

Machine Protection Systems Performance and Issues 2012

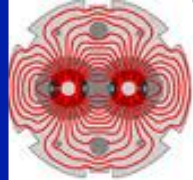
D. Wollmann

Thanks to:

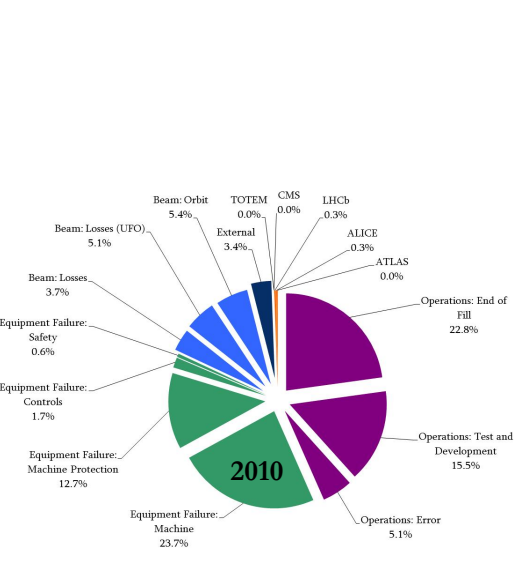
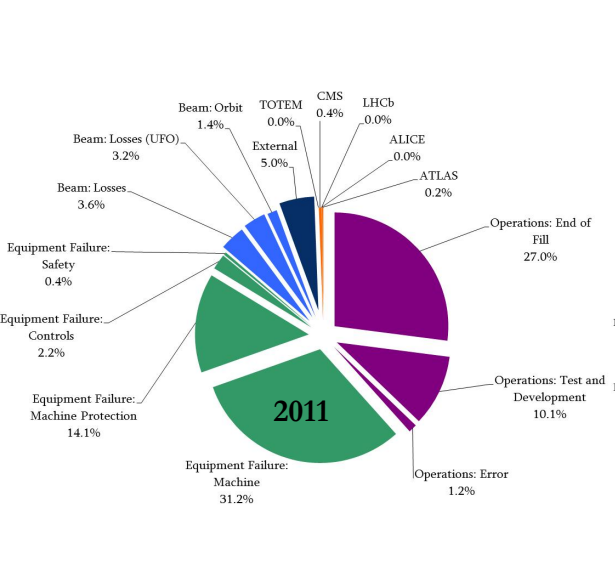
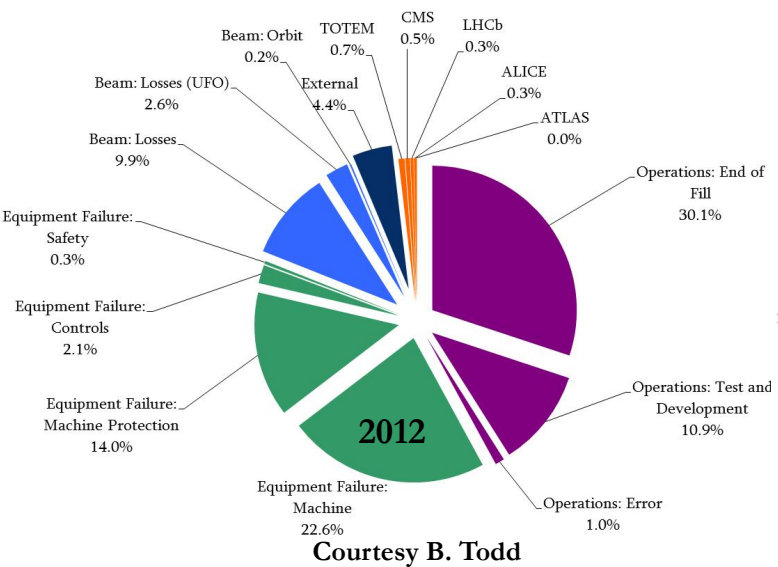
rMPP, MPP, L. Ponce, R. Schmidt, J. Wenninger

