

2nd COFI School: Closeout

Kevin Pedro (FNAL)

December 17, 2023

Program

2nd COFI Advanced Instrumentation and Analysis Techniques School (Dec. 9-17, 2023)

from Saturday, December 9, 2023 (8:00 AM) to Sunday, December 17, 2023 (11:00 PM)
San Juan, Puerto Rico

🕒 : Sessions / 🗨 : Talks / ☕ : Breaks

	Dec 9, 2023	Dec 10, 2023	Dec 11, 2023	Dec 12, 2023	Dec 13, 2023	Dec 14, 2023	Dec 15, 2023	Dec 16, 2023	Dec 17, 2023
AM	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Grand challenges of particle physics and cosmology (I) - Prof. Dan Hooper (Fermilab/University of Chicago) ☐ 10:00 AM Introduction to machine learning and artificial intelligence - Michael Kagan (SLAC National Accelerator Laboratory (US)) ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Introduction to machine learning and artificial intelligence - Michael Kagan (SLAC National Accelerator Laboratory (US)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Grand challenges of particle physics and cosmology (II) - Prof. Dan Hooper (Fermilab/University of Chicago) ☐ 10:00 AM Advanced Statistics - Nick Smith (Fermi National Accelerator Lab. (US)) ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Introduction to machine learning and artificial intelligence - Michael Kagan (SLAC National Accelerator Laboratory (US)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Advanced Statistics - Nick Smith (Fermi National Accelerator Lab. (US)) ☐ 10:00 AM Challenges in Dark Matter - Prof. Dan Hooper (Fermilab/University of Chicago) ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 1:00 PM) ☐ 11:30 AM Software and Computing in the Era of Artificial Intelligence - Lindsey Gray (Fermi National Accelerator Lab. (US)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Challenges in Dark Matter - Prof. Dan Hooper (Fermilab/University of Chicago) ☐ 10:00 AM Advanced Statistics - Nick Smith (Fermi National Accelerator Lab. (US)) ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 1:00 PM) ☐ 11:30 AM Software and Computing in the Era of Artificial Intelligence - Lindsey Gray (Fermi National Accelerator Lab. (US)) ☐	9:00 AM Session 1 (until 7:00 PM) ☐ 9:00 AM --- Excursion Day --- 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Advanced Statistics - Nick Smith (Fermi National Accelerator Lab. (US)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Standard model and effective field theory - Prof. Frank Petriello (Northwestern University and Argonne National Lab) ☐ 10:00 AM Numerical techniques - Prof. Alexander (Sasha) Tchekhovskoy (Northwestern University) ☐ 11:00 AM --- Coffee --- 11:30 AM Session 3 (until 12:30 PM) ☐ 11:30 AM Advanced Statistics - Nick Smith (Fermi National Accelerator Lab. (US)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Standard model and effective field theory - Prof. Frank Petriello (Northwestern University and Argonne National Lab) ☐ 10:00 AM Numerical techniques - Alexander (Sasha) Tchekhovskoy ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Simulation and generative models - Gregor Kasieczka (Hamburg University (DE)) ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Grand Challenges in Neutrino Physics - Kate Scholberg ☐ 10:00 AM Numerical techniques - Alexander (Sasha) Tchekhovskoy ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Gaussian processes and Bayesian optimization, reinforcement learning - Auralee Edelen ☐	9:00 AM Session 1 (until 11:00 AM) ☐ 9:00 AM Grand Challenges in Neutrino Physics - Kate Scholberg ☐ 10:00 AM Numerical techniques - Alexander (Sasha) Tchekhovskoy ☐ 11:00 AM --- Coffee --- 11:30 AM Session 2 (until 12:30 PM) ☐ 11:30 AM Gaussian processes and Bayesian optimization, reinforcement learning - Auralee Edelen ☐
PM	12:30 PM --- Lunch --- 1:30 PM Session 3 (until 3:00 PM) ☐ 1:30 PM Basic tools and resources needed for machine learning - Nick Manganelli (University of Colorado Boulder (US)) ☐ 4:00 PM Session 4 (until 6:05 PM) ☐ 4:00 PM Welcome Event - Mayda Velasco (Northwestern University (US)) ☐	12:30 PM --- Lunch --- 3:00 PM Session 3 (until 4:30 PM) ☐ 3:00 PM Basic tools and resources needed for machine learning - Nick Manganelli (University of Colorado Boulder (US)) ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 7:00 PM) ☐ 5:00 PM Principles and Future of Quantum Computing - Prof. Jens Koch (Northwestern University) ☐ 7:00 PM --- Dinner ---	1:00 PM --- Lunch --- 3:00 PM Session 3 (until 4:30 PM) ☐ 3:00 PM Unsupervised Artificial Intelligence - Lindsey Gray (Fermi National Accelerator Lab. (US)) ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 7:00 PM) ☐ 5:00 PM Principles and Future of Quantum Computing - Jens Koch (Northwestern University) ☐ 7:00 PM --- Dinner ---	12:30 PM --- Lunch --- 3:00 PM Recurrent networks and transformers - Kazuhiro Terao (SLAC National Accelerator Laboratory) ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 7:00 PM) ☐ 5:00 PM Quantum Machine Learning - Jack Araz ☐ 7:00 PM --- Dinner --- 7:30 PM Evening Colloquium (until 9:00 PM) ☐ 7:30 PM Measuring Planetary Habitability - Prof. Abel Mendez (UPR) ☐	7:00 PM Dinner Banquet --- 7:00 PM Restaurant "La Princesa" ☐ 7:00 PM La Princesa Restaurant	12:30 PM --- Lunch --- 3:30 PM Session 3 (until 5:00 PM) ☐ 3:30 PM Convolutional and graph networks - Corey Adams ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 6:30 PM) ☐ 5:00 PM Artificial Intelligence on Trigger, FPGA & ASIC - M Liu ☐ 6:30 PM Colloquium - "The Physics of Climate Change in the Caribbean" - Prof. Jose Hernandez Ayala (Universidad de Puerto Rico) ☐ 7:00 PM --- Dinner ---	12:30 PM --- Lunch --- 3:30 PM Session 3 (until 5:00 PM) ☐ 3:30 PM Convolutional and graph networks - Corey Adams ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 6:30 PM) ☐ 5:00 PM Quantum Sensors in Particle Physics - Tim Kovachy ☐ 6:30 PM --- Dinner ---	12:30 PM --- Lunch --- 3:00 PM Session 3 (until 4:30 PM) ☐ 3:00 PM Simulation-based inference - Becky Nevin (Fermilab) ☐ 4:30 PM --- Coffee --- 5:00 PM Session 4 (until 7:30 PM) ☐ 5:00 PM Quantum Sensors in Particle Physics - Tim Kovachy ☐ 7:30 PM --- Dinner ---	12:30 PM Session 4 (until 1:00 PM) ☐ 12:30 PM Closeout - Kevin Pedro (Fermi National Accelerator Lab. (US)) ☐ 1:00 PM --- Lunch ---

