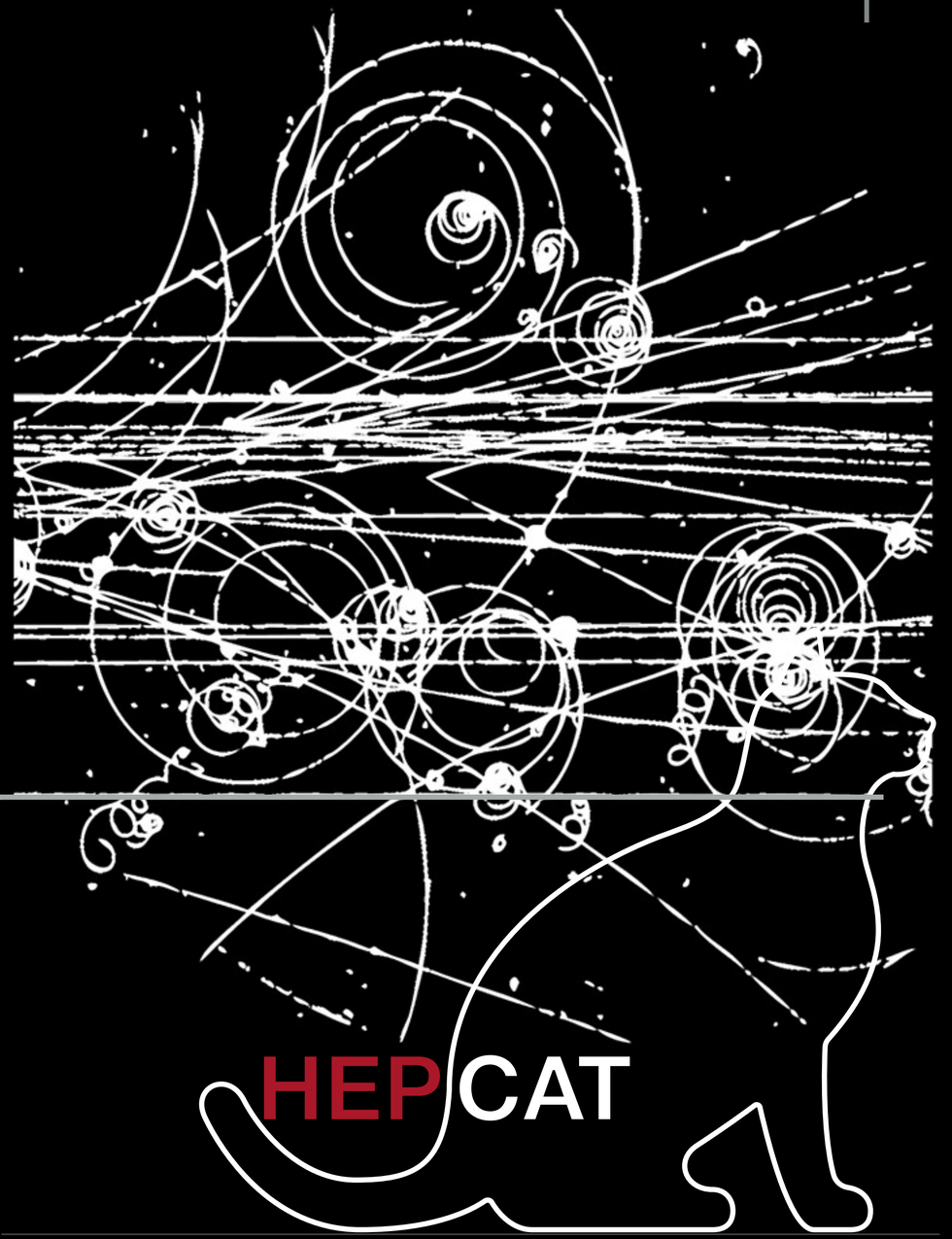
UCSD

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)





