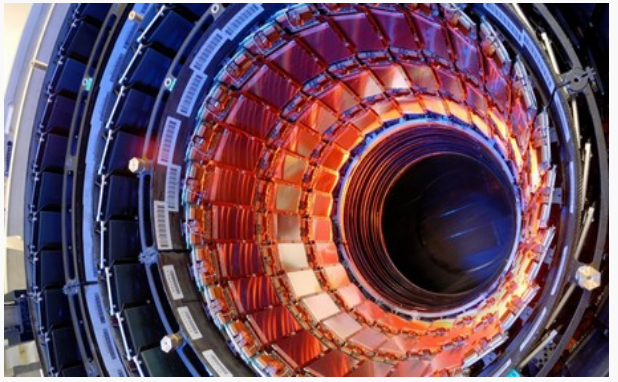
Tracking and Vertexing Short Exercise Introduction



CMS Data Analysis School at CERN 2023

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Introduction

- Welcome to the wrap-up session of the Tracking and Vertexing Short Exercise (**Twiki** , **Mattermost Channel**) !

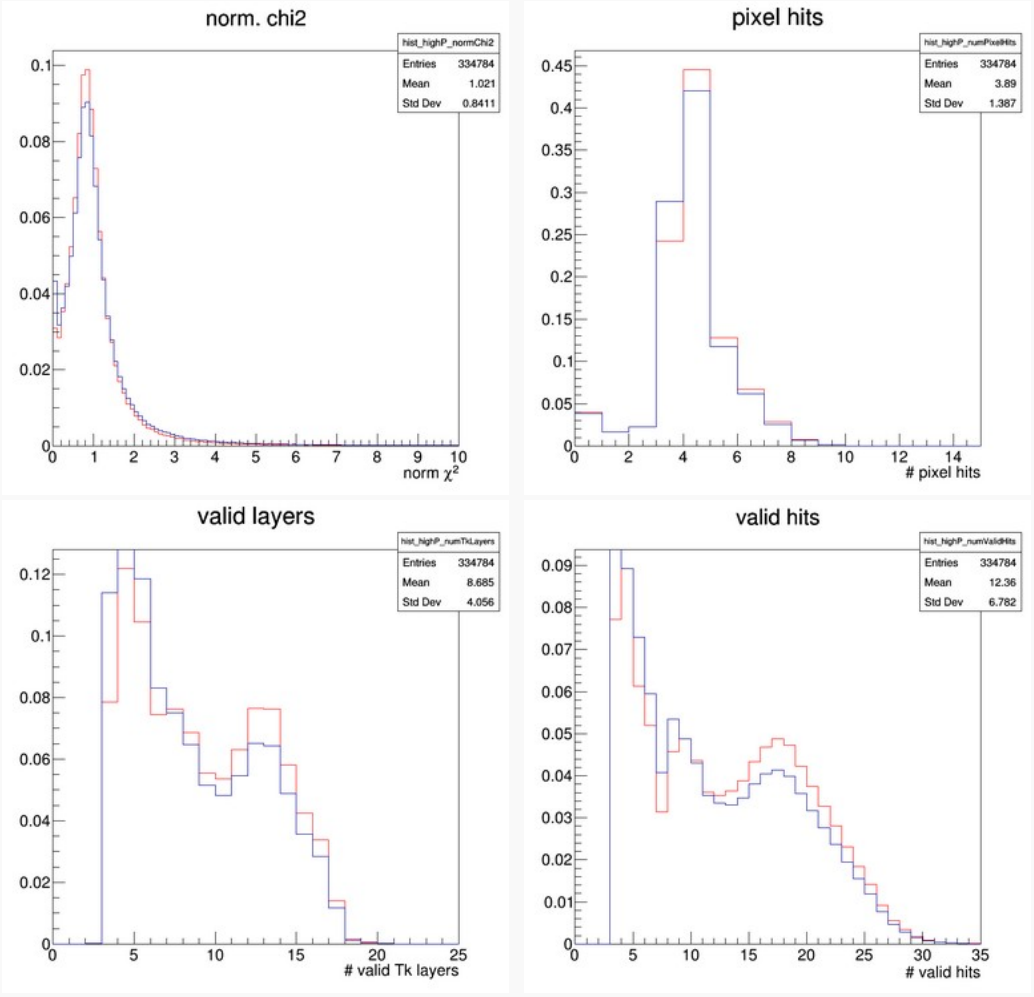
Recap: Goals of the exercise

- We wanted to you to familiarize yourself with the basic properties of charged particle tracks
- What information is available and how can it be accessed in different analysis data formats?
- How can tracks be used to find the real physics in our events?
- How to combine tracks to reconstruct vertices and use them to improve our understanding of an event

- In this session we want to go through the results of the exercises and discuss them
- Your chance to ask all your questions and make sure you understood it all!

