Evian 2012 : Session 3 - Beam Based Systems and Control: 2012 performance and 2014 outlook

What we want

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Many thanks to

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Introduction

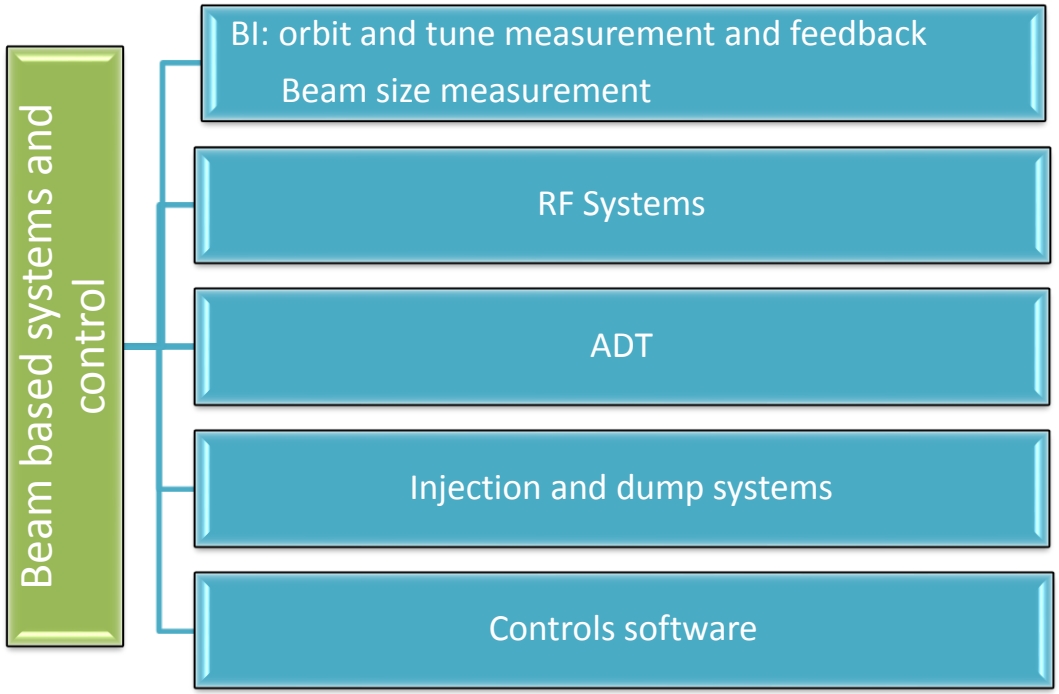
LHC performance

Amazing team

Reliable and performing equipment & control systems

Availability and talent of the experts

Scope



TALK CONTENT

- Focus on the issues
- Requirement from operation team for after LS1

Numbers given for equipment downtime:

come from the faults as recorded in the logbook

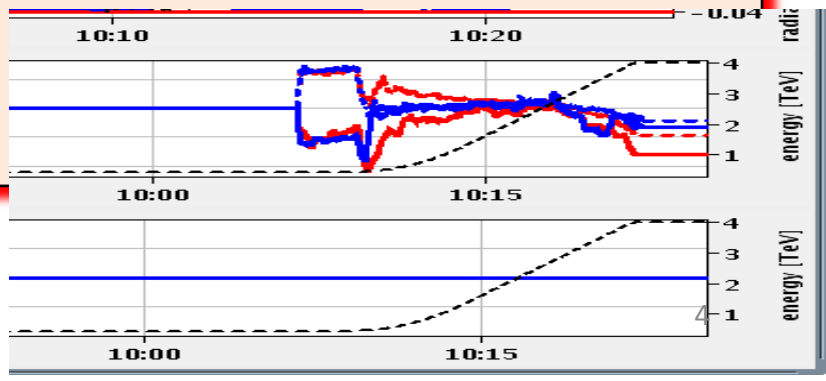
can not be really compared with 2011

Tune measurement and feedback

Tune measurement: poor tune signal quality

- ADT gain has been doubled in 2012
- Octupoles strength tripled during ramp (from 1.5 in 2011 to 4.5 in 2012)
- 8 KHz and 50Hz perturbation is back, difficult to get rid of

- Difficult to measure chromaticity
- Tune feedback :
  - Keeps stopping during ramp, chirp needed (not the best for beam)
  - Has to be turned off for squeeze, we rely on feed forward and the very good reproducibility of the magnets
  - End of ramp : tunes are driven away by the feedback.



