

# A3D3 Postbacc Experience

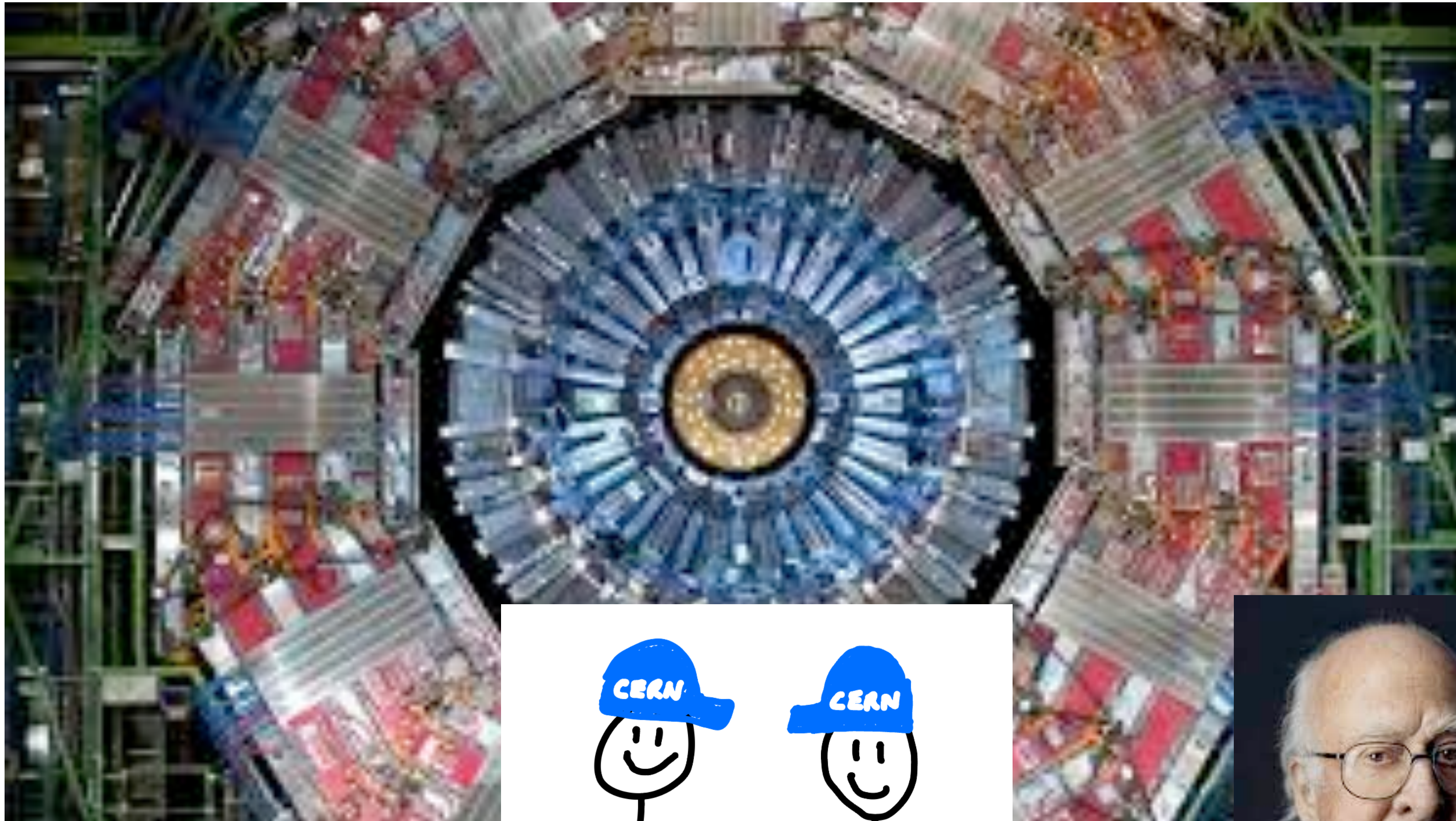
Research, Workshops, Conferences, Friends, and What is Beyond the Standard Model?

