

# **O2DQ Tutorials: Standalone muons**

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# O2DQ tutorials



Mattermost channel dedicated to DQ framework :

<https://mattermost.web.cern.ch/alice/channels/o2-dq-analysis-framework-alpha>



# O2DQ tutorials : muon

Locally or on lxplus (requires up-to-date version of O2Physics):

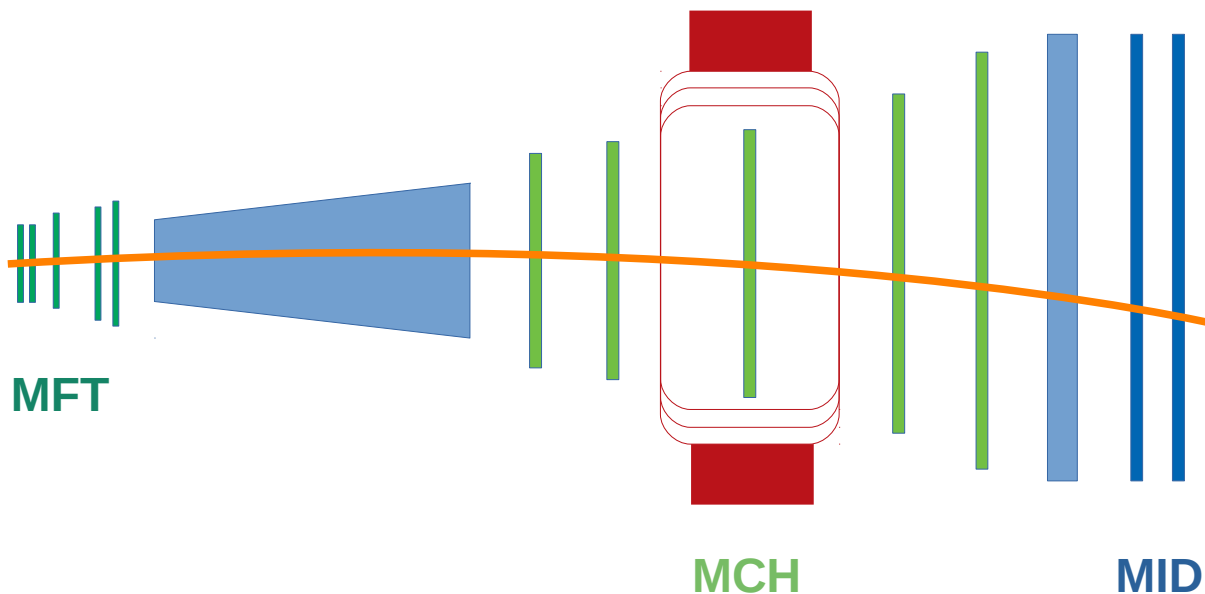
- mkdir O2DQTutorials2025
- Download content of <https://cernbox.cern.ch/s/aGki48PSiQyuT4d>
- Verify it has the following content :
  - muon\_files
  - configs
  - scripts

# Backup : run on lxplus

- Connect using: `ssh -Y yourusername@lxplus.cern.ch`
- You need a grid certificate loaded in your lxplus account (follow <https://alice-doc.github.io/alice-analysis-tutorial/start/cert.html>)
- By default, you are in your user folder, e.g. `/afs/cern.ch/user/m/mcoquet/` but the disk space is limited. To access more space, you can go to the work directory:  
e.g. `cd /afs/cern.ch/work/m/mcoquet`
- Enter your preferred O2Physics environment using cvfms:  
e.g. `/cvmfs/alice.cern.ch/bin/alienv enter VO_ALICE@02sim::v20251106-1`
- Initialize your token with `alien-token-init`

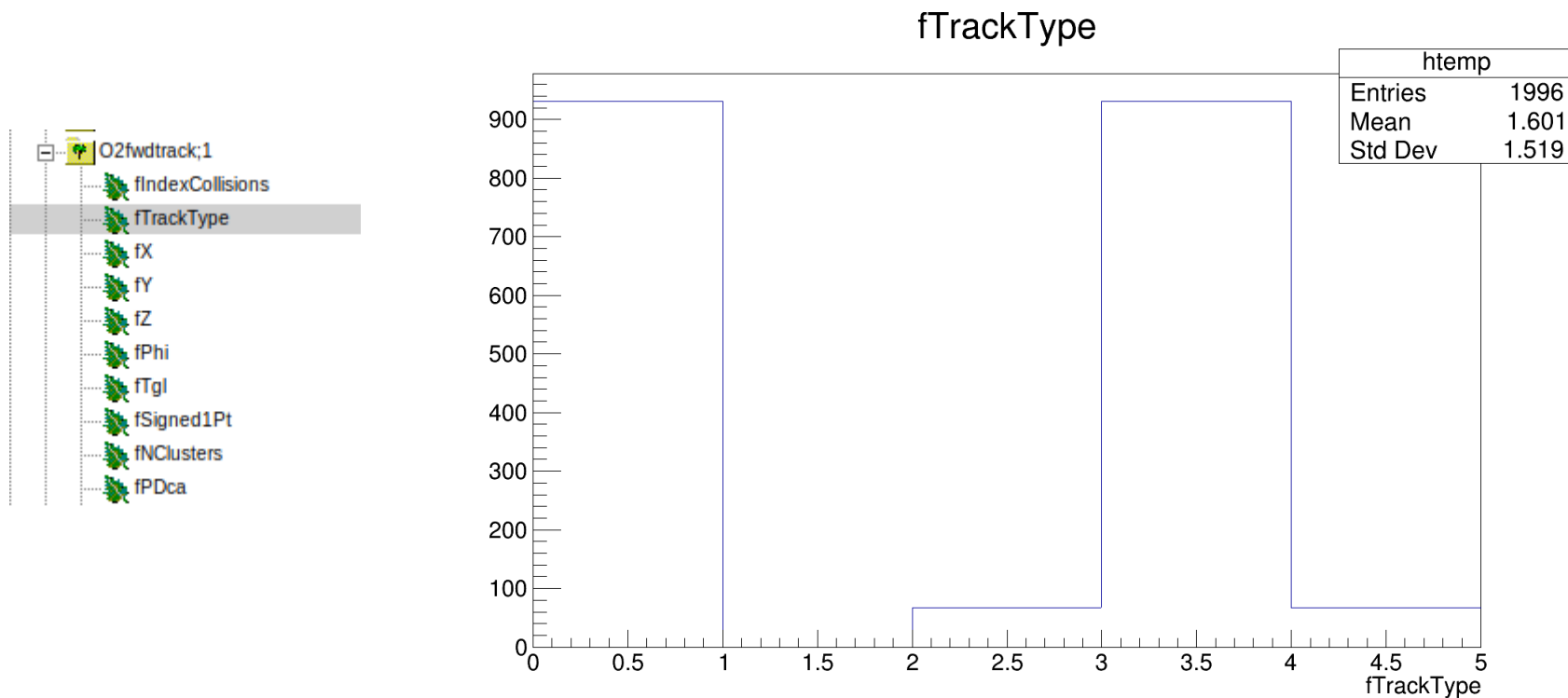
# Muon definitions

- Please refer to the following documentation for more complete explanation of AO2D content and DQ configurations for muons : [https://codimd.web.cern.ch/fiM1\\_e6oQki7NIjHOFTYqw#](https://codimd.web.cern.ch/fiM1_e6oQki7NIjHOFTYqw#)



