Run 15 diffractive EM-jet A_N study update

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Outline

- Final results for run 15 diffractive EM-jet A_N.
- East RP coincidence rate in data and simulation.

General Information

- 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).

Event selection and corrections

- **FMS**
  - 9 Triggers (include sm-bs-3) , 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 > 2 GeV, $p_T > 1$ GeV/c, trigger p_T threshold cut, FMS point as input.
  - Apply energy correction.
- **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: (Diffractive EM-jet A_N analysis only)**
- 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 > 6 planes

  b) $-2 < \theta_X < 2$ mrad , $1.5 < |\theta_y| < 4.5$ mrad
  - Sum of west RP track energy and all EM Jet energy (see detail in table)
- **BBC ADC sum cuts: (Diffractive EM-jet A_N analysis only)**
  - West Large BBC ADC sum < 90 and West Small BBC ADC sum < 90

Corrections:
EM-jet energy correction and
Underlying Event correction

x_F	E sum Cut
0.1 - 0.15	E_{sum} < 108 GeV
0.15 - 0.2	E_{sum} < 108 GeV
0.2 - 0.25	E_{sum} < 110 GeV
0.25 - 0.3	E_{sum} < 110 GeV
0.3 – 0.45	E_{sum} < 115 GeV

Calculate the systematic uncertainty

- We use the method of calculating the systematic 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.

Systematic uncertainty (All photon multiplicity)

- Systematic uncertainties for residual background using the new systematic uncertainty calculation.
  - Energy sum cut: change the energy sum cut to check the uncertainty.
  - Small BBC ADC sum cut: change 90 to 60
  - Large BBC ADC sum cut: change 90 to 60
- Ring of fire : Remove Trigger: fms-sm-bs3

x_F	E sum Cut original	E sum cut for systematic
0.1 - 0.15	E_{sum} < 108 GeV	E_{sum} < 112 GeV
0.15 - 0.2	E_{sum} < 108 GeV	E_{sum} < 112 GeV
0.2 - 0.25	E_{sum} < 110 GeV	E_{sum} < 114 GeV
0.25 - 0.3	E_{sum} < 110 GeV	E_{sum} < 114 GeV
0.3 – 0.45	E_{sum} < 115 GeV	E_{sum} < 120 GeV

Blue beam

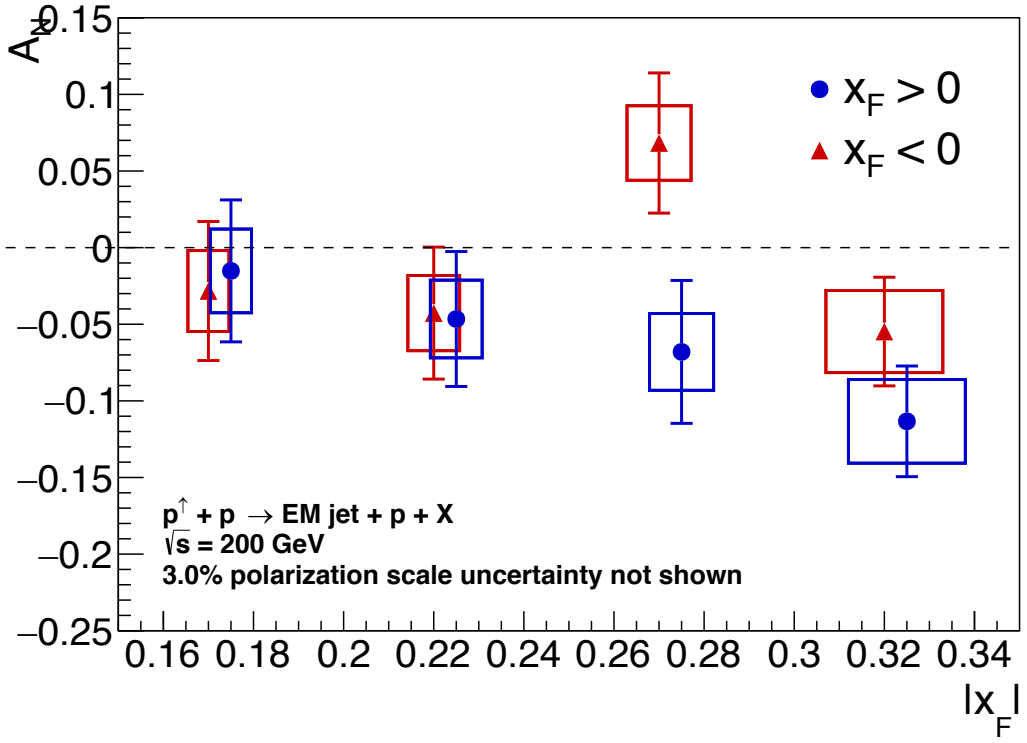
x_F range	Ring of Fire	E_sum	Small BBC	Large BBC	Summary
0.175	18%	32%	104%	142%	180%
0.225	8%	9%	33%	42%	54%
0.275	11%	9%	23%	26%	37%
0.325	17%	7%	12%	11%	24%

