Measurement of W Asymmetry in Transveresely Polarized pp Collisions at STAR

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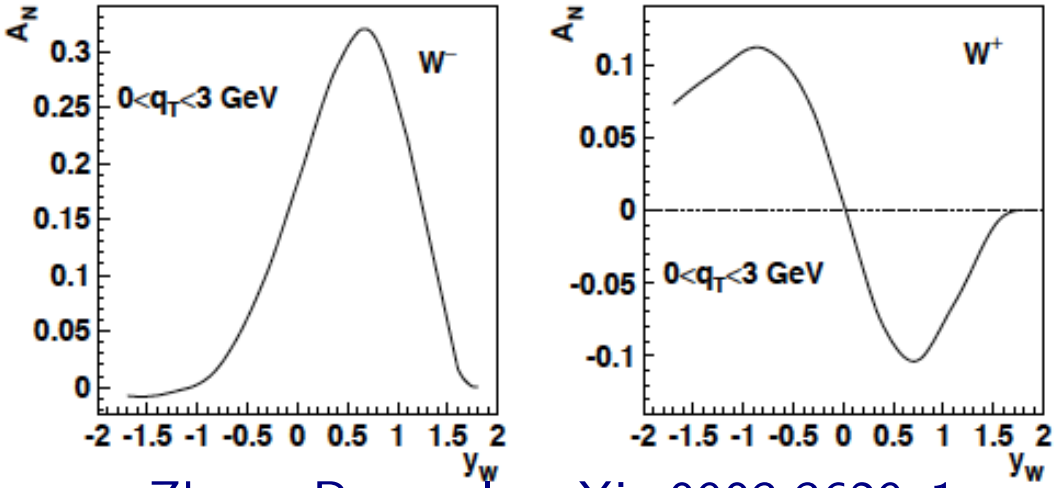
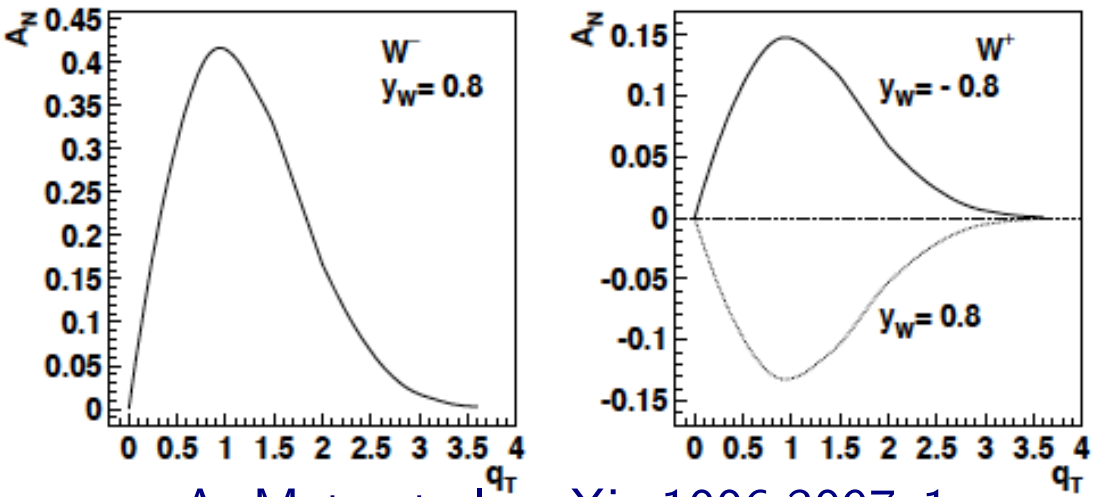
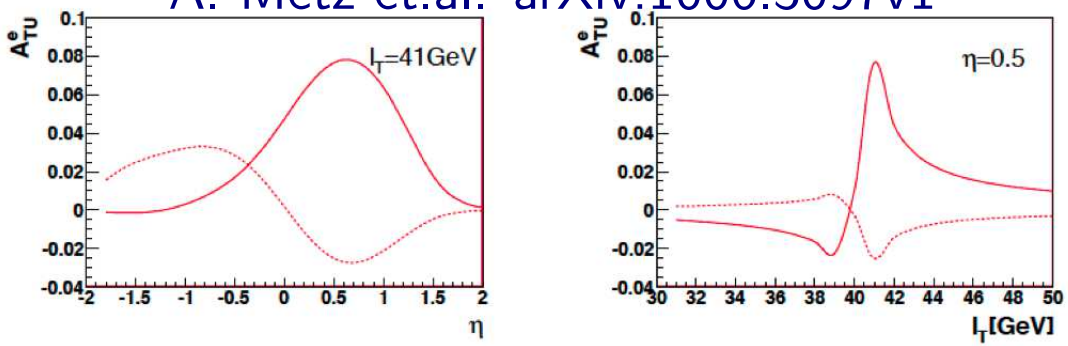
Motivation



Zhong-Bo et.al. arXiv:0903.3629v1



A. Metz et.al. arXiv:1006.3097v1



- As with DY process the W production can be used to measure the sign change of the Sivers function

  $$\text{Sivers(SIDIS)} = -\text{Sivers(DY)} = -\text{Sivers}(W^{\pm})$$

- The W asymmetry is expected to be larger than the lepton one
- While the lepton direction is measured directly the W asymmetries require the knowledge of W momentum
- **This is the first attempt to reconstruct the W kinematics at STAR**

Data and MC Samples

- **Data:** ~ 900 runs from Run 11
  - $L \approx 25$ pb^{-1}
  - Initial sample size 6.2M events (high threshold barrel or endcap trigger)
- **MC samples:**
  - $W \to e\nu_e$: Perugia Tune, **zero bias embedded,** $\sim 100k$ events
  - $W \to \tau\nu_\tau \to e\nu_e\nu_\tau$
  - $Z \to ee$
  - Data-driven QCD
- Events selected according to W event signature
  - High $p_t > 25$ GeV electron isolated in $R = 0.7$ cone
  - High $p_t > 18$ GeV neutrino, i.e. $\vec{\not{E}}_T$

Monte-Carlo Tuning

- In transverse plane:

$$\vec{p}_{T,W} = \vec{p}_{T,e} + \vec{p}_{T,\nu} \approx -\vec{p}_{T,\text{recoil}}$$

