

121.3.21 Linac - Test Infrastructure

Accelerator Support Systems

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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

- Overview
- Test Infrastructure
 - CMTS1
 - PIP2IT
 - STC
- Scope/Deliverables/Technical Progress
- Requirements
- Interfaces
- ESH&Q
- Cost
- Schedule
- Summary

About Me:

- PIP-II Manager for Test Infrastructure at Cryomodule Test Facility (CMTF)
 - WBS 121.3.21.2, 121.3.21.3
- Senior Principal Engineer, joined Fermilab in 1992
- Current responsibilities/roles
 - Project Leader for Accelerator Division SRF Test Facilities
 - CMTF - Cryomodule Test Stand #1 (CMTS1) & PIP-II Injector Test (PIP2IT)
 - Fermilab Accelerator Science and Technology facility (FAST/IOTA)
 - CMTS1 Project Manager for LCLS-II Project
 - SRF Systems Group Leader (Accelerator Division)

About Joe Ozelis:

- PIP-II Manager for Test Infrastructure at Meson Detector Building
 - Spoke Test Cryostat (STC) – WBS 121.3.21.1
- Sr. Engineering Physicist, joined Fermilab in 1989
- Previous experience/activities
 - Horizontal Test Facility Manager (HTS, STC) (current)
 - Vertical Test Stand (VTS) Area Leader (2006-2012)
 - LHC/SSC Magnet & Detector Programs (1989-2000)
 - Test Facility Coordinator, QA Group Leader (SNS @ JLab, 2000-2006)
 - Cryomodule Project Engineer, Sr. SRF Coordinator (MSU/FRIB, 2012-2014)

Scope: WBS Dictionary

- WBS Dictionary: pip2-docdb #599

121.3.21 Linac - Test Infrastructures (TI)

This WBS entry covers design, procurement, fabrication and testing/commissioning of the test infrastructure necessary for the project. Included are CMTS1 (modifications for 650 MHz operation to the Cryomodule Test Stand in the Cryomodule Test Facility), PIP2IT (the injector Test facility at CMTF), and STC (the spoke test cryostat at Meson Detector building).

