## PERSONAL DETAILS

Family name, First name: Årrestad, Thea Klæboe ORCID: 0000-0002-7671-243X Date of birth: 23.11.1987 Nationality: Norwegian Web site: <u>thaarres.github.io</u>

## •<u>Education</u>

### 04/2019 PhD Physics

University of Zurich (CH) / 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. Ben Kilminster

Thesis committee: Prof. Jesse Thaler, Prof. Andreas Hinzmann, Prof. Florencia Canelli

### 02/2014 M.S. Physics

University of Zurich / ETH Zürich A dedicated boosted Higgs boson tagging algorithm at CMS, Advisor: Prof. Ben Kilminster

#### •<u>Current position</u>

01/2022 - Present ETH Zürich (Institute for Particle Physics and Astrophysics) SNSF Ambizione fellow, project leader and PhD supervisor

### •Previous position

2019 - 2021 Research Fellow Experimental Physics Department, CERN (CH)

# **RESEARCH ACHIEVEMENTS**

### **Research achievements**

- First Machine Learning trigger in CMS: Proposed a novel machine learning-based trigger algorithm to select anomalous events with nanosecond latency on FPGAs (<u>E. Govorkova et al., Nature Machine Intelligence 4 (2022) 154-161</u>). Created a public dataset (<u>Govorkova, E. et al., Nature Scientific Data 9, 118 (2022</u>)) and organised a <u>data challenge</u> to foster the development of innovative anomaly detection algorithms for triggering. This work then led to, as part of my <u>SNSF Ambizione grant</u>, the development and successful deployment of the algorithm in the CMS trigger in 2024, marking the first ML-based trigger in the CMS experiment, which is currently collecting data (<u>CMS-DP-2024-059</u>).
- 2. Designing open tools for ML inference on FPGAs: Developed novel workflows and software libraries (hls4ml and QKeras) for deploying highly efficient neural networks on FPGAs, leading teams from Google and CERN (C. N. Coelho et al., Nature Machine Intelligence, Volume 3 (2021)). These tools (including the latest HGQ library, developed by a student under my supervision (arxiv:405.00645)) have become the standard for deploying ML algorithms on FPGAs across multiple LHC experiments and beyond. Invited to present this work at a CERN Data Science Seminar with over 500 participants. Additionally, I give tutorials, e.g. for newcomers in the CERN NGT project and invited tutorials abroad.
- 3. Developed novel model-agnostic analysis: Heading a team of over ten researchers from seven different institutions in the first model-agnostic anomaly detection search for New Physics in CMS (arxiv:2412.03747). This result was highly impactful, resulting in the team being invited to present at a CERN Data Science Seminar. I was invited as an expert to discuss the key statistical challenges of applying these methods to LHC data and gave a blackboard presentation at the CERN Theory Department on the topic. Invited as an expert to author a review article on anomaly detection in particle physics together with my PhD student (Belis, V., Odagiu, P., Aarrestad, T.K. Machine learning for anomaly detection in particle physics. Rev. Phys. 12, 100091 (2024)).
- Cross-domain expertise: I have contributed to and led multiple cross-disciplinary projects, such as semantic segmentation for autonomous vehicles with Volvo's subsidiary Zenseact (<u>T. Aarrestad et al. 2021 Mach. Learn.: Sci. Technol. 2 045015</u>, <u>N. Ghielmetti et al 2022 Mach. Learn.: Sci. Technol. 3 045011</u>), and DVS camera denoising (accepted at <u>IEEE CVPRW 2023</u>). I have contributed to



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several high-profile events in other domains, including serving as plenary speaker and chair of the new AI track at the <u>2024 IEEE Nuclear Science Symposium</u>. In energy and sustainability, I delivered an invited talk at the <u>2020 Energy Efficient ML and Cognitive Computing Workshop</u> and a keynote on low-power inference at the <u>Emerging Technologies for Net Zero</u> conference. I have also contributed to FPGA programming with an invited presentation at the <u>IWLS 2021</u> conference, one of the largest workshops on integrated circuits and systems. In 2024, I was one of two keynote speakers at the AMD Tech Summit, addressing 300 senior engineers at AMD, one of the world's largest semiconductor companies.

