Fermi National Accelerator Laboratory

Fermilab

PIP-II Linac Complex
Technical Requirements Specification

Document number: ED0010906

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U.S. Department of Energy Office of Science
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U.S. DEPARTMENT OF ENERGY | Office of Science

Document Approval

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Revision History

Revision	Date of Release	Description of Change
---	29 October 2019	Initial Release for Review

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1. Purpose

A Technical Requirements Specification (TRS) is a means to communicate what type of system is being designed and implemented, lists the attributes of that system as it conforms to a specific metric and establishes consensus amount stakeholders on what the system is expected to provide.

A TRS describes the technical aspects that a system or component must fulfill, such as the technical characteristics, the performance requirements and/or the reliability requirements. TRS requirements may be derived from higher-level requirements such as Functional Requirements Specifications (FRS), Interface Control Documents (ICD), or derived from the design process. TRS requirements may or may not be specific to a particular design concept.

2. Scope

This TRS addresses the technical requirements of the Linac Complex which includes the elements of work normally included in conventional construction such as earthwork, utilities, structural concrete, structural steel, architectural cladding, finishes, roofing, plumbing, process piping, heating ventilation and air conditioning (HVAC), fire protection, fire detection, lighting and electrical.

The Linac Complex is comprised of the following components:

2.1. High Bay Building

The High Bay Building (HBB) includes the construction package including the below grade and above grade structures, mechanical, electrical, conveying systems and related support systems to house the Warm Front-End components and related infrastructure;

2.2. Linac Tunnel

The Linac Tunnel (LT) that includes the work required to install the below grade beamline enclosure to accommodate the beamline components and related support infrastructure;

2.3. Linac Gallery

The Linac Gallery (LG) includes the above grade service building and associated infrastructure to support the technical equipment for the beamline components;

2.4. Beam Transfer Line

The Beam Transfer Line (BTL) that includes the work required to install the below grade beamline enclosure from the downstream end of the LT to a point approximately 50 feet east of the existing Main Ring tunnel. The BTL will accommodate the beamline components, beam absorber and related support infrastructure.

3. Acronyms

ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
APS-TD	Applied Physics and Superconducting Technology Division
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	ASTM International (American Society for Testing and Materials)
BTL	Beam Transfer Line
CDS	Cryogenics Distribution System
CHW	Chilled Water
CPB	Cryogenic Plant Building
DLR	Downstream Laser Room
DOE	Department of Energy
DWS	Domestic Water Supply
EPDM	Engineering Process Document Management
ES	Exterior Space
F	Fahrenheit
FESHM	Fermilab ES&H Manual
FRCM	Fermilab Radiological Control Manual
FRS	Functional Requirements Specification
HB650	High Beta 650 MHz
HBB	High Bay Building
HVAC	Heating, Ventilation and Air Conditioning
HWR	Half Wave Resonator
IBC	International Building Code
ICW	Industrial Cooling Water
kVA	Kilo Volt Amps
L2	WBS Level 2
L3	WBS Level 3
LB650	Low Beta 650 MHz
LC	Linac Complex
LG	Linac Gallery
Linac	Linear Accelerator

LT	Linac Tunnel
MHz	Megahertz
MUW	Make Up Water
NFPA	National Fire Protection Association
ODH	Oxygen Deficiency Hazard
PIP-II	Proton Improvement Plan II Project
RAW	Radioactive Water
RDS	Room Data Sheet
RFS	Radio Frequency Separator
RH	Relative Humidity
SAN	Sanitary Sewer
SCD	System Configuration Document
SS	Support Space
SSR1	Single Spoke Resonator, Type 1
SSR2	Single Spoke Resonator, Type 2
TC	Teamcenter
TRS	Technical Requirements Specification
ULR	Upstream Laser Room
UPS	Uninterruptible Power Supply
V	Volt
WBS	Work Breakdown Structure
WFE	Warm Front End

4. Reference

#	**Reference**	**Document #**
1	Conventional Facilities Engineering Process Document Management (EPDM)	ED0002857
2	Conventional Facilities System Configuration Document (SCD)	ED0008133
3	Linac Complex Functional Requirement Specification	ED0008043
3	Fermilab Engineering Manual	NA
4	Fermilab Environmental Safety and Health Manual	NA
5	Fermilab Radiological Control Manual	NA

