# Conventional Facilities (WBS 121.5)

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PIP-II Independent Project Review

12-14 December 2017

In partnership with:

India/DAE
Italy/INFN
UK/STFC
France/CEA/Irfu, CNRS/IN2P3

# Outline

- Requirements
- Conceptual Design, Maturity
- Scope/Deliverables
- Organization
- Interfaces
- Technical Progress to Date
- Design Review Plan
- Plan for CD-2/Preliminary Design
- ESH&Q
- Risk
- Cost
- Schedule
- Breakout Session topics
- Summary

# About Me:

- PIP-II Associate Project Manager for Conventional Facilities
- Relevant Experience
  - Licensed Architect;
  - Project Management Professional (PMP);
  - LEED Accredited Professional;
  - 25+ years at Fermilab;
  - NOvA Project L2 Manager for Site and Buildings;
  - General Plant Project Manager for 15+ years
    - Short Baseline Neutrino (SBN) Near Detector Building;
    - Short Baseline Neutrino (SBN) Far Detector Building;
    - CDF Refurbishment;
    - Experimental Operations Center;

# Conventional Facilities Requirements

Charge #2

## Key Performance Parameters (KPP):

| # | Description of Scope | Threshold KPP | Objective KPP |
|---|---|---|---|
| 1 | SRF linac | 700 MeV beam delivered to the Booster Injection Region | 800 MeV beam delivered to Booster Injection Region |
| 2 | Booster/RR/MI upgrades | L11 Booster injection region, Recycler RF upgrades, and MI RF upgrades, hardware installed in respective machines. Linac beam injected and circulated in the Booster. | 8 GeV beam transmitted through Recycler and Main Injector, delivered to the MI dump. |
| 3 | Cryogenic Infrastructure | Cryogenic plant and distribution lines ready to support pulsed RF operation, and operated to 2 K. | Cryogenic plant and distribution lines ready to support CW RF operation, and operated to 2 K. |
| 4 | Civil Construction | Tunnel enclosures and service buildings ready to support 700 MeV SRF linac and transfer line to the Booster | Tunnel enclosures to support 1 GeV SRF linac and transfer line to the Booster. Service buildings to support 800 MeV SRF linac and transfer line to Booster. |

**Threshold and Objective KPP** met with Base Design;

KPP from PIP-II Preliminary Project Execution Plan (PIP-II-doc-115)

# Conventional Facilities Requirements

Charge #2

- Functional Requirements Specification: [1]

## Section 5

"Associated conventional facilities including enclosures, equipment galleries, and utilities. The linac enclosure will be constructed with a length to accommodate two HB650 cryomodules beyond the nominal compliment required for 800 MeV."

## Section 6

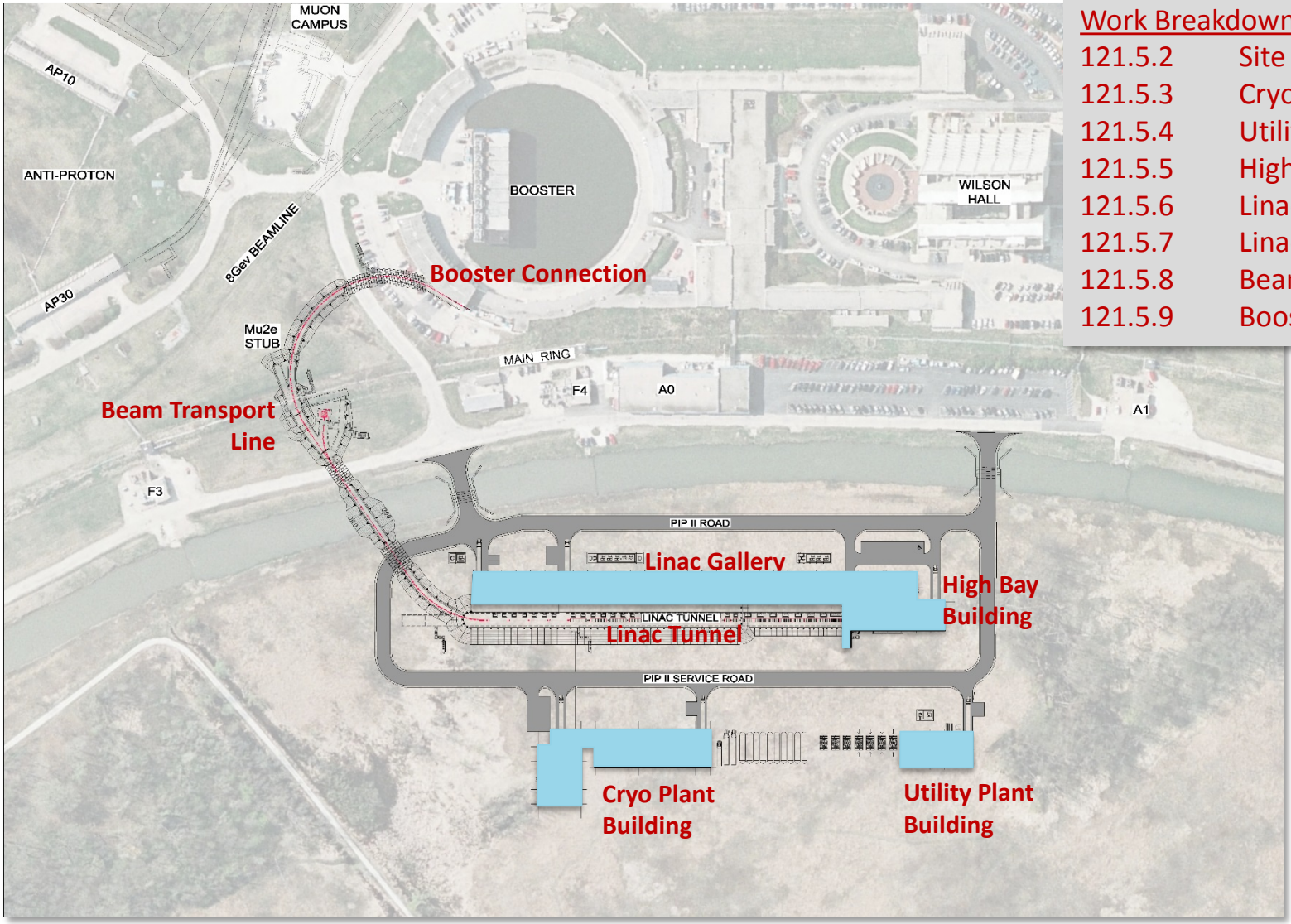
| Requirement | Description | Value |
|---|---|---|
| I1 | The siting of the PIP-II facility will be consistent with future replacement of the existing 8-GeV Booster with either an 8 GeV Rapid Cycling Synchrotron or superconducting pulsed linac | |
| I2 | The siting of the PIP-II facility will be consistent with future upgrades to provide 100 kW beams to the Mu2e hall on the Muon Campus | |
| I3 | The SC Linac will be constructed of components capable of operating in CW mode, following modest upgrades | |
| I4 | The SC Linac will be constructed in a manner that allows installation and commissioning without interruption to ongoing accelerator operations | |
| I5 | Residual Activation from Uncontrolled Beam Loss in areas requiring hands-on maintenance. | <20 mrem/hour (average)<br><100 mrem/hour (peak) @ 1 ft |
| I6 | Scheduled Maintenance Weeks/Year | 8 |
| I7 | SC Linac Operational Reliability | 90% |
| I8 | 60-120 GeV Operational Reliability | 85% |
| I9 | Facility Lifetime | ≥40 years |

