Luke Martin Vaughan

Oklahoma State University | ATLAS Collaboration | luke.vaughan@okstate.edu

Research Interest

Experimental high energy particle physics; using machine learning to model complex data with focused concentration on Higgs physics, pileup mitigation, top quark polarimetry, boosted jet tagging, data reconstruction, and calibration techniques.

Education

May 2026 (Expected)	PhD Physics at Oklahoma State University	(GPA: 3.9)
May 2024	M.S. Physics at Oklahoma State University	(GPA: 4.0)
May 2021	B.S. Physics at Oklahoma State University	(GPA: 4.0)
May 2021	B.S. Aerospace Engineering at Oklahoma State University	(GPA: 4.0)
May 2021	B.S. Mechanical Engineering at Oklahoma State University	(GPA: 4.0)

Research Experience

ATLAS Analysis: Hadronic Higgs in the VH production mode Spring 2023 - Fall 2023

I investigated adding a new low pT region with high statistics in the 1-Lepton channel to better constrain backgrounds. Due to the high statistics, this region caused significant pulls on nuisance parameters which I mitigated by implementing a new set of decorrelated parameters. By including this region the Z boson sensitivity increased by nearly 20% which allowed for 5.2σ on the $VZ, Z \to c\bar{c}$ process [1].

ATLAS Analysis: Hadronic Higgs in VBF production mode Fall 2023 - Current

VBF Higgs production is a stat-limited channel and subtracting the large non-resonant QCD background poses a significant challenge. I designed and optimized a framework to train adversarial NNs to construct signal regions with minimal background sculpting. The final fit combination that I performed indicates the strongest results to date regarding $VBF, H \to b\bar{b}$ significance and $VH + VBF, H \to c\bar{c}$ limits[2].

ATLAS Analysis: GN2X $t\bar{t}$ Calibration Spring 2023 - Spring 2024

GN2X is a novel boosted jet tagging algorithm to distinguish between Hbb, Hcc, top, and QCD. I contributed to the evaluation and calibration of GN2Xv01 on semi-leptonic ttbar events. I performed a likelihood fit to derive scale factors to quantify the mistag rate for tagged $t\bar{t}$ events.

R&D Project: Pileup Mitigation using Graph & Attention NN Fall 2023 - Current

Pileup mitigation will be a crucial problem for the High-Lumi LHC, and implementing state of the art algorithms is necessary to maximize the LHC discovery potential. I developed graph and attention based neural networks in PyTorch to encode events and extract event-wide correlations. This approach provides continuous energy and mass corrections at the jet level and demonstrates significant improvement to diHiggs reconstruction in HL-LHC environment[3]. For this project, I developed a simulation framework using MadGraph + Pythia for HPC environment, that scales efficiently to $\langle\mu\rangle = 200$.

R&D Project: Hadronic Top Quark Polarimetry using ML Fall 2024 - Current

Top quark entanglement can be studied at high energy through the spin correlations of decay products. Traditionally, only the leptonic decays of the W boson are studied, however I have developed an attention NN to analyze the hadronic decays of the W boson which enables top entaglement analyses to cover a broader phase space with more statistics.

Publications

[1] The ATLAS Collaboration. *Measurements of WH and ZH production with Higgs boson decays into bottom quarks and direct constraints on the charm Yukawa coupling in 13 TeV pp collisions with the ATLAS detector*. 2025. URL: https://doi.org/10.1007/JHEP04(2025)075.

[2] The ATLAS Collaboration. *Search for $H \to c\bar{c}$ and Measurement of $H \to b\bar{b}$ in Vector-Boson Fusion Production with the ATLAS Detector*. CURRRENTLY CIRCULATING TO BE PUBLISHED VERY SOON.

[3] Luke Vaughan et al. *PileUp Mitigation at the HL-LHC Using Attention for Event-Wide Context*. 2025. arXiv: 2503.02860 [hep-ex]. URL: https://arxiv.org/abs/2503.02860.

Skills

Programming Languages	Python, C/C++, Bash, GNU Linux
Monte-Carlo Simulation	MadGraph, Pythia, Delphes, FastJet, ATLAS Software
Data Analysis	ROOT, Numpy, Awkward, Matplotlib, PyTorch, TensorFlow, Scikit-Learn
Computing	Parallel Computing, Accelerated Computing, NFS Shares, Homelab SysAdmin

Conference Presentations

Lepton-Photon 2025 Madison, Wisconsin August 2025

Measurements of Higgs Bosons Decaying to Bottom and Charm Quarks from Vector August 2025 Boson Fusion Production with the ATLAS Experiment

PAKDD 2025 Sydney, Australia June 2025

PileUp Mitigation at the HL-LHC Using Attention for Event-Wide Context arXiv 2503.02860

APS Mini-Symposium: Top Quark Physics and Beyond Anaheim, California April 2025

Boosted $X \to b\bar{b}$ tagger calibration using semi-leptonic ttbar events collected with the ATLAS detector

APS AI/ML Poster Session Anaheim, California April 2025

Pileup Mitigation at the High-Luminosity LHC using Attention Neural Networks

Workshops

ATLAS 8^{th} Machine Learning Workshop CERN March 2025

Presented work on Attention Neural Networks for Jet energy and mass corrections for High-Lumi LHC.

CoDaS-HEP Sixth Computational and Data Science School for HEP Princeton July 2024

Learned Awkward arrays in depth from the project developers. Introduced to high performance parallel computation.

How to do ATLAS Analysis - a hands on Tutorial SLAC October 2023

Gained knowledge of ATLAS analysis tools such as AnalysisBase and how to apply them for general analysis.

US ATLAS Machine Learning Training Lawrence Berkeley National Lab July 2023

Discussed application of various models in physics: MLP, Convolutional, Graph, Attention, Adversarial, Generative, Normalizing Flows, Invertible.

Leadership and Service

President of Physics Graduate Student Association at OSU Summer 2024-Spring 2025

Hosted events and meetings for the benefit of the graduate student population. Organized a poster symposium for graduate students to share and advertise research to new students. Represented the Physics Graduate Student body at the college-wide Student Government Association and applied for funding from the College.

Teaching and Outreach

Mentor for REU Summer Students Summer 2025

Aided upper-level undergraduate students with getting started with HEP-Ex research. Introduce them to software tools in HEP which include: simulation, preprocessing, plotting, and physical interpretation.

Teaching Assistant PHYS 1114 Labs and Recitations Spring 2019-Fall 2023

Guide students through introductory mechanics labs: gravity, springs, pendulums, etc.

Tour Guide OSU Physics Department 2023-Current

Lead tours for incoming prospective students to show them various physics labs and motivate them to study physics.

High School Talks 2025

Invited to speak to students at Bishop Kelley High School to encourage science, robotics, and STEM involvement.