Diffractive EM Jet A_N at FMS with run 17 data preliminary request

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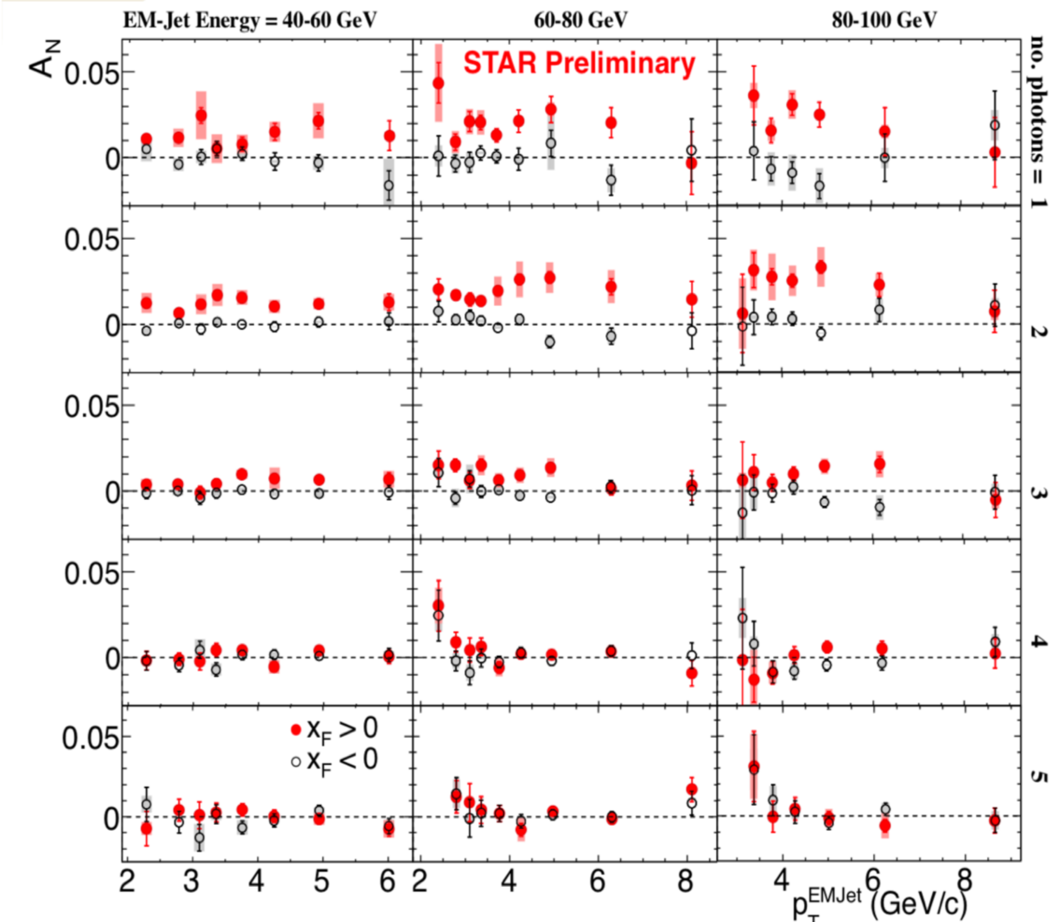
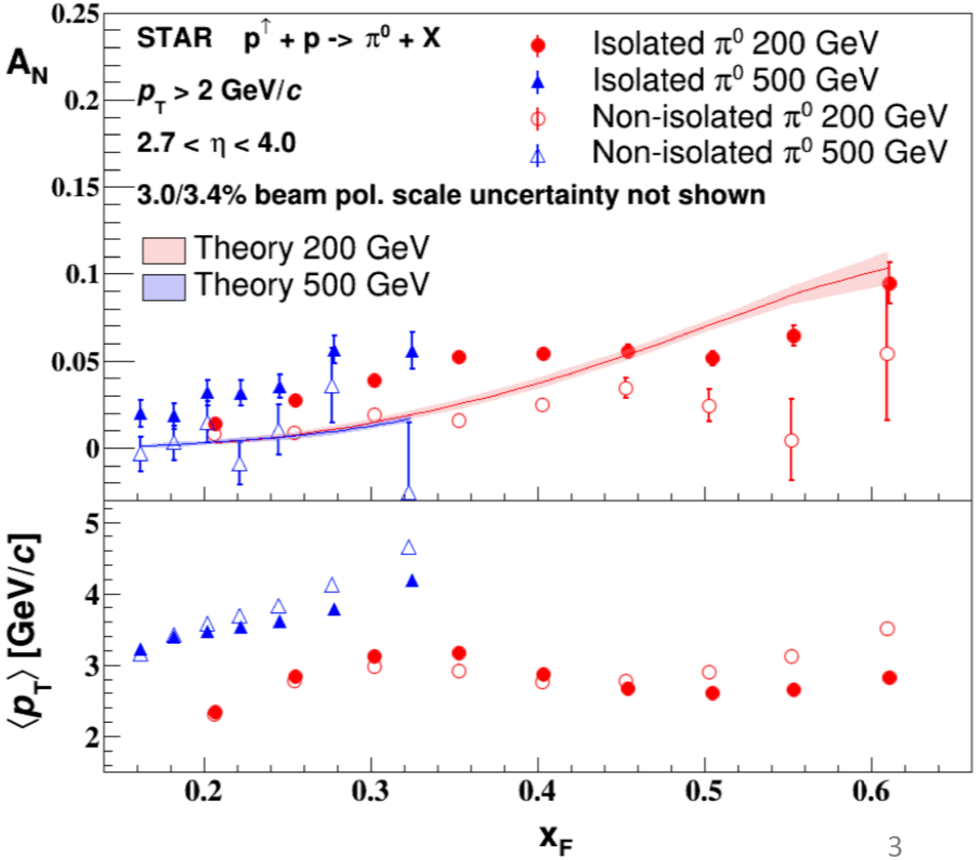
Physics motivation

