

Beam Loss Monitor Upgrade

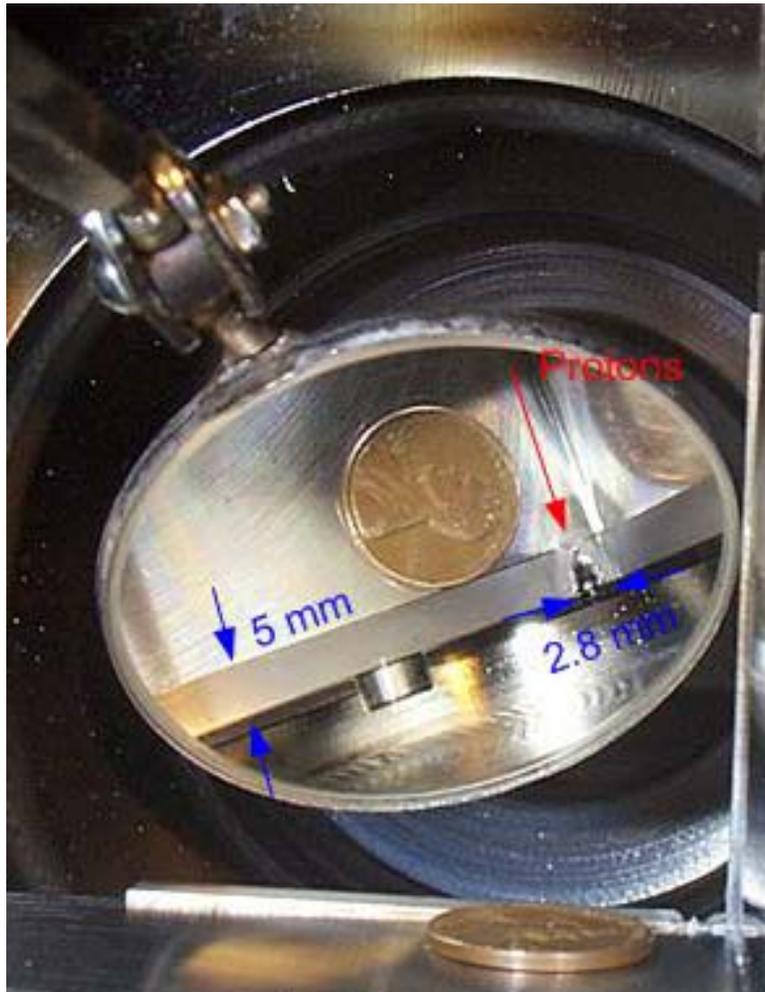
J. Lewis

Run 2 Meeting

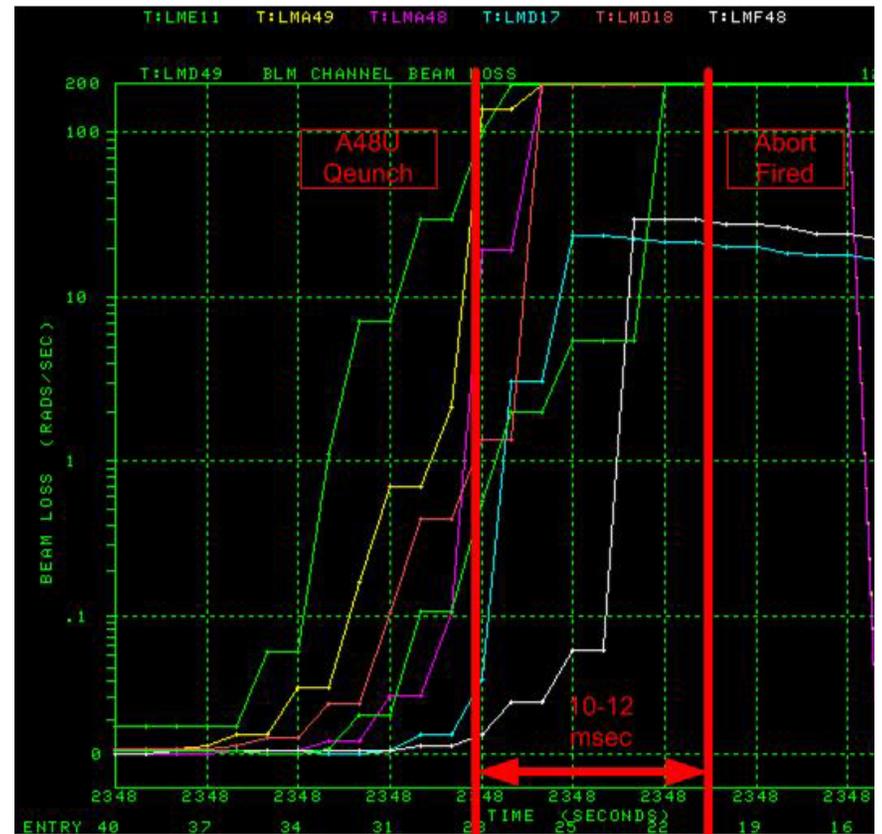
27 January 2005

Motivation

- Don't do this again.



