

LBNF Update to the FNAL Physics Advisory Committee

C. J. Mossey, Deputy Director for LBNF

21 June 2016



Topics in this update

From January PAC Report:

“The PAC endorses the focus areas laid out by the LBNC for FY2016 and looks forward to progress reports in the identified areas:

- LBNF: **Execution against final design plan for CD-3a scope”**
- Also, updates on:
 - CM/GC contract
 - Test blast vibration study
 - Excavated Rock Disposal plan
 - Reliability Projects (Ross Shaft)
 - Lease and easements
 - Fiscal update
 - Summary

Quick Project Overview: LBNF/DUNE

LBNF and DUNE: two sub-projects

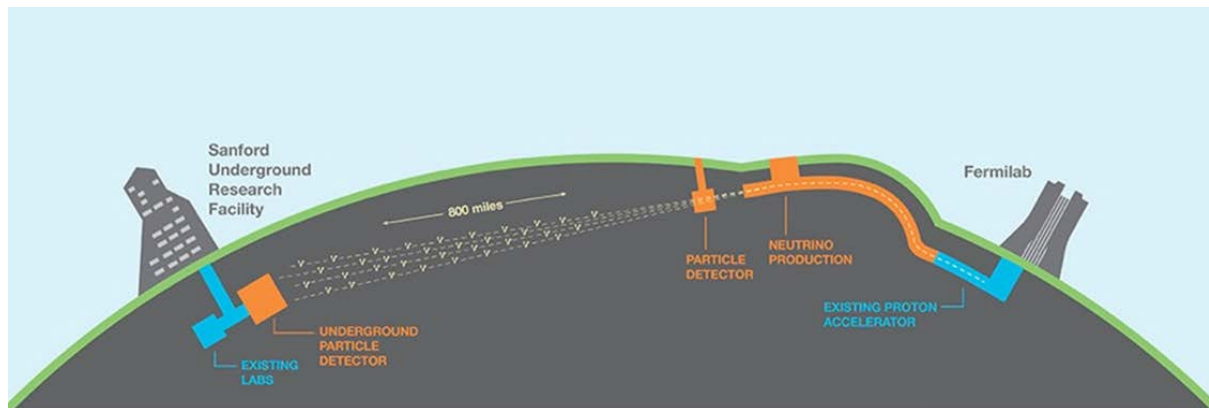
- This facilitates CERN as a facility partner
- Share common project office resources

LBNF: **DOE project with support from non-DOE partners.** Provides facility infrastructure at two locations to support the experiment:

- Near site: Fermilab, Batavia, IL – facilities to create neutrino beam
- Far site: Sanford Underground Research Facility, Lead, SD – facilities to support DUNE detectors

DUNE: Deep Underground Neutrino Experiment

- Near and far site detectors: **U.S. as partner in international project**



Quick Project Overview: LBNF/DUNE

LBNF and DUNE: two sub-projects

- This facilitates CERN as a facility partner
- Share common project office resources

LBNF: DOE project with support from non-DOE partners. Provides facility infrastructure at two locations to support the experiment:

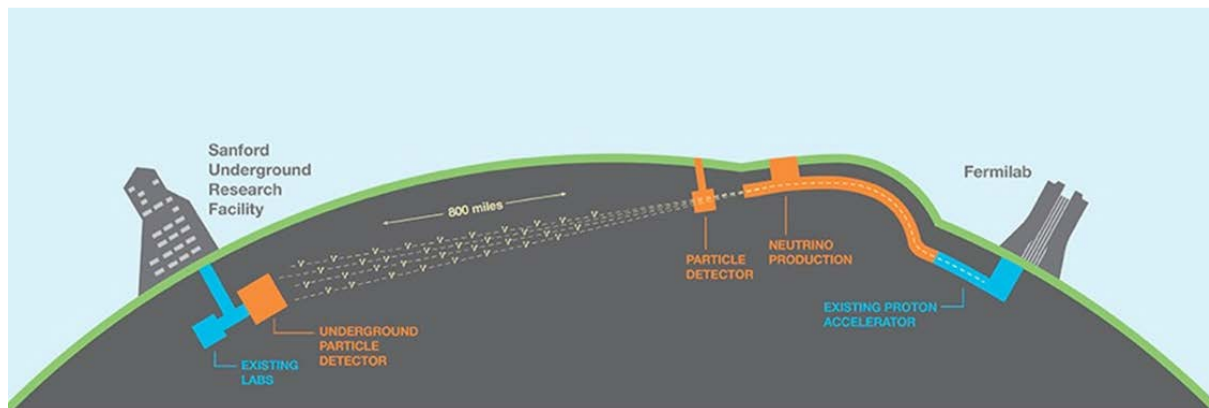
- Near site: Fermilab, Batavia, IL – facilities to create neutrino beam
- Far site: Sanford Underground Research Facility, Lead, SD – facilities to support DUNE detectors

Present focus

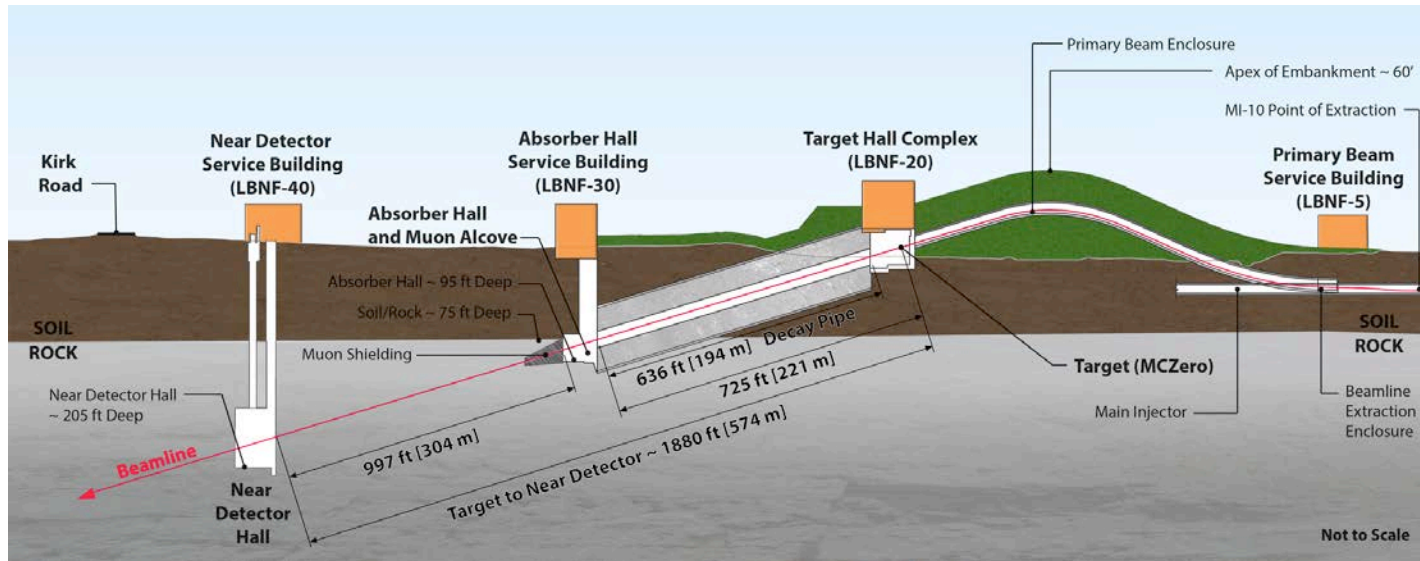


DUNE: Deep Underground Neutrino Experiment

- Near and far site detectors: U.S. as partner in international project



Overview - “Near Site” – LBNF/DUNE at Fermilab, Batavia, IL



- Primary proton beam @ 60-120GeV extracted from Main Injector
- Initial 1.2 MW beam power, upgradable to 2.4 MW
- Embankment allows target complex to be at grade and neutrino beam to be aimed to Lead, SD
- Decay region followed by absorber
- Four surface support buildings
- Near Detector facility
- **DUNE Near Detectors (fine grained straw tube with gas targets)**

Beamline design based on Fermilab's NOvA beam, currently the most powerful neutrino beam in the world

Quick Overview – “Far Site” – LBNF/DUNE at Sanford Lab

- **Conventional Facilities:**

- Surface and shaft Infrastructure including utilities
- Drifts and two caverns for detectors
- Central utility cavern for conventional and cryogenic equipment

- **Cryostats:**

- Four membrane cryostats supported by external steel frames

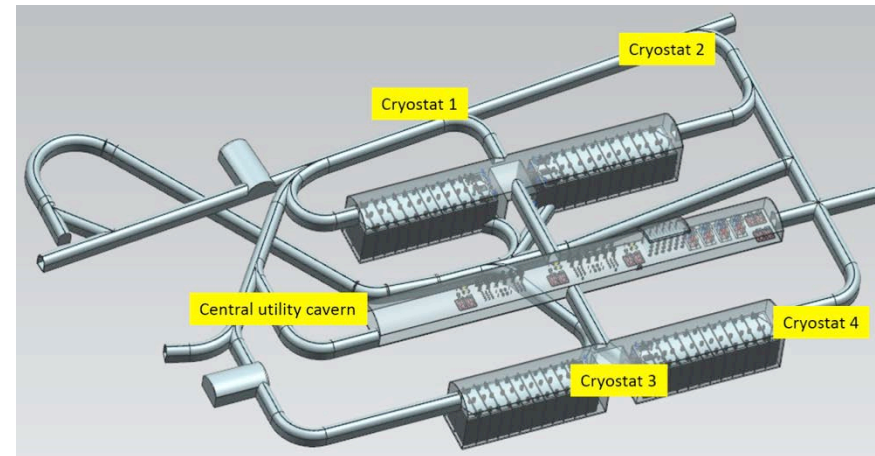
- **Cryogenic Systems:**

- LN2 refrigeration system for cooling and re-condensing gaseous Argon
- Systems for purification and recirculation of LAr

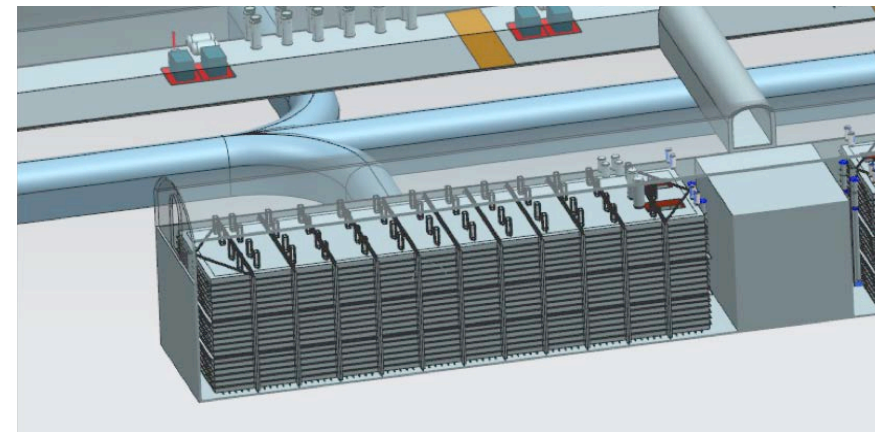
- **Argon: 70kt LAr (~40kt “fiducial” mass)**

- **DUNE LAr-TPC Detectors**

Extensive prototyping program in progress to scale LAr TPC detector technology to 10kt fiducial volume



4850L cavern and drift layout



Single cryostat

Far Site Scope – Overview of Phases of Work

1. Sanford Lab Reliability Projects

FY16 – 18

- Ross shaft rehab
- Hoist motor rebuilds, more...