Conventional Facilities Related requirements

[1] – PIP-II Functional Requirements Specification can be found in PIP-II-doc-1166 ( TeamCenter ED0001222)

# Conventional Facilities Overview

Charge #2




Work Breakdown Structure

| | |
|---|---|
| 121.5.2 | Site Preparation |
| 121.5.3 | Cryo Plant Building |
| 121.5.4 | Utility Plant Building |
| 121.5.5 | High Bay Building |
| 121.5.6 | Linac Tunnel |
| 121.5.7 | Linac Gallery |
| 121.5.8 | Beam Transfer Line |
| 121.5.9 | Booster Connection |

# Conventional Facilities Overview


*Looking Southeast From Wilson Hall – Fall 2016*


*Looking South Along Beamline*

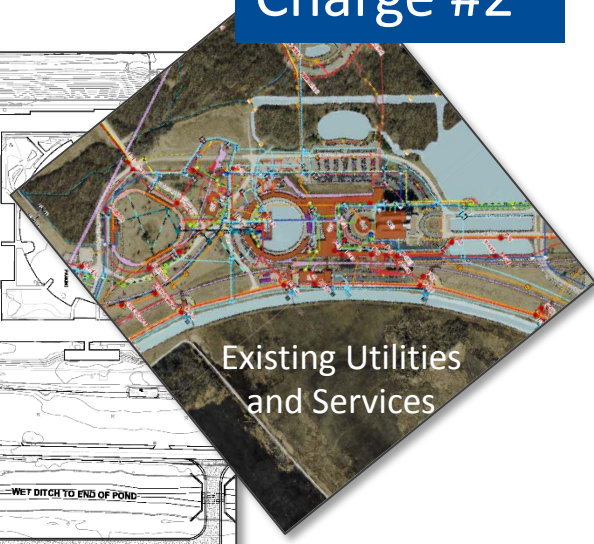
*View from Wilson Hall*

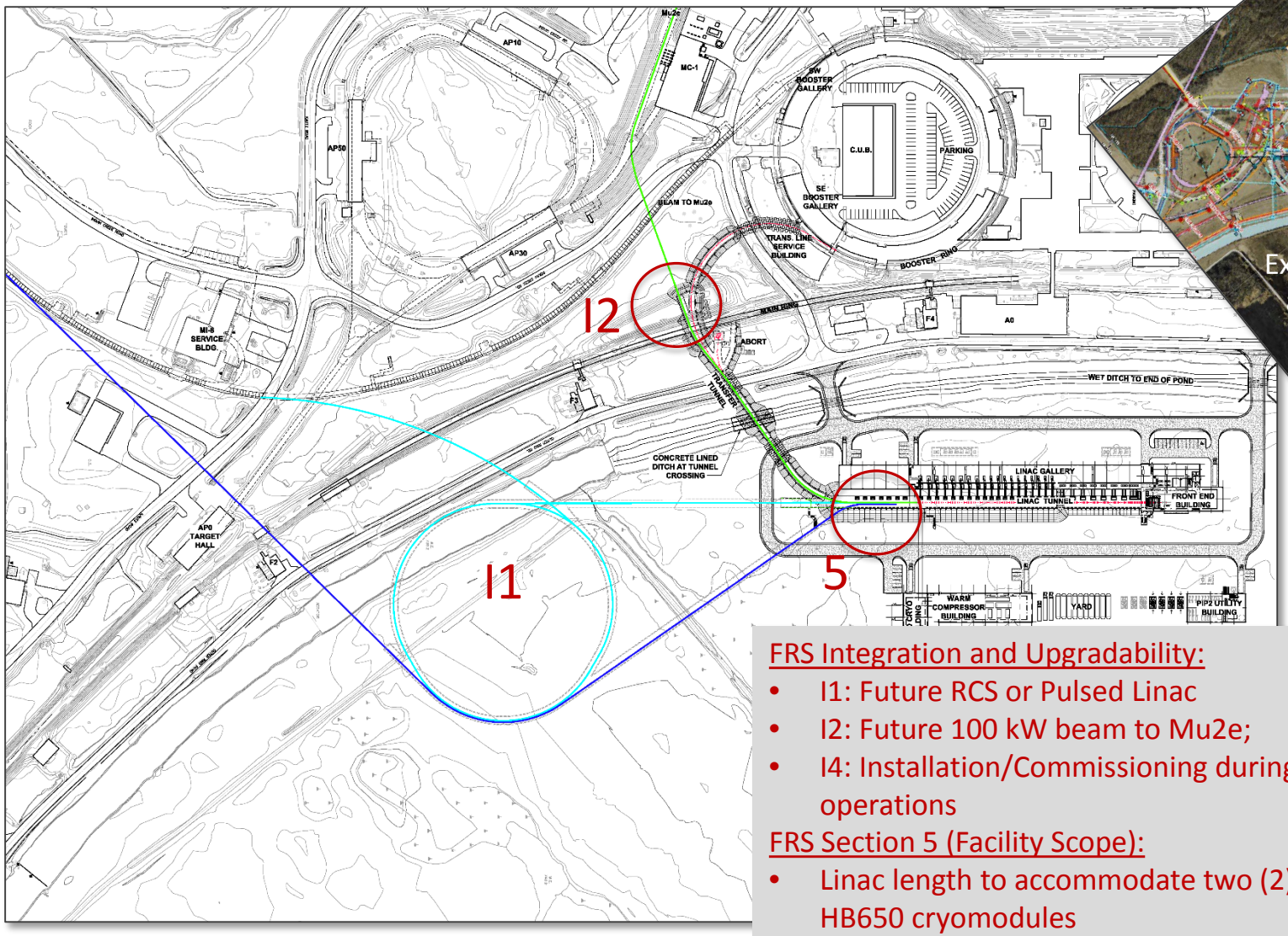


PIP-II

# Siting Considerations

Charge #2




FRS Integration and Upgradability:

- I1: Future RCS or Pulsed Linac
- I2: Future 100 kW beam to Mu2e;
- I4: Installation/Commissioning during ongoing operations

FRS Section 5 (Facility Scope):

- Linac length to accommodate two (2) additional HB650 cryomodules

# Conceptual Design and Design Maturity

Charge #2

Breakout Talk

- Meetings with Stakeholders:
  - Goal: Document the spatial and infrastructure requirements for PIP-II facilities; [2]
  - Started in January 2016;
- Results:
  - Conceptual Design drawings and text that described the sizes/arrangement of spaces and buildings to accommodate the functional requirements; [3]
  - Documented Cost Estimate Assumptions; [4]
  - Life Safety Analysis; [5]
  - Developed cooling strategies for pulsed mode and continuous wave operation that could be implemented in a modular fashion;
  - **Conventional facilities are similar to typical Fermilab construction**;

