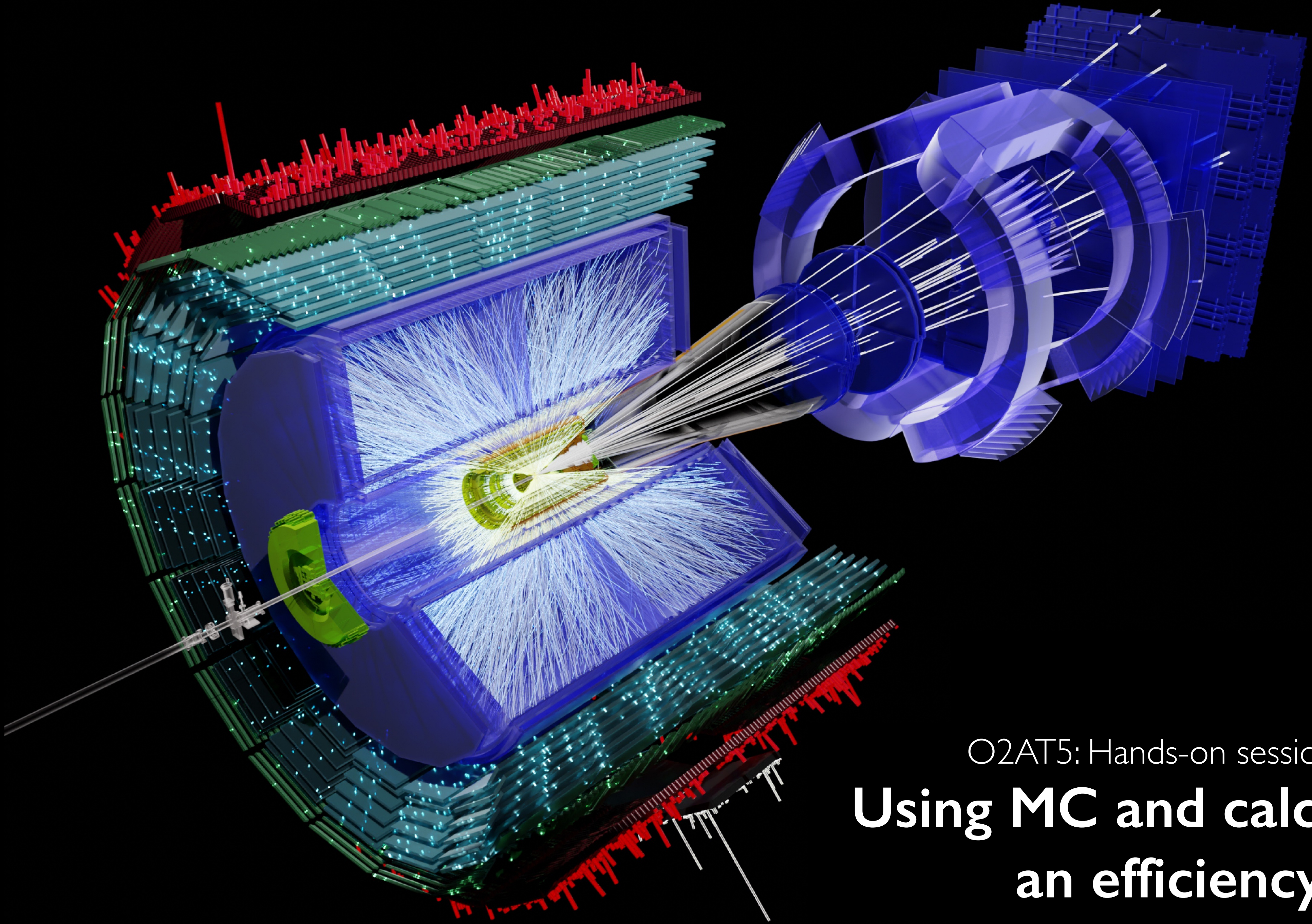
Image reference: https://zenodo.org/records/13732384