2. Pre-Excavation

FY17 - 20

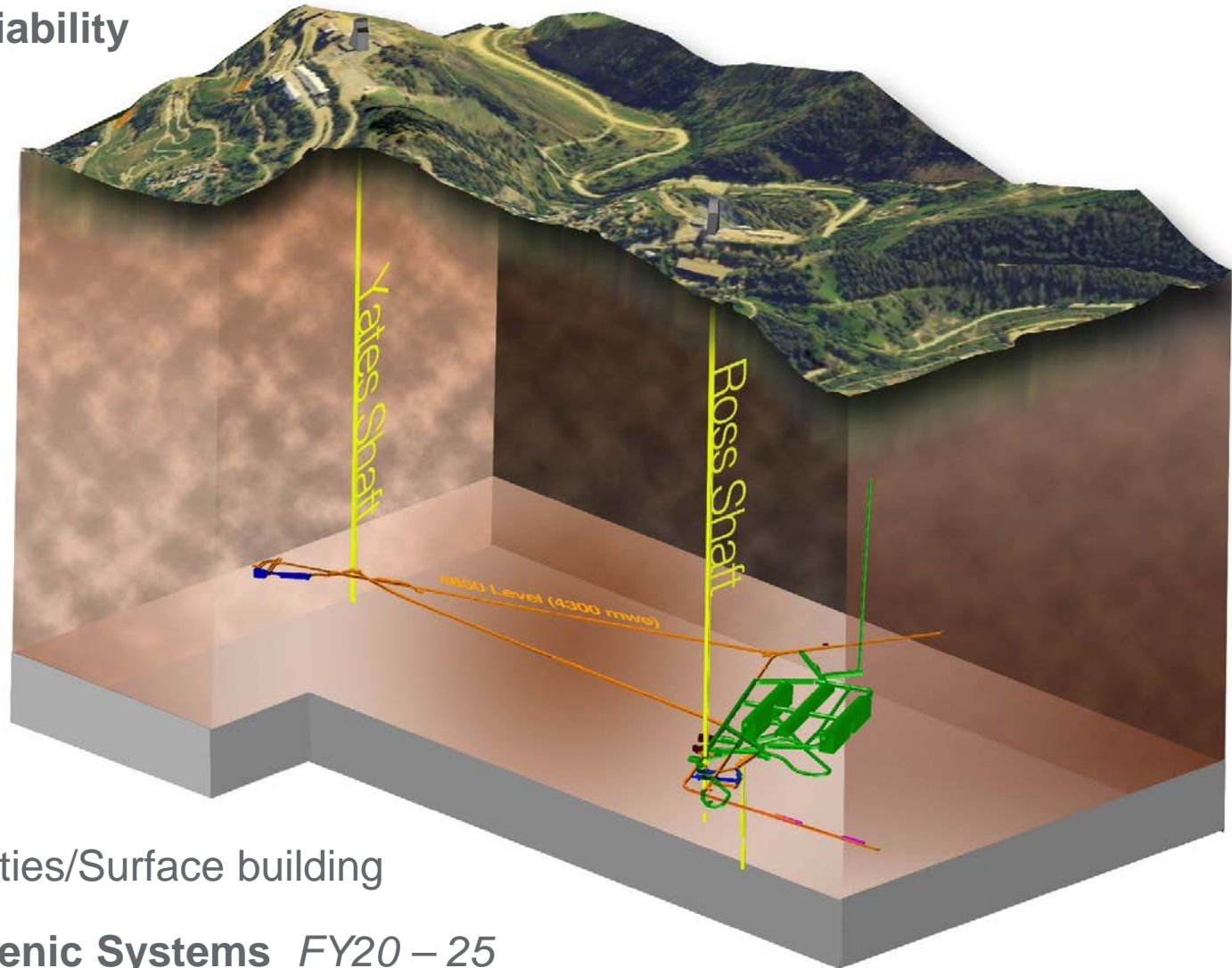
- Rock disposal systems
- Utilities support, more...

3. Excavation/Construction

FY18 – 22

- Caverns/Drifts/Utilities/Surface building

4. Cryostats/Cryogenic Systems *FY20 – 25*



Final Design Plan

Far Site Conventional Facilities

Far Site Conventional Facilities Final Design - Plan

- Final design includes pre-excavation, excavation, and buildings and site infrastructure scopes
 - Deliverables planned at 30%, 60%, 90%, and 100% of final design
 - Provides defined points for stakeholder review
 - CM/GC involvement through independent cost / schedule estimate generation and estimate reconciliations and constructability reviews
- In addition to construction contract document production (drawings and technical specifications), cost estimates & schedules, calculations, final design scope includes:
 - Basis of Design report
 - Geotechnical Baseline Report and 3D geotechnical modeling
 - An instrumentation and ground monitoring program
 - Concept of Operations report
 - Fully integrated 3D Revit model

Far Site Conventional Facilities Final Design – Current Status

- Final design for Pre-excavation underway:
 - 30% pre-ex final design was received and reviewed.
 - 60% pre-ex design technical submittal expected on July 14. Cost and schedule submittal will arrive 3 weeks later.
- Final design for Excavation and Buildings & Site Infrastructure to start in December 2016
- Other design status updates:
 - Recent focus has been on rock handling systems and shaft infrastructure including fiber optic and power cables, water, and gas piping.
 - At CD-3a review, the Project was tracking 17 open design items; have since resolved all but 3 items:
 - Drift size optimization. Expect to closeout in June.
 - Sizing the number of fiber optic connections between 4850L and surface to support DUNE detectors. Expect to closeout in June.
 - DUNE detector rack cooling approach - Discussions in process.

Far Site Conventional Facilities Final Design - Schedule

				FY16					FY17												FY18															
Activity Name	Dur	Start	Finish	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D									
Pre-Excavation Design																																				
Pre-EXC - 30% Final Design	56	04-Jan-16	22-Mar-16																																	
Pre-EXC - 60% Final Design	69	11-Apr-16	14-Jul-16																																	
Pre-EXC - 90% Final Design	64	15-Jul-16	13-Oct-16																																	
Pre-EXC - 100% Final Design	33	14-Oct-16	30-Nov-16																																	
Main Scope Design Excavation and B&SI																																				
30% Final Design	74	07-Dec-16	24-Mar-17																																	
60% Final Design	74	27-Mar-17	10-Jul-17																																	
90% Final Design	75	11-Jul-17	23-Oct-17																																	
100% Final Design	28	24-Oct-17	05-Dec-17																																	

CM/GC Contract

(Construction Manager/General Contractor)

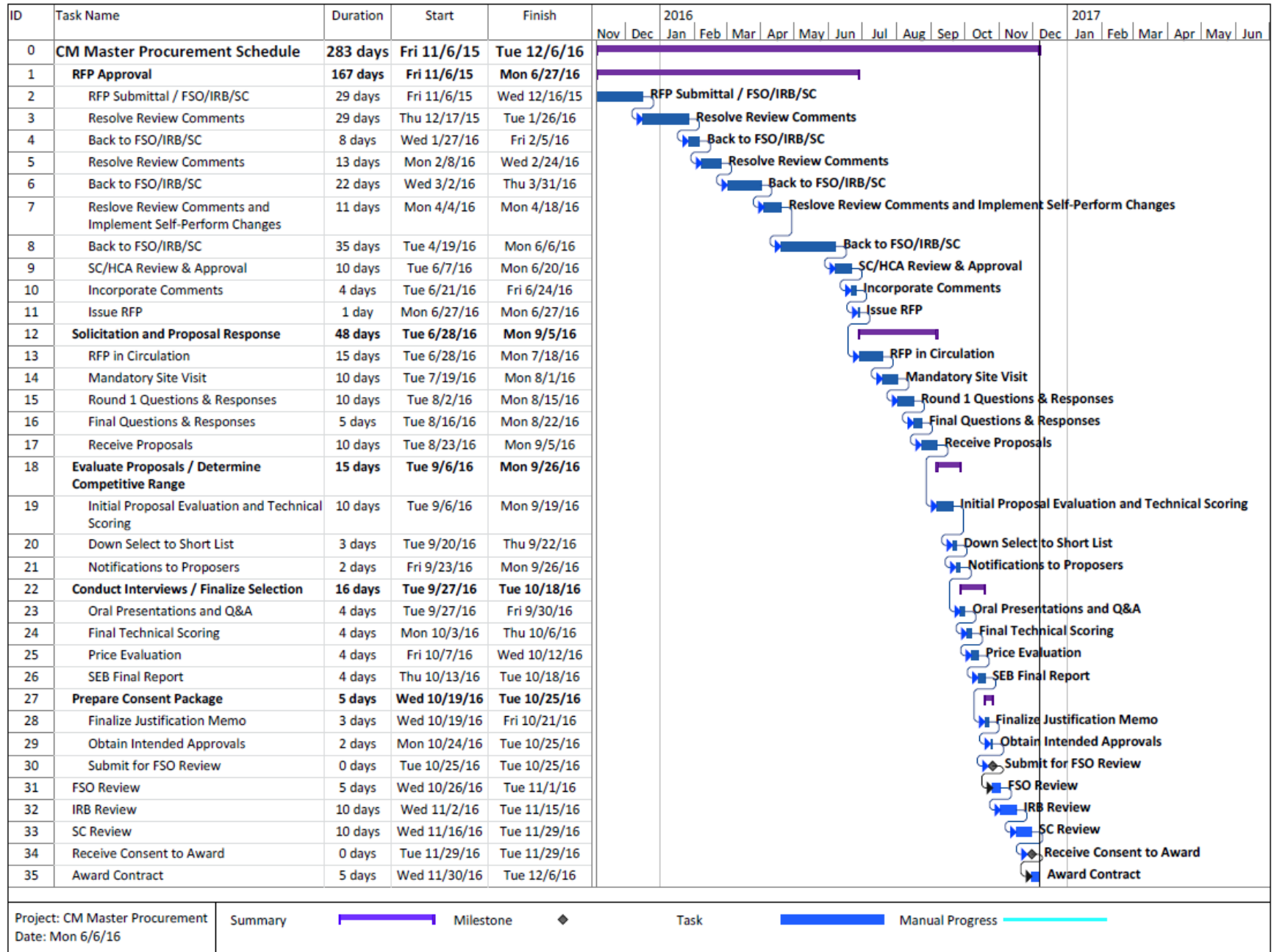
Many Procurements in Support of LBNF – not just CM/GC

