Machine learning approaches for parameter reweighting in MC samples of top quark production in CMS

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Reweighting with a Machine Learning (ML) classifier:

For LHC analyses Monte Carlo (MC) samples of simulated events needed

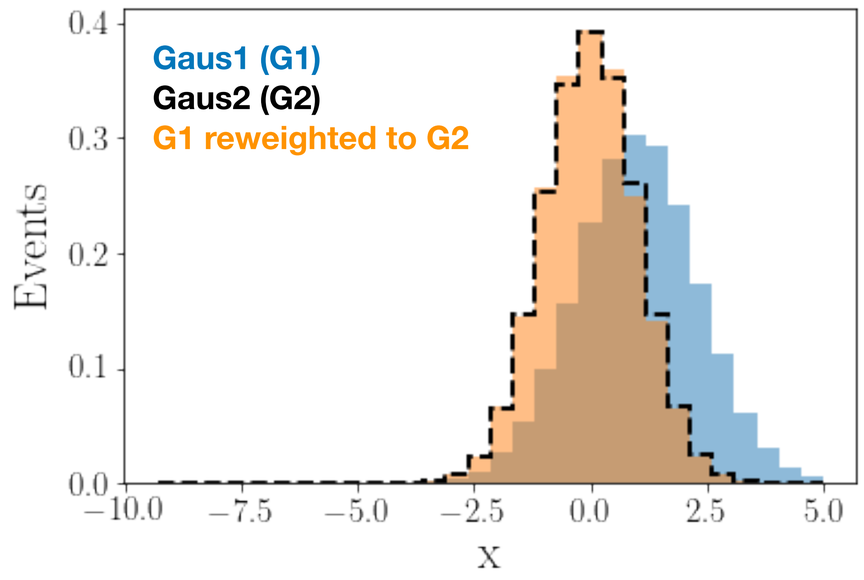
- Work-flow process:
  1. Generation of the physics event → ~1 minute
  2. Simulation of the detector → ~several minutes
- Alternative samples needed to evaluate systematic uncertainties
  → High computational cost

➡ **Reweighting** nominal sample avoids need of simulating detector response many times

New approach: Deep neural network using Classification for Tuning and Reweighting **(DCTR),** PRD 101, 091901 (2020)

Benefits ML reweighting (DCTR)

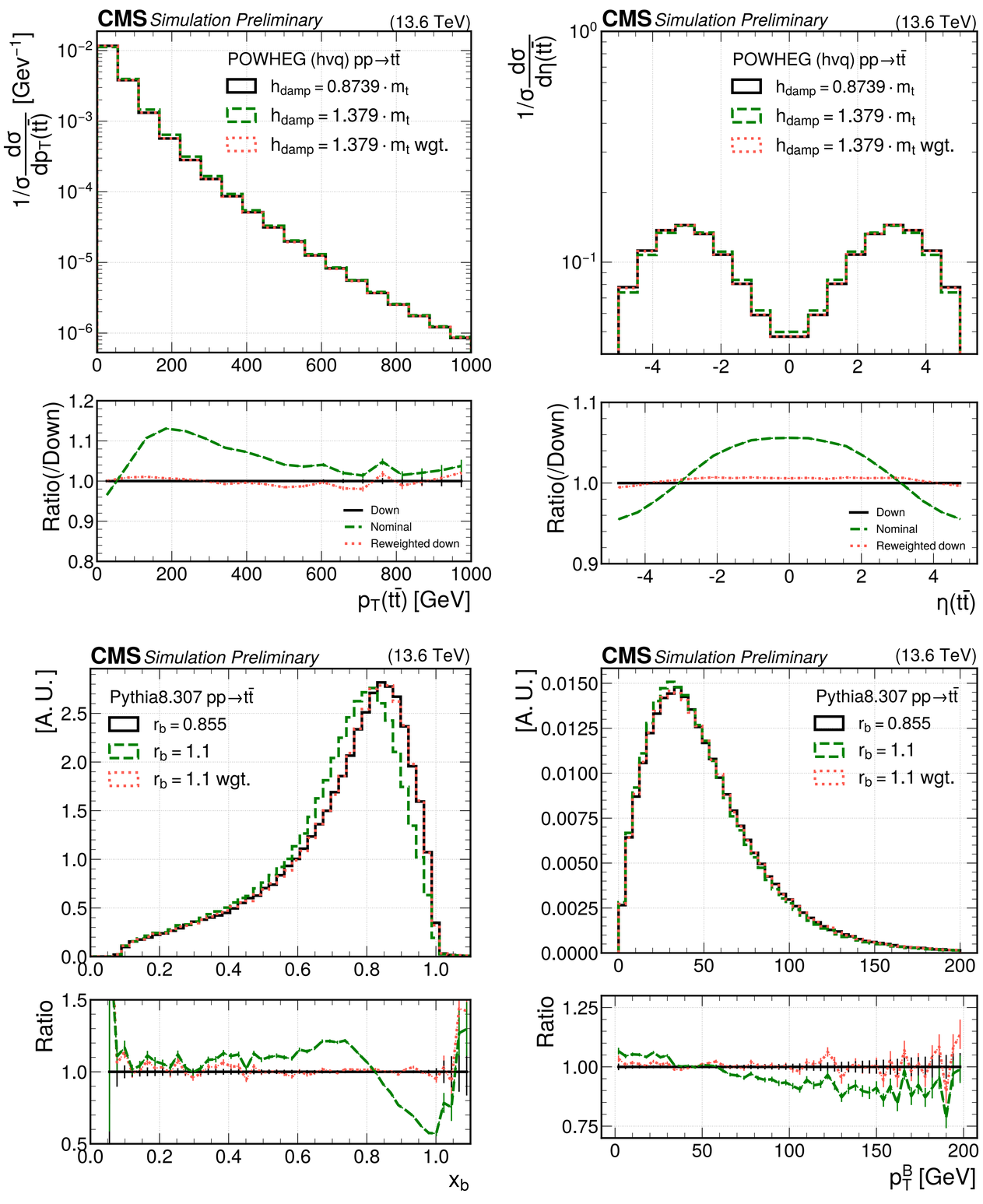
- **Multidimensional** and **unbinned** information
- **Continuous** as function of any MC parameter