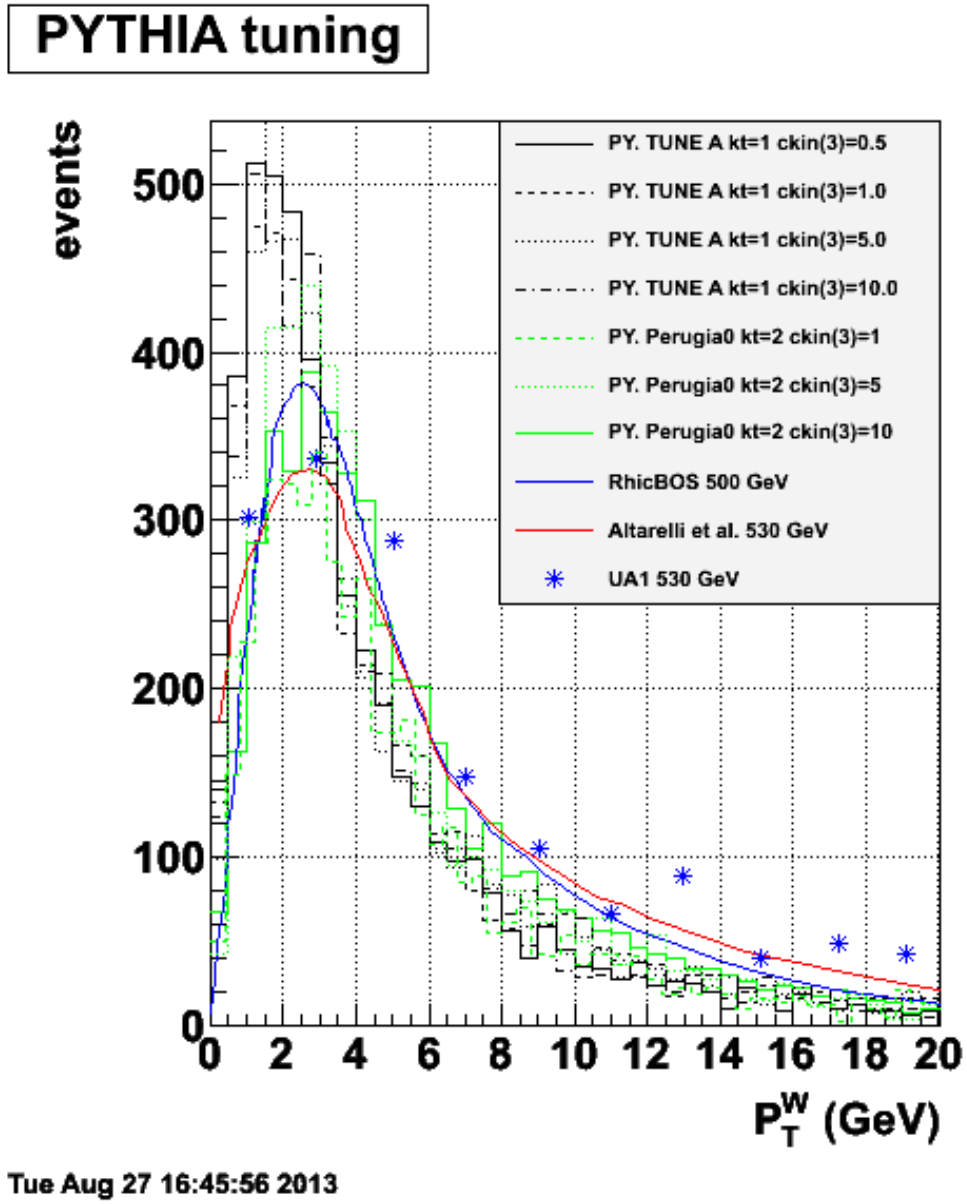
$$\vec{p}_{T,\nu} \approx \vec{\not{E}}_T = -\sum_{i \in \substack{\text{tracks,}\\ \text{clusters}}} \vec{p}_{T,i}$$

$$\vec{p}_{T,\text{recoil}} = \left(\sum_{i \in \substack{\text{tracks,}\\ \text{clusters}}} \vec{p}_{T,i} - \vec{p}_{T,e} \right)$$

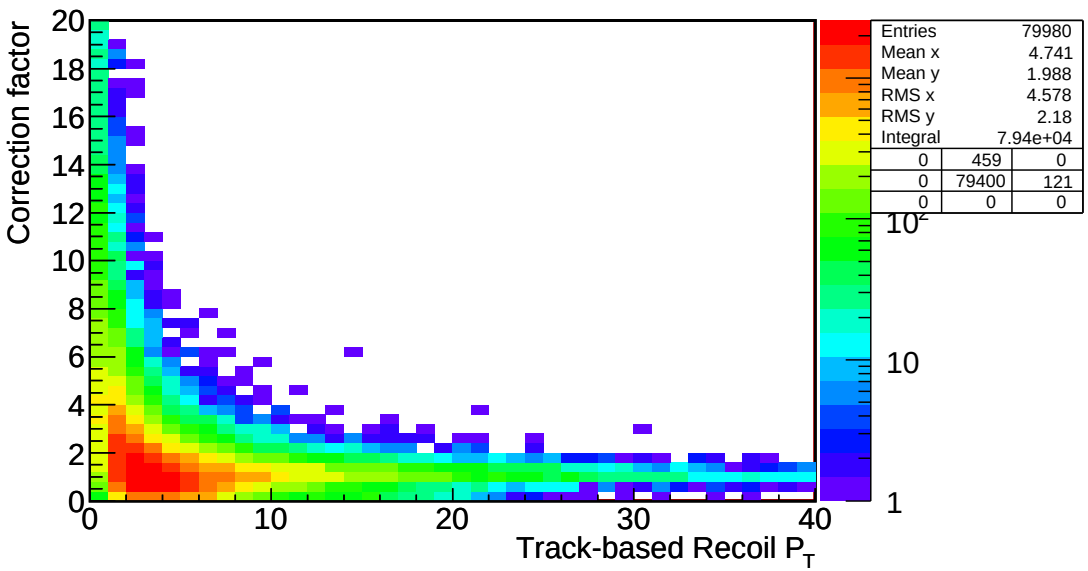
- Recoil reconstructed in data has to be corrected

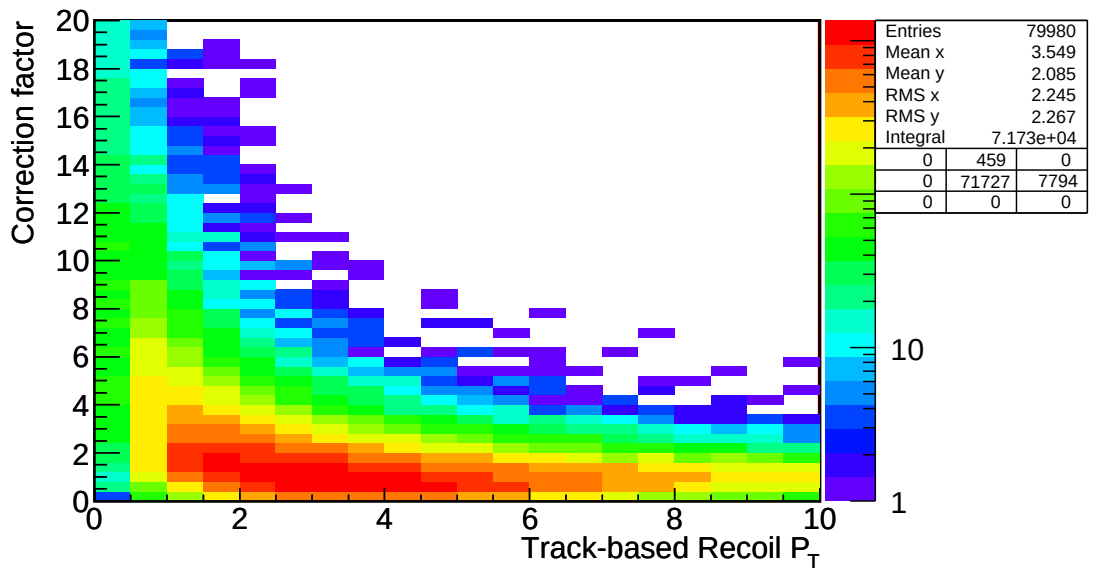
$$p_{T,W} = k \times p_{T,\text{recoil}}$$

