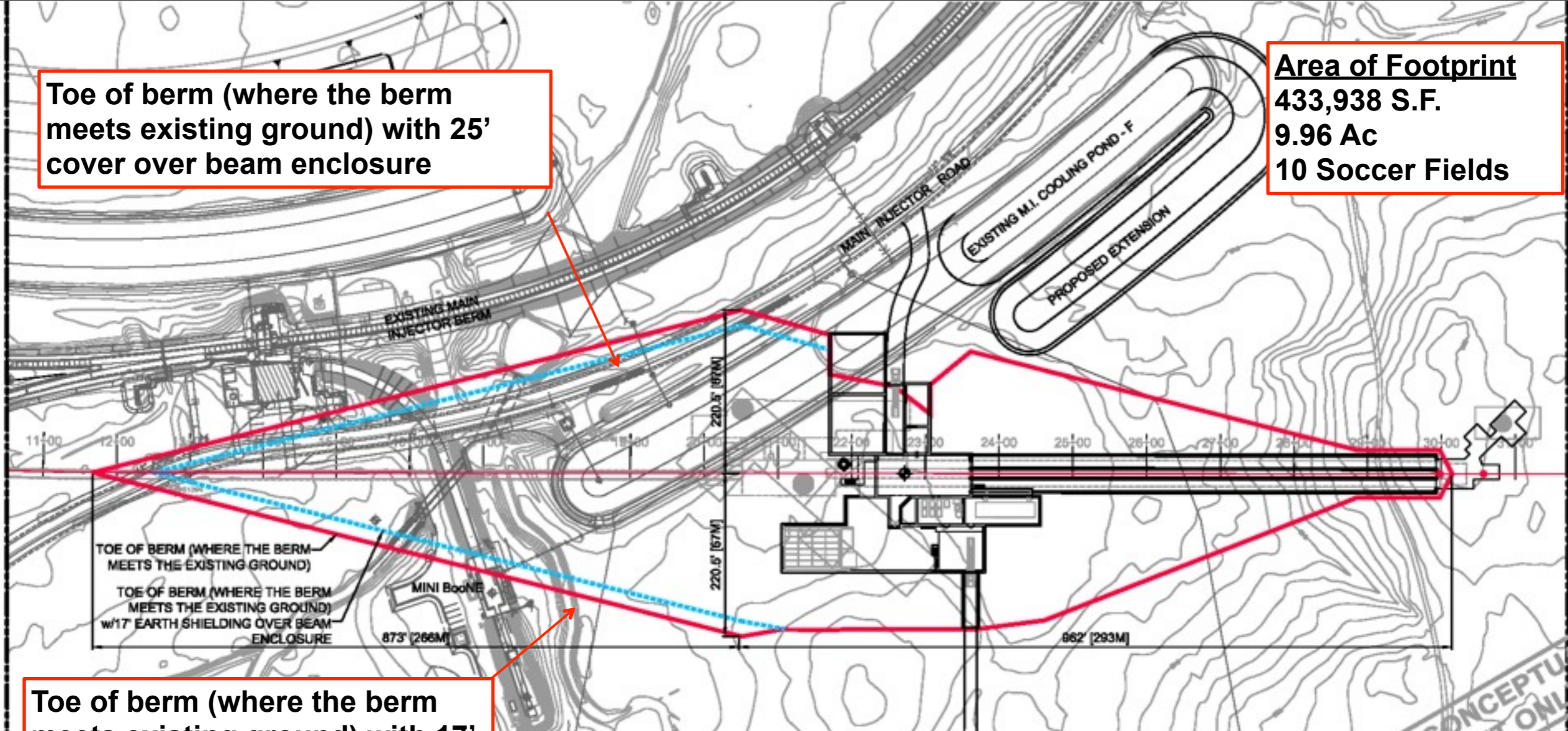
48 degree hor. bend to point to SD

LBNE Primary Beam ~ 1/6 of Main Injector

Primary beam energy (protons from the Main Injector) from 60 to 120 GeV

Toe of berm (where the berm meets existing ground) with 25' cover over beam enclosure

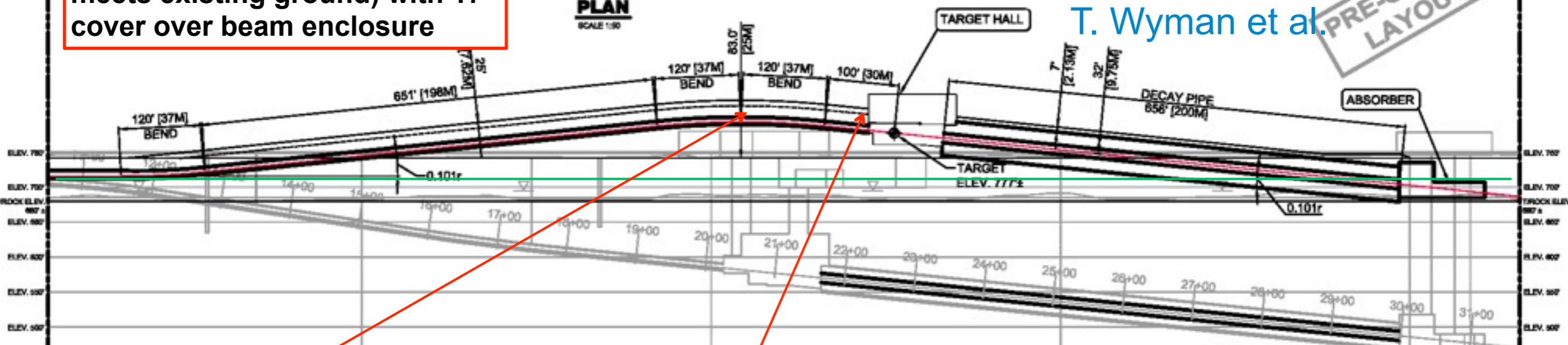
Area of Footprint  
433,938 S.F.  
9.96 Ac  
10 Soccer Fields



Toe of berm (where the berm meets existing ground) with 17' cover over beam enclosure

