Run 17 diffractive EM-jet A_N update

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Situation and status

- Run 17 analysis current situation:
  1. The Roman Pot track cuts are need to better considered.
  2. The systematic uncertainty calculation need to be better considered.
- We use the elastic scattering events to investigate the cuts for the RP track.
- Use another method to calculate the systematic uncertainty.
- Data set: run 17 pp transverse $\sqrt{s} = 510$ GeV ,fms stream
  - (pp500_production_2017)

Elastic scattering events

- Possible elastic scattering event: p + p -> p + p
- Only 1 east RP track and only 1 west RP track.
- The final state proton momentum is close to initial state proton momentum (beam energy).
  - Determine the elastic scattering events : The 2 final state proton momentum are close ($\Delta P < 5\ GeV/c$).

Roman Pot track P_Y vs P_X

- We use the elastic **scattering events** to check the Roman Pot track P_Y vs P_X.
  - Determine the elastic scattering events : The 2 final state proton momentum are close ($\Delta P < 5\ GeV/c$).
- Consider the new acceptable Roman Pot track P_Y vs P_X region (Yellow):
  - $-0.25 < P_X < 0.3$ GeV/c ; $-0.6 < P_Y < -0.4$ GeV/c or $0.3 < P_Y < 0.55$ GeV/c

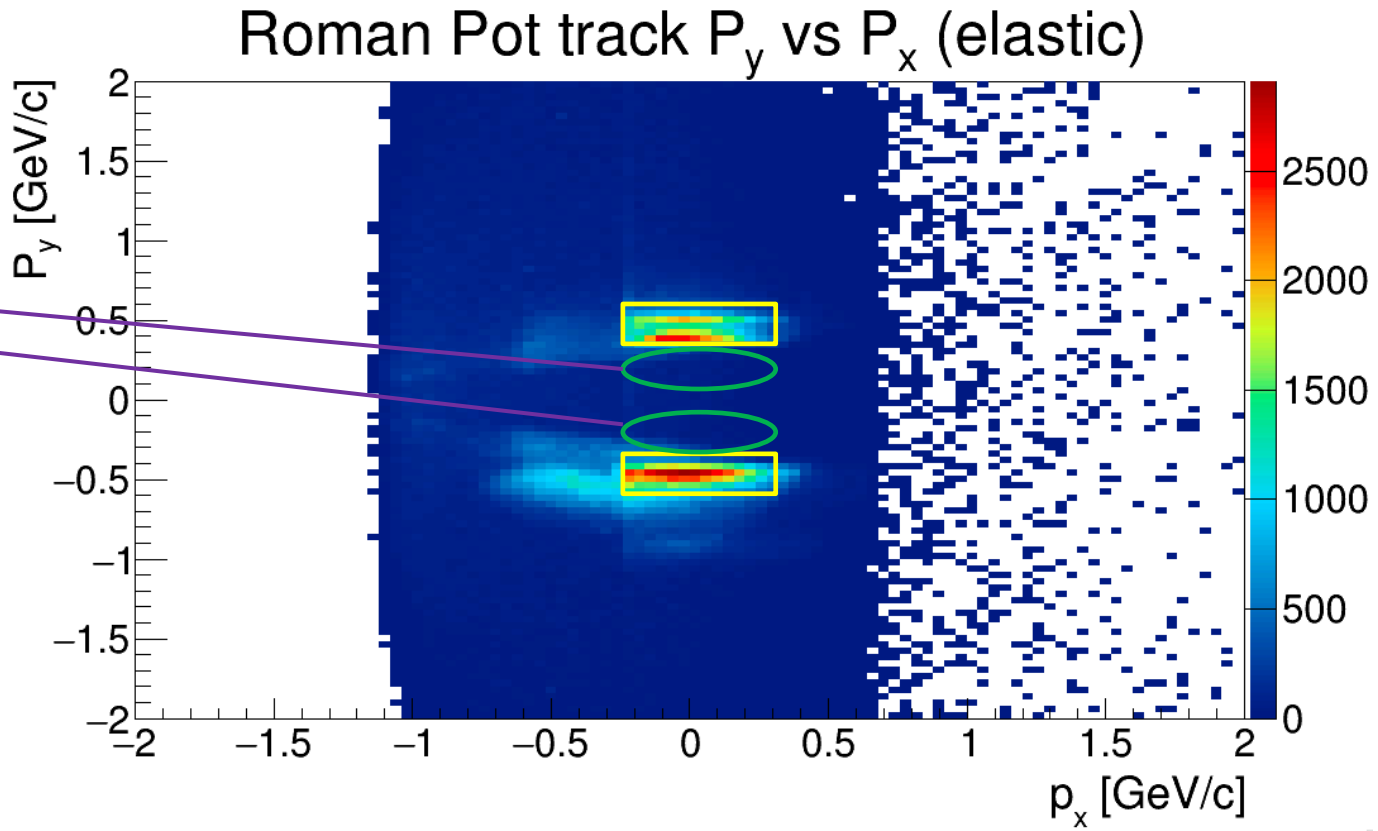
Note: the old Roman Pot track P_Y vs P_X region (Green):