Tune measurement and feedback

Improvement with Gated acquisition:

ADT gain lowered for first 6 bunches, BBQ acquisition gated on one only

- Acceptable measurement at injection for pilot and nominal (2 FFT systems), better chromaticity measurement
- Better at the beginning of the ramp, where feedback is most needed
- Bunch/bunch acq possible with extra software

- Gated acquisition reduces the sensitivity of the measurement
- From the middle of the ramp , we still see double peaks

→ we still can not trust measurement (c.f. tune feedback) at flat top.

Tune measurement and feedback

What we want

- Reliable tune measurement along the cycle, and keep the feedback ON
  - → now we rely on the Quadrupole currents to estimate where the tune is at flat top.
  - → Situation improved with gated acquisition, but not ideal yet

- Release management and testing to be improved
- To be better informed on what has been modified by the release, and the possible implication for operation
  - → E.g. Big confusion after the new gated system was released: we had inversed sign for chromaticity measurement, the change from one FFT to another crashed the feedback system, B1 chirp affecting B2…

Orbit measurement and feedback

BPM measurement: much improved, still some quality issues

- Temperature control still an accuracy limitation
- Non-linearities in strip-lines to be corrected
- Beam pattern effect
- Accuracy of measurement in/around common vacuum chamber to be improved

Interlock BPM IR6 :

- Very noisy signal for certain ranges of I/bu
  - Lots of spurious dumps at injection (32 in total, 14 in May)
  - Struggle to find the right gain/attenuator configuration : in May, OK for nominal intensity
  - Still a problem for special types of operation with intermediate I/bu like proton-Lead, MDs
- Beam is dumped as soon as **a single** bunch loses intensity

Orbit measurement and feedback

Orbit Feedback stays ON from start of ramp to end of squeeze : stable and reliable most of the time

Nevertheless, 21 dumps assigned to Orbit feedback (mostly in ramp and squeeze)

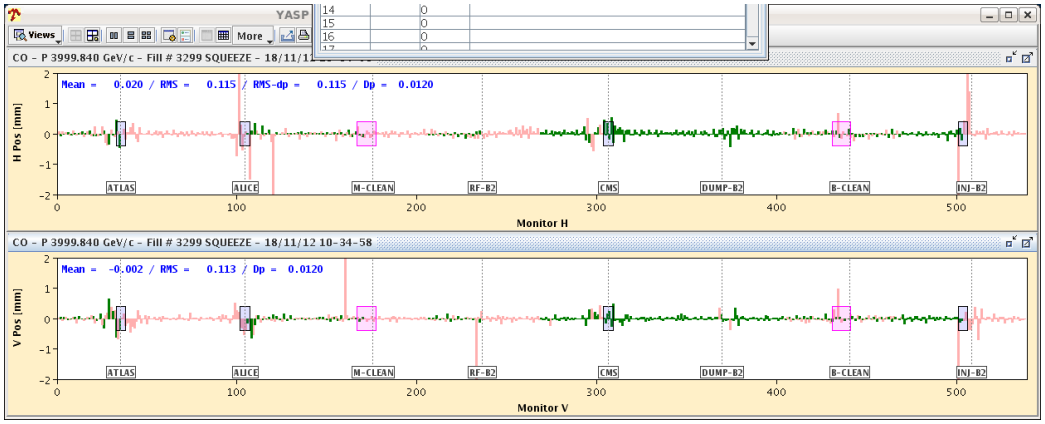
issues

- Optics reference not loaded
- Orbit reference not loaded or corrupted
- Corrector mask corrupted and correctors in the common region used by the feedback
- We had periods when OFSU was unstable, crashed quite often, not always recovering nicely
  - OFSU crash in ramp or squeeze = beam dump

To be noted : Once the feedback has introduced crazy RT trims, no way to recover the situation, beams have to be dumped

Orbit measurement and feedback

Another annoying issue :
BPM feedback enable flickering
→Very confusing; what's happening to the correction?



