

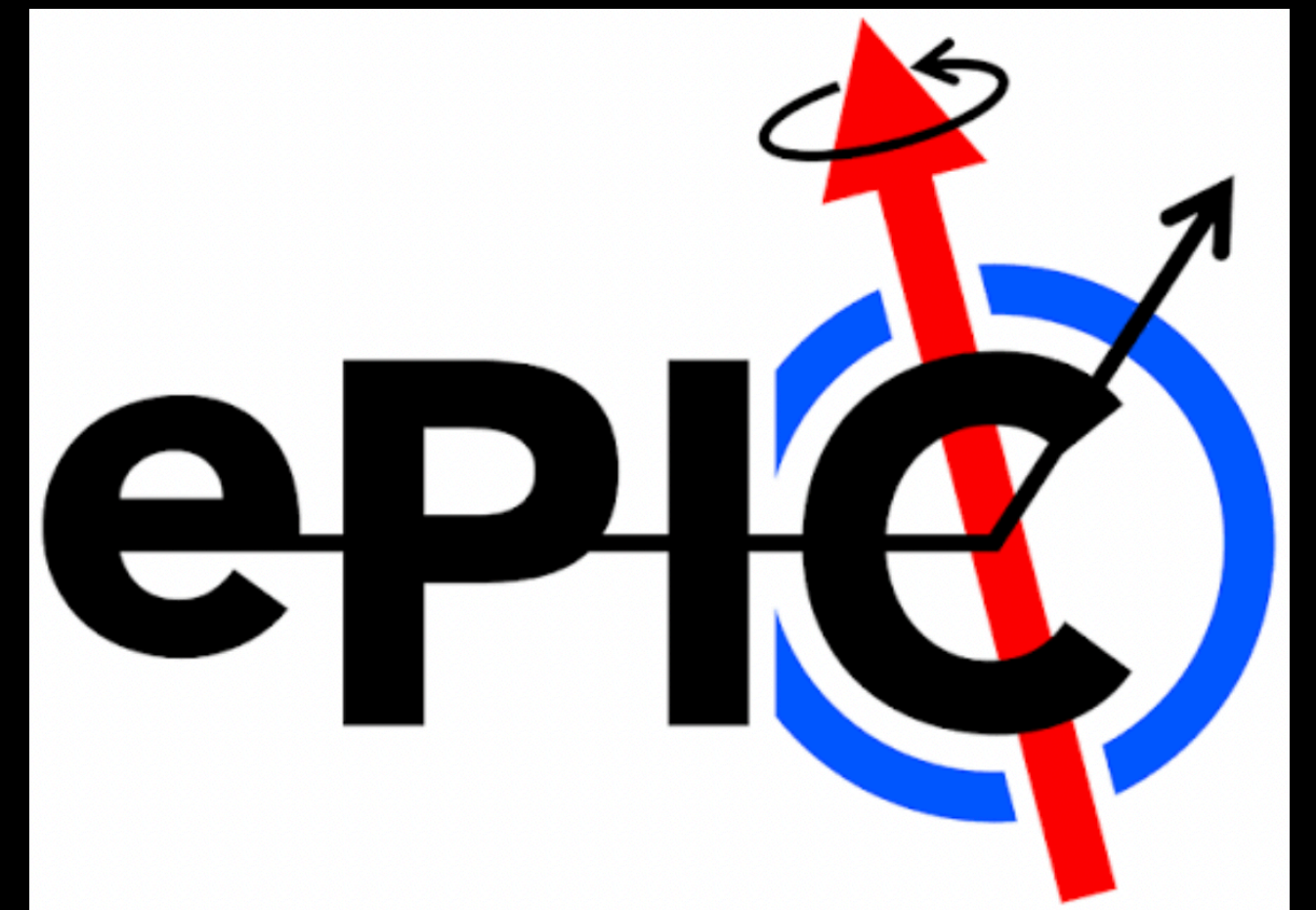
BHCal Neutron energy calibration

(Machine Learning Approach)

With Prof. David Ruth

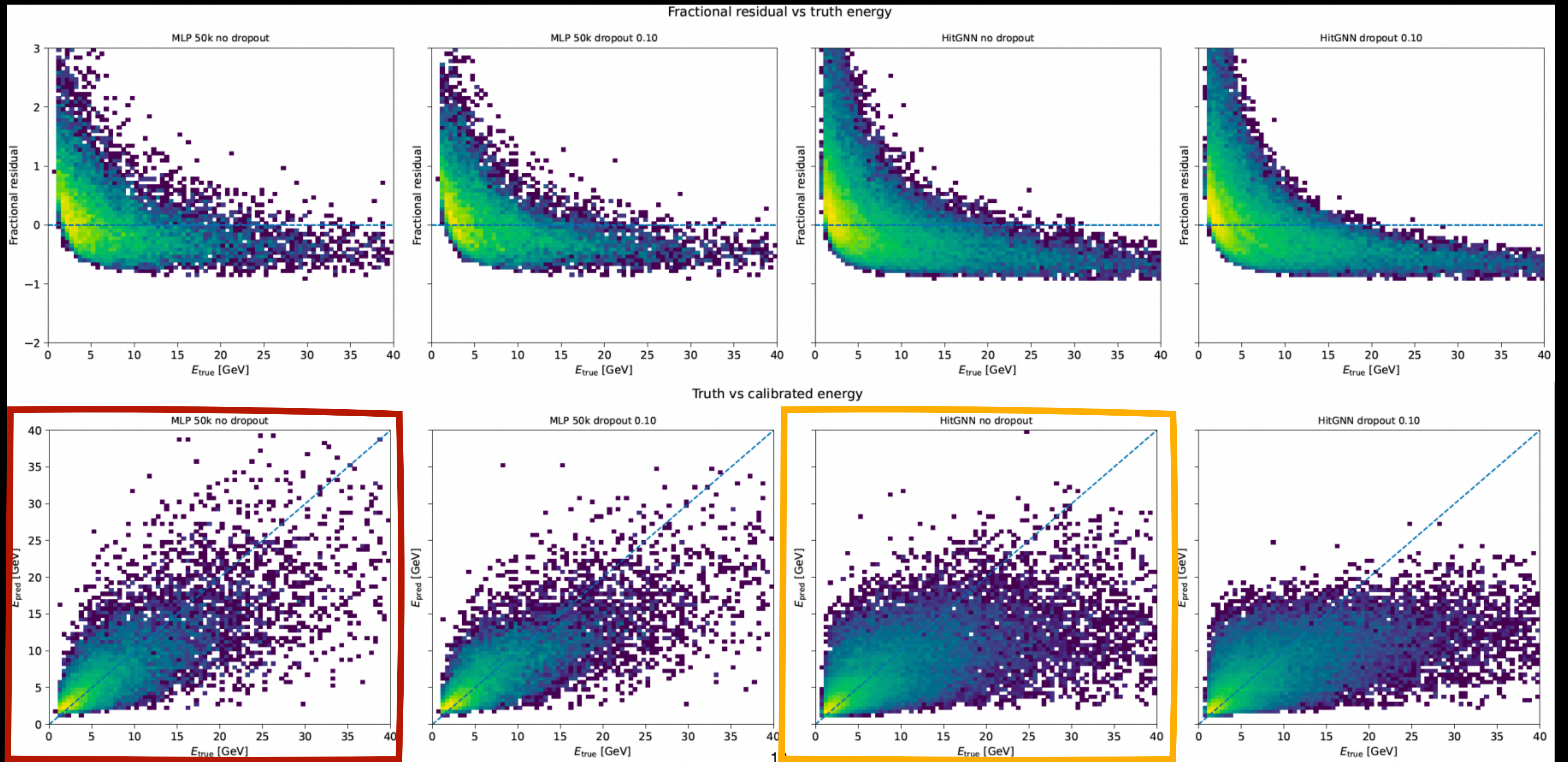
NM STATE
UNIVERSITY

Churamani Paudel



New Mexico State University

Recap/issues

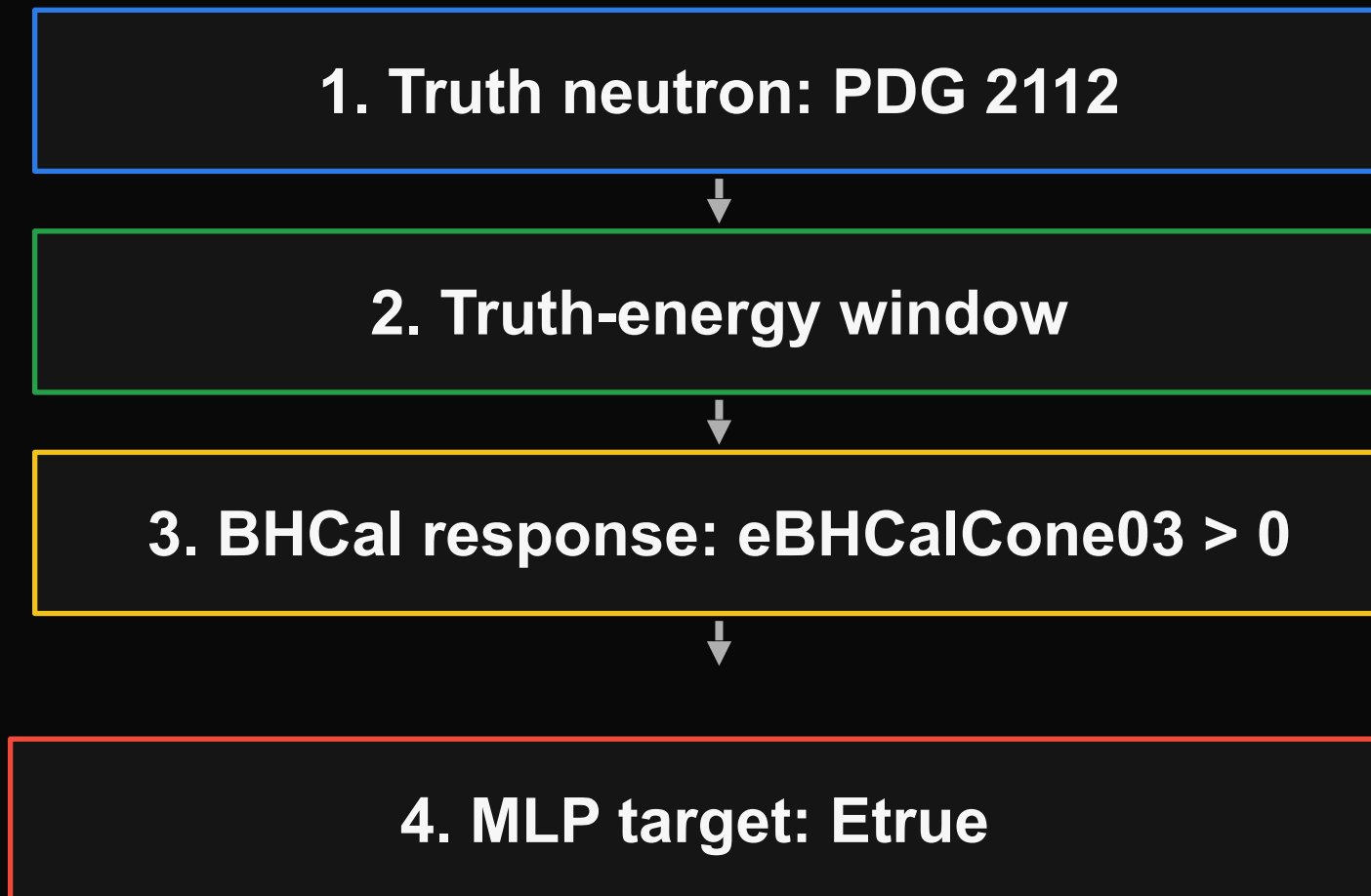


Neutron Selection & Detector-Input Staging

Truth neutron definition

- Final-state truth particle: PDG = 2112
- ML target: truth neutron energy, E_{true}
- Energy windows used:
0–10 GeV, 0–3 GeV, 3–10 GeV
- Require BHCAL response:
 $e\text{BHCALCone03} > 0$

