SUMMARY: JOINT SESSION OF OTHER TECHNOLOGIES AND ENERGY EFFICIENCY

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Abstract

This paper summarizes the presentations and discussions at the joint session of "Other Technologies" and "Energy Efficiency." It also highlights several key issues for R&D in these fields.

INTRODUCTION

For future high energy high luminosity e+e- colliders such as FCC-ee and CEPC, power consumption is a critical issue. The synchrotron radiation power for the two machines is 100 MW each in their present design. Due to limited efficiency to deliver energy to the beam, the wall plug power would be substantially higher than 100 MW. For example, Figure 1 shows the relative power consumption of each system in the CEPC design [1].

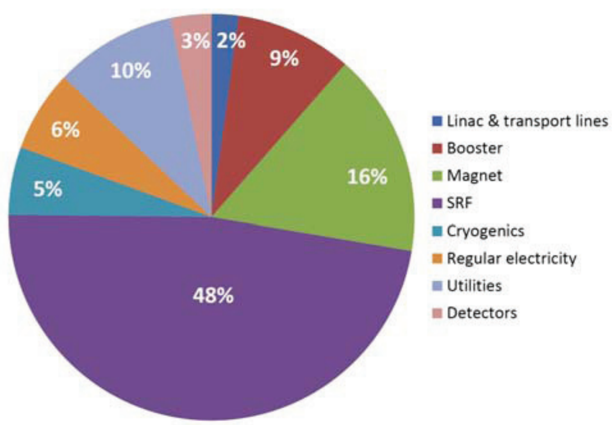

Figure 1: Relative power consumption of each system in the CEPC.

The total power is about 500 MW, which is almost an order of magnitude higher than the power consumption at Fermilab during Tevetron running (58 MW), and three times as high as that at CERN during the 2012 LHC running (183 MW). Assuming 4,000 hours for annual collider operation (i.e., 1.5 Snowmass unit), the electricity alone would cost RMB 1 billion (about USD 150 million). Apparently this is a key R&D item and one has to find a more efficient way to deliver power to the beam.

From Figure 1, it can be seen that the two biggest power consuming systems are SRF (48%) and magnet (16%). This session has two presentations on improving SRF system efficiency (high efficiency klystrons by David Constable and Ken Watanabe, respectively). And one presentation on improving magnet efficiency (Frank Zimmermann).

This session also has two presentations on beam dump, one by Armen Apyan on traditional beam dump, another by Alex Chao on a novel beam dump concept based on beam-plasma interaction. The latter has the potential to recycle the dumped beam energy so the overall energy efficiency of the collider would be improved.

This session also has a presentation by Oleg Malyshev discussing NEG coating and its recent progress.

HIGH EFFICIENCY KLYSTRON

The wall power is delivered to the beam through a number of steps: modulators, klystrons, waveguides, SRF power coupler, cavity, etc. Among them, the klystron efficiency is the key because it is relatively low (40-50%) compared to other components. Therefore, in order to reduce the collider power consumption, one needs to focus on improving the klystron efficiency.

Constable presented the work of the HEIKA collaboration [2]. Its goal is to increase the efficiency of the FCC-ee HEKCW tube to 90%. The klystron uses multiple beams (16) and employs non-traditional bunching mechanism: one called core oscillation method (COM), another called bunching-alignment-collection (BAC) method. Figure 2 is an illustration of COM. As a proof-of-principle test, a SLAC 5045 S-band klystron has been retrofitted using the BAC scheme and is scheduled for testing in 2016. The efficiency is expected to increase from current 45% to 62.5%.

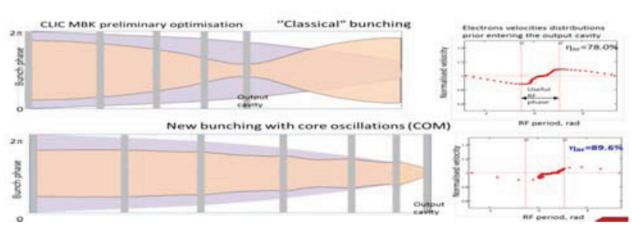

Figure 2: Comparison of the traditional bunching (top) and core oscillation method (COM, bottom). The simulation shows the latter has an efficiency of 89.6% (bottom right).

Watanabe reported the work at KEK in collaboration with Toshiba [3]. It uses a different method called collector potential depression (CPD), which was developed for gyrotron. An insulator is inserted between the body and the collector so a high voltage of Vc (30 kV) can be applied to the body for energy recovery. (Figure 3) A Toshiba E37703 tube was tested and the efficiency was increased from 42% (without CPD) to 62% (with CPD).

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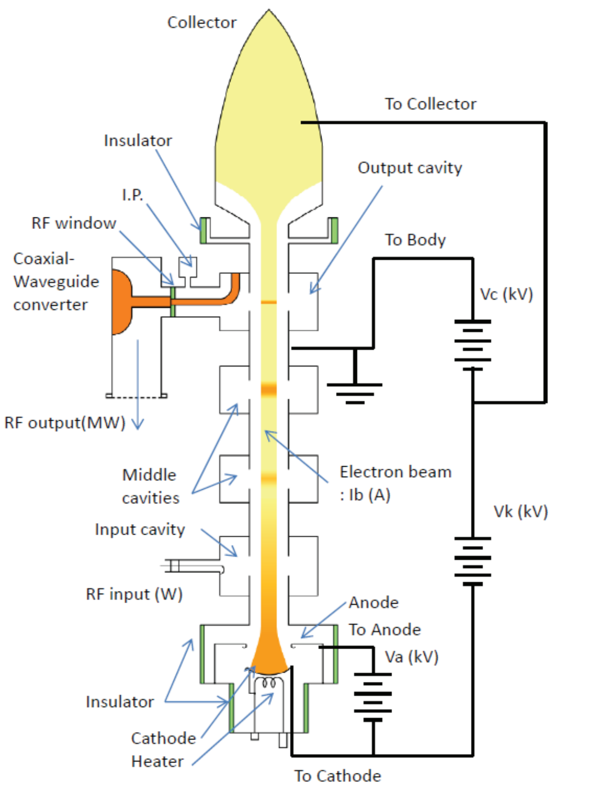

Figure 3: Illustration of a CPD klystron.

