

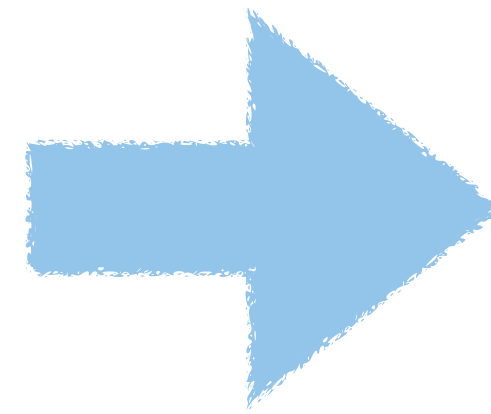
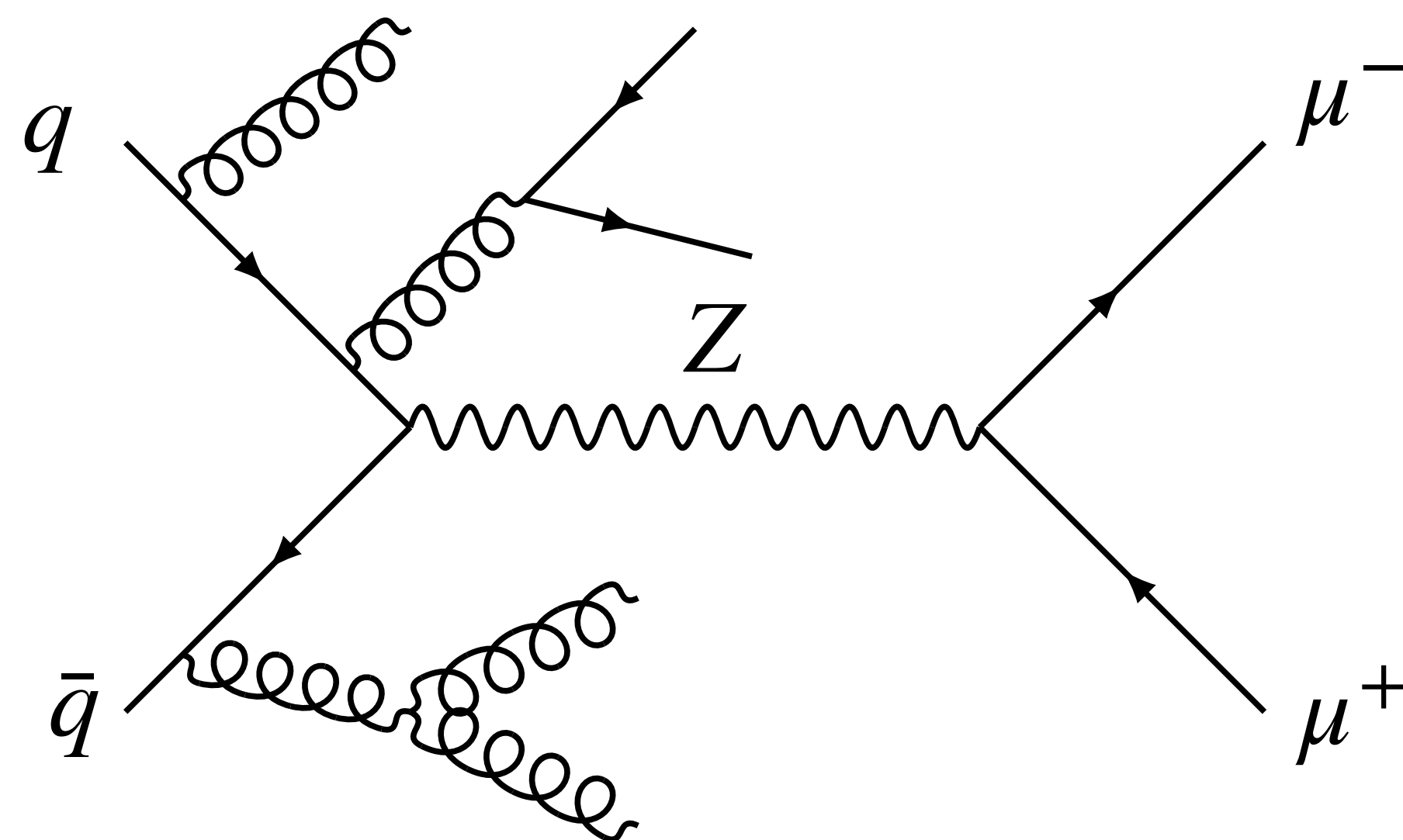


