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Status and Plans of LHC AC Dipole Task

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Outline

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- Task overview
- Task status
  - LHC ac dipole status
    - Hardware and control
    - Commissioning plan
  - Dynamic tuning development
  - Experiment results on linear gradient error correction from RHIC
  - Simulation of emittance growth due to ac dipole noise
- Plans for FY2010

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Task Overview

- Goal of the task:
  - Commission the ac dipoles for LHC optics measurement as well as linear gradient error correction
  - Demonstrate Dynamic tuning technique with RHIC high Q ac dipole
- FY2009 budget
  - $35k to support a BNL/LARP post-doc: G. Wang
- LARP collaboration with CERN instrumentation+ABP
  - CERN: R. Tomas, J. Serrano, V. Kain
  - BNL: M. Bai, R. Calaga, P. Oddo, R. Calaga(LARP LTV), R. Miyamoto(Toohig fellow)
  - FNAL: A. Jansson, M. Syphers

LHC ac dipole status: goal and achieved

Courtesy of J. Serrano

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	Achieved	Goal
Peak Current (A)	1800A	1800A
Bandwidth (Tune units)	± 0.01	$\geq \pm 0.01$
Frequency (kHz)	Horizontal 2.8 Vertical 3.2	3
Peak Field (Gm)	190	190

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Achieved bandwidth and further improvement

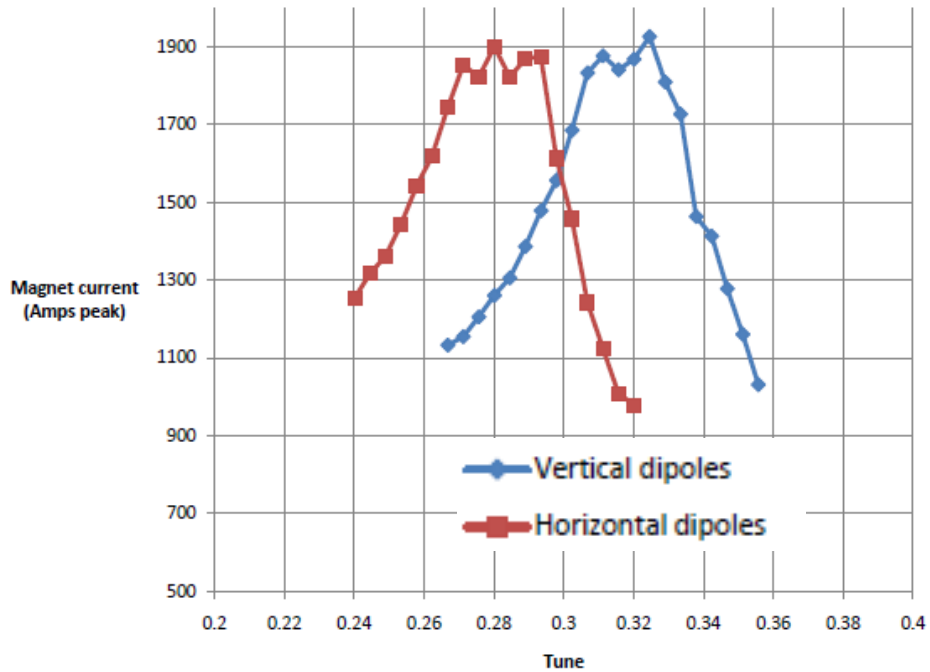
Courtesy of J. Serrano

- Achieved Bandwidth (tune units):

$$\pm 0.01$$

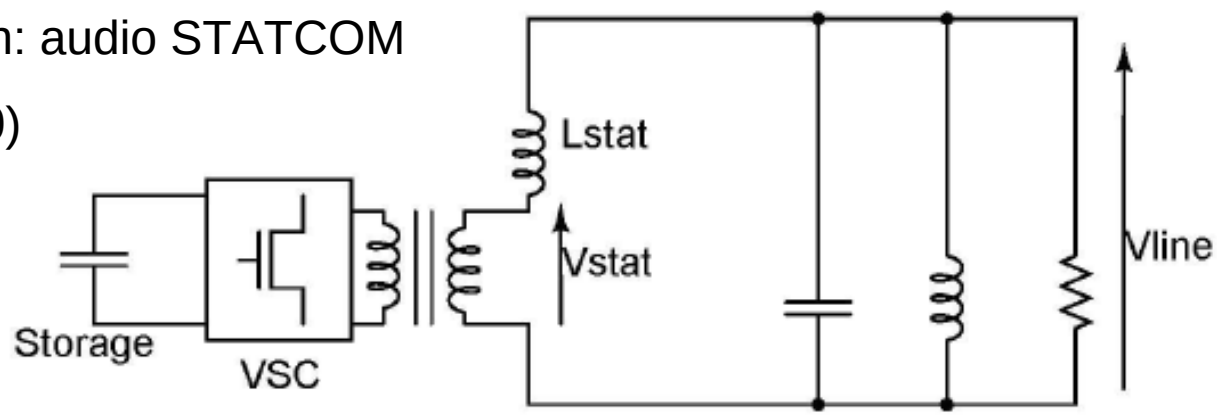
- Further improvement of bandwidth will help on the adiabaticity of the excitation.

