Curriculum Vitae

Associate Professor Matthew Herndon

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Education

Ph.D., Physics, University of Maryland, November 1998
Thesis topic: Search for the B_c Meson in Hadronic Z^0 Decays
Thesis adviser: Professor Hassan Jawahery

B.S., Physics, University of Texas at Austin, August 1994

Professional Employment

07/2009 to present: Associate Professor, Department of Physics, University of Wisconsin-Madison:
Participating in the CDF and CMS experiments at the Tevatron and LHC colliders.

08/2005 to 06/2009: Assistant Professor, Department of Physics, University of Wisconsin-Madison:
Participating in the CDF and CMS experiments at the Tevatron and LHC colliders.

11/98 to 08/2005: Associate Research Scientist, Department of Physics and Astronomy, Johns Hopkins University (Supervisor: Professor Bruce Barnett):
Participating in the CDF experiment at the Tevatron collider.

1/93 to 11/98: Research Assistant, Department of Physics, University of Maryland (Adviser: Professor Hassan Jawahery):
Participating in the OPAL and BaBar experiments at the LEP and PEPII colliders.

9/92-12/93: Teaching Assistant, Department of Physics, University of Maryland(Supervisor: Professor Richard Ellis)
My duties involved leading recitations and laboratory sessions for introductory physics courses.

1/91 to 8/92: Student Researcher, Applied Research Laboratory Austin, Texas.
Programing for naval sonar simulation.

Research Activities

Higgs Physics: Co-convener CDF Higgs Discovery Group 2007-2008
Participating in the SM Higgs boson searches for associated Higgs production with a W boson, WH, with decays to lnu and bb respectively, and inclusive Higgs production with decay to two W bosons followed by lnu lnu.
The Higgs group is one of six major research groups in the CDF collaboration. This

research group was formed in 2007 to meet the challenge of searching for the Higgs boson at CDF and I was appointed one of its two inaugural conveners. During the two years of my convenership the group has tripled the amount of integrated luminosity used in analysis and we have further improved the sensitivity of the Higgs searches by a factor 1.5 beyond the factor of 1.7 expected from adding new data to the analyses alone. In low mass Higgs searches my graduate student, Jason Nett, has developed a new trigger for muons making it possible to trigger muons in the forward muon detectors which will substantially increase acceptance for Higgs events in searches such as associated Higgs boson production, WH, with decays to munu bb. In high mass Higgs searches an improved analysis developed by myself and my postdoctoral researcher, Dr. Jennifer Pursley, has resulted, when combined with a similar search from the DØ experiment, in the first exclusion of a range Higgs masses since the final results from the Large Electron Positron collider. This research effort has led to one paper that has been submitted to Physical Review Letters (PRL). In addition, this research effort has led to three new papers in preparation for publication on the subjects of the improved high mass Higgs search, a combination of high mass Higgs results with the DØ collaboration, and the SM WW production cross-section.

B Physics: Co-convener CDF B Physics Group 2006-2007

Participating in the analysis of Bs meson oscillation and the search Bs meson decay to two muons.

As B group convener I directed the CDF B and Charm physics program. The B physics group was conducting more than 50 physics analyses on a diverse number of subjects. In B physics my research program has led to two publications in PRL on the subject of Bs meson oscillations including the first evidence and the observation of oscillations and three publications in PRL on the subject of the search for the rare decay of the Bs meson to two muons. New preliminary result, performed with undergraduate David Sperka, on the rare decays of Bs mesons are the most stringent limits on the decay rate to two muons to date and approach within a factor of ten of the expected Standard Model rate.

J/Psi Physics: Co-convener of the CDF J/Psi Physics Subgroup 2005

As convener of the J/Psi subgroup I supervised low transverse momentum di-lepton physics including subjects from rare decay searches to mass, lifetime and branching ratio measurements of b hadrons.