Yellow beam

x_F range	Ring of Fire	E_sum	Small BBC	Large BBC	Summary
0.175	7%	16%	54%	74%	93%
0.225	7%	10%	35%	44%	57%
0.275	10%	9%	22%	25%	37%
0.325	34%	14%	24%	22%	49%

A_N results for all photon multiplicity

- Constant fit is applied to calculate the significance of non-zero
- Blue beam A_N is 2.5 σ to be non-zero.
  - Constant fit: -0.065 ± 0.025
- Yellow beam A_N is 0.7 σ to be non-zero.
  - Constant fit: -0.018 ± 0.025



One sample T-test

- Do the one sample T-test for inclusive and diffractive EM-jet A_N to check if they are consistent.
  - Compare only EM-jet with all photons (only statistical uncertainty)
- Check for $p_T > 1\ GeV/c$ with trigger threshold cut

Inclusive EM-jet A_N	stat	Diffractive EM-jet A_N	stat	**d = Inclusive EM-jet A_N - Diffractive EM-jet A_N**	d/stat
0.002373	0.00279	-0.015184	0.046309	0.0175567	0.37843842
0.004168	0.000607	-0.046571	0.044019	0.0507395	1.15256815
0.00892	0.000439	-0.068043	0.046632	0.0769638	1.65038304
0.011882	0.000443	-0.113356	0.036108	0.1252378	3.46819999

Results	d/d_sta
mean:	1.662397403
Stdev	1.312699998
count:	3
t	2.193461392
P	**< 20%**

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n-1}}$$

Where $\bar{x}$ is the average of the A_N difference over uncertainty **(d/stat),** μ is 0 for this hypothesis, s is standard derivation, n is number of data points.

t Table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05
df							
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182

Systematic uncertainty (photon multiplicity 1 & 2)

- Systematic uncertainties for residual background using the new systematic uncertainty calculation.
  - Energy sum cut: change the energy sum cut to check the uncertainty.
  - Small BBC ADC sum cut: change 90 to 60
  - Large BBC ADC sum cut: change 90 to 60
- Ring of fire : Remove Trigger: fms-sm-bs3

x_F	E sum Cut original	E sum cut for systematic
0.1 - 0.15	E_{sum} < 108 GeV	E_{sum} < 112 GeV
0.15 - 0.2	E_{sum} < 108 GeV	E_{sum} < 112 GeV
0.2 - 0.25	E_{sum} < 110 GeV	E_{sum} < 114 GeV
0.25 - 0.3	E_{sum} < 110 GeV	E_{sum} < 114 GeV
0.3 – 0.45	E_{sum} < 115 GeV	E_{sum} < 120 GeV

