Tracking with ML

5th February 2025

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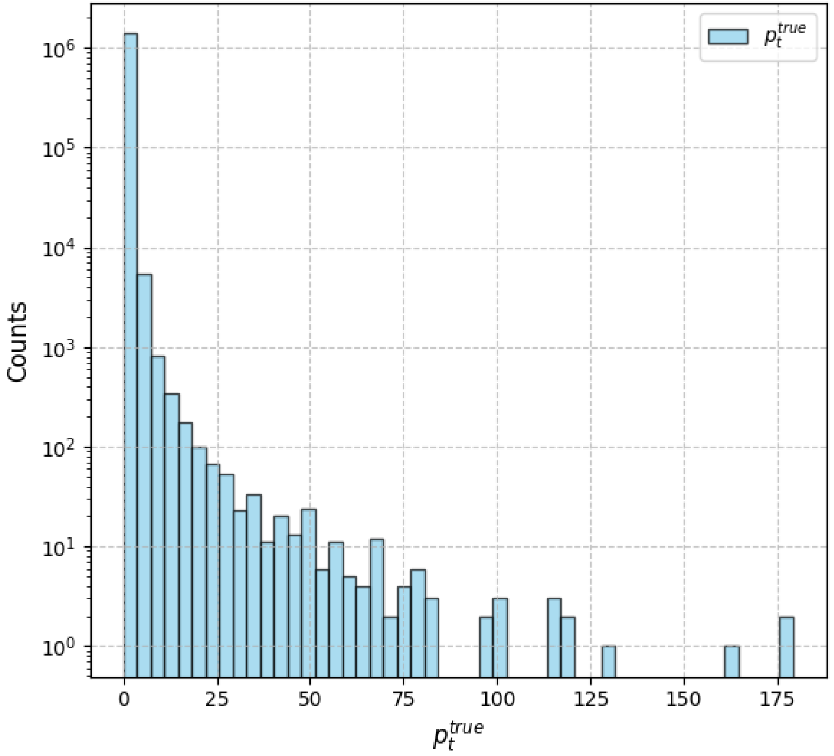
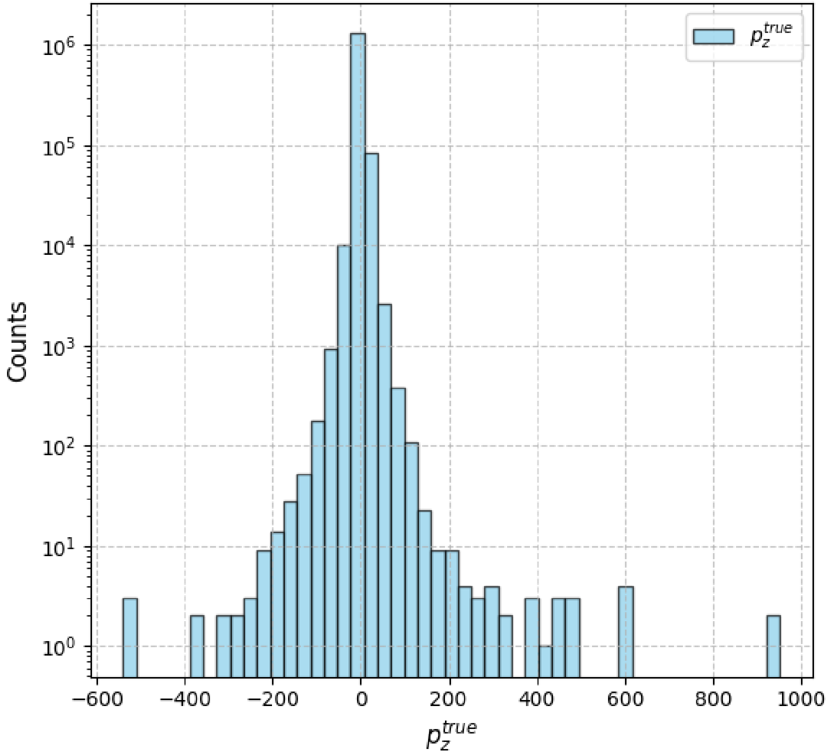
Target variables





Dataset selection

Selections:

- nhits >= 3
- 0.5 <= pT <= 10   [GeV]
- |v_x| < 1 && |v_y|< 1   [mm]
- |eta| <= 1

Before:

Training: 11 222 273 particles
Validation: 1 334 273 particles
Testing: 1 404 273 particles

$\xrightarrow{/\ 10}$

After:

Training: 1 232 896 particles
Validation: 154 082 particles
Testing: 153 788 particles

Dataset selection details

Selections:

- nhits >= 3
- 0.5 <= pT <= 10   [GeV]
- |v_x| < 1 && |v_y|< 1   [mm]
- |eta| <= 1

Test dataset:

Total: 1643787 particles

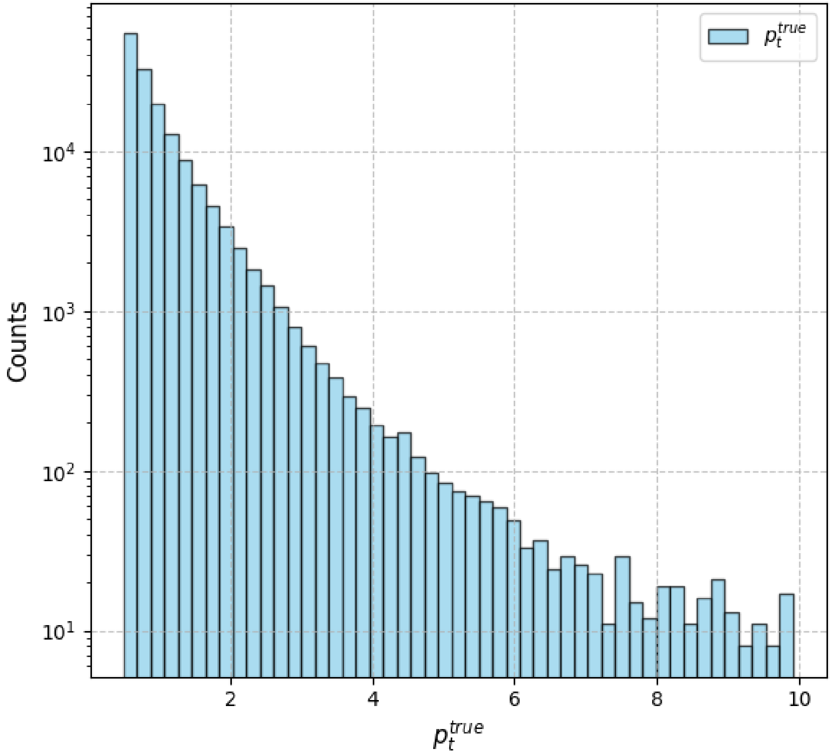
621539 particles, min_pt=0.5, max_pt=10

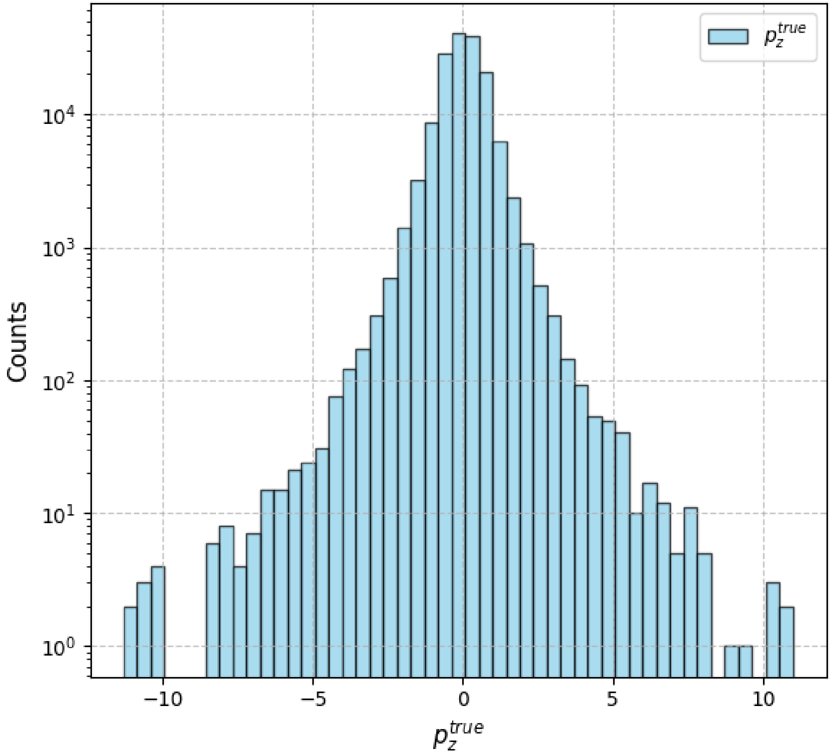
599332 particles, min_hits=3, min_pt=0.5, max_pt=10, keep_secondaries=True

553606 particles, min_hits=3, min_pt=0.5, max_pt=10, keep_secondaries=False ("|vx| < 1 && |vy| < 1" cut)

153788 particles, min_hits=3, min_pt=0.5, max_pt=10, keep_secondaries=False, max_abs_eta=1

Target variables





Training

Architecture:
- input_dim: 3
- model_dim: 128
- num_classes: 2
- num_heads: 4
- num_layers: 2