Selection flow used before training



Explicit cut for 0–10 GeV sample

```
abs(pdgPar - 2112) < 0.5  
ePar >= 0 && ePar < 10  
eBHCALCone03 > 0
```

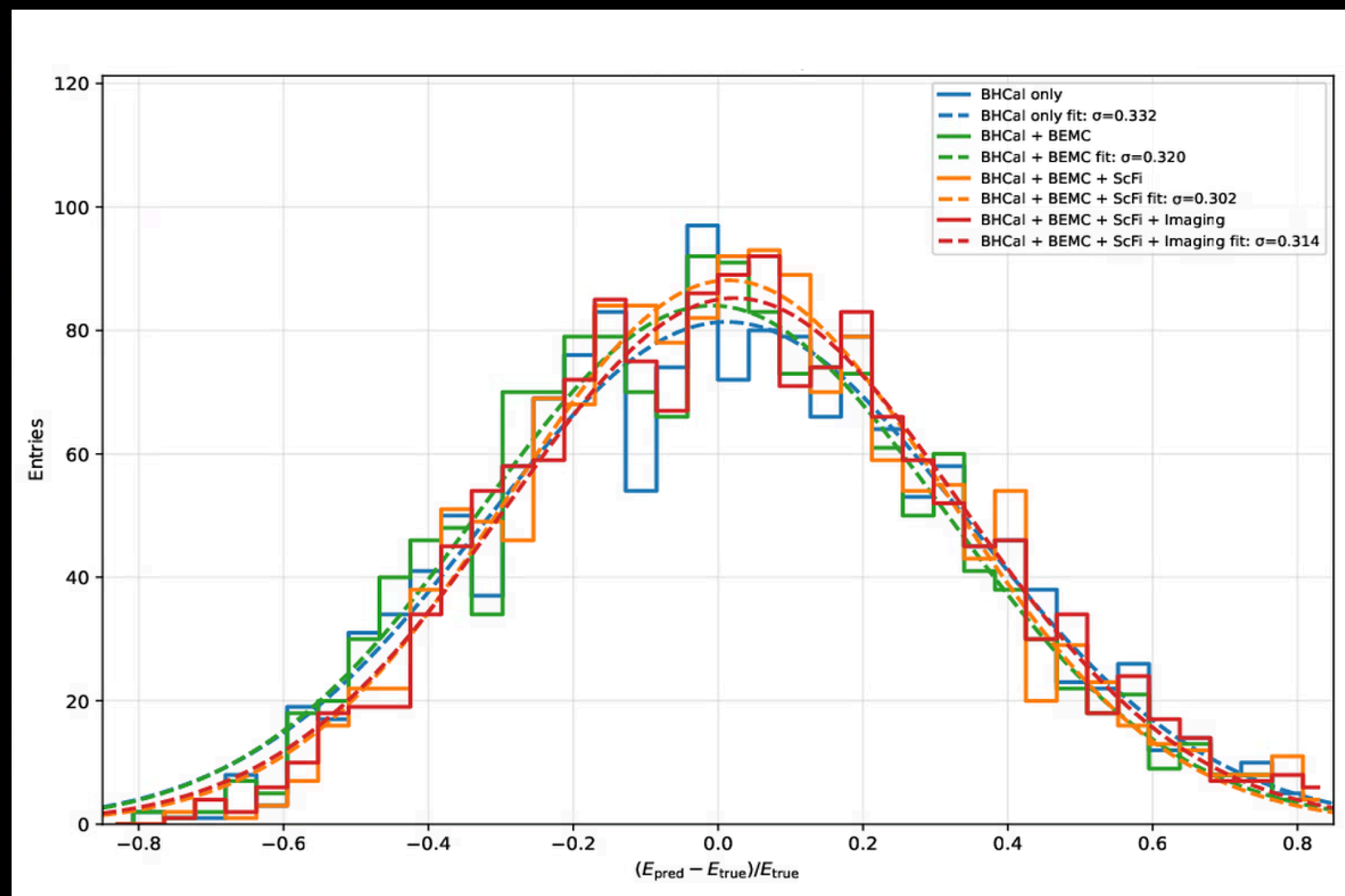
Detector-input staging

Same selected neutrons for every model:

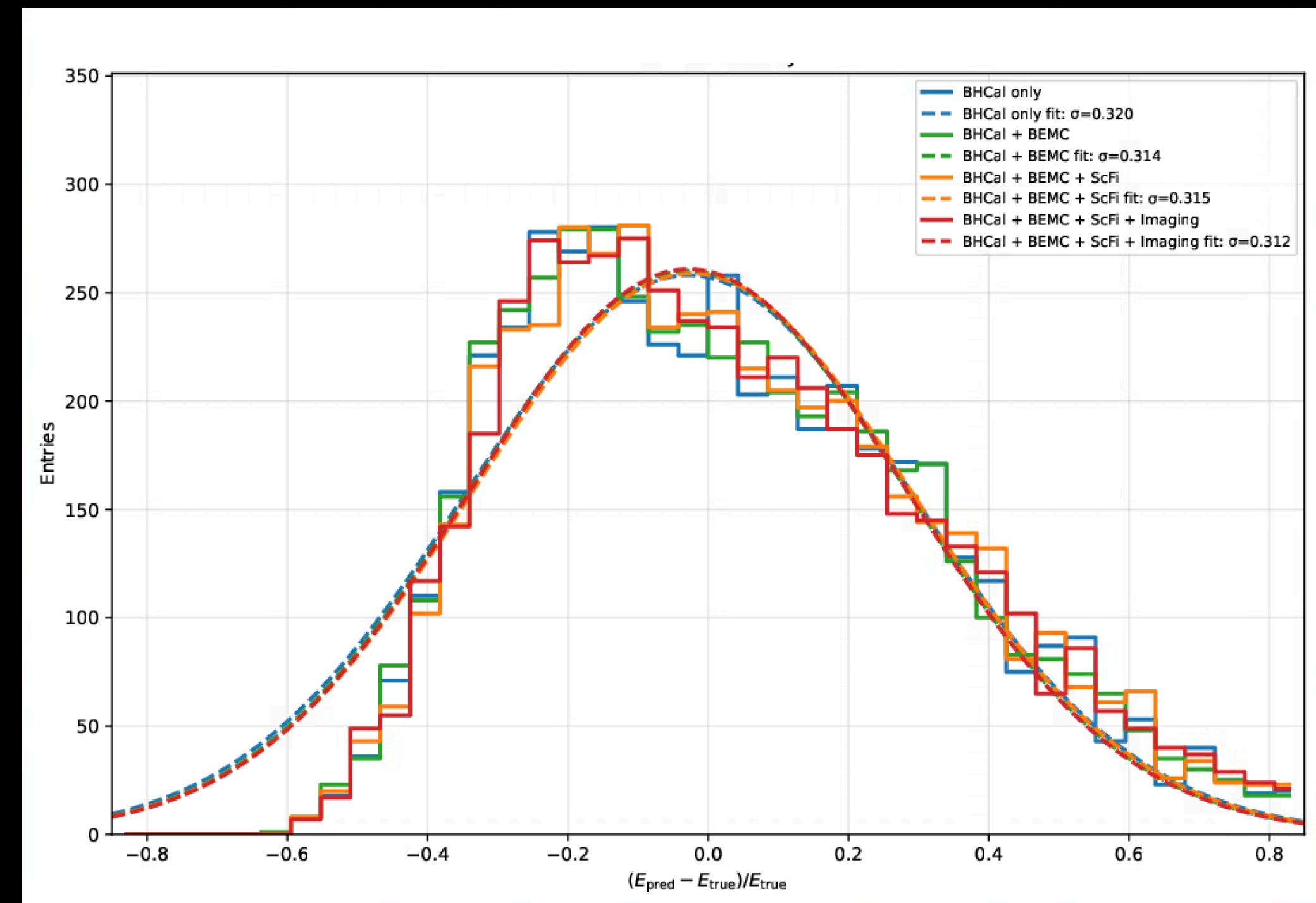
1. BHCAL only
2. BHCAL + BEMC
3. BHCAL + BEMC + ScFi
4. BHCAL + BEMC + ScFi + Imaging

Detector labels are feature sets — not separate neutron selections.

