LHC Beam Operation Committee

Notes from the meeting held on 10th May 2011

1. Alice polarity flip – J. Jowett (slides) and W. Herr (slides)

The agenda had W. Herr on the ALICE polarity flip but J. Jowett prepared a presentation on the same subject. It was agreed John presents the possibilities for the polarity flip while Werner will comment if it will be needed.

J. Jowett explained that to reverse the spectrometer polarity it is necessary to reverse the external angle and this means that a full set-up of the TCTs, orbit reference, interlocks etc in IR2 is also needed over the full cycle (injection, ramp, squeeze and collision).
A possible alternative solution proposed by Joerg consists in reverting the polarity of the ALICE spectrometer without inverting the polarity of the external crossing angle. This would be done at the end of the ramp before going in collision. The separation at the end of the ramp is sufficient to guarantee a 10 sigma separation for parasitic encounters. This has not been verified during the ramp. During the inversion of the external angle at the end of the ramp the minimum separation for parasitic encounters will decrease to 4-5 sigmas which is not sufficient.
Conclusion: the ALICE spectrometer polarity reversal will imply setting-up the full protection system.
W. Herr proposed another option which consists in adding on top of the crossing angle a vertical parallel bump. Werner said that a first look at this option doesn't show any negative point then if it is commissioned and works then it could be used anytime without the need of a full set-up any time ALICE asks for a flip of the spectrometer but we will need to match two bumps.
Comments:
M. Ferro-Luzzi mentioned that if what Werner suggested is a long term solution then it is worth going for it because ALICE would like to flip polarity of the spectrometer at every technical stop. **It is proposed to postpone the ALICE polarity reversal to a later date until the alternative options are fully investigated.**

2. Trasverse Coupled Bunch Instabilities– E. Metral (slides)

Elias presented the past and present knowledge on Transverse Coupled Bunch Instabilities (TCBIs) for the LHC.
In the past it was believed that TCBI was one of the most critical instabilities, which could have limited the intensities of the nominal LHC beams without the action of a transverse damper. Elias summarized the main modes expected to appear from predictions and the different impacts/cures to apply during the operational stages of injection and top energy.

Past calculations of the instabilities rise time showed the need for a transverse feedback to damp instabilities with rise times of 20-40 turns. This damping time ensures to cover the different instabilities rise times of the different modes and at all operational stages.

The main cure to the TCBI is to use a transverse feedback at injection and top energy.

All previous evaluations are based on nominal beam parameters while it is clear that with the LHC achievable reduced transverse emittances all the stability areas are reduced due to a reduced tail population and also with all Landau octupoles at full power will not be enough to stabilize TCBI since the excited modes lay outside the stability area, in this case it is needed to reduce the single bunch intensity.

The effect of chromaticity is also shown. The chromaticity must be kept positive and low values (between 0 and 2) in order to stabilize the various modes.

Another option to enlarge the stability area is to populate the bunch tails more than in the case of a normal Gaussian distribution in order to enhance Landau Damping to damp the modes for coupled bunch instabilities.

Recent studies have allowed the possibility to simulate and reproduce the operational cases of non-equally spaced bunches and bunch trains structures. By using numerical tools it is now possible to estimate TCBI characteristics for these more realistic scenarios. N. Mounet's first estimates show that the rise time of TCBIs stays almost constant over a wide range of frequencies from few MHz up to several kHz at top energy. The same situation occurs at injection energy. This explains the need for a transverse damper with optimized gains constant over the full frequency range.

Recent results from Nicolas predict instabilities rise times for TCBI for the present LHC beam filling schemes and results are here summarized:

- Top-energy 1 train 36 bunches at 50 ns show rise time of (0.9 , 1-1.4) s in horizontal and vertical respectively. For a fully filled machine with 1782 bunches with 50 ns spacing one should expect a reduction of the instability rise times to (0.4, 0.6) s in horizontal and vertical, respectively.
- Injection energy: one train of 36 bunches show rise times of (0.15, 0.25) s which also depends on the bunch position in the train. While for a fully filled machine with 1782 bunches with 50 ns spacing the expected rise time is around (0.06, 0.07) s with tune shoft of the order of 6 10-4. Differently from top-energy case at injection there is also a dependency on the bunch location along the train.

Elias expressed some recommendations to keep TCBI under control:

1. Chromaticity should be kept small as possible to move the Head-tail mode 1 and higher order modes inside the stable area for both injection and 3.5 TeV case.
2. Transverse damper should provide almost constant gain over a large frequency range (10MHz up - 10 kHz)

3. In case one can still enhance Landau damping by use of octupoles with very low current when the reduction of chromaticity has reached the lower limit. The impact on the dynamic aperture must be evaluated for that.

