Single diffractive EM Jet A_N at FMS with run 15 data preliminary request

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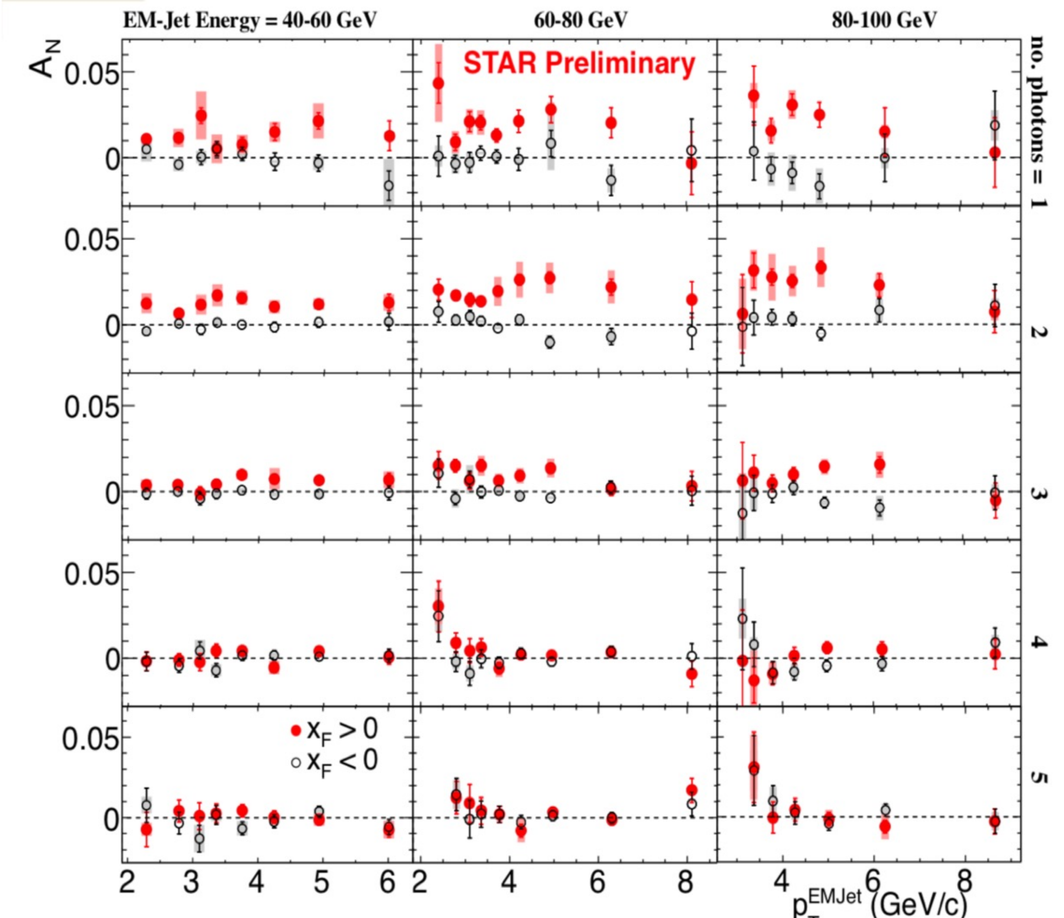
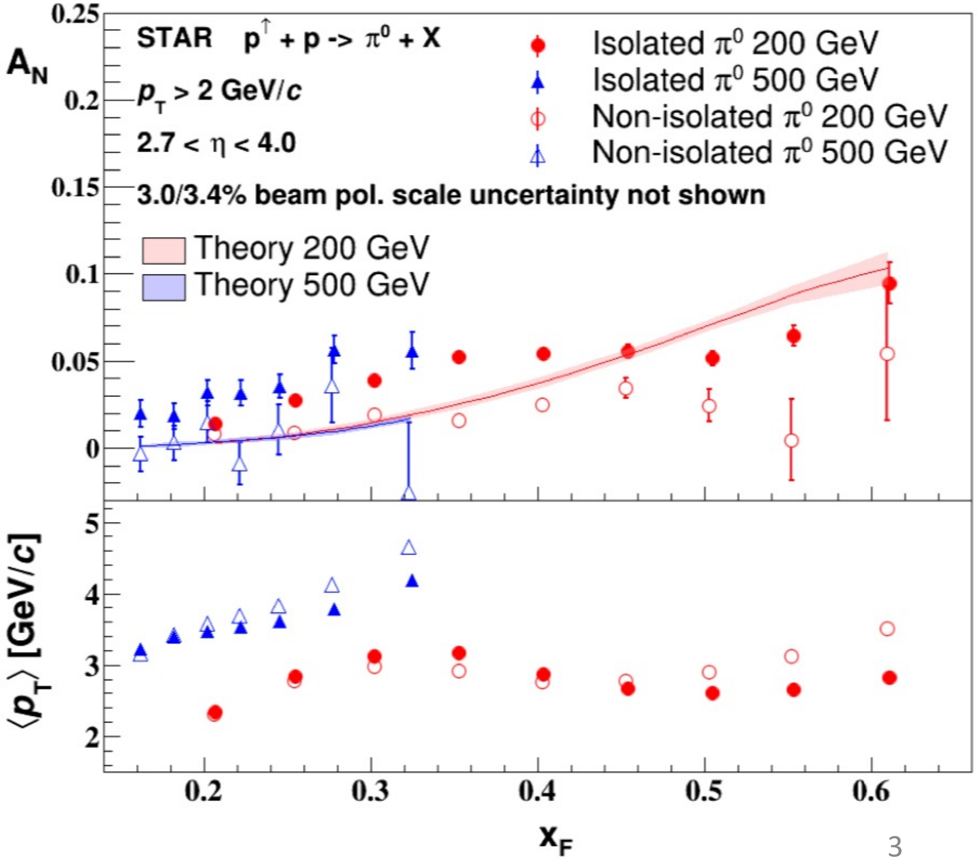
Physics motivation

