Diffractive EM Jet A_N analysis with run 15 FMS

Xilin Liang

Mar. 23, 2022

Data sets and event selection

- Data sets: Run 15 transverse p + p collision (production_pp200trans_2015) , $\sqrt{s} = 200\ GeV$, st_fms stream
- Event selection:
- **FMS**
  - 8 Triggers (avoid ring of fire) , veto on FMS-LED
  - bit shift, bad / dead / hot channel masking (include fill by fill hot channel masking) , FMS tower energy > 2 GeV
  - Jet reconstruction: StJetMaker2015 , Anti-kT, R<0.7 , p_T > 1 GeV/c, FMS point as input
- **Vertex** (Determine vertex z priority according to TPC , VPD, BBC.)
  - Vertex $|z| < 80\ cm$
- **Roman Pot and Diffractive process**
  - Acceptable cases:

1. Only 1 east RP track + no west RP track
2. Only 1 west RP track + no east RP track
3. Only 1 east RP track + only 1 west RP track

  - RP track must be good track:

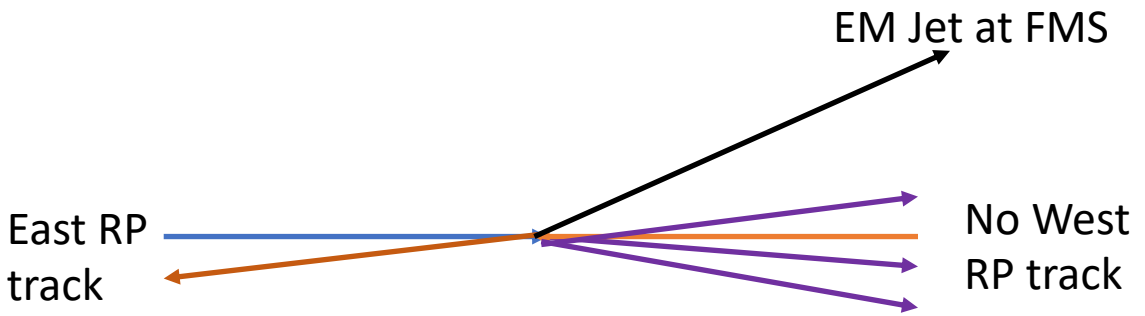
a) Each track hits > 6 planes

b) $-2 < \theta_X < 2\ \mathrm{mrad}$, $1.5 < |\theta_y| < 4.5\ \mathrm{mrad}$

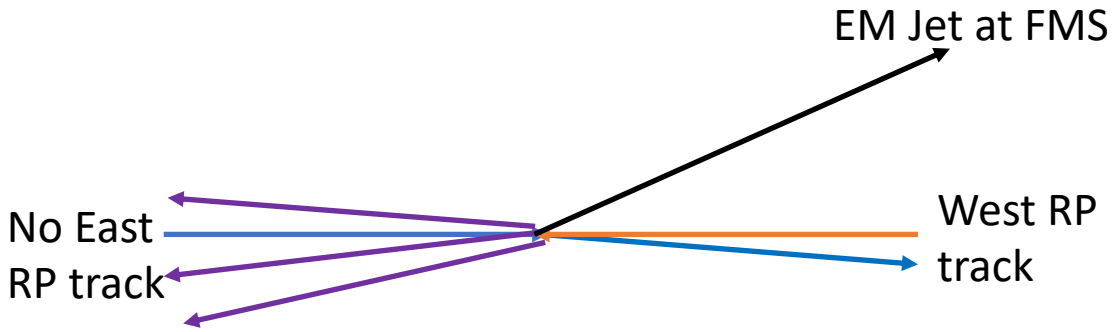
  - For case 2 & case 3: Sum of west RP track energy and all EM Jet energy < 108 GeV
- **BBC ADC sum cuts** (for case 2 & case 3):
  - West Large BBC ADC sum < 60
  - West Small BBC ADC sum < 100

Diffractive process

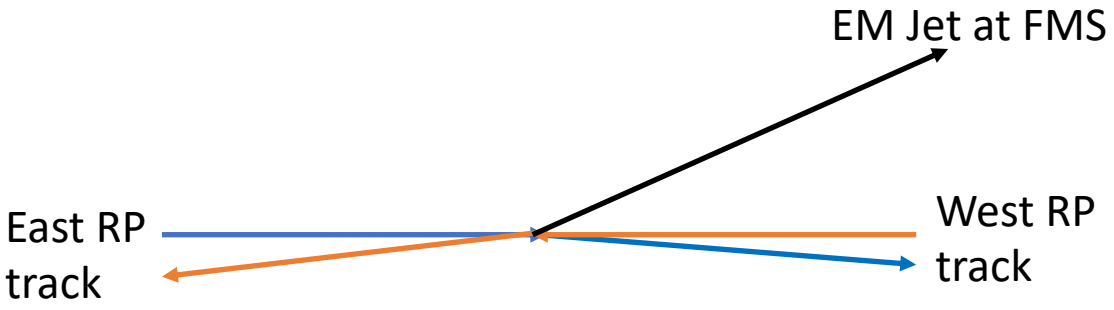
Case 1:
Single diffractive event: we can detect only 1 proton track on east side RP.
Require: only 1 east side RP track



