Conventional Facilities

Steve Dixon
DOE Independent Project Review of PIP-II
15 November 2016

Charge Item: #4

Steve Dixon

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

Outline

- Construction Phase Scope of Work
- R&D Phase Goals
- R&D Status
- R&D Schedule to Complete
- IIFC Interface
- Summary

Construction Phase Scope of Work

- Conventional Facilities to Support PIP-II:
  - Site Work
    - Utilities (electrical, communication, ICW, DWS, sanitary, chilled water);
    - Site Improvements (roads, parking area, hardstands, tank foundations);
  - Linac
    - Below Grade Enclosure;
    - Linac Service Building;
  - Transport Line
    - Transport Line Enclosure;
    - Beam Absorber Enclosure;
    - Connection to existing Booster;
  - Cryo Plant Building
  - Mechanical Plant

R&D Phase Goals

- Conceptual Design:
  - Conceptual Design Report Text;
  - Conceptual Design Drawings;
- Life Safety Analysis
- Support Analysis of Alternates
- Support NEPA Process
- Prepare for CD-1
  - R&D Phase resource loaded schedule
  - Construction Phase resource loaded schedule
- Prepare for CD-2/3a
  - Advanced Preliminary Design for Site Prep work
  - Advanced Preliminary Design for Cryo Plant Building

R&D Phase Goals and Status

- Conceptual Design:
  - Conceptual Design Report Text; - Draft Complete
  - Conceptual Design Drawings; - 95% Complete [1]
- Life Safety Analysis - Draft Complete [2]
- Support Analysis of Alternates – Complete
- Support NEPA Process - Ongoing
- Prepare for CD-1 – Ongoing
  - R&D Phase resource loaded schedule - Complete
  - Construction Phase resource loaded schedule – Ongoing
- Prepare for CD-2/3a – Not started
  - Detailed Design for Site Prep work
  - Detailed Design for Cryo Plant Building

Charge Item: #1

Charge Item: #1

Charge Item: #5

Charge Item: #2

[1] – Conceptual Design Drawings can be found in TeamCenter ED0005473

[2] – Draft LSA can be found at PIP-II-doc-120

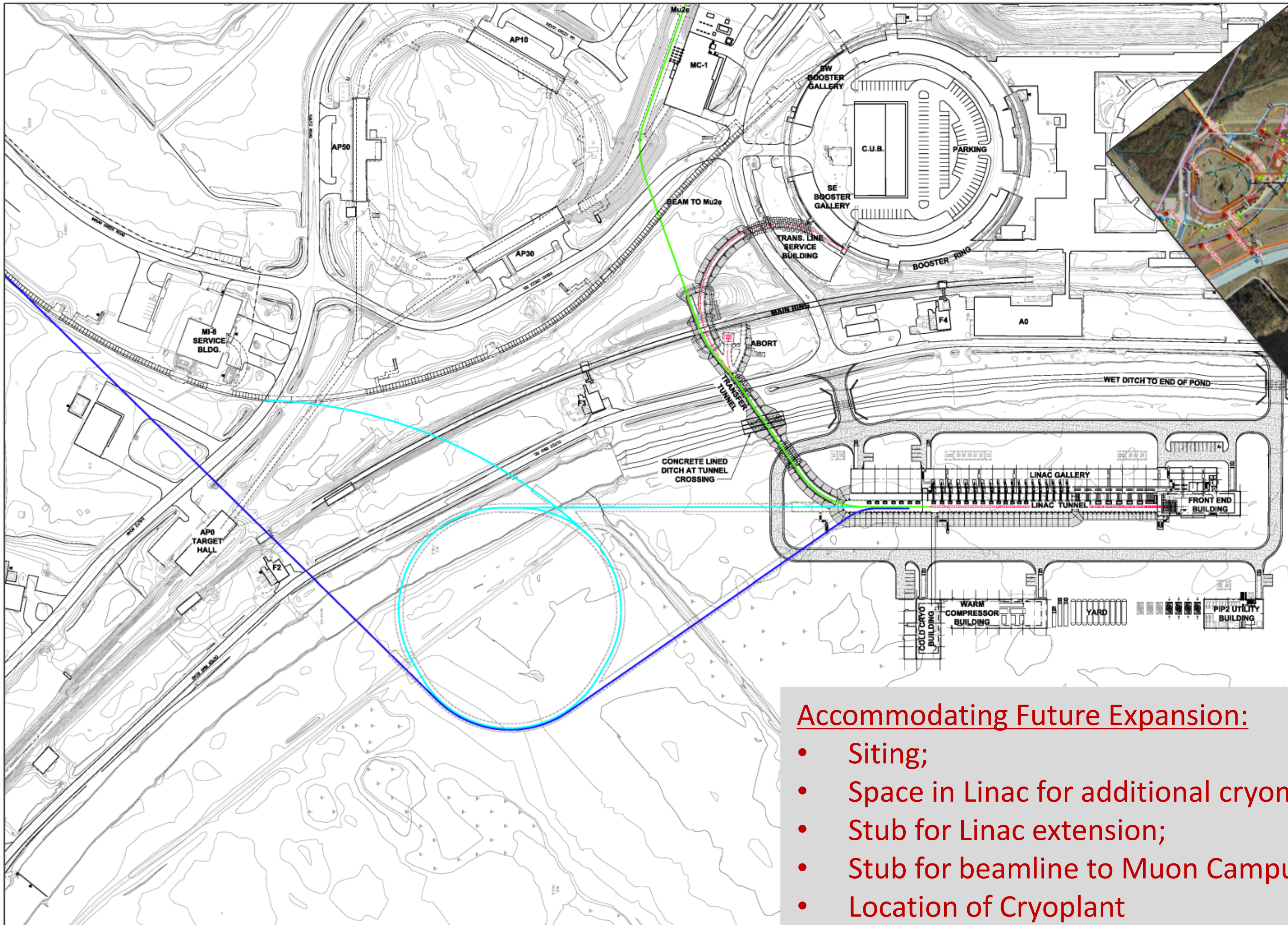
Conceptual Design Process

- Meetings with Stakeholders:
  - Goal: Document the spatial and infrastructure requirements for PIP-II facilities;
  - Started in January 2016;
  - Product was the Conceptual Design drawings and text;
- Results:
  - Developed cooling strategies for pulsed mode and continuous wave operation;
  - Conventional facilities are similar to typical Fermilab construction;
  - Backup material has additional details

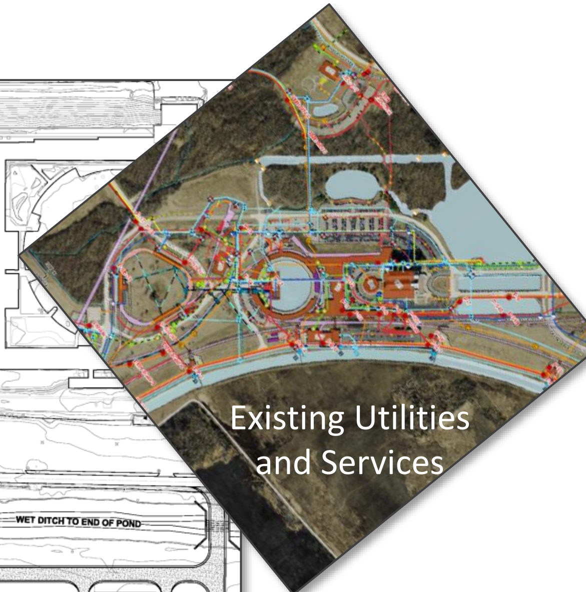
R&D Status – Overview

Fermilab PIP-II

R&D Status – Siting Considerations



Site Plan with Possible Future Expansion



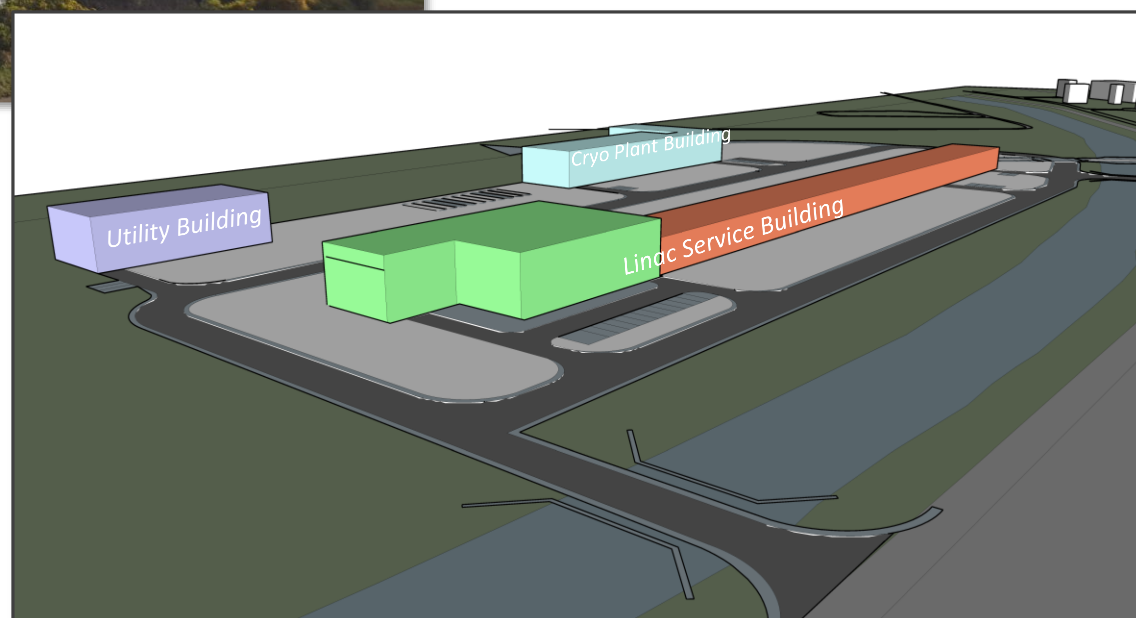
<u>Accommodating Future Expansion:</u>

- Siting;
- Space in Linac for additional cryomodules;
- Stub for Linac extension;
- Stub for beamline to Muon Campus;
- Location of Cryoplant
- Size of Linac Enclosure (ongoing)

