# 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 and M&S cost
- Features of Test Board
- 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.

# TeV BLM Review Introduction

**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)*

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

*Beam Loss Monitor Requirements*

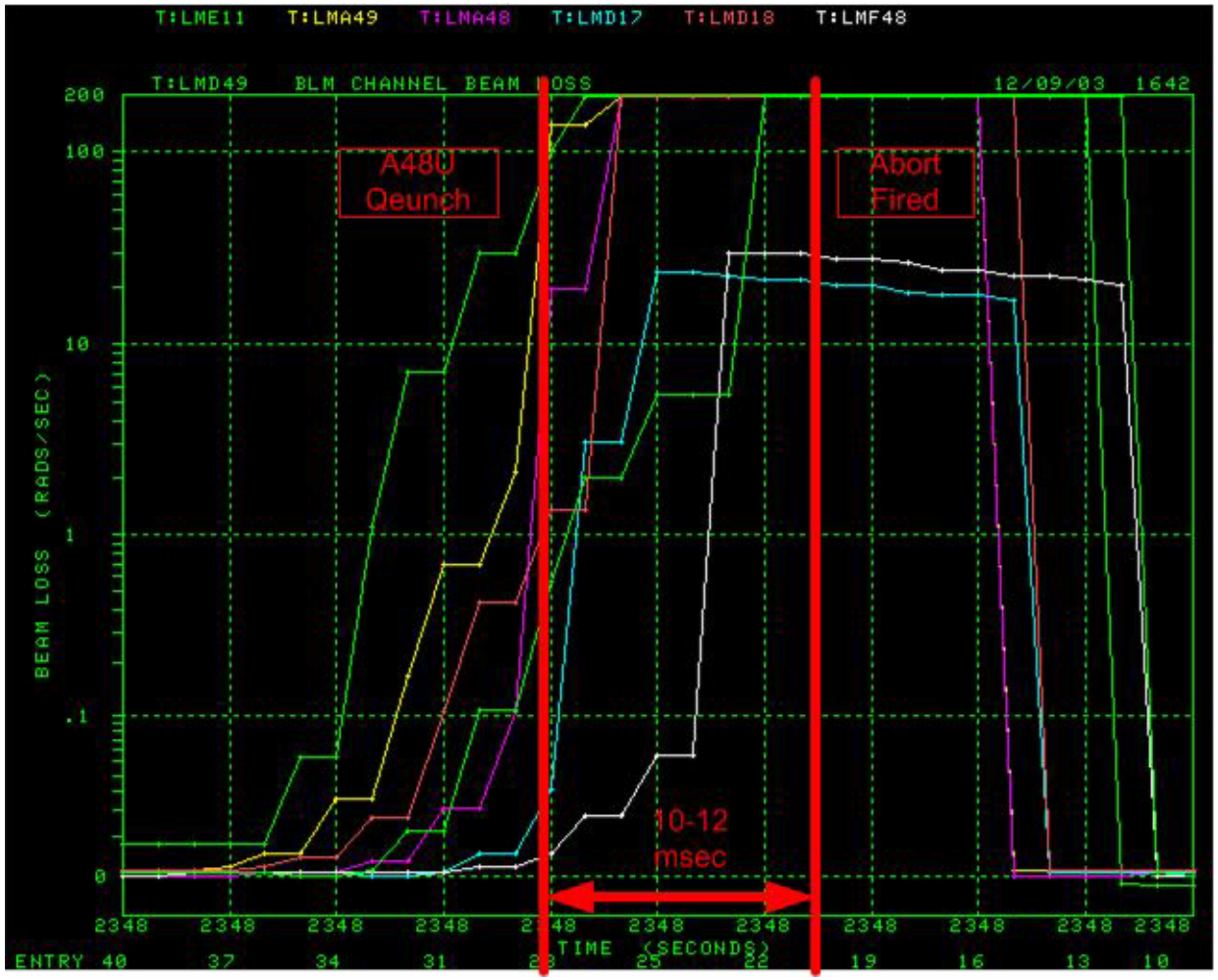
The present Tevatron Beam-Loss Monitor (BLM) system is considered to have satisfactory functionality by its users….

The long-term system requirement is that any proposal consider the next 6* years of Tevatron operation.

Then we suffer the quench of December 5th.

(* *before BTeV go-ahead)*

# TeV BLM Review Introduction




Quench of Dec. 5th

Courtesy of Dean Still

Loss Monitors are signalling but they are ignored. By the time the abort is pulled, there is no beam left in the machine.

# TeV BLM Review Introduction

## *Situation has changed*.

The functionality of the Tevatron BLM system is **no longer** considered satisfactory.

**Two mandates**.

From Dec 5th Incident:

produce a BLM system that can be used to abort the Tevatron reliably (ie without missed aborts) and robustly (ie without spurious aborts)

⇒ ***identify limitations of present system and consider new one***

From DOE Review of Feb 2004:

expectation that Fermilab will use common new BLM system for Tevatron and Main Injector in NuMI era.