Tracking: Co-convener of the CDF Tracking Group 2003-2005

As tracking group convener I directed the tracking software development for offline data processing and high-level trigger at CDF. During my convenership the final version of the tracking software used for all CDF data reconstruction was established. I am also an active author of the CDF silicon tracking code. This work includes: Authorship of the forward silicon tracking algorithm including a recently developed version, which is ten times faster with similar efficiency and was essential to meet the challenge of high luminosity running. This work led to a Nuclear Instruments and Methods(NIM) article on forward tracking at CDF. Implementation of the specialized version of the silicon tracking used in the CDF high-level trigger. Authorship of the software used to perform pattern recognition in the innermost silicon layer (L00). The implementation of software to use the L00 in the Bs meson oscillations analysis substantially improved

the sensitivity to oscillations, for instance improving the significance of the observation analysis from a significance of 3sigma to 5sigma. Authorship of the primary software used to study silicon data during the CDF commissioning run. Design of the interfaces used for realistic simulation of the silicon detector. Authorship of a detailed and a parameterized realistic silicon simulation in collaboration with other CDF personnel. Authorship of the primary tools used for silicon simulation and tracking validation. As an expert on tracking I also served in the task force formed to study the feasibility and methods for optimizing the performance of the CDF detector for the Bs meson mixing measurement and the task force formed to study computing usage for analysis at CDF.

CDF Silicon Commissioning and Power Supplies

Leadership of the group established to study the silicon data during the CDF commissioning run. Manager of the silicon vertex detector power supply project. This work included the design of testing procedures, the coordination of the testing and the installation of all power supplies; the design, purchase and supervision of installation of all silicon vertex detector cabling; serving as on call expert for the silicon power supply sub system and training of new experts.

CMS Muon Triggers

I am participating in development of the CMS high-level muon trigger with my student, Jeff Klukas. Our research has led to substantial improvement in the performance of the trigger including improved efficiency for muons from sources such as Z bosons and from W bosons in top decay and also substantially improved rejection of QCD backgrounds. We are also in charge of all online validation of CMS muon triggers.

CMS Physics

At the CMS experiment I am participating in SM physics measurements and searches for new physics in channels involving pairs of W or Z bosons. This research program leverages my experience in tracking, muon detection, and di-boson physics at the CDF experiment. Jeff Klukas, will perform his thesis research on searches for technicolor particles in the WZ decay mode. As part of this analysis we also intend to perform a measurement of the SM cross section for WZ production.

OPAL and Babar

As a graduate student at the University of Maryland I worked in the High Energy Physics group on the BaBar and OPAL experiments. For the BaBar experiment I performed a study of precision Time-Of-Flight measurements using scintillation counters and Fine Mesh Photomultiplier Tubes. This work was part of an investigation of several techniques considered for hadron identification in the B factory detector (BaBar) at SLAC. An almost identical system was installed and is functioning at CDF. The study included the design, construction and analysis of the data from the prototype TOF detector and is published in NIM. At OPAL my activities included duties as on call expert for the Hadron Calorimeter high voltage and gas systems, rewriting the Hadron Calorimeter simulation to correctly simulate the response of the detector to jets at LEP2 energies and improving the Hadron Calorimeter calibrations to account for non-linear calorimeter response for higher energies. My thesis analysis was a search for the Bc meson using decay modes involving the J/Psi and is published in Physics Letters B. In addition, my physics activities included implementation of seed based jet clustering for

jet finding in the hadronic W boson decay channels and implementation of W mass fit routines that made use of the Breit-Wigner shape of the W resonance for use in the W mass and width analyses.

Students

Jason Nett - Graduate Student, thesis topic: Search for the standard model Higgs boson in the channel WH to lnu bb at CDF. Service: development of forward muon triggers, 2006-present.

Jeff Klukas - Graduate Student, thesis topic: Search for W-Prime particle in the WZ decay mode at the CMS. Service: monitoring, validation and development of the CMS muon high level trigger, 2007-present.

