

1) Study of charged particle distributions and two particles correlations in pp interactions at $\sqrt{s}=13$ TeV with ATLAS at the LHC

2) The tasks of this study are measurements of inclusive charged-particle distributions and two particles correlations in pp collisions at a centre-of-mass energy of 13 TeV. The charged-particle distributions measurements provide insights into soft-QCD processes, which are dominating pp collisions at the LHC, and into the strong interactions at low energy-scales, thus helping to constrain the parameters in phenomenological models, which are necessary to describe non-perturbative soft-QCD processes. These models are continuously tuned to data via simulations using Monte Carlo generators with tuneable free parameters. The minimum-bias measurements also play an important role in the determination of biases on high- p_T phenomena due to underlying events and event pileup effects, which can have an impact on the measurements of hard-scattering processes. They also facilitate the prediction of charged particle properties at higher centre-of-mass energies, which makes them indispensable for current as well as future LHC physics. Inclusive charged-particle distributions have been previously measured in pp and pp^- collisions as well as pPb and PbPb collisions at a wide range of centre-of-mass energies from 30 GeV up to 7 TeV [1]. The measurements will use the first of data recorded by the ATLAS experiment at 13 TeV. A similar strategy to that in [1] is used. The distributions are corrected for detector effects and are presented as inclusive-inelastic distributions, in a well-defined fiducial region. Each event is required to have at least one charged particle with momentum component transverse to the beam direction, p_T , of at least 100 or 500 MeV and absolute pseudorapidity $|\eta|$ less than 2.5. For these events the following distributions will be measured: $1/N_{ev} \cdot dN_{ch}/d\eta$, $1/N_{ev} \cdot 1/2\pi p_T \cdot d^2N_{ch}/d\eta dp_T$, $1/N_{ev} \cdot dN_{ev}/dn_{ch}$ and $\langle p_T \rangle$ vs. n_{ch} , where n_{ch} is the number of charged particles in an event, N_{ev} is the number of events, N_{ch} is the total number of charged particles in the data sample and $\langle p_T \rangle$ is the average p_T for a given number of charged particles. These distributions are compared to particle level Monte Carlo (MC) predictions.

Particle correlations play an important role in the understanding of multiparticle production. Correlations between identical bosons, called Bose-Einstein correlations (BEC), are a well-known phenomenon in high-energy and nuclear physics. The BEC are often considered to be the analogue of the Hanbury-Brown and Twiss effect in astronomy, describing the interference of incoherently emitted identical bosons. They represent a sensitive probe of the space-time geometry of the hadronization region and allow the determination of the size and the shape of the source from which particles are emitted.

A student will learn the ATLAS experimental setup, Inner Detector (ID) of ATLAS, tracks reconstruction in the ID, Inner parameters (IP) of tracks, and methods of calculation IP resolution, misalignment and material budget using tracks impact parameters. A student will learn the method of Bose-Einstein correlation study on the base of events collected with minimum-bias and high multiplicity track triggers at 13 TeV.

3) The ATLAS detector (Fig.1) [2] at the Large Hadron Collider (LHC) [3] covers almost the whole solid angle around the collision point with layers of tracking detectors, calorimeters and muon chambers. For the measurements presented in this paper, the tracking devices and the trigger system are of particular importance.

The ATLAS Inner Detector shown on the Fig.2 has full coverage in φ and covers the pseudorapidity range $|\eta| < 2.5$. It consists of a silicon pixel detector (Pixel), a silicon microstrip detector (SCT) and a transition radiation straw-tube tracker (TRT). These detectors cover a sensitive radial distance from the interaction point of 33–150 mm, 299–560 mm and 563–1066 mm, respectively, and are immersed in a solenoid that provides a 2 T axial magnetic field. The barrel (end-cap) parts consist of 4 (2×3) Pixel layers, 4 (2×9) double-layers of single-sided silicon microstrips with a 40 mrad stereo angle, and 73 (2×160) layers of TRT straws. Note that the inner most Pixel layer (the insertable B-layer) was added during the shutdown between Run 1 and Run 2 and leads to improved resolution. Typical position resolutions for the Pixel, SCT and TRT are 10, 17 and 130 μm for the $r\varphi$ co-ordinate. The resolution of second measured co-ordinate (z) of the first layer of the Pixel barrel detector is 72 μm , while the remaining layers have a resolution of 115 μm . When the two measurements of the SCT modules are combined, they obtain a resolution of the second measured co-ordinate of 580 μm . A track from a charged particle traversing the barrel detector would typically have 12 silicon hits (4 pixel clusters and 8 strip clusters) and more than 30 TRT straw hits. A hit is a measurement point assigned to a track. The ATLAS detector has a two-level trigger system: Level 1 (L1), High Level Trigger (HLT). Note that the HLT is no longer divided into L2 and Event Filter as was the case during Run 1. For this measurement, the trigger relies on the L1 from the Minimum Bias Trigger Scintillators (MBTS). The MBTS are mounted at each end of the detector in front of the liquid-argon end-cap calorimeter cryostats at $z = \pm 3.56$ m.

