# PID in O2Physics

o2 analysis tutorial

https://indico.cern.ch/event/1326201

7th November 2023

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# Objective of the session

- What is **PID ?**

-  Work with additional **helper task**.

- To perform **identification of particles** in analysis.

- Produce **beautiful plots** for PID performance.

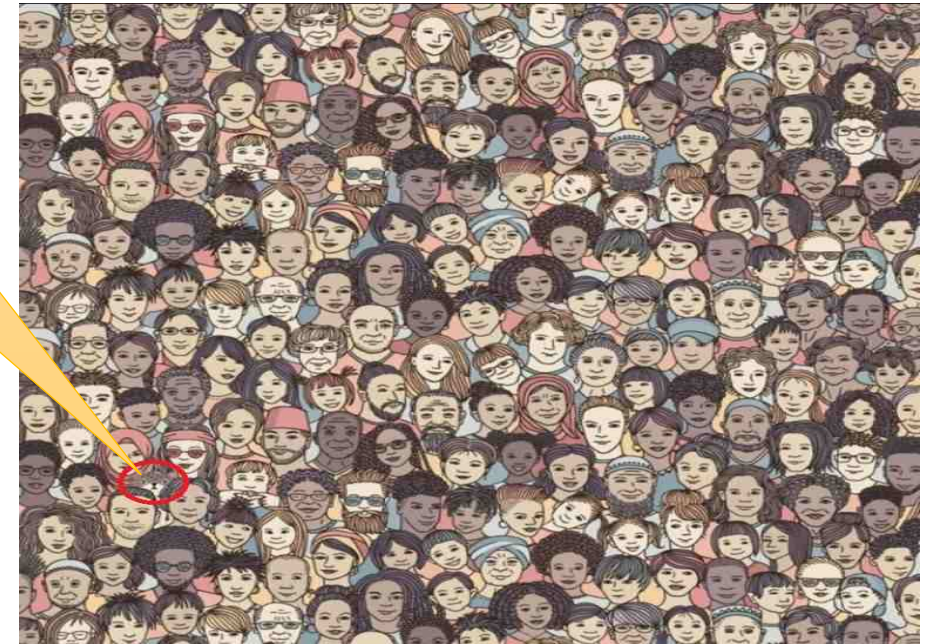- To introduce places for **further discussion**.

11/7/23

# Particle Identification



Can you see a cat here?
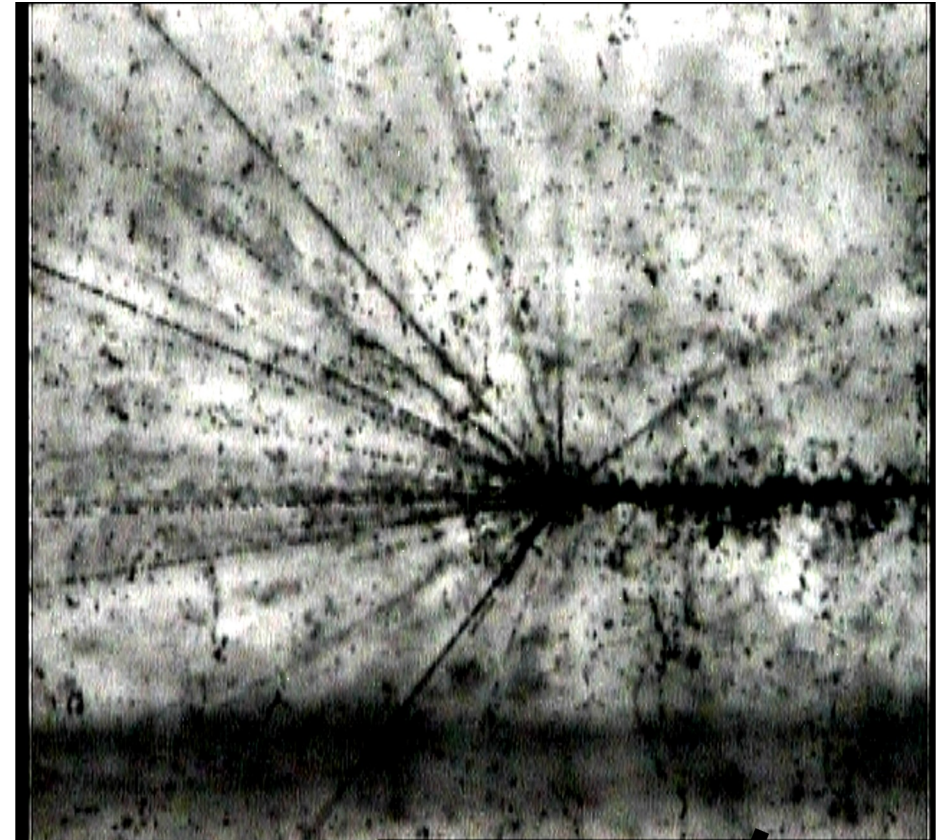
# Particle Identification

O2AT Banajit Barman (GU)

# Particle Identification

➢ A real photograph of an event of HIC.