David Sperka - Undergraduate Student, thesis topic: Search for Flavor Changing Neutral Current Decay of Bs mesons to two muons at CDF, 2008-2009. Graduated 2009, now attending graduate school at Boston University. Service: validation of CDF L00 data.

Michael Glatzmaier - Graduate Student, summer student working on silicon detector safety at CDF and B Physics, Summer 2007.

Postdoctoral Researcher

Dr. Jennifer Pursley - Involved in the search for Standard Model Higgs boson in the two W boson decay channel, measurement of the Standard Model WW boson production cross section, measurement of the top production cross section, and observation of excited b flavored hadrons Bs** and SigmaB. Serving as CDF operations manager.

Professional Activities

Teaching

Fall 2005 - Physics 107, Ideas of Modern Physics
Spring 2005 - Physics 104, General Physics II
Fall 2006 - Physics 107, Ideas of Modern Physics
Spring 2007 - Physics 103, General Physics I
Fall 2007 - Physics 535, Introduction to Particle Physics
Spring 2008 - Physics 103, General Physics I
Fall 2008 - Physics 103, General Physics I Spring 2009 - Physics 104, General Physics II
Fall 2009 - Physics 103, General Physics I

Departmental

Preliminary Exam Committee, 2005-present, Chair, 2009-present.
Physics Counsel, 2009-present.
Colloquium Committee, 2006-2007.
Qualifying Exam Committee, 2006-2009.
Graduate Program Committee, 2007-present.
Web Committee, 2008-2009.

Other Professional Activities

Co-convener CDF Higgs Discovery Group 2007-2009

Co-convener CDF B Physics Group 2006-2007
Co-convener of the CDF J/Psi Physics Subgroup 2005
Co-convener of the CDF Tracking Group 2003-2005
Convener CDF Silicon Tracking Group 2001-2002
Organizing Wisconsin High Energy Physics Seminar
Organizer "Higgs Physics" session at the DPF APS July Meeting, 2009, Detroit, Michigan.
Organizer "Heavy Flavor Physics" session at the Hadron Collider Physics Symposium, 2007, Elba, Italy.
Convener "B Physics" session at the American Physical Society April Meeting, 2007, Jacksonville, Florida.
Organizer "Heavy Flavor Physics and Search for New Particles" session at the Particles and Nuclei International Conference, 2005, Santa-Fe, New Mexico.

Academic Honors

University of Texas at Austin
National Merit Scholarship (1988-1992)
Farah Corporation Scholarship (1989)
University of Texas Honors Scholar (1991)
Golden Key Honor Society (1991)
Applied Research Laboratory Scholarship (1991-1992)

Selected Publications

Primary Author

Papers of particular scientific note on which I was a primary author with substantial contributions to the research.

[14] The CDF Collaboration, T. Aaltonen, et al., "Search for a Higgs Boson Decaying to Two W Bosons at CDF," Submitted to *Phys. Rev. Lett.* **102**, 021802 (2009), arXiv:hep-ex/0809.3930.
In addition to supervising all analysis performed in the Higgs Discovery Group during the time period 2007-2008, I am a primary author on the search for the Higgs boson decaying to two W bosons. I developed a methodology for accessing systematic uncertainty on our understanding of the production of Heavy particles with jets in processes initiated by gluons inside the proton. This allowed us to expand this Higgs search to events including two W bosons and one additional jet substantially increasing the sensitivity of this search. In collaboration with my postdoctoral researcher, Jennifer Pursley this program of research has been expanded to also include events with two or more jets. These improvements have led to the first exclusion of a range4 of possible Higgs masses since the final analysis of the LEP collaboration and two papers are in preparation for publication on the subject.

