Multivariate MET Analyses

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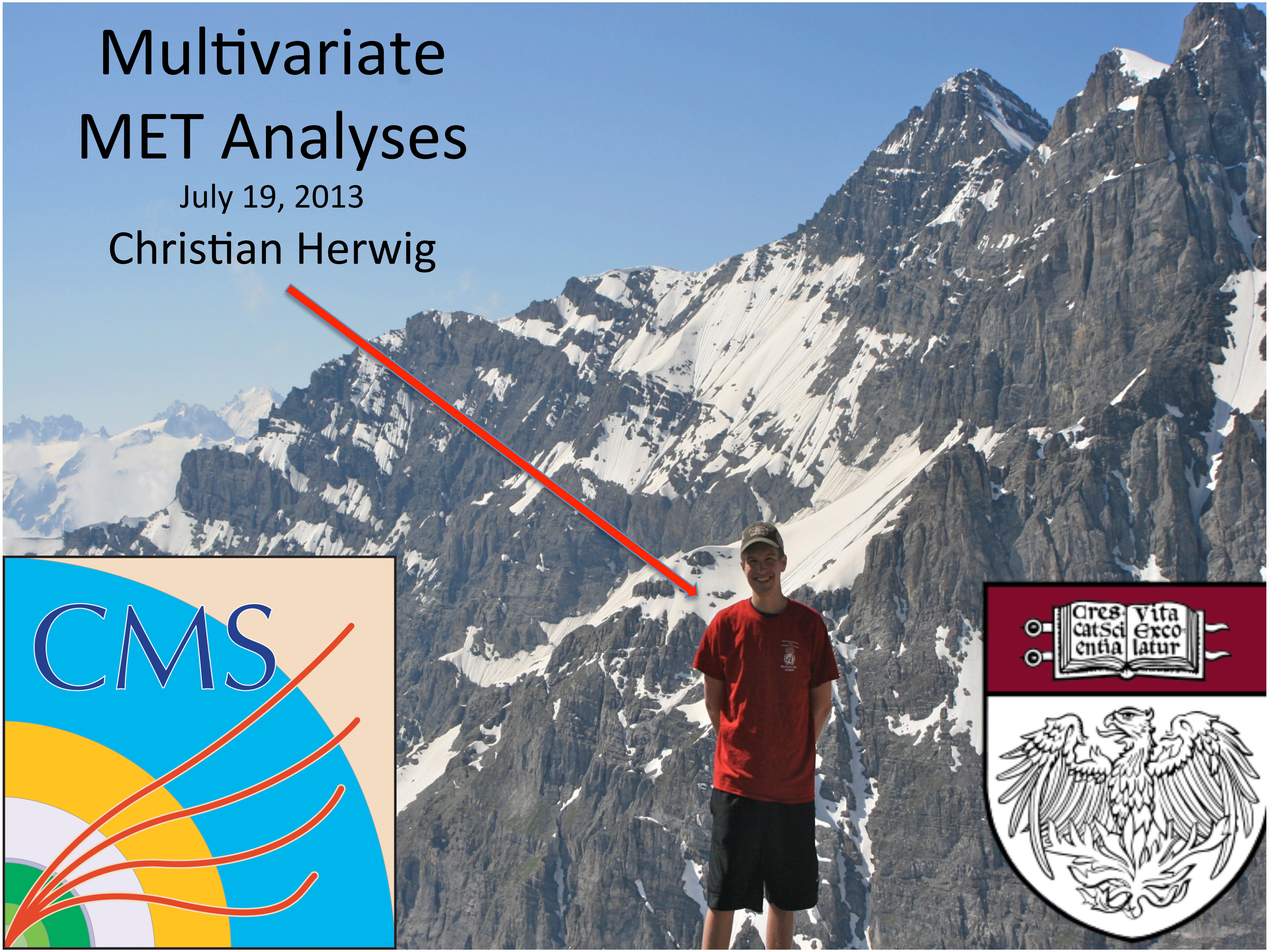
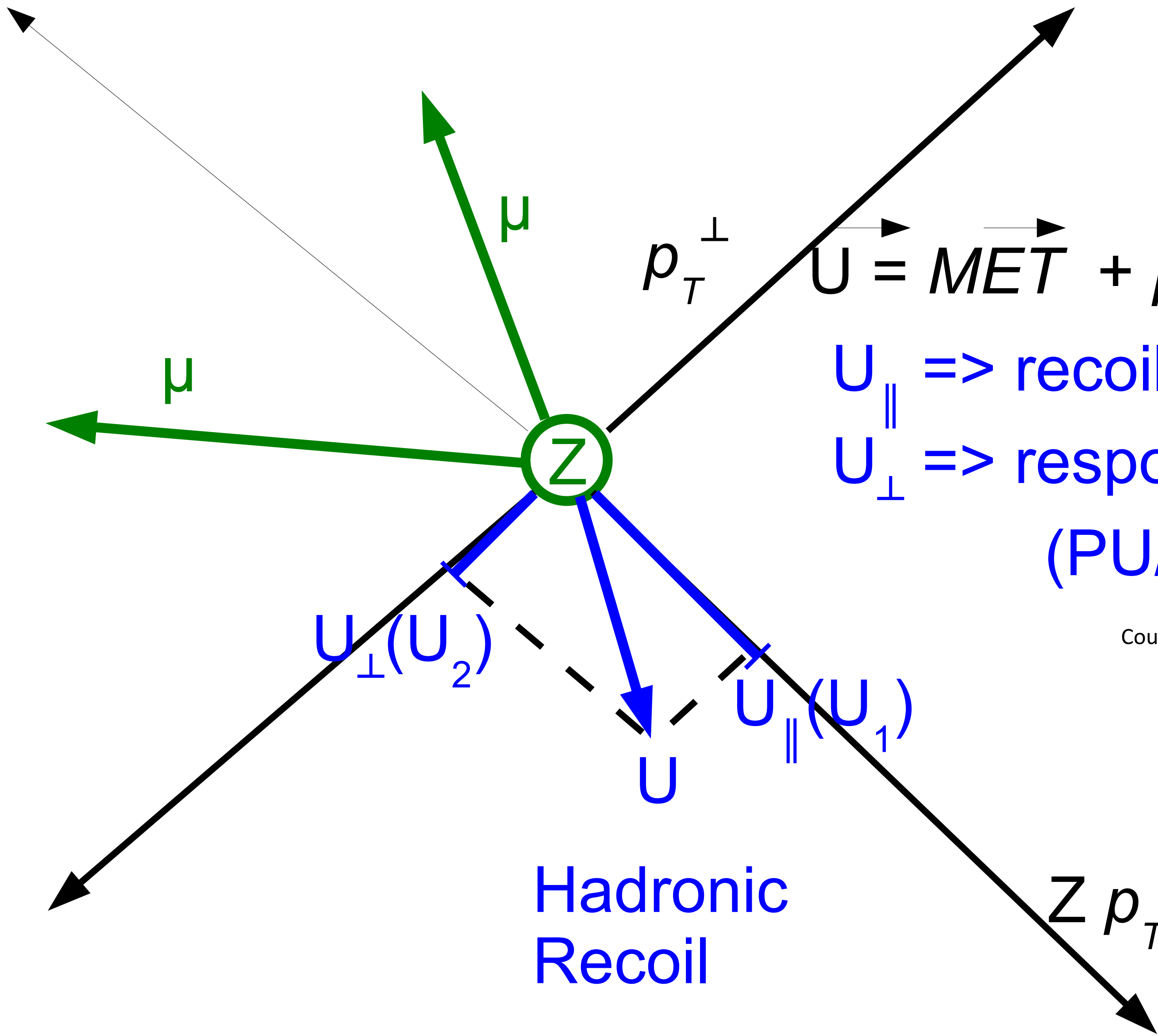