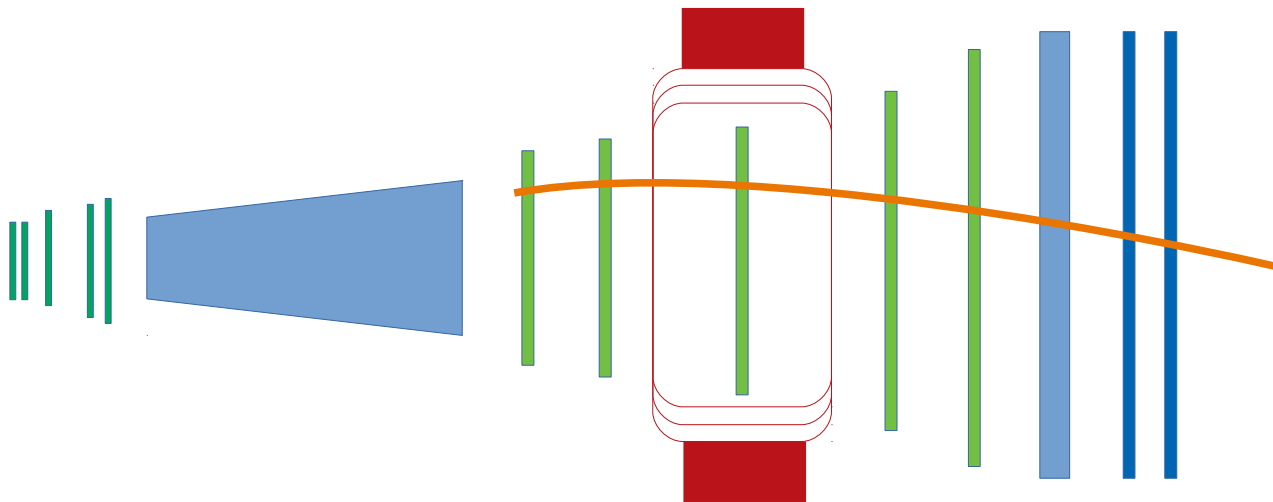
# Muon definitions

In the O2fwdtracks table of AO2D, multiple track types are stored



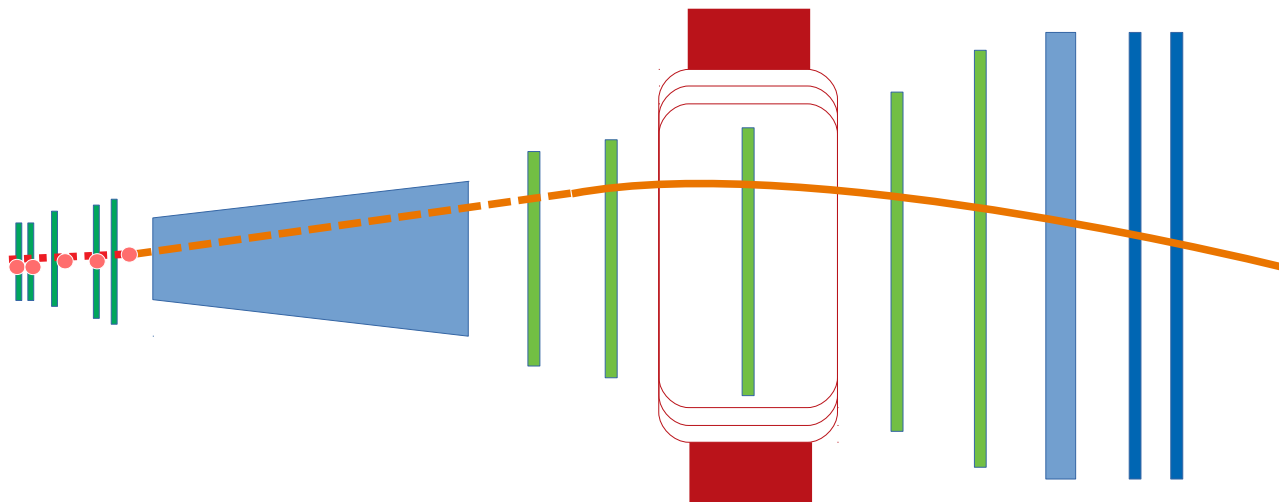
# Muon definitions

- MCH-MID tracks (trackType=3) → **Standalone MUON**  
→ track parameters evaluated at the first MCH layer



# Muon definitions

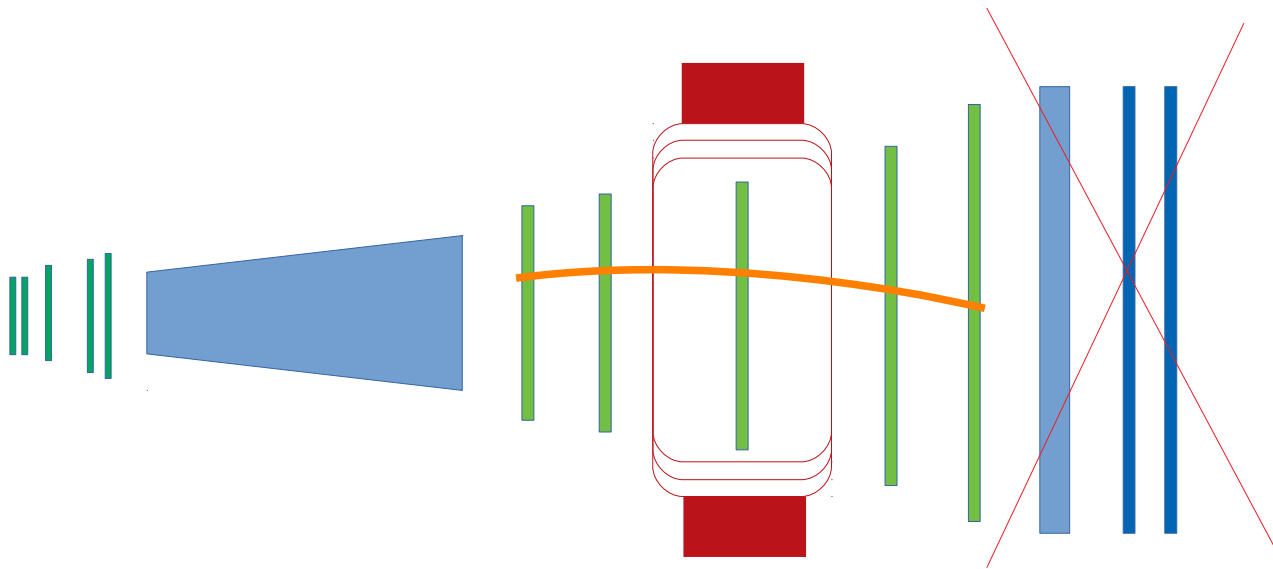
- MFT-MCH-MID tracks (trackType=0) → **Global MUON**  
→ track parameters evaluated at the first MFT layer