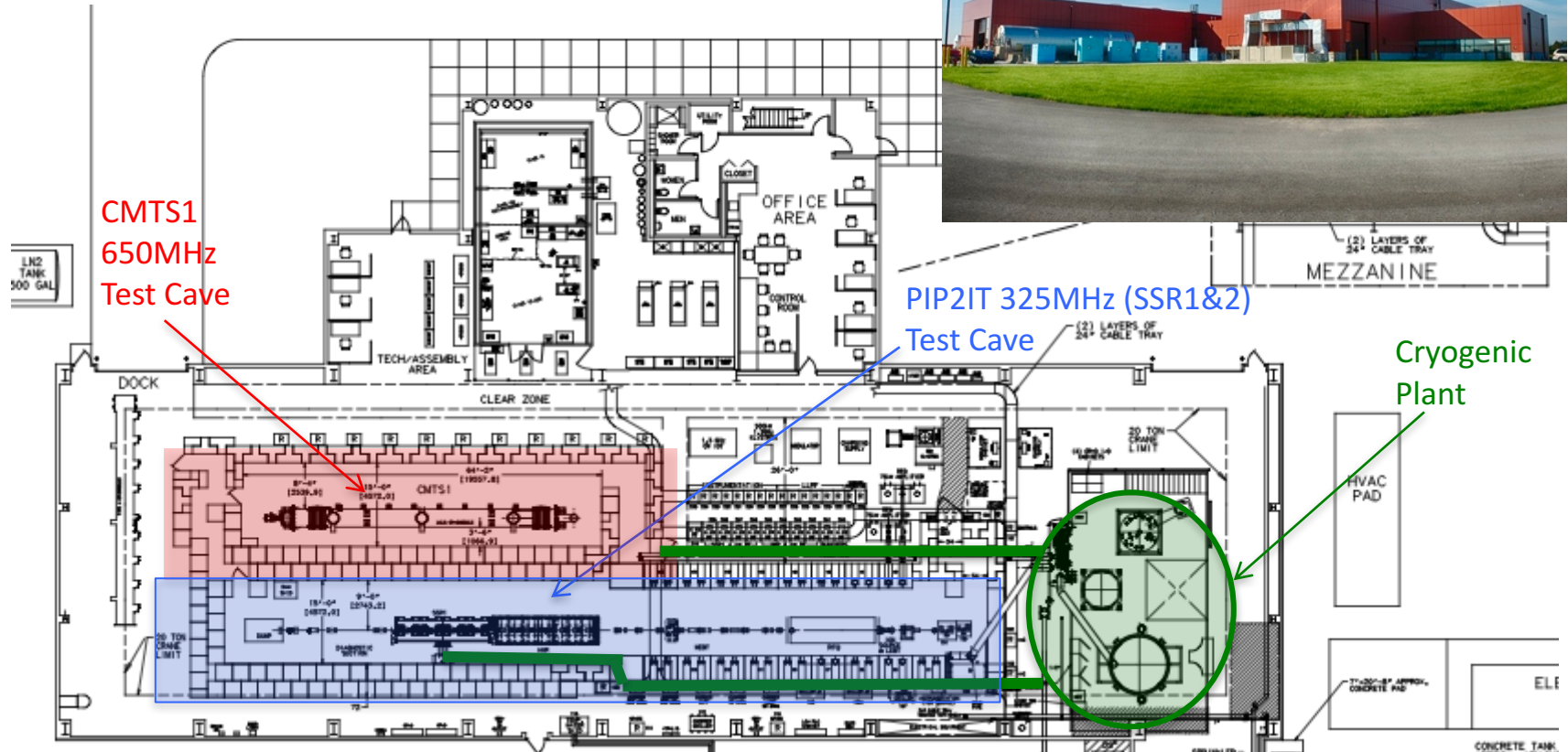
WBS L3 Overview

- This WBS covers the design, preparation, installation and commissioning of the Linac Test Infrastructure to facilitate PIP-II cavity and cryomodule testing
- There are 3 separate test facilities that make up the PIP-II Test Infrastructure
 - CMTS1
 - PIP2IT
 - STC
- Each facility will test a specific component or system for PIP-II
- Test Infrastructure contributes to achieving KPP#1

CMTF – Cryomodule Test Facility

Charge #2

- The CMTF Building contains two of the Test Infrastructure test stands (CMTS1 and PIP2IT)



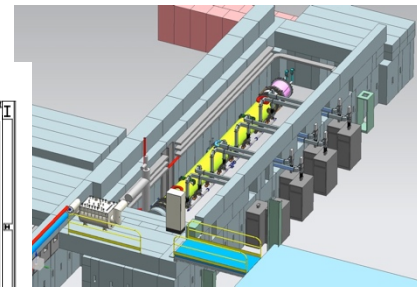
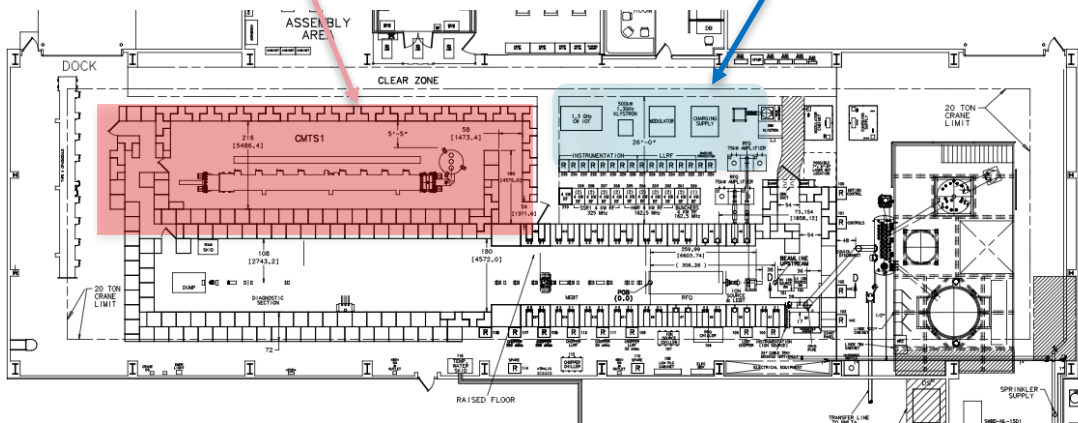
CMTS1 – 121.3.21.2

- CMTS1 (Cryomodule Test Stand #1)
 - Fully operational test stand for cold RF testing of cryomodules (no beam)
 - Currently testing LCLS-II cryomodules (1.3 & 3.9 GHz, CW)
 - After LCLS-II testing is complete, infrastructure will be reconfigured to test PIP-II 650 MHz cryomodules
 - WBS Deliverable: CMTS1 ready to test first 650 MHz cryomodule