- 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 sets and triggers

- Data sets: run15 pp transverse data , $\sqrt{s} = 200\ GeV$ (production_pp200trans_2015)
- Stream: st_fms
- 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-sm-bs3, FMS-lg-bs1, FMS-lg-bs2, FMS-lg-bs3. (9 triggers)
- Requirement: Event must also contain at least 1 Roman Pot track.
- Trigger veto: FMS-LED
- STAR library: SL20a

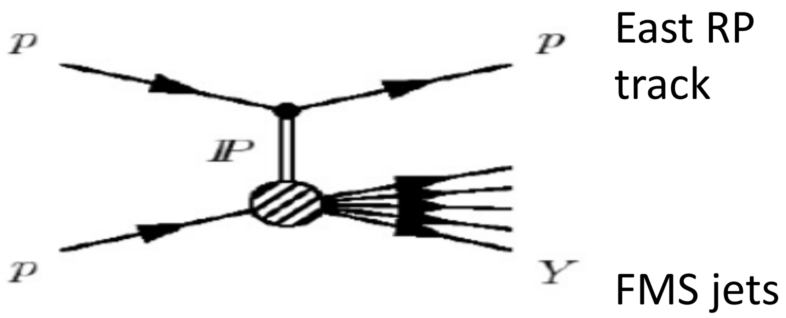
Single diffractive EM-jet A_N using FMS

Motivation and goal: study the A_N for diffractive process and explore its contribution for large A_N in inclusive processes

Determine the single diffractive process (SD):

only 1 proton track on east side RP. No west side RP track requirement. FMS EM-jet on the west side.
Require: small and large BBC east cut

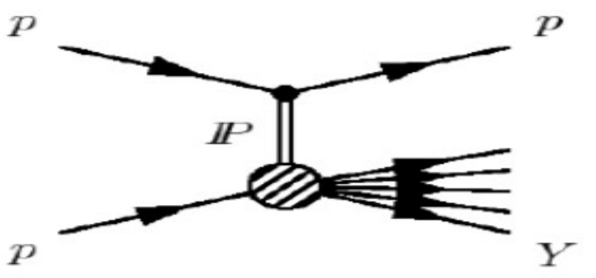
East proton	Rapidity gap	FMS Jet



Event selection and corrections for SD process

- **FMS**
  - 9 Triggers, veto on FMS-LED
  - Only 1 EM-jet per event is allowed
  - bit shift, bad / dead / hot channel masking (include fill by fill hot channel masking)
  - Jet reconstruction: StJetMaker2015 , Anti-kT, R<0.7 , FMS point energy > 1 GeV, $p_T > 2$ GeV/c, trigger p_T threshold cut, FMS point as input.
- **Only allow acceptable beam polarization (up/down).**
- **Vertex** (Determine vertex z priority according to TPC , VPD, BBC.)
  - Vertex $|z| < 80\ cm$
- **Roman Pot and Single Diffractive process:**
- Acceptable cases:
  1. Only 1 east RP track , no requirement on west RP
  - RP track must be good track:
  a) Each track hits > 6 planes
  b) East RP ξ dependent θ_X , θ_Y , P_X and P_Y cuts
  c) East RP $0 < \xi < 0.15$
- East Large BBC ADC sum < 80 and East Small BBC ADC sum < 90

Corrections:
EM-jet energy correction and Underlying Event correction



East RP track

FMS jets

Background study: FMS EM-jet and BBCE veto (RG)

- The process with FMS EM-jets and BBCE veto are one potential source of the background
  - The east BBC covers a unit of 3 for pseudorapidity gap. We call it Rapidity Gap event set (RG)
  - They are a subset of inclusive process
- The study of RG events also serves as additional enrichment for the inclusive process and help to separate the diffractive and non-diffractive process with the rapidity gap requirement.
- Also, we use this set of events to estimate the background fraction: about 1.8 -1.9%

The random coincidence of the single diffractive events in the RG events is 0.2% (zerobias events)

$$frac_{bkg} = \frac{n_{AC}}{n_{mea}} = \frac{n_{AC}}{n_{RG}} \times \frac{n_{RG}}{n_{mea}}$$

Counting yields of each kinematic bins for RG events and measured FMS events

Event selection and corrections for RG process

- **FMS**
  - 9 Triggers, veto on FMS-LED
  - Only 1 EM-jet per event is allowed
  - bit shift, bad / dead / hot channel masking (include fill by fill hot channel masking)
  - Jet reconstruction: StJetMaker2015 , Anti-kT, R<0.7 , FMS point energy > 1 GeV, $p_T > 2$ GeV/c, trigger p_T threshold cut, FMS point as input.
- **Only allow acceptable beam polarization (up/down).**
- **Vertex** (Determine vertex z priority according to TPC , VPD, BBC.)
  - Vertex $|z| < 80\ cm$
- **No Roman Pot requirement**
- East Large BBC ADC sum < 80 and East Small BBC ADC sum < 90

