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# **PIP-II Overview: Goals, Status, and Strategy**

Steve Holmes

PIP-II Collaboration Meeting

9 November 2015

# Outline

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- Update since Last Meeting (June 2014)
- PIP-II Status and Strategy
- FY16-17 Goals and Budgets
- Meeting Goals and Agenda

## Our websites:

<http://pip2.fnal.gov/>

(See Collaboration Information for useful links)

## Meeting website:

<https://indico.fnal.gov/conferenceDisplay.py?confId=10586>

## News Since June (2014)

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- Reference Design Report (RDR)
  - Released in May in advance of the DOE Review

<http://pip2-docdb.fnal.gov/cgi-bin/ShowDocument?docid=1>
- PIP-II Machine Advisory Committee (P2MAC)
  - Met in March 2015 (3<sup>rd</sup> meeting)
  - Review of Reference Design and associated R&D Program

<https://indico.fnal.gov/categoryDisplay.py?categId=366>

## News Since June (2014)

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- DOE Independent Review of PIP-II/June 16-17, 2015  
<https://indico.fnal.gov/conferenceDisplay.py?confId=9939>
  - Review based on:
    - RDR
    - Cost Estimate with offsets for international contributions
    - Construction period FY2019-FY2023
  - Proposed cost range: \$465-\$695M
    - (cost to DOE after international contributions)
  - Review committee report:
    - “The proposed concept is well advanced, beyond what is required at this stage...most likely will satisfy the P5 recommendation”
    - “The presented cost range appears reasonable. For the most part, the scheduling strategy fits with other major projects at FNAL.”
    - “After the funding profile for the higher end of the TPC of \$695M was established, the Committee judged that the project is ready to proceed to CD-0...”

## News Since June (2014)

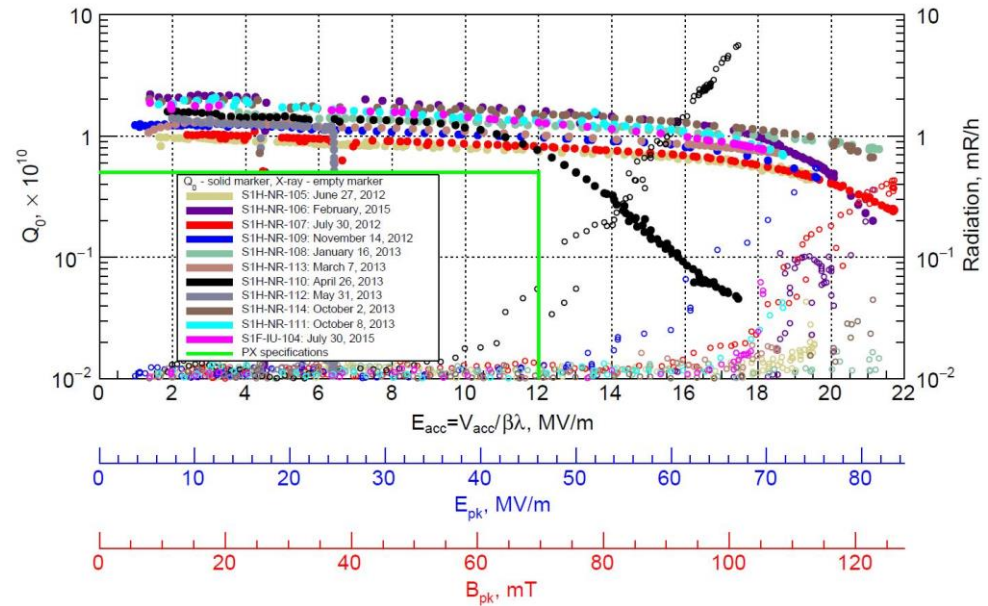
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- CD-0
  - Subsequent to the review the upper end of the cost range was lowered to \$650M
    - We provided a funding profile consistent with this number
  - Mission Need Statement approved by the Office of Science
  - ESAAB scheduled for November 12
- PXIE
  - LEBT beam characterized and meets requirements
  - RFQ has arrived and is under vacuum at PXIE!
  - MEBT magnets received from BARC