What we want

- Better release management: testing procedure and communication of the modifications.
  → most of the issues happen after a release
- Very complex system, even experts are sometimes unable to understand why the system does not behave as expected (scary…) : we need information on what's happening in the different parts of the systems, and a kind of consistency check
- Filtering of BPM to be improved
- Optics and trajectory reference management also very obscure for most of us.
- Interlock BPMs to be revisited: how can we stay safe and not dump unnecessarily?

Beam size measurement

- Hardware robustness issues
  - BSRT mirror moved toward beam, temperature problem
    → No B2 measurement since end of August (beam size and abort gap monitor)
  - Wire scanner weakening at the end of the run; OP instructed to use it as little as possible; no more wire scanner for HB1.

- Calibration issues
  - BSRT : doesn't give coherent beam size measurements along the cycle
  - BGI : still experts tool, data analysis difficult

What we want

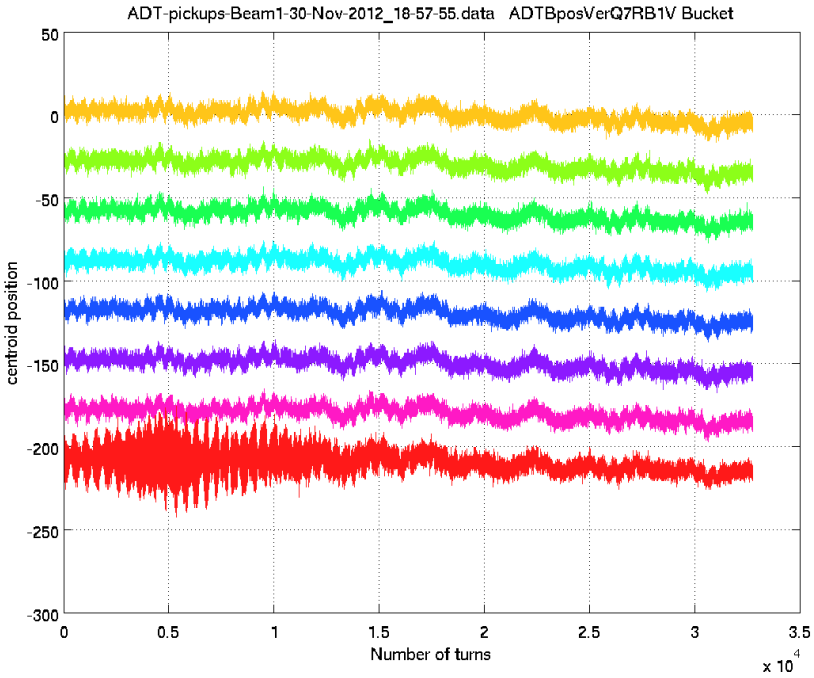
- Bu/Bu emittance measurement must be coherent
  - along the cycle
  - along the accelerator complex

- Operational applications in CCC (now we are using only expert application)
  - BSRT application: automatic scans now, but application still difficult to use
  - Wire scanner application: very inefficient, to be re-written to meet OP needs
  - LDM : used mainly to check satellite level, we need an operational display

