DuRA Meeting

Science Integration Physics Experiments

M. G. D. Gilchriese
Project Deputy Scientific Program

Fermilab

September 2, 2010

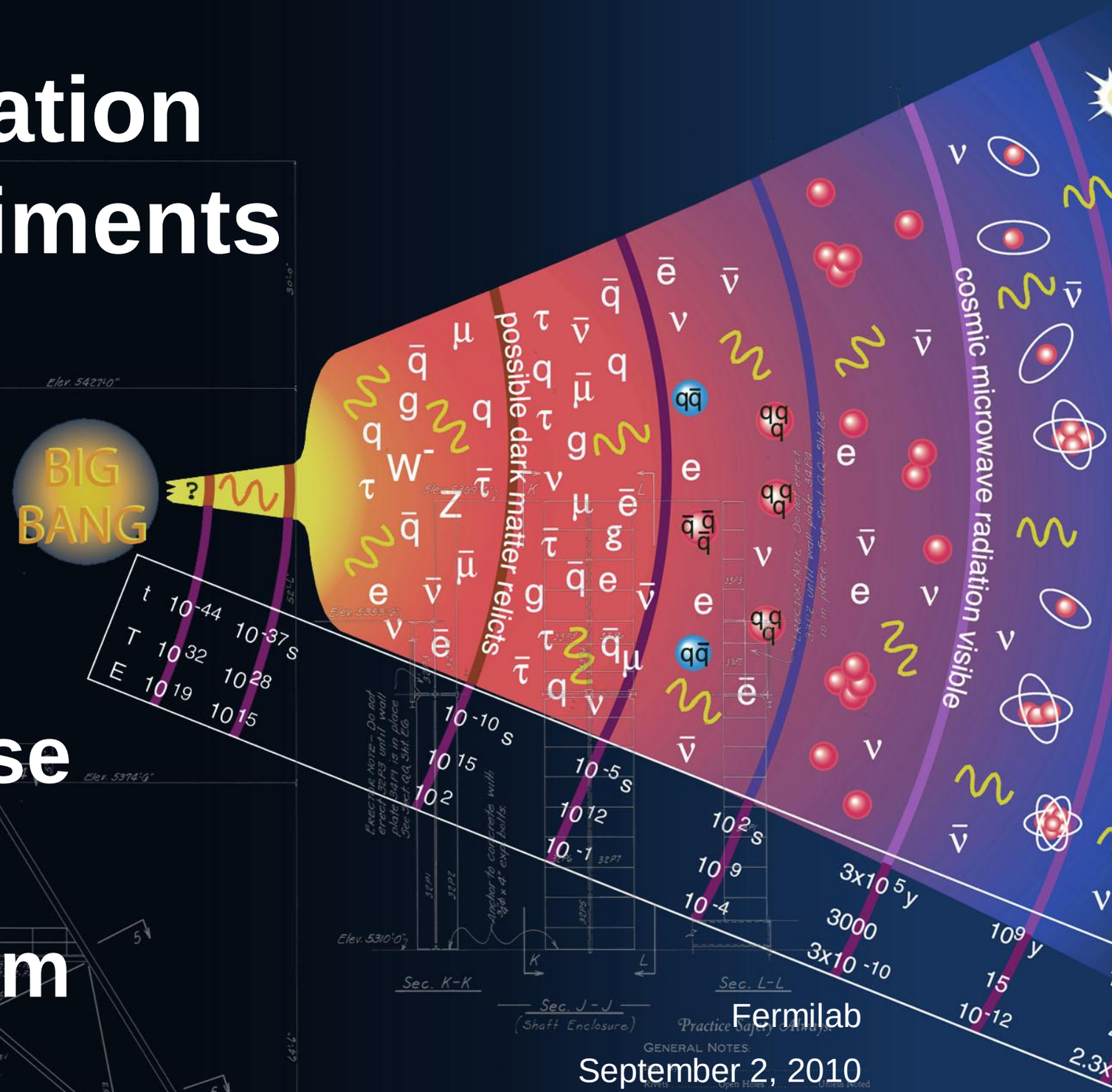
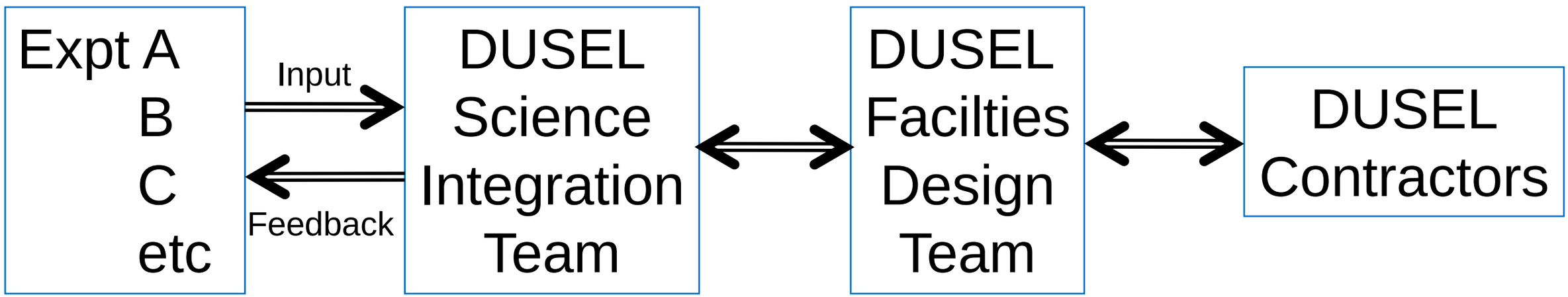


Figure Courtesy PDG and LBNL

Topics

- Science integration role in facility design
- Overview of physics experiments used to establish facility design requirements
- Status of science integration and facility requirements
- Connection with Sanford Lab program
- Facility and suite of experiments
- Integration issues and plans for ~ 2011
- Community involvement

Science Integration <–> Facility Design



- **The major role of the DUSEL science integration team is to provide an interface with the DUSEL facilities design team and contractors.**
- **Facilities design team and contractors want requirements – space, power, water, ventilation, hazards, occupancy, etc.**

Scientific Liaisons/Contacts

For all ISE: Science and Engineering: M. Gilchriese and S. Marks Systems Engineering: W. Kalinowski EH&S: C. Lichtenwalder, R. Hislop Project Controls: D. Jacobs		
ISE Group	**Science Contact(s)**	**Engineering Contact**
Dark Matter: LZD, MAX, GEODM, COUPP, CLEAN	Azriel Goldschmidt	Steve Marks
0νββ: 1TGe, EXO	Jason Detwiler, Ryan Martin	Steve Marks
Nuclear Astrophysics: DIANA	Alberto Lemut	Dave Plate
Low Background Counting: (F)AARM	Yuen-Dat Chan	Dave Plate
LBNE: Water Cherenkov, LAr	Richard Kadel	Dave Taylor
Other Physics: **LENS, DUGL, Atom Interferometry, NNBAR, Misc.** **TPCs, DM R&D** **CUBED** **DAEdALUS**	Azriel Goldschmidt Yuen-Dat Chan Richard Kadel	Steve Marks
CO_2	Rohit Salve	Dave Plate
THMCB	Rohit Salve	Dave Plate
EcoHydrology	Rohit Salve	Dave Plate
Facility Monitoring	Rohit Salve	Dave Plate
Cavity Monitoring	Bill Roggenthen	Dave Plate
Fractures	Bill Roggenthen	Dave Plate
Transparent Earth	Bill Roggenthen	Dave Plate

Small team

~ 3.5 FTE scientists(Berkeley based)

~3 FTE engineers(2 Berkeley&1 Lead). Open position for another engineer based in Lead.

~ 1 system engineer (part of SE team) coordinates requirements compilation/organization

<0.1 FTE for cost/schedule

Flat personnel, at best, in 2011

We rely on community!
Visitor(s)?