➢Limited particles.
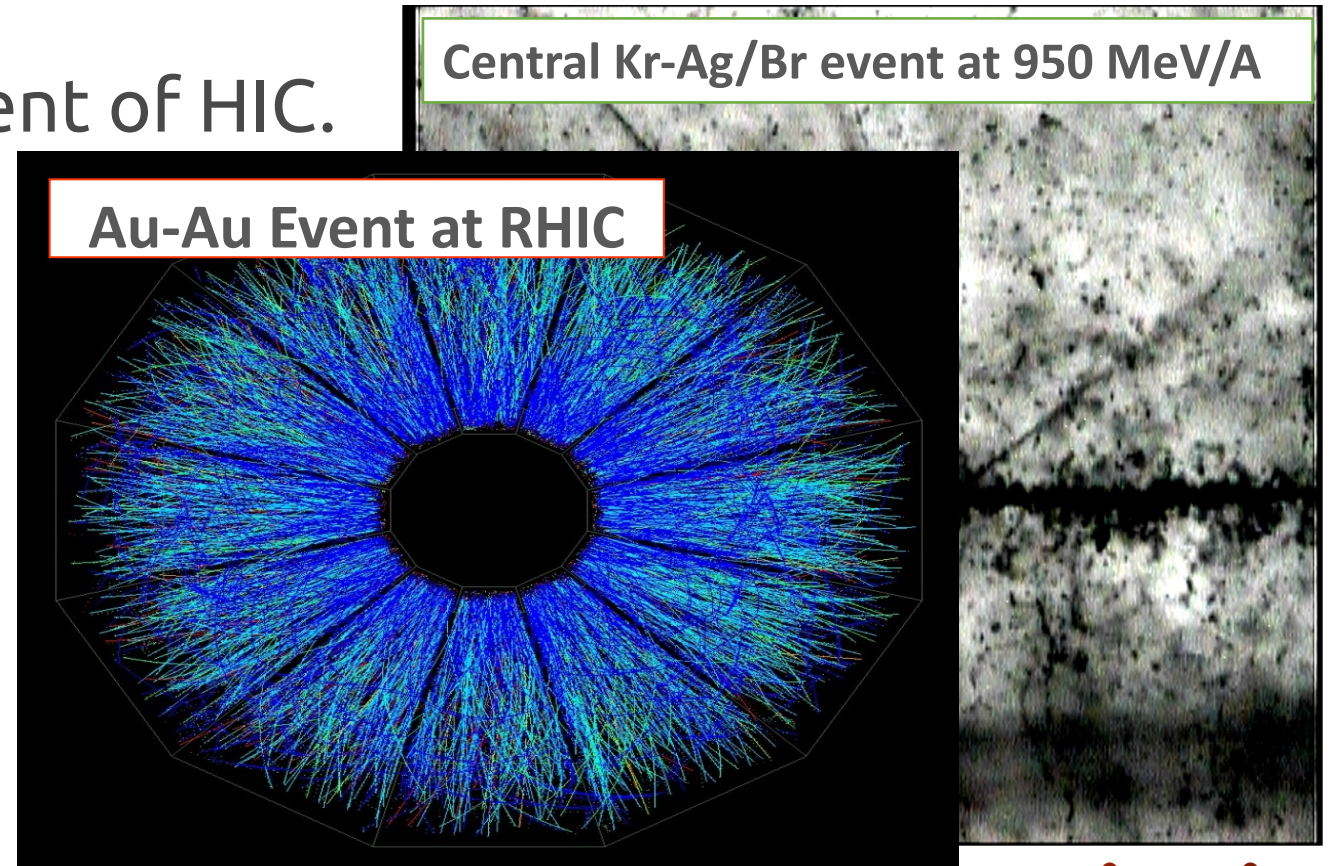
**Central Kr-Ag/Br event at 950 MeV/A**



**Few particles only**

# Particle Identification

➢ A real photograph of an event of HIC.

➢ Thousands of particles

➢ No microscope to measure their properties.

Central Kr-Ag/Br event at 950 MeV/A
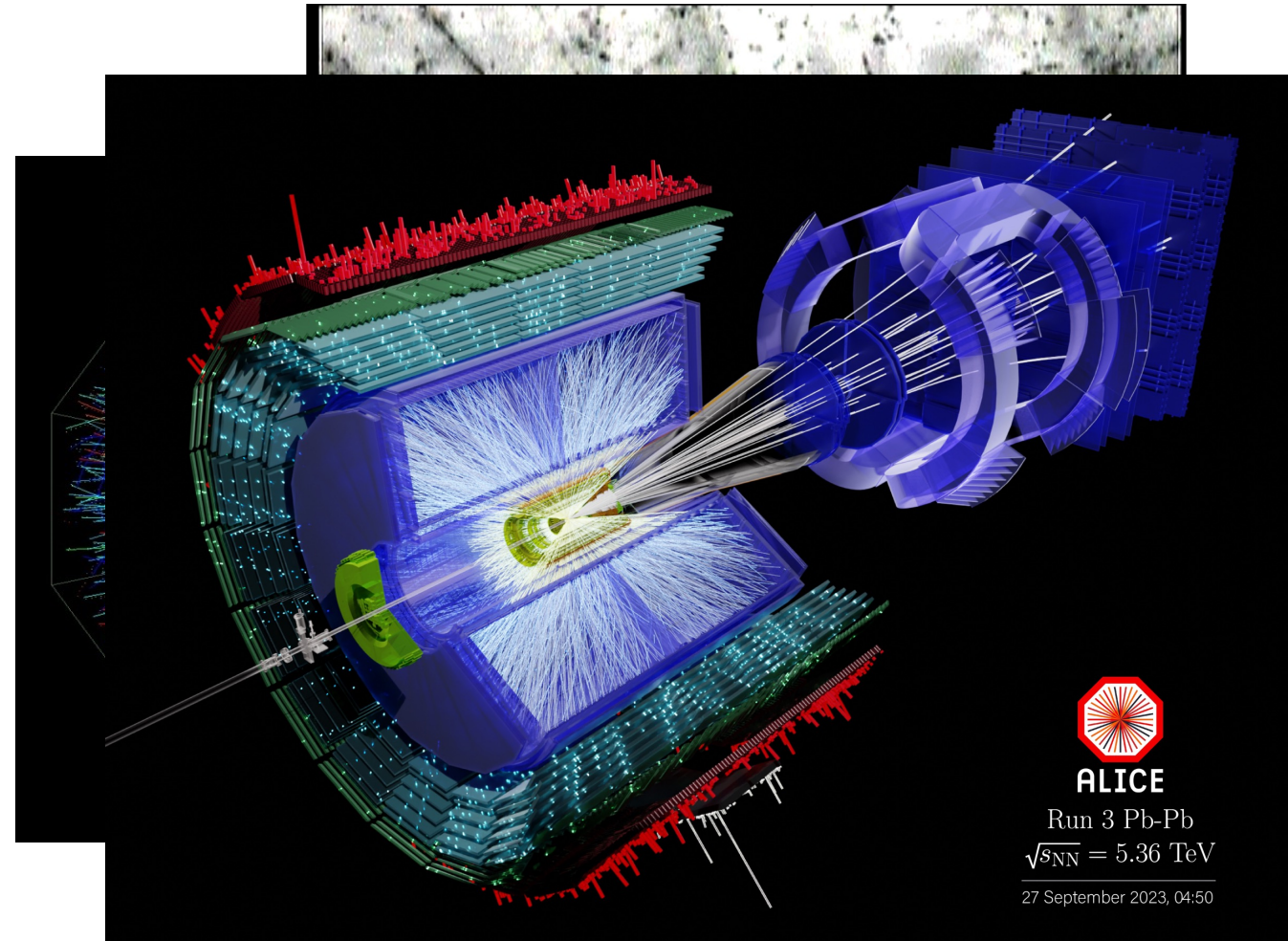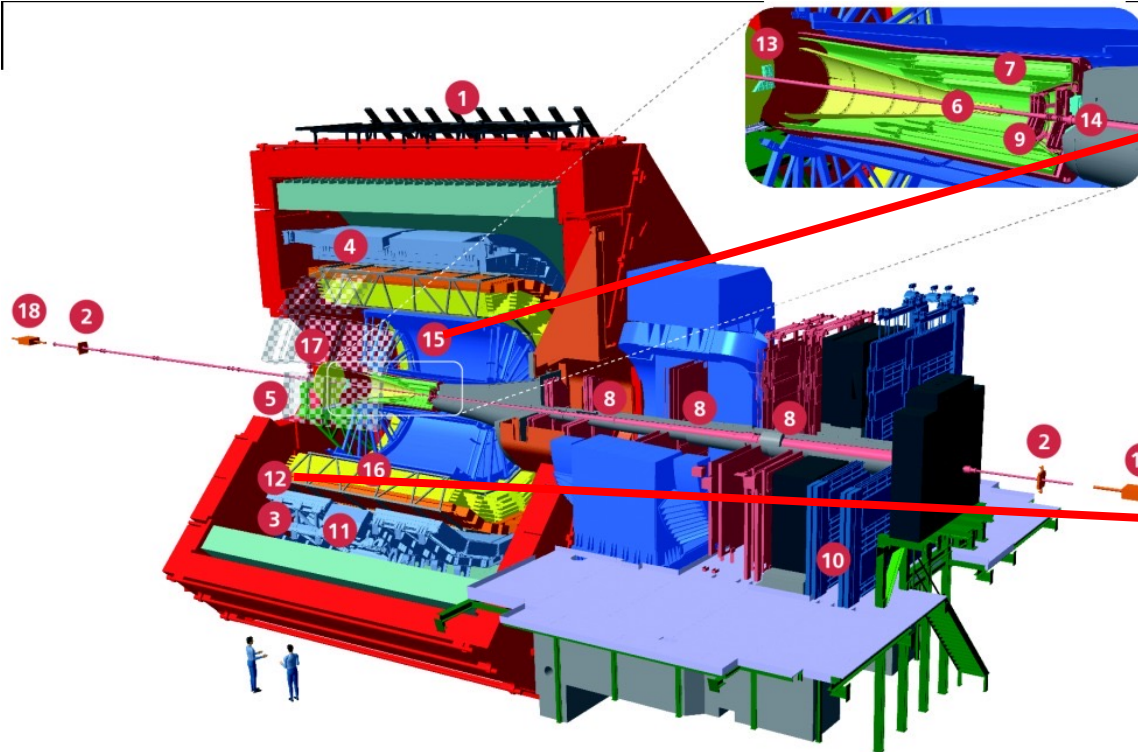
Au-Au Event at RHIC