Loss profile: Roman-pot 16-house quench



Existing System Characteristics and Limitations

- **Signal properties**
 - Good resolution and dynamic range
 - Fast leading edge response, slow discharge
- **Tevatron Aborts**
 - Fast: ~ 50-100 μ s
 - Fires on single channel over threshold
 - Minimal compatibility with multiple machine configurations
 - Two abort levels, high and low field
 - Not allowed to Abort when pbars are in the machine
- **Read out**
 - Via the old BPM system using the External Device Bus
 - The BPM is dead. Long live the BPM
 - New system commissioned by March 2005
 - Updates slowly: ~ 3 ms period
- **Difficult to enhance and maintain**
 - 23 years old

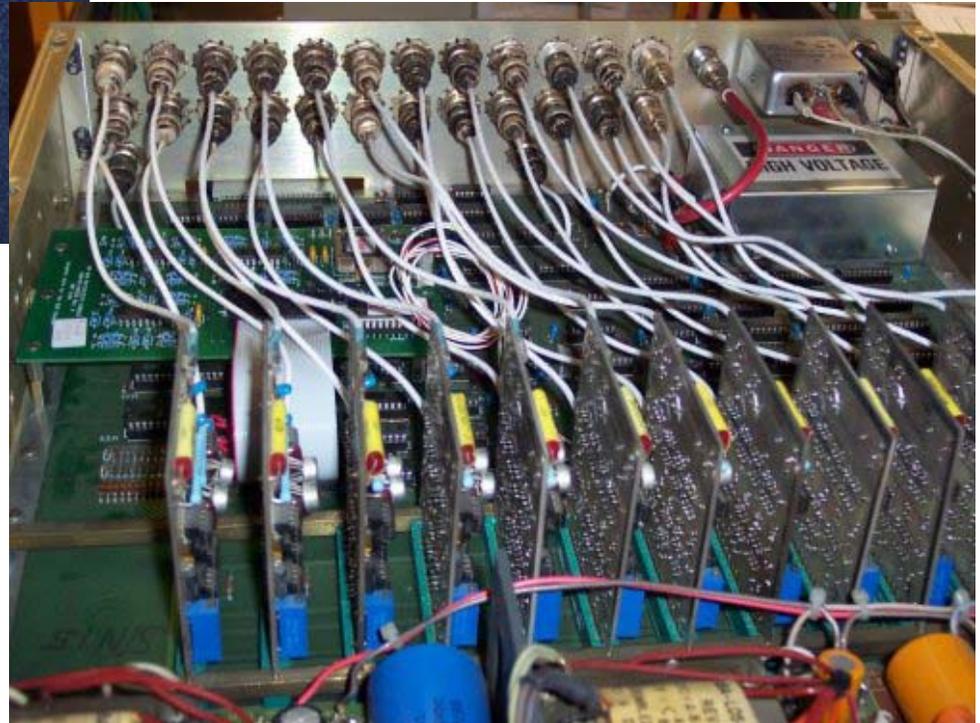
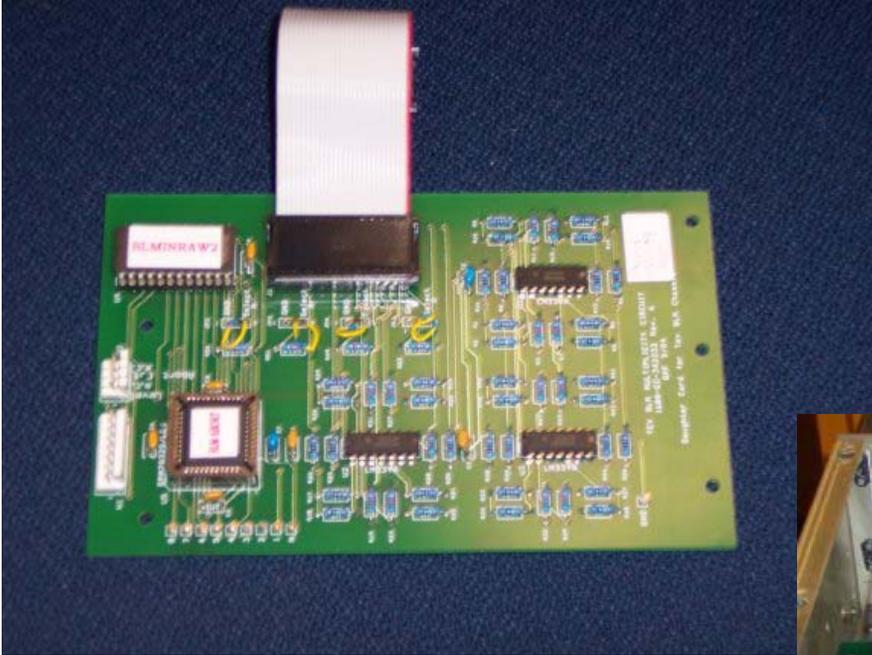
Requirements for New System

- **Robustness: No false aborts**
- **Reliability: No missed aborts**
- **Respond to changing machine configurations**
 - Change abort channel-by-channel abort thresholds and masks in response to TCLK or MDAT events
- **Maintain resolution**
 - System designed around low-noise integrator
- **Good time resolution and depth**
 - Multiple integration periods, each with >4k sample history
- **Also work for MI and Booster**
 - Accelerator activation due to beam losses limits increased intensity
- **Include experiments in Tevatron BLM system**
 - Two camac crates with special electronics hard to maintain

Temporary Fix for Old System

- **Can allow TeV BLMs to be used to abort during store**
- **Issue: false aborts due to individual BLM hiccoughs**
- **Stephen's Remedy**
 - **Multiplicity requirement**
 - During HEP require >1 BLM to give signals
 - **Programmable Carrier card with logic**
 - e.g. $>N$ consecutive BLMs, ($N = 2, 3$)
 - Sits in existing BLM chassis:
- **Status:**
 - **Designed and 30 produced (Czarapata and Federwitz)**
 - **Under test in lab (Olson)**
 - **Discussions on testing in field? (Tevatron Dept.)**