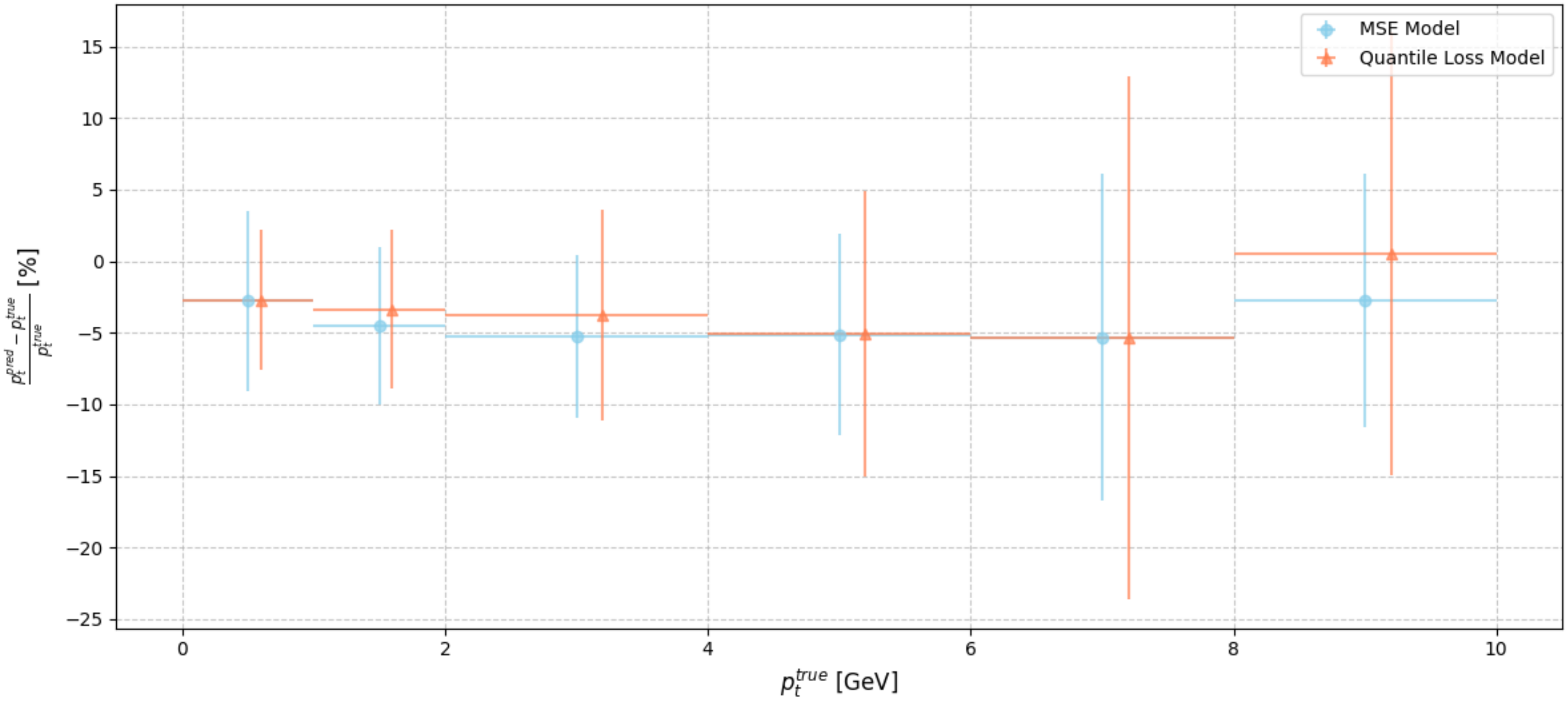
Training:
- warmup: 100
- lr: 0.0005
- dropout: 0.1
- input_dropout: 0.1
- batch_size: 1024
- max_epochs: 100

Saving:
- monitor: val_loss
- mode: min

Variables:
- input:
  - tx, ty, tz
- input:
  - tr, tphi, tz
- target:
  - pt, pz