T. Wyman et al.

PRE-CONCEPTUAL LAYOUT ONLY



Apex of "Hill"  
~ 83' above existing grade

Roof of Target Hall  
~ 95' above existing grade



# 1. WILSON HALL - 16 WEST (BEFORE)

Friday, March 4, 2011

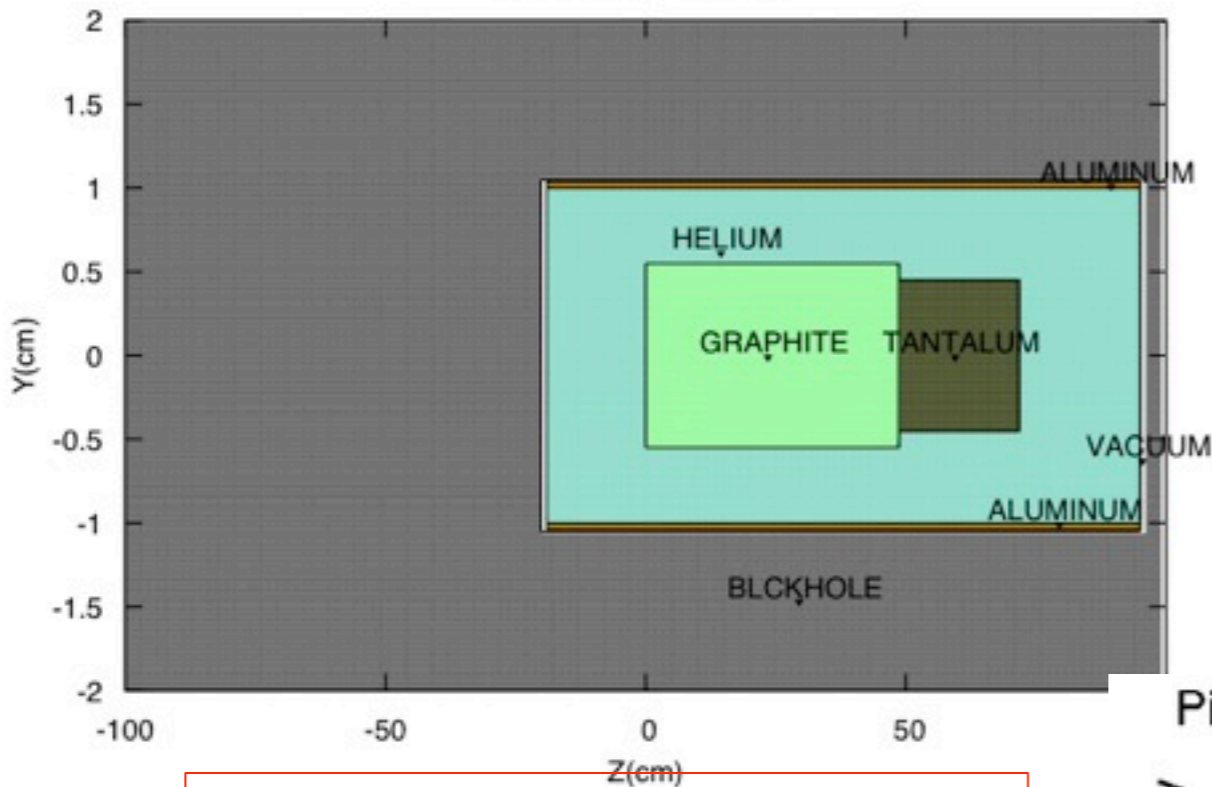


# 1. WILSON HALL - 16 WEST (AFTER)

Friday, March 4, 2011

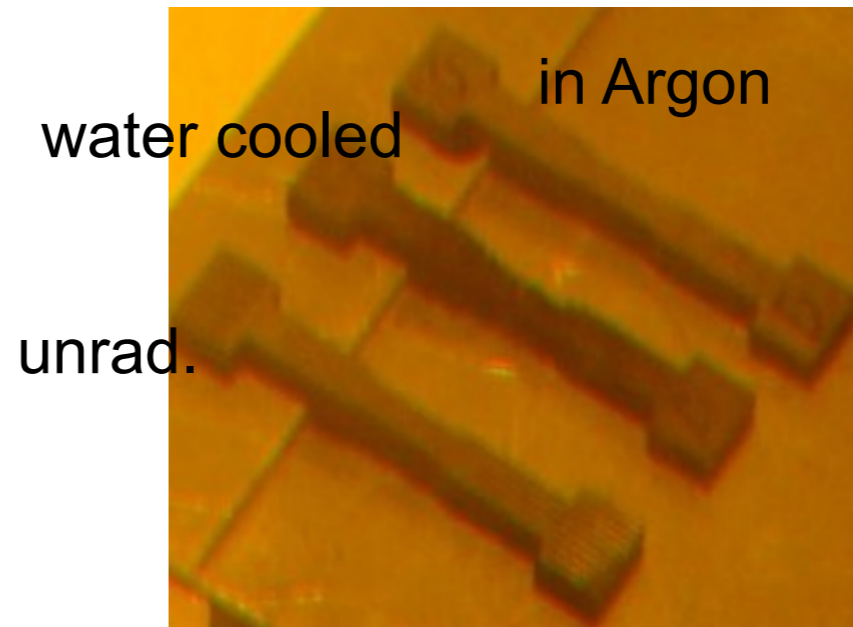
# Targets R&D

LBNE Geometry Y-Z



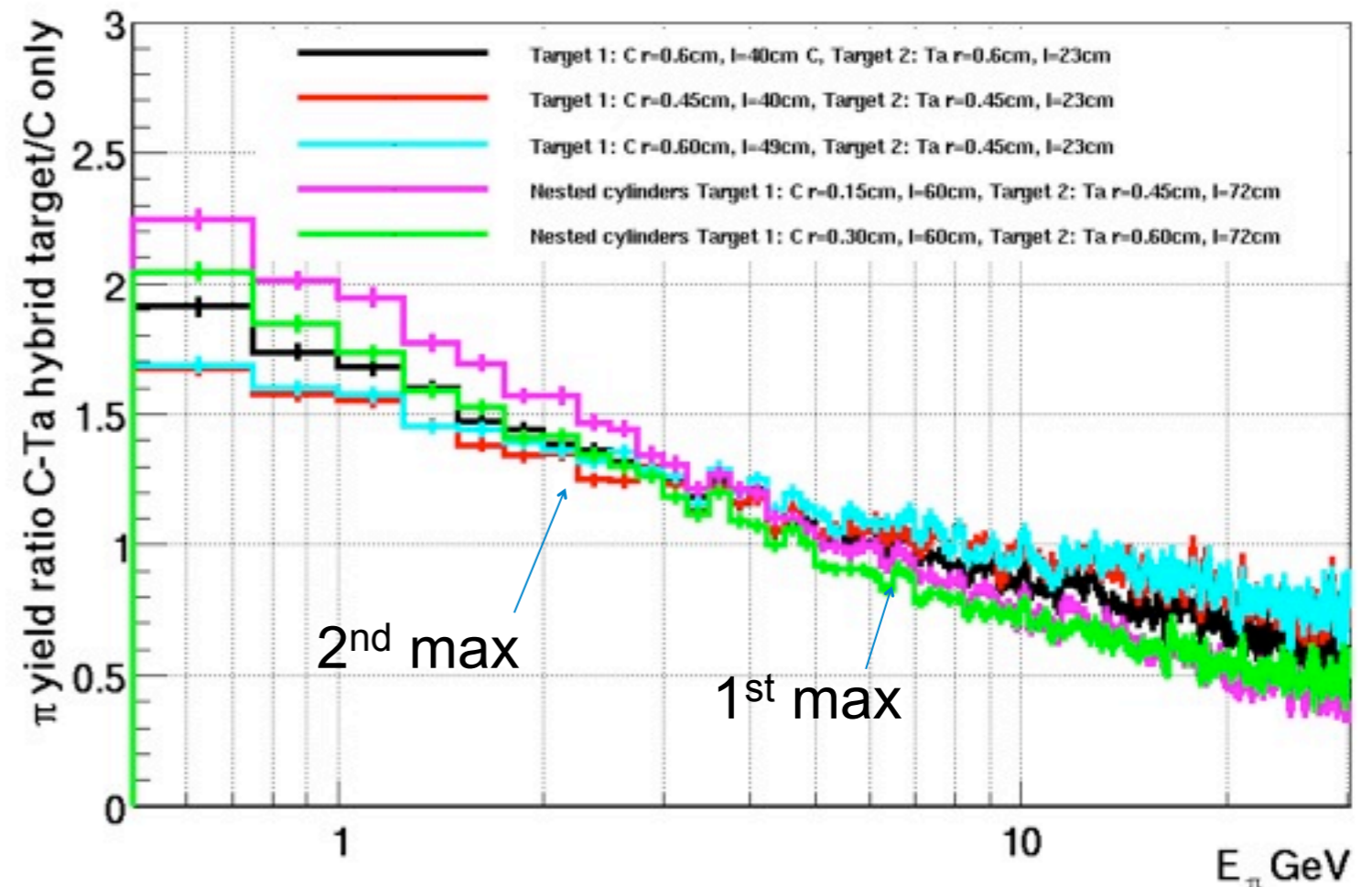
M. Bishai, Yi Lu (Highschool)

Using hybrid targets, the pion yield at the 2<sup>nd</sup> maximum can be increased by 50% without changing the pion yield at the 1<sup>st</sup> maximum. The high energy pion yield can be also reduced by > 50%.



