FCC-hh General Design Meeting

Notes from the meeting held on 25th February 2016

Last week there were some discussions on the extended straight sections and how they are used. Next week we will discuss the findings of the extraction team, to understand their preferred solution and the compatibility with collimation.

Javier Barranco Garcia - Preliminary Beam-Beam Studies for the FCC-hh

J. Barranco presented results from preliminary beam-beam studies which started just before christmas. EPFL is now responsible for beam-beam studies for FCC-hh. These studies will define several parameters of the IR layout (crossing angles, crossing schemes, etc) and should ensure not to limit the performance of the collider. The same tools for LHC and HL-LHC studies can be used and have been set up to work for FCC. He presented baseline parameters which are used for the simulations ($L^*=45$ m / $\beta^*=30$ cm / $I=10$^11 ppb / $\varepsilon = 2.2$ µmrad, crossing scheme HV).
D. Schulte adds that $L^*=36$ m and 61 m do not need to be considered. T. Pieloni comments that one should still check and quantify the impact on beam-beam. D. Schulte agrees that these studies are useful, however for clarification the only change we expect for the moment could be a change of triplet length or β^* but with the same L^* of 45 m.
Results from DA studies are presented. No errors are in the lattice, only beam-beam effects will drive the beam outside. Different parameters are scanned (ε, I, crossing angle) to see how they influence DA. Before the spectrometer is introduced there is only an external/effective crossing angle. B. Holzer asks if this spectrometer is like in LHCb. D. Schulte confirms and adds that this is a request from the experiments and we won't object unless there are good reasons.
For the DA limit 6σ were chosen as a figure of merit from LHC experience, which gives an isoline in the DA plot for scanning different parameters. For example for larger intensities the isoline is moving to the right (larger crossing angles), which means that one needs to increase the beam separation as the long range effect is limiting the DA.
B. Holzer asks if this corresponds to the LHC experience. X. Buffat replies if one scales (energy, ε) then the DA will be similar.
B. Dalena asks if head-on and long range are both considered in the simulation. J. Barranco confirms. D. Schulte asks if it's for a β^* of 1.1 m or 30 cm and if there are crab cavities. J. Barranco replies that he uses 30 cm and no crab cavities. If one introduces now the spectrometer one has two angles in the crossing scheme (internal and effective/external).
B. Holzer asks if a compensator magnet is foreseen. D. Schulte confirms, a 7 Tm dipole is already in the layout which is almost a full compensation.
The DA was studied with a fixed internal angle, and using the three different cases for the spectrometer (on/off and two polarities). This means head-on is the same and long range effects change slightly. In a second step the angle was scanned. D. Schulte asks which angle is scanned. T. Pieloni replies it's a knob that changes both, it's changing in first order the internal one (angle at IP), but depending on the spectrometer polarity it changes also the effective/external one.
D. Schulte asks if one can conclude that the first few crossings sort of take all the blame. X. Buffat disagrees, with the spectrometer on average they are all a bit worse, but the effect on DA is not dramatic. The effect on aperture from this might be more important.

Tatiana Pieloni - Crossing Schemes Considerations and work plan

T. Pieloni presented the HV crossing scheme in the LHC, with two experiments azimuthally in the ring, one with H crossing and the opposite one with V crossing. There are two types of beam-beam effects, head-on in the IP to be maximised for luminosity, and long range which is disturbing beam

dynamics. It has effects for example on closed orbit, tune shift, tune shift and chromaticity. The long range interactions break symmetry between the planes and could excite resonances. They affect particles with large amplitudes and could even be different bunch by bunch. The reason to start with HV crossing is because it allows for passive compensation of several long range effects. For head-on the detuning with amplitude and tune footprint was shown. For long range the detuning with amplitude in the horizontal and vertical has an opposite sign for a beam separation of e.g. 8 σ, which results in a passive compensation of this shift in case of HV crossing. It gets more complicated if during the fill different bunches have different amounts of interactions (PACMAN). Tune footprints were shown for the different cases of H, V, and HV crossing with and without the PACMAN effect. In opposite to H or V crossing, for HV crossing the working point will not be shifted bunch by bunch. What is not compensated with alternating crossing are orbit effects, which change bunch by bunch. Plots were presented that show the tune shift bunch by bunch and also the shift in chromaticity for H crossing and HV crossing, showing the compensation effects in case of HV.
B. Holzer concludes that there is no good reason to go away from well established HV crossing. X. Buffat adds one could think of it in case of strong asymmetries, like in emittance (flat beams). The spread in the tune footprint could be reduced by a tilted (e.g. 45°) HV crossing, which still profits from passive compensation. W. Bartmann asks if this is more difficult due to dispersion closing. T. Pieloni replies that they were more worried about coupling. D. Schulte adds that it is interesting to explore and understand this. R. Martin comments that there was one argument against 45°, as the radiation cannot be distributed as good anymore with switching the crossing planes. I. Besana adds that there were studies that looked into this and the tilted strategy shared the bad features of both pure H and V crossing. F. Schmidt asked about the interplay with the octupoles. X. Buffat replies that it is the same as for LHC, one can switch them off for collision.
The beam-beam plans for Rome are summarised. The parameter space will be explored. Scaling laws should be defined for DA vs. Intensity / Emittance / Crossing angles. Crab cavities are not yet on the list. D. Schulte comments that if it's not too difficult it would be nice to study them too, as they are in the ultimate design. It was concluded to stay with HV crossing for now.
F. Schmidt asks if beam beam is also studied at injection. T. Pieloni replies that this needs to be looked at. B. Holzer asks if this assumes that one cannot separate the beam enough at injection to still see the beam beam effect. D. Schulte adds that one should have an estimate for this to understand how critical it can be. T. Pieloni asks if there are multipolar errors for injection that define DA. F. Schmidt replies one could just turn on the octupoles as everything else is a minor effect.
For long term, sensitivity and margins should be studied for DA, which depends also on the input of multipolar errors. Further options are flat optics and different compensation schemes (crab cavities, multipoles, wires, e-lenses). D. Schulte comments for the experimental insertions it would be good to calculate specifications, e.g. the preferred location of crab cavities. T. Pieloni agrees.
Another study case would be the 5ns bunch spacing. X. Buffat adds the long range is the easy part as the intensity is split into 5 bunches so the strength is the same. For head-on it is more difficult as one has a smaller emittance from the start. D. Schulte comments that there are now more than 1000 background events per bunch crossing with 25ns. He suspects that the 5ns could become urgent in the future, so it's good to keep that option in mind.