MP Internal review, 17-18 June 2010 Summary

http://indico.cern.ch/conferenceDisplay.py?confId=97349

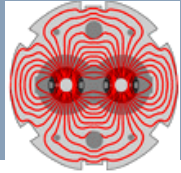
Programme

- Beam Interlock System, Bruno Puccio
- SMP, Benjamin TODD
- PIC, WIC and FMCM, Markus Zerlauth
- LBDS, Jan Uythoven
- Collimation, Ralph Assmann
- Transfer and injection, Verena Kain
- Dump protection, Wolfgang Bartmann
- BPM system, Rhodri Jones
- Orbit feedback, Ralph Steinhagen
- RF frequency and power interlocks, Andrew Butterworth
- BLM system, Bernd Dehning
- Software Interlock System, Jorg Wenninger
- Experiments, Massimiliano Ferro-Luzzi
- OP review summary, Mike Lamont
- Post-mortem system, Markus Zerlauth

Beam Interlock System - B. Puccio

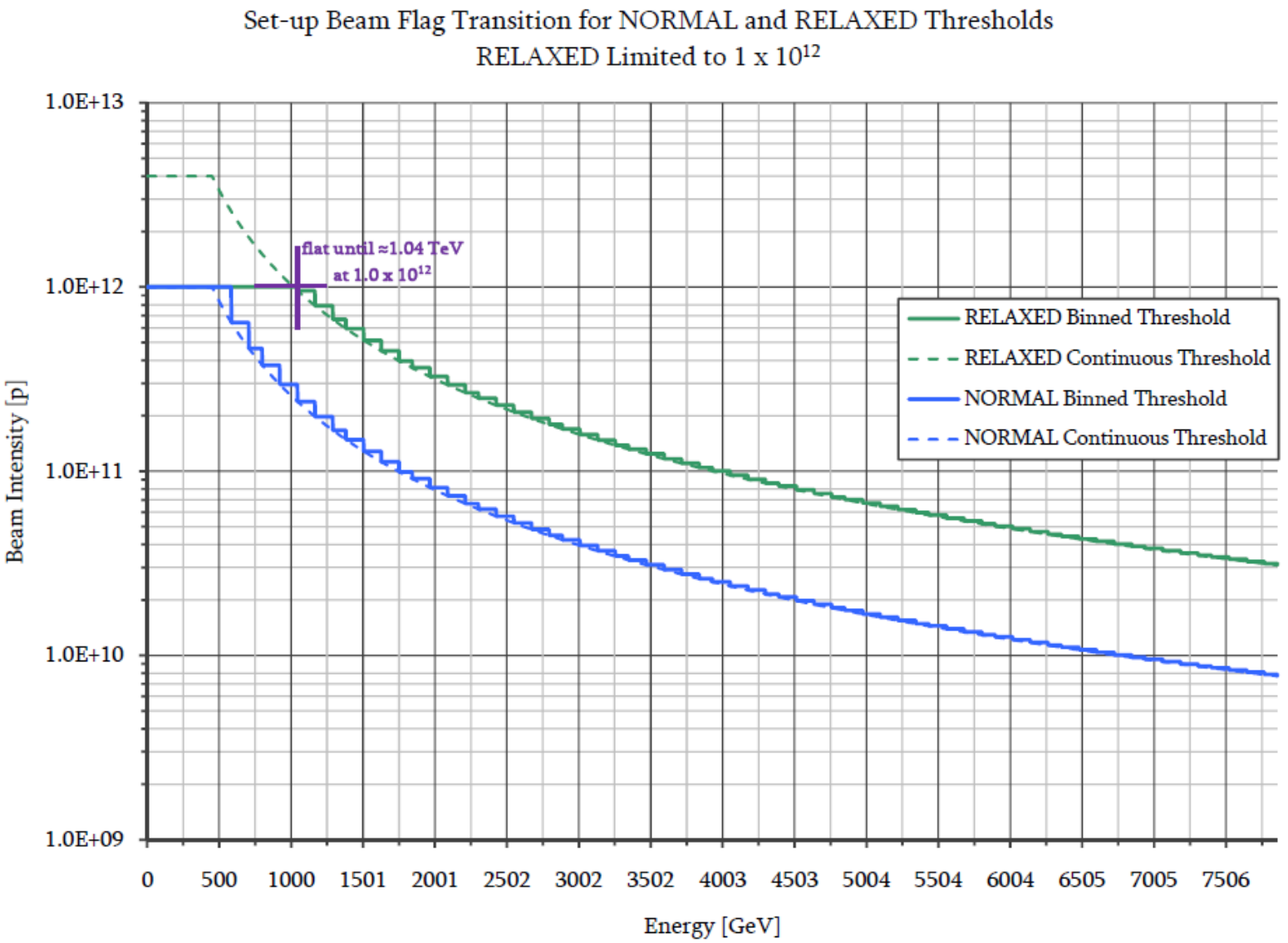
- No critical failure was observed
- VME bus controller board failures - availability
  - Lost of diagnostics, no re-arm possible (no loss of safety)
- Redundant power supplies - availability
  - Few failures but never caused a beam dump (by chance)
  - Installed on same “reglette”, to be modified
- Automated connection tests with users - safety
  - BLM, BTV, PIC, WIC, FMCM done
  - Vacuum, experiments etc. to be added
- Beginning of the ramp – operation - safety
  - Safe Beam Flag to FALSE and unmask all inputs (sequencer)
  - Will be done in the near future
- Radiation – longer term
  - BIC crate in UJ56 will be moved to USC55, other crates could move to surface
  - User interface: moves with the user, should be radiation tolerant
  - Redundancy ensures safety

SMP - B. Todd



- Without SMP – masking would be a disaster (lack of discipline)
- Energy distribution check, since there is no redundancy in the SMP – safety
  - SIS check of consistency with current read from RBs at 0.5 Hz
  - SIS check of BLM energy consistency at 0.5 Hz
  - Checks the entire system including every BLM crate
- Intensity for SBF - safety
  - No redundant readings, one DC BCT system for the moment
  - Will become less critical when Safe Beam Flag to FALSE at start of ramp
- SBF limit – MPS commissioning / availability – safety
  - Possibility to increase x 4 the limit for a limited duration (experts only), design ongoing and EDMS document drafted
  - Acceptable since this is only used during specific tests

