Understanding Where the Dijets are in the Data Sample

Varsha ramakrishnan

$p\bar{p}$ collision at $\sqrt{s} = 1.96$ TeV. The events are selected with photon candidate transverse momentum p_T^γ within $60 \leq p_T^\gamma \leq 80$ GeV, leading jet $p_T > 25$ GeV and two additional jets with $p_T > 15$ GeV. The values of f_{DP} are measured in three intervals of the second jet transverse momentum p_T^{jet2} which spans the range of $15 \leq p_T^{jet2} \leq 30$ GeV. We found that the f_{DP} fractions drop with increasing p_T^{jet2}. In the same three p_T^{jet2} intervals, we also calculate an effective cross section σ_{eff}, a process-independent parameter which contains information about the parton density inside the proton and represents possible parton correlations. The value obtained from averaging over the three p_T^{jet2} intervals is $\sigma_{eff}^{aver.} = 15.1 \pm 1.9$ mb.

II. Any pair of objects (photon and jets) must be separated in the $\eta - \phi$ space by $\Delta R(\eta, \phi) > 0.5$ to avoid photon and/or jets overlapping. To suppress background from $W \rightarrow e\nu$ events and cosmics, the missing transverse energy in the event is required to fulfill $E_T^{miss} < 0.7\, p_T^\gamma$.

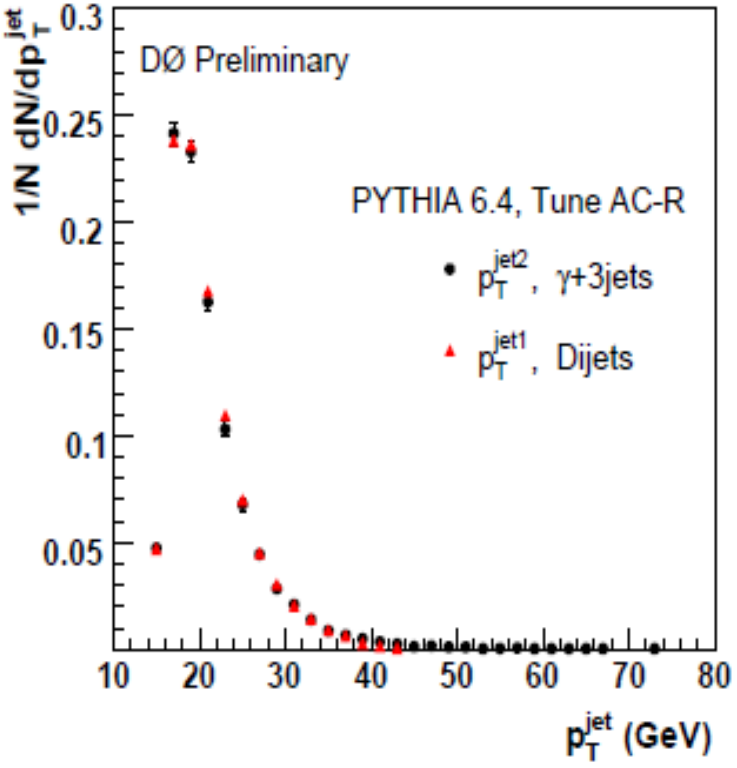
PREVIOUS CDF ANALYSIS	MY CUTS
Leading and Second Jet PT > 5 GeV && <300 GeV	Leading and Second Jet Pt >7 GeV
ONLY 3 Jets	Only TWO Jets
ΔR(Photon,Jet)>0.8 ,ΔR(Jet1,Jet2)>0.7	ΔR(Electron,Closest-Jet)>0.92 ,Δφ(Electron,MET)>0.7 ,Δφ(Jet,MET)>0.7

The assumption that the additional interaction in the DP events can be considered as independent from the main hard interaction was tested using PYTHIA [12]. In that case, the regular dijet events should describe very well kinematic properties of the second interaction in the DP events. A telling illustration of the independence of the DP interactions could be the p_T and η distributions of the dijet events produced in the $\gamma + 3$ jets DP and regular dijet events. As a

[12] T. Sjöstrand, Comp. Phys. Comm. **82** 74 (1995) 74. Version 6.4 has been used here.

model for the DP events, we simulated $\gamma + 3$ jets events without initial and final state radiation but with the MPI model (tune A-CR) turned on [1]. This should guarantee that the jets produced in addition to the leading jet in the $\gamma + 3$ jets system are caused by just additional interactions. The regular dijets events were generated without initial

[1] Tune A-CR is usually considered as an example of a model with strong color reconnections and usually give "extreme" predictions for track multiplicities and/or average hadron p_T (see http://home.fnal.gov/~mskands/leshouches-plots/ and also, for example, Fig. 2 from hep-ph arXiv:0807.3248.)