Goal $\geq \pm 0.02$



Currently favored solution: audio STATCOM

(not before end 2010)



Spectral quality

Courtesy of J. Serrano

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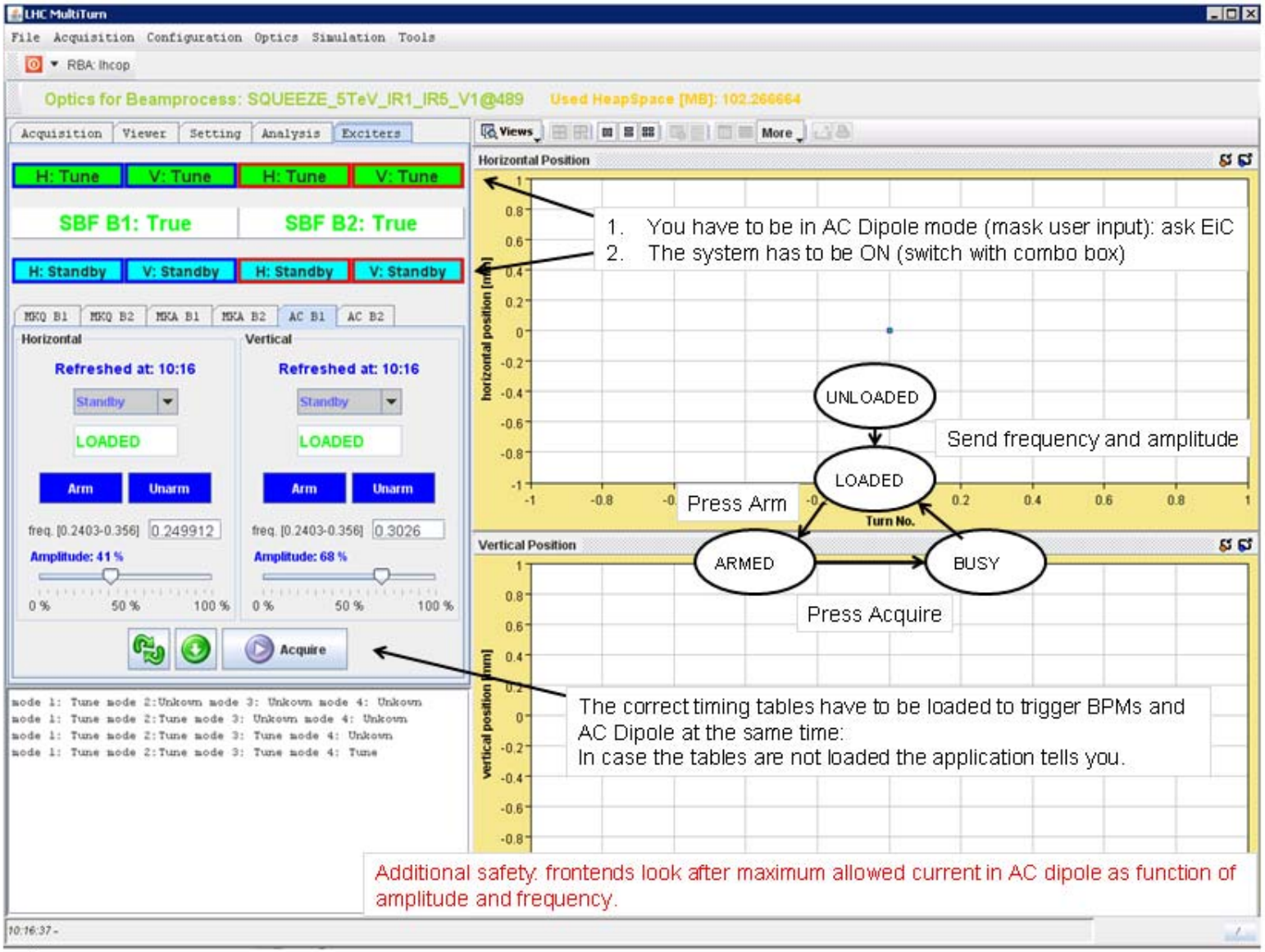
- Tests this Summer showed some signal quality issues:
  - 100 Hz side bands.
    - Discovered to be caused by the Ross Relay.
    - Found a cure: Solenoid Saver®. (Install on January?)
  - Harmonics (even and odd).
    - Some non-physical high frequencies present: acquisition artifact?
    - Nothing done so far, but we can't reproduce it! Possible explanation: recent changes in filtering.

