PXIE Cryomodule Design: Work Organization and Priorities

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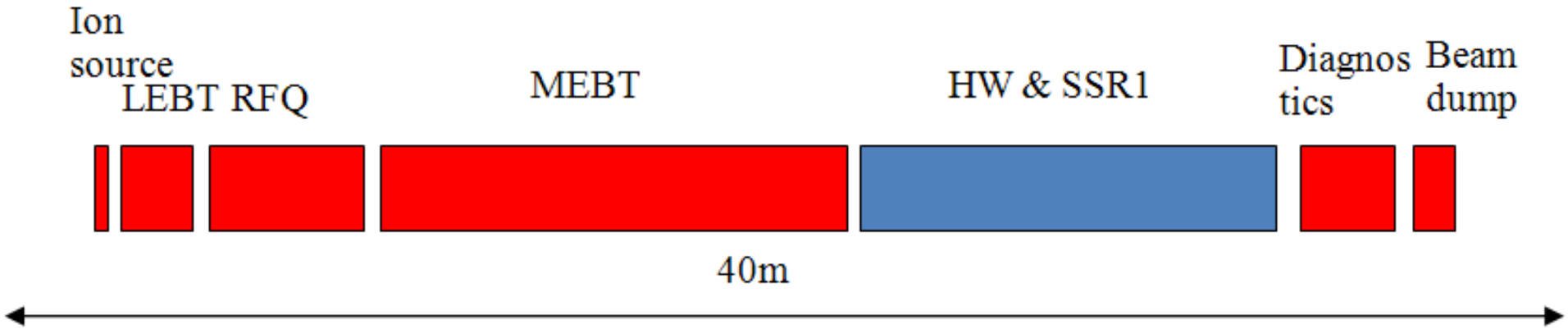
Cryomodule design meeting
Fermilab
Sep. 20, 2011

Project X Injector Experiment - PXIE

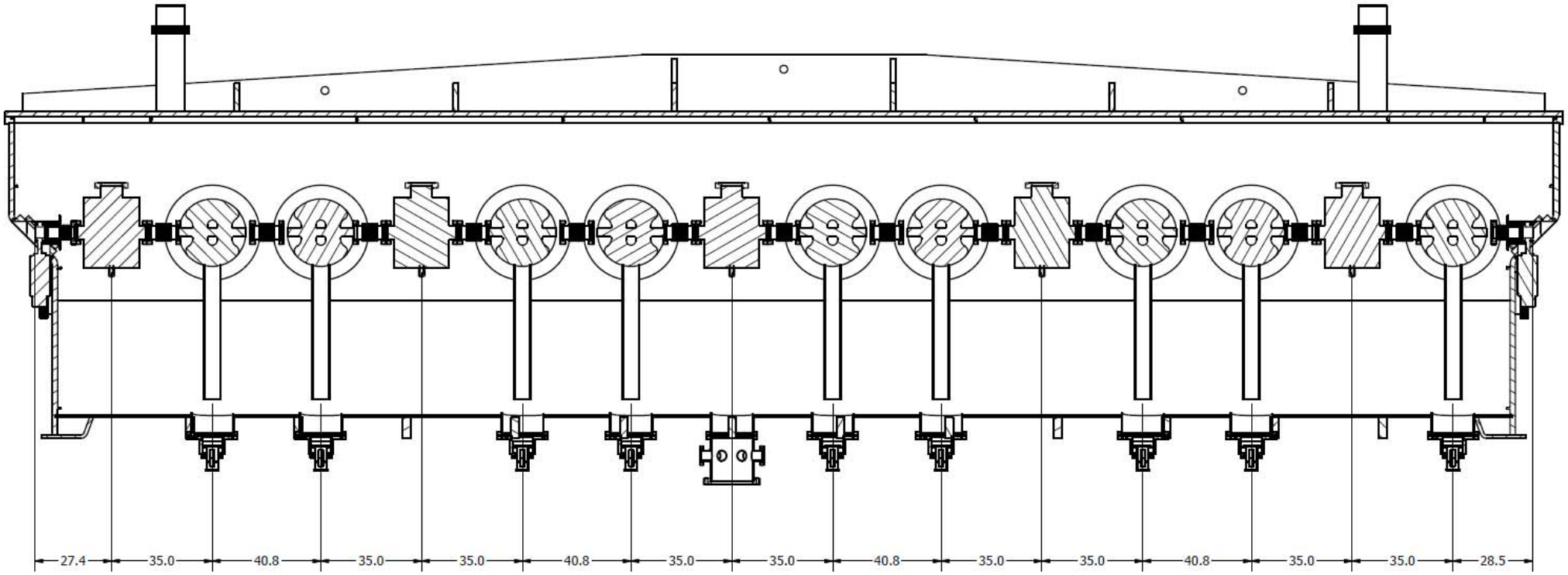
- PXIE should deliver 1 mA CW beam to ~30 MeV energy
- PXIE includes



