LBNF Report to the FNAL Physics Advisory Committee

C. J. Mossey, Deputy Director for LBNF

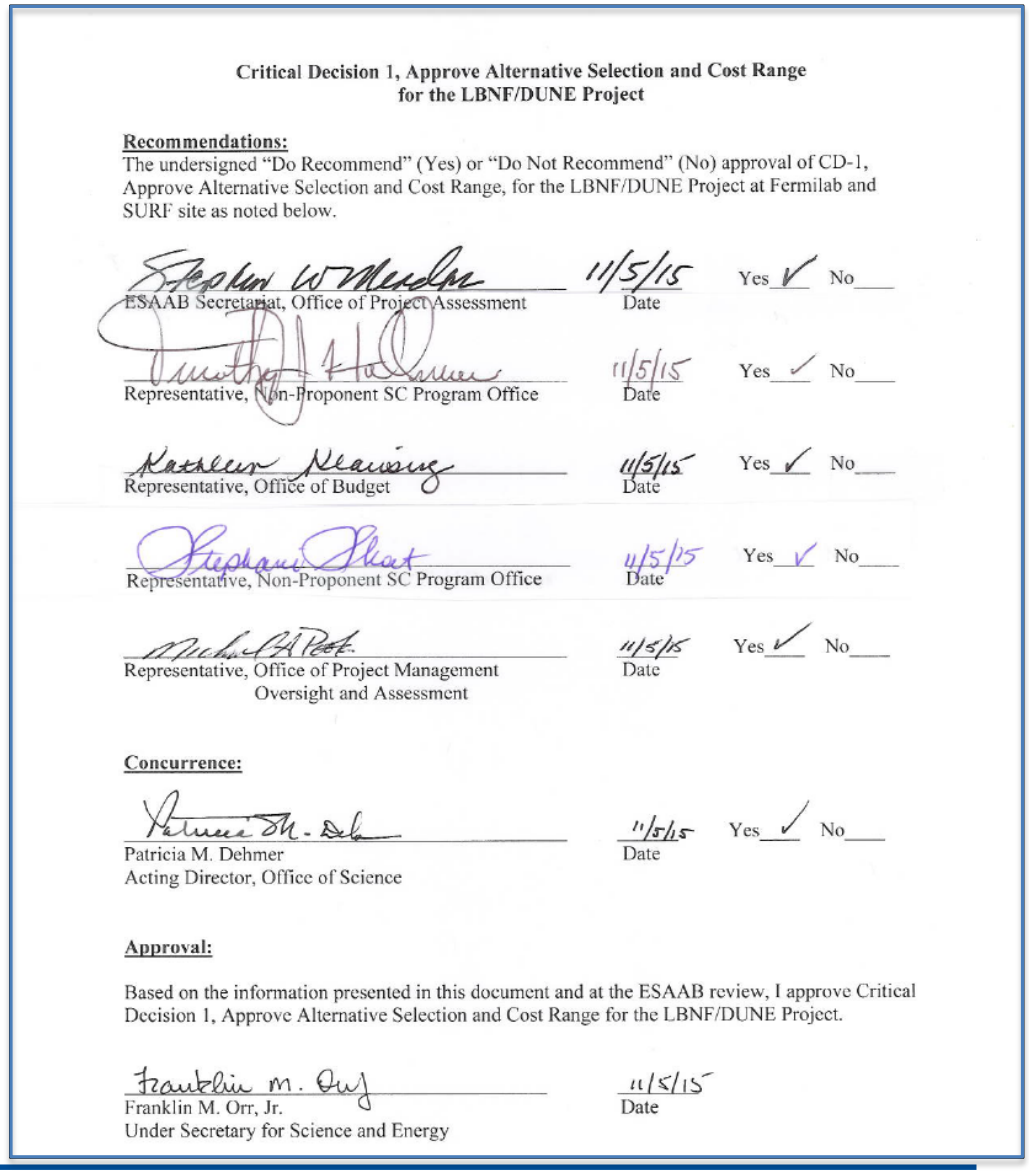
20 January 2016

Topics

- CD-3a overview and update
  - Far Site scope and schedule
  - CD-3a rationale
  - DOE IPR and outcomes
- Current key actions
  - Final Design Plan
  - Lease
  - CM/GC contract RFP
- Near-term events/actions

DOE Critical Decision (CD) Milestone Status:

- CD-0 was approved in January 2010
- CD-1R was approved in November 2015
- DOE IPR conducted December 2nd – 4th 2015 to request approval of milestone CD-3a, ***Approve Initial Far Site Construction*.**
- Expect CD-3a milestone decision by end of 2nd quarter FY2016



Critical Decision 1, Approve Alternative Selection and Cost Range for the LBNF/DUNE Project

Recommendations:
The undersigned "Do Recommend" (Yes) or "Do Not Recommend" (No) approval of CD-1, Approve Alternative Selection and Cost Range, for the LBNF/DUNE Project at Fermilab and SURF site as noted below.

ESAAB Secretariat, Office of Project Assessment — 11/5/15 — Yes ✓ No
Representative, Non-Proponent SC Program Office — 11/5/15 — Yes ✓ No
Representative, Office of Budget — 11/5/15 — Yes ✓ No
Representative, Non-Proponent SC Program Office — 11/5/15 — Yes ✓ No
Representative, Office of Project Management Oversight and Assessment — 11/5/15 — Yes ✓ No

Concurrence:

Patricia M. Dehmer, Acting Director, Office of Science — 11/5/15 — Yes ✓ No

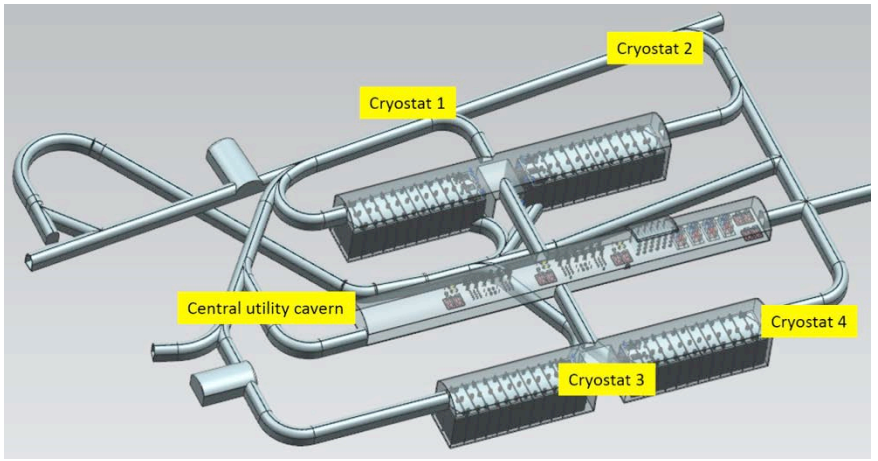
Approval:

Based on the information presented in this document and at the ESAAB review, I approve Critical Decision 1, Approve Alternative Selection and Cost Range for the LBNF/DUNE Project.

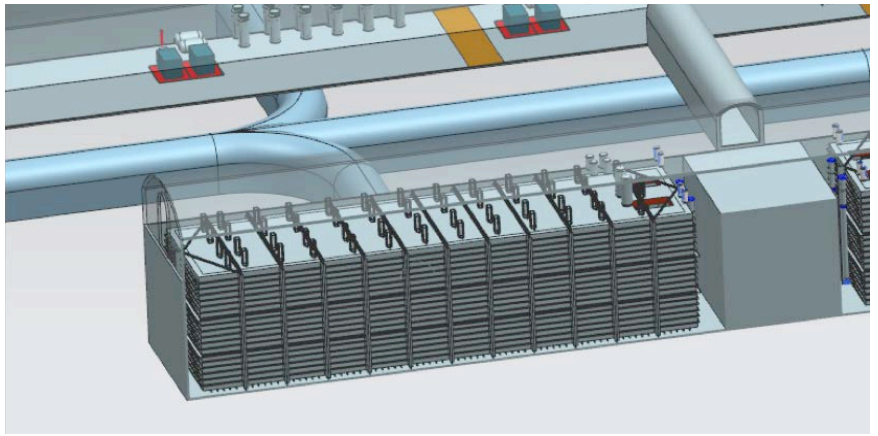
Franklin M. Orr, Jr., Under Secretary for Science and Energy — 11/5/15

Quick Review of LBNF FS Scope – Major Components Perspective

- **Conventional Facilities**:
  - **Drifts** and two **caverns** for four **detectors**
  - **Central utility cavern** for conventional and cryogenic equipment
  - **Surface** and **shaft** Infrastructure including utilities
- **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)



