DQ Checks of 2024 Data

Track Variables

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Introduction

- Verify the quality of track reconstruction in 2024 data
- Compare with 2023 data and identify any discrepancies
- Detailed objectives highlighted in the following TODO List: [General Physics Meeting 19 Nov]

Data Description

- 2024 data can be found in the directories
  - **/eos/experiment/faser/phys/2024/p0011**
  - **/eos/experiment/faser/phys/2024/p0012**
- 2023 data can be found in the directory
  - **/eos/experiment/faser/phys/2023/p0010**
- The runlist (luminosities) used are from: **/afs/cern.ch/user/t/torrence/public/faser/runlist/**
  - **../runlist/2024/faser_runlist_2024_stable.csv**
  - **../runlist/2023/faser_runlist_2023_stable.csv**
- Runs excluded from above list
  - **11214** - 0 Lumi; **11705,6** - Pb Col.
  - **10417-538, 11461-91** - HighGain
  - **16851,2** - Directory is empty
  - **16932, 16943, 16972** - ROOT Files empty
- No cuts have been applied, since we want to look at the DQ

Overview of Tracking Variables

- New tracking variables have been added to the 2024 NTuples
  - Track_hitSet
  - Track_module_eta0
  - Track_module_phi0
- There are 56 tracking variables in total (excluding the above)
- They can be broadly classified as:
  - Track Parameters (e.g. χ^2, charge, etc.) (10)
  - Track Positions at various modules (24)
  - Track Momentum (angles) at various modules (22)

Distribution of Track Parameters

- Number of Tracks
- Track Charge
- Track χ^2
- Track nDoF [in Backup]
- Track In Station [in Backup]
- Track nLayers [in Backup]
- Track Propagation Error

Distribution of longTracks

- Overall a higher number of tracks in 2024
- Partially can be due to much higher muon rate in 2024
- See this talk to see the difference in backgrounds [12 April General Meeting]

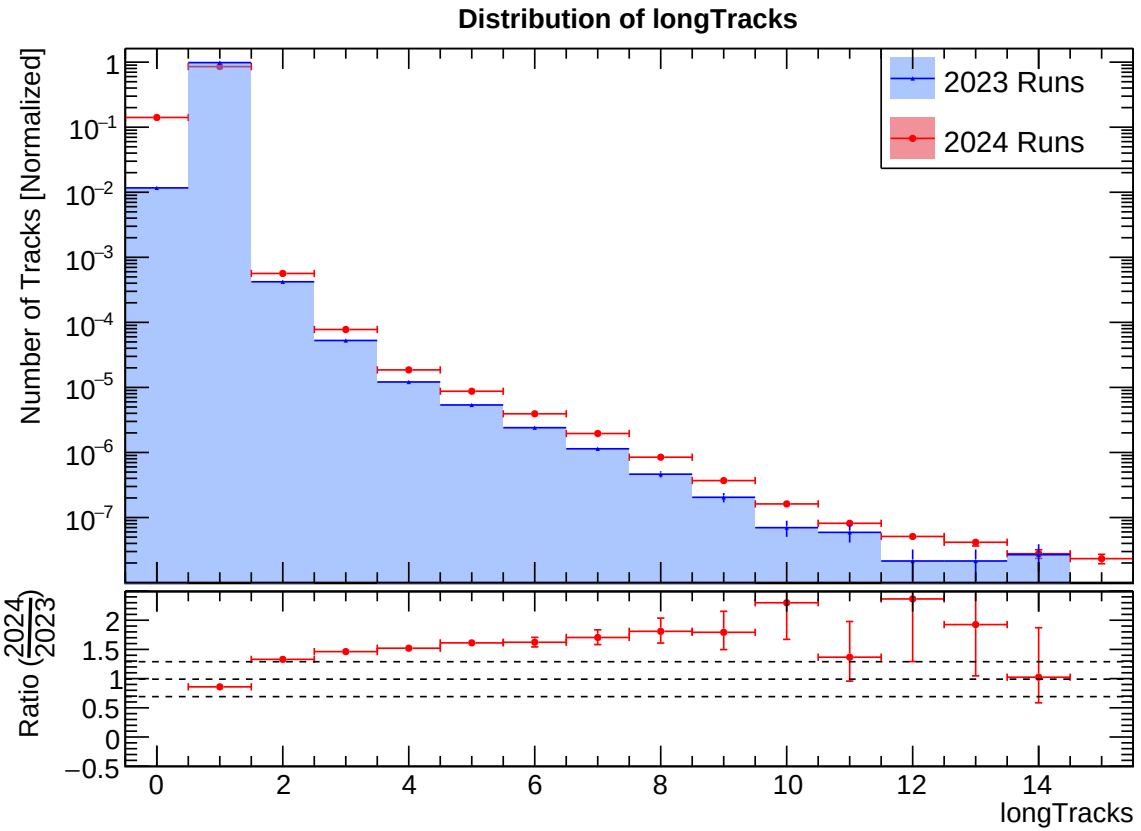


Figure: Distribution of Number of Tracks

Distribution of Track Charge

- We have a higher percentage of anti-muons
- Consistent with earlier observation of "Much larger population of very high energy positive muons" [see Talk]

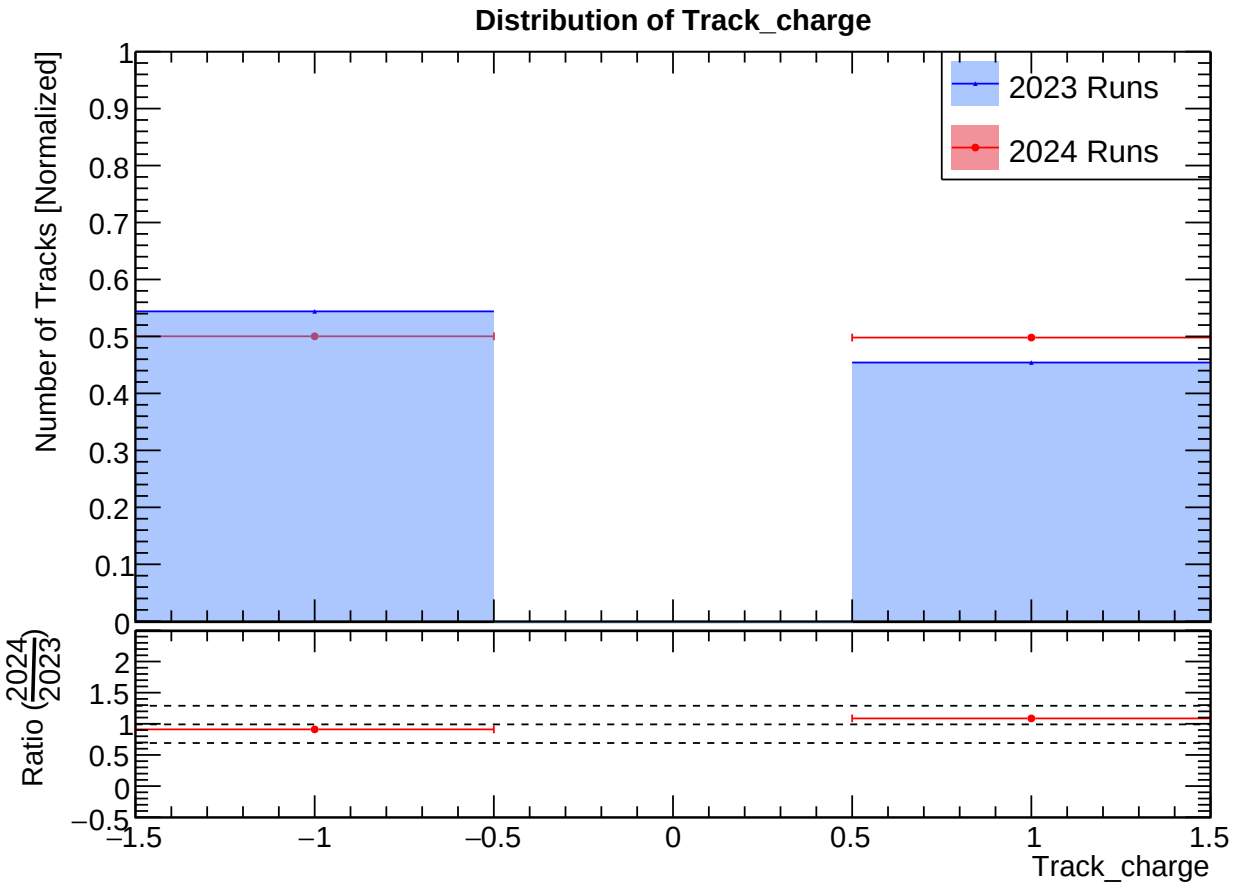


Figure: Distribution of Track Charge

Distribution of Track χ^2

- Overall we observe a lower Track χ^2 in 2024
- Do we understand why?

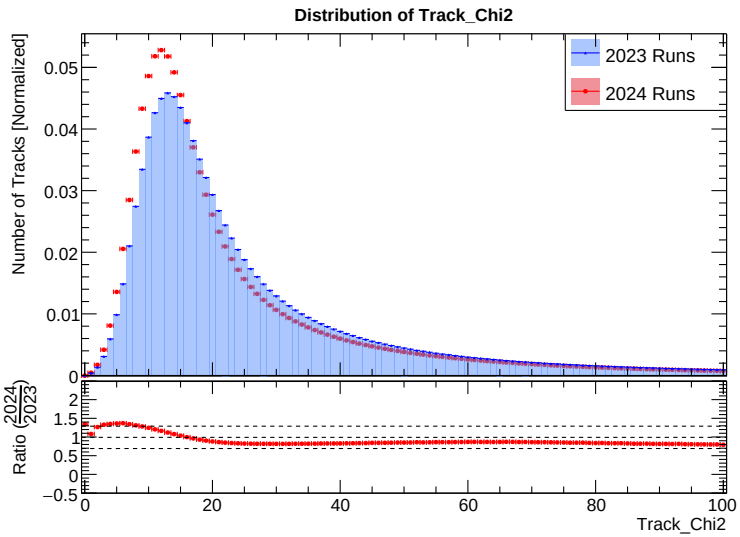


Figure: Distribution of Track χ^2

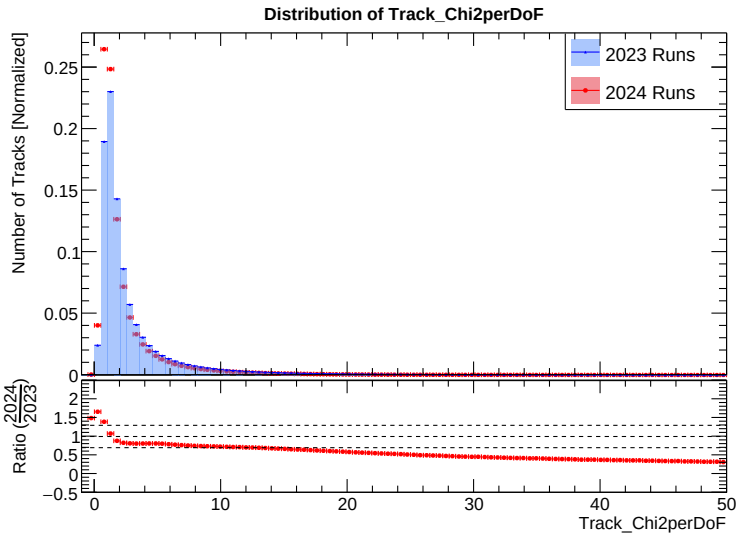


Figure: Distribution of Track χ^2 per DoF

Track Propagation Error

- Much higher Track Propagation Error in 2024 !
- How does this affect the track reconstruction?

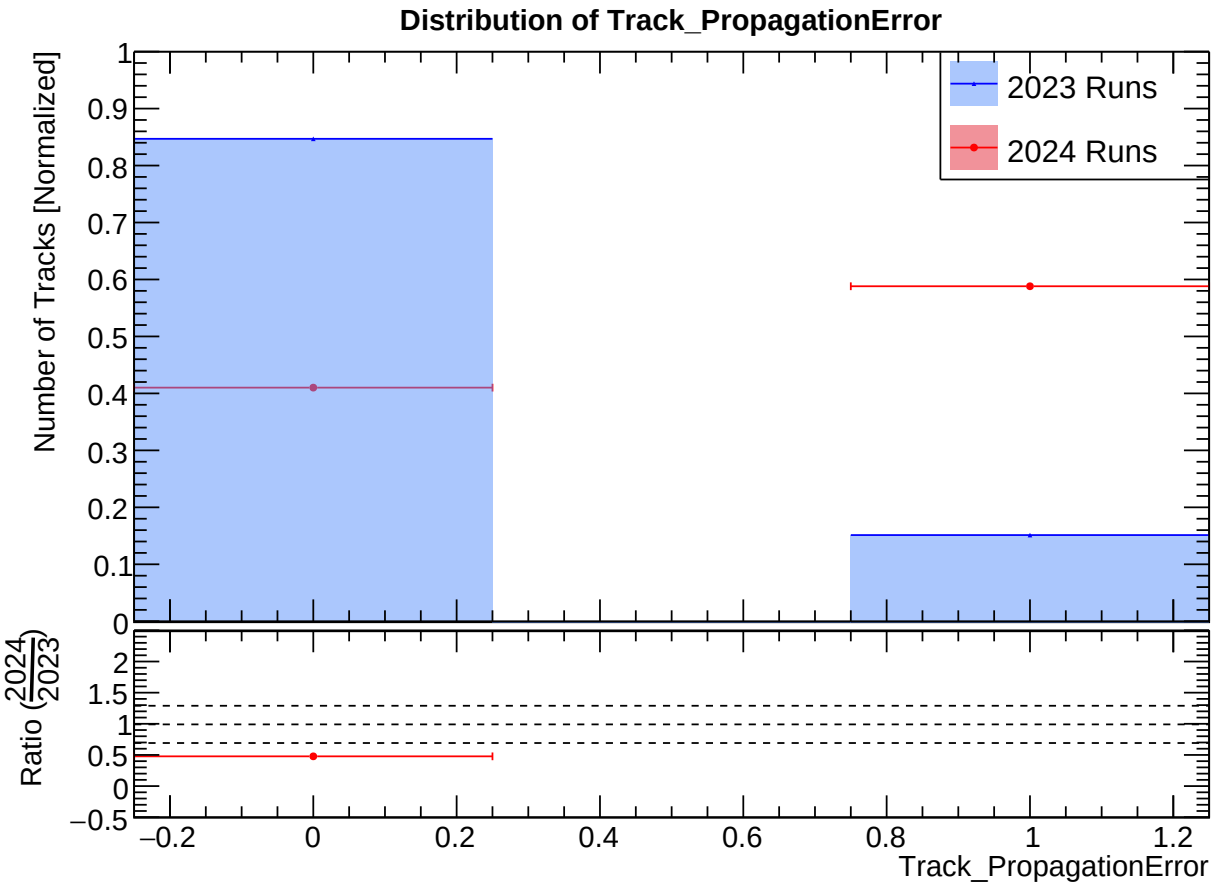


Figure: Distribution of Track Propagation Error

Track Positions (x, y)

- Vetonu
- VetoStation 1 [in Backup]
- VetoStation 2 [in Backup]
- Trigger/Timing Station [in Backup]
- Tracking Station 1
- Tracking Station 3
- Preshower 1 [in Backup]
- Preshower 2 [in Backup]
- Calo
- Max Radius [in Backup]

