ICHEP 2022 BOLOGNA
ICHEP 2022 XLI
International Conference on High Energy Physics
Bologna (Italy)
6 13 07 2022

Contribution ID: **1092** Type: **Parallel Talk**

High Field Magnet Development for HEP in Europe – A Roadmap by the LDG HFM Expert Panel

Thursday, 7 July 2022 17:35 (15 minutes)

The European Laboratory Directors Group (LDG) was mandated by CERN Council in 2021 to oversee the development of an Accelerator R&D High Energy Physics Accelerator Roadmap. To this end, a set of expert panels was convened, covering the five broad areas of accelerator R&D highlighted in the ESPPU, drawing upon the international accelerator physics community for their membership, and tasked to consult widely and deeply.

High Field Magnets (HFM) is one of these R&D axes and is among the key technologies that will enable the search for new physics at the energy frontier. Approved projects (HL-LHC) and potential future circular machines such as proton-proton Future Circular Collider (FCC-hh) and Super proton- proton Collider (SppC) require the development of superconducting (SC) magnets that produce fields beyond those attained in the LHC.

The present state of the art in HFM is based on Nb3Sn, with magnets producing fields in the range of 11 T to 14 T. We have tackled in the last years the challenges associated with the brittle nature of this material, but we realize that more work is required, and that manufacturing is not yet robust enough to be considered ready at an industrial scale.

Great interest has been also stirred in recent years by the progress achieved on HTS, not only in the fabrication of demonstrators for particle physics, but also in the successful test of magnets in other fields of application such as NMR, fusion, and power generation. This shows that the performance of HTS magnets will exceed that of Nb3Sn, and that the two technologies can be complementary to produce fields in the range of 20 T, and possibly higher.

In this presentation, we lay out the European roadmap for HFM, which will build upon and advance beyond the results achieved over the past twenty years in European and international programs, most notably US LARP and HL-LHC. The R&D program, which is published in [https://doi.org/10.23731/CYRM-2022-001], has two main objectives.

The first is to demonstrate Nb3Sn magnet technology for large-scale deployment. This will involve pushing it to its practical limits in terms of performance (towards the 16 T target required by FCC-hh), and moving towards production scale through robust design, industrial manufacturing processes and cost reduction. The second objective is to demonstrate the suitability of High Temperature Superconductor (HTS) for accelerator magnet applications, providing a proof-of-principle of HTS magnet technology beyond the range of Nb3Sn, with a target in excess of 20 T. These goals are only indicative in nature since the decision on a cost-effective and practical operating field will be one of the main outcomes of the development work.

The proposed roadmap comprises three focus areas: 1) Nb3Sn and HTS conductors, 2) Nb3Sn magnets, and 3) HTS magnets. These are enabled by three cross-cutting activities: 4) materials, cryogenics, and models, 5) powering and protection, and 6) infrastructure and instruments. The methodology of the proposed program is based on sequential development happening in steps of increasing complexity and integration, from samples to small scale magnets, short magnets, and long magnets, to produce a fast-moving technology progression. We are convinced that innovation and fast turnaround are crucial to meeting the declared goals on a reasonable time scale.

The conductor activities, besides the necessary procurements, will focus on two aspects. Nb3Sn R&D will push beyond the state-of-the-art to consolidate the critical current capability establishing robust wire and cable configurations with reduced cost. These will then be the subject of a four-year period of industrialization, which will be followed by a similar period of industrial optimization. On the HTS side, the intention is to identify and qualify suitable tapes and cables and follow up with industrial production to ensure the feasibility of large unit lengths of HTS tapes with characteristics meeting the requirements for accelerator magnet applications. This HTS conductor R&D phase is expected to last for seven years.

The Nb3Sn magnet development will improve on areas of HL-LHC technology that have been found to be sub-optimal, notably the degradation associated with the fragile conductor, targeting the highest practical operating field that can be achieved. The R&D will explore design and technology variants to identify robust design options for the field level targeted. Two tracks have been defined: the development of a 12 T demonstrator of proven robustness suitable for industrialization, in parallel to the development of an accelerator demonstrator dipole reaching the ultimate field for this material, towards the target of 16 T. The magnet technology R&D will progress in steps over a projected period of seven years but is intended to provide crucial results through demonstration magnets in time for the next update of the European Strategy for Particle Physics (ESPP). Another five years are expected to be necessary to extrapolate the demonstrator results to full-length units.

R&D plans for HTS magnets focus on manufacturing and testing of sub-scale and insert coils as a vehicle to demonstrate performance and operation beyond the range of Nb3Sn. A dual objective is proposed: the development of a hybrid LTS/HTS accelerator magnet demonstrator and a full HTS accelerator magnet demonstrator, with a target of 20 T. In addition, attention will be devoted to the possibility of HTS-only magnets, operating in an intermediate temperature range (10K to 20 K), in line with the increasing societal push for energy-efficient infrastructures.

The projected duration of this phase is seven years. A least five more years would be required to develop HTS demonstrators that include all the necessary accelerator features, surpassing Nb3Sn performance or working at temperatures higher than liquid helium. Nb3Sn is today the natural reference for future accelerator magnets, but HTS represents a real opportunity if there will be a steady increase in production scale and price reduction.

In-person participation

Yes

Primary authors: Dr BALLARINO, Amalia (CERN); AUCHMANN, Bernhard (PSI/CERN); Dr SHEPHERD, Ben (STFC); Dr BAUDOUY, Bertrand (CEA, Saclay); Prof. SENATORE, Carmine (University of Geneva); Dr ROCHEPAULT, Etienne (CEA, Saclay); Dr BOTTURA, Luca (CERN); Prof. ROSSI, Lucio (INFN, Milano); Dr GARCÍA-TABARÉS, Luis (CIEMAT); Prof. NOE, Mathias (KIT); Dr FAZILLEAU, Philippe (CEA, Saclay); Dr VÉDRINE, Pierre (CEA, Saclay); Dr PRESETEMON, Soren (LBNL)

Presenter: AUCHMANN, Bernhard (PSI/CERN)

Session Classification: Accelerators: Physics, Performance, and R&D for future facilities

Track Classification: Accelerators: Physics, Performance and R&D for future facilities