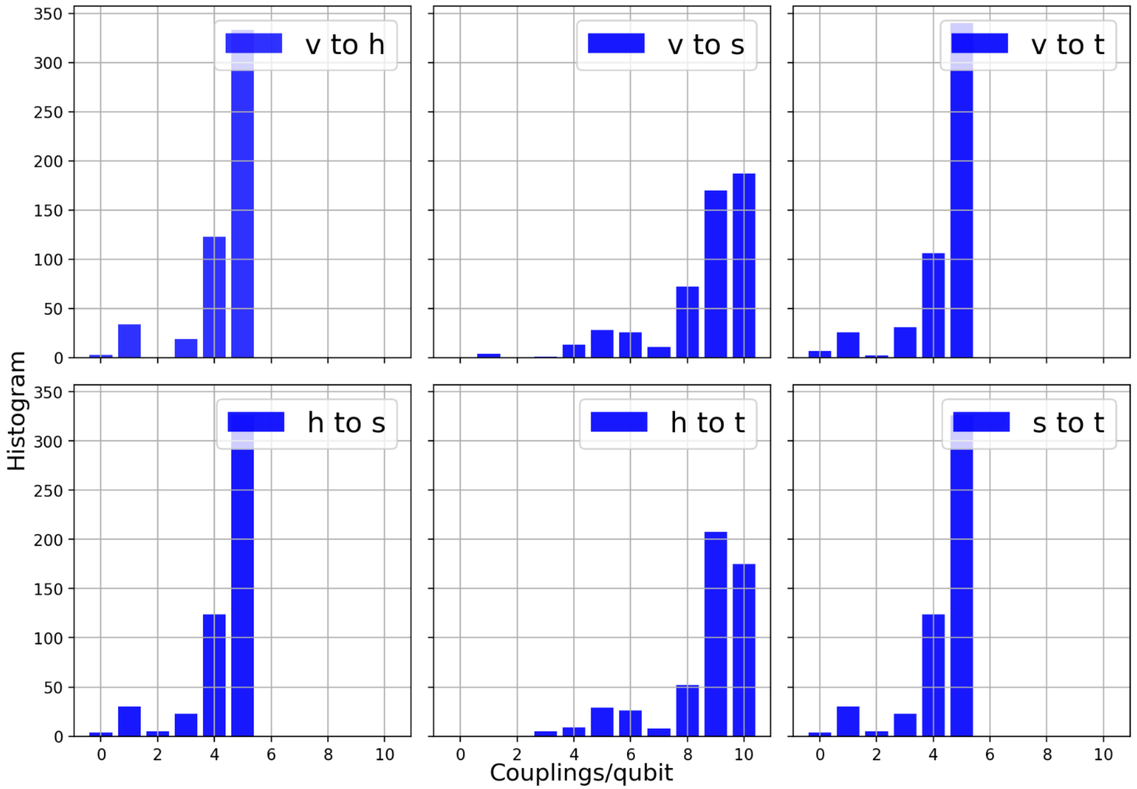
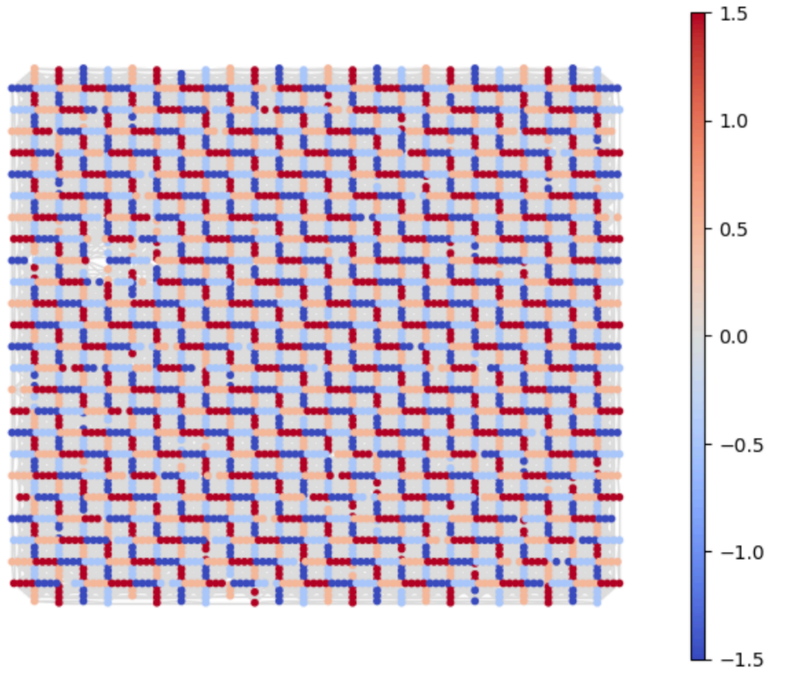
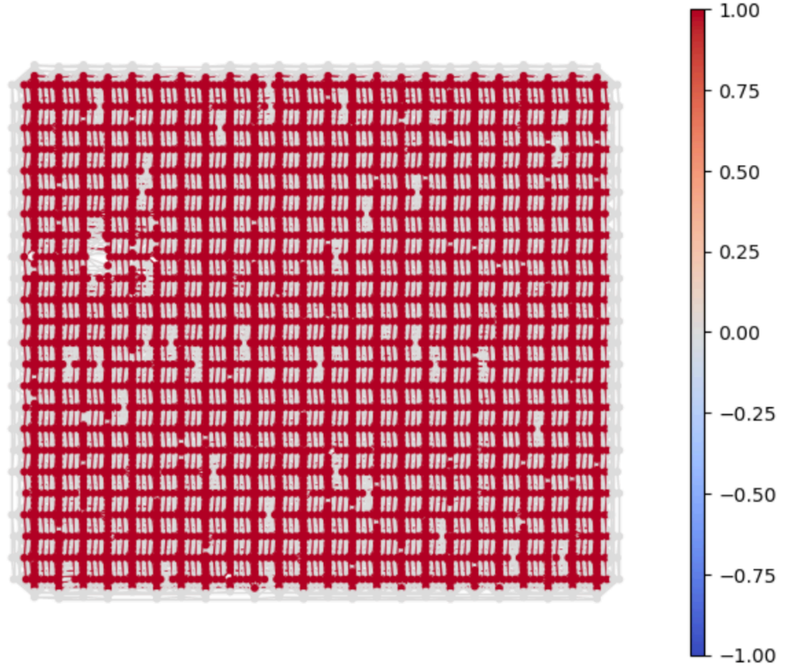
Calo4pQVAE: Progress and updates

