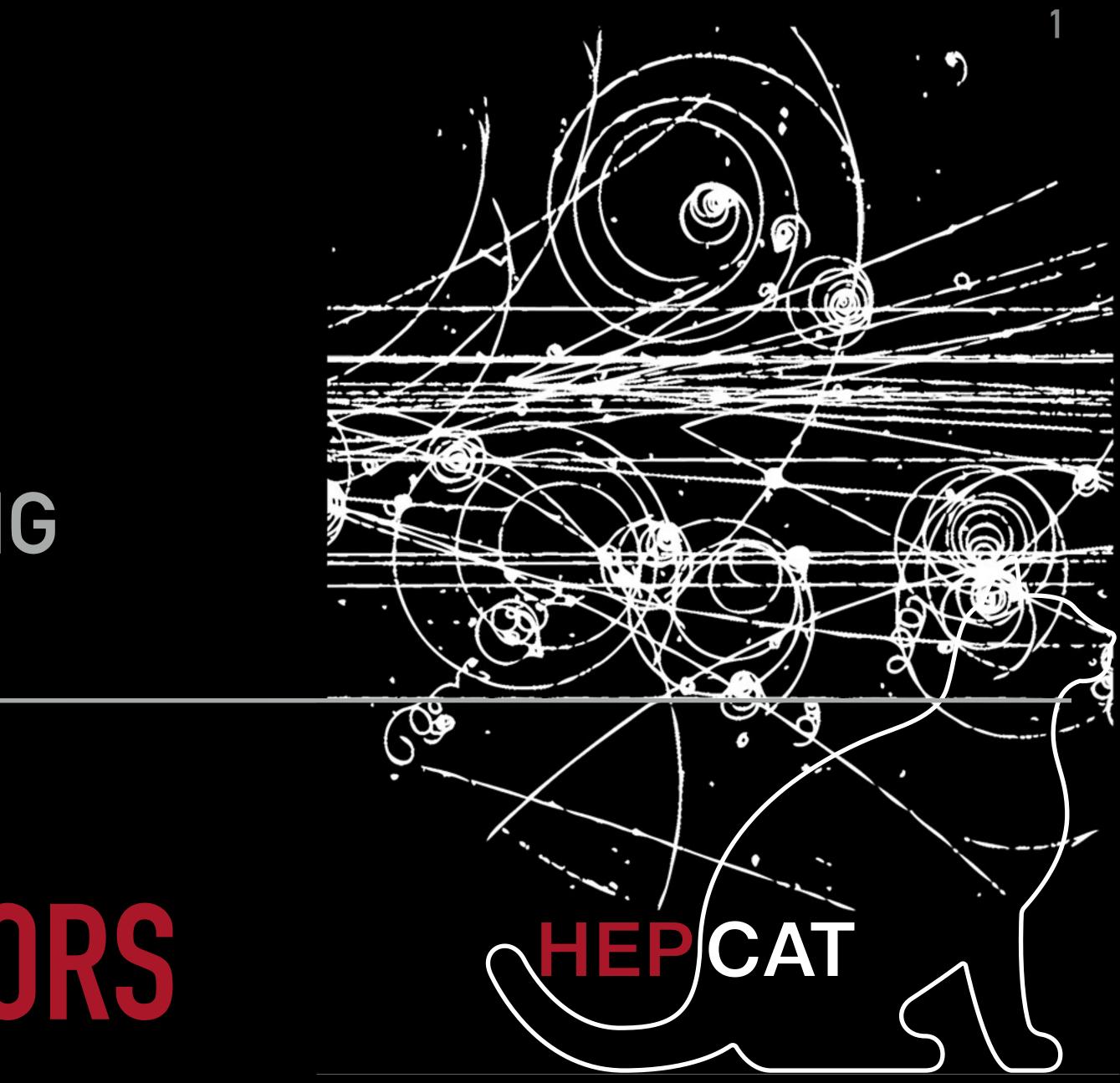


JAVIER DUARTE HEPCAT ANNUAL MEETING NOVEMBER 1, 2024

HEPCAT TG7: AI/ML FOR DETECTORS

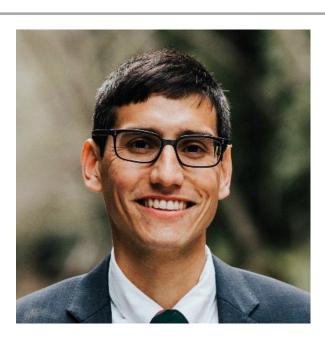


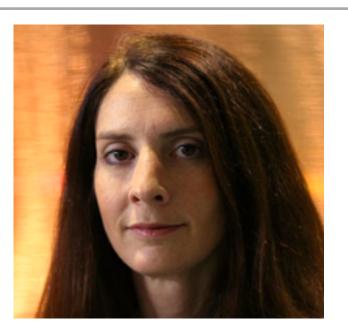
TG7: AI/ML FOR DETECTORS

- University Mentors:
 - Jianming Bian (UC Irvine)
 - Javier Duarte (UC San Diego)
 - Robin Erbacher (UC Davis)
 - Harvey B. Newman (Caltech)
 - Maria Spiropulu (Caltech)
 - Daniel Whiteson (UC Irvine)
- Laboratory Mentors:
 - Michael Kagan (SLAC)
 - Maria Elena Monzani (SLAC)
 - Benjamin Nachman (LBNL)
 - Ariel Schwartzman (SLAC)
- HEPCAT Slack channel #tg-07_ai-ml-detectors
- Webpage: <u>https://hepcat.ucsd.edu/topical-groups/tg7-ai-ml-for-detectors-2/</u>

















