Evian 2014 - summary

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Abstract

A terse summary of the workshop is presented in which an attempt is made to highlight issues with direct bearing on post LS1 operation. A preliminary attempt is made to estimate the potential post LS1 performance, outline the commissioning strategy and the potential limitations for Run 2.

INTRODUCTION

The 3 day workshop attempted a survey of the following areas with the emphasis very much on identifying issues pertinent to operations in the post LS1 era. The sessions covered:

- Operations in 2015
- Systems: status and commissioning plans
- Machine Protection
- Availability
- Planning and preparation for 2015

OPERATIONS

Experiments' requirements

Broadly, the experiments clearly recognize 2015 as a commissioning year and an investment for the future. 25 ns bunch spacing is very strongly favoured (even at expense of luminosity in 2015), however they will accept up to 1 fb^{-1} at 50 ns during the ramp-up phase. They request the target energy by the end of summer 2014. 6.5 TeV is the clearly stated target and also the maximum value to be considered for 2015, however this will only be confirmed at end of the powering tests. A peak mean pile-up of around 50 is considered to be acceptable for the high luminosity experiments.

With 25 ns ALICE will required offset levelling. This will require relatively large beam separation and as a halo probe it is a potentially interesting exercise.

Actions identified were:

- Intermediate energy proton-proton reference run is still to be scheduled
- The 2015 special run schedule needs to be established with prioritization as necessary.
- The early scheduling of the LHCf/VdM run needs to be confirmed.

Beam in the injectors

The principle goals for the injectors for the LHC are:

- 25 and 50 ns standard and BCMS beams
- Doublet beam for LHC (and SPS) scrubbing. Here reaching the target intensity (1.6e11 p/doublet) will be challenging.
- 8b+4e beam as low e-cloud option

The foreseen 25 ns performance is summarized in table 1.

Table 1: Foreseen 25 ns beams to be delivered at exit SPS in 2015

Scheme	ppb 10^{11}	emittance exit SPS [μm]
Standard	1.3	2.4
BCMS	1.3	1.3
Design	1.15	3.5

As regards the number of collisions for the various possibilities:

- BCMS with 5 injections from the PS to SPS gives an injection scheme of 25ns_2508b_2496_2108_2204_240bpi12inj
- BCMS with 6 injections from PS to SPS give 2592 colliding pairs in IPs 1 and 5
- For the nominal 25 ns scheme on has 2736 colliding pairs in IPs 1 and 5

As regards private bunches, all 25 ns schemes have 12 initial bunches that do not collide in 1 and 5.

Collimation and β^*

As was well established in Run 1, collimation influences the key operational parameters. In protecting the aperture limits of the machine, collimation hierarchy determines minimum protected aperture and thus sets the limit for β^*. The collimation system's effective cleaning efficiency, together with beam lifetime, sets the limit for the maximum intensity.

For Run 2, many things have changed. We will need to start carefully and push performance later. There was a clear consensus at the workshop to adopt a relaxed approach initially and then step up later in 2015 (as, indeed, we did in 2011). The thinking at Evian was along the lines of:

- Start-up with β^*=65 cm with a crossing angle of 160 microrad. This was based on the assumption of : 2012 collimator settings in mm; 2012 aperture; 2012 orbit stability; 11 sigma long range separation; and standard 25 ns beam sizes.

- During commissioning thoroughly check the stability, aperture etc.
- An even more conservative β^* of around 80 cm was suggested. The acceptable margins for initial β^{**} (aperture, orbit, optics) was subsequently revisited in the LMC and this initial value of β^* was accepted. The around 2 σ additional margin can be utilized in a number of ways: increased crossing angle, enjoying a high minimum aperture; retracting the TCTs reducing the risk of hitting them during an asynchronous dump; retracting the collimators and possibly reducing the two beam effects in the squeeze.
- The ultimate β^* in 2015 was established to be 40 cm. Clearly experience previously in the run will determine the final value.

β^* levelling, collide and squeeze

In 2012 we saw beam instabilities towards, and after, the end of the squeeze. One way of avoiding these would be to perform the squeeze in IPs 1 and 5 with colliding beams, the so-called "collide and squeeze". This is non-trivial because one must guarantee that beams stay in collisions during the process. A robust operational solution will require some effort, testing and commissioning. To complicate start-up with the commissioning of such a scheme would appear not to be such a good idea.

However the more limited scheme of β^* levelling in LHCb looked good to go and seemed appropriate as a first test of principle. Investigation of the need for validation at intermediate optic points is required. (Subsequent analysis showed a, perhaps, prohibitive commissioning time for the collection of optics involved.)