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

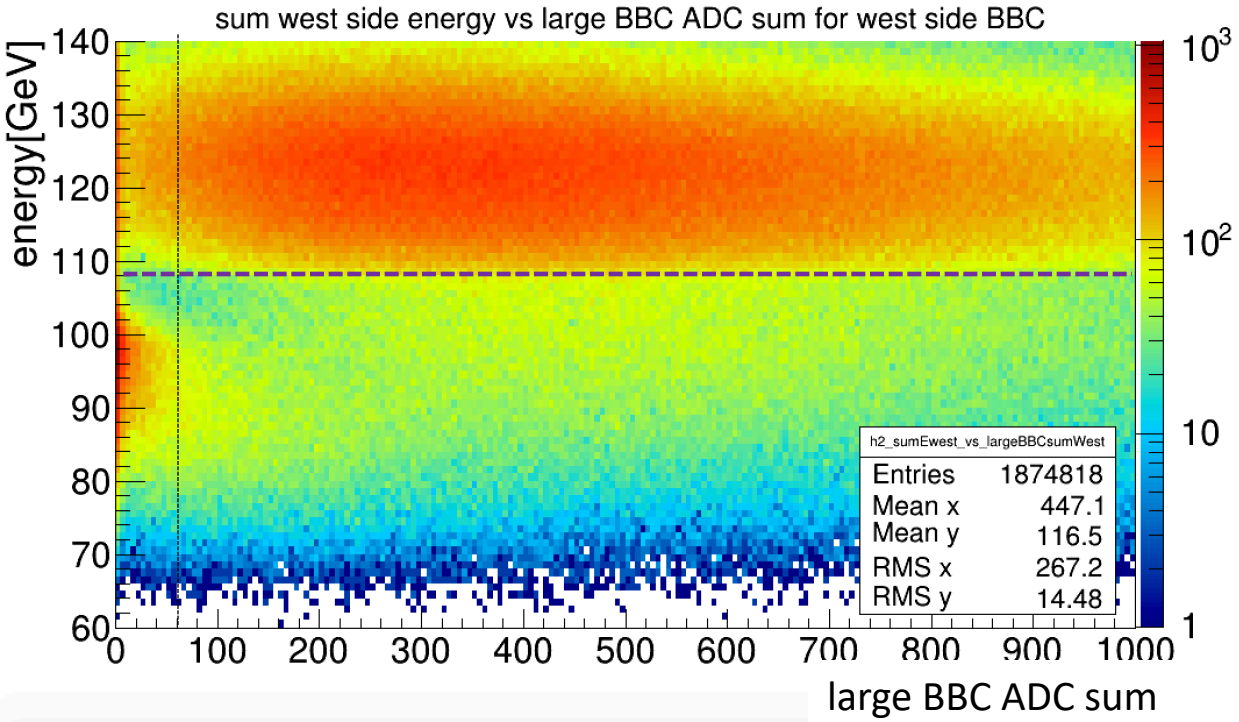


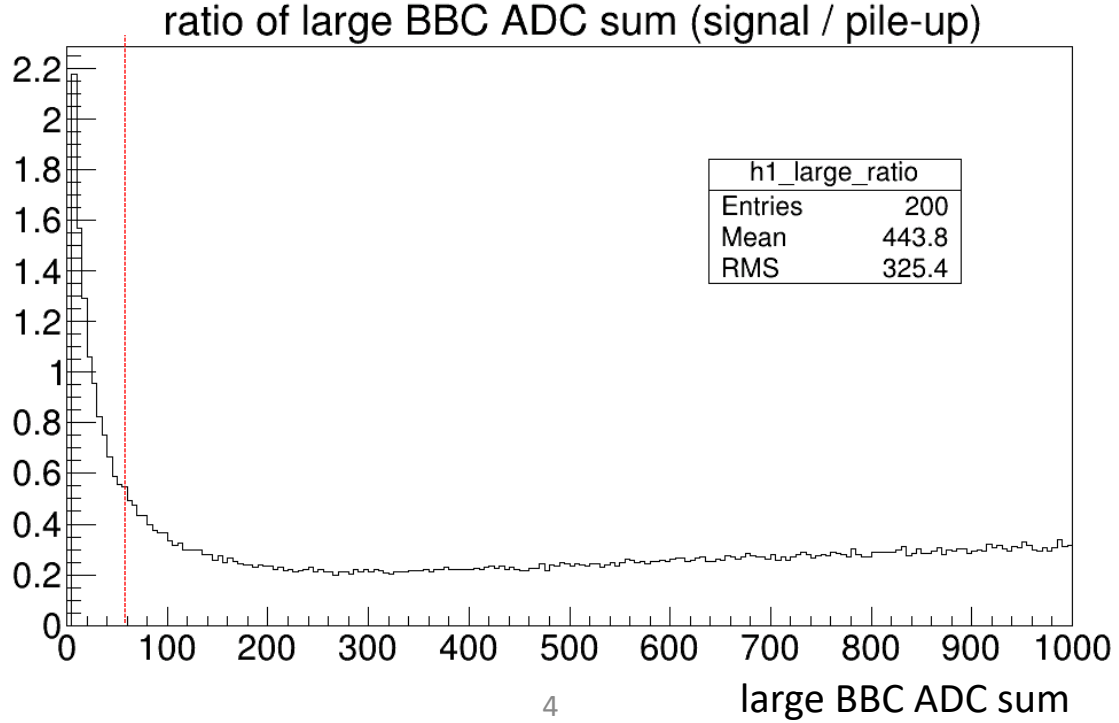
Case 3:
Double diffractive event: we can detect 1 proton track on east side RP and 1 proton track on west side RP.
Require: sum of west side tracks energy (proton + EM Jet) less than beam energy



Sum of west side RP + EM Jet energy vs west large BBC ADC sum

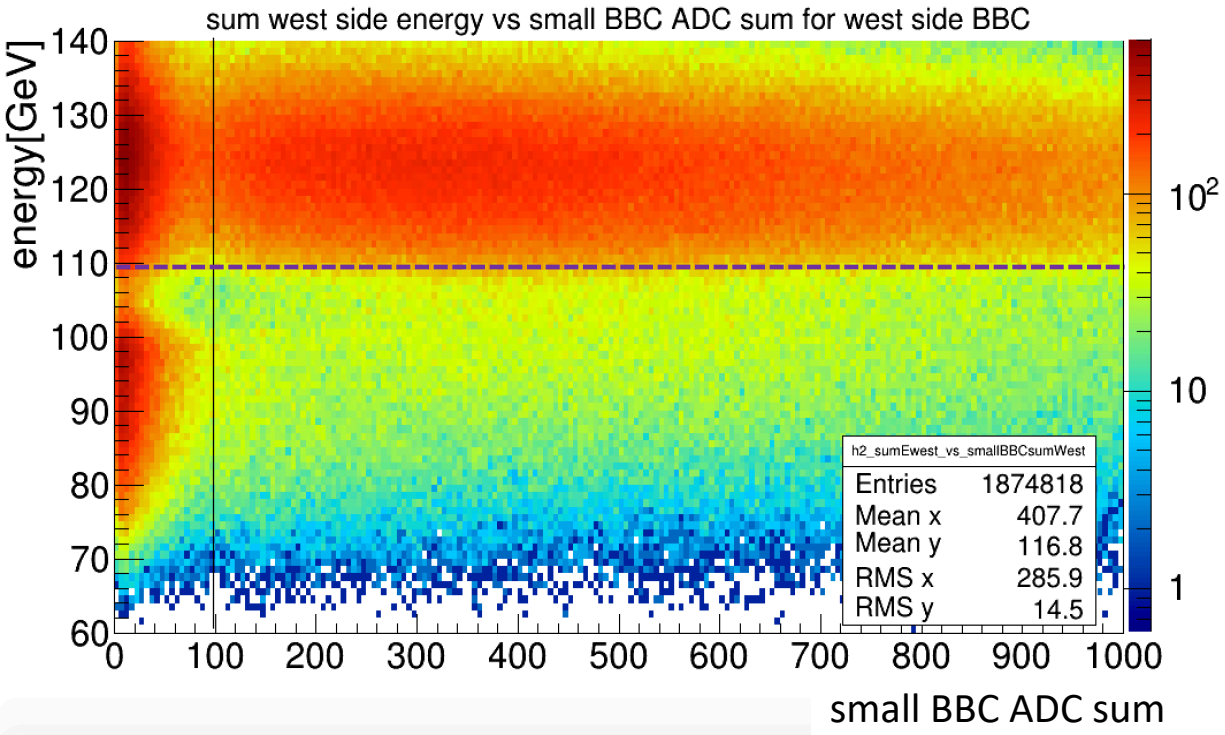
- Only the events with 1 west side RP track (case 2 & 3)
- Signal: sum energy < 108 GeV; pile-up: sum energy > 108 GeV
- We can consider cut on west BBC from the plots below:
  - West Large BBC ADC sum < 60

