David Wilkins Miller

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Education

2006 - 2011 Stanford University, Stanford, CA
Doctor of Philosophy, Physics

2001 - 2005 University of Chicago, Chicago, IL
B.A. with honors, Physics, Specialization in Astrophysics

Professional Experience

University of Chicago	2013-present	Neubauer Family Assistant Professor
Enrico Fermi Institute	2011-2013	McCormick Fellow (ATLAS experiment)
SLAC, Stanford University	2006-2011	Graduate research assistant (ATLAS experiment)
University of Chicago	2005-2006	Research technician (ATLAS experiment)
University of Chicago	2003-2005	Undergrad research assistant (CAST experiment)

Honors

Neubauer Family Assistant Professor Award, University of Chicago, 2013
ATLAS Thesis Award for outstanding contributions to ATLAS, 2011
IEEE Real-Time Conference Outstanding Paper Award, 2010
Stanford University Paul H. Kirkpatrick Graduate Teaching Award, 2007
National Science Foundation Graduate Research Fellowship, 2005-2008
American Physical Society LeRoy Apker Undergraduate Physics Achievement Award, 2005
University of Chicago Fire Department Scholar, 2001-2005

Research Experience

2013 - Present **Physics Department, University of Chicago**
Neubauer Family Assistant Professor

- Electronics for global feature extraction (gFEX) Run III Level-1 boosted object trigger
  - Responsible for the slow control and configuration of the board
  - Development of substructure-based Level-I trigger algorithms
- ATLAS Deputy Jet Trigger Signature coordinator
  - Development and deployment of the Run II Jet Trigger menu
  - Coordination of approx. 8-10 students, 5-7 postdocs, and 3-4 faculty (8-10 FTE)
- Co-Director of the 2014 Enrico Fermi Institute Summer Interns Program
  - Hosted 17 7th graders (ranging from 11-13 years old) for 1 week of experiments, lectures, and demonstrations in physics at the beginning of July.
  - Includes building DIY magnetometer circuits using the Arduino platform, a trip to the Museum of Science and Industry, and in-class demonstrations of magnetic fields, forces, and their relationship to electricity.

2011 - 2013 **Enrico Fermi Institute, The University of Chicago**
Enrico Fermi Fellow, Postdoctoral Scholar (ATLAS experiment)

- Co-convener of the R-Parity Violating (RPV) Signatures Group within the Supersymmetry (SUSY) Physics Working Group.
  - I served as one of two conveners responsible for the coordination of this physics group whose goal is to explore and publish results on the search for evidence of SUSY that do not rely on the canonical missing transverse energy signatures.
  - This group is tightly related to understanding of the detector systems of ATLAS since many of the signatures utilized rely on time-of-flight measurements, exotic energy deposition signatures in the tracker, calorimeters, and muon systems, and other detailed instrumentation details.
  - During my tenure as SUSY RPV Group co-convener (until August 2013) 5 conference reports and 1 paper were published.
- Co-convener of the Jet Substructure and Tagging Performance Group.
  - I served as one of two conveners responsible for the coordination of this group. The group is charged with the calibration and validation of new non-standard jet and tagging algorithms for physics, the study of their performance and systematic uncertainties, and the development of tools for partonic flavor tagging and the identification of heavy boosted objects decaying to jets.
  - We have published five conference reports on the use of quark/gluon discrimination, jet algorithm modification procedures and performance, subjet energy scales and validation, and the performance of boosted hadronic top quark reconstruction in ATLAS.
  - A comprehensive 72 page journal article on the foundations of boosted object measurements resulted from this work.

- Contact physicist for the search for boosted supersymmetric (SUSY) particle decays.
  - This new class of analysis leverages the hadronic final state tools and understanding gained in the past several years of theoretical and experimental development to search for R-parity violating gluino and neutralino decays to three quarks, as well as new approaches to searches traditionally based on missing energy signatures. If not for the advent of these new algorithms, these searches would not be possible at low mass.
- Co-coordinator of the Tile Hadronic Calorimeter Calibrations group.
  - I am jointly responsible for the short and medium-term organization and operation of the of the various calibration systems deployed in the hadronic calorimeter in ATLAS.
  - In this role, I have overseen new phases in the usage of these systems. We commissioned the use of the laser system for intercalibration of readout channels during periods between absolute recalibrations derived from Cesium source scans of the individual scintillator response. We also introduced new tools for evaluating calibration quality and performance, including a web-based calibration viewer.
- Responsible for deployment of new jet algorithms in ATLAS and the evaluation of systematic uncertainties used in measurements of and searches for highly boosted W bosons, top quarks, and di-boson resonances.
  - In addition to the analysis that I lead, these tools are being made available to the entire ATLAS collaboration for use in a wide range of new physics analyses characterized by a common final state signature.

