Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Fermilab PIP-II R&D Plan

CY2015-CY2018

Shekhar Mishra **(edited by Don Mitchell)**

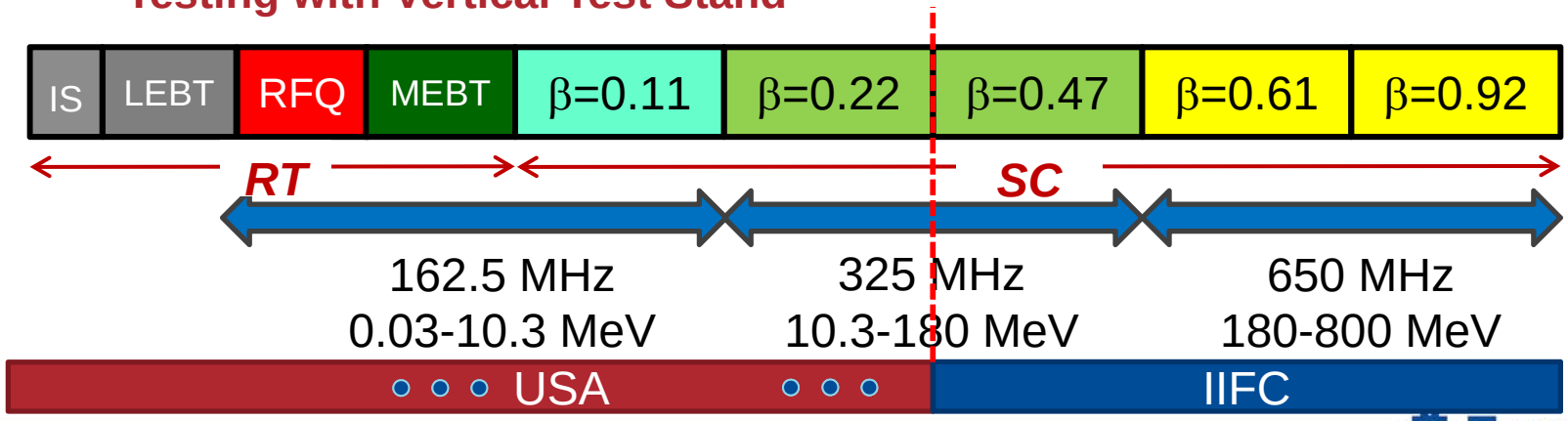
(On behalf of the PIP-II Management and Fermilab PIP-II Sub-Project Managers)

PIP-II, Fermilab

May 19, 2015

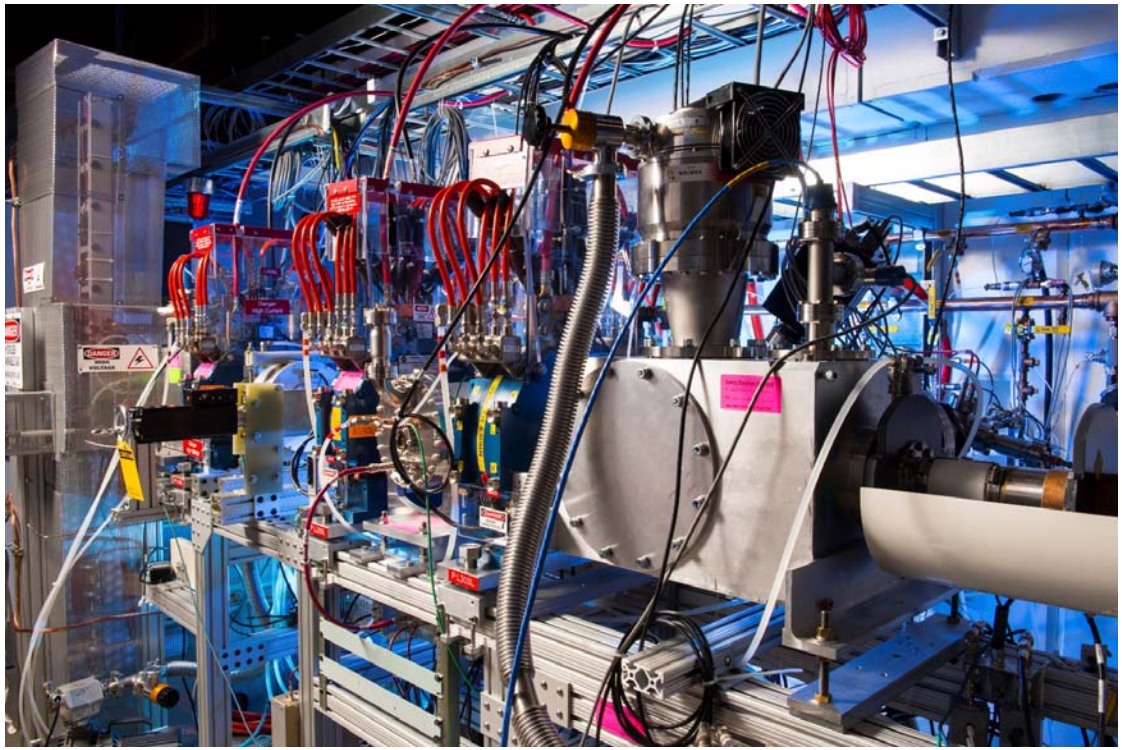
PIP-II R&D Goals:

- US Collaboration
  - Development of PXIE (~25 MeV) Test Linac
    - Source, LEBT, RFQ, MEBT, HWR CM, SSR1 CM
- Indian Institutions and Fermilab Collaboration (IIFC)
  - Development and testing of SSR1 Cryomodule
    - Testing with beam at PXIE
  - Development and testing of one HB650 MHz Cryomodule
    - Testing with the Cryomodule Test Facility at Fermilab
  - Development LB650 Dressed Cavities.
    - Testing with Horizontal Test Stand
  - Development of SSR2 Cavities.
    - Testing with Vertical Test Stand