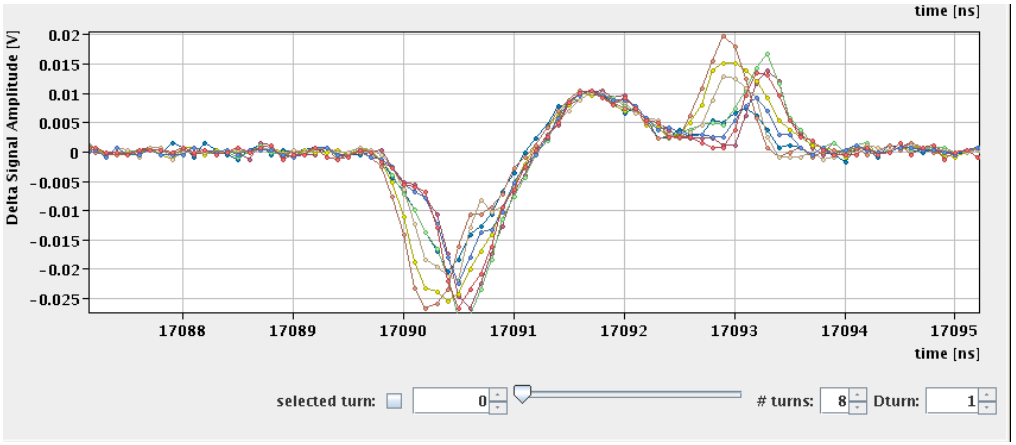
Bunch/bunch Instabilities (input from ABP)

- In 2012, with the smaller emittances and B*, and more intensity per bunch, bunch/bunch instabilities started to really **reduce LHC efficiency**
- **A better observation** of these instabilities would have allowed to understand their nature and put in place good strategies to correct their effect.

End of Squeeze instability caught by the ADT pickup on the red bunch (Nov 2012)



B2H Instability caught by the Headtail monitor at injection



→ Head-Tail instability mode 1

Bunch/bunch Instabilities (input from ABP)

