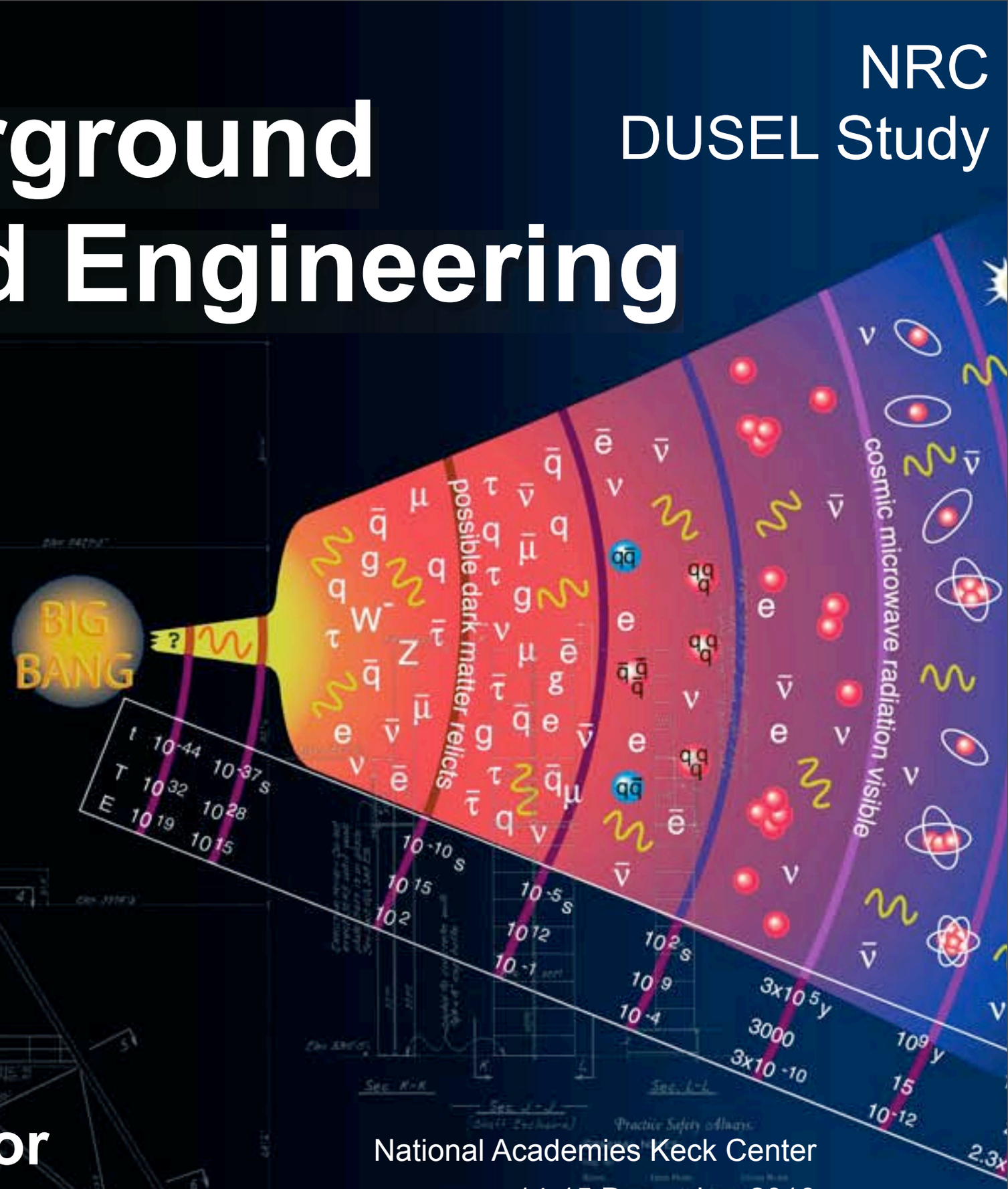
NRC
DUSEL Study

Deep Underground Science and Engineering Laboratory (DUSEL) Project Overview



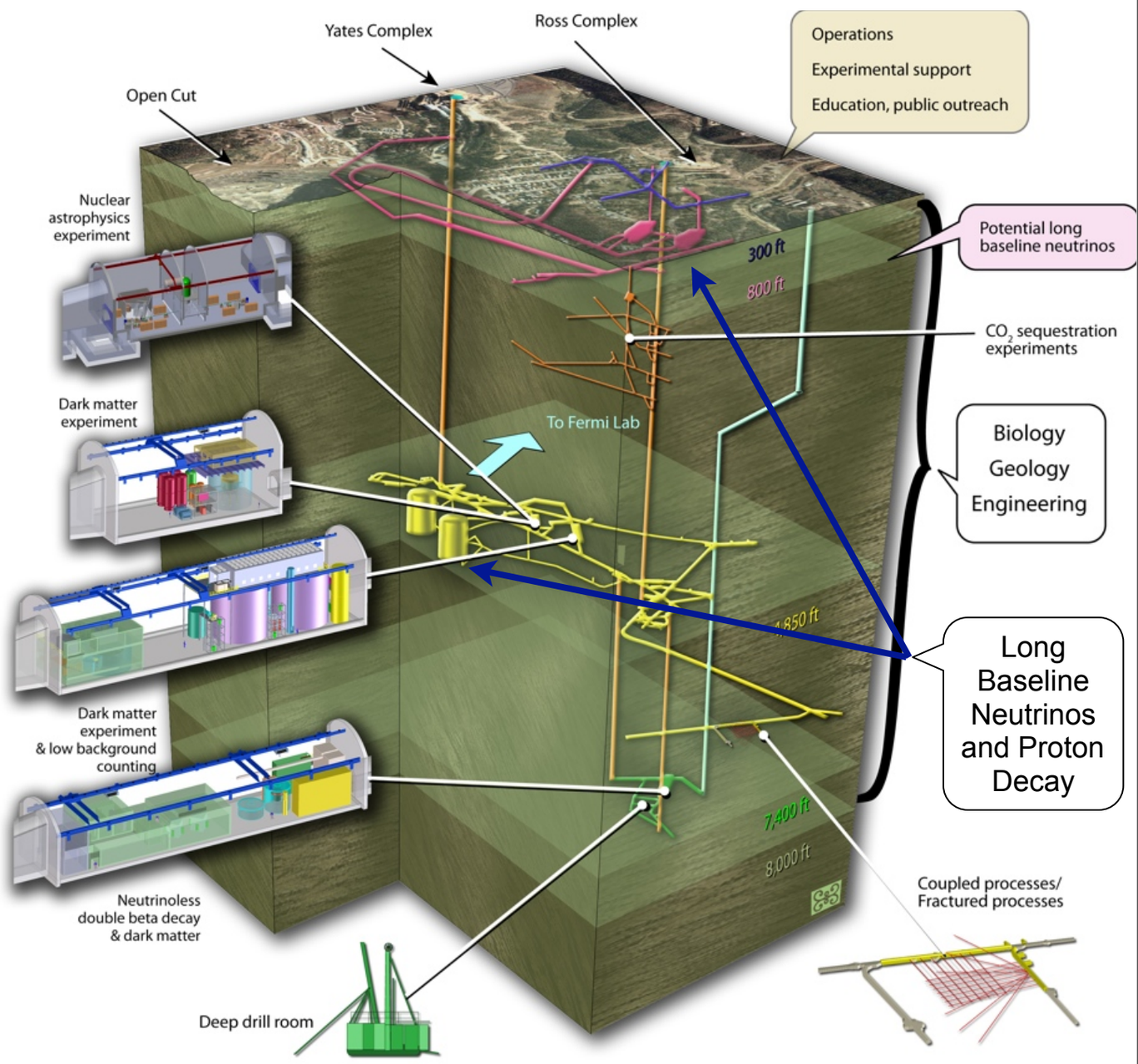
Kevin T. Lesko
Principal Investigator

National Academies Keck Center
14-15 December 2010

Figure Courtesy
PDG and LBNL

Presentation Outline

- DUSEL's Science Goals and Partnerships to Achieve these Goals
- DUSEL Project
  - –Facility
  - –Experiments
- Facility Design, Project Timelines, Estimates, and Partnerships
- Summary



Developing DUSEL Catalyzes Transformational Science

DUSEL will promote critical science, exploit synergisms, maximize the benefits of a dedicated facility with its best-in-class EH&S program, and integrate Education and Outreach functions within a world-class facility

- Neutrinos - discover new physics, known-unknown physics
- Dark Matter - identify ~25% of the known-unknown universe
- Dark Life - limits of life, life in extremes, life in isolation, new life
- Origin of the Elements - how, where did the elements originate
- Symmetries and High Energy Scale Physics - matter/antimatter asymmetry, the universe at extreme energies and physics of the early universe -- **the Intensity Frontier**
- Natural Resources - understanding, probing & predicting
- Engineering - safer, deeper, larger & faster
- Energy and Carbon Research - imperative societal questions
- Education and Outreach - welcome, attract, excite & engage

DUSEL's Scientific Goals have been Extensively Reviewed and Documented

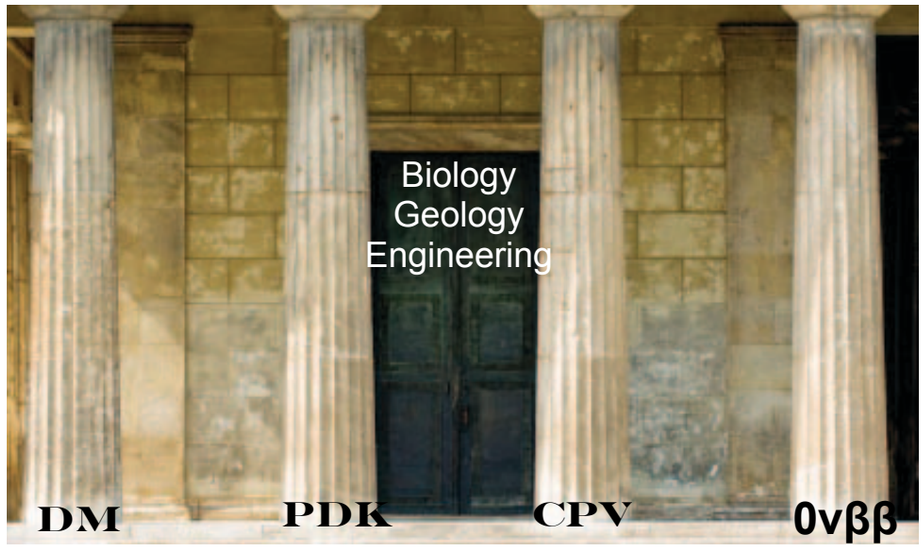
- Bahcall Committee Report 2001
- Nuclear Physics Long Range Plan 2002
- Connecting Quarks to the Cosmos
- HEPAP Long Range Plan 2003
- Neutrinos and Beyond
- EarthLab
- Physics of the Universe
- The Neutrino Matrix
- Discovering the Quantum Universe
- Deep Science
- Nuclear Physics Long Range Plan 2007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

DUSEL Founded on a Suite of Critical, Multidisciplinary Experiments

Founded on Four Experimental Physics Pillars

and

Three Research Tenets:



1. Dark Matter Searches
2. Long Baseline Neutrinos from FNAL
3. Proton Decay
4. Neutrinoless Double Beta Decay

- Diverse multidisciplinary research efforts in Biology, Geology, and Engineering
- Additional well-motivated experiments
- Integral Education and Outreach

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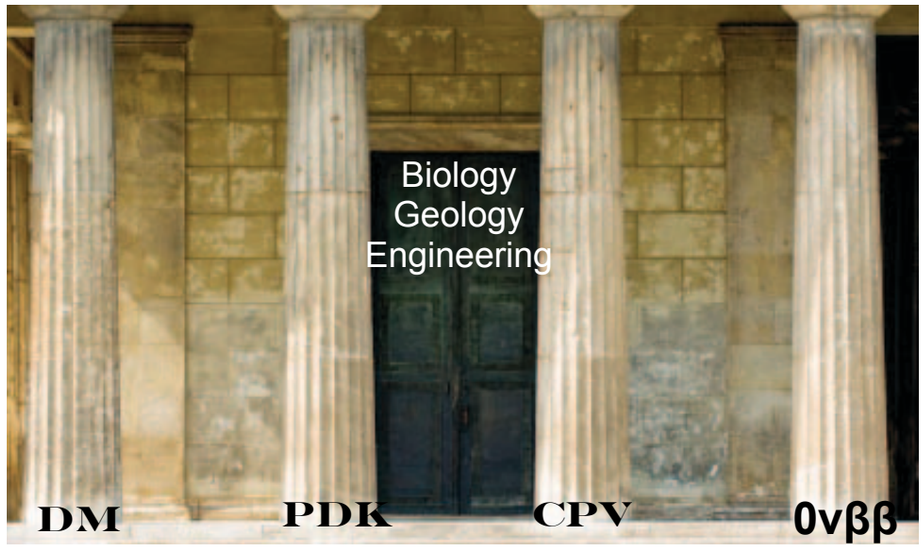

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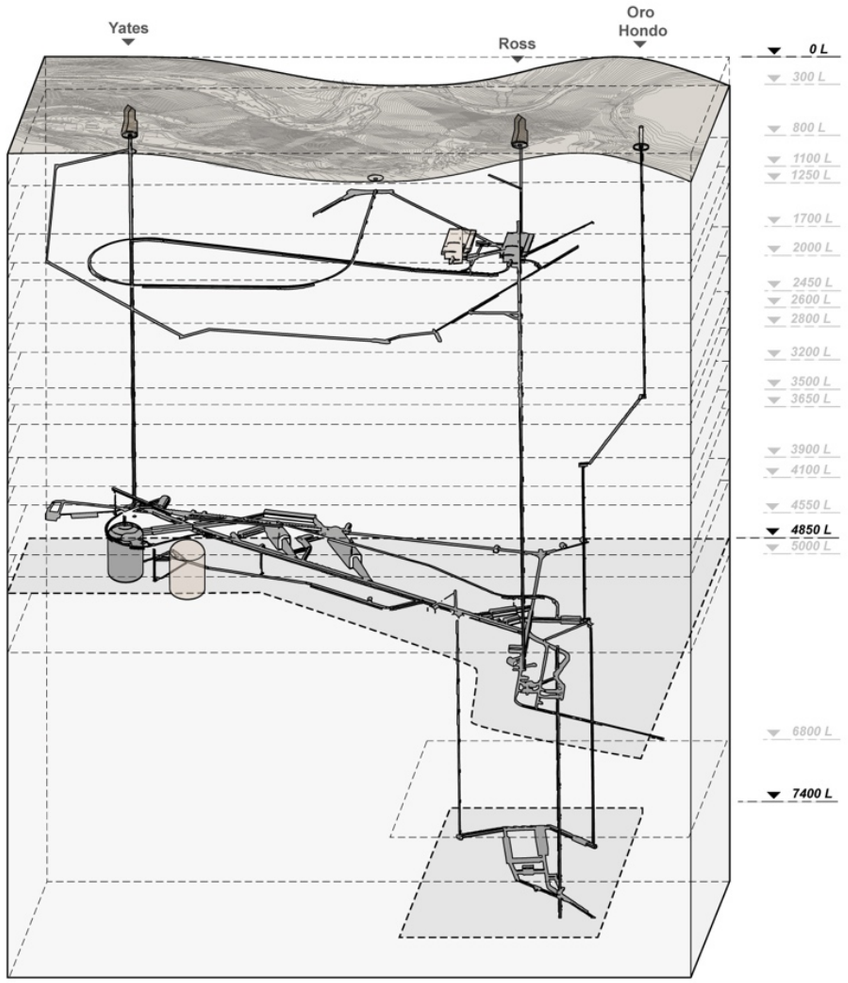
DUSEL's Suite of Experiments is congruent with all scientific and agency guidance

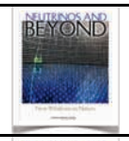
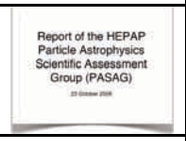
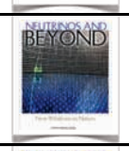
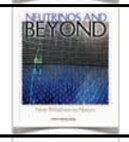
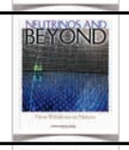
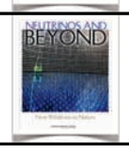
DUSEL Deep Underground Science and Engineering Laboratory

DUSEL Facility Designed to Host this Suite of Critical Experiments

- Physics
  - Long Baseline Neutrino and Proton Decay
    - Water Cherenkov and/or Liquid Argon Detectors totaling 200kT WCE
  - Dark Matter
    - at least one Generation-3 experiment
    - R&D, Generation-1 and -2 as consistent with Sanford Lab scope
  - Neutrinoless Double Beta Decay
    - a ~ tonne-class experiment
    - Generation 2 (~100-kg) effort as consistent with Sanford Lab scope
  - Nuclear Astrophysics Facility
  - Advanced Low Background Counting & Assay
- Biology - Geology - Engineering
  - Fixed Ecohydrology sites and distributed efforts
  - Fixed Coupled Processes site
  - Fixed CO_2 Sequestration (vertical) site
  - Fixed Geophysics and Geology sites and distributed efforts
  - Initial efforts as consistent with Sanford Lab scope (~16 efforts)
- Education and Outreach Facility
  - Initial efforts as consistent with Sanford Lab scope