PIP-II Source, LEBT and MEBT

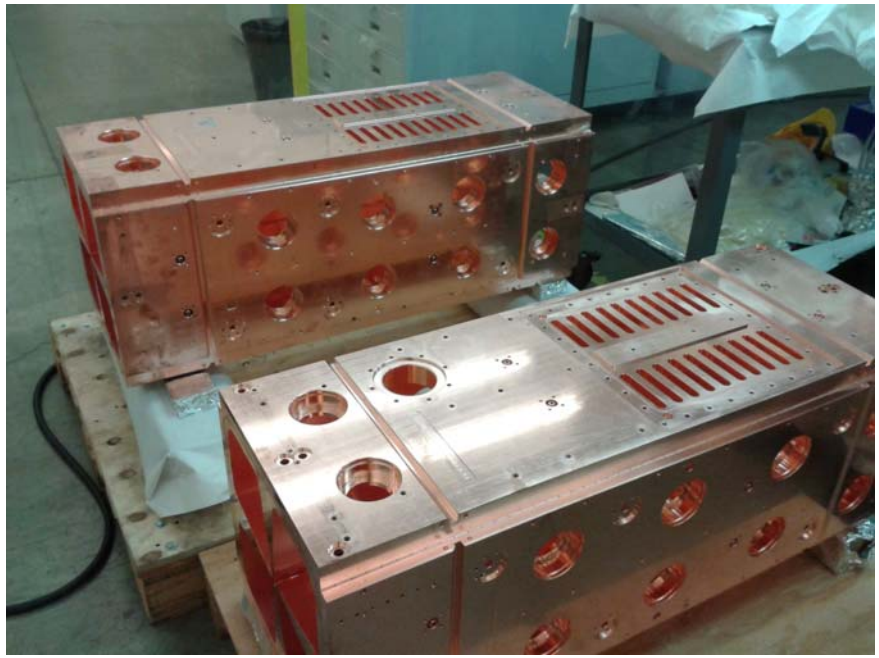
- **PIP-II Ion Source and LEBT installation ready for RFQ commissioning.**



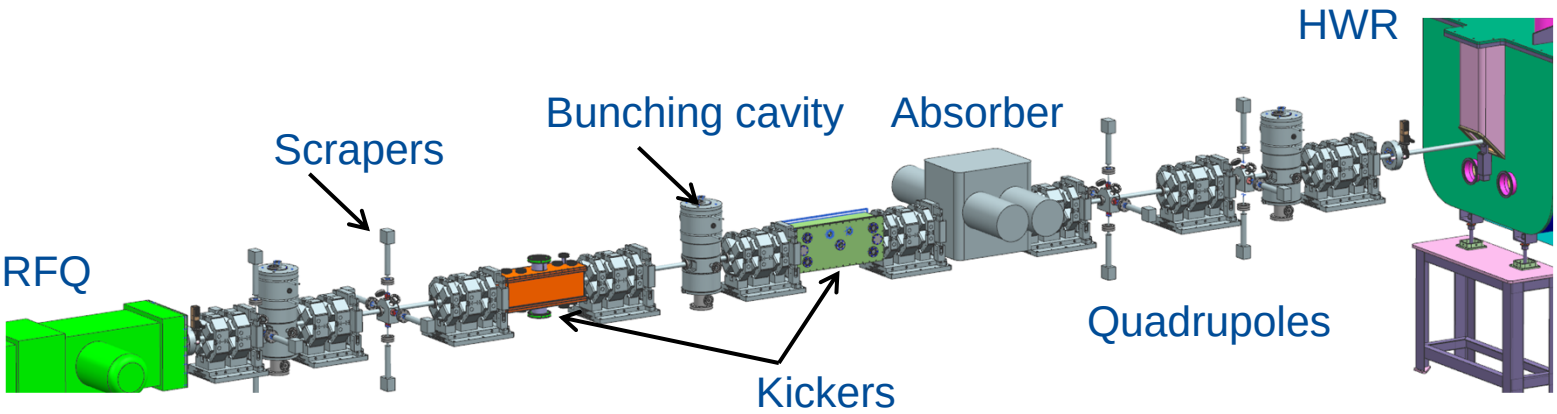
- **CY15 – Beam through RFQ**
  - **Pulsed then CW**

Radio Frequency Quadrupole

- RFQ Commissioning Schedule (2015)
  - RFQ Modules Complete April 15
  - Bead Pull Tuning June 15
  - Input Coupler June 15
  - Start installation July 30
  - RF Commissioning Sept 15
  - First Beam Nov 15

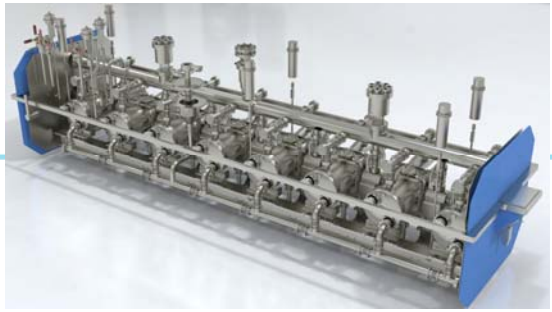


PIP-II MEBT



- **MEBT Magnets (BARC) May 2016**
- **FY16 – installation and commissioning of MEBT-1 thru April**
  - **2 doublets, 1 Buncher cavity, diagnostics**
- **FY16 (May-June) – installation and commissioning of MEBT-2**
  - **Add 4 triplets, 1 Buncher cavity 2 kicker prototypes**
- **FY16 – Design full-length MEBT (as shown above)**
- **FY17 – Run full-length MEBT**
- **FY17 – MEBT characterization**
- **FY18 – demonstration of bunch-by-bunch separation**

