Run 17 diffractive EM-jet A_N systematic uncertainty study

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Status of the systematic uncertainty

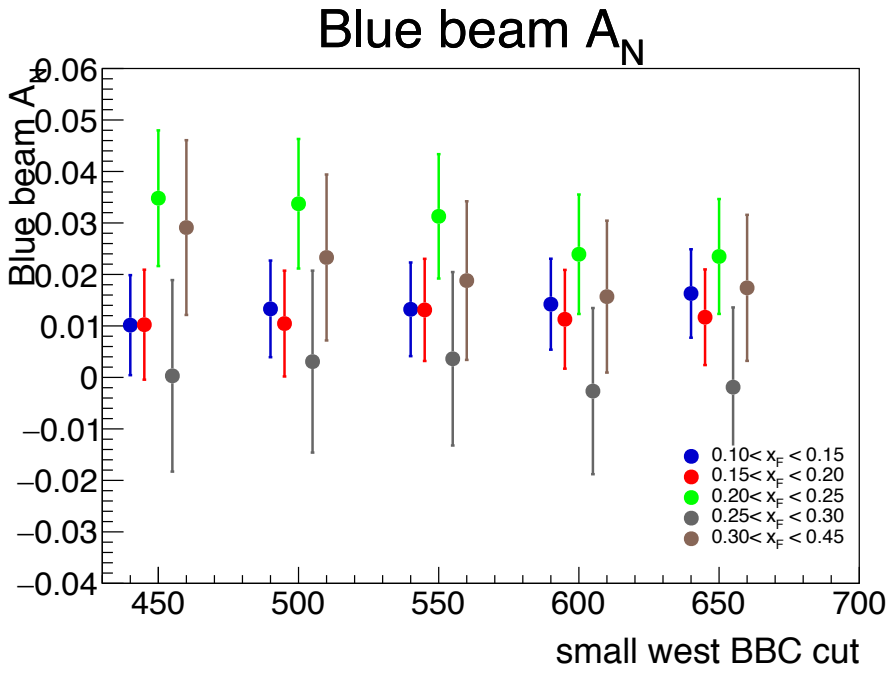
- The systematic uncertainty is still needed to better consider:
  1. They might be over-estimated for the systematic uncertainty.
  2. Applying the A_N difference over A_N as systematic uncertainty is not a good idea since the A_N could be small or negative which could result to a large and unreasonable systematic uncertainty value.
- Two methods are proposed for calculating the systematic uncertainty.
- Note: this slide only include the systematic uncertainty of small east/west BBC ADC sum cut. The sum energy cut is still investigating for a better cut, but we temporally use the old sum energy cut presented before.

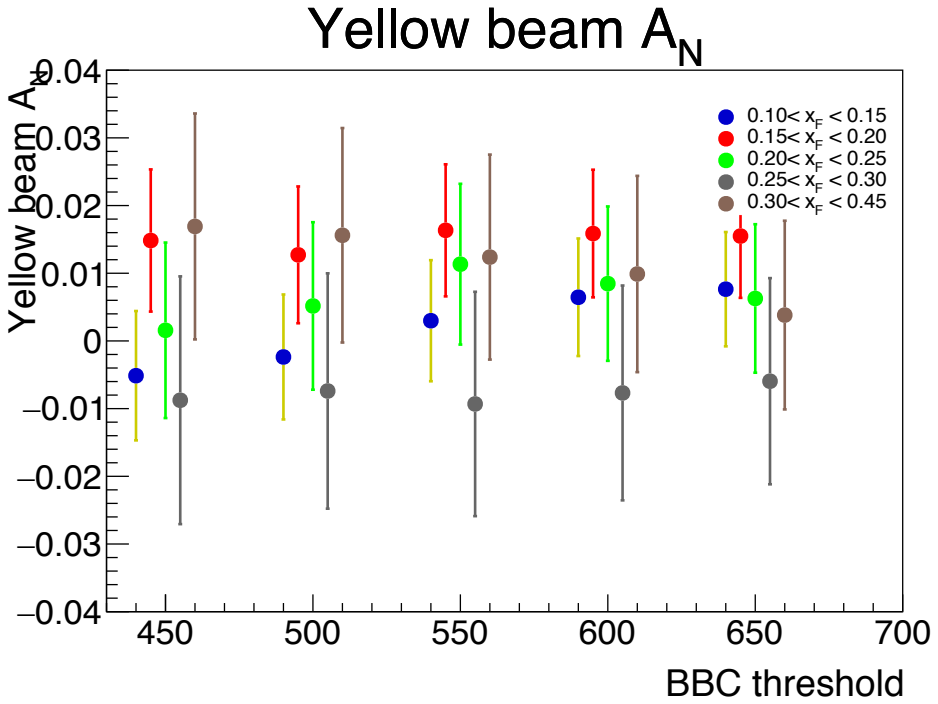
Method 1 (suggested by Oleg)

