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Report

MC simulation of underlying event

Student: Orestes Tumbarell Aranda

Supervisor: Hannes Jung

Abstract

A Rivet routine have been developed in order to measure different underlying event observables. A good agreement between simulation results and experimental data is observed. Finally some parameters are changed to observe its influence in the results of the simulation.

Contents

1 Introduction

The underlying event (UE) is defined, in the presence of a hard parton parton scattering with large transverse momentum transfer, as any hadronic activity that is additional to what can be attributed to the hadronization of parton involved in the hard scatter. So the UE is related to the hadronization of partonic constituents that have undergone multiple parton interactions (MPI).

Taking into account that a correct understanding of UE activity is important for precision measurement of standart model processes the main goal of the present work is to implement a Rivet routine to measure the different underlying event observables, compare the results with experimental data and finally to change different parameters to observe its influence in simulation results.

The outline of this work is as follows: Firstly is explained the way to obtain the underlying event observables. Later the simulation results are compared with experimental data [1], [2]. Finally the values of different parameters are changed in order to see the way in which the simulation results are changed.

2 Underlying event observables

To obtain the different underlying event observables, is followed the same path taken at CDF detector in Fermilab, the target is to find stable charged particles whose transverse momentum and pseudorapidity lies in the next range**: pTcut** = 0.5 Gev/c η_{cut} = 0.8.

Besides, the valid events will be those in which at least one charged particle is generated. For each one of these valid events is selected the charged particle with the highest pT, and starting from this direction is measured the azimuthal angle of all the other charged particles generated during the event, if this angle belongs to the range: **60º <φ< 120º** or **240º <φ< 300º** (transverse regions 1 and 2 in figure 1) then the particle is taken into account to obtain the different underlying event observables.

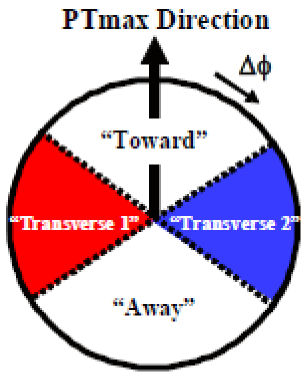


FIGURE 1 TRANSVERSE REGIONS

For each valid event the following magnitudes are defined:

NchgP1, NchgP2: Number of charged particles in each region.

PTsumP1, PTsumP2: scalar pt sum of the charged particles in each region, which allow to define the following transverse magnitudes:

Nchgptot = NchgP1 + NchgP2

NchgPmin = min (NchgP1, NchgP2)

NchgPmax = max (NchgP1, NchgP2)

PTsumPtot = PTsumP1 + PTsumP2

PTsumPmin = min (PTsumP1, PTsumP2)

PTsumPmax = max (PTsumP1, PTsumP2)

From these are define the following densities:

NchgPden = NchgPtot/(2×Area)

NchgPMXden = NchgPmax/Area

NchgPMNden = NchgPmin/Area

PTsumPden = PTsumPtot/(2×Area)

PTsumPMXden = PTsumPmax/Area

PTsumPMNden = PTsumPmin/Area

$$\text{where Area} = 2\eta_{cut} \times \frac{2\pi}{6} \xrightarrow[\eta_{cut}=0.8]{} 1.6 \times \frac{2\pi}{6} \approx 1.6755$$

NchgPDFden = NchgPMXden – NchgPMNden

PTsumPDFden = PTsumPMXden – PTsumPMNden

Once that the previous densities are defined for each valid event, the average densities are obtained adding all the event contributions, and dividing by the total number of valid events.

In this way the following UE observables are obtained:

NchgPden = “transAVE” charged particle density

NchgPMXden = “transMAX” charged particle density

NchgPMNden = “transMIN” charged particle density

NchgPDFden = “transDIF” charged particle density

PTsumPden = “transAVE” charged PTsum density

PTsumPMXden = “transMAX” charged PTsum density

PTsumPMNden = “transMIN” charged PTsum density

PTsumPDFden = “transDIF” charged PTsum density

3 Comparison with experimental data

Once the UE observables are defined, and using the set of parameters listed in table1 for generator Pythia6, the different underlying event observables are obtained, and the results are compared with experimental data.