Recall the Defn of MET

- MET measures the amount of ‘stuff’ that our detector doesn’t see
  - Defined as the p_T of the invisibles
- Use conservation of momentum in the transverse plane
- MET is defined as the negative vector sum of all reconstructed physics objects

$$\vec{\not{E}}_T + \sum_{objects} p_T = 0$$

Defining Recoil



$\vec{U} = \vec{MET} + \vec{p}_T\text{(leptons)}$

$U_{\parallel}$ => recoil response to Z

$U_{\perp}$ => response to non-Z

(PU/UE/Detector)

Courtesy of P. Harris

Defining Recoil in Di-muon Evts (Z→μμ)

- Instead of talking about MET, it is instructive to define the recoil

$$\vec{u} = \vec{\not{E}}_T + \sum \vec{\ell}$$

- Gives the direction of the recoil of the Z
- Break into components relative to the Z boson

$$\vec{u}_{||} = (\vec{u} \cdot \vec{p_T^Z})\hat{p_T^Z} \qquad \vec{u}_{\perp} = \vec{u} - \vec{u}_{||}$$

- Recoil drives the MET resolution
  - Want to utilize in our MVA

MET Variables

- Recoil can be broken into categories
  - Where in the detector is it identified?
  - Is it a 'good' feature, or from pileup?

$$\vec{u} = \sum_{\text{tracks}} p_T + \sum_{\text{jets}} p_T + \sum_{\text{hadronic}} p_T$$

$$\vec{u} = \sum_{\text{pv tks}} p_T + \sum_{\text{non-pv tks}} p_T + \sum_{\text{good jets}} p_T + \sum_{\text{PU jets}} p_T + \sum_{\text{hadronic}} p_T$$