6	PIP-II Project Assumptions	PIP-II-doc-144
7	PIP-II – Fermilab Interface Document	PIP-II-doc-528
8	PIP-II Room Data Sheet	ED0009544
9	PIP-II Cryomodules Envelopes	F10051442

5. Key Assumptions

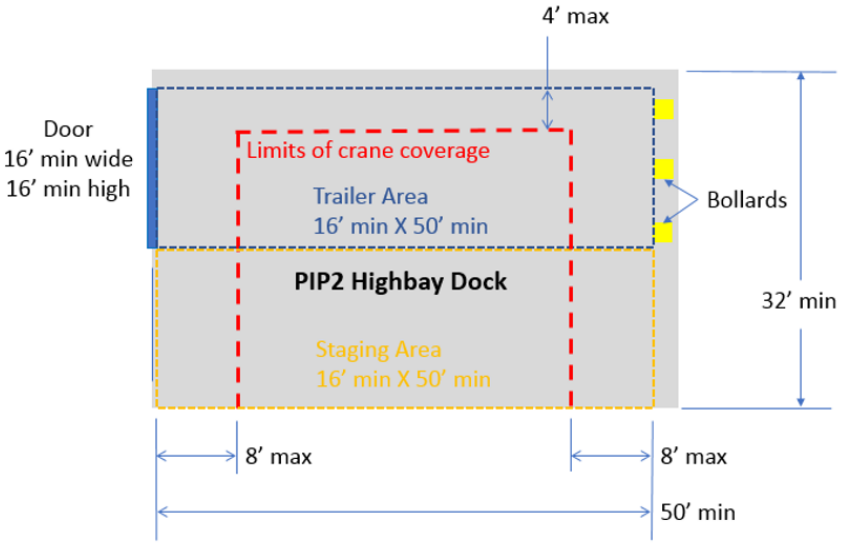
The key assumptions for the Linac Complex include:

1. The Linac Tunnel portion is the only section of the Linac Complex that will be designated as a Oxygen Deficiency Hazard (ODH) system. The ODH system shall be designed in accordance with Fermilab policies and guidelines. The mechanical equipment (louvers, fans, ductwork) that interface with building systems shall be installed as part of the LC work scope. The ODH analysis, design and installation of the control components, wiring, sensors and related work as well as commissioning is the responsibility of the WBS 121.02.05 (Cryogenic Distribution) subproject.
2. The technical equipment will be installed by other PIP-II subprojects.
3. The existing sitewide Industrial Cooling Water (ICW) will be used for fire suppression.
4. In order to accommodate the installation of technical components, the Linac Complex will have the Authorization for Use and Possession (AUP) prior to completion in the following order:
    a. High Bay Building
    b. Linac Tunnel
    c. Beam Transfer Line
    d. Linac Gallery

6. Technical Requirements

Requirement ID	FRS Reference	Requirement Statement
A - General		
T-121.06.05-A001	*F-121.06.05-A001*	The LC shall be designed to accommodate safe access for maintenance and operation including roof access with minimal personal protective equipment.
T-121.06.05-A002	*F-121.06.05-A025*	The flatness and levelness of the new floor slabs built as part of the conventional facilities shall be designed for normal construction tolerances and a ASTM E1155 floor flatness value of F(F) 25 and a floor levelness F(L) of 20.
T-121.06.05-A003	*F-121.06.05-A027*	HVAC systems shall conform to ASHRAE 90.1 and ASHRAE 62.
T-121.06.05-A004	*F-121.06.05-A028*	Ventilation of outside air shall be supplied to the spaces in accordance with the requirements of ASHRAE 62.1.
T-121.06.05-A005	*F-121.06.05-A029*	All plumbing work shall be designed in accordance with Illinois Plumbing Code and Standard Specifications for Water & Sewer Main Construction in Illinois.
T-121.06.05-A006	*F-121.06.05-A032*	The LC shall include a generator backed UPS for sump pumps, fire alarm equipment, door security and oxygen deficiency hazard (ODH) control equipment sized for 8 minutes of full load run time.