- Goals
  - Validate the Project X concept and eliminate technical risks
    - Bunch-by-bunch chopper
    - Initial stage of acceleration in SC linac – never tested in experiment
      - † Complications can be due to beam loss of RFQ tails in SC linac
    - CW RFQ
  - Obtain experience in design and operation of CW SC proton linac
- Can be financed from existing budgets (Project X, SRF, GAD)

Structure of Half-wave cryo-module

- Final details should be settled by Collaboration meeting (End of Oct.)
- Present vision
  - 9 cavities, 6 solenoids (C S C S C S C S C C S C C S C) (periods: 70 & 110.8 cm)
  - L≈5.341→5.586 m (same element-to-element distances are used as in the Peter's drawing)
  - Four-button BPM near each solenoid (X & Y & S)
  - Each plane corrector is located every second solenoid (x y x y ..)
  - Solenoid polarity is changed in each next solenoid (simplifies orbit correction)



This is preliminary engineering model. It includes 5 short BPMs (0.62" along beamline). Flange-to-flange distance=534.1 cm.
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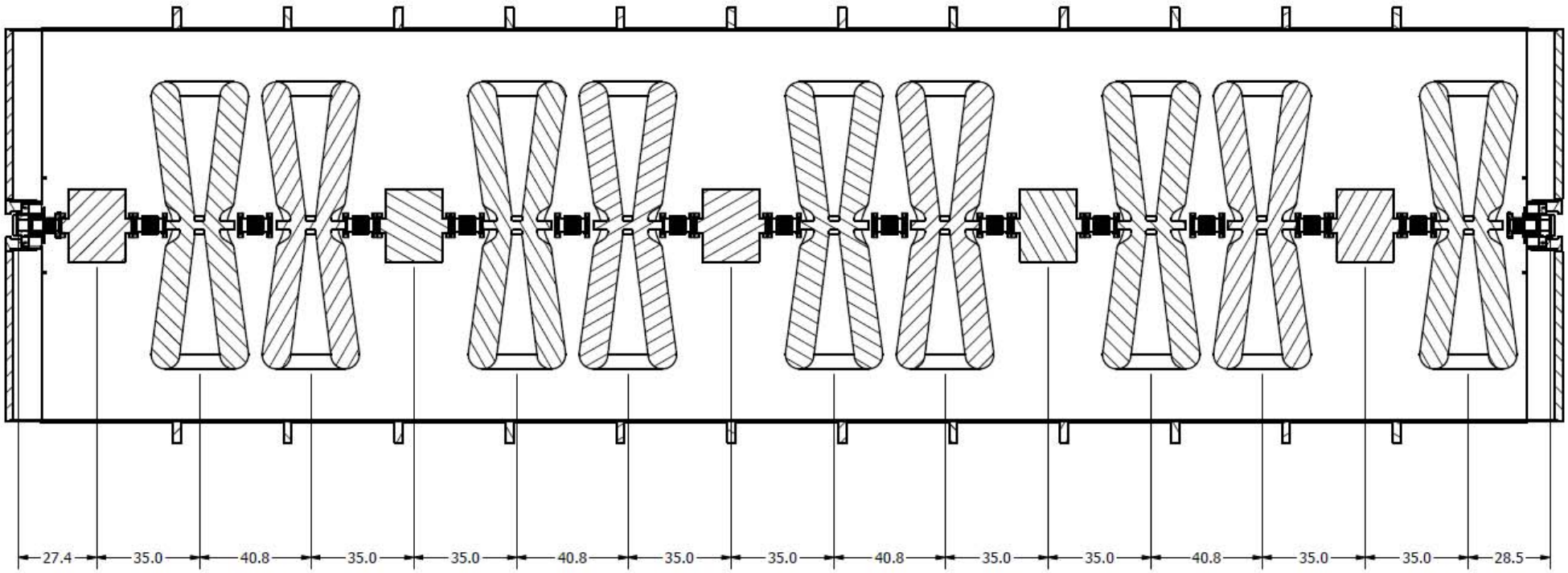
Top view



