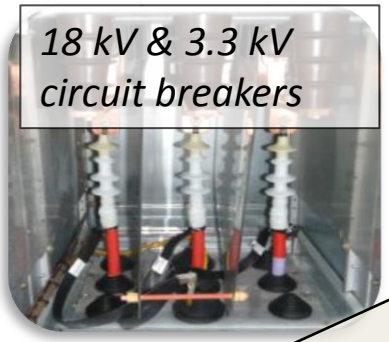
LHC re-commissioning
Dry runs and cold checkout

IRWG 26/03/2015

Delphine Jacquet

LSI modifications


UPS

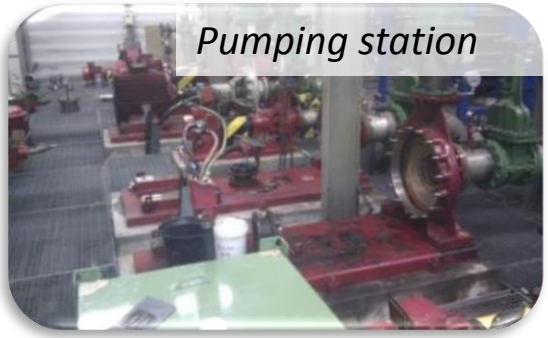

18 kV & 3.3 kV circuit breakers


Vacuum


P7 enclosure

+ personnel changes, including OP/LHC !


Cryogenics


Pumping station


ACS transport

General Strategy

- Intensive individual system tests by the experts are essential
- As soon as systems are ready, even partially: test campaigns of operational uses-cases by OP team from the control room (dry runs)
- A dedicated machine checkout period (full integration tests) between the end of LS1 and the start of beam commissioning for a smooth transition
- Commissioning of superconducting magnet circuits :
  - 5 months to tests 1600 circuits (quench protection system, interlock system, training quenches of the dipoles etc) : started in September 2014
  - OP and experts on shifts
  - Coordinated by Matteo and Mirko
  - Not cover in this presentation

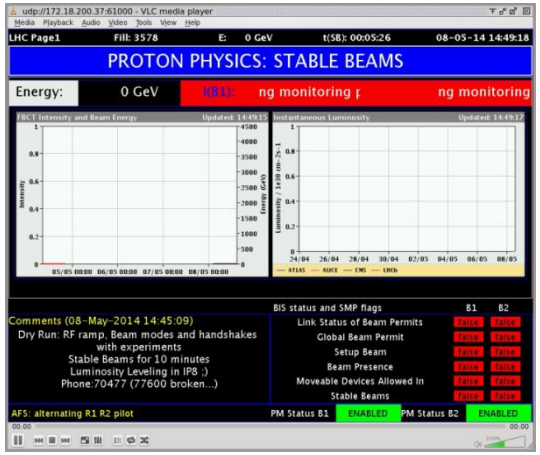
System tests scope

- System tests from the control room by the operation team with the help of the equipment experts
- Not individual equipment tests, but tests of several systems working together
- Run of operational scenario
  - as far as possible without beam
  - with the systems available
  - Including the experiments
  - i.e. operational sequence, interlocks, beam mode, post mortem, logging, timing

