

Thea Klæboe Årrestad, PhD

Date of birth: 23.11.1987

ETH Zurich


Institute for Particle Physics and
Astrophysics (IPA)

Otto-Stern-Weg 5, 8093 Zurich

Office: HPK E 29 Tel: +41 44 633 45 68

 [linkedin.com/in/thea-aarrestad](https://www.linkedin.com/in/thea-aarrestad)

 github.com/thaarres

 [thaarres.github.io](https://github.com/thaarres)

 0000-0002-7671-243X

 pentakvark.wordpress.com



Employment

- 01.2022 - present **ETH Zürich (Institute for Particle Physics and Astrophysics)**
SNSF Ambizione fellow, project leader. Group of Prof. Dr. Günther Dissertori
Research areas: Design and deployment of Machine Learning based anomaly detection algorithm on FPGAs for CMS experiment, anomaly detection for New Physics searches, cross-departmental collaborations on real-time ML
Other: Teaching/Lecturing (particle physics and Machine Learning in Physics), institute outreach responsible, student supervision (doctoral, master, and semester theses)
- 11.2019 - 12.2021 **CERN (European Organization for Nuclear Research)**
Senior Research Fellow, Advisor: Maurizio Pierini
Research areas: Optimisation of **machine learning** algorithms for low-latency inference on CMS L1 trigger **FPGAs**, **jet algorithms** on FPGA hardware, searches for anomalous new physics using Machine Learning, **jet substructure** algorithms and **New Physics** searches in diboson final states.

Education

- 02.2015 - 04.2019 **Ph.D. Physics**, University of Zurich / CMS experiment, CERN
"A Novel Multidimensional Search for Diboson Resonances in the Boosted Dijet Final State and Encoding Jet Substructure in a Deep Neural Network",
Advisor: Prof. Dr. Ben Kilminster, Date 14.03.2019
Thesis committee: Prof. Dr. Jesse Thaler, Dr. Andreas Hinzmann, Prof. Dr. Florencia Canelli
- 09.2012 - 12.2014 **M.S., Physics**, University of Zurich
"A dedicated boosted Higgs boson tagging algorithm at CMS", Advisor: Prof. Dr. Kilminster
- 09.2010 - 06.2012 **B.S., Physics**, University of **Bergen** / Exchange **ETH Zurich**
"Unstable Dark Matter in the Milky Way", Advisor: Prof. Dr. Per Osland

Research highlights

- Real-time ML **"Autoencoders on field-programmable gate arrays for real-time, unsupervised new physics detection at 40 MHz at the Large Hadron Collider"**, *Nature Machine Intelligence* volume 4, pages 154–161 (2022)
"Applications and Techniques for Fast Machine Learning in Science", *Frontiers in Big Data*
"Fast convolutional neural networks on FPGAs with hls4ml", main author, *Thea Aarrestad et al 2021 Mach. Learn.: Sci. Technol.* 2 045015
- Collaborations industry/cross-departmental **"Automatic deep heterogeneous quantization of Deep Neural Networks for ultra low-area, low-latency inference on the edge at particle colliders"**, main author, CERN/Google collaboration, (*Nature Machine Intelligence* (2021))
"Within-Camera Multilayer Perceptron DVS Denoising", collaboration with sensor groups of A. Rios-Navarro (Seville), T. Delbruck (UZH/ETH), R. Kastner (San Diego), CVPR 2023

"Real-time semantic segmentation on FPGAs for autonomous vehicles with hls4ml",
Volvo/Zenseact collaboration, Machine Learning: Science and Technology DOI
10.1088/2632-2153/ac9cb5

Physics

"Vector boson scattering processes: Status and prospects", ML for VBS review, Reviews in Physics Volume 8
"LHC physics dataset for unsupervised New Physics detection at 40 MHz", Nature Scientific Data 9, Article number: 118 (2022)
"Improving Variational Autoencoders for New Physics Detection at the LHC With Normalizing Flows", Front. Big Data, Sec. Big Data and AI in High Energy
"Detecting long-lived particles trapped in detector material at the LHC", Phys.Rev.D 105, L051701
"Searching for diboson resonances in the boosted all-hadronic final state at $s=13$ TeV with CMS", single-author invited review article published in MPLA , 10.1142/S0217732320300141 (summary of three papers on diboson resonance searches where I was main author)

In process (submitted, to appear)

"Machine Learning for Anomaly Detection in Particle Physics", V. Belis, P. Odagiu, T. Aarrestad, invited review to appear in Reviews in Physics
"Anomaly Detection in the CMS Global Trigger Test Crate for Run 3", CMS Collaboration, key contributor, CERN-CMS-DP-2023-079
"Machine learning techniques for model-independent searches in dijet final states", CMS Collaboration, key contributor, CERN-CMS-NOTE-2023-013
"Distilling particle knowledge for fast reconstruction at high-energy physics experiments", submitted to MLST, <https://arxiv.org/abs/2311.12551>

Outreach highlights

Schools

Dec 23 **"ML@L1T tutorial: Edge inference for the Level-1 trigger"**, CMS tutorial
Sep 23 **Lecture series on Machine Learning** at Herbtschule fur Hochenergiephysik Maria Laach
Jul 23 **Accelerating Discovery with Machine Learning at CERN"**, invited lecturer at Machine Learning Summer School, Krakow, MLSS^S
Sep 22 **"Machine Learning at CERN"**, invited lecture at Lake Como School of Advanced Studies
Nov 22 **"Fast inference with HLS4ML: Machine Learning with FPGA at LHC"** INFN FPGA School
Mar 21 **"Particles and fields at the LHC"**, Initiatives for Girls in Physics Nepal
Jan 21 **"Machine Learning at CERN"**, for NGO MBUCO who promotes science in NGO countries

