ATS Seminar 13 June 2013:

MPP workshop 2013, Annecy

Ses.2: Injection, Extraction & Beam Dump

Ses.3: Beam Diagnostics

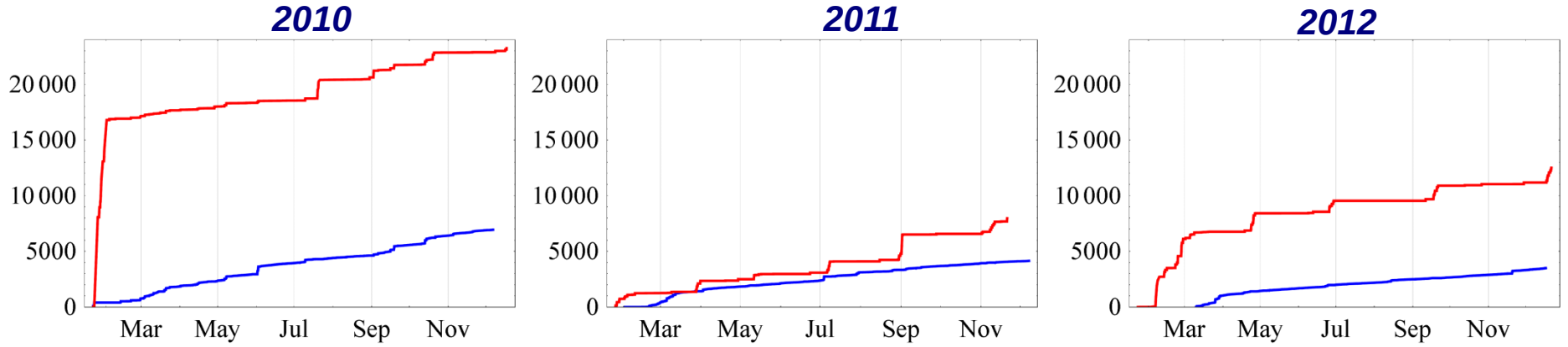
Jan Uythoven

Thanks to the authors of the different presentations, Bernd Dehning as chairman of the BI session and all participants for the stimulating discussions