Corrections:
EM-jet energy correction and Underlying Event correction

Systematic uncertainty for SD and RG events

- We use Bayesian method for systematic uncertainty study. (ref: arXiv:hep-ex/0207026)
- First of all, for the cuts we choose, varying each individual cut value for calculating the asymmetry. **The first three terms apply for both processes**
  - Small BBC east ADC sum cuts: choose < 70, < 80, <100, <110 for systematic uncertainty
  - Large BBC east ADC sum cuts: choose < 60, < 70, <90, <100 for systematic uncertainty
  - Ring of Fire (get rid of small-bs-3 trigger)
  - Background (Only for SD events)
- Then, find out the maximum ($A_N(1) \pm \delta(1)$, with statistical uncertainty) , and the minimum ($A_N(2) \pm \delta(2)$, with statistical uncertainty) for the varying cuts as systematic uncertainty.
- If the $\frac{|A_N(1)-A_N(2)|}{\sqrt{|(\delta(1))^2-(\delta(2))^2|}} > 1$ (Barlow check), use the **standard deviation** of all the A_N from varying all the cuts for this systematic term (σ_i), otherwise, the systematic (σ_i), for this term will be assigned 0
- The final systematic will be counted bin by bin (x_F bins) : $\sigma_{summay} = \sqrt{\sum_i (\sigma_i)^2}$

Systematic uncertainty results for SD process

All Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0.0043	0.0037	0	0.0035	0.0067
0.2 - 0.25	0.0015	0	0	0.0032	0.0035
0.25 - 0.3	0	0.0022	0.0029	0.0029	0.0037
0.3 – 0.35	0	0	0	0.0028	0.0028
0.35 – 0.4	0.0018	0.0029	0	0.0032	0.0047
0.4 – 0.45	0.0027	0.0041	0.011	0.0039	0.013

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0	0.0040	0	0.0034	0.0052
0.2 - 0.25	0.0019	0.0023	0.0012	0.0031	0.0045
0.25 - 0.3	0.0020	0.0017	0	0.0028	0.0039
0.3 – 0.35	0.0016	0.0035	0	0.0028	0.0048
0.35 – 0.4	0	0.0029	0	0.0031	0.0043
0.4 – 0.45	0.0014	0	0	0.0038	0.0040

1 or 2 Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0.0063	0.0077	0	0.0042	0.011
0.2 - 0.25	0.0025	0	0.0015	0.0040	0.0050
0.25 - 0.3	0.0021	0	0.0026	0.0038	0.0050
0.3 – 0.35	0.0015	0	0	0.0038	0.0041
0.35 – 0.4	0.0029	0	0	0.0041	0.0050
0.4 – 0.45	0.0051	0.0064	0.021	0.0049	0.023

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0.0022	0.0033	0	0.0041	0.0057
0.2 - 0.25	0	0.0029	0.0019	0.0039	0.0053
0.25 - 0.3	0.0017	0.0019	0	0.0037	0.0045
0.3 – 0.35	0.0024	0.0026	0	0.0036	0.0051
0.35 – 0.4	0	0.0035	0	0.0040	0.0053
0.4 – 0.45	0.0013	0.0039	0.011	0.0048	0.013

3 or more Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0.0038	0.0057	0	0.0061	0.0092
0.2 - 0.25	0.0015	0.0065	0	0.0051	0.0084
0.25 - 0.3	0.0020	0.0027	0	0.0045	0.0056
0.3 – 0.35	0	0.0032	0	0.0043	0.0053
0.35 – 0.4	0.0017	0.0047	0.0096	0.0050	0.012
0.4 – 0.45	0.0025	0	0	0.0063	0.0068

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Background	Summary
0.1 - 0.2	0	0.0080	0.00095	0.0061	0.010
0.2 - 0.25	0.0050	0.0075	0	0.0050	0.010
0.25 - 0.3	0.0029	0.0022	0.0038	0.0045	0.0069
0.3 – 0.35	0.0033	0.0072	0.0044	0.0042	0.010
0.35 – 0.4	0.0033	0.0042	0	0.0049	0.0073
0.4 – 0.45	0	0	0.018	0.0062	0.019

Systematic uncertainty results for RG process

All Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0.00066	0.00095	0	0.0012
0.2 - 0.25	0.00043	0.0012	0.00027	0.0013
0.25 - 0.3	0.00066	0.00098	0	0.0012
0.3 – 0.35	0.00050	0	0	0.00050
0.35 – 0.4	0.0011	0.00067	0.0029	0.0031
0.4 – 0.45	0.0010	0.0010	0	0.015

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0.00076	0	0	0.00076
0.2 - 0.25	0	0.00096	0	0.00096
0.25 - 0.3	0.00060	0.0013	0.00060	0.0016
0.3 – 0.35	0.00064	0.00036	0	0.00074
0.35 – 0.4	0.00078	0.00089	0.0018	0.0022
0.4 – 0.45	0.00096	0.00098	0	0.0014