- Idea: estimate the systematic uncertainty by the average A_N difference from varying the cuts.
- List of cuts to study:
  - Small BBC west sum
    - Original cut value: 550
    - Systematic uncertainty cut values: 450, 500, 600, 650
  - Small BBC east sum
    - Original cut value: 150
    - Systematic uncertainty cut values: 90, 120, 180, 210

Study the BBC cuts for systematic uncertainty

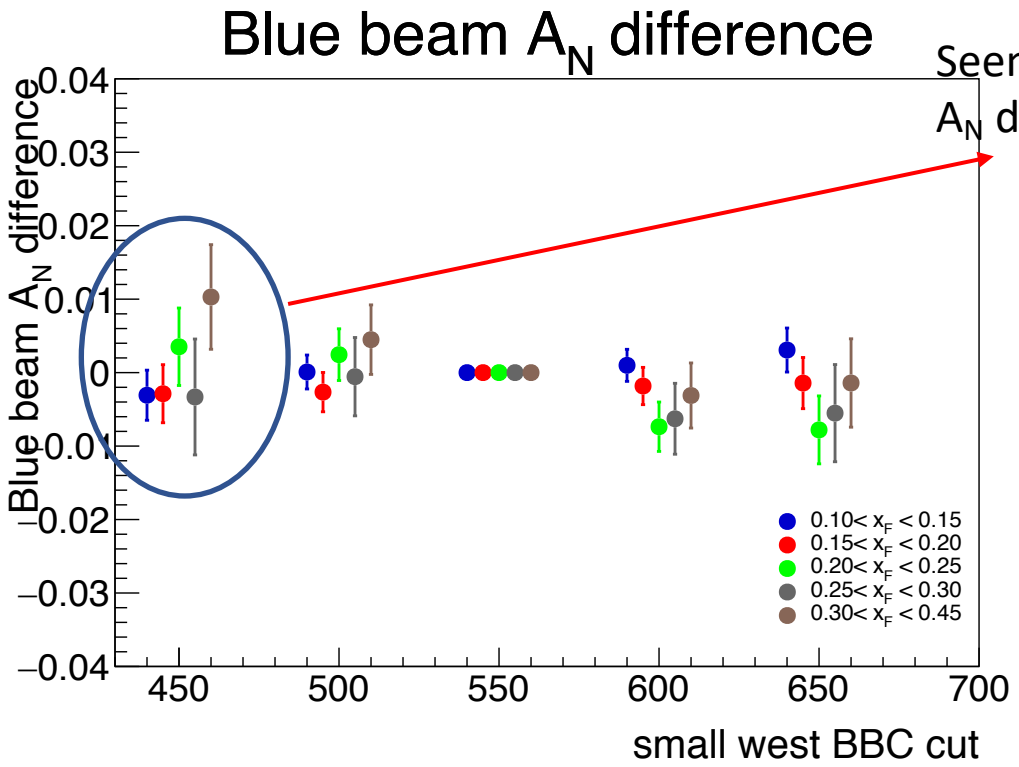
- Small west BBC cut as example:
  - List of small west BBC cut (max): 450, 500, 550, 600, 650
- Left plot show the A_N value for blue beam with statistical uncertainty.
- Right plot show the A_N value for yellow beam with statistical uncertainty.



