2022 First CEPC IARC Meeting

IARC Committee

June 17th, 2022

The Circular Electron Positron Collider (CEPC) and Super Proton-Proton Collider (SppC) Study Group, currently hosted by the Institute of High Energy Physics of the Chinese Academy of Sciences, completed the conceptual design of the CEPC accelerator in 2018. As recommended by the CEPC International Advisory Committee (IAC), the group began the Technical Design Report (TDR) phase for the CEPC accelerator in 2019, with a completion target year of 2022. Meanwhile an International Accelerator Review Committee (IARC) has been established to advise on all matters related to CEPC accelerator design, the R&D program, the study of the machine-detector interface region, and the compatibility with an upgrade to the t-tbar energy region, as well as with a future SppC.

The 2022 CEPC International Accelerator Review Committee was held remotely due to the Covid-19 pandemic on June 7th to 10th 2022.

A total of 24 talks were presented on a variety of topics.

The charges to CEPC IARC for this meeting are:

1. For the TDR, how are the accelerator design and the technology R&D progress towards the TDR completion at the end of 2022. Are there any important missing points in the accelerator design and optimization?

2. based on CEPC TDR design, the CEPC dedicated key technology R&D status and the technologies accumulated from the other IHEP responsible large-scale accelerator facilities, such as HEPS, could the CEPC accelerator group start the TDR editorial process and EDR preparation?

3. with the new progresses between CEPC and FCCee possible synergy and the continuing collaboration with SuperKEKB, are there more suggestions on the next steps of international collaborations?

1 General comments

The Committee is impressed by the amount and quality of the work performed since last October by the CEPC team. In particular, the progress on the R&D of the hardware components looks very promising. Other areas of note include:

- There is much improved coherence across the various parts of the machine in terms of running parameters and scenarios for Z, W, Higgs and ttbar;
- There is also progress in demonstrating coherent overall system studies for key topics - for example magnets, vacuum, etc., increasing the confidence in the coverage and completeness of the machine design studies, complemented by beam tests and prototypes;
- Very impressive progress has been made e.g. in beam dynamics and operational studies. In particular, the IARC was impressed by the great effort in prototyping key elements of the project. There are no major missing points in the accelerator design.

Recommendations

1. The technical work seems to be proceeding well, and the CEPC team can proceed with the writing of the TDR, that likely will take many months;
2. The TDR should outline plans for the Engineering Design phase;
3. The IARC notes that a full TDR will require, in addition to the various elements presented at this review, a detailed costing which would need to be site independent. Both the TDR and the costing will need international review by a panel including specialist members. The IARC members are willing to participate in both reviews;
4. The TDR will require a comprehensive safety concept for the project;
5. The IARC encourages the team to continue working with international accelerator or technology experts e.g. from KEK on SuperKEKB as well as international physicists on the physics goals of CEPC. The IARC encourages the IDRC to meet again, at least remotely, to review progress on detector and physics studies, which have a number of important impacts on the accelerator design.

The next section gives detailed remarks and recommendations on the topics presented. Once again, the IARC wishes to congratulate the CEPC team on the excellent progress that these represent.

2 Reports on single presentations

2.1 Overview of CEPC R&D status for TDR (Jie Gao)

Comments:

The IARC appreciated the high-level overview in Jie Gao's talk. It clearly testifies to the enormous amount of work that has been achieved since the last IARC meeting. The details will be covered in the talks reviewed below.

2.2 The lattice and dynamic-aperture optimization for the collider (Yiwei Wang)

Comments: The design of a lattice which will perform well for 4 very different energies is not an easy task and a lot of effort has been put into this activity. A review of the collider lattices for all energies, including the near IP region where quadrupoles are switched on and off according to the beam energy, was presented. A new 8-sextupoles scheme was presented which improves the correction of the second-order horizontal chromaticity. This allows for a better correction scheme also at the W and Z modes.

Dynamic aperture with errors was computed, however only for a small number of seeds, at least at the Z mode. It is understood that this is work in progress. At the moment the DA seems smaller than required at injection. At the other energies, the DA seems to be at the limit of the requirements: a further optimization would be required, including multipole-field errors in the IR quadrupoles, in order to increase the energy acceptance, which will have an impact on the lifetime. Some results of DA optimization still show an imbalance between initial phases.

A rationale for the beam-lifetime calculation was not presented. So far the lifetime has been evaluated from the luminosity and the beamstrahlung. The dynamic aperture will give another limitation on the lifetime, especially in the case of large beam-energy spread enhanced by beamstrahlung in the Z^0 running. In the parameter table, the numbers for the total lifetime are about one half those implied from Bhabha scattering and beamstrahlung, but no justification was given.

The beam lifetime has a significant impact on the collimation scenario. As the stored beam energy at Z^0 is about 20 MJ, which is about roughly 200 times higher than the B-factories, the associated beam loss goes into the collimators.

The correction of the machine errors was implemented and COD and beta-beat correction performed. While the COD correction seems adequate, the remaining beta-beating seems to be around 10%, which should be improved. Also, girder misalignment should be taken into account.

Recommendations:

1. Evaluate the beam lifetime due to dynamic aperture, especially for the Z^0 running, where the beam-energy spread will be greatly increased by beamstrahlung;

2. Determine the maximum value of Q' that does not reduce the dynamic aperture too much;

3. Improve DA with errors, including multipole-field errors in the IR quadrupoles, and increase the number of seeds examined;

4. Improve the correction of machine errors for beta-beating;

5. Consider effects from long-range misalignment and deformation of the tunnel.

2.3 Booster lattice and error study (Dou Wang)

Comments: The Booster and Damping Ring have been presented. The lattices were presented at the last meeting. A new study of the dynamic aperture including the effects of errors, was carried out. It seems that the DA is critical at 20 GeV, while adequate at higher energies.

Currently the normalised emittance of $400\,\mu$m has been assumed for the injection to the booster. This number corresponds to that from the thermionic electron gun. If an RF gun will be used, the injected emittance can be reduced to less than $20\,\mu$m, which is comparable to that of positrons from the damping ring.

On-axis injection has been assumed so far. Such a scheme requires a very fast injection kicker for a short bunch spacing for Z^0 running. If a small emittance beam is available, off-axis injection may become possible, which does not require a very fast kicker.

The target injection efficiency from the end of the Linac to the Booster is assumed to be 99%. This number is probably difficult to achieve, however is was noted that only about 30% of the Linac total charge (3 nC) will be needed in the Booster.

Recommendations:

1. Continue to improve the dynamic aperture, including the effect of errors, at 20 GeV;

2. Explore the possibility of using an RF gun, which would allow off-axis injection, thereby removing the need for a fast kicker.

2.4 Impact of Beam-beam effect in CEPC (Yuan Zhang)

Comments: A new sigma-mode instability was observed in simulations with beam-beam including transverse and longitudinal impedances. This is not something expected in simulations, including for other machines.