4850L cavern and drift layout



Single cryostat

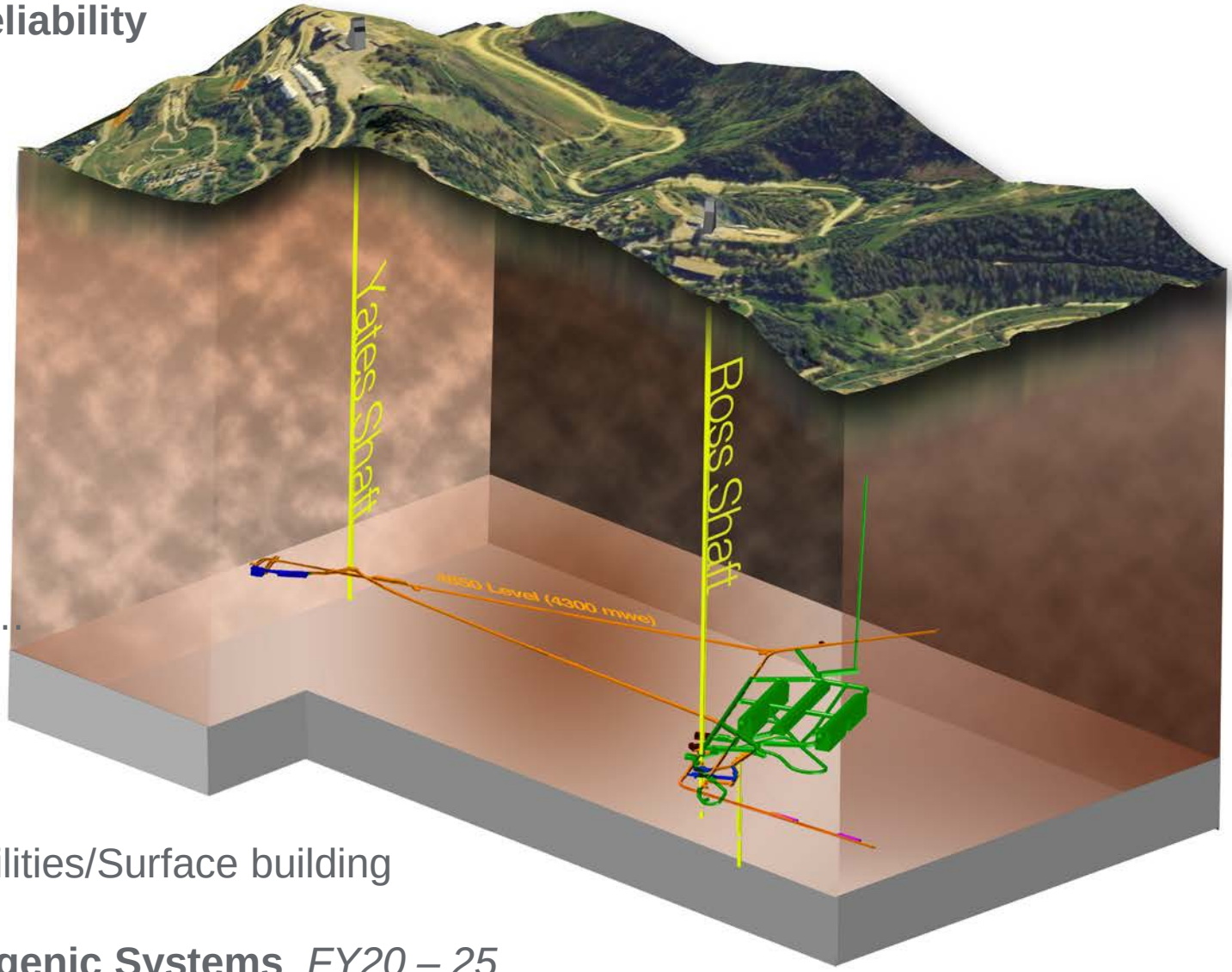
LBNF Far Site – Phases of Work Perspective

1. **Sanford Lab Reliability Projects**
   FY16 – 18
   - Ross shaft rehab
   - Hoist motor rebuilds, more…

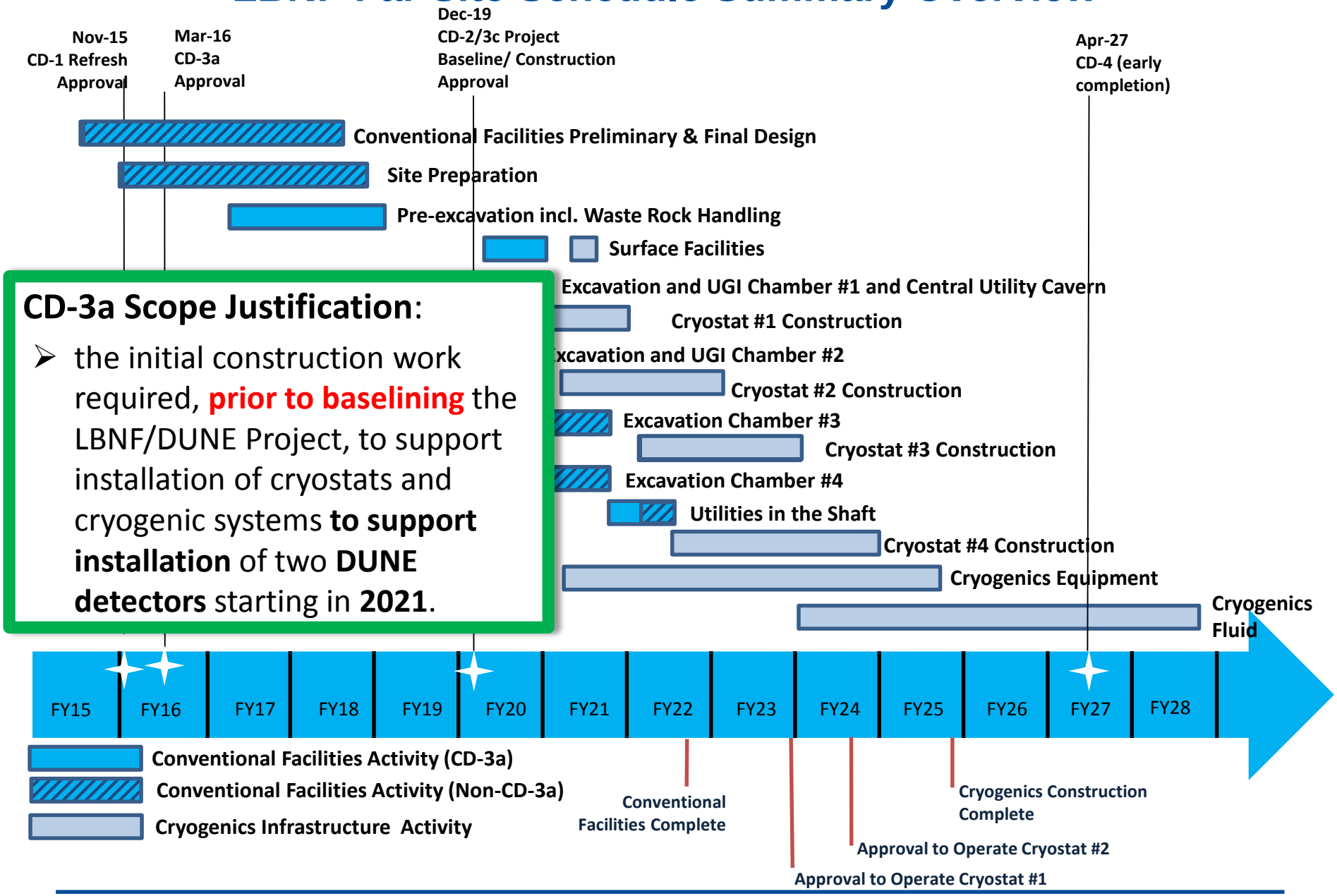
2. **Pre-Excavation**
   FY17 - 20
   - Rock disposal systems
   - Ross brow expansion, more…

3. **Excavation/ Construction**
   FY18 – 22
   - Caverns/Drifts/Utilities/Surface building

