

Garrett Merz
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Github Page: <https://github.com/GarrettMerz>
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EDUCATION:

University of Michigan, Ann Arbor MI: Ph.D. Physics 2021; M.Sc. Physics, 2017

The Ohio State University, Columbus, OH: B.S. Physics, Mathematics with Honors Research Distinction, 2016

RESEARCH INTERESTS: Explainable machine learning (self-supervised learning, representation learning, mechanistic interpretability) for science. Computer vision on “non-natural scene” imagery (geospatial data, high-energy physics detector signals, etc.). Development of “bespoke” deep learning architectures for specific research problems in order to further understanding of feature learning dynamics.

EXPERIENCE:

University of Wisconsin-Madison Data Science Institute

Postdoctoral Researcher: March 2023-Present

Supervising PI Kyle Cranmer

- Develop Transformer models for the calculation of high-energy physics scattering amplitudes, together with scientists from SLAC and Meta.
- Collaborate with IRIS-HEP-affiliated postdoctoral researchers to develop self-supervised learning models for collider events.

Intelinair, Inc.

Machine Learning Scientist: November 2021- January 2023

- Lead development on a self-supervised Hierarchical Pretrained Vision Transformer model for monitoring the growth of corn and soybean fields using hyperspectral remote-sensing imagery, pretrained on unlabeled data using the DINO paradigm.
- Design, build and deploy to production a ResNet-based classifier for modeling the growth state of corn and soybean fields with 1m Airbus satellite imagery. Monitor throughout model lifecycle for domain-shift. Train on synthetic data, generated using transfer functions applied to 10cm fixed-wing RGBN imagery.
- Attend, review for, and moderate panel discussion for 2023 Computer Vision and Pattern Recognition (CVPR2023) Agriculture-Vision workshop.

ATLAS High Energy Experimental Physics Group at University of Michigan

PhD Candidate; Advisor Thomas Schwarz

Measurements of Higgs Boson Properties in the Diphoton Decay Channel at $\sqrt{s} = 13$ TeV with the ATLAS Detector: May 2018-April 2021

- First-ever observation of rare top-associated Higgs production process (ttH)
 - (Press Release: <https://atlas.cern/updates/briefing/observation-tth-production>)
- Generate template signatures for key observable in background classes, perform signal shape parameterization, measure major systematic uncertainties related to signal mismodelling
 - Process real and synthetic data samples on the Worldwide LHC Computing Grid using HTCondor and CERN Grid high-throughput-computing architectures

- Develop, implement and test a novel Bayesian Gaussian Process Regression (GPR) tool to model shape of underlying continuum background process
 - Validate GPR efficacy using statistical tests across multiple regimes
- As HGAM analysis group data manager, produce and validate DAOD data/ Monte Carlo samples
 - Respond promptly to ATLASSIAN JIRA tickets
 - Maintain data sample production codebase

CP Properties of Higgs Boson Interactions with Top Quarks in the $t\bar{t}H$ and tH Processes Using $H \rightarrow \gamma\gamma$ with the ATLAS Detector: October 2018-March 2020

- Implement and compare novel “semantically high-level” top-quark-jet classification methods (XGBoost, kinematic likelihoods) using “semantically low-level” features extracted from images of proton-proton collisions taken using CERN’s ATLAS Detector.
- Use synthetic data to train two complementary BDT classifiers to sort observed collision events into null-hypothesis signal, alternative-hypothesis signal, and background categories using a mixture of high-level and low-level engineered features
- Parameterize expected statistical distributions of major observables for null-signal, alternate-signal, and background events in many regions of differing classifier confidence; perform simultaneous Maximum Likelihood Estimation across these regions in order to measure total contribution of signal process to observed event counts and whether it does or does not conform to null hypothesis
- Supervise undergraduate students in introductory data analysis tasks
- Lead paper editor responsible for writing and maintaining internal analysis documentation