Kludge Board Under Test in BLM Chassis



System Overview

- **Integrate BLM current and digitize at Tevatron turn frequency**
- **Form three running sums for additional integration periods**
 - **Programmable time constants**
- **One abort threshold per integration period for each channel**
- **Abort thresholds and masks changed in response to machine states**
 - **Embedded microprocessor**
 - **Custom local bus on J2**
 - Isolated from VME and Ethernet

Components

- **Digitizer**
 - 4 channels with integrator and ADC
 - Generates primary abort signals
- **Timing Card**
 - Synchronizes digitizers
 - Latches control signals
- **Abort Card**
 - Masking and multiplicity of inputs from digitizer
- **Controller**
 - Interface to VME for crates with abort
- **High Voltage**
- **Front-End CPU**
 - MVME 2xxx: Acnet interface, etc.

Digitizer

- **4 Loss Monitor Channels**
 - **Dual Charge Integrator (Burr Brown ACF2101)**
 - Alternately integrating or being readout and reset
 - Provides continuous measurement
 - 50 kHz maximum sample rate
 - **16-Bit SAR ADC**
 - **DAC to give analog scope output**
- **FPGA**
 - **Controls integrators**
 - **Reads ADCs**
 - **Stores readings (raw measurements)**
 - **Forms three running sums**
 - Example: 1ms, 10ms, 1s periods
 - **Compares readings and sums to programmed thresholds**
 - Results sent to Abort Concentrator
- **512 kByte RAM to store 64k raw data in circular buffer**
 - **Not available via VME. Add triggered turn-by-turn buffer?**
- **Maximum 16 cards per crate**

Timing Card

- **Provides synchronous integration clock to digitizers**
 - **External input (Beam Synch Clock)**
 - Can also be divided (e.g. $AA \div 2$ for MI)
 - **Internal oscillator**
 - **Time stamp buffer in sync with the digitizers' 64k data buffers**
 - Time stamp raw measurement data
- **TCLK decoder to receive clock events**
- **MDAT receiver to get machine state changes**
 - **Using frame \$12**
- **Real Time Clock for Data Tagging**
 - **Set via I/O from Host**
 - **Reference to \$8F**
 - **Microsecond counter**
 - Fine time stamp
 - Synchronize with BPM
- **Keeps time for sampled measurements (Snap Shot Buffers)**

Abort Card

- **FPGA receives abort info from the digitizer cards, compares against abort masks and multiplicities and makes the abort signals**
 - **One abort input for each time-range from each channel**
 - Maximum 32 channels per crate participate in abort
 - **Separate decisions for each time-range**
 - Independent masks and multiplicities
 - Ranges can be redundant
- **Aborts are formed in < 20 microseconds**
- **TTL Abort signals driven off on 50 ohm cables**
 - **One for each of 4 ranges**
 - **One global OR**

Controller Card

- **Communicates with other cards on control bus**
 - **Bus master**
- **Isolates Abort functions from outside world**
 - **FPGA VME slave and control-bus eZ80 access shared memory**
 - Circular buffers for running-sum data (snapshots)
 - Stores BLM thresholds and abort requirements for each machine state
 - **Loads parameters into digitizer and abort concentrator cards based on machine state**
 - **Maintains “Flash”, “Profile”, and “Display” frame buffers (response to TCLK)**

High Voltage

- **1 or 4 channels depending on location**
- **Voltages set via VME**
- **Includes reading of return voltage from BLM daisy chain and current**

Chassis

- **Weiner 6U VME crate**
 - **Low-noise power supply**
 - 15mV p-p on 5V
 - **Excellent track-record**
 - **Housekeeping readout via Ethernet**
 - Fans, voltages, temperatures, remote VME reset

Front End CPU

- **Tevatron**
 - **Recycle MVME2301 from CDF**
 - **30 available by 2005 shutdown**
 - Need 27 plus spares
- **MI and Booster**
 - **Buy MVME 2434-1**

Software

- **Programs Using Tevatron BLM Data (B. Hendricks 9/03)**
 - PA0384 (D40) - Hardware diagnostics (rewrite)
 - PA0506 (T38) - Ringwide hardware tests and status readbacks (rewrite)
 - PA0422 (T40) - General display program (BLM display) (rewrite)
 - PA1048 (T39) - General display program (flash, display, snapshot, profile)
 - PA0272 (T44) - BLM time plot (rewrite)
 - PA1670 (T117) - Orbit closure (flashes and displays)
 - PA1753 (C50) - Tevatron orbit program (snapshots and profiles)
 - PA0769 (C116) - Orbit program (old) (snapshots and profiles) (obsolete?)
 - PA1551 (W10) - Orbit program (old) (snapshots and profiles) (obsolete?)
 - PA1585 (W62) - Collider luminosity calculation (snapshots) (obsolete?)
 - PA1981 (W132)- BPM library test program
 - UL_CBSAUX - BPMUTI (BPM support library)
 - TEVCAL - Tevatron calculation OAC (saves snapshots in file)
 - Also need store totals for experiments (JDL)
- **Need comparable lists for Main Injector and Booster**
- **Front-end code is all new**

Proposed Machine States

- **Tevatron Operation**

- Proton Studies (i.e. uncoalesced batch at 150)
- Proton Injection
- Activate Separators
- Pbar Injection
- Ramp
- Squeeze
- Scraping
- HEP

- **F Sector (change mask)**

- P2 Beam
- P2 & P3 Beam
- F-Sector Restore

- **Experiments**

- CDF Silicon Biased
- CDF Silicon Off
- D0 Silicon Biased
- D0 Silicon Off

What's missing?