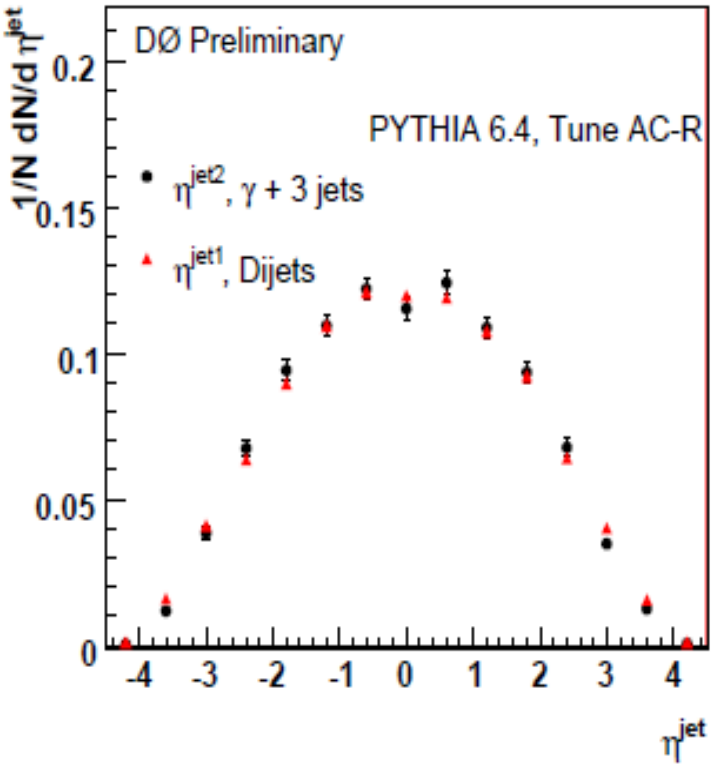


FIG. 1: Difference between the p_T spectra of the second jet in γ + jets events (black circles) and the first jet in the dijet events (red triangles), generated with "tune A-CR" MPI model.

and final state radiation as well, using tune A-CR for the MPI model. The left plot in Fig. 1 compares the p_T spectra of the first jet from DP interaction (second jet in γ + jets events, black circles) and the first jet in the dijet events (red triangles) while right plot compares the η distributions of these jets. We can see a good agreement between kinematics of the second parton interaction and regular dijet events. The same comparison has been done using tunes A and S0 with similar good agreement. Another convincing test of this topic is discussed in the Section V (see the text to Fig. 7).

In the present analysis, we analyse a sample of photon candidate with at least 3 jets events (refered below as "$\gamma + 3$ jets" events) collected by the D0 experiment during Run IIa with an integrated luminosity of 1 fb^{-1} in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV to determine the fraction of the double parton interaction in a single $p\bar{p}$ collision and also the value of σ_{eff}. The latter allows, given the $\gamma +$ jets $\sigma^{\gamma j}$ and dijet σ^{jj} cross sections, the calculation of the σ_{DPS} cross section as:

$$\sigma_{DPS} \equiv \frac{\sigma^{\gamma j}\sigma^{jj}}{\sigma_{\text{eff}}} \qquad (1)$$

We use two models for DP and DI events which are obtained by combining pairs of real events. For the DP model we mixed 1VTX $\gamma+ \geq 1$ jet events and 1VTX minimum bias (MB) events with ≥ 1 jets. The resulting mixed event with jets re-ordered in p_T are also required to have at least one photon candidate and at least three jets with the criteria described above. As we see, the built DP model (called MIXDP) [11] assumes *independent scatterings of* $\gamma+$jet *and dijet events by construction.*

To build the DI model we exploit the fact that the jets in this sample should originate from separate $p\bar{p}$ collisions. This condition is satisfied by preparing a mixture of $\gamma+\geq 1$ jet events from the 2VTX $\gamma+$ jets data with the 2VTX MB events with ≥ 1 jets. In case of ≥ 2 jets in the MB component of the mixture, the jets are required to originate from the same vertex using the jet tracks information. Similarly to MIXDP, in the mixed events, the jets are re-ordered in p_T and required to pass the $\gamma+3$ jets event selection. We will call this model MIXDI. As a background to the DI events, we also consider the 2VTX $\gamma+3$ jets sample without a hard interaction in the second vertex (BKG2VTX). It was obtained by a direct requirement that all three jets originate from the same vertex using the jet tracks information.

