MI/RR RD&D Summary

Ioanis Kourbanis/Rob Ryne

Project X Collaboration Meeting

September 8-9, 2010

Main Elements

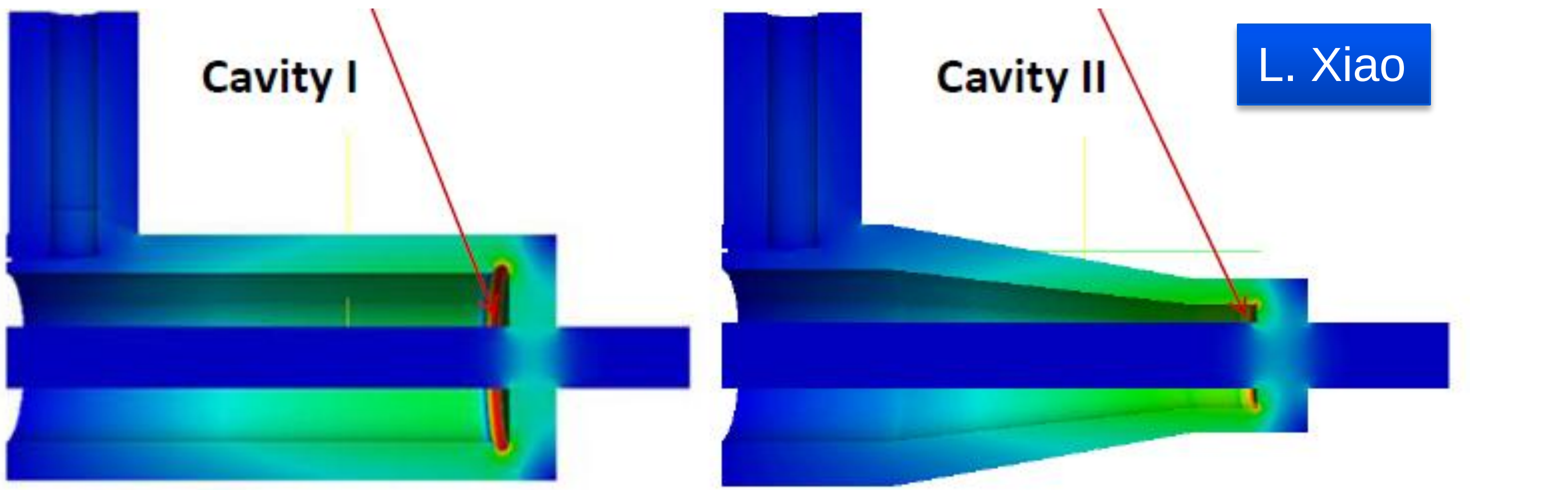
- Develop a new MI RF system including a second harmonic cavity with enough power to accelerate the Project X intensities.
  - We plan to use the same RF cavities in Recycler
- Investigate and simulate e-cloud effects in MI with current intensities. Simulate e-cloud beam effects with Project X intensities. Investigate ways to mitigate the e-cloud effects (coatings).
- Simulate space charge effects in MI. Determine how much of space charge tune shift we can tolerate with Project X intensities.
- Design a gamma-t jump for MI.
  - Design already developed.

New MI RF

- Have fixed the rf frequency and developed the rf requirements.
  - Have expanded the tuning range from 6GeV-120GeV.
- Have developed an RF cavity design with perpendicular biased tuners and R/Q~60 Ohms. We are collaborating with SLAC in optimizing the cavity shape.
  - Working on the HOM dampers.
- We have bought a high power tube (Eimac 8973) that can drive the new cavity and plan to build a PA for testing.
- The goal is to have a cavity design review in FY11.