Blue beam

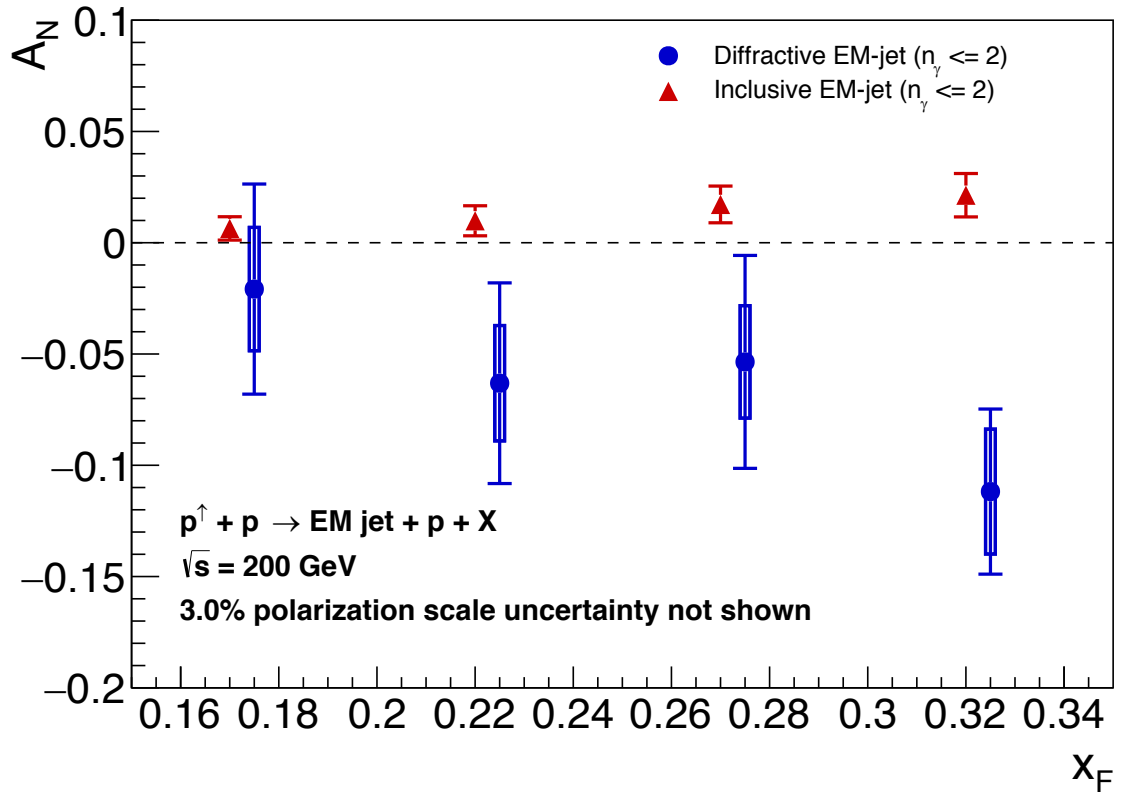
x_F range	Ring of Fire	E_sum	Small BBC	Large BBC	Summary
0.175	13%	23%	78%	105%	133%
0.225	6%	7%	25%	31%	41%
0.275	14%	11%	29%	32%	47%
0.325	18%	7%	12%	11%	25%

Yellow beam

x_F range	Ring of Fire	E_sum	Small BBC	Large BBC	Summary
0.175	8%	17%	61%	82%	104%
0.225	6%	9%	32%	39%	51%
0.275	11%	10%	25%	28%	40%
0.325	34%	13%	23%	21%	48%

A_N results for 1 & 2 photon multiplicity

- Blue beam A_N is 2.5 σ to be non-zero.
  - Constant fit: -0.067 ± 0.026
- Compare with inclusive EM-jet A_N results (1 & 2 photon multiplicity).



One sample T-test

- Do the one sample T-test for inclusive and diffractive EM-jet A_N to check if they are consistent.
  - **Compare only EM-jet with 1 or 2 photons**
- About 1 sigma non-consistency are obtained for both analyses.

