



121.3.5-6 Linac - SSR1, SSR2

SC Acceleration Modules and Cryogenics

Donato Passarelli

PIP-II Director's Review

10-12 October 2017

In partnership with:

India Institutes Fermilab Collaboration

Istituto Nazionale di Fisica Nucleare

Science and Technology Facilities Council

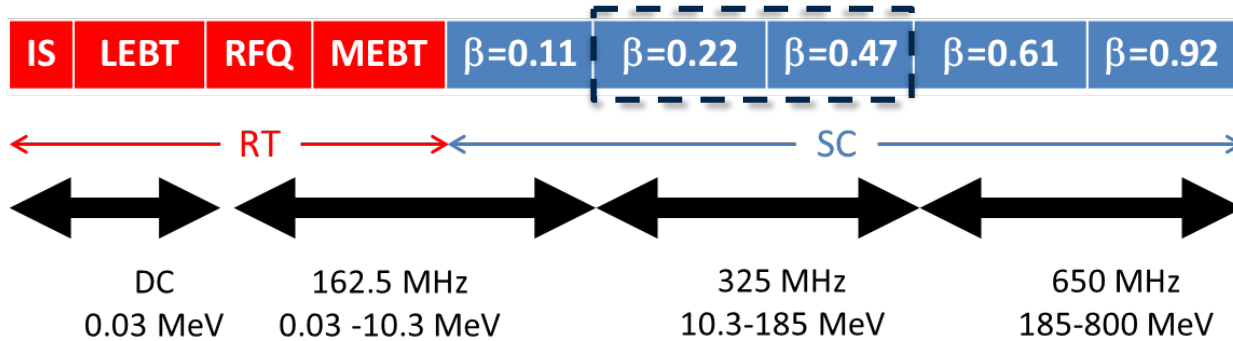
Outline

- Overview of SSR1 (WBS 121.3.5) and SSR2 (121.3.6)
- Requirements
- Scope and Deliverables
- Design maturity and current status
- Interfaces
- Organization
- ESH&Q
- Risk
- Cost
- Schedule
- Summary

About Me:

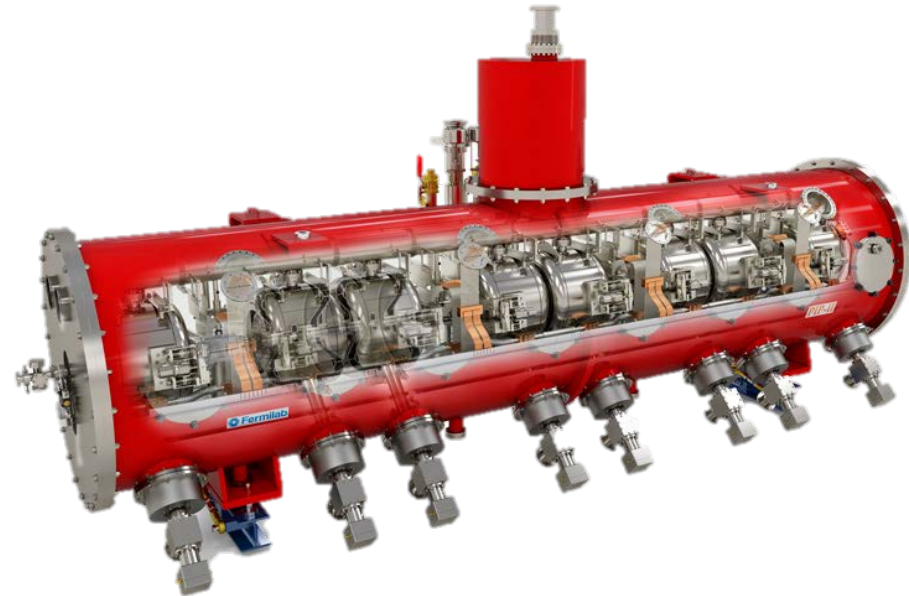
- Donato Passarelli, PhD
- L3 Manager for WBS 121.3.5, .6 (SSR1, SSR2)
 - Since 2010 working in Technical Division, SRF Dept.
 - SSR1 cavities and tuners: design, manufacturing, and testing
 - SSR1 cryomodule design

121.3.5-6 SSR1, SSR2: Overview



PIP-II Conceptual Design Report:
DocDb# 113

	SSR1	SSR2
# CMs	2	7
Cavities per CM	8	5
Solenoids per CM	4	3
CM configuration c: cavities; s: solenoids	4x (csc)	scscscsc
CM length (m)	5.2	6.5



SSR CMs capable of operating in both pulsed and CW modes with a beam current of 2 mA

121.3.5 SSR1: Requirements

Functional Requirement Specification (FRS) are defined and traceable in Teamcenter:

- SSR1 cryomodule: **TC# ED0001316**
- SSR1 cavities: **TC# ED001317**
- SSR1 solenoids: **TC# ED0001315**

Parameter	Value
Max Leak Rate (room temp)	$< 10^{-10}$ atm-cc/sec
Operating gain per cavity	2.05 MeV
Maximum Gain per cavity	2.4 MeV
Q₀	$> 6 \times 10^9$
Maximum dynamic power dissipation per cavity at 2 K	< 3 W
Sensitivity to He pressure fluctuations	< 25 Hz/Torr
Lorentz Force Detuning coefficient	< 5 Hz/(MV/m) ²
Field Flatness	Within $\pm 10\%$
Multipacting	none within $\pm 10\%$ of operating gradient
Operating temperature	1.8-2.1 K
Operating Pressure	16-41 mbar differential
MAWP	2 bar (RT), 4 bar (2K)
RF power input per cavity	Up to 15 kW (CW, operating)

Cavity operational/test requirements

Cryomodule	
Physical beam aperture, mm	30
Overall length (flange-to-flange), m	≤ 5.4
Overall width, m	≤ 1.6
Beamline height from the floor, m	1.3
Cryomodule height (from floor), m	≤ 2.60
Ceiling height in the tunnel, m	3.30
Maximum allowed heat load to 35-50 K, W	255
Maximum allowed heat load to 5 K, W	80
Maximum allowed heat load to 2 K, W	50
Maximum number of lifetime thermal cycles	50
Intermediate thermal shield temperature, K	35-50
Thermal intercept temperatures, K	5 and 35-50
Cryo-system pressure stability at 2 K (RMS), mbar	~ 0.1
Environmental contribution to internal field	< 15 mG
Transverse cavity alignment error, mm RMS	< 1
Angular cavity alignment error, mrad RMS	≤ 5
Transverse solenoid alignment error, mm RMS	< 0.5
Angular solenoid alignment error, mrad RMS	< 0.5
Cavities	
Number, total	8
Frequency, MHz	325
β optimal	0.222
Operating temperature, K	2
Operating mode	CW and pulsed
Operating energy gain at $\beta=0.222$, MV/cavity	2.05

Table of cryomodule requirements

121.3.6 SSR2: Requirements

Charge #1

Functional Requirement Specification (FRS) are defined and traceable in Teamcenter:

- SSR2 cryomodule: **TC# ED0001829**
- SSR2 cavities: **TC# ED0001854**
- SSR2 solenoids: **TC# ED0004357**

Parameter	Value
Max Leak Rate (room temp)	$< 10^{-10}$ atm-cc/sec
Operating gain per cavity	5 MeV
Maximum Gain per cavity	5.8 MeV
Q_0	$> 8 \times 10^9$
Maximum dynamic power dissipation per cavity at 2 K	11 W
Sensitivity to He pressure fluctuations (when jacketed)	< 25 Hz/mbar
Lorentz Force Detuning (when jacketed)	< 2.8 Hz/(MV/m) ²
Bandwidth (f_0/Q)	64 Hz
Field Flatness	Within $\pm 10\%$
Multipacting	None within $\pm 10\%$ of operating gradient
Operating temperature	1.8-2.1 K
Operating Pressure	16-41 mbar differential
MAWP	2 bar (RT), 4 bar (2K)
B_{peak} at operating gradient	65mT
RF power input per cavity	Up to 30 kW (CW, operating)

Cavity operational/test requirements

Cryomodule	
Physical beam aperture, mm	40
Overall length (flange-to-flange), m	≤ 6.5
Overall width, m	≤ 1.6
Beamline height from the floor, m	1.3
Cryomodule height (from floor), m	≤ 2.60
Ceiling height in the tunnel, m	3.30
Maximum allowed heat load to 35-50 K, W	250
Maximum allowed heat load to 5 K, W	80
Maximum allowed heat load to 2 K, W	75
Maximum number of lifetime thermal cycles	50
Intermediate thermal shield temperature, K	35-50
Thermal intercept temperatures, K	5 and 35-50
Cryo-system pressure stability at 2 K (RMS), mbar	~ 0.1
Environmental contribution to internal field	< 15 mG
Transverse cavity alignment error, mm RMS	< 1
Angular cavity alignment error, mrad RMS	≤ 5
Transverse solenoid alignment error, mm RMS	< 0.5
Angular solenoid alignment error, mrad RMS	< 0.5
Cavities	
Number, total	5
Frequency, MHz	325
β optimal	0.475
Operating temperature, K	2
Operating mode	CW & pulsed
Operating energy gain at $\beta=0.475$, MV/cavity	5
Coupler type – standard coaxial with impedance, Ω	105
Coupler power rating, KW	30

Table of cryomodule requirements

121.3.5 SSR1: Scope and Deliverables

Charge #1

Design, procure, integrate, install in PIP2IT and test to performance requirements two 325 MHz 8-cavity superconducting cryomodules.

- 121.3.5.2 Project management and coordination
- 121.3.5.3 SSR1 1st CM
 - FNAL R&D scope:
 - Qualification of 8 jacketed cavities with coupler and tuner
 - Complete design, procurement, QA/QC and integration of all cryomodule components
 - RF testing and verification of cryomodule performance at PIP2IT
 - DAE (BARC/IUAC) scope:
 - Delivery of 2 dressed cavities
- 121.3.5.4 SSR1 2nd CM
 - FNAL scope:
 - Finalization of design and procedures using lessons learned from CM #1
 - Procurement, QA/QC and integration of the full cryomodule
 - RF testing and verification of cryomodule performance at PIP2IT

Complete Scope and Deliverables and Assumptions:

BOE docDB #'s	384-v15	387-v10	393-v9	396-v15	399-v8	402-v11	405-v12
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121.3.6 SSR2: Scope and Deliverables

Charge #1

Design, procure, integrate and deliver to the LINAC tunnel seven 325 MHz 5-cavity superconducting cryomodules.

- FNAL scope and deliverables:
 - Project management and coordination of all scope within this WBS.
 - Perform all required design, analysis, reviews, procurement, QA/QC, device design verification testing, and integration of seven 5-cavity cryomodules
 - Support DAE partner in design and fabrication activities
 - Testing at PIP2IT of 1st, 2nd, 3rd and 4th cryomodule
 - M&S: Niobium material, 2 prototype and 20 production dressed cavities, 20 tuners, 20 couplers and cryomodule components
- DAE (BARC) scope:
 - Design of bare and jacketed cavities
 - M&S: 2 prototype cavities; 20 dressed cavities; 21 solenoids, leads and BPMs; 20 tuners and 20 couplers.

Complete Scope and Deliverables and Assumptions:

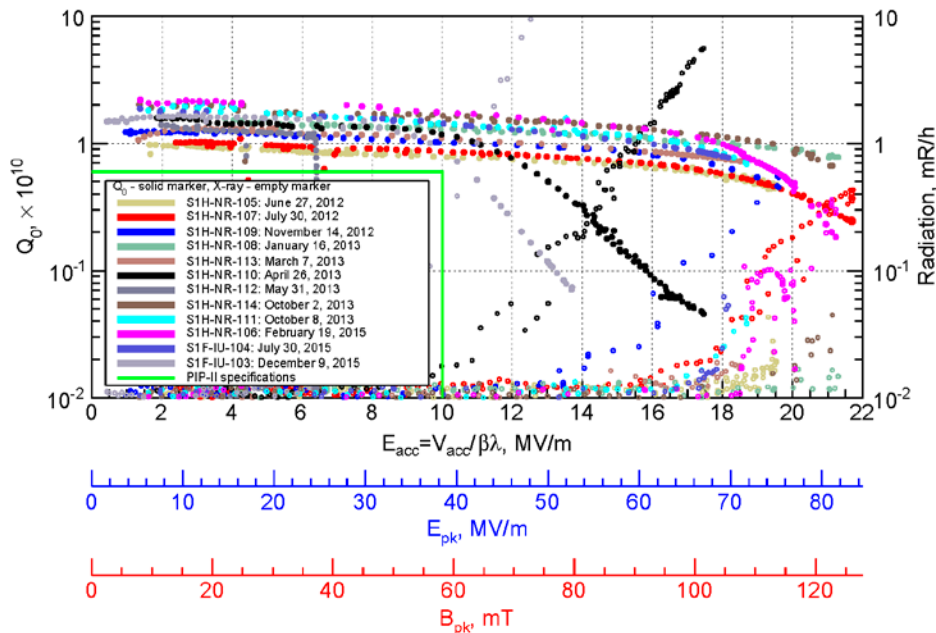
BOE docDB #'s	423-v16	426-v14	429-v10	432-v8	438-v10	441-v12	444-v14
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121.3.5 SSR1: Cavities Design Maturity

Charge #1

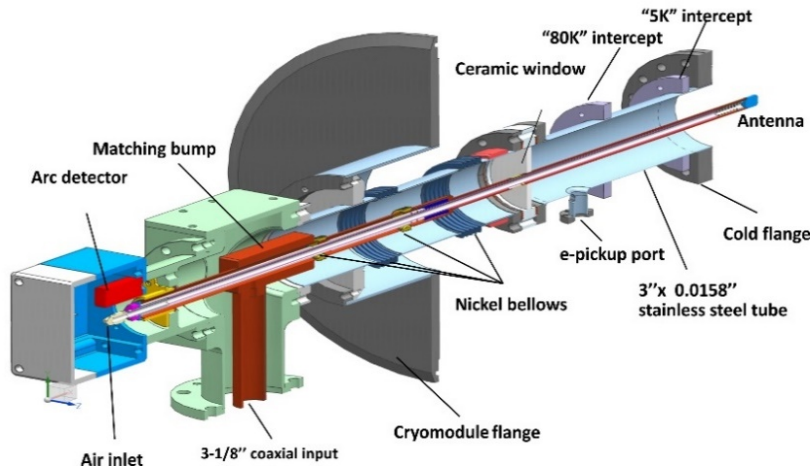
□ *SSR1 CM1 is well beyond the conceptual design.*

- SRF technology enabled: 12 SSR1 cavities (10 FNAL + 2 DAE BARC/IUAC) met PIP-II requirements in VTS testing.
- 10 FNAL cavities were jacketed with stainless steel vessels.
- 2 DAE BARC cavities are currently receiving the He- vessel
- Cavities qualification tests in the Spoke test cryostat and resolution of technical issues (field emission, multipacting, coupler reliability) is ongoing.