- 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)

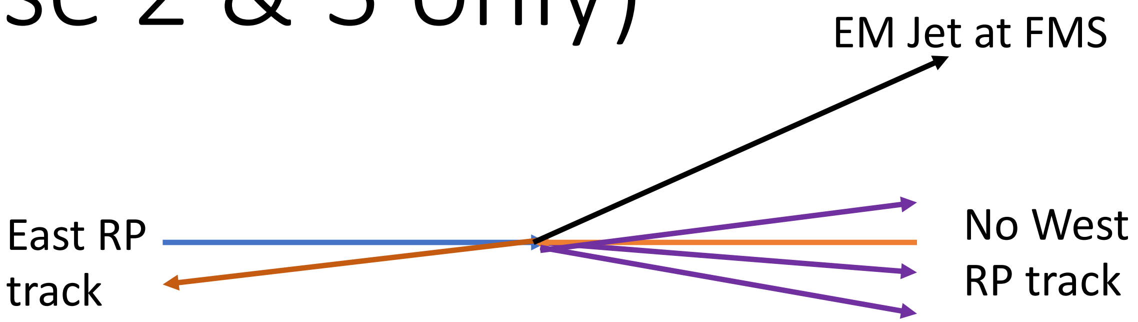
Data set

- Data set: run 17 pp transverse $\sqrt{s} = 510$ GeV ,fms stream
  - (pp500_production_2017)
- Production type: MuDst ; Production tag: P22ib
- STAR library: SL20a
- Triggers 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-sm-bs3, FMS-lg- bs1, FMS-lg-bs2, FMS-lg-bs3
  - Trigger veto: FMS-LED
- Requirement: Event must contain Roman Pot (RP) information (pp2pp).
  - Already filter out events without RP response. Totally 180 fills.

