Transverse Single-Spin Asymmetry for inclusive and diffractive process with $p^{\uparrow} + p$ collision at $\sqrt{s} = 200$ GeV

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General Information

- Data set: run 15 pp transverse $\sqrt{s} = 200$ GeV ,fms stream
  - (production_pp200trans_2015)
- Production type: MuDst ; Production tag: P15ik
- Trigger for FMS : FMS small board sum, FMS large board sum and FMS-JP.
  - Trigger list: FMS-JP0, FMS-JP1, FMS-JP2, FMS-sm-bs1, FMS-sm-bs2, FMS-lg-bs1, FMS-lg-bs2, FMS-lg-bs3. (8 triggers)
- EM-jet reconstruction: Anti-k_T algorithm with R=0.7

Paper Information

- Title: Transverse Single-Spin Asymmetry for inclusive and diffractive process with $p^{\uparrow} + p$ collision at $\sqrt{s} = 200$ GeV
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- Target journal: TBD
- Webpage and analysis note: TBD

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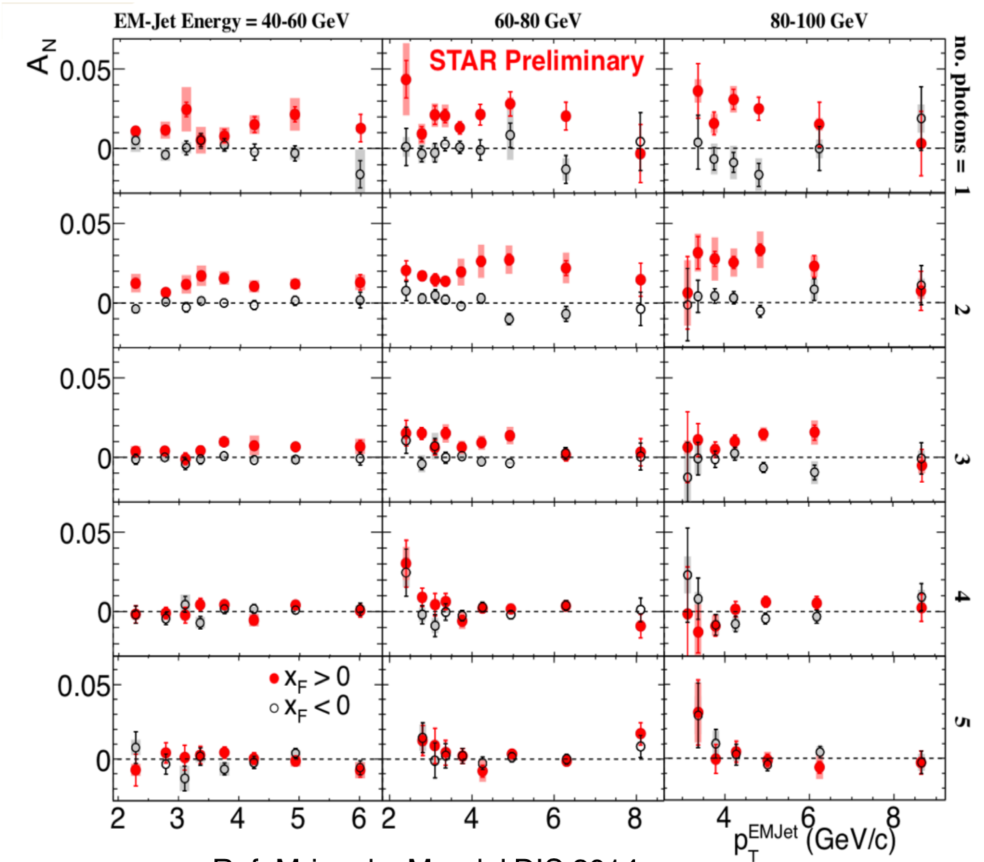
Abstract