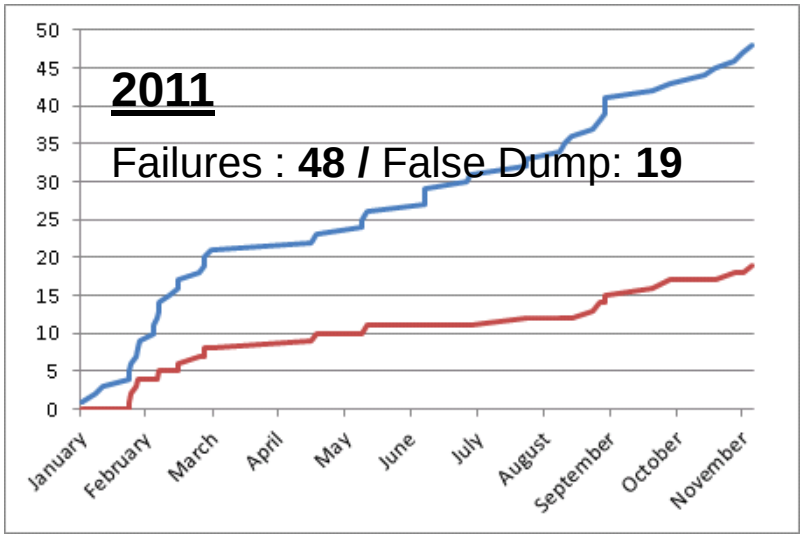
Session 2

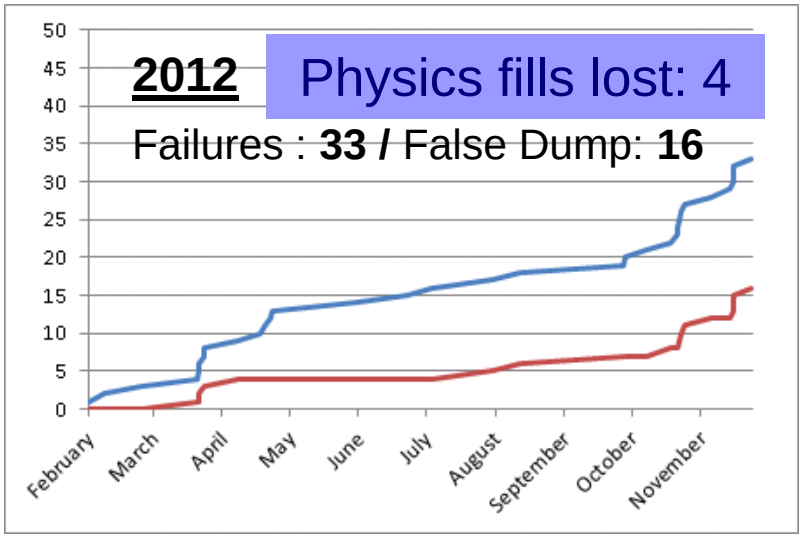
- Injection, Extraction and Beam Dump
  - LHC beam dump kickers – Nicolas Magnin
  - LHC beam dump protection – Brennan Goddard
  - Injection – Wolfgang Bartmann
  - SPS interlocking – Jorg Wenninger
- These systems are related to the most critical failure scenarios
  - The only way we quenched the machine with beam outside MDs
  - The BLM safety net cannot be used to stop an injection or extraction; once launched they're on their way

LHC Beam Dumping System Kickers – Nicolas Magnin



- 2010 – 2011 – 2012
  - > 40'000 pulses (=dumps) in LOCAL: **justified?**
  - > 12'000 pulses (=dumps) in REMOTE
- **All dump requests were correctly executed**
- Number of "False Dumps" for Beam 1 in 2011 and 2012:





Beam Dumping System failures

- Availability of the system has been good
- Failures
  - More than 80 % of the failures are detected and beam is safely dumped.
  - Some failures are 'fail silent', but still safely dumped because of fault tolerance.
- More than 50 % of the interventions were remote
- False eXternal Post Operational Check (XPOC) errors 2012 – 2013
  - Total of 430, 50 % of them false errors, the fast majority due to filling pattern cleared before dumping
  - Will be improved during LS1
- 2012: 4 physics beams dumped due to LBDS self-trigger
  - 2 x ASI bus error
  - 2 x BEM ANYBUS module error

Procedure required for running with masks or enlarged tolerances
Degraded mode should be visible on LBDS fixed display?

Review of LBDS reliability presently performed by external expert, based on failures which occurred and foreseen system changes

ATS seminar 4th July

Dangerous Failures

- Trigger Fan Out (TFO) driver chip burned: asynchronous trigger of 2 extraction kicker magnets MKD. Pilot in the machine.
  - Re-cabled to prevent this in future
  - Review of TFO: no design fault
- Wiener (crate) power supply failure, several crates down: asynchronous dump, happened without beam
  - Review of LBDS powering: added 2nd UPS, fuses for each crate, …
  - Studies resulted in an anticipated failure mode which did not happen: loss of 12V PS on TSU crate: this would have resulted in no dump when requested by BIS
    - Stopped the machines to make a fix, consolidated in LS1
- 2009: after installing cooling of the extraction kicker generators, sparking above 6 TeV beam energy
  - Cooling modification was added after reliability run in 2007: procedural problem
  - Beam dump limited to 5 TeV beam energy until LS1
  - Upgrade during LS1 - reliability run up to 7 TeV

