The rapidity gap study for diffractive events in ep collision

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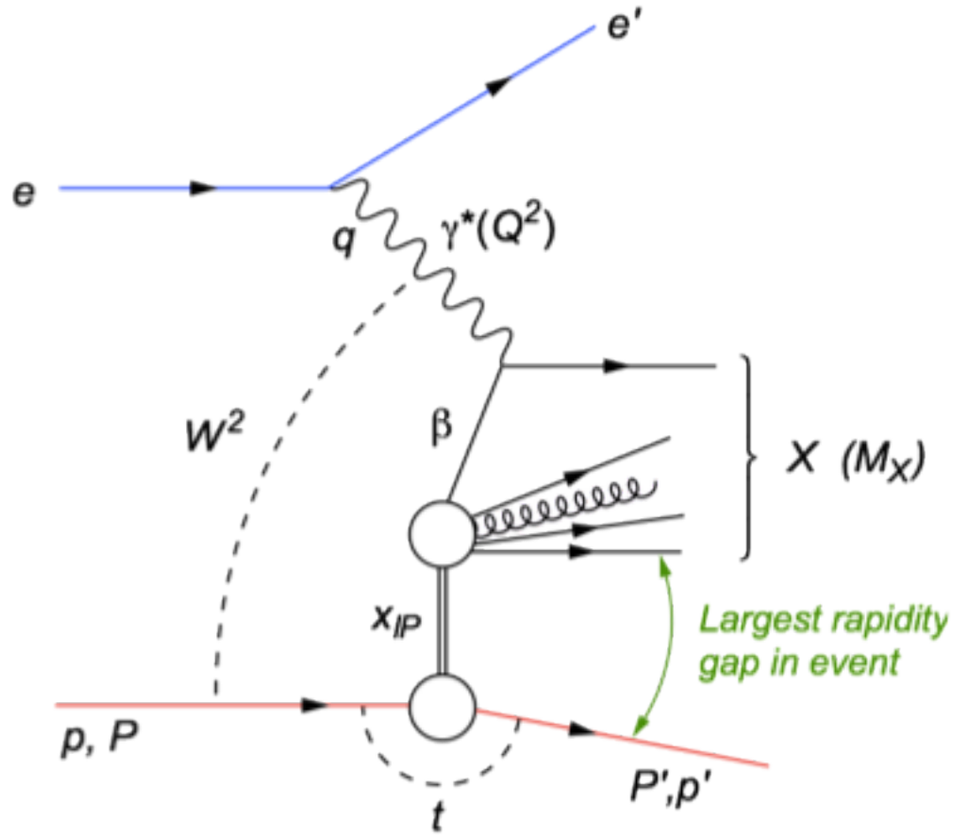
Diffractive events in ep

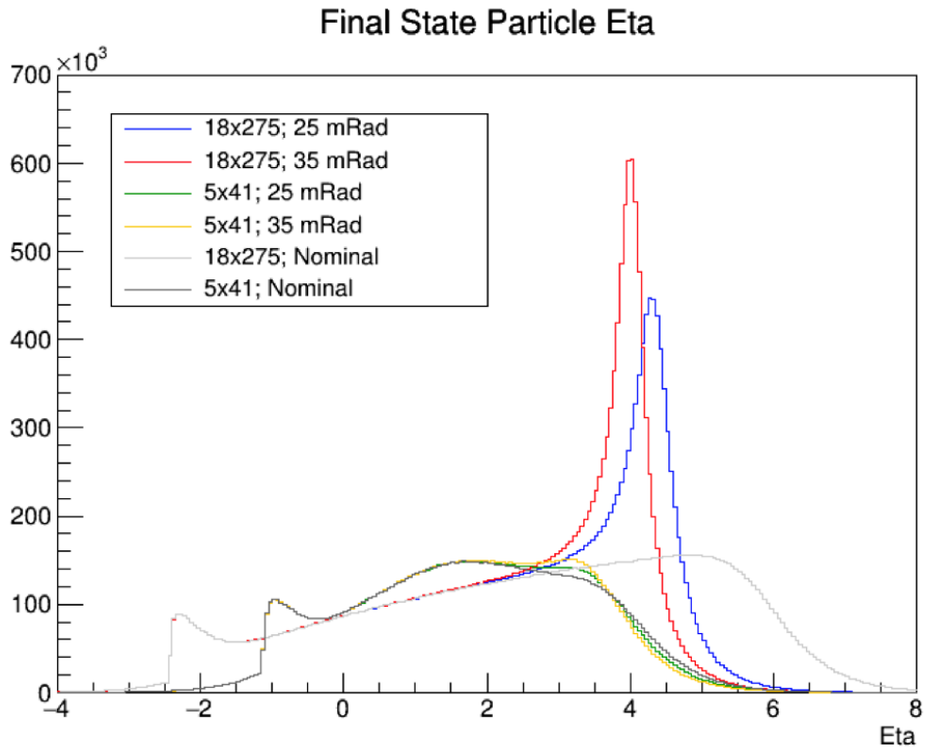


- One technique to tag on diffraction is to require a "rapidity gap" in the detector. This means that there is a region in the detector from the hadron beam towards the center of the detector in which there is no activity from the hadronic final state.
- The efficiency for detecting, and the purity of, diffractive events therefore depends strongly on the rapidity coverage of the detector.

Pythia8 configuration

```
pythia.readString("Beams:idA = 11");
pythia.readString("Beams:idB = 2212");
pythia.readString("Beams:eA = 18.");
pythia.readString("Beams:eB = 275.");
pythia.readString("PDF:lepton2gamma = on");
pythia.readString("PDF:lepton2gammaSet = 1");
photonFlux = new Lepton2gamma2(11);
pythia.readString("Photon:Wmin = 5.0");

pythia.readString("SoftQCD:all= on”);
pythia.settings.parm("PhaseSpace:Q2Min", 1.e-09);
pythia.settings.parm("Photon:Q2max",2);
pythia.settings.parm(“PhaseSpace:mHatMin",1.0);

pythia.readString("SpaceShower:dipoleRecoil = on");
pythia.settings.forceParm("PhaseSpace:pTHatMinDiverge",1.0)
pythia.readString("PhaseSpace:pTHatMin = 1.624”);
pythia.readString("SpaceShower:pTmaxMatch = 2”);
pythia.readString("SigmaElastic:Coulomb=on");

pythia.readString("PartonLevel:MPI = on”);
pythia.readString("MultipartonInteractions:pTmin = 1.9");
pythia.readString("PartonLevel:all= on");


pythia.readString("PDF:pSet = 2”);
pythia.readString(“PhotonPhoton:pT0Ref=3.0");

//set random
pythia.readString("Random:setSeed = on");
pythia.readString("Random:seed=0");
```