- Far Site Facilities CM/GC (detailed status on next slide)
- 2017 Ross Shaft rehab work:
 - Since Jan 2016, working under LBNL-SDSTA cost-reimbursable construction contract
 - Putting similar Fermilab-SDSTA contract in place – working through sole source, authority for work on non-federal property, and other contractual/legal issues with DOE
 - Working to have contract in place late 2016
- Plan for other SURF Reliability Project activities
 - Believe this should be done by SDSTA
 - Developing best acquisition approach in conjunction with Fermilab's SURF Services (Operations) contract for FY17
- Evaluating LN2 Systems design-fab-install strategy

CM/GC Contract Status

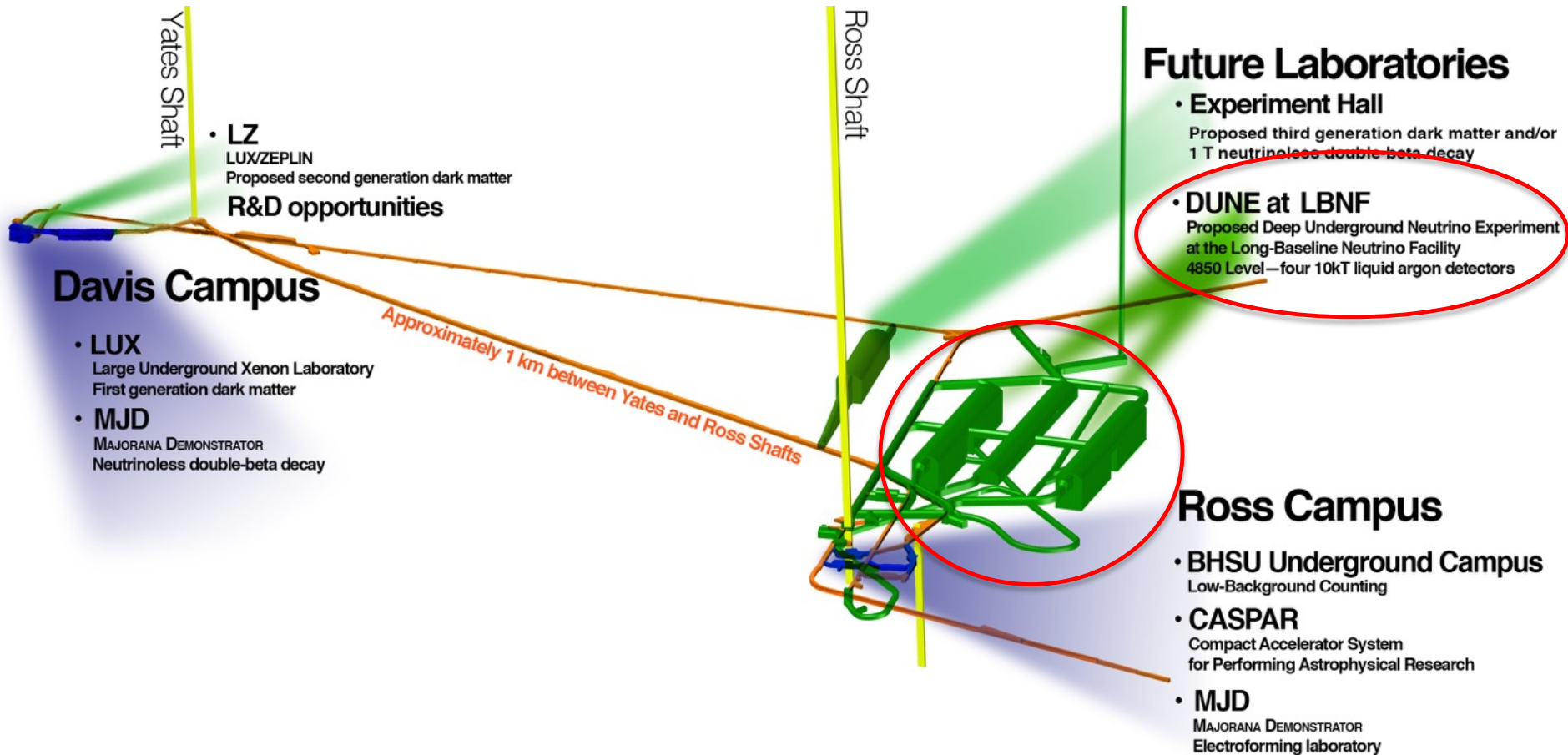
- CM/GC Acquisition Plan Amendment and Request for Proposal have completed DOE Independent Review Board (IRB) process.
 - IRB recommended approval
- Package forwarded to DOE Office of Science senior contracting officer for final approval on 8 June. Assuming no unexpected issues, expect final approval in approximately two weeks.
- Schedule considerations:
 - Project desires award of CM/GC contract by 6 Dec 2016 to align with final excavation and BSI design effort. Schedule to support this shown on next slide.
 - After CM/GC approval, next critical milestone is pre-proposal conference, tentatively scheduled for 19 July at Sanford Lab.
 - To allow the construction industry time to plan, the complete draft RFP has been released on [FedBizOps website](#) that ties to the [public docdb link for the RFP](#).

CMGC Procurement Schedule



Test Blast Vibration Study

Blast Vibration Study – LBNF in context of Underground Laboratory

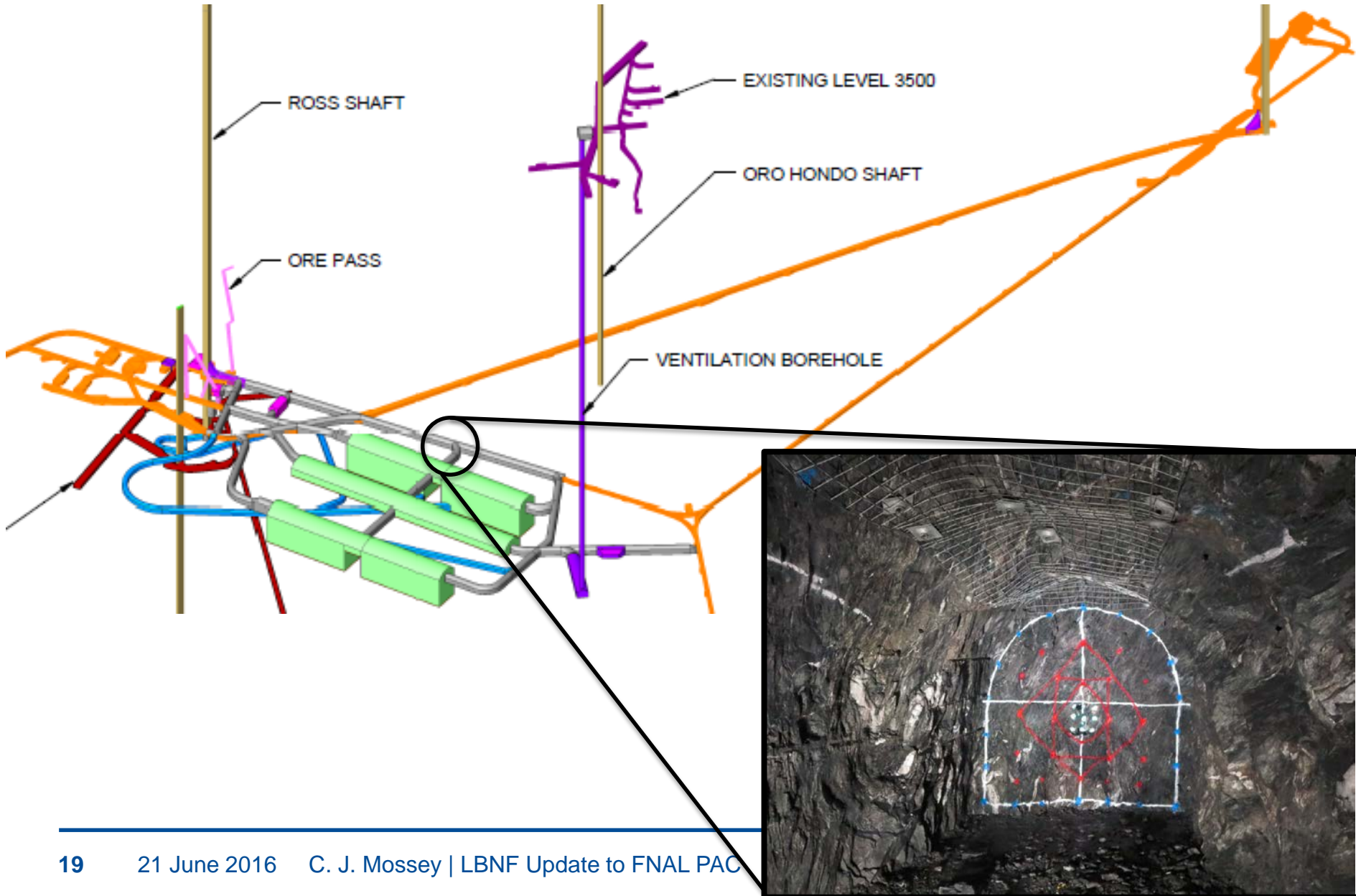


Blast Vibration Study - Background

- Excavation design includes a model for blast vibration & air overpressure
 - Initial model based on industry experience and geotechnical site investigation
 - Potential risks to other 4850L experiments discussed during Logistics Workshop held August 2015 at SURF
 - Blast Vibration Study was proposed to validate model
- Two Phase Blast Vibration Study was completed March 11th
 - 18 monitoring instruments were deployed on 4850L
 - Experiment specific data was collected by LBCs, LUX, MJD
 - Lessons learned from the December blasts were incorporated into March efforts
 - Adjusted blast pattern and utilized non-electronic detonators
 - Seismic data collected by DUGL, Transparent Earth, GEOXTM evaluated
 - Results have confirmed the blast vibration & air overpressure model to inform excavation final design

