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# Charged particle pseudorapidity density in proton-proton collisions at $\sqrt{s}$ = 900 GeV with the ALICE MFT and ITS2

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Charged-particle pseudorapidity density measurements help in understanding particle production mechanisms in high-energy hadronic collisions, from proton-proton to heavy-ion systems. Performing such measurements at forward rapidity, in particular, allows one to access the details of the phenomena associated with particle production closer to the fragmentation region of the colliding nuclei. In ALICE, this measurement will be performed in LHC Run 3 exploiting the Muon Forward Tracker (MFT), a newly installed detector extending the inner tracking pseudorapidity coverage of ALICE in the range $-3.6 < \eta < -2.5$. The performance of the ALICE MFT will be presented for the pilot beam data taking of October 2021 for proton-proton collisions at $\sqrt{s}$ = 900 GeV, along with a preliminary result of charged-particle pseudorapidity density at midrapidity obtained with the newly installed Inner Tracking System (ITS2).

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## 1. Introduction

The MFT is a high precision tracking detector enabling prompt and non-prompt quarkonia separation by adding vertexing capabilities to the ALICE muon spectrometer. This new detector also allows ALICE to extend its multiplicity measurements to more forward regions.

Charged particle pseudorapidity density is defined as the number of primary charged particles per collision and unit of pseudorapidity, in other terms this is a multiplicity measurement as a function of the pseudorapidity. Thanks to the addition of the MFT, charged particle pseudorapidity density can now be studied in ALICE in two pseudorapidity regions: the central one $-1.2 < \eta < 1.2$ and the forward one $-3.6 < \eta < -2.5$.

In the following, the detectors used to derive the charged particle pseudorapidity density will be presented, and their performance in the pilot pp run at $\sqrt{s} = 0.9$ TeV will be shown.

## 2. Description of the detectors

The two ALICE sub-detectors used to derive the results are the updated Inner Tracking System (ITS2) and the Muon Forward Tracker (MFT).

The MFT and the ITS2 are two detectors used for tracking and vertexing purposes. Both are equipped with ALPIDE chips, novel CMOS (Complementary Metal–Oxide–Semiconductor) Monolithic Active Pixels Sensors (MAPS) technology developed by ALICE. These chips have the particularity of integrating both sensor and read-out electronics to create a single detection device [5], with a space resolution of 5 $\mu$m and a time resolution lower than 4 $\mu$s. It is the first large-scale application of this technology in an LHC experiment.

The ITS2 is an upgraded version of the ITS present in Run 2 and is made of seven cylindrical detector layers (from $R = 22$ mm to $R = 400$ mm). Its pseudorapidity coverage is $|\eta| < 0.9$.

The MFT is a new detector that has been installed in the ALICE cavern at the end of 2020, allowing for charged particles tracking at forward pseudorapidity, which was not possible in Run 1+2 in ALICE. This detector is made of five detection disks perpendicular to the beam axis, between $z$=-460mm and $z$=-768mm ($z$=0 representing the interaction point), each consisting of a front and back detection planes [6] and covering the pseudorapidity region $-3.6 < \eta < -2.5$.

## 3. MFT performance

In order to test the behaviour of the detectors a short proton-proton run at a centre-of-mass energy of $\sqrt{s} = 0.9$ TeV was acquired in October 2021, called pilot beam.

In this section we will show a few performance plots which have been derived using pilot beam data and simulation such as the distribution of $(x, y)$ positions of clusters in the farthest disk from the interaction point (in the left panel of Figure 1) and the MFT acceptance times efficiency (Acc $\times$ Eff in the right panel of Figure 1). As one can see in the left panel of Figure 1 there are very few and limited dead zones, which are visible in white. In the right panel of Figure 1 one can see that the $\eta$ acceptance region of the MFT is $-3.6 < \eta < -2.5$, and that its acceptance times efficiency is higher than 90% in the central $z_{\mathrm{vtx}}$ region.

These two figures demonstrate high MFT acceptance and low loss of detecting regions.