Irradiation damage in water-cooled 3D carbon composite LBNE candidate target samples irradiated at BLIP.

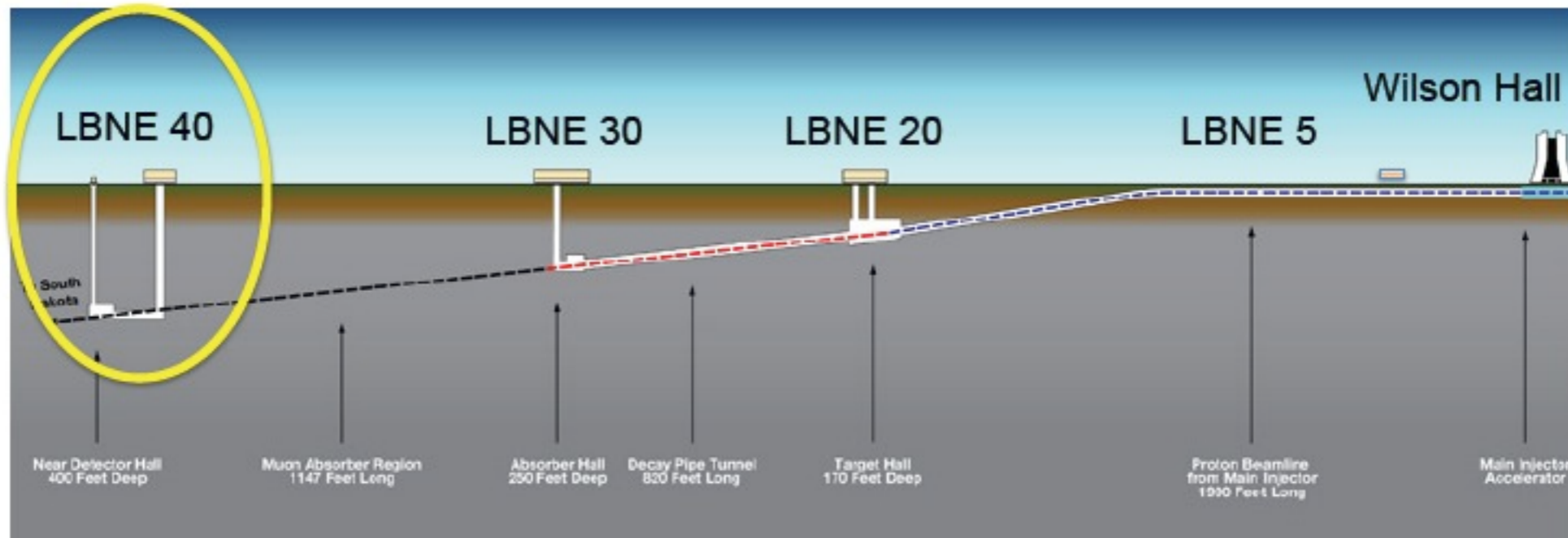
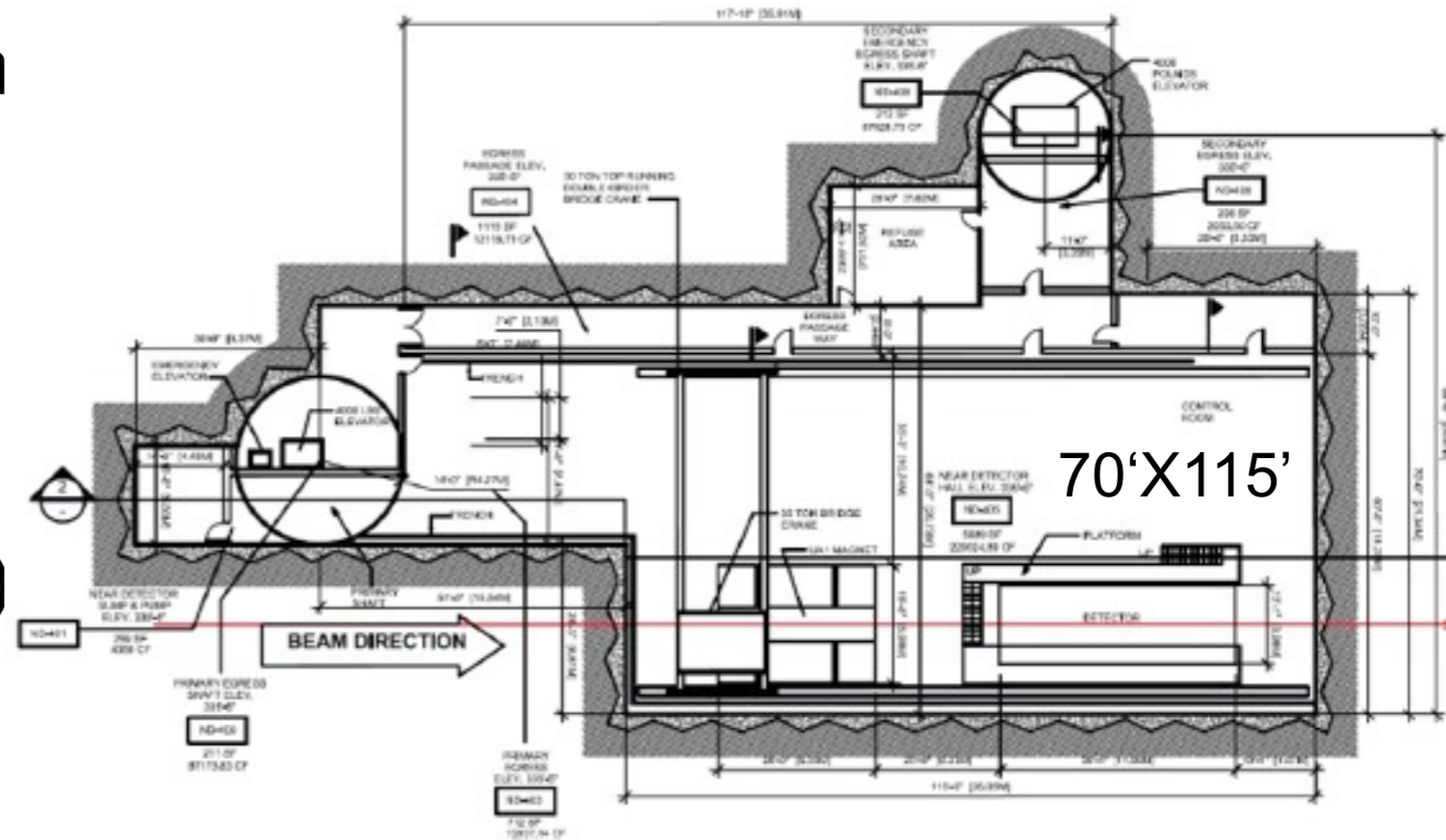
Pion yields from a hybrid C-Ta target at 120 GeV



