

An aerial photograph of a rural landscape, likely in France, showing a patchwork of agricultural fields in various shades of brown and green. A large, semi-transparent blue rectangular box is centered over the image, containing white text. The text is arranged in three lines: a main title, a name, and a date. The background image shows a winding road and a small town or village in the distance.

# Follow-up of recent MPP anomalies - CMS Solenoid trip, LHCb trip + RQX.L2

M. Zerlauth

MPP

14<sup>th</sup> September 2012

# Beam dump on 10.08.2012

- LHC beams dumped on 10.08.2012 @ 08:20:04 by SIS, following a failing BLM HV check in IR7

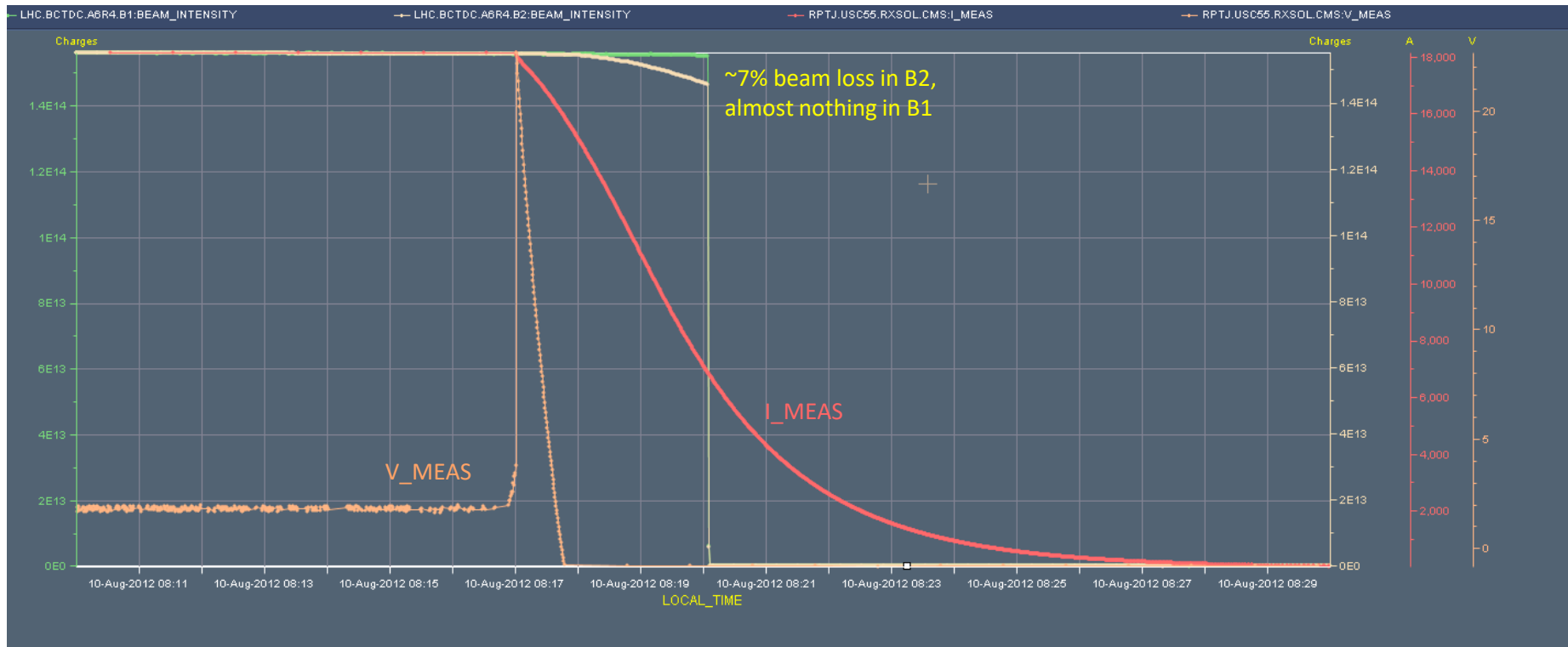
The screenshot displays the 'Final analysis is confirmed' window for a beam dump event. The interface is divided into several sections:

- Dump context:** Provides event details such as timestamp (2012.08.10 08:20:04 CEST), fill number (2934), filling pattern (50ns\_1374\_1368\_0\_1262\_144bpl2lnj), and beam mode (PROTON PHYSICS / STABLE BEAMS).
- Event sequence:** Shows the event category (PROTECTION\_DUMP) and classification (MULTIPLE\_SYSTEM\_DUMP). A highlighted box contains the list of triggered BIC inputs, including SW Permit(S3.B1), Ch 2-LBDS-b1 (TSU)(L6.B1), Ch 11-BLM\_MSK(L6.B1), Ch 11-BLM\_MSK(L6.B2), Ch 2-LBDS-b2 (TSU)(R6.B2), Ch 10-BPMs L&R syst.'B'(L6.B2), Ch 8-BPMs L&R syst.'A'(R6.B1), Ch 8-BPMs L&R syst.'A'(R6.B2), Ch 10-BPMs L&R syst.'B'(L6.B1), SW Permit(S3.B2), Ch 3-LBDS-b1 (PLC)(L6.B1), and Ch 3-LBDS-b2 (PLC)(R6.B2). SCEvents are listed as 'No power converter events found'.
- Machine protection features:** Lists various protection systems with their status (all green checkmarks): BIC IPOC, FMCM ISA, PIC IPOC, XPOC B1, XPOC B2, and PM Overall. The event description is 'BIC\_IPOC analysis finished with warnings'.
- Comments:** A highlighted box contains the text: 'Fast discharge of CMS solenoid (due to cooling problem). The orbit became bad and in a bit more than a minute the SIS dumped the beams on BLM HV status in IP7.' Below the comment are buttons for 'Confirm', 'Discard', and 'Release SIS'.