R&D Status

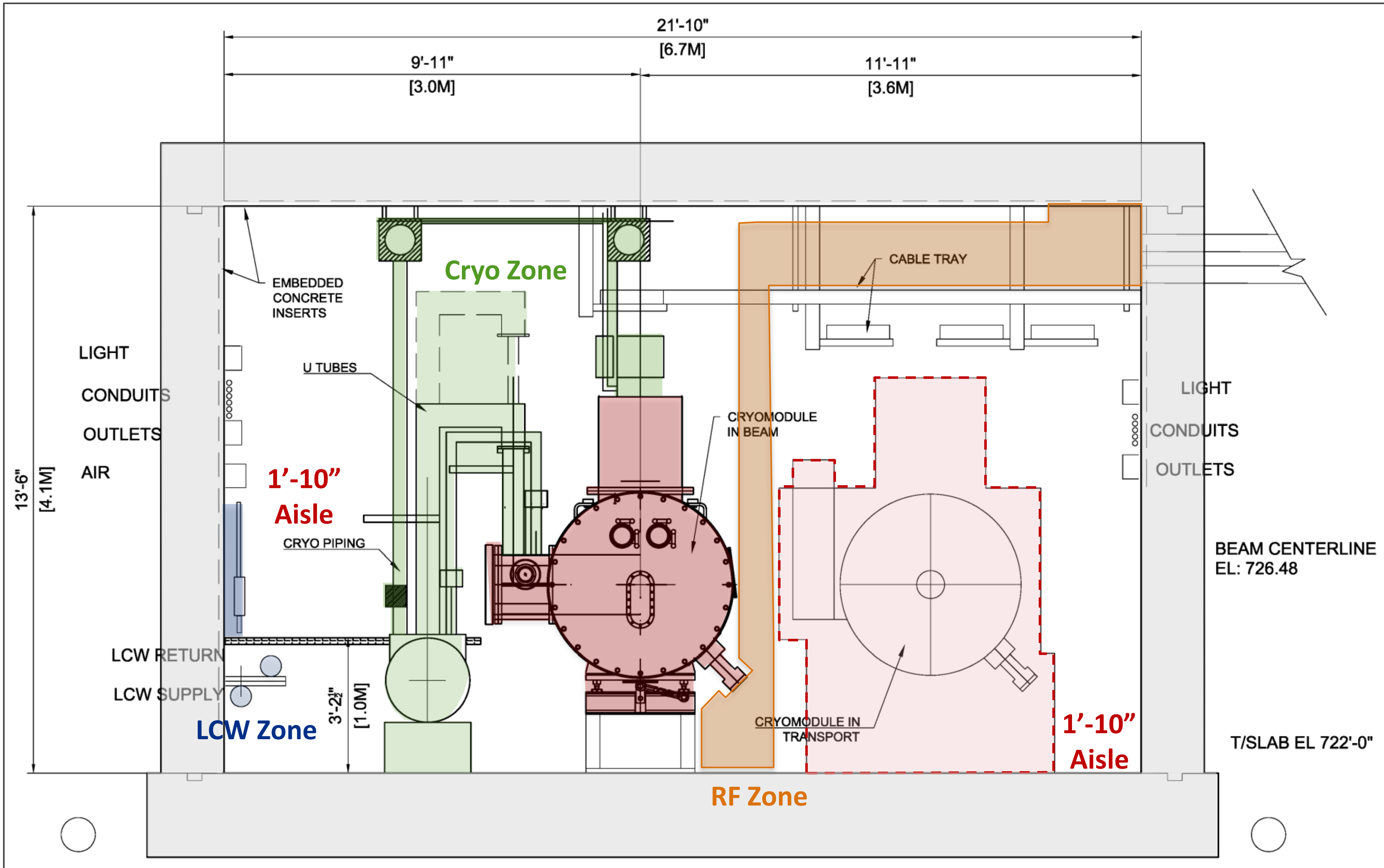
Looking Southeast From Wilson Hall

Looking South Along Beamline

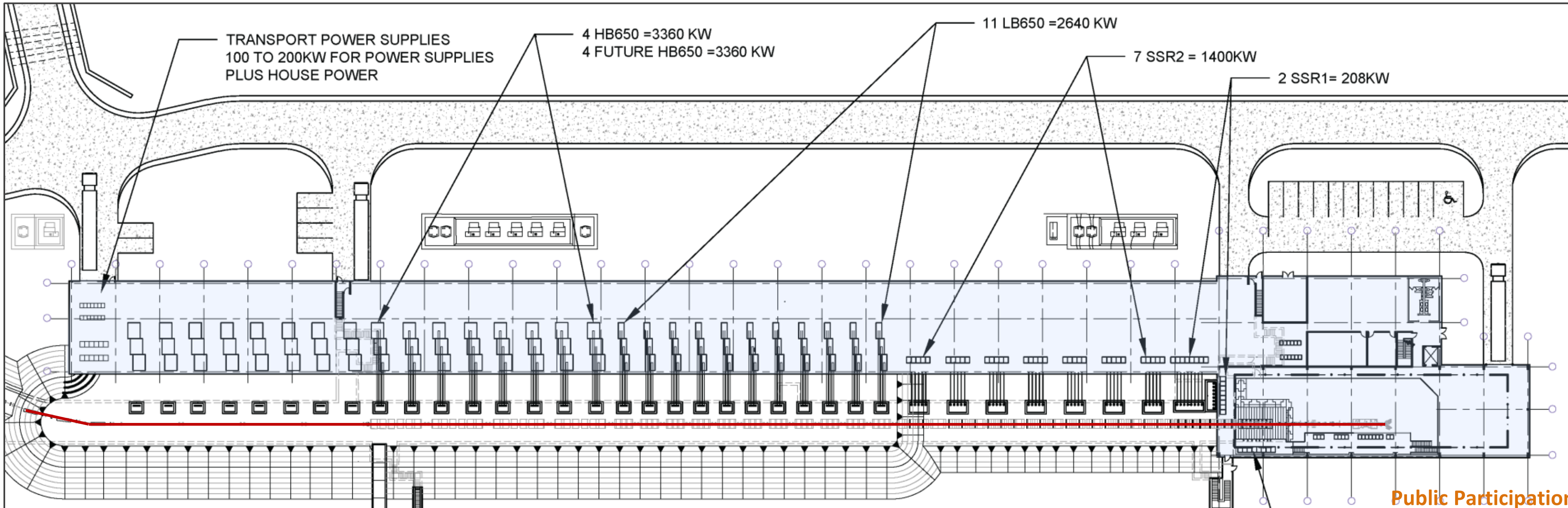


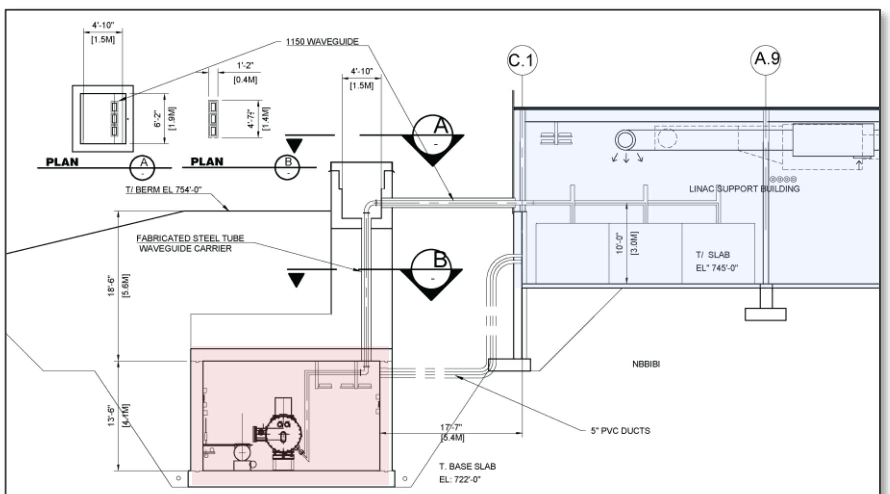
Surface Building Massing

R&D Status
Typical Linac Cross Section

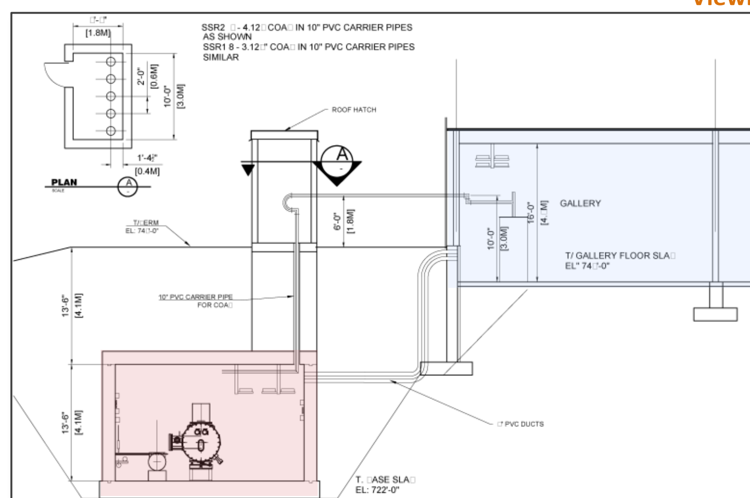


R&D Status – Linac Plan



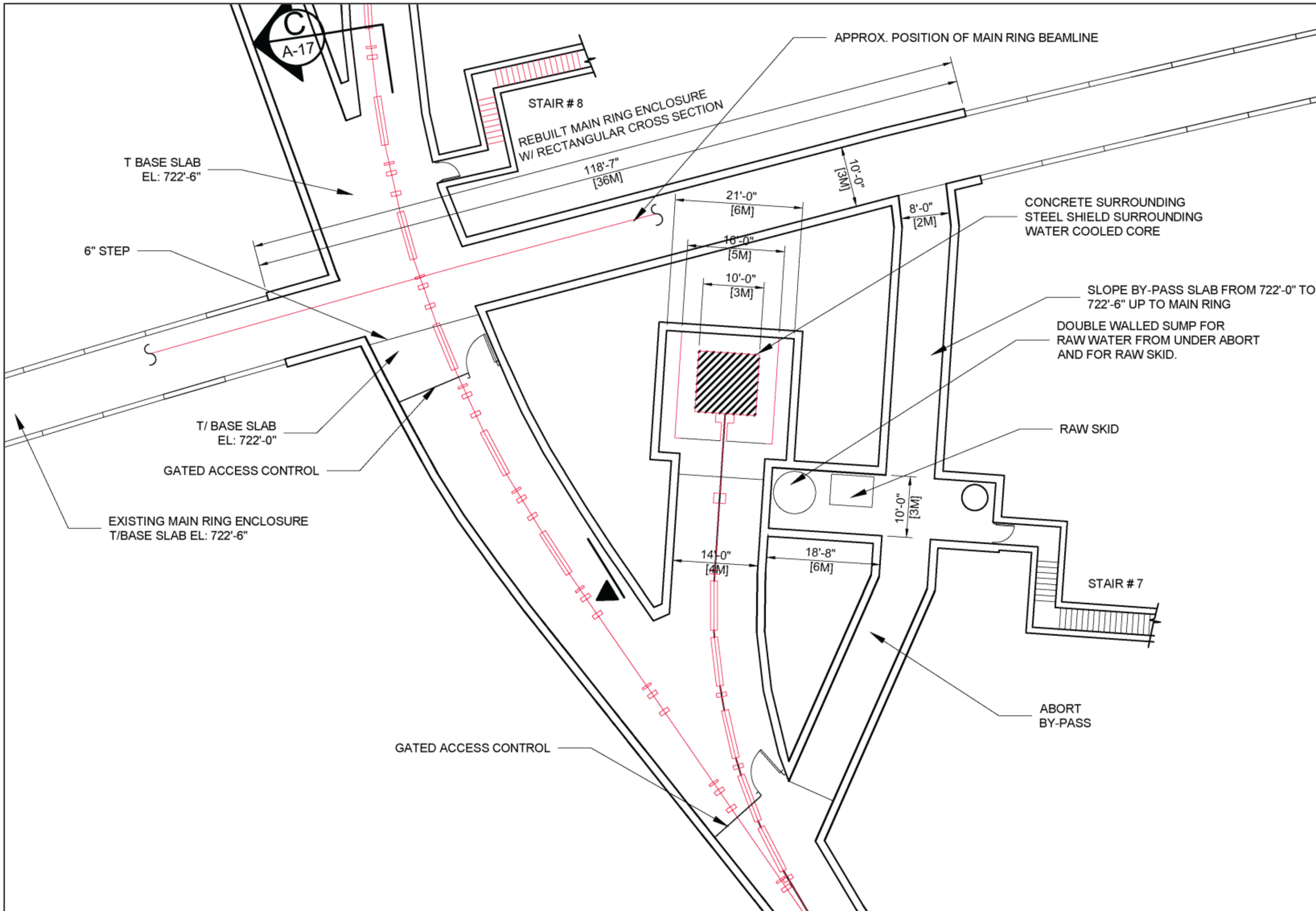


