Reconstruction of missing features in data

Regression analysis to determine neutrino p_z in $W \to \ell\nu$ decay

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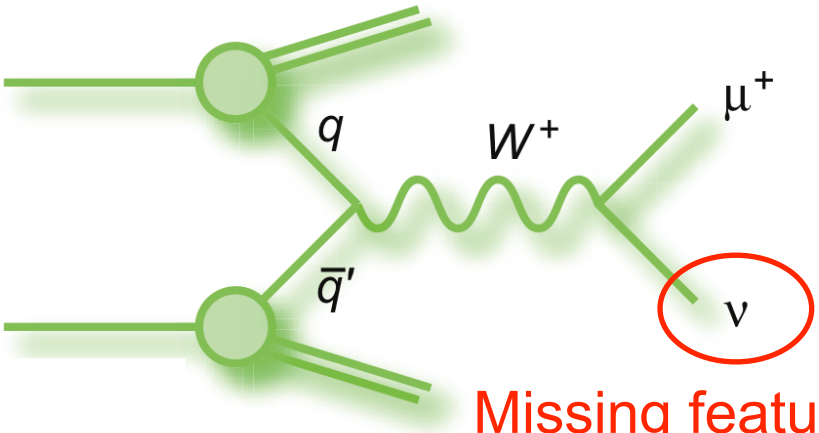
Inputs



- Lepton momentum 4-vector
- Missing energy & its direction

- Sum energy in the event
- W boson p_T, rapidity

Missing feature:
neutrino p_z

Target: neutrino p_z
Discriminant: Boosted Decision Tree (ada boost)

Training and validation

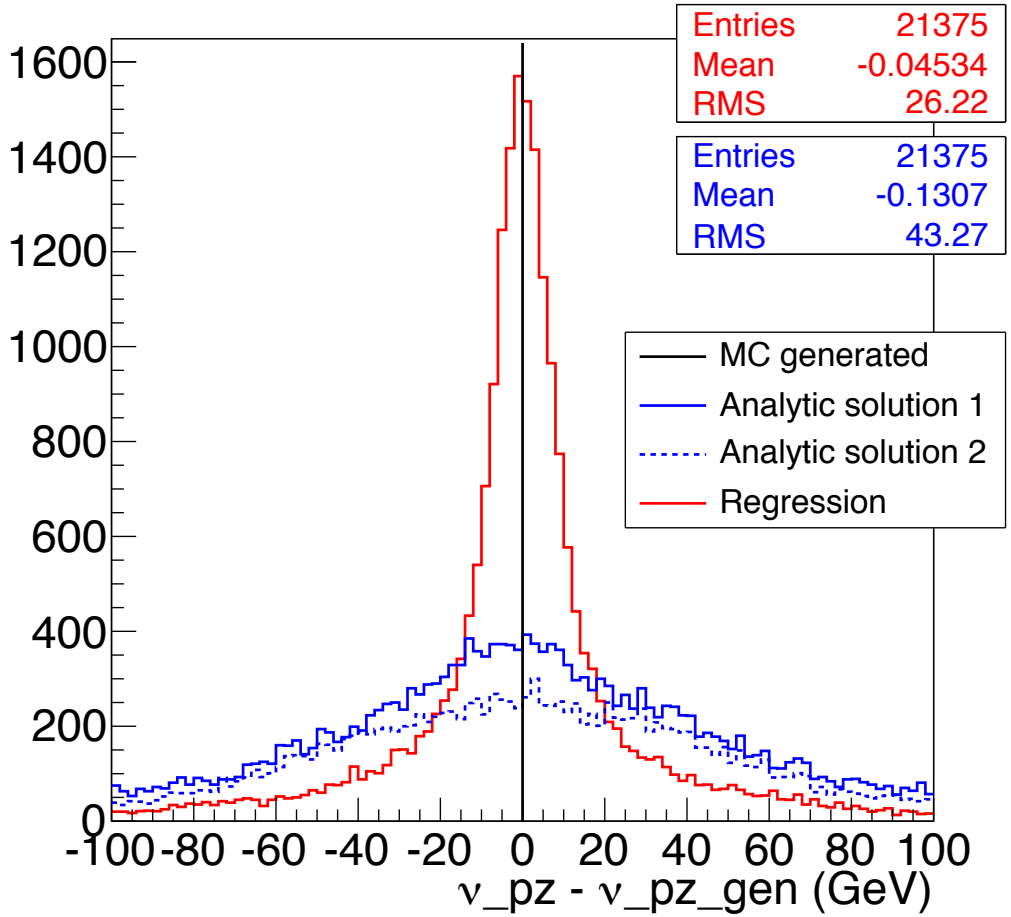
Trained and validated on WW→ℓνqq Monte Carlo events with the requirement

$$|m(\ell\nu) - 80.4| < 10 \text{ GeV}$$

at generator level.