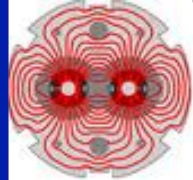
J. Uythoven, M. Zerlauth, et al

- **Review of Dumps**
- **Issues of Machine Protection and Related Systems.**
- **Review on MP Procedures for Machine Developments**
- **Proposed Improvements for after LS1**
- **Conclusion**



- ~ **1000 clean beam dumps** performed in 2012:
 - 585 beam dumps **above 450GeV**.
 - majority of dumps with **beam energies > 100MJ** (reaching max 146MJ).
- **No beam induced magnet quenches @4.0TeV** in 2012.
- **No equipment damaged** due to beam (excl. heating, corrector coils of RQTX3.L2).
- Reasons and MPS response **analyzed** in detail and **validated** for all beam dumps >450GeV. ➔ More details see talk from **B. Todd**





- **Post Mortem DB** with operator and MPS expert comments.
- 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).

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LHC intensity cruise – check list

Version 1.4 – 04.04.2012

- 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](#)**.

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	
EL Net	8	
RF	4	
PIC	-	
Beam Loss	6	
BLM	3	
Vacuum	7	
PC	10	
Orbit	-	
Feed Back 1 / 2	7 / 1	
Collimators	3	
LBDS	4	

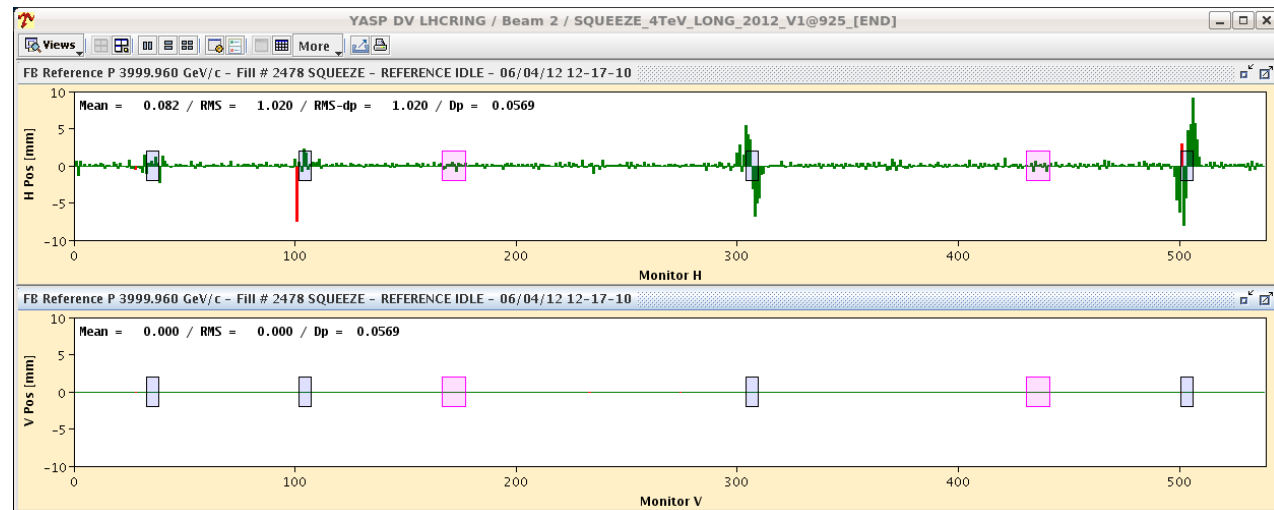


Fill 2478, 06.04.2012:

- **Reference of orbit feedback** was suddenly set to '0' during 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.



