Run II PMG
Stacking Rapid Response Team Report

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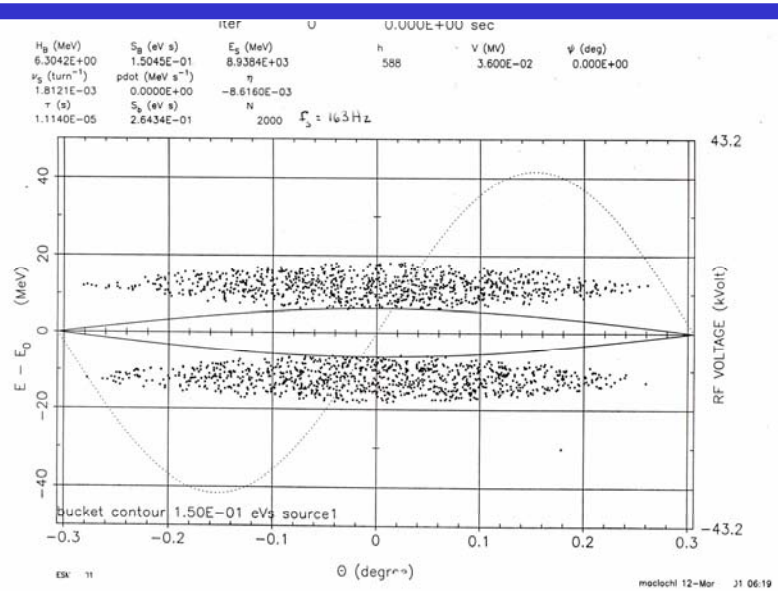
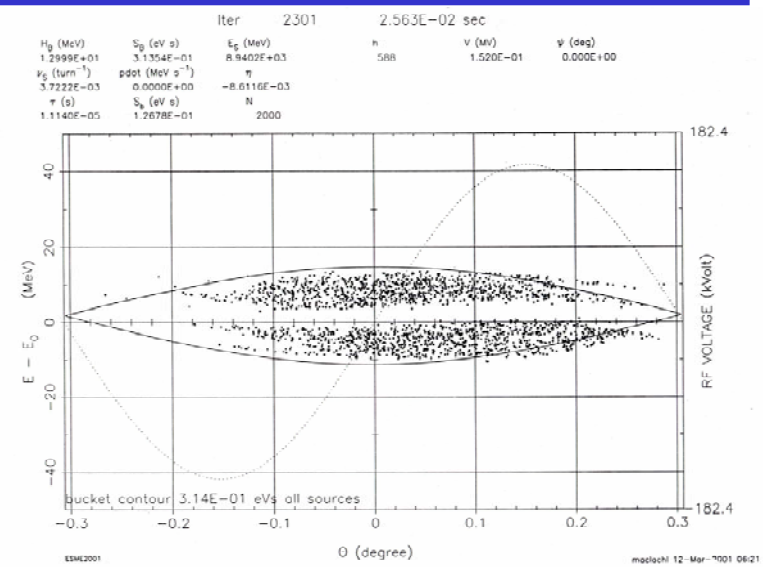
July 20, 2005

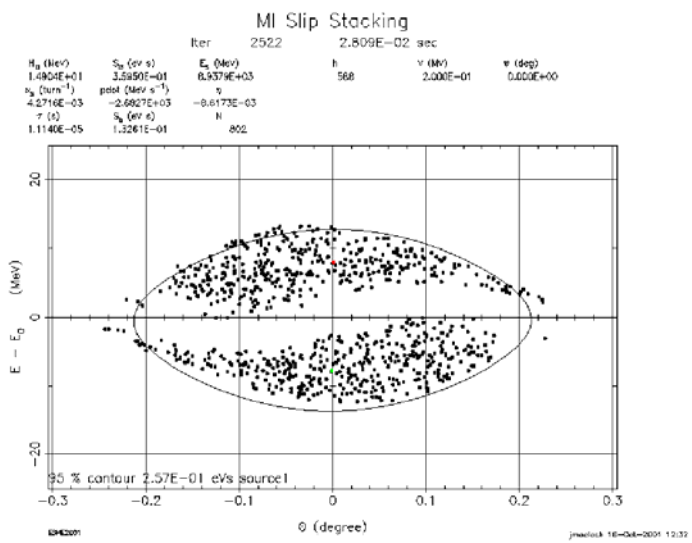
Protons on Target

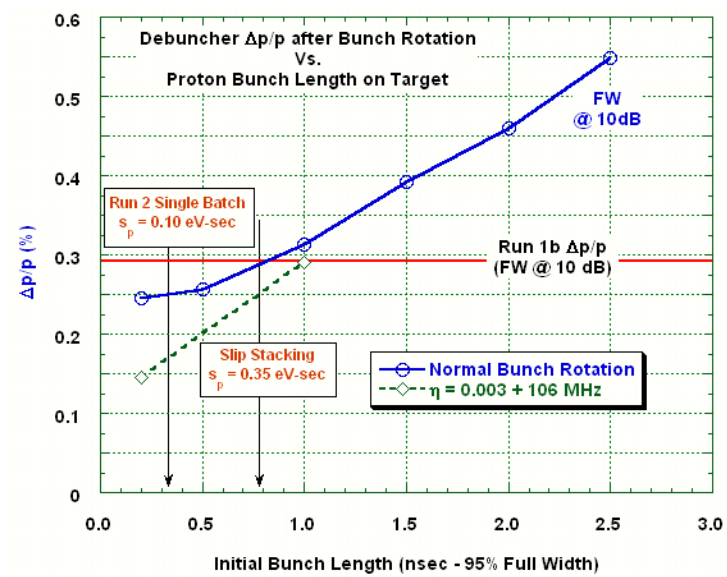
- Goal:
  - 4.5e12/ Booster batch with a longitudinal emittance of 0.12 eV-sec/bucket and a momentum spread of 18 MeV
  - 8e12 protons on target with a 1.5 nS bunch length and an acceleration efficiency of 95% and single point Rad limit of 1 Rad/hr in the MI tunnel.
- Recent focus has been trying to reduce longitudinal emittance blowup at transition in the Booster