# News Since June (2014)

- SRF
  - Two SSR1 cavities received from IUAC
  - SSR1 dressed cavity successfully tested
  - Lab 2 renovation going great guns
  - Preparing for SSR1 string assembly in FY16
  - Preparing for HWR string assembly in FY16 (ANL)
  - Significant advances in high- $Q_0$  and resonance control programs
- Indian Collaboration
  - “Annex I” signed by DOE and DAE
  - Project Plan for R&D phase signed (DOE and DAE)
  - 7 Indian engineers at Fermilab for 2-year residencies
    - 650 MHz C&CM, LLRF, Cryo, Accel Phys (PXIE)



## News Since June (2014)

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- Personnel Changes
  - New Technical Division Head: Sergey Belomestnykh
    - Replaces Hasan Padamsee (retired)
  - SRF Program Management Team:
    - TD PIP-II Coordinator: Allan Rowe
    - 325 MHz cavities and cryomodules: Leonardo Ristori
    - 650 MHz cavities and cryomodules: Tom Nicol
    - SRF Development Department: Slava Yakovlev
      - Cavity Performance and Testing: Anna Grasselino
      - Resonance Control: Yuriy Pischalnikov

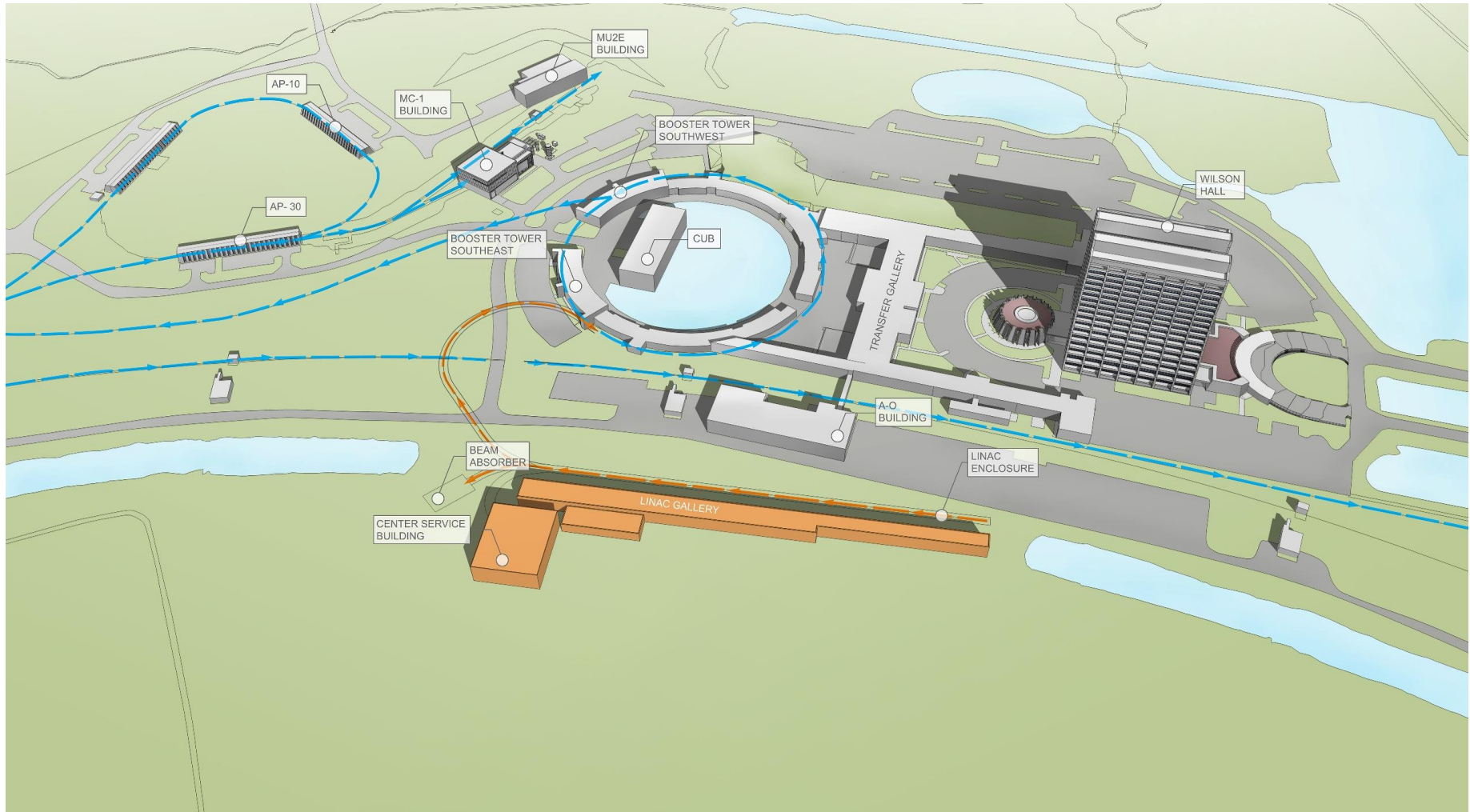
# PIP-II Status and Strategy

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- Reference Design Report describes:
  - An 800-MeV superconducting linac, constructed of CW-capable components, operated initially in pulsed mode
  - Modifications to Booster/Recycler/Main Injector to accommodate higher intensities
    - New Booster injection region to accept 800-MeV beam
    - Upgrades to Booster damper and collimator systems
    - LCW system upgrades (reliability)
    - Recycler RF upgrade for slip-stacking at 0.7 sec cycle time
    - MI RF power upgrade
    - MI  $\gamma_t$ -jump system
  - Increase of Booster repetition rate to 20 Hz
    - Maintain 1 MW down to 60 GeV or,
    - Provide factor of 2.5 increase in power to 8 GeV program