At the bottom left, a status bar indicates '21:55:24 - session confirmed by: msolfaro'.

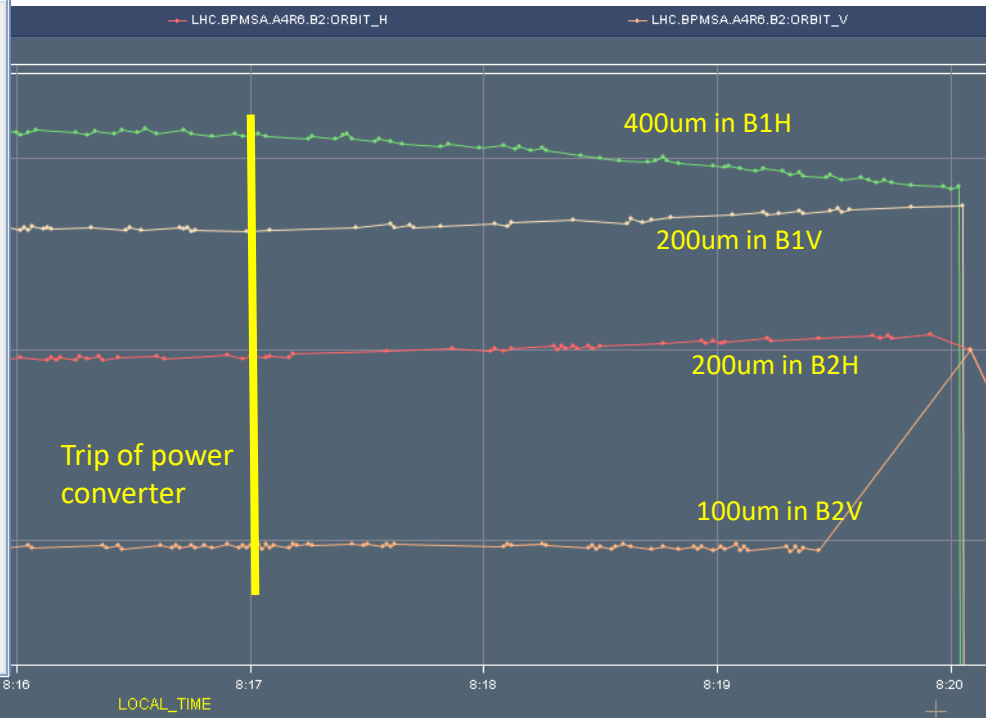
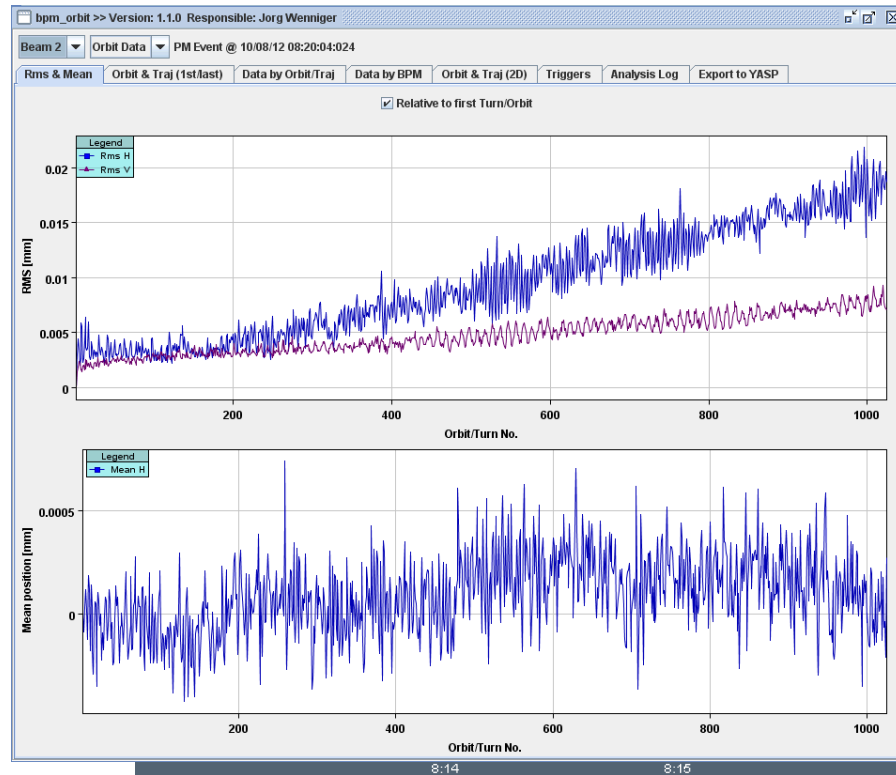
# Event Sequence 10.08.2012

- Solenoid magnet actually trips 3 minutes prior to the beam dump (@ 08:17) due to cooling problem
- Solenoid current at time of dump already < 40% of I Nom



