

## Jahred Adelman, Associate Professor

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### Education

Ph.D. Physics, University of Chicago, 2008  
Sc.B. Physics, Brown University, 2002 (with honors)

### Academia (NIU, 2014-)

Director of Graduate Studies, Northern Illinois University Department of Physics (2020-)  
Associate Professor of Physics, Northern Illinois University (2018-)  
Director, Northern Illinois Center for Accelerator and Detector Development (2019-2022)  
Assistant Professor of Physics, Northern Illinois University (2014-2018)

### ATLAS Research (NIU, 2014-)

#### Search for new physics in the $hh$ final state (2014-)

I led the ATLAS Run 1 search for enhanced production of  $hh$  events in the  $bb\gamma\gamma$  channel [1], which is sensitive to an anomalous  $t\bar{t}hh$  vertex, resonant  $hh$  production and other models that enhance the rate of pair production of Higgs bosons [2–21]. My group, led by former postdoc D’Eramo, has driven more recent Run 2 analyses, including multiple conference results and papers, culminating in a recent full Run 2 paper [22], a combination result with other channels [23] and a study of future prospects for the analysis [24]. Examining Higgs boson pair production is a key long-term goal of the LHC, as it helps us to explore and directly probe the non-zero vacuum expectation value of the Higgs field and make tests of electroweak symmetry breaking.

#### Diphoton plus heavy flavor measurements (2020-)

My graduate student (Lancaster) is working with postdoc Sedlaczek towards a first-ever measurements of inclusive diphoton plus heavy flavor cross sections. He is building on work from my former student Dwyer, who received an SCGSR award to work at Argonne National Laboratory (ANL) to develop the  $\gamma\gamma$  + heavy flavor analysis. Processes with this final state are an important background for  $hh \rightarrow \gamma\gamma b\bar{b}$  as well as  $t\bar{t}h(\gamma\gamma)$  analyses.

#### EF Tracking and Hardware track triggers (2014-)

I am the US ATLAS Deputy Level 3 manager for the ATLAS EF Tracking Project. I also serve as the International ATLAS L4 manager for Software Framework and Technology for EF Tracking. My team (Lancaster, Sedlaczek) studies the potential and performance of Hough transform implementations and linearized  $\chi^2$  goodness of fit tests inside of FP-GAs. Sedlaczek is also studying fast CPU-based tracking performance. From 2014-2017 I served as the Fast TrackKer (FTK) software coordinator, in charge of coordinating all simulation, optimization and software for the FTK system [25]. My group played critical roles in the commissioning and planned integration of FTK. I also oversaw the design and

development of the simulation and software framework for the ATLAS HL-LHC HTT track trigger upgrade [26], and my team led studies of the potential for an L1Track variant of the upgrade [27].

### **US ATLAS Operations (2018-)**

I served as the US ATLAS Physics Support Manager from 2018-2020, in charge of 10+ scientists and postdocs working on physics analysis and tools support, software infrastructure and ATLAS application software within the US. I also oversaw all funds for US ATLAS centers used to send students, faculty and postdocs from universities in the US to the four national labs working on the ATLAS experiment. My postdoc (Duran) oversees user support at the shared U. Chicago analysis facility for US ATLAS.

### **Photon identification (2018-)**

My former graduate student (Burch) received an SCGSR award in 2018 to spend a year at ANL to develop improved photon identification using machine learning (ML) techniques. By adding new calorimeter variables and moving from a cuts-based method to ML techniques, we have shown significant gain in background rejection for the same photon efficiency. My current graduate student (Mercado) is studying calibration of this work.

### **Searches for new physics in the $h \rightarrow \gamma\gamma$ final state (2017-)**

My group, working with a few other colleagues, set what were the world's best limits on single production of vector-like B quarks [28] in the diphoton final state. My student (Kostecka) is exploring this analysis with the full Run 2 data set. In addition, Sedlaczek is co-leading a new analysis effort and mentoring Mercado in a search for charged Higgs bosons in the diphoton final state.

### **Computational HEP efforts (2022-)**

As the PI for the Chicagoland Computational Traineeship in High Energy Particle Physics (C<sup>2</sup>-THE-P<sup>2</sup>) I lead a joint effort between NIU and UIC to train new graduate students in computational skills necessary for the future of particles physics [29, 30]. My student (Kraus) is studying how to optimize ROOT I/O and memory usage as part of the ATLAS derivation production chain.

