Discussion: Run 15 Diffractive EM-jet A_N at Forward Rapidity using $p^{\uparrow} + p$ collisions at $\sqrt{s} = 200$ GeV

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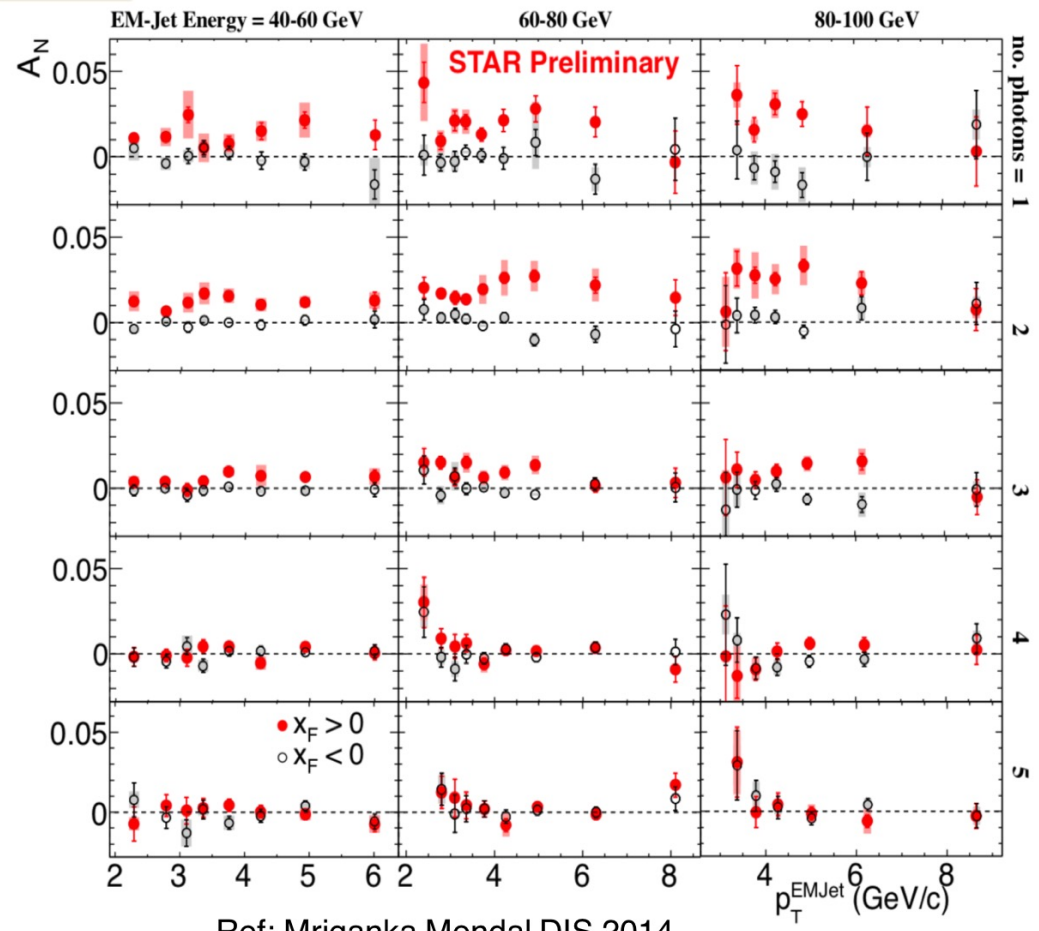
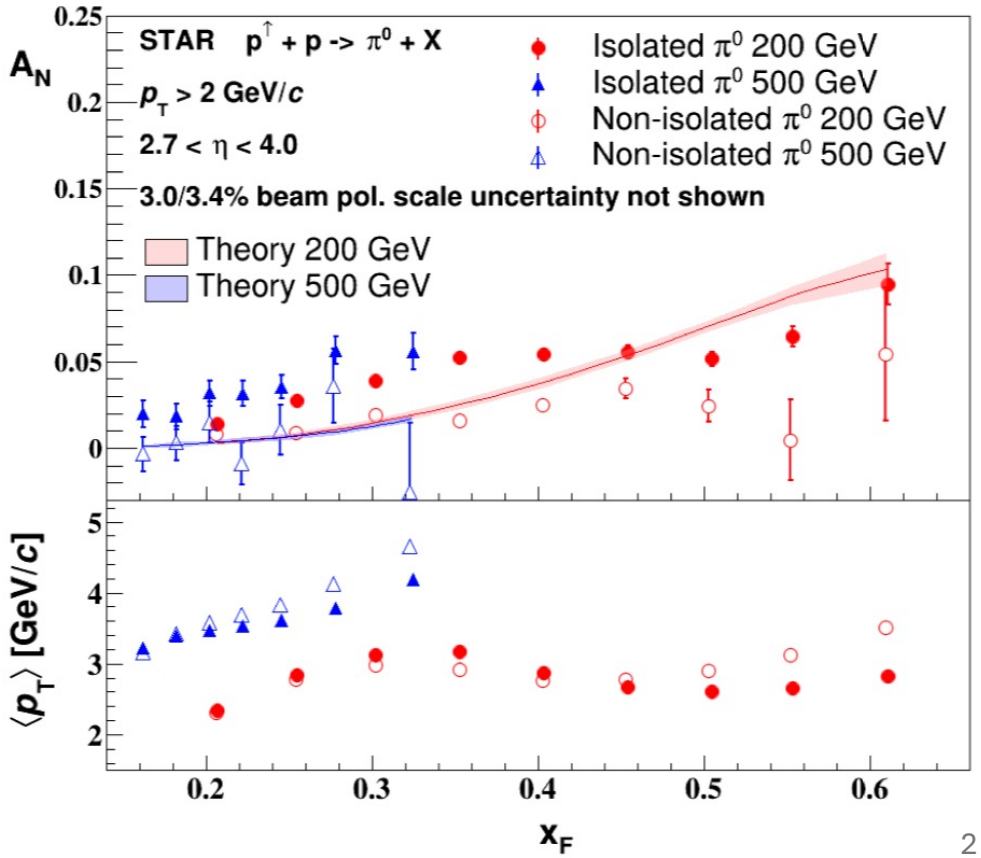
Motivation

- 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)

