LHC Beam Operation Committee

Notes from the meeting held on 3rd May 2011

1. Fidel test on 29.04.2011– M. Strzelczyk (slides)

Marek highlighted the models equations behind the Sextupolar dynamic decay during injection in the LHC referring to EDMS Document No. 908232. Then from the coefficients used in the empirical scaling laws used to describe the effect he explained which parameters are important in the Fidel model in practice.

There are 3 fitting parameters in the decay model that describe the multipolar decay following a double exponential equation. The three coefficients describing the decay are based on the measurements campaign done for the dipole magnets for a standard LHC cycle at the SM18 laboratory. The model contains six additional coefficients that are used to take into account differences in the powering history (flat-top time, flat-top current and preparation time at flat-bottom).

Tests of the Fidel feed-forward correction:

First test (27.04.2011): The tune was stable (already achieved before) while b3 compensation failed. The Fidel model coefficients did not match the present operation of the LHC (20 min at pre-injection plateau at 100A and ramp-rate of 10 A/m instead of 50 A/m).

Second test (29.04.2011): The coefficients were updated for a 6000 A flat-top, 1000 s steady state at flat-top and 1200 s at 100 A pre-injection plateau. The automatic Fidel trims for b3 and tune were applied every minute at injection. At injection the tune had a slight drift which still has to be understood, while chromaticity was stable within 1-2.5 unit after the precycle. Drift in chromaticity of 0.5 units over ½ hour were observed without the precycle. The snap-back was partially corrected but there is something happening during the first 2 minutes of the ramp, which is maybe not related to the snap-back effect. The following runs showed a stable chromaticity.

Future work: there is a need for a proper scaling of the Fidel model coefficients when the precycle is varied. Many powering history parameters are available in LSA to adjust the scaling manually. An automatic recognition of the powering history is under development for an automated update of the model parameters. A fixed display to track what the Fidel model is doing is highly desirable for OP. Since all results are based on a one single test, more data are needed to draw any further conclusion.

Comments: Ezio reminded that a 2 units drift of chromaticity is an extremely good result but from statistics one should expect fluctuations of 10 units. Jorg asked which is the effect of a zero preparation time spent at flat-bottom on chromaticity. Ezio said one should expect a change of 30% for the total decay - which is not negligible.

M. Lamont asked what does the parameter d describes in the model. Marek explained it is the expected amplitude of the b3 decay after 1000 seconds at injection, for an infinite time b3 reaches 0.5 units.
S. Redaelli asked what happens if for access reasons one has to stay at 100A for a long time. Ezio said that after a certain time the effect saturates, so it is not going to give a much larger effect.

2. Update on the Decay Correction– E. Todesco (slides)

Ezio showed the statistics of the chromaticity decay at injection observed in 2011 and 2010. He showed the horizontal and vertical chromaticity average and 2 σ deviation for 2011 measurements and compared them to the 2010 average. The expected fluctuations are ±10 units in horizontal and ±5 units of vertical chromaticity. Then he summarized the basis of the Fidel modeling of the decay of tune and chromaticity. The models are based on the equations defined by Bottura et al. that are still valid and confirmed. The problem of the coefficients stored in the Fidel DB is mainly due to the fact that these are based on obsolete cycling conditions that play an important role in the scaling laws: lower flat-top energy of 3.5 TeV instead of 7 TeV and especially a lower ramp-rate of 10 A/s while the dipole measurement campaign was based on 50 A/s. The calculation of the coefficients is now based on a mixture of magnetic measurements results and beam measurements whenever possible, but there is still space for improvement.
Ezio then showed different updates done over the years to the Fidel coefficients. The cycling strategy has changed and some special measurements have been carried out to update the Fidel model to new needs. Presently no pre-injection plateau is used during precycle. Instead a plateau at 100 A is used to allow for tunnel access.
With this new precycling strategy there are important effects which are not yet understood and which could be important for the model: the 600 s at flat-top energy may be too short to guarantee reproducibility and no info is available on the effect of the time at 100 A pre-injection plateau.
Conclusions: the pre-cycle strategy applied in 2011 seems to ensure good reproducibility, however the operational conditions of the LHC are different with respect to measurements (no pre-injection plateau and reset at 100 A). Therefore a dependency study of the history as done in the past should be done now with the new conditions, a campaign of measurements is needed since in this way reproducibility could be further improved.
Comments:
Ezio stressed the fact that variability of decay is intrinsic in the physical phenomenon so no correction at the 1 unit level should be expected from magnet modeling. Moreover measurements on magnets are needed to retune the model parameters since the operational scenario of the LHC is really different from what used for the Fidel modeling, especially for flat-bottom. Marek moreover would like to have chromaticity measurements for varying pre-cycle conditions in order to retune further the model coefficients. Jorg mentioned maybe worth putting chromaticity