$-0.5 < P_X < 0.3$ GeV/c ;

$-0.4 < P_Y < -0.25$ GeV/c or

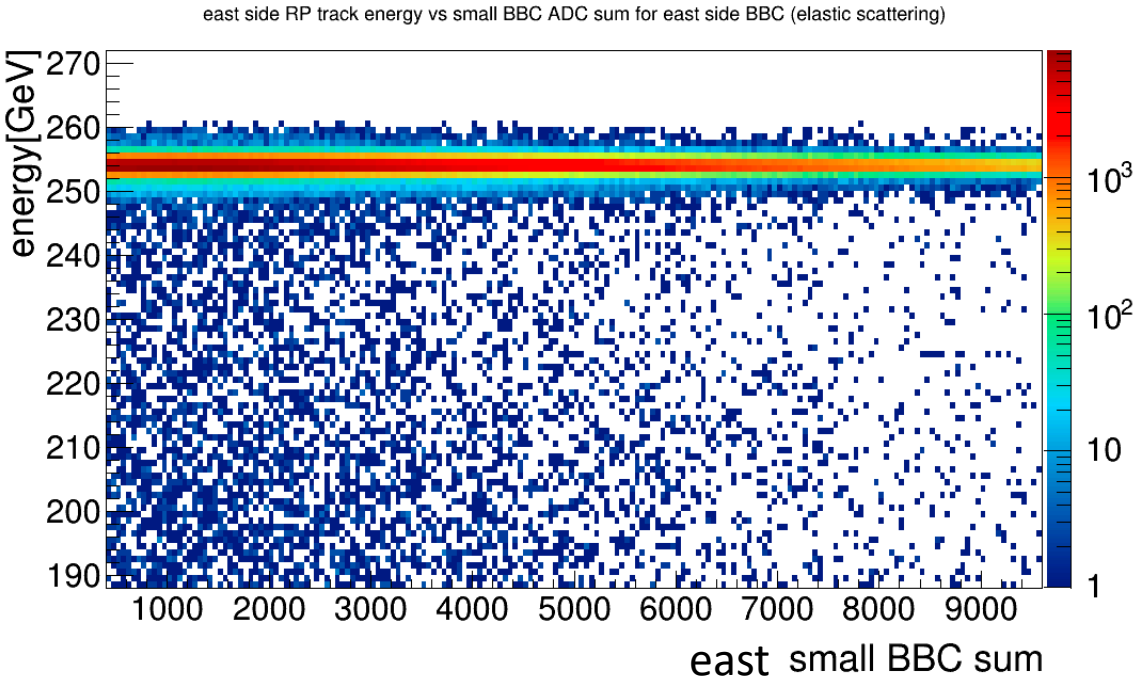
$0.25 < P_Y < 0.4$ GeV/c

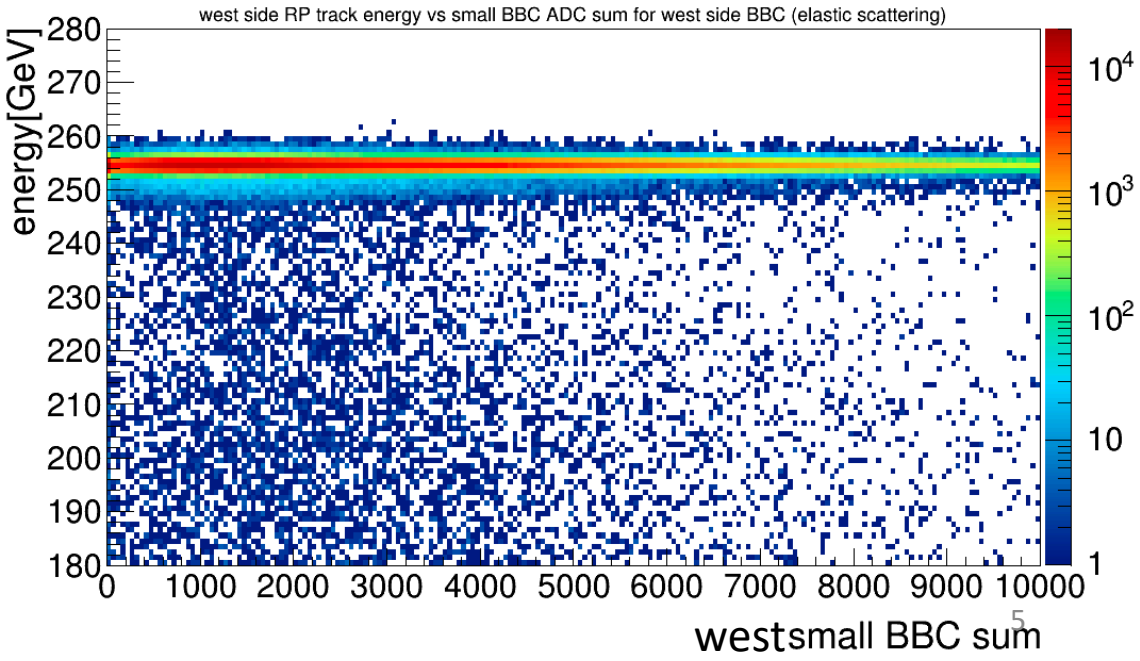
This region is determined by fraction of RP track hits 8 planes to RP track hits <8 planes. But RP group mentions that the tracks with low PY regions might come from beam, but not real collision events.