CMTS1 Test Stand

**CMTS1 650 MHz
Test Cave**

**650MHz RF
Stations**



3-D model of current CMTS1



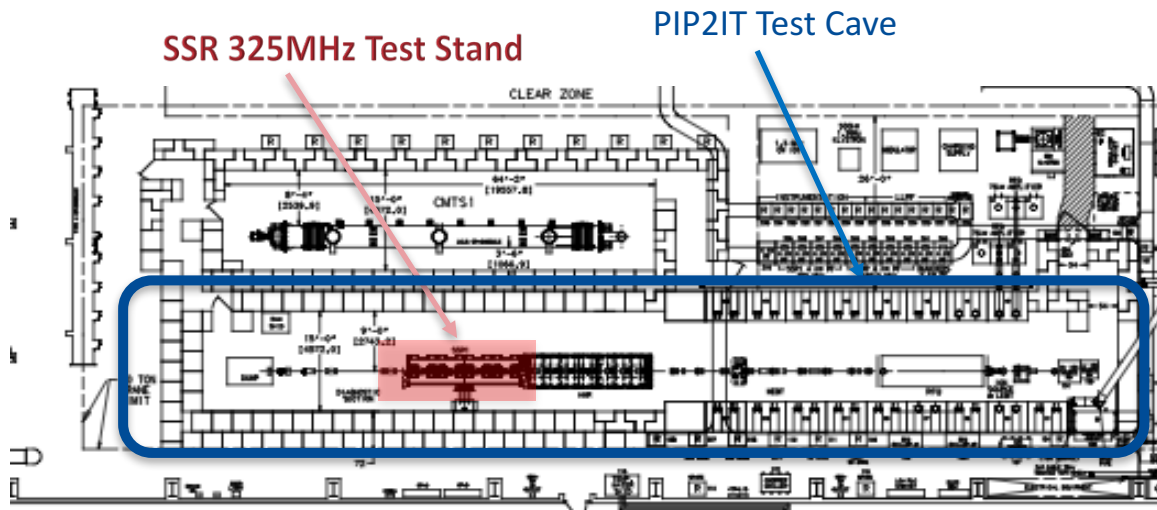
CMTS1 – 121.3.21.2

- Scope
 - After LCLS-II cryomodule testing is complete, infrastructure will be reconfigured/modified to test PIP-II 650 MHz cryomodules
 - Cryogenic distribution, RF power, mechanical & electrical infrastructure, controls, safety, etc.
- Schedule
 - The duration is estimated to be 6 months to install the new systems, followed by 2 months of commissioning. This is based on experience from configuring the CMTS1 test cave for the LCLS-II project
- Design Maturity
 - The plan is at a preliminary stage and the details are under development. Scope of work is similar to, and all estimates are based on, previous experience/costs from constructing and commissioning CMTS1 for LCLS-II
- There is an experienced team already in place that developed, operates and maintains all systems associated with CMTS1 and this same team of experts will be involved in the modification of CMTS1 for PIP-II

PIP2IT – 121.3.21.3

Charge #2

- PIP2IT (PIP-II Injector Test)
 - Near full scale test of PIP-II front-end with beam
 - 1st 325 MHz cryomodule (SSR1) will be tested in PIP2IT as part of front-end test
 - PIP2IT will be converted to RF test SSR2 cryomodules (no beam)
 - SSR1 test stand will require minimal modifications to accommodate SSR2 cryomodule testing
 - WBS Deliverable: PIP2IT ready to test first SSR2 cryomodule



PIP-II Injector Test (PIP2IT)

PIP2IT – 121.3.21.3

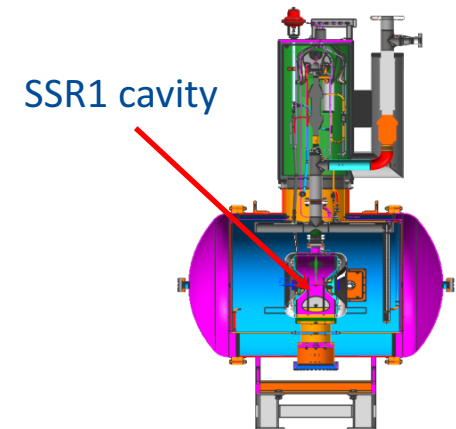
- Scope
 - After initial SSR1 cryomodule testing is complete, infrastructure will be modified to accommodate testing PIP-II SSR2 cryomodules
 - Cryogenic distribution, mechanical & electrical infrastructure, controls, etc.
- Design Maturity
 - The plan is at a preliminary stage and details are under development. Scope of work is similar to, and all estimates are based on, previous experience/costs from constructing and commissioning CMTS1 for LCLS-II
- PIP2IT Infrastructure
 - This WBS also includes the general infrastructure associated with PIP2IT for FY18-FY20 to support SSR1/HWR testing. The estimates for this portion of the WBS are based on actual PIP2IT infrastructure costs from previous years
- There is an experienced team already in place that developed, operates and maintains all systems associated with PIP2IT and this same team of experts will be involved in the modification of PIP2IT for SSR2 testing

STC – 121.3.21.1

- The Spoke Test Cryostat (STC) is located at the MDB test facility and was designed for testing 325MHz SSR1 cavities at 4K and 2K
- STC is used for comprehensive “system-level” tests of cavity+coupler+tuner
- Presently in use testing cavities for SSR1 CM#1
- After modification, STC will be used for design verification studies and initial qualification for SSR1, SSR2, and HB650 cryomodule cavities



