

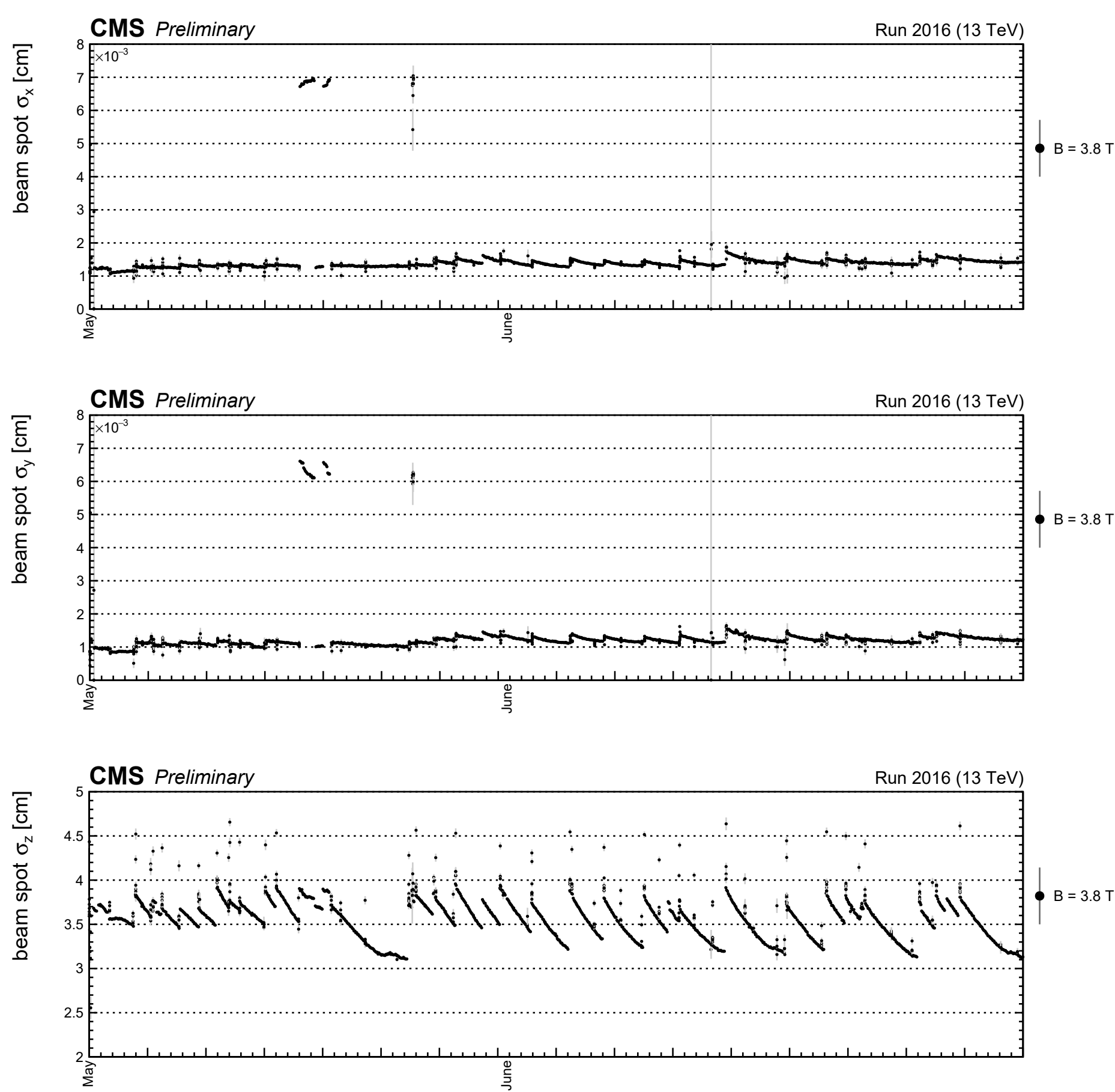
With the start of Run II in June 2015, LHC has re-started delivering pp collisions. LHC has ultimately achieved a center of mass energy of 13 TeV and a bunch time separation of 25 ns with a mean of more than 25 inelastic collisions superimposed on the event of interest. In these new conditions, the CMS collaboration has re-calibrated and verified the performance of the whole detector. Here the CMS tracking performance for Run II obtained through both direct and indirect measurements is presented.

