

BIB mitigation with AI

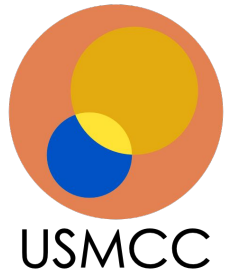
Simons progress report
June 9, 2026

John Dervan¹, Kiley Kennedy², Ryan Roberts³

¹*University of Tennessee, Knoxville*

²*Princeton University*

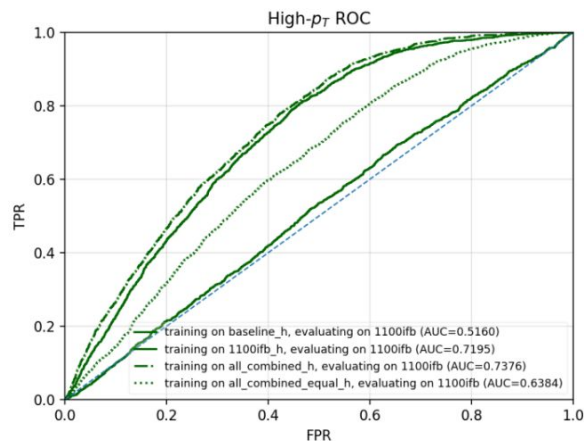
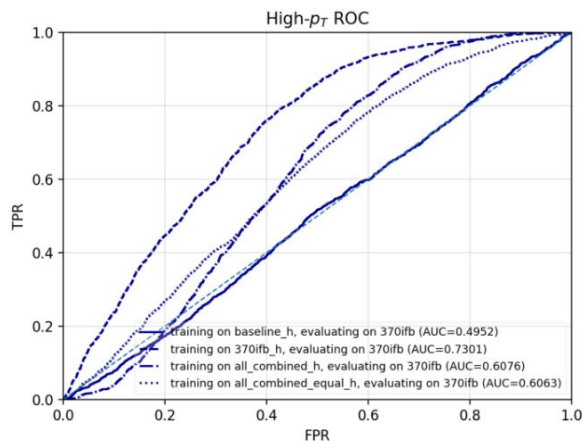
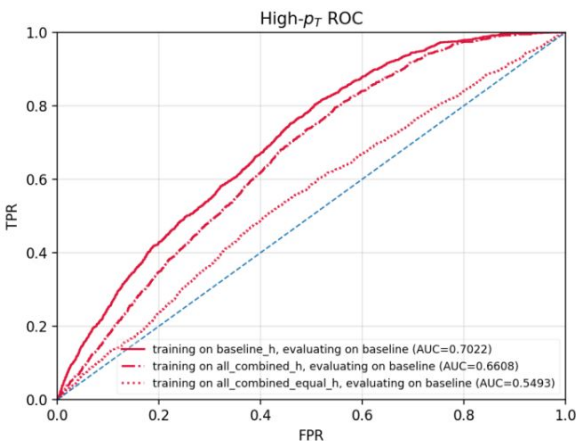
³*University of Chicago*



Major Updates

Report on SmartPixels / LGN – Princeton

- Studying the impact of sensor irradiation using SmartPixels irradiated datasets (0, 370, 1100 fb)
- Participated in HSF-India Scientific Computing Workshop
 - Prepared a hackathon task studying different strategies for dealing with radiation damage in DNNs
 - Students studied training on samples with no radiation damage, full radiation damage, or mixed datasets
 - Also studied providing TID as input to the NN as a flag
 - Results consistent Mila's – Model trained without radiation damage does better at highest TID (370ifb @ HL-LHC) than at intermediate TID (1100 ifb @ HL-LHC)



Major Updates

DNN Model Update – Chicago (Daniel)

- Combined Pareto front featuring all 3 models
- Non-closure between QKeras and HLS still larger than expected

SmartPixel ASIC – Chicago (Daniel)