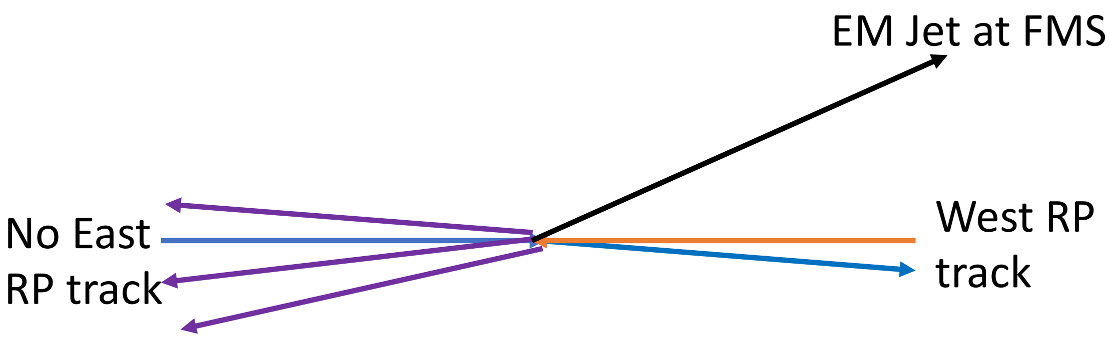
Total number of events from data set sample (with FMS and RP coincidence)	882 M
Total number of events with FMS points	874 M
Total number of events with FMS EM-jets	860 M

Diffractive process (case 2 & 3 only)

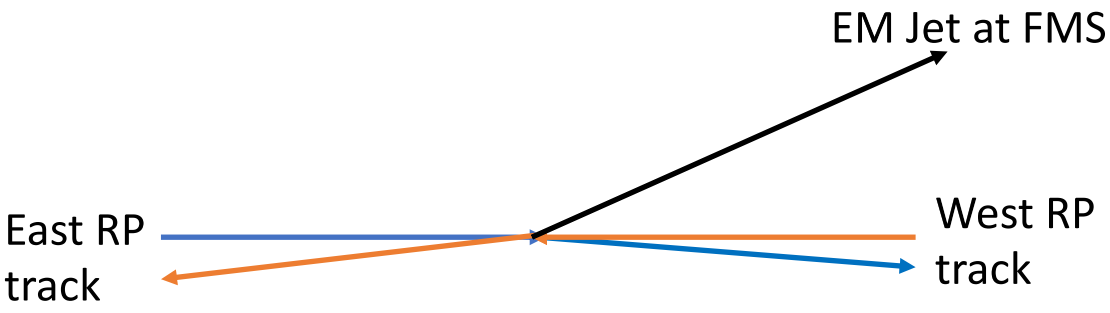
Case 1:
Single diffractive event: we can detect only 1 proton track on east side RP.
Require: only 1 east side RP track



Case 2:
Single diffractive event: we can detect only 1 proton track on west side RP.
Require: sum of west side tracks energy (proton + EM Jet) less than beam energy



Case 3:
Double diffractive event: we can detect 1 proton track on east side RP and 1 proton track on west side RP.
Require: sum of west side tracks energy (proton + EM Jet) less than beam energy



Procedure for data analysis

MuDst files

Trigger selection, FMS bad/hot channel masking, jet reconstruction, event contains at least 1 RP track information

Nano Dst files (keep the physics measurements used for this analysis)

Event selection with vertex cut, RP cuts , FMS EM jet, sum energy cut and BBC cut

Physics measurements and uncertainty study

Cross ratio method for A_N calculation

Systematic uncertainty

Event selection and corrections

- **FMS**
  - 9 Triggers, veto on FMS-LED
  - bit shift, bad / dead / hot channel masking
  - Jet reconstruction: StJetMaker2015 , Anti-kT, R<0.7 , FMS point energy > 2 GeV, $p_T > 2$ GeV/c, 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:**
- Acceptable cases: (in next slide)
  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 7 or 8 planes

