Transverse Single Spin Asymmetry (A_N) for Electromagnetic-Jet in FMS

Dataset run 17 p↑ + p collision at √s=510 GeV

Preliminary request
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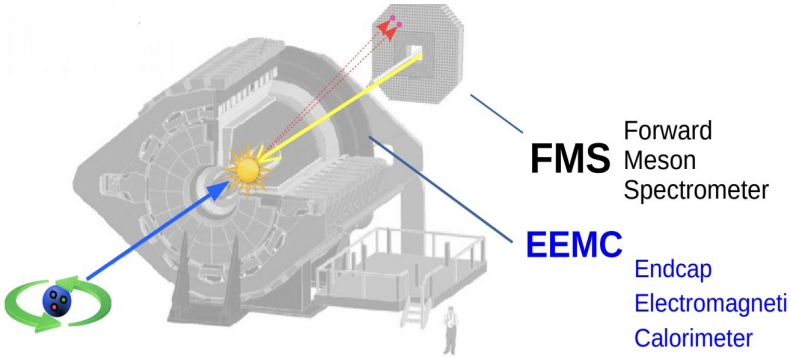
My Blog

EM-jet A_N ($p\uparrow + p \rightarrow$ EM-jet + X)

- Characterize A_N as a function of EM-jet-$p_{T,}$ energy, and photon multiplicities
- Explore the potential sources of large A_N



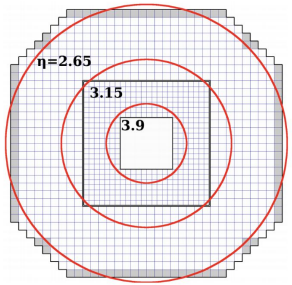
Data Features:

- Data-stream: FMS-stream
- Dataset: Run 17 ($\sqrt{s}$ = 510 GeV pp trans)
- Transversely polarized protons (<P>= 59%)
- Triggers: Small BS, Large BS, FMS-JP trigger
- Vertex z priority : TPC, VPD, BBC
- Calibration from Minghui
- FMS hot channel masking before reconstruction
- Exclude highly bit-shifted FMS channels
- Production tag : P18ic
- STAR Library version: SL20a

EM-jet: Jet reconstructed out of photons only

Jet Reconstruction

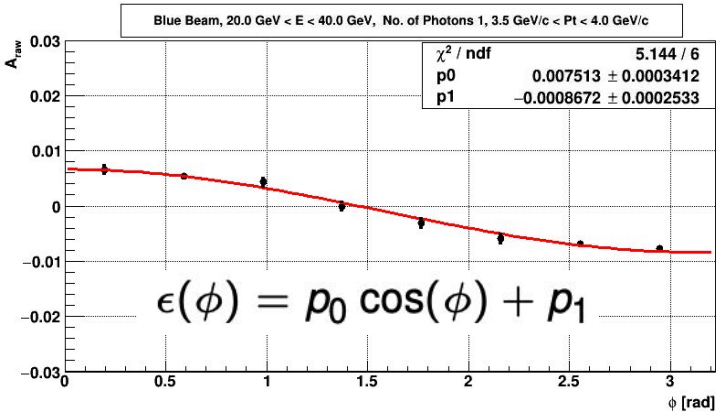
- Anti-k_T jet clustering algorithm with R= 0.7
- Eγ > 1.0 GeV
- -80 < z < 80 cm
- Jet p_T > 2.0 GeV/c
- 2.8 < η < 3.8



EM-Jet A_N Extraction

A_N as a function of EM-jet p_T, EM-jet energy, and photon multiplicity

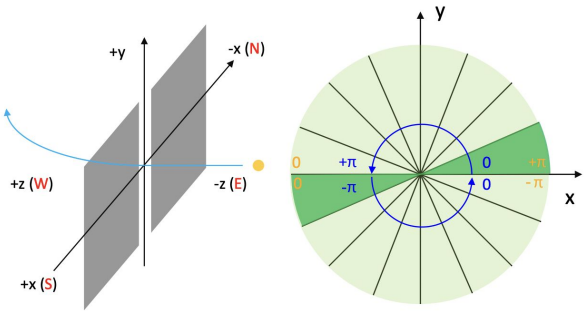
- Energy bins: [0-20] , [20 -40], [40 -60], [60 -80] , and [80 -100] GeV
- 16 equal $\boldsymbol{\phi}$ bins in the range - $\boldsymbol{\pi}$ to $\boldsymbol{\pi}$
- 3 photon multiplicity bins [n_γ<2, n_γ =3 , and n_γ>4]
- Separately for x_F>0 and x_F<0