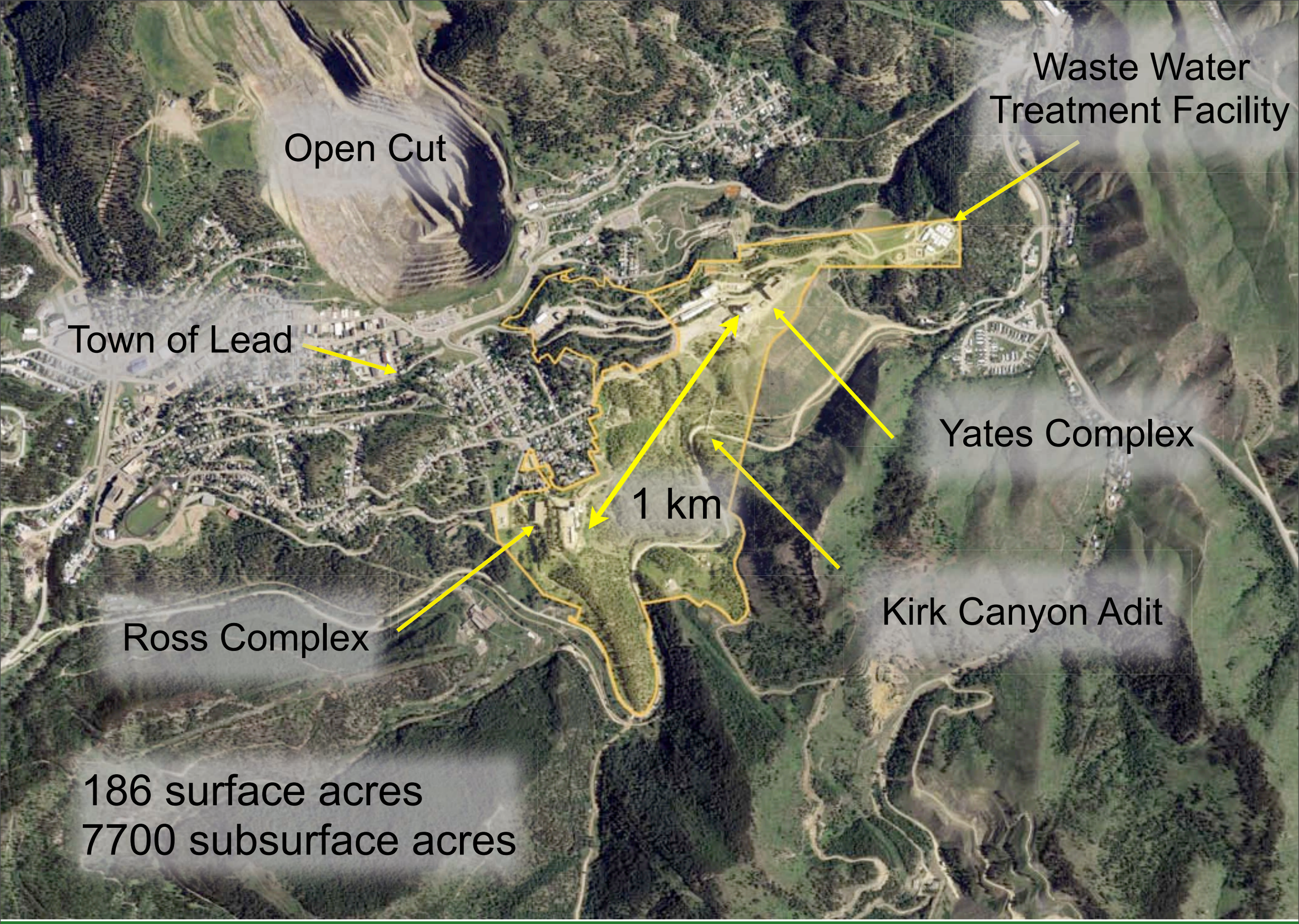


DUSEL's Experiments is Well-aligned with Critical Science Questions

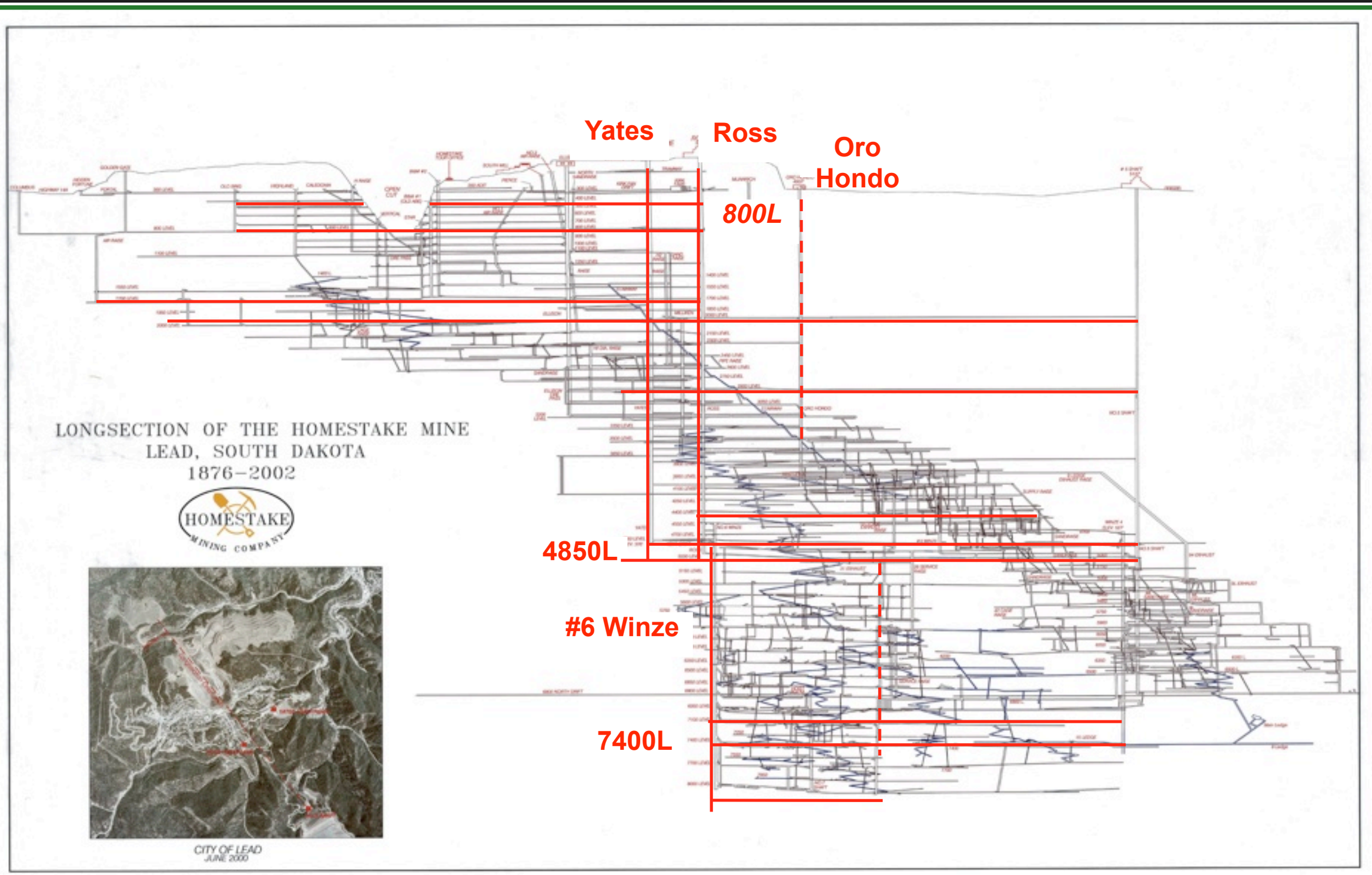
	Quarks to the Cosmos 2001	Neutrinos & Beyond 2003	Earthlab 2003 - 4 ARMA	Deep Science 2006	Nuclear Physics LRP 2007	P5 2008	PASAG 2009	P5 2010
Dark Matter								
CPV & Long Baseline Neutrinos								
Proton Decay								
Neutrinoless Double Beta								
Nuclear Astrophysics								
Ecohydrology								
Coupled Processes								
Fault Rupture								
Transparent Earth								
Engineering & Energy								

Development of the Critical Suite of Experiments is Progressing Well

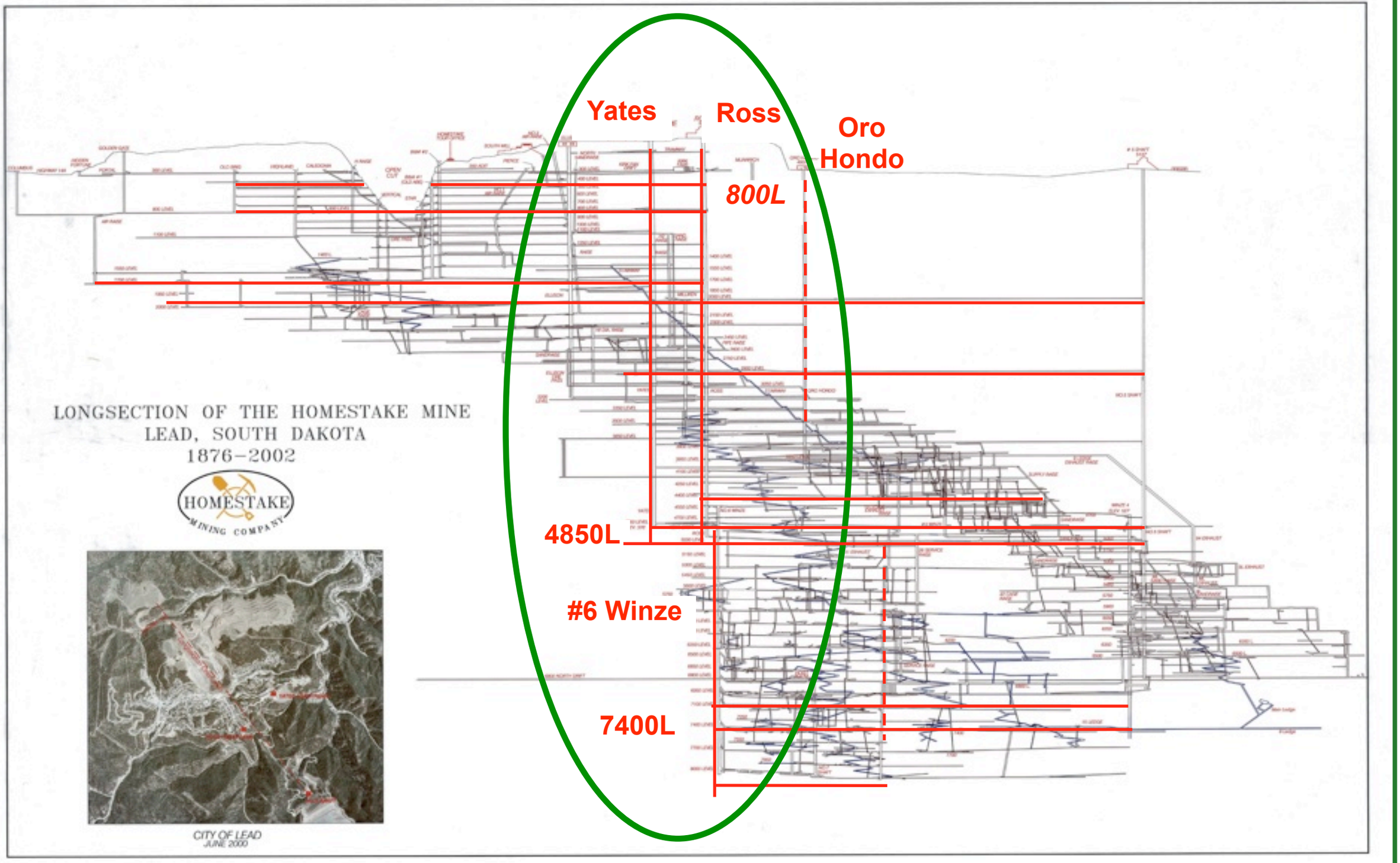
- Experiment Collaborations are conducting substantive R&D and design tasks: funded by NSF and DOE
- Sanford Lab and South Dakota investment plays a critical role in hosting pre-DUSEL experiments and continuing into DUSEL construction period
- The DUSEL facility is designed to house world-leading experimental programs
- Choices between competing technologies, selection of final collaborations and definitions of the participation levels to be established in the future as the collaborations advance their designs
- The support for DUSEL's experiments is shared between the DOE and NSF


Waste Water
Treatment Facility
Open Cut
Town of Lead
Yates Complex
1 km
Ross Complex
Kirk Canyon Adit
186 surface acres
7700 subsurface acres

Cross Section of the Homestake Site



Cross Section of the Homestake Site



South Dakota and Sanford Lab Participation Critical in Preparing for DUSEL

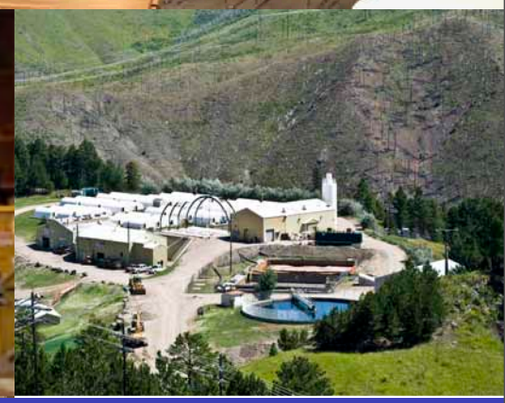
- Major Financial Support from the State of South Dakota
  - $50M from State (HUD grant and General Fund)
  - $70M from Philanthropic Donation (T. Denny Sanford)
  - Owns the Property

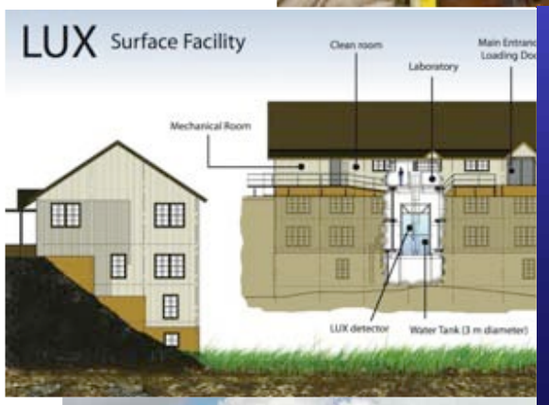
- Partnership to “achieve DUSEL”
- DUSEL assimilates Sanford Lab at MREFC Construction
- Facility work well-advanced (site preparation & risk reduction)
  - Rehabilitation of Surface and Underground Infrastructure
    - Lifts & Shafts
    - Pumps & Water Treatment
    - Facility Stabilization and Rehabilitation
    - Initial Operations, Environment, and Safety Program

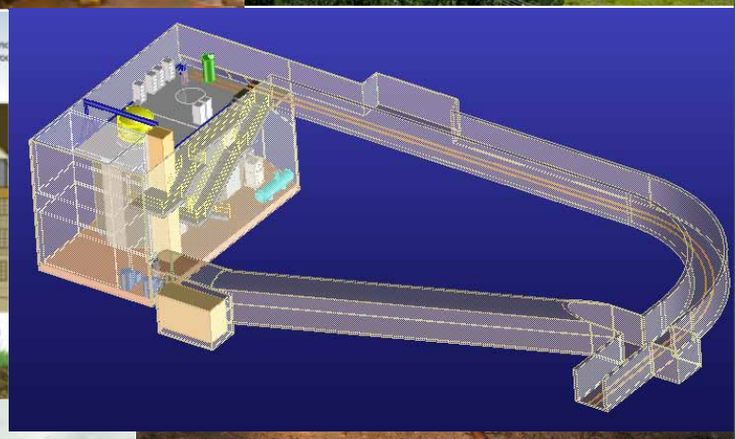
  - Options to acquire additional property to expand access to the site (including Rock Disposal sites)

South Dakota's Investments are Critical for DUSEL

- Trained and talented workforce
- Key infrastructure
  - shafts - deferred maintenance
  - safety improvements
  - water pumping and treatment
- Surface and Underground Space & Science during DUSEL construction
  - Surface Assembly Lab
  - Majorana Temporary Space
  - Davis Campus
  - Transition Space
- Education and Outreach
  - Davis Bahcall Scholarships
  - Neutrino Day
  - Significant Cultural Outreach (GEAR UP)
  - Workshops and Field trips
  - Public Lectures







DUSEL Deep Underground Science and Engineering Laboratory

Initial Science: BGE and Characterization Research Groups and Locations

Surface USD/BHSU – *Gamma, Rn*
Regis – *Muon*
SDSMT – *Climate station*
UT/BHSU – *Mag field, Ross/Yates*
USGS – *Microgravity*

300L DUGL – *Low-frequency seismometer*
USD/BHSU – *Rn*
SDSMT – *Signal propagation*
BHSU – *Biology baseline samples*

800L DUGL – *Low-frequency seismometer*
USD/BHSU – *Gamma, Rn*
Regis – *Muon/neutron*
LBNL – *CO_2 sequestration*
MAJORANA – *Pb, Cu storage*
PODS – *Geology (pet,ore dep,struct)*

1250L SDSMT – *Climate station*
USD/BHSU – *Rn*

1700L SDSU – *Bio samples*

2000L SDSMT/FNAL/UW – *Water-level tiltmeters (x3), climate*

2000L SDSMT/UCB – *Seismo/tilt (x2)*
(cont) DUGL – *Low-freq seismometer (x3)*
USD/Regis – *Gamma, Rn and muon/neutron*
BHSU – *Seeps, fungus samples (x2)*
LBNL – *CO_2 sequestration*

2600L SDSMT – *Climate station (x2)*

3350L Utah – *Extensometers*

4100L DUGL – *Low-freq seismometer (x3)*
UW/MT – *Optical extensometers*
SDSMT/UCB – *Seismometers/tilt*
BHSU, Many – *Biology sampling*