MET Variables

$$\vec{u}_{pfu} = \sum (\text{Everything})$$

$$\vec{u}_{tk} = \sum_{\text{good tks}} p_T$$

$$\vec{u}_{pu} = \sum_{\text{PU tks}} p_T + \sum_{\text{PU jets}} p_T$$

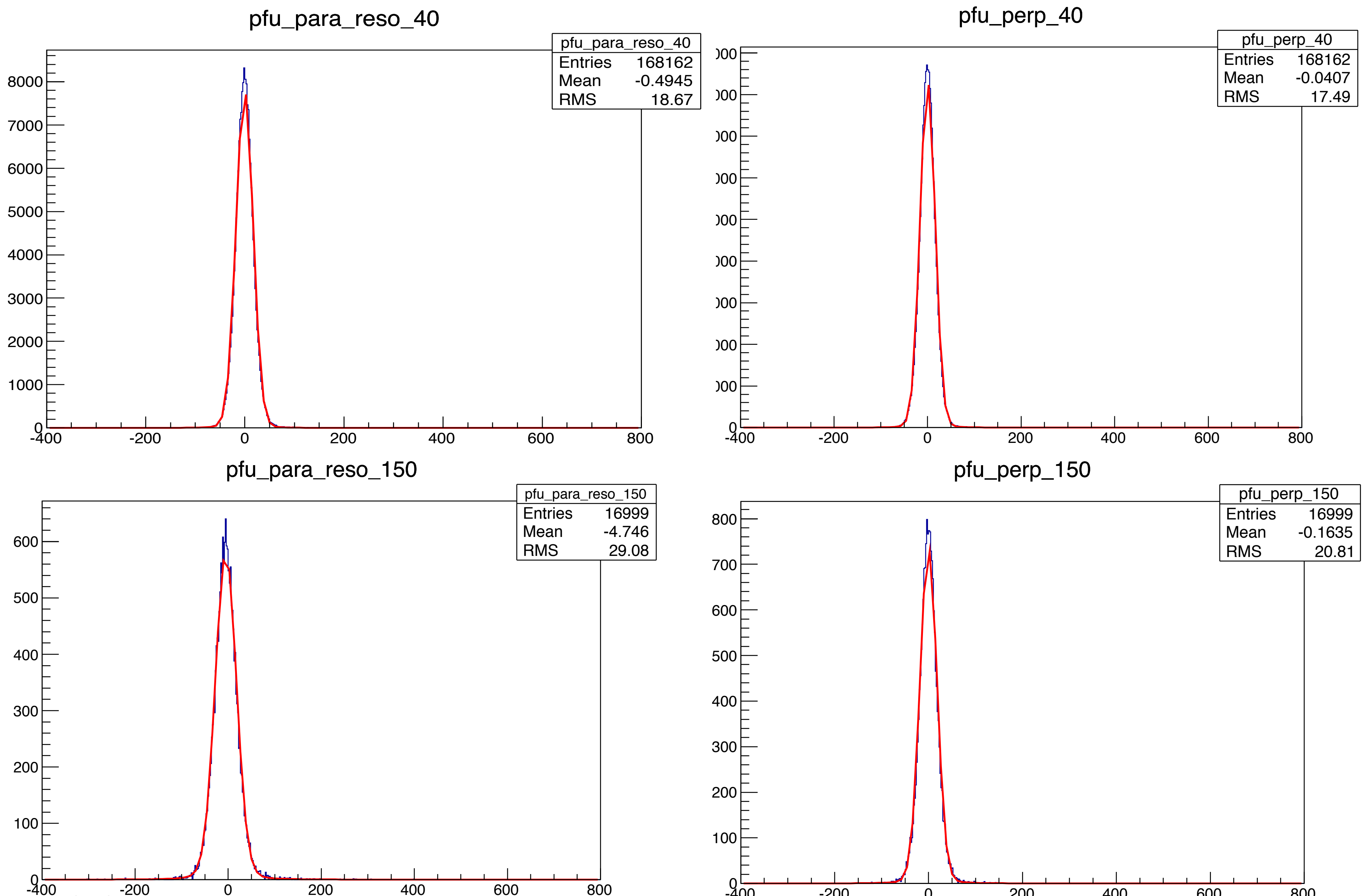
$$\vec{u}_{nopu} = \sum_{\text{good tks}} p_T + \sum_{\text{good jet}} p_T$$

$$\vec{u}_{puc} = \sum_{\text{good tks}} p_T + \sum_{\text{good jet}} p_T + \sum_{\text{hadronic}} p_T$$