Blast Vibration Study Location

Two “trim” blasts and two “production” blasts executed

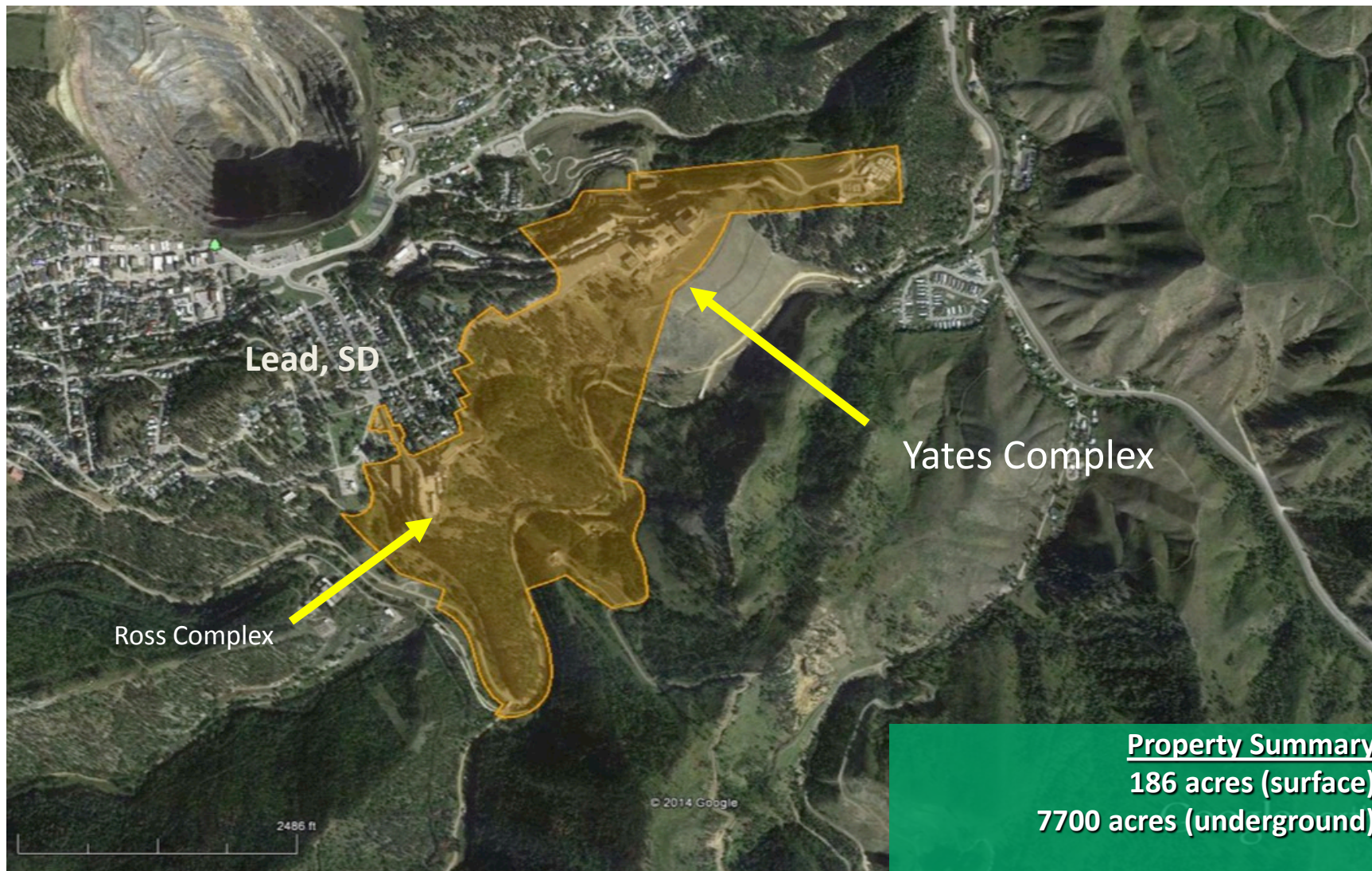


Blast Vibration Study - Conclusions

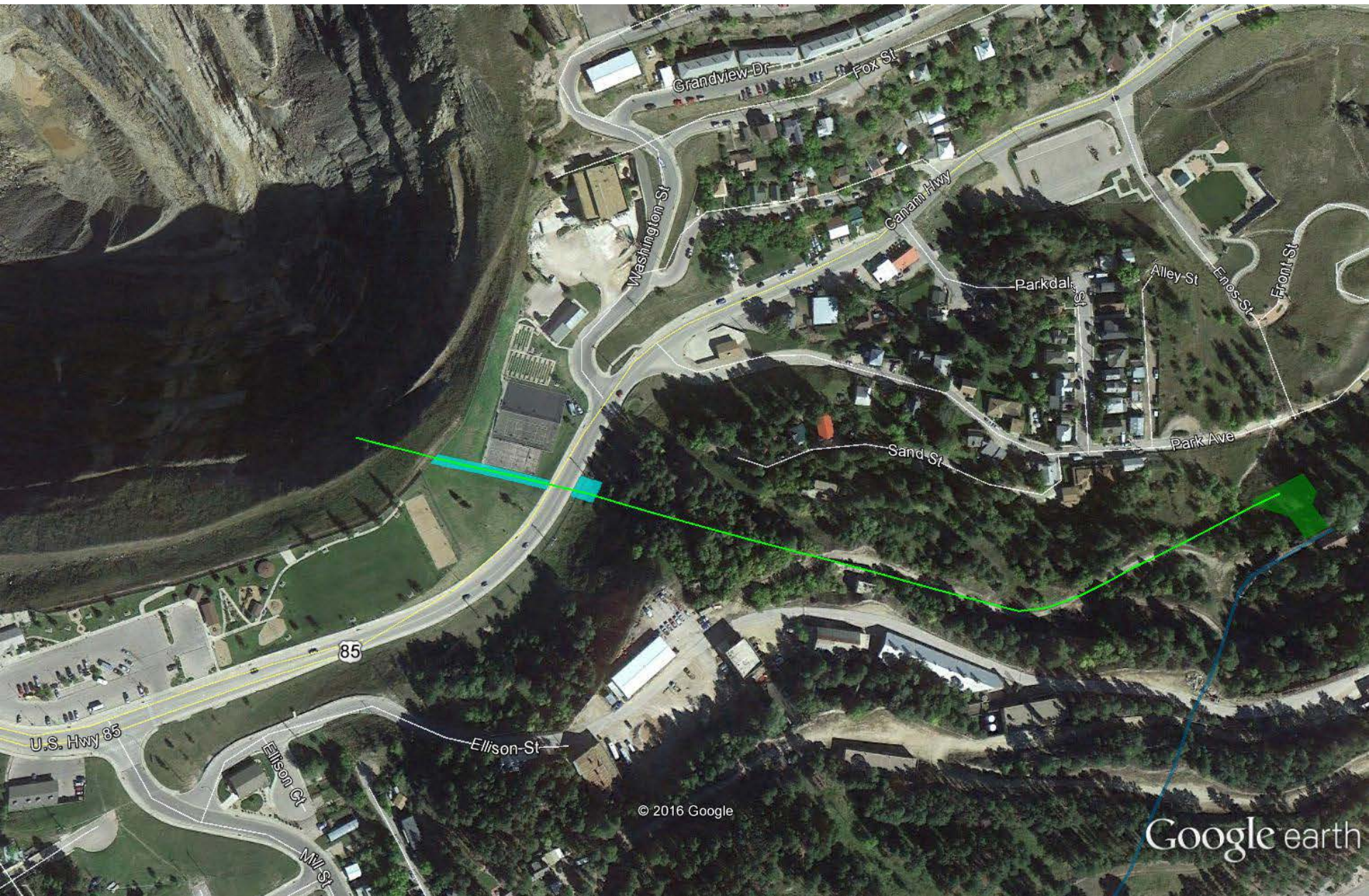
- Excavation within 300 feet of the Ross Campus may exceed the current 0.5 in/sec threshold for peak particle velocity (PPV) for science spaces.
- The 133 dB limit for air blast overpressures at the Ross Campus can be managed with properly designed and operated air lock style bulkheads.
- During excavation, there may be periods when access to the Ross Campus facilities may be limited / modified.
- Activities during final design:
 - Continue evaluation of the upper allowable limits for peak particle velocity near the Ross Campus. Experience at other labs suggests a higher limit may be acceptable.
 - Evaluate the pros / cons of removing the blast resistant bulkhead currently planned between LBNF detector chambers 1 and 2
 - Assess whether excavation of chambers 3 and 4 impacts installation of cryostat #1. Determine if blasting plans need adjustment or if detailed coordination is sufficient.

Excavated Rock Disposal

Far Site Location – Sanford Lab in Lead, SD



Conveyor Path from SURF to the Open Cut



Previous Homestake Surface Conveyor System



Excavated Rock Handling Update

Rock placement location secured. Land easements in place.