Comments:

Concerning the Landau damping of more populated tails: W. Hoefle asked if by depopulating the core and populating the tails one can damp more using the LD mechanism. E. Shaposhnikova stressed that even if LD occurs, which is proved and known, with populated tails it is still a non-controllable mechanism and one cannot rely on this to stabilize the beams.

Concerning the octupoles on to stabilize: W. Hoefle mentioned that if one uses the octupoles to LD the instabilities this translates in larger spread and therefore larger noise for the transverse damper. Moreover the gain needed to cover the frequency range requested by Elias is very narrow if we look at the stability diagrams. E. Shaposhnikova said one couldn't rely on the calculations used for the stability diagrams because they are based on single bunch with space charge but there is no theory for multibunchs beams.

Gianluigi rised the doubt about what happens during the ramp especially at the beginning since chromaticity varies rapidly and the damper gains are reduced while no evident sign of instability was observed when we start the ramp.

3. Start-up after technical stop – how do we proceed with the intensity ramp up?– G. Arduini (slides)

Gianluigi presented the main points to be addressed in terms of beam types (bunches per injection) and things to be commissioned/addressed before going for physics and the plan to proceed after the technical stop.

Before the stop we had 3 fills with 768 bunches per beam for a total of 8 hours of physics. We need now to have a couple of good physics fills of approximately 12 hours at the same number of bunches per beam to deliver physics and reproduce operational scenario as before the technical stop then:

- Injection of 912 bunches per beam will require injections of trains of 108 bunches which was tried only once during the scrubbing run.
- Injection of 1056/1200/1380 bunches per beam will require injections of trains of 144 bunches.

The list of things to be done includes:

1. Machine recovery after technical stop
2. ALICE polarity reversal
3. Van der Meer scans
4. TOTEM/ALPHA beam based alignment
5. Set-up of the damper with optimized gain for higher frequencies

A plan of week 20 and 21 has been presented with possible time scales to address the steps in intensities with the long list of things to commission/set-up for future operation.

Comments:

Jorg mentioned **loss maps at injection need to be repeated as part of the regular verification of the collimation system**. S. Redaelli is not available at CERN and no answer so far from collimation team about the presence of any experienced person able to set-up the collimation system during the week-end in case of ALICE polarity reversal. . Also M. Ferro-Luzzi expressed the need to have the **TOTEM/ALPHA beam based alignment before the Van der Meer scans**: he will check with Stefano if he can be available. J. Uythoven added that the **positions of the TCDIs** should be verified since they have seen injection oscillations which couldn't be totally corrected. M. Lamont asked when we will try a double batch injection from the SPS and Gianluigi said we will try to go double batch 50 ns beams after having 1380 bunches per beam in the machine and starting from bunch intensities and emittances comparable to those achieved so far with 50 ns beams obtained with single batch injection in the PS

Concerning the set-up of the damper: W. Hoefle expressed the need of one fill with 768 bunches to compare blow up at flat-bottom and compare luminosity to situation before technical stop before applying any change on damper settings. Then one should apply changes on damper gains and check differences if any in beam parameters and if instabilities will occur. Even if he is not at CERN for the next week D. Valuch can set-up the damper gains. W. Hoefle also mentioned that the abort gap cleaning post mortem data is now available they will need to test the post-mortem event damping with many bunches which will come for free during the next weeks.

Concerning the beams: M. Ferro-Luzzi suggested to start with a small number of bunches with 50 ns spacing to verify the status of the machine then go for 768 bunches per beam. J. Uythoven mentioned they would prefer to have at least 5 fills with 108 bunches per beam to gain experience before move to the 144 bunches per train. Gianluigi remind that at least 2-3 fills at 450 GeV will be foreseen for both cases (108 and 144 bunches/train) to check heat-load, vacuum and RF before preparing for a fill for physics.

Concerning frequency ramp and acceleration rates for RF trims: RF will make the acceleration rate a factor 10 slower. This will not affect the real time trims. **Action: A. Butterworth**.

Concerning RF monitoring: Philippe asked for a test of the effect of a klystron trip for increasing beam intensities since due to the recent high reliability of the klystrons none have been observed so far and it is important to keep track of it while increasing the beam intensities. It will be done at the end of the first fills.

4. <u>AOB</u>