Cavity shapes comparisons using Omega3P

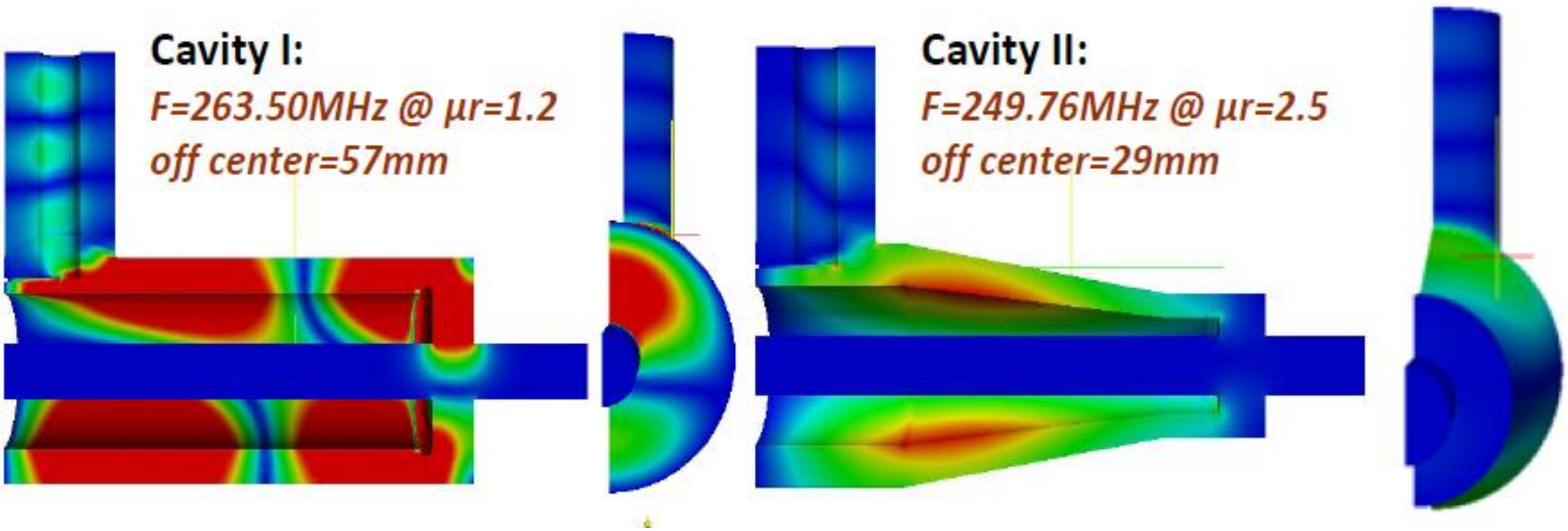
@μr=2.5, Vgap=240kV, tuner intrusion=55mm		MI-Cavity-I	MI-Cavity-II
Operating Mode	R/Q (Ω)	51.23	56.95
	Δf (KHz)	584	539
	Max. Es (mV/m)	7.4	12.2
	Max. Bs (T)	37.2	30.9
Monopole HOM Modes <300MHz	No. of Modes	2	2
	Max. R/Q (Ω)	22	19
Horizontal Dipole Modes < 300MHz	No. of Modes	3	1
	Max. R/Q_T (Ω)	17	1.5
Vertical Dipole Modes < 300MHz	No. of Modes	3	1
	Max. R/Q_T (Ω)	17	1.6
	Max. center shift (mm)	43	29
Power Distributions	P(kW) (wall/ferrite/ceramic)	117/39/0.7	104/28/6
MP	Gap Voltage for MP barrier (kV)	<75kV	<150kV



L. Xiao

Off-center Vertical Dipole Mode

- Due to the ferrite vessel, the vertical dipole modes are all off-center;
- Even the beam is on z-axis, the vertical dipole modes can be excited and generate transverse kick to the beam. The monopole component effects to the beam need to be considered in beam dynamic analysis.



L. Xiao

Eimac 8973 Power Tetrode

J. Dey

- Output power greater than 1MW.
- Max. operating frequency 110 MHz
- Plate Dissipation 1MW.

Received September 2010

E-Cloud

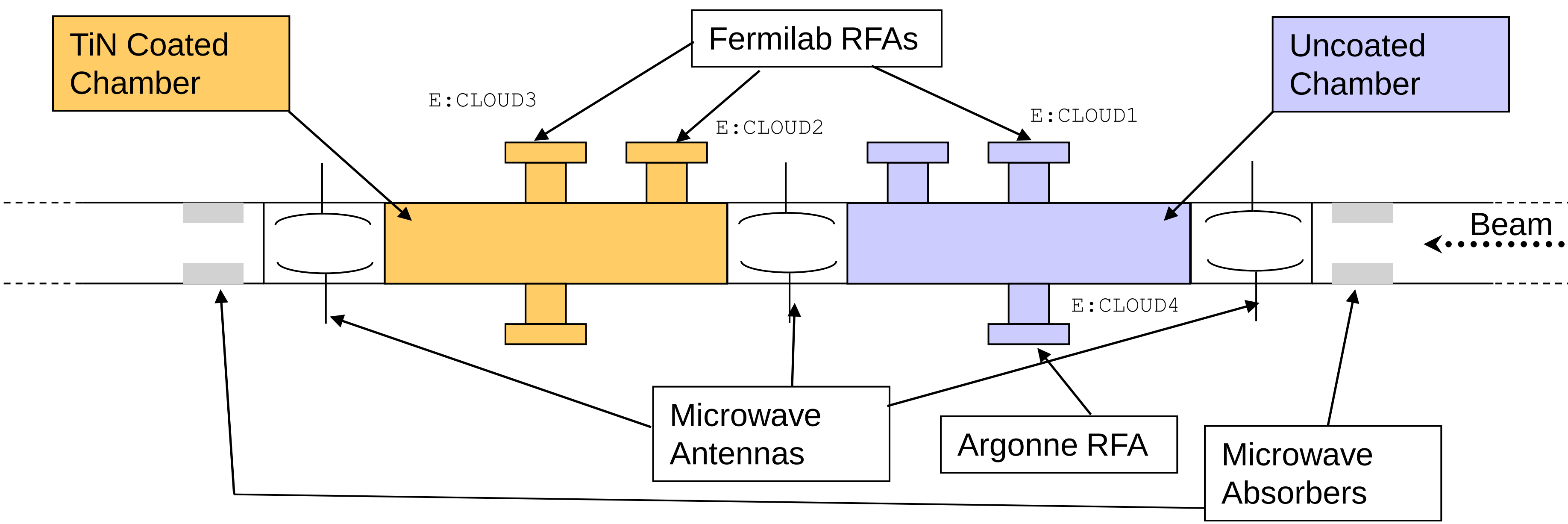
- Continuing the e-cloud simulations and comparisons with measurements. Started new simulations using VORPAL (Tech-X).
- Have established dedicated measurement set-up in MI-52 and have developed new RFA detectors. Have mw measurements set-ups at MI-40 and MI-52.
  - Have already installed a TiN coated beam piece and compared it with SS.
  - Plan to install SEY test stand in MI.
- We are getting ready to establish our own beam-pipe coating set-up in E4R. Our goal is to coat a beam-pipe inside an MI dipole with TiN in collaboration with SLAC.
- We are collaborating with CERN and we are learning from their experience with amorfous carbon coatings.
  - Have received a carbon coated beam pipe piece that was installed in MI-52

