



$\Delta P_m = V \rho w S_m$ - displacement
 $f = \frac{v}{\lambda} = \frac{\Delta v}{2L}$
 $\Delta L = L \alpha \Delta T$
 $\Delta v = v \beta \Delta T$
 $Q = c m \Delta T$ - specific heat
 $Q = L$
Heat = Power P_s
 $I = \frac{\text{Power}}{\text{Area}} = \frac{P_s}{A}$

FAST MAGNET CURRENT CHANGE MONITOR ANALYSIS MODULE

Summer Student Sessions

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TE department. MPE group. MS section.

August 14th, 2012





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1. 2004 incident.
2. Fast Magnet Current change Monitor.
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2004 incident

TT40 damage during high intensity SPS extraction

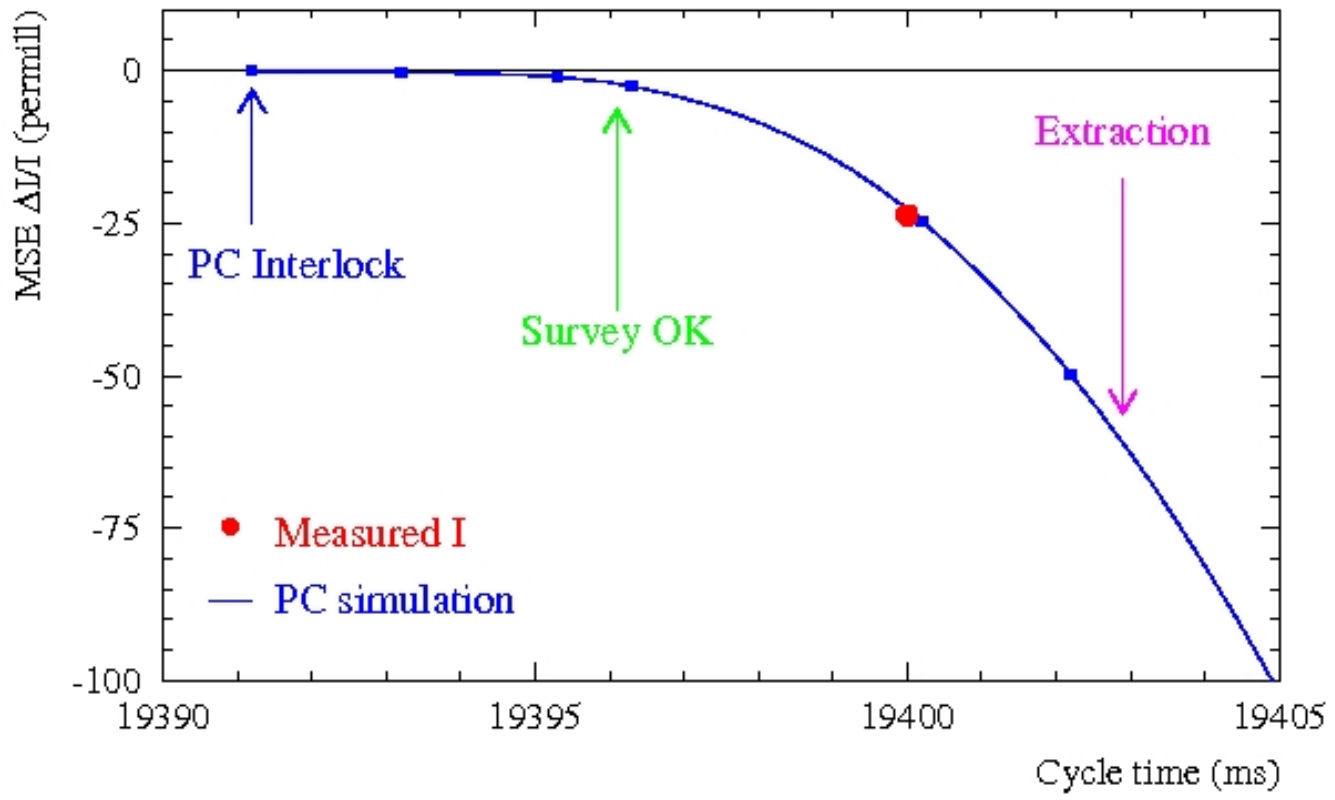
- ❁ Powering failure in a magnet.
 - Magnet with low time constant.
- ❁ Beam extraction with the wrong trajectory.
- ❁ Vacuum chamber badly damaged.



