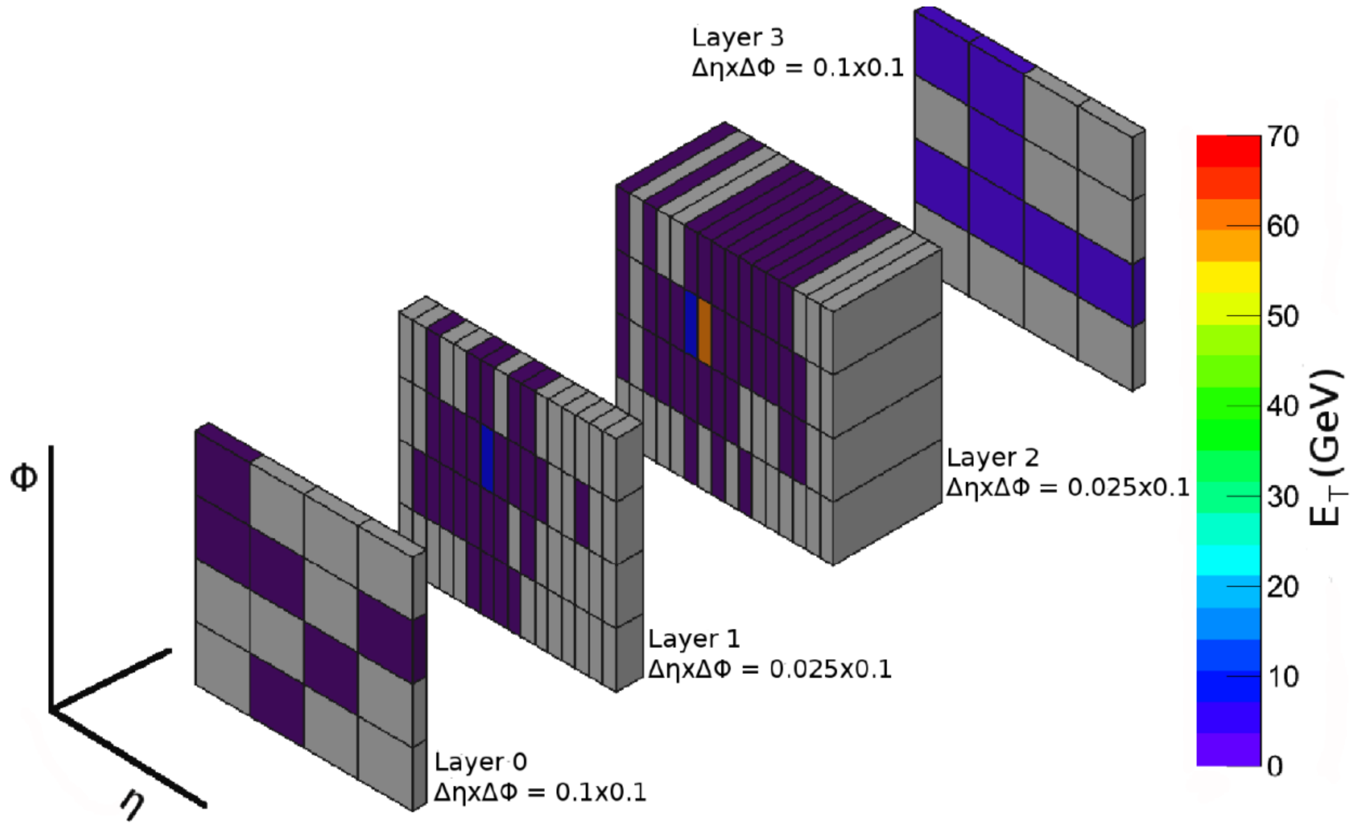
HSE University
Faculty of Computer Science
LAMBDA Laboratory

Calibrating for the Future: Enhancing Calorimeter Longevity with Deep Learning

Ali Saraa , Bocharnikov Vladimir , Derkach Denis ,
Ryzhikov Artem

Calorimeter Architecture and Energy Measurement



A calorimeter is a device used in particle physics to measure the energy of particles. By absorbing and measuring the total energy of an incoming particle, it provides crucial data about the particle's properties