B - Architectural		
T-121.06.05-B001	*F-121.06.05-A037*	The LC shall be developed based on the 2018 Fermilab Campus Master Plan including the desire that the “design of buildings and open spaces should encourage interaction, creating the settings to bring staff, users and visitors together, becoming vibrant centers of laboratory life." To this end, the LC will incorporate the appropriate portions of the design guidelines including: • Entrances and ground floors that are welcoming and provide an opportunity for interactions; • Entrances that are evident in the daytime and at night; • The ground floor will emphasize transparency; • Service and utilities areas will be located so as to not negatively affect pedestrian paths or building entrances; • Provide long term flexibility and life cycle value; and • Uphold the unique character of Fermilab.
C - Utilities		
T-121.06.05-C001	*F-121.06.05-A019*	The LC shall connect and extend the Fermilab medium voltage electrical infrastructure from the utility corridor to the LC point of use.
T-121.06.05-C002	*F-121.06.05-A020*	The LC shall connect and extend the Fermilab domestic water supply (DWS) from the utility corridor to the LC point of use.
T-121.06.05-C003	*F-121.06.05-A012*	The LC shall connect and extend the Fermilab industrial cooling water (ICW) from the utility corridor to the LC point of use.
T-121.06.05-C004	*F-121.06.05-A022*	The LC shall connect and extend the Fermilab sanitary sewer (SAN) from the utility corridor to the LC point of use.
T-121.06.05-C005	*F-121.06.03-A023*	The LC shall connect and extend the Fermilab chilled water (CHW) from the utility corridor to the LC point of use.
T-121.06.05-C006	*F-121.06.03-A023*	The LC shall connect and extend the Fermilab make up water (MUW) from the utility corridor to the LC point of use.
T-121.06.05-C007	*F-121.06.03-A024*	The LC shall connect and extend the Fermilab data/communication infrastructure from the utility corridor to the LC point of use.
D – High Bay Building		
T-121.06.05-D001	*F-121.06.05-A004*	The High Bay Building (HBB) shall include an overhead bridge crane with the following criteria: • Capacity of 25 tons (50,000 pounds); • Hook limits to provide coverage for the major equipment and loading dock; • Minimum hook height of 25 feet above finished floor; • Hook rotation is required.
T-121.06.05-D002	*F-121.06.05-A003*	The HBB shall include at grade loading dock space to accommodate a standard 55-foot-long semi-trailer with the following minimum requirements: • A portion of the loading dock will be beneath crane coverage.

		• Width: 32’ with 16’ aligned with overhead door and 16’ staging area to one side on trailer • Depth: 50’ See image below for conceptual layout of loading dock: 
T-121.06.05-D003	*F-121.06.05-A003*	The HBB shall include, as a minimum, a 16-foot-wide by 16-foot-tall overhead door;
T-121.06.05-D004	*F-121.06.05-A002*	The HBB shall provide space and infrastructure to accommodate the **Warm Front-End (WFE)** components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-D005	*F-121.06.05-A006*	The HBB shall provide space and infrastructure to accommodate the **Half Wave Resonator (HWR)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-D006	*F-121.06.05-A002*	The HBB shall provide an elevator that connects the above grade and below grade portions of the HBB. The elevator will be used for both equipment and personnel movement. The minimum elevator requirements include: • 6,000-pound capacity; • Equipment size: 4’ x 6’ x 7’ high (minimum) • Sized not less than FESS/E Design Standards for personnel access; • Elevator and machine room (if needed) to be located outside interlocked zones at all levels.
T-121.06.05-D007	*F-121.06.05-A001* *F-121.06.05-A002* *F-121.06.05-A007*	The HBB shall provide space for a 3-foot-thick shield door or stacked shield blocks to separate the downstream end of the lower portion of the HBB from the adjacent Linac Tunnel (LT). The minimum opening for the shield door shall accommodate the cryomodule envelope as documented in drawing F10051142.