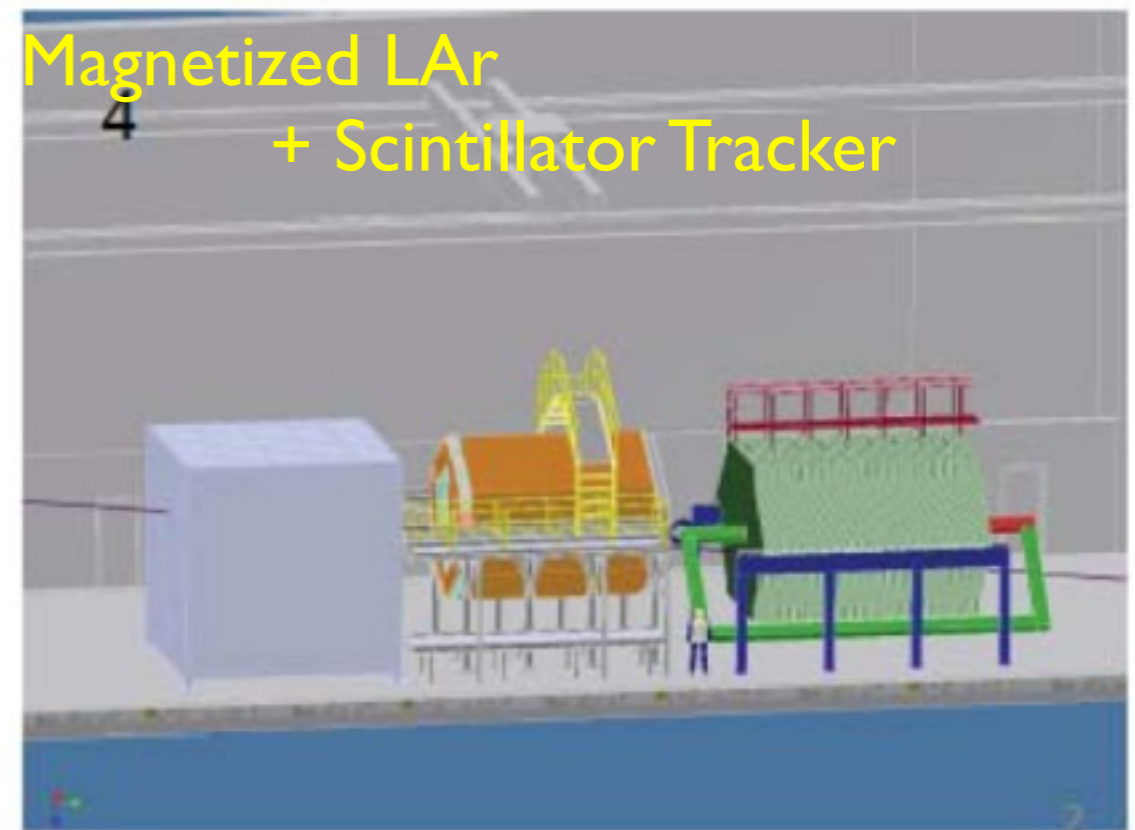
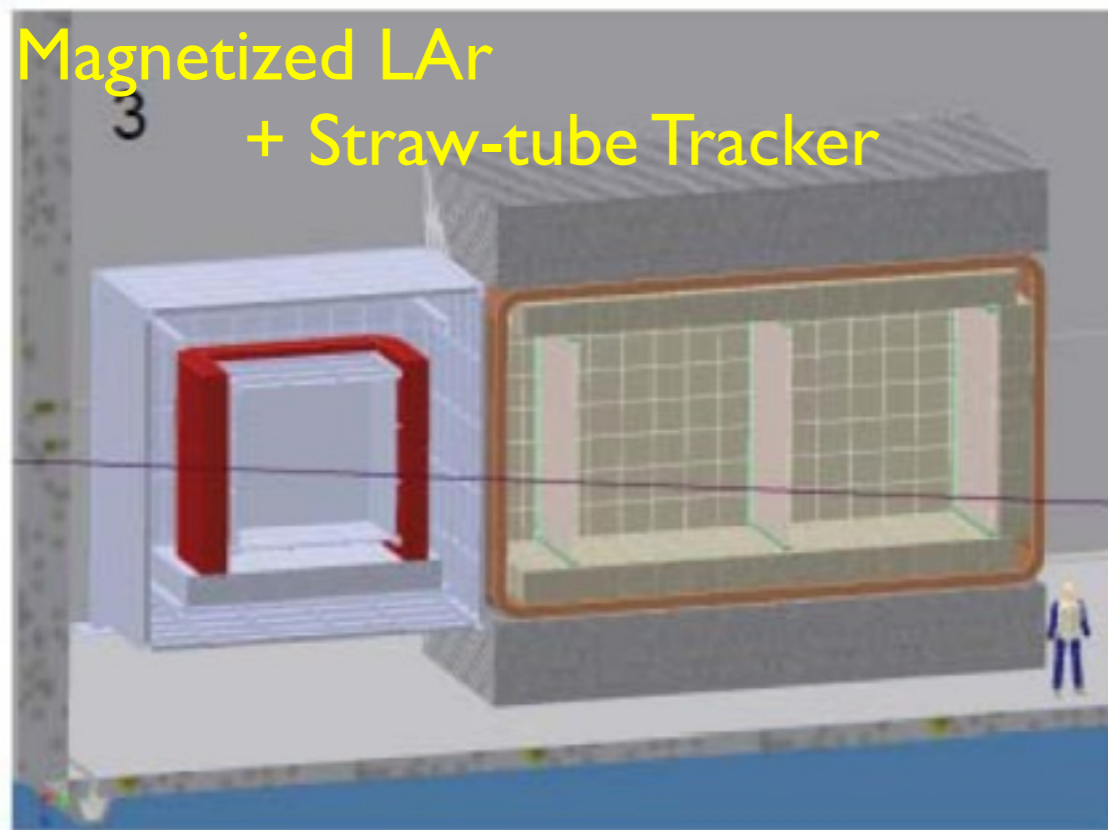
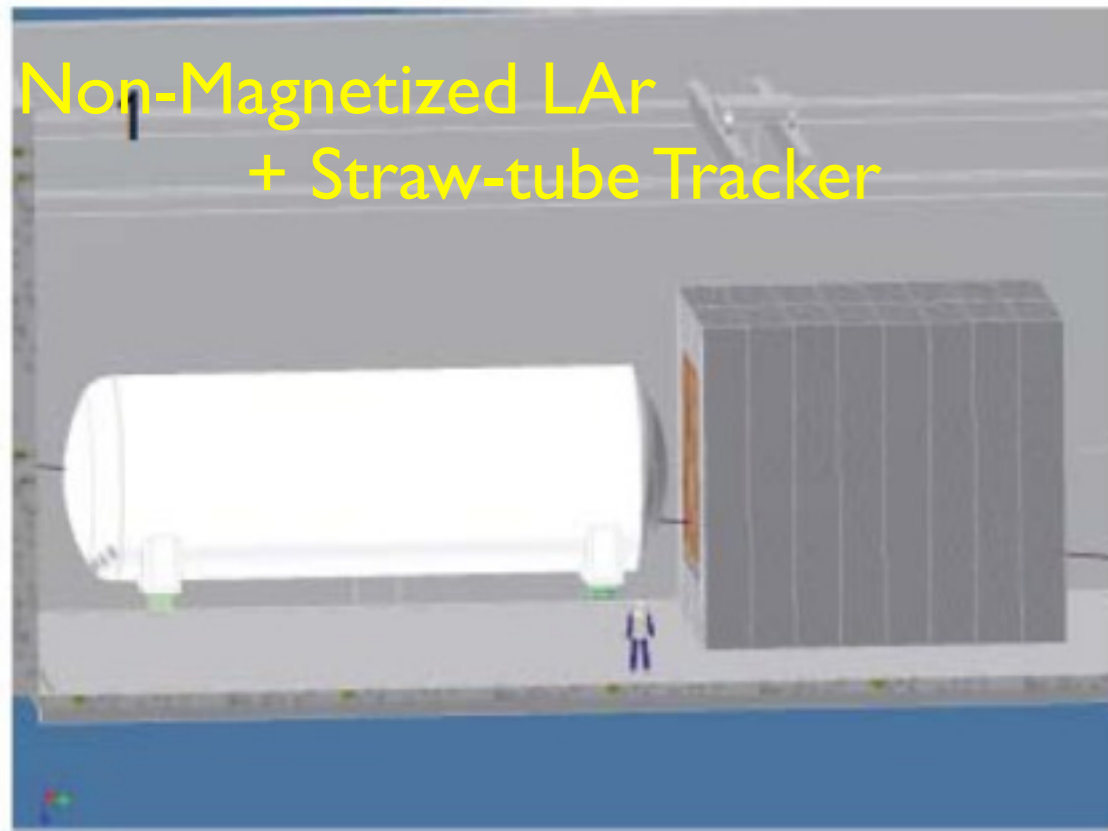