- 5. Novel analysis fitting strategies: Developed a novel three-dimensional fit technique for diboson resonance searches in the boosted all-hadronic final state, enhancing analysis sensitivity by 30% (Eur. Phys. J. C 80, 237 (2020)). As the lead analyst, I published three searches for diboson resonances in this final state, including the first 13 TeV analysis, which presented significant calibration challenges (JHEP 2017, 162 (2017)), and also the first analysis to commission and use a novel substructure technique for vector boson tagging (Phys. Rev. D 97, 072006 (2018)). For this work, I was selected as one of the three best PhD students in Experimental or Theoretical Particle Physics in Switzerland and shortlisted for the CHIPP Prize 2019. Invited to summarise these results in a single-author invited review article (Aarrestad T., Modern Physics Letters A Vol. 35, No. 32, 2030014 (2020).
- 6. Physics object reconstruction: Developed low-latency ML algorithms to improve jet identification (<u>Odagiu P. et al 2024 Mach. Learn.: Sci. Technol. 5 035017</u>) and pileup mitigation (<u>Mach. Learn.: Sci. Technol. 5 025033 (2024</u>)) in the HL-LHC Level-1 trigger. I have also worked on ML-aided fast jet reconstruction techniques (<u>CHEP 2021</u>). Additionally, I designed and commissioned vector boson identification techniques based on jet substructure, which became the primary algorithm used in CMS, along with the necessary corrections I derived (<u>CMS-PAS-JME-16-003</u>).

#### Peer recognition

#### Fellowships and prizes:

- 1. Shortlisted for the CHIPP Prize 2019 (one of three best PhD students in Particle Physics in Switzerland)
- 2. Swiss National Science Foundation Ambizione Fellowship 2021
- 3. CERN Research Fellowship 2019

#### **Invited talks:**

Within the past two years I have given invited particle physics seminars at Sapienza University of Rome, RWTH Aachen, Imperial College London, University of Bristol, Technical University of Munich, Milano-Bicocca, University of Bonn, DESY, ETH Zürich, University of Zürich, PSI Zürich, Rutherford Appleton Laboratory, and the University of Stavanger. A selection of invited talks at large international conferences and workshops, include

- 1. <u>Conference on Innovative Data Systems Research (CIDR) 2025</u>: Invited keynote, "Pushing the limits of real-time ML: Nanosecond inference for Physics Discovery at the Large Hadron Collider". Amsterdam (NL)
- 2. <u>NeurIPS 2024</u> Machine Learning and the Physical Sciences keynote, "Hardware-software co-design for real-time inference", invited keynote at at one of the major Machine Learning conferences. Also invited keynote and panel at the <u>Women in Machine Learning Workshop @ NeurIPS</u>. Vancouver (Canada).
- 3. <u>IEEE NSS 2024</u> Keynote "AI at the Extreme Edge: Nanosecond inference for New Physics Discovery at the Large Hadron Collider". Florida (USA)
- 4. **2024 IAIFI Symposium on the Impact of Generative AI in the Physical Sciences**, "Physics-Motivated Approaches to Hardware Design", Boston (USA)
- 5. <u>CERN 70 year symposium</u>, "CERN: a Laboratory for AI Research", Bergen (NO)
- 6. <u>PHYSTAT Statistics meets ML 2024</u>, "Detecting New Physics as data anomalies at the LHC: Transitioning from small-scale toy datasets to millions of complex proton collisions", London (UK)
- 7. **AMD Tech Summit 2024**, "AI at the Extreme Edge: Nanosecond inference for New Physics Discovery at the LHC", Belfast (Ireland)
- 8. <u>EuCAIFCon 2024</u>, Invited Panelist "AI Infrastructure", Amsterdam (NL)
- 9. Hammers & Nails 2023, "Bigger data, shorter time: Real-time inference on specialised hardware for scientific discovery", Ascona (CH)
- 10. LHCP 2023 "Fast Interfaces". Invited talk at one of the major particle physics conferences, Prague (CZ)
- 11. Spåtind 2023, "Recent developments in Machine Learning in Particle Physics", Fefor (NO)
- 12. <u>CERN Data Science Seminar 2022</u>, "Real-time Machine Learning in particle physics", CERN (CH)
- 13. <u>30th International Workshop on Logic and Synthesis (IWLS2021)</u>, "Nanosecond Inference Engines for Particle Detectors", Virtual