1 or 2 Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0.0011	0.00088	0	0.0014
0.2 - 0.25	0	0.0015	0.00056	0.0016
0.25 - 0.3	0.00066	0.0011	0	0.0013
0.3 – 0.35	0.00065	0	0	0.00065
0.35 – 0.4	0.0018	0.0015	0	0.0022
0.4 – 0.45	0	0.0014	0	0.0014

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0	0	0	0
0.2 - 0.25	0	0.0012	0	0.0012
0.25 - 0.3	0.0011	0.00093	0.0010	0.0017
0.3 – 0.35	0.00060	0.00080	0	0.0010
0.35 – 0.4	0	0.0013	0	0.0013
0.4 – 0.45	0.00093	0	0.0043	0.0044

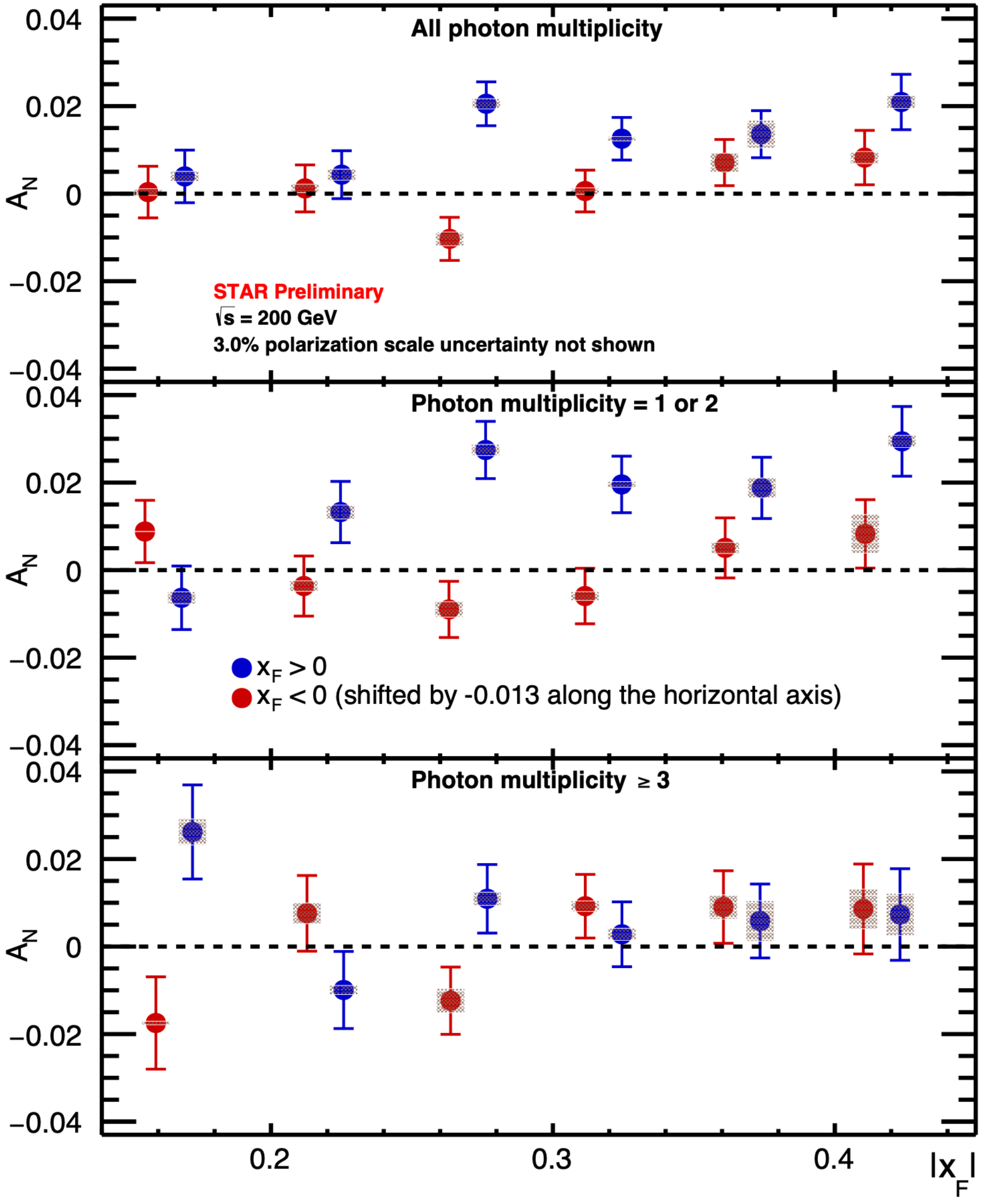
3 or more Photon multiplicity

Blue beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0.0021	0.0022	0	0.0030
0.2 - 0.25	0.0010	0	0	0.0010
0.25 - 0.3	0.00085	0.0013	0	0.0015
0.3 – 0.35	0	0	0.0014	0.0014
0.35 – 0.4	0	0	0.0046	0.0046
0.4 – 0.45	0.0024	0.0021	0.0035	0.0048

Yellow beam x_F	Small BBC east	Large BBC east	Ring of Fire	Summary
0.1 - 0.2	0	0	0.00041	0.00041
0.2 - 0.25	0	0.0024	0	0.0024
0.25 - 0.3	0.0013	0.0024	0	0.0027
0.3 – 0.35	0.0012	0	0	0.0012
0.35 – 0.4	0.0012	0.00083	0.0024	0.0028
0.4 – 0.45	0.0013	0.0020	0.0038	0.0045

Preliminary plot 1: A_N for RG events

Preliminary figure 1: A_N for rapidity gap events as a function of x_F for 3 different photon multiplicity cases: all photon multiplicity (top), 1 or 2 photon multiplicity (middle), and 3 or more photon multiplicity (bottom). The A_N for $x_F < 0$ (red points) shifts -0.013 along the x-axis.