Exercise 1 - Accessing track variables

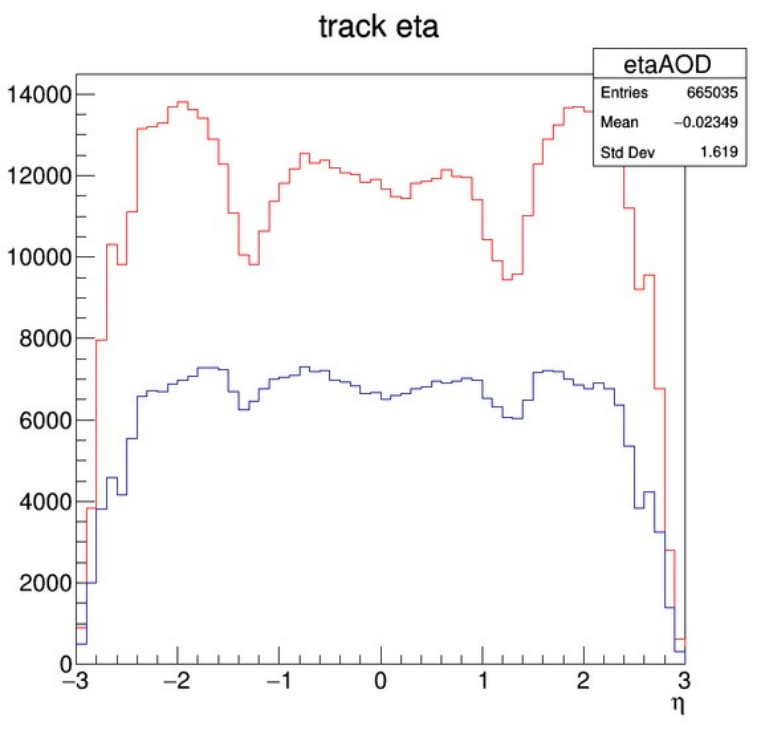
- Distributions of **track variables** **before** and **after** **high purity** track selection

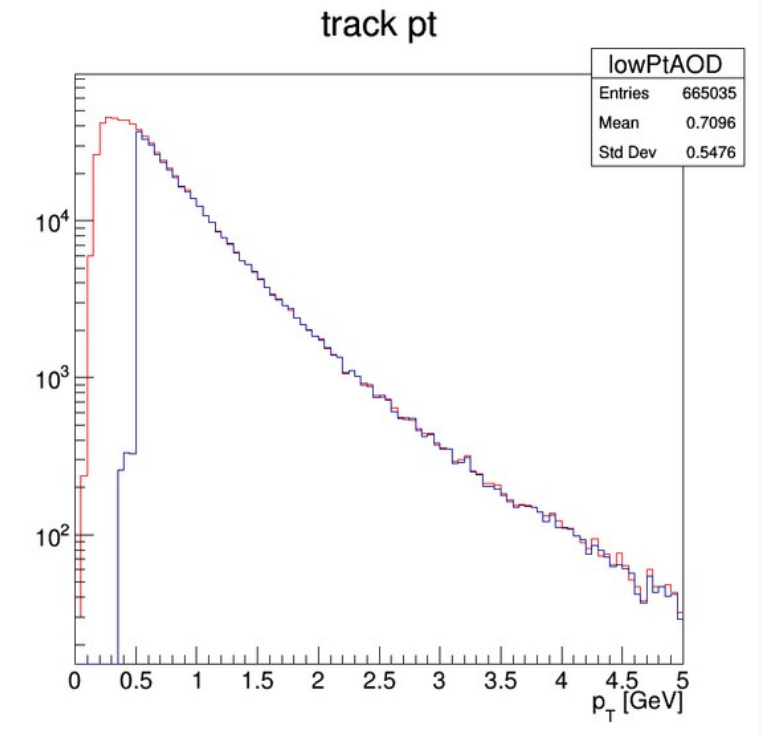


- Do these distributions make sense to you? (*mind, plots are normalized to the area!*)

Exercise 1 - Accessing track variables in miniAOD

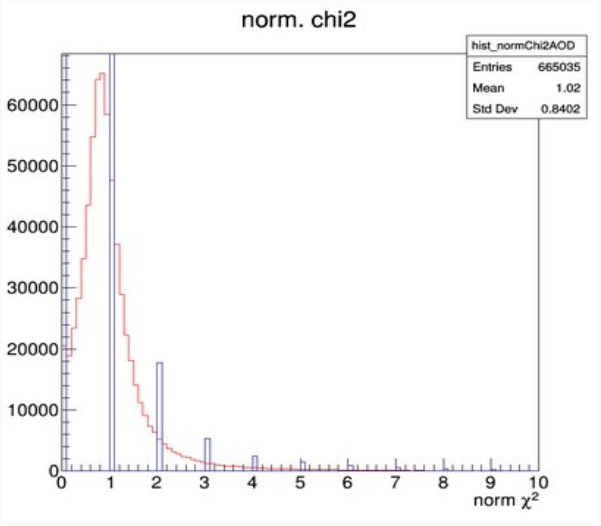
- All tracks are stored in the **generalTracks** collection in **AOD**
- In **MiniAOD** they are accessible in a less straightforward way (**packedPFCandidates**, **lostTracks** collection)
- Not all tracks are available!