Electron Cloud Experimental Upgrade - 2009

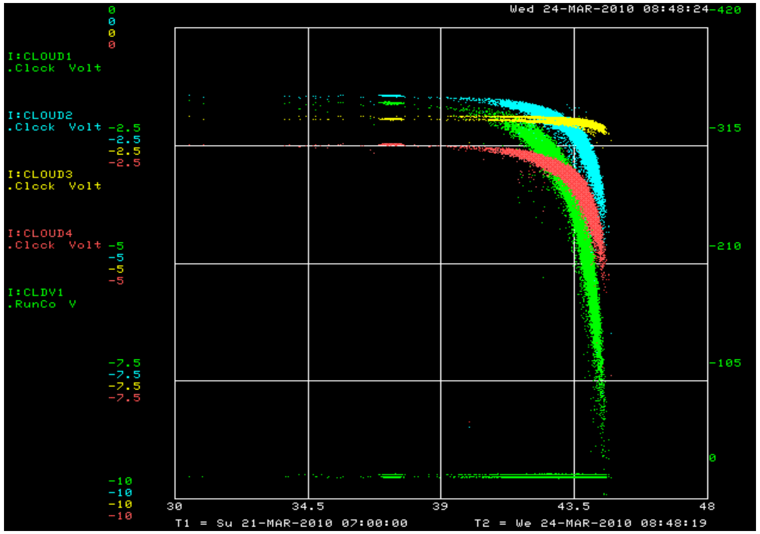
Major upgrade installed summer 2009

- 2 New experimental Chambers
  - Identical 1 m SS sections, except that one is coated with TiN
- 4 RFAs (3 Fermilab & 1 Argonne)
- 3 microwave antennas and 2 absorbers
  - Measure ECloud density by phase delay of microwaves

- Primary Goal: validate TiN as a potential solution for Project X
- Secondary Goals:
  - Remeasure threshold and conditioning
  - Further investigate energy-dependence
  - Measure energy spectrum of electrons
  - Test new instrumentation
  - Directly compare RFA and Microwave
  - Measure spatial extinction of ECloud



Evolution of thresholds for TiN coated pipe compared with SS



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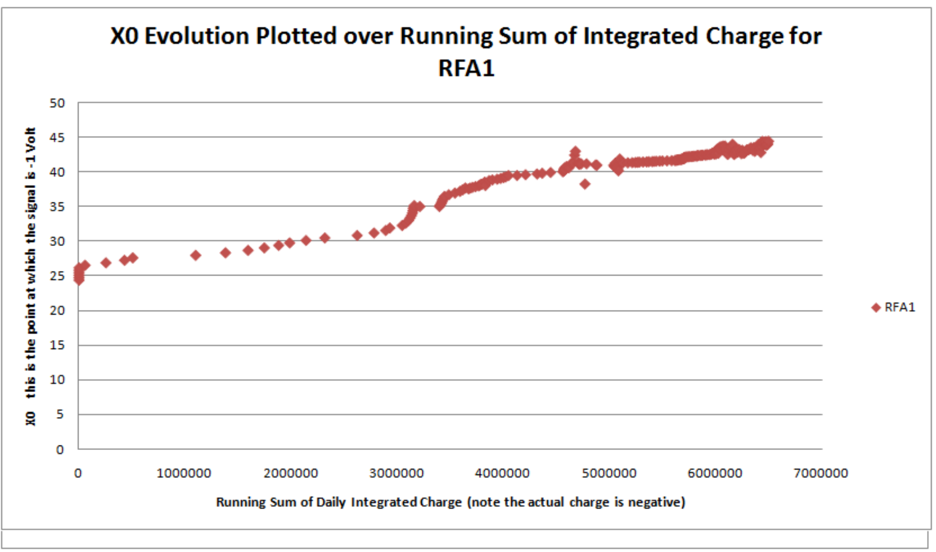
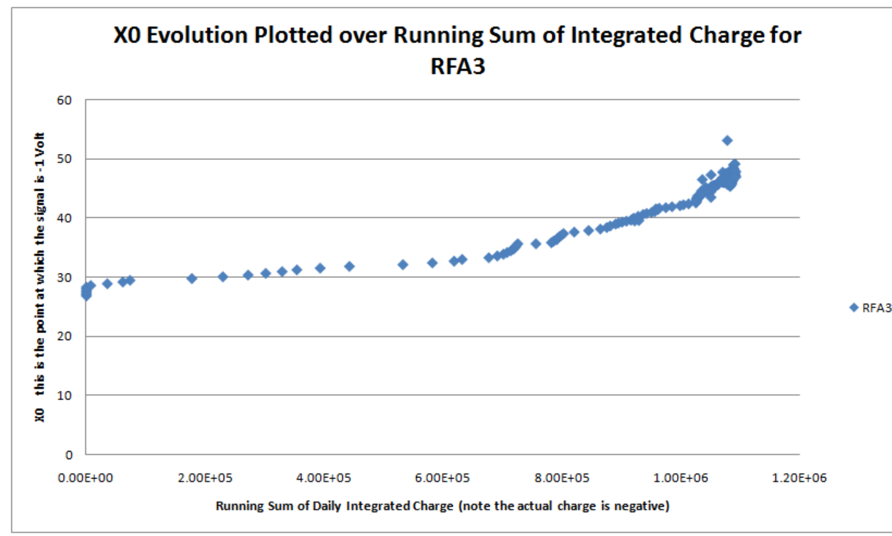