Preliminary plot 2: A_N for single diffractive events

Blue beam A_N is 2.1 σ to be non-zero for EM-jet with all photon multiplicity.

Constant fit: 0.015 ± 0.0070

$\chi^2/n.d.f$: 1.61

Blue beam A_N is 2.2 σ to be non-zero for EM-jet with 1 or 2 photon multiplicity.

Constant fit: 0.021 ± 0.0092

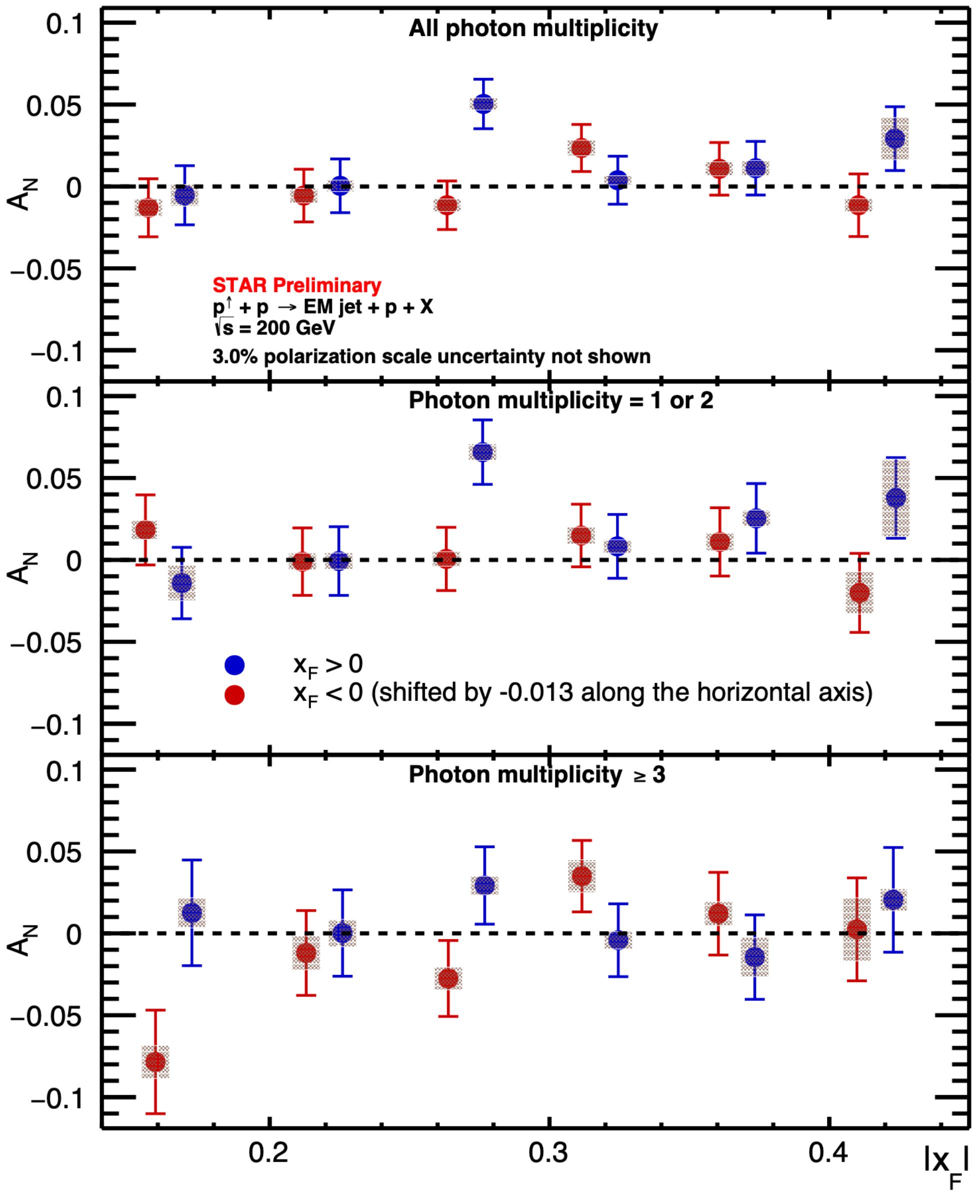
$\chi^2/n.d.f$: 1.73

Blue beam A_N is 0.61 σ to be non-zero for EM-jet with 3 or more photon multiplicity.