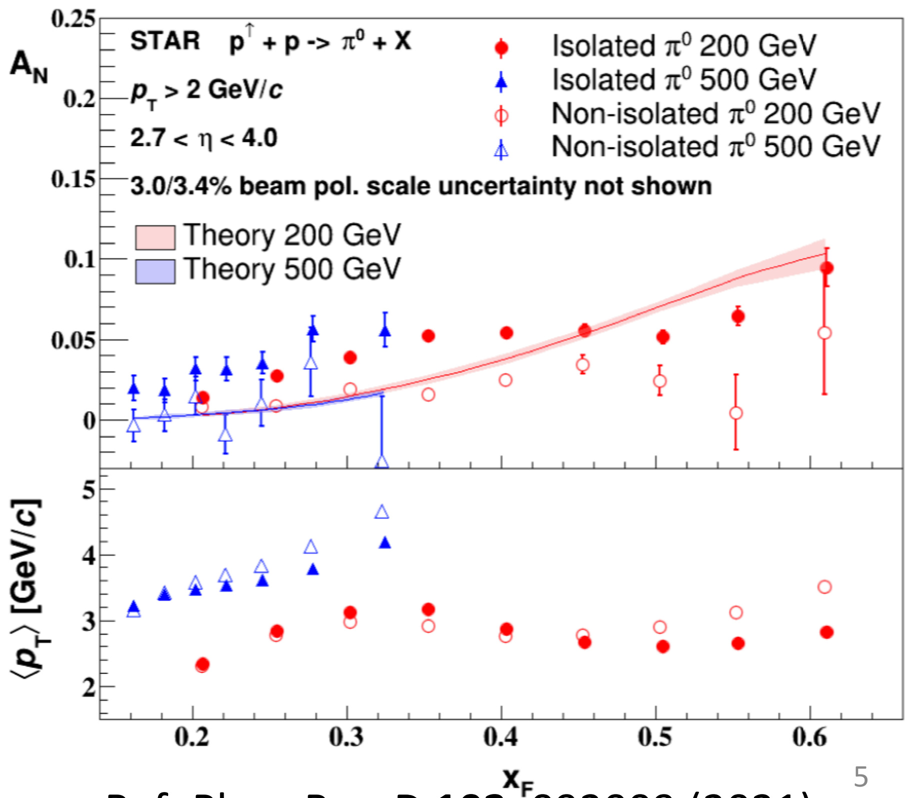
- The STAR Collaboration reports the measurements of transverse single-spin asymmetry, A_N, for inclusive and diffractive electromagnetic jets (EM-jets) at center-of-mass energy of 200 GeV in transversely polarized proton-proton collisions in the pseudorapidity region of 2.6 to 4.1. The photon-multiplicity dependent (jetness) A_N results of inclusive EM-jets are investigated. It shows the A_N of lower jetness inclusive EM-jets is significantly larger than that of higher jetness inclusive EM-jets. The A_N of inclusive EM-jets is observed to increase with increasing Feynman x (x_F) regardless of the jetness of the inclusive EM-jets. For the diffractive EM-jets, the non-zero A_N is observed with 3.8-sigma significance. However, the A_N value is negative, which is opposite to the results for inclusive EM-jets A_N. The diffractive process is not the possible explanation for sources of larger A_N for lower jetness inclusive EM-jets or isolated π^0.

Motivation

- Explore inclusive EM-jet A_N separated by different photon multiplicity.
- Diffractive process may play a role to explain large A_N.
  - A_N decreases with Increasing number of photons in EM jets.
  - Isolated π^0 events have larger A_N.



Ref: Mriganka Mondal DIS 2014

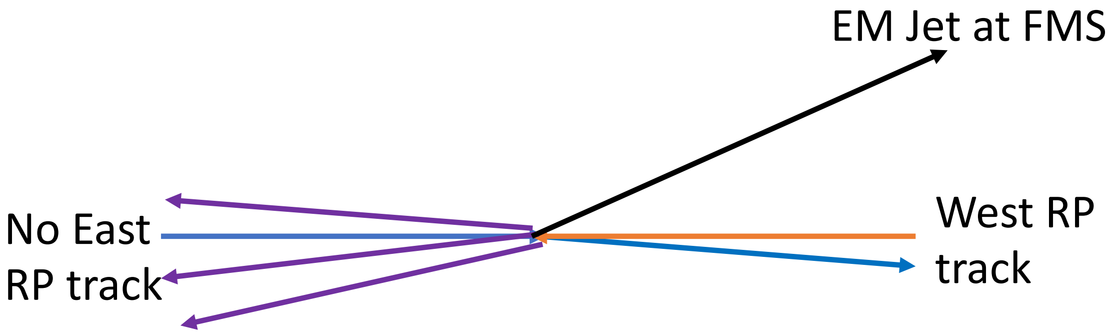


Ref: Phys. Rev. D **103**, 092009 (2021)