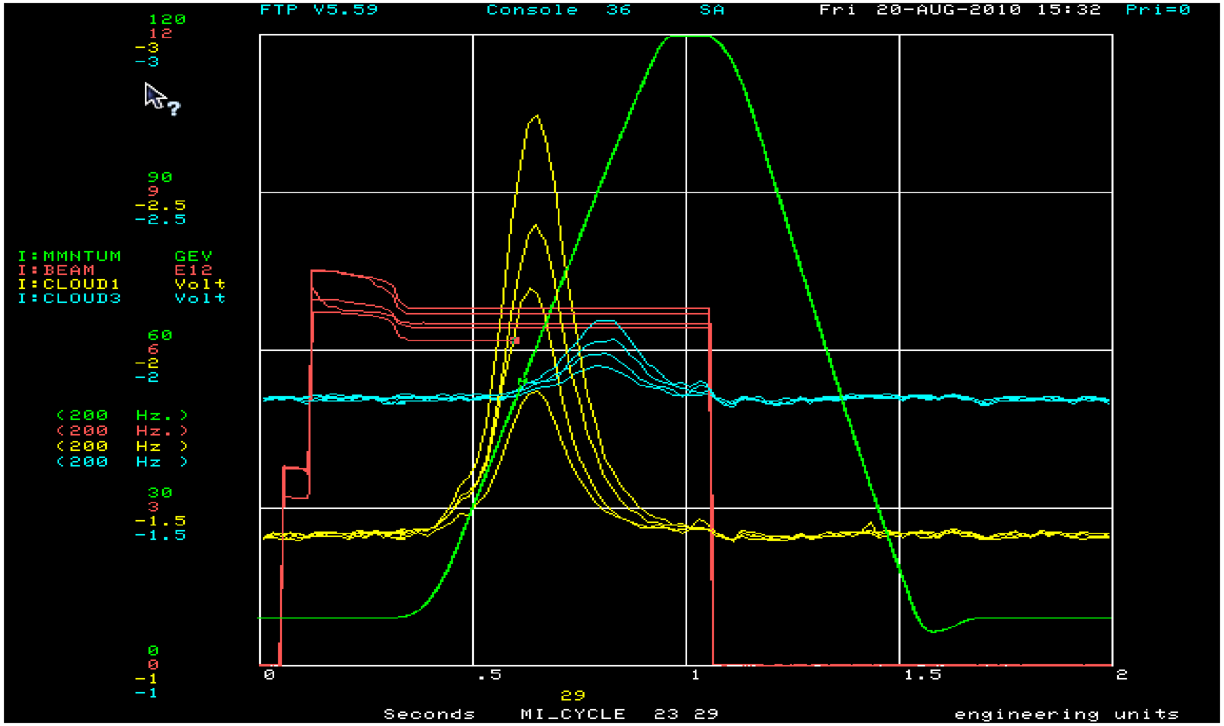
SS Pipe

TiN Coated Pipe

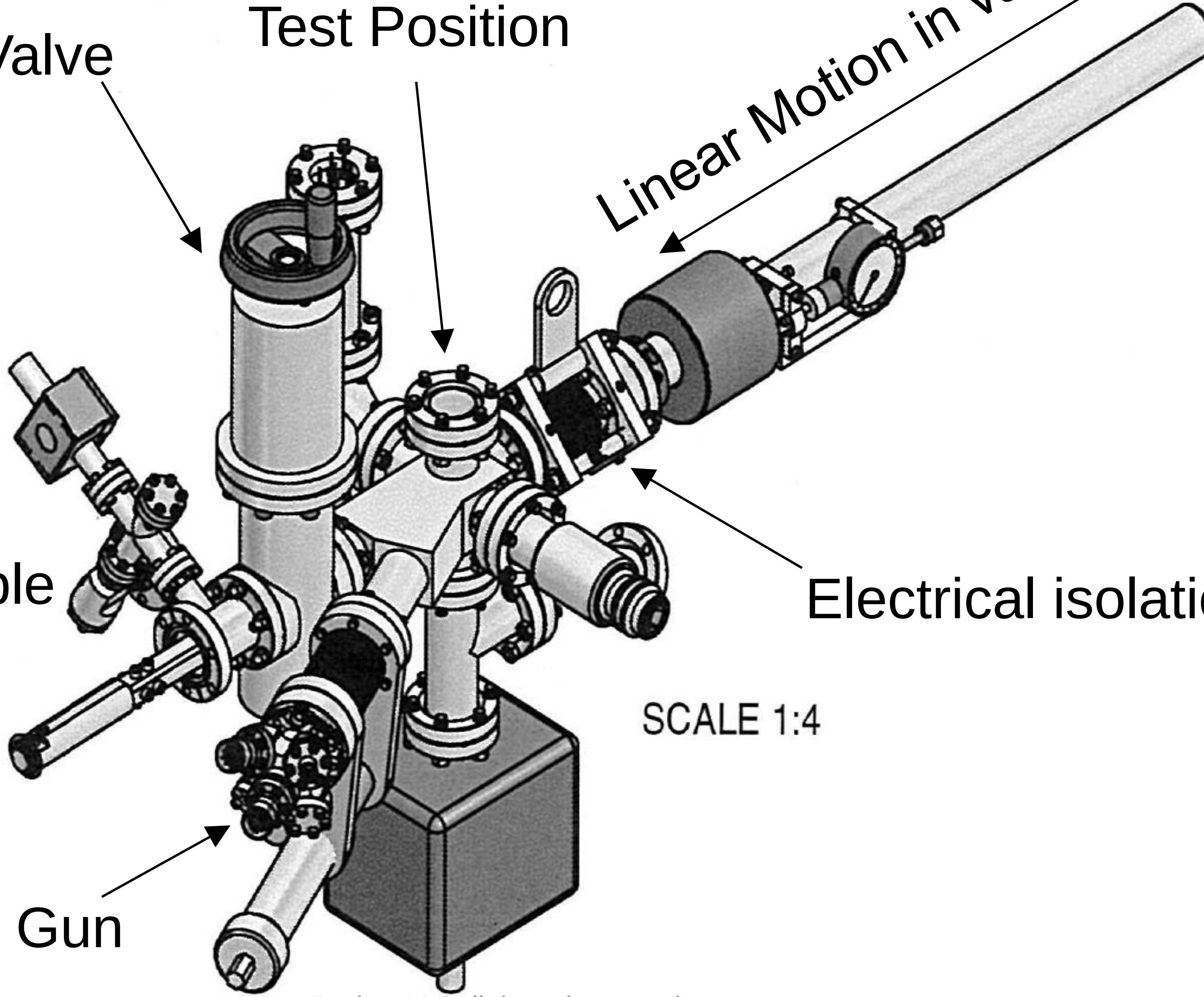
Early Carbon Measurements

