Measurement of multiplicity in heavy-ion collisions with ALICE during the LHC Run 3

Defence of a research task

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Outline

- Multiplicity
- LHC and ALICE upgrade
- Analysis of Pb–Pb collisions

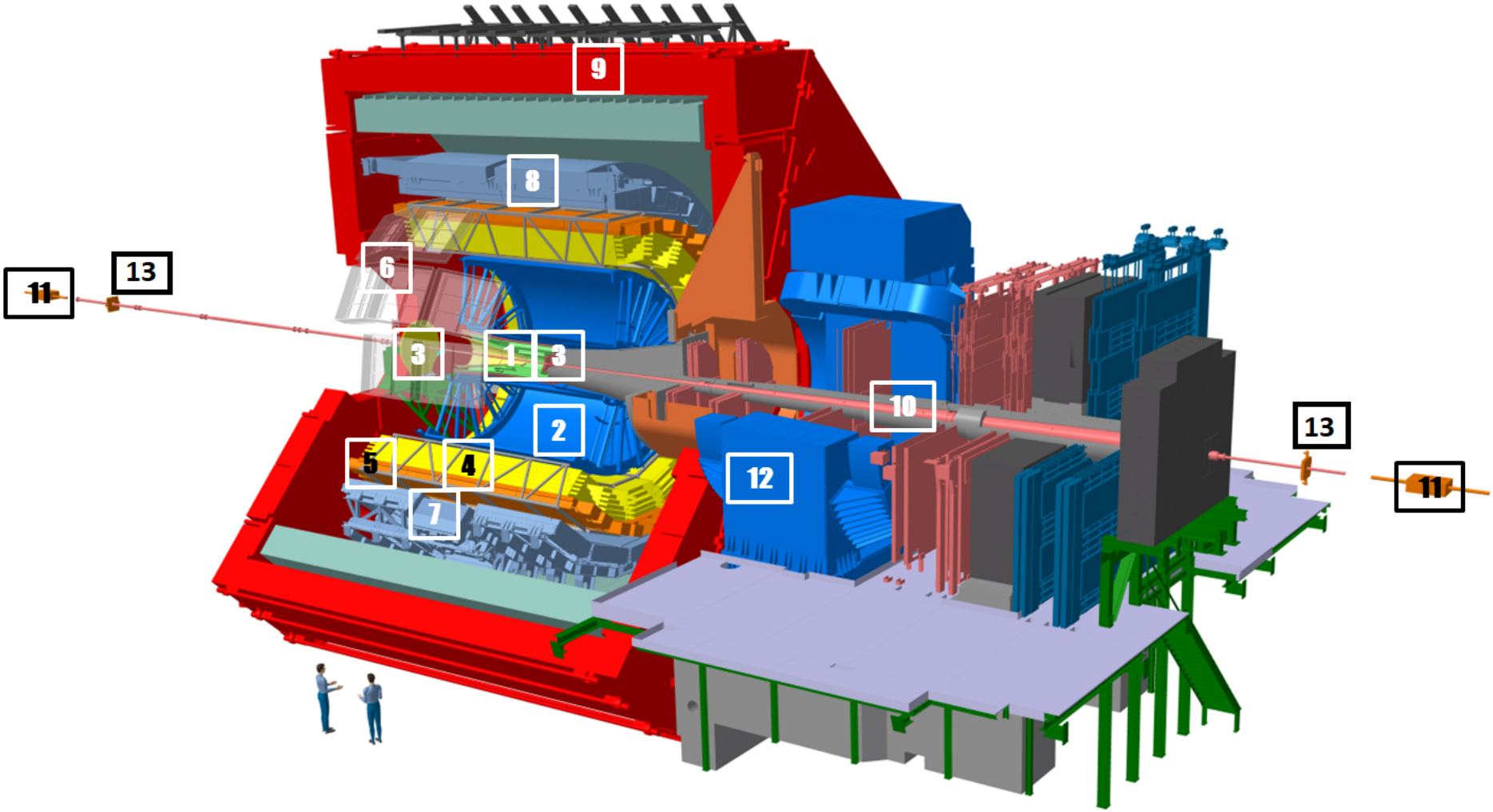
Multiplicity

- Number of charged particles produced in a Pb–Pb collision
- Multiplicity as a function of pseudorapidity at mid rapidity
- Global observable
- Used to estimate initial energy density
- Measured using ALICE: mainly ITS and TPC

