Contribution ID: **69** Type: **not specified**

Future Opportunities with Lepton-Hadron Collisions

Deep Inelastic lepton-hadron Scattering (DIS) is a cornerstone of particle physics discovery and the precision measurement of the structure of matter. This document surveys the international DIS landscape, exploring current and future opportunities to continue this rich heritage, leading to new understandings and enabling discoveries. Of immediate relevance to the future of the field in Europe, the Large Hadron electron Collider (LHeC) offers an impactful bridge between the end of the HL-LHC and the beginning of the next CERN flagship project, both in terms of technology development and new scientific exploration from Higgs physics to the partonic structure of the proton.

More generally, the facilities described here cover centre-of-mass energies from a few GeV to multiple TeV and address a wide range of physics topics, with unique sensitivity to Quantum Chromodynamics and hadron structure at their core. In addition to their stand-alone importance, these topics enhance the precision measurement and new physics search programmes at hadron-hadron colliders.

The very high luminosity fixed-target CEBAF programme that is in progress at Jefferson Laboratory probes nucleon and light ion structure at large x in novel ways, while high energy neutrino DIS is being enabled at the FASER and SND@LHC experiments by the intense LHC beams; both have exciting potential upgrade programmes. The Electron Ion Collider (EIC) is on course for deployment at Brookhaven in the early 2030s, and will provide lepton-nucleus and double-polarised lepton-proton/light-ion collisions for the first time. Its science includes a 3-dimensional mapping of the internal structure and dynamics of hadrons, leading to a thorough understanding of the mechanisms that generate proton mass and spin, whilst establishing accelerator and detector technologies of direct relevance to next-generation facilities. Adding the LHeC provides a Europe-based lepton-hadron frontier. The LHeC extends DIS capabilities to include a complementary Higgs, top and electroweak programme to the HL-LHC, together with precise determinations of proton and nuclear structure in a kinematic range that improves HL-LHC sensitivities. In the longer term, plasma wakefield acceleration and the Future Circular Collider offer different possible pathways for major steps forward in centre-of-mass energy, extending into a low parton momentum-fraction domain where our present understanding fails and new strong interaction discoveries are guaranteed.

This review emerges from the 'DIS and Related Subjects'conference series, which provides an annual focus for the diverse community of scientists involved in Deep Inelastic Scattering, currently estimated to consist of around 3000 experimental and theoretical particle, nuclear and accelerator physicists worldwide.

Authors: LEVY, Aharon (Tel Aviv University (IL)); CALDWELL, Allen (Max-Planck-Institut fur Physik (DE)); Prof. OLNESS, Fred (Southern Methodist University (US)); ROJO CHACON, Juan (Nikhef National institute for subatomic physics (NL)); NEWMAN, Paul Richard (University of Birmingham (GB)); ENT, Rolf; DALLA TORRE, Silvia (Universita e INFN Trieste (IT))