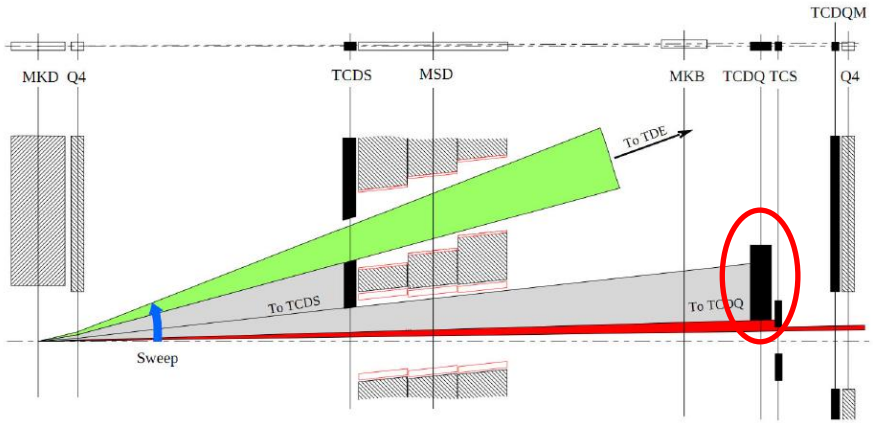
Main changes foreseen during LS1

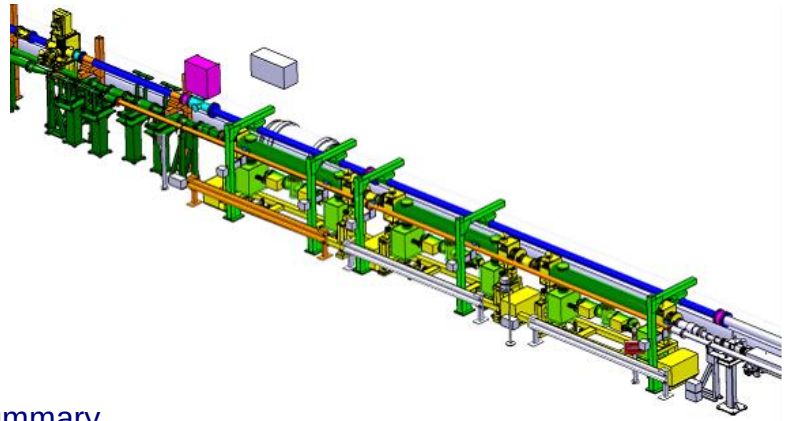
- Beam Interlock System to send an additional trigger to the LBDS re-triggering system, with 250 μs delay
  - Takes away the Trigger Synchronisation Unit (TSU) as single point of failure (12 V VME problem)
- Upgrade of TSU card following external & internal review
  - External review: no major issues, but …
  - Internal review: powering, put in 3 different crates instead of 1
- Powering modifications
  - Second UPS, individual circuit breakers, monitoring software
- Dilution kickers MKB vacuum glitches: to be sorted out !
- Generators extraction kickers MKD:
  - HV insulators -> 7 TeV
  - One brand of switches, as less sensitive to radiation effects
  - Upgrade power triggers: run at fixed power trigger voltages

Full re-commissioning required including 3 months reliability run preformed from the CCC

Dump System Protection – B. Goddard

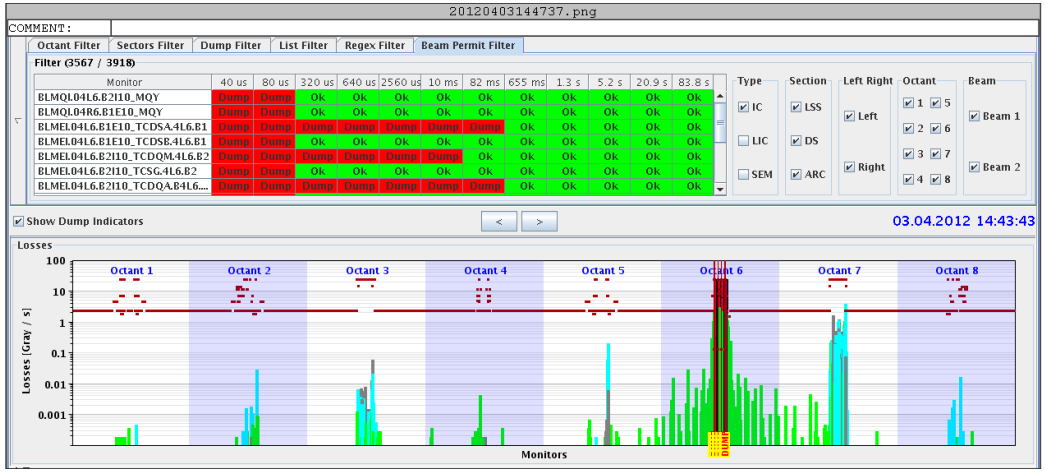
- We are still waiting for the 1st Asynch dump with full machine at top energy…
- With running at 6.5 TeV and repeated dumps expect dump block TDE ΔT up to 55 K and Δp up to 233 mbar
  - Check / watch venting of N_2 pressure of TDE block
- Improved protection during LS1
  - TCDQ from 2 to 3 blocks: 9 m of CfC diluter: HL-LHC
  - TCDQ in BETS – maskable BIS input. Under preparation
  - TCSGP with jaw BPMs: gain in setting up time and (interlock) accuracy
- Requests to Beam Instrumentation
  - Interlocked BPMS: dynamic range and PM buffers (to XPOC)
    - **Improving availability is improving safety**
  - Abort gap monitoring more reliable – automatic cleaning and dump !
    - Combine / back-up with other systems: diamonds / experiments