Cross Section Looking South at Waveguide Penetrations



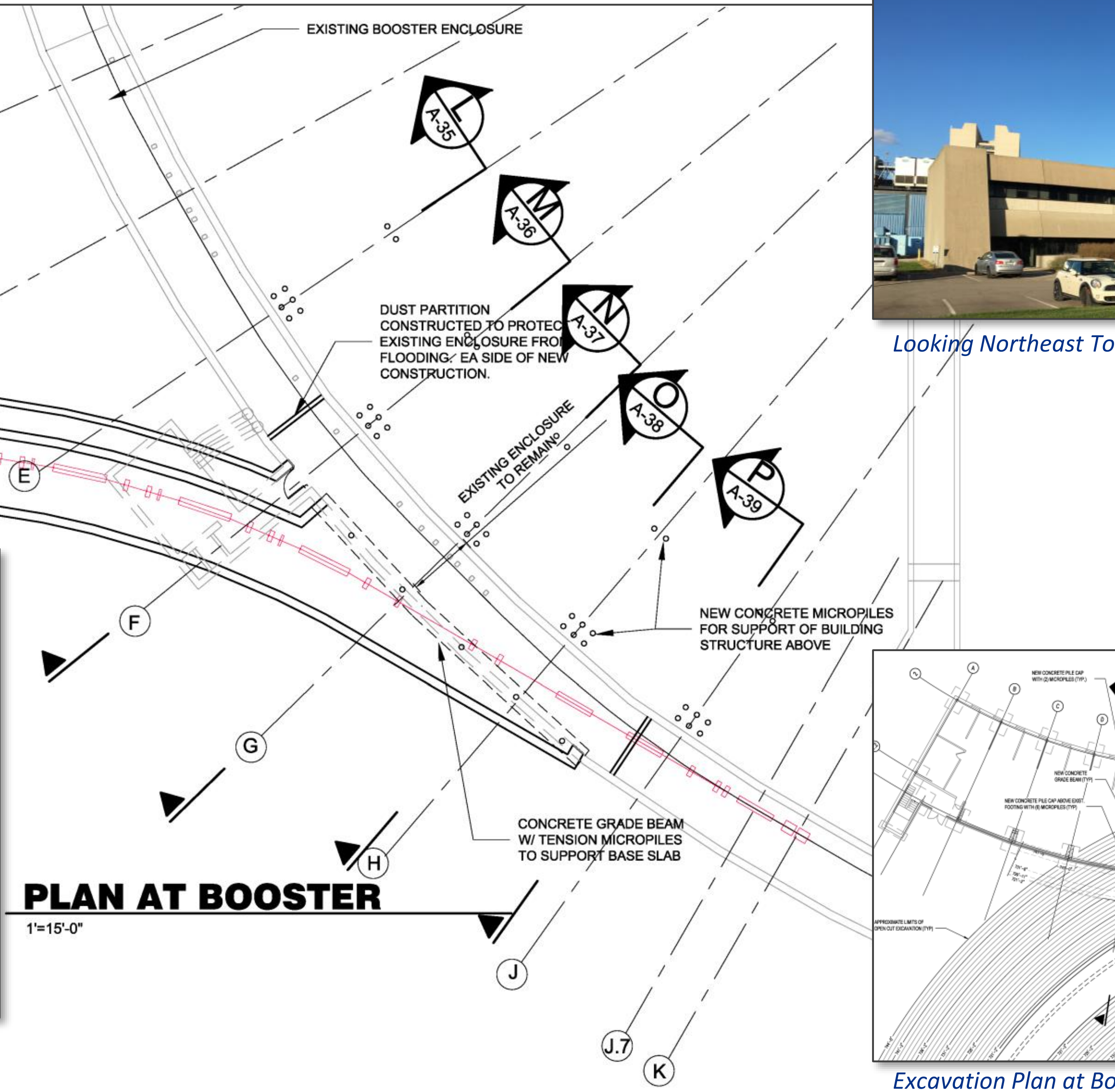
Cross Section Looking South at Coax Penetrations

R&D Status – Main Ring/Transport Line



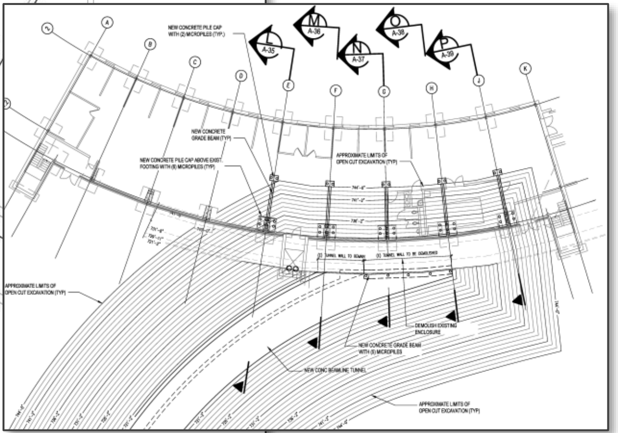
Fermilab
PIP-II

R&D Status – Transport Line/Booster



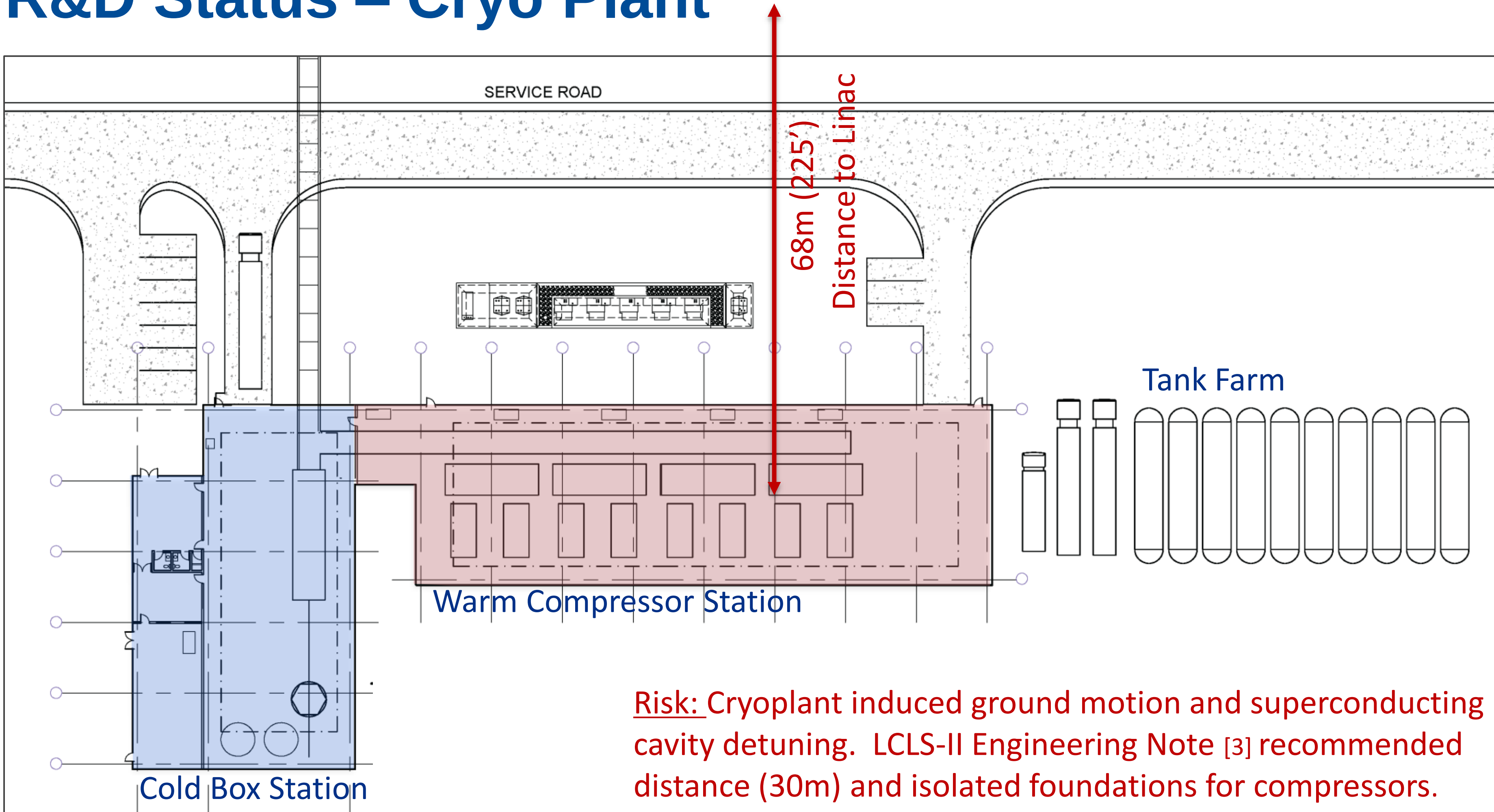
Looking Northeast Towards Booster Tower East