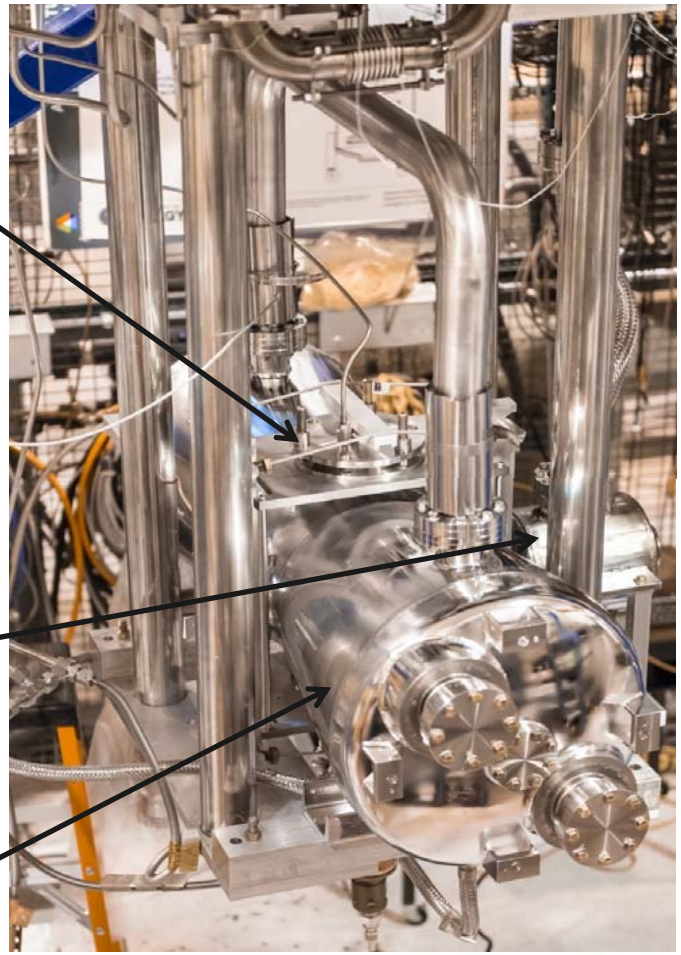
Half Wave Resonator Cryomodule



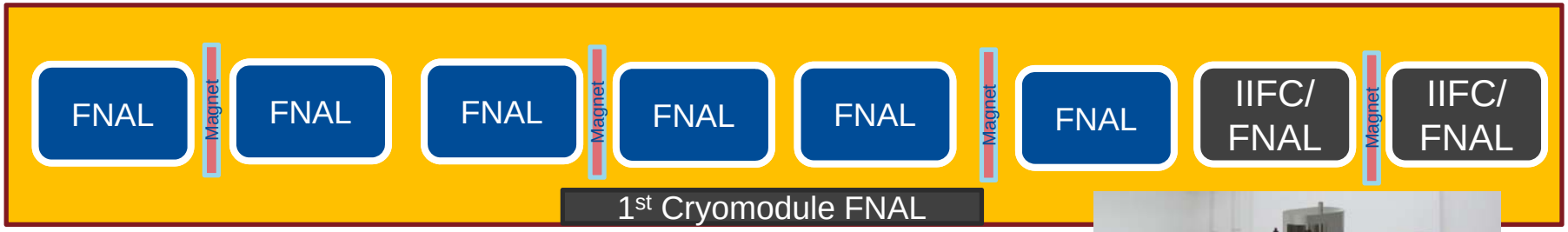
FY15 Deliverables

	Deliverables	Status
1	Complete all design work for the HWR cryomodule.	Complete
2	Complete fabrication (including helium vessel) of all remaining 7 production cavities.	In progress
3	Complete fabrication (including helium vessel) of all remaining 7 superconducting solenoids.	In progress
4	Perform cold/RF testing of the second prototype HWR together with SC solenoid.	Complete
5	Complete assembly of cryostat vessel with thermal and magnetic shields installed.	April 2015
6	Complete fabrication of helium and vacuum manifolds	Complete
7	Complete fabrication of the strongback.	Complete

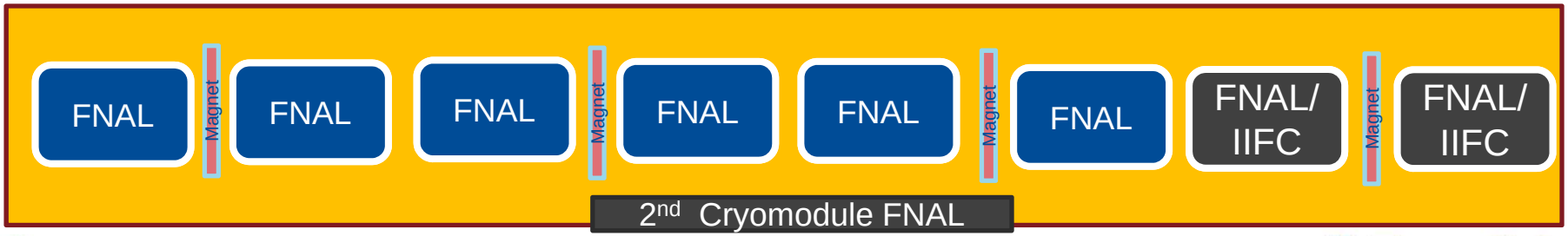
- **FY16**
  - **Testing of 7 production cavities**
  - **Clean assembly of the cold mass.**
- **FY17**
  - **Assembly of the cryomodule**
  - **Off-line testing**
  - **Delivery and installation at FNAL**
  - **Beam Commissioning**