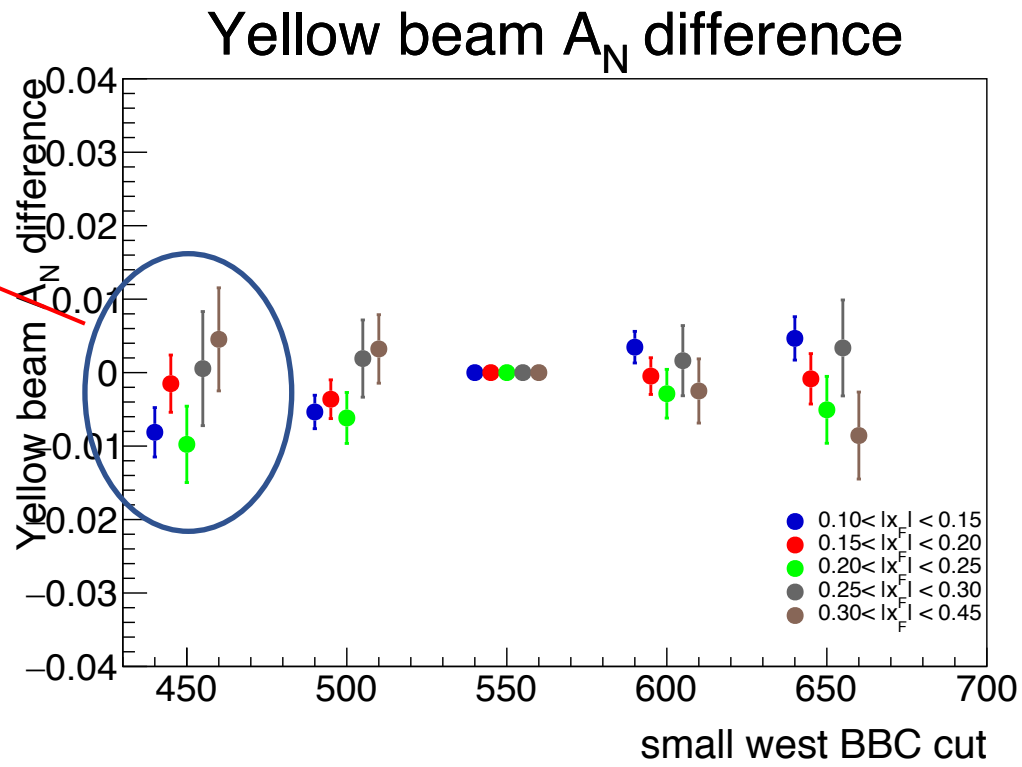


A_N difference for small west BBC ADC sum cut

- Original cut: 550
- Modified cuts for systematic uncertainty study: 450, 500, 600, 650
- A_N difference: A_N (modified) - A_N (original) ,plot A_N difference for different BBC cut
- Error bar: correlated uncertainty