# Orbit changes

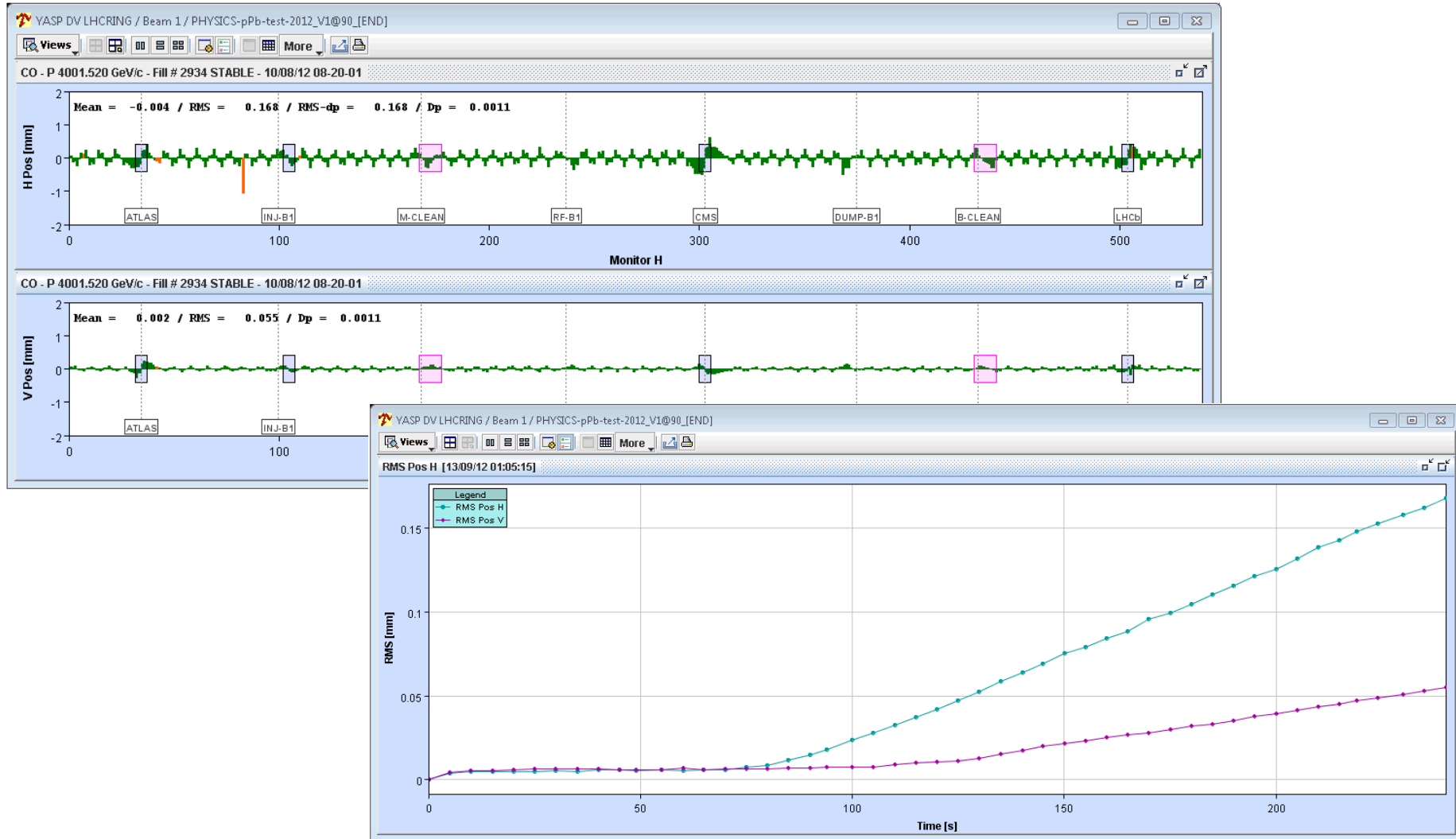
- PM recordings did not show big orbit deviations (last ~25 seconds only), while LHC Logging shows orbit changes up to 400um (last 3 minutes) – Note: Measured at interlocked BPMs
- OFB not active in Stable Beams!