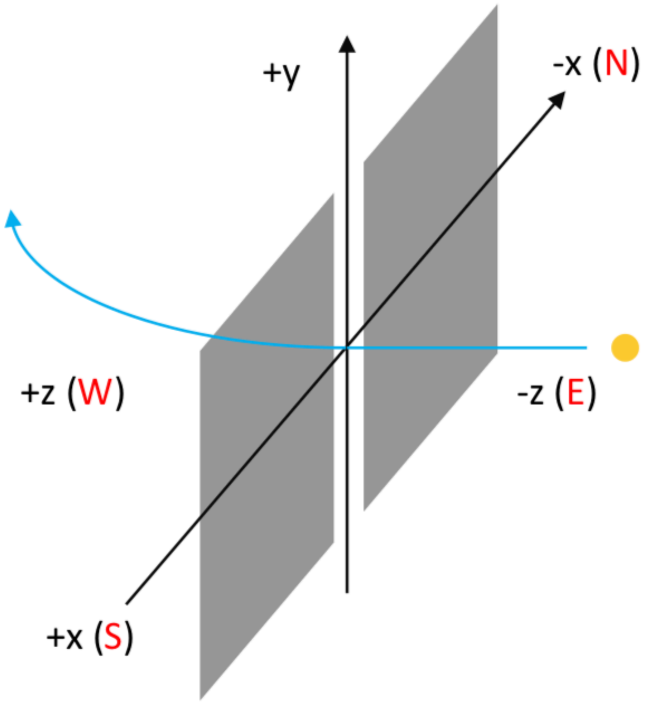
  $b)$ $-0.5 < p_x < 0.3$ [GeV/c] , $0.25 < |p_y| < 0.4$ [GeV/c]
  - Sum of west RP track energy and all EM Jet energy
- **BBC ADC sum cuts:**
  - West Small BBC ADC sum < 450

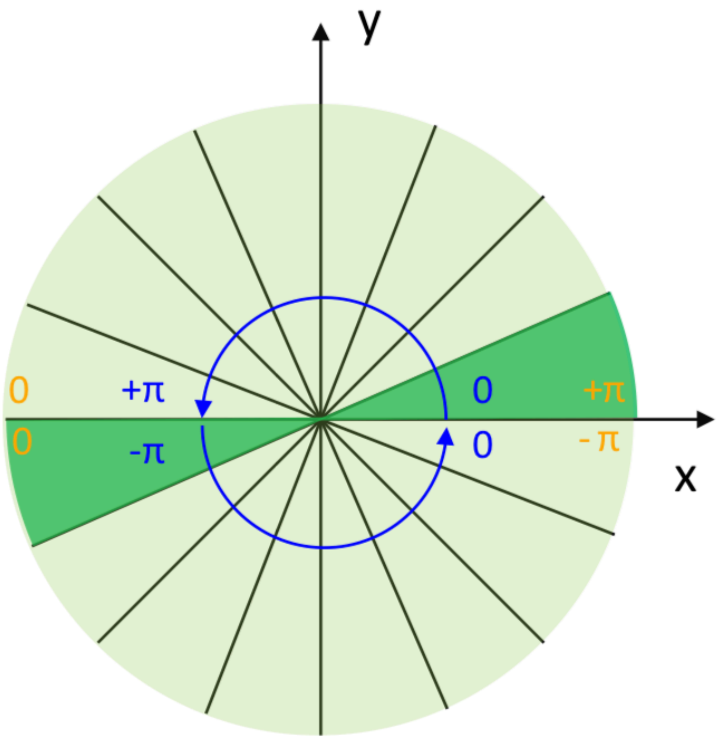
Corrections:
Energy correction and
Underlying Event correction

x_F	E sum Cut
0.1 - 0.15	E_{sum} < 265 GeV
0.15 - 0.2	E_{sum} < 280 GeV
0.2 - 0.25	E_{sum} < 295 GeV
0.25 - 0.3	E_{sum} < 305 GeV
0.3 - 0.35	E_{sum} < 315 GeV
0.35 - 0.4	E_{sum} < 330 GeV
0.4 – 0.45	E_{sum} < 340 GeV