Track Positions at Vetonu

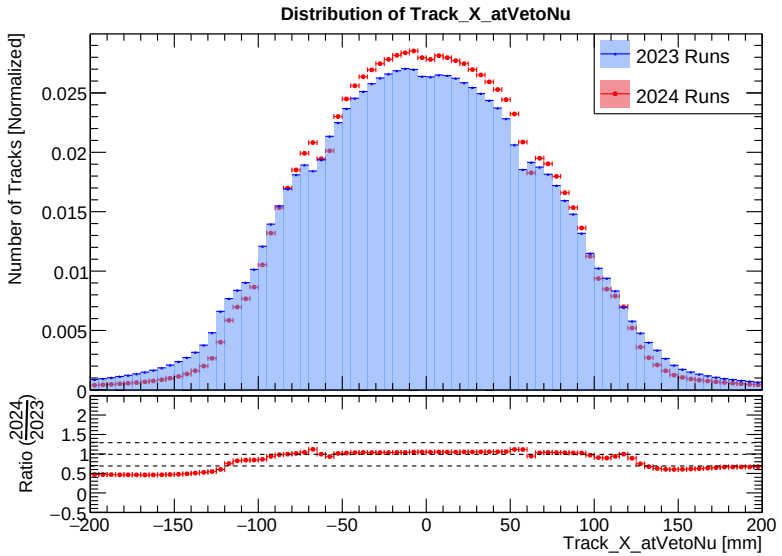


Figure: Track Position x at VetoNu

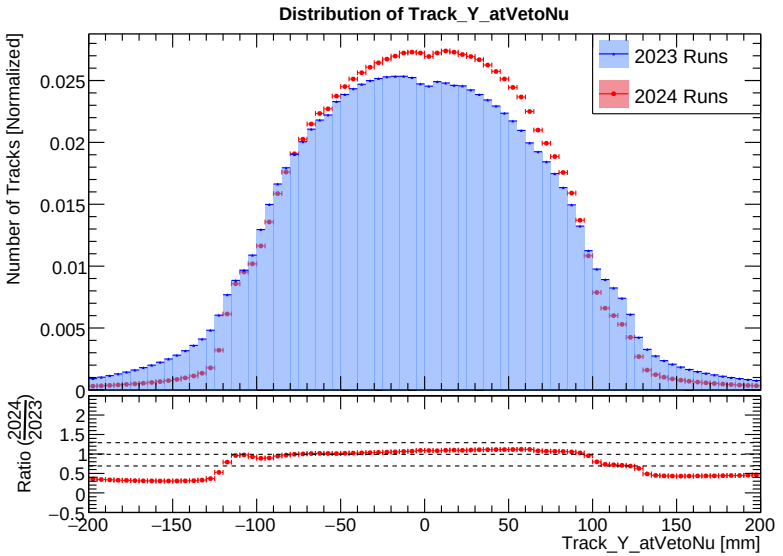


Figure: Track Position y at VetoNu

- Sharper Distribution in 2024: More particles on center? REF?
- The ypeak has shifted to the positive side. Expected with the change in beam crossing angle
- Same comments hold for the rest of the positions.

Track Positions at Tracking Station 1

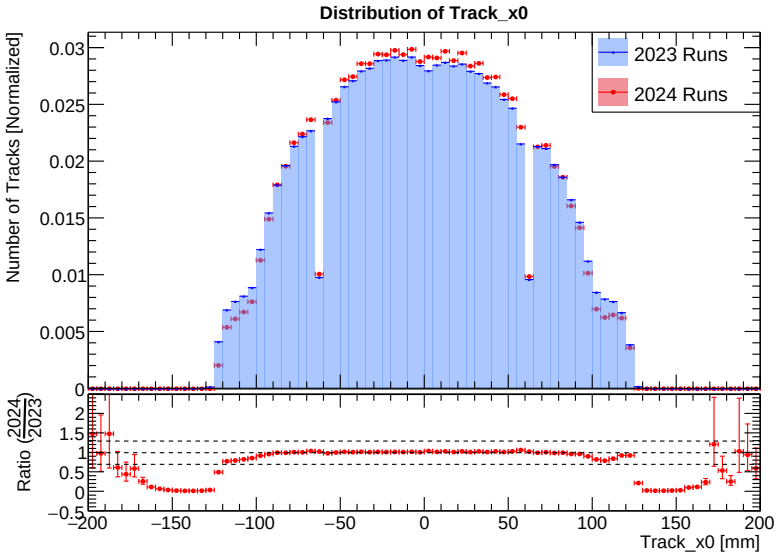


Figure: Track Position x at Tracking Station 1

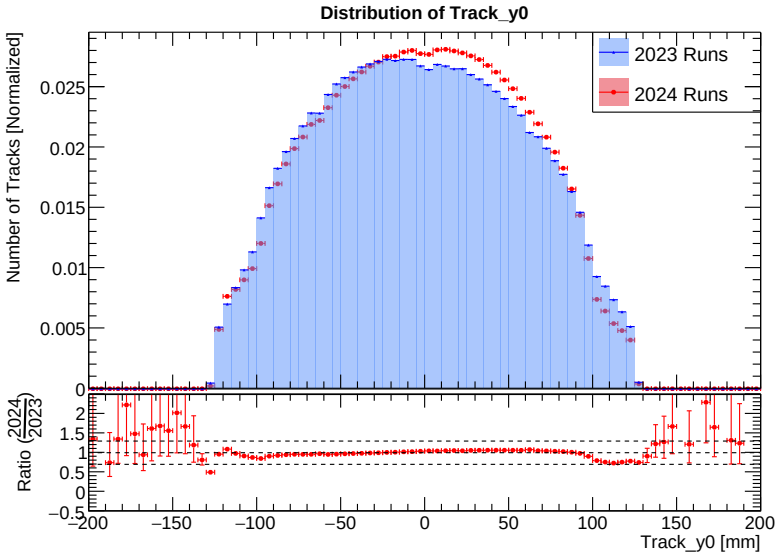


Figure: Track Position y at Tracking Station 1

Only qualitative difference from the VetoNu plots are the sharper peaks here which are from the cut off at 125 mm. And the dips in the x-distributions at around 60mm are from the geometry of the tracking stations.

Track Positions at Tracking Station 3

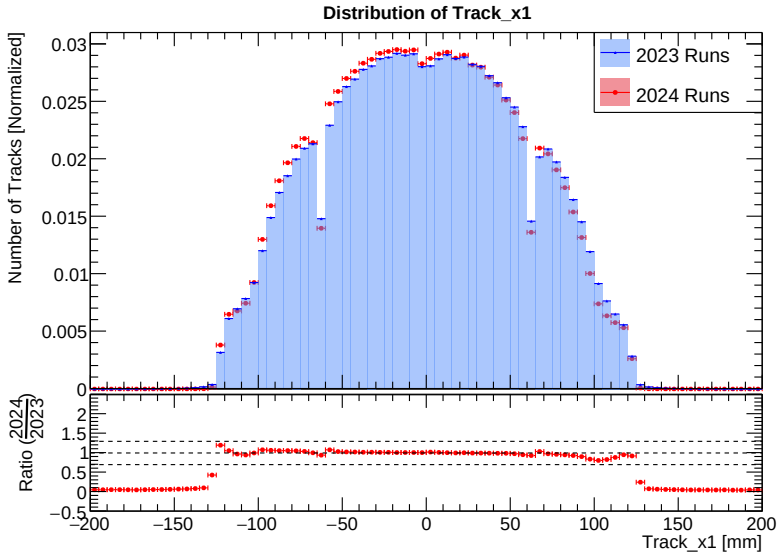


Figure: Track Position x at Tracking Station 3

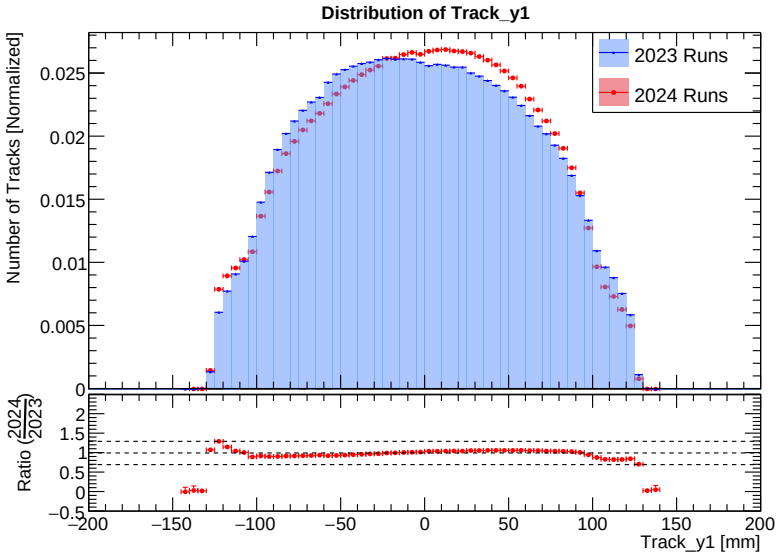


Figure: Track Position y at Tracking Station 3

Track Positions at Calo

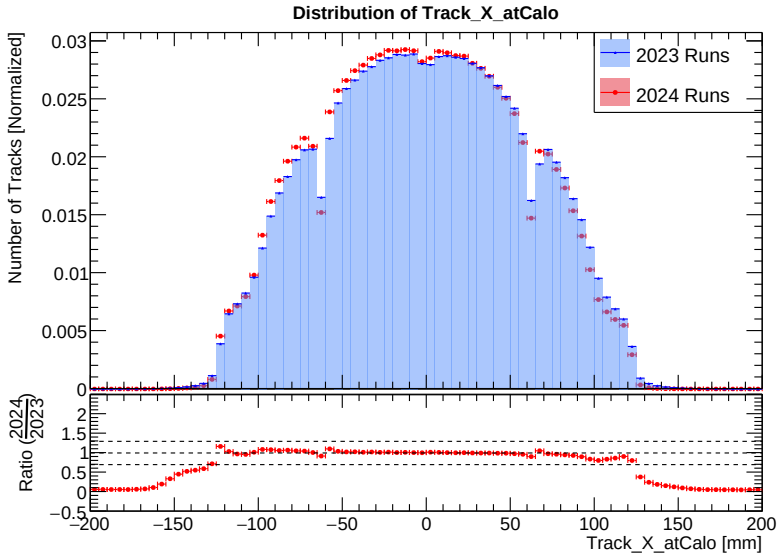


Figure: Track Position x at Calo

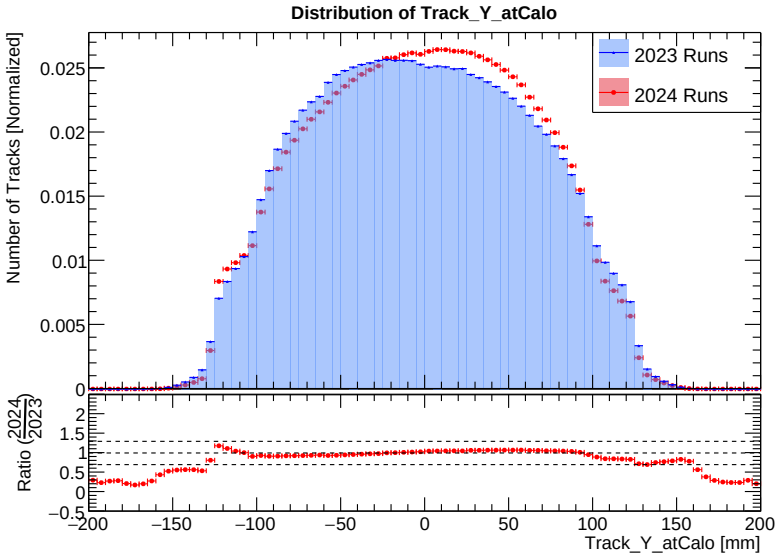


Figure: Track Position y at Calo

Track Angle (θ_x, θ_y) at Various Stations

- Vetonu
- VetoStation 1 [in Backup]
- VetoStation 2 [in Backup]
- Trigger/Timing Station [in Backup]
- Tracking Station 1
- Tracking Station 3
- Preshower 1 [in Backup]
- Preshower 2 [in Backup]
- Calo [in Backup]
- Track Momenta at Station 1

Note: Track angles defined as $\theta_x = \arctan \frac{p_x}{p_z}$ and $\theta_y = \arctan \frac{p_y}{p_z}$

Track Angles at VetoNu

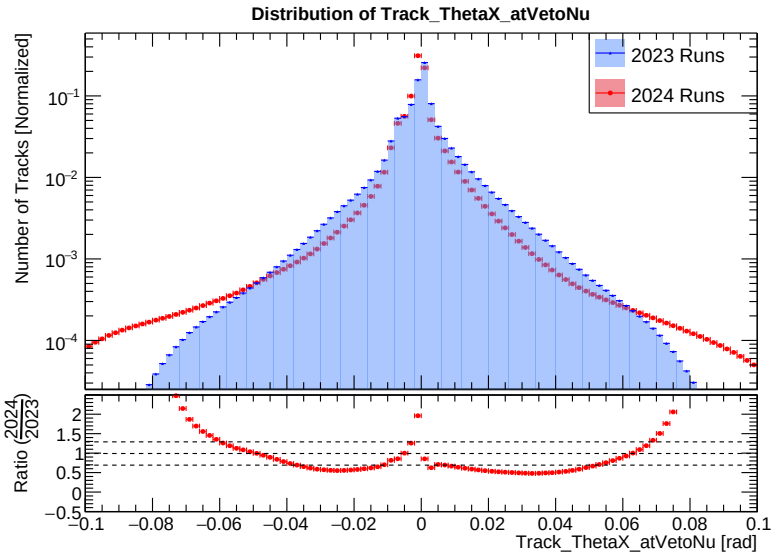


Figure: Track ThetaX at VetoNu

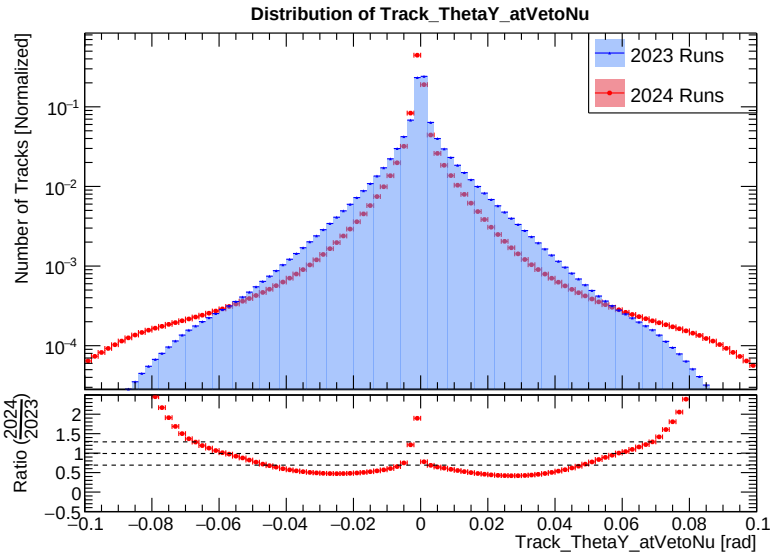


Figure: Track ThetaY at VetoNu

- Flatter distribution in 2024 compared to 2023
- Needs investigation to understand where the difference comes from

