Project X RD&D Plan
RR and MI Rings

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Outline

- Description of the scope of the system.
- Performance specification of the system.
- Primary technical issues and the strategy to address them.
- Goals of the plan by year.
- Role of outside collaborators.
- Conclusions

System Scope RR/MI

- RR
  - Accept the Linac beam and Inject into MI (bucket to bucket transfer) with good efficiency.
  - Make the extra Linac cycles available for distribution at 8 GeV.

- MI
  - Accept beam from the RR in one turn.
  - Provide 2MW of beam power from 60-120GeV by accelerating one Linac pulse of beam (1.6E14 protons).

Project X Recycler Requirements

Description	Req.	Unit
Recycler		
Energy	8	GeV
Storage Efficiency	99.5	%
Average Recycler Beam Current	0.6	A
Availability	95	%
Injection Rate	5	Hz
Maximum Space Charge Tune Shift	0.05	
95% normalized transverse emittance	25	p-mm-mrad
r.m.s. normalized transverse emittance	13	p-mm-mrad
Bunching factor	2	
Longitudinal emittance per Bunch	0.5	eV-Sec
Cycle Time	1.4	sec
RF Frequency	53	MHz
Abort Gap Length	700	nsec
Peak Recycler Beam Current	2.356	A
Fast Extraction Rate	15	Hz
Fast Extraction Pulse Length	1.6	microsec

Second harmonic rf

Longitudinal painting

53 MHz rf system

MI Requirements

Description	Req.	Unit
Main Injector		
120 GeV cycle Time	1.4	sec
RF Frequency	53	MHz
Abort Gap Length	700	nsec
Acceleration Efficiency	99	%
Main Injector Beam Current	2.356	A
Final Energy	120	GeV
120 GeV Beam Power	2.1	MW
Availability	87	%
Injection Energy	8	GeV
Longitudinal emittance per Bunch	0.5	eV-Sec
Space Charge Tune Shift	0.05	0
95% normalized transverse emittance	25	p-mm-mrad
r.m.s. normalized transverse emittance	13	p-mm-mrad
Bunching factor	2	0

Second harmonic rf

Technical Issues

- The current MI rf system does not have enough power to accelerate the beam. We currently have no second harmonic system in MI. Need a 53MHz rf system (including a second harmonic) for RR.
- The MI crosses transition.
- Electron cloud instabilities.
- Beam stability and losses.

Technical Strategy

- Develop a new 53MHz rf system including second harmonic for both MI and RR.
  - The goal for the R@D plan is to have cavity prototypes tested within 4 years.
- Have a design for a first order matched gamma-t jump system
- Determine the severity of the electron cloud for both rings and investigate possibilities for medication.
  - Benchmark generation codes with MI data
  - Run beam dynamics codes
  - Investigate the possibility of beam pipe coating for both rings.

Project X Goals and Timeline (1)

- FY09
  - Develop and install two new RFA detectors. Develop and install permanent set-up for microwave e cloud measurements. Compare e cloud signals in the field free region for coated (TiN), un-coated pipes.
  - Compare e cloud generation code (PONSIT) with beam measurements. Compare also with another generation code. Start beam dynamics simulations.
  - Learn about TiN coatings (DC sputtering vs. magnetron sputtering). Examine coated pipes with both methods.
  - Update the 53 Mhz design for a higher R/Q. Run cavity software simulations (include LLRF stability). Model perpendicular biased tuner. Complete a paper design of second harmonic cavity.

Project X Goals and Timeline (2)

- FY10
  - Run beam dynamic simulations with e cloud and space charge. Evaluate the effect on the beam. Can broadband dampers have an effect?
  - Install ECLOUD1-SEY station in MI and measure the effect of beam conditioning on the SEY of various coatings.
  - Proceed with a TiN coating set-up at Fermilab. Experiment with coatings of straight beam pipes. Develop cathode targets for elliptical MI beam pipe.
  - Schedule 53MHz cavity review. Finalize cavity and tuner design. Order major components for a prototype construction. Finish second harmonic cavity design.