Slip Stacking







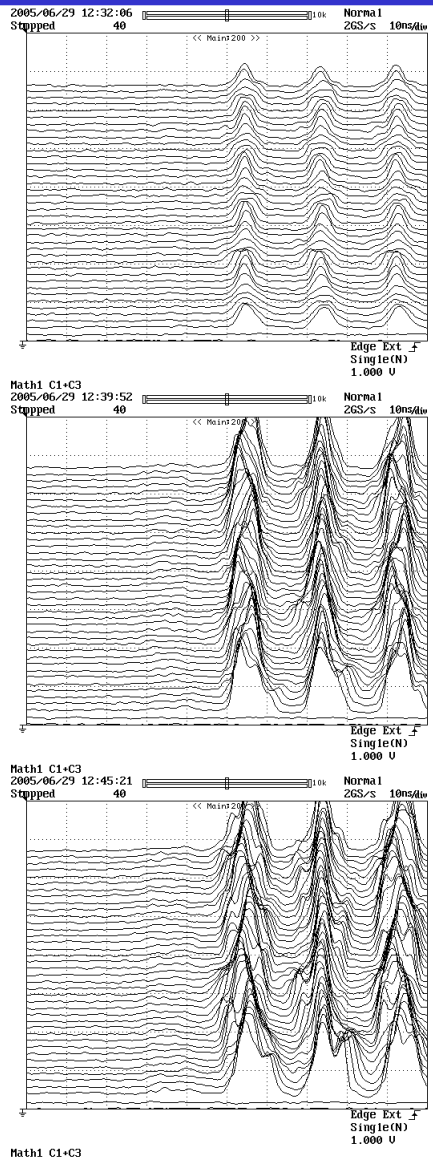


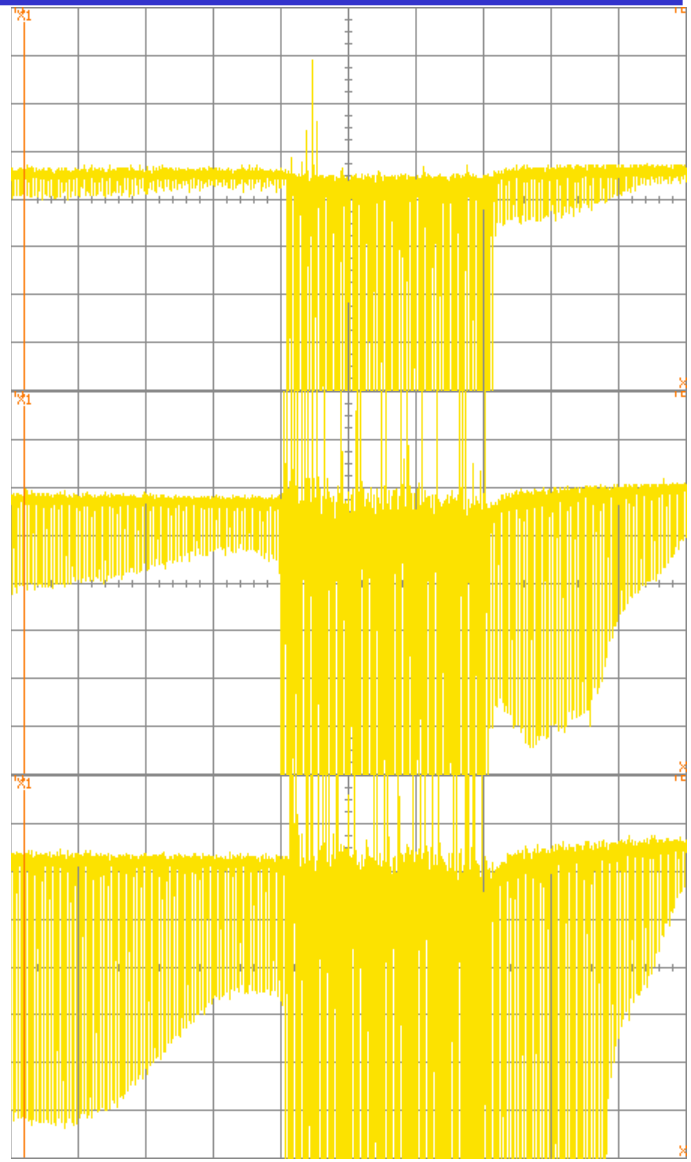
Main Injector Slip Stacking

2 turns

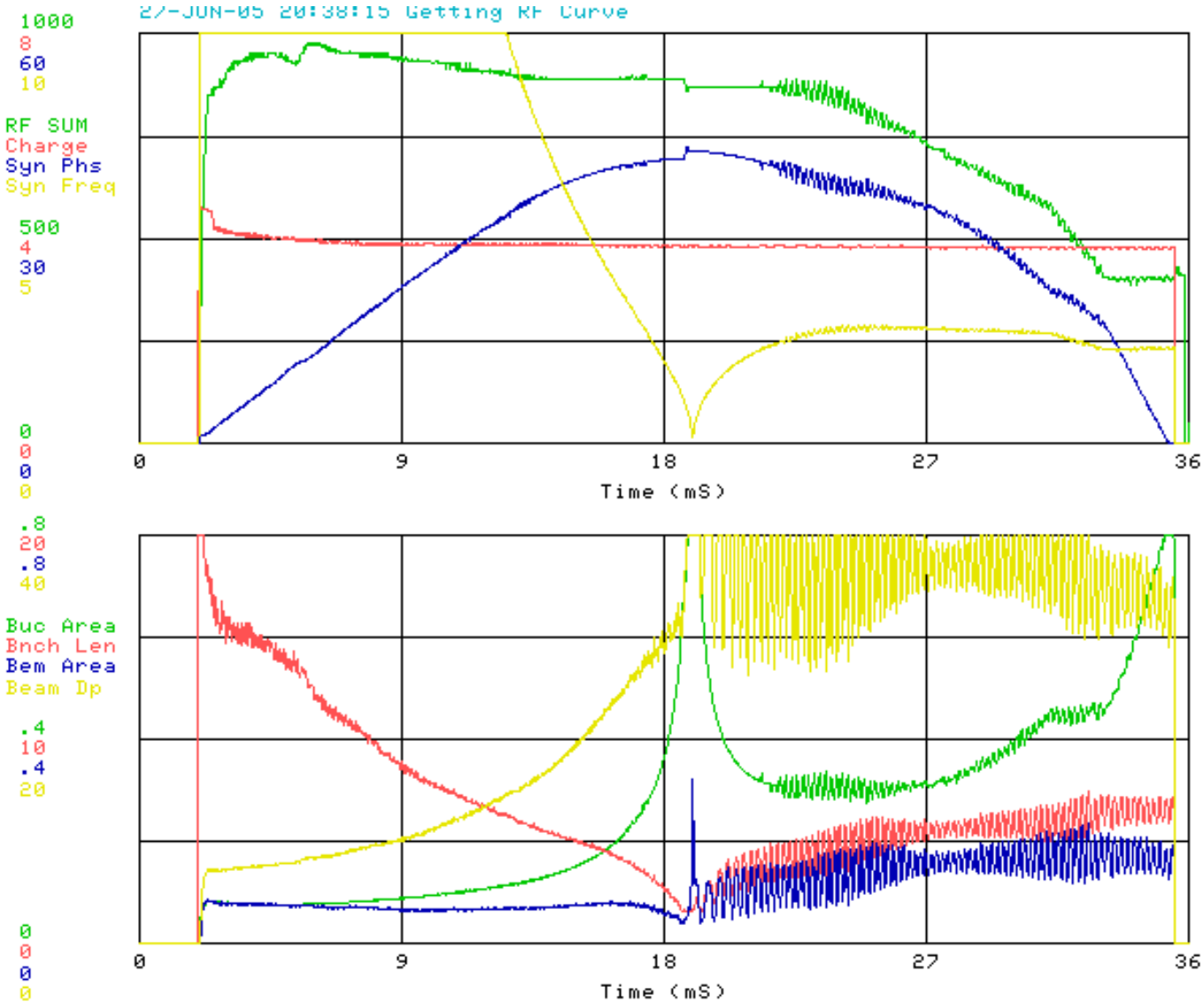
8 turns

11 turns

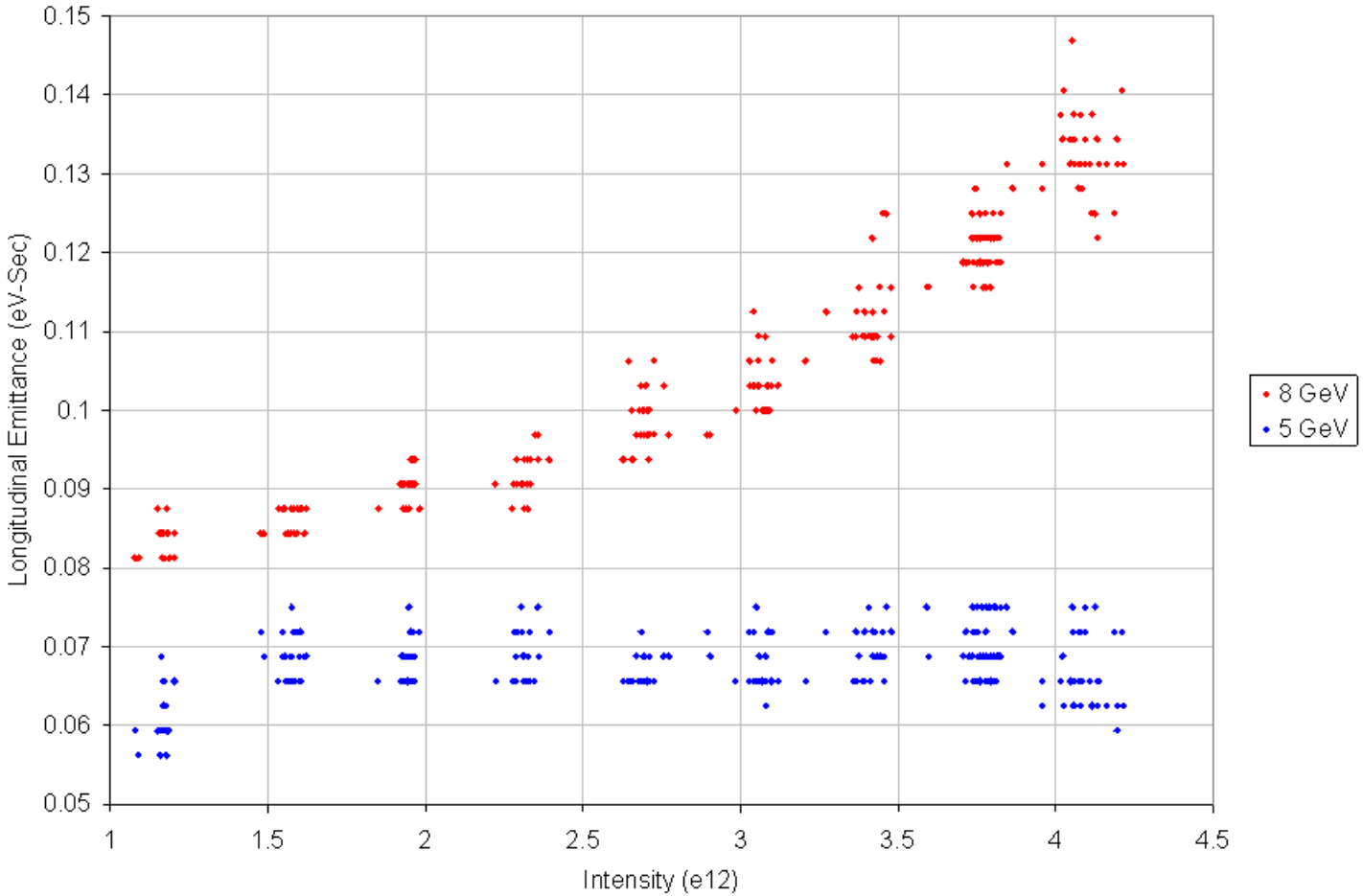




Booster Longitudinal Emittance



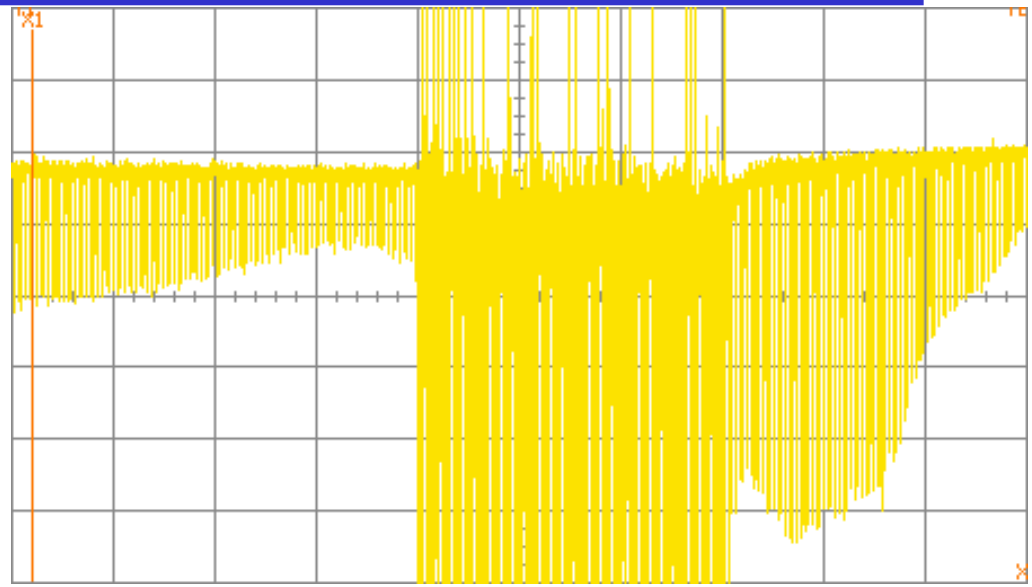
Booster Longitudinal Emittance