- Cross-ratio formula to calculate A_N

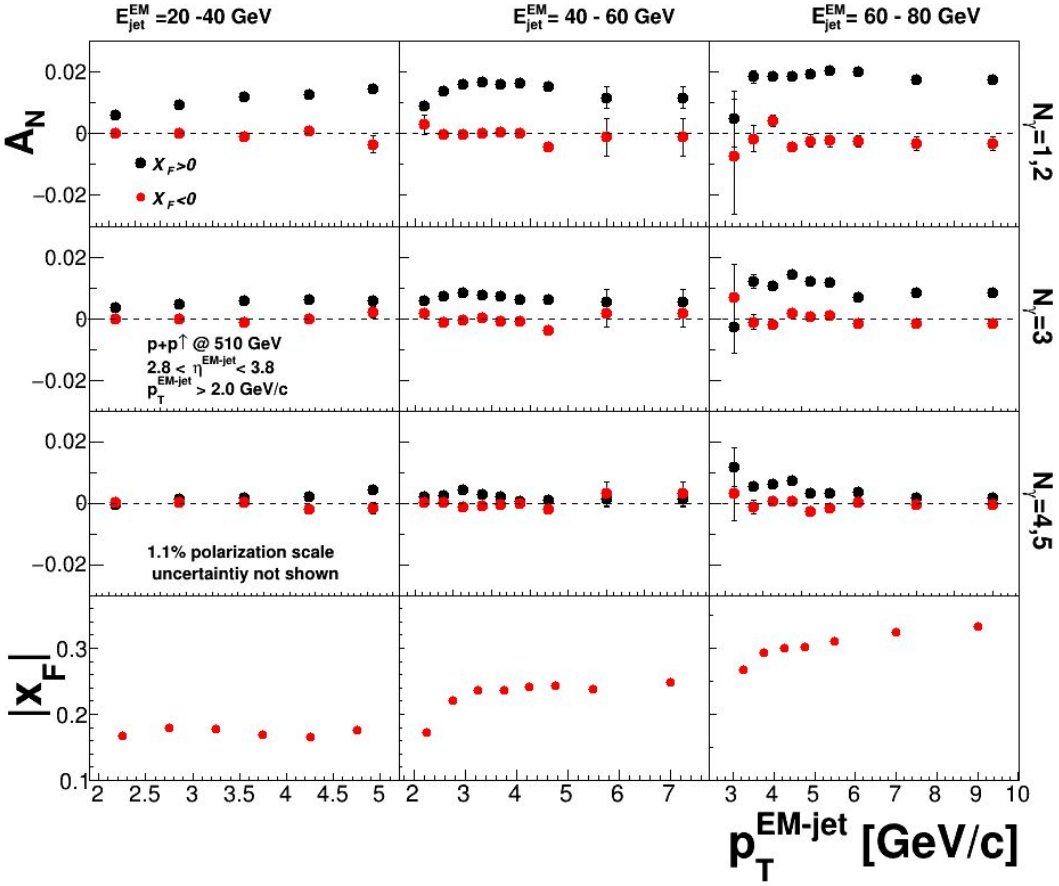
$$\epsilon = A_N \times P \times \cos(\phi)$$

$$\epsilon \approx \frac{\sqrt{N_\phi^\uparrow N_{\phi+\pi}^\downarrow} - \sqrt{N_{\phi+\pi}^\uparrow N_\phi^\downarrow}}{\sqrt{N_\phi^\uparrow N_{\phi+\pi}^\downarrow} + \sqrt{N_{\phi+\pi}^\uparrow N_\phi^\downarrow}}$$