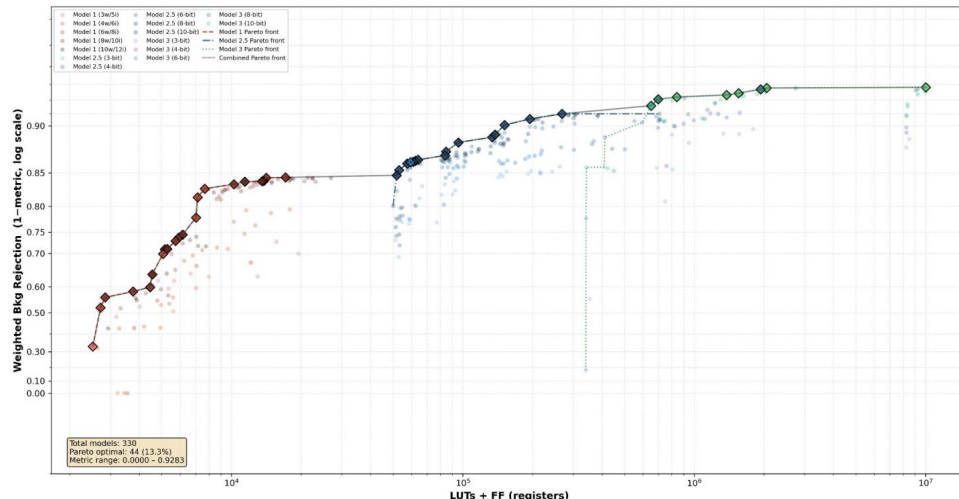
- Resumed cold testing and isolated source of noise in the cold box
- DUT may have sustained damage during handling – investigation open

Current Roadblocks

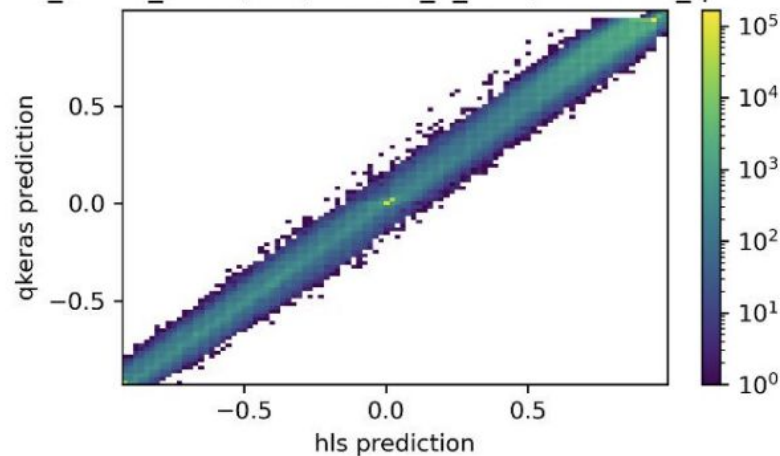
Neuromorphic networks (UTK) –

Personpower/collaborators. Possibly refocusing the calorimeter AI BIB mitigation efforts.

Model 1 vs Model 2.5 vs Model 3 – Sub-fronts + Combined Pareto
Weighted Bkg Rejection vs LUTs + FF [x-log, y: 1–metric log]



lider_Smart_Pixels/eric/Model2_5_tahn/model2.5_quantizedi



General Status

- Still largely working as distinct groups
 - Hoping to converge on shared resources as current efforts wind down (timelines unclear)
- Weekly progress reports provide a useful forum for feedback
 - Currently circulating [when2meet](#) to find a new Summer meeting time
 - Will probably switch to new time starting **next week**

Update: April 24, 2026

Major updates since last time

Meetings:

Wednesdays at 11 am ET

[\[Indico\]](#) — all welcome!

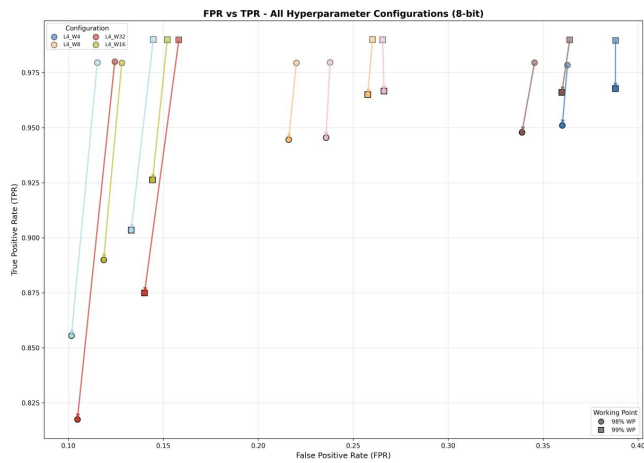
- **Report on SEE Impact Studies – Chicago**

- General degradation of model performance

- Models with high background rejection generally see significant degradation when subjected to radiation effects
- Possible mitigations under study