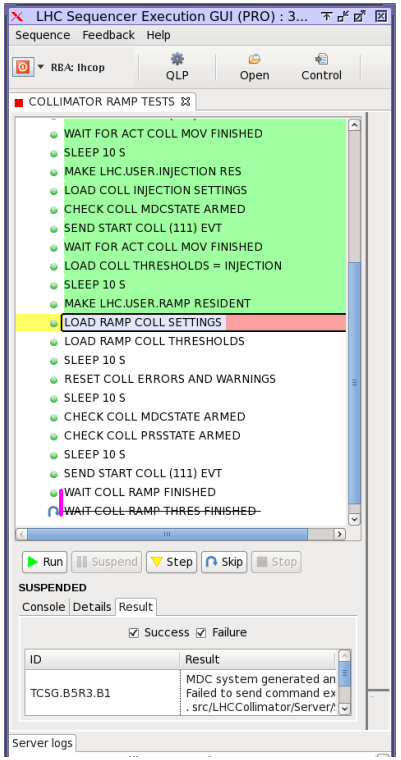
Early start in May 2014

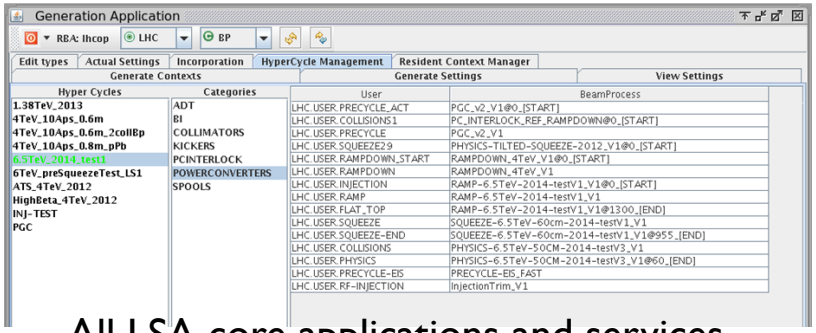
- Why so early?
  - Detection of issues as soon as possible
  - Provide still plenty of time for corrective action, even for complete review of a system, if needed.
  - Ensure a tight collaboration with the expert and follow-up by OP of the new implementations and functionality
  - Some stress tests or reliability tests have to be performed during several weeks. (collimators, LBDS, timing)
- Drawback
  - Lots of systems are not stable yet, most of the time only partial tests are possible.
  - Part of the tests will have to be repeated when the complete systems are ready.
  - Restart of the injectors is the priority : experts not always available to help and solve issues immediately

Operational control environment need to be in place

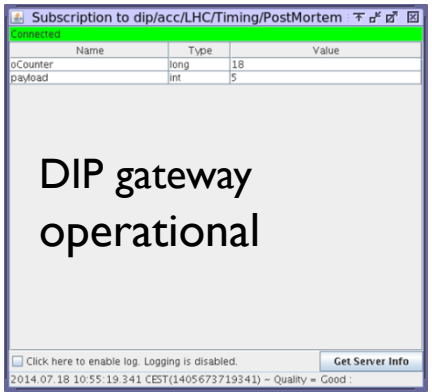


Page 1 up and running to communicate with experiments



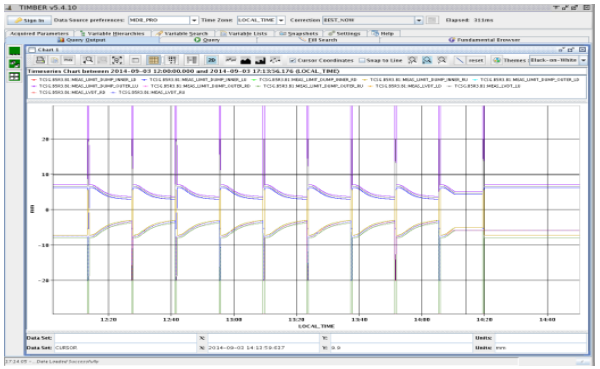


All LSA core applications and services operational. (→new 6.5 TeV hypercycle generation)