Check with elastic scattering events

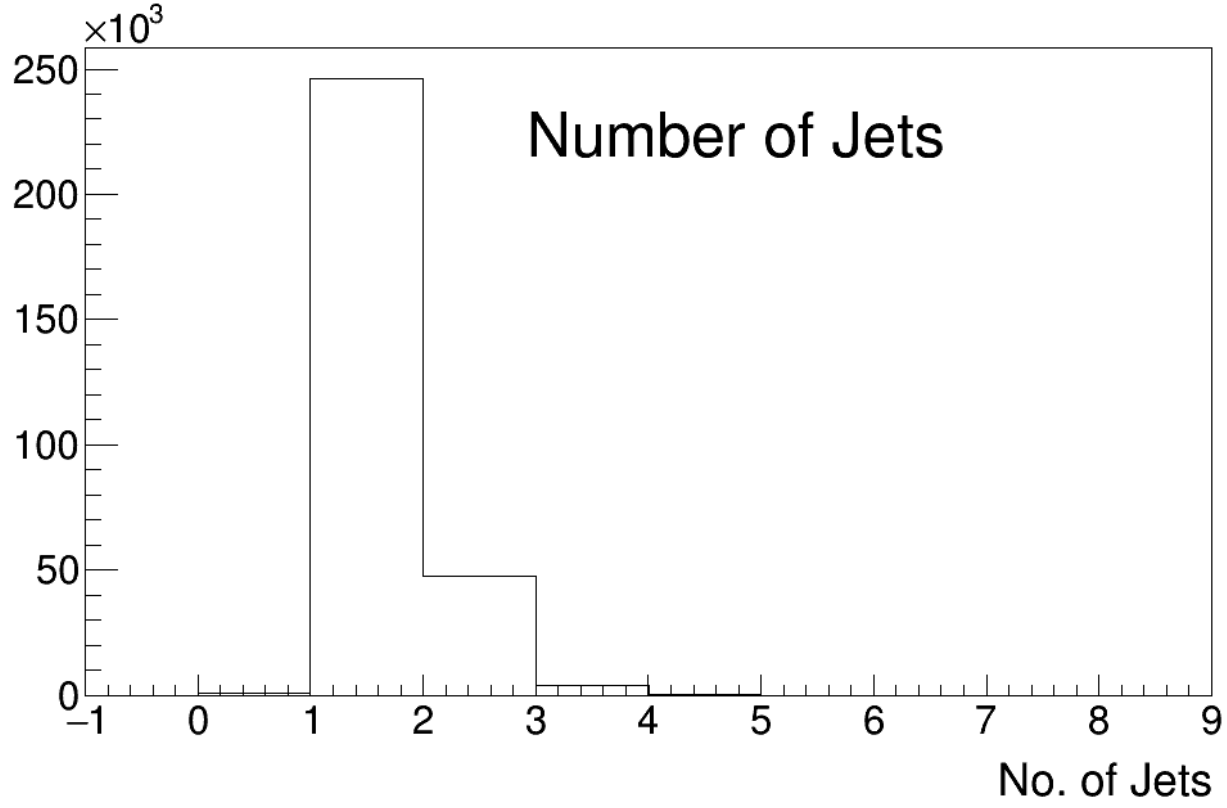
- With the new RP P_X , P_Y cuts, more than 99% of the elastic scattering events are with the proton track close to beam energy (real elastic scattering events).
- We still don't see bias for the BBC sum from the elastic scattering events.
  - Other cuts are still needed to minimize the pile-up events!