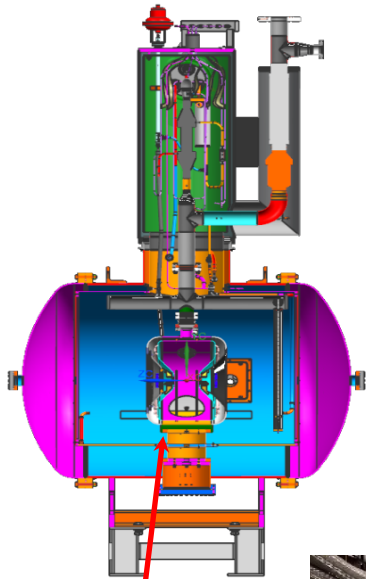
STC cryostat at MDB



STC – 121.3.21.1

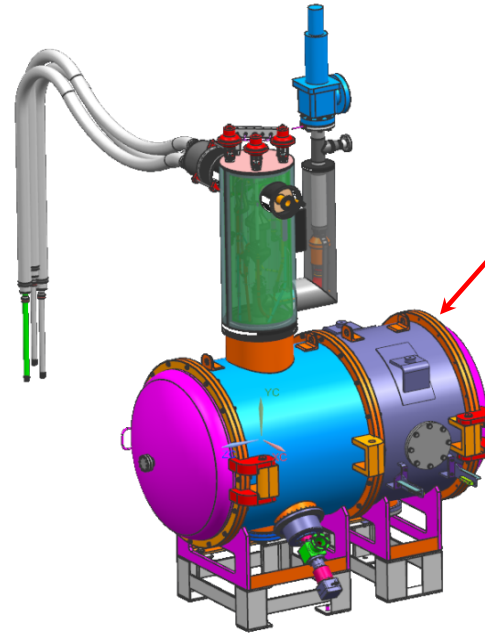
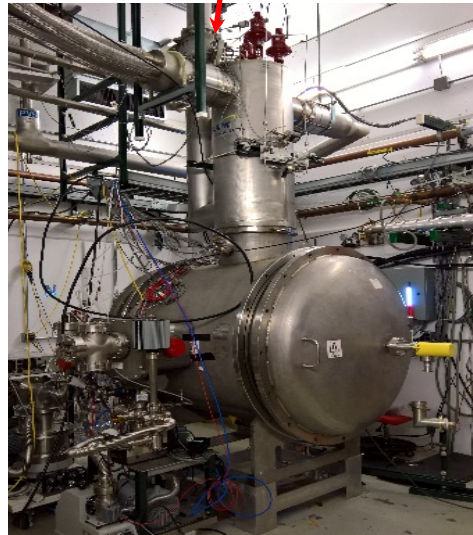
- Scope
 - After SSR1 CM1 cavity testing is complete, infrastructure will be modified to accommodate testing 650MHz elliptical, and SSR2 cavities
 - Cryostat extension, modified support structure and LHe header
 - Installation of 650MHz RF distribution and integration of existing 650MHz IOT with controls/interlocks (covered under WBS 121.3.9.4.1, in parallel with this activity)
 - No changes to cryogenics, instrumentation, or vacuum systems
- Deliverable/Schedule
 - WBS Deliverable: A modified STC capable of testing dressed HB 650MHz Elliptical and SSR2 cavities
 - Modifications will commence with the completion of the SSR1 CM1 cavity test program in 3QFY18, and completion is expected 3 months later, in time to test the first jacketed HB650 ($\beta=0.9$) cavity
- Design Maturity
 - The plan is at an advanced stage. Components for cryostat modification/extension have been ordered and are being fabricated (FDR/PRR held February 2017)
- There is an experienced team already in place that developed, operates and maintains all systems associated with STC and this same team of experts is involved in the modification of STC

STC – 121.3.21.1

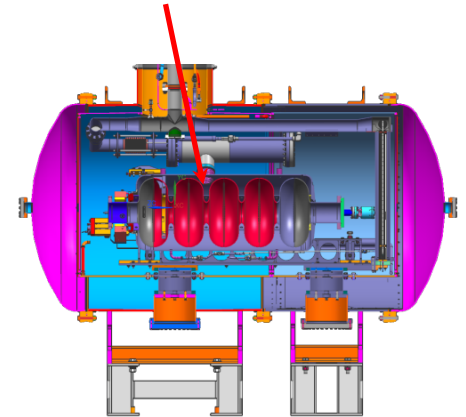


Existing STC cryostat as used for SSR1 cavity testing

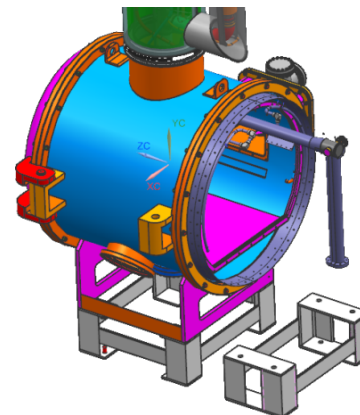
SSR1 cavity



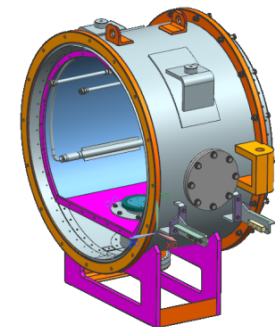
STC cryostat modified with extension to accommodate 650MHz cavities.



Existing cryostat modified with extended He piping,



Cryostat extension



WBS L3 System Requirements/Reviews

Charge #2

- Requirements are captured in functional/technical requirement specification documents (FRS/TRS), controlled in Teamcenter:
 - CMTS1 : LCLS-II Document **LCLSII-4.5-FR-0246-R0** (FRS for CMTS1 configured for LCLS-II CMs – PIP-II version will be very similar)
 - STC : TC# **ED0006117** (FRS for STC)
 - PIP2IT : FRS for PIP2IT exists TC# **ED0001223**. FRS for PIP2IT CM testing to be developed
- Interface Documents
 - Interface documents for CMTS1 and PIP2IT Test Infrastructure will be derived from CM-specific interface documents (under development)
- Design Reviews
 - The Test Infrastructure WBS activities adhere to the PIP-II Project Management Plan for reviews
 - Preliminary and Final Design Reviews and Procurement Readiness Reviews will be held in accordance with policies/criteria established by the PIP-II Project Mgt. Plan and FNAL Engineering Manual
 - Appropriate review milestones will be integrated and tracked in P6