- Less signal on Carbon coated pipe(x6) than SS
- Temporal shift is similar to TiN

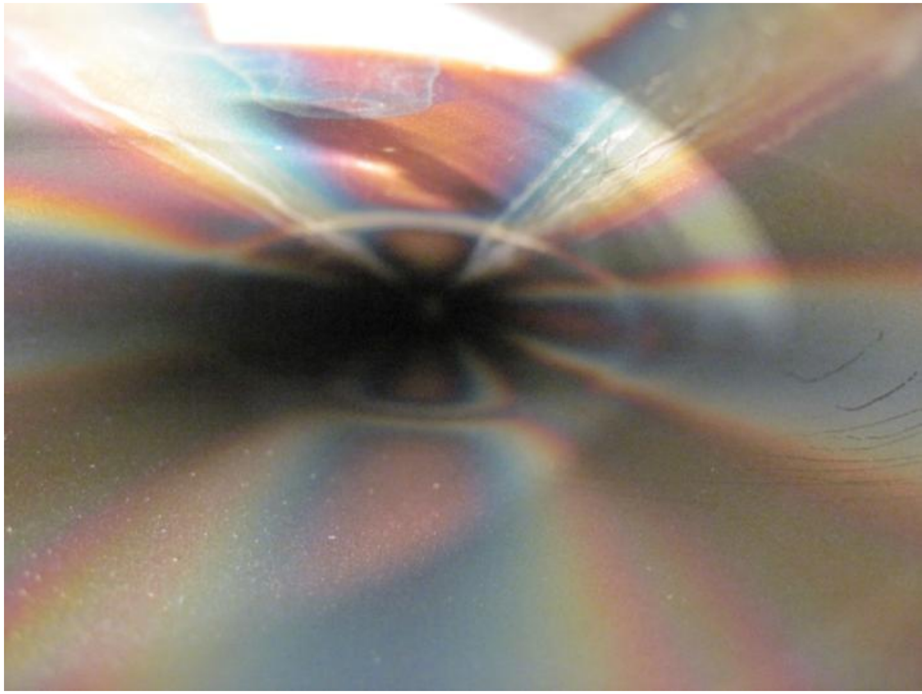
R. Zwaska et al.