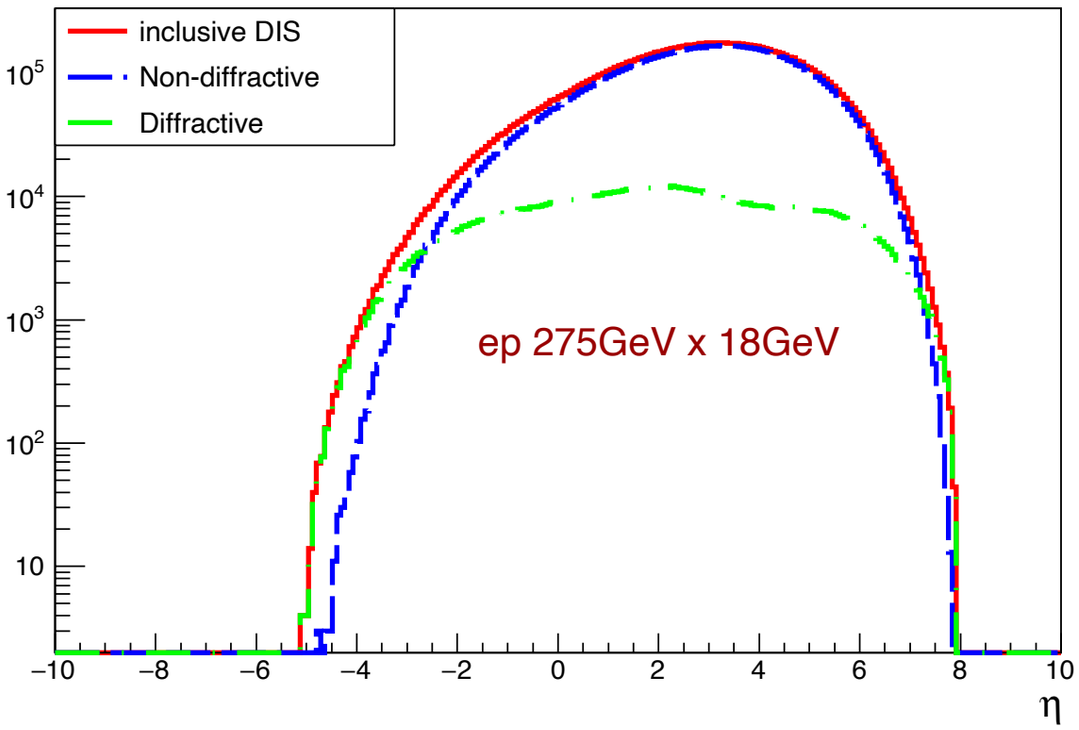
We do not add the beam effects in our study yet.



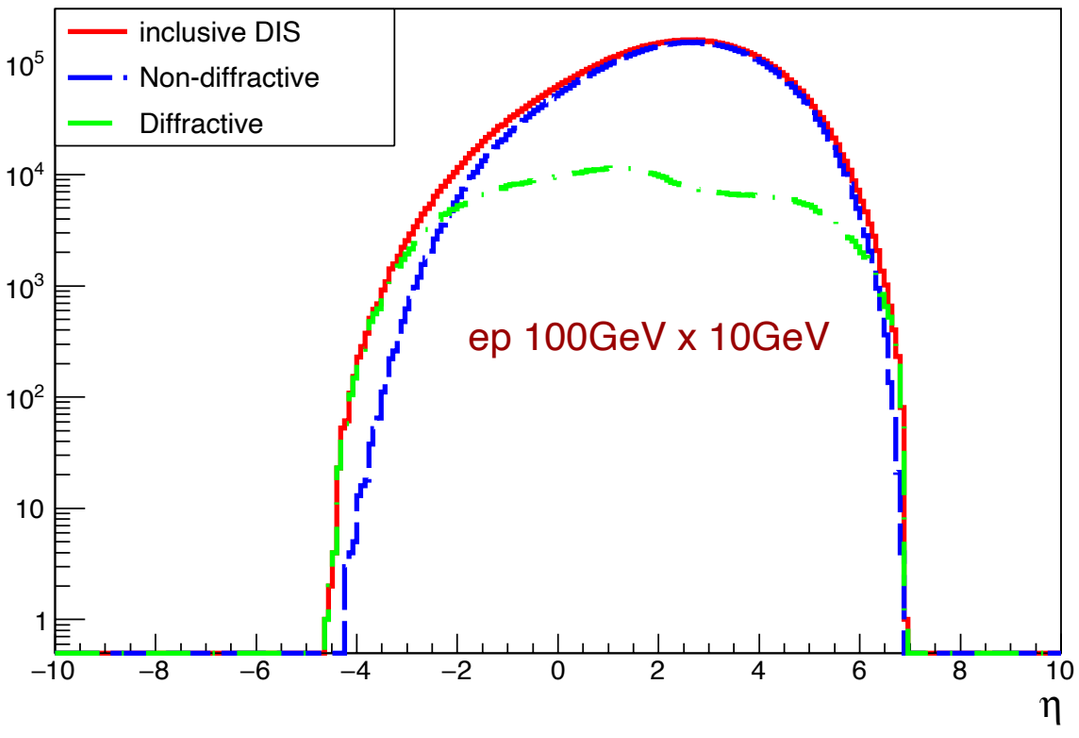
(b) Pseudorapidity Projection

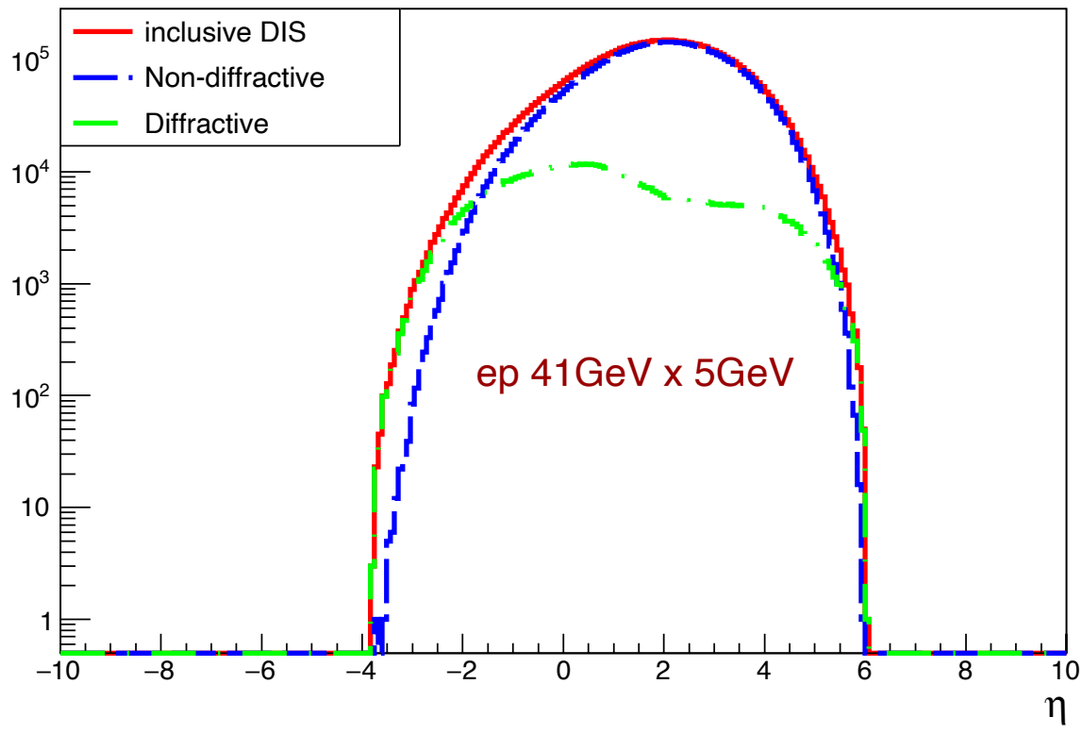
Distributions for the four beam energy and crossing angle combinations. Colored lines show the distributions with all beam effects included , while the grayscale lines show the distributions obtained from the head-on collisions with no other beam effects included.

