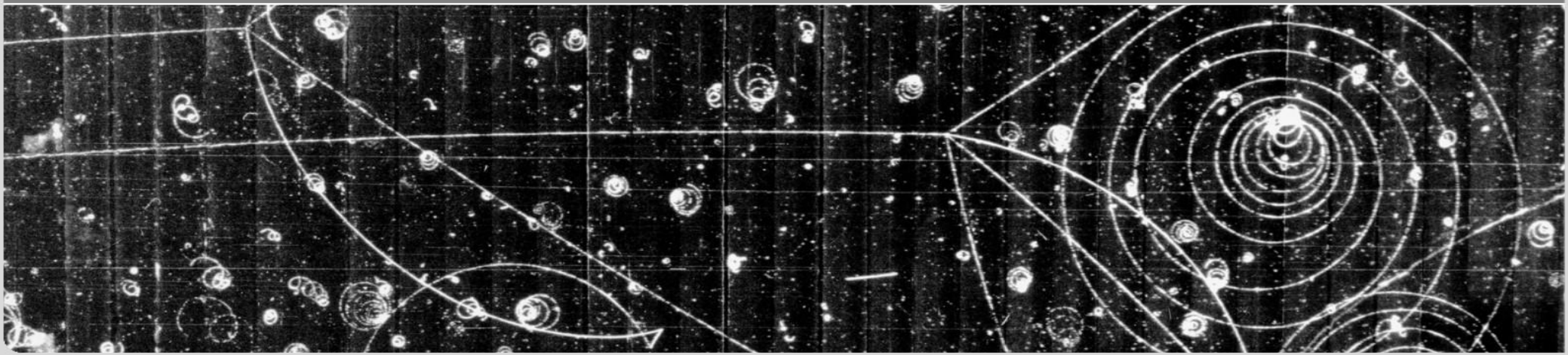
Karlsruhe Institute of Technology

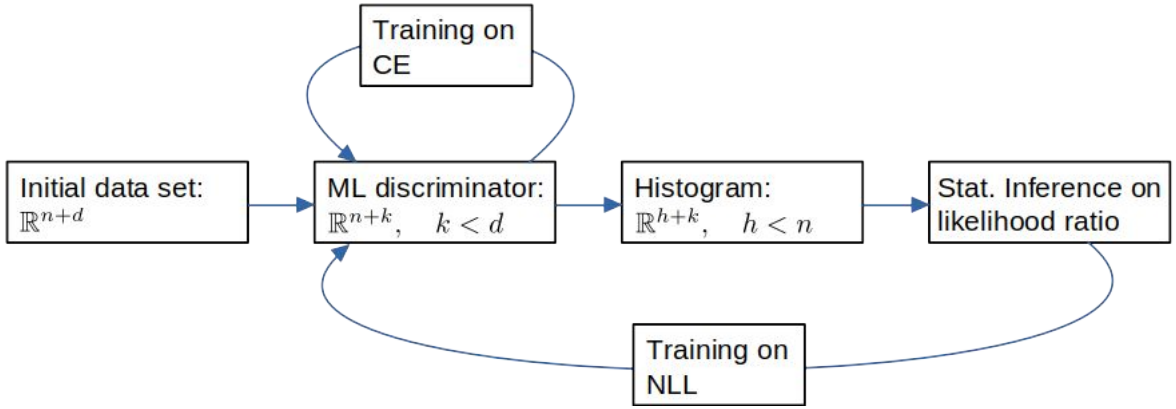
ML Projects at ETP - CMS

Lars Sowa et al.

