LHC Beam Loss Monitoring System

LHC Beam Commissioning Workshop
19-20 January 2010

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Contents

1. **Acquisition**
2. **Threshold Values**
3. **Processing**
4. **Applications & Databases**
5. **Reliability**

Section 1:

ACQUISITION

Offset Level

Relevant for:

- Minimum detectable signal or
  Sensitivity of loss measurements
- False triggers – LHC availability

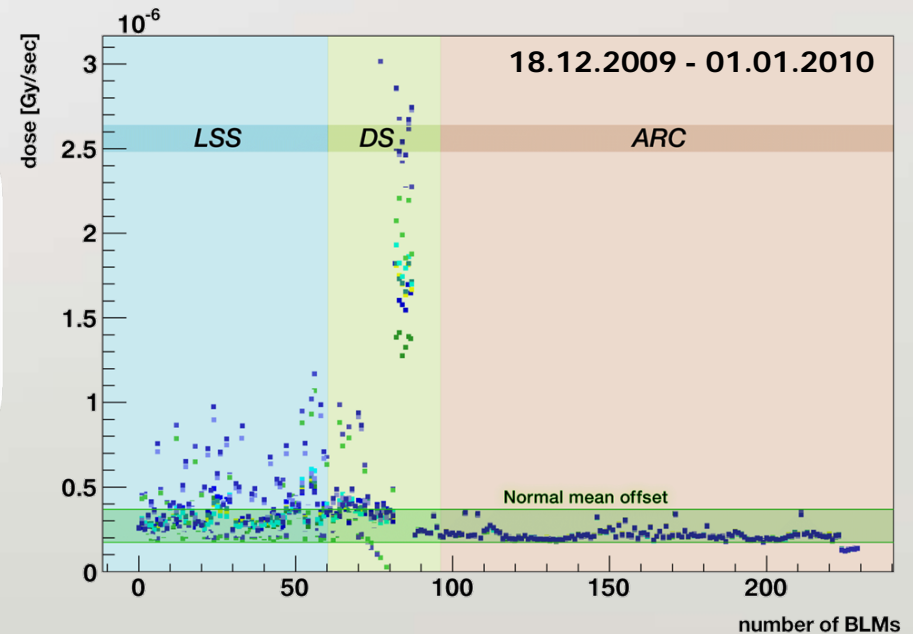**Mean offset values for all IC monitors**

1 hours of data – 18/12/2009

Offset [pA]	% of total	Comments
1-8	6.91%	Too low (problem has been identified)
10-20	77.71%	Very good
20-30	6.83%	Good
30-80	3.28%	High (DAC reset needed)
>80	5.00%	Problematic
=0	0.28%	no data (faulty cards/connections)

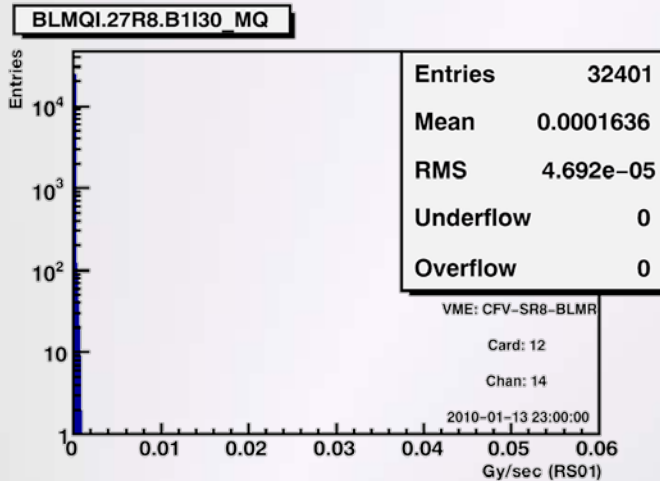Mean Offset Level in R3 (RS09)
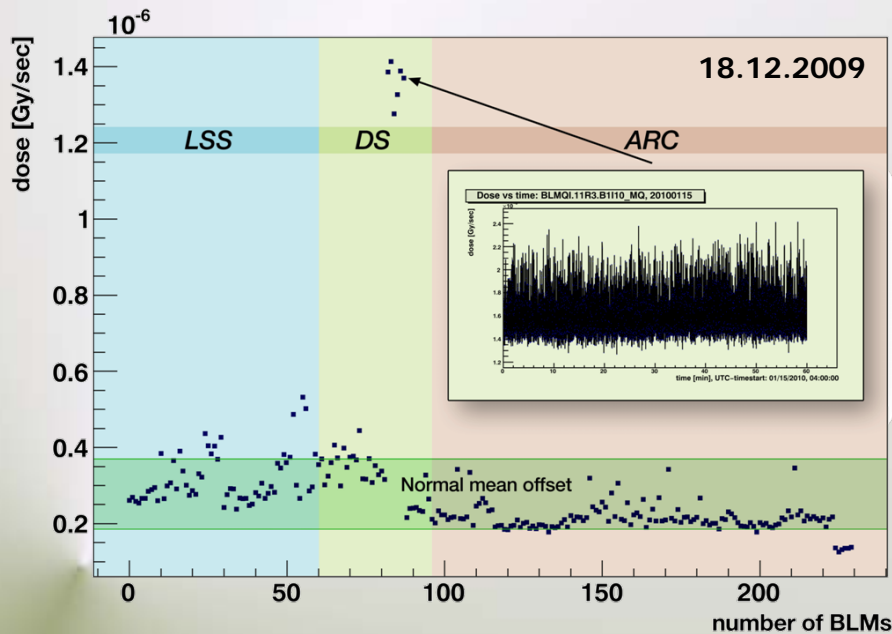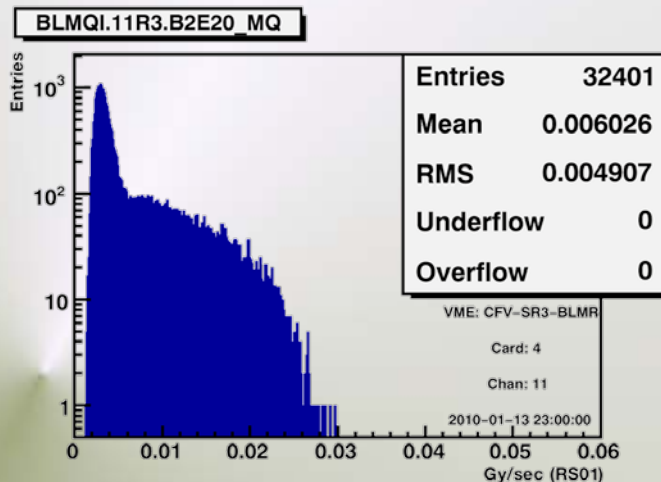