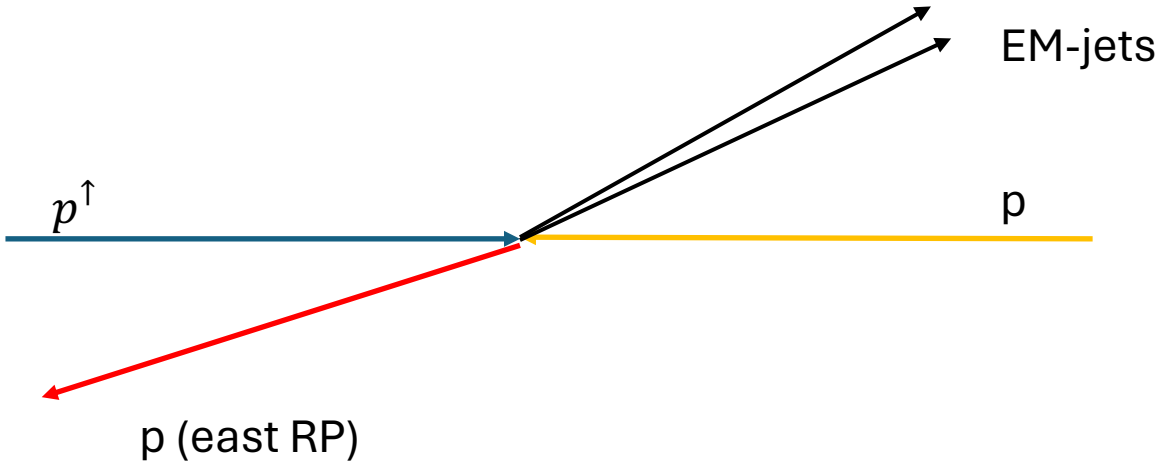
General Information for the analysis

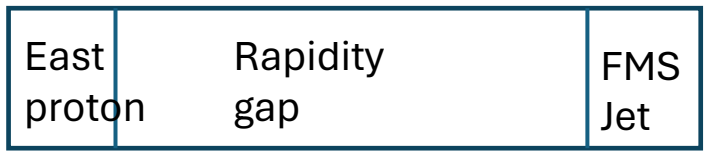
- Motivation and goal: study the A_N for diffractive process and explore its contribution for large A_N in inclusive processes
- Data set: run 15 pp transverse $\sqrt{s} = 200$ GeV ,**fms stream**
  - (production_pp200trans_2015)
- Production type: MuDst ; Production tag: P15ik
- Trigger for FMS : FMS small board sum, FMS large board sum and FMS-JP.
- EM-jet reconstruction: Anti-k_T algorithm with R=0.7
  - EM-jet: the jet reconstructed using only photons (FMS point)
  - FMS point minimum energy: 1 GeV

Single diffractive process and Semi-exclusive process

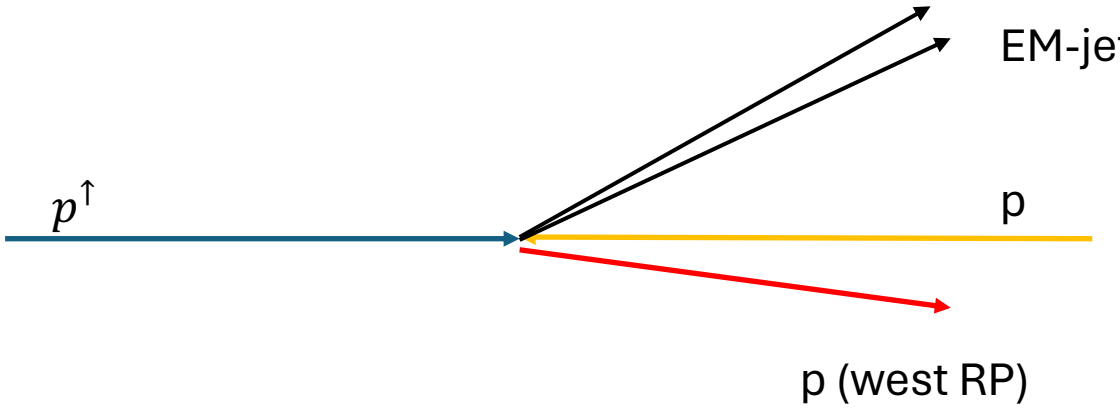
Event selection for Single diffractive process and Semi-exclusive process

- Single diffractive process:
  1. Only 1 EM-jet at FMS
  2. Only 1 east RP track and it must be good RP track
  3. East BBC veto