O2AT5: Hands-on session II

# Using MC and calculating an efficiency

# Data for this exercise

- Single AO2D file from 2024 MC anchored to pp LHC23zzh pass4 (LHC23g3)
- Alien_cp:

```
alien_cp alien:///alice/sim/2025/LHC25b8a_v8b3c/0/544122/AOD/001/AO2D.root file:./AO2D-mc.root
```

- Dropbox:
- https://www.dropbox.com/scl/fi/tmmvrm92q2hgetuk253gq/AO2D-mc.root?rlkey=5q6ke2l8jxnstq0lqvb2yhvce&dl=0
- Download now! I will now explain the exercise in full until the end and then we do the hands-on

```cpp
struct myExampleTask {
  // Histogram registry: an object to hold your histograms
  HistogramRegistry histos{"histos", {}, OutputObjHandlingPolicy::AnalysisObject};


  Configurable<int> nBinsPt{"nBinsPt", 100, "N bins in pT histo"};
  Configurable<float> maxDCAxy{"maxDCAxy", 0.2, "max DCAxy (in cm)"};
  Configurable<float> minTPCCrossedRows{"minTPCCrossedRows", 70, "min crossed rows in the TPC"};
  Configurable<float> maxPVz{"maxPVz", 100.0f, "max value of PVz (cm)"};


  void init(InitContext const&)
  {
    // define axes you want to use
    const AxisSpec axisCounter{1, 0.0f, +1.0f, ""};
    const AxisSpec axisEta{30, -1.5f, +1.5f, "#eta"};
    const AxisSpec axisPt{nBinsPt, 0.0f, 10.0f, "p_{T}"};
    // create histograms
    histos.add("eventCounter", "eventCounter", kTH1F, {axisCounter});
    histos.add("etaHistogram", "etaHistogram", kTH1F, {axisEta});
    histos.add("ptHistogram", "ptHistogram", kTH1F, {axisPt});
  }


  void process(aod::Collision const&, soa::Join<aod::Tracks, aod::TracksExtra, aod::TracksDCA>
const& tracks)
  {
    if(fabs(collision.posZ())>maxPVz){
      return; // skip outside a certain region
    }
    histos.fill(HIST("eventCounter"), 0.5f);
    for (auto& track : tracks) {
      if( track.tpcNClsCrossedRows() < minTPCCrossedRows ) continue; //badly tracked
      if( fabs(track.dcaXY()) > maxDCAxy) continue; //doesn't point to primary vertex
      histos.fill(HIST("etaHistogram"), track.eta());
      histos.fill(HIST("ptHistogram"), track.pt());
    }
  }
};
```

# The starting point: a simple task to do a collision loop

- Starting point: the previous code!
- The good old:

**`myExampleTask.cxx`**

**+**

**Changes ([link](link))**

- We'll now study:
  1. How do we calculate $p_T$ resolution?
  2. How do we calculate efficiencies?
  3. How can we understand collision reconstruction efficiency in the TF era?

- For this, we'll employ more tools!
- And fundamentally: access simulation data!

# Acessing the MC information for each track

- You will now need to de-reference the MC particle for each and every track.
- This is done via a label: that is an index column pointing to the **`McParticles`** table.
- This index column is the sole element in the **`McTrackLabel`** table – joinable with tracks!

```
//This is an example of a convenient declaration of "using"
using myCompleteTracks = soa::Join<aod::Tracks, aod::TracksExtra, aod::TracksDCA, aod::McTrackLabels>;
```

- Now you have a track label that you can de-reference!
- …but to de-reference it, you also need to subscribe to the **`McParticles`** table (or you won't have those!)

```
void process(aod::Collision const& collision, myCompleteTracks const& tracks, aod::McParticles const&)
```

- Let's also create a histogram to store the momentum resolution – this time, a two-dimensional one – in **`Init()`**:

```
const AxisSpec axisDeltaPt{100, -1.0, +1.0, "#Delta(p_{T})"};
(…)
histos.add("ptResolution", "ptResolution", kTH2F, {axisPt, axisDeltaPt});
```