Time evolution of Offset Level in R3 (RS09)

Noise Level

Single channel frequency distribution:

Noise on short cable (RS01)

Noise on long cable (RS01)

Noise in RS01 for all IC monitors
9 hours of data; maximum values – 13/01/2010

Noise [BITS]	Monitors	% of total	Comments
1-30	1083	30.1%	very good
30-100	1646	45.7%	good
100-200	600	16.7%	ok
200-300	201	5.6%	candidates for problematic channels
> 300	54	1.5%	critical noise (channels to be repaired)
= 0	18	0.5%	no data from 3 cards

Several cables have been exchanged
- some of them 800m long
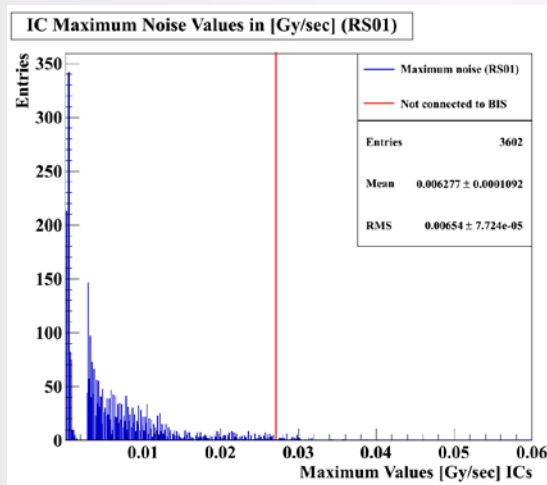- Installation consists of 3 batches from different manufacturers

Expected noise reduction
- Standard cables is factor 2
- New cables is > factor 5 (single pair shielded)
Mid-term plan use new type of cables

Noise Level

Max. noise value frequency distribution:

Ionisation Chambers (3602)

Secondary Emission Monitors (302)