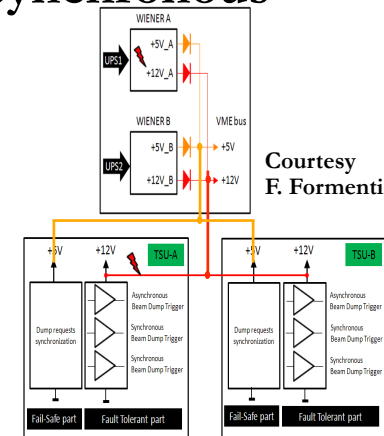


Two problems in the LHC Beam Dumping System (LBDS) were discovered:

1. 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)

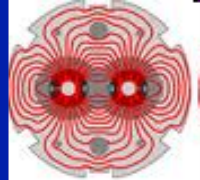


2. **Lab checks** discovered (08.06.2012) a **common mode failure point** in a +12V DC powering system ➔ **no beam dump possible!**

➔ 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 and **redundant BIS channel** to LBDS re-triggering line.

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



Top five issues: BSRT mirror support degradation

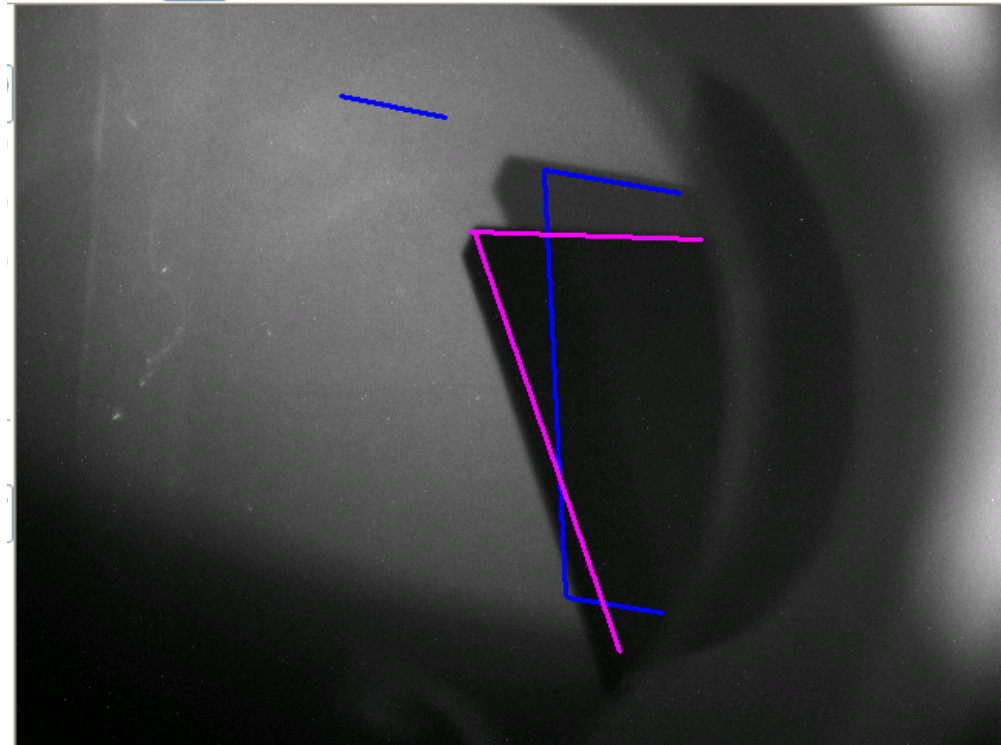


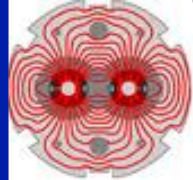
- BSRTs in B1 and B2 used to **monitor the population of the abort gap (BSRA)**. RF heating lead to degradation.
 - 27.08. **B2-BSRT deteriorates suddenly. Mirror threatens to drop from support and damage the viewport.** The B1 system remained ‘stable’.
- ➔ **Dump fill 3012** on 28.08. to remove B2 BSRT.

➔ Abort gap population not anymore observable ➔ **turning on frequently abort gap cleaning and observing its effect.**

➔ Alternative solutions for monitoring of abort gap under investigation (e.g. diamonds, Alice, ...)

