

Run 17 FMS diffractive EM-jet A_N systematic uncertainty study

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Data set

- Data set: run 17 pp transverse $\sqrt{s} = 510$ GeV ,fms stream
 - (pp500_production_2017)
- Production type: MuDst ; Production tag: P22ib
- Triggers for FMS : FMS small board sum, FMS large board sum and FMS-JP.
- Requirement: Event must contain Roman Pot (RP) information (pp2pp).
 - Already filter out events without RP response. Totally 180 fills.

Total number of events from data set sample (with FMS and RP coincidence)	882 M
Total number of events with FMS points	874 M
Total number of events with FMS EM-jets	860 M

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, $p_T > 1$ GeV/c, 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:**
- 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 8 planes
 - b) $-0.5 < p_x < 0.3$ [GeV/c] , $0.25 < |p_y| < 0.4$ [GeV/c]
 - Sum of west RP track energy and all EM Jet energy
- **BBC ADC sum cuts:**
 - West Small BBC ADC sum < 600

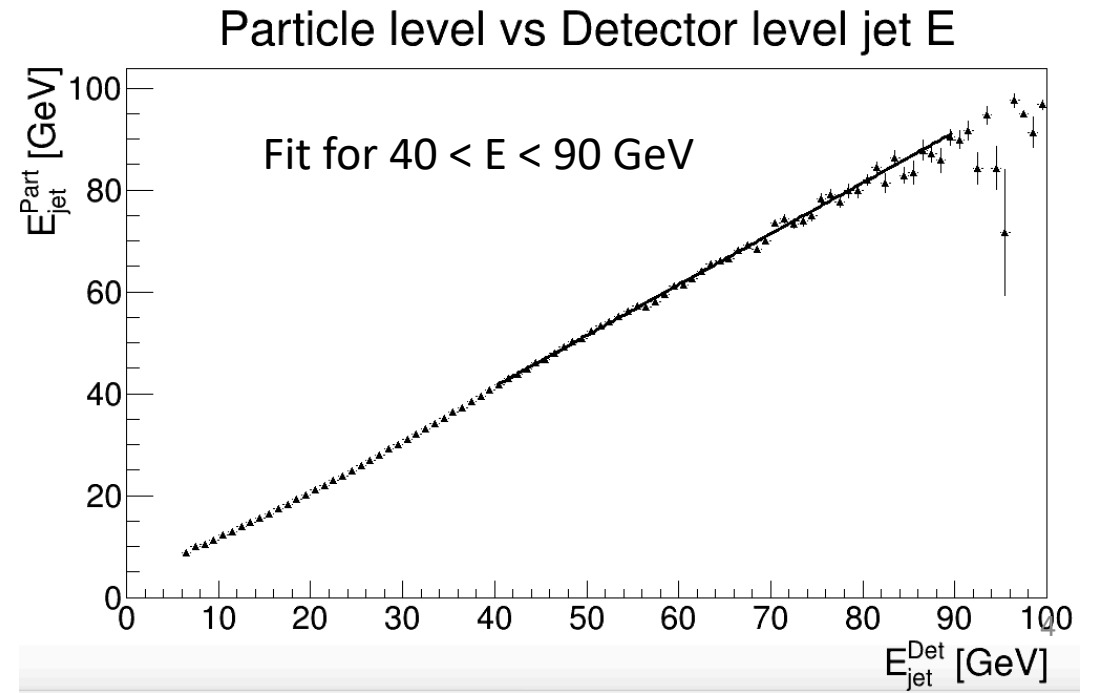
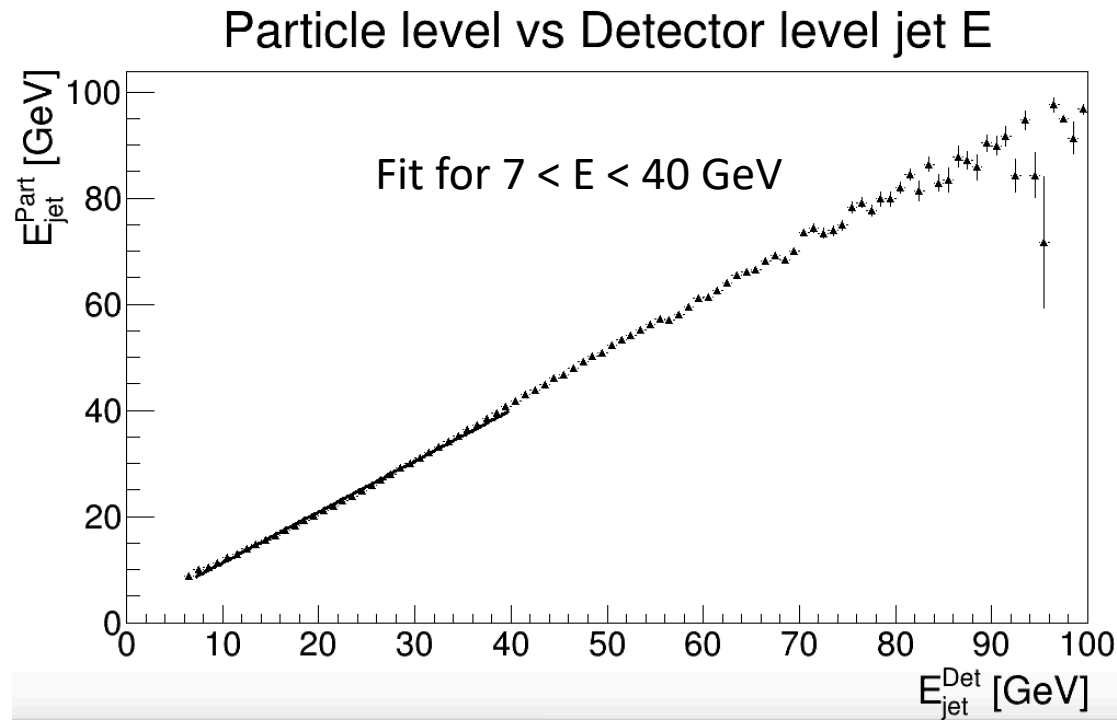
Corrections:

Energy correction and Underlying Event correction

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

Energy correction

- Detector level to particle level energy correction
- Apply linear fit for 2 different detector level energy regions:
 - $7 < E < 40$ GeV
 - $40 < E < 90$ GeV
 - The other energy region do not apply energy correction.



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 BBC ADC sum cut: change 600 to 500

Calculate each systematic uncertainty by result difference fraction when changing the cuts:

$$uncertainty = \frac{|A_{N,change\ cut} - A_{N,origin}|}{|A_{N,origin}|}$$

• Ring of fire ?

- Exclude Trigger: fms-sm-bs3

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

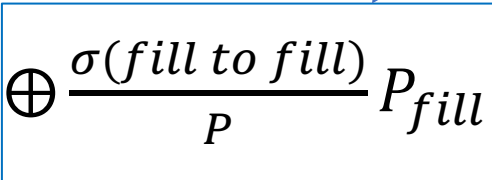
Blue beam

x_F range	Ring of Fire	E_sum	Small BBC	Summary
0.1 - 0.15	88%	32%	397%	408%
0.15 - 0.2	69%	19%	149%	165%
0.2 - 0.25	30%	30%	14%	44%
0.25 - 0.3	624%	57%	82%	632%
0.3 - 0.45	71%	48%	53%	101%

Yellow beam

x_F range	Ring of Fire	E_sum	Small BBC	Summary
0.1 - 0.15	26%	0%	4%	27%
0.15 - 0.2	26%	39%	50%	68%
0.2 - 0.25	80%	32%	90%	124%
0.25 - 0.3	365%	113%	68%	388%
0.3 - 0.45	103%	31%	80%	134%