[2] – Meeting Minutes can be found in PIP-II-doc-70
[3] – Conceptual Design Drawings can be found in PIP-II-doc-1155
[4] – Assumptions can be found at PIP-II-doc-333
[5] – Final LSA can be found at PIP-II-doc-120

# Scope and Deliverables [6]

Charge #2

Breakout Talk

## WBS 121.5.2 – Site Preparation Package

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the construction of the Site Preparation work scope. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA)

## WBS 121.5.3 – Cryogenic Plant Building – 23,245 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the construction of the Cryo Plant Building work scope. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

## WBS 121.5.4 – Utility Plant Building – 7,995 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the construction of the Utility Plant work scope. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

## WBS 121.5.5 – High Bay Building – 21,275 square feet.

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the construction of the High Bay Building work scope. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

[6] – Descriptions from WBS Dictionary (PIP-II-doc-599)

# Scope and Deliverables

**WBS 121.5.6 – Linac Tunnel** – 19,935 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the Linac Tunnel enclosure. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

**WBS 121.5.7 – Linac Gallery** – 32,905 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for the Linac Gallery. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

**WBS 121.5.8 – Beam Transfer Line** – 14,435 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for Beam Transfer Line enclosure. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

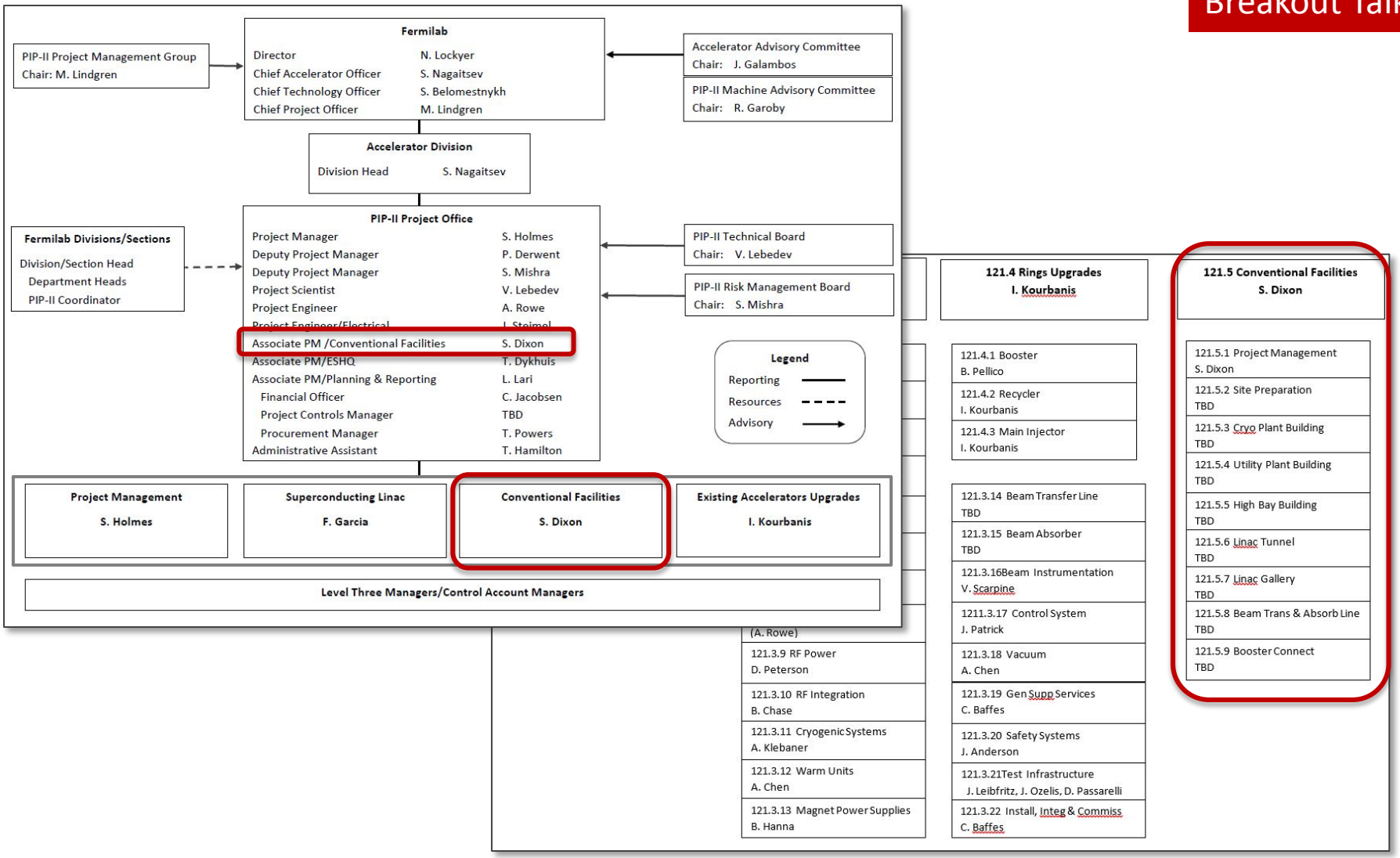
**WBS 121.5.9 – Booster Connection** – 7,750 square feet

This WBS covers procurement and management for all contracted labor, materials, tools, equipment, and services needed for Booster Connection. It describes the labor resources, materials and services necessary for management, organization, planning, oversight and engineering, design, inspection and administration (EDIA).