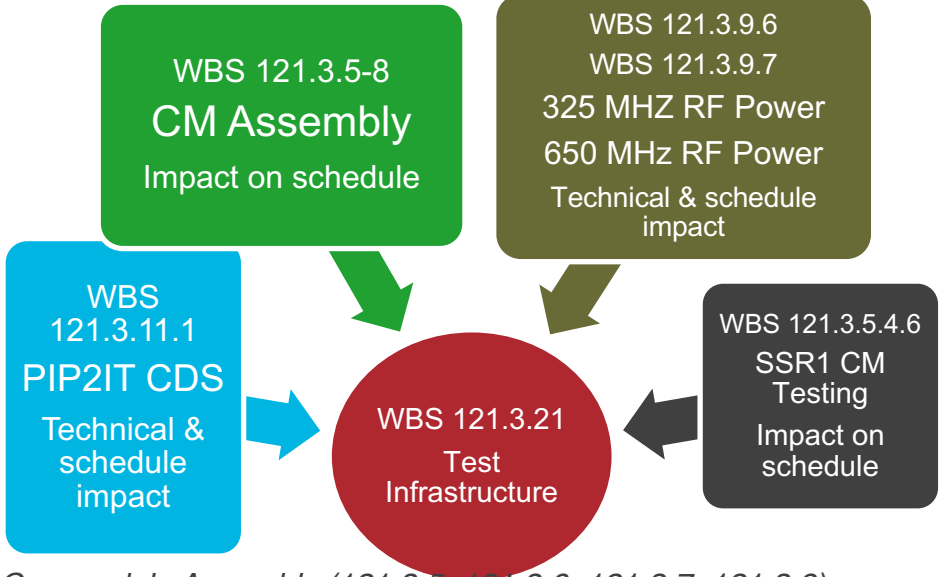
Interfaces/Risk

- All of the Test Infrastructure facilities rely upon services provided by other WBSs in order to provide full functionality for testing
 - CM Integration/Assembly (121.3.5-8)
 - RF Power (121.3.9.6, 121.3.9.7)
 - LLRF (121.3.10.3.1, 121.3.10.3.2)
 - Controls (121.3.17.3)
 - PIP2IT Cryodistribution (121.3.11.1)
 - Safety systems (121.3.20.3-5)
 - Vacuum systems (121.3.18.3)
- These interfaces will be defined by controlled documents
- Test Infrastructure WBS managers will actively monitor progress of interfacing WBSs
- Risks – No risks in the Risk Register exist directly for this WBS, but there are risks associated with other WBSs that interface with the Test Infrastructure that could impact cost and/or schedule

WBS Interfaces - Test Infrastructure

Charge #2

Top 4 systems this WBS interfaces to:



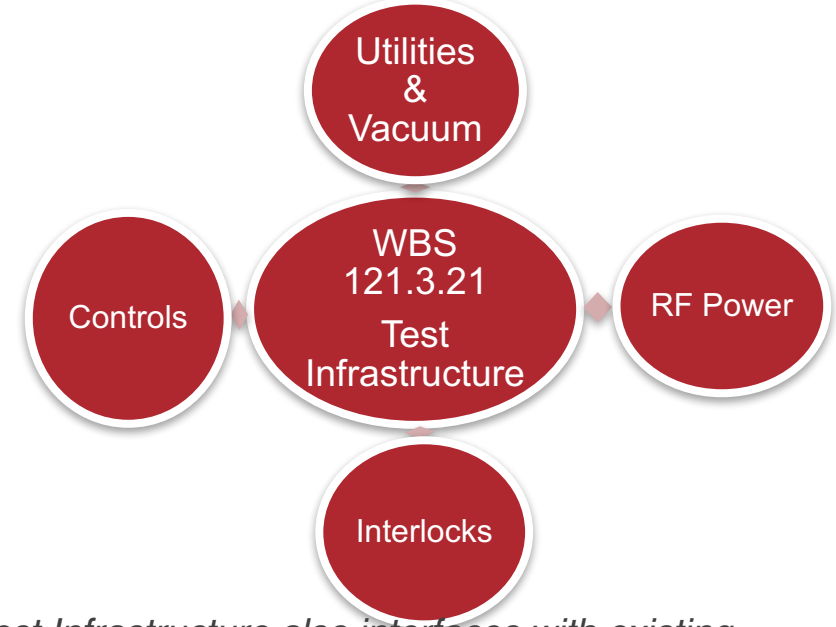
*Cryomodule Assembly (121.3.5, 121.3.6, 121.3.7, 121.3.8)
Test Infras. expected to be ready when CM assembly complete*

*RF Power systems (121.3.9.6, 121.3.9.7)
Amplifiers are needed for Test Infrastructure functionality*

*PIP2IT Cryodistribution system (121.3.11.1)
Need to be able to support cryo demands for CM testing*

*SSR1 CM Testing (121.3.5.4.6)
Testing must be completed before SSR2 re-configuration can begin*

Top 4 interfaces within this WBS:



Test Infrastructure also interfaces with existing systems

- Controls*
- Interlocks/PPS*
- HLLRF/LLRF*
- Utilities (water, compressed air, N₂)*
- Vacuum systems (beamline, coupler, insulating)*

These interfaces are managed by Interface Control Documents (ICD's)



ESH&Q

Charge #5

- Project team is committed to construct PIP-II in a safe, environmentally respectful, and cost efficient manner that meets our stakeholder's needs
- Safety is an essential element in all work we do
 - The construction/operation of all the Test Infrastructure facilities will be in full compliance with the PIP-II IESH program (docdb # 141), Laboratory and DOE standards and practices
 - Construction/assembly activities use the appropriate Hazard Analyses, Work Planning processes, LOTO procedures, etc. in compliance with Fermi ES&H Manual
- Prior to commissioning any reconfigured system/facility, a series of reviews and approvals take place, culminating in an official Operational Readiness Clearance (ORC) approval. This also applies to in-kind deliverables
 - These reviews cover systems such as:
 - Oxygen Deficiency Hazards (ODH)
 - Radiation Shielding/Radiation Safety
 - Personnel Protection Systems (interlocks, etc.)
 - Machine (Device) Protection Systems
 - Mechanical & Electrical Safety
 - Cryogenic Safety

