

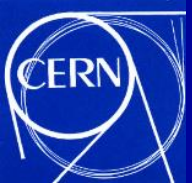
Machine Protection Systems Performance and Issues 2012



D. Wollmann, CERN/TE

09.11.2012

71st MPP



Acknowledgments

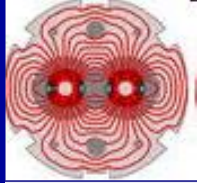


Members of rMPP and MPP,

R. Schmidt, J. Wenninger

M. Zerlauth, ...

CERN, Geneva

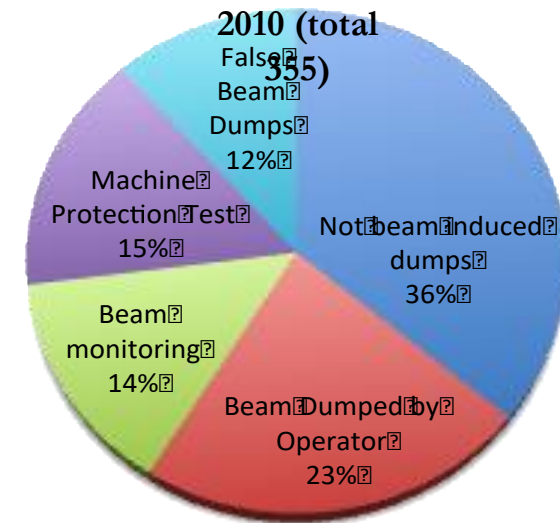
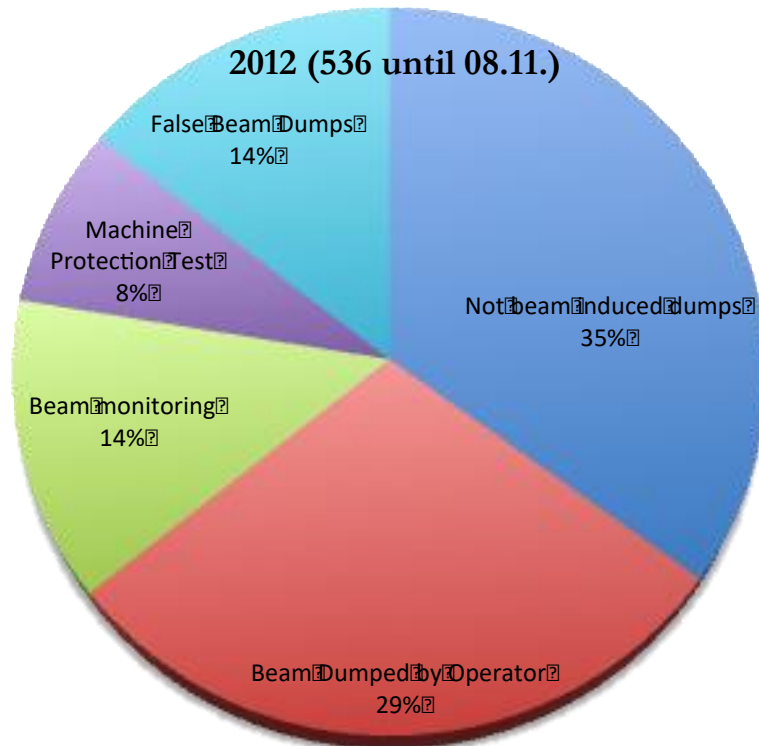
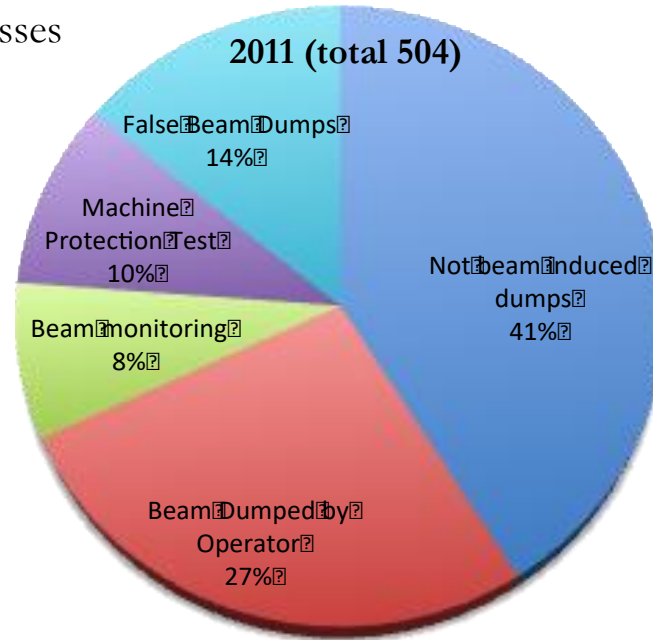