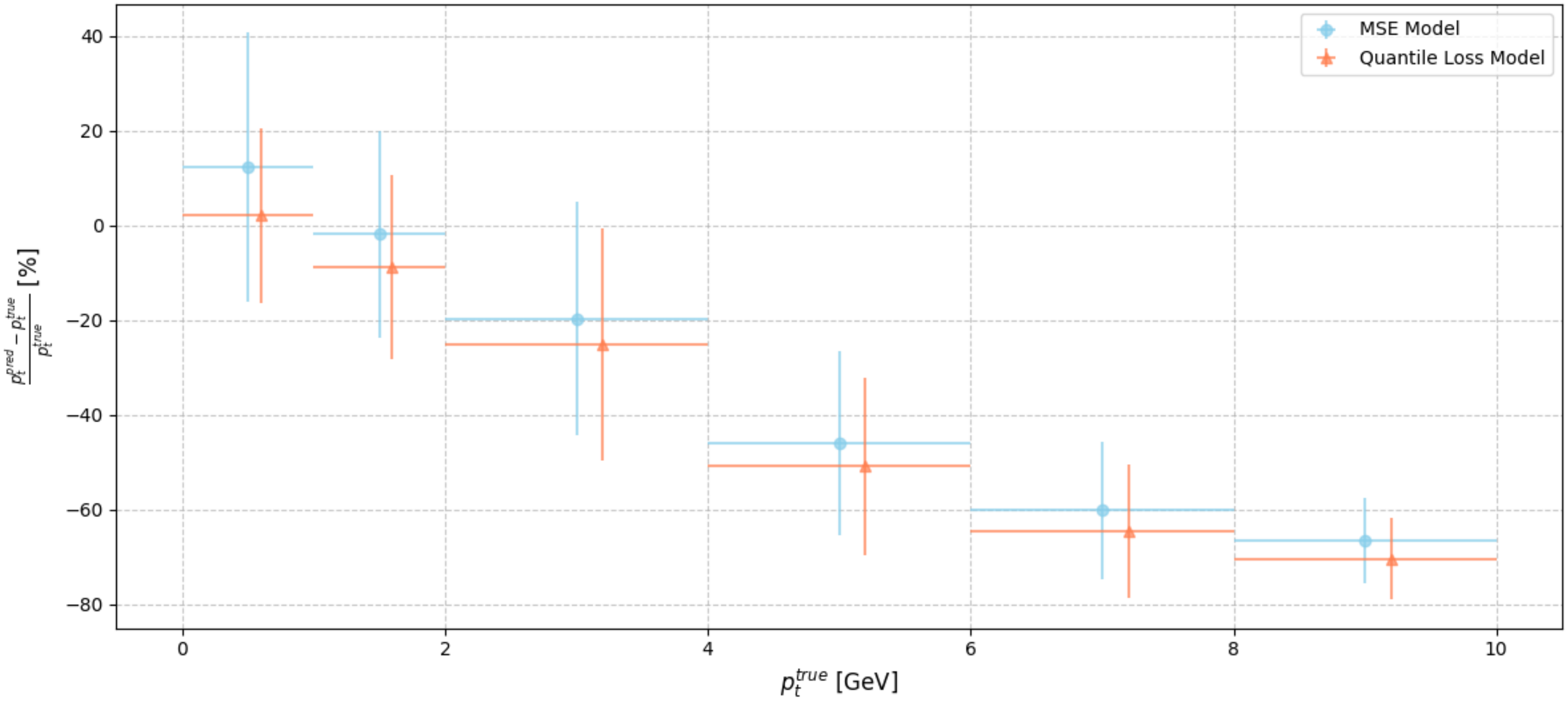
Resolution

x y z



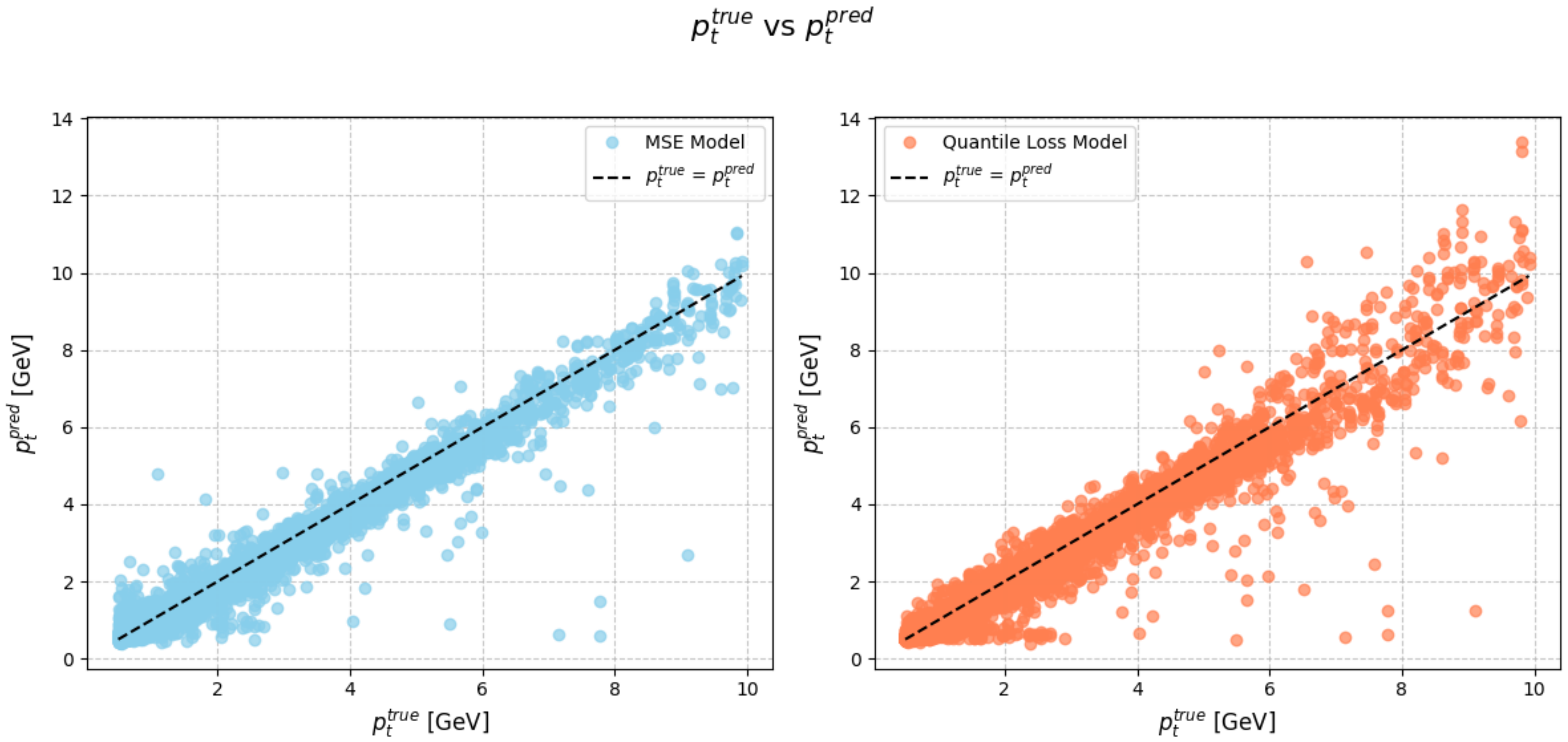
Resolution

r phi z



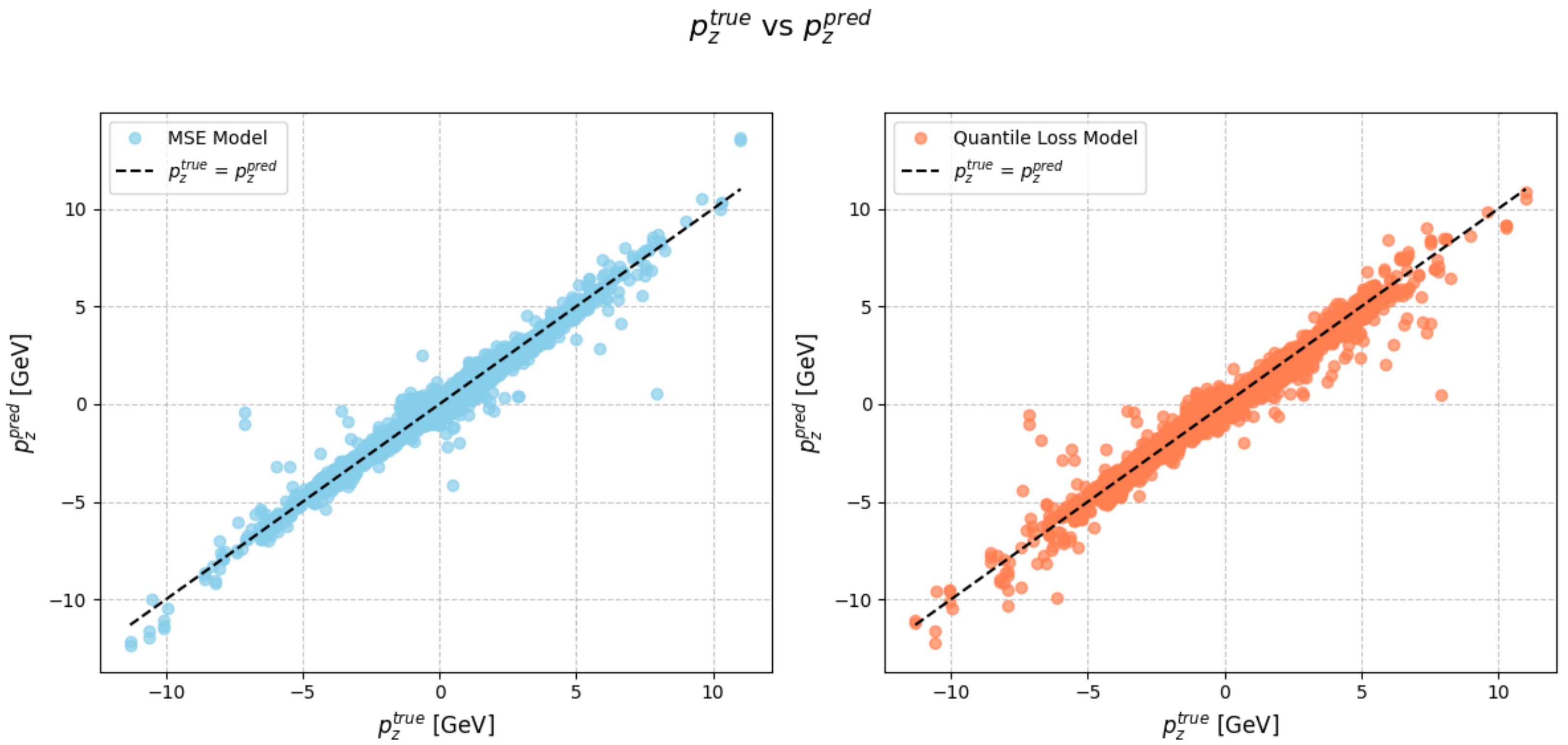
More results

x y z



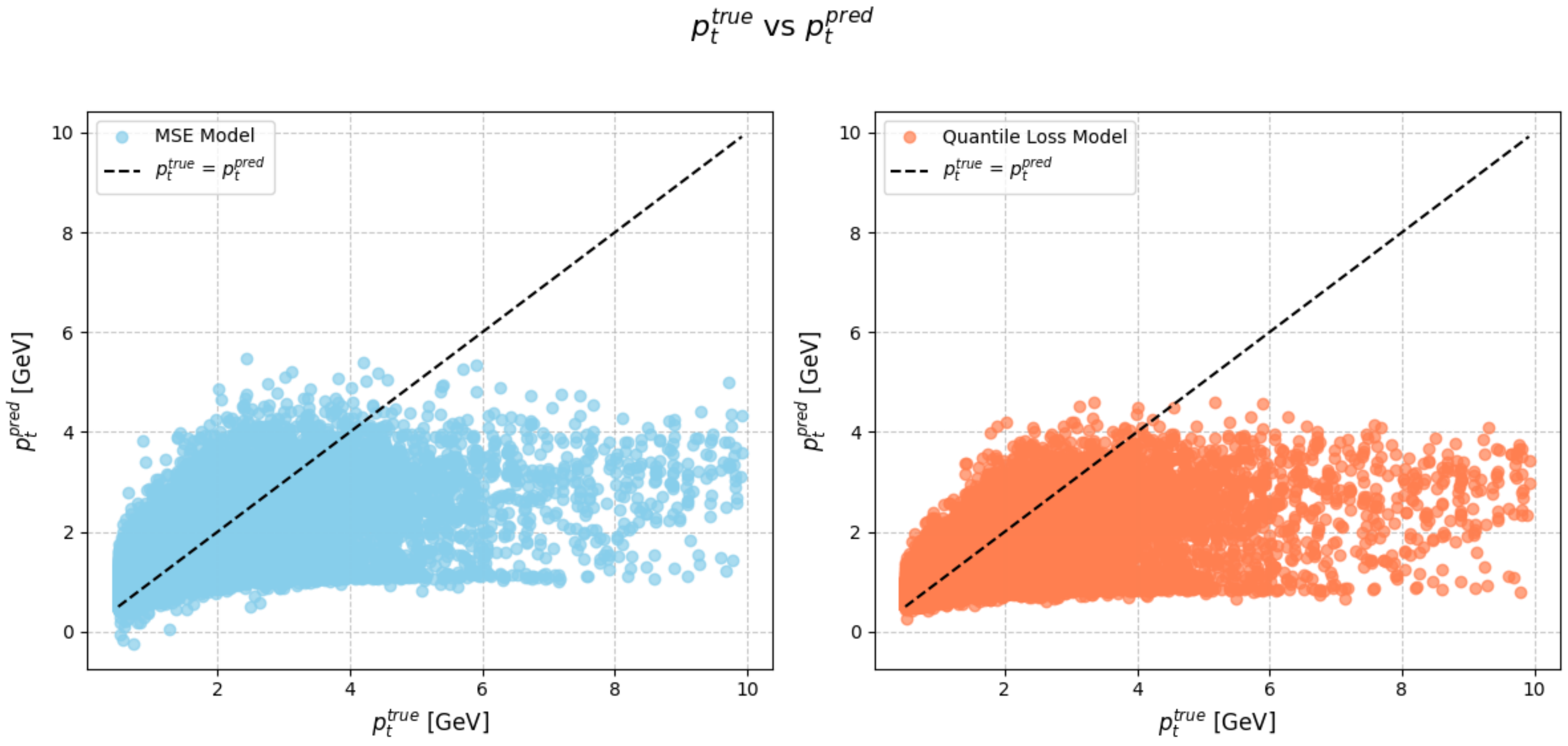
More results

x y z



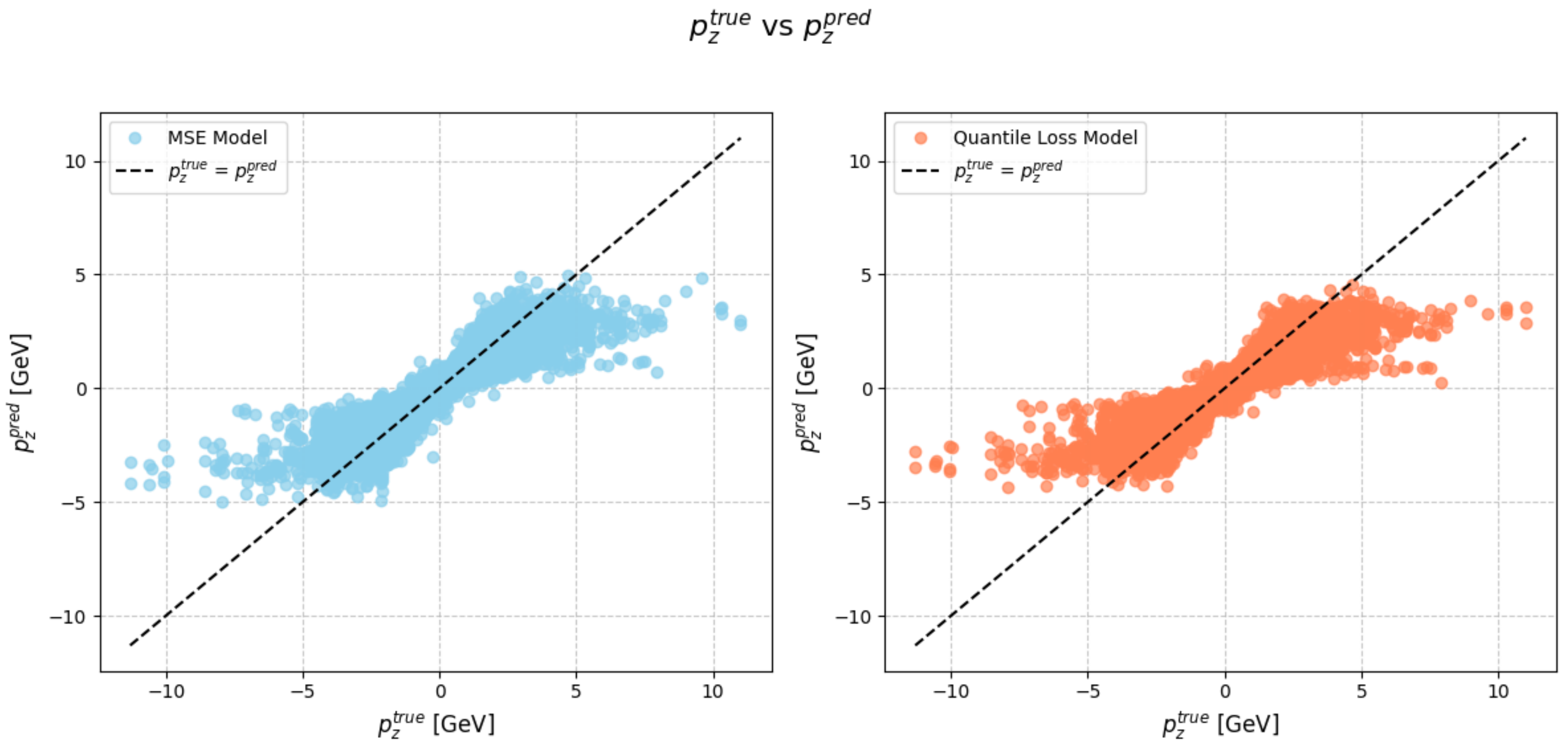