# Organization

Charge #4

Breakout Talk



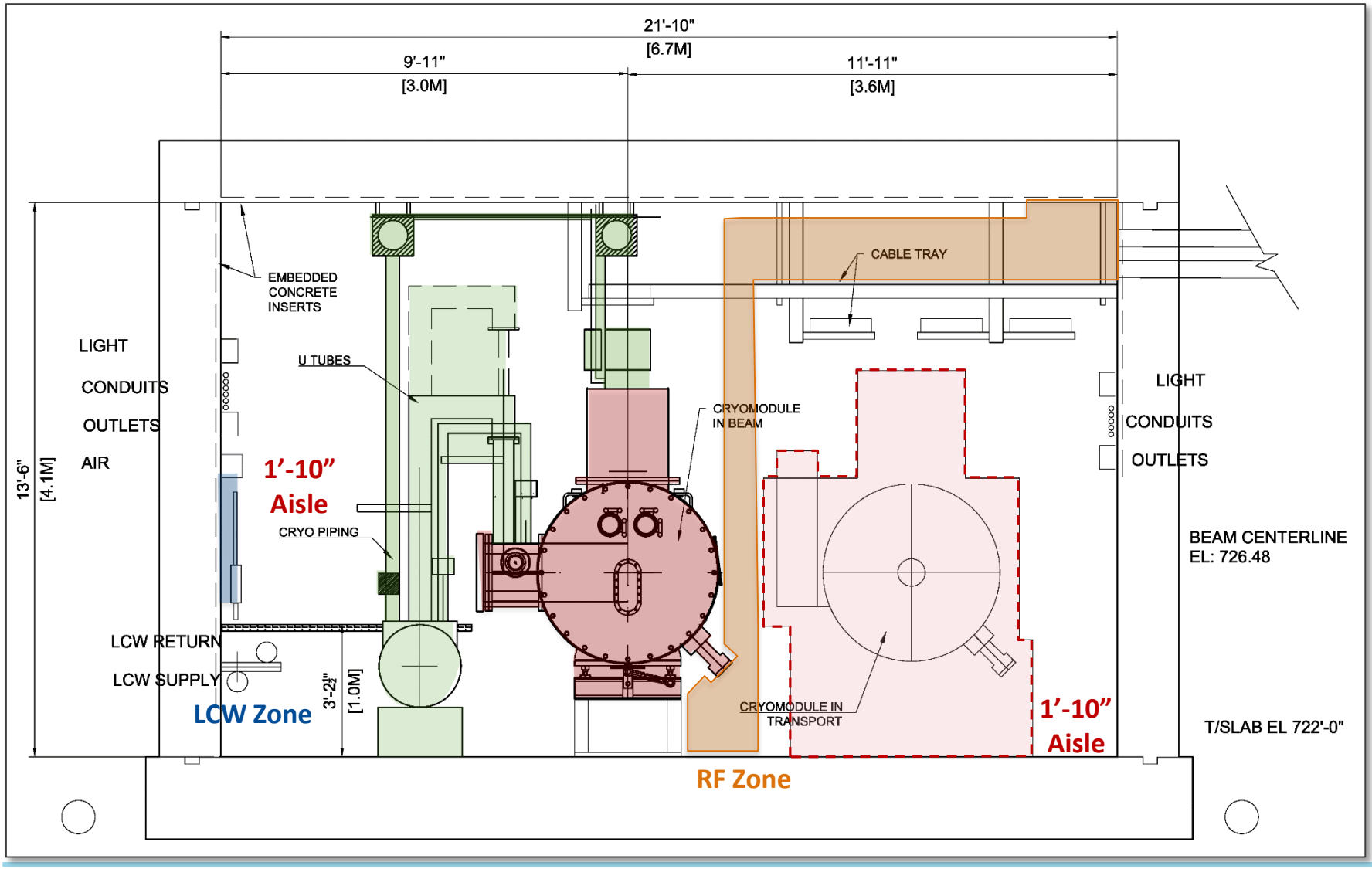
# Interfaces – Other Subprojects

Charge #2




PIP-II

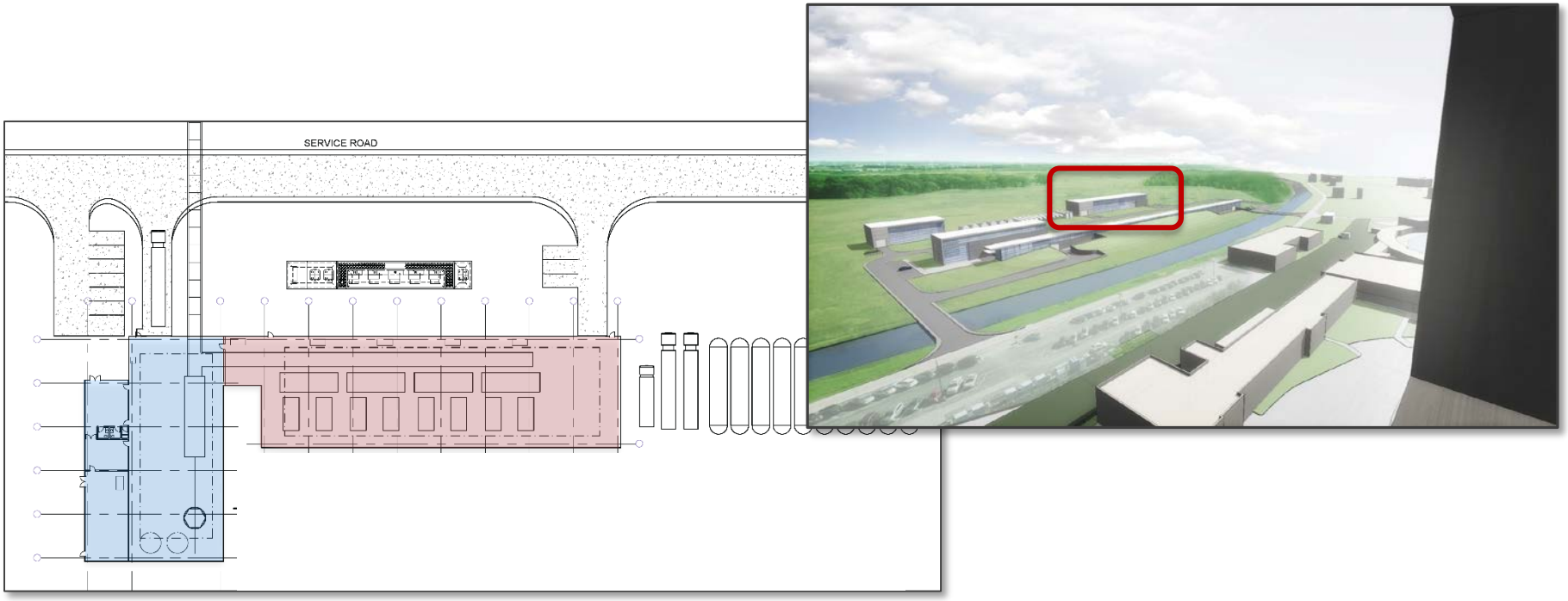
# Interfaces – Linac Tunnel Cross Section



# Interfaces – International Partners

Charge #7

- Cryoplant equipment is part of the Indian contribution;
- Involved in the development of conceptual design;
- Interface is through 121.3.11 (Cryogenics subproject);



# Progress to Date

Charge #3

- Conceptual Design: Breakout Talk
  - Conceptual Design Report Text;
  - Conceptual Design Drawings;
  - Life Safety Analysis;
  - Construction Cost /Schedule Estimate [7, 8] Breakout Talk
- Selected Architect/Engineering firm;
- Supported Analysis of Alternatives; [9]
- Supported NEPA Process;
- Prepare for CD-1
  - Resource Loaded Schedule
  - Basis of Estimates
  - Documentation Breakout Talk
  - Risk Analysis

[7] – Construction Cost Estimate can be found in PIP-II-doc-333
[8] – Construction Schedule Estimates can be found in PIP-II-doc-581
[9] – Analysis of Alternates can be found at PIP-II-doc-107

# Design Review Plan

Charge #3

- Completed Reviews/Presentations
  - Conceptual Design Drawings (September 2016);
  - CD Independent Project Status Review (November 2016);
  - PIP-II Machine Advisory Committee (P2MAC) (March 2016, April 2017);
  - FESS Presentation (March 2017);*
  - ESH&Q Presentation (May 2017);*
  - Tritium Task Force Presentation (June 2017);*
  - FESS/Roads and Ground Presentation (November 2017);*
  - Functional Requirement Specifications/Technical Requirement Specifications;
- Planned Reviews
  - Independent Cost/Schedule Estimate;
  - Constructability Reviews;
  - 60% and 90% complete reviews of each construction package;