4. **Cryostats/Cryogenic Systems** *FY20 – 25*



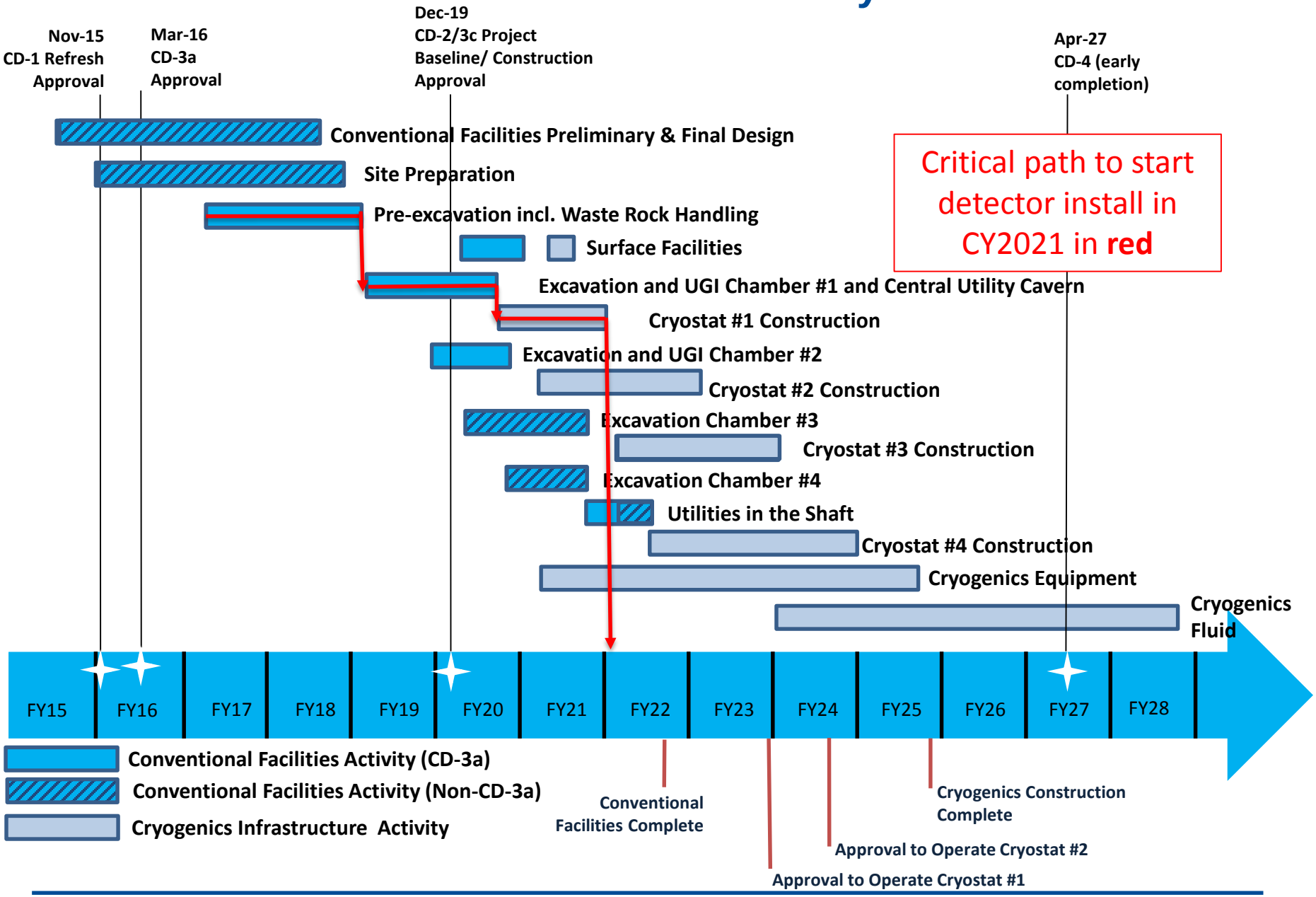
LBNF Far Site Schedule Summary Overview



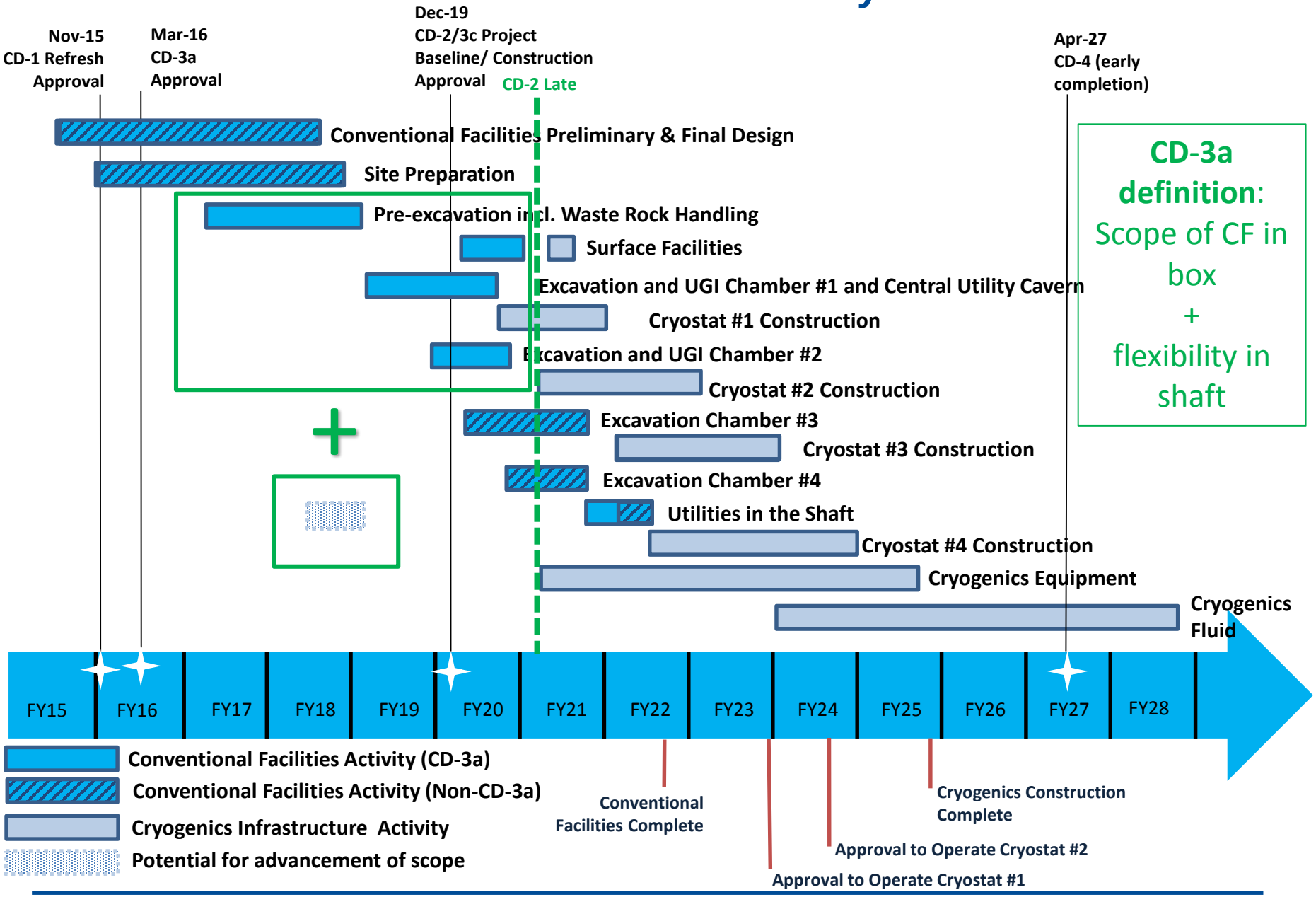
CD-3a Scope Justification:

- the initial construction work required, **prior to baselining** the LBNF/DUNE Project, to support installation of cryostats and cryogenic systems **to support installation** of two **DUNE detectors** starting in **2021**.

LBNF Far Site Schedule Summary Overview



LBNF Far Site Schedule Summary Overview



DOE CD-3a Independent Progress Review (IPR) – Dec 2–4, 2015 at Sanford Lab

- Six subcommittees looked at project readiness to begin **conventional facilities** construction at far site
- Review focus:
  - Science → Requirements → CF design
  - Interfaces: Detectors → Cryostats + cryo systems → Caverns
  - Conventional facilities design maturity
  - Technical risks: Identified and addressed
  - Credible schedule and cost analysis with adequate contingency
  - Environmental, Safety, & Health issues addressed
  - Project organization and management
  - Have previous review recommendations been addressed

DOE CD-3a IPR Outcomes

- Reviewers generally very positive
  - Conducting review at Sanford Lab site seen as helpful
- IPR closeout:
  - Reviewers answered “yes” to charge questions with a few qualifications (see backup for list of questions)
  - **“Ready to proceed to CD-3a Milestone”**
  - 19 actionable recommendations (see backup)
  - Three recommendations need to be closed before construction start approval by DOE:
    - Consider adding backup power to the booster compressors to allow some reduced capacity…in even of a sustained outage **(Analyzing)**
    - Review and revise open-cut disposition plan to ensure consistency with the EA (FONSI) **(Essentially done)**
    - Revisit and update the scope contingency plan prior to CD-3a **(Done)**

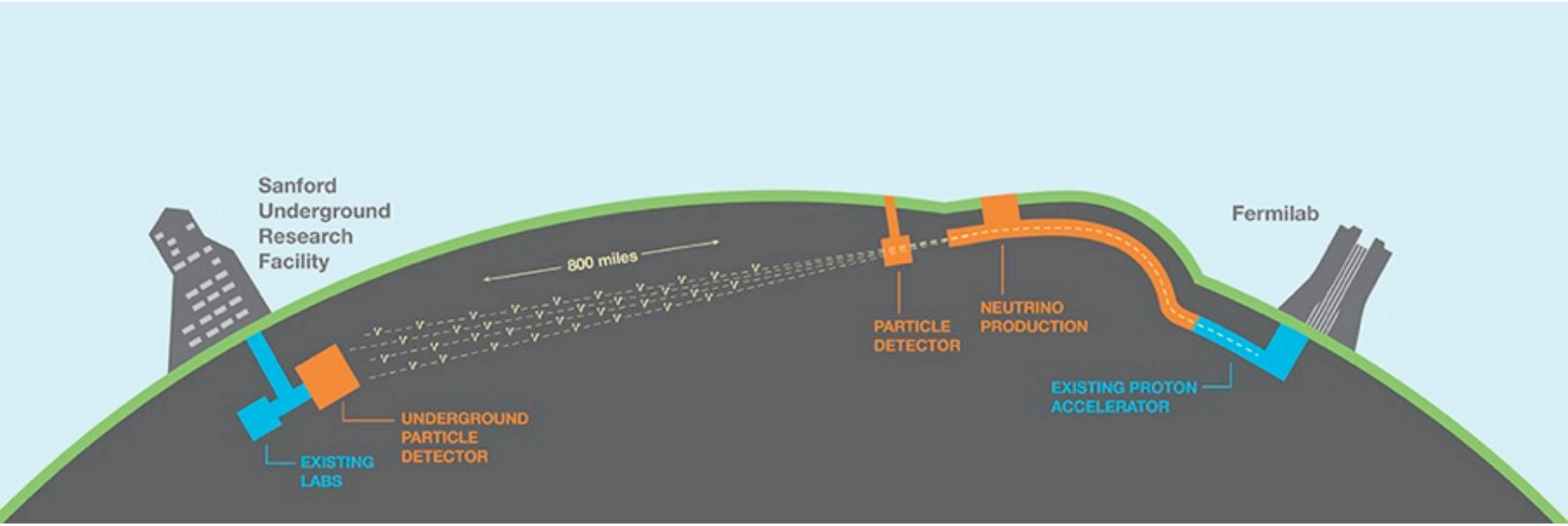
Current Key Actions

- Begin **Final Design process** for Far Site conventional facilities; three parallel tracks:
  - **Pre-excavation design (starts this month)**
  - Excavation design (starts July)
  - Buildings, Structures, Infrastructure (BSI) design (starts August)
- Finalize **Lease** for underground and surface areas
  - Expect to sign lease this month; effective 1 May 2016
  - Planning an “ORC-like” process to take control of leased space
- **Award CM/GC contract** for phase 1 (pre-award CM services)
  - Complete DOE review process of entire CM/GC contract
  - Synopsize (advertise)
  - Select best value proposer and complete award review process