Noise in RS01 for all IC monitors
9 hours of data; maximum values – 13/01/2010

Noise [BITS]	Monitors	% of total	Comments
1-30	1083	30.1%	very good
30-100	1646	45.7%	good
100-200	600	16.7%	ok
200-300	201	5.6%	candidates for problematic channels
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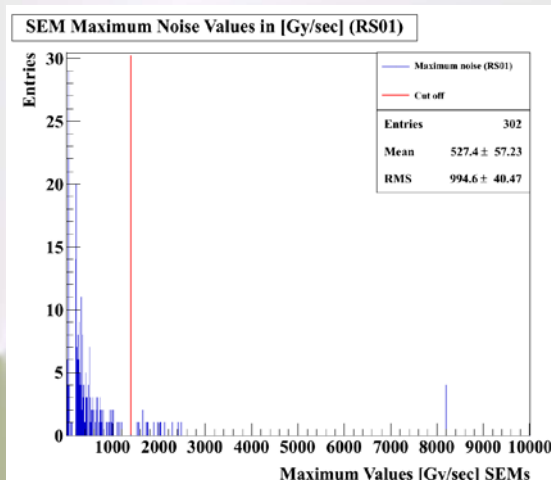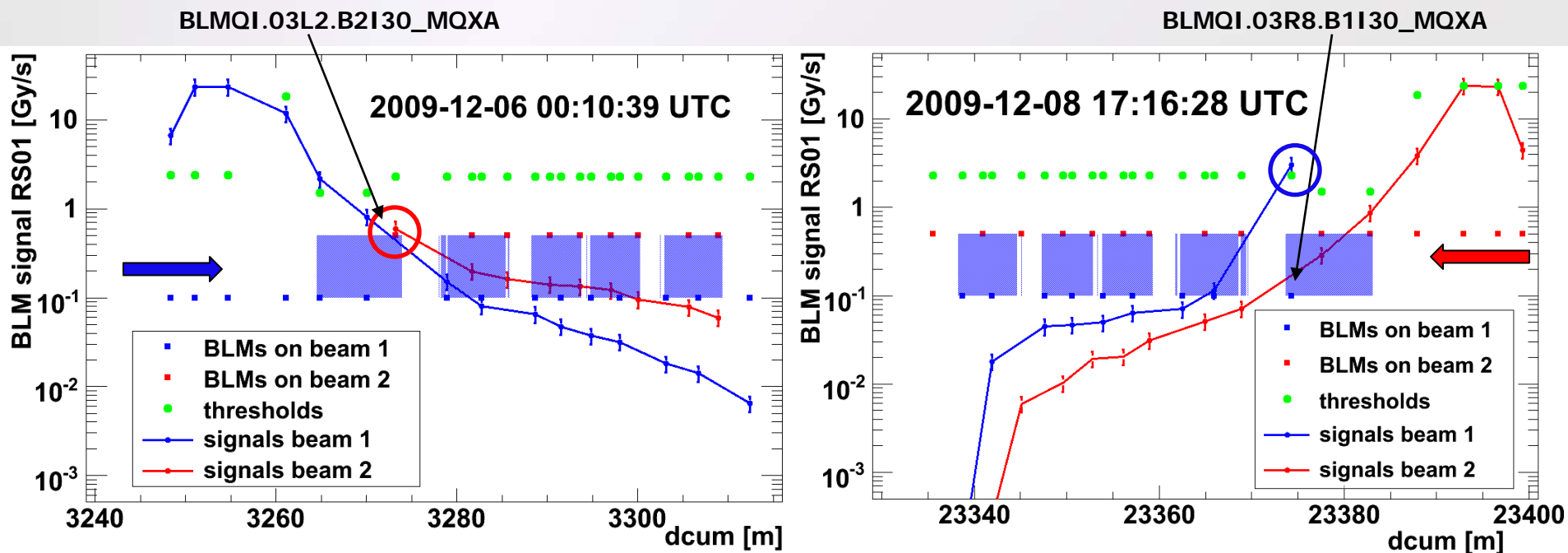Mid-term plan use new type of cables
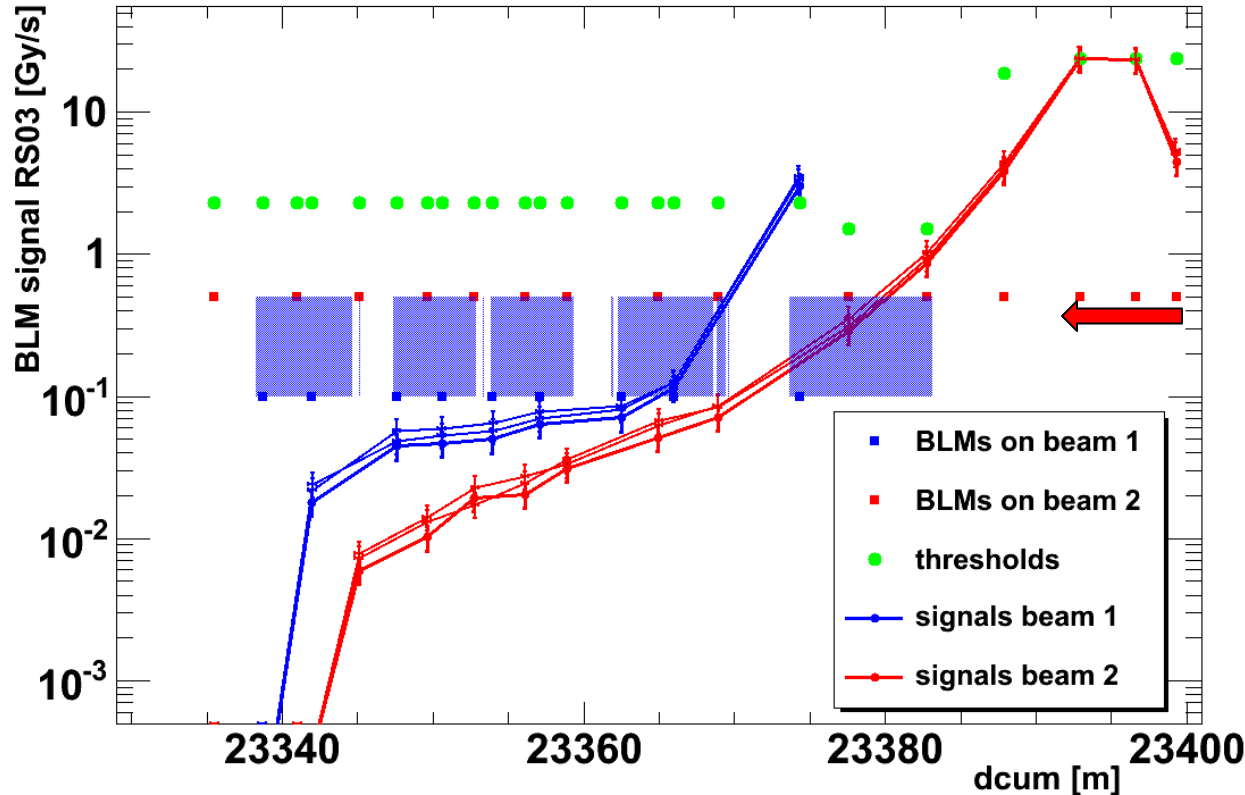
Over-Injection problem

