Electron cloud meeting #58, 06/07/2018

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Arising matters (G. Iadarola):

- During the run with β*=90 m it was possible to collect heat-load data with different bunch spacing (100, 50 ns). Once again, it could be observed that with 100 ns and 50 ns the eight arcs do not display any significant heat-load difference.

E-cloud observations from the LHC Vacuum Pilot Sector (E. Buratin)

Elena presented observations from the Vacuum Pilot Sectors (VPS) installed in point 8 (straight section):

- The objective of the VPS is to study the Electron Cloud (EC) phenomenon and the Synchrotron Radiation (SR) effect in the presence of different surface properties.
- A description of the VPS layout was provided. It operates at room temperature in a straight section of LHC (point 8) in the absence of magnetic fields. It is composed by four stations, exposing to the beam different materials: ex-situ NEG, amorphous carbon coating, unbaked copper (installed in 2016) and unbaked copper (installed in 2015).
- Different detectors were designed, build and installed in the VPS in order to study EC and SR phenomena. These are: shielded and non-shielded pickup used to acquire the EC signal and the beam signal (trigger) with an oscilloscope and a picoammeter, calorimeters for power deposition measurements, Bayart-Alpert gauges for the total pressure, and gas analysers (not discussed here).
- During a typical fill with 50 ns bunch spacing, on the shielded pickups no electron signal is observed at injection while a signal appears during the energy ramp, probably due to photoelectrons. The energy at which the signal becomes visible (2.8 TeV) is consistent with simple estimates. The electron flux seems to scale with the forth power of the beam energy.
- With 25 ns beams the EC signal is visible already at injection energy and is two orders of magnitude larger than with 50 ns. This indicates that multipacting is taking place. The dynamics is very reproducible from fill to fill, and a strong dependence is observed both on the bunch intensity and on the bunch length. The electron flux tends to become stronger for longer bunches.

- The dynamics of pressure and temperature during a fill for 25 ns bunch spacing shows the same behavior as the electrical signals. A similar behavior is observed also on other gauges in the straight sections.
- The three different surfaces (ex situ NEG, Carbon, Copper) are compared for a fill with a bunch spacing of 50 ns. A signal becomes visible for beam energies above ~2800 GeV in all the stations. Assuming that these three different materials have similar reflectivity and that the impinging radiation is similar one can conclude that $PEY^*_{carbon} < PEY^*_{ex\ situ\ NEG} < PEY^*_{copper}$.
- Performing the same comparison for a 25 ns fill, one can conclude $SEY_{carbon} < Th < SEY_{ex\ situ\ NEG} < SEY_{copper}$ where Th is the multipacting threshold.
- Using the previous measurements, an estimation and discrimination of the signals due to EC and SR can be achieved, using the 50 ns curves as SR contributions and calibrating for the 25 ns beam intensity. The EC+SR current curves asymptotically reaches the number of photo electrons in all three cases.
- Future studies include EC observations with an oscilloscope. The first signal was visible in June 2017. New amplifiers and filters were installed in April 2018.
- During the discussion it was remarked that it would be very useful to perform simulations of this system to compare these data against the model. It would be also important to assess the evolution of the electron current over several months of LHC operation in order to understand whether the behavior is compatible with scrubbing measurements from the laboratory. The e-cloud team would be very interested to have the data from the VPS made available for analysis and comparisons against models and simulations.

Scrubbing observations at SPS with high intensity 25 ns beams (H. Bartosik)

Hannes presented some first high intensity studies in SPS for 2018 and some scrubbing observations with 25 ns beams:

- The PS is recently able to deliver 25ns BCMS beams with intensity larger than 2.5e11 ppb. The bunch length is nicely distributed along the train while optimization of bunch rotation in PS is still ongoing. Some high-intensity studies in SPS are planned for Thursdays this year normally in parallel to north area physics, and some preparatory studies will take place on a short parallel MD cycle (injection 2.5e11ppb).
- Some beam time with high-intensity 25ns beams was available due to a power converter problem that prohibited North Area Physics for a week. An ad-hoc mini scrubbing run was performed, alternating with HiRadMat and other preparatory work.

