

# Ho Fung Tsoi

Postdoctoral Researcher

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## Research Interests

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Experimental particle physics at the CERN [Large Hadron Collider](#) (ATLAS experiment) for new physics searches beyond the Standard Model; development of novel machine learning algorithms: self-supervised pretraining, anomaly detection, symbolic regression; low-latency (sub-microsecond) machine learning algorithms on FPGAs.

## Education

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**University of Wisconsin–Madison**, Ph.D. Physics 2024

Thesis: [Search for exotic Higgs boson decays with CMS and fast machine learning solutions for the LHC](#)

Advisor: Sridhara Dasu

**The Chinese University of Hong Kong**, B.Sc. Physics 2018

Thesis: First passage time problem of the time-dependent Ornstein-Uhlenbeck process

Advisor: Chi-Fai Lo

Visiting student at University of California Berkeley & Berkeley Lab (Jan – Aug 2017)

## Professional Experience

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**Postdoctoral Researcher**, University of Pennsylvania (Supervisor: Dylan Rankin) 2024 – Present

## Awards and Honors

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CERN, [CMS PhD Thesis Award](#) 2024

UWisconsin, Cornelius P. and Cynthia C. Browne Fellowship 2024

CUHK, CN Yang Scholarship 2017

CUHK, Wei Lun Foundation Exchange Scholarship 2017

CUHK, Professor Dennis Yam Kuen Lo Physics Award 2016

## Selected Research Experience

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### New Physics Search at the LHC

- Lead analyst of the CMS Run 2 search for exotic Higgs boson decays into pseudoscalars in the final state of two b quarks and two  $\tau$  leptons, and of the combination with the  $\mu\mu b\bar{b}$  final state [5] (2020–2024).

### Novel ML Algorithms for Particle Physics

- Self-supervised pretraining methods for jet tagging [1] and mass regression (2025–Present).
- Symbolic regression for automating parametric modeling of binned distributions in LHC physics analyses [3] (2024–2025).

### Low-Latency (Sub-Microsecond) ML Algorithms on FPGAs

- Neuromorphic spiking neural networks (SNNs) for  $dN/dx$  clustering counting in drift chambers [2] (2025–Present).
- Sparse CNNs for spatially sparse image data on FPGAs [1] (2024–Present).
- Compression of neural networks using symbolic regression for fast inference [4][6] (2022–2024).

### Trigger System at the LHC

- Commissioning of the GNN-based tau trigger (GNTau) at the ATLAS High-Level Trigger for Run 3 [4] (2024–Present).
- Development of the CICADA anomaly detection trigger algorithm at the CMS Level-1 Trigger [3][7] (2022–2024).
- Development of the Data Quality Monitoring (DQM) software for the Calorimeter Layer-1 subsystem at the CMS Level-1 Trigger (2020–2024).
- HL-LHC trigger sensitivity projection for the CMS searches for exotic Higgs boson decays [9] (2020–2021).

## Selected Publications

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Listed below are selected publications, conference proceedings, and technical reports to which I was a primary author or made significant contributions (\*: refereed). I also co-authored papers by [CMS](#) and [ATLAS](#) as a collaboration member. For the complete list see [INSPIRE](#). Preprints at [arXiv](#).

### 2026

- [1] **jBOT: Semantic Jet Representation Clustering Emerges from Self-Supervised Pre-Training**  
Ho Fung Tsoi, Dylan Rankin  
*manuscript in preparation*
- [2] **Neuromorphic Cluster Counting**  
Kam Wai Lai, Ho Fung Tsoi, Dylan Rankin  
*manuscript in preparation*
- [3] **Anomaly Detection in the CMS Level-1 Trigger in Run 3**  
CMS Collaboration  
*manuscript in preparation*
- [4] **Performance of the ATLAS Tau Trigger in Run 3**  
ATLAS Collaboration  
*manuscript in preparation.*

### 2025

- [1] **SparsePixels: Efficient Convolution for Sparse Data on FPGAs**  
Ho Fung Tsoi, Dylan Rankin, Vladimir Loncar, Philip Harris  
submitted to *ACM Trans. Reconf. Tech. Syst.* [[arXiv:2512.06208](#)]
- [2] **hls4ml: A Flexible, Open-Source Platform for Deep Learning Acceleration on Reconfigurable Hardware**  
Jan-Frederik Schulte et al.  
submitted to *ACM Trans. Reconf. Tech. Syst.* [[arXiv:2512.01463](#)]
- [3\*] **SymbolFit: Automatic Parametric Modeling with Symbolic Regression**  
Ho Fung Tsoi, Dylan Rankin, Cecile Caillol, Miles Cranmer, Sridhara Dasu, Javier Duarte, Philip Harris, Elliot Lipeles, Vladimir Loncar  
*Comput Softw Big Sci* **9**, 12 (2025) [[arXiv:2411.09851](#)]
- [4\*] **SymbolNet: Neural Symbolic Regression with Adaptive Dynamic Pruning for Compression**  
Ho Fung Tsoi, Vladimir Loncar, Sridhara Dasu, Philip Harris  
*Mach. Learn.: Sci. Technol.* **6**, 015021 (2025) [[arXiv:2401.09949](#)]