- MPS performance 2012 in comparison to 2011 and 2010.
 - Protection dumps.
 - Dumps from beam monitoring.
 - False dumps.
- Issues of Machine protection Systems
 - Top 3 issues.
 - Further issues from check lists.
- Conclusion

Protection dumps



- Beam Monitoring: more dumps due to beam losses (49%) and transverse instabilities (32%).
- False dumps: Constant share.
- Slight increase in operator dumps.



Not beam induced dumps: Vacuum, Cryo, Coll, OFB, QFB, MD, El-Net, Exp, etc.

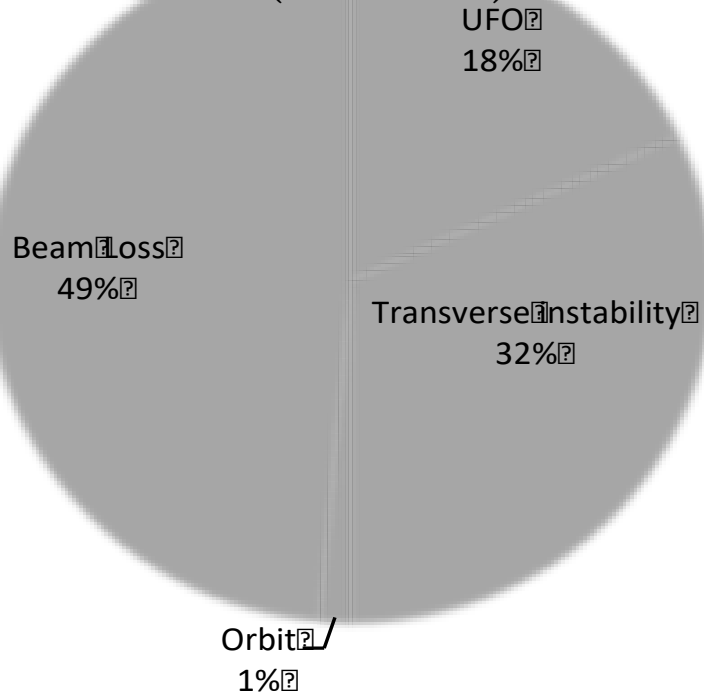
Beam monitoring: UFO, Transv. Instability, Orbit, Beam Losses

