Instrumentation for LARP, PEP-II, and Tevatron

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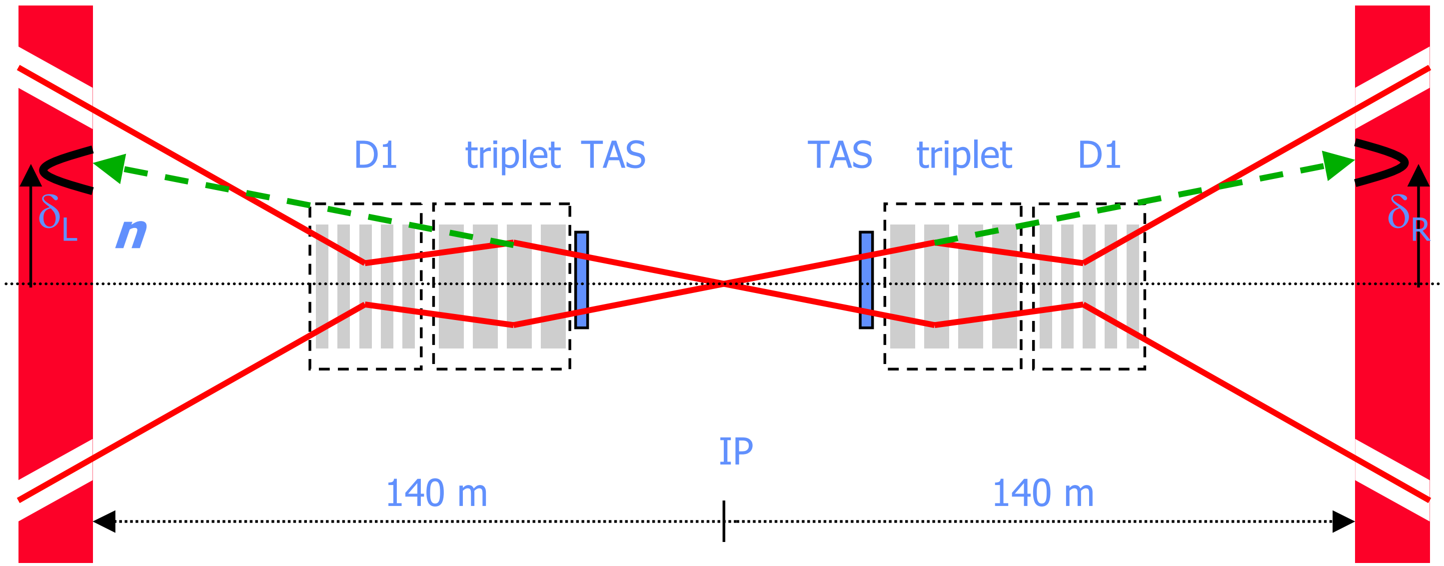
17 March 2005

Overview

- Beam instrumentation and diagnostics for LHC
  - —High bandwidth luminosity monitor
  - —design study for abort gap monitor
- PEP-II
  - —upgrade of transverse feedback system
  - —electron cloud diagnostics
- Tevatron
  - —abort gap monitor studies