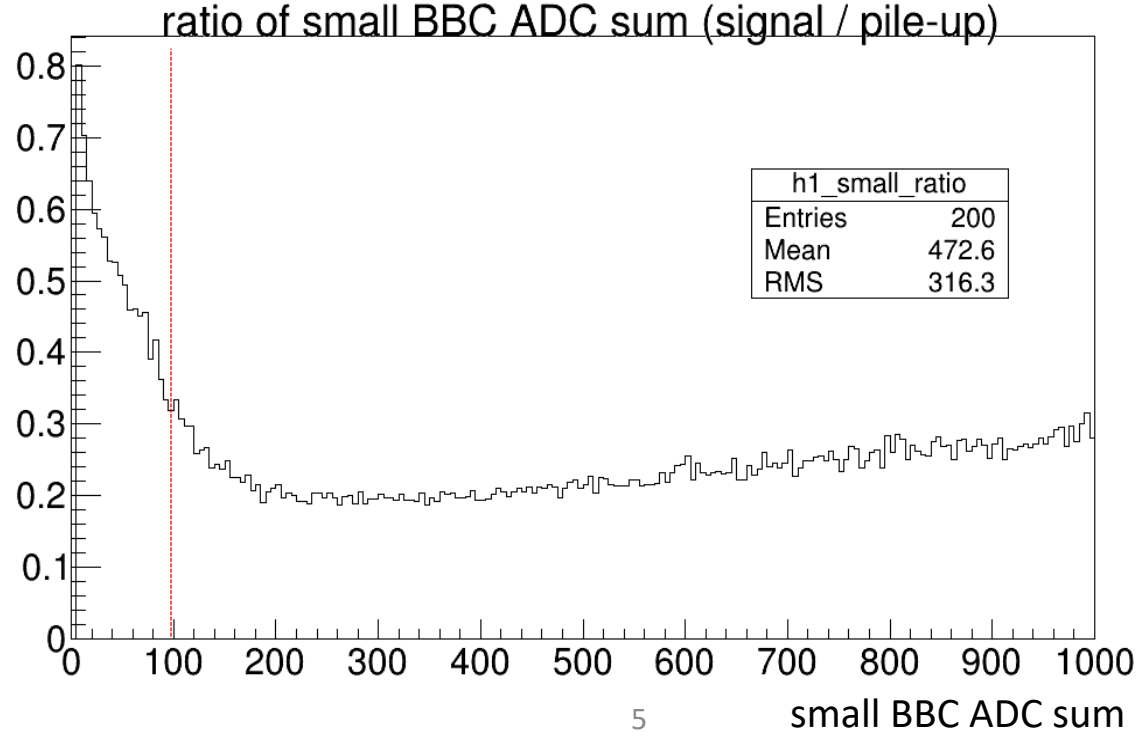




Sum of west side RP + EM Jet energy vs west small BBC ADC sum

- Only the events with 1 west side RP track (case 2 & 3)
- Signal: sum energy < 108 GeV; pile-up: sum energy > 108 GeV
- We can consider cut on west BBC from the plots below:
  - West Small BBC ADC sum < 100

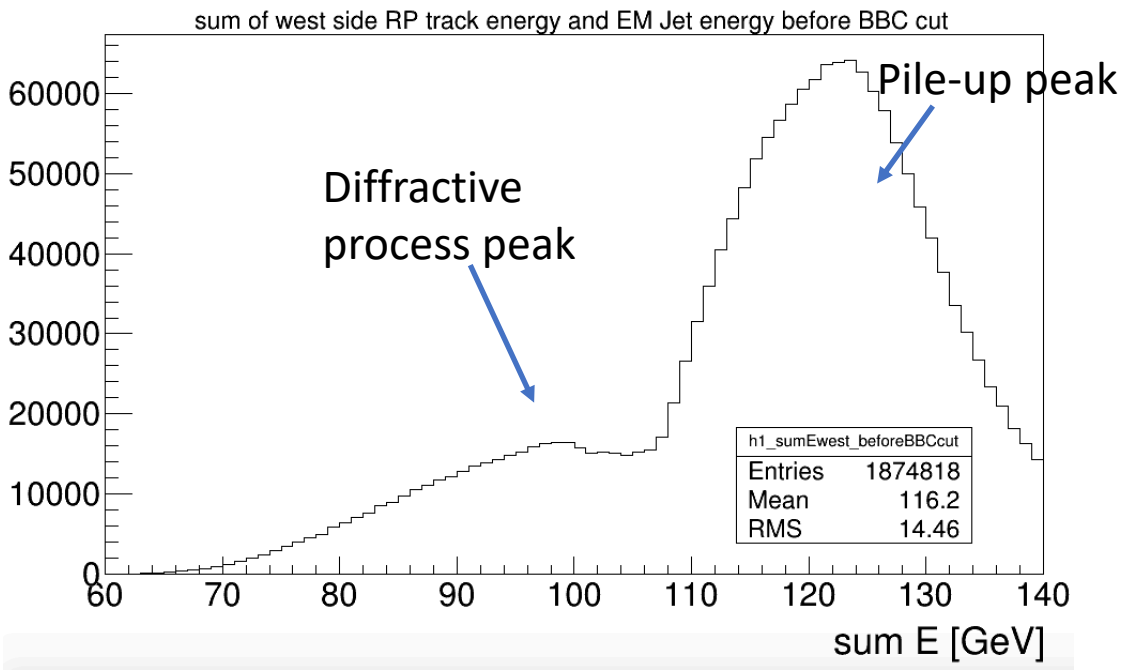




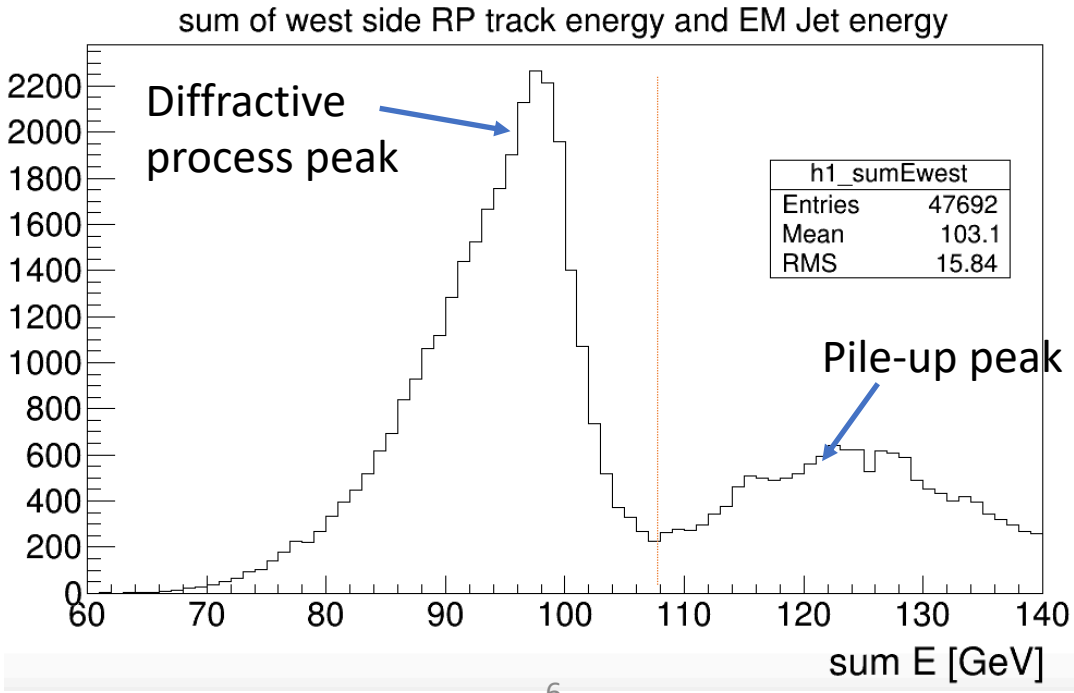
Sum of west RP track E and EM jet E

- Before (left plot) and after (right plot) cut on west small/large BBC ADC sum. We can see the pile-up peak is suppressed.
- We can consider to accept the event with sum E < 108 GeV