Constant fit: 0.0068 ± 0.011

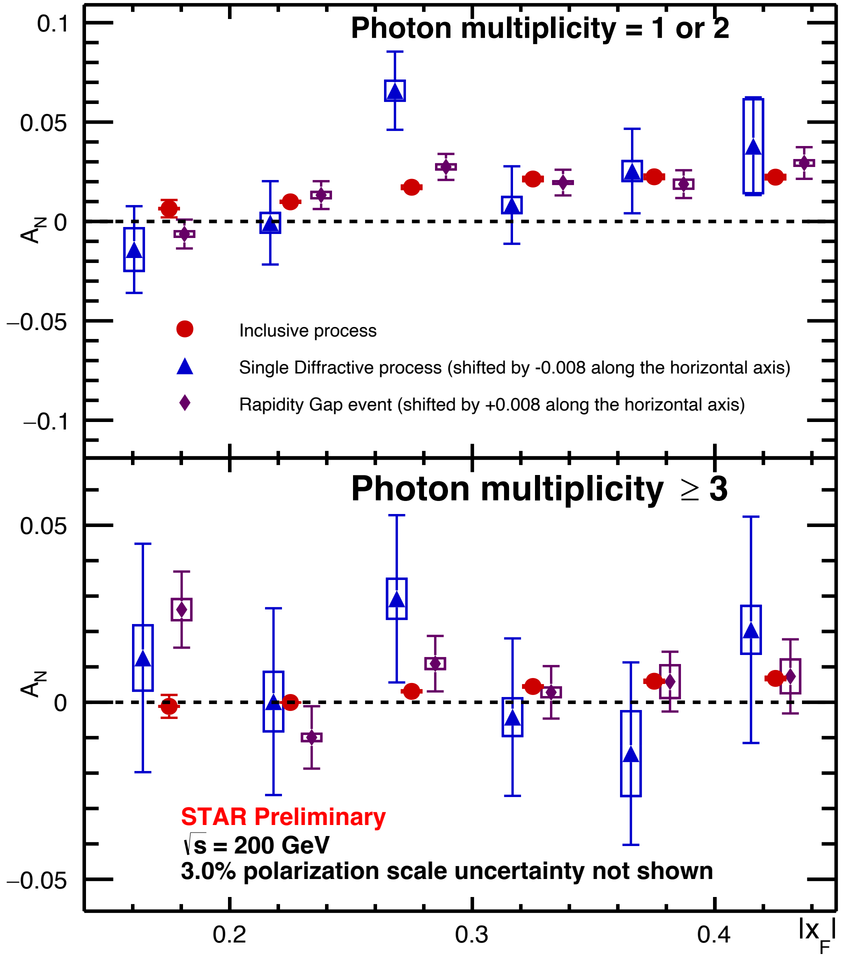
$\chi^2/n.d.f$: 0.38

Yellow beam A_N is consistent with zero for all cases.



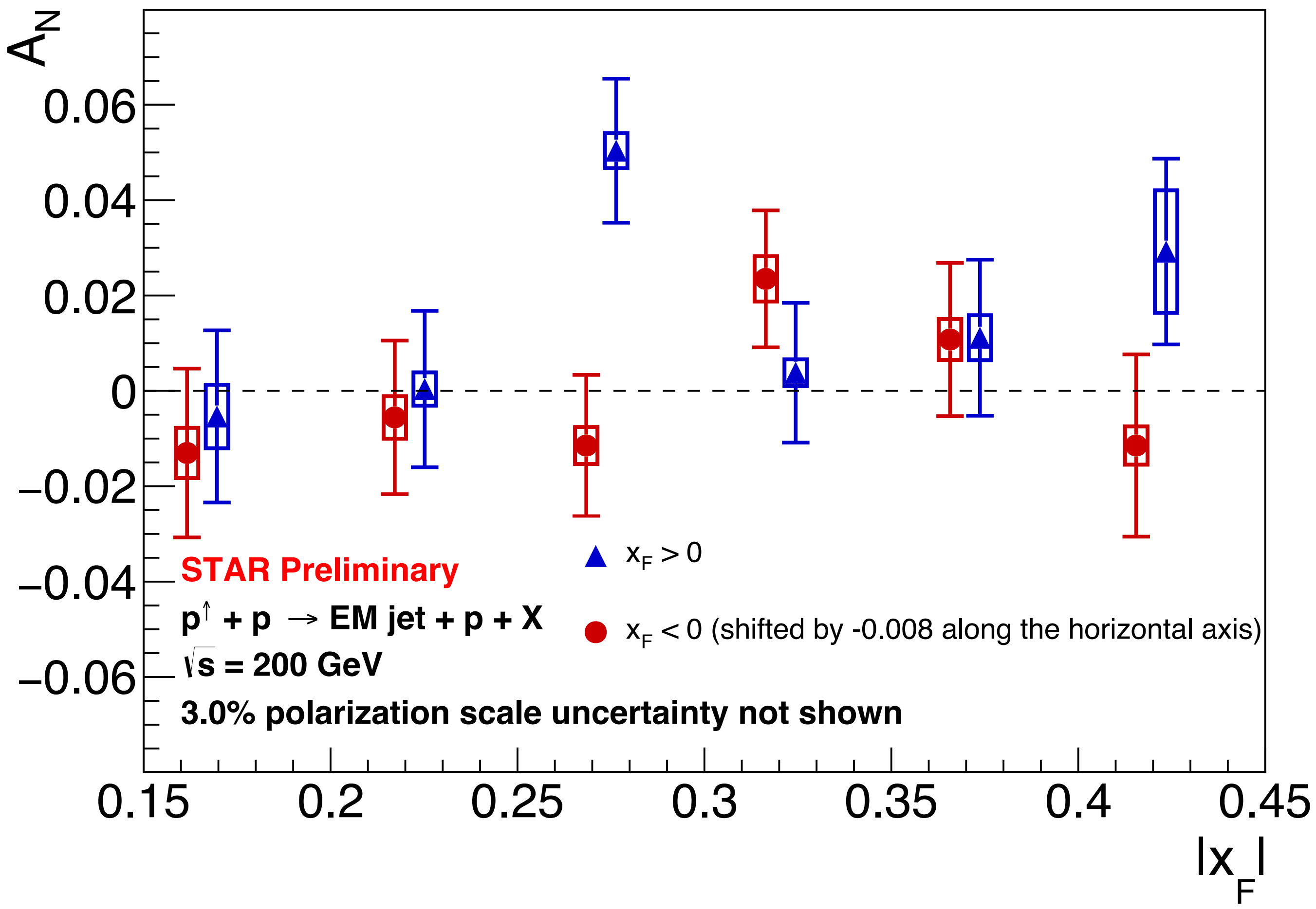
Preliminary figure 2: A_N for single diffractive events as a function of x_F for 3 different photon multiplicity cases: all photon multiplicity (top), 1 or 2 photon multiplicity (middle), and 3 or more photon multiplicity (bottom). The A_N for $x_F < 0$ (red points) shifts -0.013 along the x-axis.