Eta distribution for diffractive and non-diffractive events

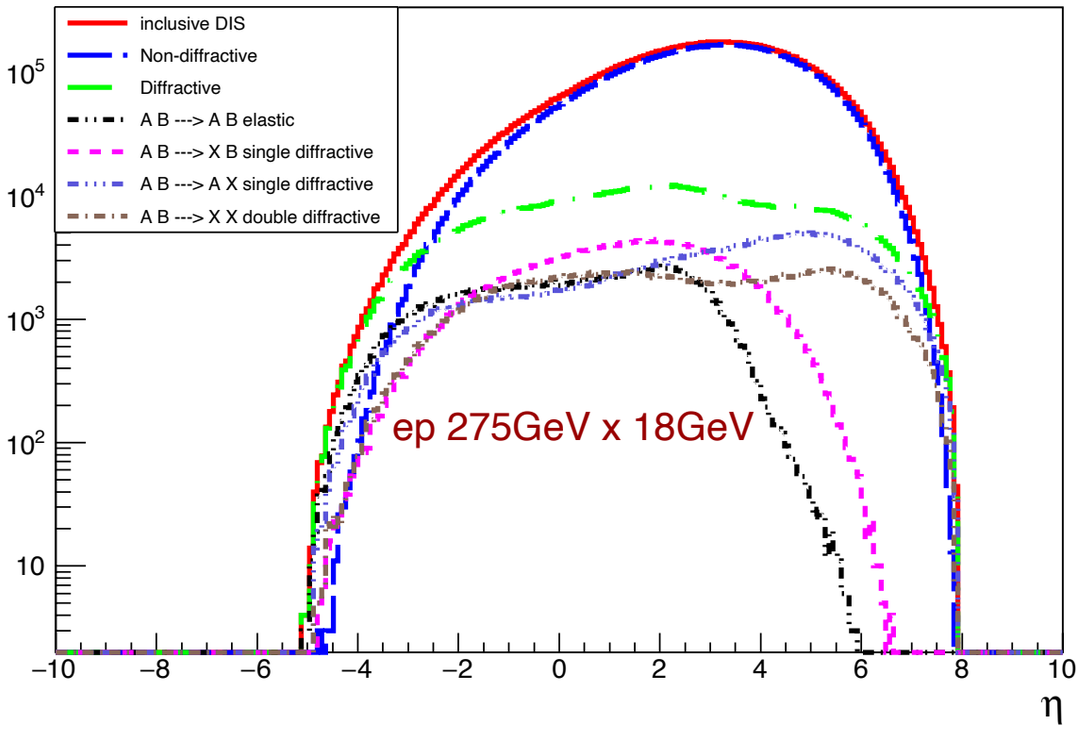


- We here use softQCD processes represents the total cross section of the ep collisions, with the exception of the "rare processes" that one wishes to study separately;
- Since the current framework in Pythia8 can handle only (quasi-)real photons, an upper limit needs to be set for the photon virtuality. This can be done with the parameter Photon:Q2max. So we have the limit of $Q^2 < 2\ GeV^2$ in our study;
- Pt > 0.2GeV;