**Thousands of particles!**

# Particle Identification

➢Thousands of particles

➢No microscope to measure their properties.

➢Even more tracks in Run 3 PbPb.

➢ Out of a particle crowd we need to identify **concerned particles** as the cat in the picture.



ALICE
Run 3 Pb-Pb
$\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV
27 September 2023, 04:50

# ALICE In Run 3



**TPC**

- Use energy loss value given by **Bethe-Bloch** for PID.

**TOF**

- Use particle **time-of-flight** from collision vertex to TOF for PID

| | | |
|---|---|---|
| 1 | **ACORDE** | ALICE Cosmic Rays Detector |
| 2 | **AD** | ALICE Diffractive Detector |
| 3 | **DCal** | Di-jet Calorimeter |
| 4 | **EMCal** | Electromagnetic Calorimeter |
| 5 | **HMPID** | High Momentum Particle Identification Detector |
| 6 | **ITS-IB** | Inner Tracking System - Inner Barrel |
| 7 | **ITS-OB** | Inner Tracking System - Outer Barrel |
| 8 | **MCH** | Muon Tracking Chambers |
| 9 | **MFT** | Muon Forward Tracker |
| 10 | **MID** | Muon Identifier |
| 11 | **PHOS / CPV** | Photon Spectrometer |
| 12 | **TOF** | Time Of Flight |
| 13 | **T0+A** | Tzero + A |
| 14 | **T0+C** | Tzero + C |
| 15 | **TPC** | Time Projection Chamber |
| 16 | **TRD** | Transition Radiation Detector |
| 17 | **V0+** | Vzero + Detector |
| 18 | **ZDC** | Zero Degree Calorimeter |

# Get familiar with helper tasks

➢ **Helper task** are for carrying out advance analysis.

https://aliceo2group.github.io/analysis-framework/docs/basics-usage/HelperTasks.html



## Helper tasks

Table of contents:

- Timestamp
- Event selection
- Multiplicity and centrality selection in O2
- Particle identification (PID)
- Track Selection
- Track Propagation

## Timestamp

The timestamp task is needed to fill the table with timestamps. Timestamp contains the time of a bunch crossing since the start of the run. This time is often needed to retrieve objects in the CCDB (see Tutorial CCDB).

Since the Timestamps table has an entry per bunch crossing it can be joined with table BC. The join is defined by o2::aod::BCsWithTimestamps (see list of defined joins and iterators).

## Event selection

Table of contents:

- Concept
- Basic usage in user tasks
- Trigger aliases
- Event selection criteria
- Event selection decisions
- Found bunch crossings
- Configurables
- Remarks

### Concept

# Get familiar with helper tasks

➢ **Helper task** are for carrying out advance analysis.

➢ **Particle identification** section.
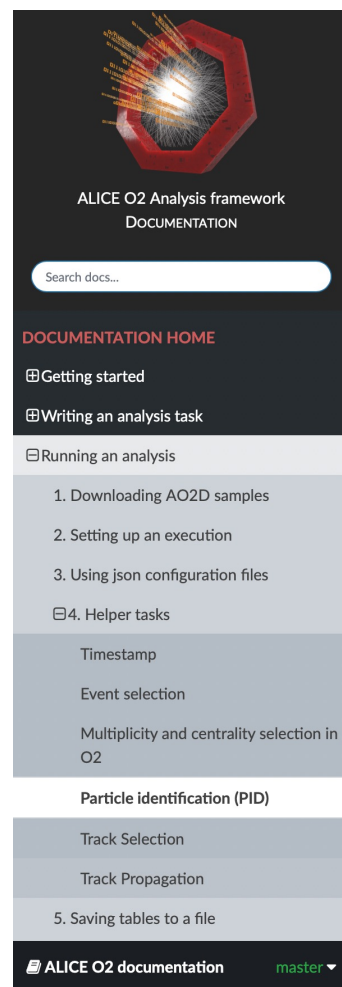
# Get familiar with helper tasks

➤ **Helper task** are for carrying out advance analysis.