Main Power Couplers: status

Charge #1



□ Prototype main power couplers

- Design, procurement and testing: completed
- Three prototypes were procured and tested:
 - All units were successfully tested up to 30 kW (in full reflection mode) on the RF test stand at room temperature
 - One unit was tested to failure at 47 kW (in full reflection mode) on the RF test stand at room temperature
 - One unit was successfully qualified during tests in STC
 - Several lessons learned

□ Production main power couplers

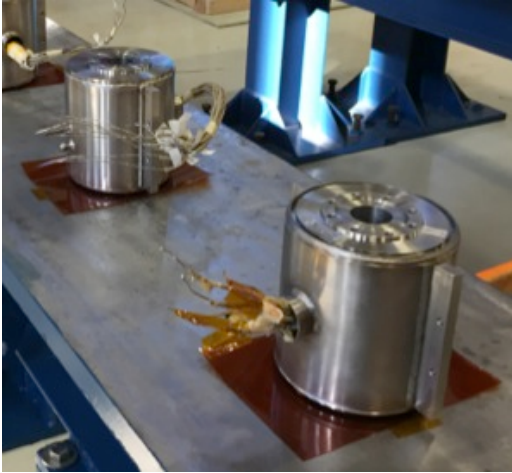
- Design completed
- Procurement: in progress
 - The procurement of coupler antennas presented a series of technical issue that led them to be on the ***critical path***.



121.3.5 SSR1: Solenoid and BPMs

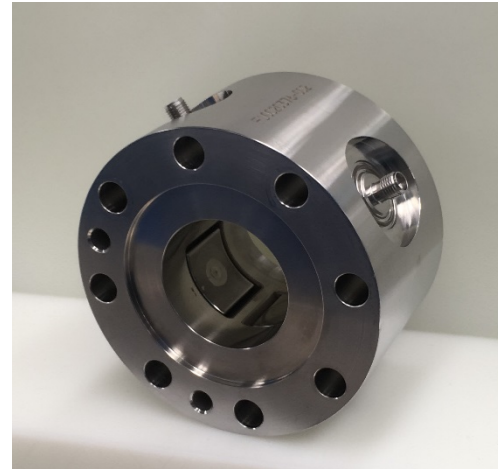
Charge #1

- Four production solenoids were successfully designed, procured and qualified.



TC# ED0001264

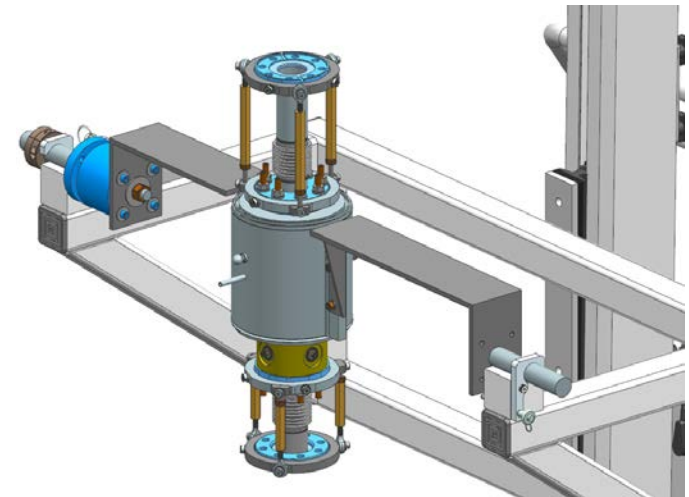
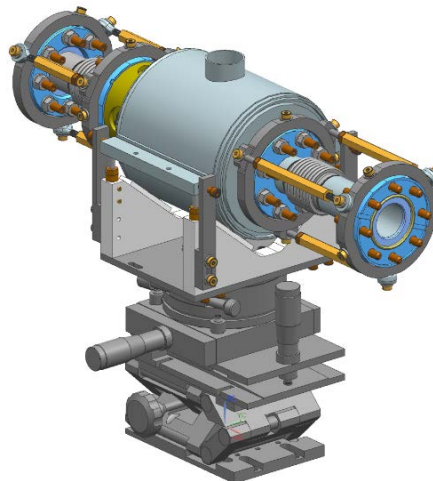
- Four production BPMs were successfully designed, procured and qualified.



Joint collaboration
ANL & FNAL

TC# ED0005680

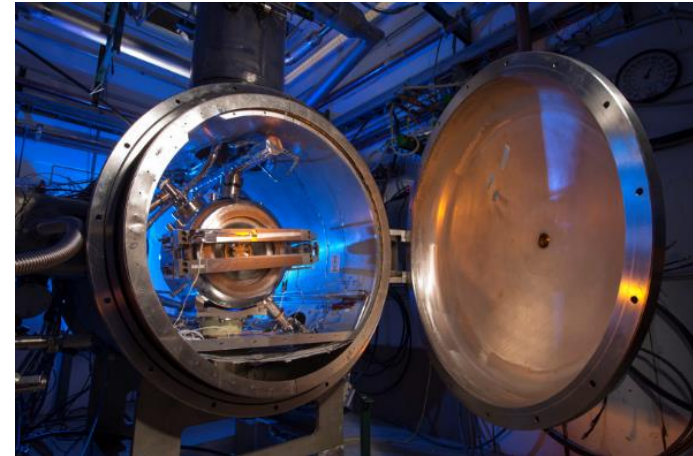
- Free particle assembling procedure of the solenoid/BPM sub-assembly is under development



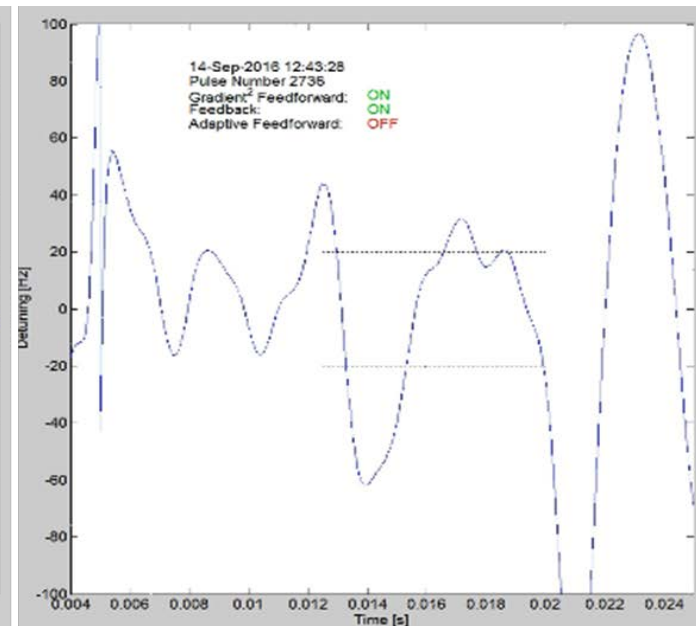
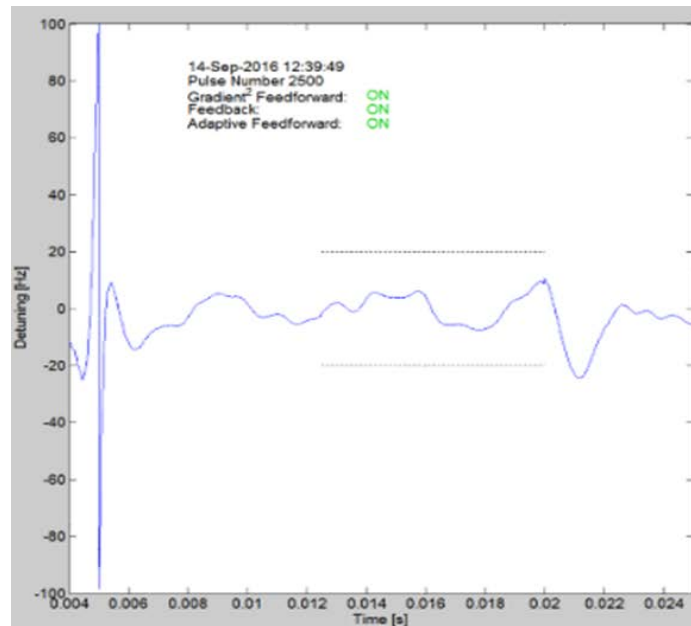
121.3.5 SSR1: Tuner and resonance control

Charge #1

- ❑ **Prototype SSR1 tuner**
 - Design completed and one unit was prototyped
 - Successfully tested at 293K and cold temperature
- ❑ **Production SSR1 tuner**
 - Design completed
 - 1 out of 10 units was received and currently used for resonance control of SSR1 cavities



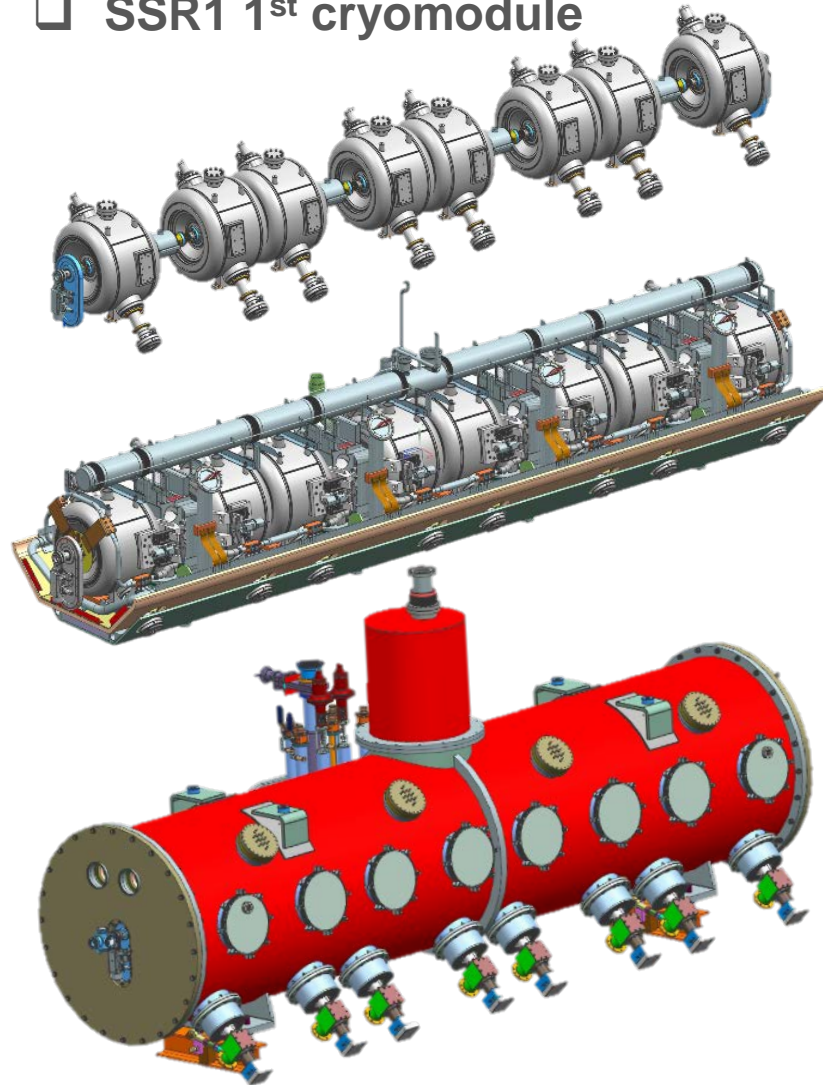
- ❑ **Resonance control studies**
 - Requirements: microphonics <20 Hz
 - Significant progress has been made toward PIP-II specification of detuning.



121.3.5 SSR1: CM Design Maturity

Charge #1

❑ SSR1 1st cryomodule



SSR1 string assembly

- Design: completed
- Procurement: completed
- Assembly starts in March 2018

SSR1 coldmass

- Design: completed
- Procurement: in progress
- Assembly starts in July 2018

SSR1 final cryomodule

- FDR in Dec. 2017
- Procurement: in progress
- Assembly starts in Nov. 2018

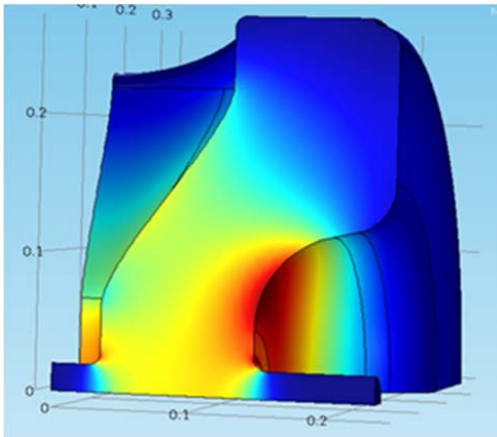
❑ SSR1 2nd cryomodule

We are collecting lessons learned and list of improvements from the experience in designing and developing the SSR1 1st cryomodule.

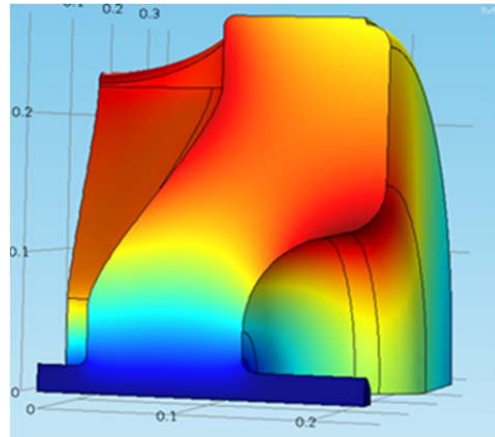
121.3.6 SSR2: Design Maturity

Charge #1

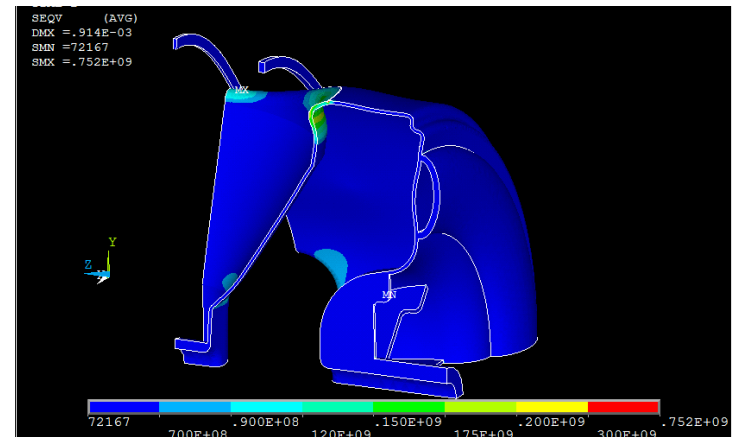
- The design of the SSR2 cryomodule (including solenoids, couplers, tuners, etc.) will derive from lessons learned with the development of the SSR1 cryomodule.
- SSR2 development is on the Linac critical path.
- SSR2 cavities: DAE (BARC) is currently working on the cavity design. PDR scheduled for Nov. 2017 at BARC



SSR2 Electric 3D fields (an eight of the full model) computed by COMSOL.



SSR2 Electric 3D fields (an eight of the full model) computed by COMSOL.



Structural mechanical analyses performed by Int'l partners.