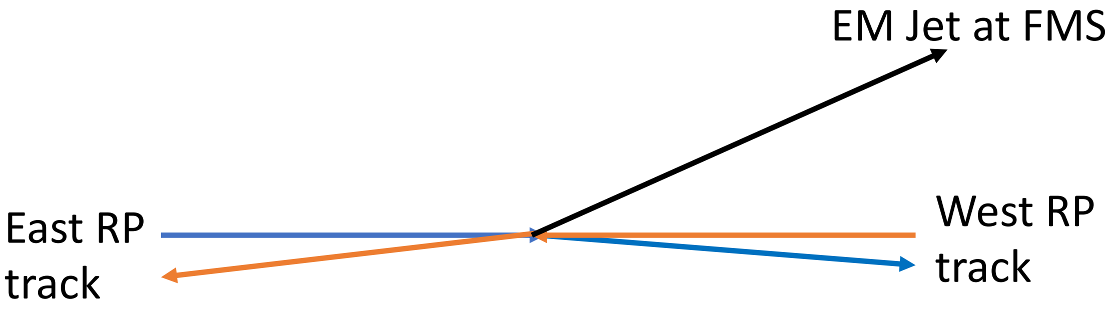
Diffractive process channels

2 diffractive channels are considered. They all contain only 1 west RP track.

Single diffractive event: Only 1 proton track on west side RP.
Require: sum of west side tracks energy (proton + EM Jet) less than beam energy



Double diffractive event: Only 1 proton track on east side RP and only 1 proton track on west side RP.
Require: sum of west side tracks energy (proton + EM Jet) less than beam energy



Event selection and corrections

- **FMS**
  - 8 Triggers (avoid ring of fire) , veto on FMS-LED
  - bit shift, bad / dead / hot channel masking (include fill by fill hot channel masking)
  - Jet reconstruction: StJetMaker2015 , Anti-kT, R<0.7 , FMS tower energy > 2 GeV, p_T > 1 GeV/c for diffractive EM-jet (p_T > 2 GeV/c for inclusive EM-jet), FMS point as input
  - Apply energy correction.
- **Only allow acceptable beam polarization (up/down).**
- **Vertex** (Determine vertex z priority according to TPC , VPD, BBC.)
  - Vertex $|z| < 80\ cm$
- **Roman Pot and Diffractive process (diffractive EM-jet only)**
  - Acceptable cases:
  1. Only 1 west RP track + no east RP track
  2. Only 1 east RP track + only 1 west RP track
  - RP track must be good track:
  a) Each track hits > 6 planes
  b) $-2 < \theta_X < 2$ mrad , $1.5 < |\theta_y| < 4.5$ mrad
  - Sum of west RP track energy and all EM Jet energy (see detail in table)
- **BBC ADC sum cuts (diffractive EM-jet only):**
  - West Large BBC ADC sum < 60 and West Small BBC ADC sum < 100

Corrections:
EM-jet energy correction and Underlying Event energy correction

x_F	E sum Cut
0.1 - 0.15	E_{sum} < 108 GeV
0.15 - 0.2	E_{sum} < 108 GeV
0.2 - 0.25	E_{sum} < 110 GeV
0.25 - 0.3	E_{sum} < 110 GeV
0.3 – 0.45	E_{sum} < 115 GeV

Technical details

- Event selection
- Corrections:
  - Energy correction: based on simulations, apply correction from detector level to particle level.
  - Underlying correction: use off-axis cone method.
- A_N extraction: cross ratio method.

Systematic uncertainty

- Inclusive EM-jet A_N:
  - Event misidentification (from Unfolding)
  - Background uncertainty: pile-up, Abort gap, Ring of Fire, Underlying events.
  - Polarization uncertainty
  - Energy / p_T uncertainty: calibration uncertainty, energy / p_T correction, uncertainty due to radiation damage.
- Diffractive EM-jet A_N:
  - Background uncertainty: Ring of Fire, energy sum cuts, BBC cuts.
  - Polarization uncertainty
  - Energy / p_T uncertainty: calibration uncertainty, energy / p_T correction, uncertainty due to radiation damage.