Inclusive EM-jet A_N	sta	sys	Diffractive EM-jet A_N	sta	sys	**d = Inclusive EM-jet A_N - Diffractive EM-jet A_N**	d/sta	d/sta+sys
0.00642878	0.00437334	0.00032144	-0.0208303	0.0472086	0.0288379	0.02725908	0.57495583	0.49121394
0.00986271	0.00088661	0.00049314	-0.0631285	0.045086	0.0204169	0.07299121	1.61862	1.47445663
0.0172103	0.00065177	0.00086052	-0.053546	0.047842	0.0280362	0.0707563	1.4788206	1.27575819
0.0213545	0.00065943	0.00106773	-0.111829	0.0370969	0.0311435	0.1331835	3.58958466	2.74872739

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n-1}}$$

Where $\bar{x}$ is the average of the A_N difference over uncertainty **(d/uncertainty),** μ is 0 for this hypothesis, s is standard derivation, n is number of data points.

Results	d/sta	d/sta+sys
t	2.47607419	2.669457845
P	**<10%**	**<10%**

t Table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$
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df							
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71
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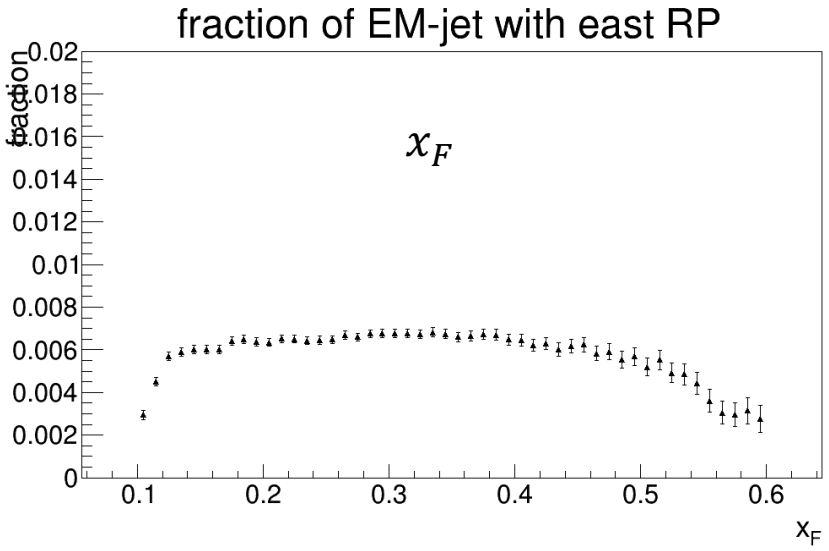
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182

