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

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

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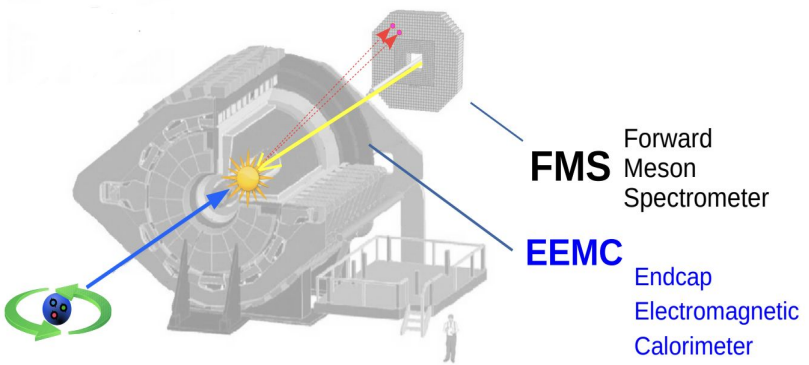
Follow up for the status presented here

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

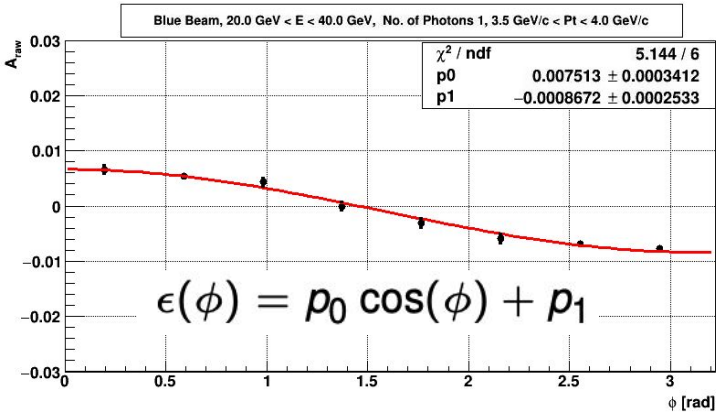
Jet Reconstruction

- 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 (expect JP)
- 2.8 < η < 3.8

EM-Jet A_N Extraction

A_N as a function of EM-jet p_T, energy, and photon multiplicity (FMS data)

- Energy bins: [0-20] , [20 -40], [40 -60], [60 -80] ,
- and [80 -100] GeV
- 16 equal $\boldsymbol{\Phi}$ bins in the range - **π** to **π**
- 5 photon multiplicity bins
- Separately for $x_F>0$ and $x_F<0$