Personnel

- **Alan Baumbaugh (PPD/EED)**
 - System design, Controller card
- **Kelly Knickerbocker (PPD/EED)**
 - Timing card, infrastructure
- **Craig Drennan (AD/BS)**
 - Digitizer
- **Marvin Olson (AD/ID)**
 - System support
- **Cecil Needles (PPD/EED)**
 - Digitizer Firmware
- **Mike Utes (PPD/EED)**
 - Abort Card
- **Jonathan Lewis (PPD/CDF)**
 - Management
- **Stephen Pordes (AD/ID)**
 - Wisdom and advice (solicited or otherwise)
- **Alberto Marchionni (AD/MID)**
 - MI contact
- **Brian Fellenz**
 - HV card

Status

- **Digitizer**
 - Extensive standalone testing of prototype
 - Updating design to extend functionality
- **Timing Card**
 - Stuffing prototype today, start testing next week.
- **Crate**
 - First article received in December and approved for production
 - Custom backplane prototype in hand
 - Timing card required for testing
- **Abort and HV Cards**
 - Design nearly complete
- **Controller**
 - Firmware working in simulation
 - Card design just started

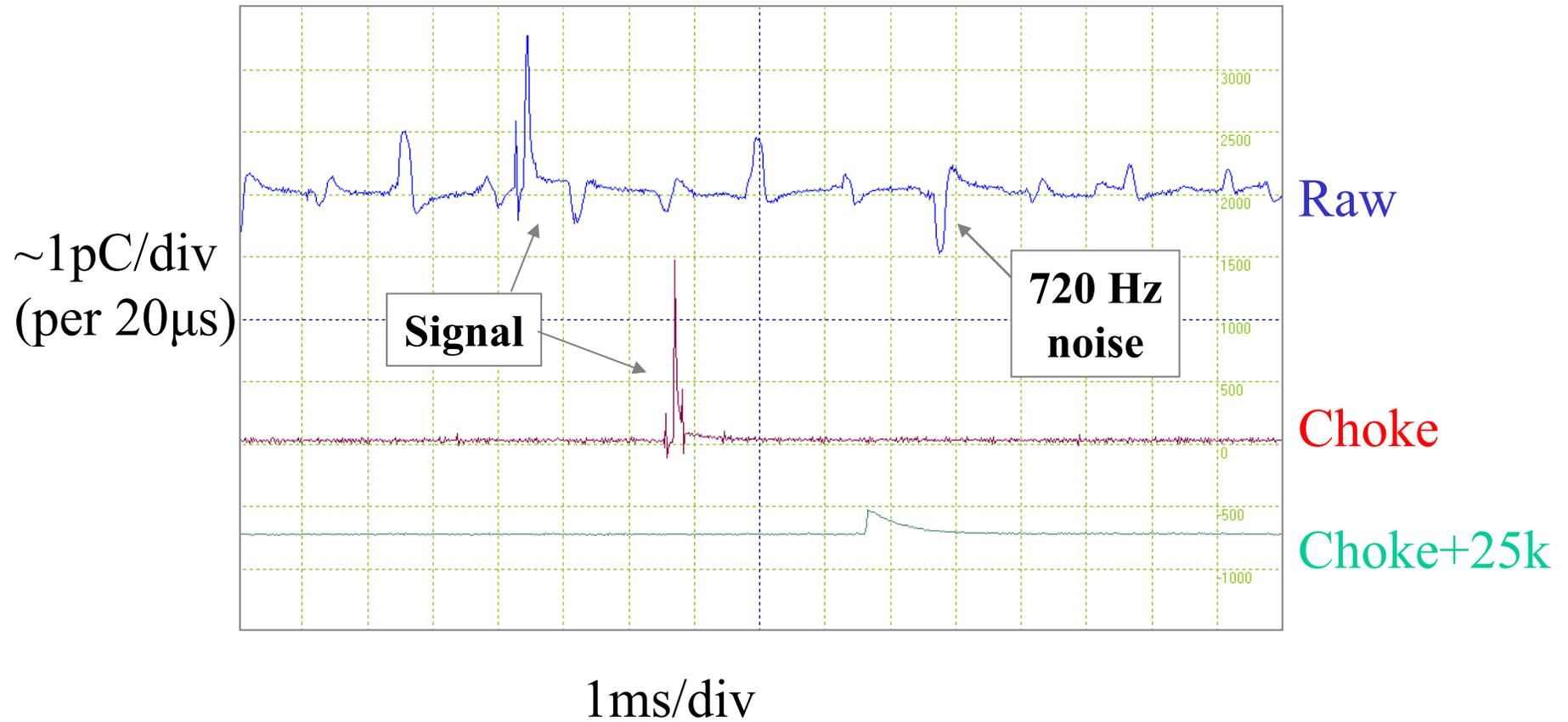
Schedule

- **Full-crate test in April**
 - Can do extensive testing with VME readout before Controller complete
 - Have 6 duplicate BLMs in E1 to test with beam and compare to legacy system
 - Develop and test software
 - Get operational experience
- **Install crates when old BPM electronics removed**
 - Get host CPUs running ASAP
- **Install modules as available**
 - Exercise (nearly) complete system in summer 2005
- **Move BLM cables to new system in 2005 Shutdown**