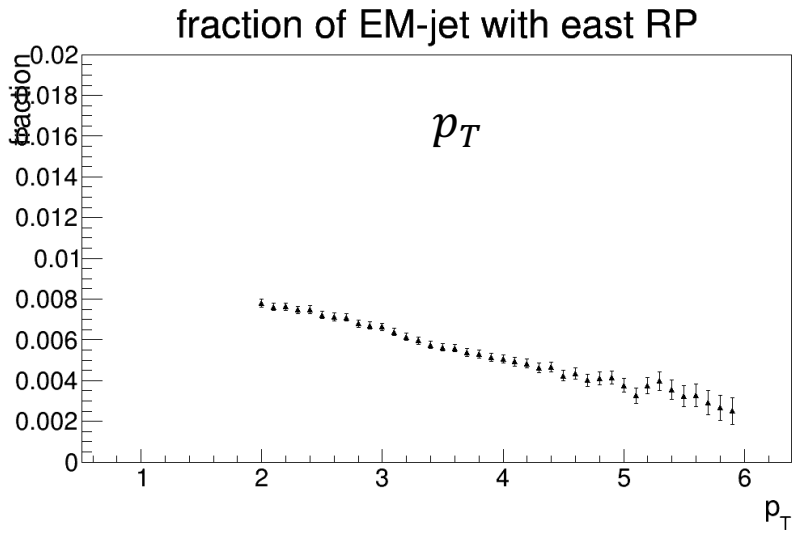
Background study: zerobias stream

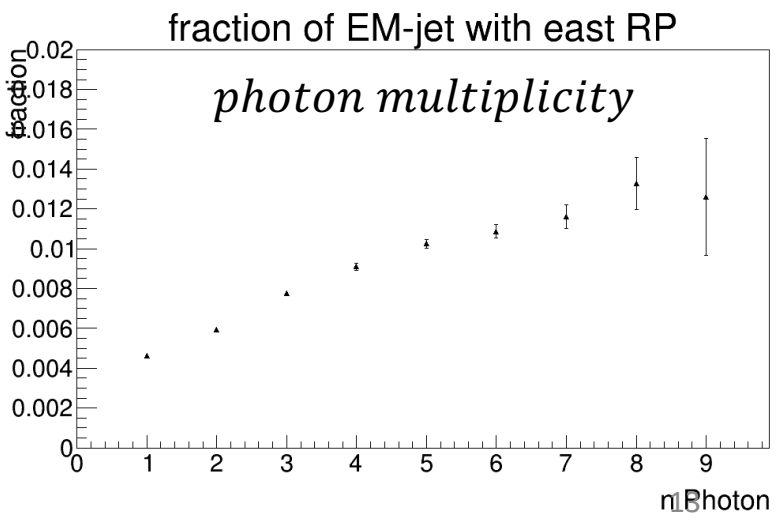
- Motivation: study the fraction of east RP coincident rate for elastic scattering events.
- Data production and stream : **production_pp200trans_2015 , st_zerobias_adc**
- Production tag: P16id
- Elastic scattering: $|\mathrm{P}_{west\ RP\ track} - \mathrm{P}_{east\ RP\ track}| < 5\ GeV$
- Event distribution:
  - Total N events: 724,485
  - 7093 events (1%) contain 1 east good RP track
  - 3610 events (0.5%) contain 1 east good RP track and 1 west good RP track.
  - 3398 **(0.47%)** events are the elastic scattering events.

Fraction of EM-jets with 1 east RP track from data

- Fraction=$\frac{n_{EM-jets\ with\ 1\ east\ RP\ track}}{n_{EM-jets}}$
  - Samples used for east RP coincidence study for the plots below: 6 fills from fms stream.
- The east RP track random coincidence rate from elastic scattering is 0.0047. The fraction shown below have already subtracted such rate from elastic scattering events.