ESH&Q

Charge #5

- Quality Assurance and Control
 - Procurement, fabrication, and acceptance of components will follow the Project's QA Plan (docdb # 142) utilizing established Project/Division mechanisms:
 - incoming inspections
 - acceptance testing
 - control of non-conformances (discrepancy reports, discrepancy resolutions)
 - vendor feedback
 - This includes not only purchased/fabricated components, but also applies to in-kind deliverables

BOE Summary

Charge #3

WBS Number	Title	Docdb #
121.3.21.1.2	Test Infrastructure STC PM and Coordination	851
121.3.21.1.3-5	Test Infrastructure STC Design, Prep, IIC	857
121.3.21.2.2	Test Infrastructure CMTS1 PM and Coordination	839
121.3.21.2.3-5	Test Infrastructure CMTS1 Design, Prep, IIC	842
121.3.21.3.2	Test Infrastructure PIP2IT PM and Coordination	845
121.3.21.3.3-5	Test Infrastructure PIP2IT Design, Prep, IIC	848

Cost Summary

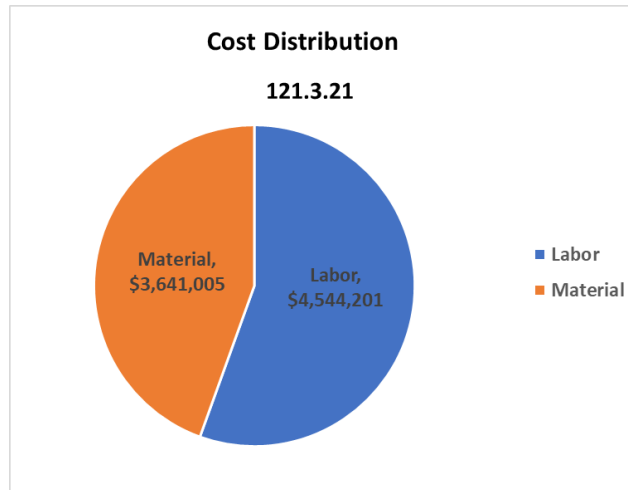
Charge #3

Level 4 WBS - Name	Direct Hrs	Direct M&S	Full Burden+Esc	EUC	% EUC	Total Cost
121.3.21.01 - Linac - TI - Spoke Test Cryostat (STC)	1,934	\$57,634	\$291,793	\$59,718	20.5%	\$351,508
121.3.21.02 - Linac - TI - CryoModule Test Stand (CMTS)	8,347	\$1,179,235	\$2,988,911	\$659,814	22.1%	\$3,648,740
121.3.21.03 - Linac - TI - PIP2IT Test Infrastructures	19,462	\$1,417,202	\$4,904,502	\$1,226,121	25.0%	\$6,130,624
Grand Total	29,743	\$2,654,071	\$8,185,206	\$1,945,653	23.8%	\$10,130,872

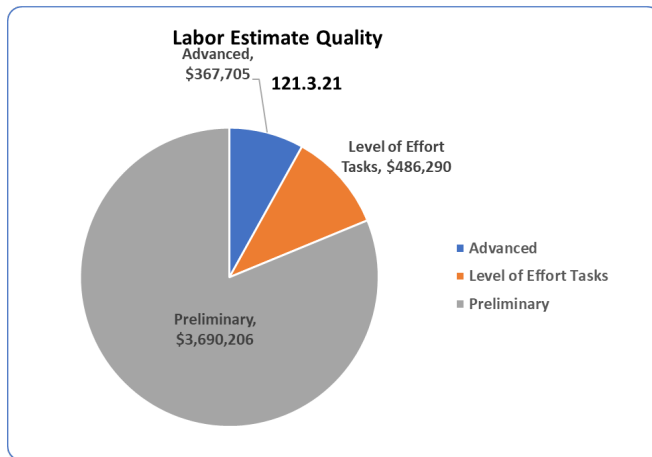
Full Burden + Esc = BOE + Escalation + Overhead

Cost Distribution and Estimate Quality

Charge #3



- Costs are approximately evenly split between labor and M&S
- Most estimates (labor and M&S) are at the preliminary stage (CMTS1 and PIP2IT) with the exception of STC, which is at an advanced stage