What we want

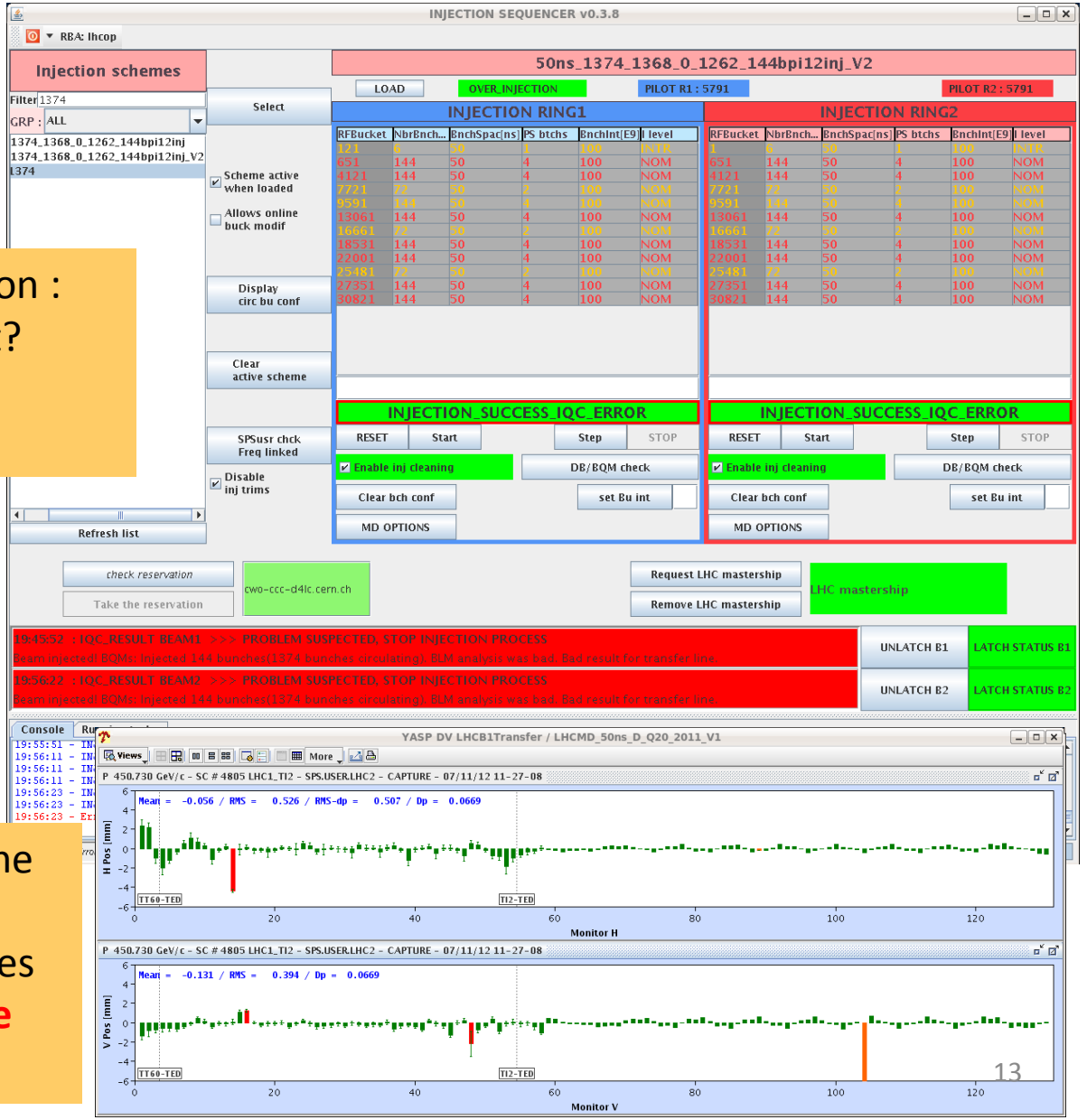
- **High resolution**, as the instabilities are fast (can come and go in 200 turns)
- **Large data buffer** as needed to acquire all bunches for a maximum of turns
- **Triggering system** for the acquisitions when instabilities are detected (by BBQ, BLM, other system?) , to make sure the instabilities are always caught when they occur

- bunch/ bunch beam size measurement
- bunch/bunch position and tune measurement :
  - ADT PU : position meas limited to 8bu/6s or 1374bu/72 turns. Tune measurement tests promising
  - BBQ PU needs another signal processing, with gated acquisition we get only one bunch at a time
- bunch/ bunch tune measurement
  - Schottky monitor: is there hope to make it operational?
  - Diamond detector (BLM) : could be used by ABP expert for the tune measurement, but also need bigger data buffer (now limited to 30ms, can be pushed to 1s)
- Chromaticity measurement : continuously during the cycle (Schottky, other system???)
- Transverse motion along a bunch to identify the type of instability (mode coupling and Head-tail mode number) → need for several time domain traces during the instability onset.
  - Head tail monitor : unusable for the moment, scope and server crash all the time, need to acquire both plane both beam at the same time, efficient triggering and adequate gain needed.

Injection and dump systems: steering

IQC latches almost every injection : are the **Thresholds** correctly set? Can we still afford this with 288 bunches ?

This shows the difference of the trajectory with the reference, when the oscillations and losses are very good: **is the reference valid?**



Injection and dump systems: steering

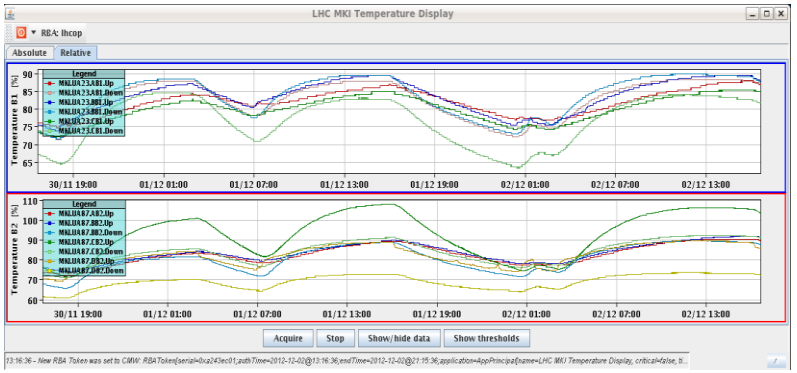
- It is difficult to know what is acceptable or not in terms of beam position and beam losses.
  - Most of the time we unlatch IQC with no corrective action
  - Or we waste time steering, when in reality the injection losses come from the beam quality in the injectors (i.e. satellites)