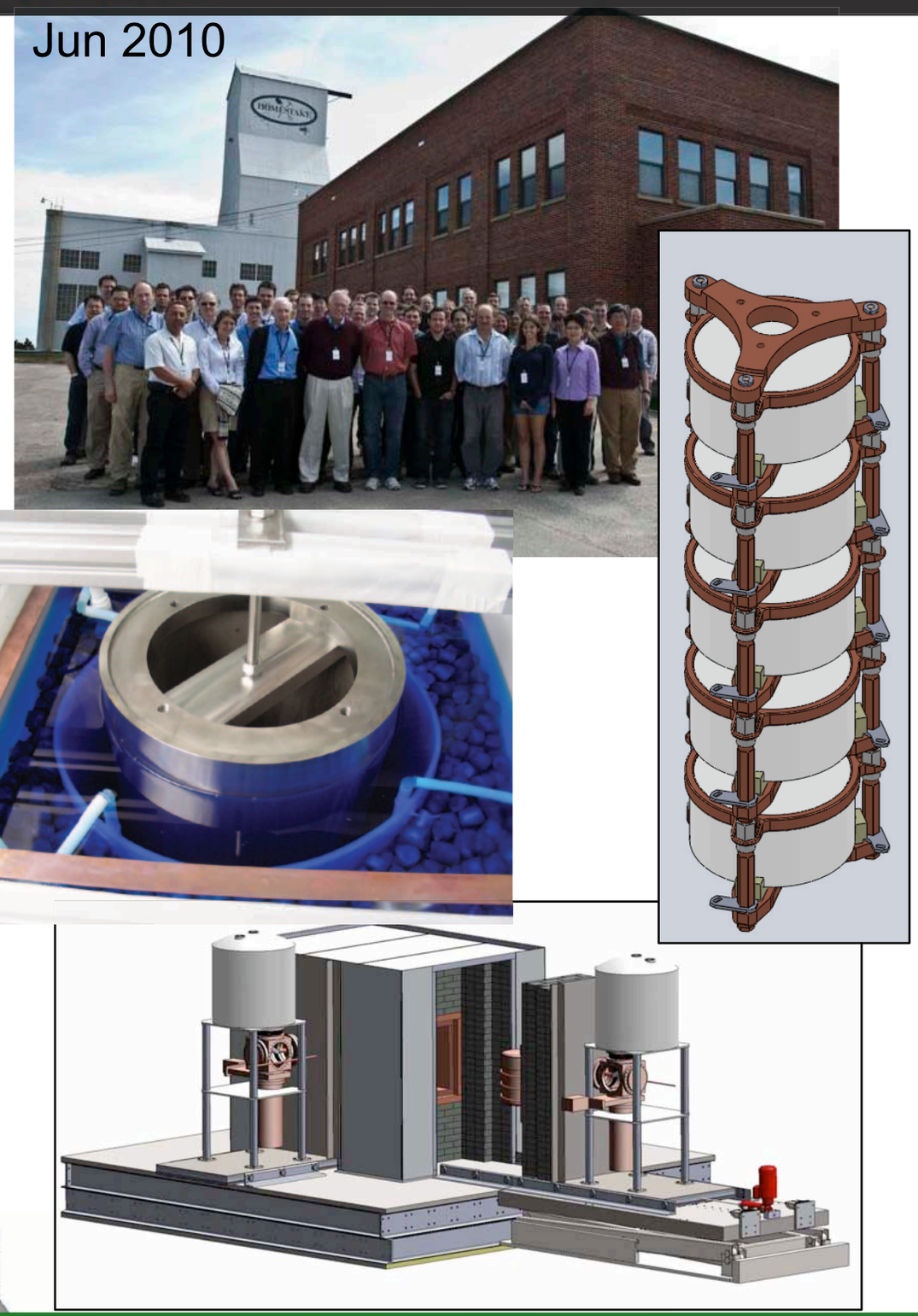
4550L USD – *Gamma, Rn*
Many – *Bio samples pump water*

4850L SDSMT – *Hydrometry probes*
LBNL – *CO_2 sequestration (removed)*
BHSU, Many – *Biology samples*
USD/BHSU – *Rn*
Many – *Core holes (hydrology, bio)*

Initial Science: Physics

MAJORANA DEMONSTRATOR

- Project:
  - → *Investigate neutrinoless double beta decay using 40 kg Ge (some natural, some enriched ^{76}Ge)*
  - → *Demonstrating technology for 1- tonne detector (requires < 1 bkgd count per year near signal region!)*
  - → *Electroform copper for shielding and detector components*
  - →*~ $20M DOE Effort*
- Collaboration:
  - → *~93 researchers (including students)*
  - → *18 institutions + Sanford Lab*
- Milestones:
  - → *Jun/Aug 09: Pb, Cu onsite*
  - → *Dec 09: Temp lab work begins*
  - → *Winter 10: Occupy TCR, e-form*
  - → *Fall/Winter 11: Davis Campus*



Initial Science: Physics

Large Underground Xenon (LUX-350)

- Project:
  - → *Direct search for dark matter using 350 kg of xenon*
  - → *Occupy Surface Laboratory to exercise procedures, test installation and detector operation*
  - → *Small water tank to allow operation (larger one underground)*
  - →*NSF and DOE support*
- Collaboration:
  - → *~52 researchers (including students)*
  - → *14 institutions + Sanford Lab*
- Milestones:
  - → *Sep 09: Grad students onsite*
  - → *Dec 09: Surface Lab activity starts*
  - → *Winter 10 ->: Surface detector ops*
  - → *Fall/Winter 11: Davis Campus*

Initial Science: Physics

Center for Ultra-low Background Expts at DUSEL

- Project:
  - → *South Dakota Governor's Research Center ($3M funded 2009-2014)*
  - → *Manufacture high-purity crystals (Ge; possibly NaI, $CdWO_4$)*
  - → *Activities include crystal growth, zone refining and detector development*
  - → *$3M from DOE EPSCoR (3 yrs)*
- Collaboration:
  - → *~54 researchers (incl students)*
  - → *7 institutions + advisors*
- Milestones:
  - → *May 09,10: Collab meeting at Lab*
  - → *Jun 10: Xstal pullers, Ge at USD*
  - → *Next 2 yrs: Surface labs*
  - → *Summer 12: Underground lab*

Stewardship Model: Sharing Responsibilities Between the Agencies

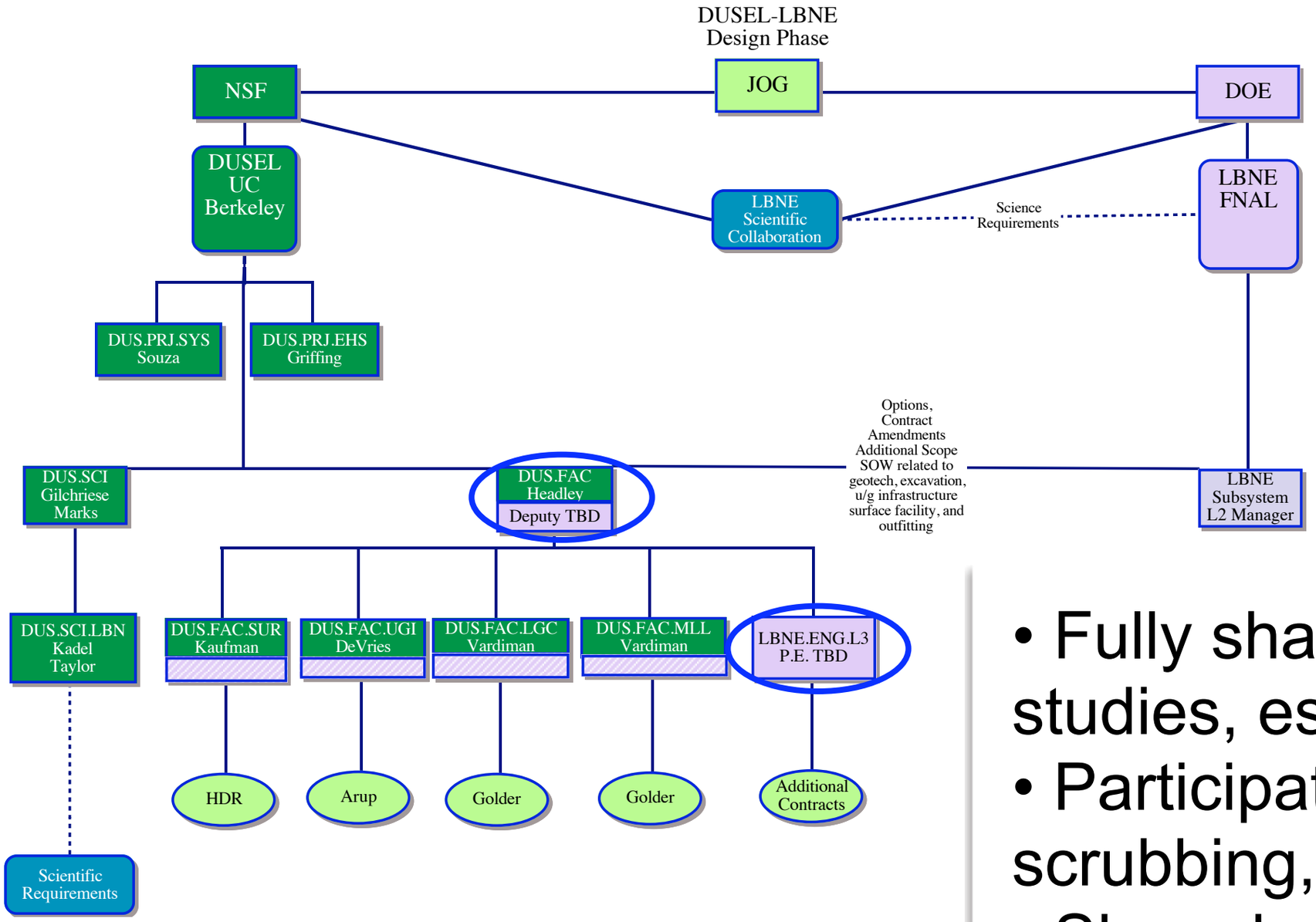
- steward verb: supervise arrangements, keep order, manage or look after (another person's) property

- NSF & DOE are working closely together to steward DUSEL's science
- Physics Efforts Coordinated through the Joint Oversight Group (JOG), Working Groups Established for:
  - Long Baseline Neutrinos and Proton Decay
  - Neutrinoless Double Beta Decay
  - Nuclear Astrophysics
  - Dark Matter Searches
- JOG will negotiate and mediate major decisions parsing scope, funding, timing between the agencies and projects
- Integration of LBNE with DUSEL efforts serves as an effective model for other major experiments

Agencies' Stewardship Model for DUSEL

Program	Steward Agency	Collaborating Agency
DUSEL Facility	NSF	DOE
Dark Matter	NSF	DOE-OHEP
0νββ	DOE-ONP	NSF
Long Baseline Neutrinos & Proton Decay	DOE-OHEP	NSF
Nuclear Astrophysics	NSF	DOE-ONP
Advanced low background & assay	NSF	DOE
Bio/Geo/Eng	NSF	DOE(-BES/BER)

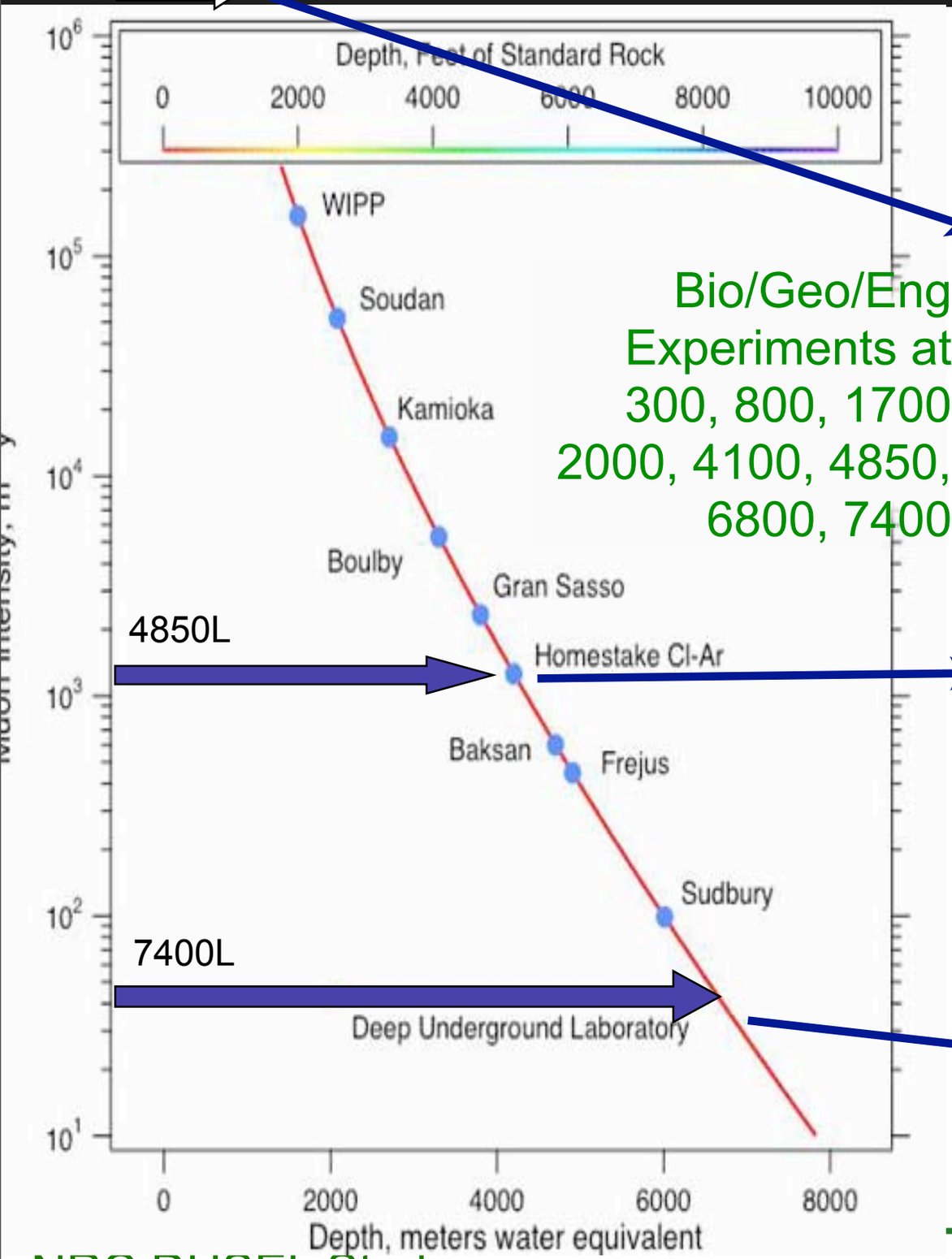
Stewarded Design Efforts Resulting in Melding the LBNE Organization with DUSEL



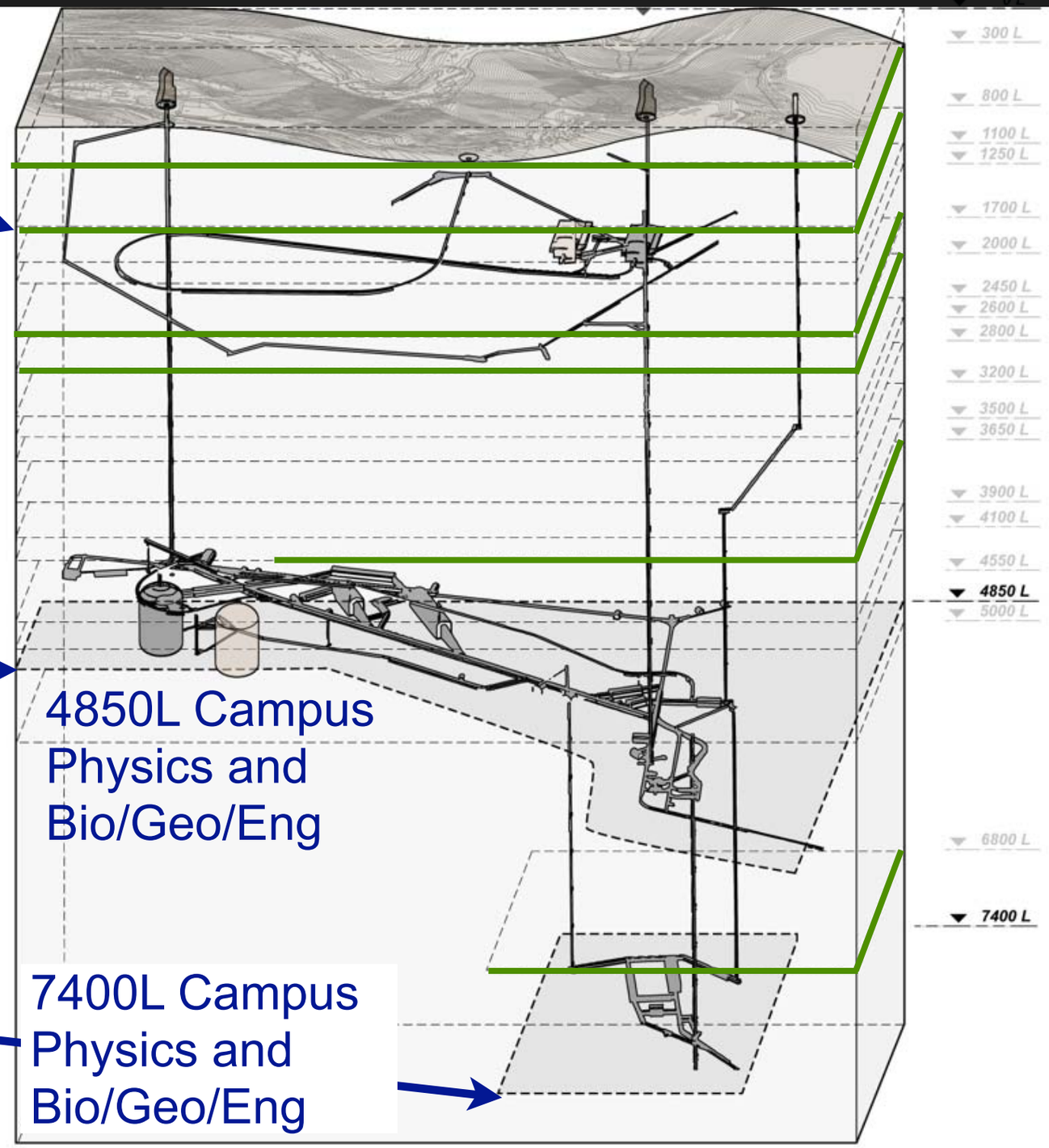
- Fully shared access to A/E, studies, estimates and reports
- Participation in reviews, cost scrubbing, workshops
- Shared engineering staff
- LBNE relying on DUSEL for LC design for CD1 review