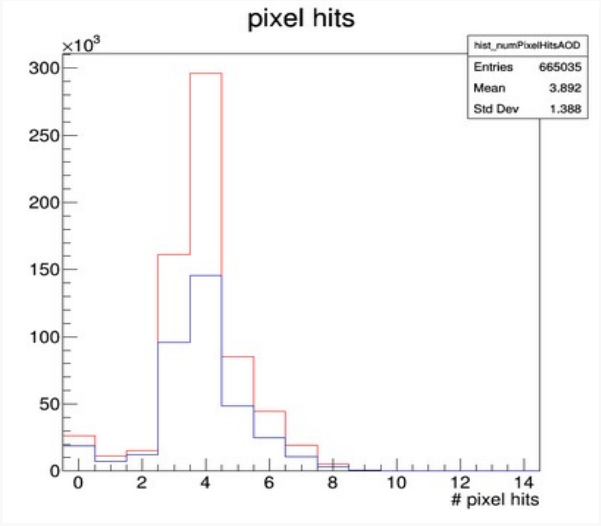


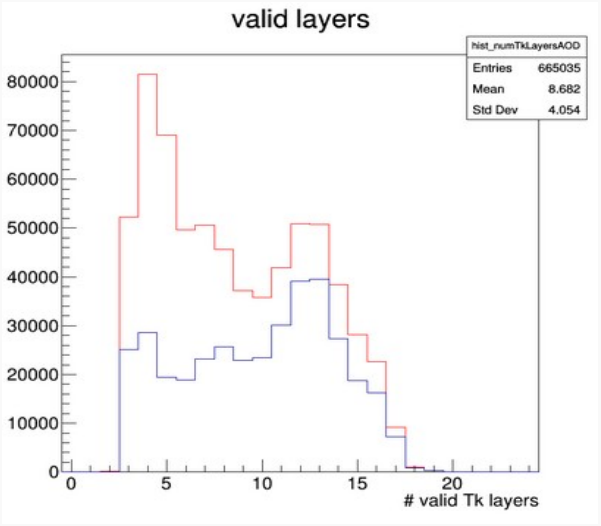


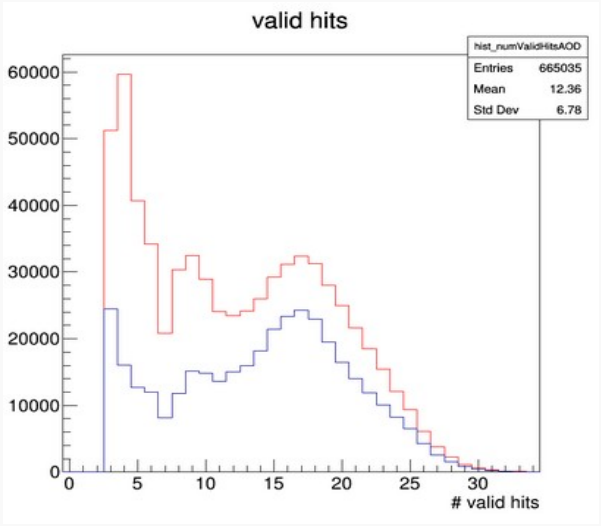
Exercise 1 - Accessing track variables in miniAOD

- The pre-selection of tracks in **MiniAOD** also affects the distribution of the track quality parameters (w.r.t. **AOD**)
- Do these changes make sense when you keep in mind that **very low p_T tracks** are left out?