Booster Tower West
Shielding Upgrade - 1998



Excavation Plan at Booster Tower East

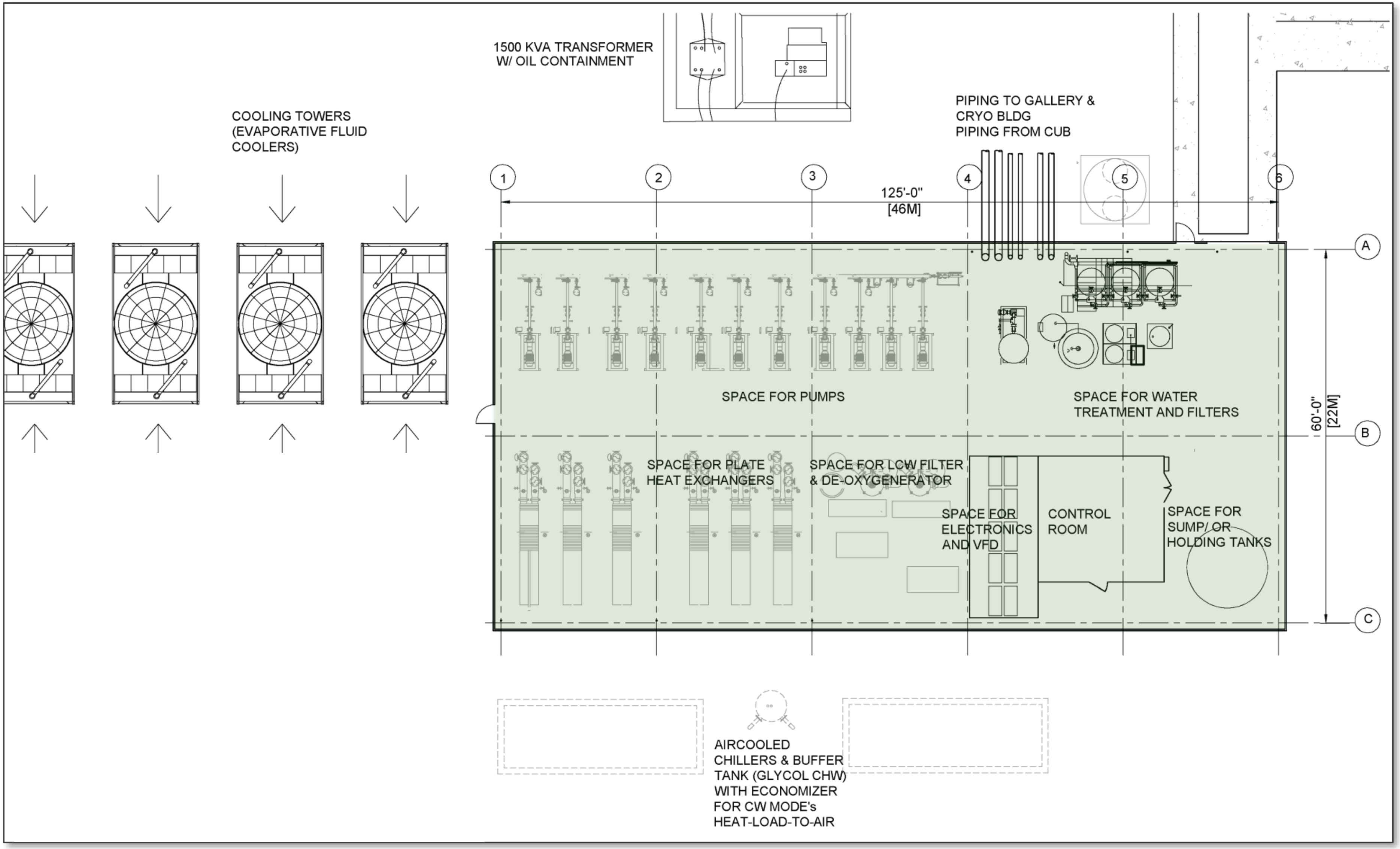
R&D Status – Cryo Plant



Risk: Cryoplant induced ground motion and superconducting cavity detuning. LCLS-II Engineering Note [3] recommended distance (30m) and isolated foundations for compressors.

[3] – Engineering Note LCLSII-4.8-EN-0326-R0 can be found at PIP-II-doc-122

R&D Status – Utility Building

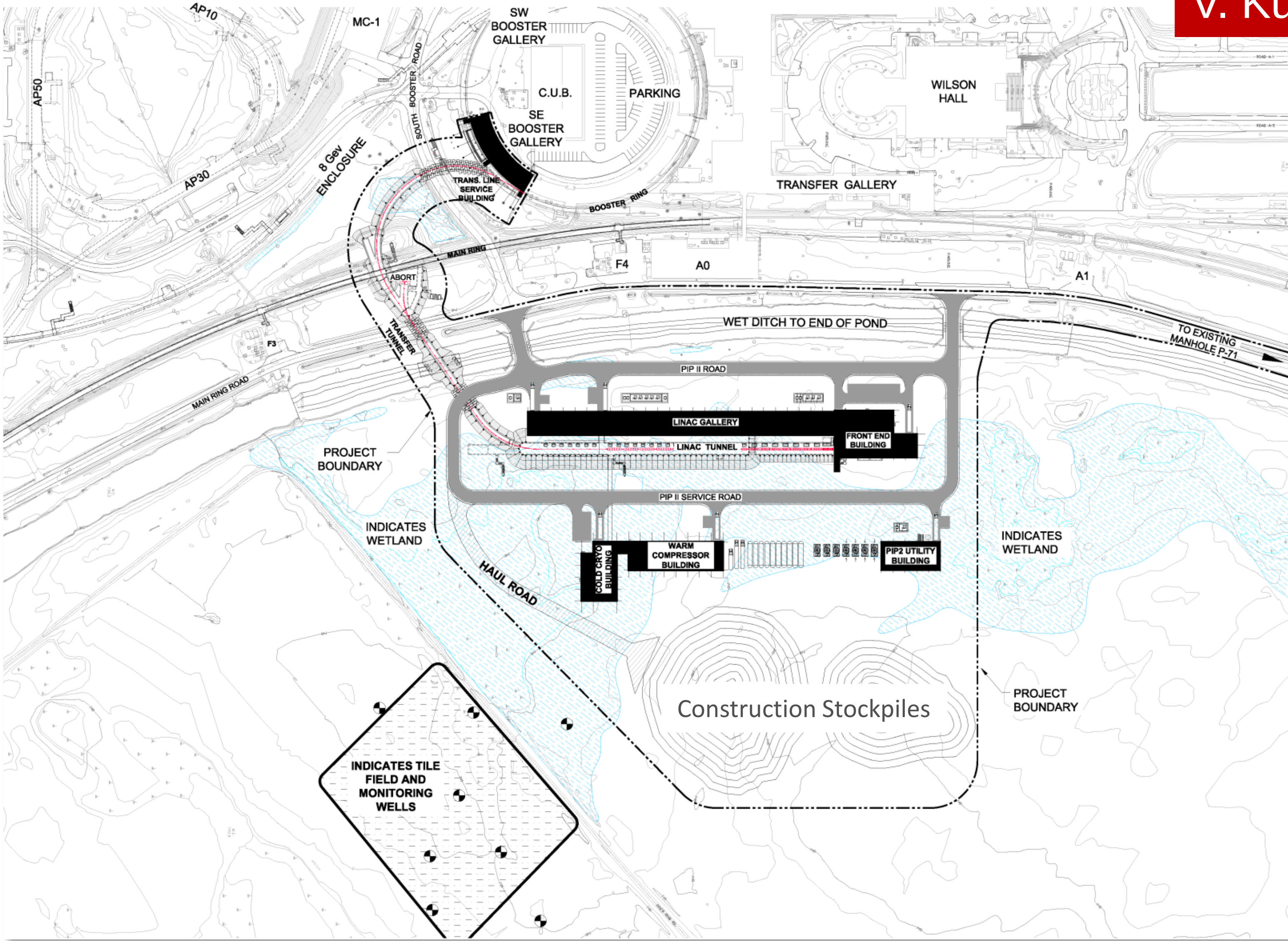


Fermilab PIP-II

R&D Status – Support NEPA

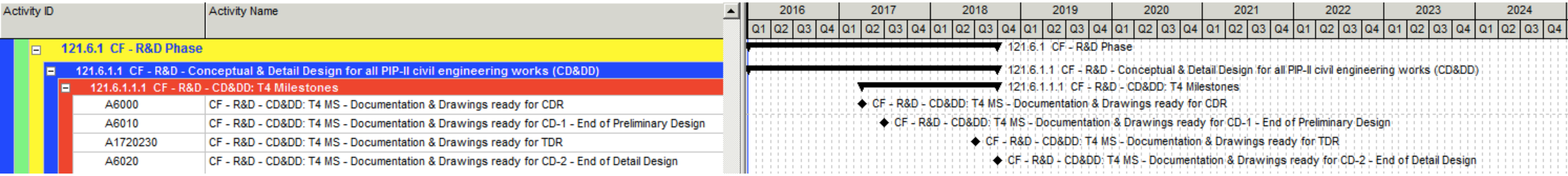
Charge Item: #5

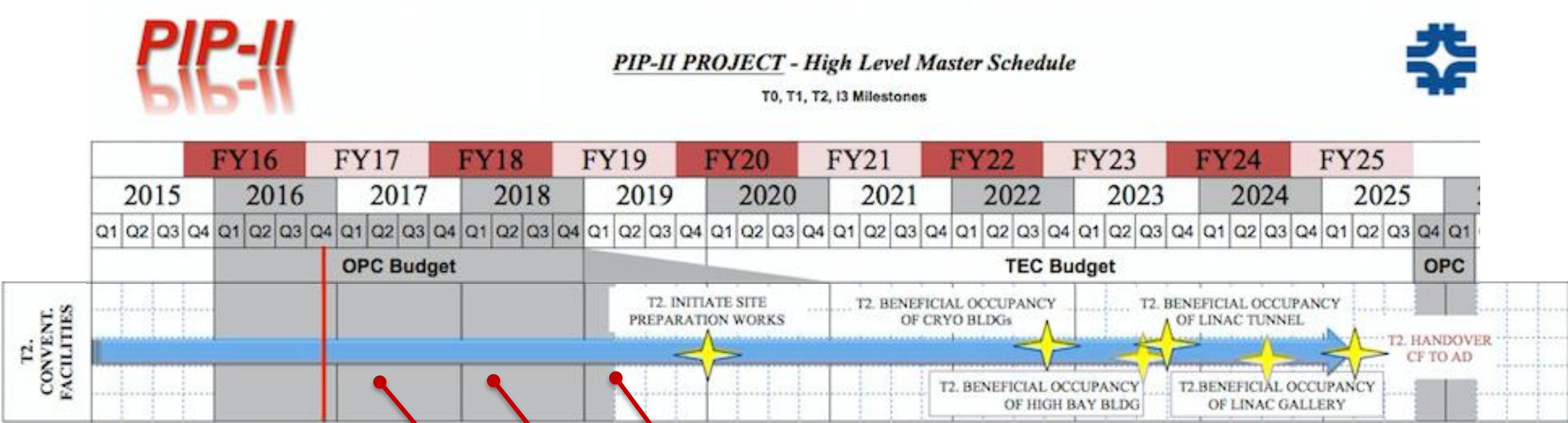
V. Kuchler



Site Plan with 2016 Wetland Delineation

R&D Phase Schedule to Complete





FY19 : Final Design begins (includes Site Prep)

FY18:Begin Detail Design for Site Prep package

FY17:Select an Architect/Engineer;

- Update the drawings;
- Refine cost estimate;

IIFC Interface

- Accommodate the cryo plant equipment
- Interface is with Cryogenics Department (Arkadiy)

Summary

- Technical Design is based in iterative discussions and meetings with stakeholders and the conceptual design of the conventional facilities can meet the specified technical performance requirements;
- The scope of the conceptual design for the conventional facilities is sufficiently well defined to support the preliminary cost and schedule estimates;
- The cost estimate will be refined in the coming month as part of the early tasking of the architect/engineer (A/E);
- To date, the conventional facilities portion has been accomplished by a combination of in-house staff supplemented with consultants. This effort will continue with an A/E firm in FY17;
- Conventional facilities has been involved with ES&H activities to date and will continue to be in the coming stages;
- The IIFC interface for the conventional facilities is primarily the cryo plant and this interface is well defined;