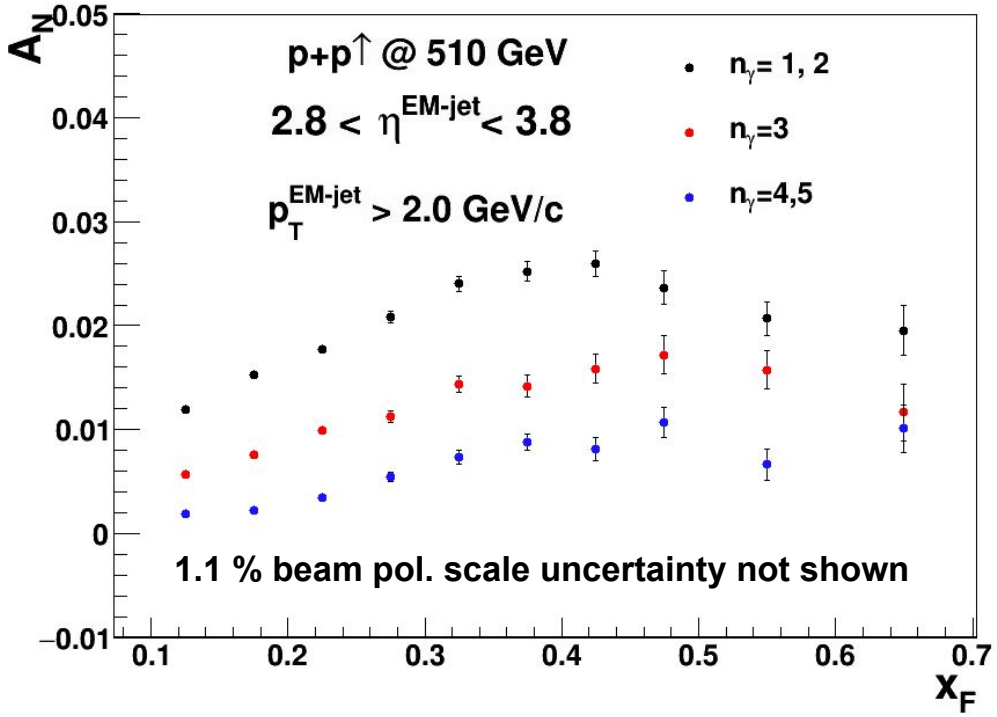
Cancels systematics, such as luminosity and detector effects

EM-Jet A_N at $\sqrt{s}$=510 GeV



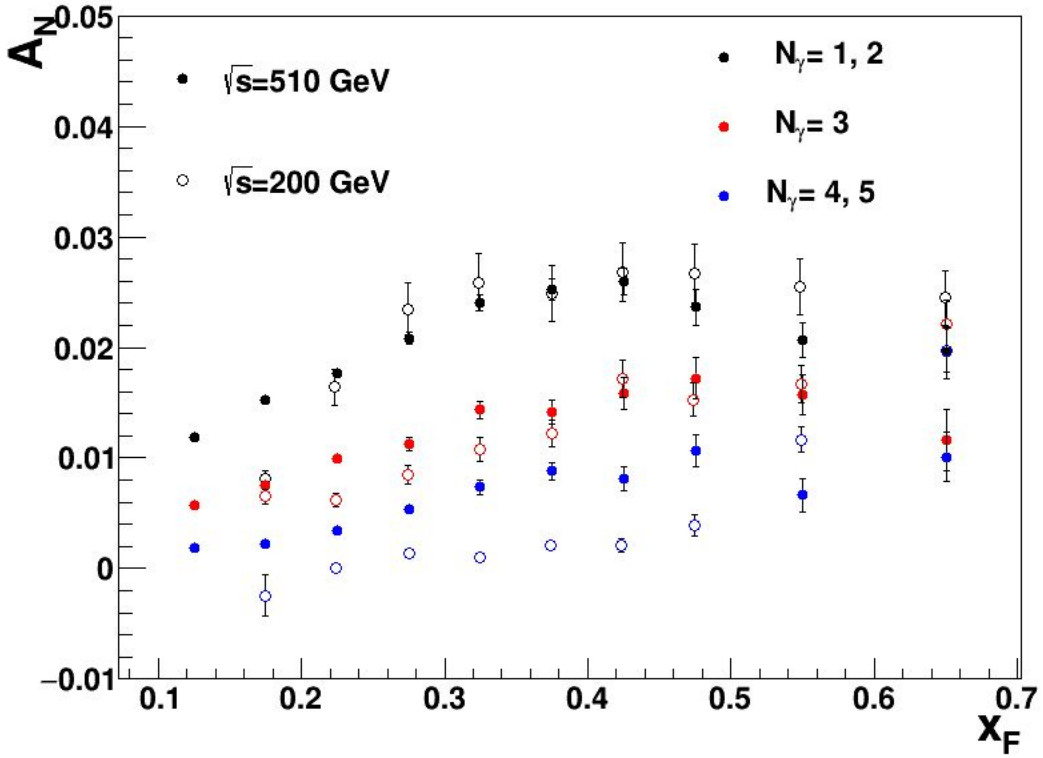
- A_N for 1 or 2 photons, 3 photons, and 4 or 5 photons
- Error bars statistical only
- A_N dependence on photon multiplicity
- A_N decreases as complexity increases

EM-Jet A_N at $\sqrt{s}$=510 GeV



Dependence photon multiplicity

A_N at different √s and photon multiplicities



[L.Kabir p↑ + p @200 GeV]