Same tracks as trackType=3 tracks with added MFT information

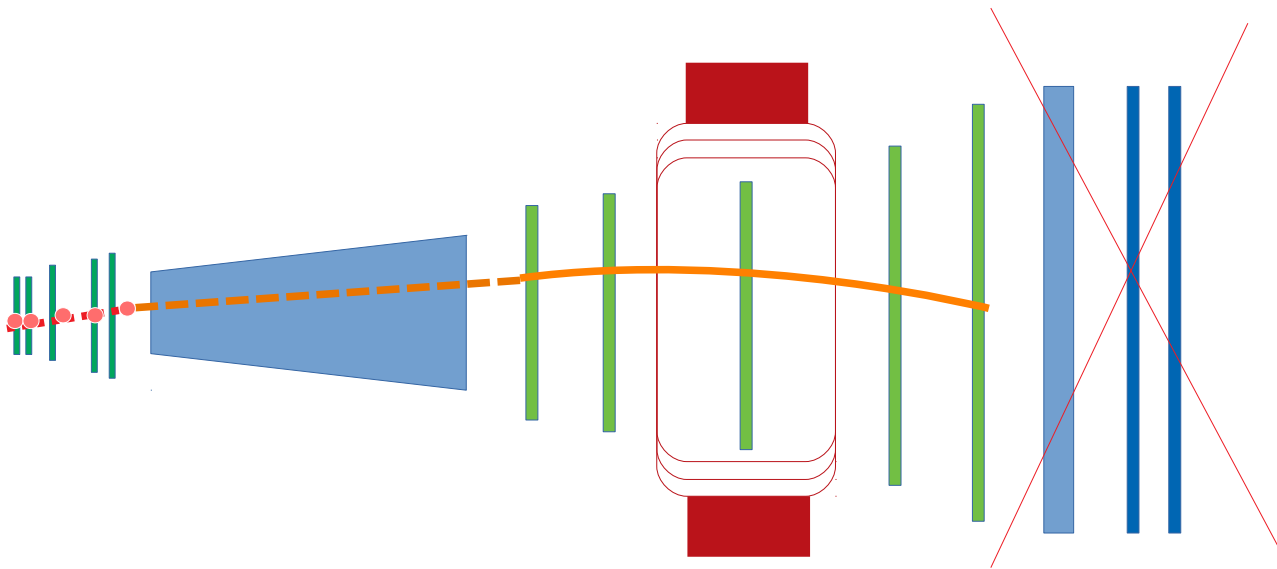
# Muon definitions

- MCH tracks which couldn't be matched with MID (trackType=4)



# Muon definitions

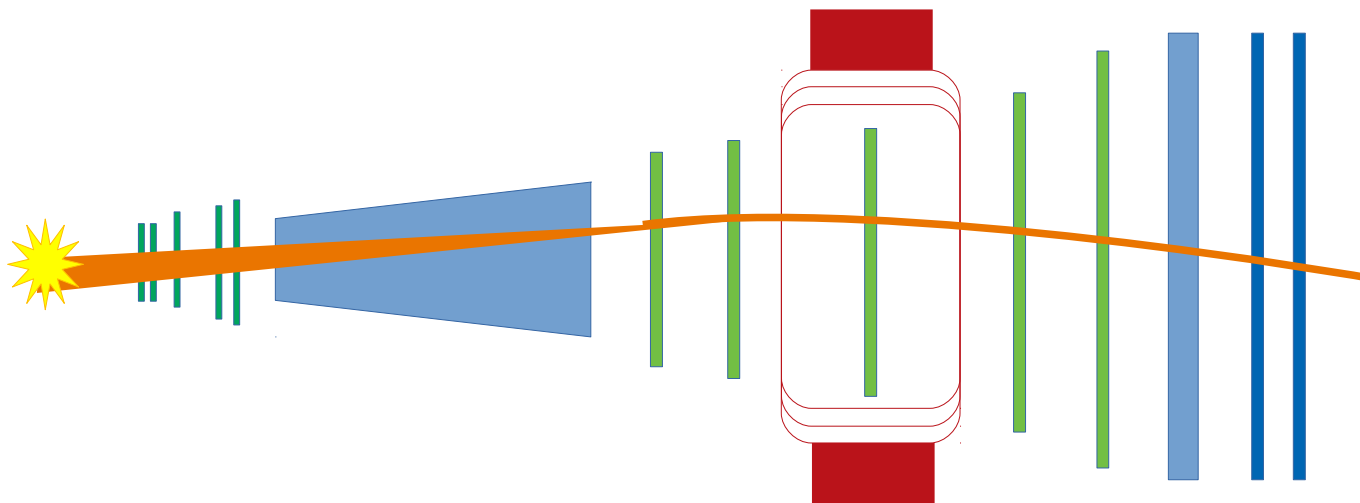
- MFT-MCH tracks which couldn't be matched with MID (trackType=2)



# Standalone MUON propagation

When using Standalone muons, the tracks must be propagated to the collision vertex.  
The kinematic parameters of the tracks are recomputed and improved.