➤ **Particle identification** section.

➤ Guide for PID



https://aliceo2group.github.io/analysis-framework/docs/basics-usage/HelperTasks.html#particle-identification-pid

# Accusing PID Data Formats

➢ Include this header into your task.

Stores all the **PID information** like

- All tables for PID

- Expected values (Bethe Bloch, expected TOF time)

- Expected resolutions

- Separation in N$\sigma$

- Extra PID information ( TOF mass, TOF beta etc)

#include "Common/DataModel/PIDResponse.h"

**El, Mu, Pi, Ka, Pr, De, Tr, He($^3$He), Al**

# Accessing PID Data Formats

```
#include "Common/DataModel/PIDResponse.h"
```

- After including the **header.**

- Need to **subscribe** for each particle for each detector separately.

TPC Pion          TOF Pion

```
void process(soa::Join<aod::Tracks, aod::pidTPCPi, aod::pidTOFPi> const&) { ....
```

- For more than one particle - join the table for each particle.

```
void process(soa::Join<aod::Tracks, aod::pidTPCPi, aod::pidTPCKa, aod::pidTOFPi, aod::pidTOFKa >
const&){ ...
```

# Accessing PID Information

- How to get table content

```
void process(soa::Join<aod::Tracks, aod::pidTPCPi, aod::pidTPCKa, aod::pidTOFPi, aod::pidTOFKa>
                        const& tracks) {
        for (auto& track: tracks) {
                track.tpcNSigmaPi(); // TPC Nsigma of pions
                track.tofNSigmaPi(); // TOF Nsigma of pions
                track.tpcNSigmaKa(); // TPC Nsigma of kaons
                track.tofNSigmaKa(); // TOF Nsigma of kaons }
        ....
```

# Accessing PID Information

- How to get table content

```
void process(soa::Join<aod::Tracks, aod::pidTPCPi, aod::pidTPCKa, aod::pidTOFPi, aod::pidTOFKa>
                    const& tracks) {
        for (auto& track: tracks) {
                track.tpcNSigmaPi(); // TPC Nsigma of pions
                track.tofNSigmaPi(); // TOF Nsigma of pions
                track.tpcNSigmaKa(); // TPC Nsigma of kaons
                track.tofNSigmaKa(); // TOF Nsigma of kaons }

....
```

- Same can be done using helper function

```
void process(soa::Join<aod::Tracks, aod::pidTPCPi, aod::pidTPCKa, aod::pidTOFPi, aod::pidTOFKa>
                    const& tracks) {
        for (auto& track: tracks) {
                o2::aod::pidutils::tpcNSigma<2>(track);// Pions: index runs from 0 to 8
                o2::aod::pidutils::tofNSigma<2>(track);// Pions: index runs from 0 to 8

.....
```

# How to run the task in workflow

- Task to include for TPC PID

  o2-analysis-pid-tpc | o2-analysis-pid-tpc-base | o2-analysis-timestamp

- Task to include for TOF PID

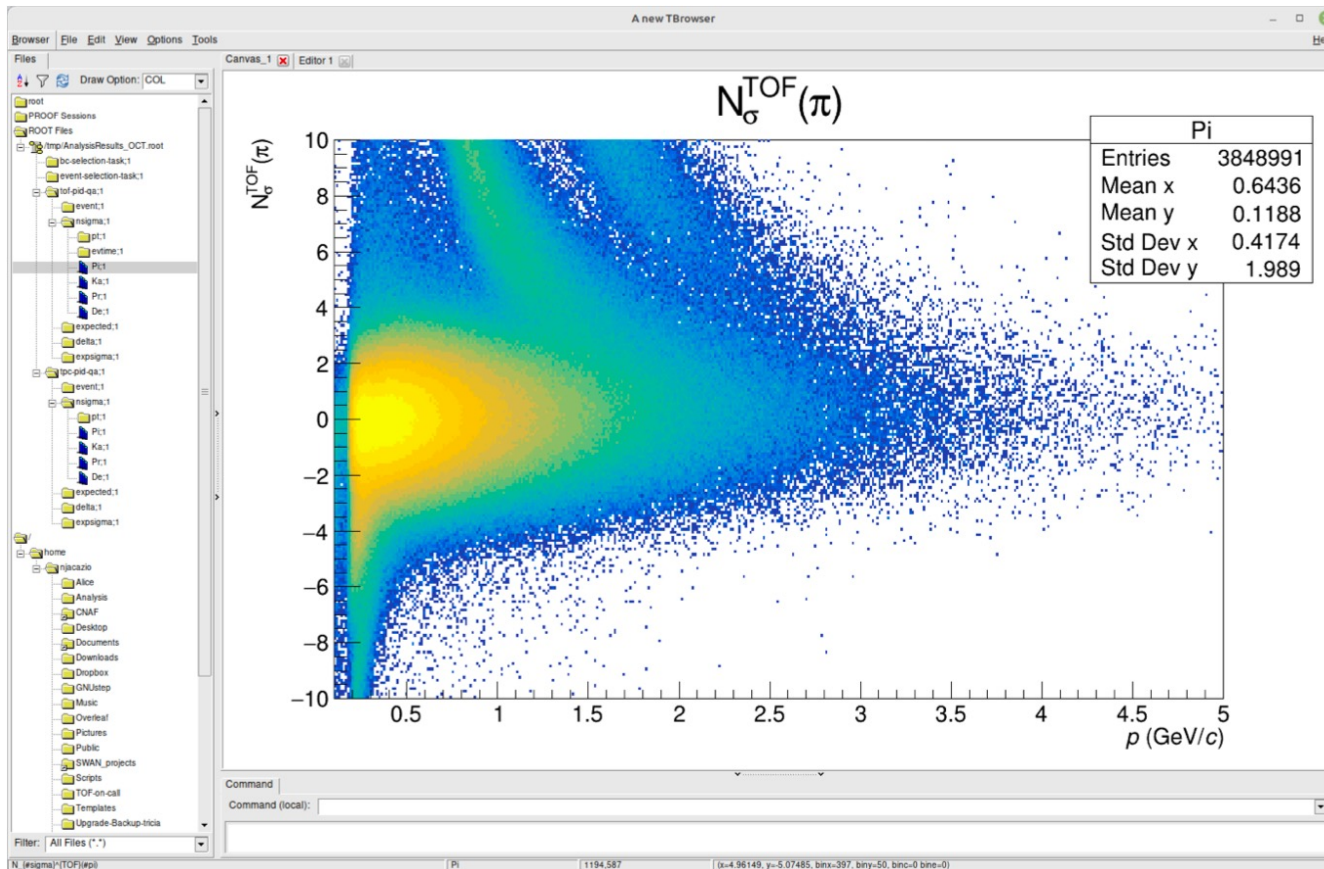  o2-analysis-pid-tof | o2-analysis-pid-tof-base | o2-analysis-timestamp

**Dependencies**

- Here we compute the N-Sigmas for each particle.
- Need to subscribe for specific particle in your task.