Invited seminars

Jun 23 **"Next-Generation Event Filtering at LHC: Leveraging Real-Time ML for Handling Massive LHC Data Streams"**, invited, A3D3 seminar
Feb 23 **"Machine learning in particle physics: state of the art"**, invited seminar, Sapienza, Rome
Feb 23 **"Ultrafast Machine Learning Inference at the Large Hadron Collider"**, invited seminar, Physics Colloquium RWTH Aachen, Germany
Jan 23 **"Ultrafast Machine Learning Inference at the Large Hadron Collider"**, Imperial College High Energy Physics Seminar, UK
Dec 22 **"Real-time Machine Learning in particle physics"**, invited CERN Data Science Seminar,
Jun 22 **"Fast Machine Learning at LHC"**, Origins Data Science Lab, Technical University of Munich
Jun 22 **"Fast Machine Learning at the LHC"**, Milano Bicocca Phenomenology Seminar

- May 22 **“Ultrafast ML Inference in FPGAs at the LHC”**, [University of Bonn Physics Seminar](#)
- Dec 21 **“Ultrafast Machine Learning Inference in FPGAs at the LHC”**, [DESY Data Science Seminar](#)
- Oct 22 **“Ultrafast Machine Learning Inference at the Large Hadron Collider”** [IPA Colloquium](#)
- Jul 22 **“Machine Learning Applications: An Experimental Perspective”** [Semivisible Jet Workshop](#)

Invited

Conference Talks

- Sep 23 **“Fast Machine Learning at the Large Hadron Collider experiments”**, plenary speaker, [Fast Machine Learning for Science 2023](#), Imperial College, UK
- Sep 23 **“Bigger data, shorter time: Real-time inference on specialised hardware for scientific discovery”**, invited speaker, [Hammers & Nails 2023](#), Ascona, Switzerland
- May 23 **“Fast inferences”**, invited speaker at [LHCP 2023](#)
- Jan 23 **“Recent developments in Machine Learning in Particle Physics”**, invited talk [Spätind 2023](#)
- Jul 21 **“Nanosecond Inference Engines for Particle Detectors”**, invited talk at 30th International Workshop on Logic and Synthesis ([IWLS2021](#))
- Jan 21 **“Machine Learning for VBS”**, invited talk at [VBS at Snowmass](#)
- Dec 20 **“Designing Nanosecond Inference Engines for the Particle Collider”**, invited talk at [6th Workshop on Energy Efficient Machine Learning and Cognitive Computing](#)

Theses supervised

- PhD **“Scouting for anomalous events with unsupervised AI in the CMS hardware trigger”**, PhD thesis of Patrick Odagiu at ETH Zurich, co-supervised with Günther Dissertori, ongoing

- Master **“AXOL1TL: Real-time anomaly detection in the CMS hardware trigger”**, master thesis of Chang Sun ETH Zürich, co-supervised with Günther Dissertori, [presented at Fast Machine Learning for Science 2023](#), grade: 6

“Latency and resource-aware decision trees for faster FPGA inference at the LHC”, master thesis of Andrew Oliver, co-supervised with M. Guillame-Bert (Google) and Prof. Dr. G. Dissertori (ETHZ), [presented at Fast Machine Learning for Science 2023](#), grade: 6

- Bachelor **“Deep Neural Network to Identify High-Energy B Hadrons via their Hit Multiplicity Increase through Pixel Detection Layers”**, UZH Bachelor Thesis, main supervisor, M. Sommerhalder, Feb-Aug 2018, github.com/msommerh/bTag_HitCount

- Semester projects **“Explainable Anomaly Detection for New Physics searches at the LHC with PIDForest”**, Jessica Prendi, Sep-Nov 2023, co-supervised with Prof. Dr. G. Dissertori (ETHZ), Dr. S. Summers (CERN), Dr. M. Guillame-Bert and Dr. R. Stotz (Google)

- Other **“Detecting long-lived particles trapped in detector material at the LHC”**, CERN summer student project of Jasmine Simms, co-supervised with Juliette Alimena, published in [Phys.Rev.D 105, L051701](#)

“Convolutional Autoencoders for Anomaly Detection in the L1 Trigger” CERN Student 2020, Sierra Weyhmiller, co-supervisor, <https://indico.cern.ch/event/947570/>

“Variational autoencoders with Normalizing Flows for anomalous event detection” DIANA-HEP fellow, co-supervisor, Pratik Jawahar, "arxiv.org/abs/2105.14027

"A Deep Neural Network capable of discriminating between jets coming from the decay of longitudinally and transversely polarized W or Z bosons with a large Lorentz boost", CERN Summer Student Project, main supervisor, July 2018, Jan De Boer, Copenhagen University

References

Maurizio Pierino (maurizio.pierini@cern.ch)

Research Staff, CERN

Jean-Roch Vlimant (vlimant@cern.ch)

Staff Researcher, California Institute of Technology (Caltech)

Ben Kilminster (ben.kilminster@physik.uzh.ch)

Professor, University of Zurich

Nhan Viet Tran (ntran@fnal.gov)

Staff Researcher, Fermilab

Andreas Hinzmann (andreas.hinzmann@cern.ch)

Emmy-Noether Research Group leader, Universität Hamburg

Salvatore Rappoccio (salvatore.rappoccio@cern.ch)

Associate Professor, State University of New York at Buffalo

Petar Maksimovic (petar.maksimovic.jhu@gmail.com)

Professor, Johns Hopkins University

Günther Dissertori (disserto@ethz.ch)

Professor, ETH Zurich