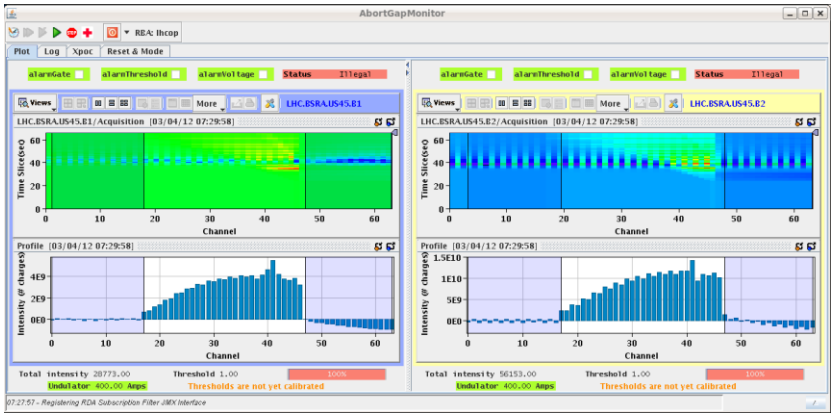




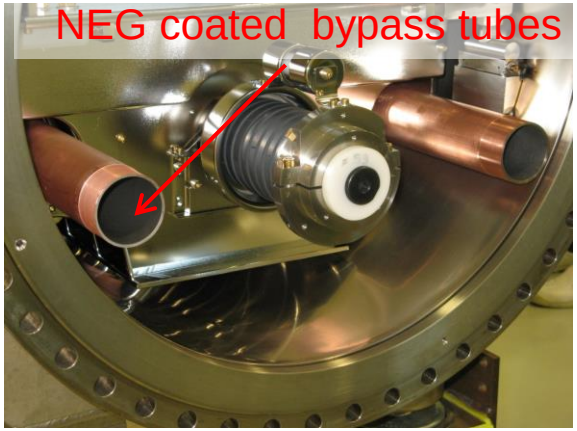
Dump System Protection

- System tolerances – IPOC / XPOC / BETS
  - Keep them tight (if it doesn't complicate too much, procedures)
  - Allows for tight surveillance of any system changes
- Standardise ***when*** asynch dump loss maps need to be made
- Procedures – commissioning (changes) in case of interventions or non-conformities
  - It is not easy to say "we need to stop the machine while we think", but it's much better than exposing the machine to potential damage
- Need to continue rMPP as online reactive body





Injection Systems – Wolfgang Bartmann

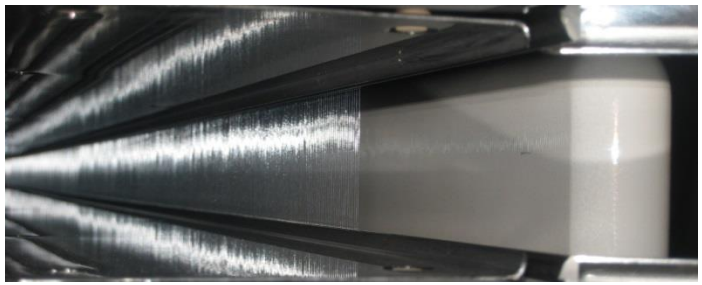


- Injection kicker MKI magnet upgrade
  - From 15 to 24 screen conductors:
    - The end of the heating problem (gain factor 3 – 4)
  - E-cloud: NEG coating of bypass tube and more
  - Unidentified Falling Objects (UFOs):
    - Improved cleaning
    - Applied on MKI replaced in TS3: promising
- Injection absorber TDI upgrade
  - Only intermediate solution for LS1; reinforced beam screen etc.
- Connection to injection Beam Energy Tracking System (BETS) of injection septum MSI current and TDI gap, to maskable BIS input
  - Under preparation: MSI OK, TDI need to check details
- Transfer line collimators TCDI settings to go with the right optics
  - Define a virtual β^* for transfer line and use SIS
- BLMs in injection region: LICs & sunglasses as back-up
  - Proposals presently on the table, studied by LIBD & MPP
- Injection Quality Check – to contribute to safety it needs fewer resets
  - Software can never be safety critical, but helps operational discipline

Changes in SPS interlocking – J.Wenninger

- SPS Machine Protection is not as tight as LHC MP - but the risk is also much reduced (max ~2 MJ / beam).
- Software Interlock System SIS was initially designed for SPS and used heavily
- Beam Interlock System and SIS need to be cycle dependent for the SPS
- The period 2006-2013 saw ~5 MP incidents.
  - 2 incidents resulted in equipment damage (ZS and MBB) ⟹ 2007 & 2008
  - the others were near–misses.
- Up to LS2 no major improvements expected
- SPS extraction interlocking
  - New extractions to be confirmed for about 2016: AWAKA, SBLNF
  - Different beams identified by the beam energy @ extraction: OK
  - Interlocking of beam position at extraction: under-performing for LHC beams