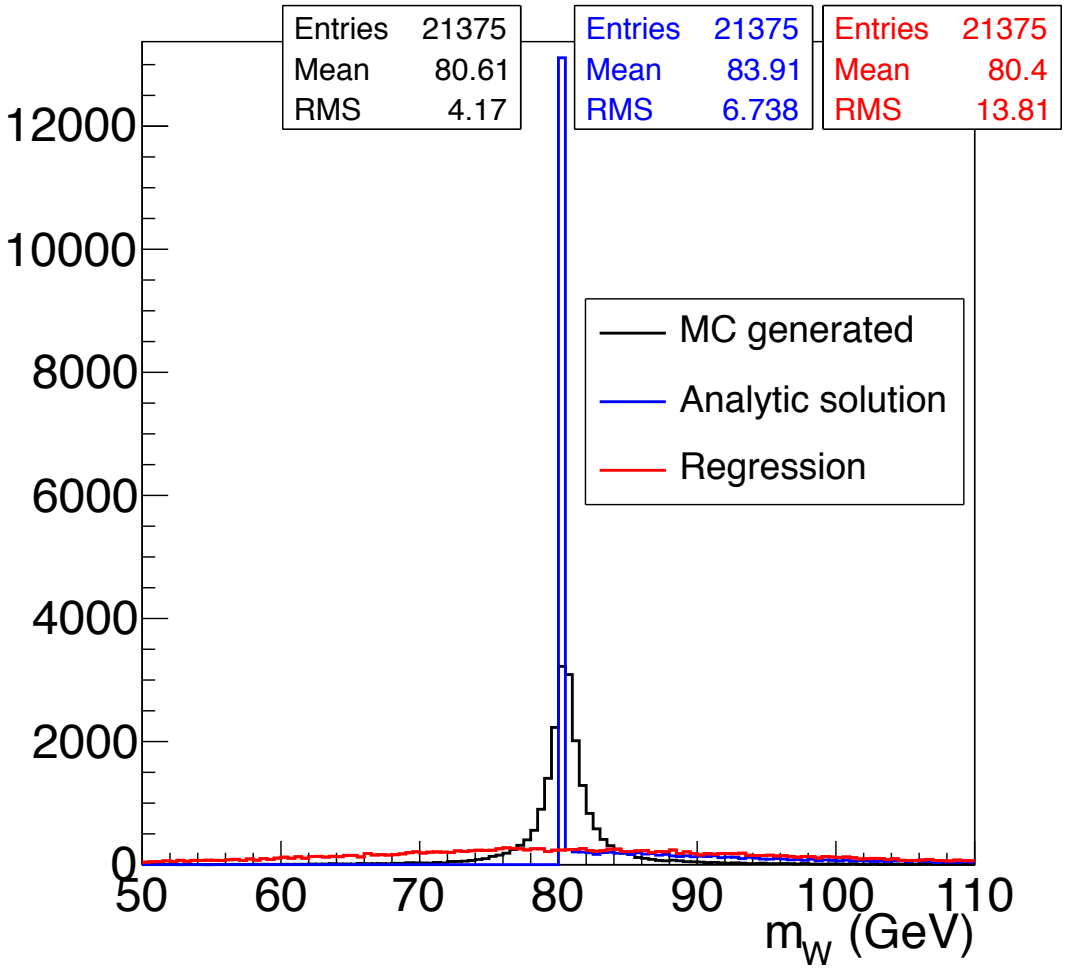
However, the result should be applicable to any W→ℓν event because I used only lepton and missing energy related inputs.

Output: neutrino p_Z



- The regression clearly gives a better behaved solution.
- The problem can also be solved analytically assuming nominal value (= 80.4 GeV) for W mass and then solving a quadratic equation. We will see on the next slide why this isn't a good assumption.