May 30 2025

✦Zephyr 1.1 added as default RBM arch





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total qubits 4800
max degree 20
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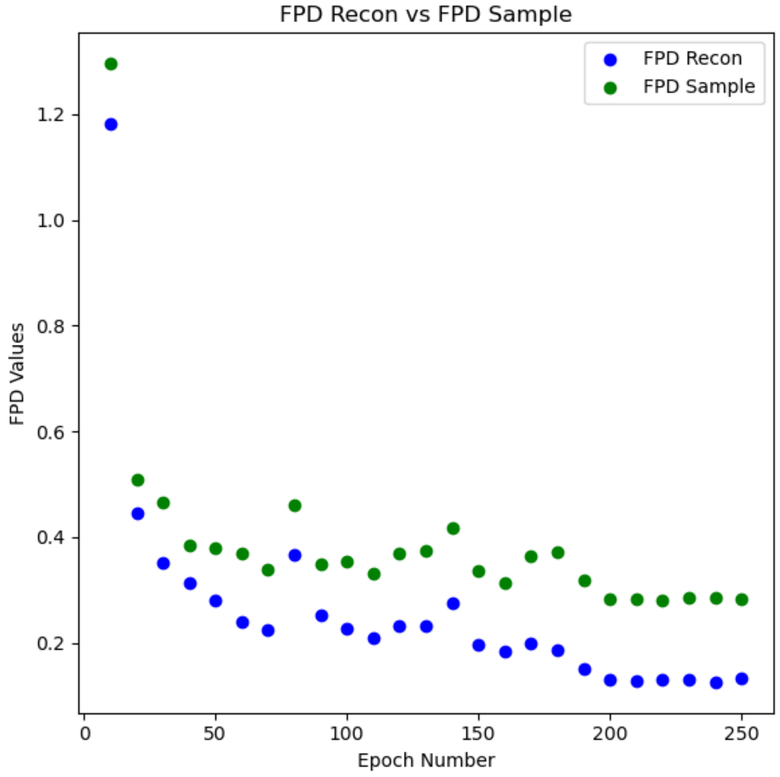
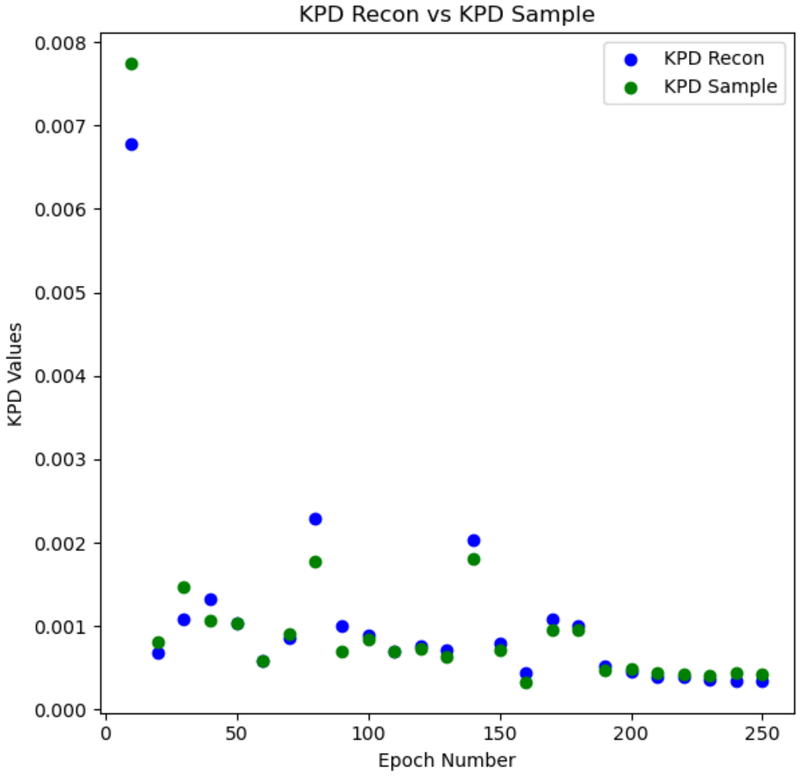
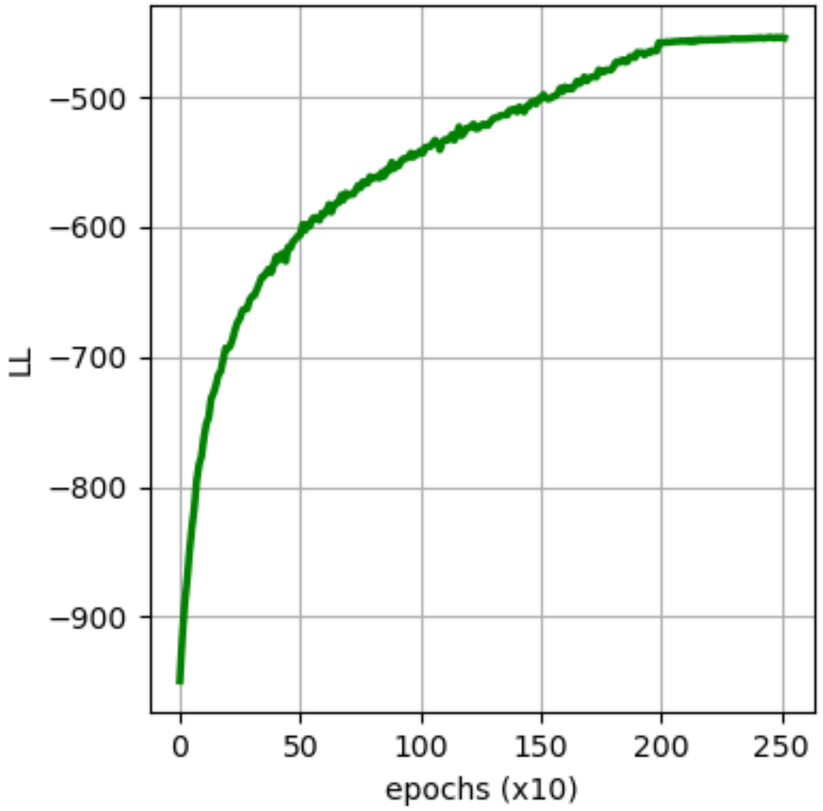
CaloChallenge w/ new Zephyr