Inside of the vacuum chamber

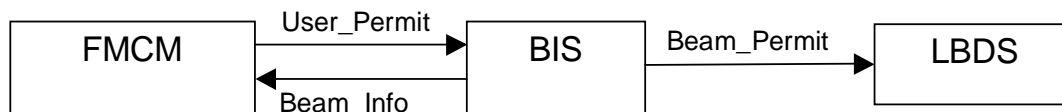


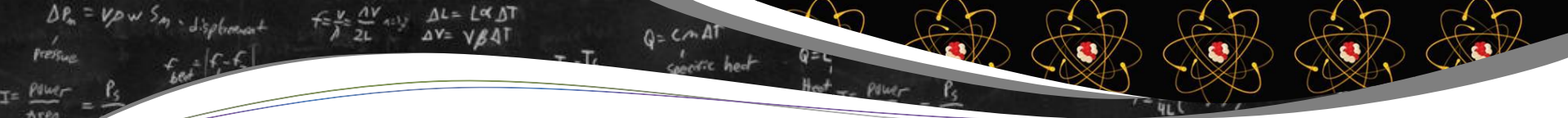
Outside of the vacuum chamber

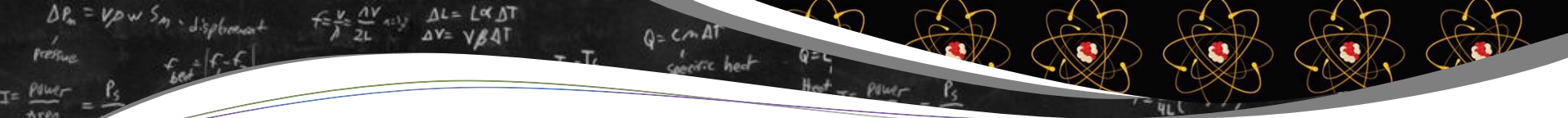


Fast Magnet Current change Monitor

- ❁ FPGA based devices that monitor the state of a normal conducting magnets (“warm magnets”).
- ❁ Measures the voltage across magnets to detect fast current changes.
- ❁ Can trigger a **beam dump**.
 - When signals are above predefined thresholds.