### **Tile Calorimeter (2021-)**

I took over leadership of NIU's tile calorimeter responsibilities in 2021, including database expertise (Smirnov), and low-voltage power supply construction for the HL-LHC upgrade. Former work from students also included data quality leadership.

### **Differential and fiducial cross sections in the $h \rightarrow \gamma\gamma$ final state (2017-2022)**

Led by my former student (Dwyer), our team made significant contributions to recent ATLAS results of fiducial and differential cross section measurements in the Higgs to diphoton final state. Such measurements are important to test whether the observed Higgs boson has any deviations from Standard Model predictions. Our recent paper [31] followed up on earlier results [32, 33] in which we studied generic production of Higgs bosons plus heavy flavor, an as-of-yet unexplored final state that nevertheless plays important roles as a background for a variety of physics searches in the diphoton group, as well as made interpretations in

the context of Effective Field Theory (EFT) models and modified charm Yukawa couplings.

#### **ATLAS Publications Committee (2020-2021)**

I served as a member of the ATLAS Publications Committee, a small team of senior physicists on the experiment that vets all analyses for final approval before publication. Together, our team carefully read and scrutinized close to 200 papers and conference notes each year.

#### **Search for new physics via the $t\bar{t}h$ coupling (2014-2018)**

I was an analysis coordinator for ATLAS searches for  $t\bar{t}h$  events where the Higgs boson decays to  $b\bar{b}$ . I helped to run the Run 1 analysis [34], then coordinated and oversaw groups trying to use larger Run 2 data sets. The top quark Yukawa coupling is one of the key measurements of the Higgs physics program at the LHC, and could point us in the direction of physics beyond the Standard Model [35]. Our paper used significantly improved  $b$ -tagging and analysis categorization strategies [36], and was a major part of the ATLAS combination. I also organized and led studies of the potential use of advanced machine learning techniques in searches for  $t\bar{t}h$  with colleagues at NIU and Argonne [37].

## **ATLAS Research (Postdoc with Paul Tipton, Yale University, 2008-2014)**

Search for new physics with  $hh \rightarrow \gamma\gamma bb$  events (2013-2014)

Search for new physics via the  $t\bar{t}h$  coupling (2012-2014)

Top-Jet Resonance Search (2011-2012)

Test of CPT invariance in top sector (2008-2013)

Exotics Multilepton Group Leader (2011-2012)

Leptoquark Analysis Co-Group Leader (2010-2011)

First observation of the top quark at the LHC (2010)

Analysis Model Framework task force (2013-2014)

Top Reconstruction Convener (2012-2013)

Snowmass Top Quark Coupling contact (2013)

FTK Vertical Slice activities (2012-2013)

TRT Offline Software Coordinator (2010-2012)

TRT Data Quality Coordinator (2009-2010)

Online Monitoring (2008-2009)

Numerous Editorial Boards (2012-2014)

## **CDF Research (2011-2012)**

Top-Jet Resonance Search (2011-2012)

Chromophilic  $Z'$  Resonance Search (2011-2012)

## **CDF Research (Graduate student with Melvyn Shochet, University of Chicago, 2002-2008)**

### **Thesis: Top Quark Mass Measurement**

My thesis was a measurement of the mass of the top quark [38]. I played key roles in early CDF top quark mass analyses, including what was at the time the world's single most precise measurement. For my thesis, I improved on previous measurements by moving away from parameterized probability density functions, instead using a more accurate two-dimensional, non-parametric kernel density estimate approach. As the analysis was a precision measurement, careful attention was paid to systematic uncertainties. The event selection was optimized for both statistical and systematic uncertainties, and more robust systematic uncertainty estimation was developed for jets from b-quarks. The analysis was published as part of [39].

### **Top Width Upper limit**

As the only quark to decay before combining with other quarks into more stable bound states, the top quark is a unique particle. I co-led a team that published the world's first upper limit on the top quark width [40].

## CDF Service Tasks

### Silicon Vertex Trigger (SVT)

SVT was a crucial piece of CDF's B-physics program, and enabled CDF to publish the world's first precision measurement of the  $B_s^0$  oscillation frequency [41]. I adopted and installed a general-purpose CDF trigger electronics board as an improved and significantly faster track fitting board for the SVT, writing all the firmware for the conversion. The upgrade [42] was necessary to keep SVT running at higher instantaneous Tevatron luminosities and CDF trigger rates. I tested, debugged and checked over 100 mezzanine cards containing large amounts of memory needed for the upgrade, and was an on-call expert for the entire SVT system.