Plans for Research Campuses Optimized for Science and Engineering Goals

800L



Bio/Geo/Eng Experiments at 300, 800, 1700 2000, 4100, 4850, 6800, 7400



4850L Campus Physics and Bio/Geo/Eng

7400L Campus Physics and Bio/Geo/Eng

NRC DUSEL Study

DUSEL Deep Underground Science and Engineering Laboratory

High Level Milestone Schedule for DUSEL's Suite of Experiments

Science Goal	Known Technologies/ Collaborations	Generic Suite Deploy	Technology Choice/ Experiment Downselect	Ready to Install (begin detector installation)	Location
Physics					
Dark Matter	4	≥1 G3	G2 2013-2017 Tech choice 2013 and PAC Review 2013	2017	4850/7400
0νββ	2	1 G3 *DOE-Led*	G2 2010-2017 Tech choice/PAC 2015	2018	7400
Long Baseline Neutrinos & Proton Decay	2 (WC/LAr)	*1 WC* *DOE-Led*	CD2 2013 CD3 2015	2018 (CD process informed)	800/4850
Nuclear Astrophysics	1	1	PAC Review 2012-13	LE 2016 HE 2017	4850
Advanced Low Background & Assay	1	1	some need by expts before construction	Potential Sanford Lab options/ LM 2017	4850
Bio/Geo/Eng					
Distributed Instruments	5	2	Community Review 2013 PAC Review 2014	2014 geophys 2015 eco hyd	various
Construction and Engineering	2	1	Community Review 2013 PAC Review 2015	2016 with LMs	4850
Dedicated Laboratories	4	3	Community Review 2013 PAC Review 2015	2016, 2017 access driven	0-1700, 4850, 7400

Approximate Experiment Durations and Future Upgrades or Choices

	2014	2024	2034	2044	2055
DUSEL Construction	DUSEL Construction				
Long Baseline Neutrinos		LBNE SuperBeams	Enhanced SuperBeams? Neutrino Factory?		
Proton Decay		Statistics Limited Measurements of Proton Decay			
Supernova and Other Neutrinos		On-going Measurements of Astronomical Neutrinos, Atmospheric Neutrinos and Non-standard Model Physics			
Neutrinoless Double Beta	G1 @ Sanford & WIPP	G2 ~ 1 tonne scale	Additional Nuclei Detector Mass?		
Dark Matter Searches	LUX; G2	G3 WIMP Mass	W-N Coupling/Spin Directionality & Velocity Distrib	Dependence	
Nuclear Astrophysics		Cross section measurements of critical reactions in stellar Hydrogen and Helium burning			
Ecohydrology		Distributed Instruments; Ultradeep Eco-hydrology Lab			
Seismic + Geophysics		On-going Seismic Monitoring and Array Enhancements			
CO2		Initial Site Work; Dedicated "LUCI" Laboratory			
Fracture Processes		Distributed Instruments; Dedicated Laboratory			
Coupled Processes		Distributed Instruments; Dedicated "THMCB" Laboratory			

Large and Active DUSEL User Community

- Multidisciplinary Science and Engineering Users Community
  - Physics
  - Biology
  - Geology
  - Engineering
  - E&O

  } 700 to 1000 participants

- DUSEL Experiment Development Committee ⇒ DUSEL Users Research Association and Executive Committee
  - Charter
  - Workshops
  - Regular Interactions with DUSEL
- International Interest continues to grow
  - Some experiments have explicit international agreements and partnerships
  - Large scale experiments awaiting “selection” to begin more formal discussion

Experimental Requirements Drawn from S-4 and Other Collaborations

- **Physics - S4**
  - EXO (DBD) - Gratta (Stanford)
  - GE1T (DBD) - Wilkerson (UNC)
  - MAX (DM) - Galbiati (Princeton)
  - LZ20 (DM) - Shutt (Case Western)
  - GEODM (DM) - Golwala (Caltech)
  - COUPP (DM) - Collar (Chicago)
  - LBNE (Long Baseline Nus, PDK) - Svoboda (UCD) & LBNE Project (FNAL)
  - DIANA (Nuclear Astro) - Wiescher (Notre Dame)
  - (F)AARM (Low Background Assay) - Cushman (Minn.)
- **Bio/Geo/Eng - S4**
  - Transparent Earth - Glaser (UCB)
  - Fiber Optic Array - Wang (Wisconsin)
  - Fault Rupture - Germanovich (Georgia Tech)
  - THMC (coupled processes) - Sonnenthal (UC/LBNL)
  - CO_2 (Sequestration) - Peters (Princeton)
  - EcoHydro - Boutt (U. Mass)
  - Monitoring - Bobet (Purdue)

- **Physics**
  - Long Baseline Nus (LAr) - Fleming (Yale)
  - N-Nbar (vertical shaft) - Kamyshkov (U. Tenn)
  - Atomic Interferometry (vertical shaft) - Kasevitch (Stanford)
  - Gaseous TPCs (DM and DBD)
    - Nygren (LBNL)
    - Sciolla (MIT)
    - Loomba (UNM)
  - CLEAN (DM + Solar nu) - Hime (LANL)
  - LENS (Solar nu) - Raghavan (VT)
- **Bio/Geo/Eng**
  - Seismic Arrays - Pavlis (U. Indiana)
- **DUSEL/Sanford Initial Science**
  - Majorana Demonstrator (DBD) - Wilkerson (UNC) Elliott (LANL)
  - LUX (DM) - Gaitskell (Brown) Shutt (Case Western)
  - LUX + Zeplin-3 (DM) - Gaitskell, Shutt, ...
  - SD 2010 - Center (u/g xtal production) - Mei (USD)
  - Seismic Arrays - Roggenthen (SDSM&T) Glaser (UCB)
  - Bio sampling - Anderson (BHSU)
  - Hydrochemistry - Stetler (SDSMT)
  - Characterization Efforts - Mei (USD) Grey (Regis) Smith (LBL)
  - DUGL (Gravity Wave) - Mandic (U. Minnesota)

Engaged DUSEL Program Advisory Committee

DUSEL Program Advisory Committee

Michael Witherell
Allen Caldwell
Boris Kayser
Hitoshi Murayama
Peter Parker
Michael Ramsey-Musolf
Heidi Schellman
Abe Seiden
Yoichiro Suzuki

Mark Zoback
Don DePaolo
Steve Hickman
Art McGarr
Patricia Sobecky

- **DUSEL Preliminary Design Baseline and Approach to the MREFC Proposal** – Is the Project on an appropriate path to complete a comprehensive Preliminary Design and one likely to obtain National Science Board approval?
- **DUSEL Generic Suite** – Is the proposed Generic Suite of Experiments appropriate to the vision of a world-class facility? Are there experimental elements missing from the suite? Should experiments be reconsidered for inclusion in the generic suite?
- **Planning for the Scientific Program** – Are the proposed preliminary plans and timescale for review and definition of the DUSEL scientific program, including the evolution of the experimental activities at the Sanford Laboratory, appropriate?

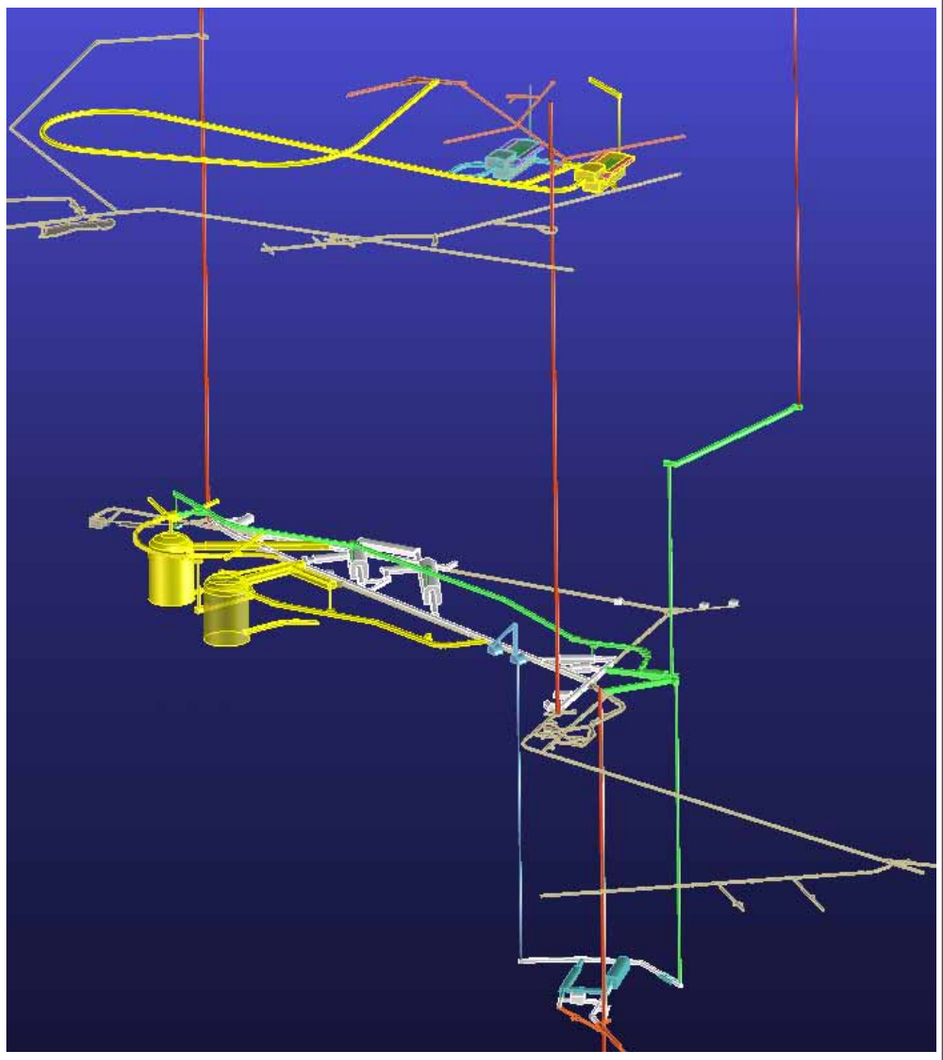
Planning Joint DUSEL-FNAL PAC Meeting this summer

Program Advisory Committee Actively Interacting with DUSEL

- *The envisioned program in physics and astrophysics will address fundamental questions about the Universe and its fundamental laws, such as the question of why the universe contains matter but no antimatter, the nature of dark matter, the origin of neutrino mass, and the genesis of the chemical elements.*
- *The biology program will study life in extreme conditions underground to shed light on the origin and evolution of life.*
- *The geosciences program will have opportunities to study directly at depth variety of the thermal, hydrological, mechanical, chemical, biological-mass, and energy-transport phenomena on a scale not done before.*
- *The engineering program will study rock properties in situ to enable better design and use of underground space.*

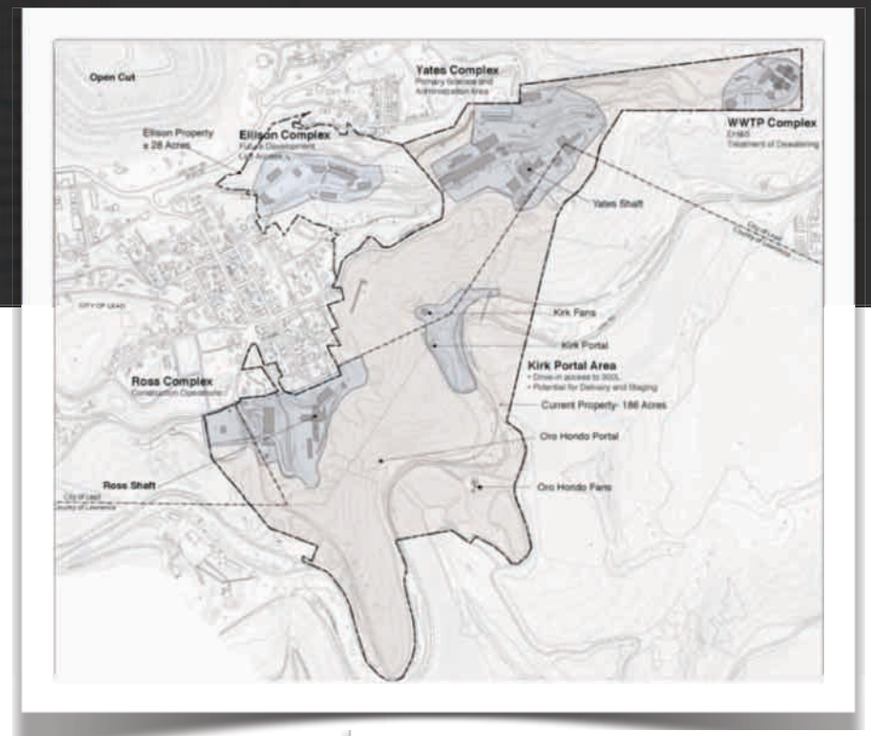
Facility Design Refined to Foster this Suite of Critical Experiments

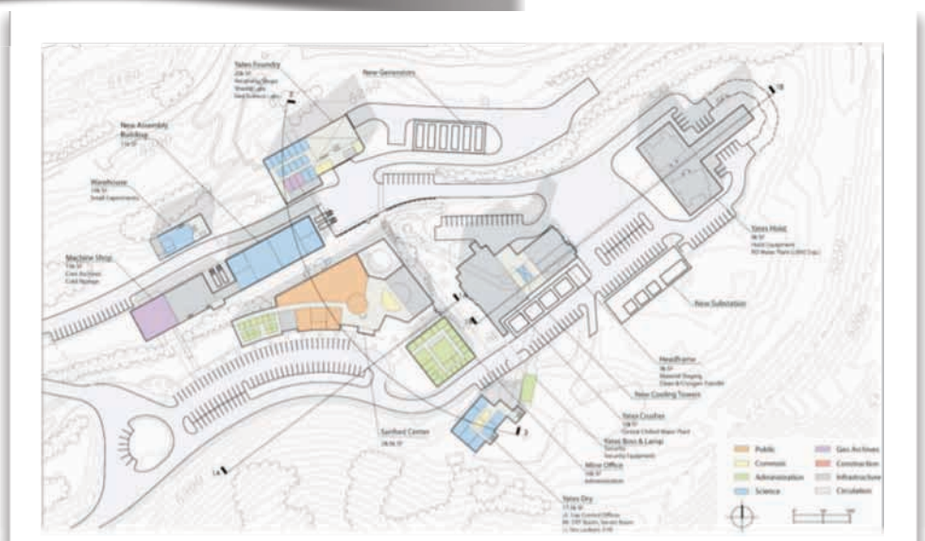
- **World-Class Facility**
  - Research Campuses
    - Surface (~27,000 m^2/ 1,100 m^2 total/assembly)
    - 4850L (~25,000 m^2 /6,200 m^2 total/science)
    - 7400L (~7000 m^2 /1,300 m^2 total/science)
    - Other Levels and Ramps (~30 km: ~50/50 ops/sci)
  - Dual Access to Research Campuses
  - Best-practices Life Safety Systems and Programs
  - Experimental Support
  - Design Enabling Future Expansion
  - Project Enabling Participation by Other Agencies
  - Integrated Education and Outreach Efforts

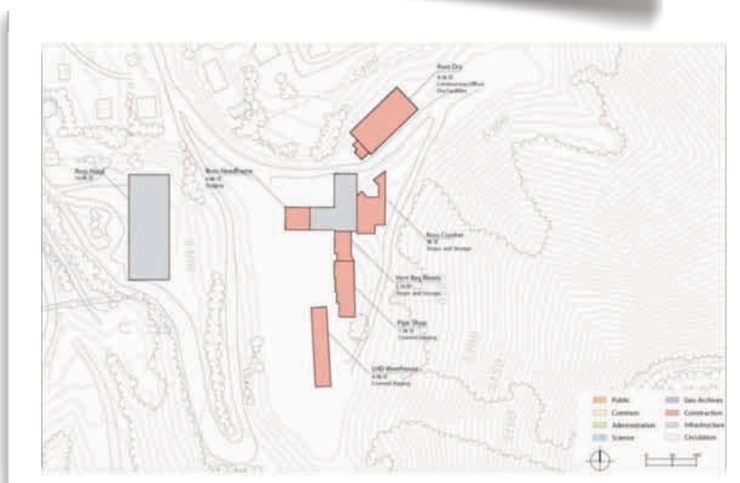


Surface Campus

- Yates - Science Campus
  - –Administration
  - –Science support
    - assembly
    - shops
    - offices
  - –Science Underground Access
  - –Education and Outreach
- Ross - Maintenance and Operations Campus
  - –Support underground operations
  - –M&O Underground Access