		The shield blocks/shield door will be provided and installed by the WBS 121.04.05 (Linac Installation) subproject.
T-121.06.05-D008	*F-121.06.05-A002*	The HBB shall provide space/infrastructure for the **Upstream Laser Room (ULR)** that includes: • The Laser Room will need to be light tight and house a ~4'x8' laser table; • The size of the room is ~12'x15' to allow for equipment storage and access around the table; • A light tight vestibule (~4'x5') will be provided; • Interlocks will be required; • A 6' wide x 8' high set of double doors will allow for the installation of the laser table; • Environmental control in the laser room is important. A stable temperature (+/- 3 degrees F) is required; • The primary location of the laser room should be near the warm front end of the Linac; • If it is located beneath the loading dock, vibrations should be considered;
T-121.06.05-D009	*F-121.06.05-A005* *F-121-06.05-A006*	The HBB shall include 480V, 60-amp welding receptacles sized and located to accommodate standard Fermilab welding machines and cord lengths.
T-121.06.05-D010	*F-121.06.05-A005* *F-121-06.05-A006*	The HBB shall include one (1) 120V, 20-amp receptacle at each column line.
T-121.06.05-D011	*F-121.06.05-A001* *F-121.06.05-A005* *F-121-06.05-A006*	The HBB shall be provided with general lighting to achieve an average of 30 foot-candles.
T-121.06.05-D012	*F-121.06.05-A005* *F-121-06.05-A006*	The HBB shall have a HVAC system capable of achieving the following space parameters: • Temperature in Cooling Mode: 78 degrees Fahrenheit (+/- 5F) • Temperature in Heating Mode: 68 degrees Fahrenheit (+/- 5F) • Humidity: 55% RH Max, No Minimum
T-121.06.05-D013	*F-121.06.05-A001* *F-121.06.05-A006* *F-121.06.05-A007*	The HBB shall include provision for shield block access over the Half Wave Resonator (HWR). The building design shall accommodate standard Fermilab precast concrete "G" blocks. The shield blocks will be provided and installed by WBS 121.04.05 (Linac Installation) subproject.
T-121.06.05-D014	*F-121.06.05-A001*	The HBB shall include space/infrastructure to accommodate informational/educational tour groups. This interior space will include the following: • Sized to accommodate up to fifteen people; • Contain informational display materials (video and printed); • Located for access from the Wilson Hall footprint area; • Includes access to the interior of the building to view the WFE equipment.

T-121.06.05-D015	*F-121.06.05-A026*	The below grade portion of the HBB shall include embedment Unistrut anchors at approximate 6-foot spacing to accommodate future technical equipment.
T-121.06.05-D016	*F-121.06.05-A001*	The HBB shall not require ODH ventilation.
E – Linac Tunnel		
T-121.06.05-E001	*F-121.06.05-A006*	The LT shall accommodate the installed beamline components and an adjacent access aisle to allow for the transportation and installation of cryomodules and related equipment. The minimum cryomodule envelope will be as documented in drawing F10051142.
T-121.06.05-E002	*F-121.06.05-A006*	The LT shall provide space and infrastructure to accommodate the **Half Wave Resonator (HWR)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E003	*F-121.06.05-A006*	The LT shall provide space and infrastructure to accommodate the **Single Spoke Resonator, Type 1 (SSR1)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E004	*F-121.06.05-A006*	The LT shall provide space and infrastructure to accommodate the **Single Spoke Resonator, Type 2 (SSR2)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E005	*F-121.06.05-A006*	The LT shall provide space and infrastructure to accommodate the **Low Beta 650 Mhz (LB650)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E006	*F-121.06.05-A006*	The LT shall provide space and infrastructure to accommodate the **High Beta 650 Mhz (HB650)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E007	*F-121.06.05-A006* *F-121.06.05-A038*	The LT shall provide space and infrastructure to accommodate an **LT Upgrade** to the beamline components consisting of two (2) additional **High Beta 650 Mhz (HB650)** cryomodule components and related equipment and one (1) **Radio Frequency Separator (RFS)** components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-E008	*F-121.06.05-A011*	The upstream end of the LT will be located at the downstream end of the HBB
T-121.06.05-E009	*F-121.06.05-A001* *F-121.06.05-A007*	The LT shall provide for up to 20 feet of earth equivalent shielding to allow for unrestricted access on grade during normal beam operating conditions.
T-121.06.05-E010	*F-121.06.05-A001* *F-121.06.05-A007*	The LT shall provide exit corridors and passageways that incorporate shielding labyrinths to reduce radiation exposure to as low as reasonably achievable (ALARA) levels per Fermilab Radiological Control Manual (FRCM).
T-121.06.05-E011	*F-121.06.05-A014*	The LT shall provide radio frequency waveguide penetration that connect to the LG. There will be one (1) penetration per cryomodule cavity plus spare.
T-121.06.05-E012	*F-121.06.05-A014*	The LT shall provide cable penetrations that connect to the LG. There will be one (1) penetration per cryomodule cavity plus spares and penetrations required for controls, instrumentation and related cabling.