AC Dipole Control

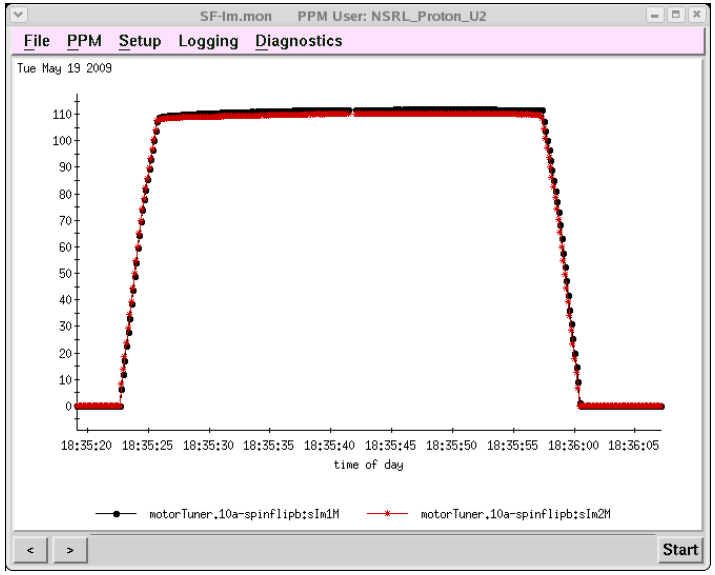
Courtesy of V. Kain

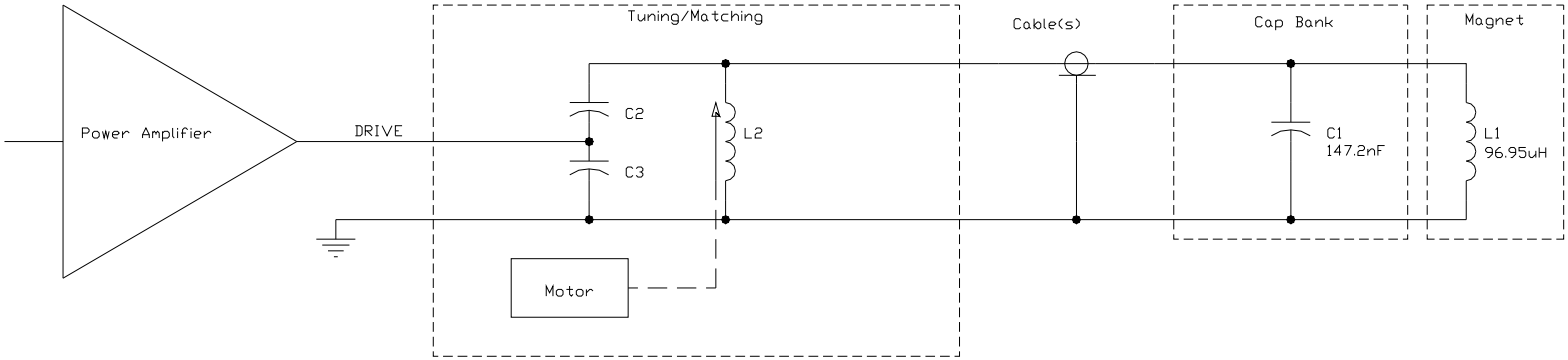


Dynamic Tuning

Courtesy of P. Oddo

- Successfully used mechanical tuning
  - Swept frequency over ±0.012 tuning range (38.0-39.9kHz)
  - 100 G·m @ ~600W





Status of gradient error correction at RHIC

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- Three experiment sessions was devoted to Linear optics corrections in RHIC 2009 run. The SVD algorithm was verified from these experiments. As a result of corrections, the rms phase beat was reduced by 40% and 30% respectively for two preset quadrupole errors.

- Substantial variations of measured phases were observed, possibly due to the slow magnets variation.

- New algorithm need to be developed in order to improve the noise tolerances and identify qudrupole errors.
  - Bpm data quality and the number of available bpms
  - The range of knobs.

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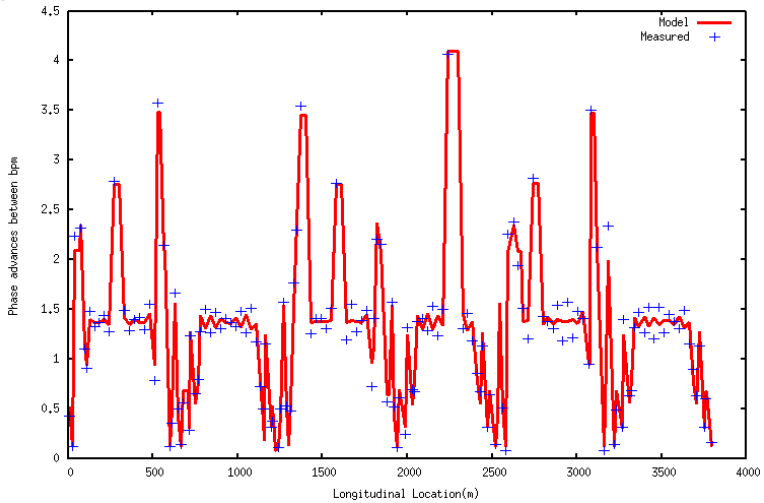
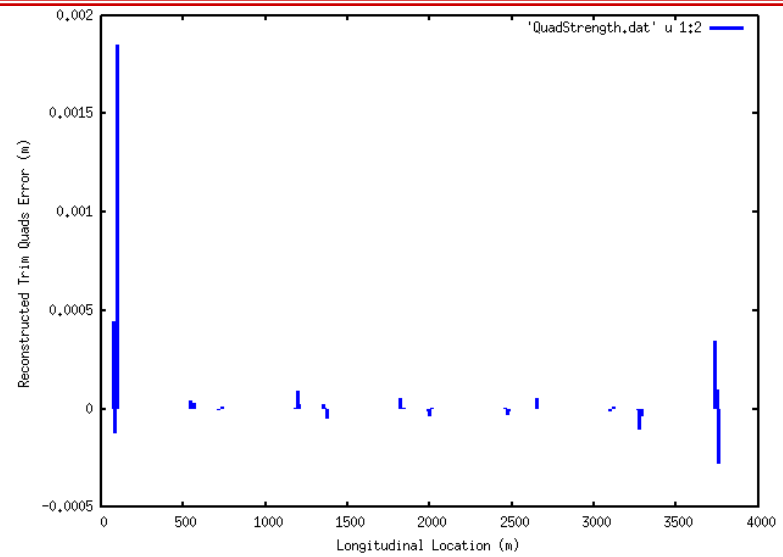
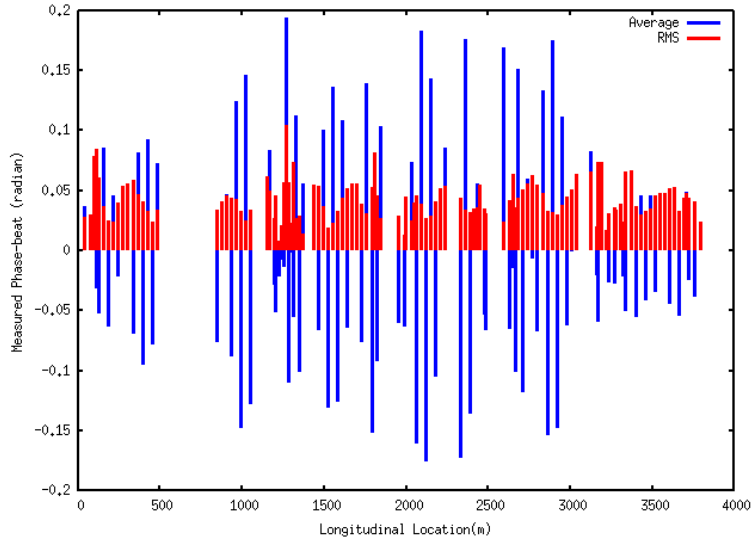
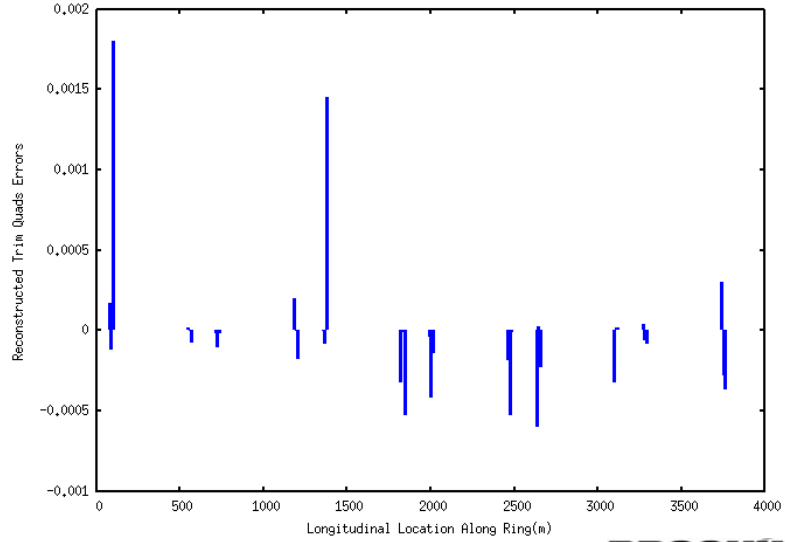
Experiment of Linear Optics Correction