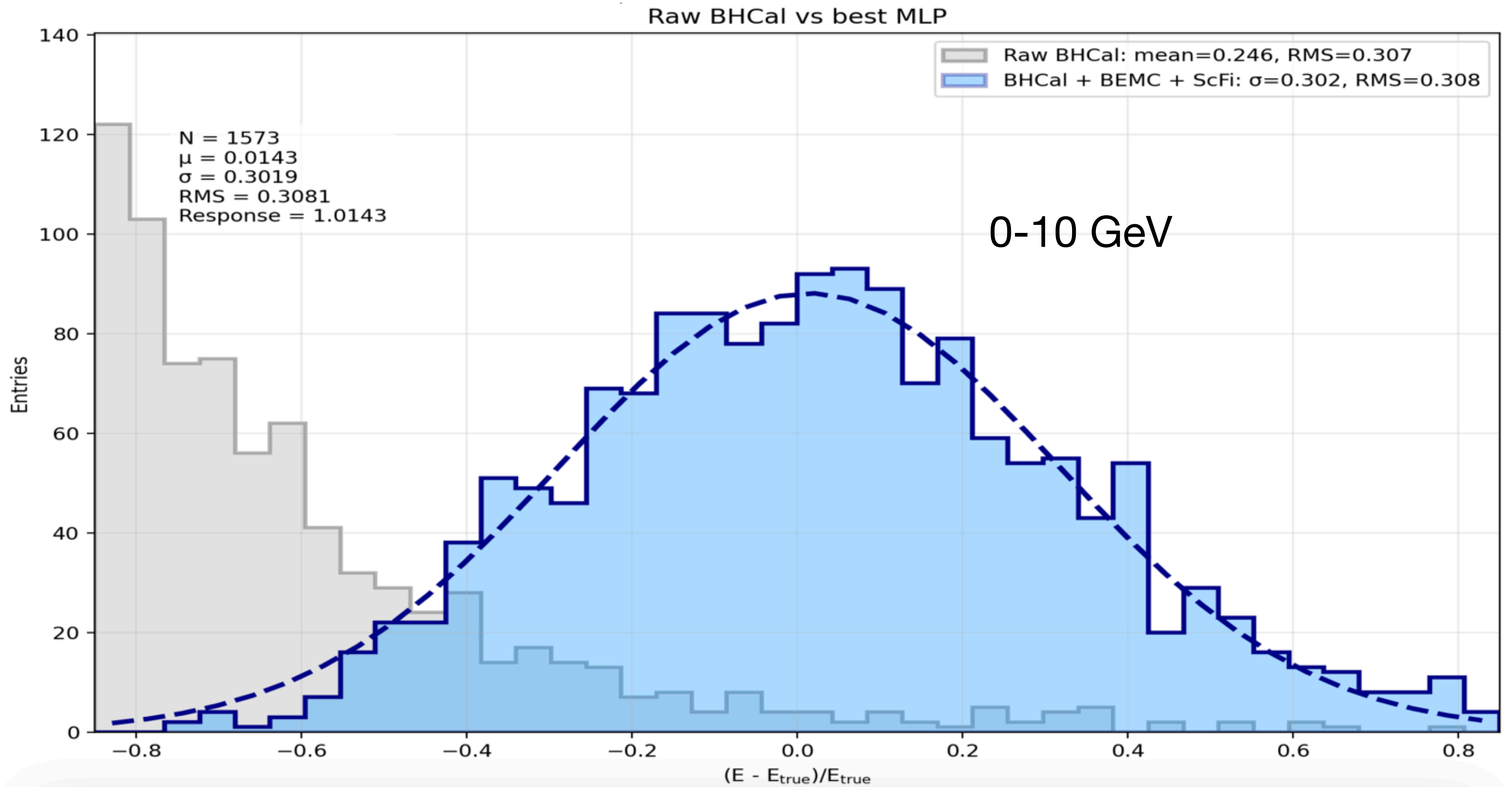
26.05.0 NC 9x275 Q210-100



26.04.1 CC 18x275 Q21000

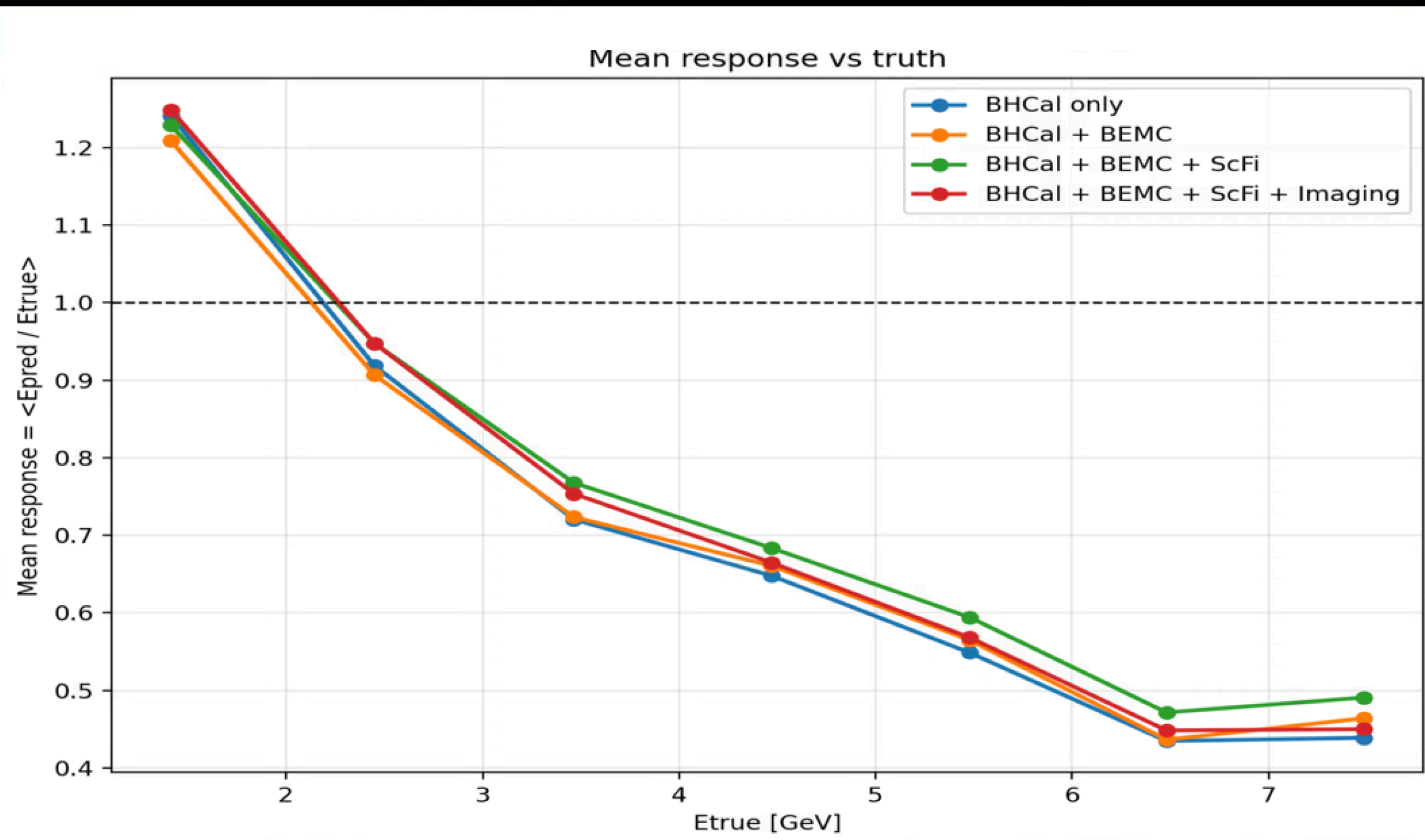


NC DIS Raw vs MLP

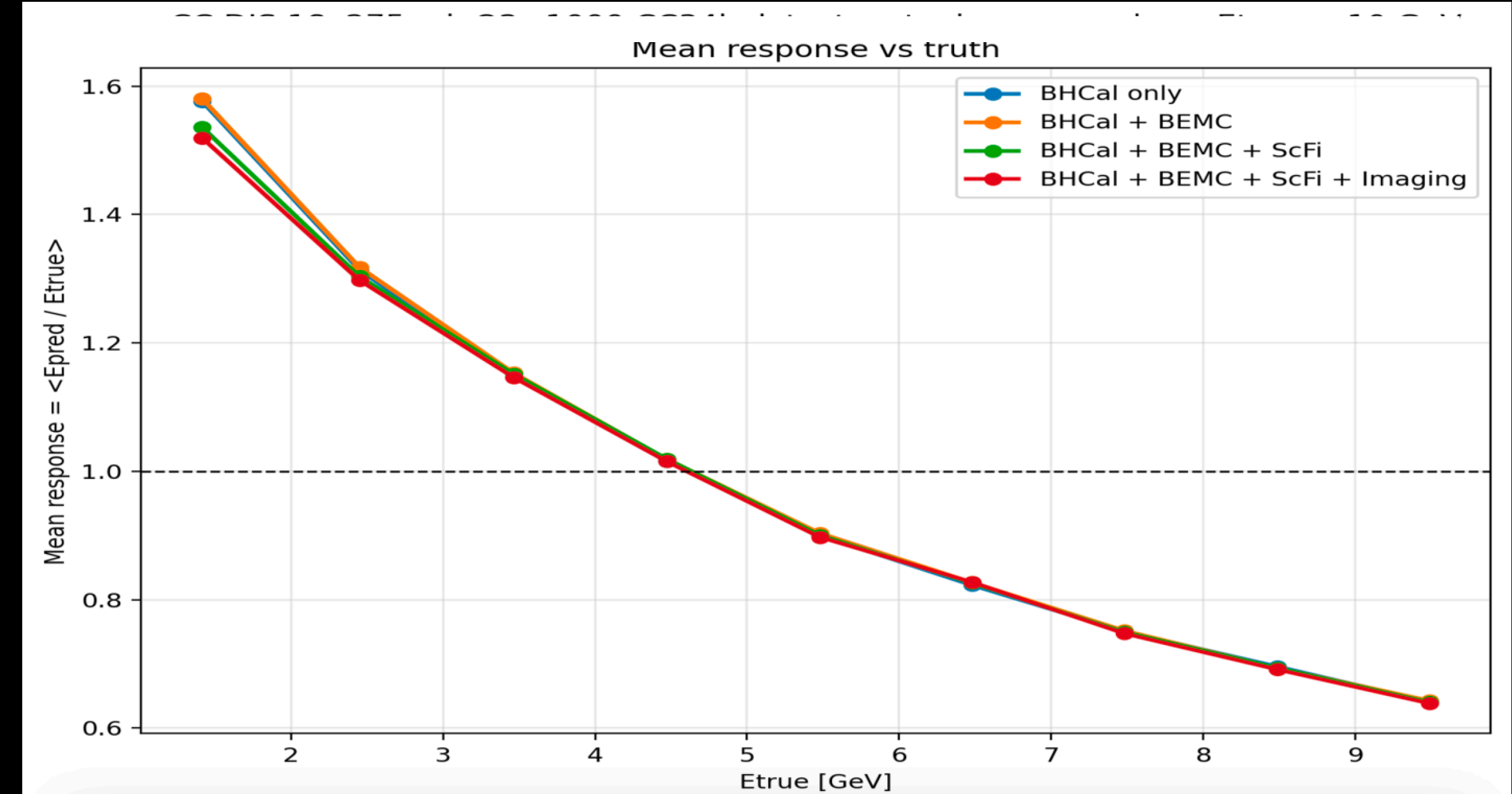


Mean response vs E_{true}

26.05.0 NC 9x275 Q^2 10-100



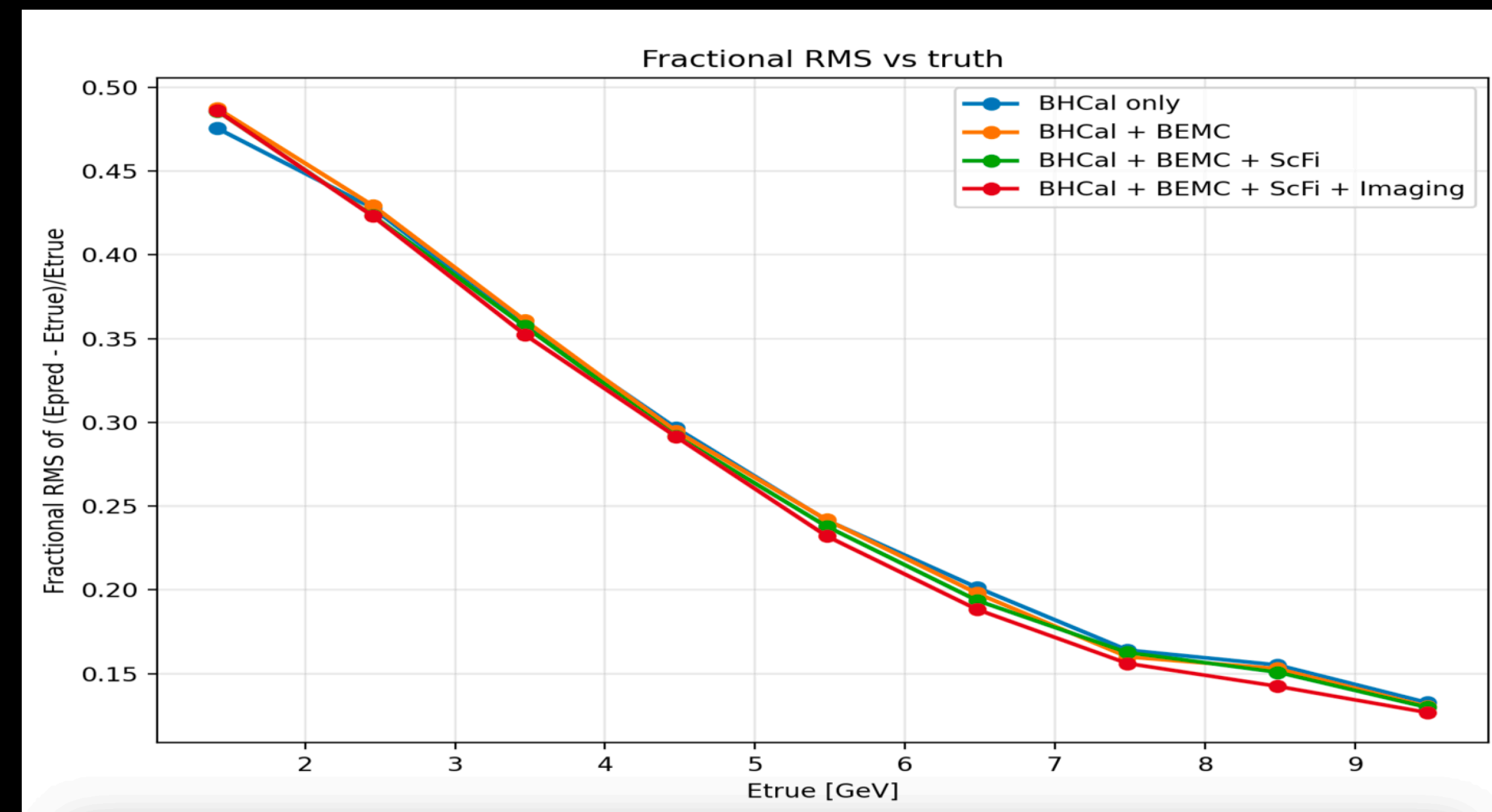
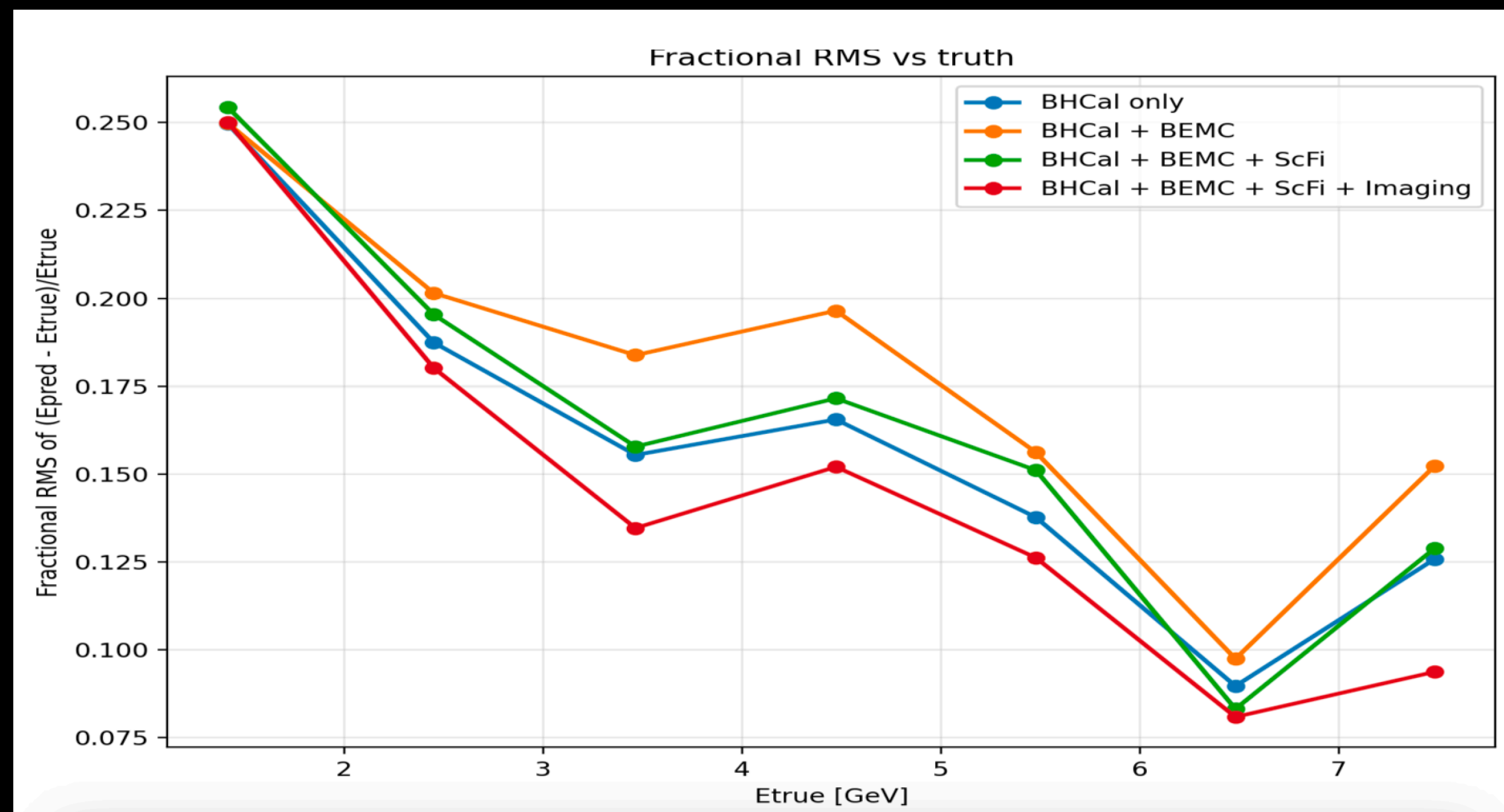
26.04.1 CC 18x275 $Q^2 > 1000$