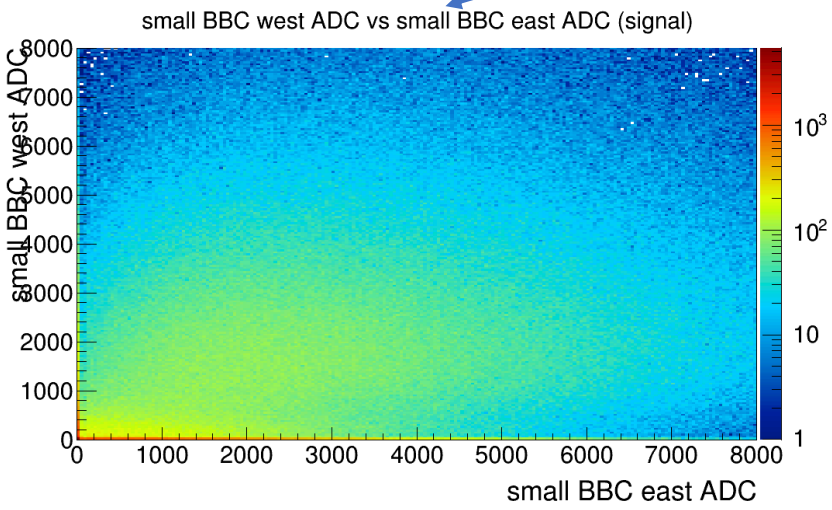
Number of EM-jets in simulation

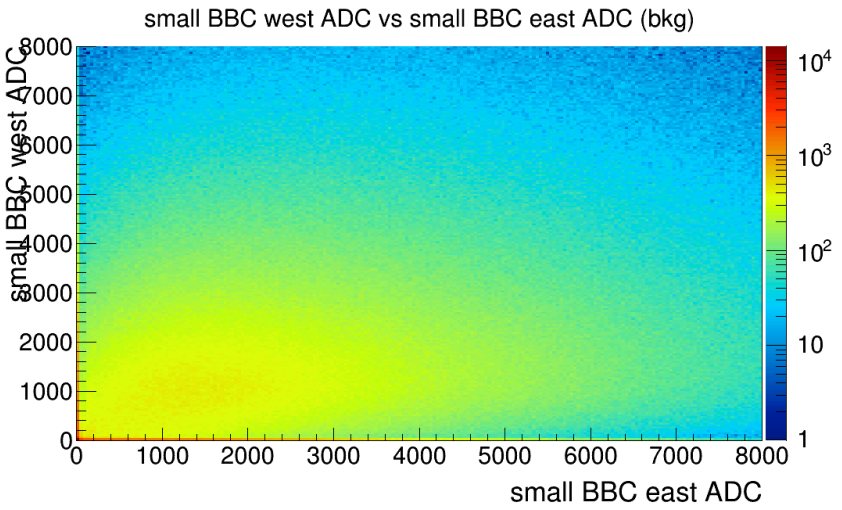
- Number of EM-jets in FMS in the simulation for inclusive process.
- 1 EM-jets per events is preferred. We should consider the events with low number of EM-jets for data.

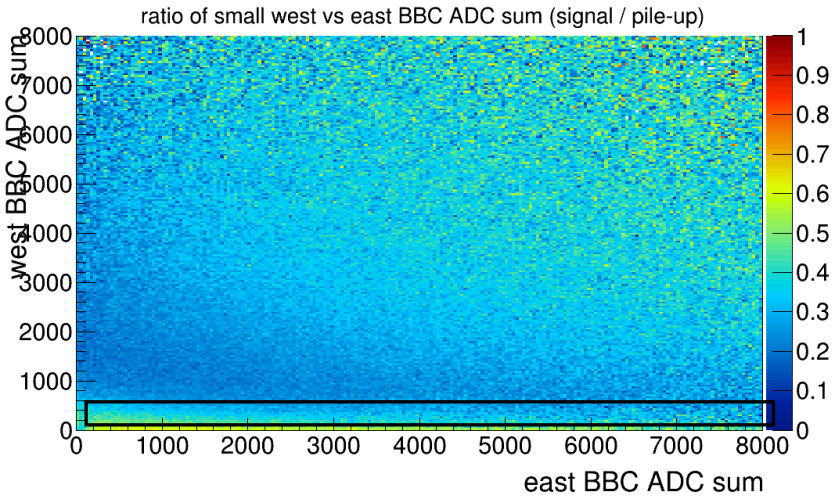


Check small BBC west ADC vs small BBC east ADC

- Events with only 1 EM-jets
- Consider $E_{sum} < 260$ GeV and $E_{west\ RP} < 240$ GeV as signal
- Otherwise, $E_{sum} > 260$ GeV or $E_{west\ RP} > 240$ GeV as background
  - E_{sum}: sum of FMS EM-jet energy and west RP track energy
- Plot the signal / background ratio
  - Consider cut on small BBC west ADC < 550 and small BBC east ADC > 150







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.
  - Only 1 EM-jet per event
- **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
  - $-0.25 < P_X < 0.3$ GeV/c ;
  - $-0.6 < P_Y < -0.4$ GeV/c or $0.3 < P_Y < 0.55$ GeV/c
  - Sum of west RP track energy and all EM Jet energy
- **BBC ADC sum cuts:**
  - small BBC west ADC < 550 and small BBC east ADC > 150

Data set: run 17 pp transverse $\sqrt{s} = 510$ GeV ,fms stream (pp500_production_2017)