Near Term Events/Actions

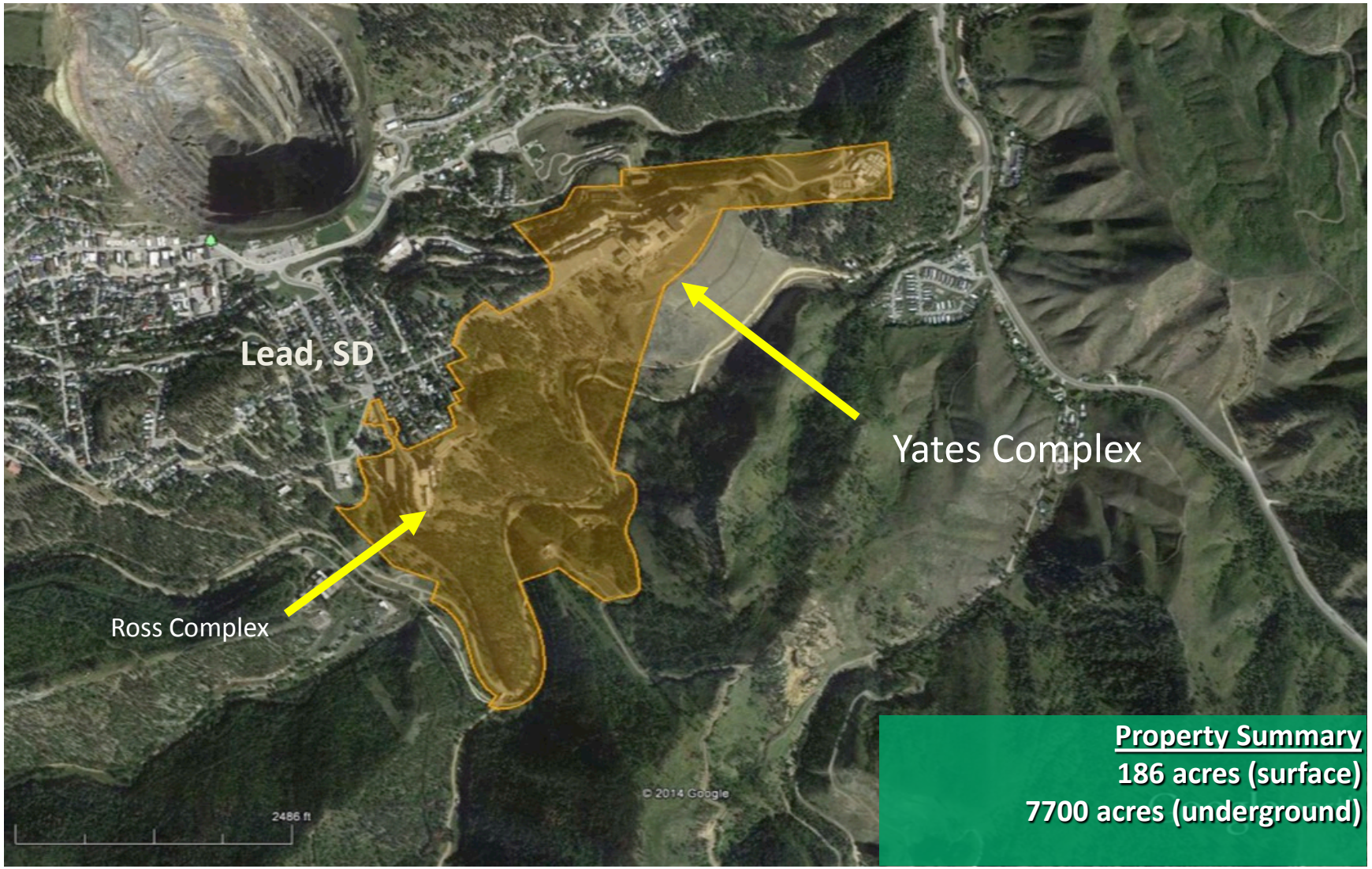
- Finalize LBNF/DUNE strategic communications plan
  - Developing communications tools/products
- President's FY2017 Budget to the hill – o/a 9 February
  - Adjust funding profile if required
- Achieve CD-3a Milestone (early construction start):
  - Respond to DOE packaging/"chunking" charge letter – early Feb
  - DOE complete Indep. Cost Estimate – draft report just received; final report – mid Feb
  - Close out DOE IPR recommendations that must be completed prior to ESAAB
  - DOE PMRC assessment on CD-3a milestone – mid to late Feb
  - DOE ESAAB to approve CD-3a milestone – March

Questions?


Sanford
Underground
Research
Facility
800 miles
Fermilab
PARTICLE
DETECTOR
NEUTRINO
PRODUCTION
EXISTING PROTON
ACCELERATOR
UNDERGROUND
PARTICLE
DETECTOR
EXISTING
LABS

Backup Slides

Far Site Location – Sanford Lab in Lead, SD



DOE CD-3a IPR Charge Questions

1. a) Is the Far Site CF design technically sound and sufficiently mature to support proceeding with procurement and initiation of initial construction activities?
   b) Does the design flow down from the requirements?
   c) Have technical risks been appropriately addressed?
   d) Has the interface definition between CF and the cryostat/cryogenic systems and CF and the detector, as well as the logistics of excavation, construction, and technical systems installation been sufficiently developed?
2. Is the CD-3a scope identified by the project necessary and sufficient to enable installation of the cryostat, cryogenic infrastructure, support systems and detector?
3. a) Are the cost and the schedule for initial far site construction activities credible, with adequate contingencies?
   b) Doe the project have a credible plan to track performance associated with these activities?
   c) Are risks identified and managed appropriately?

DOE CD-3a IPR Charge Questions - continued

4. Are ES&H aspects being properly addressed and are future plans sufficient given the project's current stage of development?
5. a) Is the project being effectively managed?
   b) Is it properly organized and staffed to successfully execute project plans, especially as they relate to the initiation of Far Site construction activities?
6. Has the project responded appropriately to recommendations from the last DOE review, in particular, in relation to the Far Site CF?
7. Is the project ready to seek approval of CD-3a to initiate Far Site construction?

CD-3a IPR Recommendations – 1 (yellow = for ESAAB)

RECOMMENDATION # *(Rxx)*	Project Acronym	RECOMMENDATION DESCRIPTION	OWNER	RESPONSE	SCHEDULED CLOSE	ACTUAL CLOSE
1	FD	FNAL management should encourage better communication among the LAr TPC groups, perhaps with understandings that the information is privileged.	James	Head of Neutrino Division has agreed to try to facilitate this communication.	1-Jul-16	
2	FD	DOE and the labs should consider plans to increase the supply of critically needed engineers.	James	Fermilab is developing a critical laboratory skills analysis to address this very issue	1-Apr-16	
3	FD	DUNE, FNAL, and DOE should consider plans to ensure adequate U.S. involvement in ProtoDUNE to ensure technical readiness at CD-2.	James	DUNE is working with HEP on this issue. In addition, the January collaboration meeting provides an opportunity to work to involve nonDOE partners in ProtoDUNE.	1-Oct-16	
4	CRYO	Consider adding back up power to the booster compressors to allow some reduced capacity refrigeration operation in the event of a sustained power outage prior to CD-3a.	Montanari	Analysis is underway to determine the need for backup power and the level of power requirement	1-Feb-16	
5	CRYO	Given the complexity of operation and the difficulty in recruiting cryogenic resources, develop a cryogenic and cryostat systems operations staffing plan that intentionally hires a few key positions in advance of critical cryogenic system design milestones in the project prior to CD-2.	Montanari	This will be evaluated and resolved 6 months prior to CD-2.	1-May-19	
6	ESH	Complete revision of Homestake Mining Permit 332 and agreement between SURF & Homestake to manage the rock disposition into the open cut.	Headley	Discussions have occurred with Barrick and are ongoing with landowners adjacent to the Open Cut from whom easements are required. It is believed that negotiations can be concluded when the conceptual design is available to discuss with them.	1-Apr-16	
7	ESH	Review and revise open-cut disposition plan to ensure consistency with the Environmental Assessment (the Record of Decision).	Andrews	The layout for possible conveyor routes has been overlaid with the historic area, and processes for potential EA amendment, if necessary, are being understood	1-Feb-16	
8	ESH	Clarify in the ODH design analysis whether all aspects of the Project spaces will be ODH Hazard Classification Level 1 and whether further mitigation (controls) will be employed for work activities on cryogenic systems and confined spaces.	Montanari	Agreed, will clarify and document.	1-Jun-16	
9	ESH	Provide a signature concurrence line on all documents that can affect SURF facility design, existing infrastructure interfaces or expectations of delivery by SURF team.	Andrews	Agreed, in process.	1-Jun-16	
10	ESH	Perform a gap analysis of the DOE Explosives Manual, and South Dakota State (BATF) and SURF requirements. (Prior to CM/GC award)	Andrews	Agreed.	1-Jun-16	
11	ESH	Provide guidance to CM/GC bidders on Incident/Injury reporting requirements, DOE's ability to stop work, invoke penalties and sequential re-start path. (Companies with no Federal experience will need enlightenment)	Wray	We are evaluating the best manner to communicate this issue.	1-Feb-16	

CD-3a IPR Recommendations – 2 (yellow = for ESAAB)