T-121.06.05-E013	*F-121.06.05-A014* *F-121.06.05-A017*	All penetrations that connect to the LG shall be sealed to reduce the extent possible air movement between the spaces.
T-121.06.05-E014	*F-121.06.05-A003*	The LT shall have a HVAC system capable of achieving the following space parameters: • Temperature in Cooling Mode: XX degrees Fahrenheit (+/- 5F) • Temperature in Heating Mode: XX degrees Fahrenheit (+/- 5F) • Humidity: 55% RH Max, No Minimum
T-121.06.03-E015	*F-121.06.05-A003* *F-121.06.05-A001*	The LT shall have a louvers, dampers and fans to accommodate ODH mitigation with the following capabilities: • Air flow: 5,000 cfm (placeholder) • Intake location: • Exhaust Location • See preliminary ODH Assessment (ENXXXX)
T-121.06.05-E016	*F-121.06.05-A006*	The LT shall include 480V, 60-amp welding receptacles sized and located to accommodate standard Fermilab welding machines and cord lengths.
T-121.06.05-E017	*F-121.06.05-A006*	The LT shall include, at a minimum, one (1) 208V, 20-amp receptacle each alcove
T-121.06.05-E018	*F-121.06.05-A006*	The LT shall include, at a minimum, one (1) 120V, 20-amp receptacle at each alcove.
T-121.06.05-E019	*F-121.06.05-A006*	The LT shall be provided with general lighting to achieve an average of 10 foot-candles.
T-121.06.05-E020	*F-121.06.05-A006*	Electronics in the LT shall be suitable for radiation environments.
T-121.06.05-E021	*F-121.06.05-A026*	The LT shall include embedment Unistrut anchors at the walls and ceilings at approximate 6-foot spacing to accommodate future technical equipment.
T-121.06.05-E022	*F-121.06.05-A001* *F-121.06.05-A007* *F-121-06-05-A035*	Sump pumps discharges from the LT shall be directed to cooling ponds or ICW return ditches.
T-121.06.05-E023	*F-121.06.05-A038*	The LT shall provide a future expansion stub at the downstream end of the LT. The stub will be the full width and height of the LT and extend a suitable length (~30') to allow for construction of future expansion during normal accelerator operations.
T-121.06.05-E024	*F-121.06.05-A006*	The LT shall provide a means of installing the cryogenic transfer line from an exterior location to a point upstream of the HWR.
T-121.06.05-E025	*F-121.06.05-A038*	The LT shall provide a chase to accommodate a future cryogenic distribution line at the downstream end of the LT.
T-121.06.05-E026	*F-121.06.05-A001* *F-121.06.05-A008*	The LT shall have a regulated exhaust to allow for XX minutes of decay time prior to discharge.
T-121.06.05-E027	*F-121.06.05-A001* *F-121.06.05-A030*	The LG and HBB will be pressurized by 0.05" water column with respect to the LT.
F – Linac Gallery		
T-121.06.05-F001	*F-121.06.05-A009*	The LG shall provide space and infrastructure to accommodate the **General Technical Requirements** as detailed in RDS, Rev B, dated 09SEP19.

