Updates from HFCC AI, Integration, & Microelectronics (AIM)

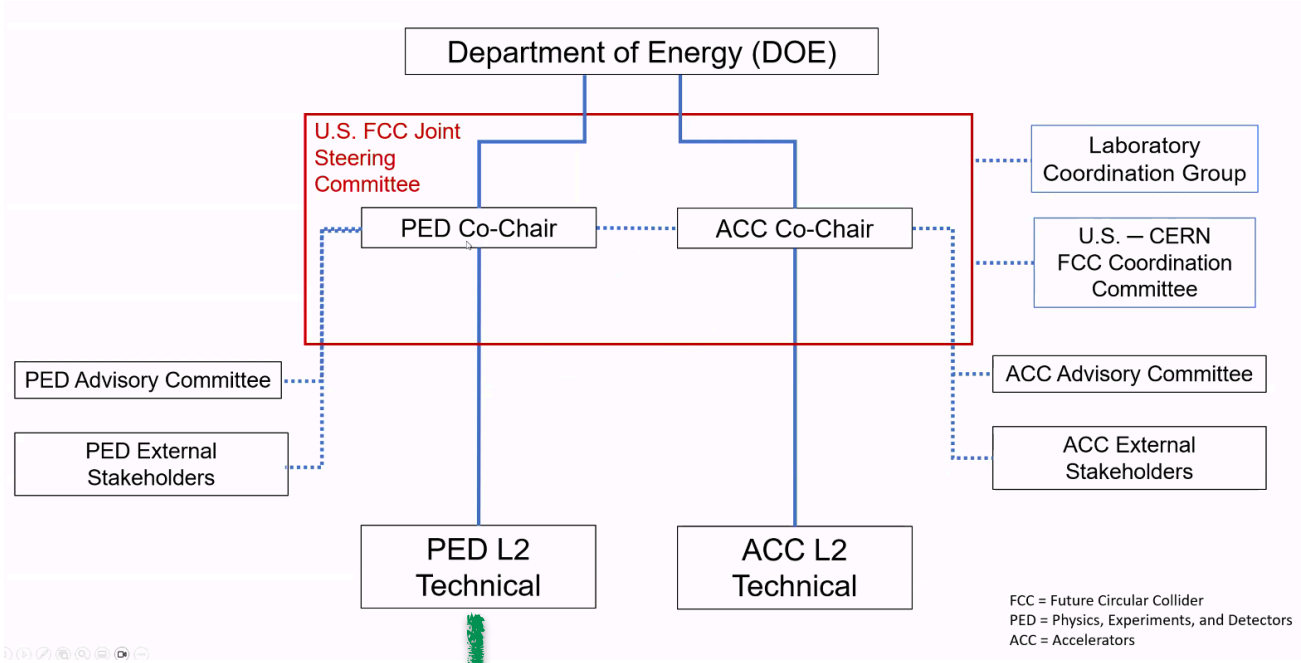
Julia Gonski
SLAC HF Meeting

29 January 2026

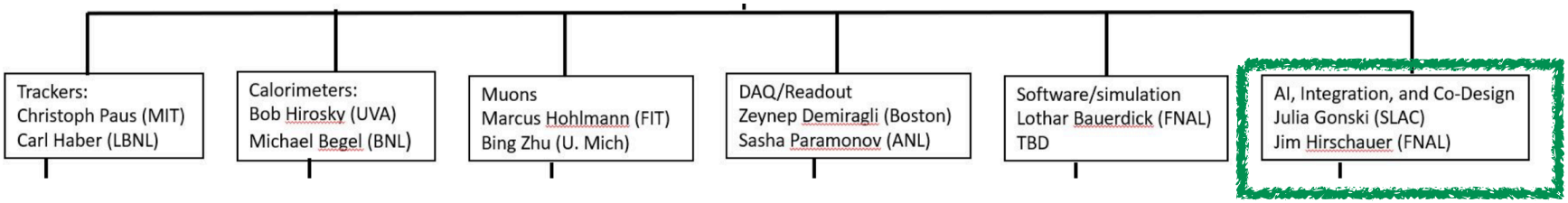
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Reminder: US Higgs Factory Circular Collider



