TeV BLM Review Introduction.

- Motivation for replacing present system:

=> *Requirements on replacement system*

=> *Motivation for architecture of proposed new system*

- Technology of proposed new system

- Features of Test Board

- Cost and Draft Schedule

From The Tevatron BPM requirements document: Beams Doc-554 v4 (10/03)

The Tevatron Beam Loss Monitor System serves the following functions.

to provide a signal to abort the beam in the Tevatron when the losses become unacceptable and threaten a quench. The signal must be provided both in case of a sudden loss and in the case of a continuous loss - see the system description for how this is handled in the present system.

to provide a diagnostic history showing the location of losses that may have caused a quench and the local/ring wide pattern of losses for 1 second before the quench.

to provide loss information to allow aperture scans and other studies to proceed without quenching the Tevatron and to allow accurate determination of apertures. This includes the ability to plot the loss information of each BLM using the fast time plot (FTP) facilities of the Beams Division control system.

more from The Tevatron BPM requirements document: (10/03)

Beam Loss Monitor Requirements

The present Tevatron Beam-Loss Monitor (BLM) system is considered to have satisfactory functionality by its users.[1]

Given this situation, the requirements for the BLM part of the BLM/BPM Tevatron upgrade are:

Any upgrade or replacement of part of the BLM system shall provide all the present functionality of the present system. (The Tevatron department may identify some obsolete features.) Key features include the dynamic range which is 4 decades, the capability to check the integrity of the hardware, the flexibility to mask out individual detectors for specific situations, and the large amount of application software to control and monitor the BLM system and display its data.

Any change in the way the BLM system communicates with the systems it serves (for example the way it provides data to ACNET, the signals it generates to abort the beam) must be agreed to by the people responsible for the systems served.

yet more from the Tevatron BPM requirements document: (10/03)

There shall be a functioning Tevatron Beam Loss Monitoring system for operations at all times except perhaps for unavoidable interruptions due to installation of the new Tevatron Beam Position Monitoring System. While there are some features which could be added to the present system and there are some motivations to replace twenty-year old electronics with modern components, the major consideration in any proposed replacement should be to ensure that a BLM system is available at any time that it is needed.

The long-term system requirement is that any proposal consider the next 6* years of Tevatron operation. In particular, a proposal to leave part of the present system as is should either state that this part of the system will stay as is for the next 6 years or give a schedule for a replacement project. This may lead to a staged project where the Multibus functionality is replaced directly while leaving the BLM chassis as is.

[1] For the record, additions to the system have been requested and include: 1) an application to store and compare BLM loss profiles in a manner similar to BPM profiles and 2) a programmable front-end capability to abort the beam on slow losses that would allow aborts at lower levels of slow loss than the present integrator time constant allows.

* *before BTeV go-ahead*

Current Situation.

BLMs are disabled (masked out at the Abort Concentrator) from pulling the abort once antiprotons are in the Tevatron - except BLM detectors at CDF and DZero where they *are* used to avoid damage to the silicon vertex detectors.