# More with PID

- QA Tools developed by detector expert and DPG
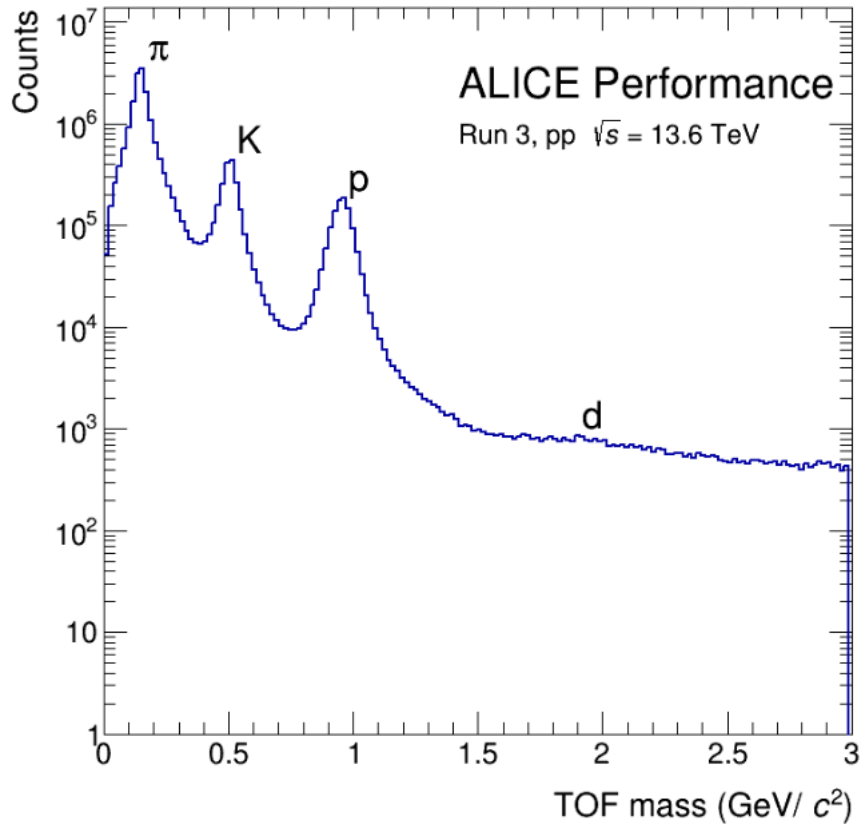- Monitor and reported at async-QC meeting



o2-analysis-pid-tpc-qa
o2-analysis-pid-tof-qa

- Monitor N$\sigma$
- Include performance plot for TPC/TOF signal
- Check QA for MC

o2-analysis-pid-tpc-qa-mc
o2-analysis-pid-tof-qa-evtime
o2-analysis-pid-tof-qa-beta
o2-analysis-pid-tof-qa-mc

# More with PID

## TOF Mass and TOF Beta



```
void process(soa::Join<aod::Tracks, aod::pidTOFmass,
                       aod::pidTOFbeta> const& tracks) {
    for (auto& track: tracks) {
                track.beta(); // TOF beta
                track.mass(); // TOF mass } ...
```

- Access by the following task in your workflow
- Also available with QA

```
o2-analysis-pid-tof-beta
o2-analysis-pid-tof-beta-qa
```

Event time for TOF

```
o2-analysis-pid-tof-base
o2-analysis-pid-tof-qa-evtime
```

# Helper task on Hyperloop

## PID with TPC

- Dependencies on Hyperloop
- Include both Run 2 and Run 3.
- Include the one as per your need



PID with TPC — AliHyperloop analyses list:
My Analyses | All Analyses | Dashboard

- PIDTPC
- PIDTPC_APass3_deprecated
- PIDTPC_Run2
- PIDTPC_withTPConly
- PIDTPCBase
- PIDTPCBase_Run2
- PIDTPCFull
- PIDTPCFull_APass3_deprecated
- PIDTPCFull_Run2
- PIDTPCFull_withTPConly
- PIDTPCFullNN
- PIDTPCFullNN_withTPPConly
- PIDTPCNN
- PIDTPCNN_withTPConly

# Helper task on Hyperloop

## PID with TOF

- Dependencies on Hyperloop
- Include both Run 2 and Run 3.
- Include the one as per your need
- Ask the experts in case you have any doubt.

My Analyses    All Analyses    Dashboard                          AliHyperloop 🦢

PIDTOFBaseRun2_Data

PIDTOFBaseRun2_MC

PIDTOFBaseRun3

PIDTOFBetaRun2_Data

PIDTOFBetaRun2_MC

PIDTOFBetaRun3

PIDTOFFullRun2_Data

PIDTOFFullRun2_MC

PIDTOFFullRun3

PIDTOFRun2_Data

PIDTOFRun2_MC

PIDTOFRun3

AliHyperloop

# Helper task on Hyperloop

## Take as reference

- copy the configuration into your **json** for locally running.