**“À la Run 2” tracks**



# Selection Cuts



- **eventStandardSel8:**  $vtx_z \in [-10.0, 10.0]$ , Sel8 trigger (TVX + No TF Border + ITS ROF Border)
- **muonQualityCuts:**  $-4.0 < \eta < -2.5$ ,  $17.6 < R_{abs} < 89.5$  cm,  $pDCA < 6\sigma$ , **MCH-MID + MFT-MCH-MID**
- **matchedQualityCuts:**  $-4.0 < \eta < -2.5$ ,  $17.6 < R_{abs} < 89.5$  cm,  $pDCA < 6\sigma$ , **MFT-MCH-MID**
- **matchedMchMid:** **ONLY MCH-MID tracks**
- **matchedGlobal:** **ONLY MFT-MCH-MID tracks**
- **muonLowPt:**  $p_T > 0.5$  GeV/c
- **muonLowPt2:**  $p_T > 0.7$  GeV/c
- **muonLowPt5:**  $p_T > 1$  GeV/c

Whole list can be found here: [PWGDQ/Core/CutsLibrary.cxx](http://PWGDQ/Core/CutsLibrary.cxx)

# Histograms

## Event-related histograms

- **vtx**: collision vertex X, Y and X vs Y histograms
- **mult**: TPC, FIT, Tracklets, FTO, FDD, FVO multiplicities

## Single muon histograms

- **muon**: nb of clusters/track, pDCA,  $R_{abs}$ ,  $\chi^2$  of track,  $\chi^2$  for MCH-MID matching,  $\chi^2$  for MFT-MCH-MID, muon  $DCA_x/DCA_y$  vs  $\phi/\eta$

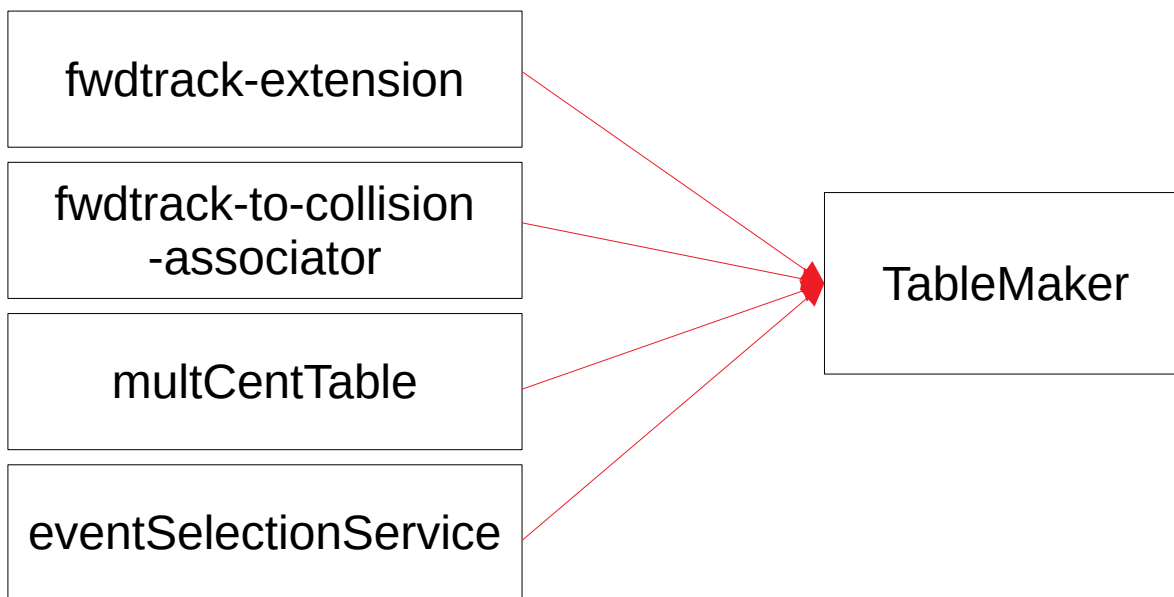
## Dimuon histograms

- **vertexing-forward**:  $L_z$ ,  $\tau_{z, \tau}$ ,  $\chi^2$  of PCA,  $P_z$ , secondary vertex coordinates, primary vertex coordinates
- **dimuon**: mass vs  $y$ , mass vs  $p_T$

Whole list can be found here: [PWGDQ/Core/HistogramsLibrary.cxx](https://alice.web.cern.ch/ALICE/Physics/PhysicsTools/PWGDP/Core/HistogramsLibrary.cxx)

# TableMaker\_withAssoc config: Standalone MUON

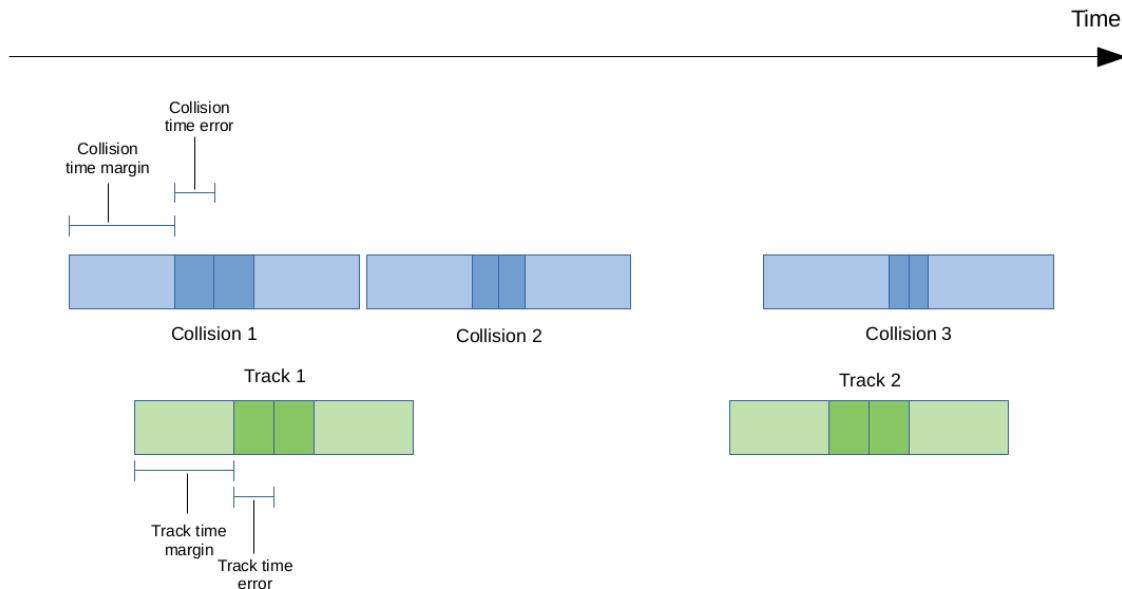
- Most common dependencies of TableMaker for muons :



# TableMaker\_withAssoc config: Standalone MUON



- Association between muon tracks and collisions, done by **fwdtrack-to-collision-associator**, is based on time. If resolutions are poorly constrained, can have large number of **ambiguous** muon tracks (compatible in time with multiple collisions)



- In DQ, ambiguous tracks will be duplicated: once for each possible compatible collision. It is up to the analyzer to decide how to handle these ambiguous tracks

# TableMaker\_withAssoc config: Standalone MUON

In file `configs/configTableMakerData_withAssoc_muon_2025.json`

```
"internal-dpl-clock": "",
"internal-dpl-aod-reader": {
  "aod-file-private": "muon_files/AO2D_muon.root",
  "time-limit": "0",
  "orbit-offset-enumeration": "0",
  "orbit-multiplier-enumeration": "0",
  "start-value-enumeration": "0",
  "end-value-enumeration": "-1",
  "step-value-enumeration": "1"
},
```