ZS in 2007



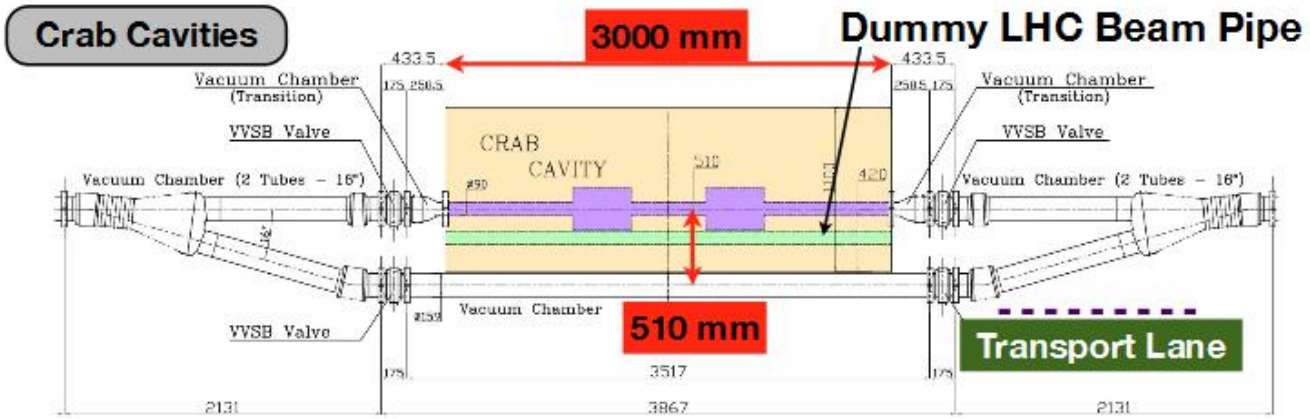
Controls 'problem' turned a slow into a fast-slow extraction

CNGS in 2008

Timing system problem

SPS interlocking

- CNGS Success Story: PJ and μSv
- "The diagnostics of timing problems for LHC beams remains rather tricky" -> wrong beam to the LHC
  - In 2012 a rather 'innocent looking' change of injection timings in the SPS lead to a problem where the LHC was expecting beam in one ring, and the SPS ended up sending the beam into the other ring.
  - Wrong MKI pulsed, beam on the TDI: **importance of the LHC injection absorber !**
  - Problem has been understood and will be fixed, backed probably by more SIS interlocks.
- LS1: SPS power converters from ROCS to FCG
- Proto-type crab cavity in LSS4 – movable – interlocking
- Looking for new Mister / Missis MP for the SPS