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: $\varepsilon = \frac{\sqrt{N^{\uparrow}(\phi)N^{\downarrow}(\phi+\pi)}-\sqrt{N^{\downarrow}(\phi)N^{\uparrow}(\phi+\pi)}}{\sqrt{N^{\uparrow}(\phi)N^{\downarrow}(\phi+\pi)}+\sqrt{N^{\downarrow}(\phi)N^{\uparrow}(\phi+\pi)}} \approx pol * A_N * \cos(\phi)$
  - Plot A_N as a function of X_F. ($x_F = \frac{E_{EM\ jet}}{E_{Beam}}$) , $x_F \in [0.1, 0.45]$
  - Divide full ϕ range [-π , +π] into 16 bins.





Systematic uncertainty **(EM-jet with all photon multiplicity)**

- Systematic uncertainties for residual background effect mainly come from the cut for selecting signal from background.
  - Energy sum cut: change the energy sum cut to check the uncertainty.
  - Small west BBC ADC sum cut: change 450 to 400
- Polarization uncertainty: 1.1 % (back up)

Calculate each systematic uncertainty by result difference fraction when changing the cuts:

$$uncertainty = \frac{|A_{N,change\ cut} - A_{N,origin}|}{|A_{N,origin}|}$$

x_F	E sum Cut original	E sum Cut systematic
0.1 - 0.15	E_{sum} < 265 GeV	E_{sum} < 255 GeV
0.15 - 0.2	E_{sum} < 280 GeV	E_{sum} < 265 GeV
0.2 - 0.25	E_{sum} < 295 GeV	E_{sum} < 275 GeV
0.25 - 0.3	E_{sum} < 305 GeV	E_{sum} < 290 GeV
0.3 - 0.35	E_{sum} < 315 GeV	E_{sum} < 300 GeV
0.35 - 0.4	E_{sum} < 330 GeV	E_{sum} < 310 GeV
0.4 – 0.45	E_{sum} < 340 GeV	E_{sum} < 320 GeV