T-121.06.05-F002	*F-121.06.05-A009*	The LG shall provide space and infrastructure to accommodate the **Single Spoke Resonator, Type 1 (SSR1)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F003	*F-121.06.05-A009*	The LG shall provide space and infrastructure to accommodate the **Single Spoke Resonator, Type 2 (SSR2)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F004	*F-121.06.05-A009*	The LG shall provide space and infrastructure to accommodate the **Low Beta 650 Mhz (LB650)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F005	*F-121.06.05-A009*	The LG shall provide space and infrastructure to accommodate the **High Beta 650 Mhz (HB650)** cryomodule components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F006	*F-121.06.05-A009* *F-121.06.05-A038*	The LT shall provide space and infrastructure to accommodate an **LG Upgrade** to the beamline components consisting of two (2) additional **High Beta 650 Mhz (HB650)** cryomodule components and related equipment and one (1) **Radio Frequency Separator (RFS)** components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F007	*F-121.06.05-A009* *F-121.06.05-A012*	The LG shall provide space and infrastructure to accommodate the **Beam Transfer Line (BTL)** components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-F008	*F-121.06.05-A009*	The LG shall provide space/infrastructure for the **Downstream Laser Room (DLR)** that includes: • The Laser Room will need to be light tight and house a ~4'x8' laser table; • The size of the room is ~12'x15' to allow for equipment storage and access around the table; • A light tight vestibule (~4'x5') will be provided; • Interlocks will be required; • A 6' wide x 8' high set of double doors will allow for the installation of the laser table; • Environmental control in the laser room is important. A stable temperature (+/- 3 degrees F) is required; • The location of the DLR shall be in the LG at the downstream of the upgrade section. • Connection between the LG and LT will be via a similar penetration as described for radio frequency penetrations.
T-121.06.05-F009	*F-121.06.05-A009*	The LG shall provide space to accommodate a technician/storage area of about 1,250 square feet
T-121.06.05-F010	*F-121.06.05-A009*	The LG shall provide an elevator that connects the above grade LT and below grade LT. The elevator will be used for both equipment and personnel movement. The minimum elevator requirements include: • 6,000-pound capacity; • Equipment size: 4' x 6' x 7' high (minimum) • Sized not less than FESS/E Design Standards for personnel access;

		• Elevator and machine room (if needed) to be located outside interlocked zones at all levels.
T-121.06.05-F011	*F-121.06.05-A009*	The LG shall provide a loading area that is able to accommodate small equipment deliveries. This loading area will be located at the downstream end of the LG adjacent to the elevator.
T-121.06.05-F012	*F-121.06.05-A005* *F-121-06.05-A006*	The LG shall have a HVAC system capable of achieving the following space parameters: • Temperature in Cooling Mode: 78 degrees Fahrenheit (+/- 5F) • Temperature in Heating Mode: 68 degrees Fahrenheit (+/- 5F) • Humidity: 55% RH Max, No Minimum
T-121.06.05-F013	*F-121.06.05-A012*	The LG shall include 480V, 60-amp welding receptacles sized and located to accommodate standard Fermilab welding machines and cord lengths.
T-121.06.05-F014	*F-121.06.05-A003*	The LG shall include one (1) 208V, 20-amp receptacle at each column line.
T-121.06.05-F015	*F-121.06.05-A003*	The LG shall include one (1) 120V, 20-amp receptacle at each column line.
T-121.06.05-F016	*F-121.06.05-A003*	The LG shall be provided with general lighting to achieve an average of 30 foot-candles.
T-121.06.05-F017	*F-121.06.05-A001* *F-121.06.05-A007*	The LG shall be designed to reduce radiation exposure to as low as reasonably achievable (ALARA) levels per Fermilab Radiological Control Manual (FRCM).
T-121.06.05-F018	*F-121.06.05-A014*	The LG shall provide radio frequency waveguide penetration that connect to the LG. There will be one (1) penetration per cryomodule cavity plus spare.
T-121.06.05-F019	*F-121.06.05-A014*	The LG shall provide cable penetrations that connect to the LG. There will be one (1) penetration per cryomodule cavity plus spares and penetrations required for controls, instrumentation and related cabling.
T-121.06.05-F020	*F-121.06.05-A014* *F-121.06.05-A017*	All penetrations that connect to the LT shall be sealed to reduce the extent possible air movement between the spaces.
G – Beam Transfer Line		
T-121.06.05-G001	*F-121.06.05-A018*	The beamline components in the Beam Transfer Line (BTL) enclosure are conventional (non-cryogenic)
T-121.06.05-G002	*F-121.06.05-A018*	The BTL shall provide space and infrastructure to accommodate the **Beam Transfer Line (BTL)** components and related equipment as detailed in RDS, Rev B, dated 09SEP19.
T-121.06.05-G003	*F-121.06.05-A018*	The upstream end of the BTL will be located at the downstream end of the LT
T-121.06.05-G004	*F-121.06.05-A001* *F-121.06.05-A008*	The BTL shall provide for up to 20 feet of earth equivalent shielding to allow for unrestricted access on grade during normal beam operating conditions.
T-121.06.05-G005	*F-121.06.05-A001* *F-121.06.05-A008*	The BTL shall provide exit corridors and passageways that incorporate shielding labyrinths to reduce radiation exposure to as low as reasonably achievable (ALARA) levels per Fermilab Radiological Control Manual (FRCM).