Dependence on √s, especially at lower photon multiplicity

Electromagnetic-Jet A_N Correction and Uncertainty

- **Underlying event correction, correction in p_T from detector-particle level done**

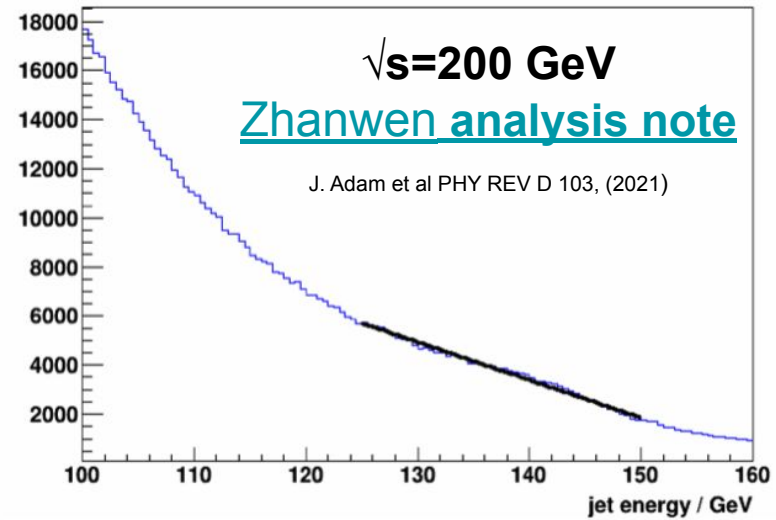
- **Polarization Error (~1.1%)**
  [1] W.B. Schmidke , RHIC Polarization for Run 9-17
  [2] Z. Chang, Example calculation of fill-to-fill polarization uncertainties

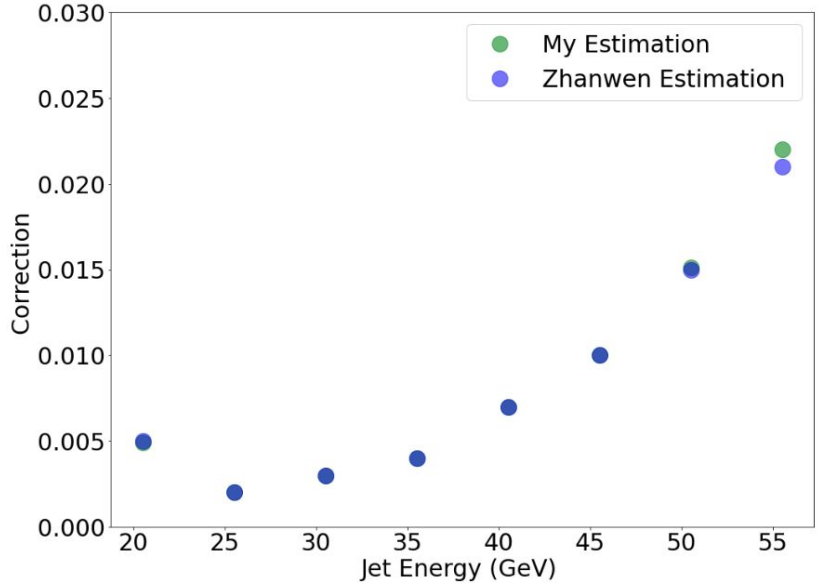
- **Energy or p_T Corrections and Uncertainties (~4%):**
  - **Calibration uncertainty (3.5%)**
  - **Energy or p_T correction (0.5%)**
  - **Uncertainty due to radiation damage (1.5%)**

- Systematic on A_N
  - Contamination from unphysical events in A_N energy bin as in J. Adam et al PHY REV D 103, (2021), (Zhanwen analysis note)

Systematic on Em-Jet A_N

Reproducing existing results (run 15)

