A preliminary analysis of pilot beam data from ALICE's new ITS and MFT detectors

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Honour's Research Project
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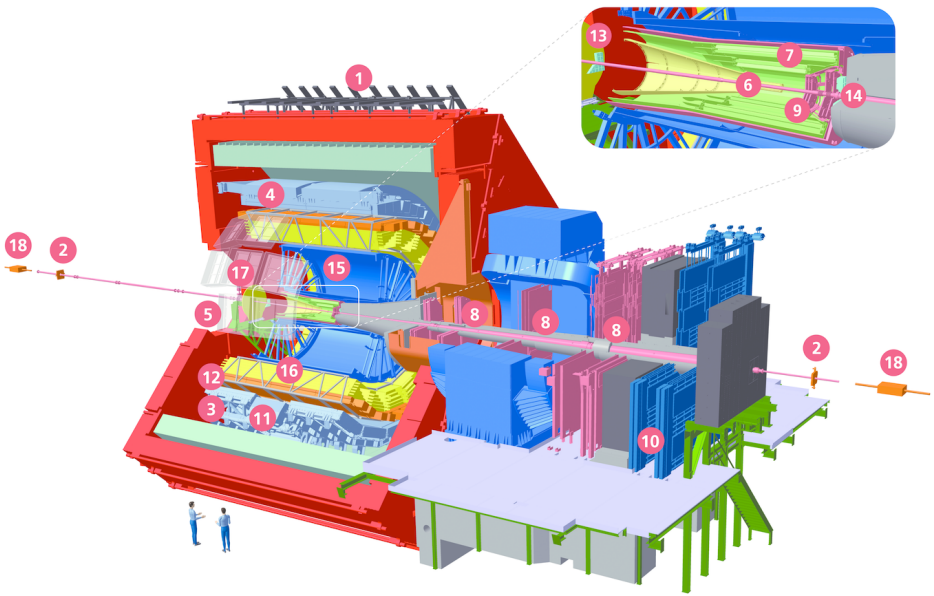
ALICE Run 3

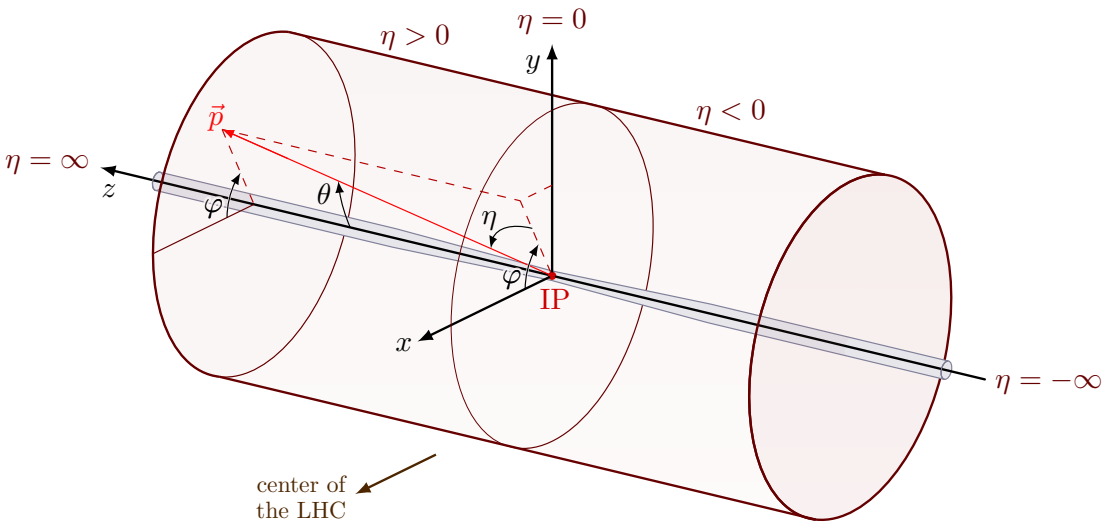


ALICE Run 3 Detector Array

- LHC Run 3 comes with increased $\sqrt{s}$ and luminosity of collisions
- This requires a new untriggered data capture scheme, so detector readout electronics were upgraded at ALICE
- The MFT (9) was added, the ITS (6, 7) was upgraded, and the analysis framework was overhauled entirely (called O2)
- Learning this framework, and how the MFT and ITS interact with it, was the main goal of this project

Coordinate System

- Z: Distance along Z-axis (cm)
- φ: Azimuthal angle around beam axis
- θ: Polar angle



- p_{T}: Transverse momentum (GeV/c)

$$p_{\mathrm{T}} = \sqrt{p_x^2 + p_y^2}$$

- y: Rapidity

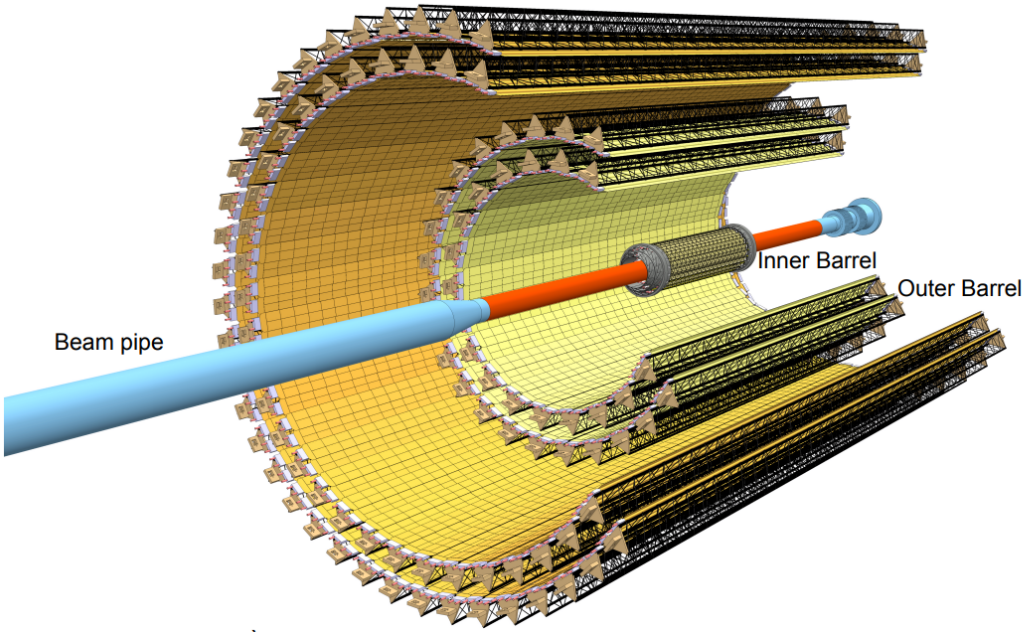
$$y = \frac{1}{2} \ln \frac{E + p_z}{E - p_z}$$