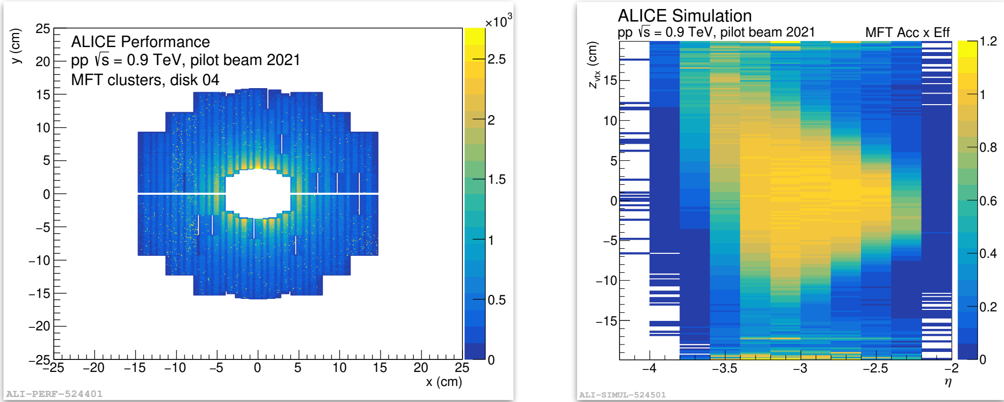


**Figure 1:** Left panel: $(x, y)$ position of MFT clusters in the farthest disk from the interaction point; Right panel: MFT Acceptance times efficiency as a function of $z_{\text{vtx}}$ and $\eta$

## 4. Analysis strategy

In this section the general analysis strategy is described. This analysis task was implemented in the new analysis framework of ALICE [7]. At the time of the conference, the final result of the charged particle pseudorapidity density with the MFT has yet to be derived and therefore will not be shown.

In this analysis, at midrapidity, ITS + TPC (Time Projection Chamber) tracks are used, at forward rapidity, MFT tracks are used (tracks in the MFT with a hit in at least 4 different MFT disks) and are corrected by their corresponding acceptance times efficiency. The acceptance times efficiency is derived exploiting PYTHIA8 simulations and GEANT3 tracking through the experimental setup, with the corresponding plot for the MFT shown in the left panel of Figure 1.

The correction procedure is comprised of two different types of correction: the track-to-particle correction and the triggering efficiency correction [2]. The track-to-particle correction corresponds to the acceptance times efficiency profile.

On top of these two corrections, an additional correction is necessary to account for the underestimated cross-section of diffraction events in PYTHIA8: the single and double diffractive events, representing respectively 20% and 10% of the total inelastic cross-section [4], are underestimated by PYTHIA8. Consequently, the total number of inelastic events is also underestimated and the charged particle pseudorapidity density is overestimated. This issue will be better studied in future analysis, and systematic uncertainties will be considered based on different models.

## 5. Results

The charged particle pseudorapidity density in the pilot beam data is derived for the class of all inelastic events and is shown in the Figure 2 in the pseudorapidity interval $|\eta| \leq 1.2$. The projected systematic uncertainty is represented by the red error band and has been derived by using the previously published systematic uncertainty in Ref. [3] without a new specific computation. This result is also compared with a previously published result of charged particle pseudorapidity density obtained with Run 1 data [3], and with PYTHIA8. The overall shift between the pilot beam

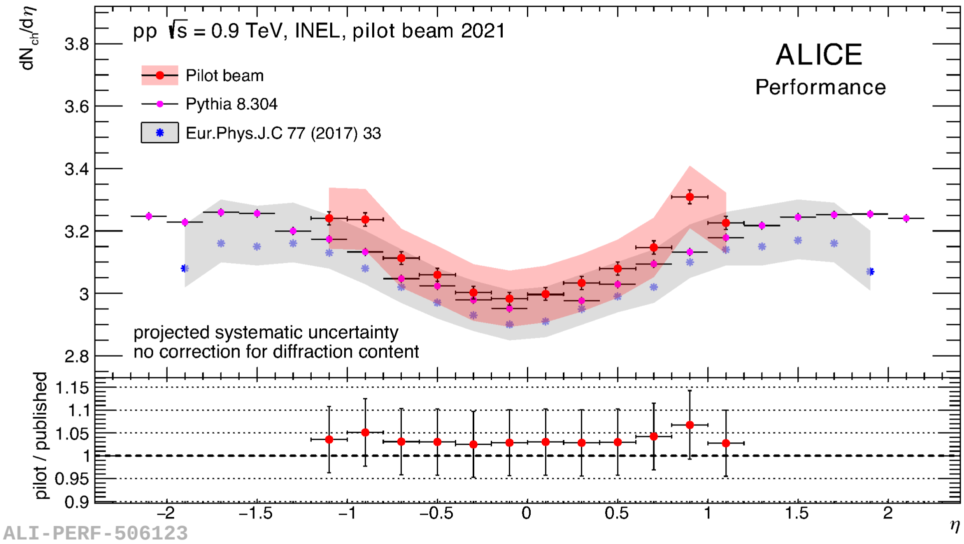


**Figure 2:** $dN_{ch}/d\eta$ result in pilot beam October 2021 at midrapidity

and Run 1 results is due to the lack of diffraction tuning of the pilot beam MC simulation used, as mentioned in Section 4. The Run 1 and Run 3 data are compatible within uncertainties, which provides a reliability check on the performances of the ITS2 and of the new analysis framework.

The full measurement including the MFT points is expected in the coming months, extending the results in the region $-3.6 < \eta < -2.5$.

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