# Bruce Knuteson

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## POSITIONS

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| 2003 Jul – | Assistant Professor of Physics, MIT |
| 2002 Jan – 2003 Jun | Fermi/McCormick Fellow, University of Chicago |
| 2001 Aug – 2001 Dec | NSF International Research Fellow, CERN |
| 2001 Jan – 2001 Jul | Fermi/McCormick Fellow, University of Chicago |

## EDUCATION

**University of California at Berkeley**
Ph.D. Physics, December 2000
GPA: 4.00 / 4.00

**Rice University**, Houston, Texas
B.A. Physics and Mathematics, May 1997
GPA: 4.02 / 4.00
*summa cum laude*

## HONORS

APS Tanaka Dissertation Award
NSF International Research Fellowship
Enrico Fermi Fellowship (University of Chicago)
Pappalardo Fellowship (MIT)†
CERN Fellowship†
National Defense Science and Engineering Graduate Fellowship
National Science Foundation Graduate Fellowship†
Department of Physics Fellowship (Berkeley)
Churchill Scholarship Finalist
Rhodes Scholarship Semifinalist
Rice University Outstanding Senior Award
Outstanding Senior in Physics (Rice University)
Phi Beta Kappa
Sigma Pi Sigma
Sigma Xi
Who's Who Among Students in American Universities and Colleges 1996, 1997
Karl Taylor Compton Fellowship (MIT)†
First Year Merit Fellowship in Science and Mathematics (Princeton)†
Robert A. Millikan Fellowship (Caltech)†
Associated Western Universities Research Fellowship
DPF Snowmass Fellowship
National Merit Scholarship

## GRANTS

*Principal investigator*

- NSF grant INT-0107322
  "The Breaking of Electroweak Symmetry in the Standard Model"

RESEARCH

*Assistant Professor of Physics, MIT (CDF)*
July 2003 – present

- Leading Run IIb upgrade of CDF Event Builder
- Pursuing global understanding of Tevatron high-$p_T$ data

*Enrico Fermi Fellow, University of Chicago (CDF)*
Henry Frisch, Mel Shochet (advisors), January 2001 – June 2003
Enrico Fermi Institute / Fermi National Accelerator Laboratory

- Initiated encompassing comparison of high-$p_T$ data to Standard Model
- Developed electron, photon, and muon identification algorithms
- Developed a method (QUAERO) for making collider data publicly available

*NSF International Research Fellow, CERN (LEP/CLIC)*
August – December 2001

- Led efforts to make LEP data publicly available
- Investigated the effect of intrabeam scattering in CLIC damping rings

*Graduate student, University of California at Berkeley (DØ)*
Mark Strovink (advisor), June 1998 – December 2000.
Lawrence Berkeley Laboratory / Fermi National Accelerator Laboratory
Visitor, LPNHE, Paris, France, May 1999

- Thesis: *Quasi-Model-Independent Search for New High $p_T$ Physics at DØ*
- Developed a novel quasi-model-independent search strategy (SLEUTH) for physics beyond the Standard Model.
- Developed a technique for reducing backgrounds in which missing transverse energy arises from instrumental mismeasurement.
- Designed a test stand and two printed circuit boards for a full system test of DØ's scintillating fiber tracker readout electronics.

*Undergraduate student, Rice University (experimental atomic physics)*
Randy Hulet (advisor), January 1997 - May 1997.

- Helped to design and build part of a laser-stabilization feedback system.

*Undergraduate student, Rice University (DØ)*
Hannu Miettinen (advisor), May 1995 - August 1996

- Thesis: *Measurement of the Top Quark Mass*

## TEACHING

Massachusetts Institute of Technology

- *Electricity and Magnetism* (8.02t), Spring 2004
  Lecturer
- *Special Relativity* (8.20), January 2004
  Guest lecturer (5.9/7.0)
- *Vibrations and Waves* (8.03), Fall 2003
  Recitation instructor (6.0/7.0)

Rice University

- *Leadership Rice* (Univ 201), Spring 1997
  Teaching assistant
- *Electricity and Magnetism* (Phys 102), Spring 1997
- *Mechanics* (Phys 101), Fall 1996
  Recitation instructor
- *General Physics II* (Phys 126), Spring 1996
- *General Physics I* (Phys 125), Fall 1995
  Recitation instructor

## INTERNATIONAL SCHOOLS

*Attendance*

- CTEQ Summer School on QCD, Wisconsin, June 2000
- NATO Advanced Study Institute on Techniques and Concepts of High Energy Physics, St. Croix, USVI, June 2000
- SLAC Summer Institute on Particle Physics, August 2000