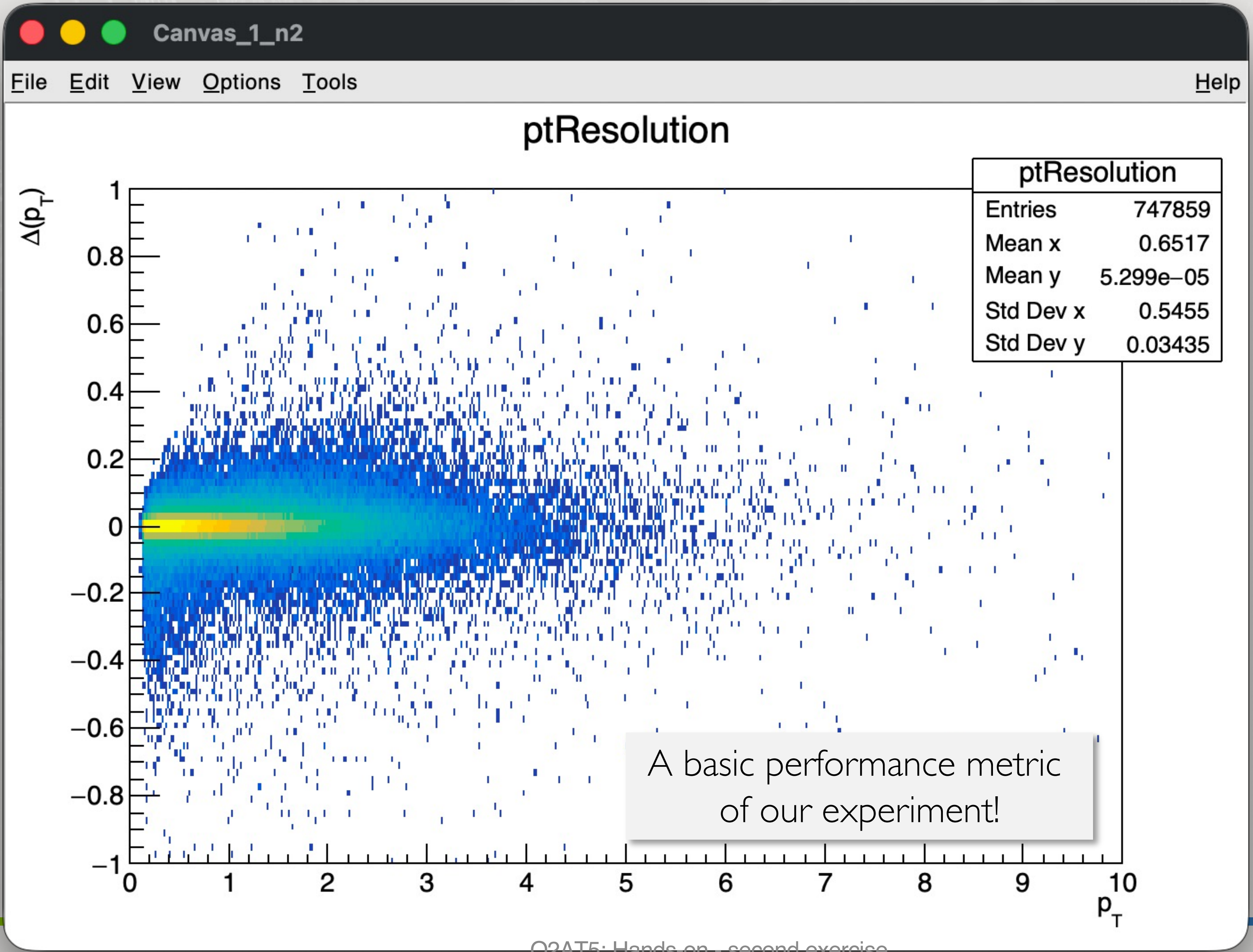
- Now comes the magic: the immediate de-referencing!

```
if(track.has_mcParticle()){
     auto mcParticle = track.mcParticle();
     histos.fill(HIST("ptResolution"), track.pt(), track.pt() - mcParticle.pt());
}
```

*And that's it!*

For running, you can still use the same run.sh you used before!

