Analysis of a few beam dumps – functionality of protection systems

- D1 switched off with FMCM active
- D1 switched off with FMCM masked
  - Event 2/12/09 00:21:29.411

- Trip of RB in sector 12
  - Event 5/12/09 19:30:26

D1 switched off with FMCM active

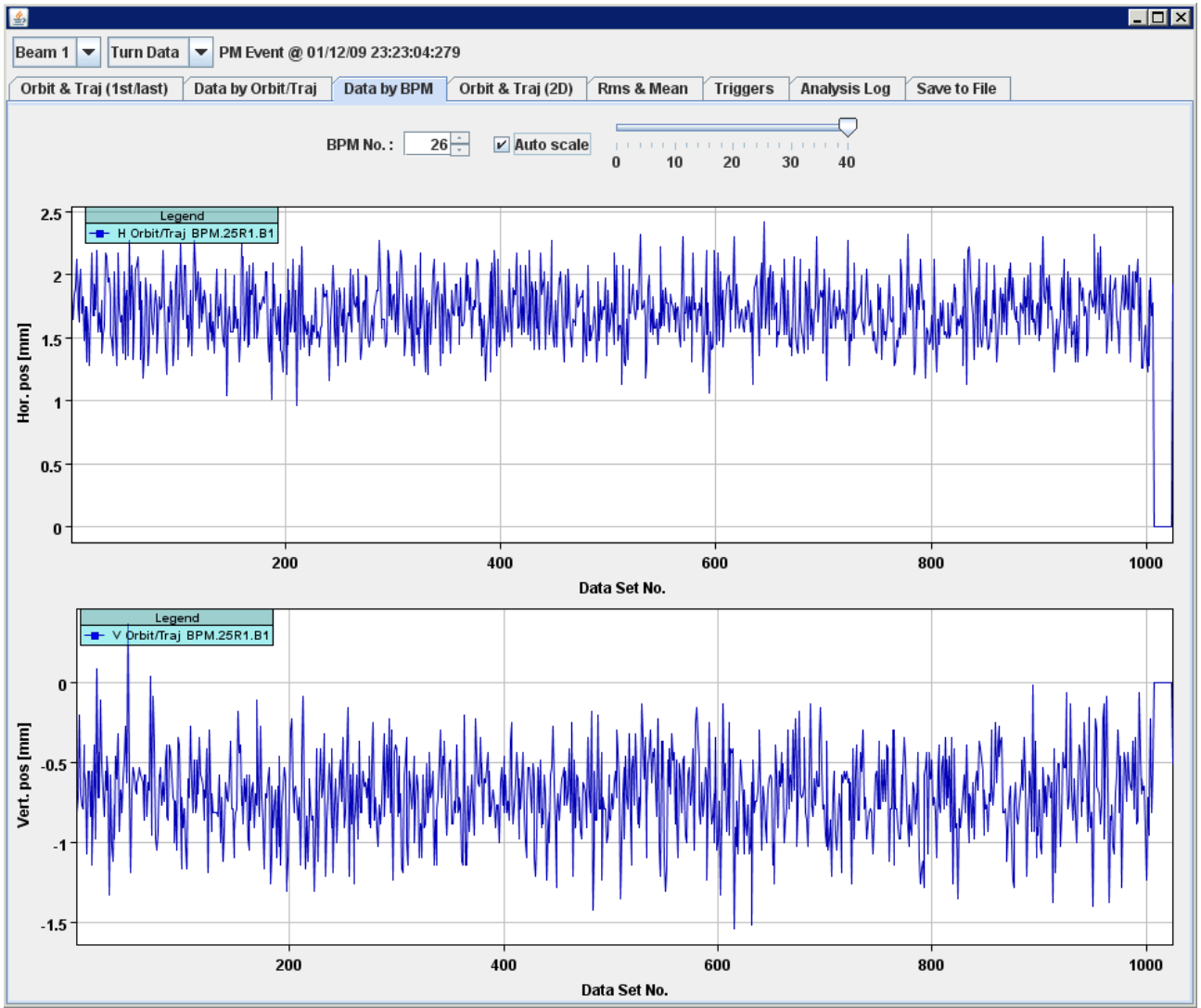
- Switching off the D1 leads to fast beam movements, one of the most critical failures
- The FMCM detects a trip of the power converter, and dumps the beam
- As redundant protection, the beam loss monitors are expected to dump the beam

With low intensity

- switch off D1 with nominal protection
- switch off D1 with the FMCM masked

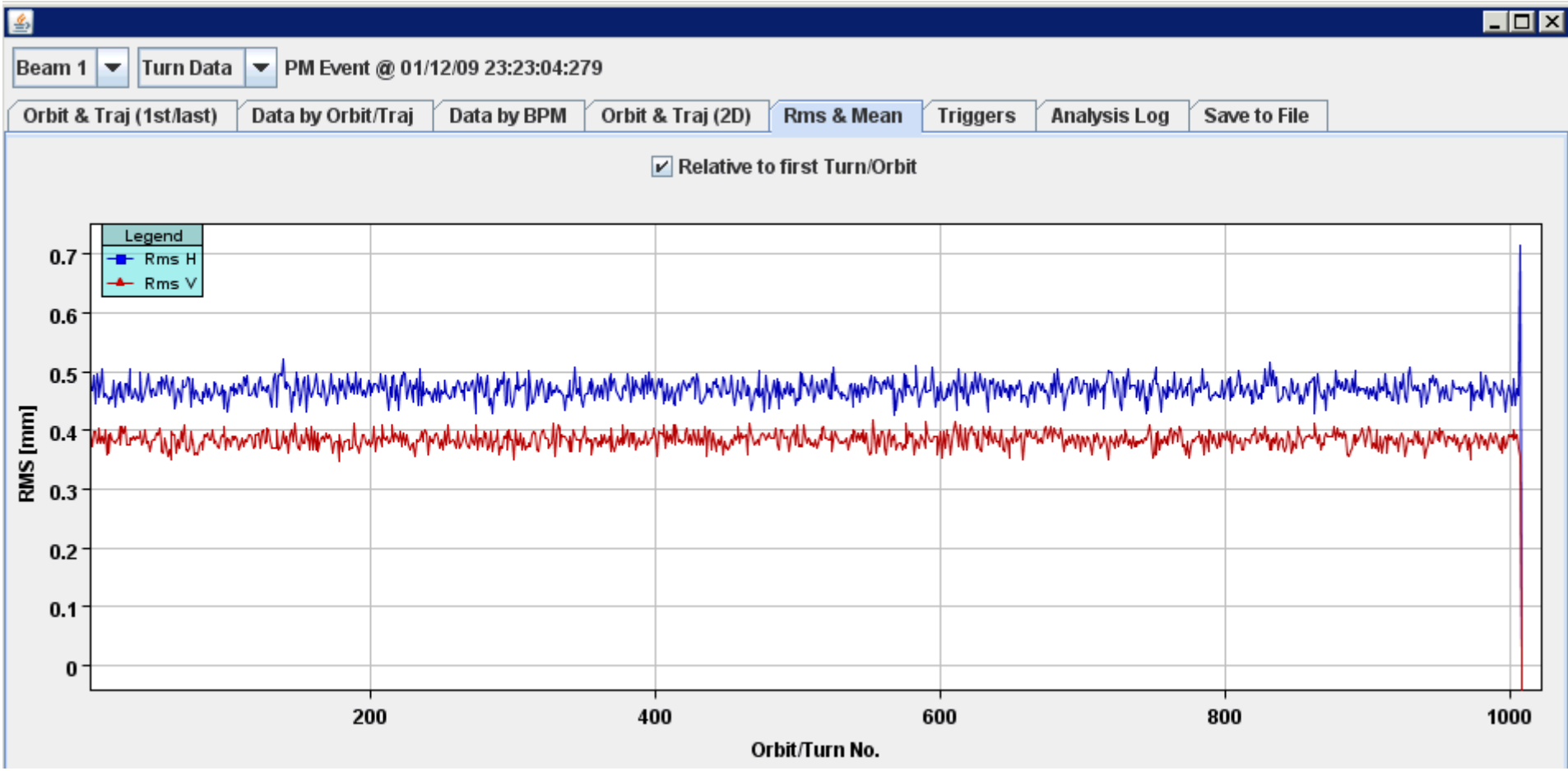
RD1 OFF - FMCM active

Trajectory evolution after OFF send to RD1.LR1, with FMCM active.



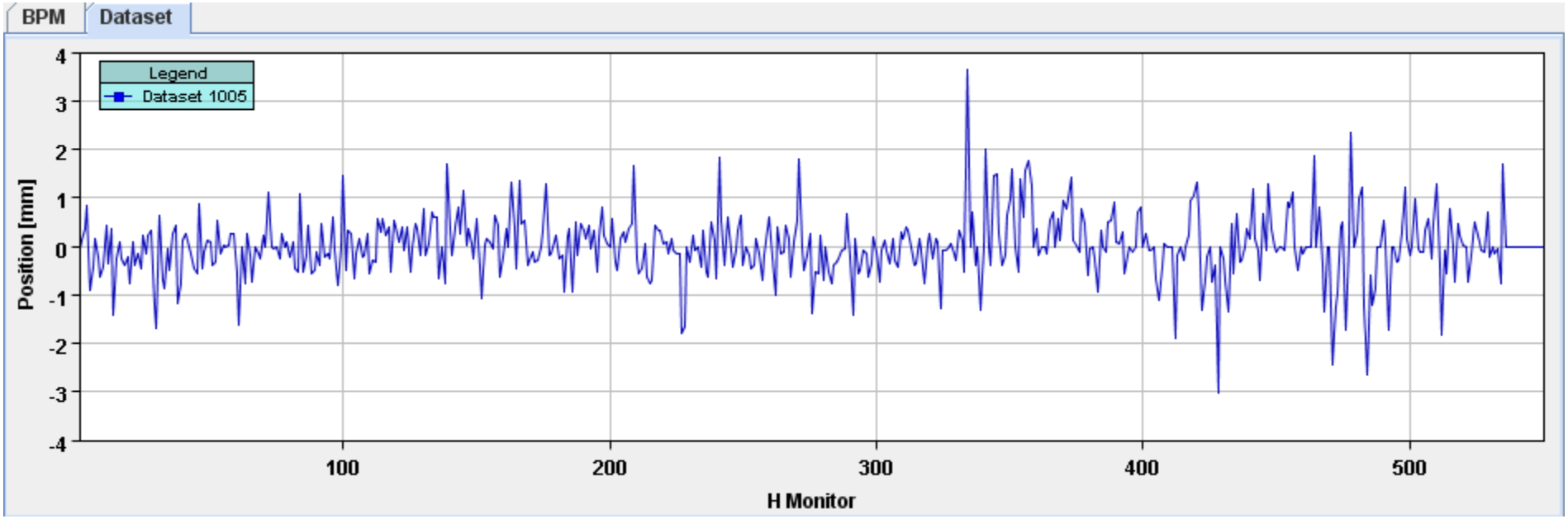
RD1 OFF - FMCM active

Trajectory rms evolution after OFF send to RD1.LR1, with FMCM active.