NEW MAGNET DRESIGN

Zimmermann presented a new twin-aperture design for FCC-ee dipoles and quadrupoles [4]. (Figures 4 and 5) In addition to their compact size, one big advantage is power saving. If two single aperture quads are used, the total power of the FCC-ee quadrupoles would be 43 MW. But for twin-aperture quads, it is reduced to 21.5 MW, a reduction of 50%.

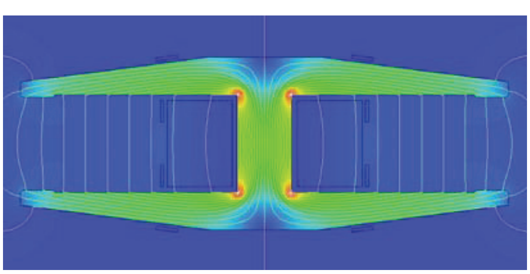

Figure 4: FCC-ee twin-aperture dipole.

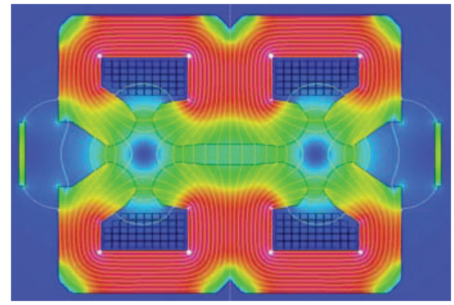

Figure 5: FCC-ee twin-aperture quadrupole.

BEAM DUMP

Apyan presented a design for the FCC-ee extraction line consisting of an abort kicker, a septum, a dilution kicker and an absorber [5]. (Figure 6) It is similar to the LEP beam dump but needs to absorb 0.4 MJ/beam. The absorber is made of aluminium and graphite.

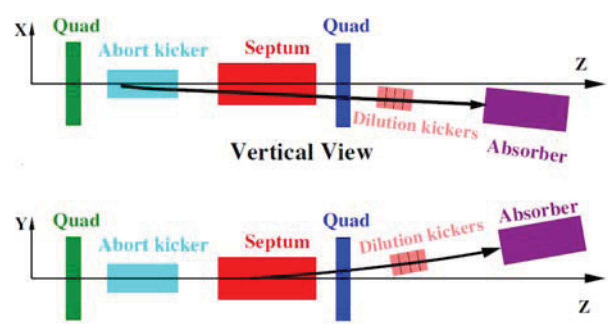

Figure 6: FCC-ee beam extraction line.

Chao reported the formation of a study group of “Green ILC Beam Dump,” including members from KEK, University of California at Irvine, ELI-NP, SLAC and LAPP/IN2P3 [6]. It is funded by JSPS. It uses plasma wakefield deceleration for beam dump replacing solid or liquid absorbers. (Figure 7) The simulation shows that when a beam is dumped into a plasma, it loses 15% of energy after 3 meters. In principle, the dumped energy can be recovered and turned into electricity.

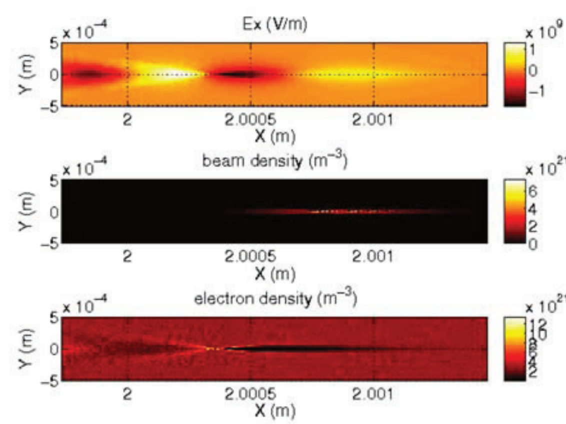

Figure 7: Plasma-beam deceleration simulation.

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NEG COATING

Malyshev discussed the recent progress of the NEG coating technology. Unlike NEG strips, which act as a vacuum pump, NEG coating acts as a barrier that prevents gas particles (H_2, CH_4, CO, CO_2, etc.) from being desorbed from the pipe surface. (Figure 8) The activation temperature is relatively low (190 °C). It has been successfully applied in ESRF (France), ELETTRA (Italy), Diamond (UK), Soleil (France) and LHC straight sections. It is also the choice for the CEPC vacuum chamber eliminating the need of an antechamber (as in the LEP).

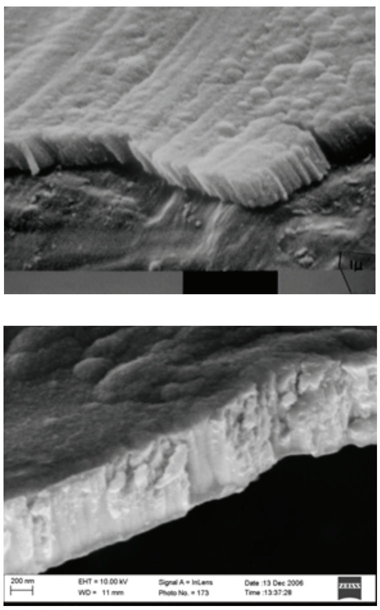

Figure 8: SEM image of NEG coating: top – columnar, bottom – dense.

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