Institute for Experimental Particle Physics



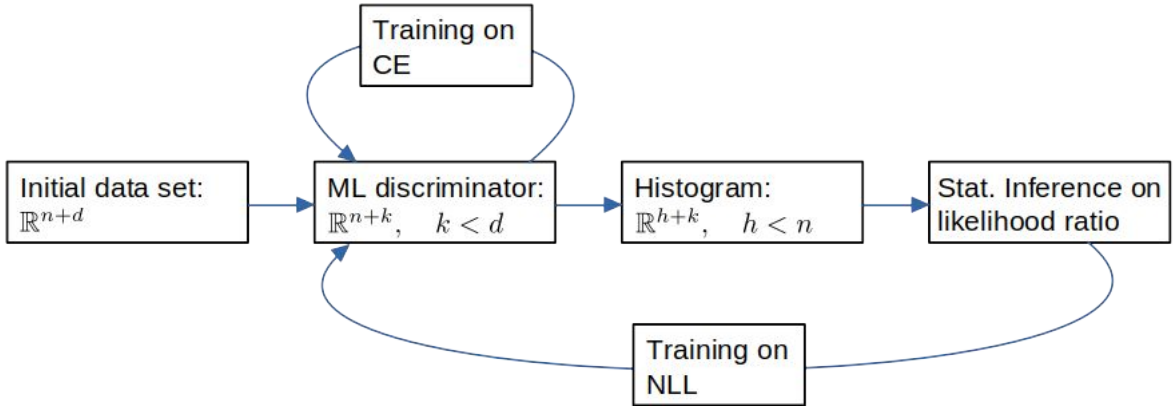
Systematic-Aware Training



Reduce systematic uncertainties with NLL training

$$\mathcal{L}(\boldsymbol{\theta}) = \prod_{i=1}^{h} \mathcal{P}(d_i|\mu s_i + b_i + \eta\Delta_i) \cdot \mathcal{N}(\eta)$$

Systematic-Aware Training



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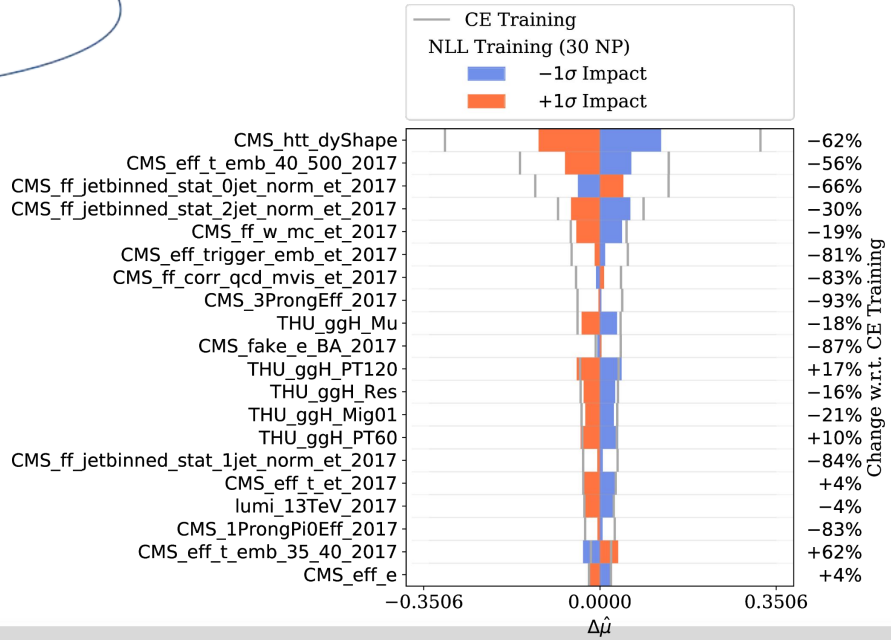
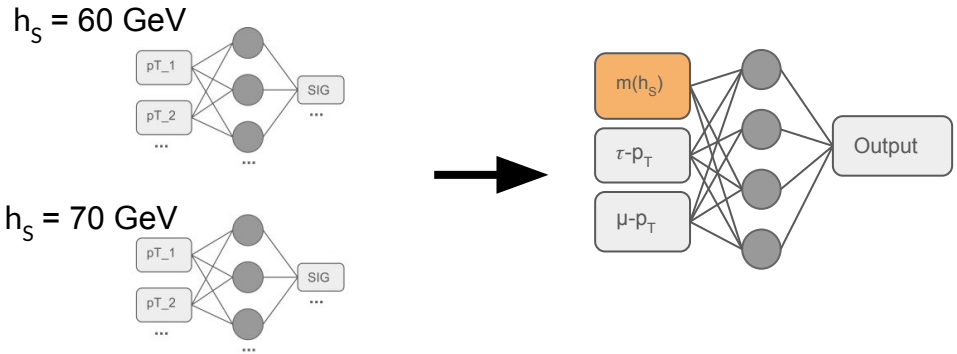
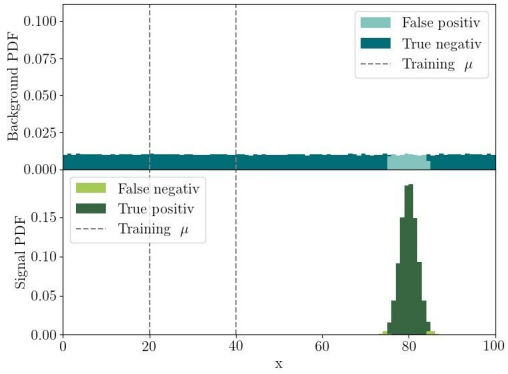