Track Angles at Tracking Station 1

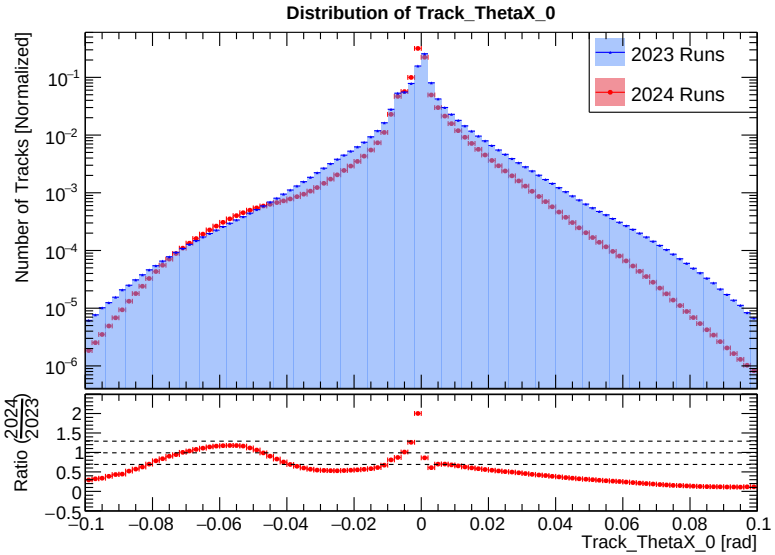


Figure: Track ThetaX at Tracking Station 1

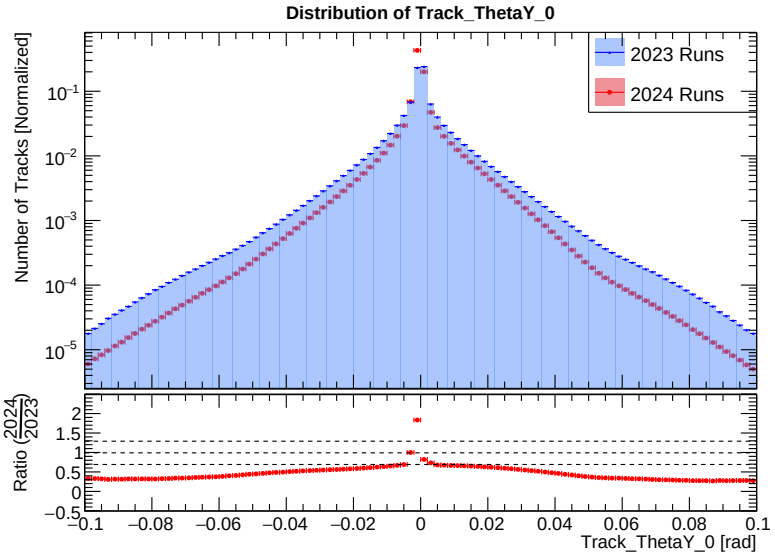


Figure: Track ThetaY at Tracking Station 1

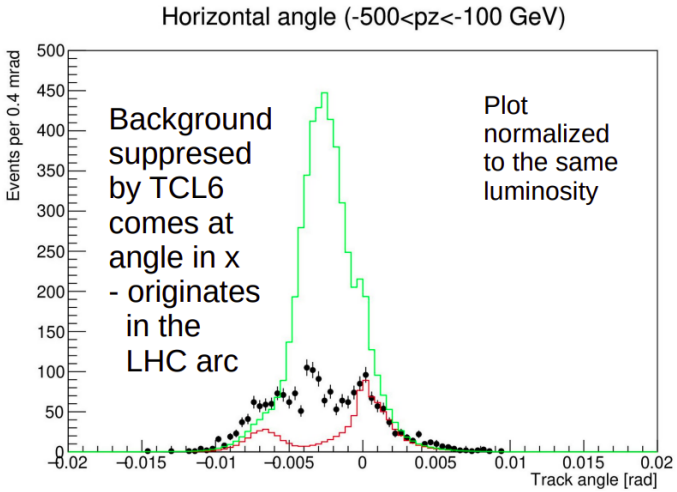


Figure: Background studies (slide16).

- There is a peak in 2024 ThetaX at -0.07 rad. Do we understand why?
- Similar features observed in the Background studies. [See Page 15-16]

Track Angles at Tracking Station 3

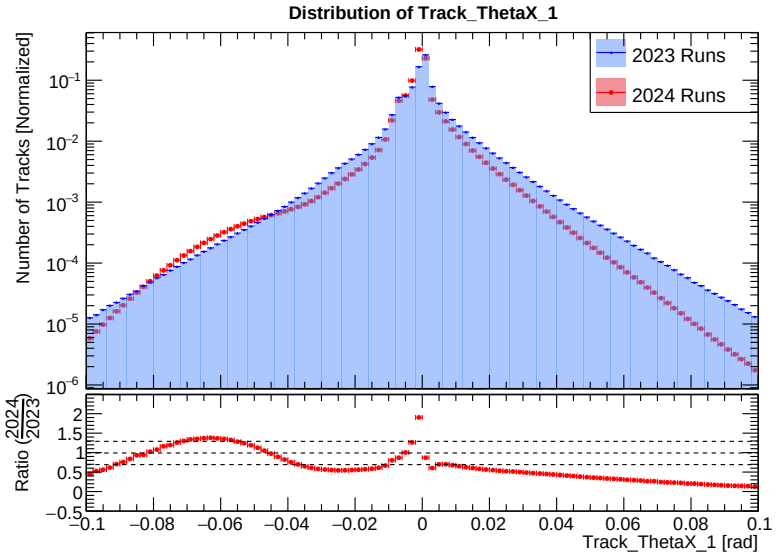


Figure: Track ThetaX at Tracking Station 3

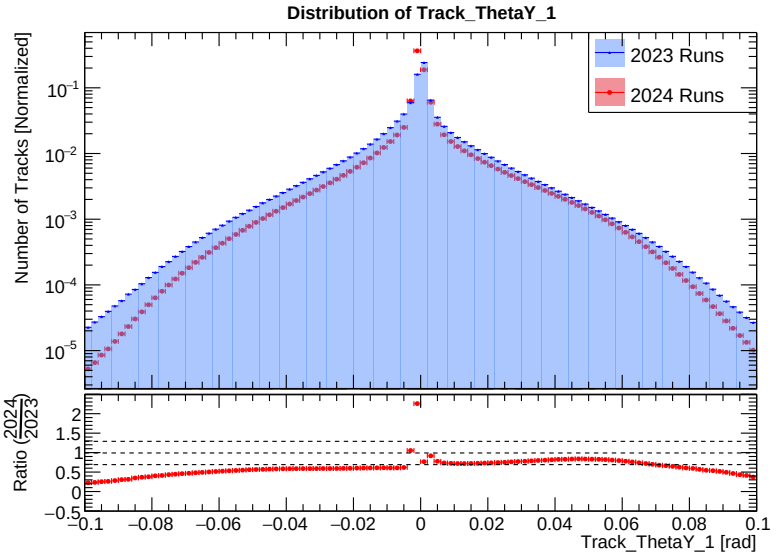


Figure: Track ThetaX at Tracking Station 3

Track Momenta at Tracking Station 1

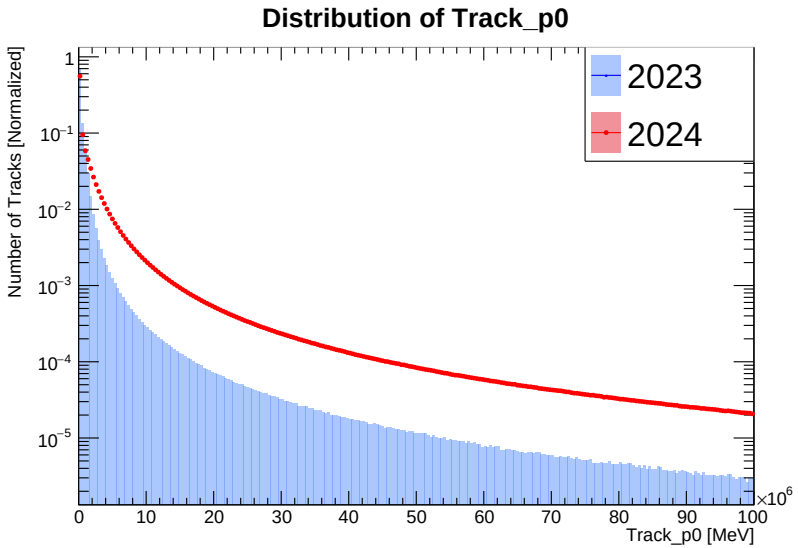


Figure: Track momentum at Station 1 (linear p scale)

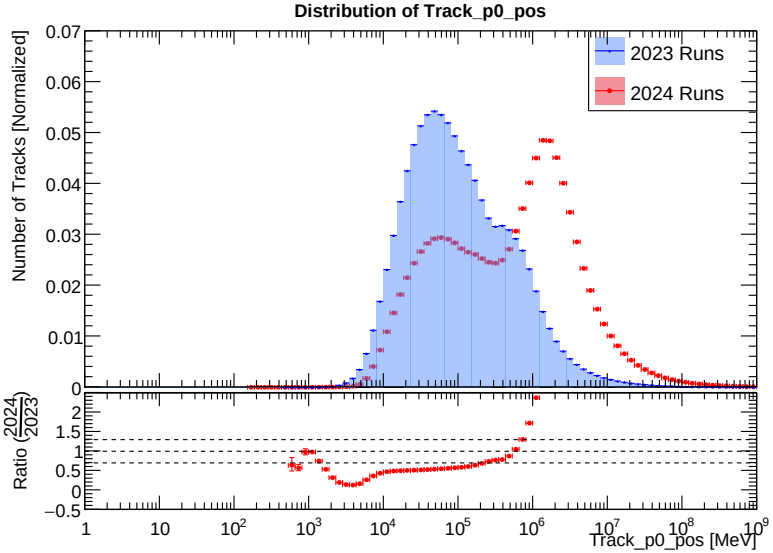


Figure: Track momentum at Station 1 (positive)

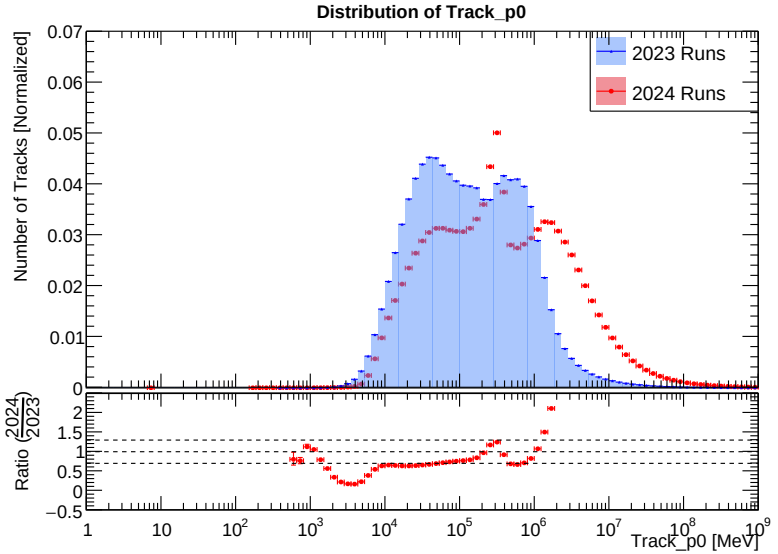


Figure: Track momentum at Station 1 (log p scale)

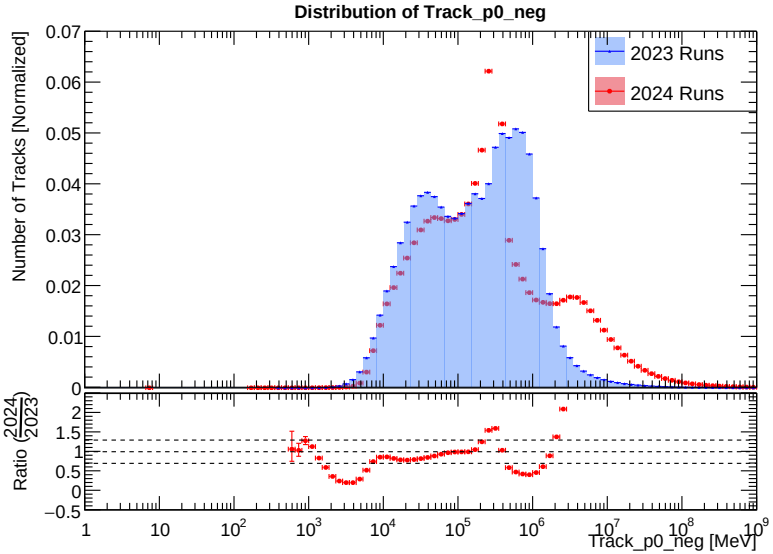


Figure: Track momentum at Station 1 (negative)

Track Momenta at Tracking Station 1 (contd.)

- We have more high momenta positively charged muons in 2024.
- Background studies again showed similar features.
- See Page 15-16 of earlier talk

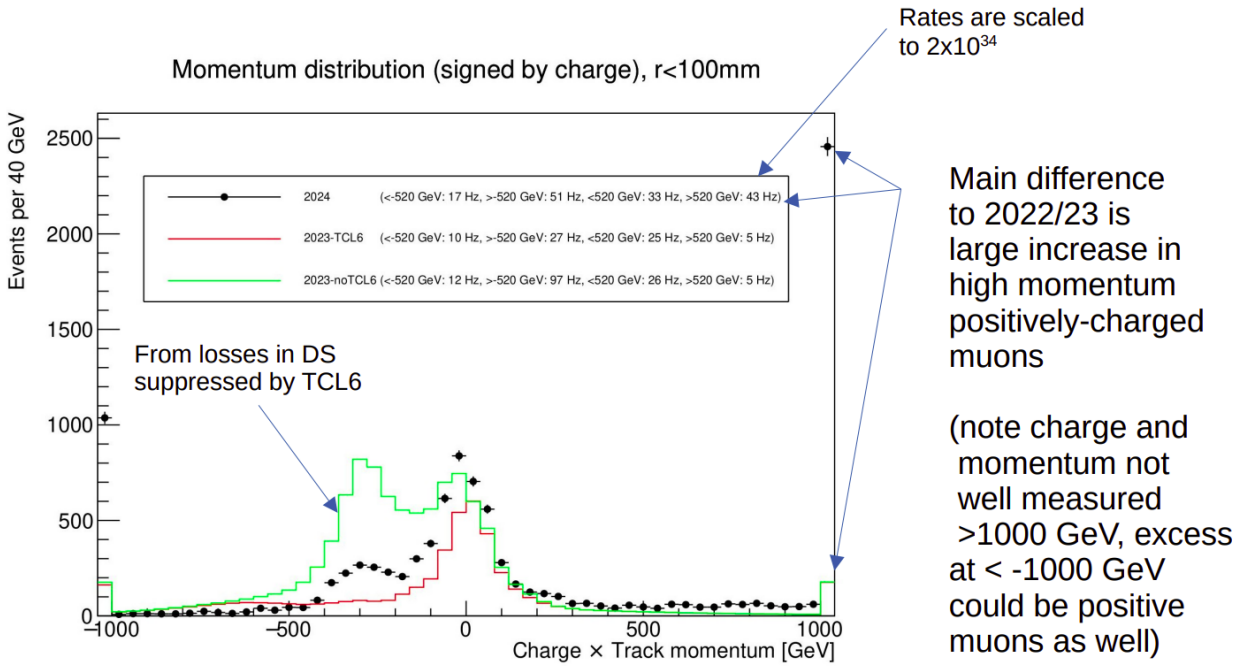


Figure: Background studies (slide15)

2024 Runs Splits

- Due to the higher backgrounds FaserNu had to be replaced every 10 ifb.
- The replacement schedule was as follows