[43] The CDF Collaboration, T. Aaltonen, et al., "Search for Bs to mumu and Bd to mumu Decays with 2fb-1 of ppbar Collisions," *Phys. Rev. Lett.* **100**, 101802 (2008), arXiv:hep-ex/0712.1708.
I am a primary author on the search for Bs mesons decaying to two muons. Based on my expertise in tracking and silicon detectors I developed a selection for muons with silicon detector position information, or hits, that is high efficiency while maintaining a low rate of mis-measurements that can lead in inaccurate lifetime measurements. The accurate measurement of the long lifetime of Bs mesons is the key method of separating the signal from background. In addition, I developed a multivariate discriminant for muon identification that further improves selection efficiency and rejection of background events. This analysis has resulted in the most stringent bound on the rate of Bs meson decay to two muons and severely restricts many new models of physics.

[97] The CDF Collaboration, D. Abulencia et al., "Observation of Bs Oscillations," *Phys. Rev. Lett.* **97**, 242003 (2006), arXiv:hep-ex/0609040.
In addition, to supervising all analysis performed in the B physics group during the time period 2005-2006, I was also a primary author on the analysis that observed the process of oscillation in Bs mesons which converts them from their mater to antimatter states. The oscillation process of the Bs meson is extremely fast and the tens of micron level accuracy of the CDF silicon detector is necessary to observe the process. I implemented the use of the innermost layer of silicon of the CDF silicon detector for this analysis, which substantially enhances the resolution for Bs meson lifetime measurements making is possible to observe the oscillation process as a function of time. The use of the innermost silicon layer was the single most important factor in achieving the sensitivity necessary for the observation of Bs

oscillations and without the enhanced sensitivity this analysis would not have even achieved the statistical sensitivity necessary for the lesser claim of evidence.

Papers on which I was a primary author with substantial contributions to the research.

[103] The CDF Collaboration, D. Abulencia et al., "Measurement of the Bs Oscillation Frequency," *Phys. Rev. Lett.* **97**, 062003 (2006), arXiv:hep-ex/0606027.
I was a primary author on this paper focusing on the integration of the innermost silicon layer into the measurement and developing a model of the lifetime resolution when using the innermost silicon layer.

[137] The CDF Collaboration, D. Acosta et al., "Search for Bs to mumu and Bd to mumu Decays in ppbar Collisions with CDF II," *Phys. Rev. Lett.* **95**, 221805 (2005), arXiv:hep-ex/0508036.
I pioneered the use of the innermost silicon layer in this analysis. The innermost silicon layer had not been used in any previous analysis due to substantial noise problems in the data from the detector. I assisted in developing a method to suppress the noise, authored code to find and add position data from the detector to precisely measure the trajectories of charged particles, calibrated the detector for optimum physics performance, and characterized the resolution of the detector. Following this analysis the innermost silicon layer is now used in all CDF analysis.

[159] C. Hays, M. Herndon *et al.*, "Inside-out Tracking at CDF," *Nucl. Instrum. Meth. A* **538**, 249 (2005).
I was a primary author of a new tracking algorithm to identify charged particle trajectories over a larger solid angle of the detector. This new algorithm, which primarily uses the silicon detector rather than the drift chamber, is now used in all CDF analysis.

[185] The CDF Collaboration, D. Acosta et al., "Search for Bs to mumu and Bd to mumu Decays in ppbar Collisions at sqrt(s) = 1.96 TeV," *Phys. Rev. Lett.* **93**, 032001 (2004), arXiv:hep-ex/0403032.
I was a primary author on the first search for the decay of a Bs meson to two muons in CDF Run 2 involved in all aspects of the analysis. This paper was the forth paper published in Run 2 from CDF.

[264] Thesis: M. Herndon, "Search for the Bc Meson in Hadronic Z Decays using the OPAL detector at LEP," UMI-99-26738(1999).
My thesis analysis was a search for the heaviest possible ground state mixed quark meson known as the Bc meson. I developed and performed all aspects of the analysis independently.

[303] The OPAL Collaboration, K. Ackerstaff et al., "Search for the Bc Meson in Hadronic Z Decays," *Phys. Letters B* **420**, 157 (1998), arXiv:hep-ex/980126.
Letter based on my thesis analysis.