- η: Pseudorapidity

$$\eta = -\ln \tan \frac{\theta}{2}$$

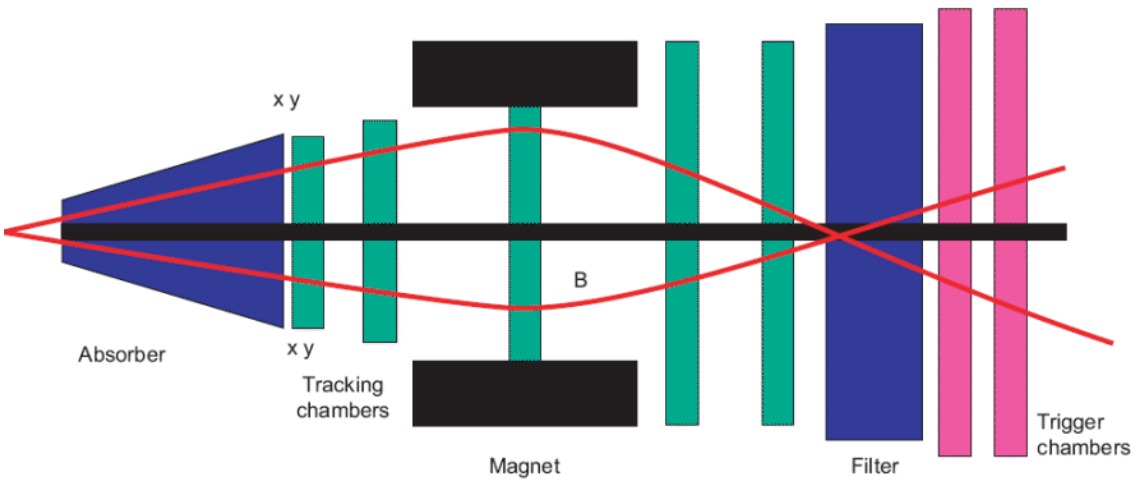
Inner Tracking System (ITS)

- Fully revamped for Run 3 with 7 layers of brand new pixel detectors
- Used to determine position of the primary vertex and help with particle tracking
- 22.4 mm to 391.8 mm radial extension from IP
- Covers $|\eta| < 1.22$
- Stand-alone tracking has no minimum required number of clusters per track



Muon Spectrometer (MCH)

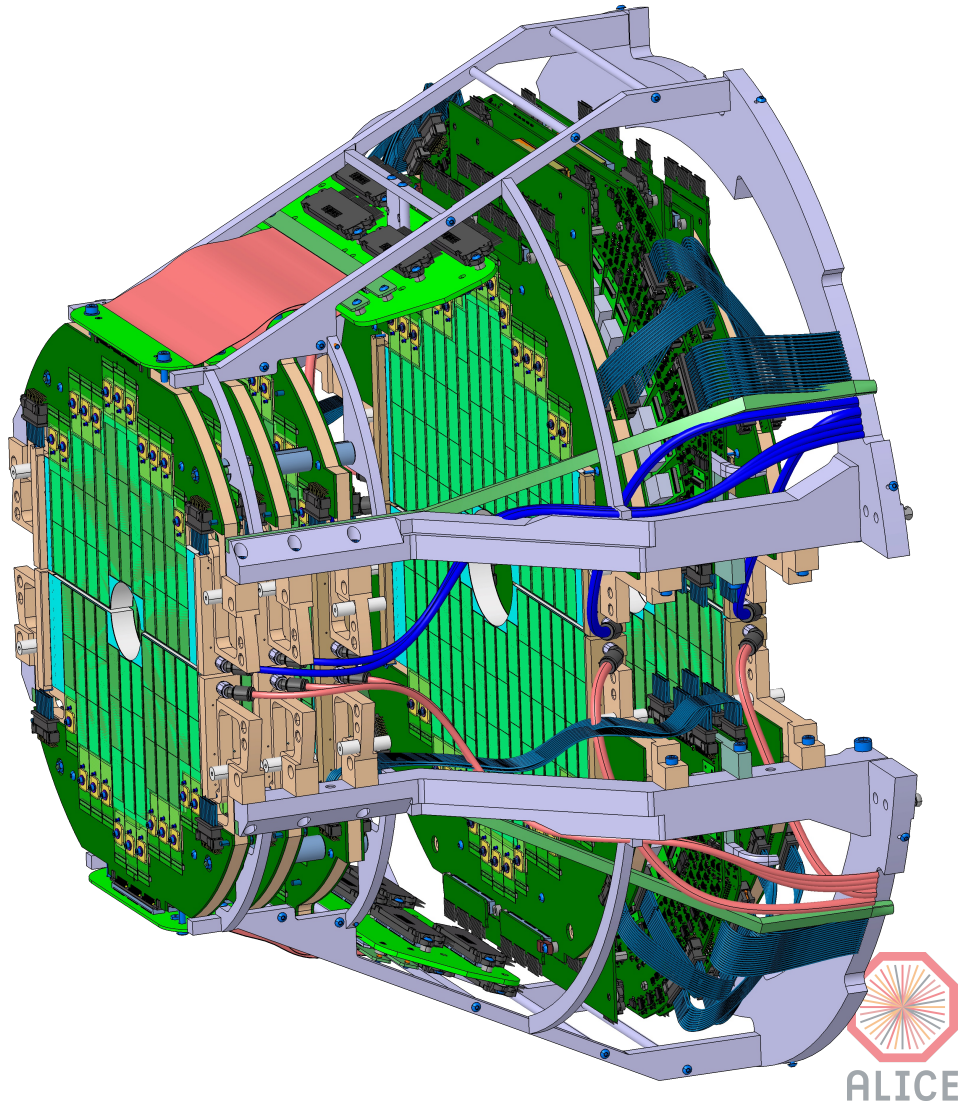
- Used to study various heavy particle decays via their single- and di-muon decay channels
- All detector material sits behind $\sim$4 m of hadronic absorber



- Covers $-4 \leq \eta \leq -2.5$
- Outside the range of the ITS so previously had to perform its own tracking and vertexing
- Run 3 added the Muon Forward Tracker in front of the absorber to fill this role

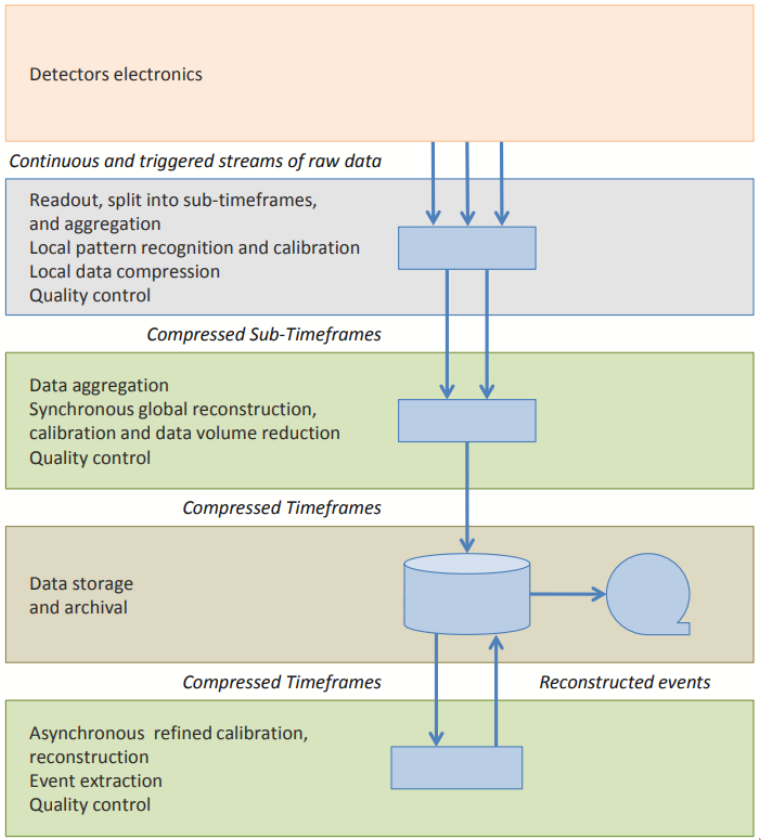
Muon Forward Tracker (MFT)

- Uses the same pixel detector technology as the ITS in a better-suited geometry
- Sits in front of the hadronic absorber, with 5 double-sided disks between $z = -46$ cm and $z = -76.8$ cm
- Each disk is 1.4 cm thick
- Covers $-3.6 \leq \eta \leq -2.45$
- Reconstructing a track requires contribution from 4 of the 5 disks, according to the documentation