Attention to the side effects of an elliptic beam pipe, in particular the incoherent tune shift due to the image current, should be given.

The effect of dispersion on the transverse impedance has been examined; the effect was not visible.

Recommendations:

1. Explore a wider range of tune space to investigate whether there are any better working points;

2. Examine if a small difference in the betatron tunes between two beams affects the sigma-mode;

3. For the sigma-mode, explore the effect of transverse feedback, including its resistive/reactive phase.

2.5 Superconducting RF system and design and R&D Progress (Jiyuan Zhai)

Comments: Based on the outstanding preliminary results already presented at past meetings, the mid-T treatment (900 °C 3h + exposure to air + 300 °C 3h + HPR) has been chosen as the baseline for the SRF cavity production, both at 650 MHz and 1.3 GHz, and parameters optimised having in mind both the required outstanding performances and their industrial reproducibility. In particular, several single-cell cavities at 650 MHz have been produced and tested, consolidating the mid-T treatment recipe with the best cavities reaching world records in terms of an exceptionally high quality factor, Q=6.4E10, at the very high accelerating field of 31 MV/m. These results were obtained with the cavity tested at the CEPC operating temperature of 2 K. The IARC warmly congratulates the SRF team for these impressive results and the CEPC leadership for having since the beginning understood the strategic importance of acquiring a world-leading position in SRF science and industrialised technology, putting the CEPC in a good position to compete to be the next global HEP machine. The IARC took note that all the critical components were produced in China and most, although not all, of them by an IHEP start-up.

The IARC took also note of the strengthening of the collaboration between IHEP and the other Chinese institutes responsible for the realisation of large FEL projects. This synergy recommended by the IARC in its previous meetings has turned out to have been very important for both parties, as expected. In this way, IHEP supports other important science infrastructures in China and disseminates its SRF expertise and experience. The preparation of a 1.3 GHz, high-Q, CW cryomodule for the Dalian Advanced Light Source is in progress and the vertical test results of the 8 9-cell cavities are excellent, somewhat better than those produced for LCLS-II in US and fulfilling the requirements for the CEPC Booster. All the other ancillaries are available or in progress, the module assembly is planned at PAPS from August, followed by the horizontal test in November. Despite Covid-19, the PAPS infrastructure seems to be fully functional, providing great potential for a further consolidation of world-leading SRF technology in China.

The consolidation of the SRF technology led by IHEP in China and the subsequent higher confidence in the present and future potential of SRF cavities and their major ancillaries, such as the main and the HOM couplers, substantially confirmed the CEPC parameters for the TDR. They suggested a careful reorganisation of the machine staging to optimize the physics potential while reducing the downtime needed for moving between machine setups. The inclusion in the physics programme of a high-luminosity ttbar factory as a third stage is now confirmed and well planned. The results obtained in a few years on the improvement of SRF cavity performances and the contextual involvement of Chinese industry that covers all the process from Niobium production to cavity treatments, ancillaries and cryogenics make the achievement of the demanding parameters required for a multipurpose CEPC as requested by physicists credible.

The IARC concurs with the suggested three-stage operational scheme and supports its definition in the TDR. The actual SRF technology achievements once fully industrialized in the next few years, thanks also to the ongoing FEL and ADS projects in China, will be sufficient to guarantee all that is required for the stage 1, i.e., a high-performance Higgs factory. After a few years, Z and W with a luminosity an order-of-magnitude higher than was available at LEP-II can be achieved. Stage 1 should include the implementation of the four beam bypasses at each RF point from the start, allowing easy transition from half to full filling of the rings. An increase of the beam power from 30 MW to 50 MW should always be possible provided the requisite funding is available. Once the three-stages scheme is approved and consequences implemented in the CEPC design, the conversion of stage 1 to stage 2 looks reasonably simple. It mainly consists of the displacement of the existing cavities to the center of the RF/switchyard region and the installation in their original place of the 1 MW single-cell cavities at 650 MHz. These require years of R&D from the present state of the art. A few high-current 1.3 GHz modules must also be installed in the booster, bypassing the standard ones, to reach extremely high luminosity for the Z^0 running. With this configuration, thanks to the bypasses, the H and W modes are still possible. Finally, stage 3 is dedicated to ttbar and requires an important increase of the available accelerating gradients per turn in both collider and booster.

The versatility given by the structural installation of the four bypasses at each of the two RF regions, together with the possibility to switch from high voltage to high current in the booster, guarantee a long physics life to the CEPC. Once completed, it could in principle still be operated at each of the previous operation modes after modest effort.

To conclude, the IARC endorses the three-stage evolution scheme presented at the meeting and encourages the project team to implement further details to be included in the TDR.

Recommendations:

1. Implement a detailed analysis of the three-stages scheme for the TDR, optimising the procedures and the time needed to go between them;

2. Maintain the focus on the industrialisation of the SRF components in China but also prioritise efforts to extend international collaboration, crucial for a global project of the size of CEPC;

3. Prioritise the importance of growing deep knowledge of Niobium material science inside the SRF group, including all production steps and their effects on cavity treatments and SRF performance.

2.6 Normal conducting magnets for booster and collider (Mei Yang)

Comments: The development status of the normal conducting magnets for the booster ring and the collider ring, and the field measurement system was reported. For the booster ring, the dipole magnets of low magnetic field smaller than 500 Gauss were designed. The dipole-field specification is 0.1 % uniformity and 0.05 % reproducibility. Achieving the magnet design specification of 63 mm pole gap and a good field region of 55 mm diameter in production is not easy. Currently, two types are being studied: a CT coil and one that is iron dominated. The 4.7 m long prototypes are being constructed: while the CT prototype is delayed due to COVID-19, the iron dipole will be completed in July. The field-measurement systems for these magnets are ready. The measurement probes are the rotating coil and the Hall probe. Two probes are used for the different specific measurements. The rotating coil will be completed in June, while the Hall probe is purchased from F. W. Bell. The Hall probe is prepared for the absolute integral field measurement. The commercial Hall probe has about 0.1 % error even when it is calibrated by the company and has a characteristic dependence on temperature.

For the collider, dual-aperture dipole and quadrupole magnets are being developed. The design of the 28.7 m long dual-aperture dipole (DAD) has been completed and the prototype magnet is under construction. The IARC looks forward to the construction completion and to the good performance of this magnet.