Backup Material

Stakeholders:

Fermilab:

Alessandro Vivoli, Anindya Chakravarty, Anthony F Leveling, Arkadiy L Klebaner

Beau F. Harrison, Curtis M. Baffes, David E Johnson, David W Peterson

Don Cossairt, Donald V Mitchell, Emil Huedem, Jim Niehoff, Fernanda G Garcia

Jerry R Leibfritz, Jerzy Czajkowski, John E Anderson Jr, Luisella Lari

Matthew Quinn, Maurice Ball, Paul Derwent, Ralph J Pasquinelli

Todd M Sullivan, Valeri A Lebedev, William A Pellico

Consultants:

Tom Lackowski, TGRWA

Ron Jedziniak, LG Associates

Rick Glenn, Jensen Hughes

Meeting Minutes (PIP-II-doc-70)

- 01 - Coordination Meeting - 17FEB16 (pdf)
- 02 - Cryogenic Department Meeting 19FEB16 (pdf) – Cryo Meeting
- 03 - Coordination Meeting - 02MAR16 (pdf) – Linac Enclosure
- 04 - Coordination Meeting - 09MAR16 R1 (pdf) – Linac Enclosure and Cooling
- 05 - Coordination Meeting - 24MAR16 R1 (pdf) – Linac Enclosure and Cryo Plant
- 06 - Cryo Coordination Meeting - 01APR16 (pdf) – ICW Cooling and Cryo
- 07 - Coordination Meeting - 14APR16 (pdf) – Penetrations and Cooling Strategy
- 08 - Coordination Meeting - 28APR16 (pdf) – Cooling Strategy
- 09 - Coordination Meeting r1 - 12MAY16 (pdf) – Shielding and Transport Line
- 10 - Coordination Meeting - 09JUN16 (pdf) – Shielding Summary
- 11 - Coordination Meeting - 07JUL16 (pdf) – RF Distribution and LCW Cooling
- 12 - Coordination Meeting - 21JUL16 (pdf) – High Bay Equipment
- 13 - Coordination Meeting - 04AUG16 (pdf) – Cryo Summary and Linac Gallery
- 14 - Coordination Meeting - 15SEP16 (pdf) – Sitewide Electrical Distribution

Drawings (TeamCenter ED0005473)

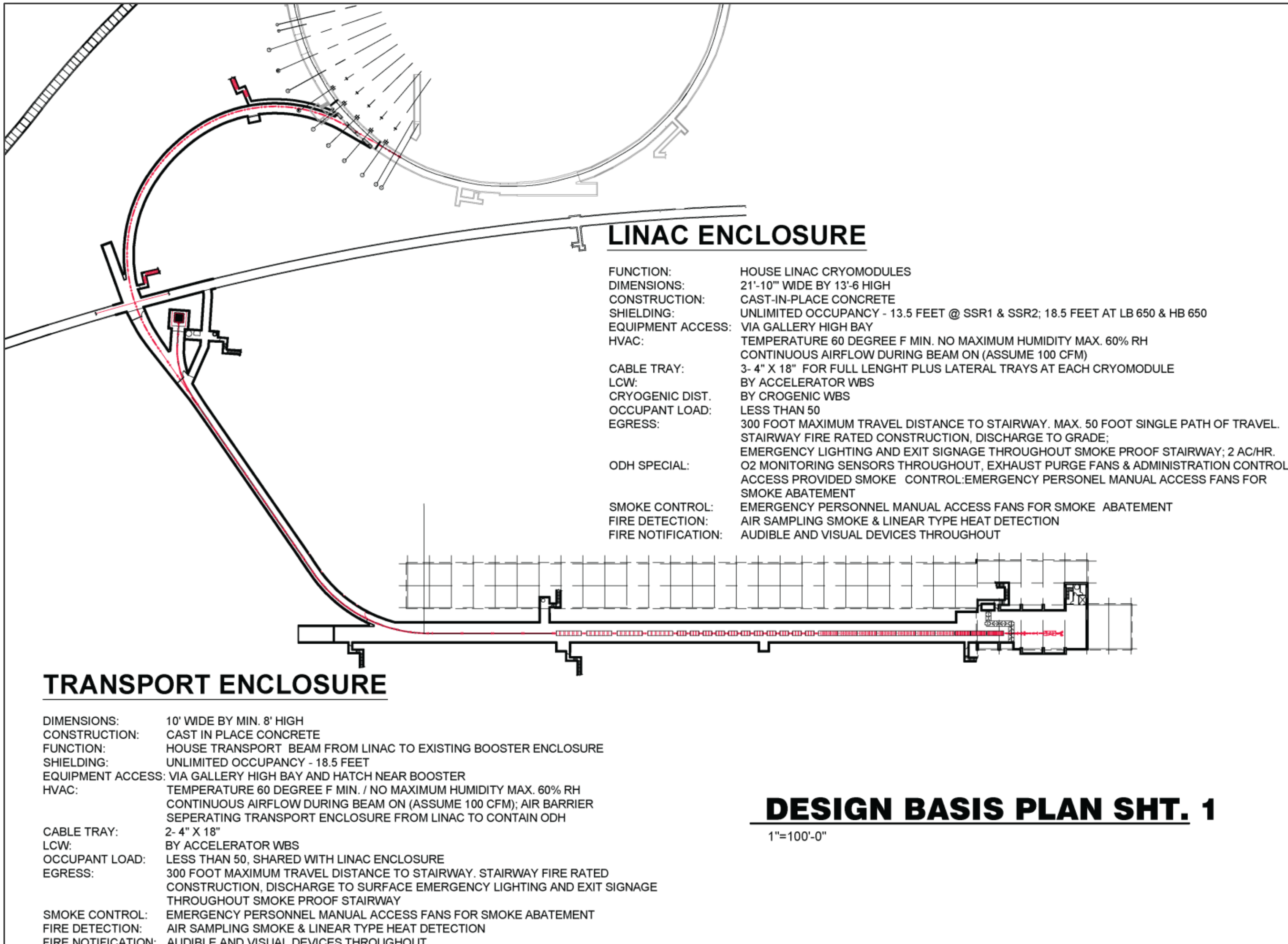
54 Drawings

- One (1) General sheet
- Six (6) Civil sheets
- Forty-Three (43) Architectural sheets
- Three (3) Mechanical sheets
- One (1) Electrical sheet

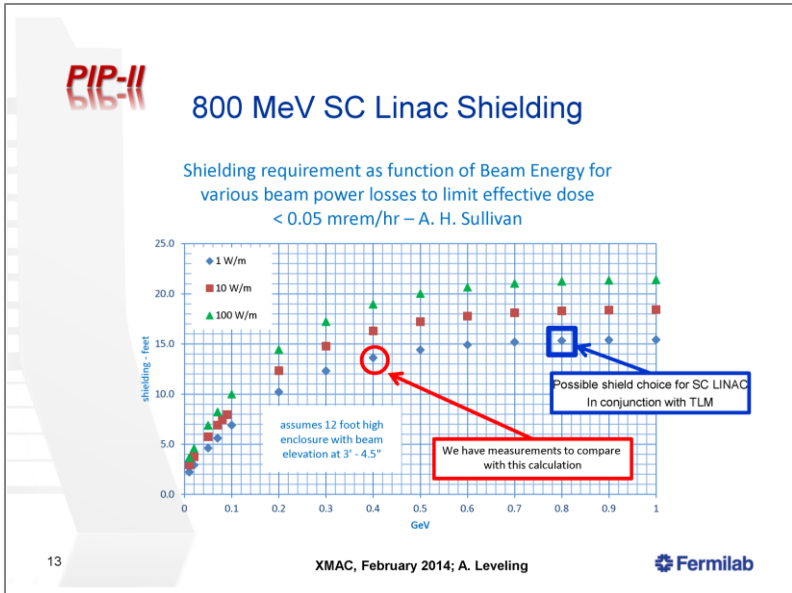
LIST OF DRAWINGS

G-1	TITLE SHEET, LIST OF DRAWINGS
C-1	SITE IMAGE
C-2	FUTURE BEAMLINES SITE PLAN
C-3	WETLANDS SITE PLAN
C-4	SITE PLAN
C-5	ENLARGED PLAN AT ABSORBER
C-6	SITE UTILITY PLAN
A-1	DESIGN BASIS - SHEET 1
A-2	DESIGN BASIS - SHEET 2
A-3	DESIGN BASIS - SHEET 3
A-4	LIFE SAFETY
A-5	ENCLOSURE KEY PLAN
A-6	LINAC ENCLOSURE PLAN - SHEET 1
A-7	LINAC ENCLOSURE PLAN - SHEET 2
A-8	LINAC ENCLOSURE PLAN - SHEET 3
A-9	LINAC ENCLOSURE PLAN - SHEET 4
A-10	TRANSPORT ENCLOSURE PLAN - SHEET 1
A-11	TRANSPORT ENCLOSURE PLAN - SHEET 2
A-12	TRANSPORT ENCLOSURE PLAN - SHEET 3
A-13	TRANSPORT ENCLOSURE PLAN - SHEET 4
A-14	TRANSPORT ENCLOSURE PLAN - SHEET 5
A-15	TYP. LINAC ENCLOSURE SECTION
A-16	TYP. TRANSPORT ENCLOSURE SECTION
A-17	ELEVATION AT MAIN RING CROSSING
A-18	PIP II CAMPUS PLAN
A-19	LINAC SUPPORT BUILDING KEY PLAN
A-20	LINAC SUPPORT BUILDING PLAN - SHEET 1
A-21	LINAC SUPPORT BUILDING PLAN - SHEET 2
A-22	LINAC SUPPORT BUILDING PLAN - SHEET 3
A-23	LINAC SUPPORT BUILDING PLAN - SHEET 4
A-24	LINAC SUPPORT BUILDING PLAN - SHEET 5
A-25	SOUTHEAST BOOSTER BUILDING - DEMO PLAN
A-26	SOUTHEAST BOOSTER BLDG. - EXCAVATION PLAN
A-27	SOUTHEAST BOOSTER BUILDING - PLAN
A-28	SECTION THRU RECEIVING
A-29	CROSS SECTION THRU HIGH BAY
A-30	CROSS SECTION @ HWR
A-31	SECTION THRU HIGH BAY
A-32	SECTION @ COAX FOR SSR1, SSR2
A-33	SECTION @ WAVEGUIDE FOR LB 650, HB 650
A-34	SECTION AT LINAC ALCOVES
A-35	SECTION SHEET - 1
A-36	SECTION SHEET - 2
A-37	SECTION SHEET - 3
A-38	SECTION SHEET - 4
A-39	SECTION SHEET - 5
A-40	CRYOGENIC PLANT
A-41	COLD BOX STATION PLAN
A-42	COMPRESSOR STATION PLAN
A-43	PIP II UTILITY PLANT PLAN
M-1	CONCEPTUAL DESIGN BASIS - SHEET 1
M-2	CONCEPTUAL DESIGN BASIS - SHEET 2
M-3	COOLING HEAT REJECTION CONCEPT
E-1	POWER SINGLE LINE DIAGRAM