Direct Measurements

BEAMSPOT MEASUREMENT

The beam spot parameters are estimated with two different methods for each luminosity section:

- 3-Gaussian likelihood fit of the 3D distribution of the reconstructed primary vertices.
- Iterative χ^2 fit of the correlation between the track impact parameter (d_0) and its azimuthal angle (ϕ).



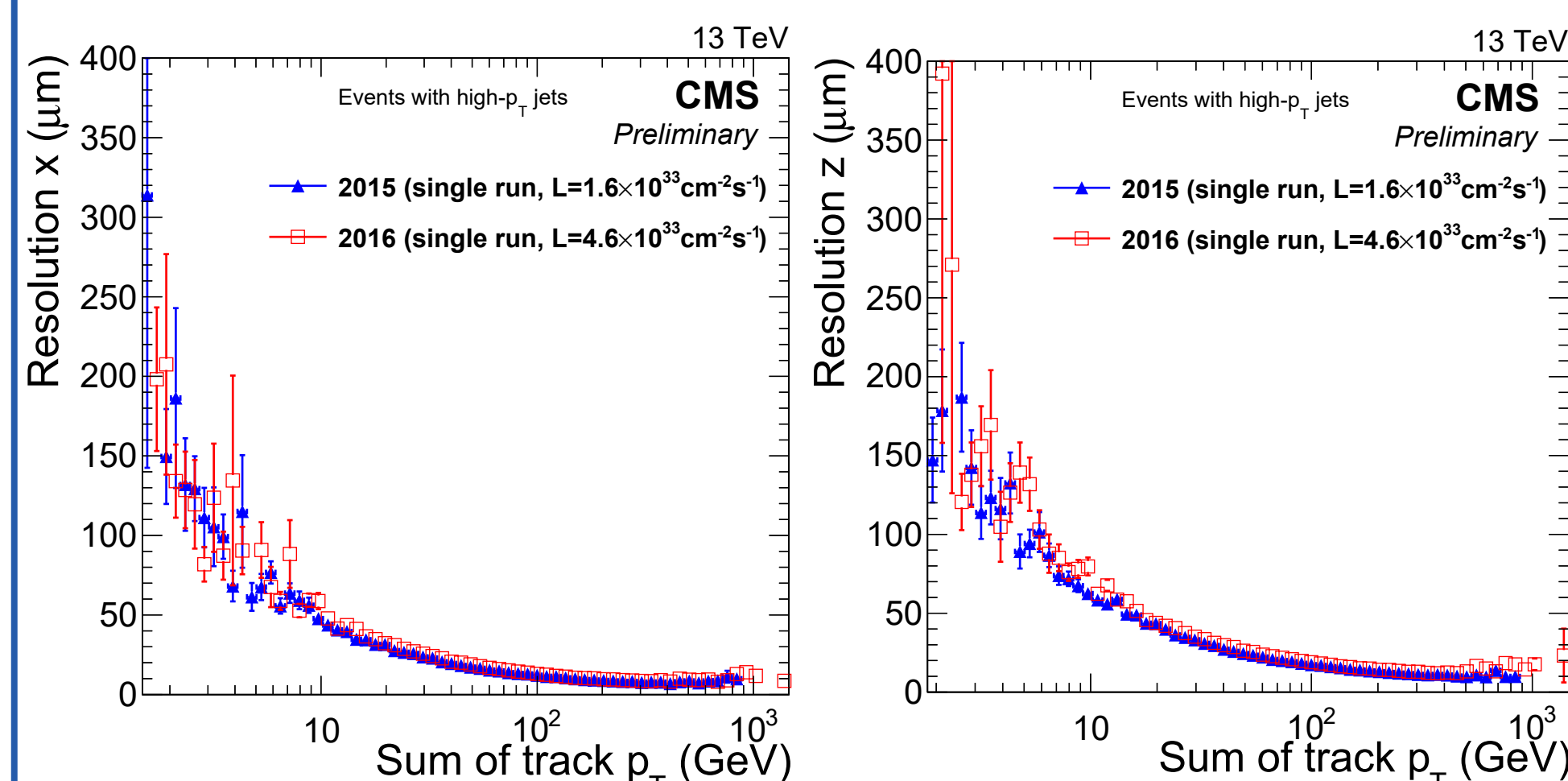
X-, Y- and Z-dimension of the luminous region in CMS interaction point for events coming from collisions at 13 TeV collected in 2016.