The study of the dual-aperture quadrupole (DAQ) is ongoing, with a short prototype. From the results up to this point, the b1 and b3 components changed with the energy (coil current), and the quadrupole-field center changed in the horizontal direction with the current. In general, the b1 and b3 components in the quadrupole magnet are due to the dipole deformation (ellipse) of the quadrupole magnet. For the DAQ, the coils are placed at the up and down positions of the quadrupole. By transferring the current to the coil, the coil temperature rises, and in consequence, the ambient iron temperature rises and the iron expands. This process leads to the deformation of the four pole positions in quadrupole symmetry. In this magnet, the horizontal distance between the poles is expanded, which induces b1 and b3 components. The directions of the shift of the quadrupole center for the A and B bores are opposite, which is also due to the temperature rise of the iron near the coil.

Recommendations:

1. The required precision of the measurement system depends on the field specification of the magnet from the optics group. Nevertheless, the magnet group should confirm the precision of the field-measurement systems;

2. The magnet group should complete the prototype magnets for the booster and collider rings and confirm their magnetic-field characteristics;

3. There are fundamental problems with the DAQ. The group should try to understand the source of the changes of b1, b3 and magnet center with magnet current.

2.7 MDI study upgrade (Sha Bai)

Comments: Significant progress has been and is being made towards bringing more realism to several parts of the CEPC MDI, taking into account also experience from BEPC II/BES III and SuperKEKB / BELLE II facilities. A single aperture 0.5 meter model of the SC QD0 quadrupole is being constructed for testing and will be followed by a dual aperture model. A new beam-pipe design was presented, which was used both in comprehensive background simulations and for a detailed thermal analysis to estimate heating from HOM power losses and from synchrotron radiation and beam background processes. In most cases, simulations show that adequate control of the beam-induced backgrounds is achieved after implementing sufficient shielding, masks and collimators. The largest power-loss densities are in the crotch region of the beam pipe 805-855mm from the IP, where the common central beam pipe separates into two.The heating can apparently be handled by the planned water cooling. The reliability of electromagnetic simulations of impedance and HOM power losses and of thermal simulations of heating/cooling in real conditions is not necessarily guaranteed when handling relatively complex mechanical structures such as the sections of beam pipe near the IP and collimators.

A pure tungsten beam pipe is proposed inside the SC final double quadrupoles as part of the shielding. The accumulated dose rates from all sources of particle loss estimated in this beam pipe were reported to remain at an acceptable level. A set of button electrode BPMs are planned in the central part of the beam pipe to enable at least rough orbit control and provide bunch-timing information within the closest magnets on both sides of the IP; 8-button BPMs will be installed. However, the function and necessity of the BPMs are not clear. It is not recommended to install unnecessary fragile items such as feedthroughs in such a place, which is fairly difficult to access.

Work in progress on the full detector simulation and luminosity calorimeter were also briefly presented, however with few details.

Recommendations:

1. The IARC recommends that the group re-consider whether 8-button BPMs in the central beam pipe are necessary and, if not urgently needed, remove;

2. After completing the 0.5 meter QD0 single-aperture prototype, a double-aperture prototype is also planned. Since additional windings in the QD0/QF1 final-doublet SC magnets are foreseen to generate higher-order multipole fields for the purpose of local optical corrections, it would be useful to include such additional windings in the planned prototype and test their effectiveness in the magnetic measurements;

3. The tolerance to power loss in the SC magnet to avoid quenching should be investigated. Also important is to ensure that the single bremsstrahlung (RBB) losses, which are concentrated between 2 and 4 meters after the IP, generate sufficiently low heating of the tungsten beam pipe, which is foreseen without cooling, to avoid SC magnet quenches;

4. There have been surprises in the past on the reliability of electromagnetic simulations of impedance and HOM power losses and of thermal simulations both at ATF2 and at SuperKEKB, where predictions underestimated the real-world behaviour. For the most critical cases, e.g. the crotch region of the beam pipe, and some collimators, the IARC recommends building real mechanical models for testing and bench marking of the simulations;

5. For the TDR, the IP orbit-feedback system will need to be studied at least at the conceptual level and in terms of its goals and specifications;

6. Specifications and design goals of the luminosity measurements based on calorimetry needed for the experiment should be elaborated in more detail. Luminosity monitoring for the purpose of machine tuning should be addressed at this stage, in order to reserve space that may be needed in the crowded IR region. Alternatively the planned luminosity calorimeter should be adapted for fast-enough relative measurements. Monitoring beamstrahlung pairs and single bremsstrahlung (known as RBB) rates should also be considered;

7. To guarantee vertex-detector safety in the presence of abnormal beam loss, which has been seen to be sometimes quite large in the IR of SuperKEKB, a set of diamond sensors has been installed to measure particle rates/dose at several positions in the vertex-detector volume. Signals from these diamonds are calibrated carefully, and are used to set thresholds to abort the beam. Such devices should be considered in the vertex-detector design of CEPC.

2.8 Collective instability and countermeasures to collider, booster and damping (Na Wang)

Comments: It is very interesting that the picture of the beam-mode spectrum shows a strong instability before the coupling of the main modes, if potential-well distortion is involved. Many estimates assume the natural bunch length of the collider. However, using the bunch length with beamstrahlung should be evaluated with the highest priority.

The CSR impedance in the booster has been estimated, and found to be at an acceptable level.

Recommendations:

1. Regarding the booster, the impedance budget should take into account the presence of a large number of RF cavities, particularly for taking Z^0 calibration data during H and $t\bar{t}$ operation;

2. Specify the necessary requirements on the beam feedback systems for the booster and the collider rings for each energy and operation mode.

2.9 Timing and bunch pattern for different operation energies and the relevant transporting beam line (Xiaohao Cui)

Comments:

In comparison with the talk for the previous IARC meeting, this talk presented non-critical changes of the bunch numbers and bunch population in all modes of the collider operation. Good progress is apparent in the optics structure design of the beam transport lines for the damping ring, from linac to booster and from booster to collider. The line from linac to damping ring consists of arc, required to match the geometry restrictions, chicanes for bunch-length control and a section for matching the beam Twiss parameters at injection into the ring. The design looks reasonable; however, the matching section includes only five quadrupole lenses. This may not be sufficient for the Twiss matching and dispersion suppression in the presence of horizontal dispersion. The line from linac to booster is designed in a standard way and is flexible enough for all required functions. The geometry of the line from booster to collider is not clear. Its functions are to provide achromatic parallel displacement of the beam in the vertical direction by 2.4 m. The line includes 2 dipole and 11 quadrupole magnets. Beam extraction from the booster and injection into the collider are provided using Lambertson magnets, which leads to non-zero vertical dispersion at the entrance and exit of the line. In these conditions, the matching of the line can be complicated.

Recommendations:

1. Discuss the possibility to locate the matching section in the transport line from linac to damping ring in a dispersion-free area of the beam line;

2. Prepare 3D model of the transport line from booster to collider on the basis of the real dimensions of the magnets of the booster, collider and transport line. Examine the procedure to carry out beam matching, taking account of expected geometry imperfections. The transfer-line location between the two rings will also influence the mechanical-support system, which requires special design.