Main Injector Slip Stacking with Booster Quad Damper

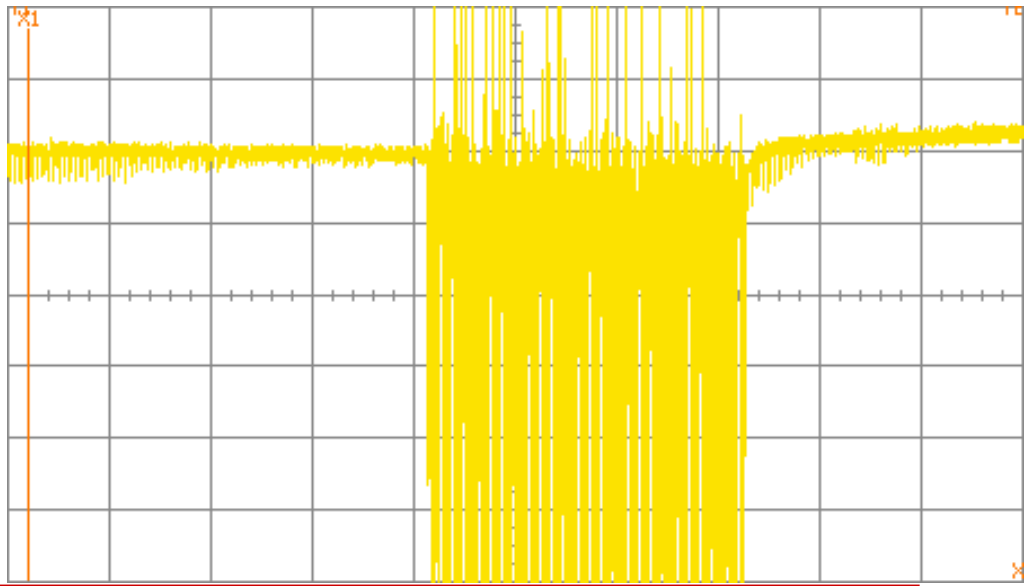
8 turns

Quad Damper off

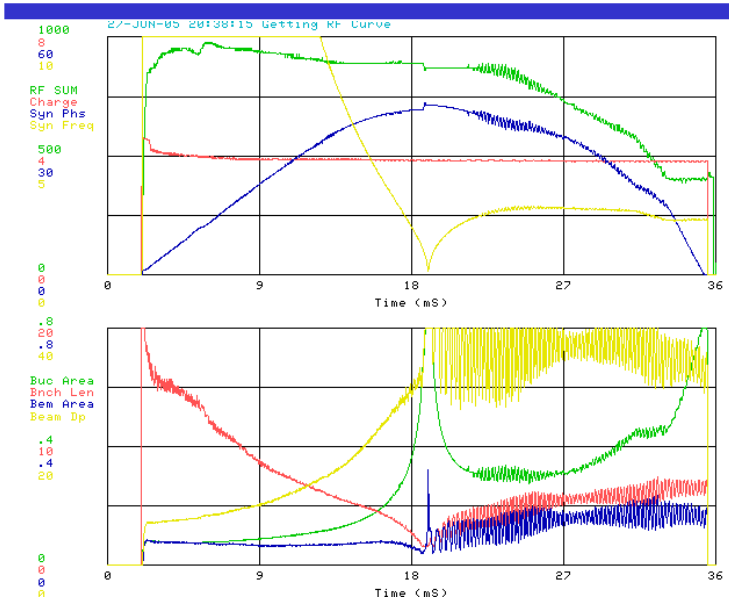


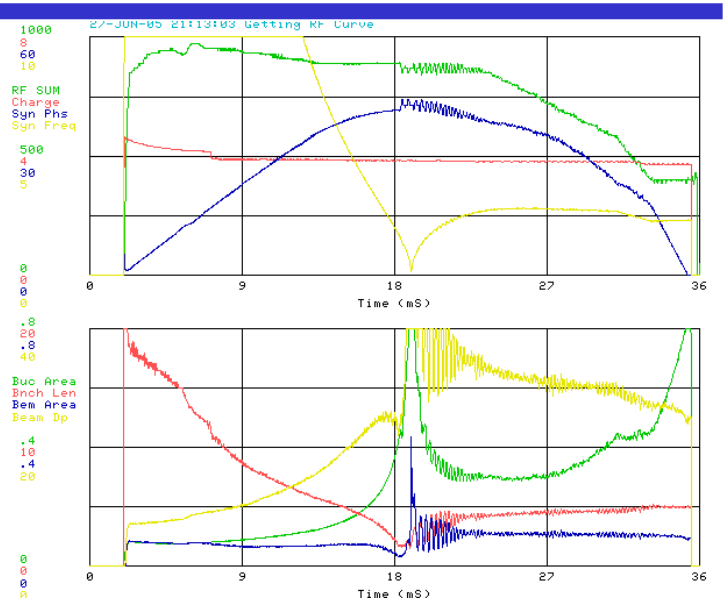
9 turns

Quad Damper on

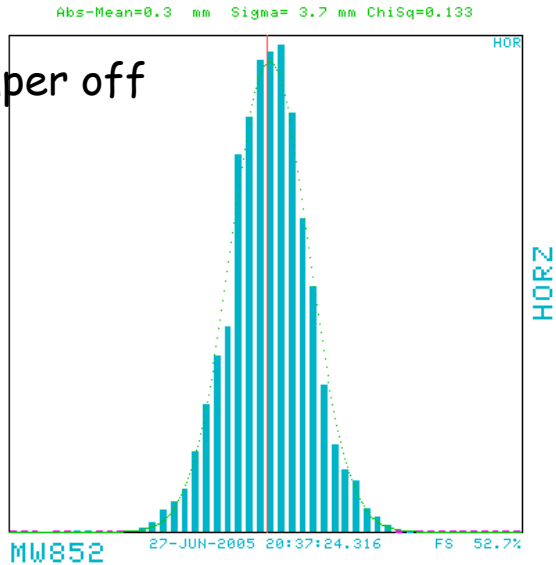


Booster Quadrupole Damper

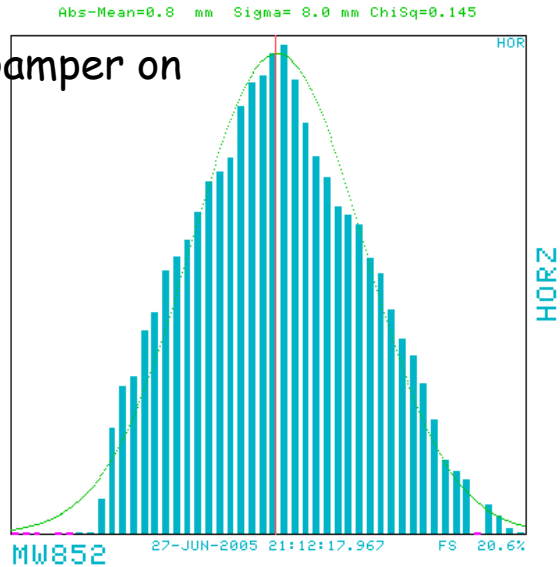