Corrections for EM-jet:
Energy correction and
Underlying Event correction

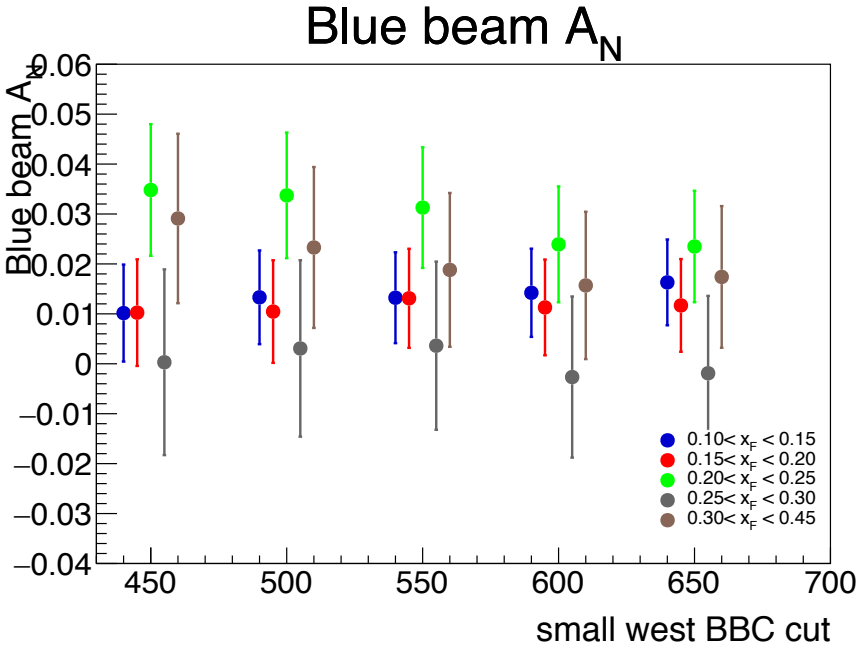
x_F	E sum Cut
0.1 - 0.15	E_{sum} < 265 GeV
0.15 - 0.2	E_{sum} < 280 GeV
0.2 - 0.25	E_{sum} < 295 GeV
0.25 - 0.3	E_{sum} < 305 GeV
0.3 - 0.35	E_{sum} < 315 GeV
0.35 - 0.4	E_{sum} < 330 GeV
0.4 – 0.45	E_{sum} < 340 GeV

