Charged particle distributions in Xe+Xe collisions measured with ATLAS detector at the LHC

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Introduction - aim of the project

- Perform analysis for Xe+Xe collisions similar to the one done for charged particles in *pp* interactions [1]
- Analyze properties of reconstructed tracks and their transverse momentum and pseudo-rapidity distribution in Xe+Xe collisions at the centre of mass energy of 5.44 TeV
- Calculate the efficiency of reconstruction and weights of tracks for particular range of transverse momentum and pseudo-rapidity
- Apply the corrections to the data and compare it with the MC simulation in order to check how well the simulation describes the results of the experiment

Introduction - ATLAS detector

ATLAS inner detector (ID), which is shown in the figure, consists of:

- B-Layer (IBL)
- pixel silicon detector
- silicon microstrip detector (SCT)
- Transition Radiation Tracker (TRT)

ID can be used to measure trajectories and momenta of charged particles up to about $|\eta| = 2.5$ and p_T from about 100 MeV [2].

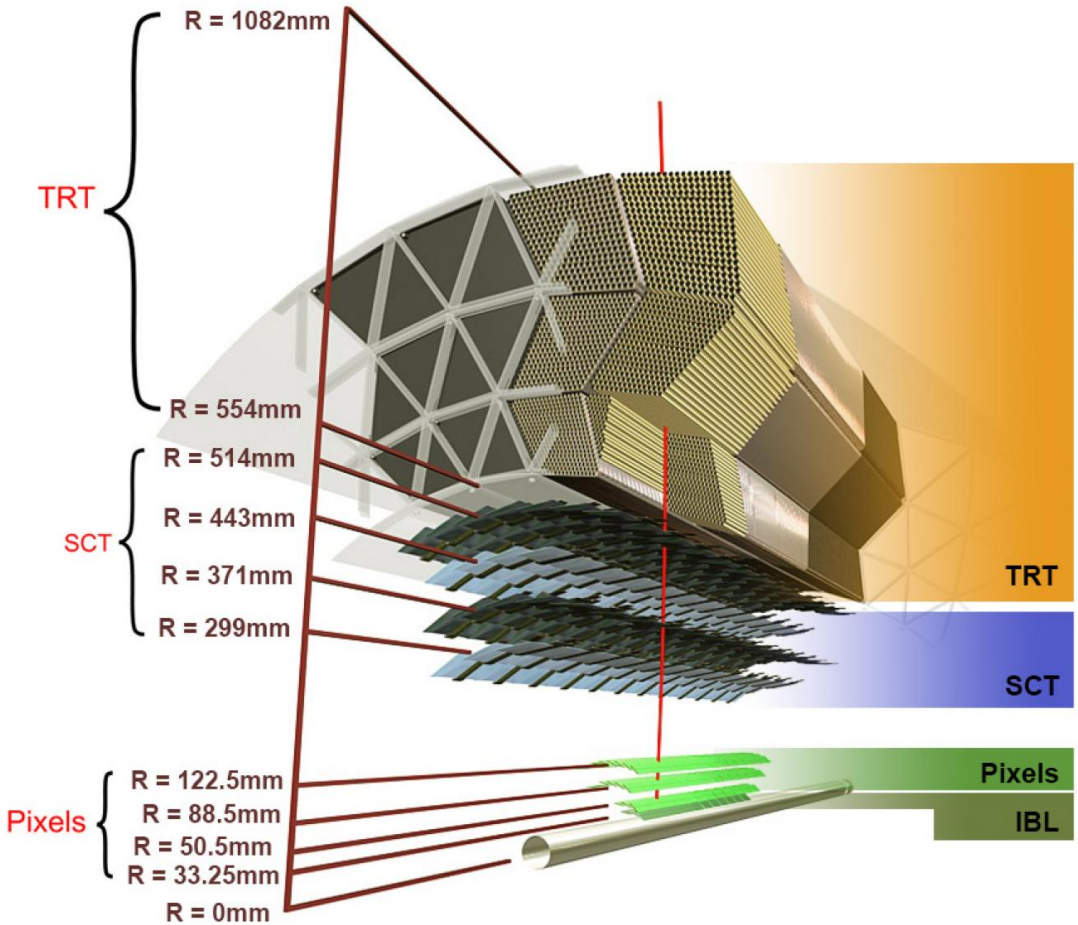

Figure: Sketch of the ATLAS inner detector

Tracks selection

In order to take into account tracks which were correctly reconstructed several conditions were applied [**?**]. The most important ones are:

- $|\eta| < 2.5$ (99 % left)
- $p_T > 500$ MeV (70 % left)
- at least one pixel hit (99,0 % left)
- at least six SCT hits (95 % left)

After all cuts about 64 % of tracks was left for further analysis.