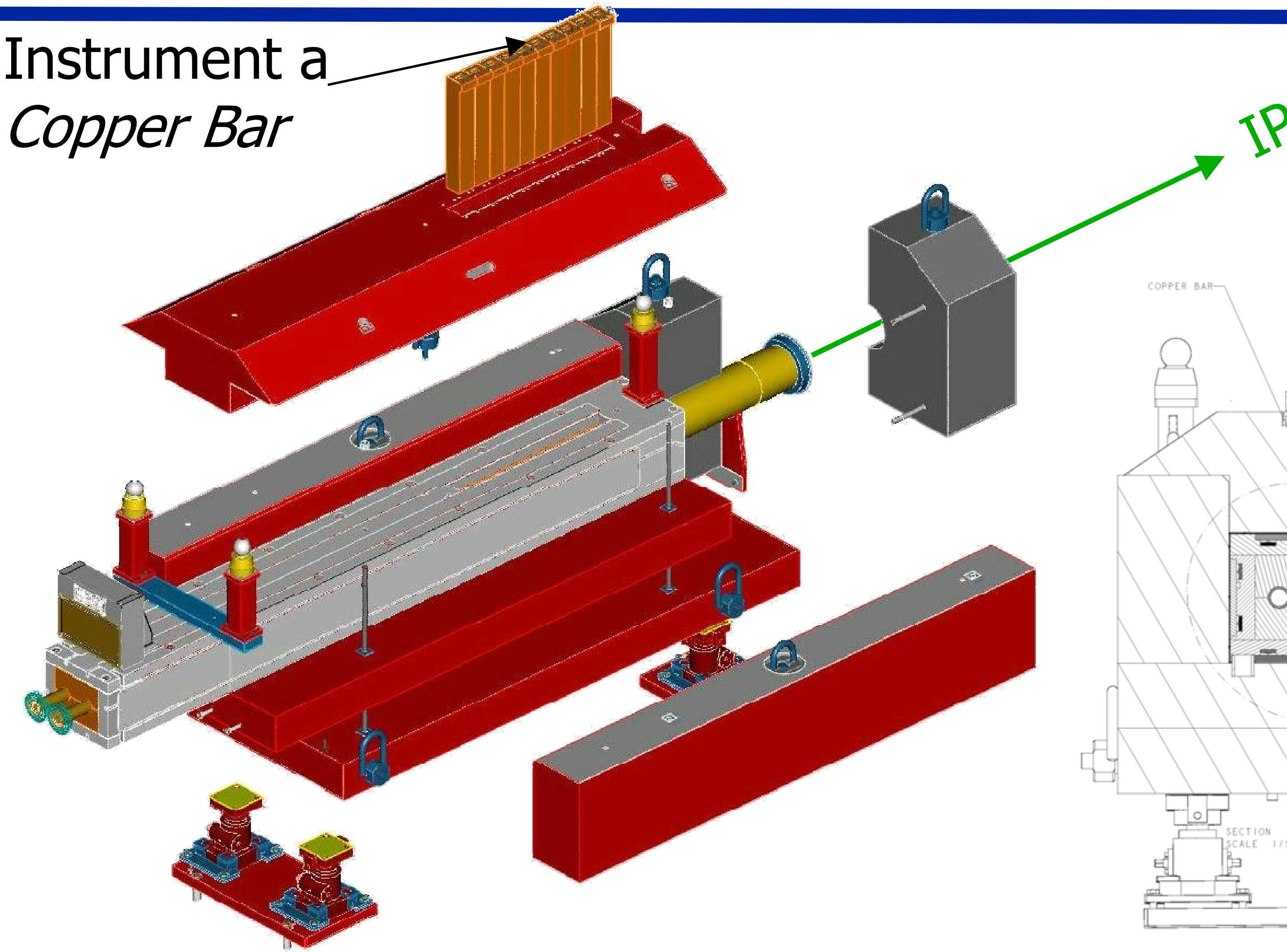
High Bandwidth Luminosity Monitor

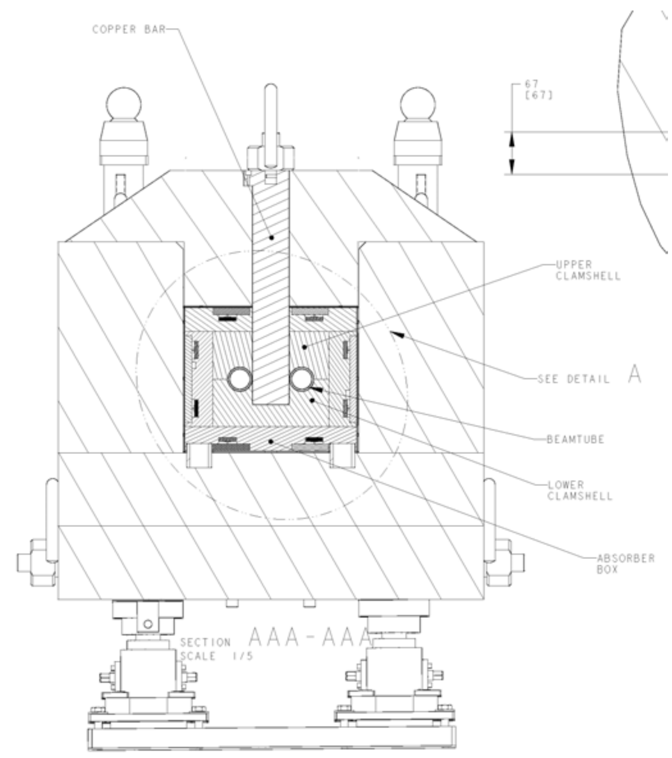
Instrument US-built TAN absorbers to measure and optimize the luminosity of colliding bunch pairs with 25 nsec separation



- Luminosity ∝ N_{MIP} from ***n*** shower
- Crossing Angle ∝ $\delta_L + \delta_R$

Instrumented TAN absorber





LHC Luminosity Monitor

The challenge:

- **High radiation environment (100 MGy/year)**
- **Bunch-by-bunch capability (25 nsec separation) with 1% resolution.**

The solution:

- **Segmented, multi-gap, pressurized ArN_2 gas ionization chamber constructed of rad hard materials**

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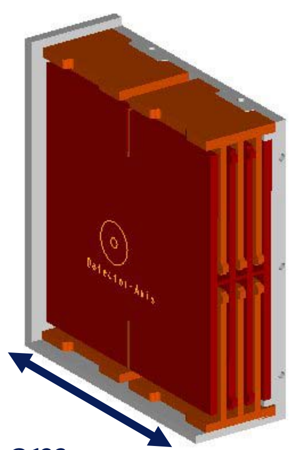
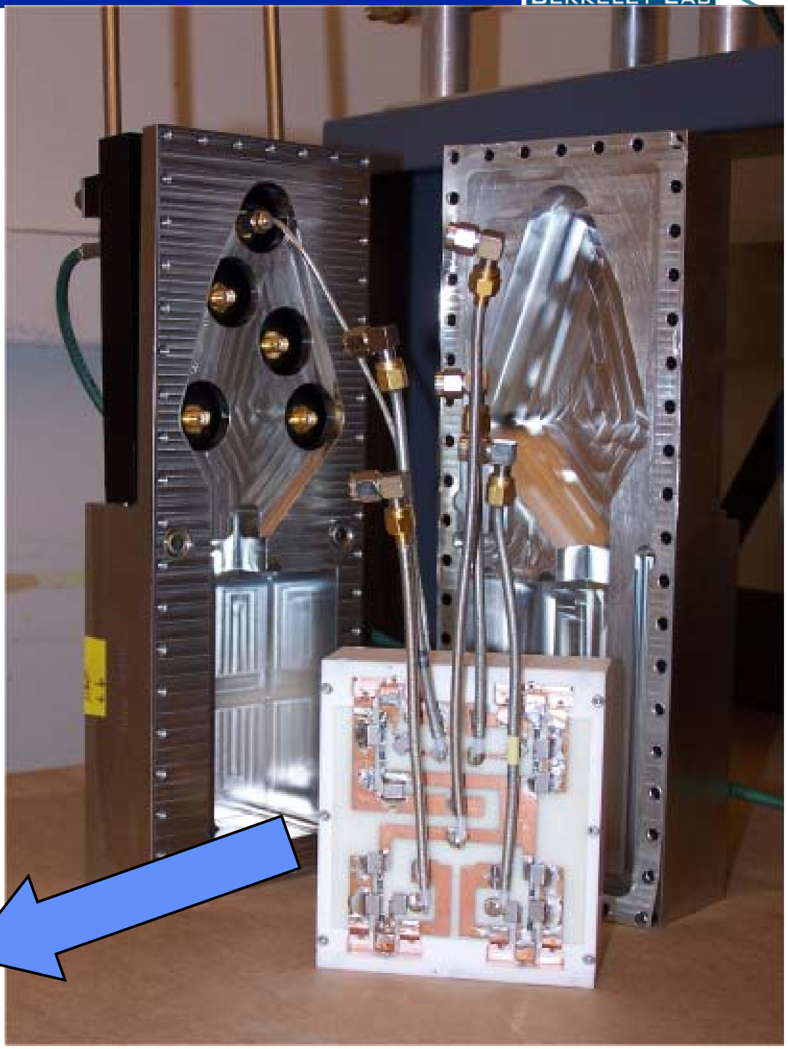


