Thea Klæboe Årrestad

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Employment

2019 - Present CERN
Senior Research Fellow
Advisor: Maurizio Pierini
Research areas: Optimisation of machine learning algorithms for extreme low-latency inference on CMS L1 trigger FPGAs, and searches for new physics using jets with substructure

Education

2015 - 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
Thesis committee: Prof. Dr. Jesse Thaler, Dr. Andreas Hinzmann, Prof. Dr. Florencia Canelli

2013 - 2014 M.S., Physics, University of Zurich / ETH Zurich
"A dedicated boosted Higgs boson tagging algorithm at CMS"
Advisor: Prof. Dr. Ben Kilminster

2010 - 2012 B.S., Physics , University of Bergen / 1 semester exchange ETH Zurich
"Unstable Dark Matter in the Milky Way"
Advisor: Prof. Dr. Per Osland

Responsibilities

2019 - now Convener of the Beyond 2 Generations (B2G) Resonances subgroup
2019 - now Organiser of mPP Machine Learning Tutorials (latest https://indico.cern.ch/event/882992/)
2020 - now Organiser of Machine Learning Journal Club (https://indico.cern.ch/category/10172/)

Selected publications

2019 - now "Ultra Low-latency, Low-area Inference Accelerators using Heterogeneous Deep Quantization with QKeras and hls4ml" , CERN hls4ml and Google QKeras collab., submitted to ICCAD arXiv:2006.10159

Research experience

Analysis

Specialising in Beyond Standard Model physics with a focus on models attempting to solve the hierarchy problem, like composite Higgs and Warped Extra Dimensional (WED) theories.

Main author and analyst of the first 13 TeV search for diboson resonances in the all-hadronic final state. High-profile analysis due to excess observed (3.4σ) in 8 TeV data. Amongst first 13 TeV analyses published and set the most stringent limits to date for vector boson final states.
2.6 fb^{-1} of 2015 data, published in 10.1007/JHEP03(2017)162

Main author and analyst of first CMS analysis using new, improved vector boson tagging (V-tagging) algorithm (which I also optimised and commissioned). First 13 TeV search for excited quarks decaying to a quark and a W/Z. Only CMS search in this channel.
37 fb^{-1} of 2016 data, published in 10.1103/PhysRevD.97.072006

Development of novel multi-dimensional fit method for diboson searches, improving search sensitivity by 35%. Allows us to search for BSM physics scenarios with new heavy and intermediate mass boosted bosons in one single analysis (July 2017 - present).
80 fb^{-1} of 2016+2017 data, DOI: http://dx.doi.org/10.1140/epjc/s10052-020-7773-5

Algorithms

Demonstrated the first dedicated boosted Higgs tagging algorithm in CMS as part of master thesis. Helped develop version currently implemented in the CMS software, with a focus on tagger p_T/n de-correlation and performance against various backgrounds
July 2014 - July 2015, published in CMS-PAS-BTV-15-002

Studied, optimised and commissioned novel V-tagging algorithm and jet mass corrections, currently the default algorithm in CMS. Has better resilience against pile-up and is perturbatively robust compared to previous. Co-author of paper on jet algorithms performance in 13 TeV data. Improved method for calculating V-tagging scale factors, improving limits of diboson resonance search by up to 40%
Jan-Nov 2016, published in CMS-DP-2016-039, CMS-PAS-JME-16-003

Developing compressed convolutional neural networks for ultra low-latency inference on FPGAs (through quantisation and pruning), in collaboration with CERN, Google Research and Zenuity(Volvo).
Nov 2019 - present,

Hardware

Calibration of the CMS pixel detector charge response after exposure to radiation. Implemented method to handle radiation effects affecting charge-injection system. Responsible for all 2018 gain calibrations
Jan 2018 - April 2019

Talks and posters

Conferences

"Highlights on searches for new physics with vector bosons and Higgs bosons in boosted topologies", BOOST 2018, July 2018, Paris, France

"W/H tagging at CMS", BOOST 2017, July 2017, Buffalo, USA

"Search for heavy resonances in the W/Z-tagged dijet mass spectrum at CMS", Zurich PhD seminar 2015, Aug 2015, PSI, Switzerland

Seminars and workshops

"Searching for VV resonances in the boosted dijet final state at 13 TeV", SLAC Experimental Seminar, January 2019, Stanford, CA (invited)

"Lorentz-invariance based DNN for W-tagging", Joint CMS/LHCb seminar, May 2018, Zurich (invited)

"A search for all-hadronic X→VV with multi-dimensional fit", B2G Workshop May 2018, Hamburg