Interfaces - Technical

Charge #1

WBS 121.3.5-.6 interface across the PIP-II WBS Matrix

Interfaces to SSR1 (121.3.5) and SSR2 (121.3.6)	
121.3.4 – HWR (<i>SSR1 only</i>)	121.3.17 – Control Systems
121.3.5/.6 – SSR1/SSR2	121.3.18 – Vacuum
121.3.7 – LB650 (<i>SSR2 only</i>)	121.3.19 – General Supt. Serv.
121.3.9 – RF Power	121.3.20 – Safety Systems
121.3.10 – RF Integration	121.3.21 – Test Infrastructure
121.3.11 – Cryo Systems	121.3.22 – Install., Integ., and Comm
121.3.13 – Magnet PS	121.5 – Conventional Facilities
121.3.16 – Beam Instrum.	

- Technical interfaces are understood and are or will be under revision control and managed through Teamcenter.
 - 121.3.5 SSR1 external interfaces: **TC# ED0004129, TC# F10051442**
 - 121.3.5 SSR1 internal interfaces: **TC# F10002433, TC # F10082628, and SSR1 team meetings ([Indico link](#))**

Interface - Partners

- Final Partner deliverables to be formalized in advance of CD-2.
- SPC/SPM and POC direct communication is essential to the success of this collaboration.
- Timely information and material transfer between stakeholders is essential to meet technical and schedule requirements.

- 121.3.5 SSR1 partner: DAE-BARC/IUAC
 - fabrication of two dressed cavities

- 121.3.6 SSR2 partner: DAE-BARC
 - Bare and dressed cavities design and production
 - Tuners design and fabrication
 - Solenoids, leads and BPS design and fabrication

Organization

- FNAL L3 Manager Assigned
 - Single L3 for SSR1 (121.3.5) and SSR2 (121.3.6)
 - L4 technical POCs identified within the Technical Division org.
 - Support area staffing and POCs map directly to Technical Division org. chart: VTS testing, Cavity processing and Facilities, QA/QC, etc.
 - Organization is moving with good technical progress.
 - CM design team well-established and experienced.
- Partner organization is established in the DAE.

121.3.5 SSR1: Design Review Plan

- SSR1 1st cryomodule (WBS 121.3.5.3)
 - PDR, FDR and PRR of the key-components up to the string assembly were held and successfully passed.
 - Future reviews are tracked in P6 as milestones with design activities preceding and following the PDR, concluding with the FDR, and procurement support activities starting with the PRR milestone.

121.3.5.3 Linac - SSR1 - 1st Prototype CryoModule (1stCM)		02-Oct-17	22-Mar-18	116d	
121.3.5.3.3 Linac - SSR1 - 1stCM - COLD MASS integration		02-Oct-17	13-Dec-17	50d	
121.3.5.3.3.1 Linac - SSR1 - 1stCM - COLDMASS - CryoModule Components		02-Oct-17	10-Nov-17	30d	
121.3.5.3.3.1.1 Linac - SSR1 - 1stCM - COLDMASS - CMComp: Fermilab scope (FTE)		02-Oct-17	10-Nov-17	30d	
121.3.5.3.3.1.1.1 Linac - SSR1 - 1stCM - COLDMASS - CMComp - 4CurrLProtCONTR: S. to Aw. 4 Prot.Curr. Leads C.and to D.		02-Oct-17	10-Nov-17	30d	
A17709850	Linac - SSR1 - 1stCM - COLDMASS - CMComp - 4CurrLProtCONTR - R&DPh: Prep. RQN for 4 Prot. Current Leads Contr. after FDR	02-Oct-17	10-Nov-17	30d	393
121.3.5.3.3.2 Linac - SSR1 - 1stCM - COLDMASS - Tooling Components		02-Oct-17	13-Dec-17	50d	
121.3.5.3.3.2.1 Linac - SSR1 - 1stCM - COLDMASS - ToolComp: Fermilab scope (FTE)		02-Oct-17	13-Dec-17	50d	
121.3.5.3.3.2.1.1 Linac - SSR1 - 1stCM - COLDMASS - ToolComp - Design of Tooling Components		02-Oct-17	13-Dec-17	50d	
A17719910	Linac - SSR1 - 1stCM - COLDMASS - ToolCompDes - R&DPh: Develop Final Design of Tooling Components after FDR Cold Mass	02-Oct-17	12-Dec-17	50d	393
A17719920	Linac - SSR1 - 1stCM - COLDMASS - ToolCompDes - R&DPh: T5 M5 - FDR/PRR Reviews for Tooling Components	13-Dec-17		0d	393
121.3.5.3.4 Linac - SSR1 - 1stCM - CryoModule final INtegration		21-Dec-17	22-Mar-18	60d	
121.3.5.3.4.1 Linac - SSR1 - 1stCM - INT - CryoModule Components		21-Dec-17	22-Mar-18	60d	
121.3.5.3.4.1.1 Linac - SSR1 - 1stCM - INT - CMComp: Fermilab scope (FTE)		21-Dec-17	22-Mar-18	60d	
121.3.5.3.4.1.1.1 Linac - SSR1 - 1stCM - INT - CMComp - Design of CM components		21-Dec-17	22-Mar-18	60d	
A17720180	Linac - SSR1 - 1stCM - INT - CMCompDes - R&DPh: T5 M5 - Final Design Review (FDR) for CM Components	21-Dec-17		0d	393
A17720190	Linac - SSR1 - 1stCM - INT - CMCompDes - R&DPh: Prepare documentation for CM Components PRR	21-Dec-17	21-Mar-18	60d	393
A17720200	Linac - SSR1 - 1stCM - INT - CMCompDes - R&DPh: T5 M5 - Prod. Readiness Review (PRR) for CM Components	22-Mar-18		0d	393
121.3.5.3.4.2 Linac - SSR1 - 1stCM - INT - Tooling Components		01-Mar-18	01-Mar-18	0d	
121.3.5.3.4.2.1 Linac - SSR1 - 1stCM - INT - ToolComp: Fermilab scope (FTE)		01-Mar-18	01-Mar-18	0d	
121.3.5.3.4.2.1.1 Linac - SSR1 - 1stCM - INT - ToolComp - Design of Tooling Components		01-Mar-18	01-Mar-18	0d	
A17720240	Linac - SSR1 - 1stCM - INT - CMToolDes - R&DPh: T5 M5 - Final FDR/PRR for CM Tooling	01-Mar-18		0d	393

121.3.5 SSR1: Design Review Plan

SSR1 2nd cryomodule (WBS 121.3.5.4)

- Critical component design review cycles are organized as follows: FRS and/or TRS → PDR → FDR → PRR
- Reviews are tracked in P6 as milestones with design activities preceding and following the PDR, concluding with the FDR, and procurement support activities starting with the PRR milestone.

WBS	Task	Start	End	404d
121.3.5.4	Linac - SSR1 - 2nd Production CryoModule (2ndCM)	10-Sep-18	20-Apr-20	404d
121.3.5.4.2	Linac - SSR1 - 2ndCM - Dressed Cavities qualification	10-Sep-18	06-Feb-19	100d
121.3.5.4.2.1	Linac - SSR1 - 2ndCM - DCAV - Design Finalization and Fabrication	10-Sep-18	15-Oct-18	25d
A17720400	Linac - SSR1 - 2ndCM - DCAV - ProdDes - ConstPh: TS MS - Final Des. Rev. (FDR) for Dr. Cav. after 1m 1st CM string ass.	10-Sep-18		0d 399
A17720410	Linac - SSR1 - 2ndCM - DCAV - ProdDes - ConstPh: Prepare documentation for Dressed Cavities PRR	10-Sep-18	12-Oct-18	25d 399
A17720420	Linac - SSR1 - 2ndCM - DCAV - ProdDes - ConstPh: TS MS - Production Readiness Review (PRR) for Dressed Cavities	15-Oct-18		0d 399
121.3.5.4.2.2	Linac - SSR1 - 2ndCM - DCAV - Power Couplers	10-Sep-18	06-Feb-19	100d
121.3.5.4.2.2.1	Linac - SSR1 - 2ndCM - DCAV - Coupl: Femilab scope (FTE)	10-Sep-18	06-Feb-19	100d
121.3.5.4.2.2.1.1	Linac - SSR1 - 2ndCM - DCAV - Coupl: Production Design	10-Sep-18	06-Feb-19	100d
A17708930	Linac - SSR1 - 2ndCM - DCAV - COUPLERS - Design - ConstPh: Prod. Coupl. Fin. Des. after FDR and 1st CM 1st DCAV STC	10-Sep-18	07-Jan-19	80d 399
A17708940	Linac - SSR1 - 2ndCM - DCAV - COUPLERS - Design - ConstPh: TS MS - Production RF Power Couplers PDR	08-Jan-19		0d 399
A17732380	Linac - SSR1 - 2ndCM - DCAV - COUPLERS - Design - ConstPh: Prepare documentation for RF Power Couplers PRR	08-Jan-19	05-Feb-19	20d 399
A17732390	Linac - SSR1 - 2ndCM - DCAV - COUPLERS - Design ConstPh: TS MS - Production Readiness Review (PRR) for Couplers	06-Feb-19		0d 399
121.3.5.4.2.3	Linac - SSR1 - 2ndCM - DCAV - Tuners	10-Sep-18	16-Nov-18	50d
121.3.5.4.2.3.1	Linac - SSR1 - 2ndCM - DCAV - Tuners: Femilab scope (FTE)	10-Sep-18	16-Nov-18	50d
121.3.5.4.2.3.1.1	Linac - SSR1 - 2ndCM - DCAV - Tuners: Production Design	10-Sep-18	22-Oct-18	30d
A17720500	Linac - SSR1 - 2ndCM - DCAV - TunersProdDes - ConstPh: Dev. Final Des. of Tuners after FDR DCAV CM2	10-Sep-18	19-Oct-18	30d 399
A17720510	Linac - SSR1 - 2ndCM - DCAV - TunersProdDes - ConstPh: TS MS - FDR/PRR for Tuners	22-Oct-18		0d 399
121.3.5.4.2.3.1.2	Linac - SSR1 - 2ndCM - DCAV - 9TunersProdCONTR: Supp. to Aw. 8+1 Tuners Contract and Deliv.	22-Oct-18	16-Nov-18	20d
A17707360	Linac - SSR1 - 2ndCM - DCAV - 9TunersProdCONTR - ConstPh: Prep. RQN for 9 Prod. Tuners Contract after PRR DCAV CM2	22-Oct-18	16-Nov-18	20d 399
121.3.5.4.2.4	Linac - SSR1 - 2ndCM - DCAV - Helium Vessels / Jacketed cavities	10-Sep-18	13-Nov-18	23d
121.3.5.4.2.4.1	Linac - SSR1 - 2ndCM - DCAV - HeVProd: Femilab scope (FTE)	10-Sep-18	13-Nov-18	23d
121.3.5.4.2.4.1.1	Linac - SSR1 - 2ndCM - DCAV - 9HeVProdCONTR: S. to Aw. the 8+1 He Vessel Contr. and to Del.	10-Sep-18	13-Nov-18	23d
A17709170	Linac - SSR1 - 2ndCM - DCAV - 9HeVProdCONTR - ConstPh: Prep. RQN for 9 Prod. He Vessels contract after PRR DCAV	10-Sep-18	13-Nov-18	23d 399
121.3.5.4.3	Linac - SSR1 - 2ndCM - STRING integration	08-Jan-19	06-Sep-19	170d
121.3.5.4.3.1	Linac - SSR1 - 2ndCM - STRING - Design Finalization and Fabrication	08-Jan-19	01-May-19	80d
A17720640	Linac - SSR1 - 2ndCM - STRING - IntegDesign - ConstPh: Dev. Fin. Des. String after CM1 string ass'em, FDR: PC Tun. DCAV	08-Jan-19	02-Apr-19	60d 402
A17720650	Linac - SSR1 - 2ndCM - STRING - IntegDesign - ConstPh: TS MS - Final Design Review (FDR) for String Integration	03-Apr-19		0d 402
A17720660	Linac - SSR1 - 2ndCM - STRING - IntegDesign - ConstPh: Prepare documentation for String Integration PRR	03-Apr-19	30-Apr-19	20d 402
A17720670	Linac - SSR1 - 2ndCM - STRING - IntegDesign - ConstPh: TS MS - Prod. Readiness Review (PRR) for String Integration	01-May-19		0d 402
121.3.5.4.3.2	Linac - SSR1 - 2ndCM - STRING - Focusing Elements	01-May-19	06-Sep-19	90d
121.3.5.4.3.2.1	Linac - SSR1 - 2ndCM - STRING - FocElem: Femilab scope (FTE)	01-May-19	06-Sep-19	90d
121.3.5.4.3.2.1.1	Linac - SSR1 - 2ndCM - STRING - FocElem: Production Design	01-May-19	12-Jul-19	80d
A17720700	Linac - SSR1 - 2ndCM - STRING - FocElem - ProdDesign - ConstPh: Dev. Final Design of Focusing Elements after String PRR	01-May-19	12-Jun-19	30d 402
A17720710	Linac - SSR1 - 2ndCM - STRING - FocElem - ProdDesign - ConstPh: TS MS - Final Design Review (FDR) for Focusing Elements	13-Jun-19		0d 402
A17720720	Linac - SSR1 - 2ndCM - STRING - FocElem - ProdDesign - ConstPh: Prepare documentation for Focusing Elements PRR	13-Jun-19	11-Jul-19	20d 402
A17720730	Linac - SSR1 - 2ndCM - STRING - FocElem - ProdDesign - ConstPh: TS MS - Prod. Readiness Review (PRR) for Focusing Element	12-Jul-19		0d 402
121.3.5.4.3.2.1.4	Linac - SSR1 - 2ndCM - STRING - FocElem: 4 BPM detectors fabrication	12-Jul-19	06-Sep-19	40d
A17720790	Linac - SSR1 - 2ndCM - STRING - FocElem - 4BPMFab - ConstPh: Support to Procurement for BPM Detectors after PRR Foc. El.	12-Jul-19	06-Sep-19	40d 402
121.3.5.4.4	Linac - SSR1 - 2ndCM - COLDMASS integration	11-Nov-19	11-Feb-20	60d
121.3.5.4.4.1	Linac - SSR1 - 2ndCM - COLDMASS - CryoModule Components	11-Nov-19	11-Feb-20	60d
121.3.5.4.4.1.1	Linac - SSR1 - 2ndCM - COLDMASS - CMComp: Femilab scope (FTE)	11-Nov-19	11-Feb-20	60d
121.3.5.4.4.1.1.1	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - Design Finalization & Fabrication	11-Nov-19	11-Dec-19	20d
A17720860	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - Des - ConstPh: TS MS - FDR for Cold Mass Comp. 1m after RF test CM1 starts	11-Nov-19		0d 402
A17720870	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - Des - ConstPh: Prepare documentation for Cold Mass Components PRR	11-Nov-19	10-Dec-19	20d 402
A17720880	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - Des - ConstPh: TS MS - Prod. Readiness Review (PRR) for Cold Mass Components	11-Dec-19		0d 402
121.3.5.4.4.1.1.2	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - 4CurrLCONTR: S. to Aw. 4 Current Leads Contrand to Del.	11-Dec-19	13-Jan-20	20d
A17709270	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - 4CurrLCONTR - ConstPh: Prep. RQN for 4 Curr. Leads Contr. after PRR ColdM.	11-Dec-19	13-Jan-20	20d 402
121.3.5.4.4.1.1.3	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - 1 Thermal Shield fabrication	11-Dec-19	11-Feb-20	40d
A17720890	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - 1ThShFab - ConstPh: Support to Proc. for Thermal Shields after ColdMass PRR	11-Dec-19	11-Feb-20	40d 402
121.3.5.4.4.1.1.4	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - 1 Strongback/Support Posts system fabrication	11-Dec-19	11-Feb-20	40d
A17720930	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - StrkFab - ConstPh: Supp. to Proc. for Str. Supp. Posts after ColdMass PRR	11-Dec-19	11-Feb-20	40d 402
121.3.5.4.4.1.1.5	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - Piping, Insulation and Thermal Strap fabrication	11-Dec-19		
A17720970	Linac - SSR1 - 2ndCM - COLDMASS - CMComp - PipeFab - ConstPh: Supp. Proc. for Pip. Ins. and Th. Str after ColdMass PRR	11-Dec-19		
121.3.5.4.5	Linac - SSR1 - 2ndCM - CryoModule final Integration			
121.3.5.4.5.1	Linac - SSR1 - 2ndCM - INT - CryoModule Components			
121.3.5.4.5.1.1	Linac - SSR1 - 2ndCM - INT - CMComp: Femilab scope (FTE)			
121.3.5.4.5.1.1.1	Linac - SSR1 - 2ndCM - INT - CMComp - Design Finalization & Fabrication			
A17721080	Linac - SSR1 - 2ndCM - INT - CMComp - Des - ConstPh: TS MS - FDR for CryoModule Comp			
A17721090	Linac - SSR1 - 2ndCM - INT - CMComp - Des - ConstPh: Prepare documentation for			
A17721100	Linac - SSR1 - 2ndCM - INT - CMComp - Des - ConstPh: TS MS - Prod. R-			
121.3.5.4.5.1.1.3	Linac - SSR1 - 2ndCM - INT - CMComp - 1 Magnetic			
A17721110	Linac - SSR1 - 2ndCM - INT - CMComp - 1MagnShp			

