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Amplifying Statistics with Ensembles of Generative Models

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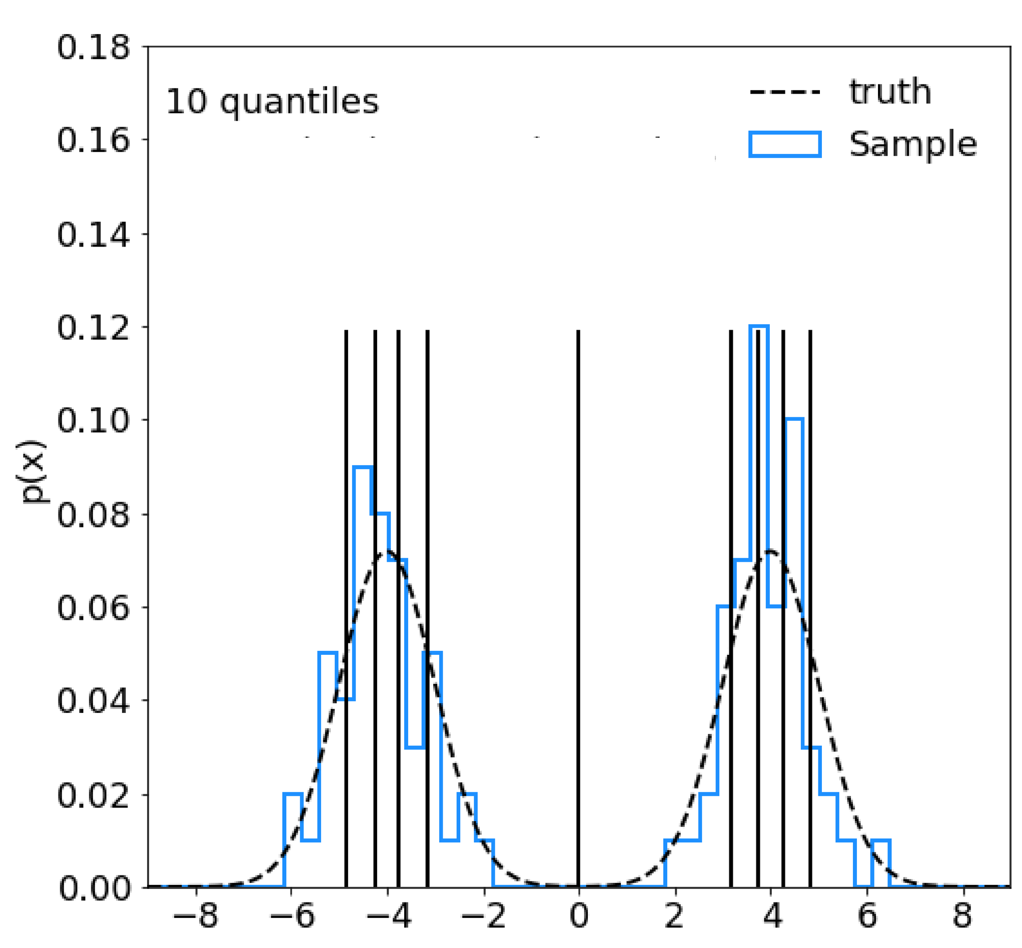
Introduction

- Deep generative models are used to accelerate or augment slow physics simulators.
- If you train a generator using N examples and produce M, what is the statistical power of the M examples?
- Test this using simplified dataset
- For more information see the full paper on arxiv