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Structure of SSR1 cryo-module

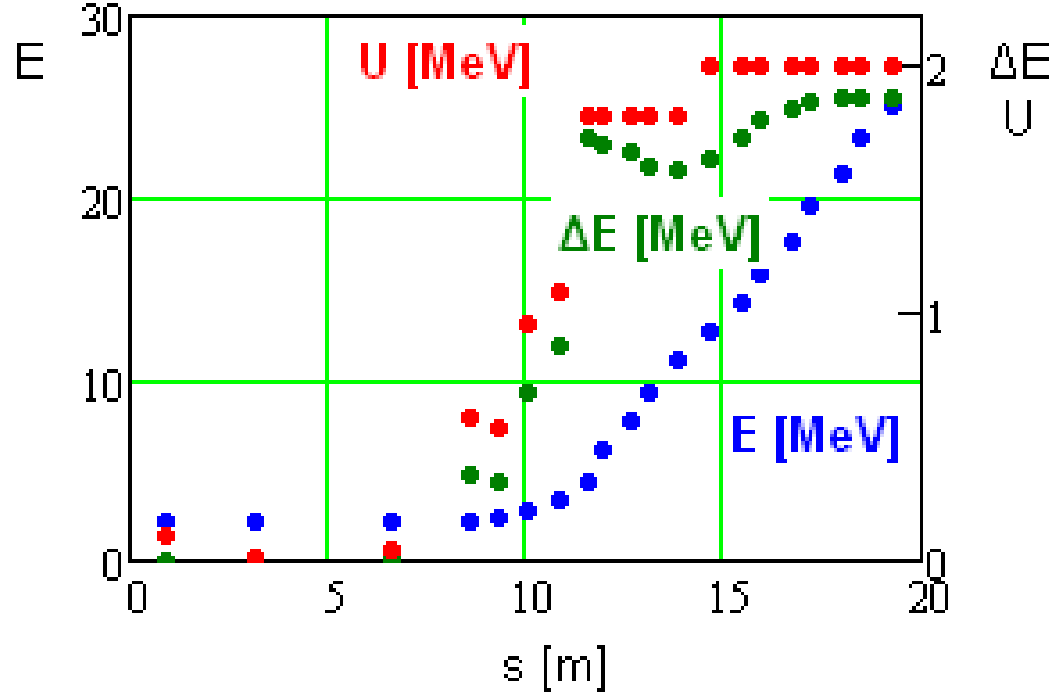
- Final details is a subject of our work
- Present vision
  - L ≈ 5.4 m
  - 8 cavities, 4 solenoids (C S C C S C C S C C S C) (period: ~125 cm)
  - Four-button BPM near each solenoid (X & Y & S)
  - Each plane corrector is located every second solenoid (x y x y ..)
  - Solenoid polarity is changed in each next solenoid