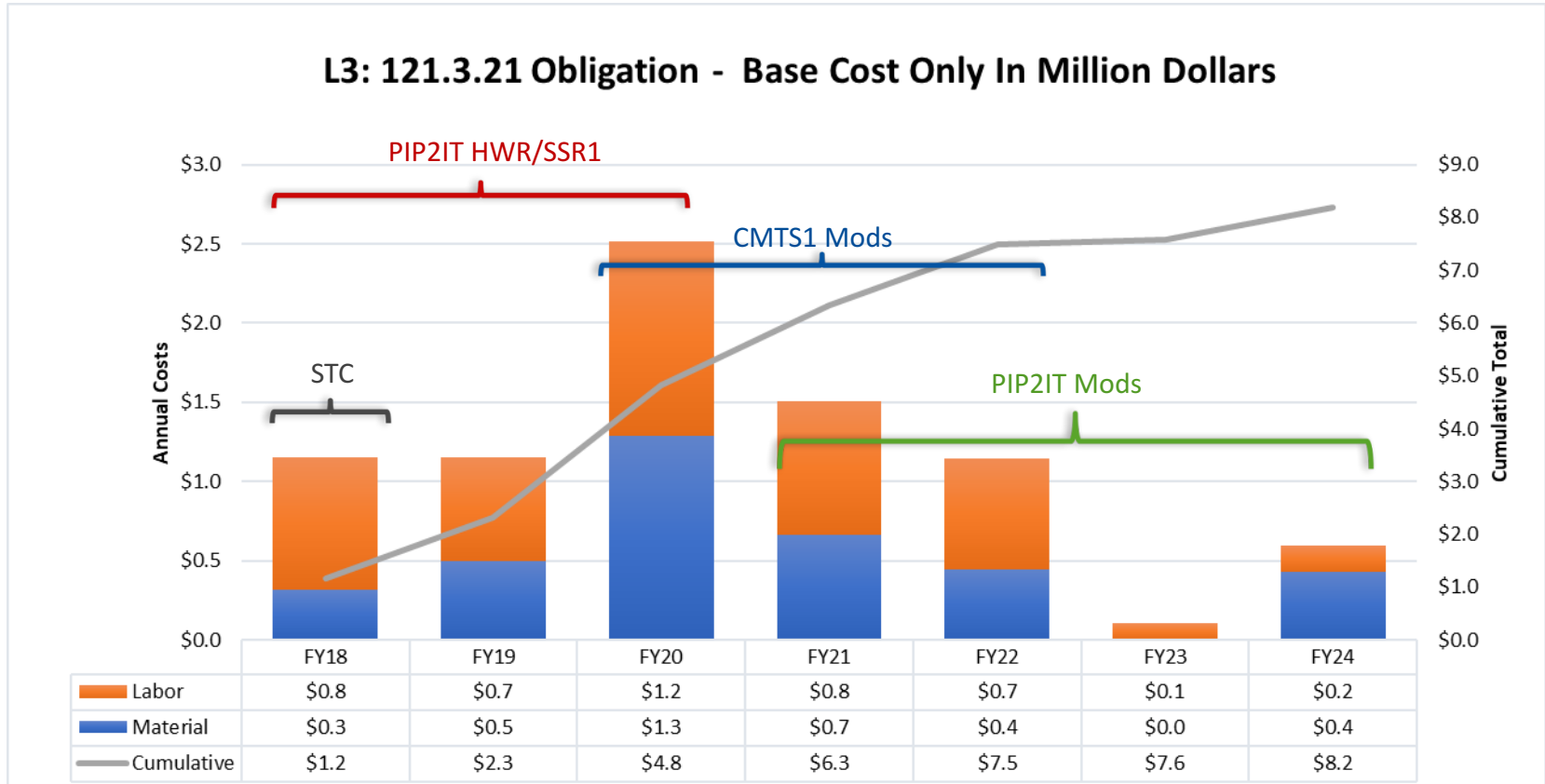


Costs = BOE + Overheads + Escalation

Estimate Quality Categories are per FermilabStandards and descriptions can be found in Docdb item number 345