SBF – nominal & relaxed

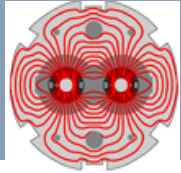


to be discussed for 7 TeV what to do…. but this is not urgent

SMP - B. Todd

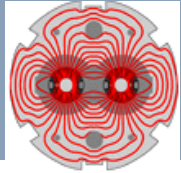
- Beam Presence Flag / availability
  - Denial of service for diagnostics due to noisy input. Filter ready for implementation
- Beam Presence Flag – change of source - safety
  - Now uses the FBCT, too complex for providing a safe system soon
  - New BPF signal source based on sum signal from BPMs, to be commissioned in September in collaboration with BI (Marek Gasior)
- New release of SMP to be done during July technical stop
  - At least 2 shifts of tests to be foreseen after the technical stop.
- New SMP version for 2011
  - Full redundancy on the hardware level
  - Monitoring of timing telegrams

PIC, WIC and FMCM – M. Zerlauth



- PIC - excellent dependability due to thorough HWC
  - In 2010, 55 dumps from the PIC (10% of total)
- After technical stops and interventions the traceability of changes and required testing must be documented –'sloppy' as compared to HWC - safety
- PIC configuration - safety
  - Automated tests of configuration and BIC connection to be performed more regularly (3-4 hours for full machine)
  - Some circuit trips do not dump beam (RCD, RCO, ROD, RQS, RSS and 60A COD)
- FMCM
  - Very sensitive to electrical disturbances
  - Beam dumps in general justified – no change of threshold should be made since we plan for more intensity

LBDS - J. Uythoven

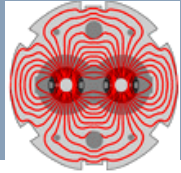


- No asynchronous beam dumps until now, no other (major) faults when dumping the beams
- XPOC
  - Total false XPOCs 92, improving
  - 'False' XPOCS mostly due to beam in abort gap
  - In the future, reset for beam in abort gap can be done by EIC
  - Reliability of some beam instrumentation data not good enough
- Technical stop modifications - safety
  - What needs to be redone? Procedures after interventions are required
  - Improved check after exchange of generator are required (extensive tests initially, but changes during operation are an issue)
- Interlocked beam position monitors - safety
  - Threshold and algorithms needs to be addressed
- MSD septum calibration improved
  - More improvements possible for 450GeV (measurements of MSD, hysteresis, …)

LBDS – J. Uythoven

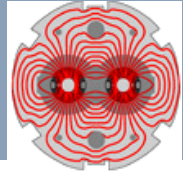
- External reviews
  - Faulty timing transmission
  - FPGA code review and test bench
- Internal review of LBDS
  - 14 actions with MP repercussions, 8 done, 3 in progress, 3 to be addressed
  - BLM tests, need to be analysed, some more tests needed
  - Set-up TCSG/TCDQ
  - BLM calibration
- During the time with few bunches with nominal intensity
  - BLMs with a direct link to the beam dump (not using the BIC) to be commissioned
  - Abort gap monitoring / cleaning to be commissioned

Collimation – R. Assmann



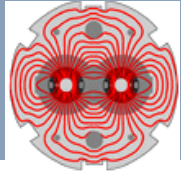
- Collimation system provided excellent cleaning and protection functionality
  - All tests done, list of all tests are on the WEB
  - Redo tests after major stops
- Thresholds: jaw position and gaps ±0.5mm
- BLM thresholds at collimators are defined for nominal operation (not the damage threshold)
  - E.g. low thresholds, prevents tungsten collimators to become primary collimator
- BLM thresholds ensure the hierarchy for slow(er) losses
  - No help for single turn
- Tungsten collimators
  - Sensitive to shock impact – deformation not excluded, most critical for small beta function
  - Multi-turn losses: robust
  - Setting up by touching the beams: no risk

Collimation – R. Assmann



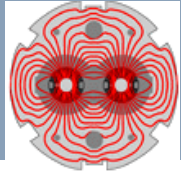
- Issue of tilted gap (…largely solved?)
  - Can lead to wrong conclusions for beam size, more critical for long devices, difficult if beam is very small
- Beam tests for verification
  - System is well understood
  - Must be done regularly once per week. Many post-mortem events provide excellent data for cleaning quality under 'extreme' failure conditions and observations during normal operation validate system
  - Leakage from IR6 to IR5 understood, no issue for collimators in 5
- Flexibility to be improved….
  - It will be possible to increase for beam intensity limit of the setup-beam flag in the future by a factor of 4
- Machine stability important, some worries - safety
  - Beam losses over 400 turns (damper exciting the beam) – some slides
  - Orbit not conform – to be better controlled (e.g. 5/6/2010 local bump in IR5 and other examples)
  - Orbit drifts with time
  - Less than 400 um required to avoid damage

Collimation – R. Assmann



- Lifetime
  - Sometimes lifetime is low, part of beam lost….
  - Loss spikes appearing
- Nominal loss rate with 0.1% of intensity
  - Steady state losses are different from failure transients. During failures that are not intercepted by powering interlocks etc, the beam almost always hits the collimators first, and the BLMs trigger a dump when the interlock (nominal) loss rate is reached
- Operational issues
  - Sequences are being improved, progress must continue
- Checking also opening of all gaps with energy ramp and squeezing
  - Can happen that a collimators does not move with operational state
- What about squeeze and collimator closure?
  - E.g. squeezing attempt to 2 m, beam was dumped before