where $k = (p_{T,W}/p_{T,\text{recoil}})_{MC}$



MC Based Recoil Correction k

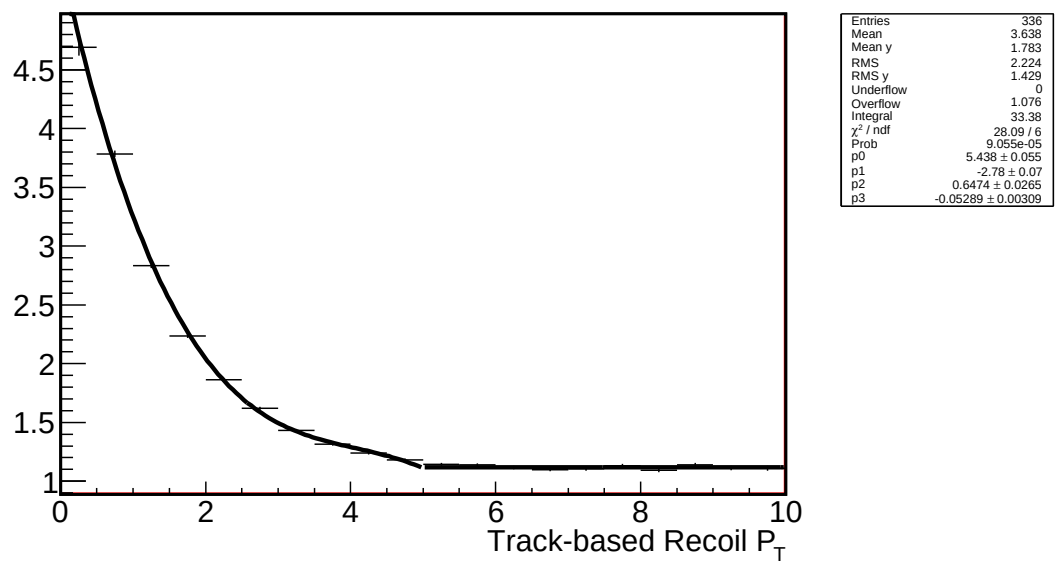




- Recoil correction is event-based

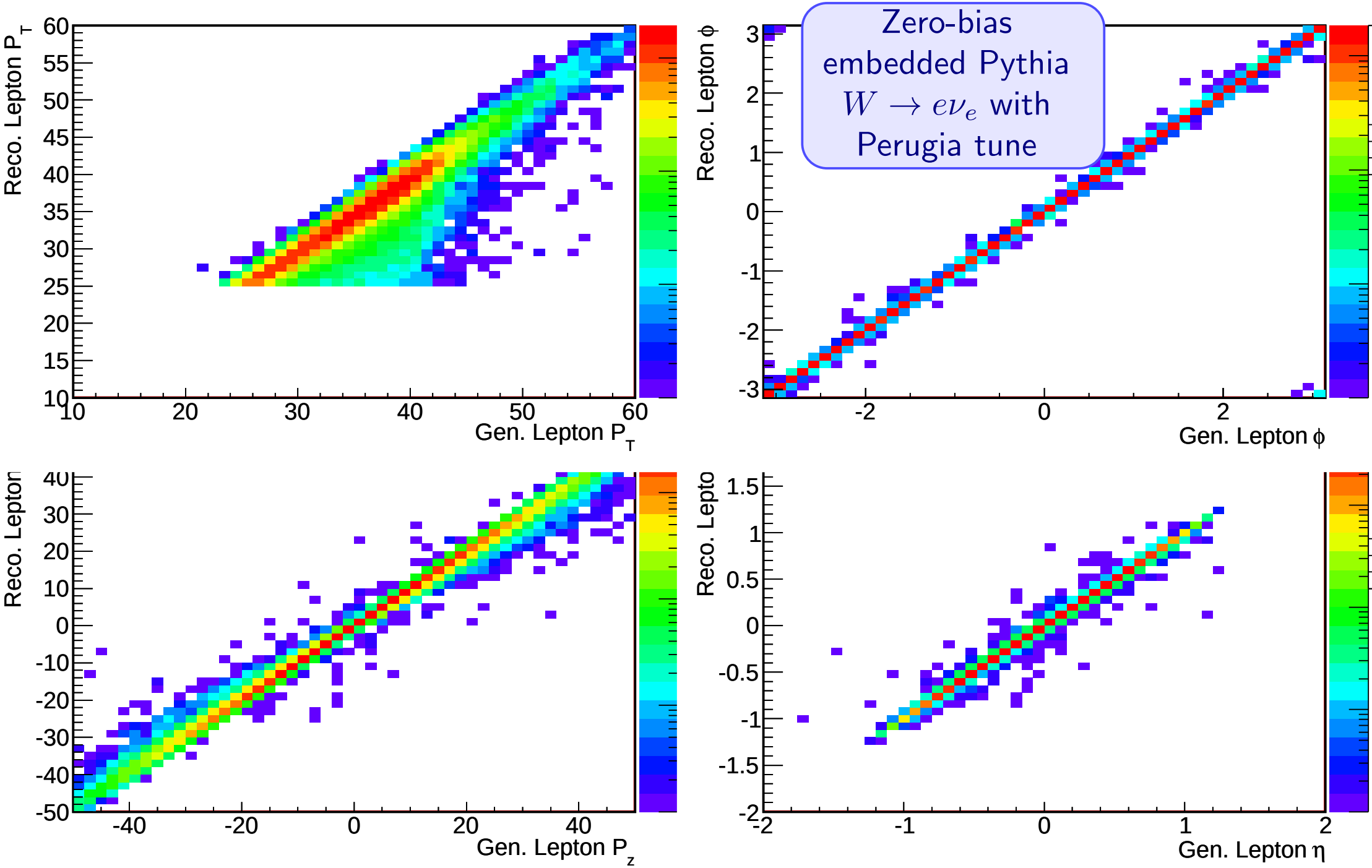
$$p_{T,W} = k \times p_{T,\text{recoil}}$$

$$k = \left(p_{T,W}/p_{T,\text{recoil}}\right)_{MC}$$



- Here we use zero bias embedded Pythia $W \to e\nu_e$ with Perugia tune

Reconstructed vs. Generated: $e^{\pm}$



Neutrino ν Reconstruction

- In transverse plane:

$$\vec{p}_{T,\nu} \approx \vec{\not{E}}_T = -\sum_{i \in \substack{\text{tracks,}\\ \text{clusters}}} \vec{p}_{T,i}$$

- Longitudinal z-component can be reconstructed from invariant mass. Currently assume constant M_W for W produced on-shell