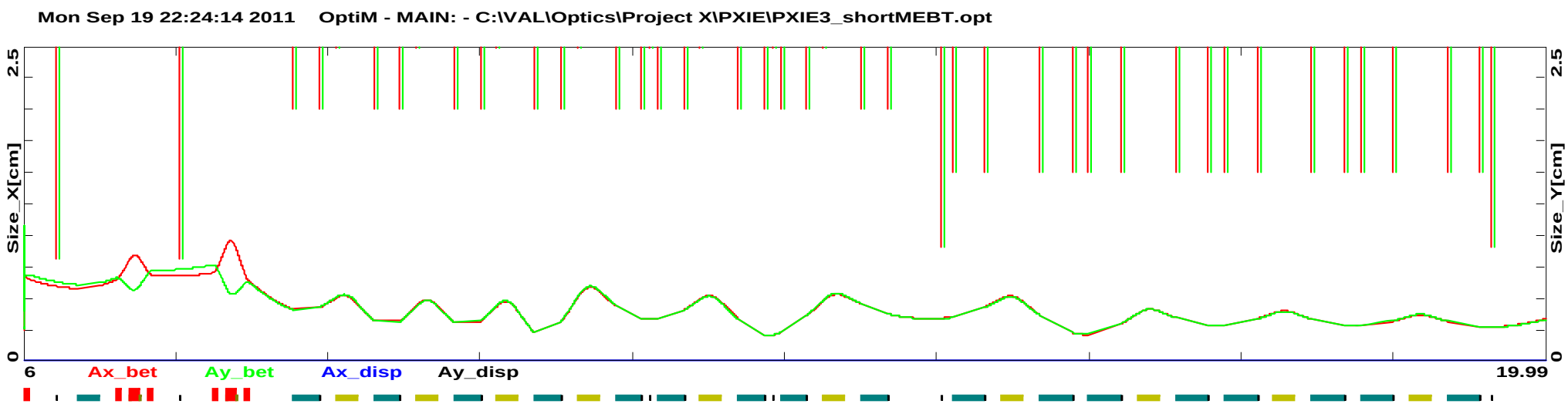
HW-to-SSR1 interface

- HW-to-SSR1 transition goes through room temp. vacuum chamber
  - Optimistically cavity-to-cavity – 74 cm (87 cm in present optics file)
  - Possible structure:
    - HW ~15 cm
      - Valve ~3 cm
      - Below ~3 cm
      - Box (Laser strip monitor, vacuum port) ~6 cm
      - Valve ~3 cm
    - SSR1
- Total length of two cryo-modules + interface ≈ 11 m

Acceleration in PXIE

- SC cavities parameters
  - HW: 1.8 MV, ~60 mT, aperture 40 mm, 9 cavities
  - SSR1: 2 MV, ~60 mT, aperture 30 mm, 8 cavities
- That yields:
  MEBT – 2.1 MeV
  HW – 11 MeV,
  SSR1 – 27 MeV





3σ transverse beam size

Responsibilities

- The meeting goal
  - Coordination of work on the design and construction of the PXIE SC part
    - Design and build one SSR1 cryomodule
    - Design and build interface box between HW & SSR1 cryomodules
    - Participation in the design of HW cryo-module
    - Design and build cryo-distribution lines
- It will be a working meeting to be held weekly
  - Normally there will not be long scientific or engineering presentations, and only people involved into a suggested agenda have to be there. Other can come if they wish.
  - Discussions should be mainly concentrated on
    - what was done,
    - what needs to be done,
    - and what are the pending problems.