Transfer and injection – V. Kain



- Still transferring low intensity (only one bunch)
- Injection steering - operation
  - Settings: copy from one SPS cycle to other cycle to be improved
- BPM sensitivity settings – operation / safety
  - Automated and reliable sensitivity switching of the BPMs must be put in place for injection – when changing intensity
- TCDI collimators - safety
  - Position and gap energy interlocks to be implemented. **Done**
- Higher intensity (unsafe beam) injection - safety
  - Qualification of TCDI protection level
  - Adjustment of TDI angles
  - Adjustment of LHC BLM thresholds in injection areas
  - Scraping in SPS if needed
- RF checks
  - Check issue of local clock in the SPS

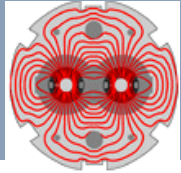
Transfer and injection – V. Kain

- Injection kickers
  - SIS interlock with kickers disabled
- Injection sequence
  - Prevent over-injection of nominal bunch

Dump protection – W. Bartmann

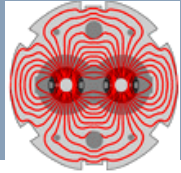
- TCDQ
  - State management to be addressed, ensure that it moves correctly
  - Angle setting
- Asynchronous dump tests
  - All tests passed
  - Losses at Q4: factor 100 above BLM threshold, no quench (beam diluted by TCSG/TCDQ)
  - Losses from TCDQ – only scattered protons, very low density of protons. In the worst case a small fraction of a nominal bunch leaks through (with huge emittance)
  - Losses are consistent with measurements
- Abort gap monitoring and cleaning – will become a safety issue
  - Signal from abort gap monitor not understood (de-bunching beam)
  - More work needed on monitor and on cleaning, not yet ready
  - For the time being not too critical, no magnet quench yet

BPM issues – R. Jones



- BPM readings dependence on intensity
  - BPM readings for B2 as expected
  - Issue with the BPM readings for B1: dead zone 3-5E10
  - Intensity range 6E10 – 1E11: orbit error of 150-200 um max.
  - Need a long term approach for critical location (IR3, IR7, TCT-IR regions).
- BPM as function of temperature of acquisition cards
  - To be measured and possibly corrected (offset) - up to 200 um
- Sensitivity switching
  - Recurrent issue to be solved
- Calibration
  - Strategy to be defined (daily… ?)
- Interlock BPMs
  - Issue at 5-6E10 p/bunch for low sensitivity
  - It may be possible to avoid switching gains – possible issue for very small bunch populations (ions?)
- Longer term: can the stability be improved by a factor of, say, 10?
  - At least for a part of critical BPMs (cleaning and dump insertions, …)

Orbit feedback – R. Steinhagen

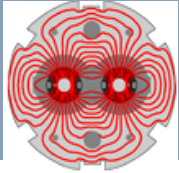


- LHC operation relies on feedbacks !
  - With the new ramp and squeeze, there is one single reference all along (until separation bumps are collapsed).
- Feedbacks are complex
  - 3400 inputs
  - Many failure modes, dependent on input. Not always easy to take appropriate decision (in real time)
  - Aim to address problems at the source
- Reduce large corrections by shifting RT trims to LSA
  - Reduces feedback trims, less sensitive to feedback stops
- Orbit correction strategy – safety
  - Number of Eigenvalues for orbit correction important. Defines correction quality, but also how easily bumps can creep in
  - Not trivial issue to avoid bumps (detection by monitoring the current of orbit dipole correctors? – first results in some weeks)
  - BPM error detection to be fine tuned and improved

RF frequency and power - A. Butterworth

- Interlock on total RF voltage (vector sum) ready to be activated
  - Proposed threshold ~ 1.7 MV **Done**
- Interlock of RF frequency ready to be (re)-activated
  - f-RF range +-200 Hz
  - Relies on SW processes, with a watchdog to ensure correct transmission of the energy (for the f-RF reference)
  - Sequencer task checks the watchdog state, else possible (false) dump in early part of the ramp
  - Some tests needed, and then interlock can be enabled

BLM system – B. Dehning



- BLM system is running without the need to disable monitors
- A few component failures were observed – availability
  - Connectors, optical links and receivers, SRAM, electronics components
- IP3 noise and strange signals
  - Protection should be ok – being investigated
  - Beam tests required: shots on the collimator at 450 GeV
- BLM tests do not work from sequencer in IP2 – availability – solved
- SEMs
  - Not working as expected – more work required
  - Issue for diagnostics with high intensity
- Filters installed on some IC monitors to increase dynamic range
  - Solves the saturation issues for fast losses
  - Analysis for fast losses (more) tricky

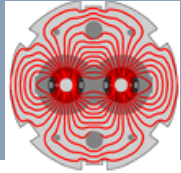
BLM system – B. Dehning

- Thresholds - safety
  - Tools for threshold generation to be improved
  - Automated checks most be performance
  - Threshold change procedure must involved 2 persons
  - Roll back being improved
- Data from “direct dump” BLM – safety / redundancy of protection
  - Should be possible to derive thresholds from data that have been taken
- Tool for looking at BLMs as a function of time (from logging DB)
  - being discussed, high priority to understand transient losses during fill when part of beam is lost without beam dump
- External audit of BLM is planned in September
  - Audit all software aspects: thresholds, FPGA etc

Software Interlock System - J. Wenninger

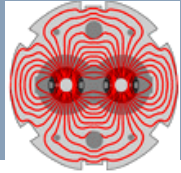
- Injection interlocking, circulating beam interlocking, powering interlocks for access, beta function publishing
  - Simple to complex interlock tests
  - Very reliable, did not fail during operation
- Injection
  - Monitoring: main magnet currents, RF, BTV, bucket, injection mode, energy, Pre-Post-checks, LHCf, triplet alignment, …
- Circulating beam
  - SMP energy and distribution, BETS (still masked)
  - TCDQ with respect to beam (three parts)
  - Closed Orbit Dipole (COD) integral (energy….), orbit, COD settings in stable beams, COD 60A trips
- Orbit
  - 10 BPM out of tolerance, tolerances see slides, can be tightened, possibly to 1 mm, with time and stable beam conditions
  - maybe deactivation with low intensity beam