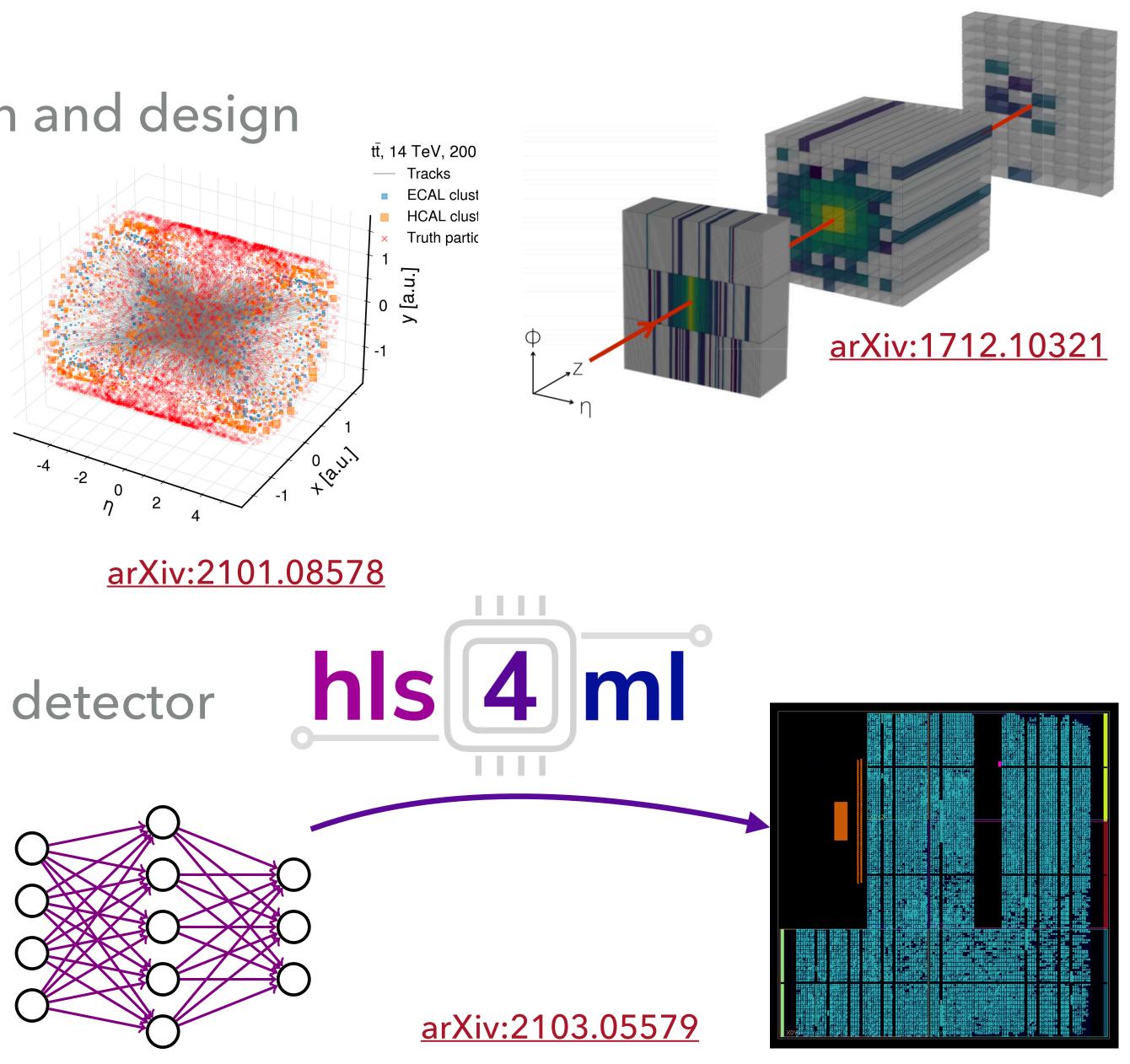






RESEARCH TOPICS

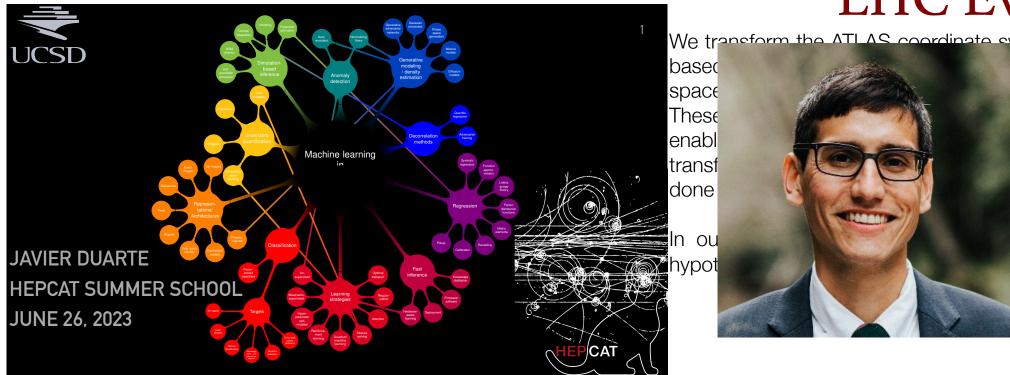
- ML for instrumentation:
 - detector modeling for optimization and design
 - detector simulation
 - detector calibration
 - particle identification
 - Iow-level tracking
 - high-level detector combination
 - strategies for noise suppression
 - identification of under-performing detector elements
- specialized instrumentation for ML:
 - ML on FPGAs/ASICs for trigger/on-detector





AINL SPEAKERS @ HEPCAT SUMMERAS detector is one of the two general-purpose experiments at the LH Charmet detector canter and the two general-purpose experiments at the LH

- 2022: Ben Nachman
- 2023: Javier Duarte
- 2024: Ben Nachman, Julia Gonski





the two general-purpose experiments at the LHC. The 100 million nots of particle collisions occurring 40 million times per second. We focus our attention to the Calorimeter, which we treat as a digital camera in cylindrical space

Below, we see a snapshot of a 13 TeV proton-p



Machine Lea and Instrume

Benjamin Nachman

Lawrence Berkeley National Laboratory

bpnachman.com 🔰 @bpnachman 🌎 bnachman bpnachman@lbl.gov



BERKELEY INSTITUT

HEPCAT Summer School

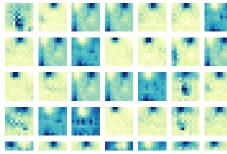
LHC Events as Images

We transform the ATLAS coordinate system (η , ϕ) to a rectangular grid that allows for an imagesion, energy from particles are deposited in pixels in (η, ϕ) Id use them as the pixel intensities in a greyscale analogue. were first introduced by our group [JHEP 02 (2015) 118], C physics event reconstruction and computer vision.. We around the jet-axis, and normalize each image, as is often or non-discriminative difference in pixel intensities.