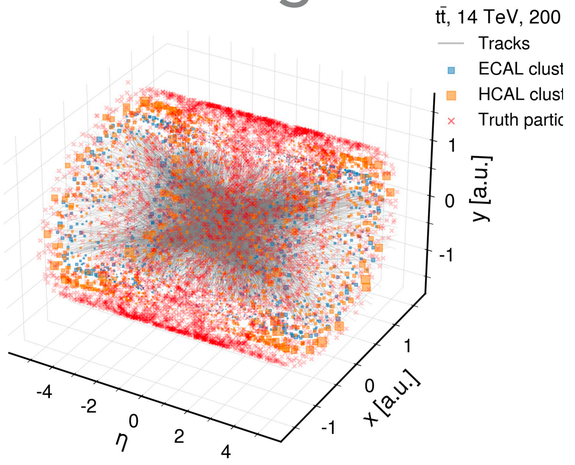




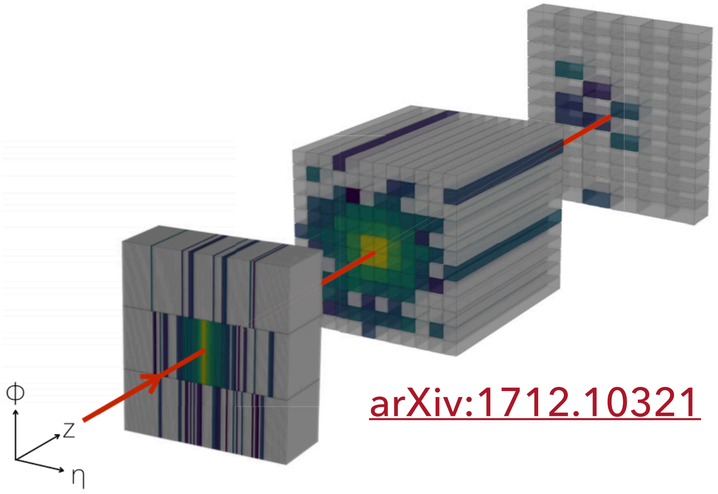

- HEPCAT Slack channel #tg-07_ai-ml-detectors
- Webpage: https://hepcat.ucsd.edu/topical-groups/tg7-ai-ml-for-detectors-2/

RESEARCH TOPICS

- ML for instrumentation:
  - detector modeling for optimization and design
  - **detector simulation**
  - detector calibration
  - particle identification
  - low-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**

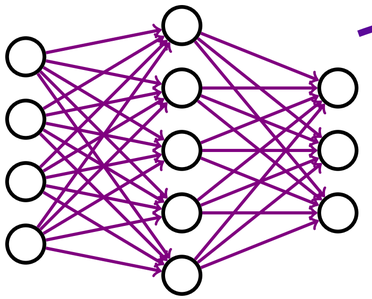


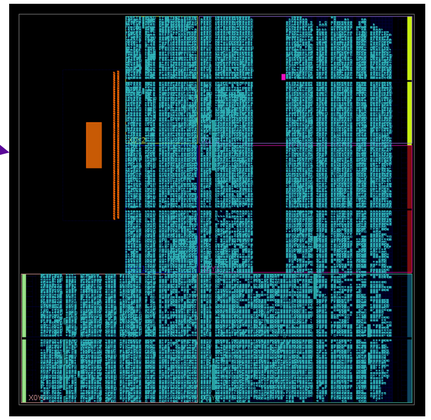
arXiv:2101.08578



arXiv:1712.10321

hls 4 ml





arXiv:2103.05579

AI/ML SPEAKERS @ HEPCAT SUMMER SCHOOLS

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

Machine Learning and Instrumentation

Benjamin Nachman

Lawrence Berkeley National Laboratory

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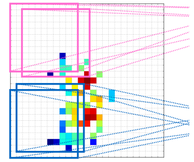
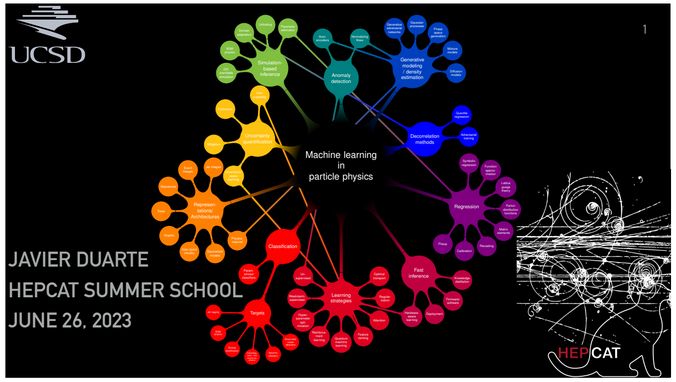
bpnachman@lbl.gov