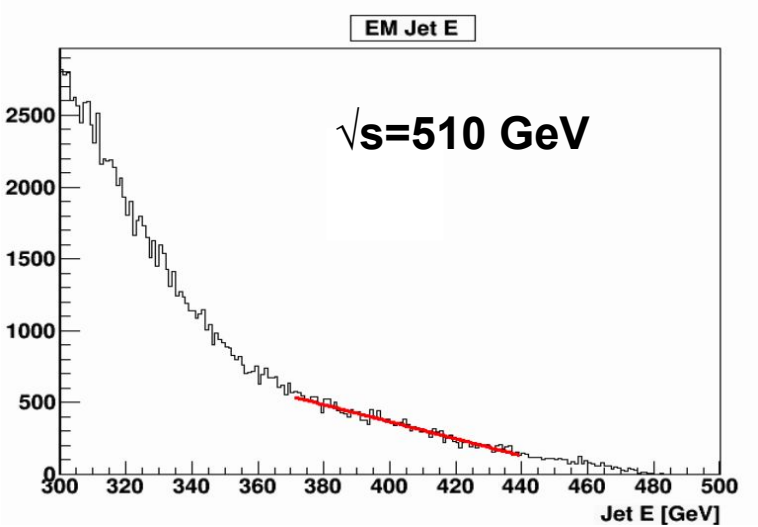


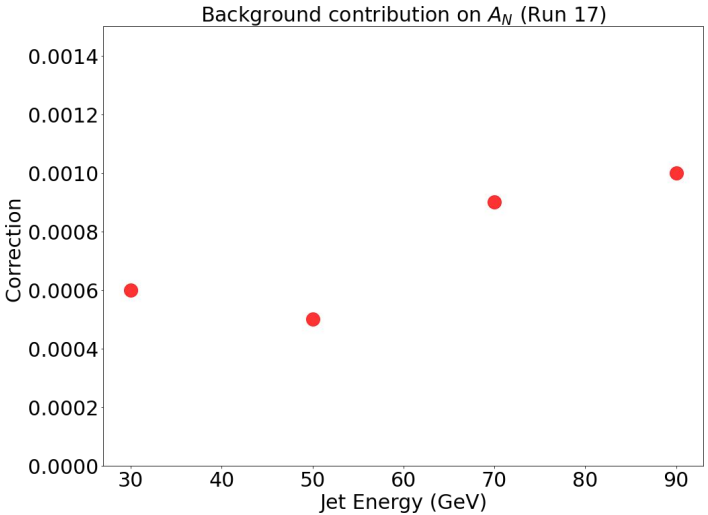


- Unphysical events, events with Jet E larger than beam energy
- Contamination from unphysical events is extrapolated to A_N energy bin for systematic on A_N
- Able to reproduce Zhanwen results (Run 15)

Correction from Unphysical events

Run 17, beam energy 255 GeV





- For run 17 (beam energy 255 GeV) the contamination from unphysical events is insignificant
- **“In Run11 (beam energy 250 GeV), since we are working at the energy range that is far away from the beam energy, the influence of the background is considered to be negligible”** Zhanwen **analysis note**

EM-Jet A_N Existing result

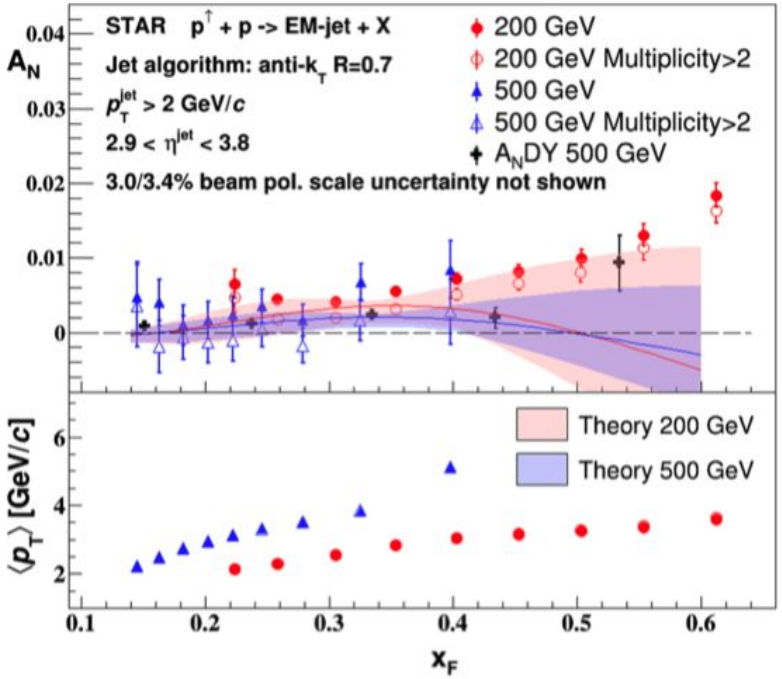


FIG. 9. Transverse single-spin asymmetry as a function of x_F for electromagnetic jets in transversely polarized proton-proton collisions at $\sqrt{s} = 200$ and 500 GeV. The error bars are statistical uncertainties only and the systematic uncertainties are negligible.