Polarization uncertainty

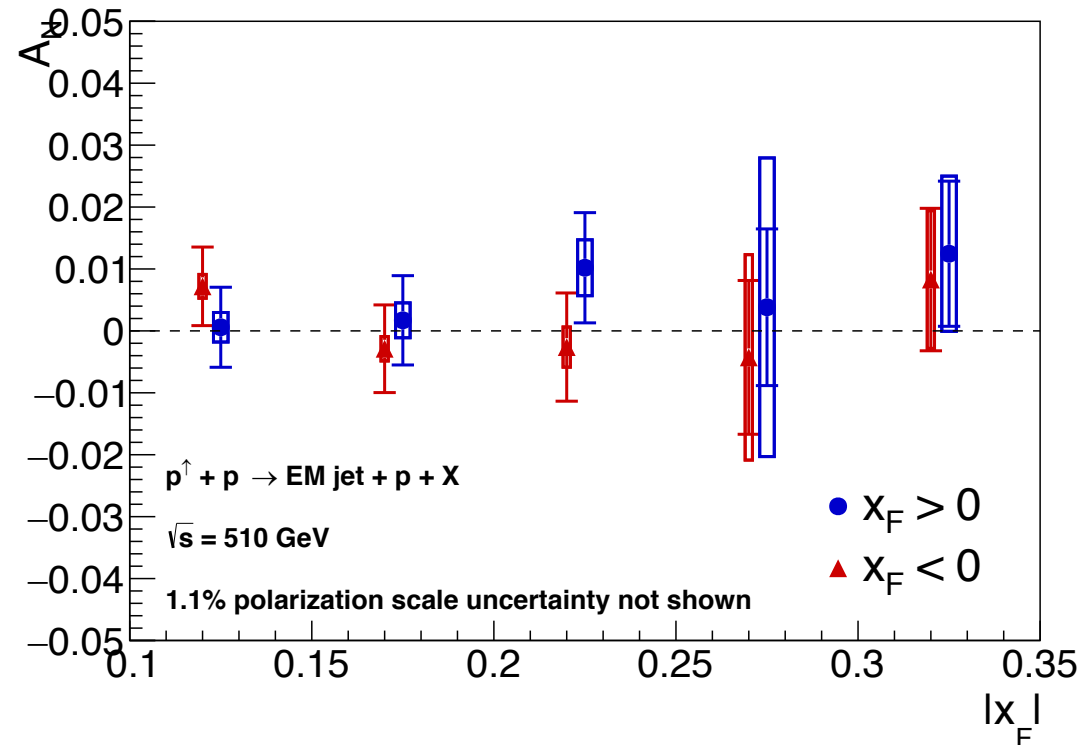
- $\sigma(P_{set}) = P_{set} \cdot \frac{\sigma(scale)}{P} \oplus \sigma_{set}(fill\ to\ fill) \oplus P_{set} \cdot \frac{\sigma(profile)}{P}$
- $\frac{\sigma(scale)}{P} = 1.1\% \text{ [1]}$
- $\frac{\sigma(profile)}{P} = \frac{2.2\%}{\sqrt{M}} = 0.17\% \text{ [1]}$ $M=179, N=190$
- $\sigma_{set}^2(fill\ to\ fill) = \left(1 - \frac{M}{N}\right) \frac{\sum_{fill} L_{fill}^2 \sigma^2(P_{fill})}{(\sum_{fill} L_{fill})^2}$
 - $\sigma_{set}(fill\ to\ fill) = 0.06\%$
 - $\sigma(P_{fill}) = \sigma(P_0) \oplus \sigma\left(\frac{dP}{dt}\right) \left(\frac{\sum_{run} t_{run} L_{run}}{L_{fill}} - t_0\right) \oplus \frac{\sigma(fill\ to\ fill)}{P} P_{fill} \text{ [2]}$

- so $\sigma(P_{set}) = 1.1\%$

[1] W. B. Schmidke, [RHIC polarization for Runs 9-17](#)

[2] Z. Chang [Example calculation of fill-to-fill polarization uncertainties](#)

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]
- They seems to get A_N close to 0.



Systematic uncertainty (EM-jet with 1 or 2 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 BBC ADC sum cut: change 600 to 500

Calculate each systematic uncertainty by result difference fraction when changing the cuts:

$$uncertainty = \frac{|A_{N,change\ cut} - A_{N,origin}|}{|A_{N,origin}|}$$

- Ring of fire ?**

- Exclude trigger: fms-sm-bs3

x_F	E sum Cut original	E sum Cut systematic
0.1 - 0.15	$E_{sum} < 265\text{ GeV}$	$E_{sum} < 255\text{ GeV}$
0.15 - 0.2	$E_{sum} < 280\text{ GeV}$	$E_{sum} < 265\text{ GeV}$
0.2 - 0.25	$E_{sum} < 295\text{ GeV}$	$E_{sum} < 275\text{ GeV}$
0.25 - 0.3	$E_{sum} < 305\text{ GeV}$	$E_{sum} < 290\text{ GeV}$
0.3 - 0.35	$E_{sum} < 315\text{ GeV}$	$E_{sum} < 300\text{ GeV}$
0.35 - 0.4	$E_{sum} < 330\text{ GeV}$	$E_{sum} < 310\text{ GeV}$
0.4 - 0.45	$E_{sum} < 340\text{ GeV}$	$E_{sum} < 320\text{ GeV}$