Blue beam

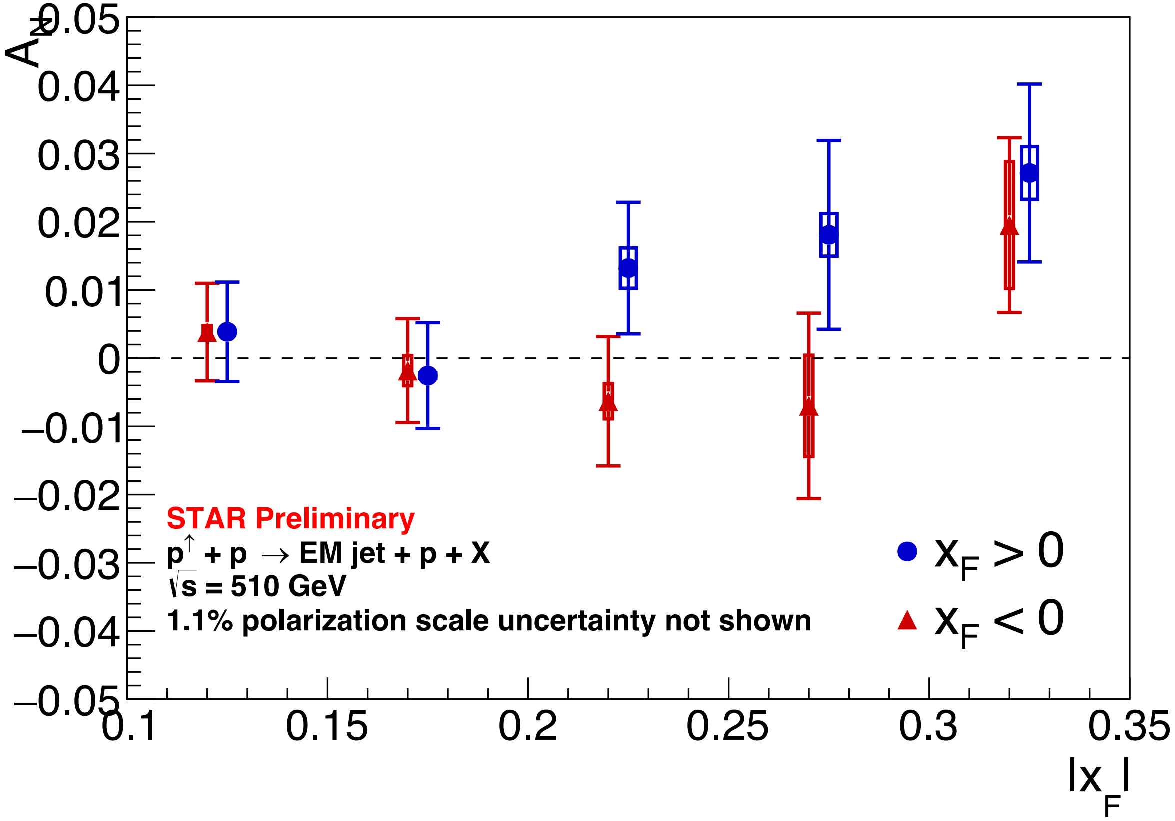
x_F range	E_sum	Small BBC	Summary
0.1 – 0.15	5%	2%	5%
0.15 – 0.2	3%	15%	15%
0.2 – 0.25	8%	21%	22%
0.25 – 0.3	15%	9%	17%
0.3 – 0.45	9%	11%	14%

Yellow beam

x_F range	E_sum	Small BBC	Summary
0.1 – 0.15	15%	20%	25%
0.15 – 0.2	49%	111%	121%
0.2 – 0.25	3%	41%	41%
0.25 – 0.3	63%	85%	106%
0.3 – 0.45	34%	33%	48%

Run 17 FMS diffractive EM-jet A_N results

- **EM-jet with all photon multiplicity**
- Cross ratio method is applied to extract the A_N.
- Consider only 5 x_F ranges: [0.1,0.15], [0.15, 0.2], [0.2, 0.25], [0.25, 0.3], [0.3, 0.45]



- They seems to get A_N close to 0 at low x_F ranges, but A_N greater than 0 at high x_F ranges.
- The sign is mostly positive, different from run 15 results.
- Preliminary request plot 1

Systematic uncertainty **(EM-jet with 1 or 2 photon multiplicity)**

- Systematic uncertainties for residual background effect mainly come from the cut for selecting signal from background.
  - Energy sum cut: change the energy sum cut to check the uncertainty.
  - Small BBC ADC sum cut: change 450 to 400

Calculate each systematic uncertainty by result difference fraction when changing the cuts:

$$uncertainty = \frac{|A_{N,change\ cut} - A_{N,origin}|}{|A_{N,origin}|}$$

x_F	E sum Cut original	E sum Cut systematic
0.1 - 0.15	E_{sum} < 265 GeV	E_{sum} < 255 GeV
0.15 - 0.2	E_{sum} < 280 GeV	E_{sum} < 265 GeV
0.2 - 0.25	E_{sum} < 295 GeV	E_{sum} < 275 GeV
0.25 - 0.3	E_{sum} < 305 GeV	E_{sum} < 290 GeV
0.3 - 0.35	E_{sum} < 315 GeV	E_{sum} < 300 GeV
0.35 - 0.4	E_{sum} < 330 GeV	E_{sum} < 310 GeV
0.4 – 0.45	E_{sum} < 340 GeV	E_{sum} < 320 GeV