# PIP-II Status and Strategy/Site Layout

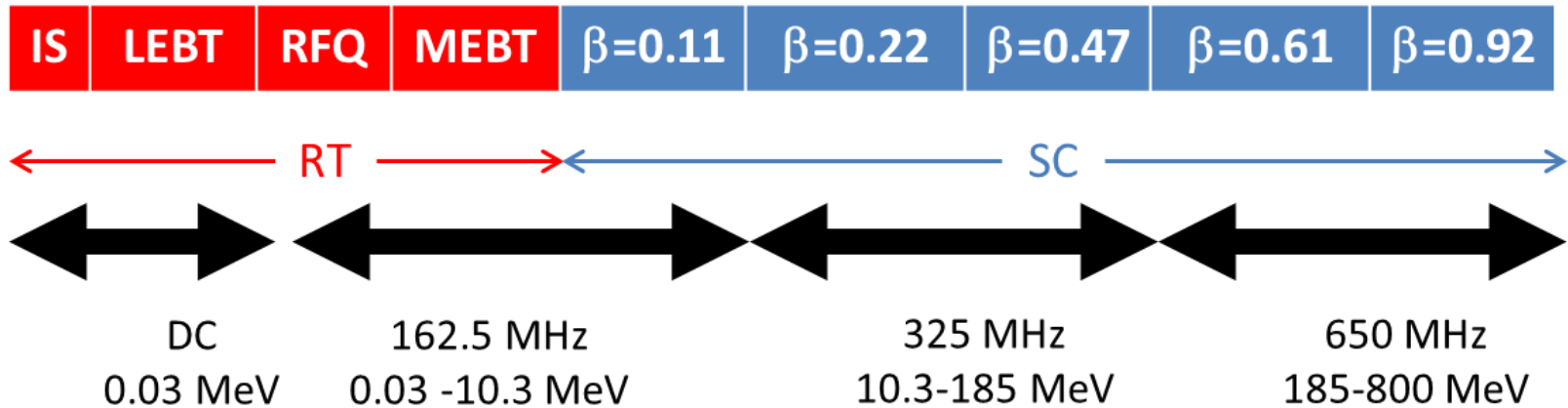


# PIP-II Status and Strategy/Performance Goals

Performance Parameter	PIP	PIP-II	
Linac Beam Energy	400	800	MeV
Linac Beam Current	25	2	mA
Linac Beam Pulse Length	0.03	0.5	msec
Linac Pulse Repetition Rate	15	20	Hz
Linac Beam Power to Booster	4	18	kW
Linac Beam Power Capability (@>10% Duty Factor)	4	~200	kW
Mu2e Upgrade Potential (800 MeV)	NA	>100	kW
Booster Protons per Pulse	$4.3 \times 10^{12}$	$6.5 \times 10^{12}$	
Booster Pulse Repetition Rate	15	20	Hz
Booster Beam Power @ 8 GeV	80	160	kW
Beam Power to 8 GeV Program (max)	32	80	kW
Main Injector Protons per Pulse	$4.9 \times 10^{13}$	$7.6 \times 10^{13}$	
Main Injector Cycle Time @ 60-120 GeV	1.33*	0.7-1.2	sec
LBNF Beam Power @ 60-120 GeV	0.7*	1.0-1.2	MW
LBNF Upgrade Potential @ 60-120 GeV	NA	>2	MW

\*NOvA operations at 120 GeV

# PIP-II Status and Strategy/Technology Map



Section	Freq	Energy (MeV)	Cav/mag/CM	Type
RFQ	162.5	0.03-2.1		
HWR ( $\beta_{\text{opt}}=0.11$ )	162.5	2.1-10.3	8/8/1	HWR, solenoid
