

# Michela Paganini

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Artificial intelligence researcher. Expert in science of deep learning and deep learning for science. Leading investigations into the inner workings of over-parametrized and sparsified neural networks, with focus on pruning and compression. Pioneered GANs for physics simulation at CERN.

## Education

**Yale University**, May 2013 - Oct 2018

*Ph.D.*, Physics, 2019

*M.Phil.*, Physics, 2016

*M.S.*, Physics, 2014 - student marshal

**University of California, Berkeley**, Aug 2010 - May 2013

*B.A.*, Astrophysics, 2013

*B.A.*, Physics, 2013

**University of Cambridge**, Summer 2012

Pembroke-King's Programme

## Dissertation

*Machine Learning Solutions for High Energy Physics: Applications to Electromagnetic Shower Generation, Flavor Tagging, and the Search for di-Higgs Production*  
[[arXiv:1903.05082](#)]

## Research

**FAIR (Facebook Artificial Intelligence Research)**

*Postdoctoral Researcher*

October 2018 - present

- Investigating learning dynamics, initializations, “Lottery Tickets”, and scientific approaches to deep learning phenomenology in the over-parametrized and under-parametrized regimes, with focus on reproducibility and fairness.
- Contributed centralized methods for neural network pruning in PyTorch ([🐍](#)).
- Cross-functional collaboration with product teams to investigate pruning for memory and computational footprint reduction, and with engineering teams on quantization and interpretability.
- Supervised summer intern projects.

**NERSC (National Energy Research Scientific Computing Center)**

*Research Affiliate*

August 2016 - present

- Researched, developed, and deployed customized Generative Adversarial Networks to accelerate computationally intensive Physics simulation of particles interacting with matter in heterogeneously segmented 3D detectors.
- Explored and benchmarking deep neural networks training and evaluation in HPC environment on Cori (#6 TOP500) with TensorFlow optimizations for modern Intel architectures.
- Applied Computer Vision solutions for the identification of new Physics events from data in multi-channel, high-resolution sparse image format, using the search for R-parity violating supersymmetry as a case study.

## **CERN (European Organization for Nuclear Research)**

*Ph.D. Student, ATLAS Experiment*

2013 - 2018

- Designed and implemented location-aware auxiliary-classifier GANs for fast detector-level physics simulation. Joined task force to deploy in ATLAS simulation production code.
- Developed multi-stream LSTMs for event-level classification for the  $hh \rightarrow \gamma\gamma b\bar{b}$  analysis. Coordinated a team of students on this project.
- Designed Recurrent Neural Networks for impact parameter based flavor tagging. Led effort to integrate into live analysis deployment by contributing to [LWTNN](#) code development.
- Using Dark Knowledge to replace the Matrix Element Method (MEM) — a Physics driven, computationally intensive routine — in order to streamline the  $t\bar{t}H$  with  $H \rightarrow b\bar{b}$  analysis pipeline.
- Refined boosted top-tagging technique using Deep Learning discrimination versus QCD background. Performed in-depth studies of pile-up and  $p_T$  dependence. Compared to efficiency of substructure taggers.
- Contribution to code testing, maintainability, and documentation.

## **Cambridge Institute of Astronomy**

*Summer Exchange Student*

July-August 2012

- Simulated galactic dynamics, mass-velocity profiles, and anisotropy variation to test modified gravity models.

## **Università degli Studi di Milano**

*Summer Research Assistant*

June 2012

- Analytical predictions of positronium formation for anti-hydrogen production at the AEGIS experiment at CERN.

## **SETI Institute, University of California, Berkeley**

*Undergraduate Research Assistant*

2011

- Remote observing for Optical SETI.

## **Space Sciences Lab, University of California, Berkeley**

*Undergraduate Research Assistant*

2010-2011

- Data collection and analysis for MAVEN, STEREO and VEX missions.
- Catalogs of coronal mass ejections, live monitoring of solar activity.