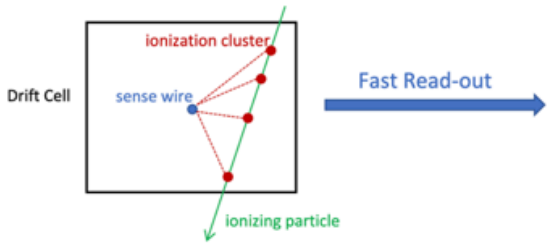
- Recall "FCC work-workshop" in August 2025
- Likely rehosting this summer (maybe in conjunction with US FCC @ SLAC?)
  - Great student/ postdoc opportunity with some funding!

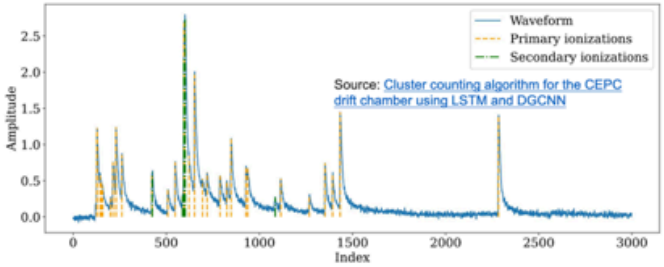


eFPGAs for FCC: Drift Chamber

Recall… [Sept 2025]

- Drift chamber designs for FCC (eg. IDEA) target high granularity and sampling rate: O(TB/s) data rates motivate *edge data compression*
- Good PID performance is crucial: motivates *cluster counting* instead of traditional dE/dx to reduce fluctuations of Landau tails in deposited energy





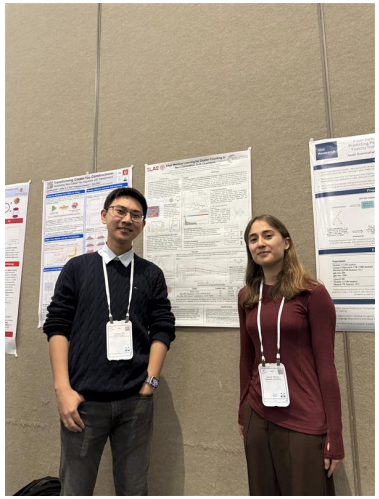
➡ Accepted to NeurIPS ML for the Physical Sciences workshop & presented by Deniz + Liangyu! [2511.10540]

Edge Machine Learning for Cluster Counting in Next-Generation Drift Chambers

Deniz Yilmaz, Liangyu Wu, Julia Gonski, Dylan Rankin, Christian Herwig

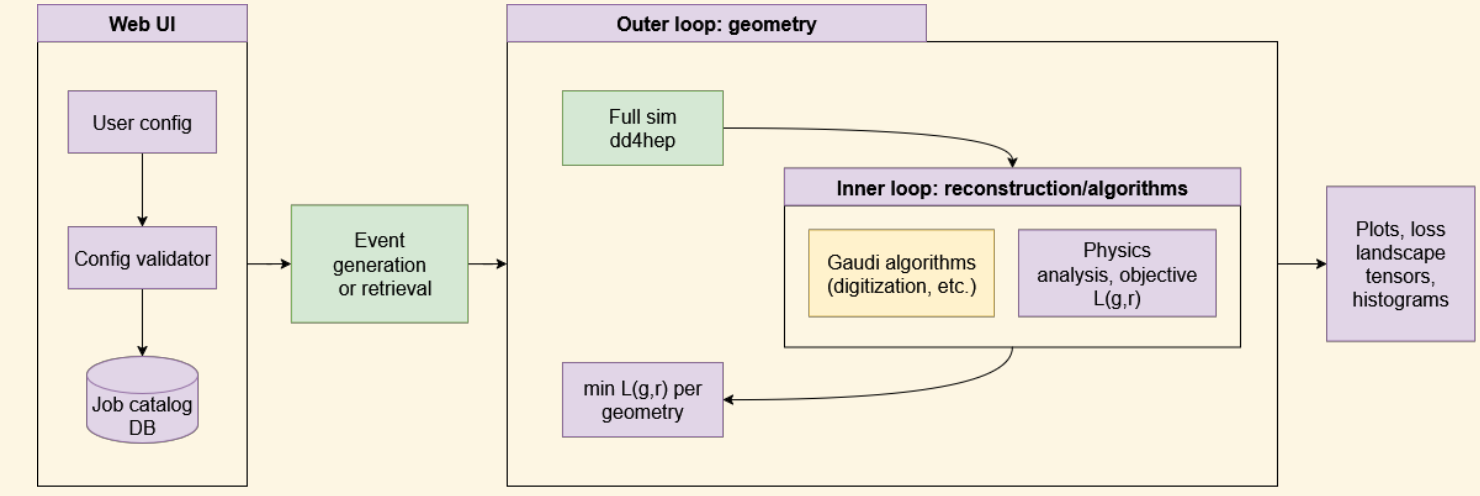
Drift chambers have long been central to collider tracking, but future machines like a Higgs factory motivate higher granularity and cluster counting for particle ID, posing new data processing challenges. Machine learning (ML) at the "edge", or in cell-level readout, can dramatically reduce the off-detector data rate for high-granularity drift chambers by performing cluster counting at-source. We present machine learning algorithms for cluster counting in real-time readout of future drift chambers. These algorithms outperform traditional derivative-based techniques based on achievable pion-kaon separation. When synthesized to FPGA resources, they can achieve latencies consistent with real-time operation in a future Higgs factory scenario, thus advancing both R&D for future collider detectors as well as hardware-based ML for edge applications in high energy physics.