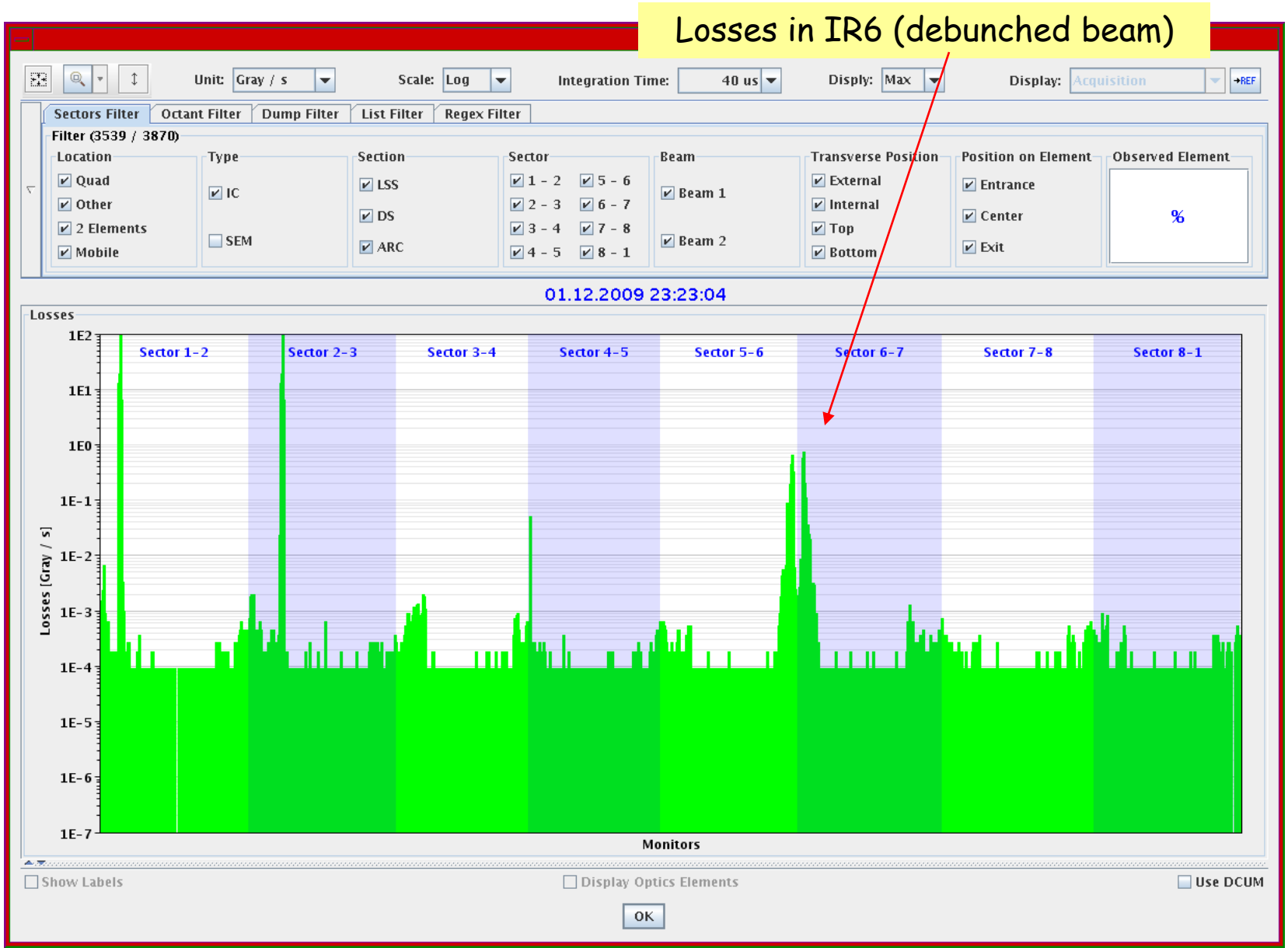


RD1 OFF - FMCM active

Trajectory difference after OFF send to RD1.LR1, with FMCM active.



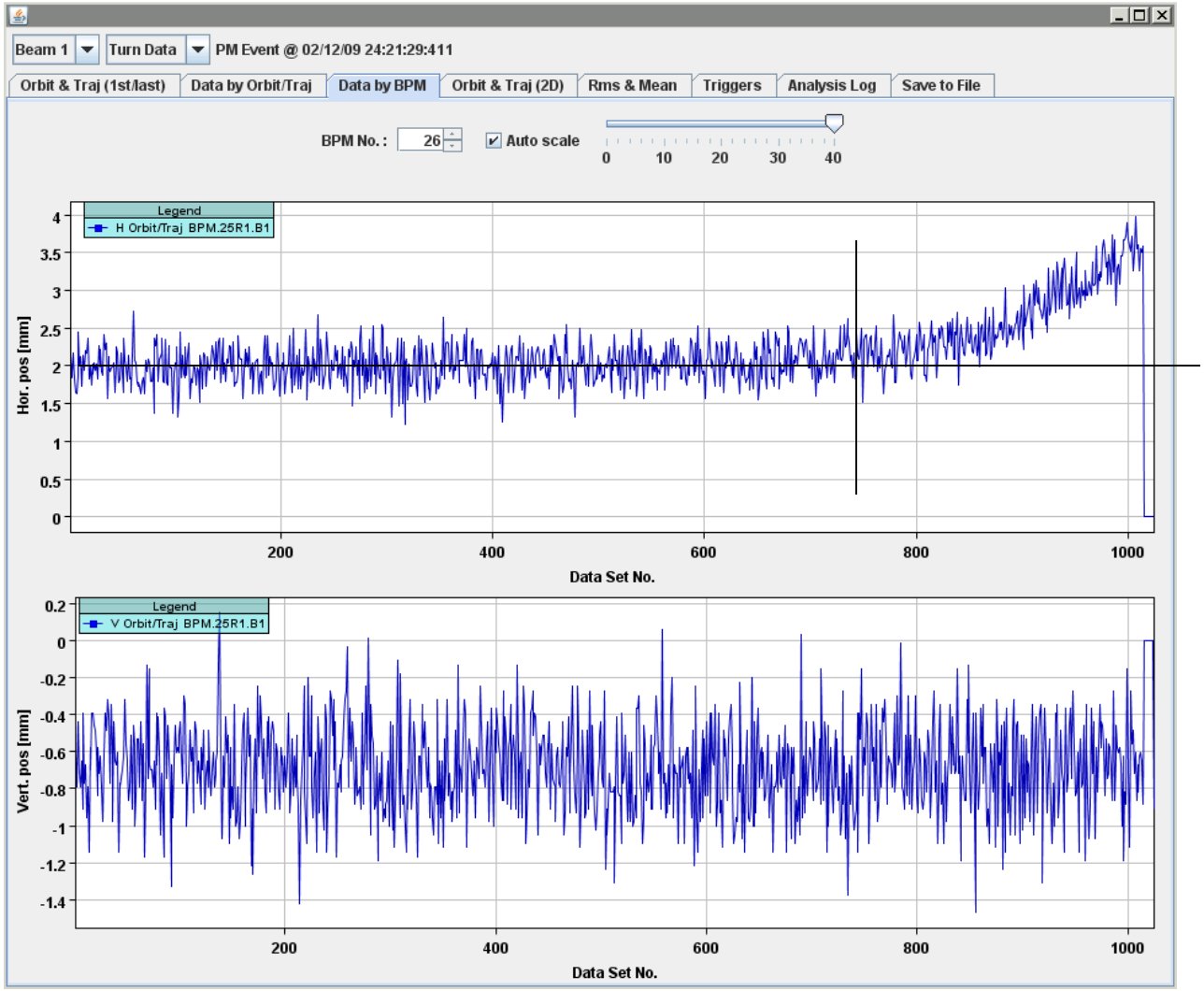
RD1 OFF - FMCM active



RD1 OFF – FMCM masked – one BPM

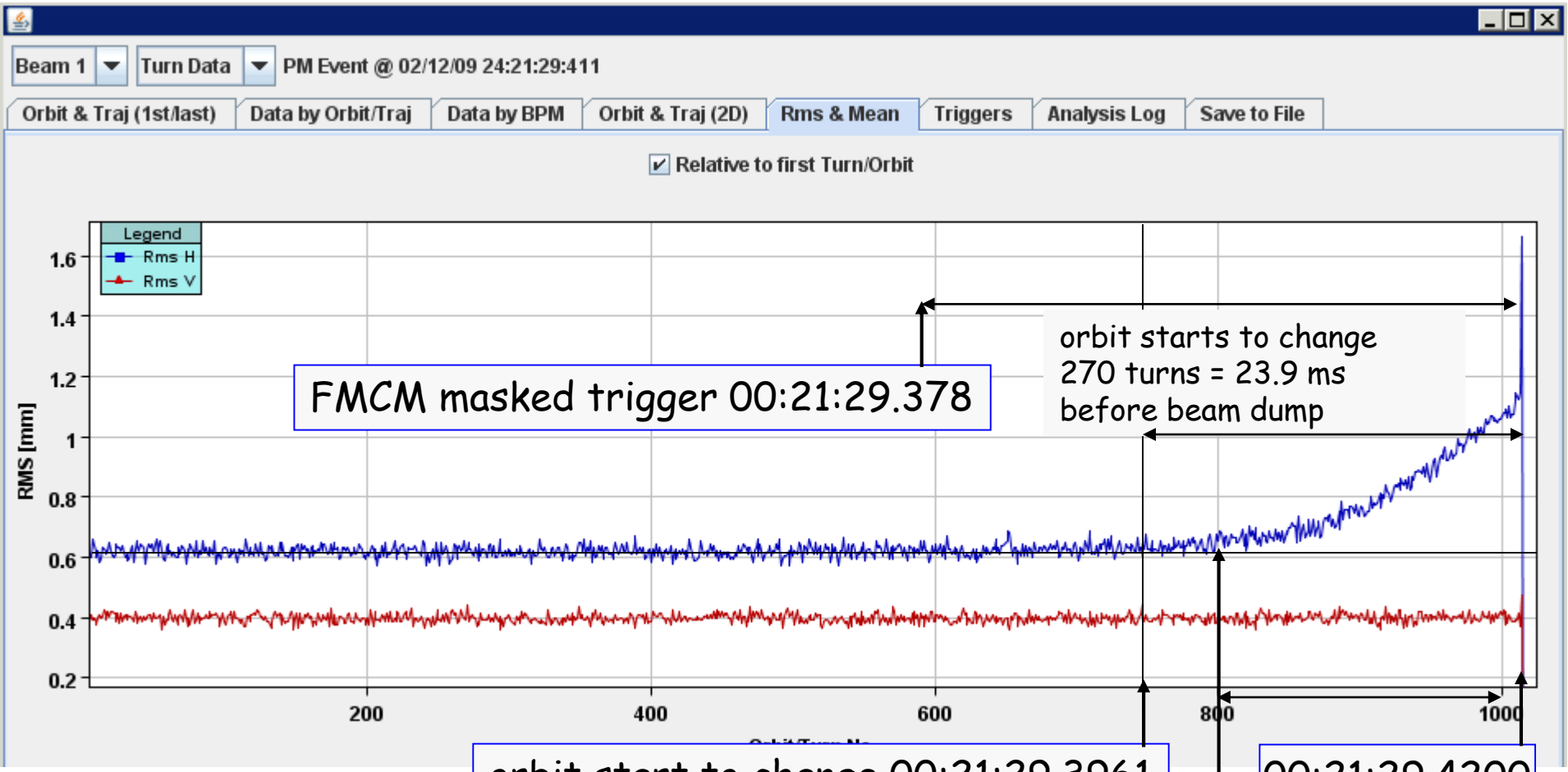
Trajectory evolution after OFF send to RD1.LR1, with FMCM masked.

PM event: 2/12/09 00:21:29.411
FMCM (masked) trigger: 00:21:29.378
BLM trigger: 00:21:29.420



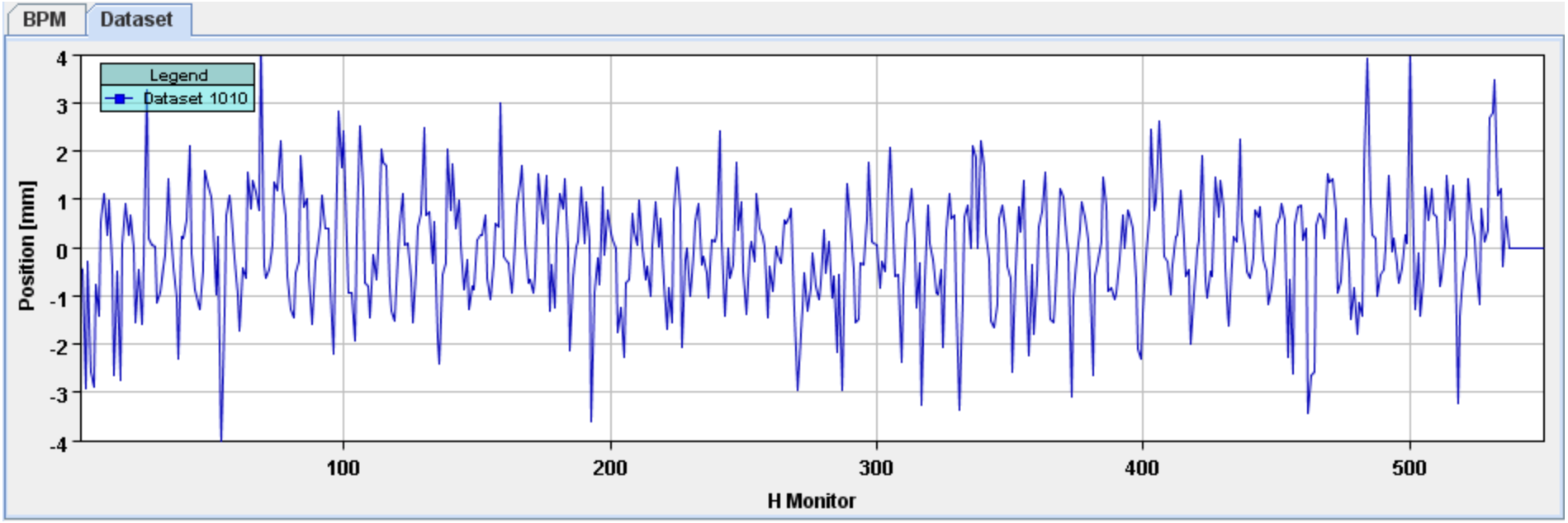
RD1 OFF - FMCM masked H-orbit RMS

Trajectory rms evolution after OFF send to RD1.LR1, with FMCM masked.