PRESENTATIONS

QUAERO*: A Method for Making HEP Data Publicly Available*

- PhyStat 2003, SLAC, September 2003*
- Computing in High Energy Physics 2003, UC San Diego, March 2003*
- Experimental Nuclear/Particle Seminar, Columbia University, February 2003
- Research Progress Meeting, LBNL, March 2002
- Experimental seminar, SLAC, March 2002
- HEP seminar, Princeton University, February 2002
- Enrico Fermi Institute HEP Brown Bag Lunch Talk, January 2002
- HEP seminar, LAL Orsay, France, November 2001
- HEP seminar, LPNHE, Paris, France, November 2001
- HEP seminar, Rutherford Appleton Laboratory, UK, October 2001
- HEP seminar, Oxford University, UK, October 2001
- DESY seminar, Hamburg, Germany, October 2001
- Fermilab Wine and Cheese, Fermilab, IL, August 2001

*Sleuthing for Physics beyond the Standard Model*

- Physics Colloquium, University of Colorado at Boulder
- Invited plenary talk, Advanced Computing and Analysis Techniques (ACAT) 2003, Japan, December 2003*
- HEPL Seminar, Harvard, September 2003
- Physics Department Colloquium, Northeastern University, October 2003
- HEP seminar, Caltech, January 2003
- University of British Columbia, January 2003
- Particle and Nuclear Physics Colloquium, MIT, December 2002
- Oxford University, November 2002
- Physics Department Colloquium, Columbia University, September 2002
- DPF/DPB Awards Session, APS April Meeting 2002, Albuquerque
- Undergraduate colloquium, Valparaiso University, February 2002
- HEP seminar, University of Aachen, Germany, November 2001
- Physics Colloquium, University of Zurich, Switzerland, November 2001
- NSF Run II Day, Arlington, VA, June 2001
- Moriond QCD, Les Arcs, France, March 2001*
- Brookhaven National Laboratory HEP seminar, February 2001
- Fermilab Wine and Cheese, Fermilab, IL, February 2001
- University of Rochester HEP seminar, Rochester, NY, February 2001
- Rice University Physics Department Colloquium, Houston, TX, January 2001
- Rice University Bonner Lab HEP seminar, Houston, TX, January 2001
- Enrico Fermi Institute HEP Brown Bag Lunch Talk, January 2001
- Boston University HEP Seminar, Boston, MA, December 2000
- Harvard University HEP Seminar, Cambridge, MA, November 2000
- Top Thinkshop 2, Fermilab, November 2000
- University of Michigan HEP Seminar, Ann Arbor, MI, November 2000
- VII International Workshop on Advanced Computing and Analysis Techniques in Physics Research, Fermilab, IL, October 2000*
- UW-Madison HEP Seminar, Madison, WI, September 2000
- LBNL Research Progress Meeting, Berkeley, August 2000
- DPF 2000, Columbus, Ohio, August 2000*
- New Perspectives Fermilab Graduate Student Conference, Fermilab, July 2000
- NATO-ASI 2000, St. Croix, USVI, July 2000

Miscellaneous

- *Particle Physics*, Saturday Scholars Program, Aurora University, IL, October 2002
- *A Tirade on Binning*, Enrico Fermi Institute HEP Brown Bag Lunch Talk, September 2002
- *A Monte Carlo Wish List*, Run II Monte Carlo Workshop, Fermilab, April 2001
- *Unbiased Setting of Cuts*, APS Centennial, Atlanta, Georgia, March 1999
- *A Measure of Sensitivity*, New Perspectives Fermilab Graduate Student Conference, Fermilab, July 1998
- *DØ Optimized Search for Leptoquarks Decaying to eejj*, New Perspectives Fermilab Graduate Student Conference, Fermilab, July 1997
- *A Multivariate Probability Density Estimation (PDE) Method Applied to Top Quark Mass Analysis*, High Energy Physics Snowmass Workshop, Snowmass, Colorado, August 1996
- *Measuring the Top Quark Mass with Probability Density Estimates*, National Conference on Undergraduate Research, Asheville, North Carolina, April 1996

PUBLICATIONS

Articles with primary authorship

- B. Knuteson, P. Padley. *Statistical Challenges with Massive Data Sets in Particle Physics.* Journal of Computational and Graphical Statistics, special December issue 2003; hep-ex/0305064.
- B. Knuteson. *Optimal Binning for Likelihood Ratios.* Submitted to Nuclear Instruments and Methods A.
- B. Knuteson, H. Miettinen, L. Holmström. *$\vec{\alpha}$PDE: A New Multivariate Technique for Parameter Estimation.* Computer Physics Communications, Vol. 145 (3) (2002) pp. 351-356; physics/0108002.
- DØ collaboration. *Search for New Physics Using* QUAERO*: A General Interface to DØ Event Data.* Phys. Rev. Lett. 87, 231801 (2001); hep-ex/0106039.
- DØ collaboration. *A Quasi-Model-Independent Search for New High $p_T$ Physics at DØ.* Phys. Rev. Lett. 86, 3712 (2001); hep-ex/0011071.
- DØ collaboration. *A Quasi-Model-Independent Search for New Physics at High Transverse Momentum.* Phys. Rev. D 64, 012004 (2001); hep-ex/0011067.
- DØ collaboration. *Search for New Physics in $e\mu X$ Data at DØ using* SLEUTH*: A Quasi-Model-Independent Search Strategy for New Physics.* Phys. Rev. D 62, 92004 (2000); hep-ex/0006011.