The transverse width is around 14 μm in X and 12.5 μm in Y, while longitudinal width along Z is between 3 and 4 cm.

VERTEX RESOLUTION

A "splitting method" has been used:

- Select primary-vertex with ≥ 4 tracks associated
 - Sort tracks in descending order of $p_{T\gamma}$ and then grouped them in pairs.
 - For each pair, assign tracks randomly to one or the other set of tracks, so that the two sets have same kinematic properties.
 - Fit these two sets of tracks independently with the adaptive vertex fitter.
 - Fit a Gaussian to the difference of the re-fitted vertex positions.
- The primary vertex resolution is the standard deviation of the Gaussian fit divided by $\sqrt{2}$.



Comparison of the primary vertex resolution in X and in Y as a function of the p_T sum of the associated tracks for 2015 (blue triangles) and 2016 (red squares).

In 2016 data the transverse resolution is better than 14 μm , and the longitudinal is better than 19 μm for primary vertices with sum of track $p_T > 100$ GeV.

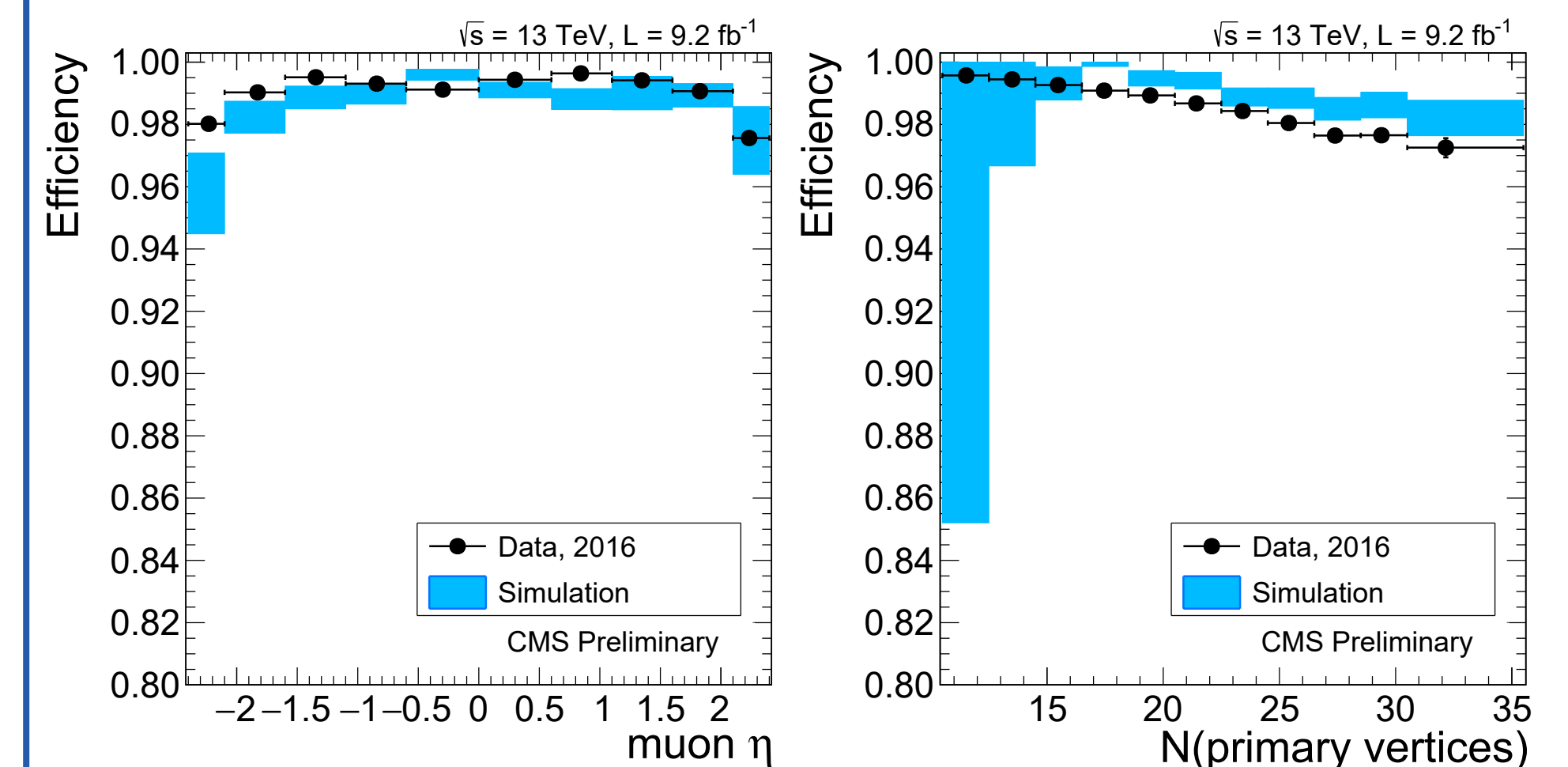
MUON TRACKING

The tag and probe method has been used at the Z mass peak to extract the muon tracking efficiency. The definitions used are:

- tag: a muon with $p_T \geq 15$ GeV, associated to one leg of the resonance and with a single muon trigger.
- probe: any stand-alone muon with ≥ 1 valid hit.
- passing probe: any probe muon that can be matched to at least one track. The matching is defined using the size of the cone in the space drawn around the stand-alone muon.

The (tag + passing/failing probe) invariant mass spectrum is fitted.

The efficiency is the fraction of (tag + passing probe) pairs.