[*] – These presentations can be found in PIP-II-doc-587

# Next Steps toward CD-2/3a

- 2018
  - Subsurface Investigation;
  - Value Engineering Exercise;
  - Finalize Interfaces with other sub projects;
  - Detailed Design for WBS 121.5.2 – Site Preparation
- Prior to CD-2/3a
  - Finalize L3 manager and CAM assignments;
  - Independent Cost/Schedule Estimate;
  - Constructability Review;

# ESH&Q - Overview

Charge #5

- Consider and plan for ESH&Q issues throughout the project life cycle;
- Conceptual Design Phase
  - Provided conventional facilities specific input to ESH&Q documents;
  - Life Safety Analysis [10] completed for conceptual design;
  - Considered ESH&Q in architect/engineer selection process;

[10] – Final LSA can be found at PIP-II-doc-120

# ESH&Q - Hazards

## Preliminary Hazard Analysis Report (PHAR) [11]

**Table 4-1: PIP-II Conceptual Design Baseline Hazards List**

| Hazard ID: PIP-II – PHA-1 | Hazard ID: PIP-II – PHA-2 |
|---|---|
| Construction Hazards | Natural Phenomena Hazards |
| Site Clearing | Seismic |
| Excavation | Flooding |
| Vertical/Horizontal Conveyance Systems | Wind |
| Confined space | Lightning |
| Heavy Equipment | Tornado |
| Work at Elevations (steel erection, roofing) | |
| Material Handling (rigging) | |
| Utility interfaces, (electrical, chilled water, ICW, natural gas) | |
| Slips/trips/falls | |
| Weather related conditions | |
| Scaffolding | |
| Transition to Operations | |
| Radiation Generating Devices | |

Design inputs

| Hazard ID: PIP-II – PHA-3 | Hazard ID: PIP-II – PHA-4 |
|---|---|
| **Environmental Hazards** | **Waste Hazards** |
| Construction impacts | Construction Phase |
| Storm water discharge (construction and operations) | Facility maintenance |
| Operations impacts | Experimental Operations |
| Soil and groundwater activation/contamination | Industrial |
| Tritium contamination | Hazardous |
| Air activation | Radiological |
| Cooling water activation (HVAC and Machine) | |
| Oils/chemical leaks or spills | |
| Discharge/emission points (atmospheric/ground) | |
| **Hazard ID: PIP-II – PHA-5** | **Hazard ID: PIP-II – PHA-6** |
| **Fire Hazards** | **Electrical Hazards** |
| Facility Occupancy Classification | Facility |
| Construction Materials | Experimental |
| Storage | Job built Equipment |
| Flammable/combustible liquids | Low Voltage/High Current |
| Flammable gasses | High Voltage/High Power |
| Egress/access | Maintenance |
| Electrical | Arc flash |
| Lightning | Electrical shock |
| Welding/cutting/brazing work | Cable tray overloading/mixed utilities |
| Smoking | Exposed 110v |
| | Stored energy (capacitors & inductors) |
| **Hazard ID: PIP-II – PHA-7** | **Hazard ID: PIP-II – PHA-8** |
| **Noise/Vibration/Thermal/Mechanical Hazards** | **Cryogenic/Oxygen Deficiency Hazards** |
| Construction Tools | Thermal |
| Machine Shop Tools | Cryogenic distribution systems |
| Industrial Vehicles | Pressure |
| Drilling, Cutting, Grinding | Handling & Storage |
| Pressure/Vacuum Vessels & Lines | Liquid argon/nitrogen spill/leak |
| High Temp Equipment (Bakeouts) | Use of inert gases (nitrogen, helium) |
| | Specialty gases accelerator operation |
| **Hazard ID: PIP-II – PHA-9** | **Hazard ID: PIP-II – PHA-10** |
| **Confined Space Hazards** | **Ionizing Radiation Exposure, inside of the accelerator or beamline enclosure** |
| Sumps | Prompt radiation |
| Utility Chases | Residual (activated components) |
| | Contamination |
| | Airborne Contamination |

| Hazard ID: PIP-II – PHA - 11 | Hazard ID: PIP-II – PHA – 12 |
|---|---|
| **Chemical/Hazardous Material Inventory** | **Accelerator/Beamline Hazards** |
| Toxic | Vacuum/Pressure |
| Compressed gas | Cooling water |
| Combustibles | Compressed gas |
| Explosives | Electrical |
| Flammable gases | Heavy equipment handling |
| Lead (shielding) | High Magnetic Fields |
| Cryogenic | Shielding |
| | Mechanical (moving shutters, valves and actuators) |
| **Hazard ID: PIP-II – PHA - 13** | **Hazard ID: PIP-II – PHA – 14** |
| **Ionizing Radiation Hazards, outside accelerator or beamline enclosure** | **Lasers & other Non-Ionizing Radiation Hazards** |
| Prompt Radiation | Alignment Laser |
| Tritium production | Testing and Calibration |
| Radioactive contamination | Magnetic Fields |
| Activation (equipment) | Calibration & Testing |
| Radioactive material (dispersible use, storage, surface contamination) | |
| Airborne Radionuclides | |
| Radiation Generating Devices used for nondestructive measurement purposes, including soil compaction. | |
| **Hazard ID: PIP-II – PHA - 15** | |
| **Material Handling Hazards** | |
| Overhead cranes/hoists | |
| Fork trucks | |
| Manual material handling | |
| Delivery area distribution | |
| Manual movement of materials | |
| Hoisting & Rigging | |
| Lead | |
| Oils, Solvents, Acids | |
| Cryogens | |
| Compressed Gases | |

Conventional construction hazards are **"Moderate"** risk.

Addressed in design, procurement and construction processes.

[11] – PHAR can be found in PIP-II-doc-140

# ESH&Q – Construction Safety

**Goal**: Zero Accidents/Lost Time Incidents

- Incorporate safety during the design process:
  - FESHM 7010 (July 2017) requirement for constructability review "including ES&H issues" no later than 60% design completion:
  - Component of planned constructability reviews;
- Incorporate safety during the procurement process:
  - Include safety performance as part of the selection process;
  - Experience Modification Rate (EMR) of less than 1 and 3 year safety record for =< 85% of General Construction stats
- Safety during the construction process:
  - Detail the responsibilities for team members including the Construction Subcontractor and Fermilab Construction Coordinator;
  - Independent Oversite by ESH&Q.

*Experience Modification Rate (EMR) is used by insurance companies to gauge a company's dedication to safety, according to Western National Insurance (WNI). This number is based on a company's past costs because of safety issues and its future risk of safety-related costs.*

# ESH&Q - Sustainability

## Sustainability Goal:

*Fermilab is committed to designing, locating, constructing, maintaining and operating its facilities in an energy efficient and sustainable manner that strives to achieve a balance that will realize maximum attainable reuse and recycling of depletable resources, in an economically viable manner and consistent with with Fermilab's mission and goals.*

## Implementation

- Consider Project Siting during the conceptual design phase;
- Design/construct to meet the DOE's Guiding Principles for High Performance Sustainable Building; [12] Breakout Talk
- Review the plan throughout the design process;
- Implement the plan during construction.