Before BBC ADC sum cut

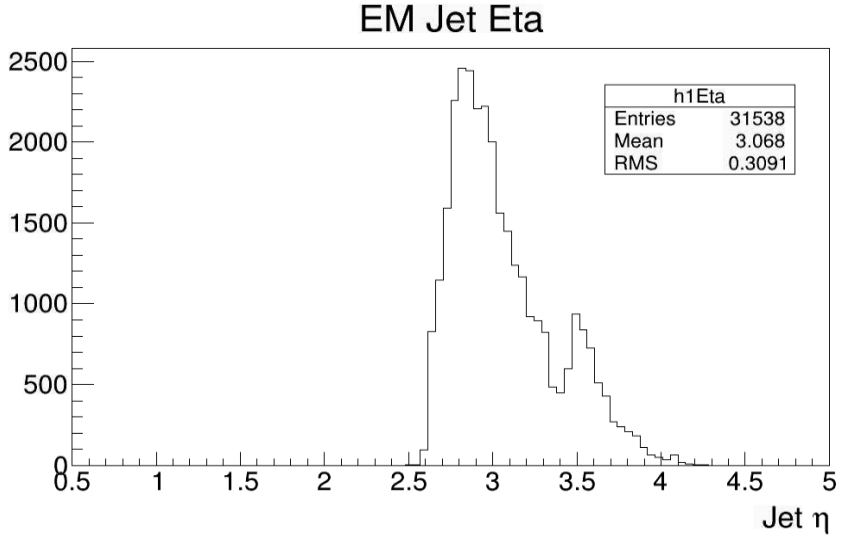


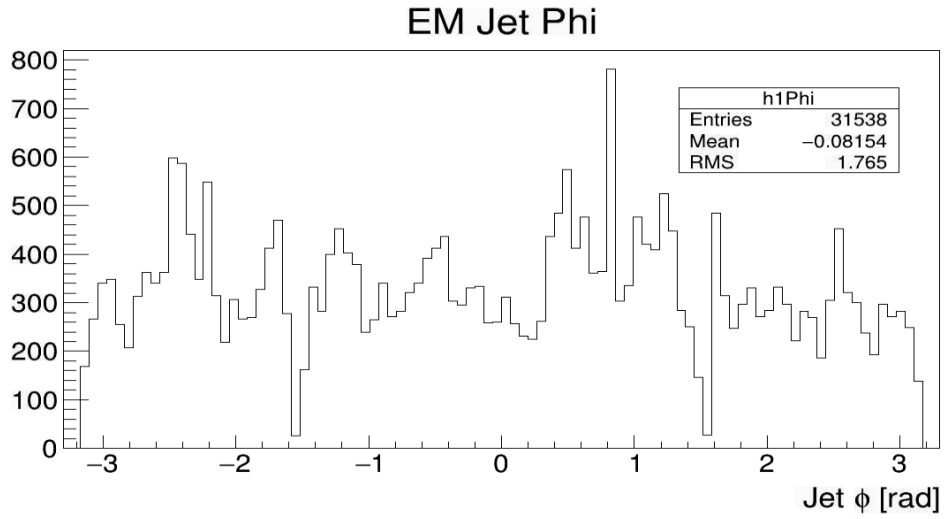
After BBC ADC sum cut

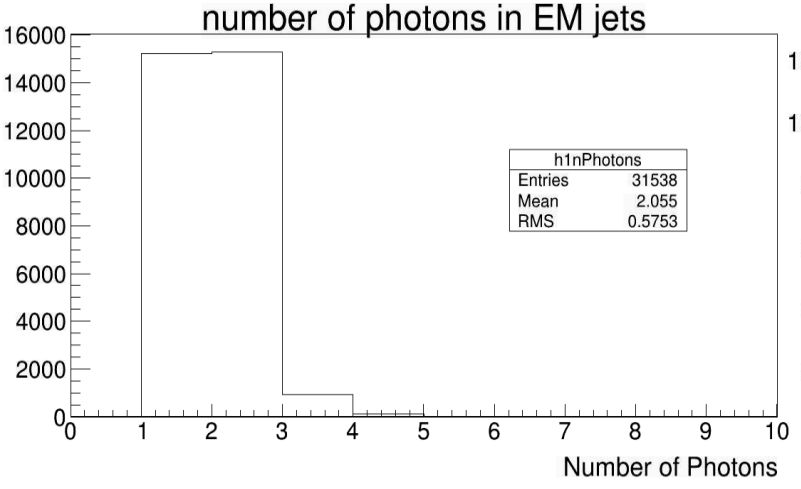


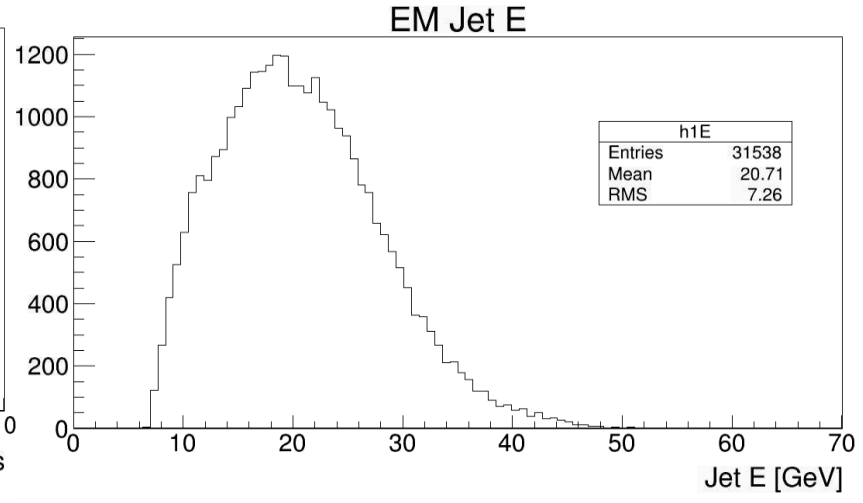
QA for EM Jet in FMS (case 2 & 3)

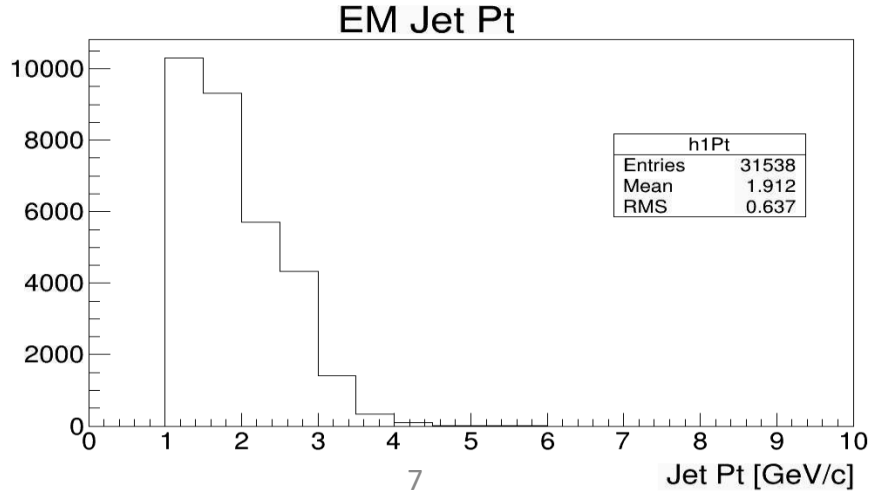
- EM jets are all the events with all cuts for case 2 and case 3.