η and p_T distributions on tracks

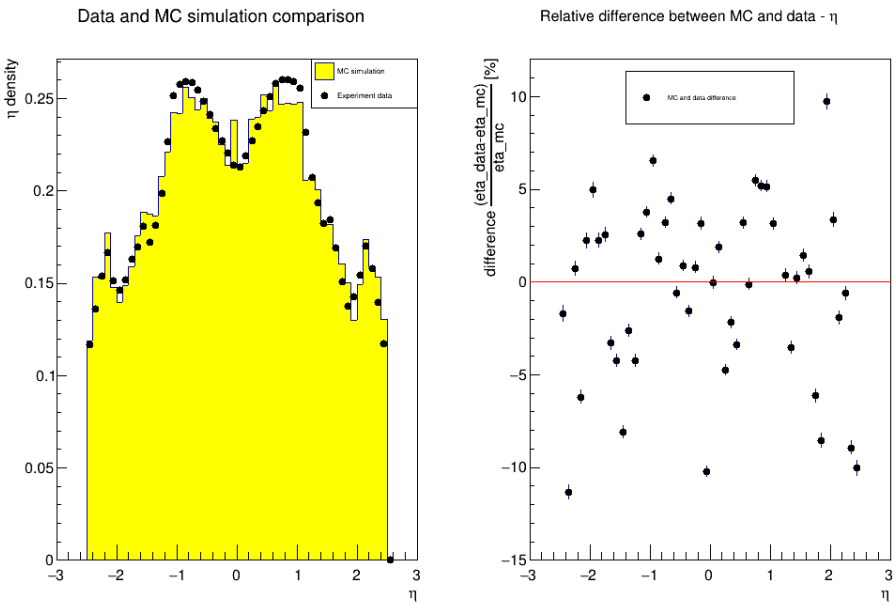

Figure: Pseudorapidity (η) distribution

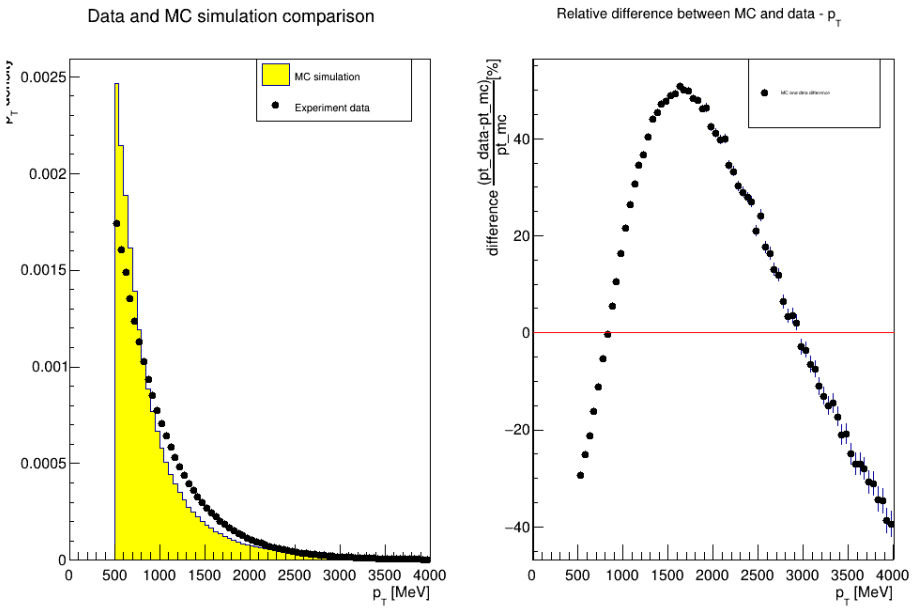

Figure: Transverse (p_T) distribution

Pseudorapidity track distribution is described quite well by the MC simulation. However, the difference between track distribution and MC simulation is significant in case of p_T distribution.