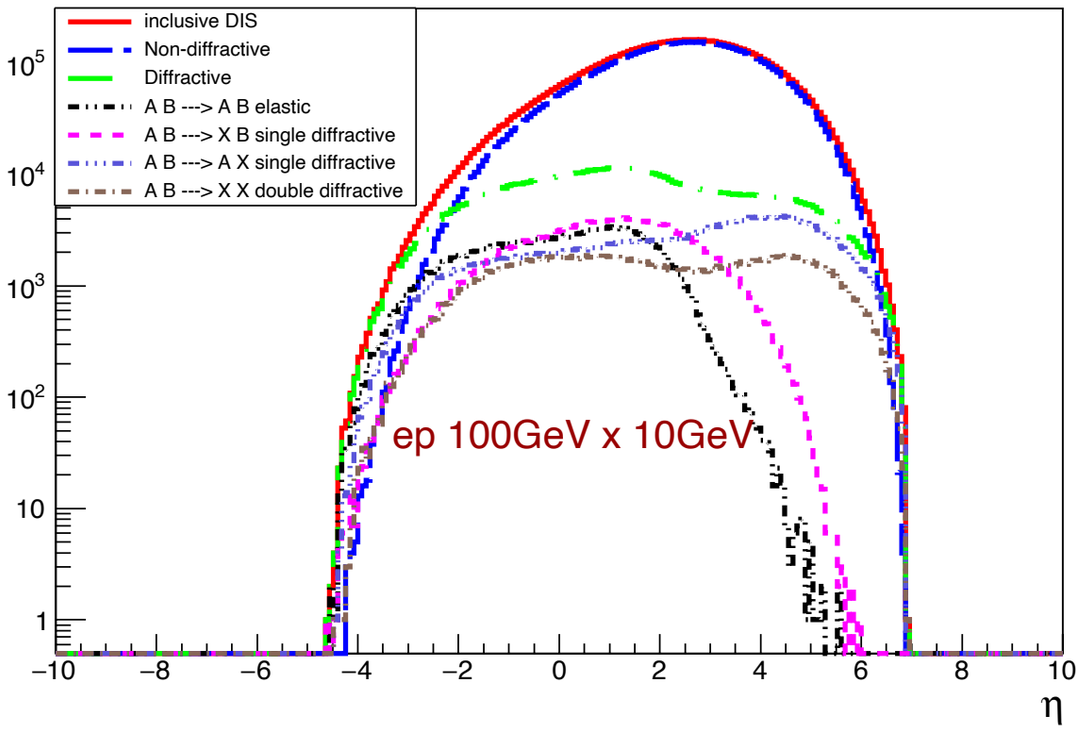


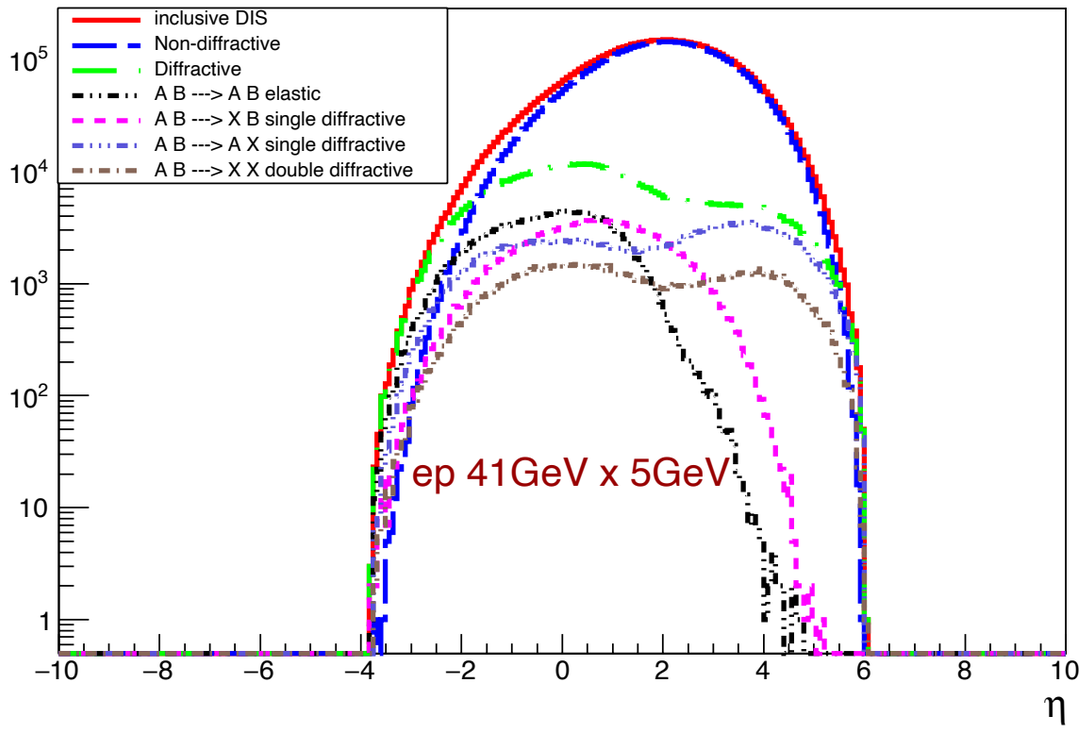
Eta distribution for each subprocess



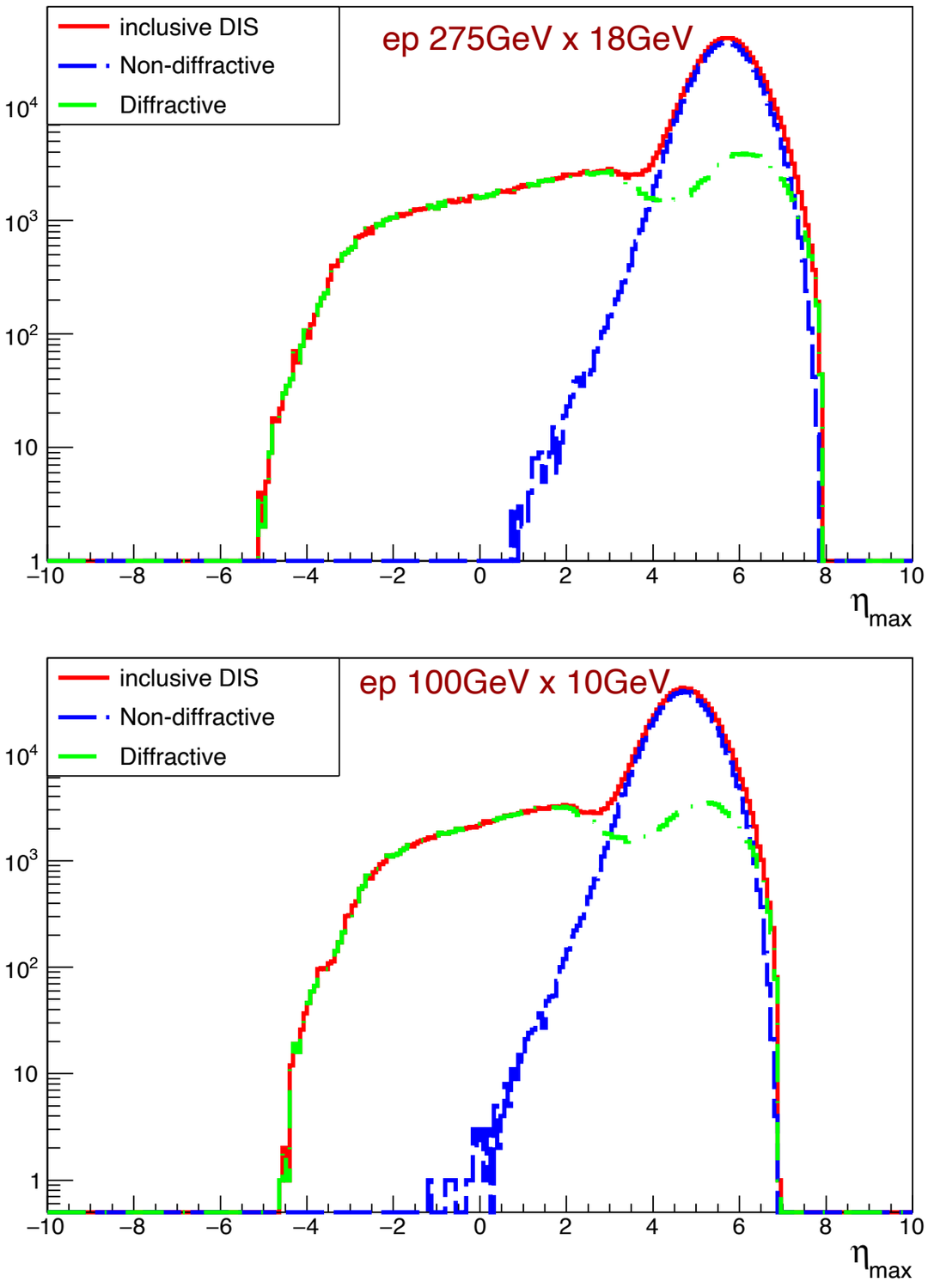
Here "Diffractive" includes these four processes:

- A B -> A B elastic
- A B -> X B single diffractive
- A B -> A X single diffractive
- A B -> X X double diffractive