J. Adam *et al* PHY REV D 103, (2021)

Conclusion

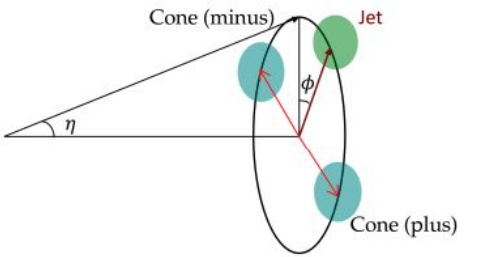
- A_N for EM-jet are extracted using run 17 data set, p↑ + p collision at √s=510 GeV

- A_N are extracted as function of EM-jet p_T, x_F , photon multiplicities for different energies bin

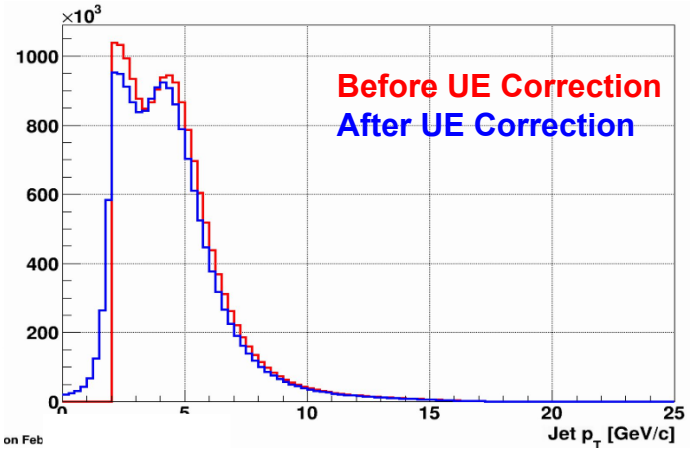
- Data is corrected with underlying events correction and
- A_N shows similar trend as previous results, decreases with higher photon multiplicities
- A_N shows larger dependence with center of mass energy at higher photon multiplicities
- A_N systematic computed based on similar analysis at **J. Adam *et al* PHY REV D 103, (2021)**
- A_N systematic is insignificant, result consistent to previous result **J. Adam *et al* PHY REV D 103, (2021)**

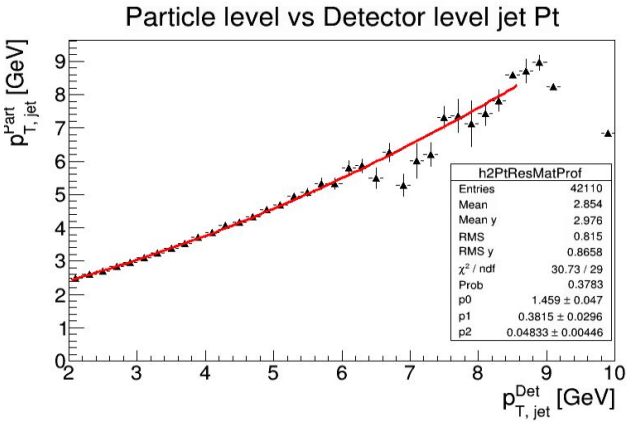
Backup

Underlying Event (UE) Correction and particle-detector level correction



Phys Rev D **91** 112012 (2015), ALICE Collaboration





- Underlying event is a part of a jet but not from the parton fragmentation could be secondary scattering
- EM-jet p_T values are corrected for contaminations from underlying events (UE) using off-axis cone method
- Correction to jet p_T, dp_T = underlying Event Density x Area
- Corrected Jet $\mathbf{p_T = p_T - dp_T}$

Correction is applied to the presented result

Polarization Uncertainty

$$P_{fill} = \sigma(P_0) + \frac{dp}{dt} \cdot \left(\frac{\sum_{run} t_{run} L_{run}}{L_{fill}} - t_0 \right)$$

$$P_{set} = \frac{\sum_{fill} L_{fill} P_{fill}}{\sum_{fill} L_{fill}}$$

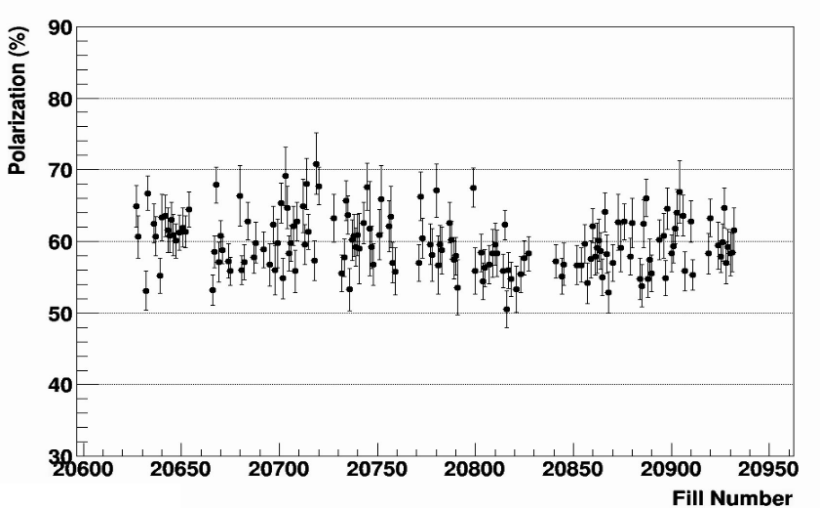
$$\frac{\sigma_{P_{Set}}}{P_{Set}} = \frac{\sigma(scale)}{P} \oplus \sigma_{fill-to-fill} \oplus \frac{\sigma(profile)}{P}$$

