DRAFT TE 2024-11-29

The ‘Particle Physics at ESS’ meeting on 2024-11-26 of members of the FREIA, the Nuclear Physics and the High Energy Departments at Uppsala University

Participants: Yasin Alekajbaf, Ting Choi, Tord Ekelof, Rikard Enberg, Carlos Perez de los Heros, Gunnar Ingelman, Stefan Leupold, Pawel Marciniewski, Stefano Moretti, Maja Olvegård, Wietse Van Gothem, Magnus Wolke

Agenda

Introduction Rikard Enberg

ESSnuSB Tord Ekelof

HIGHBEAM/NNBAR and REDTOP Magnus Wolke

SEνNS Stefano Moretti

Discussion All

The meeting was organized to discuss the strategy for Particle Physics at the ESS with reference to the remit given to the European Strategy Group for Particle Physics that “the Strategy update should also indicate areas of priority for exploration complementary to colliders and for other experiments to be considered at CERN and at other laboratories in Europe, as well as for participation in projects outside Europe”

The ECFA guidelines for the discussion of the European Strategy for Particle Physics contain three questions. The first question is: *What other areas of physics [than collider physics] should be pursued, and with what relative priority?* In the current situation of elementary-particle physics the intensity-frontier particle-physics area, which is complementary to that of the energy-frontier particle-physics, should be pursued with equally high priority. It may be noted that, quite generally, a very high intensity, lower energy particle accelerator and the experimental equipment required for a Particle Physics program at that accelerator requires significantly less investment funding than any of the proposed future very high energy colliders. The the ESS proton linac, which is planned to produce, when completed, the highest intensity proton drive beam in the world, has very high potential for a series of different intensity-frontier experiments, among those ESSnuSB, HIGHBEAM/NNBAR, REDTOP and SEνNS which all have Uppsala participation and which were reviewed during the meeting.

The two first of these experiments will seek for a confirmation of the two first Sacharov conditions for the existence of matter in the Universe, those of CP violation and Baryon-number violation through measurements of neutrino oscillations and discovery of neutron-antineutron oscillation and proton decay. The third Sacharov condition, that of departure from thermal equilibrium in the early Universe, is one of the problems studied by the HEF Theory Group and is related to the ATLAS group’s studies of the Higgs potential through di-Higgs production. The link that the three Sacharov conditions constitute between the plans for ESS-based research of the FREIA Division, the Nuclear Physics Division and the High Energy Divisions was reviewed by Rikard as an introduction to the meeting. REDTOP is focused on beyond the Standard Model physics by measuring rare decays of the η mesons and searching for light scalar and vector bosons. SEνNS will measure coherent scattering of neutrinos from nuclei with the goal of detecting light gauge bosons like a Z’. These plans and others will be reviewed at workshop on “Fundamental Nuclear and Particle Physics at the ESS” in Lund 15-17 January 2025: <https://indico.ess.eu/event/3663/> . The fact that this workshop is organized by ESS is one of the clear evidences for that the ESS management is supporting a Particle Physics program at ESS.

The second question is: *What are the most important elements in the response to i) Physics potential, ii)   Long-term perspective, iii) Financial and human resources: requirements and effect on other projects, iv) Timing, v) Careers and training and vi) Sustainability.* In the review of the three proposed particle physics experiments ESSnuSB, HIBEAM/NNBAR and REDTOP given by Tord and Magnus the different elements under each of these six points are marked in the attached presentation slides with the lower-case-letters roman-numbers i to vi.

The third question is: *To what extent should CERN participate in nuclear physics, astroparticle physics or other areas of science, while keeping in mind and adhering to the CERN Convention? Please use the current level and form of activity as the baseline for comparisons.* The purpose of the meeting was to discuss the experimental program at ESS. CERN is providing considerable support to DUNE which is an intensity frontier experiment in the US. The CERN support to the intensity-frontier particle physics program at ESS through the ESSnuSB CERN Group is, even if very modest, very welcome. CERN needs to keep diversity in its program and have contacts with other particle physics laboratories in Europe. For the same reason CERN should continue to support non-collider projects at CERN like ISOLDE, SHIP and others. CERN also needs to develop further its eminent accelerator physics capability, in particular by continuing to develop high-field superconducting magnets. However, above all, CERN should aim at being a leading energy-frontier particle-physics research-infrastructure in Europe (and maybe in the world) and as the investment cost of any of the discussed energy-frontier particle-colliders is considerable, CERN will need to reserve the major part of its resources to support the construction of a very high-energy particle collider.