Prepared by:
Timothy M. Engel
May, Adam, Gerdes & Thompson LLP
503 S. Pierre Street
PO Box 160
Pierre, South Dakota 57501
605-374-5803



Doc #: 2016-01972
Date: 05/04/2016 10:24:00
Sheree L. Green
Register of Deeds
Lawrence Co. - Fee \$30.00

EASEMENT

This Easement is made and entered into this 2nd day of MAY, 2016, by and between the City of Lead, South Dakota, a South Dakota municipal corporation, 801 W. Main Street, Lead, South Dakota, 57754 ("Grantor") and the South Dakota Science and Technology Authority, 630 East Summit Street, Lead, South Dakota, 57754 ("Grantee"). For and in consideration of the mutual covenants and conditions contained herein, and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the parties agree as follows:

1. **Grant of Easement.** Subject to the terms and conditions hereof, Grantor hereby donates and grants to Grantee a permanent easement for, over and upon the real estate described on the attached Exhibit "A", as further described on the attached Exhibit "A," for the permitted uses described herein (the "Easement").

2. **Permitted Uses.** Grantee may only use the Easement for the purpose of the construction, maintenance and operation of an overhead conveyor system to be used to dispose of waste rock excavated from the former Homestake gold mine located in and near Lead, South Dakota for the purposes of the construction, enlargement, modification or maintenance of underground laboratory facilities and related support and infrastructure facilities (the "Permitted Use").

3. **Further Conditions of the Easements.** The Easement is subject to the following further terms and conditions:

(a). The overhead rock conveyor system shall be designed and constructed generally as shown on the attached Exhibit "B," which is incorporated herein by this reference. The overhead rock conveyor system shall be designed by reputable design professionals and constructed by a reputable contractor or contractors. The design and construction shall conform to current industry standards relating to such systems.

(b) When the overhead rock conveyor system is placed in operation, Grantee shall maintain all required environmental and safety features, such as dust suppression, noise suppression and lighting, in good working order and in accordance with industry standards.

(c). Grantee shall maintain the overhead rock conveyor system in good working order such that it will not pose a danger to the general public while in operation, and will maintain its appearance and keep it and the surrounding real estate covered by the Easement free of debris.

- LBNF will place excavated rock in the Open Cut. The EA considered 2 options.
- SDSTA has now secured required agreements to make this plan a reality
 - October 2015, SDSTA secured easement with Barrick / Homestake allowing placement of up to 5M tons of rock in the Open Cut
 - May 2nd 2016, SDSTA secured an easement with the City of Lead for a conveyor system from SURF's property to the Open Cut
- These agreements represent a major step forward to facilitate LBNF excavation
- Currently working with SD DENR on a revision to Homestake's mining permit for the Open Cut. ECD is Jan 2017.

Reliability Projects

Ross Shaft Renovation

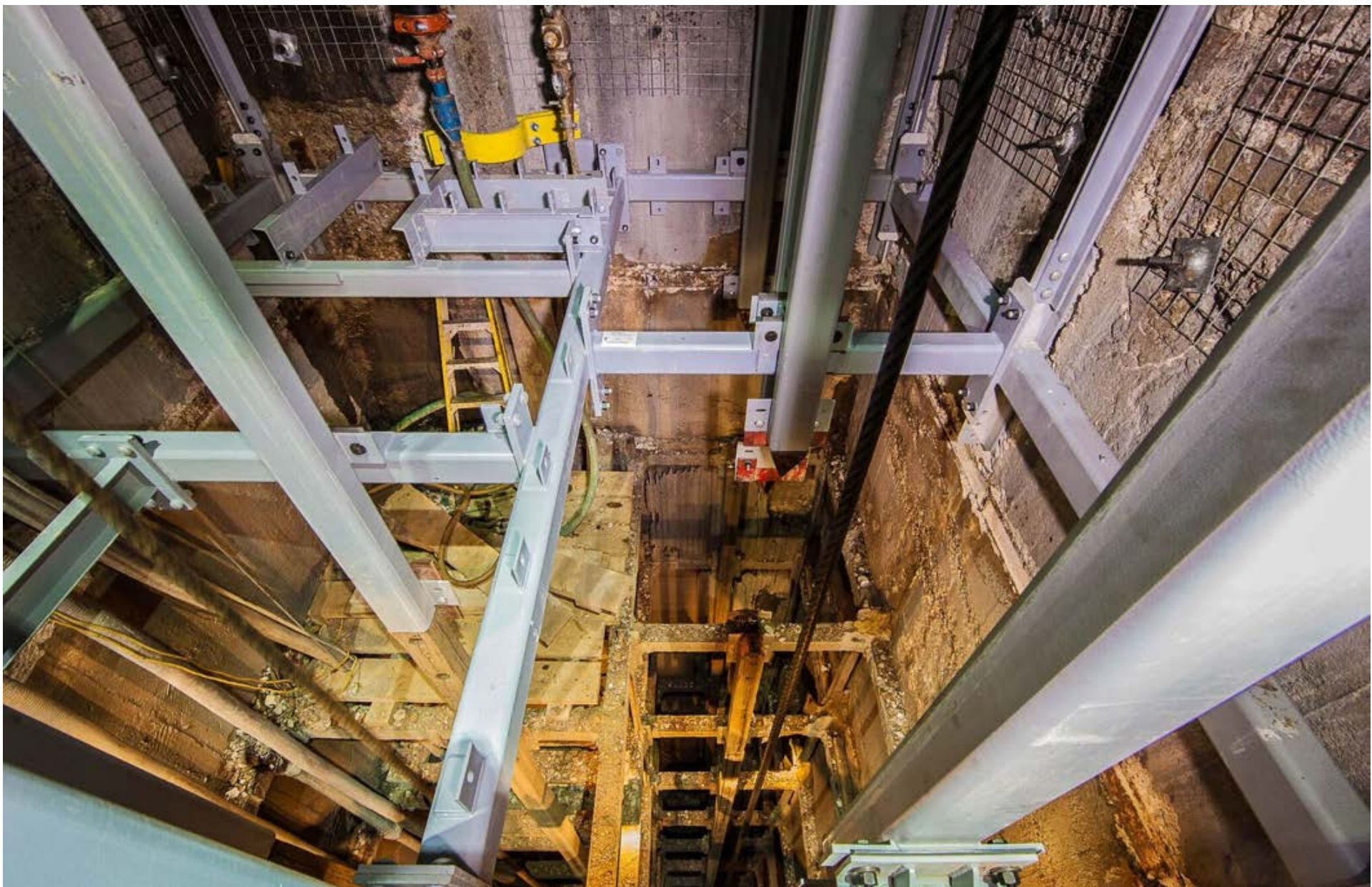
Ross Shaft Refurbishment Update

3,765 feet down from surface (75% completed overall)

Surface		Schedule
Tramway	Completed	
300 L		
800 L		
1250 L		Q1 CY2014
1400 L		
1550 L		
1700 L		
1850 L		
2000 L		
2150 L		
2300 L		Q1 CY2015
2450 L		
2600 L		
2750 L		
2900 L		
3050 L		
3200 L		
3350 L		
3500 L		Q1 CY2016
3650 L		
3800 L		
3950 L		
4100 L		
4250 L		
4400 L		
4550 L		Q1 CY2017
4700 L		
4850 L		
5000 L		Mid CY2017

- Ross Shaft refurbishment needed to support hoisting of the ~800,000 tons of excavated rock and transport of personnel and materials for LBNF construction
- Rehabilitation started in August 2012. SDSTA (state and private funds) provided first \$20M. SDSTA purchased the structural steel for entire project.
- New contract established in January 2016 between LBNL and SDSTA. Provides DOE funds to complete remainder of the refurbishment to the 5000 foot level.
- Have reached the 3765L . On track for Aug 2017 finish.
- Working to transfer contracting responsibility for Ross Shaft to FNAL effective 1 Jan 2017.

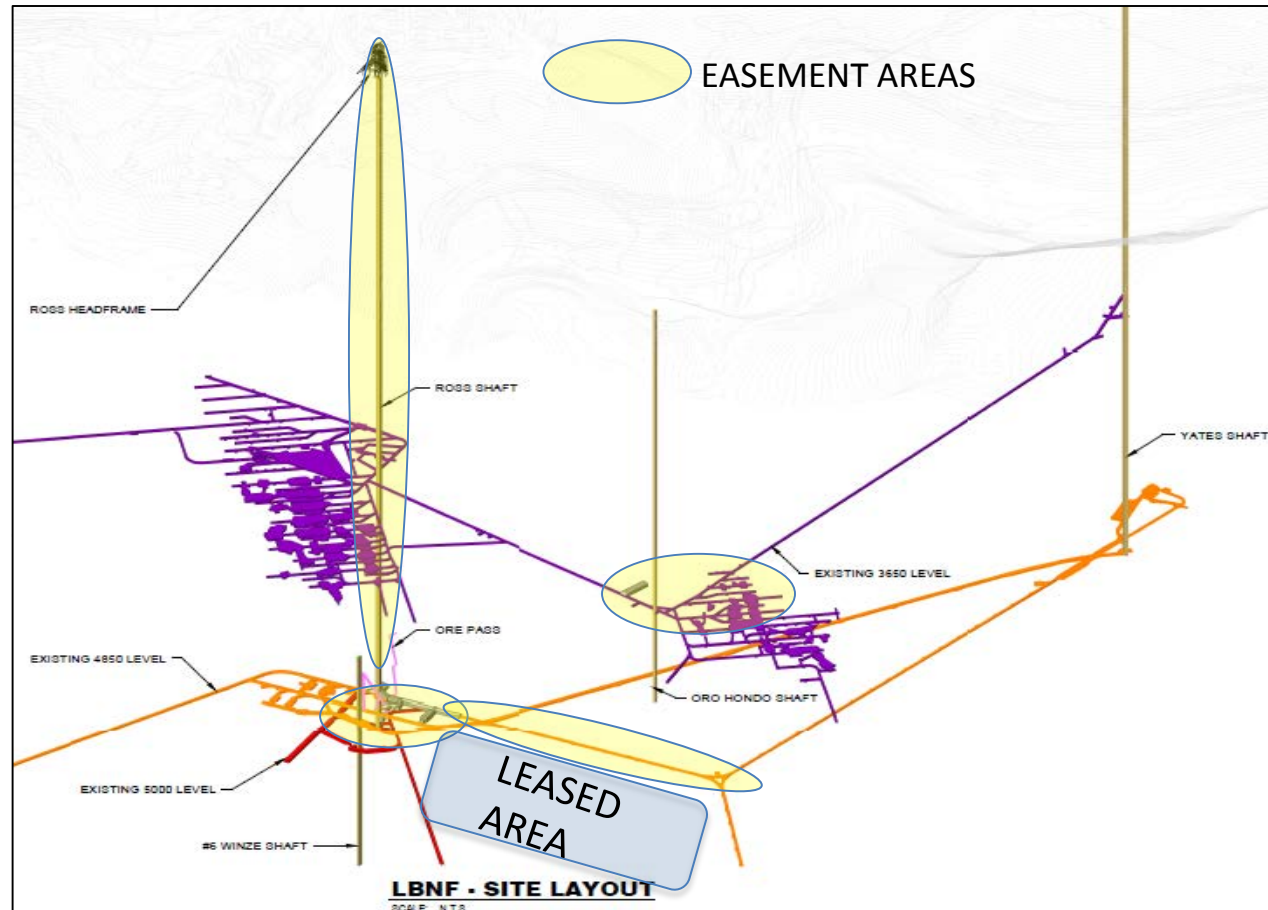
Ross Refurbishment - Recent New Steel Installation