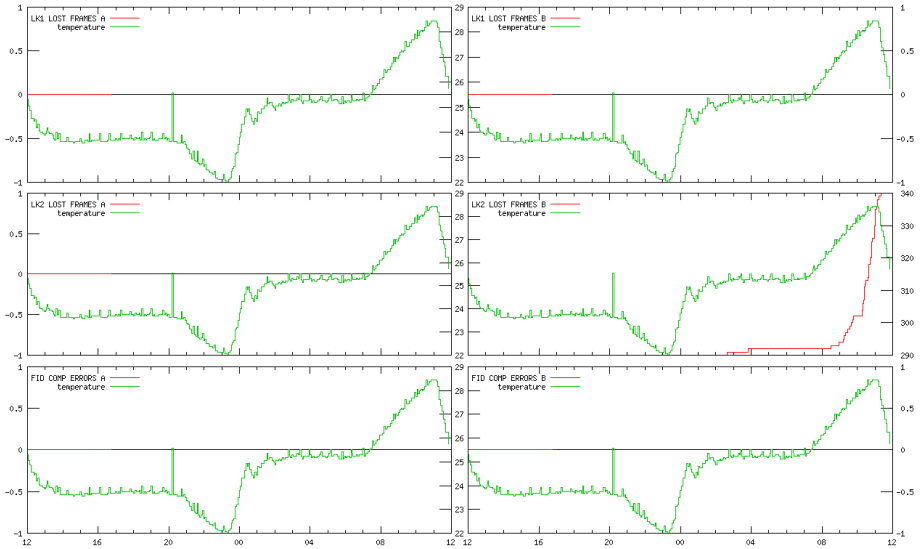


Session 3

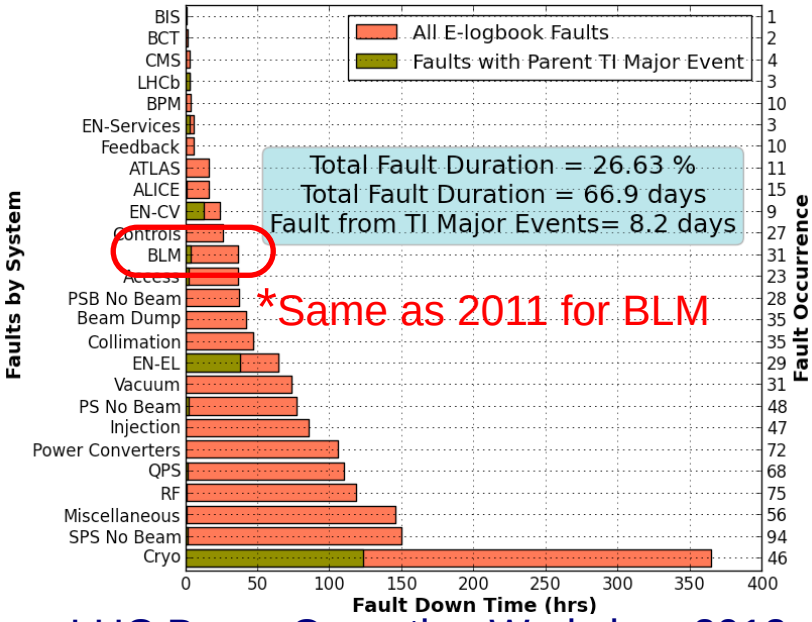
- Beam Diagnostics
  - Hardware changes in BLM system during LS1
    - Christos Zamantzas
  - Beam losses and thresholds
    - Eduardo Nebot Del Busto
  - Experiences with feedback systems and foreseen improvements for LS1
    - Ralph Steinhagen
  - Experiences with MPS related systems and foreseen improvements for LS1
    - Enrico Bravin

Beam Loss System – Christos Zamantas

- Beam Loss Monitors are the safety net of LHC machine protection
- Functioned extremely well during LHC running period I
- 2012 achievements:
  - Fast 12.5 Hz buffers for collimator alignment and capture buffers for UFO studies
  - Little Ionisation Chambers (LICs), which allow measurement of larger losses without RC filter, now *qualified* for operational use
  - Daily automatic analysis of the BLM system performance:
    - Many interventions in the shadow before affecting the LHC



Example of the daily optical link report



LHC Beam Operation Workshop 2012

courtesy A. Macpherson

BLM changes foreseen for LS1

New locations of the detectors

- Dismantle all detectors in the ARC and DS (~2500) and
- Dismantle 70% of the detectors in LSS (~1000)
  - in order to allow intervention in the interconnections
- Exchange 40 multi-wire cables with the NES18 type
  - Reduce noise on 240 detectors
  - Continuation of campaign to exchange all
- Relocate 816 detectors
  - New supports, cable extension
  - Improve MB protection a
- Electronics exchange and ons, replacement of all racks
  - Hundreds and hundreds o s, boxes etc., modification of firmware, …
  - Add two crates which allow injection inhibit ('sunglasses')
- Changes to application software, XPOC buffers, System Management etc.

Complete re-commissioning required.
Equal to LHC start-up

Beam Losses and Thresholds, E. Nebot del Busto

New locations of the detectors

- 2 out of 6 monitors relocated from Quadrupoles to Main Bends to protect against quenches from Unidentified Falling Objects (UFOs)
- Quench tests 2013:
  - As results adapt BLM dump thresholds (based on QP3 model ?)
- A specific procedure is followed every time a new set of thresholds have to be introduced in the system
  - Adapt 1.5 Million dump threshold values:
    4000 (BLMs) x 12 (RS) x 32 (Eb)= 1.5E+6
  - BLM threshold generation within LSA database – maintainable
- Continue quench test working group
- After LS1:
  - 'Sunglasses' possibly be used to blind out losses in injection region during injection: hardware will be installed
    - Combination IC, LIC, RC-filter & sunglasses
  - Complete re-commissioning: hardware, software & thresholds