- From Thomas' measurements on the measured RF voltage for 2.5e11ppb, all four cavities run into RF power limitation and RF voltage drops to about a half in the long cavities. This has to be taken into account for interpretation of results.
- Some first emittance observations on the long cycle were conducted (Thursday MD block on May 31st). A twenty seconds flat-bottom cycle ("scrubbing cycle") was used with 48 bunches of BCMS beam with 1.9e11ppb. A clear transverse emittance growth along flat bottom was observed, with e-cloud pattern along the batch.
- First results were available from the BGI. A measurement example for ~2.0e11ppb injected shows that the emittance growth appears to be continuous. Optimization of the BGI settings with BI expert is still ongoing.
- A mini scrubbing run was conducted on the 2nd – 3rd of June, alternating a high intensity BCMS beam with four batches with other activities. Doing regular emittance measurements for 48 bunches a clear improvement could be observed.
- The horizontal chromaticity has a clear impact on the losses (as was seen in the past) as well as on transverse emittances in both planes (to be further investigated and understood).
- Future developments would include
    - Checking the compatibility of high intensity 25ns beam on flat bottom with ZS sparking, trying to avoid cycling the ZS voltage to minimize risk, given that we are running already with one ZS missing.
    - Further optimization of the cycle (800 MHz and other longitudinal settings, transverse damper, tunes)
    - Some further conditioning (if possible)
    - Studies of flat bottom losses (e.g. for different RF voltages)
    - Dependence of losses and emittance growth on working point
    - Studies of the horizontal instability observed last year.

Impact of the Secondary Emission Model on e-cloud build-up (L. Bitsikokos)

Loizos presented EC build-up simulations investigating the impact of the secondary emission model with 25 and 50 ns beams:

- Recent heat-load measurements seemed to point to very high heat-load densities (>10 W/m) with 25 ns spacing. This would point to very high SEY, for which a high heat load with 50 ns would also be expected, while this is not experimentally observed. However, more recent analysis by the cryo team shows, in fact, lower heat-load densities which could be compatible with our models.

- Nevertheless, it is desirable to understand which features of the surface modeling influence the heat-load ratio between 25ns and 50ns bunch spacing. In order to do so, we change different values of the Cimino et al. model implemented in PyECLOUD, to investigate which parameters can affect the 50ns/25ns heat-load ratio. The investigation probed also unphysical and exaggerated changes in order to better assess the impact.

- The main question is what 50ns heat-load to expect given a certain heat-load with 25 ns. In order to answer this question instead of plotting the heat-loads for 25 ns and 50 ns as a function of the SEY parameter a different strategy is chosen by plotting the heat-load of 50 ns as a function of the heat-load with 25 ns.
- Firstly, the parameter E0 of the elastic component was changed from 150 eV (standard value of Cimino et al.) to 75 eV. Although a visible difference is produced between the heat-loads for 25 and 50 ns in function of the same SEY parameter plotting the heat-load of 50 ns as a function of the heat-load 25 ns shows no significant impact on the 50ns/25ns heat-load ratio.
- Secondly, the parameter R0 of the elastic component was changed from 0.7 (Cimino et al.) and 0.0, the latter corresponding to the unphysical case where no elastic electrons are produced. Although the heat-load vs sey parameter plots for the two cases (0.7, 0.0) show a significant difference, when plotting the heat-load 50ns vs heat-load 25 ns only a minor difference is visible between the two curves.
- For the true secondary component, the s parameter was scanned between 1.2, and 1.7, changing the shape of the true secondary curve both below and above the maximum delta. Once again, a clear difference among the three cases is observed in the heat-load vs sey parameter plots, while no effect is observed on 50 ns vs 25 ns plot.
- In addition, the Emax parameter of the true secondary component was scanned using the values 200 eV, 332 eV (Cimino et al.), 400 eV, provoking significant changes on the true secondary component of the SEY. Nonetheless, this change does not produces a difference in the heat-load 50 ns vs heat-load 25ns (where only a minor impact is observed) despite the significant difference between the three models in respect to heat-load vs sey parameter.
- Finally, the parameter mu true (mufit) of the true secondaries energy spectrum was scanned. The energy spectrum of the true secondaries concerns the probability distribution used for assigning energy values to the produced true secondary electrons. Ten different values for the mu parameter were chosen starting from the Cimino et al. value of 1.6636 up to 3.3272 (double the standard value. Unlike any other surface parameter studied, the mu scan produces a significant difference of the 50ns/25ns ratio.

LB, 06 July 2018