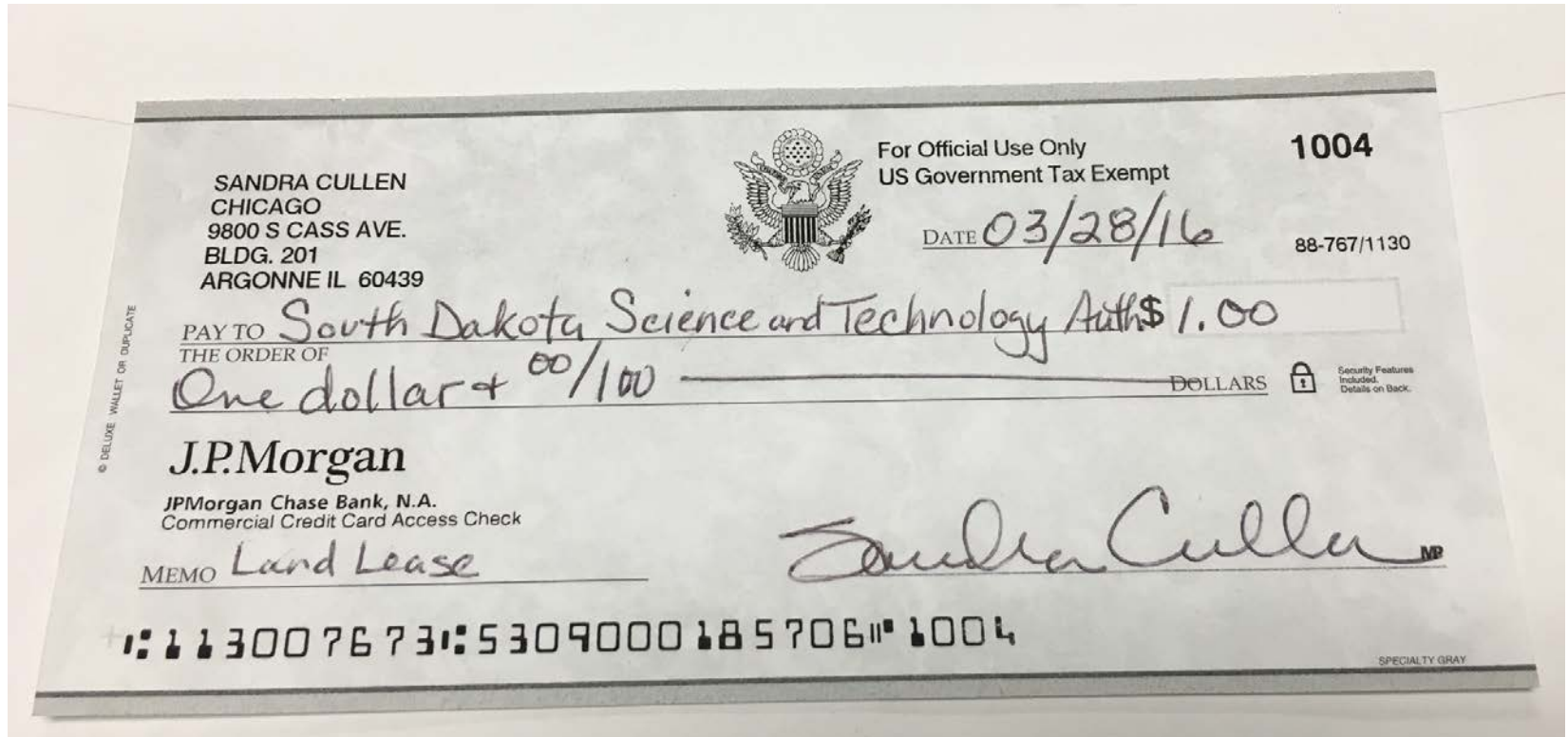
Lease & Easements

Leases and Easements at Sanford Lab

- Generally, government funds cannot be used to make improvements in property not owned by the U.S. government.
- Investment of U.S. federal funds at Sanford lab require proper authorities in accordance with Comptroller General (GAO) policy:
 - Working to finalize easement requirements for shaft, drifts, other “common access” areas at Sanford Lab
 - Lease for LBNF site has been signed; “pre-acceptance” inspection completed; lease went into effect on 1 May 2016
 - First year of lease has been paid for.



Leases and Easements at Sanford Lab



Check for 1st year's lease

Fiscal Update

Congressional Appropriations Status

- **FY17 Funding Status:**

- President's budget submit requested \$45M for LBNF/DUNE
- House and Senate both propose to increase LBNF funding in FY2017 above the President's budget request:
 - House: +\$5M
 - Senate: +\$10M
- both House and Senate versions of appropriations bill authorize start of construction at Sanford Lab in FY2017.
- Continuing resolution risk (next slide)

Continuing Resolution Planning

- Continuing resolutions have potential to significantly impact project execution at this stage of maturity:
 - Year-to-year funding is significantly ramping up
 - Require authorization to begin construction operations at Far Site in FY17
- Have developed multiple funding scenarios to anticipate potential FY17 appropriations timeline, including:
 - 3 month continuing resolution
 - Full year continuing resolution
- Mitigation measures include:
 - Month-to-month funding of Ross Shaft renovation and university POs
 - In longer CR scenarios, will negatively affect project schedule

Road to CD-3A Milestone

Road to CD-3A Milestone: Funding Profile Update

- Because of size of CD-3a funding request in advance of baselining, DOE Under Secretary for Science and Energy desires to have supportable funding profile for entire project understood concurrent with approval of CD-3a milestone
- LBNF Project team has been working closely with DOE Program manager to develop funding profiles that support “stake in the ground” milestones for DUNE collaboration:
 - 2021 - Start of detector installation
 - 2024 – Start of detector commissioning
 - 2026 – Deliver first neutrino beam
- The LBNF/DUNE project leadership, in consultation with DOE leadership, has agreed that the optimum time to request ESAAB approval of the CD-3A milestone is the August-October 2016 timeframe.
 - This aligns the timing of the ESAAB review with the DOE's internal FY18 budget development process
- This timing does not impact the existing project schedule.
- Status: Profile under review by SC-2
 - Currently responding to request for information on final CD-3A funding requirement as element of each year’s funding profile.

The Road to CD-3A Milestone - Summary

Status of actions required to achieve “early construction start” milestone:

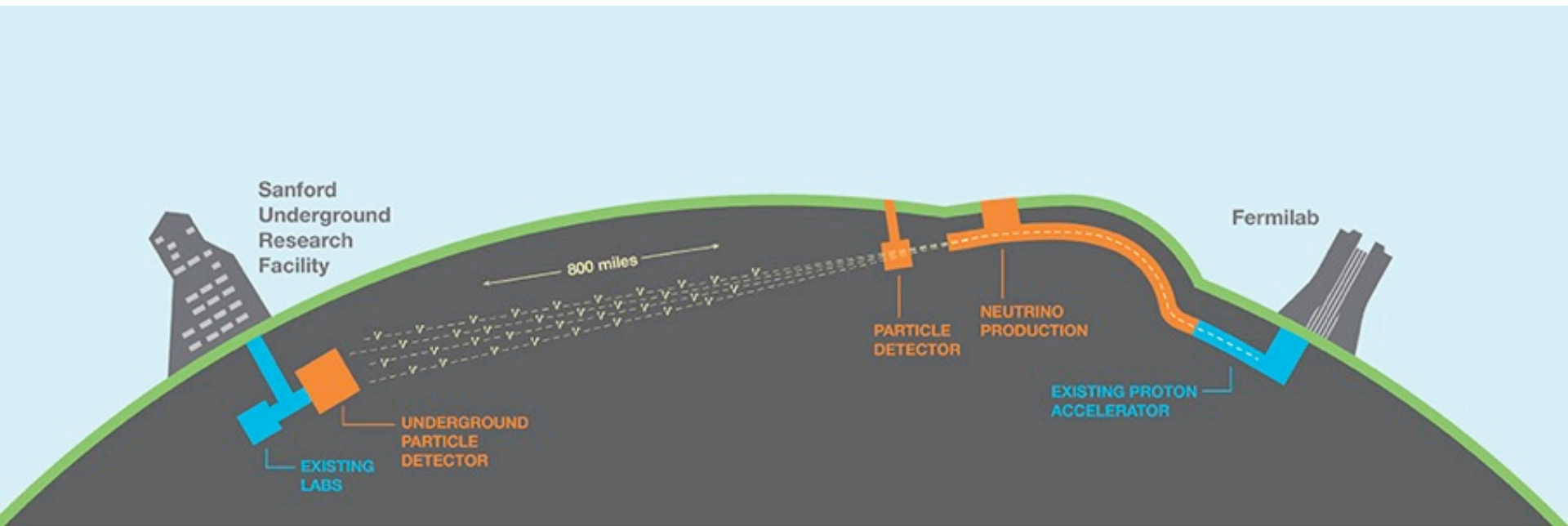
- ✓ Recommendations from December DOE IPR necessary for CD-3a milestone have been addressed.
- ✓ Independent Cost Estimate (ICE) completed
 - DOE PM office conducted review of LBNF cost estimate for CD-3a scope from Dec 2015 to Jan 2016
 - Conclusions of review include:
 - ICE base estimate \$12M less than project estimate
 - ICE estimated contingency \$20M less than project estimate
 - ICE estimate for Total CD-3a Request **10% below** project estimate
- ❑ DOE project funding profile approval by Under Secretary Orr (anticipated late July to August timeframe)
- ❑ PMRC and ESAAB review/approval August/September timeframe

Summary

LBNF Activities Recently Completed, Underway and Planned

- ✓ Began execution by DOE/FNAL of Sanford Lab “Reliability Projects” such as Ross Shaft refurbishment, to reduce risk during main excavation operations
- ✓ Began final design for Far Site conventional facilities
- ✓ Executed Lease for LBNF exclusive use areas at Sanford Lab
- Achieve DOE CD-3a milestone
- Award CM/GC contract
- Start construction activities at Sanford Lab in 2017
- Initiate major cavern excavation construction work in 2018
- Complete first cryostat and cryo systems construction to enable detector install to begin in 2021, with commissioning in 2024
- Produce neutrino beam in 2026!