[357] M. Foucher, M. Herndon and H. Jawahery, "A Study of the Timing Characteristics of Scintillator Counters With Fine Mesh Photomultiplier Tubes," *Nucl. Instr. & Meth.* **A 374**, 57 (1996).
I was the primary of this paper on the construction of the Time of Flight detector. I constructed the apparatus, assembled the data acquisition system and analyzed the data.

Contributing Author

Papers on which I contributed physics or technical studies essential to the physics results.

The CDF Collaboration, T. Aaltonen et al., "Measurement of Resonance Parameters of Orbitally Excited Narrow B0 Mesons," Submitted to *Phys. Rev. Lett.*, arXiv:hep-ex/0809.5007.

I developed an improved selection for finding very low momentum particles useful for finding excited B hadrons. This work was used in searches for the Sigmab baryon and excited states of the B0 meson. I also provided supervision for the graduate student thesis of Jennifer Pursley.

[71] The CDF Collaboration, T. Aaltonen et al., "First Observation of Heavy Baryons Sigmab and Sigmab-," *Phys. Rev. Lett.* **99**, 202001 (2007), arXiv:hep-ex/0706.3868. See previous.

[80] The CDF Collaboration, D. Abulencia et al., " First Measurement of the Ratio of Central-Electron to Forward-Electron W Partial Cross Sections in ppbar Collisions at sqrt(s) =1.96 TeV," *Phys. Rev. Lett.* **98**, 251801 (2007), arXiv:hep-ex/0702037. The new tracking algorithm I designed which primarily used the silicon detector rather than the drift chamber was first used in this analysis, which expanded the solid angle over with the W boson production cross section is measured.

[117] The CDF Collaboration, D. Abulencia et al., "Measurement of sigma(Lambdab)/sigma(B0) x BR(Lambdab to Lambda pi-) / BR(B0 to D+pi-) in ppbar Collisions at sqrt(s) = 1.96 TeV," *Phys. Rev. Lett.* **98**, 122002 (2007), arXiv:hep-ex/0601003.

I developed a method for measuring the trigger efficiency of protons in the CDF drift chamber. Protons have significantly different ionization rates in a gas compared to other particles, which effect the efficiency of detecting them. This method is used in several analyses involving B baryons that decay into protons and other particles.

[165] The CDF Collaboration, D. Acosta et al., "Measurement of the J/Psi Meson and b-Hadron Production Cross Sections in ppbar Collisions at sqrt(s) = 1.96 TeV," *Phys. Rev. D* **71**, 032001 (2005), arXiv:hep-ex/0412071.

I developed a stringent selection for adding silicon detector position information to improve the position resolution of charged particles. I also characterized the performance in terms of efficiency and resolution for the silicon detector. This work was critical for this measurement of the lifetime of B hadrons in decay channels involving J/Psi mesons and is used in all subsequent analysis that measure B hadron lifetimes.

[184] The CDF Collaboration, D. Abulencia et al., "Measurement of the ttbar Production Cross Section in ppbar Collisions at sqrt(s) = 1.96 TeV using Dilepton Events," *Phys. Rev. Lett.* **93**, 142001 (2004), arXiv:hep-ex/0404036.

I developed a method to measure the efficiency of finding high momentum tracks in the CDF drift chamber. This technique was first applied in the measurement of the top production cross-section in decays involving two charged leptons and in all subsequent cross section measurements using charged leptons.

[196] The CDF Collaboration, D. Acosta et al., "Measurement of Prompt Charm Meson Production Cross Sections in p anti-p Collisions at s**(1/2) = 1.96 TeV," *Phys.*

Rev. Lett. **91**, 241804 (2003), arXiv:hep-ex/0307080.
I developed a method for measuring the efficiency of the CDF drift chamber to detect low momentum charged particles. This method was used in all subsequent absolute cross section or branching ratio measurements involving B or charm hadrons.