### 2024

- [5\*] **Search for Exotic Decays of the Higgs Boson to a Pair of Pseudoscalars in the  $\mu\mu b\bar{b}$  and  $\tau\tau b\bar{b}$  Final States**  
CMS Collaboration  
*Eur. Phys. J. C* **84**, 493 (2024) [[arXiv:2402.13358](#)]
- [6\*] **Symbolic Regression on FPGAs for Fast Machine Learning Inference**  
Ho Fung Tsoi, Adrian Alan Pol, Vladimir Loncar, Ekaterina Govorkova, Miles Cranmer, Sridhara Dasu, Peter Elmer, Philip Harris, Isobel Ojalvo, Maurizio Pierini  
*EPJ Web of Conferences* **295**, 09036 (2024) [[arXiv:2305.04099](#)]

### 2023

- [7] **Level-1 Trigger Calorimeter Image Convolutional Anomaly Detection Algorithm**  
CMS Collaboration  
[CMS Detector Performance Summaries \(2023\)](#), CERN-CMS-DP-2023-086
- [8] **Searches for exotic Higgs boson decays with the CMS experiment**  
Ho Fung Tsoi  
[Proceedings of the European Physical Society Conference on High Energy Physics \(PoS EPS-HEP2023 402\)](#)

### 2021

## [9] The Phase-2 Upgrade of the CMS Data Acquisition and High Level Trigger

CMS Collaboration

[CMS Technical Design Report \(2021\)](#), CERN-LHCC-2021-007, CMS-TDR-022

## Conference, Workshop, Seminar Talks

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Coordinating Panel on Advanced Detectors (CPAD) — UPenn, USA <a href="#">SparsePixels: Efficient Convolution for Sparse Data on FPGAs</a>	Oct 2025
2024 CMS Thesis Award Ceremony Talk (CMS Week) — CERN, Switzerland <a href="#">Search for Exotic Higgs Boson Decays with CMS and Fast Machine Learning Solutions for the LHC</a>	Oct 2025
Fast Machine Learning for Science Conference (FastML) — ETH Zurich, Switzerland <a href="#">SparsePixels: Efficient Convolution for Sparse Data on FPGAs</a>	Sep 2025
High-energy physics seminar — UPenn, U.Washington, Fermilab <a href="#">Search for Exotic Higgs Boson Decays with CMS and Fast Machine Learning Solutions for the LHC</a>	Nov 2023, Mar 2024
US LHC Users Association Meeting (US LUA) — Fermilab, USA <a href="#">CICADA: Anomaly Detection for New Physics Searches at the CMS Level-1 Trigger</a>	Dec 2023
Machine Learning at Level-1 Trigger Workshop (ML@L1) — CERN, Switzerland Anomaly Detection – CICADA: Status, Plans, and Prospects for Phase-2	Dec 2023
CMS Machine Learning Town Hall — CERN, Switzerland L1 Anomaly Detection with Calorimeter Inputs: Status and Opportunities	Sep 2023
European Physical Society Conference on High Energy Physics (EPS-HEP) — Hamburg, Germany <a href="#">Searches for exotic Higgs boson decays with the CMS experiment</a>	Aug 2023
International Conference on Computing in High Energy & Nuclear Physics (CHEP) — Norfolk VA, USA <a href="#">Symbolic Regression on FPGAs for Fast Machine Learning Inference</a>	May 2023
International Conference on Applied Mathematics — CityU, Hong Kong First Passage Time Problem of the Time-Dependent Ornstein-Uhlenbeck Process: a Model for Stochastic Decision-Making Process	May 2016

## Professional Service

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### Membership

• Member, <a href="#">ATLAS Collaboration</a> , CERN	2024 – Present
• Affiliated member, <a href="#">Accelerated AI Algorithms for Data-Driven Discovery (A3D3) Institute</a>	2024 – Present
• Member, <a href="#">CMS Collaboration</a> , CERN	2020 – 2024

### Collaboration Role

• <b>Co-convener</b> , SUSY Monte Carlo & Interpretation subgroup [CMS]	2023 – 2024
• <b>Contact person</b> , Higgs boson Monte Carlo group [CMS]	2021 – 2023
• <b>Software developer</b> , Data Quality Monitoring system for CaloLayer-1 trigger [CMS]	2020 – 2024

### Journal Referee

- *IEEE Transactions on Evolutionary Computation*
- *Advanced Theory and Simulations*

## Teaching and Mentoring

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### Teaching

- Guest speaker, PHYS 3359 [UPenn]: Data Analysis for the Natural Sciences II: Machine Learning (Spring 2025)
- Teaching assistant, undergraduate physics courses [U.Wisconsin] (Fall 2018 – Spring 2020)

### Master students

- Kam Wai Lai [UPenn]: Neuromorphic AI with spiking neural networks on FPGAs (2025 – Present)
- Yuyan Wang [UPenn]: Self-supervised learning with JEPA-based pretraining for LHC jet tagging (2025 – Present)

**Undergraduate students**

- Alex Yang [UPenn]: Self-supervised learning with SimCLR/VICReg for reconstructing the mass of supersymmetric particles (2025 – Present)
- Ashni Kumar [Drexel]: Acceleration of reinforcement learning agent inference on FPGAs for astronomical observations (2025)