LHC Event Generation with JetGPT

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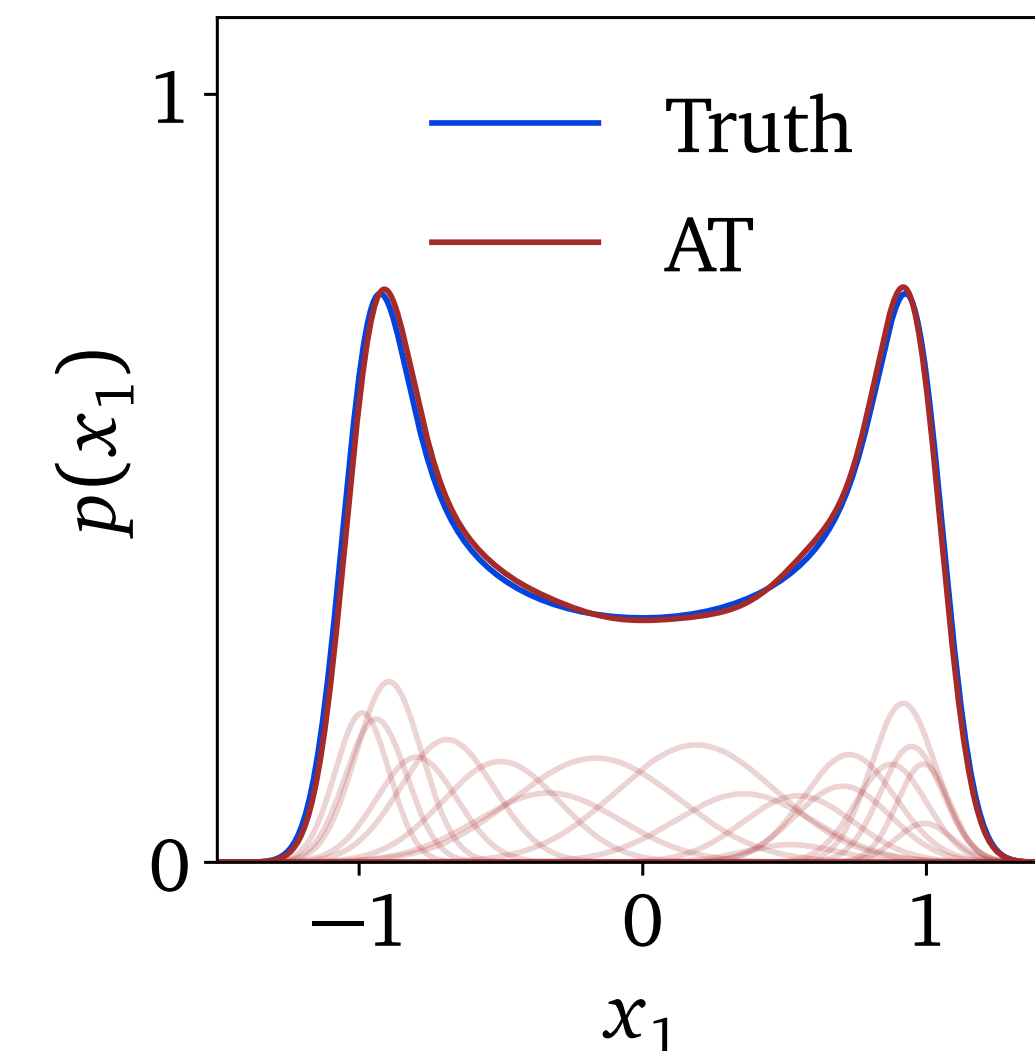
Physics problem