Problem consists of losses at the LHC TDI and exceeding thresholds at the MQXA

- Some small difference between injected beams
- Installation has been verified to be correct.

Over-Injection tests

Extensive tests done (with beam 2):

A. Over-injection, TDI open, 2e9 proton
B. Injection on closed TDI (+- 3mm), kicker off
C. Injection on closed TDI (+- 3mm) and TCTV (upper jaw -6 mm, down jaw -12 mm)

- No significant difference observed

- Most probably losses come from outside the cryostat

Over-Injection Solutions

- Spread the signal by hardware means
    - installation of an additional capacitor

- Add shielding
    - most favourable
    - needs simulations

- Last year's test with threshold values set over the maximum allowed limit is not a safe solution.

Ongoing Modifications

- Some acquisition cards need to be exchanged
  - Cards affected ~ 4%
  - Too low offset current

- Interconnection boxes
  - Ionisation of the air inside the box measured
  - Adding better isolation to all SEM

- Global reset of cards not reliable
  - Cards affected ~ 5%
  - Expected to get some improvement with WorldFIP; uncertain on WorldFIP reliability under radiation
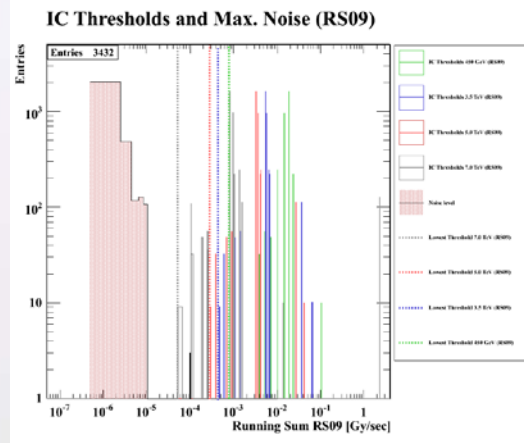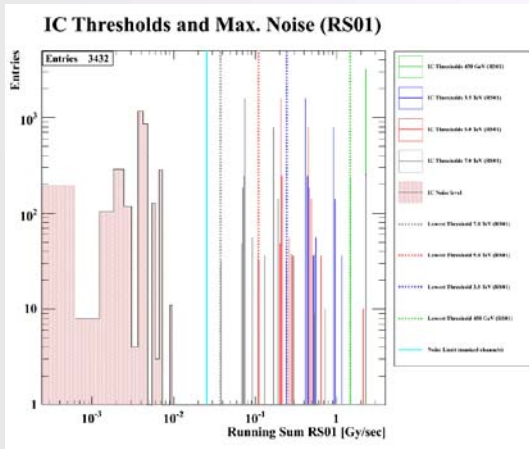 - Currently only point 6 has been connected.

Section 2:

THRESHOLD VALUES

Thresholds & Noise

Frequency distribution of the maximum noise values over 14 days for each channel
(starting from 18-12-2009)

All Ionisation Chamber monitors except on collimators (= 3432)
Threshold values are **MASTER * 0.1** (i.e. default monitor coefficient)

- No significant problems expected
- Some channels to be repaired

- Thresholds can be increased with no safety impact.