Andrew Skivington

# What is Water?

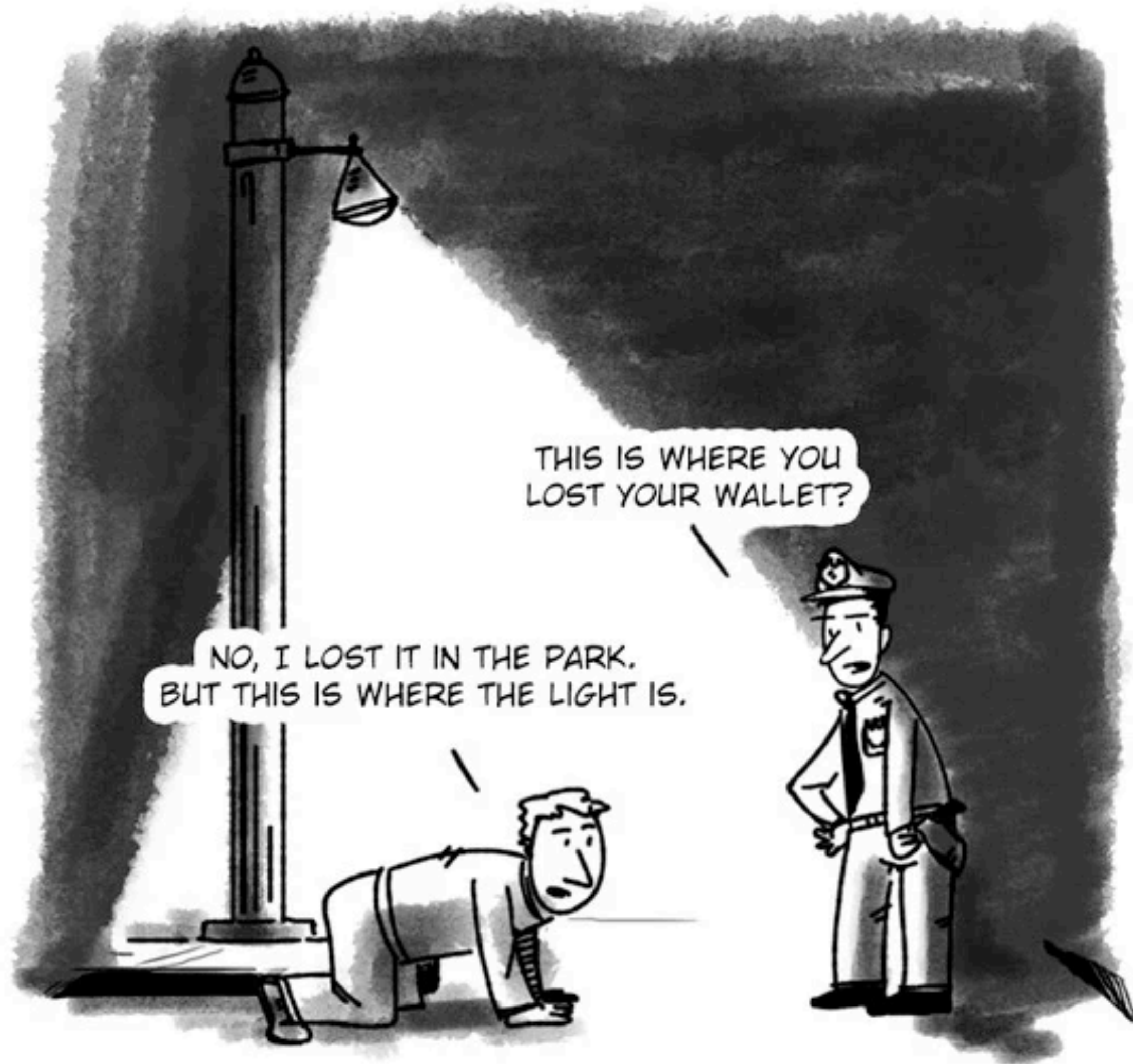


# What is Beyond the Standard Model?



Morning,  
found any new physics  
beyond the standard model?

# The Street Light Effect



- We need to “search where the light isn’t” - Dr. Kevin Pedro (Fermilab Wine & Cheese Seminar, Jan. 13, 2023)
- How do particle physicists plan to do this?
  - Anomaly Detection!

# ML and Anomaly Detection

## Autoencoders

- Two main kinds of algorithms being explored and implemented in CMSSW:
  - DNN autoencoders (AE)
  - DNN variational autoencoder (VAE)
- The paradigm of geometric deep learning (my current research):
  - GNN (graph neural network) AE
  - GNN VAE

# How It Works

## Train, test, Nobel prize?

- We train the autoencoder on physics we know
  - i.e. standard model QCD background
- Model learns to reconstruct SM events very well
- Anything the AE takes as input that doesn't match SM
  - high reconstruction loss → new physics?

# What Physicists Want

## ML trigger for experimental anomaly search

- Offline analysis is powerful to extract more info from existing data
- But...what if the really interesting data isn't being collected???

➔ need for anomaly detection (AD) trigger

- Hence, research is being centered around autoencoder models for AD @ L1-trigger
- Currently working to show that GNN autoencoders are a potential option (or maybe not)
- Questions to answer:
  - Can GNNAE fit on an FPGA and meet required latency for L1 trigger?
  - Can knowledge distillation work to compress the teacher network into a smaller student GNN without l.o.g

# What is being done

- Developing models and training them on ZeroBias2018D QCD background
- Specific GNN model being studied is the interaction network (IN)
  - INAE
  - INVAE