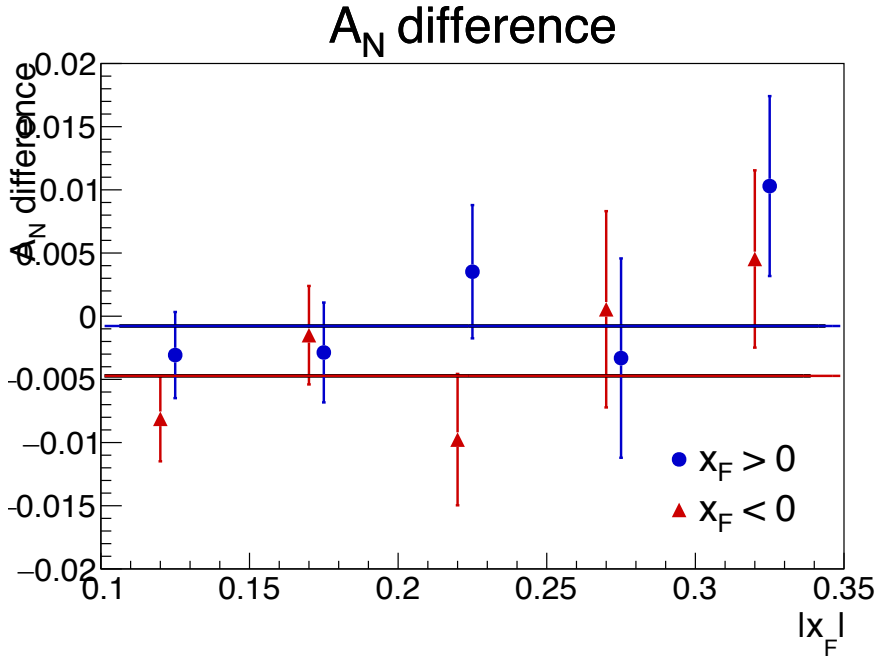


Seems to have largest A_N difference



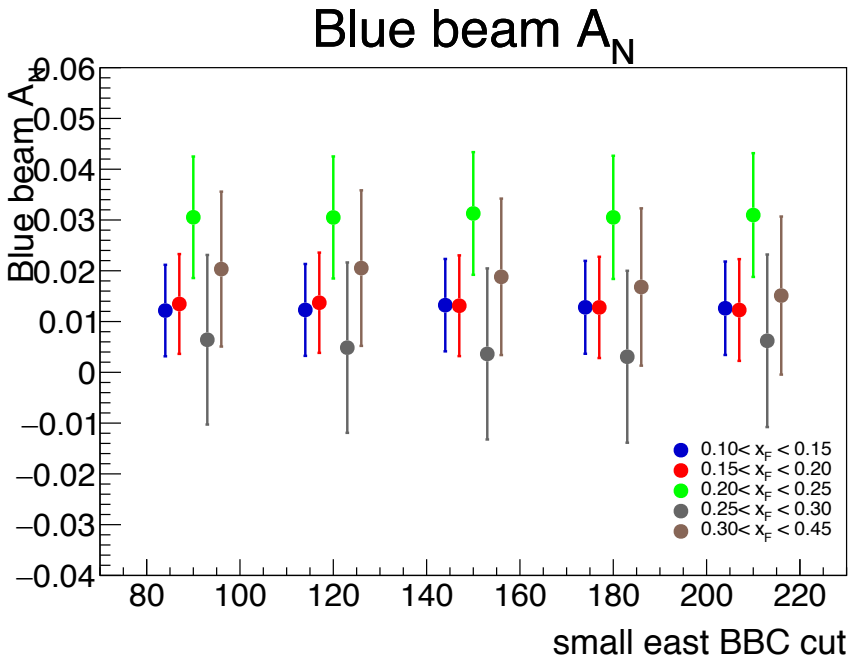
Estimate the systematic uncertainty from A_N difference

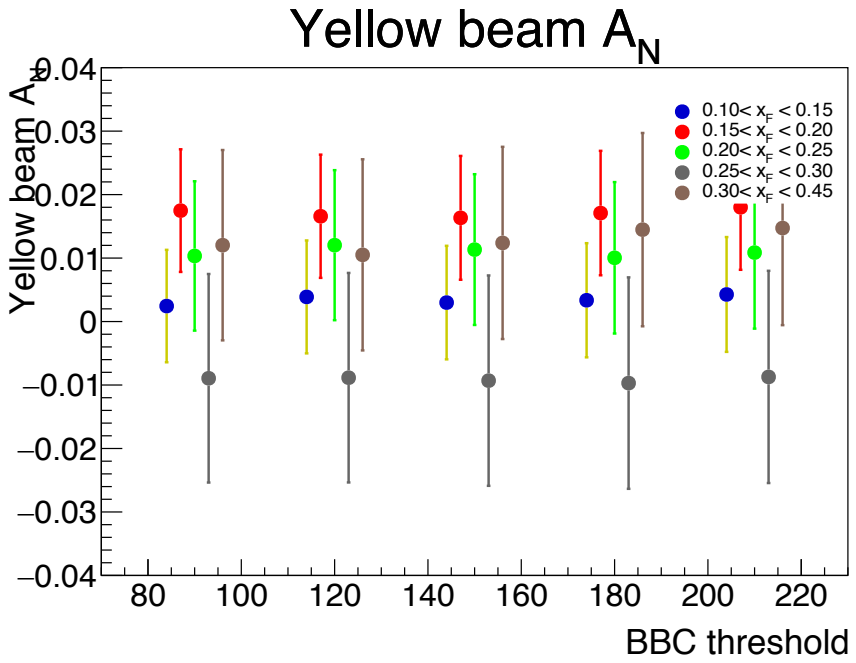
- Extract the A_N difference between small BBC west cut 550 and 450, since they seems to have largest A_N difference .
- Plot A_N difference as function of x_F. Blue points are for blue beam ($x_F > 0$); Red points are for yellow beam ($x_F < 0$)
- Use the constant fit to estimate their average A_N difference from all x_F bins for blue or yellow beam, so to assign it as systematic uncertainty for all x_F bins.
- Fit results:
  - Blue beam: -0.00077
  - Yellow beam: -0.0047
- Therefore, assign uniform syst:
  - Blue beam: 0.00077
  - Yellow beam: 0.0047