Top analysis application in $t\bar{t}$ analyses:

Reweight two different classes of systematics

- h_{damp}
  - Controls resummation of NLO radiation
  - Two point like
- **B-fragmentation**
  - Energy fraction of b jet that comes from B hadron
  - Continuous

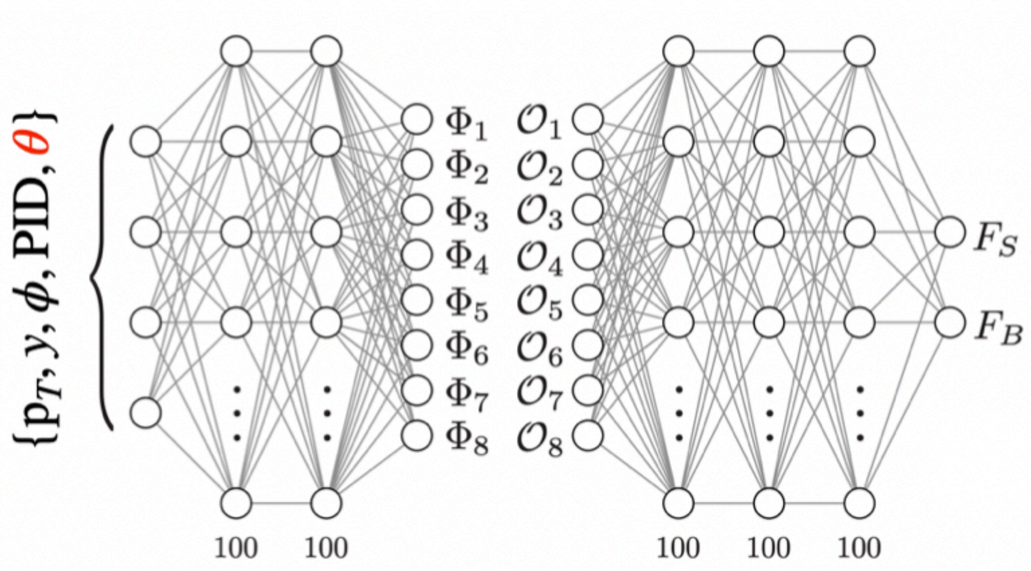


Neural Network architecture:

Particle Flow Network

- **Parton level information** as inputs to DCTR:

  4-vector (pT, y, φ, m) and particle PID (top, antitop)



$$f(\{p_i\}) = F\left(\sum_{i=1}^{n} \Phi(p_i)\right)$$

Results and conclusions:

The method found to work very well!

- **Method closure within 2%**
- h_{damp} variations can be computed with DCTR
- Method also tested on **B-fragmentation,** where **continuous reweighting** found to work very well

Method implemented into CMS software framework for both h_{damp} and B-fragmentation

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