UMATLAS Virtual and Augmented Reality Outreach Program: June 2016-April 2021

- Present ATLASRift virtual reality software (showcasing the ATLAS detector in virtual reality using HTC Vive and Oculus Rift software) to the general public at museums and showcases
- Develop novel pedagogical experiences integrating virtual and augmented reality demonstrations into introductory physics laboratory classes (ongoing effort through UMich Center for Academic Innovation XR Grant)

CMS/CDF Computational Physics Lab at The Ohio State University
Undergraduate Researcher; Advisor Dr. Richard Hughes

Using Convolutional Neural Networks to Identify $t\bar{t}H$ Events at the LHC: August 2014-June 2016

- Build a simple VGG/AlexNet style Deep Convolutional Neural Network model in Lua/Torch7 to distinguish between signal process ($t\bar{t}H$) and background ($t\bar{t}+jets$) using raw physics detector signals rather than high-level engineered features
- Compare CNN against traditional MLP-based methods for classification of synthetic event images generated from a simulated high-energy physics detector using the Monte Carlo method

Georg-August Universität Göttingen, Second Institute of Physics: June 2014- August 2014
DAAD RISE Intern

Group Leader: Prof. Dr. Arnulf Quadt

Project Advisor: Philipp Stolte

- Assist in development of KLFitter kinematic likelihood fitter for top quark jet reconstruction.
- Attend HASCO 2014 Hadron Collider Summer School

Selected Publications:

1. ATLAS Collaboration. CP Properties of Higgs Boson Interactions with Top Quarks in the $t\bar{t}H$ and tH Processes Using $H \rightarrow \gamma\gamma$ with the ATLAS Detector. Phys. Rev. Lett. 125. 9 April 2020. 10.1103/PhysRevLett.125.061802
2. ATLAS Collaboration. Measurement of the properties of Higgs boson production at $\sqrt{s}=13$ TeV in the $H \rightarrow \gamma\gamma$ channel using 139 fb⁻¹ of pp collision data with the ATLAS experiment. Journal of High Energy Physics 07. JHEP 07 (2023) 088
3. ATLAS Collaboration. Searches for third-generation scalar leptoquarks in $\sqrt{s}=13$ TeV pp collisions with the ATLAS detector. Journal of High Energy Physics 06. 28 June 2019. 10.1007/JHEP06(2019)
4. ATLAS Collaboration. Observation of Higgs boson production in association with a top quark pair at the LHC with the ATLAS detector. Phys. Lett. B 784 (2018) 173.
5. Precision Measurements of Higgs Boson Couplings in the Diphoton Decay Channel with Run-2 of the ATLAS Detector. 2020. University of Michigan, Ph.D. Thesis.
6. ATLAS Collaboration. Measurement of the properties of Higgs boson production at $\sqrt{s}=13$ TeV in the $H \rightarrow \gamma\gamma$ channel using 139 fb⁻¹ of pp collision data with the ATLAS experiment. ATLAS Conference Note ([40th International Conference on High Energy Physics](#), Prague, Czech Republic). 3 Aug 2020.
7. ATLAS Collaboration. Measurements of Higgs boson properties in the diphoton decay channel with 36 fb⁻¹ of pp collision data at $\sqrt{s}=13$ TeV with the ATLAS detector. Phys. Rev. D 98 (2018) 052005.
8. ATLAS Collaboration. Search for pair production of heavy vectorlike quarks decaying into hadronic final states in pp collisions at $\sqrt{s}=13$ TeV with the ATLAS detector. Phys. Rev. D 98 (2018) 092005.
9. ATLAS Collaboration. Combination of the searches for pair-produced vector-like partners of the third-generation quarks at $\sqrt{s}=13$ TeV with the ATLAS detector. Phys. Rev. Lett. 121, 211801 (2018).
10. Merz, Garrett W. Novel Applications of Image-Processing Techniques to Particle Physics. 2016. The Ohio State University, undergraduate thesis. <https://kb.osu.edu/handle/1811/76804>.
11. Kevin Jablonka et al. 14 Examples of How LLMs Can Transform Materials Science and Chemistry: A Reflection on a Large Language Model Hackathon. *Digital Discovery*, **2023**. 8 August 2023