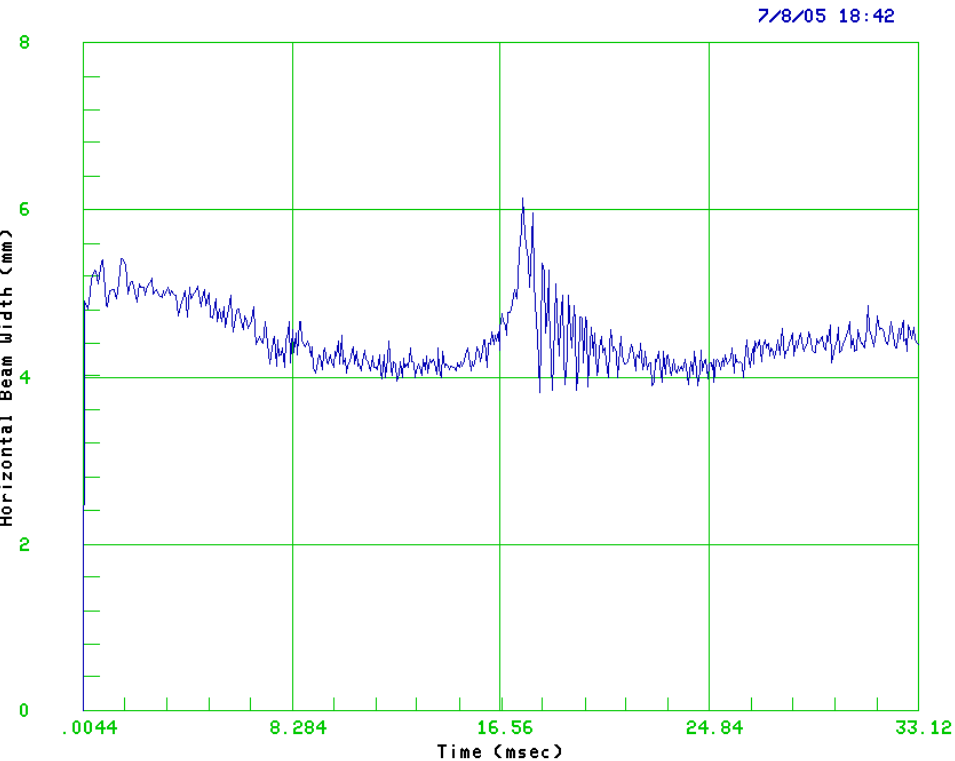
Quad Damper off



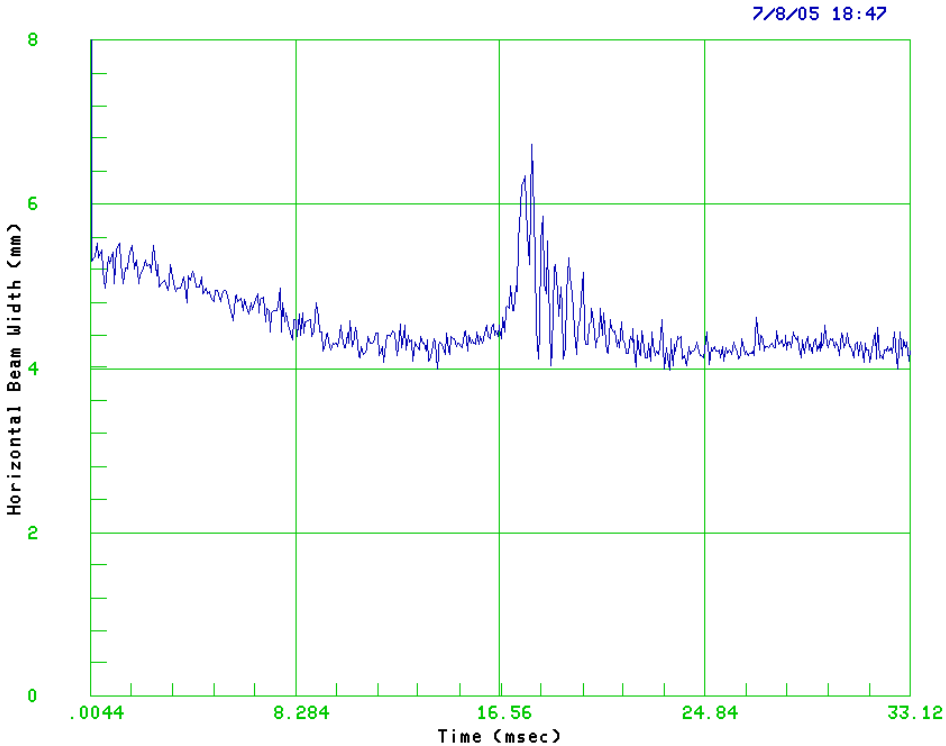
Quad Damper on



Booster Quadrupole Damper and Chromaticity



Nominal Chromaticity



Increased Chromaticity

Protons on Target

- Other Solutions for Booster Longitudinal Emittance Blowup
  - Gamma-t jump does not look attractive
    - Large orbit shift confuses cogging
  - RF Step at Transition (pre-focus)
    - Calculations finished – look very promising
    - Hardware under development
- Instrumentation
  - MI Slip stacking needs two critical pieces of instrumentation
    - Turn by Turn Injection batch phase monitor
    - Turn by Turn Injection batch bunch length monitor