Software Interlock System - J. Wenninger



- COD settings
  - aim to catch bump like structures (50 urad, 25 urad)
  - analysis needed, envelope needs to be defined
  - depends on machine stability
  - COD trips if strength is more than 10 urad, dump beam
- TCDQ – centring in TCSG, 2 mm, 1mm in reach
  - BPMSB position reading intensity dependent
- Most conditions are maskable (independent of SBF) - safety
  - how to avoid masking .. forgetting to unmask? Introduce SBF?
- Settings management - needs update (help needed) ….
- Might evolve from hardware to software for some systems
  - After getting experience with SIS, interlocks might be done in HW
  - BPM interlocks …. maybe some into HW in the future ???
- Running faster? Only marginal gain for 1s
- Timeout in the BIC (20 s)

Experiments - M. Ferro-Luzzi

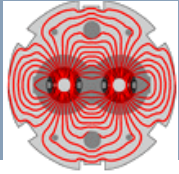


- BCM work well - very few dumps
  - Thresholds and running sums differ between experiments
- ALICE – trips, beam related ? no clear..
- ATLAS
  - Few events with increased losses … no worries
- CMS
  - no aborts, no events…
  - correct setting of TCDQ / TCSG important
- LHCb
  - spikes during over-injection, depends on stored beam
  - some other events… orbit movement not clear
- TOTEM
  - complex interlocks, well tested
- LHCf – rely on MP, and front counter rates available if of interest
- In general, too early, too little beam to comment on issues

OP review summary - M. Lamont

- Problems during operation stressing the MP systems
  - Number of issues…
  - Timing system wide open (in the CCC)
  - LSA is too wide open – can do many wrong actions at the wrong time – not solvable by RBAC
  - ‘Equipstate’ program much too powerful !!
  - All command controlled / channeled through a state machine?
- Settings
  - Extended settings check using MAD?
  - Settings incorporation
- Sequencer
  - To be improved….alternative pathways might be dangerous
  - Everything (?) should be driven through the sequencer
- Front-ends
  - Crashed – not always detected on time
  - Close back doors !

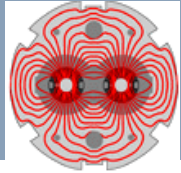
OP review summary - M. Lamont



- Feedbacks
  - Thorough testing not always done (but also very little beam time allocated)
  - Perform systematic feed-forward
  - Too dependent on a single person
- Orbit and OFB
  - More robust behaviour in case of incorrect data input. Limit impact of certain issues
  - Orbit bumps are tricky to avoid in all circumstances
- Collimators
  - How to ensure the references are correct?

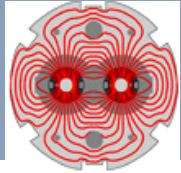
- Conclusion of Mike: not yet ready for 0.5-1.0 MJ

Post-mortem system - M. Zerlauth



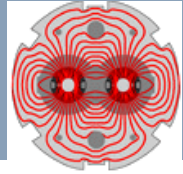
- Powerful system, validates if Machine Protection is ok
  - PM SIS channel to become un-maskable?
- Powering analysis is required for the future, help to MP3, for July/August
- SIS interlock is masked - when it should not happen…..
  - QPS and FGC take at least 8 minutes
  - Proposal: could allow unlatching of SIS after 1min, depending on energy
- Auto-eMail to expert in case of problems, or confirm by expert
  - next is BIC
- Experiments data: what…. under what conditions… to be discussed
- Further improvements on the way
  - Add predefined checks / buttons
  - Versatile data viewer – shopping basket (needs some work from BI for time axis)

Comments



- Stable orbit
  - Orbit bumps can be dangerous, in particular in case of asynchronous beam dump and at injection of high intensity beam
  - Orbit non-conformities increase risk of damage, to be detailed…
- Coherence between machine status and collimator positions to be ensured (injection, flat-top, squeeze, physics, luminosity scans, ….)
  - Take into account possible failures, such as squeezing to wrong beta-function, failures in hardware systems, ….
- Non-conformities due to machine protection tests
  - Un-masking SIS not to be forgotten – to be addressed
- Re-commissioning of protection systems after short technical stops
  - Every intervention on a protection system has some risks, procedures are required that determine what tests need to be performed
- VME front ends crates crash – need to be understood
  - Leads to beam dump in case of SIS tries to access crates
- **Most important: stable running period for improvements**
- **Use the time before (much) higher intensity to sort out things**

