## 0.1 Diffractive events

**Q**: What is the fraction of Single-Diffractive, Double-Diffractive component in our MinBias sample?
**A**: See the table below for Z2 and D6T tunes at 7 TeV. This is the fraction out of all events

| | Z2 | | D6T | |
|---|---|---|---|---|
| | Before PV filter | after PV filter | Before PV filter | after PV filter |
| SD1 | 0.0954 | 0.0529 | 0.0963 | 0.0540 |
| SD2 | 0.0967 | 0.0538 | 0.0955 | 0.0531 |
| DD | 0.1299 | 0.0771 | 0.1301 | 0.0780 |
| total | 0.3220 | 0.1838 | 0.3219 | 0.1851 |

### 0.1.1 Primary Vertex filter efficiency

**Q**: Does the $\varepsilon_{PV}$ efficiency depend on the fraction of diffractive events?
**A**: Yes, it does in low multiplicity. See the numbers.
**Q**: Does $\varepsilon_{central}$ depend on the fraction of diffractive events?
**A**: Yes, see the tables. Finally we want to see an effect on $\varepsilon_{PV} \cdot \varepsilon_{central}$. See the tables and fig. 0.1.1

Here is the numbers for $\varepsilon_{PV}$ and $\varepsilon_{central}$ (for $p_T > 0.5$, $|\eta| < 2.4$ and $< 0.8$) if no attempt to remove diffractive events done.

| M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| $\varepsilon_{PV}$ | 0.0539 | 0.5382 | 0.7955 | 0.9125 | 0.9648 | 0.9852 | 0.9960 | 0.9993 | 0.9998 |
| $\varepsilon_{central}$, $\|\eta\| < 2.4$ | 0.8307 | 0.9416 | 0.9299 | 0.9336 | 0.9448 | 0.9534 | 0.9690 | 0.9832 | 0.9927 |
| $\varepsilon_{PV} \cdot \varepsilon_{central}$ | 0.0448 | 0.5067 | 0.7397 | 0.8520 | 0.9115 | 0.9392 | 0.9652 | 0.9825 | 0.9926 |
| $\varepsilon_{central}$, $\|\eta\| < 0.8$ | 0.8343 | 0.9434 | 0.9361 | 0.9377 | 0.9400 | 0.9428 | 0.9511 | 0.9598 | 0.9691 |
| $\varepsilon_{PV} \cdot \varepsilon_{central}$ | 0.0450 | 0.5077 | 0.7446 | 0.8557 | 0.9069 | 0.9288 | 0.9473 | 0.9590 | 0.9689 |

Removed diffractive events:

| M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| $\varepsilon_{PV}$ | 0.0894 | 0.5783 | 0.8188 | 0.9260 | 0.9701 | 0.9875 | 0.9966 | 0.9993 | 0.9998 |
| $\varepsilon_{central}$, $\|\eta\| < 2.4$ | 0.8198 | 0.9493 | 0.9394 | 0.9434 | 0.9555 | 0.9639 | 0.9763 | 0.9872 | 0.9945 |
| $\varepsilon_{PV} \cdot \varepsilon_{central}$ | 0.0733 | 0.5490 | 0.7692 | 0.8736 | 0.9269 | 0.9518 | 0.9730 | 0.9864 | 0.9943 |
| $\varepsilon_{central}$, $\|\eta\| < 0.8$ | 0.7654 | 0.9551 | 0.9346 | 0.9365 | 0.9382 | 0.9445 | 0.9530 | 0.9612 | 0.9699 |
| $\varepsilon_{PV} \cdot \varepsilon_{central}$ | 0.0684 | 0.5524 | 0.7653 | 0.8672 | 0.9101 | 0.9327 | 0.9497 | 0.9605 | 0.9697 |

**Conclusion**: Extra-systematics should be assigned to the low M-bins of $\varepsilon_{PV}$ and $\varepsilon_{central}$. (Or combined value)

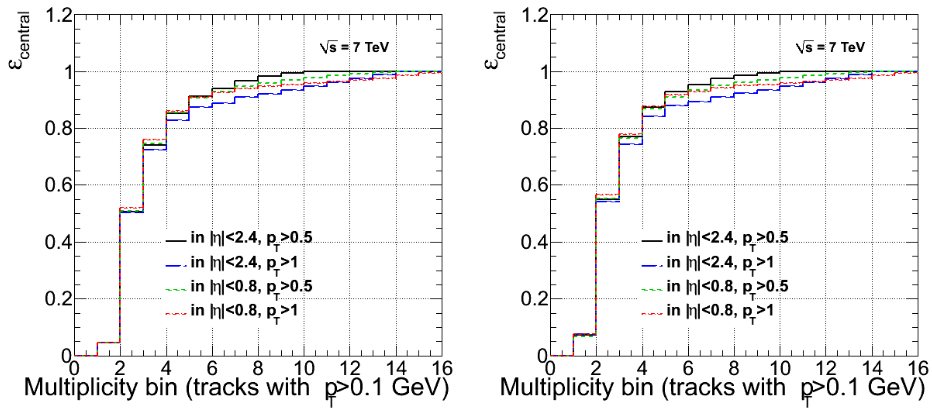


Figure 1: $\varepsilon_{PV} \cdot \varepsilon_{central}$ for all events (left) and removed diffraction (right)