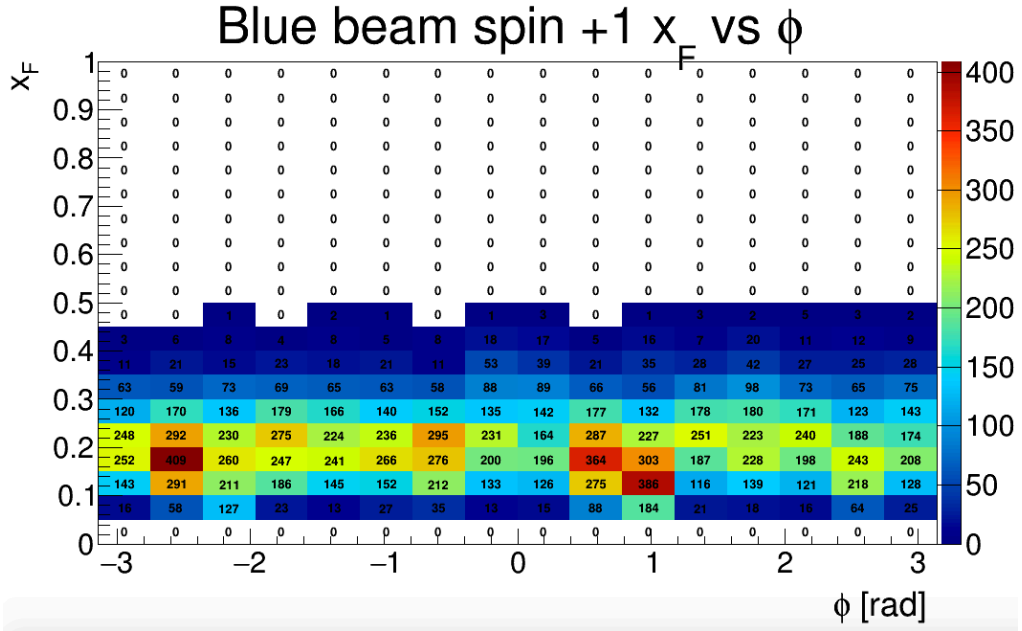




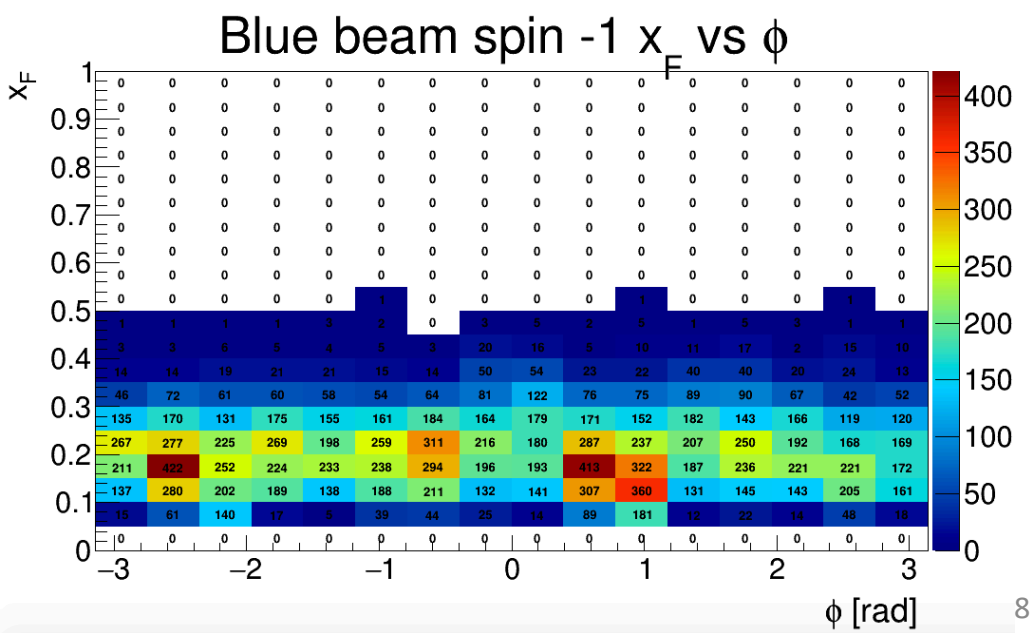


Transverse single spin asymmetry (A_N) calculation

- 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. ($x_F = \frac{E_{EM\ jet}}{E_{Beam}}$) , 4 bins in range $x_F \in [0.1, 0.3]$
  - Divide full ϕ range [-π , +π] into 16 bins.
- Separate the events with 1 west side RP track (case 2 & 3) , and only 1 east side RP track (case 1)



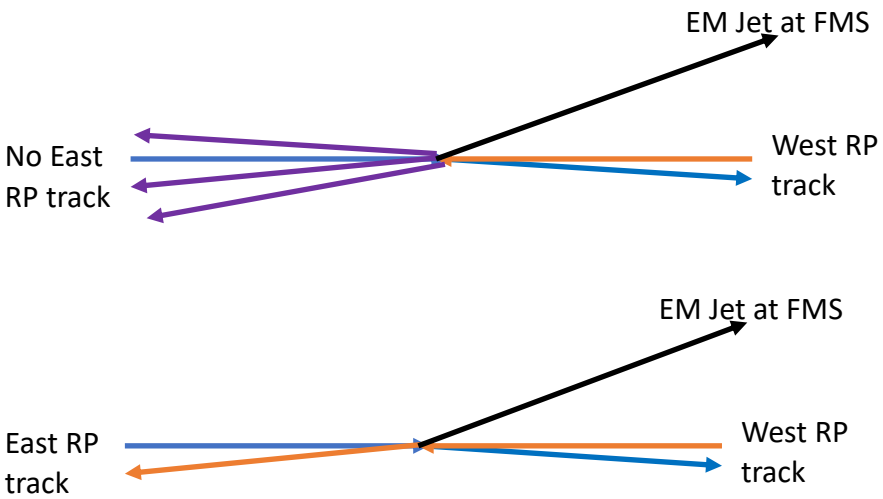
Example EM jet yield for case 2 & 3

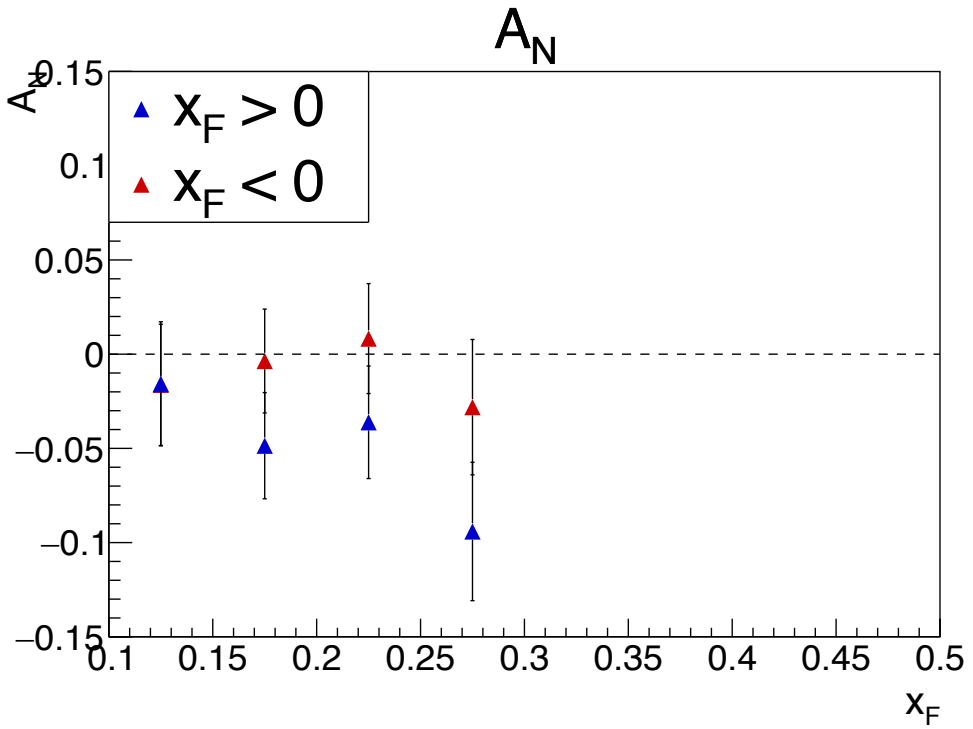


A_N for case 2 & 3

A_N for events with 1 west side RP track. We can see the reasonable diffractive event with west side proton track intact have relatively large asymmetry.