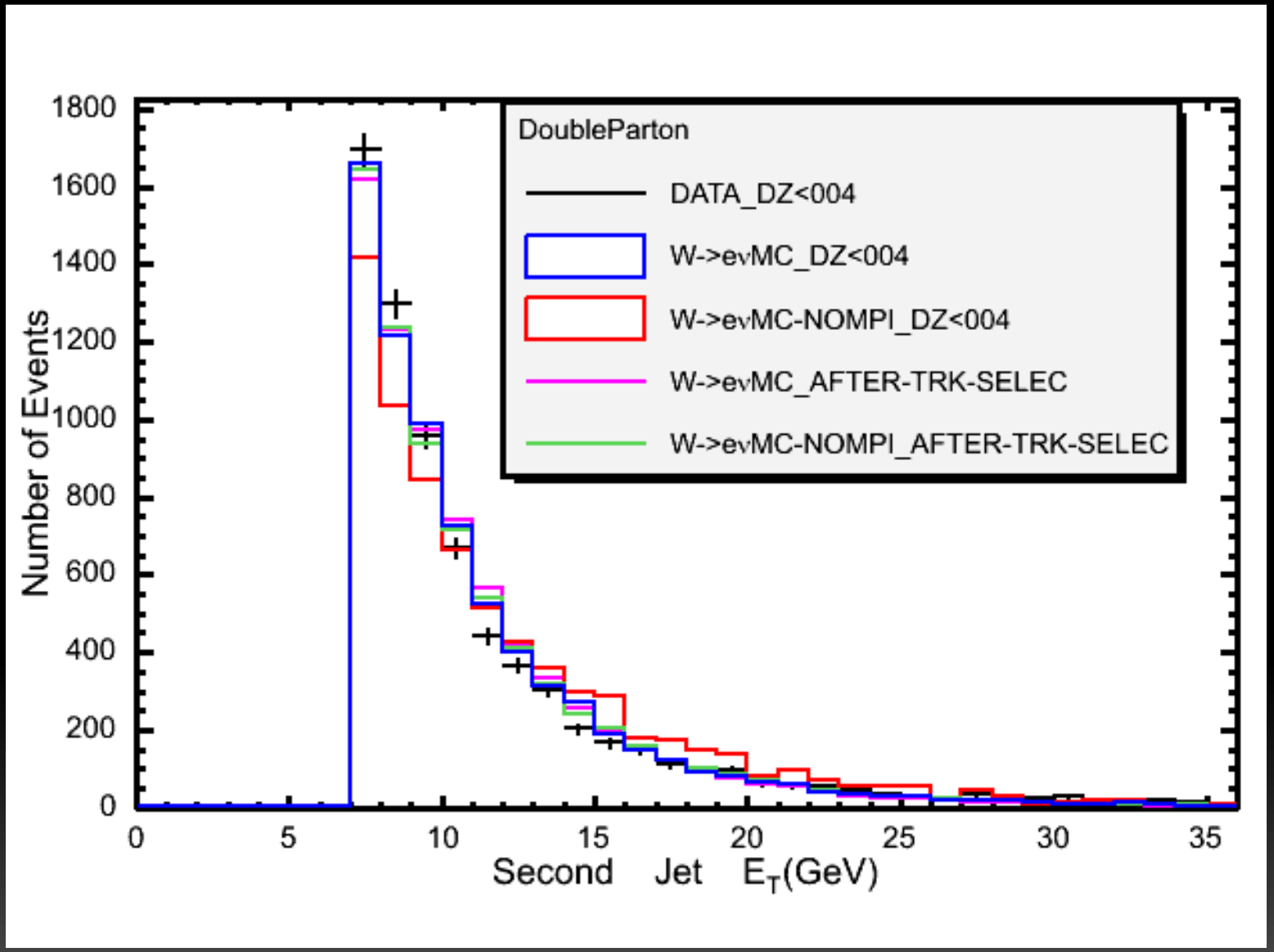
It is worth emphasizing that MIXDP and MIXDI samples differ only by the size of "underlying event" energy that comes from soft interactions in either one or two $p\bar{p}$ collisions. This energy contributes to the jet and photon ID cones