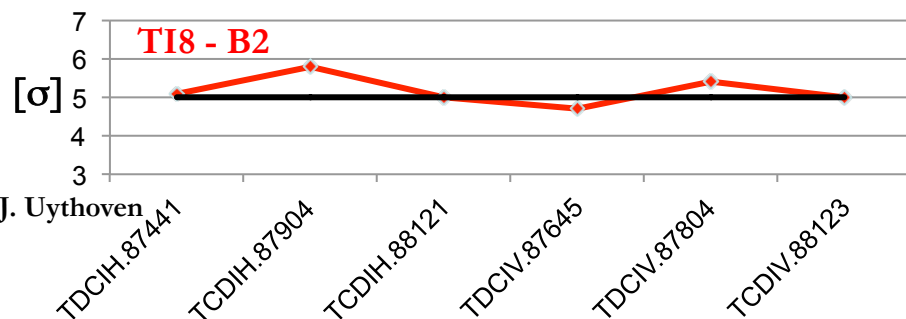
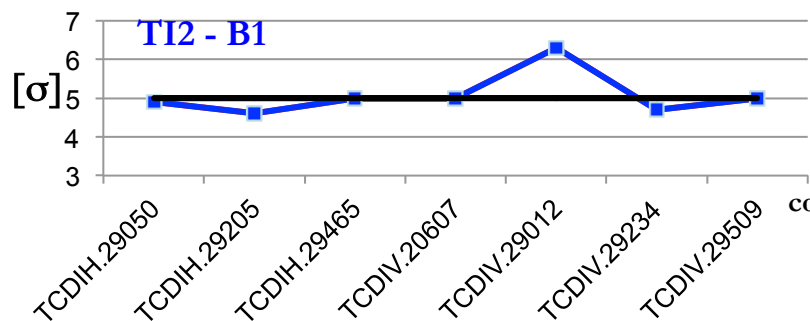
- Re-design and re-installation of BSRT during TS3.





Problem discovered at 19.11., ~2 months after introducing Q20 in TS3:

- Transfer lines matched to Q20 optics in SPS but **TCDI settings as with Q26 optics.**
- Difference in TCDI settings up to **1.3 sigma**: → **reduced protection.**



courtesy J. Uythoven

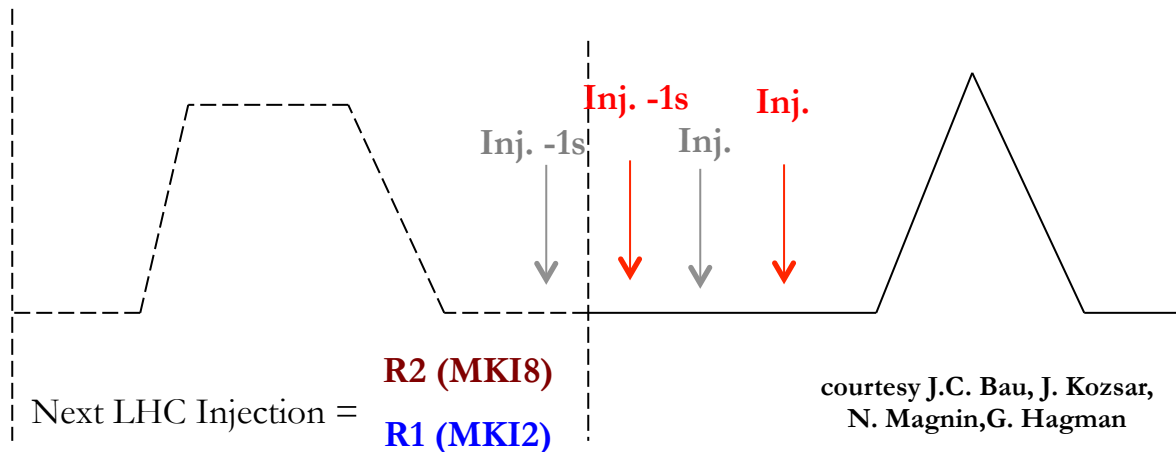
- Mitigated **immediately** after discovery: stop of operation, **TCDI re-setup and validation.**
- **PM analysis in ABT** and re-defining of internal procedures and responsibilities.
- **Tighten MP procedures** → MPP, MPS workshop in March 2013
- **Add additional checks** in control system, to avoid repeat → after LS1

For details see presentations in [LMC 21.11.2012](#), [MPP 07.12.2012](#) and [minutes](#).