Study the BBC cuts for systematic uncertainty

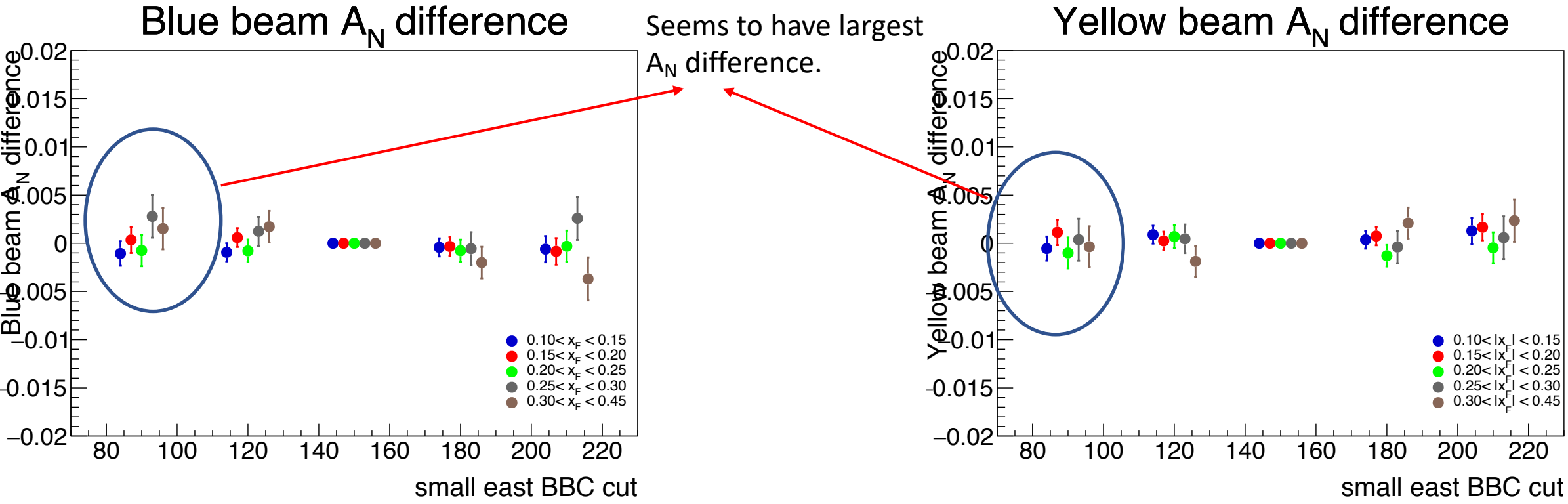
- Small east BBC cut:
  - List of small west BBC cut (min): 90, 120, 150, 180, 210
- Left plot show the A_N value for blue beam with statistical uncertainty.
- Right plot show the A_N value for yellow beam with statistical uncertainty.





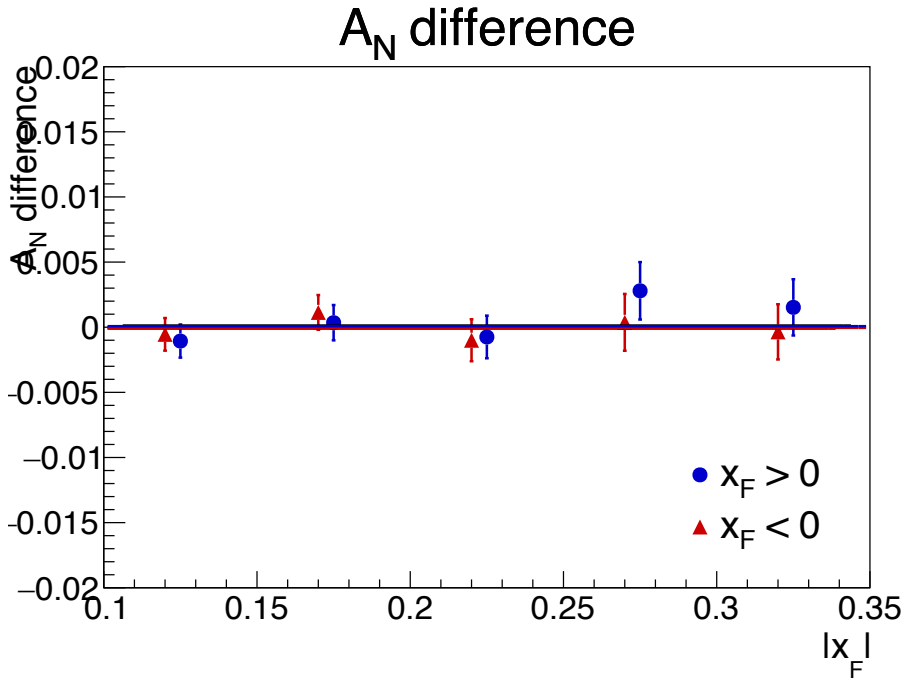
Small east BBC ADC sum cut

- Original cut: 150
- Modified cut for systematic uncertainty study: 90, 120, 180, 210
- A_N difference: A_N (modified) - A_N (original) ,plot A_N difference for different BBC cut
- Error bar: correlated uncertainty



Estimate the systematic uncertainty from A_N difference

- Extract the A_N difference between small BBC east cut 150 and 90.
- Plot A_N difference as function of x_F. Blue points are for blue beam ($x_F > 0$); Red points are for yellow beam ($x_F < 0$)
- Use the constant fit to estimate their average A_N difference from all x_F bins for blue or yellow beam, so to assign it as systematic uncertainty for all x_F bins.
- Fit results:
  - Blue beam: 0.000078
  - Yellow beam: -0.000047
- Therefore, assign syst:
  - Blue beam: 0.000078
  - Yellow beam: 0.000047