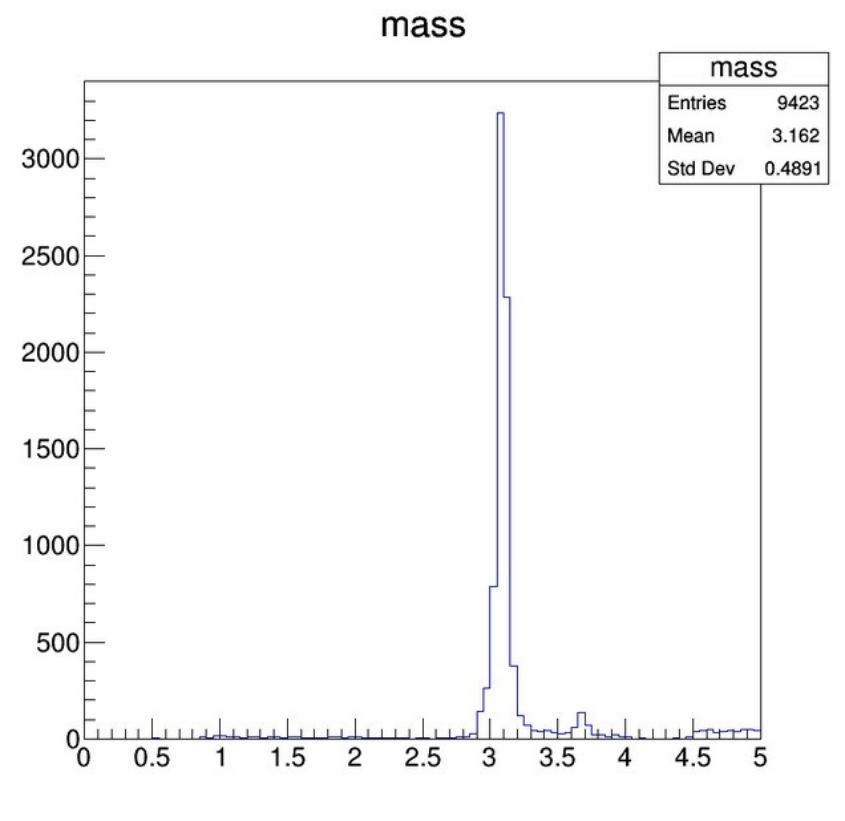






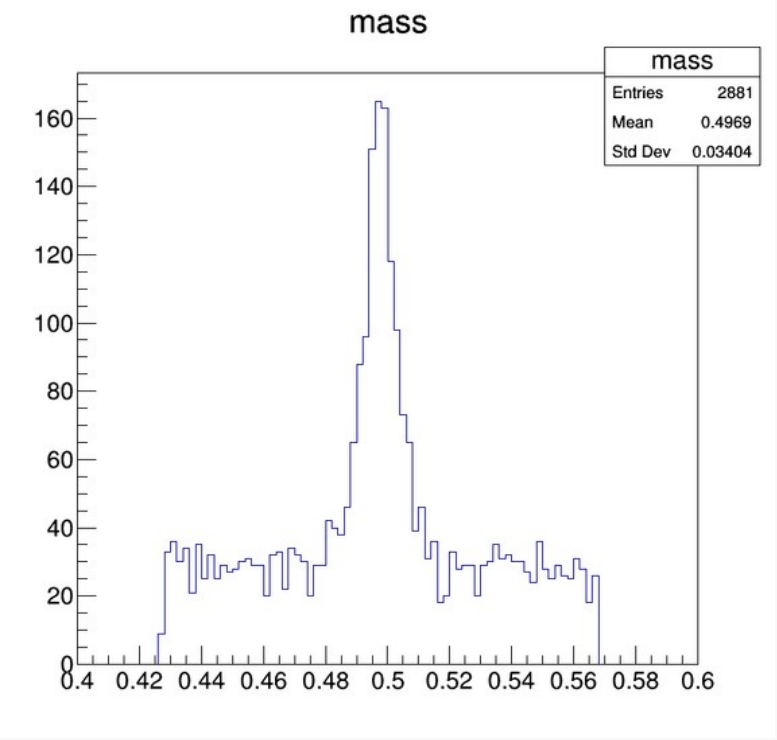
Exercise 2: Tracks as particles

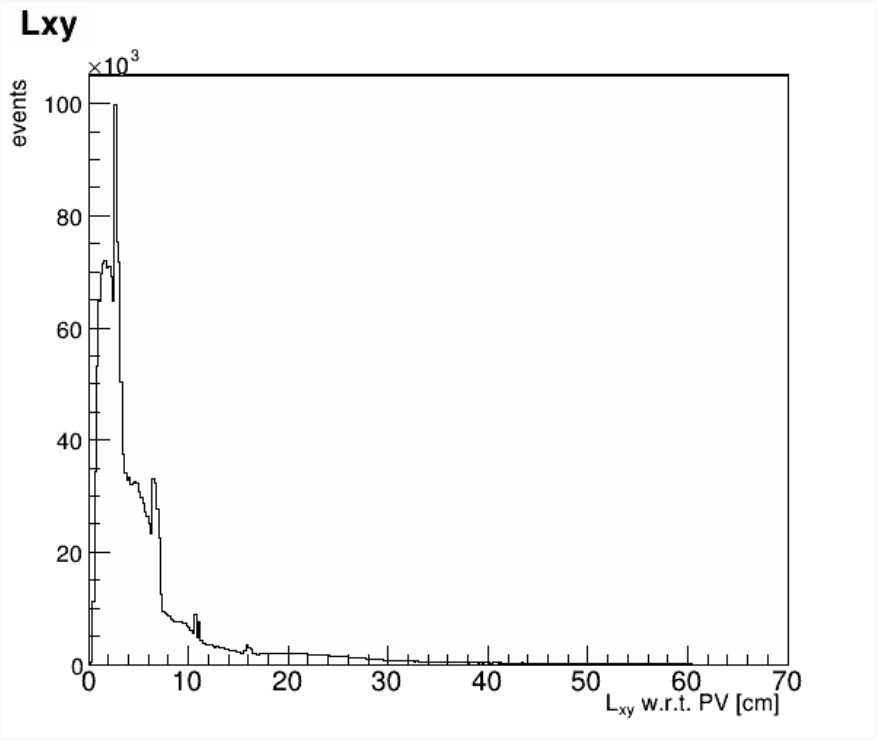
- Tracks give us a **direct handle** on **actual particles**
- Thus they can easily be used to **reconstruct other particles** in the event
- Here we simply **combined muon tracks** and calculated the **invariant mass**
- What does **this distribution** tell us?



Exercise 3: Vertexing

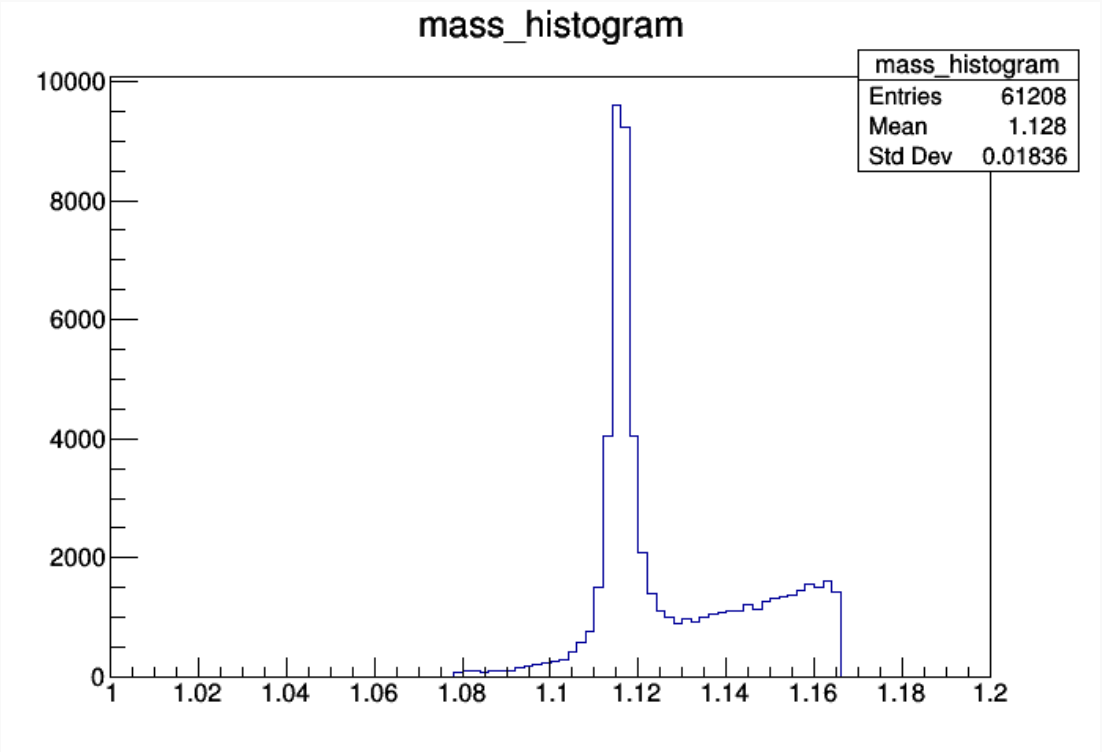
- **Two** or **more tracks** can be used to reconstruct their **common point of origin**, the vertex
- Requiring two tracks to originate from the same vertex is a powerful tool to **identify particles that decayed in the detector**
- In this case we reconstructed the K^0_S
- In the exercise we presented this plot of the **flight distance distribution** of the K^0_S. Were you able to explain the **weird structures** in the **distribution**?