All Ionisation Chamber monitors on collimators (= 160)
Threshold values are **MASTER * 1.0** (i.e. maximum monitor coefficient)
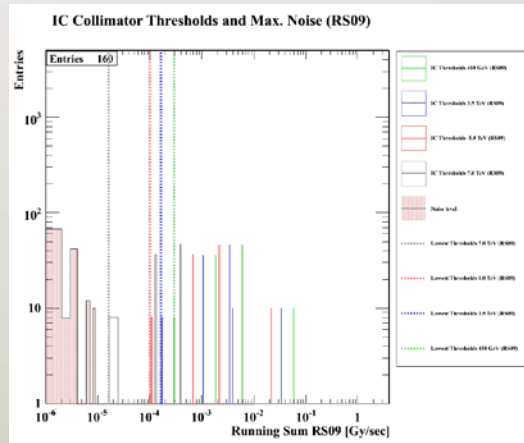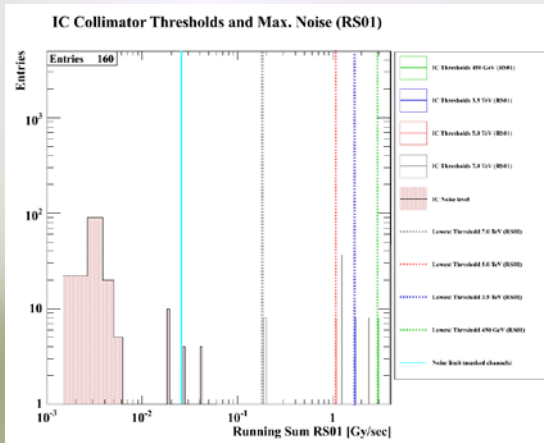
- Significantly lower values
- Thresholds cannot be increased using the coefficient.

- Recalculation of values will be done.

12

Threshold Values

No threshold values are missing

- There are some weak points
- Some precise simulations are missing

Tests for verification and fine tuning of the threshold values.

- transient losses with special nQPS
- steady-state losses with temperature sensors

More on the Chamonix talk.

Section 3:

PROCESSING

System latency

Analysed several Beam Dumps in detail.

Difference in time between the bunch at the MKI and the break of the beam permit loop (by the BLMS) recorded at the BIC was always between **100** and **130 µs**.

- Time of flight:
    - MKI => monitor = **10 µs**
    - monitor => acq. electronics (0.5 km cable) = **3 µs**
    - Acq. => processing electronics (1 km fibre) = **3 µs**
- Detection of change in frequency in the daisy-chain = **5 µs**
- Integration in the acquisition electronics = 40 µs.
- Decision at the BLETC (for fast losses) is taken every 40 µs.
- Processing of data to decide < 1 µs.

System Self-Monitoring

Activation of all the self-monitoring processes:

- Acquisition operation state monitoring (8 cases)
- Configuration cross-check (one case)
- Data transmission between the tunnel and the surface installation (14 cases)
- Inhibit Beam Dump requests from cards not connected to BIS (2 cases)

Failed cases induce a beam dump

Example: Continuous checks on the data transmission between the tunnel and the surface installation:

Link A	Link B	ERR A	ERR B	Ignore CFC	CHOISE	Comment
0	0	0	0	x	LK_B	all ok (choice based on PCB properties)
0	0	0	1	x	LK_A	LK_B has errors
0	0	1	0	x	LK_B	LK_A has errors
0	0	1	1	x	Dump & LK_B	LK_A and LK_B have errors
0	1	0	x	x	LK_A	LK_B is down
0	1	1	x	x	Dump & LK_A	LK_B is down and LK_A has error
1	0	x	0	x	LK_B	LK_A is down
1	0	x	1	x	Dump & LK_B	LK_A is down and LK_B has error
1	1	x	x	0	Dump & LK_B	LK_A and LK_B are both down
1	1	x	x	1	LK_B	Both links down but CFC not present

Section 4:

APPLICATIONS & DB

Storage of Parameters

- Restructure of all databases:
    - **MTF** – remove BLMS architecture; keep only ref. measurements and components track history [ongoing]
    - **Layout** – become the entry point for updated or new connections or installations [ongoing]
    - **LSA** – reorganisation of tables to become more relational [done]

- Internal LSA DB Constrains will be reviewed

- Internal DB Check for disabled channels [in testing]
    - Based on monitor criticality and adjacent disabled channels
    - Each monitors is being tagged on its criticality
    - Current version only informs on rules violations

Data Concentration

- **Logging data**
  - Reason for losing packets still uncertain – investigation continues
  - Modification of CMW settings and Concentrator have improved the situation (positive side effect: FECs have stopped rebooting)

- **Capture data**
  - Temporary solution with "synchronised GET" seems to work
  - Will test more and return to 2048 samples

- **JMS broker** – new configuration and tests are foreseen

ALARMS

Warnings for the ALARMS consoles to be added:

- System Check is ON-GOING
  - concentrated from all checks
- Timeout from last System Check - TEST MANDATORY
  - MCS online, Connectivity, Beam Permit, …
- System Check has failed
  - console should give some details on actions

- System has requested a Beam Dump.

