

**Department of Physics  
COLLEGE OF ARTS & SCIENCES**

**SUMMER RESEARCH OPPORTUNITIES  
FOR UNDERGRADUATE WOMEN**

**APPLICATION DEADLINE: March 2, 2009**

*The Department of Physics is pleased to offer the following research project for the summer of 2009. Interested students are urged to contact the faculty member(s) directing the project that most interests them. By contacting the faculty member, you can discover more about the project, learn what your responsibilities will be and, if possible, develop a timetable for the twelve-week research period.*

**Project Title: Explorations of the strange beauty meson**

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**Project Description**

Protons and neutrons are each composed of three particles known as quarks and contain different combinations of the lightest two quarks. The b- or beauty-quark is the second-heaviest of the six known quarks and has been a rich source of information about the weak interaction and matter-antimatter asymmetry. Electron-positron annihilation at center-of-mass energies around 10 GeV (equivalent to ten proton masses) produce a series of states known as the Upsilon's - bound states of the b-quark and its antiquark. The fourth state, known as Upsilon(4S), decays mainly to the B meson, a bound state of the b-quark and one of the two lightest antiquarks, and its antiparticle. Each B meson is unstable, decaying to many other particles in approximately one picosecond and producing a splash of particles, known as an "event", which is recorded digitally in the multi-ton, multi-layered Belle detector. The Belle experiment, operating since 1999 at the KEKB collider in Japan, has recorded nearly a billion of these B-pair events and has made many significant measurements at the frontier of the field. The 2008 Nobel Prize in Physics was awarded for the Kobayashi-Maskawa Theory, for which key confirming evidence was measured by Belle.

Our research group has led the Belle collaboration in exploring data taken with a slightly higher center-of-mass energy, where the so-called Upsilon(5S) is created. At that energy, the detector has recorded over a million events containing pairs of Bs mesons, particles containing a b-quark and a s- or strange-antiquark, the third lightest. The Upsilon(5S) is relatively unexplored territory, and there are many interesting measurements waiting to be made with these data.

In this Cincinnati-based research project, a student will explore one of the following measurements in Upsilon(5S) data:

- 1) a precise measurement of the  $B_s$  lifetime, which is known to be approximately one picosecond.
- 2) the measurement of the rate of  $B_s$  decay to one or more specific final states.

She will specifically be using the vast computer resources at the KEK laboratory in Japan as well as the local cluster in the Department of Physics to generate simulated data for specific lifetime values and analyze it, adapting Belle techniques to the analysis at hand. If time permits, she will be able to make the measurement in real data. She will learn some particle physics, special relativity, computer programming in C++ and with the ROOT analysis package, and analysis techniques. Previous experience programming is desirable but not necessary. Previous knowledge of particle physics is not required.