measurements after longer access as standard operational procedure to help. Ezio reminded that longer does not mean the effect will be big, actually after a certain time the effect will be independent of the length of the flat-bottom, they need measurements with different conditions and statistics. Jorg asked when measurements in the SM18 will start and Ezio answered they are in the pipeline and will start soon but beam measurements should be still performed any time it is possible. W. Hoefle mentioned the possibility to measure continuously chromaticity from filamentation of the pilot bunch when injected. R. Steinhagen replied that this kind of measurement couldn't give reliable measurements with precisions of 1 unit of chromaticity.

3. What do we need in the CCC for mastering the 50 ns high intensity beams– W. Venturini (slides)

Walter presented possible improvements on beam monitoring and single bunch diagnostics, which could be important/useful to operate the 50 ns high intensity beams.
He mainly highlighted four important points:

- **Q and Q' monitoring and control** at injection is fundamental to preserve beam quality. Despite the Fidel dynamic correction one should still expect fill to fill variation. A Q' monitoring with radial modulation cannot be used for very high intensity and during injection. The Q reading gets with high intensity due to the high damper gain and it is not possible to directly measure the intensity dependent Q shift. It could be important to make use of Schottky monitoring during injection for Q and Q', not as a bunch-by-bunch diagnostic tool but as a beam monitoring. The system is not always reliable but there is still room for improvements.
- **Bunch by Bunch monitoring**: **the BSRT measurements** can be a useful observable to monitor the quality before deciding for more injections if one batch shows large emittance blow up. But this instrument still needs a proper calibration to have reliable absolute values of emittances, the gating at single bunch level is still dove via an expert application, results from TIMBER need another external application for plotting. A fixed display with online update of the bunch-by-bunch emittance should be developed. Another instrument, which can give important information on 50 ns beams, are the **ADT pickups**. These measurements can give warnings on coupled bunch oscillations developing over the beam but it is still relying on expert applications and needs hardware changes to allow for all bunches measurements. A fixed display could be done with a refreshing of 30 s frequency.
- **Heat Loads monitoring** based on 5 half-cells calibrated to beam induced heat load on the beam screens. The picture can be improved by calibrating more cells. That requires running with blocked JT valves, else correlating the DT and valve opening can give overview of the heating due to beam losses.

- **Vacuum Synoptic**: a better graphical representation of the vacuum activity over the different vacuum gages is needed. An expert application exist but in form of excel macro which highlights the worse 10 locations where pressure rise occurs. A fixed display showing these information could be important to detect pressure activity before beam losses become important.
- **Bunch by bunch data in post mortem database**: so far only the FBCT are logged in the post-mortem database for analysis. A wish list of possible data to have available are the data from the ADT pickups, the interlocked BPMs and RF data.

Comments:

Concerning Q and Q' monitoring by use of Schottkys: R. Steinhagen commented that continuous measurements of chromaticity using Schottkys is not reliable since the method has problems with longitudinal coherent oscillations and needs stable beams. Last year's measurement that were shown by Walter were taken after waiting half an hour for the beams to stabilize.

Concerning the BSRTs: J. Uythoven mentioned that to monitor the abort gap population they need to have the BSRAs always calibrated or at least they should be informed when a calibration is needed. Jorg asked if the LDM can be used to calibrate the BSRAs and Federico answered that the LDM needs longer integration time so they cannot be compared. The FBCTs are used but studies on the calibration stability should be carried out. M. Ferro-Luzzi also mentioned that LDM measurements could be of interest for the experiments to detect satellites. Federico reminded that the LDM FESA class is still under development and that BI expert and OP applications need to be developed. If the experiments show interest in such a system things can be speeded up.

Concerning the vacuum synoptic: Jan mentioned the fact that signals of the vacuum activity versus time are important and should be available and that a selection of worse 10 locations where activity is on-going should be available.

4. AOB

Mike and Jorg asked Elias to explain coupled bunch instabilities for the case of 36 bunch trains and 72. Elias mentioned that from past knowledge of coupled bunch instabilities, one can calculate rise times analytically for equally spaced bunches. The rise time of the instability is of the order of 40-50 ms. For configuration with trains and empty gaps between trains new simulations show that from 36 bunches trains to 72 bunch trains the effect gets worse but less than a factor two, the coming MD on coupled bunch instabilities will tell us which is the real situation.

Jorg remind that the MD period is starting soon and that no intensities changes are allowed. For any urgent request for changes R. Schmidt should be called.