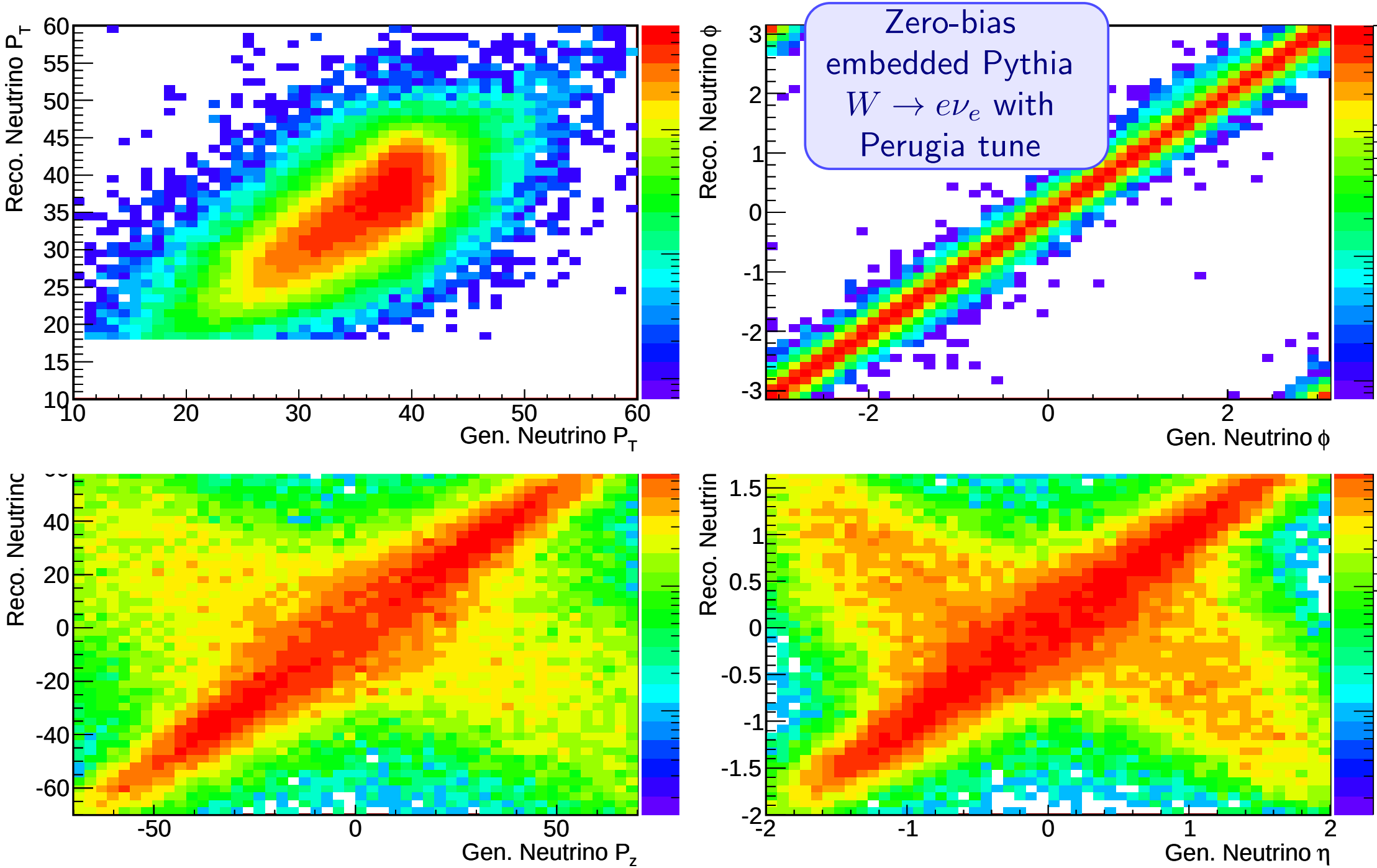
$$M_W^2 = (E_l + E_\nu)^2 - (\vec{p}_l + \vec{p}_\nu)^2$$

- Quadratic equation for $p_{z,\nu}$:

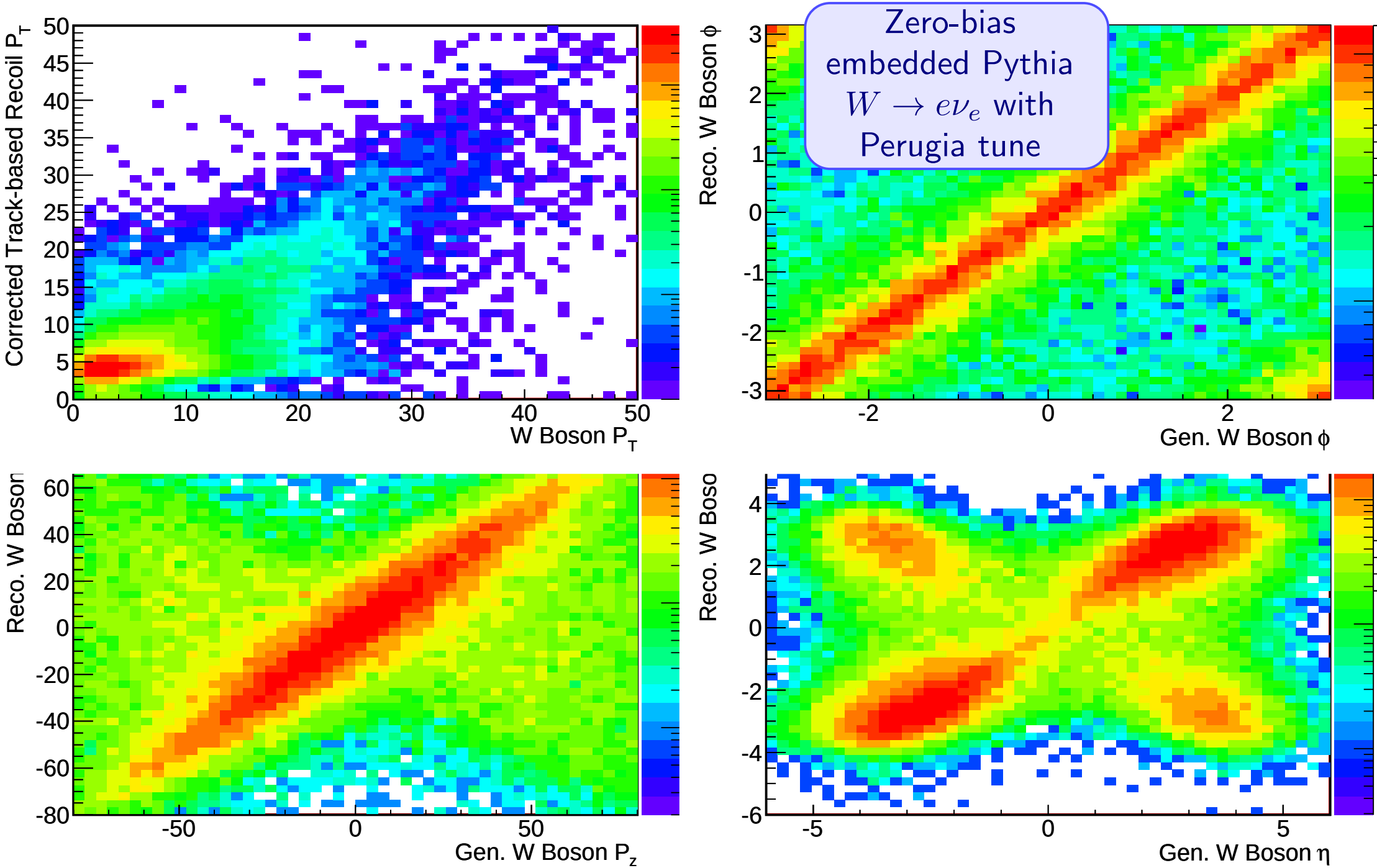
$$|\vec{p}_{T,l}|^2 p_{z,\nu}^2 - 2A p_{z,l} p_{z,\nu} + |\vec{p}_{T,\nu}|^2 |\vec{p}_l|^2 - A^2 = 0$$
$$A = M_W^2/2 + \vec{p}_{T,l} \cdot \vec{p}_{T,\nu}$$