- Susceptibility of individual bits

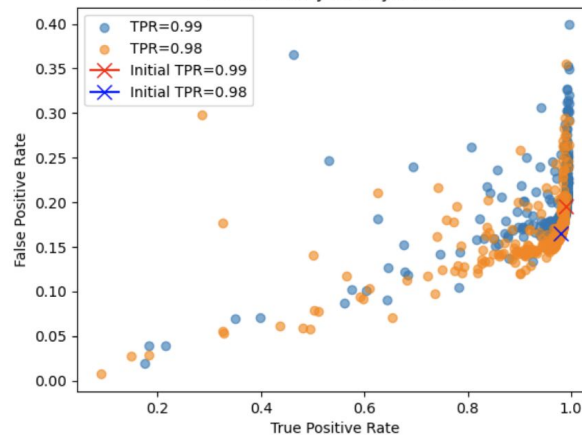
- Individual bits that are particularly important can cause temporary module failures
- Should be able to identify and reset modules on time scales \ll interfill (Tova)



with both external lik
timing information p

ral networks on Sr
ized NNs for Model
with simulated sens
level of damage

Bit Sensitivity for Layer 2MSB



3

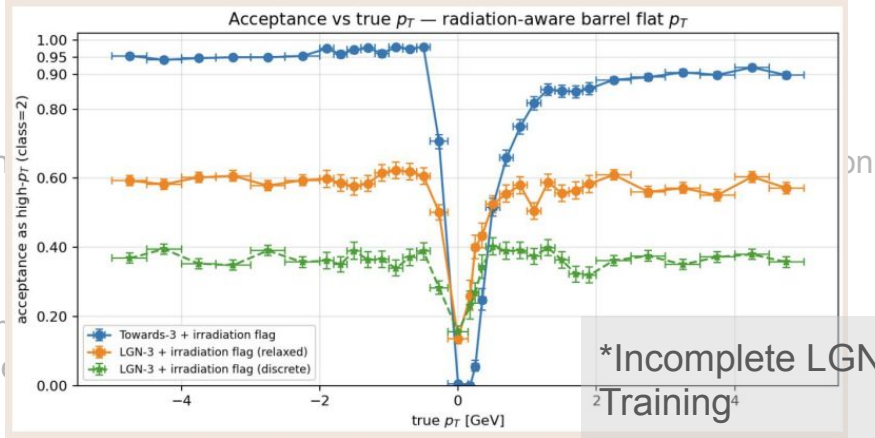
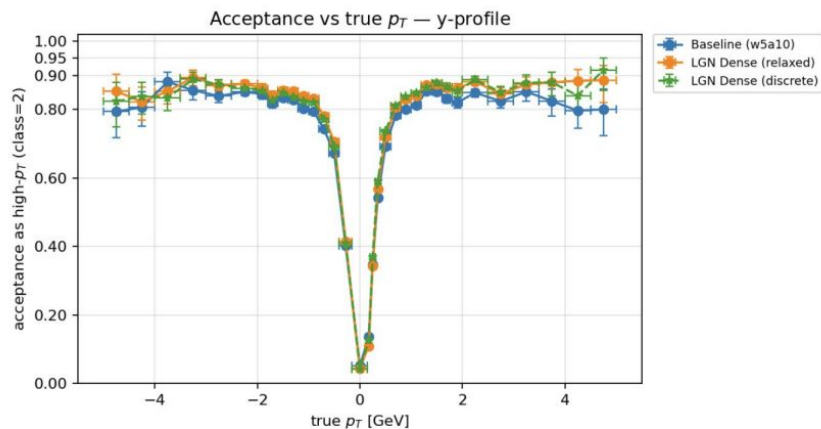
son for LGN

Major updates since last time

Meetings:

Wednesdays at 11 am ET

[[Indico](#)] — all welcome!



● report on LGN synthesis — Miia

- LGN synthesis now possible with both external library ([da4ml](#)) and in-house script
 - FPGA resource usage and timing information produced for Models 2 (cluster profiles) and 3 (convolutions)
- Quantized torch training of neural networks on Smartpixels dataset to provide fair comparison for LGN
 - LGNs outperforming quantized NNs for Model 2
- Initial studies using datasets with simulated sensor damage from radiation
 - Testing possibility of providing level of damage as model input

Update: April 10, 2026

Meetings:

Wednesdays at 11 am ET

[\[Indico\]](#) — all welcome!