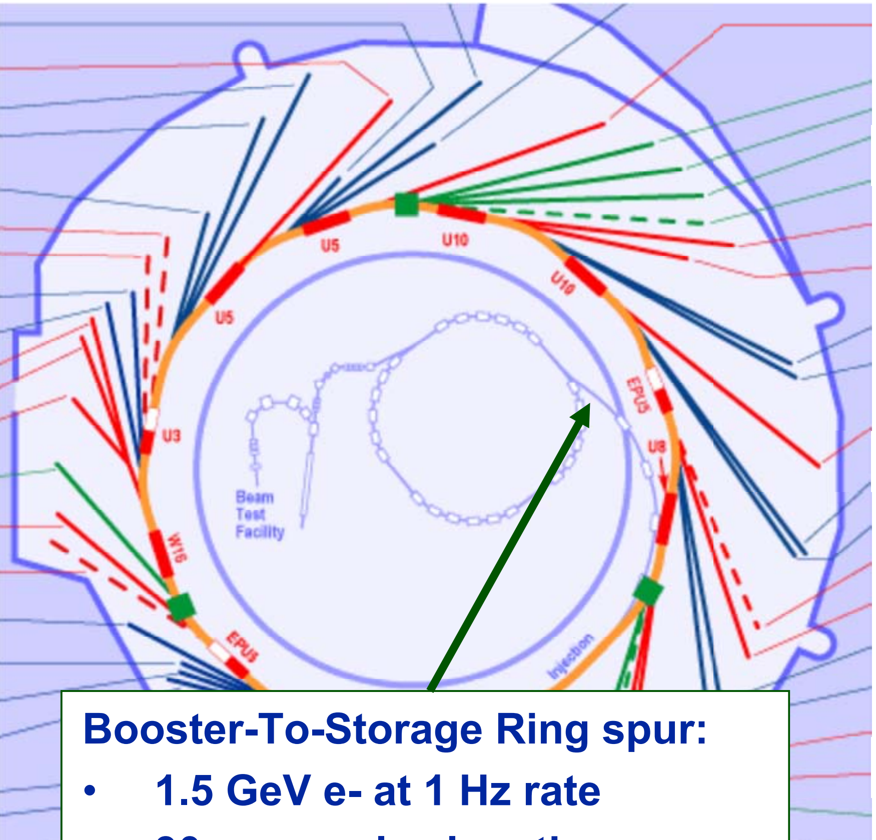
9 cm



Lumi R&D

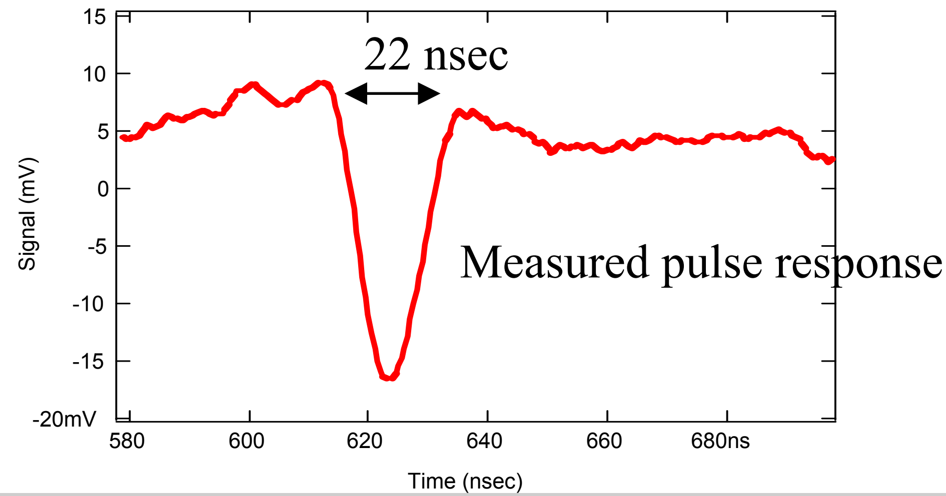
- Test single pulse chamber response
  - —demonstrate gas speed
  - —test pulse shaping electronics
  - —determine quadrant position sensitivity
- Improve pulse shaping electronics to achieve 25 nsec response
- Develop 40 MHz test of full system
  - —verify negligible space-charge effects
  - —test system integration

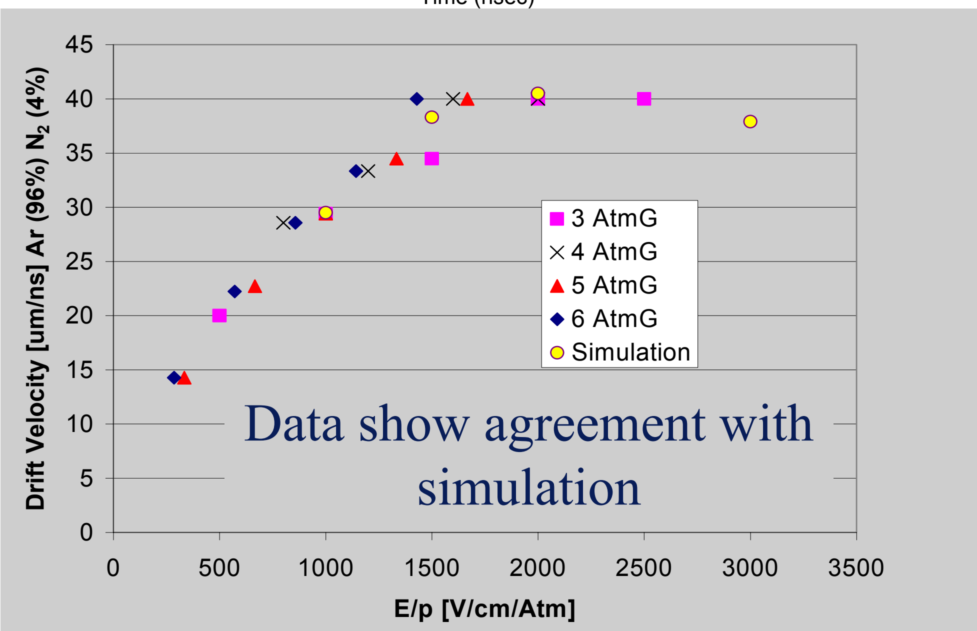
Single pulse response



Booster-To-Storage Ring spur:

