(Excerpt from the)
Mission Need Statement

for a

Next Generation B Factory Detector Systems

1. STATEMENT OF MISSION NEED

Since the end of operations of the B-Factory at SLAC in 2008, the U.S. does not have a facility capable of making precision measurements of the properties of B mesons and other types of heavy quarks and leptons. Precision measurements are part of the Intensity Frontier of the particle physics road map developed by the Particle Physics Project Prioritization Panel (P5), a subpanel of the High Energy Physics Advisory Panel. The P5 road map points out that at the Intensity Frontier; scientific opportunities exist in the measurement of rare processes to indirectly probe for scientific discoveries at and beyond the energy range of the Large Hadron Collider. **The panel continues with a recommendation that the U.S. should pursue significant participation in one overseas next-generation *B* factory which would have a luminosity that is 10-100 times greater than the SLAC B-Factory**. A suite of detector systems to utilize these foreign facilities is the needed capability to carry out the recommended program.

2. CABILITY GAP/MISSION NEED

Capability Gap

The U.S. has a capability gap for measuring rare processes involving B mesons and other heavy flavor particles as part of the HEP Intensity Frontier program. The U.S. no longer has an electron-positron collider facility capable of producing B mesons; therefore U.S. physicists are no longer able to pursue Intensity Frontier research on the properties of B mesons and other heavy flavor particles within the U.S. There are two planned facilities, one in Italy and another in Japan to continue this research. U.S. physicists with expertise developed at the SLAC B-factory and the Japanese B-Factory KEKB would be welcome to participate in scientific collaborations that conduct research at the experiments planned for these facilities, if they make in-kind technical contributions needed for the detectors. These facilities will need either upgraded or new detectors capable of handling the higher data rates produced at them. The detectors at high energy physics colliders are typically supplied by the collaborating researchers.

Priority of Mission Need

The HEP strategic roadmap developed by P5 calls for a balanced program of research across all three frontiers: Energy, Intensity, and Cosmic. P5 also called out participation at higher intensity electron-positron accelerator facilities, which are being planned in Japan and Italy, as a worthwhile investment for the Intensity Frontier.

The Super-B Factories are in their planning stages now and will move into their construction phases in the near future. The timely development of detectors capable of exploiting the potential of these new facilities must proceed in parallel.

Other Potential Capabilities

The only other potential capabilities to make high precision measurements of B mesons are the LHC-B experiment at CERN. The high backgrounds at a hadron collider limit the number of precision measurements that can be made. There have been no indications from the LHC-B experiment that they desire new U.S. participation at this time, and there also has been no indication that the U.S. community is interested in pursuing this option.

Impact if Gap is Not Resolved

Failure to approve this mission need will run contrary to the advice of the HEPAP P5 subpanel. Also failure to approve will leave the United States with a diminished Intensity Frontier research program with fewer opportunities for development and implementation of new detector technologies and for training of the future technology workforce.

Benefits from Closing the Gap

A new detector at a Super B Factory could resolve the current flavor puzzles discovered by the previous generation of experiments, help discriminate among new physics identified at the LHC, or even discover evidence for new particles or forces inaccessible to the LHC. The pursuit of this mission would position the United States in the forefront of investigation within the Intensity Frontier in the study of rare processes, and provide valuable experience for scientists working at a facility at the forefront of particle accelerator and detector technology.

Internal/External Drivers

The primary driver is internal. The HEP strategic roadmap developed by P5 calls for this investment as part of a strong and well-balanced U.S. research program. The timing of this investment is being driven by the opportunities presented by development of new facilities in other countries, which would welcome our participation.

3 POTENTIAL APPROACH

Experienced scientific teams along with supporting detector infrastructure exist and can move expeditiously to participate in the construction of major detector systems for either a new or upgraded detector. Two options exist to meet these goals. Option A is the upgrade of the current Belle detector at KEK. Option B is joining the SuperB effort in Italy.

The chosen option was Option A - following the KEK roadmap, the KEKB accelerator will be upgraded in 3~4 years to reach an initial target luminosity of 8×10^{35} $cm^{-2}s^{-1}$ (about 10x the current data rate of the current accelerator complex). The US participated in the present detector and in the subsequent data analysis. The US would continue its participation by taking key roles in the upgrade of the present Belle detector to match the planned upgrade in accelerator capabilities.

The Report from the Comparative Review of Intensity Frontier Projects August 10–12, 2010 looked at proposals for three new initiatives for Intensity Frontier projects. One is for an upgrade of the muon g-2 experiment and the others were for possible next generation B Factory detector systems. Their report strongly endorsed the Belle-II at SuperKEKB proposal. This merit panel pointed out that the Belle-II proposal is an upgrade to an existing facility with little civil construction involved; and KEK has a strong track-record of delivering accelerator projects on schedule. In addition the upgrade is underway. The panel also pointed out that historically there has been a strong US participation in the Belle program.

> *"The SuperKEKB proponents also have a very strong history of producing interesting and important physics results on the Belle experiment. For more than a decade, these groups have been playing a key role in the Belle experiment."*

Further the reviewers found the Belle-II proposal to be very cost-effective and a "good value" for the investment.

The next step is to identify the resources that can be applied to continue this line of research, determine what enhancements will be necessary to meet the new challenges, and determine how these elements fit into the new colliders.