T-121.06.05-G006	*F-121.06.05-A016*	The BTL shall provide power penetrations that connect to the LG.
T-121.06.05-G007	*F-121.06.05-A016*	The BTL shall provide cable penetrations that connect to the LG. There will be one (1) penetration per beamline component plus spares and penetrations required for controls, instrumentation and related cabling.
T-121.06.05-G008	*F-121.06.05-A016* *F-121.06.05-A017*	All penetrations that connect to the LG shall be sealed to reduce the extent possible air movement between the spaces.
T-121.06.05-G009	*F-121.06.05-A003*	The BTL shall have the following space parameters: • Temperature in Heating Mode: 60 degrees Fahrenheit (+/- 5F) • Humidity: 55% RH Max, No Minimum
T-121.06.05-G010	*F-121.06.05-A018*	The BTL shall include 480V, 60-amp welding receptacles sized and located to accommodate standard Fermilab welding machines and cord lengths.
T-121.06.05-G011	*F-121.06.05-A018*	The BTL shall include, at a minimum, one (1) 208V, 20-amp receptacle each alcove
T-121.06.05-G012	*F-121.06.05-A018*	The BTL shall include, at a minimum, one (1) 120V, 20-amp receptacle at each alcove.
T-121.06.05-G013	*F-121.06.05-A018*	The BTL shall be provided with general lighting to achieve an average of 10 foot-candles.
T-121.06.05-G014	*F-121.06.05-A018*	Electronics in the BTL shall be suitable for radiation environments.
T-121.06.05-G015	*F-121.06.05-A018*	The BTL shall include embedment Unistrut anchors at walls and ceilings at approximate 6-foot spacing to accommodate future technical equipment.
T-121.06.05-G016	*F-121.06.05-A001* *F-121.06.05-A008* *F-121-06-05-A035*	Sump pumps discharges from the BTL shall be directed to cooling ponds or ICW return ditches.
T-121.06.05-G017	*F-121.06.05-A001* *F-121.06.05-A008* *F-121-06-05-A034* *F-121-06-05-A035*	The area around the BTL Beam Absorber area shall have a dedicated sump pump that collects ground water from the vicinity.
T-121.06.05-G018	*F-121.06.05-A001* *F-121.06.05-A008* *F-121-06-05-A035*	The BTL shall have a regulated exhaust to allow for XX minutes of decay time prior to discharge.
T-121.06.05-G019	*F-121.06.05-A001* *F-121.06.05-A008*	The BTL Beam Absorber shall have an adjacent room for a radioactive water (RAW) processing skid. This room will include a floor depression and basin to retain potential spills. The basin and floor will be epoxy coated.
T-121.06.05-G020	*F-121.06.05-A001* *F-121.06.05-A008* *F-121-06-05-A018*	The BTL Beam Absorber will include passive shielding and support structure to accommodate a Fermilab provided core that will be installed by WBS 121.05.03 (Beam Transfer Line Installation) subproject
T-121.06.05-G021	*F-121-06-05-A018*	The BTL shall be designed to allow for connection to the Booster Connection (BC) construction package to be constructed at a later date.
H - Support Space		
T-121.06.05-H001	*F-121.06.05-A005*	The Support Space (SS) shall provide space/infrastructure for a **Commissioning Space** that will accommodate a minimum of eight (8) work stations, monitors and related equipment.