Method 2 (suggested by Carl)

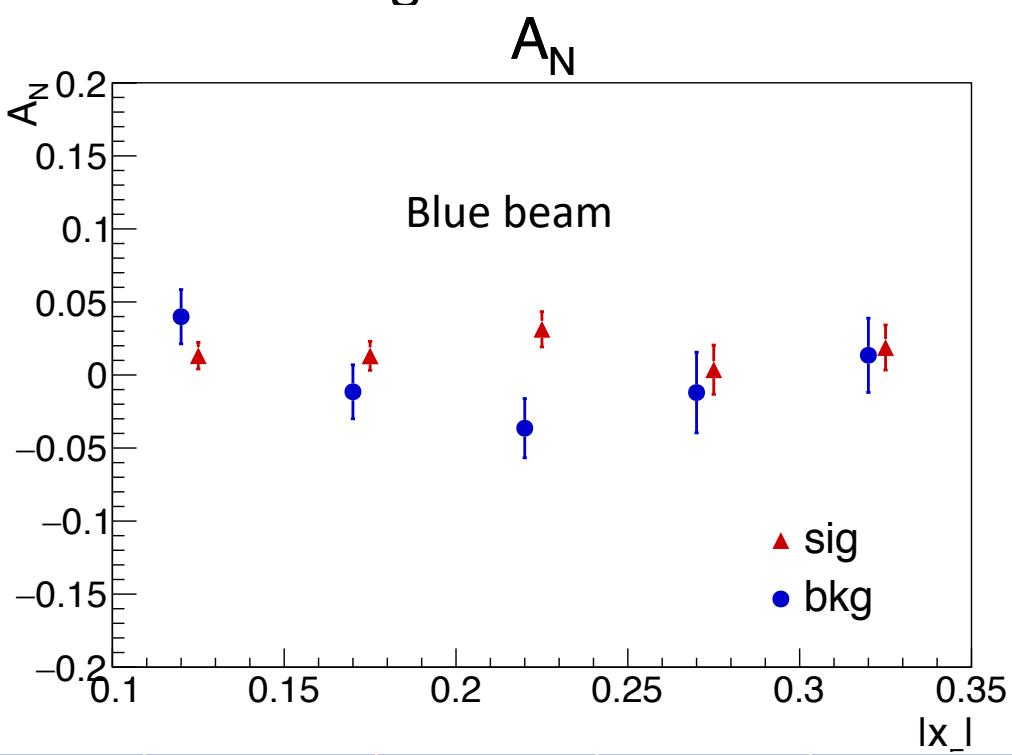
- For a certainty cut, choose an entirely different region from signal for the background. Calculate their A_N difference and statistical uncertainty.
- Small BBC west sum (sBBCW):
  - Signal region: sBBCW < 550
  - Background : 550 < sBBCW < 750
- Small BBC east sum (sBBCE):
  - Signal region: sBBCE > 150
  - Background : 50 < sBBCE < 150
- Use the formula below to calculate the systematic uncertainty:

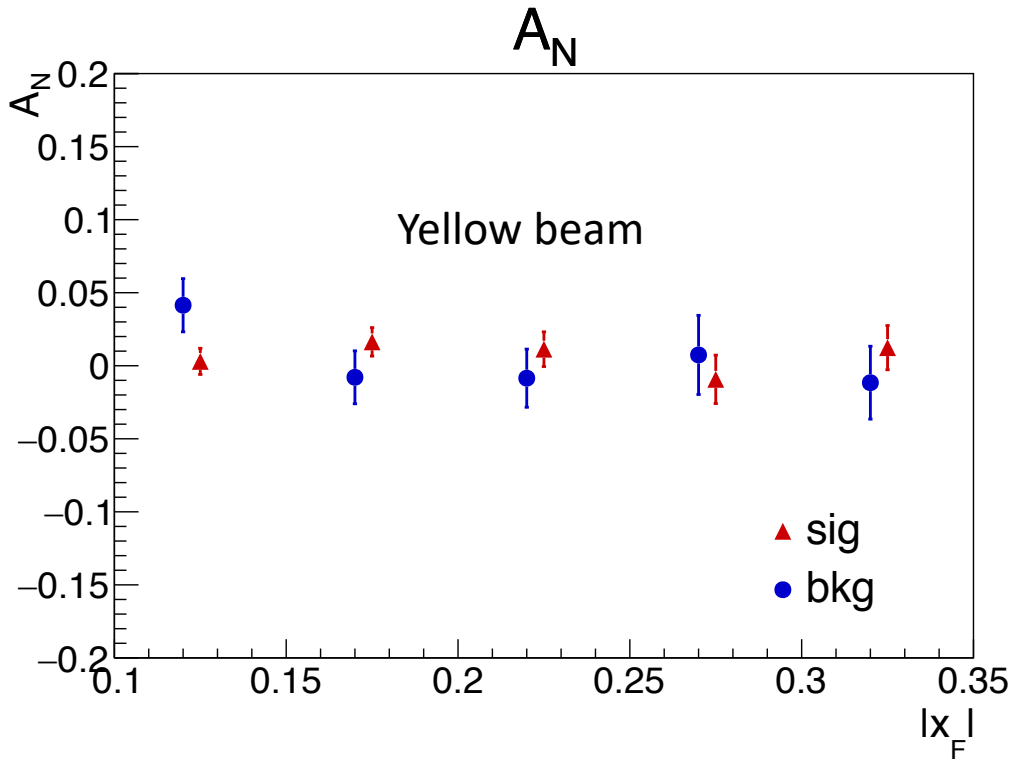
$$Syst = \max\{(|A_N(sig) - A_N(bkg)| - \sqrt{\sigma_{sig}^2 + \sigma_{bkg}^2}), 0\}$$