More results

r phi z



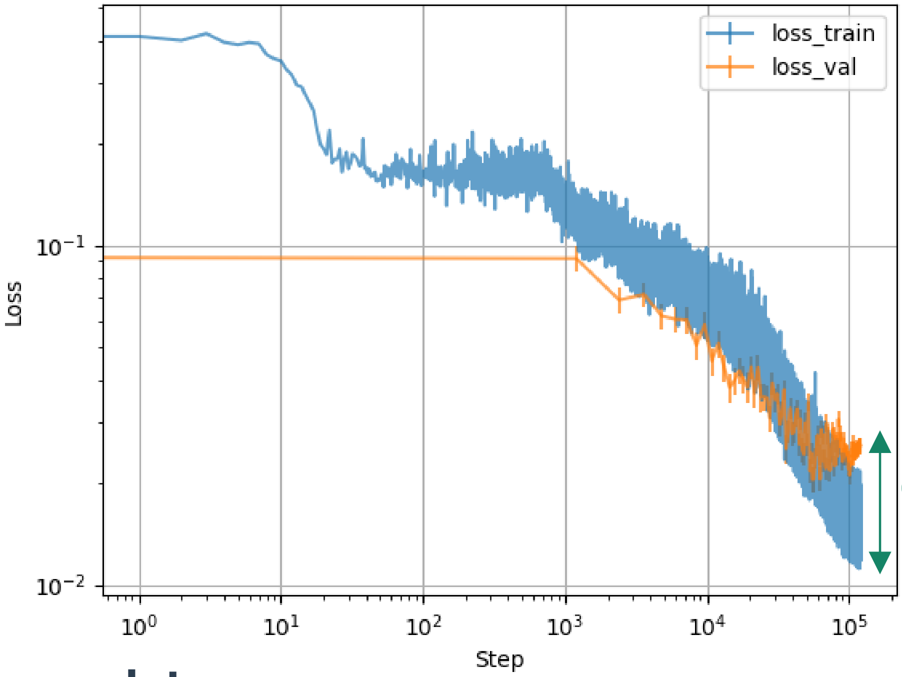
More results

r phi z

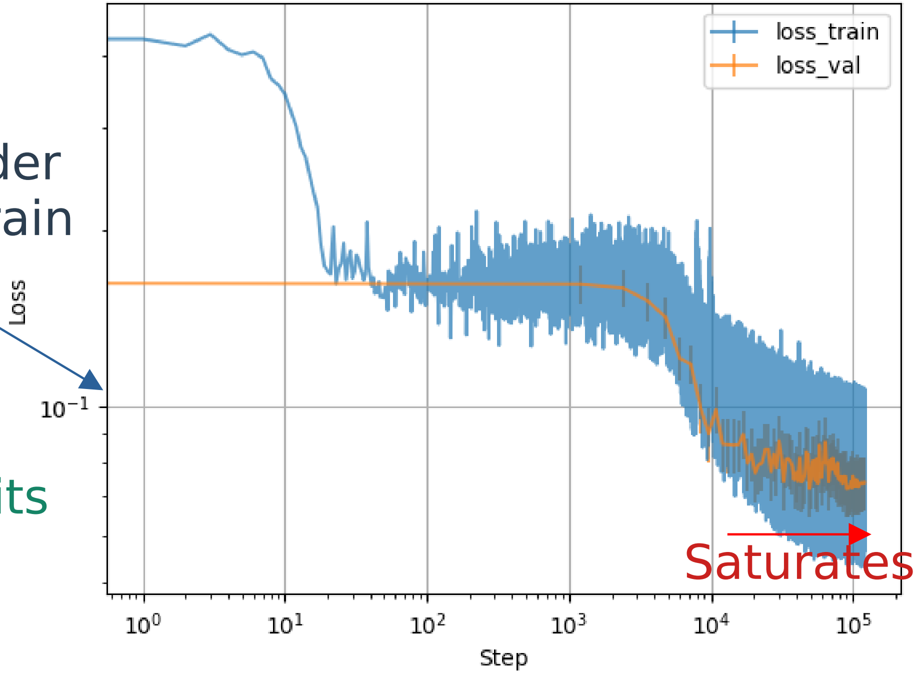


Loss curves

Quantile Loss **x y z**



Quantile Loss **r phi z**



Harder to train

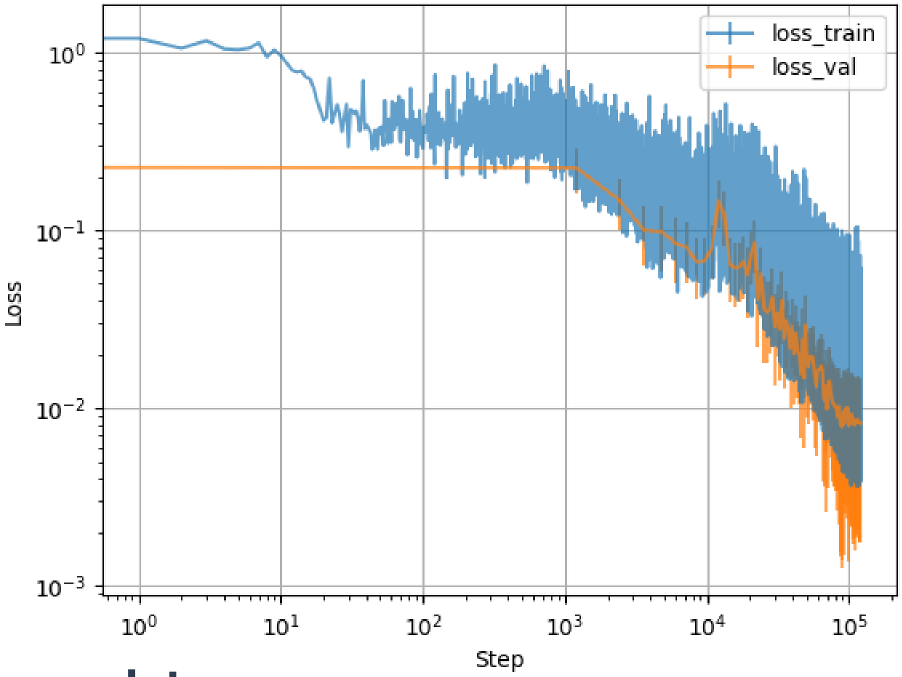
Overfits

Saturates

Same data

