The Large Hadron Electron Collider (LHeC) is a proposed facility for deep-inelastic electron-proton/nucleus scattering, realized by colliding one of the two LHC proton (or heavy-ion) beams with 60 GeV electrons provided by a new accelerator. Following the release of its conceptual design report in 2012, the configuration of an energy recovery linac with racetrack shaping has been chosen as the LHeC baseline.

In parallel the design of an LHeC Test Facility (LTF) has been advanced. Aside from various other technical and physics goals, this test facility will, in particular, aim at investigating the ERL principle in an LHeC-like configuration, including electron injection and return-arc magnets, at providing a test stand for superconducting SRF cavity modules, as well as at performing some LHeC-related detector R&D. One possible user application of the LTF beam is for generating controlled beam induced quenches of SC magnets. A planned staged construction of the LTF, including a number of well-defined intermediate steps, will lead to an ultimate beam energy of about 1 GeV.

LHeC ERL main parameters

<table>
<thead>
<tr>
<th>TARGET PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUM. TURNS (MW)</td>
<td>900</td>
</tr>
<tr>
<td>NORMALIZED EMITTANCE μm [µm]</td>
<td>50</td>
</tr>
<tr>
<td>BEAM CURRENT [mA]</td>
<td>&gt;70</td>
</tr>
<tr>
<td>BUNCH SPACING [ns]</td>
<td>25 [10]</td>
</tr>
<tr>
<td>PASSES</td>
<td>3</td>
</tr>
</tbody>
</table>

Proposed Staged Design

The ERL test facility is designed to be constructed in stages. A first phase with recirculation would only use two 4-cavity cryomodules and single recirculation — it could reach 150 MeV [Fig. 1]. A second phase could feature multi-pass operation to reach 300 MeV [2 passes] or 450 MeV [3 passes] [Fig. 2]. Adding two more cryomodules could boost the top energy to 900 MeV [Fig. 3].

In its full energy version, the ERL test facility will consist of two anti-parallel linacs with two 4-cavity cryomodules in each. Vertical spreaders/combiners separate the beams into up to 3 vertically separated arcs, each of which is optimized for its nominal energy. The highest energy arc is adjusted in length to assure arrival in the deceleration phase when entering the linac again.

Transport Optics

Appropriate recirculation optics are of fundamental concern in a multi-pass machine to preserve beam quality. The design comprises three different regions, the linac optics, the recirculation optics and the merger optics. Due to the demand of providing a reasonable validation of the LHeC final system our designed is, at present, involving a FMC cell based lattice. Specifications require isochronicity, path length controlability, large energy acceptance, small higher-order aberrations and tunability. An example layout which fulfills these conditions is shown in Fig. 4 and it describes the optics solution for the lower energy arc.

Linac Design

Multi-Pass Linac Optics

Complete lattice for Pass 1 including Linac1 (5 MeV to 155 MeV), Arc1 (155 MeV), Linac2 (155 MeV to 300 MeV), Arc2 (300 MeV).

Horizontal (red curve) and vertical (green curve) beta-functions amplitude are illustrated. Blue and black curves show, respectively, the evolution of the horizontal and vertical dispersion.

Cavity and cryomodule concepts

The frequency for the RF cavities has been chosen to be 801.58 MHz serving at low RF power levels, high beam stability thresholds and synergies with the existing SPS RF system and HL-LHC upgrade project by providing a higher-harmonic RF system for the HL-LHC. The cavity design is based on existing SPS and ALAB experience. HMS dampers will have to be designed for 3 accelerating and 3 decelerating passes, adding up to 80 mA and thus have to cope with substantial power. JLAB has already designed an 805 MHz cryomodule for SNS, which is a good starting point for the 802 MHz design.

CONCLUSIONS

The test facility will have a variety of important goals: the development of superconducting RF at CERN under realistic operational beam conditions, with high gradients for continuous wave operation (> 20 MV/m) and of high quality Q<sub>0</sub> > 10<sup>11</sup>, the development of high-current electron sources, which are also required for the FCC-ee, and further applications, such as magnet test tools in a low-radiation environment and detector test tools with an electron beam of up to 70 MeV. An initial cost estimate will be given with a preliminary Conceptual Design Report by the end of 2015. Further work on the concept is planned.

FUTURE READINGS


ABSTRACT

The Large Hadron Electron Collider (LHeC) is a proposed facility for deep-inelastic electron-proton/nucleus scattering, realized by colliding one of the two LHC proton (or heavy-ion) beams with 60 GeV electrons provided by a new accelerator. Following the release of its conceptual design report in 2012, the configuration of an energy recovery linac with racetrack shaping has been chosen as the LHeC baseline.

In parallel the design of an LHeC Test Facility (LTF) has been advanced. Aside from various other technical and physics goals, this test facility will, in particular, aim at investigating the ERL principle in an LHeC-like configuration, including electron injection and return-arc magnets, at providing a test stand for superconducting SRF cavity modules, as well as at performing some LHeC-related detector R&D. One possible user application of the LTF beam is for generating controlled beam induced quenches of SC magnets. A planned staged construction of the LTF, including a number of well-defined intermediate steps, will lead to an ultimate beam energy of about 1 GeV.

Staying open has been identified with the MEGA project at Mainz University, help with the design and construction of the 802 MHz cavities and cryomodules will result from collaboration with JLAB, who have already contributed significantly to the lattice and with their relevant experience operating CERN in ERL mode.

ACKNOWLEDGMENT

The project has received funding from the European Unions Seventh Framework Programme for research, technological development and demonstration under grant agreement no 291055.

INTERNATIONAL COLLABORATIONS