LHC and ALICE upgrade

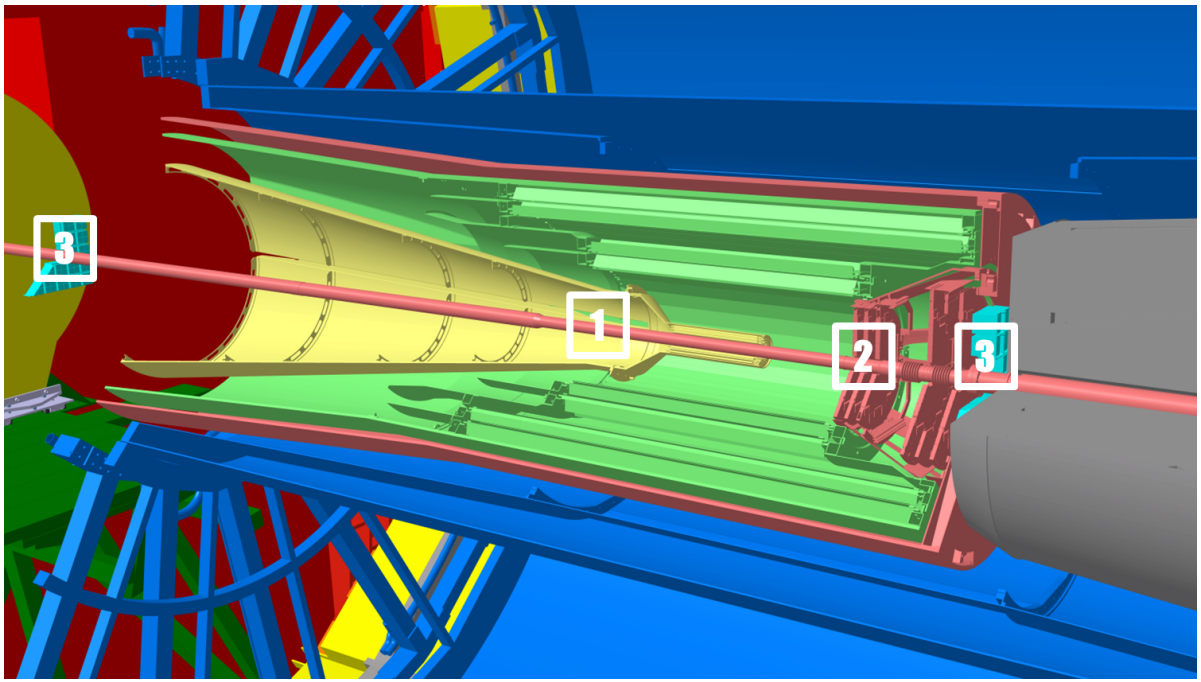
- Long Shutdown 2 period (LS2), from 2019 to July of 2022
- Upgrade of old detectors and adding new ones
- Higher interaction rate:
  - Pb–Pb from 8 kHz to 50 kHz
  - p–p from 200 kHz to 1 MHz
- Continuous readout
- Need for a new analysis software: Online-Offline analysis software O^2

Upgraded ALICE schema



ITS efficiency

- Upgraded ITS: seven layers of silicon trackers
- Innermost layer: ± 27 cm wide in z direction
- Detector efficiency dependent on z position and pseudorapidity of a particle and on multiplicity of a collision



Pseudorapidity density calculation

- Correction for detector efficiency
- N the number of particles (multiplicity), N_{trk} the number of tracks, N_{evt} the number of events, Z_{vtx} the position of the vertex on the z axis, and η the pseudorapidity
- Starred quantities: the real data
- ϵ: the efficiencies determined from simulations

$$\left.\frac{1}{N_{evt}}\frac{dN}{d\eta}\right|_{\eta=\eta'} \sim \frac{\int_{z_{min}}^{z_{max}(\eta')}(\eta')N^{*}_{\mathrm{trk}}(Z_{\mathrm{vtx}},\eta')/\epsilon_{\mathrm{trk}}(Z_{\mathrm{vtx}},\eta')}{\int_{z_{min}}^{z_{max}(\eta')}(\eta')\sum_{N}N^{*}_{\mathrm{evt}}(Z_{\mathrm{vtx}},N)/\epsilon_{\mathrm{evt}}(Z_{\mathrm{vtx}},N)}, \tag{1}$$

$$\epsilon_{\mathrm{trk}}(Z_{\mathrm{vtx}},\eta)=\frac{N^{\mathrm{rec}}_{\mathrm{trk}}(Z_{\mathrm{vtx}},\eta)}{N^{\mathrm{gen}}_{\mathrm{trk}}(Z_{\mathrm{vtx}},\eta)},\ \epsilon_{\mathrm{evt}}(Z_{\mathrm{vtx}},\eta)=\frac{N^{\mathrm{rec}}_{\mathrm{evt}}(Z_{\mathrm{vtx}},N)}{N^{\mathrm{gen}}_{\mathrm{evt}}(Z_{\mathrm{vtx}},N)}. \tag{2}$$