Fractional RMS vs E_{true}

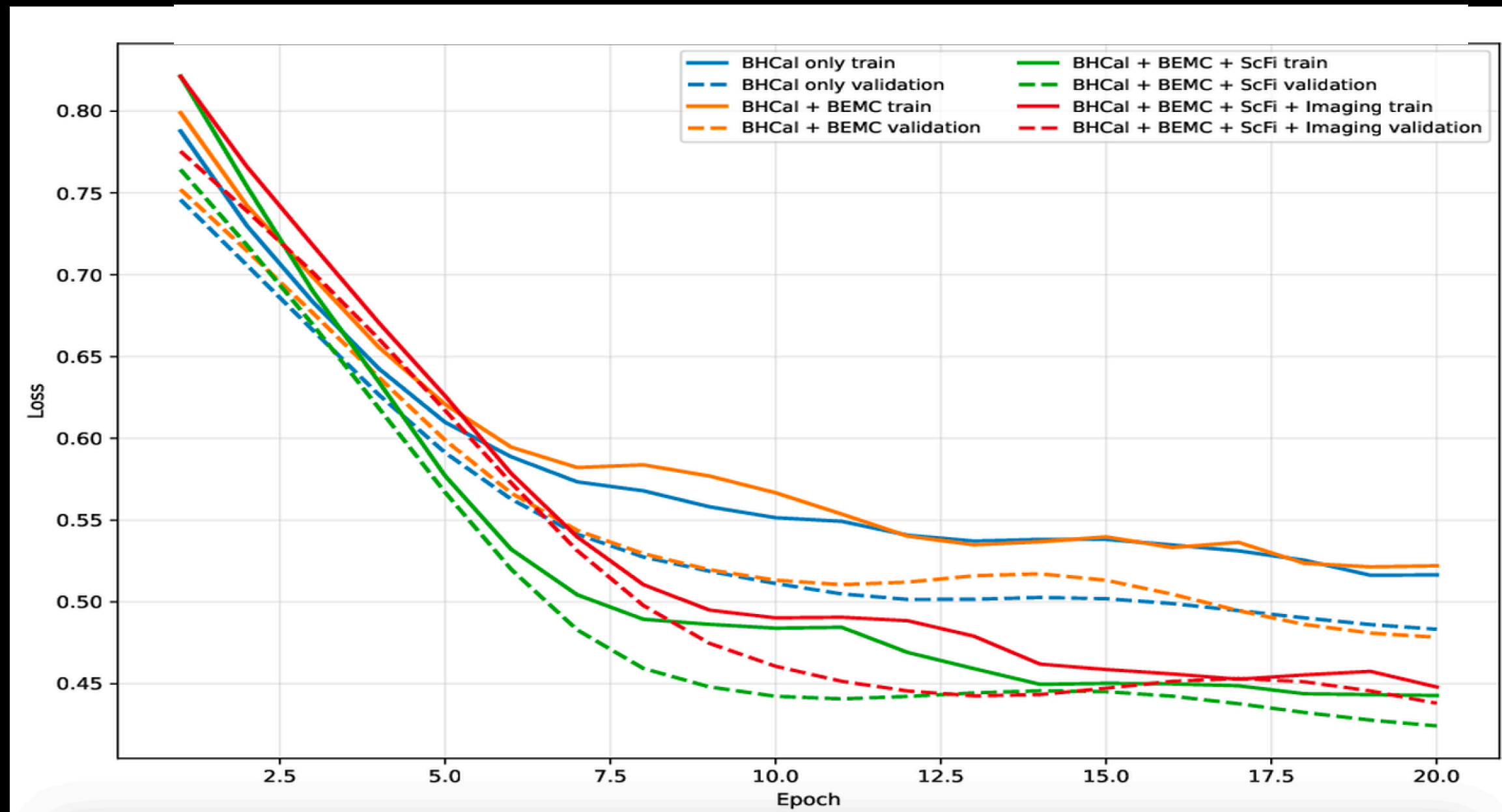
26.05.0 NC 9x275 Q^2 10-100

26.04.1 CC 18x275 Q^2 1000

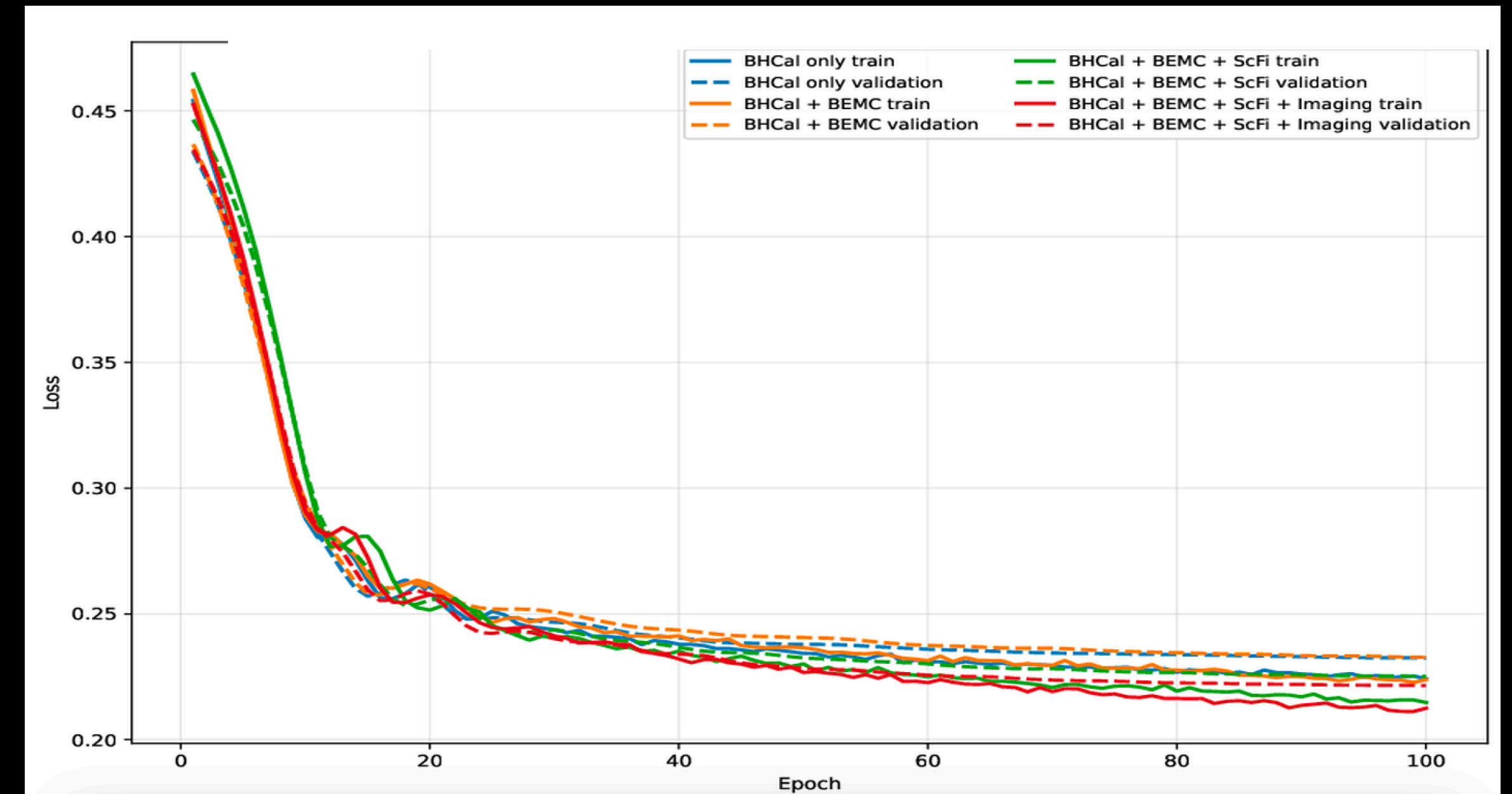