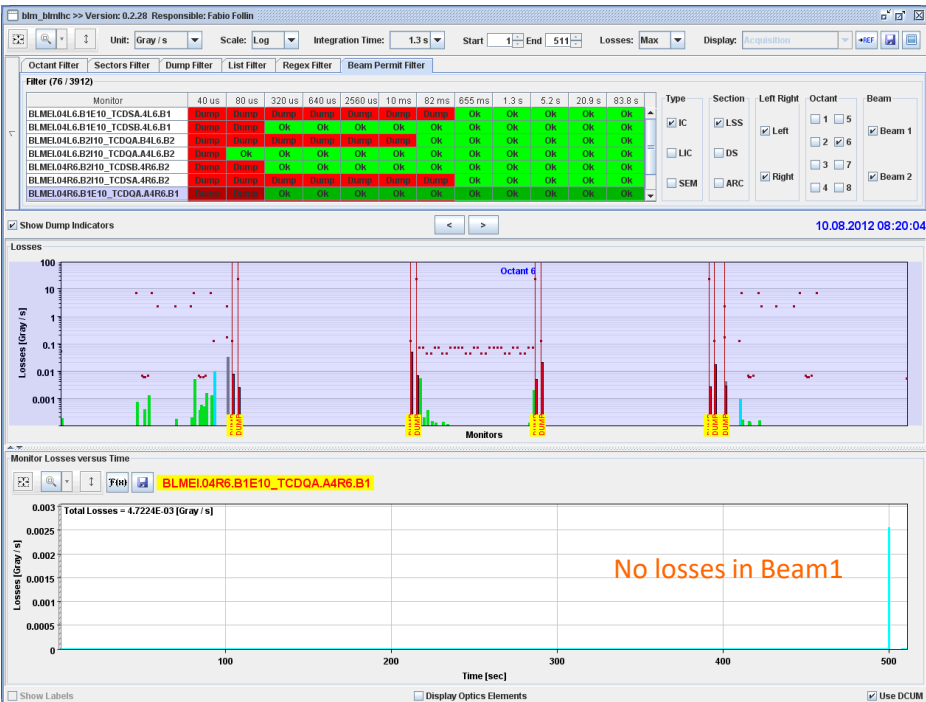
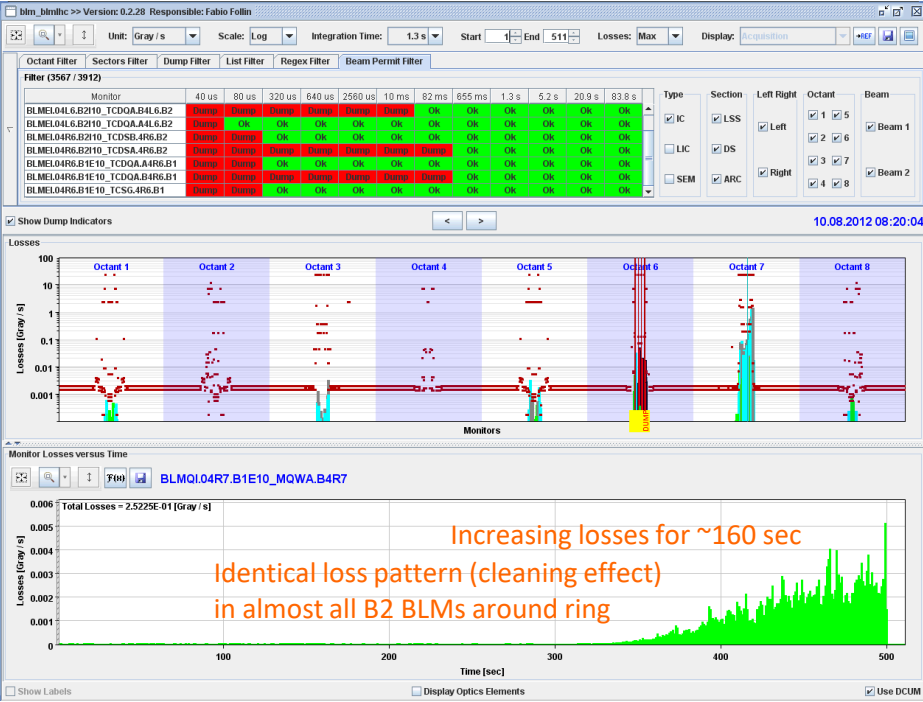
# Orbit changes from YASP

- rms change is  $\sim 150\mu\text{m}$  in H, a factor of 2 below SIS limit



# Beam Losses

- Clearly visible increase of beam losses in almost all B2 BLMs as of ~160 sec prior to the dump
- Despite bigger change of orbit almost no losses in B1



- Solenoid has a **slow but non-negligible effect** on the beams
- **Very slow and distributed losses**, not (yet) reaching BLM thresholds (set around 200kW), dump on known limitation of BLM HV (via SIS)
- Solenoid current at time of **dump**  $\sim 40\%$  of  $I_{nom}$
- **Agreement with CMS**: Provisions will be taken to provide an interlock in case of a Fast Discharge (new design of MSS already ongoing)
- **In parallel looking for  $> LS1$  into slow OFB in Physics** (needed for levelling) and SIS interlocking

# Beam dump on 19.08.2012

- LHC beams dumped on 19.08.2012 @ 09:15 by LHCb magnet trip, interlock took some 25 ms to be generated....

PM PLAYBACK PRO GUI: 0.13.5  
File Basket Session Help  
RBA: zerlauth

GLOBAL : GPM1 : 19.08.2012 09:15:42 (1345360542000000000) - PLAYBACK by zerlauth on 14.09.2012 at 14:30:56  
Final analysis is finished

Session confirmation Modules graph Results

BCT BIC IPOC BLM LOSSES BLMDiamond BLM LHC BPM ORBIT BQBQ ISA COLL HIERARCHY COLLHC ISA EVENT SEQ FGC DATA RED PIC IPOC PM EVENT POWER LOSS RF SMP SMP IPOC

### Dump context

Event timestamp: 2012.08.19 09:15:42 CEST  
Fill number: 2985  
Filling pattern: 50ns\_1374\_1368\_0\_1262\_144bpi12inj  
Acc / Beam mode: PROTON PHYSICS / RAMP  
Energy: 1516920 MeV  
Intensity B1: 22290 e<sup>10</sup> charges  
Intensity B2: 22235 e<sup>10</sup> charges  
SMP flags: PRESENT / PRESENT  
BSTAR 1/2/5/8: 11.0 / 10.0 / 11.0 / 10.0 m

### Event sequence

Event category: PROTECTION\_DUMP  
Event classification: MULTIPLE\_SYSTEM\_DUMP  
Event sequence: First LSP PERMIT change: Ch 13-LHCb\_Mag: A.T...  
Triggered BIC inputs: Ch 13-LHCb\_Mag(RB.B2), Ch 13-LHCb\_Mag(RB.B1), Ch 2-LBDS-b1 (TSU)(L6.B1), Ch 11-BLM\_MSK(L6.B1), Ch 10-BPMs L&R syst.'B'(L6.B1), Ch 8-BPMs L&R syst.'A'(R6.B2), Ch 10-BPMs L&R syst.'B'(L6.B2), Ch 3-LBDS-b1 (PLC)(L6.B1)  
SCEvents: RPTI.SR8.RBLWH.RB;