Optics and run configuration

A number of options are ruled out for initial commissioning. These include so-called flat beams; combined ramp and squeeze; tilting of LHCb's crossing angle. The choice of optics is between:

- nominal optics as used in 2012;
- a modified version of this with adjustments in IR4 to optimize the beam sizes for instrumentation;
- an ATS compatible optics.

The decision was made shortly after Evian to have as the baseline the ATS compatible optics including: new collision optics in 1 and 5; new collision optics and squeeze sequence for IR2; new optics in IR4 (at WS, BSRT, BGI, ADT); and a new crossing scheme in IR8.

Subsequent validation reveal some potential issues. Loss map simulations showed some new loss spikes in the arc to the right of IP8. There is loss of protection margin because of the change in phase advance from beam 2's dump kickers to IP5s tertiary collimators. Given this, it was felt prudent to stick with the nominal optics for re-commissioning, and investigate further ATS in MD and perhaps change during a year end stop.

Table 2: Machine parameters at start-up

Parameter	Value
Maximum energy	6.5 TeV
Target bunch spacing	25 ns (but via 50 ns)
Injection tunes	0.28/0.31 – as in 2012
Injection beta*	11,10,11,10 – as in 2012
Optics	nominal with modifications in 4 and 8
Initial β^*	80 cm
Beating	at least as good as 2012
Chromaticity	high – around 15
Ocutpoles	negative detuning
Initial bunch length	1.25 ns

Stability limits

All 25 ns beams should be stable with a negative octupole polarity in the two foreseen collimator scenarios (2012 mm kept and 2 sigma retraction), although the BCMS is only marginally stable in the pushed scenario (2 sigma retraction).

The long-range beam-beam contribution to stability in squeeze and the dependence on octupole polarity was considered. From long-range beam-beam perspective there is a "clear preference for positive polarity". However, the consensus at the workshop was to start-up with negative octupole polarity and high Q (this combination has not yet been tried operationally). It was also recommended to step back in β^* to avoid the most serious long-range beam-beam regime.

Measurements are required during commissioning to establish the single beam instability limits as function of Q', ADT gain and octupole polarity. LRBB measurements of the limits of instability and thresholds as a function of chromaticity and damper gain is essential in 2015. Meaningful LRBB measurements will only be feasible during the intensity ramp-up at the earliest.

Emittance blow-up

There has been some advance in understanding the issues, with important input from optics measurements in the ramp. Looking to 2015, it is essential to perform optics measurements with AC dipole and k-modulation, and ensure calibration of all transverse profile monitors at the start of Run 2. Comparison of wire scanner, luminosity and SMOG during Van der Meer scans should be performed at the beginning of Run 2.

Baseline machine parameters

Bunch length

An interesting strategy was presented to reduce bunch length in Stable Beams. An increase in voltage to 16 MV during physics would reduce bunch length by around 20%

from 1.25 ns (2.0 eVs) to 1.0 ns. The instantaneous luminosity increases by 15% in theory. Any reduction of the blow-up target must be done in small steps and with careful monitoring of heating and transverse stability. Subsequent discussion shows the reduction in luminous length seems to be OK with the experiments although LHCb still have reservations.

SYSTEMS

Detailed system talks were presented by the following proponents.

- RF (Philippe Baudrenghien)
- ADT (Daniel Valuch)
- Collimation (Gianluca Valentino)
- Injection (Wolfgang Bartmann)
- Beam Dump System(Nicolas Magnin)
- Cryogenics (Krzysztof Brodzinski)
- Vacuum (Giuseppe Bregliozzi)
- Beam instrumentation and feedbacks (Georges Trad, Thibaut Lefevre, Enrico Bravin)
- Machine protection backbone and QPS (Ivan Romera Ramirez)
- BLMs and thresholds (Mariusz Sapinski)

Major modifications across the board have taken place during LS1. These have addressed: reliability, availability, performance, operations and protection. These modifications translate into a huge amount of changes and upgrades to: hardware all systems; software at all levels; controls at all levels; additional interlocks (hardware and software).

The ensemble represents an impressive range of:

- Maintenance & consolidation & repairs;
- Improvements based on creative thinking and experience;
- Deployed technology: processing speed; noise reduction; temperature control;
- Improved diagnostics: resolution, stability;
- Data, data transfer rates, analysis tools;
- Improved functionality;
- Better fault tracking;
- Enhanced safety.

Theres a lot to be re-commissioned without and with beam. This is going to take some time. The importance of hardware commissioning, dry runs, reliability runs, machine checkout, re-qualification, with and without beam, can not be understated. A full summary would not be useful here, some key points are highlighted.