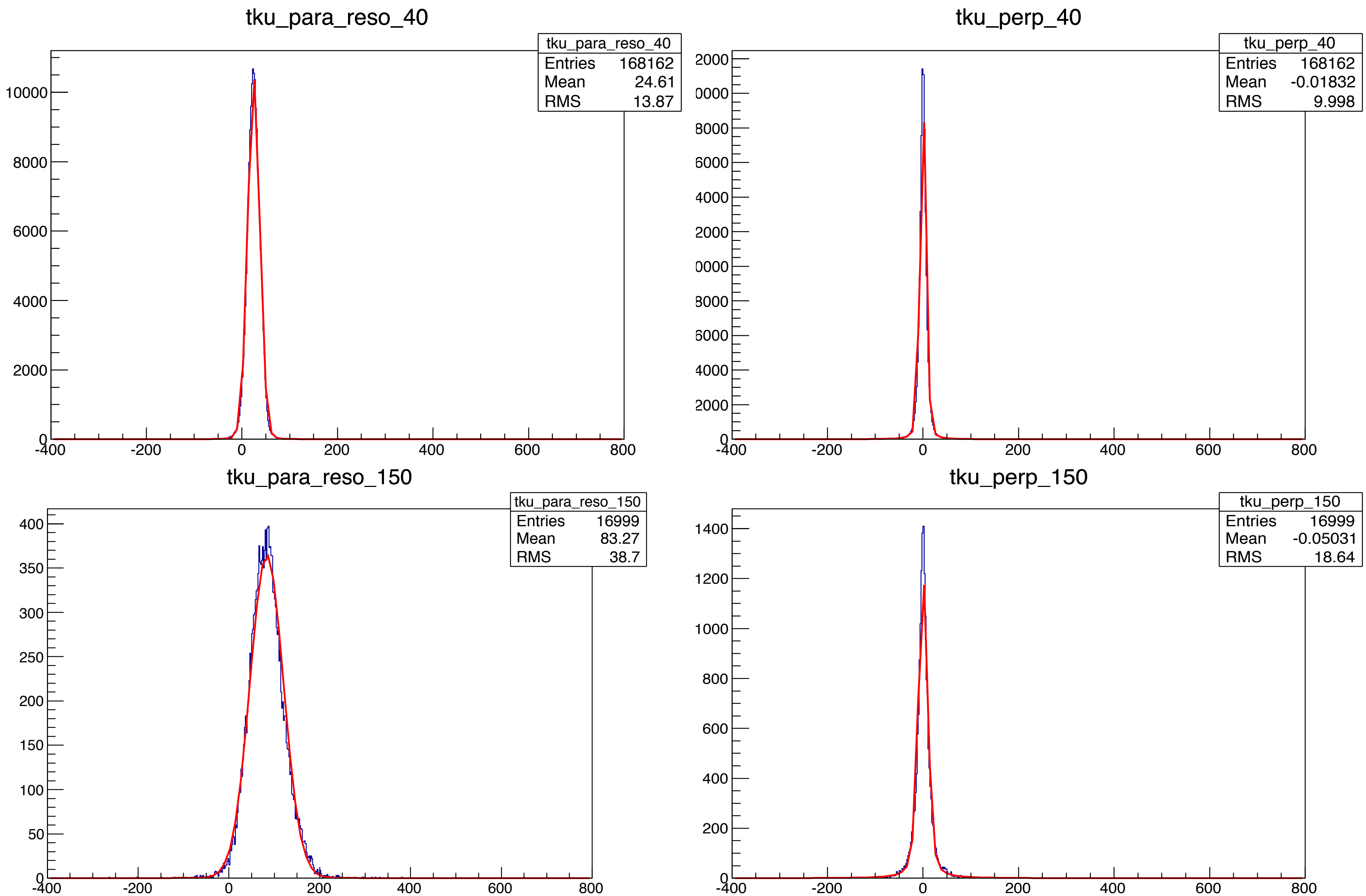
Recoil Components

- Look at Z→μμ events – expect recoil only from the lepton pair
- Expect $u_{\perp} = 0 \quad \text{and} \quad u_{||} = -\sum_{\text{leptons}} p_T$
- In reality get distribution (Voigt)
- Key point: these events should have no 'real' MET (i.e. neutrinos, etc), so the characteristics of u that we measure correspond exactly to our performance