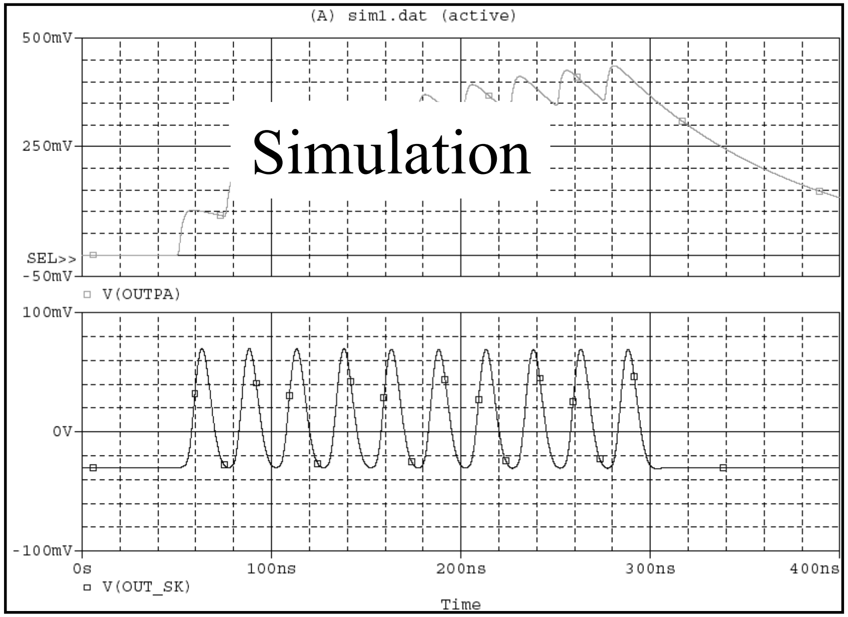
- **1.5 GeV e- at 1 Hz rate**
- **30 psec pulse length**
- **intensity from 1 to 1e9 e- (1e3 typical)**
- **daily access and availability**