[267] The OPAL Collaboration, K. Ackerstaff et al., "Measurement of the W Mass and Width in e+e- Collisions at sqrt(s) = 183 GeV," *Phys. Letters B* **453**, 138 (1999), arXiv:hep-ex/9901025.
I adapted a seed based jet finding algorithm for finding jets in the OPAL detector. I also designed a framework for comparing the performance of all jet finding algorithms which was used to identify the best jet finding algorithm in terms of jet energy resolution and accuracy. This work was also used in subsequent measurements of the W boson mass.

[318] The OPAL Collaboration, K. Ackerstaff et al., "Measurement of the W Boson Mass and W+W- Production and Decay Properties in e+e- Collisions at sqrt(s) = 172 GeV," *Eur. Phys. J.* **C1**, 395 (1998), arXiv:hep-ex/9709006.

[354] The OPAL Collaboration, K. Ackerstaff et al., "Measurement of the Mass of the W Boson in e+e- Collisions at sqrt(s) = 161 GeV," *Phys. Letters B* **389**, 416 (1996).

Conference Talks

Invited Plenary Talks

"B Physics at the Tevatron," Plenary talk at the 10-25 Years of DØ France, Paris, France, October 13-14 29, 2008.

"Searches for the Higgs Boson," Plenary talk at the 34th International Conference of High Energy Physics, Philadelphia, Pennsylvania, July 29-August 5, 2008.

"Flavor Physics and Dark Matter," Plenary talk at the Dark Side of the Universe, Minneapolis, Minnesota, June 5-10, 2007.

"B Physics at the Tevatron," Plenary talk at the American Physical Society April Meeting, Jacksonville, Florida, April 14-17, 2007.

"B Physics at CDF," Plenary talk at the XVII Les Recontres de Physique de la VAllee d'Aoste, La Thuille, Italy, March 9-15, 2003.

Contributed Talks

"Searches for New Physics in the Flavor Sector at the Tevatron," DIS 2005 XIII International Workshop on Deep Inelastic Scattering, Madison, Wisconsin, April 27 - May, 2005.

"Bs(d) to mumu and Direct Searches," CKM 2005, Workshop on the Unitarity Triangle, B, San Diego, California, March 15-18, 2005.

"Searches for FCNC Decays Bs(d)," 32nd International Conference on High Energy Physics, Beijing, China, August 16-22, 2004.

"New B Physics Results from CDF," The Tevatron Connection, Batavia, IL, August 9-10, 2004.

"Tracking at CDF," Computing in High Energy and Nuclear Physics, La Jolla, California, March 24-28, 2003.

"Search for the Bc Meson in Hadronic Z Decays," 1998 Joint American Physical Society and American Association of Physics Teachers Meeting, Columbus, Ohio, April 18-21, 1998.

"Measurements of the Bs and Lambdab Lifetimes," 1998 Joint American Physical Society and American Association of Physics Teachers Meeting, Columbus, Ohio, April 18-21, 1998.

Workshops

"Standard Model Higgs Searches at CDF," Higgs Days 2009, Santander, Spain, September, 2009

"Searches for the Standard Model Higgs Boson," Collider Physics 2009, Argonne National Laboratory, Illinois, May, 2009

"Searches for the Standard Model Higgs Boson," LoopFest VIII 2009, Madison, Wisconsin, May, 2009

"Searches for the Standard Model Higgs Boson," Zurich Workshop on Higgs Boson Phenomenology, Zurich, Switzerland, January, 2009

"B Physics at Hadron Colliders", Fermi National Accelerator Laboratory Academic Lectures, Batavia, Illinois, February 8th, 2007.

"B Physics at the Tevatron" SSI 2006, 34th SLAC Summer Institute On Particle Physics, Menlo Park, California, July 17-28, 2006

"CDF Experience with Tracking Software," CMS Tracking Workshop, FermiLab, Batavia, Illinois, August 3rd, 2004.