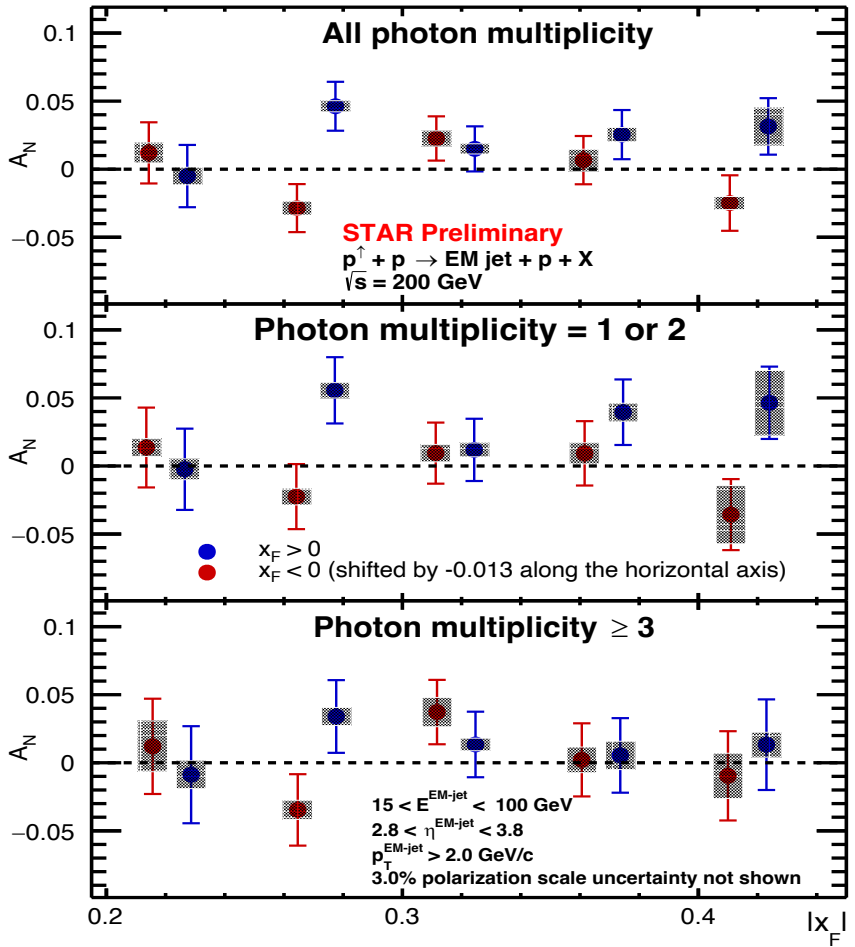


- Semi-exclusive process
  1. Only 1 EM-jet at FMS
  2. Only 1 west RP track and it must be good RP track
  3. West BBC veto
  4. E sum requirement

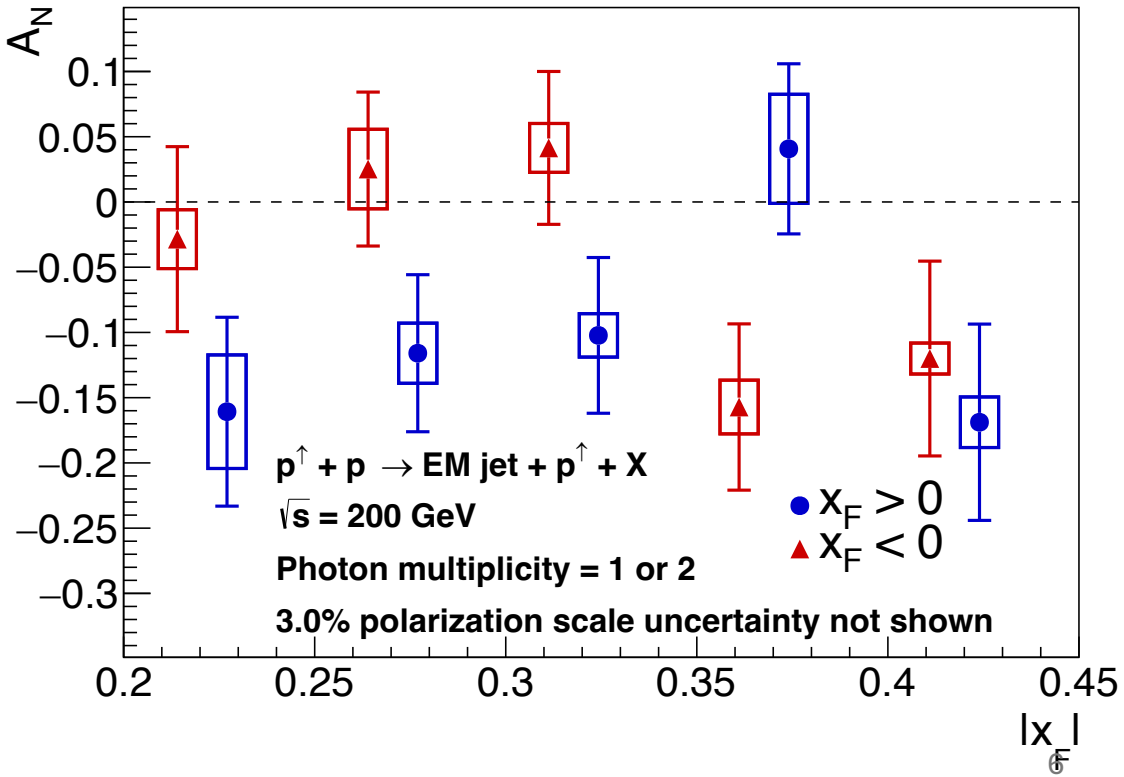


Results for Single diffractive process and Semi-exclusive process

- Single diffractive process:
  - Blue beam A_N is 2.7 σ to be non-zero for EM-jet with all photon multiplicity.



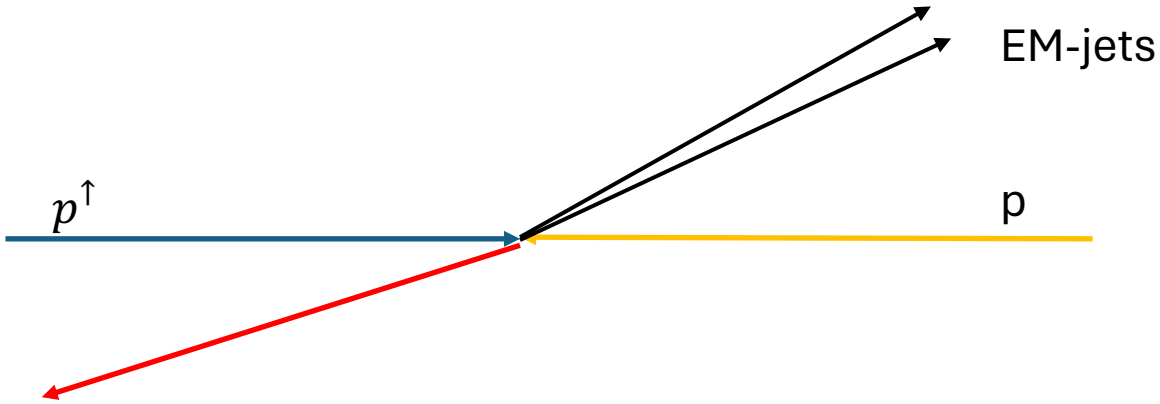
- Semi-exclusive process:
  - Blue beam A_N is 3.1 σ to be non-zero.
  - Negative A_N is observed.