HEPCAT
Summer School
June 26, 2022



Fast AI/ML in Hardware for Particle Physics

Julia Gonski

22 August 2024
HEPCAT @ SLAC

ATLAS EXPERIMENT

SLAC NATIONAL ACCELERATOR LABORATORY

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Machine Learning and Instrumentation

Benjamin Nachman

Lawrence Berkeley National Laboratory

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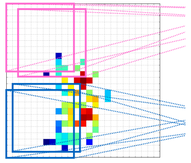


HEPCAT
Summer School
Aug. 23, 2024

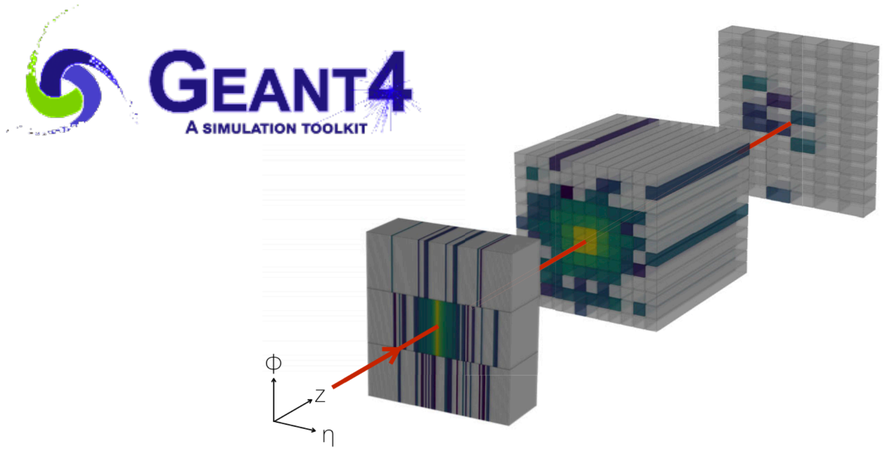
TG7 HEPCAT FELLOWS

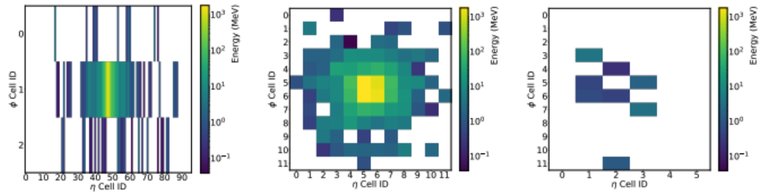
- Anthony Vizcaíno Aportela
  - Spring 2022 Cohort, UC San Diego
  - Research project: hardware-accelerated machine learning for the long-lived particle trigger in CMS for HL-LHC