- **Fast** generation of LHC events
- Learn challenging correlations to **percent-level**
- **Transfer knowledge** from cheap low-multiplicity events to expensive high-multiplicity events



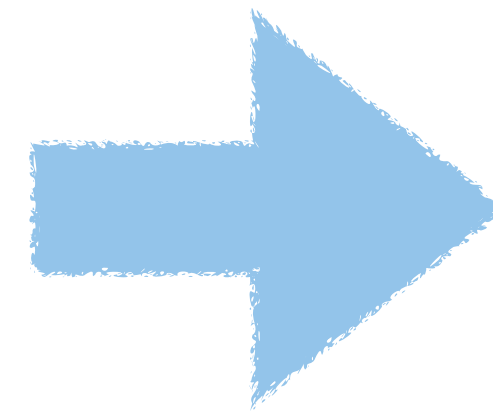
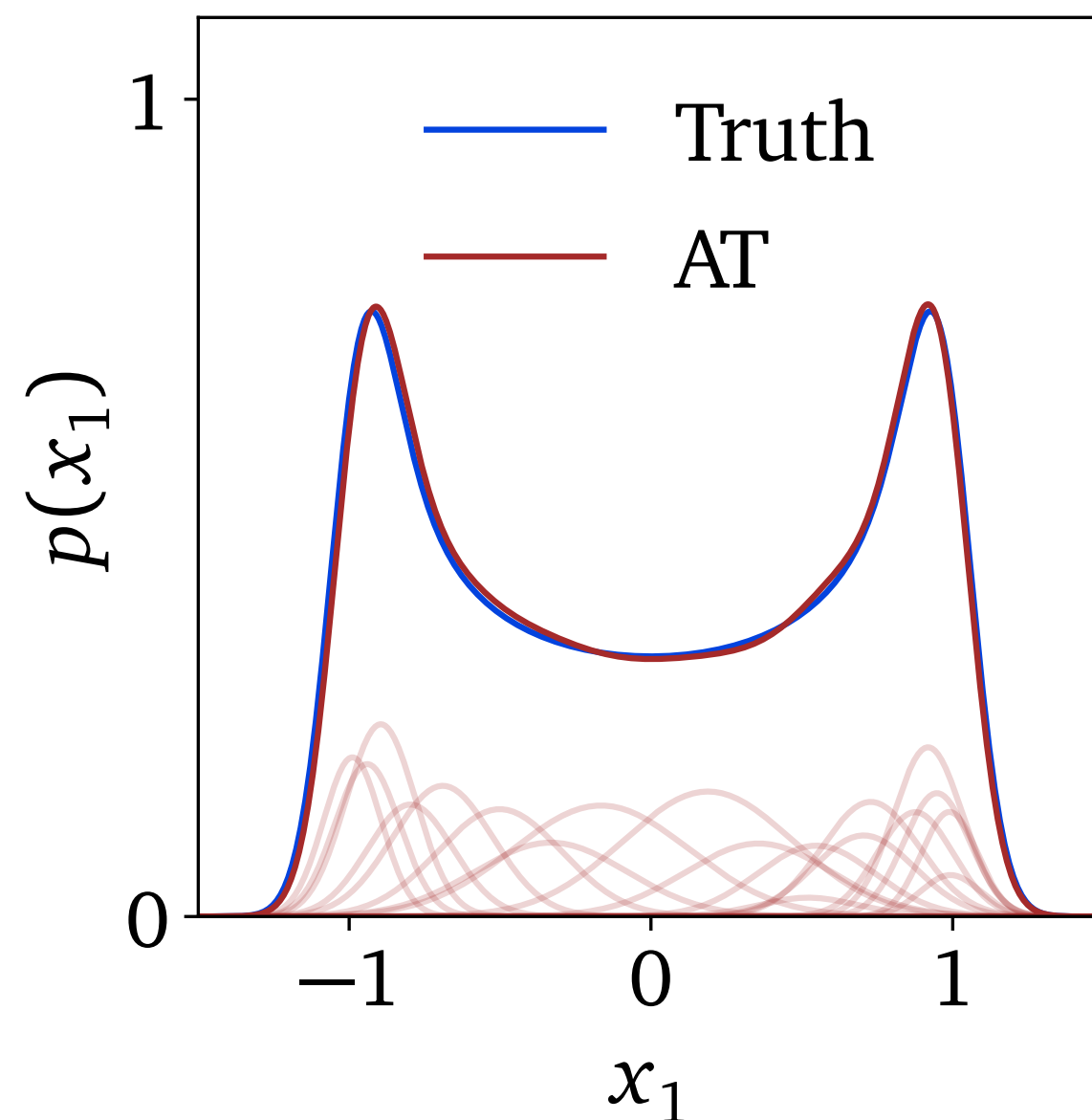
ML solution

