ML techniques in $H^+ \to \tau\nu$ mass reconstruction

Max Isacson, Mikael Mårtensson,
Camila Rangel Smith, Henrik Öhman

UPPSALA
UNIVERSITET

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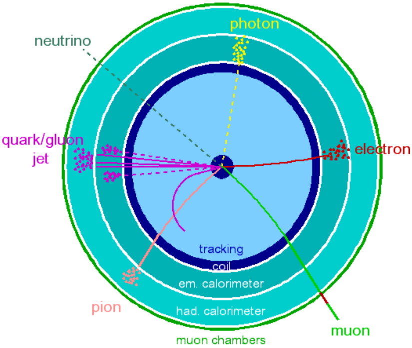
All HEP experiments have to deal with *missing (transverse) energy* (MET, E_T^{miss}). Usually in the form of *neutrinos* escaping the detector without interacting.

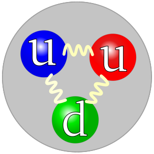


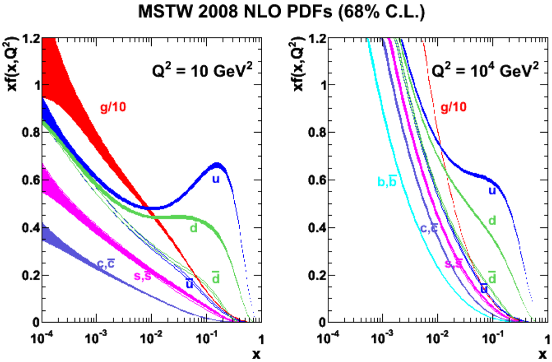
The missing energy can be reconstructed in the transverse plane, by energy conservation:

$$E_{x,y}^{\text{miss}} = -\sum E_{x,y} \tag{1}$$

However in hadron colliders the longitudinal energy information is lost.

This is because we are acutally colliding the *partons* inside the hadrons, which carry an unknown fraction x of the longitudinal momentum.

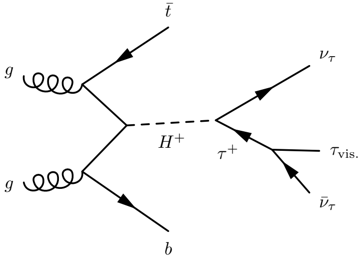




Definitions

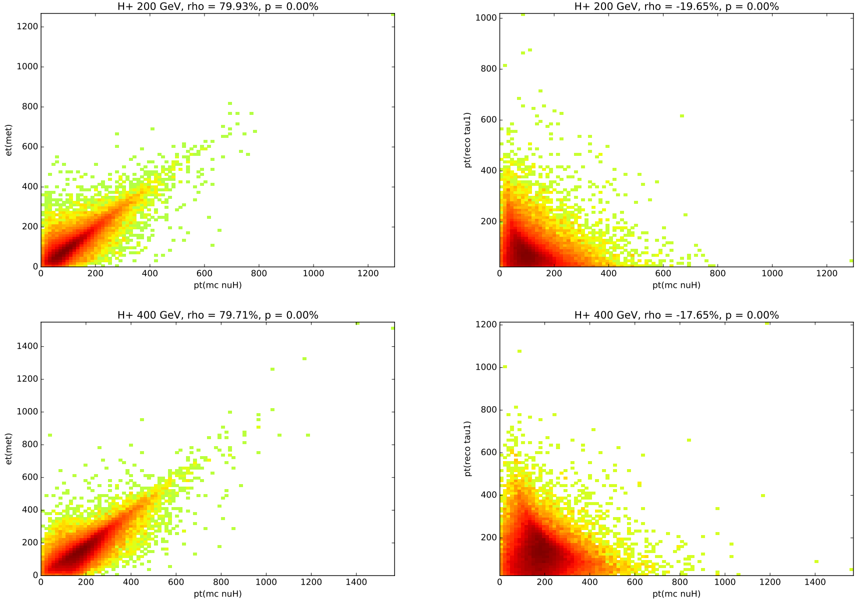
- Response of X — The ratio between a reco. quantity X and the true value X_{truth}, as a function of X_{truth}.
- Resolution of X — The distribution of $(X_{\text{truth}} - X)/X_{\text{truth}}$.
- Transverse mass m_T — The mass in the transverse plane between objects 1 and 2, $m_T = \sqrt{2E_T^1 E_T^2 (1 - \cos(\phi_1 - \phi_2))}$.