Calorimeter calibration

- Calorimeter calibration
  - Hardware calibration
    - Internal pulse injection
    - Radioactive source / laser
  - Test beam calibration
    - Single particles of a known type and energy
  - In situ calibration
    - Well known physics sample (e.g. $Z \rightarrow ee$, $W \rightarrow jj$)
  - Some calibrating procedures have to be repeated after beam exposure
    - Requires effort
    - Many parameters to optimize -> automatize with data-driven ML

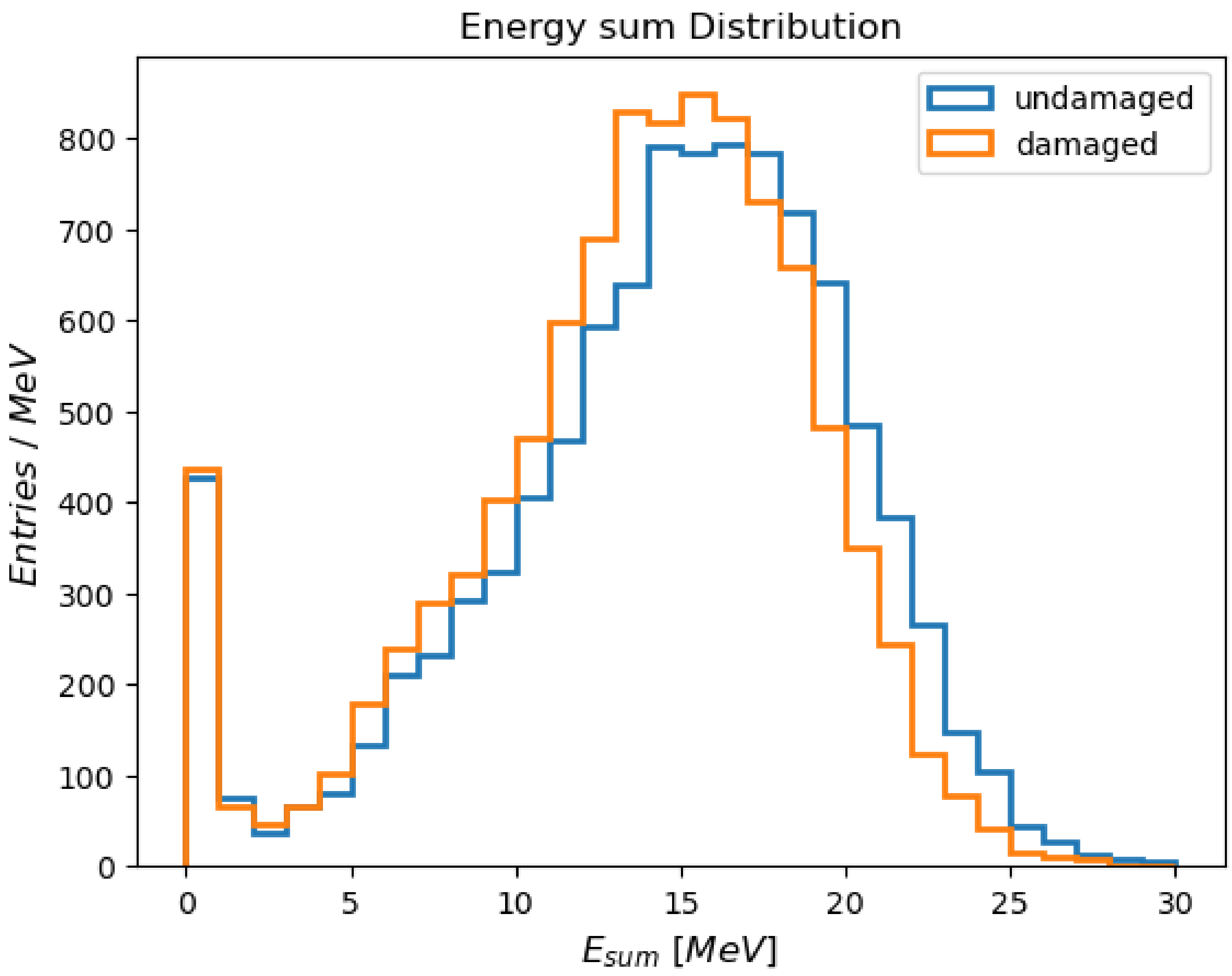
Energy Sum Distribution in damaged vs. undamaged Calorimeters

Event Simulation: Simulated 10,000 events using 10 GeV pions in a granular calorimeter, reflecting future collider experiment setups.