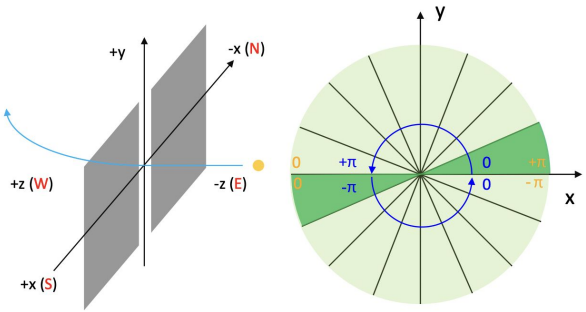


- Cross-ratio formula to calculate A_N

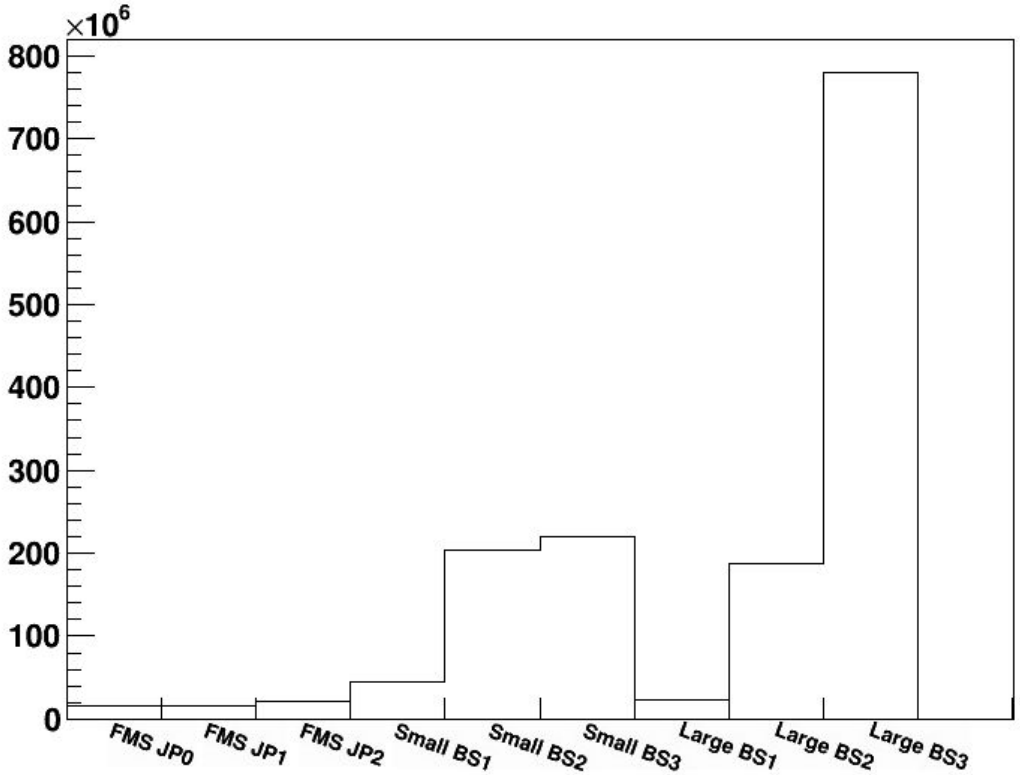
$$\epsilon = A_N \times P \times \cos(\phi)$$

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

- Cancels systematics, such as luminosity and detector effects



Trigger distribution in Data



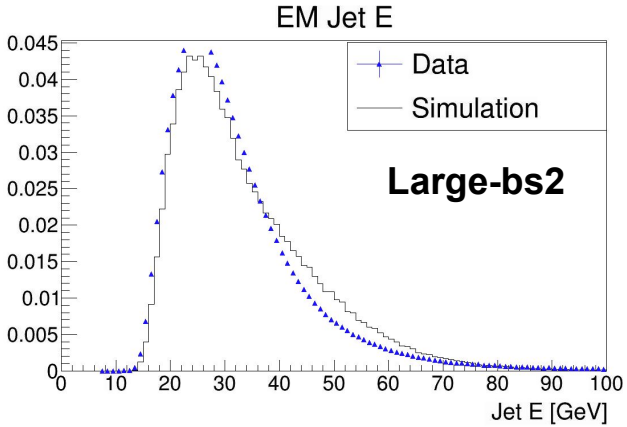
- Analyzed both data and simulation with trigger threshold > 2GeV
- Trigger threshold for JetPatch (JP) was set to 7.5 GeV for run 17 period
- Analyzed data excluding JP in both data and simulation

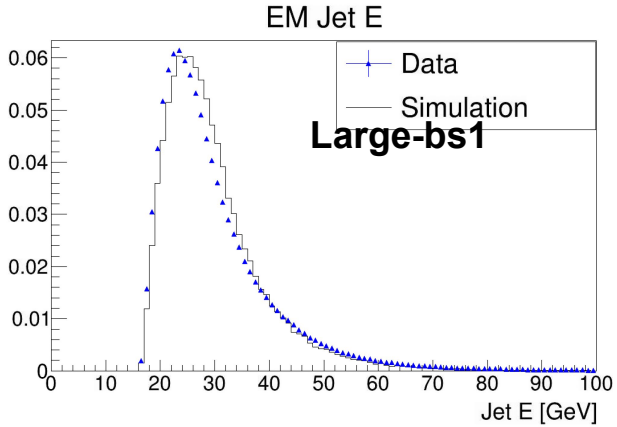
- JP trigger was set to high threshold (7.5 GeV)
- About 2.5% of events triggered by JP trigger (JP0 + JP1 + JP2)