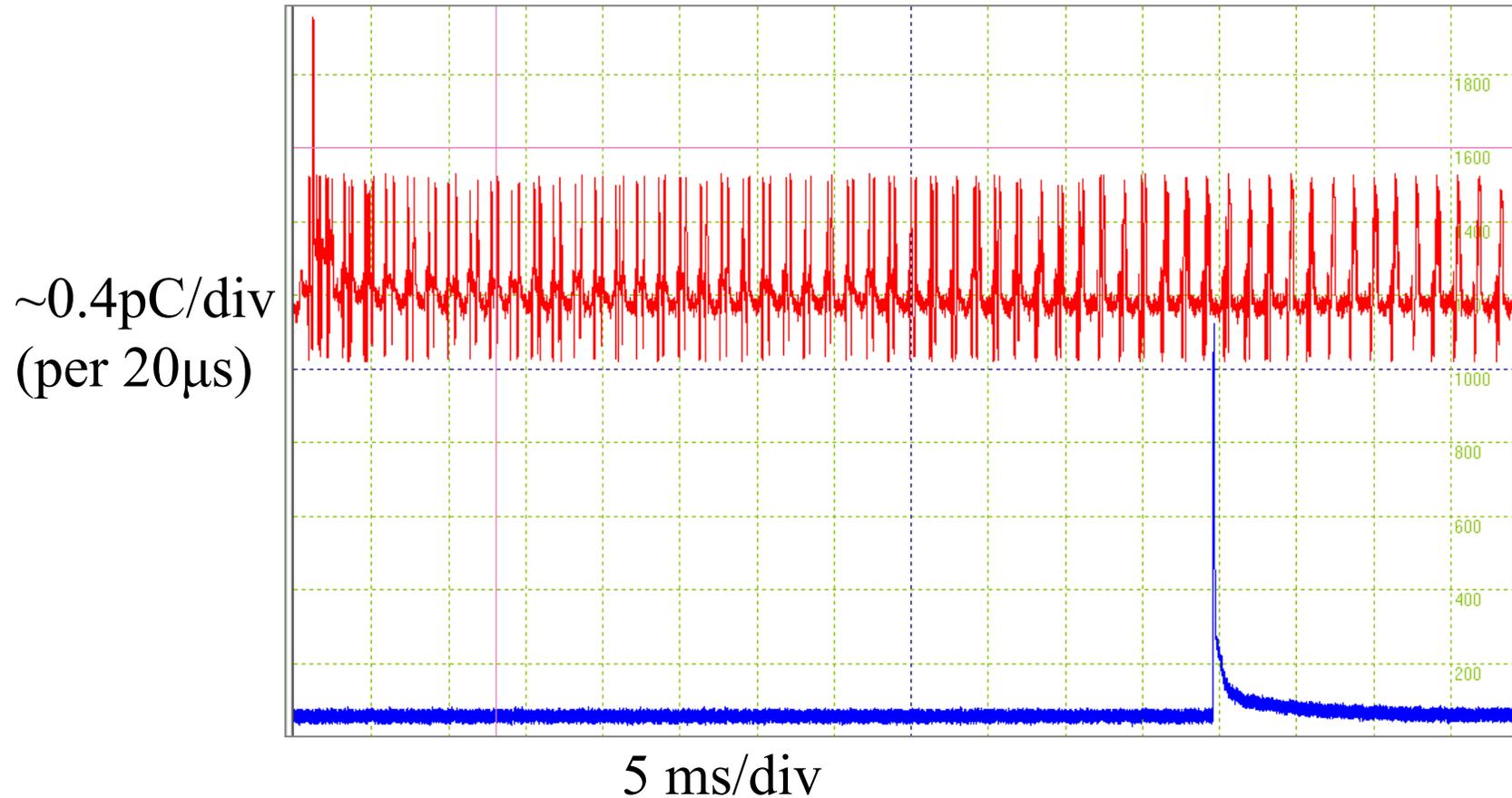
Experience

- **Studies with 2-channel digitizer test card**
- **Understand signals and noise**
 - Selected sites in Tevatron, MI and Booster
- **Check calibration for Tevatron**
 - Old system: $50\text{nA} \leftrightarrow 0.84 \text{ Rad/s}$ ($1 \text{ Rad} \leftrightarrow 60\text{nC}$)
 - New system: $50\text{nA} \leftrightarrow 56 \text{ counts}$ ($20\mu\text{s}$ bins)
- **Explored noise suppression**
 - **Wide channel-to-channel variation**
 - **Filters**
 - Chokes for common mode
 - Resistor to increase effective integration time
 - **Running sums**