Online-Offline Analysis Framework (O2)

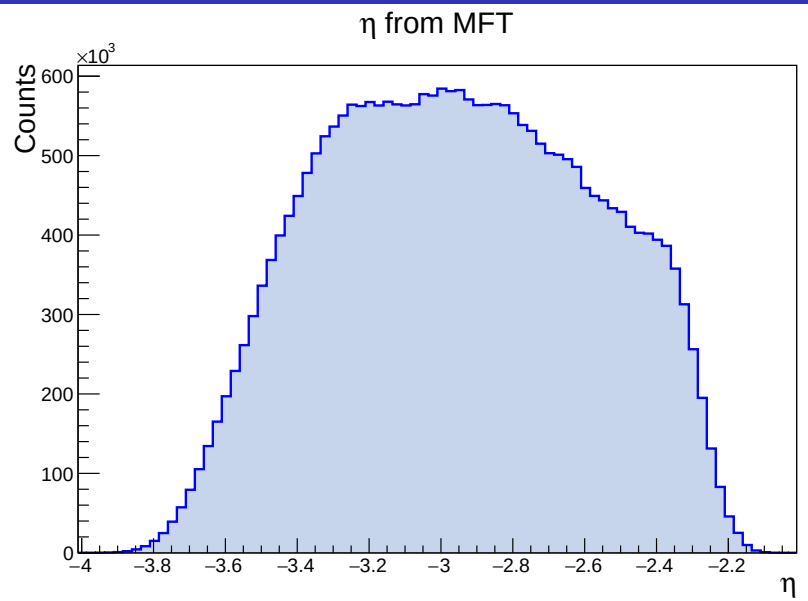
- Created for Run 3 to deal with untriggered data capture, splitting it into 10 ms “timeframes” in online processing, then compressed timeframes (CTFs), which are saved to disk
- Raw data converted to usable data with “reconstruction passes” in the offline stage, producing Analysis Object Data (AOD) files
- Then analysed with C++ and ROOT to make the most of computational resources and to minimise disk space usage
- Don’t breathe near O2, or it might break

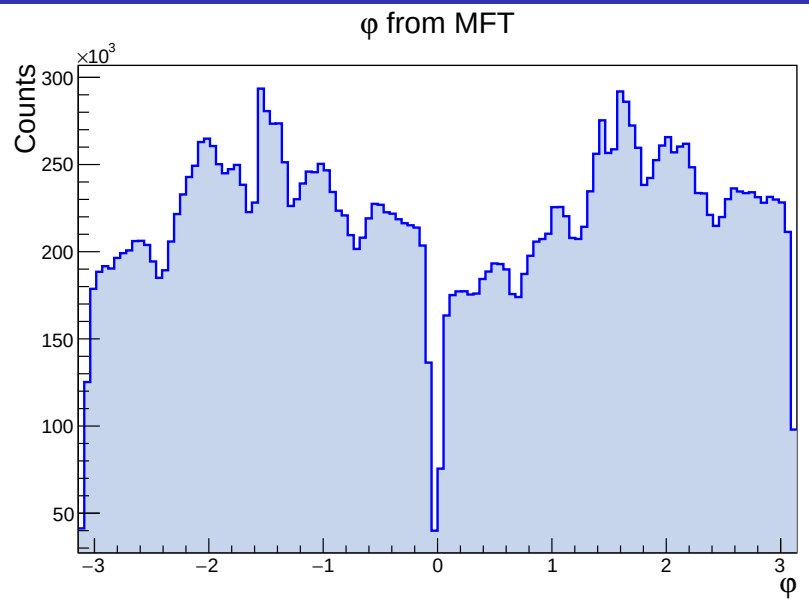


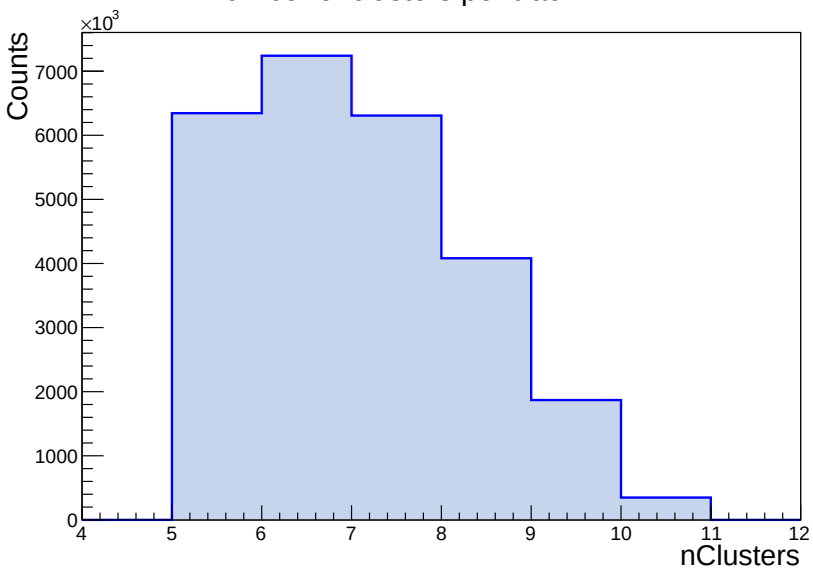
What data are we using?

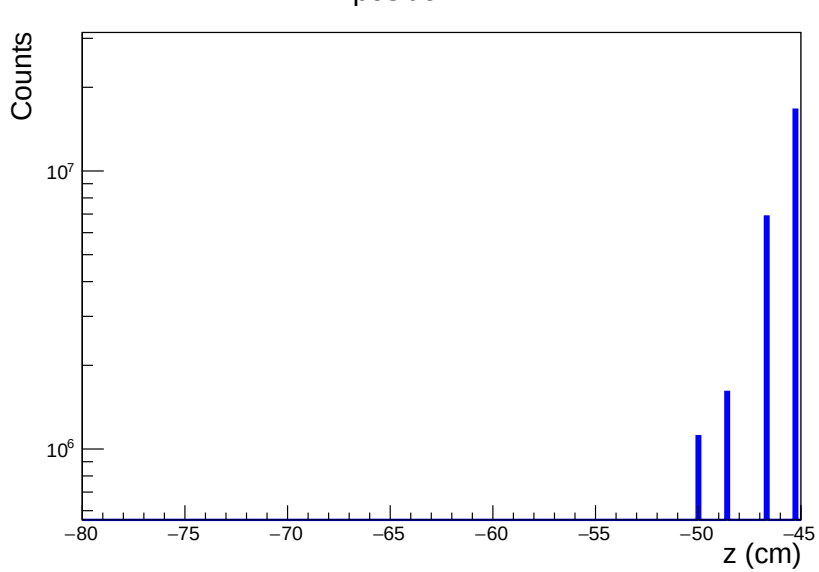
- Pilot beam runs 505548 and 505645 from October 2021
- Non-nominal centre of mass energy $\sqrt{s} = 900\,\mathrm{GeV}$
- Detectors running: ITS, MCH, MFT, MID, TOF, TPC, TRD
- All plots include data from both runs
- We used data from two different reconstruction passes

MFT Kinematics (pass 3)