Fig. 1: A_N for inclusive EM-jet separated by EM-jet energy and jetness

- Fig. 1: Measurement of transverse single-spin asymmetry for three different jetness and three different EM-jet energy region, expressing as a function of EM-jet transverse momentum. The statistical uncertainties are shown in bar and the systematic uncertainties are shown in box. The lowest panel shows the average $|x_F|$.

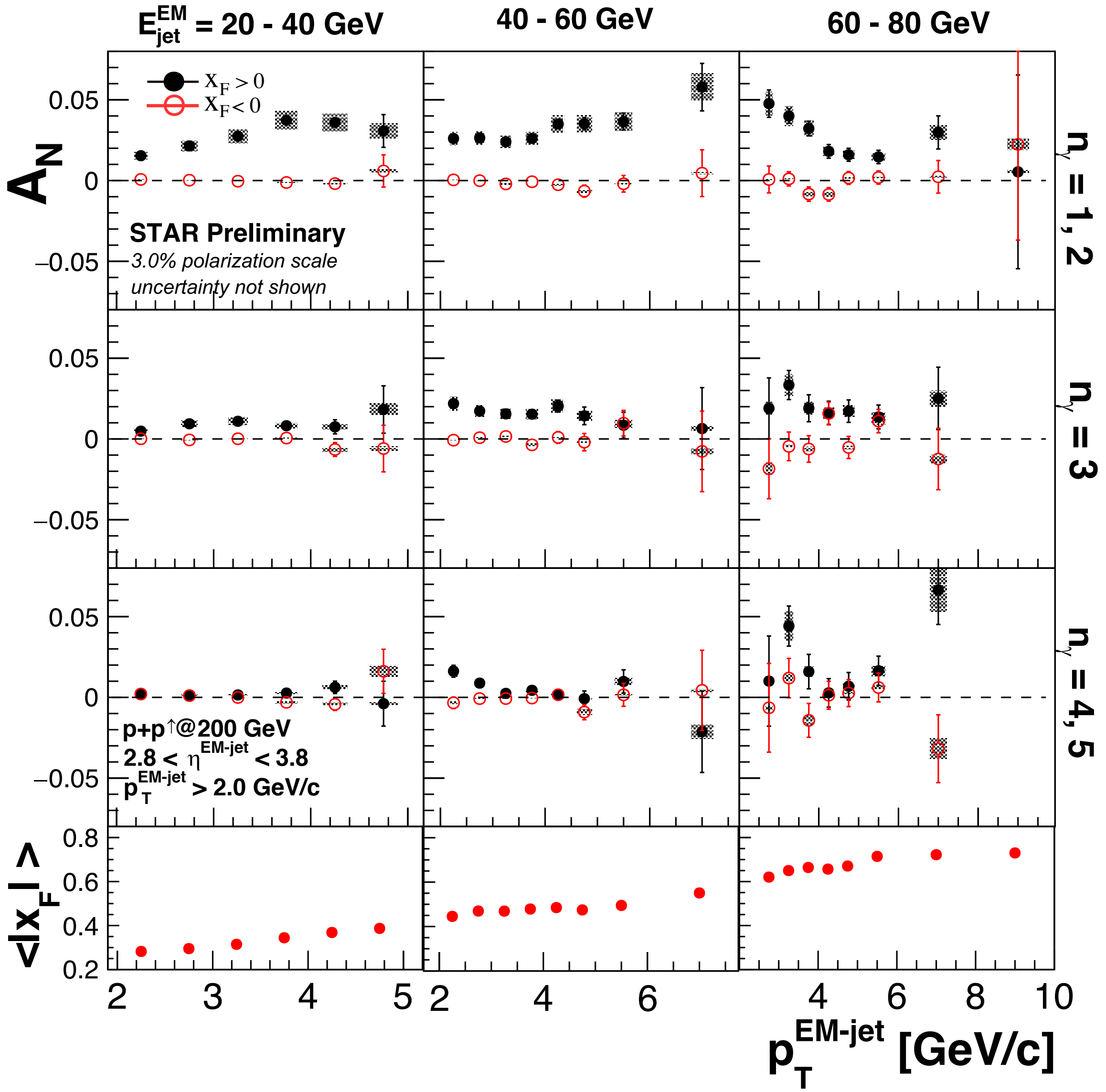


Fig. 2: A_N for inclusive EM-jet vs x_F

- Fig. 2: Measurement of transverse single-spin asymmetry for three different jetness as a function of x_F. The statistical uncertainties are shown in bar and the systematic uncertainties are shown in box.