✦KPD and FPD = 0.42 and 283.84

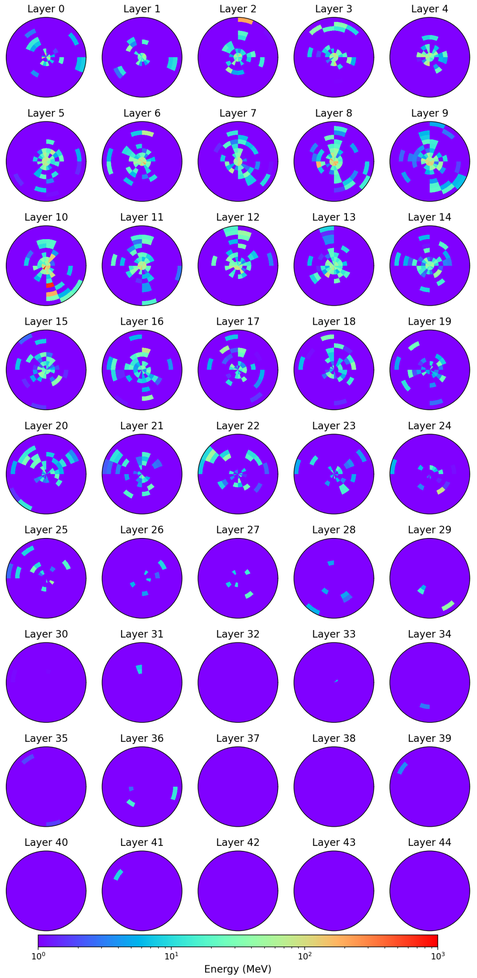


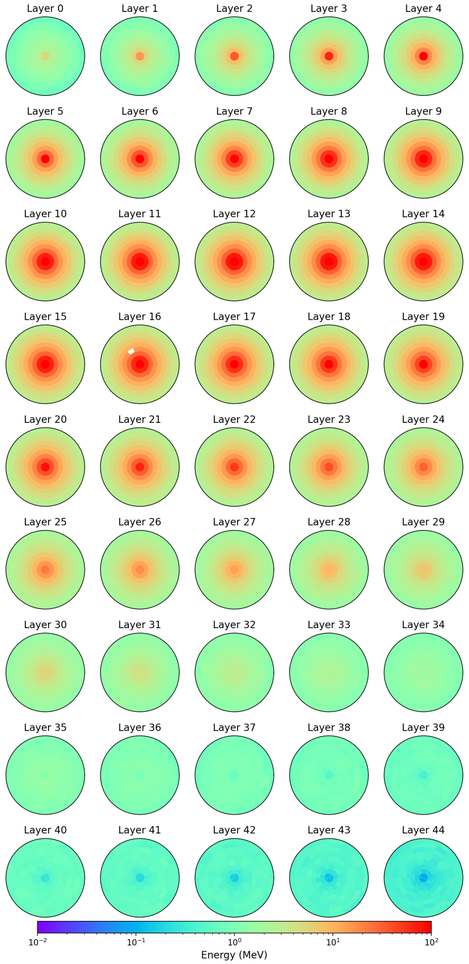




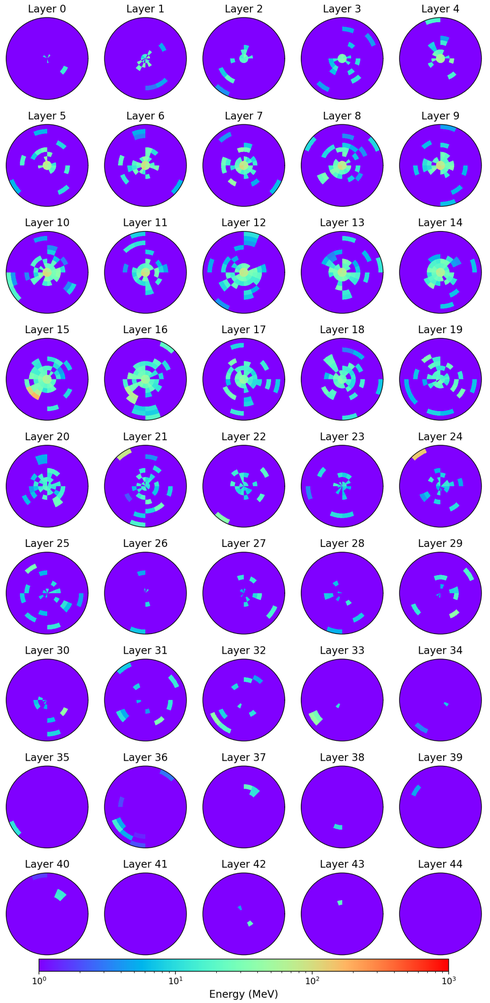
CaloChallenge w/ new Zephyr

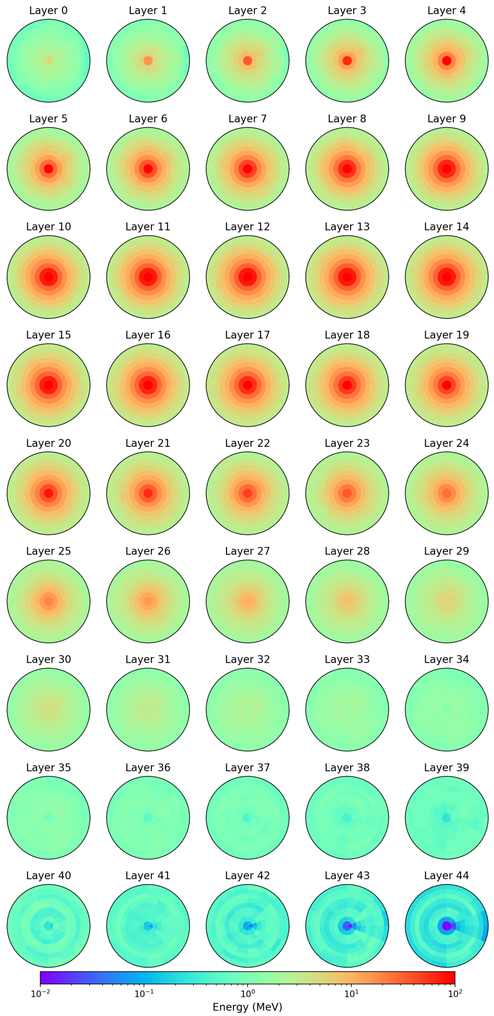
GT

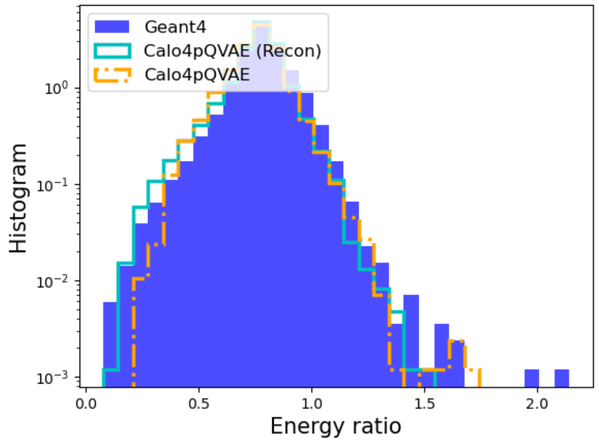


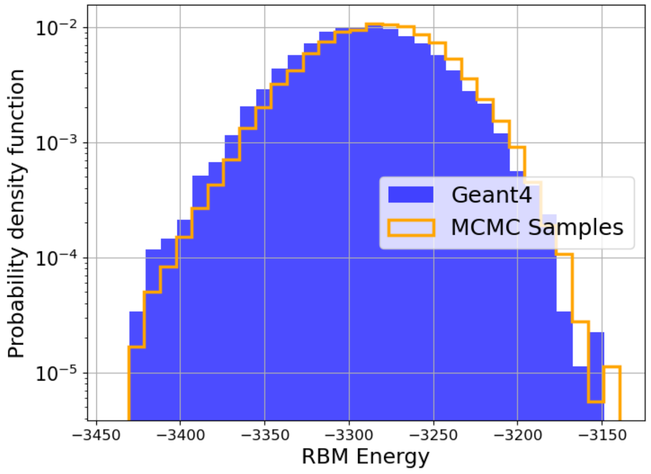


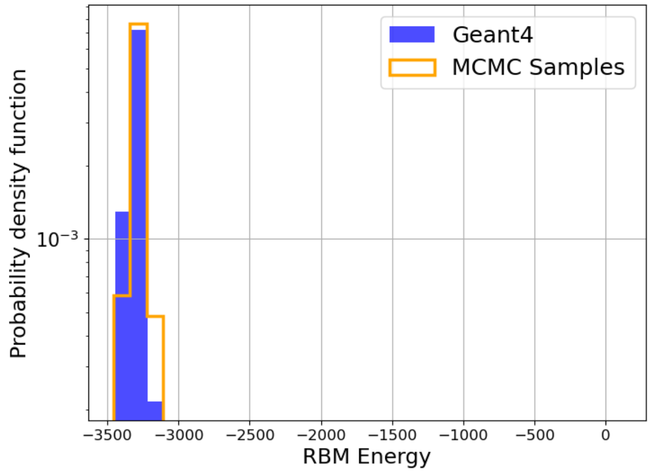
Sample

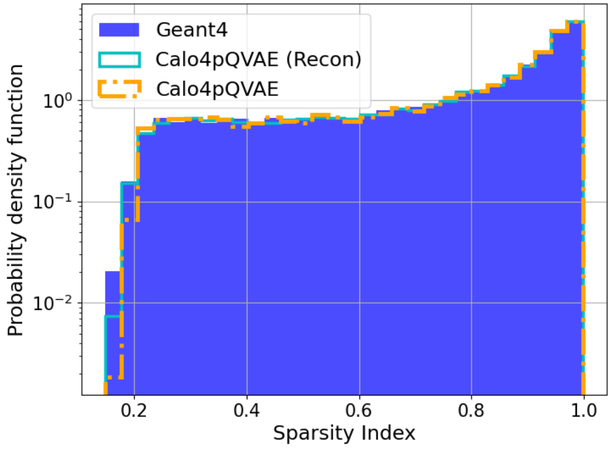


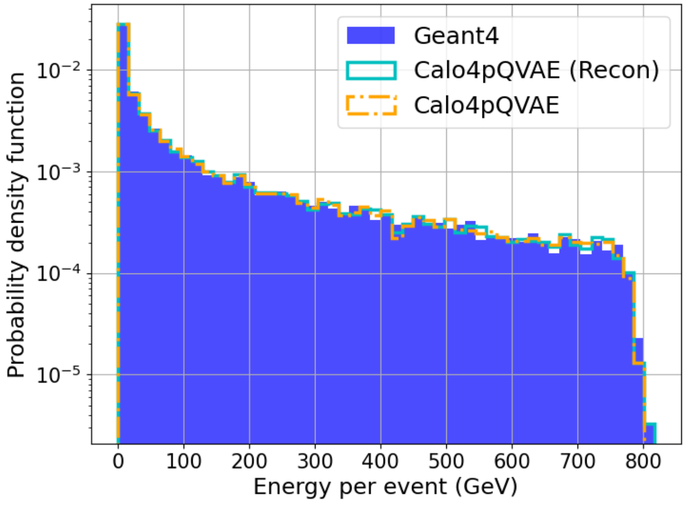


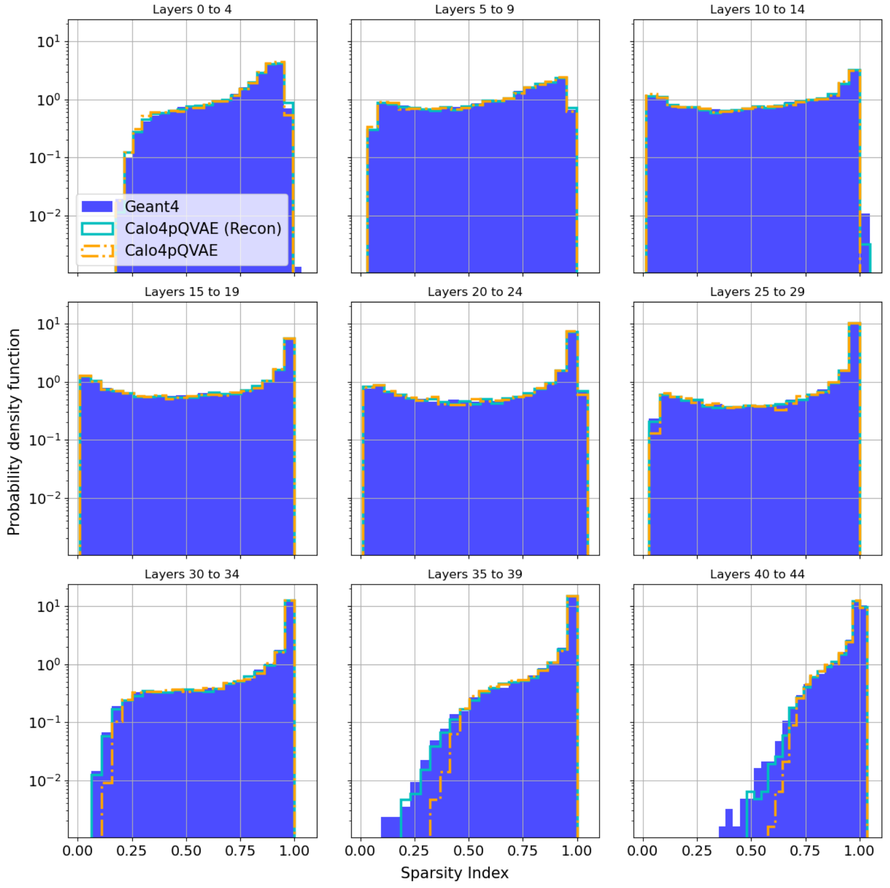

Geant4
Calo4pQVAE (Recon)
Calo4pQVAE
Histogram