# The outcome: momentum resolution as a function of transverse momentum




# Getting the reconstructed pion, kaon and proton spectra

- Yes! This will eventually turn into an efficiency…
- Let's declare three more histograms: a pion, a kaon and a proton $p_T$ histogram!

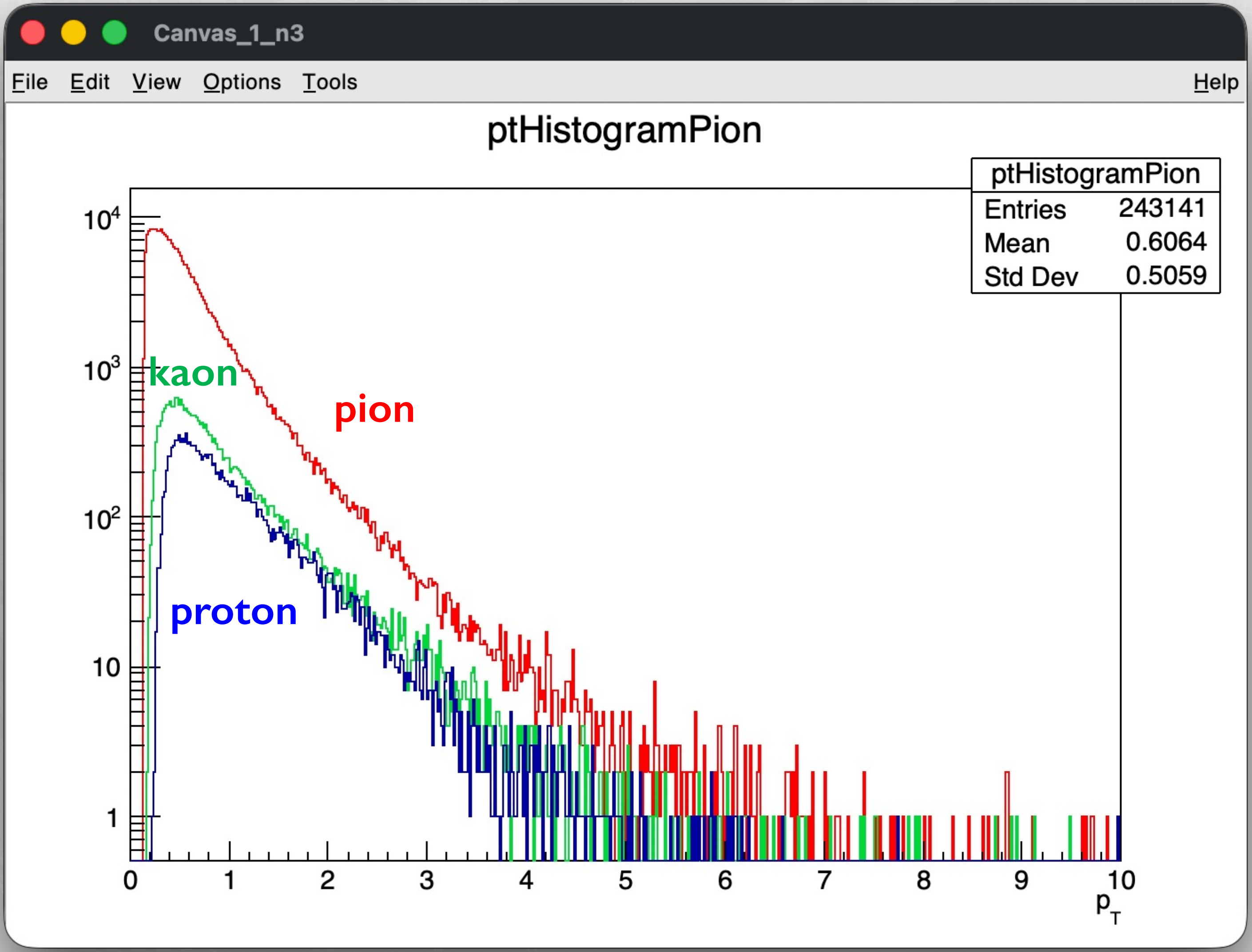
```
histos.add("ptHistogramPion", "ptHistogramPion", kTH1F, {axisPt});
histos.add("ptHistogramKaon", "ptHistogramKaon", kTH1F, {axisPt});
histos.add("ptHistogramProton", "ptHistogramProton", kTH1F, {axisPt});
```