SSR1 ( $\beta_{\text{opt}}=0.22$ )	325	10.3-35	16/8/ 2	SSR, solenoid
SSR2 ( $\beta_{\text{opt}}=0.47$ )	325	35-185	35/21/7	SSR, solenoid
LB 650 ( $\beta_g=0.61$ )	650	185-500	33/22/11	5-cell elliptical, doublet*
HB 650 ( $\beta_g=0.92$ )	650	500-800	24/8/4	5-cell elliptical, doublet*

\*Warm doublets external to cryomodules

**All components CW-capable**

# PIP-II Strategy

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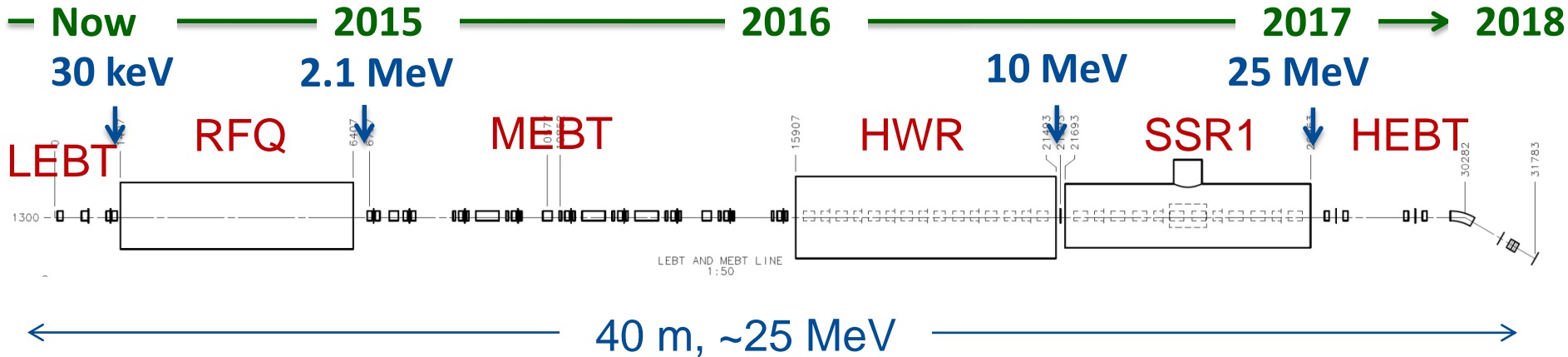
- PIP-II will be executed as a DOE 413.3b project
- Strategy
  - Develop/evolve concepts aligned with community needs
  - Undertake R&D targeting major technical/cost risk elements
  - RDR defines concept for meeting community requirements, and provides context for R&D
  - Coordinate with other Fermilab projects and programs
- Status
  - PIP-II endorsed by P5 as a key element in the U.S. neutrino program
  - R&D program underway
  - P2MAC review of RDR and R&D program (March)
  - Strong collaboration with Indian and U.S. laboratories
    - Possible collaboration with Europe
  - Project Office established