2006 - 2011 **SLAC National Accelerator Laboratory, Stanford University**

Graduate student research assistant (ATLAS experiment: Pixel detector group, Jet/E_T^{miss} performance group, Trigger-DAQ group, Standard Model physics group)

- **Ph.D. thesis:** *Measurement of Hadronic Event Shapes and Jet Substructure in Proton-Proton Collisions at 7.0 TeV Center-of-Mass Energy with the ATLAS Detector at the Large Hadron Collider.*
  - My thesis work consisted primarily in understanding and overcoming the experimental challenges that are a result of the high luminosity environment at the LHC and developing new techniques for utilizing the hadronic final state as both a measurement tool for the Standard Model and as a discovery tool for new physics.
  - I have played a leading role in developing experimental strategies to utilize jet substructure techniques to perform a set of measurements with the first data: Boosted top decays, boosted W bosons, and searches for boosted new heavy particles. The calibration and validation of these detailed tools performed with the first 3 pb^{-1} builds on expertise in both the detector and the theoretically motivated tools for searching for signatures of exotic boosted objects.
  - The study of hadronic event shapes provides an excellent tool for testing perturbative QCD at high-energy while controlling systematic uncertainties related to the jet energy scale and other dominant systematic uncertainties. These measurements will eventually be used to further tune the Monte Carlo simulation for non-perturbative effects such as underlying event and hadronization effects.

- Jet properties and reconstruction
  - As co-editor of the first public analysis results in ATLAS on jet properties at both $\sqrt{s}$ = 900 GeV and 7 TeV, I have helped to establish an understanding of both experimental and theoretical effects on the hadronic final state for the experiment. These studies form the basis upon which nearly all first results involving jets and hadronic final states rely. The internal energy flow of jets, track-based jet properties, and jet reconstruction techniques based on several different input signal types were all studied in detail. The results were then used to understand the interplay of detector effects and physical properties of the hard-scattering on the observed hadronic final state and presented by me at the CALOR'10 conference.
  - Prior to first collisions, I implemented the topological noise-suppression technique for the tower-based input signal for jets, thus allowing for a straight-forward method to correct for the effects of multiple interactions using a data-driven approach. Jets constructed from these noise-suppressed towers are now present by default in all ATLAS data, and are being actively used.

- Heavy ion jet quenching measurement
  - Building on the expertise gained in studying jet properties and the information endowed by utilizing tracking information, I performed the crucial systematics cross-checks and alternate track-jet analysis for the first observation of jet quenching in heavy ion collisions. These measurements allowed the observation of a calorimeter jet asymmetry – indicative of the energy loss of quarks and gluons traversing a hot, dense medium of quark-gluon plasma – to quickly proceed from initial observation to publication in a matter of days. As a result, ATLAS was able to publish this important measurement in Physical Review Letters within a week of the initial indications seen in the data.
  - The cross-checks I performed included developing an alternative track-jet analysis, not dependent on the underlying event subtraction procedure inherent in the calorimeter jet reconstruction algorithms for heavy ion collisions. I also produced tests of the jet energy scale and the subtraction procedure itself by using track-jets matched to calorimeter jets as an unbiased metric which were critical to bring this analysis to publication in such short time scale.

- Techniques for high-luminosity jet identification and calibration
  - The rate of multiple simultaneous proton-proton interactions, or "pile-up", has already nearly reached the overall LHC design goals in the first 5 fb^{-1} of data at the LHC. This rate is furthermore expected to rise in 2012. Techniques to mitigate the effects of pile-up are both essential for the first physics analyses in ATLAS, and will become more important in the future as the luminosity of the LHC increases.
  - I introduced to ATLAS a method pioneered by the Tevatron experiments to subtract the soft, diffuse background from jets measured in the calorimeter. I developed a novel approach for validating this "offset" correction *in-situ* that combines the information from the calorimeter with jets built only from charged tracks measured in the Inner Detector. This correction has also been demonstrated to accurately correct the differential jet shape, which significantly extends its application beyond that pursued by previous experiments.
  - A technique developed by the DØ collaboration uses tracks to associate jets to their primary interaction vertices, providing a discriminant with which to select or reject a jet based on its origin. I was responsible for the implementation of this algorithm in ATLAS and its further development and commissioning with first data. I demonstrated that the so-called "jet-vertex fraction" can be used to provide jet-by-jet energy scale corrections for multiple interactions. This discriminant is now being used in nearly all analyses involving jets, such as the "re-discovery" of the top quark within ATLAS, searches for supersymmetry, and is even being considered for use in the trigger system.

