Improving Λ Signal Extraction with Domain Adaptation via Normalizing Flows

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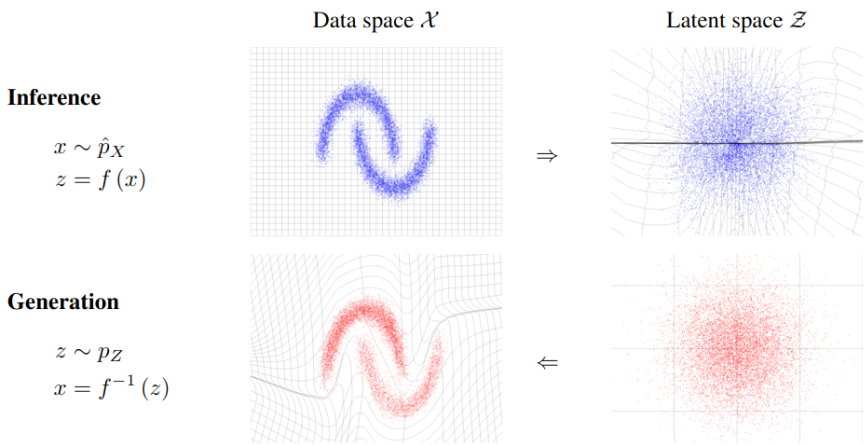
Normalizing Flows

- Normalizing flows (NFs) are generative models that **learn the probability density function of a complex distribution.**
- NFs transform samples from a complex probability distribution to a simple distribution via a sequence of **invertible, differentiable functions.**
- Calculate log-likelihood from change of variables formula
  - Train network by **minimizing negative log-likelihood**



Idea

- Lambdas: important for studying Baryon spin structure
  - Decay before detection, need to be reconstructed based on decay products:
  - $\Lambda \rightarrow p + \pi^-$
- Neural networks can help identify which $p\pi^-$ pairs are signal and background (classifier)
  - Classifiers struggle due to differences between MC and data
- If data looks more like MC, classifiers may perform better: **Need to transform data to MC domain before classification**

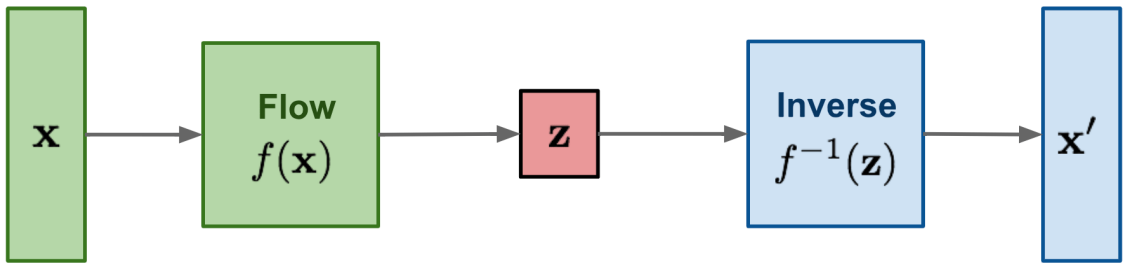


Figure: Transformation process

Applying GNNs to Λs

- Extract latent representation with Graph Neural-Network (GNN)
- Classify signal/bg with classifier on latent space