## Teaching **Department of Physics, Yale University**

Teaching Fellow, Physics 440 (Quantum Mechanics and Natural Phenomena I), Spring 2015

Teaching Fellow, Physics 180 (University Physics - Mechanics), Fall 2014

Teaching Fellow, Physics 166L (General Physics Laboratory - E&M), Spring 2014




Teaching Fellow, Physics 165L (General Physics Laboratory - Mechanics), Fall 2013

## **College of Letters and Science, University of California, Berkeley**

Undergraduate Student Instructor (UGSI), Sense and Sensibility and Science, 2012-2013

Reader, Physics H7A (Physics for Scientists and Engineers), 2012

## Publications

Author of over 300 papers with the ATLAS Collaboration. Profiles:     
Selected publications with substantial personal contribution:

*Artificial Intelligence applied to Particle Physics*, [International Journal of Modern Physics A](#), in preparation (book).

M. Paganini, *Prune Responsibly*, under review [[arXiv](#)].

M. Paganini, J. Forde, *Bespoke vs. Prêt-à-Porter Lottery Tickets: Exploiting Mask Similarity for Trainable Sub-Network Finding*, under review [[arXiv:2007.04091](#)].

M. Paganini, J. Forde, *dagger: A Python Framework for Reproducible Machine Learning Experiment Orchestration*, [[arXiv:2006.07484](#)].

M. Paganini, J. Forde, *Streamlining Tensor and Network Pruning in PyTorch*, ICLR 2020 workshop [[arXiv:2004.13770](#)].

M. Paganini, J. Forde, *On Iterative Neural Network Pruning, Reinitialization, and the Similarity of Masks*, ICLR 2020 workshop [[arXiv:2001.05050](#)].

A. S. Morcos, H. Yu, M. Paganini, Y. Tian, *One Ticket to Win Them All: Generalizing Lottery Ticket Initializations across Datasets and Optimizers*, NeurIPS 2019 [[arXiv:1906.02773](#)].

J. Forde, M. Paganini, *The Scientific Method in the Science of Machine Learning*, ICLR 2019 workshop [[arXiv:1904.10922](#)].

L. de Oliveira, B. Nachman, M. Paganini, *Electromagnetic Showers Beyond Shower Shapes*, [NIMA 951, 162879 \(2019\)](#), [[arXiv:1806.05667](#)].

HEP Software Foundation, *HEP Software Foundation Community White Paper Working Group - Detector Simulation*, [[arXiv:1803.04165](#)].

HEP Software Foundation, *A Roadmap for HEP Software and Computing R&D for the 2020s*, [[arXiv:1712.06982](#)].

M. Paganini, L. de Oliveira, B. Nachman, *Controlling Physical Attributes in GAN-Accelerated Simulation of Electromagnetic Calorimeters*, in [Proceedings of ACAT 2017, J. Phys. Conf. Ser. 1085 \(2018\) no.4, 042017](#), [[arXiv:1711.08813](#)].

W. Bhimji, S. Farrell, T. Kurth, M. Paganini, Prabhat, E. Racah, *Neural Networks for Physics Analysis on low-level whole-detector data at the LHC*, in [Proceedings of ACAT 2017, J. Phys. Conf. Ser. 1085 \(2018\) no.4, 042034](#), [[arXiv:1711.03573](#)].

M. Paganini, *Machine Learning Algorithms for b-jet tagging at the ATLAS experiment*, in [Proceedings of ACAT 2017, J. Phys. Conf. Ser. 1085 \(2018\) no.4, 042031](#), [[ATL-PHYS-PROC-2017-211](#)].

M. Paganini, L. de Oliveira, B. Nachman, *Accelerating Science with Generative Adversarial Networks: An Application to 3D Particle Showers in Multi-Layer Calorimeters*, [Phys. Rev. Lett. 120, 042003 \(2018\)](#), [[arXiv:1705.02355](#)].

M. Paganini, L. de Oliveira, B. Nachman, *CaloGAN: Simulating 3D High Energy Particle Showers in Multi-Layer Electromagnetic Calorimeters with Generative Adversarial Networks*, [Phys. Rev. D 97, 014021 \(2018\)](#), [[arXiv:1712.10321](#)].

L. de Oliveira, M. Paganini, B. Nachman, *Learning Particle Physics by Example: Location-Aware Generative Adversarial Networks for Physics Synthesis*, [Comput. Softw. Big Sci. \(2017\) 1: 4](#), [[arXiv:1701.05927](#)].