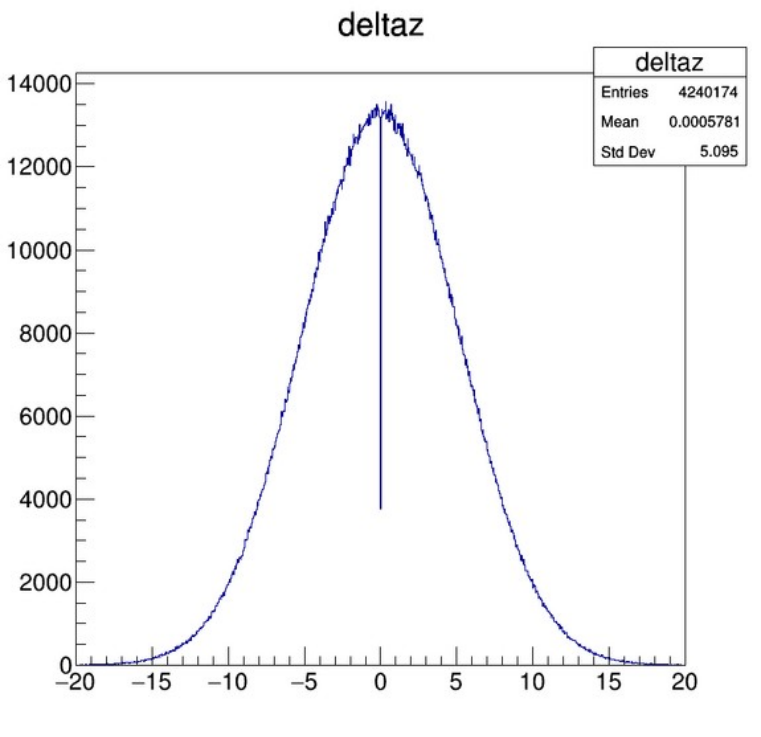
Exercise 3: Vertexing in MiniAOD

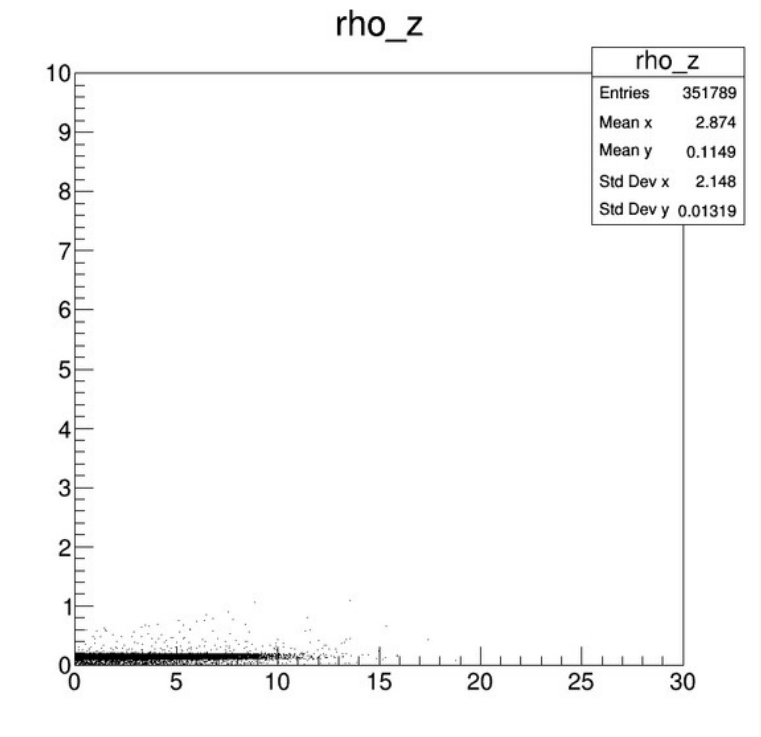
- In the MiniAOD format, collection of two long-lived mesons, K^0_S and Λ^0 are already present
- Here we plotted the **mass distribution** of the Λ^0s