SSR1 Cryomodule

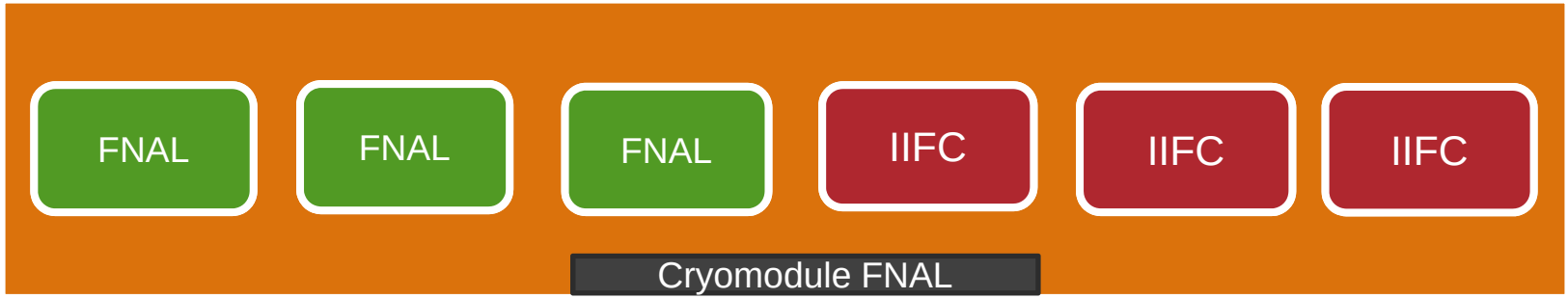


- **Fermilab has 10 SSR1 cavities in hand today.**
  - **The 1st SSR1 CM will be assembled by May 2017.**
  - **Integration and commissioning by July 2018 at PXIE.**
  - **Full system test with beam by end of CY2018.**
- **It is desirable to include two SSR1 Dressed cavities produced by IIFC in the 1st SSR1 CM for system test with beam.**
  - **It will be only possible if IIFC provides 2 dressed cavities by June 2016 using the two cavities built by IUAC.**
- **If IIFC could not meet this schedule**
  - **These two cavities along will be included in the 2nd SSR1 CM. Beam test could be in CY19 or CY20.**



HB650 Cryomodule

- **Fermilab has 8 HB650 5-cell cavities. They are at different stages of manufacturing, processing and testing.**
- **It is desirable to include HB650 Dressed Cavities produced by IIFC in this CM for system testing with RF.**
  - **Maximum of 3 Dressed HB650, 5-cell cavities will be needed from IIFC by end of FY17 (October 2017).**
- **Fermilab should procure 4 additional HB650 bare cavities. (ship to FNAL by April 2017 – *still under consideration*)**



HB650 Delivered to CMTF by September 2018

LB650 Dressed Cavities

- **IIFC with VECC as the lead laboratory, has worked to develop a preliminary LB650 5-cell cavity design.**
- **It is planned that**
  - **LB650 Dressed Cavities will be built by VECC/DAE**
  - **Two Dressed LB650 Cavities will be produced by IIFC**
  - **High Power tests of the Dressed Cavity will be done at Fermilab**
- **A minimum of two Dressed cavities will be needed to certify the design by Q4 CY2018.**

IIFC

IIFC

SSR2 Cavity

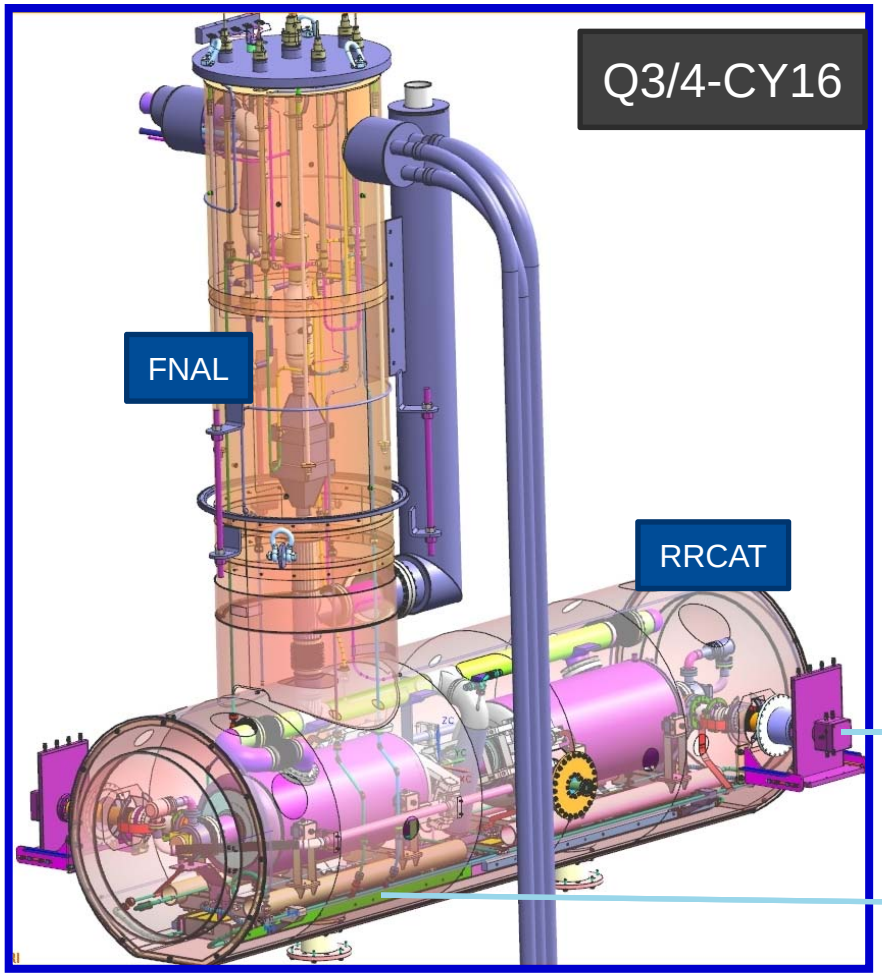
- **IIFC with BARC as the lead laboratory will work to develop a SSR2 cavity design.**
- **It is planned that**
  - **Fermilab will provide Nb for two SSR2 Cavities to BARC**
  - **SSR2 Cavities will be built by BARC**
  - **Processing and Low Power tests of the SSR2 Cavities will be done at Fermilab**
- **A minimum of two cavities will be needed to certify the design by Q4 CY2018.**