121.3.6 SSR2: Design Review Plan

Charge #3

- PDRs, FDRs and PRRs are planned and tracked in P6 for SSR2 CMs and components.
- Design reviews are also planned for Partner deliverables as appropriate to ensure technical and ESH&Q requirements are met.
- Partner milestone dates exist in P6, but require formal agreement.

Item ID	Description	Start Date	End Date	Count
121.3.6.4	Linac - SSR2 - 2nd to 7th Production Cryomodules (2nd-7thCM)			
121.3.6.4.1	Linac - SSR2 - 2nd-7thCM - Bare CA/Ties qualification	03-Nov-21	23-Oct-22	4904
121.3.6.4.1.1	Linac - SSR2 - 2nd-7thCM - BCAV - Cav: Fermilab scope (FTE)	04-Mar-22	31-Mar-22	204
121.3.6.4.1.1.1	Linac - SSR2 - 2nd-7thCM - BCAV - Cav: Fermilab scope (FTE)	04-Mar-22	31-Mar-22	204
121.3.6.4.1.1.2	Linac - SSR2 - 2nd-7thCM - BCAV - Cav - 16CAVProdCONTR: Supp. to Aw. 15H1 Prod. Cav. Contr. and Del.	04-Mar-22	31-Mar-22	204
A1770820	Linac - SSR2 - 2nd-7thCM - BCAV - Cav - 16CAVProdCONTR - ConstPR: Prep. RON for 16 Prod. Bare Cav. after FDR PAV	04-Mar-22	31-Mar-22	438
121.3.6.4.2	Linac - SSR2 - 2nd-7thCM - Dressed Cavities qualification	03-Nov-21	23-Mar-22	100d
121.3.6.4.2.1	Linac - SSR2 - 2nd-7thCM - DCAV - S. to PIP-II Intern. Partn. Dressed Cavities Design Final & Fabric.	04-Feb-22	04-Mar-22	204
A1775260	Linac - SSR2 - 2nd-7thCM - DCAV - ProdDes - ConstPR: TS MS - Final Des. Rev. (FDR)	04-Feb-22	04-Feb-22	0438
A17752370	Linac - SSR2 - 2nd-7thCM - DCAV - ProdDes - ConstPR: TS MS - Production Readiness Review (PRR) for Dressed Cavities PRR	04-Feb-22	03-Mar-22	0438
A17752380	Linac - SSR2 - 2nd-7thCM - DCAV - ProdDes - ConstPR: TS MS - Production Readiness Review (PRR) for Dressed Cavities	04-Mar-22	04-Feb-22	0438
121.3.6.4.2.2	Linac - SSR2 - 2nd-7thCM - DCAV - Power Couplers	03-Nov-21	03-Dec-21	204
121.3.6.4.2.2.1	Linac - SSR2 - 2nd-7thCM - DCAV - Coupl: Fermilab scope (FTE)	03-Nov-21	03-Dec-21	204
121.3.6.4.2.2.1.1	Linac - SSR2 - 2nd-7thCM - DCAV - Coupl: S. to PIP-II Intern. Partn. Coupl. Design Final & Fabric.	03-Nov-21	03-Dec-21	204
A1775266	Linac - SSR2 - 2nd-7thCM - DCAV - Coupl - Supp&FNALDes - ConstPR: TS MS - Int. Partn. and FNAL PDR for Proto Couplers	03-Nov-21	04-Feb-22	0438
A1775267	Linac - SSR2 - 2nd-7thCM - DCAV - Coupl - FNALDes - ConstPR: Prepare FNAL documentation for Proto Couplers PRR	03-Nov-21	03-Dec-21	0438
A1775290	Linac - SSR2 - 2nd-7thCM - DCAV - Coupl - FNALDes - ConstPR: TS MS - FNAL PRR for Proto Couplers	03-Dec-21	03-Feb-22	0438
121.3.6.4.2.3	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners	03-Dec-21	03-Feb-22	404
121.3.6.4.2.3.1	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners: Fermilab scope (FTE)	03-Dec-21	03-Feb-22	404
121.3.6.4.2.3.1.1	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners: S. to PIP-II Intern. Partn. Tuners Design Final & Fabric.	03-Dec-21	06-Jun-22	204
A1775370	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners - Supp&FNALDes - ConstPR: TS MS - Int. Partn. and FNAL PDR for Proto Tuners	03-Dec-21	04-Feb-22	0438
A1775380	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners - FNALDes - ConstPR: Prepare FNAL documentation for Prod. Tuners PRR	03-Dec-21	06-Jun-22	0438
A1775390	Linac - SSR2 - 2nd-7thCM - DCAV - Tuners - FNALDes - ConstPR: TS MS - FNAL PRR for Proto Tuners	06-Jun-22	04-Feb-22	0438
121.3.6.4.2.3.1.2	Linac - SSR2 - 2nd-7thCM - DCAV - 14TunersProdCONTR: Supp. to Aw. 12x2 Prod. Tuners Contr. and Del.	06-Jun-22	03-Feb-22	204
A1775400	Linac - SSR2 - 2nd-7thCM - DCAV - 14TunersProdCONTR - ConstPR: Preparation RON for 12-2 Tuners Contr. after PRR	06-Jun-22	03-Feb-22	438
121.3.6.4.2.4	Linac - SSR2 - 2nd-7thCM - DCAV - Helium Vessels	04-Mar-22	31-Mar-22	204
121.3.6.4.2.4.1	Linac - SSR2 - 2nd-7thCM - DCAV - HeV. Fermilab scope (FTE)	04-Mar-22	31-Mar-22	204
121.3.6.4.2.4.1.1	Linac - SSR2 - 2nd-7thCM - DCAV - 16HeVProdCONTR: Supp. to Award 15H1 Helium Vessels Contr. and Del.	04-Mar-22	31-Mar-22	204
A1771980	Linac - SSR2 - 2nd-7thCM - DCAV - 16HeVProdCONTR - ConstPR: Preparation RON for 16 HeV Tanks Prod. Contr. after PRR DCAV	04-Mar-22	31-Mar-22	438
121.3.6.4.3	Linac - SSR2 - 2nd-7thCM - STRING integration	25-Sep-23	23-Oct-23	20d
121.3.6.4.3.1	Linac - SSR2 - 2nd-7thCM - STRING - S. to PIP-II Intern. Partners String Design Finaliz. & Fabric.	25-Sep-23	23-Oct-23	20d
A1775440	Linac - SSR2 - 2nd-7thCM - STRING - IntgDesign - ConstPR: TS MS - Final Design Review (FDR) for String Integration	25-Sep-23	23-Oct-23	441
A1775450	Linac - SSR2 - 2nd-7thCM - STRING - IntgDesign - ConstPR: TS MS - Prep. documentation for String Integration PRR	25-Sep-23	20-Oct-23	0441
A1775460	Linac - SSR2 - 2nd-7thCM - STRING - IntgDesign - ConstPR: TS MS - Prod. Readiness Review (PRR) for String Integration	23-Oct-23	23-Oct-23	0441
121.3.6.4.4	Linac - SSR2 - 2nd-7thCM - COLD MASS integration	25-Aug-23	25-Sep-23	20d
121.3.6.4.4.1	Linac - SSR2 - 2nd-7thCM - COLDMASS - CryoModule Components	25-Aug-23	25-Sep-23	20d
121.3.6.4.4.1.1	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp: Fermilab scope (FTE)	25-Aug-23	25-Sep-23	20d
121.3.6.4.4.1.1.1	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Design of CM Components	25-Aug-23	25-Sep-23	20d
A1772200	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Des - ConstPR: Des. and Prep. Design for Cold Mass Comp. after Final PRR DCAV	25-Aug-23	25-Sep-23	429
A1772240	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Des - ConstPR: Des. and Prep. Design for Cold Mass Comp. after Final PRR DCAV	25-Aug-23	25-Sep-23	429
A1772260	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Final Design Review (FDR) for Cold Mass Components	25-Aug-23	25-Sep-23	429
A1772270	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Prep. documentation for Cold Mass Components	25-Aug-23	25-Sep-23	429
A1772280	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Prod. Readiness Review (PRR) for Cold Mass Components	25-Aug-23	25-Sep-23	429
121.3.6.4.4.1.2	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - 4CurMCONTR: S. to Aw. 4 CurMCONTR	25-Aug-23	25-Sep-23	429
A1773190	Linac - SSR2 - 2nd-7thCM - COLDMASS - CMCComp - 4CurMCONTR - ConstPR: Prep. RON for 4 CurMCONTR	25-Aug-23	25-Sep-23	429
121.3.6.4.5	Linac - SSR2 - 2nd-7thCM - INT - CryoModule final Integration			
121.3.6.4.5.1	Linac - SSR2 - 2nd-7thCM - INT - CryoModule final Integration			