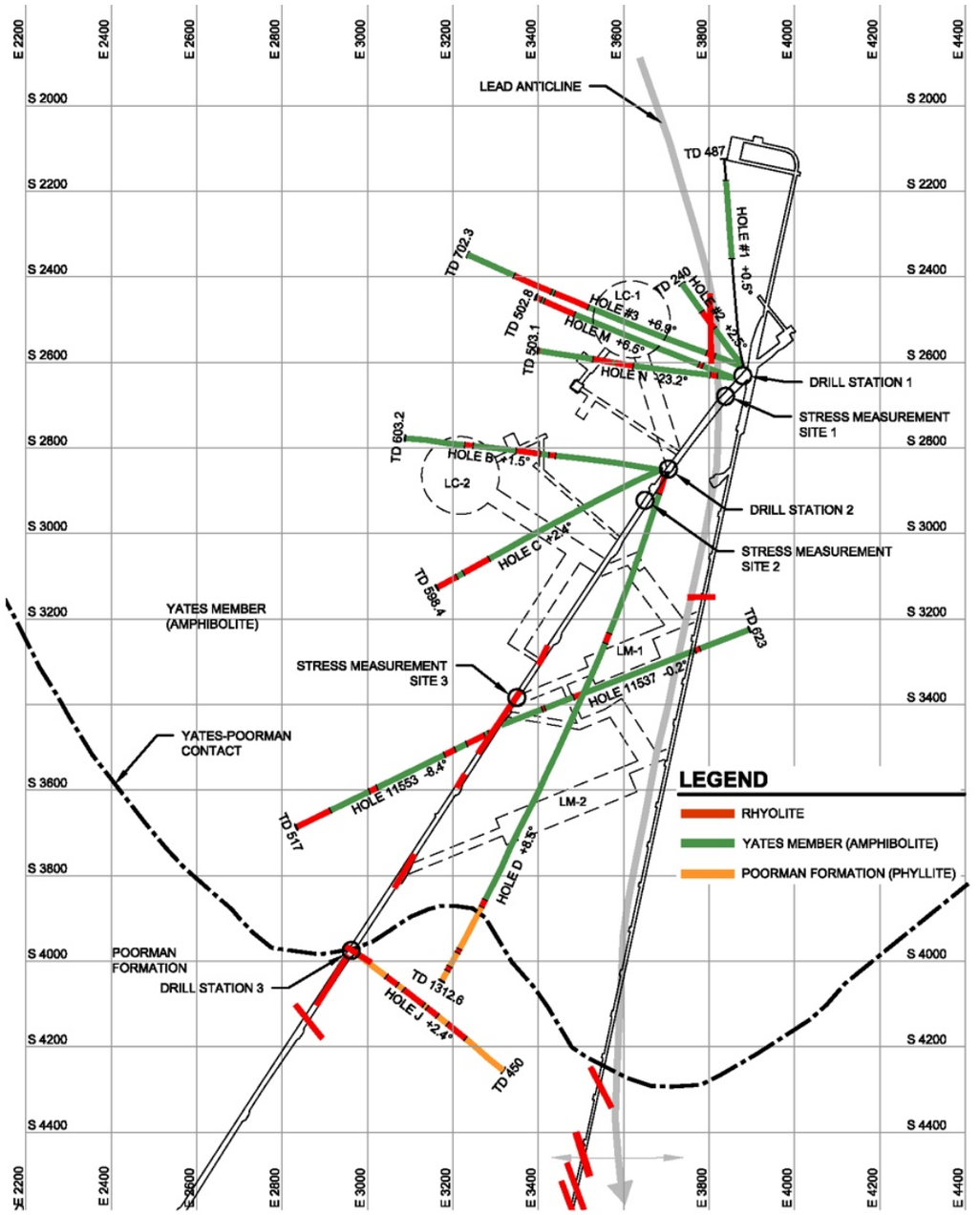




Completed Critical Geotechnical Investigations

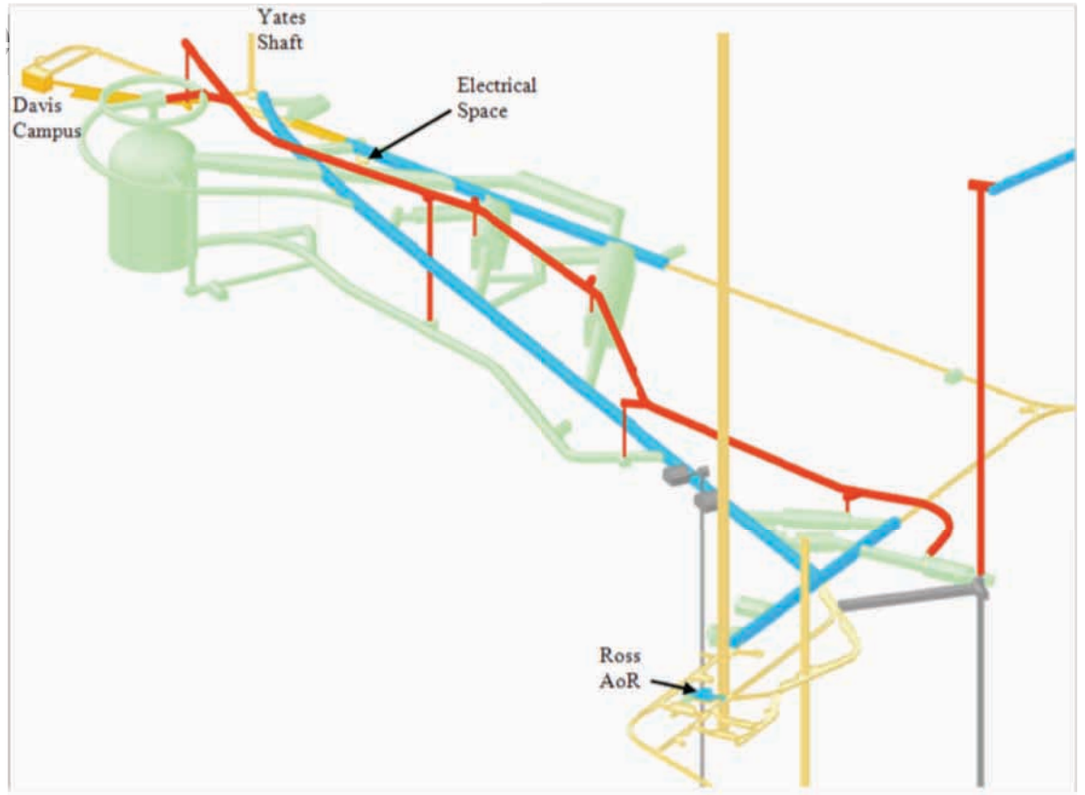
- 300 & 4850 Level Mapping - Completed
- Geological Model - Developed
- Coring and Logging - Completed
  - holes 1, 2, 3: Sanford Lab
  - holes 3, M, N: LC 1
  - holes B, C: LC 2, LC3
  - holes D, J: 4850 Lab Modules
  - 5,399 feet of core: logged, televiewed
  - "enough geotech for preliminary design" - Large Cavity Advisory Board
- *In situ* testing - Completed
- Laboratory testing - Completed

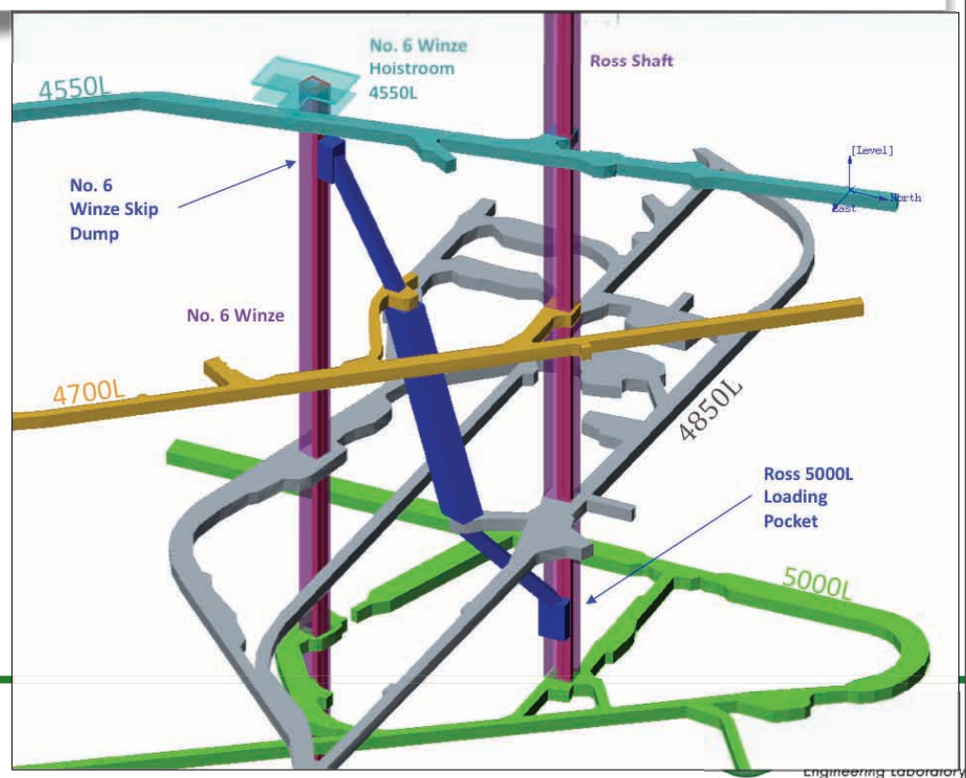
  Good news: Little Water, Good to Very Good Rock Quality



Design of Underground Infrastructure Advanced to Support the Science Goals

- Maintenance shops, utility rooms, storag
  and containment areas
- Drifts and ramps required for access,
  egress, and ventilation
- Cyber-infrastructure controls and
  monitoring systems
- Material handling systems
- Air quality and ventilation systems
- Waste (rock) handling systems
- Electrical power distribution systems
- Dewatering systems
- Water inflow management systems
- Chilled water systems
- Life safety systems and areas of refuge
- Plumbing systems
- Compressed air systems

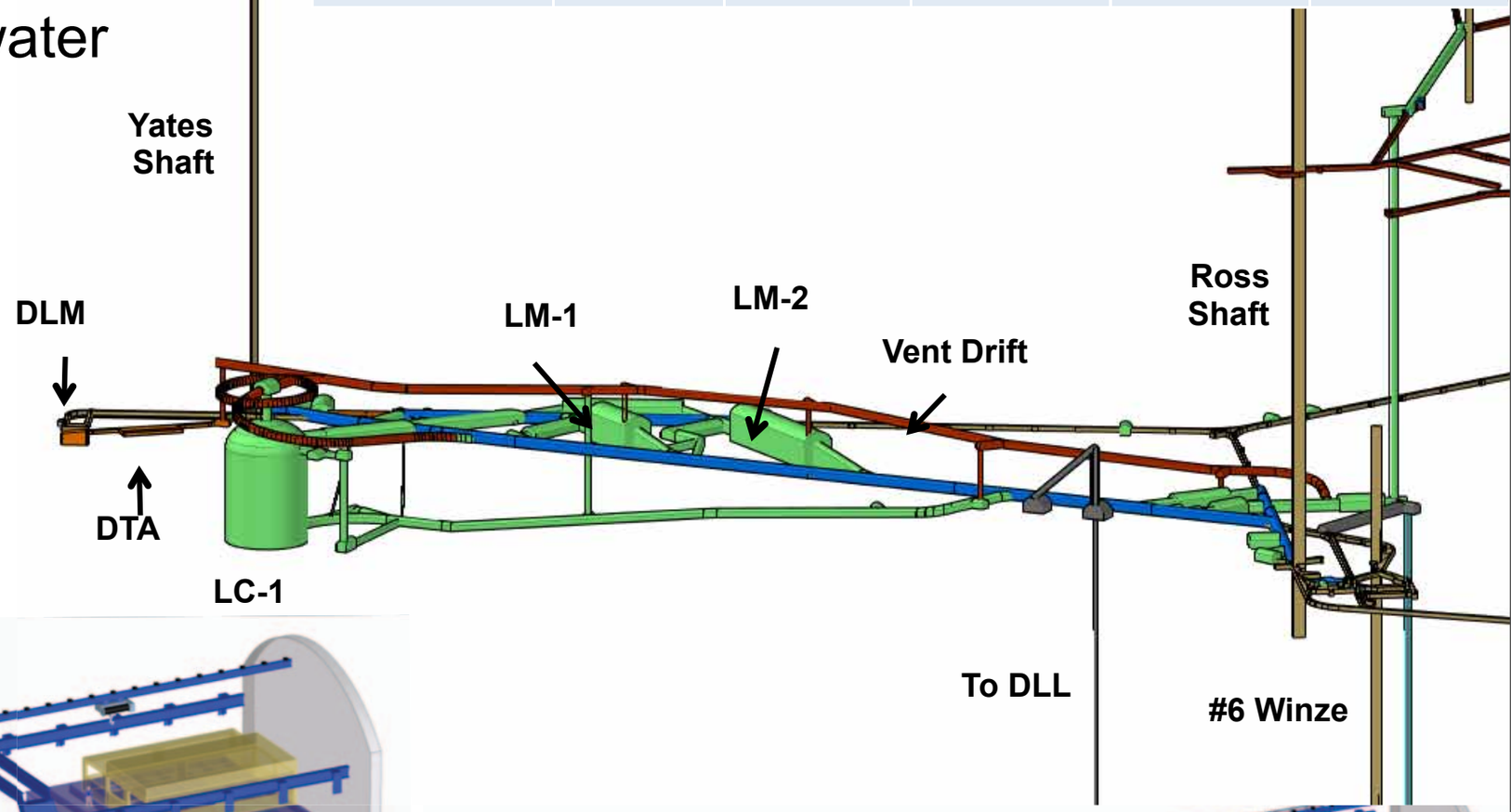


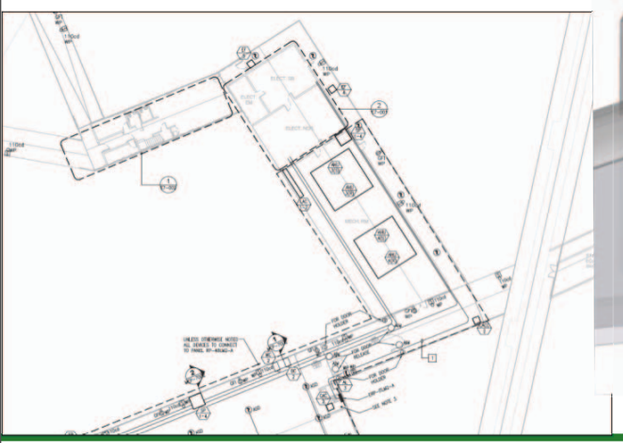


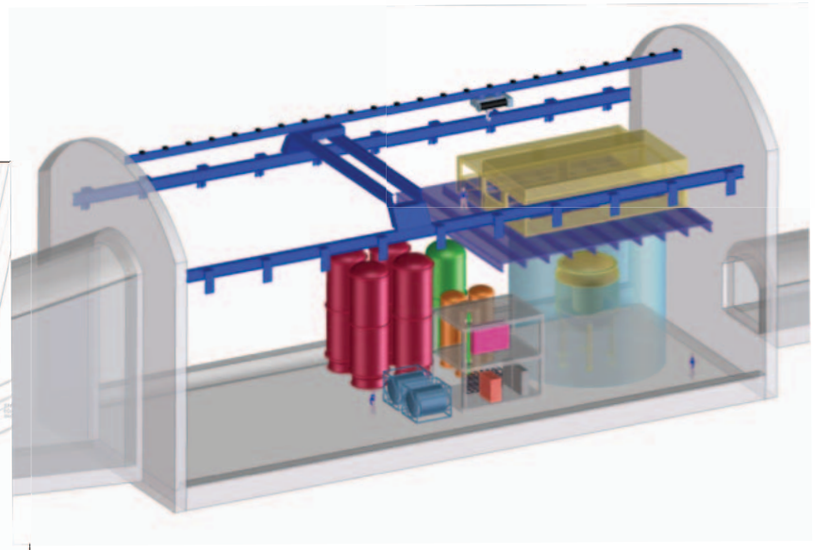
Midlevel Lab - 4850L

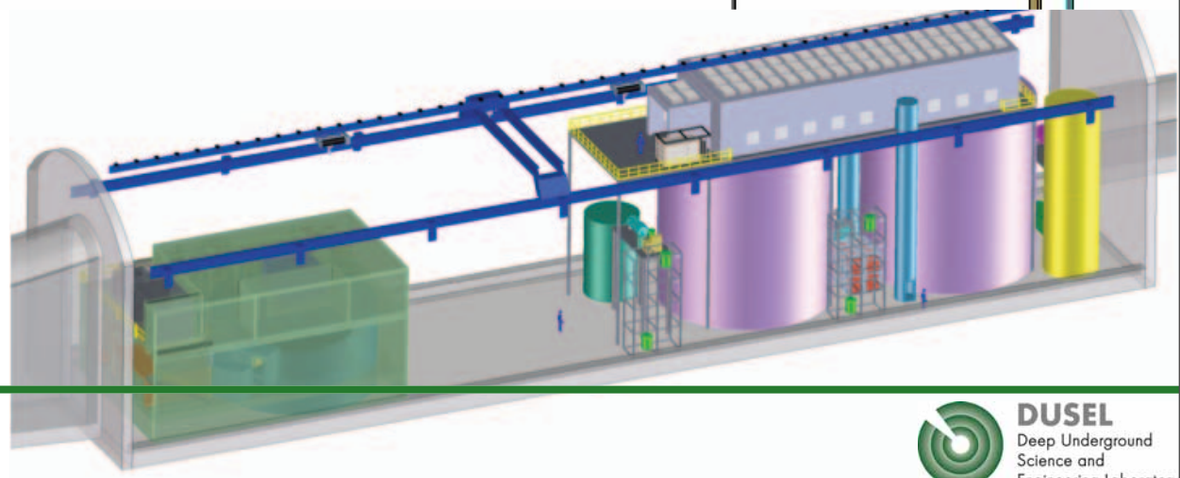
- Experimental Support
  - 2000kW (standby 100kW)
  - 1100kW (standby 160kW)
  - Chilled, industrial, potable water
  - 20T, 40T bridge and monorail cranes
  - 10Gbps
  - 15 - 30k cfm per LM ventillation
  - 100k cfm emergency ventilation
  - Fire-life-safety