Studied data

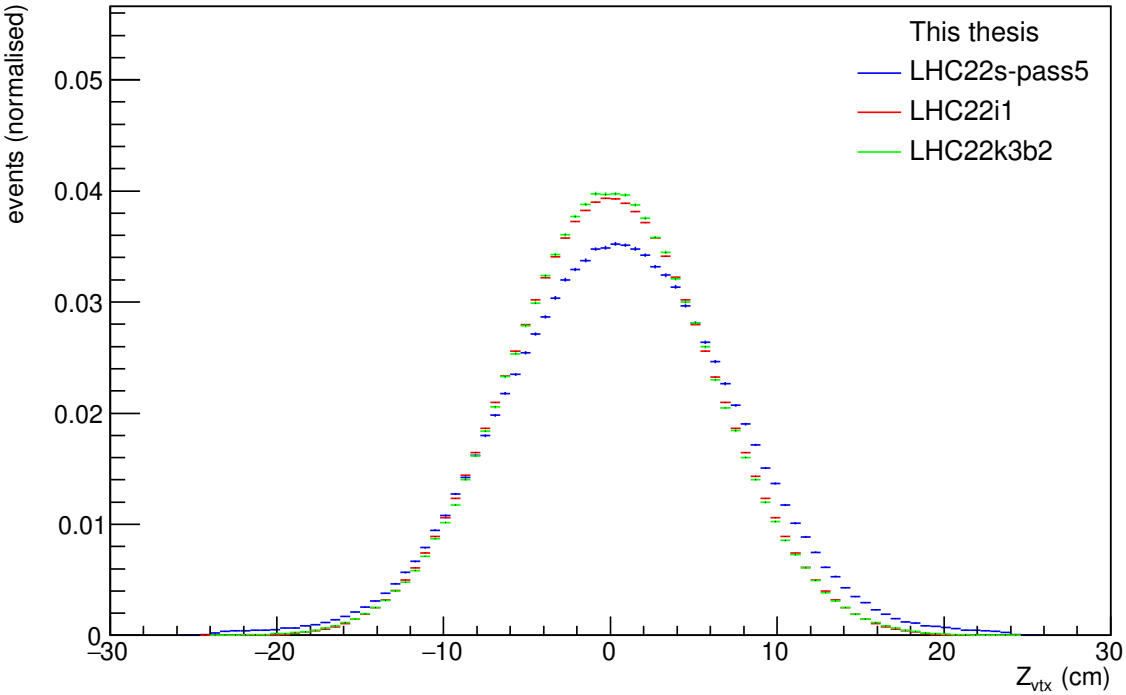
- Acquired on 18th of November 2022
- Pb–Pb collisions, center-of-mass energy of $\sqrt{s} = 5.36$ TeV
- Pass5 used runs 529397, 529399, 529414, 529418
- Monte Carlo simulated data unanchored
  - LHC22i1: runs 310015, 310016, 310017
  - LHC22k3b2: runs 311010, 311011
- Analysis: O^2 software used, data stored on the Grid and run over using Hyperloop

Applied selections

- Selections applied on reconstructed data
- Limit on DCAxy: 0.2 cm
- Short tracks excluded: `'track.tpcNClsCrossedRows()<70'` criterion
- LHC22i1: 2.50×10^7 events
- LHC22k3b2: 1.59×10^5 events
- LHC22s-Pass5: 1.29×10^6 events