The ATLAS Collaboration, *Optimisation and Performance Studies of the ATLAS b-Tagging Algorithms for the 2017-18 LHC Run*, [[ATL-PHYS-PUB-2017-013](#)].

The ATLAS Collaboration, *Identification of Jets Containing b-Hadrons with Recurrent Neural Networks at the ATLAS Experiment*, [[ATL-PHYS-PUB-2017-003](#)].

The ATLAS Collaboration, *Search for Higgs boson pair production in the  $b\bar{b}\gamma\gamma$  final state using  $pp$  collision data at  $\sqrt{s} = 13$  TeV with the ATLAS detector*, [[ATLAS-CONF-2016-004](#)].

## Invited Talks, Posters, Panels, and Lectures

Mediterranean Machine Learning School, Jan 2021  
UCI Symposium on Reproducibility in Machine Learning, Sep 2020  
6<sup>th</sup> Machine Learning in High Energy Physics Summer School, Jul 2020  
Machine Learning & Data Science Meetup, Rome, Jul 2020  
Workshop on Machine Learning Retrospective, ICML, Jul 2020  
Workshop on Practical ML for Developing Countries, ICLR, Apr 2020  
RE·WORK Deep Learning Summit, San Francisco, Jan 2020  
Applied Machine Learning Days, Lausanne, Jan 2020  
Introduction to PyTorch Workshop, WiMLDS, NYC, Nov 2019  
Workshop on Preregistration in Computer Vision, ICCV, Nov 2019  
PyTorch DevCon, San Francisco, Oct 2019  
Workshop on Debugging Machine Learning Models, ICLR, May 2019  
3<sup>rd</sup> Inter-experimental Machine Learning workshop, CERN, Apr 2018  
Workshop on Machine Learning for Phenomenology, Durham Univ., Apr 2018  
NVIDIA GTC 2018, Silicon Valley, Mar 2018  
Workshop on Machine Learning for Jet Physics, LBNL, Dec 2017  
Women in Machine Learning (WiML) workshop, NIPS, Dec 2017  
Workshop on Deep Learning for Physical Sciences, NIPS, Dec 2017  
Mitchell Institute for Fundamental Physics and Astronomy, TAMU, Nov 2017  
Rice University seminar series, Nov 2017  
NASA Ames workshop on Radiation Characterization from Earth to Moon,  
Mars, and Beyond, Nov 2017  
LUX Collaboration week, LBNL, Oct 2017  
NERSC Data Day, LBNL, Sep 2017  
18<sup>th</sup> Int'l Workshop on Advanced Computing and Analysis Techniques  
in Physics Research (ACAT 2017), University of Washington, Aug 2017  
Women in Computer Vision (WiCV) workshop, CVPR, Jul 2017  
Workshop on Machine Learning and *b*-Tagging in ATLAS, SLAC, May 2017  
Fermilab machine learning group kick-off, FNAL, May 2017  
Data Science @ HEP workshop, FNAL, May 2017  
Berkeley Institute for Data Science faire, UC Berkeley, May 2017  
AI at SLAC seminar, SLAC, March 2017  
2<sup>nd</sup> Inter-experimental Machine Learning workshop, CERN, Mar 2017  
2<sup>nd</sup> Developers@CERN forum, CERN, May 2016  
3<sup>rd</sup> HEP Software Foundation workshop, LAL Orsay, May 2016

## Awards and Fellowships

**High Energy Physics Center for Computational Excellence Summer Fellowship**, NERSC and Lawrence Berkeley National Laboratory, 2017  
**Leigh Paige Prize**, Yale Physics Department, 2013  
**UC Summer Grant**, UC Berkeley, 2012  
**University of California Undergraduate Grant**, UC Berkeley, 2011-2012  
**UC Freshman Scholarship**, UC Berkeley, 2010