→ Path to input AO2D file

```
"fwd-track-to-collision-association": {
  "nSigmaForTimeCompat": "3",
  "timeMargin": "0",
  "includeUnassigned": "true",
  "fillTableOfCollIdsPerTrack": "true",
  "bcWindowForOneSigma": "115",
  "processFwdAssocWithTime": "true",
  "processFwdStandardAssoc": "false",
  "processMFTAssocWithTime": "true",
  "processMFTStandardAssoc": "false"
},
```

→ Forwardtrack-collision association configuration  
→ recommended parameters:

- Nb of time res sigma = 3
- Additional time margin = 0

# TableMaker\_withAssoc config: Standalone MUON

```
"table-maker": {  
  "cfgEventCuts": "eventStandardSel8",  
  "cfgMuonCuts": "muonQualityCuts",  
  "cfgAddEventHistogram": "vtx",  
  "cfgAddMuonHistogram": "muon,vertexing",  
  "cfgAddFile": "0"
```

Event selection

Single muon selection

```
"processOnlyvBCs": "0",  
"processPPMuonOnly": "1",  
"processPPMuonMFT": "0",  
"processPPMuonMFTWithMultsExtra": "0",  
"processPPWithFilterMuonOnly": "0",  
"processPPWithFilterMuonMFT": "0",  
"processPPRealignedMuonOnly": "0",  
"processPbPbMuonOnly": "0",  
"processPbPbMuonMFT": "0",  
"processPbPbMFT": "0"
```

TableMaker process to run

- MuonOnly for standalone MUON
- PPWithFilter for unskimmed pp data
- PP for skimmed pp data
- PbPb for PbPb data

# TableMaker\_withAssoc config: Standalone MUON



```
"cfgAddEventHistogram": "vtx",  
"cfgAddMuonHistogram": "muon",  
"cfgQA": "1",  
"cfgDetailedQA": "1",  
"cfgSaveBDTFile": "0"
```

→ Histograms to be produced

```
"cfgPropMuon": "true",
```

→ Enable muon propagation to collision vertex

# Run TableMaker\_withAssoc

In the O2DQTutorials/:

- Enter local O2Physics environment (ideally not older than 6<sup>th</sup> November),  
or on lxplus: `/cvmfs/alice.cern.ch/bin/alienv enter VO_ALICE@O2sim::v20251106-1`
- `python3 scripts/runTableMaker_withAssoc.py`  
`configs/configTableMakerData_withAssoc_muon_2025.json -runData`
- Output:

```
coquet 1,1K nov. 5 17:24 aodWriterTempConfig.json
coquet 1,3M nov. 5 17:24 reducedAod.root
coquet 860K nov. 5 17:24 AnalysisResults.root
coquet 9,6K nov. 5 17:24 dpl-config.json
```

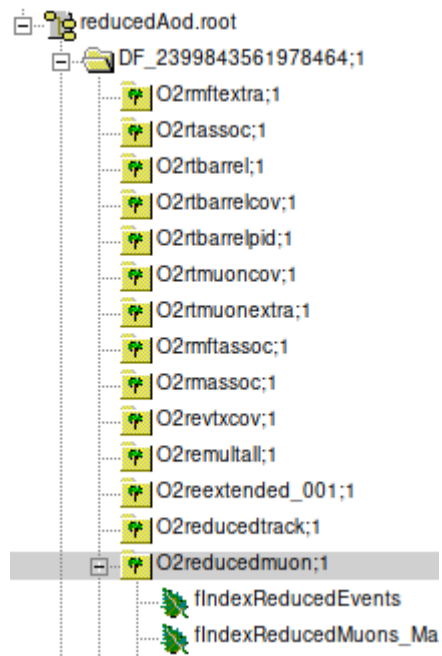
Reduced tables

Requested histograms

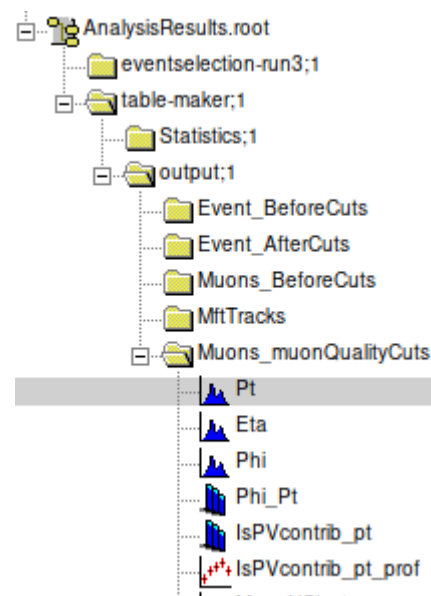
# Run TableMaker\_withAssoc



- Reduced tables:



- Histograms:

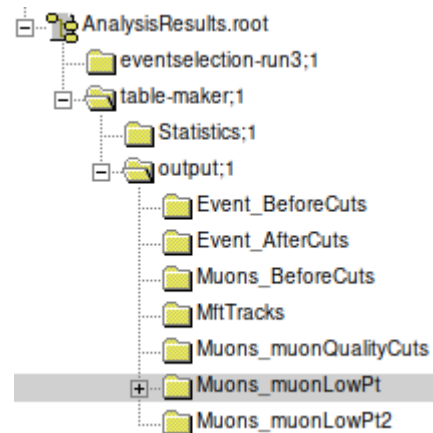


# Run TableMaker\_withAssoc



- Histograms filled for each provided selection cut
- Example:

```
"cfgEventCuts": "eventStandardSel8".  
"cfgMuonCuts": "muonQualityCuts,muonLowPt,muonLowPt2",  
"cfgAddEventHistogram": "vtx",  
"cfgAddMuonHistogram": "muon",  
"cfgAddAssocHistogram": "assoc",
```



# TableReader\_withAssoc config: Standalone MUON

In file `configs/configAnalysisData_withAssoc_muon_2025.json`

```
"internal-dpl-aod-reader": {  
  "aod-file-private": "reducedAod.root",  
  "time-limit": "0",  
  "orbit-offset-enumeration": "0",  
  "orbit-multiplier-enumeration": "0",  
  "start-value-enumeration": "0",  
  "end-value-enumeration": "-1",  
  "step-value-enumeration": "1"
```

Path to reduced tables

```
"analysis-event-selection": {  
  "cfgEventCuts": "eventStandardSel8",  
  "cfgAddEventHistogram": "VTX",  
  "processDummy": "0",  
  "processSkimmed": "1",  
  "processSkimmedWithZdc": "0",  
  "processSkimmedWithMultExtra": "0",  
  "processSkimmedWithMultExtraZdc": "0",  
  "processSkimmedWithQvectorCentr": "0",
```

