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ERL17 WORKSHOP, WG2 SUMMARY: OPTICS, BEAM DYNAMICS AND INSTRUMENTATION

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During the workshop a number of interesting projects were discussed: ERL at KEK, ALICE, PERLE, LHeC, eRHIC, CBETA, ERL for MESA and bERLinPro; a nice mixture of future, existing and past facilities. As a message for future ERL facilities, past operational experience and optimization efforts from ALICE were highlighted (P. Williams/Daresbury). Importance of implementing separate diagnostics for the lattice and the beam was emphasized along with a need for simulations aimed at step-by-step modeling of procedures one needs to exercise to establish the beam conditions defined by milestones of the project. Valuable experience of high charge per bunch operation of compact ERL at KEK was also presented (T. Miyajima/KEK).

Three talks were devoted to beam dynamics challenges of CBETA (G. Hoffstaetter/Cornell, C. Mayes/SLAC, S. Berg/BNL); covering lattice design, magnet technology and orbit control. With four different energies CBETA becomes a test-bed for multi-pass beam dynamics issues, such as: time of flight control for beams with energy spread and the recirculative BBU (addressed by cavity design with strong damping).

Extending the quest for more passes in a racetrack ERL, optimized linac optics for 5-pass ER@CEBAF was presented. Multi-pass energy recovery in a racetrack topology explicitly requires that both the accelerating and the decelerating beams share the individual return arcs. This in turn, imposes specific requirements for the TWISS function at the linacs ends.

As an ultimate application of multi-pass ERLs the FFAG, 6-pass e-RHIC ring was highlighted (V. Ptitsyn/BNL). Here, CBETA will provide an important synergistic input. Even so, recently the Ring-Ring option has become more in the focus for the eRHIC design, there are still efforts on ERL-Ring option for eRHIC.

A comprehensive review of beam dynamics driven design of the LHeC, 60 GeV ERL was presented (D. Pellegrini/CERN), which is probing the longitudinal acceptance limits in high energy ERLs. Extreme synchrotron radiation effects (almost 2 GeV energy loss around a 3-pass racetrack) were simulated to assure that the SR induced energy spread and corresponding emittance dilution due to quantum excitations will not impede the energy recovery process on the decelerating passes. These effects along with beam-beam, short and long range wake-fields and imperfections were simulated with PLACET2 and ELEGANT. The resulting End-to–End simulation showed acceptable levels of energy spread and emittances all the way to the dump, vastly dominated by the synchrotron radiation effects.

Probing the limits of virtual power vs RF power in high current ERLs, two presentations on rapidly developing bERLinPro highlighted the overall design and project commissioning status (A. Jankowiak/HZB), as well as the beam dynamics challenges of the extreme high current (100 mAmp) operation (M. Abo-Bakr/HZB). In the same category of high power ERLs, PERLE – the newly proposed ERL Test Facility at Orsay – was introduced (W. Kaabi/LAL) along with its current layout and optics design (A. Bogacz/JLAB). A future R&D program was presented to fully develop a Technical Design Report, which will require work in the following areas:

- Liner lattice optimization and initial magnet specs
- Momentum acceptance and longitudinal matching
- End-to-End simulations with synchrotron radiation, CSR micro-bunching (ELEGANT)
- Correction of nonlinear aberrations (geometric & chromatic) with multipole magnets (sextupoles and possibly octupoles)
- RF cavity design, HOM content BBU studies (TDBBU)
- Injection line/chicane design space-charge studies at injection
- Diagnostics & Instrumentation
- Multi-particle tracking studies of halo formation
- Final magnet specs
- Engineering design

Operational experience of another superconducting linac based nuclear physics user facility – MESA – was described (F. Hug/U. of Mainz). This two-pass, high current (10 mAmp) ERL truly excels in versatility providing highly polarized beams to large number of experiments.

Finally, a clever lattice mitigation scheme for CSR/micro-bunching suppression was presented (C. Tennant/JLAB). As the lattice figure of merit, a variation of M_{56} (max value of M_{56} across the lattice) was chosen. Two lattices with diverse values of M_{56} variation were simulated with ELEGANT, introducing initial density fluctuation 'seed' and looking for the onset of micro-bunching instability. The results revealed striking suppression of instability growth for the case of minimum M_{56} variation.

In summary, we witness a rather vigorous development of new ERLs, aggressively pushing the limits:

- Maximizing number of passes
- Maximizing virtual beam power
- Opening longitudinal acceptance
- Mitigation of limiting factors: BBU, CSR/micro-bunching
- Diagnostics & Instrumentation for multiple beams
- Multi-particle tracking studies of dark current and halo formation (M. McAteer/HZB).

A bright future can be expected for the field.