- Autoregressive **transformer**
- **Gaussian Mixture Model** likelihood
- **Neural classifier** to locate and reweight remaining discrepancies



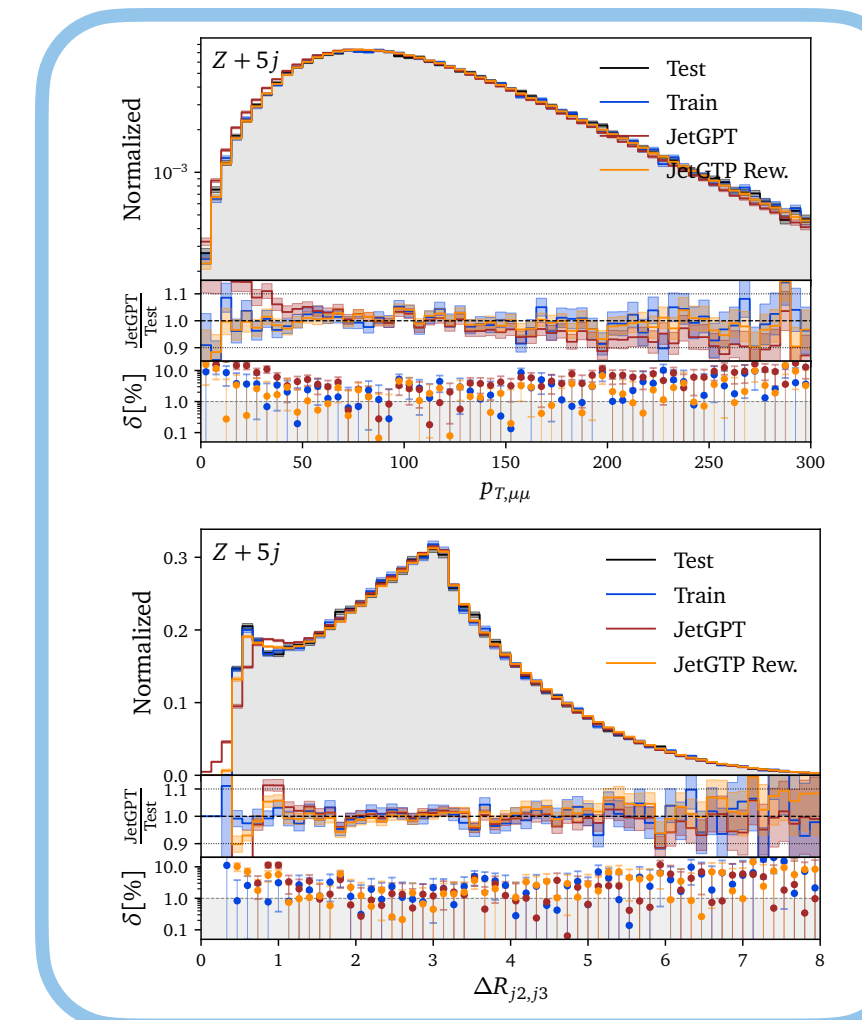
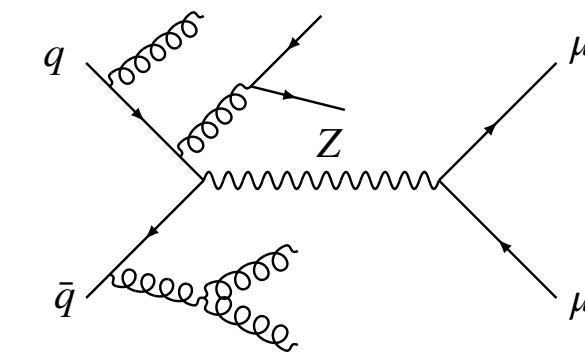
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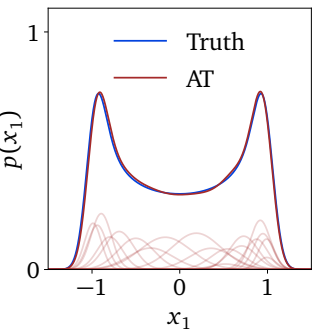
Results