Facility Design – Generic Experiments

- **The challenge: facility design prior to definition of initial experiments**
- **We have defined experimental facility requirements as follows(in brief)(non – LBNE)**
  - **Obtain detailed as possible requirements from the S4 candidates (and a few others), with iteration/interactions**
  - **Define a generic set of requirements based on this input, other underground labs and facility constraints (primarily cost)**
  - **Assign requirements(power, water, etc) to specific facility lab modules or areas as needed by design contractors**
- **For LBNE, requirements for a large water Cherenkov detector/cavity as the DUSEL facility baseline. Liquid argon at conceptual design phase. Will say more about LBNE later.**

Experimental Input - Physics

- **Facility design based primarily on detailed input and interactions with S4 awardees.**

Experiment Type	Experiment	Principal Investigator
Dark Matter	MAX	Galbiati
Dark Matter	LZ	Shutt
Dark Matter	GEODM	Golwala
Dark Matter	COUPP	Collar
0νββ	EXO	Gratta
0νββ	1TGe	Wilkerson
Long baseline ν, proton decay	LBNE-WCD	Svoboda
Nuclear astrophysics	DIANA	Wiescher
Low Background Assay	(F)AARM	Cushman

- **Primary interaction regarding long baseline ν, proton decay, etc has been directly with the LBNE Project since project office at FNAL was established.**

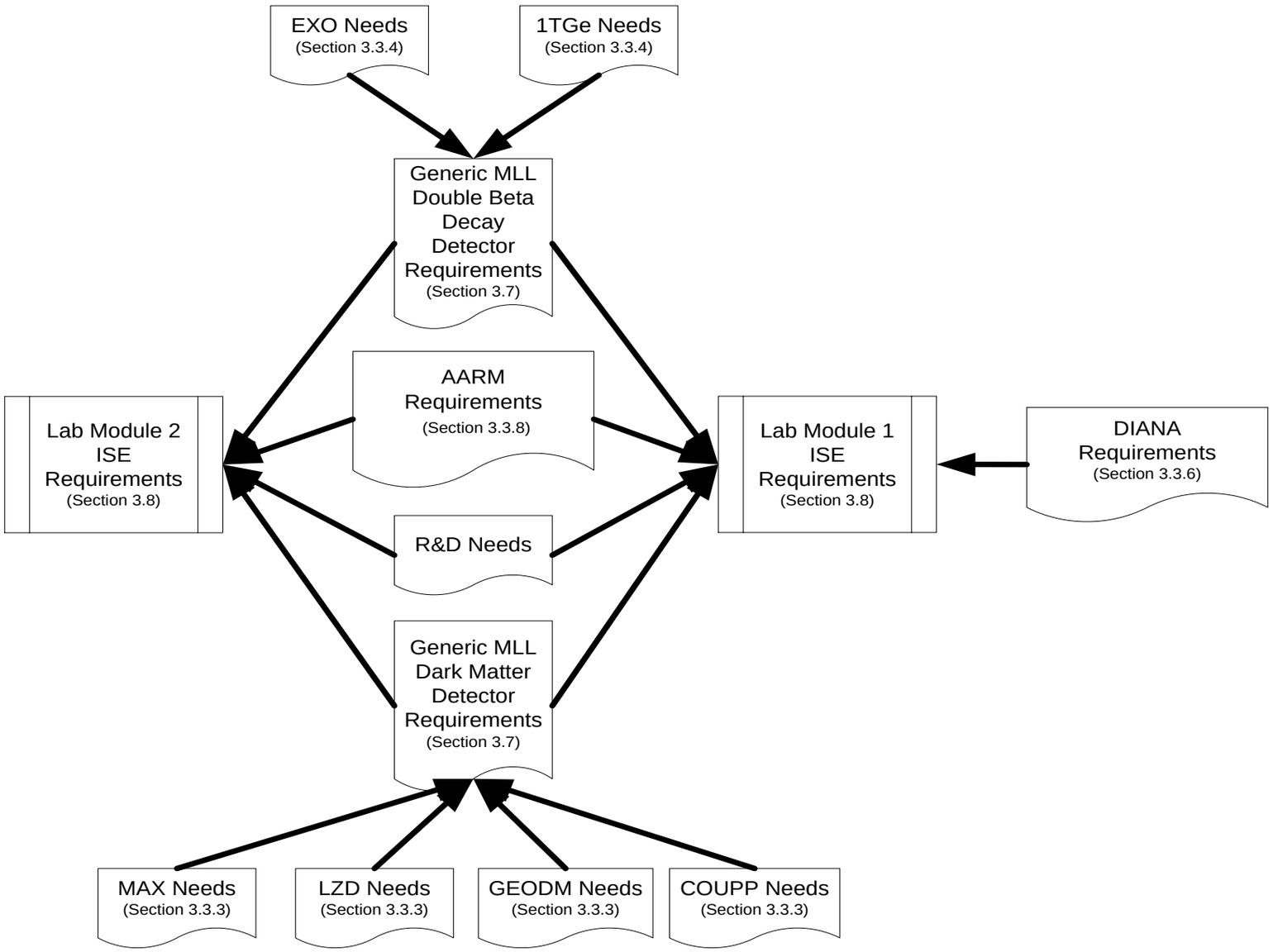
S4 Science Integration Process

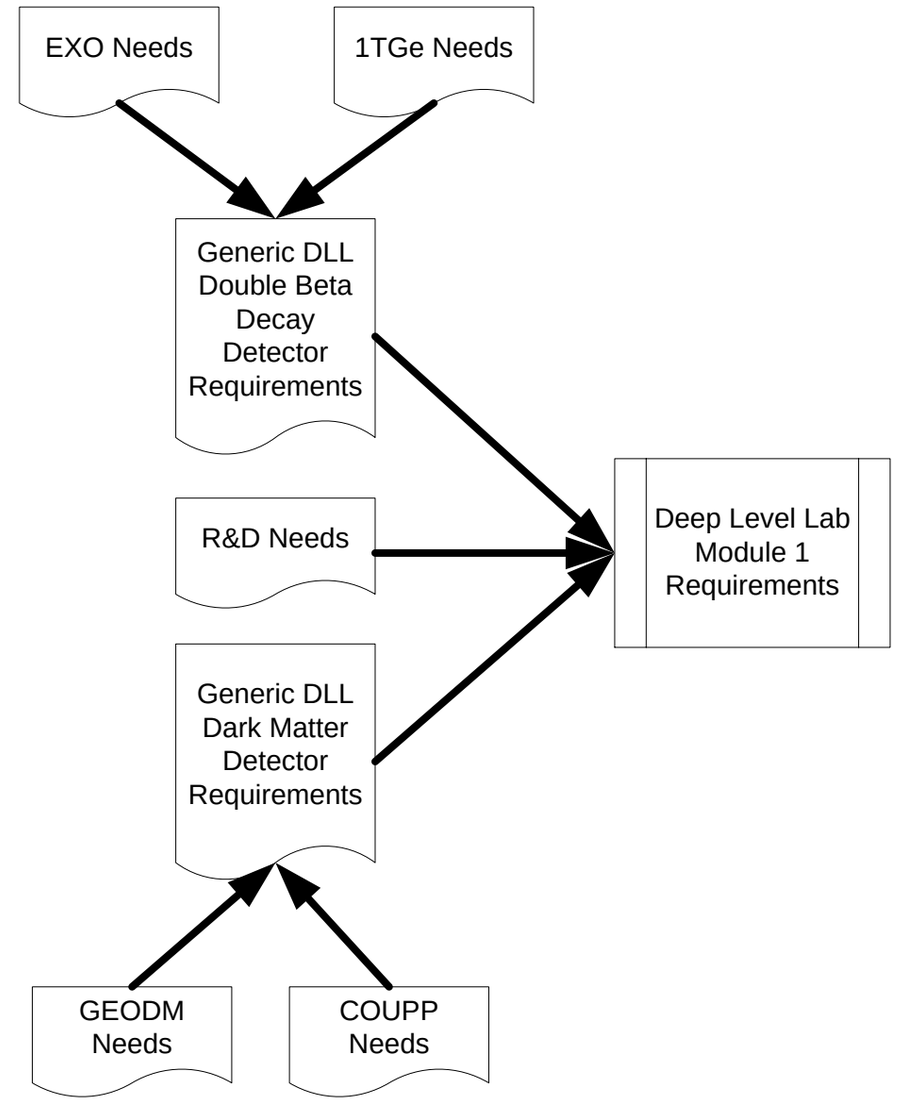
- **Series of requests made to S4 groups**
- **Information retained in dedicated Docushare area, accessible to S4 and DUSEL team.**
- **S4 groups have delivered requested information**
- **Many interactions between liaisons scientists/engineers and S4 groups**
- **One-on-one meetings to systematically review material**
- **LBNE unique in that multiple engineering/facility meetings per week and other interactions now underway**

Date	Deliverables
12/18/09	• Team roles and responsibilities, project contacts • Science and project objectives, phases and evolution
1/29/10	• Location of proposed experiment • Experiment layout drawing, showing all major subsystems • Requirements and hazard identification, via entries to the database
3/19/10	• Cost estimate, conceptual design level or better • Schedule, conceptual design level or better. To include major milestones through design, assembly, and installation. • Depth document, justification for those requesting installation at the deep-level campus.