# TableReader\_withAssoc config: Standalone MUON



```
"analysis-muon-selection": {  
  "cfgMuonCuts": "matchedMchMid",  
  "cfgAddMuonHistogram": "",  
  "processDummy": "0",  
  "processSkimmed": "1",
```

```
"analysis-same-event-pairing": {  
  "cfgMuonCuts": "matchedMchMid",  
  "cfgPatrCuts": "",  
  "cfgQA": "1",  
  "cfgAddSEPHistogram": "dimuon,barrel,vertexing",  
  "processAllSkimmed": "0",  
  "processMixingAllSkimmed": "0",  
  "processMuonOnlySkimmed": "1",  
  "processMuonOnlySkimmedMultExtra": "0",  
  "processMixingMuonSkimmed": "0",
```

```
"cfgFlatTables": "1",
```

Produce output dimuon tree

# Run TableReader\_withAssoc

In the O2DQTutorials/:

- **o2-analysis-dq-table-reader-with-assoc** -b --configuration **json://configs/configAnalysisData\_withAssoc\_muon\_2025.json** --aod-file reducedAod.root (**--aod-writer-json configs/writerTableReaderFlatTable.json**)

→ Optional, to produce output dimuon table

- Output:

```
nov. 5 17:53 configs
nov. 5 17:54 A02D.root
nov. 5 17:54 AnalysisResults.root
nov. 5 17:54 dpl-config.json
```

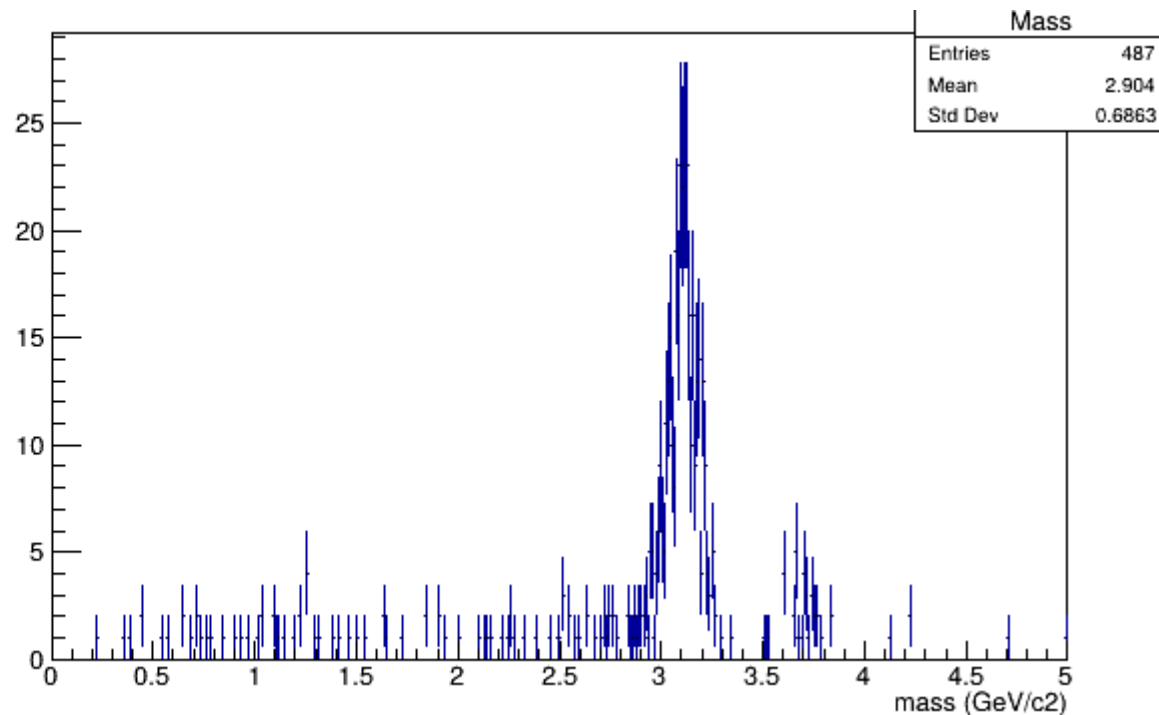
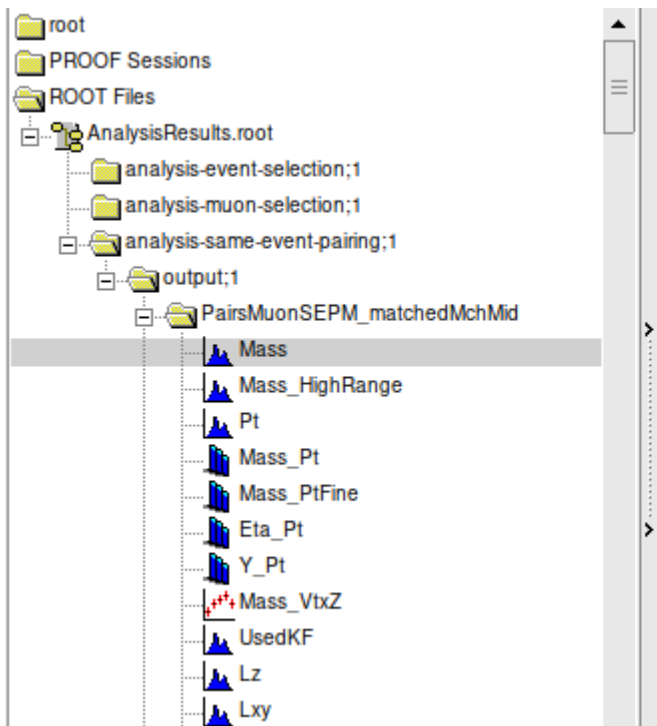
→ Flat dimuon table

→ Requested histograms

# Run TableReader\_withAssoc

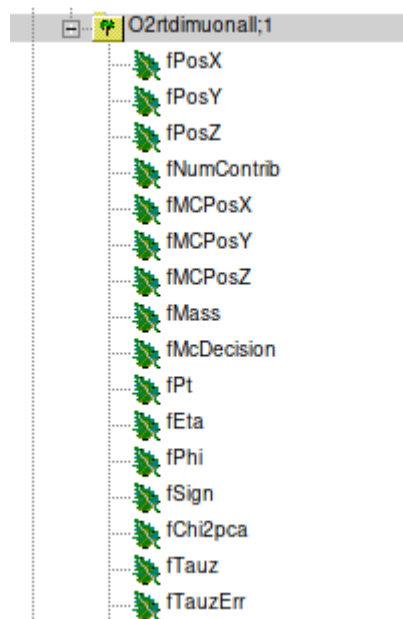


- Histograms:



# Run TableReader\_withAssoc

- Dimuon table:



Contains single muon, dimuon kinematics, vertexing information, MC information

# Hyperloop operations

- Once the new analysis appears on your own hyperloop, go to

My Analyses **All Analyses** Dashboard AliHyperloop 🐥 Train Submission Train Runs Data

## All Analyses

💡 Reset all filters

| Analysis                                         | Analyzers                        | W                                                |
|--------------------------------------------------|----------------------------------|--------------------------------------------------|
| <input type="text" value="Search 5 records..."/> | <input type="text" value="mco"/> | <input type="text" value="Search 5 records..."/> |
| <a href="#">Run 3 muon analysis</a>              | mcoquet 📄                        | tableReader,<br>tableMaker_<br>others            |
| <a href="#">O2DQ muon tutorial</a>               | mcoquet 📄                        | fwdtrack-col<br>TableMaker_<br>others            |
|                                                  |                                  | alice3_OTED                                      |

# Hyperloop operations

- Clone each of the wagons to your own new analysis:

| Wagon                                                 | LHC25c3b                                       | Last run |                                                                                                                                                                            |
|-------------------------------------------------------|------------------------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">TableMaker_globalmuon_pp</a>              | ×                                              | 547870   | vs   |
| <a href="#">TableMaker_muon_pp</a>                    | ×                                              | 547871   | vs   |
| <input type="text" value="O2DQ muon tutorial"/> ×   ▾ | <input type="text" value="tableMaker_muon"/> ✓ |          |  Clone                                                                                  |

# Hyperloop operations

| Wagon                      |                                                                                   | DQ_LHC24_... LHC25ad_pa... |                                                                                       |
|----------------------------|-----------------------------------------------------------------------------------|----------------------------|---------------------------------------------------------------------------------------|
| TableMaker_globalmuon_pp   |                                                                                   | ×                          | ×                                                                                     |
| TableMaker_muon_pp         |                                                                                   | ×                          | ✓  |
| TableMakerMC_globalmuon_pp |  | ×                          | ×                                                                                     |

General

Derived Data

Test

Package tag

Dataset

Enabled by

Test status

Start Time

End Time

O2Physics::daily-20241012-200-1

LHC23\_pass4\_skimmed

mcoquet

Done  [\(output\)](#) (browse) [Speedscope](#)

12 October 2024 at 17:49:07 CEST

12 October 2024 at 17:54:46 CEST

# Hyperloop operations

## Filename

merge\_test1/

merge\_test2/

merge\_test3/

A02D.root

AnalysisResults.root

OutputDirector.json

QAResults.root

configuration.json

download.log

dpl-config.json

env.sh

full\_config.json

input\_data.txt

merge.log

performanceMetrics.json

performanceMetrics\_processed.json

profile.linux-perf.txt

status.json

stderr.log

stdout.log

wn.xml

Output tables and histograms of the test

Config for the hyperloop wagon

Log output (useful for debugging)

# Run hyperloop locally

- `cd O2DQTutorials2025/`
- Download the previous “full\_config.json” corresponding to the wagon you want to run locally
- Create a “input\_data.txt” containing the list of AO2D files over which you want to run
- Download the “run\_train.sh” file from [these instructions](#)
- `./run_train.sh --skip-perf`
- Output:

```
8,2K oct. 12 18:13 configuration.json
162 oct. 12 18:13 OutputDirector.json
173K oct. 12 18:13 A02D.root
2,1M oct. 12 18:13 AnalysisResults.root
629 oct. 12 18:13 QAResults.root
380K oct. 12 18:13 performanceMetrics.json
12K oct. 12 18:13 dpl-config.json
```

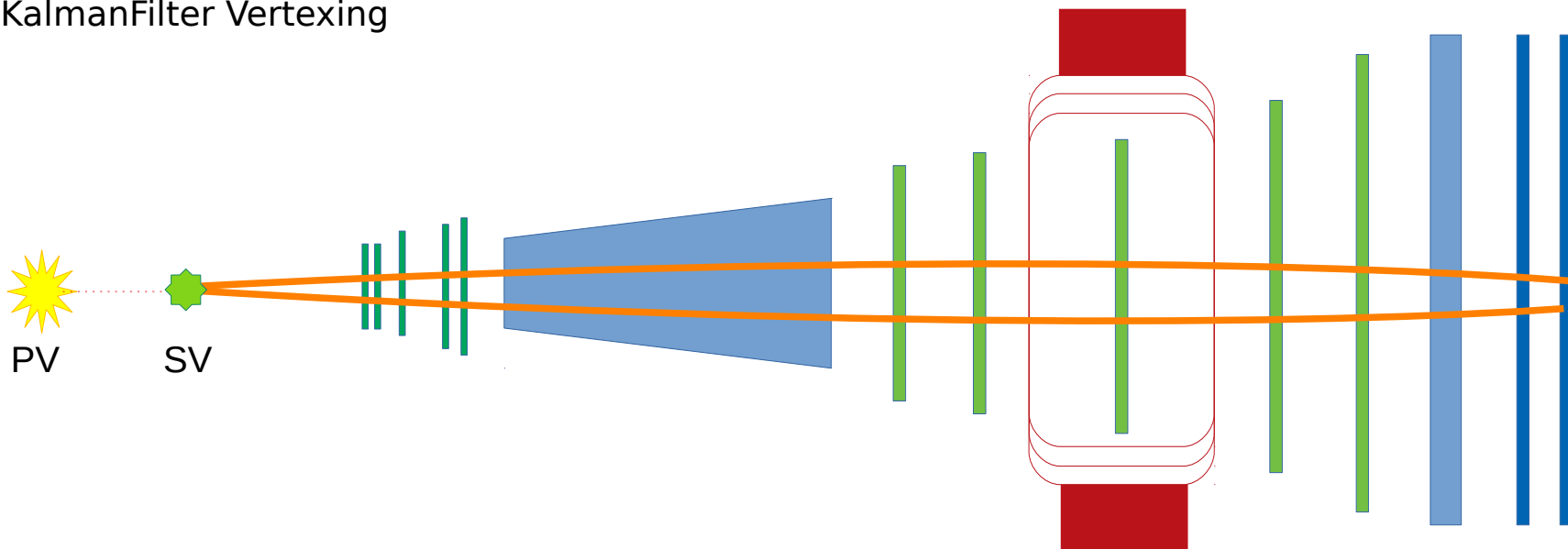


ALICE

# Global muons

# Secondary vertexing

- Global muon tracks contain MFT information and can be used for secondary vertexing
- Two different secondary vertexing algorithms are currently implemented in DQ:
  - DCAFitter
  - KalmanFilter Vertexing



