FAIR Universe

HiggsML Uncertainty Challenge

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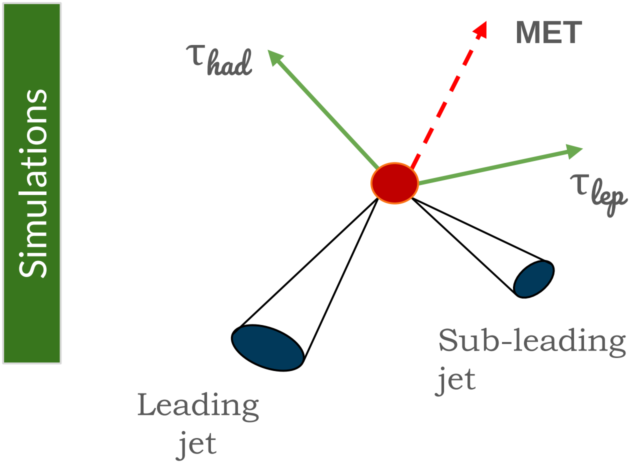
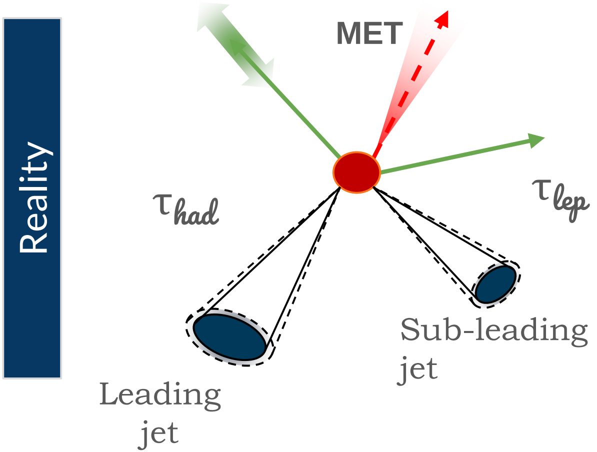
European AI for Fundamental Physics Conference
2025 - Cagliari, Sardinia Italy

Bias and uncertainty in Higgs Physics

At the LHC we analyse proton collision with specific final state Eg. evidence for the higgs boson





Search for : $H \rightarrow \tau^{+}\,(had, \nu)\,\tau^{-}(l\,, \nu, \nu)$

- **There are possible biases**
- **Eg. In calibration of particle energy**

Many methods developed, but **NO Common Benchmark**

Fair Universe: HiggsML Uncertainty Challenge

FAIR UNIVERSE - HIGGS UNCERTAINTY CHALLENGE

160 PARTICIPANTS

347 SUBMISSIONS

A pool of 4000 USD

https://www.codabench.org/competitions/2977/

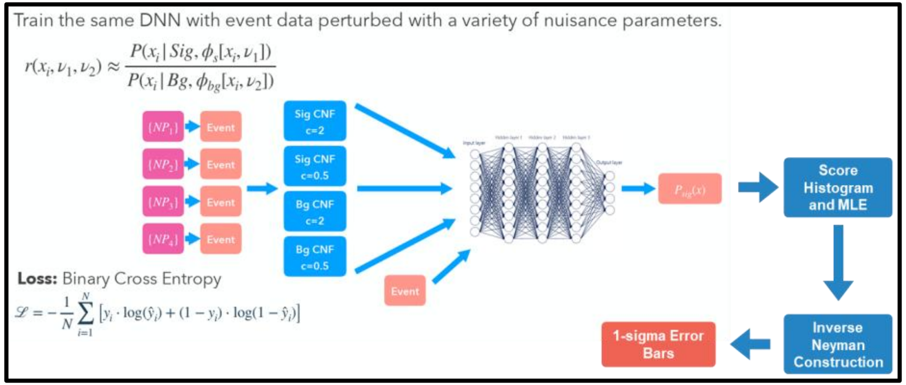
- Ran from September 12 to March 14th
- Accepted as NeurIPS competition 2024
- Dedicated workshop at NeurIPS - 2024
- Final results presented last month at CERN (satellite event of IML - 2025)

- **NEW** Simulated dataset -220M events, 28 features: https://zenodo.org/records/15131565
- **6 Parameterized systematics**
- **Metric** : Signal strength (μ) and Confidence Interval
- **Inference** : With pseudo-experiment

Winners

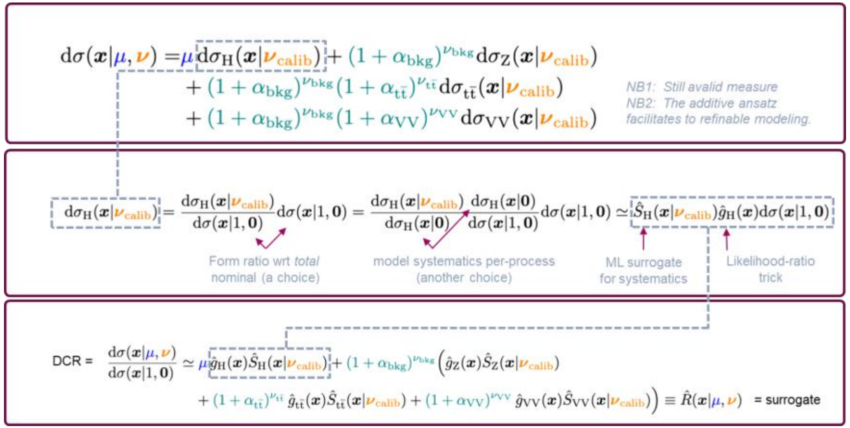
Contrastive Normalizing Flow (CNF) - Ibrahim

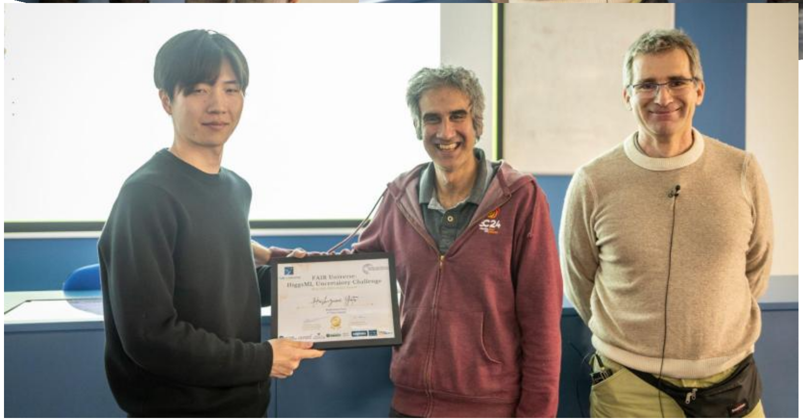
- Trains CNFs on augmented data
- Trained CNFs to produces bias-free variables
- New Variables Used to Train the DNN



Unbinned measurements with refinable systematics - HEPHY

- Based on tradition histogram analysis in LHC
- Build ML surrogate for estimating systematics
- Uses these ML surrogates for μ estimation





Thank you for your attention!

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