Personal responsibilities

1. Vyacheslav Yakovlev - concept and physics design
2. Nikolai Solyak - beam dynamics design
3. Mohamed Hassan - EM and mechanical simulations
4. Ivan Gonin - cavity EM design
5. Leonardo Ristori - cavity mechanical design
6. Yury Pischslnikov & Warren Schappert - tuner and alignment concept
7. Allan Rowe - surface processing.
8. Timergali Khabiboulline - cavity tests
9. Yuri Tereshkin - lens design
10. Sergey Kazakov - coupler design
11. Manfred Wendt – BPMs and other instrumentation
12. Arkady Klebaner – cryogenics and cryo-distribution lines
13. Tom Nicol - all design work integration, responsible for CM design & production
14. Mark Champion - general leadership
15. Valeri Lebedev - meeting's chair and overall responsibility for the design

- Other people in the distribution list
  - Steve Holmes, Bob Kephart, Sergey Nagaitsev, Jim Kerby, Peter Ostroumov, Rich Stanek
- Responsibilities are not necessarily limited to the written above subject

Documentation

- Project X data base keeps everything
- Separate web space for the design effort referenced from the Project X page supported by Valeri
  - Meeting minutes (very concise)
  - The latest versions of all specifications and other documents important for our work

The plan

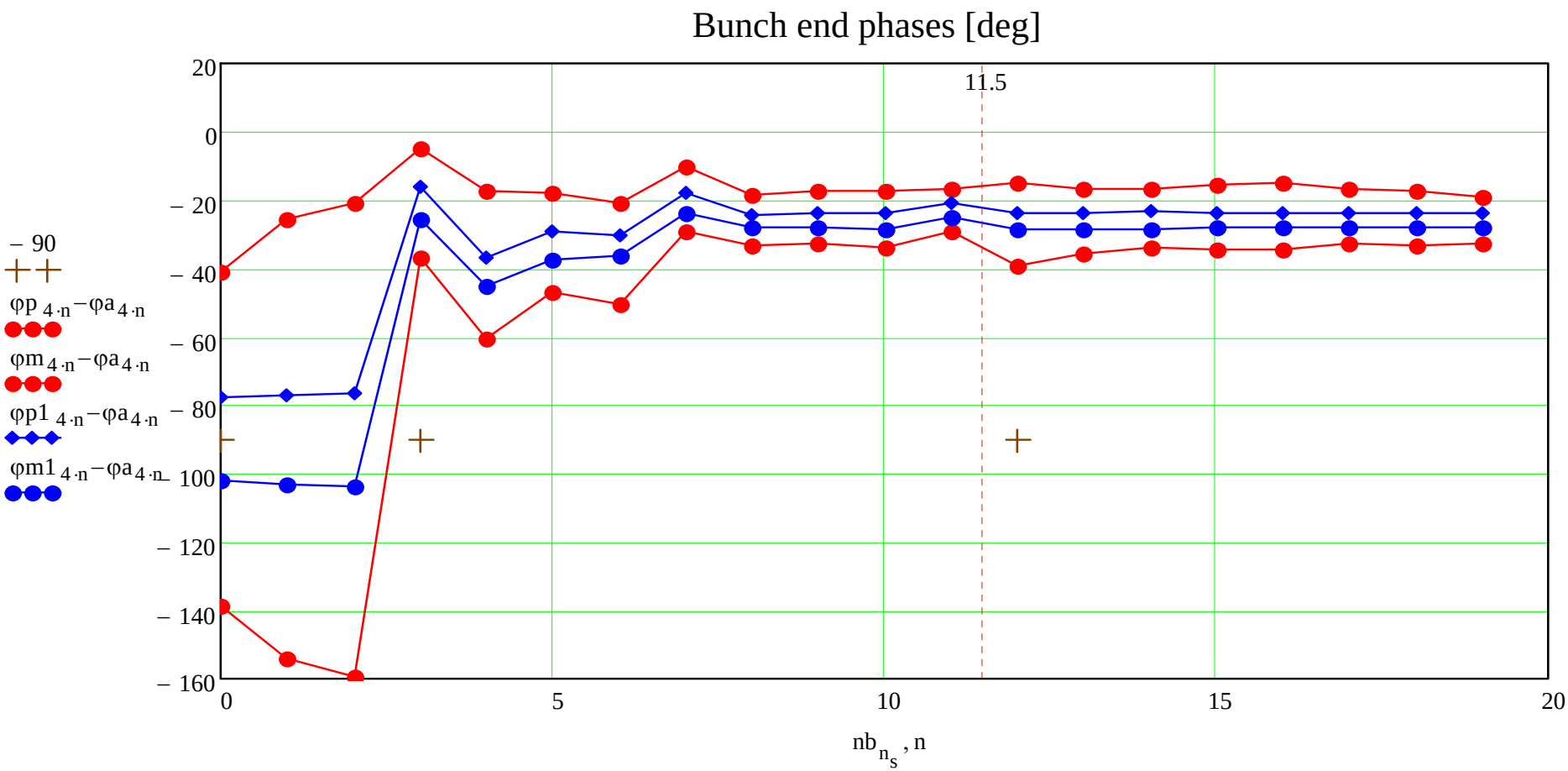
- To have PXIE operating by October 2016
- Location – attached to the CMTF building (Cryomodule Test Facility)
- Major FY'12 goals (not finalized yet)
  - Warm part
    - Test chopper kicker prototype
    - Finish RFQ design
    - Warm part design is half done
  - Half-wave resonators
    - Finish the design of prototype HW cryo-module.
    - All details of the interface to the MEBT and SSR1 are settled
  - SSR1
    - Design of one period of the cryomodule is complete
      - Cryomodule design should be finished by June 2013.
    - SSR1 lens design is complete (including all required exp. tests)
      - Decision on possible use of build solenoids is made
    - Prototype cavity (designed for CW operation) is ordered.
      - Decision on possible use of ordered cavities is made.