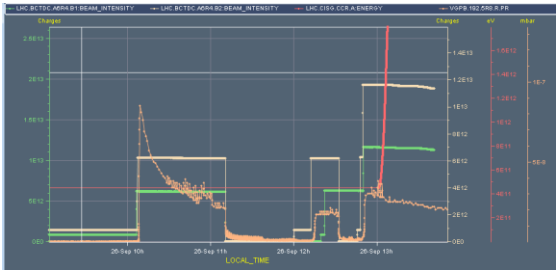
What we want

- Reduce the time we spend steering the lines
  - Improvement of the line stability
  - Steering only when necessary, we need clear boundaries
    - Good transfer line references
    - IQC thresholds properly set
  - Steering takes time because we always have to compromise between good injection oscillations and good injection losses : can't we get both?

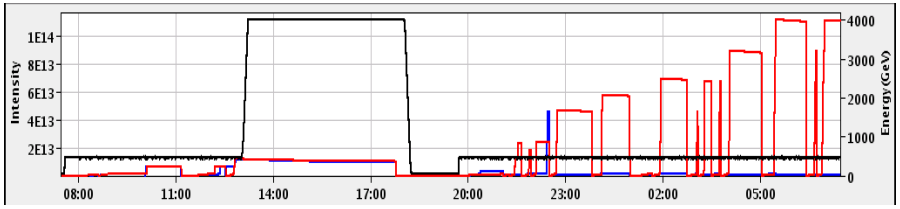
Injection and dump systems : MKIs

MKI temperature interlock:
18h in total spent to wait for the temperature to go down





TS3: replacement of the MKI8D
→conditioning , scrubbing needed



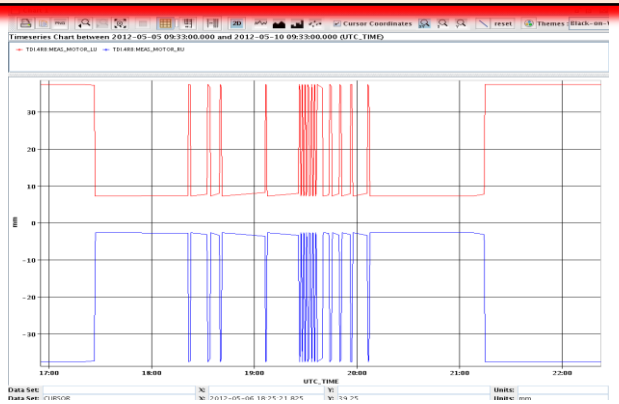
Actual vacuum interlock threshold is not compatible with 25ns run (increased just for end of year 25ns run)

Injection and dump systems : TDI - LBDS

➢ Total downtime assigned to TDI : 26h (almost no downtime in 2011)
Significant examples below

➢ Heating problem for TDI IP8

drift of the LVDTs of TDI IP8 outside position thresholds due to a deformation of the jaw induced by heating during injection
→ instructions to OP to cycle the TDI until the LVDTs are within the thresholds. After a while increase a bit the position thresholds



➢ Mechanical problem for TDI IP2

a “goupille” broke and one jaw fell into the aperture while preparing for injection, access needed, position reference lost