Experiment Space	Length (m)	Width (m)	Height (m)	Floor Area (m^2)	Finished Volume (m^3)
LM-1	50	20	24	1000	22,495
LM-2	100	20	24	2000	44,990
LC-1	55 (dia)	-	83	2376	185,947
DLM	17	11	13	187	2431
DTA	43	16	5	688	3440



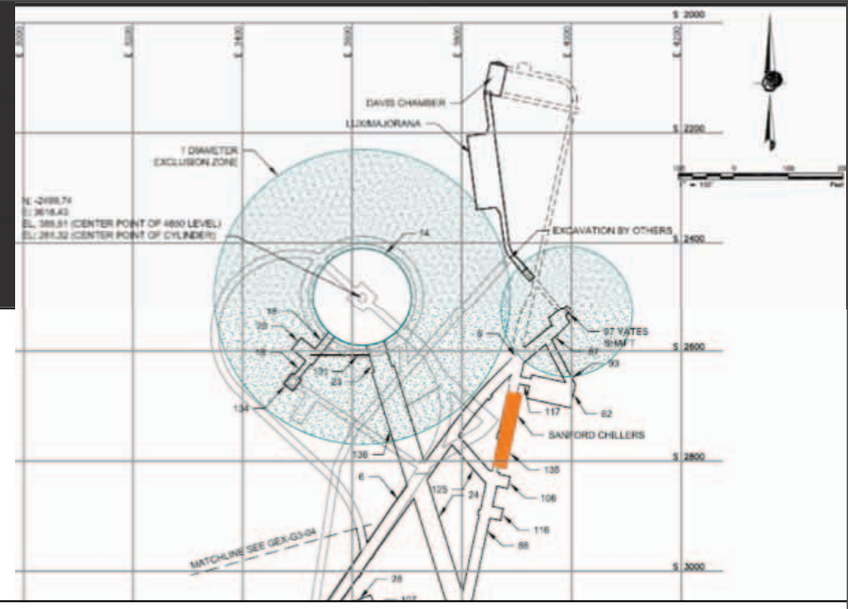


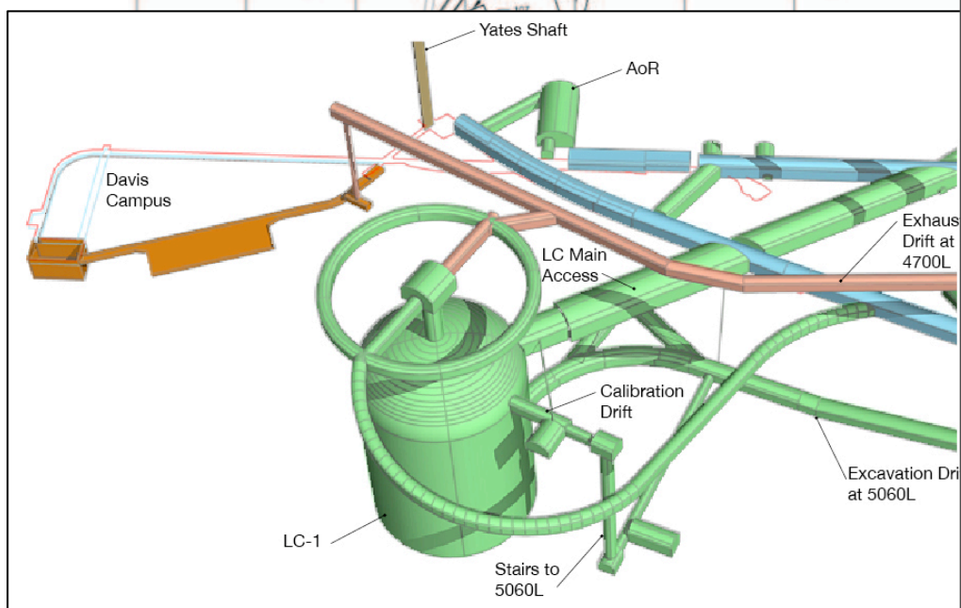


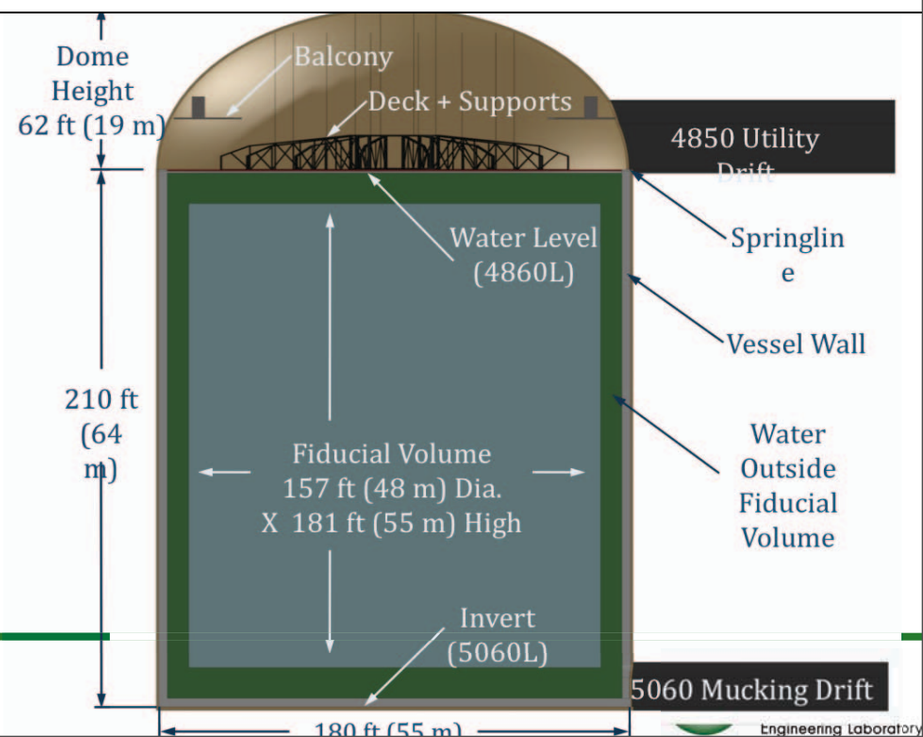


Large Cavity Design

- Project stewarded by DOE
- Design initiated by DUSEL for LC1 including preliminary geotechnical site investigations
- Gained confidence in positioning, excavation design, excavation sequencing, ground support, and long-term stability
- Understand DUSEL and LBNE Scope
- Design and Engineering Teams well integrated



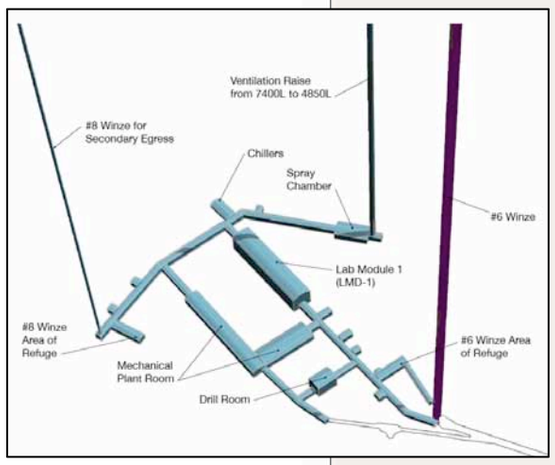


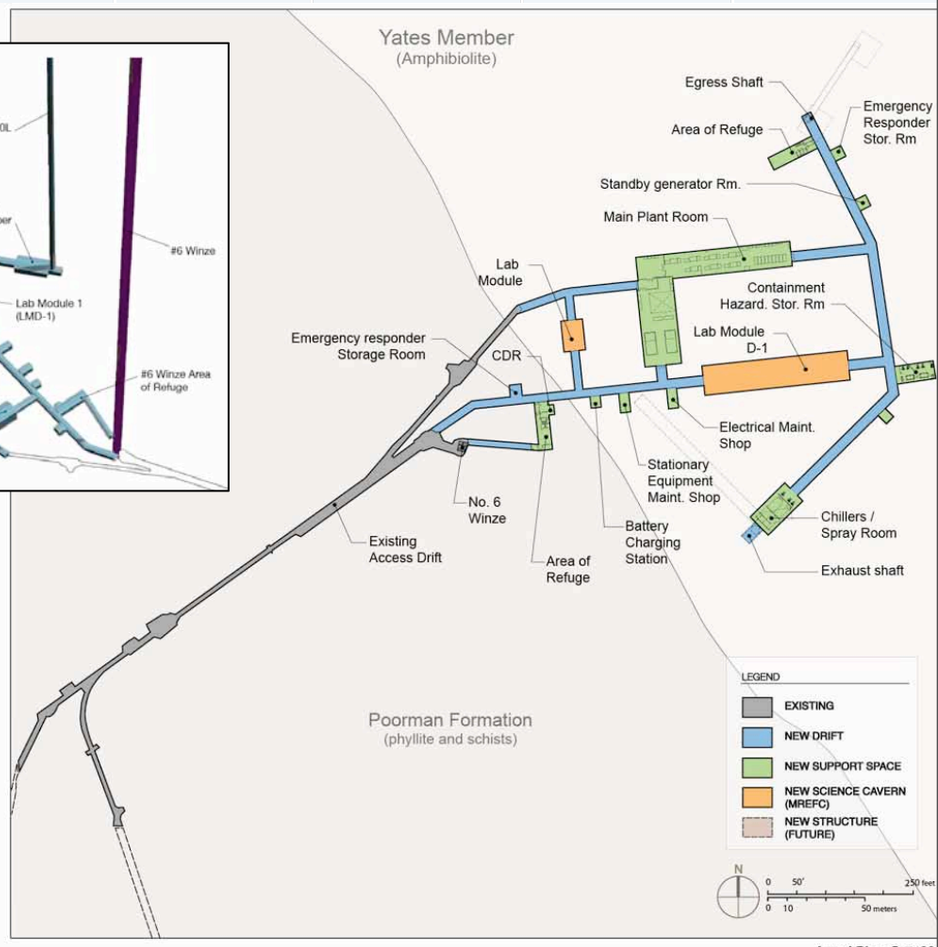


Deep Level Campus 7400L

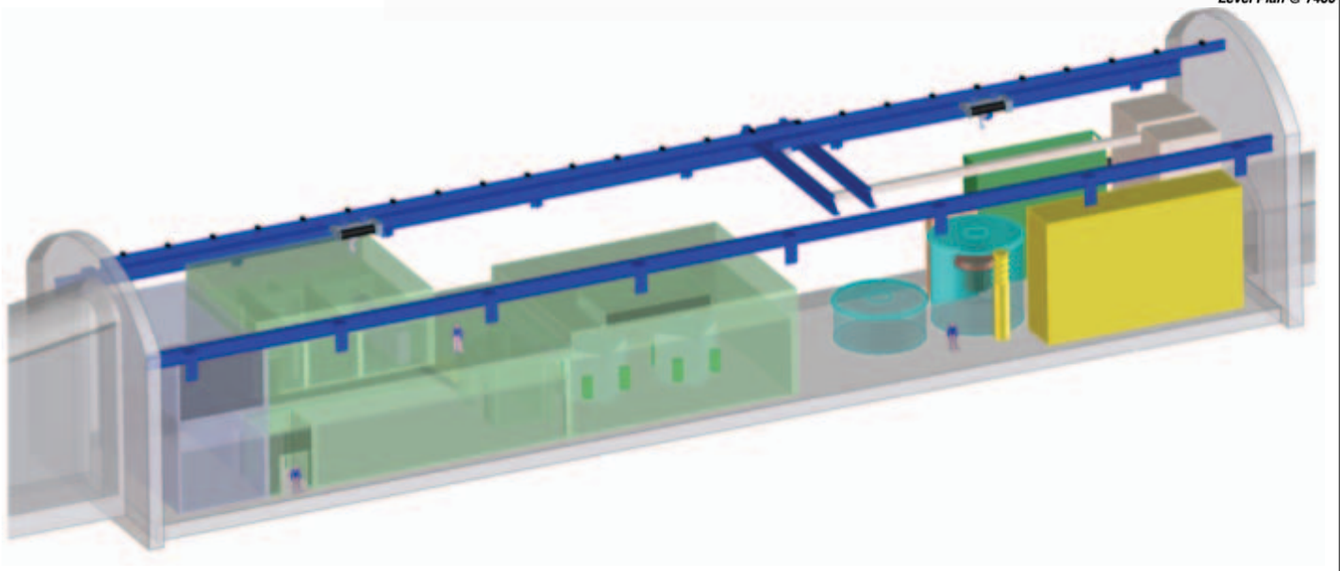
Experiment Space	Length (m)	Width (m)	Height (m)	Floor Area (m^2)	Finished Volume (m^3)
LM-1 (DLL)	75	15	15	1125	14,288
Drill Room	*16*	*11*	*11*	*176*	*1,644*

- Deep Lab Module
- Deep Ecohydrology Lab
- Experimental support
  - –650kW + standby
  - –Chilled, potable, industrial water
  - –20T, 40T bridge and monorail cranes
  - –10Gbps
  - –30k cfm ventilation
  - –100k cfm emergency ventilation
  - –Fire-life-safety