Example of beam loss



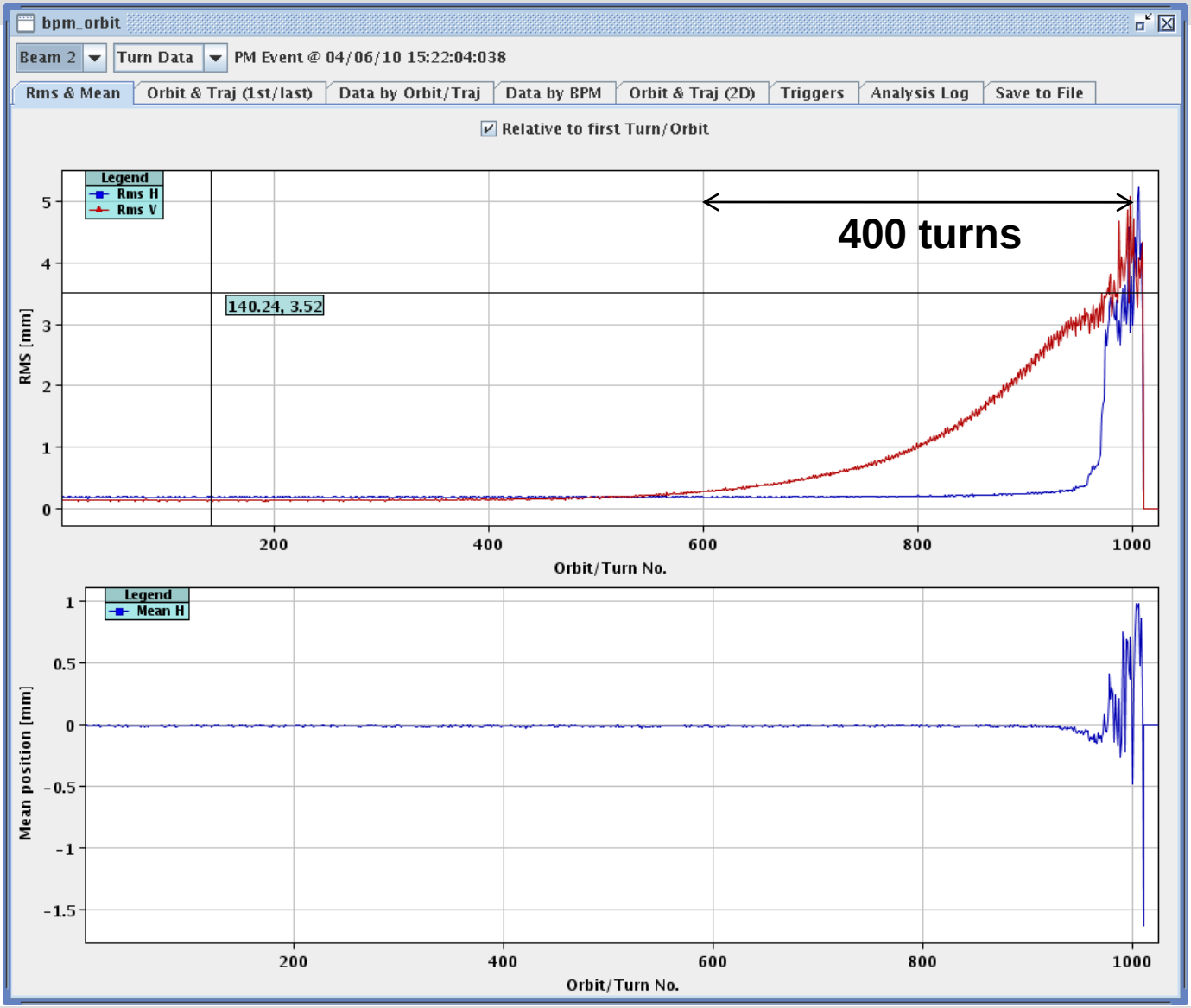
4/6/2010 15.22.04 injection 457200 [GeV]

- Beam 2 was excited by the damper, at 450 GeV
- The beam intensity (about 1.5E10) remained constant during the excitation, very little beam was lost
- The beam was dumped with the BPM interlock in IR6
- There were some losses at the collimators in IR7, but below threshold

In case of higher intensity….

- Redundant protection would have worked
- Collimators did their job protecting efficiently against such failures
  - losses limited to the collimation section, no losses in the arc
- BLM demonstrate that they can detect very fast losses
- Thresholds and algorithm for beam position monitor used as interlock to be reviewed
  - with more bunches, possibly faster trigger over fewer turns

Very Fast Losses (Unexpected?)



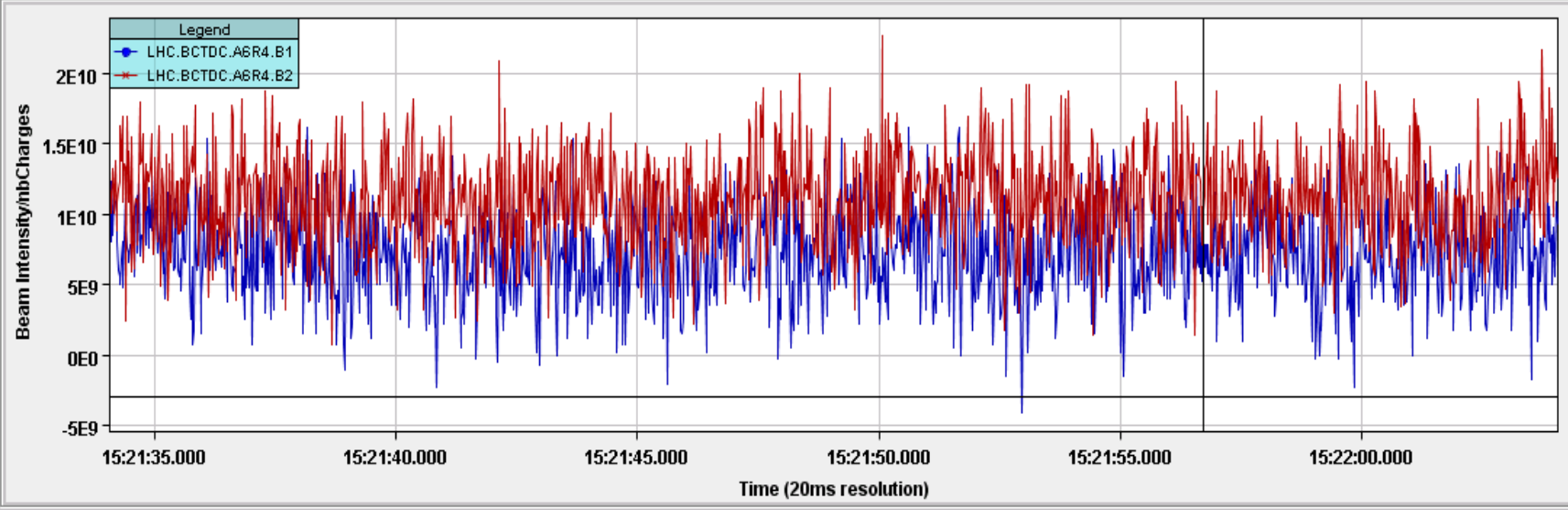
4/6/2010 15.22.04 injection 457200 [GeV]

bct

PARAMETERS

Parameter	BCTDC.A6R4.B1	BCTDC.A6R4.B2	BCTDC.B6R4.B1	BCTDC.B6R4.B2	BCTFR.A6R4.B1	BCTFR.A6R4.B2	BCTFR.B6R4.B1	BCTFR.B6R4.B2
Energy	0	0	0	0	0	0		
FillNum	1132	1132	1132	1132	1132	1132		
LastLifeTime					2.3750478E-31	2.3750478E-31		