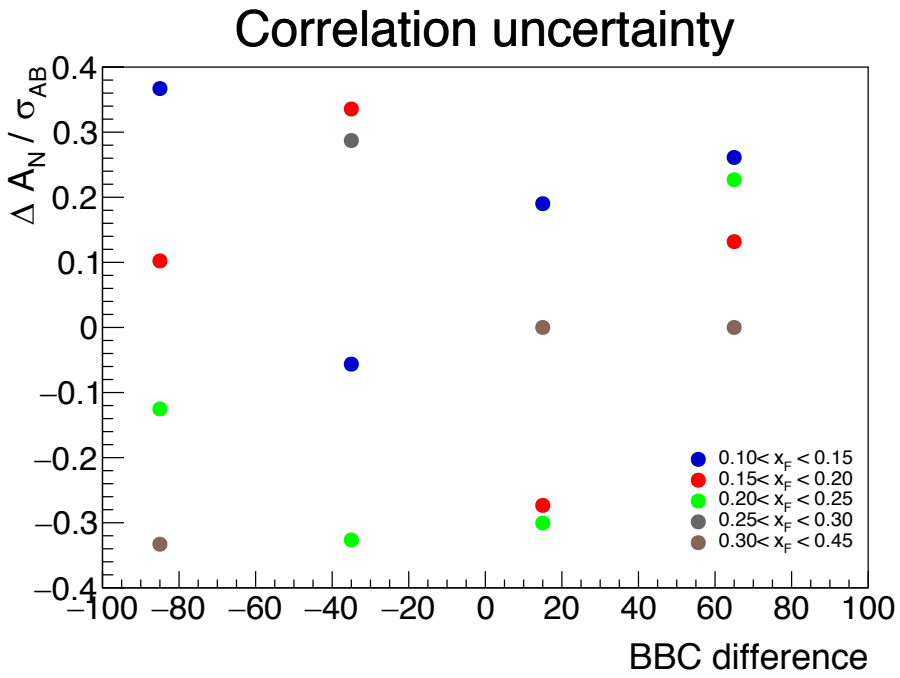
Calculate the correlated uncertainty

- We use the method of calculating the correlated uncertainty of the difference between two correlated data sets A and B:
  - For this analysis, data set B comes from changing the cut from data set A for the systematic uncertainty study.
- For the two sets of data set A and B:
  - Uncertainty: $\sigma_{AB}^2 = \sigma_A^2 - 2cov_{AB} + \sigma_B^2$, where $\sigma_{A(B)}$ is the statistical uncertainty.
  - If we assume that data set A and B are fully correlated, we have: $cov_{AB} = \sigma_A^2$.
  - So , $\sigma_{AB}^2 = \sigma_B^2 - \sigma_A^2$, where data set B is fully contained in data set.

Study the BBC cuts with correlated uncertainty

- Use small west BBC cut as example:
  - List of small west BBC cut (max): 450, 500, 550, 600, 650
