

LHC Commissioning Workshop Wrap Up

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There is a lot to do!

... and summarizing it all is not easy

Just pull a series of points out for discussion rather than try to exhaustively go through all the presentations and all the issues.

... Light on Details ... these will be pulled out of the talks by the commissioning team.

Probably quite a bit of Motherhood and Apple pie

Overview

In the 4 weeks before before Christmas we were trying to explore the ground and make as rapid progress as possible to get beams in, up and into Physics

.... And this worked very well!

We are now embarking on a (hopefully) sustained period of operation during several months.

We need to prepare the machine with this in mind A Cunning Plan

Every significant change to the machine parameters/setup will require a re-qualification of the machine protection/collimation.

... Need to ORDER things correctly to avoid needless re-cycles of re-qualification (will still need to do it as we go to higher intensities and numbers of bunches)

Overview II

Problems/Issues/Tuning/Optimization

- Can be broadly split into 3 classes

- Things that must be sorted out early in the commissioning since they impact on our basic settings
 - β -beat, separation etc.
- Things that will need to be revisited regularly as we push the number of bunches and intensity per bunch
 - MP checks and qualification, RF, injection schemes ...
- Things that can be slotted in as and when circumstances, or needs arise
 - Injection matching, TFB, long emittance blow-up, sequence optimization ...

450 GeV

Set the machine up as we would like to operate it:

Get the beams separated!

- Injection setup with Separated beams
- Clean correction of separation bump effects

Sort out the Beta Beating

- Sources!
- IT in IR2 ? Warm quads?

Working point

- Track down the tune jitter
- The 8kHz line
- The Tune Bump.

Longitudinal Emittance

- At lower intensities the longitudinal emittance is very small ($\sim 0.3 \text{ eV.s}$)
 - Could this be causing problems already at injection?
 - Will go up as the intensity increases (but clearly will cause problems if it is preserved as we increase the energy)
 - Is it worth trying to blow up the beam in the SPS to around 0.7-0.8 eV.s?

Experiments

- Understand the compensation calibration and set-up to allow change of polarity without major upheaval.

Injection

Over Injection

- Triggers the BLM -> Beam dump.
- Different behavior in IP2 and IP8 (works in IP2 – losses seen on IT BLM x2 lower)
- Understanding? A visit to the machine called for.
- In any case we need to over-inject – so we need a solution
 - Shielding (needs Simulation) and intervention
 - Increase Thresholds for fast losses
 - Add Capacitors

Same Thing?

Initially Stick with Single bunch Injection

- But multi-bunch injection will be needed if we want to go beyond 16 bunches per beam – should not be a major problem, but needs preparation.

Presently rather long-winded to fill the machine

- Experimental Handshakes ...
- Passage from Pilot to 'normal' bunches
- Each injection generally takes more than 1 SPS supercycle ... even though the SC is rather long.
- Tighten up the sequences and procedures to move towards more routine injection

Beta Beating

Important to get this corrected early

- Otherwise we have to re-visit MP and other optimization afterwards.
- Eats into our aperture ($1-1.5\sigma$)

Beta Beating actually not bad! But some distinct sources seem to be present

Important to understand the sources and not just stuff large corrections into the machine

IR3 and IR7

- Q6 not pre-cycled ... should be
- Can largely correct β -beat with 3% change in warm quads – Very large change!!
 - Should investigate how this could happen on the Hw level
 - ... Long Position, Magnetic errors, PC DCCT calibration? Check These NOW.

IR2 & IR8

- 50 units on Q2 (IR2) – rather large
- Is it reasonable to just tweak individual IT quads? Understanding needed

Thinking Time will be needed to iterate

- Get started early!

Working Point

Injection working point was designed for separated beams

Should be better when the beams are separated

Except for the other 'tune' features observed

- **Tune Jitter**
 - $\sim 5 \times 10^{-4}$ at 450 GeV. Energy Dependent **'white noise' - blame the PC's??**
 - Main Quads were cited as a possible source – but I seem to remember the warm quads were identified as a possible source (and we need to check them anyway for β -beat)
- **8kHz line**
 - Seem to understand that this comes from the UPS – but not all ways in which this feeds onto the beam have been identified.
- **Tune 'Hump' rapid excitation**
 - Source still not identified!