BCT_DC PLOTS

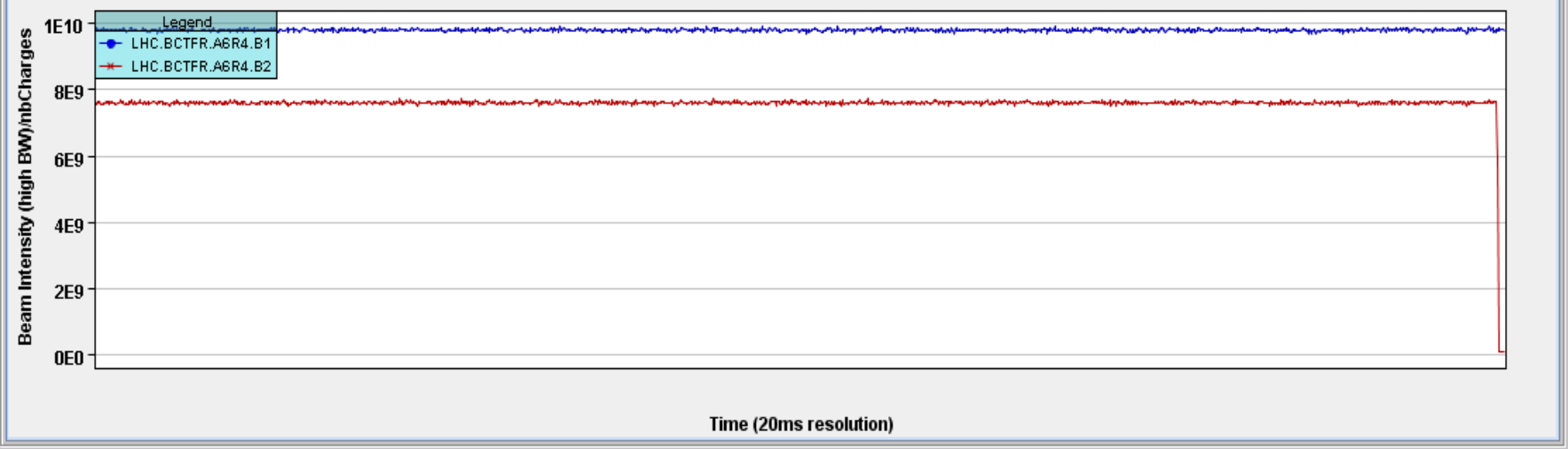


FILTERS

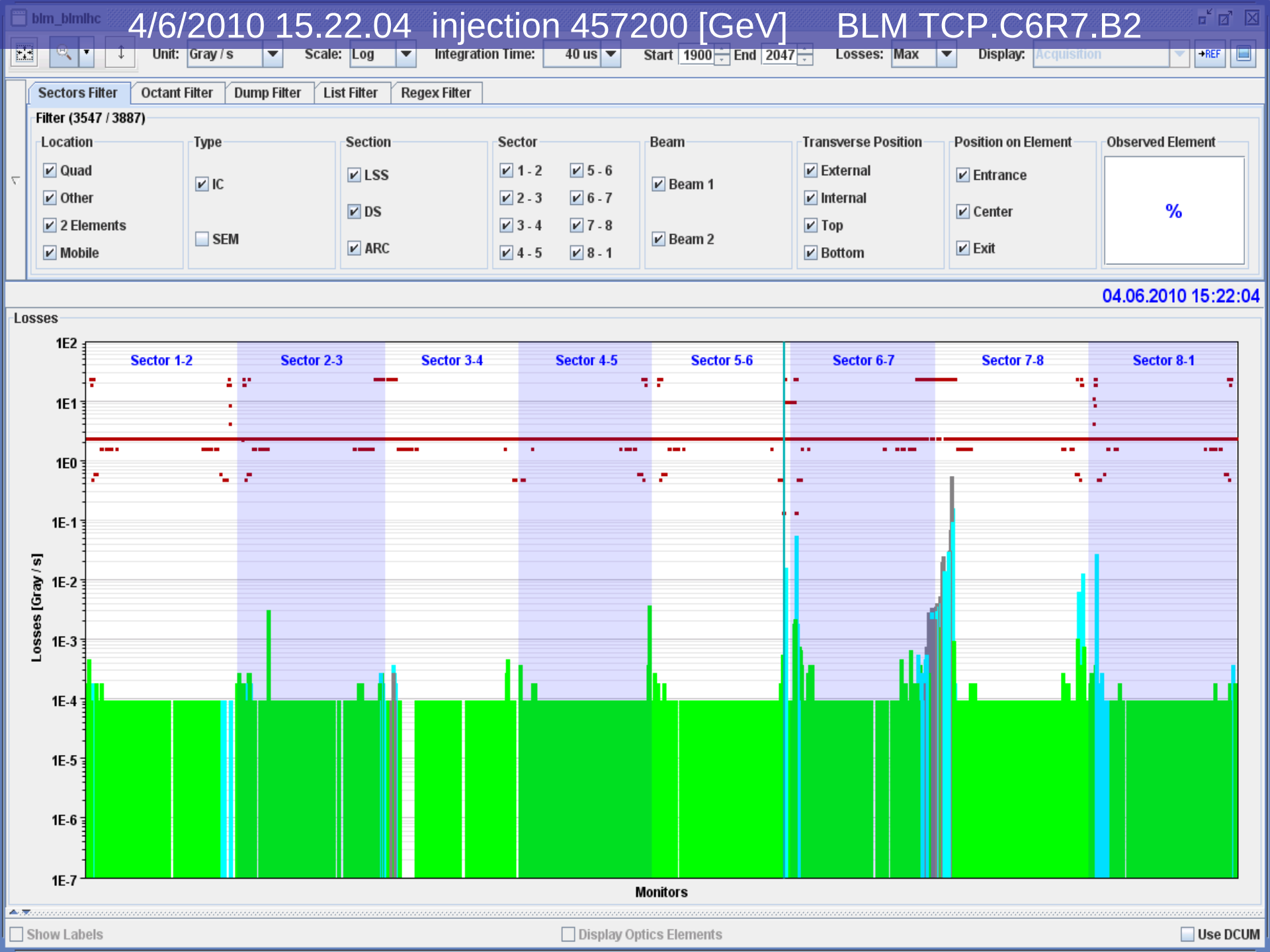
- [x] BCT_A
- [ ] BCT_B
- [x] Beam_1
- [x] Beam_2