TABLE 1 SET OF PYTHIA6 PARAMETERS

Parameter	Value	Parameter	Value
MSEL	0	MSTP(52)	2
MSUB(91)	1	PARP(82)	1.921
MSUB(93)	1	PARP(89)	1800
MSUB(94)	1	PARP(90)	0.227
MSUB(95)	1	MSTP(95)	6
MSUB(11)	1	PARP(77)	1.016
MSUB(12)	1	PARP(78)	0.538
MSUB(13)	1	PARP(80)	0.1
MSUB(28)	1	PARP(83)	0.356
MSUB(53)	1	PARP(84)	0.651
MSTU(21)	1	PARP(62)	1.025
MSTJ(22)	2	MSTP(91)	1
PARJ(71)	10	PARP(93)	10.0
MSTP(33)	0	MSTP(81)	21
MSTP(2)	1	MSTP(82)	4
MSTP(51)	10042		

The results of the routine are compared, first, with experimental data from CDF detector at three different energies: 300 GeV, 900 GeV and 1.96 TeV, and then with data from CMS detector at 900 GeV and 7 TeV.

The agreement is good, being better at higher energies.

Figure 2 UE observables at 300 GeV. Comparison with CDF data

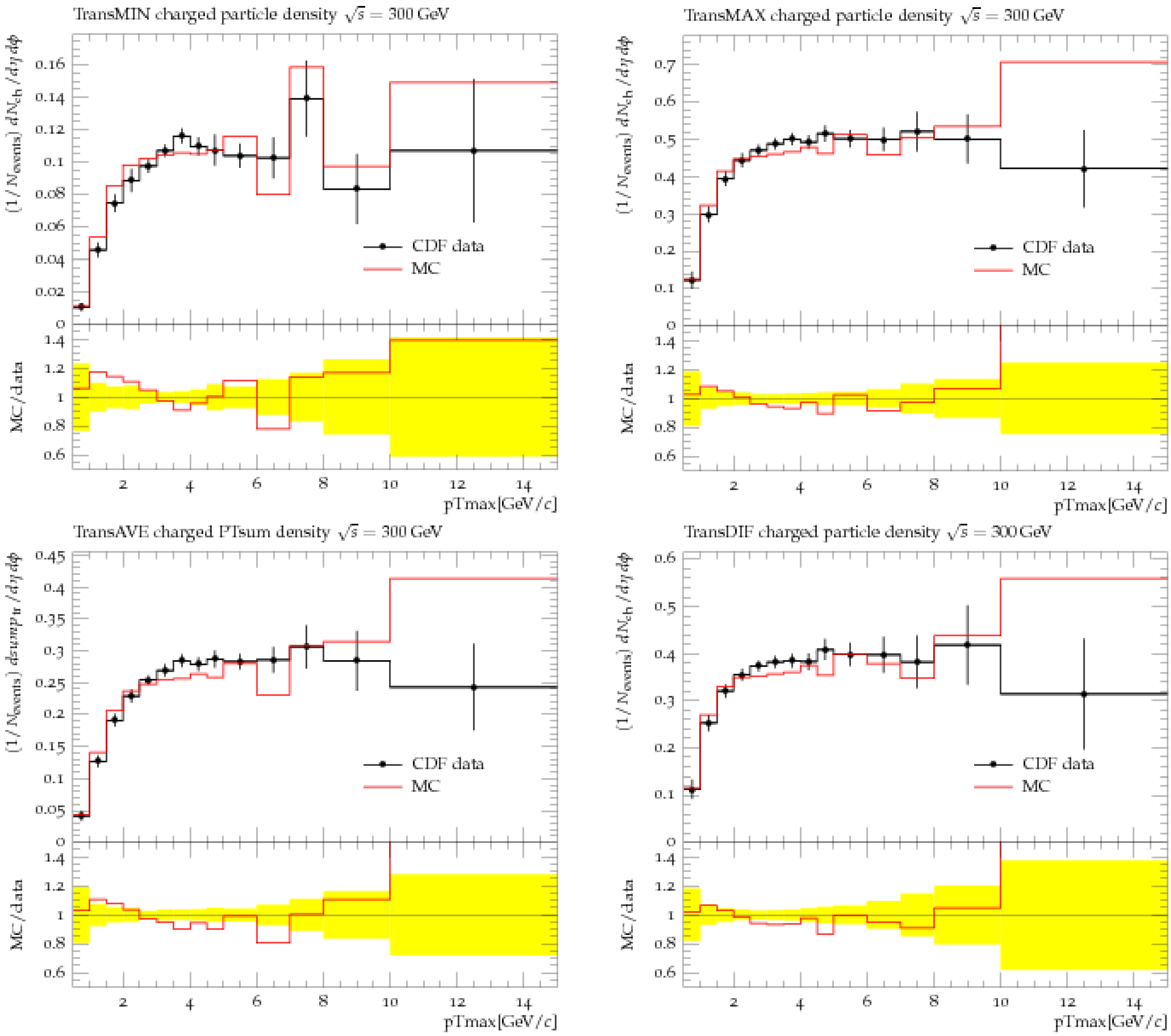


FIGURE 3 UE OBSERVABLES AT 300 GEV. COMPARISON WITH CDF DATA

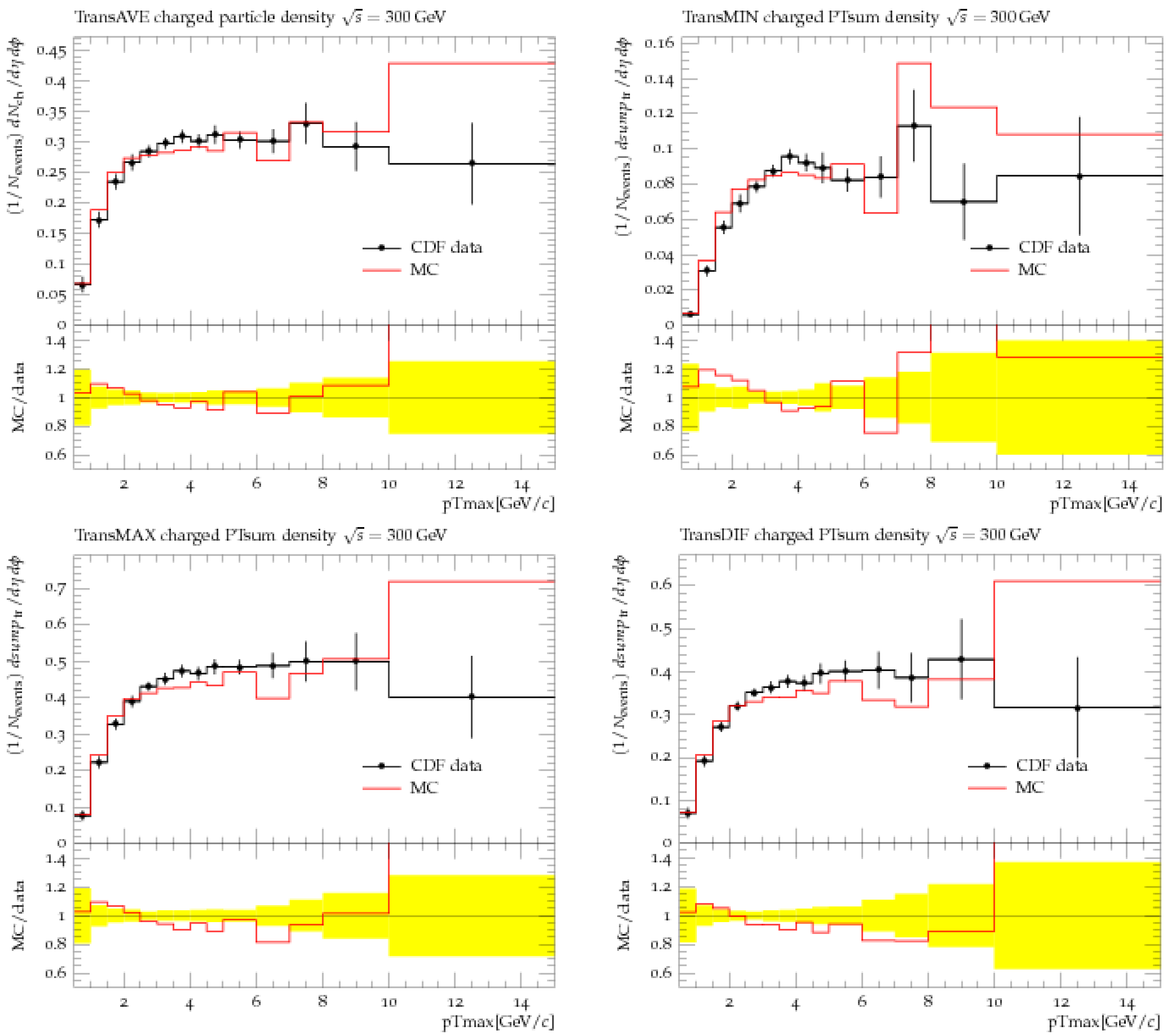


FIGURE 4 UE OBSERVABLES AT 900 GEV. COMPARISON WITH CDF DATA

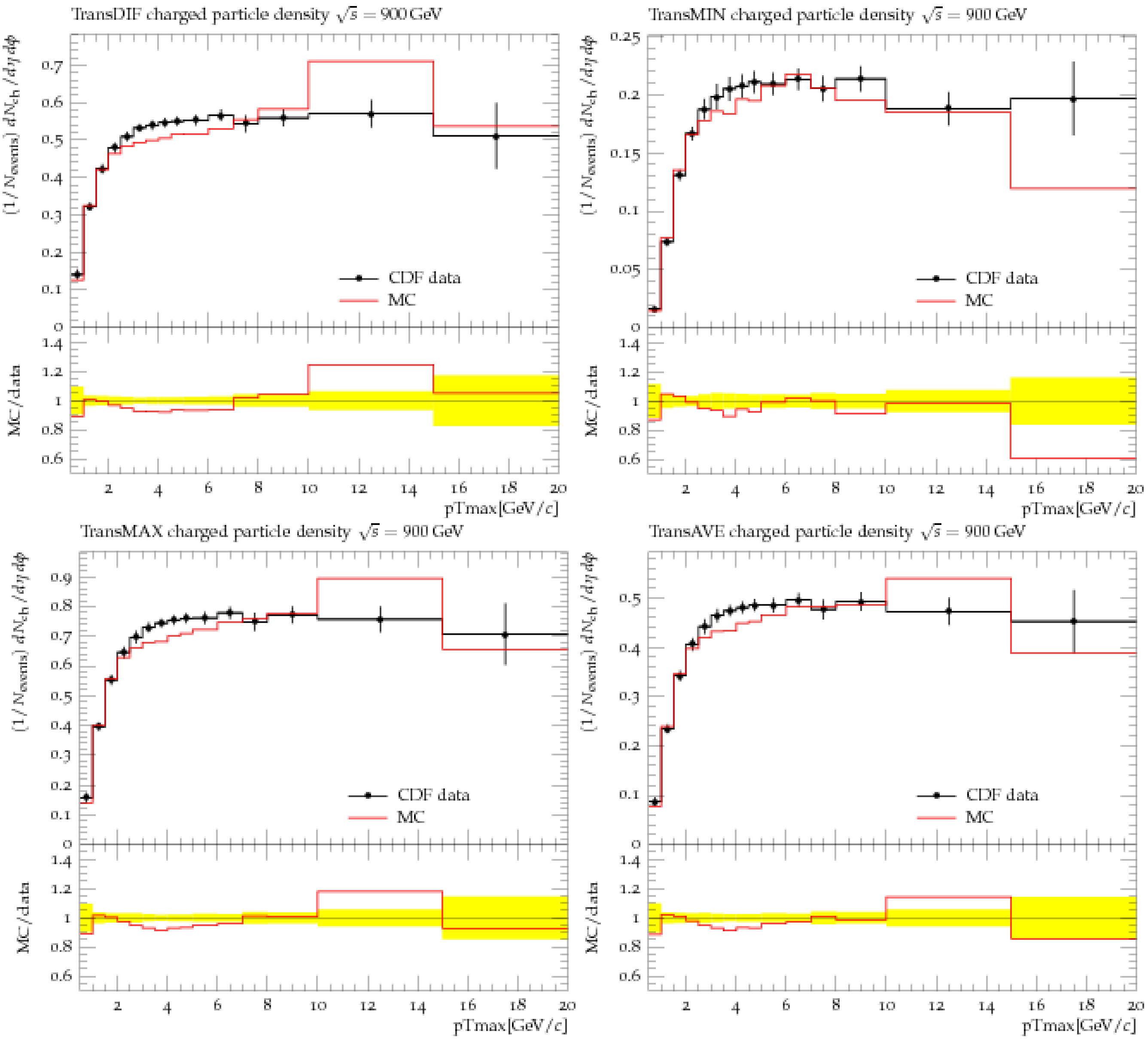