DIP gateway operational

Sequencer and sequences editor operational

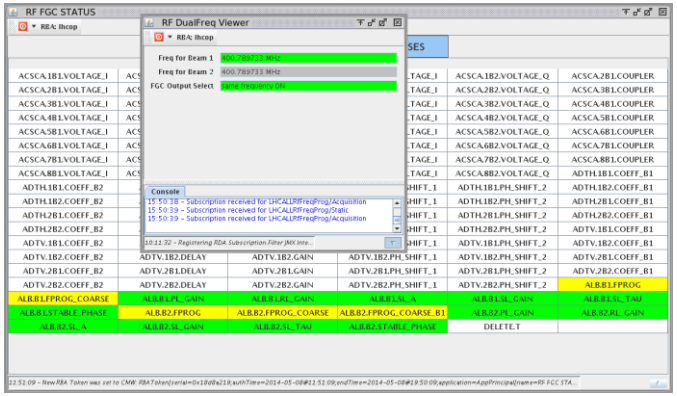


Logging service and timber application

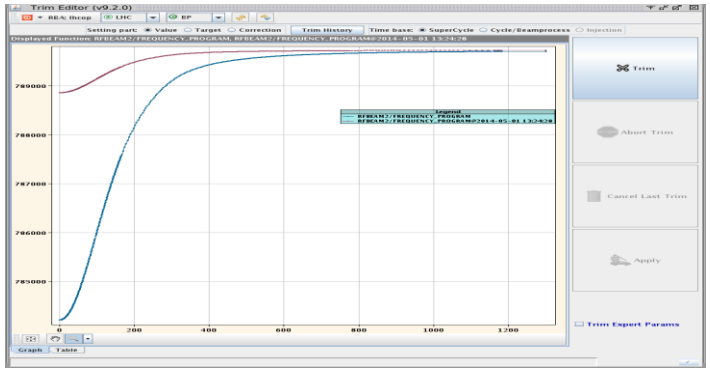
Examples of tests achieved early before beam

RF synchro and Frequency ramp

- Launch the frequency ramps with a RF beam control resynchronisation between each ramp.

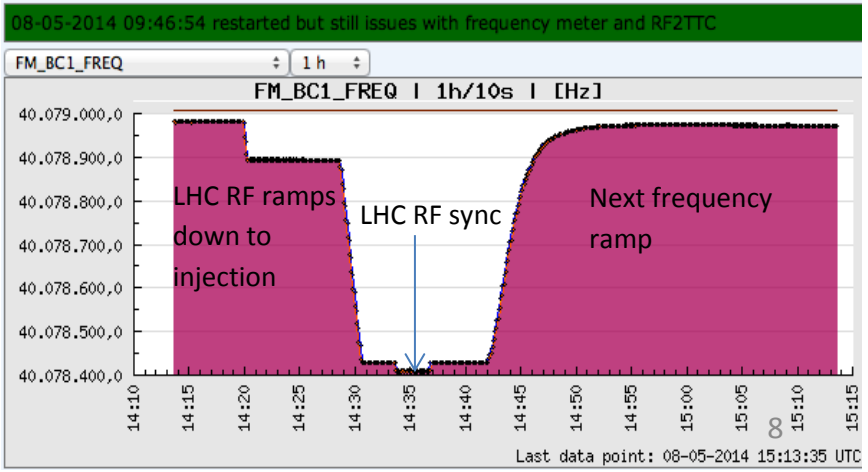


Frequency monitoring RF FGCs in running state



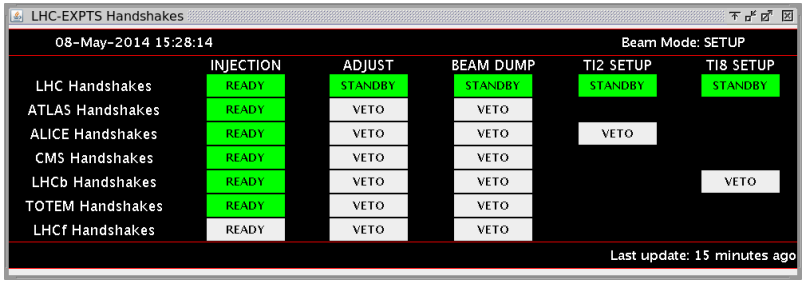
Proton and ions frequency settings for 6.5 TeV ramp

- Frequency is properly received by the experiments
- Resynchronisation of beam control successful.