Feedback Systems – Ralph Steinhagen

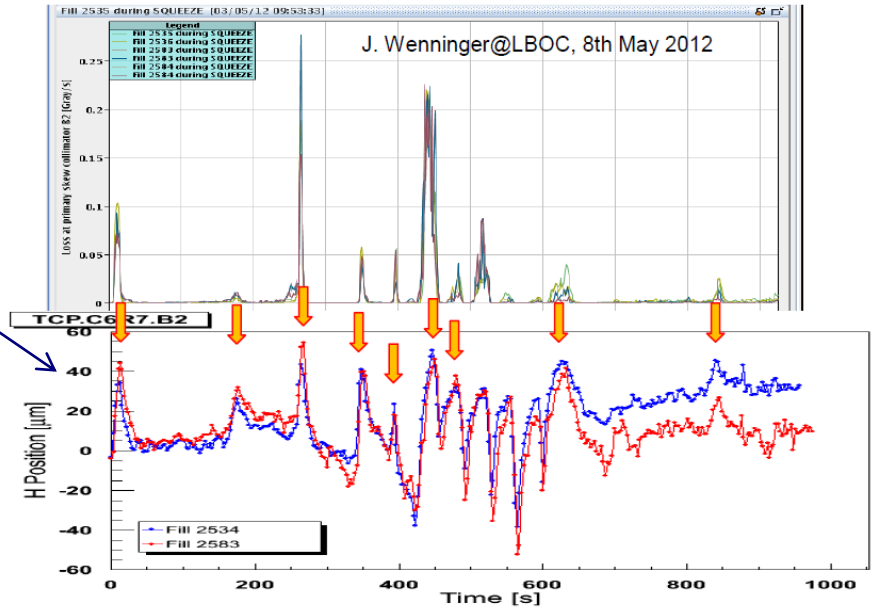
- Real time Tune Feedback & Orbit Feedback systems
- no “direct” link to MPS but can create dangerous, combined failure modes
  - Local orbit bump + fast kick / loss of collimator hierarchy
  - Q/Q’ being off-reference: driving beam instabilities
- Large system many devices & services involved
- Affect LHC availability:

	Total PMs:	FB & Co:	Percentage:
2010	453	8	1.7%
2011	684	30	4.4%
2012/13	851	28	3.3%

- Main issues of 2012 dumps with beam related to:
  - Beam measurement quality
  - Front-end/SW infrastructure problems: FESA, CMW, Timing & network
  - Insufficient loop stability margin due to data latencies
- However, increased criticality of the control of orbit and Q/Q’
  - Smaller β*, tighter collimator settings, larger bunch intensities

Feedbacks

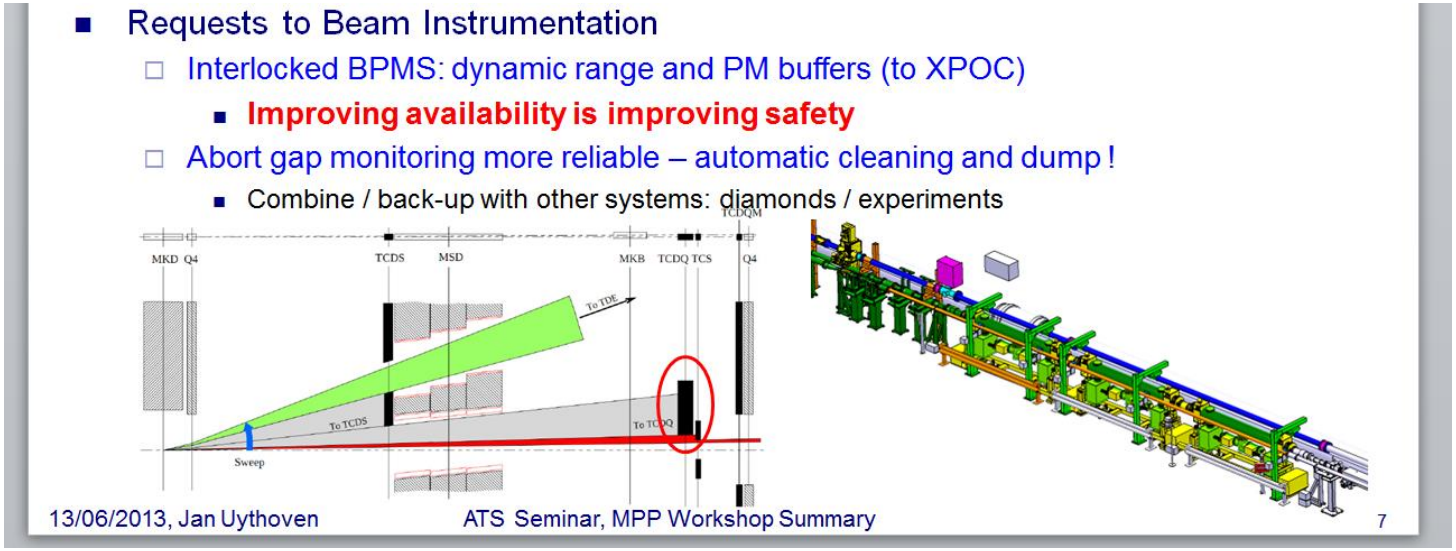
- Maximum drift rates of 40 μm/s
  → (close to) limit of Orbit-FB at 4 TeV