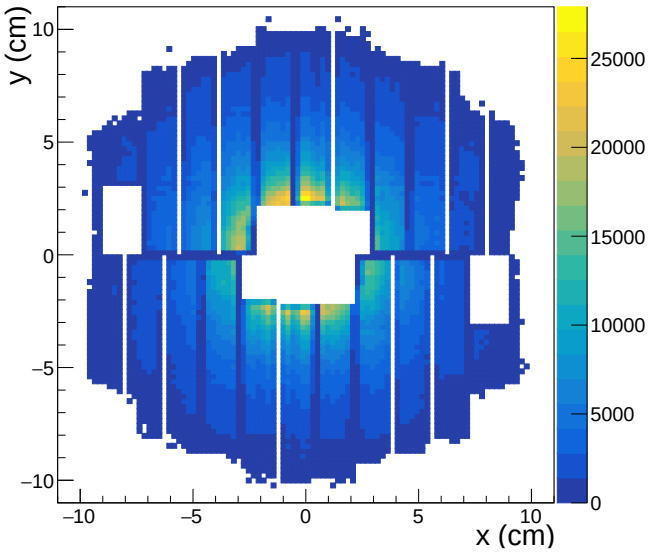




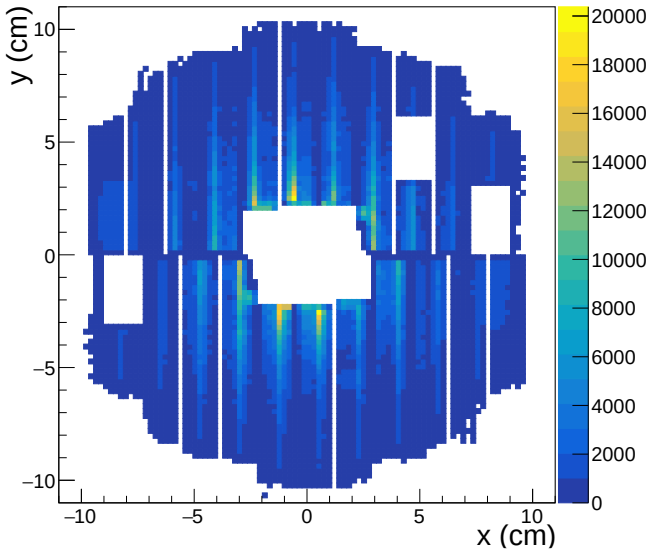


MFT x-y Plots (pass 3)