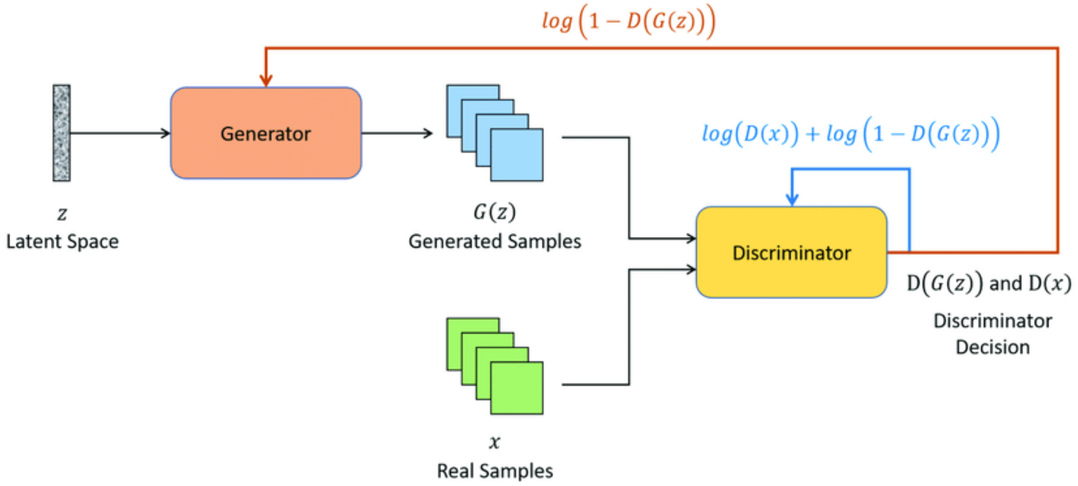
- Dylan Smith
  - Spring 2022 Cohort, UC Irvine
  - Research project: machine learning to develop generalized calorimeter simulations to help study the performance of future detectors