PROCEEDINGS

Proceedings with primary authorship

- B. Knuteson. *Systematic Analysis of High Energy Collider Data*. Prepared for ACAT 2003, KEK, Japan, 01-05 Dec 2003; hep-ex/0402029.
- B. Knuteson. *Systematic Analysis of HEP Collider Data*. Prepared for PHYSTAT 2003, SLAC, 07-11 Sep 2003; hep-ex/0311059.
- B. Knuteson. QUAERO*: Motivation, Summary, Status*. Prepared for 2003 Conference for Computing in High Energy and Nuclear Physics (CHEP 03), La Jolla, California, 24-28 Mar 2003; hep-ex/0305065.
- B. Knuteson. SLEUTH*: A Quasi-Model-Independent Search Strategy for New High-$p_T$ Physics*. Prepared for 7th International Workshop on Advanced Computing and Analysis Techniques in Physics Research (ACAT 2000), Batavia, Illinois, 16-20 Oct 2000.
- B. Knuteson. *Search For New Physics In e$\mu$X Data At The Tevatron Using* SLEUTH*: A Quasi-Model-Independent Search Strategy For New Physics*. Prepared for The Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2000), Columbus, Ohio, 9-12 Aug 2000. Int. J. Mod. Phys. A **16S1B**, 888 (2001).
- B. Knuteson. SLEUTH*: A Quasi-Model-Independent Search Strategy for New Physics*. Presented at 36th Rencontres de Moriond on QCD and Hadronic Interactions, Les Arcs, France, 17-24 Mar 2001. hep-ex/0105027.

†Declined
*Proceedings available

## Selected accomplishments

### QUAERO

Knuteson is responsible for an idea (QUAERO) that allows a high energy collider collaboration to make its data publicly available, used for the first time by DØ in 2001. Recognizing the potential utility of LEP data in the deciphering of new physics in Tevatron Run II, he was awarded an NSF International Research Fellowship to carry out a similar program at CERN, and has been working with members of the ALEPH and L3 collaborations to understand all of the LEP II data in sufficient detail that they can be made available through QUAERO, for use by physicists worldwide.

### SLEUTH

Although we expect to observe physics beyond the Standard Model in Run II of the Fermilab Tevatron or at the Large Hadron Collider at CERN, we can only speculate what form that new physics will take. Faced with this situation, the standard search strategy in our field, in which data are analyzed in the context of a particular model, is inadequate. For his dissertation Knuteson developed a data-driven and model-independent approach (SLEUTH), in which the data are partitioned into exclusive final states, regions of excess above expected background are searched for at large transverse momentum, and the many places that a signal might have appeared (but did not) is rigorously accounted for. The development and application of SLEUTH to a large fraction of DØ's Run I data has resulted in two articles published in Physical Review D and one Physical Review Letter. This work was recognized by the American Physical Society with the Mitsuyoshi Tanaka Award for best dissertation in experimental high energy physics in 2002.

### HARDWARE — CDF EVENT BUILDER

The CDF Event Builder is a networking switch and associated software that collects the fragments of events passing the level 2 trigger from individual subdetectors and builds them into a single object within the memory of a single PC, which can then make a global event trigger decision. Knuteson is leading the implemention of a gigabit ethernet solution to the higher throughput requirements demanded of the system in Tevatron Run IIb.

### HARDWARE — DØ VLPCs

Visible light photon counters (VLPCs) are a relatively new technology employed to convert photons from DØ's Run II central fiber tracker into electrical signals. In 1998–99 Knuteson designed a system test of DØ's VLPCs, readout, and tracking trigger logic. This included his design of two printed circuit boards, built on time and within budget. The first board contained ten layers routing signals at 53 MHz and housed controlling firmware, dual-ported static RAMs to hold track trigger patterns, and DACs to convert these trigger patters to analog signals. These signals were received by a second board containing a grid of fast LEDs patched into a bundle of fiber optics to simulate the scintillation light produced by a charged particle traversing the fibers of the central tracker. The initial prototypes of both boards met specifications.