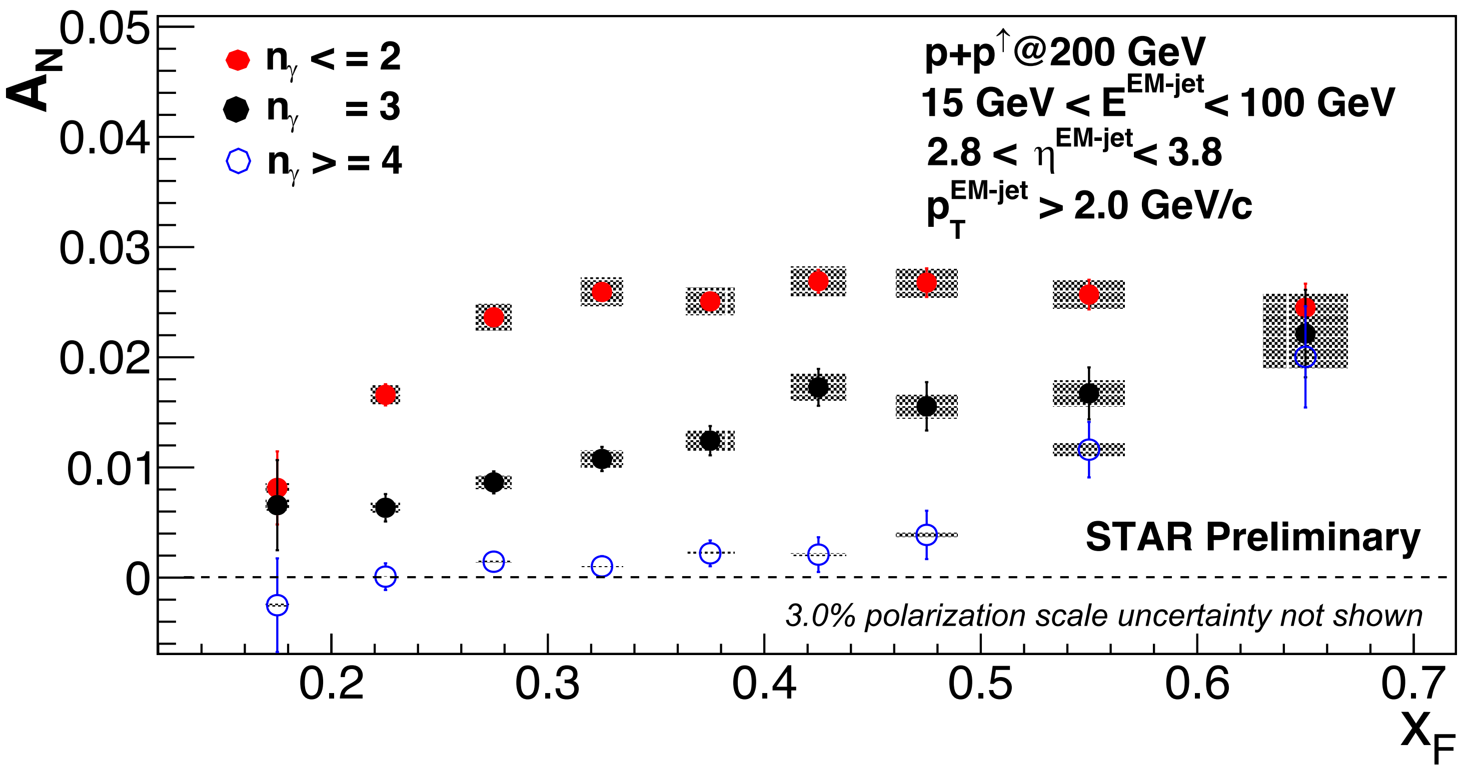
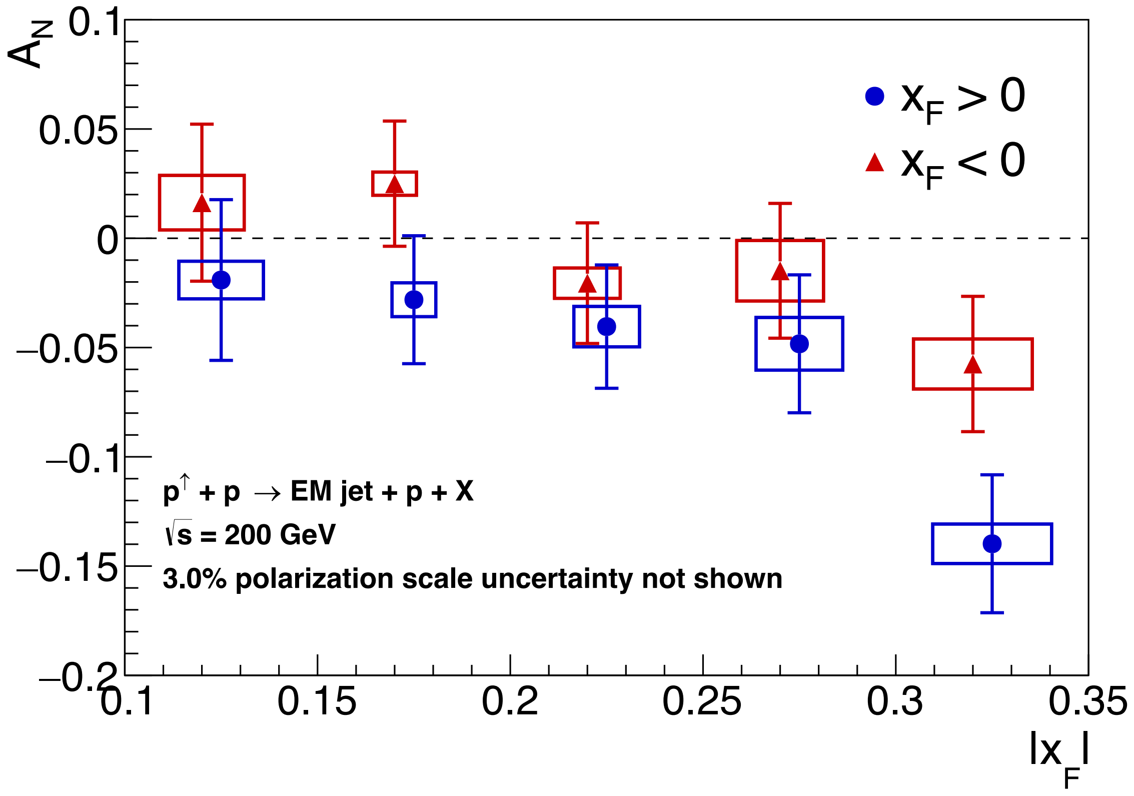