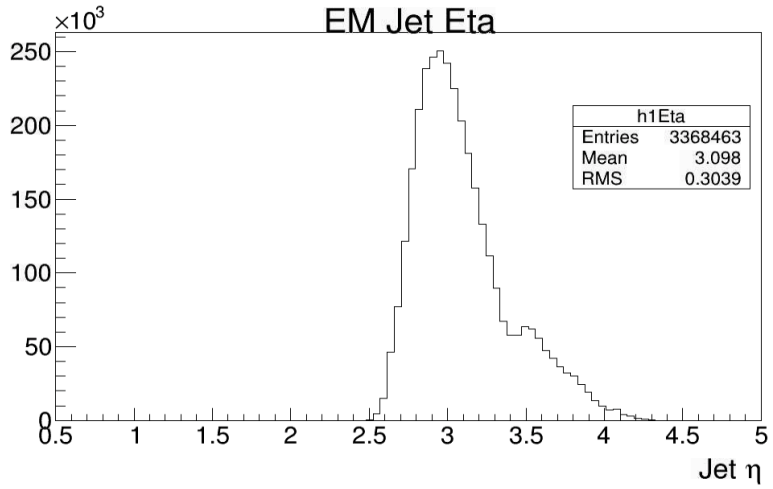
However, the sign for blue beam A_N for case 2 & 3 is negative, which is different from inclusive EM jet A_N.

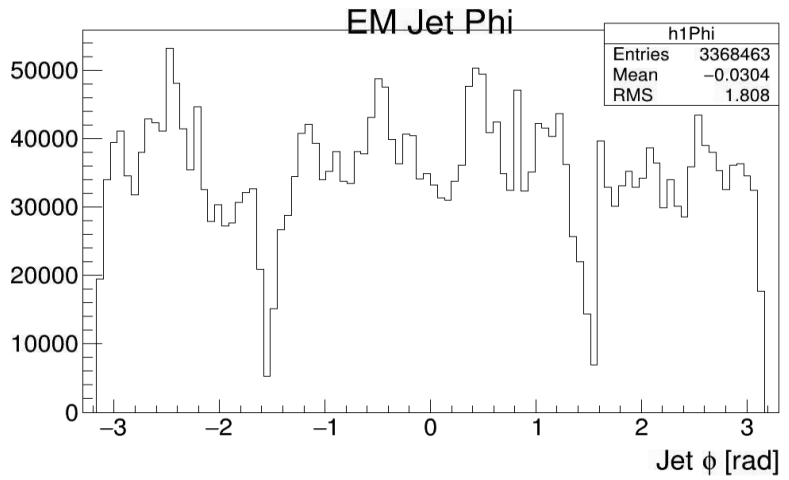


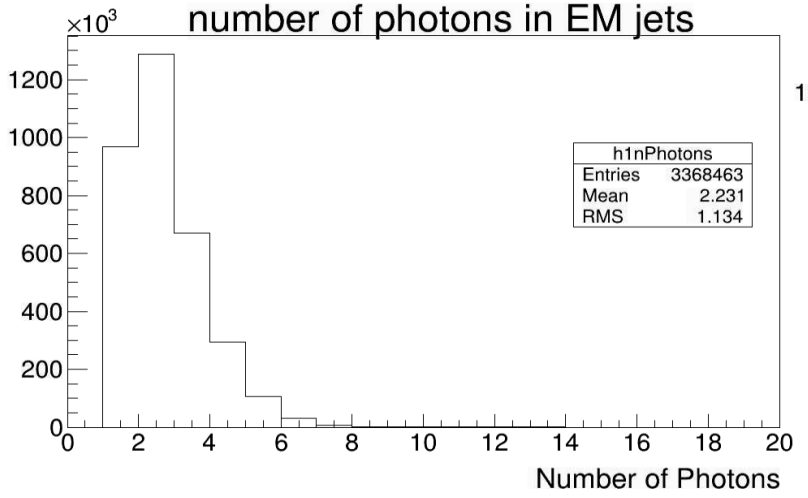


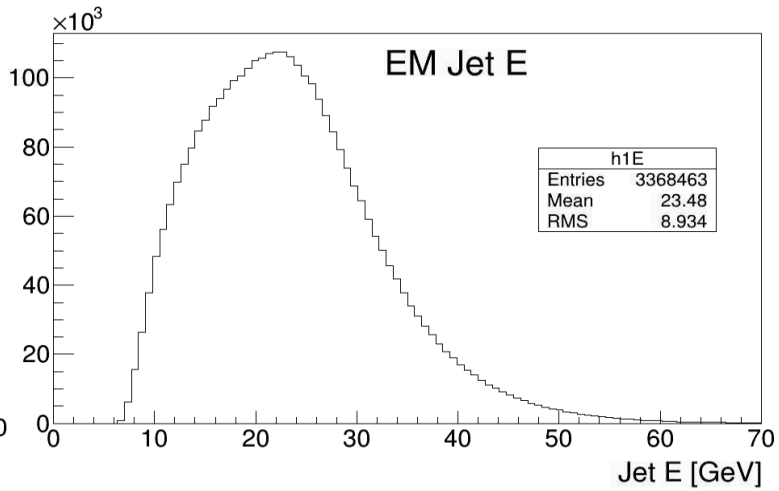
QA for EM Jet in FMS (case 1)

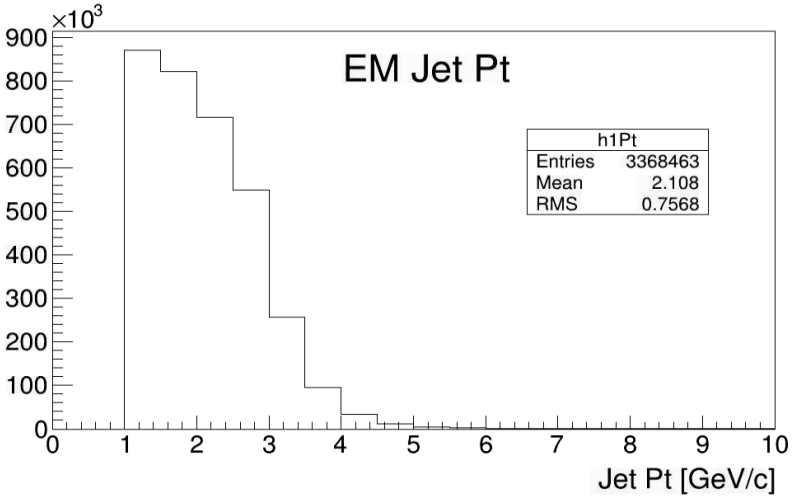
- EM jets are all the events with all cuts for case 1. (No sum of west side track energy cut and no BBC ADC sum cut.)