- Online beam spot measurement
  - The second level of the ATLAS trigger system is the first stage of the read-out chain that has access to the detailed measurements made by the Inner Detector tracking system, a process performed many thousands of times per second. Measuring the LHC beam position and shape (the "beam spot") within this time window is both technically challenging and crucial for the identification of long-lived b-quarks in the short time window available in the trigger system. The online beam position measurement provides a robust and precise references for measuring the transverse impact parameter of tracks for so-called "b-tagging".
  - From its inception, I have been involved in all aspects of the online measurement and characterization of the LHC beam position and profile within ATLAS. The algorithm design, implementation, system testing and finally online integration within the ATLAS trigger system were my responsibility and resulted in the first joint LHC-ATLAS conference paper, presented at the IPAC'10 conference.
  - This measurement provides a high accuracy, self-consistent beam position and size determination for use by the b-tag trigger. By counting the primary vertices reconstructed by this algorithm, I provided the first independent track-based relative luminosity measurement at $\sqrt{s} = 900$ GeV. Real-time updates are able to follow changes in the beam position over time, a functionality necessary for efficient and accurate impact parameter estimation over the course of a long run. These results were presented by me at the RealTime'10 conference and awarded an Outstanding Student Paper award.
  - Measurements provided by the online beam spot were used to provide feedback to the LHC operators for beam adjustments during the first LHC runs, are available continuously for all stable beam periods, and have proved crucial for the correct operation of the b-tag trigger algorithms.

- Pixel detector hardware
  - During the construction and connectivity phase of the installation of the silicon Pixel vertex detector, I was partially responsible for testing and certifying components of the final high-voltage distributions system. These tests directly led to improvements in the construction of the circuit boards installed in the current system.
  - The placement of the Pixel detector at the heart of ATLAS denies the possibility for conducting tests or debugging system problems *in-situ*. I worked closely with a team of students and postdocs to install and operate a small-scale replica of the full silicon Pixel detector to serve as a test stand at CERN for the lifetime of the experiment. This work involved setting up the high-voltage distribution system, performing calibration tests, some light machining of parts, and becoming familiar the software infrastructure for data acquisition and calibration.
  - Due to the high bandwidth required to extract the data from the 80 million channels of the Pixel detector, the timing of each read-out channel must be known to within 25ns. I was responsible for the synchronization of the entire detector, and provided the crucial first measurements that allowed for a full-detector tuning and thus the ability to meet the strict timing requirements for the experiment.

2005 - 2006 **Enrico Fermi Institute** (University of Chicago)
Research technician (ATLAS experiment: TileCal calorimeter detector group)

- Calorimeter installation and commissioning
  - During the installation and commissioning phase of the ATLAS Tile calorimeter, I performed the duty as front-end electronics connections team leader. In this role, I was responsible for coordinating and reporting the progress and quality control of the read-out chain integrity and readiness. Weekly reports to the TileCal detector group and periodical reports to the ATLAS commissioning coordination were both necessary. I also helped to organize activities with other subdetector groups who were conducting installation and commissioning tasks. Finally, perhaps one of the most important and fruitful responsibilities was the identification and solution of hardware problems uncovered by the measurements for which I was responsible.
  - I performed *in situ* stability tests of front-end power supplies and on-detector electronics which included coordinating measurements and results with the data acquisition and data quality teams and analyzing results. In the process, I gained a very intimate familiarity with the entire read-out chain of the hadronic calorimeter system.