- Currently select the smallest absolute solution

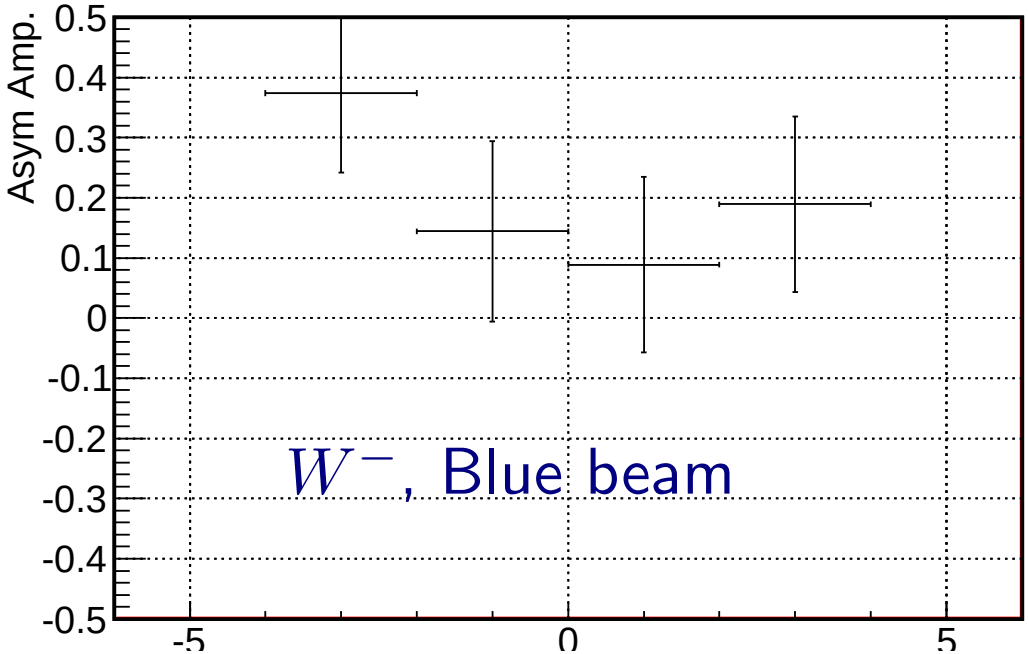
Reconstructed vs. Generated: ν

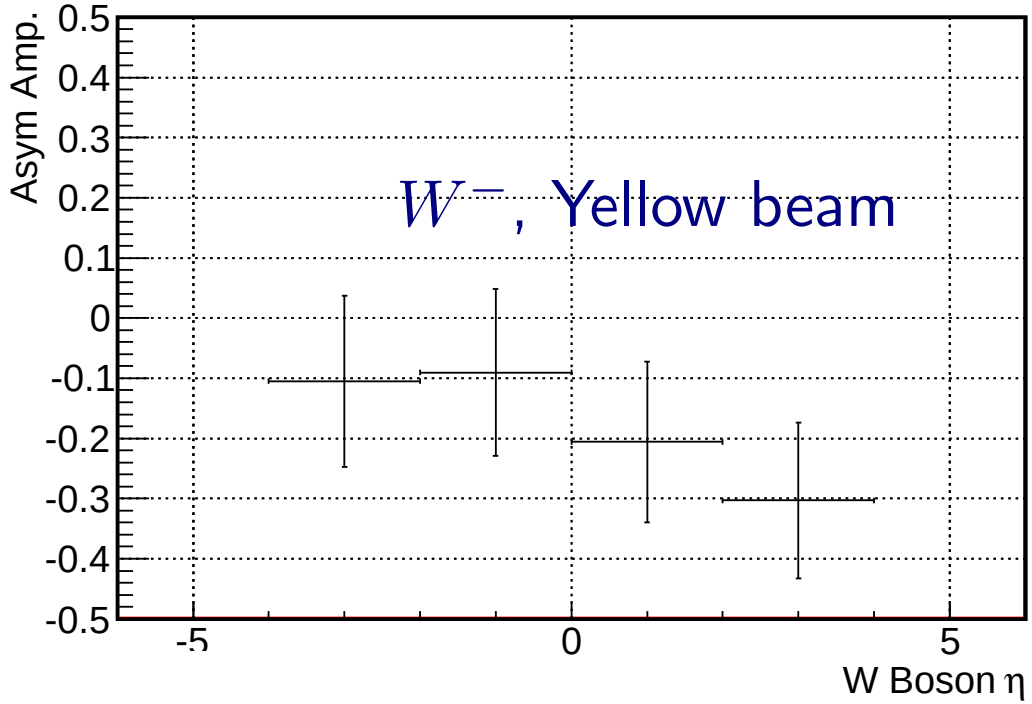


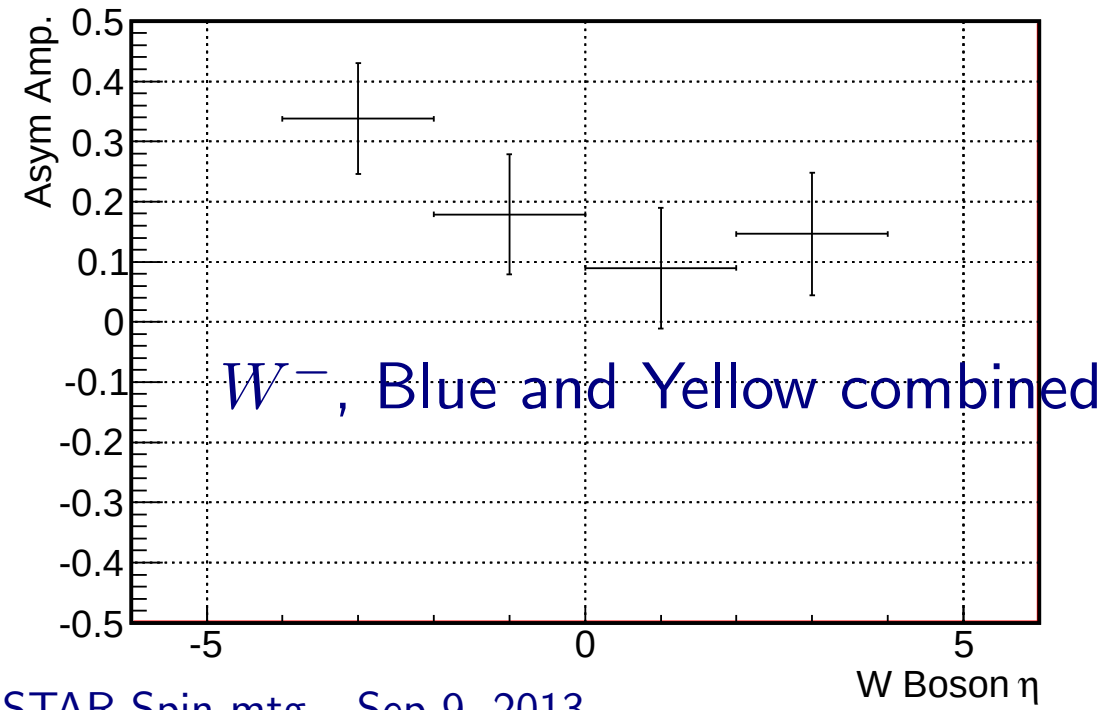
Reconstructed vs. Generated: $W^{\pm}$



How we Combine Blue and Yellow Beams: W^- vs. η



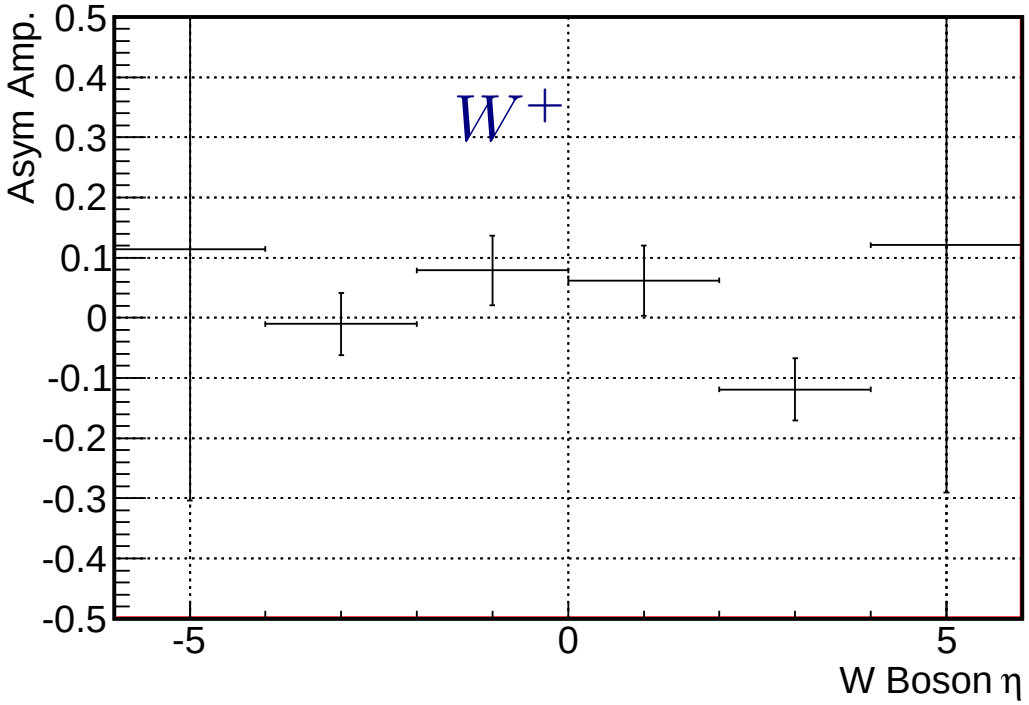