Loss vs Epochs

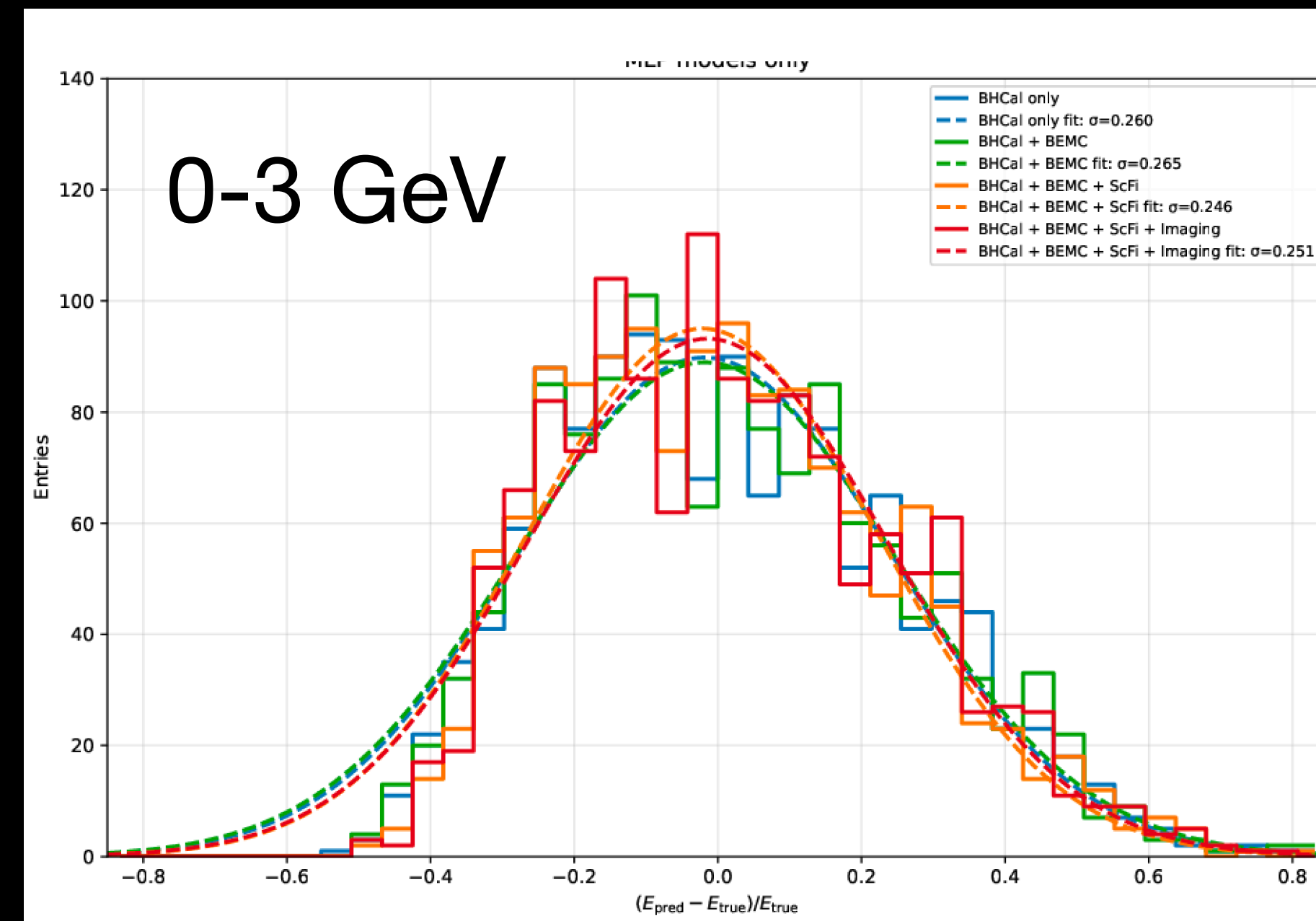
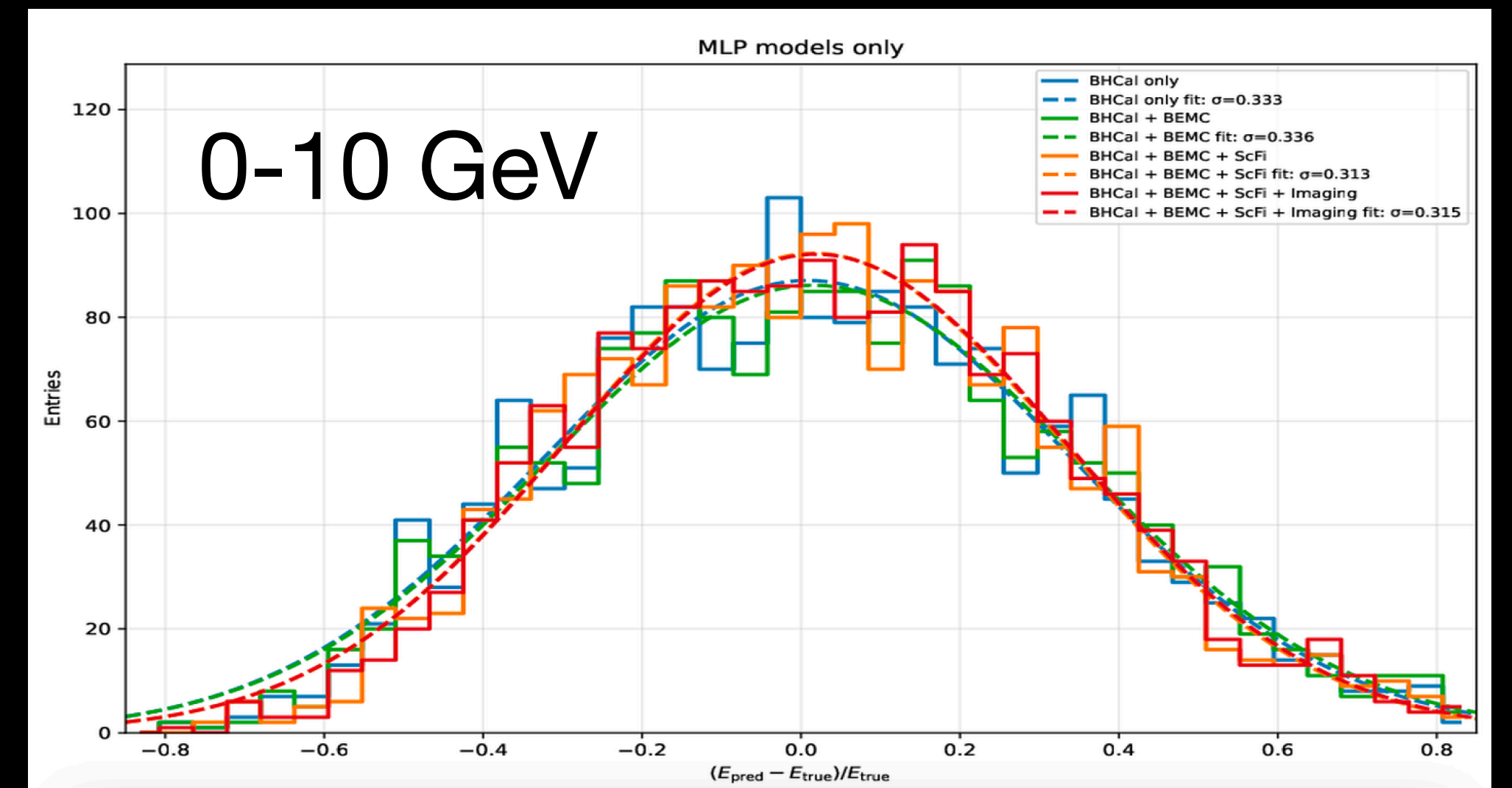
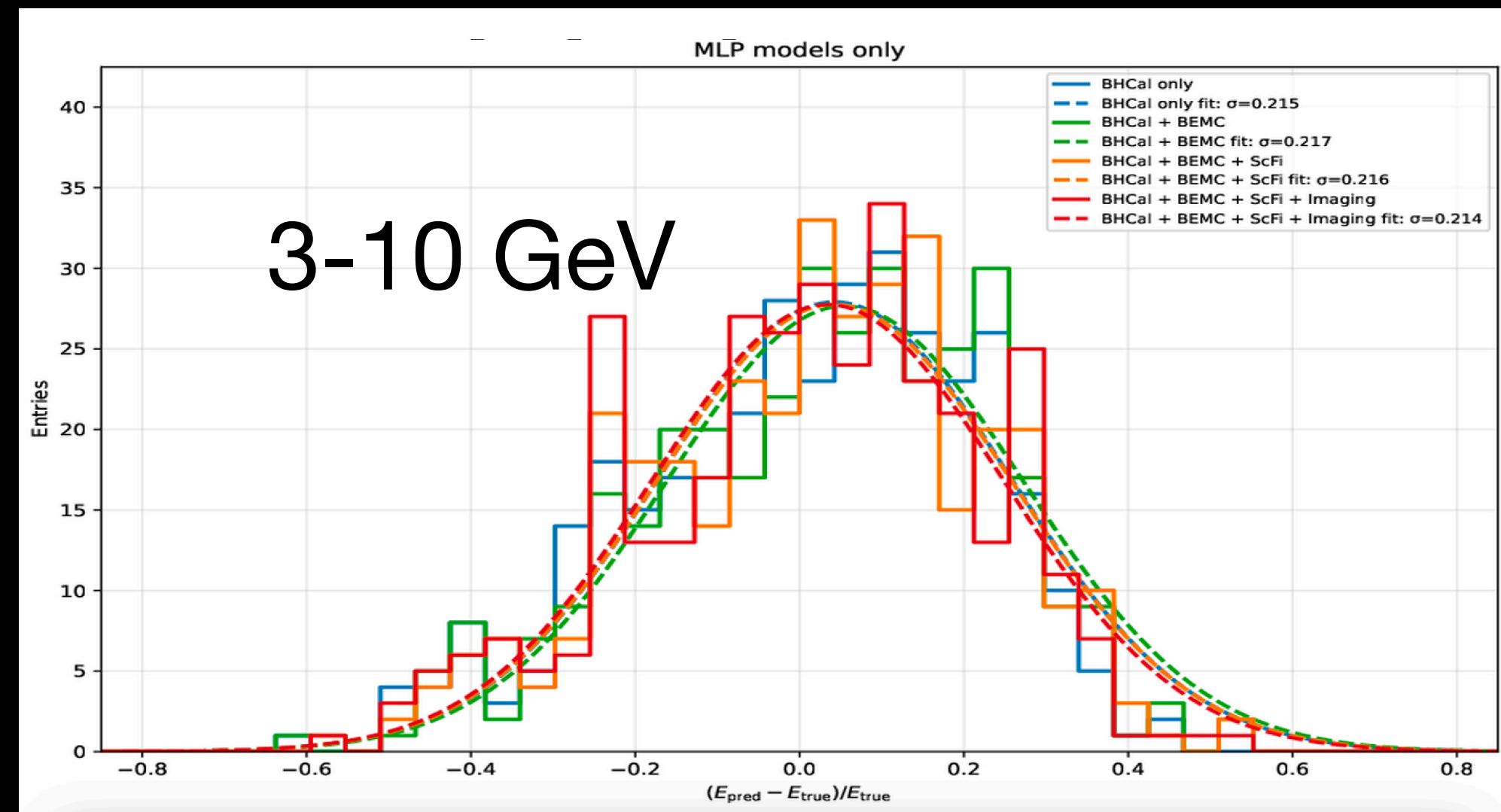
26.05.0 NC 9x275 Q^2 10-100