Exercise 3: Vertex Distributions

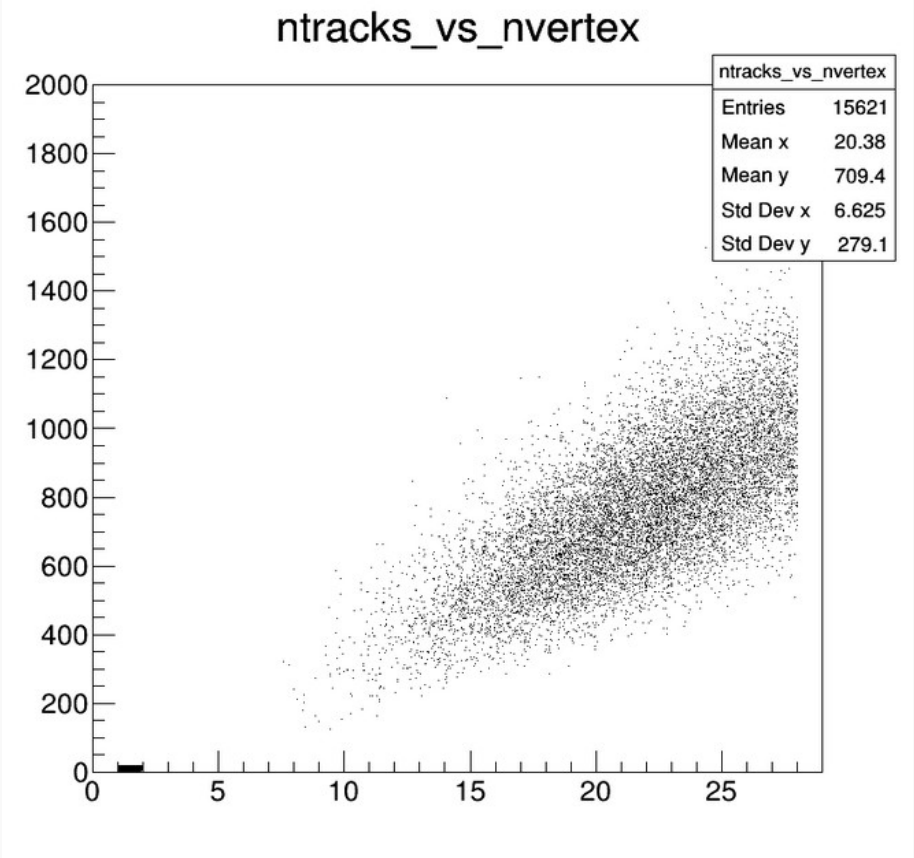
- From the secondary vertices we advanced to **primary vertices**.
- Looking at the distribution of the **distance between two primary vertices in z**, can you remember the reason for the **dip at 0**?
- What do we learn from the **rho-z distribution** of the vertices?





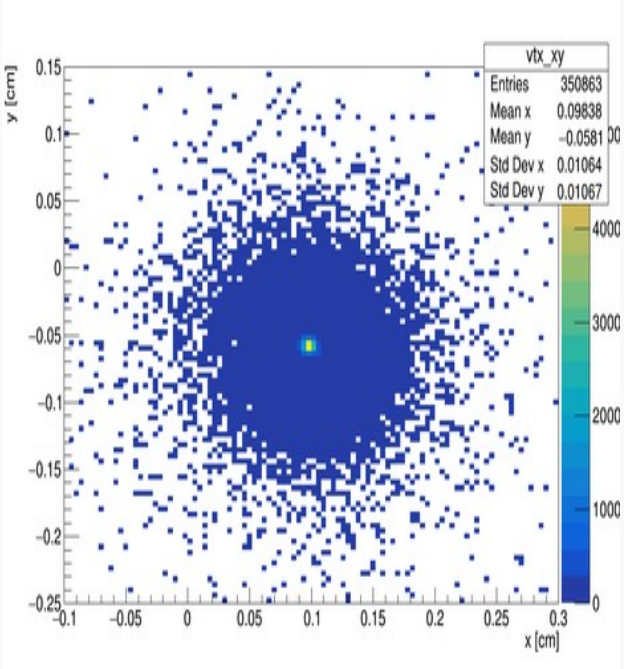
Exercise 3: Primary Vertex Distributions

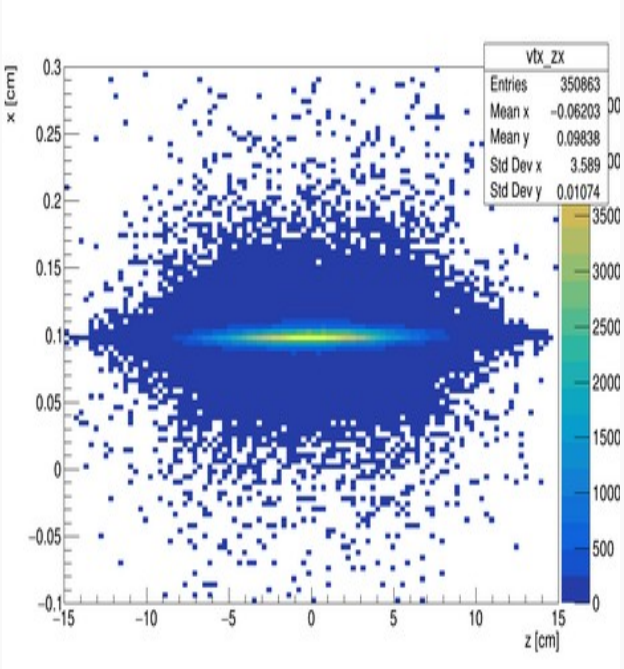
- The **number of tracks** versus the **number of primary vertices** shows a **roughly linear correlation**
- Is that what you expect?

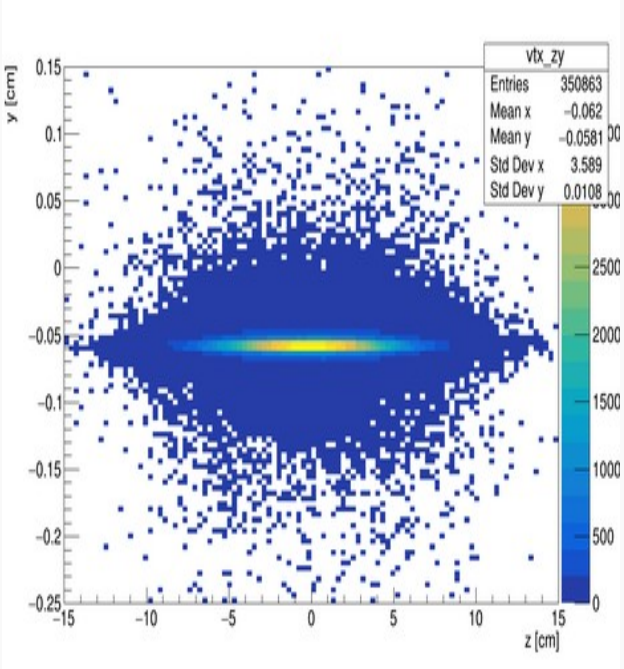


Exercise 3: Primary vertices and the beam spot

- The exercise emphasized the difference between the **primary vertices** and the **beam spot**. Can you recall what it is?
- We had a look at the **2D distribution** of **primary vertices** in the **x-y**, **z-x**, and **z-y** projections. What can we learn from that about the **interaction region** in CMS?

