

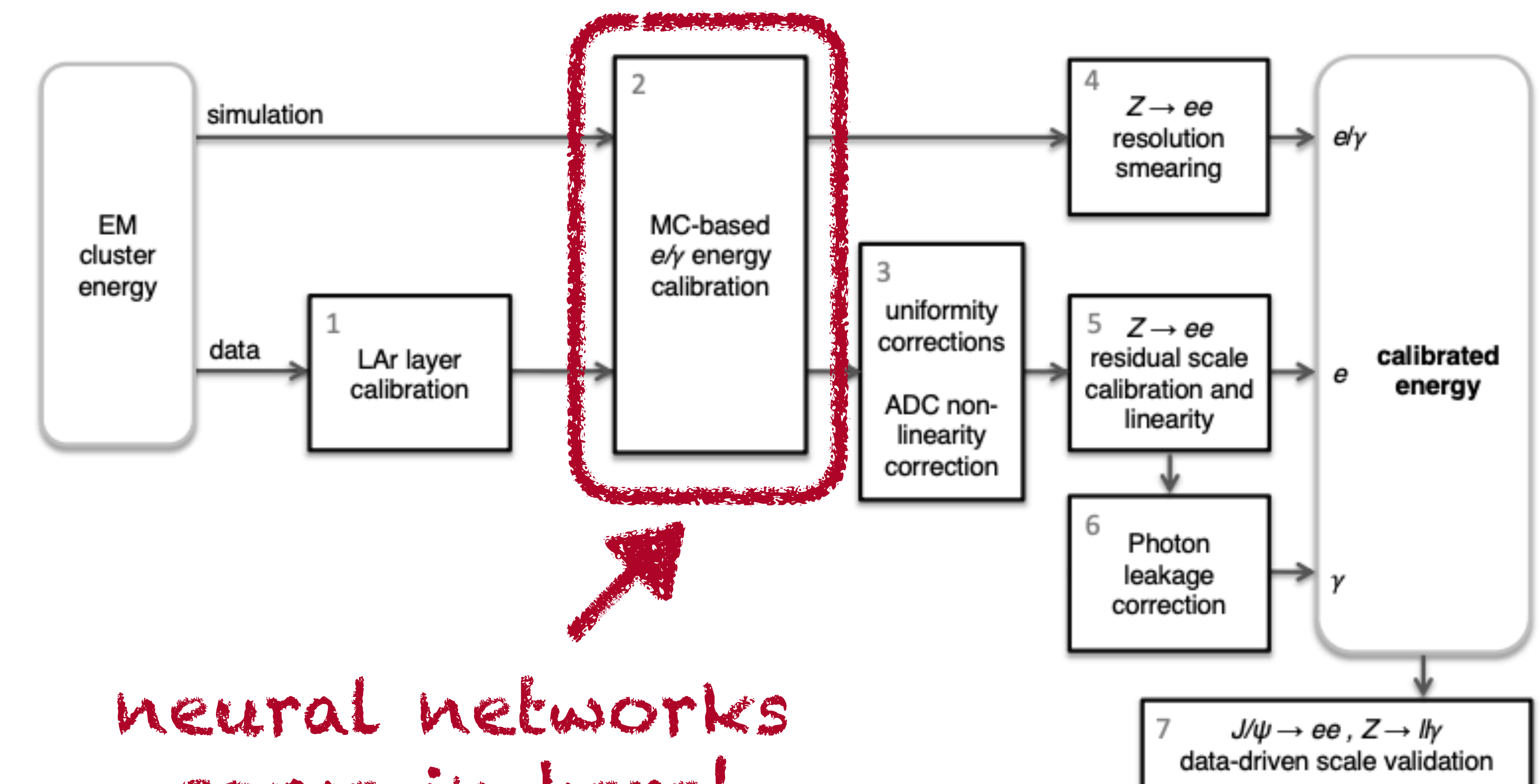
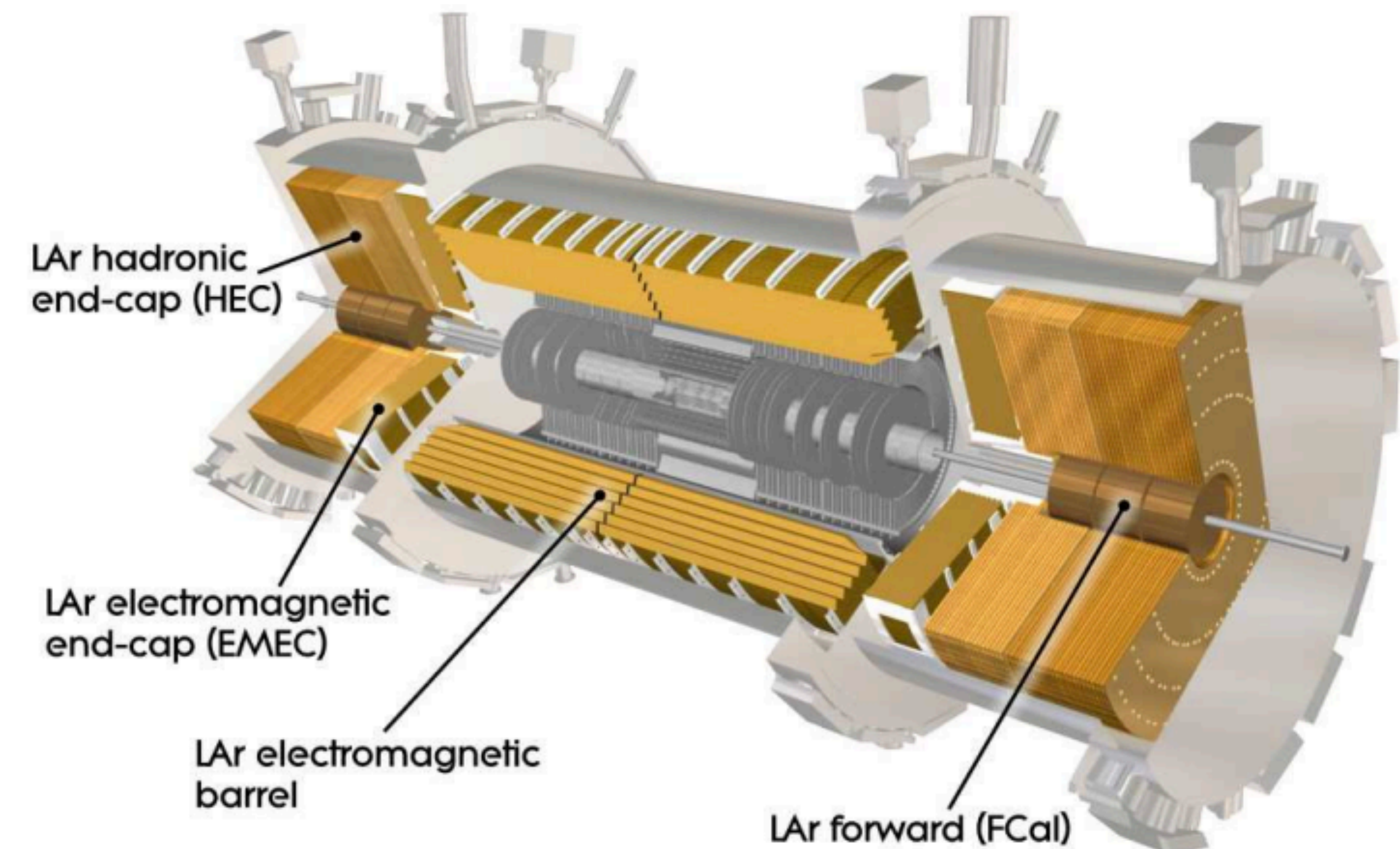
Calibrating e/γ Energies with Transformers in ATLAS