Blue beam

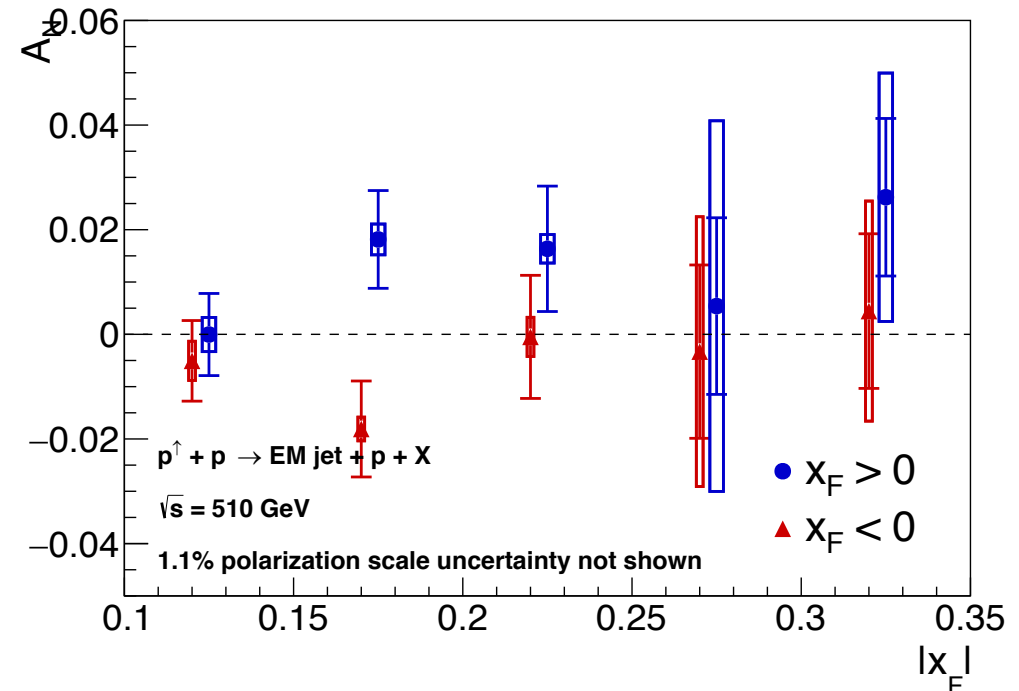
x_F range	Ring of Fire	E_sum	Small BBC	Summary
0.1 - 0.15	3795%	963%	7903%	8820%
0.15 - 0.2	8%	5%	13%	16%
0.2 - 0.25	5%	15%	5%	17%
0.25 - 0.3	648%	9%	101%	656%
0.3 - 0.45	87%	22%	12%	91%

Yellow beam

x_F range	Ring of Fire	E_sum	Small BBC	Summary
0.1 - 0.15	10%	15%	72%	74%
0.15 - 0.2	1%	8%	10%	13%
0.2 - 0.25	515%	289%	489%	767%
0.25 - 0.3	724%	142%	251%	779%
0.3 - 0.45	458%	50%	108%	473%

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 .
- Still 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 larger A_N values are observed for EM-jet with 1 or 2 photon multiplicity, but we can still consider them as close to 0.



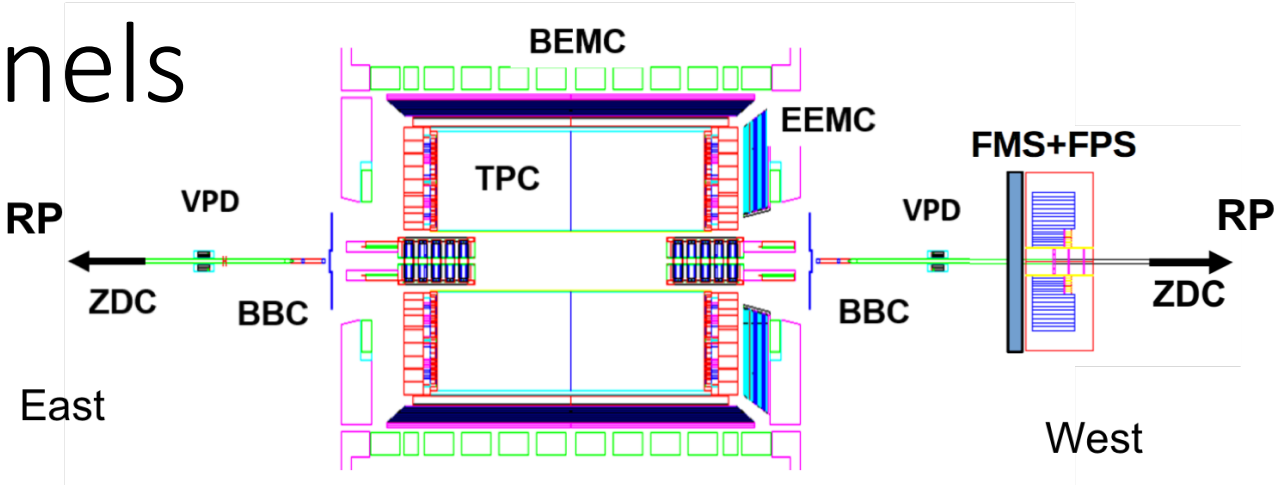
Conclusion and outlook

- Run 17 diffractive EM-jet A_N with systematic uncertainty study is finished. More studies needed for preliminary?
- Should we consider the Ring of Fire (excluding sm-bs-3 trigger) into systematic uncertainty for run 17?
- Next to do:
 - Finalize the run 17 diffractive EM-jet A_N analysis for preliminary.
 - Compare with run 17 inclusive EM-jet A_N analysis to see if diffractive process will contribute to large A_N .