TURBOSIM

Accurate simulation of detector response to collisions at the energy frontier is typically achieved with a detailed Monte Carlo propagation of individual particles through the detecting medium. Attention to physical detail is achieved at high cost in speed, with present simulations requiring ten seconds (CDF) to ten minutes (ATLAS) for the simulation of modestly busy events on a 2 GHz PC. Past analyses have successfully utilized parametric detector simulations at high cost in development time, with detector foibles painstakingly parametrized. In an effort to address the deficiencies of both approaches, Knuteson has developed a general purpose parametric detector simulation that tunes itself to the result of the detailed simulation, achieving a fast simulation that adequately reproduces the full simulation even in the complicated environment of $p\bar{p}$ collisions, that can be used without modification by any frontier energy collider experiment, and that runs at the turbo-charged speed of 10 milliseconds per event.

ACCELERATOR PHYSICS

While at CERN, Knuteson worked in the accelerator theory group to investigate the contribution of intrabeam scattering to the emittance in CLIC damping rings. Together with John Jowett, he characterized the dependence of emittance growth due to intrabeam scattering on tunable parameters of the lattice. These results were shown at the Ninth International Workshop on Linear Colliders in February 2002.

PARAMETER ESTIMATION

*Top quark mass*

Knuteson's undergraduate senior thesis contained a new technique for measuring the mass of the newly discovered top quark, using kernel estimates to improve upon previous template-based approaches.

*Leptoquarks*

Knuteson was involved in the analysis that ruled out the interpretation of events observed at the ZEUS and H1 experiments at HERA in 1997 as evidence of the production of leptoquarks, contributing an improved leptoquark mass estimator for final states in which the kinematics are underconstrained.

*$\vec{\alpha}$PDE*

Together with collaborators from Finland, Knuteson has generalized the methods developed for estimating top quark and leptoquark masses into a multipurpose and multivariate analysis technique ($\vec{\alpha}$PDE). By manipulating probability densities directly, $\vec{\alpha}$PDE provides an intuitive and transparent alternative to methods like neural networks, which are often justifiably criticized as black boxes. An article describing $\vec{\alpha}$PDE has been published in Computer Physics Communications.

## PARTICLE IDENTIFICATION

*Missing transverse energy*

While working at the Laboratoire de Physique Nucléaire et de Hautes Energies (LPNHE) in Paris on an exchange supported by the France-Berkeley Fund, Knuteson developed an algorithm for checking the consistency of an event with the hypothesis of negligible missing transverse energy, using maximal information about the topology of the event and resolution of measured quantities. This technique substantially improves upon the simple angular selection used in previous analyses at CDF and DØ.

*Electrons and photons*

Knuteson has developed likelihood-based algorithms for identifying energetic and isolated electrons and photons in the CDF central and forward calorimeters that significantly improve upon the selection criteria used in Run I.

## TEACHING

In his junior year at Rice University, Knuteson was one of two recitation instructors for *General Physics I* and *General Physics II*, a year-long introductory sequence for students in the life sciences. In his senior year, Knuteson was the sole recitation instructor for *Mechanics* and *Electricity and Magnetism*, the year-long introductory sequence for students in engineering and the physical sciences. Although his semiweekly sessions, which covered lecture material, problems, and questions, occasionally attracted over one hundred students, he also tutored students individually and in small groups. His peers at Rice named Knuteson a Rice University Outstanding Senior, citing these contributions to physics education.

## Research goals

### ELECTROWEAK SCALE PHYSICS

Knuteson has invested significantly in both the CDF and DØ experiments at the Fermilab Tevatron, and is excited by both the near-term discovery potential at the Tevatron and the longer-term discovery potential at the CERN LHC. He plans to continue research at the Tevatron throughout Run II, and then move to the LHC.

### PHYSICS BEYOND THE STANDARD MODEL

The Tevatron and LHC experiments hold the exciting promise of pointing a direction beyond the standard model of particle physics. While previous attempts to discover this direction have focused on the testing of specific models and signatures, a more thorough and systematic approach is necessary if we truly hope to discover something unexpected. In a departure from the way in which we have traditionally analyzed data, Knuteson has initiated a global comparison of all high-$p_T$ Run II data with the standard model to test for the existence of gross discrepancies. Once this has been accomplished, SLEUTH provides the only framework so far developed for carrying out a systematic search for new low cross section physics at high $p_T$. Building upon work begun at DØ and continued at CDF, he intends to systematically search Tevatron and LHC data for evidence of new physics.

### PRECISION MEASUREMENTS WITHIN THE STANDARD MODEL

A prerequisite for performing any analysis is the understanding of the data and its associated standard model and instrumental backgrounds. These in hand, QUAERO provides a natural method for making any of a number of precision measurements. QUAERO allows the straightforward combination of results among different final states and different experiments, with complete propagation of systematic errors. Building upon work begun at DØ and continued at LEP, Knuteson intends to use QUAERO to perform a number of top quark and electroweak measurements, where a deviation from prediction may indicate the presence of new physics.