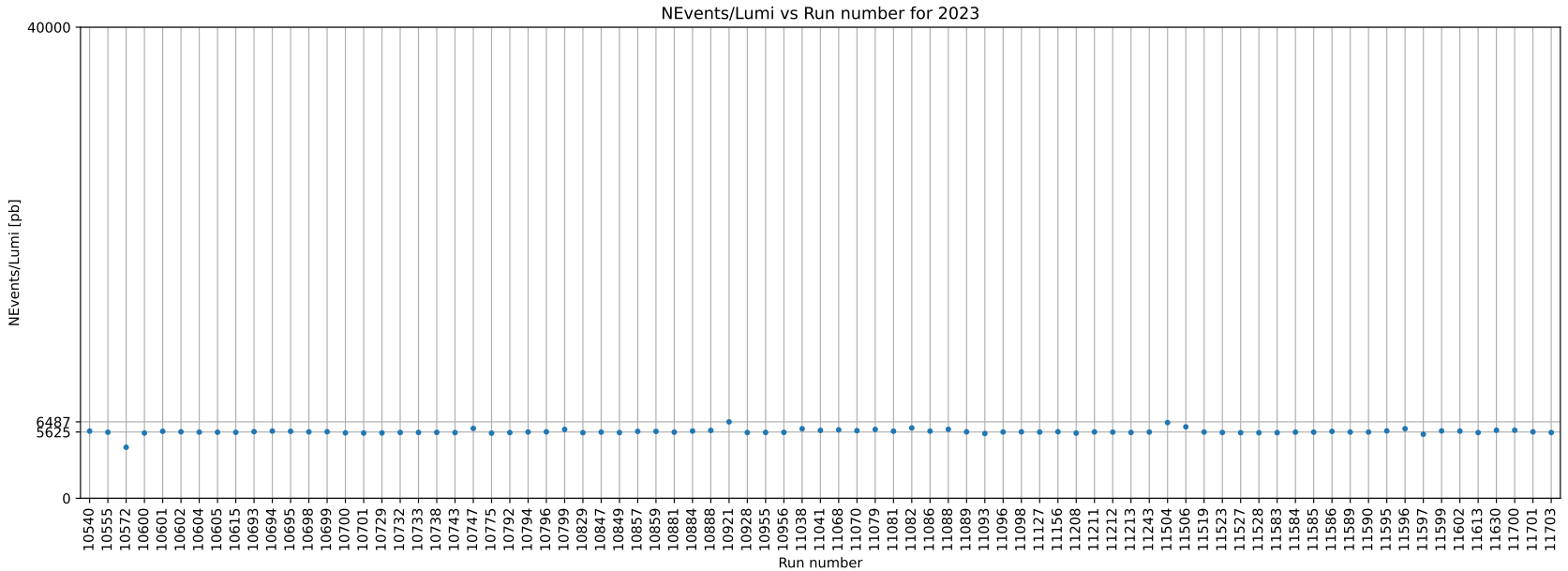
Box	**Installed**	**Removed**	**Lumi (ifb)**
F241	20/3	6/5	11.6
Tungsten only	6/5	12/6	18.5
F242	12/6	8/7	9.9
CaloNu	10/7	4/10	69.8
F243	4/10	22/10	11.9

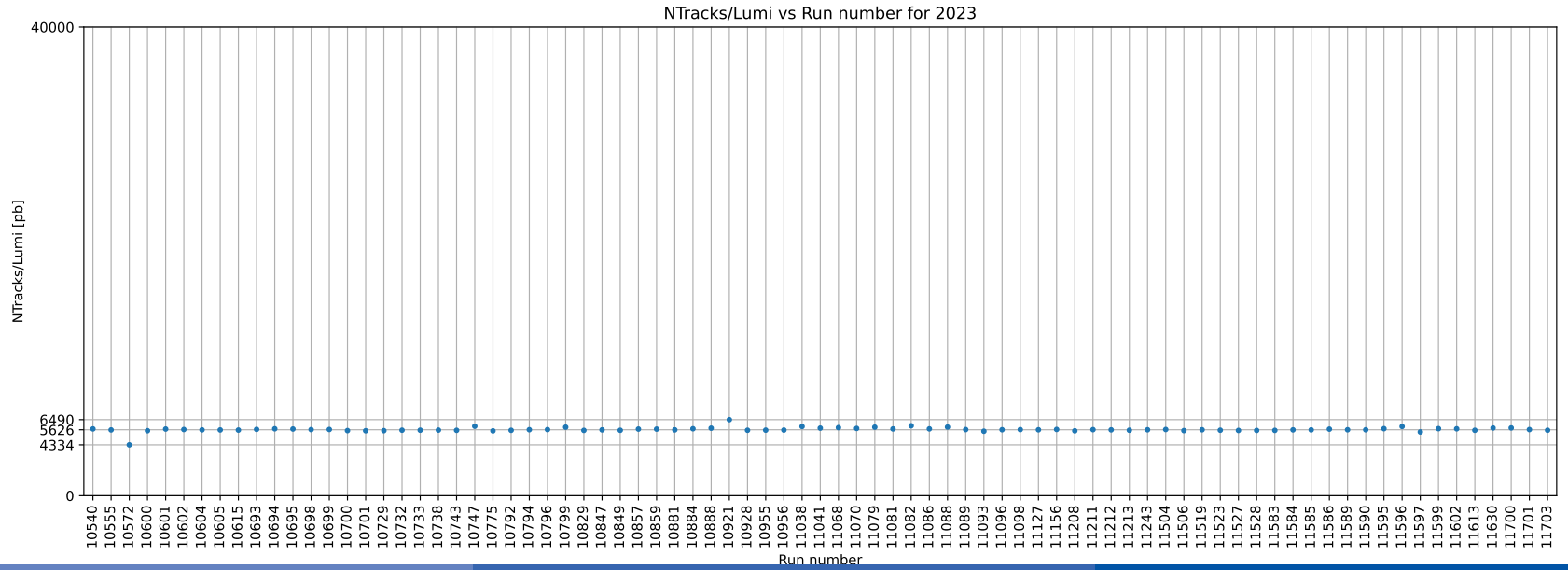
Table: Replacement Schedule [Source: FASER General Meeting 8.11.24]

- The runs are split into categories based on the above schedule
- Allowed a construction of Yield plots for each category, NEvents/Lumi (Top) and NTracks/Lumi (Bottom)

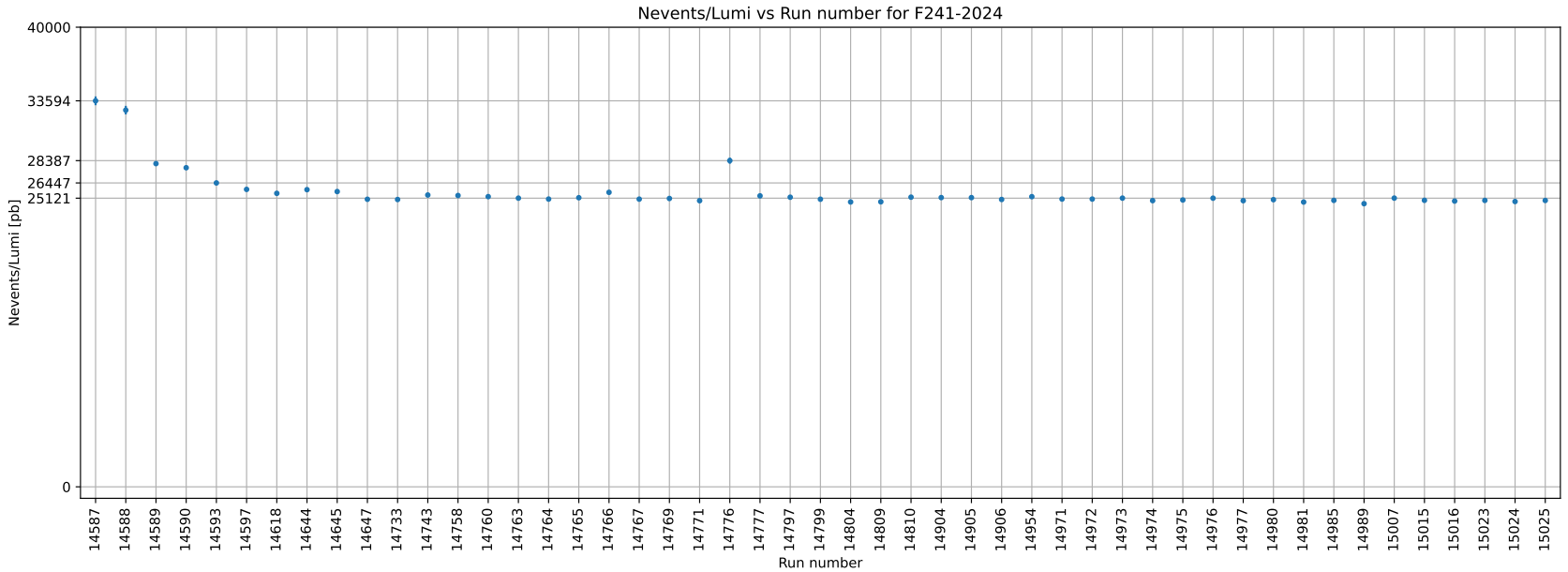
Note: Run numbers are estimated from the schedule and aforementioned run-list thus, it may not be accurate or complete.

