R. Calaga, Jun 14, 2012

**Technical Decription**

The overlap of the LHC bunches due to the finite crossing angle leads to significant luminosity loss (60% or larger) for HL-LHC parameters which can only be recovered with the use of a crab scheme. This scheme requires superconducting deflecting cavities at 400 MHz with a compact size to be compatible with the available space in LHC interaction regions.

As a result of an intense R&D program initiated within the LARP and EuCARD networks over the last 4-5 years, novel high performance compact deflecting cavities at 400 MHz have been proposed and are under development. These new topologies make it possible to integrate the cryomodules in the present LHC interaction region and also allow for the horizontal/vertical alternating crossing scheme which is a prerequisite.

**Cost Estimate**

The total cost for R&D and construction of the final 10 cryomodules until 2022 is estimated by CERN to 166 MCHF for manpower, 83 MCHF for material cost and 15 MCHF of material industrial support.

At present the LARP contribution has been significantly ramped up in FY12 to $800k, primarily allocated for cavity design studies of the two U.S. prototypes and beam dynamics studies in the presence of crab crossing. An additional request of 189k was placed from the contingency for material procurement and partial fabrication of the U.S. prototypes.

It is requested to keep the present level of funding with approximately 10% of contingency until FY15 (3 years). A major portion will be directed towards the design and fabrication of HOM couplers and tuners for the two novel designs. In addition, further development and testing of prototype cavities will also be covered under this funding, with the use of existing vertical test facilities both in the U.S. and CERN. Some beam dynamics studies related to beam-beam and machine protection will also be carried under this funding request.

An additional 500k/yr for the next 3 years (FY13-15) is requested to accommodate the FNAL proposal to design and fabricate a prototype cryomodule to host two cavities for SPS beam tests in collaboration with ODU-JLab and BNL. The SPS test is a major project milestone, and has to be done in 2016, to fit in with CERN’s long term planning (see below)

The contribution beyond the prototype cryomodule to construct the final cryomodules will have to be defined within the context of HL-LHC project. The funding for crab cavities inside LARP could be reduced to beam dynamics studies and a small amount to cryomodule design studies to assist during the construction but mainly for the testing of the cavities, couplers and cryomodule systems.

**Schedule and Milestones**

The overall schedule for the R&D and construction of the crab cryomodules is prepared based on the LHC operation and shutdowns over the next 10 years.

1. The first milestone is the cavity validation of the three different designs up to the nominal field in a vertical test setup by the end of 2012 with tests continuing in 2013. In parallel, conceptual designs of a prototype cryomodule for beam tests in the SPS and LHC IR4should be envisaged by the end of 2012. Infrastructure and preparation for the SPS tests such a cryogenic, RF power, instrumentation, RF controls and other services are foreseen to take place in Long Shutdown LS1 and subsequent technical stops until 2015.
2. The second milestone is the construction of a prototype cryomodule with two cavities, to be tested first in the SM18 test facility early 2015 and then installed in the SPS BA4 region in the 2015 technical stop for beams test in 2016, just before LS2.
3. Upon successful beam tests in the SPS and qualification of appropriate safety aspects for the LHC, the construction of 8 cryomodules plus 2 spares will take place between 2016-2020 for series testing and qualification in SM18, to be followed by installation in the LHC.

LARP is already playing a major role in realizing milestone 1. Two of the three candidates are U.S. contributions from ODU-JLab and BNL. A new proposal by FNAL to contribute a significant effort in the R&D of the prototype cryomodule to realize milestone 2 is pending approval.

With these proposed contributions, LARP would continue to play a key role in the LHC and its luminosity upgrade, at the same time maintaining and promoting development of US expertise in the field of novel superconducting RF cavity and cryomodule design.