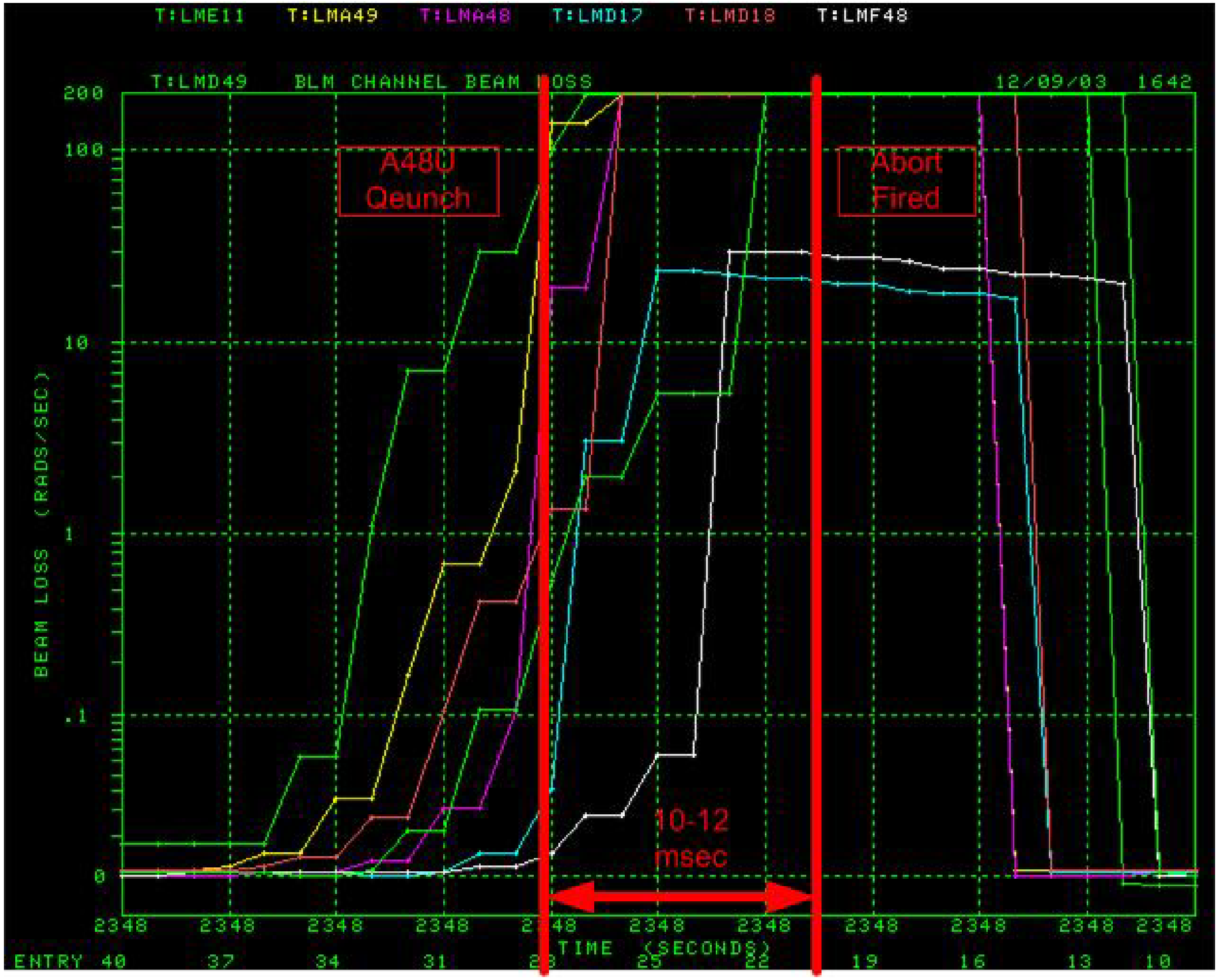
Rationale:

the Quench Protection Monitor (QPM) system (current bandwidth 16 Hz) will protect the magnets and, overall, it takes less time to recover from avoidable quenches than to replace the antiprotons lost through spuriously triggered aborts from the BLM system. *(This policy is under review for a limited enabling of some BLMs)*

Problem:

Nature finds a way..

Quench of Dec. 5th..



Loss Monitors are screaming and no-one is listening. By the time the abort is pulled, there is no beam left.

Technical Issues an upgrade needs to meet:

(want to emphasize that the present system (Shafer et al.) was very well engineered)

Robustness and Reliability – no missed aborts, no false aborts.

Flexibility in thresholds/masking capabilities for different machine states (present system can accommodate 2 states – low and high field – cf ~the 20 states of the Tevatron)

Accommodate the dynamic range and speed required for aborts (high end) and studies (low end)

Keep an eye on requirements of other accelerators served by these BLM systems, including the Main Injector and Booster.

Description of present Tevatron BLM system

The present BLM system has 4 parts:

The ion-chambers.