False beam dumps: failure in LBDS, PIC, BLM, BIC, SIS, QPS

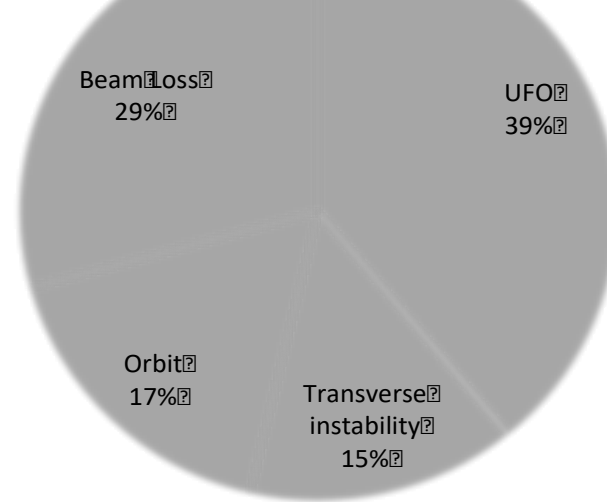
Dumps from Beam Monitoring



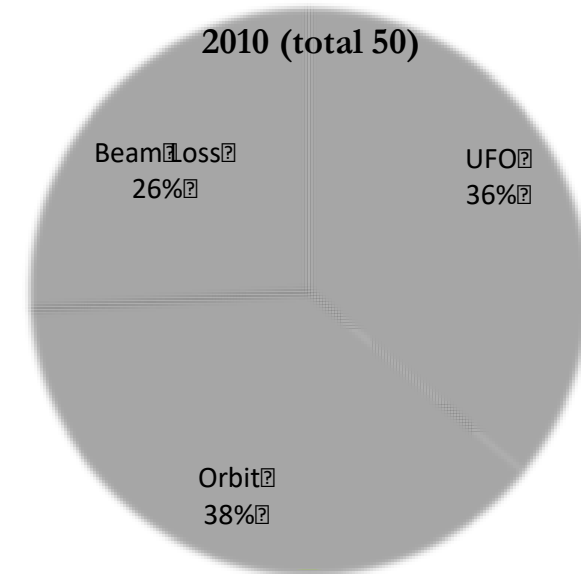
2012 (72 until 08.11.)



2011 (total 41)



2010 (total 50)

