NORTHROP GRUMMAN

ENGINEERING & SCIENCE STUDENT DESIGN SHOWCASE

FLORIDA TECH

Ultra-Fast Detector Simulation using Deep Learning Methods

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BACKGROUND

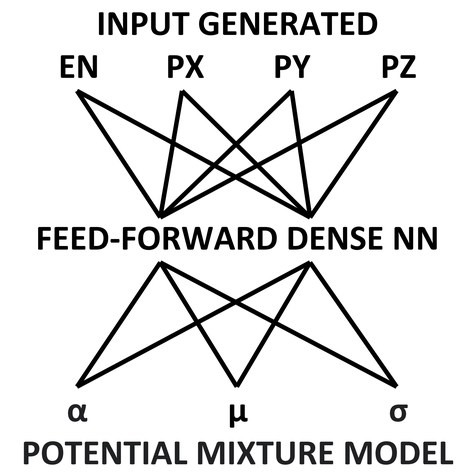
Simulations in particle physics need to take into account the resolution effects from detectors before they can be recreated in laboratories. GEANT4 is the most commonly used software for this application. However, it requires extensive CPU power and time to run.

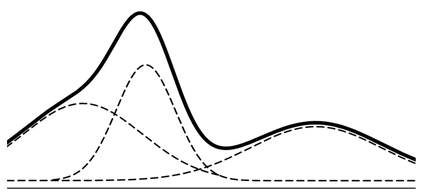
RESEARCH OBJECTIVE

Our goal is to accelerate the data production process using Neural Networks. This entails the reconstruction of particles' characteristic four-vectors [EN, PX, PY, PZ].

THE METHOD

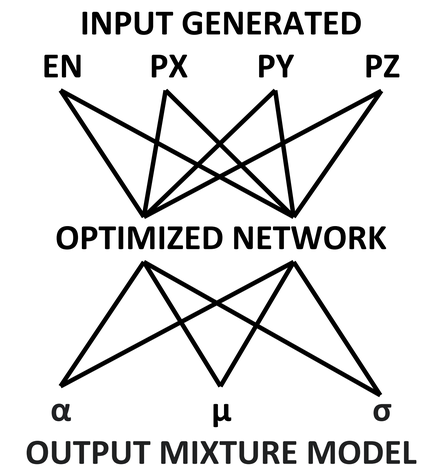
TRAINING

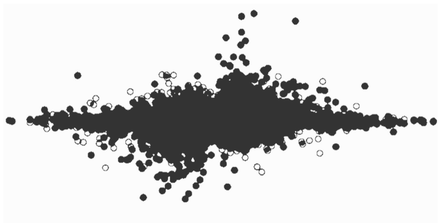




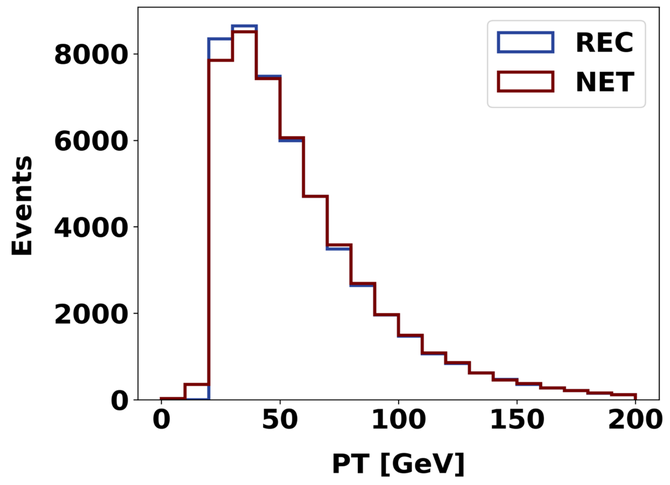
MINIMIZE
NEGATIVE LOG-LIKELIHOOD
OF GEANT4 OUTPUT

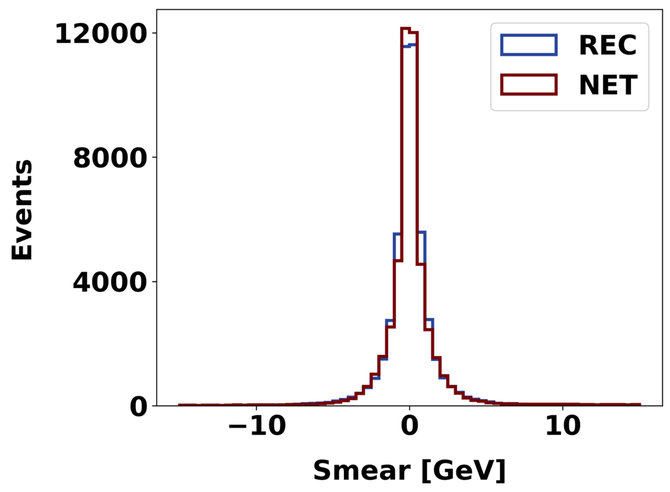
IMPLEMENTATION

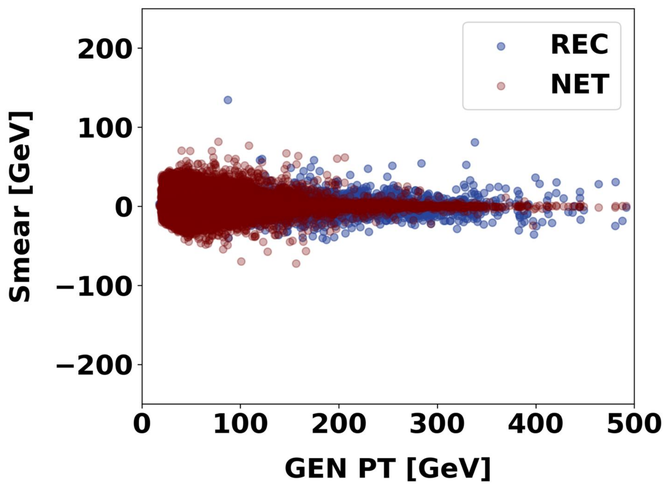




RESULTS







The figures represent how we analyze overall statistics. These compare our network's results (NET) vs. the GEANT4 reconstruction (REC) for the transverse momentum of electrons.

$$PT^2 = PX^2 + PY^2$$

From top to bottom:

Fig 1. Reconstruction distributions
Fig 2. Smear from initial values
Fig 3. Smear-Generated phase space

We define the smear as the difference between a simulated vector and an input vector. This can be thought of as the resolution effect from detectors.

ANALYSIS

We do not expect our reconstruction to be numerically identical to GEANT4. However, the overall NET distributions should be comparable to REC.

We have observed this for electrons and muons. Further fine-tuning will be done to improve the statistics on the high GeV end of the four-vectors.

FUTURE WORK

- ❑ New methods for verifying results
- ❑ Optimize sampling method
- ❑ Reconstruction of other particles

ACKNOWLEDGEMENTS

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