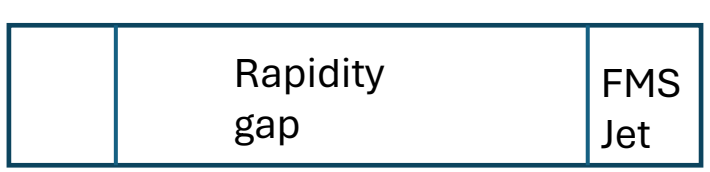


Single diffractive process and Rapidity gap events

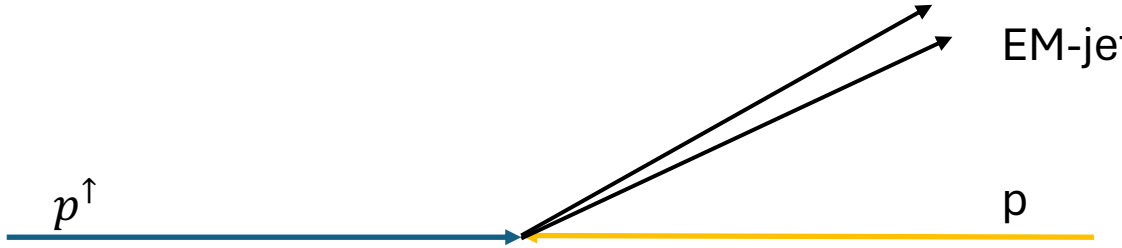
Event selection for Single diffractive process and Rapidity gap events

- Single diffractive process:
  1. Only 1 EM-jet at FMS
  2. Only 1 east RP track and it must be good RP track
  3. East BBC veto



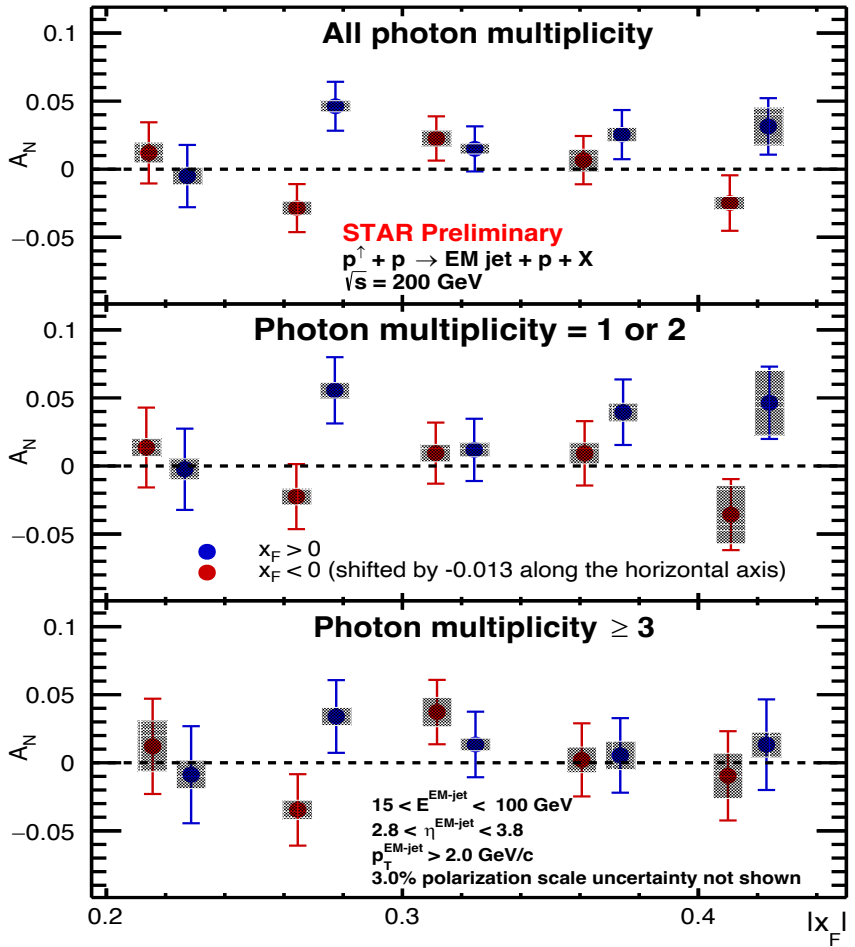


- Rapidity gap events
  1. Only 1 EM-jet at FMS
  2. East BBC veto

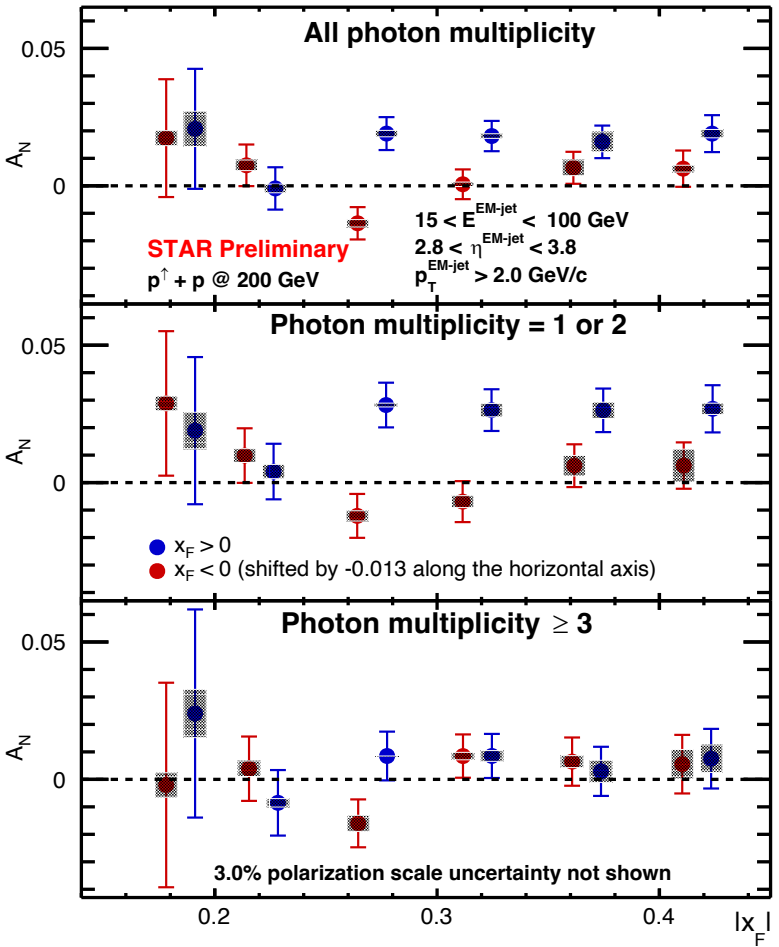


Results for Single diffractive process and Rapidity gap event

- Single diffractive process:
  - Blue beam A_N is 2.7 σ to be non-zero for EM-jet with all photon multiplicity.