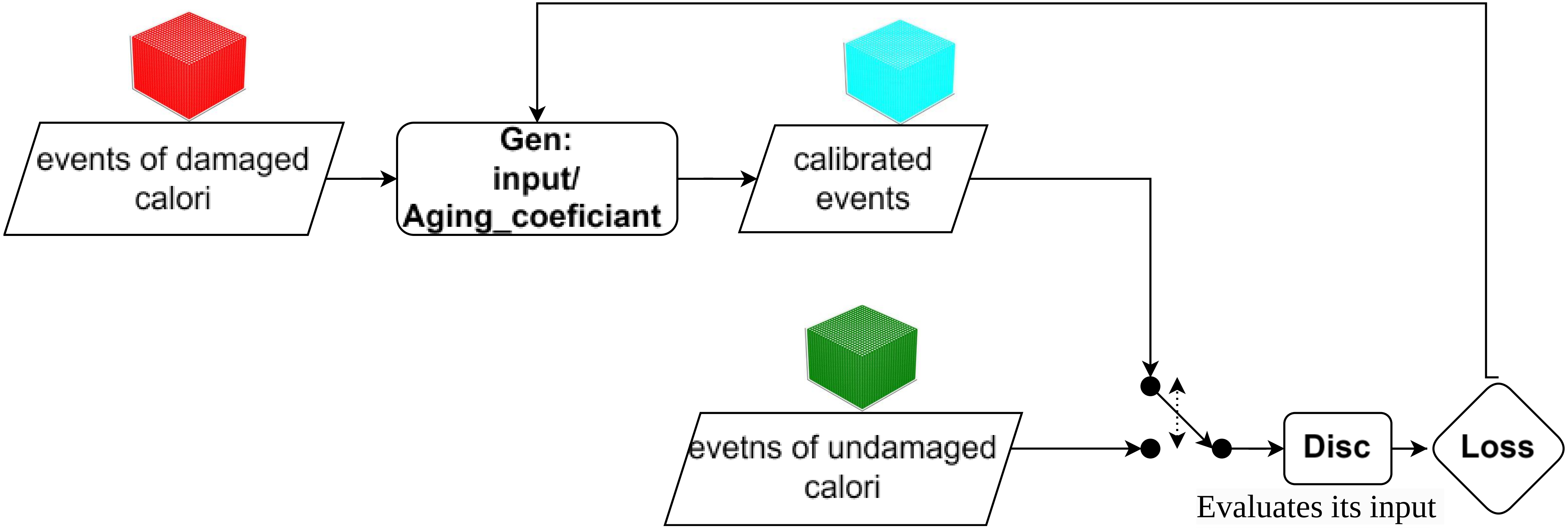
Synthetic Ageing: Assigned ageing coefficients to each cell based on cumulative energy deposition across simulations.

Histograms reveal shifts in energy measurements, highlighting synthetic ageing effects on calorimeter performance.

This work examines radiation damage that leads to lower signal amplitude in cells.