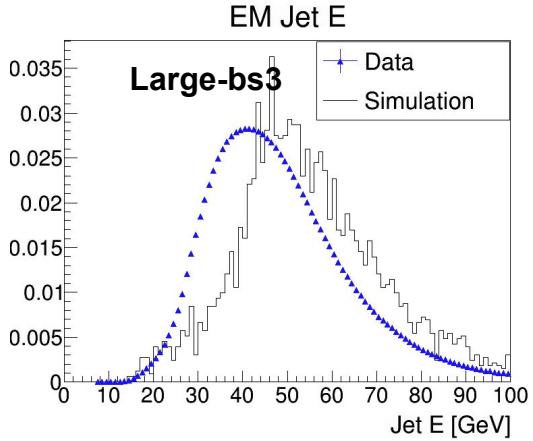
Data vs Simulation

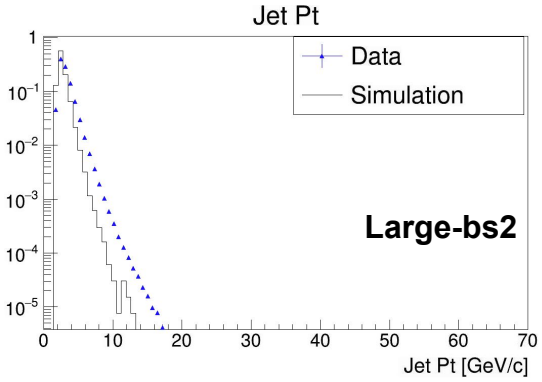
Cuts:

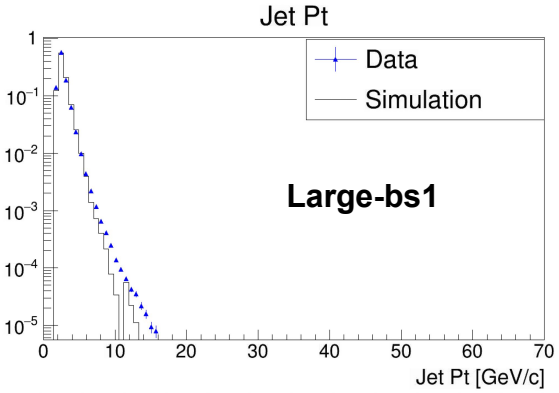
- -80 < z < 80 cm, 2.8 < η < 3.8
- Jet p_T > 2.0 GeV/c