Pixel and SCT distributions on tracks

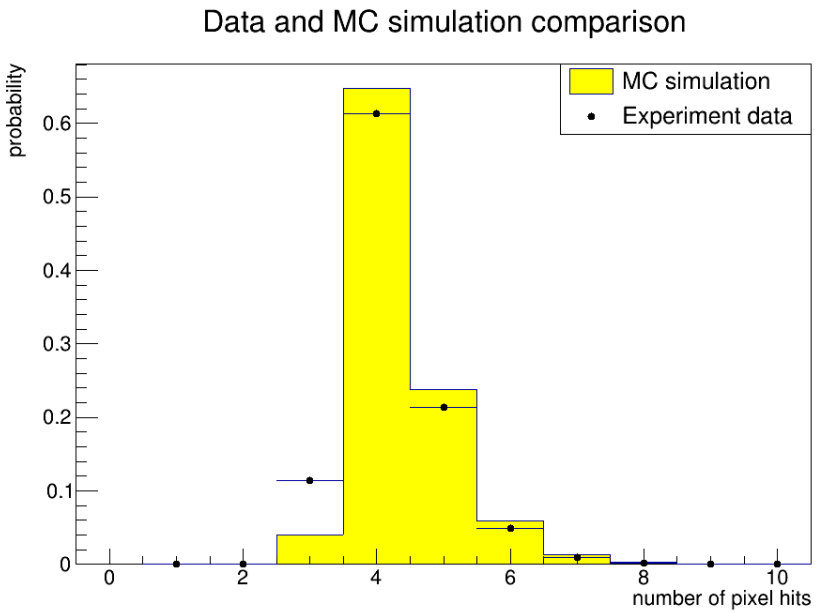

Figure: Pixel hits distribution

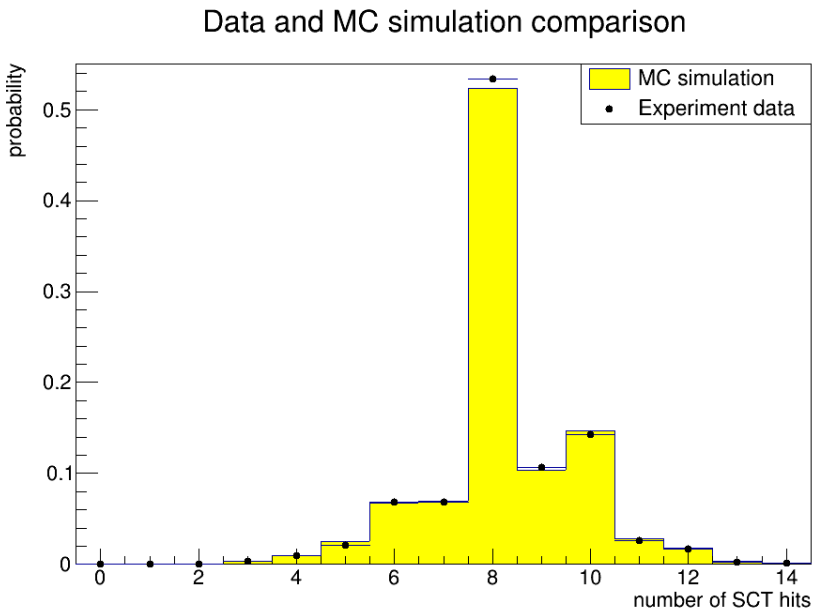

Figure: SCT hits distribution

In case of SCT and pixel hits distribution data is well described by the simulation.

Correction procedure and efficiency function

Trigger selection, vertex and track reconstruction cause inefficiencies. In order to obtain correct inclusive distribution of p_T and η for charged primary particles correction procedure was applied. Track reconstruction efficiency was calculated from the formula [1]:

$$\epsilon_{trk}(\eta, p_T) = \frac{N_{rec}(\eta, p_T)}{N_{gen}(\eta, p_T)} \tag{1}$$

Corrections were applied by filling histograms with tracks with the following weights [1]:

$$w(\eta, p_T) = \frac{1 - f_{sec}(\eta, p_T)}{\epsilon(\eta, p_T)} \tag{2}$$

Where f_{sec} is a fraction of tracks left by secondary particles in MC simulation, this correction is of the order of a few percent.