# Let's look at the data
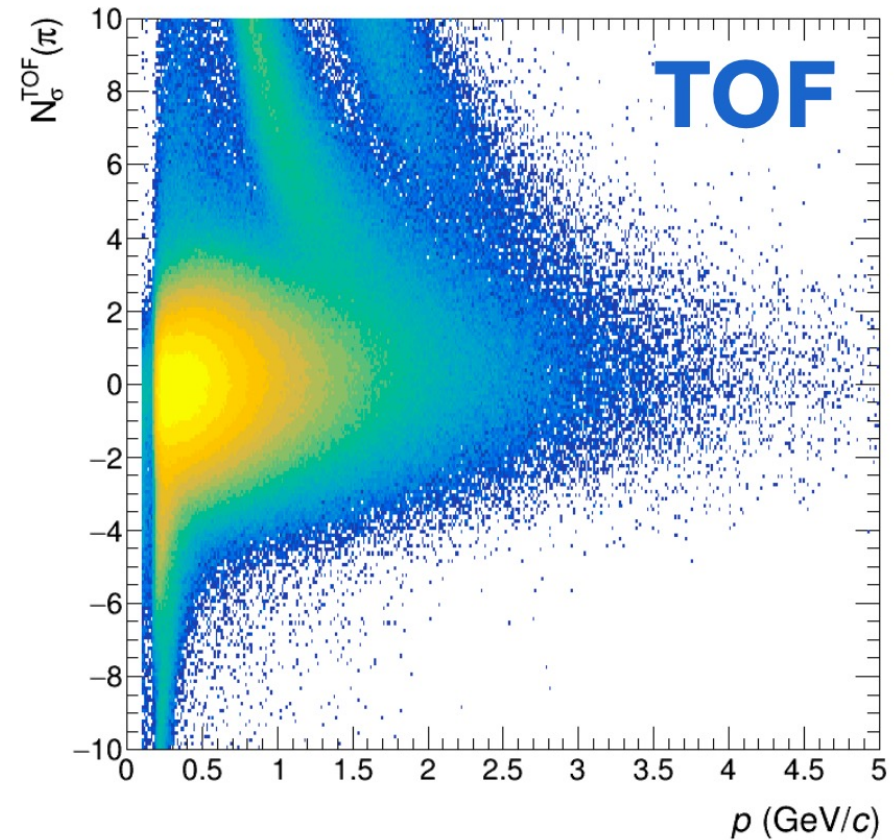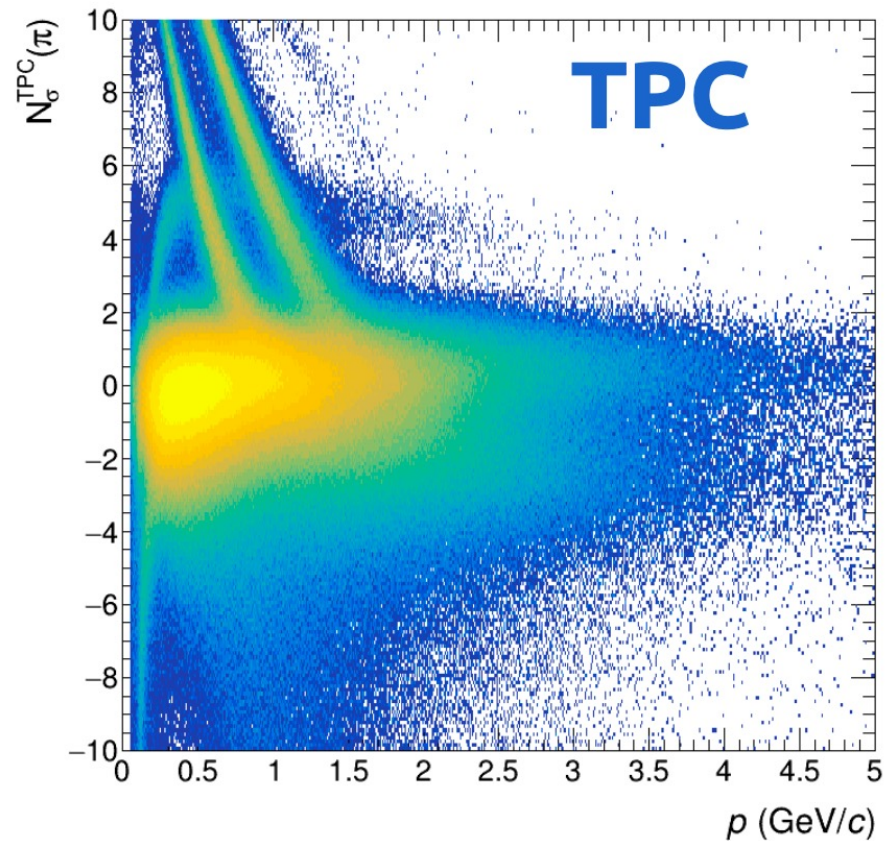
Raw Data
AO2D.root

# Let's look at the data

Raw Data
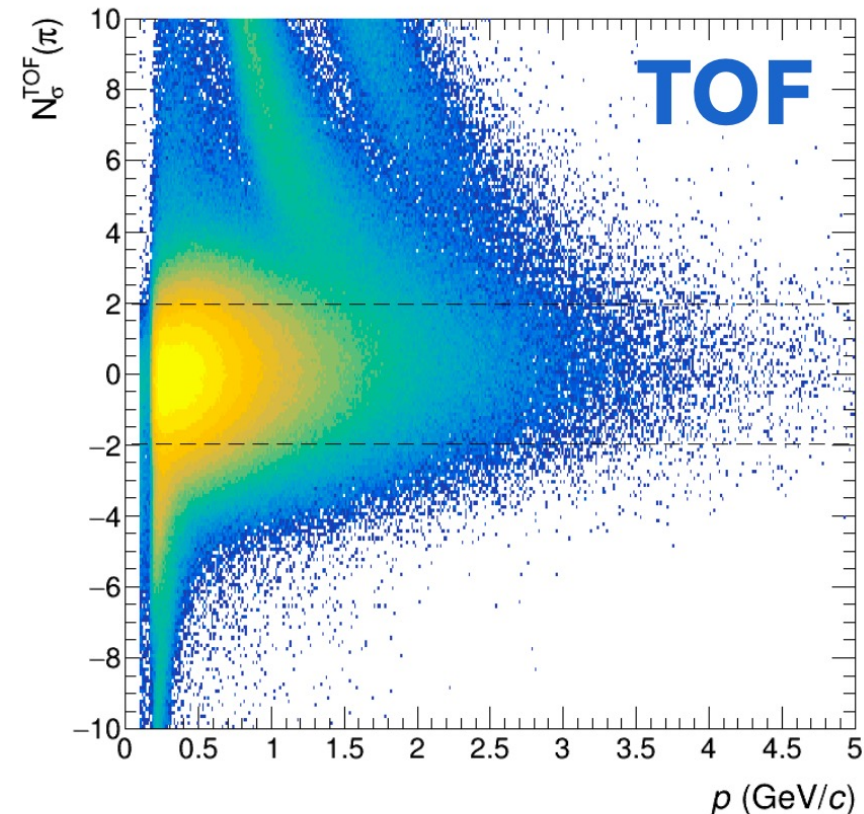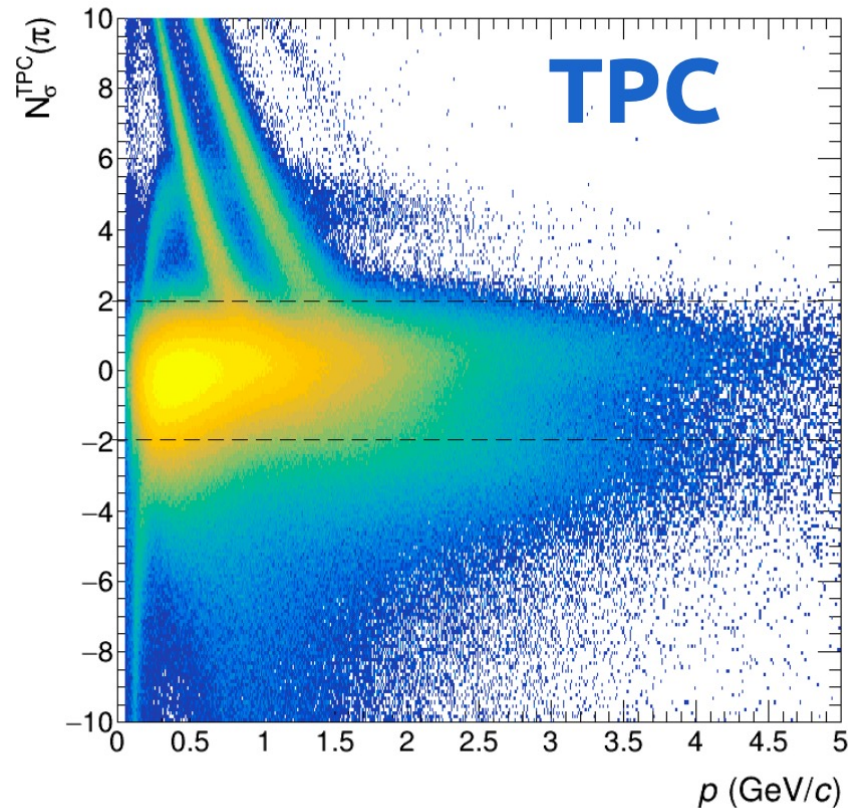AO2D.root