325 MHz test coupler design is complete and the coupler is ordered

Next few meetings

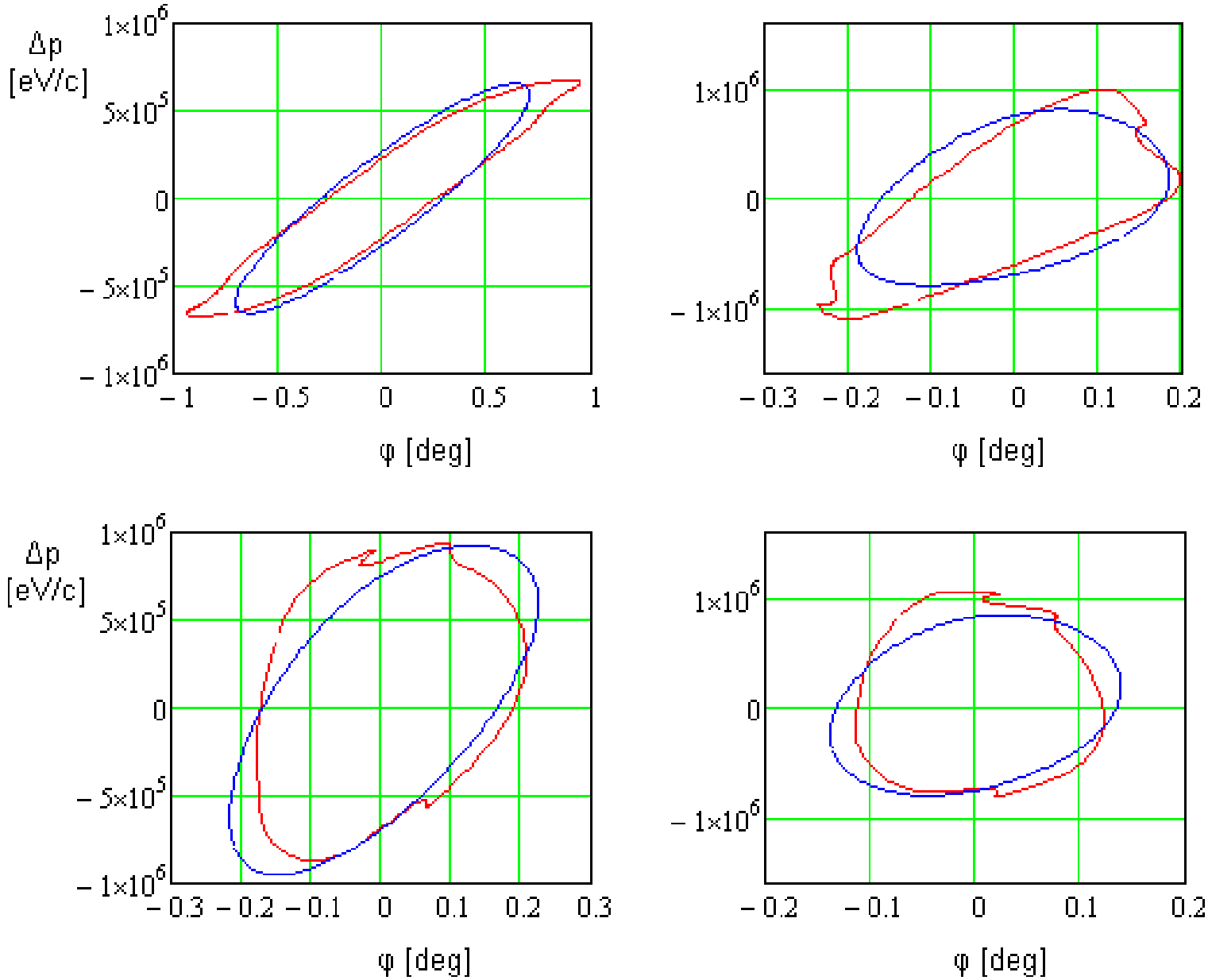
- Determine if the ordered SSR1 cavities can be used for PXIE
- Choice of solenoids, in particular, can the solenoids built for HINS be used
- Built a credible schedule for SSR1 design and production and update the cost estimate
- Cryomodule Functional Requirements Specifications for
  - HW
  - SSR1

