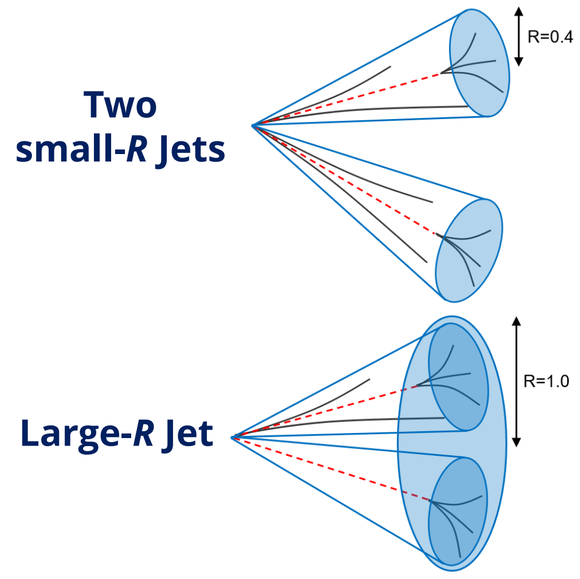
Transformer Networks for Constituent-Based *b*-jet Calibration with the ATLAS Detector

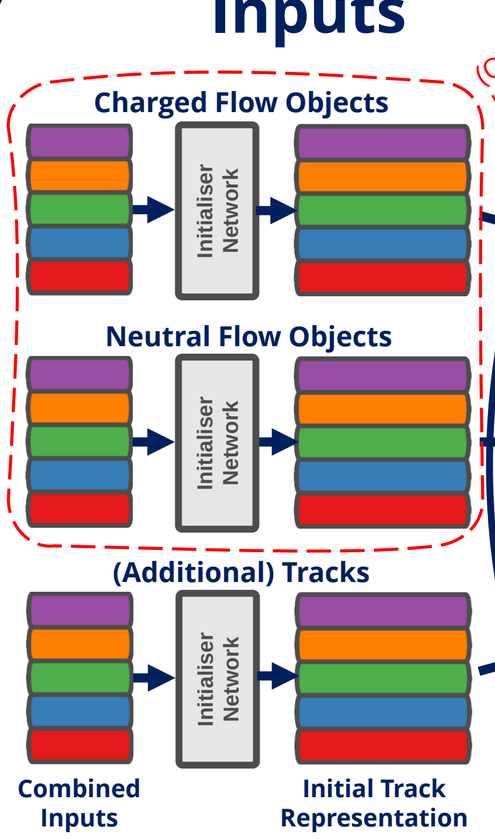
b-Jet Calibration

- ***b*-jets differ from light quark and gluon jets due to high mass and large semileptonic branching fraction, requiring specific *b*-jet calibration**
- **Precise measurement of *b*-quarks is critical to physics program, e.g. small-*R* jets for $HH \to b\bar{b}b\bar{b}$, large-*R* $b\bar{b}$-jet for boosted $H \to b\bar{b}$**
- **Transformers proven powerful for tasks like *b*-jet tagging**



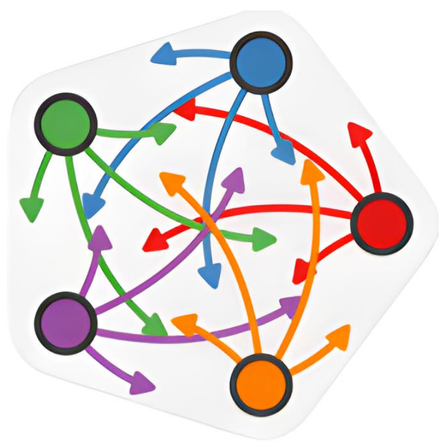
Architecture

Inputs

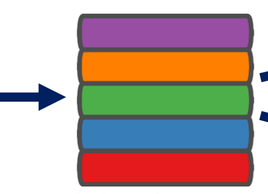


- **Initialised separately**
- **Common: jets + tracks**
- **Small-*R*: + soft lepton features**
- **Large-*R*: + charged & neutral UFOs**

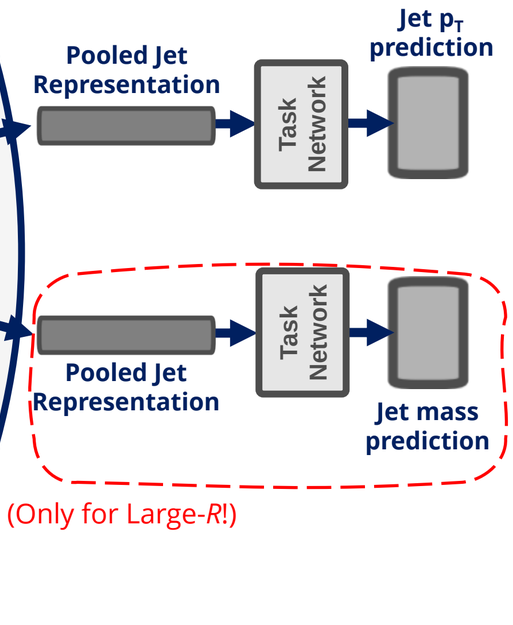
Transformer Encoder



- **Inputs combined Constituents-Jet vectors**
- **Produces conditional representations**
- **Global jet representation → weighted sum over constituents**