Back up

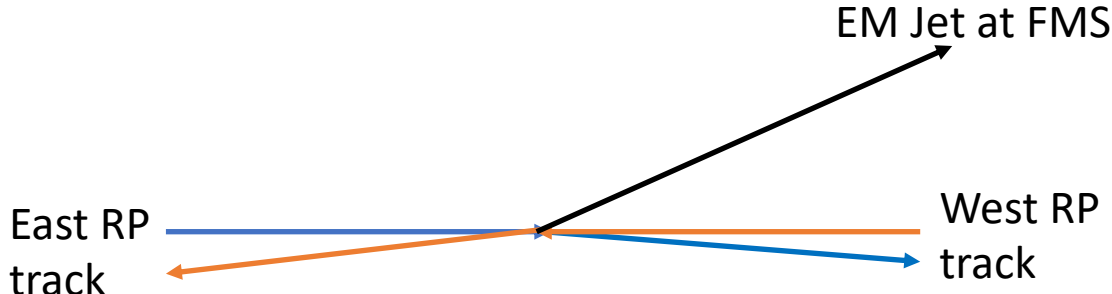
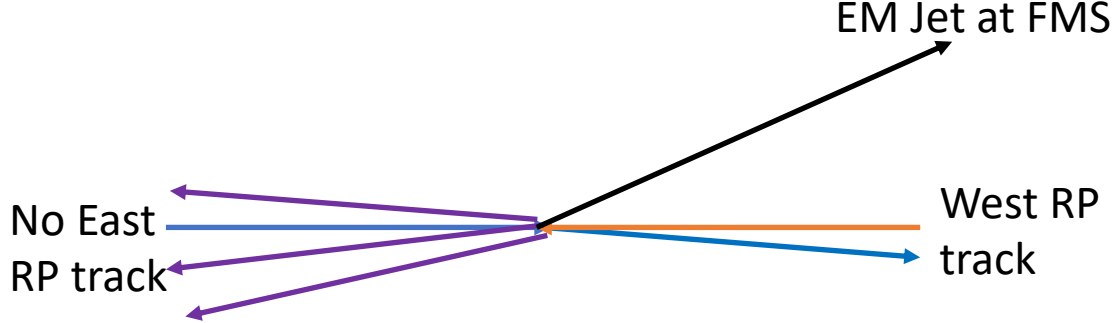
Diffractive process channels

2 diffractive channels are considered.



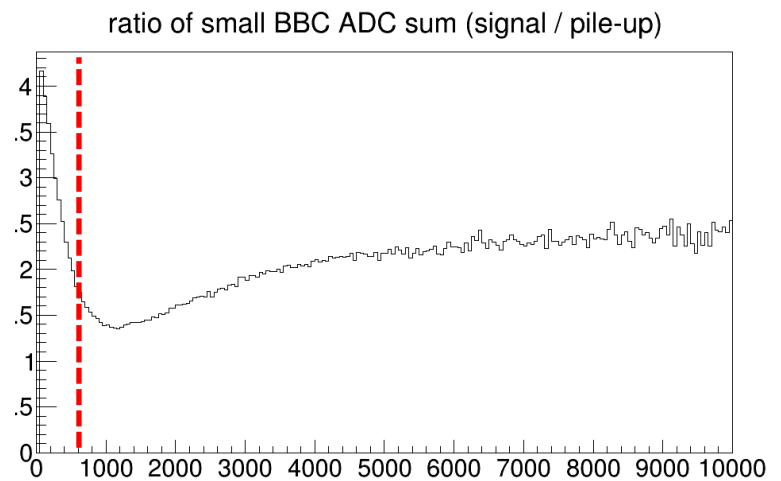
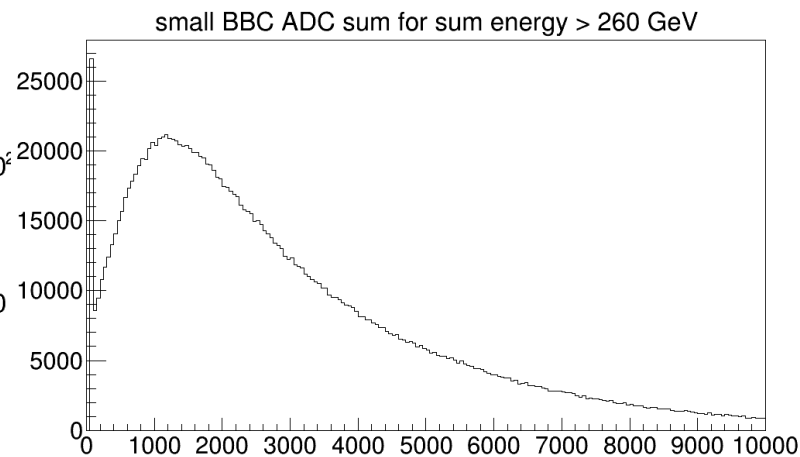
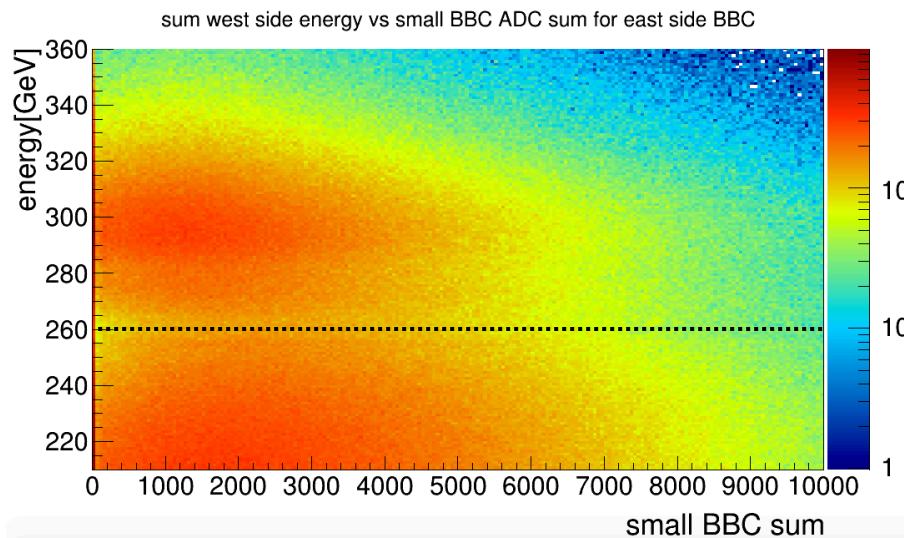
Require:

- Contain only 1 west RP track.
- Either no east side RP track or only 1 east side RP track.
- sum of west side tracks energy (west side proton + EM Jet) less than beam energy



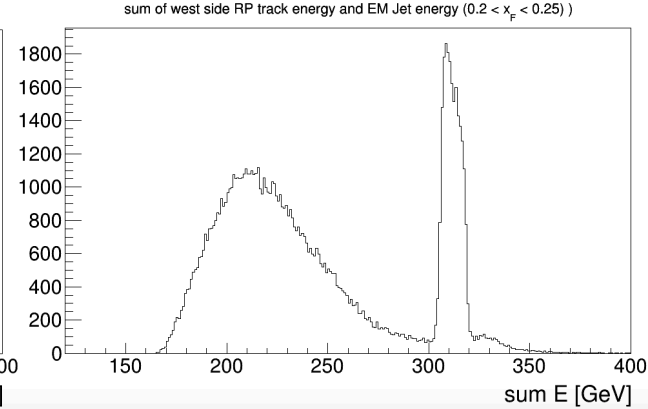
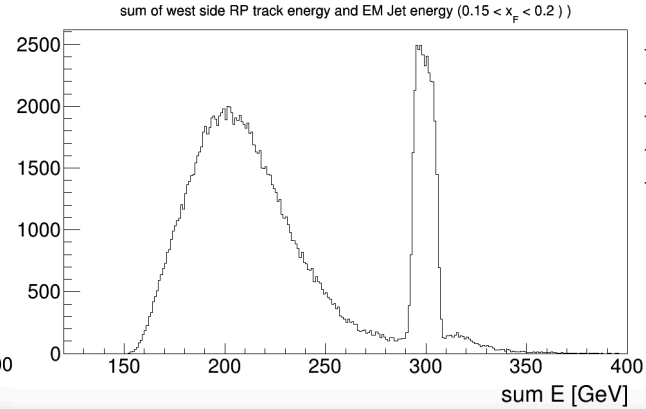
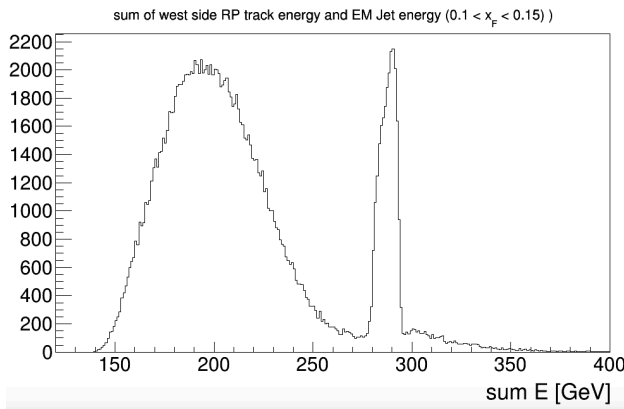
West side small BBC ADC sum cut

- Plot sum energy vs small BBC ADC sum
 - Sum energy: sum of west side RP track energy and all FMS EM-jet energy.
 - Consider $E_{sum} < 260$ GeV as signal and $E_{sum} > 260$ GeV as pile-up
- Plot ratio of signal to pile-up events as function of small BBC ADC sum
 - Apply small BBC ADC sum < 600 as cut.