FIGURE 5 UE OBSERVABLES AT 0.9 TEV. COMPARISON WITH CDF DATA

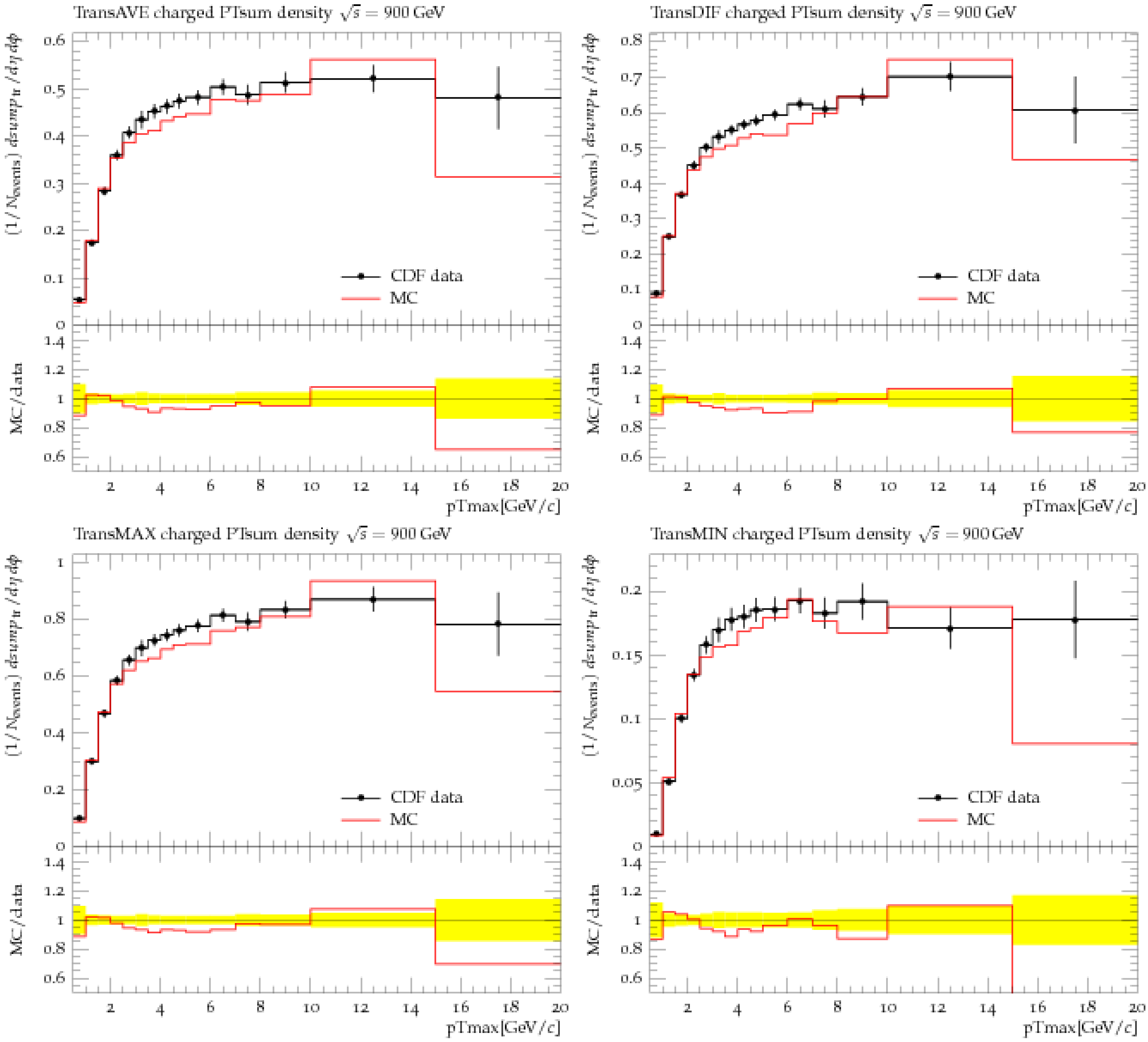


FIGURE 6 UE OBSERVABLES AT 1.96 TEV. COMPARISON WITH CDF DATA

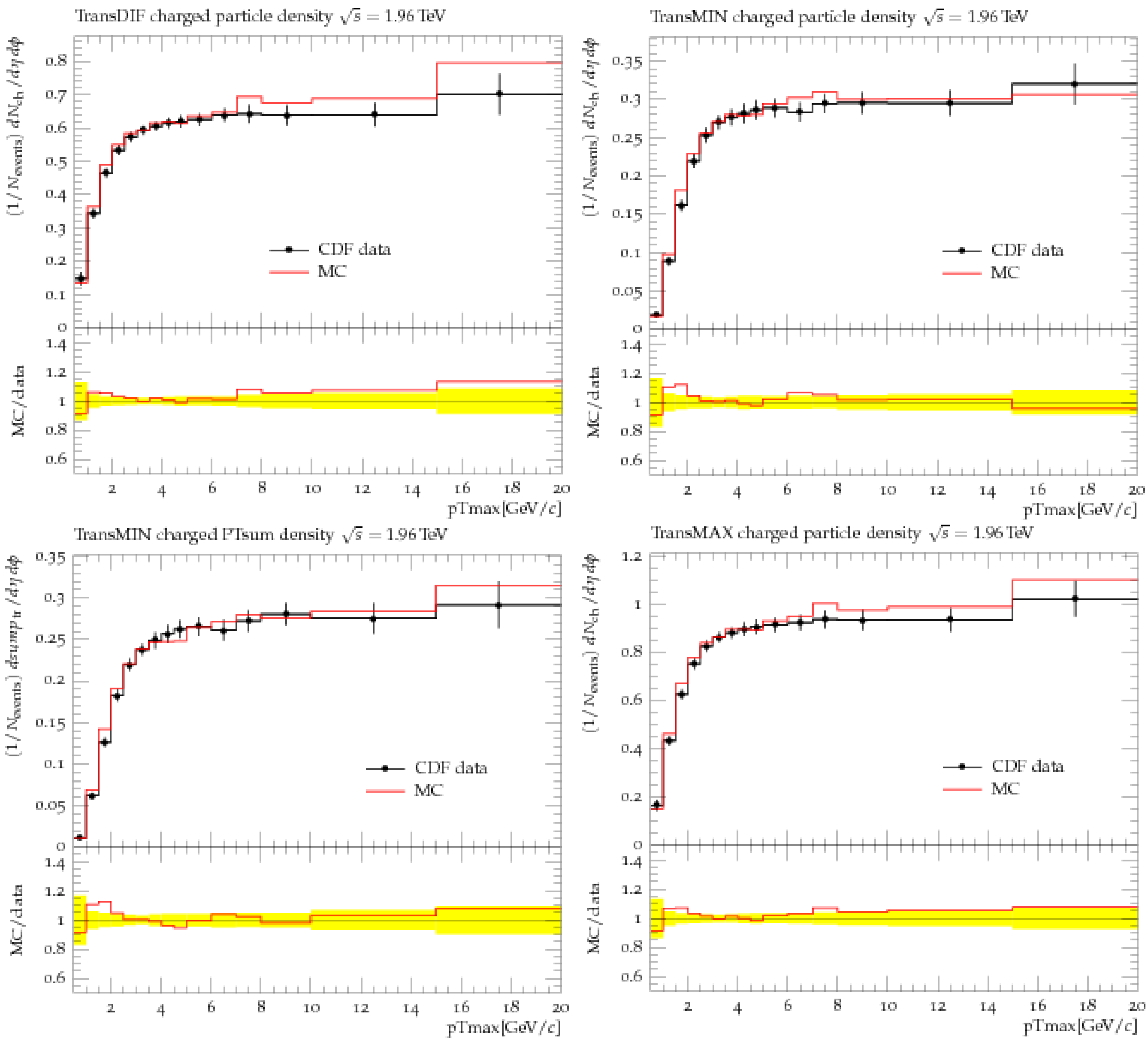
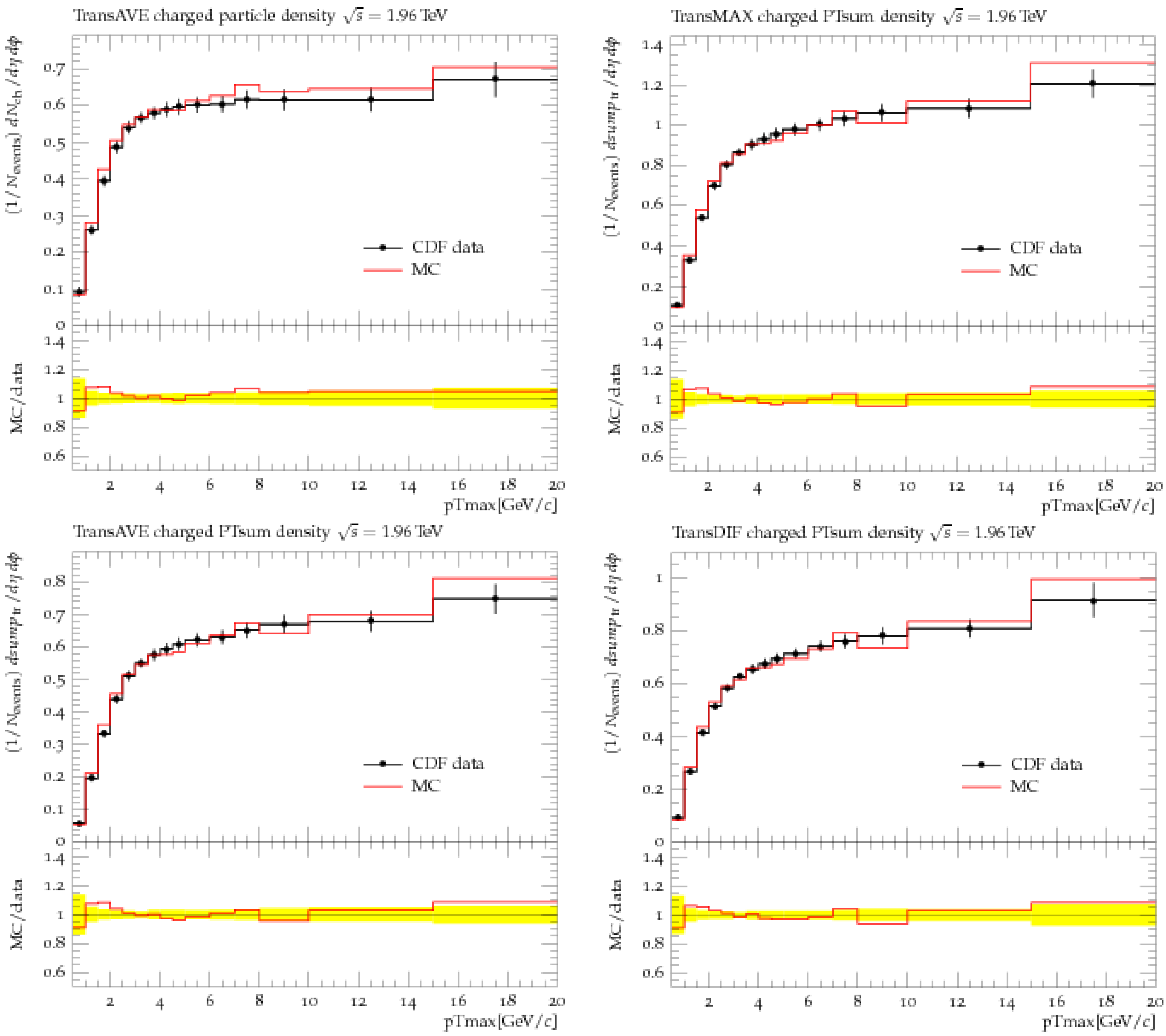