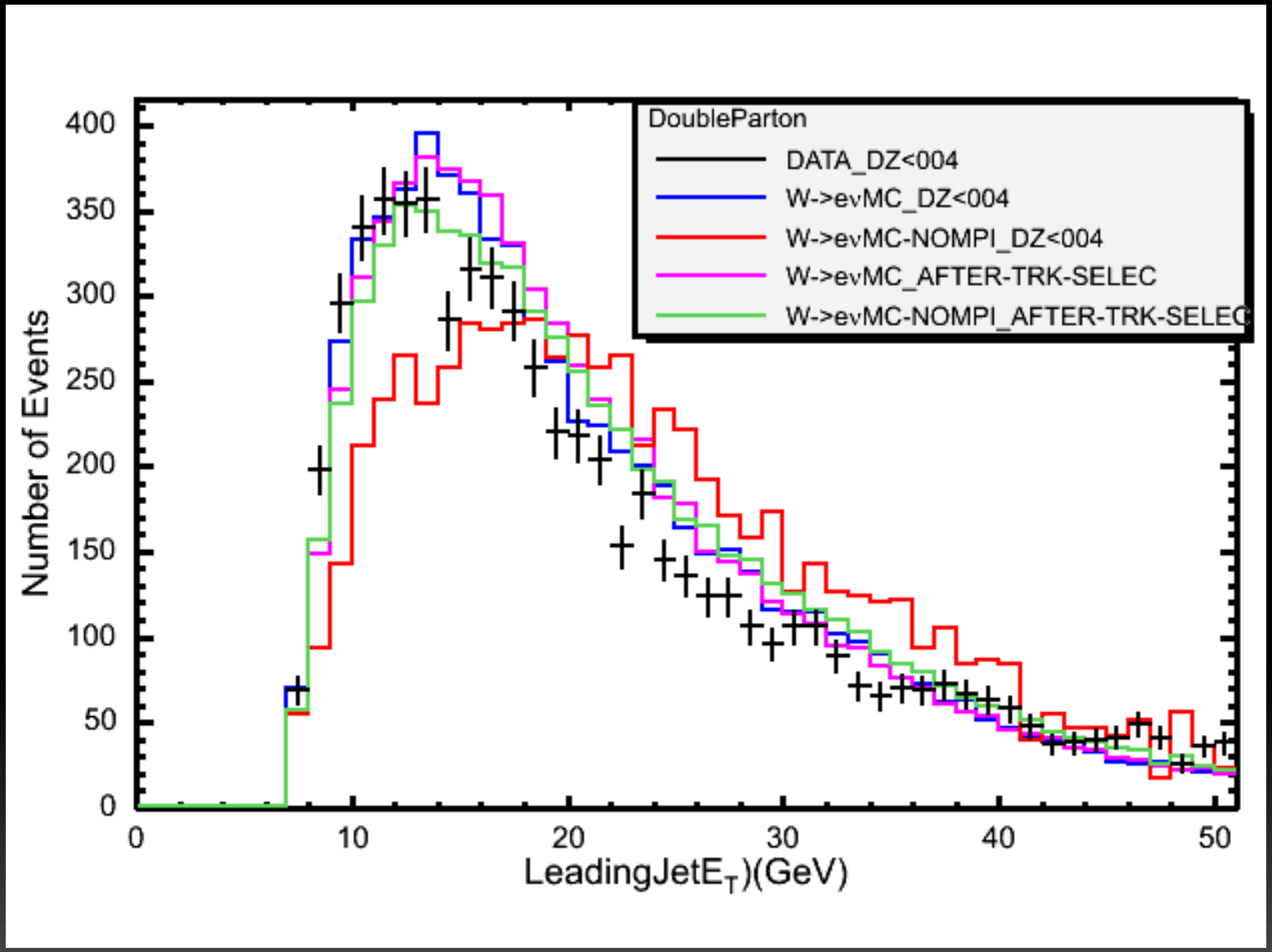
Conclusion

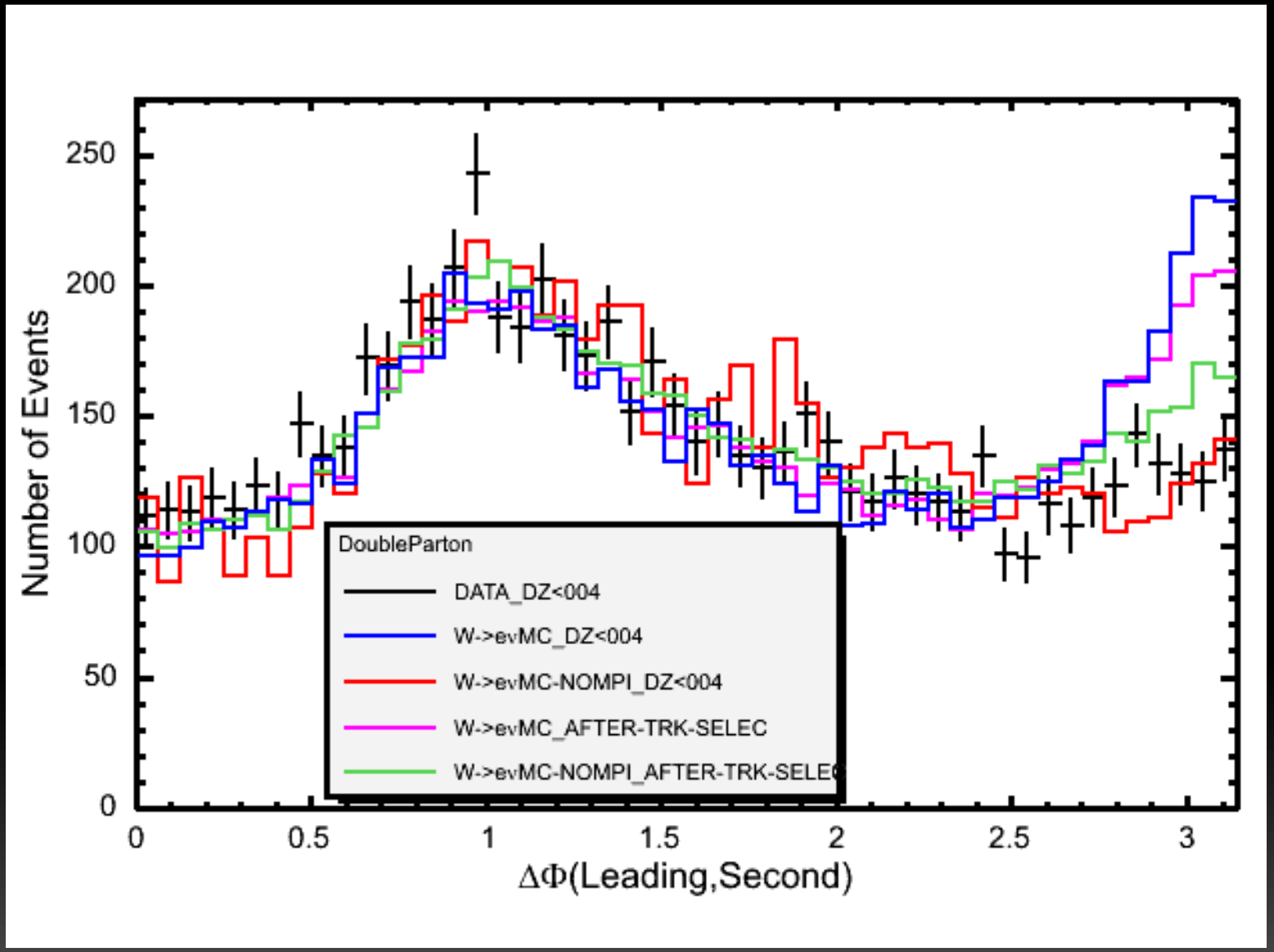
Previous Double Parton analysis Cuts	Relevance to My analysis
Mixing in Minbias Jets at the Reconstruction Level(Increases DiJets in DATA)	I don't have enough Dijets in my Data Sample Low Jet ET➔ Not Dijet enough Highers Jet ET-> Low Statis
Asymmetric Jet ET cuts on Leading and Second	Adding in the Minbias Excludes the Leading from having to balance the Second Jet