PID Helper task
do their job

# Let's look at the data

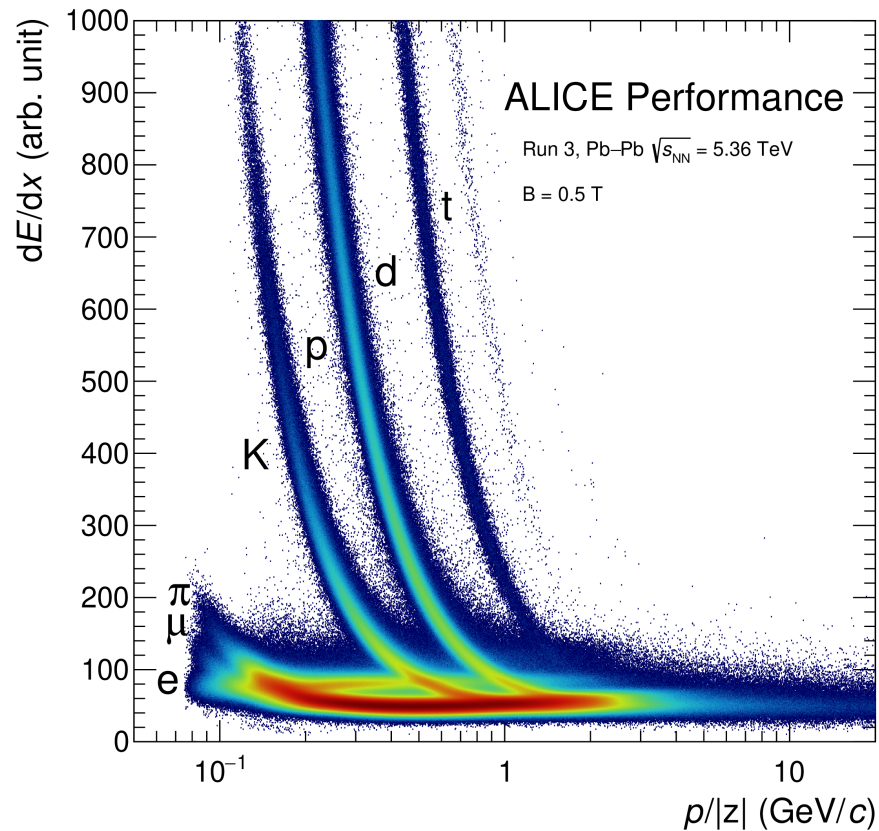Raw Data AO2D.root → PID Helper task do their job → Use $2\sigma$ cut (filters or partitions)

# Let's look at the data

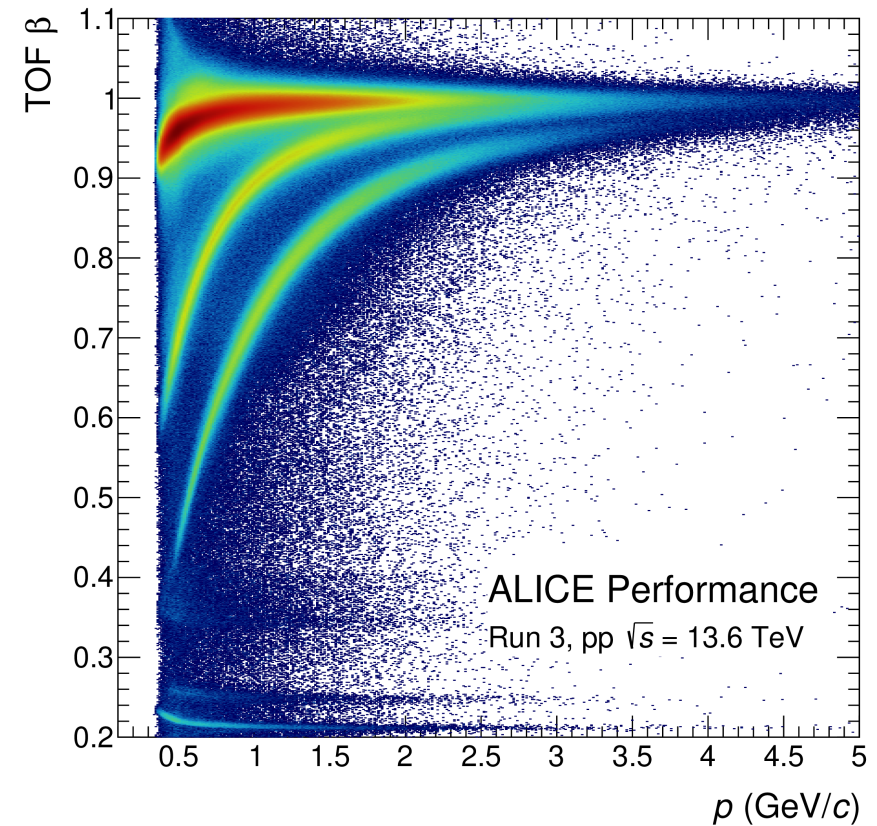Raw Data
AO2D.root

PID Helper task
do their job

Use $2\sigma$ cut
(filters or partitions)