[12] – HPSB implementation strategy can be found in PIP-II-doc-184

# ESH&Q - Quality

- Architect/Engineer Quality Program:
  - Part of A/E selection process;
  - Task specific quality requirements included in tasking agreements;
  - Constructability Reviews;
- External Reviews:
  - Independent Design Review;
  - Commissioning Agent;
- Internal Controls:
  - Lab-wide review process at key milestones in the design process;
  - ESH&Q included as part of review team;
  - Responsibility of Construction Coordinator during construction.

# Risk: Conventional Facilities

Charge #3

Breakout Talk

- Following the procedures in the PIP-II Risk Management Plan [13];
- Managing **42** Threats and **9** Opportunities
- Top six (6) Conventional Facilities risks:

| Title | Technical Impact | P * Impact (k$) | P * Impact (months) | Probability |
|---|---|---|---|---|
| Subproject Changes Impact Conventional Facilities | 1 (L) - somewhat substandard | 285 | 2.0 | 30.00% |
| Construction Bids Exceed Estimates | 1 (L) - somewhat substandard | 68 | 0.2 | 15.00% |
| RF LCW Temperature Delta Too Low | 1 (L) - somewhat substandard | 63 | 0.9 | 20.00% |
| Unclear/Incomplete Delineation Between Construction Packages | 1 (L) - somewhat substandard | 58 | 0.3 | 25.00% |
| Design Complexity | 1 (L) - somewhat substandard | 43 | 0.0 | 15.00% |
| Poor Interface Definition | 1 (L) - somewhat substandard | 40 | 1.3 | 25.00% |

[13] – Risk Management Plan can be found in PIP-II-doc-163

# Risk Mitigation

## Subproject Changes Impact Conventional Facilities

- Summary

  If the subproject requirements changes then the design of the conventional facilities will need to be modified jeopardizing the cost and schedule objectives

- Cause/Trigger

  Changes to the subproject requirements

- Mitigation
  - Include subproject managers in design meetings;
  - Include subproject managers in formal design reviews;
  - Management control of changes through a change/configuration control process;

# Cost Summary

Charge #3

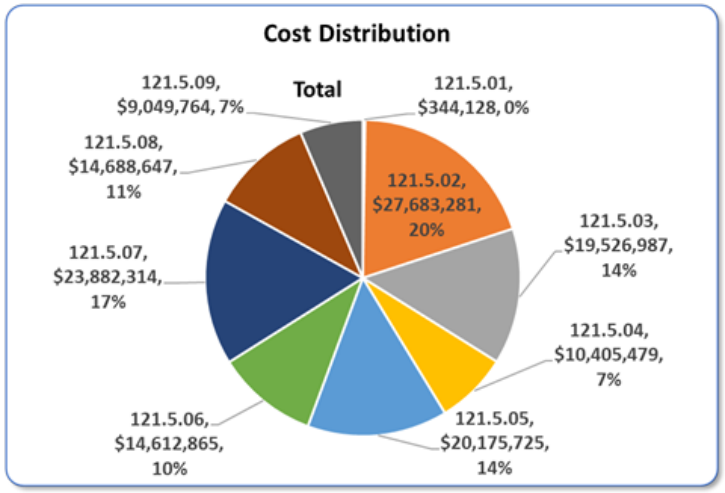
| Level 3 WBS - Name | Direct Hrs | Direct M&S | Full Burden+Esc | EUC | % EUC | Total Cost |
|---|---|---|---|---|---|---|
| 121.5.01 - CF - Project Management & Coordination | 1,591 | $0 | $344,128 | $34,412 | 10.0% | $378,540 |
| 121.5.02 - CF - Site Preparation | 3,237 | $22,594,346 | $27,683,281 | $5,536,657 | 20.0% | $33,219,934 |
| 121.5.03 - CF - Cryo Plant Building | 2,748 | $15,358,404 | $19,526,987 | $3,905,398 | 20.0% | $23,432,377 |
| 121.5.04 - CF - Utility Building | 1,928 | $7,607,405 | $10,405,479 | $2,081,097 | 20.0% | $12,486,572 |
| 121.5.05 - CF - High Bay Building | 3,152 | $15,609,053 | $20,175,725 | $4,035,145 | 20.0% | $24,210,875 |
| 121.5.06 - CF - Linac Tunnel | 2,346 | $10,753,485 | $14,612,865 | $2,922,570 | 20.0% | $17,535,446 |
| 121.5.07 - CF - Linac Gallery | 2,615 | $17,287,955 | $23,882,314 | $4,776,461 | 20.0% | $28,658,773 |
| 121.5.08 - CF - Beam Transfer Line & Absorb Line | 2,089 | $10,438,395 | $14,688,647 | $2,937,730 | 20.0% | $17,626,373 |
| 121.5.09 - CF - Booster Connection | 3,928 | $5,763,400 | $9,049,764 | $1,809,953 | 20.0% | $10,859,718 |
| **Grand Total** | **23,634** | **$105,412,443** | **$140,369,190** | **$28,039,423** | **20.0%** | **$168,408,608** |

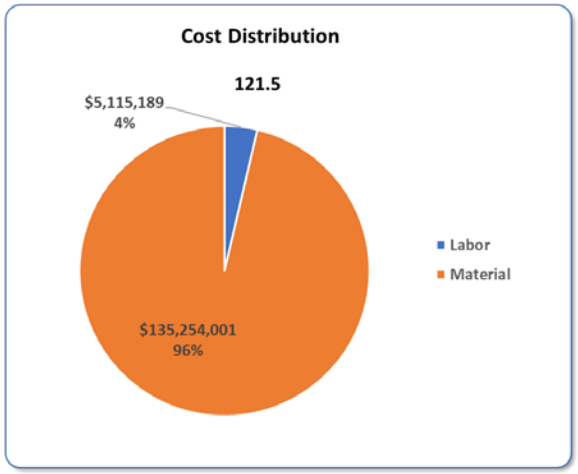
**121.5 Total Managed Amount**

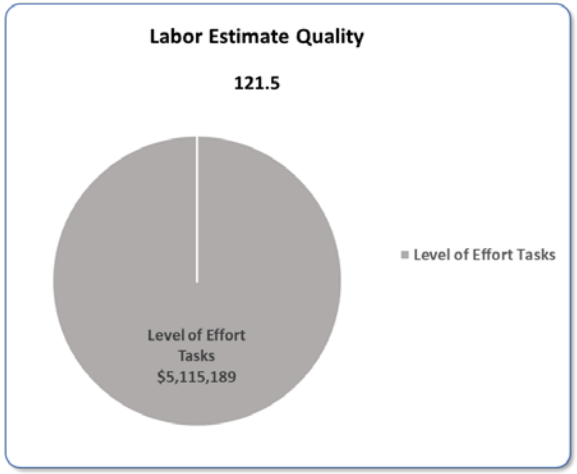
- Costs generated from resource loaded schedule;
- Estimate Uncertainty (EUC) follows project guidelines;