FIGURE 7 UE OBSERVABLES AT 1.96 TEV. COMPARISON WITH CDF DATA

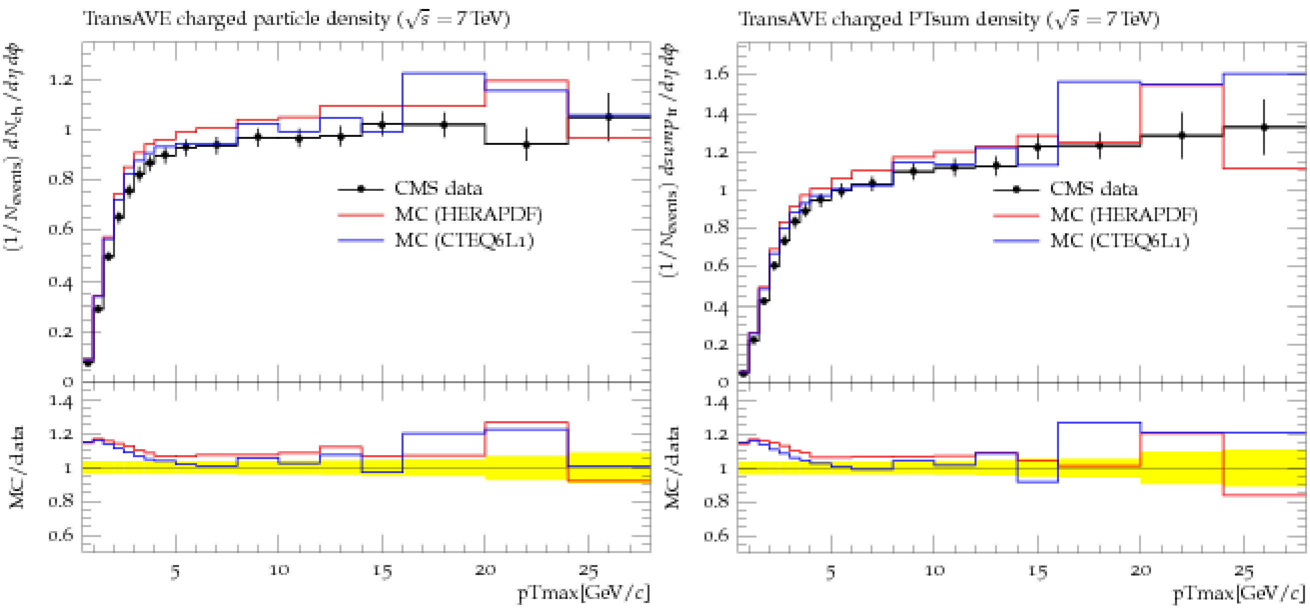


4 Changing parameters

At this point would be interesting to change some parameters to observe how are modified the simulation results.