Efficiency plots

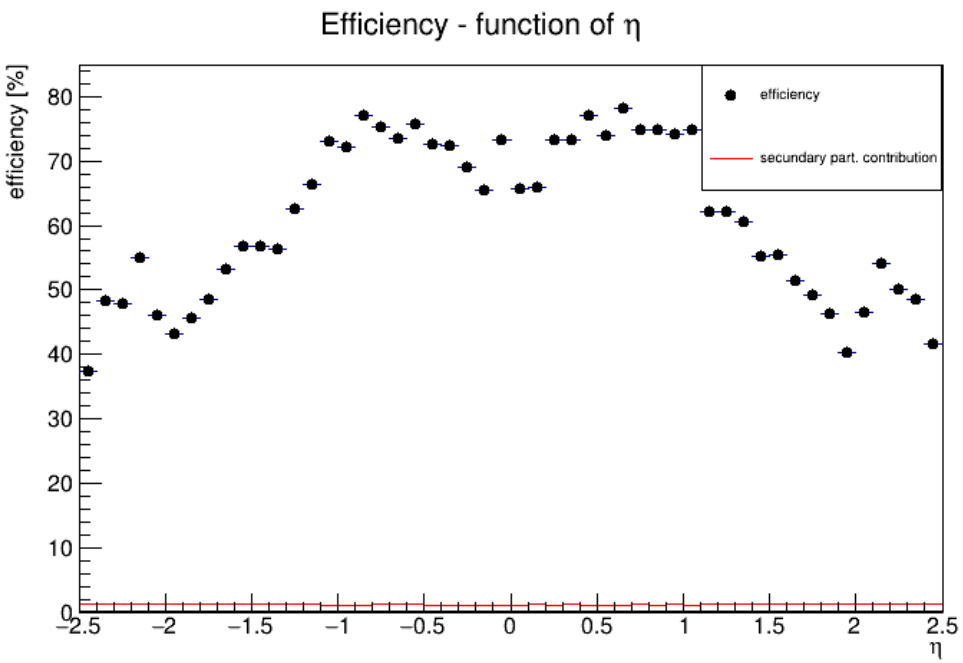

Figure: Efficiency - function of η

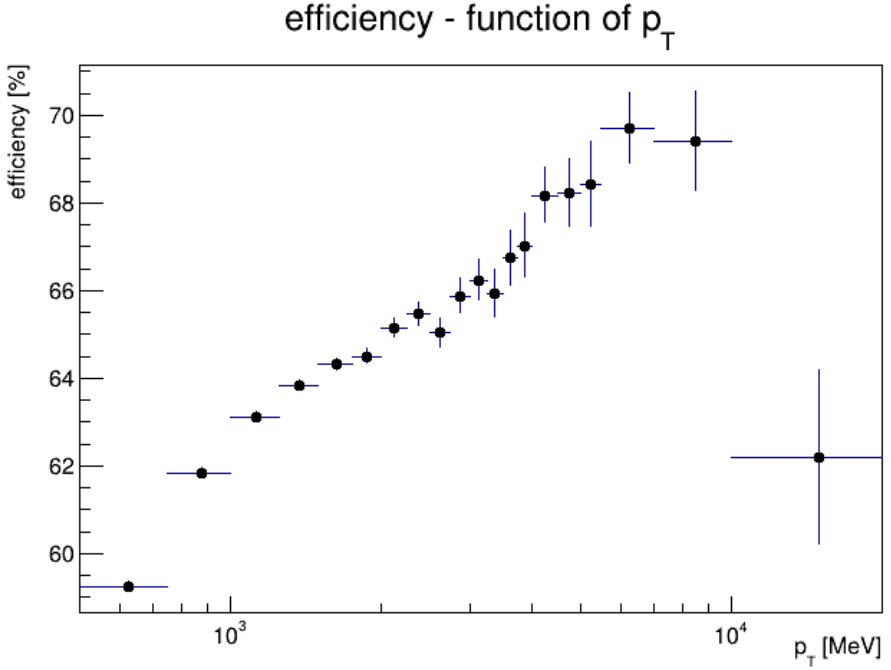

Figure: Efficiency - function of p_t

The efficiency is about 40-80 %. Efficiency increases for greater p_T values.

Correction procedure and efficiency function

Trigger selection, vertex and track reconstruction cause inefficiencies. In order to obtain correct inclusive distribution of p_T and η for charged primary particles correction procedure was applied. Track reconstruction efficiency was calculated from the formula[1]:

$$\epsilon_{trk}(\eta, p_T) = \frac{N_{rec}(\eta, p_T)}{N_{gen}(\eta, p_T)} \tag{3}$$

Corrections was made by filling histograms with tracks with the following weights[1]:

$$w(\eta, p_T) = \frac{1 - f_{sec}(\eta, p_T)}{\epsilon(\eta, p_T)} \tag{4}$$

Where f_{sec} is a fraction of tracks left by secondary particles in MC simulation, this correction is of the order of a few percent.

