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Meeting Minutes of the
203rd FCC-ee Accelerator Design Meeting & 74th FCCIS WP2.2 Meeting

Indico: `https://indico.cern.ch/event/1498720/`
When: 27.02.2025, 15:00-17:00 GVA time

Agenda

Presenter	Title
I. Karpov	**Status update on RF duty factor studies at the FCC-ee booster**
W. Hofle	**Updates on optics requirements for depolarizer**

1 Status update on RF duty factor studies at the FCC-ee booster

I. Karpov presents a status update of the RF duty factor studies. He says that an old value of the beam current was used for the W mode but he has changed it. He mentions that dynamic power losses in RF cavity are proportional to V^2 of the cavity. For cryogenics the average power over the peak power matters, which he defines as the RF duty factor. He shows the change of beam current for the W mode. The Z/W RF voltage in extraction is smaller than for ZH. The power of RPO depends on the number of focusing/defocusing magnets used. The grey areas on the plot show the SR power with +/-5 % margin. He mentions that for the ttbar having a high quality factor would be difficult to control. We need to step down in quality factor results in 30 Hz cavity bandwidth which is acceptable. According to his studies $1.5 \cdot 10^7$ is the optimal quality factor for ZH which is very close to W with $N_f - N_d = 16$. For ttbar we assume the vertical dashed line for quality factor and for other modes it is the solid line.

Next he shows an analysis of the energy cycle and goes through the same set of plots created for each operation mode. He starts with the ttbar mode and shows plots of cavity voltage and phases as a function of time over the energy cycle. The total RF voltage and energy programs are provided by **A. Chance**. Four regimes are required to cover RF voltage requirements during the ramp. Choice of constant voltage impact RF power and dynamic losses. Significant RF power imbalance for focusing and defocusing cavities and a low “constant” voltage leads to very low RF power. About 40% RF power overshoot due the choice of loaded quality factor of $2.7 \cdot 10^7$. Peak dynamic losses up to 24 W, while average value is only 4.2 W.

Next he moves on to the analysis of the ZH mode which is the same a the ttbar. The same plots as before are shown for this mode. The total RF voltage and energy programs are provided by **A. Chancé**. Four regimes are required to cover RF voltage requirements during the ramp and the choice of constant voltage impact RF power and dynamic losses. There is a significant RF power imbalance for focusing and defocusing cavities and a low “constant” voltage leads to very low RF power.

For WW mode the RPO scheme allows to cover RF voltage requirements during the entire ramp (except no beam segment). The same RF power for focusing and defocusing cavities. Significant RF power overshoot at the moment of extraction needs to be verified with dynamic mode (opening feedback loops might be required). Cavity detuning becomes more significant. A tiny RF power overshoot is seen due the choice of loaded quality factor of 10^7 (excluding injection and extraction transients). Peak dynamic losses are up to 10 W, while the average value is only 1.7 W.

for Z mode, there is an overshoot to shrink transverse emittances which results in strange voltage evolution. The whole cycle can be run with RPO and the cavities will be counterphased all the time. Significant RF power overshoot at the moment of extraction needs to be verified with dynamic mode (opening feedback loops might be required). Cavity detuning becomes even more significant. vOn the plots the vertical dashed line is denoting the extration. We might need to reduce voltage as we need to make sure there is no multipacting. A tiny RF power overshoot due the choice of loaded quality factor of 10^7 (excluding injection and extraction transients). Peak dynamic losses up to 3.8 W, while average value is only 0.7 W.

He concludes the presentation by summarizing the key points. The reverse phase operation and other schemes are necessary to provide the required RF voltage during HEB ramps. A first analysis shows significant lower average dynamic loss values compared to the peak values. An analysis of RF power transients is necessary to clarify average RF power requirements and further optimization to be done based on requirements for the cryogenic systems.

Discussion

K. Oide asks why do we have a spike at extraction at Z?

I. Karpov answers that voltage amplitude and phase are not what they are supposed to be.

K. Oide asks what is meant by clamp?

I. Karpov answers that the clamp is just for calculation a capping of the power at 50 MW. The max. power should be about 3 MW for Z.

K. Oide asks if the sudden change of power could cause a trip of RF?

I. Karpov says that if you keep the loop closed yes, we need to open the loop then there is a detuning and voltage drops.

C. Carli asks if the ramp down would get to 0 V?

I. Karpov responds that no it wouldn't but in theory it could but needs to be checked. For ZH and ttbar its not critical but for Z and W it is. We need to synchronize the damper. One can put some interlocks that can prevent increase of power.

2 Updates on optics requirements for depolarizer

W. Hofle starts by saying that for resonant depolarization powerful transverse electromagnetic kickers are needed in FCCee that provide vertical kicks with fields that can be modulated to target witness bunches placed in gaps between the trains of bunches used for physics. For physics bunches the same type of kicker system can be used to continuously or on demand to shake the beam to prevent polarization build-up. The same kickers can also be used to fulfill the function of transverse feedback. He shows some updates on discussion on how to place the kickers. There are 2 options: return arc, part of arc close to IPs, or a section of regular arc. The feedback kickers will be distributed around ring.

He mentions that there are requirements on the bandwidth. The phase advance has to be chosen well. One proposal is to use in a single bump which would require 10 μrad kick angle at Z energy to open and close bump. If we distribute it would be quarter of that. He adds that adequate protection is needed.

The initial proposal is compatible with the vacuum chamber in arc dipoles. He shows that a relatively homogeneous EM filed can be achieved to provide vertical kick to depolarize. There is a constraint on length of structure due to bandwidth. He emphasizes that the location of magnet installation is important.

A confirmation is needed on available space in arcs or for modified return arc optics suitable for depolarizer. The feasibility of small diameter vacuum chamber kicker needs confirmation including studies on beam impedance, needed tapers, synchrotron radiation. We also need a follow-up on machine protection considerations. In addition an optimization of electrode design is needed, with possible consideration of advantages of higher line impedance kicker.

Discussion

K. Oide comments that due to the scheme of **I. Karpov** there is vacant space in the lattice for ttbar. This space is about 2.7 m long. It could be possible to install the kicker there.

M. Koratzinos asks if the electrodes are placed 9 mm away counted from the beam, are there no problems with impedance?

W. Hofle answers that it needs to be looked at.

K. Oide comments that you will need taper on both sides of kicker to reduce impedance.

W. Hofle answers that by itself the structure creates impedance. The question is with this additional magnet you need for ttbar, is there a possibility of modifications of space?

K. Oide comments that this affects the entire design of arc. It should be possible but it may affect many things. He asks how many bumps are needed?

W. Hofle answers that 4 for e+ and 4 for e- so 8 in total.

K. Oide comments that the arc at close to end of straight section has been modified already. That part can be usable for these bumps. At each RF straight section, the arc connecting to that part was modified to extend space for RF cavities and that part could be usable for this bump, all 4 of them.

W. Hofle says that another argument to distribute over 4 locations is that we don't want to have 1 mm offset of the beam. The larger the kick the larger the orbit offset.

K. Oide asks what about 8 bumps instead of 4 with smaller amplitude?

W. Hofle answers that you can do 8 but it becomes more complex to operate.

C. Carli asks where the 10 μrad deflection comes from? Can it be changed with different boundary conditions?

W. Hofle answers that it is based on computations. For 2 quantities investigated it gives quick responses. It depends on where you put this, if you go to larger section of arc, it becomes bad again. As a next step one can study the diameter of dipole and compute beam impedance.

35 Participants:
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