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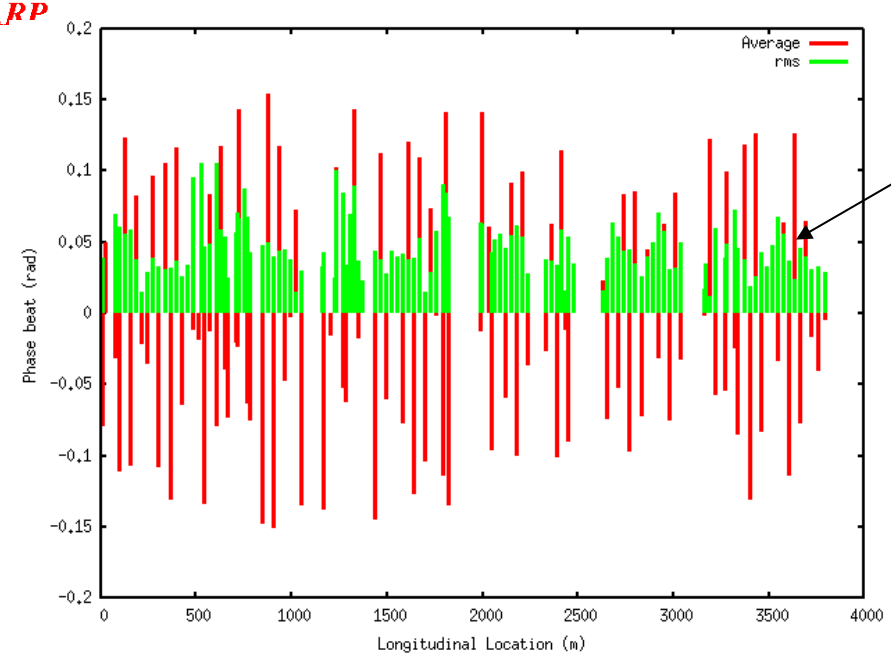
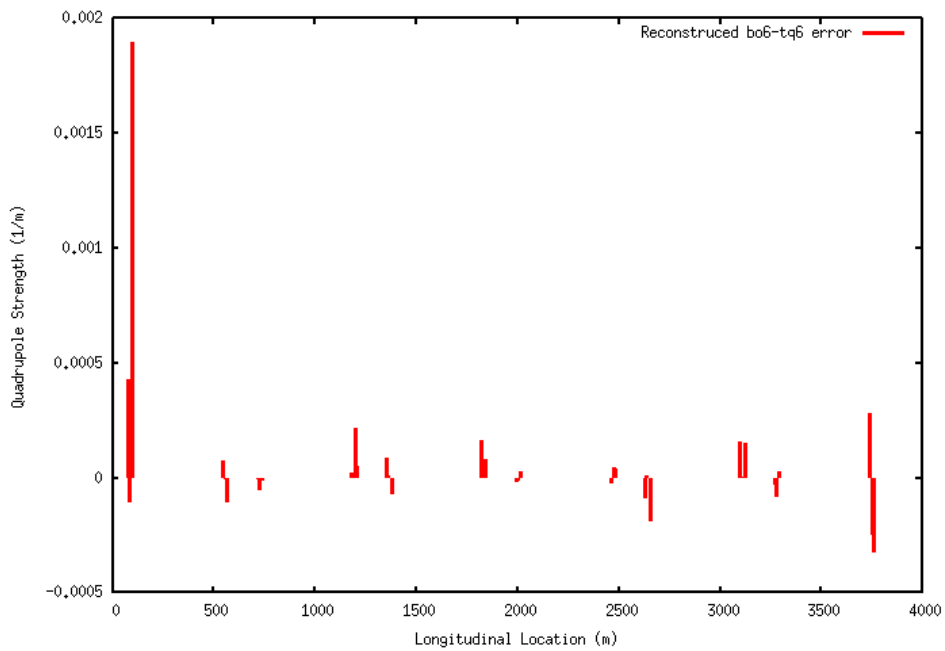
Experiment of Linear Optics Correction Continued 1



Substantial variation from measurement to measurement, possibly due to magnets oscillation.