Obligation Profile – P6 Base Cost Only

Charge #3

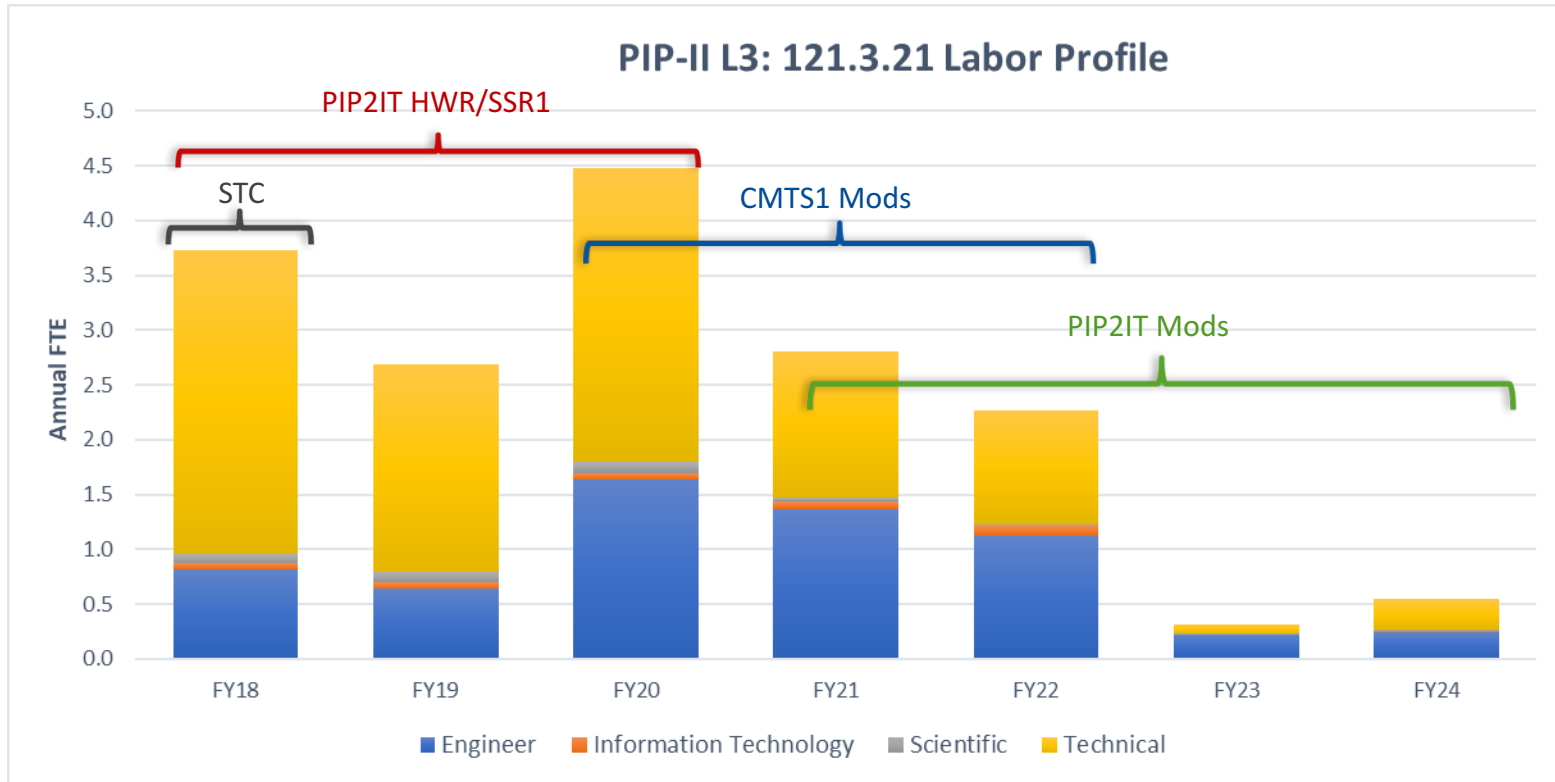


P6 Base Costs = BOE + Overheads + Escalation

- STC Modifications (minimal cost and effort) - FY18
- **PIP2IT HWR/SSR1 testing infrastructure – FY18-20**
- **CMTS1 Modifications (design/prep/install) – FY20-22**
- **PIP2IT Modifications for SSR2 (design & planning) – FY21-22**
- **PIP2IT Modifications for SSR2 (procure & installation) – FY23-24 (ready for SSR2 – 8/1/2024)**

Labor Profile – P6 Hours/FTE

Charge #3



- Labor profile indicates a higher Tech to Engineer ratio in FY18-20 due to STC Installation work (FY18) and **PIP2IT HWR/SSR1 infrastructure activities (FY18-20)**
- Engineering effort increases in **FY20-22 for CMTS1 modification design/prep/install**; and **PIP2IT Modification design work (FY21-22)**
- **PIP2IT Modification procure/install work is minimal and occurs in FY23-24** to meet 8/1/24 milestone of being ready to test 1st SRR2 cryomodule

Schedule – Test Infrastructure

Activity ID	Activity Name	FY2018				
		FQ1	FQ2	FQ3	FQ4	F
121.3.21.01	Linac - TI - Spoke Test Cryostat (STC)					
121.3.21.01.01	Linac - TI - STC - T4 Milestones					
X-A17733650	Linac - TI - STC - IIC - DevPh: T4 MS - STC Facility Commissioning Ready for first DCAV B.90 STC test - HB650 1st CM					

STC Modifications

Activity ID	Activity Name	FY2020				FY2021				FY2022			
		FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4
121.3.21.02	Linac - TI - CryoModule Test Stand (CMTS)												
121.3.21.02.01	Linac - TI - CMTS - T4 Milestones												
X-A17733690	Linac - TI - CMTS - IIC - DevPh: T4 MS - CMTS1 Ready to Start Testing of 1st CM HB650												

CMTS1 Modifications

Activity ID	Activity Name	FY2018				FY2019				FY2020				FY2021				FY2022				FY2023				FY2024			
		FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4	FQ1	FQ2	FQ3	FQ4
121.3.21.03	Linac - TI - PIP2IT Test Infrastructures																												
121.3.21.03.01	Linac - TI - PIP2IT - T4 Milestones																												
X-A17763260	Linac - TI - PIP2IT - DevPh: T4 MS - PIP2IT Ready to Start Testing HWR & SSR1 CryoModule																												
X-A17733700	Linac - TI - PIP2IT - ConstrDPH: T4 MS - PIP2IT Ready to Start Testing 1st SSR2 CryoModule																												

PIP2IT HWR/SSR1 Test Infrs. & PM + Preparation for SSR2

Summary

- Fermilab currently operates an array of world-class SRF test facilities, many of which are critical to the success of the PIP-II project
- Several of the existing test facilities will require modifications to accommodate PIP-II components
- The details of these modifications exist at the preliminary (and in some cases advanced) level, being similar in nature to the current and historical use of this Test Infrastructure for LCLS-II, SRF R&D Program, etc.
 - All cost and schedule estimates are based on historical data from initial construction or recent modifications of these facilities and are well understood
 - Experienced personnel are in place
 - Activities are planned so that modifications are completed and can be commissioned before cavities and cryomodules arrive for testing
- Thank you for your attention!