Requirements Flow

Non - LBNE





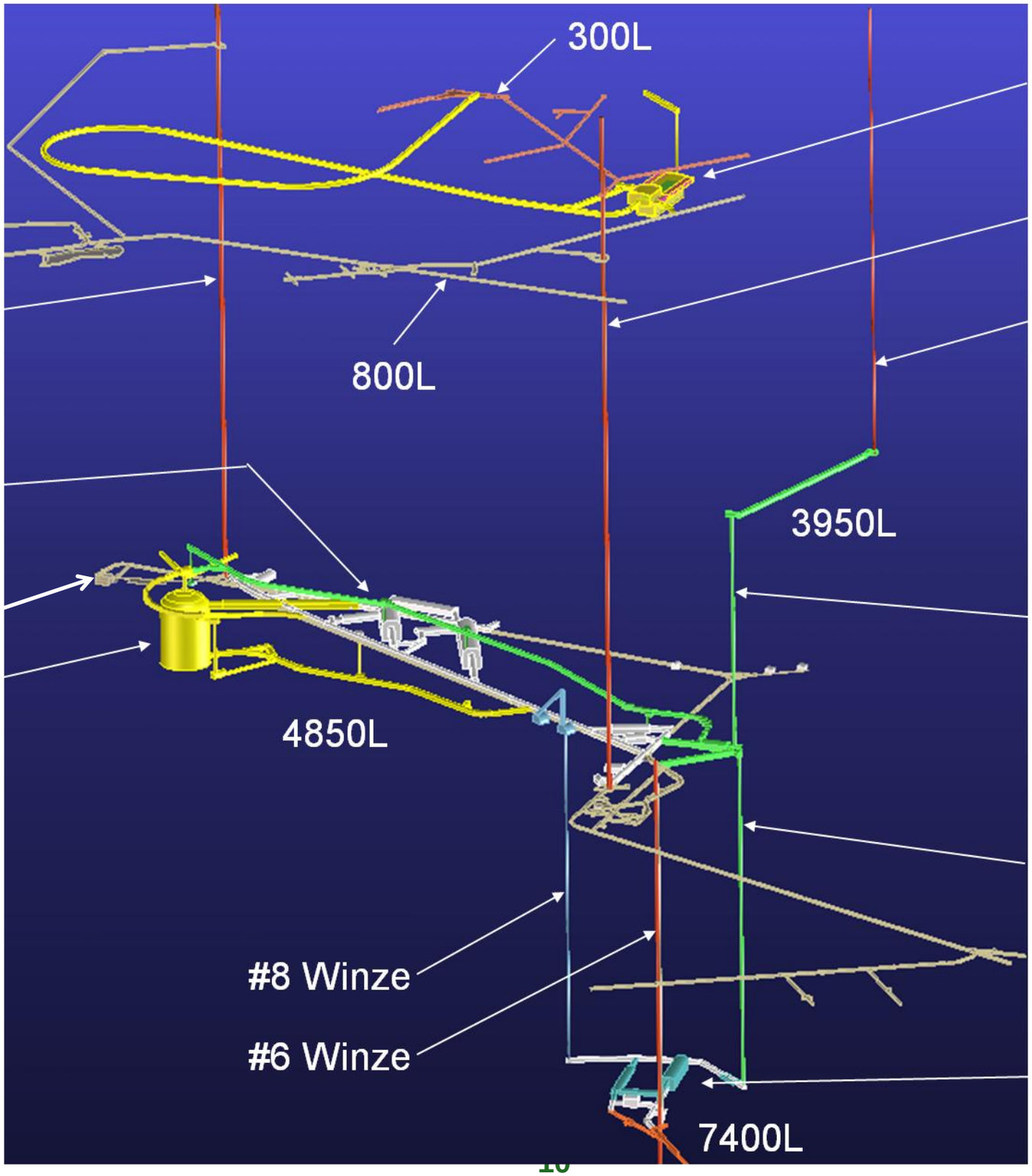
4850L lab modules

7400L lab modules

Requirements Status

- **Requirements from S4 and other gathered(Docushare + interchange)**
- **Integration team extracts from these best estimate of representative (usually, but not always, most demanding) values. In some cases team identifies and adds margin.**
- **Applies constraints(space, cost, etc.) and other underground lab experience**
- **Interact with facility design team, system engineers and iterate**
- **Documented by systems engineers in Interface Requirements Document (IRD) at relatively high level (but still 100+ pages)(posted for this meeting)**
- **Have similarly captured other facility requirements (not directly associated with experiments)**
- **This is a living document, under change control.**
- **Chapters 3.5-3.9 in the Science Integration Volume of the Preliminary Design Report will provide summary.**
- **Additional material will be in Systems Engineering and Facilities Volumes**

Underground Physics Lab Layout



Science at Sanford Lab

Physics
LUX-350 – *Dark Matter*
MAJORANA DEMONSTRATOR – *0νββ*

CUBED – *Crystal growth + other*

Bkgd Characterization – *μ,n,γ, Rn*

(also Screening Lab in future)

Geology CO_2 Sequestration – *Environment*
DUGL – *Seismic characterization*
Fiber Sensors – *Extensometer, Temp*
Hydrology – *SDSMT/Sanford/DUSEL*
Hydro-Gravity – *USGS (SD,AZ)*
PODS – *Petrology, ore dep, structure*
Tiltmeter – *Rock deformation*
Transparent Earth – *Seismic*

Biology Microbiology – *Bang, Anderson*
Lignocellulose – *Bleakley*
Manifold Sampling – *Onstott, Pfiffner*
Microbiology/Cellulose – *Sani*

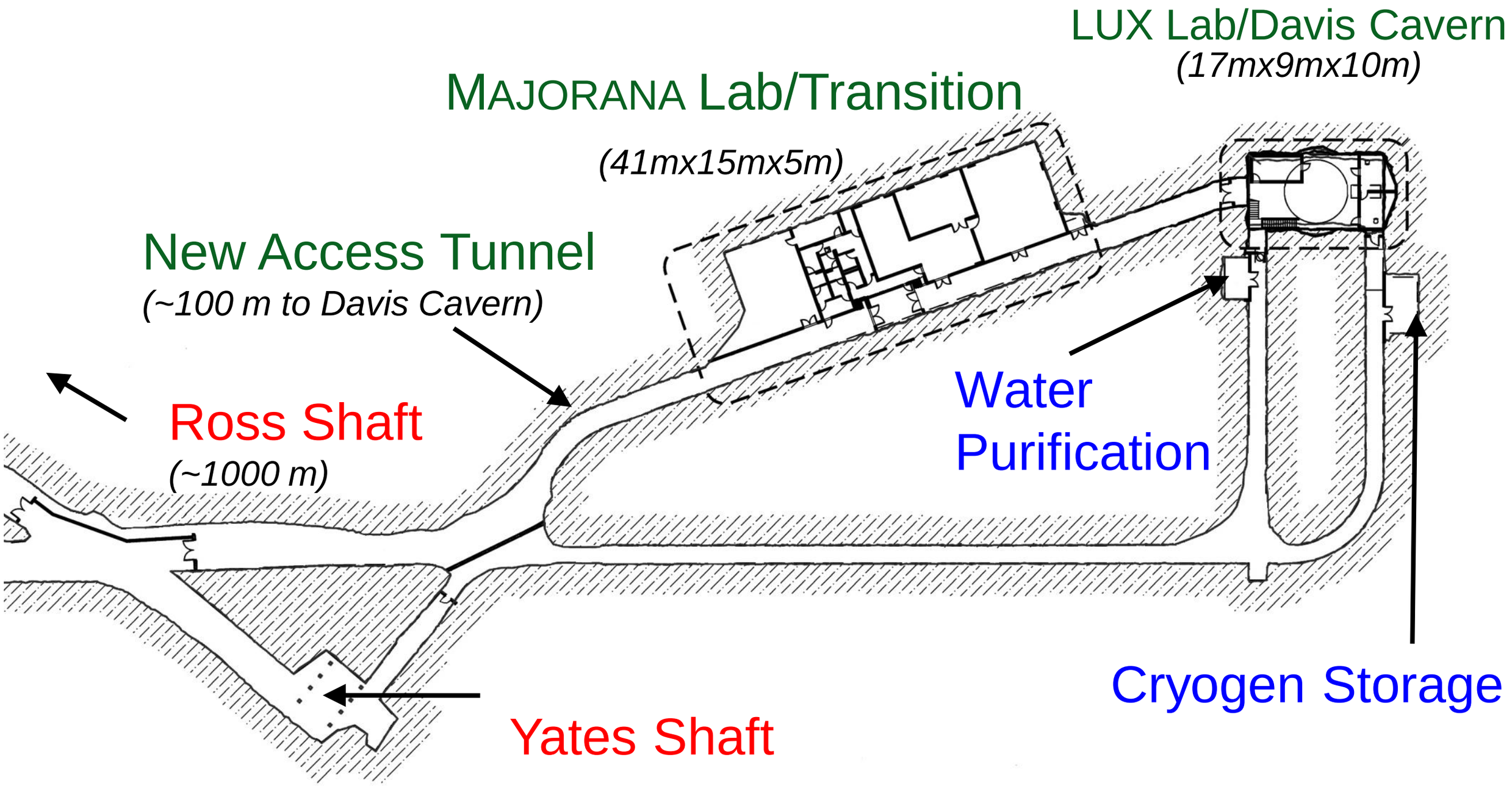
Engineering
Signal Propagation – *Anagnostou*
Submersible – *McGough*