Questions?



Animation Links:

- [LBNF/DUNE animation \(YouTube\)](#)
- [Video page \(FNAL website\)](#)

Social Media Links:

- [LBNF Facebook](#)
- [DUNE Facebook](#)
- [LBNF Twitter](#)
- [DUNE Twitter](#)

Backup Slides

Why we care about vibration (peak particle velocity)

“Receptor” Distance From Blast	Explosive weight per delay to meet $PPV = 400SD^{-1.34}$ = 0.5 in/sec	Indicative Round Length*	Unmitigated Overpressure at “Receptor”	Unmitigated Overpressure at bulkhead	Assumed distance to bulkhead
100	0.46 lb/delay	1.8 ft	1.8 psi	3.3 psi	30 ft
150	1.0 lb/delay	2.8 ft	1.5 psi	2.5 psi	50 ft
200	1.9 lb/delay	4.20 ft	1.3 psi	1.8 psi	100ft
250	2.9 lb/delay	6.0 ft	1.1 psi		
300	4.2 lb/delay	8.1 ft	1.0 psi		

*Indicative Round Length has been calculated based on the length of a 13/8” diameter hole that would require the maximum weight of explosive allowed. This assumes each hole is detonated as a single delay.

- When the “receptor” is close to the blast location, the round length must be shortened to meet the PPV threshold
- Shorter rounds equals more drill and blast cycles and increased time and cost

International Codes and Standards

- As an international project with major in-kind contributions, LBNF/DUNE needs the ability to accept non-U.S. design standards within DOE 10CFR851 construct.
- Fermilab has finalized and implemented new FESHM Chapter 2110 – *Establishing Code Equivalency with International Codes and Standards*.
- Working with SBN project team, have developed priority sequence to review non-U.S. mechanical and electrical design standards proposed for equipment coming from CERN. Task forces being formed to complete focused reviews.
- Code equivalency review status:
 - EN 13455 – Unfired Pressure Vessels – complete
 - EN 13480 – Metallic Industrial Piping – underway
 - EN 12434 Cryogenic Flexible Hoses, EN 13458 Cryogenic Vessels, EN 13648 Cryogenic Vessels-Safety Devices for Overpressure protection, and ISO 4126 Safety Devices for Overpressure protection – planned
 - Similar strategy for Electrical device standards in development

LBNF/DUNE Risk Status

- Status as of end of May for on-project risks
 - 55 high and medium ranked open threats
 - Expect to retire some risks during workshop and may change some probabilities & impacts

WBS	Closed - Managed	Closed - Retired	Open	Proposed
131.01.01 - LBNF PO		6	19	6
131.01.02.02 - CFFS		2	16	1
131.01.02.03 - Cryo			12	2
131.01.03.02 - CFNS		1	16	
131.01.03.03 - Beamline			32	6
131.02.01 - DUNE PO			1	
131.02.02 - FD		2	32	16
131.02.03 - ND	3	1	5	1
Total	3	12	133	32

Beamline Optimization Status

- In coordination with DUNE and at the collaboration's request, investigating alternate configurations through FY17 to provide better physics.
- Recently optimized beamline design requires conceptual engineering and costing analyses on targets, horns (3 vs. 2), and target chase atmosphere (He or N vs. air).
 - Plan is to work at Fermilab and RAL over next 15 months on conceptual engineering and costing before deciding whether these are viable options to existing design.
 - In discussion with Fermilab AD regarding engineering resources
- Radically different beam idea presented at May DUNE collaboration meeting. Physics analyses being done first by DUNE to validate consideration of this approach, presently thought to be cost-neutral.
 - Collaboration evaluating tune-ability of the idea
 - EFIG will hear collaboration evaluation at 13 July meeting
 - Then will decide if further development is worthwhile, balancing available resources and cost/benefit/risk
- Need beamline preliminary design to start in fall 2017 for 2019 baselining.

Project Risk Management

- Update since January: Added 4 new risks related to existing SURF infrastructure needed for LBNF/DUNE:
 - PM-150 Ross Hoists break down – multiple components
 - PM-151 Ross cage hoist brakes failure
 - Ross skip hoist brakes failure
 - Ross skip drum cracks require repair
- Mitigated by including motor repairs & new brakes/clutches in base plan
- Retained as risks with low probabilities/impacts
- Risk workshop held last week at Fermilab:
 - reviewed and updated all current medium and high ranked risks
 - added brainstorm & discuss any new or proposed risks
 - prepare for updated monte carlo analysis to inform risk cost (for DOE-only) and schedule contingency calculations

Project Staffing

- Project Office hires:
 - LBNF/DUNE QA manager – interviews complete, pursuing one candidate
 - LBNF/DUNE Financial Manager – replacement hired, will start August 1st
 - Senior Procurement Administrator fully matrixed to LBNF - interviewing
- Have developed plan with Directorate approval to ensure sufficient on-site management and oversight for SURF activities

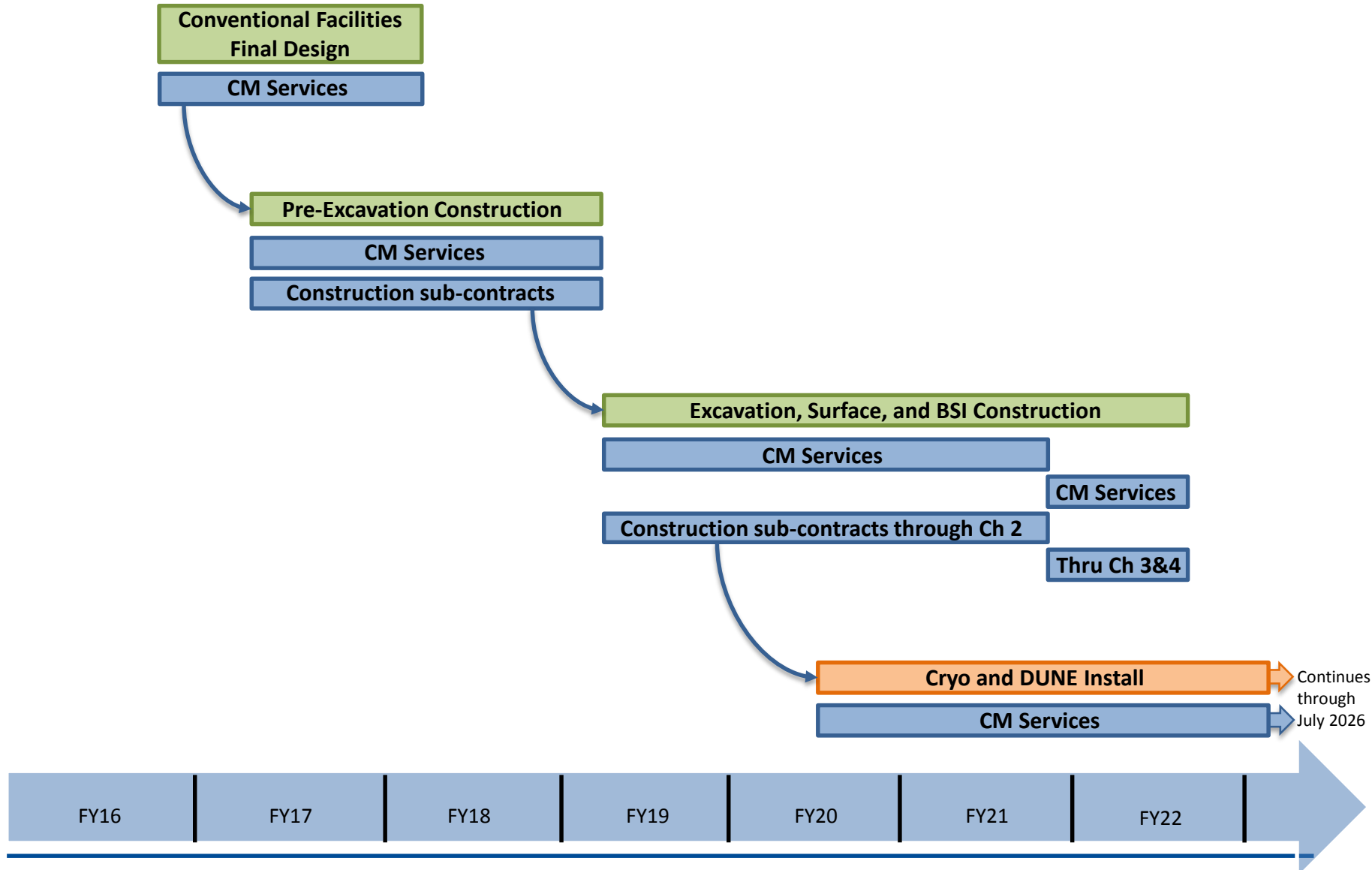
Cryogenic Infrastructure Design Status

- Cryostat: No progress since CD3a because focus is on ProtoDUNEs, from which much will be learned.
 - Working through question of side penetrations with LBNF Cryogenic Safety Review Panel.
 - Expect to restart this design in 2017; working on understanding what inputs are needed to achieve GTT final design and early procurement schedule at CERN
- N2 and LAr Systems:
 - Recently resources have been working on designing ProtoDUNEs cryogenic systems
 - As reported in ProtoDUNE mini-review, cryo systems is out for bid by CERN
 - Procurement of the LAr pumps for ProtoDUNEs is underway at Fermilab.
 - Working on furthering LAr cryo systems requirements, which will be vetted by DUNE Cryo Task Force
- Discussing idea of a design-build-install approach to the LN2 system.
 - RFI to industry regarding this vs. separate design, fab, and install contracts is under evaluation
- Internal cryogenics and the interface with the detector being discussed with DUNE