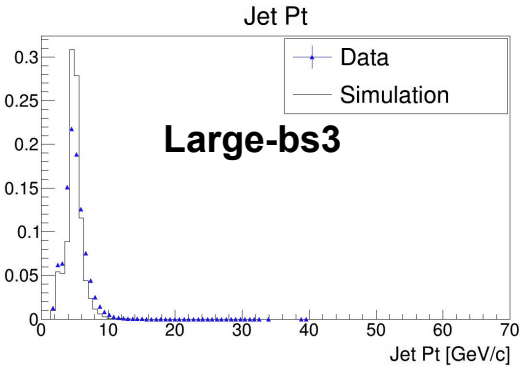




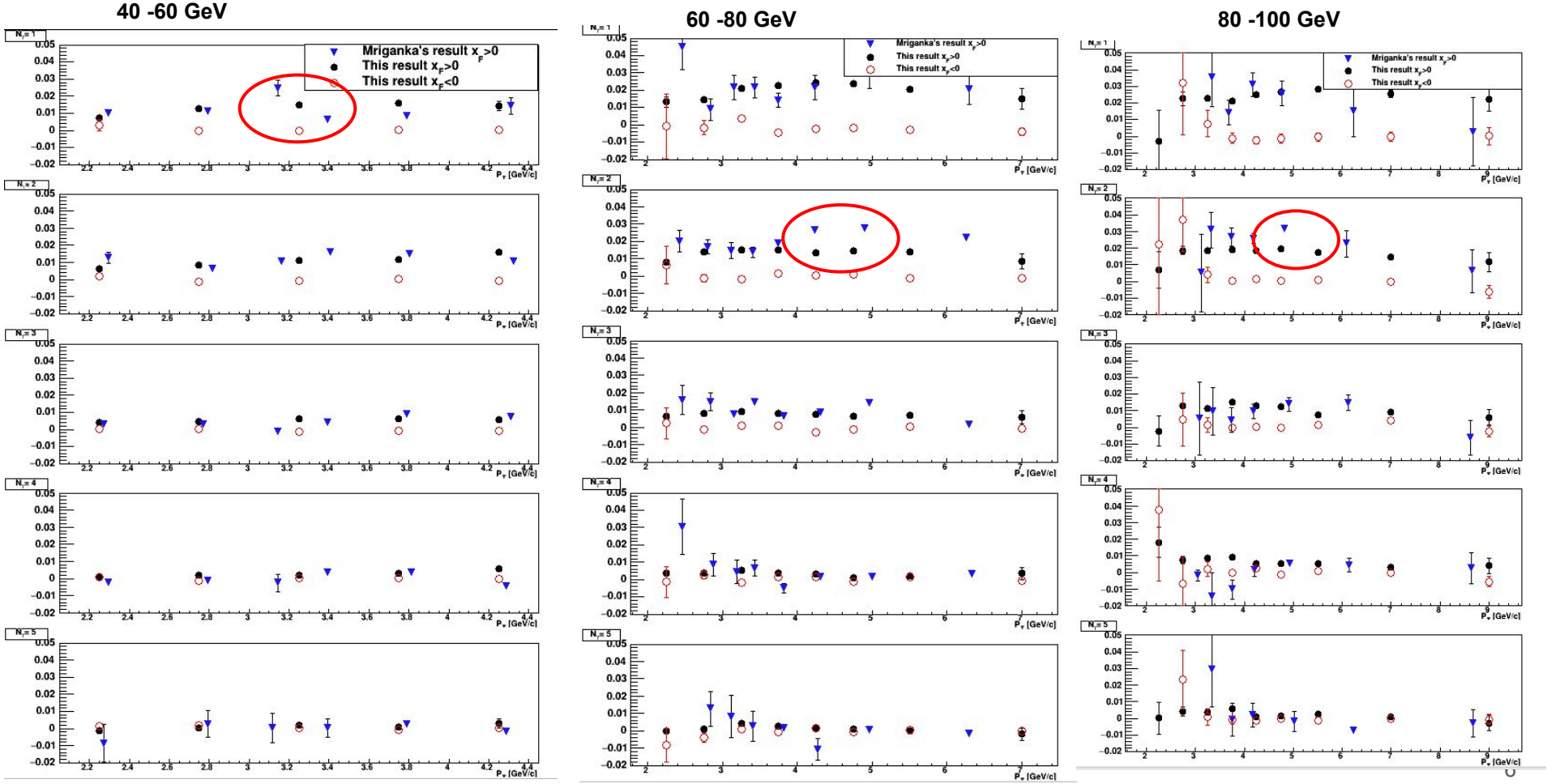




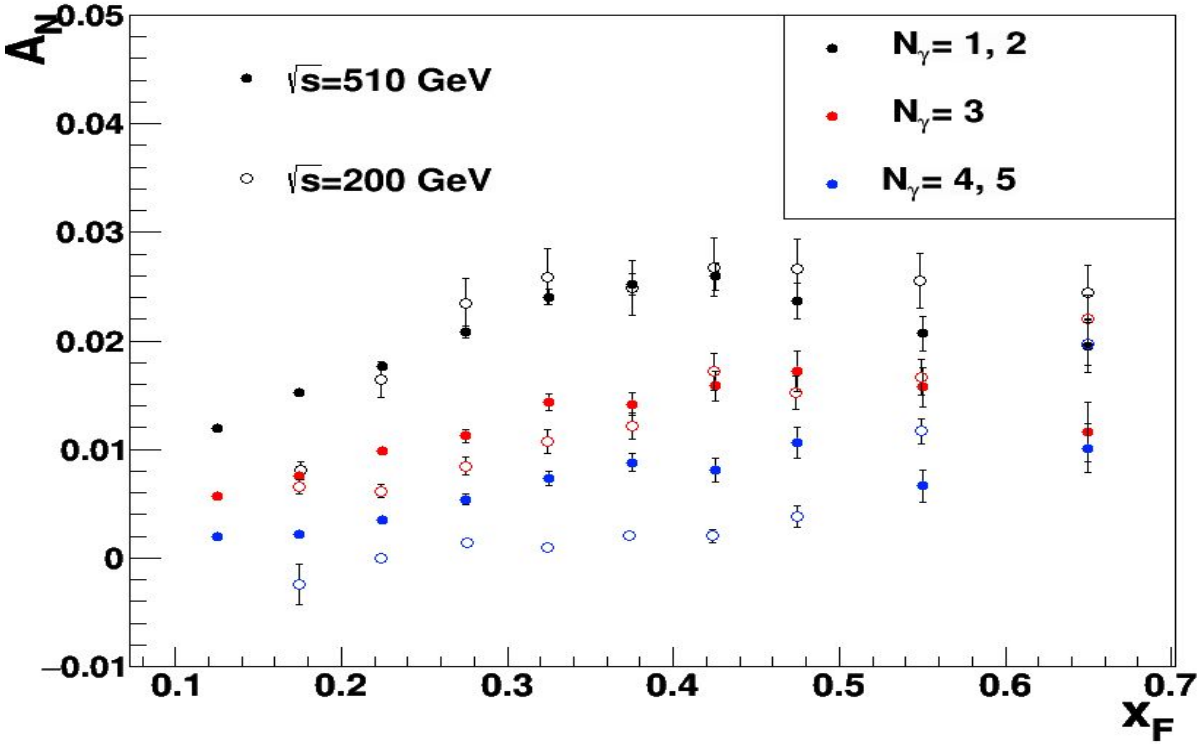




Comparison with existing results (Run 11, √s=500 GeV Mriganka Mouli Mondal)



A_N with $\sqrt{s}$ and photon multiplicities



Electromagnetic-Jet A_N Correction and Uncertainty

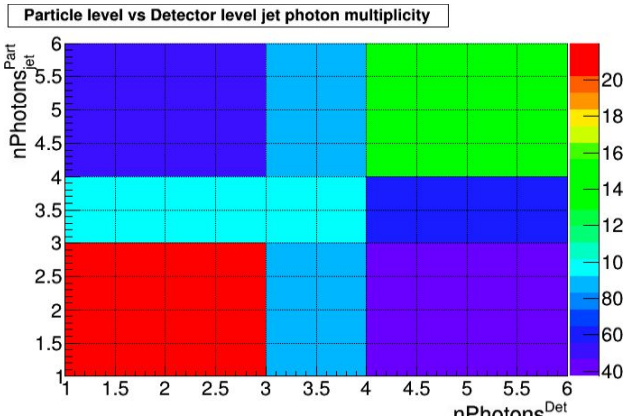
- Underlying event correction, correction in p_T from detector-particle level done

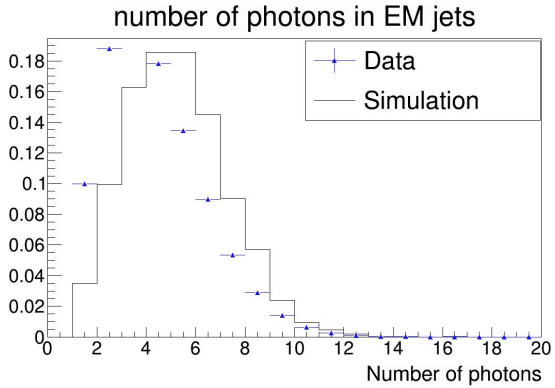
- **Polarization Error (~1%)**

  [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
  - Energy or p_T correction
  - Uncertainty due to radiation damage

- **Event Misidentification: (About 15 -20 % uncertainty)**
  - Misidentification of 1, 2 etc photons as other types (2, 1, etc)
  - TSVD Unfolding Class from ROOT framework
    - A_N for given E, p_T
    - Number of photons in detector-particle level matrix
  - Mriganka (run 11) Latif (run 15) reports 5-7% systematic
  - Relies on simulation and data agreement