If the above are not solved is the present working point OK for injection?

- What about the collision tunes to avoid the jump later? Problems??
- Again, decide reasonably early to the machine can be optimized to this WP.

Ramp

Cycle and Ramp to 6kA – dynamic effects will be larger

New calculation of the snapback – looks like it will mop-up better what we observed

Decay on Injection Plateau not taken into account yet? Not a problem if we start having shorter periods sitting around at injection level.

Q-FB and Orbit-FB mandatory for the ramp.

- **But I would still advocate feed-forward to reduce the amount of work the RB has to do.**
- **Remember to clear the RT channel on all elements before the next fill !!**

Tune drift during the ramp

- **Can be mopped up by the FB/FF but do we need to understand better**
- **Will be interesting to see if it continues in the same direction at higher energies.**
- **Some part of it might come from the error(s) causing the β -beat (if confirmed)**

Q' Change during the ramp – hopefully mopped up by change in snapback model.

Longitudinal Emittance

- **Do we need to worry about the (small) Longitudinal Emittance (0.3-0.8 eV.s)**
- **Commission the controlled Blow-up? Maybe once we really see the need ...**

Squeeze

Once again FB are mandatory

Tune jump before starting the squeeze – if we need it, is it a good idea to do it so slowly?

Should rapidly go towards squeezing IP1 and IP5 at the same time

- **How quickly should we try to squeeze all IPs at once?**
- **How quickly should we squeeze to small(-ish) betas?**
 - **Perhaps establish machine reasonable quickly at around 5m beta**
 - **Leave squeezing further to later**
 - **Decide if we should optimize at 2m (OK for ≤ 156 bunches) but not for trains.**
 - **Is it worth going below 3m – depends on the time we plan to spend with equidistant bunches.**

Collisions

No more 'Quiet' Beams !! Presumably no more collisions at 450GeV.

Progress in number of bunches

- Start with 1x1/4x4 of course.
- Do we want to do much with 16x16?
- As fast as possible go to 43x43 bunches – balance between the experiments
- Step to 156x156 should be relatively minor (apart from 4x the number of bunches)

How long should we run with equidistant bunches?

- Werner prefers to go to 50ns trains asap.
- .. not so sure! Still requires x2 intensity to get to the same luminosity
- Would it not be better to push towards nominal bunch intensity on 156 first?

How early should we bring the crossing angle on even if we don't need it?

- I think I agree that it is a good idea to get the crossing angle on reasonably early
- Since it implies revisiting many parts of the machine ...

Other Stuff

Roles and Sequencer - Management Follow-up?

Need Better working point for the RF

- More economic on Power
- Less stress on the Klystrons

Injection matching and the Synchrotron Light Monitor

- OTR use non-Rad hard Camera – Rather cumbersome to use
- Sync Light looks much more promising ... Would be nice to get this going
- Get the 2nd Undulator working !!!
- I think this monitor will be very valuable for understanding the machine.
- Abort gap monitoring – work in progress.

MCBX

- Any hope to use these at a faster rate?
- Can share out the strength between the 3 MCBX – tools and better ways to do this?

Lead Ions

- Don't forget we have to do ions later in the year – injection did not look very clean for them (beam quality?). Might need some studies at injection during Proton operation – are we capable of doing this??

Summary

A huge number of details came out in the talks over the 2 days

Thanks to all the Speakers and Participants

Only a fraction dealt with here

- The rest must be followed up by appropriate bodies -
 - MPWG, LCWG and pulled together in the LMC.
- And fed into the cunning plan.

The cunning plan reflects the idea of setting up the machine for several months of operation

- Should be more rigorous in following it?

As we move out of the safe beam regime

- Make sure we know the envelope for operation already established
- Clearly identify the conditions needed to go outside this envelope

Time spent early in the commissioning to get things right will pay off later and usually is the quickest way to get good operating conditions