Energy ratio

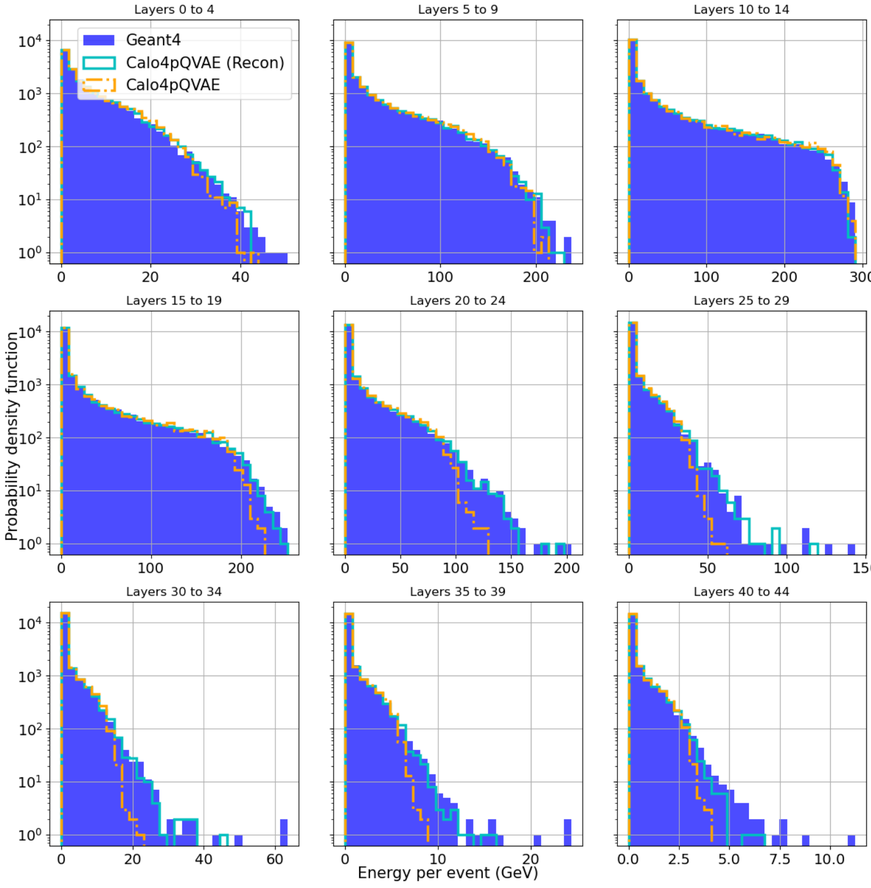

Geant4
MCMC Samples
Probability density function
RBM Energy

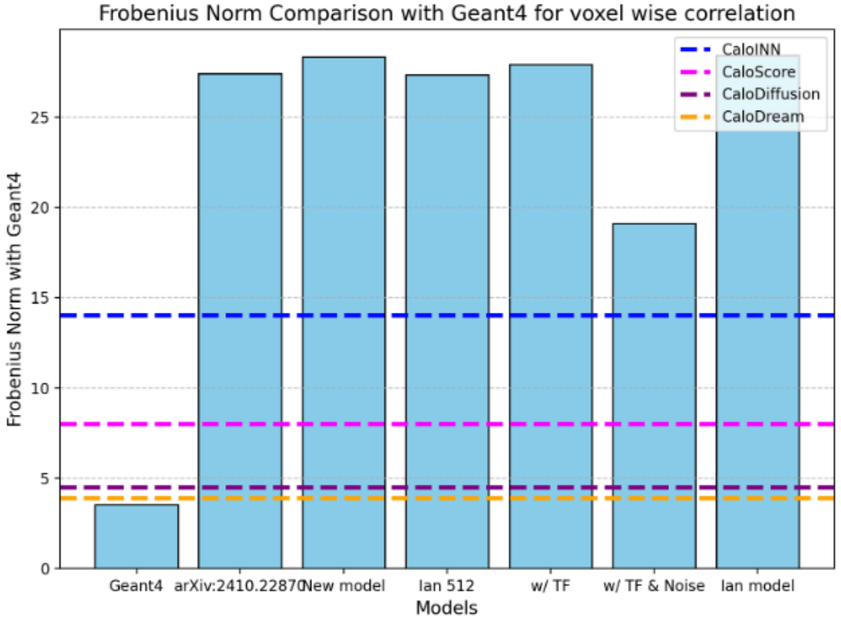

Geant4
MCMC Samples
Probability density function
RBM Energy

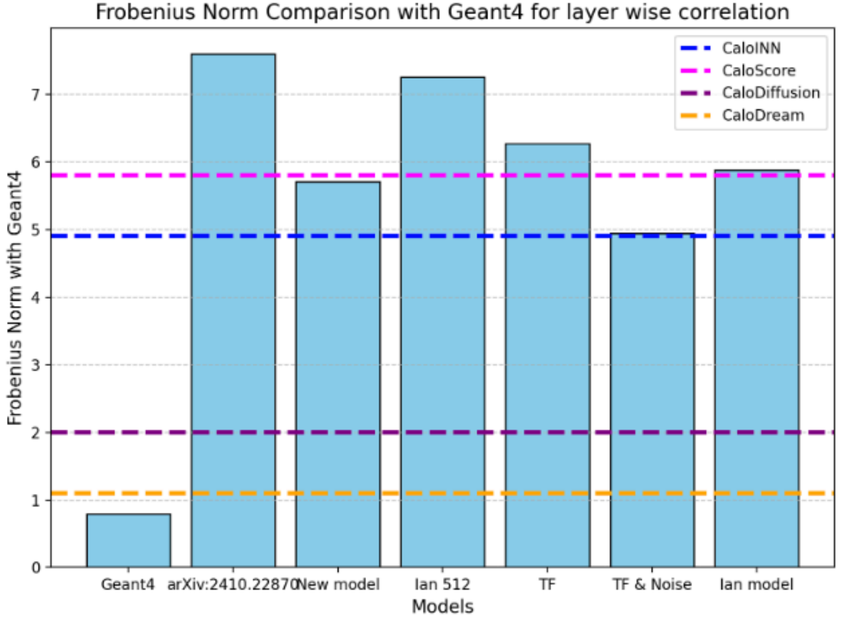

Geant4
Calo4pQVAE (Recon)
Calo4pQVAE
Probability density function
Sparsity Index


Geant4
Calo4pQVAE (Recon)
Calo4pQVAE
Probability density function
Energy per event (GeV)


Layers 0 to 4
Layers 5 to 9
Layers 10 to 14
Layers 15 to 19
Layers 20 to 24
Layers 25 to 29
Layers 30 to 34