Comments: 6 pages, 3 figures, 1 table. Machine Learning and the Physical Sciences Workshop, NeurIPS 2025
Subjects: **Instrumentation and Detectors (physics.ins-det)**; Machine Learning (cs.LG)



ML-Based Detector Optimization

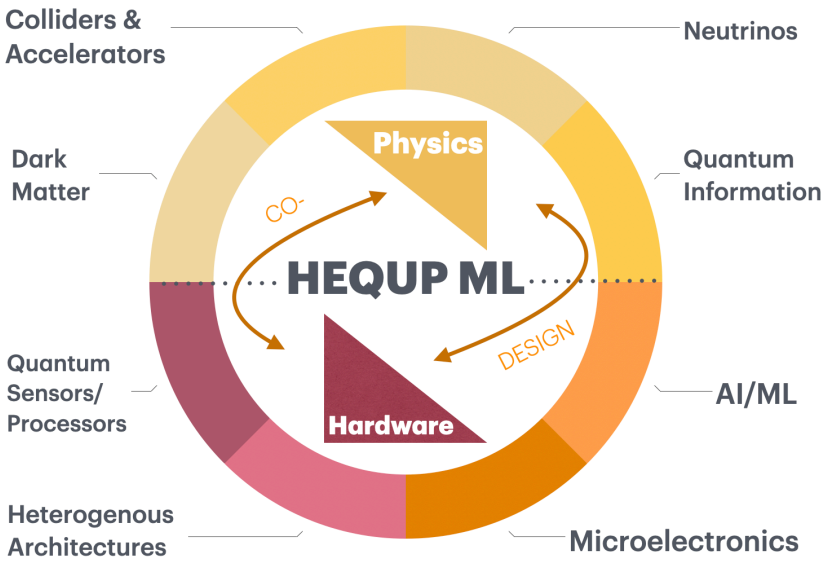
- FY26 HFCC funding awarded to Physics, Software, & Computing + AIM for **differentiable detector optimization**
  - Wonyong Chung (Princeton)
- Scan the phase space (g,r) of (detector geometry parameters in DD4HEP, reconstruction algorithm parameters Gaudi/EDM4HEP) against a physics objective
- Envision first deployable tool with README ~end March
  - Then looking for beta testers!



[20 Jan 2026]

Hardware ML in HEP White Paper

- White paper effort emerging from ML for Front-End (ML4FE) workshop [May 2025]
  - "**H**eterogeneous, **E**dge, and **QU**antum Hardware for Machine Learning in **P**article Physics" (**HEQUP ML**)
- Complementary to FastML, HFCC AIM, SLAC AI strategy, GENESIS, microelectronics initiatives, etc.
- Finalizing draft now; next step circulate to community (~early February)



Backup