$$\frac{\sigma(scale)}{P} = 1.1\ \%$$

$$\frac{\sigma(profile)}{P} = \frac{2.2}{\sqrt{M}}$$

$$\sigma_{fill-to-fill} = \left(\sqrt{1 - \frac{M}{N}} \right) \frac{\sum_{fill} L_{fill} \sigma_{P_{fill}}}{\sum_{fill} L_{fill}}$$

$$\sigma(P_{fill}) = \sigma(P_0) \oplus \sigma \left(\frac{dp}{dt} \right) \cdot \left(\frac{\sum_{run} t_{run} L_{run}}{L_{fill}} - t_0 \right)$$

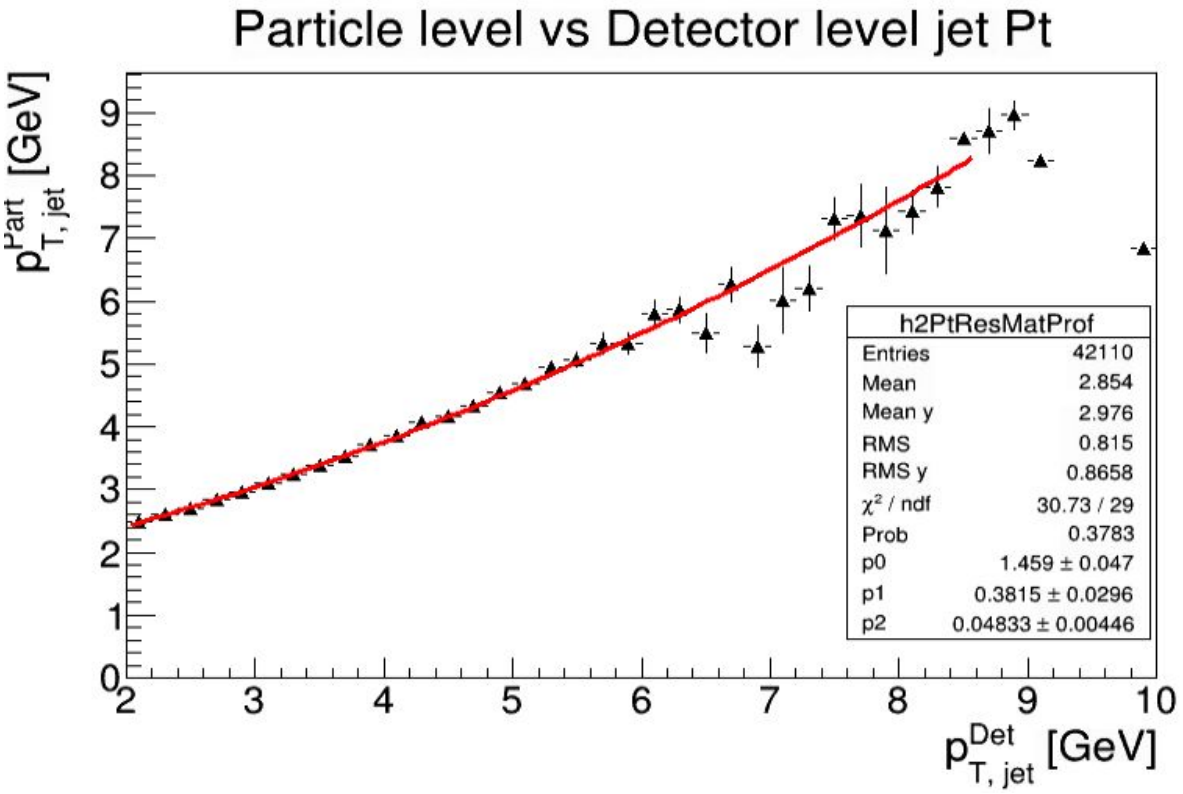


- M = 162
- N = 190
- $\sigma_{\text{fill-to-fill}}$ = 0.05 %
- P_{Set} = 59.94 %
- σ_{PSet} = 1.07 %