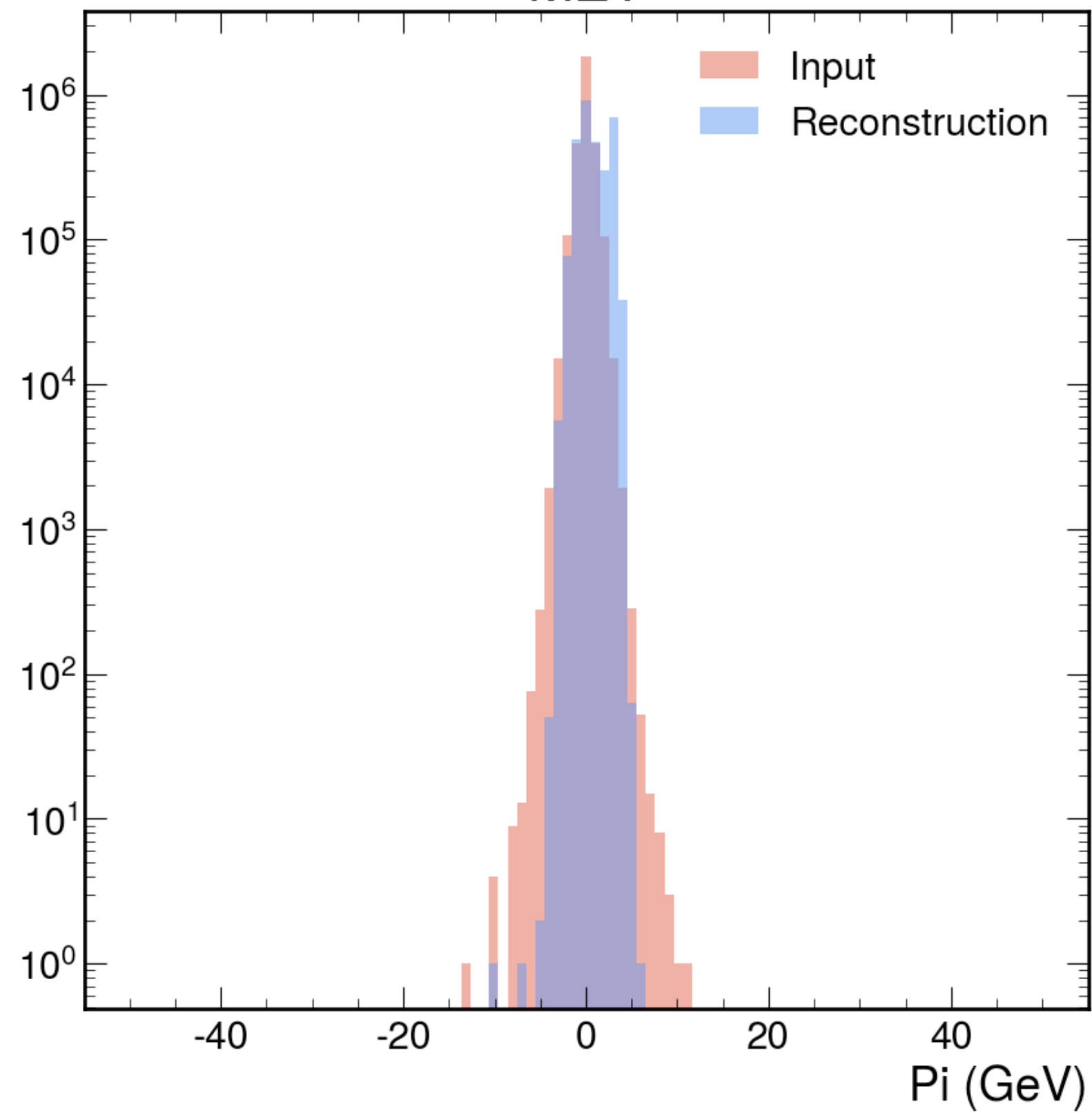
# DNNAE v. GNNAE

- DNNAE
  - Pros:
    - Good performance
    - Quantizes well w.l.o.g
    - Less computational resources required
  - Cons:
    - Less generalizable to collider data, which is naturally non-Euclidean
- GNNAE
  - Pros:
    - Comparative performance?
    - More generalizable for graph like input data (i.e. collider/detector data)
    - (Possibly) more generalizable/sensitive to a wider range BSM signal models
  - Cons:
    - Computationally expensive because large adjacency matrix is employed