Typical Design Basis Sheet

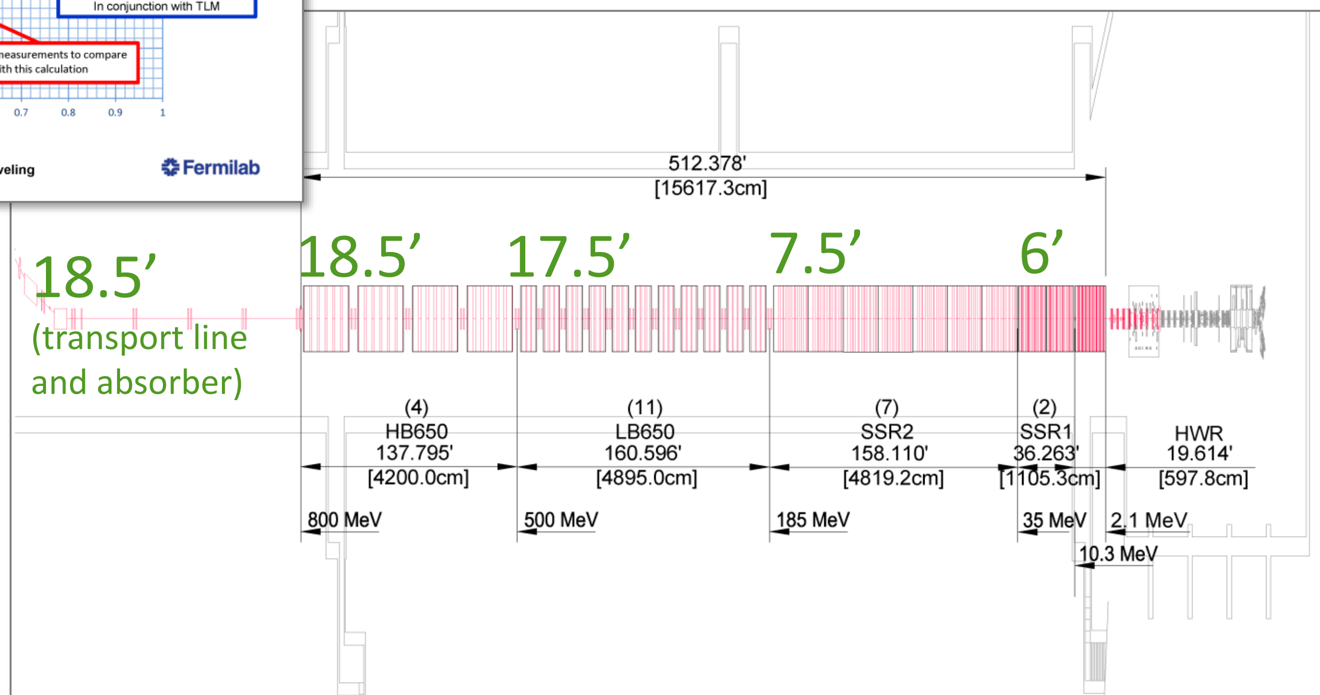


Preliminary Shielding Considerations



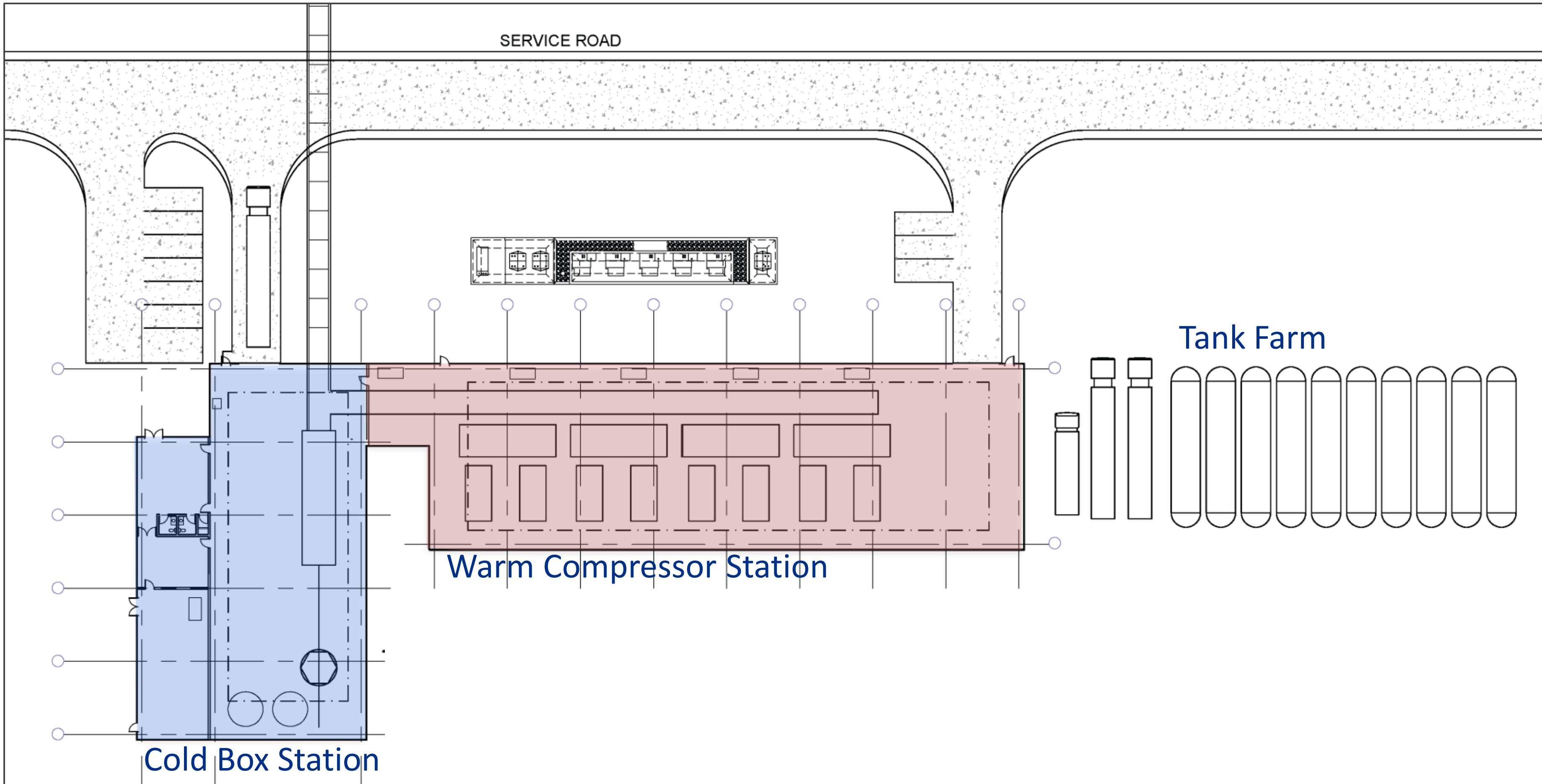
Used the 10W/m curve for the conceptual design

Preliminary Shielding Depths shown below. **Further analysis required**, especially at the Booster.



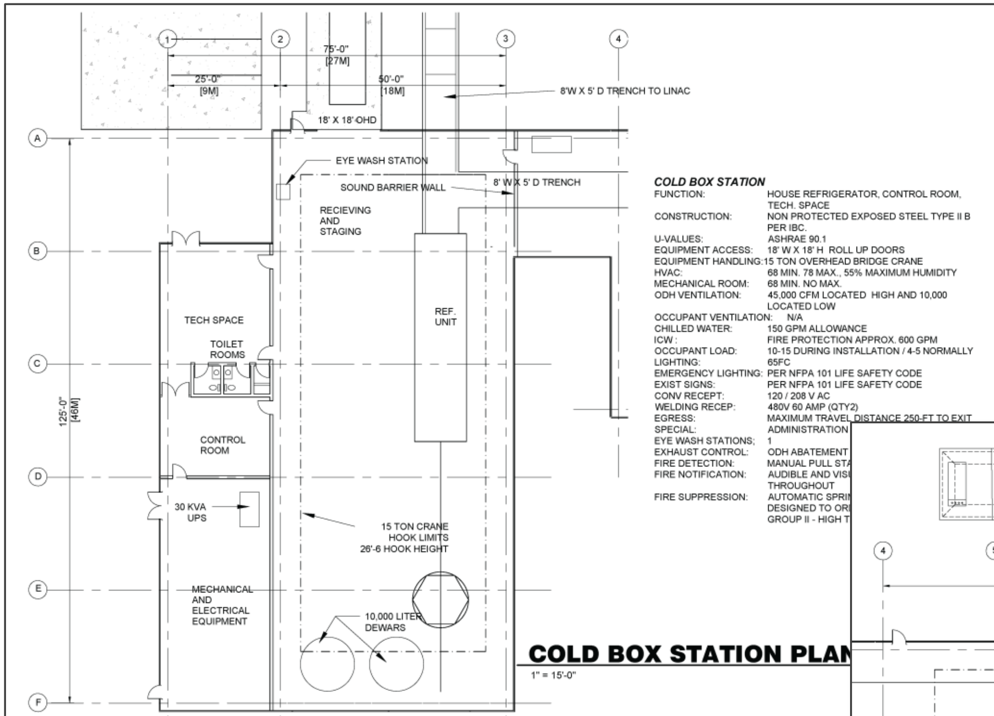
Thanks to D. Cossairt, T. Leveling and M. Quinn

