LHC Beam Operation Committee

Notes from the meeting held on 18th September 2012

Participants

1. TS#3-2102 Activities – K. Foraz (slides)

K. Foraz reminded that the detailed schedule of the TS#3 interventions is available on line. Usual maintenance and consolidation works are ongoing and the machine should be ready for operation on Friday late afternoon (last patrol will start in point 5 at 5 p.m.). Powering tests and x-rays are foreseen in different sectors; RQ7.R4 and RQX.L8 tests will be performed if cryo conditions will be back on Thursday night. Modifications in the energy extraction have been implemented in sector 34. The new system has to be validated and eventually implemented in all the remaining sectors; this would require about 2 hours of powering tests on Friday.
The main activities of the TS are: the consolidation of the BSRT in point 4 and the exchange of one MKI in point 8.
An RP survey was done and high activation was found in point 7: some interventions have been postponed to the Christmas stop. High activation was also measured at the inner triplets in IP1, IP5 and IP8. The foreseen activities could be performed providing the required documentation for works in a supervised area.

Discussion:

G. Arduini asked if, due to the RP issue, it will still be possible to perform the x-rays in point 7.
K. Foraz confirmed that the x-rays will be done with RP supervision.

G. Arduini asked if point 2 and point 8 will be closed on Thursday night. This would allow carrying out extraction tests for Q20 optics. Cryo conditions do not need to be back since the beams will be dumped at the TEDs.
K.Foraz answered that this depends on the MKI status.
G. Arduini added that the radiation piquet will be needed to take out the radiation veto.

2. Luminosity-calibration systematics from Non-Linear x-y Correlations in the 3-d L Distribution - W. Kozanecki (slides)

W. Kozanecki explained that the Van der Meer (vdM) scan calibration allowed reaching, in 2011, an unprecedented precision in Luminosity measurements in a Hadron collider. Nevertheless, the scans which were performed in 2012 brought in evidence some issues. The scans relay on the assumption that the Luminosity can be expressed as the factorization of independent x and y terms (x-y factorization). This is a key feature since it implies that the scan in one plane (i.e. x) does not depend on the separation in the orthogonal plane (i.e. y) and thus one scan is sufficient to fully characterize the transverse distribution in Luminosity. The contribution from linear coupling is negligible (0.1%).

W. Kozanecki clarified that the transverse beam size measured at the experiments depends on the size of both beams and gave the definition of the convolved beam size Σ_x (Σ_y), which is dominated by the largest beam, and the luminous size $\sigma_{x,L}$ ($\sigma_{y,L}$), which is dominated by the smallest beam (see table in slide 4). $\Sigma_{x,y}$ and $\sigma_{x,y,L}$ should not depend on the offset in the perpendicular plane to the scan. Measurements were done performing scans with centered and off-centered beams and different and not reproducible results were found. In ATLAS, an offset of 9% and 15% in Σ_x was recorded for two consecutive scans. A huge discrepancy, of up to 60%, was measured for $\sigma_{x,y,L}$ during vdM scans in July 2012. A similar behavior was observed also in CMS and LHCb (smaller effects because of smaller offsets) excluding an instrumental problem.
All these observations show a clear evidence of a non-linear x-y correlation; the consequent impact on the Luminosity calibrations performed at 7 TeV and 8 TeV has to be understood.
Data showing the evolution of the luminous centroid position as a function of the separation in the horizontal, vertical and longitudinal plane (performed in October 2010 and May 2011) were also analyzed and gave an evident indication of the presence of non-Gaussian tails. W. Kozanecki reminded that for strictly Gaussian beams, even if different in x and y size and even in case of linear coupling, the transverse luminous size does not depend on the beam separation during vdM scans. Simulations were done with Mathematica using a double Gaussian distribution (one with narrow tails and the other with wide tails; in this way the core of one beam probes the tails of the other beam) to try to reproduce the observed beam centroid displacement and $\sigma_{x,y,L}$ change. These studies allow a 3-d visualization of the Luminosity distribution . The model manages to reproduce the measurements with the centered beams reasonably well, but so far fails for the off-axis scans.
A complementary approach is being tried to estimate the calibration error introduced by the non-linear coupling. The fit of the vdM scan curves was done using an uncorrelated and a correlated double Gaussian model. The correlated model showed an acceptable agreement with the data of the scans performed in March 2011 and April 2012. Other coupled models should be considered for a better understanding, and in particular for estimating the systematic uncertainty associated with the assumed description of the non-linear x-y coupling.
W. Kozanecki concluded showing the todo list foreseen by ATLAS and asked inputs from the machine experts. Clear non-Gaussian tails, especially in the vertical plane, are visible in the beam profiles measured with the wire scanners (background noise not yet removed from the signal); the origin of these tails and possible solutions to make the beams more Gaussian should be investigated. Moreover, the beam conditions that could explain the x-y factorization violation observed in 2012 (beam-beam, bunch-by-bunch difference, beam from the injectors, octupoles, impedance, highly non-linear optics) have to be inspected.