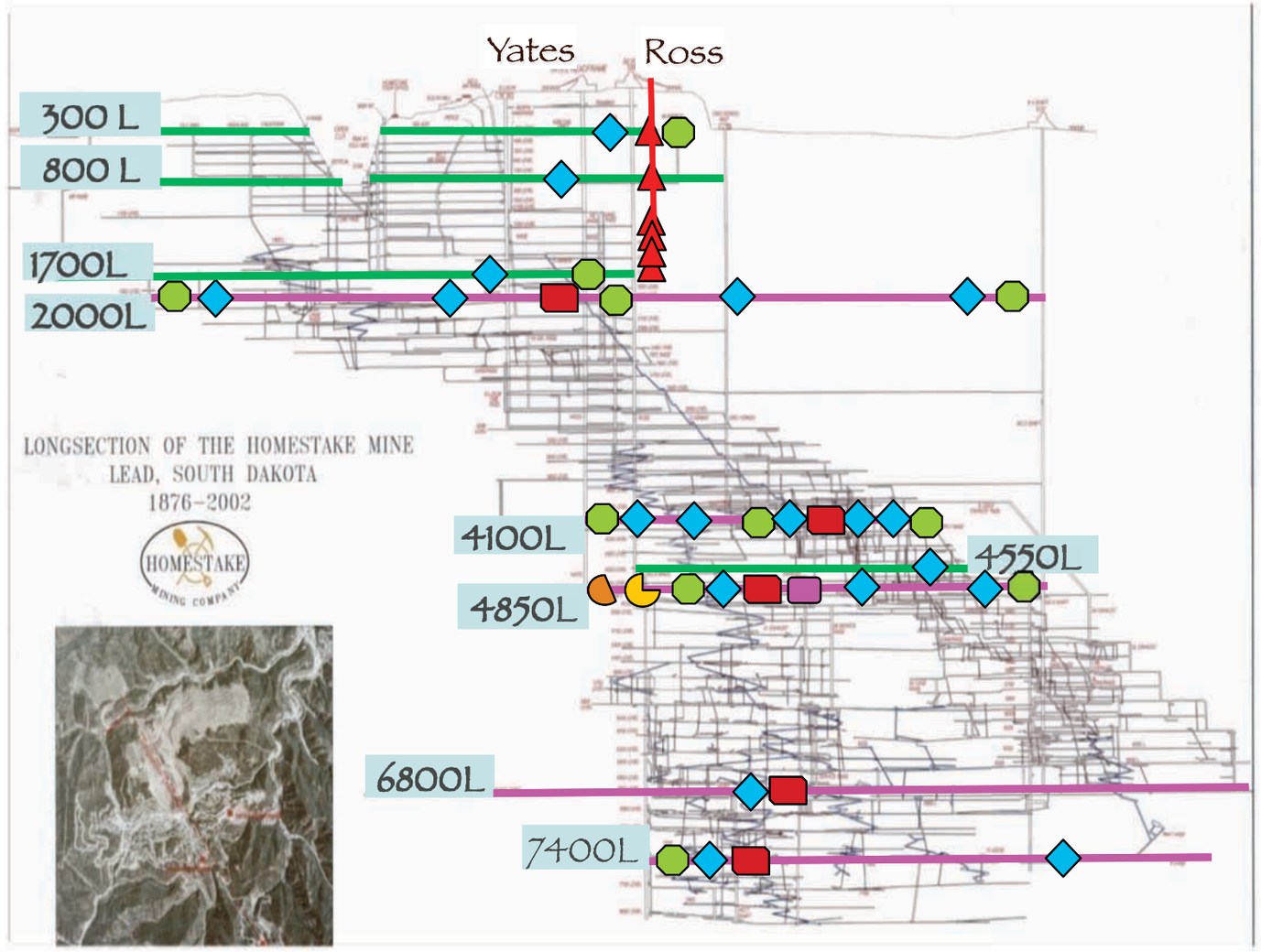


Level Plan @ 7400



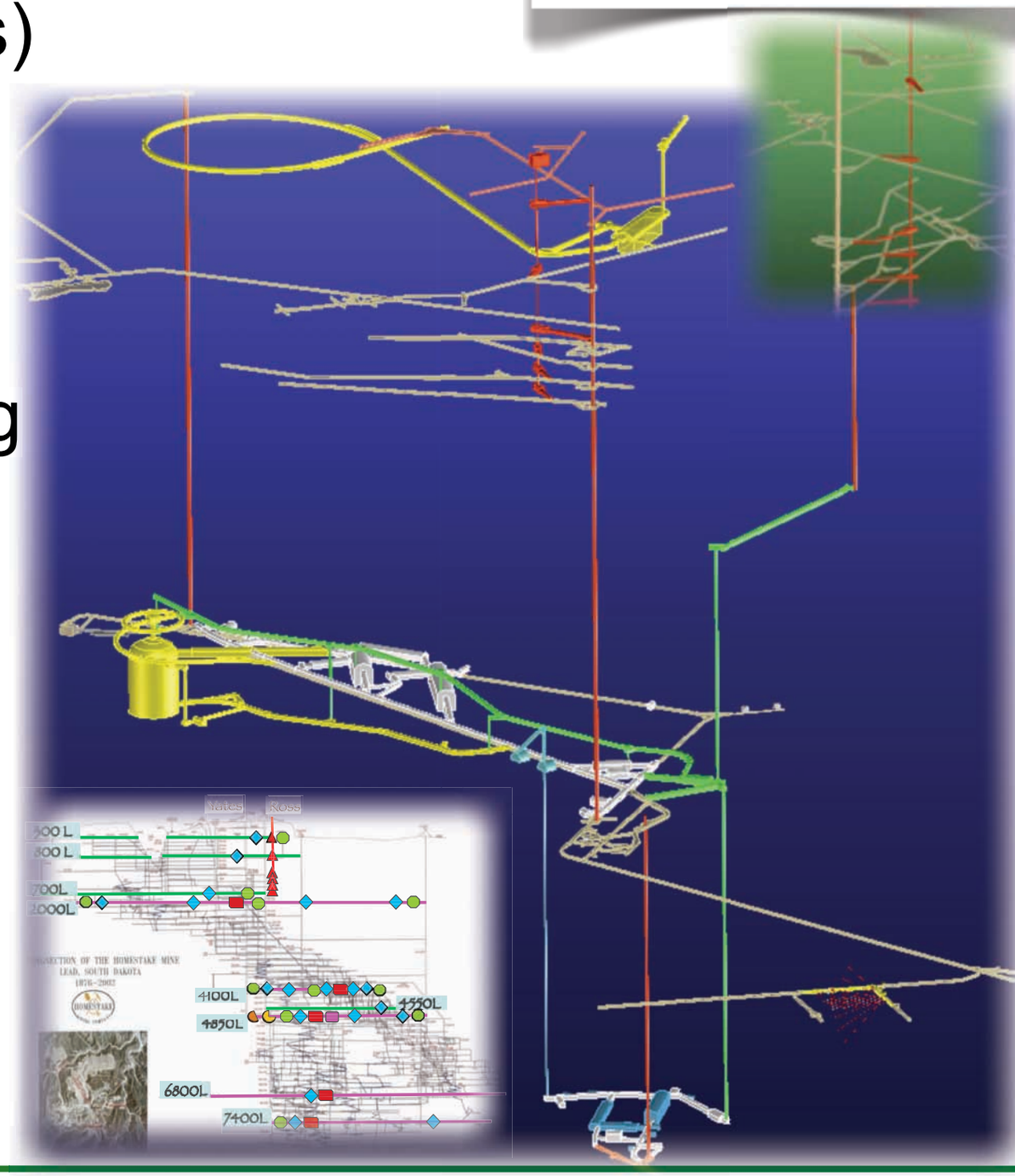
Other Levels and Ramps

- Refinement of the “levels of interest” defined in the CDR
- ~ 30 km of underground access available for science
- Levels chosen to maximize the access to the Homestake site areas of scientific interest
- Power, communications, ventilation, fire-life-safety



Facility Preliminary Design Developed to Host these Critical Experiments

- **Surface Campus**
- **0 to 1700L** (Vertical Experiments)
- **4850L**
  - 1 Large Cavity (+ Options totaling 200kT 4850L or 800L)
  - 2 Lab Modules + Davis hosting
    ~ 4 - 5 Physics Experiments
  - Earth Science Experiments
- **7400L**
  - 1 Lab Module hosting
    ~ 2 Physics Experiments
  - Earth Science Experiments
- **Other Levels & Ramps**



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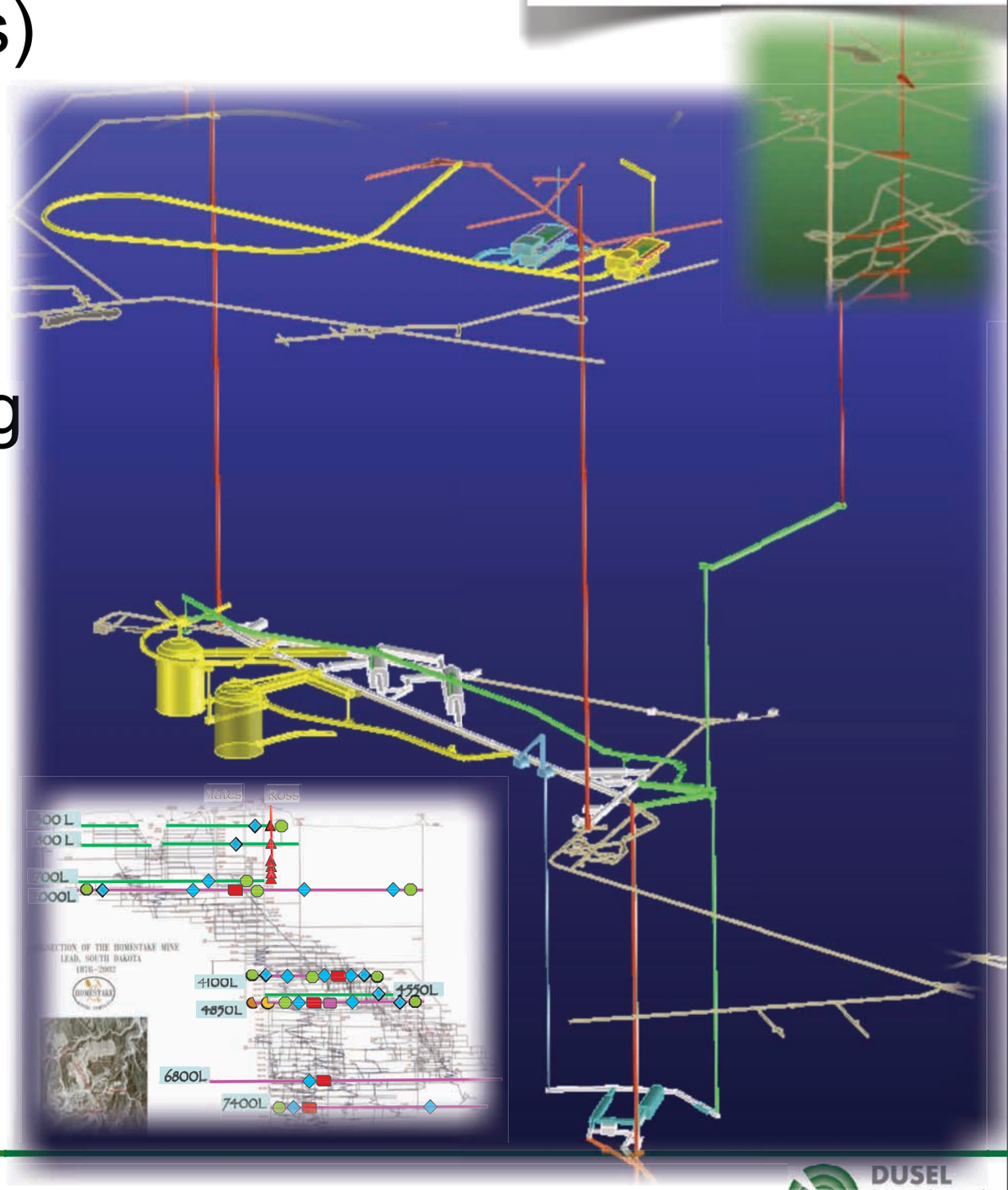

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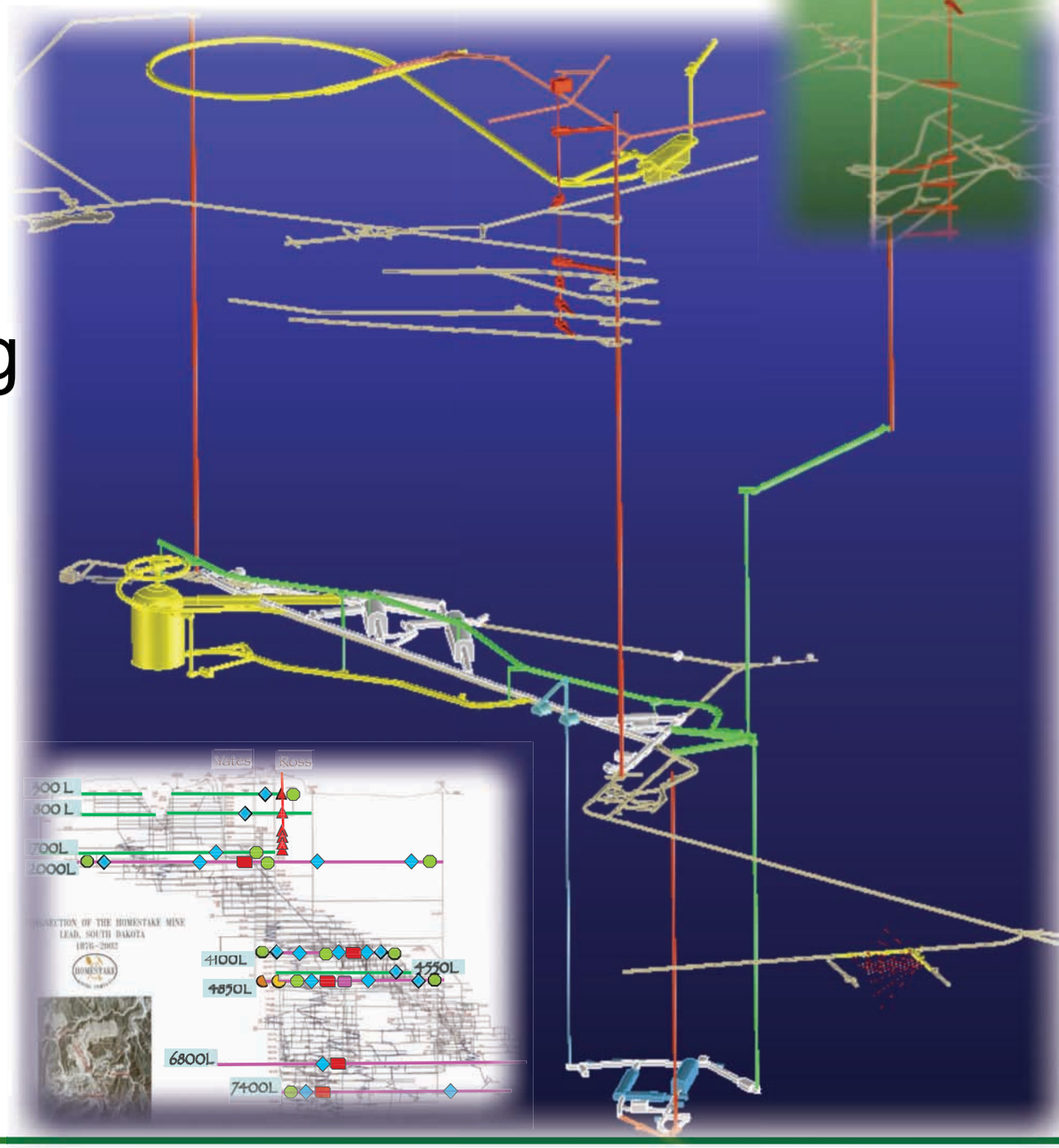
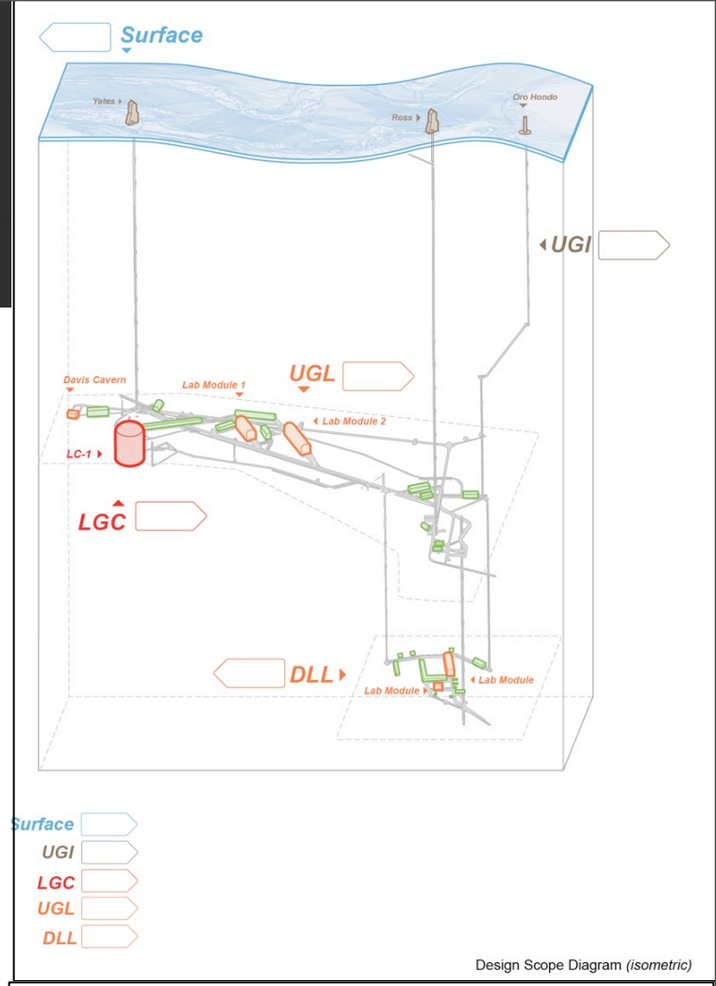
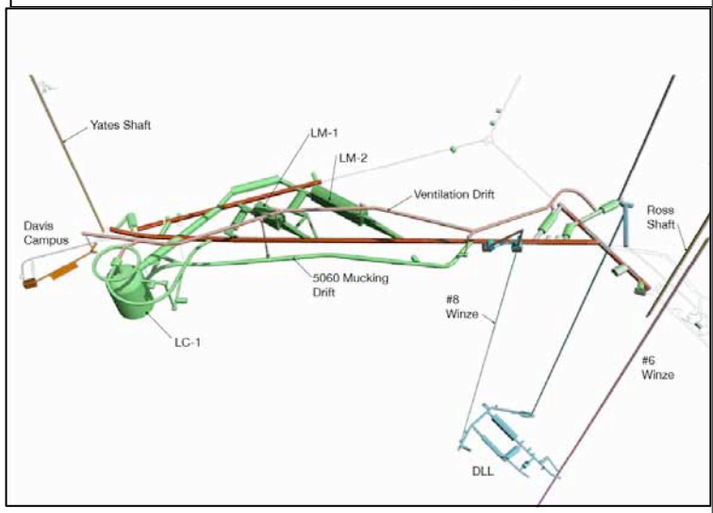


The DUSEL MREFC Project

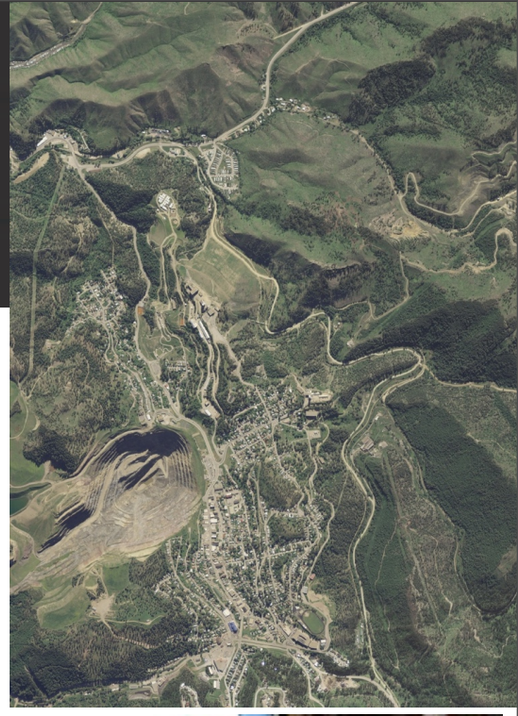
- DUSEL will be a NSF Major Research Equipment and Facility Construction (MREFC) Project: including
  - Facility
  - Suite of Compelling Multidisciplinary Experiments
- UC Berkeley Providing Leadership for the Project
  - Reports to the Vice Chancellor for Research
  - Established the Berkeley Project Office
  - University Business Systems supporting Project
    - HR, Travel, Contracts, SPO, ...
  - UCB provides key leadership and managerial positions