→ Often, beam based alignment needed after a problem with TDIs

➢ Total downtime assigned to LBDS : hardware : 25h, controls : 17h } 42 h

➢ 08/05/12 : Machine protection issues discovered for LBDS
  - ➢ Lack of redundancy of a 12V power supply could have lead to a situation where a dump would be impossible.
  - ➢ Beams dumped immediately, access for corrective action test ramp needed

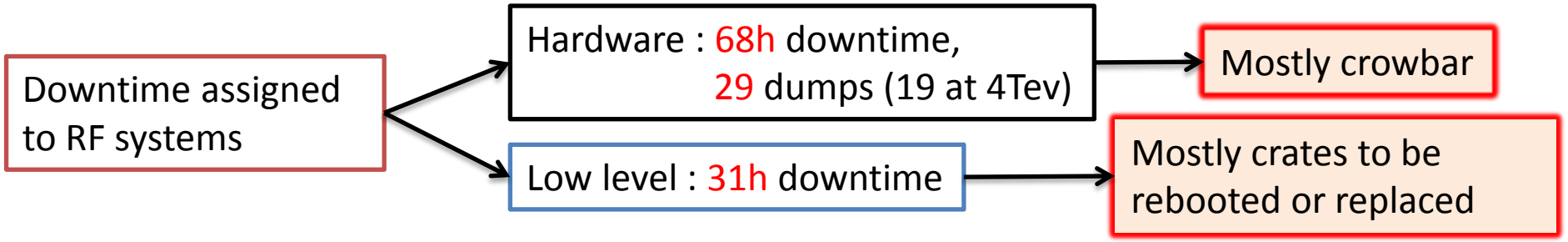
➢ Very critical system : quality control requires testing and re-validation (time consuming)

Injection and dump systems

What we want

- We want to inject 25ns beam for physics : proper vacuum threshold for MKI has to be determined, a good compromise between equipment safety and operation efficiency
- We want to restart injecting immediately after the rampdown: what is foreseen for the MKI temperature problem?
- TDI: heating, deformation, mechanical weakness of the system : will not get better with 25ns beam. What is foreseen to mitigate these problems?

RF systems



What we want

- **Reliable hardware** : What is the impact of 25ns beam on equipment performance?(more power will be needed) What is foreseen in LS1 to strengthen the hardware and improve availability?
- More diagnostics on RF interlocks : HW interlocks are there but we miss the details of RF low level interlocks
  - Not always clear if we need to call low level, controls or hardware piquet.
- Phase acquisition batch/batch, now we only see the average of all bunches
- Bunch longitudinal profile measurement : available only as expert application
- BQM : faster update of the data (now 1 update/5s, we want 1update/1s)
- Phase and amplitude noise display for each klystron
- Batch/batch blow up : still need diagnostics and control for OP. (injection phase and synchro error measurement compatibility?)

Transverse Dampers (ADT)

Injection oscillation damping

Injection cleaning

Abort gap cleaning

Transverse blow-up (used for loss maps)

Instabilities detection (with the damper PU)

Tune measurement

- A few Hardware problems : 12 hours downtime assigned to ADT hardware

What we want

- Settings management to be simplified/ clarified
  - Lots of functionality implies many parameters and settings
  - some are functions, some are discrete and stored in many beam processes
  - Difficult to find our way through the jungle, easy to get lost
  - We still rely a lot on experts
- A better solution for Gain and interlock settings that depend on the I/bu, now loaded manually by Experts.