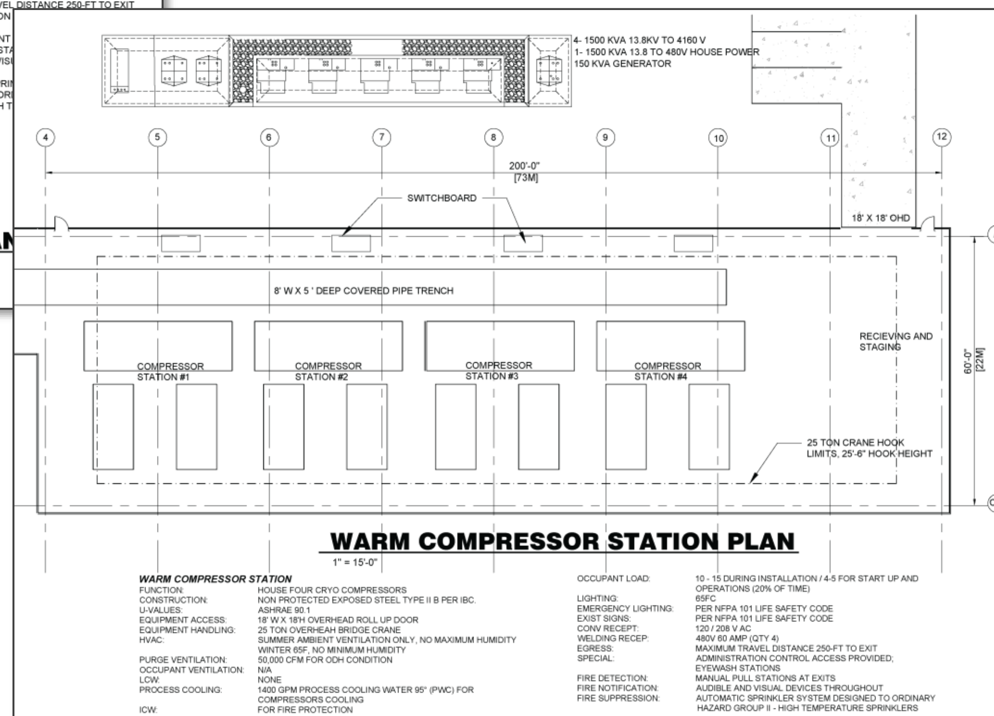
Cryo Plant



SERVICE ROAD
Tank Farm
Warm Compressor Station
Cold Box Station

Cryo Plant





Fermilab

PIP-II

Cryo Plant Cooling Requirements

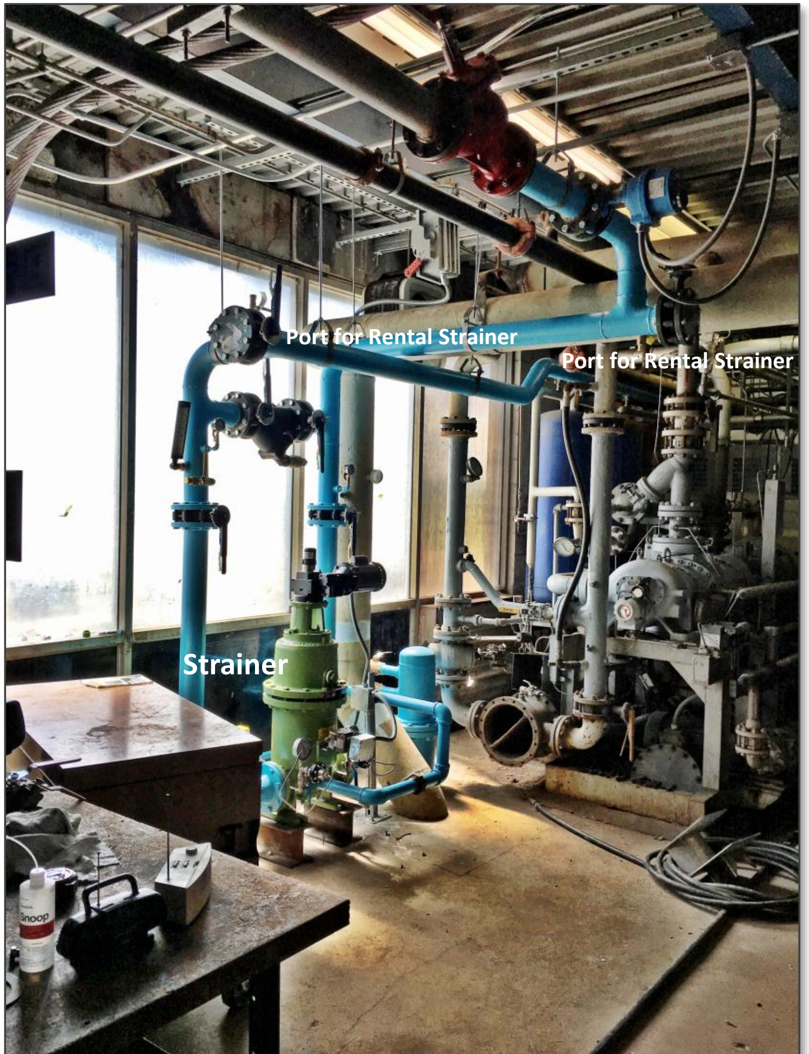
- Water Requirements
  - 1,200 – 1,500 gpm flow
- Pond System
  - Chemical characteristics met by Pond system;
  - Solids content characteristics NOT met by Pond system;
  - No Pond - ~$500-$700k per acre;
- ICW System
  - Chemical characteristics met by existing ICW system;
  - Solids content characteristics NOT met by ICW system;
  - Sampling ICW;

Cryo Plant – Water Quality Requirements

		PIP-II Requirements		Water Analysis Report		
Desription	**Unit**	**Closed loop**	**Open loop**	Range	Units	
pH value		7.5 - 9.0	7.5 - 9.0	7.82 - 7.89		
Hardness	[dH]	< 20	< 20	20.79 - 23.02	ppm CaCO3	*1 dH = 17.848 mg CaCO3*
Carbonate hardness	[dH]	< 20	< 4	0.96 - 1.02	Ca/Mg ratio	
Chloride (Cl)	[mg/l]	< 100	< 100	5-15	ppm	
Dissolved iron (Fe)	[mg/l]	< 0.2	< 0.2	0.04 - 0.01	ppm	*1 ppm = 1 milligram/liter*
Sulphate (SO_4)	[mg/l]	< 200	< 200	84.51 - 115.51	ppm	
Sulfide (S_{2-})	[mg/l]	< 0.1	< 0.1			*Future water analysis*
Silicic acid (SiO_2)	[mg/l]	< 200	< 200	10.63 - 11.56	ppm	
HCO_3 / SO_4	-	> 1	> 1			*Future water analysis*
Electrical conductivity	[µS/cm]	10 - 800	10 - 1500			*Future water analysis*
Ammonium (NH_4)	[mg/l]	< 1	< 1			*Future water analysis*
Dissolved manganese (Mn)	[mg/l]	< 0.2	< 0.1	0.00	ppm	
Phosphate (PO_4)	[mg/l]	< 15	< 15			*Future water analysis*
Glycol	[%]	20 - 40	-			*Future water analysis*
Solids (particle size)	[mm]	< 0.1	< 0.1	**?**	**?**	**Requires Further Investigation**
Solids (particle amount)	[mg/l]	< 10	< 10	**?**	**?**	**Requires Further Investigation**
Appearance		clear, colorless	clear, colorless			
Total bacterial count	[CFU/ml]	$< 10^4$	$< 10^4$	**?**	**?**	**Requires Further Investigation**
Proportion of non-dissolved solids	[ppm]	< 20	< 20	**?**	**?**	**Requires Further Investigation**
Algae		- not allowed	- not allowed	**?**	**?**	**Requires Further Investigation**
Magnesium				189.46 - 204.43	ppm CaCO3	
Calcium				181.52 - 206.42	ppm CaCO3	
Copper				0.00 - 0.01	ppm	
Total Phosphorus				0.06 - 0.13	ppm	
Zinc				0.0 - 0.01	ppm	
Sodium				23.84 - 34.98	ppm	
Molybdate				0.01 - 0.3	ppm	
Boron				0.55 - 0.65	ppm	
Aluminum				0.02 - 0.03	ppm	

Thanks to A. Klebaner and A. Chakravarty

Cryo Plant – Water Quality Test Stand



- Installed as part of the Mu2e Cryo work for CDF;
- Installed test ports to sample the ICW before and after the strainer;
- Includes a Adams strainer with “standard” slot sizes (baseline);
- Two month rental of a Lakos strainer to reduce the solids;
- Replacement filter elements in Adams strainer with smaller slot size;
- Arranged for FESS/O water testing service to increase the testing to include solids;
- Scheduled testing on same duration as CUB;
- Compare strainer options with water quality requirements.

BZero Compressor Building

PM vs. CW Considerations

- Driven by duty factor of the equipment
  - 15% for Pulsed Mode
  - 100% for Continuous Wave Mode
- Common For Both Modes
  - Physical arrangement of heat producing equipment;
  - Electrical power supply (not usage);
  - Conventional Facilities handles the heat load to air (HLA);
- Difference is Primarily Cooling
  - 5.0 mw in pulsed mode;
  - 10.5 mw in continuous wave mode;

PM vs. CW Considerations - Cooling

Heat Loads	Pulsed Mode (MW)	Continuous Wave Mode (MW)
Low Conductivity Water (LCW)	1.65	7.07
Cryoplant Cooling (Cryo)	3.4	3.4
Total (MW)	**5.05**	**10.47**

Basis for Estimate

	Industrial Cooling Water (ICW)	Cooling Ponds (PW)	Towers (close)	Towers (open)
Pulsed Mode	*MW to GPM Conversion 682.79* LCW 1,125 gpm Cryo 1,400 gpm @17 Fdt 2,525 gpm	*MW to Acres Conversion 800kw/acre* LCW 1.98 acres Cryo 4.08 acres 6.06 acres	LCW 1.0 towers Cryo 2.0 towers 3.00 towers *exclude standby*	LCW 1.0 towers Cryo 1.0 towers 2.00 towers *exclude standby*
CW Mode	*MW to GPM Conversion 682.79* LCW 4,827 gpm Cryo 1,400 gpm @17 Fdt 6,227 gpm	*MW to Acres Conversion 800kw/acre* LCW 8.48 acres Cryo 4.08 acres 12.56 acres	LCW 4.0 towers Cryo 2.0 towers 6.00 towers *exclude standby*	LCW 2.0 towers Cryo 1.0 towers 3.00 towers *exclude standby*
	Other Considerations *Strainers, Drought Conditions*	*Other Considerations* *Strainers, Heat Exchangers, Treatment* *Drought Conditions*	*Other Considerations* *Heat Exchangers, Treatment, Make Up* *Building Costs*	*Other Considerations* *Heat Exchangers, Treatment, Make Up* *Building Costs*