Alex Sapiro

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e/γ energy calibration in ATLAS

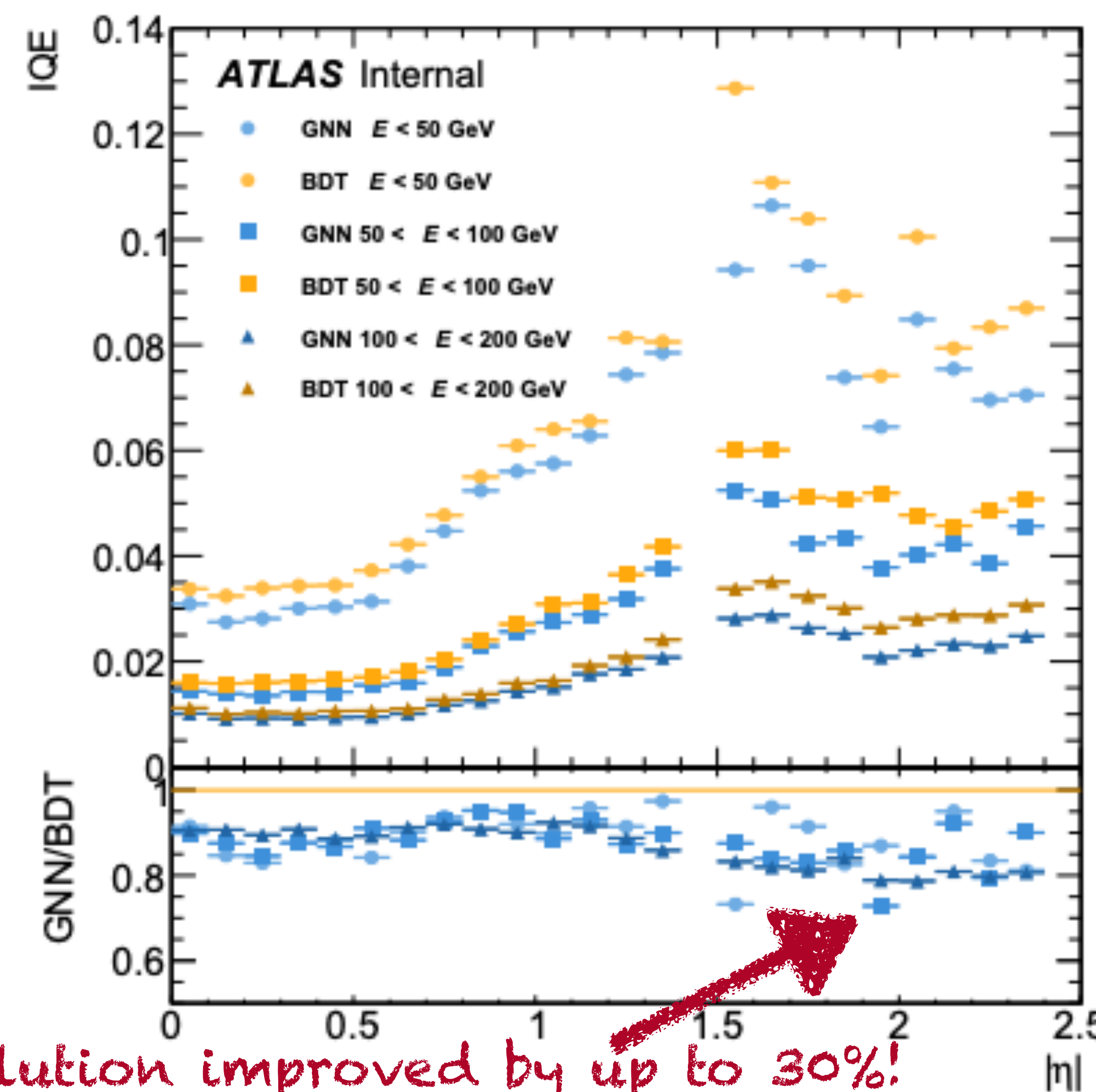
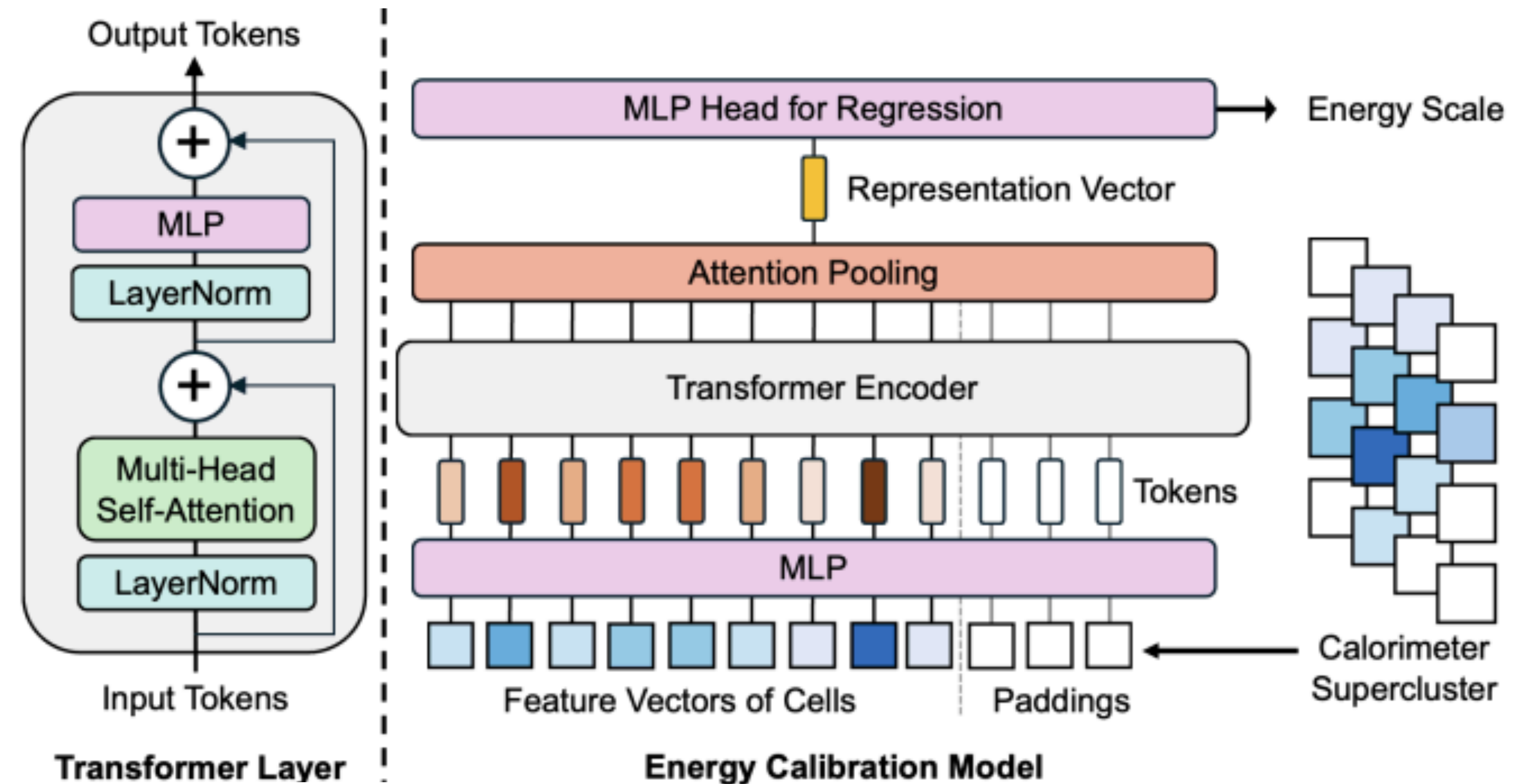
- Higgs Boson discovery channels $H \rightarrow \gamma\gamma$ & $H \rightarrow 4\ell$ historically important benchmarks for sensitivity of ATLAS measurements
- Energies of electrons and photons are measured using the ATLAS Liquid Argon calorimeter
 - ▶ Non-compensating
 - ▶ Uniform, close to linear response
 - ▶ 4π azimuthal coverage, $|\eta| < 4.9$ (including forward calo), service gap at $|\eta| = 1.475$
 - ▶ Good pileup suppression thanks to bipolar readout pulse
- Reconstructing particle energies is a complex multi-step process. Very roughly:
 - ▶ Group topologically connected energy deposits into clusters
 - ▶ Correct for losses by calibrating to true particle energies in Monte Carlo simulation
 - ▶ Validate using ‘standard candle’ processes ($Z \rightarrow ee$, $J/\psi \rightarrow ee$, $Z \rightarrow \ell\ell\gamma$)