Signal process



- Most of the missing energy will be carried by ν_H — The neutrino from the Higgs decay.
- The features used are the various kinematics of the visible part of this process.
- We consider 3 masses for the H^+: 200, 300, and 400 GeV

Predictors

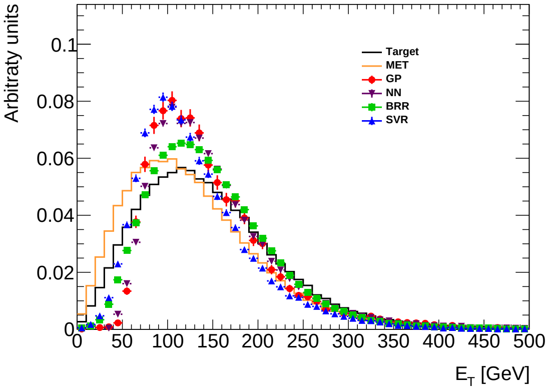

H+ 200 GeV, rho = 79.93%, p = 0.00%
et(met)
pt(mc nuH)
H+ 200 GeV, rho = -19.65%, p = 0.00%
pt(reco tau1)
pt(mc nuH)
H+ 400 GeV, rho = 79.71%, p = 0.00%
et(met)
pt(mc nuH)
H+ 400 GeV, rho = -17.65%, p = 0.00%
pt(reco tau1)
pt(mc nuH)

Regressors

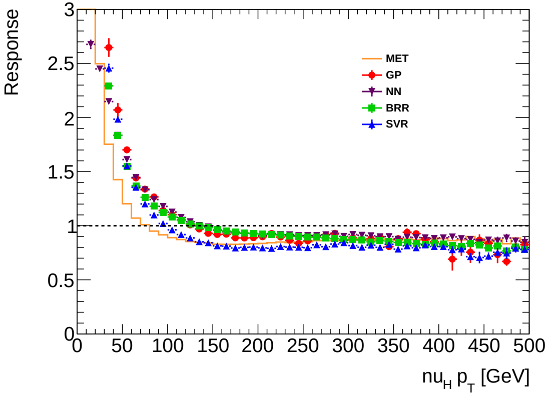
- Gaussian process
- Neural network
- Bayesian ridge regression
- Support vector regression

- The target for the training is always the p_T of ν_H.
- We consider 4 measures of quality, the distribution of the predicted p_T, the response, the resolution, and the reconstructed m_T using the predicted p_T.
- These are compared to the standard MET.

Reconstruction of $p_T(\nu_H)$

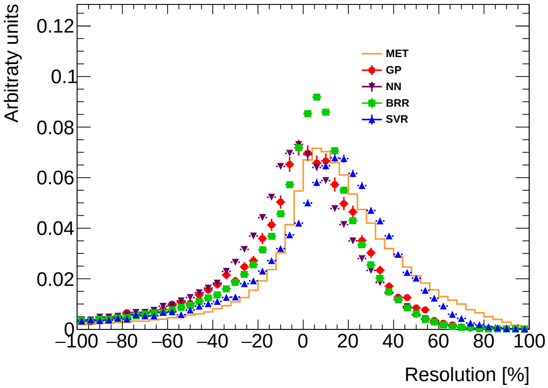


p_T response

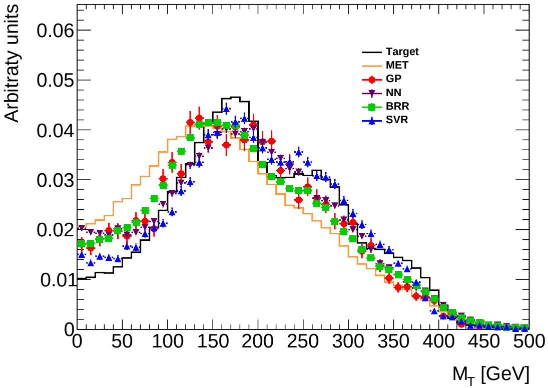


Response
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
350
400
450
500
nu_H p_T [GeV]
MET
GP
NN
BRR
SVR

p_T resolution



Reconstruction of m_T



Conclusions and plans

Conclusions

- The neural network and bayesian ridge regression are the best performers.
- NN has the smallest bias, but larger variance than the BRR.
- However, all methods fails to reconstruct the spectrum at low p_T.
- More detailed studies has to be performed to draw more accurate conclusions.

Plans

- We plan to continue this in the future – Will be of interest to HBSM searches at ATLAS and other hadron experiments.
- The performance will probably be better when training against the full 4-vector of ν_H.
- More complicated variables could also be included in the training.