In Situ SEY TestStand



E4R Service Building Coating Tests at FNAL

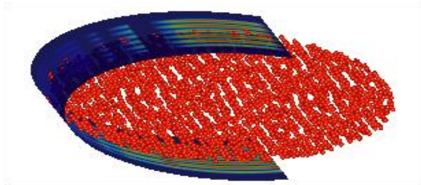


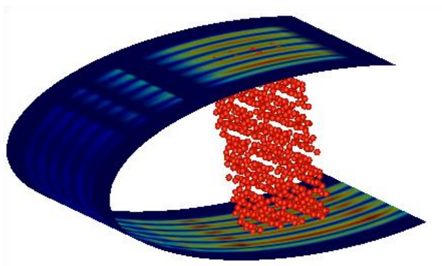
- Cathode and coated tube has been received at FNAL from SLAC
- Ordering parts to reproduce SLAC test.
- Hope to be able to coat an elliptical pipe by the end of 2010

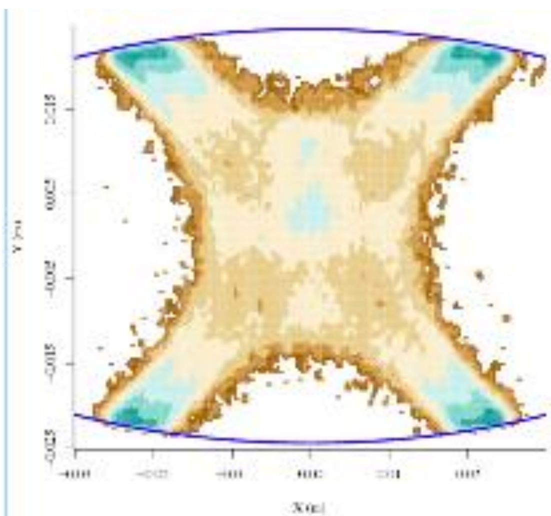
D. Capista,
L. Valerio

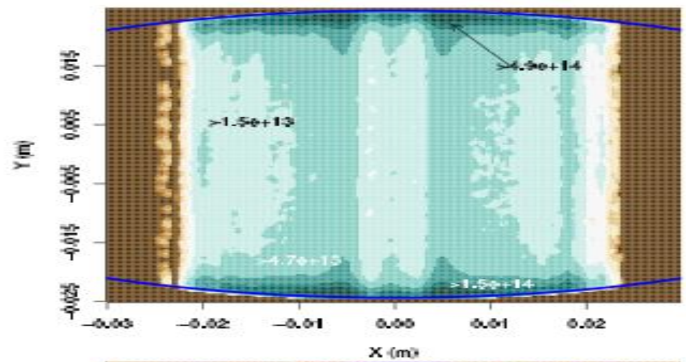
3-D Vorpal e-Cloud Simulations

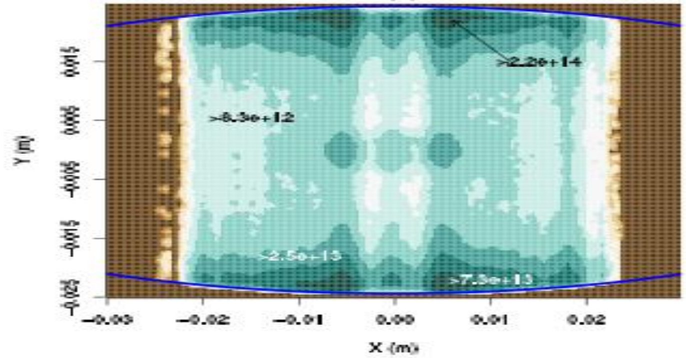
P. Lebrun, S. Veitzer











Plasma simulation code can measure realistic beam pipe responses to travelling wave diagnostics.