### Machine protection features

Event description: BIC\_IPOC analysis finished with warnings.  
Highest beam losses: BLMEI.04L6.B1E10\_TCDSA.4L6.B1 BLMEI.04L6.B1E10\_TCDSB.4L6.B1 BLMEI.04R6.B2I10\_TCDSB.4R6.B2  
Magnet quenches: No magnet quenches found  
nQPS triggers: No nQPS events found

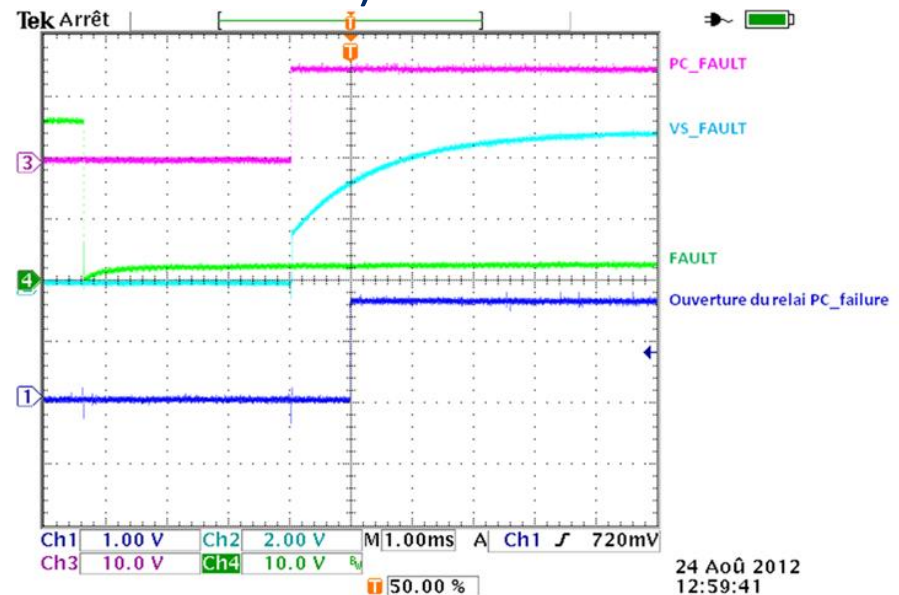
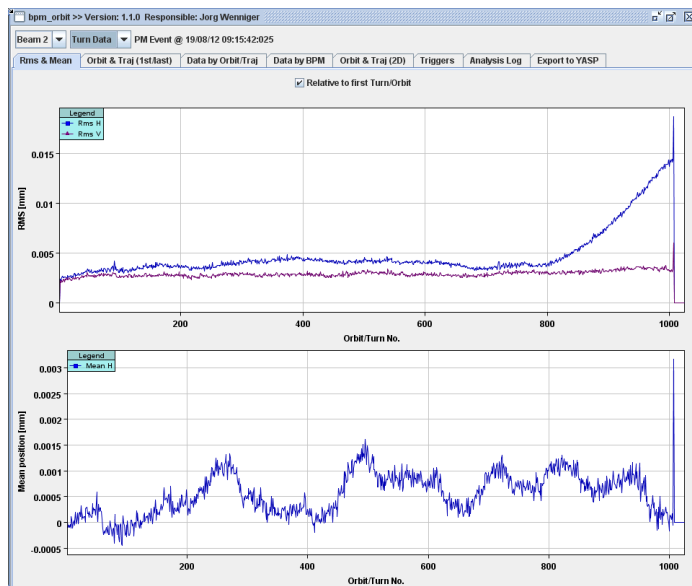
BIC IPOC: <input checked="" type="checkbox"/>	FMCM ISA: <input checked="" type="checkbox"/>	PIC IPOC: <input checked="" type="checkbox"/>
XPOC B1: <input checked="" type="checkbox"/>	XPOC B2: <input checked="" type="checkbox"/>	
Safe for injection?: <input checked="" type="checkbox"/>	PM Overall: <input checked="" type="checkbox"/>	

### Comments

User:   
Advised actions:   
**Input your comment and confirmation parameters for session confirmation:**  
Beam Losses:  Loss type:   
Orbit Changes:  Classification:



- Discussion with Hugues and Sylvain Ravat:
- MSS (Magnet Safety System) re-design ongoing (see previous discussion for CMS) – same MSS is used for all experiments
- Re-design based on NI Rio FPGA card already ongoing, replacing (obsolete) fuse programmable FPGA
- Will investigate to improve input filtering at output relay contact to bring down MSS transit time to 5 ms (instead of 25ms)



24 Août 2012  
12:59:41



- Beams were dumped while in STABLE\_BEAMS at 11:28:47 on 7<sup>th</sup> of September due to Beam Losses in IR7

cerntsab22 - Remote Desktop Connection

PM ONLINE PRO GUI : 0.13.5

File Basket Expert Settings Session Help

RBA: zerlauth

GLOBAL : GPM1 : 07.09.2012 11:28:47 (1347010127544573225) - ONLINE

Final analysis is confirmed

Session confirmation Modules graph Results

BCT BIC IPOC BLM LOSSES BLMDiamond BLMLHC BPM ORBIT BQBQ ISA COLL HIERARCHY COLLHC ISA EVENT SEQ FGC DATA RED PIC IPOC PM EVENT POWER LOSS RF SMP SMP IPOC

### Dump context

Event timestamp: 2012.09.07 11:28:47 CEST  
Fill number: 3036  
Filling pattern: 50ns\_1374\_1368\_0\_1262\_144bpi12inj  
Acc / Beam mode: PROTON PHYSICS / STABLE BEAMS  
Energy: 3999960 MeV  
Intensity B1: 18521 e<sup>10</sup> charges  
Intensity B2: 18350 e<sup>10</sup> charges  
SMP flags: PRESENT, STABLE, MOVEABLE / PRESENT, STABLE, MOVEABLE  
BSTAR 1/2/5/8: 0.6 / 3.0 / 0.6 / 3.0 m