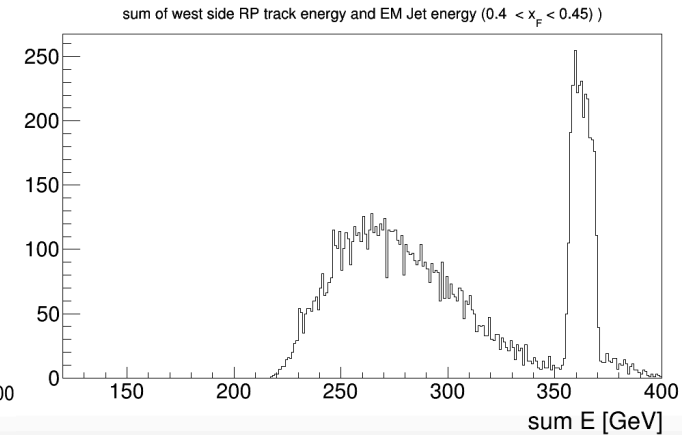
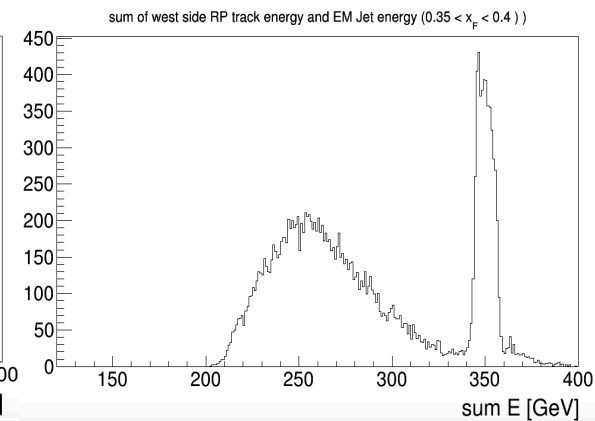
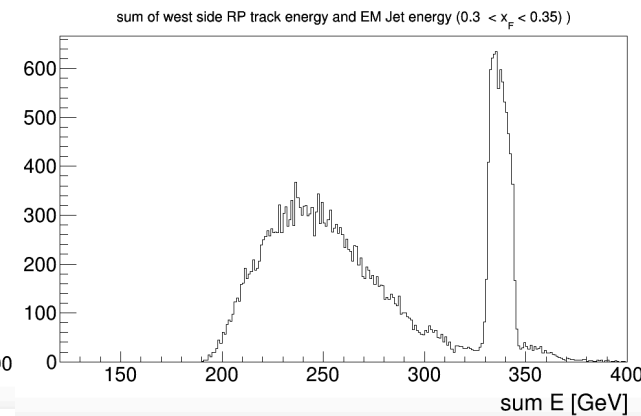
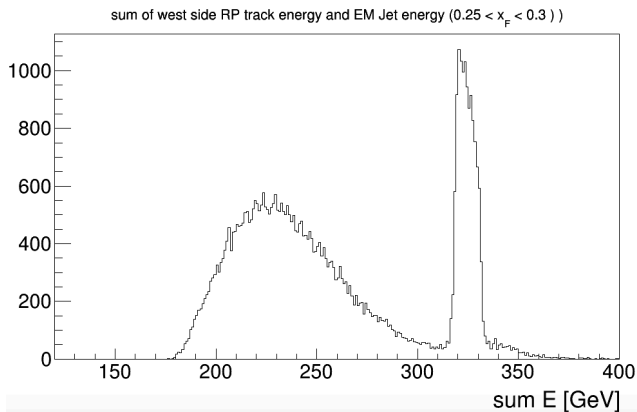


E sum cuts based on different x_F ranges

- Apply E sum cuts based on signal peak and pile-up peak splitting position.

