2021 Snowmass Process

Letter of Intent on Leading-Edge R&D effort finalized at the Interaction Regions of future Colliders

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Following the successful start of the LHC in 2010 and the Nobel-prize discovery of the Higgs boson in 2012, the LHC has continued to help answer some of the key questions of the age: the existence, or not, of supersymmetry; the nature of dark matter; the existence of extra dimensions as well as continue to study the properties of the Higgs sector.

An improvement of the LHC and its detector, called HL-LHC, has been approved in 2016 to allow the full exploitation of the LHC in the third and fourth decade of this century and to allow unique research opportunities both in fundamental discoveries and in accelerator science.

The United States government is making an investment of more than $750M in the upgrade of the LHC to achieve the High Luminosities necessary to fully exploit the research frontier at the LHC energies. These investments will support the construction of upgraded detectors (CMS, ATLAS) and the construction of new Interaction Regions (IR) designed to increase tenfold the luminosity delivered to the detectors. The new machine, called HL-LHC, is presently in its construction phase. The US is contributing to the Accelerator part of HL-LHC through a DOE approved Project called Accelerator Upgrade project (AUP), to be deployed at CERN for installation and commissioning of HL-LHC in the 2024-2027 period.

This 2021 Snowmass Process plans to map the road for Particle Physics in the upcoming decades for the US HEP community on a global scale. Among the elements of possible future plans, advanced Colliders (Muon Collider, HE-LHC, Large Hadron Colliders such as FCC-hh, SppC, EIC, etc.) will play central roles. It is an historical fact, supported by the present HL-LHC construction, that the technology adopted in the final IR to achieve the highest possible luminosity is of critical importance for the physics reach of the collider mission. It is also well demonstrated by HL-LHC that the IR technology does not have to be identical to the technology deployed in the rest of the machine, but rather that it is beneficial to push the limits of technology to achieve the highest possible Luminosity in the IRs.

It is in this context of "Advance Technology for IR" that **we express the interest to work on a US National plan for the next decades to develop technical solutions for future colliders Interaction Regions.** Starting from the all-important and critical final focusing magnets, we envision a program that covers radiation-resistant materials development, SRF applications for handling of the individual buckets, development of schemes for beam-beam interaction mitigation, etc. in a well-integrated approach to have a plan to obtain as many viable tools as possible for the final collider applications.

We perceive the need to give the highest priority to the development of leading-edge technologies for High Field Magnet to be employed as Final Focusing elements, based on bringing Nb_3Sn application to its natural limit. We believe it is appropriate to push beyond the limits of Nb_3Sn by employing, in a cost effective manner, High Temperature Superconductors. Since the radiation environment at the IRs of any future Collider can be extremely demanding, we perceive also the need for critical studies of materials and solution to withstand the expected increase in deposited doses. In parallel to what has happened for HL-LHC, we expect similar efforts to take place on the study and development of single-bucket handling schemes using SRF Cavities.

We believe the US approach developed in the past in preparation for HL-LHC - with generic R&D Programs (loosely called GARD, and supporting, among other things, High Field Magnets and Conductor Development) interacting with Directed R&D Programs such as LARP (LHC Acc. R&D Program) for the development of specific solution to the specific problem of HL-LHC, finally morphing into a DOE supported Project such as AUP - has the best chances of success.

Short of being the last step of the HFM/CDP -> LARP -> AUP chain, a DOE supported Project like AUP can be the basis for the next push forward. Indeed, the HL-LHC AUP Project can provide a platform where the US community can acquire invaluable knowledge during the production of a large number (~25) of identical Nb_3Sn magnets. While the limitations of a DOE 413.3b Project like AUP do not allow investments on scope beyond the approved project goals, AUP can provide a good platform for the application of some of the technologies developed in the context of more generic US R&D programs. For example, the acoustic sensor system developed by MDP has been implemented – at zero cost to AUP – as a monitoring device to be used during the expected training of the AUP magnets. This and other applications would benefit greatly from the AUP project and we intend to build on the synergy between AUP and other US generic R&D to further US leadership in "Advanced Technology for Colliders IR".

It is not inappropriate to finish this Letter of Intent by saying that in the past the success of the US effort for HL-LHC has been based heavily on an extraordinary collaboration between US Laboratories such as BNL, FNAL and LBNL among others. Projecting the same collaborative spirit to the future can only improve the reach of the US efforts in this field.