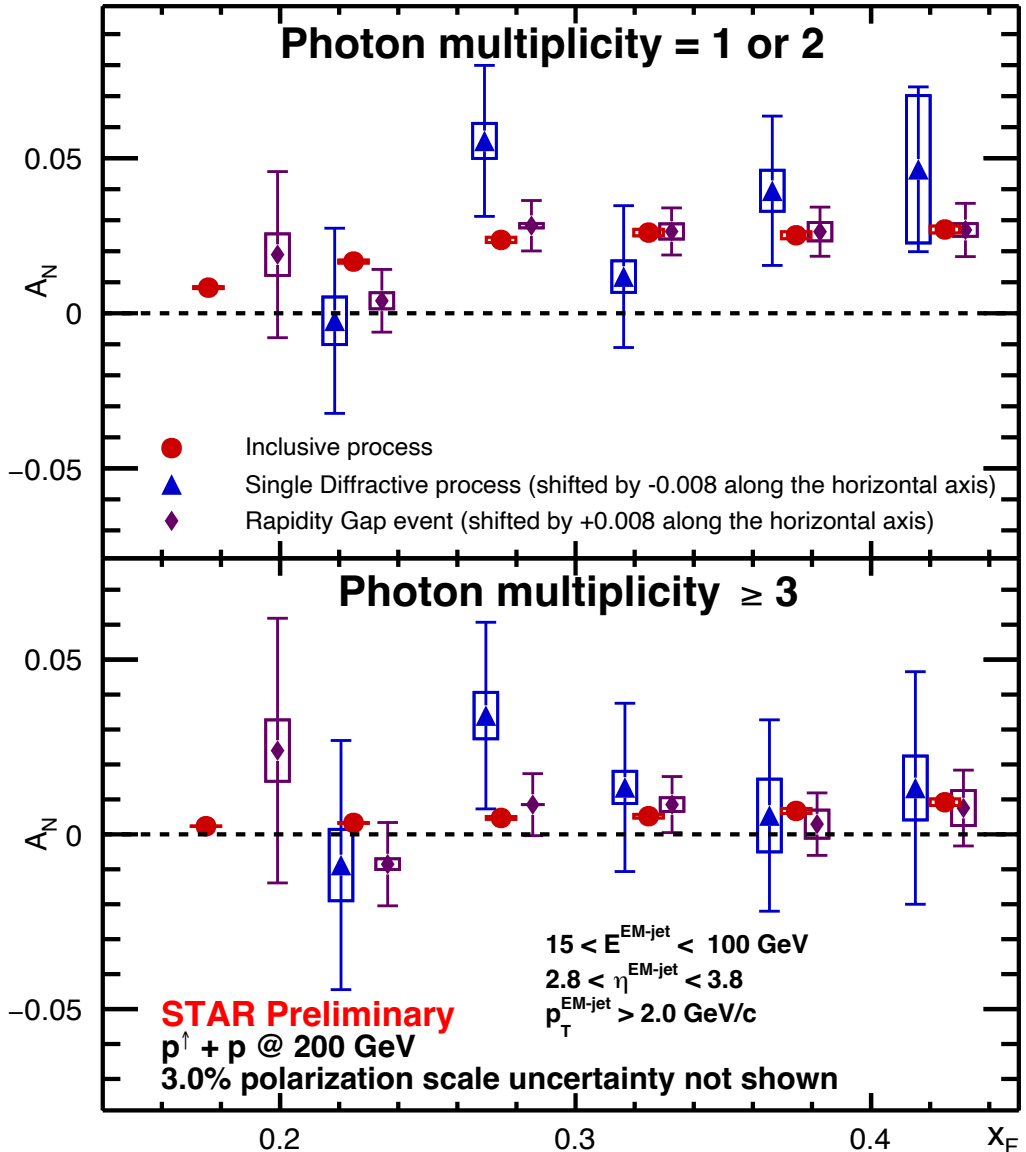


- Rapidity gap event:
  - The EM-jet A_N for rapidity gap events is consistent to that for inclusive process and single diffractive process within uncertainty



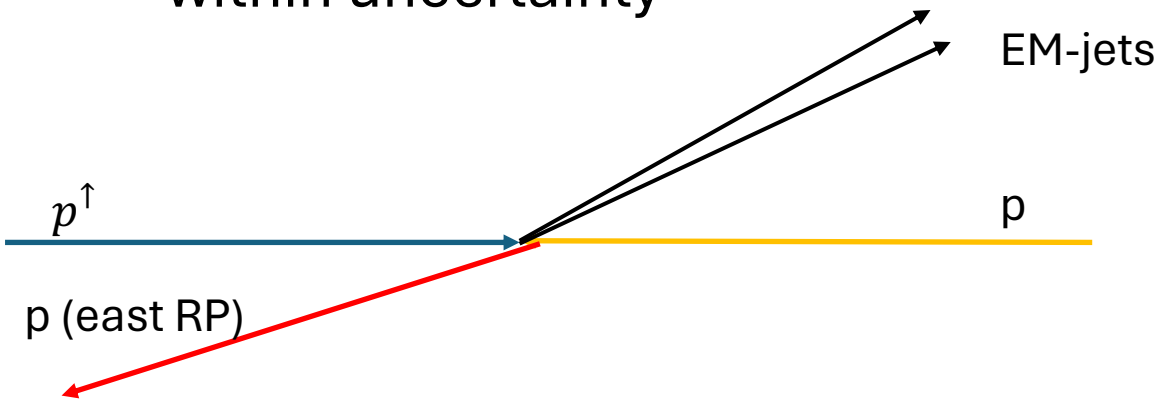
Comparison plot of A_N for inclusive, single diffractive, and rapidity gap events

- The EM-jet A_N for inclusive process, single diffractive process, and rapidity gap event are consistent within uncertainty
- Since the cross section of the diffractive process is about 20% of the cross section in forward rapidity in inclusive process, a large A_N should be expected for diffractive process if it has significant contribution to large A_N in the inclusive process
- However, we don't see it, so the single diffractive process can not provide evidence to have large A_N in the inclusive process.