### Event sequence

Event category: PROTECTION\_DUMP  
Event classification: MULTIPLE\_SYSTEM\_DUMP  
Event sequence: First USR\_PERMIT change: Ch 11-BLM\_MSK: A T -> F on CI B.SR7.S7.B1  
Triggered BIC inputs: Ch 11-BLM\_MSK(S7.B1), Ch 11-BLM\_MSK(S7.B2), Ch 2-LBDS-b2 (TSU)(R6.B2), Ch 2-LBDS-b1 (TSU)(L6.B1), Ch 11-BLM\_MSK(L6.B2), Ch 11-BLM\_MSK(L6.B1), Ch 8-BPMs L&R syst.'A'(R6.B1), Ch 10-BPMs L&R syst.'B'(L6.B2), Ch 10-BPMs L&R syst.'B'(L6.B1), Ch 8-BPMs L&R syst.'A'(R6.B2), Ch 3-LBDS-b1 (PLC)(L6.B1), Ch 3-LBDS-b2 (PLC)(R6.B2), Ch 12-PIC\_MSK(L5.B2), Ch 12-PIC\_MSK(L5.B1), Ch 5-PIC\_UNM(L5.B2), Ch 5-PIC\_UNM(L5.B1), Ch 5-PIC\_UNM(R5.B2), Ch 5-PIC\_UNM(R5.B1), Ch 12-PIC\_MSK(R5.B2), Ch 12-PIC\_MSK(R5.B1)  
SCEvents: No power converter events found

### Machine protection features

Event description: BIC\_IPOC analysis finished with warnings.  
Highest beam losses: BLMEI.04L6.B1E10\_TCDSA.4L6.B1 BLMEI.06R7.B1E10\_TCLA.A6R7.B1 BLMEI.06R7.B1E10\_TCLA.B6R7.B1  
Magnet quenches: No magnet quenches found  
nQPS triggers: No nQPS events found

BIC IPOC:  FMCM ISA:  PIC IPOC:   
XPOC B1:  XPOC B2:   
Safe for Injection?:  PM Overall:

### Comments

User: jwenning  
Advised actions:  
Beam Losses: Losses in IR5 and/or IR7 Loss type: Slow Losses (R508-12)  
Orbit Changes: Orbit changes < 0.5 mm Classification: Power converter fault(s)  
PC fault on IT R5. The BLM trigger came once more before the PIC, the orbit oscillation on B2 exceeded 0.1 mm peak, no surprise this gave a dump.

Confirm Discard Release SIS

13:49:10 - session confirmed by : jwenning



- Actual cause was converter trip of RQX.R5, which however was reported to the interlock systems only 2.06s later!

**HEADER**

System	BIC
Class	EVENT_SEQ
Source	ISA
Event stamp	11:28:47.544 07/09/12
Version	0.4.11
Encoding	BICEVENT_SEQ
Qualifier	
Analysis flags	[NORMAL]

**SUMMARY**

pmAnalysisModuleVersion	0.4.11
Analysis result description	First USER_PERMIT change: Ch 11-BLM_MSK A T-> F on CIB.SR7.S7.B1
Triggered BIC inputs	Ch 11-BLM_MSK(S7.B1), Ch 11-BLM_MSK(S7.B2), Ch 2-LBDS-b2 (TSUJ)(R6.B2), Ch 2-LBDS-b1 (TSUJ)(L6.B1)...
Beam 1 propagation delay to LBDS	25000 ns
Beam 2 propagation delay to LBDS	26000 ns
OVERALL	38 BICs triggered valid PM data