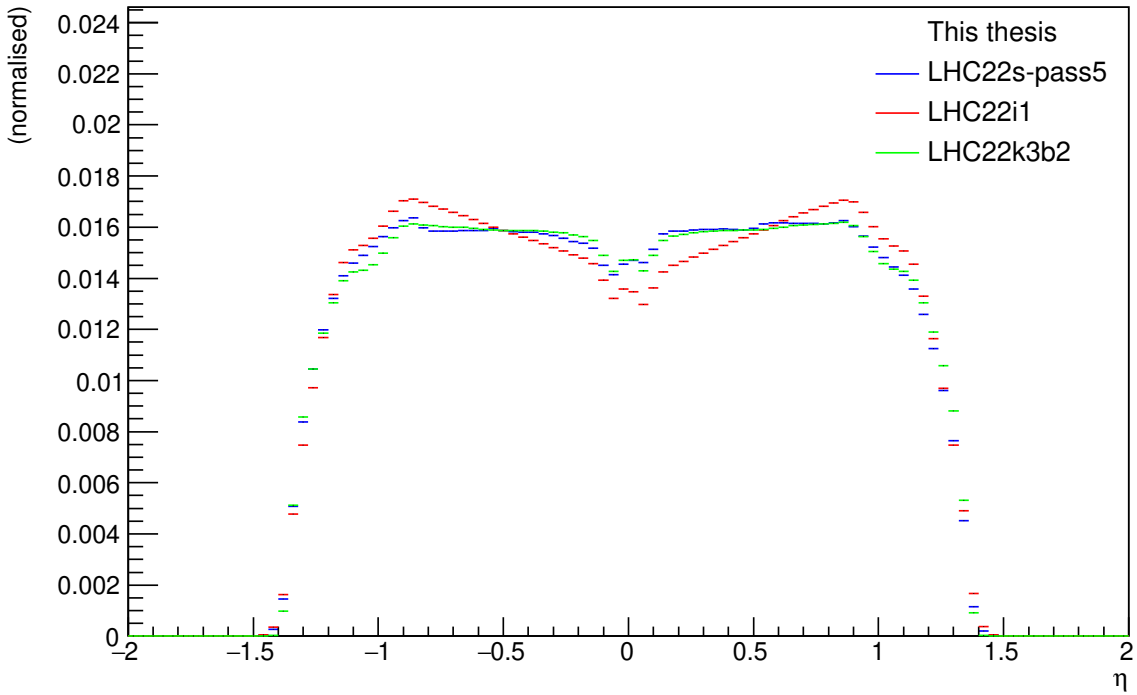
Vertex reconstruction

- Expected normal distribution
- MC simulated data: shifted mean and different width of the distribution



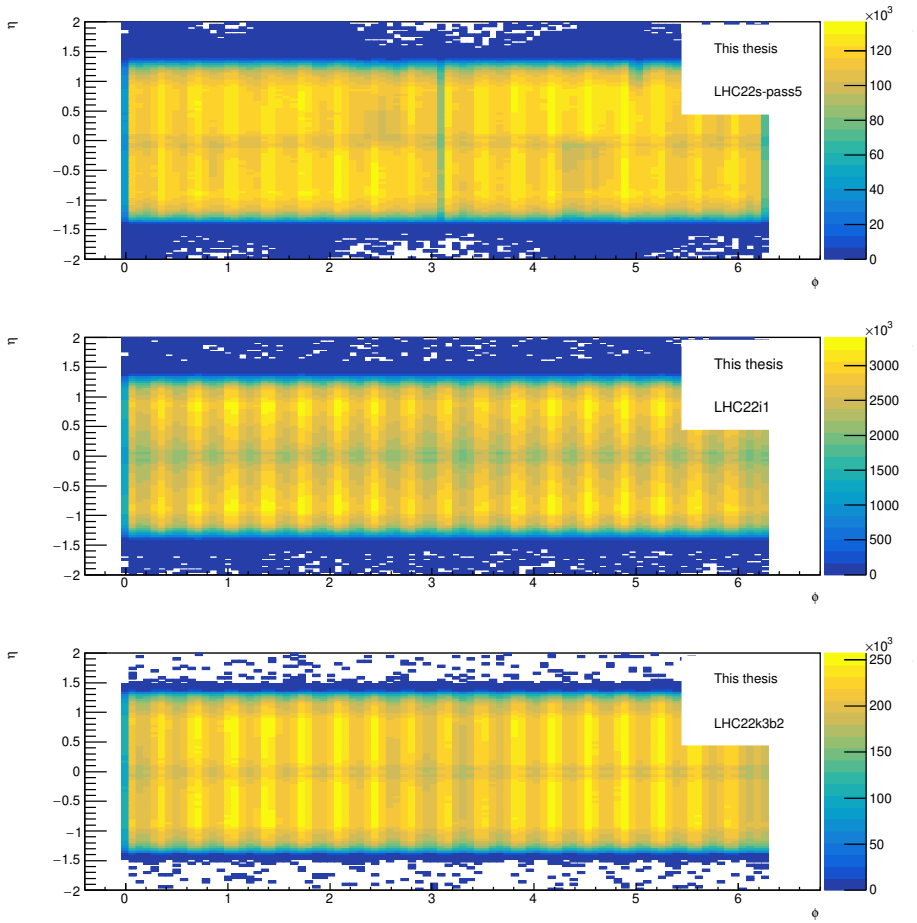
Pseudorapidity distribution

- Smaller difference between measured data and MC simulations LHC22k3b2, than LHC22i1