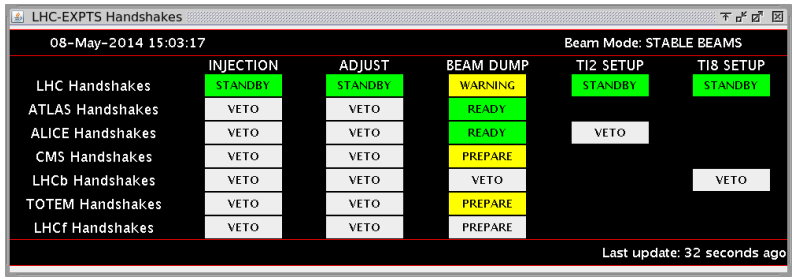


Handshakes and beam modes

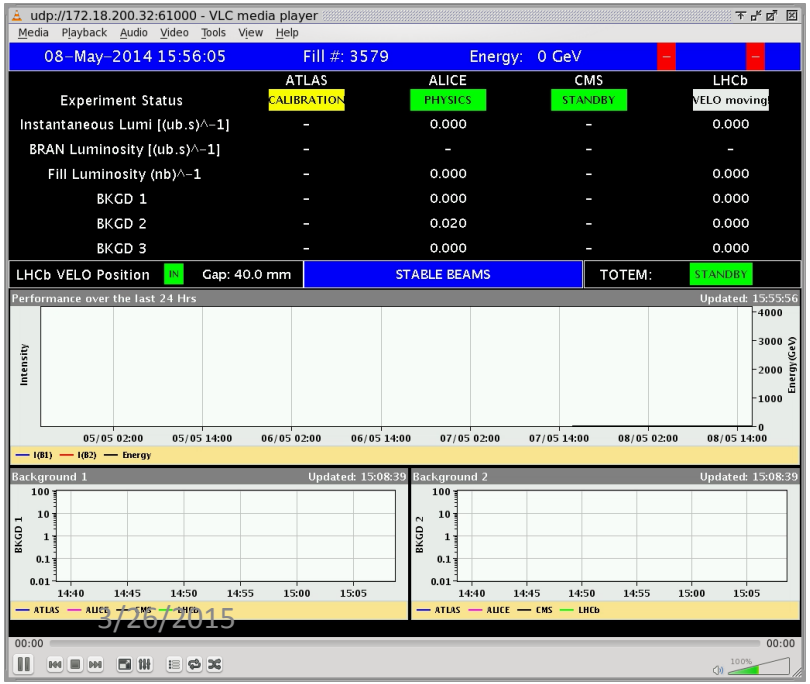
- Sequence prepared to mimic the consecutive handshakes and beam mode changes of the nominal sequence.