BCT_FR PLOTS

Intensity History | Beam Lifetime | Turn Intensity History



PM Event @ 04/06/10 15:22:04:038


4/6/2010 15.22.04 injection 457200 [GeV] BLM TCP.C6R7.B2
blm_blmlhc
Unit: Gray / s
Scale: Log
Integration Time: 40 us
Start 1900
End 2047
Losses: Max
Display: Acquisition
Sectors Filter
Octant Filter
Dump Filter
List Filter
Regex Filter
Filter (3547 / 3887)
Location
Quad
Other
2 Elements
Mobile
Type
IC
SEM
Section
LSS
DS
ARC
Sector
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
7 - 8
8 - 1
Beam
Beam 1
Beam 2
Transverse Position
External
Internal
Top
Bottom
Position on Element
Entrance
Center
Exit
Observed Element
%
04.06.2010 15:22:04
Losses
Sector 1-2
Sector 2-3
Sector 3-4
Sector 4-5
Sector 5-6
Sector 6-7
Sector 7-8
Sector 8-1
1E2
1E1
1E0
1E-1
1E-2
1E-3
1E-4
1E-5
1E-6
1E-7
Losses [Gray / s]
Monitors
Show Labels
Display Optics Elements
Use DCUM

4/6/2010 15.22.04 injection 457200 [GeV] BLM TCP.C6R7.B2

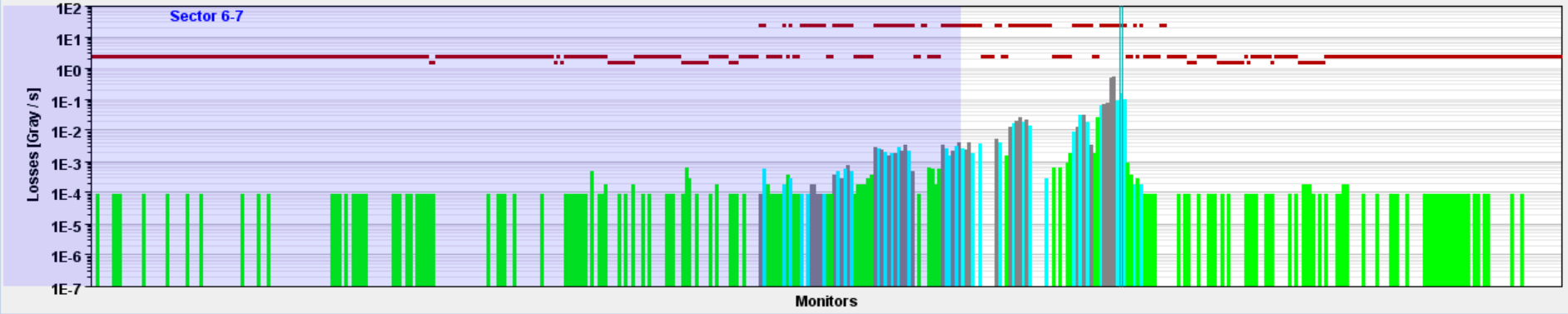
Sectors Filter | Octant Filter | Dump Filter | List Filter | Regex Filter

Filter (3547 / 3887)

Location	Type	Section	Sector	Beam	Transverse Position	Position on Element	Observed Element
☑ Quad	☑ IC	☑ LSS	☑ 1 - 2 ☑ 5 - 6	☑ Beam 1	☑ External	☑ Entrance	%
☑ Other	☐ SEM	☑ DS	☑ 2 - 3 ☑ 6 - 7	☑ Beam 2	☑ Internal	☑ Center	
☑ 2 Elements		☑ ARC	☑ 3 - 4 ☑ 7 - 8		☑ Top	☑ Exit	
☑ Mobile			☑ 4 - 5 ☑ 8 - 1		☑ Bottom		