Other Cummingtonite – *Geology (Berman)*
(Site Selection Only) Vertical Array – *Geology (Dahlgren)*
THMCB – *Geology (DUSEL S4)*
Fracture Group – *Geology (DUSEL S4)*
EcoHydro Group – *Geology (DUSEL S4)*

Total Active = ~19 groups
(Plus Others)

New Sanford Lab Infrastructure

4850L Davis Campus: 745 m² (Total) / 455 m² (Science)

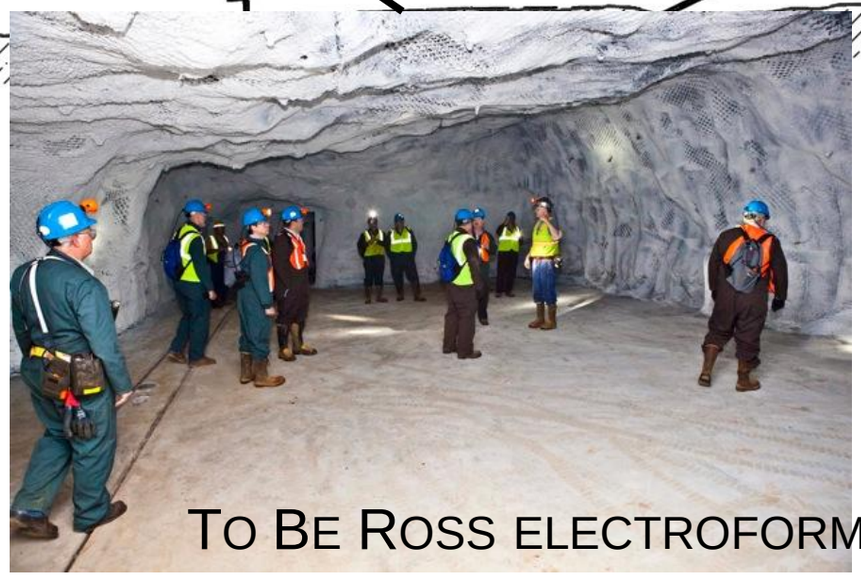


Excavation nearly complete. Outfitting, make into lab by ~ October 2011

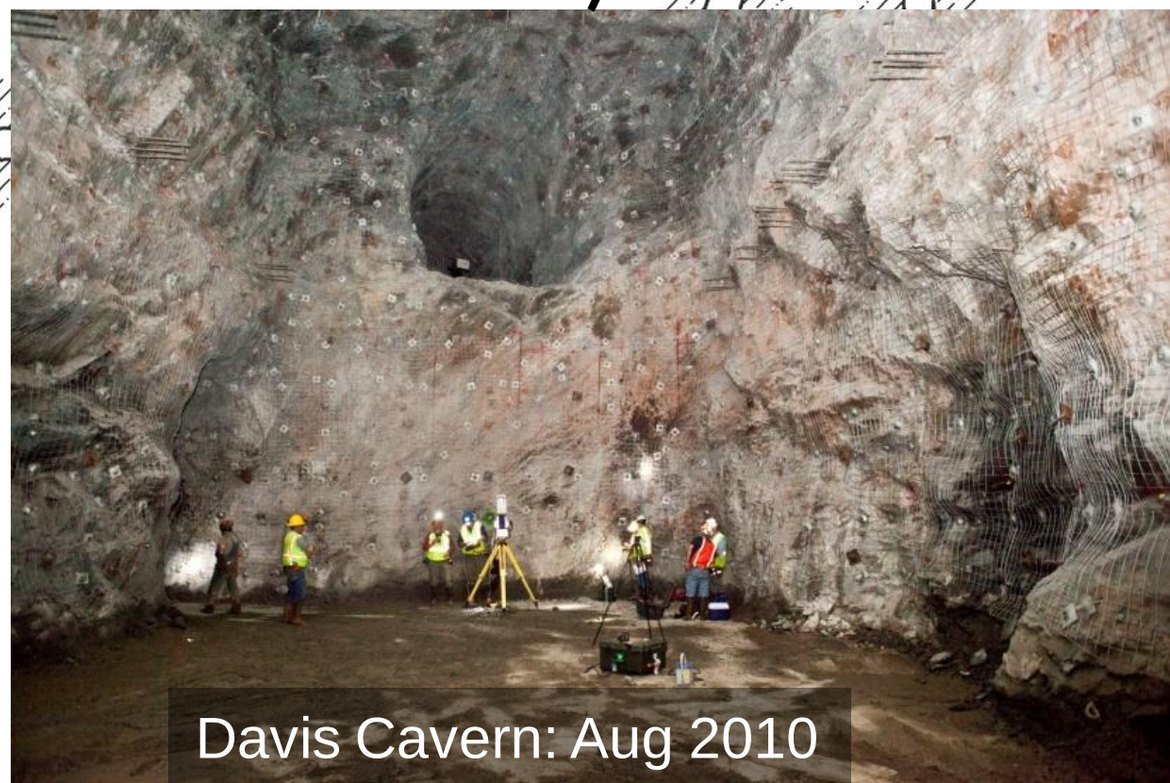
Electroforming for MAJORANA Demonstrator start near Ross Shaft this year