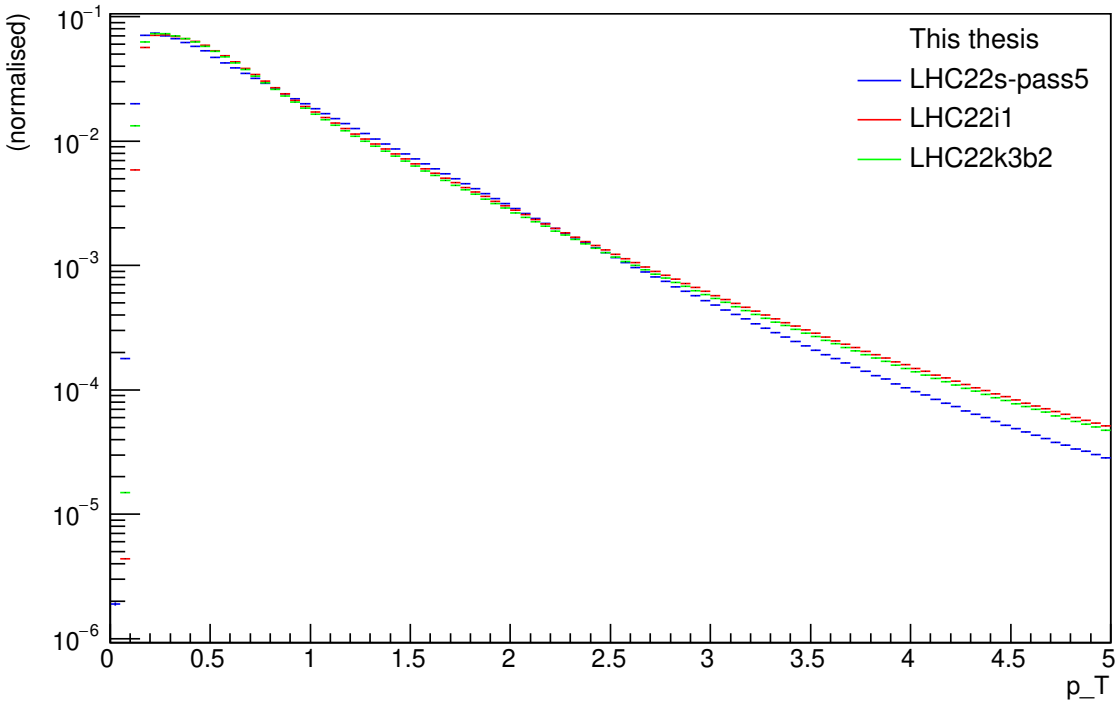
$\Phi - \eta$ distribution

- Measured data: slight gap around π in azimuthal angle
  - Possibly a detector's inefficiency