## 0.2 Shape of $\varepsilon_{central}$

**Q**: Why $\varepsilon_{central}$ has such a strange shape (fig. 0.2 left)? Particularly, the rise at bin M=2.

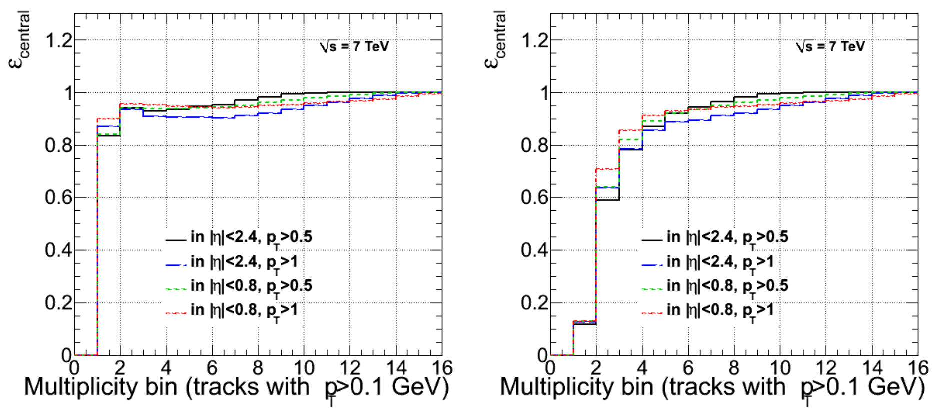


Figure 2: Central track efficiency. With PV filter used (Left) and without it (right)

**A**: This is an effect of PV filter. The $\varepsilon_{central}$ is calculated after the PV filter is applied. If PV filter is removed, the $\varepsilon_{central}$ looks like the usual efficiency (on the right plot). If we carry on the analysis without PV filter ($\varepsilon_{PV}(M) = 1$) and $\varepsilon_{central}$ as on the right plot in fig. 0.2, the results of dNdEta stay the same (within the errors)
**Note**: If PV filter is not applied we have events in which PV algorithm fails to reconstruct the vertex. In those cases BeamSpot position is used.
**Conclusion**: The systematics can be applied from that study. Also, from the fact that the result doesn't change, we may conclude that there are no gas-beam background events left. (That was the main reason to apply PV filter - to remove the backgroungs)

## 0.3 Best PV selection, nTracks() vs chi2/ndof

**Q**: Is this a good choice to select the best PV based on higher number of tracks? How is it different from minimum chi2/ndof selection?
**A**: We think nTracks() is better than chi2/ndof. The real Primary Vertex most likely to have more tracks attached to it. While low number of tracks suggests that it is a fake Vertex or a Vertex from secondaries. On figure 3 the distributions of nTracks() values plotted for two cases in MC.

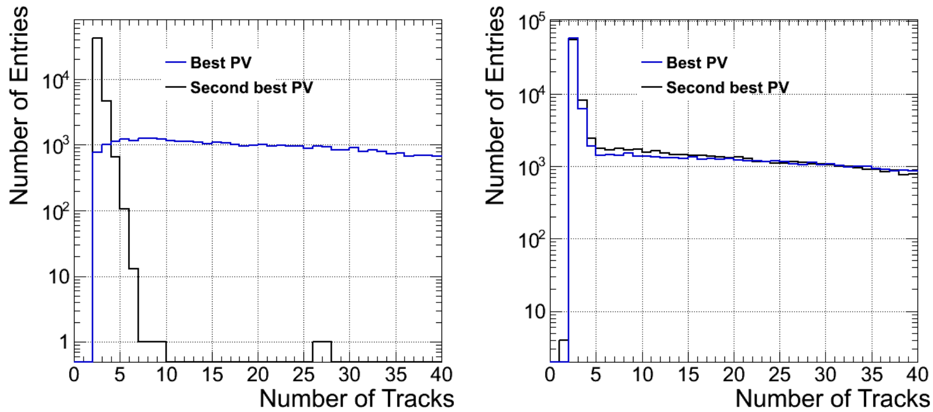


Figure 3: Plotted: vtx→nTracks() value. Selection based on higher nTracks value (left) and smallest chi2/ndof (right). It is clear that in first case we identify real primary vertex as the best one, while in second case it is 50/50 chance to pick a fake (secondary) vertex as a primary

**Conclusion**: there is an effect on dNdEta (drop by 0-1.5% in central eta and by 1-3% in high eta) Should we include this in systematics? If we want to be conservative - yes. However, it is clear to me now that chi2/ndof selection is biased and nTracks() is appropriate one to use.