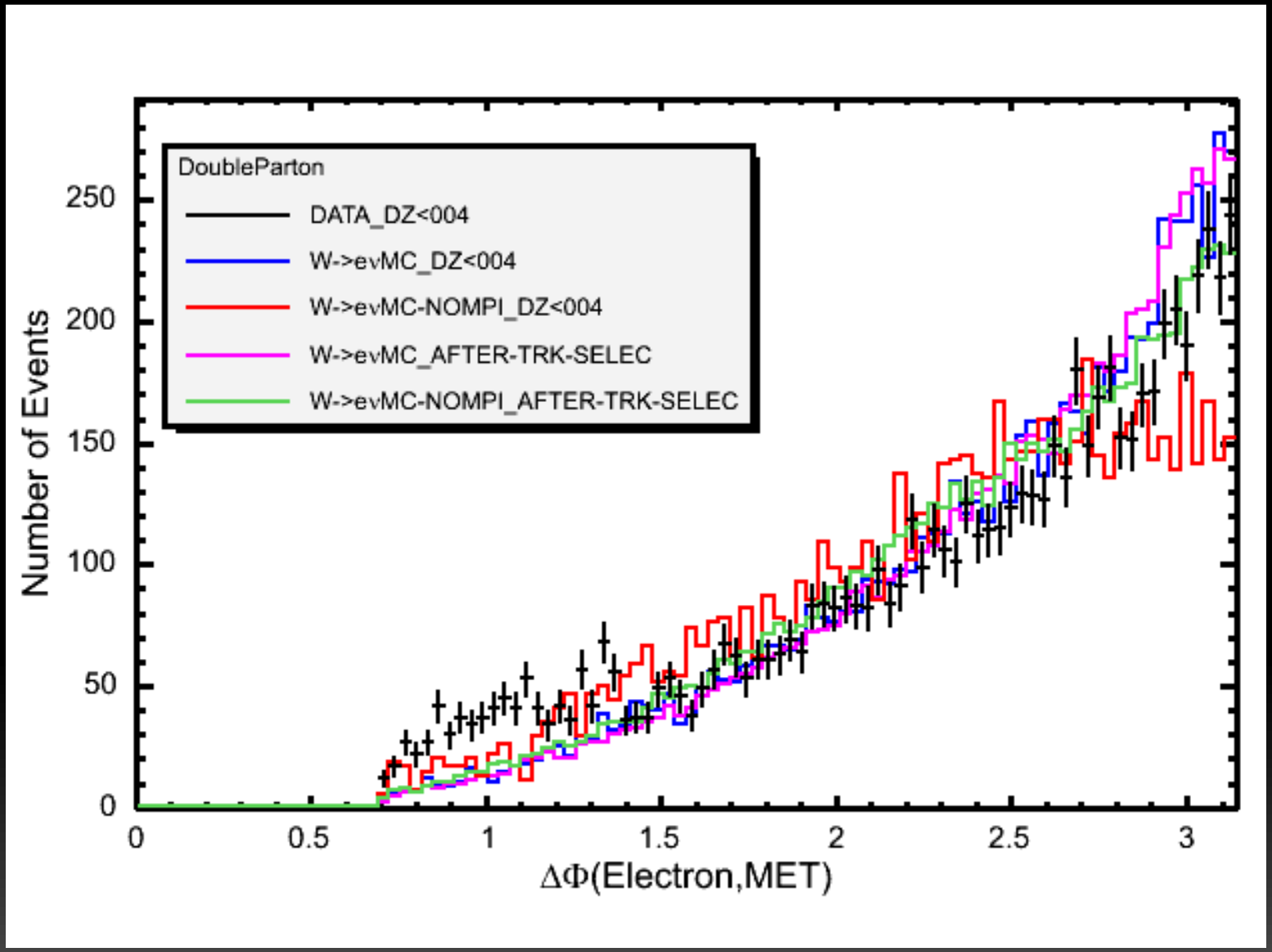
LEGENDS ON THE PLOTS	CUTS THE SIGNIFY
AFTER_TRK_SELEC	Select events that have ATLEAST ONE Track 11 THAT lies $\Delta R(Jet\_Centroid,Track11)<0.8$ AND $\Delta Z(Jet\_Centroid,Track11)<0.04cm$
DZ<004	$\Delta Z(Electron,Leading)<0.04cm$ $\Delta Z(Electron,Second)<0.04cm$ $\Delta Z(Leading,Second)<0.04cm$
ELEMET>2.5	$\Delta\varphi(Electron,MET)>2.5$
[DZ<004+ELEMET>2.5]	$\Delta Z(Electron,Leading)<0.04cm$ $\Delta Z(Electron,Second)<0.04cm$ $\Delta Z(Leading,Second)<0.04cm$ $\Delta\varphi(Electron,MET)>2.5$