# Near Detector

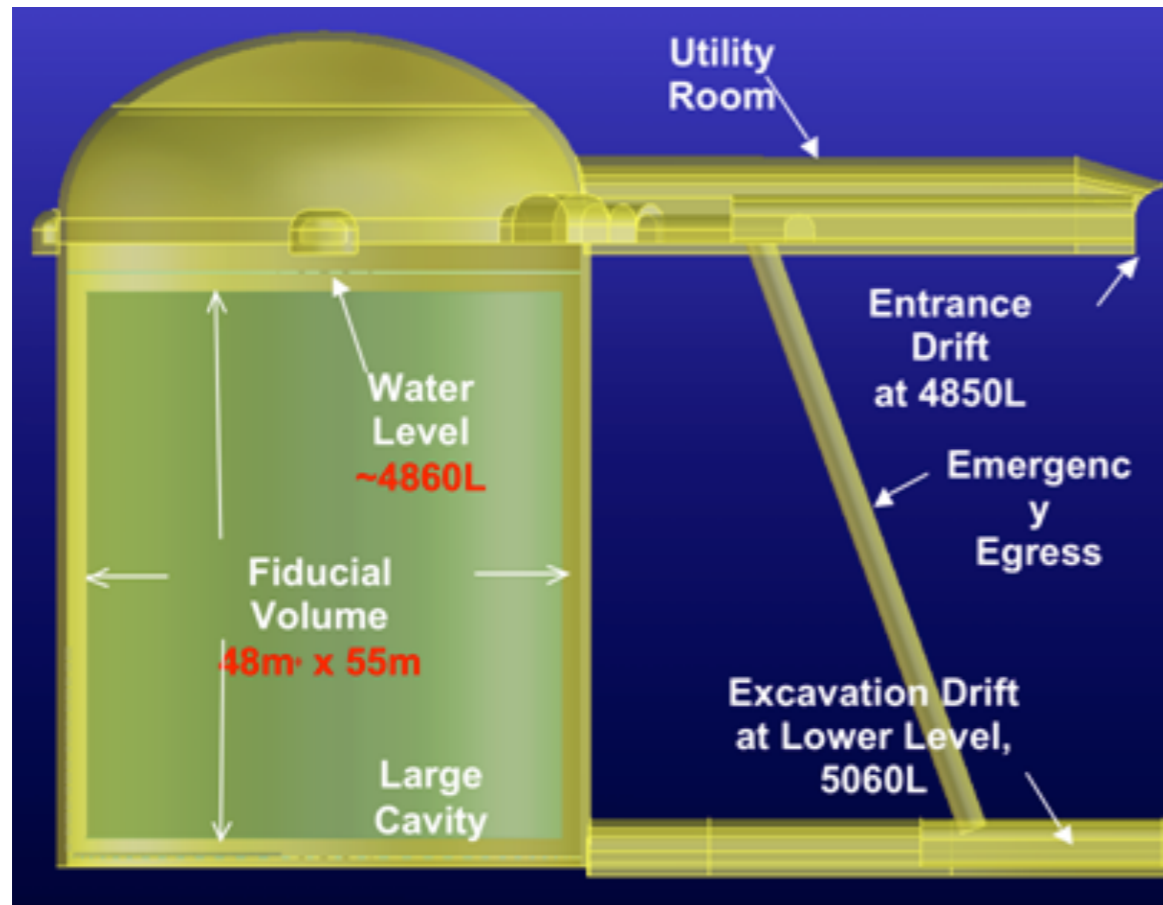
- Near detector essential for a CP experiment
- 4 options open
- Straw tube tracker
- LAR (with/without magnet)
- Scintillator



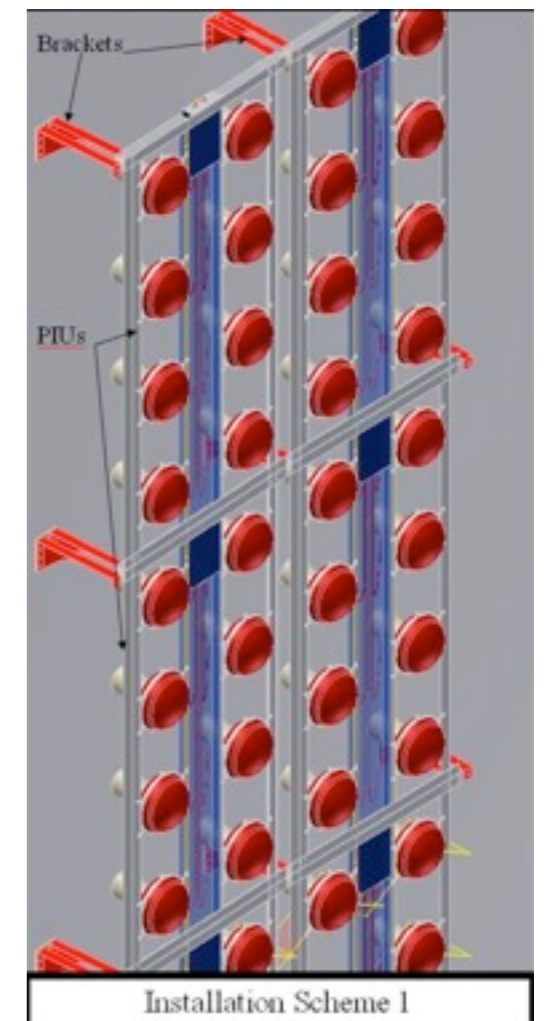
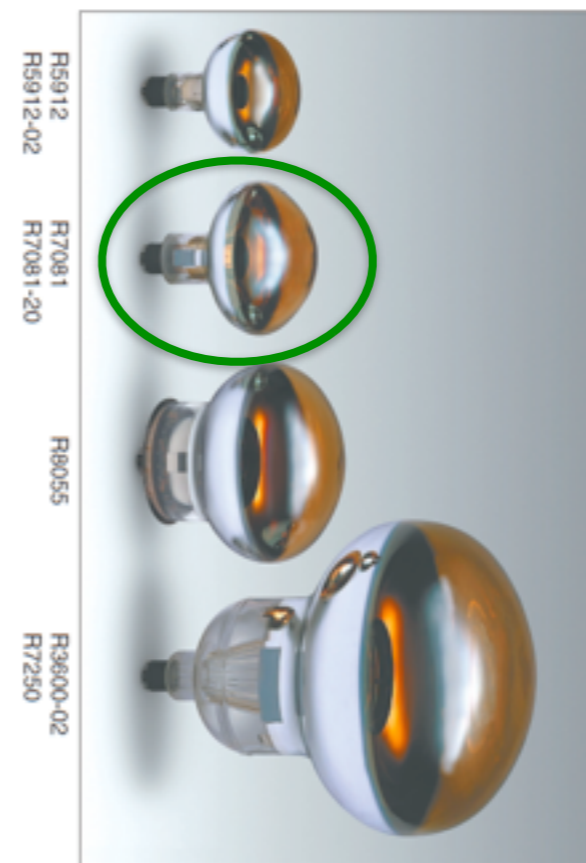
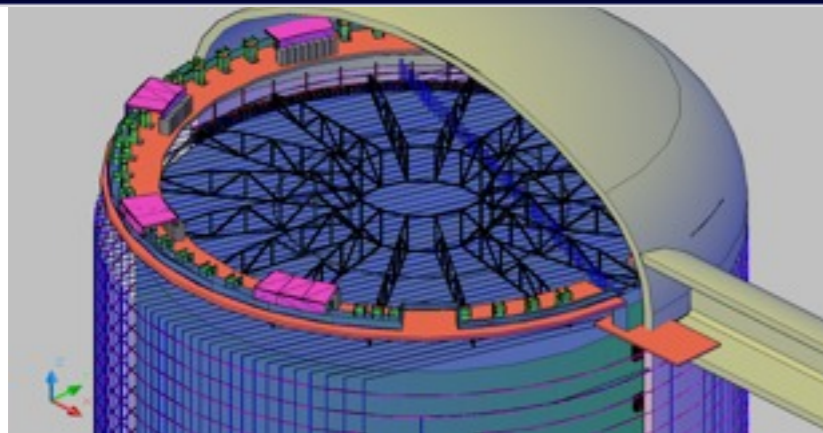
# Near Detector Options