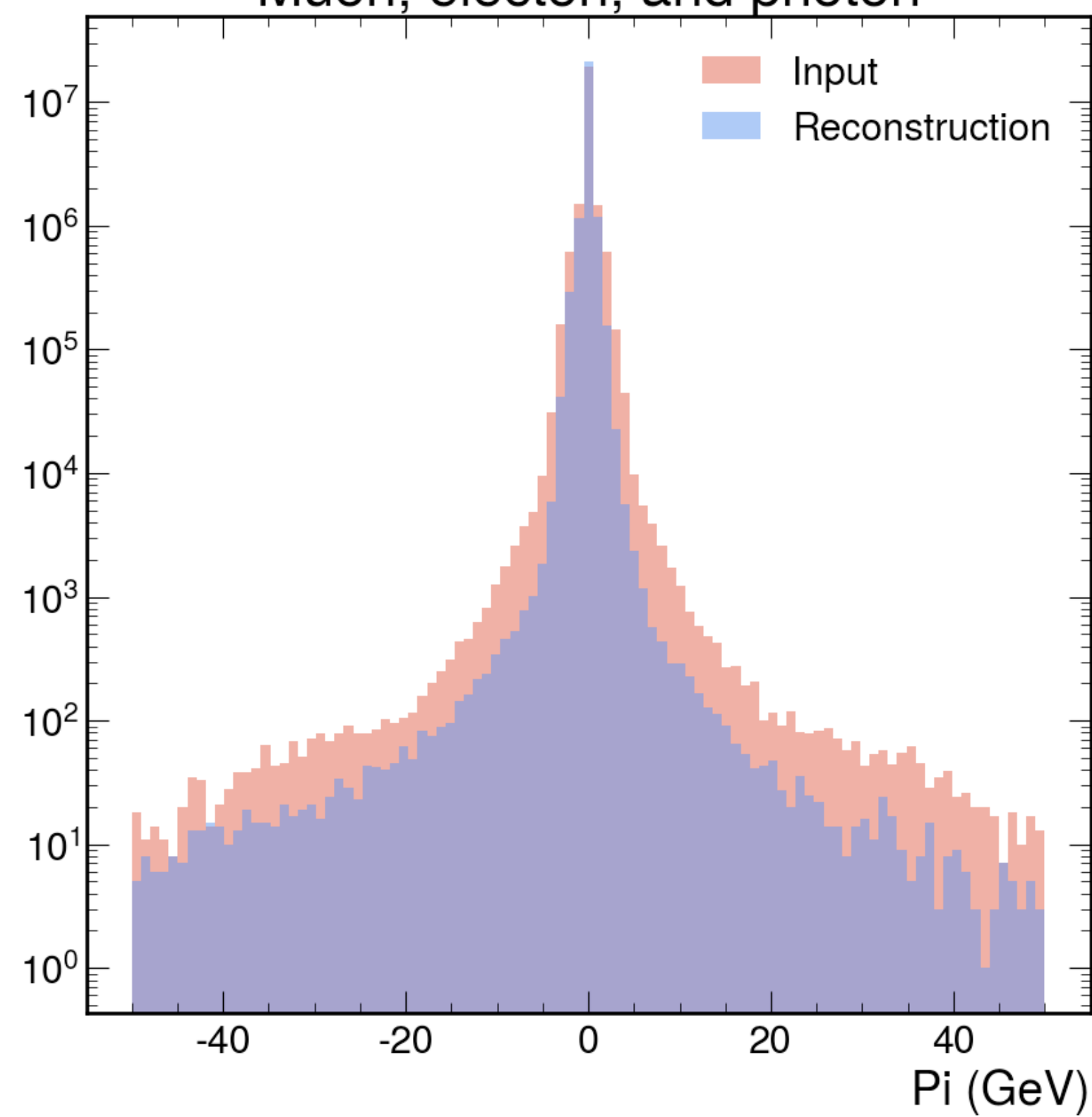
# Preliminary Results

# INAE Reconstruction Histograms