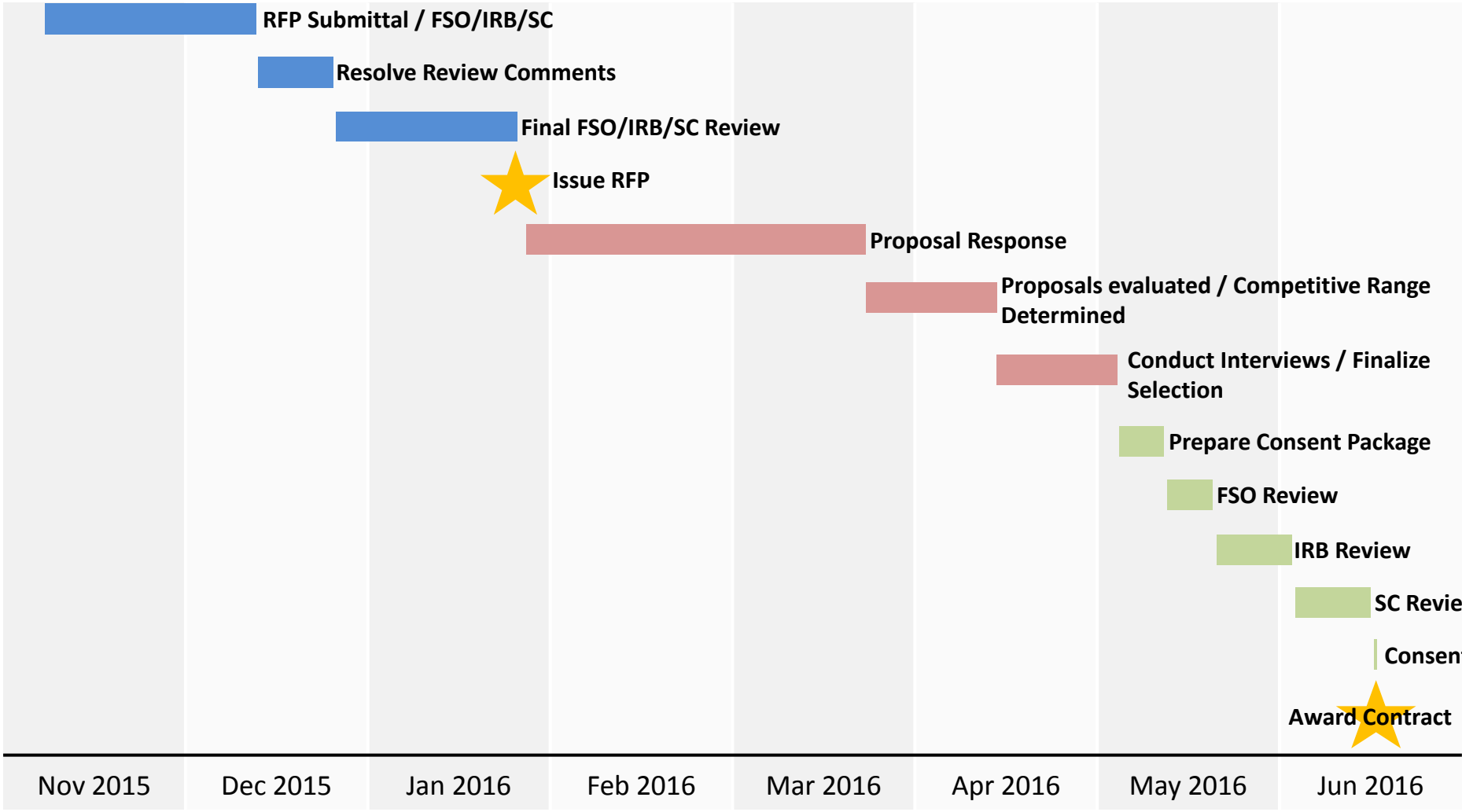
12	PM	Consider the use of schedule margin during the creation of the CD-3a baseline.	O'Sullivan	Agreed. Fermilab has a draft process that is being evaluated for implementation	1-Mar-16	
13	PM	Successfully complete an EVM implementation review prior to award of the first construction sub-package.	O'Sullivan	EMV implementation plan in progress.	1-Oct-16	
14	PM	Work with a goal of having a Far Site EHS/Q coordinator in place at least 6 months prior to start of pre-excavation.	Andrews	Will post new position in early 2016	1-Jul-16	
15	PM	Re-evaluate the number of Far Site-resident project EHS staff that will be needed.	Andrews	meeting on staffing plan scheduled for 4 Jan 2016	1-Jul-16	
16	PM	Revisit and update the scope contingency plan prior to CD-3A.	McCluskey	Contingency Analysis and Plan document is updated. Complete	10-Dec-15	10-Dec-15
17	PM	Request DOE approval of increased purchasing and subcontracting authority.	Wray	Agreed, will evaluate and pursue.	1-Apr-16	
18	PM	Perform full review of CM/GC RFP, ensuring inclusion of clearly defined evaluation criteria, prior to its release.	Wray	In progress in conjunction with evaluating & responding to 74 IRB comments.	1-Jan-16	
19	PM	Prepare for a follow-on review to be held after the 30% final design is complete and prior to issuing the construction contract for pre-excavation.	McCluskey	Agreed, will prepare for follow up review	1-Oct-16	

LBNF Far Site Conventional Facilities Scope *by Approval Phase*

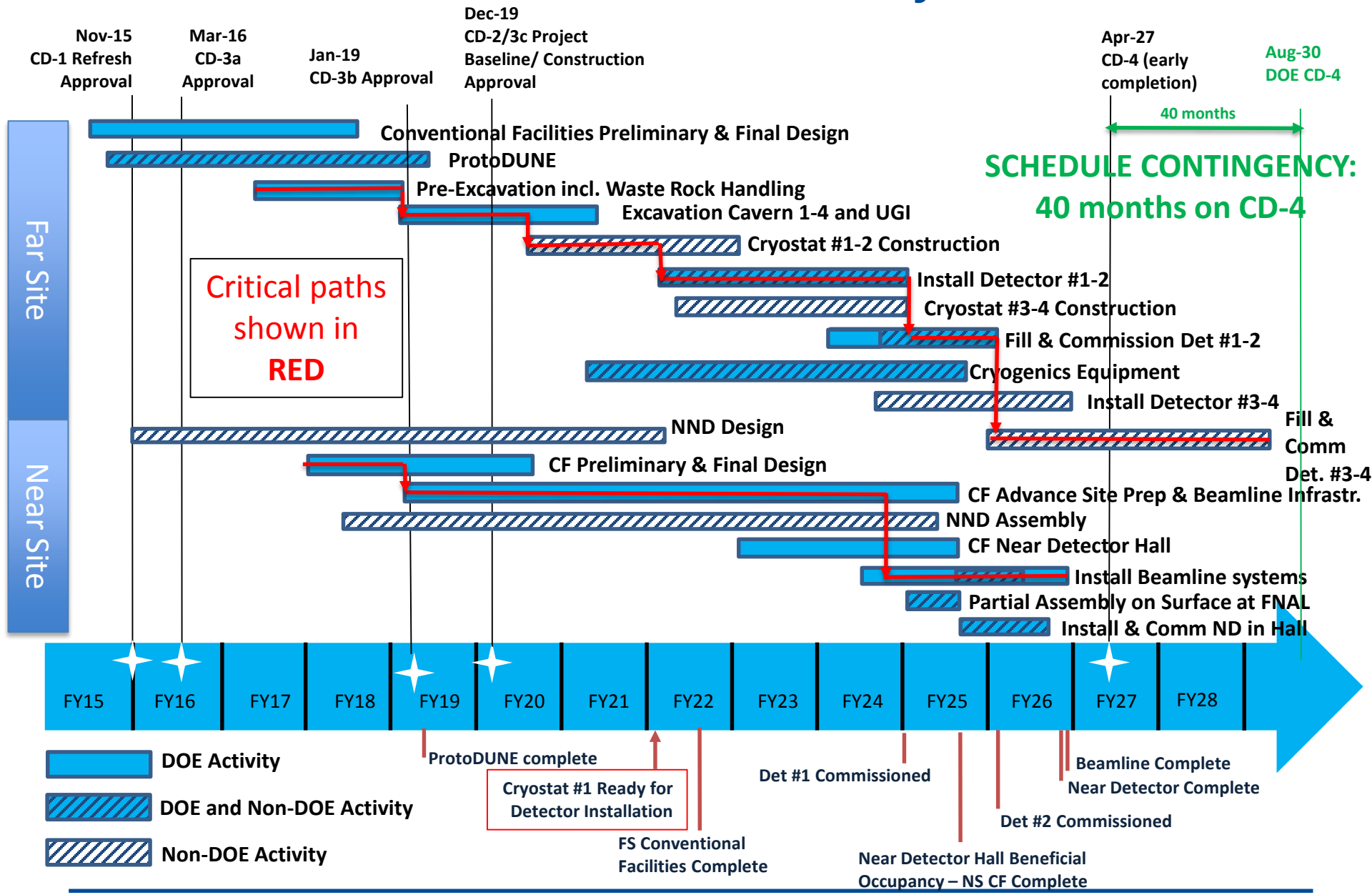
- **CD-3a Scope Justification**:
  - the initial construction work required, prior to baselining the LBNF/DUNE Project, to support installation of cryostats and cryogenic systems **to support installation** of two DUNE **detectors** starting in **2021**.
  - Includes half of gas utilities (in addition to all conventional utilities) in the shaft in order to provide **flexibility** in schedule planning as the project progresses

Approval Phase	Scope
Site Preparation (FY16-18)	**SURF reliability projects**
	Ross Shaft rehab
	Oro Hondo Fan replacement
	4850L and adit ground support
	Ross Crusher roof repair
	Water inflow mitigations
	SURF Admin parking lot repair
CD-3a Scope (FY17-20)	**FSCF Construction Management (CM)**
	SDSTA staff construction support
	A/E construction phase services
	CM construction phase services
	Pre-Excavation Work (Pre-EXC)
	Pre-EXC General Conditions
	Phase A: ventilation/blast containment, utilities relocation, Ross brow expansion, U/G rock disposal sys, early excavation
	Phase B: excavated rock handling sys, Ross shaft elect/data sys, U/G utilities relocation, concrete batch plant, slick line
	Cavern & Drift Excavation (EXC)
	EXC General Conditions
	Phase 1: drifts, chamber 1, and central utility cavern
	Phase 2: chamber 2
	Building & Site Infrastructure (BSI)
	BSI General Conditions
	Phase 1: chamber 1 and central utility cavern utilities & infrastructure; surface building and utilities
	Phase 2: chamber 2 utilities & infrastructure
	Shaft gas utilities - 50% of scope
CD-3c Scope (FY20-22)	**FSCF Construction Management (CM)**
	Cavern & Drift Excavation (EXC)
	Phase 3: chamber 3 and 4
	Building & Site Infrastructure (BSI)
	Shaft gas utilities - 50% of scope