Data Displays/Applications

- **Most applications ready.**
    - Fixed display,
    - Capture display,
    - Monitor factor editor, …

    Minor to no changes expected

- **Status application**
    - Main parts ready – still several parts missing
    - Need usability update for OP

    Ongoing

- **Management application**
    - Only GUI, missing code

    Lower priority

- **Post-Mortem modules update**
    - Adding some more variables (mainly statuses).
    - Adding more functions and better decoding of data.
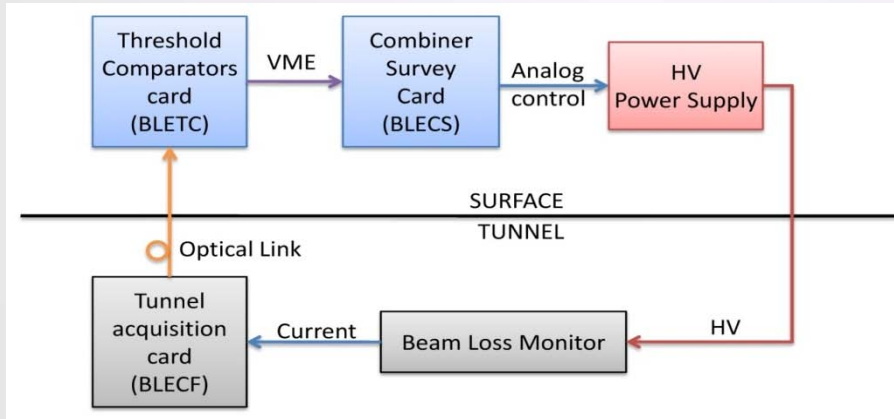
    Ongoing

Section 5:

RELIABILITY

Automated checks

- **MCS Online check**
  - Verify consistency of parameters

  One minor bug pending

- **Connectivity (HV Modulation) check**
  - Verify monitor connections

  Finalising

- **Internal Beam Permit check (BLETC -> BLECS)**
  - Verify the ability of each card to trigger a dump

  Completed

Will activate in the firmware the enforcing of the agreed periodic run of those checks by the Sequencer.
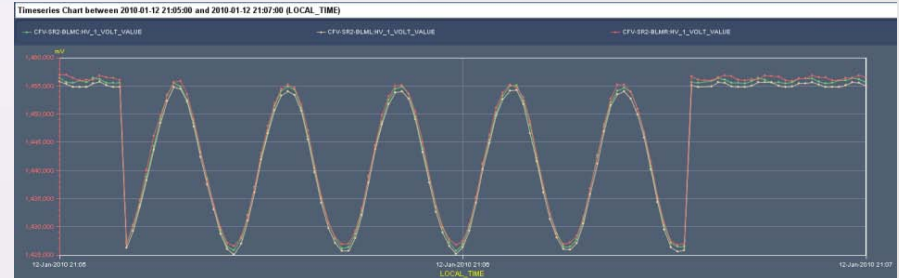
- **External Beam Permit check (BLMS -> BIS)**
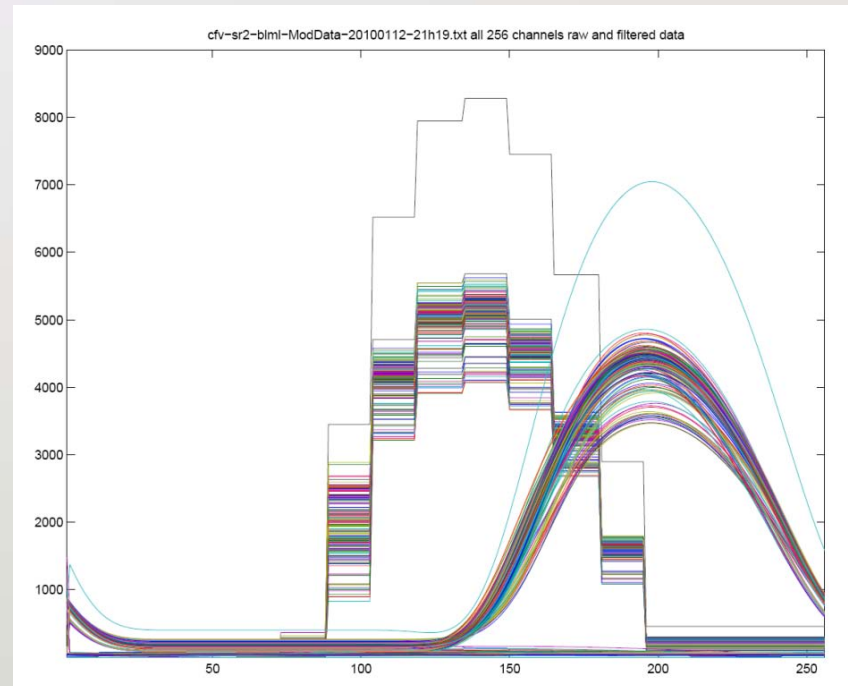 - Verify connection to BIS

  Completed

Connectivity check

View on the LHC BLM system for the connectivity check.

The high voltage power supply to the monitors is modulated with a 60mHz 30V sinusoidal signal.

A. A current on the monitors is generated by the HV modulation and detected by the normal acquisition system of the BLM.
B. The combiner card uses the running sum (RS09) from the threshold comparators to determine the amplitude and phase of each monitor (256 per crate).
C. This results are send to the Logging DB and compared to thresholds to permit or block the next injection if a non conformity is detected.
D. The signals of each monitors are stored (in the SRAMs) (see right plots) to be read on demand with the diagnostic application (under development).
E. The thresholds (called internal parameters) are unique for each monitor. They are calculated out of multiple measurements by analysing the data in the Logging DB.