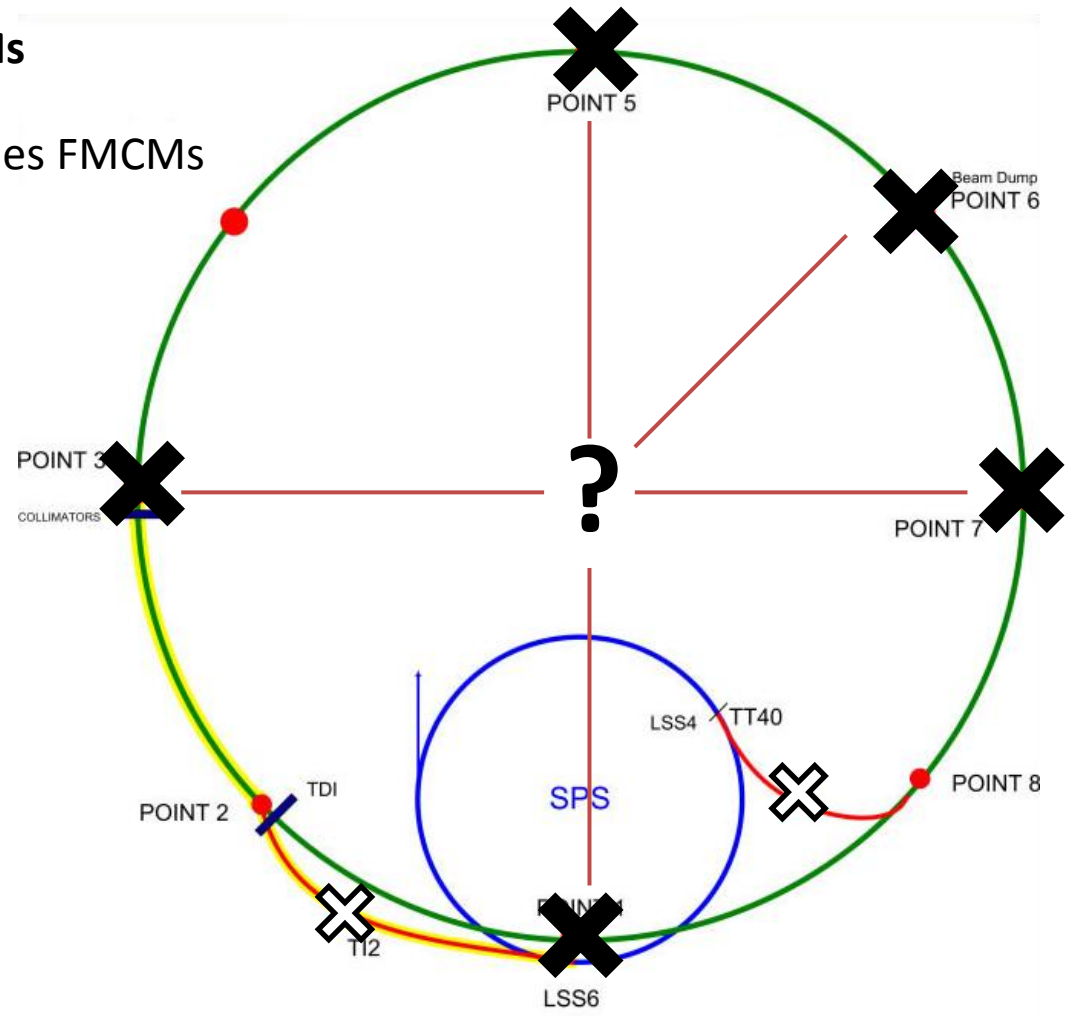




LHC FMCs



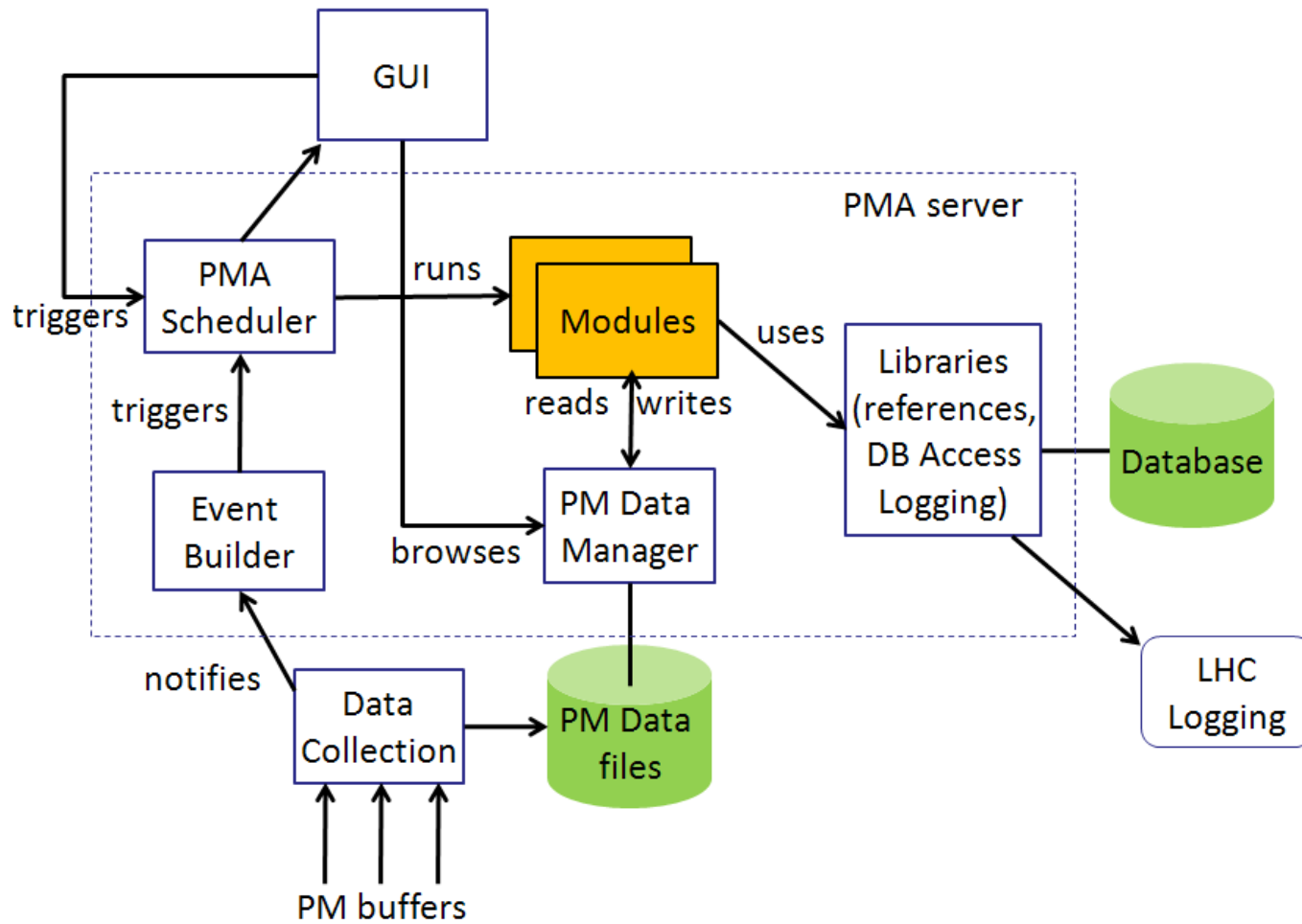
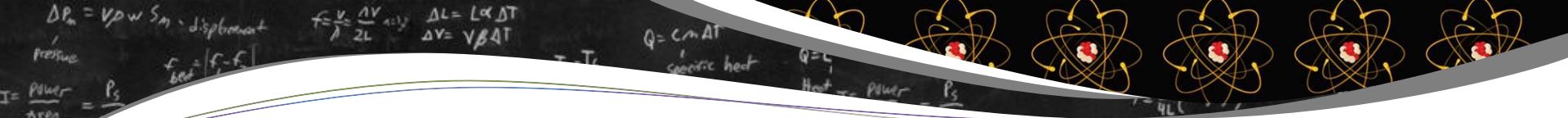
Transfer lines FMCs