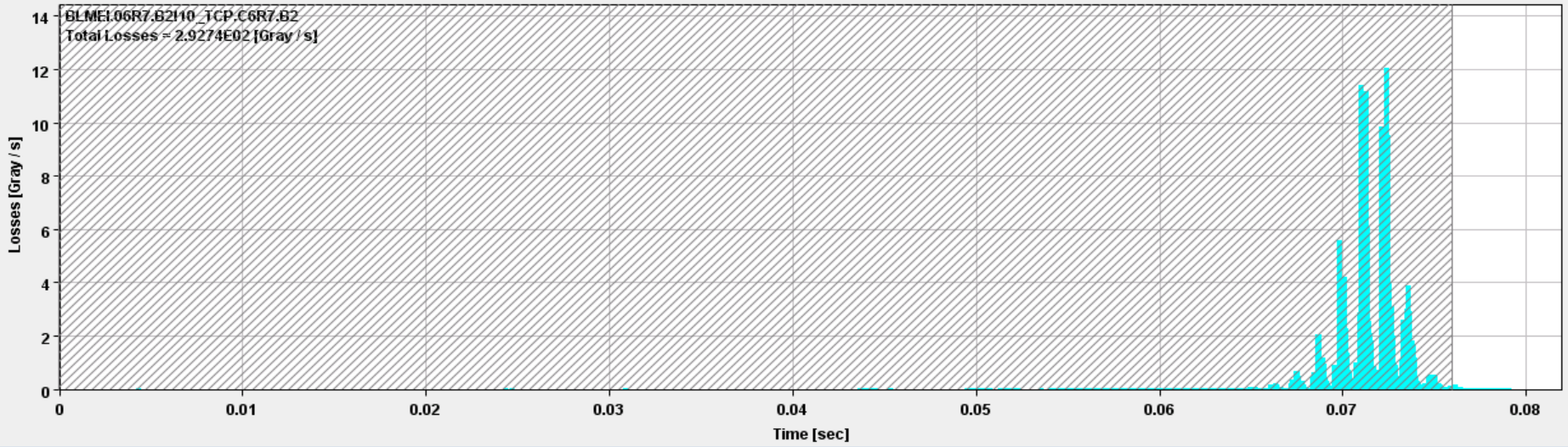
04.06.2010 15:22:04

Losses



Monitor Losses versus Time

f(x)



Show Labels | Display Optics Elements | Use DCUM

4/6/2010 15.22.04 injection 457200 [GeV] BLM at TCSG in IR6

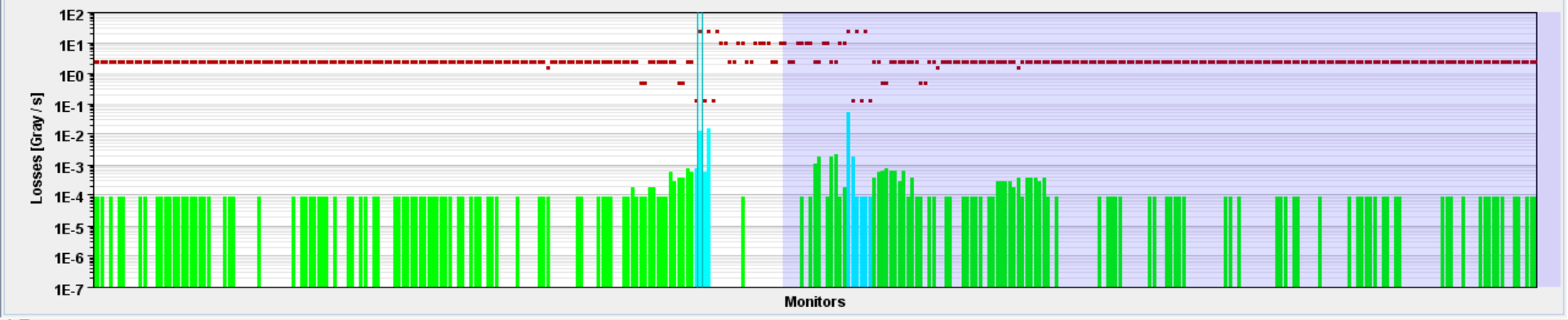
Sectors Filter | Octant Filter | Dump Filter | List Filter | Regex Filter

Filter (3547 / 3887)

Location	Type	Section	Sector	Beam	Transverse Position	Position on Element	Observed Element
☑ Quad	☑ IC	☑ LSS	☑ 1 - 2 ☑ 5 - 6	☑ Beam 1	☑ External	☑ Entrance	%
☑ Other	☐ SEM	☑ DS	☑ 2 - 3 ☑ 6 - 7	☑ Beam 2	☑ Internal	☑ Center	
☑ 2 Elements		☑ ARC	☑ 3 - 4 ☑ 7 - 8		☑ Top	☑ Exit	
☑ Mobile			☑ 4 - 5 ☑ 8 - 1		☑ Bottom		

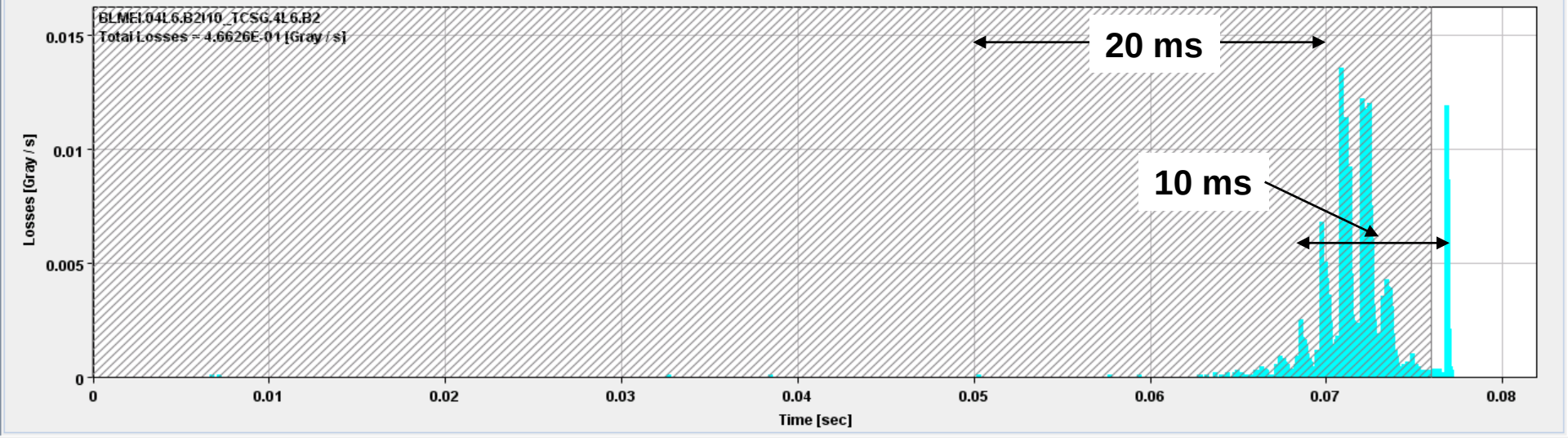
04.06.2010 15:22:04

Losses



Monitor Losses versus Time

f(x)



Show Labels | Display Optics Elements | Use DCUM

4/6/2010 15.22.04 injection 457200 [GeV] BMPYB.5L6.B2