FCC-ee design review 13-14 October 2016 – summary

on behalf of
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thanks to Yunhai Cai et al for the draft report

review agenda, 13 October '16

time	length	title	speaker(s)
08:30-08:45	15 min.	Introduction and charge	Frank Zimmermann
08:45-09:045	60 min.	Design overview, separated vs combined function arcs	Katsunobu Oide
09:45-10:00	15 min.	Arc magnet designs	(Attilio Milanese) pres. by Katsunobu Oide
10:00-10:30	30 min.	*Coffee break*	
10:30-11:00	30 min.	Alternative IR optics and possible monochromatization	Anton Bogomyagkov
11:00-11:30	30 min.	Emittance tuning	Sandra Aumon
11:30-12:00	30 min.	Tolerance and misalignment studies	Sergey Sinyatkin
12:00-13:30	90 min.	*Lunch break*	
13:30-14:00	30 min.	FCC-ee beam-beam effects, including instabilities and mitigations on the Z pole	Dmitry Shatilov
14:00-14:30	30 min.	FCC-ee beam-beam strong-strong simulations for all working and mitigations	Kazuhito Ohmi
14:30-15:00	30 min.	MDI incl. l* preferences	Manuela Boscolo
15:00-15:30	30 min.	*Coffee break*	
15:30-16:00	30 min.	IR quadrupole design choice	Eugene Levichev
16:00-17:00	60 min.	Collective effects overview incl. e-cloud	Eleonora Belli
17:00-18:00	60 min.	Closed session	

review committee

Yunhai Cai, SLAC (Chair)

Catia Milardi, INFN Frascati

Pantaleo Raimondi, ESRF

Elena Shaposhnikova, CERN

Rogelio Tomas, CERN

review tasks

1) Select a baseline IR optics
2) Comment on the choice between separate function and combined function arcs
3) Comment on near-IR layout, incl. l* in oncoming and outgoing side
4) Comment on final quadrupole design
5) Comment on tolerances and vertical emittance tuning
6) Have no important items be missed in the impedance and instability survey ?

…

review conclusions - general

Since the last review, a much more detailed study has been made including the radiation from the final focus quadrupole and introducing masks for mitigation.
A few possible improvements such as combined function dipoles, and asymmetric IR were also studied and presented in the review.
Many advances were made in the standard design study: in particular in studies of tolerances, machine tuning, impedance and collective instabilities.

The committee is pleased to see all these advances in the design, especially in the design of the interaction region.
A few issues emerged from the study done in the past year, among them coherent beam-beam instability and trapped modes near the interaction point. Some attempts were made for mitigation, but it is not clear if they present a cost-effective approach.
The committee recommends to have a comprehensive study of heating problem inside the detector and then make a proper decision how to pursuit the design.
Given the maturity of the design (KO) lattice, the committee recommends to officially declare it as a baseline so that the efforts can be more focused for a comprehensive study at a level of conceptual design.
The committee recommends also upgrading MAD-X to make it usable for the FCC-ee study, in particular, including proper implementation of synchrotron radiation (also for TWISS) and implementing tilt solenoid.

conclusions – IR optics

Select an IR optics:

Given the material shown in the review, **we recommend to select the presented lattice (KO) as a baseline to proceed for further study. Here are our motivations:**
A) It complies with100 keV maximum critical photon energy from the synchrotron radiation near the interaction point while alternative does not;
B) It has adequate dynamic and momentum apertures accommodating the large energy loss due to the beamstrahlung in the high-energy collision;
C) It has a layout that is compatible to the proton-proton collider aside from a tolerable deviation: 9.4 meter in the interaction region.