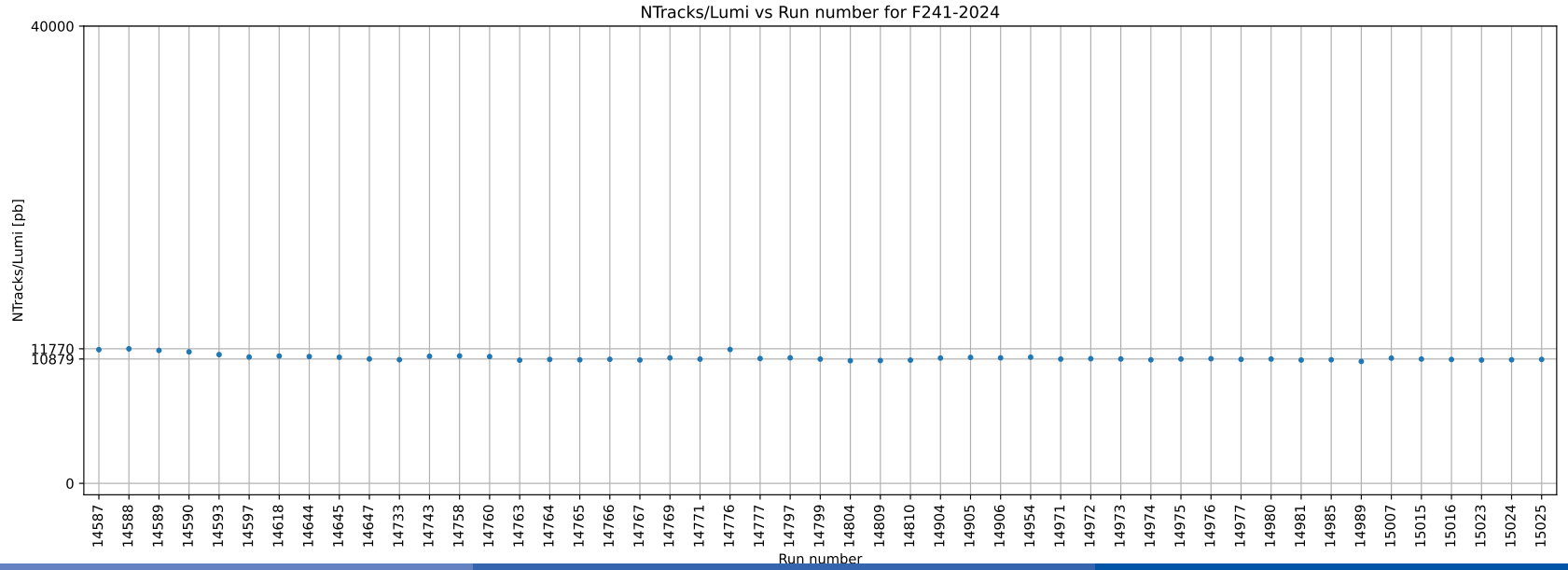
Yield Plots of 2023



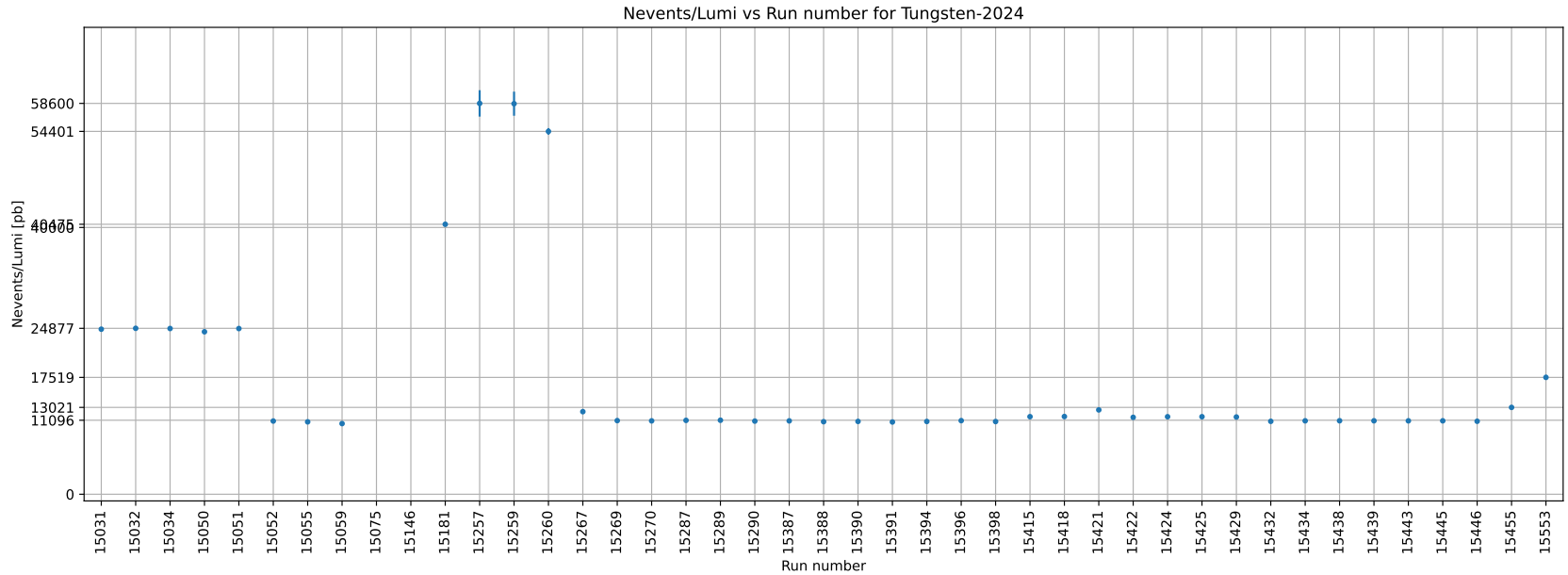


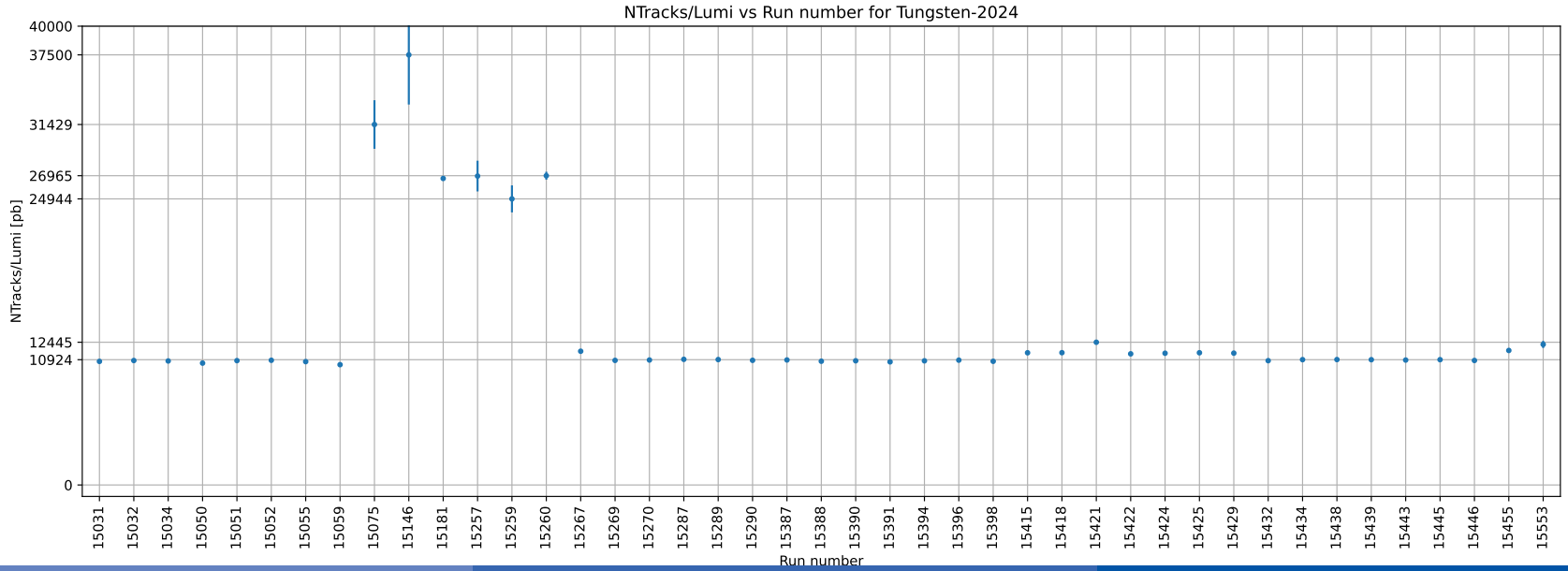
Yield Plots of F241- 2024



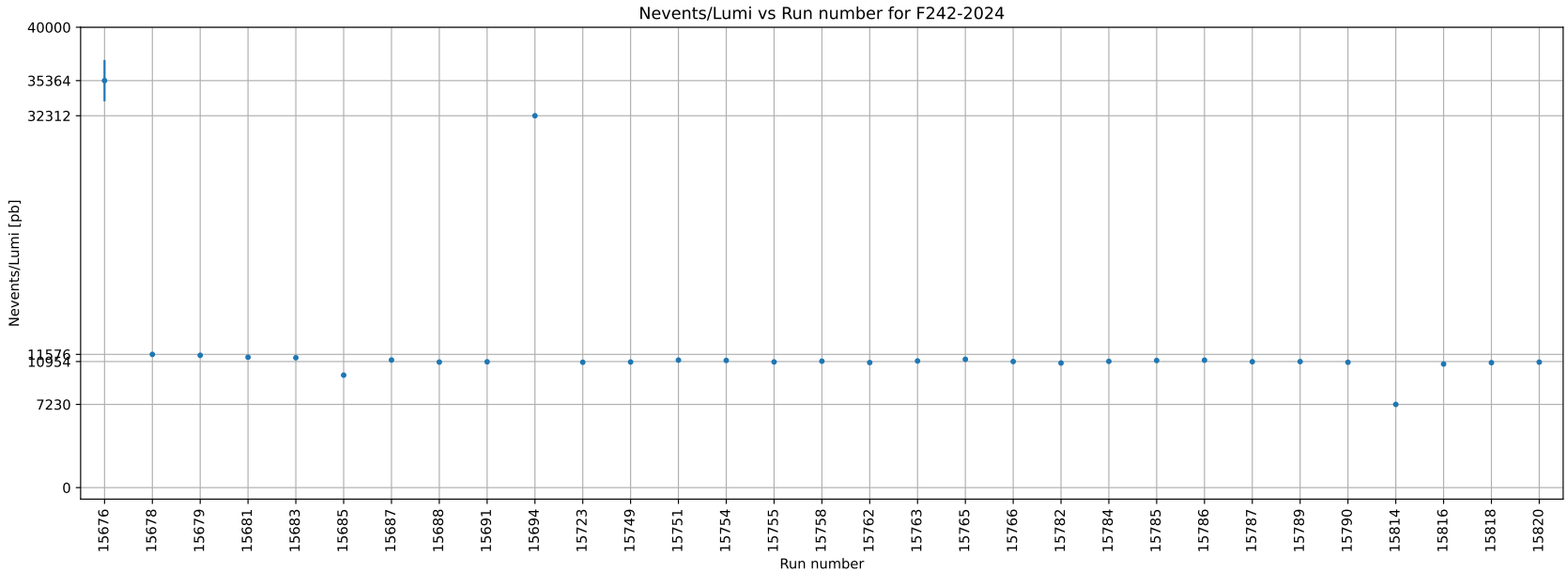


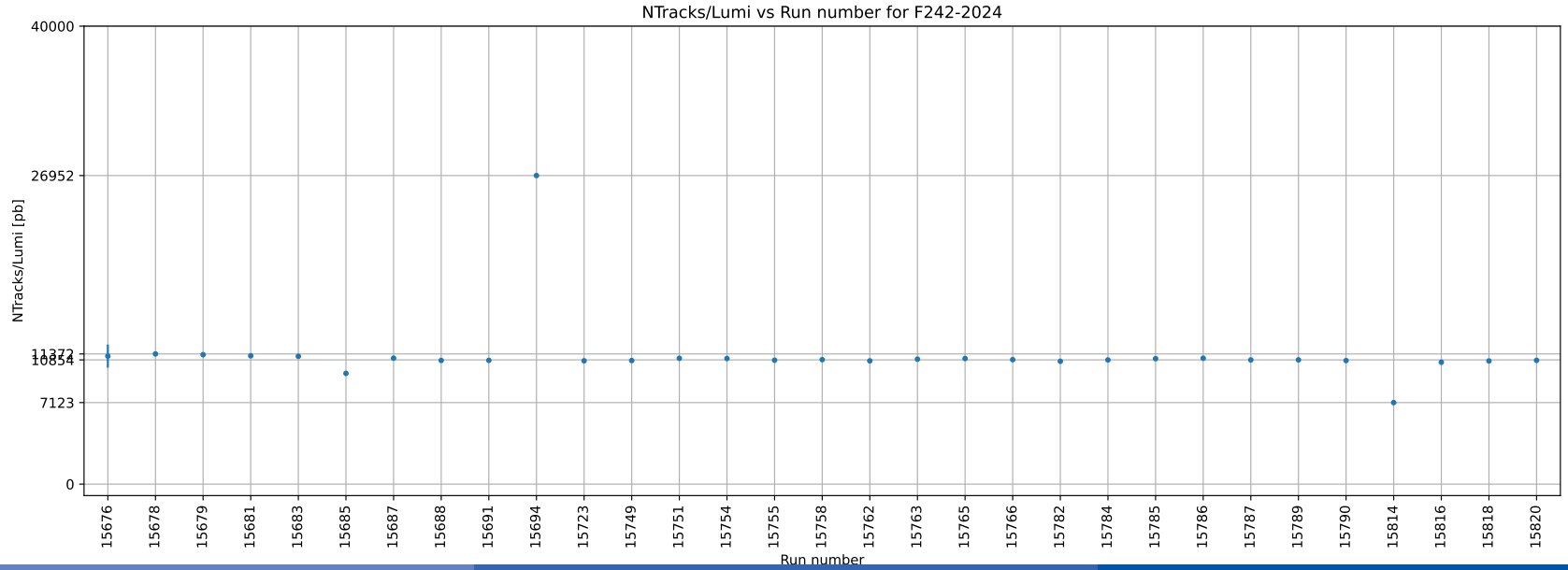
Yield Plots of Tungsten only- 2024



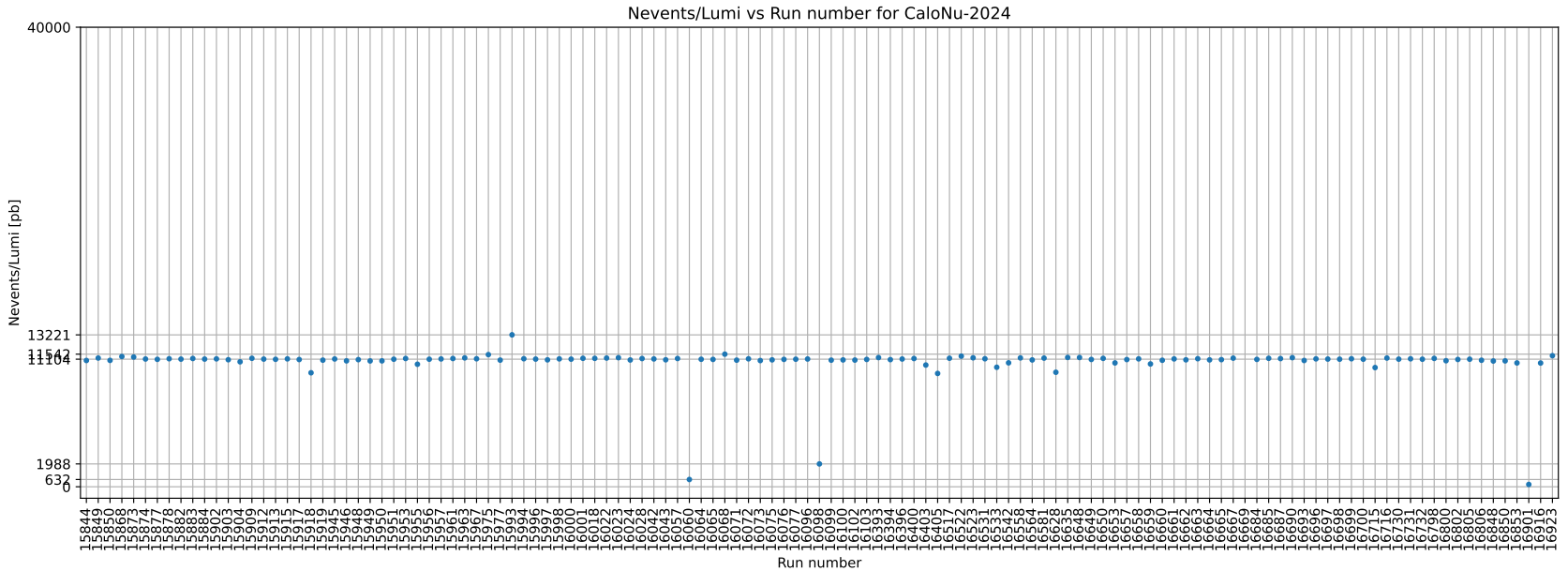


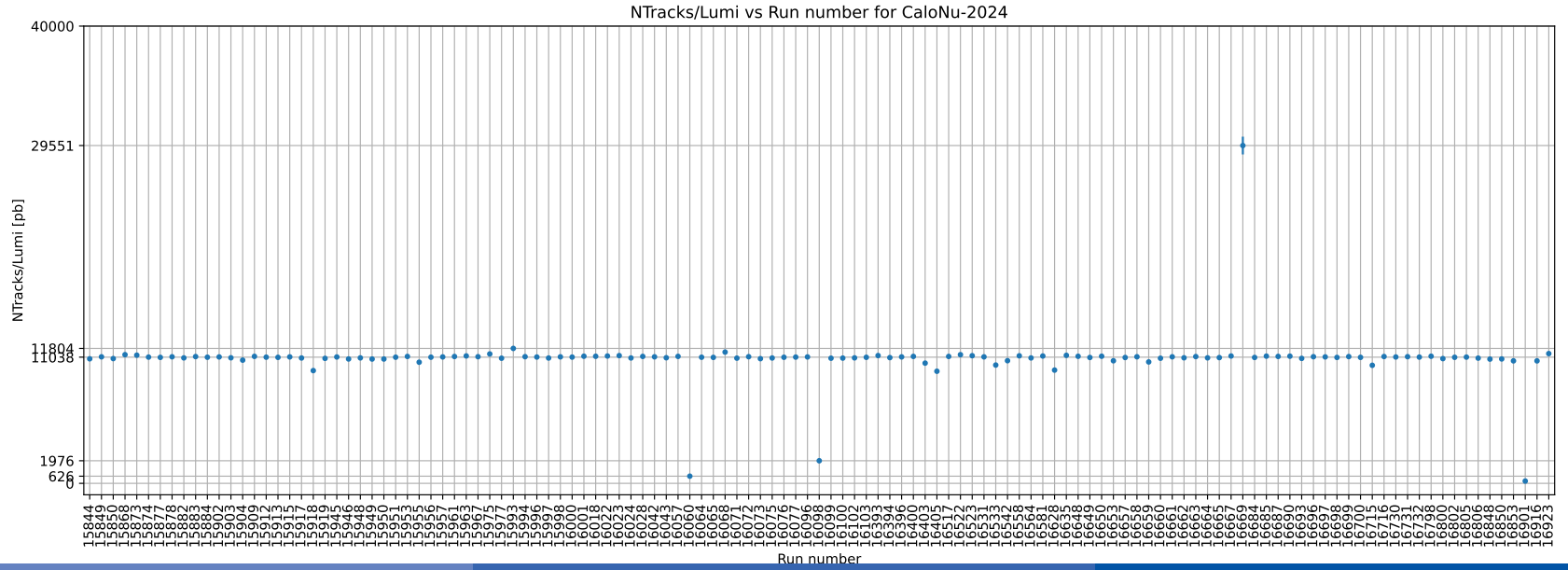
Yield Plots of F242- 2024



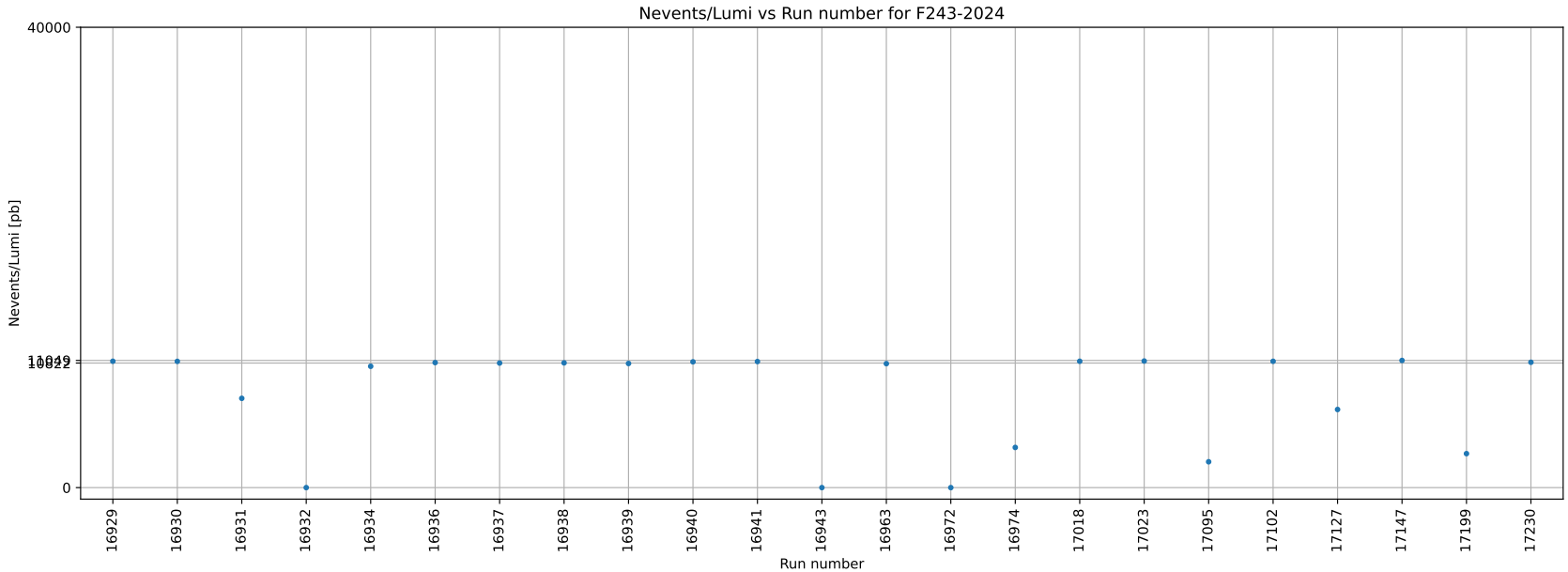


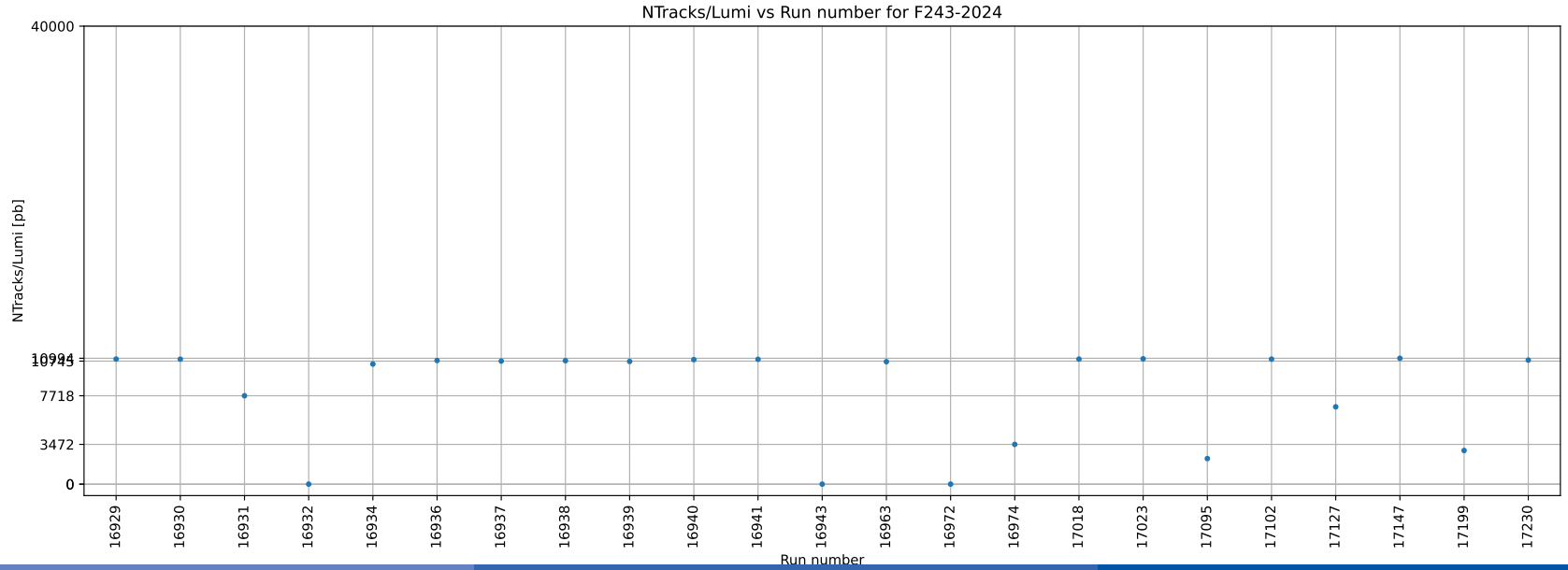
Yield Plots of CaloNu - 2024





Yield Plots of F243- 2024





Yield Plots Summary

- F241 - erratic behavior during early runs 14587-14733
- Tungsten - erratic behavior for early to mid runs 15031-15267
- F242 - relatively stable except for 15676, 15694, 15814
- CaloNu - relatively stable expect for 16060, 16098, 1669, 16901
- F243 - low Nevent/lumi for 16931, 16974, 17095, 17127, 17147, 17199
- Some 0's in F243 artifact of empty ROOT files (16932, 16943, 16972)