## Service to the Profession

Project reviewer, NASA Frontiers Development Lab 2020  
Volunteer, Women in Machine Learning (WiML) virtual workshop, ICML 2020  
Connection chair, WiML organizing committee, NeurIPS 2019  
Organizer, Machine Learning & Physical Sciences workshop, NeurIPS 2019  
Organizer, Machine Learning Retrospectives workshop, NeurIPS 2019  
Reviewer, ICLR 2019 reproducibility challenge  
Reviewer, CVPR 2019 workshop on Computer Vision for Global Challenges  
Reviewer, ICML 2019 workshop on Theoretical Physics for Deep Learning  
Scientific program committee member, DL4Sci 2019 summer school  
Track convener & reviewer, SUSY 2019  
Track convener & reviewer, CHEP 2018  
Organizer, Generative Modeling in Physics workshop, PASC 2018  
Associate Editor, Frontiers in Big Data and AI in High Energy Physics open access journal  
Organizer, Deep Learning for Physical Sciences workshop, NeurIPS 2017  
Reviewer, venues including: Comput. Softw. Big Sci., JINST, IEEE Access, ACAT, WiML

Students and Interns	<p>Jessica Forde, Brown</p> <p>Alizeh Maqbool, Yale, now at BCG</p> <p>Ilana Kaufman, Yale, now at JPMorgan Chase</p> <p>Nicholas Brown, Yale, now at Google</p> <p>Aaron Effron, Yale, now at Waymo</p>
Languages and Skills	<p><b>Languages:</b> Italian, English (bilingual), French (intermediate), Spanish (elementary)</p> <p><b>Computing:</b> Python, C, C++, Git</p> <p><b>Libraries:</b> PyTorch, Keras, sklearn, TensorFlow, NumPy, SciPy, Matplotlib, pandas, ROOT</p> <p><b>Interpersonal Skills:</b> project management, leadership, effective communication, knowledge sharing, mentoring, onboarding, event planning</p>
Schools	<p>Leadership in Science Policy Institute, Computing Community Consortium, 2019</p> <p>Scaling to Petascale Institute, 2017</p> <p>Thematic CERN School of Computing, 2017</p> <p>SLAC Summer Institute, 2016</p>
Outreach and Leadership	<p><b>Facebook AI Research</b></p> <p>AI Residency onboarding lecturer</p> <p>Computer Vision for Global Challenges (CV4GC) CVPR workshop publicity ambassador, reviewer, and mentor</p> <p>Facebook summer PhD interns mentor</p> <p>Facebook Women in AI ambassador</p> <p>Facebook AI mentorship participant</p> <p>Italian Association for Machine Learning (IAML) volunteer</p> <p>Letters to a Pre-Scientist STEM professional</p> <p><b>Lawrence Berkeley National Laboratory</b></p> <p>Deep Learning for Science 2019 summer school scientific committee member</p> <p>US LUA delegate at annual meeting with Congress in Washington, DC</p> <p>Exploratorium volunteer</p> <p><b>CERN</b></p> <p>S’Cool Lab tutor</p> <p>Open Geneva hackathon, <i>Preventing Suicide with Social Media Data</i></p> <p>DiploHack, <i>Extracting Sensitive Human Rights Data from Inaccessible Countries</i></p> <p>TEDxCERN volunteer</p> <p>THEPort CERN hackathon, <i>Integrating Humanitarian Data</i></p> <p>POP Science, Nuit des Chercheurs</p> <p>CERN tour guide</p> <p><b>Yale University</b></p> <p>Graduate Student Assembly - Representative for Department of Physics</p> <p>Graduate School of Arts and Science Executive Committee</p> <p>Academics and Professional Development Committee secretary</p> <p>McDougal Graduate Student Life Fellow</p> <p>Yale Minority Advisory Council - graduate representative</p> <p>Board member of Italian Society of Yale Students and Affiliates</p> <p>Graduate affiliate at Pierson residential college</p> <p><b>University of California, Berkeley</b></p> <p>Society of Physics Students (SPS) officer</p> <p>SWPS Physics undergraduate coordinator</p> <p>Member of Order of Omega Leadership Honor Society</p> <p>Academic tutor at Athletic Study Center</p> <p>Founder of Italian Society at Berkeley</p> <p>Team Manager - Div I Women’s tennis team</p> <p>Emerging Leaders Institute at Butler University</p>