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







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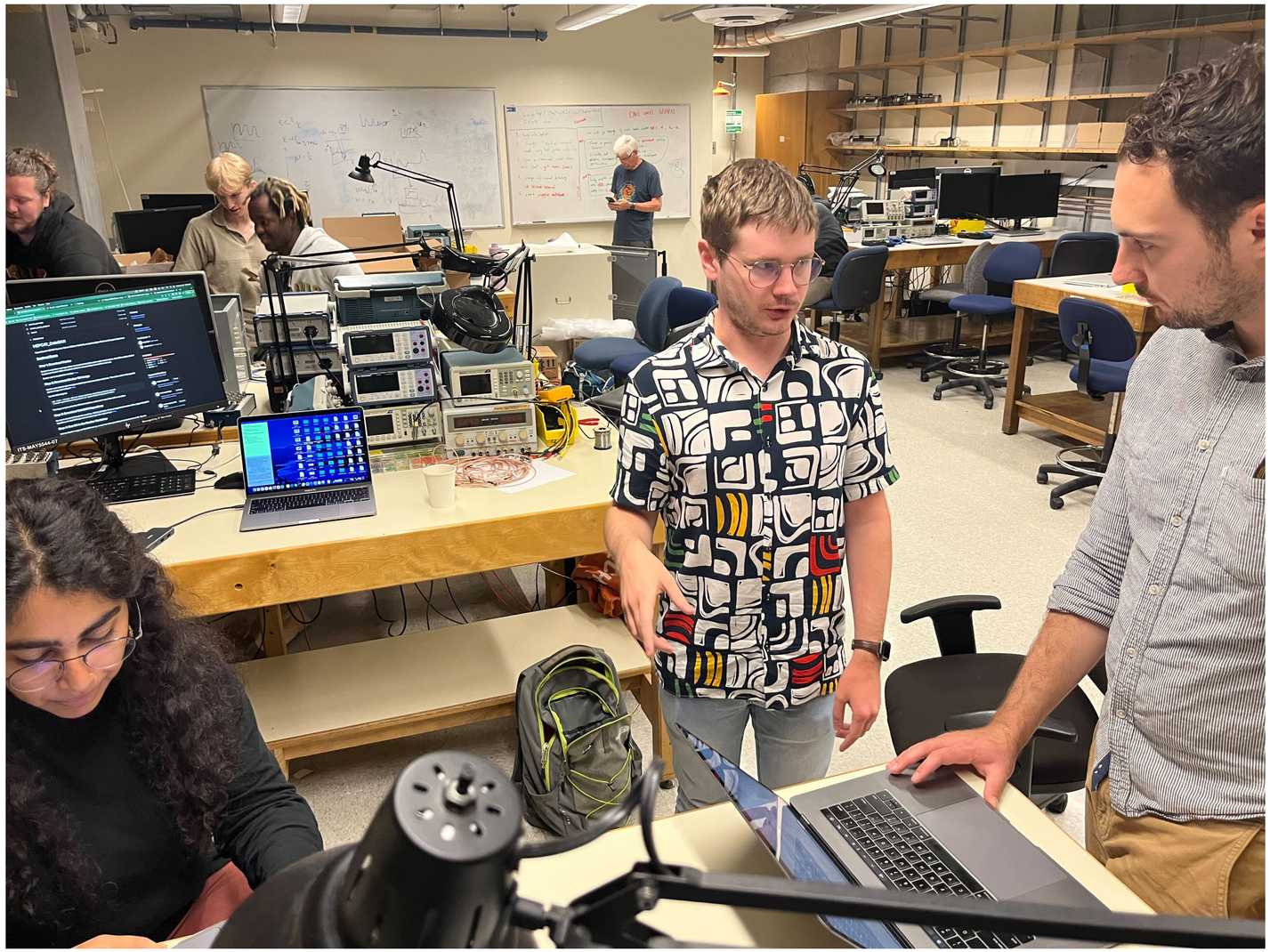