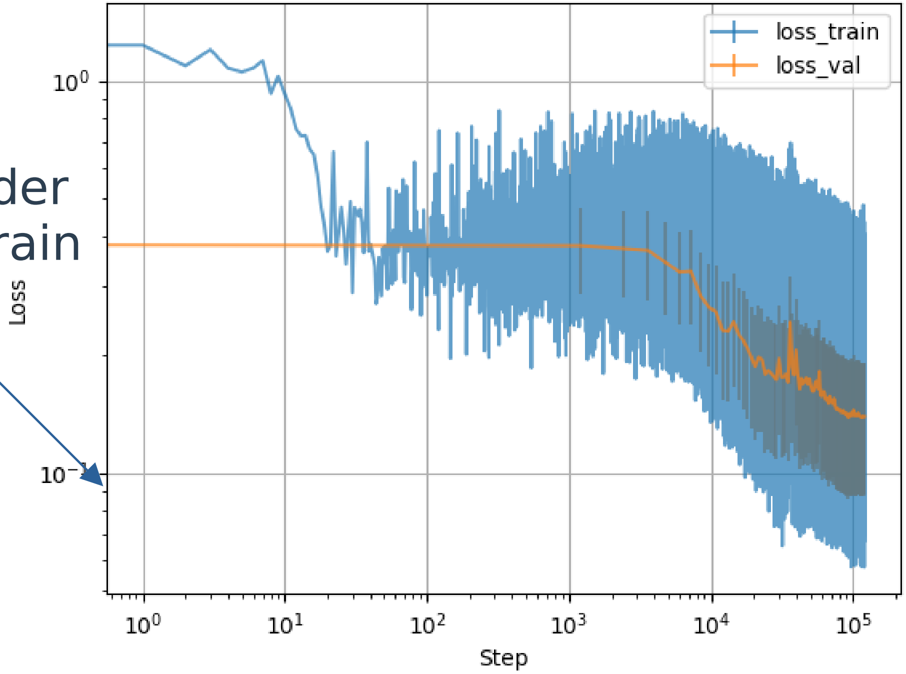
Loss curves

MSE Loss **x y z**



Harder to train

MSE Loss **r phi z**

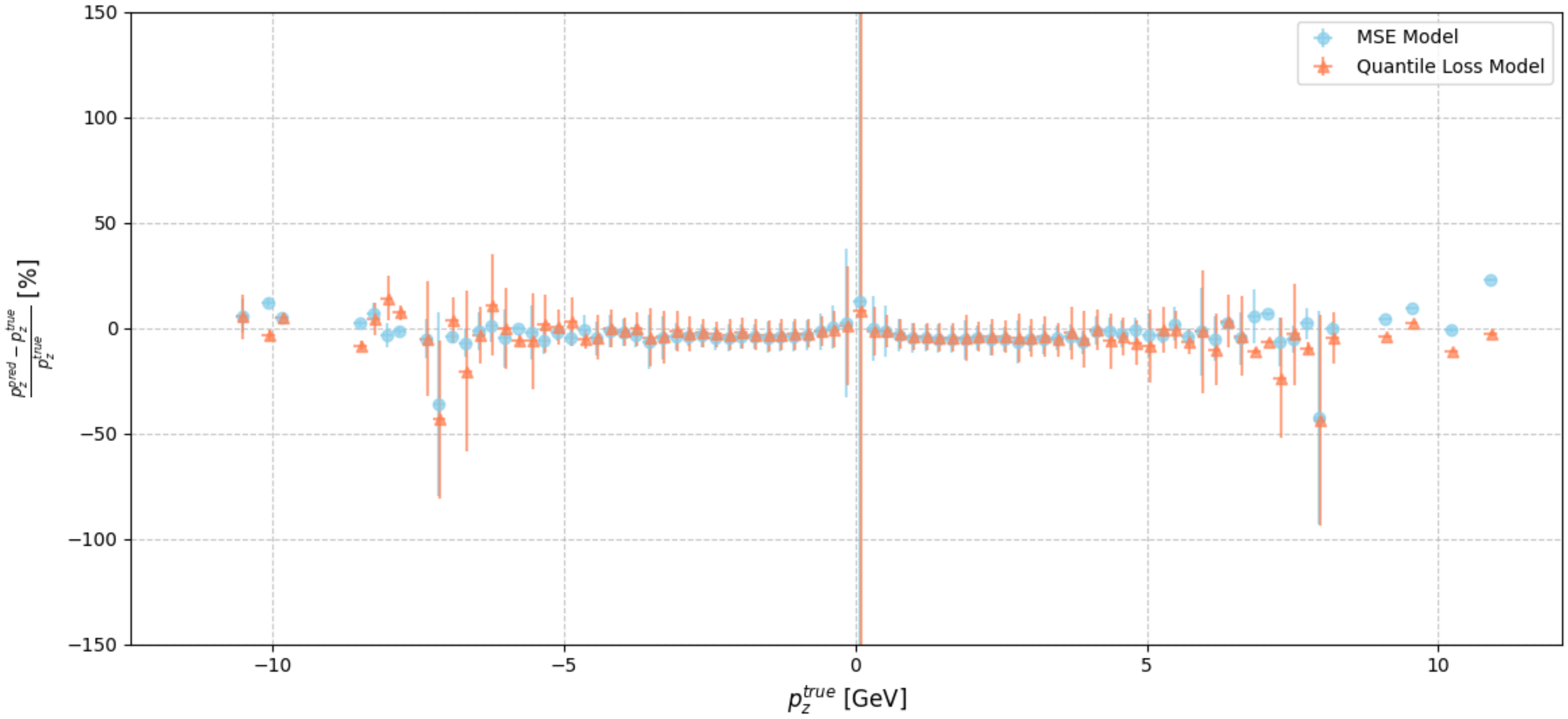


Same data

BACKUP

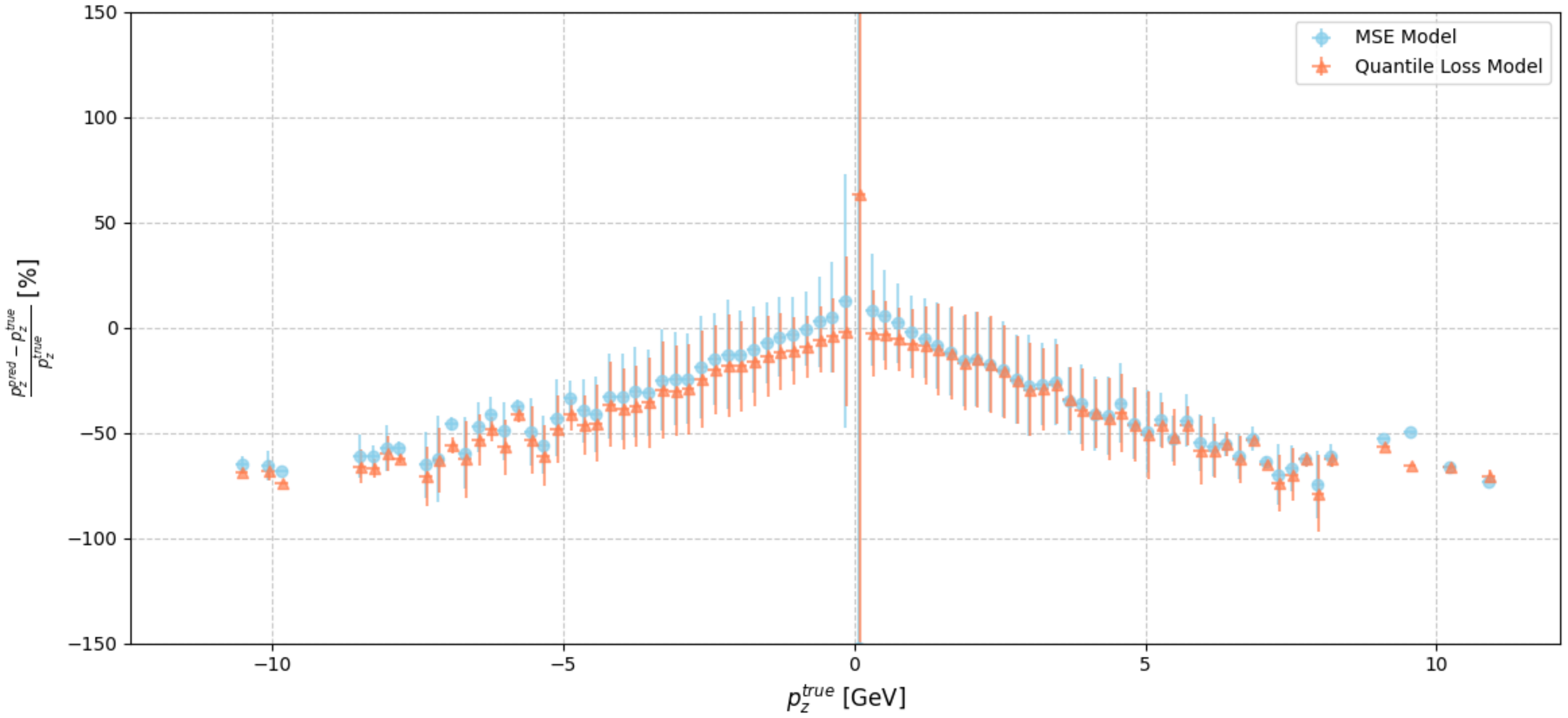
Resolution

x y z



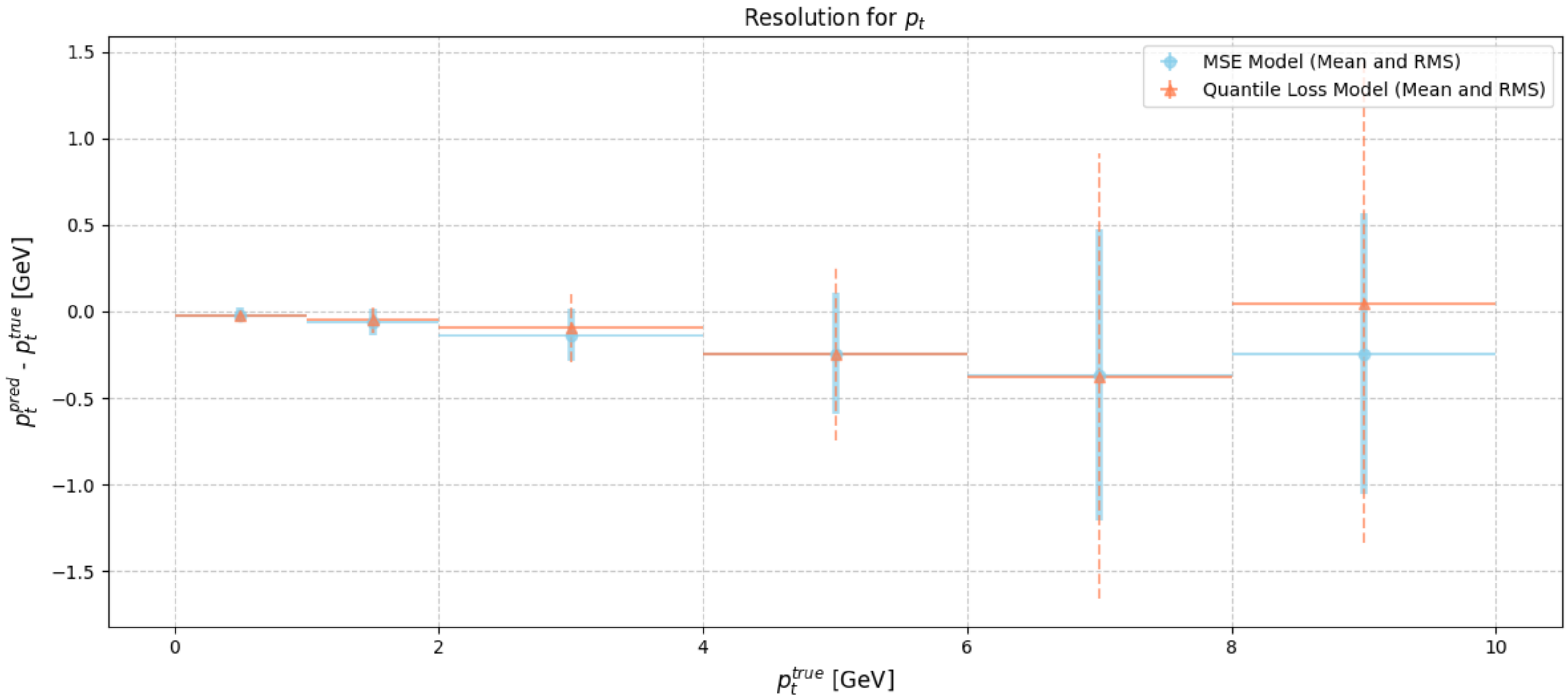
Resolution