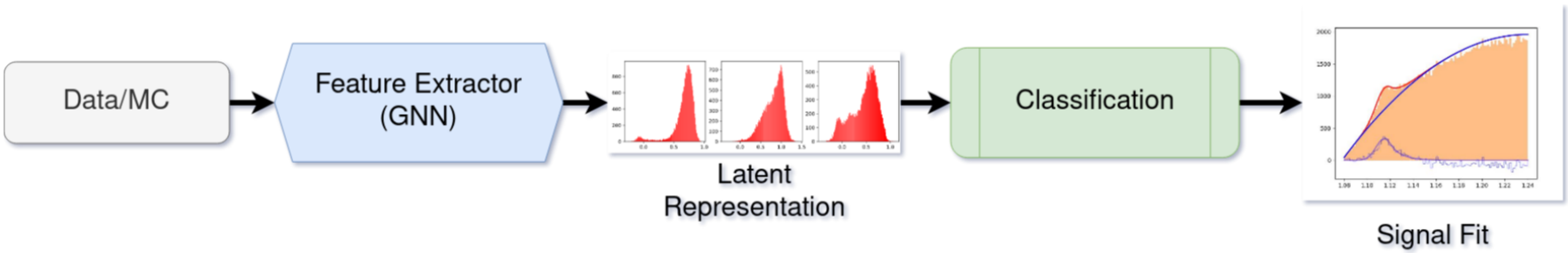
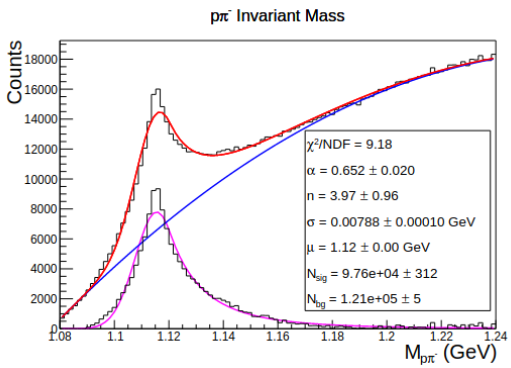
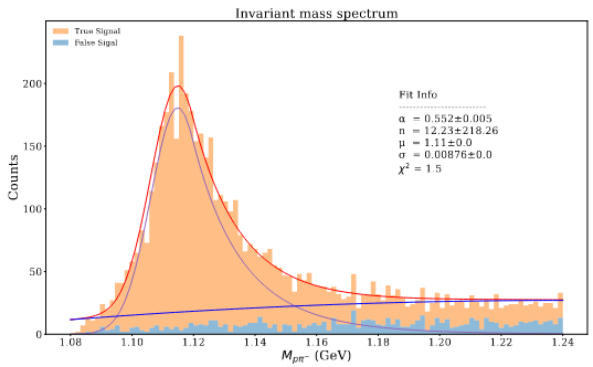