# Global muon refit at analysis level



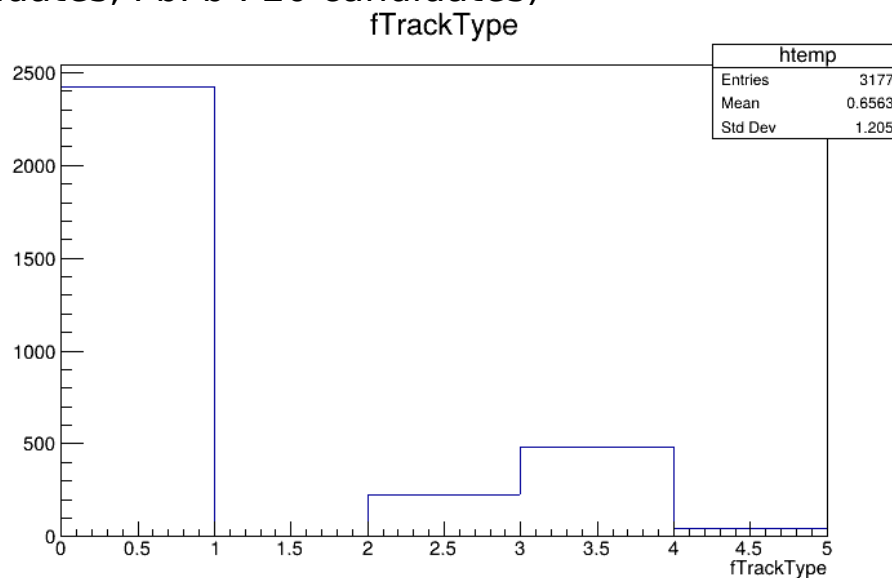
- Option in O2-DQ to recompute track parameters instead of using reco track fitting:

$$p_x = p_{\text{MCH}} \sin(\theta_{\text{MFT}}) \cos(\phi_{\text{MFT}})$$

$$p_y = p_{\text{MCH}} \sin(\theta_{\text{MFT}}) \sin(\phi_{\text{MFT}})$$

$$p_z = p_{\text{MCH}} \cos(\theta_{\text{MFT}})$$

- In some productions, multiple matching candidates are saved per standalone muons (pp/pO/OO : 5 candidates, PbPb : 20 candidates)



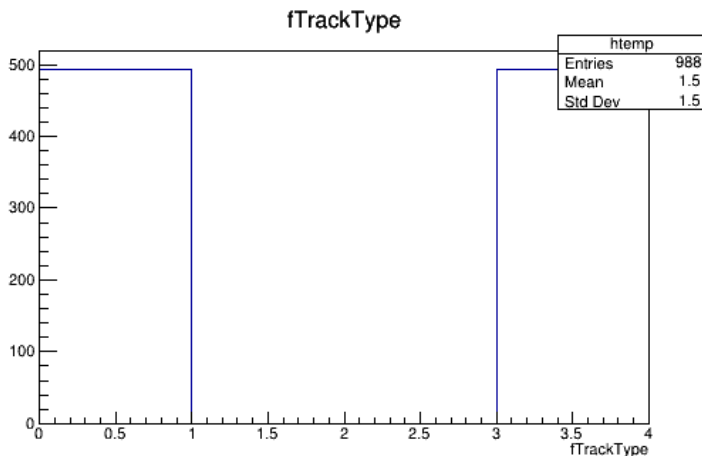
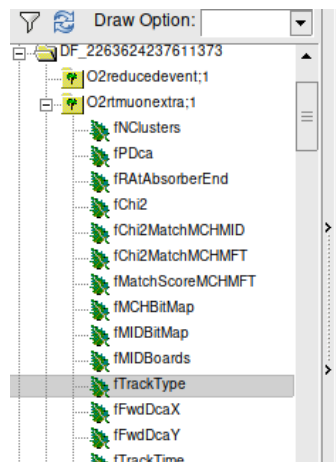
# TableMaker\_withAssoc config: global MUON

In file `configs/configTableMakerData_withAssoc_globalmuon_2025.json`

```
"table-maker": {  
  "cfgEventCuts": "eventStandardSel8",  
  "cfgMuonCuts": "matchedQualityCuts",  
  "cfgAddEventHistogram": "vtx",  
  "cfgAddMuonHistogram": "muon",  
}
```

Selection for global muons

When global muon tracks are kept, the corresponding MFT and standalone muons used for the matching are also kept in the reduced AOD tables, even when requiring only global muon tracks (e.g. w/ “matchedQualityCuts” or “matchedGlobal”)



# TableMaker\_withAssoc config: global MUON

```
"processOnlyBCs": "0",  
"processPPMuonOnly": "0",  
"processPPMuonMFT": "1",  
"processPPMuonMFTWithMultsExtra": "0",  
"processPPWithFilterMuonOnly": "0",  
"processPPWithFilterMuonMFT": "0",
```

→ Processes both Muon and MFT tracks

```
"cfgPropMuon": "0",  
"cfgRefitGlobalMuon": "1",  
"cfgKeepBestMatch": "1",  
"cfgUseML": "0",  
"cfgMuonMatchEtaMin": "-3.6",  
"cfgMuonMatchEtaMax": "-2.5",
```

→ Muon propagation to PV must be disabled if one wants to use the tracks for secondary vertexing

→ Enable global muon refit

→ Keep only best match among saved candidates

→ Exclude muons outside the MFT acceptance

# TableReader\_withAssoc config: global MUON



```
"analysis-muon-selection": {  
  "cfgMuonCuts": "matchedGlobal",  
  "cfgAddMuonHistogram": "",  
  "processDummy": "0",  
}
```

Now require only global muons in the output

```
"analysis-same-event-pairing": {  
  "cfgMuonCuts": "matchedGlobal",  
  "cfgPairCuts": "",  
}
```

```
"cfgAddSEPHistogram": "dimuon,barrel,vertexing",  
"cfgFlatTables": "true",  
"cfgUseKFVertexing": "false",
```

False: use DCAFitter, True: use Kalman Filter

# Run TableMaker\_withAssoc

In the O2DQTutorials/:

- Enter local O2Physics environment (ideally not older than 6<sup>th</sup> November),  
or on lxplus: `/cvmfs/alice.cern.ch/bin/alienv enter VO_ALICE@O2sim::v20251106-1`
- `python3 scripts/runTableMaker_withAssoc.py`  
`configs/configTableMakerData_withAssoc_globalmuon_2025.json -runData`
- `o2-analysis-dq-table-reader-with-assoc -b --configuration`  
`json://configs/configAnalysisData_withAssoc_globalmuon_2025.json --aod-file`  
`reducedAod.root (--aod-writer-json configs/writerTableReaderFlatTable.json)`