Invited Seminars and Colloquia

Colloquia

"Searches for the Higgs Boson" University of Massachusetts Amherst Physics Colloquium, Amherst, Massachusetts, December 10th, 2008.

"Matter/Antimatter Oscillations" Wayne State University Physics Colloquium, Detroit, Michigan, October 19th, 2006.

"Matter/Antimatter Oscillations" University of Wisconsin Physics Colloquium, Madison, Wisconsin, September 27th, 2006.

Seminars

"Searches for FCNC Decays Bs(d) to mumu," University of Illinois, Champaign-Urbana, Illinois, December, 2009.

"An Inclusive Search for H-¿WW at CDF," University of Maryland High Energy Physics Seminar, College Park, Maryland, October, 2009

Iowa State University High Energy Physics Seminar, Ames, Iowa, October, 2009

Fermi National Accelerator Laboratory Theory Seminar, FNAL, Illinois, August, 2009

"B Physics at Hadron Colliders: Bs Meson and New B Hadrons", State University of New York, Stony Brook, New York, April 2007.

"Search for FCNC Decays Bs(d) to mumu" Carnegie Mellon University University of Pittsburgh High Energy Physics Seminar, Pittsburgh, Pennsylvania, May 3rd, 2006.

"Searches for FCNC Decays Bs(d) to mumu," University of Minnesota, Minneapolis, Minnesota, February 11th, 2005.

University of Wisconsin-Madison, Madison, Wisconsin, January 25th, 2005.

"Current CDF B Physics Results," Stanford Linear Accelerator Center, Menlo Park, California, October 7th, 2004.

"Rare Beauty and Charm Decays and Indirect Searches for New Physics," University of Toronto, Toronto, Canada April 14th, 2004

Lawrence Berkeley National Laboratory Research Progress Meeting, Berkeley, California March 30, 2004.

University of Michigan HEP/Astro Seminar, Ann Arbor, Michigan, February 9, 2004.

University of Pennsylvania, Philadelphia, Pennsylvania January 26th, 2004

Rutgers High Energy Physics Seminar, Piscataway, New Jersey, November 11, 2003.

MIT Nuclear and Particle Physics Colloquium, Boston, Massachusetts, September 8, 2003.

"Search for Bs to mumu Decays," Notre Dame High Energy Physics Seminar, South Bend, Indiana, February 28, 2003.

Research Statement

My research interests lie in the frontier of fundamental physics. High Energy Physics (HEP) offers some of the most interesting experimental opportunities to expand our knowledge of fundamental physics and discover new physics phenomena. I am simultaneously interested in pursuing a greater understanding of the Standard Model and in studying the predictions of theories that pose solutions to the fundamental questions not answered by the Standard Model (SM) of particle physics. These questions include, within the context SM, the source of Electroweak Symmetry breaking and how the SM particles acquire mass. Beyond the context of the SM these questions include, but are not limited to, how to unify gravity with the other fundamental forces, baryogenesis and the prevalence of matter over antimatter in the universe, and the nature of dark matter. These questions have led me to pursue a diverse research program including elements such as measurements of SM cross sections, SM Higgs boson searches, and searches for new physics particles such as excited W bosons. The unifying theme of this research effort is searches for pairs of SM bosons with decays involving charged leptons.

The Standard Model of particle physics includes one major undiscovered particle known as the Higgs boson. Experimental evidence and the calculations in the framework of the SM show a large difference in the strength of the electromagnetic force and the weak force at low energy. This difference in strength is several orders of magnitude and manifests itself in the fact that electromagnetic decay interactions takes place almost instantaneously while the probability of some weak decay interactions is so low that they can take thousands of years or more. This fundamental difference is explained by the massiveness of the weak W and Z interaction bosons. Without the large mass of the weak bosons the electromagnetic and weak forces would have the same strength or be symmetric. The source of this electroweak symmetry breaking in the SM is the Higgs mechanism, which gives mass to the weak bosons and other SM particles. This theory is directly testable by observing the Higgs boson making Higgs boson research one of the primary goals of modern particle physics. At the Collider Detector at Fermilab (CDF) experiment at the Tevatron proton-anti-proton collider I lead the Higgs physics group.