Blue beam

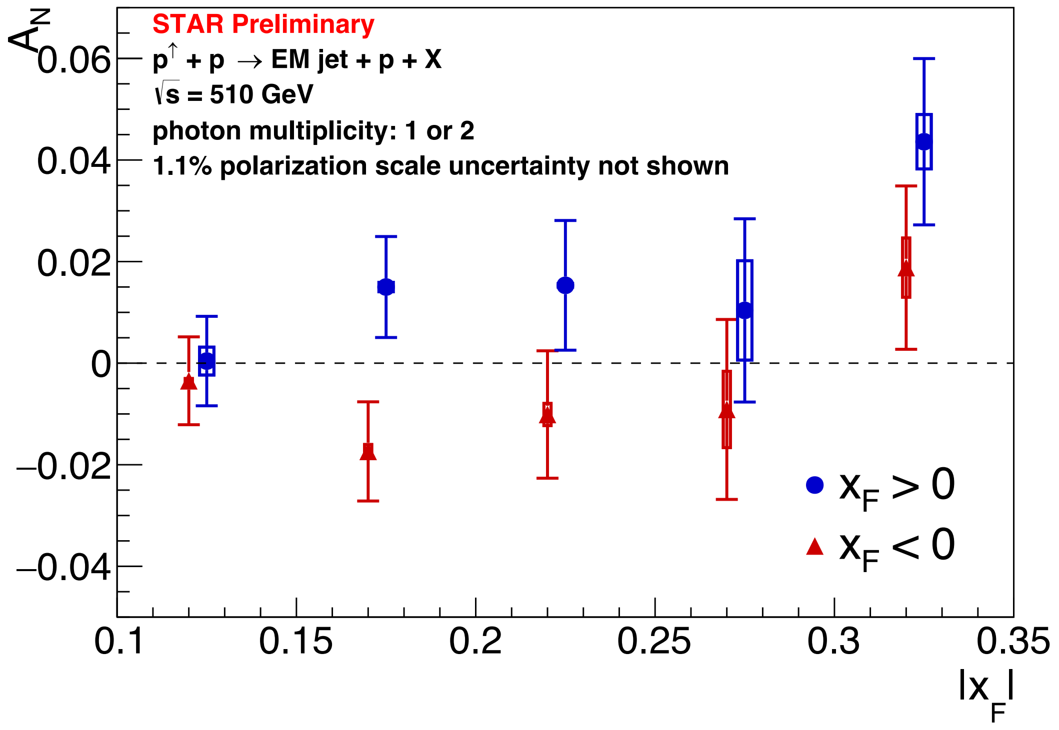
x_F range	E_sum	Small BBC	Summary
0.1 – 0.15	91%	663%	670%
0.15 – 0.2	2%	6%	6%
0.2 – 0.25	1%	2%	2%
0.25 – 0.3	9%	94%	94%
0.3 – 0.45	6%	11%	12%

Yellow beam

x_F range	E_sum	Small BBC	Summary
0.1 – 0.15	11%	7%	13%
0.15 – 0.2	8%	1%	8%
0.2 – 0.25	10%	19%	22%
0.25 – 0.3	52%	64%	82%
0.3 – 0.45	31%	5%	31%