r phi z



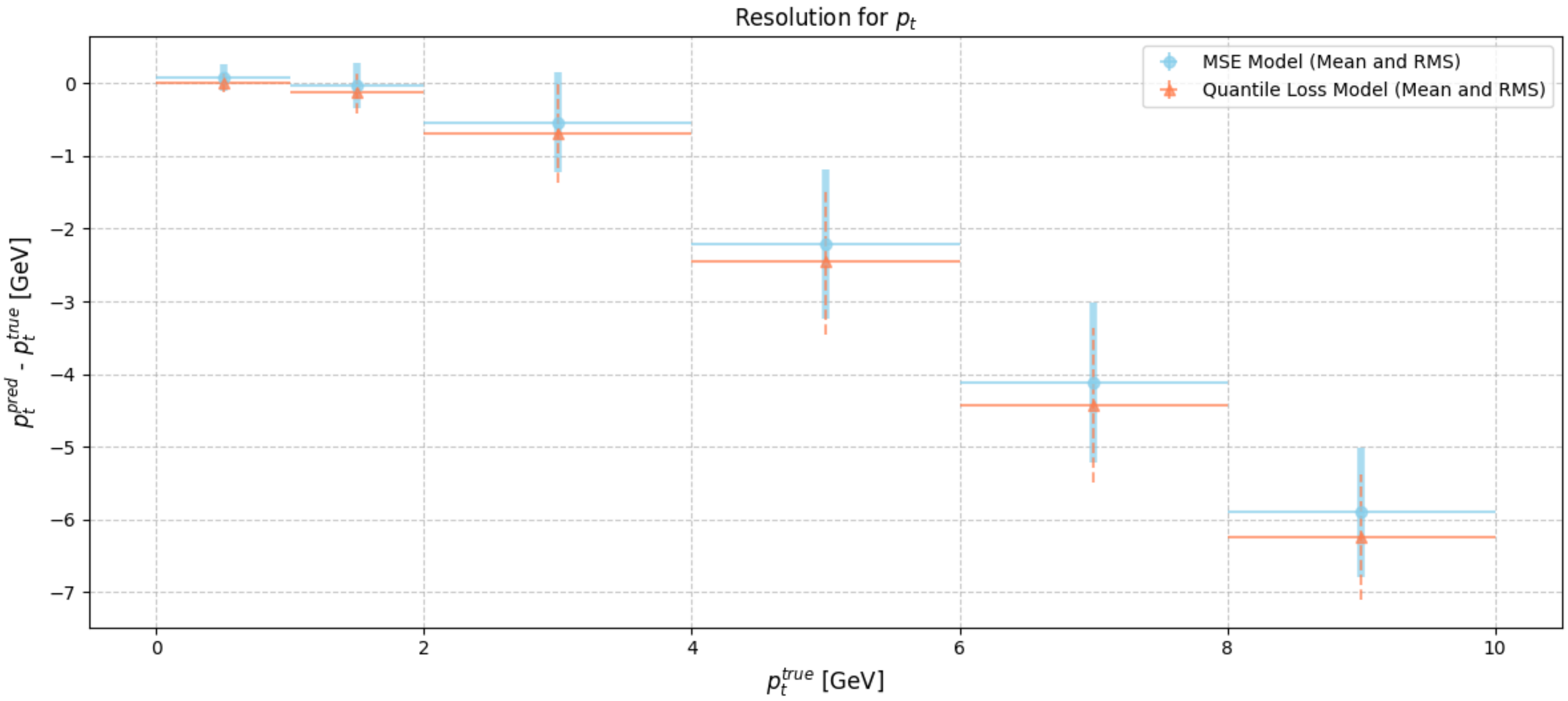
More results

x y z



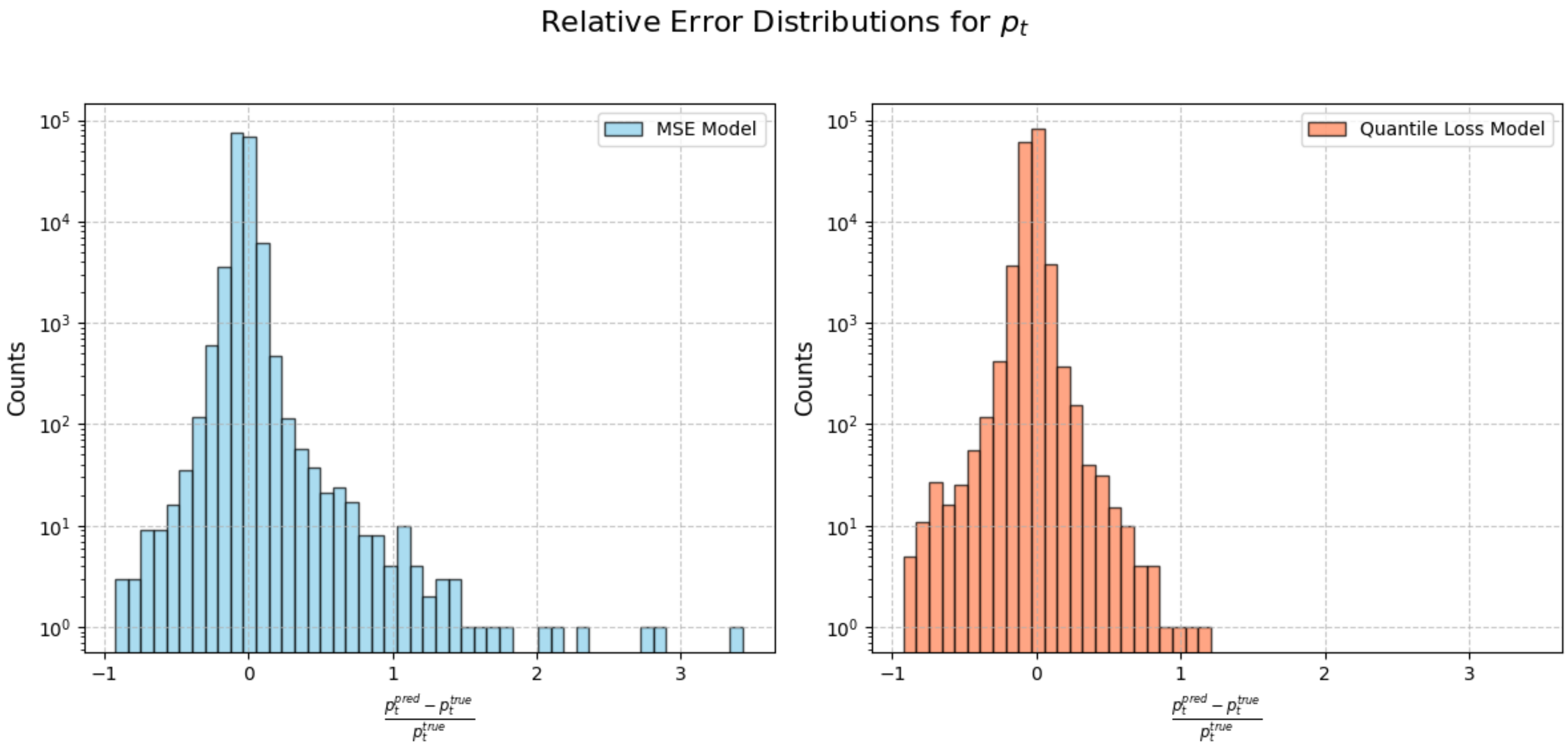
More results

r phi z



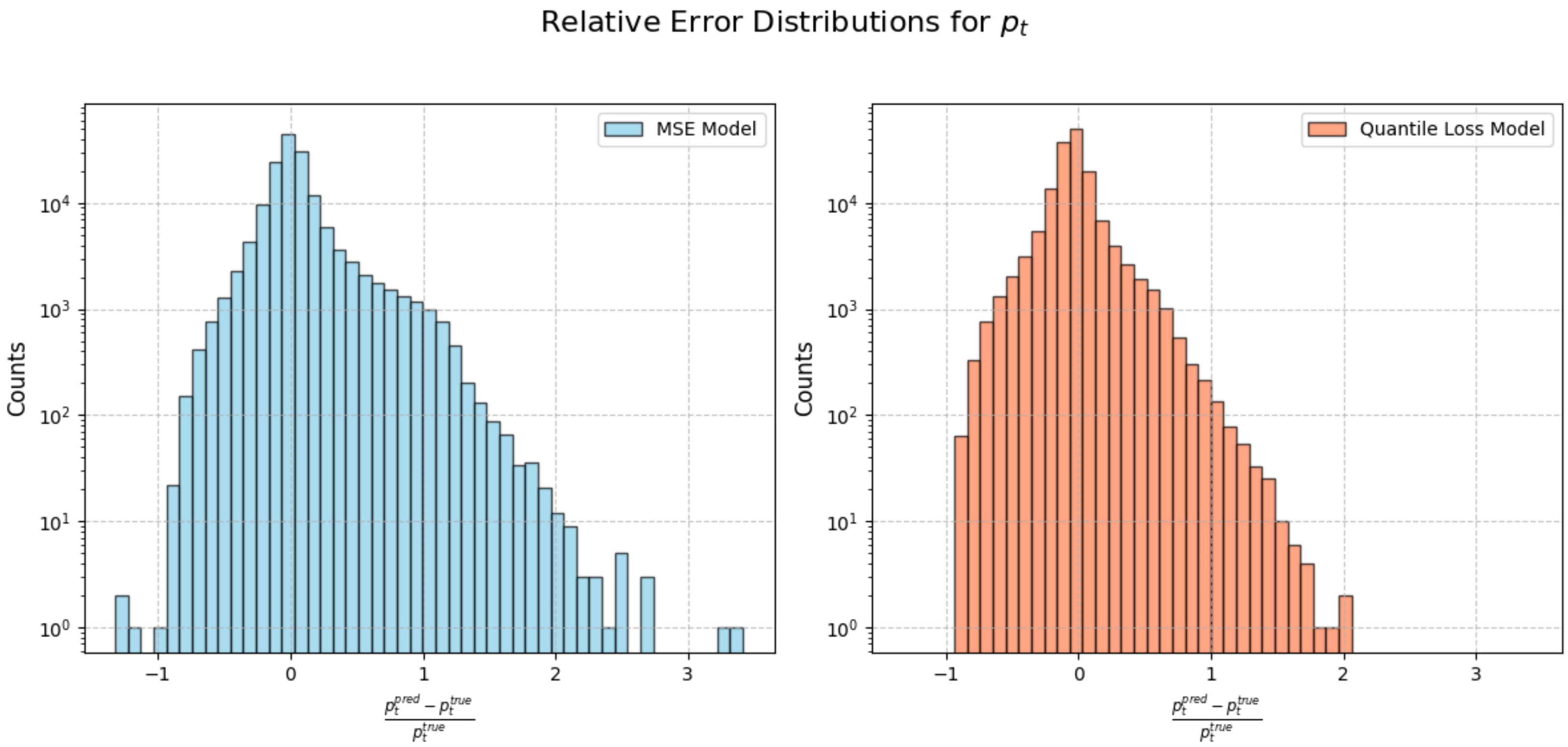
More results

x y z



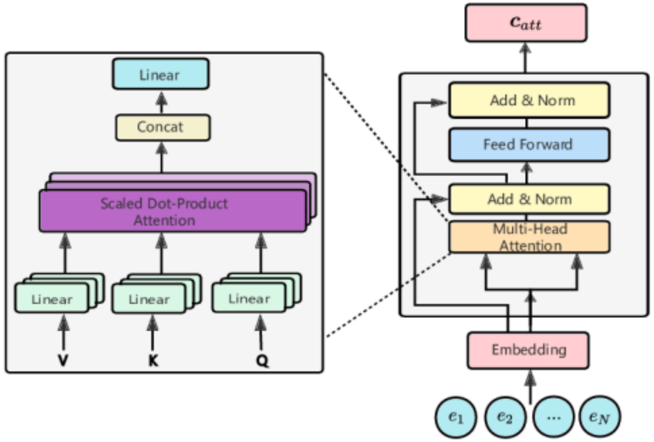
More results

r phi z



TrackFormer