New Sanford Lab Infrastructure

MAJORANA/Transition: Aug 2010



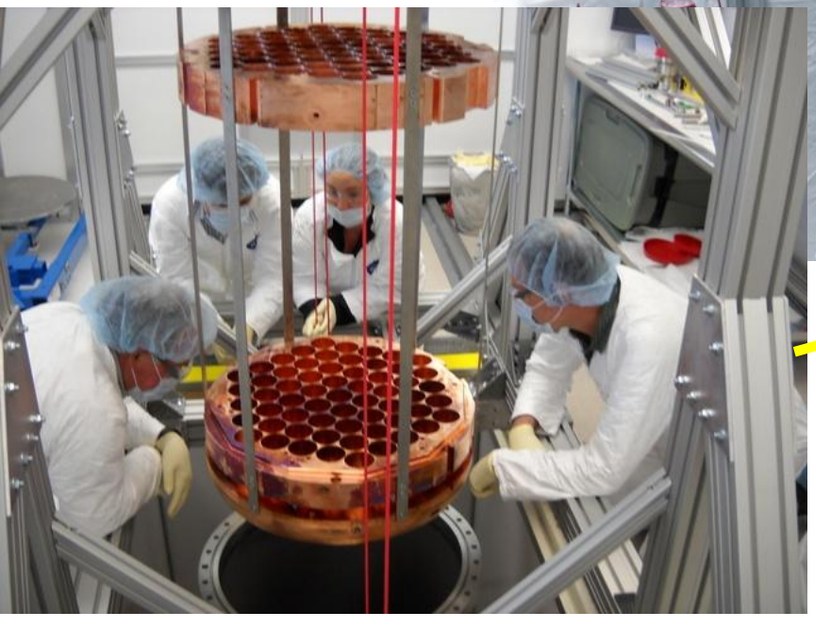
TO BE ROSS ELECTROFORMING AREA

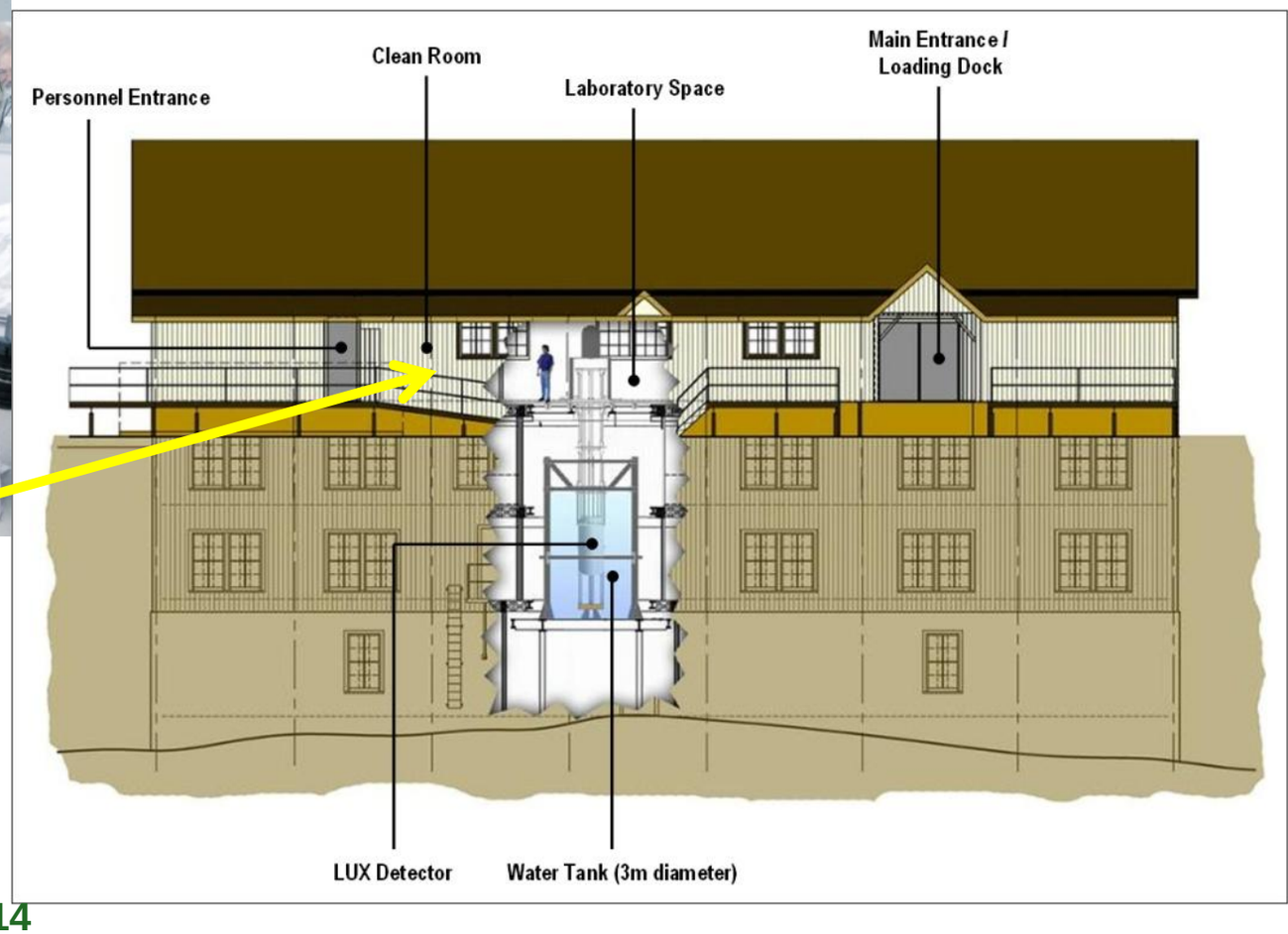


Davis Cavern: Aug 2010

Sanford Lab Status and Plan

- LUX assembly underway in dedicated lab – see below. To be followed by operation on surface in water tank later this year.
- Preparations for MAJORANA Demonstrator underground space for electroforming continuing
- Davis campus ready ~ October 2011

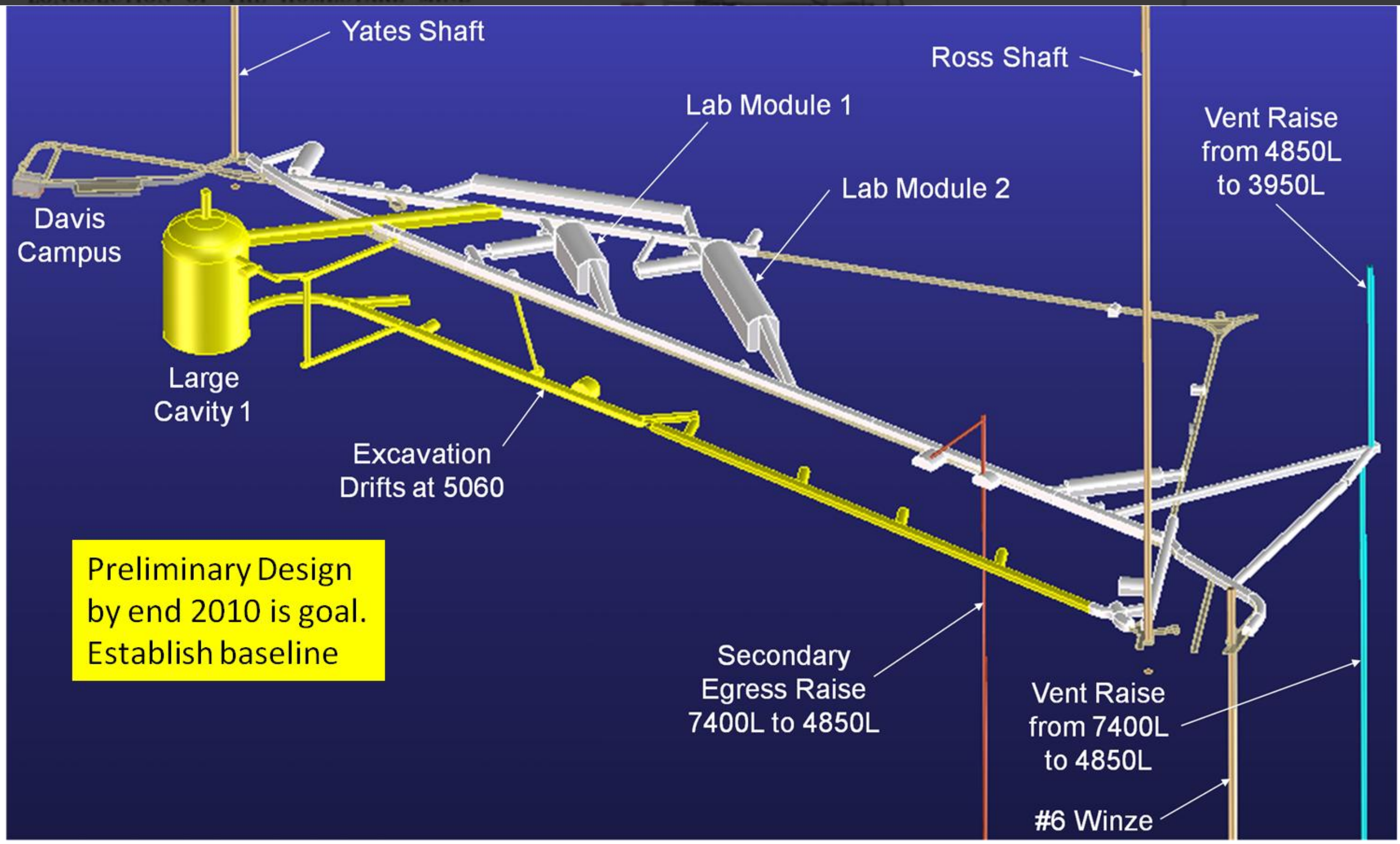




Benefits of Science at Sanford for DUSEL

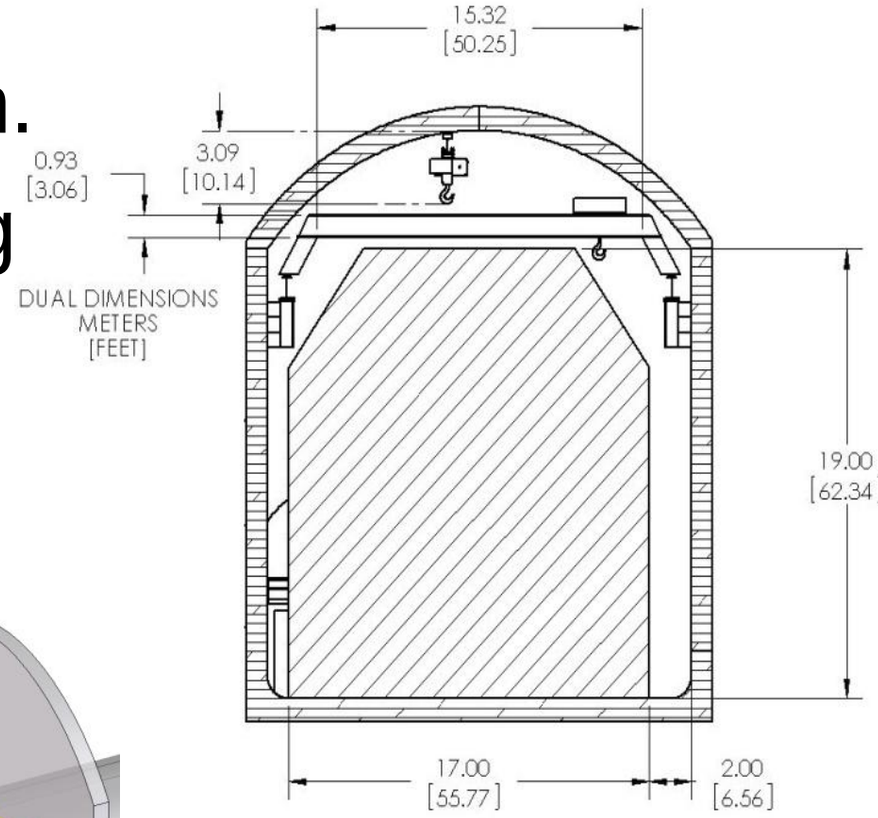
- **Beyond it's good science……**
- **Excavation experience at 4850L**
- **Shotcrete and soon lab outfitting experience for science**
- **Assembly and operational experience**
- **Background characterization and measurements**
- **EH&S**
- **Feed into DUSEL Final Design in 2012-2013**