Booster: LM23



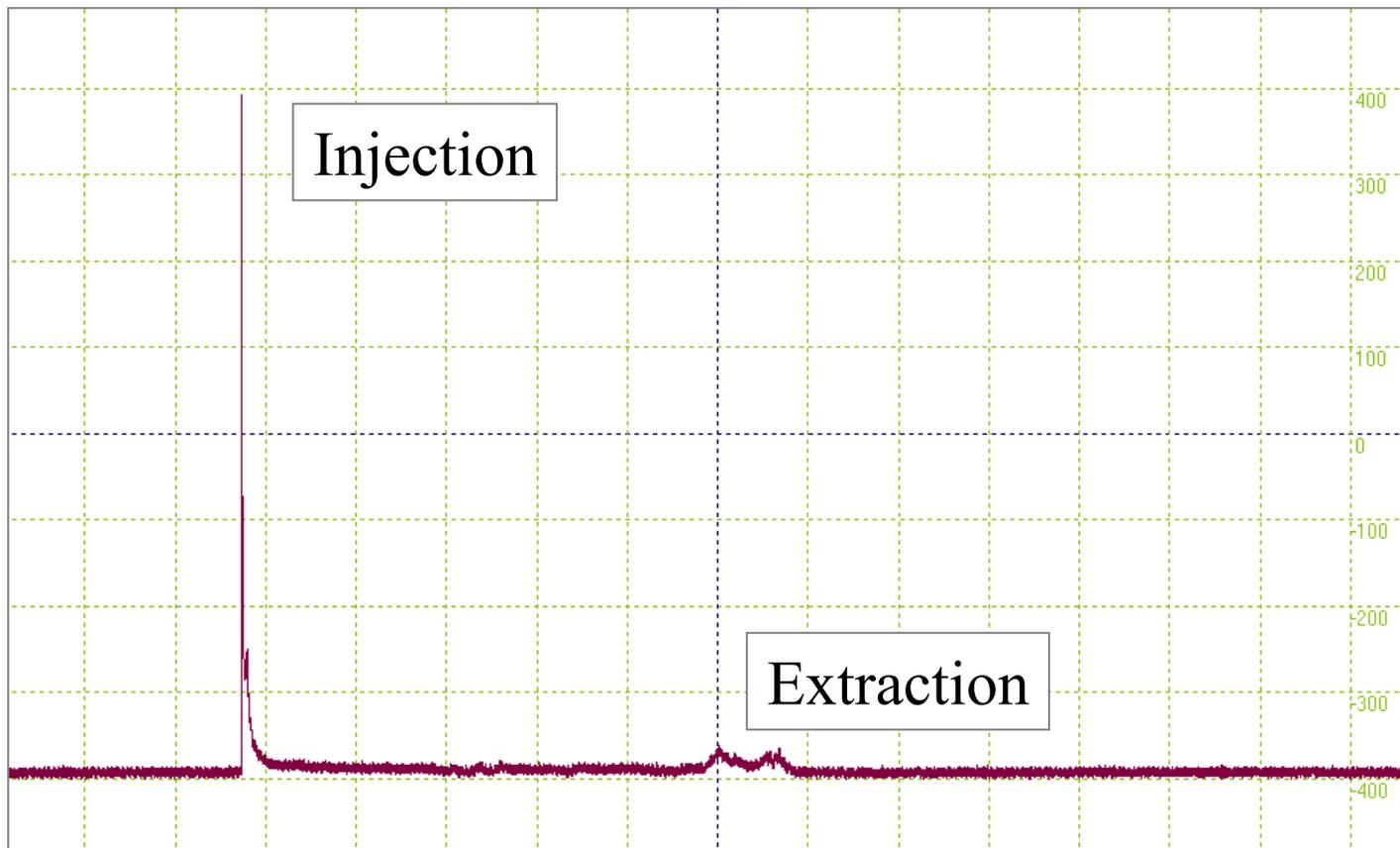
MI: LM402G



- Large common-mode rejection from small choke
- Injection loss shows up cleanly

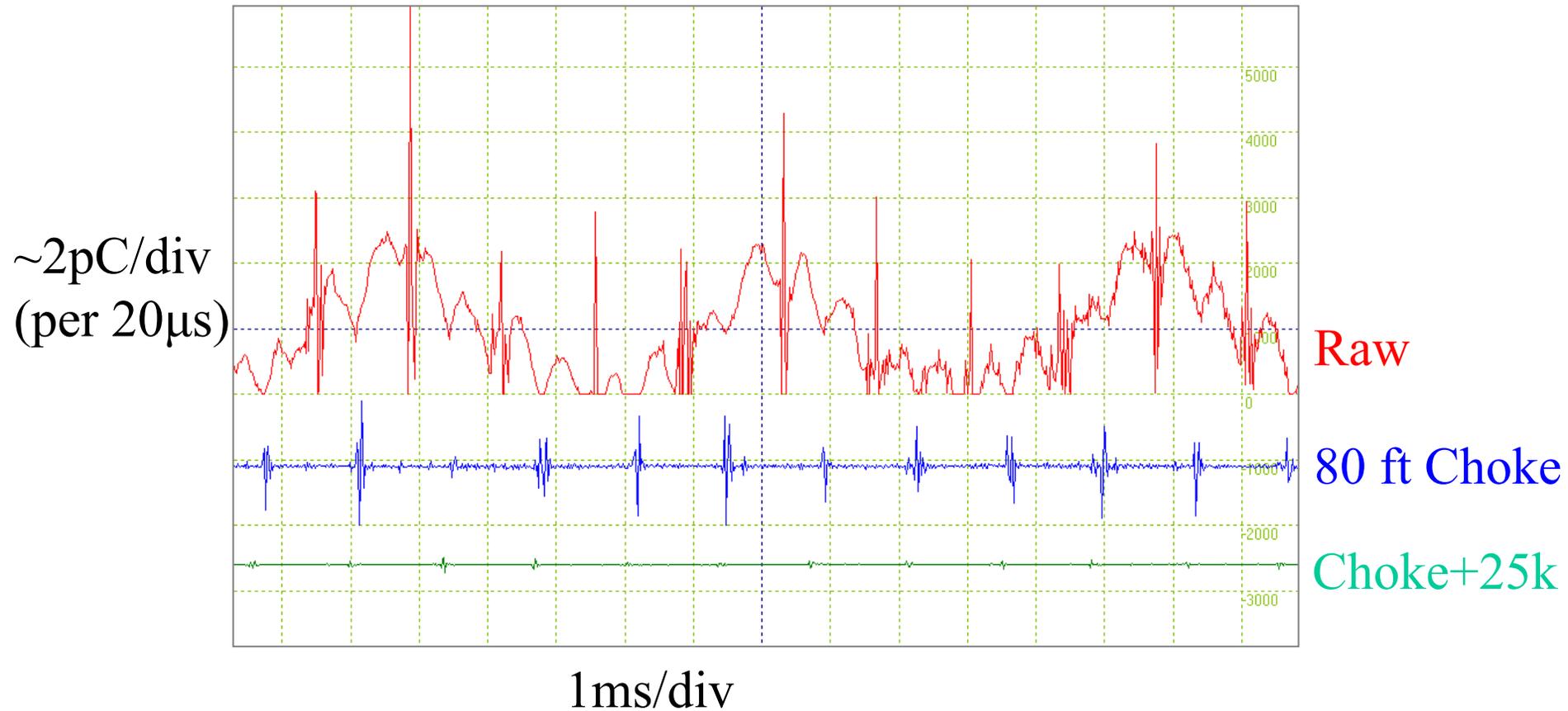