### **ADDITIONAL INFORMATION**

**<u>Grants:</u>** 1. Swiss National Science Foundation Ambizione Fellowship 2021

# **Commisions of trust:**

Since 2024 Editor of "Machine Learning for Science and Technology" Since 2022 Guest editor of "Frontiers in Big Data" Since 2024 Referee for SciPost Since 2024 Referee for IEEE NSS Since 2022 Referee for EPJ C Since 2022 Referee for JHEP Since 2022 Referee for MLST

# **Organisation of scientific meetings:**

2025 Track organiser AMLD EPFL 2025 "AI on Edge for Science and Technology"
2025 Session convener "Data handling and Computing", 2025 European Physical Society Conference on High Energy Physics, Marseille (FR)
2025 Session convener "23rd International Workshop on Advanced Computing and Analysis Techniques in Physics Research", Hamburg (DE)
2024 Organiser of the SMARTHEP + NGT School on Edge Computing
2024 Session convener "Computing and Data handling", ICHEP2024 conference, Prague (CZ)
2024 Chair "AI and Machine Learning for Radiation Detection", 2024 IEEE NSS, Florida (USA)
2024 Organiser of "AI for Accelerated Discovery" track, AI+X Summit 2023, Zürich (CH)
2023 Panel convener "AI in the physical sciences", <u>AI2S2</u> 2023, Geneva (CH)
Since 2022 Member of the organising committee for the "Fast Machine Learning for Science" workshop

# Institutional responsibilities:

2025 PhD opponent, Stefano Franchellucci, Department of Physics, University of Geneva (CH)
2025 PhD opponent, Graziella Russo, Department of Physics, Sapienza University of Rome (IT)
2024 PhD opponent, Alexander Ekman, Department of Physics, Lund University, Lund (SE)
Since 2022 Outreach and Education contact, Institute for Particle Physics and Astrophysics, ETH Zürich
2022 PhD committee member, Rita Sadek, IMT Atlantique, Nantes (FR)
2020 - 2022 Organiser of the "Collider Cross Talk" seminar series at CERN
2020 - 2021 Organiser of the "mPP tutorials" tutorial series at CERN

### Scientific responsibilities:

### 2025 Expert member <u>European Strategy for Particle Physics (ESPP) Preparatory Group (Detector</u> <u>Instrumentation)</u>

Since 2022 Coordinator of the FastML Research community

2022 - 2025 Coordinator of the a3d3 Targeted Systems group

2021 - 2022 Coordinator of the CMS Machine Learning Innovation group

2020 - 2021 Convener of the Beyond 2 Generations (B2G) Resonances group in CMS

### **Scientific collaborations:**

Since 2019 Member of the FastML Research community Since 2012 Member of the "Compact Muon Solenoid" (CMS) collaboration at CERN (CH)

### **Teaching and supervision:**

Most recent teaching:

Fall 2024 Co-teaching Applied Machine Learning at the University of Zürich
Fall 2024 Co-teaching Experimental Foundations of Particle Physics at ETH Zürich
Fall 2023-Spring 2024 Teaching Assistant, Energy and Sustainability in the 21st Century at ETH Zürich
Spring 2023 Teaching Assistant, Phenomenology of Particle Physics

### Students:

In the past three years at ETH Zürich, I have supervised one PhD thesis, six master's theses (five in physics and one in applied mathematics), eight semester theses, and one summer student. While at CERN, I co-supervised multiple PhD students as part of the <u>mPP project</u>, along with several CERN summer students.

### Schools:

2024 CERN International Teachers Week Program - AI in Particle Physics, CERN

**2024** Padova Physics of Data School - ML in particle physics, Venice (Italy)

2023 Herbstschule fur Hochenergiephysik Maria Laach - Lecture series on Machine Learning, Germany

2023 Machine Learning Summer School MLSS^S - Accelerating Discovery with ML at CERN, Poland

2022 Lake Como School of Advanced Studies - Machine Learning at CERN (Italy)

2022 INFN FPGA School - Fast inference with HLS4ML: Machine Learning with FPGA at LHC (Italy)

**2021** Initiatives for Girls in Physics Nepal - Particles and fields at the LHC (online/Nepal)

## SCIENTIFIC PUBLICATIONS SUMMARY

Author of <u>967 papers</u> in the domain of particle physics, receiving ~**82,000** citations (h-index 134).