- How can we find those pions, kaons and protons? Can we restrict to midrapidity?
- And more: how can we know they actually come from a primary collision and not from material?
- Hint: check the documentation again! This time, for **McParticles**:

| Name | | Getter | Type | Comment |
|---|---|---|---|---|
| o2::soa::Index | GI | globalIndex | int64_t | |
| o2::aod::mcparticle::Y | E | y | float | Particle rapidity, conditionally defined to avoid FPEs |
| o2::aod::mcparticle::PdgCode | | pdgCode | int | PDG code |
| o2::aod::mcparticle::IsPhysicalPrimary | D | isPhysicalPrimary | bool | True if particle is considered a physical primary according to the ALICE definition |

```
if(mcParticle.isPhysicalPrimary() && fabs(mcParticle.y())<0.5){ // do this in the context of the track ! (context matters!!!)
    if(abs(mcParticle.pdgCode())==211) histos.fill(HIST("ptHistogramPion"), mcParticle.pt());
    if(abs(mcParticle.pdgCode())==321) histos.fill(HIST("ptHistogramKaon"), mcParticle.pt());
    if(abs(mcParticle.pdgCode())==2212) histos.fill(HIST("ptHistogramProton"), mcParticle.pt());
}
```

# The outcome: three histograms with reconstructed pion/kaon/proton spectra




# Processing pure generation information

- Let's say you want to get the generated particle spectra
- It is much more convenient to do it inside a separate process function: the subscription will be very different!
- Let's now resort to process switches within the same task: you saw it in the lecture, but practice is nicer!
- Before we do that, let's add generated $p_T$ histograms to the init function:

```
histos.add("ptGeneratedPion", "ptGeneratedPion", kTH1F, {axisPt});
histos.add("ptGeneratedKaon", "ptGeneratedKaon", kTH1F, {axisPt});
histos.add("ptGeneratedProton", "ptGeneratedProton", kTH1F, {axisPt});
```