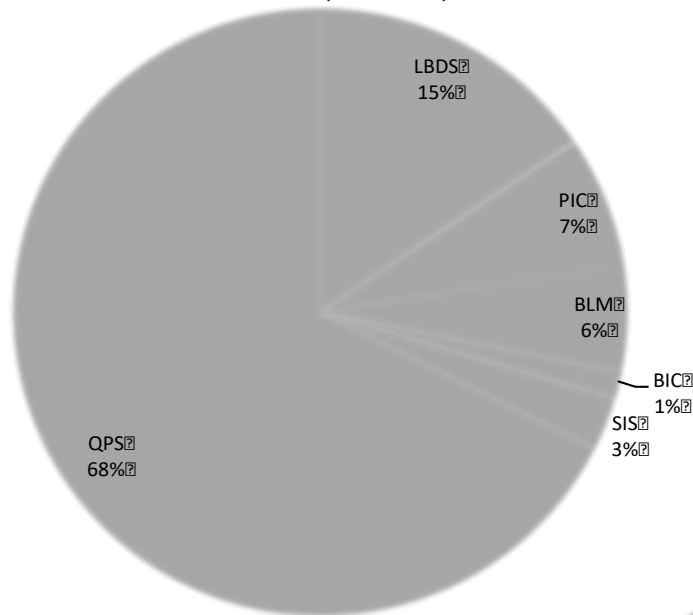


Transverse instability: mainly coherent losses.
 Beam losses: all other

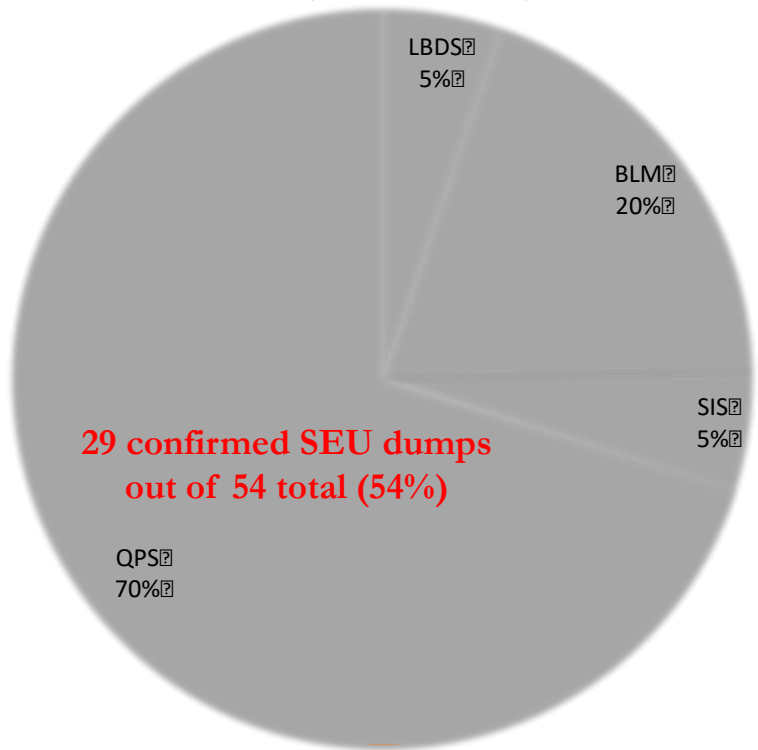
MPS False Dumps



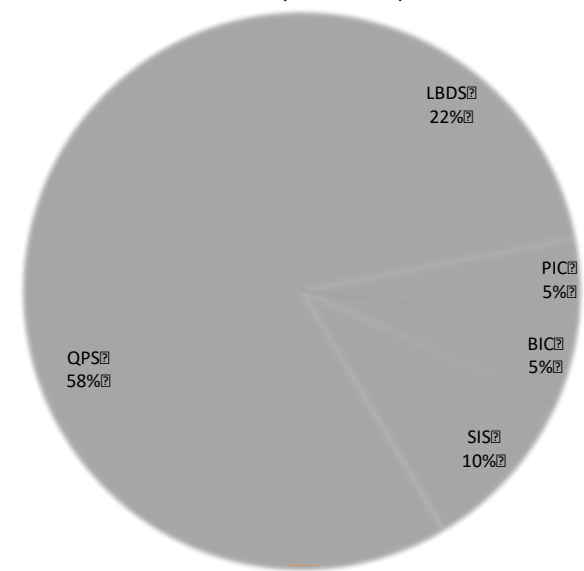
2011 (total 71)

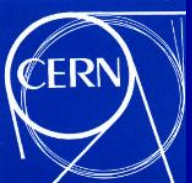


2012 (77 until 08.11.)



2010 (total 41)





Documentation of MPS issues



- **Post Mortem DB** with operator and MPS expert comments and classification (mainly fills above injection energy).
- Regular distribution of **MPS check lists** during operation to the different MP system experts with all beam dumps above injection energy for comments (Magnet powering, Beam interlocks, RF, BLM, Collimation, Feedbacks & Operation, Post-mortem, Orbit, Beam dump, Injection, Heating of equipment).
- Intensity **ramp up** (4 x 2012: 84b – 264b / 624b – 840b – 1092b -1380b).
- Intensity **cruise every 4 – 8 weeks** (5 x 2012 so far: mid May, mid June, end July, end August, beginning November).
- The final lists are stored in [EDMS](#).

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LHC Intensity Cruise - Check list Version 1.4 - 04.04.2012

Bunch pattern intensity	Mostly 1374/1368 bunches. 50ns_1374_1368_0_1262_144bpi12inj
Start date	21 August 22:52:32 (time of dump)
End date	01 November 20:11:23 (time of dump)
Fill numbers	2992 - 3250 (148 fills)
Comment	This list covers the floating MD, the high beta* and pilot proton-ion run, TS3, MD3 and the 1000m beta* run.