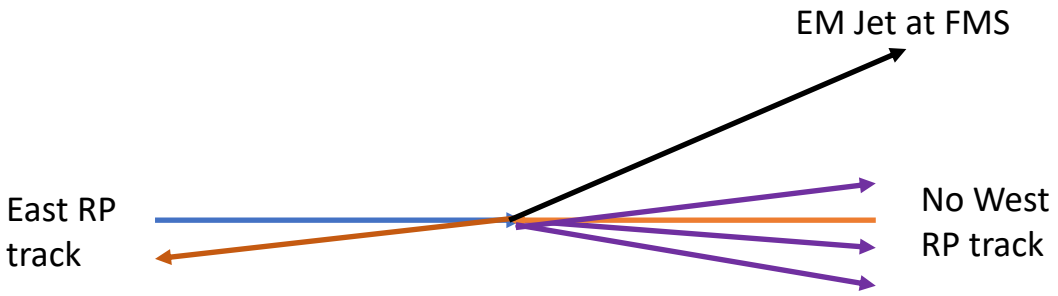


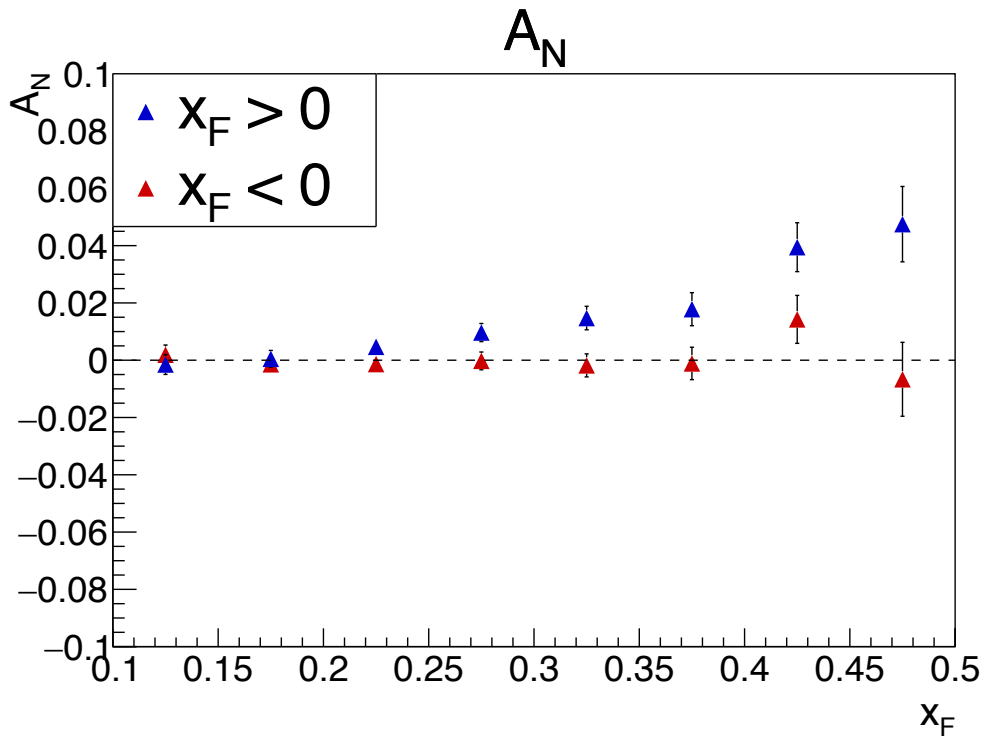




A_N for case 1

- A_N for events with only 1 east side RP track and no west side RP track (case 1 only). This types of cases of events do not have the BBC ADC sum cut.
- Still using the cross ratio method to calculate the A_N.





Plans for systematic uncertainty

- Background uncertainty
  - Pile up or accidental coincidence events
  - Ring of fire
  - Underlying events correction
- Polarization uncertainty
- FMS EM jets energy uncertainty
- Roman Pot track energy uncertainty

Conclusion and outlook

- Applying the west side BBC ADC sum cut will give us significant proportion of diffractive events than the pile up events, but this cut will lose huge amount of statistics (~90%) for case 2 & 3!
- Looking at only 1 west side RP track event (case 2&3), we can see larger A_N for those events with more proportion of diffractive events. However, we observe a sign change for A_N for those events with only west side RP track.
- Next to consider: background removal for the events with 1 east side RP track (case 1). If we still use BBC cut, it's better to have simulation on BBC to investigate the behavior for BBC result with diffractive events.
- Preliminary request (next PWG meeting): A_N plots for case 1 and case 2 & 3.

Plan for preliminary and DIS 2022

- Mar. 23: present update on diffractive EM Jet A_N for run 15 FMS in spin PWG meeting and receive feedback.
- Apr. 6: request preliminary for diffractive EM Jet A_N for run 15 FMS
- Apr. 13: continue the preliminary request if needed.
- May 2 - 6: present diffractive EM Jet A_N result for run 15 FMS in DIS 2022.