Figure: GNN Lambda ID Process



(a) Normal MC



(b) GNN Applied

Adding Normalizing Flows to GNN

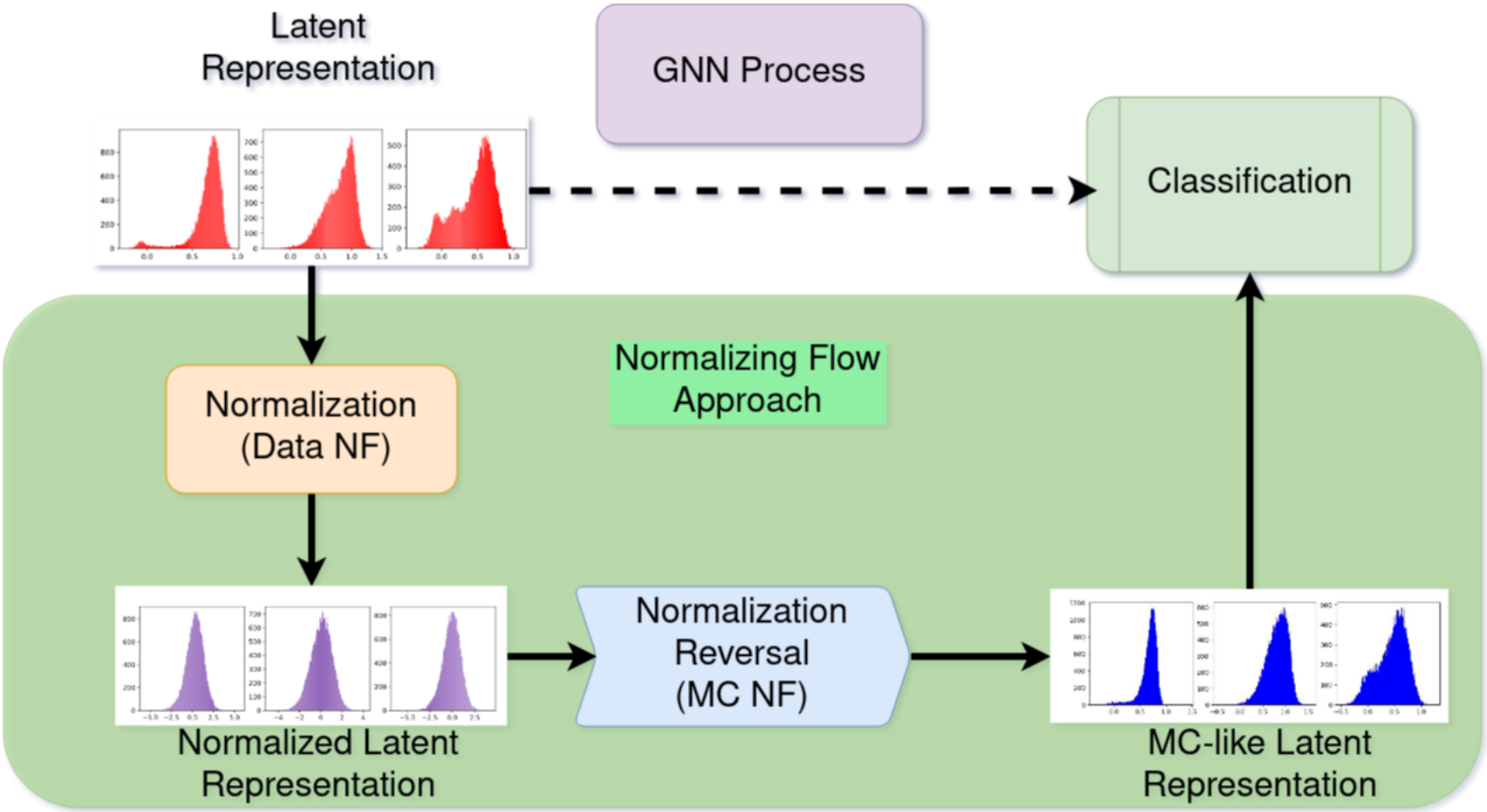


Figure: Normalizing Flow on GNN output

Results

- Calculated figure of merit ($FOM = N_{sig}/\sqrt{N_{tot}}$) through signal fit
- FOM curve **flattened** after transformation
  - **Improved generalizability** as FOM depends less on cut

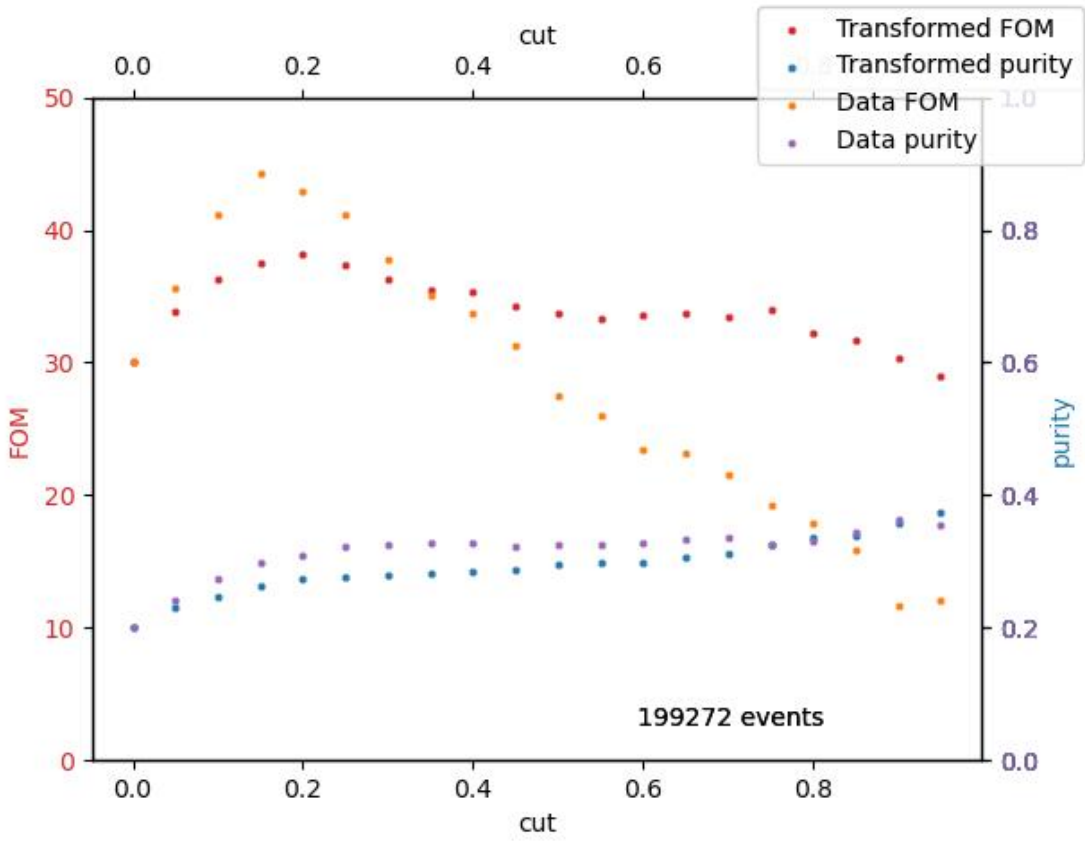


Figure: FOM and purity as functions of classifier cut