Track weights

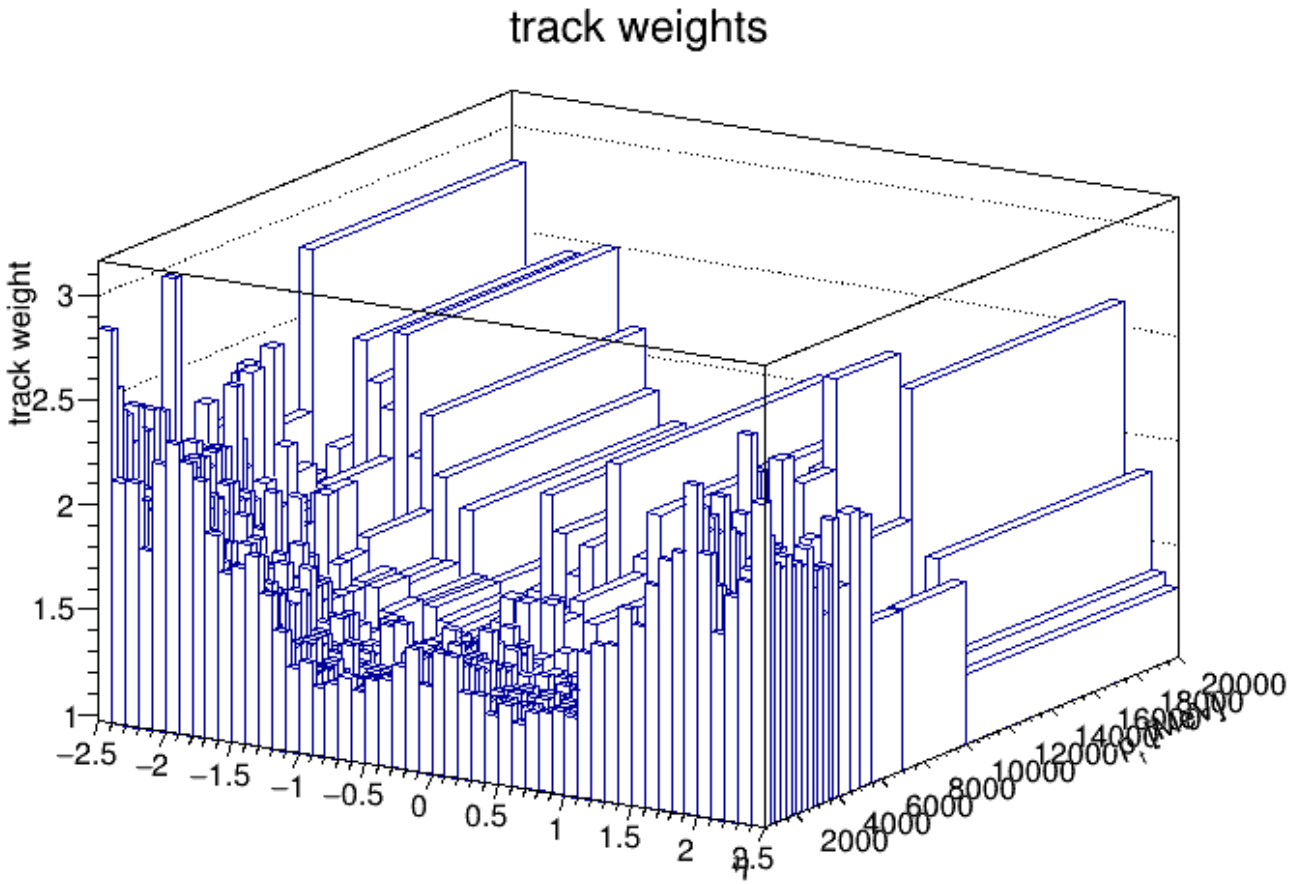

Figure: Weights of the tracks in function of η and p_T

Weights are higher in areas of η and p_T where efficiency is relatively low.