PostMortem framework

- ❁ Provides comprehensive monitoring of the functioning of machine protection system.
 - Improve efficiency of the LHC.
 - Explain damage.
- ❁ The PM event must be automatically analyzed.
 - ‘Digested’ information must be generated for operators.





PM analysis

- ❁ **4GBytes** each PM event.
 - Too much to be browsed by the operator.
- ❁ Correct functioning of protection systems:
 - Must be verified before injecting a new beam.
- ❁ Software is used to:
 - Scan for faults.
 - Inspect evidence.
 - Develop understanding.



dic_eventsq >> Version: 0.4.10 Responsible: Ivan Romero Ramirez

System	BIC
Class	EVENT_SEQ
Source	ISA
Event stamp	09:50:32.847 13/08/12
Version	0.4.11
Encoding	BICEVENT_SEQ
Qualifier	
Analysis flags	(NORMAL)

pmAnalysisModuleVersion 0.4.11
Analysis result description First USR_PERMIT change Ch 8-COLLIMOT-02 B T → F on CIB US15 R1 B2
Triggered BIC inputs Ch 8-COLLIMOT-02(R1 B2), Ch 2-LBDS-02 (TSU/R B.02), Ch 11-BLM_MSKL6 B2, Ch 11-BLM_MSKL6
Beam 1 propagation delay to LBDS 125000 ns
Beam 2 propagation delay to LBDS 117500 ns
OVERALL 38 BICs triggered valid PM data