Dump Reason	# of dumps	Comments
QPS	22	
EOF	34	
Cryo	5	
Total	66	

Top three issues: OFSU reference problem

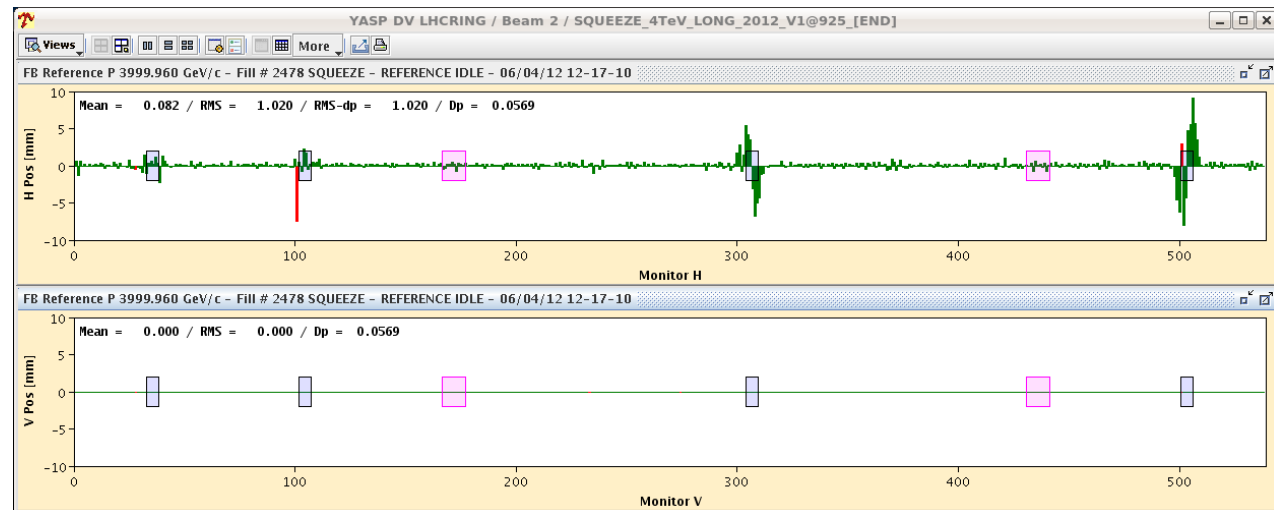


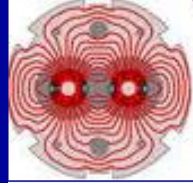
Fill 2478, 06.04.2012:

- **Reference of orbit feedback** was suddenly set to '0' at during the squeeze. The feedback tried to correct, and **changed the orbit** by up to 4 mm in some of the insertions. The beam started to **touch the tertiary collimators** in IR2 and was **dumped due to losses** above the threshold at the TCTV.R2
- Next step of intensity increase was **postponed**.
- **New SIS interlock** was introduced to cover this problem in ramp and squeeze.
- Additional **checks in sequencer and by operators** before launching ramp and squeeze.



Availability issue not
safety issue.





Two problems in the LHC beam dumping system (LBDS) were discovered:

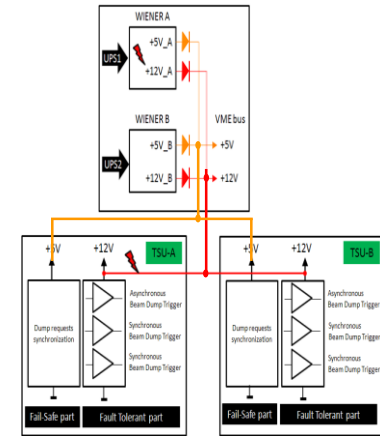
- 13.04.2012, 7:52 **Fault** of WIENER power supply **caused power loss** in whole set of general purpose beam dump crates. This would have caused an asynchronous dump with beam!

➔ **Short-term measures** (TS1): connection to 2nd UPS, fast fuses.

➔ **Review** on LBDS UPS powering (20.06.2012)

- **Lab checks** discovered (08.06.) a **common mode failure point** in a +12V DC powering system ➔ **no beam dump possible!**

➔ Operator **dump of fill 2714**, to allow the implementation of a **watch dog**, which would **force an asynchronous beam dump**. Mitigation with fail safe and fault tolerant solution during LS1.



Courtesy F. Formenti

For details see [presentation of V. Mertens](#) to 137th LMC and [65th MPP](#).