Injection handshake



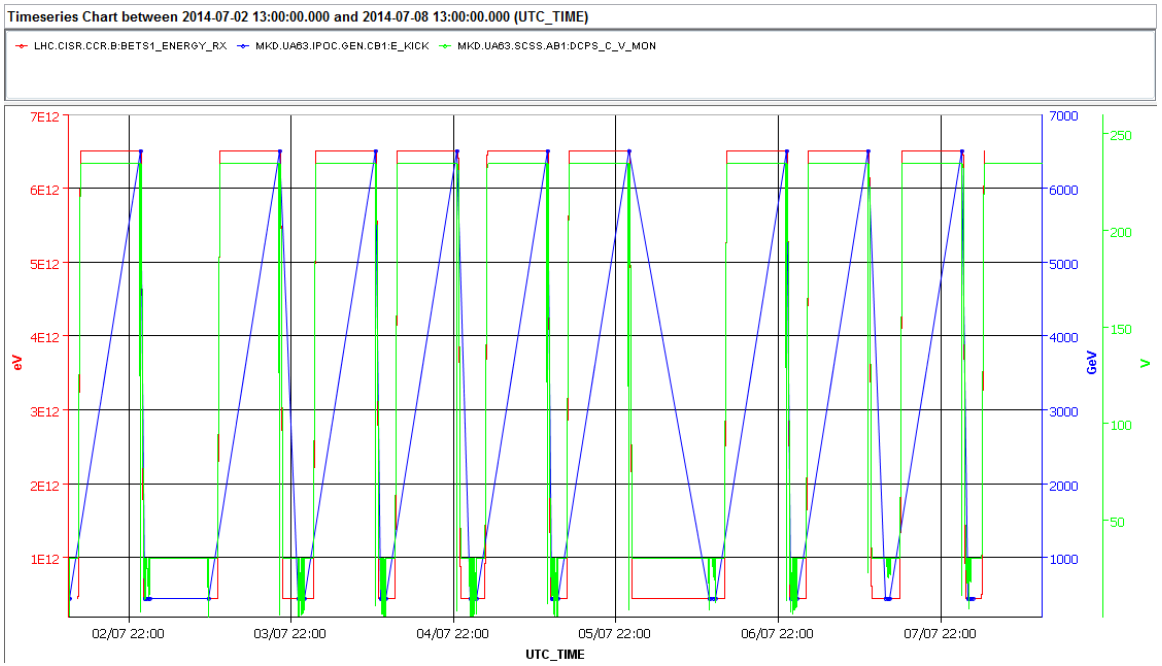
Beam dump handshake

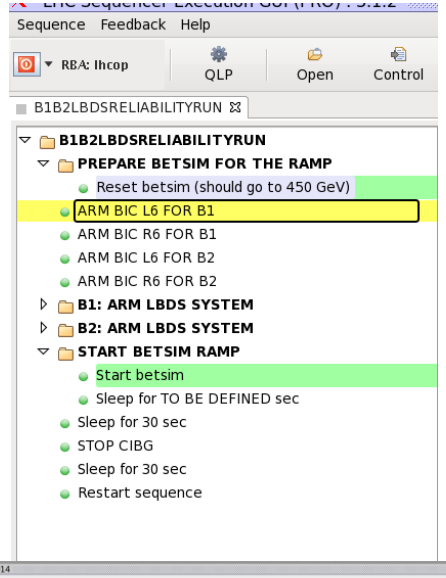


STABLE BEAM mode
LHCb velo moving

Beam dump reliability run

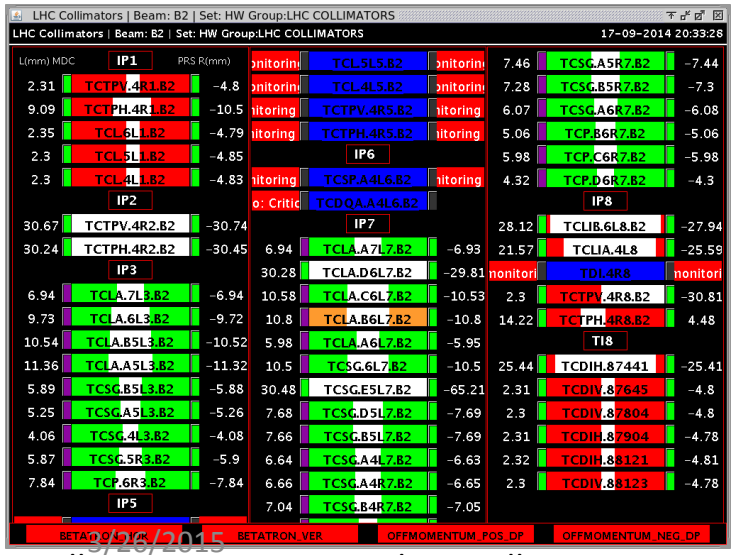
- Reliability run:
  - Sequence to arm/ ramp/ dump is played in loop for several weeks.



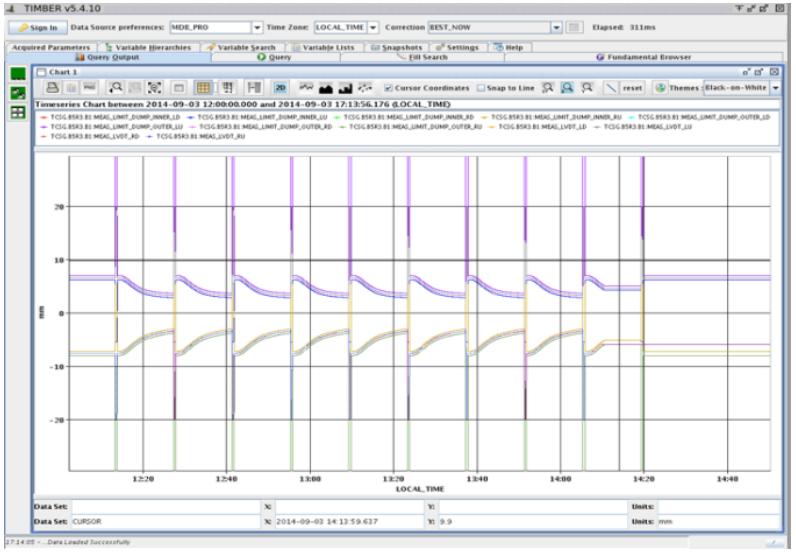


Collimators

- Tests of operational functionalities with available collimators
  - Settings generation for 6.5TeV, including new collimators
  - Loading functions for positions and thresholds, reset faults, disarm, start ramp with timing event
  - Logging functionality
  - New BPM collimators
  - Sequences and tasks



Collimator vistar. IR3 and IR7 collimators armed



TCSG.B5R3.B1 jaw positions and threshold of as logged in timber during reliability test.