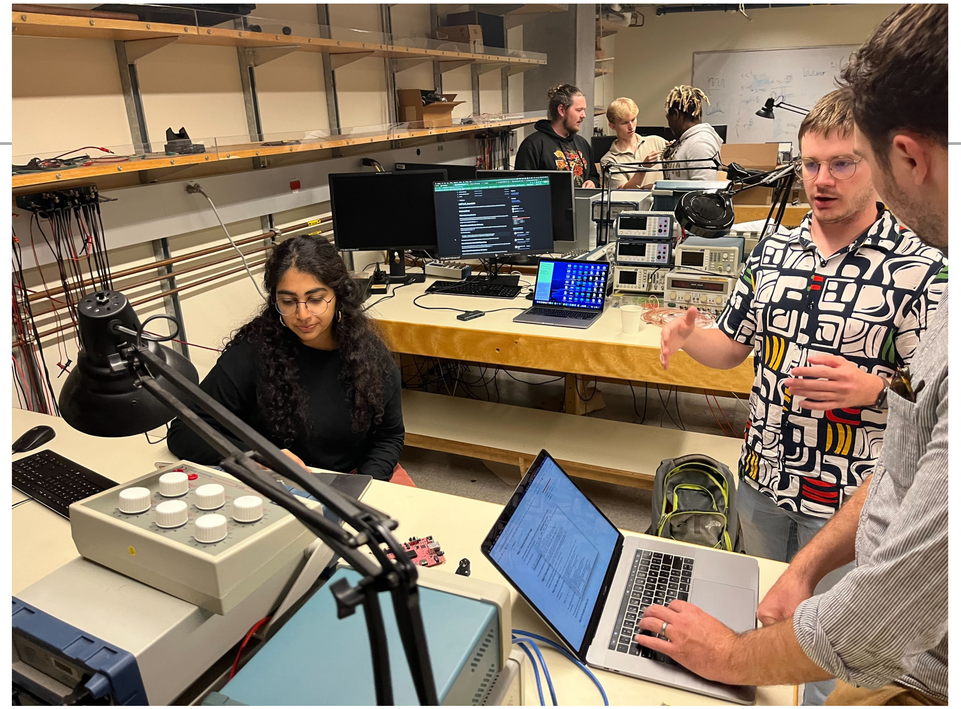
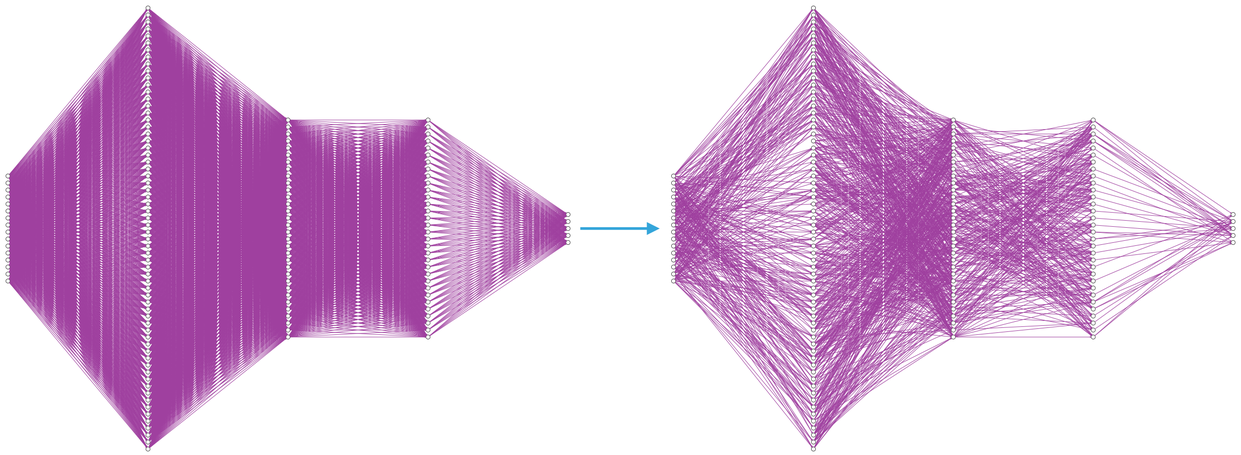
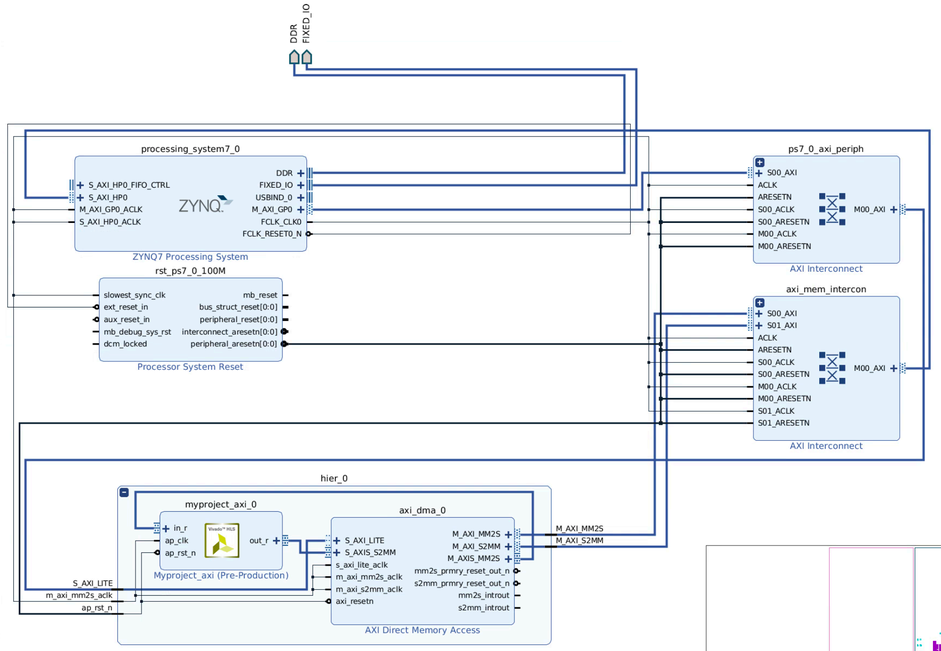