2.10 Pulse generator, septum and kicker for injection and extraction (Jinhui Chen)

Comments: The IARC compliments the CEPC team for their excellent work and progress in the design optimization and technical R&Ds for the CEPC injection and extraction. The new results from several prototypes are encouraging, which lays solid foundations for the CEPC TDR. The Lamberson design has been optimised with half-in-vacuum and embedded thin-wall vacuum-chamber structures, A 1/4 prototype has been made to verify the mechanical structure, machine and welding processing as well as NEG coating. It was followed by a full-size prototype of the half-in-vacuum LSM for the HEPS storage ring. The manufacture of components has been completed and it is now in the final assembly phase. The in-air LSM prototype for the HEPS BST is in progress; the components have already been manufactured and are being assembled. The slotted-pipe kicker prototype for the HEPS BST is making good progress. Its vacuum assembly test and the magnetic-field measurement were completed with qualified field-distribution performance. The 250ns-fast kicker pulser has been prototyped for the HEPS, and single- and double-stage full-power tests have been completed. A dual-C delay-line kicker prototype was initiated as CEPC R&D work last year; the engineering design has been completed, and, in parallel, prototype progress was made in a Ni-Zn-ferrite sample core test and the fabrication of a ceramic vacuum chamber with a special type of metallic coating.

Recommendations:

1. Update and finalise a new version of the current design based on the technical R&D for both HEPS and CEPC;
2. Secure resources to produce technical R&D and prototypes dedicated to the CEPC injection and extraction.

2.11 Linac key technology and its prospects (Jinru Zhang)

Comments: The IARC appreciates the efforts to the design optimization of the CEPC linac during the evolutions from CDR to TDR, including the energy increased from 10 GeV to 20GeV to meet the optimized booster requirement, the emittance decreased from 120nm-rad to 10 nm-rad, and adding the new operation mode for providing two bunch per pulse with 100Hz for the high luminosity Z mode. The linac beam dynamics design for both electrons and positrons has been updated with consideration of element errors and timing analysis, which meet the design specifications. The electron gun and bunching system of the HEPS linac, already built, can be used at CEPC, but the positron source is the dedicated one with a good progress in prototype development. The S-band accelerating structure for HEPS has been developed based on the CEPC linac structure version in 2019, both can meet the CEPC requirement. Its spherical cavity pulse compressor has been prototyped and ready for high power tests. The R&D of a 3/4 π mode C-band accelerating structure has been carried out with a prototype ready for high power test. The C-band SLED and BOC pulse compressors are under development, and furthermore the cryogenic C-band structure is also under consideration. In addition, the design of a 650MHz 5-cell RF cavity for the CEPC damping ring has been completed.

Recommendations:

1. Evaluate the wake-field effects of the C-band linac, which may either confirm or raise some new requirements on the C-band accelerating structure;
2. Make a prototype of a C-band accelerating unit to check if the accelerating gradient of 40MV/m is realistic for the full system operation.

2.12 CEPC RF power source progress (Zusheng Zhou)

Comments: It is well known that the total installed power for the CEPC and its operational cost will strongly depend on the plug to RF power conversion efficiency of the RF high power sources operating in the P band (650 MHz). At this frequency the RF sources are feeding the SRF cavities of the collider which are working in CW and transferring almost the totality of the available RF power to the beam power and then the CEPC luminosity. The efficiency improvement of the already available high power pulsed klystrons operating in the C (5720 MHZ) and S (2860 MHz) band that are feeding the 20 GeV injector linac are also important for the CEPC but surely less crucial.

The IARC has been once more impressed by the results presented at the meeting specifically on the realization in strong connection with industry of the first prototype of the High efficiency 800 kW klystrons at 650 MHz. This improved design klystron, while being based on a single electron beam, reached a 64% efficiency when operated at 805 kW with 30 duty factor. CW full conditioning was somehow delayed by a Covid-19 lockdown but anyhow the presented actual achievement of 67.8% efficiency at 2/3 of the nominal power is already an outstanding record that demonstrates the leading competences of the scientists involved. The very ambitious program for the development of a 80% efficiency Multi Beam Klystron (MBK) is progressing fast, design is completed, two types of windows are being compared and the fabrication of critical components is ongoing.

Concerning the other RF sources, significant effort is being dedicated to the improvement of the C band, 80 MW pulsed klystron. This effort is also supported by the growing interest of the worldwide marked on this frequency, as natural evolution for most of the several applications based on S band linacs. Finally, thanks to the experience gained so far, the efficiency of the existing 65 MW S band klystron, currently operated on the BEPCII Linac, is being upgraded from the actual 42% to 55%, rising the output power to 80 kW, thanks to an automatic optimization code developed at IHEP. All the L band (1.3 GHz) TESLA-like cavities are individually excited by SSAs and the progress of these kind of sources was not presented being mainly driven by the needs of the three large FEL projects under construction in China, which will need in total a thousand of them.

The. IARC was impressed of the presented achievements and congratulates once more the project team for the effort putted in this important technological development.

Recommendations:

1. Maintain and further improve the strong connection with industry, but also preserve the know-how of the project team;

2. Once the required specifications have been reached, with some margin, make every effort and use the margin to improve the klystron lifetime. This and the efficiency are the most important parameters.

2.13 High magnet field with high-temperature superconducting technology (Qingjin Xu)

Comments:

The development progress of the new 16T dipole magnet (LPF3) was presented. The report showed the calculations of the magnetic field and the mechanical stress in the magnet. The load-line ratio of each coil is in a reasonable range, smaller than 80 %, and the stresses in the coils during assembly at room temperature, cooling the magnet down to 4 K and exciting it to 13 T are smaller than 100 MPa, which is acceptable. As to the field quality, b3 and b5 of the design coil shape are slightly large. The degradation of the field quality due to assembly errors should be studied; the values should be acceptable to the beam-optics group. The quench protection analysis was started for the magnet. The maximum voltage at magnet quench leads to a calculated coil voltage at 4 K of 952 V. During the production stage at room temperature, a higher voltage will be applied to confirm appropriate electrical insulation. The voltage value which is applied on the constructed coils and the protection heaters should be studied. The fabrication status of LPF3 was shown with many pictures, and the progress of the magnet construction is very clear. The IARC expects that the magnet construction will be completed in July, and looks forward to the test results at its next meeting.

