Belle and Belle II experiments

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1 Goal of experiment

The main motivations for the Belle and Belle II experiments at the KEKB collider in Tsukuba, Japan are the study of CP violation (i.e. matter-antimatter asymmetry), the study of heavy flavor, and the search for physics beyond the Standard Model. The Belle measurements of CP violation in the B-meson system, together with those of the BaBar experiment at SLAC, established the Kobayashi Maskawa (KM) mechanism as a valid description of CP violation in the Standard Model. Belle II will be used to perform precision-measurements of CP violation, and to carry out a broad search for new physics that is complementary to efforts at the energy frontier [1, 2, 3].

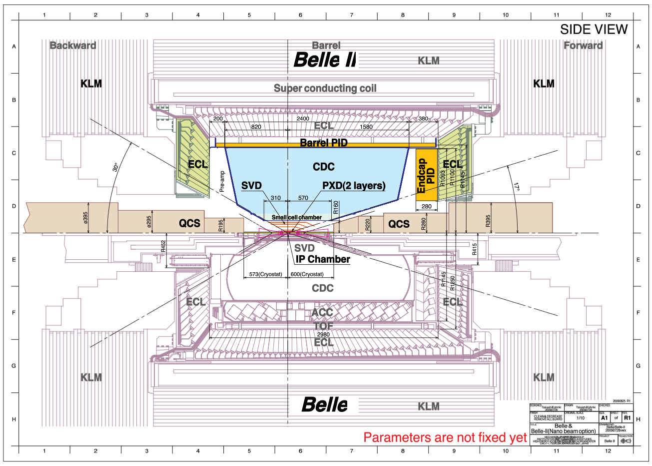

Figure 1: Upgraded Belle II spectrometer (top half) as compared to the present Belle detector (bottom half) [4].

2 Experimental setup

The Belle detector is a large-solid-angle magnetic spectrometer, which consists of a silicon vertex detector, a central drift chamber, an array of aerogel threshold Cerenkov counters, a barrel-like arrangement of time-of-flight

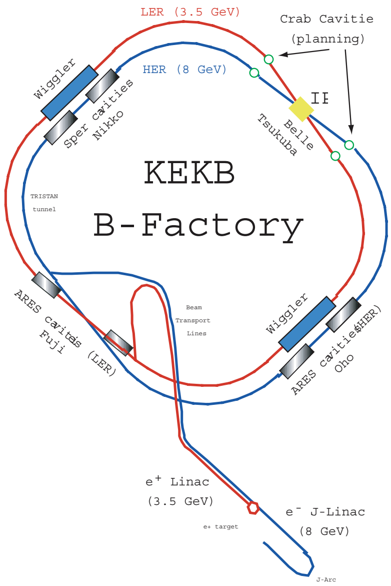

Figure 2: A schematic view of KEKB [3]. The beam energies at SuperKEKB will be 7 and 4 GeV, rather than 8 and 3.5 GeV. SuperKEKB will also include a positron damping ring, which is not shown in the figure.

scintillation counters, and an electromagnetic calorimeter of CsI(Tl) crystals located inside a super-conducting solenoid that provides a 1.5 T magnetic field. An iron flux-return located outside the coil is optimized to detect K_L^0 mesons and to identify muons. A detailed description can be found in [4]. Belle is currently being upgraded to Belle II, an upgraded detector for operation at SuperKEKB, which will have 40 times higher luminosity than KEKB [3]. In Figure 1, the Belle I and Belle II detectors are compared.

3 Accelerator or Lab Facility

The KEKB collider, located in Japan, Tsukuba, is the world's highest-luminosity electron-position collider. KEKB has produced more than $1000 fb^{-1}$ of data at center-of-mass energies corresponding to the $\Upsilon(1S)$ to $\Upsilon(5S)$ resonances, and in the nearby continuum. Figure 2 shows a schematic view of KEKB.

4 Physics Reach

Many extensions of the Standard Model introduce an additional U(1) interaction, which is mediated by a U(1) boson. This gauge boson, also known as the "Dark Photon", typically has very weak coupling to Standard Model particles. Experimental results from direct Dark Matter searches, (e.g. DAMA/LIBRA) [13, 14, 15, 16] and other experimental anomalies (e.g. g-2 [17]), can be explained by such an additional interaction [18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28]. Dark gauge bosons are typically of low mass; of order MeV to GeV. The ideal tools to discover such particles are therefore not high-energy collider experiments, but lower-energy high-luminosity collider experiments like Belle/BelleII and BaBar/SuperB, or dedicated fixed target experiments, several of which are planned or already under construction at JLAB (Newport News, USA) or at MAMI (Mainz, Germany), for example. In Belle, work on dark gauge boson searches was started only recently, and has focused on the strategies proposed by [29, 30, 31, 32, 33]. The main channels being investigated by Belle are:

- $e^+e^- \to U\gamma$
- $e^+e^- \to Uh^0$
- $e^+e^- \to Ue^+e^-$
- $e^+e^- \to \Upsilon(nS) \to X\Upsilon(1S)(\to l^+l^-U)$

where U can decay into either e^+e^-, $\mu^+\mu^-$, or $\pi^+\pi^-$ and h^0 into UU, l^+l^- or invisible.

Figure 3 [34] shows the expected sensitivity of Belle compared to other experiments as a function of the dark photon mass. For dark photon masses from 0.8 GeV/c^2 to almost 10 GeV/c^2, Belle is the most sensitive. Belle II should be able to improve the Belle reach by another factor of 40 in α/α' assuming the searches are luminosity not background limited.

The BaBar data-sheet [35] describes in more details the different analysis options and strategies for dark gauge boson searches at B-factories.

5 Status and Schedule

KEKB stopped operating in the summer of 2010, and KEK has started construction of SuperKEKB, which is to run at forty times higher luminosity, and is expected to produce a data sample of 50 ab^{-1}. The Belle collaboration

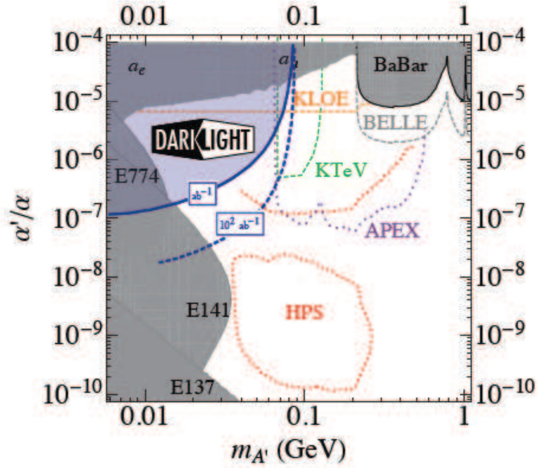

Figure 3: Expected sensitivity to the dark photon of planned fixed target and B-factory searches [34].

is now in the intense analysis phase, producing a large number of physics results with a final, reprocessed data sample. Meanwhile the Belle detector is being upgraded to Belle II. Beam commissioning of SuperKEKB is scheduled to start in fall 2014, with Belle II roll-in expected in 2015. The need for a high-luminosity B-factory has been endorsed by the US Department of Energy, which has granted Critical Decision 0 (CD-0) status to the US Belle II project, with CD-1 review expected in 2011.

6 Collaborating Institutions and Collaborators

The lists of collaborating institutions and collaborators can be found at the following web-pages: http://belle.kek.jp/ and http://belle2.kek.jp/.

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