> ninants on top of Jet Images to distinguish between a *WZ*, and a standard model background, QCD.



Below, we have the learned convolutional filters (left signal and background image after applying the le difference-visualization technique helps understand v



Fast AI/ML in Hardware for Particle Physics

Julia Gonski

ENERGY

22 August 2024 HEPCAT @ SLAC



SLAC NATIONAL ACCELERATOR LABORATORY



Benjamin Nachman

Lawrence Berkeley National Laboratory

bpnachman.com bpnachman@lbl.gov



BERKELEY LAB





Aug. 23, 2024



TG7 HEPCAT FELLOWS



Anthony Vizcaíno Aportela

- Spring 2022 Cohort, UC San Diego
- Research project: hardware-accelerated machine learning for the long-lived particle trigger in CMS for HL-LHC



- Dylan Smith
 - Spring 2022 Cohort, UC Irvine
 - Research project: machine learning to develop generalized calorimeter simulations to help study the performance of future detectors

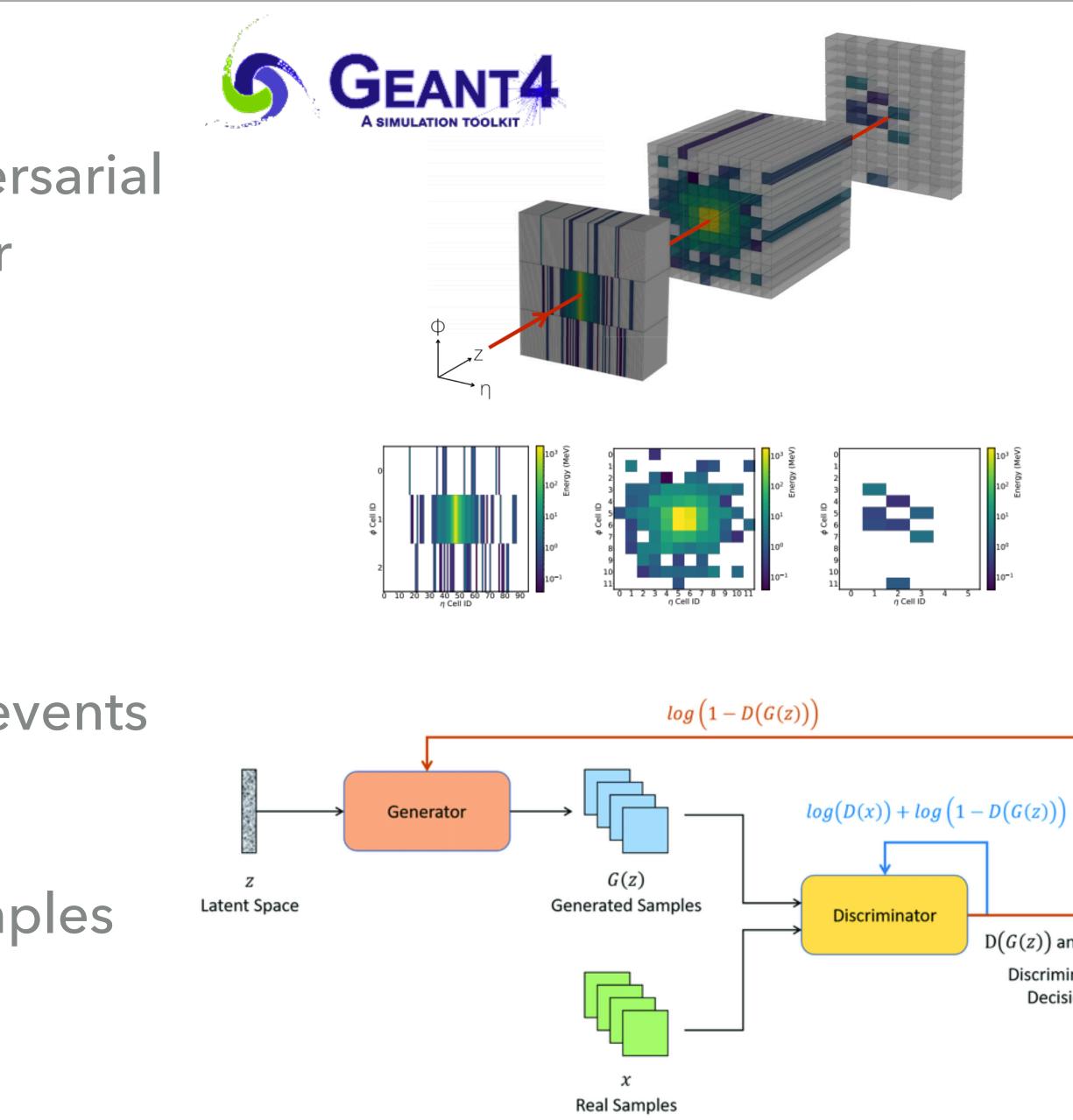




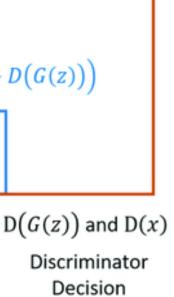


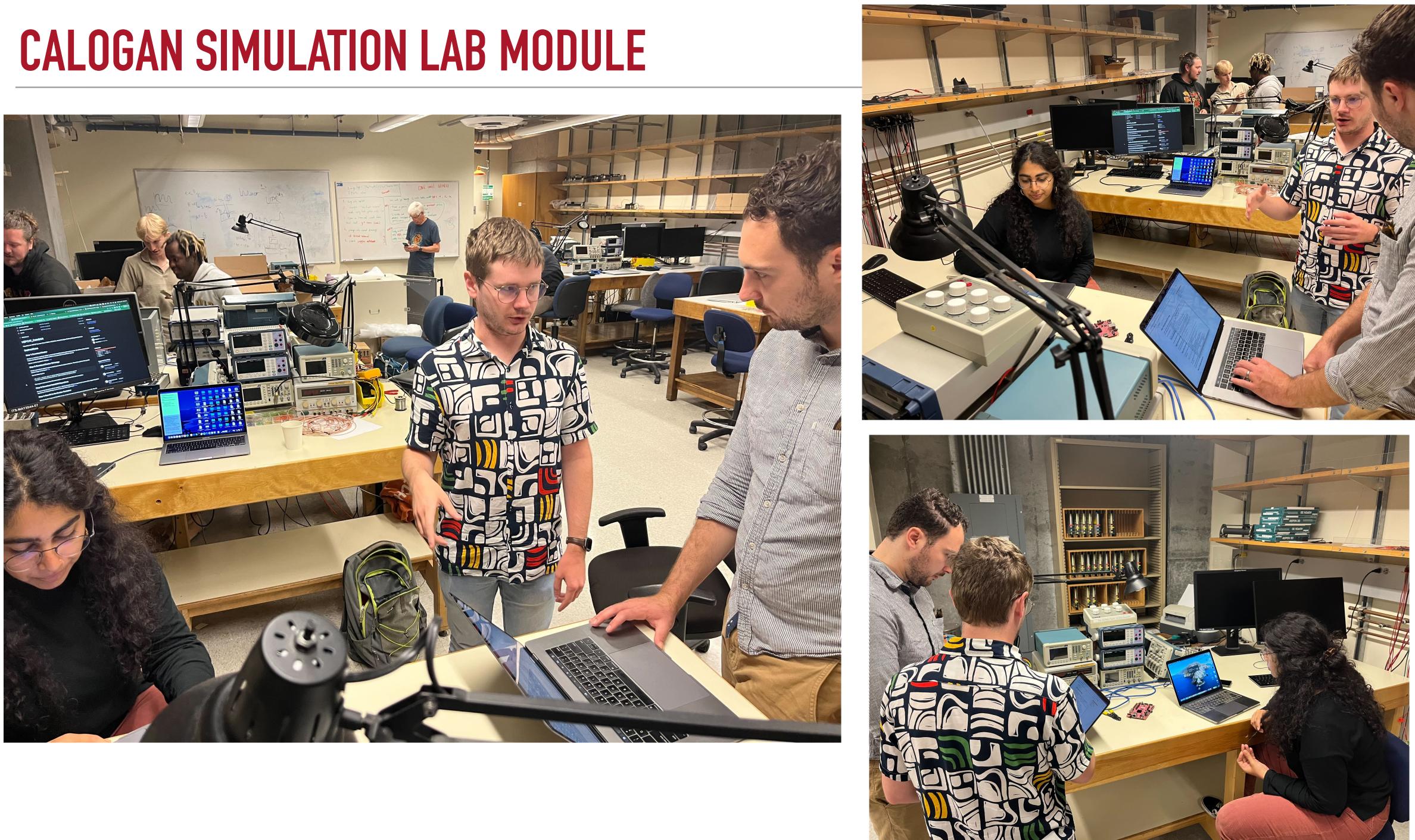
CALOGAN SIMULATION LAB MODULE

- TA: Dylan Smith
- Train and validate a generative adversarial network (GAN) to mimic calorimeter showers as simulated by GEANT4
 - Simulate GEANT4 events
 - Vary absorber material, absorber thickness, incident particle type
 - Visualize and analyze generated events
 - Train CaloGAN
 - Validate generated CaloGAN samples