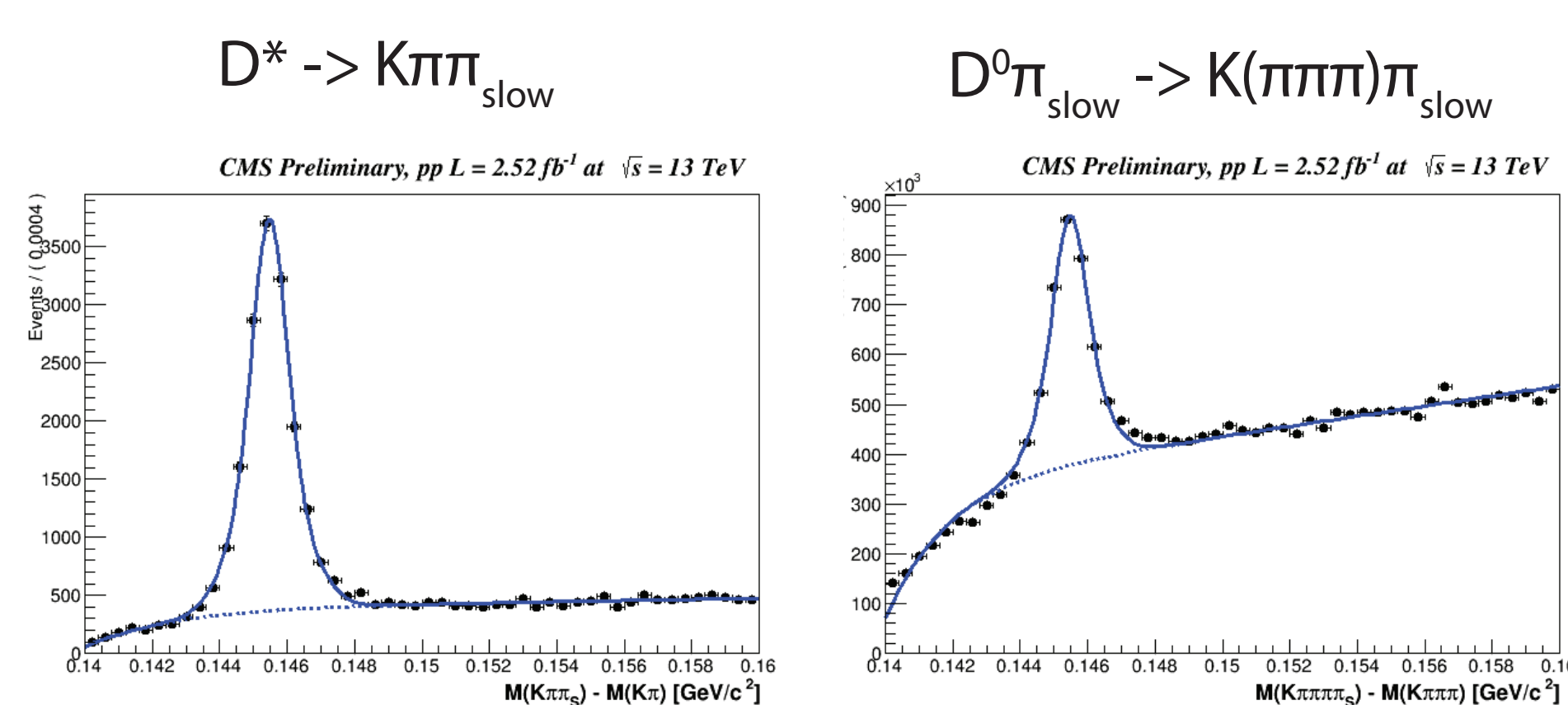
2016 data (black dots) and simulation (light blue rectangles) tracking efficiency for muons coming from the Z decay as a function of the pseudorapidity (left) and the number of primary vertices (right) of the probe muons.

The muon tracking efficiency for 2016 data is between 99.5% and 97% with a strong dependence on the number of primary vertices.