Directions going Forward

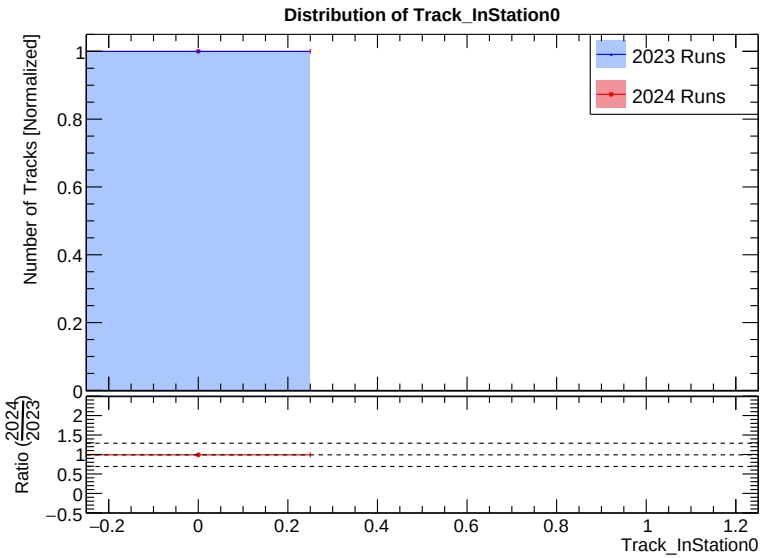
- Understand the DQ of other variables
- Investigate and understand the changes in Track Momenta
- Have a good run-list for the 2024 data (also for 2023)
- Investigate outliers in yield plots
- Investigate track variables as a function of run-splits in 2024

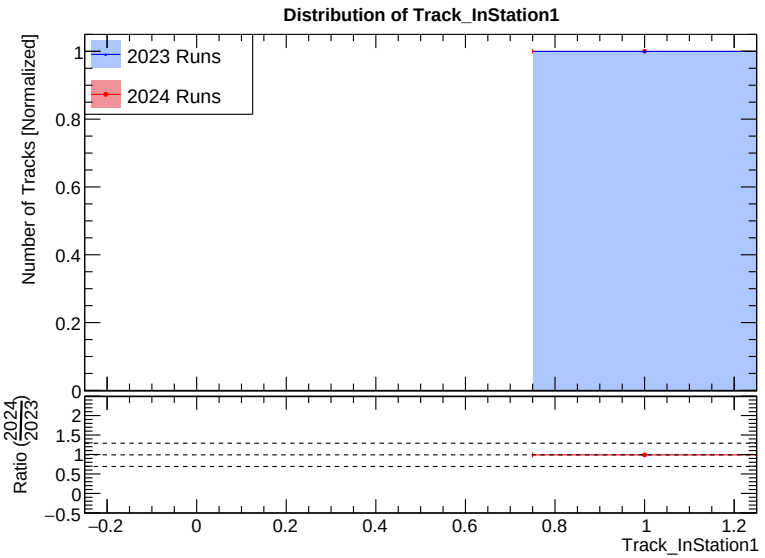
Micellaneous

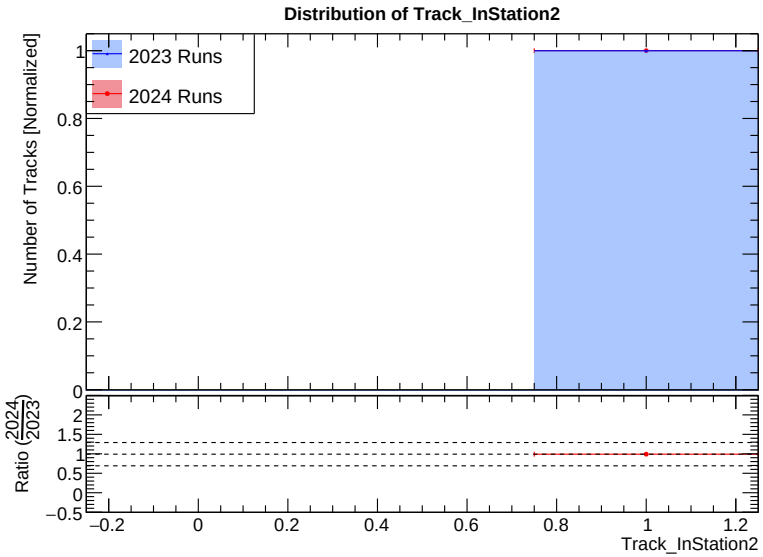
- Similar plots can be made using the compareproductions_faser tool. Some of the plots were used for validation.
- Link to Repo containing the code for plots in this presentation.
- Link to variants of the plots more more filtered like charge separated, good tracks only etc. [Will be added to above repo]
- Detailed yield plots were presented by Oscar. [See DQ Talk]

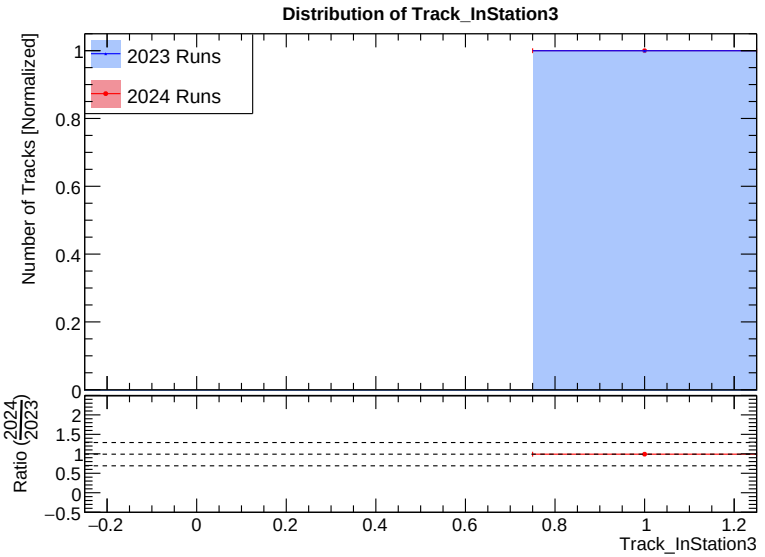
Backup

Distribution of Track in Station









There are always 0 tracks in Station0. Possibly an issue in NTupleDumper. Haven't located this yet.