2003 - 2005 **Kavli Institute for Cosmological Physics** (University of Chicago)
Undergraduate research assistant (CAST experiment: γ-ray calorimeter detector group)

- Hadronic axion search
  - The observed CP invariance in the strong interactions was not expected, *a priori*, and has been named the *strong-CP problem*. Peccei and Quinn proposed a solution to this problem which surmises the existence of a $U(1)$ symmetry, and its corresponding particle, the *axion*, and provides a physical origin for the the lack of strong CP violation. The hadronic axion models that evade the astrophysical and accelerator-based searches retain couplings to nucleons and photons and are thus detectable if emitted in nuclear transitions. The CAST gamma-ray calorimeter performed a model independent search for such *high-energy* ($\approx 1 - 100$ MeV) hadronic axions using the CAST helioscope at CERN in 2004 and 2005. The helioscope design aims to convert axions into photons of the corresponding energy using the Primakoff effect.
  - The full analysis required to interpret the potential signal from an axion emitted from a nuclear transition in the Sun in terms of the axion-photon coupling, on which the detection mechanisms are dependent. Although no significant new limits were observed beyond those determined via astrophysical searches, these results were the first to use a helioscope design and to probe for a potential axion-like signal in a model independent manner.
  - The analysis of these data formed the central component of my undergraduate research work and for which I was awarded the 2005 LeRoy Apker Undergraduate Physics Achievement Award from the American Physical Society. Upon approval from the collaboration, I was editor and corresponding author for publication of the calorimeter results in the Journal of Cosmology and Astrophysics.

- Detector design, construction, operation
  - I played a leading role in the design, construction, and installation of the CAST gamma-ray calorimeter. I tested an array of inorganic scintillating crystals and measured their properties both in terms of detector performance (e.g. efficiency and resolution) and in terms of their intrinsic radioactive contamination and pulse shape discrimination abilities. The combined results led to the choice of crystal and, in part, the overall design of the detector, which must maintain a high sensitivity to the photon signal from axions while obtaining a very low rate of background-induced signals, such as those from neutrons or α-particles.
  - During construction, I assisted in the machining of various components, designed and incorporated an *in-situ* dead-time measurement device, and constructed a dedicated low-voltage power supply to be used when mounted on the helioscope at CERN.
  - While at CERN, I was the monitoring, data acquisition, and analysis coordinator for calorimeter first run data.

- Pulse shape discrimination
  - Due to the low low expected rate of axion-photon conversion in the Sun, background rejection can be achieved using both passive rejection techniques, such as shielding, or active rejection techniques, such as pulse shape discrimination. By using the unique response of the cadmium tungstate ($CdWO_4$) crystal to ionizing interactions compared to nuclear interactions (e.g. from neutrons) it is possible to define a discriminant based on these shapes and therefore to reject signals incompatible with a photon.
  - I took the lead in developing the pulse shape discrimination and particle identification algorithms used by the CAST calorimeter. These techniques were largely based on those used by neutrinoless double β-decay experiments and achieved a 50% rejection of α-particle induced events while retaining more than 97% of γ-ray events based on the pulse shape properties alone.

Selected Publications

ATLAS Collaboration, "Search for new phenomena in final states with large jet multiplicities and missing transverse momentum at $\sqrt{s} = 8$ TeV proton-proton collisions using the ATLAS experiment", JHEP 10(2013)130 (arXiv:1308.1841) (2013)

ATLAS Collaboration (corresponding author), "Performance of jet substructure techniques for large-R jets in proton-proton collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector", JHEP 09(2013)076 (arXiv:1306.4945) (2013)

ATLAS Collaboration (corresponding author), "Search for pair production of massive particles decaying into three quarks with the ATLAS detector in $\sqrt{s} = 7$ TeV pp collisions at the LHC", JHEP 1205(2012)128 (arXiv:1210.4813) (2012)

ATLAS Collaboration (corresponding author), "Measurement of Hadronic Event Shapes at High Q^2 with the ATLAS Detector at the LHC", Eur. Phys. J. C (2012) 72: 2211 (arXiv:1206.2135) (2012)

ATLAS Collaboration, "Measurement of Jet Mass and Substructure for Inclusive Jets in $\sqrt{s} = 7$ TeV pp Collisions with the ATLAS Experiment", JHEP 1205(2012)128 (arXiv:1203.4606) (2012)

Altheimer, A. *et al.*, "Jet Substructure at the Tevatron and LHC: New results, new tools, new benchmarks", J. Phys. G39 (2012) 063001 (arXiv:1201.0008) (2011)

ATLAS Collaboration, "Jet energy measurement with the ATLAS detector in proton-proton collisions at $\sqrt{s} = 7$ TeV in 2010", accepted by EPJC (arXiv:1112.6426) (2011)

ATLAS Collaboration, "Luminosity Determination in pp Collisions at $\sqrt{s} = 7$ TeV Using the ATLAS Detector at the LHC", Eur. Phys. J. C 71 (arXiv:1101.2185) (2011)