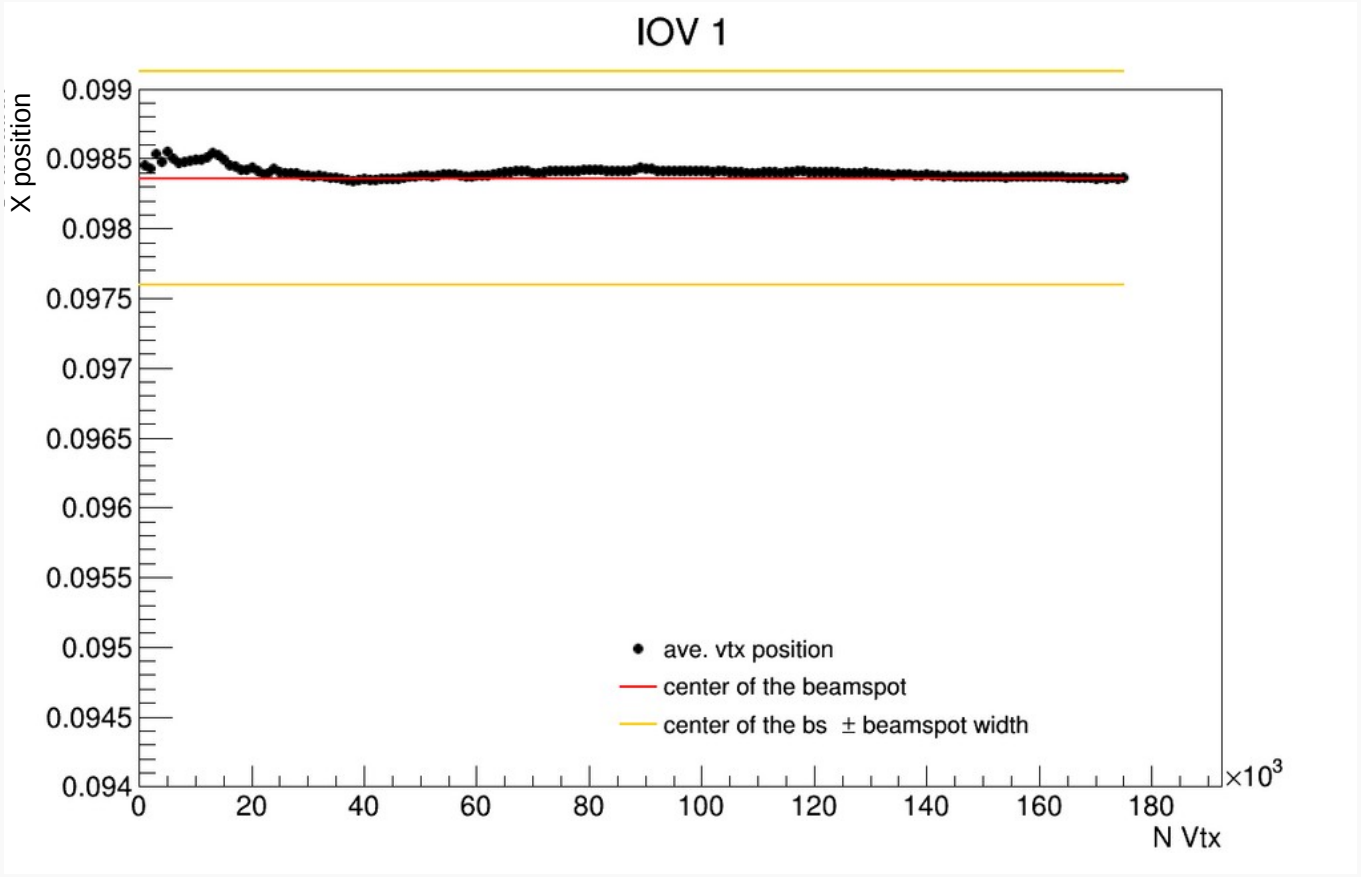






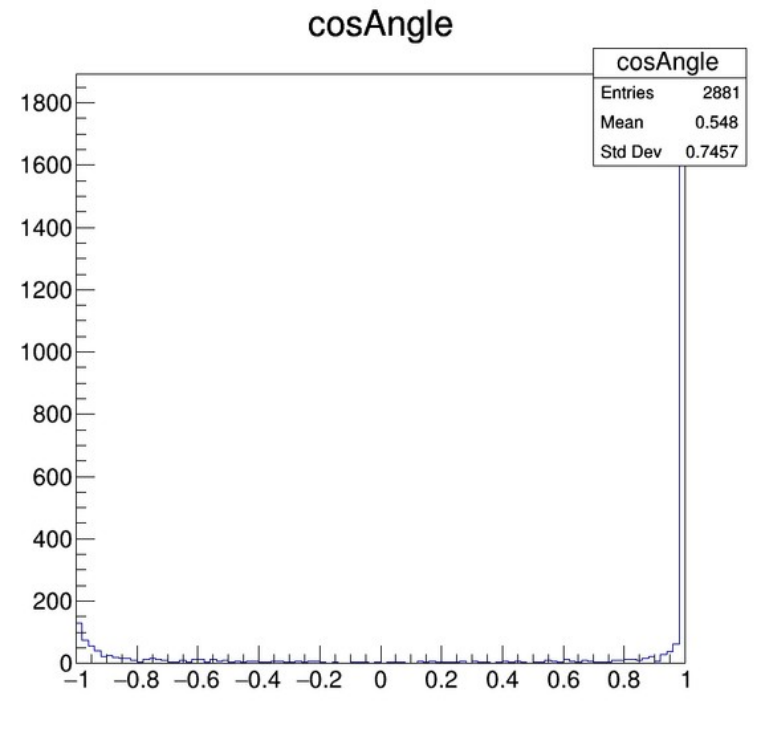
Exercise 3: Primary vertices and the beam spot