The data for SVD analysis was obtained by averaging 12 sets of measurements

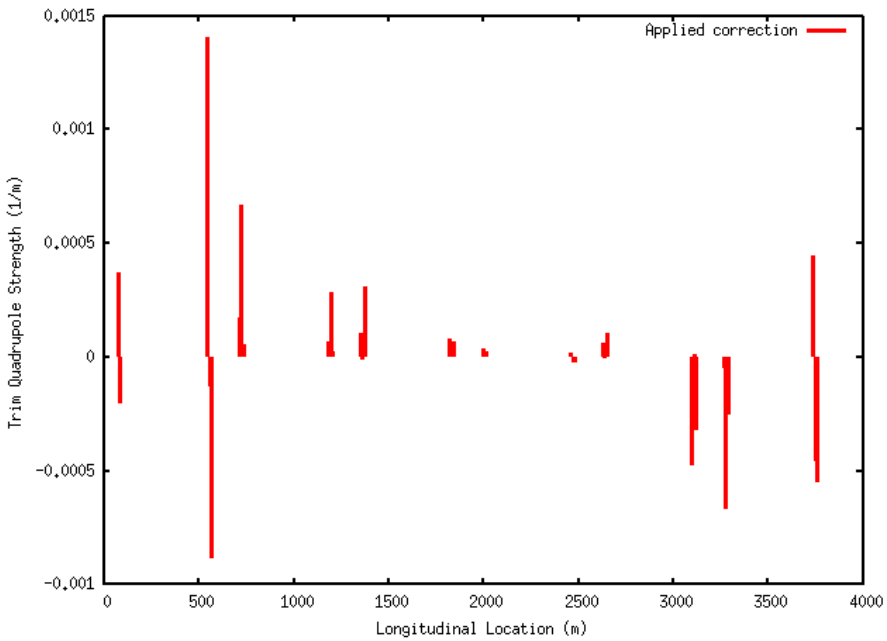
Reconstructed Quad Errors



Typical phase beat measurement (Drive at $1-Q_x-0.01$ for baseline.)

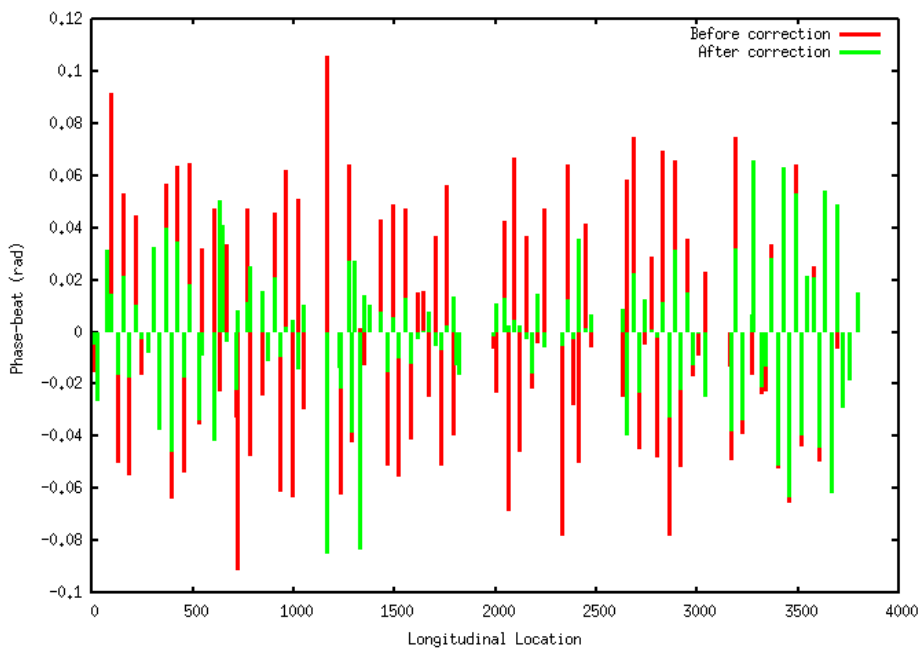
Experiment of Linear Optics Correction Continued 2

Rms phase beat reduced from 0.0454 rad (2.6 degrees) to 0.0279 rad (1.6 degrees), i.e. 40% of reduction