For the 16 T dipole magnet, the 4-module CCT magnet design was proposed. The cable, which is Rutherford type, is Nb3Sn. In the proposed design, while the calculated errors in field values are smaller than the common-coil 16 T dipole magnet, the load-line ratio of the coil for generating the dipole field at 16 T and 4.2 K is 100 % of the cable short-sample data. The CCT magnet cancels its own field, and then the load-line ratio becomes higher than the common-coil dipole magnet. This characteristic is required to be fully evaluated in designing the magnet with enough operational margin. The CCT magnets for the HL-LHC showed heavy quench training. Because the 16 T magnet will have much larger electromagnetic force on the cable, the quench training will become even heavier than for the HL-LHC CCT magnet. Countermeasures need to be carefully considered. In the magnet design process of configuring the dipole field, part of the magnetic field generated by the cable is cancelled by that of the other cable in the coil. This makes the load-line ratio of the magnet higher than conventional accelerator magnets. This is typically crucial for high-field magnets. The CCT magnet experienced long quench training. For the 16 T magnet, the stress control of the cable is important to reduce the amount of training required.

The HTS REBCO cable development advanced to the transport current, reaching about 2000 A. That is the excellent achievement in terms of the requirements of the 16 T dipole insert magnet. The dynamic loss of the transposed cable was studied, necessary for operating the accelerator magnets in the real accelerator. The IARC recommends that the HFM team reflect these results in the magnet design and evaluate the effects of them on accelerator operation. The development of the IBS cable is going on. In this report, the effect of the bending radius of the cable on the critical current was reported. This data is crucial for designing the coil shape. The mechanical characteristics of the IBS cable should be studied further and systematically. The critical current of the cable was measured under a 32T magnetic field. The current reached 60 A at 4.2 K, an impressive achievement.

For molding and reinforcing the insert REBCO dipole magnet, the IR-3 epoxy is being exhaustively studied. The study, which is supported by the IARC, is really required for fabricating the 16 T insert magnet.

The CCT HL-LHC magnets have heavy quench training. CB09 was modified, but still had more than 30 training quenches. Given the design maximum field in the coil of 2.9 T and the current of 422 A [1], this quench performance is below average. While the magnets remember the training quench after recooldown, the features of the CCT magnet should be considered in the design study of the more advanced magnet.

[1]Shaoqing Wei et al., "Manufacturing error analysis of field quality for HL-LHC CCT corrector", IEEE Trans. on Appli. Super., Vol. 30, No. 4, June 2020, 4003005.

Recommendations:

1. The IARC looks forward to the completion of the LPF3 dipole magnet in July, and receiving the excitation results at its next meeting;

2. The method of applying stress to the CCT cable of the 16 T magnet should be developed further;

3. In developments of the HTS cable and the IBS cable for the insert 16 T dipole magnet, the IARC proposes that the group studies the effect of the superconducting cross-sectional area, e.g. the filament diameter of the NbTi cable, on the accelerator magnetic field, for example its time decay.

2.14 Cryogenic System for CEPC (Rui Ge)

Comments:

The development status of the cryogenics system for CEPC was presented. The report described the SRF cryogenic system, the SC IR magnets cryogenic system and the 2 K JT heat exchanger R&D. The SRF cryogenic system for CEPC mainly consists of 4 units of 18 kW helium refrigerator; the calculated heat load for one refrigerator is 16.85 kW at 4.5 K. This heat load includes the 50 % margin to the calculated individual heat load; this estimate seems reasonable. The modified flow chart of the SRF scheme was shown with the cross section of the cryogenic transfer line. The transfer line has a thermal radiation shield without any cooling pipe. The design of this cross section should be updated to cool the shield to 40-80 K. The construction progress of the R&D and SRF test infrastructure, PAPS, were shown. PAPS has three vertical test stands, a single-cavity horizontal cryomodule test stand, a 9-cell cryomodule test stand and a beam test stand with cryomodule. The construction of PAPS has progressed very well. A horizontal 9-cell module test in PAPS is scheduled to be performed in the second half of 2022. The cryomodule of two 650 MHz 2-cell cavities has been operated in the PAPS beam test stand in 2021. In PAPS, a new cryogenic control system of MPC and ANN has been introduced, while the MPC method showed sufficient control function in the cool down and warm up of the cavities.

Concerning the SC IR magnet cryogenic system, the heat loads of the system were listed in a table. The cooling power of the required helium refrigerator for one IP is about 4 kW at 4.5 K. To improve the accuracy of the required cooling power, the temperature profiles of the IR quadrupole magnet cryostat have been studied. The heat loads to the 4.2 K area were calculated in case of the thermal shield temperature at 50 K and 77 K. The deformation and the stress in the cryostat components were shown by the specific pressures. The estimated values should be updated in the cryogenic design study of the IR magnets.

The development of the 2K JT heat-exchanger study has progressed. The cryogenic group studied three types of heat exchanger. Two types of the coiled finned-tube showed an efficiency of more than 80 %, while the finned-tube heat exchanger had around 80-90 Pa pressure drop in the low-pressure helium gas line. On the other hand, the efficiency of the plate fin heat exchanger was 65.2 %, and the pressure drop was half that of the finned-tube exchanger at the same mass-flow rate. The test results of the three models should be analysed with the calculation models shown in the report. The IARC expects the experimental data for the different types of fins, and the optimization of the fin type for the CEPC requirement to be presented at its next meeting and to be included in the TDR.

The IARC looks forward to results of the test of the 1.3 GHz 9-cell cryomodule in PAPS in the second half of 2022.

Recommendations:

1. The design of the SRF cryogenic system and the heat-load evaluation are well studied. In the table of the heat loads, the heat load in the cryogenic

transfer line takes a relatively large proportion of the total load. The IARC recommends developing a low-heat-load cryogenic transfer line;

2. In the previous IARC meeting, the sextupole magnets in the IR were changed from superconducting to normal conducting. The heat-load table and the drawing of the IR cryogenic configuration should be updated;

3. The IARC expects further progress in the study of the 2K JT heat exchanger and an experimental test at 2 K.

2.15 Instrumentation and beam diagnostics (Yanfeng Sui)

Comments: An overview of the linac, positron damping ring, booster ring and the main ring was introduced. The diameter of the button electrode for the main ring has been reduced from 8 mm to 5 mm. The time needed to measure the COD in the main ring has also been estimated. The design of the bunch-feedback system to suppress CBI has been updated to have two systems: a narrow-band system and a bunch-by-bunch system. The design of the transverse feedback kicker has also been modified in the following ways:

1. materials of the strip-line rod have been changed to copper-plated aluminum;

2. slotted holes have been added to reduce the deformation of the rod.

The bad experience of the operation of PF-AR and KEKB implies that both changes, unfortunately, are likely to make things much worse. The strip-line rod is thermally isolated so it is essential to select materials with a higher embrittlement point. Aluminum is one of the worst selections. Also, it is very difficult to make both electrical contact and allow sliding in vacuum. When the electrical contact deteriorates, an electric discharge is easily generated at the contact point, and the contact is welded. The shunt impedance of the longitudinal kicker has been tuned to have a higher value, around 2 kΩ, though it is not clear whether it includes the correct transit-time factor. The developed BPM electronics have been successfully evaluated at the BEPCII rings to have enough resolution and long-time stability.