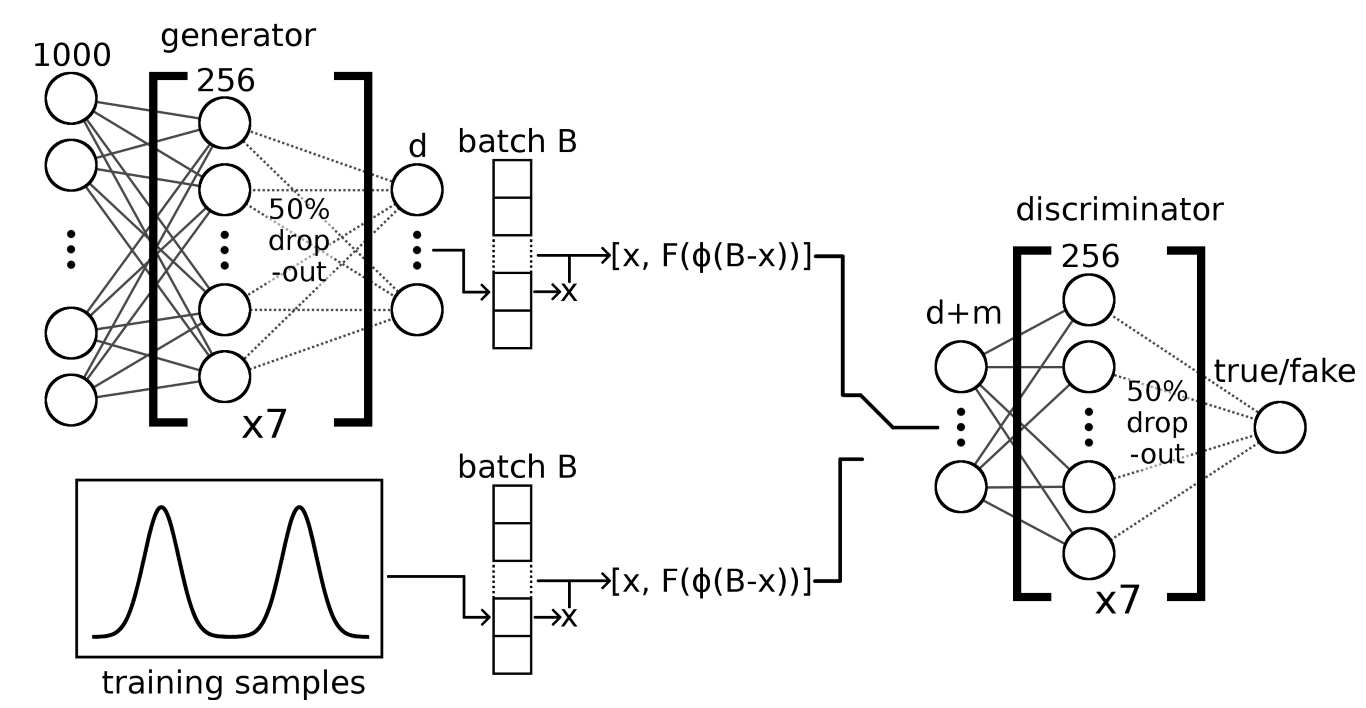
Dataset

- Camel back function
- Smooth multimodal distribution, common in physics
- Define K quantiles for comparison
  - Intervals that each contains equal probability



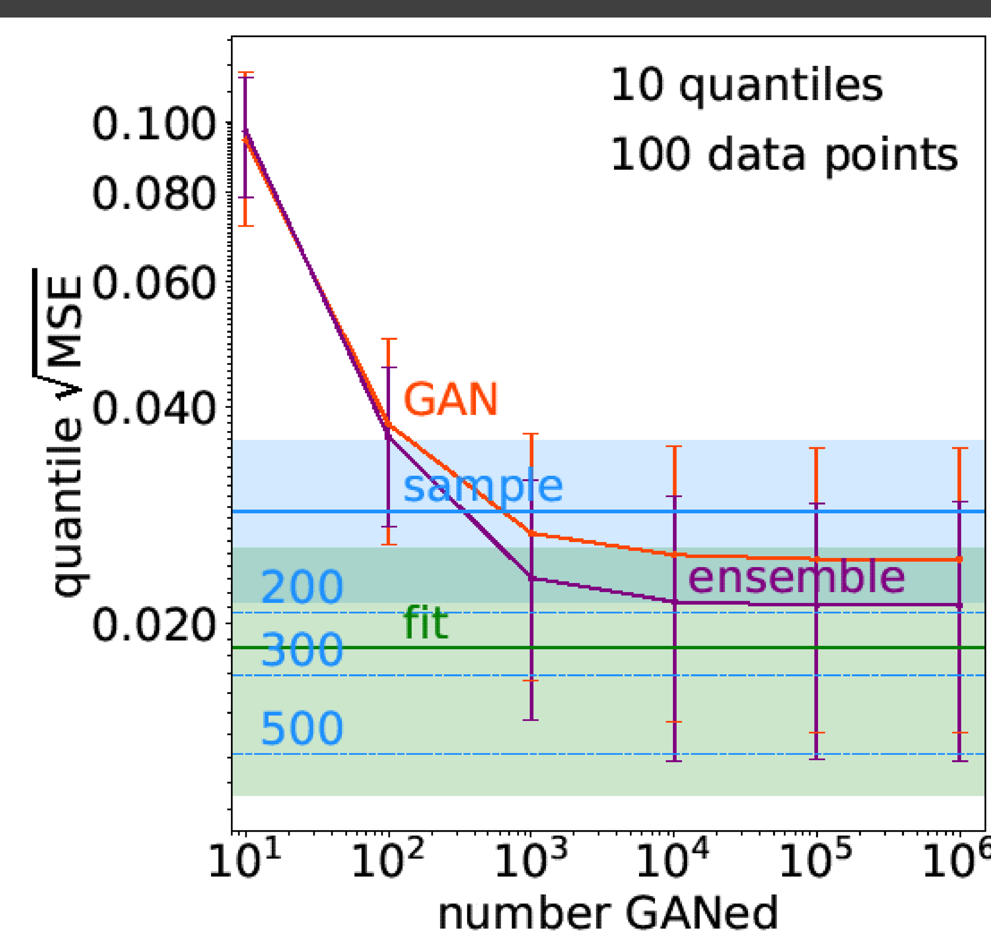
- Training sample: 100 camel back points
- Count points per quantile
- Compare quantile fractions to true values
- True fractions given by
- Baseline for comparison $\frac{1}{K_{\text{quant}}}$

