Universität Hamburg
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FAKULTÄT
FÜR MATHEMATIK, INFORMATIK
UND NATURWISSENSCHAFTEN

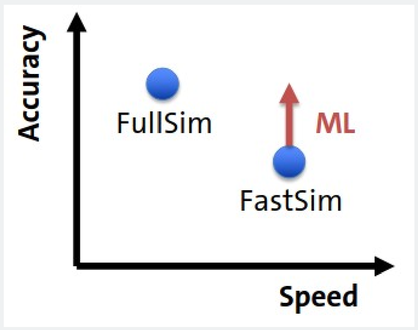
REFINING CMS FAST SIMULATION USING MACHINE LEARNING

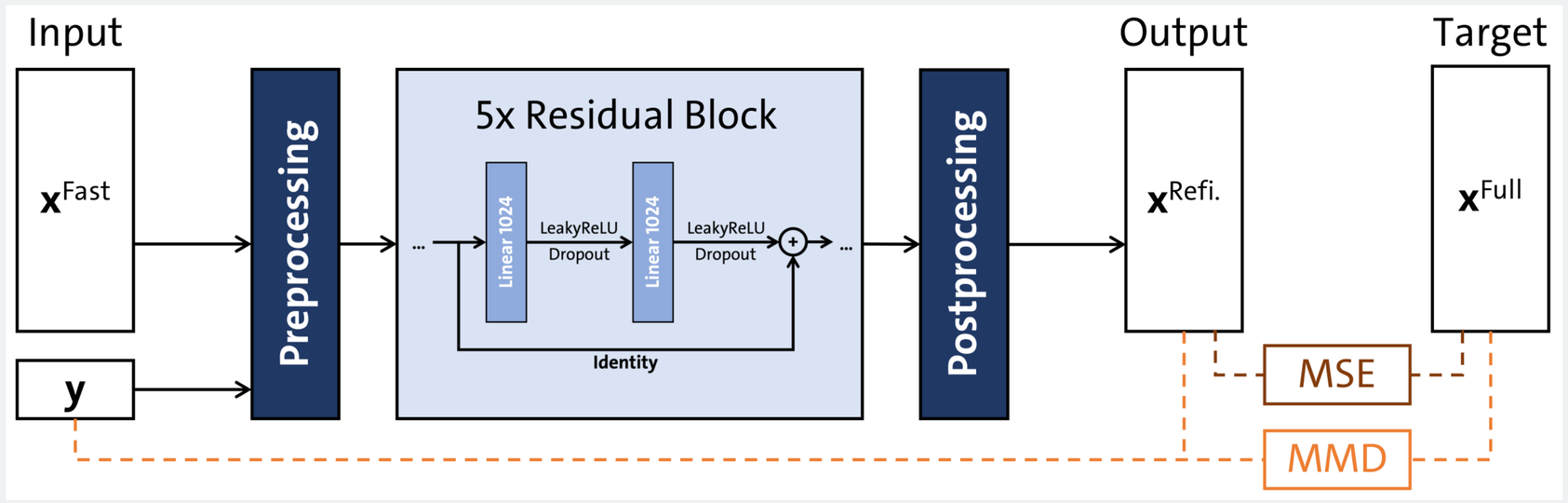
Moritz WOLF, Lars STIETZ, Peter SCHLEPER, Patrick L.S. CONNOR,
Samuel BEIN on behalf of the CMS Collaboration