# Water Cherenkov Detector



30k PMTs watching 100 ktons of ultra-pure water in each of two caverns



Also considering designs with a single detector of 150 ktons or 200 ktons fiducial mass (cavern up to 66 m diameter, 100 m high)

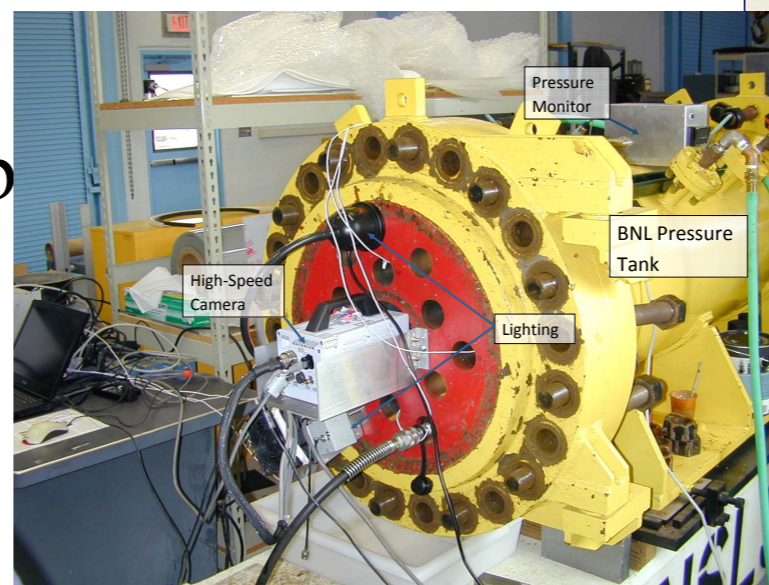
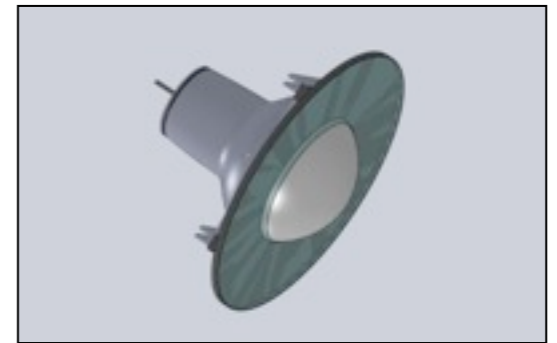
Liner and installation design are evolving.

# Photo-multiplier development

- Reference design with 10"HPK SBA tubes with QE~36%.
- HPK and ADIT/ETL (Texas) are designing new larger format tubes. (On order)
- Development on light collectors and mounting is advanced.
- Extensive program of measuring and modeling bulb breakage and resulting pressure waves in collaboration with US Navy research and material scientists.