Recoil component plots – pfu

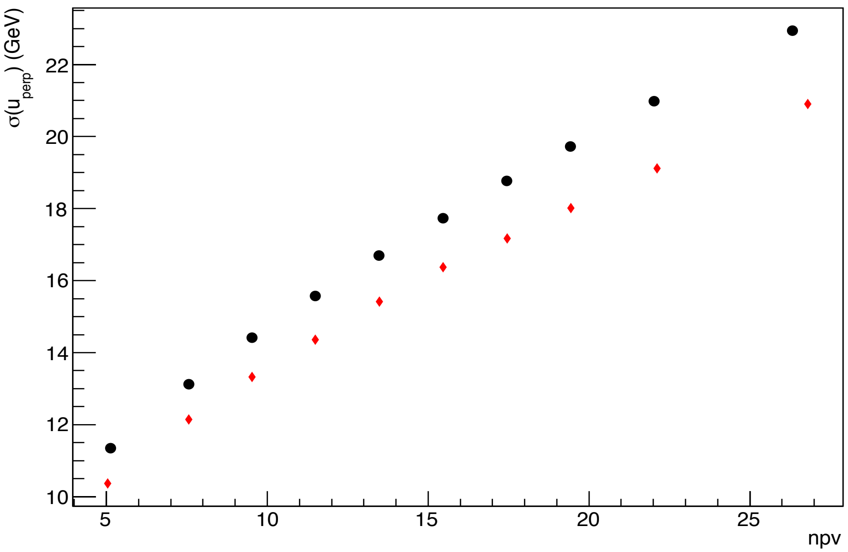


Recoil component plots – tku

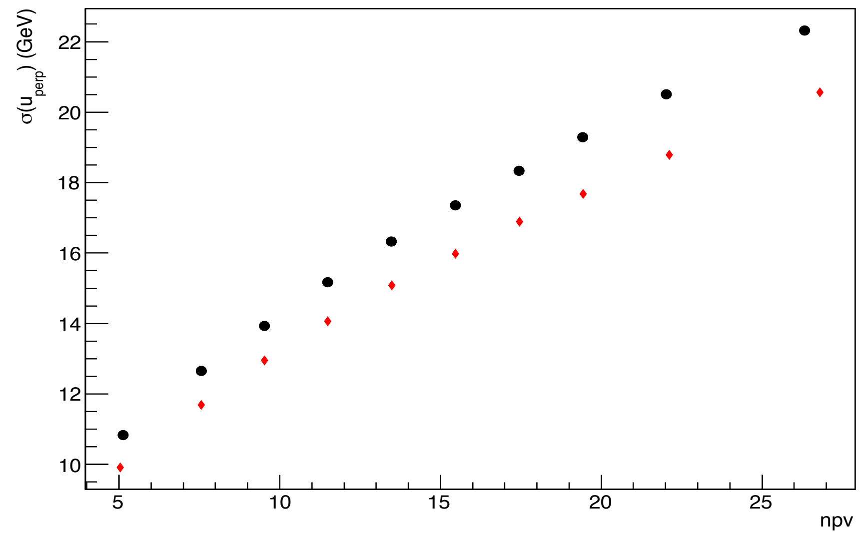


Resolution Curves $\sigma(u_i)/p_T(Z)$

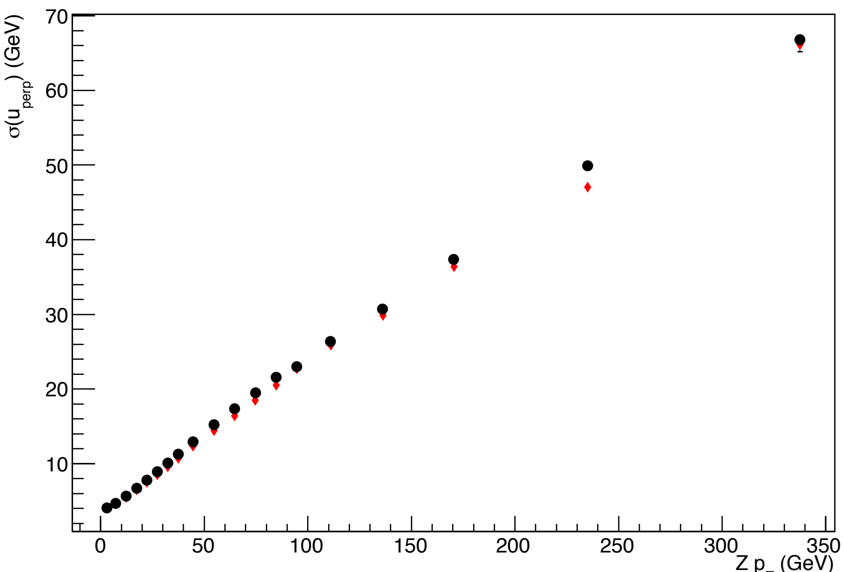
PFU_para Resolution Curve



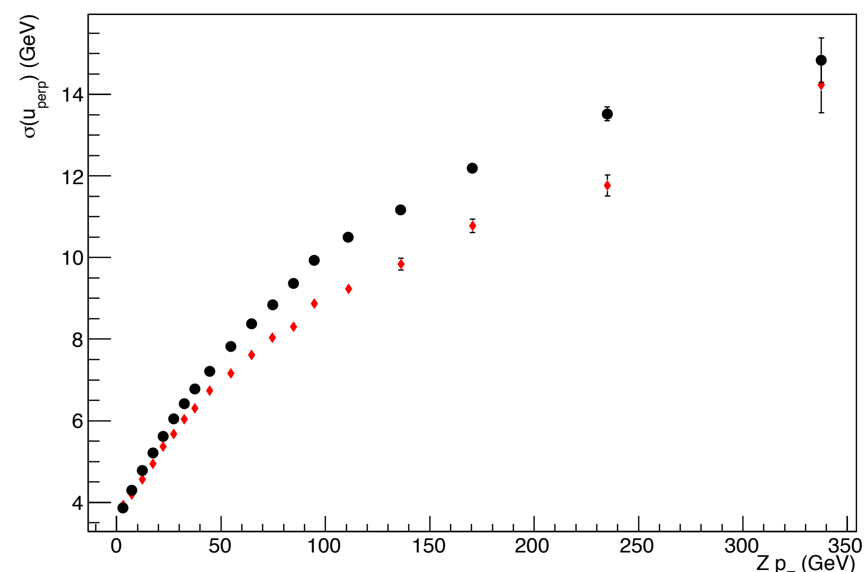
PFU_perp Resolution Curve



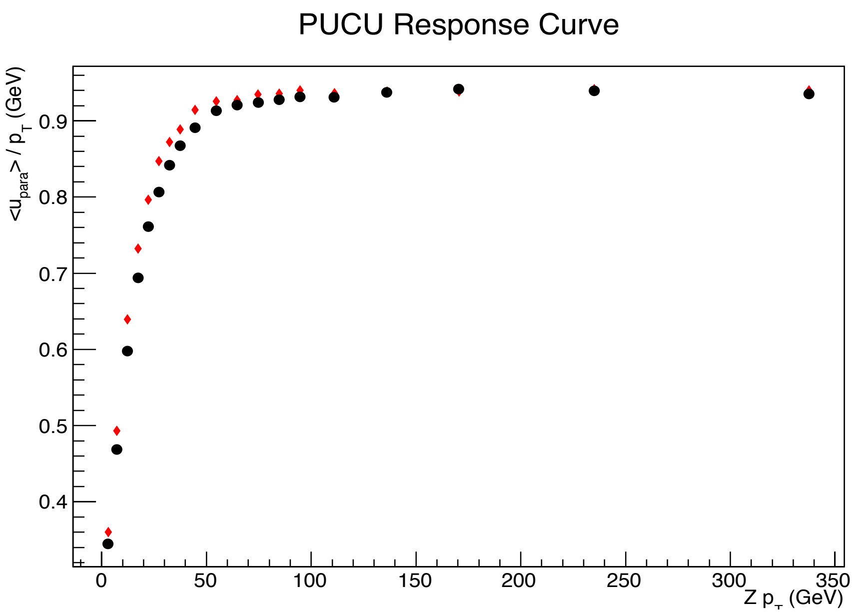
TKU_para Resolution Curve