Project X Goals and Timeline (3)

- FY11
  - Experiment with coating of MI pipes inside dipoles. Investigate the effect of remnant fields.
  - Evaluate the severity of the electron cloud problem in both RR and MI. Use measured SEY for both coated and un-coated pipes.
  - Finish assembling first prototype cavity and tuner. Start low level testing of complete prototype cavity. Schedule second harmonic cavity review. Order parts for second harmonic cavity prototype. Design/specify rf power source for second harmonic.

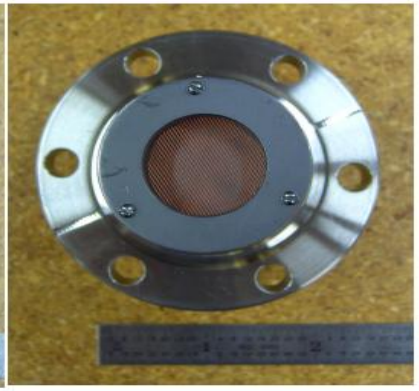
Project X Goals and Timeline (4)

- FY12
  - Test first harmonic cavity with high power in test station. Implement any necessary changes or upgrades. Install and test with beam. Assemble and test second harmonic with low power. Test second harmonic power source.
  - Present the results of the beam coating studies. Determine what it would take to coat the beam pipe in each ring.
  - Review the whole electron cloud medication strategy for both rings.

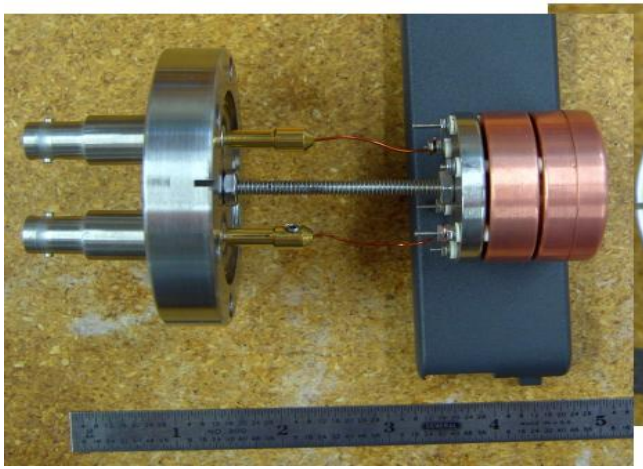
Collaborators

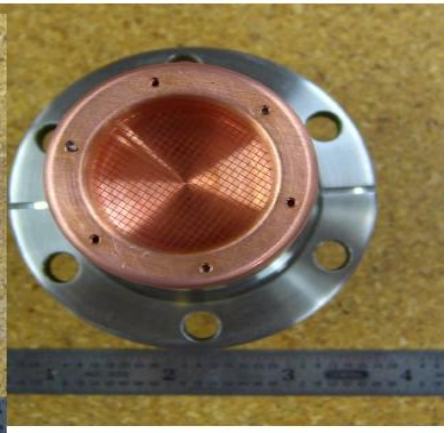
- BNL
  - Provide coated samples and technical support.
  - Collaboration on rf systems.
- SLAC
  - Provide coated samples and technical support
  - Cavity field modeling and LLRF beam stability simulations
  - Compare different generation codes and start beam dynamic simulations
  - Provide test stands for electron cloud measurements (ECLOUD1)
- LBNL
  - Collaborate on e cloud microwave measurements
  - Electron cloud simulations with PONSIT
  - Modeling of low losses due to space charge.