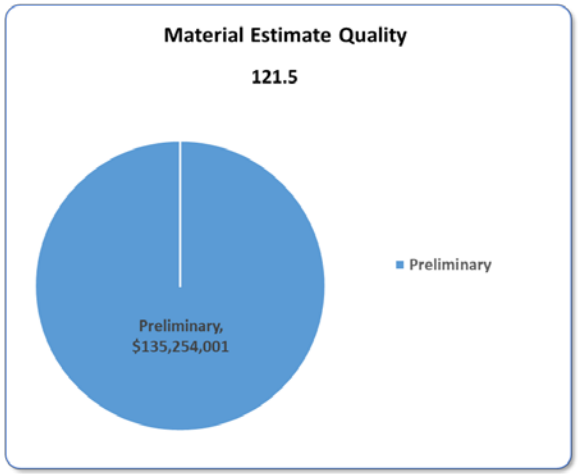
# Cost Drivers and Estimate Maturity

Charge #3



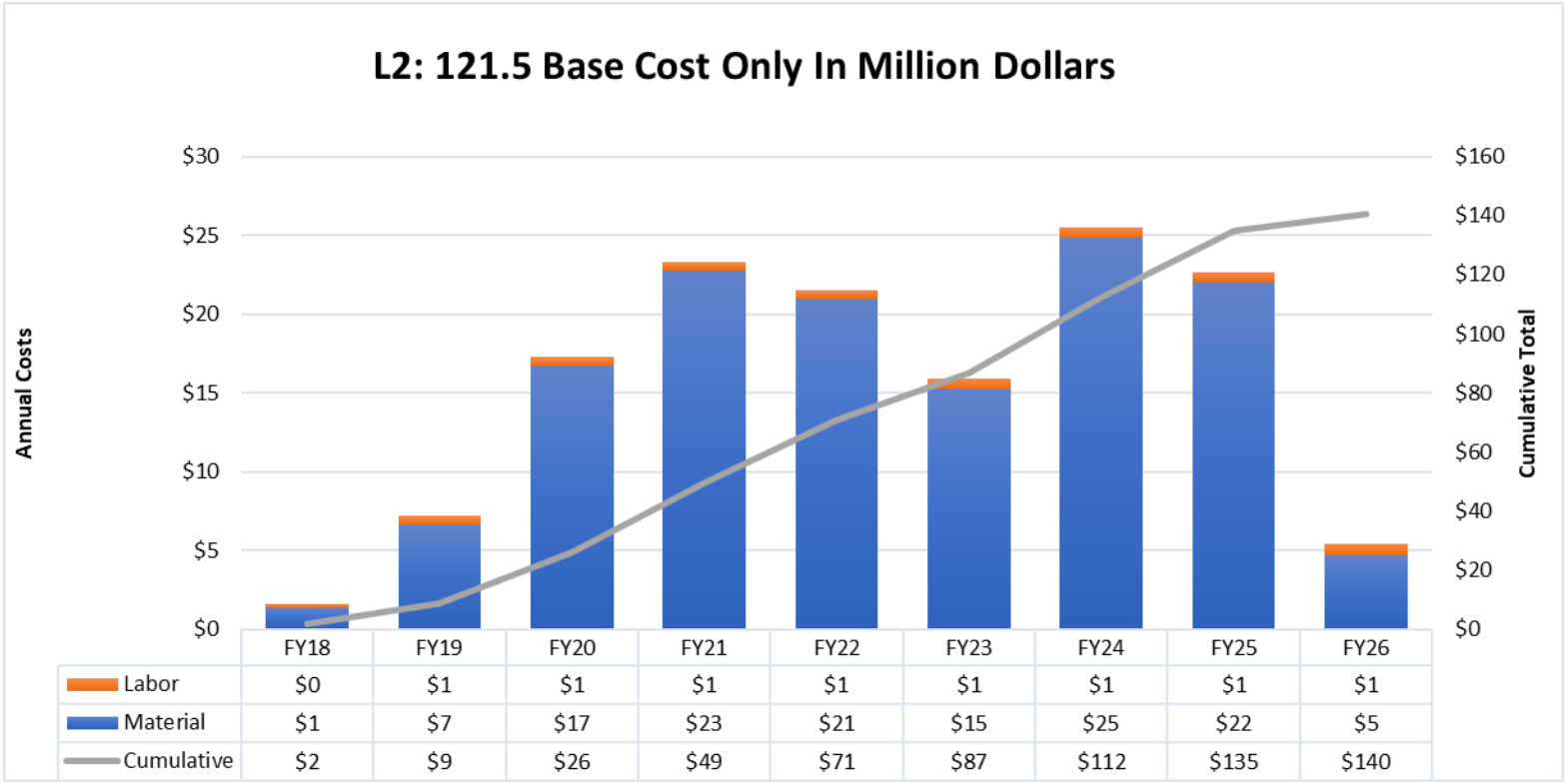




P6 Base Costs = BOE + Overheads + Escalation
Estimate Quality Categories follow Fermilab Standards and Descriptions (see PIP-II-doc-345)