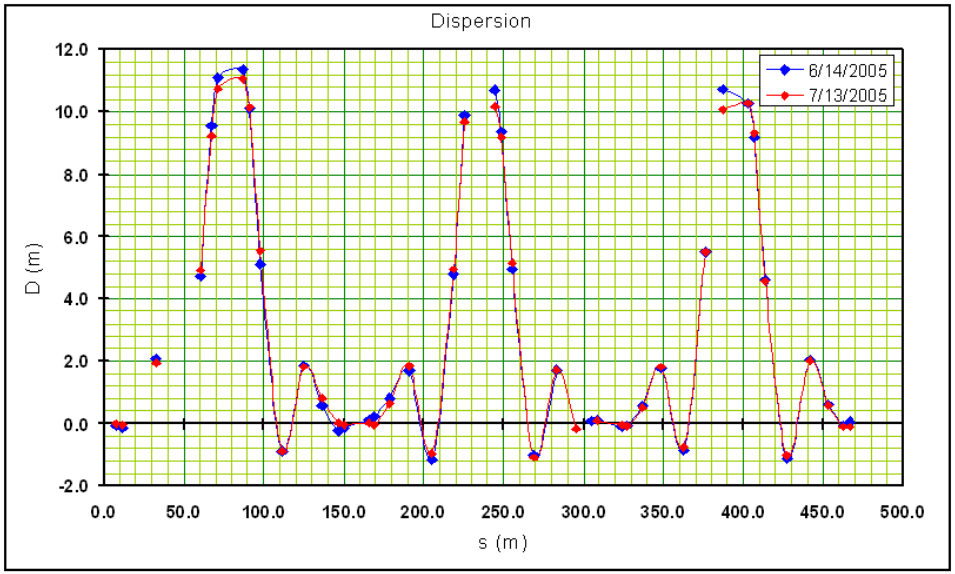
Antiproton Source

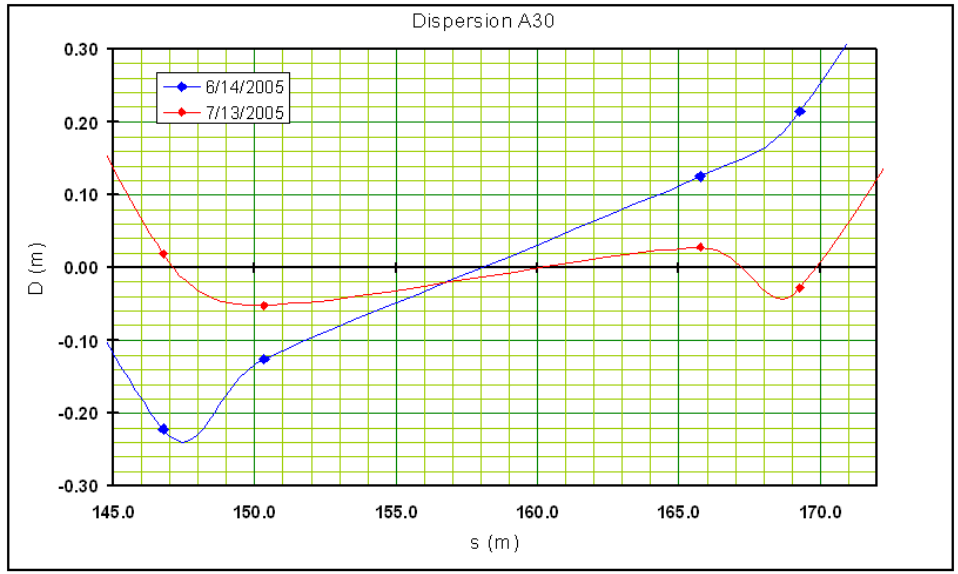
- Areas of Focus
  - 120 GeV targeting optics
  - Residual dispersion reduction in A30
  - New operating point
  - Constant cycle time operation
  - Debuncher transverse cooling characterization
- 120 GeV targeting optics
  - Original optics were "modified" to accommodate Mixed Mode operation for SY120
    - Beta and Dispersion functions at target increased
      - Spot size compromised
    - Loss in AP1 increased
  - With SY120 on its own cycle, original optics are being returned
    - Painful - On second pass of optics changes

Antiproton Source

- Residual dispersion reduction in A30
  - To push fast cycle times
    - Gain of the stacktail is increased
    - More power in the stacktail can transversely heat the core beam
      - Longitudinal tanks transversely misaligned give transverse kicks
      - Residual dispersion gives transverse kick
        - » Longitudinal kick in dispersion changes local reference orbit which results in a betatron oscillation
        - » Dispersion in A30 where stacktail tanks are located should have a dispersion function < 0.01 meters!
      - When implementing the "Shot Lattice" (over 3 years ago), a dispersion wave was created by the hysterisis of the magnet ramps
        - » This wave was not removed because we typically ran with long cycle times and stacktail heating was not as big as issue as it is today