Informal seminars

"Search for heavy resonances in the V/H-tagged dijet mass spectrum", B2G Event, May 2016, Fermilab (invited)

"Search for heavy resonances in the V-tagged dijet mass spectrum", Exotica Workshop, Nov 15, Venice

"PUPPI softdrop for W-tagging", LPC chat, Oct 2016, Fermilab (invited)

"Groomers in CMS", LPC chat, Aug 2015, Fermilab (invited)

Posters

"LoLa: Lorentz Invariance Based DNN for heavy-resonance tagging", UZH Open Day, Nov 2017, Zurich, https://www.physik.uzh.ch/en/news/news/Open-Day17 Poster 5, Awarded "Best Poster"

"Search for heavy resonances in the W/Z-tagged dijet mass spectrum at CMS", ESHEP2015, Sep 2015, Bulgaria

Organised events

Workshops and courses

"mPP tutorial series: TensorFlow 2.0,"
main organizer, https://indico.cern.ch/event/882992/, Feb 2020

"How to do ultrafast Deep Neural Network inference on FPGAs",
main organizer, https://indico.cern.ch/event/FPGA4HEP, Feb 2019

"Machine Learning for High Energy Physics - a mini course",
main organizer, https://indico.cern.ch/e/ML4HEP, Feb 2019

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Lectures

"Deep learning and future challenges at HL-LHC" by Jennifer Ngadiuba (CERN), main organizer, https://indico.cern.ch/e/ML4HEP, Feb 2019

"Scaling up TensorFlow on Accelerator" by Marvin Ritter (Google Brain), main organizer, https://indico.cern.ch/e/ML4HEP, Feb 2019

Selected publications

Main author

"Search for massive resonances decaying into WW, WZ , ZZ , qW, and qZ with dijet final states at $\sqrt{s}$ = 13 TeV" (35.9 fb^{-1}), Physical Review D, DOI: https://doi.org/10.1103/PhysRevD.97.072006

"Search for massive resonances decaying into WW, WZ or ZZ bosons in proton-proton collisions at $\sqrt{s}$=13 TeV" (2.6 fb^{-1}), Journal of High Energy Physics, DOI: https://doi.org/10.1007/JHEP03(2017)162

Direct contributor

"Jet algorithms performance in 13 TeV data", CMS Physics Analysis Summary, https://cds.cern.ch/record/2256875

Theses

"W-tagging performance in 13 TeV", CMS Detector Performance Note, CMS-DP-2016-039, https://cds.cern.ch/record/2202970

"Search for VV resonances in the all-hadronic final state with a multi-dimensional fit", (80 fb^{-1}), DOI: http://dx.doi.org/10.1140/epjc/s10052-020-7773-5

Popular articles

"Identification of double-b quark jets in boosted event topologies", CMS Physics Analysis Summary, https://cds.cern.ch/record/2195743

Mentoring

"A Novel Multidimensional Search for Diboson Resonances in the Boosted Dijet Final State and Encoding Jet Substructure in a Deep Neural Network", Ph.D. Thesis, April 2019 (expected)

Main supervisor

"A dedicated boosted Higgs boson tagging algorithm at CMS", M.S. Thesis, Oct 2014, https://thaarres.web.cern.ch/thaarres/MasterThesis_TAarrestad.pdf

"The Beauty of Physics", article in Norway's 2nd largest newspaper, Oct 2011, bt.no/btmeninger/kronikk/i/G0rnq/Vis-oss-fysikkens-skjonnhet

Teaching experience

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

"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, July 2018, Jan De Boer, Copenhagen University, https://cds.cern.ch/record/2650187

Physics Lab for bachelor students, teacher, Feb-Dec 2015
Physics I for bachelor students, teaching assistant, Jan-Dec 2016
Physics II for chemists, classroom assistant, Feb 2017 - current

Skills

Computing Python, C++, Bash, Keras, TensorFlow, Theano, ROOT, CMSSW, Pandas, scikit-learn, NumPy, SciPy++

Languages Norwegian (fluent), English (fluent), Swiss-German (fluent)

Schools "Machine Learning for High Energy Physics" (Aug 2018, Oxford)
"Scientific Programming in Python" (June 2016, Zurich)
"CERN School of High Energy Physics" (Sep 2015, Bulgaria)

References

Jesse Thaler (jthaler@mit.edu)
Professor, Center for Theoretical Physics at MIT

Salvatore Rappoccio (salvatore.rappoccio@cern.ch)
Associate Professor, State University of New York at Buffalo

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Emmy-Noether Research Group leader, Universität Hamburg

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Professor, University College London