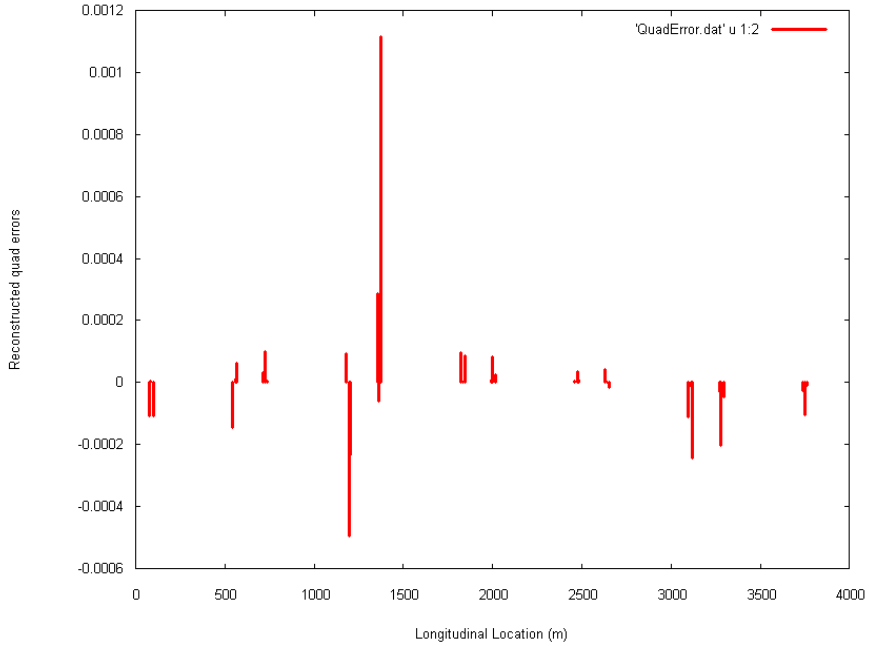


Applied Correction

Comparison of phase beat

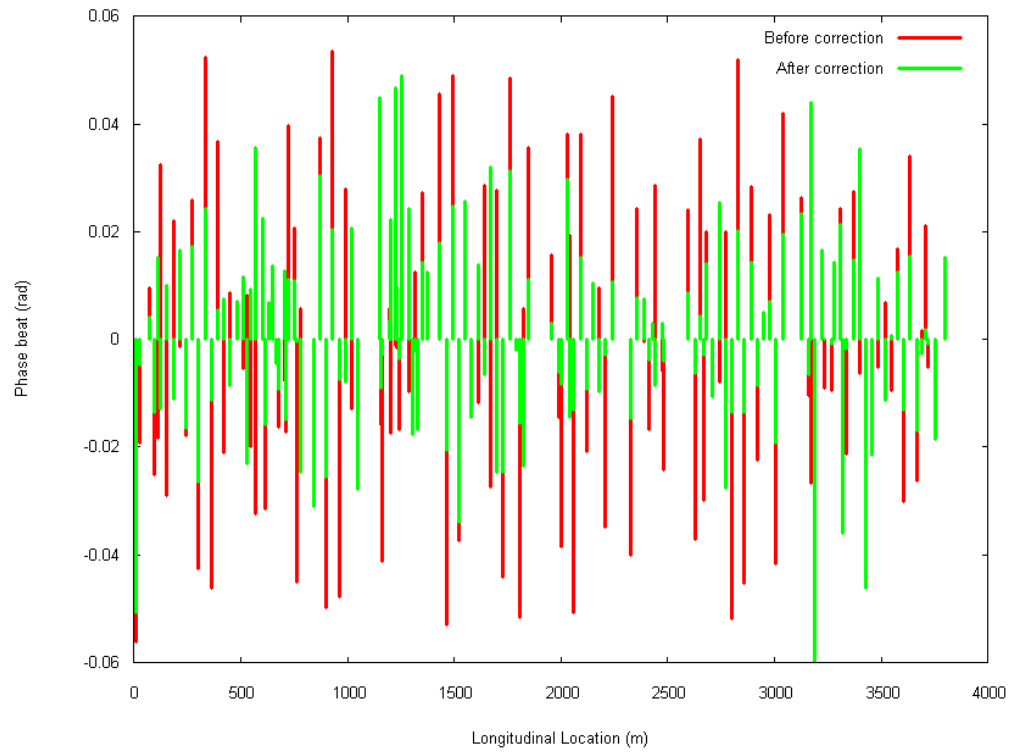


Experiment of Linear Optics Correction Continued 3



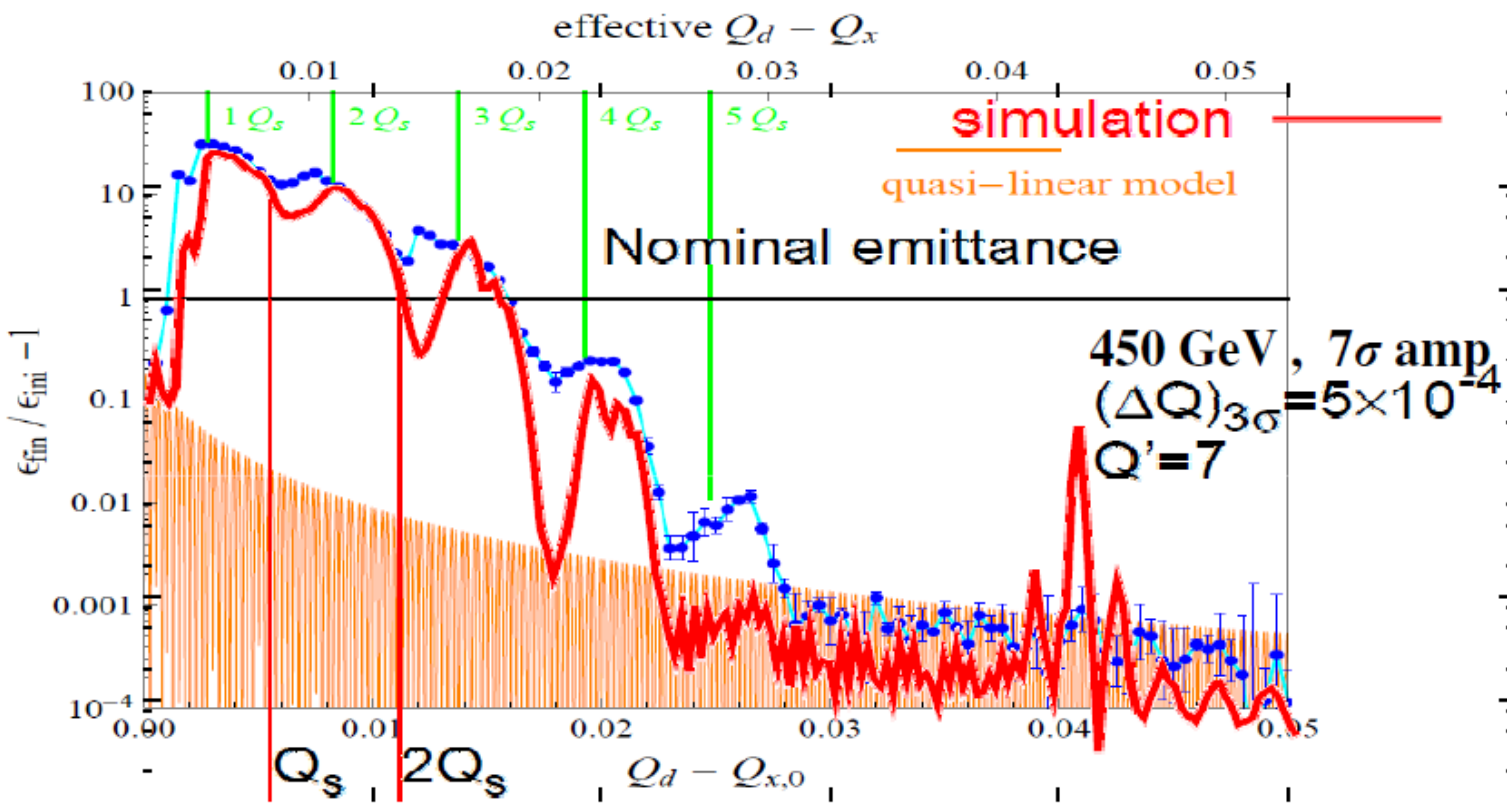
Reconstructed Quad errors are noisy and the amplitude is 40% less compared with the pre-set error.