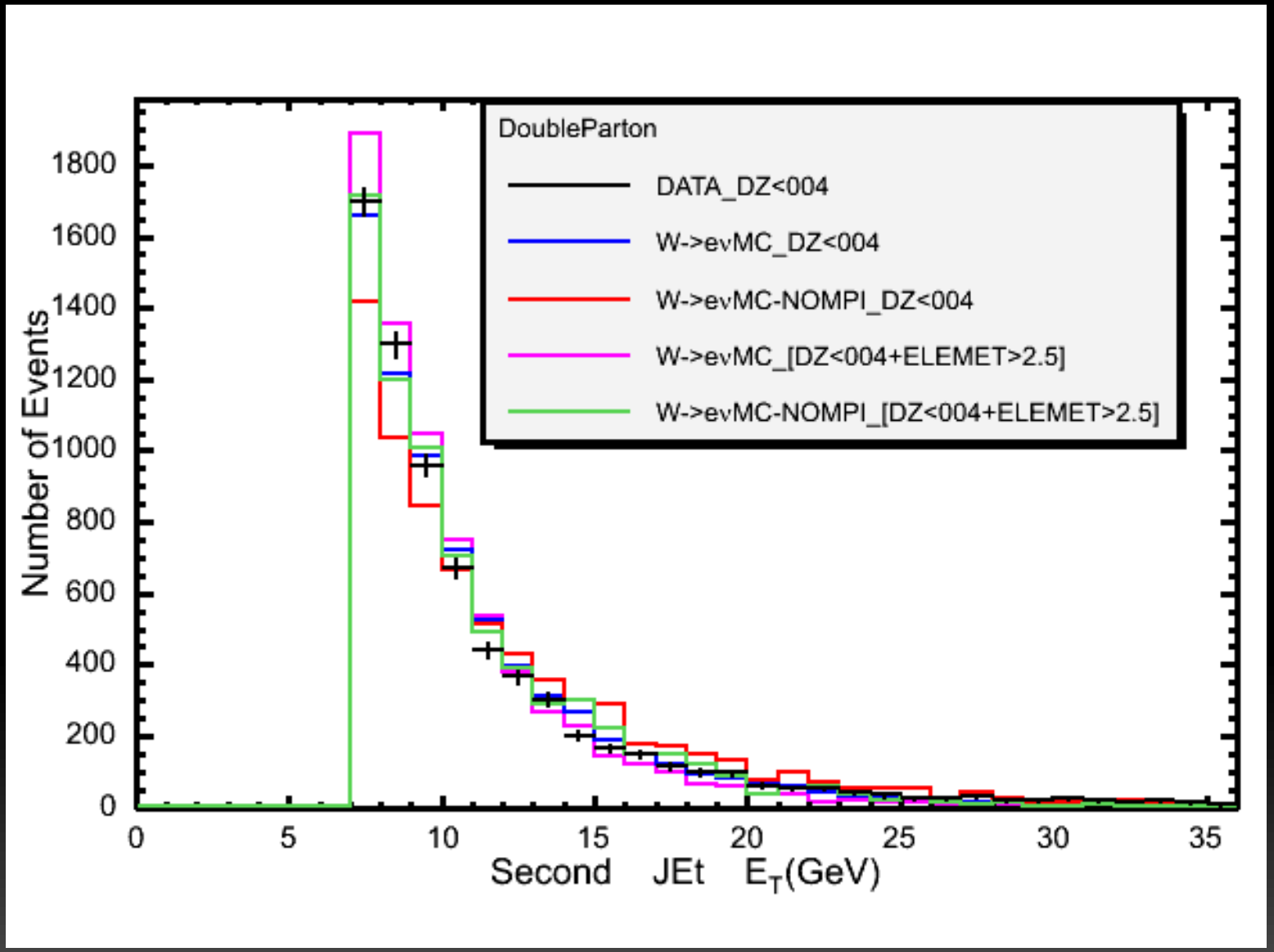
SECOND JET ET

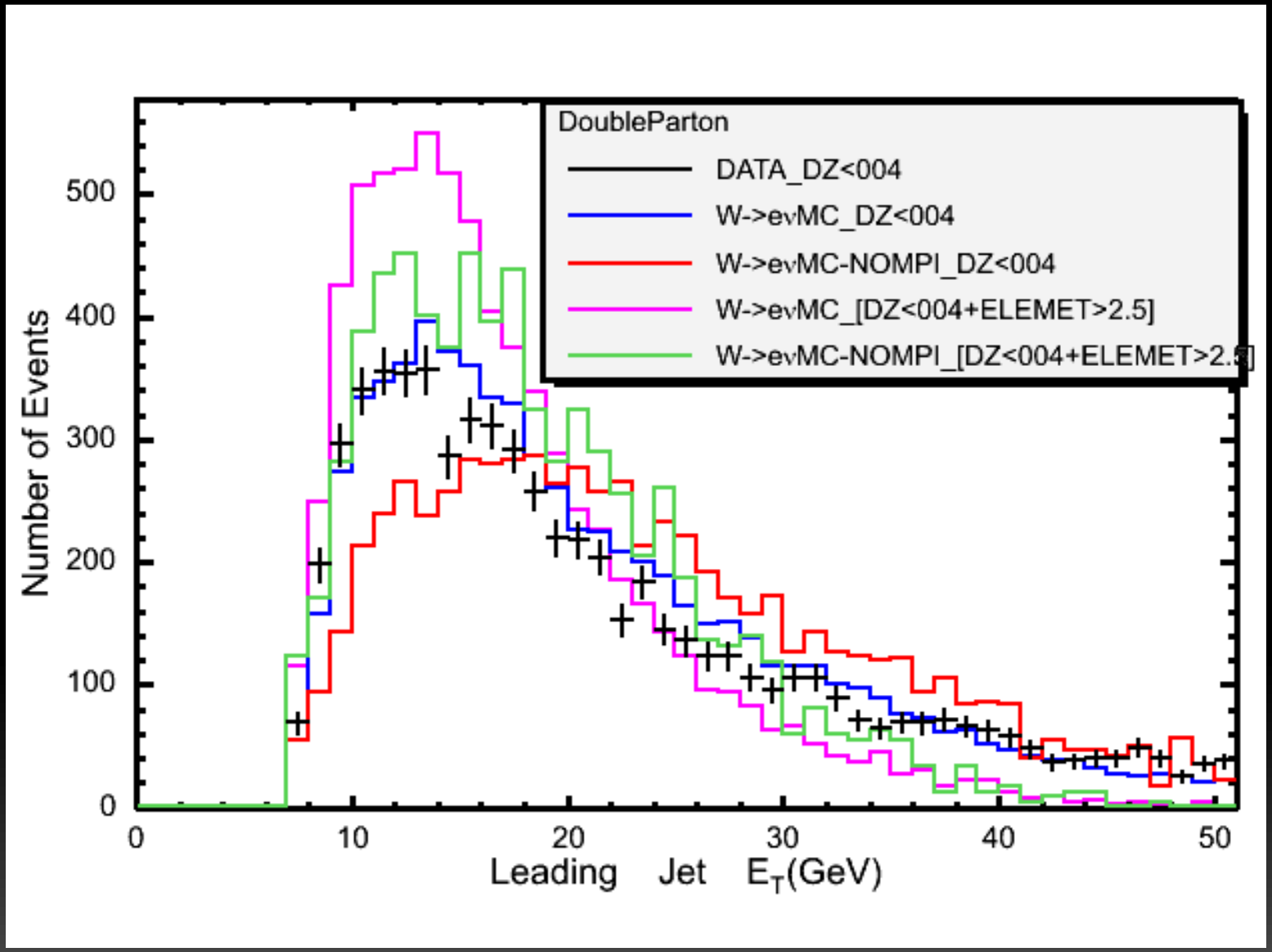


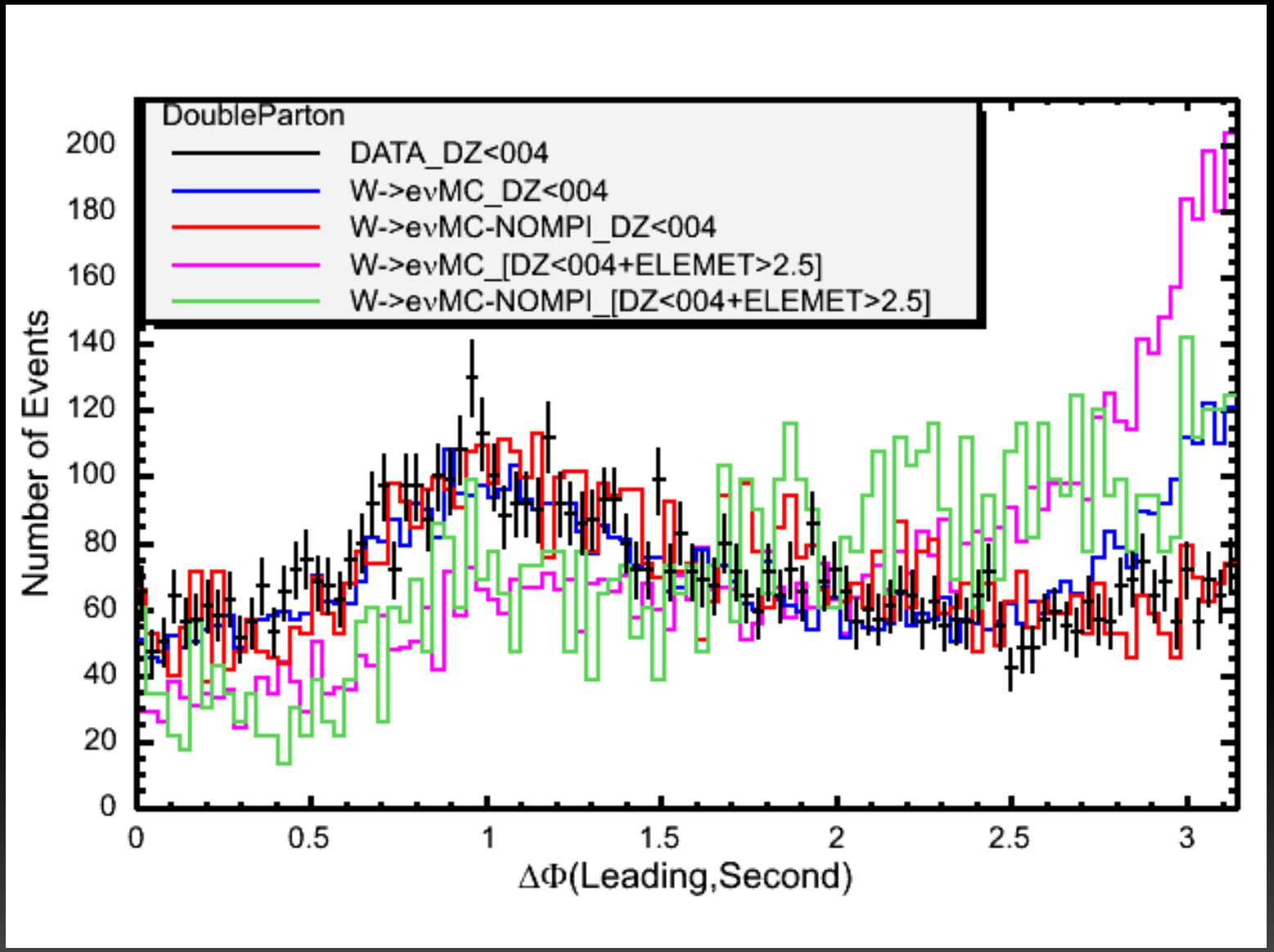

DoubleParton
DATA_DZ<004
W->evMC_DZ<004
W->evMC-NOMPI_DZ<004
W->evMC_AFTER-TRK-SELEC
W->evMC-NOMPI_AFTER-TRK-SELEC
Number of Events
0
50
100
150
200
250
300
350
400
0
10
20
30
40
50
LeadingJetE$_T$)(GeV)


Number of Events
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
ΔΦ(Leading,Second)
DoubleParton
DATA_DZ<004