Layers 35 to 39
Layers 40 to 44
Geant4
Calo4pQVAE (Recon)
Calo4pQVAE
Probability density function
Sparsity Index


Layers 0 to 4
Layers 5 to 9
Layers 10 to 14
Layers 15 to 19
Layers 20 to 24
Layers 25 to 29
Layers 30 to 34
Layers 35 to 39
Layers 40 to 44
Geant4
Calo4pQVAE (Recon)
Calo4pQVAE
Probability density function
Energy per event (GeV)


Frobenius Norm Comparison with Geant4 for voxel wise correlation
CaloINN
CaloScore
CaloDiffusion
CaloDream
Frobenius Norm with Geant4
0
5
10
15
20
25
Geant4
arXiv:2410.22870
New model
Ian 512
w/ TF
w/ TF & Noise
Ian model
Models


Frobenius Norm Comparison with Geant4 for layer wise correlation
CaloINN
CaloScore
CaloDiffusion
CaloDream
Frobenius Norm with Geant4
0
1
2
3
4
5
6
7
Geant4
arXiv:2410.22870
New model
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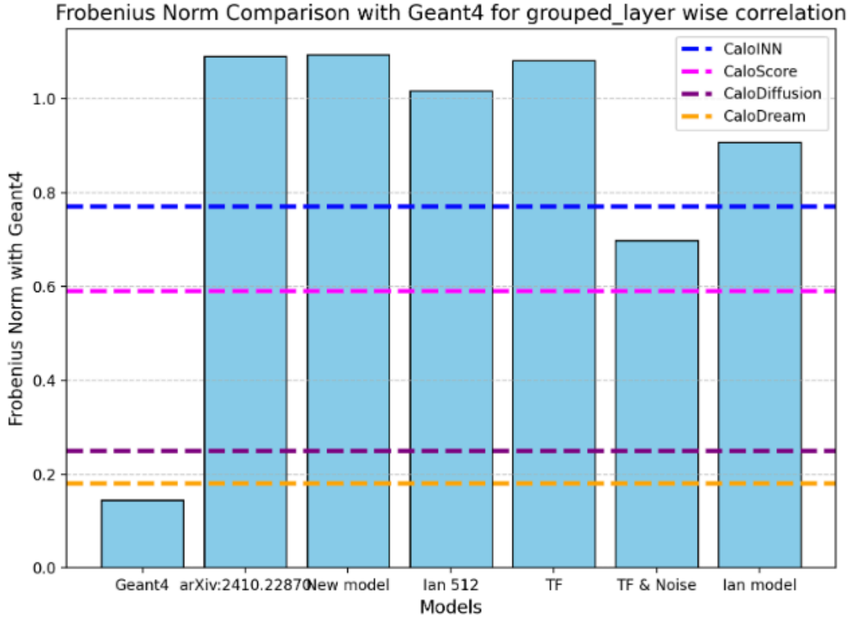
Models


Frobenius Norm Comparison with Geant4 for grouped_layer wise correlation
CaloINN
CaloScore
CaloDiffusion
CaloDream
Frobenius Norm with Geant4
0.0
0.2
0.4
0.6
0.8
1.0
Geant4
arXiv:2410.22870
New model
Ian 512
TF
TF & Noise
Ian model
Models