Transfer and injection

There have been important upgrades to the injection system during LS1. These include: much needed consolidation of the TDI; and full renovation of the injection kickers (conductors, cleaning, NEG etc.). The consolidated TDI are not the final solution and upgraded TDIs (coating, gap measurements) are to be installed Christmas technical stop 2015 to 2016. On the SPS side there have been improvements to the stability of the MSE. The injection septa are now controlled with FGCs with improved interlocks and incorporation into BETS.

The BLM system team have installed “little ionization chambers” (LICs) in the injection region. Here the deployment strategy is to be defined with a important outstanding question being about the need for temporary blinding of the LICs during the injection process.

A number of issues were identified:

- Collimation: cant move scratched TCTs (5^{th} axis) because of integration issues
- ADT: new hw/sw/functionality - team stretched - to be phased with SPS efforts
- LBDS: asynchronous dumps – 1/year/beam to be established during the reliability runs
- LBDS: need post-asynchronous dump procedure
- Strategy for deployment of upgraded orbit feedback system to be established
- Tune feedback versus QPS MP3 – increase of thresholds fro the trim quadrupoles is expected
- SPS BCT to timing telegram would be appreciated by a long list of clients (RF, TFB, BSRT)
- Full current range of the MCOs is required for operations
- Interlocking of fast power aborts for CMS, LHCb and 60A correctors is to be implemented.

Machine protection

“Quite some changes and upgrades to the backbone of the machine protection system. This includes: circuits protection, access interlocks, QPS, 600 A detection thresholds, Safe Machine Parameters, re-triggering, user inputs, FMCM, and SIS. Full and thorough commissioning with and without beam is, of course, necessary.

A proposal for the set-up beam flag (SBF) settings at high energy was proposed.

1. Normal SBF: 1.1e10 for all users.
2. Restricted SBF: 1.25e11 in 2 bunches for special users
3. Relaxed SBF: 1.5e10 in 16 bunches for MDs.

Collimator commissioning would be with 2 nominal bunches at 6.5 TeV i.e. the restricted SBF.

A full list of matters arising from MP workshop in Annecy was presented. A list of high priority issues was enumerated. These issues are being followed up in the appropriate bodies. A detailed analysis of potential BLM performance at 6.5 TeV was given. BLMs are very well adjusted up to 4 TeV. They are not yet validated for for energies greater 4 TeV.

STRATEGY

The last two Evians have seen a baseline commissioning strategy evolve.

Table 3: Approximate breakdown of LHC's 2015 schedule.

Activity	Time assigned
Machine check-out etc.	14
Commissioning with beam	56
Machine development	19
Scrubbing run for 50 ns	9
Scrubbing run 2 for 25 ns	14
Proton physics 50 ns	7 + 21
Proton physics 25 ns phase 1	44
Proton physics 25 ns phase 2	46
Change in β^*	5
Special physics runs	5 + 7
Ion run set-up	4
Ion physics run	24
Technical stops	13
Technical stop recovery	6

- Low intensity commissioning of full cycle - 2 months
- First stable beams with a low number of bunches
- Special physics run early on for LHCf and Van der Meer scans
- Scrubbing for 50 ns (partially with 25 ns)
- Intensity ramp-up with 50 ns
- Commissioning continued in this phase: systems (instrumentation, RF, TFB etc.), injection, machine protection, instrumentation with high intensity. Characterize vacuum, heat load, electron cloud, losses, instabilities, UFOs, impedance.
- Scrubbing for 25 ns with 25 ns and the doublet beam
- 25 ns operation with a relaxed β^*
- Commission lower β^*
- 25 ns operation

It was noted that the intensity ramp-up took all year in 2010, 4 months in 2011, and 2 weeks in 2012. We will certainly be involved in a learning process again in 2015.

Potential performance

Assuming the above schedule and:

- Conservative beta* to start;
- Conservative bunch population;
- Reasonable emittance into collisions;
- Same machine availability as 2012;

the potential performance is shown in table 4.

CONCLUSIONS

The stated goal is 25 ns operation at 6.5 TeV. Concerted scrubbing program required. Despite this, electron cloud could remain an issue. LHC has been pulled apart and put back together plus major system upgrades. Serious testing without and with beam will be required to re-establish the appropriate level of machine protection.

Table 4: Post LS1 performance estimates for GPDs – usual warnings apply

scheme	Nb	ppb 10^{11}	b*	Emit [μm]	Peak lumi	mu	days	Int. lumi fb^{-1}
50 ns	1300	1.15	80	2.5	4.6e33	27	21	$\approx$1
25 ns 1	2496	1.15	80	2.5	7.4e34	22	44	$\approx$5
25 ns 2	2496	1.65	40	2.5	1.3e34	39	46	$\approx$9

A non-aggressive parameter choice/strategy has been proposed as a starting point. More aggressive exploitation could be pursued later in the year, as could a number of novel developments.

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