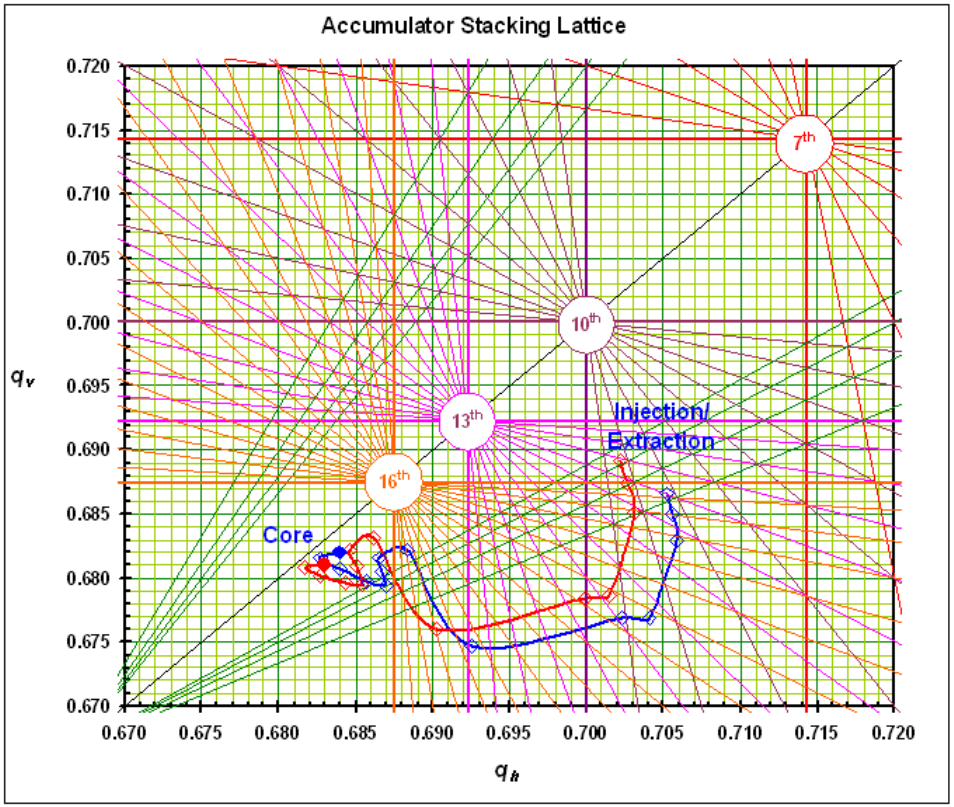
Residual Dispersion Reduction in A30

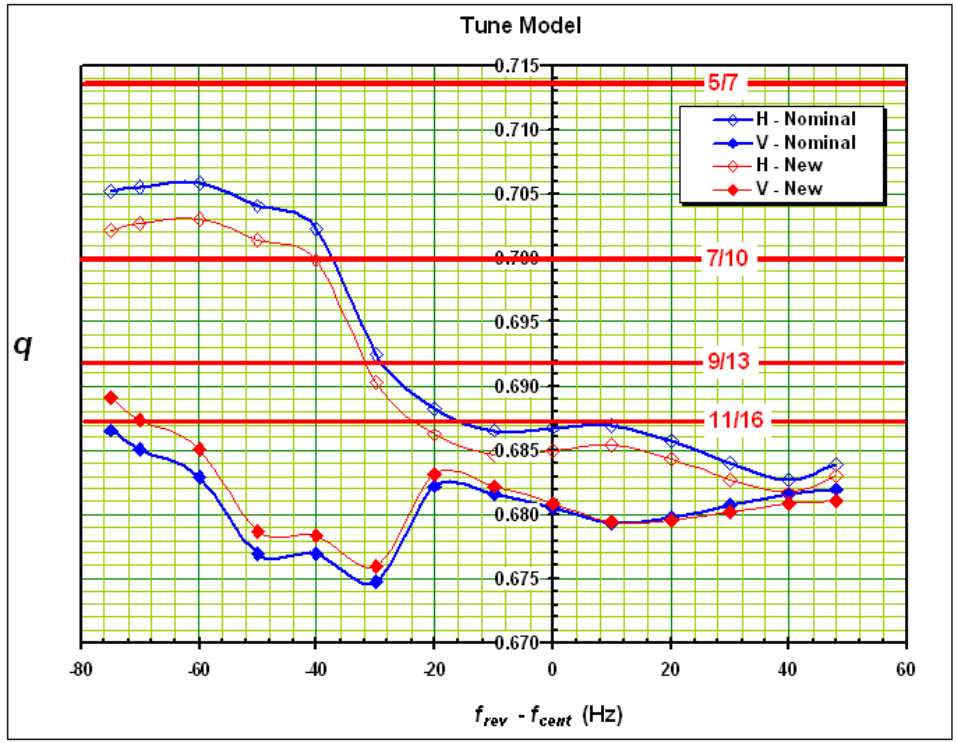




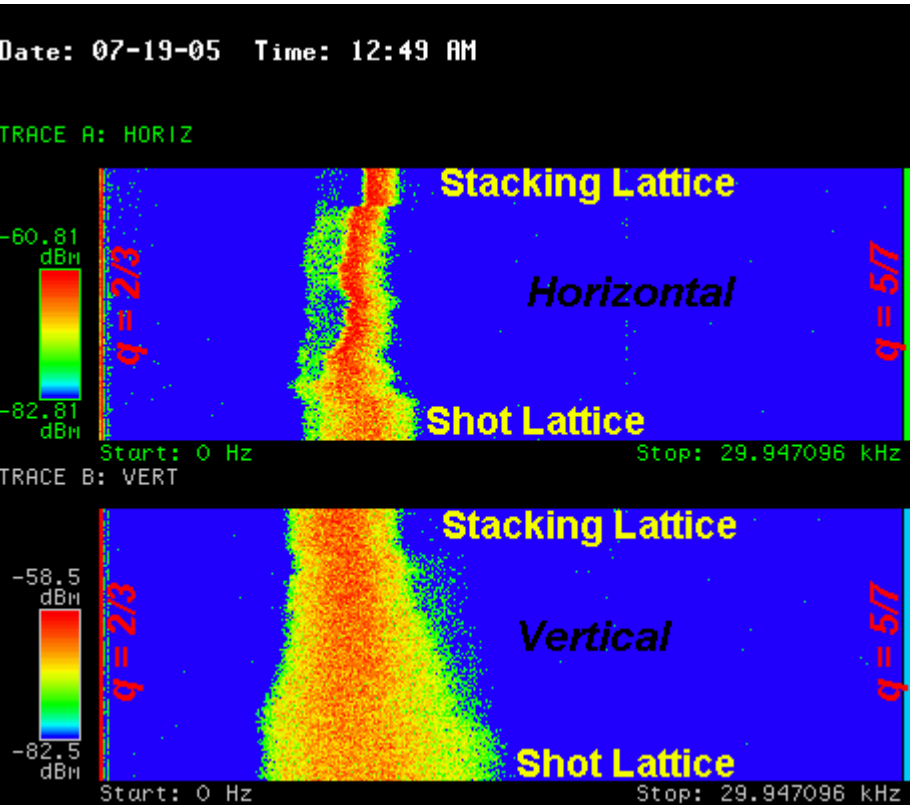
- Second Round has been completed
  - Dispersion eliminated in A10 where there are a lot of tight apertures
  - Dispersion corrections put into ramps
- Need to:
  - Center stacktail tanks using beam transfer functions
  - Aperture scan of A10
    - Local Bumps
    - Movable Devices