The eta distribution of the most forward particle



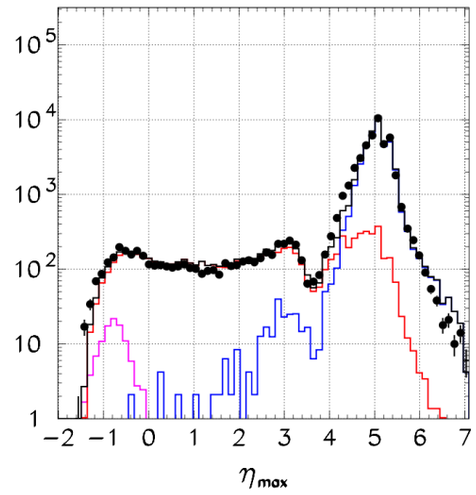
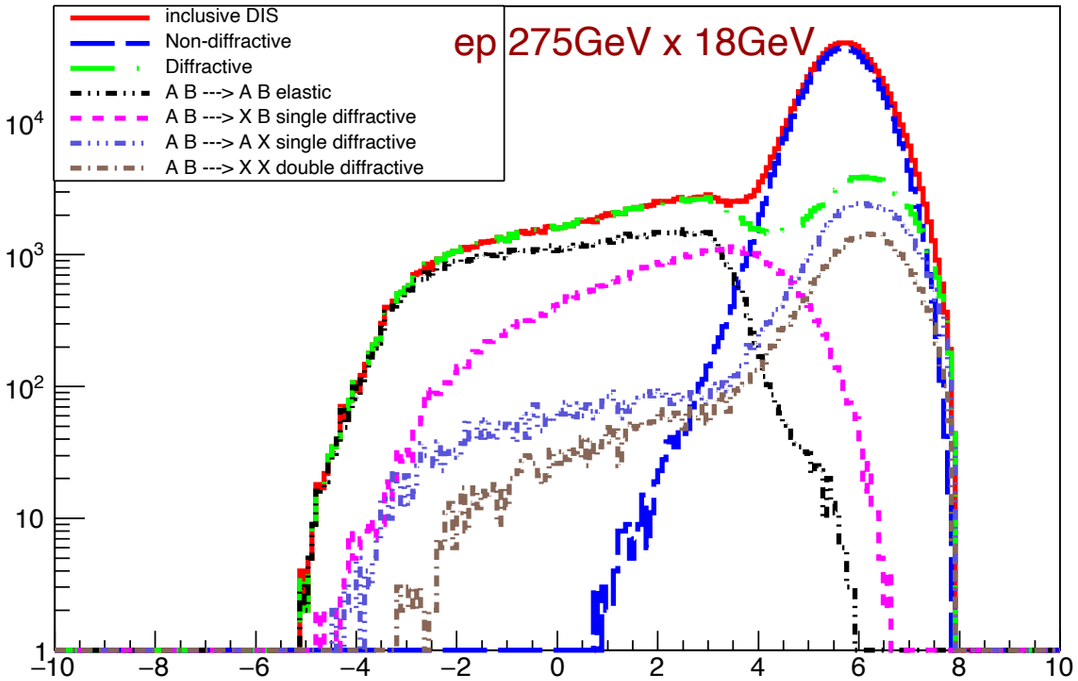
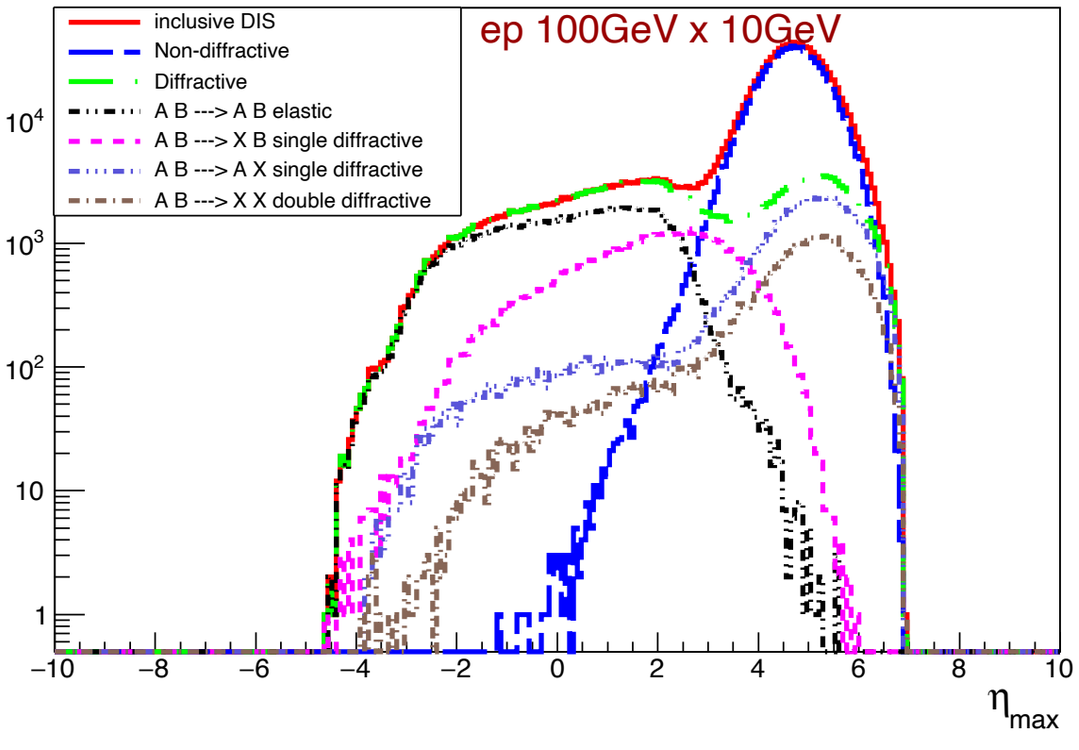
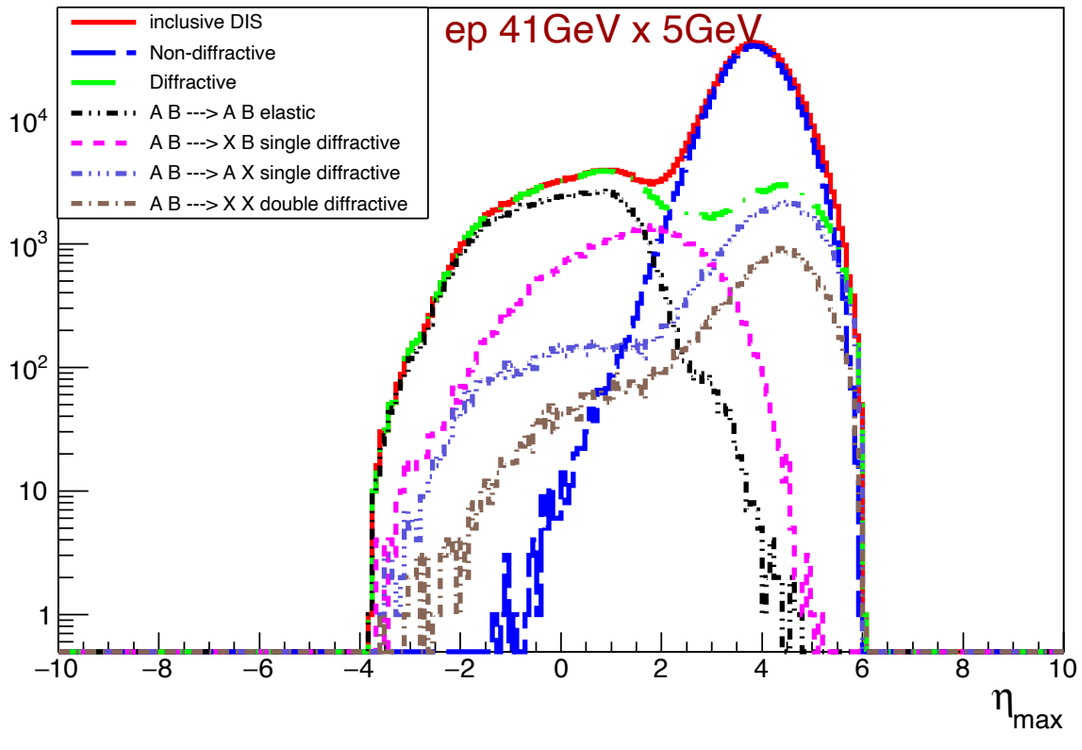


Figure 6.3: *Distribution of the η_{max} for the DIS data (dots) made for $134 < W < 164\ GeV$ and $20 < Q^2 < 40\ GeV^2$. The solid black line represents the sum of the Monte Carlo contributions: non-diffractive (DJANGOH)—blue line, diffractive (SATRAP)—red line, diffractive ρ^0 production (ZEUSVM)—purple line.*