Parametric Neural Networks (PNNs) for NMSSM Studies

- Use PNNs for large ranges of signal hypotheses

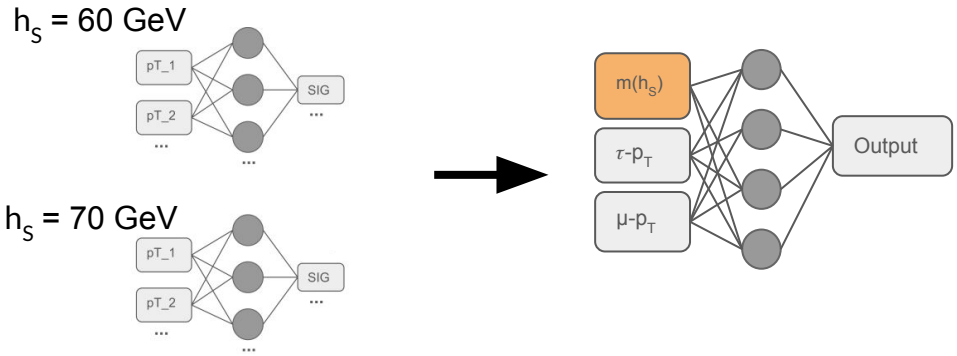


- Reduce training effort
- Great inter-/extrapolation



Parametric Neural Networks (PNNs) for NMSSM Studies

- Use PNNs for variable scans



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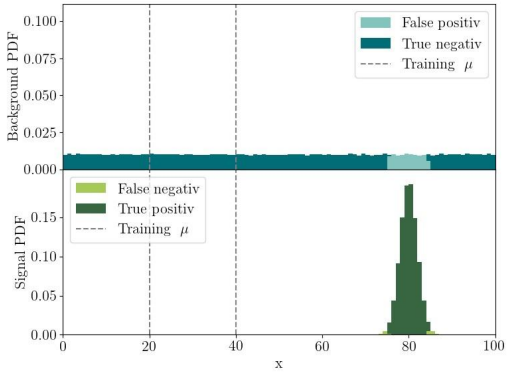