Fig. 3: A_N for diffractive EM-jet

- Fig. 3: Measurement of transverse single-spin asymmetry for diffractive EM-jet as a function of x_F. The statistical uncertainties are shown in bar and the systematic uncertainties are shown in box. The rightmost blue (red) points are for $0.3 < x_F < 0.45$ $(-0.45 < x_F < -0.3)$. All the red points shift -0.005 in x-axis.



Back up

Transverse single spin asymmetry (A_N) calculation

- We use **cross ratio** method to calculate the diffractive EM Jet A_N at FMS.
  - Raw A_N: $\varepsilon = \dfrac{\sqrt{N^{\uparrow}(\phi)N^{\downarrow}(\phi+\pi)}-\sqrt{N^{\downarrow}(\phi)N^{\uparrow}(\phi+\pi)}}{\sqrt{N^{\uparrow}(\phi)N^{\downarrow}(\phi+\pi)}+\sqrt{N^{\downarrow}(\phi)N^{\uparrow}(\phi+\pi)}} \approx pol * A_N * \cos(\phi)$
  - Plot A_N as a function of X_F, or p_T ($x_F = \dfrac{E_{EM\ jet}}{E_{Beam}}$)
  - Divide full ϕ range [$-\pi$, $+\pi$] into 16 bins.