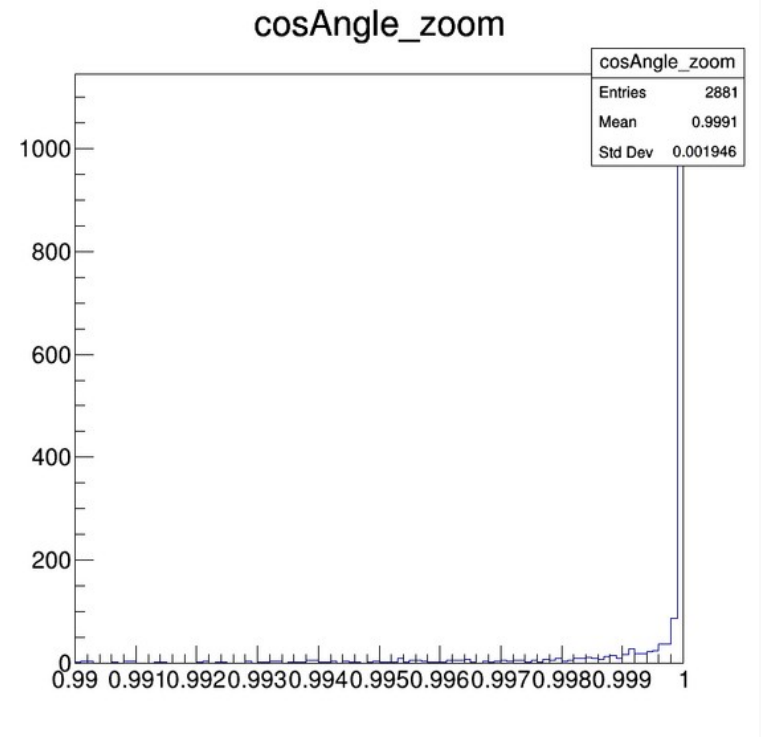
- Another way to visualize the **relation** between the **primary vertices** and the **beam spot** is this plot that compares the x-coordinate of the beam spot position (red) with the average x-position of the primary vertices, as a function of how many vertices are averaged



Exercise 3: Vertices improve physics results

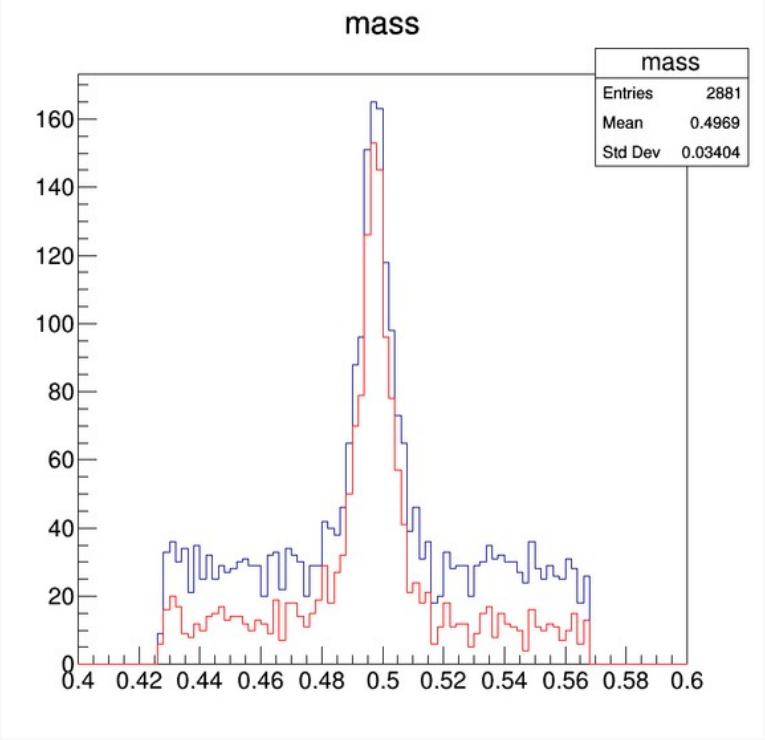
- In the last step of the exercise, we **combined primary** and **secondary vertices**
- Here we are making use of the fact that for K^0 meson its **flight direction** will align with the **direction from the primary vertex to the secondary vertex**
  - We therefore consider the **distribution of the cosine of the angle** bewteen the two direction and apply a cut





Exercise 3: Vertices improve physics results

- We use the **angle** from the previous slide as a **discriminator** to improve our signal to background ratio of our K_S^0 sample



Appendix Exercise: Tracking Efficiency via Tag and Probe technique

- Finally, we matched tracks from **lostTrack** collection to **StandAlone** Muons and computed the CMS tracking performance via the data-driven Tag and Probe technique using the Z resonance for **Data** (part of 2018 Run 2) and **MC**
- Did you get the same efficiency plot at your **first trial**?
- Is this symmetrical distribution expected?