IIFC

IIFC

Horizontal Test Stand

Q2-CY2017



Two 30 kWatt Units (RRCAT)

FNAL

FNAL

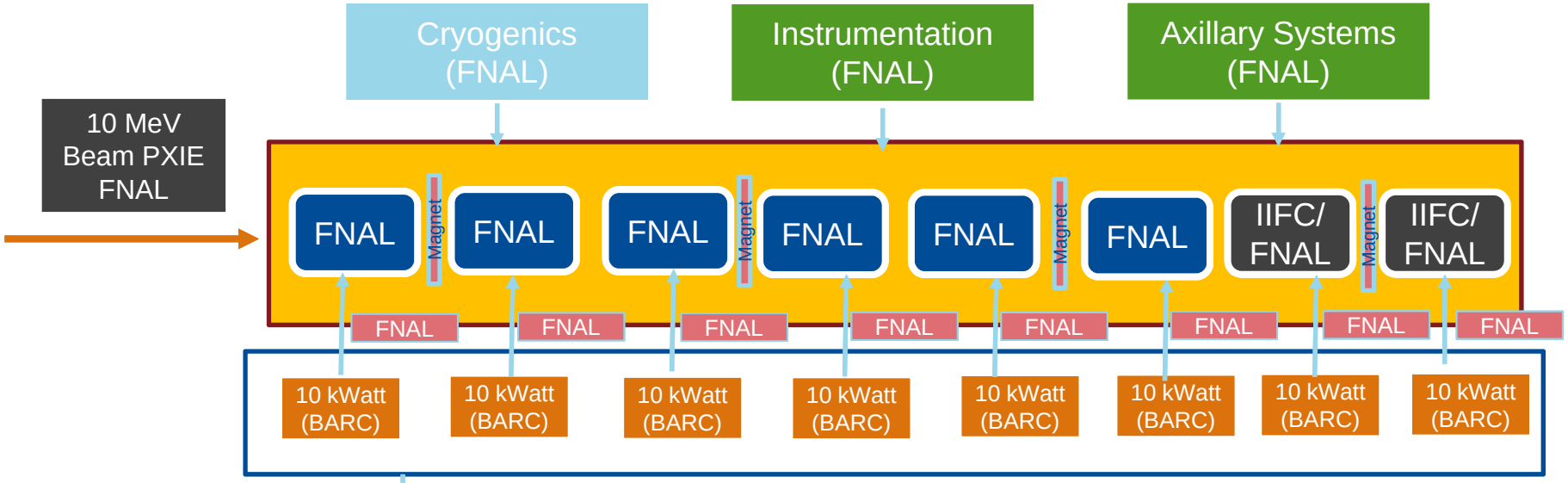
Cryostat at Fermilab July 2016
Cryogenics for HTS July 2016
Two 30kWatt RF July 2016
LLRF/RF Protection July 2016
Control System July 2016
Integration with cryostat Oct 2016
Test of 1st Dressed Cavity Jan 2017

IIFC RF Protection (FNAL/BARC)

LLRF (FNAL/BARC)

Integration and Controls (FNAL)

System Test of SSR1 CM and RF Power with Beam



IIFC RF Protection (FNAL/BARC)

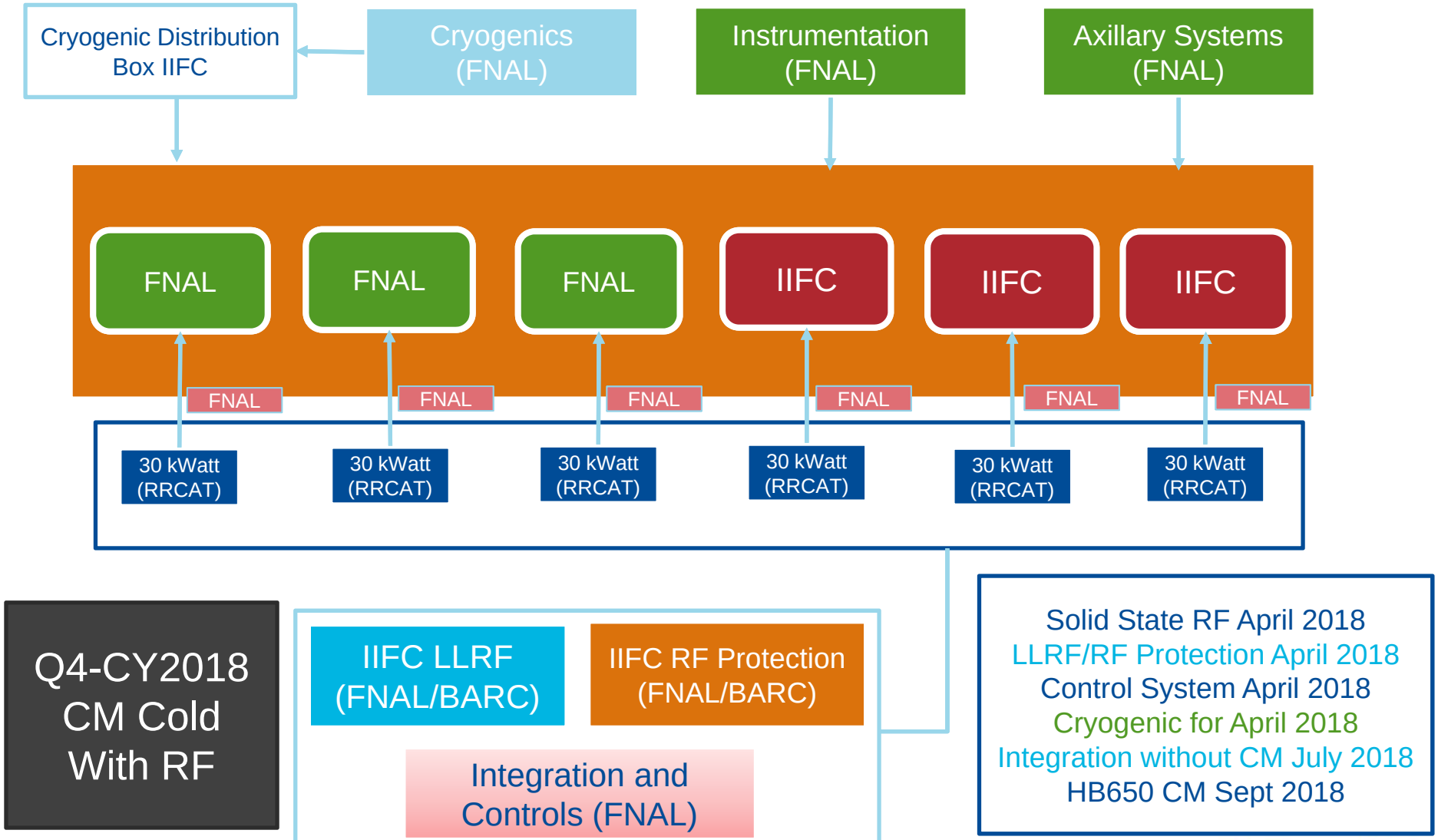
IIFC LLRF (FNAL/BARC)