Recommendations:

1. Consider much stronger material, such as stainless steel with Cu coating, or tungsten, rather than aluminum alloy for the strip-line rods;

2. Evaluate the advantages and disadvantages of slotted holes in facilitating connection of the strip-line rod to the feedthrough;

3. The correction scheme for magnet errors at collider rings presumes as the first step the correction of the closed-orbit distortions with sextupoles off. Small beam intensity can be expected due to the large natural chromaticity. The main sources of interference should be investigated and the BPM signal-to-noise ratio estimated for these conditions.

2.16 Mechanical system and MDI pipes, collimator and supporting structure (Haijing Wang)

Comments:

The progress of the MDI hardware, IR SC magnet cryostat, collimators and the supports for the regular magnets was reported. In the study of the MDI components, the IP chamber shape was optimized based on the HOM power in the pipe, and the HOM power was reduced from 4.1 kW with a mask to 1.2 kW without a mask. The calculated detailed HOM powers are listed in the table. The sealing method of the remote vacuum connector (RVC) between the IP chamber and the magnet cryostat was studied, and an improved inflatable seal chosen. The IARC recomends that the MDI group fabricates the prototype and carries out the performance test with the possible load in actual beam operation. The mechanical and thermal studies of the SC magnet cryostat have been progressed with enthusiasm. The mechanical team proposed the auxiliary support system to reduce the displacement of the cryostat. This support makes the 1st natural frequency of the cryostat higher and the amplitude of the vibration amplitude smaller. However, the cryostat will have the additional vibration source from the detector. The MDI team should consider this point for introducing this support to the cryostat mechanical system. The collimators for reducing the background and for passive machine protection have been studied. The collimator system for reducing the background consists of 4 horizontal and vertical units per IP and ring. The design of the collimator was improved by changing the chamber shape from ellipse to circle. With this modification, the SR load was estimated to be from 9.3 kW to 7.5 kW for the Higgs experiment. The collimators for machine protection were studied, and the temperature rise of the proposed collimator was calculated. The supports for the regular magnets of booster and collider rings were proposed. The adjustment range of the magnets was shown. Once the accelerator site is decided, the IARC recommends that the adjustment ranges should be checked again. The support unit of the 5.67 m dipole magnet was optimized, and the maximum deformation of the magnet is calculated to be 7 μm with 4 supports.

Recommendations:

1. The IARC recommends that the MDI team construct a prototype of the RVC and check the seal performance under the possible loads in beam operation;

2. The displacement of the helium vessel in the cryostat directly leads to QD0 and QF1 being off-centre. The evaluation of the deformation of the cryostat components by electromagnetic force and temperature is very important. This study should be completed and an adjustment mechanism designed;

3. For the collimator development, in the study of the machine protection system, the fast sensors, like diamond sensors and CLAWS sensors, that

detect the beam loss to the detector must be designed and included (as recommended in the previous IARC meeting).

2.17 Vacuum system and the NEG coating to the narrow chamber (Yongsheng Ma)

Comments: The vacuum chambers were described with their chosen technology:

- Booster, Extruded aluminum 6061. The fact that the booster has no NEG coating was commented on and needs to be checked.
- Electron Ring, Extruded copper, NEG film
- Positron Ring, Extruded copper, NEG film
- MDI, Copper/tungsten alloy, NEG film. The tungsten alloy will be for the fork vacuum chamber of the MDI

With respect to the CDR, elliptical vacuum chambers in the collider ring are replaced by circular chambers with a diameter of 56 mm. This will increase the electron-cloud density and hence tighten the requirement on the SEY (from 1.3 to 1.2). However, round chambers lead to wakefield reductions and cost reductions are also significant for magnets and chambers.

Good progress was reported on prototypes. Copper & aluminum vacuum chamber prototypes with a length of 6 m have been fabricated and tested. They meet the engineering requirements. Surface treatment of copper is being done in preparation for NEG coating. There is limited experience with NEG coating in operating accelerators in China, but HEPS (light source) is using identical technology to the one foreseen to be used in CEPC. A setup for NEG coating which has the ability to coat a 4-meter long pipe has been built for the vacuum pipes of HEPS at PAPS. Another facility, capable of handling 6m pipes, is being prepared in Dongguan. Measurements are also ongoing to understand the interplay between activation temperatures and time, and pumping speed, all important to optimise operation and performance.

Prototypes of RF shielding bellows have been fabricated. The measured contact force is uniform for the different fingers and meets the target of 125±25g.

Recommendations:

1. Verify carefully the choice not to use NEG coating for the booster;
2. Large-area NEG coating is the key technical challenge for the vacuum performance. The IARC encourages further prototyping and tests, and close collaboration with projects using the technology at significant scale.

2.18 Polarisation study for CEPC (Zhe Duan)

Comments:

The IARC welcomes the work of the team of particle and accelerator physicists to obtain a small amount of vertical beam polarisation to enable very precise beam-energy calibrations through the resonant depolarisation technique, and to enable collisions with at least 50 percent longitudinal polarisation for either one or both beams. Such possibilities would certainly substantially extend the physics reach of CEPC.

The studies of the self-polarisation of the beams and of the resonance depolarisation technique are impressive. They include defining operational scenarios for the Z pole and WW threshold based on using asymmetrical wigglers to speed up the self-polarisation of a set of pre-injected non-colliding bunches, outlining suitable timing sequences for the successive injections, simulating the expected radiation depolarisation effects and comparing with theoretical models, evaluating the performance of the Compton polarimeter that will be needed and some preliminary studies and specifications for the resonant depolarisation process. What was not described is the precision which this scheme is expected to achieve when calibrating the beam energy, and whether any biases or systematics should be considered and evaluated in relation with the described sequences and approaches.

A feasibility study for obtaining significant longitudinal beam polarisation at the IP, based on preparing and maintaining highly polarised bunches for continuous injection into the collider was also presented. Investigating the maintenance of the polarisation in the booster in the presence of errors is underway. Spin rotators to rotate the polarisation from vertical to longitudinal at the IPs have been successfully implemented into the collider lattice and their performance has been studied. The overall circumference will need to be increased to accommodate the spin rotators, by about 2.8 km at a first estimates, and the dynamic aperture is slightly reduced and will require further optimisation. More comprehensive studies of spin depolarisation effects, including from the beam-beam interaction, are planned.