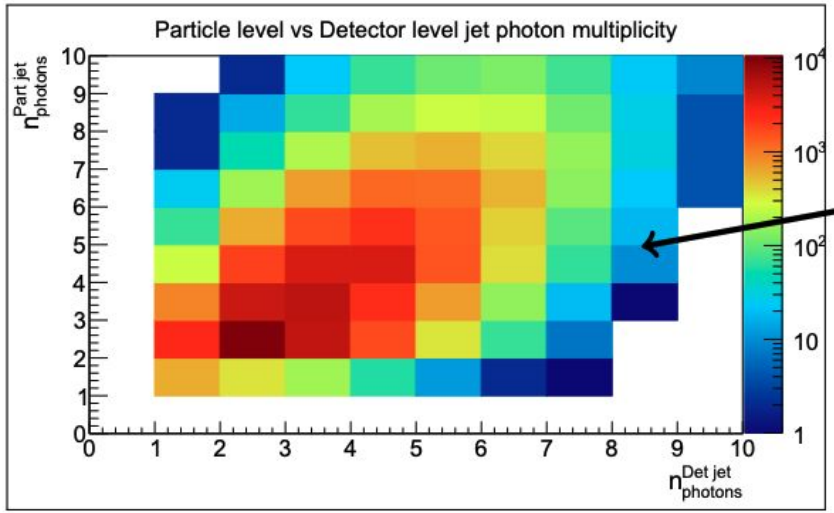


Conclusions:

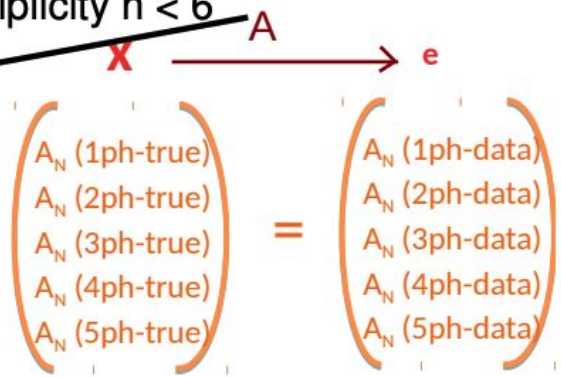
- A_N for EM-jet are extracted for different photon multiplicity as function of p_T
- A_N decreases as complexity increases (larger number of photons in EM-jet)
- Extracted A_N are consistent with Run 11 Mriganka Mouli Mondal**'s result**
- Data and simulation matches fairly well
- Underlying event correction on p_T is done
- p_T corrected with simulation (particle - detector level correction)
- Luminosity averaged polarization and associated uncertainty computed
- p_T uncertainty from Run 11 analysis (5%)
- Systematic due to event misidentification is very high

Back up

Unfolding for Event Misidentification



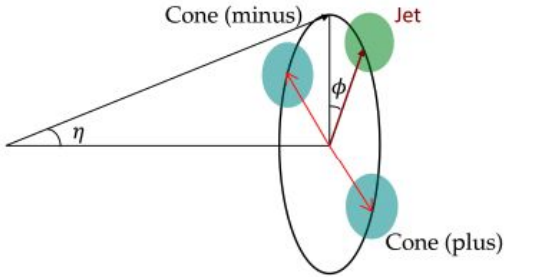
- The leading contributions come from A_N for EM-jets with photon multiplicity n < 6



- Solve a set of five linear equations with five variables for each energy and p_T bin
- Decompose A_N as a linear composition of A_N^i corresponding to n_i photons
- Use SVD for the unfolding procedure (e.g. TSVDUnfolding class)

Mriganka is reporting result in 5 photons bins but I am representing in 3 photons bins