HPK 12"  
Upenn

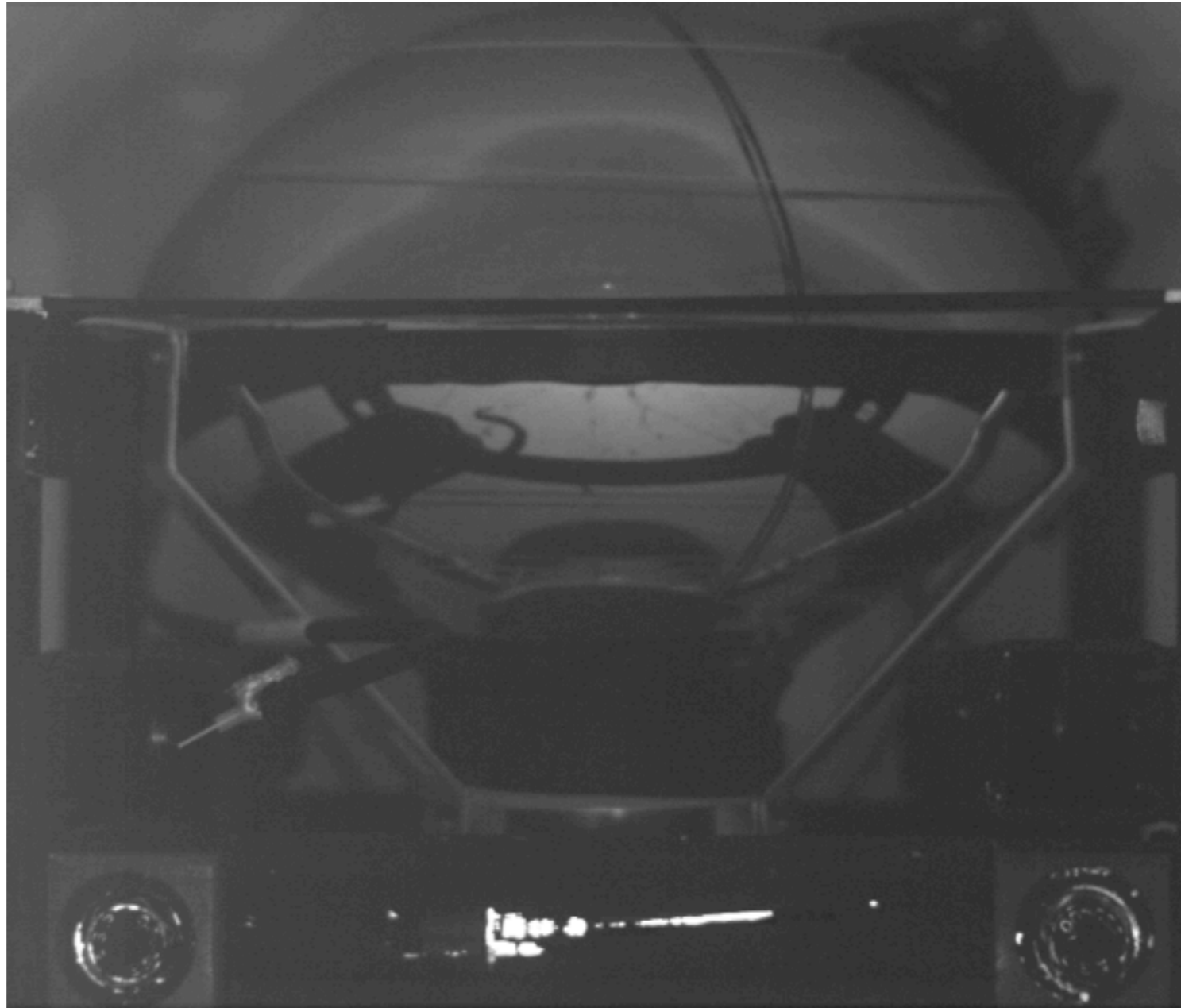


15 m sphere



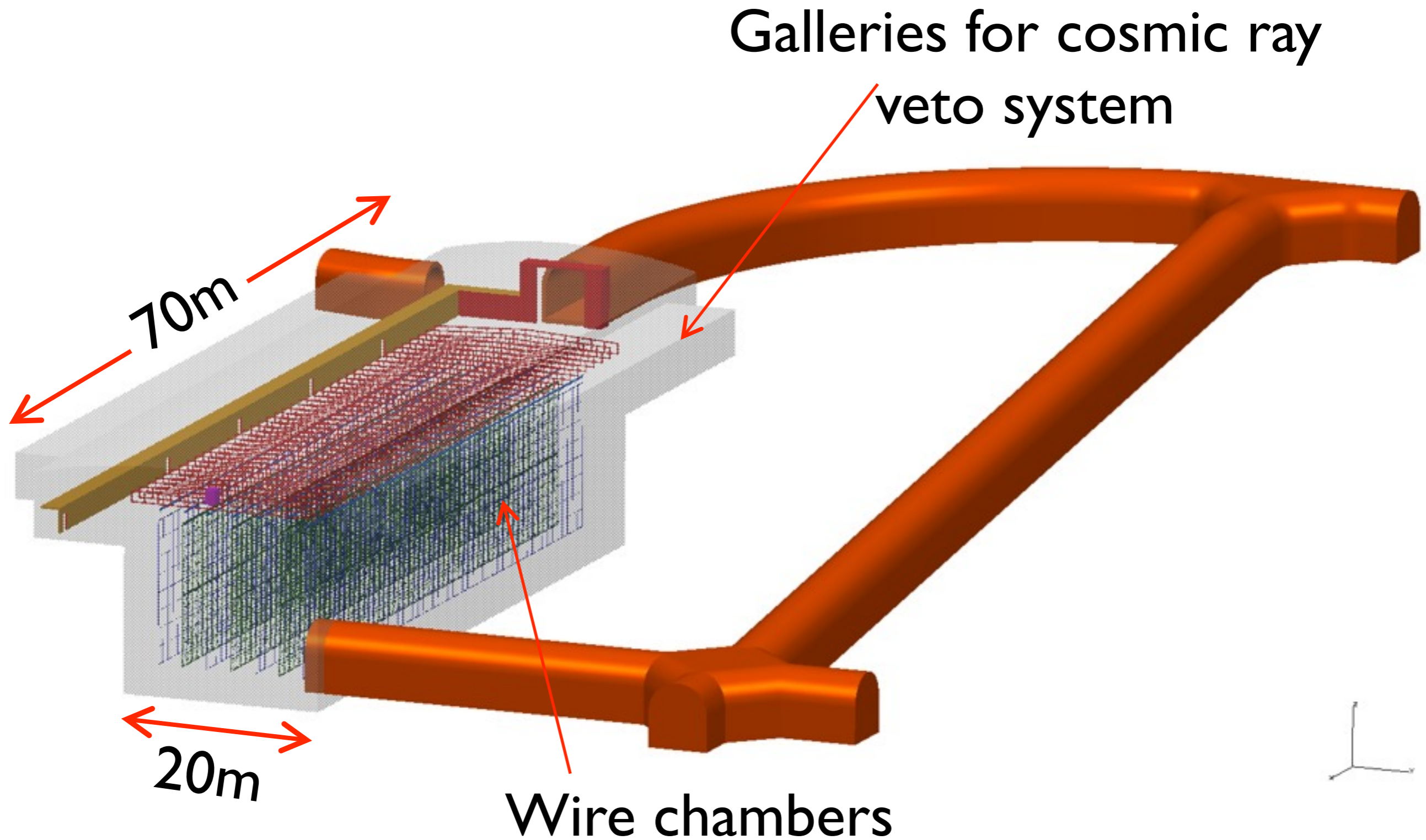
7 bar

# Failure at 18 bar in R7081

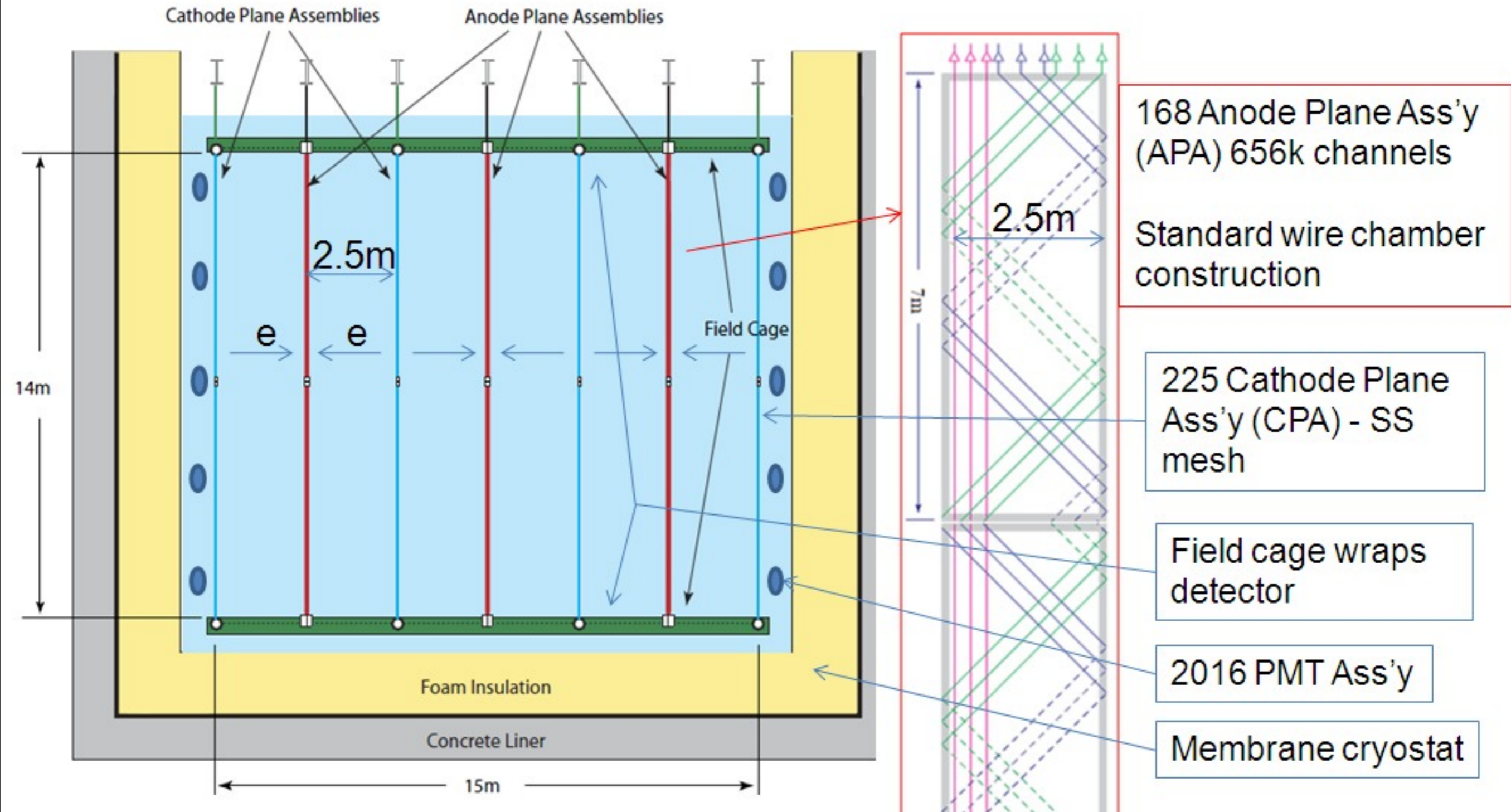


We have considerable information on failure mechanism and new confidence that we can push this type of failure to higher pressures with proper encapsulation design. We can also model it with advanced hydrodynamic code.