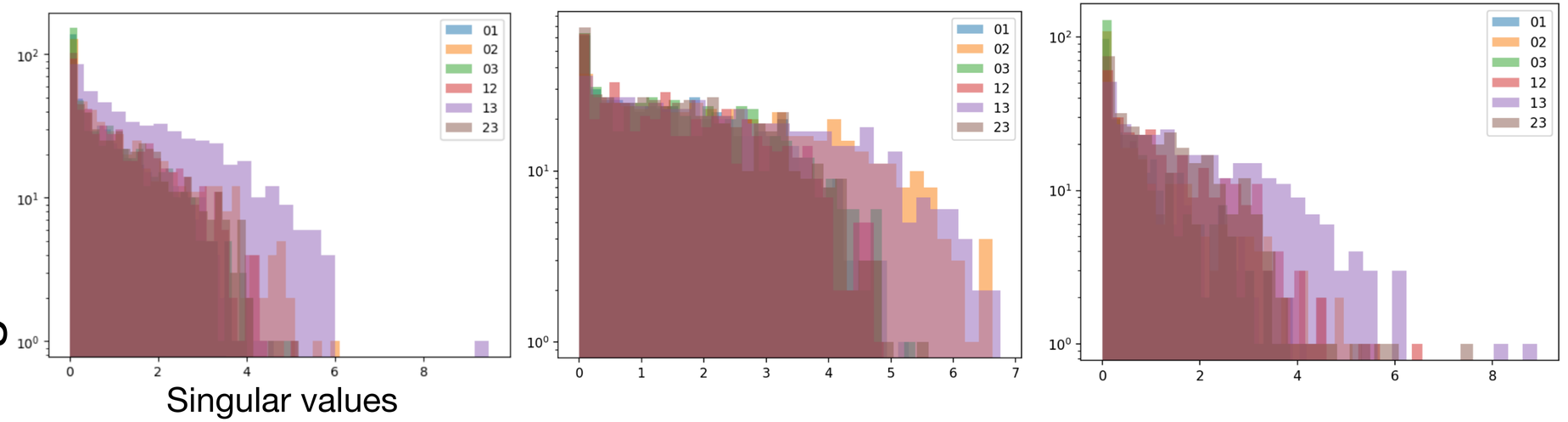
RBM singular values and weight distribution