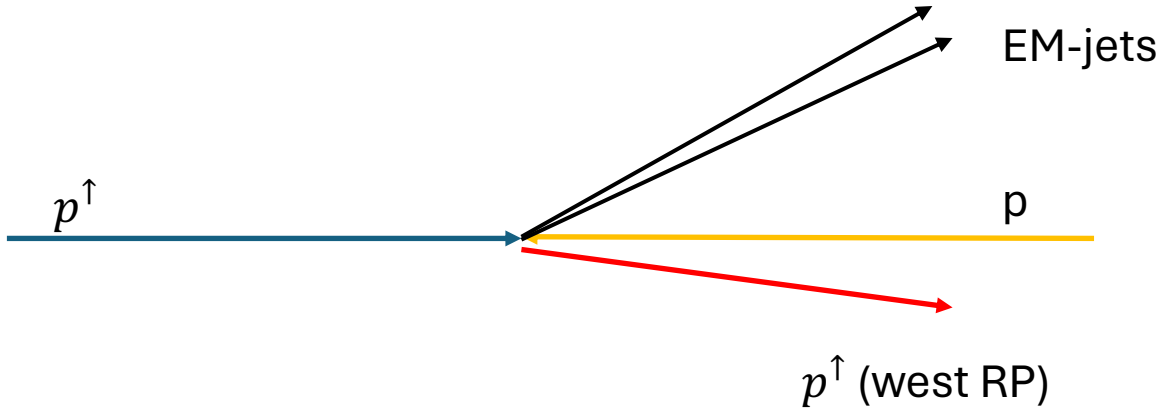


Discussion for the physics

- Single diffractive process:
  - The EM-jet A_N for inclusive process, single diffractive process, and rapidity gap event are consistent within uncertainty



- Semi-exclusive process:
  - Negative A_N is observed, and it's different from inclusive process, single diffractive process and rapidity gap events



- A_N is consistent within statistics whenever the polarized proton breaks up, independent of whether the unpolarized proton remains intact or not
- A_N is quite different when the polarized proton remains intact

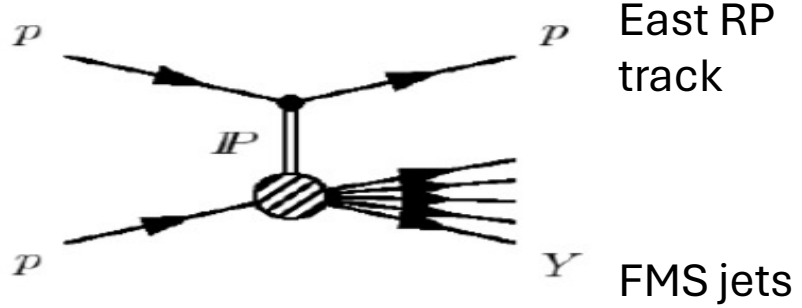
Back up

Diffractive EM-jet A_N using FMS

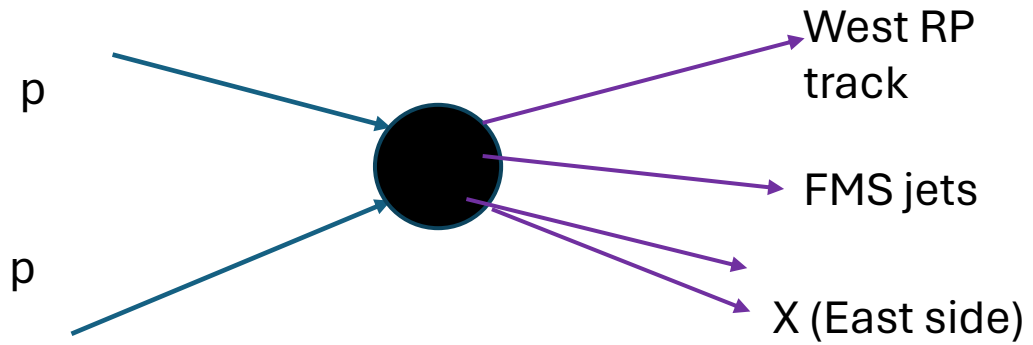
Motivation and goal: study the A_N for diffractive process and explore its contribution for large A_N in inclusive processes

Determine the process for diffractive EM-jet A_N

Case 1: (**Single diffractive process**)
only 1 proton track on east side RP. No west side RP track requirement.
Require: small and large BBC east cut



Case 2: (**Semi-exclusive process**)
only 1 proton track on west side RP. No requirement on east RP track
Require: small and large BBC west cut, energy sum (E sum) cuts



Single diffractive process

Single diffractive EM-jet A_N using FMS

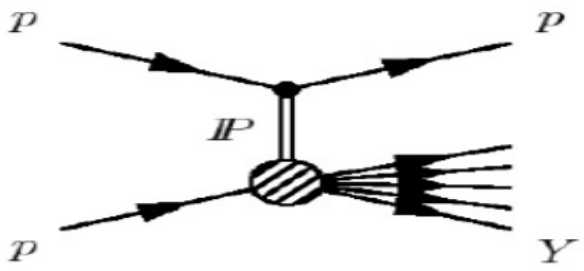
Motivation and goal: study the A_N for diffractive process and explore its contribution for large A_N in inclusive processes

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



East RP track

FMS jets

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

A_N for single diffractive events

Blue beam A_N is 2.7 σ to be non-zero for EM-jet with all photon multiplicity.

Constant fit: 0.024 ± 0.0089

$\chi^2/n.d.f$: 0.83

Blue beam A_N is 2.5 σ to be non-zero for EM-jet with 1 or 2 photon multiplicity.