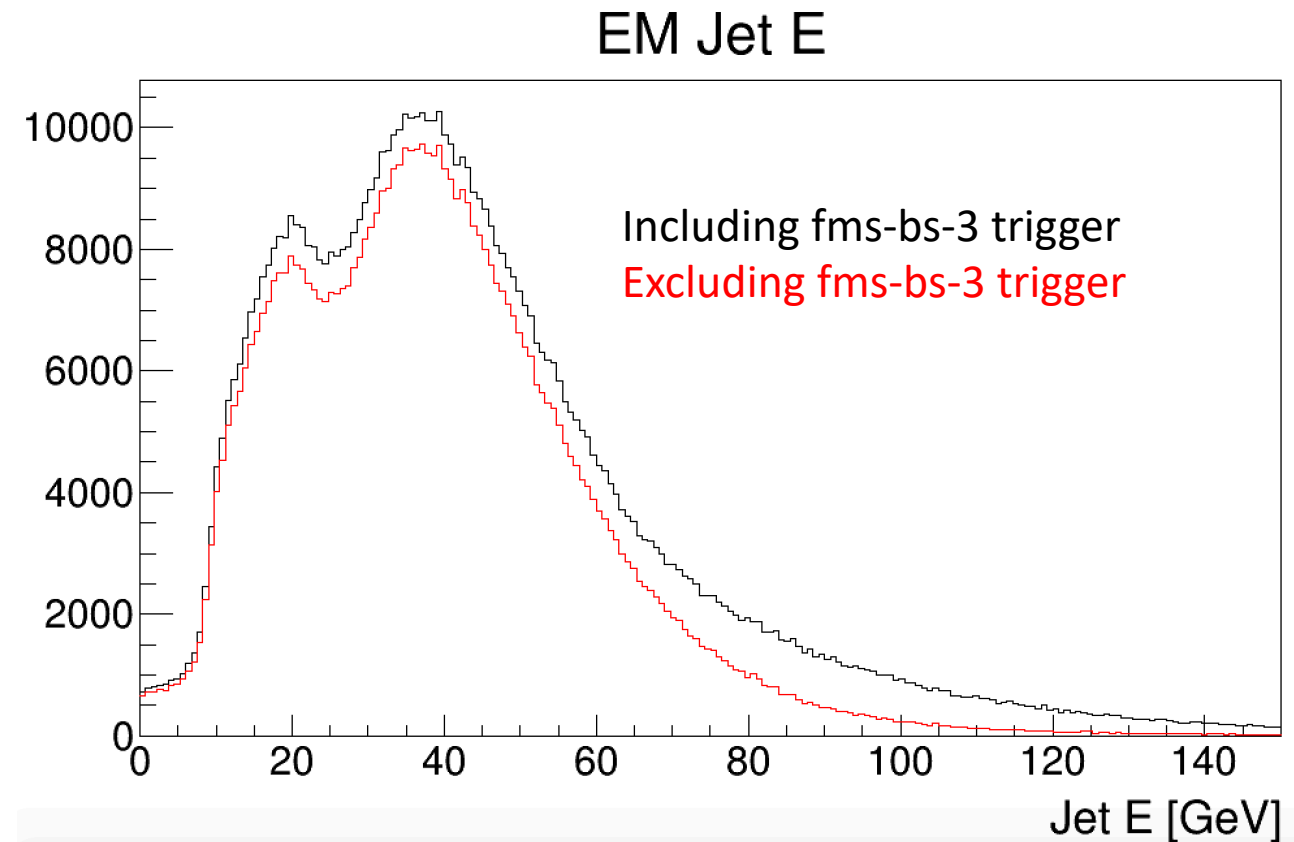


x_F	E sum Cut
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EM-jet energy for include / exclude fms-bs-3

- EM-jet energy distribution for including / excluding the fms-bs-3 trigger.
- Higher energy EM-jets are reduced significantly after excluding the fms-bs-3 trigger.



Ring of Fire (small-bs-3 trigger)

All photon multiplicity	Blue Beam Asymmetries				Yellow Beam Asymmetries			
	Including small-bs-3 trigger		Skipping small-bs-3 trigger		Including small-bs-3 trigger		Skipping small-bs-3 trigger	
	A_N	stat sigma	A_N	stat sigma	A_N	stat sigma	A_N	stat sigma
xF	5.85E-04	0.00646345	7.08E-05	0.00665188	0.00719491	0.00634432	0.0090915	0.00651025
0.125	0.00170768	0.00721155	0.00288396	0.00747117	-0.0028842	0.00707893	-0.0021421	0.00731224
0.175	0.0101958	0.00890119	0.013245	0.00957416	-0.002615	0.00873847	-0.0005342	0.00937226
0.225	0.00381631	0.0126516	0.027631	0.014875	-0.0042783	0.012418	0.0113182	0.0145581
0.275	0.0124604	0.0117214	0.00360983	0.0192146	0.00829024	0.0115033	0.0168247	0.0188027

1 or 2 photon multiplicity	Blue Beam Asymmetries				Yellow Beam Asymmetries			
	Including small-bs-3 trigger		Skipping small-bs-3 trigger		Including small-bs-3 trigger		Skipping small-bs-3 trigger	
	A_N	stat sigma	A_N	stat sigma	A_N	stat sigma	A_N	stat sigma
xF	-3.71E-05	0.0078491	-0.0014436	0.00809988	-0.0050676	0.00770472	-0.0045479	0.00792755
0.125	0.0181401	0.0093448	0.0196583	0.00976416	-0.0180932	0.00917306	-0.0181912	0.00955688
0.175	0.0163478	0.0119862	0.017229	0.0131585	-0.0004876	0.0117659	0.00202307	0.0128793
0.225	0.00539874	0.0168818	0.0403974	0.0209689	-0.0033085	0.0165671	0.0206515	0.0205208
0.275	0.0262074	0.0150591	0.0490212	0.0279238	0.00444305	0.0147792	0.0248017	0.027324