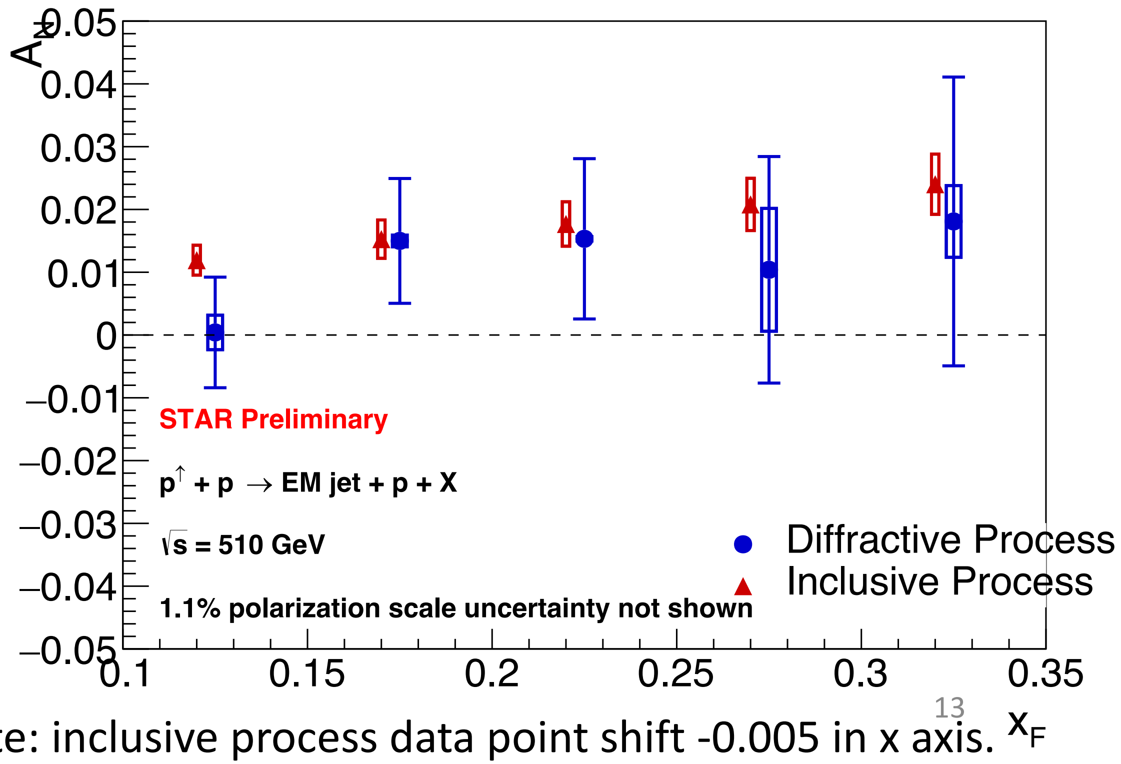
Run 17 FMS diffractive EM-jet A_N results

- **EM-jet with 1 or 2 photon multiplicity**
- Cross ratio method is applied to extract the A_N.
- Still consider only 5 x_F ranges: [0.1,0.15], [0.15, 0.2], [0.2, 0.25], [0.25, 0.3], [0.3, 0.45]
- The larger A_N values are observed for EM-jet with 1 or 2 photon multiplicity. They are 2.5 σ to be non-zero.
- Preliminary request plot 2



Comparison between run 17 FMS inclusive and diffractive EM-jet A_N results

- We compare run 17 FMS inclusive (done by Bishnu) and diffractive **1 or 2 photon multiplicity** EM-jet A_N results.
- Both results are A_N results as the function of x_F (with exactly same x_F bins [0.1,0.15], [0.15, 0.2], [0.2, 0.25], [0.25, 0.3], [0.3, 0.35])
- Preliminary request plot 3



Note: inclusive process data point shift -0.005 in x axis.

Conclusion

- Run 17 diffractive EM-jet A_N using FMS is at preliminary stage for requesting for preliminary.
- The A_N for run 17 are showing the mostly positive values but close to zero.
- We do not observe the negative sign for A_N, so it’s different from run 15 diffractive EM-jet A_N results.
- The comparison plot between inclusive and diffractive EM-jet A_N at $\sqrt{s} = 510$ GeV show that the diffractive processes do not contribute to large A_N for inclusive processes.