Generative Model



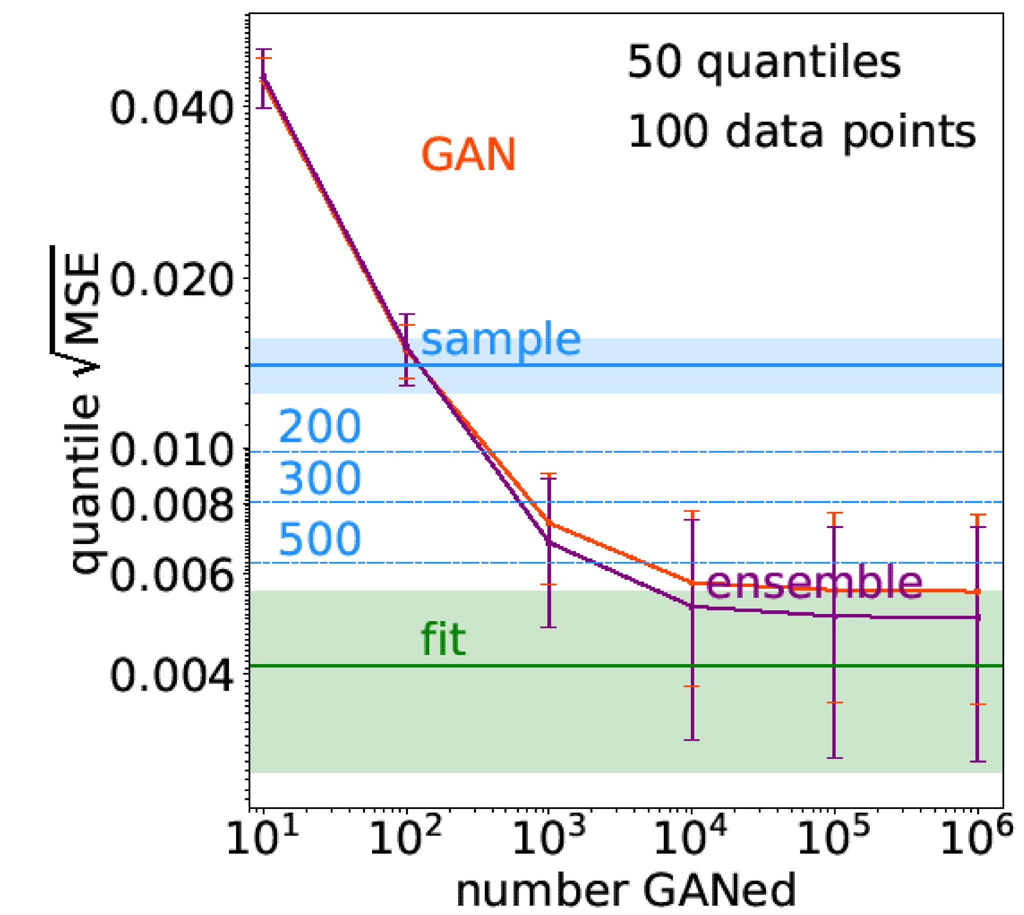
- Trained on 100 data points from training samples
  - Use regularization methods against overfitting (dropout, training noise, batch-statistics)
- Ensemble approach: train 10 independent GANs on exactly identical training data
- Calculate quantile fraction from GANed points
- Quantile MSE: $\frac{1}{K_{\text{quant}}}\sum_{j=1}^{K_{\text{quant}}}\left(x_j-\frac{1}{K_{\text{quant}}}\right)^2$

Results



- 50 training samples, 50 fits, 50 GANs
- 10,000 GANed points equal to 150 training points
- Interpretation in terms of information:
  - Sample: only data points
  - Fit: data + true function
  - GAN/ensemble: data + smooth function

- Assumption about smoothness adds information
- GAN can interpolate between points
- Interpolation allows for amplification
- Ensemble smooths out overfitting effects
- Better interpolation leading to better amplification
- More quantiles ➔ less points per quantile



- GAN interpolation more impactful for sparse data
- High dimensional data often sparse
- Promising approach for higher dimensions

Conclusion

- It makes sense to GAN significantly more events than we have in the training sample,
- Individual events carry less information than a training sample event.
- Net benefit, if the GAN sampling is sufficiently fast

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