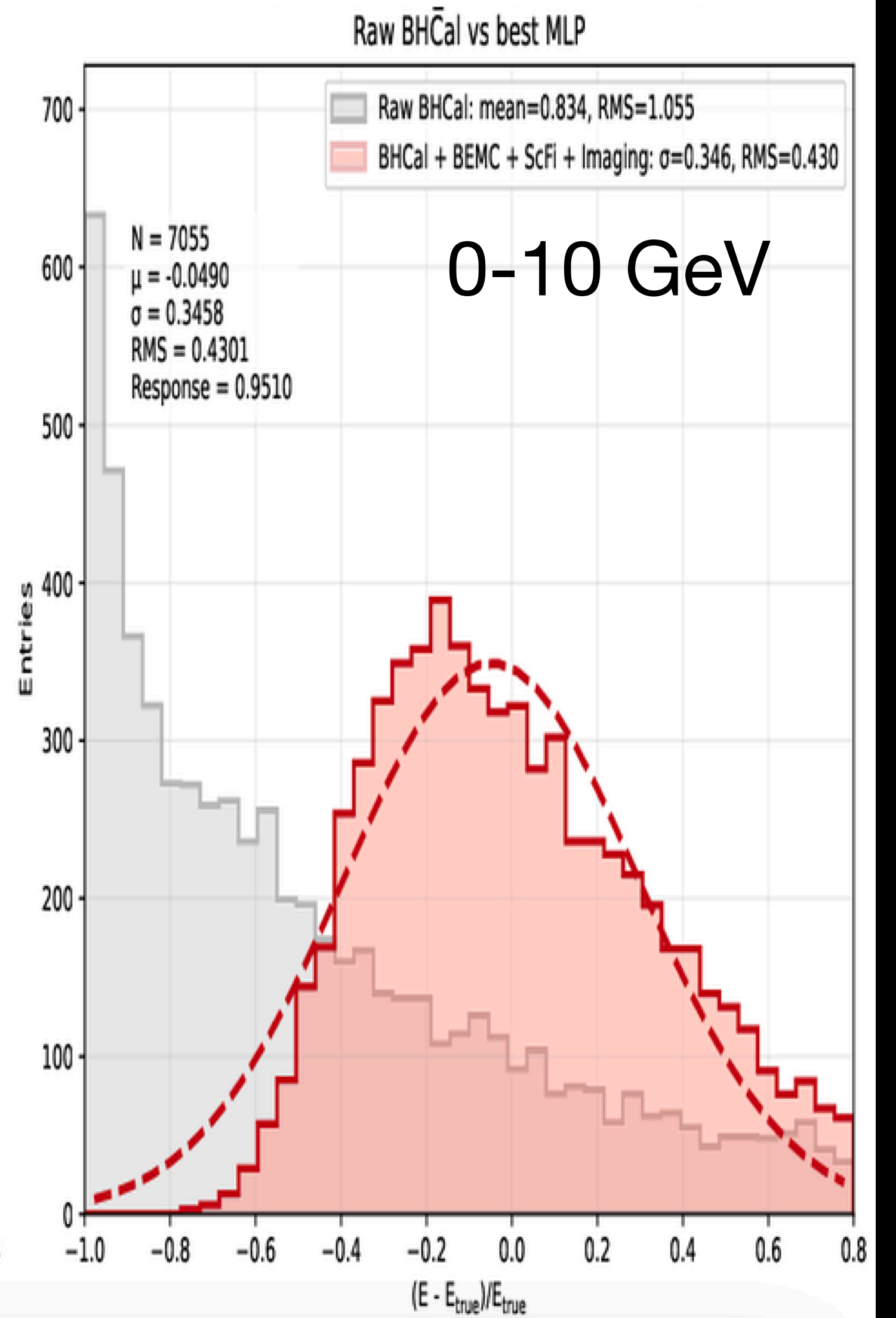
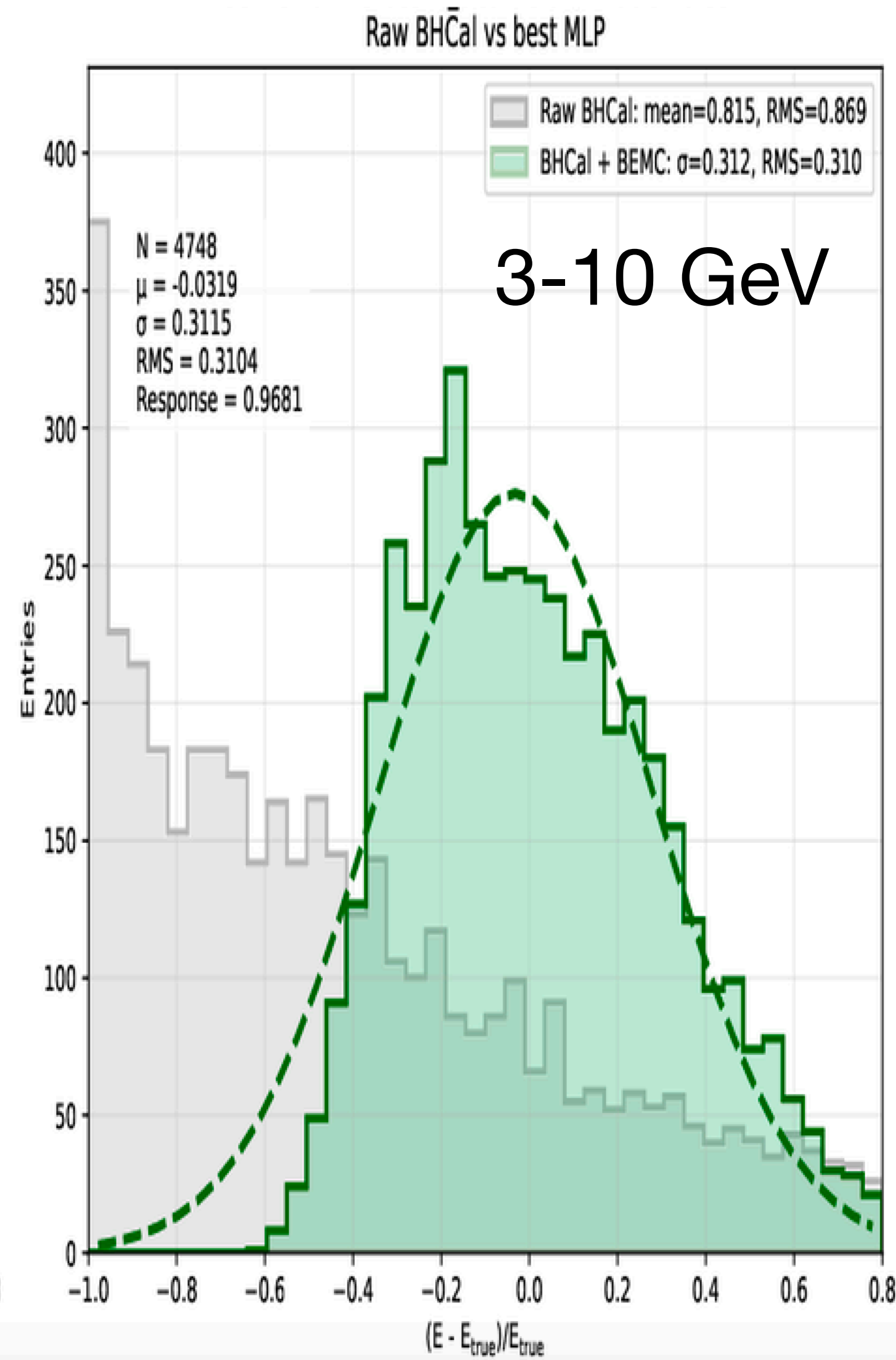
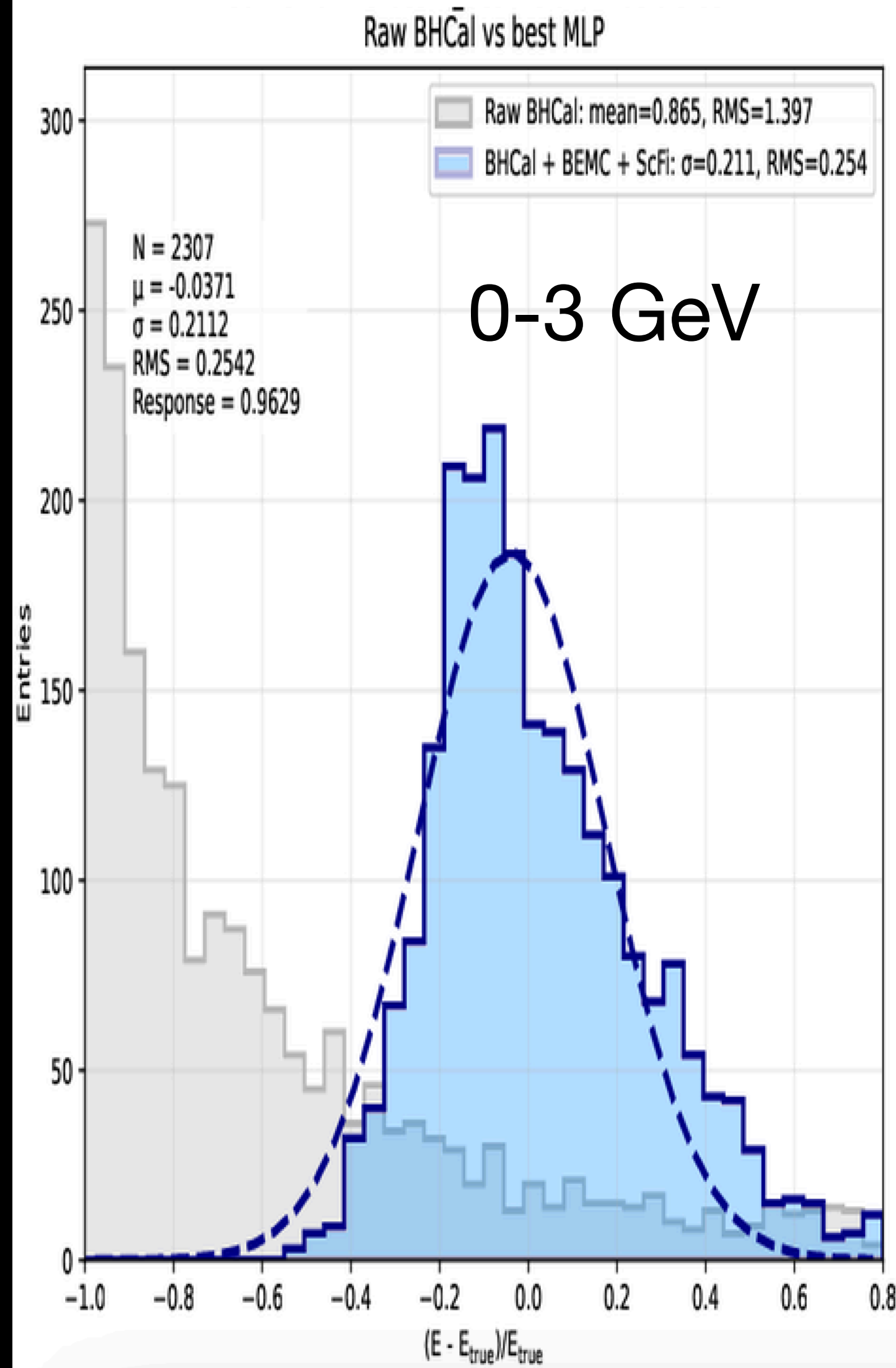
26.04.1 CC 18x275 Q^2 >1000