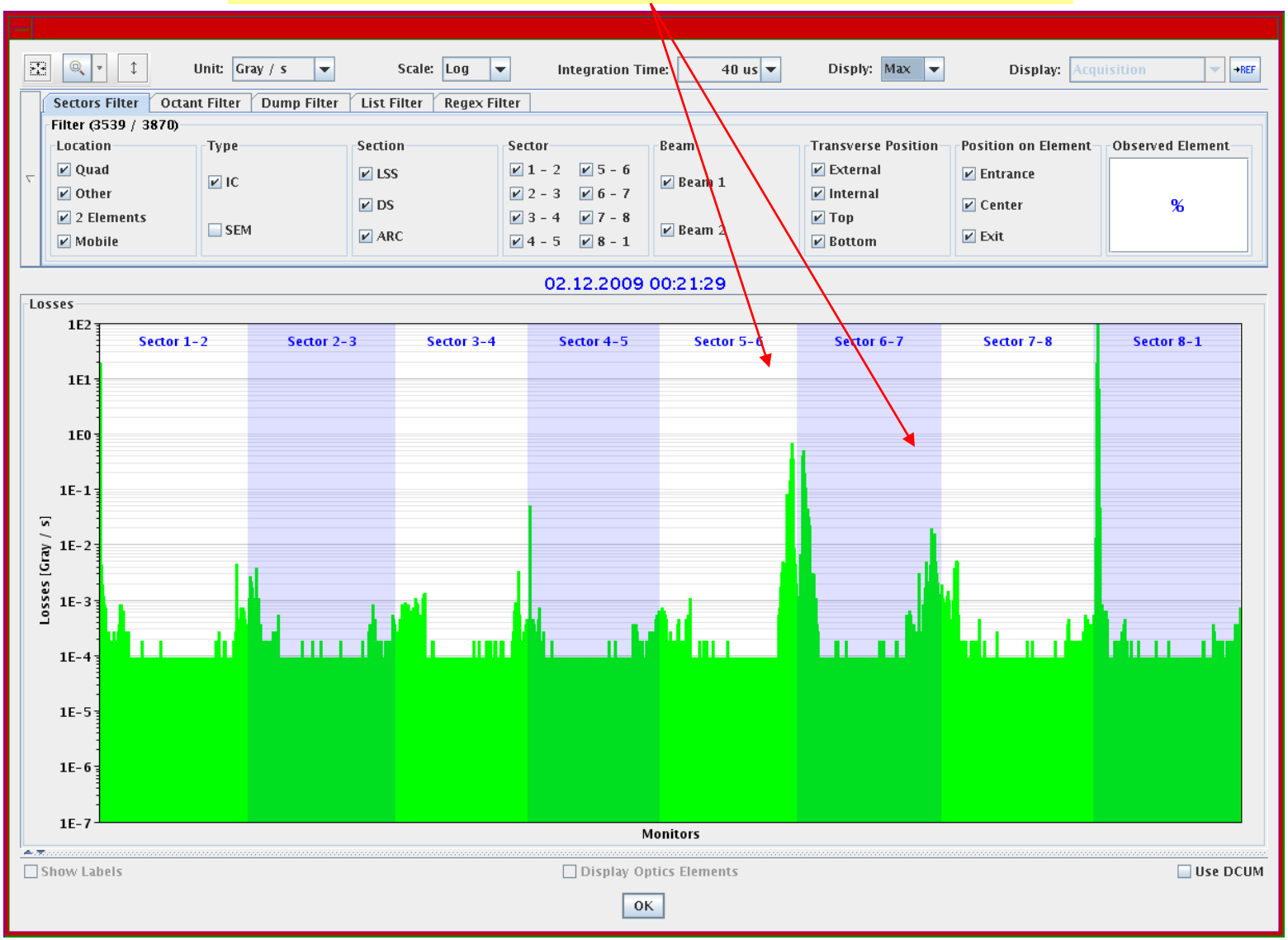
RD1 OFF – FMCM masked

Trajectory difference after OFF send to RD1.LR1, with FMCM masked.



RD1 OFF - FMCM masked -

Losses in IR6 (debunched beam) and IR7



RD1 OFF – FMCM masked

Unit: Gray / s Scale: Log Integration Time: 40 us Disply: Max

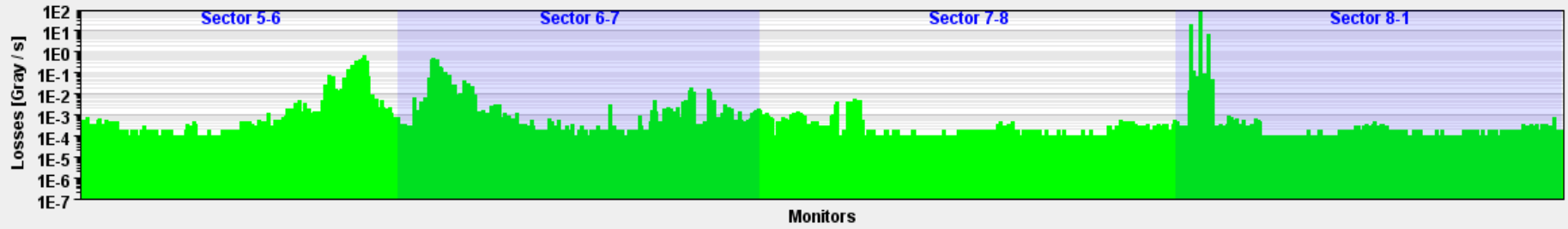
Sectors Filter | Octant Filter | Dump Filter | List Filter | Regex Filter

Filter (713 / 3870)