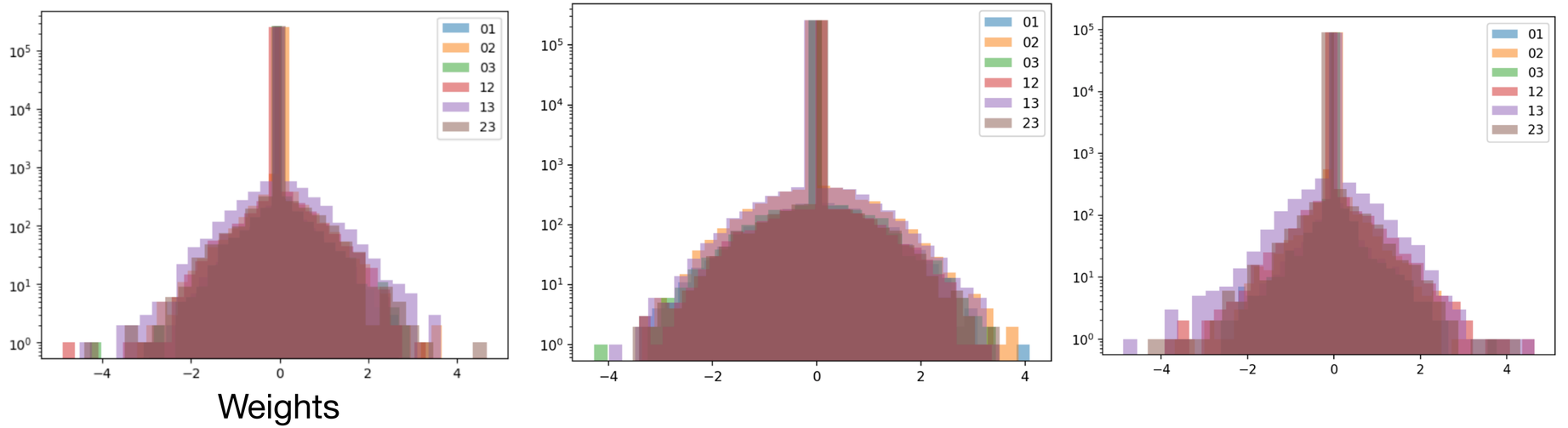
Trained 512

Non-Trained 512

Trained 302

Histogram

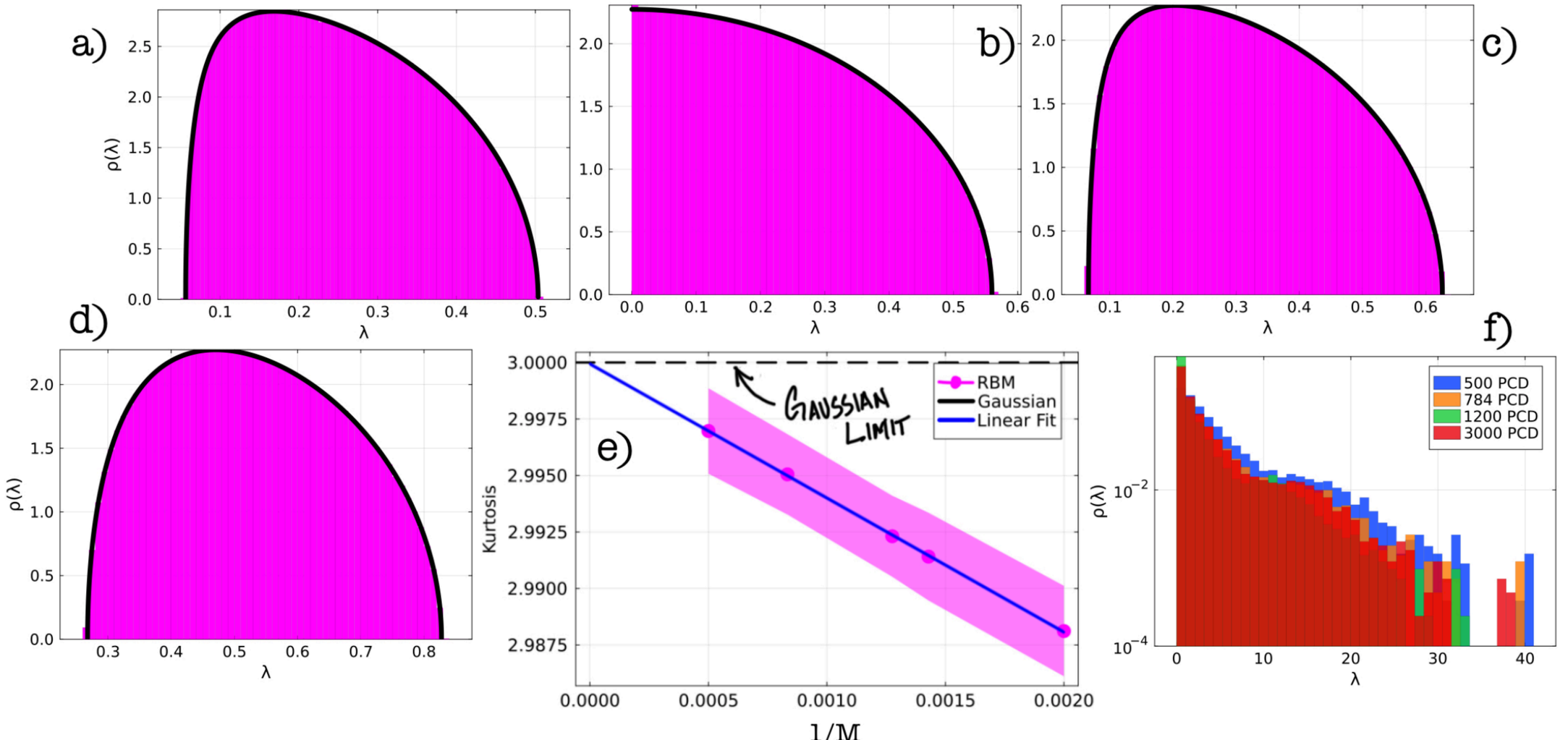




RBM singular values

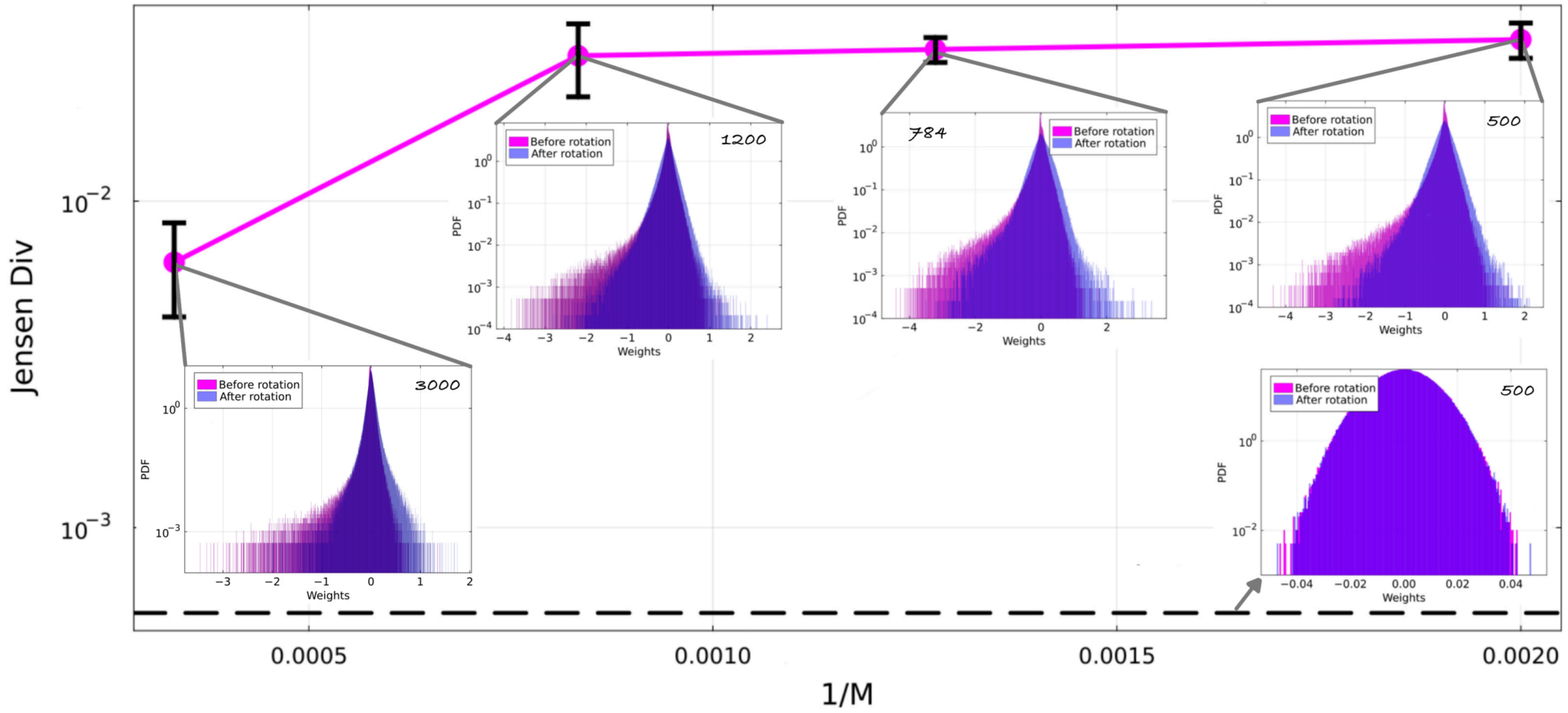
2-partite RBM non-trained and trained on MNIST

Histogram



RBM weight distribution

2-partite RBM non-trained and trained on MNIST



Some ideas on QAs

- Inverse temperature estimation. Teacher-student approach + replica method.
- Quantum training advantage(?). arXiv:2405.14689v4

$$\langle v_i v_j \rangle_{\mathrm{RBM}} \approx \frac{1}{Z} \int dh h^2 w_i w_j \exp\left(-\frac{N_\mathrm{v} h^2}{2} + \sum_k \frac{h^2 w_k^2}{2}\right) = w_i w_j \frac{1}{N_\mathrm{v}\left(1 - \sum_k w_k^2 / N_\mathrm{v}\right)},$$