Underlying Event (UE) Correction



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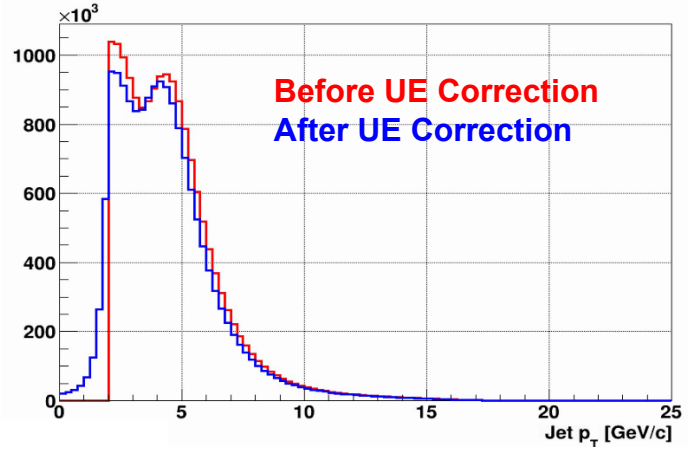
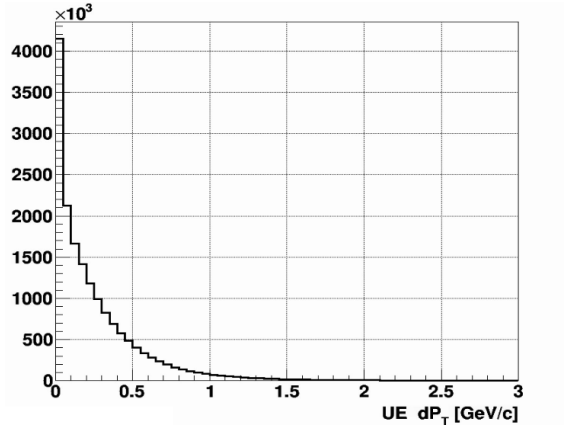
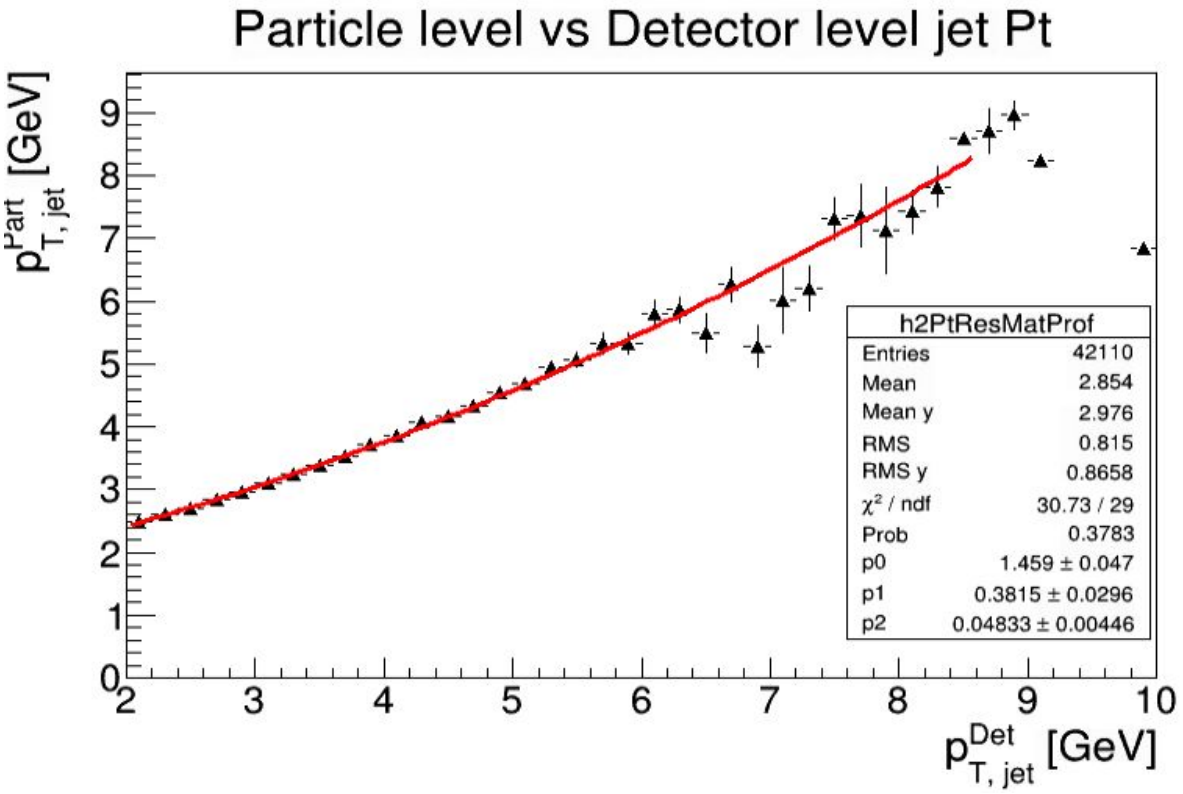