Backup slides



Bunch end phases (relative to the on-crest acceleration) for 1σ and 4σ (I_{beam} = 0)

- Careful adjustment of cavity phases and amplitudes minimizes non-linear distortions of the longitudinal phase space



Longitudinal phase space transformation for 1σ (blue) and 4σ (red) ellipses starting at the RFQ exit. 4σ ellipse is reduced by factor 4: top-left – after MEBT, top-right – after cavity 4 in HW cryo-module, bottom-left - after HW cryo-module, bottom-right - after SSR1 cryo-module.

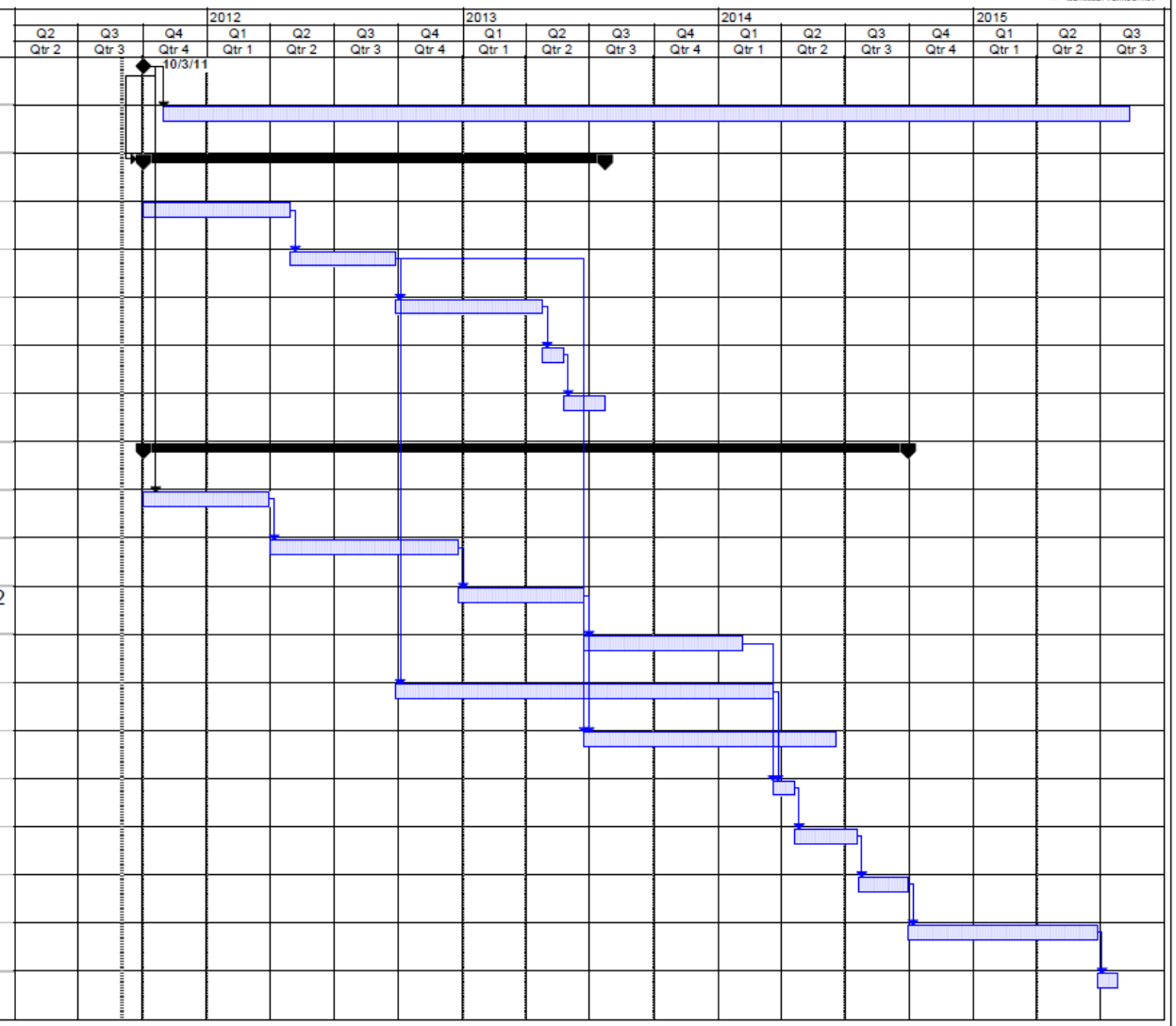
Possible schedule for Half-wave cryo-module production

REVISED: 09/01/2011

PXIE

Argonne NATIONAL LABORATORY

ID	WBS	Task Name	Start
1	1.0	Start of Project Funding	10/3/11
2	2.0	Project Management	11/1/11
3	3.0	Prototype HWR and sub-systems	10/3/11
4	3.1	EM and Mechanical Design, Engineering Analysi:	10/3/11
5	3.2	Fabrication drawings including fixturing	4/30/12
6	3.3	Fabrication	9/27/12
7	3.4	EP and clean assembly	4/25/13
8	3.5	Cold tests, 3 cool-downs	5/25/13
9	4.0	Cryostat vessel	10/3/11
10	4.1	Preliminary design	10/3/11
11	4.2	Fabrication drawings for the vacuum vessel comp	3/31/12
12	4.3	Final design complete	12/26/12
13	4.4	Fabrication complete	6/24/13
14	5.0	Fabrication of all 9 HWRs complete	9/27/12
15	6.0	Fabrication, procurement of cavity and cryomodu	6/24/13
16	7.0	Mock-up assembly	3/21/14
17	8.0	RF surface processing, cleaning	4/20/14
18	9.0	Cavity string assembly in clean-room	7/21/14
19	9.0	Cryomodule assembly, alignment, cold and RF test	9/29/14
20	10	Ready for beam	6/26/15



This schedule assumes that funding supports work appropriately, P.N. Ostroumov 9/1/2011 DRAFT