## 0.4 Efficiency dependence on multiplicity

**Q**: Why does $\varepsilon_{bin}$ depend on the event multiplicity M? (fig 0.4)
**A**: There are to reasons:

- It is conditional, i.e calculated only from events with a central track above 500 MeV reconstructed.
- I still think it is not a per-track efficiency. See an example of 'simple physics' below.

### 0.4.1 Simple Physics

Suppose that in pp collisions only four type of events could happen in equal probabilities: no charged particles produced, 1, 2 or 3 charged particles produced. Say we have a sample of 4000 events such that:

| $N_{ch}$ particles | Events |
|---|---|
| 0 | 1000 |
| 1 | 1000 |
| 2 | 1000 |
| 3 | 1000 |

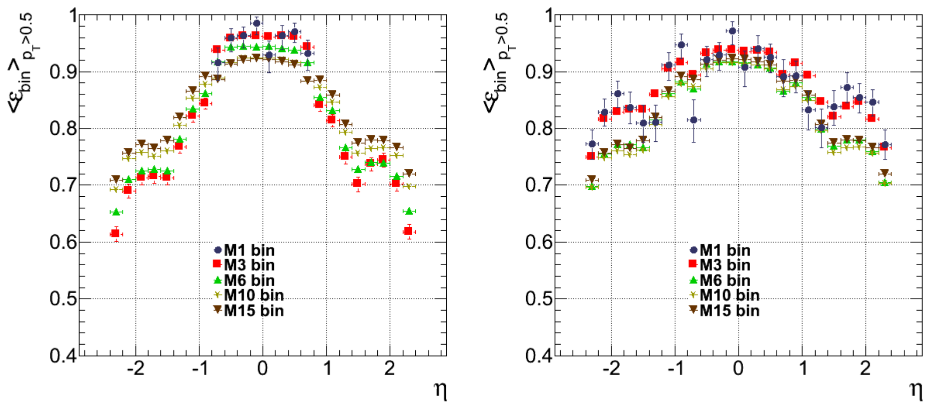


Figure 4: $\varepsilon_{bin}$ for two conditions: a reconstructed track with $p_T > 0.5$ GeV in $|\eta| < 0.8$ (left) and $|\eta| < 2.4$ (right) regions

Assume that all the particles are above pt-threshold we are interested in. And also let's only have a single eta-bin (say all the particles are produced within $|\eta| < 0.8$ region). Therefore consider a single bin in pt. In this case our M-binning is done with the same particles as for dN/dEta

### 0.4.2 Reco tracks

Now assume that the track reconstruction efficiency is **80%** (the probability to reconstruct a track) and does not depend on pt or multiplicity. Also there are no 'fakes' or 'secondaries'. Then the following table represents the outcome of the "measurement":

| $N_{ch}$ particles | Events | $N_{tracks}$ reco | Events |
|---|---|---|---|
| 0 | 1000 | 0 | 1000 |
| 1 | 1000 | 0 | 200 |
| | | 1 | 800 |
| 2 | 1000 | 0 | 40 |
| | | 1 | 320 |
| | | 2 | 640 |
| 3 | 1000 | 0 | 8 |
| | | 1 | 96 |
| | | 2 | 384 |
| | | 3 | 512 |

Now let's see how those reconstructed events are distributed in M-bins:

| M (reco track multiplicity) | Events | Sum of different $N_{ch}$ contributions |
|---|---|---|
| 1 | 1216 | = 800+320+96 |
| 2 | 1024 | = 640+384 |
| 3 | 512 | = 512 |

Now, corrections. Suppose that:
$\epsilon_{trig} = \epsilon_{PV} = \epsilon_{central} = 1$, therefore $\omega_{event} = 1$.
Since, T=D=0, we only have $\epsilon_{bin}$.

$$\epsilon_{bin}(M) = \frac{N^{reco,matched}_{tracks}(M)}{N^{true}_{particles}(M)} \tag{1}$$

| M (track multiplicity) | $\epsilon_{bin}(M)$ |
|---:|---|
| 1 | $\frac{1216}{800+2\cdot 320+3\cdot 96} = 0.704$ |
| 2 | $\frac{2\cdot 1024}{2\cdot 640+3\cdot 384} = 0.842$ |
| 3 | $\frac{3\cdot 512}{3\cdot 512} = 1.000$ |

As you can see, the efficiency changes with M, using this definition of $\varepsilon_{bin}$. It grows with M. On the figure 0.4 you can see two different behavior. Efficiency grows with M in high eta but it decreases in central-eta region.

**Explanation**: In our actual analysis, the M-binning is done with respect to the different tracks than those plotted in $\varepsilon_{bin}$. So, for M=1 the percentage of tracks above 500 MeV is $\sim$ 100% for M=2 it is $\sim$ 50%, M=3, $\sim$ 30% etc. Therefore $\epsilon_{bin}(M) = \frac{N^{reco,matched}_{tracks}(M)}{N^{true}_{particles}(M)}$ that calculated decreases with M.
And for higher M-bins, the percentage of tracks ($p_T > 0.5$) is about the same, so efficiency doesn't change.