View of the SRAM data containing the original (stairs) and filtered RS09 data of each channel for one crate.

System Verification Tests

A. Automatic extraction from DB + human inspection
(repeated daily or weekly)

- Frequency distribution of channel noise
- Optical links degradation

In the future will run inside the DB

B. Automatic on Vertical Slice Test system
(before releasing new firmware)

- Exhaustive Threshold triggering tests (also used in LHC)
- Reception and Status tests
- Linearity, impulse, and some predefined patterns of input signals check
- …

SUMMARY

Summary

- BLMS removes correctly the BEAM PERMIT signal if measurements are over threshold.

- No reliability issues observed.

- System is well understood since it has been up and running for more than a year.

- Some availability issues (false dumps) at energies higher than the injection are to be expected if thresholds don't change in some regions.

- Continuous monitoring of noise is required.

- Sequencer initiated tests will be enforced to be run regularly.

- More tests to verify and adjust the threshold values are needed.

- Investigation of spurious signals from the SEMs are ongoing and first corrections are being implemented.
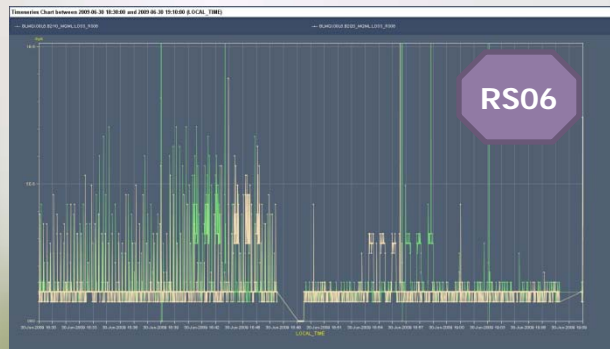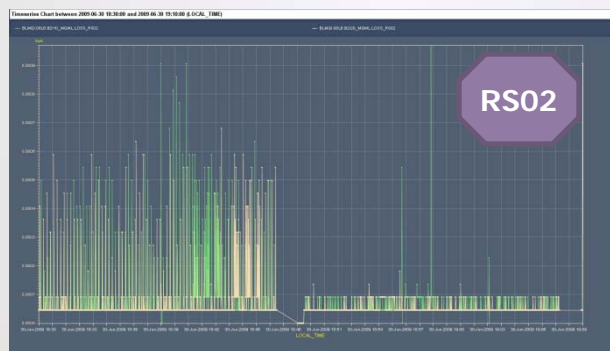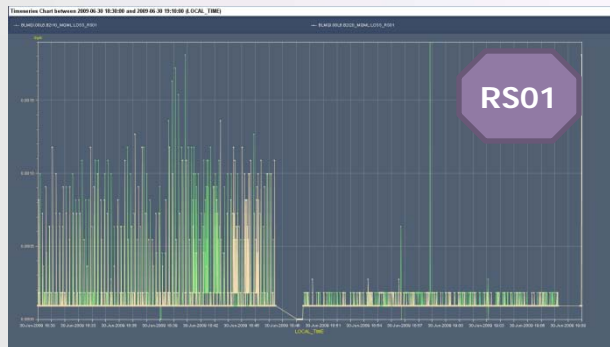
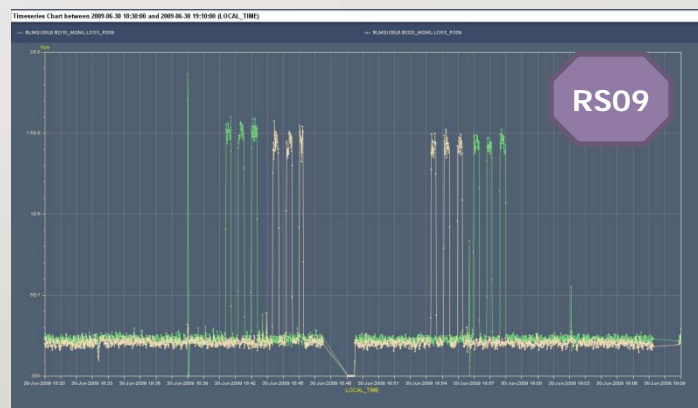# RESERVED SLIDES