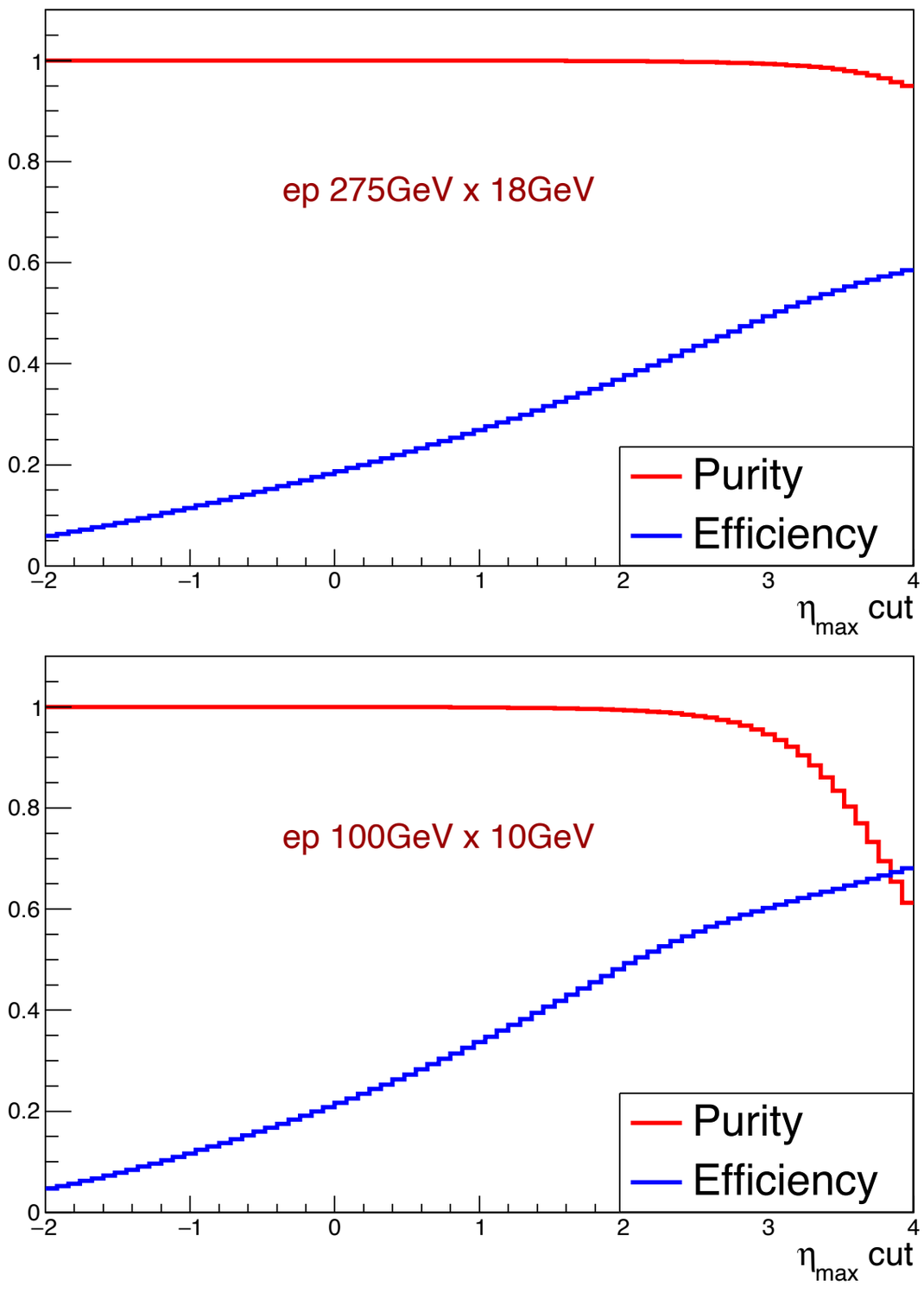
The most forward eta distribution for subprocesses







If we have the full eta coverage…

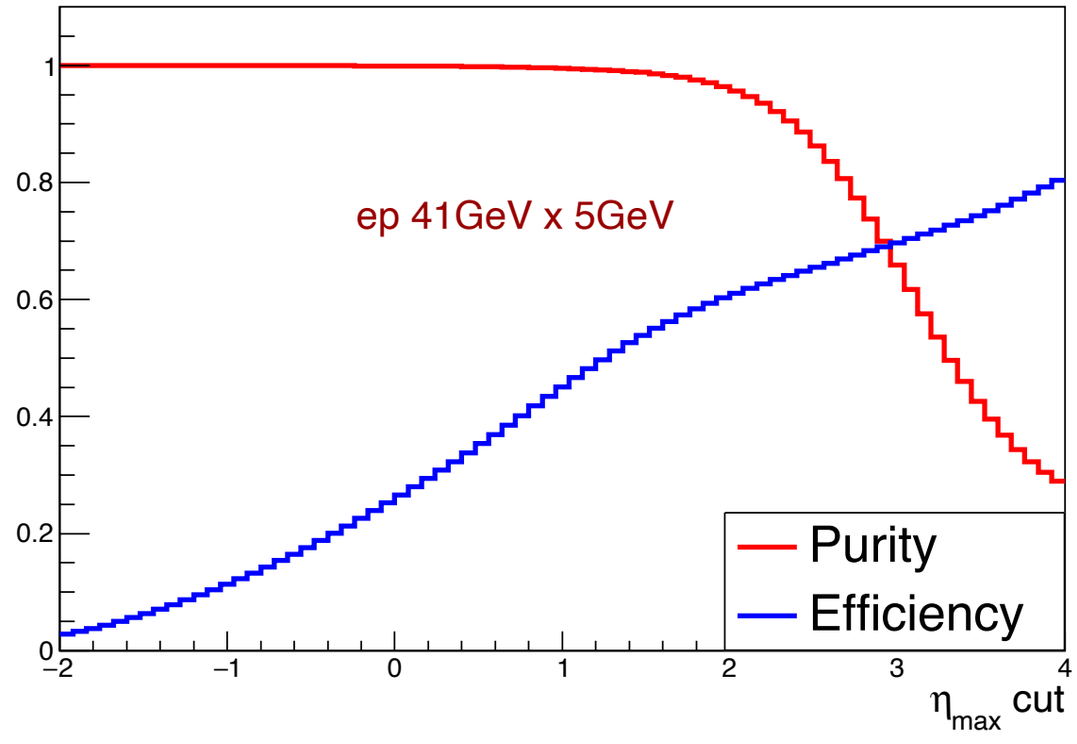


Here we define:

$$purity = \frac{NO.\ Accepted\ diffractive\ events}{NO.\ Accepted\ events}$$

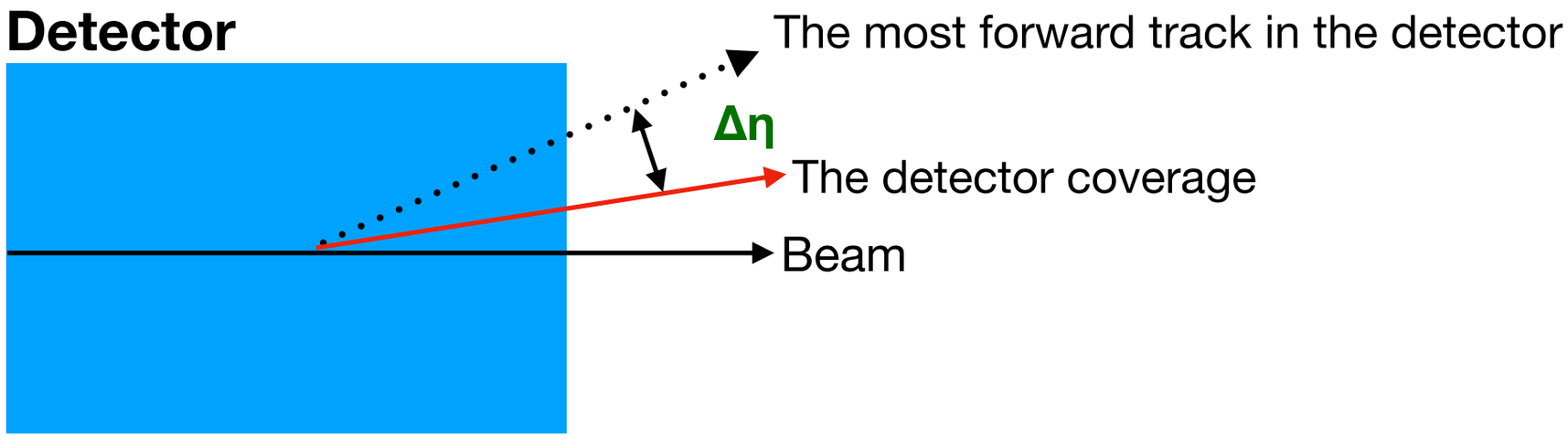
$$efficiency = \frac{NO.\ Accepted\ diffractive\ events}{total\ diffractive\ events}$$

η_{max} cut means the eta of all the tracks in the events should be less than the value of the cut here.

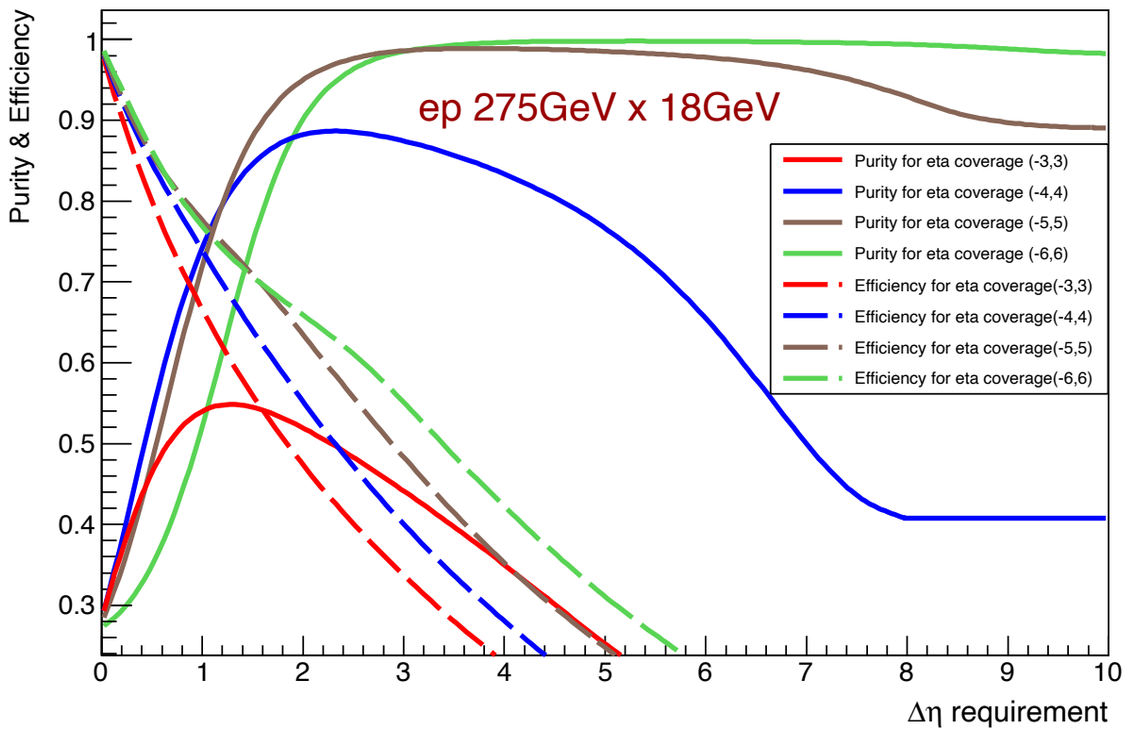


In real case, we can't have the full eta coverage.

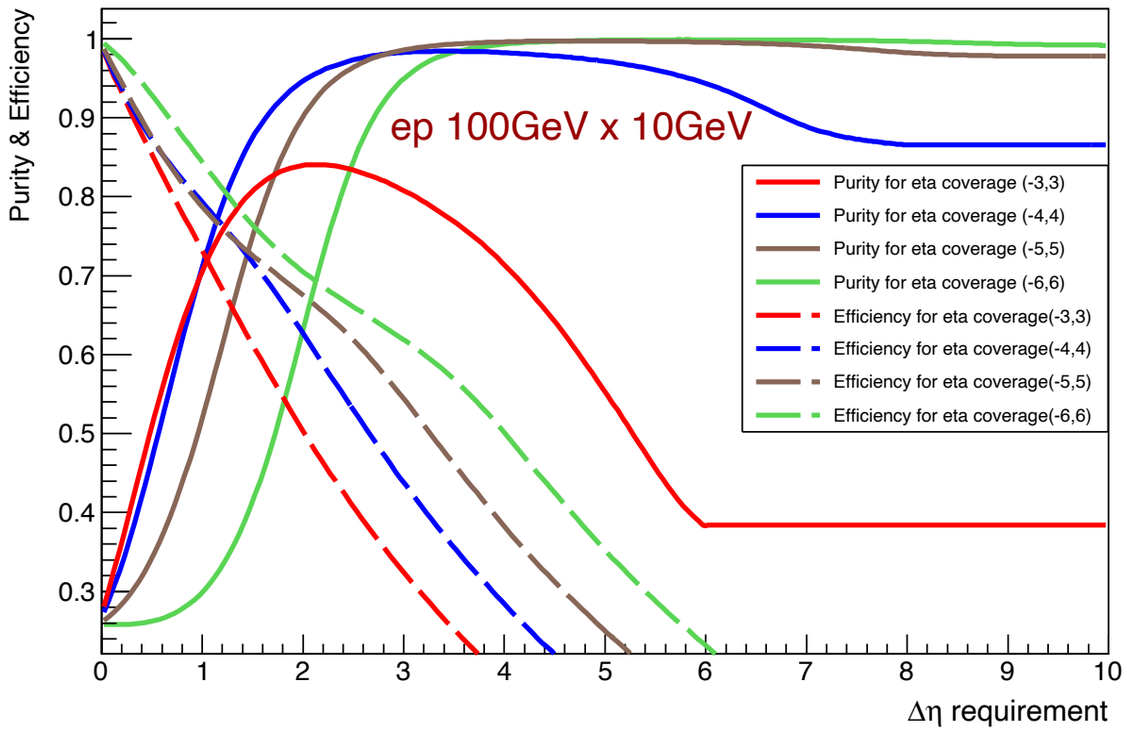
To study the detector acceptance effect, we define Δη.
Δη is the eta gap between the detector forward edge
and the most forward track in the detector coverage.