ALICE Performance

Run 3, Pb–Pb $\sqrt{s_{NN}}$ = 5.36 TeV

B = 0.5 T

ALICE Performance

Run 3, pp $\sqrt{s}$ = 13.6 TeV
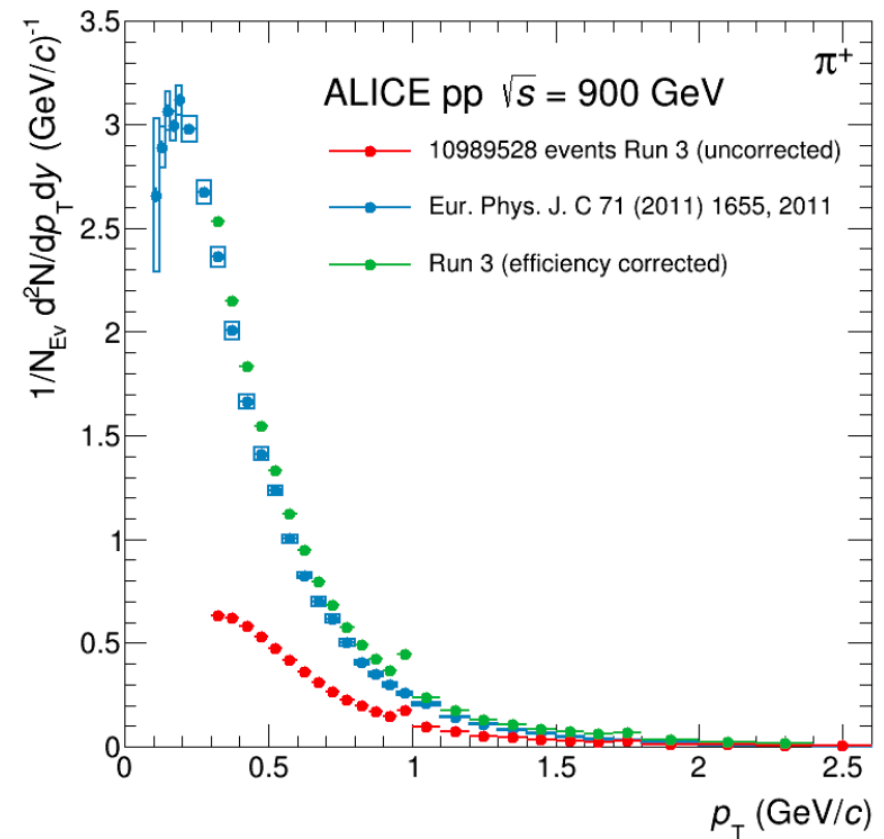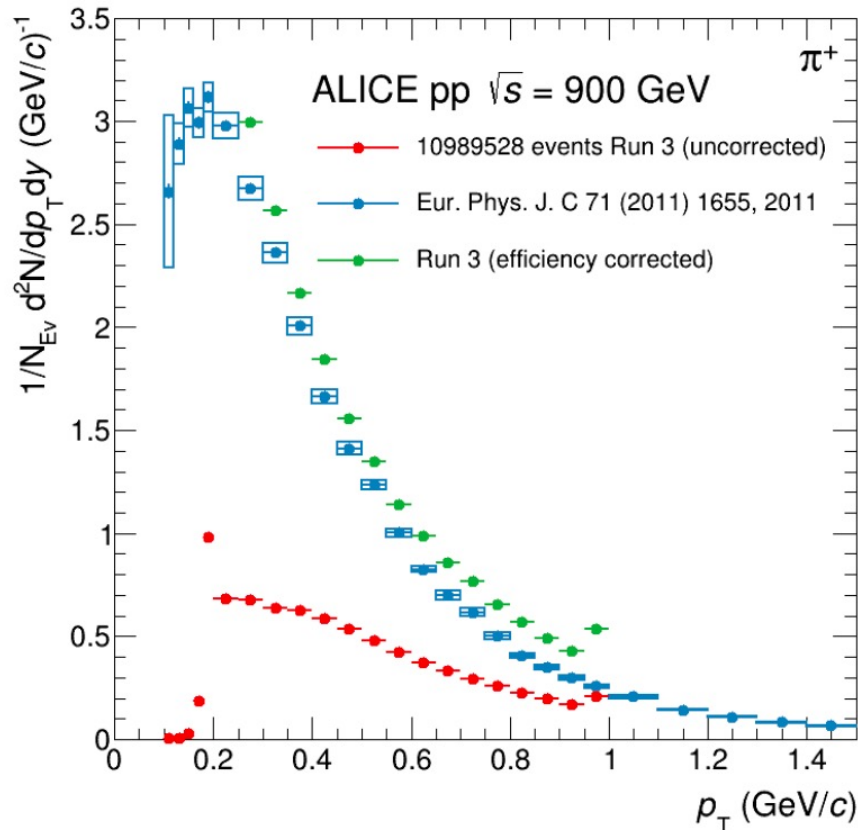
ALI–PERF–529714

ALI–PERF–528116

# Let's look at the data

Raw Data
AO2D.root

→

PID Helper task
do their job

→

Use 2$\sigma$ cut
(filters or partitions)

→

Beautiful
spectra

# Places for discussion and report your findings

- **Asynchronous Quality Control weekly** meeting. - https://indico.cern.ch/event/1344175/
- **DPG-AOT** meeting - https://indico.cern.ch/event/1337896/

**Subscribe to these channels**:

- To report - https://mattermost.web.cern.ch/alice/channels/o2-analysis
- Get announcements - https://mattermost.web.cern.ch/alice/channels/o2-analysis-announcements

**People to contact** :

- **TPC -** jeremy.wilkinson@cern.ch
- **TOF -** nicolo.jacazio@cern.ch
- **PID QA -** giovanni.malfattore@cern.ch + DPG-AOT coord

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