Preliminary plot 3 (updated): Comparison plot of A_N for inclusive, single diffractive, and rapidity gap events



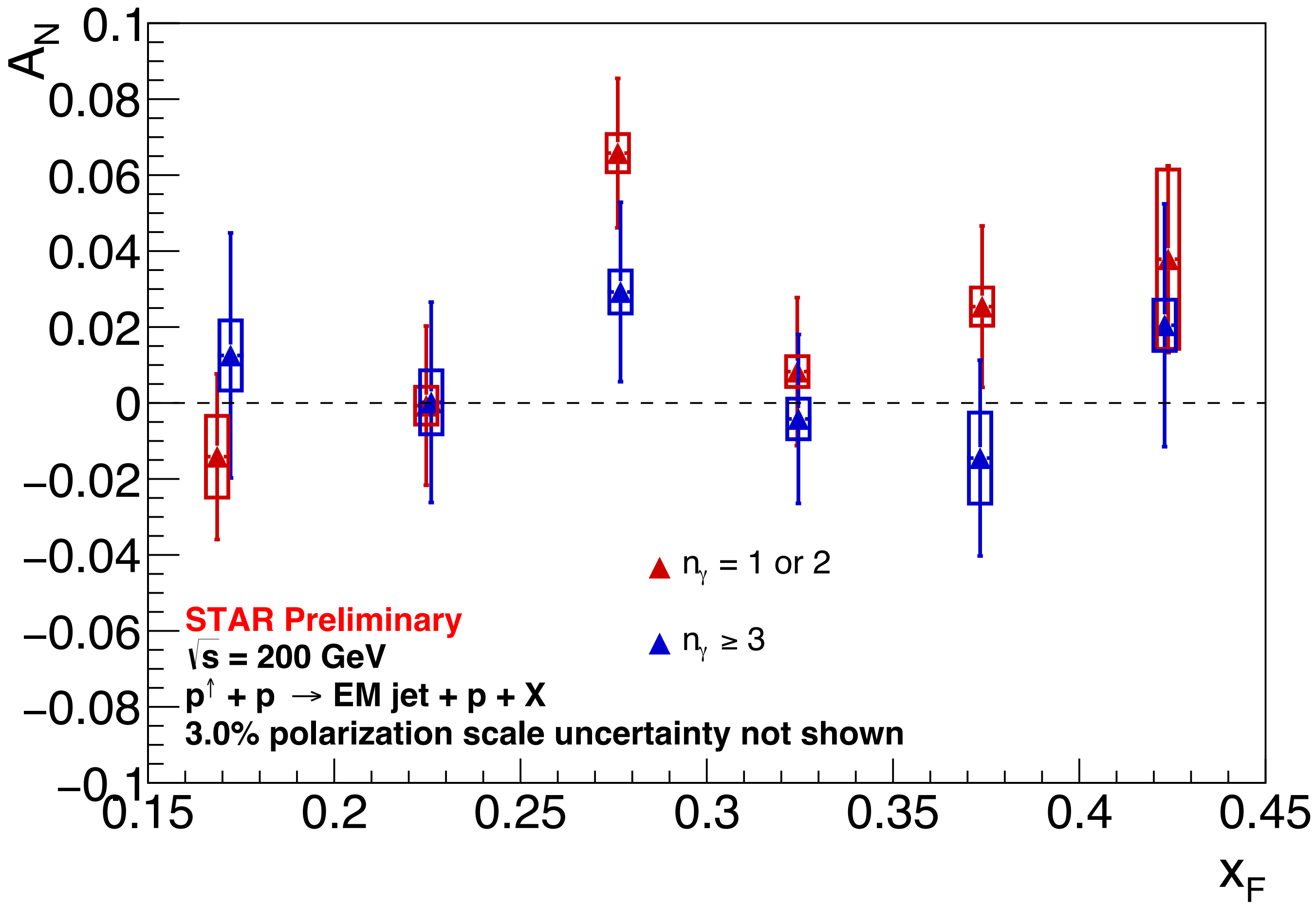
Preliminary figure 3: A_N as a function of x_F for 3 processes for the case of photon multiplicity 1 or 2 (top panel) and photon multiplicity 3 or more (bottom panel) : inclusive process (red), single diffractive process (blue), and the rapidity gap events (magenta)