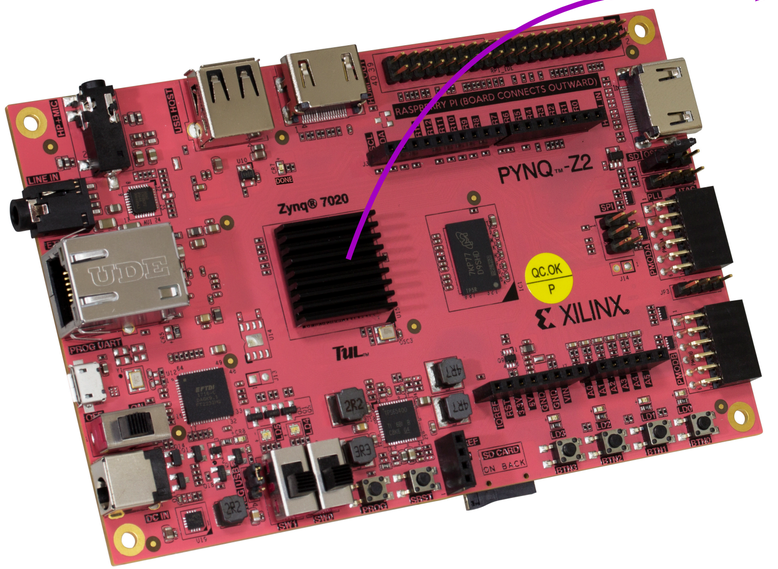


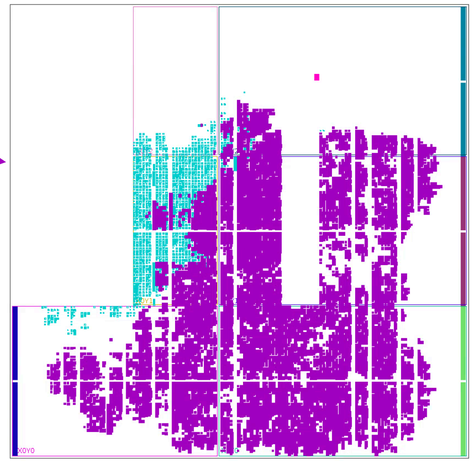
AI/ML ON FPGA LAB MODULE

- TA: Anthony Aportela
- Train and deploy an ML/trigger algorithm on a PYNQ-Z2 using python/C++/VHDL
  - Pruning
  - Quantization-aware training
  - Deployment
- Based on [hls4ml tutorial]









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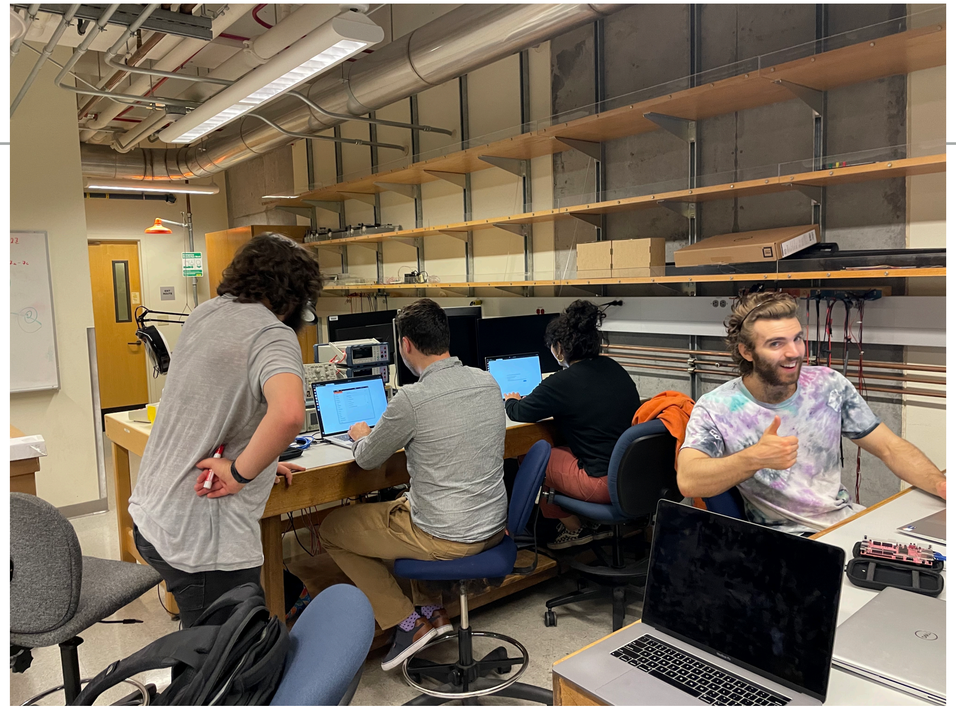

SUMMARY

- 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!

U.S. DEPARTMENT OF ENERGY | Office of Science

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BACKUP