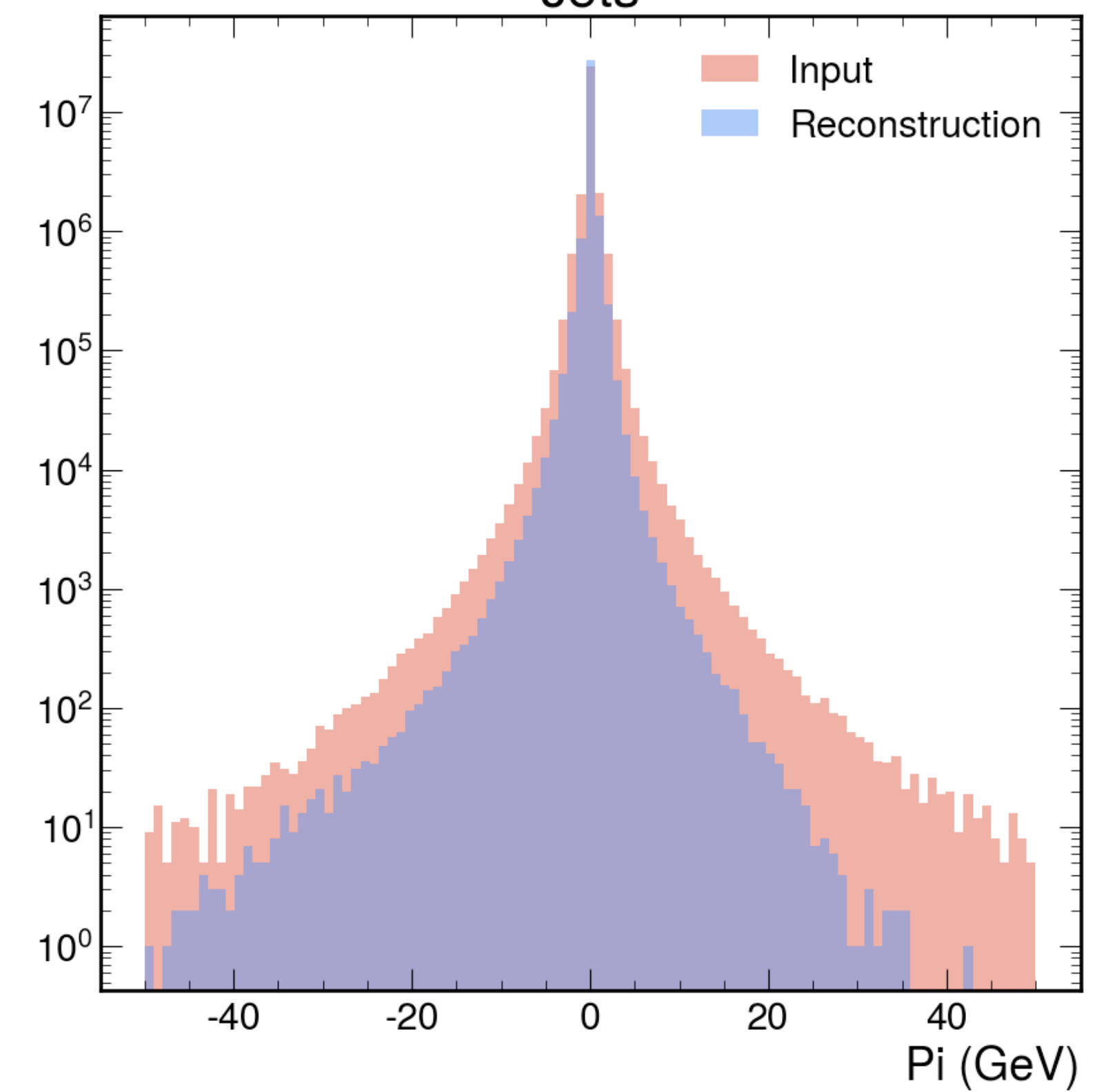
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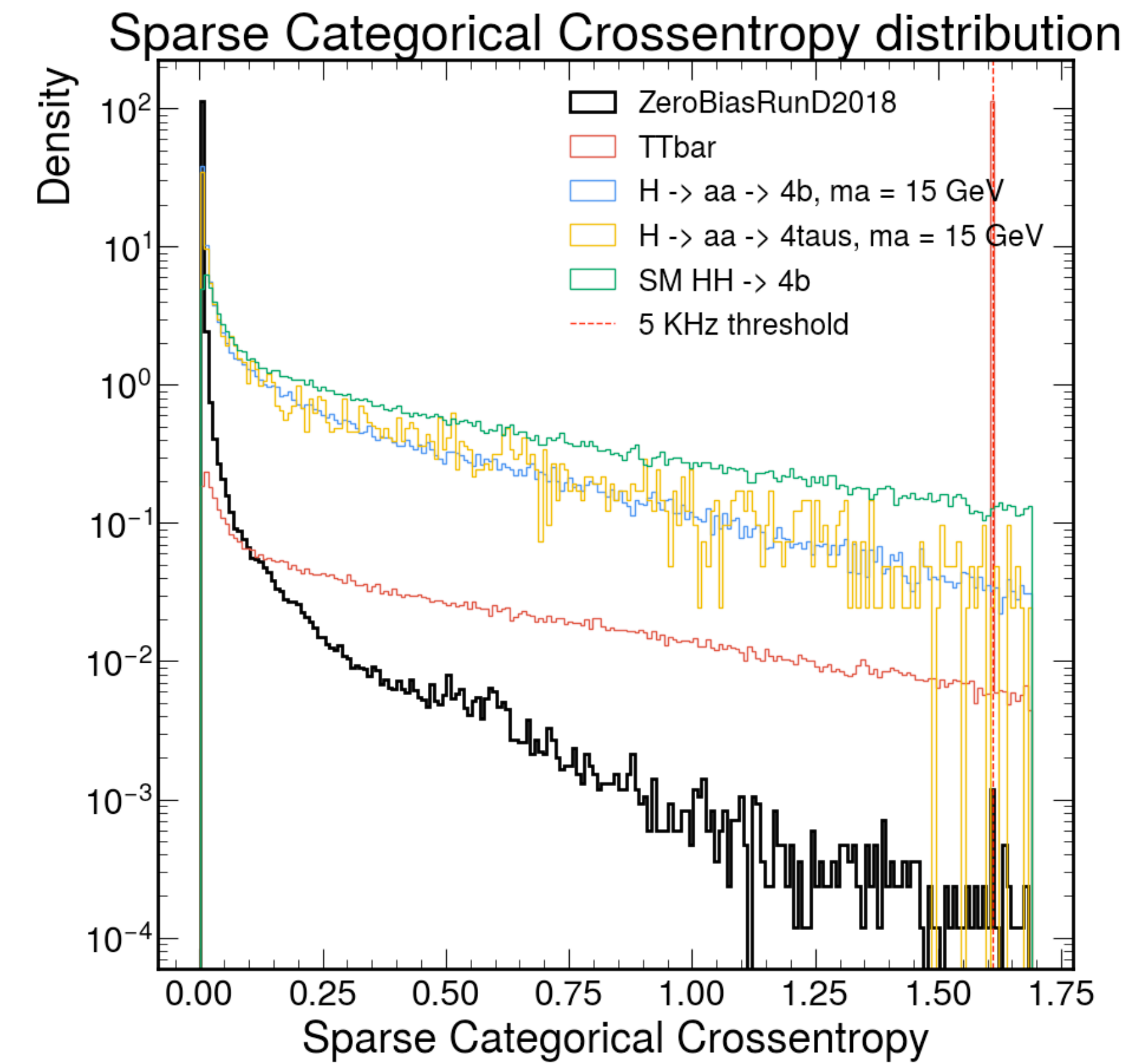