Thanks to all of our talented lecturers!

Organization

Many thanks to:

- Luli Ortega, Marianna Huerta, and Vaso Ventresca
 - For getting us here and keeping us fed!
 - School *could not have happened* without them
- Funding: DOE, NSF, Moore Foundation
- School co-director Michael Kagan
- COFI, especially our leader, director Mayda Velasco
- And finally, our photographers (whose work I borrowed for the next slides)



2nd COFI Advanced School on Analysis Techniques & Novel Instrumentation



The school will focus on Artificial Intelligence & Machine Learning (AI/ML)
Quantum Computing and Quantum Sensing for fundamental physics

San Juan, Puerto Rico

December 9 - 17, 2023

Lectures are designed to start from foundational topics:

- Statistics
- Numerical Computing
- Foundations of AI/ML
- Foundations of Quantum Computing

Advanced topics include:

- Image-, sequence-, and graph-targeted ML
- Interface of ML and simulation
- Anomaly detection
- Optimizing and controlling experiments with ML
- Quantum sensing

The school concludes with the interface of AI/ML and Quantum physics:
Quantum Machine Learning

School directors: Michael Kagan (SLAC/Stanford University) & Kevin Pedro (FERMILAB)

<https://indico.cern.ch/event/1299889/>

HEP-School@northwestern.edu



Lectures

Likelihood-based inference is challenging if the simulation is very high dimensional with lots of params

Latent parameters

Observables x

Detector / survey interactions → detect

Ray tracing and thin lens approximation → light

Cosmic evolution → cosmo

Parameters of interest θ

$p(x, \theta) = \int p(x | \text{detect}) p(\text{detect} | \text{light}) p(\text{light} | \text{cosmo}) p(\text{light} | \theta) p(\text{detect} | \text{light}) p(\text{cosmo})$

This is a nightmare

- Poisson noise, detector properties, various stochastic processes
- deterministic physics equations, integrating along the line of sight
- cosmological parameters, cosmology of dark matter and galaxies

like... profile... radius... etc

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background efficiency

Signal efficiency

ParticleNet MD bvsOCD

DeepDoubleBVL

DeepAK8-MD bvsOCD

double-b

BTV-22-001

Fermilab

A. Delannoy

Excursions



M. Liu



A. Delannoy

Banquet



Banquet



A. Delannoy

Viva San Juan!



M. Liu



Conclusion

- We hope this school will accelerate your careers in physics!
 - Not just via the topics covered in the school (astrophysics, particle physics, statistics, computing, AI/ML, quantum technologies...)
 - But also through new connections: to the lecturers and to your fellow students
- Slack channel will remain open for questions and discussion
- (Most) lecture material attached to the agenda
 - Please treat it as a reference: you will certainly encounter these topics again
- Thanks for attending, participating, and making the school a huge success!



**The COFI School
will return**