- Left plot show the A_N value with statistical uncertainty.
- Right plot show $\Delta A_N / \Delta \sigma_{AB}$, from every 2 neighboring BBC cut.





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 550 to 500
  - Small east BBC ADC sum cut: change 150 to 120
- Polarization uncertainty: 1.1 %

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 east	Small BBC west	Summary
0.1 – 0.15	4%	7%	1%	8%
0.15 – 0.2	17%	5%	20%	27%
0.2 – 0.25	6%	3%	8%	10%
0.25 – 0.3	113%	34%	15%	119%
0.3 – 0.45	56%	9%	24%	61%

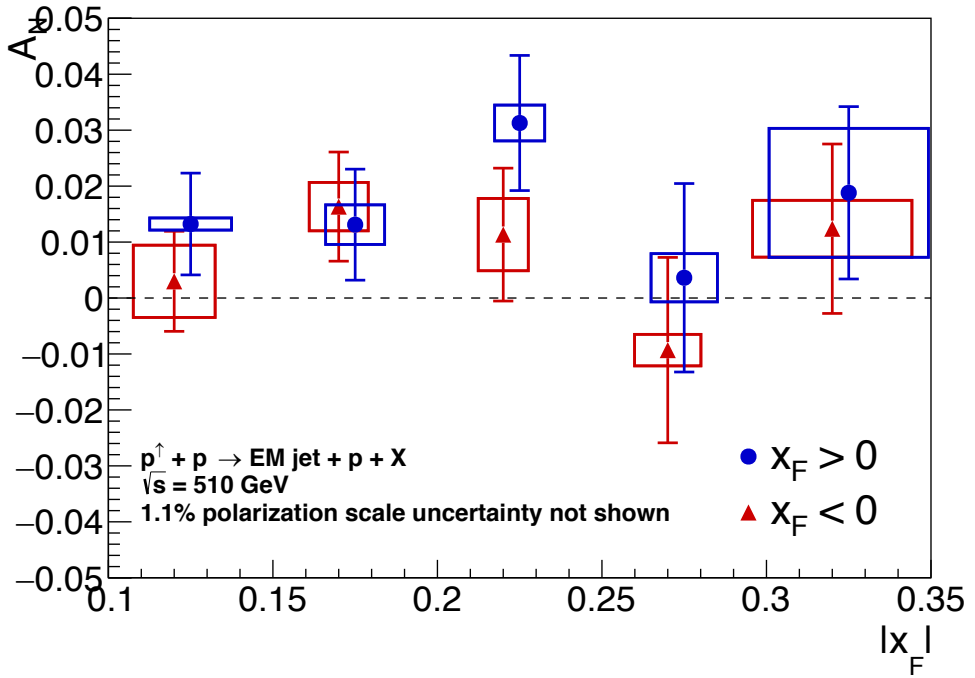
Yellow beam

x_F range	E_sum	Small BBC east	Small BBC west	Summary
0.1 – 0.15	117%	30%	179%	216%
0.15 – 0.2	14%	2%	22%	26%
0.2 – 0.25	16%	6%	54%	57%
0.25 – 0.3	22%	5%	21%	30%
0.3 – 0.45	28%	15%	26%	41%

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]