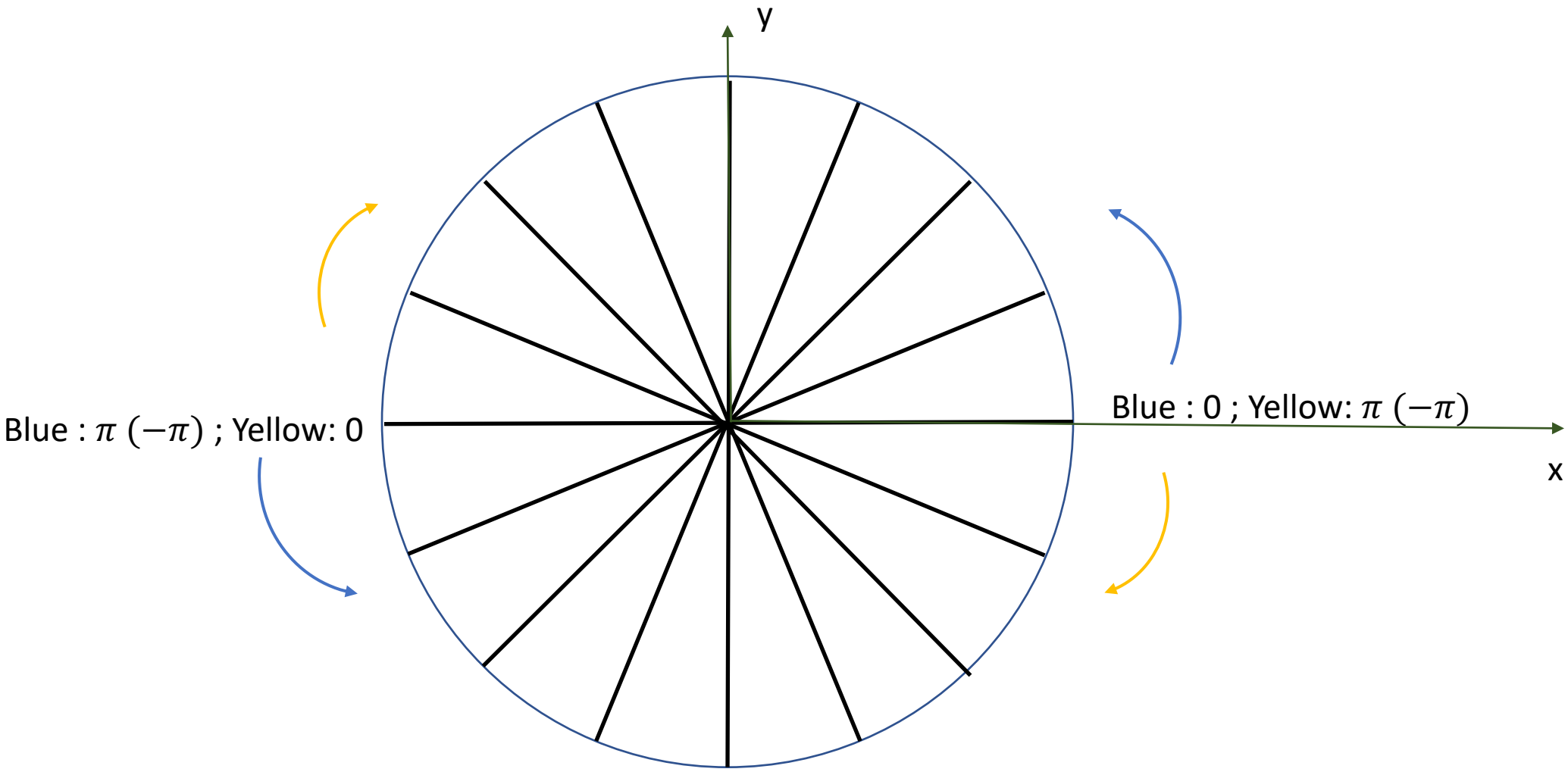
Back up

Blue/Yellow beam spin obtain

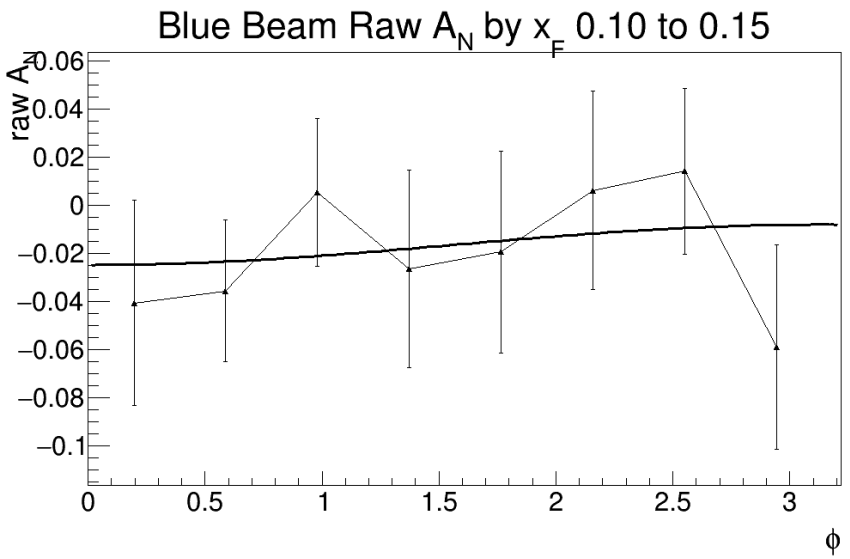
- We obtain blue and yellow spin from 4-spin bits: https://drupal.star.bnl.gov/STAR/blog/oleg/spin-patterns-and-polarization-direction
- Only accept the 4 cases below:

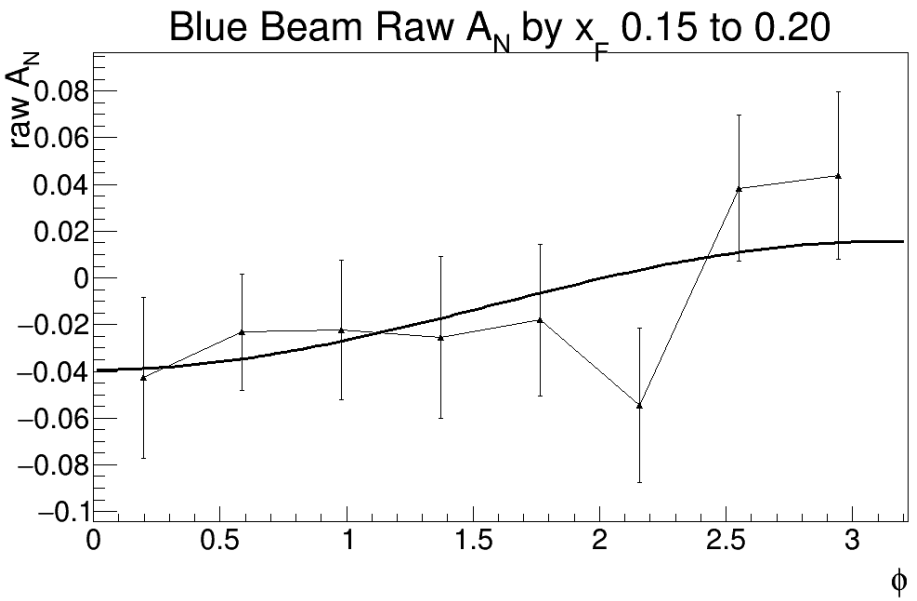
4-spin bits		Blue spin	Yellow spin
5	0101	U	U
6	0110	U	D
9	1001	D	U
10	1010	D	D

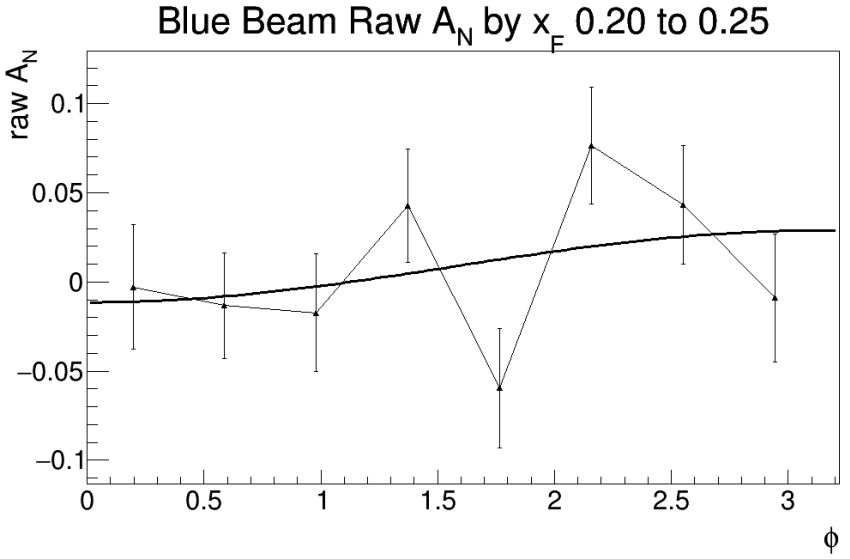
Azimuthal angle (Phi) definition

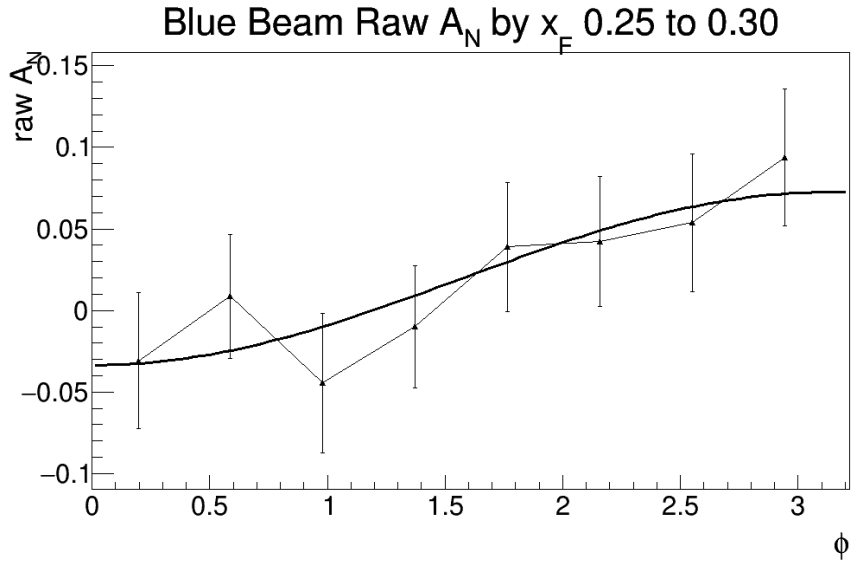


Fit for blue beam raw A_N (case 2 & 3)









QA: Small / large BBC ADC sum

For all the events with RP tracks and EM jets