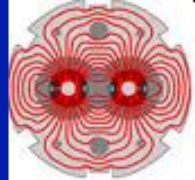
Problem appeared during **injections with high brightness beams** from PS (BCMS – h9):

- 30.11.: 24b bunches injected into B1, MKI-B2 fired → **20b into TDI**, 4b into dump.
- Reason: Extraction from PS delayed by 390 ms → injection time in the SPS delayed accordingly → injection occurring 1015 ms **after start cycle**. Bit defining the LHC ring for the next injection was not updated correctly.
- 12.12.: two hits with **48b on TDI-B2**, due to SPS RF-clock being on local.
- **No active protection** against timing issues in the SPS/TL, but **passive protection** worked as foreseen (TDI)



courtesy J.C. Bau, J. Kozsar,
N. Magnin, G. Hagman

- BCMS tests stopped.
- Back to standard physics.
- Second attempt was successful!

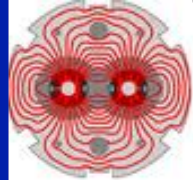


- **False collimator settings** (2 x TCTV IR2, 2x IR3), discovered 17.04. → corrected and validated during LS1 (see [presentation of S. Redaelli](#) to 68th MPP and [minutes](#)). OK
- **TDI in IR2 corner of upper jaw “falling”** onto the lower jaw, when brought into injection position (03.12.) (see [presentation of R. Losito](#) and [LHC status](#) to 158th LMC). OK
- **MKI.D flashover** (15.04.) → 50b stopped in TDI → 6 main and several 600A magnets quenched. → MKI.D replaced in TS3 (see [M. Barnes’ presentation](#) to 129th LMC and [minutes](#)). 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
- QPS: RQX.L8: **cabling problem after TS2** (end June): cable had to be changed back. OK
- **Trip of PC cause orbit drift, beams dumped due to losses:**
 - Fill 3220: Removal of powering permit for 60A correctors in sector 67. Mitigation in LS1
 - Fill 2985: trip of LHCb dipole causes orbit drift before beam is dumped.
 - Fill 2934: Fast discharge of CMS solenoid leads to orbit change and slow losses. Beam dump HV-IR7.
- Heating of different equipment due to beam: MKI.C, ALFA, TCP.B6L7.B1, TCTVB.4L8.B2, BSRT, ... Under investigation
- For a full list see [presentation to 71st MPP](#).