**EVENT OVERVIEW**

Index	Loc.Permit A/B	Time	Delta(uSec)	Description	BIC name
1056		11:28:47+545660	1118	USER_PERMIT: Ch 8-BPMs L&R syst'A: A T-> F	CIB.UA67.R6.B2
1057		11:28:47+545663	1121	USER_PERMIT: Ch 8-BPMs L&R syst'A: B T-> F	CIB.UA67.R6.B2
1408		11:28:47+587259	42717	USER_PERMIT: Ch 3-LBDS-b1 (PLOC): B T-> F	CIB.UA63.L6.B1
1409		11:28:47+587260	42718	USER_PERMIT: Ch 3-LBDS-b1 (PLOC): A T-> F	CIB.UA63.L6.B1
1410		11:28:47+589797	45255	USER_PERMIT: Ch 3-LBDS-b2 (PLOC): B T-> F	CIB.UA67.R6.B2
1411		11:28:47+589799	45257	USER_PERMIT: Ch 3-LBDS-b2 (PLOC): A T-> F	CIB.UA67.R6.B2
1412		11:28:47+597177	52635	USER_PERMIT: Ch 11-BLM_MSK A F-> T	CIB.SR7.S7.B1
1413		11:28:47+597177	52635	USER_PERMIT: Ch 11-BLM_MSK B F-> T	CIB.SR7.S7.B1
1414		11:28:47+597178	52636	USER_PERMIT: Ch 11-BLM_MSK A F-> T	CIB.SR7.S7.B2
1415		11:28:47+597178	52636	USER_PERMIT: Ch 11-BLM_MSK B F-> T	CIB.SR7.S7.B2
1416		11:28:47+700030	155488	USER_PERMIT: Ch 11-BLM_MSK A F-> T	CIB.UA63.L6.B2
1417		11:28:47+700030	155488	USER_PERMIT: Ch 11-BLM_MSK B F-> T	CIB.UA63.L6.B2
1418		11:28:47+700030	155488	USER_PERMIT: Ch 11-BLM_MSK A F-> T	CIB.UA63.L6.B1
1419		11:28:47+700030	155488	USER_PERMIT: Ch 11-BLM_MSK B F-> T	CIB.UA63.L6.B1
1420		11:28:47+703474	158932	USER_PERMIT: Ch 2-LBDS-b2 (TSUJ): B F-> T	CIB.UA67.R6.B2
1421		11:28:47+703474	158932	USER_PERMIT: Ch 2-LBDS-b2 (TSUJ): A F-> T	CIB.UA67.R6.B2
1422		11:28:47+710299	165757	USER_PERMIT: Ch 2-LBDS-b1 (TSUJ): A F-> T	CIB.UA63.L6.B1
1502		11:28:49+614369	2069827	USER_PERMIT: Ch 12-PIC_MSK: A T-> F	CIB.USC55.L5.B2
1503		11:28:49+614369	2069827	USER_PERMIT: Ch 12-PIC_MSK: B T-> F	CIB.USC55.L5.B2
1504		11:28:49+614369	2069827	USER_PERMIT: Ch 12-PIC_MSK: A T-> F	CIB.USC55.L5.B1
1505		11:28:49+614369	2069827	USER_PERMIT: Ch 12-PIC_MSK: B T-> F	CIB.USC55.L5.B1
1506		11:28:49+614371	2069829	USER_PERMIT: Ch 5-PIC_UNM: A T-> F	CIB.USC55.L5.B2
1507		11:28:49+614371	2069829	USER_PERMIT: Ch 5-PIC_UNM: B T-> F	CIB.USC55.L5.B2
1509		11:28:49+614371	2069829	USER_PERMIT: Ch 5-PIC_UNM: A T-> F	CIB.USC55.L5.B1
1510		11:28:49+614371	2069829	USER_PERMIT: Ch 5-PIC_UNM: B T-> F	CIB.USC55.L5.B1
1511		11:28:49+614380	2069830	USER_PERMIT: Ch 5-PIC_UNM: A T-> F	CIB.UA67.R6.B2
1515		11:28:49+614380	2069838	USER_PERMIT: Ch 5-PIC_UNM: B T-> F	CIB.UA67.R6.B2
1516		11:28:49+614381	2069839	USER_PERMIT: Ch 5-PIC_UNM: A T-> F	CIB.UA67.R6.B1
1517		11:28:49+614381	2069839	USER_PERMIT: Ch 5-PIC_UNM: B T-> F	CIB.UA67.R6.B1
1518		11:28:49+614382	2069840	USER_PERMIT: Ch 12-PIC_MSK: A T-> F	CIB.UA67.R6.B2
1519		11:28:49+614382	2069840	USER_PERMIT: Ch 12-PIC_MSK: B T-> F	CIB.UA67.R6.B2
1520		11:28:49+614382	2069840	USER_PERMIT: Ch 12-PIC_MSK: A T-> F	CIB.UA67.R6.B1
1523		11:28:49+614383	2069841	USER_PERMIT: Ch 12-PIC_MSK: B T-> F	CIB.UA67.R6.B1

