# What are the weak points of operation?

**B.Goddard TE/ABT**

A personal view

Thanks for input from
**Verena, Alick, Reyes, Mike, Jan, Joerg, Malika**
with acknowledgement for the efforts of everybody
Mistakes and inaccuracies I claim for myself

# Abstract

The few weeks of LHC operation in 2009 was a resounding success with extremely fast progress in the beam commissioning.

Nevertheless, the period also revealed a number of possible weaknesses in various aspects of the LHC operation, including procedures, tools, discipline, equipment and organisation. The weaknesses are discussed with a view to feeding the experience back to improve the machine operation for 2010 and beyond. The distinction is made impacting efficiency, and those points which are more serious and might impact machine protection.

**May contain traces of Motherhood and Apple pie**

# Outline of talk

- **Perceived weaknesses**
  - Preparedness
  - Injection
  - Experiment-machine interface
  - Sequencer
  - Ergonomics
  - Discipline
  - System specifics
  - Procedural
  - General
- **Conclusions and outlook**

# Preparedness

- **No clear definition of conditions/results needed to move to next commissioning step**
  - Led to (heated) ad-hoc arguments about whether safe to proceed
- **Rather informal approach (planning, tracking, …)**
  - Very efficient and gives fast progress
  - Relies on excellent and wide ranging communication and awareness (coordinators)
  - This intensity may not be sustainable for 9 months
- **Some things not fully tested in Dry Runs/Checkout**
  - Inadequate stress-tests (concentrators, proxies, CMW subscription)
  - Settings (knobs for tune, chromaticity not available for squeeze)
  - Partial tests only for some systems (alarms, collimators, feedback…)

# Injection

**Frequent accidental over-injection**

- Mistakes by EIC/experts, wrong/multiple sequences running, injecting into wrong ring, circulating beam present, IQC, debunched beam, …
- Stresses MP system (rely only on TDI position)

- **Injection Quality Check application (IQC) issues**
  - Needs to be faster (CMW subscription data latency)
  - IQC should not be ‘optional’ in Injection Sequencer (MKI protection)
  - Wrong result (‘no beam injected’) if intensity too low –> over-inject. Check in SPS with BQM/SIS?
  - MKI acquisition (IPOC) sometimes missing
- **Injection with ring with wrong settings for systems**
  - Occurred with ring only partially at injection settings, collimators, …
  - Could easily lead to quench
  - Needs overall surveillance or sanity check (SIS? check JW)

# Injection

- **BLM sensitivity and saturation for injection losses**
  - Prevents over-injection onto IR8 TDI AND setup of TDI/TCDI – to be solved
  - Higher intensity will produce loss interlocks on TCDIs near LHC
- **Beam tails and losses at injection not addressed**
  - SPS scrapers, emittance variation, losses on TCDI, BLM response
  - Concern about our ability to inject high intensity without BLM interlocks

**Injection and circulate for many turns with screens IN**

  - SIS masked, dangerous for screens even for low intensity (multiturn)

# Experiment-machine interface

- **Communication with experiments and machine modes**
  - End-of-fill not signaled
  - Machine mode changes forgotten
  - Slow handshake (e.g. injection, before dumping beam, …)
- **Manual mode change from ‘stable’ after dump**
  - Sometimes forgotten – needed by at least ATLAS to switch off
- **Some experiments slow giving injection permit after PM**
  - ATLAS much slower than all others – losing hours in some tests

- **Tacit acceptance of unofficial ‘quiet beam’ mode**
  - Sloppy and should not be tolerated – encouraging bad habits and danger for experiments
  - Instances of experiments turning ON without OP expecting it?

# Sequencer

- **Sequences left running unintentionally**
  - Inject and dump/circulate and dump, affecting injection

**Playing wrong sequence at a bad time**
  - Softstart of kickers by accident, all collimators to parking, …
  - Not strictly the sequencer's fault – but could add some 'protection'

**Wrong timing tables loaded for given sequence/mode**
  - Need task to unload/load relevant timing tables at end of sequence
  - Issue with looping sequences – special recovery sequences?

- **Sequence structures not optimal**
  - Entry points into sequences not clear
  - Sequence and subsequence hierarchies not clear

**(Too) easy to skip any line, also to edit sequences**

# Ergonomics

- **Are there any fixed fixed displays?**
  - Setup depends on personal preferences of EIC
  - Nail given displays to given consoles and never move them – how?
- **No overview of collimator positions**
  - Need an easy way to tell whether global set of positions are correct
- **Fill number clocking erratic**
  - Data retrieval difficult - is this being logged now?
- **Page 1 complicated and sometimes frozen**
  - Less is more (are 4 BTV screen shots necessary?)