EVENT OVERVIEW

Index	Loc	Permit	AB	Time	DeltauSec	Description	BIC name
375		09:50:32-847389	0			USR_PERMIT: Ch 8-COLLIMOT-02 B T → F	CIB US15 R1 B2
452		09:50:32-847583	194			USR_PERMIT: Ch 2-LBDS-02 (TSU) A T → F	CIB UA87 R6 B2
453		09:50:32-847583	194			USR_PERMIT: Ch 2-LBDS-02 (TSU) B T → F	CIB UA87 R6 B2
492		09:50:32-847625	236			USR_PERMIT: Ch 11-BLM_MSK A T → F	CIB UA63 L6 B2
493		09:50:32-847625	236			USR_PERMIT: Ch 11-BLM_MSK B T → F	CIB UA63 L6 B2
496		09:50:32-847625	236			USR_PERMIT: Ch 11-BLM_MSK A T → F	CIB UA63 L6 B1
497		09:50:32-847625	236			USR_PERMIT: Ch 11-BLM_MSK B T → F	CIB UA63 L6 B1
584		09:50:32-847694	305			USR_PERMIT: Ch 2-LBDS-01 (TSU) B T → F	CIB UA63 L6 B1
595		09:50:32-847694	305			USR_PERMIT: Ch 2-LBDS-01 (TSU) A T → F	CIB UA63 L6 B1
887		09:50:32-847934	545			USR_PERMIT: Ch 10-BPMs L&R syst B' B T → F	CIB UA63 L6 B1
890		09:50:32-847939	550			USR_PERMIT: Ch 10-BPMs L&R syst B' A T → F	CIB UA63 L6 B1
908		09:50:32-847959	570			USR_PERMIT: Ch 10-BPMs L&R syst B' A T → F	CIB UA63 L6 B2
933		09:50:32-847995	607			USR_PERMIT: Ch 10-BPMs L&R syst B' B T → F	CIB UA63 L6 B2
941		09:50:32-848044	655			USR_PERMIT: Ch 8-COLLIMOT-01 A T → F	CIB US15 L1 B1
967		09:50:32-848048	659			USR_PERMIT: Ch 8-COLLIMOT-01 A T → F	CIB US15 L1 B1
968		09:50:32-848050	661			USR_PERMIT: Ch 8-COLLIMOT-01 B T → F	CIB US15 L1 B1
1308		09:50:32-848190	777			USR_PERMIT: Ch 8-COLLIMOT-01 B T → F	CIB US15 L1 B1
1308		09:50:32-848529	1140			USR_PERMIT: Ch 8-BPMs L&R syst K' A T → F	CIB UA87 R6 B2
1259		09:50:32-848532	1143			USR_PERMIT: Ch 8-BPMs L&R syst K' B T → F	CIB UA87 R6 B2
1300		09:50:32-848977	1288			USR_PERMIT: Ch 8-BPMs L&R syst K' A T → F	CIB UA87 R6 B1
1308		09:50:32-848982	1293			USR_PERMIT: Ch 8-BPMs L&R syst K' B T → F	CIB UA87 R6 B1
1312		09:50:32-848989	1310			USR_PERMIT: Ch 8-COLLIMOT-02 A T → F	CIB US15 R1 B2
1313		09:50:32-848700	1311			USR_PERMIT: Ch 8-COLLIMOT-02 A T → F	CIB US15 R1 B2
1315		09:50:32-848701	1312			USR_PERMIT: Ch 8-COLLIMOT-02 A T → F	CIB US15 R1 B2
1582		09:50:32-815982	68593			USR_PERMIT: Ch 3-LBDS-01 (PLC) B T → F	CIB UA63 L6 B1
1583		09:50:32-815987	69193			USR_PERMIT: Ch 3-LBDS-01 (PLC) B T → F	CIB UA63 L6 B1

be-bbq-isa >> Version: 1.0.5 Responsible: Rafal Leszko

show all input files

FFT2_B1 FFT2_B2

20*log(f) vs frequency vs time

amplitude vs time

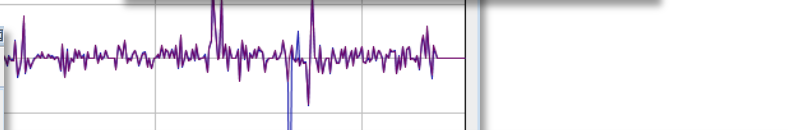
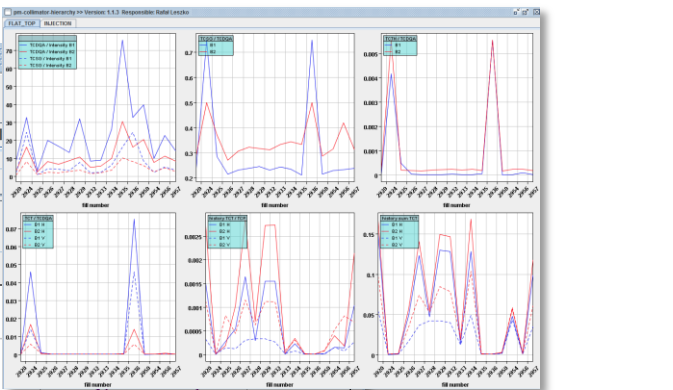
Normalization: none default highest peak

Palette type: Default

Plot type: raw data (amplitude/time) highest frequency (frequency) slider frequency (frequency)