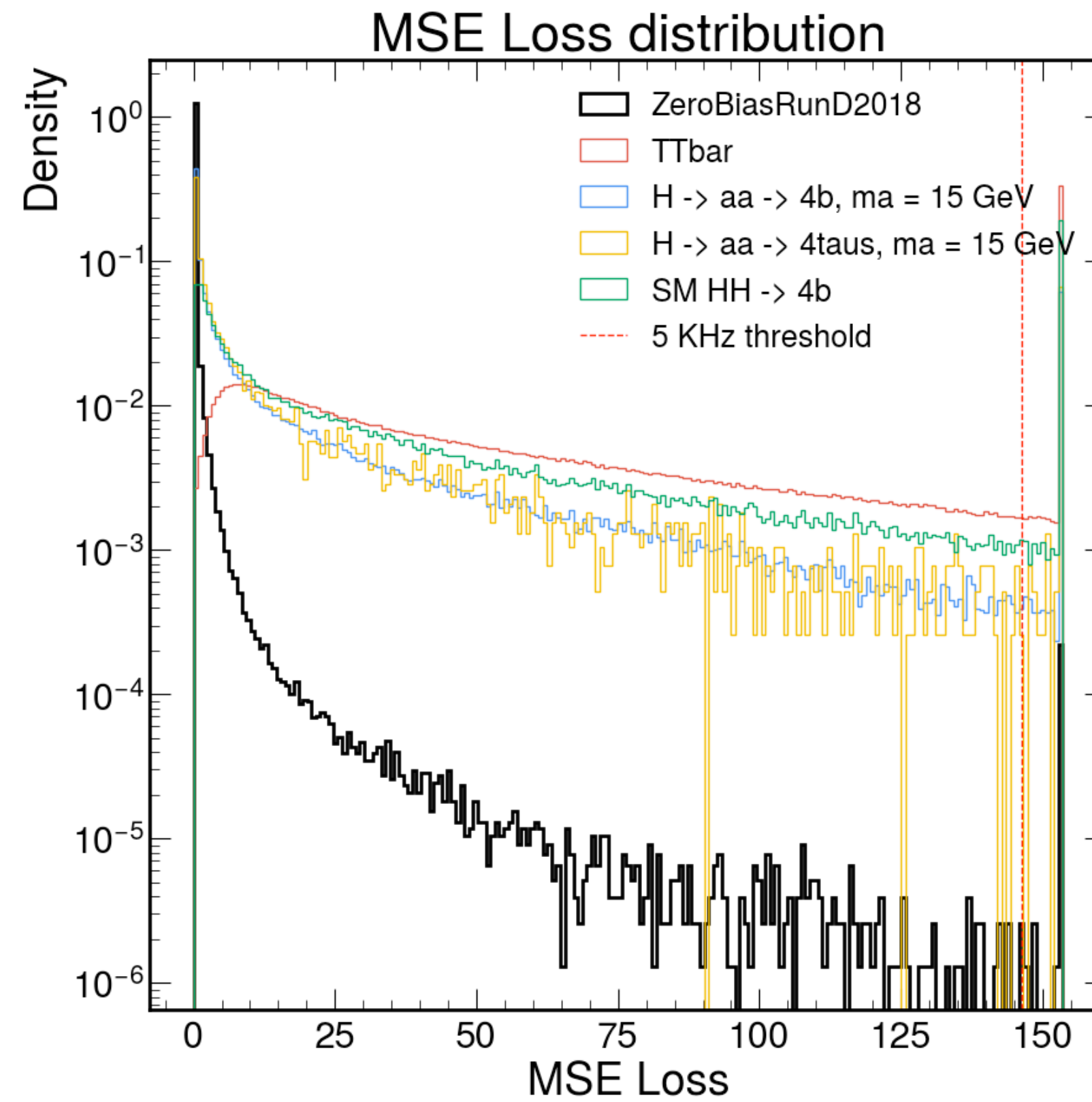
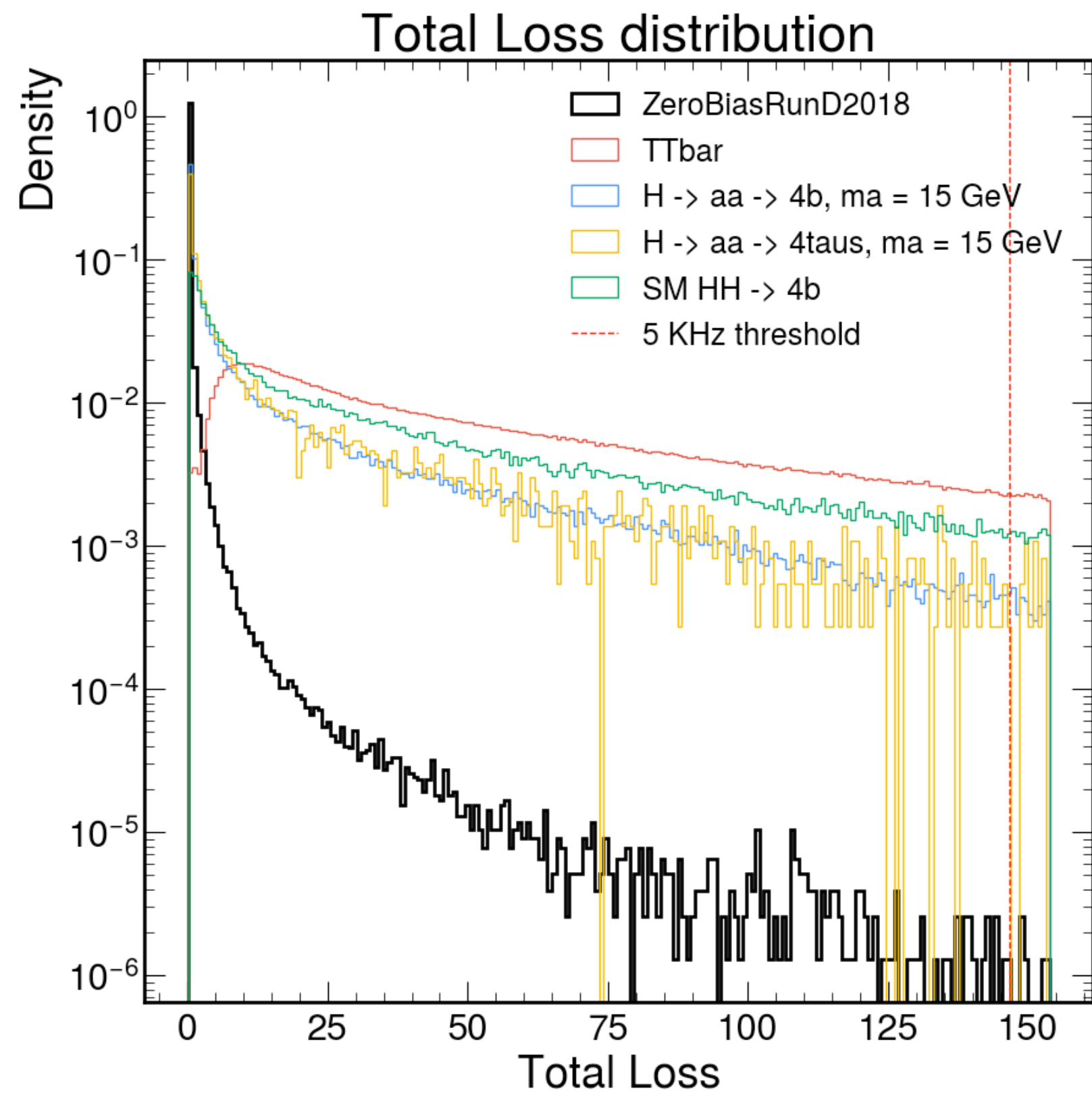
Muon, electron, and photon