4850L Overview

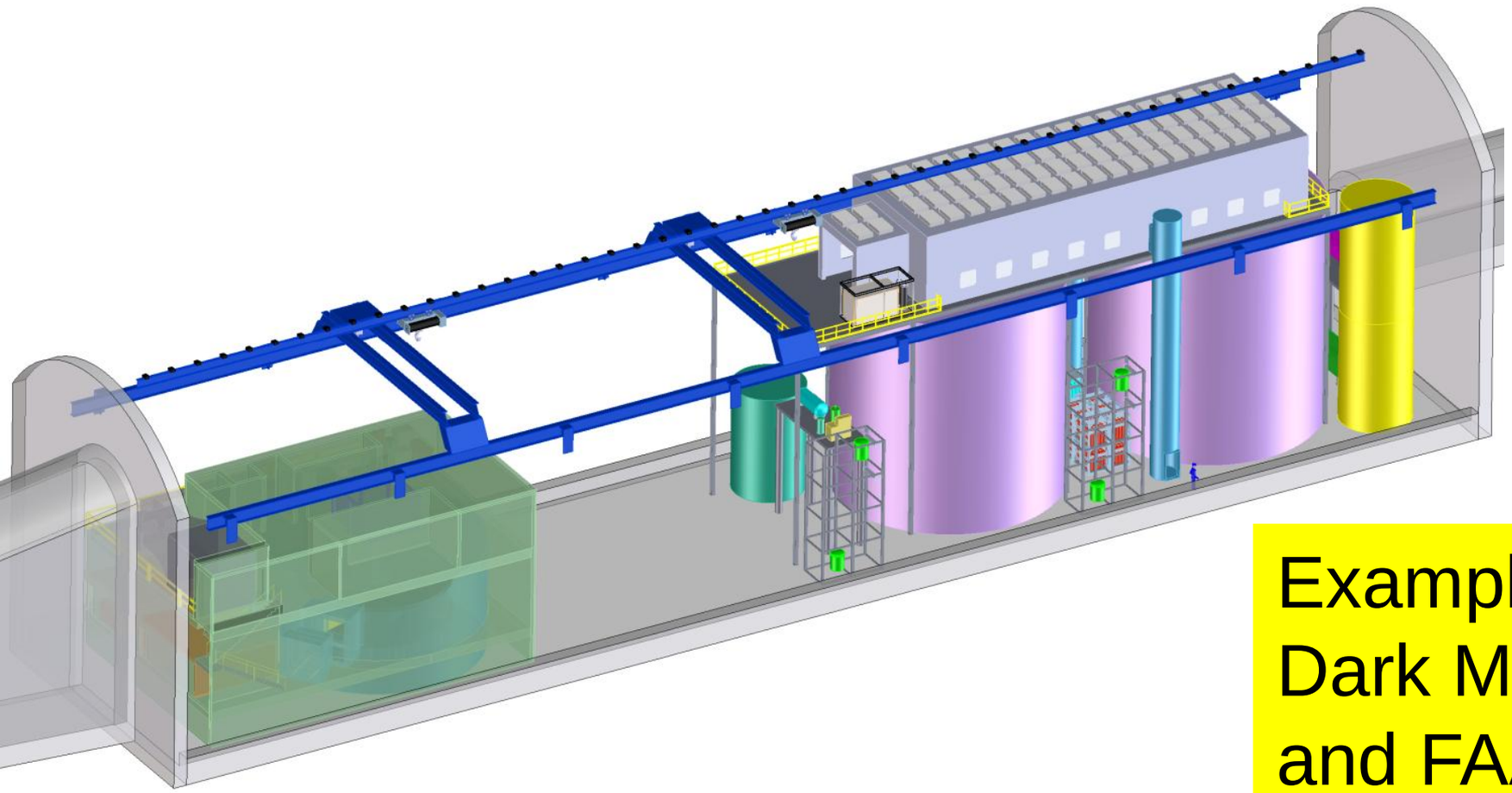


4850L Lab Modules

- LM1 and LM2 have same cross section.
- LM1 is 50m long and LM2 is 100m long
- 20m wide and 24m high to crown



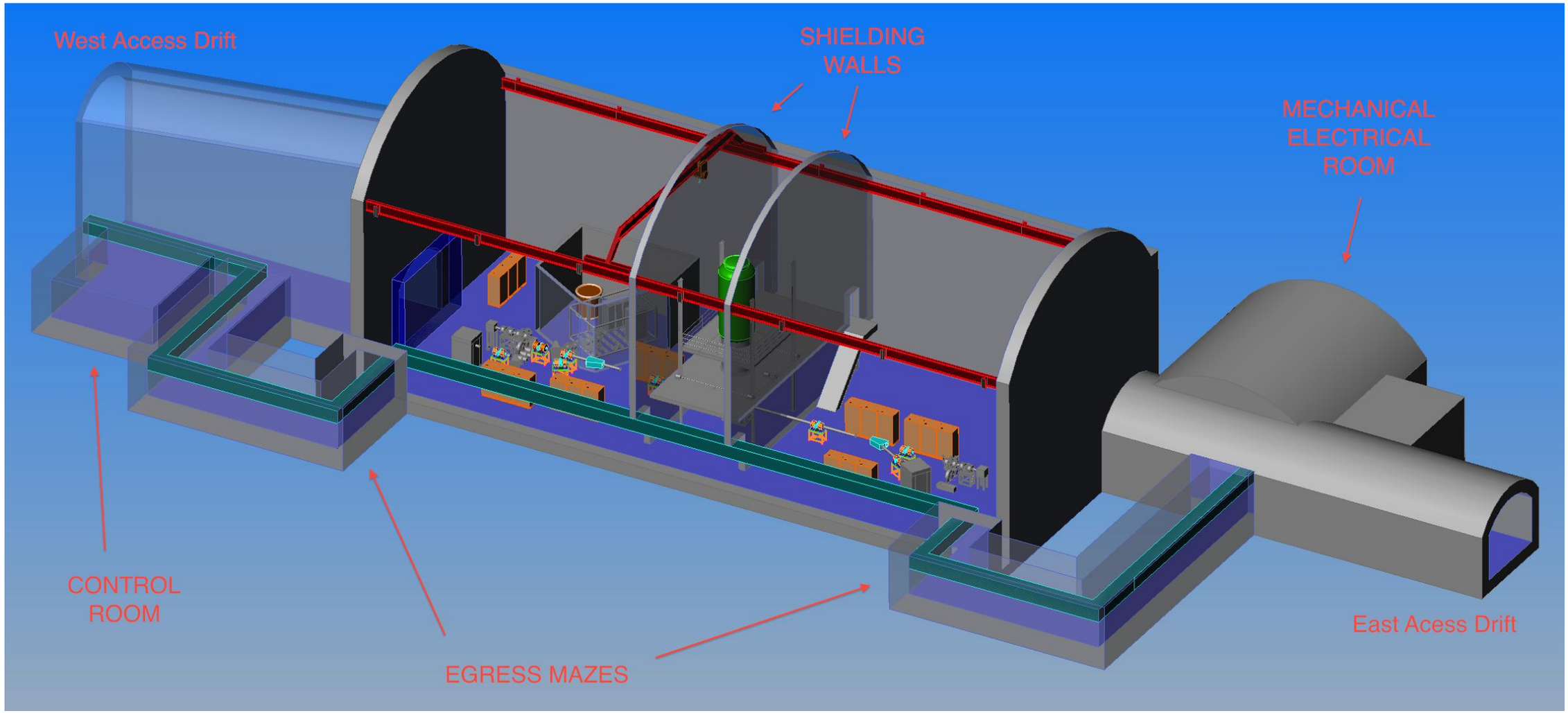
40 T monorail
20T bridge



Example of large (MAX) Dark Matter experiments and FAARM in LM2

Nuclear Astrophysics Accelerator

- **DIANA is proposed very long-term facility. Needs isolated space.**
- **Utilities requirements for LM1 mostly from DIANA, most demanding case eg. power.**
- **Generic LM1 baseline at 4850L is roughly correct size**
- **Quick parametric estimate of LM changes for DIANA indicate cost neutral or reduction but needs more study**