[1] W.B. Schmidke , RHIC Polarization for Run 9-17

[2] Z. Chang, Example calculation of fill-to-fill polarization uncertainties

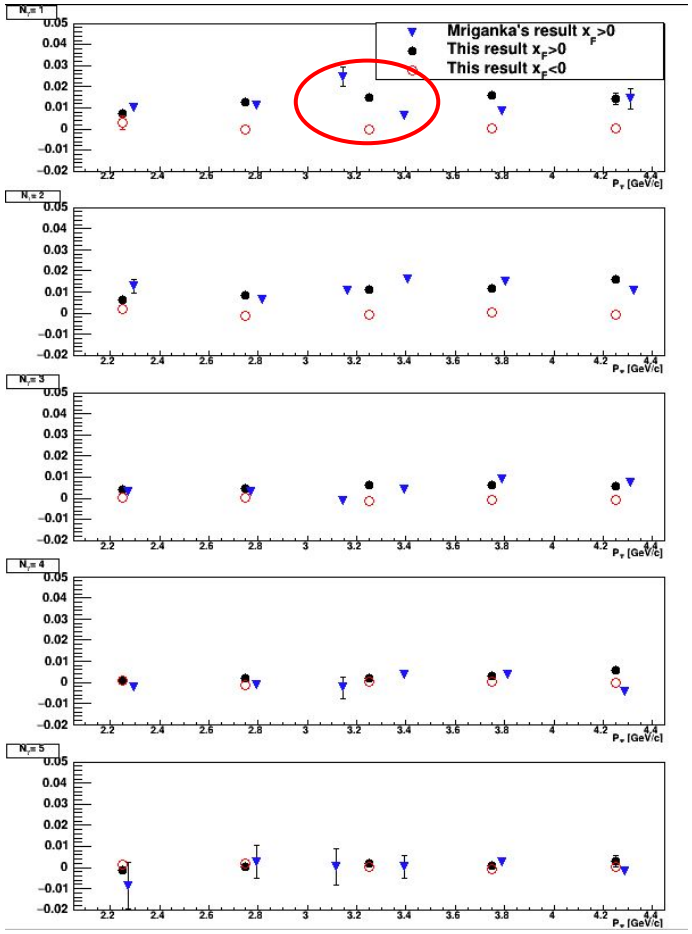
Detector to particle level correction (p_T)



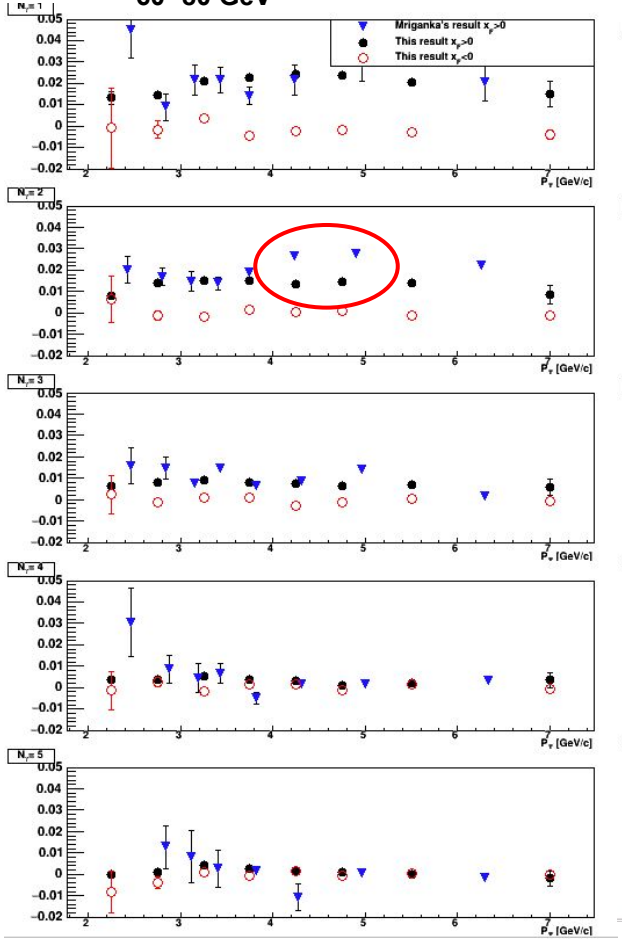
Correction is applied to the presented result

Comparison with existing results (Run 11, √s=500 GeV Mriganka Mouli Mondal)

40 -60 GeV



60 -80 GeV



80 -100 GeV