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		

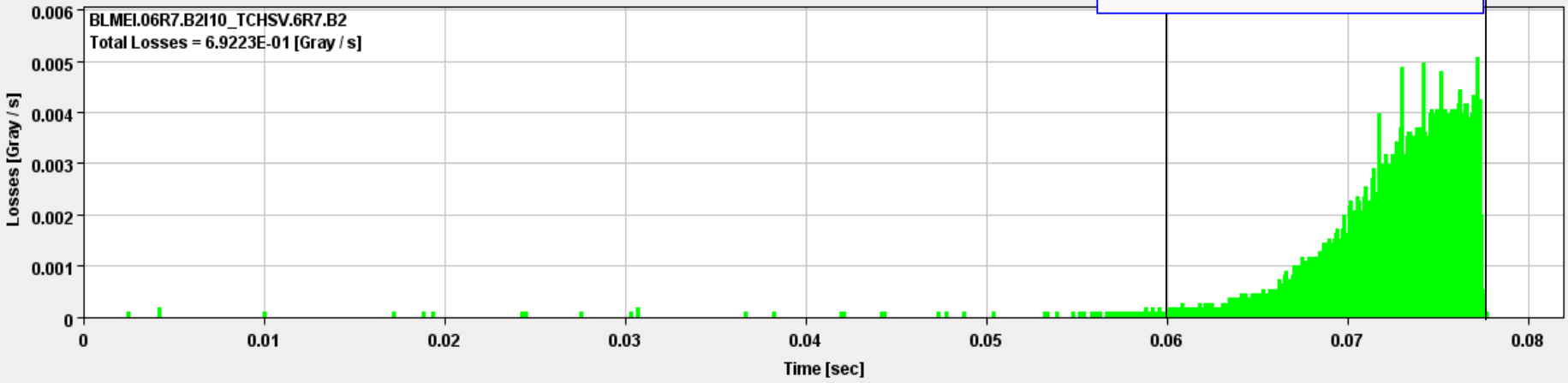
02.12.2009 00:21:29

Losses



Monitor Losses versus Time

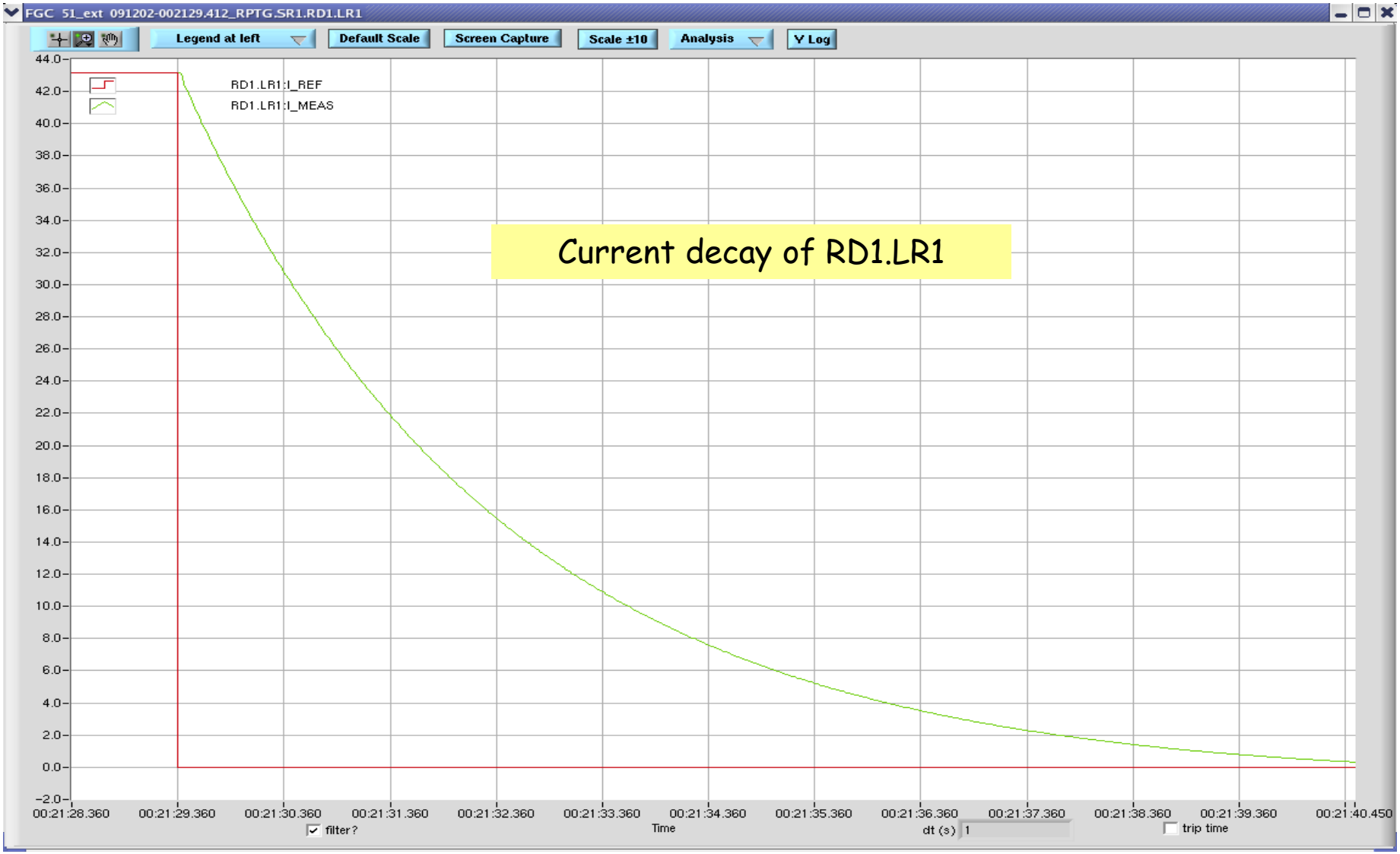
beam losses start at 00:21:29.402



☐ Show Labels ☐ Display Optics Elements ☐ Use DCUM

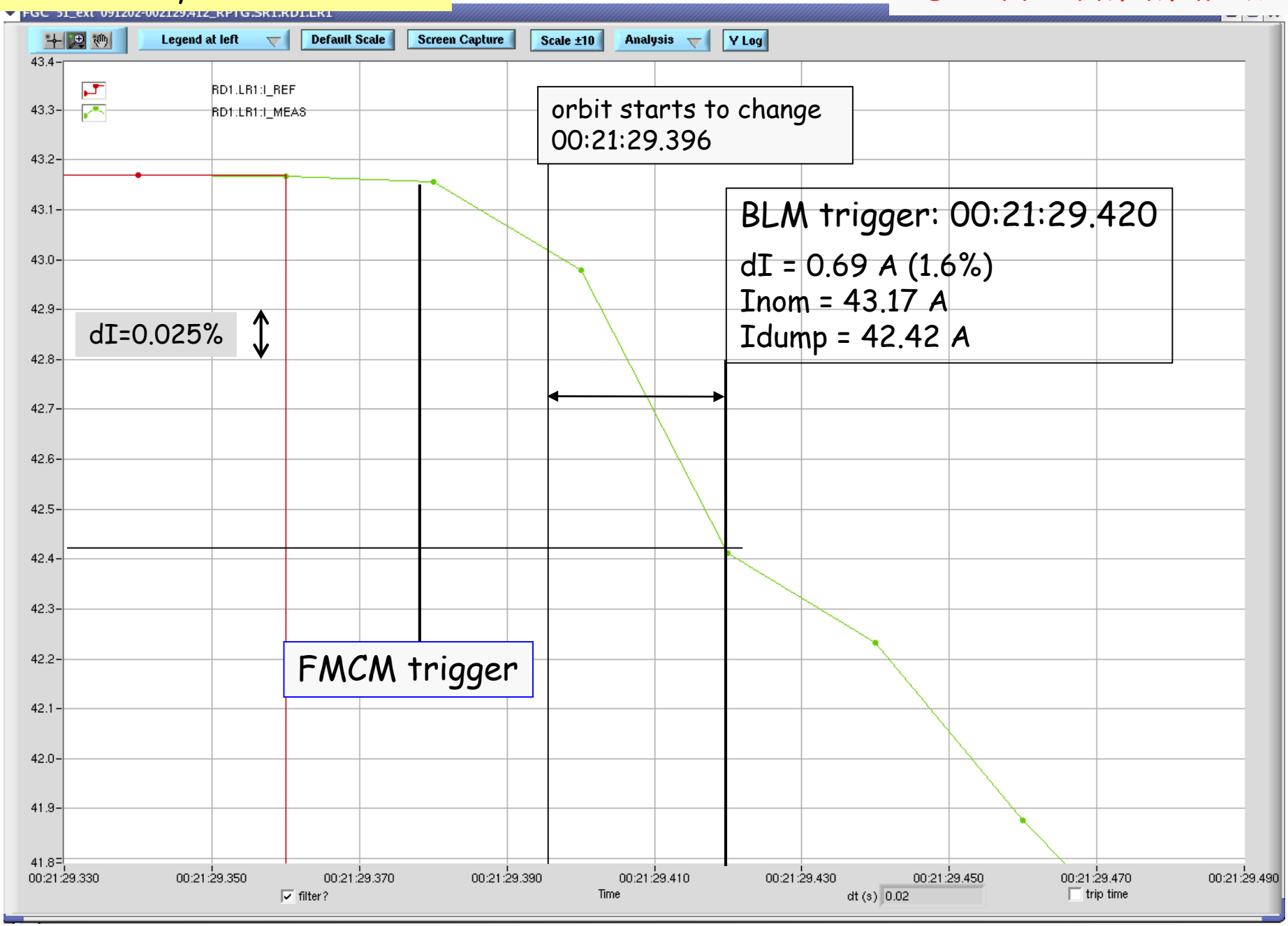
OK

RD1 OFF – FMCM masked



Current decay of RD1.LR1 zoom

RD1 OFF – FMCM masked

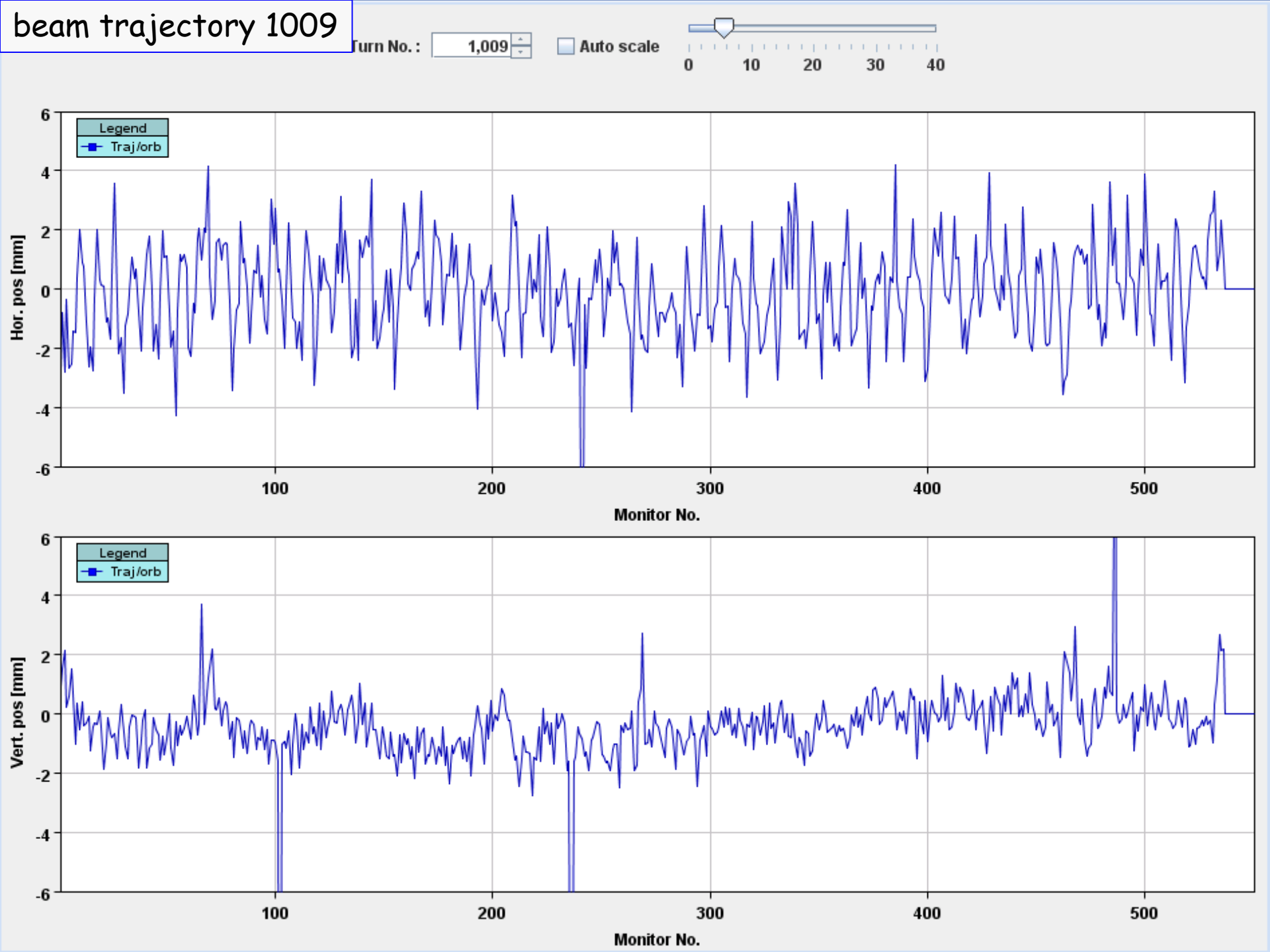


beam trajectory 100

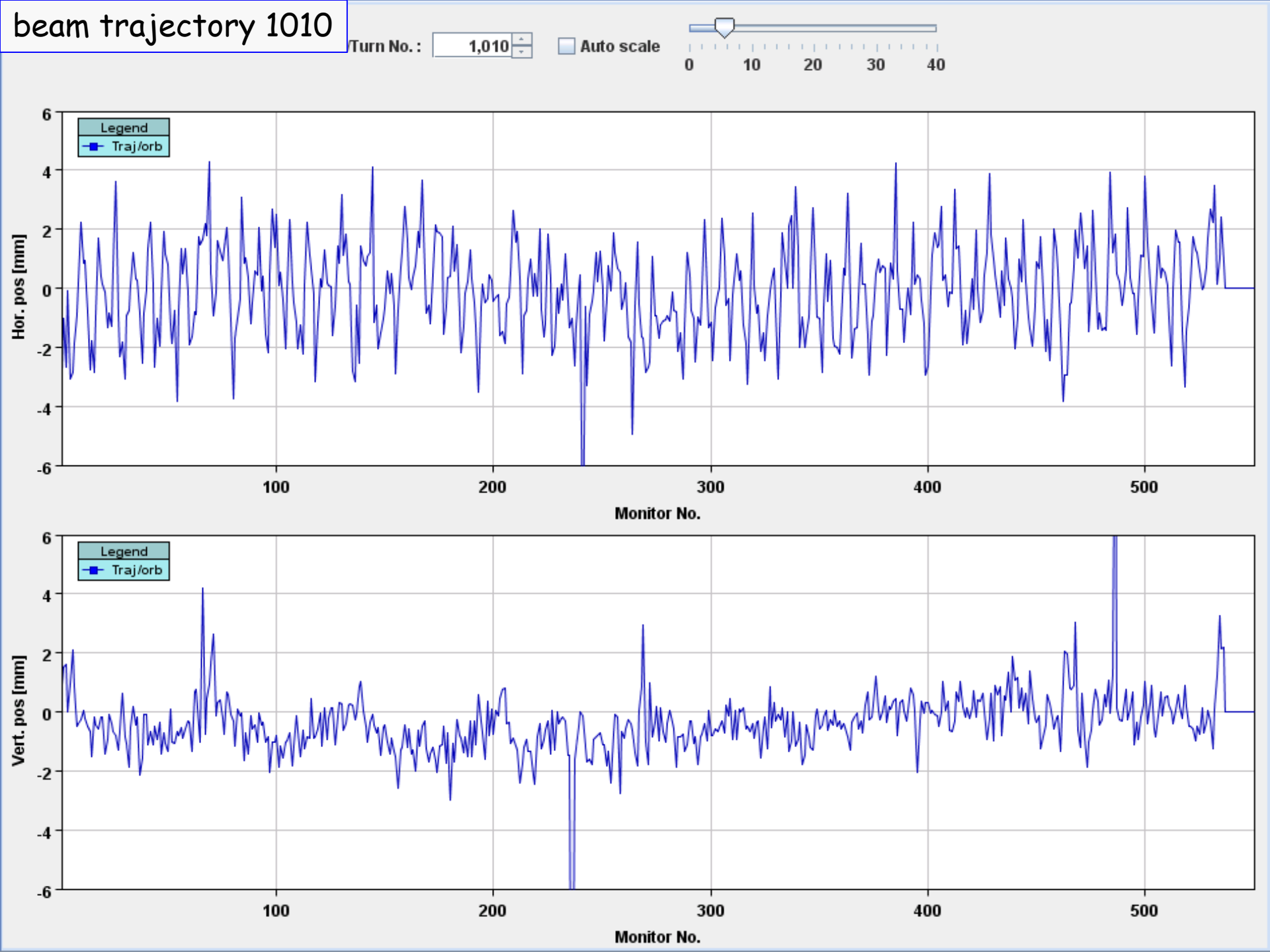
beam trajectory 101

beam trajectory 102

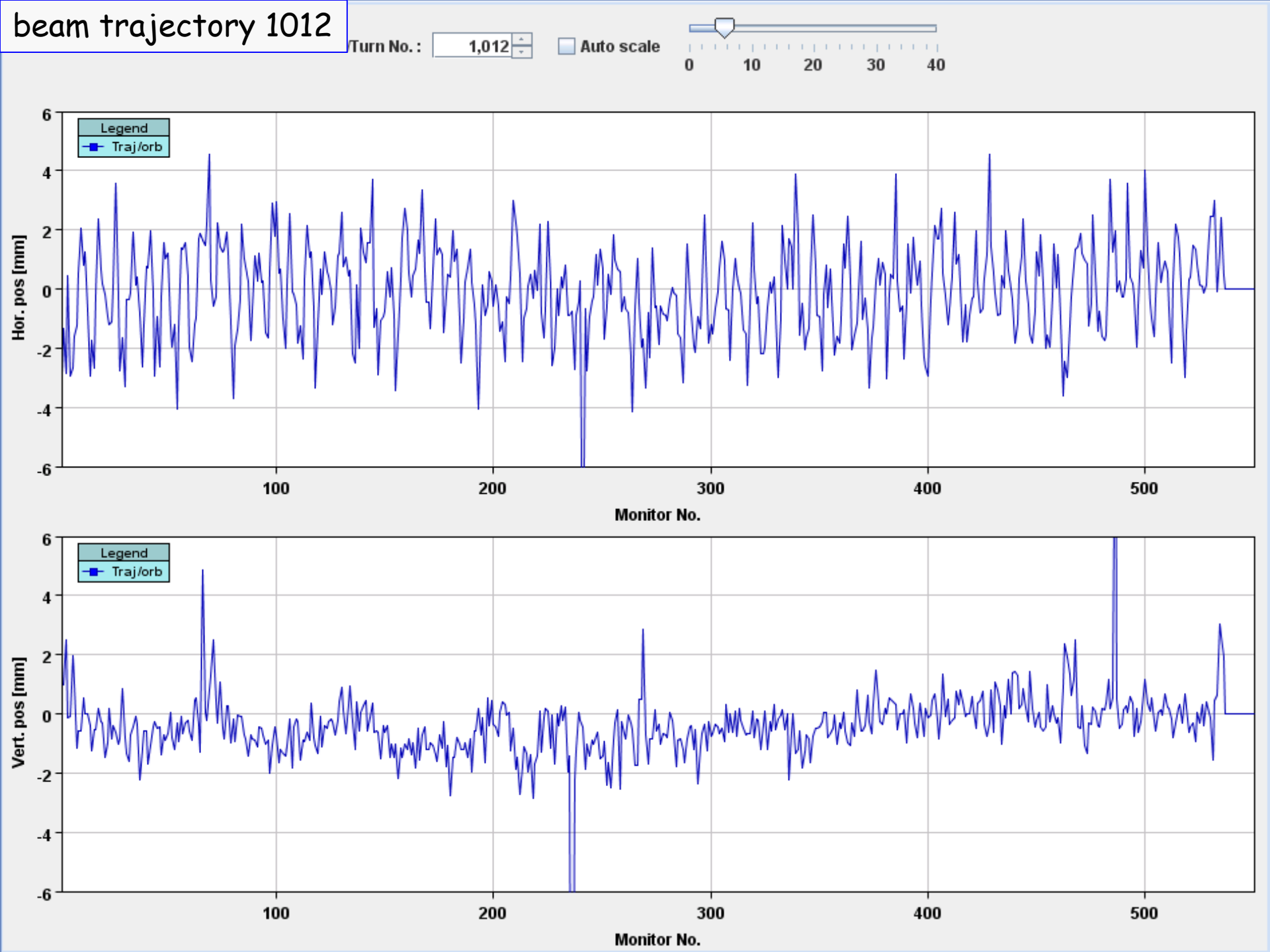
beam trajectory 1009



beam trajectory 1010



beam trajectory 1012



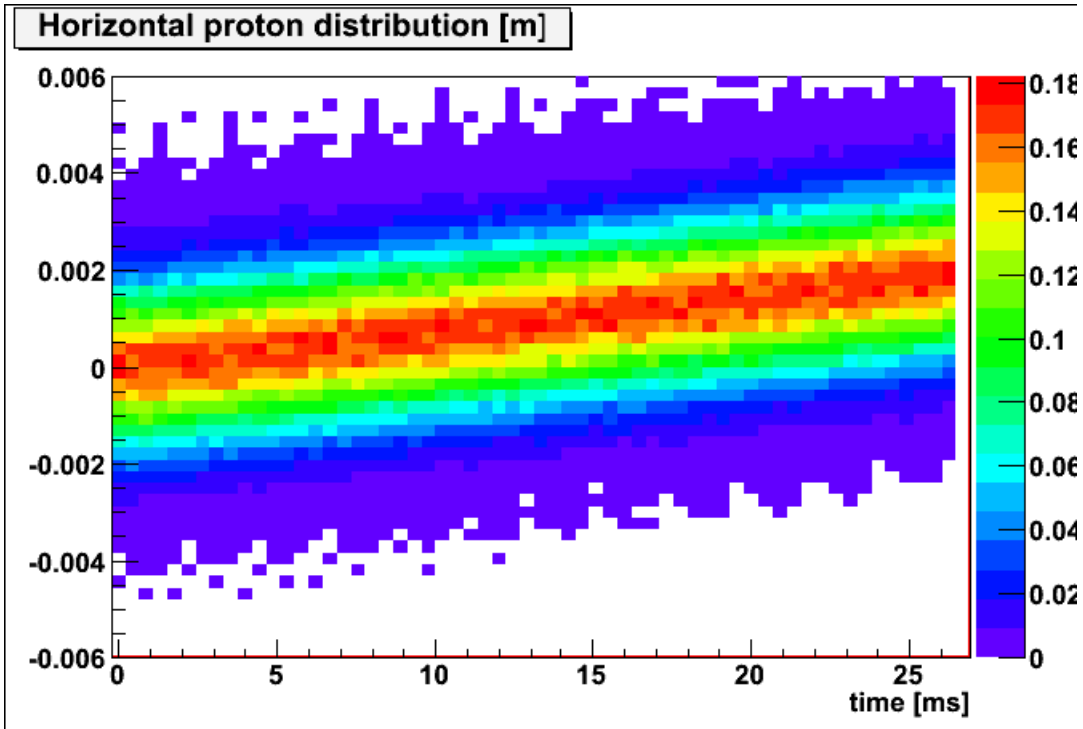
Comparing data with simulations

by Robert Appleby

- The beam movement at BPM.25R1.B1 over 300 turns after turning off RD1.LR1. The time constant of the decay is taken from the PM analysis of the current on the 2nd December test, and comes out to be 2.89 s.

- Over the 200 turns the beam moves about 1mm when the current starts to change. The calculation and plot agrees with this : 1mm of movement from 0 to 18 ms (= 202 turns). So the beam response simulations of myself, Andres and Verena predict the beam movement correctly.

- We could find plenty of other cases to check the calculations against, and once I get the collimator settings I can check the observed loss patterns.



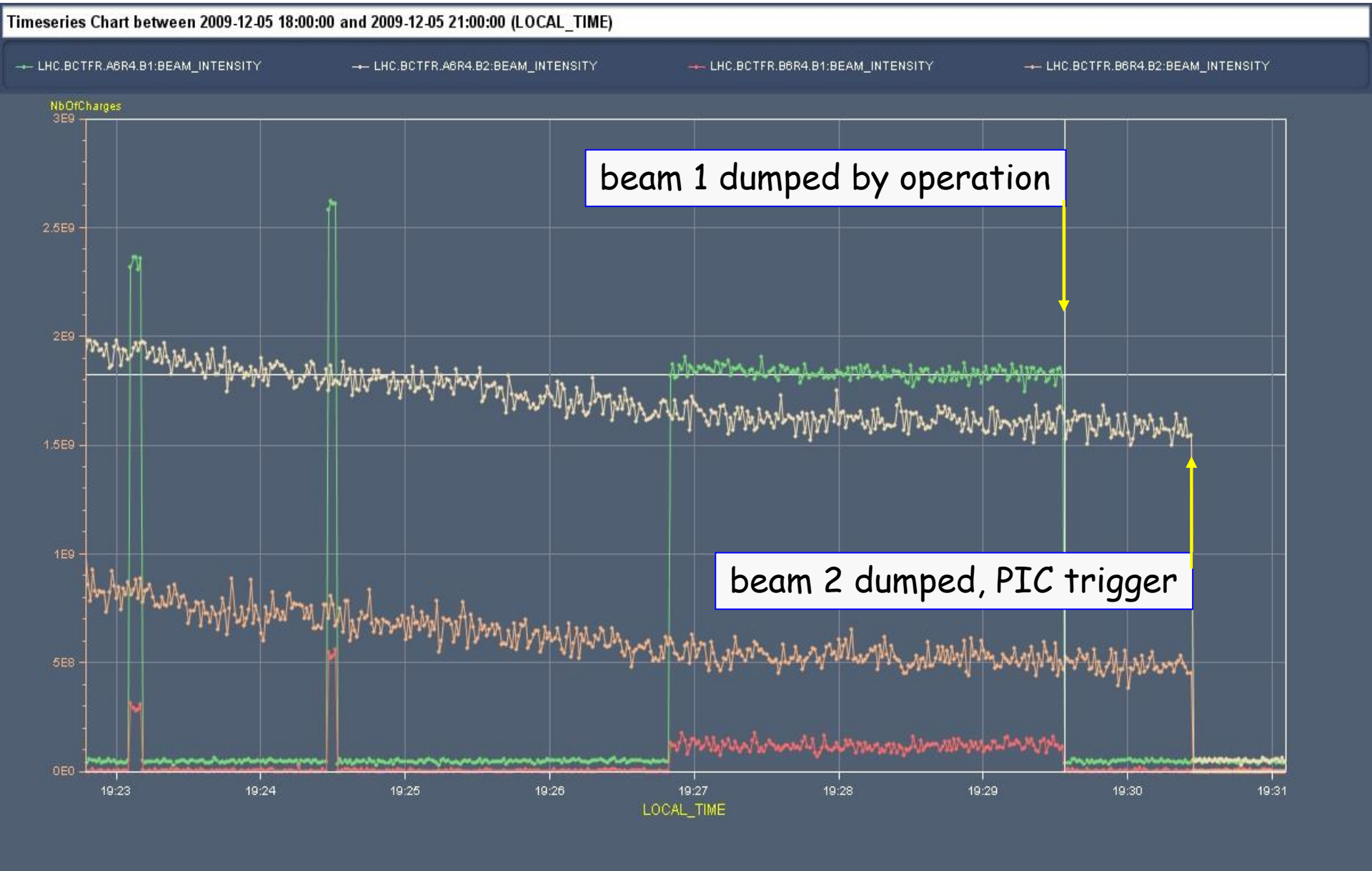
Event 5/12/09 19:30:26
RB in sector 12 off