## Selected Teaching and Outreach Experience

- PHYS 253, Fundamentals of Physics I, 2018-2022
- PHYS 684, Introduction to Particle Physics, 2016+2018+2020+2022
- PHYS 410-510, Computational Physics, 2021
- PHYS 211, General Physics II, 2017
- PHYS 210, General Physics I, 2016-2017
- PHYS 300, Analytical Mechanics, 2014
- The Physics of Baseball, 2015- (multiple presentations and locations)
- Triggering at the LHC: Too much data is a good thing, Fermilab Ask A Scientist Lecture, Columbia College Chicago public lecture, 2018
- Every Child (and Physicist's) Dream Job: Smashing Things Together and Watching What Happens, Fermilab Ask A Scientist Lecture, 2018
- Fermilab Ask a Scientist "Scientist", 2015-
- NIU QuarkNet, 2015-
- ATLAS Visitor Center guide, 2010-2013

## Mentoring

### Postdocs and scientists

- Kevin Sedlaczek, NIU: EF Tracking software,  $H^+$  searches
- Cecilia Duran, NIU: U. Chicago Analysis Facility User Support
- Iouri Smirnov, NIU: Tile DB expertise and software support
- Louis D'Eramo, NIU:  $hh$  searches in the diphoton final state, Higgs boson differential cross sections, L1Track performance studies and EF Tracking+HTT simulation (currently a staff physicist at CNRS in France)
- Rui Wang, NIU: Optimization of event generators for the HL-LHC on HPC facilities and  $hh$  multi-lepton analysis (currently a senior research associate at Argonne National Laboratory)
- Elizabeth Brost, NIU:  $hh$  and other new physics searches in the diphoton final state, FTK operations and commissioning (currently a staff physicist at Brookhaven National Laboratory)
- Nancy Andari, NIU:  $hh$  searches and FTK clustering software and development

### Graduate students

- Gretel Mercado, NIU: Photon MVA data-driven calibration, VBF  $hh$  studies and  $H^+$  searches
- Alec Lancaster, NIU:  $\gamma\gamma$  + heavy flavor studies and EF Tracking simulation
- William KostECKA, NIU: Vector-like B search in the diphoton final state and Tile DQ
- Jack Kraus, NIU (C<sup>2</sup>-THE-P<sup>2</sup> student): Optimization of ROOT I/O
- Tyler Burch, NIU:  $hh$  analysis (MVA approaches, data-MC modeling and addition of a VBF channel),  $t\bar{t}h$  searches, FTK vertexing and hit position studies, FTK operations (formerly a postdoctoral researcher at Argonne National Laboratory working on exascale supercomputing, now a data scientist for the Boston Red Sox)
- Brianna Dwyer, NIU: FTK validation procedure and commissioning, future track trigger upgrade studies,  $h \rightarrow \gamma\gamma$  cross sections and diphoton + heavy flavor analyses (currently a data scientist with the Travis County Auditor's Office)
- Elliot Parrish, NIU: Search for charged Higgs bosons decaying to  $\tau + \nu$  and Tile DQ
- Jamie Saxon, U. of Pennsylvania:  $hh$  searches
- Jared Vasquez, Yale University:  $t\bar{t}h$  studies
- Ben Kaplan, Yale University: Trilepton search, top rediscovery, TRT transition radiation monitoring
- Richard Wall, Yale University: Trilepton search, leptoquark search, top rediscovery, TRT transition radiation calibration
- Vikash Chavda, University of Manchester: Test of CPT invariance in  $t\bar{t}$  lepton+jets channel
- Dan Guest, Yale University: TRT tracking efficiency and resolution studies
- Sarah Lockwitz, Yale University: Implementation of statistical tools

### Undergraduate students

- Linzi Zheng, NIU: Diphoton + jets kinematic studies
- August Lee, NIU:  $hh$  VBF MVA and kinematic studies
- Elyzabeth Graham, Juniata College:  $hh$  VBF background studies
- Daniel Foster, Harper College:  $\gamma\gamma$  + HF Data-MC comparisons
- Nathaniel Obert, NIU:  $hh$  background studies
- Orion Arndt, NIU:  $hh$  signal studies
- Dayne Coveyou, NIU:  $hh$  VBF studies
- Emily Frame, Northern Kentucky University:  $Vhh$  studies
- Ari Josephson, Ohio State University: Photon MVA studies
- Jose Alcaraz, NIU: VLB MVA studies
- Jaime Almanza, UIUC:  $hh$  data-MC modeling
- Derek Kral, NIU: Learning Python and  $hh$  signal studies
- Kyle Wilson, NIU: Optimizing  $hh$  analyses
- Lauren Elder, NIU:  $t\bar{t}h$   $b$ -tagging studies
- Jared Vasquez, UC Irvine:  $t\bar{t}h$  studies,  $t\bar{t}$  dilepton cross section measurement