T-121.06.05-H002	*F-121.06.05-A001* *F-121.06.05-A005*	The SS shall provide space/infrastructure for a **Conference Room** that will accommodate a minimum of ten (10) people. The minimum requirements include: • Conference table and chairs; • Video display; • Teleconference equipment to provide "Zoom Room" connectivity consistent with Fermilab standards.
T-121.06.05-H003	*F-121.06.05-A001* *F-121.06.05-A005*	The SS shall provide space/infrastructure for **Open Office Space** with cubicles to house a minimum of four (4) people and associated spaces.
T-121.06.05-H004	*F-121.06.05-A001* *F-121.06.05-A005*	The SS shall be provided with general lighting to achieve an average foot-candle as follows: • Commissioning Room: 30 foot-candles, dimmable • Open Office: 30 fc • Conference Room: 30 foot-candles, dimmable • Other areas: 10 foot-candles
T-121.06.05-H006	*F-121.06.05-A001* *F-121.06.05-A027* *F-121.06.05-A028* *F-121.06.05-A029*	The SS shall have a HVAC system capable of achieving the following parameters: • Temperature in Cooling Mode: 78 degrees Fahrenheit (+/- 5F) • Temperature in Heating Mode: 68 degrees Fahrenheit (+/- 5F) • Humidity: 55% RH Max, No Minimum
I - Exterior Space		
T-121.06.05-I001	*F-121.06.05-A001*	The Exterior Space (ES) of the LC shall provide space/infrastructure to accommodate public tours of up to 15 people at a time.
T-121.06.05-I002	*F-121.06.05-A001*	The ES shall provide space for Fermilab standard garbage and recycling containers.
T-121.06.05-I003	*F-121.06.03-A003*	The ES shall provide space for maneuvering of standard 55-foot-long semi-trailers for access to the loading dock portion of the HBB.
T-121.06.05-I004	*F-121.06.03-A001*	The ES shall provide parking spaces for minimum of eight (8) vehicles.
T-121.06.05-I005	*F-121.06.03-A001*	The ES shall be provided with general lighting to achieve an average of 2 foot-candles.

7. Design Requirements

The design of the work will be done in accordance with recognized engineering practices and design standards and will comply with the applicable portions of the U.S. Department of Energy and the State of Illinois codes, orders and regulations as incorporated into contract No. DE-AC02-07CH11359 between the U.S. Department of Energy and Fermi Research Alliance, LLC.

Fermilab has adopted the Necessary and Sufficient Process (NSP) for determining the Work Smart Set (WSS) of Standards which are used to determine the appropriate environment, safety and health standards used to ensure the safe and environmentally responsible operations of the Laboratory. Where no edition or "latest edition" is noted on the Work Smart Set, it is assumed that the edition in effect at the time of the acceptance of this Project Plan will be used.

As a minimum, the system shall abide by the following:

Fermilab ES&H Manual (FESHM)
• FESHM Chapter 2000 – Planning for Safe Operations
• FESHM Chapter 5000 – Mechanical, Cryogenic and Structural Safety
• FESHM Chapter 6000 – Fire Protection
• FESHM Chapter 7000 – Occupational & Subcontractor Safety
• FESHM Chapter 8000 – Environmental Protection
• FESHM Chapter 9000 – Electrical Safety
• FESHM Chapter 10000 – Material Handling and Transportation
• FESHM Chapter 11000 – Radiation Safety
• FESHM Chapter 12000 – Quality Assurance
Fermilab Radiological Control Manual (FRCM)
DOE Orders and Standards
• DOE Order 430.2B – Departmental Energy, Renewable Energy and Transportation Management
• DOE STD-1066-99 – Fire Protection Design Criteria
• DOE Guide 420.1-2 – Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Non-Nuclear Facilities
• DOE Order 430.1B – Real Property Asset Management
• DOE Order 436.1 – Departmental Sustainability

• DOE Order 413.3 - Program and Project Management for the Acquisition of Capital Assets
Building Codes and Design Standards
• International Building Code (IBC)
• International Fire Code
• NFPA 101
• International Mechanical Code (IMC)
• NFPA 55 – Compressed Gases and Cryogenic Fluids Code
• NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating
• NFPA 90B – Standard for the Installation of Warm Air Heating and Air Conditioning Systems
• ASHRAE 90.1 – Energy Standards for Buildings
• ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality
• ANSI/ASME B31.3 – Process Piping
• ANSI 31.9 – Building Services Piping
• NFPA 13 – Standard for the Installation of Sprinkler Systems
• NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances
• NFPA 70 – National Electrical Code
• NFPA 70E – Standard for Electrical Safety in the Workplace
• NFPA 72 – National Fire Alarm Code
• NFPA 110 – Emergency and Standby Power Systems
• NFPA 80 – Fire Doors and Fire Windows
• ANSI 17.1 Safety Code for Elevators and Escalators
• ICC/ANSI A117.1 – Standard for Accessible and Usable Buildings and Facilities Illinois Accessibility Code
• ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) – 2004 will be used for those areas of facility not exempted by Fermilab policy
• Illinois Accessibility Code
• Illinois Plumbing Code and Standard Specifications for Water & Sewer Main Construction in Illinois

Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.