Discussion

R. Tomas explained that the contribution of non-linear errors in the triplets has to be considered. He added that, during the aperture measurements, a larger deviation in coupling and tune than expected was measured.

S. White commented that collisions themselves enhance the non-linearities and that the separation between the two beams acts as skew quadrupoles introducing non-linear coupling.
W. Kozanecki agreed but remarked that the effect should have been the same for all bunches while a bunch-by-bunch difference was observed.
T. Pieloni commented that a difference in emittance and intensity between the bunches could explain this behavior.
W. Kozanecki answered that INDIV bunches, separated by 1 μs and with an intensity of 0.9E11 protons, were used during the scans; a 10%-20% difference in emittance between bunches could be estimated from measurements with the wire scanners.
G. Arduini asked if the measurements were done at flattop.
W. Kozanecki answered that the emittance was measured only at injection and at the end of the scan when the intensity was low.

T. Pieloni asked if the separation was calculated as an average between all bunches.
W. Kozanecki answered that separation was the same for all bunches (only different in terms of single beam sigma).

M. Lamont commented that tails can be generated by the octupoles and that the correlation between octupole current and tail width should be checked.
Also the collimator settings during the different scans should be considered.

B. Gorini mentioned that in some of the vdM scans there were non-colliding bunches and the difference between colliding and non colliding bunches should allow to confirm or exclude beam-beam as a source of this phenomenon

G. Arduini asked whether data have been taken with the SMOG detector in LHCb as this would allow to determine the x-y contours at differ amplitudes. **Action: W. Kozanecki will follow that up**.

Action: Provide the fill numbers corresponding to the vdM scans in 2011 and 2012 ➔ W. Kozanecki to provide them so that tey can be put in the minutes

Action: Recover all the beam (emittance, bunch intensity) and machine parameters (octupoles, crossing angles, collision patterns, etc.) for the different scans and identify possible correlation with beam-beam effects (T. Pieloni)

3. Beam Loss and Beam Shape at the LHC Collimators - F. Burkart (slides)

F. Burkart presented on measures of transverse particle distribution performed via full beam scraping with the primary collimators in 2011. He explained that the knowledge of the transverse particle distribution is important for operation, machine protection and design of new components (i.e. crab cavities). A high tail population translates in high-energy deposition in case of losses during normal cleaning or in case of beam instabilities. Two dedicated MDs plus some end of fill time were dedicated to full beam scraping with horizontal, vertical and skew primary collimators at 450 GeV and 3.5

TeV. Fast (jaw moved in one step into the beam) and slow (jaw moved in small steps into the beam) scrapings were performed and the correlation between jaw position and beam losses was established. The integrated loss rate as a function of the jaw position (in measured sigma units) was plotted; non-Gaussian tails and a different beam profile were measured in the three planes at injection.
End of fill measures at 3.5 TeV were carried out; the beam was dumped by the BLM but tail scans could be performed. A similar shape was found for the tails at 450 GeV and 3.5 TeV: a double-Gaussian with over-populated tails (3.6% of the beam beyond 4 σ !).
The presented results are used as input for different studies on Crab cavities, hollow e-lens and new MDs were dedicated to halo studies in 2012.

Discussion

C. Bracco asked how the σ at the primary was measured.
F. Burkart answered that the emittance measured with the wire scanners was used instead of the nominal emittance.

B. Salvachua Ferrando asked if the vertical primary collimator was moved out before performing the full beam scraping in the horizontal plane: the losses from the vertical collimator could in fact have an impact on the measured beam profile shape.
F. Burkart explained that the measurements were done at the end of a physics fill, and it was thus not possible to move the TCPV out due to the high intensity.

4. Next meeting

Tuesday, 25/09/2012: **LBOC meeting (15:30 in 874-1-011).**