LBNF CM/GC RFP and Award Schedule Summary Overview



LBNF/DUNE - Schedule Summary Overview



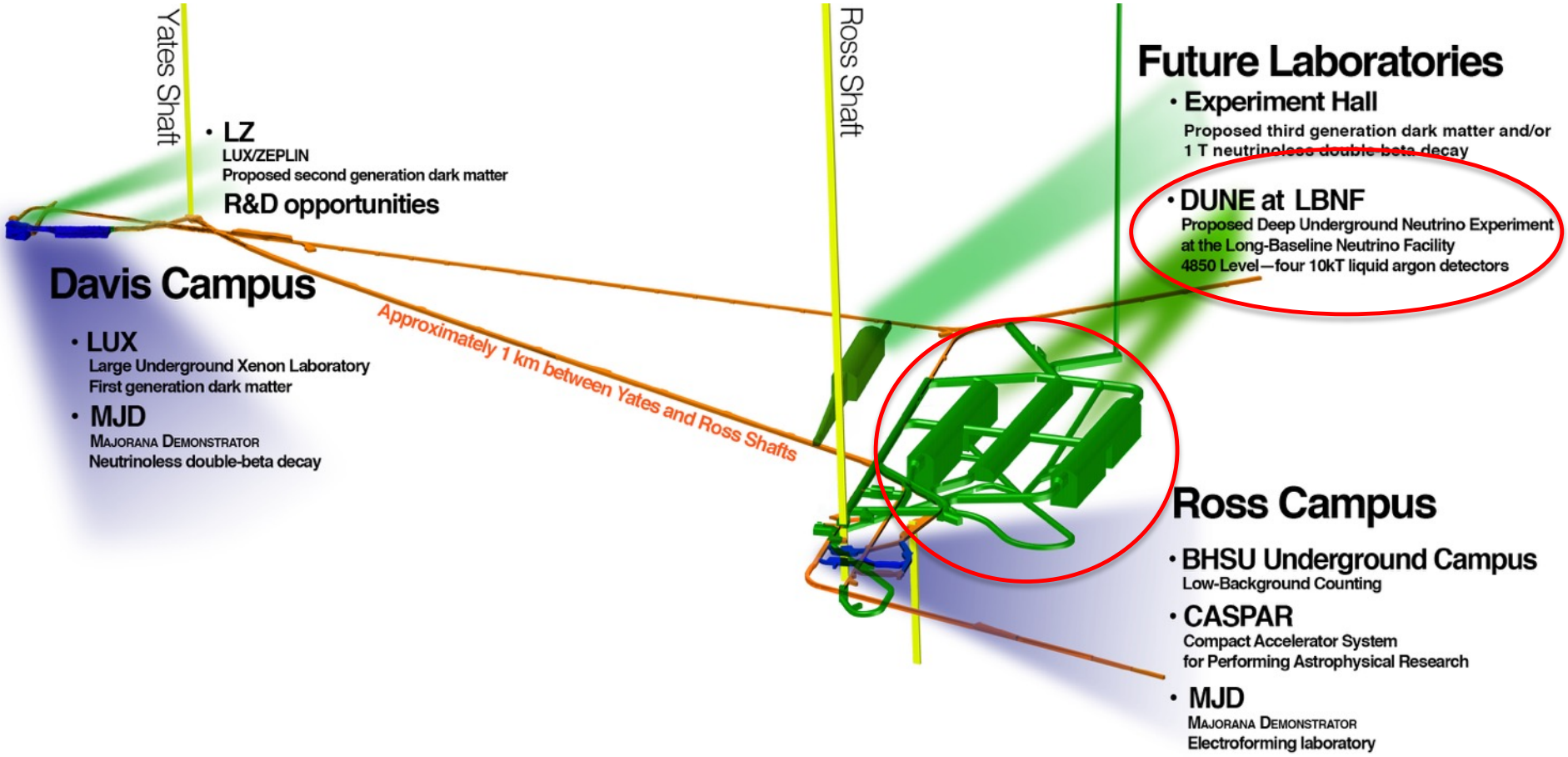
Interface Matrix – Far Site

LBNF-DUNE Far Site Interface Control Documents Matrix													
Far Site Entity	**CF, Far Site - Surface**	**CF, Far Site - Shafts and Drifts**	**CF, Far Site - Caverns**	**Far Detector Design**	**Far Detector Construction**	**Cryostat Design**	**Cryostat Construction**	**Cryogenics Ar System - Design**	**Cryogenics Ar System - Construction**	**Cryogenics N2 System - Design**	**Cryogenics N2 System - Construction**	**Cryogenic Fluids**	**SURF**
CF, Far Site - Surface													
CF, Far Site - Shafts & Drifts													
CF, Far Site - Caverns													
Far Detector Design	199	197	201										
Far Detector Construction	198	196	200										
Cryostat Design	433	483	492	102									
Cryostat Construction	230	491	499		103								
Cryogenics Ar System-Design	231	501	508	77		106							
Cryogenics Ar System-Construction	71	502	510		100		107						
Cryogenics N2 System-Design	69	504	512	75		105		74					
Cryogenics N2 System-Construction	70	506	513		101		108		73				
Cryogenic Fluids	216			104	217								
SURF				195	109	514	515	202	209	204	206	215	

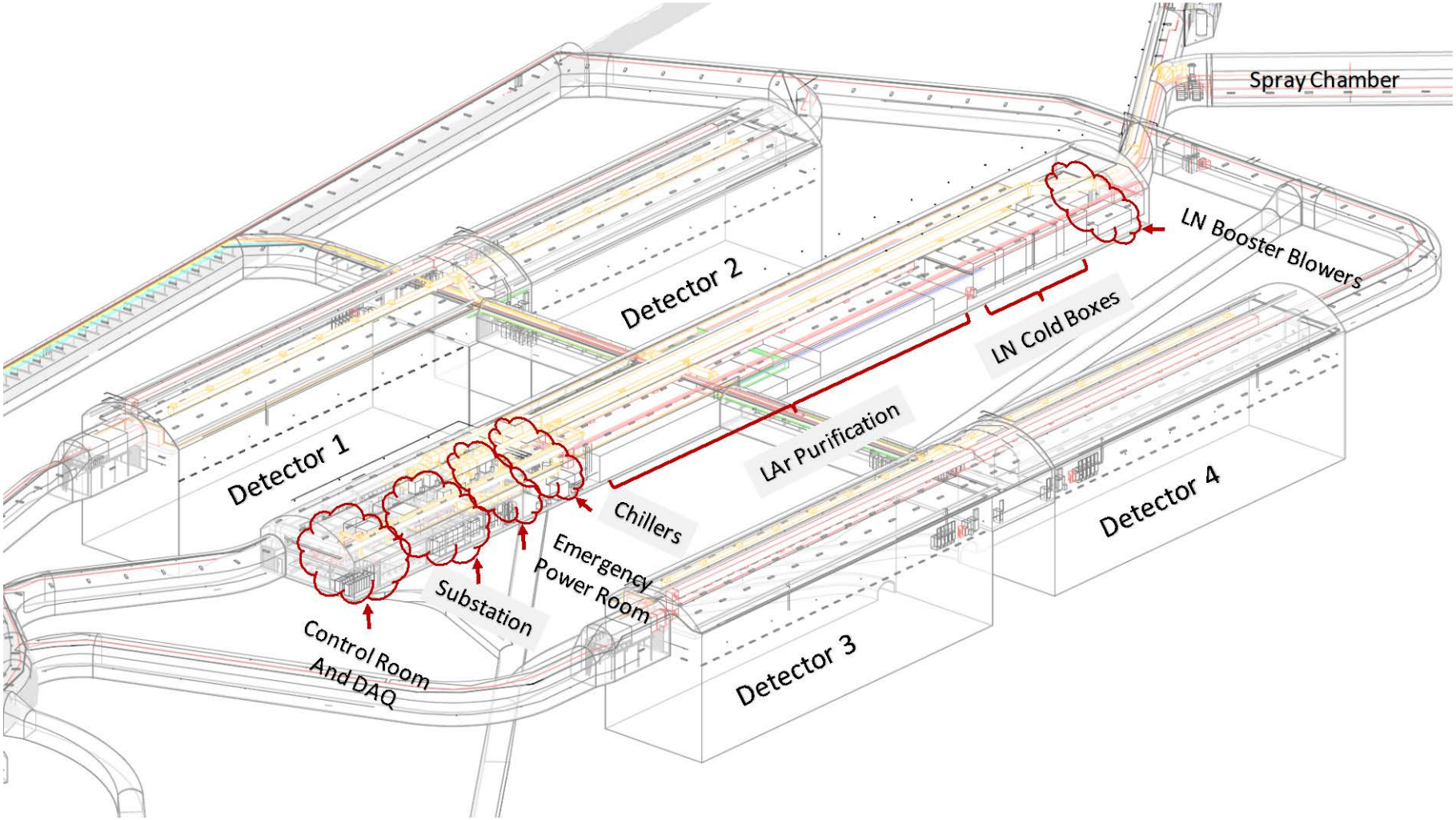
Interfaces are in place and under configuration management

Design Scope – 4850L Facilities

Four 10kt detector chambers, central utility cavern, and connecting drifts



Design Scope – 4850L Facility
Excavated material ~800,000 tons



Construction Logistics Planning

- Parallel nature of construction and installation plans at Far Site over the next 15 years requires close coordination and planning

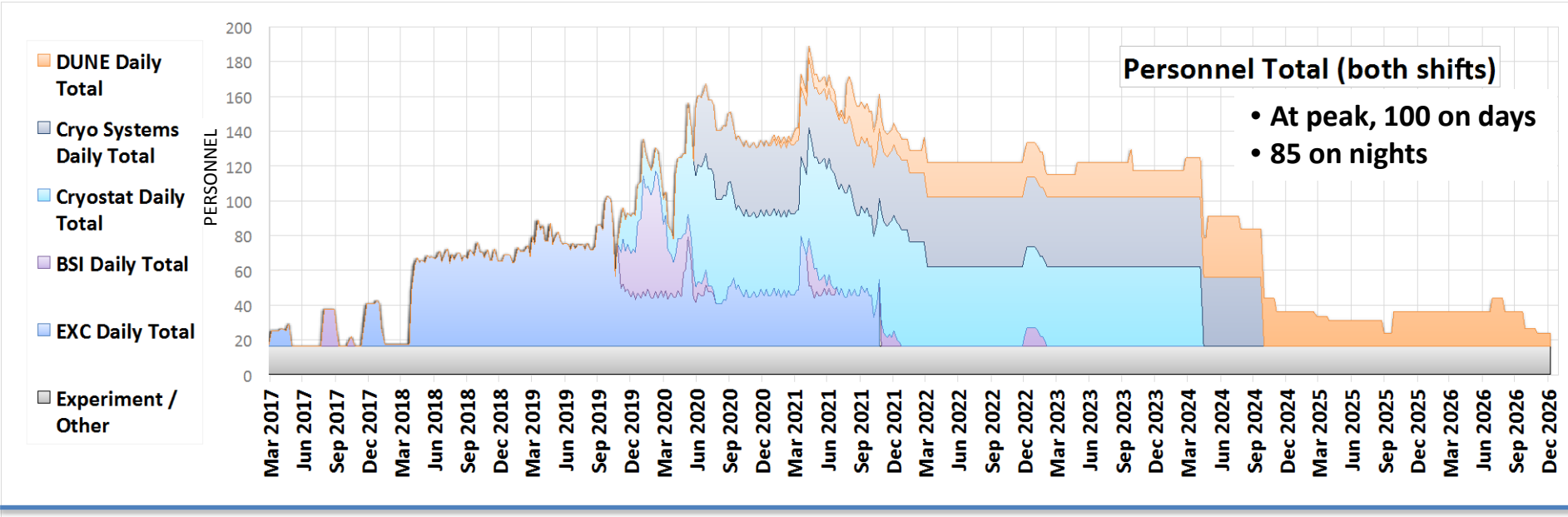
- Logistics workshop held Aug 11-13 at Sanford Lab. Included Sanford Lab Operations, LBNF/DUNE, MAJORANA, LUX/LZ, CASPAR, BHSU UG Campus, and Arup A/E team.
  - Developed an understanding of Sanford Lab infrastructure & resources
  - Reviewed plans across all planned activities through 2030
  - Documented requirements for site infrastructure, resources, interfaces
  - Developed recommendations to mitigate conflicts & documented risks.