Correlation and Difference plots for η

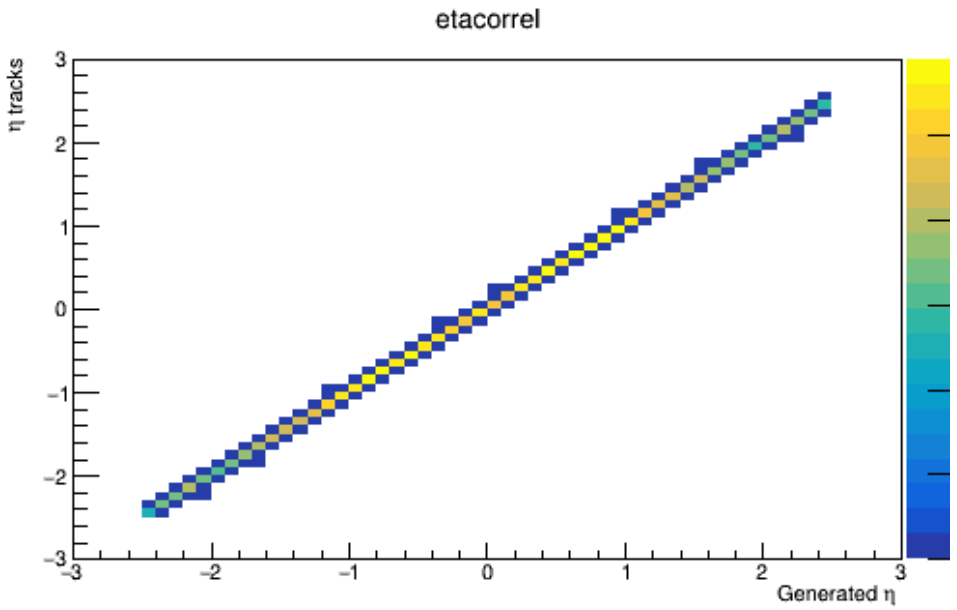

Figure: Correlation plots for $\eta_{particle}$ and η_{tracks}

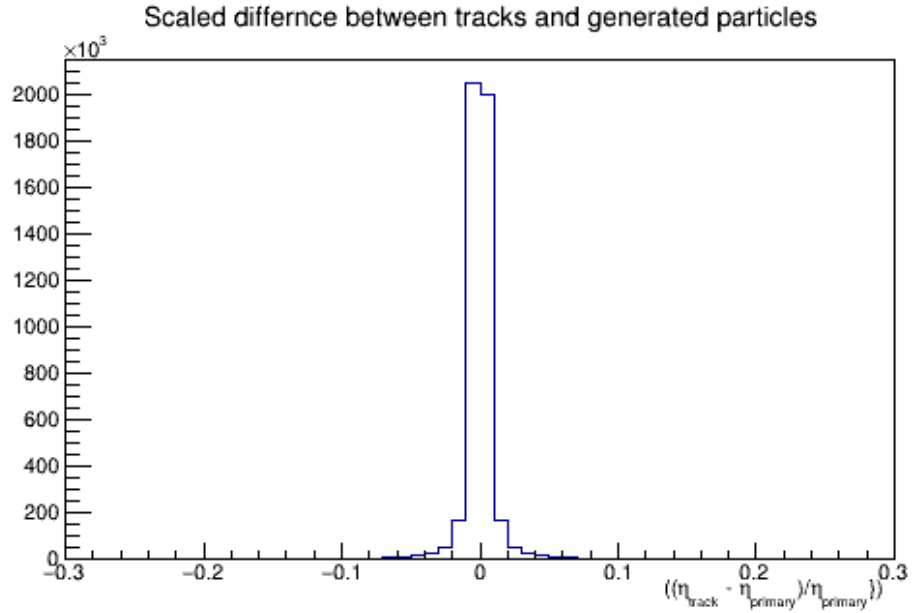

Figure: Difference between $\eta_{particle}$ and η_{tracks}

Pseudorapidity of particles is measured with a very small error.