MI: LM402G full cycle

~0.2pC/div
(per 20 μ s)

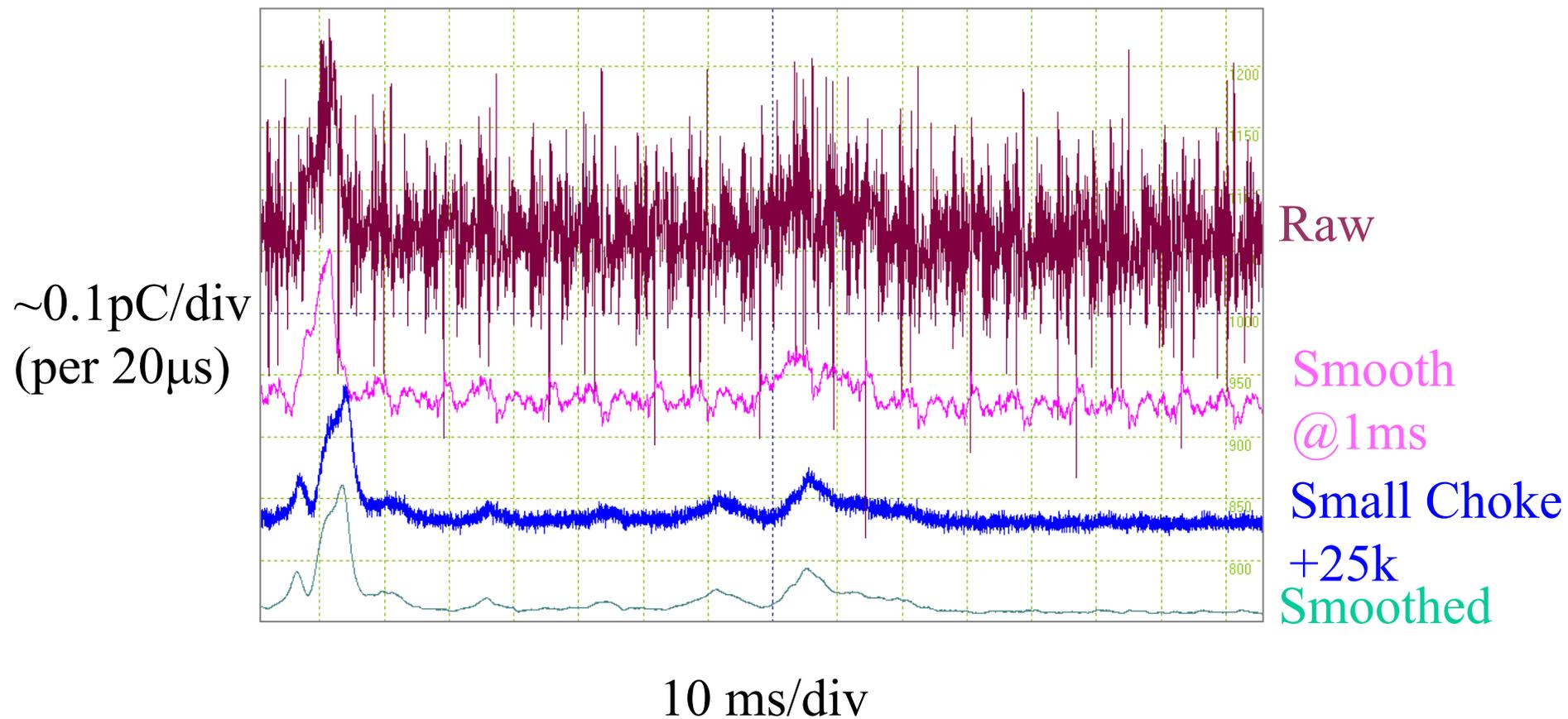


25 ms/div

Worst Case Noise: LM322



Smoothing: LM522F



Tevatron: LMF0DT

$\sim 2\text{pC/div}$
(per $20\mu\text{s}$)