Track_nLayers

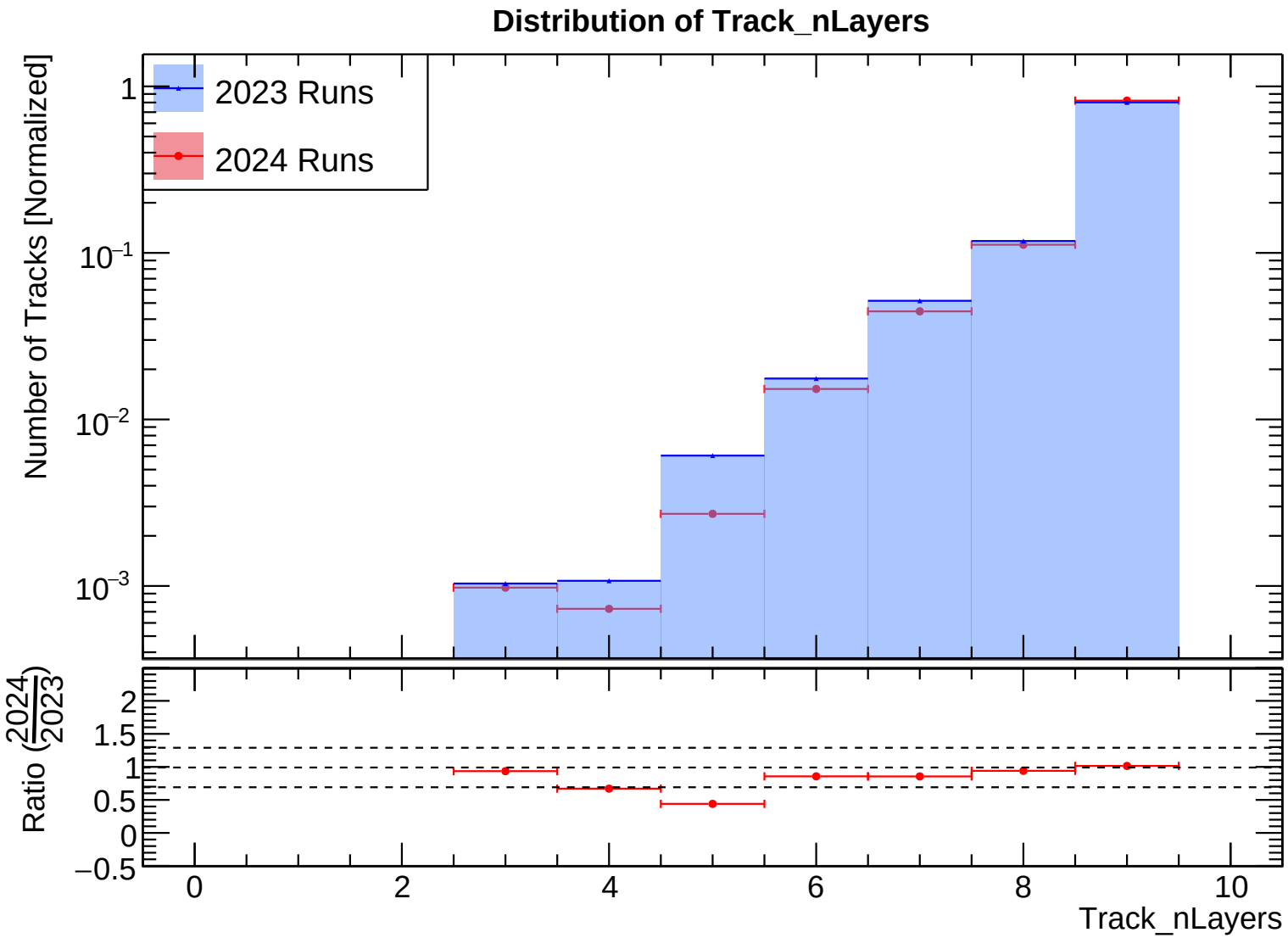


Figure: Distribution of Track_nLayers

Track Positions at Veto Station 1

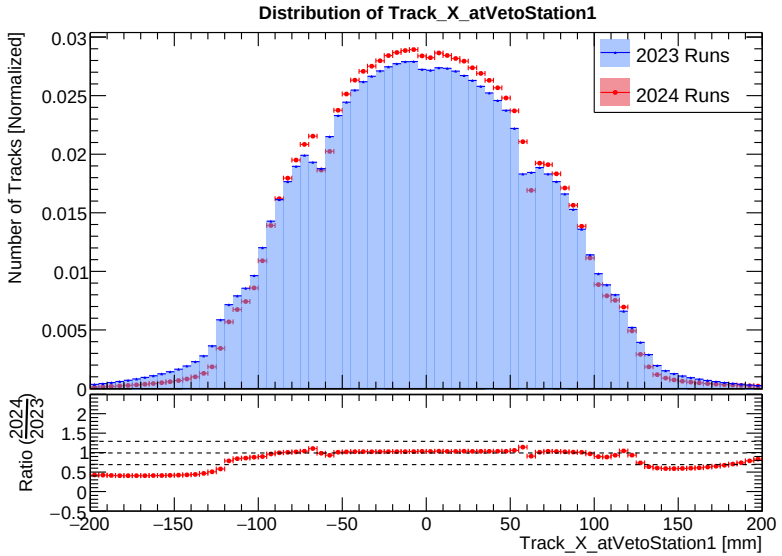


Figure: Track Position x at Veto Station 1

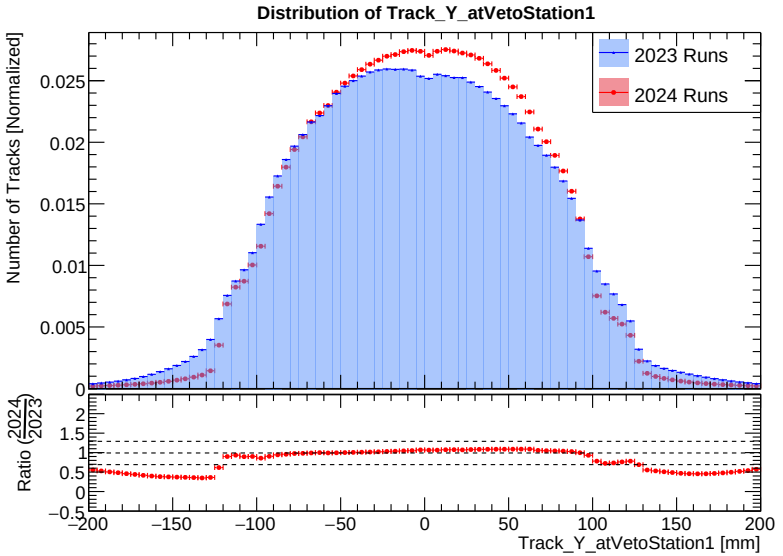


Figure: Track Position y at Veto Station 1

Track Positions at Veto Station 2

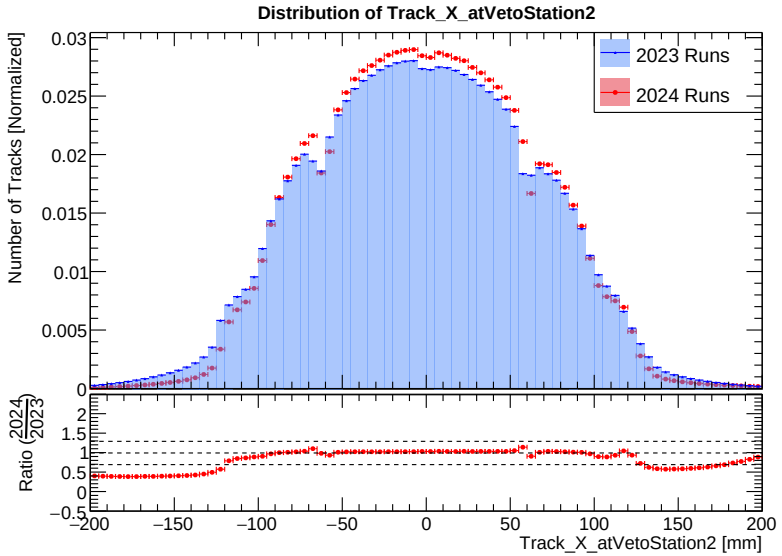


Figure: Track Position x at Veto Station 2

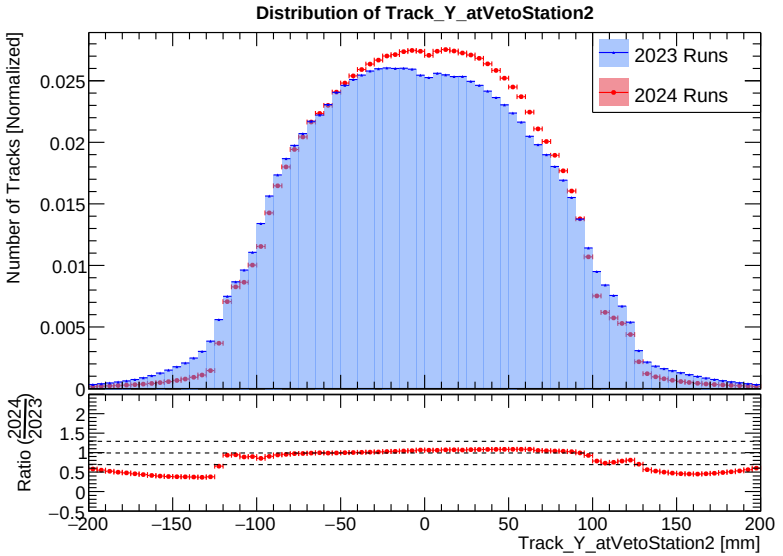


Figure: Track Position y at Veto Station 2

Track Positions at Trigger

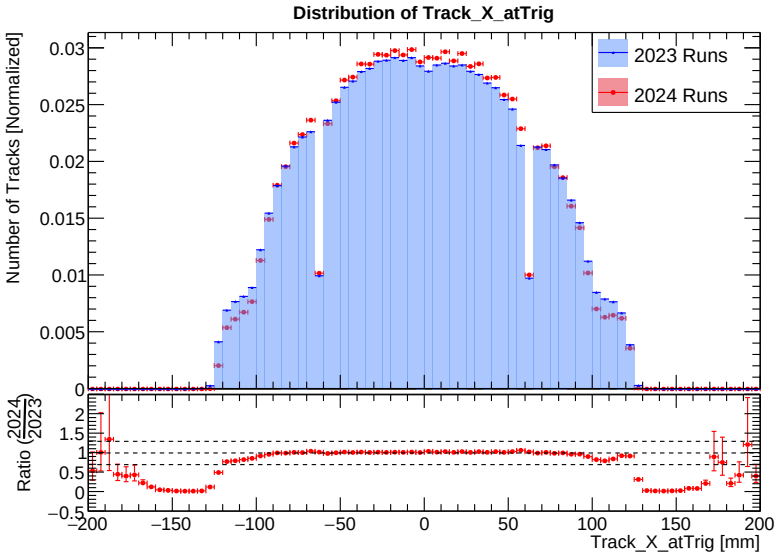


Figure: Track Position x at Trigger/Timing Station

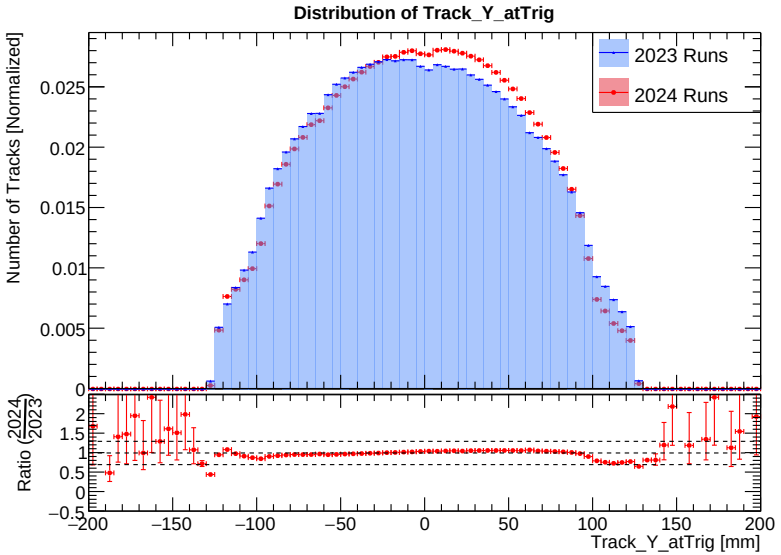


Figure: Track Position y at Trigger/Timing Station

Track Positions at Preshower 1

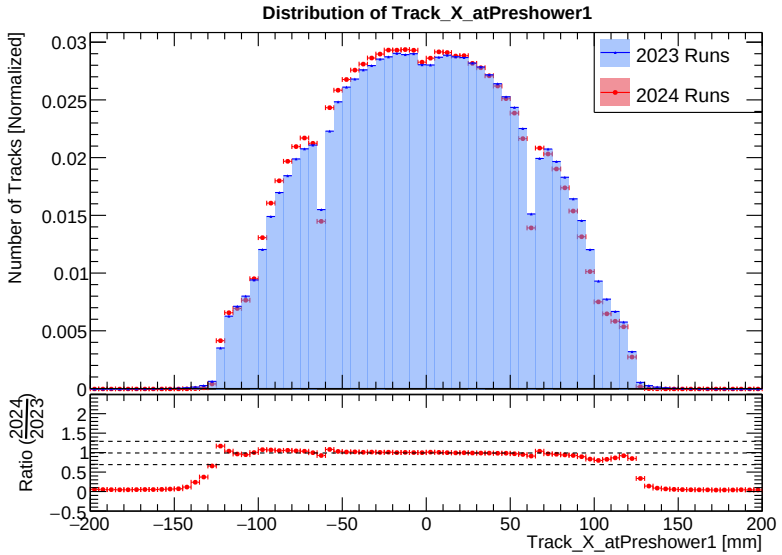


Figure: Track Position x at Preshower 1

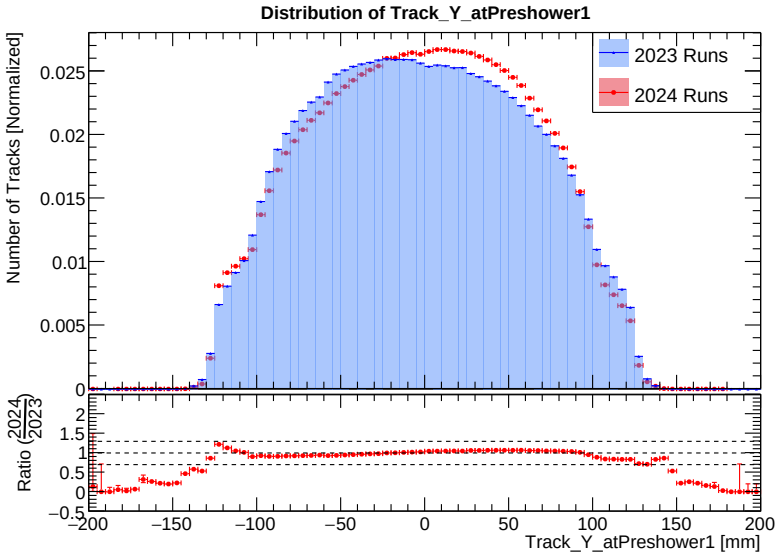


Figure: Track Position y at Preshower 1

Track Positions at Preshower 2

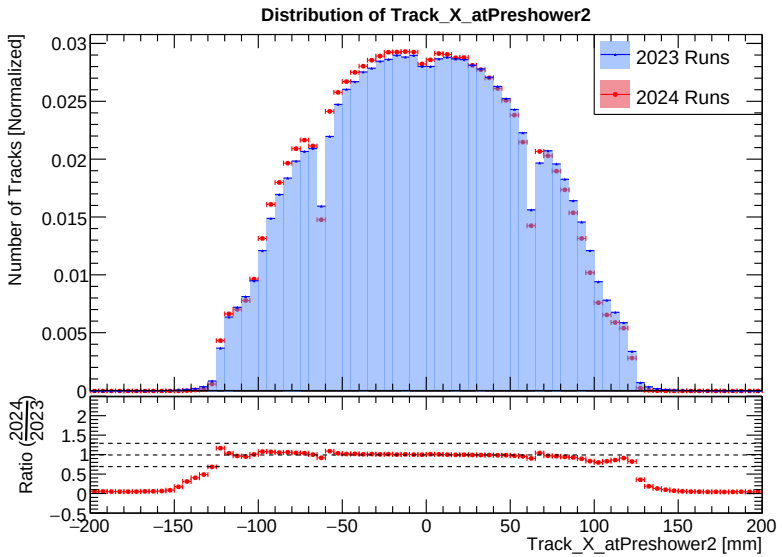


Figure: Track Position x at Preshower 2

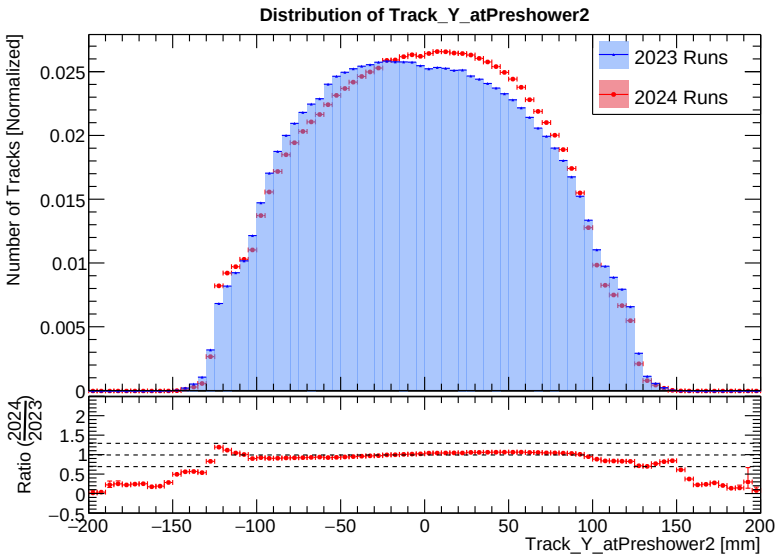
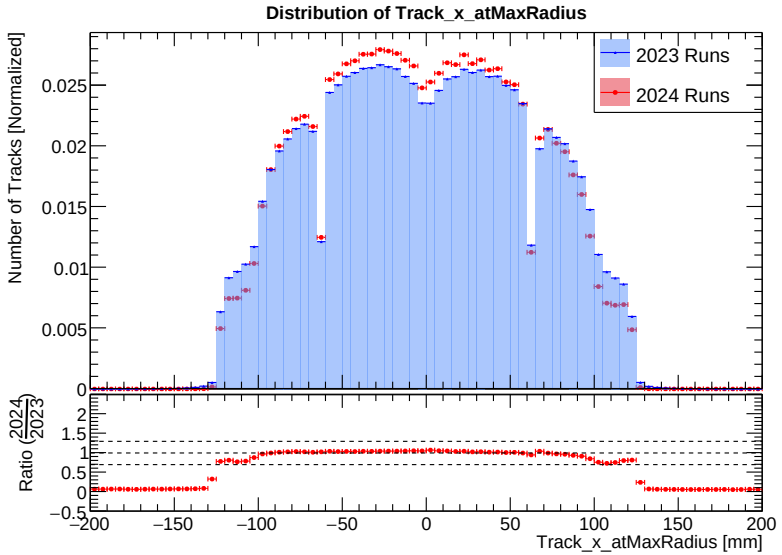
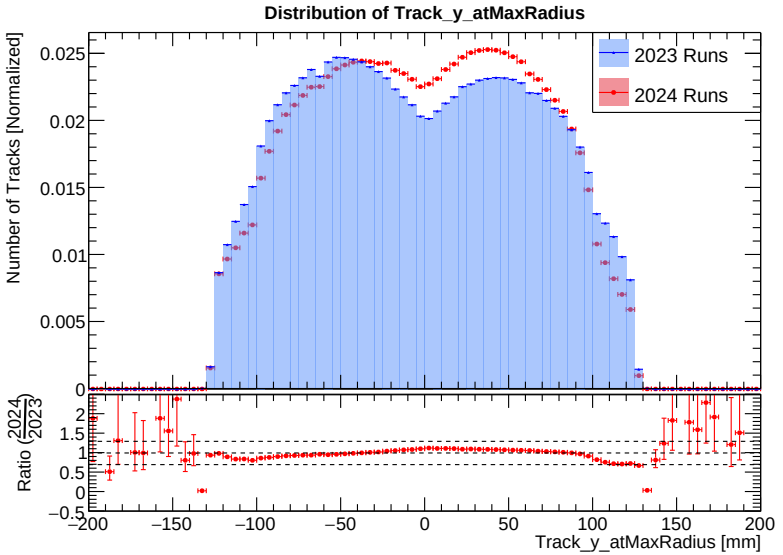


