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Photo by Reidar Hahn

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INSIDE:

B All You Can

by Sharon Butler

Back in the mid-eighties, said Fermilab Director Mike Witherell, it was hard to get anyone working on the CDF and DZero experiments excited about B physics, the physics of mesons containing the bottom quark. He remembers being rebuffed when he tried to organize a session on the topic at a Snowmass Summer Study for high-energy physics. The dominant reaction was: hadron colliders (like Fermilab's) can't do B physics, so why bother?

That sentiment changed with the advent of silicon vertex detectors, tiny electronic devices that wrap in layers around the hair-thin particle beams. These devices are able to resolve distances as small as 10 to 20 microns. Such fine resolution is critical for separating the tracks of B meson decays from the tracks of, say, W boson decays.

The introduction of silicon vertex detectors into the CDF detector reaped a nice reward when Run I data were analyzed. Last year, the scientific collaboration announced the best measurement yet suggesting evidence of CP violation in B mesons. With that measurement, the CDF scientists proved that B physics can indeed be done at hadron colliders like the Tevatron. Indeed, both the CDF and DZero collaborations will have silicon vertex detectors during Run II to pursue B physics.

The new excitement about the possibilities of doing B physics here at Fermilab drew nearly 200 physicists to a workshop on the subject earlier this month.

Photo by Reidar Hahn

The unitarity triangle, a cardboard cutout of which is held here by physicist Mark Wise, of Caltech, is a geometric translation of the constraints on various parameters of the Standard Model. Applying the triangle to B physics, scientists are hoping to find the values for each of the sides and the angles. If the Standard Model is correct, the values they find by experiment should obey the rules of trigonometry. If the values don't agree, then the experimenters will have discovered some new physics phenomena.

“Bless thee, BOTTOM! bless thee! Thou art translated.”

~ Shakespeare, *A Midsummer-Night’s Dream*

This was a “kickoff meeting to get people moving,” said Andreas Kronfeld, a theoretical physicist at Fermilab who was one of the organizers. For experimenters who are now busy completing the upgrades of their detectors, it was a chance to think about the physics they are after, added Manfred Paulini, a physicist at Lawrence Berkeley National Laboratory and another workshop organizer. Other scientists involved in pulling the workshop together were Richard Jesik, of Indiana University, Robert Kutschke and Zoltan Ligeti, of Fermilab, and Barry Wicklund, of Argonne National Laboratory.

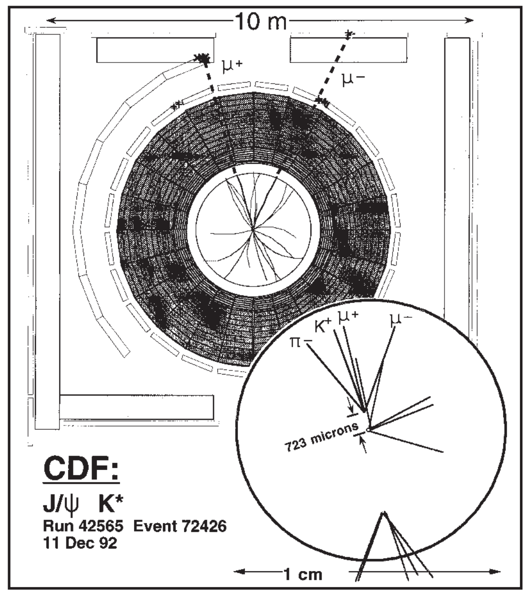
Scientists from Fermilab’s two largest scientific collaborations, CDF and DZero, attended, presenting their expectations and aspirations for B physics experiments when the Tevatron cranks up again next year. Also present were representatives of a proposed experiment at Fermilab called BTeV, which will be dedicated to studying B physics.

Following plenary sessions, in which speakers reviewed the status of the field both theoretically and experimentally, the meeting broke into parallel sessions in several areas of B physics. In those sessions, experimenters confronted theorists in an exchange that sought to clarify the capabilities of the detectors, explore new means of making critical measurements, and plan simulations of Run II experiments.

As Ligeti put it, “It’s important to lock the theorists and experimenters in one room. Features that are theoretically interesting aren’t always feasible for experimental investigation.

“The interaction between theory and experiment is a matchmaking game,” Ligeti said. “Experimentalists often have conservative views of what they can measure. The theorists have extravagant dreams about what they would like to see measured. Bringing them together can produce ideas that are both theoretically interesting and experimentally testable.”

Physicists are eager to study the B meson because its oscillation between particle and antiparticle makes it a uniquely promising system for studying the nature of matter at the shortest distance scales, in a way that is complementary to experiments involving new particle production. It is this promise of B physics to test the Standard Model and probe for where it falls apart that has led SLAC, in California, and KEK, in Japan, to build e^+e^- “B factories,” which can produce much purer samples of B mesons than hadron colliders can. On the other hand, the Tevatron offers certain advantages in the study of B physics. It produces all species of B particles, in contrast to the B factories, where only certain kinds of B particles appear.



Courtesy of Manfred Paulini

Left: A10-meter cross section of the CDF detector, showing an event in which a B meson decayed into a J/psi particle and a kaon. Inset: Enlargement of a 1-centimeter cross section showing the B decay at its point of origin, just 723 microns from the collision point of protons and antiprotons.

The Tevatron also produces about 3,000 times more B mesons than the new B factories. That allows experimenters to study rare decays: the more B mesons produced, the more likely the rare species will appear, and will appear in numbers large enough for analysis. Rare decays of particles delight physicists because of the hope that the unusual phenomena will reveal new physics.

“In rare decays,” said Kronfeld, “you’re always looking for a surprise.”

Workshop participants were sent back to their academic and research institutions with homework to do: computer simulations of experiments (dry runs, but without real data) to flesh out ways of improving measurements—or, better yet, to push the limits of experimentation. The scientists will reconvene in February and issue reports in May.