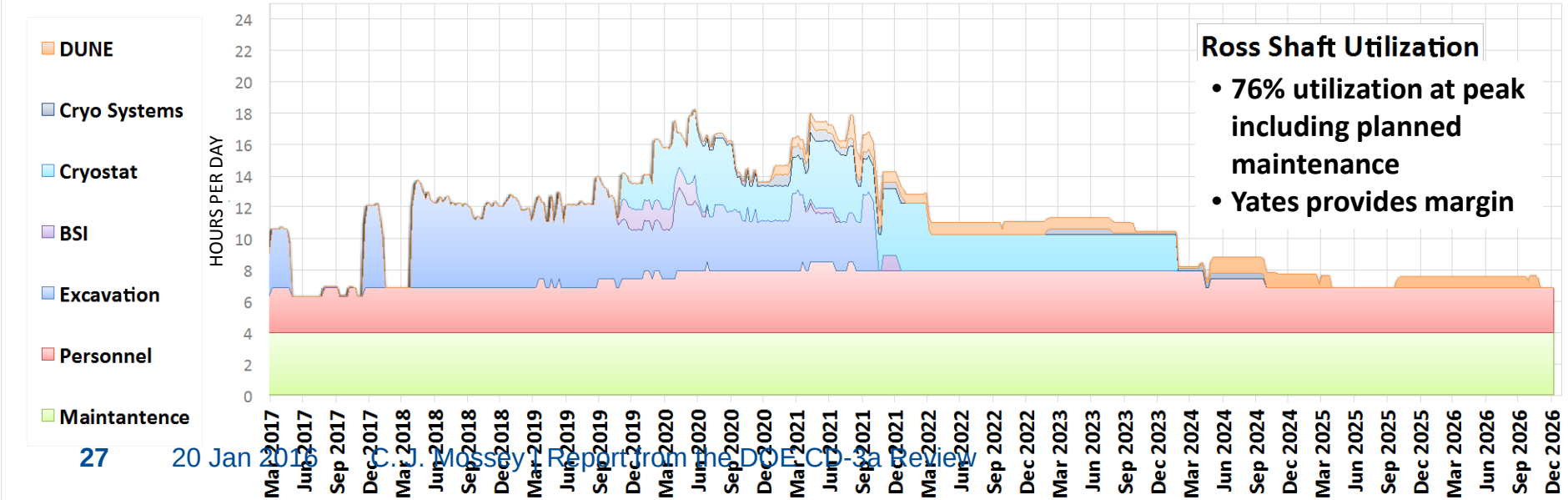
- Comprehensive Logistics Plan completed that confirms the Ross Shaft will support LBNF/DUNE activities. Yates Shaft provides additional capacity when gas piping is installed in the Ross Shaft.

- CM/GC will lead logistics planning starting in final design

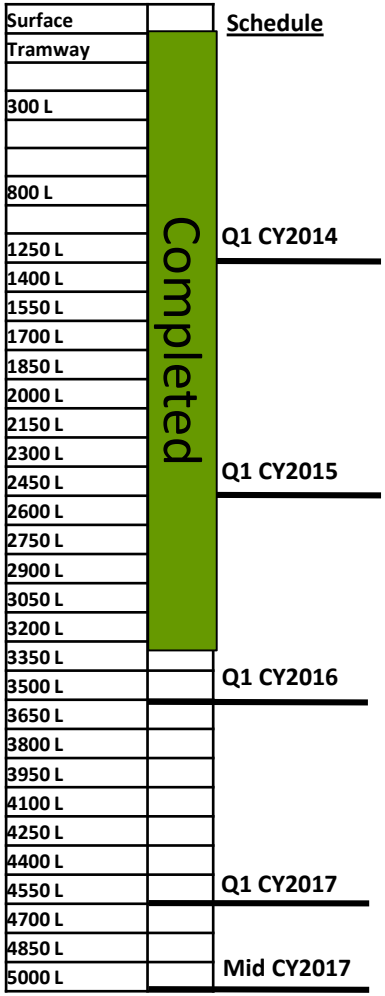
Planning Outputs: Personnel Underground & Ross Shaft Utilization

Key Sanford Lab infrastructure will handle all planned activities



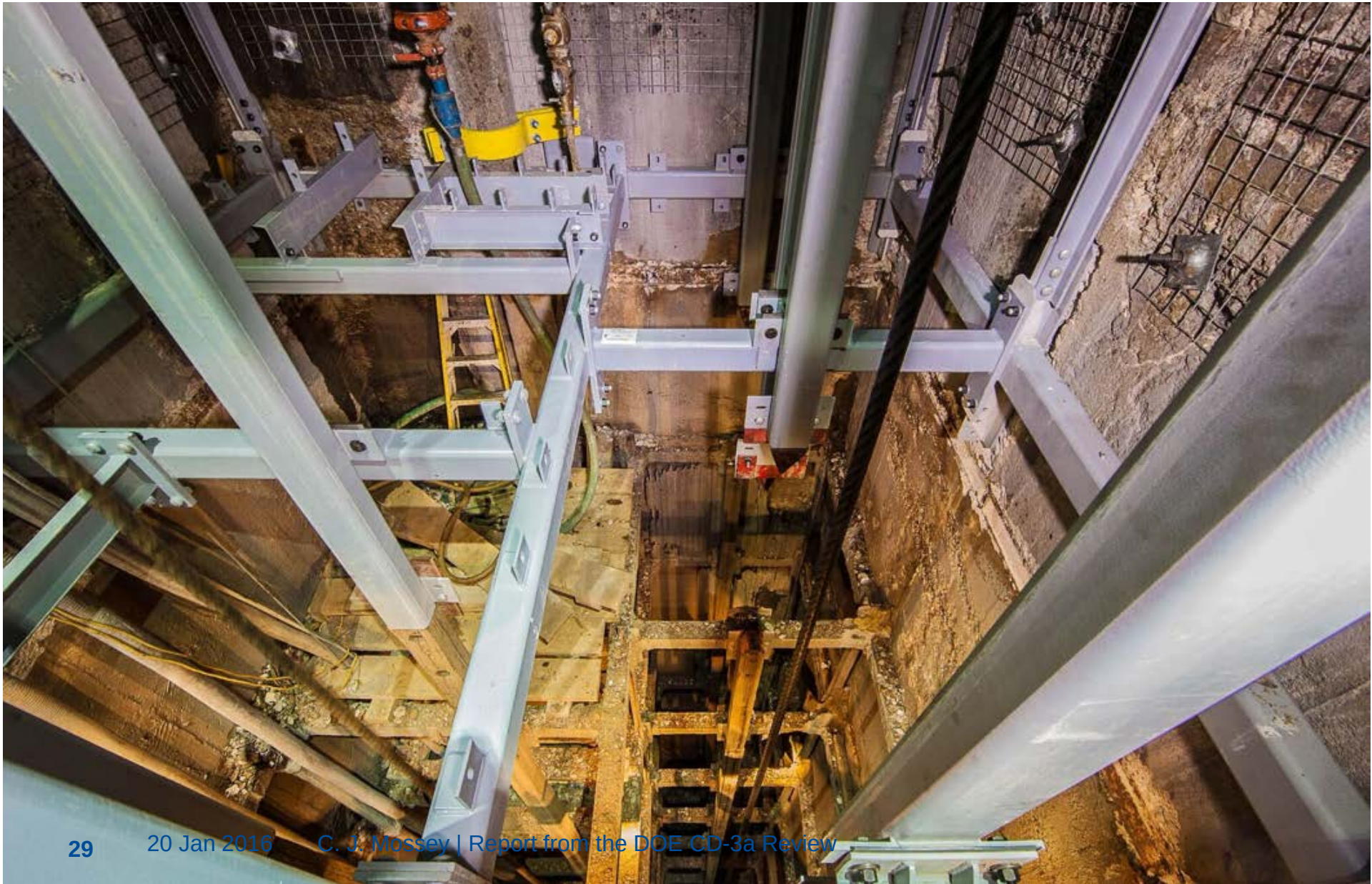


Ross Shaft Refurbishment Update
3,383 feet down from surface (66% completed)



- 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.
- SDSTA self-performing refurbishment work
- New contract established in January 2016 between LBNL and SDSTA. Provides DOE funds to complete remainder of the refurbishment to the 5000 foot level.
- Project on track to be completed in 2017. Pause in refurbishment activities at the 4850L expected during the pre-excavation construction phase

Ross Refurbishment - Recent New Steel Installation

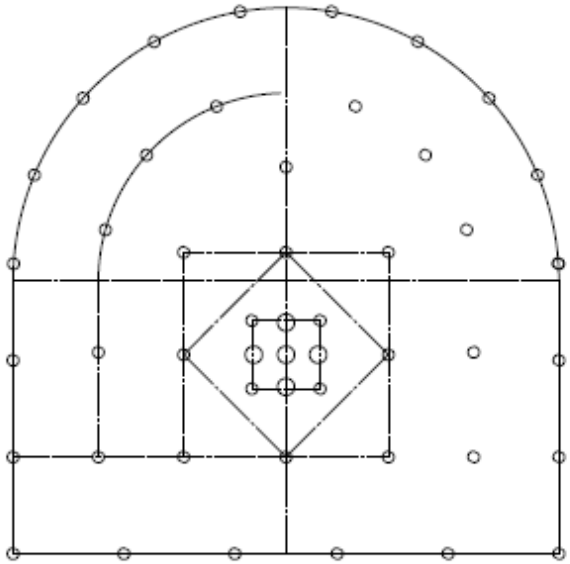


Construction Logistics Planning: Test Blast Program

- Excavation design includes a model for vibration & blast air overpressure
  - Based on industry experience and geotechnical site investigation
  - Potential risks to other 4850L experiments discussed during Logistics Workshop