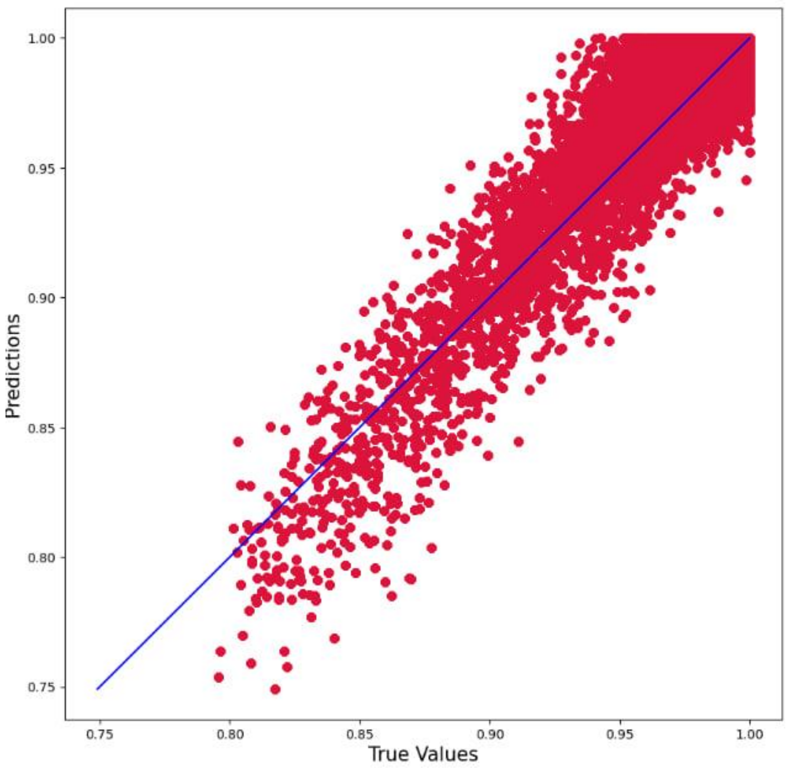
WGAN-inspired architecture for Calorimeter ageing Prediction



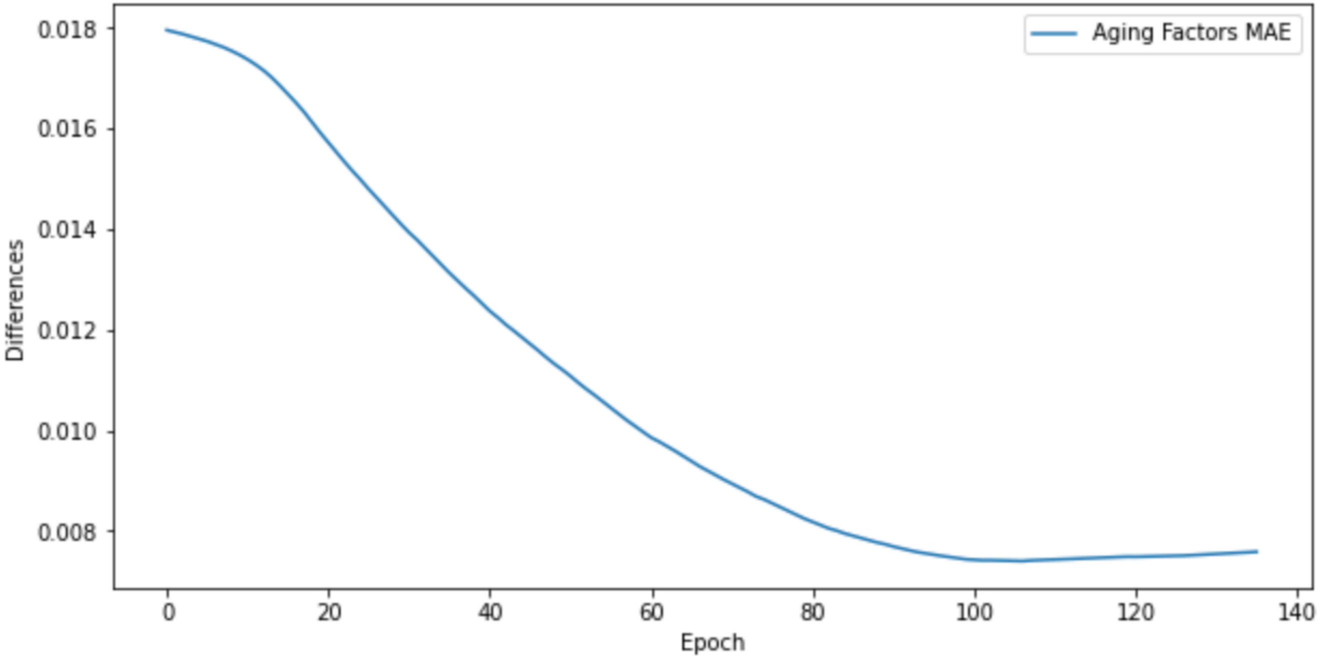
Evaluates its input if it's damaged or undamaged