Motivation

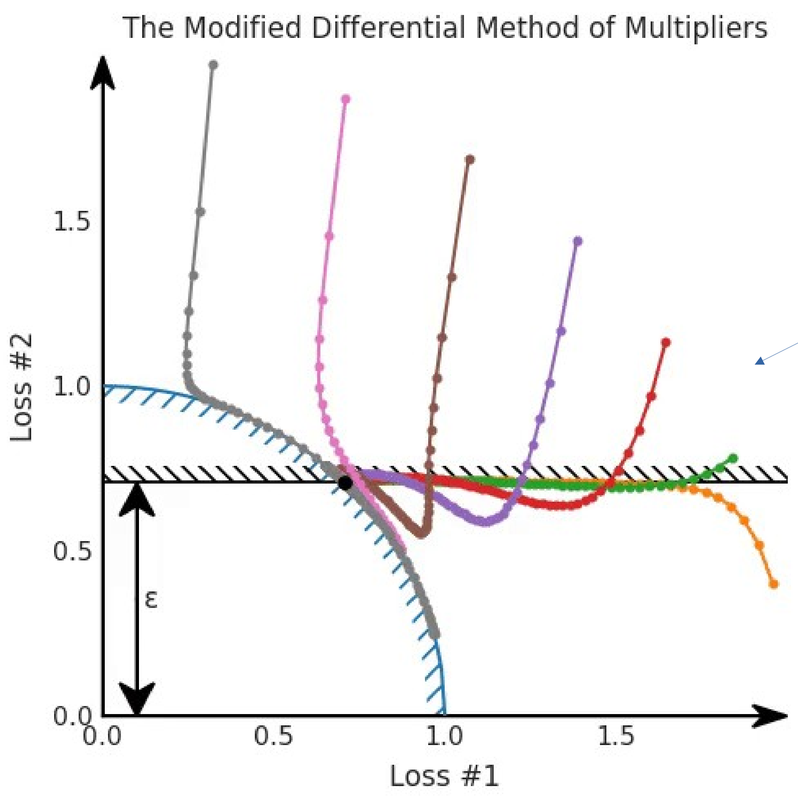
Get the performance of FullSim at the price of FastSim by refining with ML methods
→ here <u>regression</u> approach

Main challenge
FastSim & FullSim are (partially) stochastically independent





- ResNet: learn residual corrections
- Combination of two loss terms:
  0) MMD: Maximum Mean Discrepancy (compare ensembles)
  1) MSE: Mean Squared Error (compare jet pairs directly)
  ➔MDMM: Modified Differential Method of Multipliers (ensures convergence with SGD)



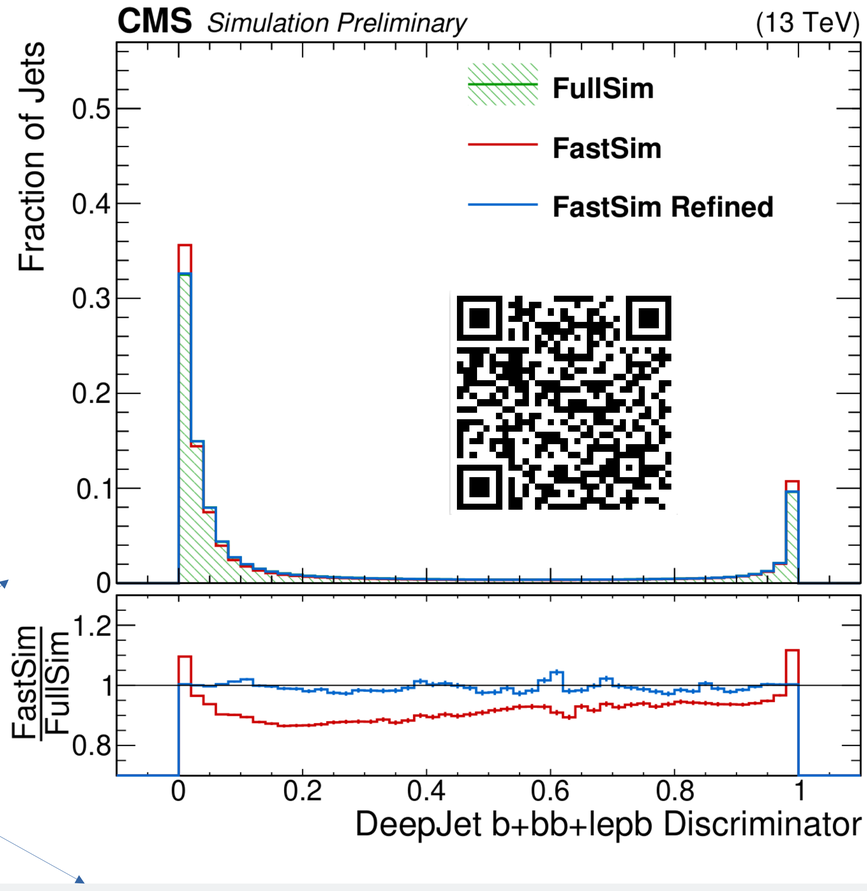
https://www.engraved.blog/how-we-can-make-machine-learning-algorithms-tunable/