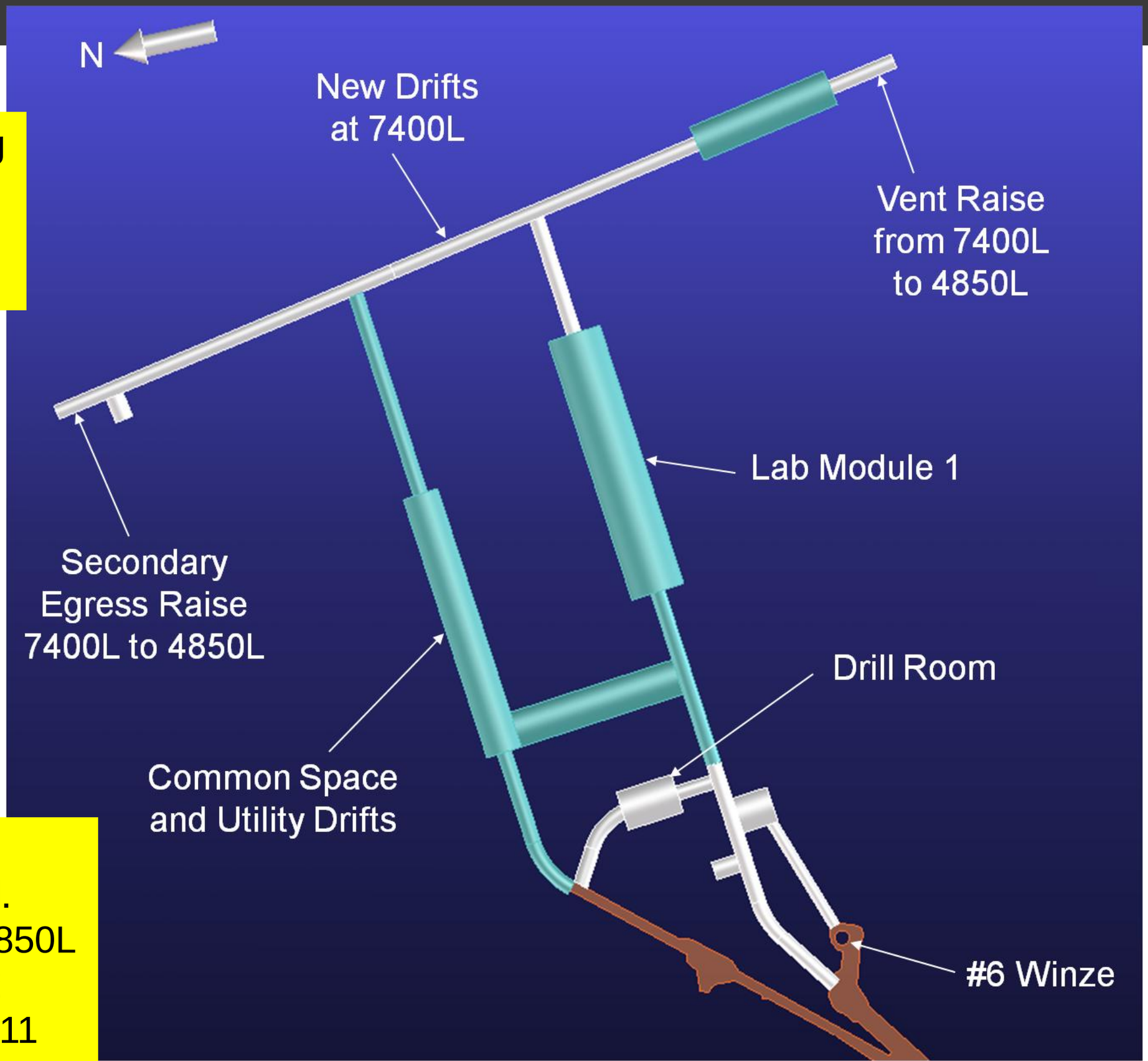


4850L LM Size

- **Recognition that more space is desired**
  - **Just more space based on general arguments…..comparison to existing labs, planning for future…**
  - **May be too tight for some specific experiments…fit problem (shielding)**
- **Current plan – PDR baseline will be established with dimensions shown to meet overall facility cost constraints**
- **But have completed parametric cost exercise for ~ 20% increases in LM2 dimensions, will be included in PDR – see below(all costs, including 40% contingency, to nearest $M).**
  - **Increase height from 24m to 28m ~ $5M**
  - **Increase width from 20m to 24m ~ $9M**
  - **Increase length from 100m to 120m ~ $5M**
- **Key goal is to work with community in 2011 to understand shielding and overall cost optimization and revisit size of 4850L LMs.**

7400L Overview

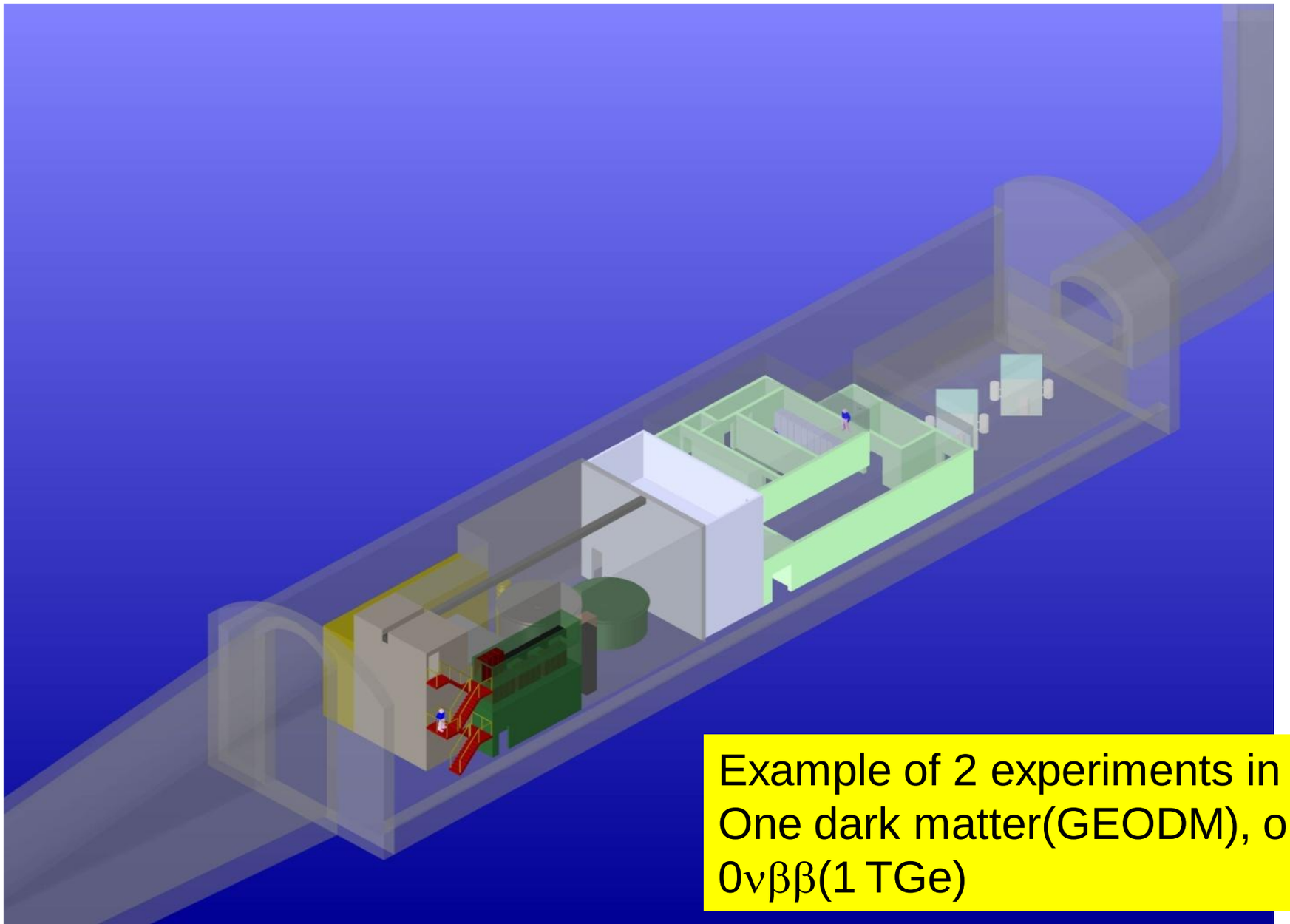
Design still evolving
Cost/schedule later
this month for PDR



Conceptual Design
by end 2010 is goal.
Not as mature as 4850L
Dewatered by 2012
Geotech studies 2011

7400L Lab Module

- Deep level lab module is 75m long, 15m wide and 15m high in present design
- Space very tight compared to requests for 7400L
- But these will be dimensions given in PDR, resulting from cost constraints
- Working on comparable ~ 20% increase in dimensions study, not quite done, need more unit cost estimates this month. Will assume 50% contingency.