Along with this recommendation, **we suggest further study:**
D) Use the baseline for engineering design and cost estimate;
E) Complete tolerance study for baseline with reasonable specification of alignment & magnetic errors along with realistic & robust correction scheme;
F) Track dynamic and momentum apertures w errors after correction;
G) Generate a set of beam parameters that are consistent and can be used to study collective instabilities; define impedance budget and bunch patterns;
H) Make sure an adequate polarization at the beam energy < 81 GeV can be achieved with the errors after the correction

conclusions – arcs

Comment on separate function or combined function arcs

Combined function seems a good idea from point of view of beam dynamics, among them: 1) a large momentum compaction factor and energy spread to mitigate microwave instability; 2) a longer bunch length to reduce the heating near the interaction point; 3) a lower synchrotron radiation power.
However, based on the study presented in Rome, 53.6 MeV of energy spread at 80 GeV is very close to the limits assumed for polarization to be feasible. Using LEP data, the limit is somewhere between 52 and 58 MeV energy spread. Note that it is the absolute value that matters as it is compared with the separation of 440 MeV between integer resonances. So **the large increase in the energy spread may lead to unacceptable degradation in polarization.**
Moreover, the design of the combined function dipole seems more complicated. The committee is not convinced that it will cost less that the flat one partially due to the speaker.
Many beam parameters will be affected. Since it will impact on the overall performance (luminosity, power, cost), it has to be carefully evaluated.
We recommend not to have the combined function dipole in the baseline, but continue to study it, especially for the polarization.

conclusions – IR Layout

Comment on near-IR layout, incl. L* in oncoming and outgoing side

We recommend keeping l*=2.2m symmetric IR as the baseline.

However at the moment, **we do not have enough elements to assess if there is a technological solution that is consistent with the lattice**. **We recommend to make changes after a comprehensive study of heating problem near the IP.**
All the implications of choice of the detector side (luminosity monitor, stay clear, synchrotron radiation) have to be carefully analyzed and quantified.

Comment on final quadrupole design

In general, there is a very good R&D for this item. It should be continued with closer interaction with the previous item. **We suggest involving the experts in SC Nb3Sn quadrupole technology in the R&D program for a possibility of substantial increase of gradient.**

conclusions – tolerances & tuning

Comment on tolerances and vertical emittance tuning

It is encouraging to see so much progress since the last review.

The work should be completed as soon as possible to settle this major uncertainty or risk in the baseline.

We suggest to have a few intermediate steps:
A) study the tolerances without radiation damping,
B) then with damping and full tapering;
C) partial tapering
to mitigate the complexity of the simulation.

The study should produce a specification for misalignment and magnetic errors that are compatible with the baseline.
The dynamic and momentum apertures should be performed based on the specification and with the errors after corrections.
This may require an upgrade of MAD-X.

conclusions – impedance & instability

Any important items missed in the impedance and instability?

Important progress was made in identification of main contributions to the impedance budget and possible instabilities and some mitigation measures have been proposed (as redesign of absorbers).

Issues related to e-cloud were presented for the first time. The mitigation measures (bunch patterns or coating) are still to be studied.

Other impedance sources to be analysed are kickers, beam diagnostics (BPMs, …), and RF system. The latter item depends on choice of RF cavities.

Transverse damping system with small time delays will require to damp resistive-wall instability, main challenge is related to the large ring size.

Ion instability needs to be studied and mitigation measures to be included into the design.

conclusions – beam-beam

Comment on the beam-beam simulations

Coherent beam-beam effects are best examined by the strong-strong simulation.
The committee recommends establishing a second strong-strong code for benchmarking.
The parameters used in the simulations should be consistent with the baseline lattice. It is important to keep the parameter set as simple as possible for the final report. **Small gains in luminosities should not result in another set of parameters at various energies.**

a concrete outcome

Before freezing the IR baseline, the committee strongly suggested **revisiting several important and entangled MDI issues, such as the various beam-pipe dimensions, choice of l*, final magnet parameters, space and location of luminosity monitors, etc.**

Following discussions in the closed session we plan to address these MDI issues all together in the form of a **mini-workshop** assembling all (most?) system experts for 1-2 weeks at CERN.

Among the main questions to be addressed are:

- Minimum dimensions for chamber layout and masking
- Trapped mode analysis
- Definitive chamber layout
- IR quad design, l* choice, incoming/outgoing layout
- Integration, luminosity monitor
- Overall detector layout and magnetic integration

We are inviting some core experts to come to CERN ideally for two weeks, or at least for one week (indicated in bold below). Several key experts would be available in the weeks
16 January – 20 January 2017
23 January – 26 January 2017