# Obligation Profile – P6 Base Cost Only

Charge #3

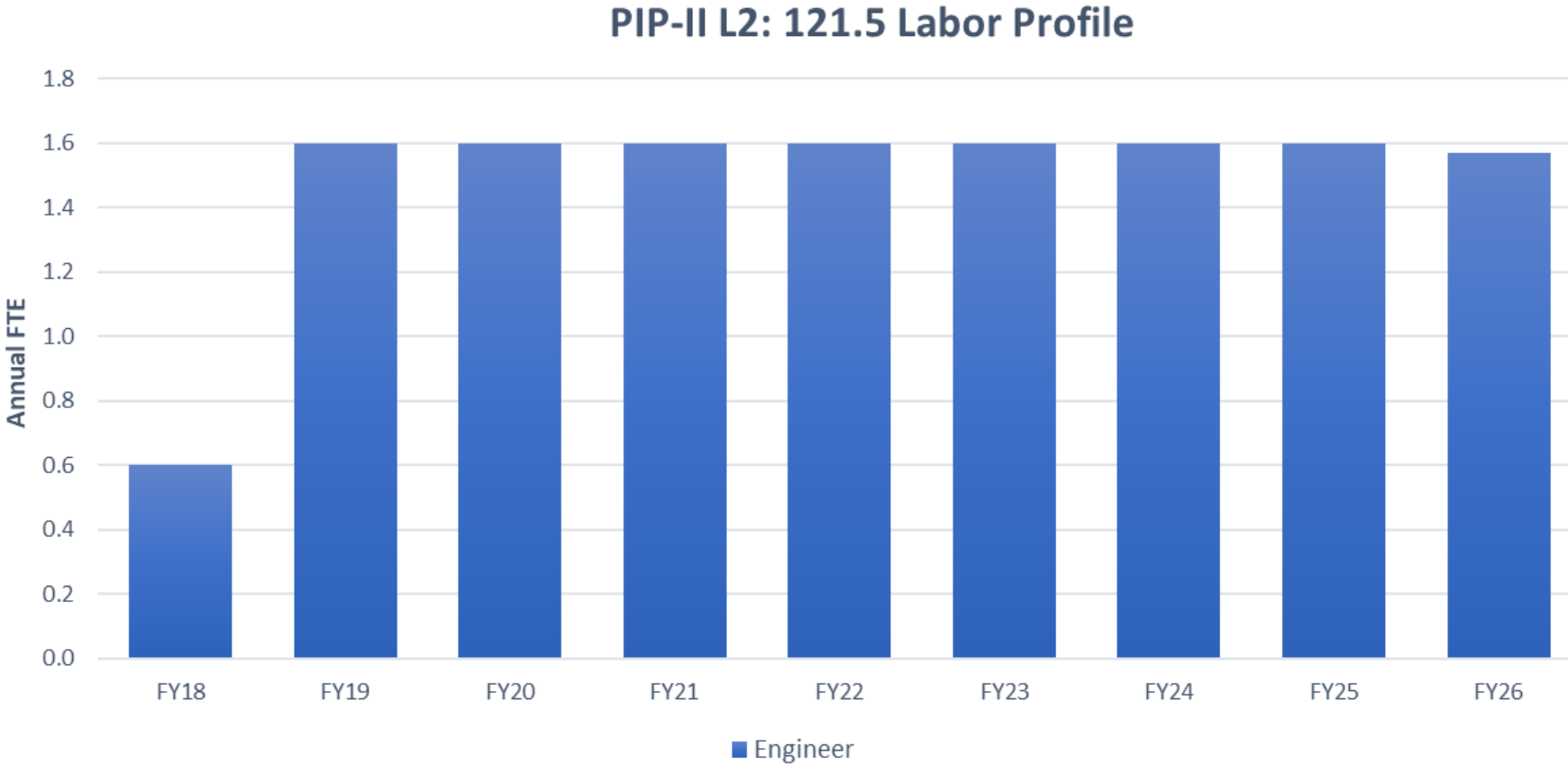



| | FY18 | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25 | FY26 |
|---|---|---|---|---|---|---|---|---|---|
| Labor | $0 | $1 | $1 | $1 | $1 | $1 | $1 | $1 | $1 |
| Material | $1 | $7 | $17 | $23 | $21 | $15 | $25 | $22 | $5 |
| Cumulative | $2 | $9 | $26 | $49 | $71 | $87 | $112 | $135 | $140 |

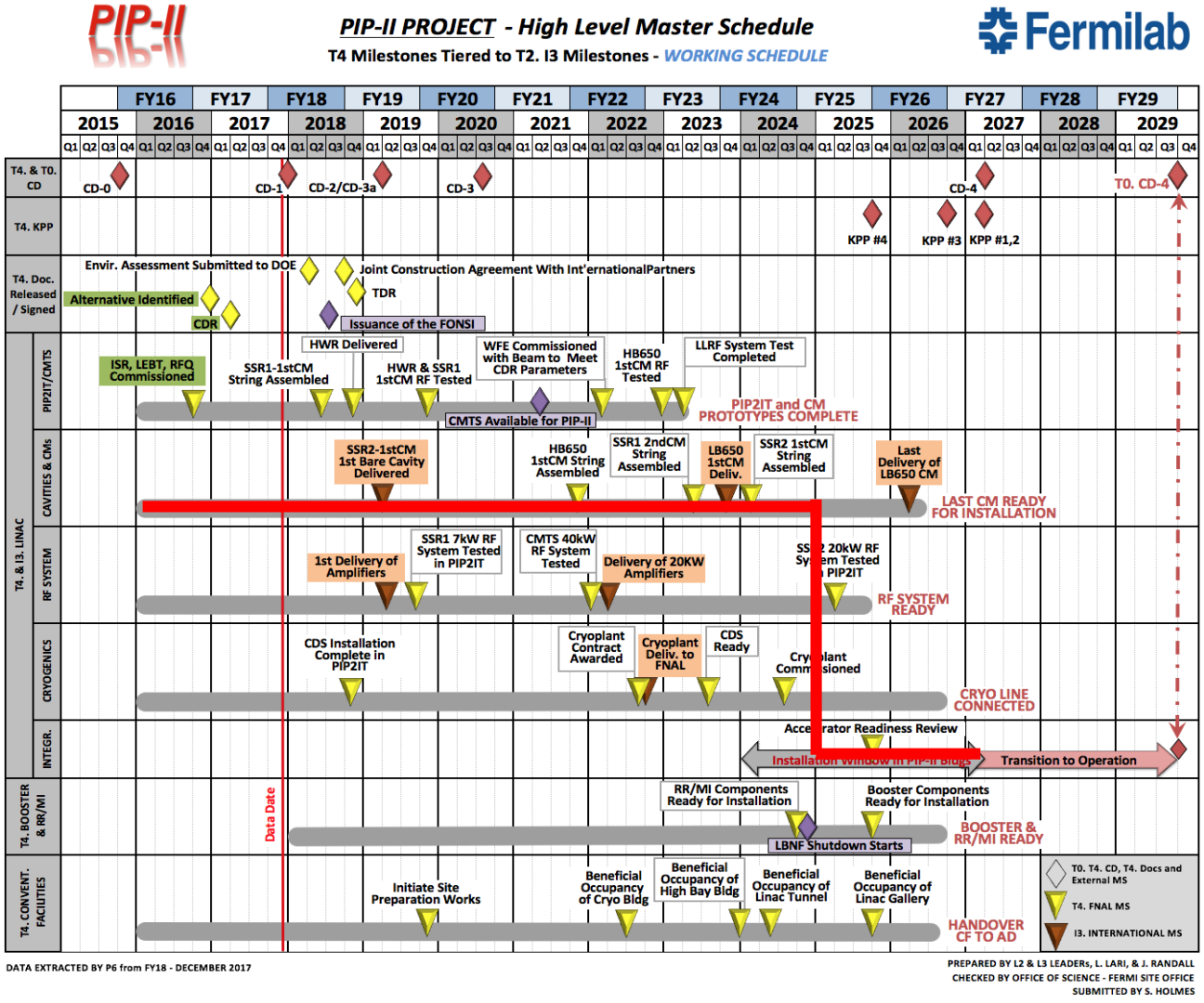
P6 Base Costs = BOE + Overheads + Escalation

# Labor Profile – P6 Hours/FTE

Charge #3



# Schedule




Focused on interfaces with other sub-projects;

# Previous Review Recommendations

Charge #8

## Director's Review for CD-1 (October 2017)

1. Secure signoff of the PIP2 Fermilab Interface Document with the Laboratory by the CD-1 review – Complete (PIP-II-doc-528)
2. Secure signoff of current Technical Requirements Specifications (TRS) and Functional Requirements Specification (FRS) documents in process by the CD-1 OPA Review - Complete

# Breakout Sessions

- These talks are available:
  - Conventional Facilities Management
  - Conventional Facilities Design and Scope
  - Conventional Facilities Cost and Schedule
  - Conventional Facilities CD-1 Documentation
  - Conventional Facilities Procurement Planning

# Summary

- Developed the conceptual design of conventional facilities based on iterative discussions and meetings with stakeholders;
- The cost and schedule estimates for conventional facilities are based on a well defined conceptual design and include adequate scope, cost and schedule contingency;
- ESH&Q issues have been incorporated in the project processes;
- The required DOE Order 413.3B documentation for CD-1 approval is complete;
- The interfaces of the other subprojects and international partners is understood and incorporated into the planning process;
- Recommendations from previous reviews have been addressed;
- We are ready for CD-1 and look forward to your feedback

# Questions