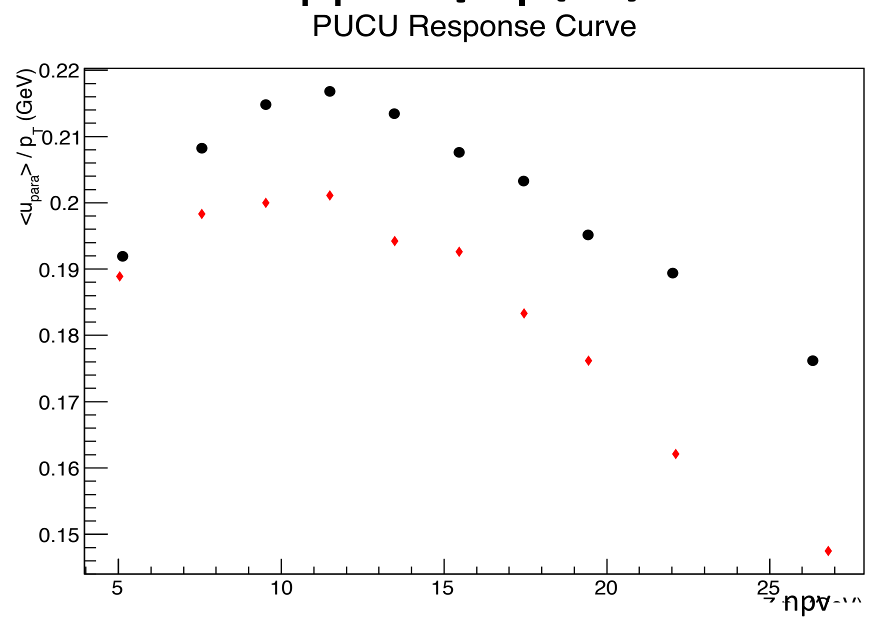


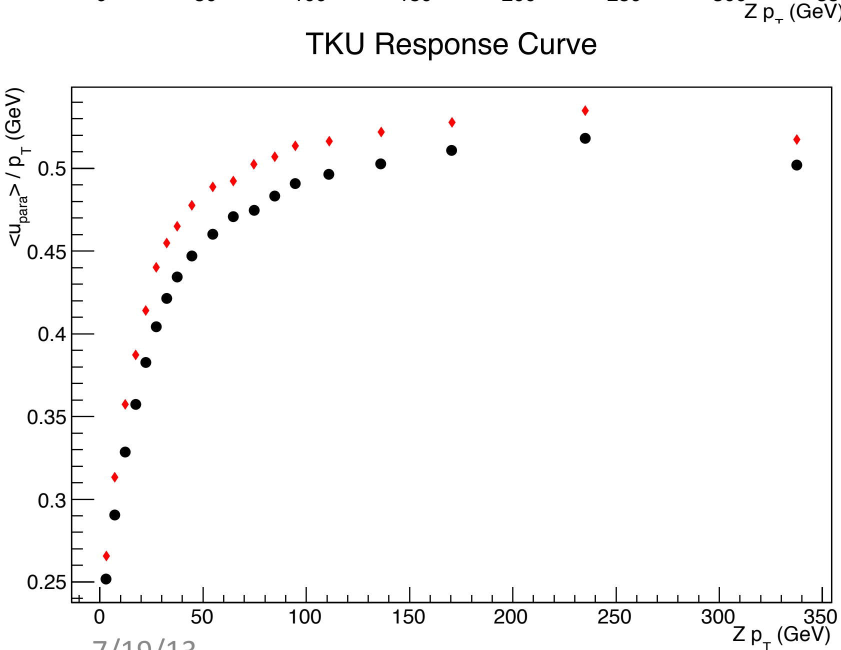
TKU_perp Resolution Curve

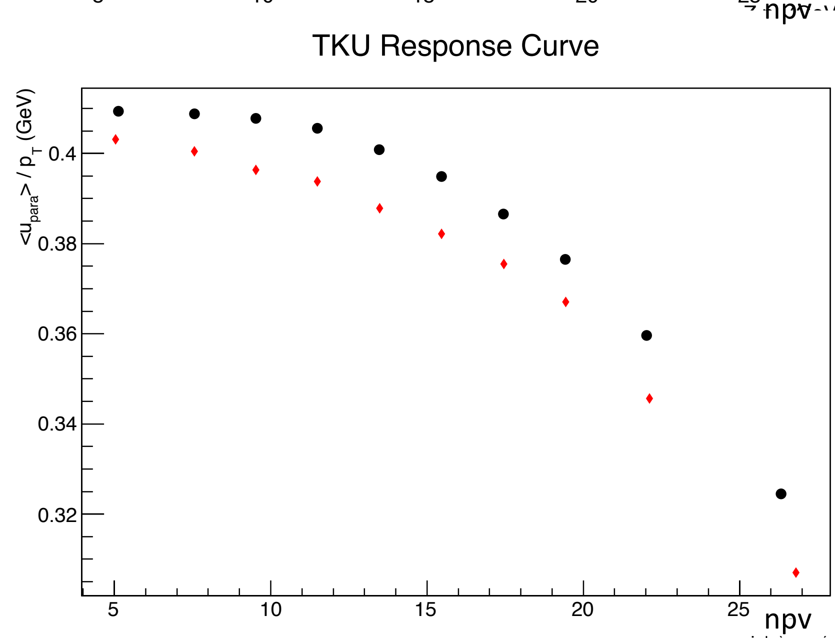


Response Curves $\langle u_{||} \rangle / p_T(Z)$



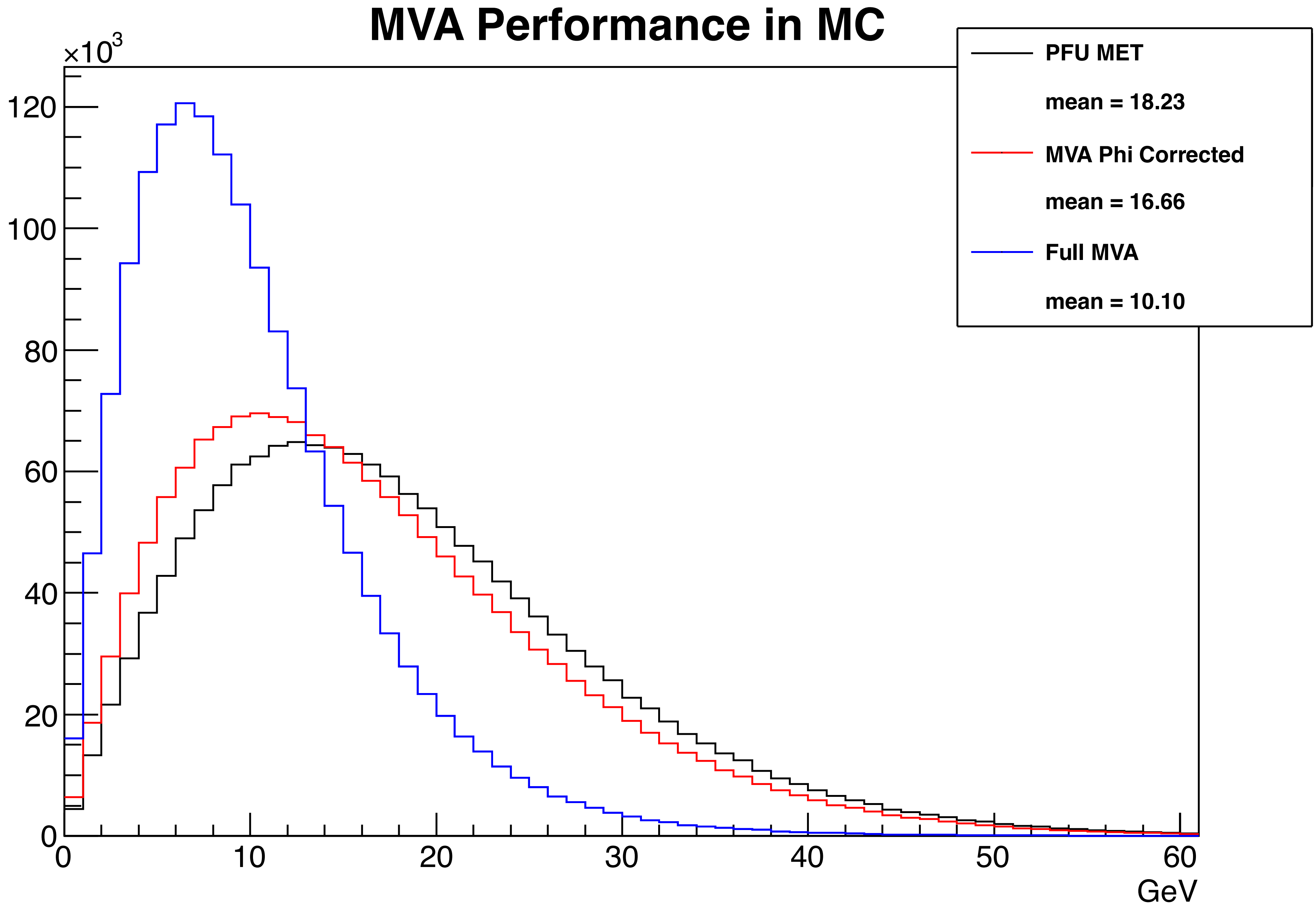


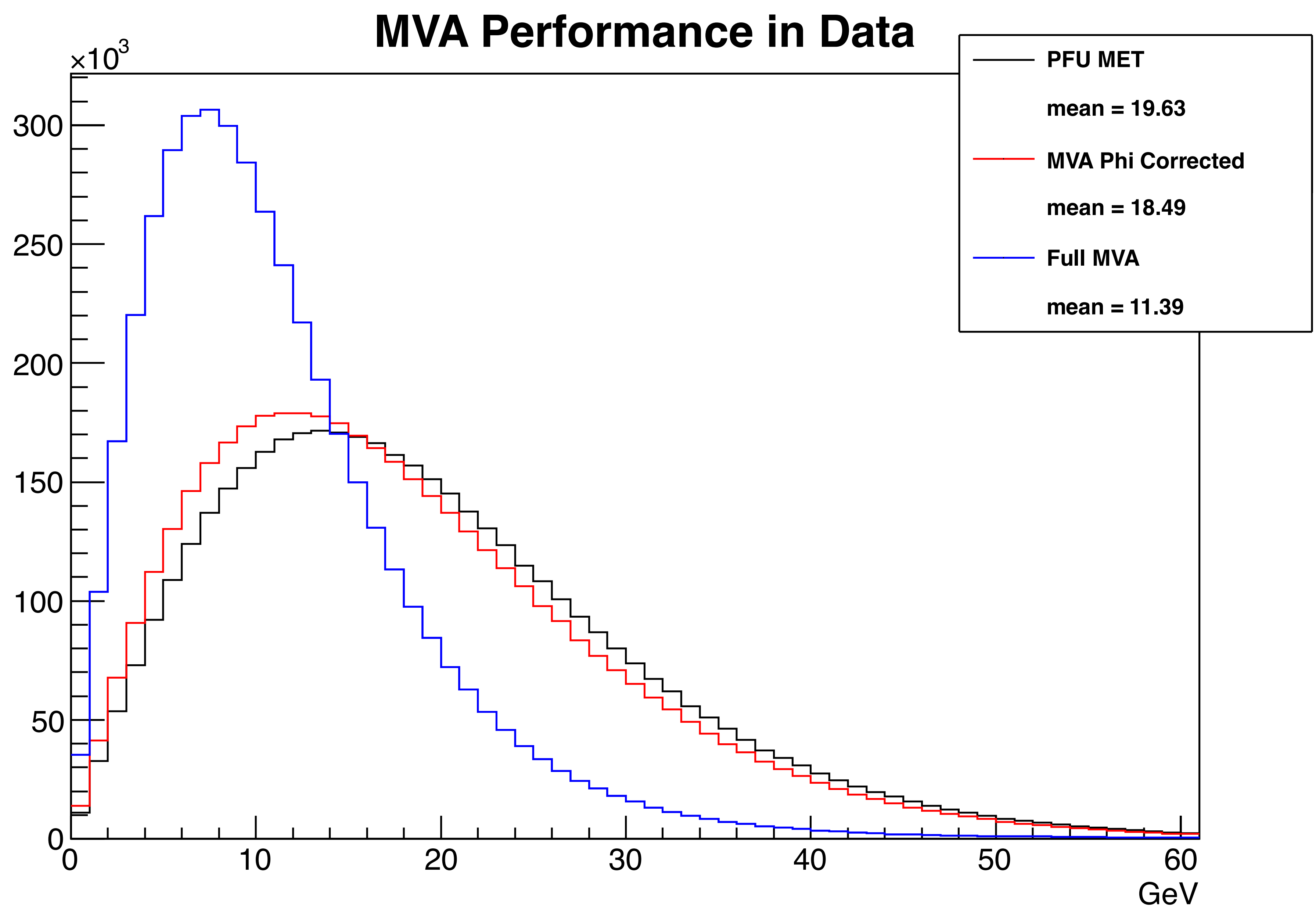




Using this info in the MVA

- Use these variables to train the MVA
  - 10 met vars (5 with magnitude and direction)
  - Leading and sub-leading jet pT, eta, phi
  - # primary vertices
- Technique: Train on the $Z \to \mu\mu$ MC sim to get corrected vars, apply to data
- Target pfu met and get corrections
- Currently a series of two 1d corrections, phi and then magnitude


MVA Performance in MC
×10^3
120
100
80
60
40
20
0
0
10
20
30
40
50
60
GeV
PFU MET
mean = 18.23
MVA Phi Corrected
mean = 16.66
Full MVA
mean = 10.10


MVA Performance in Data
×10^3
300
250
200
150
100
50
0
0
10
20
30
40
50
60
GeV
PFU MET
mean = 19.63
MVA Phi Corrected
mean = 18.49
Full MVA
mean = 11.39

Next Steps

- Short term:
  - Use Voigt fits to quantify tails
  - Retool MVA metric to correct for tails more effectively
- Long term:
  - Implement 2d training

Thanks!