Item ID	Description	Start Date	End Date	Count
121.3.6.3	Linac - SSR2 - 1st Pre-start Production Cryomodules (1stCM)			
121.3.6.3.1	Linac - SSR2 - 1stCM - Support for PIP-II International Partner Bare Cavities and FNAL Design	30-Oct-17	21-Sep-22	12724
121.3.6.3.1.1	Linac - SSR2 - 1stCM - BCAV - Supp&FNALDes: Fermilab scope (FTE)	30-Oct-17	18-May-19	1374
A1773125	Linac - SSR2 - 1stCM - BCAV - Supp&FNALDes - R&DP: TS MS - FNAL Int. Partners PDR for Bare Cavities	30-Oct-17	04-Feb-19	0438
A1773140	Linac - SSR2 - 1stCM - BCAV - FNALDes - R&DP: TS MS - FNAL Final Design Review (FDR) for Bare Cavities	16-Apr-18	04-Feb-19	0438
A1773150	Linac - SSR2 - 1stCM - BCAV - FNALDes - R&DP: Prepare FNAL documentation for Bare Cavities PRR	16-Apr-18	17-May-18	344
A1773160	Linac - SSR2 - 1stCM - BCAV - FNALDes - R&DP: TS MS - FNAL Prod. Readiness Review (PRR) for Bare Cavities	18-May-18	04-Feb-19	0438
121.3.6.3.1.2	Linac - SSR2 - 1stCM - BCAV - Cavities	30-Oct-17	31-May-19	3974
121.3.6.3.1.2.1	Linac - SSR2 - 1stCM - BCAV - Cav: Fermilab scope (FTE)	30-Oct-17	31-May-19	3974
A1770410	Linac - SSR2 - 1stCM - BCAV - Cav - IntgCONTR: S. to Aw. the NB Contr. 1 IFC Cav #2 and Deliv.	30-Oct-17	31-Jan-18	614
121.3.6.3.1.2.1.3	Linac - SSR2 - 1stCM - BCAV - Cav - 2NBProdCONTR: Supp. to Aw. the NB Contr. 2 Prof. Cav. and Deliv.	18-May-18	15-Jun-18	204
A1770490	Linac - SSR2 - 1stCM - BCAV - Cav - 2NBProdCONTR - R&DP: Prep. RON for NB Contr. for 2 Prof. Cavities after BCAV PRR	18-May-18	15-Jun-18	204
121.3.6.3.1.2.1.5	Linac - SSR2 - 1stCM - BCAV - Cav - 2CAVProdCONTR: Supp. to Aw. the 2 Prod. Cav. Contr. and Deliv.	03-May-19	31-May-19	204
A1770990	Linac - SSR2 - 1stCM - BCAV - Cav - 2CAVProdCONTR - R&DP: Prep. RON 2 Prod. Cav. Contr. after PRR BCAV, O&Q/0b	03-May-19	31-May-19	204
121.3.6.3.1.3	Linac - SSR2 - 1stCM - BCAV - PROCPREP&HTR: Fermilab scope (FTE)	18-May-18	16-Jul-18	404
121.3.6.3.1.3.1	Linac - SSR2 - 1stCM - BCAV - PROCPREP&HTR: Tooling fabrication	18-May-18	16-Jul-18	404
A1772820	Linac - SSR2 - 1stCM - BCAV - PROCPREP&HTR - HTRToolFab - R&DP: Support to Procurement for Tooling after PRR BCAV	18-May-18	16-Jul-18	404
121.3.6.3.1.4	Linac - SSR2 - 1stCM - BCAV - ColdT: Tools	18-May-18	16-Jul-18	404
121.3.6.3.1.4.3	Linac - SSR2 - 1stCM - BCAV - ColdT: Tooling fabrication	18-May-18	16-Jul-18	404
A1772780	Linac - SSR2 - 1stCM - BCAV - ColdT - VTSToolFab - R&DP: Support to Procurement for VTS Tooling after PRR BCAV	18-May-18	16-Jul-18	404
121.3.6.3.2	Linac - SSR2 - 1stCM - DCAV - Support for International Partners Dressed Cavities Design and FNAL Des.	30-Oct-17	03-Dec-21	10274
121.3.6.3.2.1.1	Linac - SSR2 - 1stCM - DCAV - SuppDes: Fermilab scope (FTE)	30-Oct-17	03-Dec-21	10274
A1773190	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: Dev. FNAL and Supp Int. Partn. Des. of Dress. Cav. after PDR BCAV	30-Oct-17	06-Jun-18	1504
A1773190	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: TS MS - FNAL Int. Partn. PDR for Dressed Cavities	07-Jun-18	04-Feb-19	0438
A1773200	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: TS MS - FNAL Int. Partn. PDR for Dressed Cavities	05-Jul-18	04-Feb-19	0438
A1773535	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: TS MS - Final Production Design Review (PDR) for Dressed Cavities	03-Nov-21	04-Feb-19	0438
A1773945	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: Prepare FNAL documentation for Dressed Cavities PRR	03-Nov-21	02-Dec-21	204
A1773955	Linac - SSR2 - 1stCM - DCAV - ProdDesign - R&DP: TS MS - FNAL Prod. Readiness Review (PRR) for Dressed Cavities	03-Dec-21	04-Feb-19	426
121.3.6.3.2.2	Linac - SSR2 - 1stCM - DCAV - Power Couplers	05-Jul-18	25-Jan-22	8974
121.3.6.3.2.2.1	Linac - SSR2 - 1stCM - DCAV - Coupl: Fermilab scope (FTE)	05-Jul-18	25-Jan-22	8974
121.3.6.3.2.2.1.1	Linac - SSR2 - 1stCM - DCAV - Coupl: Support International Partners and FNAL Couplers Design	05-Jul-18	26-Jan-19	1404
A1772190	Linac - SSR2 - 1stCM - DCAV - Coupl - Supp&FNALDes - R&DP: Supp. a FNAL Fin. Des. of Prod. Coupl. after FDR for DCAV	05-Jul-18	26-Dec-18	1204
A1772160	Linac - SSR2 - 1stCM - DCAV - Coupl - Supp&FNALDes - R&DP: TS MS - Int. Partn. and FNAL PDR for Prototype Couplers	27-Dec-18	04-Feb-19	0438
A1772170	Linac - SSR2 - 1stCM - DCAV - Coupl - FNALDes - R&DP: Prepare FNAL documentation for Prototype Couplers PRR	27-Dec-18	28-Jan-19	204
A1772120	Linac - SSR2 - 1stCM - DCAV - Coupl - FNALDes - R&DP: TS MS - FNAL PRR for Prototype Couplers	28-Jan-19	04-Feb-19	0438
121.3.6.3.2.2.1.5	Linac - SSR2 - 1stCM - DCAV - Coupl - Supp. to Award 6 PIP-Prod. Couplers Contr. and Deliv.	03-Dec-21	25-Jan-22	334
A1773070	Linac - SSR2 - 1stCM - DCAV - Coupl - Supp&FNALDes - R&DP: Prep. RON for 6 Prod. Coupl. Contr. after PRR DCAV/ STC tested	03-Dec-21	25-Jan-22	426
121.3.6.3.2.3	Linac - SSR2 - 1stCM - DCAV - Tuners	25-Dec-18	25-Jan-22	7744
121.3.6.3.2.3.1	Linac - SSR2 - 1stCM - DCAV - Tuners: Fermilab scope (FTE)	25-Dec-18	25-Jan-22	7744
121.3.6.3.2.3.1.1	Linac - SSR2 - 1stCM - DCAV - Tuners - Supp. to PIP-II International Partners and FNAL Tuners Design	25-Dec-18	24-Jan-19	204
A1772160	Linac - SSR2 - 1stCM - DCAV - Tuners - Supp&FNALDes - R&DP: TS MS - Int. Partn. and FNAL PDR for Prototype Tuners	25-Dec-18	04-Feb-19	0438
A1772170	Linac - SSR2 - 1stCM - DCAV - Tuners - FNALDes - R&DP: Prepare FNAL documentation for Proto Tuners PRR	25-Dec-18	23-Jan-19	204
A1772180	Linac - SSR2 - 1stCM - DCAV - Tuners - FNALDes - R&DP: TS MS - FNAL PRR for Proto Tuners	24-Jan-19	04-Feb-19	0438
121.3.6.3.2.3.1.5	Linac - SSR2 - 1stCM - DCAV - Tuners/ProdCONTR: Supp. to Aw. the 4+1 Tun. Contr. and Contr. and to Del.	03-Dec-21	25-Jan-22	334
A1772620	Linac - SSR2 - 1stCM - DCAV - Tuners/ProdCONTR - ConstPR: Prep. RON for 5 Prod. Coupl. Contr. after PRR DCAV/ STC tested	03-Dec-21	25-Jan-22	426
121.3.6.3.2.4	Linac - SSR2 - 1stCM - DCAV - Helium Vessels / Jaskelved cavities	05-Jul-18	01-Aug-18	204
121.3.6.3.2.4.1	Linac - SSR2 - 1stCM - DCAV - HeV. Fermilab scope (FTE)	05-Jul-18	01-Aug-18	204
121.3.6.3.2.4.1.2	Linac - SSR2 - 1stCM - DCAV - HeV - Supp. to Award 2 Helium Vessels Contr. and to Del.	05-Jul-18	01-Aug-18	204
A1770610	Linac - SSR2 - 1stCM - DCAV - HeV - 2HelVProdCONTR - R&DP: Preparation RON for 2 Prod. HeV Tanks Contr. after Prod. DCAV/ FDR	05-Jul-18	01-Aug-18	204
121.3.6.3.3	Linac - SSR2 - 1stCM - STRING integration	03-Dec-21	29-Apr-22	100d
121.3.6.3.3.1	Linac - SSR2 - 1stCM - STRING - String Design	03-Dec-21	29-Apr-22	100d
A1771880	Linac - SSR2 - 1stCM - STRING - IntgDesign - ConstPR: Des. and Prep. Design for String Integration after Final PRR DCAV	03-Dec-21	03-Feb-22	429
A1771890	Linac - SSR2 - 1stCM - STRING - IntgDesign - ConstPR: TS MS - Int. Partn. and FNAL PDR for String Integration	04-Feb-22	04-Feb-22	429
A1772190	Linac - SSR2 - 1stCM - STRING - IntgDesign - ConstPR: TS MS - Final Design Review (FDR) for String Integration	04-Feb-22	04-Feb-22	429
A1772120	Linac - SSR2 - 1stCM - STRING - IntgDesign - ConstPR: Prepare documentation for String Integration PRR	04-Feb-22	28-Apr-22	204
A1772130	Linac - SSR2 - 1stCM - STRING - IntgDesign - ConstPR: TS MS - Prod. Readiness Review (PRR) for String Integration	28-Apr-22	04-Feb-22	429
121.3.6.3.4	Linac - SSR2 - 1stCM - COLDMASS integration	11-Dec-19	18-Jul-22	650d
121.3.6.3.4.1	Linac - SSR2 - 1stCM - COLDMASS - CryoModule Components	03-Dec-21	18-Jul-22	1554
121.3.6.3.4.1.1	Linac - SSR2 - 1stCM - COLDMASS - CMCComp: Fermilab scope (FTE)	03-Dec-21	18-Jul-22	1554
121.3.6.3.4.1.1.1	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Design of CM Components	03-Dec-21	18-Jul-22	1554
A1772200	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Des - ConstPR: Des. and Prep. Design for Cold Mass Comp. after Final PRR DCAV	03-Dec-21	18-Jul-22	429
A1772240	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Des - ConstPR: Des. and Prep. Design for Cold Mass Comp. after Final PRR DCAV	03-Dec-21	18-Jul-22	429
A1772260	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Final Design Review (FDR) for Cold Mass Components	03-Dec-21	18-Jul-22	429
A1772270	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Prep. documentation for Cold Mass Components	03-Dec-21	18-Jul-22	429
A1772280	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - Des - ConstPR: TS MS - Prod. Readiness Review (PRR) for Cold Mass Components	03-Dec-21	18-Jul-22	429
121.3.6.3.4.1.2	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - 4CurMCONTR: S. to Aw. 4 CurMCONTR	03-Dec-21	18-Jul-22	429
A1773190	Linac - SSR2 - 1stCM - COLDMASS - CMCComp - 4CurMCONTR - ConstPR: Prep. RON for 4 CurMCONTR	03-Dec-21	18-Jul-22	429
121.3.6.3.4.5	Linac - SSR2 - 1stCM - COLDMASS - Tooling Components			
121.3.6.3.4.5.1	Linac - SSR2 - 1stCM - COLDMASS - ToolComp: Fermilab scope (FTE)			
121.3.6.3.4.5.1.1	Linac - SSR2 - 1stCM - COLDMASS - ToolComp - Design of Tooling			
A1772210	Linac - SSR2 - 1stCM - COLDMASS - ToolComp - Des - ConstPR: Des. and Prep. Design for Cold Mass Tooling			
A1772220	Linac - SSR2 - 1stCM - COLDMASS - ToolComp - Des - ConstPR: TS MS - Final Design Review (FDR) for Cold Mass Tooling			
A1772230	Linac - SSR2 - 1stCM - COLDMASS - ToolComp - Des - ConstPR: TS			

ESH&Q

Charge #4

- Personnel Safety and environmental and equipment protection are the highest priorities in the PIP-II Project.
- All activities will be in full compliance with the PIP-II ISM program defined in DocDb# 141.
 - Laboratory and DOE standards and practices
 - Fermi ES&H Manual
 - Division/Area specific Hazards Analyses and Training
- Procurement, fabrication, and acceptance of components will follow the Project's QA Plan (DocDB# 142) utilizing established Project/Division mechanisms regarding acceptance testing, control of non-conformances, and vendor feedback.

Risk: SSR Cavity and CM

Charge #2

Mishra

- SSR1 CM (1) Performance at PIP2IT does not meet technical requirements
- SSR2 CM (1) Performance at PIP2IT does not meet technical requirements
- SSR2 Production CMs (2-4) do not meet technical performance requirements at PIP2IT

Title	Probability	Probability Score	Impact Score - Cost	Impact Score - Schedule	Risk Rank	P * Impact (k\$)	P * Impact (months)
SSR1 CM (1) Performance at PIP2IT does not meet technical requirements	40.00%	4 (H)	2 (M)	3 (H)	3 (High)	433	2.8
SSR2 CM (1) Performance at PIP2IT does not meet technical requirements	40.00%	4 (H)	2 (M)	3 (H)	3 (High)	333	2.8
SSR2 Production CMs (2-4) do not meet technical performance	25.00%	3 (M)	2 (M)	3 (H)	3 (High)	188	1.8

121.3.5 SSR1: BOE Summary

Charge #2

WBS Number	Title	Docdb #
121.3.5.2	<u>SSR1 Project Management and Coordination</u>	<u>384-v15</u>
121.3.5.3.1	<u>SSR1 1st CM Cavities</u>	<u>387-v10</u>
121.3.5.3.2 .3 and .4	<u>SSR1 1st CM Integration and Assembly</u>	<u>393-v9</u>
121.3.5.3.5	<u>SSR1 1st CM Test</u>	<u>396-v15</u>
121.3.5.4.1 and .2	<u>SSR1 2nd CM Cavities</u>	<u>399-v8</u>
121.3.5.4.3 .4 and .5	<u>SSR1 2nd CM Integration and Assembly</u>	<u>402-v11</u>
121.3.5.4.6	<u>SSR1 2nd CM Test</u>	<u>405-v12</u>

All relevant BOE Documents (estimate roll-ups, WBS dictionaries, descriptions) exist and have been reviewed and approved.

121.3.6 SSR2: BOE Summary

Charge #2

WBS Number	Title	Docdb #
121.3.6.2	SSR2 PM and Coordination	423-v16
121.3.6.3.1 and .2	SSR2 1st CM Cavities	426-v14
121.3.6.3.3 .4 and .5	SSR2 1st CM Integration and Assembly	429-v10
121.3.6.3.6	SSR2 1st CM Test	432-v8
121.3.6.4.1 and .2	SSR2 2nd-7th CM Cavities	438-v10
121.3.6.4.3 .4 and .5	SSR2 2nd-7th CM Integration and Assembly	441-v12
121.3.6.4.6	SSR2 2nd-7th CM Test	444-v14

All relevant BOE Documents (estimate roll-ups, WBS dictionaries, descriptions) exist and have been reviewed and approved.

121.3.5 SSR1: Cost Summary

Charge #2

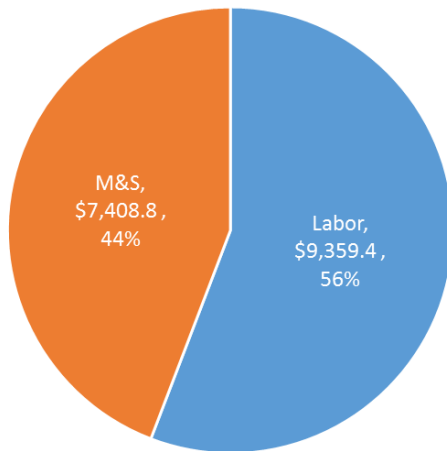
WBS Element	Hours	Labor (\$000)	M&S (\$000)	Est. Uncertainty (\$000)		Total Cost Incl. Uncrty.
	P6 Hours	P6 Base Cost	P6 Base Cost	Total	% of Base	
121.3.5 - Linac - Single Spoke Resonator 1 (SSR1)						
121.3.5.2 - Linac - SSR1 - Project Management and Coordination	6,718	\$ 1,118.3	\$ 92.4	\$ 130.3	10.8%	\$ 1,341.0
121.3.5.3 - Linac - SSR1 - 1st Prototype CryoModule (1stCM)	25,439	\$ 3,684.6	\$ 1,669.5	\$ 1,201.3	22.4%	\$ 6,555.3
121.3.5.4 - Linac - SSR1 - 2nd Production CryoModule (2ndCM)	<u>32,131</u>	<u>\$ 4,556.5</u>	<u>\$ 5,647.0</u>	<u>\$ 2,145.0</u>	<u>21.0%</u>	<u>\$ 12,348.5</u>
Grand Total	64,289	\$ 9,359.4	\$ 7,408.8	\$ 3,476.6	20.7%	\$ 20,244.8
Note: P6 base cost = BOE + overheads and escalation						

- Costs generated from resource loaded schedule (RLS).
- Estimate uncertainty and overhead are included following project guidelines.
- Estimations for SSR1 CM2 are based on direct experience with SSR1 CM1.