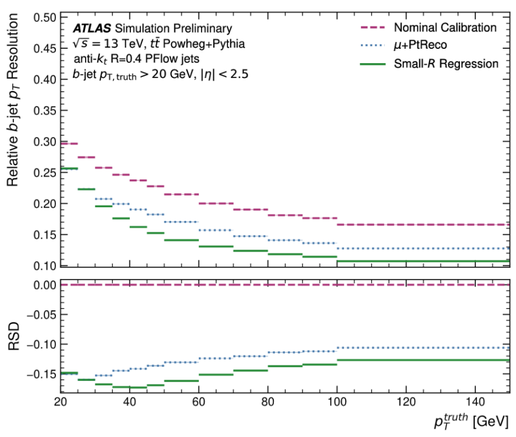


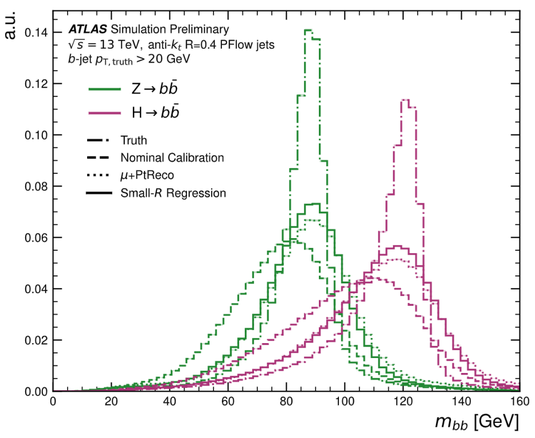
Regression Tasks



- **Independent tasks**
- **Small-*R*: Only p_T**
- **Large-*R* : Mass and p_T**
- **Target: Truth/Reco Ratio**

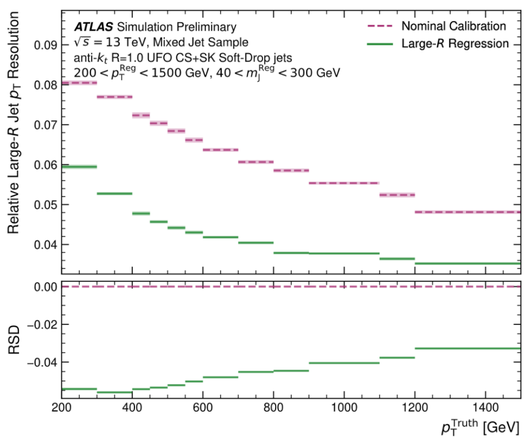
Performance

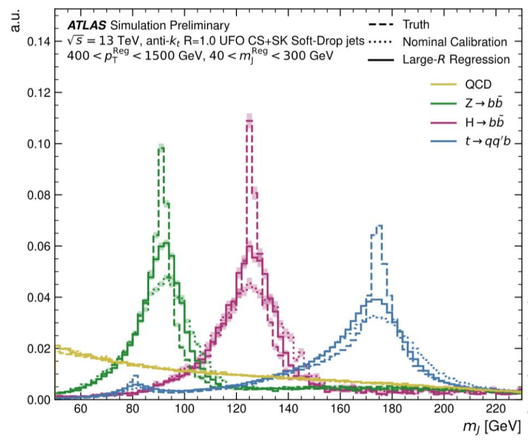




Small-*R*:

- **18-31% better $\sigma^{\text{response}}_{p_T}$ (10% over *μ*+PtReco)**
- **22% narrower *m* peaks (5% over *μ*+PtReco)**





Large-*R*:

- **25-35% better $\sigma^{\text{response}}_{p_T}$**
- **26-33% better $\sigma^{\text{response}}_{m}$**
- **10-15% narrower *m* peaks**

Glossary:

- **Response – reconstructed/truth ratio of *m* or p_T**
- **σ^{response} – relative resolution of *m* or p_T response**
- ***μ*+PtReco – *Muon-in-jet* and *PtReco*, common methods for small-*R* jet energy correction**

Summary

- **New transformer-based model for calibrating *b*-jets**
- **Yields more precise *b*-jet kinematics in both resolved & boosted regimes**

Next steps:

- **In-situ calibration**
- **Adding muon information (Large-*R*)**

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