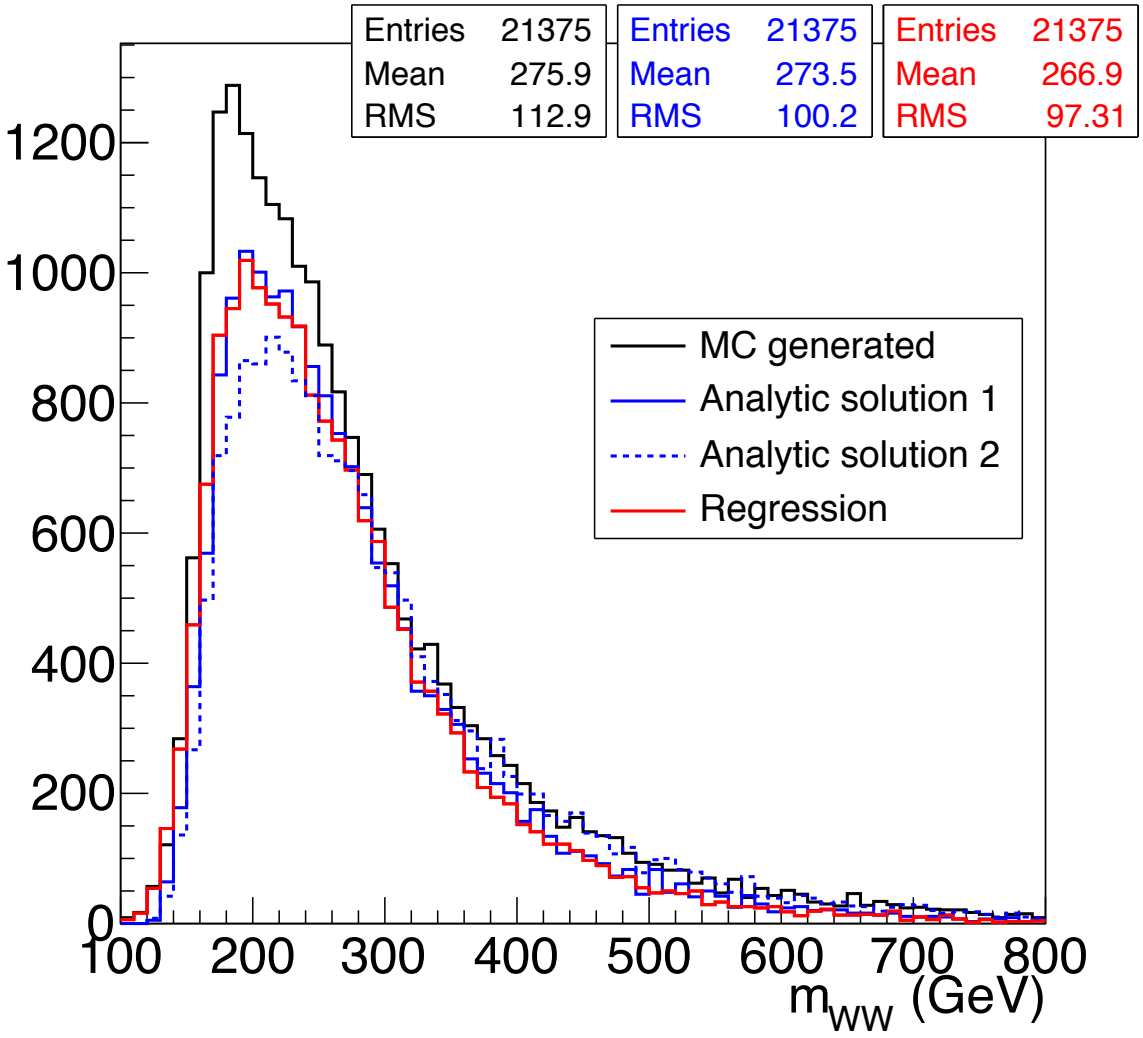
Reconstructed W mass using ν p_Z from regression



- Unlike analytic solution, the regression never predicts imaginary neutrino p_z since we sample W masses both above and below the pole.
- The analytic solution doesn't even reproduce the natural width of the W mass.

With regression the angular quantities shouldn't have weird features.

Reconstructed WW→ℓνqq invariant mass



- Not much difference among the 3 solutions.
- So, switching over to regression for neutrino p_z will make no big difference in the ℓνjj analyses, but will help WH→ℓνbb analysis.
- Resolution is ~15% in the entire range, varying from 17% to 13% as one goes up in mass.

Code and regression kernel

The regression is implemented at

https://github.com/kalanand/NeutrinoPzRegression

The analytic solution is implemented at

https://github.com/VPlusJetsAnalyzers/VPlusJets/blob/master/interface/METzCalculator.h

Drop me a line if you have questions

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