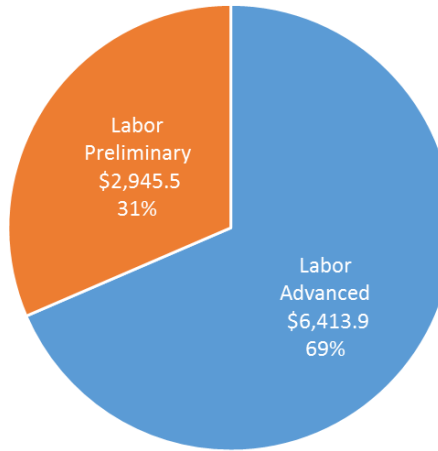
121.3.5 SSR1: Cost Drivers and Estimate Maturity

Charge #2

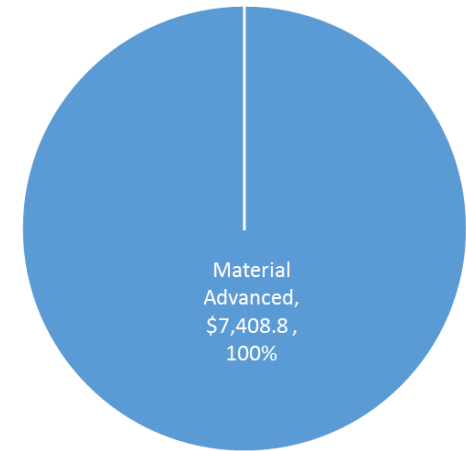
Cost Distribution - P6 Base Cost



Labor Cost Distribution - P6 Base Cost



M&S Cost Distribution - P6 Base Cost

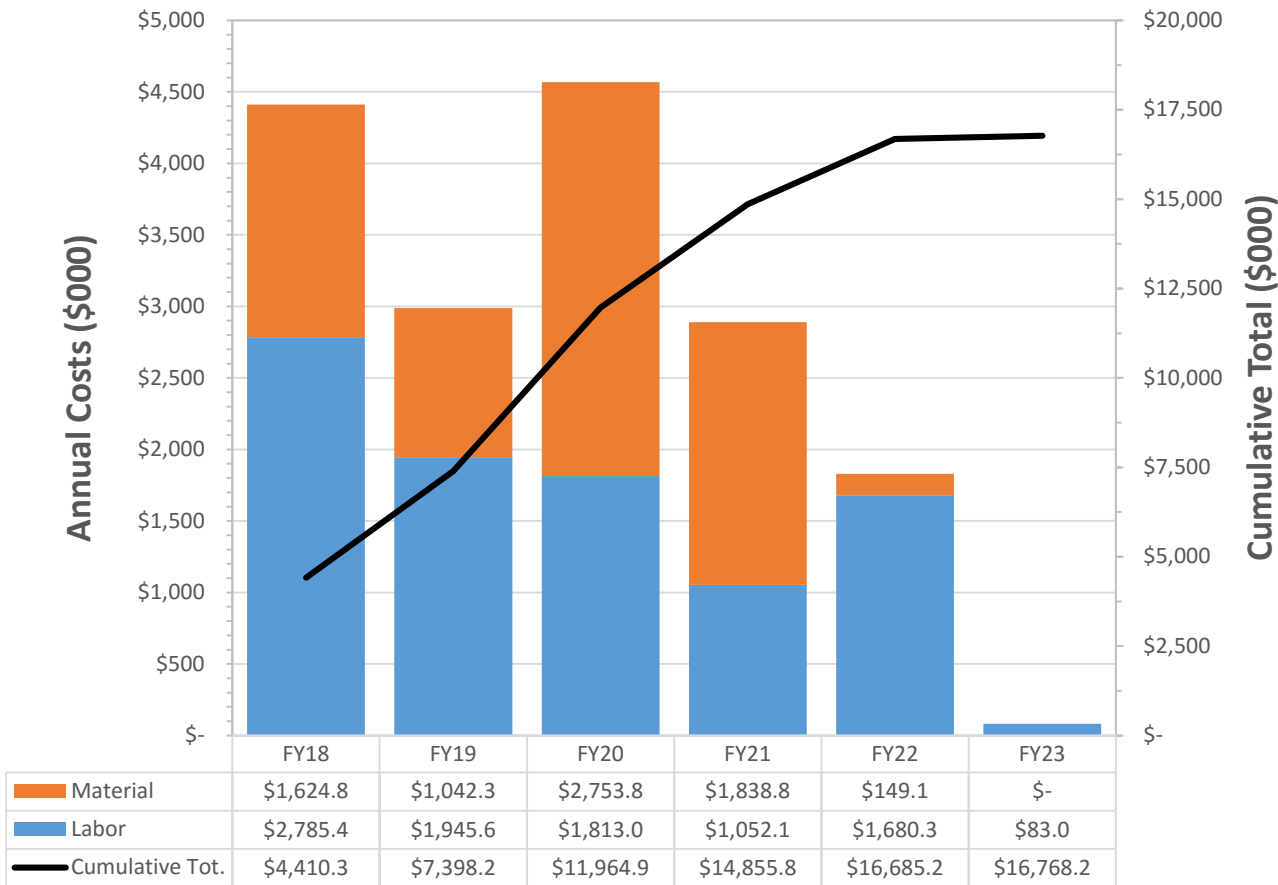


P6 Base Costs = BOE + Overheads + Escalation

- M&S are mainly driven by cavities costs.
- “Preliminary estimation”: based on similar work (ILC, LCLS-II)
- “Advanced estimation”: based on nearly identical work (SSR1)

121.3.5 SSR1: Cost Profile – P6 Base Cost Only

Charge #2

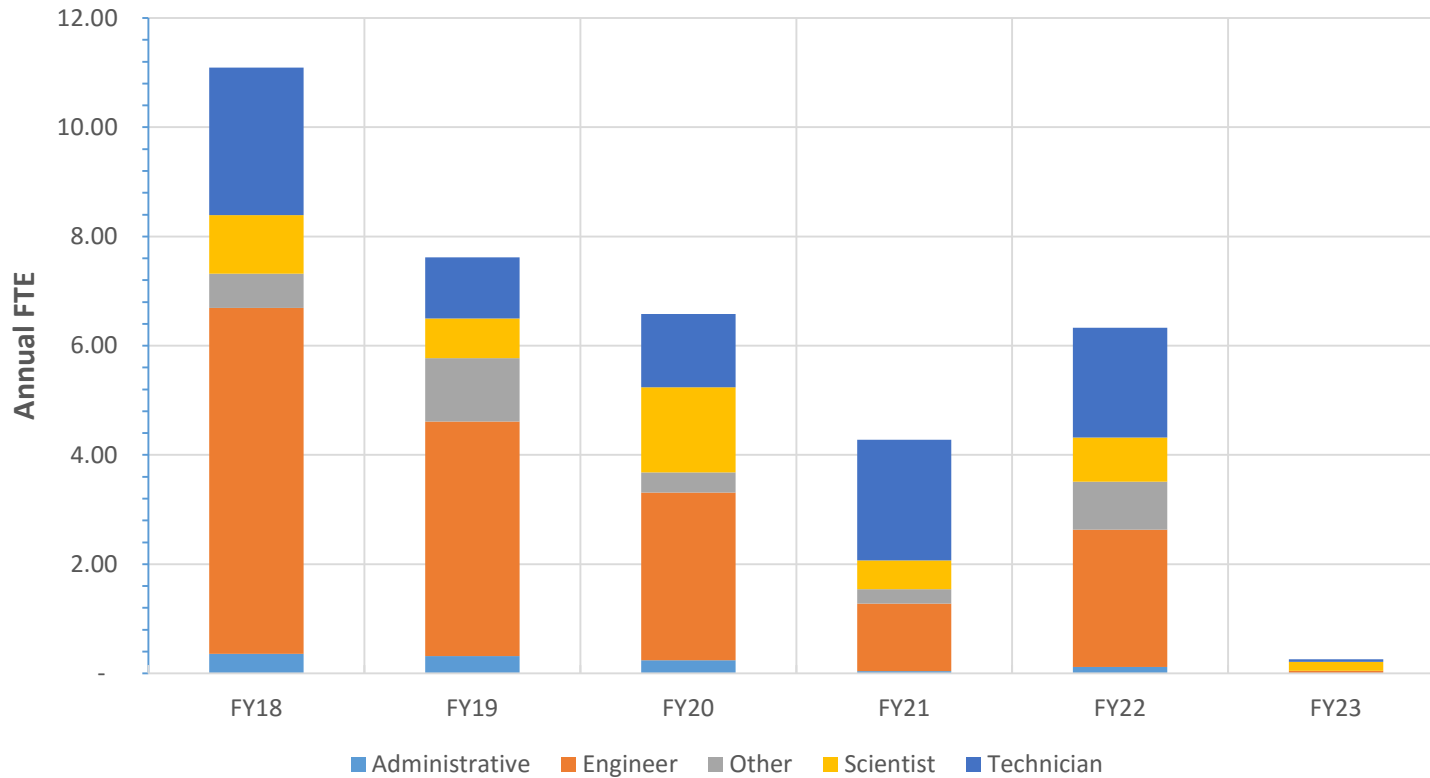


P6 Base Costs = BOE + Overheads + Escalation

Effort to complete and test SSR1 CM1 in PIP2IT (FY18 – FY20) and fully develop (from Nb procurement) and test SSR1 CM2 (FY18 – FY23)

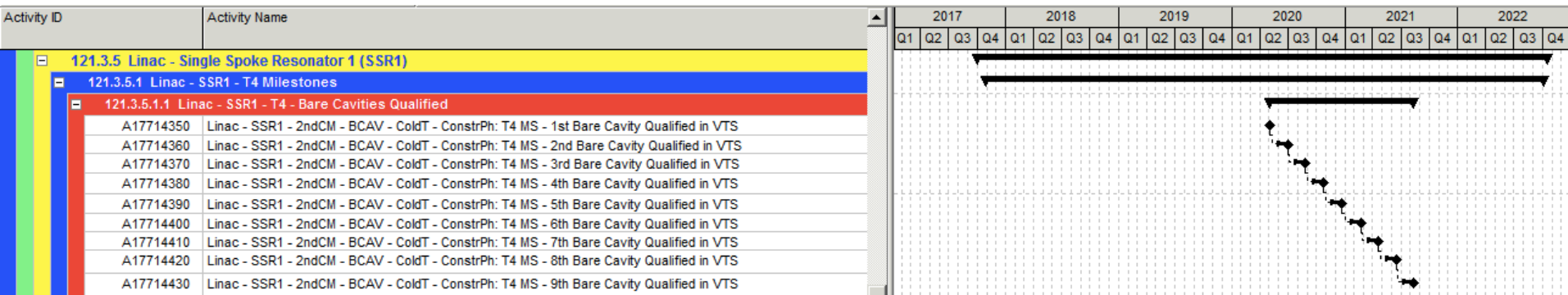
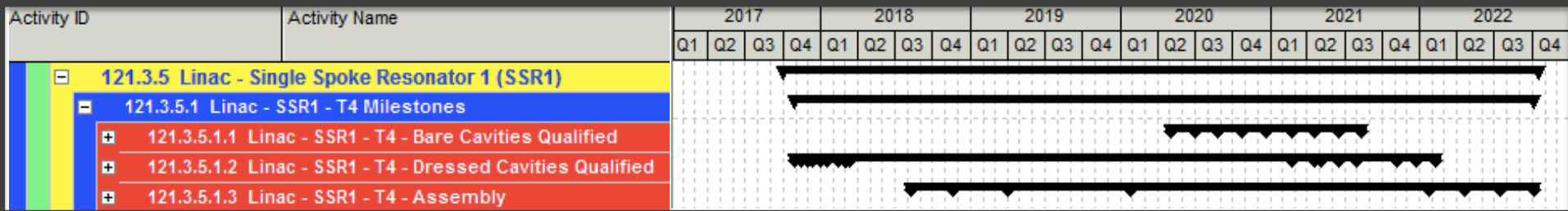
121.3.5 SSR1: Labor Profile – P6 Hours/FTE

Charge #2



121.3.5 SSR1: Schedule

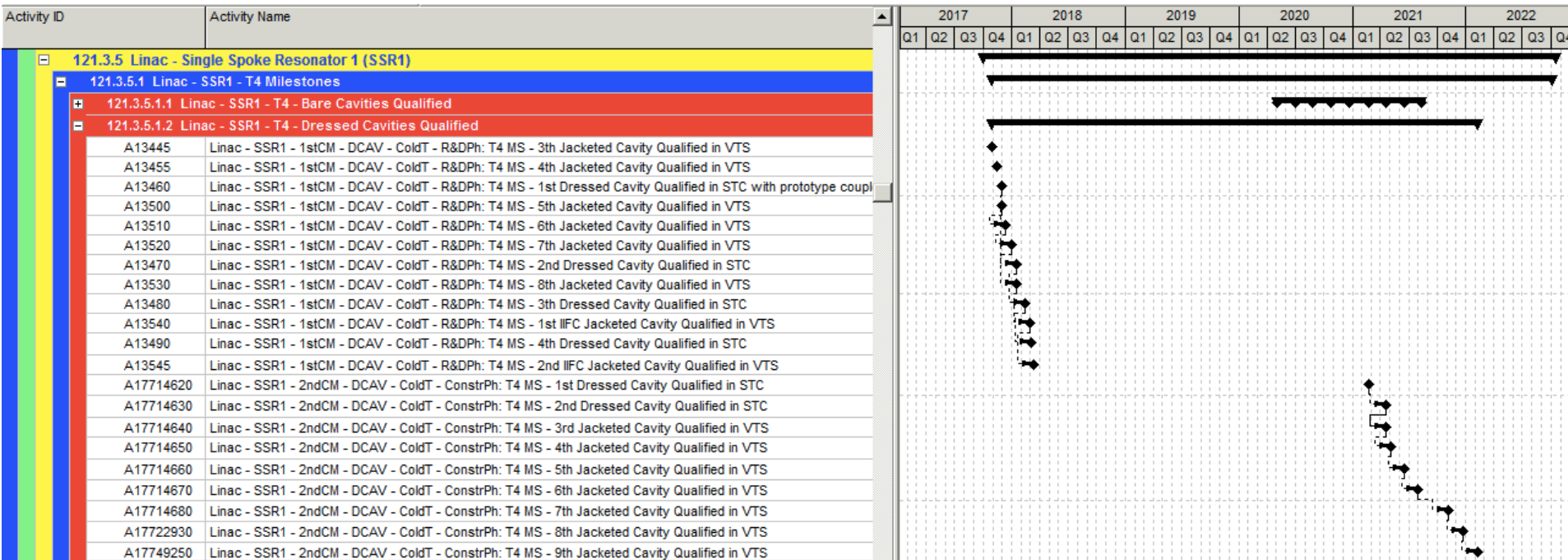
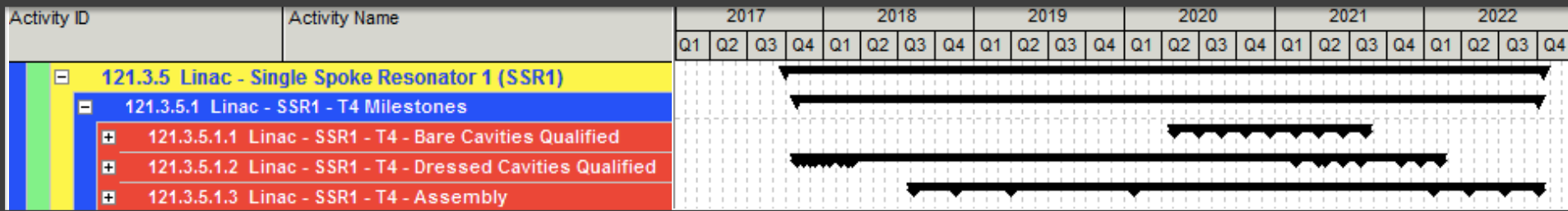
Charge #2



- Milestones are identified and reported in P6.
- All bare cavities of SSR1 CM1 are already qualified.