First are shown the results of the simulation with two different parton distribution functions.

FIGURE 8 DIFFERENT PARTON DISTRIBUTION FUNCTIONS. EXPERIMENTAL DATA FROM CMS DETECTOR



The best agreement is achieved with CTEQ6L1, although the differences are not so big.

The graphics below correspond to the switching off and on of the MPI, is evident that when the MPI is switching off, the results of the simulation are far removed from experimental data. By definition, UE activity is related to MPI, so, any model who tries to describe correctly UE must take into account the MPI.

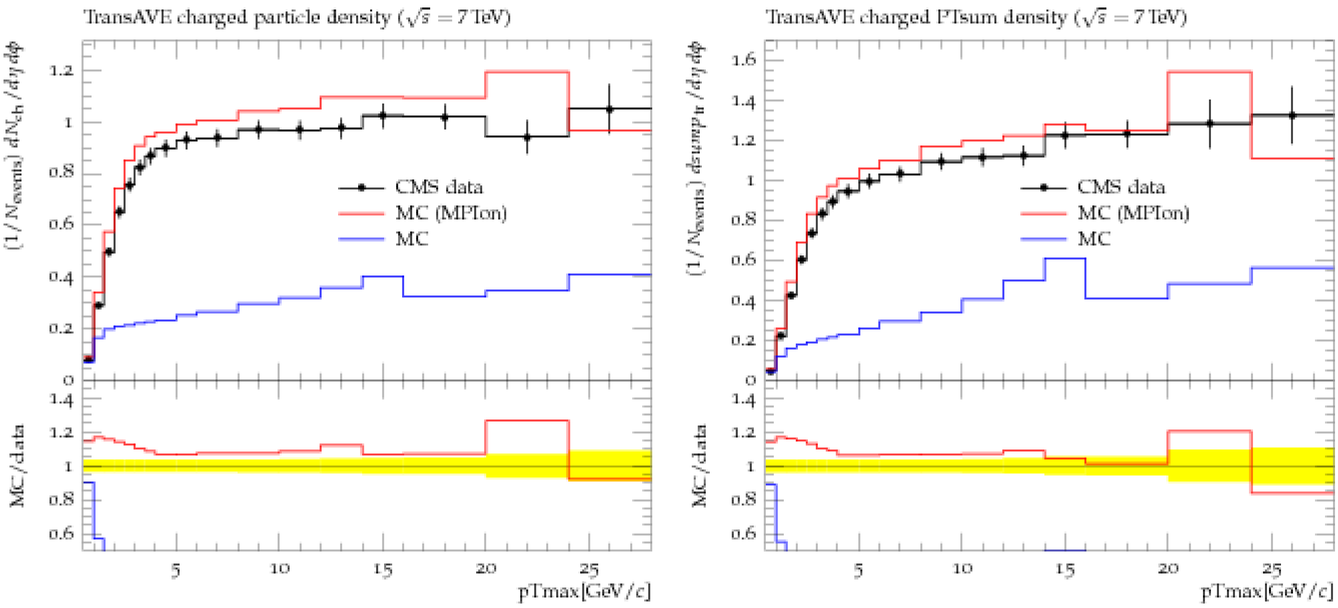


FIGURE 9 SWITCHING ON AND OFF MPI

5 Summary and conclusions

A Rivet routine has been implemented in order to evaluate the underlying event, following the same path taken at CDF detector in Fermilab.

The results have been compared with experimental data from CDF and CMS detectors, obtaining a good agreement, which is better with the increase of the energy.

Some parameters of the generator have been changed, in order to observe its influence in the simulation results, being evident the strong influence of MPI in the UE activity.

6 Acknowledgements

Thanks to DESY, especially to Mr Hannes Jung and its marvellous work group for the opportunity to be here and to learn something about High Energy Physics in one of the best places in the world to do that.

7 References

[1] CMS collaboration, *Measurament of the underlying event activity at the LHC with* $\sqrt{s} = 7\ TeV$ *and comparison with* $\sqrt{s} = 0.9\ TeV$ [doi: 10.1007/JHEP09 (2011)109].

[2] R. Field, *Physics at the Tevatron*, Acta Phys. Polon. **B 39** (2008) 2611 [SPIRES].