Major updates since last time

- **Report on SEE Impact Studies – Chicago**

- General degradation of model performance
 - Models with high background rejection generally see significant degradation when subjected to radiation effects
 - Possible mitigations under study
- Susceptibility of individual bits
 - Individual bits that are particularly important can cause temporary module failures
 - Should be able to identify and reset modules on time scales \ll interfill (Tova)

- **Report on LGN synthesis – Mila**

- LGN synthesis now possible with both external library ([da4ml](#)) and in-house script
 - FPGA resource usage and timing information produced for Models 2 (cluster profiles) and 3 (convolutions)
- Quantized torch training of neural networks on Smartpixels dataset to provide fair comparison for LGN
 - LGNs outperforming quantized NNs for Model 2
- Initial studies using datasets with simulated sensor damage from radiation
 - Testing possibility of providing level of damage as model input

Current Roadblocks

- **LGN:** Availability of muon collider dataset

Ongoing Work

- **LGNs:** Further investigation of radiation damage effects.
- **SNNs:** Evaluating personpower.
- **DNNs:** Understanding optimal choice for input quantization
- **Smartpix Lab Testing:** Calibrating cold box temperature measurement

Open Tasks

- **SNN:** Iterate on dataset, want to first conclude ECAL study before moving to smartpixels
- **Tracking:** Muon collider dataset incorporating merged clusters with detailed digitization
 - Common harness
- **General:** Gain knowledge about ASIC synthesis

Update: March 27, 2026

Major updates since last time

- *Meetings: Wednesdays at 11 am ET [[Indico](#)] — all are welcome!*
- **BDTs for BIB rejection**
 - Heard update from Jordan + nice discussion
- **SNNs (UTK)**
 - Applications to ECAL
 - Previous work: developing a training dataset
- **Outlining our overarching goals/pillars—subject to shuffling + redefinition!**
 - Defining operation of ML-enabled FEs
 - Towards a public dataset for BIB rejection
 - More advanced synthesis of BIB rejection models
 - Benchmark models using current technologies under consideration (DNN, BDT, SNN, LGN)

Current roadblocks

- **LGN** – unclear why we cannot exactly reproduce public results with SmartPixels dataset
- **Smartpix Training** – Messy environment for quantized training and synthesis – QKeras out of date, hls4ml differences for Vitis and Catapult
- **Smartpix Lab Testing** – Noisy filter outputs make validation harder

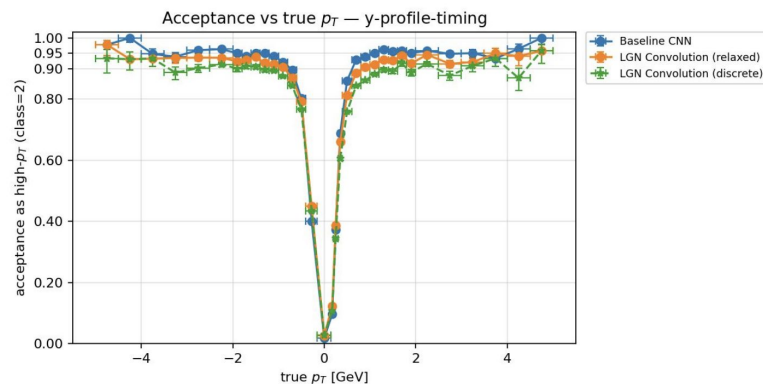
Open tasks

- **LGNs**: proceed with synthesis
- **SNNs**: iterate on dataset, want to first conclude ECAL study before moving to smartpixels
- **DNNs**: Want to refine estimates of chip area, data rate. Eventually validate synthesis on FPGA.
 - Longer term: consider differential distributions, digitization implementation.

Update: March 13, 2026

Major updates since last time (3/13/2026)

- **Meetings:** Wednesdays at 11 am ET [[Indico](#)]
 - All are welcome to join!
 - First meeting on 3/11 [[Indico](#)] – several contributions (not enough time to cover all!)
- **LGN Updates:**
 - Very nice introduction to LGNs (Lino)
 - Partially reproduced SmartPixels public results w/ conventional NNs (Mila)
 - LGNs (**relaxed** and **discretized**) perform nearly as well as **conventional NNs** on SmartPixels dataset
- **UTK ML for clustering**
 - ML applications to cluster shape to be discussed at next meeting
 - SNN for smartpixels study in revival/literature phase; training to be described
- **Chicago Smartpix NNs for BIB**
 - Understanding details of hyperparameter tuning.
 - Lab testing of filtering ASIC. (lower priority recently)
 - Rough investigation of SEE effects in weights.



Current roadblocks (3/13/2026)

- No significant roadblocks
- **LGN** – unclear why we cannot exactly reproduce public results with SmartPixels dataset
- **Smartpix Training** – Messy environment for quantized training and synthesis – QKeras out of date, hls4ml differences for Vitis and Catapult
- **Smartpix Lab Testing** – Noisy filter outputs make validation harder

Open tasks

- **LGNs**: proceed with synthesis
- **SNNs**: tasks TBD following literature conclusion
- **DNNs**: Want to refine estimates of chip area, data rate. Eventually validate synthesis on FPGA.
 - Longer term: consider differential distributions, digitization implementation.