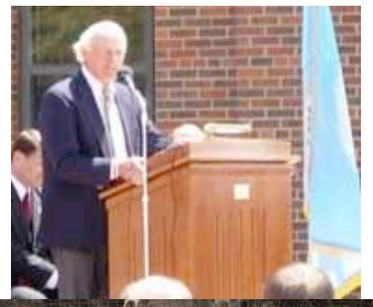
Design Scope Diagram *(isometric)*



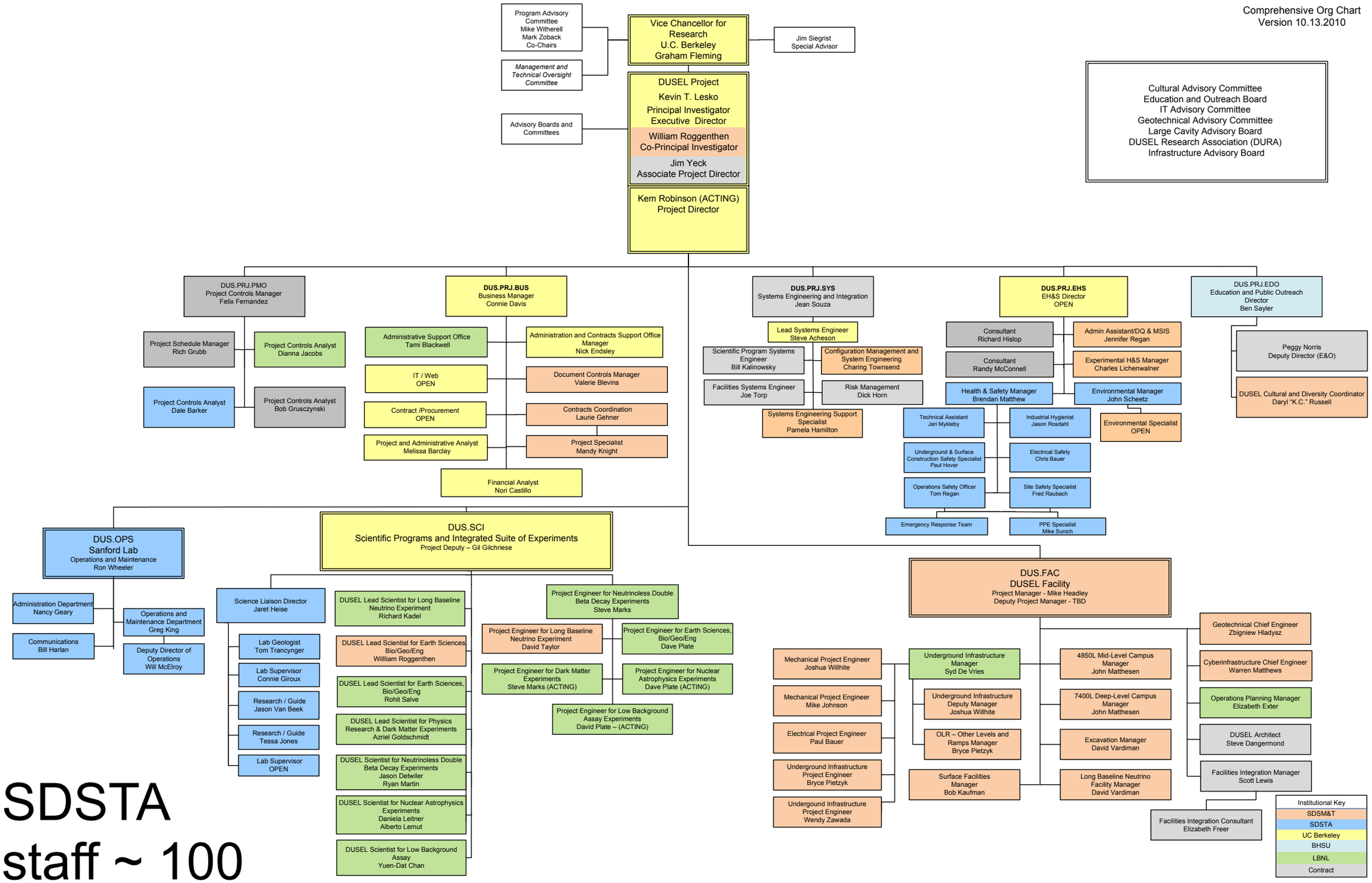
The DUSEL MREFC Project



- South Dakota heavily invested in the DUSEL partnership
  - South Dakota Universities actively engaging in DUSEL's science and E&O activities
  - South Dakota Universities have major roles in the DUSEL Construction Project
    - DUSEL's South Dakota Project Office at SDSM&T
  - Established the Science and Technology Authority with significant state support and financing
  - Received title to the facility from Barrick and discussions with Barrick concerning other property and options for use
  - Investment in rehabilitating and stabilizing the site
  - Overseeing significant philanthropic donations - the Sanford Lab
- Championing Early Implementation Program (Early Science and E&O)



The DUSEL Design Organization Nearly Complete: ~55 Staff Members



SDSTA
staff ~ 100

Expert Advice Boards and Committees Actively Consulting with DUSEL Project

- Project benefits from extensive review and consultation

Large Cavity Advisory Board
- **Evert Hoek**
- Ed Cording
- Derek Martin

Infrastructure Advisory Board
- John MacDonald*
- Bob Dengler

EH&S Oversight Committee
- **Craig Ferguson**
- Mike Andrews
- Mark Freiberg
- Jim Krebs
- Tony Iannacchione
- Jim Tarpinian

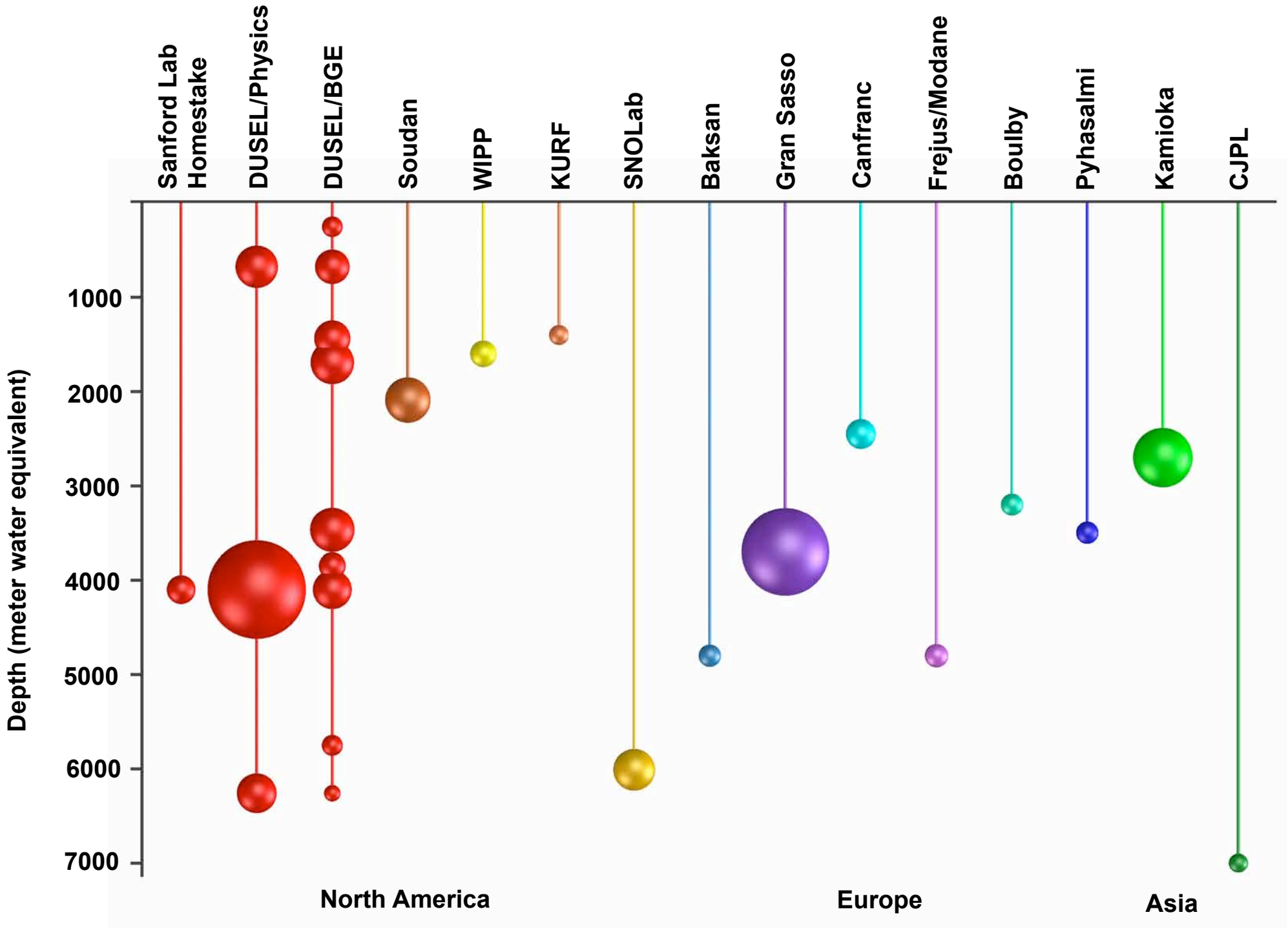
CyberInfrastructure Advisory Board
- **Greg Bell**
- Yuen-dat Chan
- Eli Dart
- Dale Finkelson
- Claude Garelik
- Greg King
- Jay Krous
- Rohit Salve
- Mike Sinatra
- David Stewart

Cultural Advisory Committee
- **K.C. Russell**
- Lowell Amiotte
- George Campbell
- Kevin Forsch
- Connie Giroux
- Bill Harlan
- Jeff Henderson
- Kay Jorgensen
- Carter Kerk
- Urla Marcus
- Peggy Norris

Milestone Schedule to Complete Preliminary Design

Design Packages and Design Activities	2010 April	May	June	July	August	September	October	November	December	2011 January	February	March	April	May
Deep Campus Conceptual Design	▲													
Surface Campus Conceptual Design	▲													
Underground Laboratories		▲			▲		▲							
Underground Infrastructure			▲			▲		▲						
Excavation Design				▲			▲		▲					
	60% Preliminary Design			90% Preliminary Design			100% PDR	Advancing Design Elements and Integrating Experiments						
DUSEL Construction Management and Project Team				▲ Reconciled 60% Estimate										
				▲ Consolidated 60% Estimate			▲ Reconciled 90% Estimate	▲	▲ Reconciled 100% Estimate					
							▲ Consolidated 90% Estimate	▲	▲ Consolidated 100% Report					
DUSEL and LBNE Project Teams		▲ Proposal FY11 Activities	▲ Proposal for CA2 Supplement					▲ Draft Preliminary Design Report					▲ LBNE CD1	
DUSEL, LBNE, Science Collaboration Reviews, Agency Meetings			▲ S-4 Physics Review	▲ LCAB IAB	▲ S-4 BGE Review	▲ PAC Meeting		▲ Internal Review of Preliminary Design	▲ Internal PDR Reviews			▲ NSF PDR Review		
		▲ Sanford Lab/DUSEL Safety Review			▲ NSB Retreat			▲ PDR Assembled	▲ NRC Assess				▲ NSB Meeting	
										Creation of New M&O Organiation			▲	

Comparison of Underground Laboratories around the World



Laboratory Volumes

DUSEL Lab Volume assumes: one 4850 LC and LAr LM at 800L

MREFC Project Scope

- We propose an MREFC Project with a scope of $875M (FY09$)
- this will support the development a dedicated, deep facility capable of supporting 30 to 50 years of multidisciplinary science, engineering, and education and outreach
- identifies adequate scientific support within the MREFC consistent with the Agency Stewardship Model and assuring the NSF of a leadership role in DUSEL's science programs
- Scientific support consistent with or exceeding previous MREFC projects

NSF MREFC Scope	Targets including Contingency
DUSEL Project Office	$575M
Surface Campus (+ $5M from Sanford)	
Underground Infrastructure and Laboratories (+ $7.5M from Sanford)	
Science Contribution	$300M
Total MREFC	$875M

NB: estimates are $FY09

Establishing the Estimated Cost Range for DUSEL's Suite of Critical Experiments

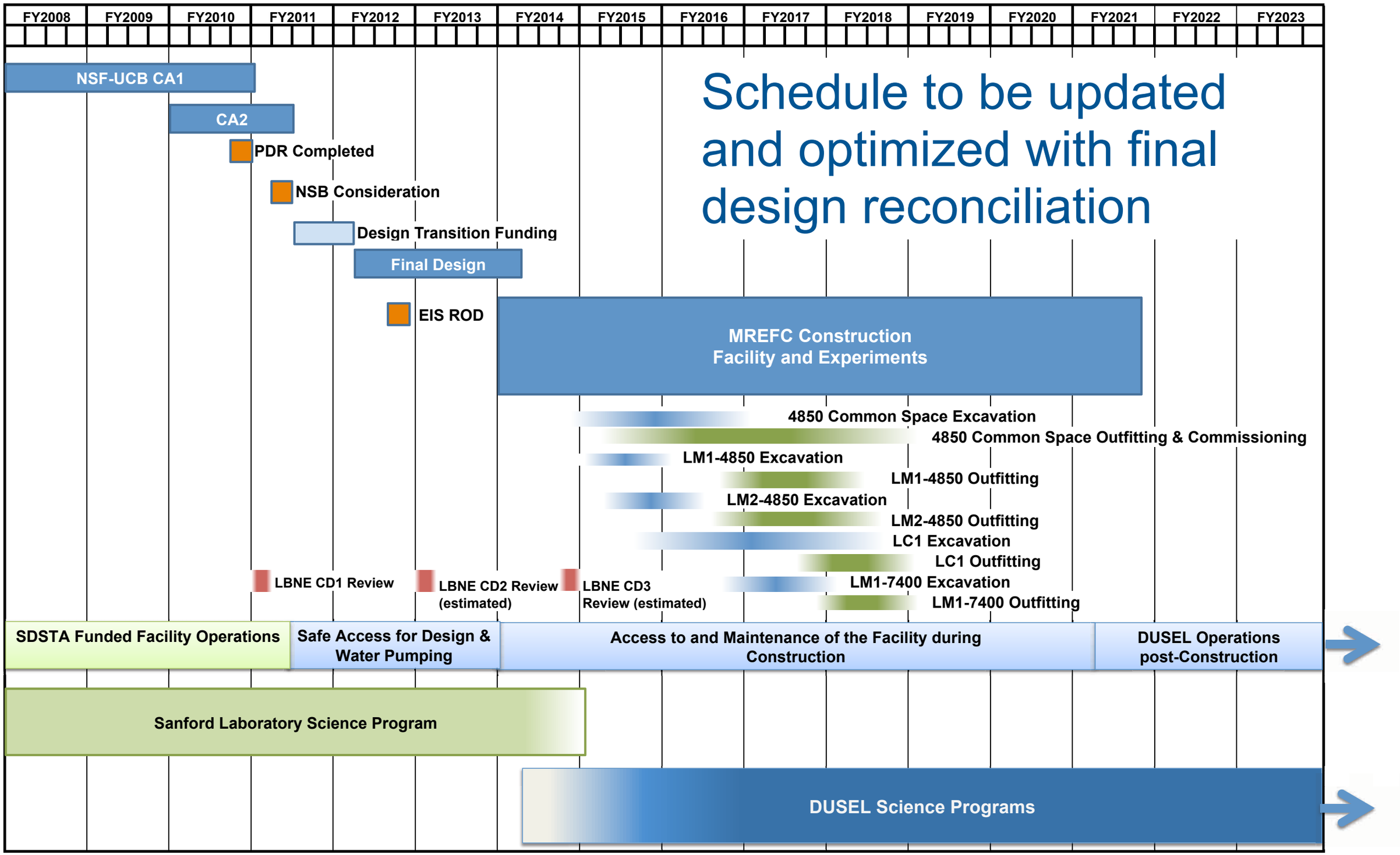
- Obtained from the S-4 collaborations, Physics reviews 13-15 July, and interactions with collaborations

Science Goal	Total Estimated Experimental Cost Range* ($M)	Proposed MREFC Contribution ($M)	Number of Deployments
Dark Matter	80 - 200	175	≥1
0νββ	250 - 350		1
Bio/Geo/Eng	60 - 180		multiple
Nuclear Astrophysics	30 - 50		1
Advanced low background & assay	10 - 15		1
Long Baseline Neutrinos & Proton Decay‡	785 - 1065	125	200 kt WCE

*NB: These Cost Ranges are not to be confused with or substituted for DOE CD estimates, estimates include ~ 50% contingency

‡NB: LBNE CD0 range includes beam, near detector and far detectors, this range includes MREFC contribution

DUSEL's Milestone Schedule through Construction



Summary of the DUSEL Project

- Well motivated and transformational science driving the facility design
- Facility design & timelines aligned with science requirements
  - Large Community Interest DUSEL science programs, over 700 scientists and engineers
  - NSF-DOE Stewardship Model functioning well
  - Collaborations are conducting essential R&D supporting DUSEL's Suite of Experiments
  - DUSEL represents strong NSF investment and alignment with NSF programs and activities
- The proposed MREFC Budget provides essential facility and science support, with the facility breaking ground in advance of the experiments, and with the facility and science experiments building on South Dakota's investments
- Despite aggressive timeline for the PDR, design ready to advance to final design stage
  - Careful oversight and integration of the designs elements and experiments
  - Strong value engineering process - integrating requirements and design optimization
  - Experienced A/E contractors developing design elements
  - Opportunity to develop a world-class Education and Outreach
  - Continued opportunities to develop and advance regional university participation