- LS1 activities
  - Temperature controlled racks & new Diode-Orbit ACQ for the IR BPMs
  - Front-end/SW infrastructure non-conformities to be addressed in a review in June
  - Operate with actual and not approximate optics (particular during squeeze)
  - Better diagnostics and pre-warning, better GUI integration, particularly concerning the system overview
- Discussion concerning data transmission latencies:
  - Upgrade to Gbit switch foreseen, prioritizing of single host possible, dedicated network not expensive … FB Architecture Review in May but no conclusions yet…

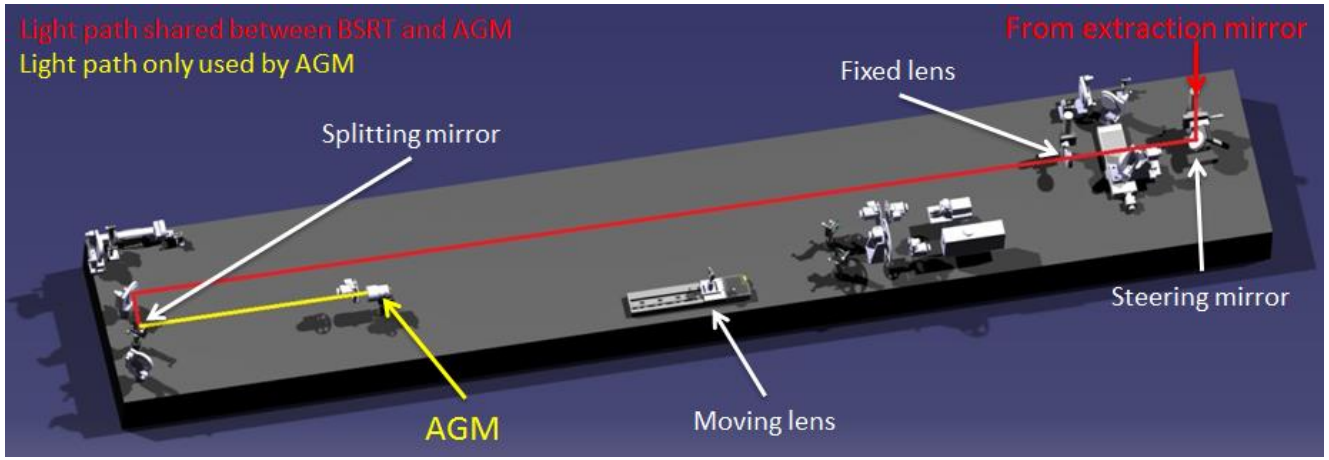
Machine Protection Related BI – E.Bravin

- From slide 7 (beam dumping system protection):



- Interlocked BPMs
  - The system always triggered when needed!
  - 158 dumps in 2012/13 run, of which 29 stable beams (of which 22 are in 2013, most during the ion run)
  - Changes foreseen for LS1:
    - Reduce reflections and increase dynamic range / autoscaling
    - Improve diagnostics and post mortem analysis
    - It is expected that the interlocked BPMs should not be a performance limit after LS1

Machine Protection Related BI – E.Bravin



- Abort Gap monitor
  - To be made more reliable & self-diagnosing by performing automatic periodic checks
  - Aim to connect up to automatic cleaning of the abort gap and dump beam when necessary
- dI/dt monitor which dumps the beam when rapid changes of beam current occurs. Based on Fast Beam Current Transformers (FBCTs)
  - Interlock has not been operational so far, tests during 2012
  - Plans for LS1:
    - Production of 6 complete units, with reduced noise floor
    - New fast beam current transformer: Out of 3 the best FBCT will be connected to the acquisition
    - Control and acquisition software will be developed
    - Questions concerning the implementation schedule outstanding

- Thank you for your attention
- Questions?
- Stefano:
  - Collimation and Movable Devices
  - Operation after LS1