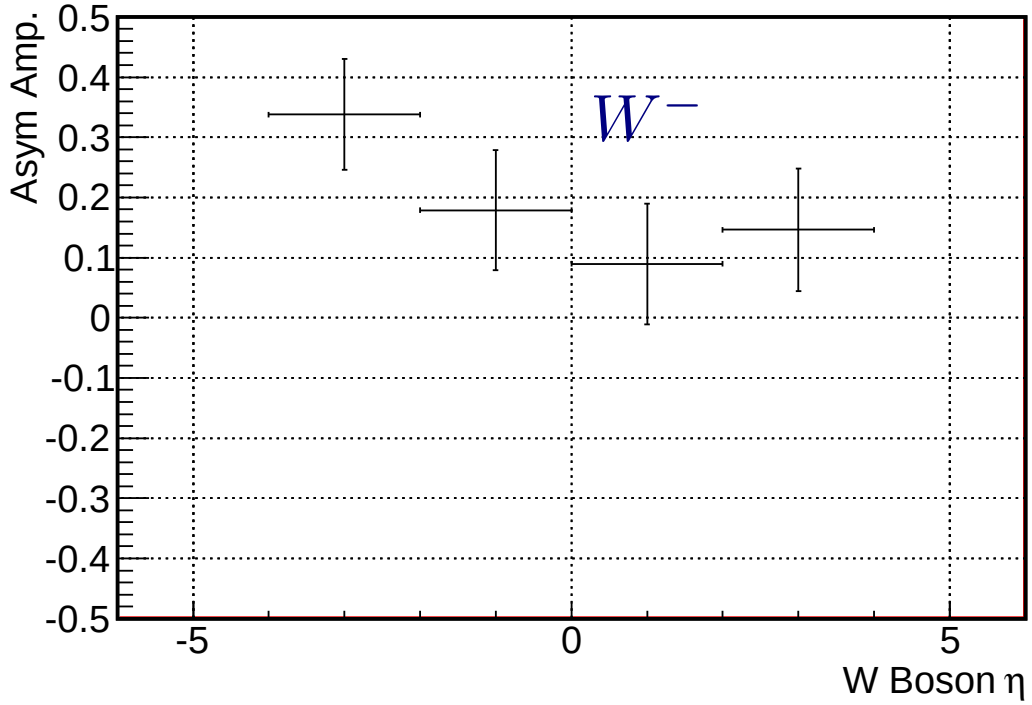


Entries	6
Mean	-0.3619
RMS	4.14
Underflow	0
Overflow	0
Integral	0.7525

- First calculate the asymmetry for both Blue and Yellow in the detector coordinate system. $+z$ collinear with Blue
- Then recalculate Yellow asymmetries for rotated around y system. $+z$ collinear with Yellow