- Christopher Ell, Yale University: Studies of systematics with PKS, electron PID using bremsstrahlung and the TRT
- Jonathan Greco, Yale University: Test of CPT invariance in  $t\bar{t}$  dilepton channel
- Emine Altuntas, Yale University: Studies of TRT performance at high pileup
- Emma Alexander, Yale University: Statistical studies
- Kurt Brendlinger, Yale University: Test of CPT invariance in  $t\bar{t}$  lepton+jets channel
- Satomi Shiraishi, University of Chicago: Upper limit on the top quark decay width

### Selected Invited Talks

- Differential Higgs boson and diboson cross sections, LHCP2019, Puebla, Mexico
- The Higgs boson at ATLAS: Past, present and future, Department colloquium, Indiana University (April 2019), UC-Santa Cruz (Oct 2018)
- BSM Searches with photons in ATLAS, Photon 2017 (May 2017), Geneva, Switzerland
- FTK status and track triggers in ATLAS at HL-LHC Plenary Talk, VERTEX2016(September 2016), Elba, Italy
- ATLAS search for  $t\bar{t}h, h \rightarrow b\bar{b}$  production, Argonne HEP Division Seminar (Sept 2016)
- Searches for new physics at ATLAS using pair production of Higgs bosons, LAL-Orsay (December 2015), UC-Irvine (April 2015), U. Michigan (March 2015), Argonne (October 2015)
- BSM Higgs searches at ATLAS, Dortmund (December 2015), Virginia Tech (Nov 2015)
- HBSM at the LHC plenary talk, Physics in Collisions 2015 Warwick, UK
- Searches for new physics at ATLAS using pair production of Higgs bosons, Fermilab Wine and Cheese seminar, June 2014
- Direct  $t\bar{t}h$  searches, TOP2013, Durbach Germany
- Search for top-jet resonances, US ATLAS workshop, U. Michigan, August 2012
- Performance of the ATLAS Transition Radiation Tracker, Workshop on Advanced Transition Radiation Detectors for Accelerator and Space Applications, Bari Italy, September 2011

### Awarded and pending external grants and funding

DOE traineeship: Chicagoland Computational Traineeship in High Energy Particle Physics (C<sup>2</sup>-THE-P<sup>2</sup>), lead PI on multi-institutional award, funded for total of \$2,565,000 over 5 years (2022-2027)

NSF Research proposal: Searches for New Phenomena in the Higgs sector at the LHC, co-PI, funded for \$1,050,000 (total) over 3 years (2021-2024)

NSF Research proposal: Searches for New Phenomena at the Energy Frontier, co-PI, funded for \$900,000 (total) over 3 years (2018-2021)

US ATLAS Postdoctoral Support for HL-LHC computing, co-PI, funded for \$70,000/year starting in 2020, expected to last for 3 years (ended early due to Wang receiving a permanent position at ANL)

NSF REU-RET proposal: REU Site: Undergraduate and teacher research in physics at Northern Illinois University, co-PI, funded for \$245,771 (total) over 3 years with 1-year COVID-19 extension (2018-2021)

NSF Cooperative Agreement with US ATLAS Postdoctoral Support for Shared T3 facilities, \$307,214 (total) for 5 years starting in 2021

NSF Research Proposal: Using the Higgs Boson to Probe and Test the Standard Model at ATLAS, funded for \$420,000 (total) over 3 years (2015-2018)

US ATLAS Scholars Award for teaching buy-out to be based at Argonne National Lab and travel for \$59,398 (2014-2015)

## References

- Paul Tipton, Professor, Yale University, paul.tipton@yale.edu
- Mel Shochet, Kersten Distinguished Service Professor of Physics, University of Chicago, shochet@hep.uchicago.edu
- Stephanie Majewski, Professor, University of Oregon, smajewsk@uoregon.edu
- Jinlong Zhang, Physicist, Argonne National Laboratory, zhangjl@anl.gov
- Daniel Whiteson, Professor, University of California Irvine, daniel@uci.edu
- John Hobbs, Professor, SUNY Stony Brook, John.Hobbs@stonybrook.edu

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- [22] Search for Higgs boson pair production in the two bottom quarks plus two photons final state in  $pp$  collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector, *PRD* **106** (2022) 052001, arXiv:2112.11876.
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