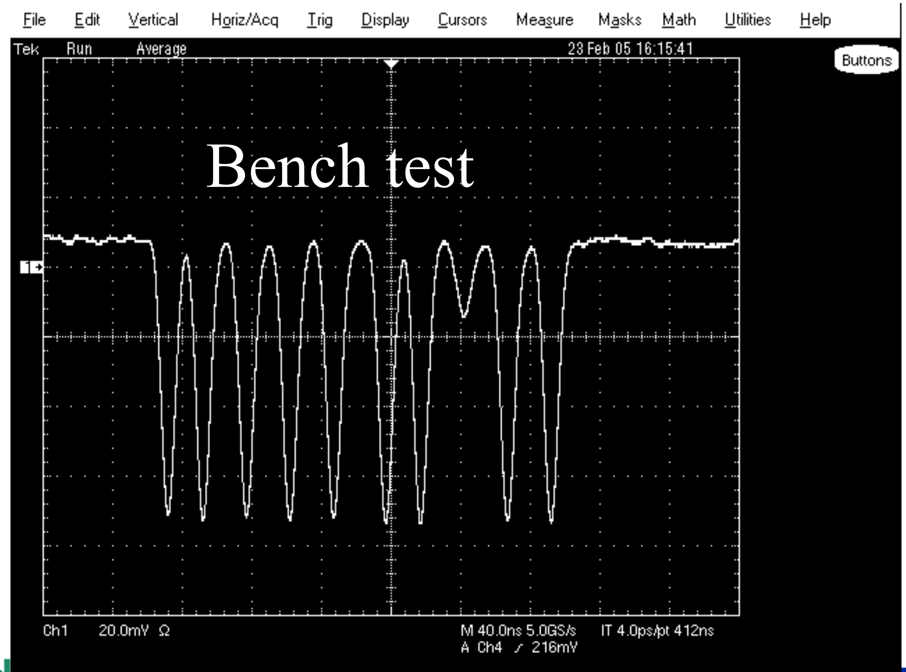




Electronics improvement

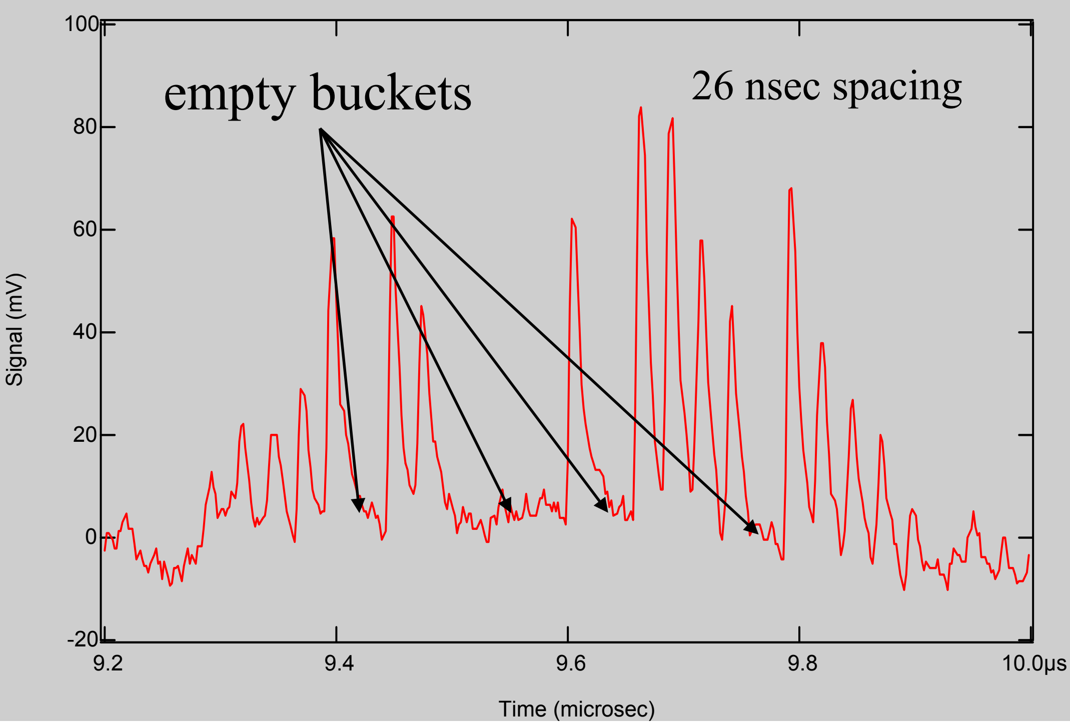
- Test and improve electronics on the bench
- Improvements in pulse shaping have reduced signal width from 35 to <25 nsec (=reduced pileup)
- Bench testing allows development of 40 MHz data acquisition for LHC operation





40 MHz Beam Test

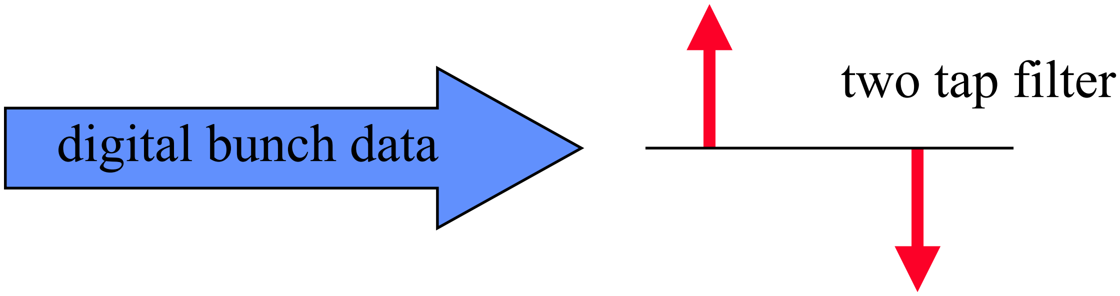
Use "spilled" beam from ALS to simulate LHC fill pattern
-generates reasonable signals
-indeterminate source
-only 0.5 microsec spill
-limited access and availability



Still seeking suitable 40 MHz source for full test
- JLab ERL (large dark current)
- MIT-Bates linac (requires pulsed laser)
- ALS Superbend BL8.3.2 (photons up to 30 keV)

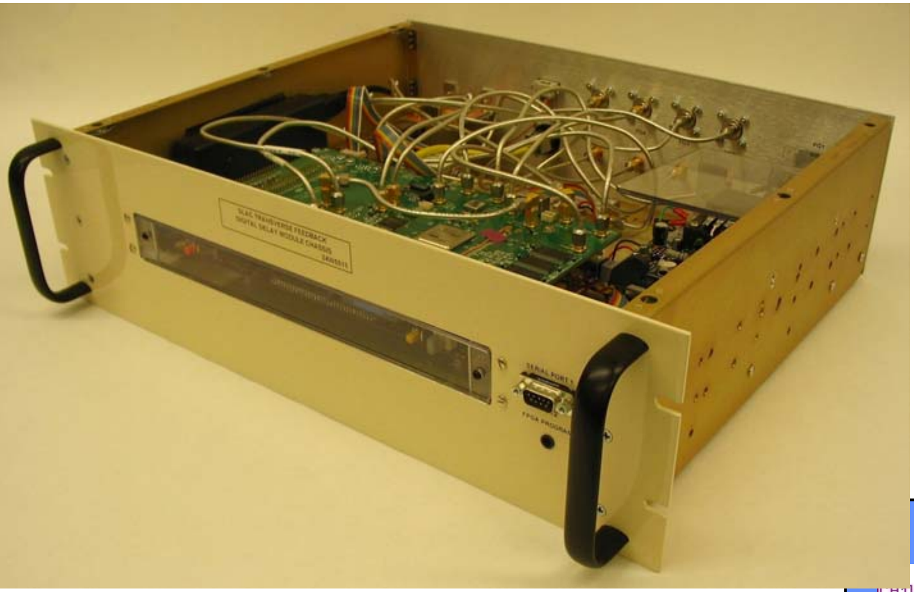
PEP-II Feedback Systems

- Problem: PEP-II transverse feedback (TFB) run at high gains to maintain beam stability. Small closed orbit offsets at TFB pickups can reduce effective dynamic range of system, limiting stability at high currents.
- Solution: increase digital dynamic range from 8 to 12 bit and incorporate DC offset rejection filter.
- Our solution: use expertise in modern FPGA technology (developed at LBL for SNS low-level RF) to implement programmable two-tap filter. Also incorporate transient recording capability.