Integration and Controls (FNAL)

Q3-CY2018 With Beam

SSR1 CM May 2017
Solid State RF Jan 2018
LLRF/RF Protection Jan 2018
Control System Jan 2018
Cryogenic for SSR1 Jan 2018
Integration with CM July 2018
(completion dates shown)

Integrated Test of HB650 Cryomodule and RF Power



High Level Scheduling Documents: *Shekhar, Steve, Hasan, Nigel, IIFC*

Fermilab PIP-II R&D Plan: CY2015-CY2018

Edited by Shekhar Mishra
(On behalf of the PIP-II Management and Fermilab PIP-II Sub-Project Managers)
PIP-II, Fermilab
Teamcenter #ED0003026

This document has been
Development RD&D goal
technologies that we are
The PIP-II RD&D is being
United States and India.
and Fermilab Collaborati

PIP-II R&D Goals:

Joint Project Document For the Research and Development Phase of the Indian Institutions and Fermilab Collaboration

Teamcenter #ED0003024

1. **Prologue**

This document has been prep
scientific, technical and finan
described in detail and agree
VECC and IUAC) addendum M
MOU. These documents were
were brought under the "Imp
United States of America and
Cooperation in the Area Acce
Discovery Science" which was
Institutional MOU on Jan 16,

*Structure Manager

* ED0001224--;1-PIP-II EPDM (eBOM) - Working; Any Status - Date - "Now"

BOM Line

- ED0001224--;1-PIP-II EPDM (eBOM)
  - ED0001225--;1-PIP-II LINAC EPDM (eBOM)
  - ED0001677--;1-PIP-II HTS-2, EPDM (eBOM)
  - ED0002103-B;1-PIP-II PRE CD0, ROLLUP, PROJECT GOALS AND TIMELINES (eBOM)
  - ED0002530--;1-IIFC DELIVERABLES (eBOM)
    - ED0002531--;1-PIP-II and IIFC Deliverable
    - ED0003024--;1-JOINT PROJECT DOCUMENT FOR THE R&D PHASE OF THE IIFC
    - ED0003026--;1-PIP-II R&D PLAN - CY2015 - CY2018
  - ED0002858--;1-CRYOGENICS, PIP-II, EPDM
  - ED0002857--;1-CONVENTIONAL FACILITIES, PIP-II, EPDM
  - ED0002859--;1-BEAM DELIVERY, PIP-II, EPDM
  - ED0002855--;1-CONTROL SYSTEMS, PIP-II, EPDM (eBOM)
  - ED0002818--;1-PIP-II REFERENCE DESIGN REPORT

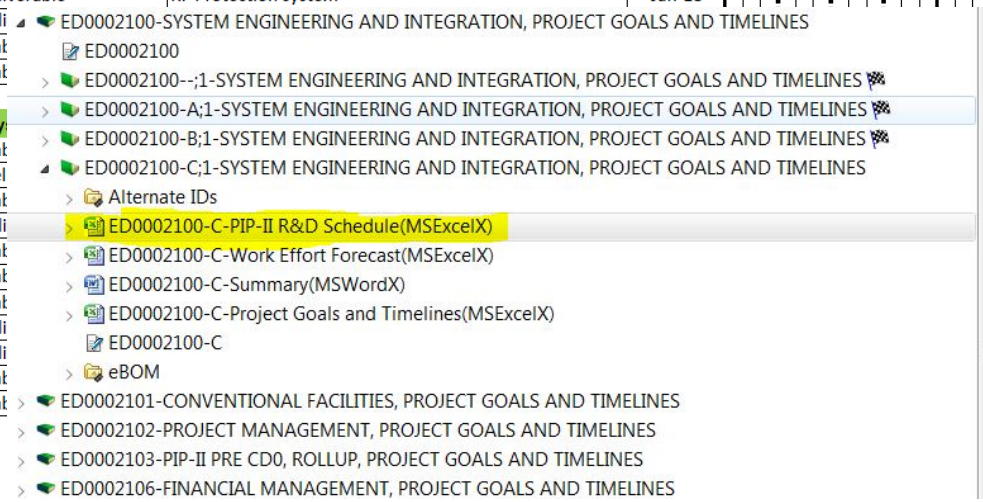
PIP-II R&D Plan

PIP-II R&D Plan thru FY 2018 (markers indicate completion date)