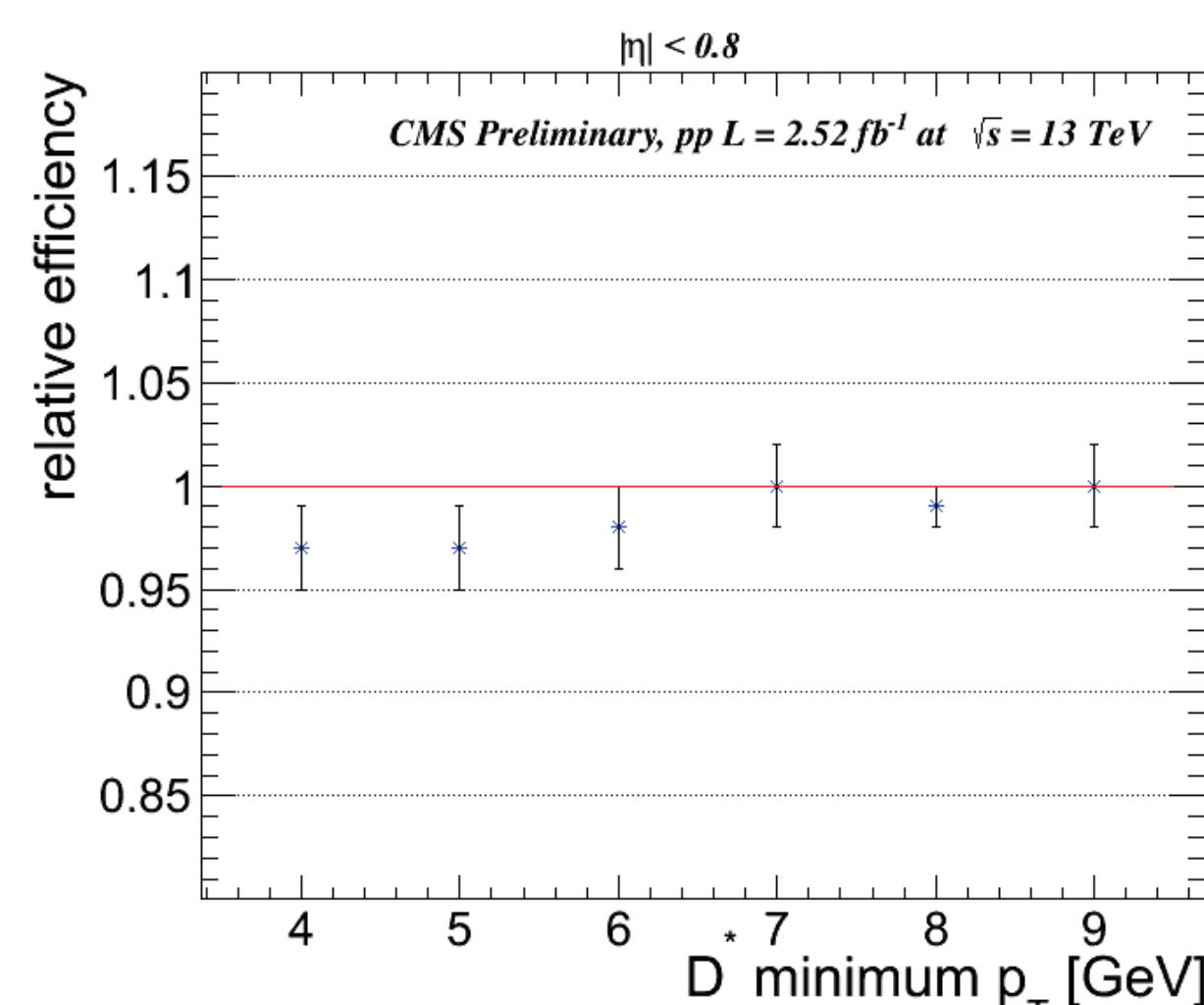
Indirect Measurements

PION RELATIVE EFFICIENCY

Two decay chains from $D^* \rightarrow D^0 \pi_{\text{slow}}$ are reconstructed in data and MC:



The ratio $R = (N_{K3\pi} \epsilon_{K3\pi}) / (N_{K\pi} \epsilon_{K\pi})$ is compared to $R_{PDG} = 2.08 \pm 0.5$ to find the pion relative efficiency:

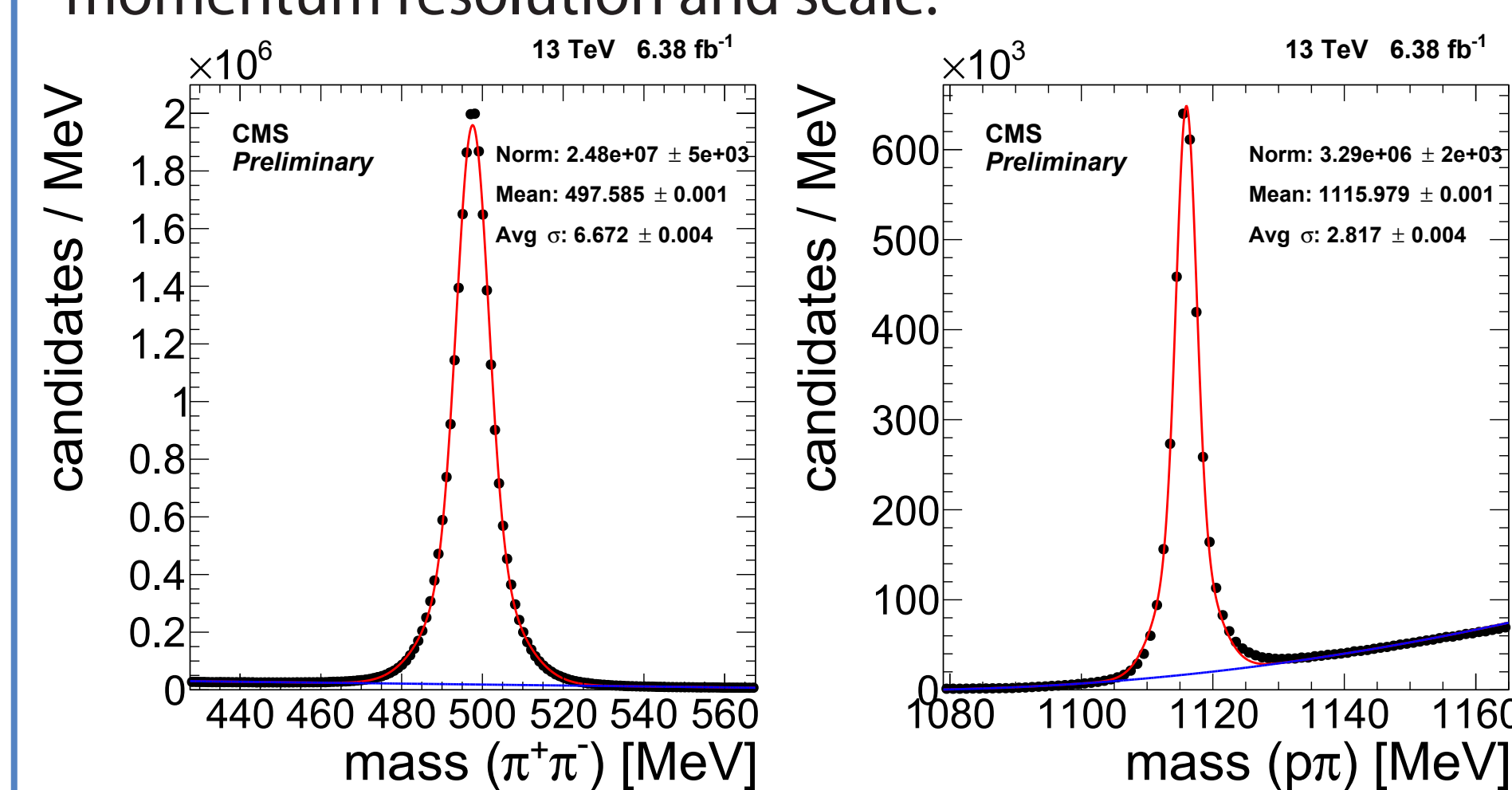


The ratio of tracking relative efficiencies for charged pions as a function of the minimum D^* candidates p_T threshold is shown in a specific pseudorapidity range.