# Project Strategy/R&D

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- Goal is to mitigate risk: Technical/cost/schedule
- Technical Risks
  - Front End
    - Delivery of beam with required characteristics, quality, and reliability
  - Operate (high  $Q_0$ ) SC Linac in pulsed mode at low current
    - Primary issue is resonance control in cavities
  - Booster/Recycler/Main Injector beam intensity
    - 50% per pulse increase over current operations
    - Longitudinal emittance from Booster for slip-stacking
    - Transition crossing
    - Beam loss/activation
  - Develop requisite capabilities of international partners and vendors
- Cost Risks
  - Superconducting RF
    - Cavities, cryomodules, RF sources represent a major portion of construction costs
- Goal: Be prepared for a construction start in 2019
  - R&D deliverables milestones established

# Project Strategy/PXIE



PXIE will address the address/measure the following:

- LEBT pre-chopping: **Demonstrated**
- Vacuum management in the LEBT/RFQ region: **Demonstrated**
- Validation of chopper performance
  - Bunch extinction, effective emittance growth
- MEBT beam absorber
  - Reliability and lifetime
- MEBT vacuum management
- CW operation of HWR
  - Degradation of cavity performance
  - Optimal distance to 10 kW absorber
- Operation of SSR with beam
  - CW and pulsed operation
  - Resonance control and LFD compensation in pulsed operations
- Emittance preservation and beam halo formation through the front end