Responsible Institution	Deliverable	Due Date	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
3.1 PIP-II Source, LEBT and MEBT							
Fermilab Deliverable	PIP-II Source	Oct-14	X				
Fermilab Deliverable	Low Energy Beam Transport	Feb-15	X				
IIFC Deliverable	MEBT Dipoles and Quadrupoles	May-16		X			
3.2 Radio Frequency Quadrupole (RFQ)							
Fermilab/LBNL Deliverable	RFQ	Jul-15	X				
Fermilab Deliverable	162 MHz, RF Power for RFQ	Jul-15	X				
Fermilab Deliverable	RF Controls and Beam Instrumentation	Aug-15	X				
3.3 Half Wave Resonator (HWR)							
Fermilab/ANL Deliverable	162.5 MHz, HWR Cryomodule with 8 cavities	Apr-17			X		
Fermilab Deliverable	Eight 162.5 MHz, RF system and it distribution system	Apr-17			X		
Fermilab Deliverable	Cryogenics to cool HWR cryomodule to 2 deg K	Apr-17			X		
Fermilab Deliverable	HWR Instrumentation	Apr-17			X		
Fermilab Deliverable	HWR Axillary System [water, electricity etc.]	Apr-17			X		
Fermilab Deliverable	RF Protection system	Apr-17			X		
Fermilab Deliverable	LLRF Station	Apr-17			X		
Fermilab Deliverable	Controls and Application	Apr-17			X		
Fermilab Deliverable	Integration and Commissioning	Jun-17			X		
3.4 Single Spoke Resonator-1 325 MHz Cryomodule							
Fermilab Deliverable	Eight SSR1 Dressed High Power Tested Cavities	Jun-16		X			
IIFC Deliverable	Two SSR1 Dressed Cavities	Jun-16		X			
Fermilab Deliverable	One SSR1 Cryomodule	May-17			X		
3.5 High Beta 650 MHz Cryomodule							
Fermilab Deliverable	Three HB650 High Power Tested Dressed Cavity	Dec-17				X	
IIFC Deliverable	Three HB660 High Power Tested Dressed Cavity	Dec-17				X	
IIFC Deliverable	HB650 CM Design	Dec-16			X		
Fermilab Deliverable	One HB650 Cryomodule	Sep-18					X
3.6 Low Beta 650 MHz Cavity							
IIFC Deliverable	Two LB650 High Power Tested Dressed Cavity	Dec-18					X
3.7 Single Spoke Resonator 2 Cavity							
IIFC Deliverable	Two SSR2 Low Power Tested Cavity	Dec-18					X
3.8 650 MHz Cavity Horizontal Test Stand							
Fermilab Deliverable	HTS-2 Top Hat components	Sep-15	X				
IIFC Deliverable	HTS-2 Cryostat to Fermilab	Jun-16		X			
DAE Deliverable	Two 30 kWatt Solid State RF Amplifire with Circulator	Jun-16		X			

PIP-II R&D Plan - Continued

3.8 650 MHz Cavity Horizontal Test Stand		
Fermilab Deliverable	HTS-2 Top Hat components	Sep-15
IIFC Deliverable	HTS-2 Cryostat to Fermilab	Jun-16
DAE Deliverable	Two 30 kWatt Solid State RF Amplifire with Circulator	Jun-16
Fermilab Deliverable	LLRF System	Jul-16
IIFC Deliverable	RF Protection System	Jul-16
Fermilab Deliverable	Control System	Jul-16
Fermilab Deliverable	Cryogenic System	Jul-16
Fermilab Deliverable	Integration of RF system	Sep-16
Fermilab Deliverable	Integration and Commissioning	Oct-16
Fermilab Deliverable	Test of 1st 650 MHZ Dressed HB650 Cavity	Jan-17
3.9 System Test of SSR1 CM and RF Power with Beam		
Fermilab Deliverable	SSR1 CM to PXIE	May-17
Fermilab Deliverable	10 MeV Beam from PXIE	Dec-17
DAE Deliverable	Eight, 10 kWatt 325 MHz Solid State RF with Circulator	Jan-18
Fermilab Deliverable	Eight, RF distribution system	Jan-18
Fermilab Deliverable	Cryogenics to cool SSR1 to 2 deg K	Jan-18
Fermilab Deliverable	SSR1 Instrumentation	Jan-18
Fermilab Deliverable	SSR1 Axillary System [water, electricity etc.]	Jan-18
IIFC Deliverable	RF Protection system	Jan-18



	A	B
1	**PIP-II R&D Plan thru FY 2018**	(markers indicate comp
2	**Responsible Institution**	**Deliverable**
3		
4	**3.1 PIP-II Source, LEBT and MEBT**	
5	Fermilab Deliverable	PIP-II Source
6	Fermilab Deliverable	Low Energy Beam Transport
7	IIFC Deliverable	MEBT Dipoles and Quadrupoles
8		
9	**3.2 Radio Frequency Quadrupole (RFQ)**	
10	Fermilab/LBNL Deliverable	RFQ
11	Fermilab Deliverable	162 MHz, RF Power for RFQ
12	Fermilab Deliverable	RF Controls and Beam Instrumentation
13		
14	**3.3 Half Wave Resonator (HWR)**	

325 MHz and 650 MHz Schedules – Teamcenter examples

ID	Task Name	Duration	Start	Finish
1	**String**	460 days?	Mon 10/27/14	Fri 7/29/1
2	Solenoid delivery			
3	Solenoid assemb			
4	Solenoid tests			
5	Solenoids ready			
6	BMP's delivery			
7	1-2 cavity deliver			
8	1-2 QC			
9	3-4 cavity deliver			
10	3-4 QC			
11	5-6 cavity deliver			
12	5-6 QC			
13	7-8 cavity deliver			
14	7-8 QC			
15	2 cavities availab			
16	2-cavity string te			
17	All bellows availa			
18	8 cavities availab			
19	String Shake-Dov			
20	**Couplers**			
21	4 coupler deliv			
22	Setup coupler			
23	RF cond 1-2			
24	RI			
25	6			