In addition to leading the Higgs physics group I am involved in the high mass Higgs boson search. The Higgs boson interacts with other particles in proportion to their mass. At high mass, around 160-170GeV, the Higgs boson will decay primarily to W bosons(mass 80GeV). The clearest signature of Higgs decays to W bosons occurs when the W bosons decays leptonicaly, H to W+W- to l+nu l-nu. This research program, which primarily involves decays to charged leptons, builds on the expertise in charged particle tracking and lepton physics I gained while I led the tracking and B physics groups and participated in B physics analyses such as the search for the rare decay of the Bs meson to two muons and the observation of Bs meson oscillations. Our latest results have achieved sensitivity to the Standard Model production rate for a high mass Higgs boson. If there were a Higgs boson in the mass range 160-170GeV we would expect to produce and observe a substantial number of Higgs bosons (approximately 16). Given that we observe no substantial signal we can rule out the production of the Higgs boson with a masses between 160-170GeV. This is the first direct information on the Standard Model Higgs boson since the final results of the Large Electron Positron

collider. My continuing research program at CDF concentrates on improving the sensitivity of this analysis in order to achieve a large exclusion or start to see evidence for Higgs production. In addition, using similar analysis techniques, we are measuring the direct SM WW production cross-section and the top pair production cross-section. These measurements will be the most sensitive measurements of their type.

With the data sample collected over the next few years of operation at the Tevatron and at the LHC, direct searches for SM particles such as the Higgs boson and new phenomena will become increasingly interesting. At the Compact Muon Solenoid (CMS) experiment located at the Large Hadron proton-proton Collider (LHC) my physics program also concentrates on signatures involving pairs of W and Z bosons with decays to charged leptons. For instance, I am involved in searches for a new particle called a W-prime. The W-prime is a heavy version of the W boson, which is responsible for weak nuclear decay. In many models of high energy physics that propose that all the forces of nature should be unified into one common force particles such as W-primes exist. We think such a unification is likely since previously we have found that forces such as electricity and magnetism are unified into one common force know as the electromagnetic force and further the electromagnetic and weak force are unified into a single electroweak force. The existence of additional gauge bosons such as the W-prime is one of the few testable hypotheses of unification theories. The W-prime particle can decay to a W and Z boson pair, which are best observed in their decays involving charged leptons. In addition, it is natural to also study SM direct WZ boson production and search for any source of anomalous production of WZ boson pairs. These types of SM and new physics measurements leverage my expertise in charged particle tracking, lepton physics and di-boson physics to pursue research into fundamental issues such as the unification of forces.

To further my physics research program I am involved in a number of projects related to the CDF and CMS. On both CDF and CMS I am involved in projects to improve the muon triggers. At CDF I am concentrating on implementing new triggers targeted for Higgs physics using the forward muon system of CDF (built by Wisconsin). At CMS I am involved the in the high-level muon trigger, which is critically dependent on tracking. In addition, I am investigating options for muon triggers for the high luminosity running of the Super LHC. These projects are all designed to improve the muon trigger abilities of each experiment, which will in turn enhance searches for new physics involving di-boson signatures.

In conclusion, I have outlined a continuing physics research program that leverages my expertise in tracking, muon triggers, and associated physics to perform searches for new physics at the CDF and CMS experiments. This physics program concentrates on di-boson signatures and covers such fundamental issues as Electroweak symmetry breaking, the origin of mass, and the unification of forces. In addition, the physics program also involves measurements of key SM physics signatures involving di-bosons and top quarks pairs. This research program is conducted at the energy frontier of physics and has the goal of expanding our fundamental knowledge of nature.