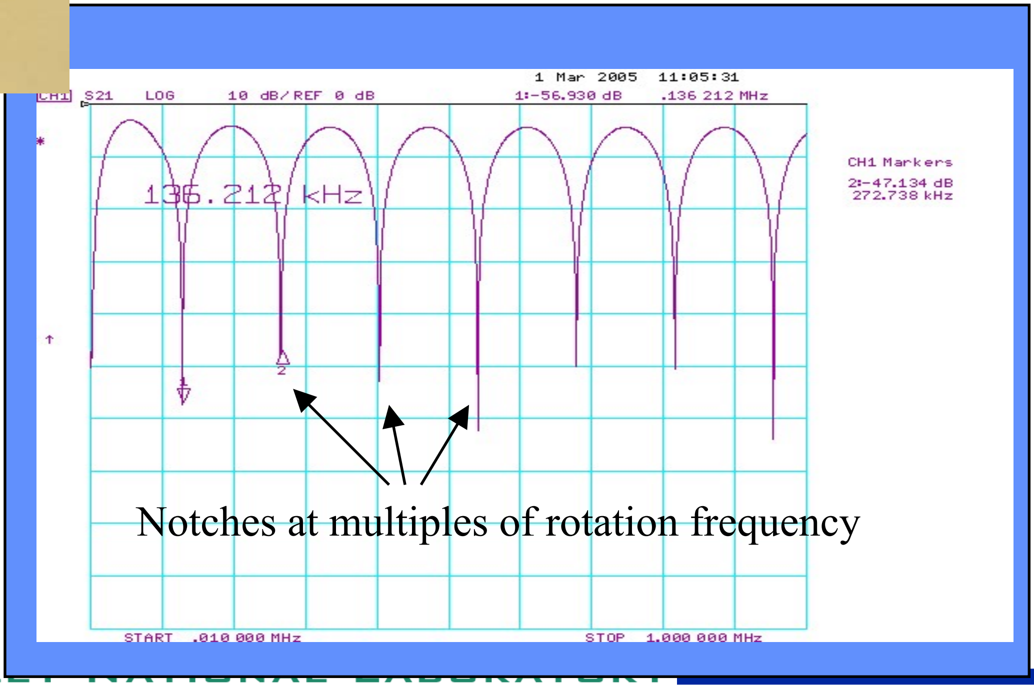


bunch-to-bunch DC orbit rejection

PEP-II TFB Upgrade



- •Statement of work in July 04
- •Funded in Oct 04 at $300k
- •Design reviewed in Oct 04
- •Delivered and installed March 05!



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PEP-II Electron Cloud Diagnostics

- Question: How to get a more global view of the low energy electrons in the beam pipe?
- Initial idea: Measure electron induced modulation of first TE waveguide modes transmitted in the beam pipe. (Caspers and Kroyer, 2004)
- The results should be directly related to the averaged electron cloud density.

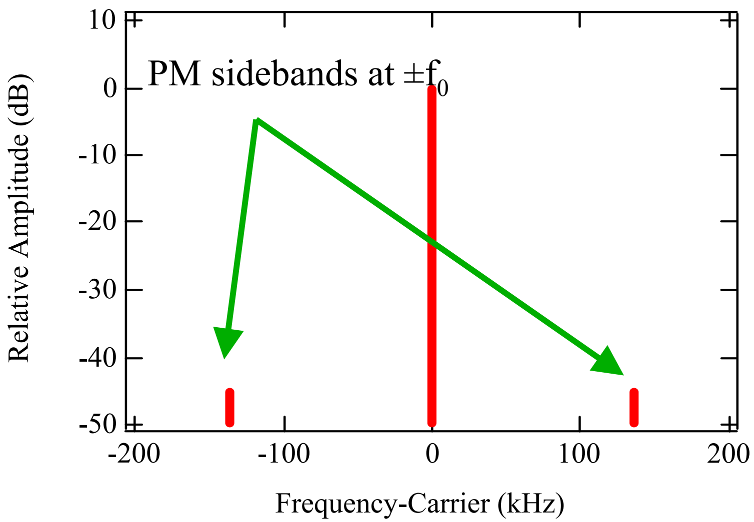
The phase shift for an angular frequency ω is given by

$$\Delta\phi = -\frac{1}{2}\frac{\omega_p^2}{\omega c}L$$

with the plasma frequency

$$\omega_p = \sqrt{4\pi\rho_e r_e c^2}$$

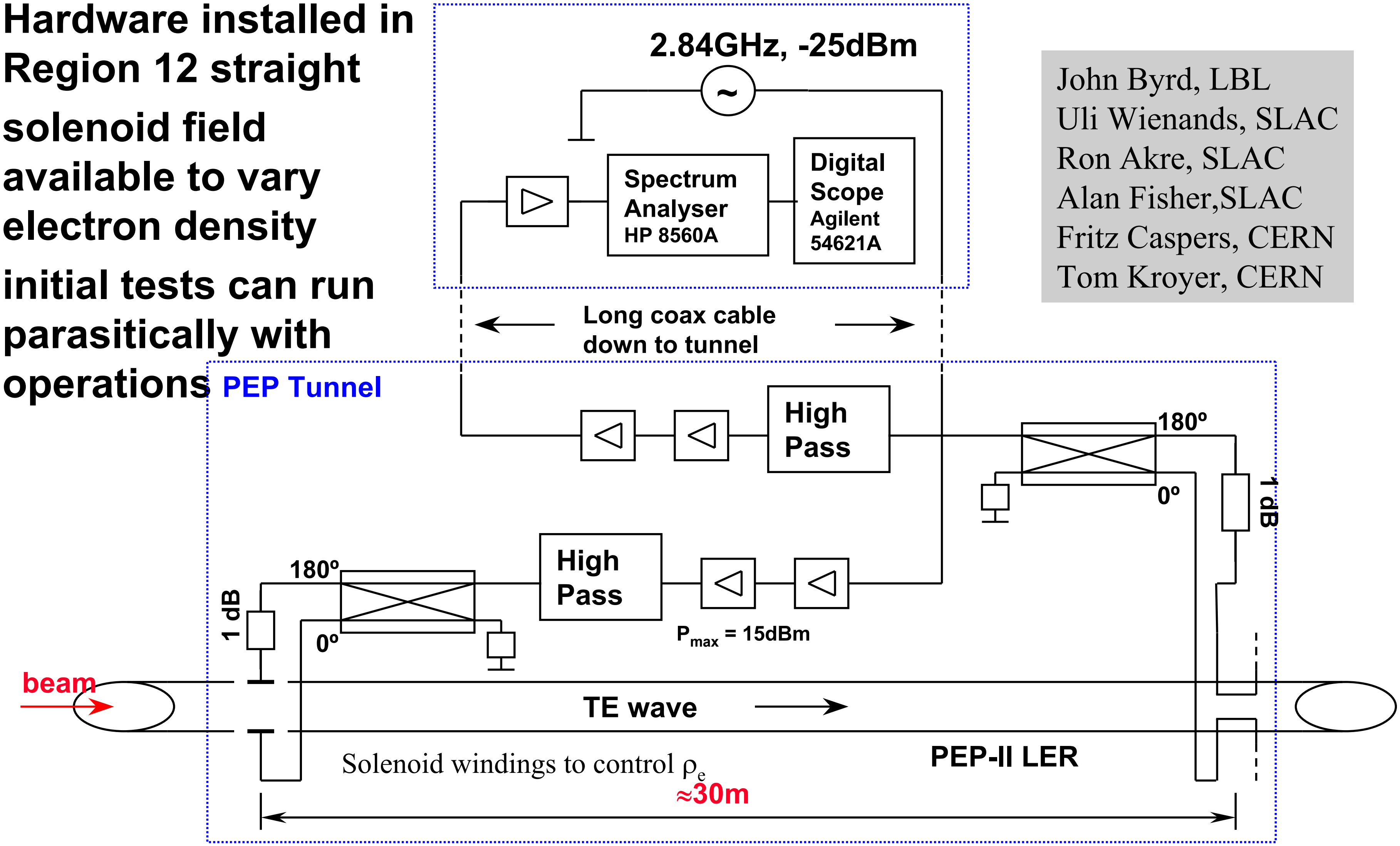
For $\rho_e = 10^{12}/\mathrm{m}^3$, $\Delta\phi \sim 1$ degree