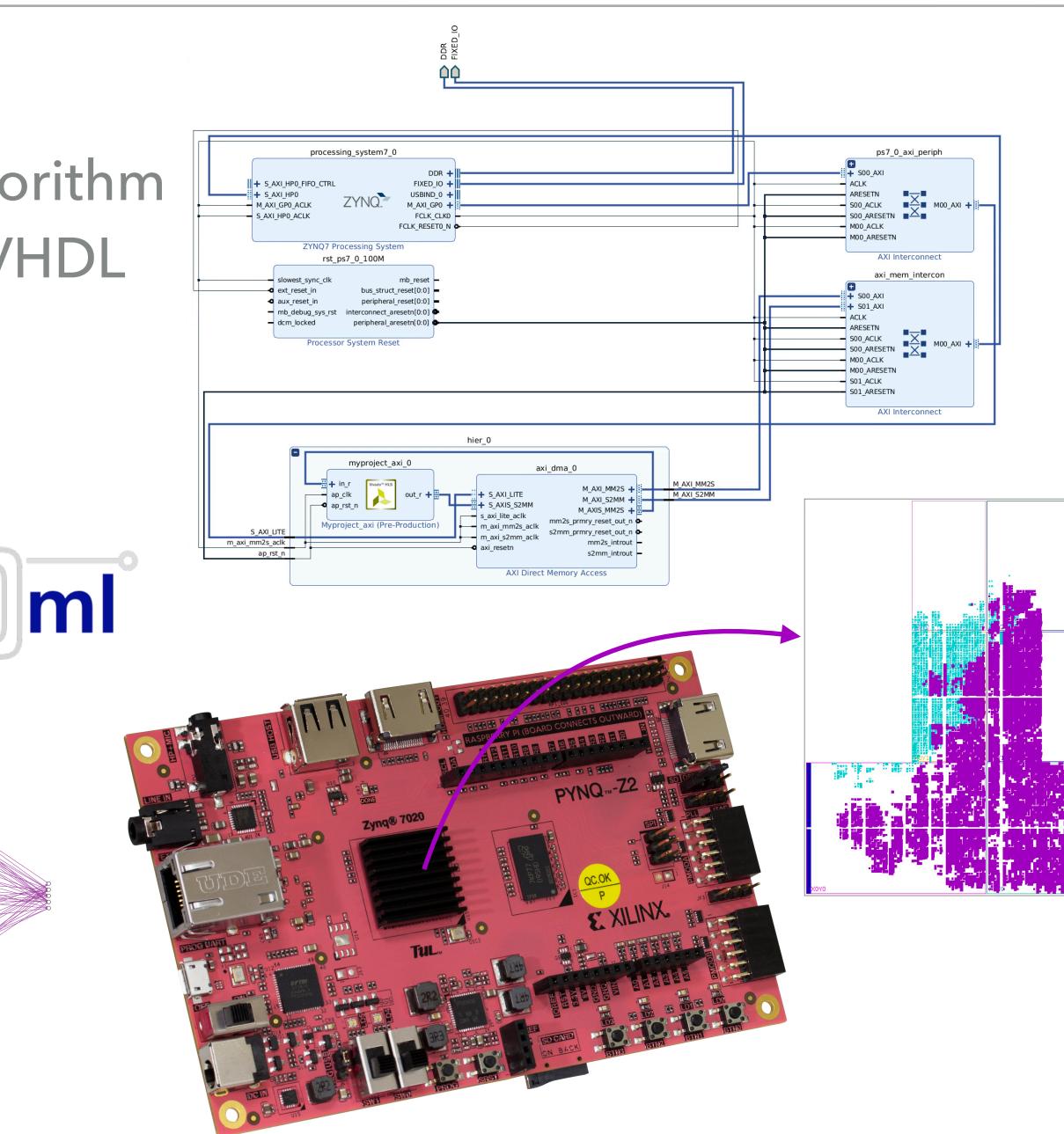


AI/ML ON FPGA LAB MODULE

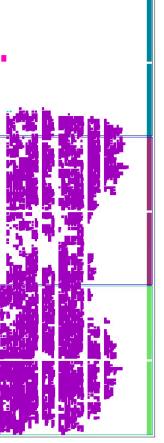
- TA: Anthony Aportela
- Train and deploy an ML/trigger algorithm on a PYNQ-Z2 using python/C++/VHDL
 - Pruning
 - Quantization-aware training

hls 4

- Deployment
- Based on <u>hls4ml tutorial</u>







AI/ML ON FPGA LAB MODULE









SUMMARY

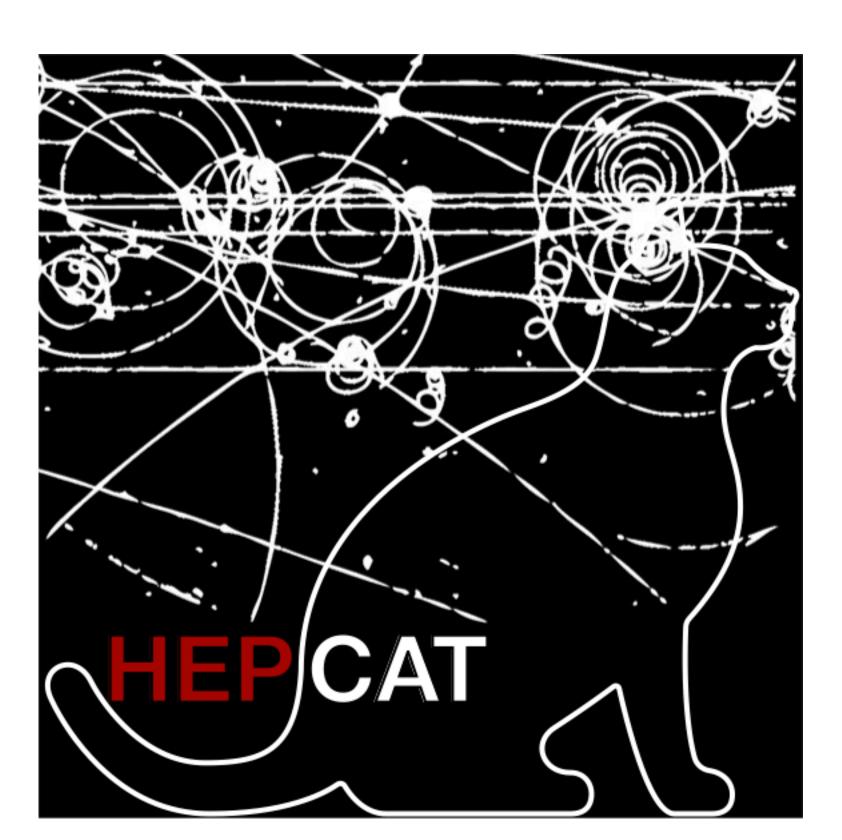
- Strengths:
 - Excellent AI/ML speakers at summer school
 - AI/ML lab modules and exercises created for reuse
 - Two fellows supported in total
- Areas for improvement:
 - Connection between AI/ML and other TGs
 - Recruitment of AI/ML for detector fellows
- Thanks to DOE Office of Science for support!



nmer school es created for reus

d other TGs or fellows

Office of Science







JAVIER DUARTE HEPCAT ANNUAL MEETING NOVEMBER 1, 2024