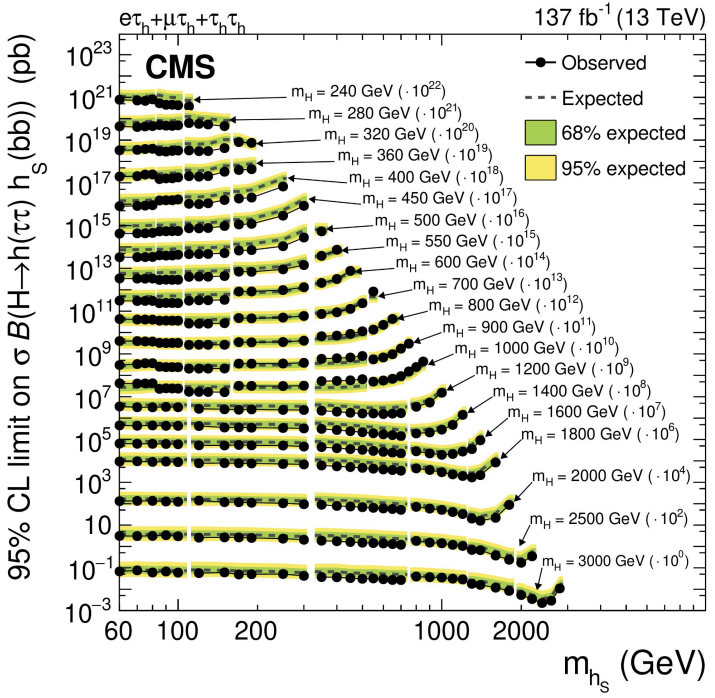
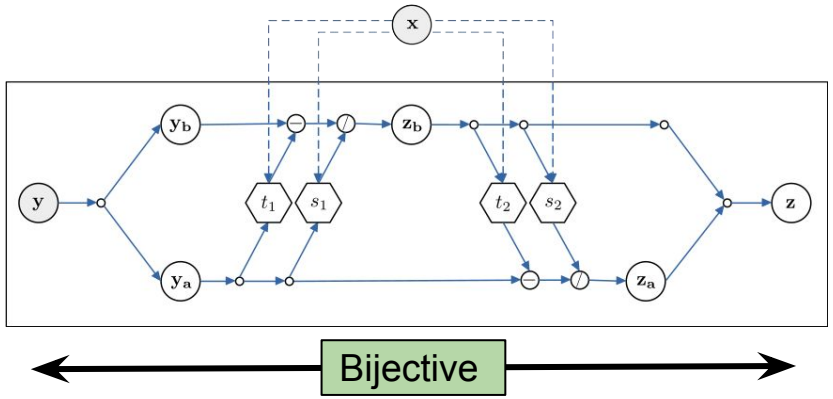
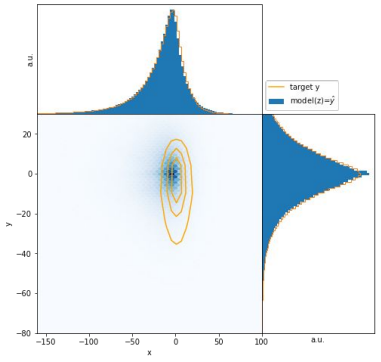
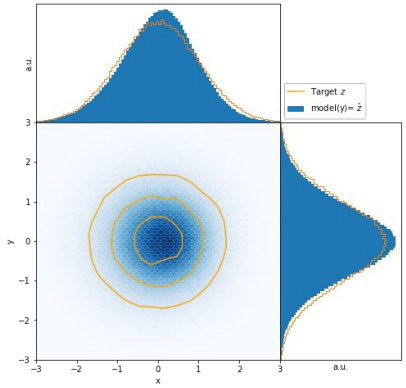




Normalizing Flows





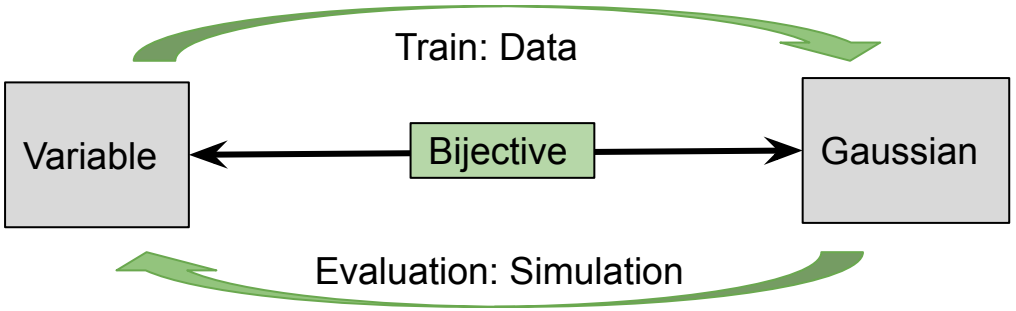


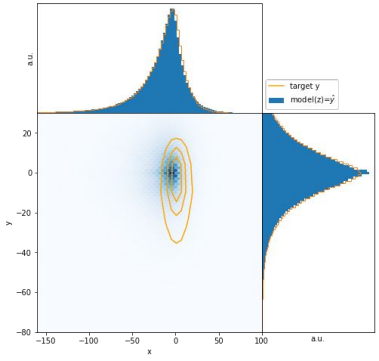
- Learn bijective and probability-preserving functions
- Bonus: use conditions x