- **Transformer for track parameter regression**
- **Tested on several dataset: ToyTracks, Acts, TrackML**



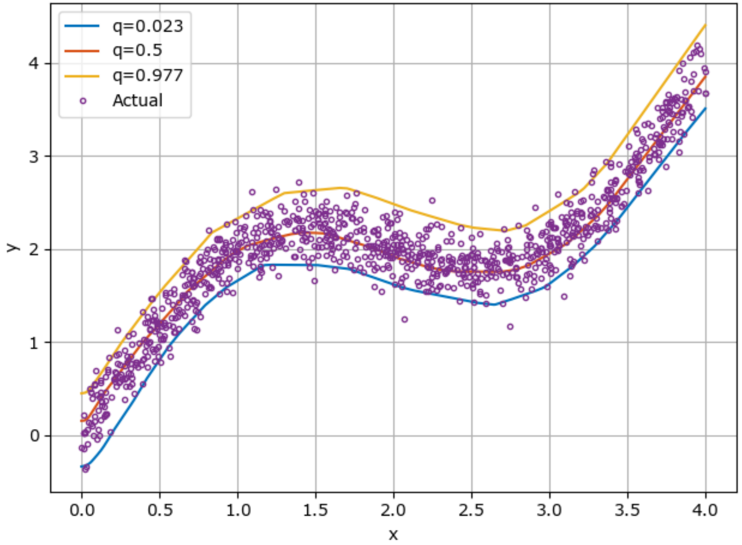
- **Regression in pt and pz**
- **Shown promising results**

Sequences were padded to a fixed length

TrackFormer loss functions

Mean squared error:

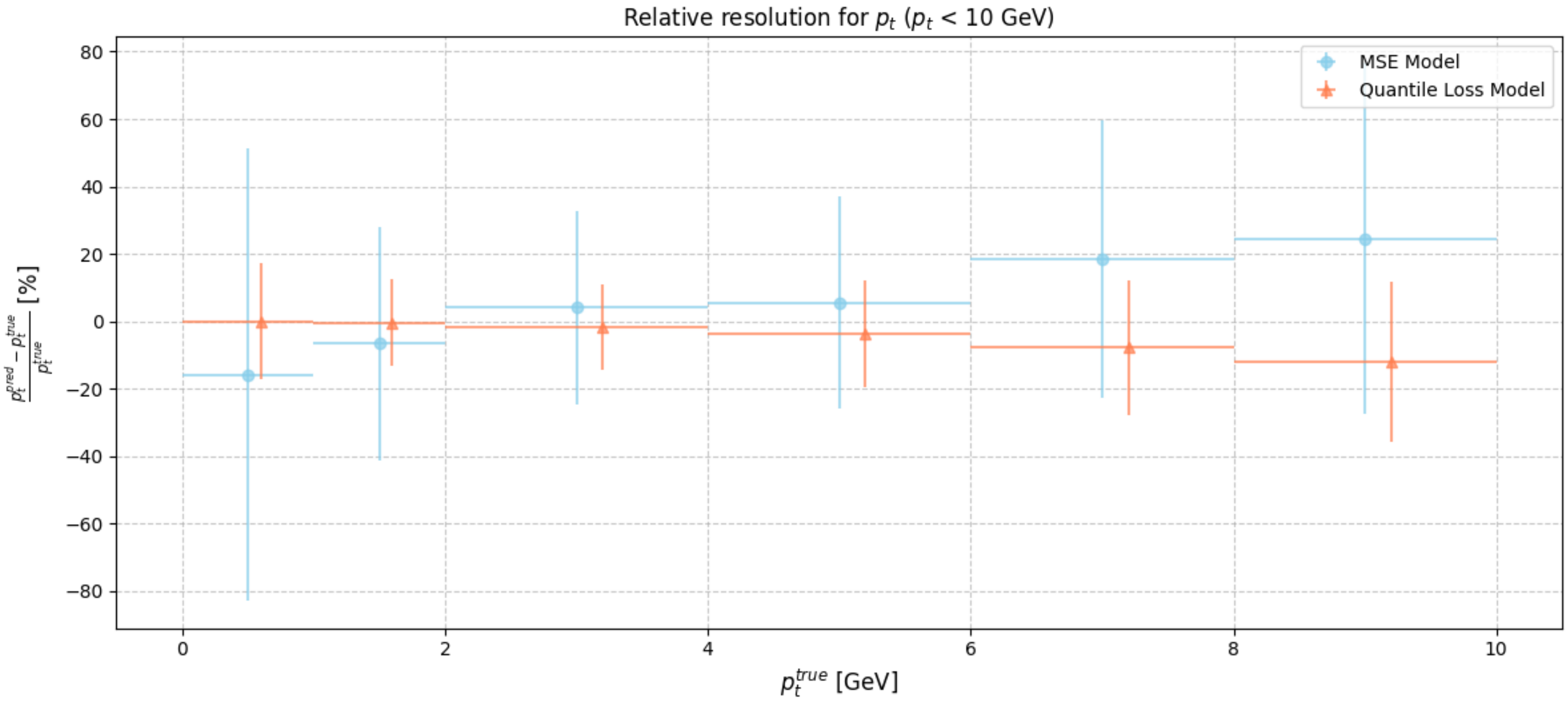
$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$



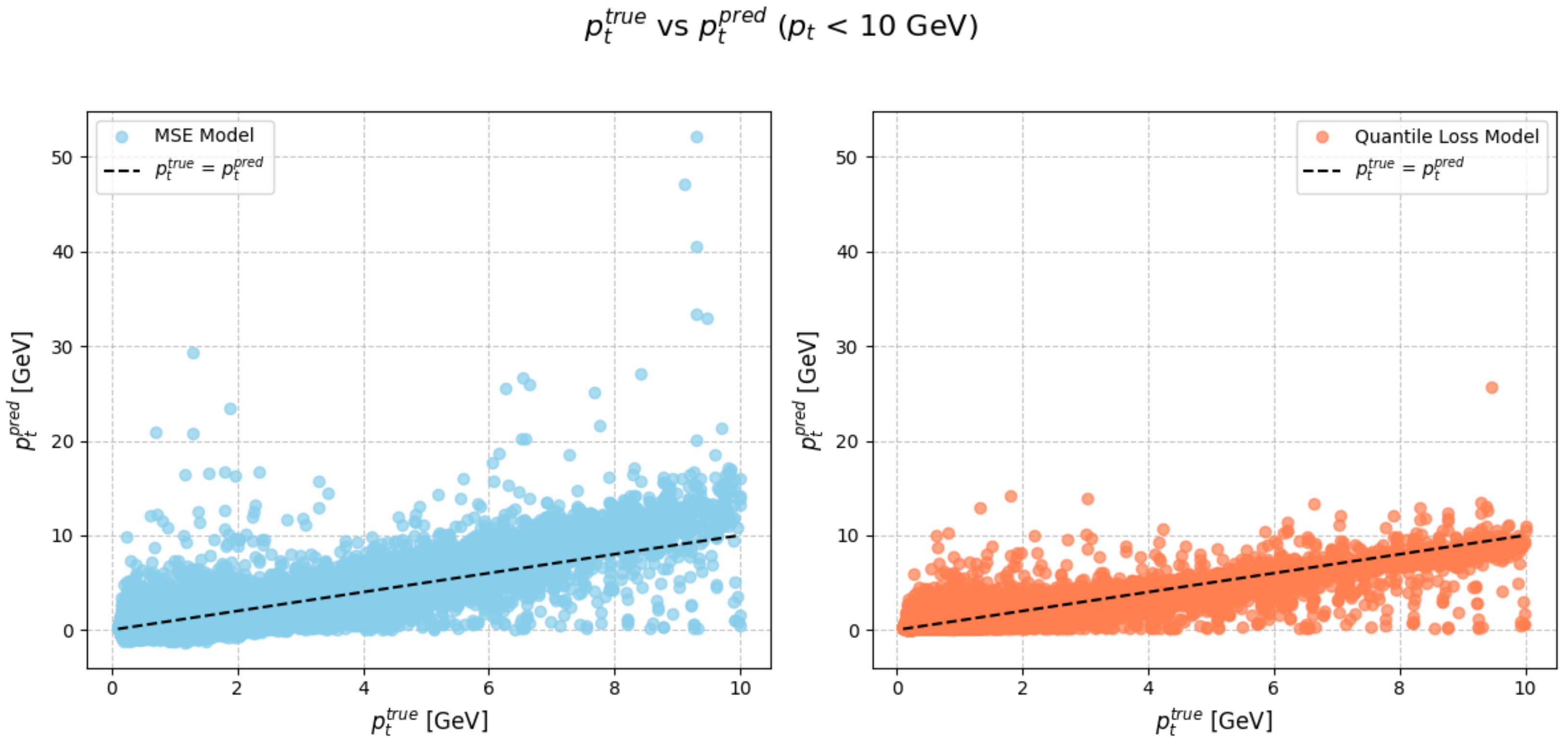
Quantile loss:

$$\mathrm{QL} = \frac{1}{n}\sum_{i=1}^{n}\left(\max(q(y_i - \hat{y}_i), (q-1)(y_i - \hat{y}_i))\right)$$

More results

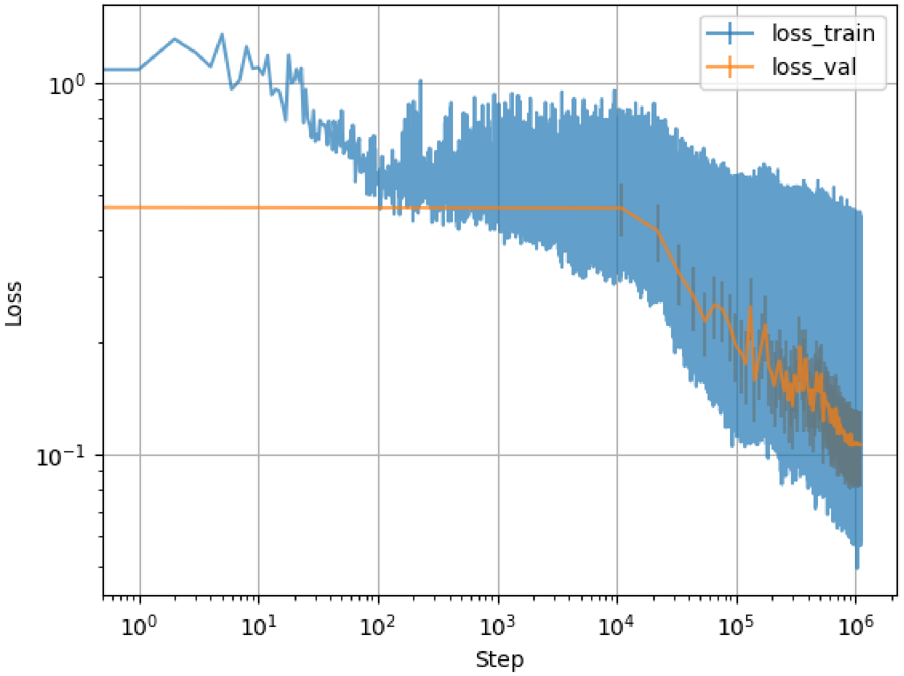


More results



Loss curves

Quantile Loss



MSE Loss