**SOURCE OVERVIEW**

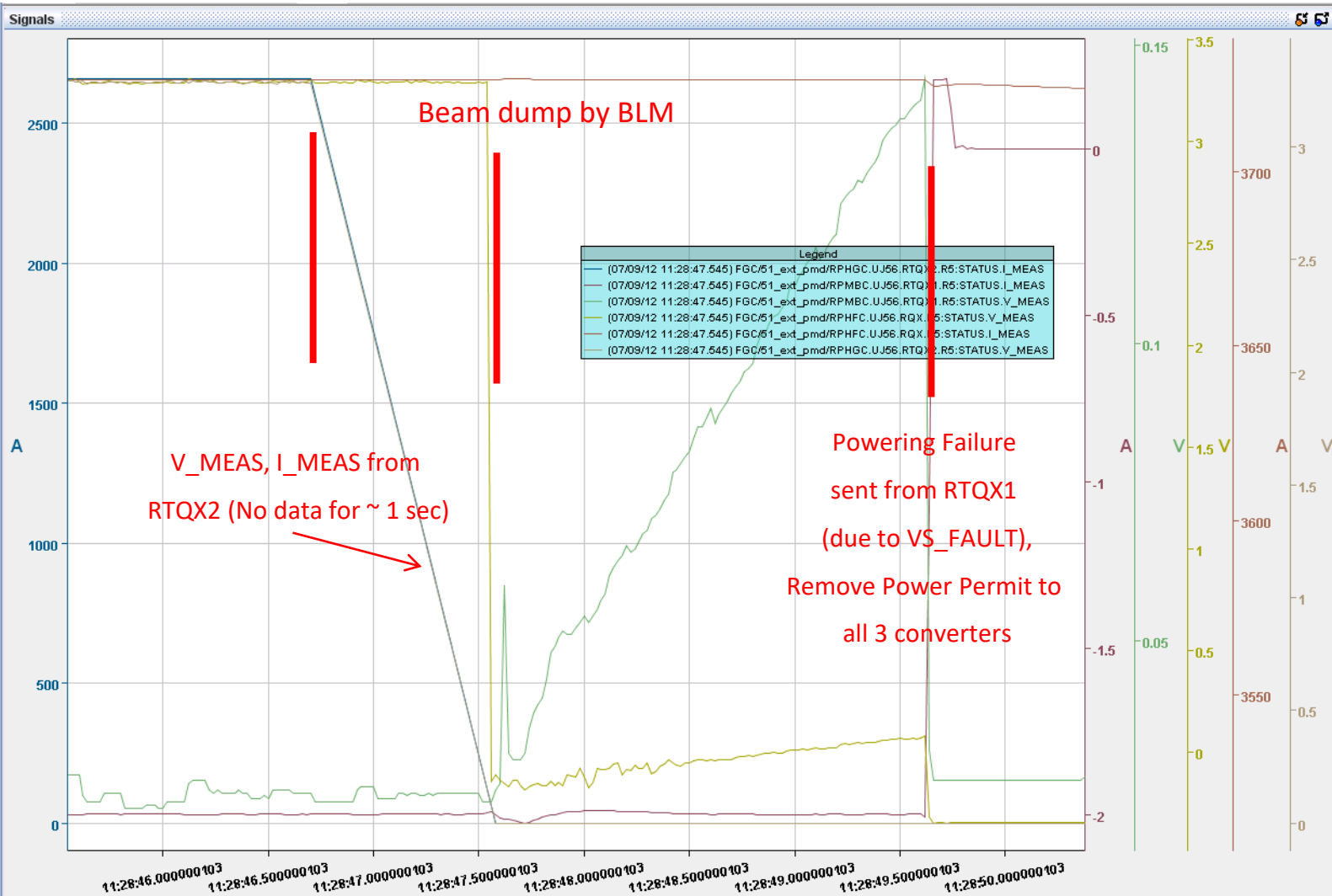
Index	Source Name	Data Valid
1	CIB.UJ56.R5.B1	true
2	CIB.UA83.L8.B2	true
3	CIB.UJ56.R5.B2	true
4	CIB.UA83.L8.B1	true
5	CIB.UJ56.L1.B1	true
6	CIB.UJ56.L1.B2	true
7	CIB.SR7.S7.B1	true
8	CIB.SR7.S7.B2	true
9	CIB.USC55.L5.B2	true
10	CIB.UA87.R8.B1	true
11	CIB.USC55.L5.B1	true
12	CIB.UA87.R8.B2	true
13	CIB.UJ56.L1.B1	true
14	CIB.UJ56.L1.B2	true
15	CIB.UJ33.U3.B2	true
16	CIB.UJ33.U3.B1	true
17	CIB.UA63.L6.B2	true
19	CIB.SR3.S3.B2	true
20	CIB.SR8.INJ.1	true
21	CIB.SR3.S3.B1	true
22	CIB.SR2.INJ.1	true
23	CIB.UA67.R6.B2	true
24	CIB.SR2.INJ.2	true
25	CIB.UA67.R6.B1	true
26	CIB.CCR.LHC.B1	true
27	CIB.UA47.R4.B1	true
28	CIB.UA23.L2.B2	true
29	CIB.CCR.LHC.B2	true
30	CIB.UA23.L2.B1	true
31	CIB.UA47.R4.B2	true
32	CIB.UA43.L4.B2	true
33	CIB.UA43.L4.B1	true
34	CIB.TZ76.U7.B2	true
35	CIB.TZ76.U7.B1	true
36	CIB.SR8.INJ.2	true
37	CIB.UA27.R2.B2	true
38	CIB.UA27.R2.B1	true

**FILTER**

Beam\_Permit\_Loop  Beam\_Permit  Local\_Permit  User\_Permit  User\_Permit\_Glitch  Software  Mask  Masked\_Permit

Disabled\_Permit  Channel\_Enable  Test  Power  Self\_Test  Time  Safe\_Beam\_Flag  Marker  Injection\_BICs

Channel A  Channel B  Beam 1  Beam 2  Generator



	Signal name	value offset	value scale factor	time offset
<input checked="" type="checkbox"/>	(07/09/12 11:28:47.545) FGC/51_ext_pmd/RPHGC.UJ56.RTQX2.R5.STATUS.I_MEAS	0	1	0
<input checked="" type="checkbox"/>	(07/09/12 11:28:47.545) FGC/51_ext_pmd/RPMBC.UJ56.RTQX1.R5.STATUS.I_MEAS	0	1	0
<input checked="" type="checkbox"/>	(07/09/12 11:28:47.545) FGC/51_ext_pmd/RPMBC.UJ56.RTQX1.R5.STATUS.V_MEAS	0	1	0
<input checked="" type="checkbox"/>	(07/09/12 11:28:47.545) FGC/51_ext_pmd/RPHFC.UJ56.RQX.R5.STATUS.V_MEAS	0	1	0
<input checked="" type="checkbox"/>	(07/09/12 11:28:47.545) FGC/51_ext_pmd/RPHFC.UJ56.RQX.R5.STATUS.I_MEAS	0	1	0



- This event seems to definitely be a **radiation related latch-up**, given that it was finally cleared by a power cycle.
- The reason that the PIC wasn't informed about the failure relates to the **design choice to keep the converter running for up to about 2s in the event of an FGC crash**. This was included in the design to theoretically allow the FGC to reset and then to recover control of the converter. However, as you know, we **never tried to implement this feature** and now we see that both the last two events were SELs which require a power cycle anyway. So we were wise not to bother.
- As a result, this **2s timeout before the CPLD switches off the converter** and sends the PWR\_FAILURE signal to the PIC is a feature that adds no value and in this case caused a problem.
- In conclusion, I would **recommend that during LS1, as part of an upgrade to the FGC2 CPLD programming, this 2s watchdog be overridden**.