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The Circular Road to a Higgs Factory and Beyond

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After the discovery in 2012, by the CMS and ATLAS experiments, of a Higgs boson at 126 GeV, a circular e+e- "Higgs factory"operating at about 15% higher beam energy than the late LEP collider has become an attractive option for the next step of particle physics, allowing for highest-precision measurements of this remarkable particle. If constructed in a new tunnel with a circumference of 80-100 km such a machine, in the following called "TLEP,"has the potential to deliver some 500 times the LEP luminosity simultaneously to each of four experiments. More specifically, the proposed TLEP machine covers the full energy range from the Z pole up to above the top quark pair threshold, with luminosities ranging from close to 1e36 cm-2s-1 per IP at the Z ("Tera-Z factory") to about 1e34 cm-2s-1 at the top threshold. Beam polarization at energies up to the W pair threshold should be possible, allowing exquisite energy calibration by resonant depolarization. Importantly, TLEP also provides a path towards a later very high energy LHC ("VHE-LHC"), with a centre-of-mass energy approaching 100 TeV in pp collisions: VHE-LHC and TLEP would be housed in the same tunnel and could share a large part of the infrastructure including experimental caverns, magnets, and major detector components. Such a complex could also provide highest-energy highest-luminosity ep and eA collisions.
In this contribution we present tentative design parameters for TLEP and VHE-LHC, discuss a few fundamental concepts, and describe the main challenges. For example, the short beam lifetime in TLEP, due to radiative Bhabha scattering, requires –in addition to the collider ring –a fast cycling accelerator ring for quasi-continuous top-up injection. Further, to mitigate and suppress an additional lifetime reduction due to beamstrahlung, a large momentum acceptance and a low vertical emittance are needed. Many of TLEP's novel design ingredients –such as an insertion with beta* equal to or less than 1 mm, and operation with beam lifetimes of a few minutes –will soon be demonstrated at SuperKEKB. By comparison, VHE-LHC is easy from the accelerator-physics point of view. The required key technologies comprise a high-power SRF system for TLEP and high-field magnets for VHE-LHC.

Primary author: OIDE, Katsunobu (KEK)

Co-author: Dr ZIMMERMANN, Frank (CERN)

Presenter: OIDE, Katsunobu (KEK)

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