Continuous Interlock systems tests

- All BIS input will have to be tested one by one
  - Almost 200 BIS inputs : PIC, FMCM, vacuum, collimators, experimental magnets, BPMs, SIS…
  - Tests organised following the readiness of the systems
  - Vacuum interlock preliminary tests foreseen end of September
  - Huge and systematic work, that is essential to ensure the machine protection before beam can be injected.

- Software Interlock system :
  less critical but nevertheless essential, every inputs logic need to be checked as well.

Intermediate Milestones

- Transfer line tests November 2014
  - LHC mastership and beam request mechanism
  - RF synchro and rephasing
  - Transfer line trajectory, kick response, stability
  - Transfer line collimator alignment test
  - Inject and dump mechanism, LHC injection kickers
- Sector test 7/8 March
  - A lot of systems could be tested : instrumentation, timing, beam dump, injection settings etc…
  - Some issues discovered : wrong magnet polarity, MKI injection permit, vacuum valves not in the interlock chain, some software interlock not operational etc…
  - Very useful exercise: the issues can be solved while the hardware commissioning is ongoing ⇨ gain of time for beam commissioning

Final machine checkout

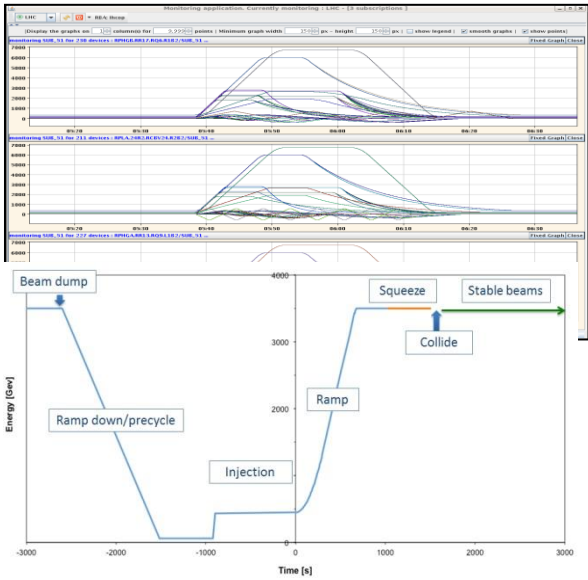
- Pre -conditions
  - Machine closed, access system ready for beam.
  - All systems are operational, mainly
    - All magnet circuits
    - PIC and QPS
    - Beam vacuum system
    - BIS

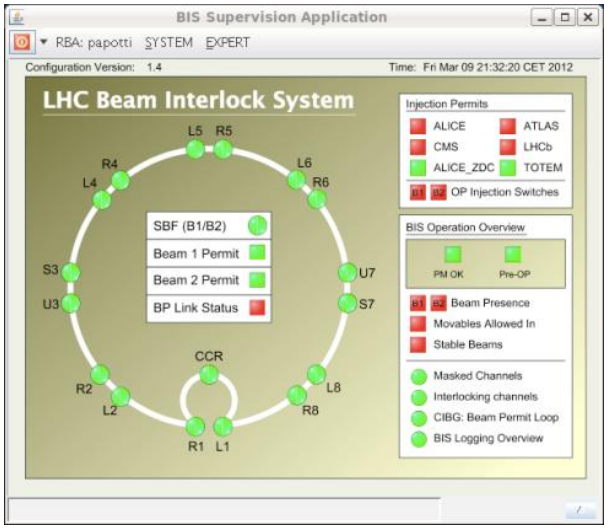
This we will have only a few days before first beam!

- Organization
  - Coordinated by Rossano Giachino and Markus Albert
  - Daily meeting in CCC to organize access needs and adjust the test plan for the day
  - Operation's team on shift day/night/week-ends

Final machine checkout

- Full integration tests : first opportunity to run the entire LHC systems together and run the tests that require the machine to be fully closed. i.e :
  - Heat run of warm magnets (already tested and polarity checked)
  - Test of complete LHC cycle (pre-cycle, injection, ramp up/down) with all the operational magnets
  - Complete the machine protection tests (all BIS inputs)
  - Close beam permit loop with all BIS inputs connected
  - Final LBDS checks : energy tracking tests under real configuration
  - Final MKI tests with full operational conditions





LHC ready for beam!