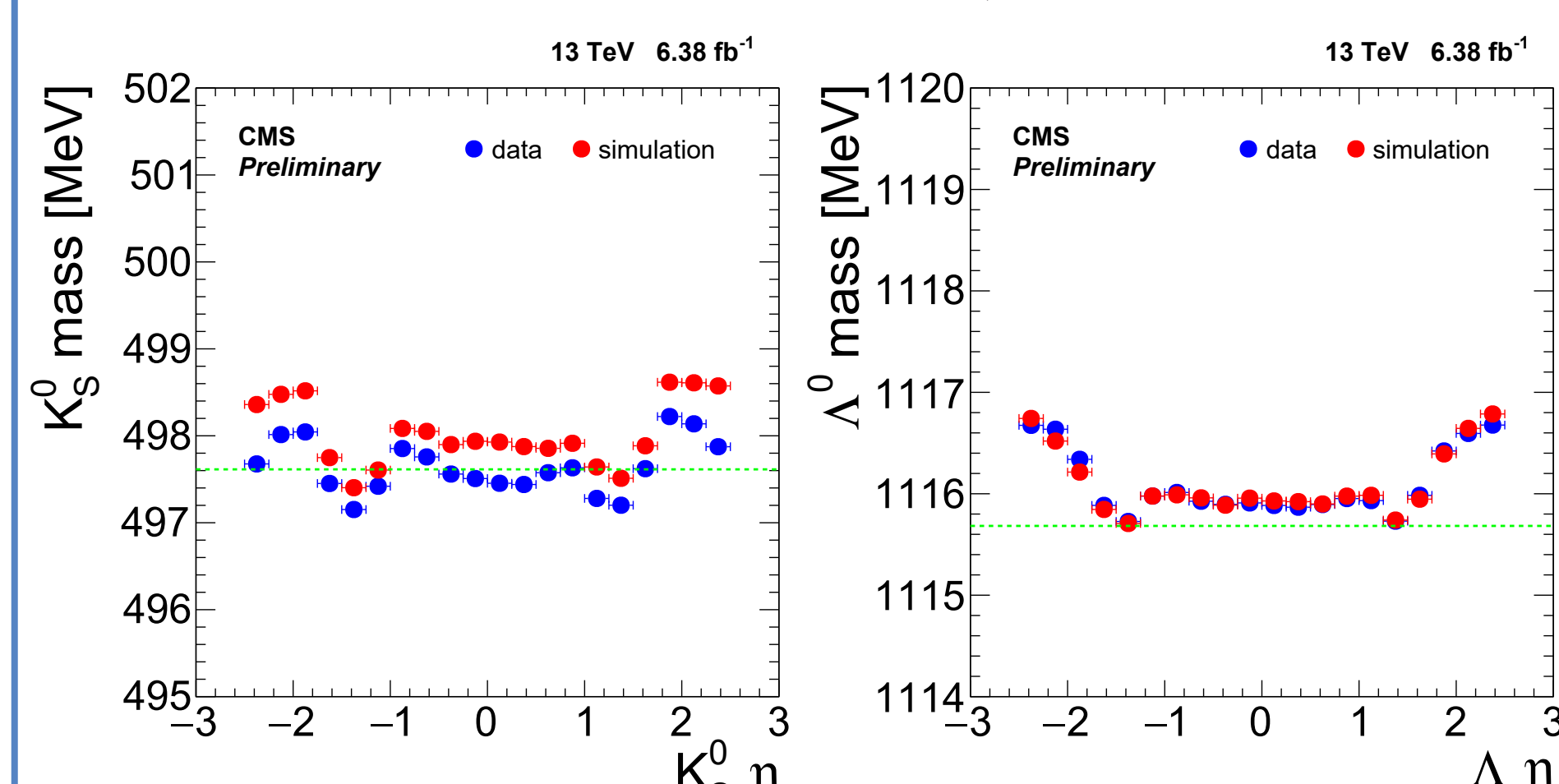
The agreement between R and R_{PDG} implies that the efficiency computed using the MC correctly reproduce the data.

LOW-MASS RESONANCES

The low-mass resonances have a narrow intrinsic width which is dominated by detector effects. Thus they can be used to determine with precision the track momentum resolution and scale.



K_S^0 (left) and Λ^0 (right) invariant mass reconstructed from oppositely-charged pion candidates and pion/proton pair respectively with data collected in 2016.



Comparison between data (blue) and simulation (red) of the reconstructed invariant mass for K_S^0 (left) and Λ^0 (right) as a function of the pseudorapidity.

The invariant mass distribution is well described by simulation. The pion momentum determination is uniform inside a 0.2% scale in the tracker volume.

Conclusions



- σ_x and σ_y of the reconstructed beam spot is around 14 μm and 12.5 μm respectively. The longitudinal width along Z is between 3 and 4 cm and changes in a fill due to synchrotron radiation at 6.5 TeV.
- In 2016 data the transverse resolution is better than 14 μm , and the longitudinal is better than 19 μm for primary vertices with sum of track $p_T > 100$ GeV.
- The muon tracking efficiency for 2016 data is between 99.5% and 97% with a strong dependence on the number of vertices reconstructed in the event.
- The pion efficiency in RunII relative to the MC value is compatible to 1 within the errors.
- The shape of the invariant mass for low-mass resonances is well described by simulation. The pion momentum determination is uniform inside a 0.2% scale in the whole tracker volume.