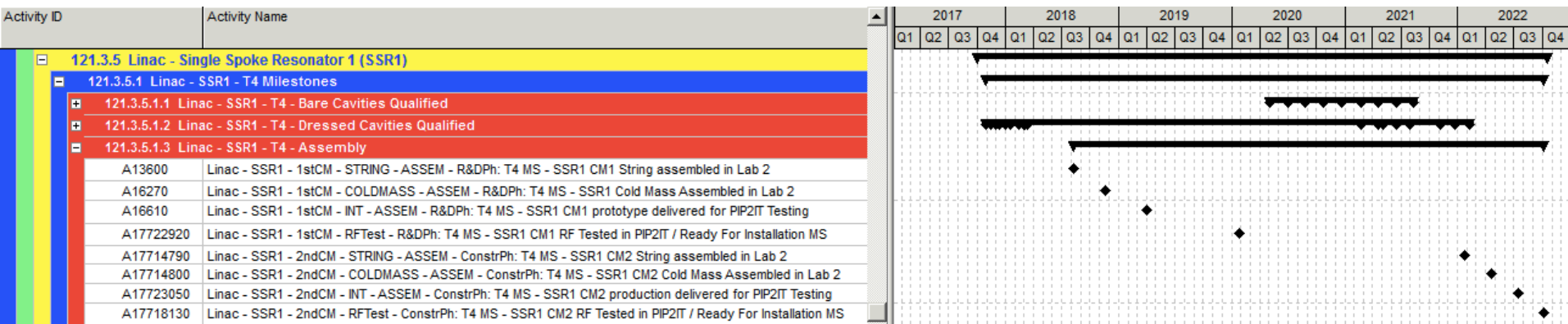
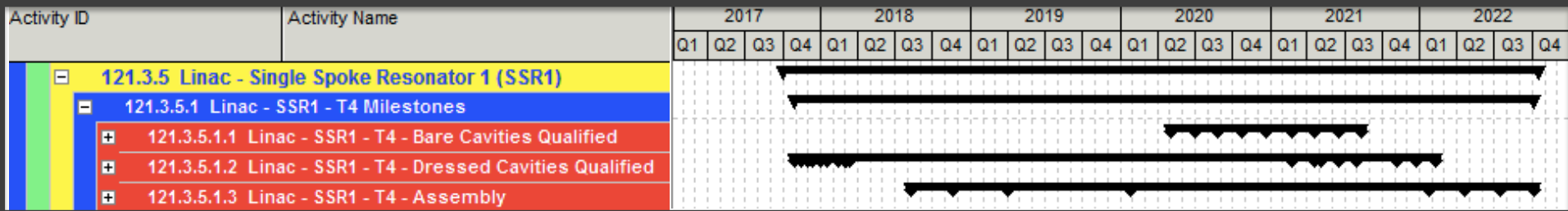
121.3.5 SSR1: Schedule

Charge #2



121.3.5 SSR1: Schedule

Charge #2



- The schedule was made such that lessons learned with SSR1 CM1 can be implemented in the design finalization of SSR1 CM2.

121.3.6 SSR2: Cost Summary

Charge #2

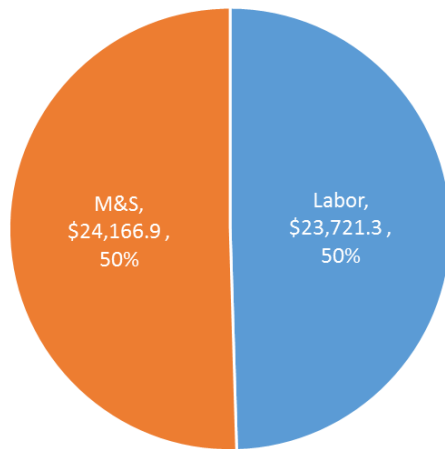
WBS Element	Hours	Labor (\$000)	M&S (\$000)	Est. Uncertainty (\$000)		Total Cost Incl. Uncrty.
	P6 Hours	P6 Base Cost	P6 Base Cost	Total	% of Base	
121.3.6 - Linac - Single Spoke Resonator 2 (SSR2)						
121.3.6.2 - Linac - SSR2 - Project Management and Coordination	6,718	\$ 1,446.5	\$ 277.6	\$ 200.2	11.6%	\$ 1,924.2
121.3.6.3 - Linac - SSR2 - 1st Pre-series Production Cryomodule (1stCM)	25,439	\$ 8,807.8	\$ 6,227.1	\$ 3,844.8	25.6%	\$ 18,879.7
121.3.6.4 - Linac - SSR2 - 2nd to 7th Production Cryomodules (2nd-7thCM)	<u>32,131</u>	<u>\$ 13,467.0</u>	<u>\$ 17,662.2</u>	<u>\$ 7,540.1</u>	<u>24.2%</u>	<u>\$ 38,669.4</u>
Grand Total	64,289	\$ 23,721.3	\$ 24,166.9	\$ 11,585.1	24.2%	\$ 59,473.2
Note: P6 base cost = BOE + overheads and escalation						

- Costs generated from resource loaded schedule (RLS).
- Estimate uncertainty and overhead are included following project guidelines.

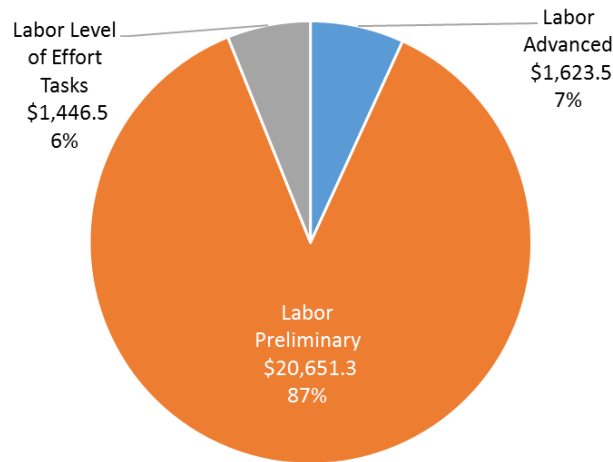
121.3.6 SSR2: Cost Drivers and Estimate Maturity

Charge #2

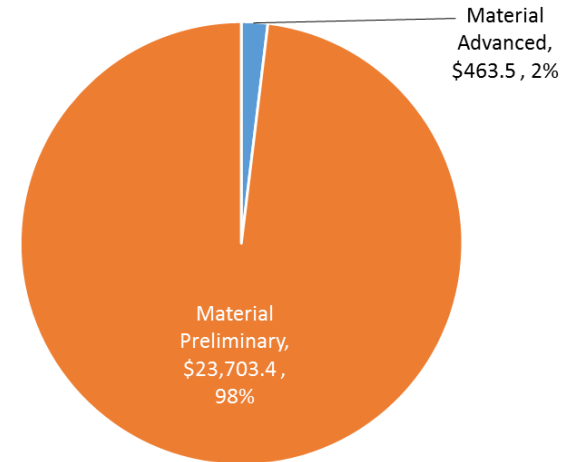
Cost Distribution - P6 Base Cost



Labor Cost Distribution - P6 Base Cost



M&S Cost Distribution - P6 Base Cost

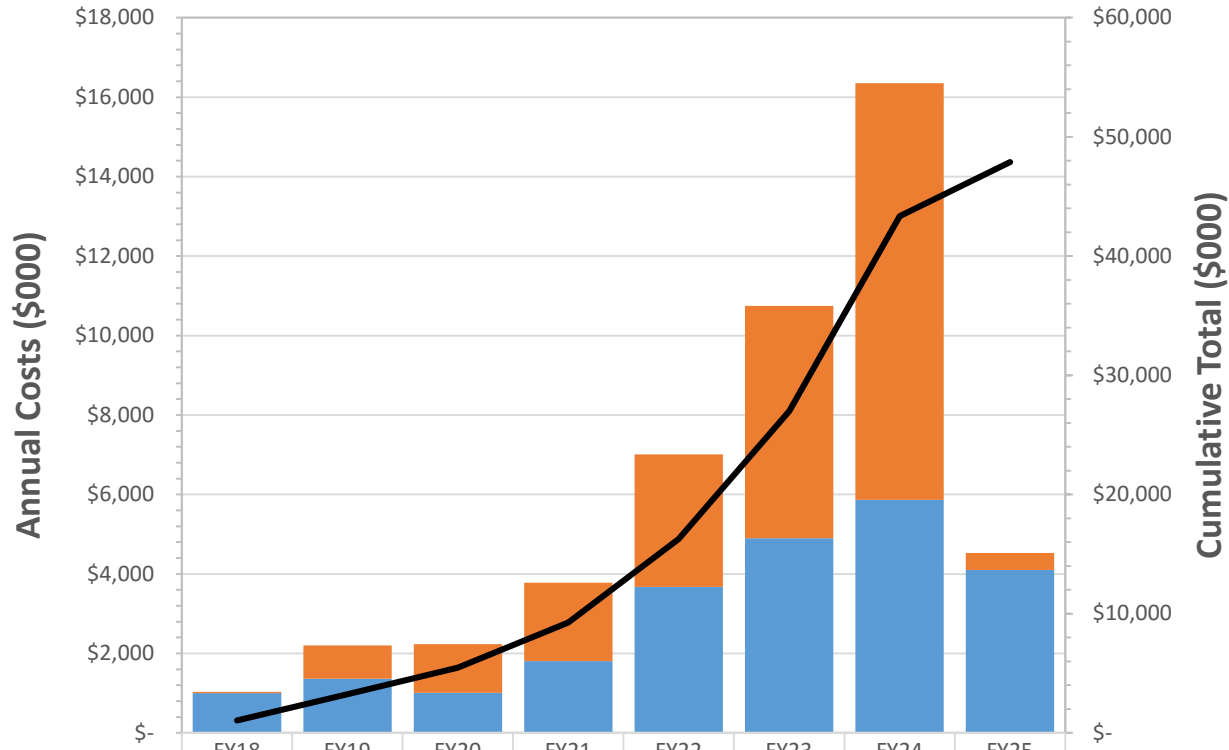


P6 Base Costs = BOE + Overheads + Escalation

- Estimations for SSR2 CMs are mainly based on experience with SSR1 CM1 (similar work --> preliminary estimations).

121.3.6 SSR2: Cost Profile – P6 Base Cost Only

Charge #2



	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25
Material	\$32.9	\$836.6	\$1,221.2	\$1,976.8	\$3,334.6	\$5,846.6	\$10,489.	\$429.2
Labor	\$1,000.0	\$1,362.0	\$1,012.4	\$1,805.1	\$3,672.4	\$4,902.7	\$5,865.7	\$4,101.0
Cumulative Tot.	\$1,032.9	\$3,231.6	\$5,465.1	\$9,247.0	\$16,254.	\$27,003.	\$43,357.	\$47,888.

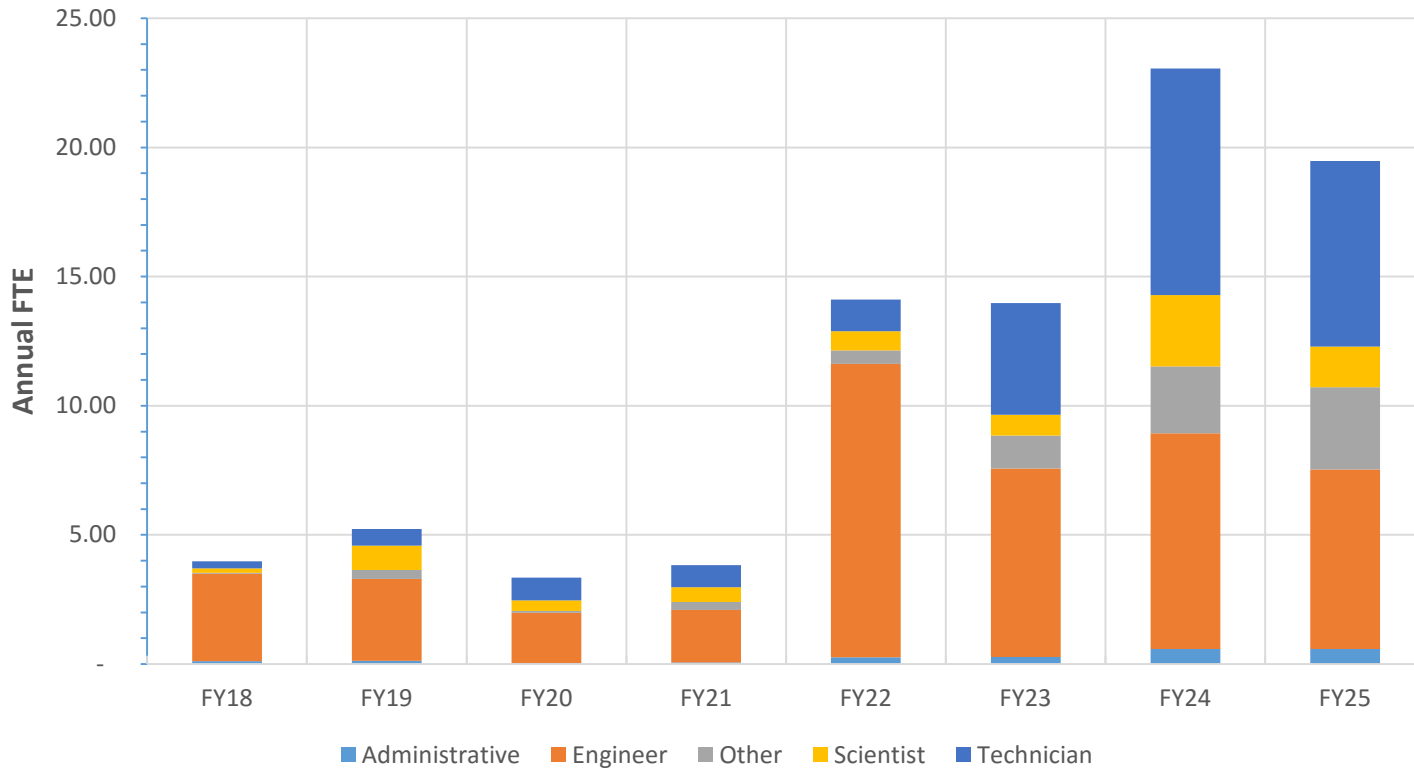
P6 Base Costs = BOE + Overheads + Escalation