1 Rad/s DC

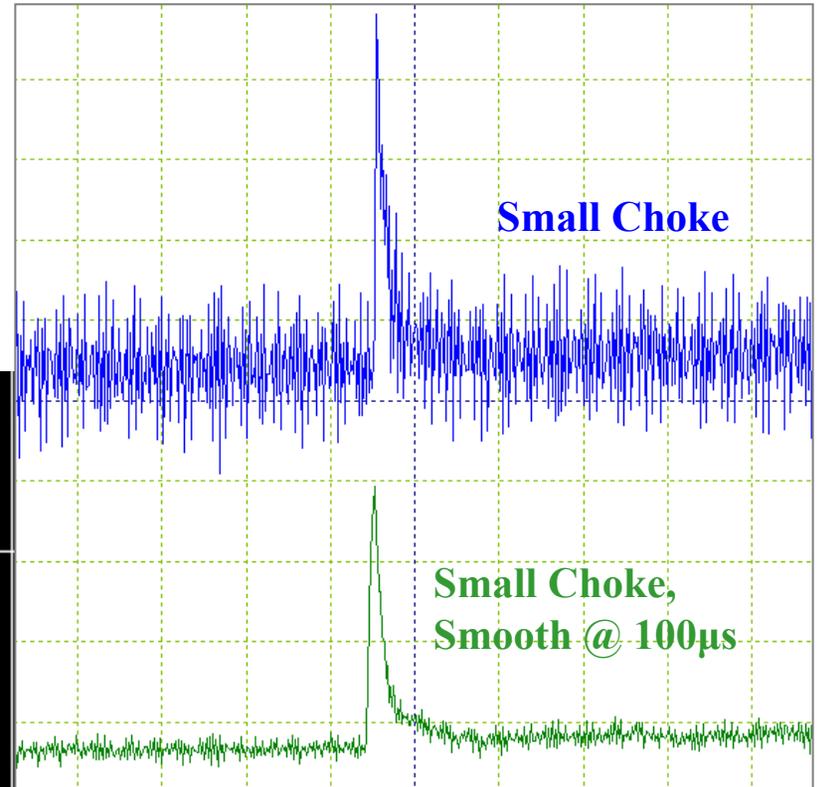


5 ms/div

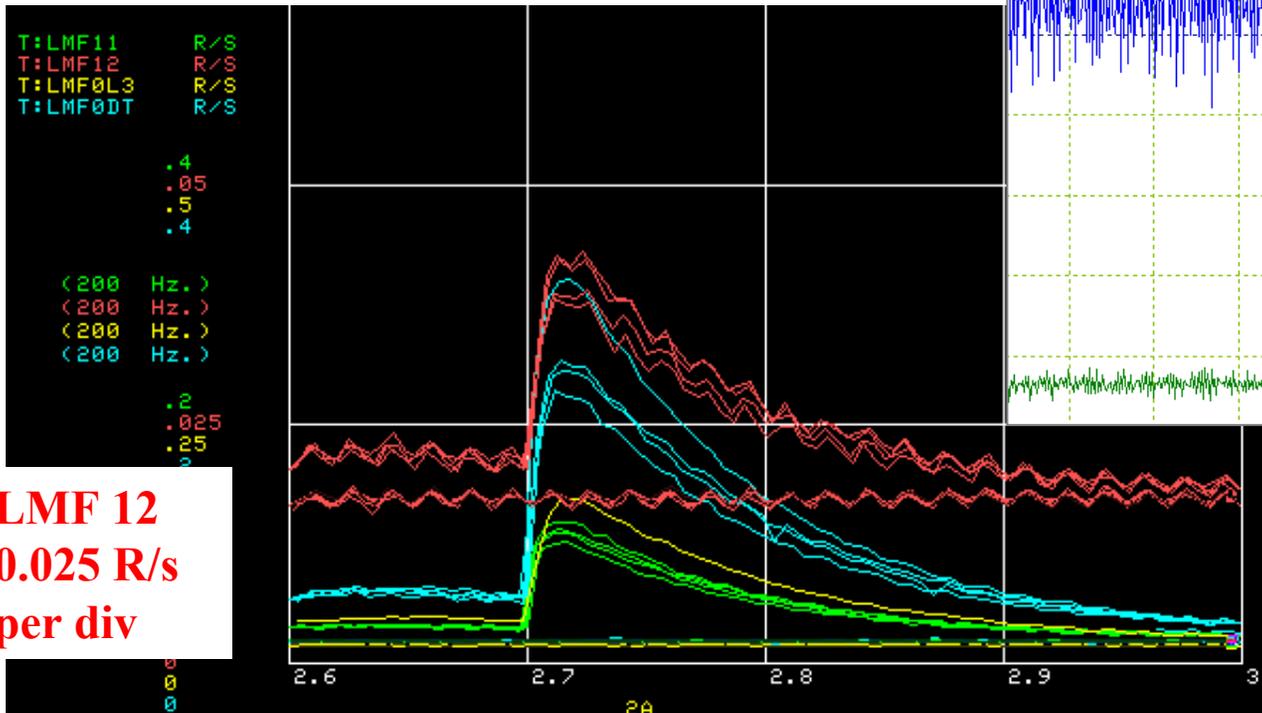
Proton Injection Loss During Shot Setup 8/22/04

LMF12: Old and New

~0.2pC/div
(per 20 μ s)



1 ms/div



100 ms/div

LMF 12
0.025 R/s
per div

Outstanding Issues

- **Specs**
 - Is this good enough?
 - Will schedule production review in ~April
- **Settings**
 - Machine states
 - Thresholds
- **Software, software, software**
 - Need detailed specs for software for Tev, MI and Booster
 - Have had preliminary discussions with Controls group