Sam **Foreman**

PhD. Candidate · Physicist / Data Scientist

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Education

University of Iowa — *Iowa City, IA*

PhD. Physics, supervisor: Yannick Meurice — *May 2019 (expected)*

University of Illinois at Urbana-Champaign — *Champaign, IL*

B.S. Engineering Physics — *May 2015*

University of Illinois at Urbana-Champaign — *Champaign, IL*

B.S. Applied Mathematics — *May 2015*

Thesis Research

University of Iowa, Department of Physics & Astronomy — *Iowa City, IA*

Research Assistant — *Spring 2016 - Present*

- Carried out interdisciplinary research focused on applying ideas from machine learning and data science to simulations in high-energy physics.
- Discovered a new method for describing the phase transition in the 2-dimensional Ising model by applying unsupervised learning techniques (PCA, k-means clustering) to Monte Carlo simulation images.
- Helped to create a new technique for implementing renormalization group transformations on arbitrary image sets, and explored potential applications in dynamic image analysis and action recognition.
- Worked with Tensorflow/Keras to construct convolutional neural networks capable of classifying configurations of the Ising model by temperature.
- Current work focuses on improving the efficiency of the Hybrid Monte Carlo algorithm by using neural networks to improve the quality of the sampler. These improvements have wide applications across a variety of industries.

Experience

Argonne National Laboratory, Computational Sciences Division — *Lemont, IL*

Graduate Research Fellow — *Summer 2018 - Summer 2019*

- Software development focused on applying machine learning models to help improve the efficiency of Hybrid Monte Carlo simulations and their use in Lattice QCD.
- Built and deployed learning models using Tensorflow/Keras on some of the world's fastest supercomputers using state-of-the-art high-performance computing techniques.
- Helped to develop a method for training Markov Chain Monte Carlo kernels parameterized with deep neural networks that shows promise in out performing traditional methods on a variety of different models.

University of Iowa, Department of Physics & Astronomy — *Iowa City, IA*

Research Assistant — *Spring 2016 - Fall 2016*

- Software and hardware development for HaloSat, a nanosatellite built with the goal of better understanding the missing baryon problem.
- Contributed to the in-flight optimization algorithms aimed at maximizing the incoming X-ray signals (by minimizing background noise) while in operation.

University of Illinois, Center for Complex Systems Research — *Champaign, IL*

Research Assistant — *Spring 2011 - Spring 2015*

- Actively maintained the legacy code base (C++ / MATLAB) for our research group and helped to test/debug new contributions.
- Helped to construct a model describing the energy density and self-discharge time of nanoscale capacitors.
- This work was submitted as a patent (pending) titled "Energy Storage in Quantum Resonators", on which I was designated a co-inventor together with my advisor Alfred Hübler.

Programming Skills & Projects

- **Languages: Python** (including Numpy, Pandas, Tensorflow, Keras, and Scikit-learn), **C/C++**, **MATLAB** and brief experience with **SQL**,**R**, **Go**, and **Ruby**.
- **l2hmc-qcd:** A python library used for training a Hybrid Monte Carlo sampler using convolutional neural networks to improve efficiency compared to traditional methods.

Publications & Talks

- S. Foreman, Y. Meurice, J. Giedt and J. Unmuth-Yockey, "Examples of renormalization group transformations for image sets," *Physical Review E.*
- S. Foreman "Machine learning inspired analysis of the Ising model transition," The 36th Annual International Symposium on Lattice Field Theory.
- S. Foreman, J. Giedt, Y. Meurice and J. Unmuth-Yockey, "RG inspired Machine Learning for lattice field theory." *arXiv:1710.02079.*
- S. Foreman, "Machine Learning Analysis of Ising Worms." Brookhaven National Laboratory, Dec. 2017 (invited speaker)
- A. Hubler, S. Foreman, J. Liu, and L. Wortsmann, "Large Energy Density in Three-Plate Nanocapacitors due to Coulomb Blockade." *Journal of Applied Physics.*