System overview
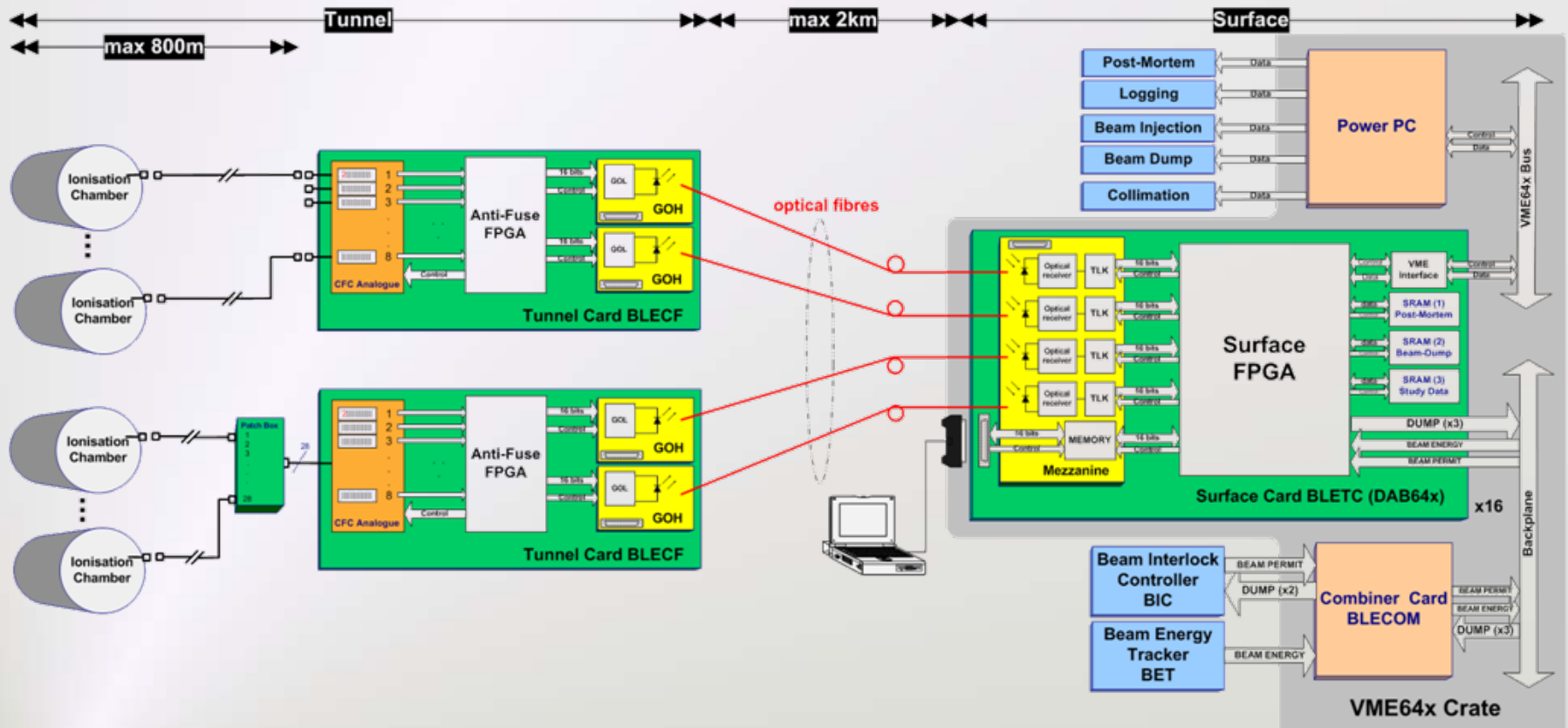
New noise reduction algorithm

Additional digital filter to reduce "noise" from the ADC circuit.

- Safe; operates only when losses are very small
- Verified to be correct; operational in 2009.

RS01

RS02

RS06

Rad Source Measurements with different firmware

OLD → ← NEW →

RS09

Variables Update

- Displays should be driven as much as possible by the electronics.

    - Avoid wrong information on the displays

    - Candidates for inclusion:

        - ChannelMask flag

        - IsCableConnected flag

        - IsConnectedtoBIS flag

- Provide a bit encoded variable for the reason of the Beam Dump Request.

    - Final details of request is being discussed

Expert Applications

- **Management of parameters (Expert Threshold App)**
  - Disabling and masking of channels
  - Configuration of mobile monitors

    Next weeks

  - Pass complete login info to DB
  - Connect using LSA DB API
  - Roll-back on history

    Next months

- **Diagnostics of misbehaving channels (for when checks fail)**
  - expert tool initially but later will hand over to OP.

Other Known Issues:

- PM/XPOC data are some times wrongly decoded [Firmware]

- PM data channels that have been over threshold remain in history [FESA]

- MCS fails always the first time [CO and FESA]

- Collimator beam based alignment will not be available for this year [Collimation and BLM]

Beam Permit Lines Check

- The internal beam permit check verifies the ability of each BLETC to remove the beam permit.

  A timer ensure that this check is done at least every 24 hours (just before the connectivity check)

- The external beam permit check verifies that the BIS (CIBUS interface) receives correctly the beam permit signal.

  These lines are under the responsibility of the interlock system. A BLM interface is available to control these lines. Regular checks are foreseen.

Daisy chain from TC1 to BLECS — BLM Crate 1

BLETC N 1 → BLETC N 2 → BLETC N 16 → BLECS

BLETC N 1 → BLETC N 2 → BLETC N 16 → Last BLECS

BIS network

CIBUS Unmaskable

CIBUS Maskable

Daisy chain of BLM crates (up to 4) from BLECS1 to CIBUS