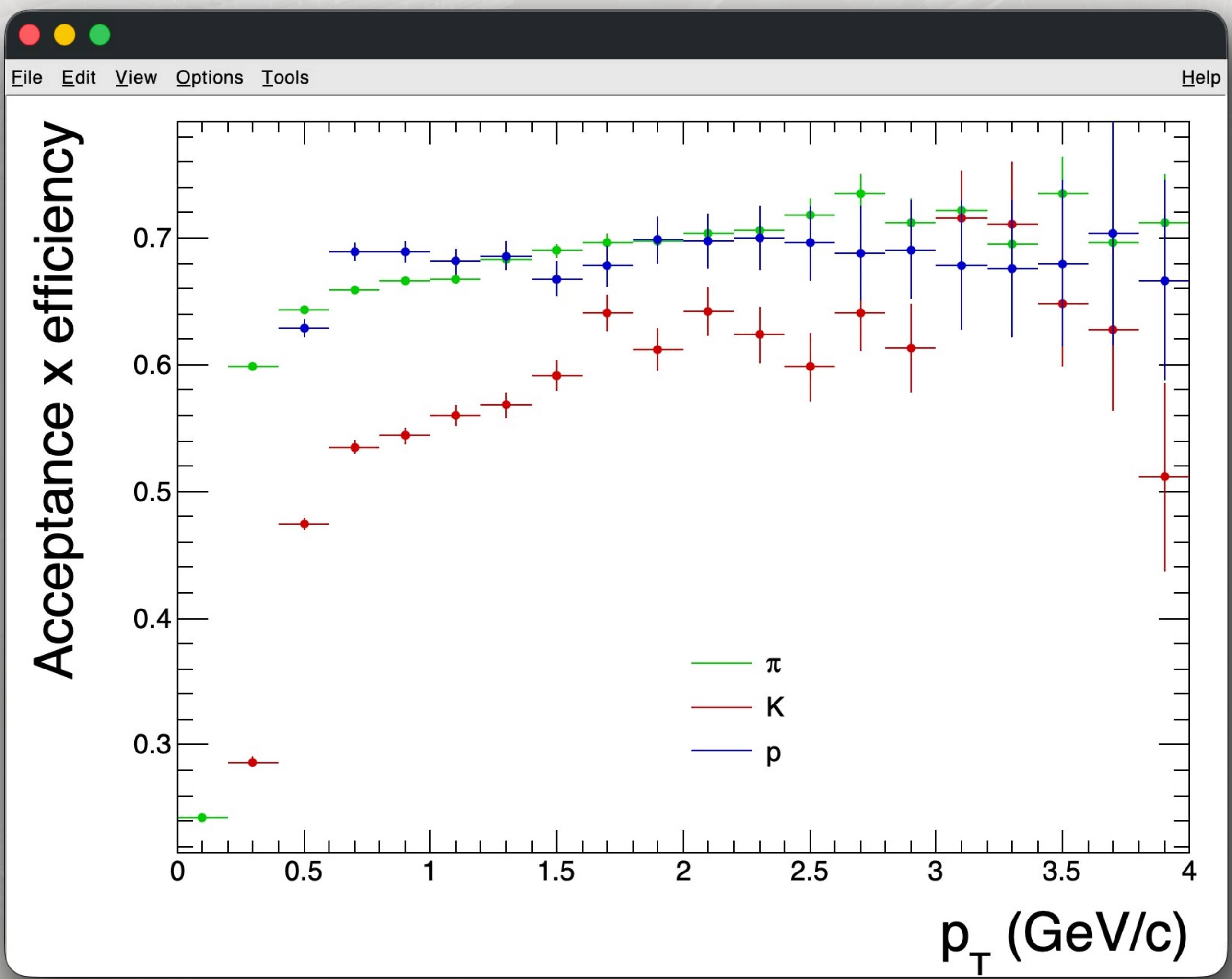
- Now let's add another process function!

```
void processReco(aod::Collision const& collision, myFilteredTracks const& tracks, aod::McParticles const&)
{
     (…)
}
PROCESS_SWITCH(myExampleTask, processReco, "process reconstructed information", true);

void processSim(aod::McParticles const& mcParticles)
{
     for (const auto& mcParticle : mcParticles) {
          if(mcParticle.isPhysicalPrimary() && fabs(mcParticle.y())<0.5){ // watch out for context!!!
               if(abs(mcParticle.pdgCode())==211) histos.fill(HIST("ptGeneratedPion"), mcParticle.pt());
               if(abs(mcParticle.pdgCode())==321) histos.fill(HIST("ptGeneratedKaon"), mcParticle.pt());
               if(abs(mcParticle.pdgCode())==2212) histos.fill(HIST("ptGeneratedProton"), mcParticle.pt());
          }
     }
}
PROCESS_SWITCH(myExampleTask, processSim, "process pure simulation information", true);
```

# The outcome: efficiencies of pion, kaon and proton

disclaimer: this is a far cry from something real! In practice, you also need PID: you will see that tomorrow in the lectures!
disclaimer 2: this also specifically makes no distinction about particles being associated to wrong collisions, etc etc




Example drawing macro can be found here

# Moving flexibly around from MC to reconstruction: going beyond!

- What about the number of times a MC collision was reconstructed?
- What about an analysis starting from the MC side and “extending” to the reconstruction?
- This can be done with sliceBy, but it can also be done with a very careful subscription!