Collaborators

ANL: HWR

LBL: LEBT, RFQ

SNS: LEBT

BARC: MEBT

IUAC: SSR1

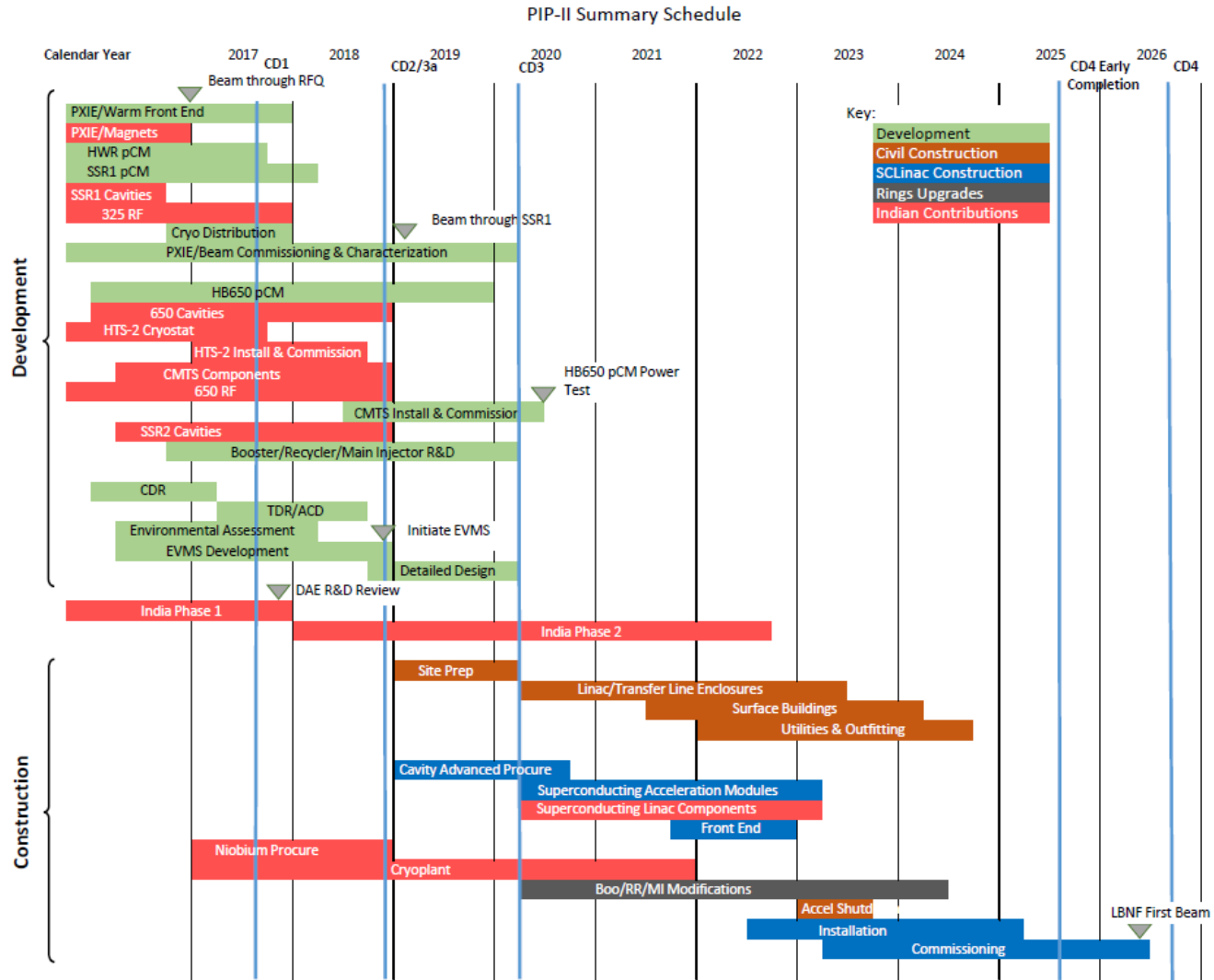


# Project Strategy/SRF Development Status (6/1/15)

Cavity	Frequency	Cavity Type	Beta	Collaboration?	Cavity EM Design Complete	Cavity Mech Design Complete	Single Cell / Prototype Ordered	Full Cavity Prototype Received	Prototype Tested	Cavities for CM Ordered	Cavities for CM Received	Cavities for CM Tested	Cavities for CM Dressed	CM Cold Mass Design	CM Parts Ordered	# of CM Assembled	Est % complete
Half Wave Resonator (HWR)	162.5 MHz	1-HWR CW	0.11	ANL	yes	yes	yes	yes	yes	9	9	2	2	yes	yes	15%	70
Single Spoke Resonator 1 (SSR1)	325 MHz	1-spoke CW	0.22	India	yes	yes	2	2	2	10	10+2	10	6	80%	70%	not started	75
Single Spoke Resonator 2 (SSR2)	325 MHz	1-spoke CW	0.47	India	yes	yes	not started	not started	not started	not started	not started	not started	not started	not started	not started	not started	10
Low Energy 650 (LE 650)	650 MHz	5-cell CW	0.6	India, JLAB	yes	yes	5	not started	not started	not started	not started	not started	not started	not started	not started	not started	10
High Energy 650 (HE 650)	650 MHz	5-cell CW	0.9	India	yes	yes	5 of 10	4	not started	9	4	not started	not started	5%	not started	not started	20

Legend: green = done, yellow = in process

# Project Strategy/Preliminary Schedule





# FY2016-17 Goals

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- Fill out project organization and achieve CD-1
  - CDR, alternatives study, cost range, RLS
  - Other supporting documentation
- Initiate work toward CD-2
  - Detailed design
  - Site characterization
  - NEPA documentation and permitting
  - EVMS implementation
- Advance PXIE
  - Commission RFQ with beam and characterize in MEBT
  - Complete MEBT installation
  - Deliver HWR and SSR1 prototype cryomodules
  - Complete cryogenic infrastructure
- Complete HB650 cryomodule design (w/ India) and initiate procurements
- Integrate seven Indian engineers at Fermilab for two year residencies

# FY2016-17 Budgets

- FY2016 \$19.5M
  - Budget allocations specified at L3 of WBS
- Adjustments required to meet budget guidance:

Deliverable	Old Date	New Date
PXIE warm: beam out of MEBT-1	Q2FY16	Q4FY16
SSR1: Resonance control testing definitive results	Q4FY16	Q4FY16
PXIE warm: beam to end of MEBT-2	Q4FY16	Q4FY16
PXIE warm: beam to end of final MEBT	Q4FY17	Q4FY17
PXIE Cold: HWR CM and associated infrastructure (cryo, RF, power, etc.)	Q3FY17	Q3FY17*
PXIE Cold: SSR1 CM and associated infrastructure (cryo, RF, power, etc.)	Q3FY17	Q1FY18*
HB650 Dressed Cavities and associated infrastructure (HTS-2, rf)	Q3FY17	Q4FY18
HM650 CM to CMTS	Q4FY18	Q1FY20
CD-1 activities: CDR, Site Characterization, civil construction drawings	Q4FY16	Q3FY17

\* Requires augmented funding in FY2016

# FY2016-17 Budgets

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- FY2017 \$19.5M
  - Detailed budget plan does not yet exist
  - Priority will be on completing elements in prior table scheduled for FY2017 and on getting to CD-1
  - There will be slippage elsewhere
- FY2018
  - We have been advised that FY2018 will be: \$22.0-25.0M

# Meeting Goals

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- Reorientation from Project X to PIP-II has a significant impact on the roles of the various collaborating institutions on PIP-II.
  - We would like to use this meeting to facilitate the realignment of collaborator roles, in particular during the R&D phase of PIP-II.

## Meeting Goals

- Review status of the R&D program
- Develop plan, including the role of collaborators, in the R&D program

## Coverage

- PXIE
  - SRF
  - LLRF/resonance control
  - RF sources
  - Instrumentation
  - Controls
  - Cryogenic systems
  - Booster/Recycler/Main Injector
- We have organized three working groups to help achieve these goals

# Meeting Goals/Working Groups

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- Conveners are responsible for organizing their sessions. Each group should:
  - Review, and modify as necessary, goals and deliverables for the R&D phase
  - Develop a work plan that defines the sharing of responsibilities among the collaborators for the R&D phase

## WG1: PXIE/P. Derwent, A. Shemyakin

Warm components

Integration of HWR and SSR1

Instrumentation

Controls

Experimental program

## WG2: Superconducting Linac/S. Mishra, V. Yakovlev, F. Garcia

SSR1, SSR2

LB650, HB650

Test Stands: HTS-2, STC

LLRF/resonance control – joint with WG1

RF sources

Cryogenic systems

## WG3: Rings/V. Lebedev, I. Kourbanis

Beam dynamics and modelling

Booster injection

RF systems

Collimation systems

Dampers

Transition crossing

# Collaboration Meeting

## Agenda

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- Monday, November 9
  - Plenary Session: Overview 08:30-11:30
  - Lunch
  - WG-1: PXIE 12:30-17:00
    - Floating Point (IARC, 3<sup>rd</sup> floor east)
  - WG-2: SCLinac 12:30-18:00
    - IARC Auditorium
  - WG-3: Rings 12:30-17:30
    - IARC 1W (IARC, 1<sup>st</sup> floor west)
  - Afternoon break will be outside IARC Auditorium  
Wednesday, June 4
- Tuesday, November 10 8:30-10:00
  - WG-1
  - WG-2
  - WG-3
- Adjourn 10:30

<https://indico.fnal.gov/conferenceDisplay.py?confId=10586>

## Our Inspiration...

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Hello Steve,

Do you have any idea whether there will be a PIP-II collaboration meeting this summer and, if yes, any guess when?

My daughter is planning her wedding in June and asks when it would be most convenient for me.

## Our Inspiration...

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I don't think your daughter should be choosing a wedding date based on the PIP-II Collaboration Meeting!

In any event, I think it is unlikely we will have the meeting in June. July or August is more likely.

Cheers,  
Steve



# Our Inspiration...

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Steve,

She is aware of the power of science...