⇒ ***encourages us to pursue a comprehensive approach***

# TeV BLM Review Introduction

**Technical Issues an upgrade needs to meet:**

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

***Flexibility in thresholds/masking capabilities for different machine states.***

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

***Accommodate requirements of other accelerators served by the BLM systems, the Main Injector and Booster, for loss information throughout the cycle.***

# TeV BLM Review Introduction

Weak points of existing BLM system(s).

There is no multiplicity requirement to reduce spurious triggers; this inhibits people from enabling BLMs in the abort.

Tevatron system can accommodate only two threshold settings which precludes covering the full range of operational states of the Tevatron.

Provides only one integration interval for losses – particularly awkward for use in fast cycling machines (Booster and Main Injector) where losses (will) affect operation and we need to understand losses throughout the cycle.

While the accelerators uses a common BLM chassis and communication protocol, each machine requires its own hardware signal-processor cards. Any new signal-processing requirement involves new hardware.

*I want to emphasize that this is not to criticize the present system (Shafer et al.) which was very well engineered and has given heroic service.*

# TeV BLM Review Introduction

The system proposed here is capable of measuring relatively small losses over short and long intervals, and it can cope with large losses. It can provide data describing losses with good time and rate resolution over a large dynamic range. It stands a good chance of dealing with new requirements without new hardware.

The scheme is conventional - condition the input signals a little, digitize at appropriate rate, process the digitized data with on-board FPGA.

The different abort types (4) are in response to a direct request. The number of states provided for (64) allows the number of Tevatron states to go from its present ~25 to beyond 32.

# TeV BLM Review Introduction

One could imagine that a less powerful system than the one proposed would satisfy the Tevatron requirements – for example that it would be acceptable to have machine states where the BLM system is not enabled and that the variety of data the system can provide is not needed.

I am not sure that the latter suggestion is valid, even for the relatively slow Tevatron cycle. However, my point of view is this.

***If we are going to invest in building a new system, it should be capable of dealing with the issues that the Main Injector and Booster face. In the NuMI era, the Main Injector will face the same radiation issues that presently affect Booster operations. It needs adequate information from the BLM system to understand and control losses. If we do not do this, Run II, while not the major consumer of protons, will suffer - together with the rest of the Laboratory program.***

# TeV BLM Review Introduction

## General Approach

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 which talks in turn to ACNet.

Keep same radiation detectors: (robust, available, chosen by RHIC)

Redo signal-processing-and-control chassis

*more thresholds to accommodate different machine states;*
*majority logic to avoid false aborts from a single BLM;*
*larger dynamic range and faster sampling rate ADCs;*
*provision of instantaneous and integrated rates on all channels*
*put processing power (FPGA) directly on digitizer card*

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. will support the project. This gives access to engineering, layout and fabrication/assembly support.*

# TeV BLM Review Introduction

Tevatron BLM readout system sensitivity specifications:

*Note of R. Shafer 5/17/81 re* : limits for energy deposition in TeV magnets:

*slow* loss 8 milliwatts/gram = 800 Rads/sec *(1 Rad = 100 ergs/gram;*

*fast* loss 0.5 millijoule/gram = 50 Rads *1 millijoule/gram = 100 Rads)*

BLM detectors see between 1/50 and 1/500 of the level into the magnet coil..
- the 1/50 is more consistent with left-bend tests. (R. Dixon)

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

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

| | | |
|---|---|---|
| Upper *slow* limit **in BLM** | = 160 Rads/sec | *(11.2 microamp)* |
| Upper *fast* limit **in BLM** | = 10 Rads | (*700 nC)* |
| Lower *slow* limit **in BLM** | = 16 millirad/sec | (*1.1 nanoamp*) |
| Lower *fast* limit **in BLM** | = 1 millirad | *(70 pC)* |

# TeV BLM Review Introduction

Present Tevatron System Parameters correspond to these:

*Note of R. Shafer 3/1/82* – logarithmic integrator electronics
full scale current = 10 microamps (140 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.

labelled Rads/sec but really a fast event of~ 5 Rads in 3 ms..

# TeV BLM Review Introduction

**Summary of proposed scheme.**

Implement multiplicity logic and multiple threshold requirements for Tevatron.
Maintain sensitivity and dynamic range (16 bit ADC).
Integrate and Digitize at adequate rate
(~ 50 kHz for Tevatron, 12 kHz for Booster, ~89/N kHz for MI )
Construct appropriate digital sums in digitizer with on-board FPGA.
$\Rightarrow$ system time-constants set by FPGA software;
Hosted by the BPM master.

Allows application across the full complex and accommodates new requirements without redoing hardware.