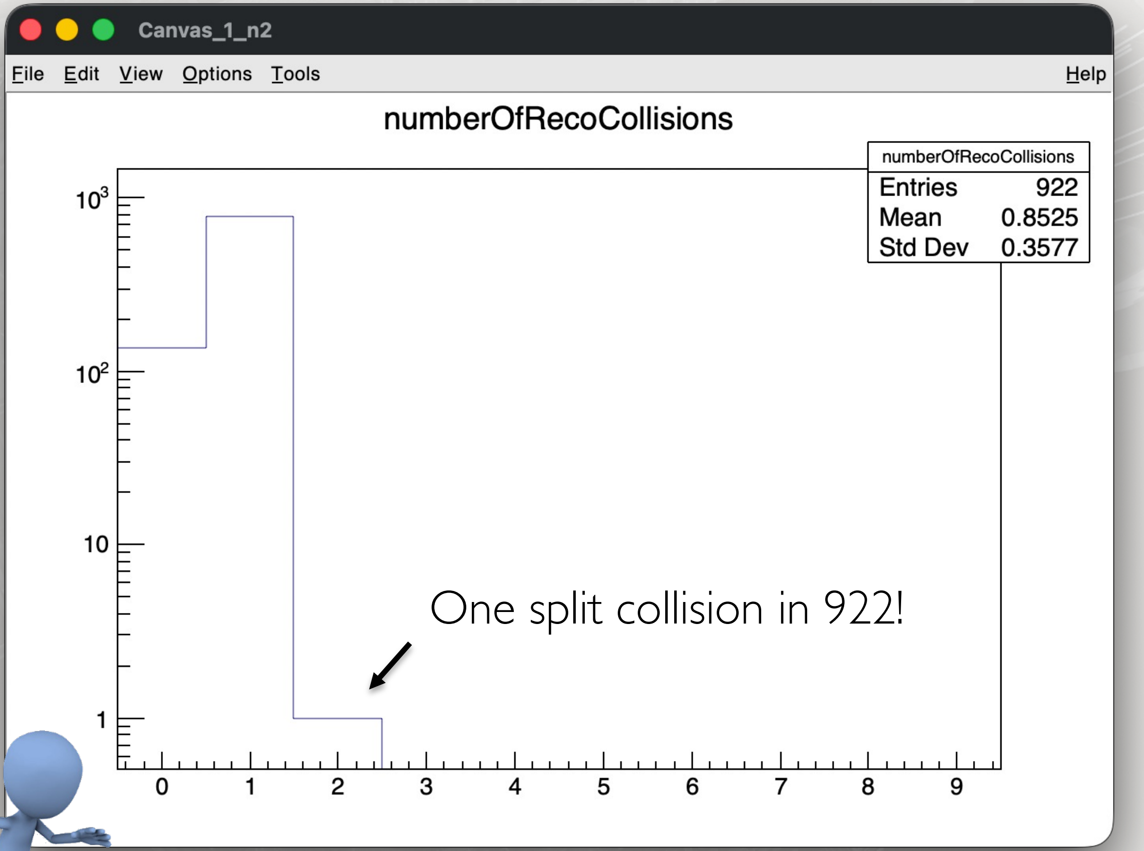
```
void processSim(aod::McCollision const& mcCollision, soa::SmallGroups<soa::Join<aod::McCollisionLabels,
aod::Collisions>> const& collisions, aod::McParticles const& mcParticles, myFilteredTracks const& tracks)
```

- A **`soa::SmallGroups`** subscription essentially does grouping for you based on the collisionId column!

```
histos.fill(HIST("numberOfRecoCollisions"), collisions.size()); // number of times coll was reco-ed
```

- Then one can immediately find out the number of times a MC collision appears by just checking the size of collisions!

# Final outcome: number of times a MC collision was reconstructed





- Here the solution: [final version of analysis task]
- Homework bonus: how does this
- Change with centrality?
- Can you implement a centrality selection based on the content of the DPG talk

# Backup

# Surgical compilation: ninja to the rescue

- **If you have a compiled O2Physics installation** and just want to recompile one subdirectory or even one particular executable, this can be done using a tool called "ninja" – it will help you be faster!

- Go to your build directory using:

Bear in mind: different path needed for any non-standard installation path

```
cd ~/alice/sw/BUILD/O2Physics-latest/O2Physics
```

- Once in that directory, load the build environment doing: (important: you should not have called alienv before!)

```
direnv allow
```

- You can then rebuild only one specific subdirectory of O2Physics:

```
ninja <directory>/install          # Example: ninja PWGCF/Tasks/install
```

- You can even rebuild only one single executable:

```
ninja stage/bin/<target>          # Example: ninja stage/bin/o2-analysis-cf-correlations
```