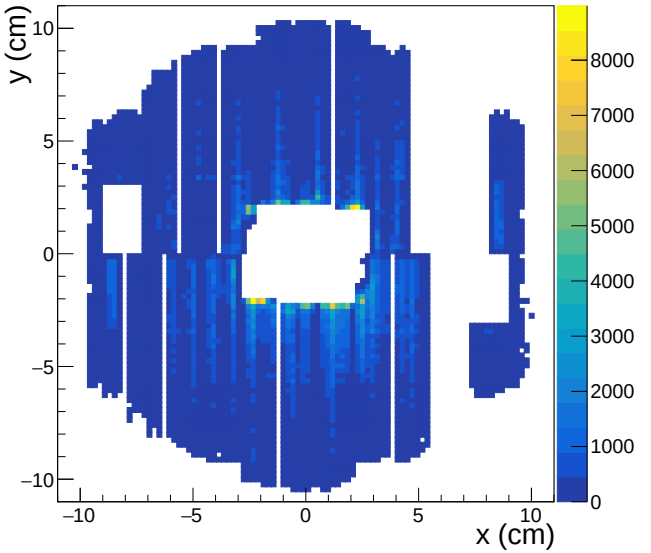
x-y at first MFT plane



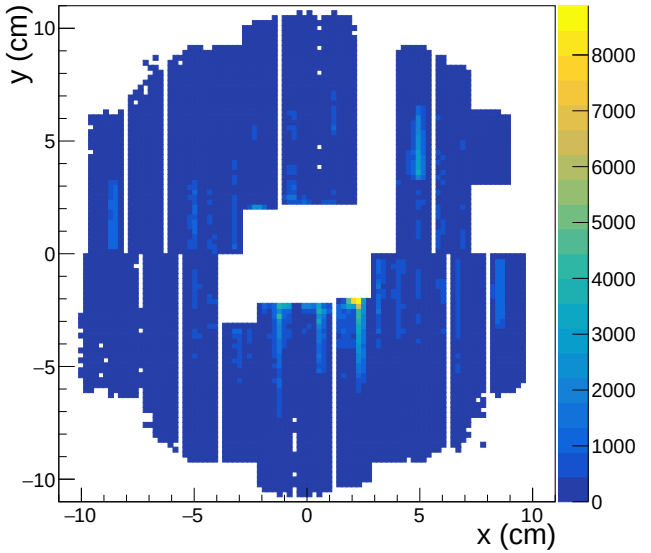
x-y at second MFT plane



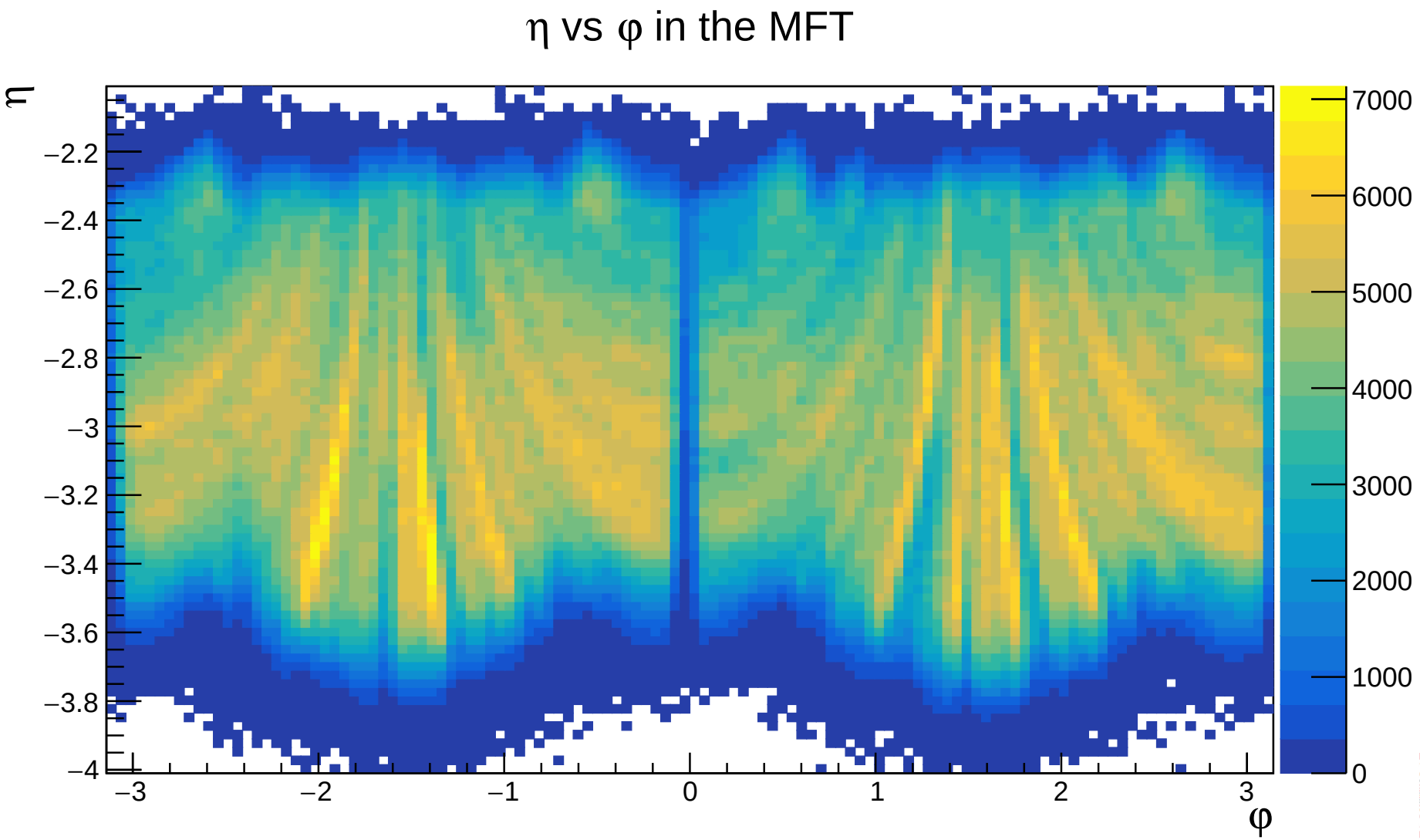
x-y at third MFT plane



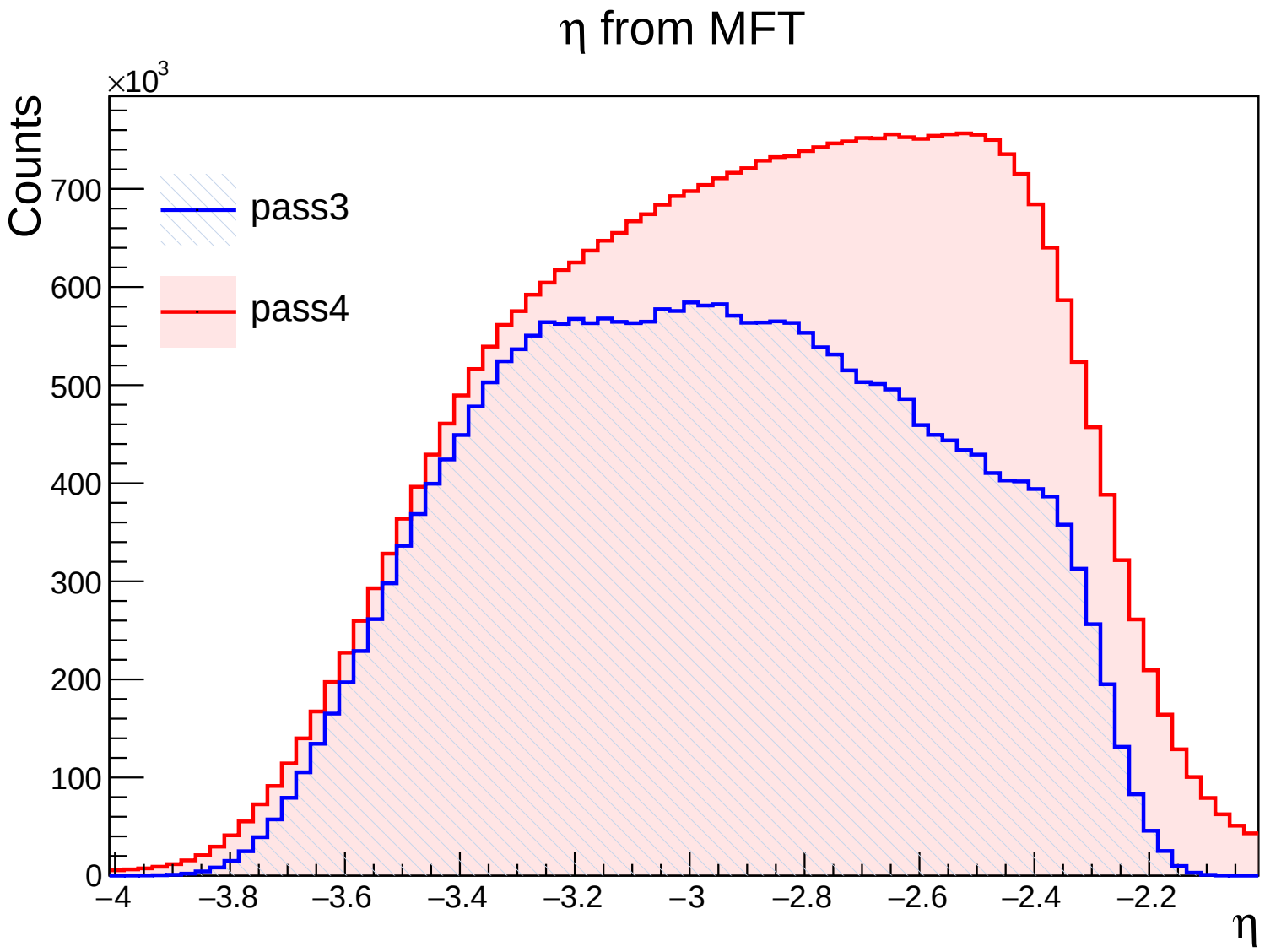
x-y at fourth MFT plane



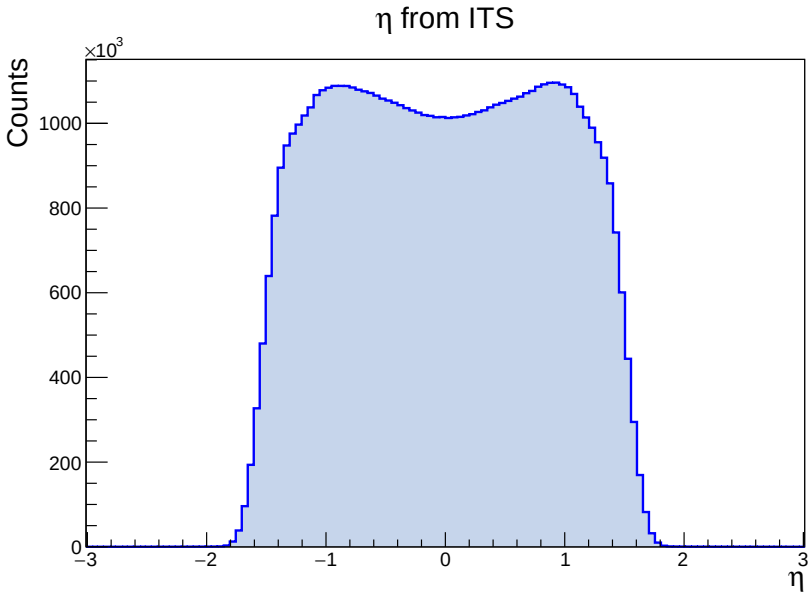
η-φ in the MFT (pass 3)