The rms phase beat went down from 0.027 rad to 0.019 rad, i.e. 30% reduction.



Emittance growth due to ac dipole

Courtesy of R. Miyamoto and R. Tomas



- 1D single turn map at the AC dipole's location
- Including linear chrom and detuning, implementing noise
- Must be the "right" side
- Side bands visible but may be shifted

Noise of the LHC AC Dipole

Courtesy of R. Miyamoto and J. Serreno

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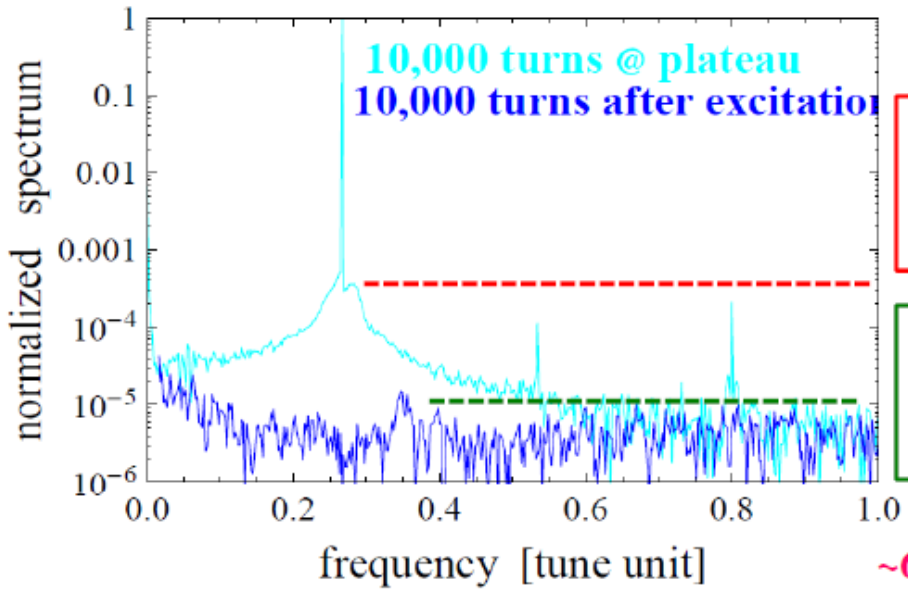
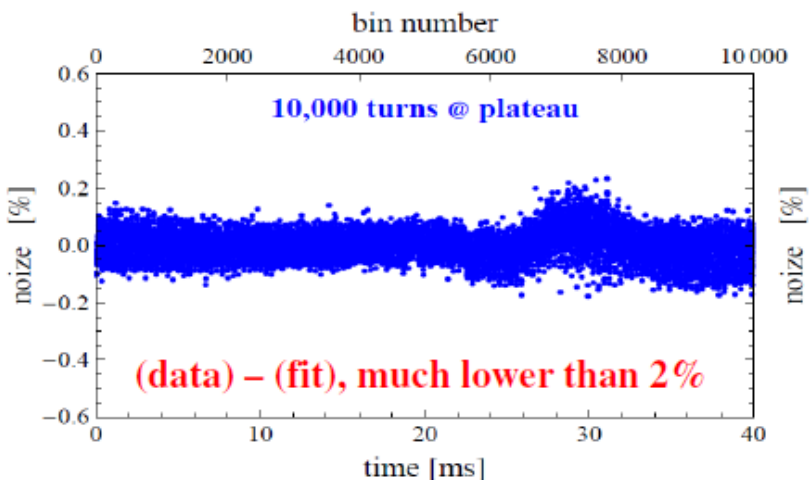
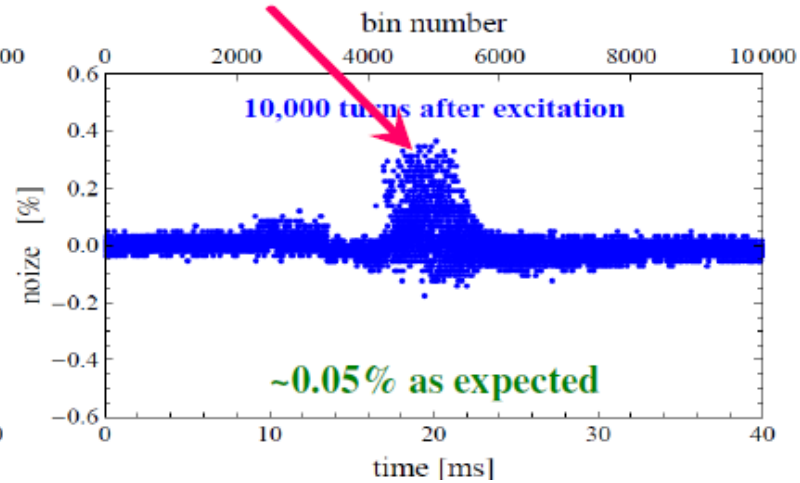