EVENT OVERVIEW

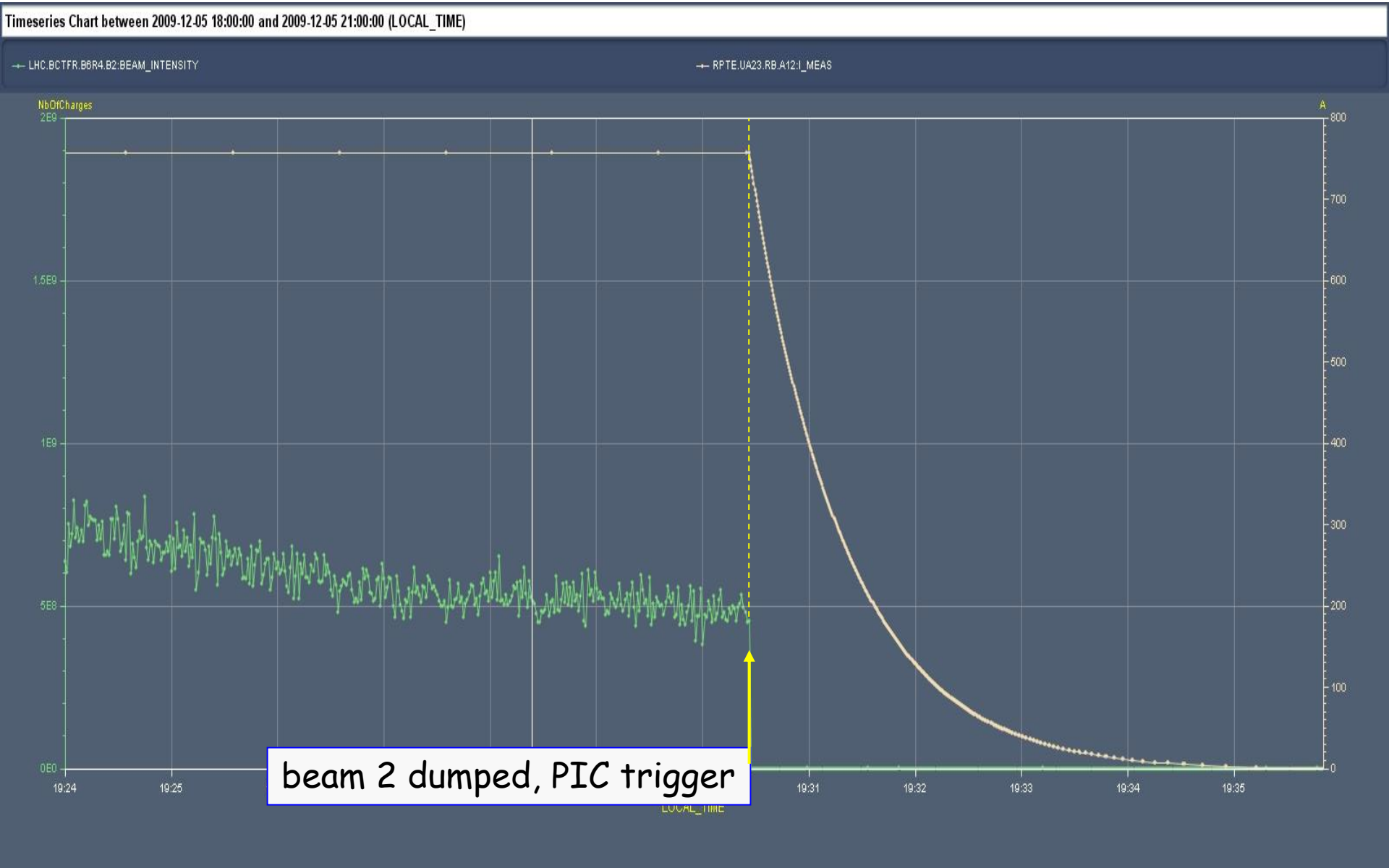
Index	Loc.Permit A/B	Time	Delta(uSec)	Description	BIC name
13		19:29:33.550+550000	-52868000	USER_PERMIT: Ch 1(Programable Dump b1): ...	CIB.CCR.LHC.B1
14		19:29:33.550+550001	-52867999	USER_PERMIT: Ch 1(Programable Dump b1): ...	CIB.CCR.LHC.B1
65		19:29:33.550+550101	-52867899	USER_PERMIT: Ch 1(Programable Dump b1): ...	CIB.CCR.LHC.B1
66		19:29:33.550+550101	-52867899	USER_PERMIT: Ch 1(Programable Dump b1): ...	CIB.CCR.LHC.B1
420		19:29:33.639+639688	-52778312	USER_PERMIT: Ch 3(LBDS-b1): B T -> F	CIB.UA63.L6.B1
421		19:29:33.639+639689	-52778311	USER_PERMIT: Ch 3(LBDS-b1): A T -> F	CIB.UA63.L6.B1
943		19:30:26.419+419187	1187	USER_PERMIT: Ch 5(PIC_UNM): B T -> F	CIB.US15.R1.B1
944		19:30:26.419+419188	1188	USER_PERMIT: Ch 5(PIC_UNM): B T -> F	CIB.US15.R1.B2
945		19:30:26.419+419188	1188	USER_PERMIT: Ch 5(PIC_UNM): A T -> F	CIB.US15.R1.B2
946		19:30:26.419+419188	1188	USER_PERMIT: Ch 12(PIC_MSK): A T -> F	CIB.US15.R1.B2
947		19:30:26.419+419188	1188	USER_PERMIT: Ch 5(PIC_UNM): A T -> F	CIB.US15.R1.B1
948		19:30:26.419+419188	1188	USER_PERMIT: Ch 12(PIC_MSK): A T -> F	CIB.US15.R1.B1
949		19:30:26.419+419188	1188	USER_PERMIT: Ch 12(PIC_MSK): B T -> F	CIB.US15.R1.B1
950		19:30:26.419+419189	1189	USER_PERMIT: Ch 12(PIC_MSK): B T -> F	CIB.US15.R1.B2
968		19:30:26.419+419211	1211	USER_PERMIT: Ch 12(PIC_MSK): B T -> F	CIB.US15.L1.B2
969		19:30:26.419+419212	1212	USER_PERMIT: Ch 12(PIC_MSK): A T -> F	CIB.US15.L1.B2