Constant fit: 0.030 ± 0.012

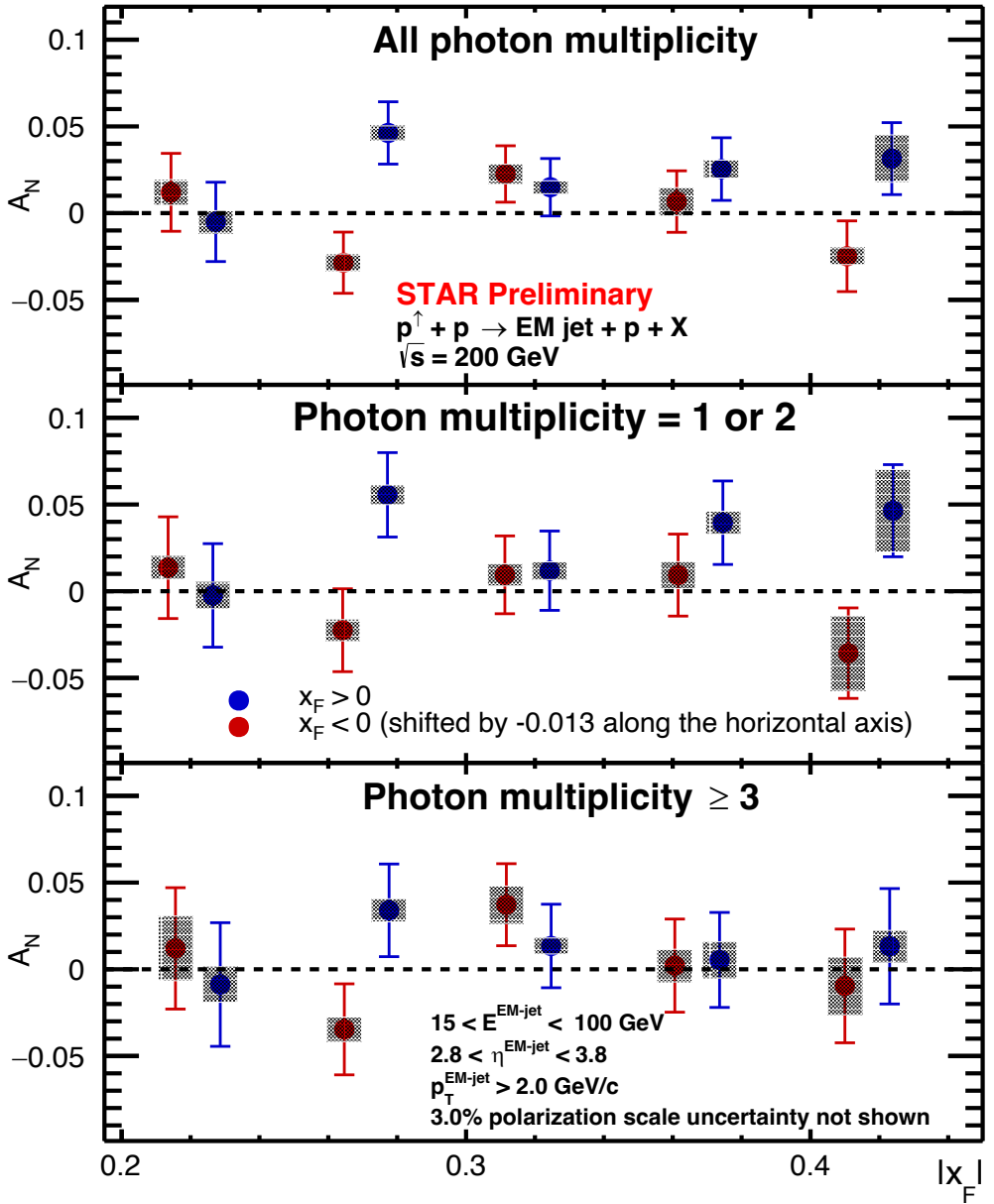
$\chi^2/n.d.f$: 0.78

Blue beam A_N is 1.0 σ to be non-zero for EM-jet with 3 or more photon multiplicity.

Constant fit: 0.014 ± 0.013

$\chi^2/n.d.f$: 0.25

Yellow beam A_N is consistent with zero for all cases.