Glass, sealed Argon ion chambers which provide a current when traversed by charged particles - these are the loss detectors. Chosen by RHIC. **We are not proposing to change these.**

The BLM chassis which in the Tevatron contains:

up to 12 daughter cards with and lossy log amplifier/integrators.. rise time ~0.1 millisecond, decay time constant is 60 milliseconds The dynamic range is > 10,000.

alarm and abort generation logic and abort signal generation.

alarm and abort threshold setting logic and control logic to mask out specific channels

registers with alarm and abort status and self-check features for continuity and voltages

controllable HV supplied to ion chambers.

multiplexing ADC for the output of the log amplifiers;

External Device Buss (EDB) communication protocol with a control computer.

the provision to send signals after the integrator stage to MADC's.

We are proposing to change this.

The Multibus CPU which sets up the BLM chassis, reads the ADC and other data, stores a history buffer, talks EDB and communicates with the accelerator control system. The CPU controls the BLM chassis. The reference document from Al Baumbaugh is Beams Doc 764.
This is being replaced.

A set of console applications to control and diagnose the BLM system and display BLM data, both house by house data and ring-wide data in a convenient way, particularly on abort or quench.
We will maintain compatibility with these.

BLM upgrade picture;

Keep same architecture; detectors in tunnel, signal-processing electronics outside tunnel in a dedicated chassis which talks to a host computer in the BPM system that talks to ACNet.

Keep same radiation detectors: (provide appropriate signals, robust, available)

Redo signal-processing-and-control chassis

implement more flexible control and logic – (eg)

more thresholds to accommodate different machine states;

majority logic to avoid false aborts from a single BLM (not many cases);

Use modern signal processing electronics – (eg)

higher sampling rate ADCs;

provision of instantaneous and integrated rates on all channels

use FPGA directly on digitizer card to process

Maintain current chassis-host communication (EDB) with new BPM system host

Maintain compatibility with present display and analysis applications.

PPD has agreed that its Electrical Engineering Dept. (has a key builder of present system) will support the project.

Origin of Tevatron BLM readout system sensitivity specifications:

Note 5/17/81 of R. Shafer says:

limits for energy deposition in TeV magnets:

slow loss 8 milliwatts/gram — *fast* loss 0.5 millijoule/gram

slow loss 800 Rads/sec — *fast* loss 50 Rads

(1 Rad = 100 ergs/gram; 1 millijoule/gram = 100 Rads)

Range: 1% of quench level to 10 times quench level => range of 1000.

BLM detectors (glass-walled sealed ion chamber) see between 1/50 and 1/500 of the level into the magnet coil.. - the 1/50 is more consistent with measurements in left-bend tests.

Note 2/25/82 of R. Shafer says **1 Rad in BLM** gives **70 nC** charge out**.**

Upper *slow* limit **in BLM** set by 800/50 x 10 = 160 Rads/sec *(11.2 microamp)*

Upper *fast* limit **in BLM** set by 50/50 x 10 = 10 Rads (*700 nC)*

Lower *slow* limit **in BLM** set by Upper/(10,000) = 16 millirad/sec (*1.1 nanoamp*)

Lower *fast* limit **in BLM** set by Upper/(10,000 = 1 millirad *(70 pC)*

Present Tevatron System Parameters:

Note of R. Shafer 3/1/82 – logarithmic integrator electronics

full scale current = 10 microamps (130 rads/sec)
full scale charge = 1 microcoulomb (14 rads in 1 ms)
lowest scale current ~ 0.2 nA (3 millirads/sec)
lowest scale charge = 0.1 nC (1.4 millirad)

time constants; slow = 1/16 sec, fast = 20 microsecond

Quench of December 5th.

readout in rads/sec but really a fast event ~ 5 rads in 3 ms..

Philosophy of proposed scheme.

Apart from implementing straightforward multiple logic and threshold requirements.

Integrate and Digitize at adequate rate (50 kHz for Tevatron) with adequate sensitivity.
Construct appropriate digital sums with on-board FPGA.

⇒ system time-constants set by software;
⇒ allows application to different conditions, or accelerators, without redoing hardware.