- EM-jet p_T values are corrected for contaminations from underlying events (UE) using off-axis cone method
- Correction to jet p_T, dp_T = underlying Event Density x Area
- Corrected Jet $\mathbf{p_T = p_T - dp_T}$

Correction is applied to the presented result

Detector to particle level correction (p_T)



Correction is applied to the presented result

Polarization Uncertainty

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

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

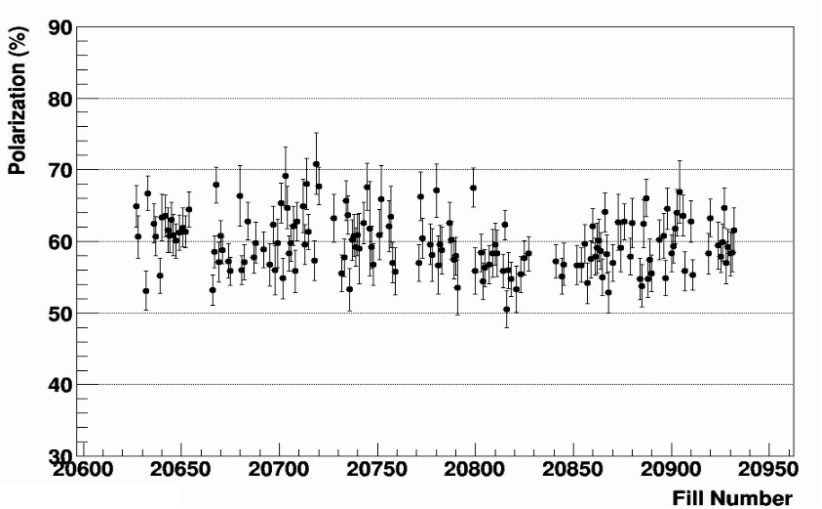
$$\frac{\sigma_{P_{Set}}}{P_{Set}} = \frac{\sigma(scale)}{P} \oplus \sigma_{fill-to-fill} \oplus \frac{\sigma(profile)}{P}$$

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

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

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

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



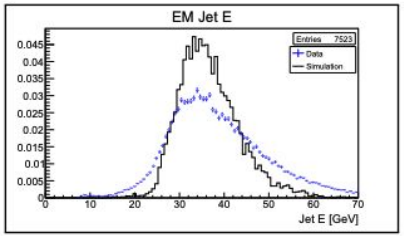
- M = 162
- N = 190
- $\sigma_{\text{fill-to-fill}}$ = 0.05 %
- P_{Set} = 59.94 %
- σ_{PSet} = 1.07 %

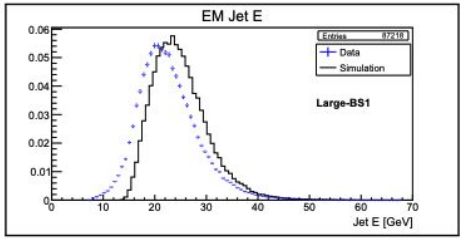
[1] W.B. Schmidke , RHIC Polarization for Run 9-17

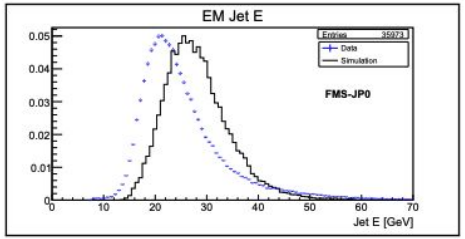
[2] Z. Chang, Example calculation of fill-to-fill polarization uncertainties

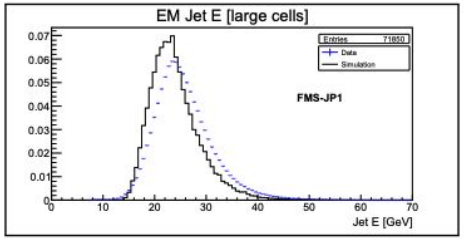
Run 15 Data vs Simulation: (Latif's Result)

FMS Jet: Data (Blue) Vs Simulation (Black)









Small-BS1 | Large-BS1 | FMS-JP0 | FMS-JP1