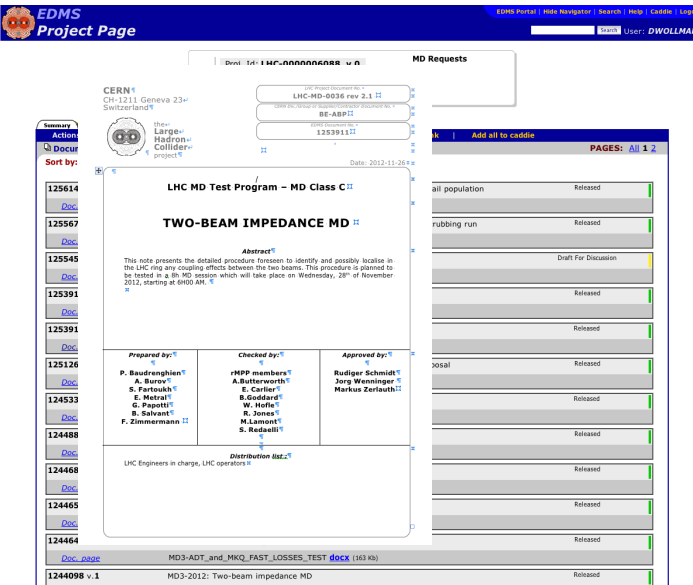
MP Procedures for Machine Development

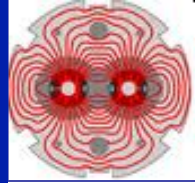


- Machine Developments **explore** per definition **new machine (protection) territory**.
- 26 documents **approved** through EDMS documents.
- Preparation phase** has proven to be useful for **MD and Machine Protection** teams
→ **improve safety and efficiency** of the MDs.
- More **last minute MD program & parameter changes** → difficult to discuss & discover **possible dangers**, perform **test with safe intensity** and go through the agreed **approval process** before MD.

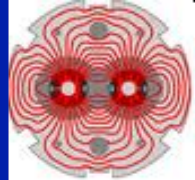
Proposed improvements:

- MD requests including MP relevant **beam parameters, thresholds, settings, MD program** mandatory for **ALL MDs**.
- Approval process** needs to start latest **2 weeks before MD**.
- Software **interlocks** for approved settings and beam parameters.

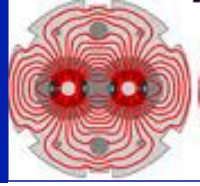




- **Redundant BIS channel to LBDS re-triggering line.**
- **DIDT** for detection of fast beam losses (~ 1 turn)
 - **Redundancy to BLM** system.
 - Proposed **already in 2004** to be part of LHC MPS.
 - **Prototype system working** with detection principle developed by DESY.
 - BI to provide **final system for LHC restart after LS1.**
- Diamond detectors:
 - **Redundant monitoring of abort gap** population.
 - Monitor losses during **injection (bunch-by-bunch).**
 - Monitor losses during **dump** (bunch-by-bunch).
- Collimation: automatic **consistency checks for settings.**
- Monitoring of aperture in **TL and ring** with **aperture meter.**

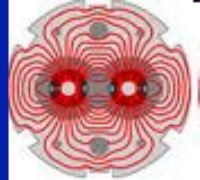


- **~ 1000 clean beam dumps** performed in 2012:
 - 585 beam dumps **above** 450GeV.
 - majority of dumps with **beam energies > 100MJ** (reaching max 146MJ).
- **No beam induced magnet quenches @4.0TeV** in 2012.
- **No equipment damaged** due to beam.
- ➔ Machine Protection Systems **worked reliably and efficiently**.
- ➔ Due diligence of Equipment teams, OP, (r)MPP, coordinators, etc.
- Still **weaknesses discovered** in procedures and MP systems.
- ➔ **Response** of coordinators, OP, (r)MPP to problems **was adequate**.
- MP procedures for MDs **worked in general well**, but recently **too many last minute program & parameter changes** ➔ risk to put machine in **unnecessary danger**.
- rMPP check lists proved their importance as prerequisite during the intensity increase and for documenting MP issues of the different systems.



Mandate

- Discuss **mid-and longer-term improvements** of the **MP systems**:
 - Review of the current **operational experience** with MP systems during the first running period (2010-2012).
 - understanding the **planned changes** of MP equipment during LS1 and the **consequences/potential limitations for operation** after LS1.
 - identify areas where **improvements** are required.
 - ensuring **coherence** between the different MP systems.
 - identify **misses**.



Draft Program

- 6 sessions, 2 ½ days
 - MPS overview during runs 2008-2012 (D. Wollmann)
 - MPS after LS1 (B. Dehning)
 - Injection and beam dumping system (J. Uythoven)
 - Beam diagnostics and collimation (S. Redaelli)
 - Electrical circuit related protection (M. Zerlauth)
 - Operational parameters after LS1 (J. Wenninger)



Where we plan to go...



End 2012: Finalization of program with session chairs (your comments and suggestions are very welcome!)

Jan 2013: Send out invitations + detailed program

11th-13th March 2013: Workshop
Menthon, Lac d'Annecy