WGAN-inspired results

Scatter Plot of Predicted vs.
True Values

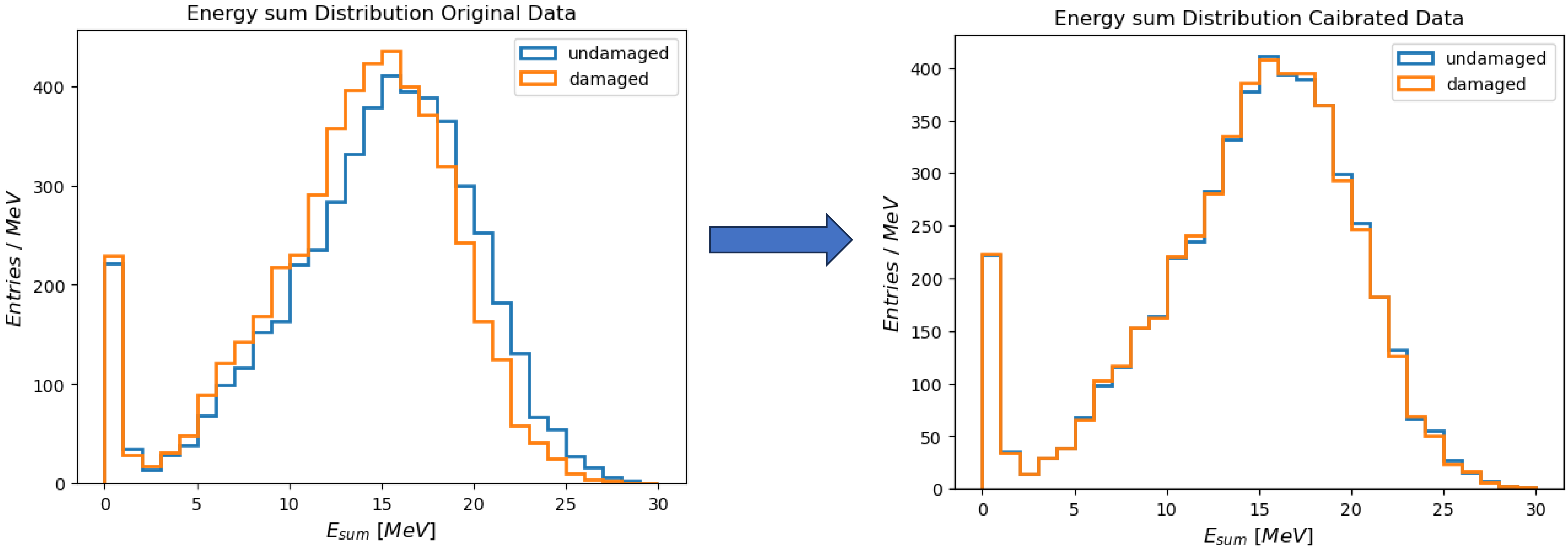


Mean absolute Error for aging
coefficients



- Mean Absolute Error (MAE) of aging factors decreases consistently throughout training, starting from 0.018 and stabilizing around 0.0074 after 100 epochs.
- This demonstrates the model's ability to fine-tune aging coefficients.

WGAN-inspired results



- Calibration is done in cell level
- The damaged calorimeter shows less changes observed in its distribution post-calibration

Conclusion

- Generative machine learning models enhance can address degradation effects of particle detectors.
- Our inspired WGAN model reconstructs calibration coefficients, achieving good overall performance.
- This efficiency translates into potentially less costly and resource-intensive experiments, allowing for calibration with reduced experimental data.
- The presented method is universal and can be applied to detectors of different shapes and physics principles.

Thank you

Generative Adversarial Networks (GANs)

Generative models are a type of artificial intelligence that are designed to create new data samples that resemble the training data.
They are used in various applications such as image generation, video enhancement, and more.
GANs consist of two parts: a generator that creates images and a discriminator that evaluates them. Together, they improve each other to produce highly realistic results.

The ultimate goal of a GAN is for the generator to learn the distribution of the real data so well that the samples it generates are indistinguishable from the real data.

Generative Adversarial Networks (GANs)