# TeV BLM Review Introduction

Cast of characters:

A.Baumbaugh (PPD/EED)
C. Drennan (AD/BD)
K. Knickerbocker (PPD/EED)
J. Lewis (PPD/CDF)
A.Marchionni (AD/MID)
C. Nelson (PPD/EED)
M. Olson (AD/ID)
S. Pordes (AD/HQ)

We are maintaining close contact with the TeV BPM project re the ACNet hosting. Bruce Hanna is our Tevatron Dept. contact.

# TeV BLM Review Introduction

What would we like to ask for coming out of this review…..

Have we understood Tevatron range and time requirements?
Have we missed something?

Endorsement of test board process.
Endorsement of crate test.
Endorsement of general architecture.

Wisdom on design choices and space constraint assumed.

Support for considering MI and Booster requirements in detail.

# Description of present Tevatron BLM system

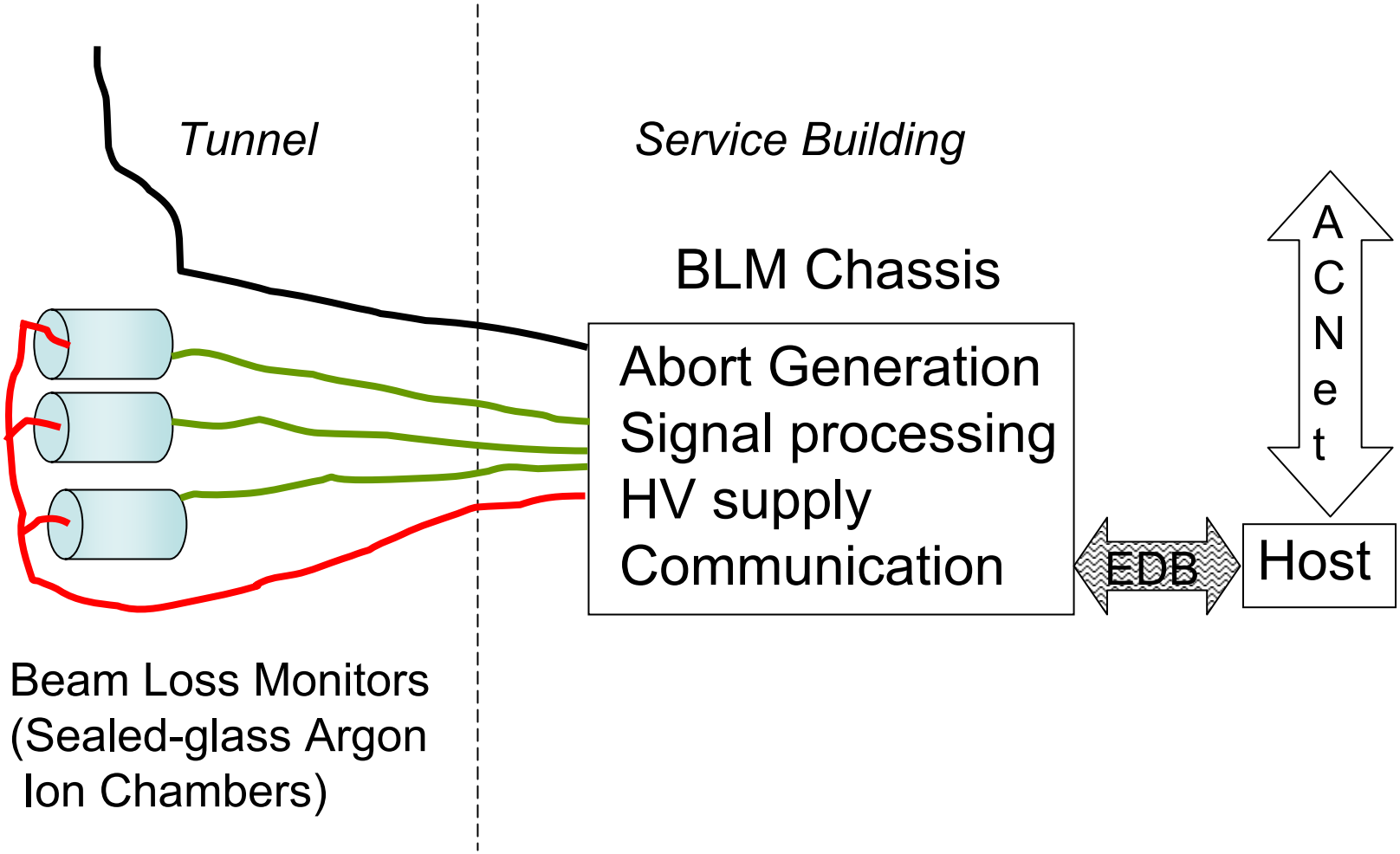
The present BLM system has 4 parts:

***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.**


Tunnel
Service Building
BLM Chassis
Abort Generation
Signal processing
HV supply
Communication
EDB
Host
ACNet
Beam Loss Monitors
(Sealed-glass Argon
Ion Chambers)