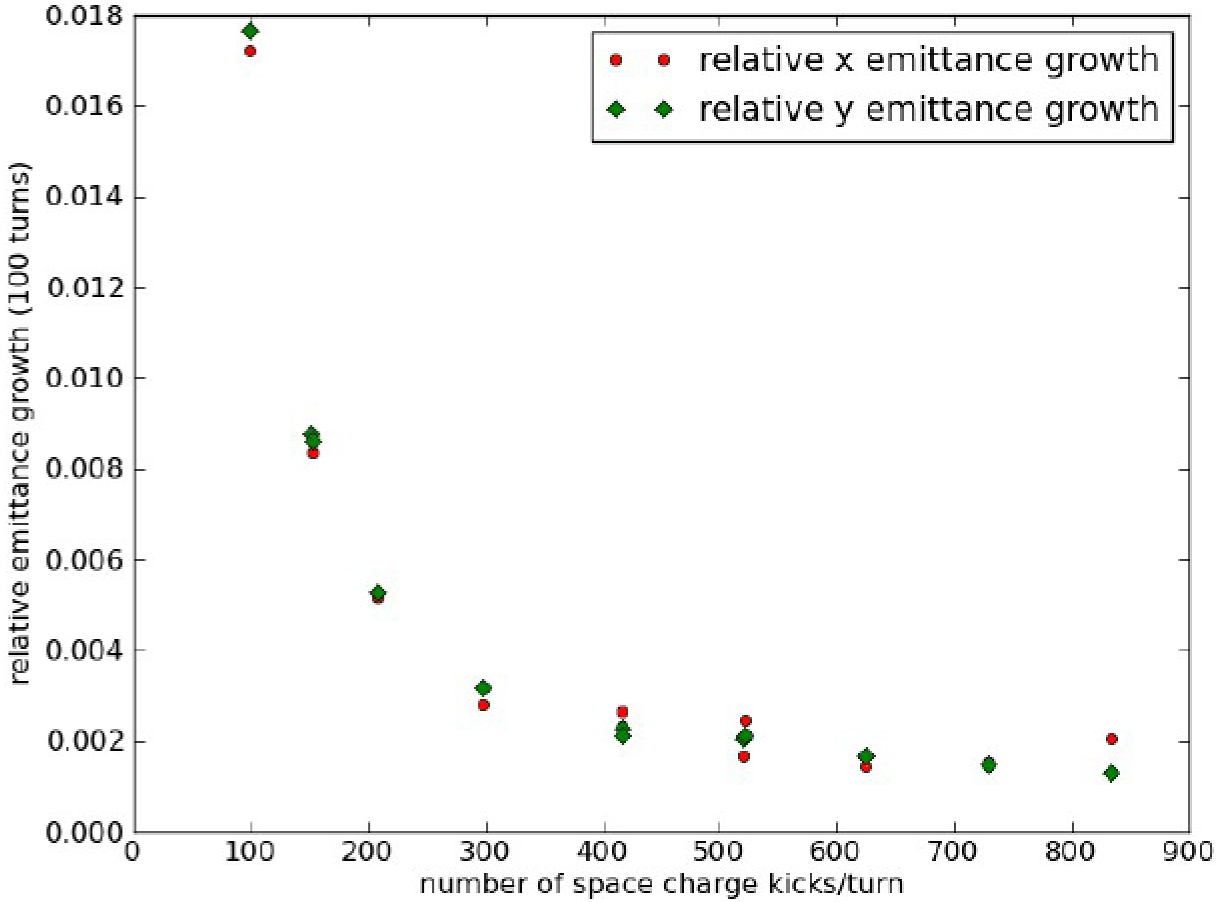
Space Charge

- Start MI space charge simulations using two different codes Synergia (FNAL) and IMPACT(LBNL).
  - Bench mark each code against each other w/w.o SC using the MI lattice.
  - Include the MI aperture and compare simulations predictions of losses with current operations.
  - Predict the sc tune shifts (spreads) and losses with and without second harmonic and bunch intensities of 3E11.
- Produce intense bunches at 8 GeV in MI for space charge measurements.

Current Status and Plans

- Using the identical lattice, achieved agreement on zero current results (tunes, chromaticities, linear lattice functions) between codes (IMPACT/MLI,Synergia)
- Computed emittance growth with space charge over 1000 turns, achieved qualitative agreement between codes.
- Studied number of space charge kicks needed for convergence.
- Computed tune spread with space charge with current conditions.
- For next year we plan to turn on non-linearities, introduce magnetic multipoles and real apertures in order to compare with beam data.