Top three issues: BSRT mirror support degradation

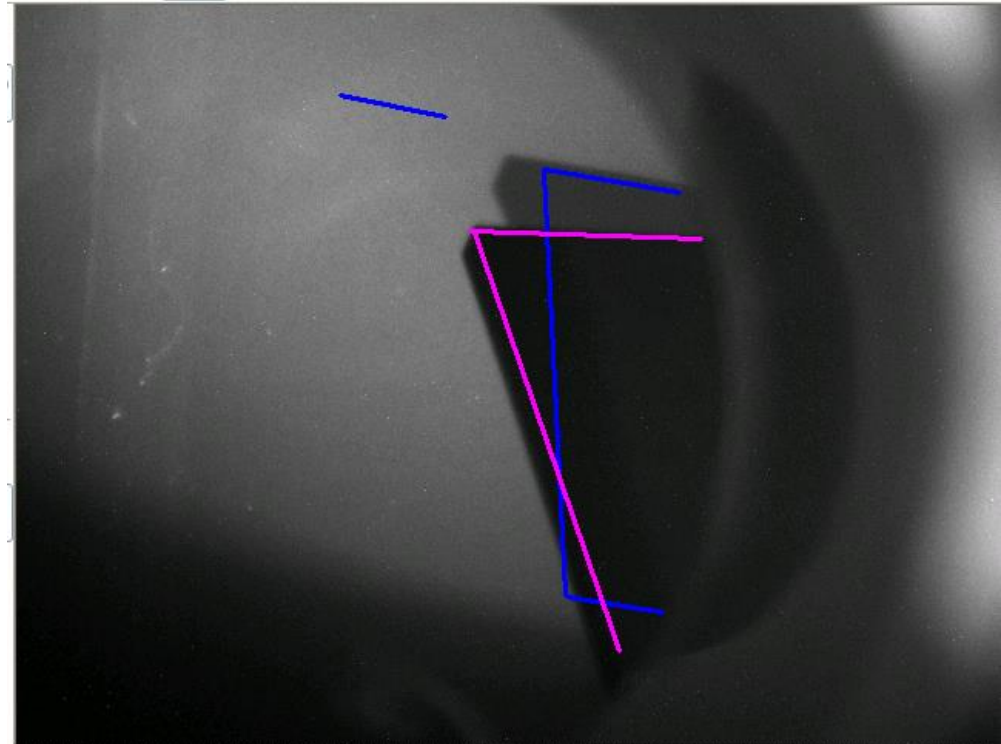


- BSRTs in B1 and B2 used to monitor the population of the abort gap (BSRA). RF heating lead to degradation.
- 27.08. B2-BSRT deteriorates suddenly. Mirror threatens to drop from support and damage the viewport. The B1 system remained 'stable'.

→ Dump fill 3012 on 28.09. to remove B2 BSRT.



- Abort gap population not anymore observable → turning on frequently abort gap cleaning.
- Alternative solutions for monitoring of abort gap under investigation (e.g. diamonds, LHCb, ...)
- Re-design and re-installation of BSRT during TS3.





- Beam interlocks:
 - Fill 2991, BIC-IPOC failure, loss of PM data. ?
- Collimation:
 - 17.04.: ver. TCTs in IR2 and 2 IR3 collimators have wrong centers due to human error and problem in settings generation tool. → Corrected in TS1 → **Setting checker** implemented. **OK**
 - Several dumps due to heating of TCP.B6L7.B1 (e.g. 27.07.). **under investigation**
 - Gap shift by 50um of TCTH.4R5.B2 (SEU?) (June /July). **OK**
 - 8 Hz collimator movement can bypass MPS motor block checks (18.06.), PRS, i.e. dump thresholds are not effected, i.e. safe. **Mitigation during LS1**
 - TCLIB.4L8.B2: LVDT of one axis disabled, as it caused an injection interlock → replaced (May / June). **OK**
 - TCTVB.4L8 (30.05, fill 2678): Heating above threshold due to too short bunch length. **Understood**
 - May-June: TCTs in IP2 did not start collision functions → no trigger signal in IP2. **??**
 - Replacement of roller screw for TCSG.5L3.B1 needed (some others were also replaced). **OK**