# Discipline

- **Machine state after MD or commissioning tests**
  - Corrector settings, protection devices at wrong settings, RF off, …
  - Reset to run configuration (assuming there is “a run configuration”)?
- **Updates of Page 1 and machine mode not made systematically**
- **Reset of latched TCDQ energy interlock after precycle**
  - By design, but needs task in sequence to reset automatically

- **Parallelism (beam 1/beam 2, and ‘parasitic) in studies**
  - Several times beam dumped by the ‘parasitic’ partner (BLMs)

- **(Too) easy to disable ‘required’ functionalities**
  - SIS channels, IQC enable, tasks in sequences, …
- **TCDI settings not updated to agree with deployed thresholds**
  - Simpler (but safe) method?

# System specifics

- **Feedbacks**
  - Not switched off after beam dump on some occasions
  - Correcting on noise after dump: put machine in unknown state
  - Erratic sending of real-time data to correctors (e.g. MCBX trip)
- **RF**
  - 18kV cells left off after access - needs clear procedure & SW check?
  - Injecting with RF off is possible; check and prevent?
  - Resynch – not always clear whether this worked or not – use BQM
- **Interlock BPMs**
  - Trip when intensity too low
  - Reset of latched interlock to be added in sequence
- **BSRA**
  - Undulator state not surveyed yet in any sequence or application

# System specifics

- **Collimator/protection device threshold management**
  - No protection on who opens thresholds and when (beam process), idem for jaw movement
  - No redundant protection for squeeze (no $\beta^*$ factor)
- **LBDS XPOC**
  - Not stable enough (timestamps, MKD energy, …)
  - BI checks to deploy
  - Threshold management too rudimentary
- **LBDS internal trigger latency to BIS**
  - Could lead to injection into machine with LBDS unarmed
- **Inputs to SMP need to be rock-solid**
  - CMW and JMS broker instabilities affected BCT
  - BCT reliability (and redundancy?)

# System specifics

- **Underground access → PCs OFF and permit removed**
  - Adds large (2 hour) overhead to short accesses
  - Is this strictly necessary (e.g. for access only to a UA)?
- **QPS resets in tunnel frequently necessary**
  - Source of inefficiency - need to remove power permit each time
- **Glitches in TIM communication for interlock on powering/access status**
  - Several times whole machine flat-lined due to this fault
  - Need a way to improve logic/communication

# Procedural

- **No tracking/enforcement of allowed 'operational envelope'**
  - Free to fill machine with 'high' intensity at anytime
- **No enforced PM analysis or systematic offline analysis of emergency dumps**
  - Setup offline mechanism for checking emergency dumps – how?
- **Patchy tracking of MP commissioning tests, no central overview**
  - Many culprits, including LBDS and BIS
- **Systematically checking tunes, orbit, lifetime, chromaticity, filling pattern, losses, … after injection**
  - How to enforce this (some aspects in IQC, procedures, …)?
- **Information exchange EICs/operators/experts/coordinators**
  - SPS-style wiki for simple knowledge base?
- **Coordination and decision making**
  - Keeping planning, status, results, information up to date
  - Pressure from experiments, experts, management to deal with

# Running with Scissors

- **Very fast progress: already have capacity to 'easily' increase beam intensity and energy, and reduce $\beta^*$**
  - High and natural pressure to get useful luminosity
- **In developmental terms LHC is now a toddler**
  - After just having learnt to walk, our baby will soon be running with scissors
- **Machine protection should not follow the progress, it should dictate the progress, or at least limit it**
  - This is not yet always our operational paradigm
  - Must remember that MPS is almost certainly not perfect (bugs still coming)
  - *"We're not at home to Mr Cockup" – we w*ill require much more discipline when we go above safe beam limit

# Conclusion

- **There are many, many strong points of LHC operation - honest**
  - Expertise, motivation, dedication, preparation, communication, coordination, teamwork, experience, support, controls, ….
- **Many of the "weaknesses" identified are minor, which can only affect machine efficiency**
  - Should follow-up in the 'normal' way by dry-run teams
- **A few points are more important or difficult to solve, and warrant concerted effort before 3.5 TeV luminosity run, e.g.**
  - Making injection solid (including transient loss concerns)
  - A priori agreement of target parameters for commissioning phases
  - Method and discipline for maintaining 'operational (MPS) envelope'
  - Machine Protection System progress tracking discipline/enforcement
  - Is present informal yet intense planning/tracking paradigm sustainable?
  - Simple knowledge base for operational aspects (SPS model?)
  - Systematic beam PM acknowledge and Emergency dump analysis