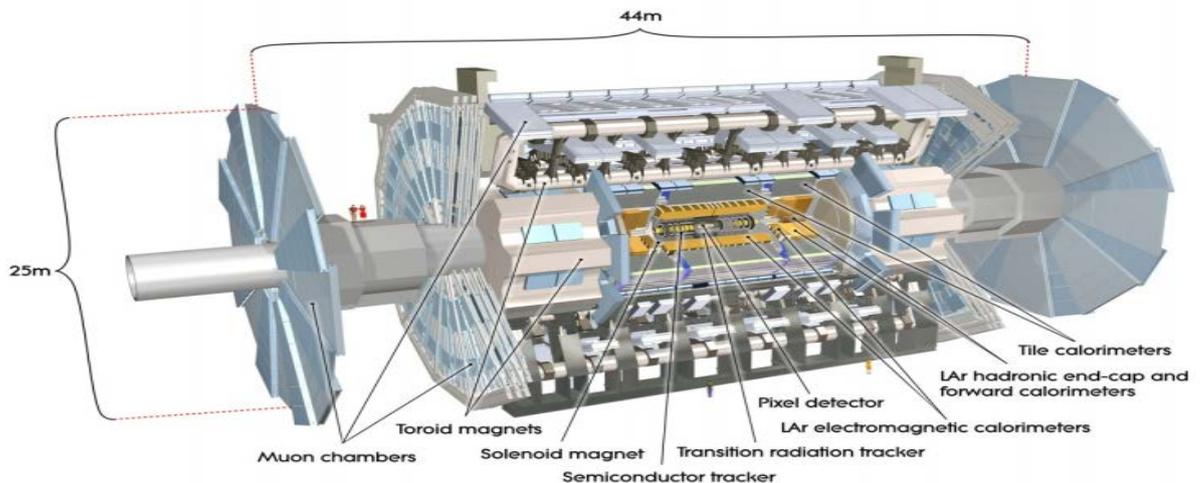


Fig.1. The ATLAS detector at the LHC.

They are segmented into eight sectors in azimuth and two rings in pseudorapidity ($2.09 < |\eta| < 2.82$ and $2.82 < |\eta| < 3.84$). The MBTS trigger used for this paper is

configured to require one hit above threshold from either side of the detector, referred to as a single-arm trigger. The efficiency of this trigger is studied with the following independent trigger. A random (unbiased) trigger at L1 filtered to obtain inelastic interactions by ID requirements at HLT, by requiring at least one reconstructed track with $p_T > 200$ MeV.

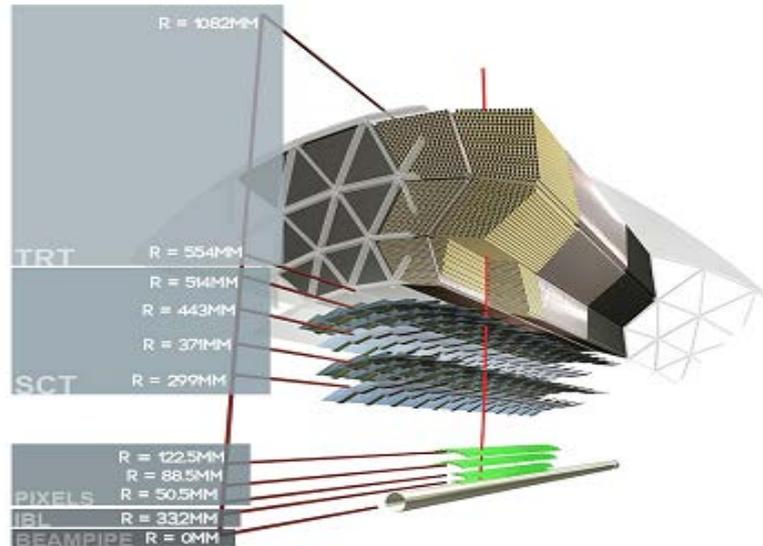


Fig.2. The Inner tracker of the ATLAS detector.

The task of a student is the analysis of Impact Parameters transverse (d_0) and longitudinal ($z_0 \sin\Theta$) distributions within the Inner Detector for selected, primaries and secondary tracks with the aim of characterizing the resolution, misalignment and material budget of ID. For this study the Monte-Carlo samples will be used. The results will be presented as a short report.

4) A student must know high energy physics and ROOT.

5) [1] G. Aad et al., *Charged-particle multiplicities in pp interactions measured with the ATLAS detector at the LHC*, *New J.Phys.* **13** (2011) 053033, arXiv: [1012.5104 \[hep-ex\]](https://arxiv.org/abs/1012.5104).

[2] G. Aad et al., *The ATLAS Experiment at the CERN Large Hadron Collider*, *JINST* **3** (2008) S08003.

[3] L. Evans (ed.) and P. Bryant (ed.), *LHC Machine*, *JINST* **3** (2008) S08001.

6) 2

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