Back up Preliminary plot 4: A_N for single diffractive events



Back up Preliminary figure 4: A_N for single diffractive events as a function of x_F for all photon multiplicity. The blue points are for $x_F > 0$, while the red points are for $x_F < 0$. The A_N for $x_F < 0$ shifts -0.008 along the x-axis.

Back up Preliminary plot 5: A_N for single diffractive events

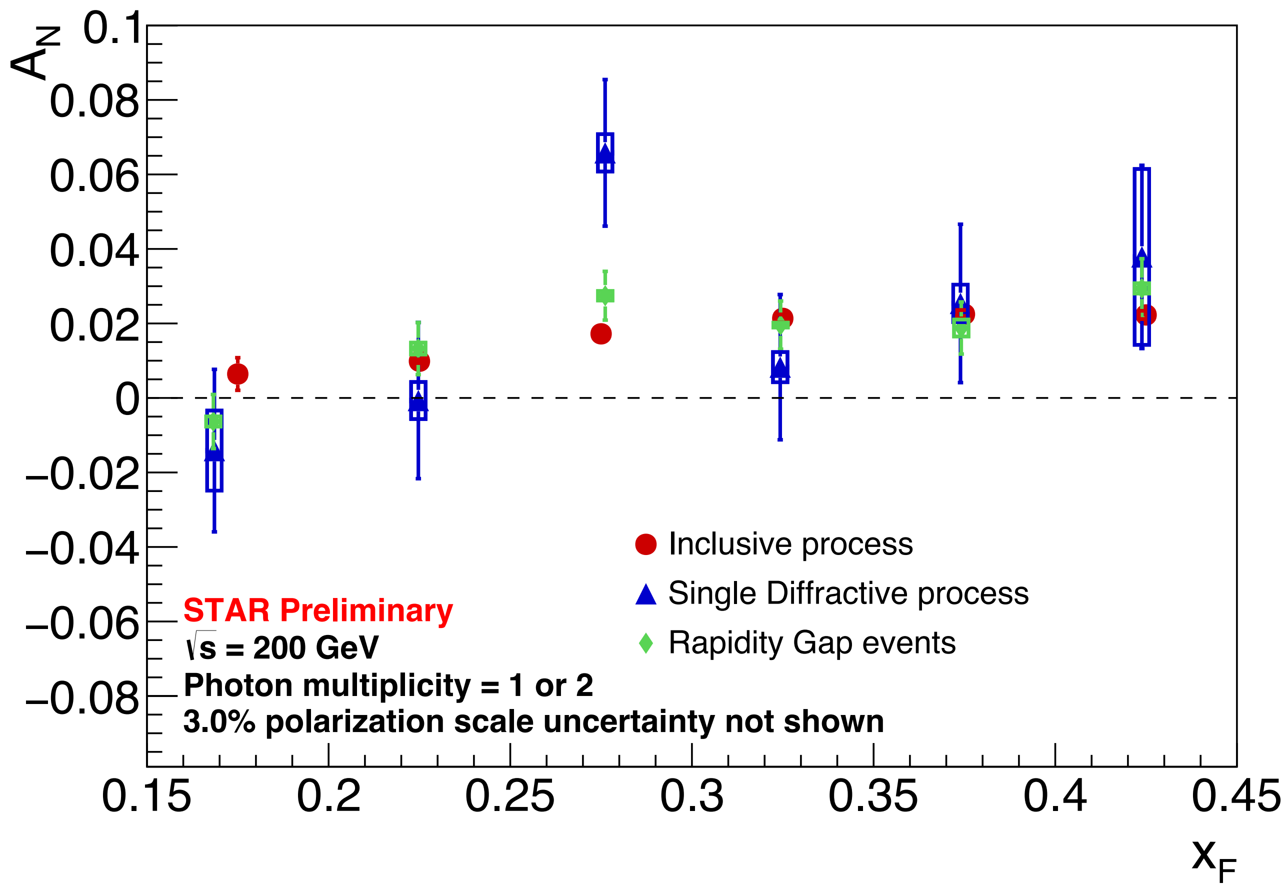


Back up preliminary figure 5: A_N for single diffractive events as a function of x_F for 2 different photon multiplicity cases: 1 or 2 photon multiplicity (red), and 3 or more photon multiplicity (blue)

Conclusion

- The EM-jet A_N for single diffractive process is observed with more than 2 sigma non-zero significant.
- The EM-jet A_N for single diffractive process does not provide strong evidence that the diffractive process can contribute to large A_N for inclusive process

Preliminary plot 3 (old): Comparison plot of A_N for inclusive, single diffractive, and rapidity gap events



Preliminary figure 3: A_N as a function of x_F for 3 processes for the case of photon multiplicity 1 or 2: inclusive process (red), single diffractive process (blue), and the rapidity gap events (green)