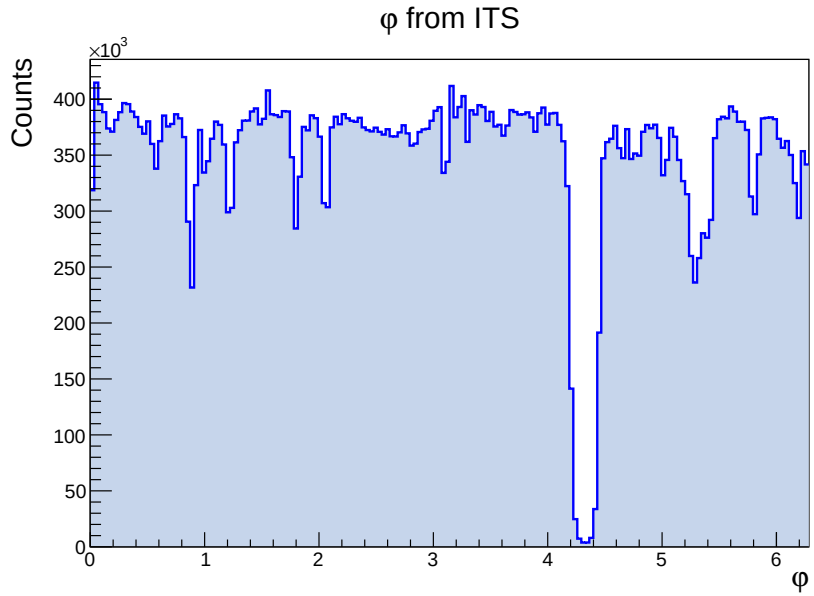


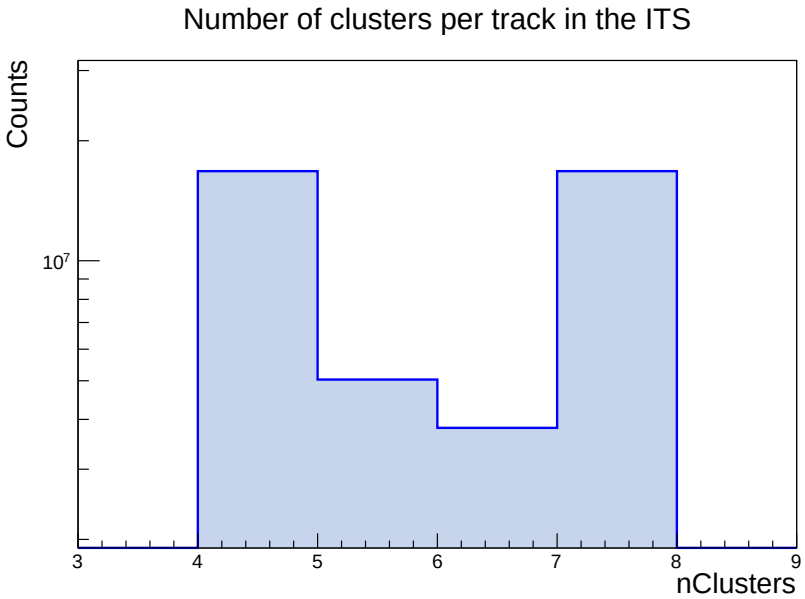
Comparison of η for pass 3 and pass 4 in the MFT

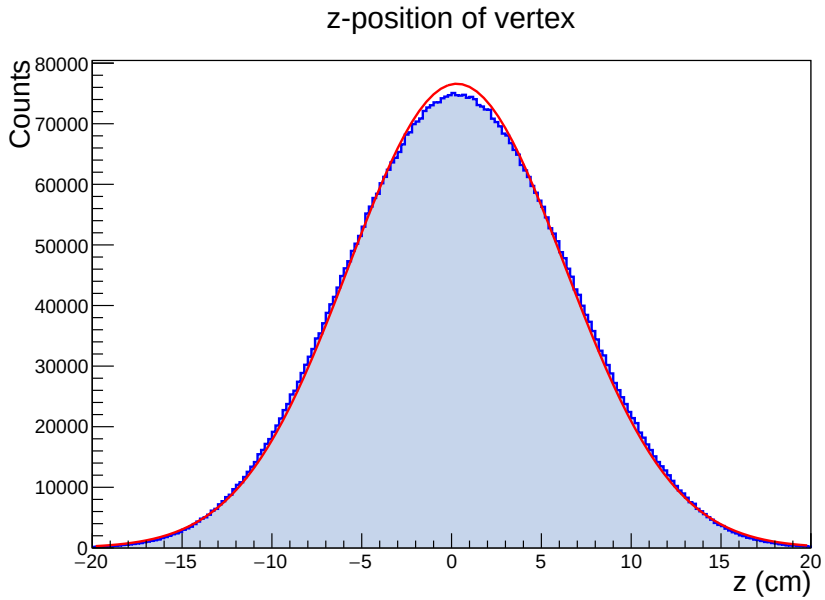


ITS Kinematics (pass 4, hasITS)

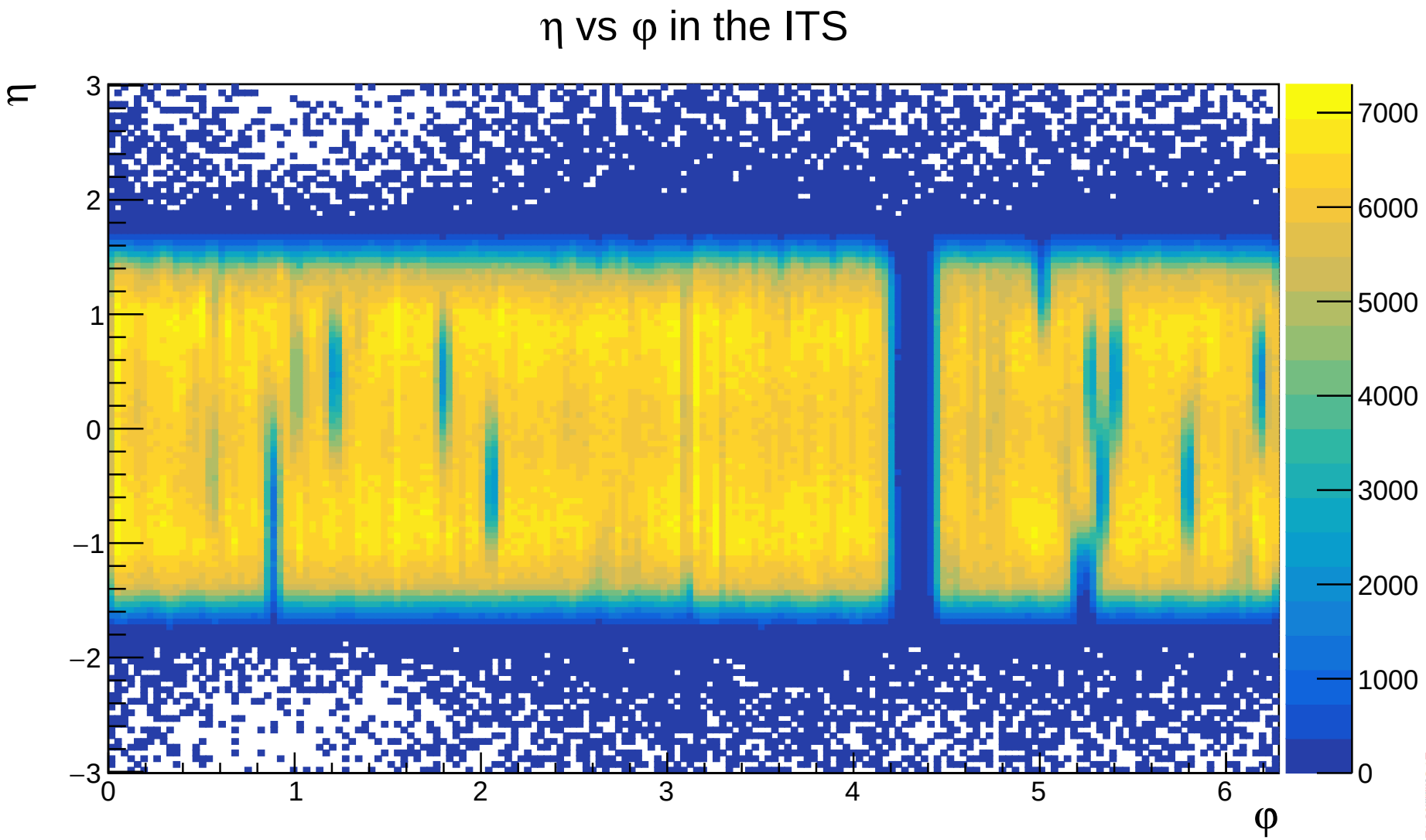








η-φ in the ITS (pass 4, hasITS)