Regional Energy MLP training NC DIS 9x275 Q^2 (10-100)

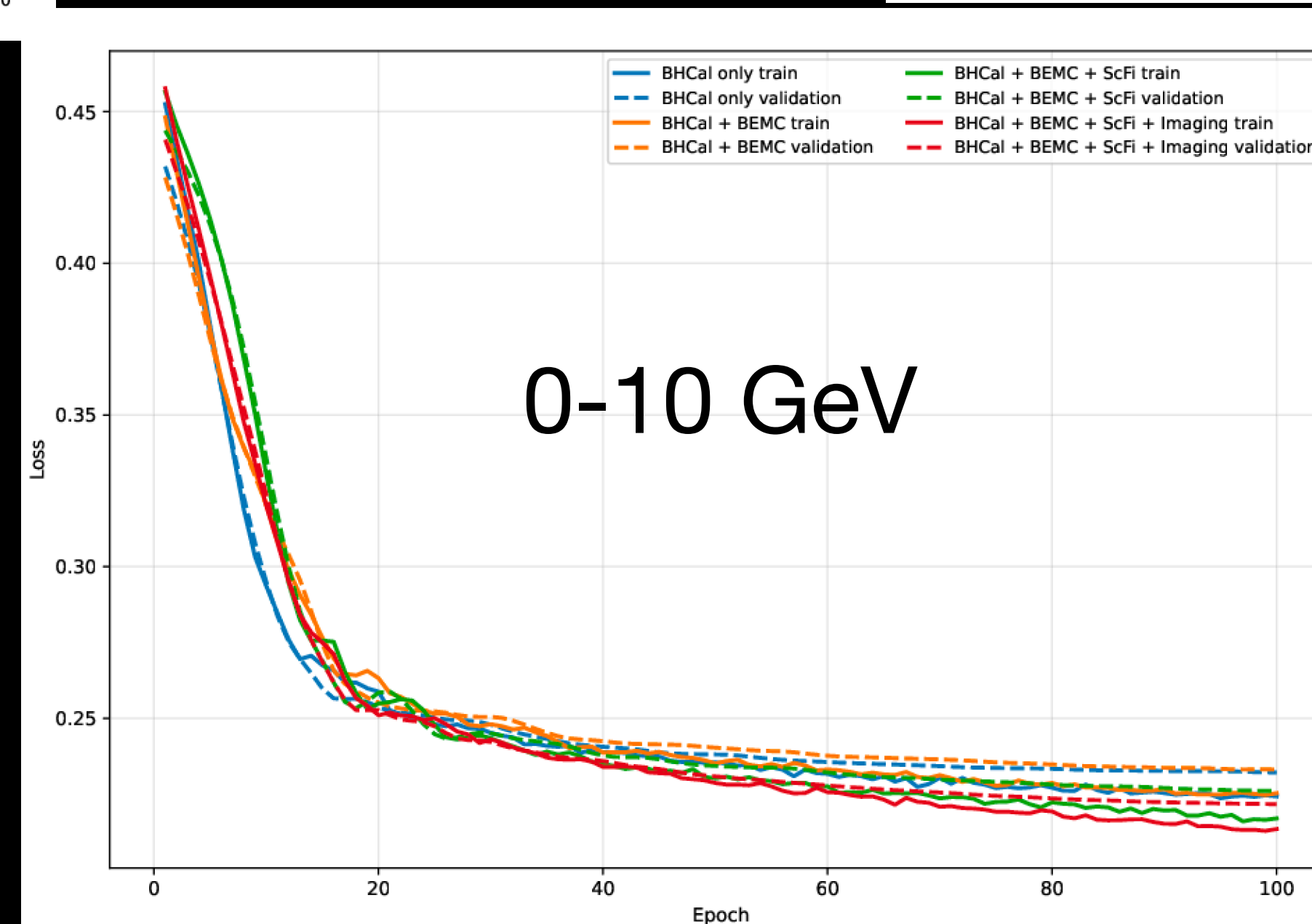
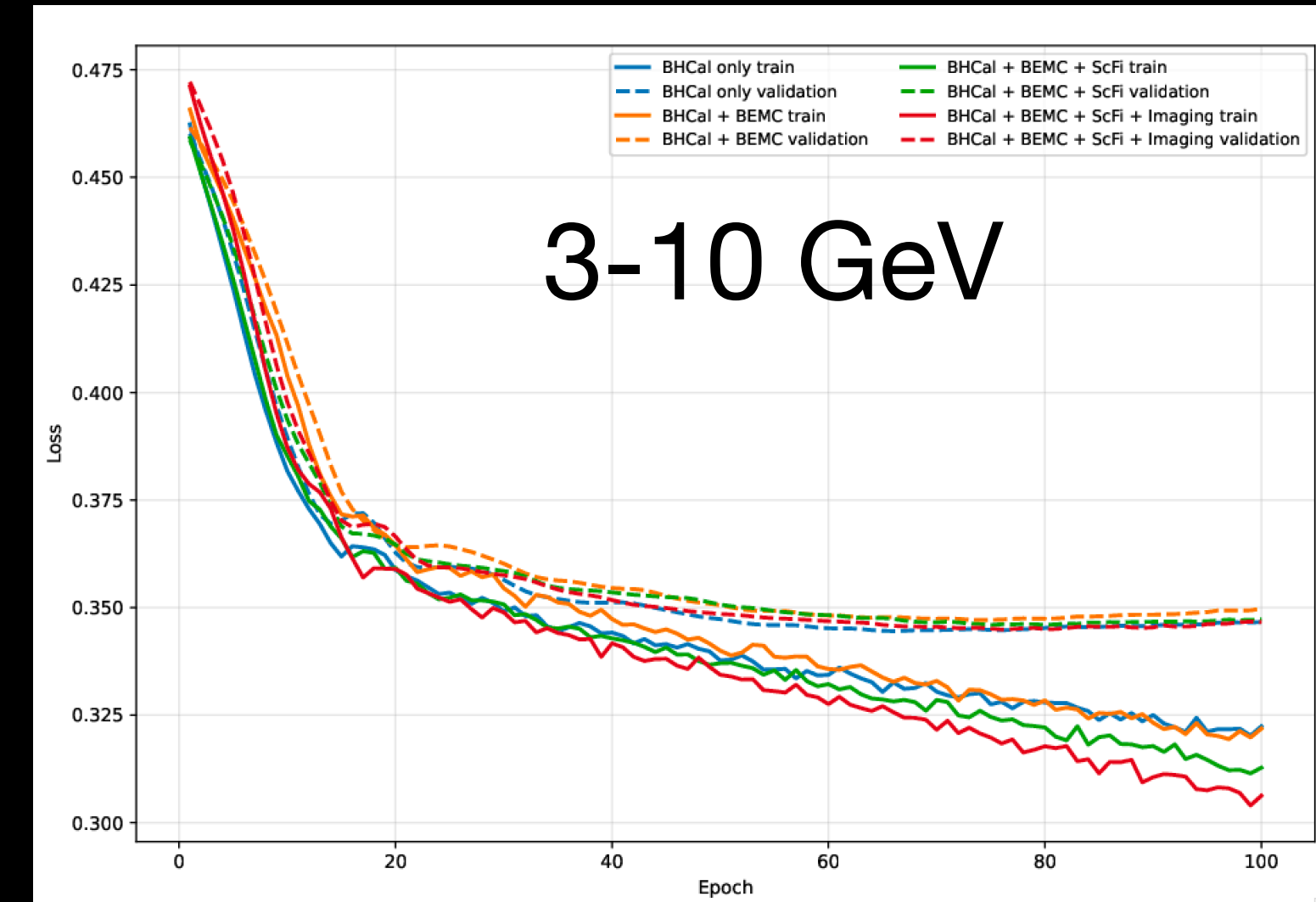
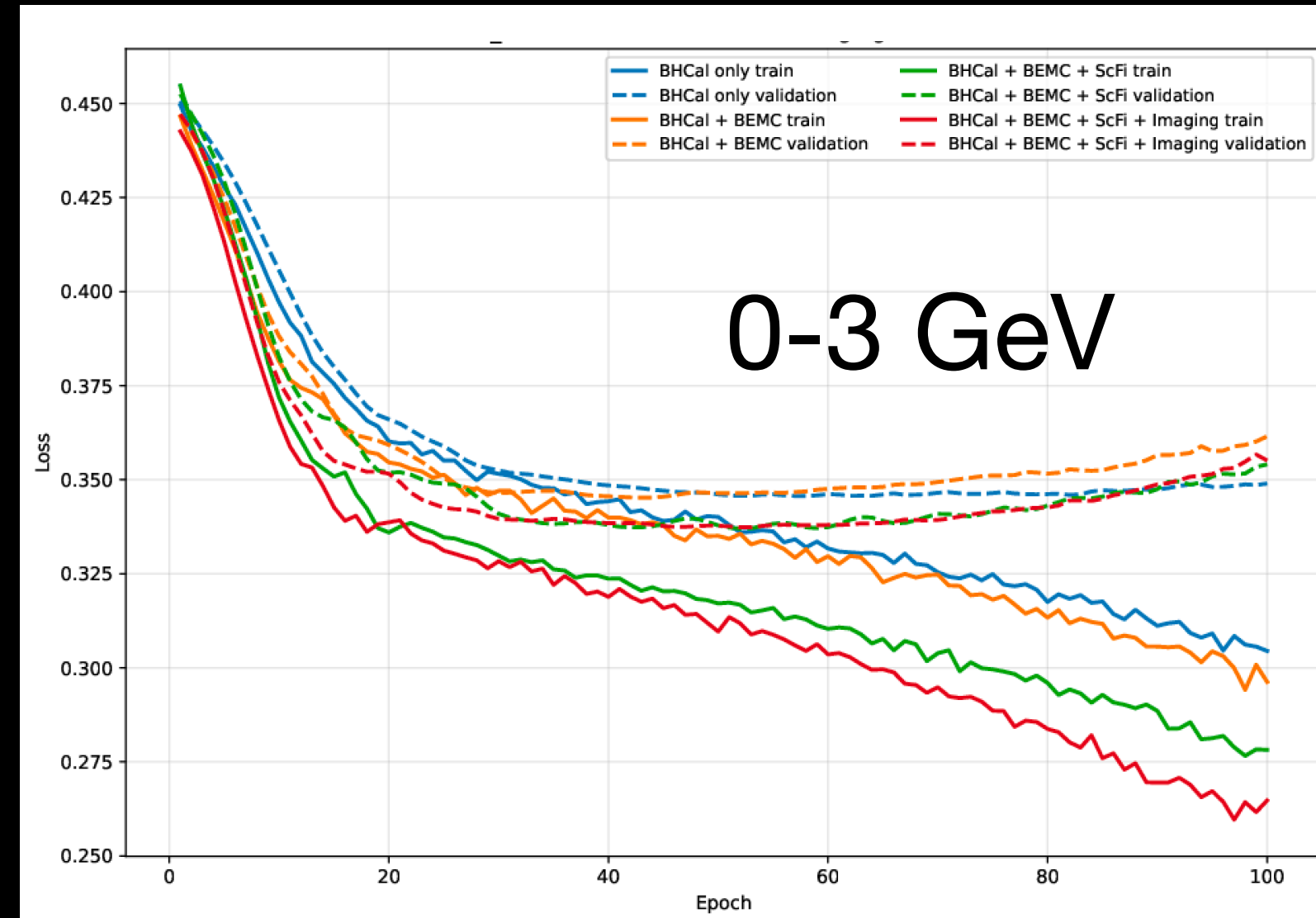


Raw vs MLP (CC DIS)