ATLAS Collaboration, "Observation of a Centrality-Dependent Dijet Asymmetry in Lead-Lead Collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS Detector at the LHC", Phys. Rev. Lett. 105, 252303 (arXiv:1011.6182) (2010)

ATLAS Collaboration, "Performance of the ATLAS Detector using First Collision Data", JHEP 09(2010)056 (arXiv:1005.5254) (2010)

ATLAS Collaboration, "The ATLAS Inner Detector commissioning and calibration", Eur. Phys. J. C 70 (arXiv:1004.5293) (2010)

CAST Collaboration (corresponding author), "Search for solar axion emission from ^{7}Li and D(p,γ)^{3}He nuclear decays with the CAST γ-ray calorimeter", JCAP **1003** 032, (arXiv:hep-ex/0904.2103) (2010)

CAST Collaboration, "Search for 14.4 keV solar axions emitted in the M1-transition of ^{57}Fe nuclei with CAST", JCAP **0912** 002, (arXiv:0906.4488) (2009)

CAST Collaboration, "Probing eV-scale axions with CAST", JCAP **0902** 008, (arXiv:0810.4482) (2008)

CAST Collaboration, "An improved limit on the axion-photon coupling from the CAST experiement", JCAP **0704** 010, (arXiv:hep-ex/0702006) (2007)

CAST Collaboration, "First Results from the CERN Axion Solar Telescope (CAST)", Phys. Rev. Lett. **94**, 121301, (arXiv:hep-ex/0411033) (2005)

Conference proceedings

Miller, D. W. "Studies of the internal properties of jets and jet substructure with the ATLAS Detector" Proceedings of the 2011 Europhysics Conference On High Energy Physics, EPS-HEP (2011)

Miller, D. W. "Jet substructure in ATLAS" Proceedings of the Division of Particles and Fields of the American Physical Society, DPF (2011)

Miller, D. W. "Online Measurement of LHC Beam Parameters with the ATLAS High Level Trigger" Proceedings of the 17th IEEE Real-Time Conference (2010)

Miller, D. W. "First measurement of jets and missing transverse energy with the ATLAS calorimeter at $\sqrt{s} = 900$ GeV and $\sqrt{s} = 7$ TeV" Proceedings of the 14th International Conference on Calorimetry in High Energy Physics, CALOR (2010)

Selected Public ATLAS Analysis Notes

ATLAS Collaboration "Performance of pile-up subtraction for jet shapes in *pp* collisions at $\sqrt{s} = 8$ TeV", ATLAS-CONF-2013-085, 2013

ATLAS Collaboration "Performance of boosted top quark identification in 2012 ATLAS data", ATLAS-CONF-2013-084, 2013

ATLAS Collaboration (editor) "Studies of the impact and mitigation of pile-up on large-R and groomed jets in ATLAS at $\sqrt{s} = 7$ TeV", ATLAS-CONF-2012-066, 2012

ATLAS Collaboration (co-editor) "Performance of large-R jets and jet substructure reconstruction with the ATLAS detector", ATLAS-CONF-2012-065, 2012

ATLAS Collaboration "Jet energy scale and its systematic uncertainty in proton-proton collisions at $\sqrt{s} = 7$ TeV in ATLAS 2010 data", ATLAS-CONF-2011-032, 2011

ATLAS Collaboration (co-editor) "In-situ jet energy scale and jet shape corrections for multiple interactions in the first ATLAS data at the LHC", ATLAS-CONF-2011-030, 2011

ATLAS Collaboration (co-editor) "Properties of Jets and Inputs to Jet Reconstruction and Calibration with the ATLAS Detector Using Proton-Proton Collisions at $\sqrt{s} = 7$ TeV", ATLAS-CONF-2010-053, 2010

ATLAS Collaboration "Characterization of Interaction-Point Beam Parameters Using the pp Event-Vertex Distribution Reconstructed in the ATLAS Detector at the LHC", ATLAS-CONF-2010-027, 2010

ATLAS Collaboration (co-editor) "Properties and internal structure of jets produced in proton-proton collisions at $\sqrt{s} = 900$ GeV", ATLAS-CONF-2010-018, 2010

ATLAS Collaboration "Inputs to Jet Reconstruction and Calibration with the ATLAS Detector Using Proton-Proton Collisions at $\sqrt{s} = 900$ GeV", ATLAS-CONF-2010-016, 2010

ATLAS Collaboration "Performance of the ATLAS Inner Detector Trigger algorithms in p-p collisions at $\sqrt{s} = 900$ GeV", ATLAS-CONF-2010-014, 2010