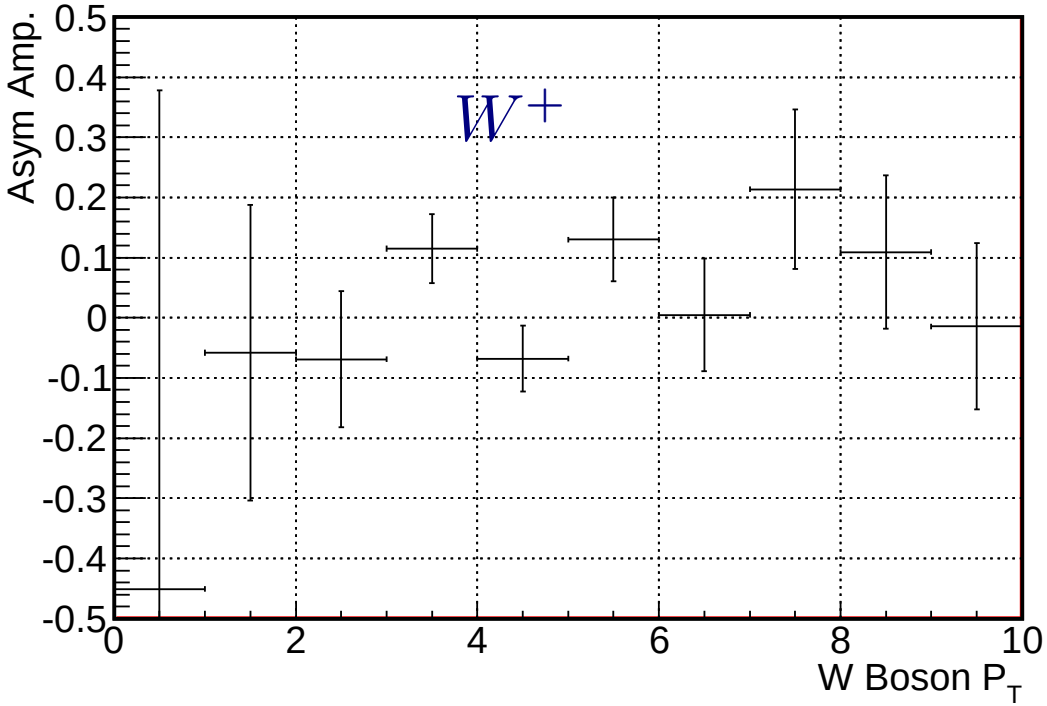
W Asymmetry vs. η

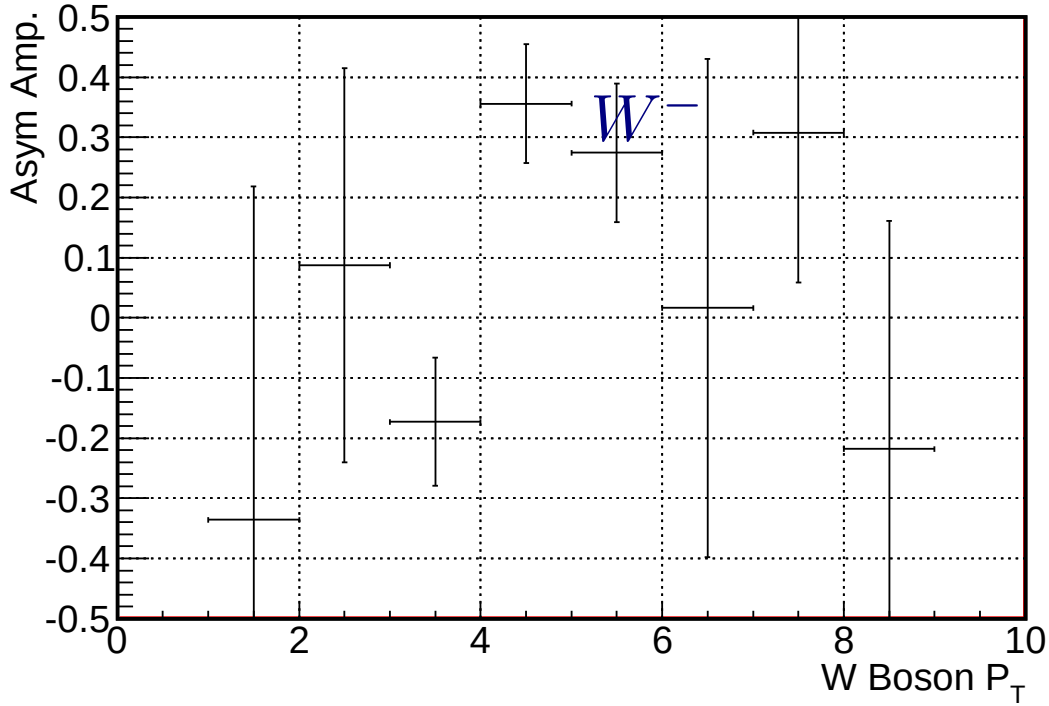




- At the moment there is no cut on $p_{T,W}$

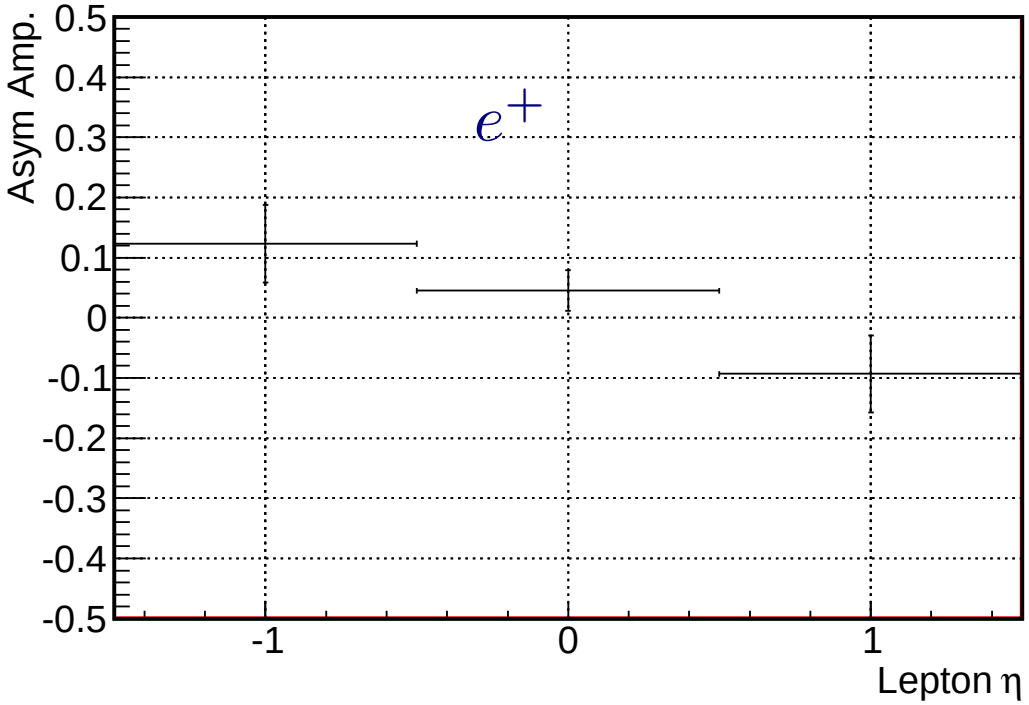
W Asymmetry vs. p_T

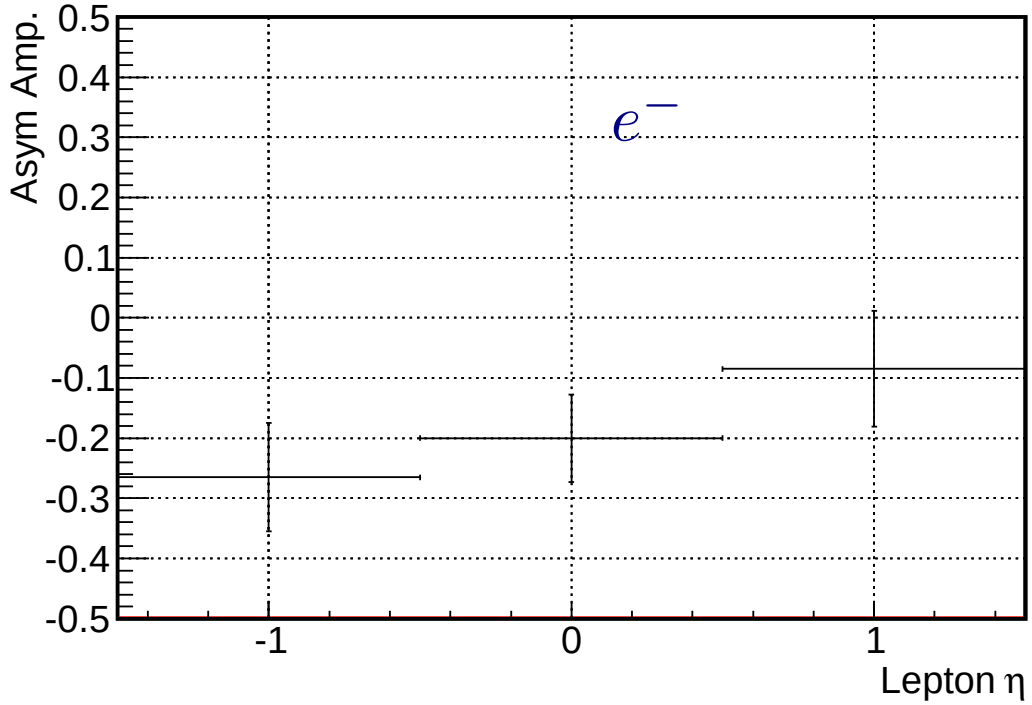




- At the moment there is no cut on η_W

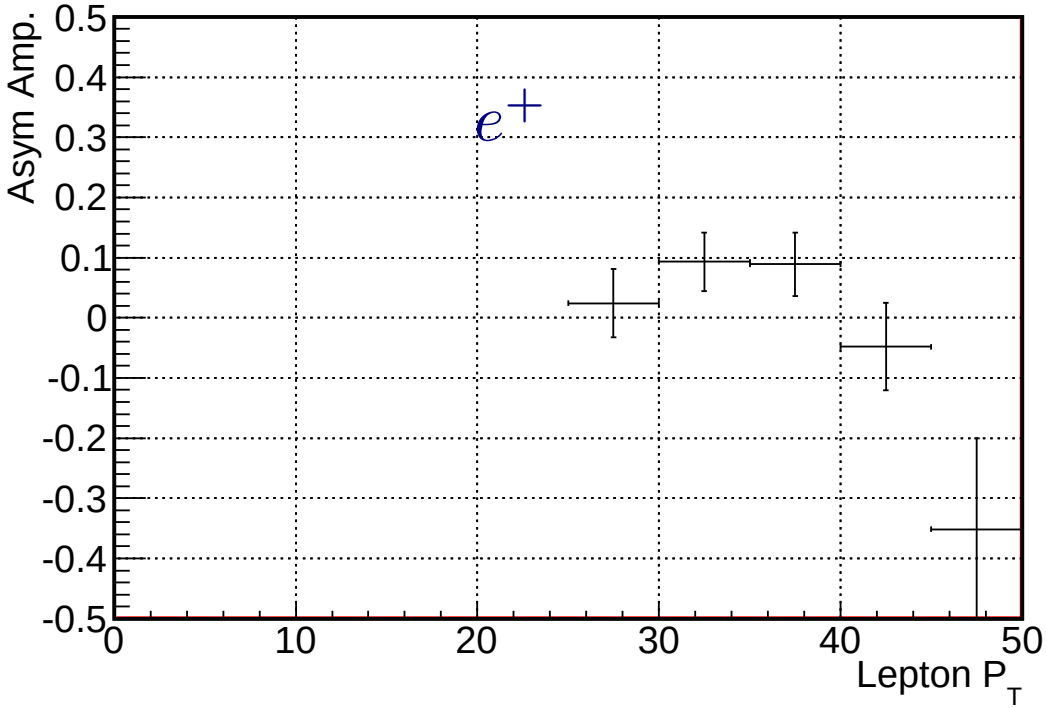
Lepton Asymmetry vs. η

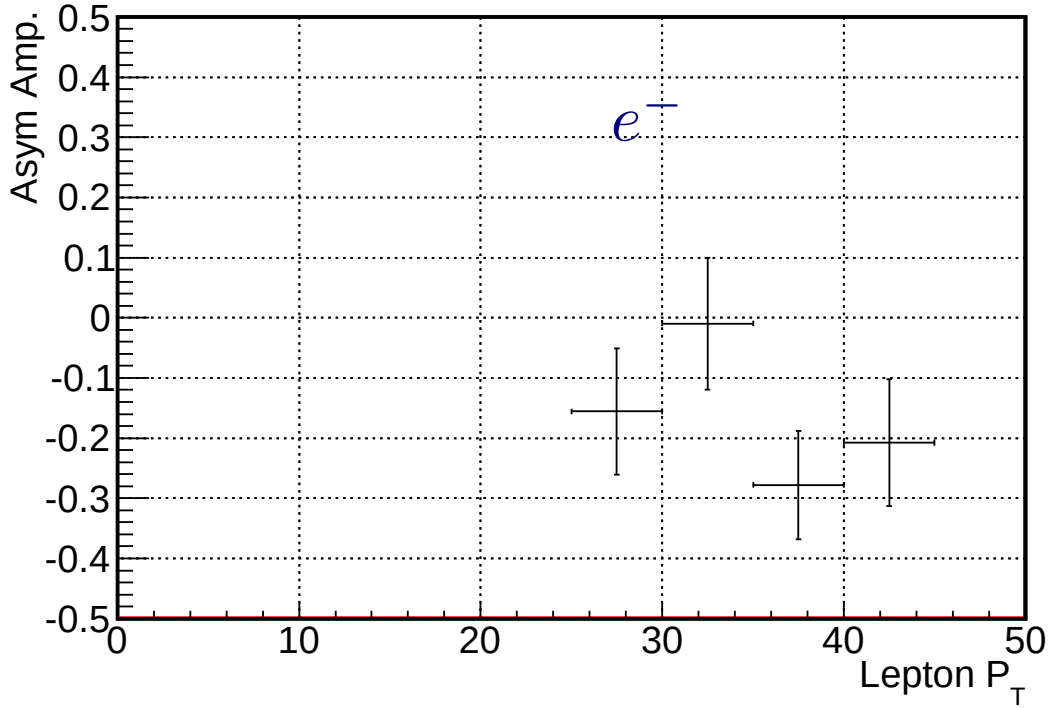




- Most energetic electron as defined on slide 3
- No additional cuts in p_T

Lepton Asymmetry vs. p_T





- Most energetic electron as defined on slide 3
- No additional cuts in η

Summary and Outlook

- First look at W asymmetries as a function of W's η and p_T
- Miss reconstructed neutrino's z component may additionally dilute the asymmetry
- Do cross checks with longitudinal pp sample

- Analysis web page
  `https://wiki.bnl.gov/rhicspin/Vector_boson_asymmetry`