PIP-II HB650 MHz Planning

Item	Institution	A-15	M-15	J-15	J-15	A-15	S-15
Design HB650 MHz Cavity, B.92	Fermilab						
Design HB650 MHz End Groups	Fermilab						
Design HB650 MHz Helium Vessel	Fermilab						
Design HB650 MHz Tuner	Fermilab/India						
Design HB650 MHz Coupler	Fermilab/India						
Design HB650 MHz Cavity Magnetic Shielding	Fermilab/India						
Design review of HB650 MHz 5-Cell cavity w/ helium vessel	Fermilab/India						
Design review of coupler, and magnetic shielding	Fermilab/India						
Design review of Tuner	Fermilab/India						
Fabricate 5-Cell, HB650 MHz cavity (India), QTY:4, B.92	India						
Fabricate 5-Cell, HB650 MHz cavity #1, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #2, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #3, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #4, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #1, B.92	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #2, B.92	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #3, B.92	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #4, B.92	Fermilab						
Order Material for 4 cavities	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #5, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #6, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #7, B.9	Fermilab	PAVAK Order: To be used for cavity					
Fabricate 5-Cell, HB650 MHz cavity #8, B.9	Fermilab						
Fabricate 5-Cell, HB650 MHz cavity #9, B.9	Fermilab						
Fabricate HB650 MHz Helium vessel, QTY:7	Fermilab						
Fabricate HB650 MHz Tuner, QTY:7	Fermilab						
Fabricate HB650 MHz Coupler, QTY:7	Fermilab						
Fabricate Cavity Magnetic Shielding, For 7 cavities	Fermilab						
VTS 5-cell, HB650 MHz Cavity (India), QTY:3	India						
VTS 5-cell, HB650 MHz Cavity #1	Fermilab						
VTS 5-cell, HB650 MHz Cavity #2	Fermilab						
VTS 5-cell, HB650 MHz Cavity #3	Fermilab						
VTS 5-cell, HB650 MHz Cavity #4	Fermilab						
Dress HB650 MHz Cavity (India), QTY:4	India						
Dress HB650 MHz Cavity #1	Fermilab						
Dress HB650 MHz Cavity #2	Fermilab						
Dress HB650 MHz Cavity #3	Fermilab						
Dress HB650 MHz Cavity #4	Fermilab						
Design HTS-2	Fermilab/India						
Procurement process of HTS-2 (accelerated Indian process)	India or Fermilab						
Fabricate HTS-2 (cryostat and Feedcan)	India						
Design and install all infrastructure at MDB for HTS-2	Fermilab						
Delivery of HTS-2 to Fermilab	India						
Commission HTS-2 at Fermilab	Fermilab/India						
HTS Testing of R&D cavities	Fermilab						

PIP-II LB650 MHz Planning

Item	Institution	A-15	M-15	J-15	J-15	A-15	S-15
Design LB650 MHz Cavity	India/Fermilab						
Design LB650 MHz End Groups	India/Fermilab						
Design LB650 MHz Helium Vessel	India/Fermilab						
Design LB650 MHz Tuner	Fermilab/India						
Design LB650 MHz Coupler	Fermilab/India						
Design LB650 MHz cavity magnetic shielding for 2 cavities	Fermilab/India						
Design review of LB650 MHz 5-Cell dressed cavity	Fermilab/India						
Fabricate 1-Cell, LB650 MHz cavity (India)	India						
Fabricate 5-Cell, LB650 MHz cavity (India), QTY:2	India						
Fabricate LB650 MHz Helium vessel (India), QTY:2	India						
Fabricate LB650 MHz Tuner (India), QTY:2	India						
Fabricate LB650 MHz Coupler (India), QTY:2	India						
Fabricate LB650 MHz cavity magnetic shielding for 2 cavities	India						
VTS 1-cell, LB650 MHz Cavity (India)	India						
VTS 5-cell, LB650 MHz Cavity (India), QTY:2	India						
Dress LB650 MHz Cavity (India), QTY:2	India						
Ship Dressed cavities and all accessories to Fermilab	India						
HTS 5-cell, LB650 MHz Cavity (India), QTY:2	Fermilab/India						

Project: SSR1-F
Date: Mon 3/1

- Budget and Financials
  - ED0001723-FY 15 Budget Estimates for TD Deliverables
  - ED0001951-HTS-2 (MDB), PROJECT GOALS AND TIMELINES
  - ED0002082-325 MHz, PROJECT GOALS AND TIMELINES
    - ED0002082
    - ED0002082--;1-325 MHz, PROJECT GOALS AND TIMELINES
    - ED0002082-A;1-325 MHz, PROJECT GOALS AND TIMELINES
    - ED0002082-B;1-325 MHz, PROJECT GOALS AND TIMELINES
    - ED0002082-C;1-325 MHz, PROJECT GOALS AND TIMELINES
      - Alternate IDs
      - ED0002082-C
      - ED0002082-C(PDF)
      - ED0002082-C-Project Goals and Timelines(MSExcelX)
      - ED0002082-C-Summary(MSWordX)
      - ED0002082-C-Work Effort Forecast(MSExcelX)
      - ED0002082-C
      - eBOM
  - ED0002083-650 MHz, PROJECT GOALS AND TIMELINES
    - ED0002083
    - ED0002083--;1-650 MHz, PROJECT GOALS AND TIMELINES
    - ED0002083-A;1-650 MHz, PROJECT GOALS AND TIMELINES
    - ED0002083-B;1-650 MHz, PROJECT GOALS AND TIMELINES
    - ED0002083-C;1-650 MHz, PROJECT GOALS AND TIMELINES
      - Alternate IDs
      - ED0002083-C-Summary(MSWordX)
      - ED0002083-C-Project Goals and Times(MSExcelX)
      - ED0002083-C-IIFC Deliverables thru 2018(MSExcelX)
      - ED0002083-C-Work Effort Forecast(MSExcelX)
      - ED0002083-C
      - eBOM

N-18	D-18

Any Questions?

Thanks for your attention!