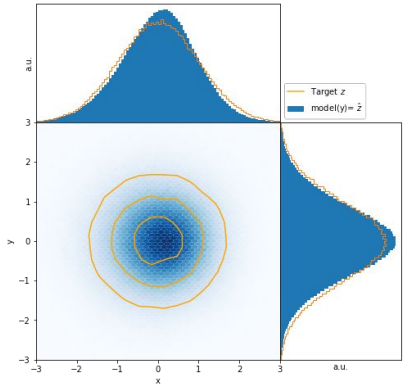
  → Unfolding

- Example: Fix mismatch between simulation and data

Normalizing Flows







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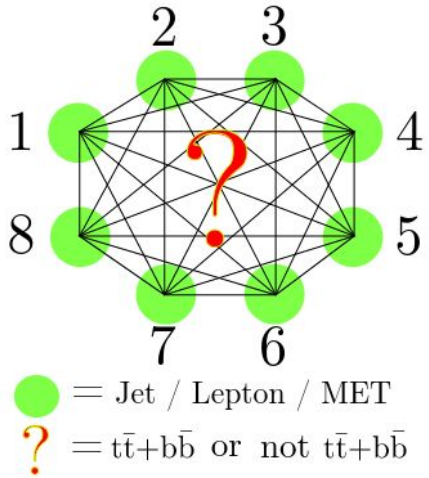
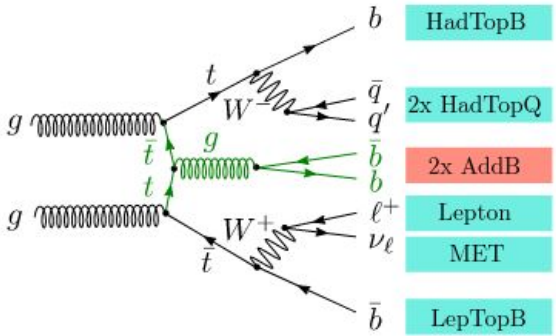
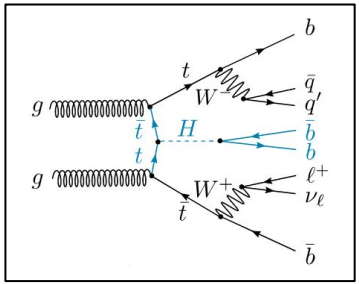
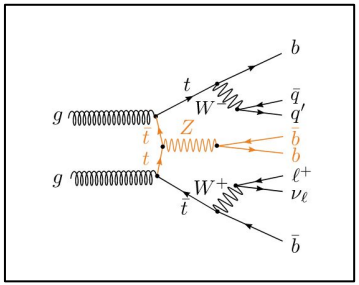
Graph Neural Networks for Identification Tasks