# Liquid Argon TPC



# Liquid Argon TPC

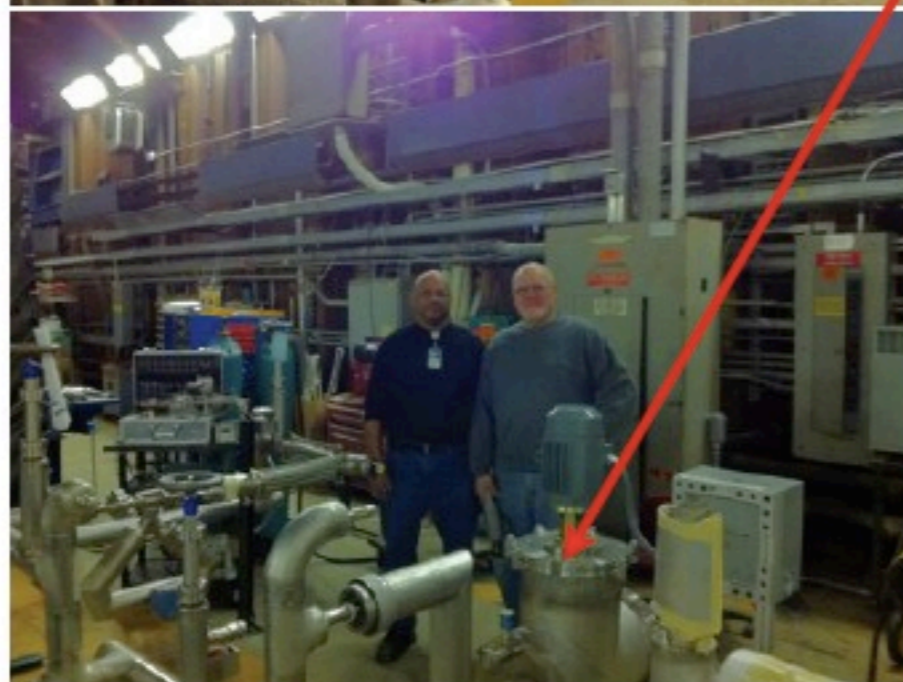


Also considering designs: 3.75 m drift; two detectors in a common cavern.

More detail from Bruce Baller

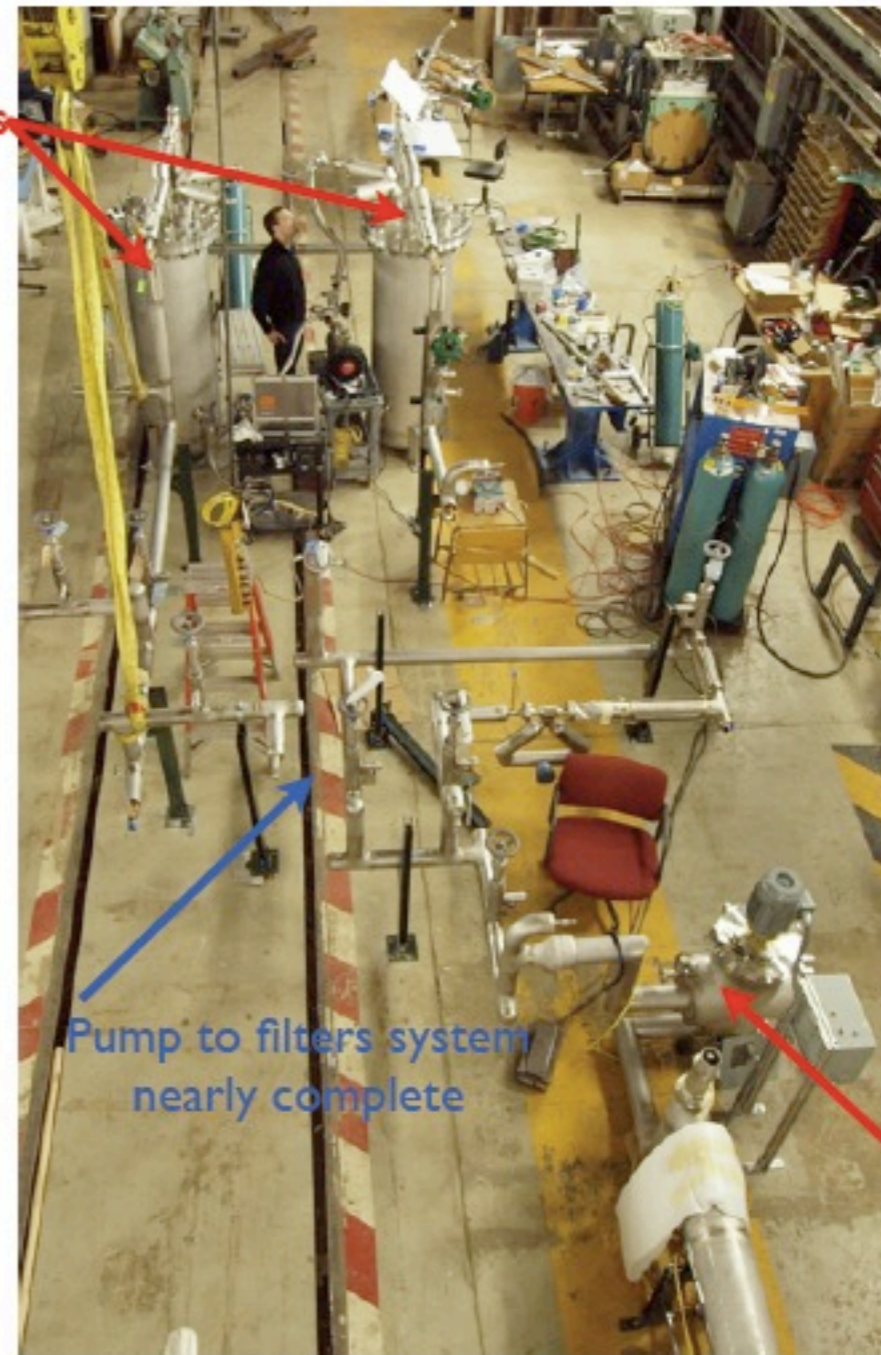
# LAR purity demonstrator

Goal: achieve required purity without evacuation



Filters

Pump

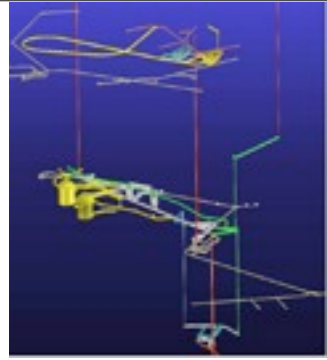


Pump to filters system  
nearly complete

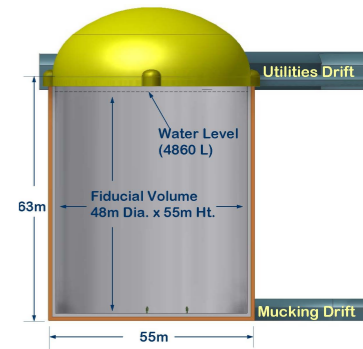
Pump

B.Rebel





# Conclusion



- LBNE was granted CD0 in January 2010.
- Next milestone is CD1, now delayed because the configuration of the far site has changed.
- Many alternatives are under investigation and we could use help.
- LBNE represents considerable investment of resources. There is much scope for information exchange and mutual reinforcement.
- **M. Goldhaber: We must work harder.**