INVITED TALKS, WORKSHOPS, AND POSTERS:

1. CVPR 2023 Agriculture-Vision Workshop: Discussion Panel Moderator. CVPR2023, New Orleans, Louisiana.
2. Full Run-2 $H \rightarrow \gamma\gamma$ Couplings Measurement. 2020 Higgs Workshop Plenary Meeting. 19 November 2020. CERN (Virtual).
3. Measuring the CP Properties of a Neutral Higgs with $t\bar{t}H \rightarrow \gamma\gamma$ in $\gamma\gamma$ in pp Collisions at $\sqrt{s}=13$ TeV with the ATLAS Detector. ATLAS HTOP 2020 Workshop. 25 March 2020. CERN (Virtual).
4. Measuring the CP Properties of a Neutral Higgs with $t\bar{t}H \rightarrow \gamma\gamma$ in $\gamma\gamma$ in pp Collisions at $\sqrt{s}=13$ TeV with the ATLAS Detector. 2019 USATLAS Collaboration Meeting. Aug 6, 2019- Aug 11, 2019. Amherst, MA.
5. Saturday Morning Physics: Update on Physics from the LHC. University of Michigan Department of Physics, 30 March 2019.
6. Third Yandex Machine Learning in High Energy Physics summer school. Reading, UK. 17 to 23 July 2017.
7. 2016 Denman Undergraduate Research Forum, First Prize in Mathematical and Physical Sciences Division. The Ohio State University. March 30, 2016.
8. 2015 Natural and Mathematical Sciences Poster Forum. The Ohio State University. Jan. 8th 2015.
9. 2014 Hadron Collider Physics Summer School. University of Goettingen. July 20, 2014-August 1, 2014.

NOTABLE SCHOLARSHIPS AND LEADERSHIP ROLES:

2018 National Science Foundation Graduate Research Fellowship

2018 UM Science Communication Fellowship Program

2017 Norman Barnett Award

2016 National Science Foundation Graduate Research Fellowship, Honorable Mention

2015 Staninovski Mathematics Scholarship

Undergraduate High Energy Physics Journal Club, OSU Chapter: *Secretary/Founding Member*, 2014-2016

2013 Hellen Cowan Book Award

2012 Valentino Physics Scholarship

2012 Honors Medalist Scholarship

Society of Physics Students, OSU Chapter: *Vice President* 2013-2015

ADDITIONAL MACHINE LEARNING EXPERIENCE:

TOOLS AND PACKAGES:

Proficiency with: Python, Pytorch/Pytorch-Lightning, TensorFlow/Keras, (scikit-learn, pandas, numpy/scipy, matplotlib/seaborn, rasterio, PIL, beautifulsoup, networkX, nltk, etc.), C++, UNIX/Linux, git, bash/csh, postgresSQL, AWS, Docker, ML lifecycle tools such as ClearML/Weights and Biases/Tensorboard, various agile workflow tools such as JIRA/Confluence, ROOT, pyROOT

Familiarity With: MatLab, Lua, Torch7

TEACHING AND SCIENCE COMMUNICATION:

ComSciCon 2019

- Attend seminars on science journalism, data visualization, podcast development
- Produce and workshop a piece of science communication writing

University of Michigan Dept. of Physics. Graduate Student Instructor: September 2016-December 2017

- Instructor for a total of seven sections of introductory physics lab work
- Design and administer weekly quizzes and facilitate the completion of weekly lab reports
 - Participate in general physics tutoring through the Physics Help Room

Students Supervised:

Noah Zipper: Undergraduate student. Currently a PhD student at CU boulder in the CMS group.

- Implemented and modified the Kinematic Likelihood Fitter (KLFitter) for use in Higgs to diphoton based analyses.

Sabrina Corsetti: Undergraduate student. Currently a PhD student at MIT in the Notaros Group.

- Developed gradient boosted decision trees for ttH CP analysis.

Thomas Sandell: undergraduate student. Currently a software Engineer at Patreon

- Supervised development of ATLASRift VR software