NEW MI RFA



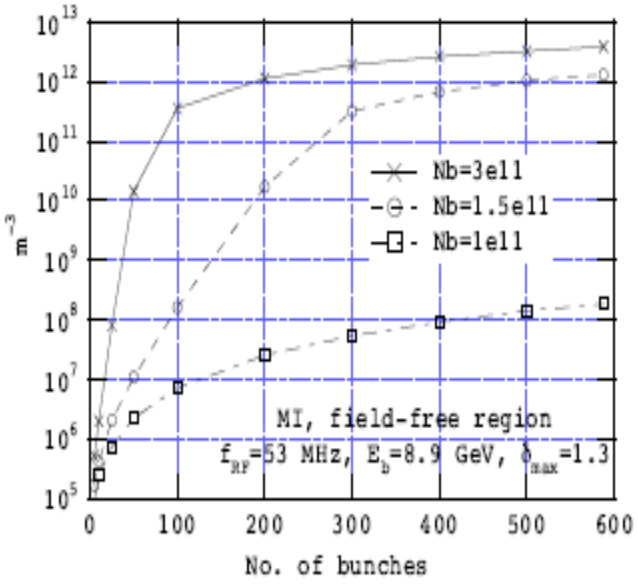
Current RFA
from ANL



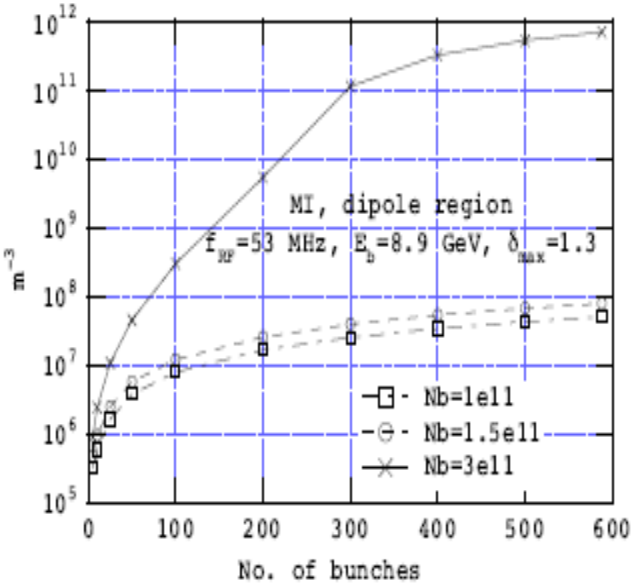


New RFA

E cloud build-up simulations for MI

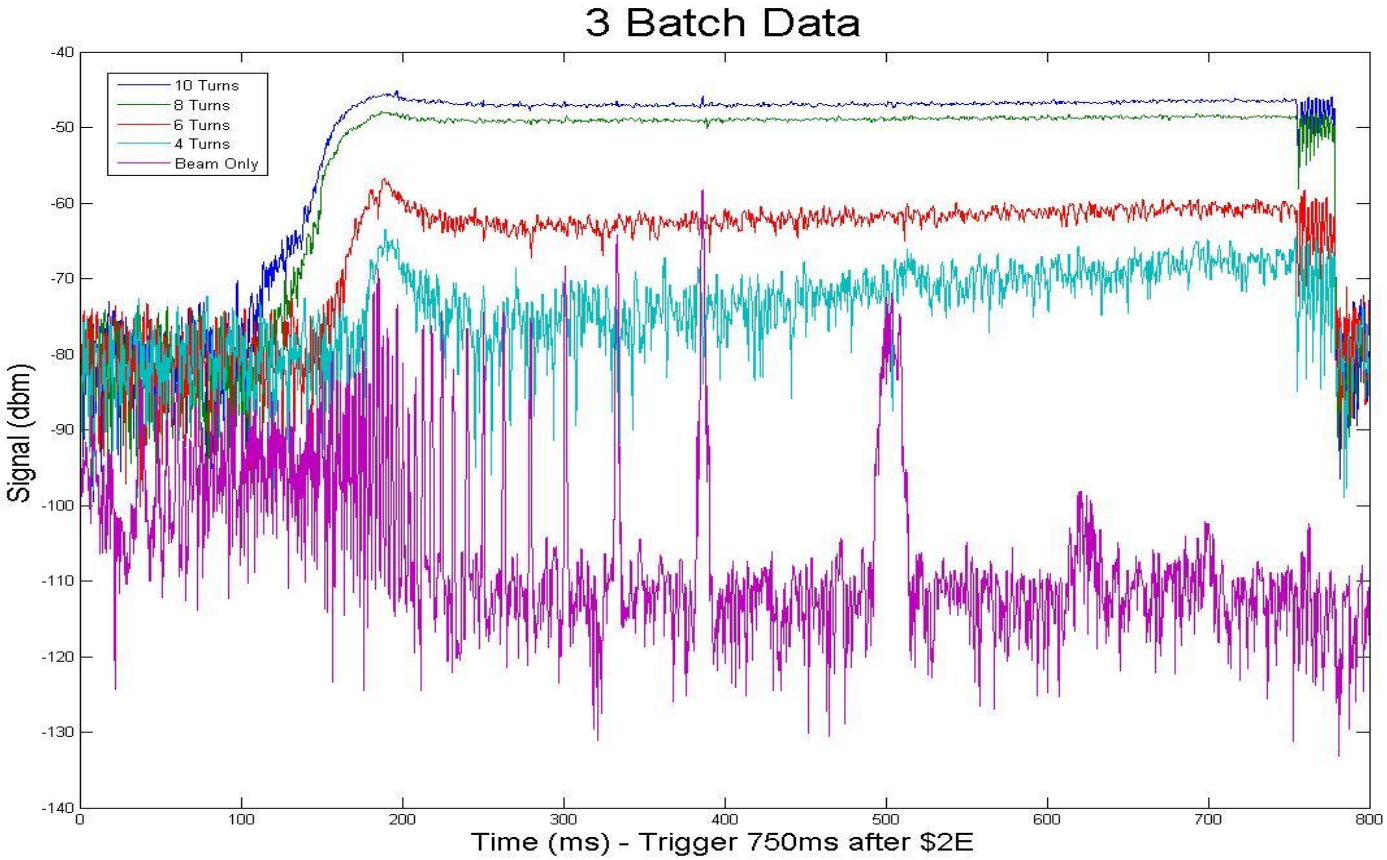


One-turn average of electron density in a field free region as a function of the numbers in the pulse

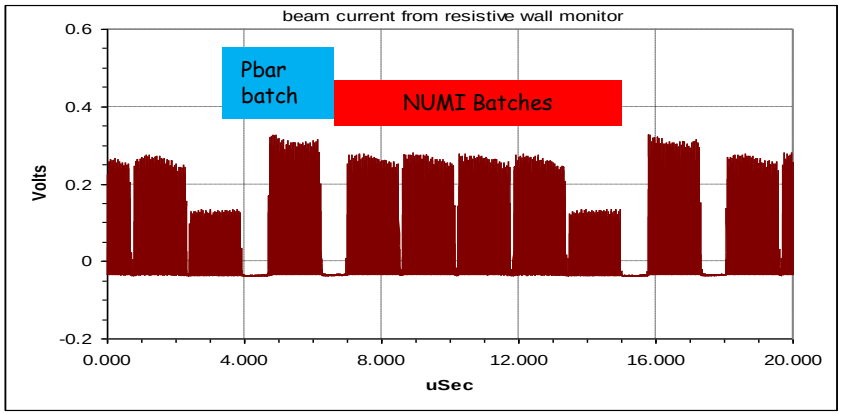


One-turn average of electron density in a dipole region as a function of the numbers in the pulse