Jets



# Loss Function Step Histograms



# Next Steps

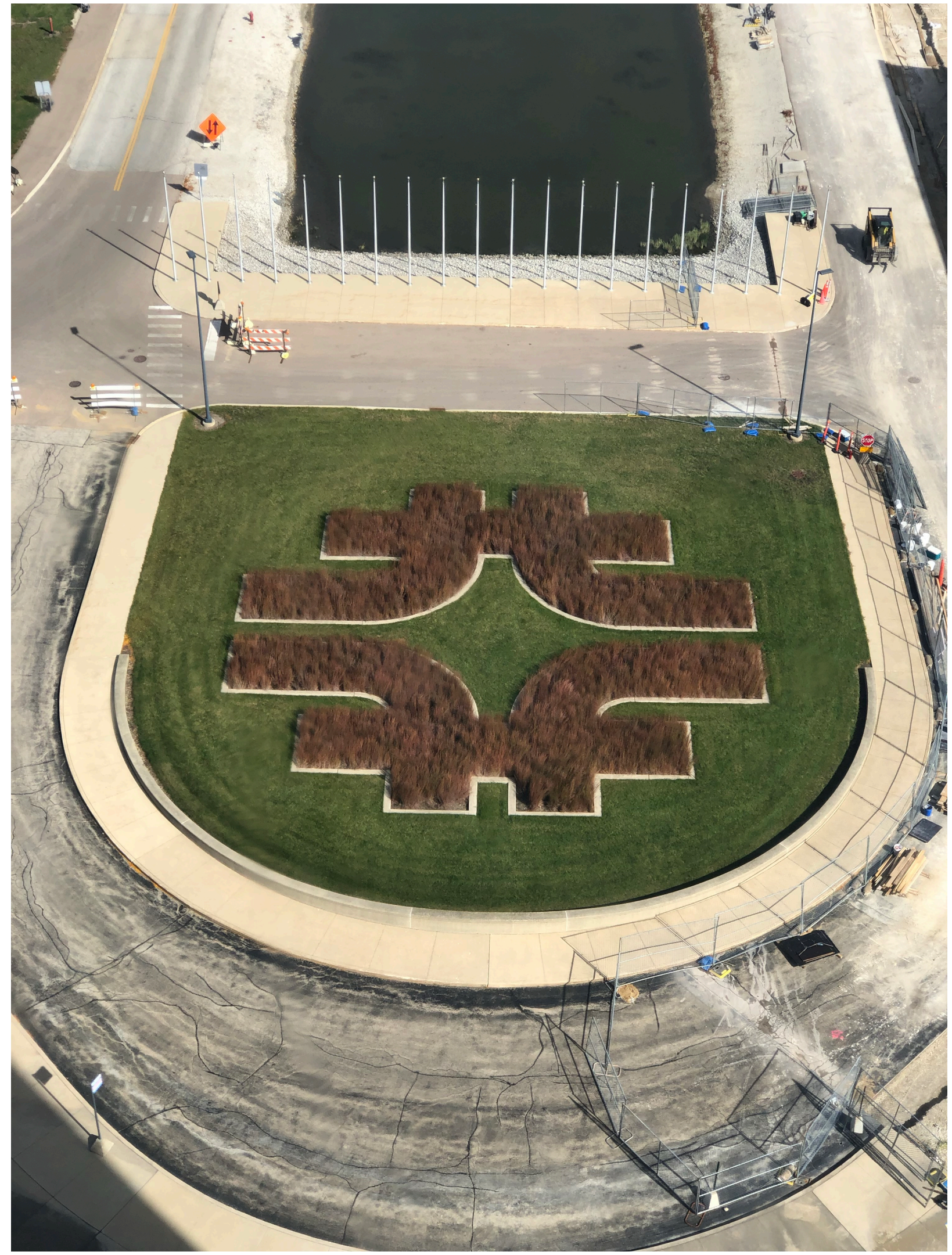
- Continue to optimize the training of the INAE
- Integrate INVAE model and train on ZeroBias2018D data and test on BSM signals
- Continue model comparison of INAE vs DNNAE
- Continue knowledge distillation research
  - Geometric Knowledge Distillation (GKD) ?