The costs build up moving from prototyping to production



121.3.6 SSR2: Labor Profile – P6 Hours/FTE

Charge #2

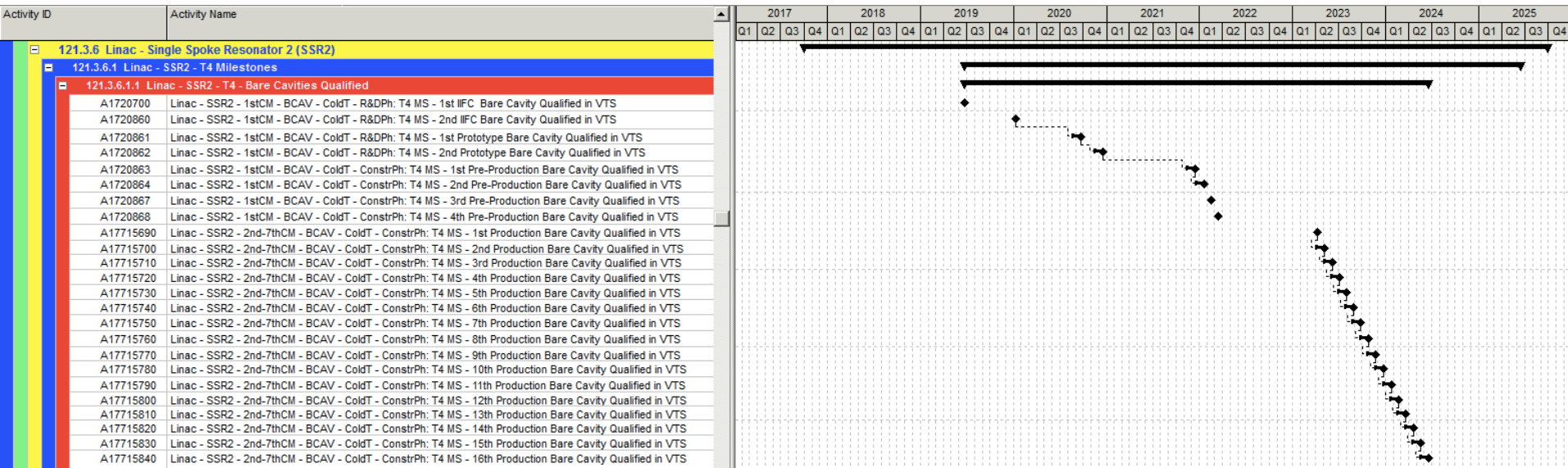
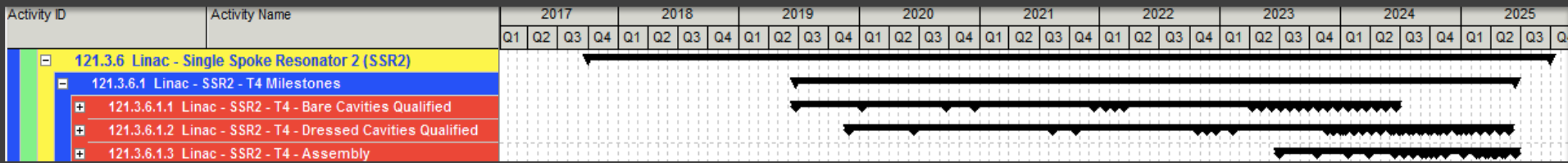


In FY 22 production activities start.



121.3.6 SSR2: Schedule

Charge #2

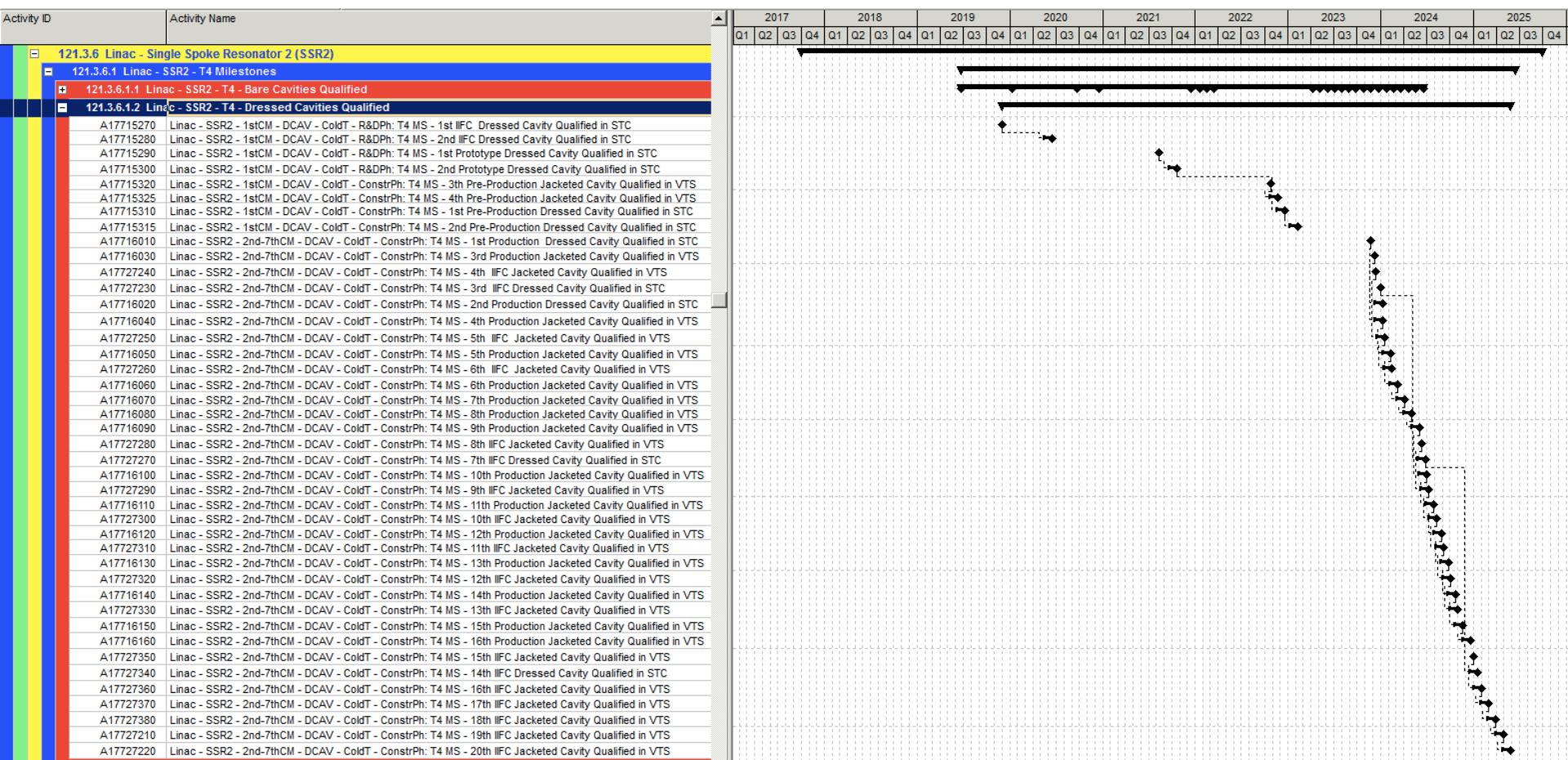
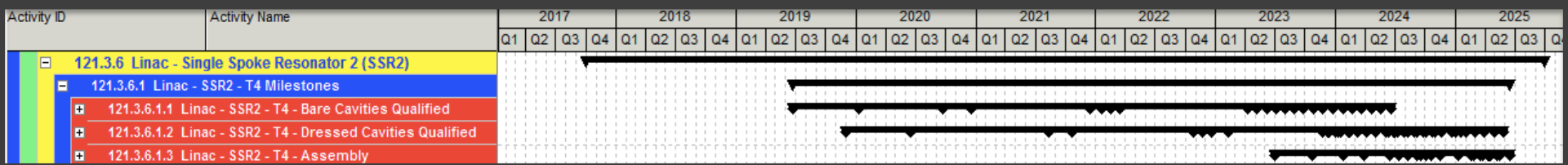


- Milestones are identified and reported in P6.
- Qualifying tests of prototypes are linked to production activities.



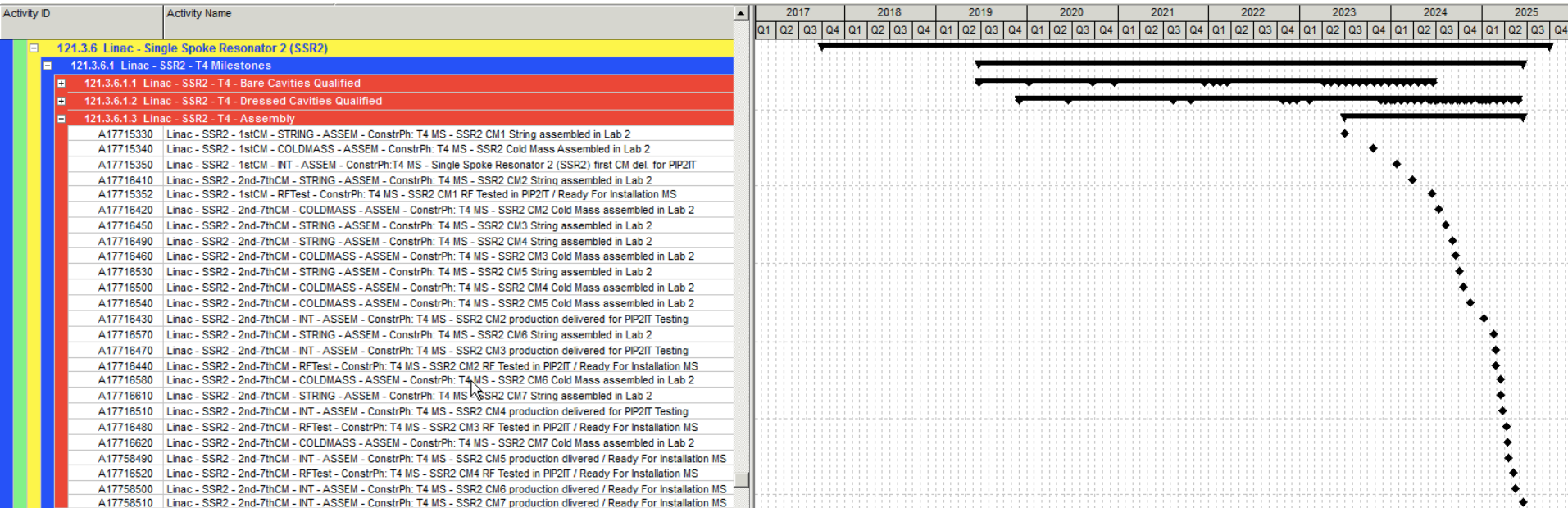
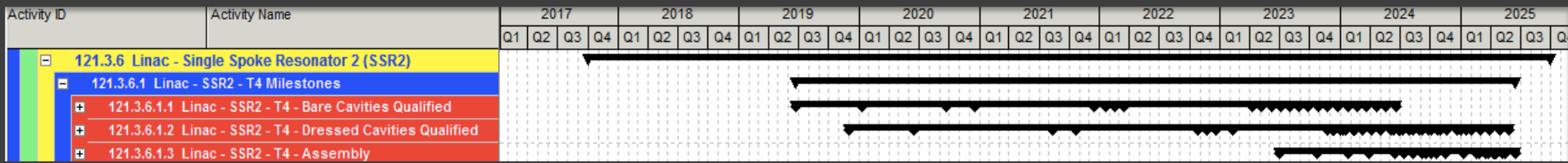
121.3.6 SSR2: Schedule

Charge #2



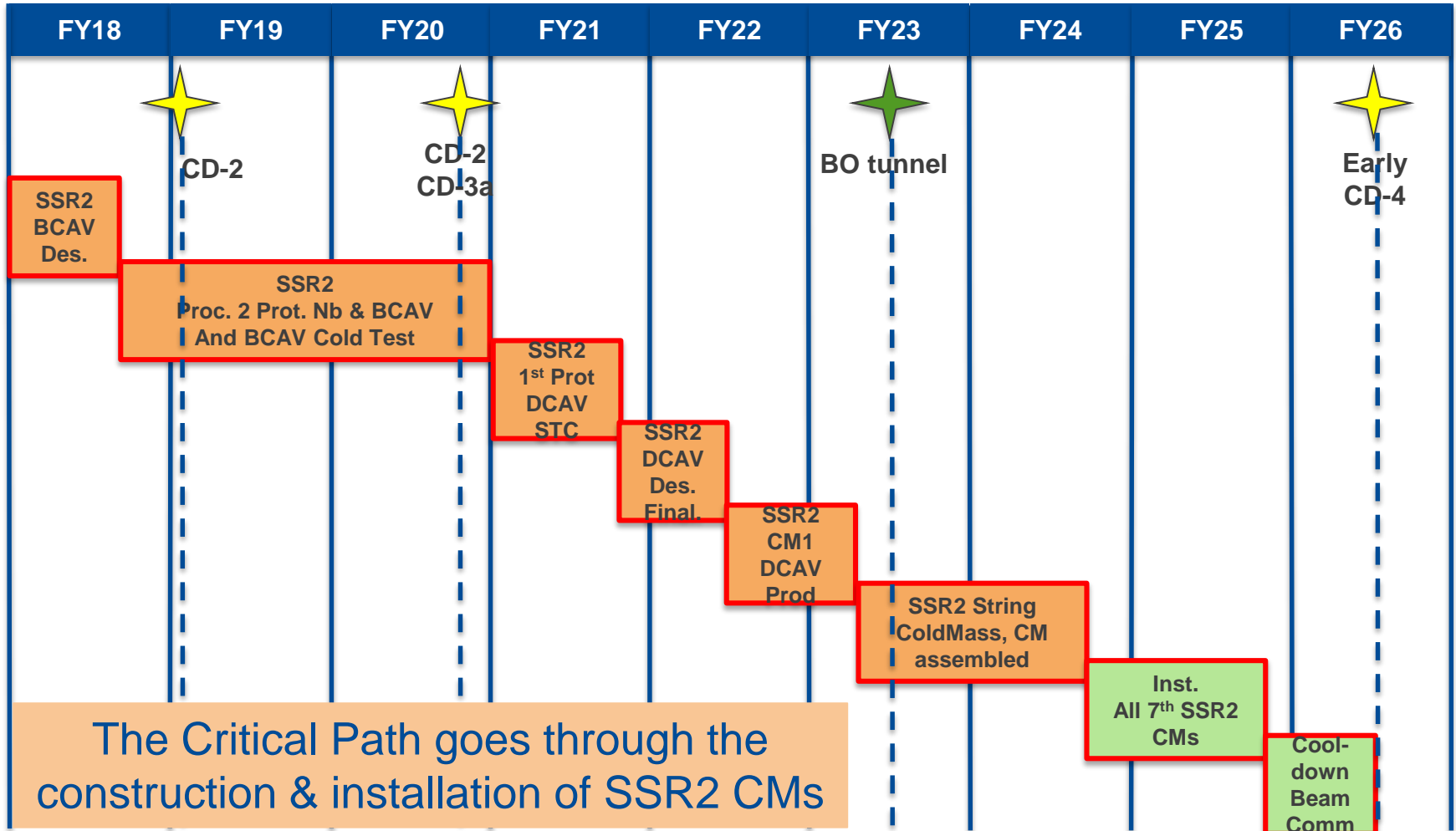
121.3.6 SSR2: Schedule

Charge #2



121.3.6 SSR2 CMs are on the Critical Path

Charge #2



Summary

- SSR1 and SSR2 requirements are defined and traceable in Teamcenter.
- The status of SSR1 1st CM is advanced. The design is sound and validated by design reviews.
- The design of the remaining SSR CMs and components will be based on the experience and lessons learned with SSR1 1st CM.
- Cost, schedule, and risks are well understood.
- FNAL team and DAE partners are motivated, qualified, and ready to deliver.
- We are ready for CD-1 and look forward to your feedback.
- Thank you for your attention.