- Beam dump of beam 1 by operation at 19:29:33
- Beam dump of beam 2 by PIC trigger in point 1 at 19:30:26.419, RB circuit trip

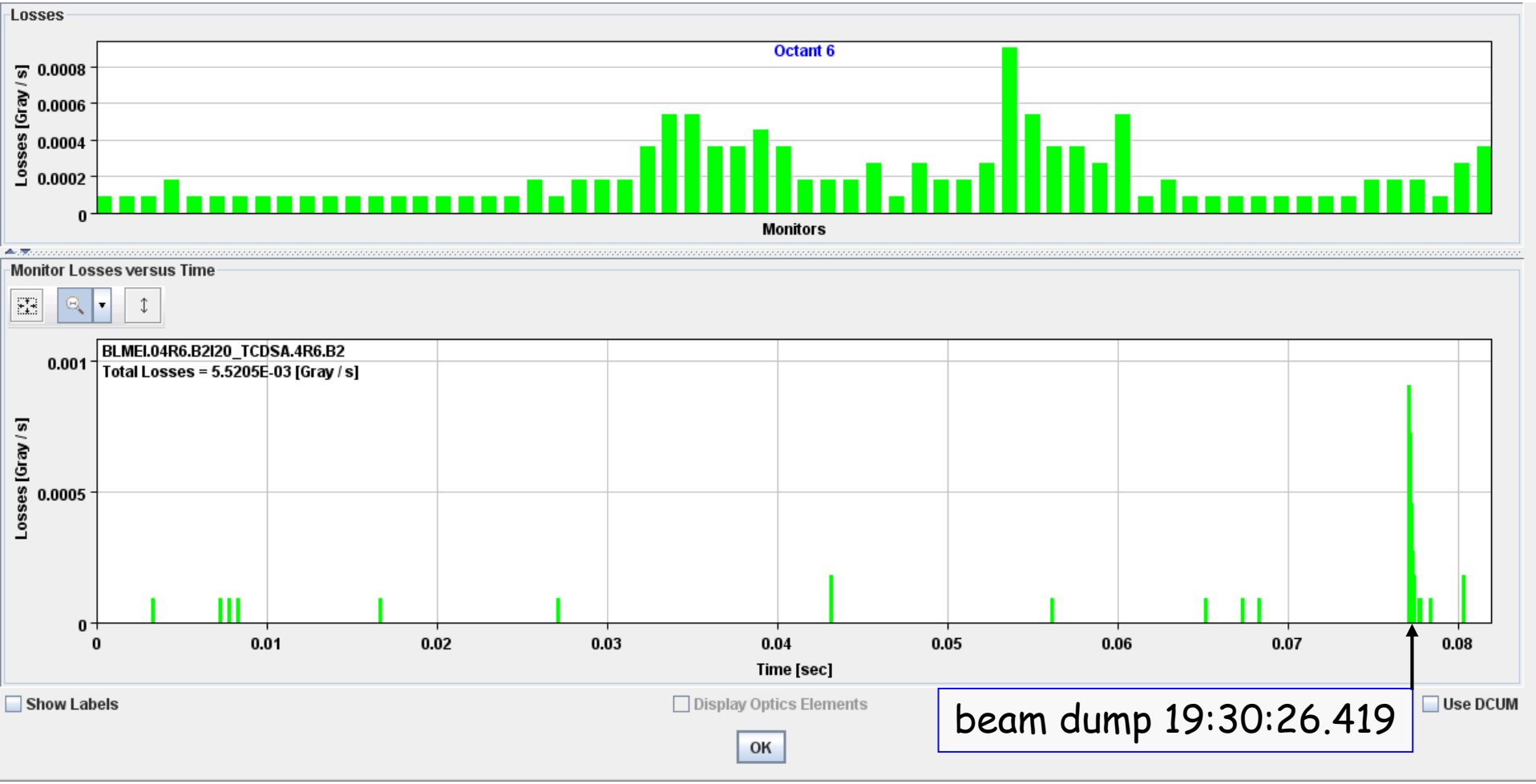
Logging: FBCT for beam 1 and beam 2



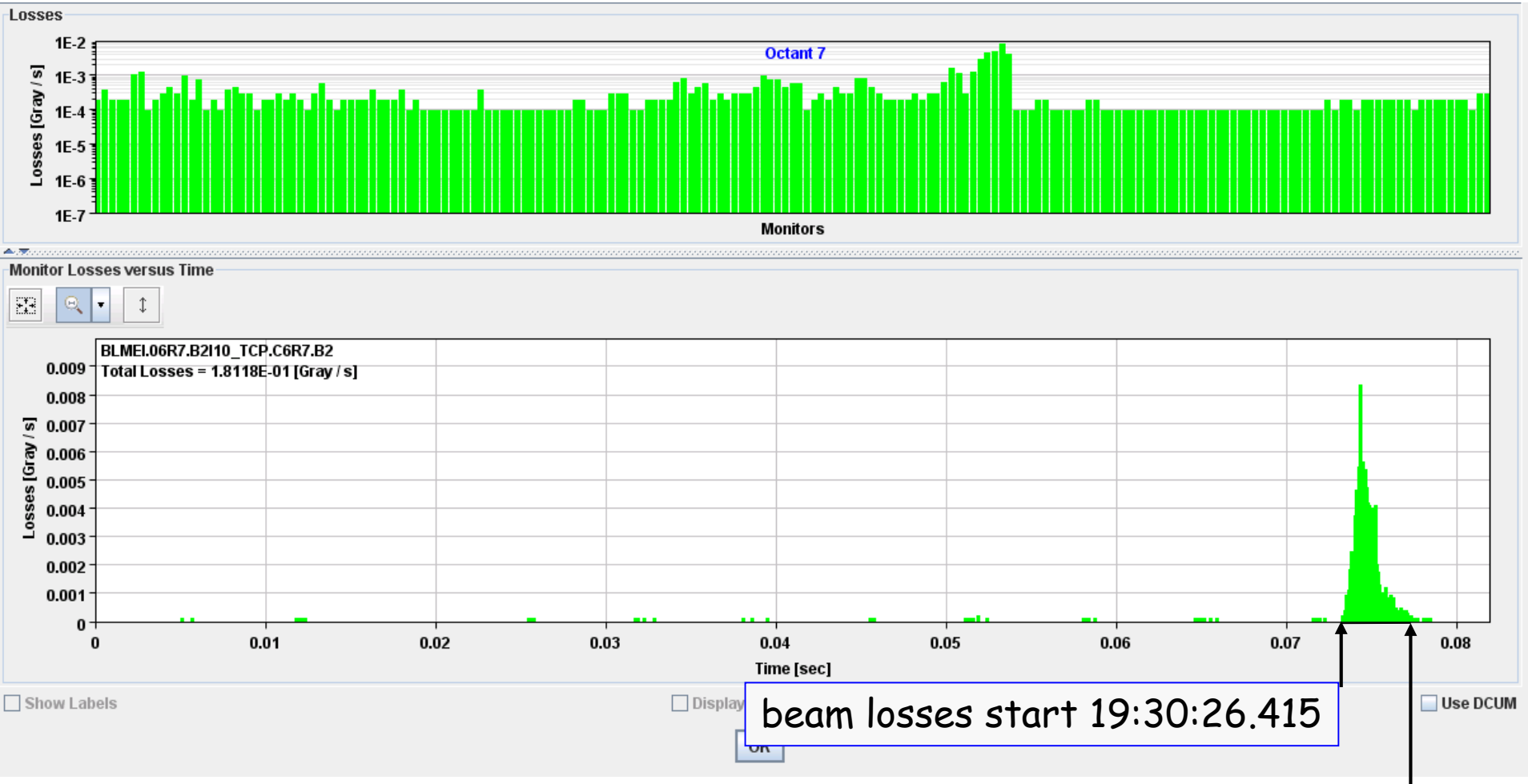
Fast BCT for B2 and current for RB.A12



Beam losses


Losses
Octant 6
Losses [Gray / s]
0.0008
0.0006
0.0004
0.0002
0
Monitors
Monitor Losses versus Time
BLMEI.04R6.B2I20_TCDSA.4R6.B2
Total Losses = 5.5205E-03 [Gray / s]
0.001
0.0005
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Time [sec]
Show Labels
Display Optics Elements
Use DCUM
OK
beam dump 19:30:26.419