$$L(\theta, \lambda) = L_0(\theta) - \lambda(\epsilon - L_1(\theta))$$

- Gradient descent for θ parameters
- Gradient ascent for λ hyperparameter
  → damped to avoid oscillations on Pareto front

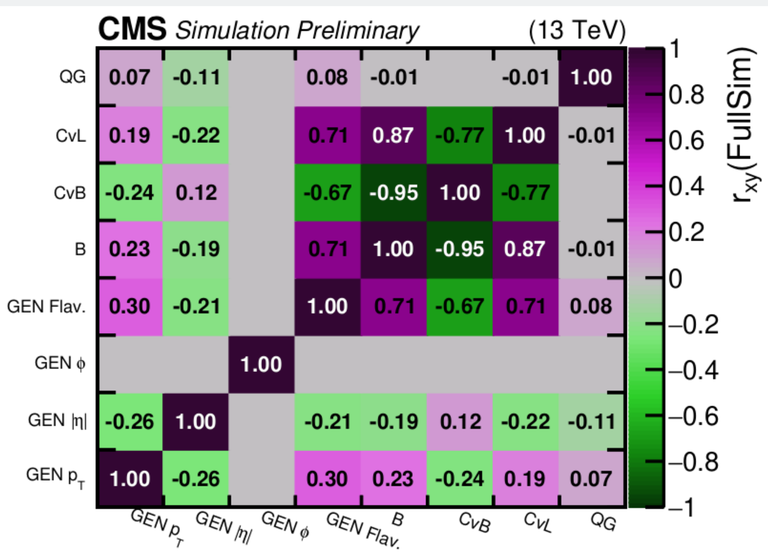
The refinement obtained with this method is now available for production of FastSim samples at CMS!

Application to heavy-flavour discriminants (DeepJet)
- 1D distributions and correlations are refined
- Correlations to kinematic variables are also treated

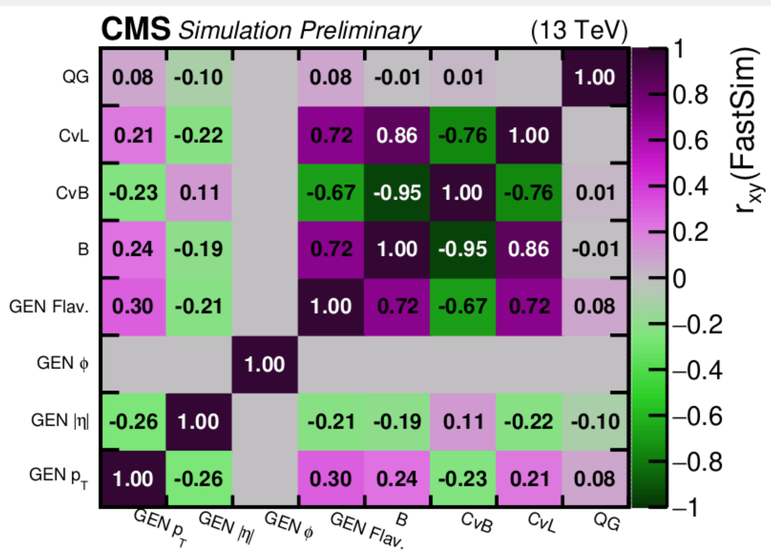


Residual Pearson correlation coefficients

FullSim



FastSim



FastSim refined