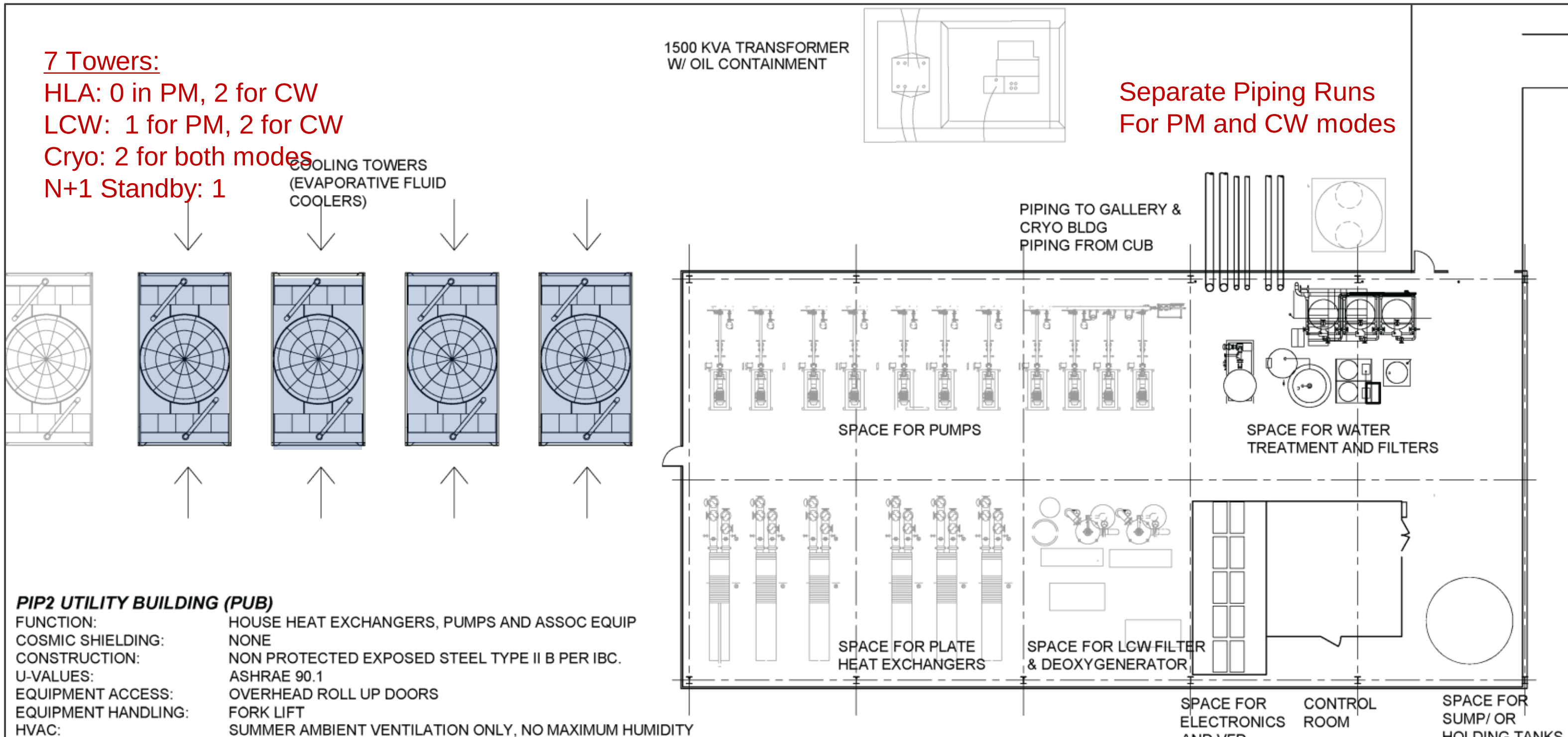
Note: 1,400 gpm is the highest flow currently available from the existing ICW system

Thanks to E. Huedem

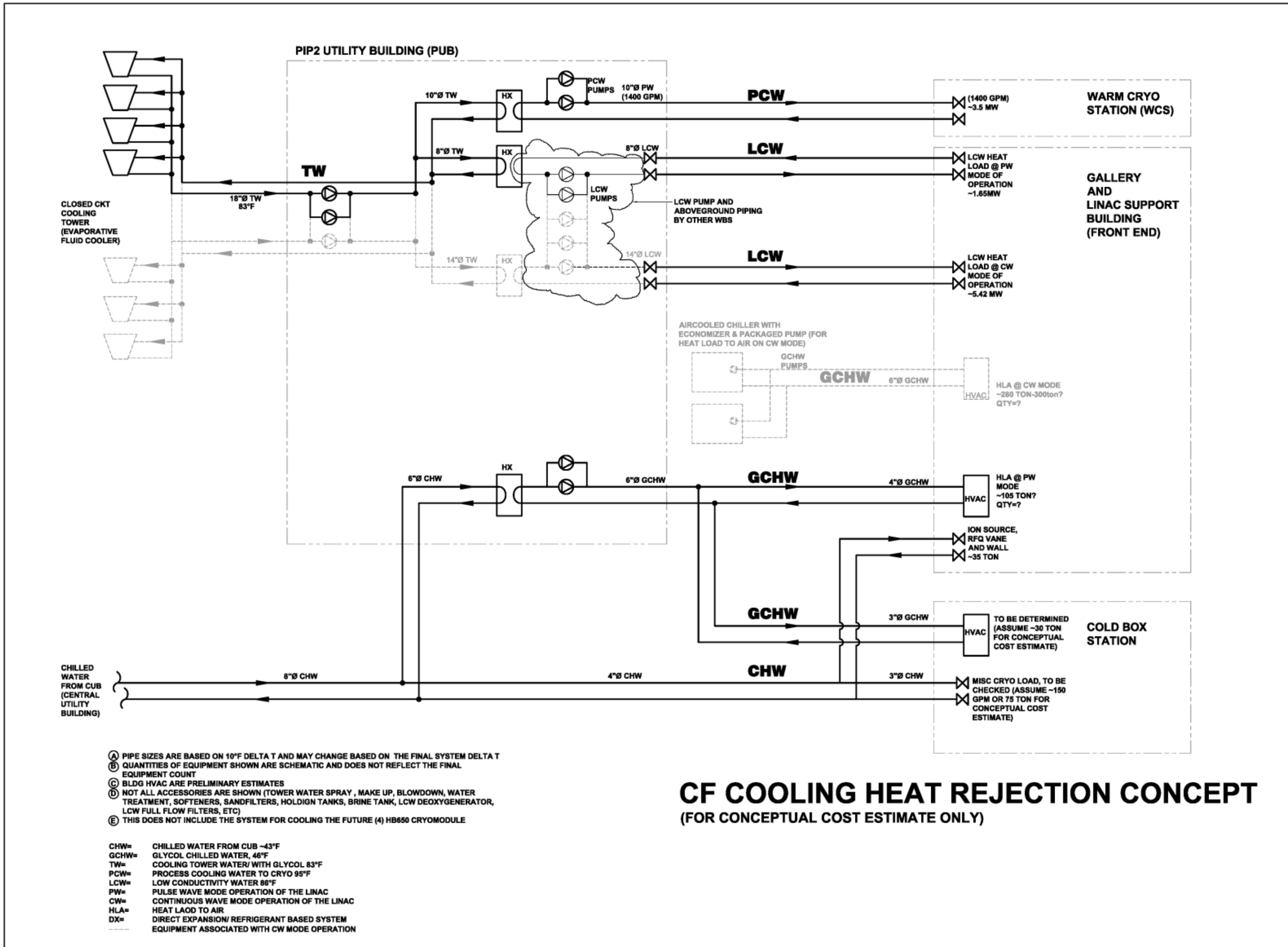
Cooling Design Approach

- Goal: Modular approach that allows for efficient operation in both modes;
- Pulsed Mode
  – Heat Load to Air (HLA): Utilize chilled water from existing CUB for equipment cooling (this utilizes the available headroom at CUB);
  – LCW: (1) Cooling tower
  – Cryo: (2) Cooling towers
- Continuous Wave Mode
  – Heat Load to Air (HLA): Install a chilled water loop to supplement the pulsed mode system with (2) cooling towers;
  – LCW: Add (1) Cooling tower
  – Cryo: No change

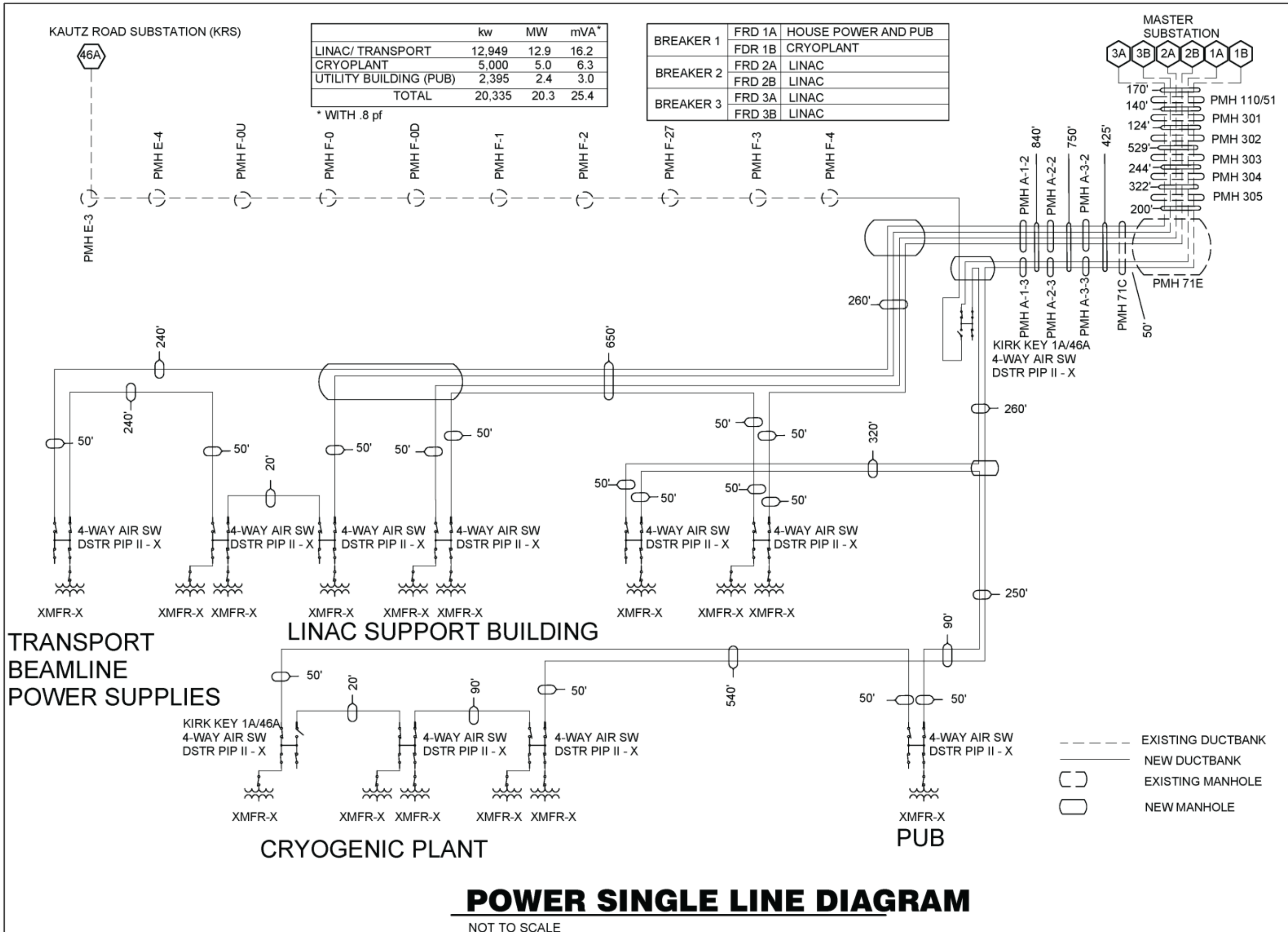
PIP-II Utility Building



Mechanical Conceptual Design



MV Electrical Conceptual Design



	kw	MW	mVA*
LINAC/ TRANSPORT	12,949	12.9	16.2
CRYOPLANT	5,000	5.0	6.3
UTILITY BUILDING (PUB)	2,395	2.4	3.0
TOTAL	20,335	20.3	25.4

* WITH .8 pf

BREAKER 1	FRD 1A	HOUSE POWER AND PUB
	FDR 1B	CRYOPLANT
BREAKER 2	FRD 2A	LINAC
	FRD 2B	LINAC
BREAKER 3	FRD 3A	LINAC
	FRD 3B	LINAC