Orbit & Traj (2D) **Triggers** **Anal**

scale 0 ————— 10

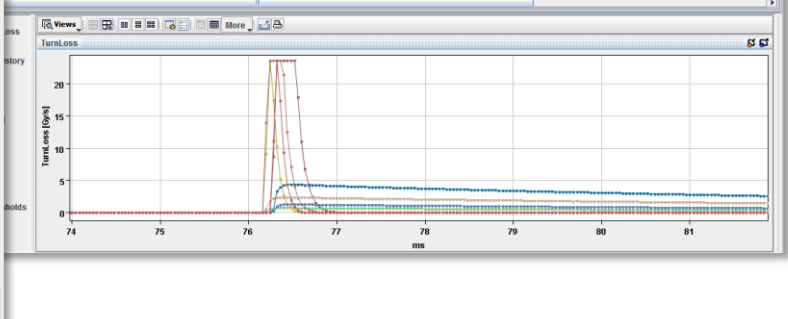


isses >> Version: 0.5.7 Responsible: Lene Norderhaug Drastal

BLM	Value	Name	Value
BLM_LOSSES		beamEnergy	3.93204 to 4.1778 TeV
BLM_LOSSES		pmAnalysisModuleVersion	0.5.3
BLM_LOSSES		pmAnalysisResultDescription	See itmOverview 2D-array in PM Data output for further information
BLM_LOSSES		BLMEI 04L6 B1E10_TCD5A 4L6 B1 BLMEI 04L6 B1E10_TCD5B 4L6 B1 BLMEI 04R6 B2I10_TCD5A 4R6 B2	
BLM_LOSSES		nsOrElms	0

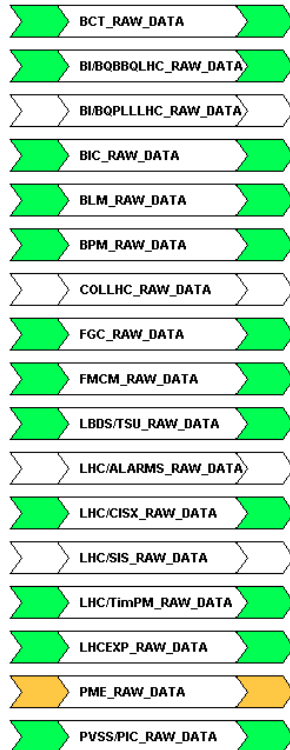
Tags INTERESTING_BEAM

Monitor name	Crata name	RS over Threshold [bins]	Integer	Total turn loss [Cyts]	Max TurnLoss [bits]	Max TurnLoss/Thresh.	Total log history [Cyts]	Max Log-history [bits]	Max
4R6 B1E10_TCSG 4R6 B1	SR6 C	●●●●●●●●●●	1	69 4565	250993	101 0000	0.0539	794765	1.00
4R6 B1E10_TCD5A 4R6 B1	SR6 C	●●●●●●●●●●	127	137 9195	14205	1008 0000	0.0270	3354718	7.00
4R6 B2I10_TCD5A 4R6 B2	SR6 C	●●●●●●●●●●	127	270 4347	25483	1680 0000	0.0439	7772973	16.0
4R6 B2I10_TCD5B 4R6 B2	SR6 C	●●●●●●●●●●	3	158 7124	251088	101 0000	0.0102	1753978	0.00
4L6 B2I10_TCD5A 4L6 B2	SR6 C	●●●●●●●●●●	1	70 5544	260014	101 0000	0.0060	781844	0.00
4L6 B2I10_TCD5B 4L6 B2	SR6 C	●●●●●●●●●●	33	78 1479	8688	574 0000	0.0204	1961948	4.00
4L6 B1E10_TCD5B 4L6 B1	SR6 C	●●●●●●●●●●	196 4443	251053	101 0000	0.0125	2193924	0.00	
4L6 B1E10_TCD5A 4L6 B1	SR6 C	●●●●●●●●●●	127	477 9969	48500	3444 0000	0.0746	13271490	28.0