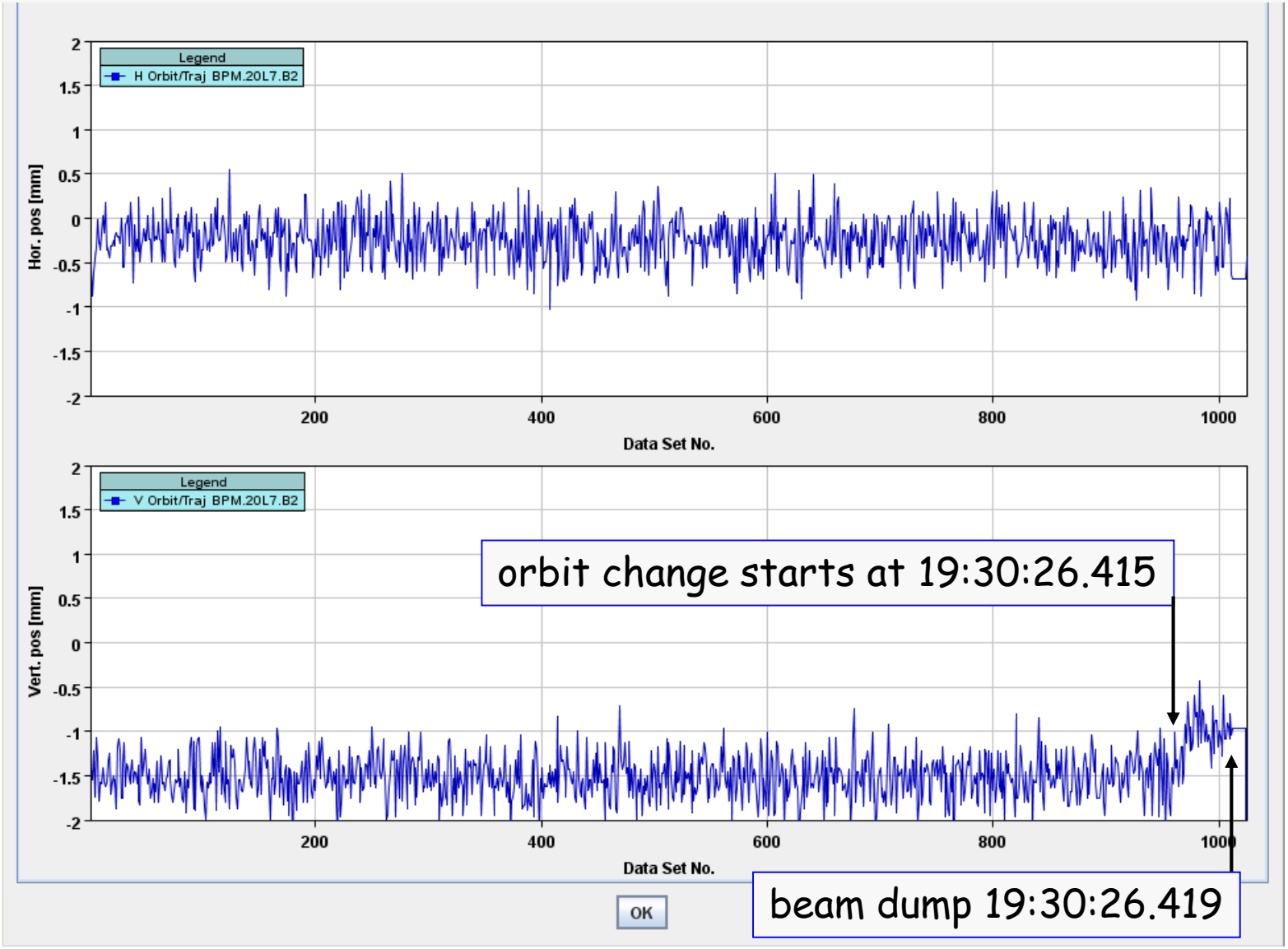
Beam losses



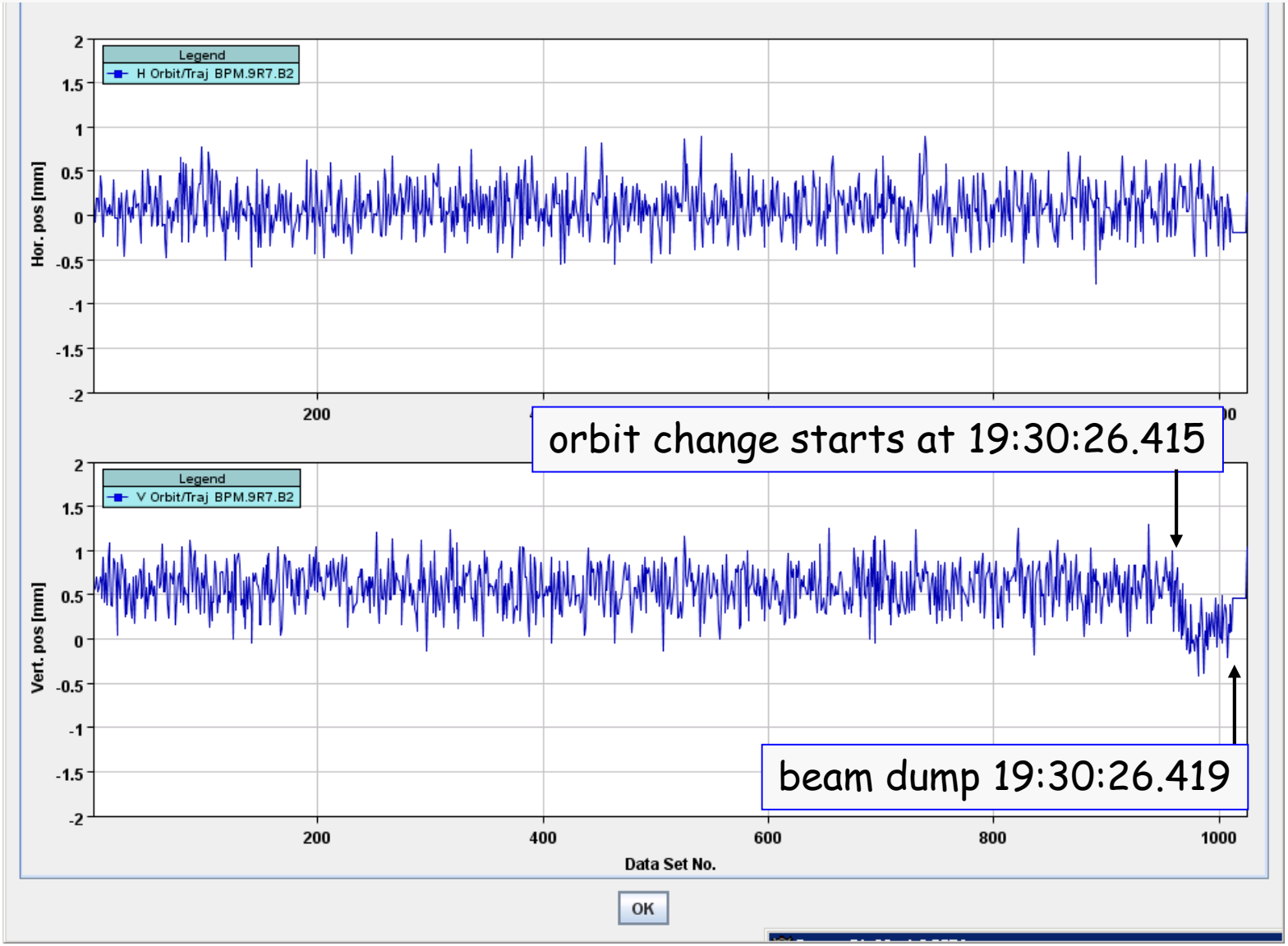
beam losses start 19:30:26.415

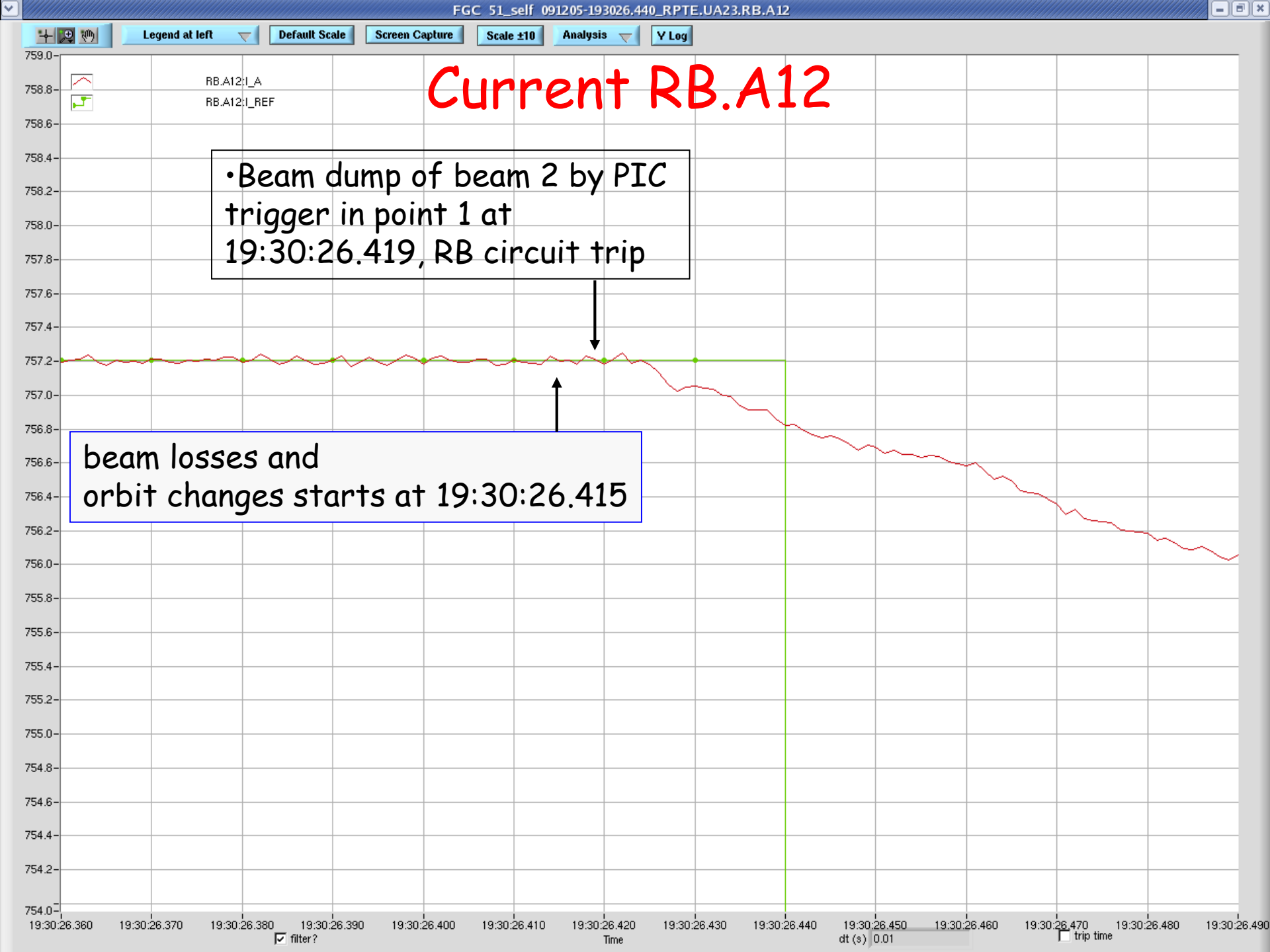
beam dump 19:30:26.419

Typical BPM (20.L7.B2)



Typical BPM (9.L7.B2)




FGC 51_self 091205-193026.440_RPTE.UA23.RB.A12
Legend at left
Default Scale
Screen Capture
Scale ±10
Analysis
Y Log
RB.A12:I_A
RB.A12:I_REF
Current RB.A12
•Beam dump of beam 2 by PIC trigger in point 1 at 19:30:26.419, RB circuit trip
beam losses and orbit changes starts at 19:30:26.415
759.0
758.8
758.6
758.4
758.2
758.0
757.8
757.6
757.4
757.2
757.0
756.8
756.6
756.4
756.2
756.0
755.8
755.6
755.4
755.2
755.0
754.8
754.6
754.4
754.2
754.0
19:30:26.360
19:30:26.370
19:30:26.380
19:30:26.390
19:30:26.400
19:30:26.410
19:30:26.420
19:30:26.430
19:30:26.440
19:30:26.450
19:30:26.460
19:30:26.470
19:30:26.480
19:30:26.490
filter?
Time
dt (s) 0.01
trip time

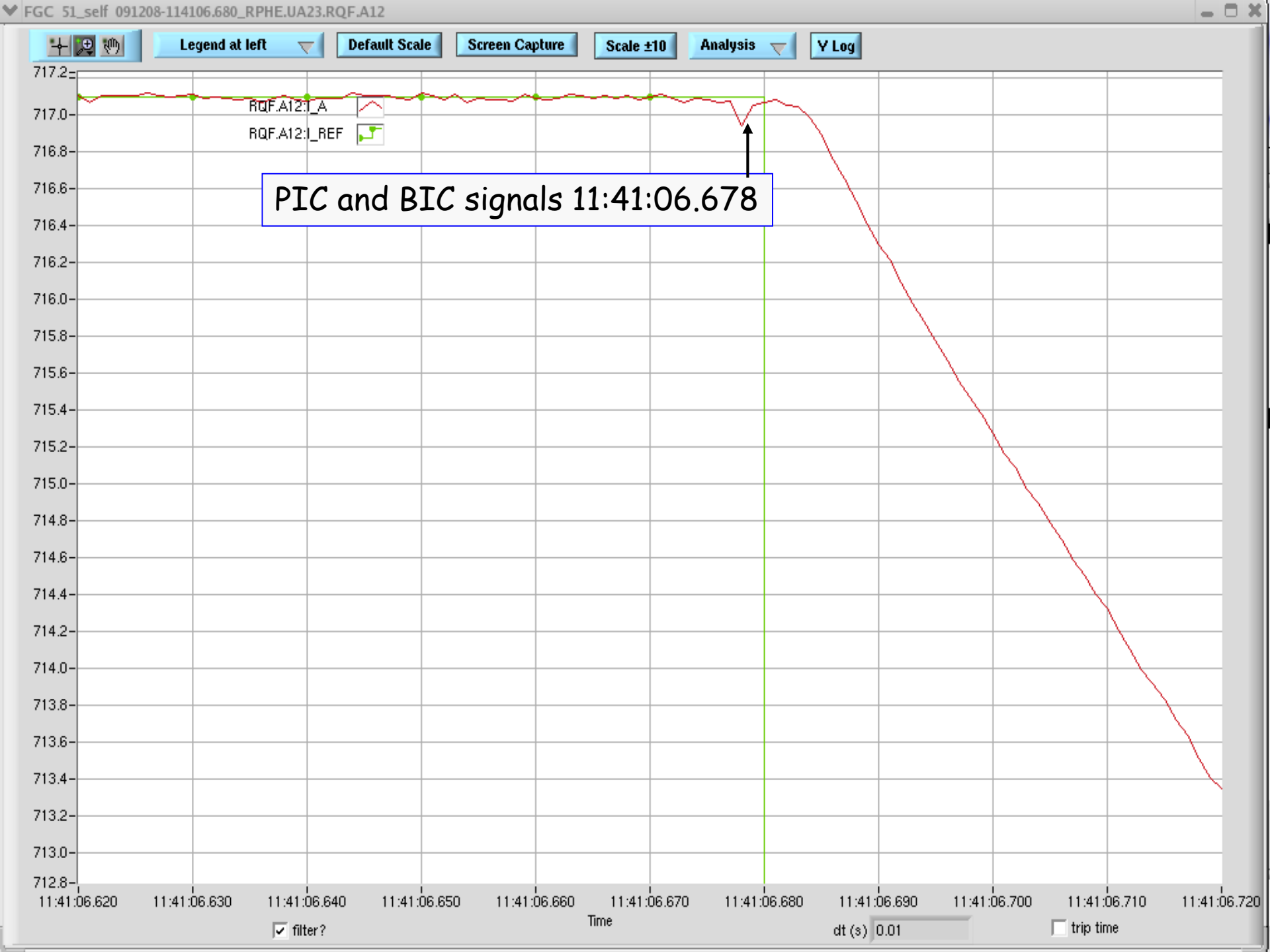
Comments

- The beam trajectory in the vertical plane changed 4ms before the beam dump
- This was not caused by the RB trip
- Needs to be understood… analysis of the trajectory to find out origin of the change