- **Joint training** on different multiplicities enhances performance and allows knowledge transfer
- **Autoregressive ordering** gives a powerful handle to control which features the model should focus on
- Neural classifiers to **locate and reweight** remaining discrepancies

Autoregressive Transformer

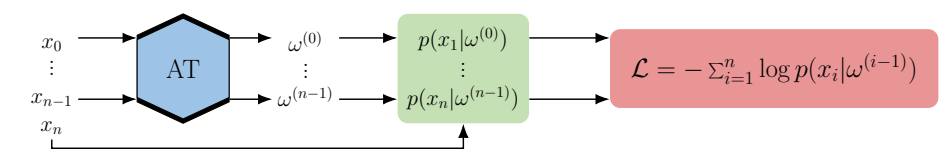
- Autoregressive **Gaussian Mixture Model**

$$p(x_1, x_2, \dots, x_n) = p(x_1)p(x_2|x_1)\dots p(x_n|x_{n-1}) = p(x_1|\omega^{(0)})p(x_2|\omega^{(1)})\dots p(x_n|\omega^{(n-1)})$$

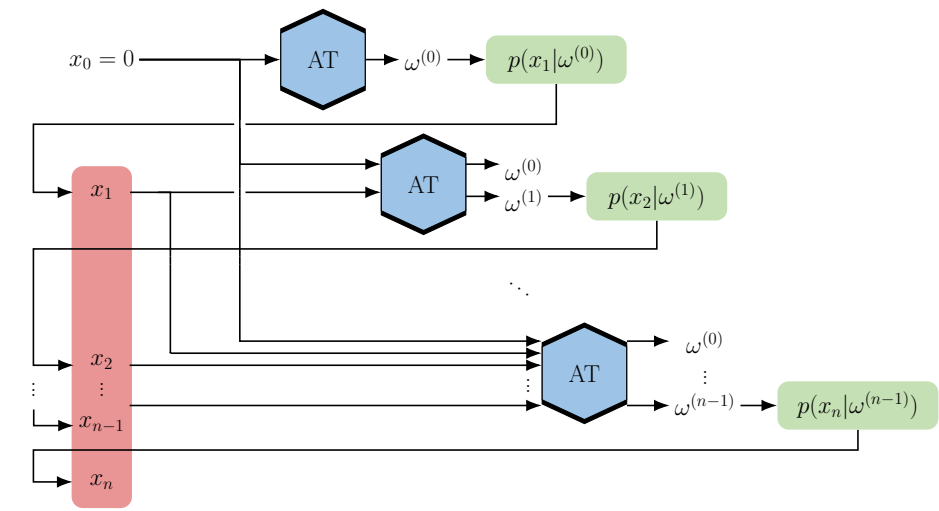


$$p(x_{i+1}|\omega^{(i)}) = \sum_{j=1} w_j^{(i)} \mathcal{N}(x_{i+1}|\mu_j^{(i)}, \sigma_j^{(i)}) \quad \omega^{(i)} = \{w_j^{(i)}, \mu_j^{(i)}, \sigma_j^{(i)}\}$$

- Training: **Parallellised density estimation**



- Generation: **Autoregressive** sampling from one-dimensional distributions



Classifier Control

- Neural classifiers approximate the **likelihood ratio**
- **Locate** discrepancies: Likelihood ratio as test statistic
- **Reweight** discrepancies: Likelihood ratio as weighting factor