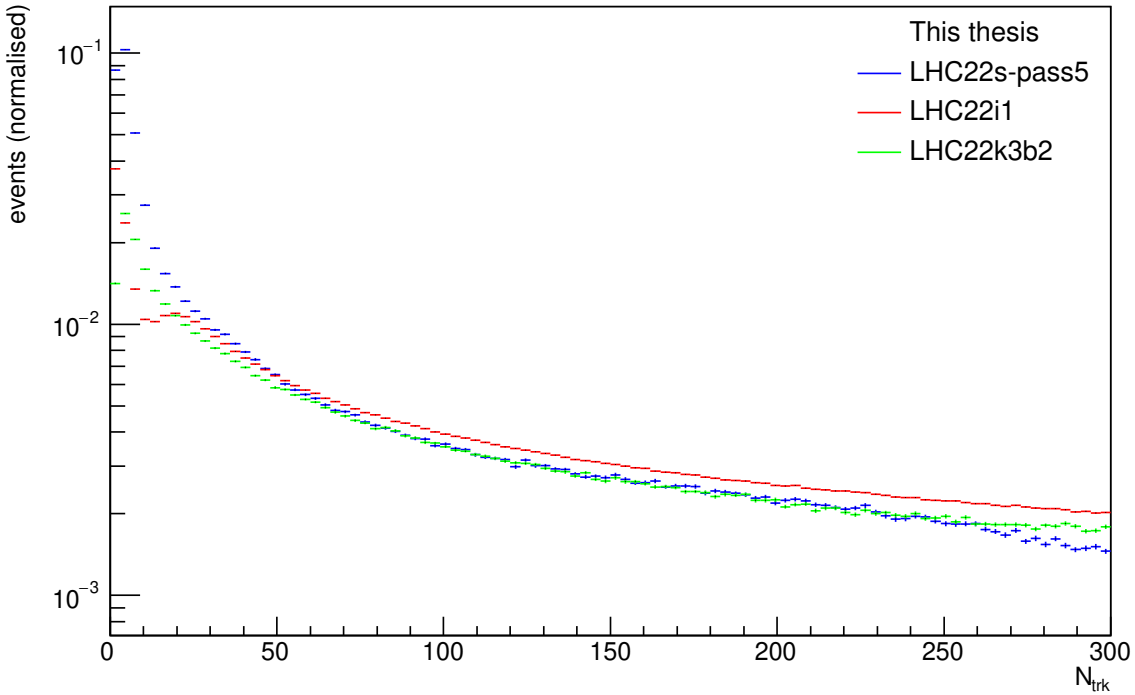
Momentum distribution

- Steeper decrease in the measured data



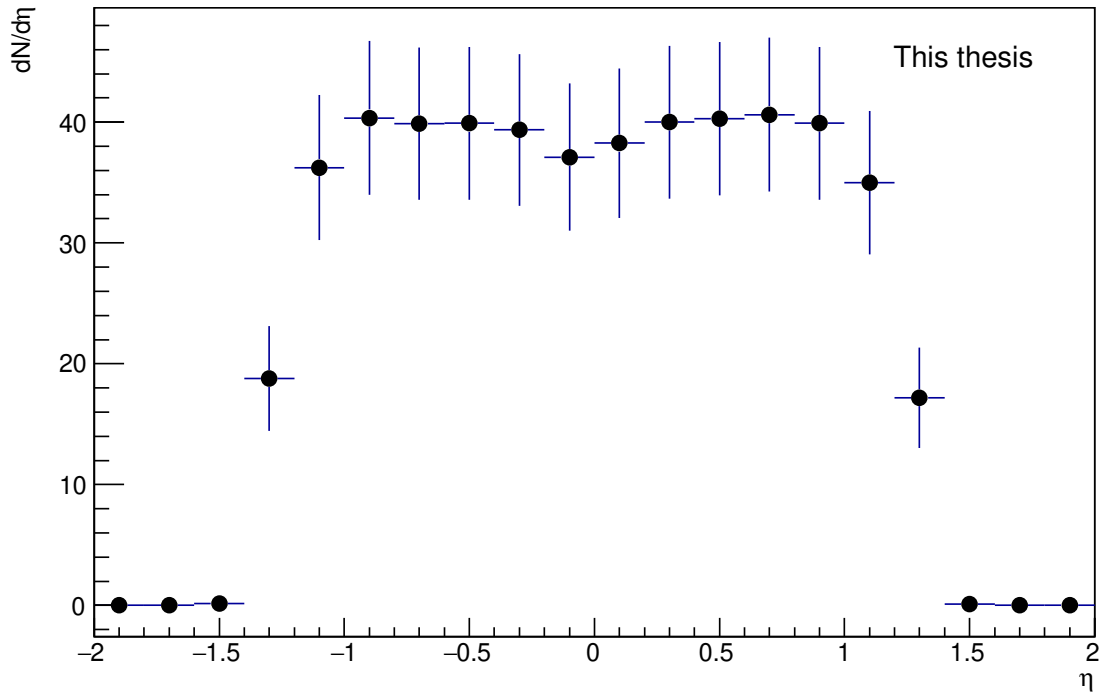
Multiplicity distribution

- LHC22i1 MC simulations differ from measured data (unexplained peak around 25)



Raw pseudorapidity density

- Corrections for detector efficiency yet to be applied



Next analysis steps

- Apply more selection criteria
- Use new anchored simulations and calculate resolutions of measurements
- Apply efficiency corrections to the pseudorapidity density distribution