- Injection, Dump:
 - BPM6 triggered during injection B2 (12.08.) → gains adjusted to allow reliable operation → further mitigation of reflection signals **ongoing**.
 - TSU fault from XPOC (19.08.) dump request coincidental with BRF signal. **?**
 - TDI got stuck under angle (24.08.2012), which caused a beam dump due to beam losses at TDI corner. → Gap interlock implemented and operational. See [C. Bracco's presentation](#) to 67th MPP and [minutes](#).(14.09.2012) **OK**
 - Fill 1494 (15.04. 04:47:07) MKI.D flash over: ~50(?) bunches stopped on TDI, quenched 6 main magnets and several 600 A circuits. See [M. Barnes' presentation](#) to 129th LMC and [minutes](#). **OK**
 - MKI heating -> MKI.D in IP8 (?) replaced in September TS. **OK**
 - MKI.D IP8 saw some flash overs during conditioning after replacement. **OK**
 - MKI.C in IP8 heating significantly more than others. **Under investigation**.
 - 20.07. vacuum spike at MKI-D in IP8 went above threshold, but no dump triggered → due to interlock cable not re-connected after TS2. **OK**
 - Twice interlock on energy tracking MKD.B2 generator L. → BEM module replaced. **OK**



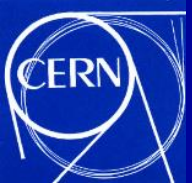
- QPS: RQX.L8: cabling problem after TS (End of June): cable had to be changed back. **OK**
- Transvers beam instabilities: MP systems reacted adequately. **OK**
- QFB not usable in squeeze (poor signal) → relying on feed forward → Since end of October additional high gain system available (gated on the first 6 bunches). **OK**
- BLMs: Increase of thresholds for long running sums in IR7 to cover 200kW losses in TCPs. **OK**
- BLM-HV, thresholds reduced in IR7. → **Not sufficient up to nominal loss rates.**
- Trip of PC cause orbit drift, beams dumped due to losses:
 - Fill 3220: Removal of powering permit for 60A correctors in sector 67 due to lost communication (PVSS to PIC). **Mitigation** by interlocking of 60A correctors **foreseen for LS1.**
 - Fill 2985: trip of LHCb dipole causes orbit drift before beam is dumped. → **Understood, mitigation planned during LS1.**
 - Fill 2934: Fast discharge of CMS solenoid leads to orbit change and slow losses. Beam dump due to HV-IR7. → **Understood, mitigation planned during LS1.**



- Beam losses and finally dump due to problem with ADT: **OK**
 - fill 2900: Connector problem at ADT module.
 - fill 2609: Trip of ADT trip.
- Equipment heating: TDI, MKI.C IP2, BSRT, ALFA **under investigation**
- Some BLM thresholds above estimated quench limit (e.g. Q4.L/R6 since August) → **OK**
no quench observed.
- False dumps after high beta run due to wrong PC settings. → **Setting change management to be improved.**



- Number of **false dumps** from MP systems comparable to last year:
 - Same share of false dumps, **dominated by QPS**.
 - **Increasing** number of false dumps from **BLM**.
- **Significant increase** in dumps from beam monitoring systems due to **instabilities**.
- Regular distributed and filled **check lists for the MP systems** provide **overview and documentation** for issues during the operation of the different systems.
- **Three MPS issues**, where machine was **stopped to implement** a short term **mitigation measures** (OFSU reference problem, LBDS common failure in 12V powering system, BSRT-B2 mirror support degradation). In all cases this **reaction was adequate** to the problem.
- Many issues, for which the machine operation hadn't to be interrupted and mitigations could be introduced with an appropriate delay.



Not discussed here - Outlook



- How did procedures work: Check list, MDs,
- Proposed improvements for MP systems.
- ...