Graph level classification for tt+X processes



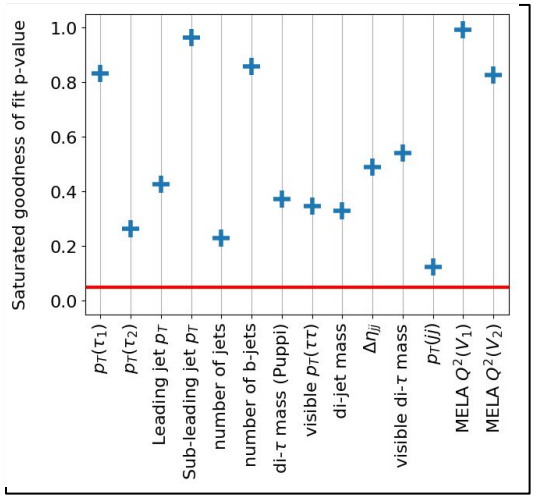


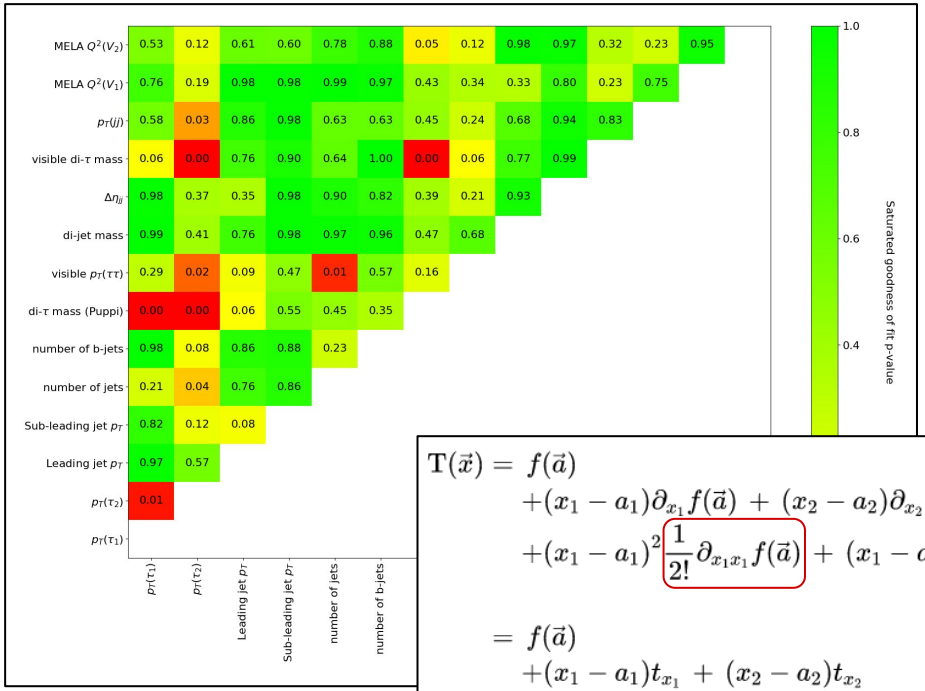




Interest in Automatized Input Space Validation

Automatized way of validating and understanding NN feature spaces, based on objective statistical measures (e.g. here based on >1200 GoF tests):

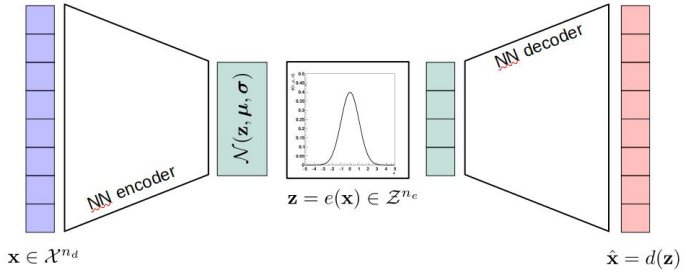




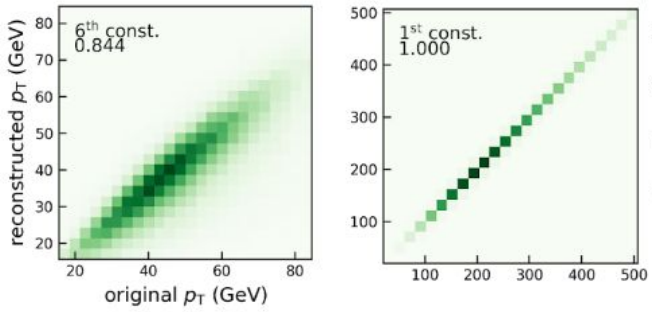
$$
\begin{aligned}
\mathrm{T}(\vec{x}) = \; & f(\vec{a}) \\
& + (x_1 - a_1)\partial_{x_1} f(\vec{a}) + (x_2 - a_2)\partial_{x_2} f(\vec{a}) \\
& + (x_1 - a_1)^2 \frac{1}{2!}\partial_{x_1 x_1} f(\vec{a}) + (x_1 - a_1)(x_2 - a_2)\,\partial_{x_1 x_2} f(\vec{a}) + (x_2 - a_2)^2 \frac{1}{2!}\partial_{x_2 x_2} f(\vec{a}) \\
= \; & f(\vec{a}) \\
& + (x_1 - a_1) t_{x_1} + (x_2 - a_2) t_{x_2} \\
& + (x_1 - a_1)^2 t_{x_1 x_1} + (x_1 - a_1)(x_2 - a_2)\, t_{x_1 x_2} + (x_2 - a_2)^2 t_{x_2 x_2}
\end{aligned}
$$

Further Interest in Probabilistic Generative NNs

- GANs or VAEs for FastSim Projects (HL-LHC)



- Anomaly detection



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Thank you for your attention!