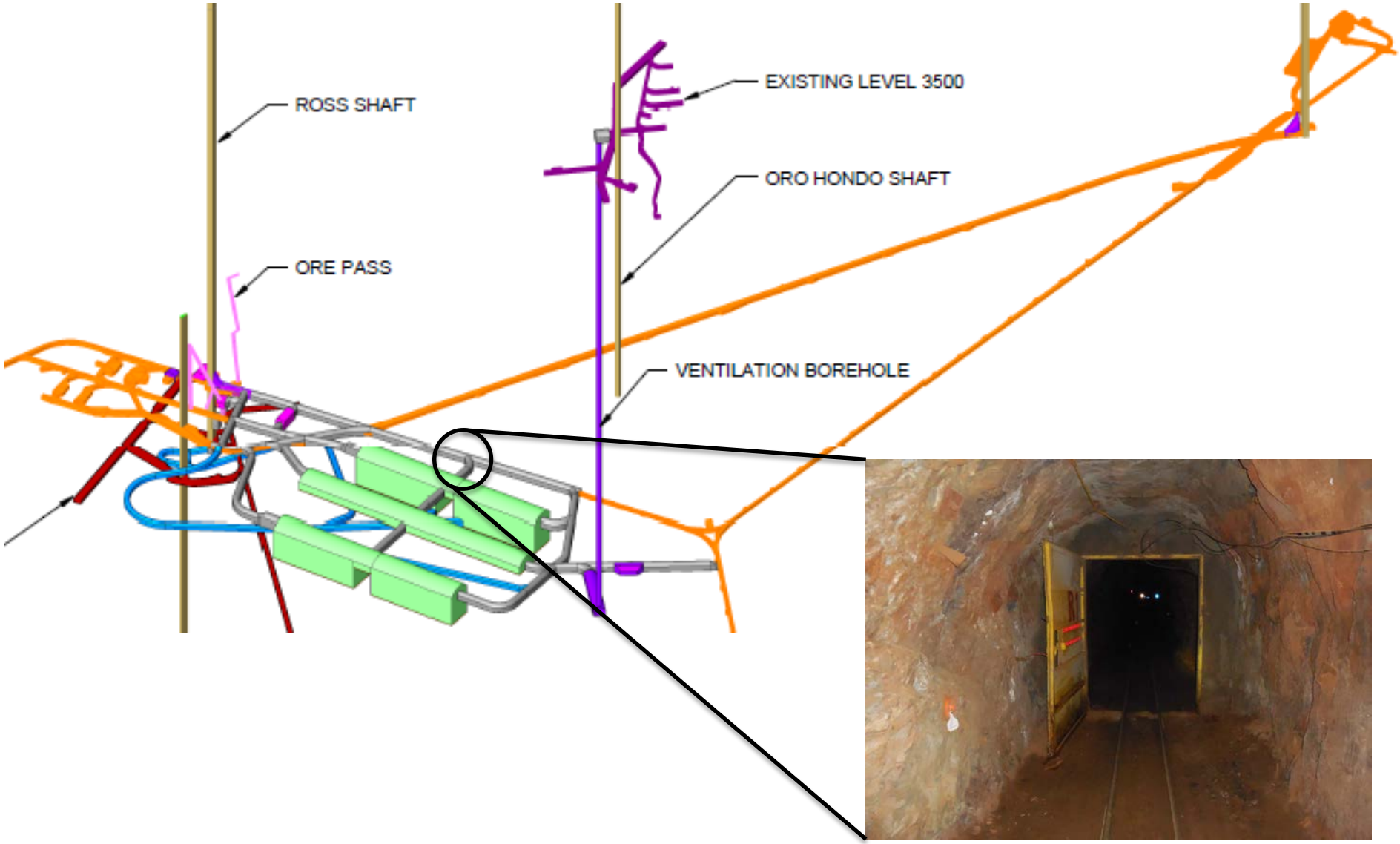
- 3 test blasts planned (8'x8'x8') at intersection of Central Access Drift and the South Drift
  - Test will confirm model, inform final design
  - 18 instruments were deployed on 4850L
  - Experiment data collected by LBCs, LUX, MJD
  - Seismic data will be collected by DUGL, Transparent Earth, GEOXTM

- First test blast attempted on December 11
  - Electronic detonators did not perform as expected
  - Gained valuable vibration and air pressure data
  - Adjusting blast design and detonator selection
  - Additional blasts planned for February



drill hole / charge layout

Test Blast Location



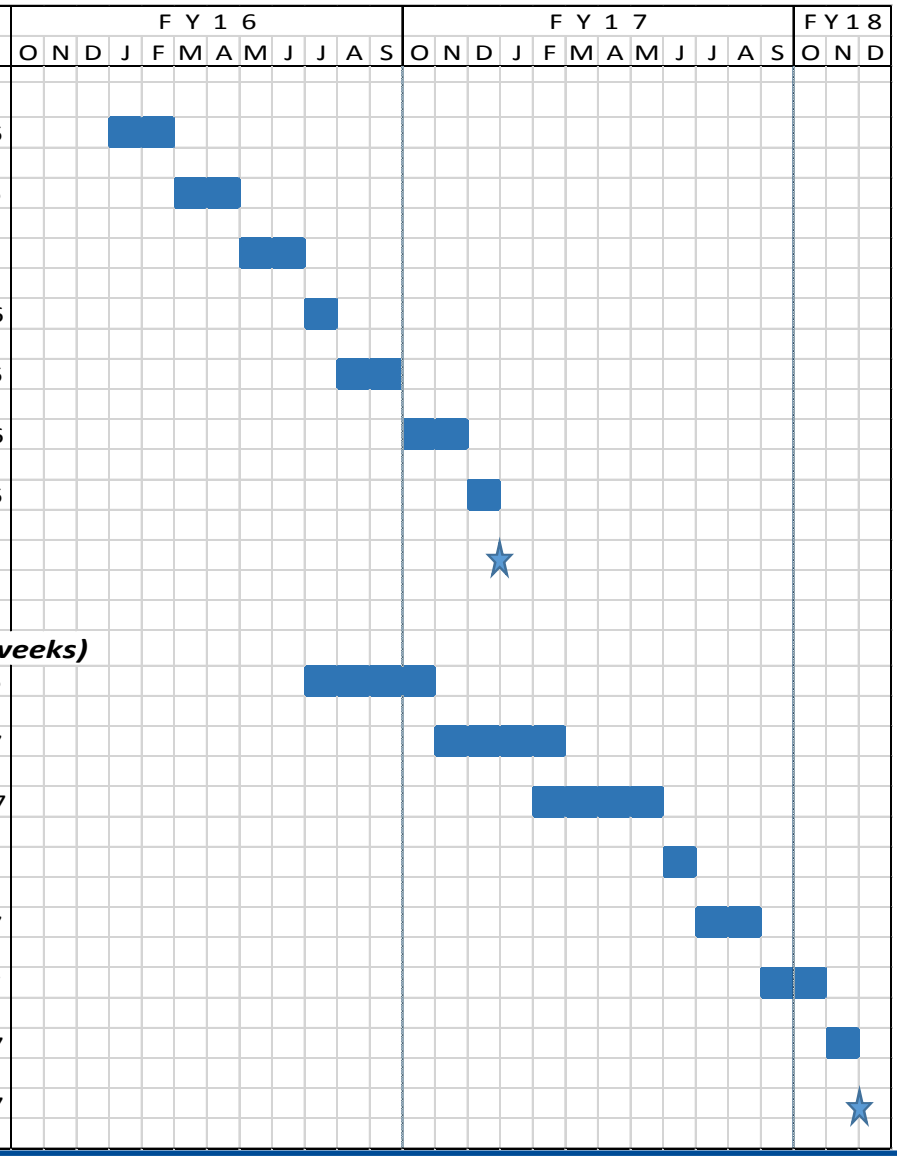
Final Design Plan

- 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

Final Design Plan and Schedule

Activity Name	Dur	Start	Finish
Pre-Excavation Design			
Pre-EXC - 30% Final Design	39	04-Jan-16	26-Feb-16
Pre-EXC - 60% Final Design	39	29-Feb-16	21-Apr-16
Pre-EXC - 90% Final Design	39	22-Apr-16	16-Jun-16
Pre-EXC - 100% Final Design	30	17-Jun-16	01-Aug-16
CM/GC Bid / Evaluate / Recommend Co	42	02-Aug-16	29-Sep-16
DOE Construction Contract Approval	40	30-Sep-16	28-Nov-16
CM/GC Finalize Construction Contract	21	29-Nov-16	29-Dec-16
Award Pre-Excavation (Pre-EXC) Contra	0		03-Jan-17
Excavation Design (EXC design shown, BSI lags EXC by 3 weeks)			
EXC - 30% Final Design	75	06-Jul-16	19-Oct-16
EXC - 60% Final Design	75	20-Oct-16	10-Feb-17
EXC - 90% Final Design	75	13-Feb-17	26-May-17
EXC - 100% Final Design	26	30-May-17	05-Jul-17
CM/GC Bid / Evaluate / Recommend Co	42	06-Jul-17	01-Sep-17
DOE Construction Contract Approval	40	05-Sep-17	30-Oct-17
CM/GC Finalize Construction Contract	21	31-Oct-17	30-Nov-17
Award Excavation (EXC) Contract	0		30-Nov-17



Chris Mossey – Background

- Career Naval Officer with 32 years of experience leading project teams:
  - Last assignment was as Commander of Naval Facilities Engineering Command and Chief of Civil Engineers
    - Responsible for 19,000 person world-wide engineering/acquisition organization with $12B annual business volume
  - Earlier assignments as senior flag officer for engineering and construction support to Atlantic Fleet and Pacific Fleet areas of operations
  - Project and program responsibilities included:
    - $1B Walter Reed/Bethesda hospital expansion
    - $5.7B Marine Corps “Grow the Force” initiative
- Registered Professional Engineer
- Masters degree in Construction Management