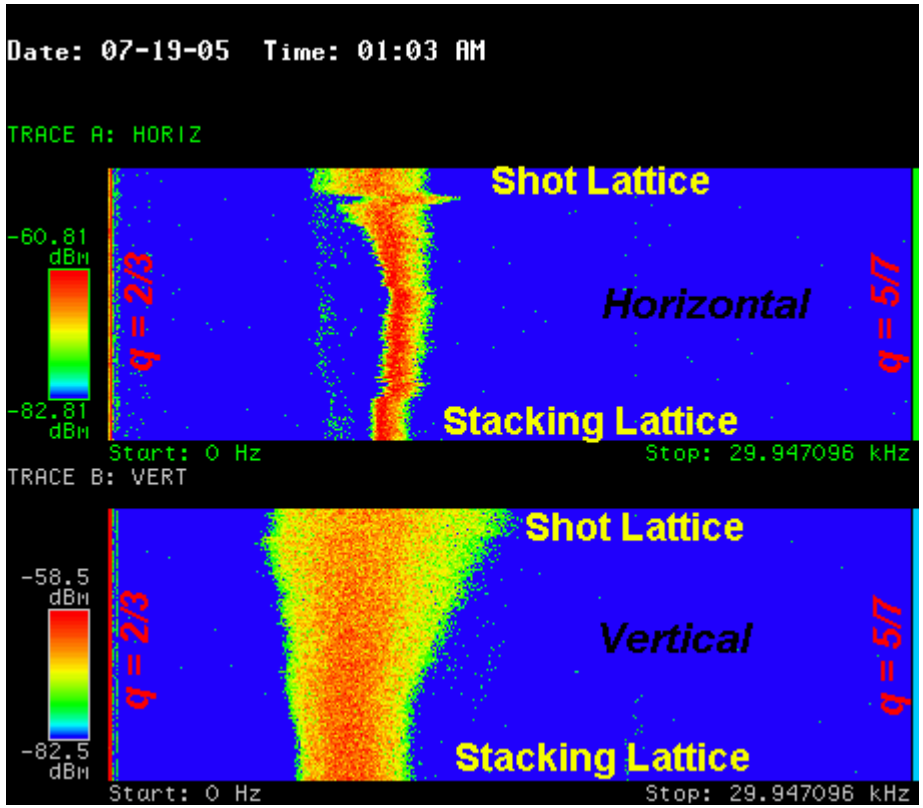
New Operating Point





New Operating Point Ramp Maintenance



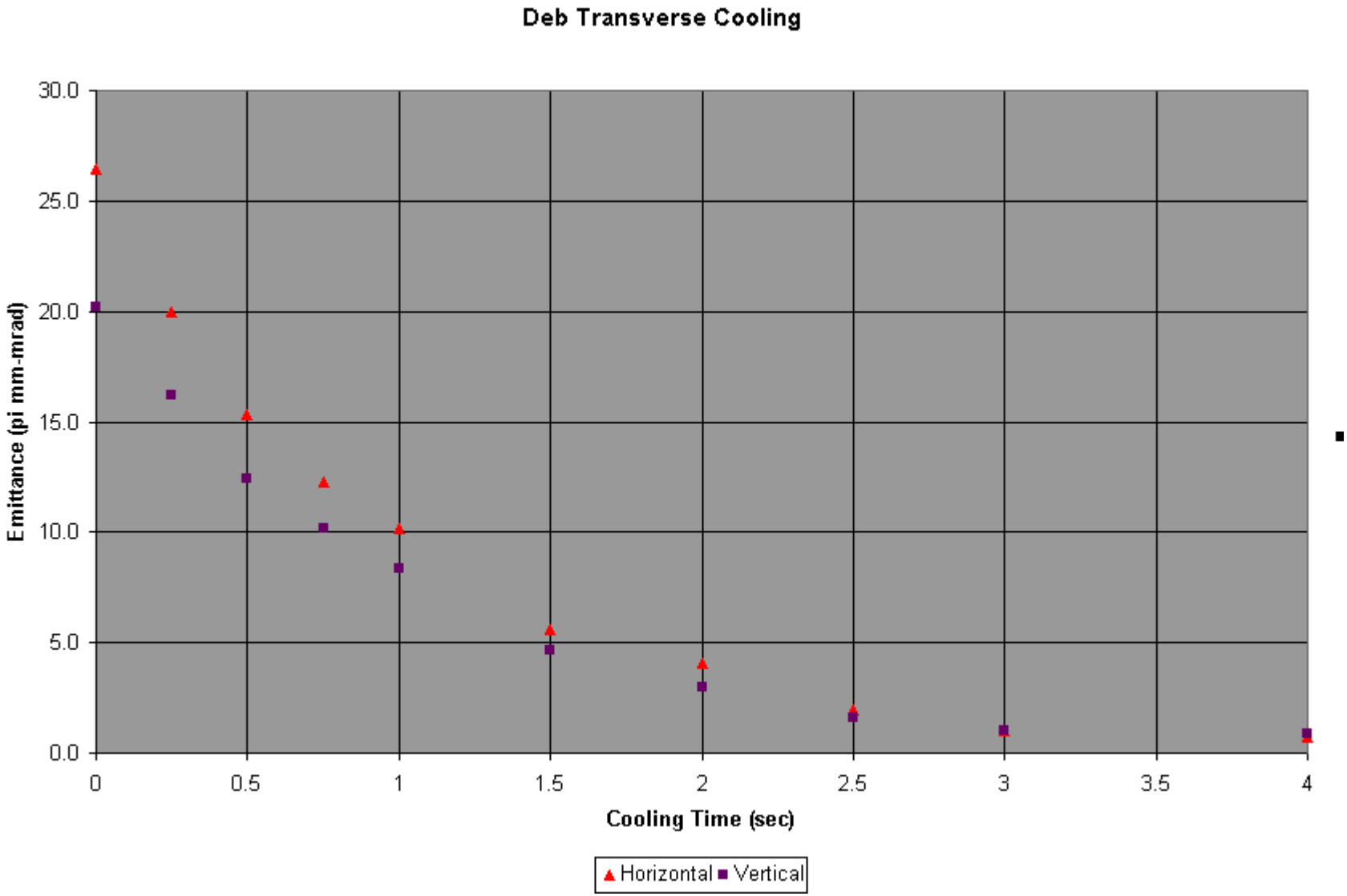


Constant Cycle Time Operation

- Present Mode of operation - Keep production constant
  - Reduce stacktail gain as the stack size increases
    - Stochastic cooling 1/N effect
  - Increase cycle time as the stacktail gain is decreased
- Future Mode – Keep cycle time constant
  - Reduce stacktail gain as the stack size increases
    - Stochastic cooling 1/N effect
  - Decrease ARF1 bucket area to deposit only the beam you can cool
- We have successfully tried this technique at 60e10 and 130e10 with about a 10% hit in stacking compared present operation
- Once the equivalent cycle time goes over 4 sec, we would interleave NUMI only and mixed mode cycles

- Concerns
  - Hit on stacking
  - Extra pulses on delicate pulsed devices
    - Lithium Lens,…
  - Losses in the Main Injector
  - Operational complexity

Debuncher Transverse Cooling Characterization



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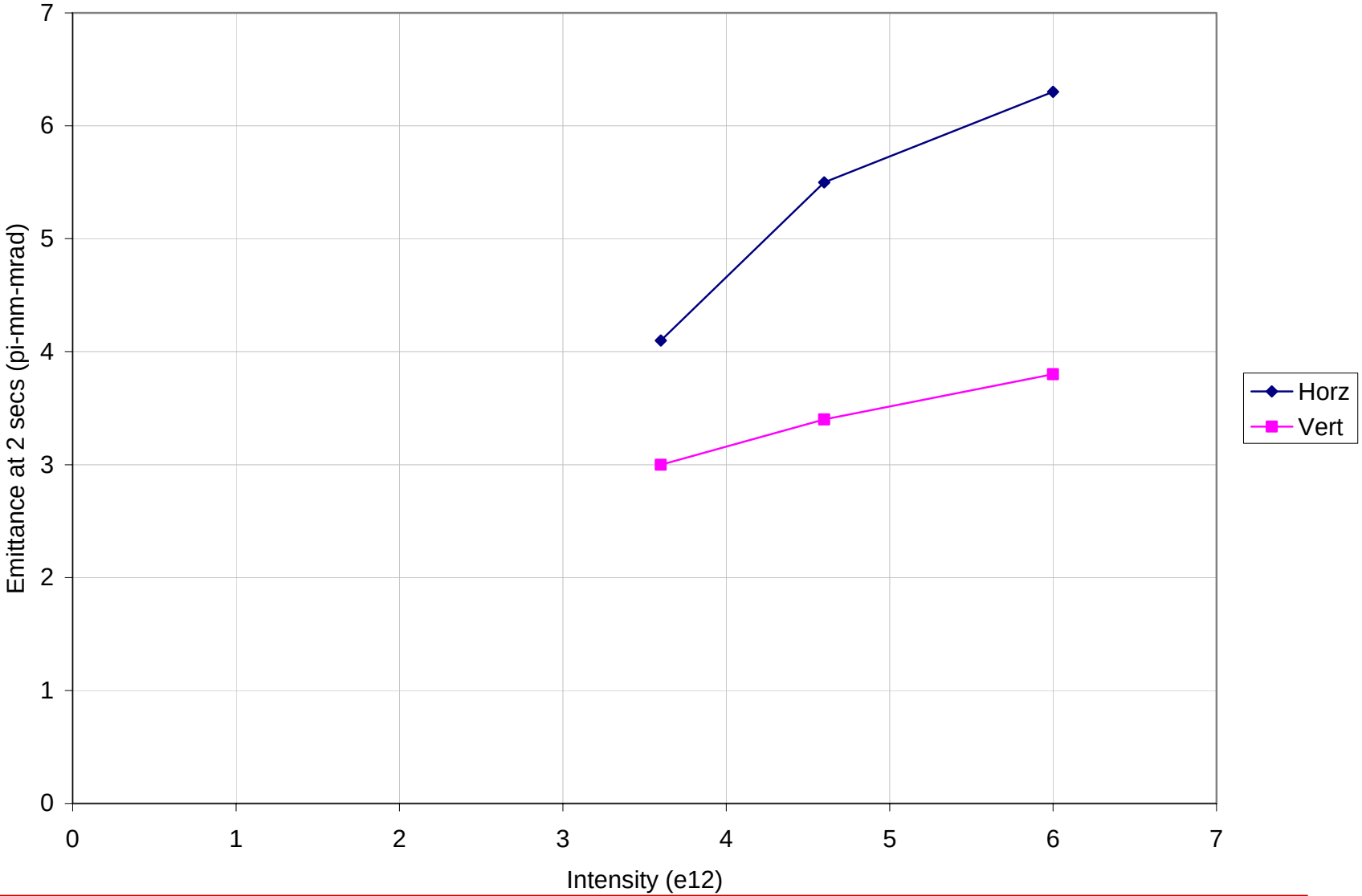

Pbar Future Work

- Protons on target
  - Quad Damper
  - Transverse instability
  - RF Step technique
  - Main Injector capture optimization
    - Bucket energy spacing
    - Bucket height
  - Main Injector batch instrumentation
    - Phase detector
    - Bunch length detector
- Antiproton Source
  - Finish 120 GeV optics
  - Finish ramp maintenance (needs a buss cycle)
  - Operational tests of constant cycle time operation
  - Center the stacktail tanks
  - Optimize the aperture in A10
  - Understand the intensity dependence of Debuncher transverse cooling
  - Re-beam base align the D/A line
    - With DEX bump and AQ104 bump
  - Characterize chain transmission efficiency vs intensity and cycle time
  - Accumulator Recycler Transfers
    - Get Pbar trajectory data
    - Check match on the stacking lattice
    - Implement recommendations for sequencer changes