

Particle physics and machine learning with undergraduates



Liberal arts college, Santa Barbara CA



WESTMONT

<https://www.westmont.edu/physics>

Ben Carlson

Assistant Professor of Physics

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Undergraduate only

3-8 physics majors / year

Member of ATLAS collaboration*

*associated with University of Pittsburgh



Summer 2023 (CERN)

LBL US ATLAS SUPER
(w/ S.C. Hsu and E. Khoda, A3D3)

5 current research students

Group interests

- Beyond the Standard Model decays of the Higgs boson (addresses 3 science drivers from the P5 report)
- ATLAS Trigger software, hardware and operations (undergraduate students involved in trigger operations)
- Machine learning methods for FPGA
- Education of undergraduate students for HEP (recruitment of diverse cohort of undergraduate physicists)



NSF-2209370



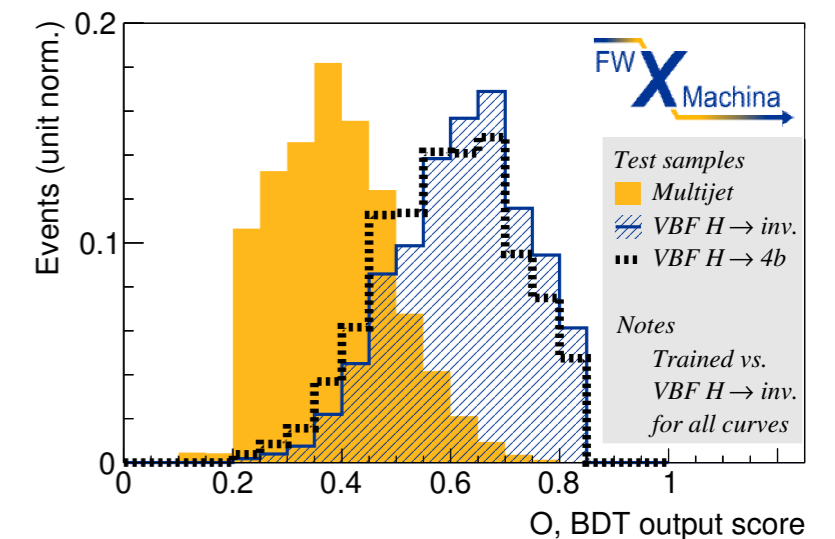
Fast machine learning

Decision trees: low latency and and resource cost



<https://www.fwx.pitt.edu/>

- Stephen Roche, Quincy Bayer, **Benjamin Carlson**, William Ouligian, Pavel Serhiayenka, Joerg Stelzer, Tae Min Hong, “Nanosecond anomaly detection with decision trees for high energy physics and real-time application to exotic Higgs decays,” submitted (2023). arXiv: [2304.03836](https://arxiv.org/abs/2304.03836).
- **Benjamin Carlson**, Q. Bayer, T.M. Hong, S.T. Roche, “Nanosecond machine learning regression with deep boosted decision trees in FPGA for high energy physics,” *Journal of Instrumentation* **17** P09039 (2022). arXiv: [2207.05602](https://arxiv.org/abs/2207.05602).
- Tae Min Hong, **Benjamin Carlson**, Brandon Eubanks, Stephen Racz, Stephen Roche, Joerg Stelzer, Daniel Stumpp, “Nanosecond machine learning event classification with boosted decision trees in FPGA for high energy physics,” *Journal of Instrumentation* **16** P08016 (2021). arXiv: [2104.03408](https://arxiv.org/abs/2104.03408).



Algorithm processor unit \longrightarrow collaboration with UW physics & engineering

- Algorithm processor unit for evaluation of ML algorithm on FPGA
- Implemented *fwX* classification and regression models in the APU
- Focusing on models in the ATLAS trigger HL-LHC context
- Preliminary results presented at CHEP 2023
- Collaboration between Westmont and UW exploring more ambitious goals for HL-LHC trigger goals for ATLAS

Zhixing “Ethan” Jiang, Bowen Zuo, Rohin Narayan, Maayan Tamari, Liron Barak, Boping Chen, Benjamin Carlson, Jeff Eastlack, Scott Hauck, Shih Chieh Hsu, "[Machine Learning Acceleration in the Global Event Processor of the ATLAS Trigger Update](#)", 26th International Conference on Computing in High Energy & Nuclear Physics (CHEP2023), 2023.