Event 8/12/09 11:41:06.678
RQ in sector 12 off

- RQF/D tripped due to QPS
- RB tripped 3 ms later (global abort)

System	Local Time	Source	Type	Item	Status
pic_1:	2009.12.08 11:41:06.678	Input	A	RQF.A12	BAD
pic_1:	2009.12.08 11:41:06.679	Input	A	RQD.A12	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RCO.A12B1	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RCO.A12B2	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B2	RQ10.L2	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQT12.L2B1	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQT12.L2B2	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQT13.L2B1	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQT13.L2B2	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQTL11.L2B1	BAD
pic_1:	2009.12.08 11:41:06.680	Input	B1	RQTL11.L2B2	BAD
pic_1:	2009.12.08 11:41:06.681	Input	A	RB.A12.EVEN	BAD


FGC 51_self 091208-114106.680_RPHE.UA23.RQF.A12
Legend at left
Default Scale
Screen Capture
Scale ±10
Analysis
V Log
RQF.A12:I_A
RQF.A12:I_REF
PIC and BIC signals 11:41:06.678
717.2
717.0
716.8
716.6
716.4
716.2
716.0
715.8
715.6
715.4
715.2
715.0
714.8
714.6
714.4
714.2
714.0
713.8
713.6
713.4
713.2
713.0
712.8
11:41:06.620
11:41:06.630
11:41:06.640
11:41:06.650
11:41:06.660
11:41:06.670
11:41:06.680
11:41:06.690
11:41:06.700
11:41:06.710
11:41:06.720
Time
filter?
dt (s) 0.01
trip time

Unit: Gray / s | Scale: Log | Integration Time: 40 us | Disply: Max | Display: Acquisition | +REF

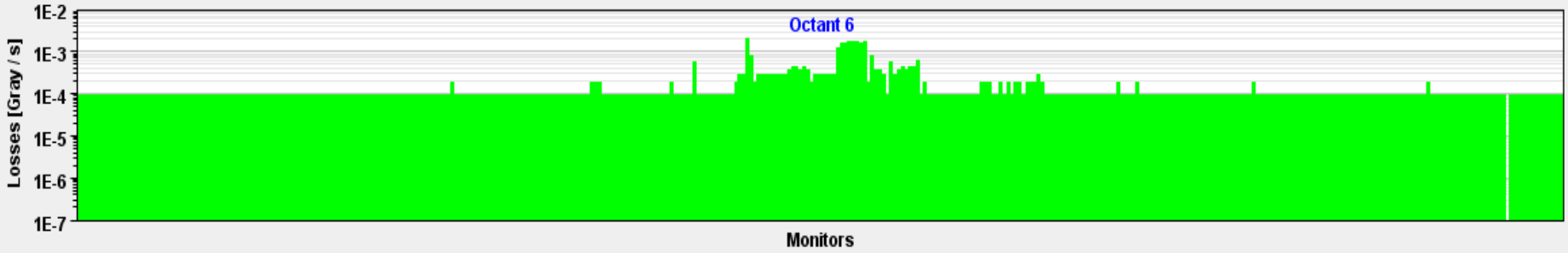
Sectors Filter | Octant Filter | Dump Filter | List Filter | Regex Filter

Filter (394 / 3506)

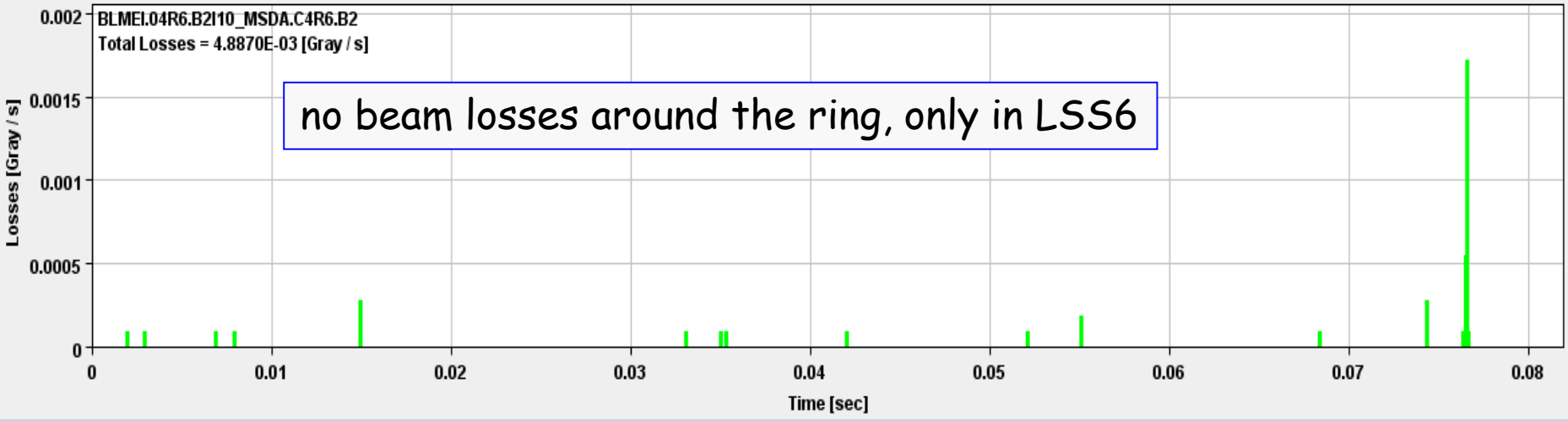
Location	Type	Section	Left Right	Octant	Beam	Transverse Position	Position on Element	Observed Element
☑ Quad	☑ IC	☑ LSS	☑ Left	☐ 1 ☐ 5	☑ Beam 1	☑ External	☑ Entrance	%
☑ Other	☐ SEM	☑ DS	☑ Right	☐ 2 ☑ 6	☑ Beam 2	☑ Internal	☑ Center	
☑ 2 Elements		☑ ARC		☐ 3 ☐ 7		☑ Top	☑ Exit	
☑ Mobile				☐ 4 ☐ 8		☑ Bottom		

08.12.2009 11:41:06

Losses



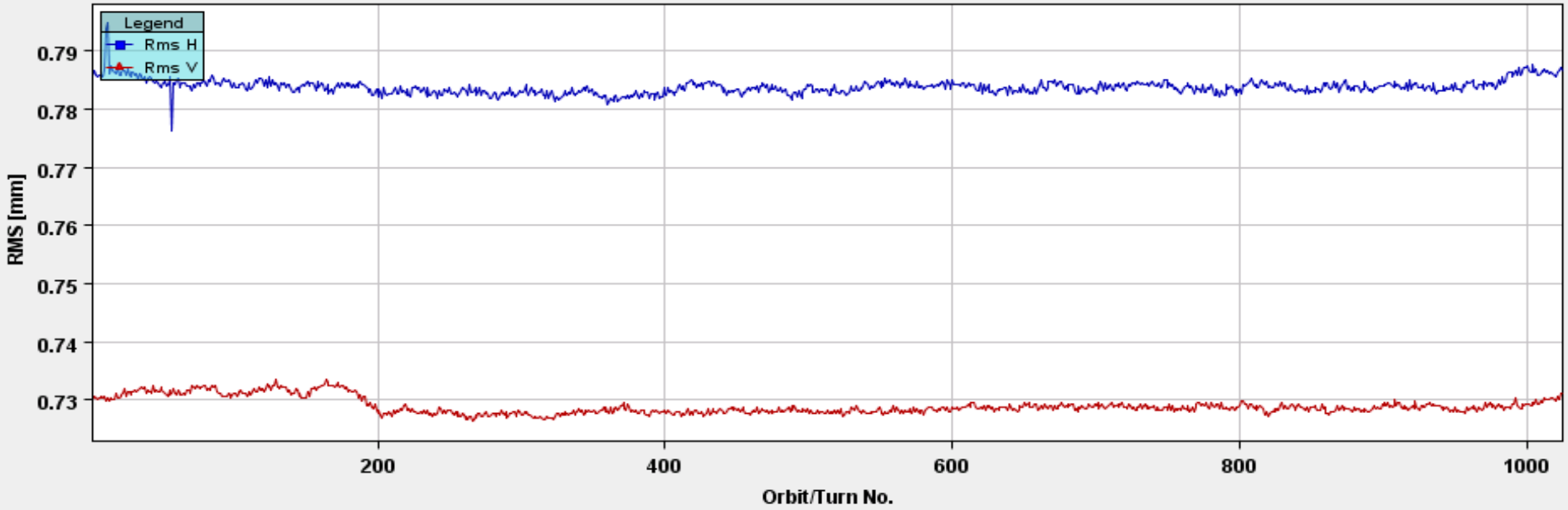
Monitor Losses versus Time

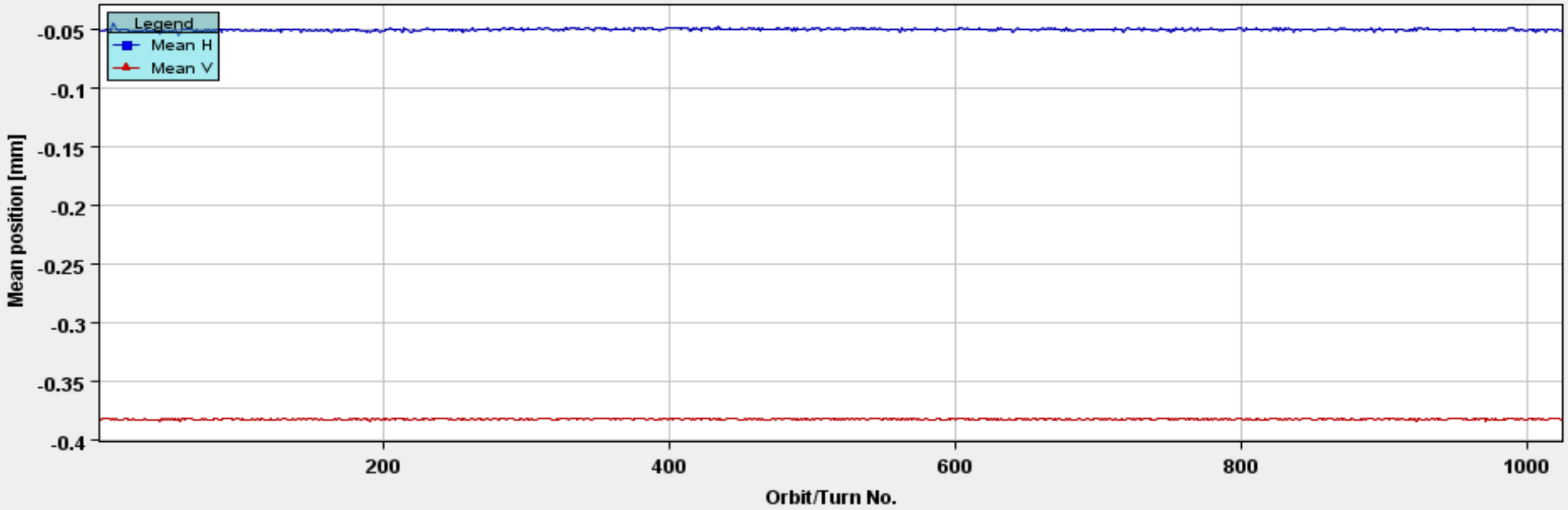


Beam 1 | Orbit Data | PM Event @ 08/12/09 11:41:06:678

Orbit & Traj (1st/last) | Data by Orbit/Traj | Data by BPM | Orbit & Traj (2D) | Rms & Mean | Triggers | Analysis Log | Save to File

Relative to first Turn/Orbit





Conclusions

- For 2.5 weeks after start up the capability of the transient recording is impressive
- We have excellent tools to analyse such event and the PM system works well
- BIC and PIC for a first level analysis are sufficient
- Some additional analysis software will be welcome

- Gaining confidence in the Machine Protection relies on understanding of all such events