A similar effect can be observed in the ionosphere, limiting the accuracy of GPS.

PEP-II Beam Pipe Transmission Expt

- Hardware installed in Region 12 straight
- solenoid field available to vary electron density
- initial tests can run parasitically with operations



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Alan Fisher, SLAC
Fritz Caspers, CERN
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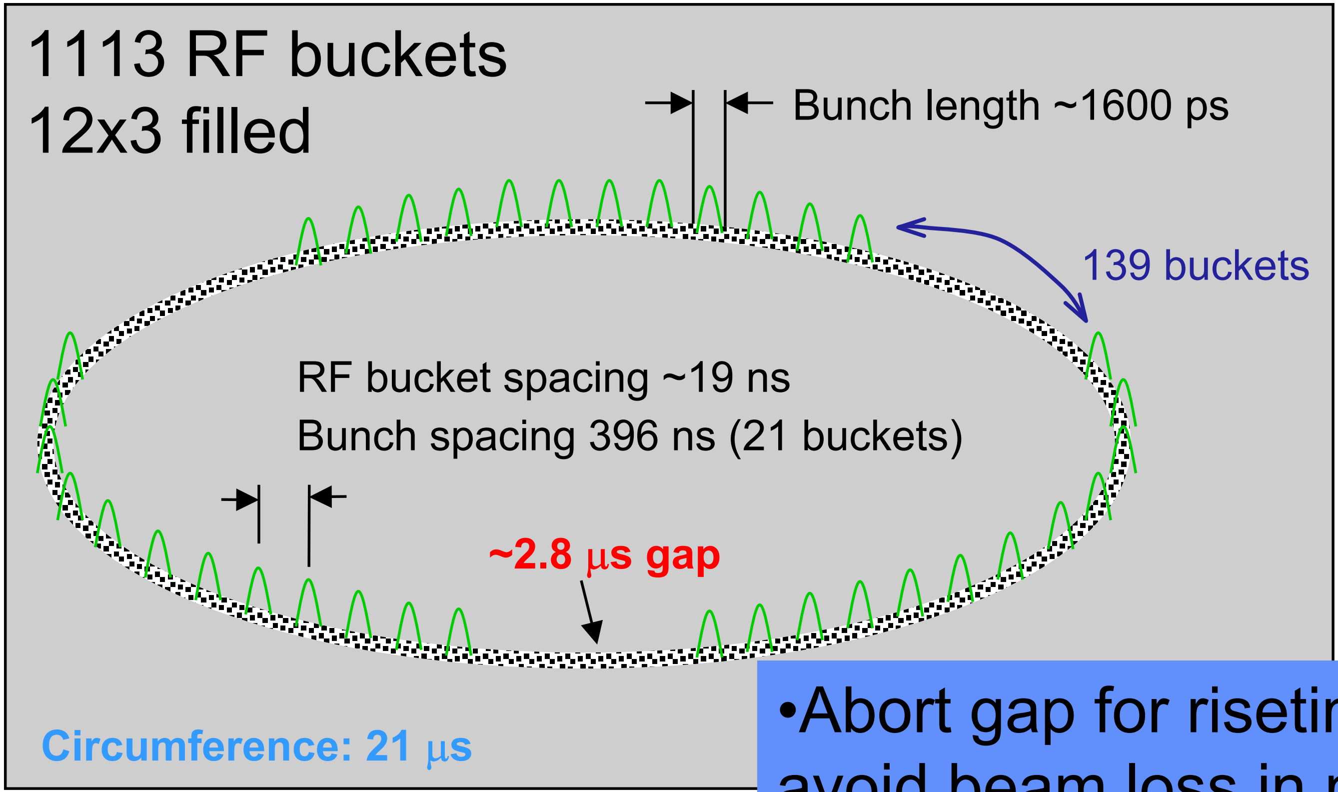
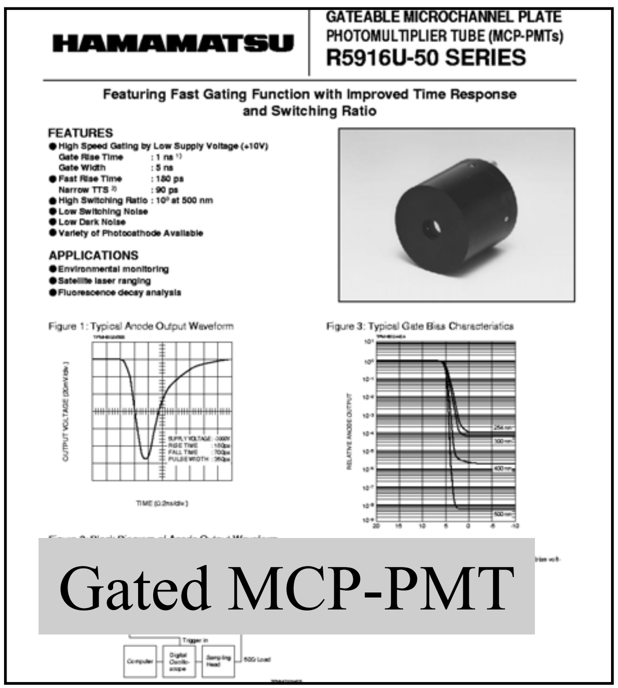
Tevatron: abort gap