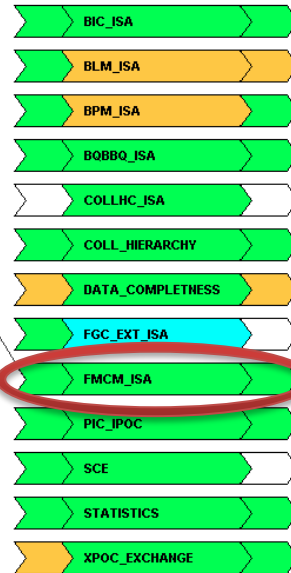




Raw data



Analysis modules



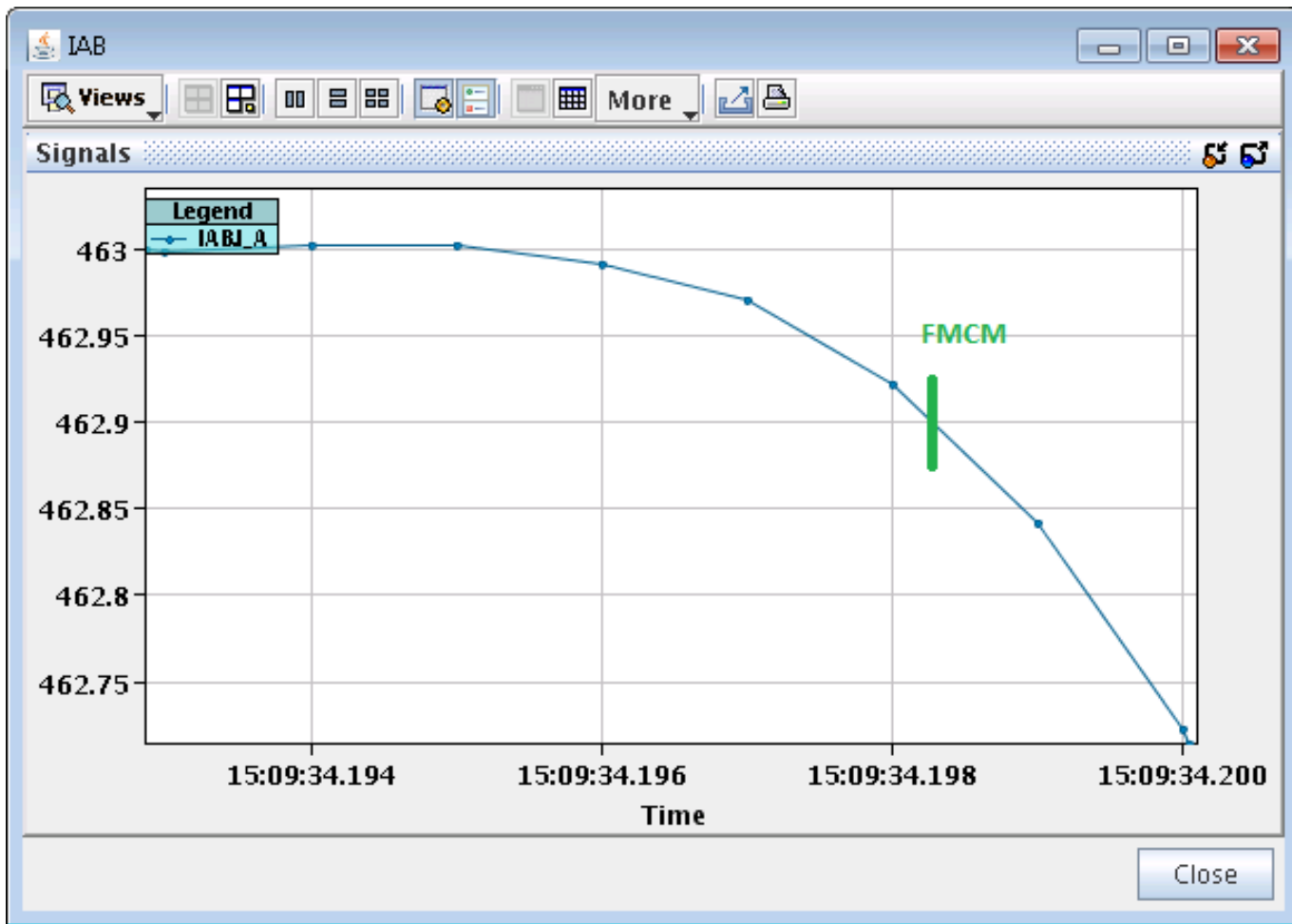
Event log

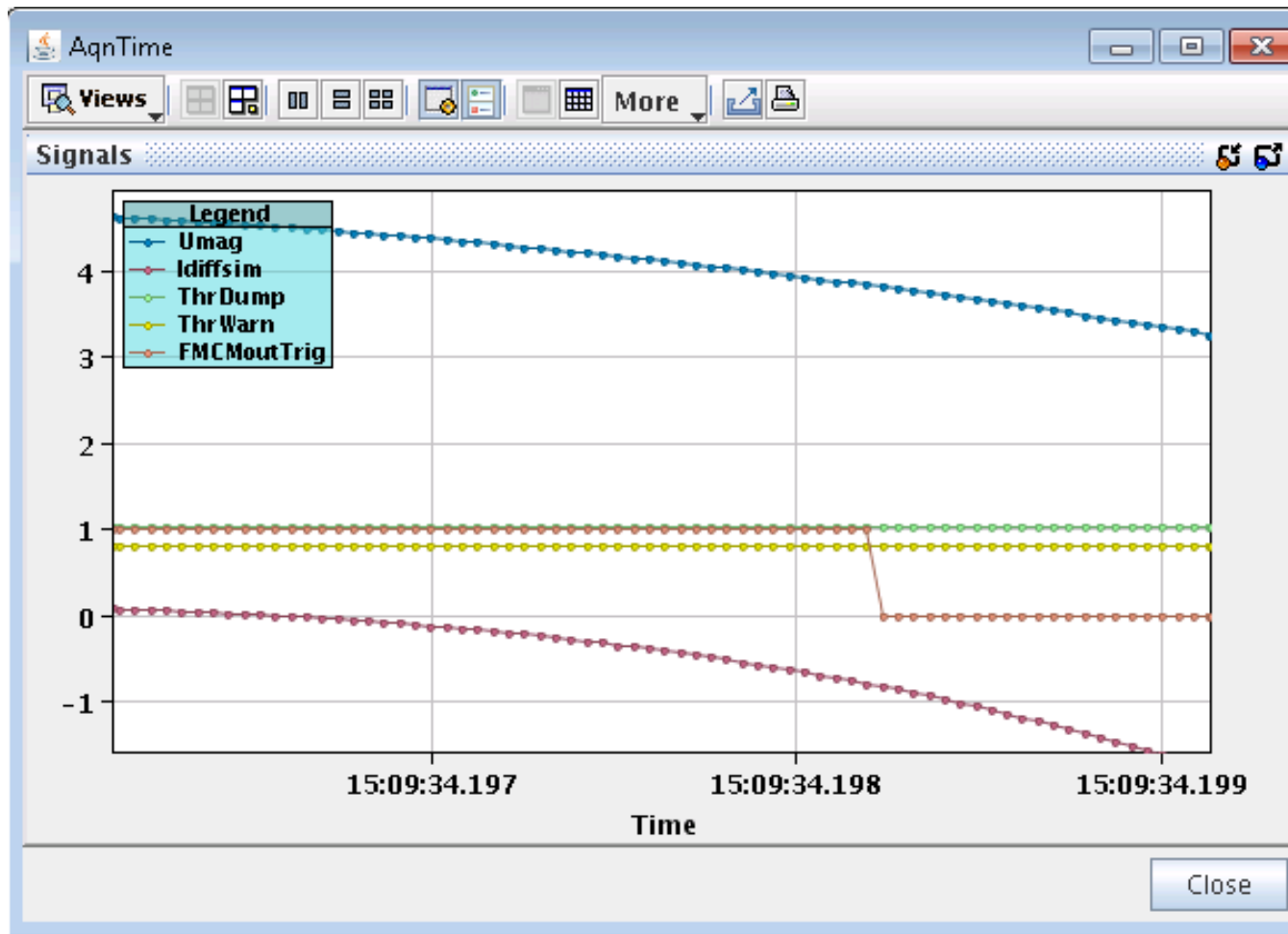




FMCM analysis module

- ❁ Were all FMCM logs correctly received?
- ❁ Are thresholds correctly set in the FMCMs?
- ❁ Was any of the FMCM responsible for a **beam dump**?
 - Correctly triggered?
 - Correct propagation to Beam Interlock System?
 - Reacted before than Warm magnet Interlock System?
 - Data:
 - Elapsed time from beam dump trigger and BIC reception.
 - Current at triggering time.
 - Relative current variation.
 - Longest excess observed.







References

- [1] B. Goddard, V. Kain, et al, “TT40 damage during 2004 high intensity SPS extraction”, AB-Note-2005-014 BT.
- [2] M. Werner, M. Zerlauth, et al, “Requirements for the Fast Magnet Current change Monitors (FMCM) in the LHC and the SPS-LHC transfers lines”, LHC-CIW-ES-0002, 2005.
- [3] M. Zerlauth, T. V. Jevard, “MPS aspects of the Fast Magnet Current change Monitors commissioning.”
- [4] O. O. Andreassen, V. Baggiolini, et al, “The LHC Post Mortem analysis framework”, CERN, Geneva.
- [5] R. J. Lauckner, “Post Mortem”, AB-LHC Review, 2003.

🌸 Acknowledgement:

- Iván Romera Ramírez, project supervisor.



$$\Delta P_m = \rho v \omega S_m \cdot \text{displacement}$$

Pressure

$$I = \frac{\text{Power}}{\text{Area}} = \frac{P_s}{4\pi r^2}$$

$$f = \frac{v}{\lambda} = \frac{\Delta v}{2L}$$

$$\Delta L = L \alpha \Delta T$$
$$\Delta v = v \beta \Delta T$$

$$Q = c m \Delta T$$

specific heat

$$Q = L$$

Heat = Power \cdot Time