~4 10^{-4} for 10,000 data points
↔ σ_V / V_{max} ~ 2% white noise in time domain

~1 10^{-5} for 10,000 data points
↔ σ_V / V_{max} ~ 0.05% white noise in time domain

~60 ms period (~15 Hz?)





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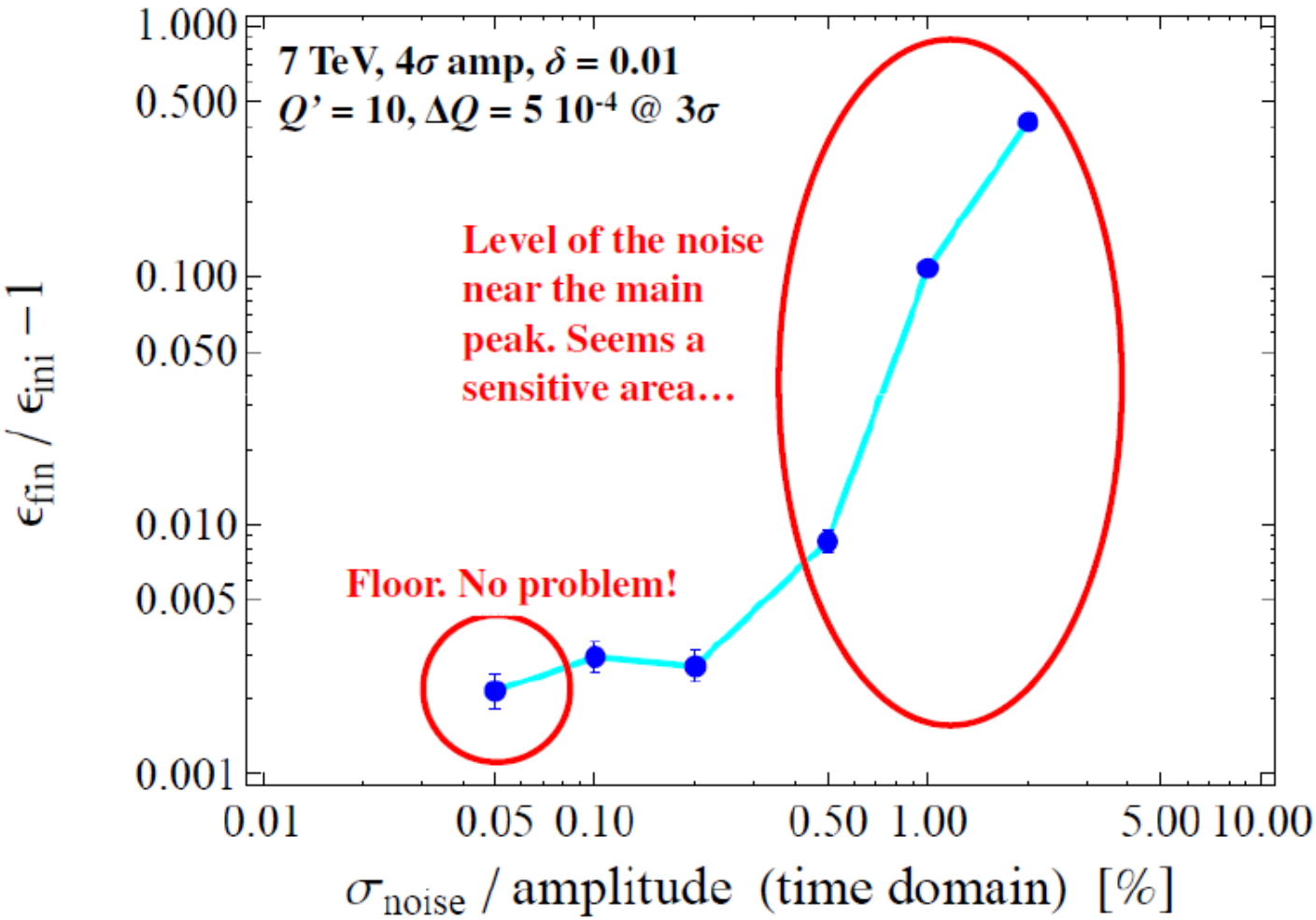
Noise vs. Emittance Growth (White Noise)

Courtesy of R. Miyamoto



Budget plan for 2010

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- $55k for FY2010
  - Continue supporting the BNL/LARP post-doc: $35k
  - Travel expense for participating the commissioning: $20k

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Plan for FY2010 and beyond

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- FY2010-FY2011
  - Participate LHC AC dipole commissioning
  - Participate commissioning of AC dipole applications in beam dynamics
    - Measure optics
    - Linear gradient error correction
      - Implement the model independent technique that we developed at CERN and RHIC.

- Beyond FY2011
  - Participate accelerator physics experiment of applying ac dipole in non-linear beam dynamics studies
  - Design dedicated high Q ac dipole system with tuning range of

    if the technique is demonstrated at BNL

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