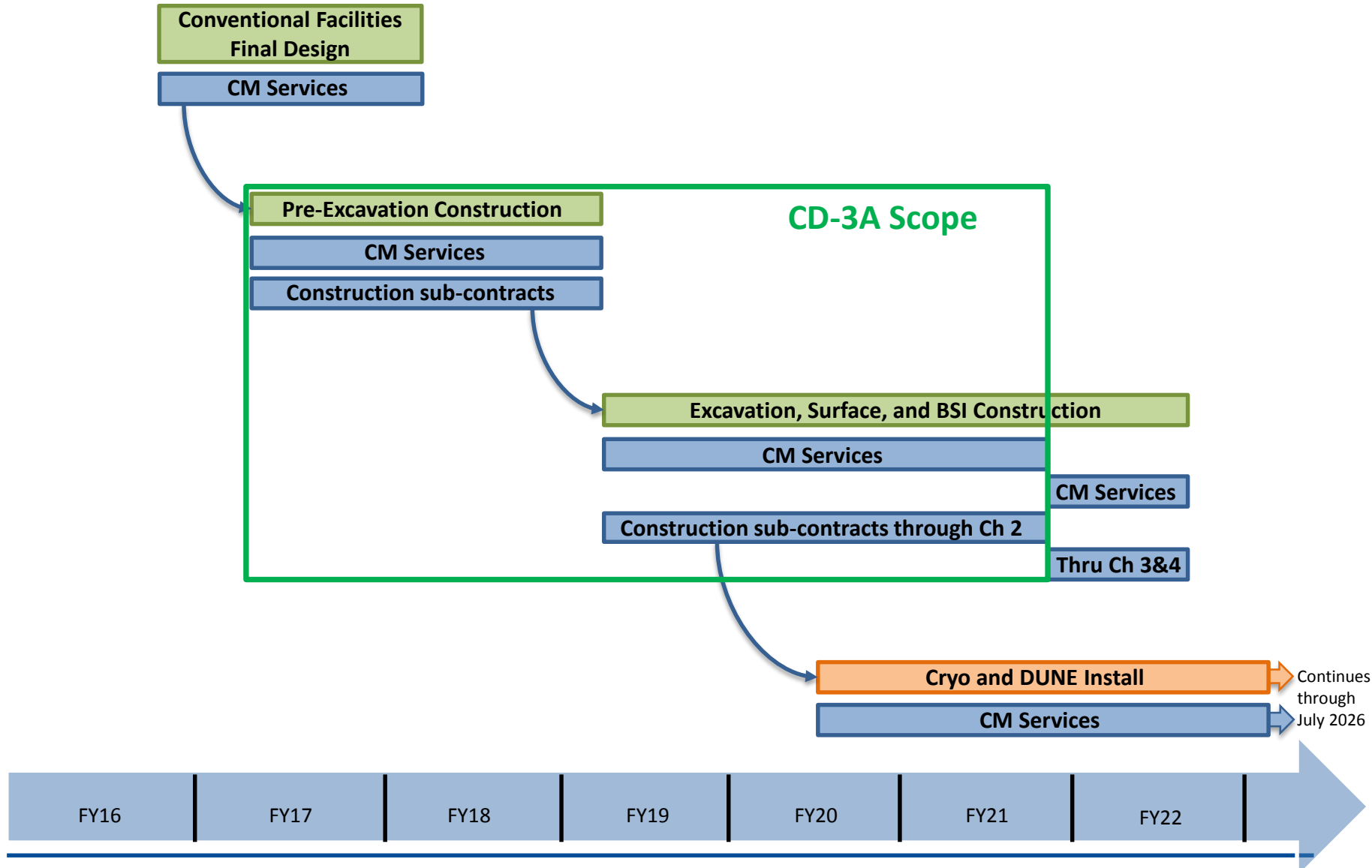
Review Recommendations – LBNF and DUNE

DATE	REVIEW	TOTAL # REC	# CLOSED	# IN- PROGRESS	# TO BE CLOSED 2016
Jun 2015	Dir CD-1R	30	27	3	-
Jul 2015	DOE CD-1R	31	19	12	3
Sep 2015	LBNC-LBNF	7	5	2	-
Oct 2015	Dir CD-3a	9	8	1	1
Dec 2015	DOE CD-3a	19	10	9	7

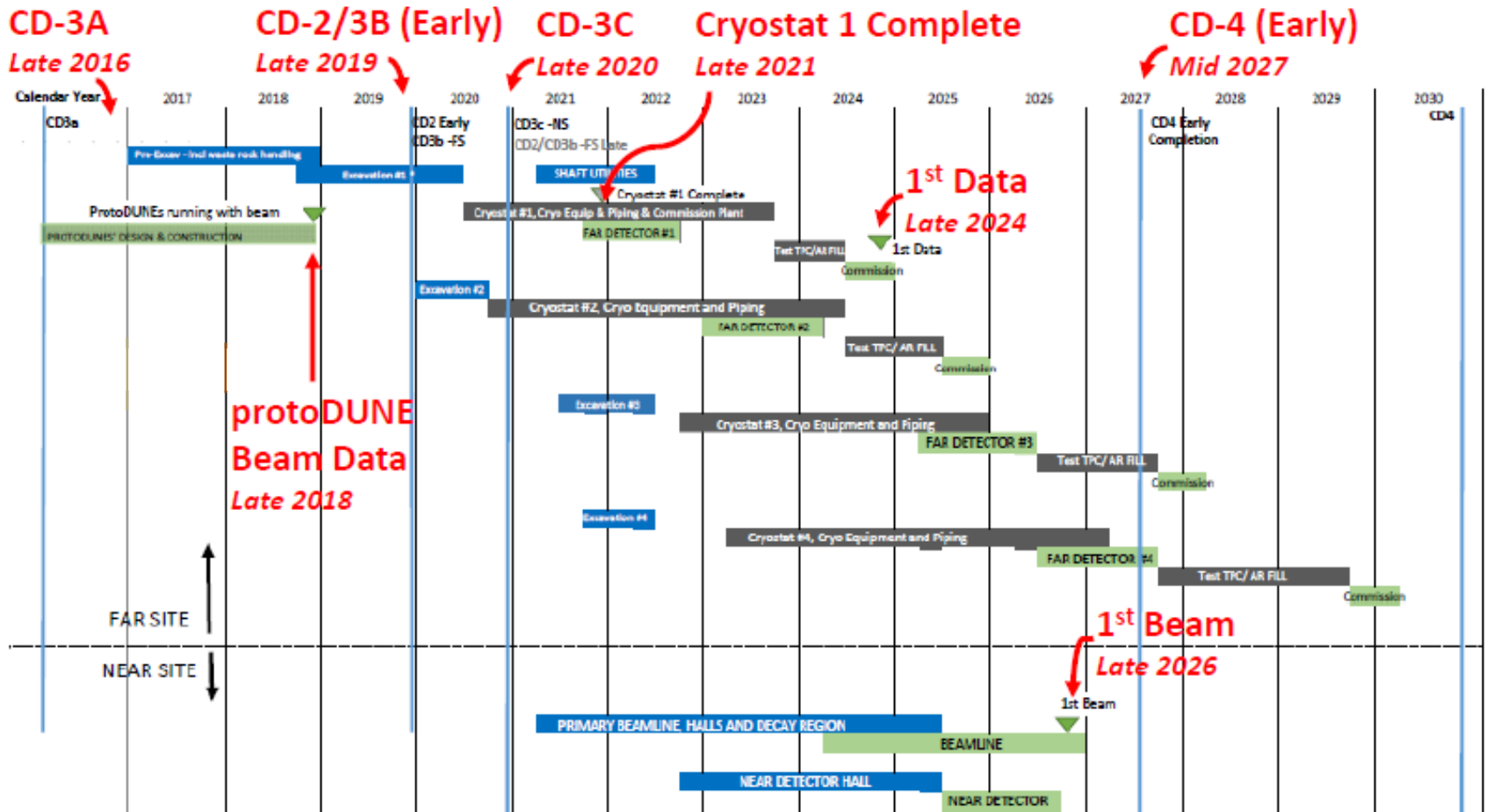
LBNF Far Site Conventional Facilities Acquisition Strategy



LBNF Far Site Conventional Facilities Acquisition Strategy



LBNF/DUNE Key Milestones/Target Dates



Schedule based on CD-1R milestone profile

International Partnership - LBNF

- CERN is a major partner in facility infrastructure at Sanford Lab and is also key to facilitate European engagement.
 - Signed four partnership protocols on 18 Dec 2015 including neutrinos
 - Have already committed to provide first cryostat (valued at \$90M U.S. TPC)
 - Facilitating engagement with member countries and European HEP community – may facilitate other LBNF partners
 - Supporting prototyping effort with short baseline and protoDUNE with CERN “neutrino platform”
- IHEP-China providing prototyping of corrector magnets
- UK proposing to do essential Target R&D
- South Dakota, where more than \$146M has been invested in the Sanford Underground Research Laboratory to date.
- India providing major contribution to PIP-II which supports LBNF

Far Site Construction/Installation Logistics Planning

- Material movement through facility:
 - Iterating with Cryo and Detector teams to understand logistical requirements through shaft and drifts
 - Modeling to inform headframe and shaft bottom modifications is underway
- Blast Vibration Study
 - Completed test program in March
 - Validating excavation rate assumptions
 - Verifying that impacts are minimal or manageable
- Studying number of personnel underground
 - Have determined that Ross Shaft could support all LBNF/DUNE access
- Recent Request for Information to local South Dakota companies and leaders for available housing, warehousing, and office space
 - Housing is the biggest challenge



Planning Outputs: Personnel Underground & Ross Shaft Utilization

Key Sanford Lab infrastructure will handle all planned activities