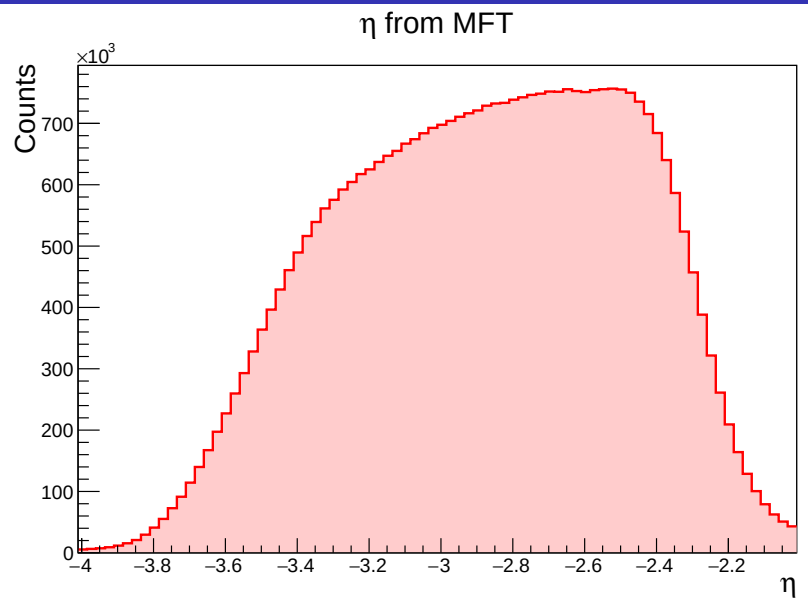


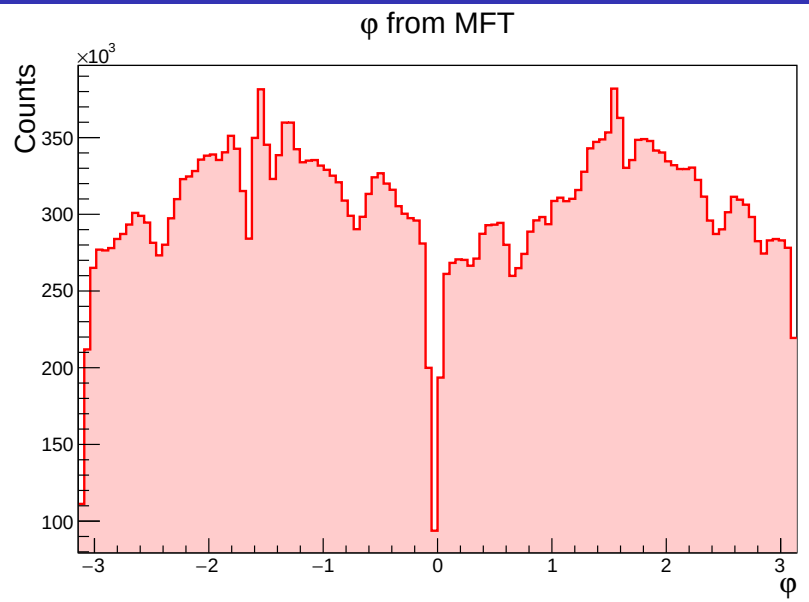
Conclusion

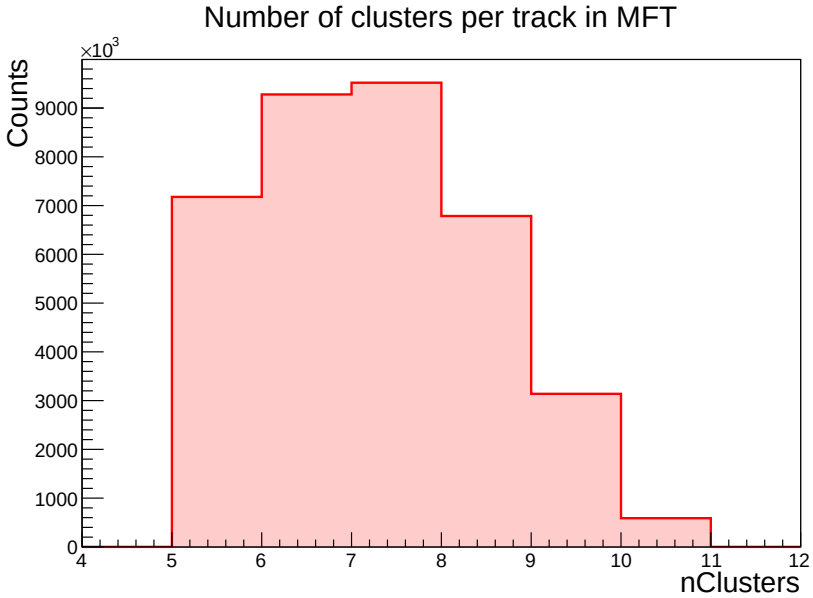
- We performed some low-level analysis of kinematic variables of tracks in the ITS and MFT but came up against some issues related to how O2 is built for more advanced analysis than what we intended
- If more analysis of this type needs to be done, we recommend that O2 gets modified quite extensively to allow for it, or the step between CTFs and AODs gets investigated first to allow a more in-depth analysis
- We also recommend investigating simulations in order to properly compare the distributions we see with what we expect, as we were only able to interpret the plots through the lens of expecting isotropic emission of particles and the geometry of the detectors

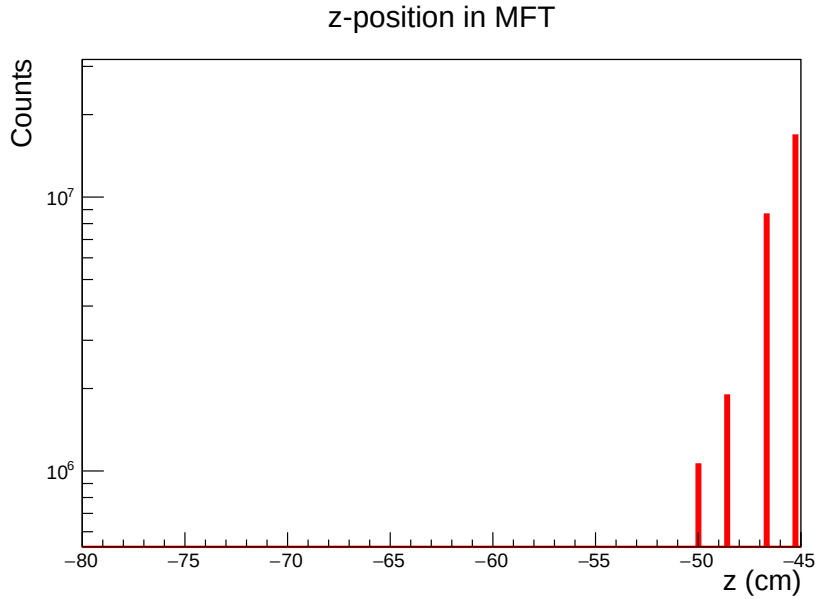
Thank you!

MFT Kinematics (pass 4)