# Workshops, Fermilab, and Fun

# CMSDAS 2023 @ Fermilab



# Fermilab





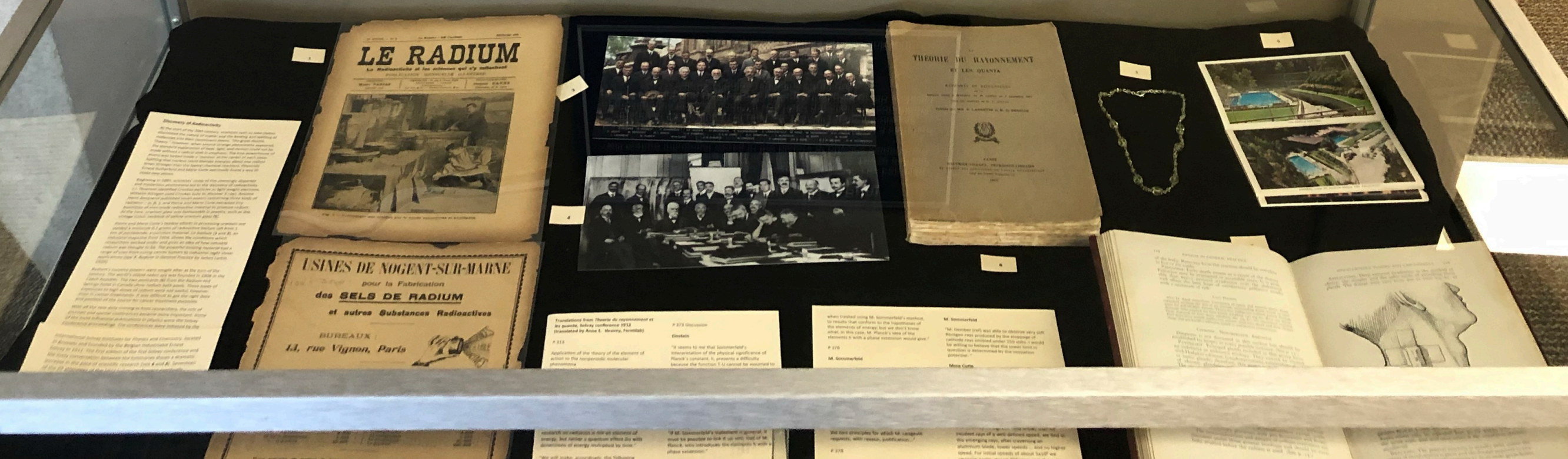
# Fermilab



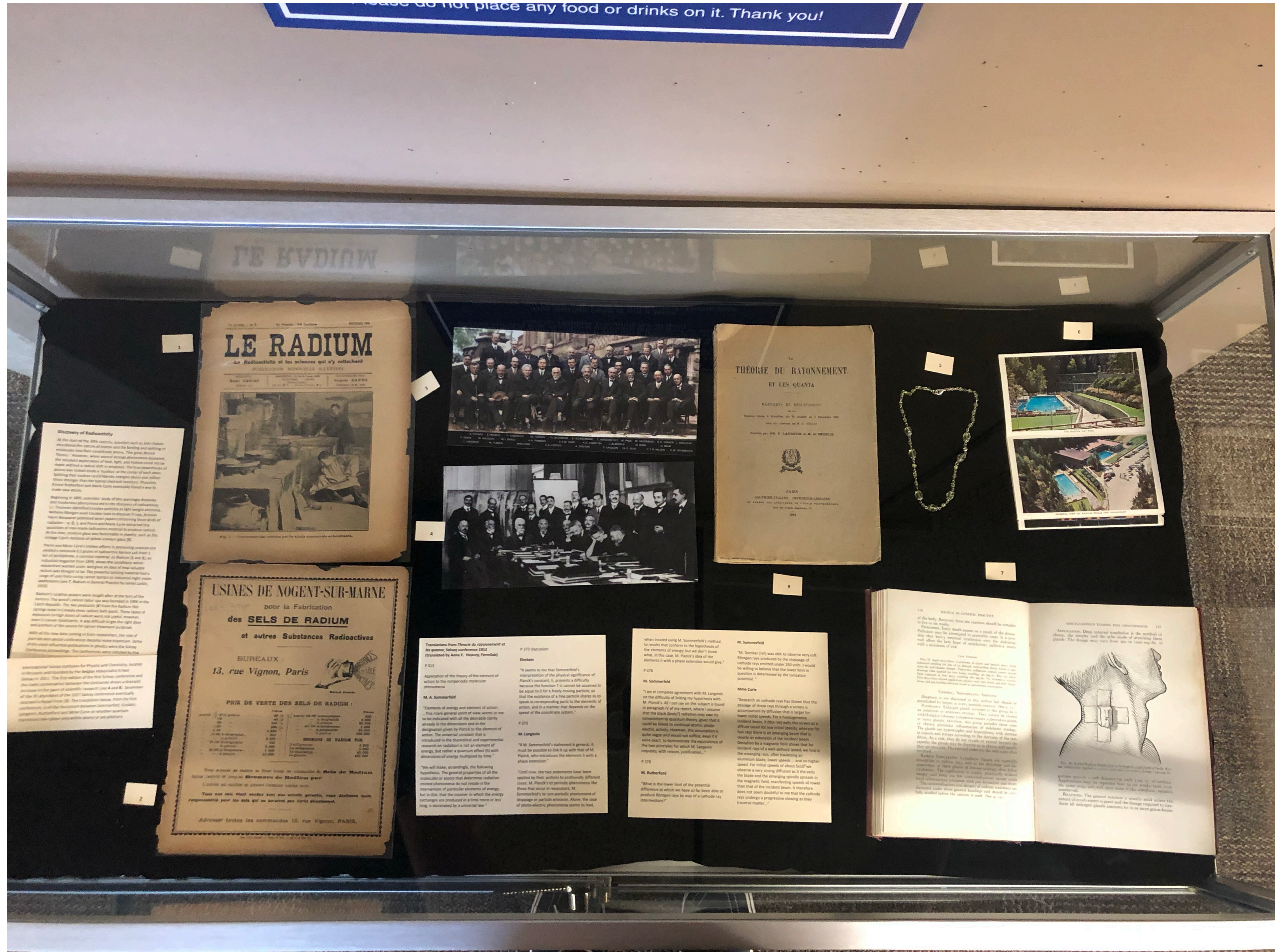
## The History of Physics in Print

This display is part of a series of exhibits organized by Fermilab scientist Erik Ramberg and the Fermilab Archives. These exhibits will feature influential works in the history of physics loaned from Ramberg's private collection. Each display will consist of several volumes illustrating a common theme in the evolution of physics. We will rotate the display approximately once a month. If you have questions or comments, please contact Erik Ramberg ([ramberg@fnal.gov](mailto:ramberg@fnal.gov)) or lab archivist Valerie Higgins ([vhiggins@fnal.gov](mailto:vhiggins@fnal.gov)).

This display case is not a table.  
Please do not place any food or drinks on it. Thank you!



# Anotha' One



# SD Skateparks and Sunsets



# Bonfires on the Beach

with friends and colleagues