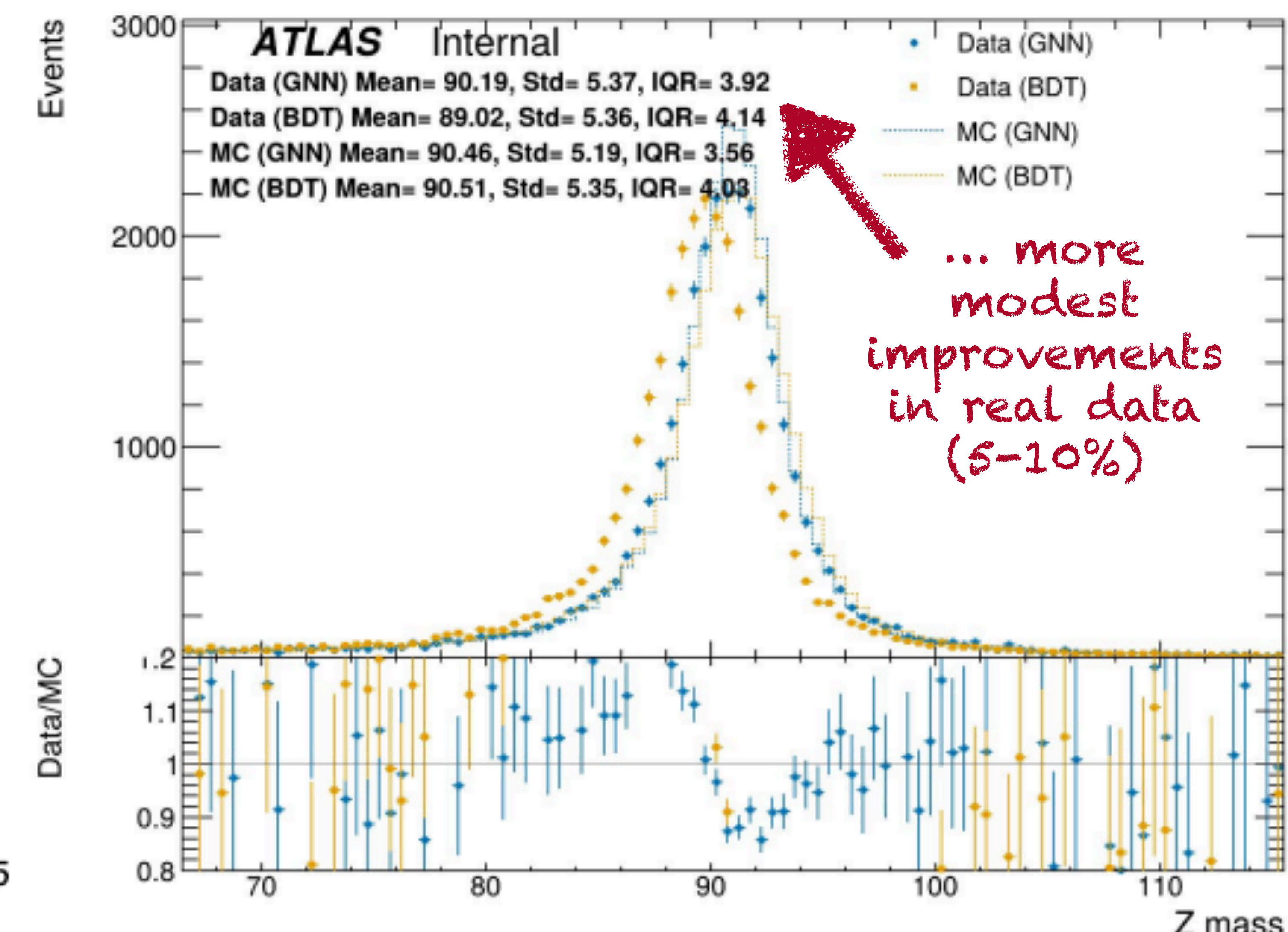
neural networks
come in here!

Transformers for e/γ energy calibration

- Use GNNs/Transformers to learn mapping
 - ▶ Cell energies (\mathbb{R}^{200}) \rightarrow calibrated cluster energy (\mathbb{R})
- Architecture captures complex cell-to-cell relationships due to
 - ▶ heterogeneous detector structure, dead material, EM shower development, etc.
- A technically challenging undertaking (culmination of >2 years work!)
 - ▶ Train on > 60 million e/γ in MC
 - ▶ Validate in Run 3 data using $Z \rightarrow ee$ events
 - ▶ Deploy model in ATLAS C++ analysis software stack (ONNX)
- Despite EM-showers considered well-modelled physics, find considerable discrepancies when MC-trained NNs are deployed on data
 - ▶ How to understand & mitigate this effect?



resolution improved by up to 30%



... more modest improvements in real data (5-10%)