Recommendations:

1. Adequate space should be provided in the TDR lattice for the polarimeters foreseen to measure the vertical beam polarisation as part of the energy calibration scheme based on resonant depolarisation;

2. Obtaining significant longitudinal polarisation for the colliding beams at CEPC is an attractive future possibility. There should be provision in the baseline TDR design to keep this possibility open in the future. In particular, the IARC supports the extension of the CEPC circumference e.g. by an extra 2 or 3 km needed to accommodate spin rotators, in view of the significant advantages provided by polarised beams for the physics programme;

3. Beam polarisation is a strong advantage as long as providing it does not imply compromising the luminosity too much. The trade-off between luminosity and polarisation can be evaluated in the context of different physics channels;

4. The accuracy required on the degree of polarisation for the physics programme needs to be known. While this is physics-channel dependent, having some general figure of merit would be useful to specify the precision needed for polarimeters, and to assess the level beyond which for instance beam-beam depolarising effects should be considered an issue.

2.19 Road map for the plasma acceleration technology (PWFA) at CEPC (Dazhang Li)

Comments: The IARC congratulates the group on the significant progress that has been made. As agreed with the team during the previous IARC review, the work on PWFA is not yet at a sufficiently advanced stage to be included in the TDR. Instead, it will be included as an Appendix. The difficulty in obtaining reliable simulations of noise with the appropriate parameters was noted. The hosing instability appears to limit operation for transformer ratios ¿ 1.5. However, using a transformer ratio of around 1.8 should be acceptable. Transverse and longitudinal offset tolerances have been studied, which are considered the most important parameters. Others studied have included driver/trailer pointing jitter, plasma density variation, driver/trailer energy spread and variation in charge, bunch lenth, beam size etc. This work is ongoing and will be continued for the next few months, including improvements to the way the QuickPIC simulation program treats noise. Work on positron acceleration has continued and simulations have been used to improved operational parameters. The group intend to fix the positron parameters by around October. Although the proposals from the team to run tests at FACET-II on their ideas for positron acceleration were warmly received, they have yet to be scheduled and the FACET-II positron programme is itself delayed.

The new baseline for the linac, with S-band and C-Band sections, leads to problems for the PWFA option as it is difficult to obtain a drive beam with sufficient charge for the transformer ratios required from a C-band machine. There is interest in reducing the number of electron guns; this could be achieved by bisecting a single beam using a collimator as carried out at FLASHForward at DESY and detailed in Schroeder et al, J. Phys.: Conf. Ser. 1596 012002.

Recommendations:

1. The team should aim to include a level of detail in the Appendix similar to that for a CDR, which requires a conceptual design of the complete system;

2. Although some of the work presented meets such a level, there are significant holes in what has been communicated to the IARC. For example, de-

tails of the plasma call, method of plasma production, gas system, plasma composition, have not been reported, or at least not recently. In addition, cooling of the cell, which must operate at 100 Hz, may not be trivial and should be investigated;

3. The functioning of the PWFA system as a replacement for the C-band linac depends critically on the beam parameters emerging from the S-band linac. These need to be clarified before the TDR for the linac is completed and if necessary iterated to take into account the requirements for the PWFA system, since it is likely that the requirements from the PWFA will be significantly more stringent than for normal operation with the baseline C-band linac;

4. Since the PWFA system is incompatible with the C-band linac, a suitable bypass must be envisaged if the PWFA is to be added at a later stage.

2.20 Power source and electrostatic deflector (Zhe Duan)

Comments:

The IARC congratulates the group on the significant progress that has been made. The prototype of the electrostatic separator has been tested. During high-voltage tests, an arc has been observed at around 90 KV. Though this is higher than the requirement for Higgs Mode operation of 75 KV, high-voltage conditioning to increase the voltage limit will be continued.

The R&D status of the power supplies of the booster magnets has been also shown. The stability of the prototype has been shown to meet the requirements.

Recommendations:

1. Evaluate the merit and demerit of electrical-energy recovery during deceleration of the booster, stored in the inductance of large magnets.

2.21 Control system outlook (Gang Li)

Comments: Steady progress on the design of the control system has been shown. The control network will be divided into several clusters to avoid contentions from EPICS broadcast traffic. A plan for the timing distribution of machine-protection systems and for other systems, with the overall control system, has been shown. Though the RF timing distribution is also the part of the timing system that is managed by the control system, the specifications are still under discussion with the RF group. The IARC believes that more resources should be devoted to the design and the evaluation of the timing system, as the scale of the system is enormous. Since there might be many users who need to use the timing signals after their generation, the system should have enough capacity in every local control room for the number and kind of timing signal likely to be required by users. The IARC also encourages the evaluation of new technology, such as White-Rabbit-based systems, which might reduce cost for the sections where precise timing is not so necessary.

Recommendations:

1. Conclude discussions with the RF group on control-system specifications;

2. Devote sufficient resources to the design and evaluation of the timing system;

3. Investigate new technological developments, particularly for those sections where precise timing is unnecessary.

2.22 Machine protection and beam dumps (Guangyi Tang)

Comments:

The active and passive machine protections are designed based on the radiological impact analysis on synchrotron radiation, random beam loss, hot spots and environment. The synchrotron radiation and random beam loss sources in the accelerator tunnel have been analysed. Dose distribution and activation analysis in the tunnels has been simulated with FLUKA and used to evaluate the absorbed dose of the insulating materials in the accelerator magnets. The effect of the lead shielding thickness on dose reduction has been analysed. A preliminary design of the collider dump has been made and reported. Although the number of beam dumps has not been decided yet, the IARC recommends that fast beam-abort systems and the beam dumps near to each beam detector should be prepared, in order to protect the detectors from catastrophic beam loss. Increasing the number of beam gaps for the abort kicker to abort the beam as soon as possible should also be considered. The estimated time delay to dump the beam of about 1 ms seems too slow.

Recommendations:

1. Prepare fast beam-abort systems and beam dumps near to the beam detectors;

2. Increase the number of beam gaps for the abort kicker;

3. Re-evaluate the time required to dump the beam in order to ensure the safety of sensitive components and detectors;

4. Use radiation-resistant insulation material for the CEPC magnet coils to reduce the thickness of lead material used to protect the coil insulation;

5. For air activation, evaluate both internal and external exposure for staff or the public;

6. Double check shielding calculation, and make comparison between calculated results and other relevant data from similar projects, such as FCC;

7. Check the working temperature upper limit of the graphite core at the collider dump to choose the proper design value;
8. Make mechanical stress analysis for the whole collider dump.

2.23 Alignment R&D and installation strategy (Xiaolong Wang)

Comments:

The IARC was very impressed by the progress reported, including overall system and project approaches to both alignment and installation planning.

Alignment requirements in the 50/100 μm range were presented. The plan is to deal with deformations and re-adjustment in the shutdowns, since dynamic adjustment systems are not included in the stands. The IARC is unclear as to whether this is a good decision, since it requires a cost versus machine-downtime risk evaluation that has not been presented to the committee. Such adjustments are likely to be more critical for elements close to the interaction point.