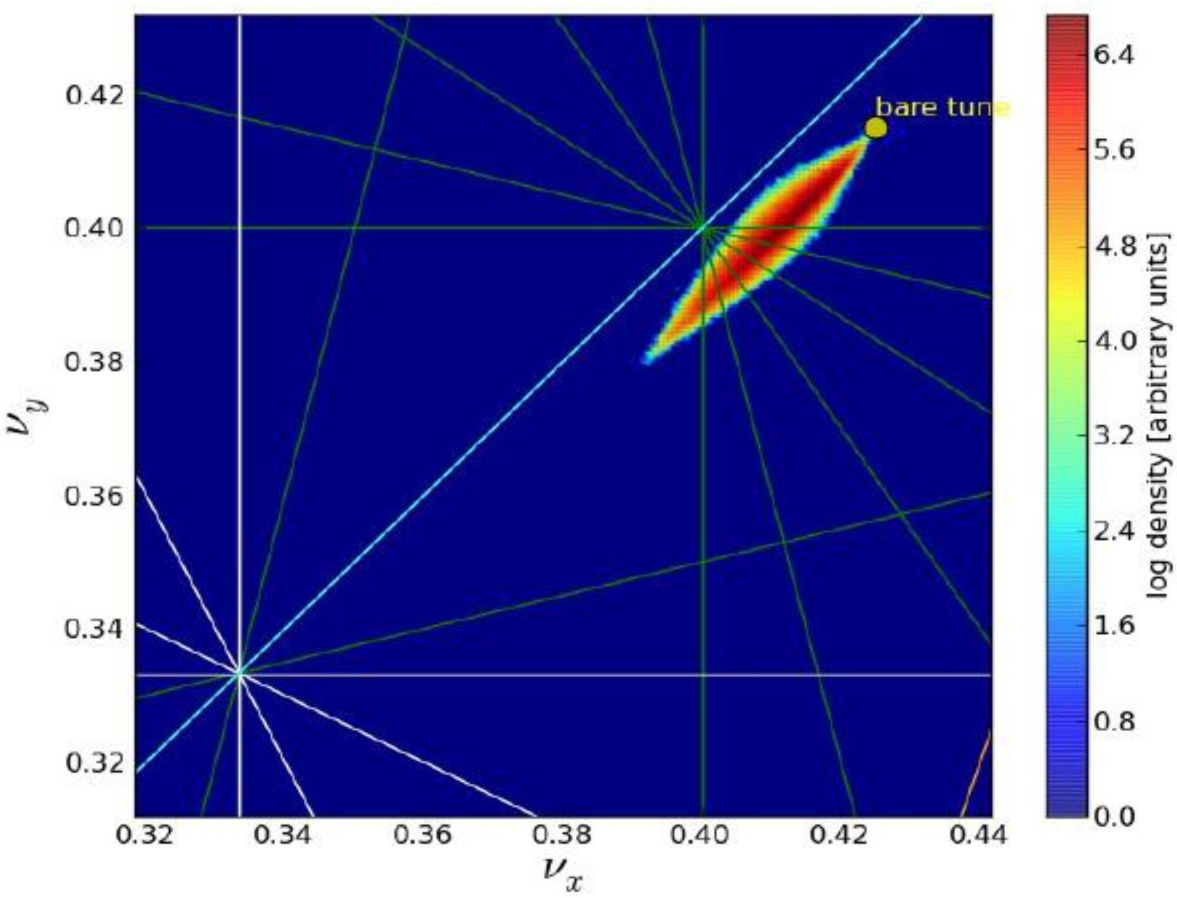
Emittance growth vs kicks



E. Stern

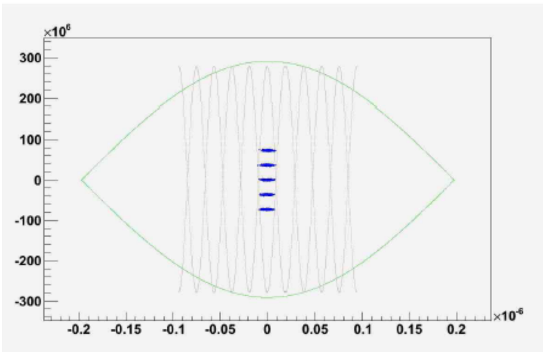
Tune footprint for 1E11

E. Stern



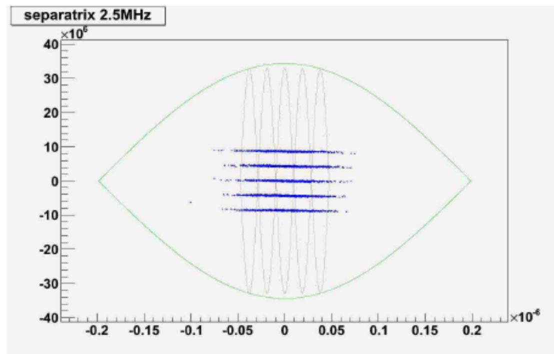
Creating intense bunches at MI 8 GeV

150 GeV



Bucket height: dE~300MeV
Synchrotron frequency: f~110Hz

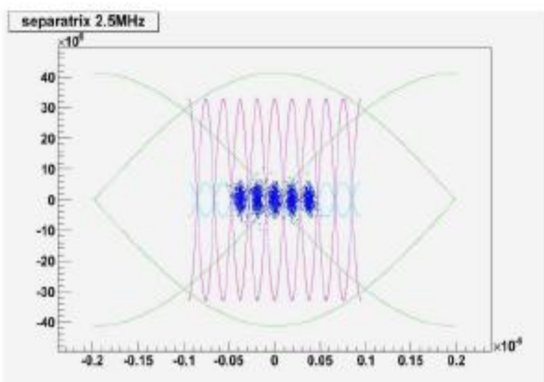
8 GeV

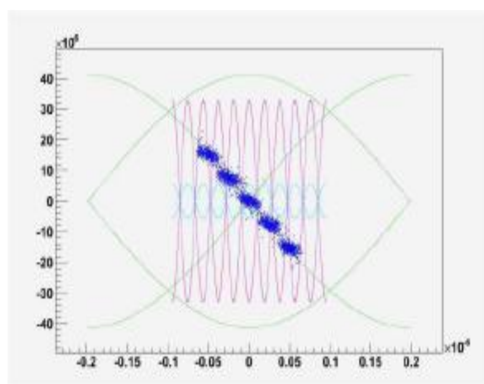


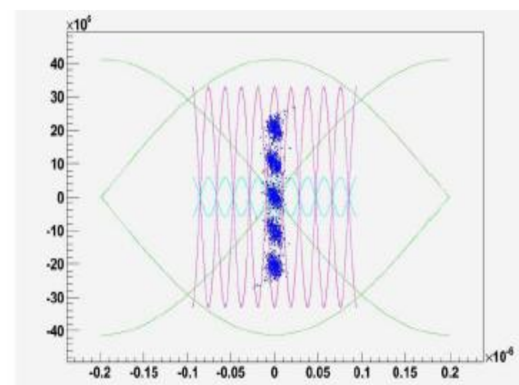
dE~35MeV
f~900Hz

K. Seiya

•Regular coalescing not efficient at 8 GeV.
•Need much smaller energy spread in 53 MHz and larger 2.5 MHz voltage.







•By using adiabatic paraphasing in 53 MHz and rotation around the unstable fixed point in 2.5 MHz can coalesce 5 bunches with 85% efficiency.
•Need much better resolution from LLRF for bunch rotations (~60 microsec)