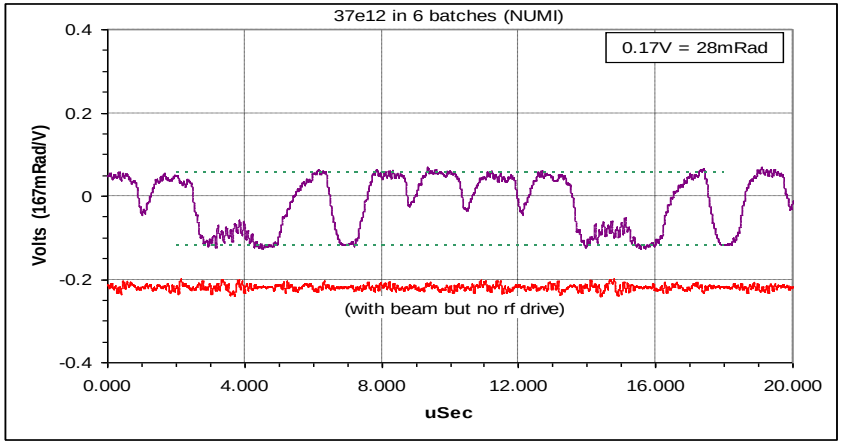
Measured phase shift due to e cloud vs time in the MI cycle



Project X Direct phase measurements of e cloud in MI



MI beam distribution



Phase shift measurements vs. time

Summary

- There are a few major issues for the existing rings (MI@RR) in order to meet the Project X requirements.

- We have developed an extensive R@D plan in collaboration with other labs in order to address them.