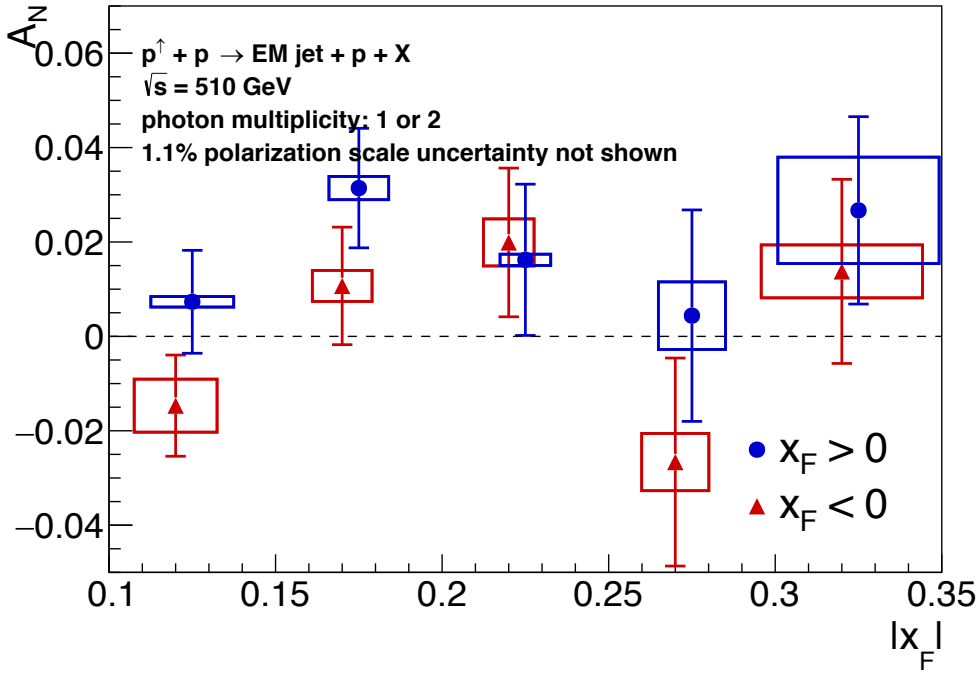
- The blue beam A_N is mostly positive, different from run 15 results.
- Constant fit for blue beam: 0.0161±0.0055 , **2.9σ** to be non-zero.
- Constant fit for yellow beam: 0.0082±0.0057 , **1.4σ** to be non-zero



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.
- 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 blue beam A_N is mostly positive, different from run 15 results.
- Constant fit for blue beam: 0.0170±0.0067 , **2.5σ** to be non-zero.
- Constant fit for yellow beam: -0.0009±0.0069 , **0.1σ** to be non-zero



Discussion: Run 15 simulation request

- I post the simulation request on Drupal: https://drupal.star.bnl.gov/STAR/starsimrequests/2023/May/31/Hard-diffraction-event-simulation
- Simulation information:
  - Type of simulation: hard diffraction events
  - Total number of hard diffraction events: 1.6 M
  - (Note: In Pythia 8.2.35, the hard diffraction events can be selected from hard QCD events. Therefore, the corresponding number of hard QCD events are 200 M.)
- Detector level simulation: FMS and RP
  - In my past experience, the simulation setup for FMS is Geant3, but the RP simulation setup (pp2pp) is Geant4. So I do them separately and match the same event by their event ID. We hope the production team have better idea for FMS and RP simulation.

Conclusion and outlook

- The Roman Pot track cuts are better considered and reasonable.
- The diffractive EM-jet A_N is observed to be non-zero with more than 2.9 σ, but the absolute value is smaller compared with that with run 15 results.
- Next to do: compare with inclusive EM-jet A_N results.

Back up

Elastic scattering events for previous RP cuts

- East (west) RP track energy vs east (west) small BBC sum
- Lots of elastic scattering events have the proton (RP) track energy less than beam energy. → The RP can't measure the track energy well for run 17, and the RP cuts are not so well.
- Therefore, better RP cuts or some other cuts are still needed.