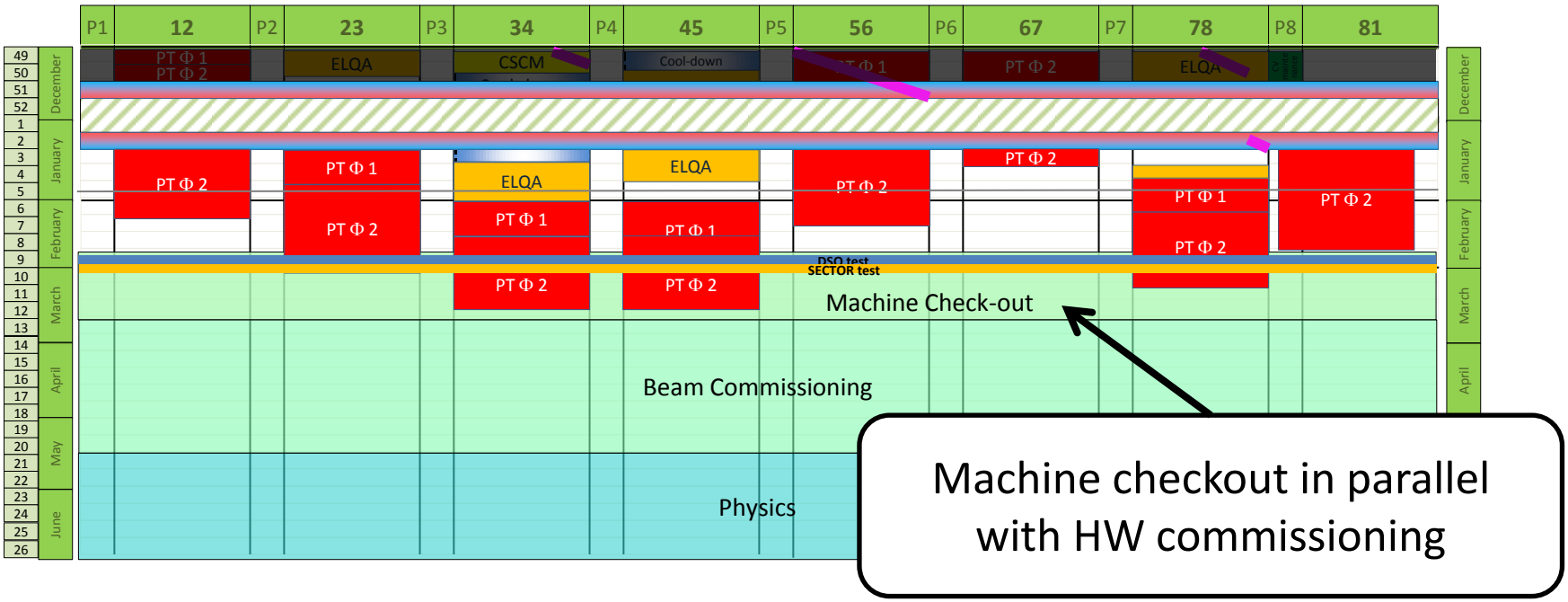
What could be improved

- We have one team for dry runs (mainly Reyes) and another one for machine check out (Rossano and Markus), with overlapping responsibilities : confusing for the equipment groups, not the most efficient
  - We should have only one team for system tests, in which the responsibility are well defined.
- Good follow up by OP of the new implementation of the systems
  - We should reorganize to involve more OP members
- We have to be careful not to overdo it : respect the equipment team priorities.
- A lot of access are needed until last moment: difficult to reduce them or concentrate them to improve the commissioning efficiency.

Conclusion

- Aside individual system tests, the LHC operations team organises various tests from the CCC with the equipment experts and experiments.
- Aim is to tests systems as early as possible to anticipate on software bugs, hardware issues etc…
- Transfer line tests and sectors tests have been very useful to anticipate on issues that would have been discovered only during beam commissioning
- Tight collaboration between OP and the equipment specialists for the organisation and follow-up of tests is essential.
- The last checkout test period is done with full operational condition and machine closed : this dedicated period shrinks as circuit commissioning is late.

V4.1H – Jan. 2015



Courtesy Marzia Bernardini