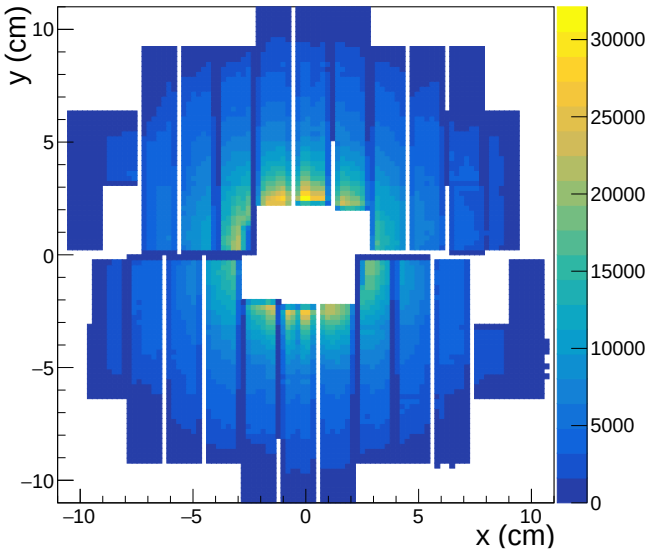




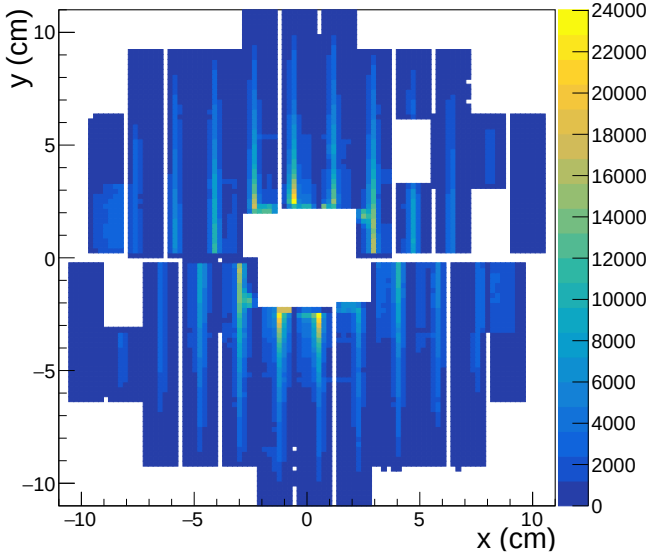


MFT x-y Plots (pass 4)

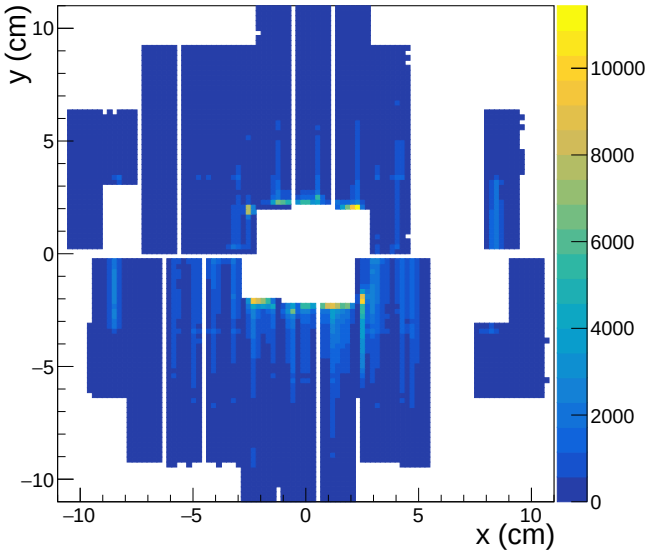
x-y at first MFT plane



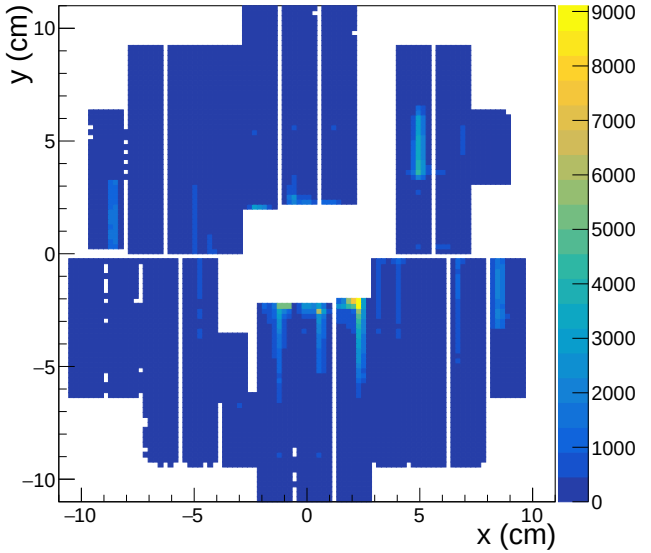
x-y at second MFT plane



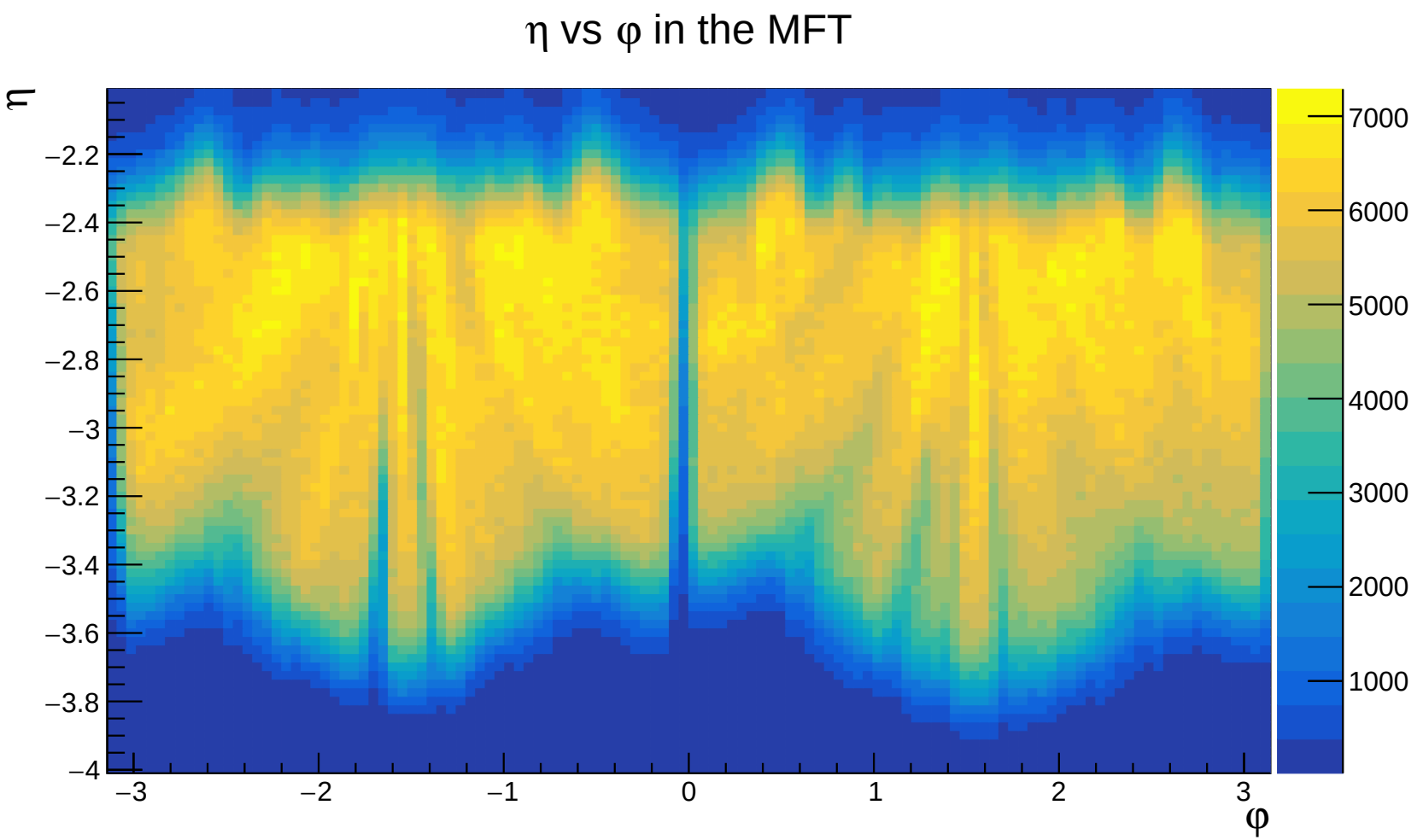
x-y at third MFT plane



x-y at fourth MFT plane



η-φ in the MFT (pass 4)



ITS Kinematics (pass 4)