Figure: Track Position y at Preshower 2

Track Positions at Max Radius



Figure



Figure

Track Angles at VetoStation 1

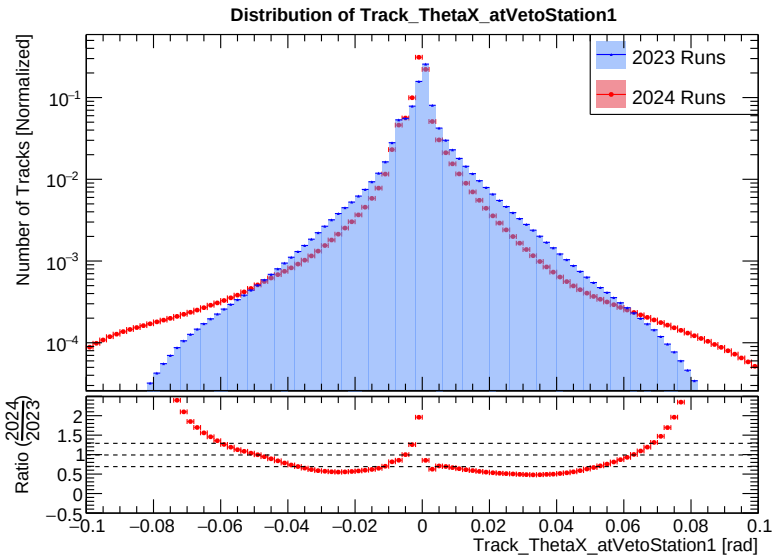


Figure: Track ThetaX at atVetoStation 1

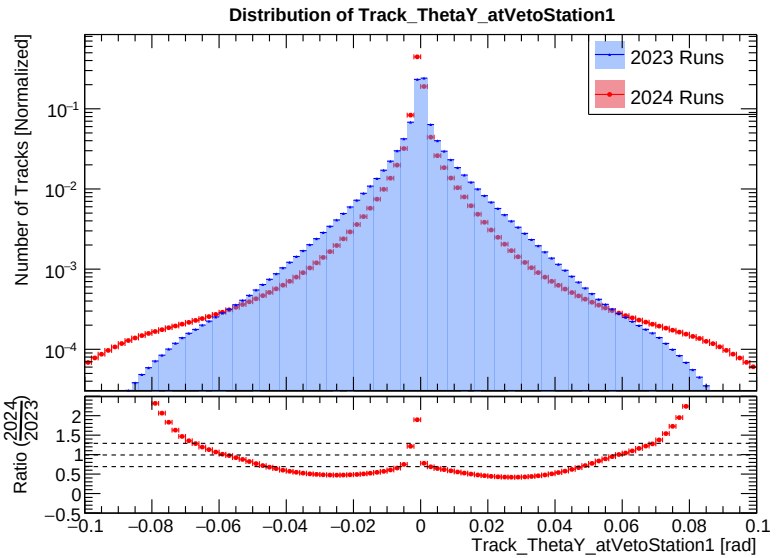


Figure: Track ThetaY at VetoStation 1

Track Angles at VetoStation 2

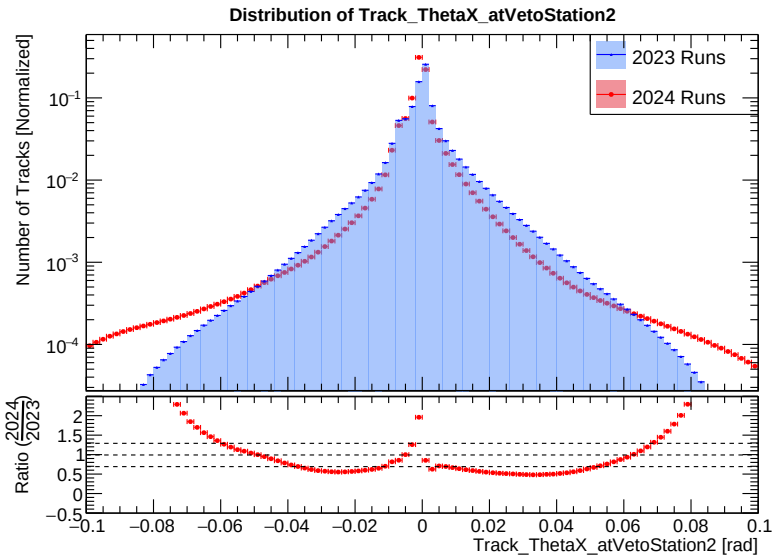


Figure: Track ThetaX at VetoStation 2

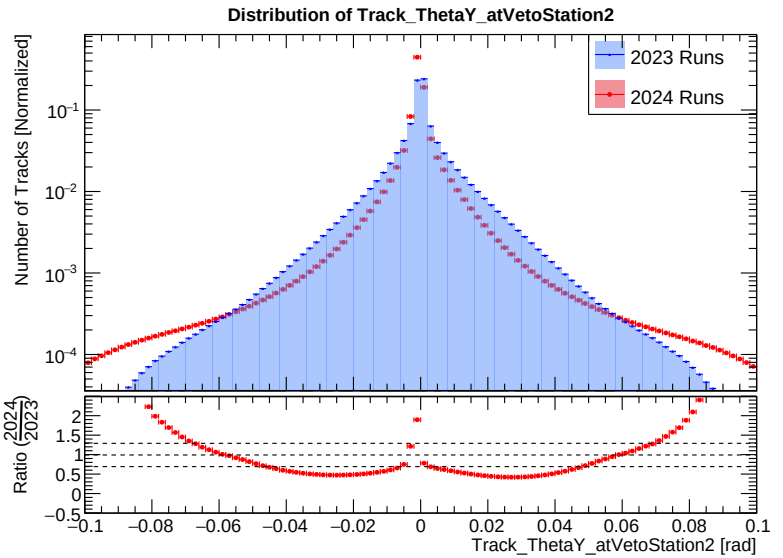


Figure: Track ThetaY at VetoStation 1

Track Angles at Trigger

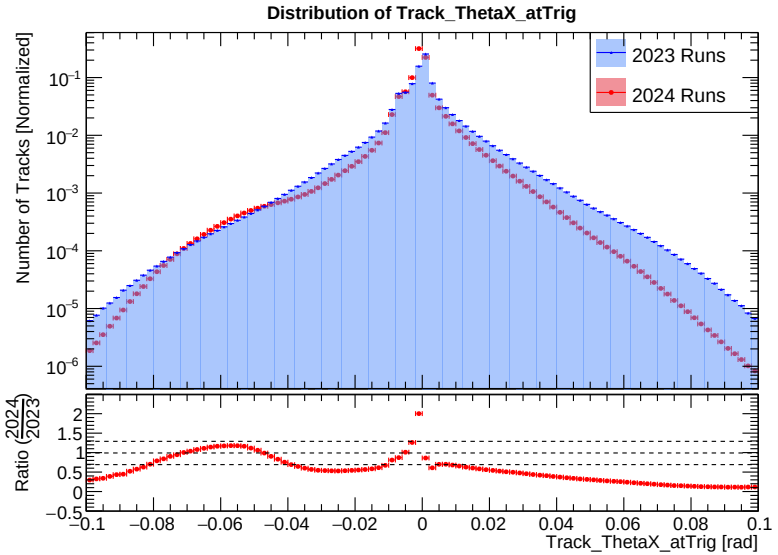


Figure: Track ThetaX at Trigger

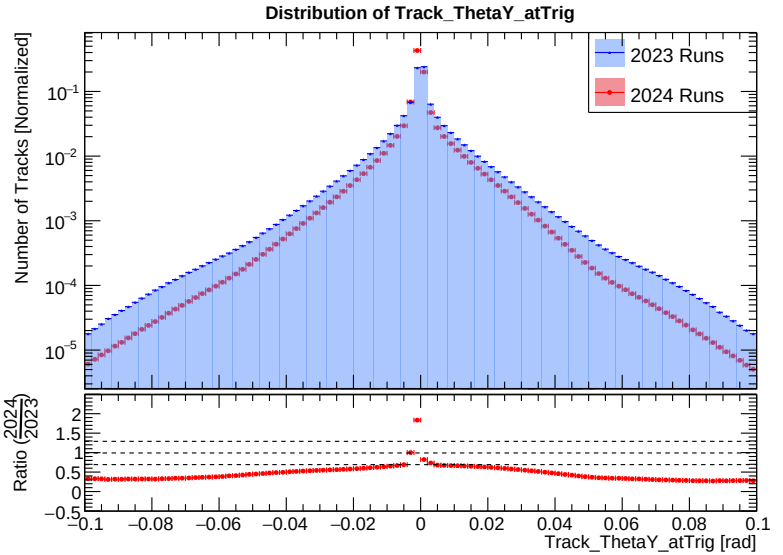


Figure: Track ThetaY at Trigger

Track Angles at Preshower 1

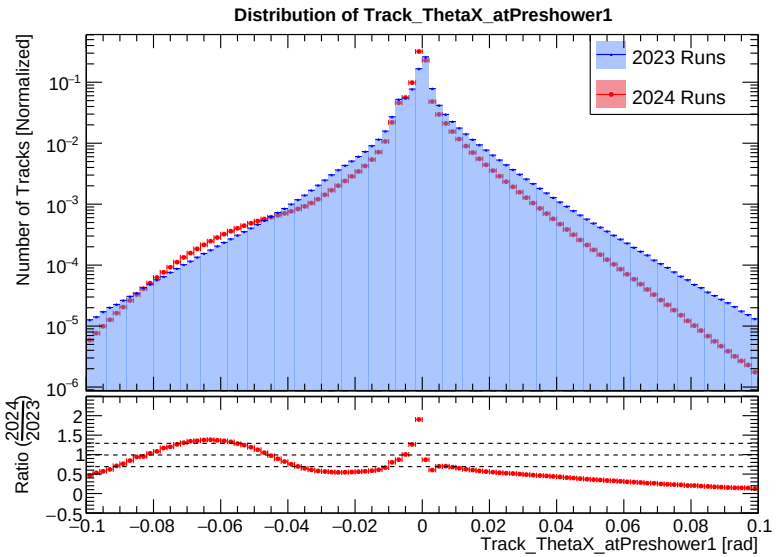


Figure: Track ThetaX at Preshower 1

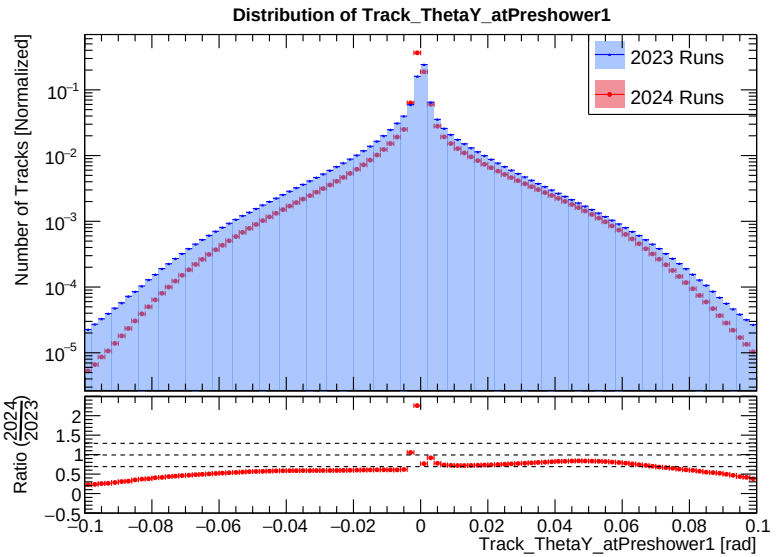


Figure: Track ThetaY at Preshower 1

Track Angles at Preshower 2

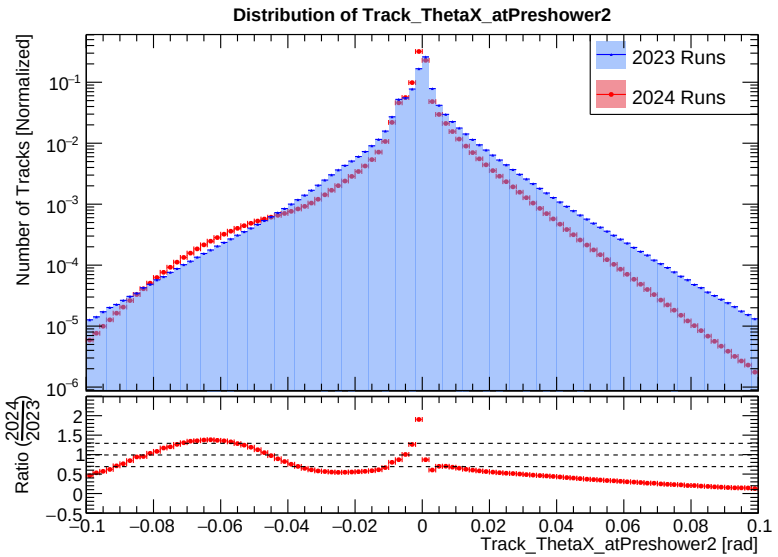


Figure: Track ThetaX at Preshower 2

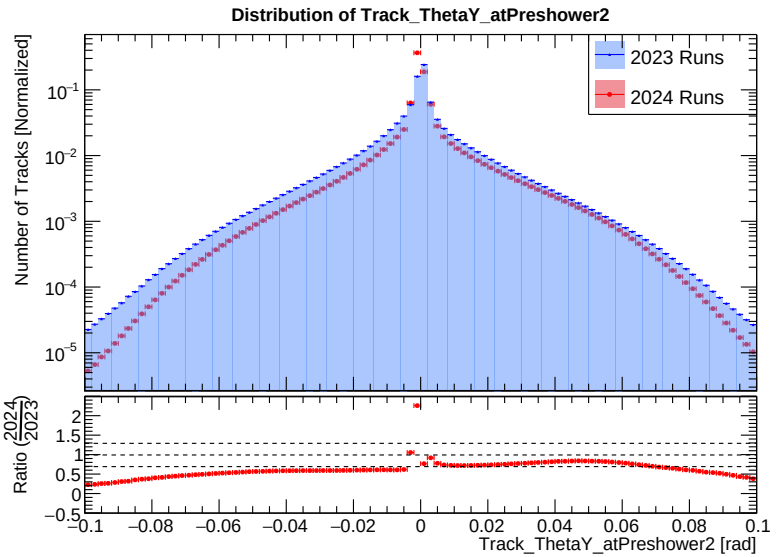


Figure: Track ThetaY at Preshower 2

Track Angles at Calo

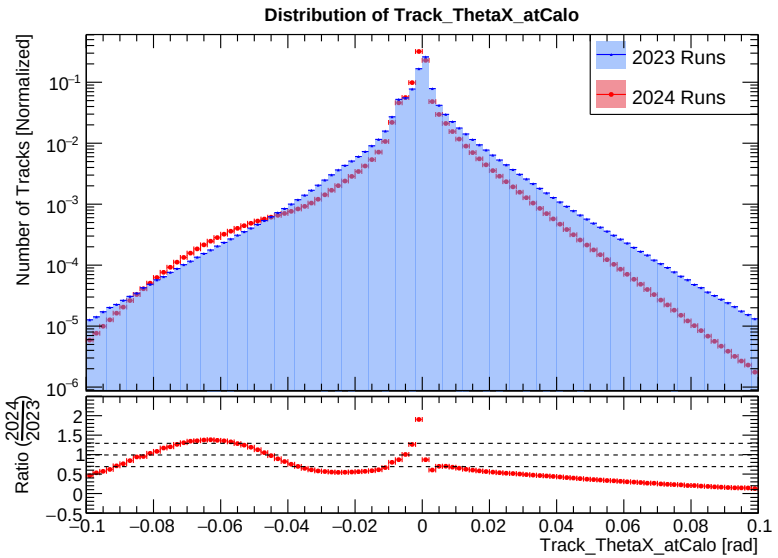


Figure: Track ThetaX at Calo

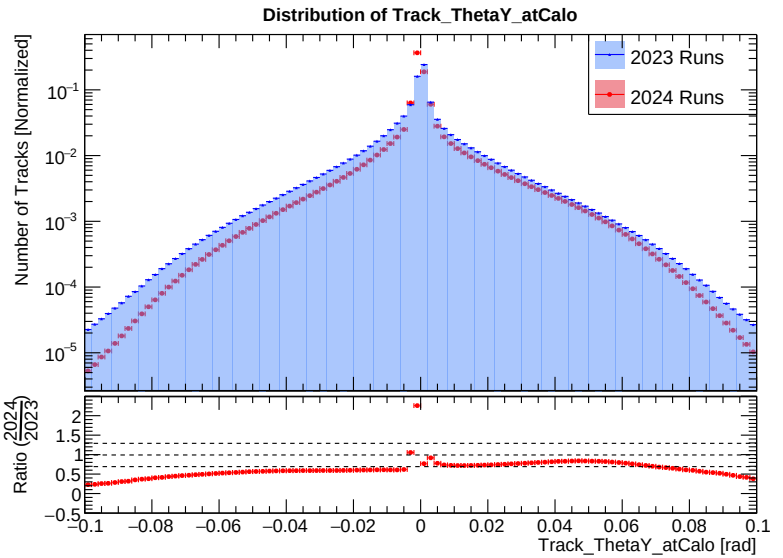


Figure: Track ThetaY at Calo