Systematic uncertainty results for method 2

- Small BBC west ADC:
  - Signal region: sBBCW < 550
  - Background : 550 < sBBCW < 750

$$Syst = \max\{(|A_N(sig) - A_N(bkg)| - \sqrt{\sigma_{sig}^2 + \sigma_{bkg}^2}), 0\}$$





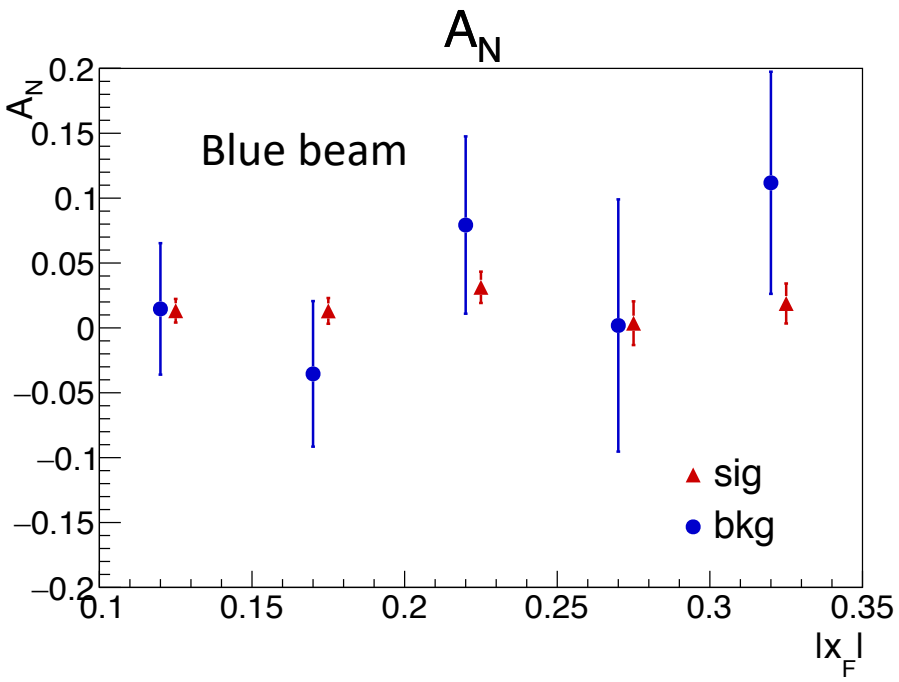
Blue x_F	0.1 – 0.15	0.15 – 0.2	0.2 – 0.25	0.25 – 0.3	0.3 – 0.45
Syst	0.0061	0.0037	0.044	0	0