The installation is planned in agreement with the civil engineering schedule over almost 4 years. As discussed in Section 2.24, the installation plan is not yet at the level required for the TDR, particularly in the area of logistics and component flow. Also personnel safety during installation is of critical importance and must be part of a comprehensive safety plan. The installation requires movements of many heavy delicate objects on the surface and into the tunnel and is inherently one of the most critical and risky parts of the project, both for personnel and components.

A visual instrument is being developed to provide high efficiency/precision measurements for photogrammetry, distances and angles. The IARC encourages this development, while noting that, although it would increase the speed of the alignment procedure significantly, it is not essential to complete the installation work.

Recommendations:

1. More details in the installation plan concerning logistics, time-estimate, *in situ* checks and component flow in general will be needed for the TDR;
2. A plan for personnel safety during installation must be drawn up as part of a comprehensive safety plan for CEPC;
3. The choice to not provide dynamic adjustment to beam elements via support stands should be better justified and explained, at least for the most critical components.

2.24 Infrastructure, Auxiliary Facility and site selection for CEPC (Xiao Yu)

Comments: The IARC congratulates the team on the continuing high quality and volume of work that is being produced in this area. Three companies are now involved involved in the site preparation work:Huadong Engineering for the Huzhou site, Zhonghan Engineering for the Changsha site and Yellow River Consultants for the other five possible sites. The local governments of many of the prospective sites have been very supportive and proactive. The Quinhuangdao, Huzhou and Changsha sites were reported to the IARC in more detail but most of the systems described are site independent. The geological and elevations of these sites were described. Possible "science city" and other surface buildings were discussed. As were auxiliary systems, including electrical, HVAC (Heating, Ventilation and Air Conditioning), Cooling water and Compressed Air systems were discussed in considerable detail. The electrical design is currently based on the baseline specification of 30 MW beams at the Higgs. The overall site power for 50 MW beam power increases only from 270 MW to 350 MW. The cooling water requirements for the site ranging from $30-40,000m^3$/hour seem large and care must be taken to ensure that this is available on all candidate sites. A detail discussion of the construction schedule was given. The entire project takes 8 years, of which civil works take up 63 months. The choice for construction between drill and blast and TBM is still open; currently D&B is slightly cheaper but the tendency is towards TBM being eventually the cheaper option - at the moment they are comparable. The overall schedule is insensitive to this choice.

Recommendations:

1. The TDR should produce a site-independent cost and the sites will be treated on a equal basis in the document;
2. The upgrade to 50 MW ought to be taken into account in the design of the electrical system in order that the upgrade path remains open;
3. The construction schedule, while remaining site independent, needs to be given in greater detail for the TDR. Elements of this, with installation plan, are to be found in the presentation on Alignment and Installation. This needs to be integrated with the schedules in this section to form an overall master schedule;
4. Check the cooling-water requirements and that these can be provided in all prospective sites;
5. There has been little discussion of safety issues in any presentation. An overall safety master concept, properly integrated with the full installation schedule, needs to be presented in the TDR.

3 Program and IARC members

Tuesday	09:00	15:00	15'	IARC members	Closed session	
	09:15	15:15	25'+5'	Jie Gao	Overview of CEPC R&D status for TDR	1
	09:45	15:45	25'+5'	Yiwei Wang	The lattice and dynamic aperture optimization for collider	2
	10:15	16:15	25'+5'	Dou Wang	Boost lattice and error study	3
	10:45	11:00	15'		Break	
	11:00	11:30	25'+5'	Yuan Zhang	Impact of Beam-beam effect in CEPC	4
	11:30	17:30	25'+5'	Jiyuan Zhai	Superconducting RF system and design and R&D Progress	5
	12:00	18:00	25'+5'	Mei Yang	Normal conducting magnets for booster and collider	6
	12:30	18:30			Adjourn	
June 8th 2021	09:00	15:00	15'	IARC members	Closed session	
Wednesday	09:15	15:15	25'+5'	Jinhui Chen	Pulse generator,septum and kicker for injection and extraction	10
	09:45	15:45	25'+5'	Jingru Zhang	Linac key technology and its prospect	11
	10:15	16:15	25'+5'	Zusheng Zhou	P-band and C-band RF power source progress	12
	10:45	11:00	15'		Break	
	11:00	11:30	25'+5'	Sha Bai	MDI study upgrade	7
	11:30	17:30	25'+5'	Na Wang	Collective instability and countermeasures to collider, booster and damping	8
	12:00	18:00	25'+5'	Xiaohao Cui	Timing and bunch pattern for different operation energies and t	9
	12:30	18:30			Adjourn	
June 9th 2021	09:00	15:00	15'	IARC members	Closed session	
Thursday	09:15	15:15	25'+5'	Qingjin Xu	High magnet field with high temperature superconducting techn	13
	09:45	15:45	25'+5'	Rui Ge	Cryogenic System for CEPC	14
	10:15	16:15	25'+5'	Yanfeng Sui	Instrumentation and beam diagnostics	15
	10:45	11:00	15'		Break	
	11:00	11:30	25'+5'	Haijing Wang	Mechanical system and MDI pipes, collimator and supporting str	16
	11:30	17:30	25'+5'	Yongsheng Ma	Vacuum system and the NEG coating to the narrow chamber	17
	12:00	18:00	25'+5'	Zhe Duan	Power source and electrostatic deflector	20
	12:30	18:30			Adjourn	
June 10th 2021	09:00	15:00	15'	IARC members	Closed session	
Friday	09:15	15:15	25'+5'	Dazhang Li	Road map for the plasma acceleration technology at CEPC	19
	09:45	15:45	25'+5'	Bin Chen	Polarization study for CEPC	18
	10:15	16:15	25'+5'	Gang Li	Control system outlook	21
	10:45	11:00	15'		Break	
	11:00	11:30	25'+5'	Guangyi Tang	Machine protection and beam dumps	22
	11:30	17:30	25'+5'	Xiaolong Wang	Alignment R&D and installation strategy	23
	12:00	18:00	25'+5'	Xiao Yu	Infrastructure, Auxiliary Facility and site selection for CEPC	24
	12:30	18:30			Adjourn	
June 17th 2022	09:00	15:00	30'	ALL	Discussions, additional Q&A	
	09:30	15:30	150'	IARC members	Closed session for document redaction	
	12:00	18:00	60'	ALL	Report presentation	
	13:00	19:00			Adjourn	

Presentations are available at:
https://indico.ihep.ac.cn/event/16801

Committee members for this meeting:

- Philip Bambade (IJCLab)
- Maria Enrica Biagini (INFN Frascati, chair)
- Brian Foster (John Adams Institute, Oxford)
- Katsunobu Oide (CERN/KEK)
- Norihito Ohuchi (KEK)
- Carlo Pagani (INFN Milan)
- Anatoly Sidorin (JINR)
- Steinar Stapnes (CERN)
- Makoto Tobiyama (KEK)
- Zhentang Zhao (SARI)