Control systems : issues

- Total downtime assigned to controls: worldfip: 10h, software: 5h, timing : 6h30 } 21h30

- **CMW** : unable to manage “bad” clients, servers get stuck and fail to send updates even to good clients.
  → SIS dumped the beam several times because of subscription timeout

- **Timing system** : twice, we had issue with the update of the next injection ring (non standard operation like new SPS cycle with different injection time)
  - **Injection in the wrong ring, potentially very dangerous**

- **LSA** : sometimes the LSA database is very slow (regeneration and incorporation)
  - When several processes access the database (i.e. database back-up)
  - Already improved during the year, but actions should be taken during LS1

Control systems: good old requirements

- Diamon :
  - we need clear information on the connection between applications, proxy, middletiers, proxy, front-end…
  - Display of server status in diamon: we want red when there is a problem and green when everything is working

- Alarms:
  - Will never be really used until it is mode dependent

- Sequencer:
  - Should allow for automatic parallel execution of sub-sequences
  - Parameterized sub-sequences (i.e. possibility to pass arguments to a sub-sequence)

- Sequence edition in the injectors (more and more flexibility required from the injectors for LHC needs)
  - Already improved with the use of spare cycle for intermediate intensity
  - Still some time lost waiting for the sequences to be edited, the timing manager could be further improved
  - Sequence change: takes always 3 to 4 supercycles to get the beams back

Control systems : what could be improved?

- Console manager :
  - more user friendly tools to edit the menus
  - automatic, periodic refresh of menu configuration from the DB (instead of manual refresh)

- Fidel :
  - fixed display to know what's going on: is it still triming? By how much…
  - In case of hypercycle change : once fidel has started, if we want to change the hypercycle we need a precycle.

- RBAC :
  - Login, login login: any alternative solution in CCC? (e.g. biometric identification methods?)
  - Roles distribution and management to be reviewed and rationalized

- State machine: not flexible enough (e.g. for MDs)
  - Distinguish between absolute requirement to go to next step and simple checks to help operational efficiency (Mains currents / tune feedback state)
  - After LS1 forcing to a state should be exceptional, even in MDs

- FESA:
  - Management of the version, not easy to know which device is running with which version
  - FESA navigator application to be reviewed

Data management

What we want

- Data Storage
  - Demand for bunch by bunch and turn by turn data is increasing rapidly as needed to hunt for instabilities
  - Presently lots of data are stored with individual ad-hoc solutions instead of going to the official logging
  - A common system is needed to log this large amount of data
  - Data could be automaticaly deleted after a configurable time period, with the possibility to keep the interesting data

- Fill by fill data analysis

  We need a tool to automatically analyse a fill
  - Extract predefined key parameters of a fill (one off or time evolution)
  - Comparisons fill to fill, to see the effect of a parameter change for example.

Outlook for 2015

Already this year, signs of premature ageing of some equipment (TDI, BSRT…)

2015 : New challenges

- 25ns beam : e-cloud, heating
- More powerful beams, more damage potential (intensity + energy increase)
- Possibly more bu/bu instabilities

LHC operation more demanding,
Less forgiven machine

Conclusion

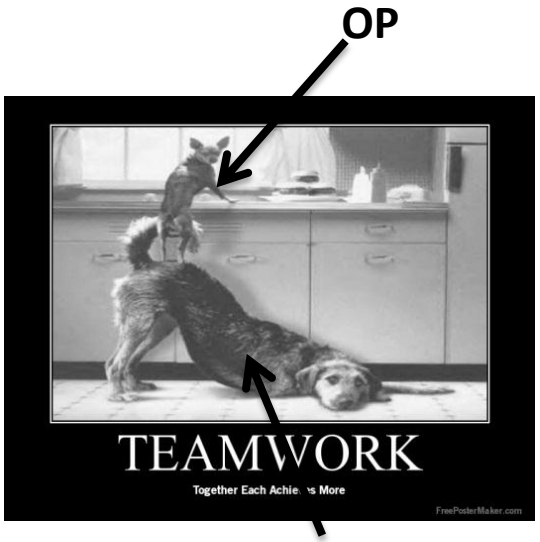
- Issues, weakness and possible improvement for beam based system and control have been presented

It shows that the success of this year did not come without struggle

Reliable Equipment & Control

LHC operation efficiency

Huge work from the equipment and control teams



Equipment & controls teams

Now, experts of each mentioned system are going to present what is foreseen during LS1 to be prepared for 2015, and realize **all** our wishes…