W->evMC_DZ<004
W->evMC-NOMPI_DZ<004
W->evMC_AFTER-TRK-SELEC
W->evMC-NOMPI_AFTER-TRK-SELE


DoubleParton
DATA_DZ<004
W->evMC_DZ<004
W->evMC-NOMPI_DZ<004
W->evMC_AFTER-TRK-SELEC
W->evMC-NOMPI_AFTER-TRK-SELEC
Number of Events
0
50
100
150
200
250
0
0.5
1
1.5
2
2.5
3
ΔΦ(Electron,MET)


DoubleParton
DATA_DZ<004
W->evMC_DZ<004
W->evMC-NOMPI_DZ<004
W->evMC_[DZ<004+ELEMET>2.5]
W->evMC-NOMPI_[DZ<004+ELEMET>2.5]
Number of Events
0
200
400
600
800
1000
1200
1400
1600
1800
0
5
10
15
20
25
30
35
Second JEt E_T(GeV)


DoubleParton
DATA_DZ<004
W->evMC_DZ<004
W->evMC-NOMPI_DZ<004
W->evMC_[DZ<004+ELEMET>2.5]
W->evMC-NOMPI_[DZ<004+ELEMET>2.5]
Number of Events
0
100
200
300
400
500
0
10
20
30
40
50
Leading Jet E_T(GeV)


DoubleParton
DATA_DZ<004
W->eνMC_DZ<004
W->eνMC-NOMPI_DZ<004
W->eνMC_[DZ<004+ELEMET>2.5]
W->eνMC-NOMPI_[DZ<004+ELEMET>2.5]
Number of Events
ΔΦ(Leading,Second)
0
20
40
60
80
100
120
140
160
180
200
0
0.5
1
1.5
2
2.5
3