US LHC Accelerator Research Program
Task Sheet

Task Name: Fiberoptic-based synchrotron radiation beam diagnostics for the LHC

Date: May 31, 2006

Responsible Person: S. DeSantis (LBNL)

Budget for FY07: LBNL $73k

Statement of work:

Introduction:
Many beam diagnostic devices in today's synchrotron rings make use of the radiation emitted by the circulating particles. Such instruments are placed in close proximity of the accelerator, where in many instances they cannot be easily accessed for safety considerations, or at the end of a beamline, which can only move the light port a few meters away from the ring because of its cost.

By choosing an appropriate fiber it is possible to keep attenuation and dispersion at negligible values over a large bandwidth, so that this method would allow to have the diagnostic instruments directly in the control room, or wherever convenient, up to several hundred of meters away from the tunnel. This would make maintaining and replacing instruments, or switching between them, possible without any access to restricted areas.

Additionally, the few components required to be near the ring (lenses and couplers) in order to couple the light into the fiber are intrinsically radiation-hard. Once the synchrotron light becomes fiber-borne, it also becomes possible to use the vast array of optical components developed for high-speed telecommunications, which are characterized by extremely high reliability and relatively low cost, to sample and manipulate the beam signal.

We are currently performing experiments on one of the ALS beamlines to test the efficiency of the coupling process and verify which properties of a light port are important in order to achieve maximum coupling. We are also comparing the measurement of the longitudinal beam parameters using a streak camera measuring the synchrotron light directly at the light port or after ~100 m of optical fiber.

Task Description:
Based on the CERN specifications (LHC-B-ES-0006) for the longitudinal diagnostics of

the LHC beams, our initial calculations indicate that a 50% coupling efficiency over a 10% bandwidth centered at 1310 nm would transmit enough photons at the end of a 200 m long fiber such as to satisfy the requirements (accuracy, resolution, sensitivity) of basically every measurement under consideration. The length of this fiber would allow to bring the diagnostic instruments to ground level, rather than having them remotely controlled in the underground tunnel.

In this task, we plan to perform a complete study of synchrotron-based diagnostics for the LHC. First, we plan to study the optimal optical extraction system in the specific region of the LHC where light extraction is possible. Then, we plan to study the use of existing commercial fibers for the optimal transmission of the extracted light outside the LHC tunnel. In addition, we want to investigate the use of commercially available optical modulators to sample the LHC beams. This involves evaluating how the device parameters match CERN specifications for longitudinal beam diagnostics. The study will consider parameters such as extinction ratio, dynamic range, bandwidth, time resolution, frequency, and is geared at satisfying CERN's specifications. In addition, we plan to prepare a feasibility study and conceptual approach of the beam measurements possible with the extracted light.

Deliverable(s):

A report on the study, covering the design of the extraction optics and of the fiber transmission system. The study will also include a possible implementation of the extracted light for beam measurements.

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Follow on funding requests:

We anticipate to complete this study in one fiscal year. Depending upon the results of this work we will submit additional requests for funding to implement some of the feasible and useful instruments in the LHC, in collaboration with the CERN AB/BI group. We will also plan validation and testing of these techniques at US colliders if the studies show that such tests will be feasible.