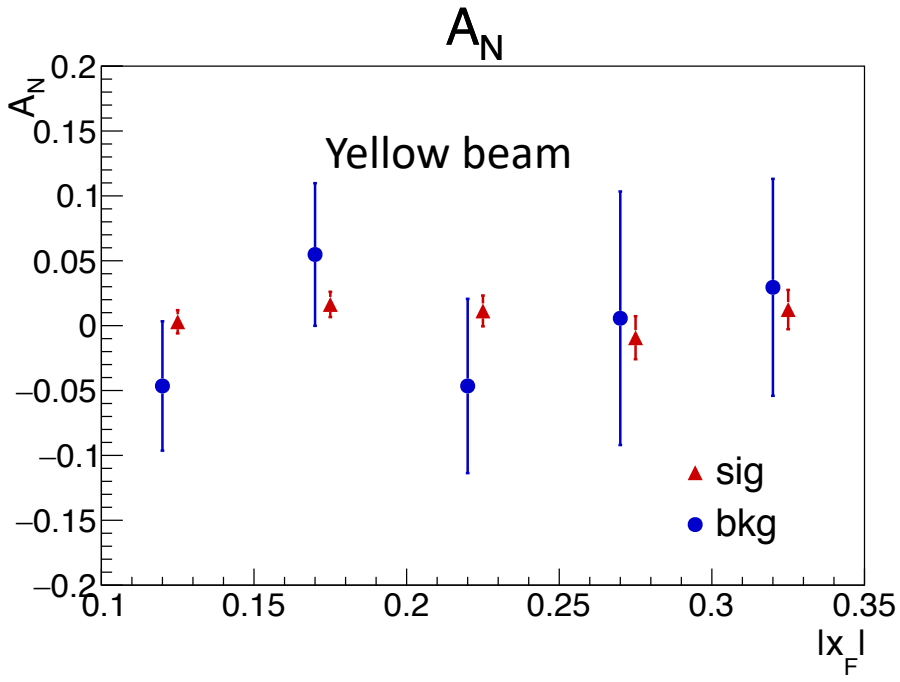
Yellow x_F	0.1 – 0.15	0.15 – 0.2	0.2 – 0.25	0.25 – 0.3	0.3 – 0.45
Syst	0.018	0.0037	0	0	0

Systematic uncertainty results for method 2

- Small BBC <u>east</u> ADC:
  - Signal region: sBBCE > 150
  - Background : 50 < sBBCE < 150

$$Syst = \max\{(|A_N(sig) - A_N(bkg)| - \sqrt{\sigma_{sig}^2 + \sigma_{bkg}^2}), 0\}$$





Blue x_F	0.1 – 0.15	0.15 – 0.2	0.2 – 0.25	0.25 – 0.3	0.3 – 0.45
Syst	0	0	0	0	0.0061

Yellow x_F	0.1 – 0.15	0.15 – 0.2	0.2 – 0.25	0.25 – 0.3	0.3 – 0.45
Syst	0	0	0	0	0

Systematic uncertainty results

- Small BBC ADC sum west systematic uncertainty calculation using the two methods.
- Blue beam

x_F range	A_N for signal	Statistical uncertainty	Syst assign with method 1	Syst with method 2
0.1 – 0.15	0.0132279	0.0091	0.00077	0.0061
0.15 – 0.2	0.0131127	0.0099	0.00077	0.00367
0.2 – 0.25	0.0312837	0.012	0.00077	0.044
0.25 – 0.3	0.00362015	0.017	0.00077	0
0.3 – 0.45	0.0188068	0.015	0.00077	0

Systematic uncertainty results

- Small BBC ADC sum west systematic uncertainty calculation using the two methods.
- Yellow beam

x_F range	A_N for signal	Statistical uncertainty	Syst assign with method 1	Syst with method 2
0.1 – 0.15	0.0030	0.0089	0.0047	0.018
0.15 – 0.2	0.016	0.0098	0.0047	0.0037
0.2 – 0.25	0.01	0.012	0.0047	0
0.25 – 0.3	-0.0093	0.017	0.0047	0
0.3 – 0.45	0.012	0.015	0.0047	0

Systematic uncertainty results

- Small BBC ADC sum east systematic uncertainty calculation using the two methods.
- Blue beam

x_F range	A_N for signal	Statistical uncertainty	Syst assign with method 1	Syst with method 2
0.1 – 0.15	0.0132279	0.0091	0.000078	0
0.15 – 0.2	0.0131127	0.0099	0.000078	0
0.2 – 0.25	0.0312837	0.012	0.000078	0
0.25 – 0.3	0.00362015	0.017	0.000078	0
0.3 – 0.45	0.0188068	0.015	0.000078	0.0061

Systematic uncertainty results

- Small BBC ADC sum east systematic uncertainty calculation using the two methods.
- Yellow beam

x_F range	A_N for signal	Statistical uncertainty	Syst assign with method 1	Syst with method 2
0.1 – 0.15	0.0030	0.0089	0.000047	0
0.15 – 0.2	0.016	0.0098	0.000047	0
0.2 – 0.25	0.01	0.012	0.000047	0
0.25 – 0.3	-0.0093	0.017	0.000047	0
0.3 – 0.45	0.012	0.015	0.000047	0

Conclusion

- Two methods are applied for calculating the systematic uncertainty.
- The systematic uncertainty is much smaller than the statistical uncertainty.

Back up

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

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

- **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 (TBD)
- **BBC ADC sum cuts:**
  - small BBC west ADC < 550 and small BBC east ADC > 150

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