Correlation and Difference plots for p_T

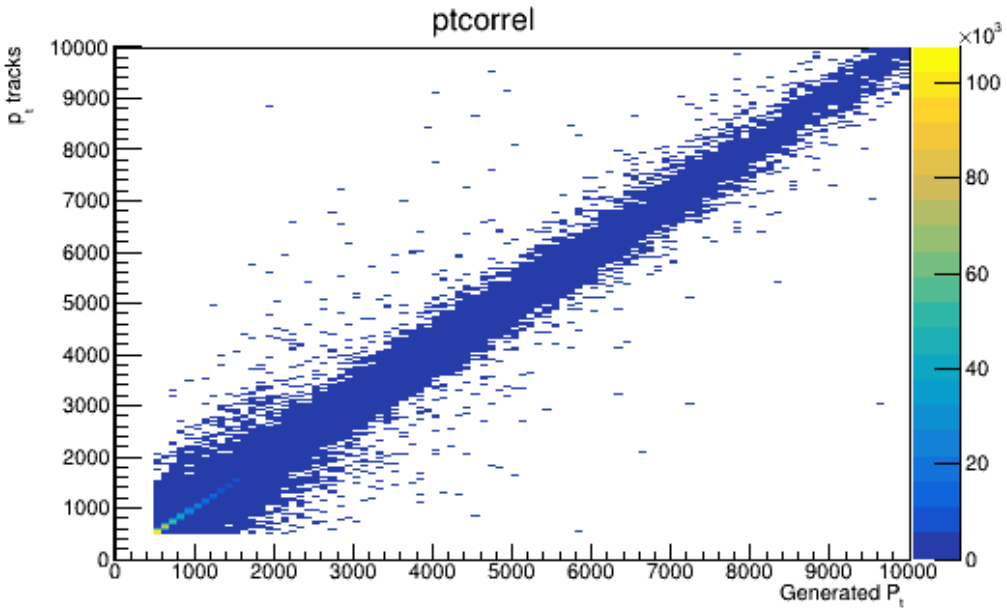

Figure: Correlation between $P_{T,particle}$ and $P_{T,tracks}$

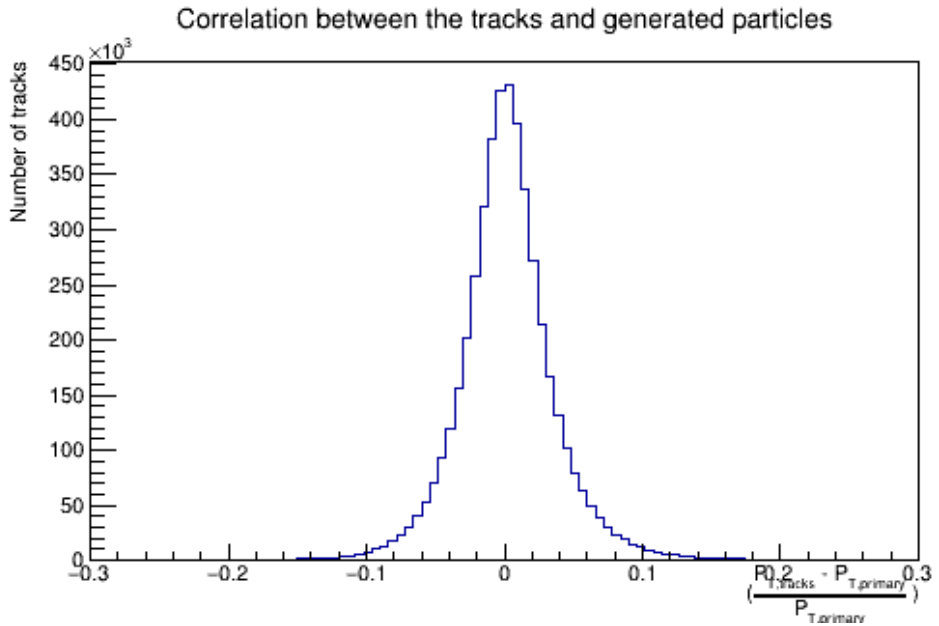

Figure: Difference between $p_{T,particle}$ and $p_{T,tracks}$

Reconstructed data

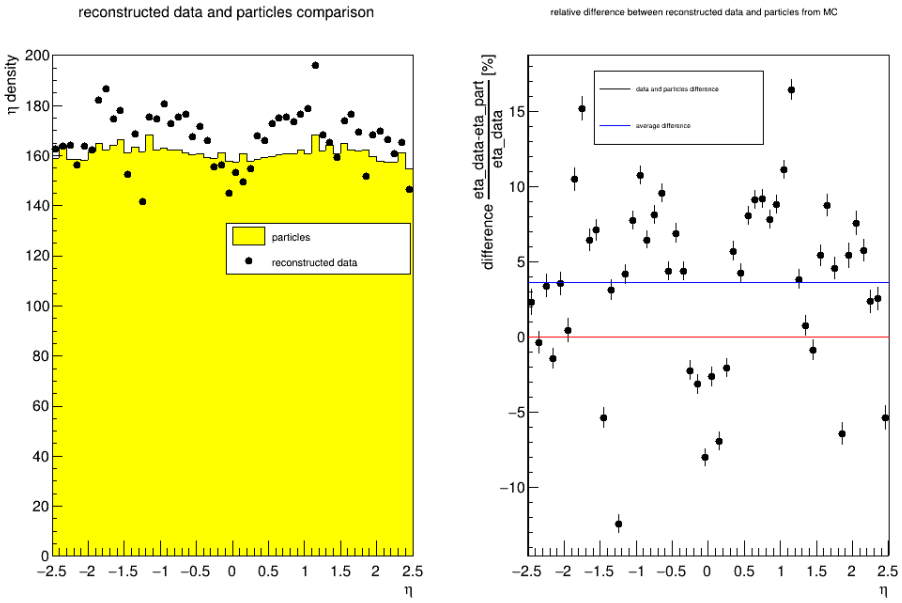

Figure: Corrected η distribution

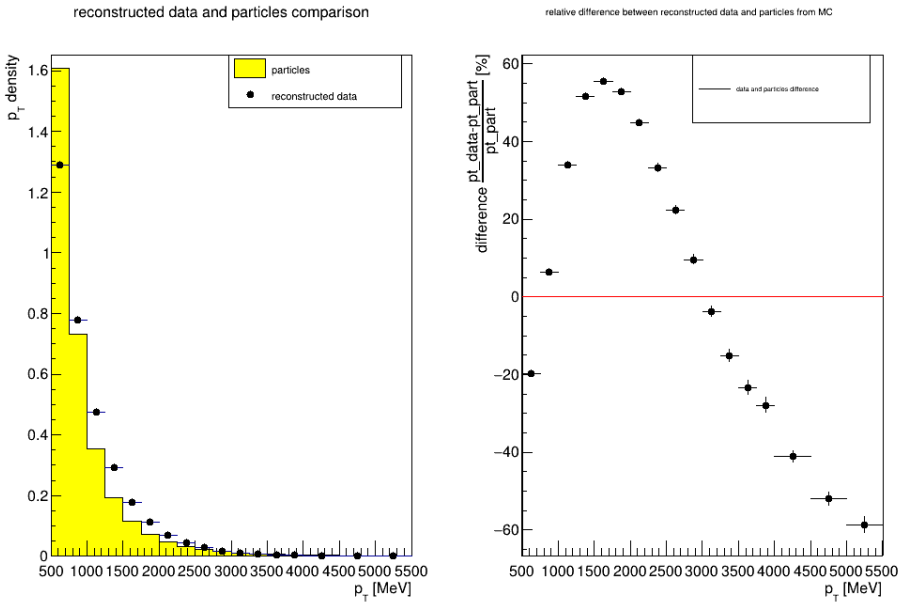

Figure: Corrected p_T distribution

The errors of reconstructed data are underestimated because the error of the weights was not taken into account. On the average there are about 4 % more particles in reconstructed data than in the simulation. Measurement of p_T is much less accurate, this causes the reconstruction of p_T to be less precise.

Comparison between the vertex positions(z) from the data and the Monte-Carlo simulations

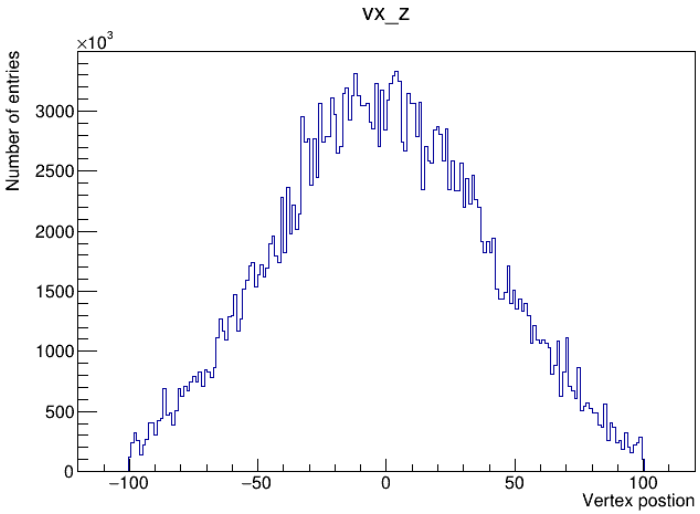

Figure: Vertex position of z axis from data

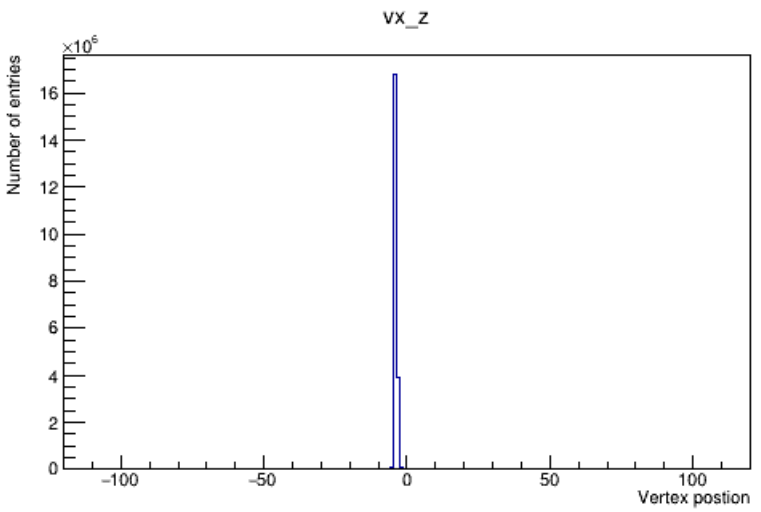

Figure: Vertex position of z axis from Monte-Carlo simulations

The fluctuations in reconstructed pseudorapidity distribution are due (at least partially) to the difference in collision vertex positions between data and simulations. The corrections from simulations are thus not fully appropriate for the data.

Conclusions

- Pseudo-rapidity (η) distribution is well described by MC simulation, the maximum difference is about 10 %. The maximum difference in transverse momentum (p_T) is over 40 % so the simulation does not fit the data. The MC model does not fully describe the data.
- The efficiency of track reconstruction is about 65 %. It is also increasing with the p_T, but the errors grow as well.
- Reconstructed data differ from simulations especially in p_T. There are also large fluctuations in η distribution. Correction from simulation is not accurate for data.
- Part of the difference between data and simulations is due to different vertex position distributions.

References

- Phys. Lett. B758 (2016) 67, *Charged-particle distributions in $\sqrt{s} = 13$ TeV pp interactions measured with the ATLAS detector at the LHC*, 18th November 2016
- ALT-PHYS-PUB-2015-018, *Track Reconstruction Performance of the ATLAS Inner Detector at $\sqrt{s} = 13$ TeV*, 23rd July 2015