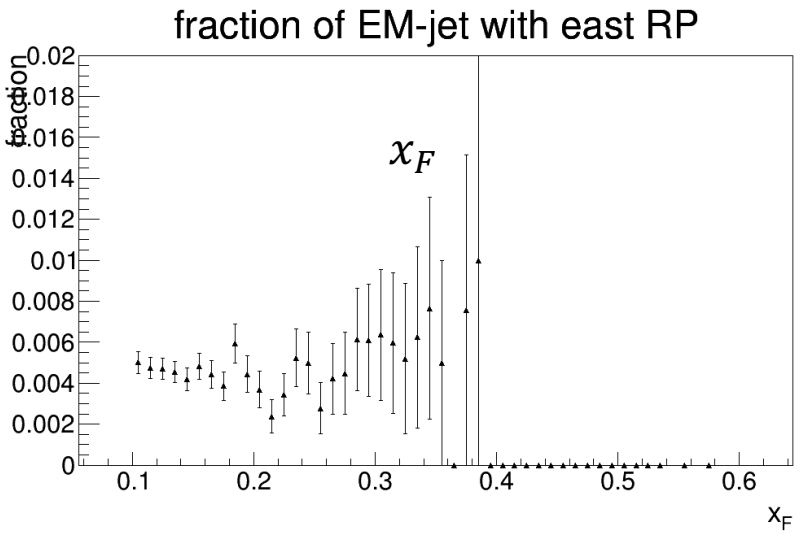


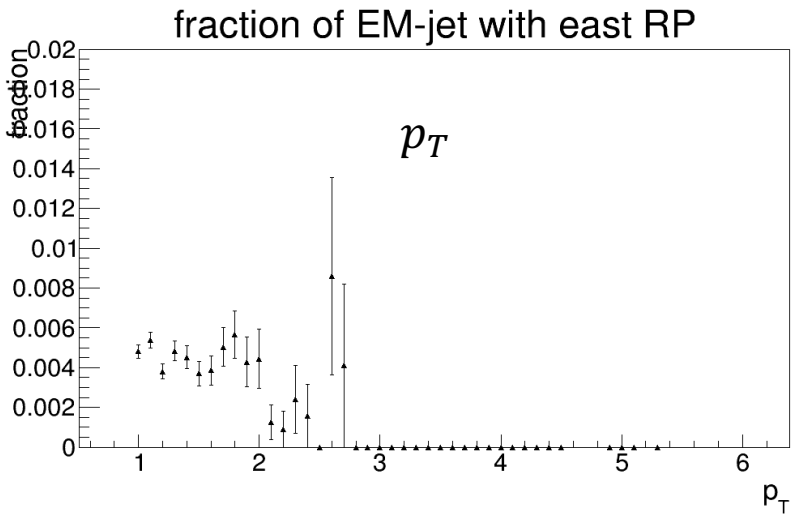


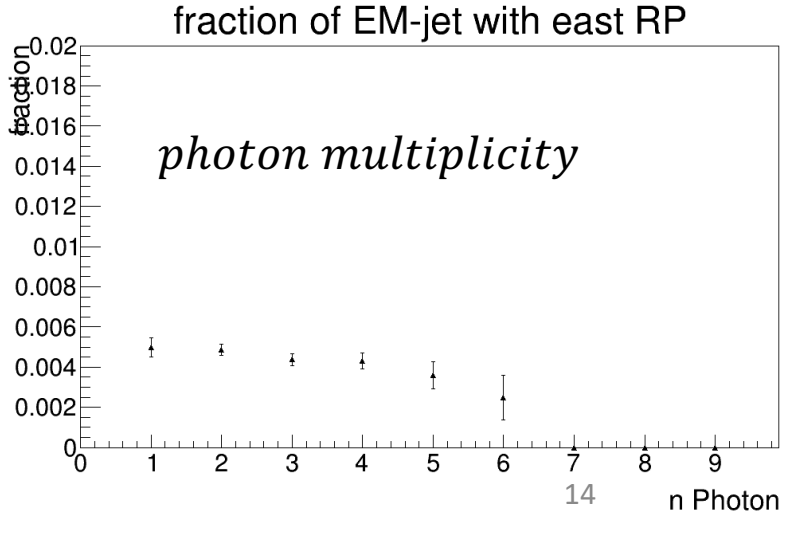


East RP coincidence in simulation

- Use hard diffraction events in Pythia 8 to study the east RP coincidence.
  - 8 M hard QCD events, with about 8% are hard diffraction events.
- Apply RP (pp2pp) simulation and FMS simulation for run 15.
- The results seem to get close to the east RP coincidence rate for data at the low kinematic region after subtracting the elastic scattering east RP coincidence rate.
  - Higher kinematic regions are difficult to access due to the limited statistics.
  - Note: fraction with 0 value means unable to calculate the results in such region.







Request help to generate simulation events

- Reason: The high kinematic region (x_F, p_T, photon multiplicity) is currently difficult to access due to the limited statistics. But they still play an important role to check with the east RP coincident rate for data.
- Goal: access the east RP coincidence rate at high kinematic (x_F up to 0.5; p_T up to 4 GeV) region in simulation.
- Request: Ask for potential help to generate sufficient amount of data:
  - Estimate: at least 16 times larger than existing simulation events. (8 M * 16 = 128 M, or even more up to 200 M) hard QCD events.
  - Require to have RP and FMS simulation.
  - Have a tag to select the hard diffraction events. -> Require PYTHIA 8.2.35 version and higher ; I have maker to keep such tag in PYTHIA simulation production.

Conclusion

- Final plots for run 15 diffractive EM-jet A_N are finished with the new method of calculating the statistical uncertainty.
- The east RP coincidence study is the last step before we complete the analysis for paper, but we need help to generate the simulation events in order to have access to study the east RP coincidence rate at the high kinematic region for simulation.
- Plan to present in the LFSUPC PWG to receive comments regarding to the cuts of diffractive processes.