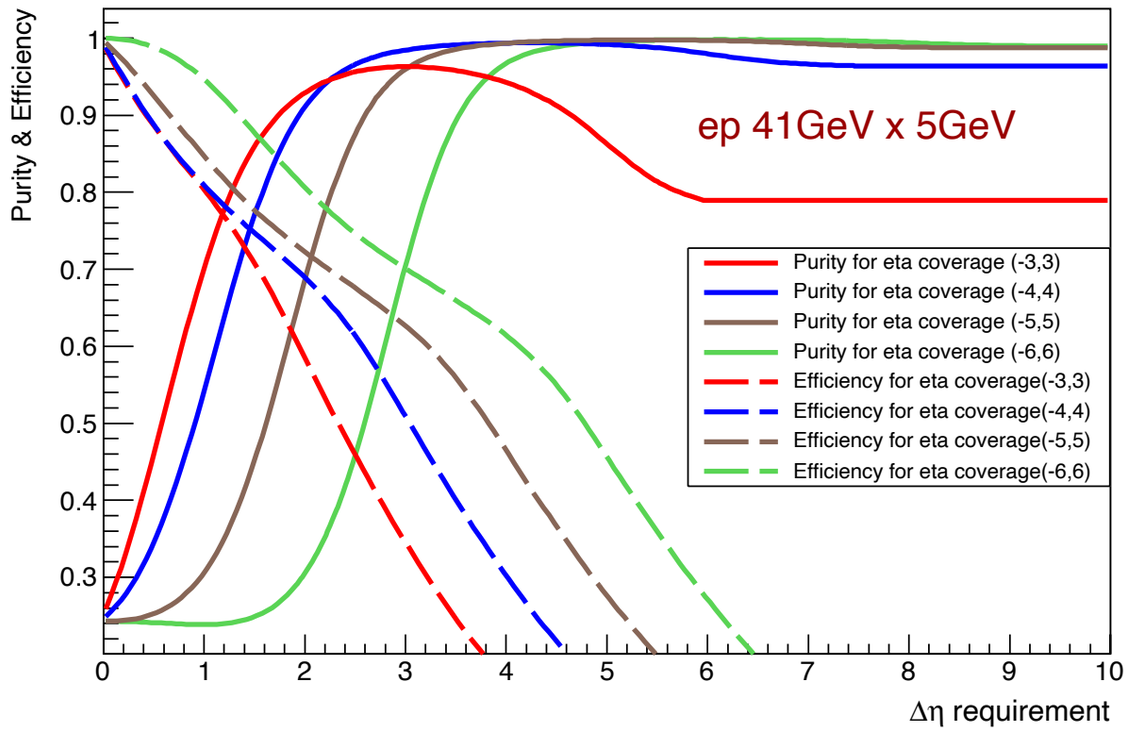


The purity and efficiency for different detector coverer



- Here we show the purity and efficiency vs. eta gap requirement for different detector coverage assumption;
- Eta coverage of (-5,5) would be good enough for selecting diffractive events with high purity and efficiency;





1.e−09<Q²<2

	Process	PYTHIA6 (mb)	PYTHIA8(mb)
softQCD	f + f' -> f + f' (QCD)	3.098E-04	3.757E-04
	f + fbar -> f' + fbar'	5.698E-06	6.111E-06
	f + fbar -> g + g	7.085E-06	8.387E-06
	f + g -> f + g	1.229E-03	1.824E-03
	g + g -> f + fbar	1.823E-05	3.447E-05
	g + g -> g + g	6.887E-04	1.456E-03
	Elastic scattering	2.982E-03	4.084E-03
	Single diffractive (XB)	2.127E-03	2.310E-03
	Single diffractive (AX)	1.741E-03	2.676E-03
	Double diffractive	1.192E-03	1.483E-03
	Non-diffraction		2.819E-02
	Low-pT scattering	8.855E-03	
	q + gamma* -> q (0<Q²<2)	1.717E-02	
	q + gamma* -> q (Q² > 10)	6.919E-05	6.495E-05
	f + gamma*_T -> f + g	1.338E-04	1.618E-04
	f + gamma*_L -> f + g	1.696E-07	
	g + gamma*_T -> f + fbar	4.043E-04	3.859E-04
	g + gamma*_L -> f + fbar	4.725E-06	

Summary

- Beam effects are important, we need to add the effects in our study;
- In Pythia8, we use softQCD processes representing the total cross section of the ep collisions, other processed would be added later;
- We present the eta distribution of the most forward particle for diffractive and non-diffractive events;
- We show the purity and efficiency distribution for different detector eta coverage;

Backup

18GeV

------- PYTHIA Event and Cross Section Statistics -------

Subprocess	Code	Number of events			sigma +- delta
		Tried	Selected	Accepted	(estimated) (mb)
non-diffractive	101	958590	729769	729769	2.824e-02 1.615e-05
A B -> A B elastic	102	142248	104165	104165	4.061e-03 6.511e-06
A B -> X B single diffractive	103	92038	58989	58989	2.290e-03 5.649e-06
A B -> A X single diffractive	104	112750	69490	69490	2.695e-03 6.332e-06
A B -> X X double diffractive	105	96412	37587	37587	1.475e-03 5.944e-06
sum		1402038	1000000	1000000	3.876e-02 2.026e-05

------- End PYTHIA Event and Cross Section Statistics -------

10GeV

------- PYTHIA Event and Cross Section Statistics -------

Subprocess	Code	Number of events			sigma +- delta
		Tried	Selected	Accepted	(estimated) (mb)
non-diffractive	101	930793	741204	741204	1.880e-02 9.857e-06
A B -> A B elastic	102	134659	106217	106217	2.699e-03 3.806e-06
A B -> X B single diffractive	103	90004	56066	56066	1.430e-03 3.710e-06
A B -> A X single diffractive	104	109028	65532	65532	1.669e-03 4.118e-06
A B -> X X double diffractive	105	81723	30981	30981	7.874e-04 3.525e-06
sum		1346207	1000000	1000000	2.539e-02 1.244e-05

------- End PYTHIA Event and Cross Section Statistics -------

5GeV

------- PYTHIA Event and Cross Section Statistics -------

Subprocess	Code	Number of events			sigma +- delta
		Tried	Selected	Accepted	(estimated) (mb)
non-diffractive	101	962360	757103	757103	1.096e-02 5.815e-06
A B -> A B elastic	102	136064	107885	107885	1.561e-03 2.163e-06
A B -> X B single diffractive	103	89642	52273	52273	7.577e-04 2.140e-06
A B -> A X single diffractive	104	106548	60051	60051	8.714e-04 2.349e-06
A B -> X X double diffractive	105	65352	22688	22688	3.264e-04 1.751e-06
sum		1359966	1000000	1000000	1.447e-02 7.188e-06

------- End PYTHIA Event and Cross Section Statistics -------