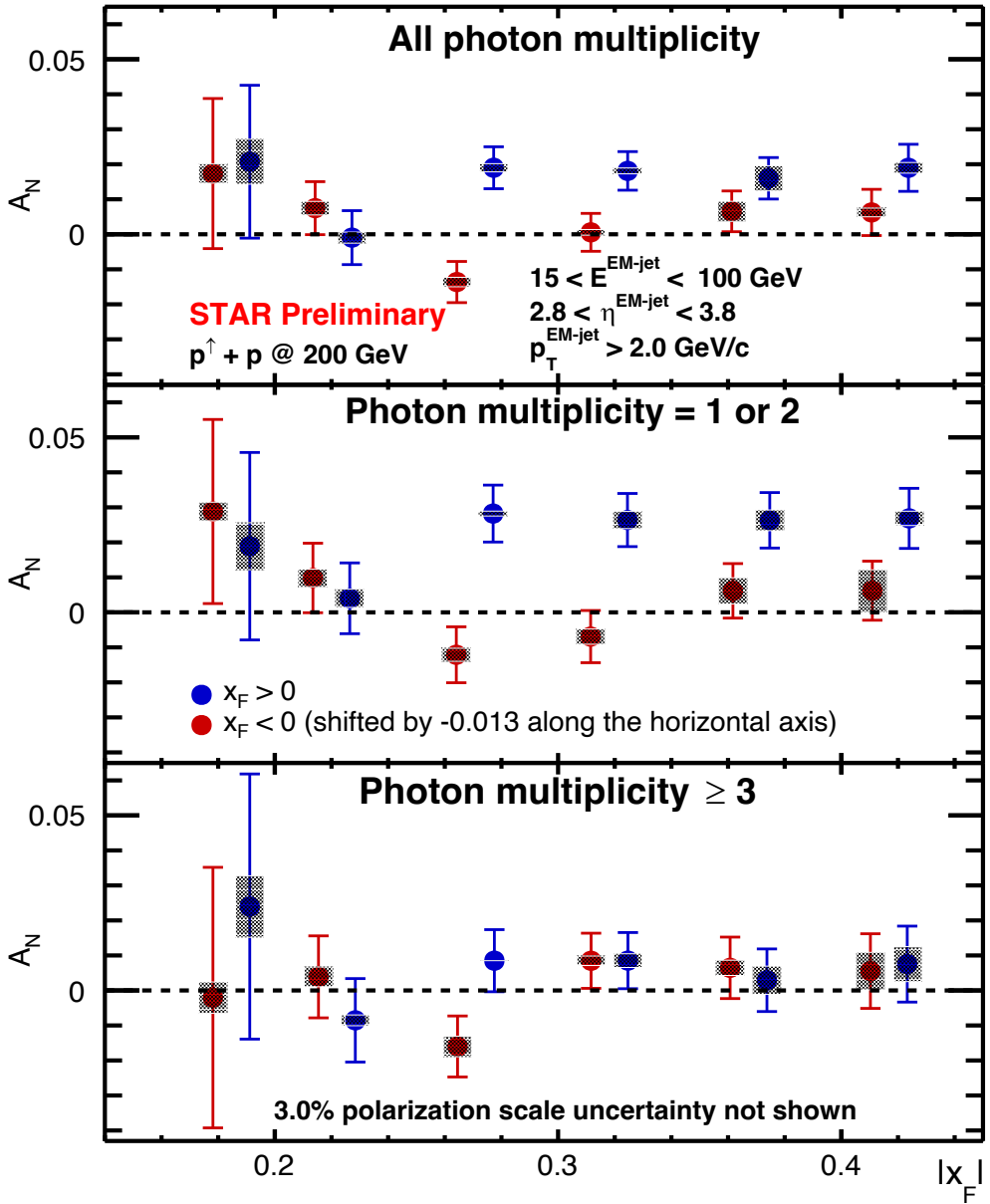
Rapidity Gap events

Rapidity Gap (RG) event

- **Motivation**
  - The single diffractive events with the proton tagged by east RP are small fraction of real single diffractive events due to limited RP acceptance
  - At least 50% RG events are single diffractive events (precise fraction is under investigation)
- **Event selection: (FMS + East BBC veto , no RP requirement)**
- **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.
  - EM-jet energy correction and Underlying Event correction
- 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**

A_N for Rapidity Gap events

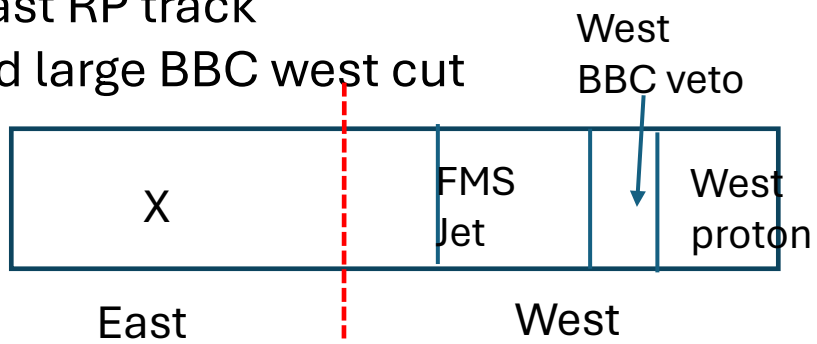
- The size of EM-jet A_N for rapidity gap events is similar to that for inclusive process
- The A_N for the EM-jet with 1 or 2 photon multiplicity is strongest

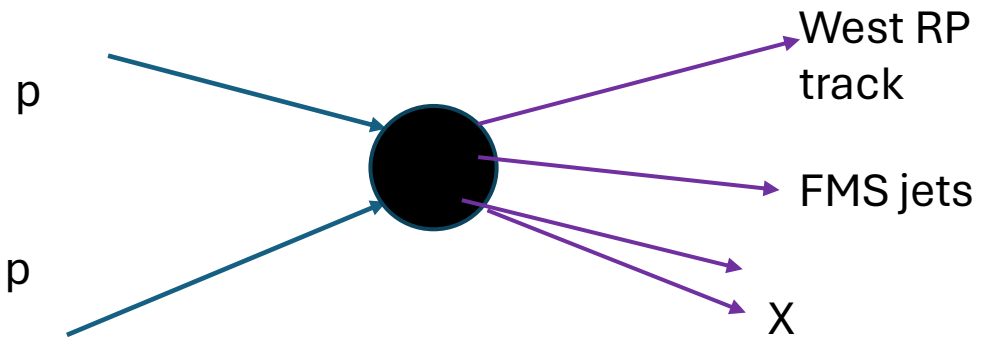


Semi-exclusive process

Semi-exclusive process with 1 west RP track

semi-exclusive process
only 1 proton track on west side RP. No requirement on east RP track
Require: small and large BBC west cut





Semi-exclusive constrain the west side proton and FMS EM-jets .
West BBC veto is for minimizing the accidental coincidence.
The rapidity gap with west BBC veto is not large enough to satisfy the requirement of diffractive process

Event selection and corrections

- **FMS**
  - 9 Triggers, 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 point energy > 1 GeV, $p_T > 2$ GeV/c, trigger p_T threshold cut, FMS point as input.
  - Only 1 EM-jet per event allowed
- **Only allow acceptable beam polarization (up/down).**
- **Vertex** (Determine vertex z priority according to TPC , VPD, BBC.)
  - Vertex $|z| < 80\ cm$
- **Roman Pot and Semi-exclusive process:**
- Only 1 west RP track (no restriction on east RP track)
- RP track must be good track:
  a) Each track hits > 6 planes
  b) West RP ξ dependent θ_X , θ_Y , P_X and P_Y cuts
  c) $0 < \xi < 0.45$
  - Sum of west RP track energy and all EM Jet energy (see detail in table)
- **West Large BBC ADC sum < 60 and West Small BBC ADC sum < 80**

Corrections:
EM-jet energy correction and Underlying Event correction

x_F	E sum Cut
0.2 - 0.25	E_{sum} < 110 GeV
0.25 - 0.3	E_{sum} < 110 GeV
0.3 – 0.35	E_{sum} < 115 GeV
0.35 – 0.4	E_{sum} < 115 GeV
0.4 – 0.45	E_{sum} < 120 GeV

A_N results for 1 or 2 photon multiplicity

- Only 5 x_F bins are considered: [0.2,0.25], [0.25,0.3], [0.3,0.35] , [0.35,0.4], [0.4,0.45]
- 1 or 2 photon multiplicity
- Constant fit is applied to calculate the significance of non-zero
- Blue beam A_N is 3.1 σ to be non-zero.
  - Constant fit: -0.10 ± 0.032
  - $\chi^2/n.d.f$: 1.17
- Yellow beam A_N is 1.4 σ to be non-zero.
  - Constant fit: -0.042 ± 0.031
  - $\chi^2/n.d.f$: 1.36