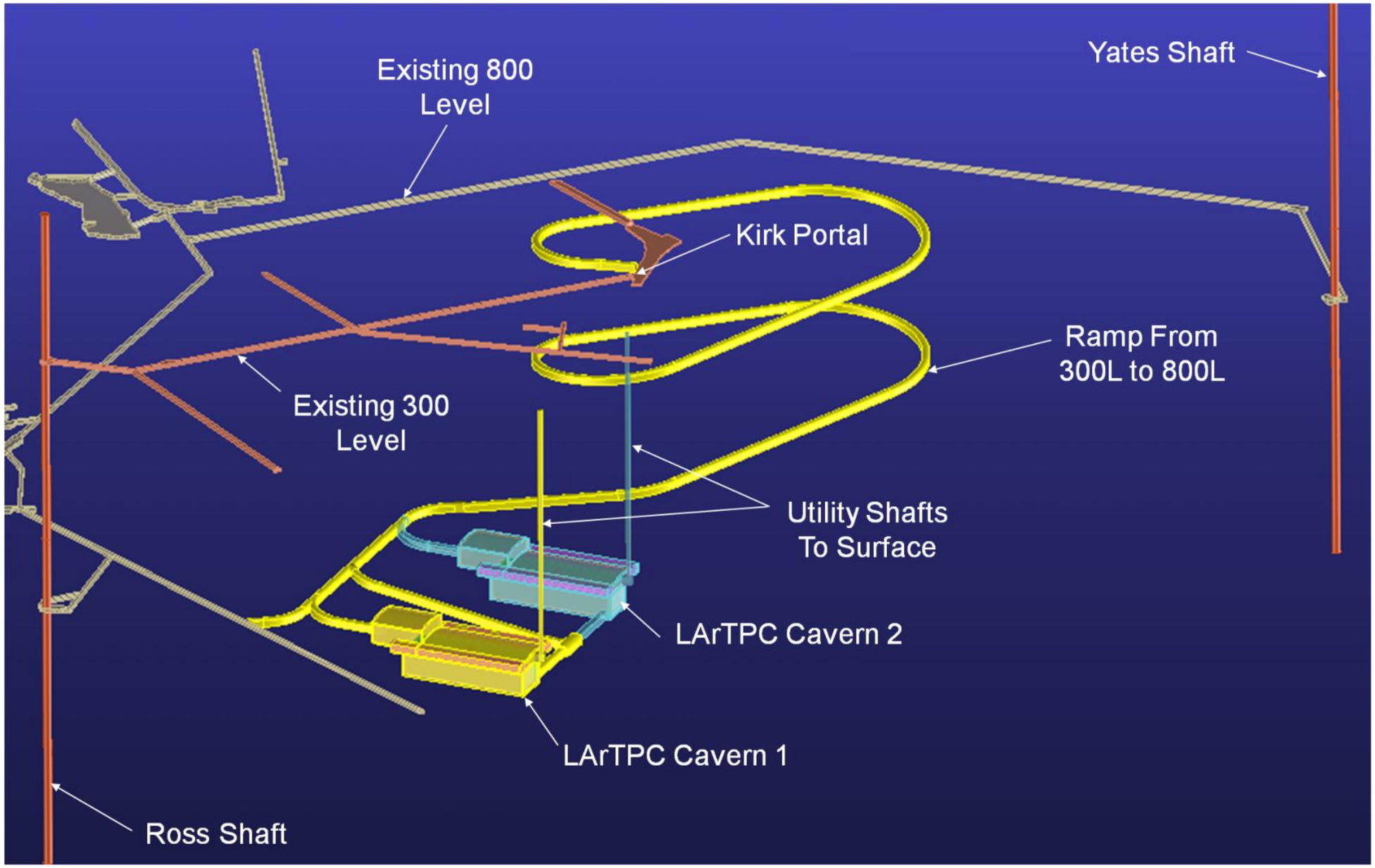
Example of 2 experiments in LMD
One dark matter(GEODM), one version of $0\nu\beta\beta$(1 TGe)

LBNE, Proton Decay and Related

- **LBNE considering options to realize equivalent of ~ 200 ktonne of water equivalent: 2 water Cherenkov detectors or 1 WC + 1 ~ 20 ktonne liquid argon detector(different depth options) or 2 liquid argon**
- **Baseline facility design(and cost and schedule) for DUSEL PDR includes one large cavity for a water Cherenkov detector**
- **60% deliverable from contractors for PDR provides information and costs needed for more than 1 large cavity at level needed by the LBNE CD1 process (review in Spring 2011)**
- **Options(different cavity shape for LC and liquid argon) under study at conceptual level via separate LBNE contracts.**
- **Requirements for water Cherenkov and 1LC and integration of them into overall DUSEL facility (into the IRD) advancing well, in good shape for PDR.**
- **A key assumption is that LBNE project will include proton decay and detection of other neutrinos. DUSEL not scoped for additional significant experiments in proton decay, other neutrino detection…**

LBNE Liquid Argon Detector(s)

- **Currently preferred liquid argon option is at 800L. Very early design phase**
- **Liquid argon detailed requirements will not be included in DUSEL facility design for the PDR or IRD, but concept is described in Science Integration Volume**
- **Inclusion of liquid argon requirements, if appropriate, a job for 2011**



Science Goals <-> Sanford Lab/DUSEL

- **Dark matter program**
  - **Generation 1 (G1) by LUX at Sanford Lab**
  - **Potentially G2 at Sanford after LUX, open competition, started prior to DUSEL construction, finish in DUSEL era(using MREFC funds early?). PAC evaluation.**
  - **One or more G3 at DUSEL**
- **0νββ decay**
  - **MAJORANA Demonstrator at Sanford lab operates into DUSEL era (~ 2017?)**
  - **One or more large, next generation experiments at DUSEL**
  - **More than one, as currently proposed, will not fit at 7400L in current lab module size**
  - **Space tight for one depending on shielding design**
- **Keep active science program at Sanford/DUSEL? Evaluate impact of construction**

Science Goals <-> Sanford Lab/DUSEL

- **Long baseline neutrinos, proton decay, other neutrinos**
  - **Fully integrate LBNE into combined, unified facility design and schedule as soon as possible, as LBNE moves towards baseline design**
- **Nuclear astrophysics**
  - **Potentially dedicated accelerator facility, decade(s) operation**
  - **Requires dedicated lab module at 4850L, modified LM1**
  - **Relatively early decision desirable. PAC advice.**
- **Low background and materials manufacturing**
  - **Very basic capability (scope being defined) will be part of DUSEL plan and located at Sanford/ DUSEL. CUBED early aspects.**
  - **Close coordination with existing facilities to meet needs of initial experiments.**
  - **Large facility, unique capabilities for future beyond initial experiments to be evaluated as part of overall scientific and R&D program**
- **Enable R&D. Space available may evolve with time, utilize lay-down space for construction, parts of lab modules. More planning needed**
- **Other physics – evaluated as part of overall scientific program – but what is it?**

Expected Status by Start 2011

- **Preliminary Design Report will have been completed, internally reviewed and submitted to NSF**
- **Generic Initial Suite of Experiments described in PDR.**
- **ISE based on preliminary interactions with proponents (S4 awardees and others), considerations of available funding and other constraints.**
- **Facility requirements, based on the above, captured in detail and process for same well established.**
- **Improved understanding of LBNE civil construction needs**
- **No specific experiments selected (possible exception is LBNE reduction in options)**
- **High-level envelope of MREFC funding for experiments proposed**

Key Integration Goals in 2011 (1)

- This is not a priority ordered list……
- Use of liquid scintillator for shielding
  - Workshop held at Fermilab last month. Safety issues have significant facility design impact, follow-up study
- Assembly studies
  - Quick study for 7400L done in collaboration with EXO. It's not easy or short.
  - Next priority for study is representative Dark Matter experiment at 4850L
- Backgrounds
  - Encourage collaborations to jointly study backgrounds and mitigation with science integration team
  - Direct feedback into shielding design, width and height of LMs
  - Key goal is to optimize LM size in 2011.

Key Integration Goals in 2011 (2)

- **Collaborative engineering design of scintillator and/or water shields and clean rooms/infrastructure for representative Dark Matter at 4850L**
  - **A number of experiments proposing shields that are major drivers of facility (size, water, low radioactivity)**
  - **Hope to initiate collaborative design during 2011 period, commonality, design report.**
  - **This pulls together many aspects(scintillator, size, assembly…)**
- **Complete study of DIANA alternative LM1 as possible within resource constraints (minimal contact with contractors in 2011)**

Key Integration Goals in 2011 (3)

- **Integrate all of LBNE into facility requirements to greatest extent possible. Realistically requires reduction in options or definition of reference design.**
- **DUSEL plans additional study of surface facilities in 2011. LBNE has initiated additional studies recently**
  - **Design this year not at PD level, improve.**
  - **Must involve all experiments.**
- **Similarly expect to evolve the design of 7400L.**
  - **Possibly geotech studies by drilling down.**
  - **Interact closely with 0νββ decay experiments as most affected at this time.**

Community Interactions in 2011

- **Provide information to experimental community about facility and evolving design, improve communication.**
- **Finishing the PDR will significantly help in this aspect.**
- **Regular meetings essential (but avoid overload)**
- **Work with DuRA.**
- **Visitors. Hope to have limited support for visitors willing to dig into facility requirements and design. See me.**

Summary of Science Integration - Physics

- **Process in place and working to integrate science requirements into facility design for PDR and beyond.**
- **Goals for 2011 understood, more detailed plan to follow in next few months.**
- **Facility design is “bare bones” but capable of meeting science goals and requirements given current expectations for funding of initial experiments**
- **Small DUSEL team, relies substantially on interested experimental community and will continue to do so**