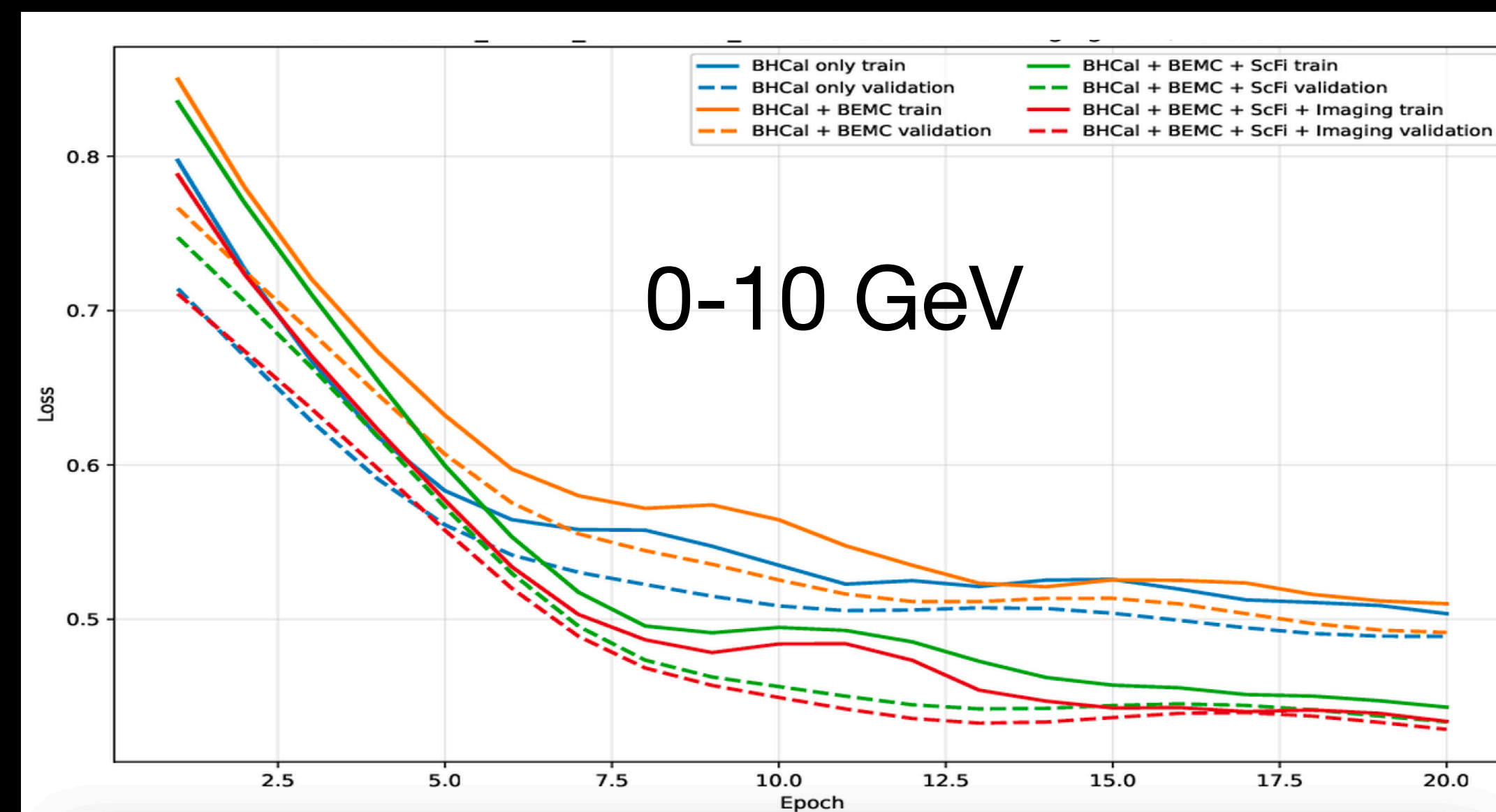
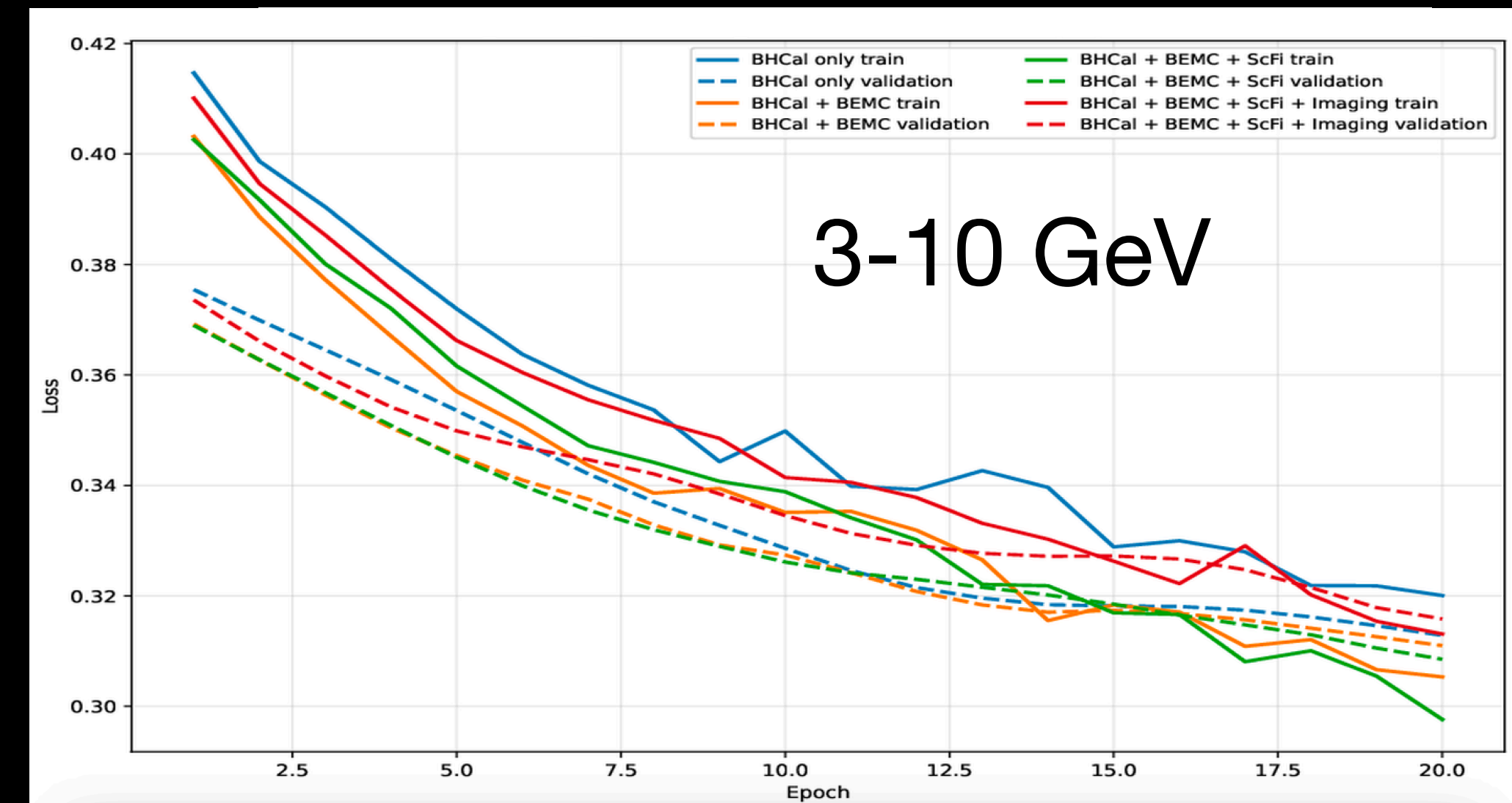
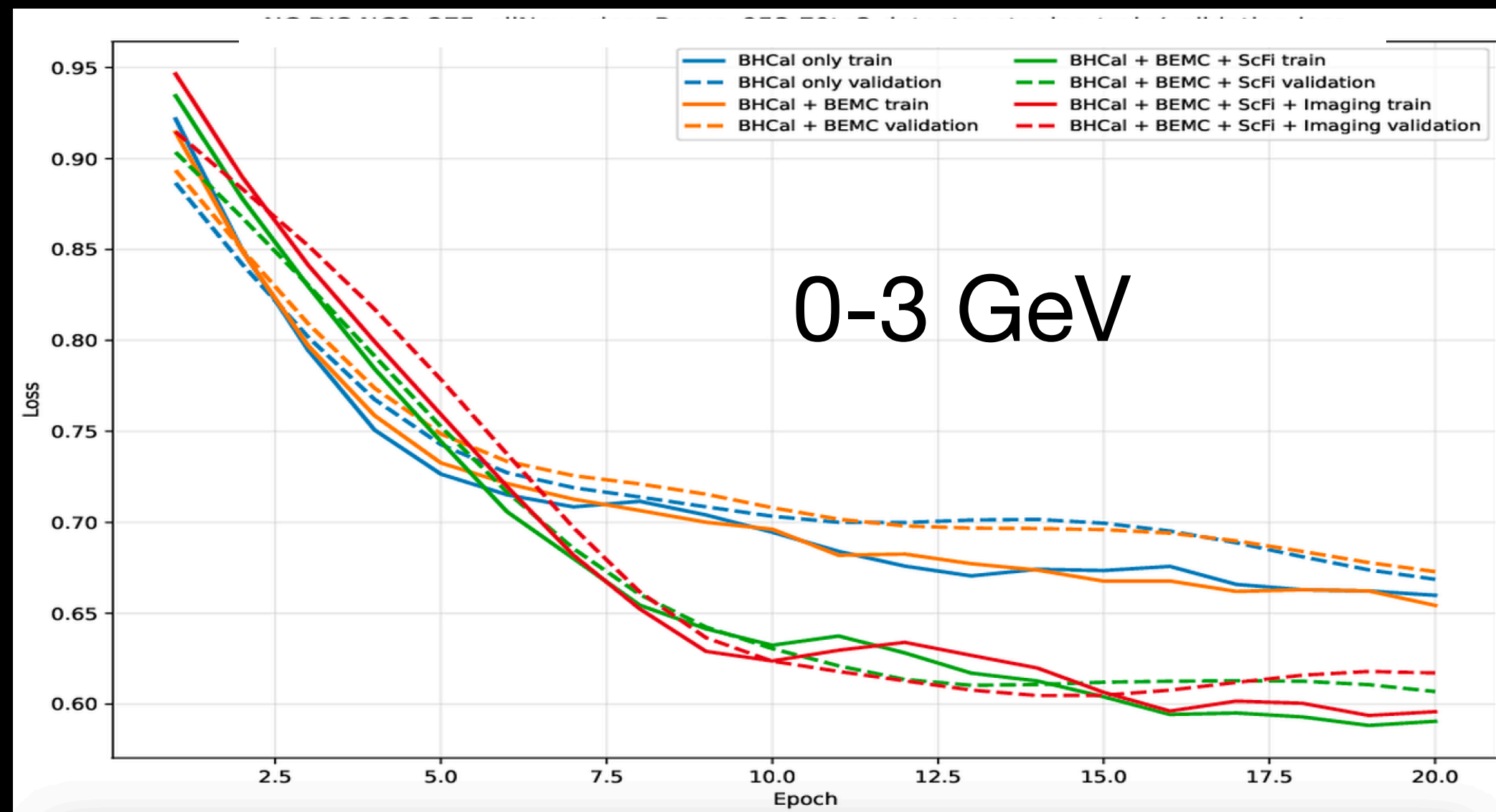


Loss vs epochs (at regional energies)

CC(DIS)



NC DIS Sample Energy Spilliting



Summary

- Increase sample size for NC, CC further study effect of high Q^2 physics (DIS activity)
- Low Q^2 samples better calibrated than high Q^2 samples, need to investigate how to calibrate neutrons from high Q^2 DIS events, different ML models for different kinematic regions and settings!!!
- Sample selection, Energy dependence and Kinematic regions