- Abort gap for risetime of kicker to avoid beam loss in magnets
- Contamination of gap can lead to magnet quenches during beam abort
- Gap can fill from several processes: injection errors, IBS diffusion.

Tevatron: abort gap studies

At 1 TeV, proton machines start to look more like electrons:
use synchrotron radiation optical diagnostics



HAMAMATSU

GATEABLE MICROCHANNEL PLATE PHOTOMULTIPLIER TUBE (MCP-PMTs)
R5916U-50 SERIES

Featuring Fast Gating Function with Improved Time Response and Switching Ratio

FEATURES

- High Speed Gating by Low Supply Voltage (+10V)
  - Gate Rise Time : 1 ns
  - Gate Width : 5 ns
- Fast Rise Time : 180 ps
  - Narrow TTS : 90 ps
- High Switching Ratio : 10⁸ at 500 nm
- Low Switching Noise
- Low Dark Noise
- Variety of Photocathode Available

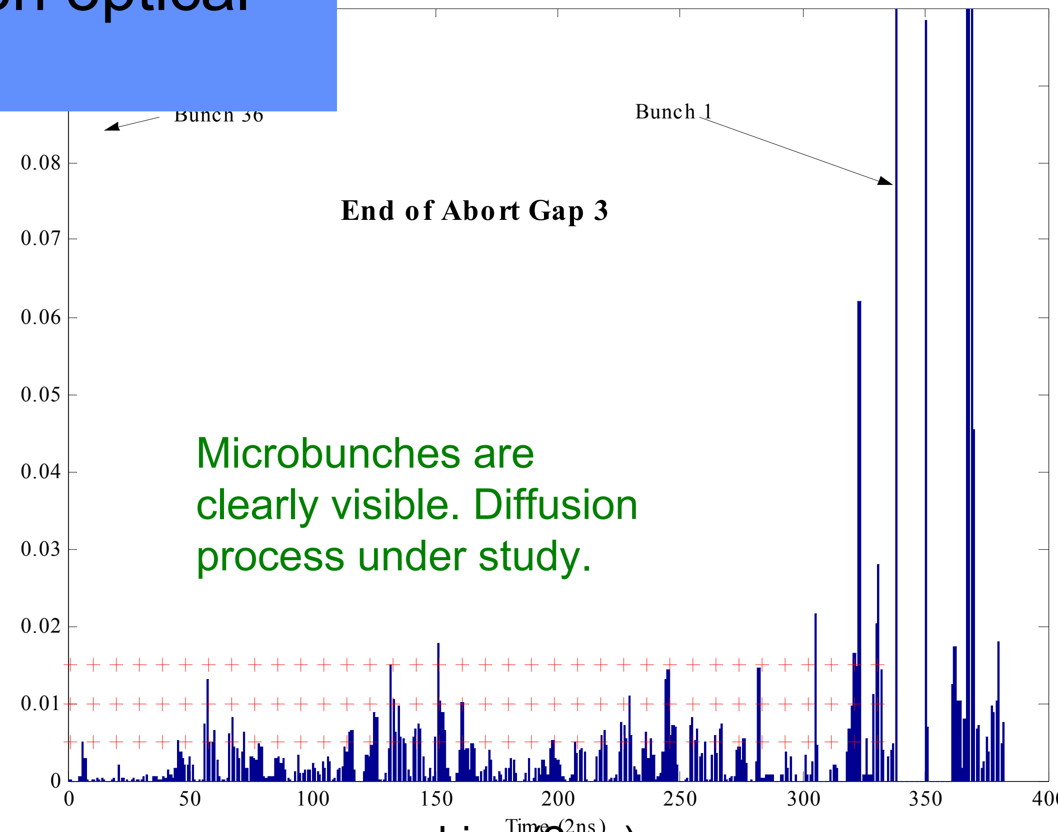
APPLICATIONS

- Environmental monitoring
- Satellite laser ranging
- Fluorescence decay analysis

Figure 1: Typical Anode Output Waveform

Figure 3: Typical Gate Bias Characteristics

Gated MCP-PMT



Microbunches are clearly visible. Diffusion process under study.

bins (2 ns)

LHC: Abort Gap Monitor Study

- Provided a design study for an LHC abort gap monitor
- Funded in FY04 by LARP at 0.3 FTE
- Delivered design study to LHC
- Possible use of monitor to study LHC diffusion processes

Design of an Abort Gap Monitor for the Large Hadron Collider

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Abstract. We present a study of an abort gap monitor for the Large Hadron Collider. This is a critical instrument in the machine protection chain and high-accuracy specifications have been laid out for it. We briefly discuss the different options for the monitor's design and present experimental results obtained using what we believe is the most suitable technique, based on a photomultiplier with a gated microchannel plate.

Summary

- *progress made in*
  - —*LHC luminosity monitor*
  - —*PEP-II feedback systems*
  - —*Tevatron synchrotron light diagnostics*
- *apply expertise in beam dynamics, RF and microwaves, and beam instrumentation to interesting problems in present and future high energy physics machines*
  - —*maintain connections with accelerator operations*
  - —*look for new ideas*
  - —*don’t forget where the control room is!*