

PID in O2Physics

o2 analysis tutorial

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

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Banajit Barman
Gauhati University (IN)



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**.



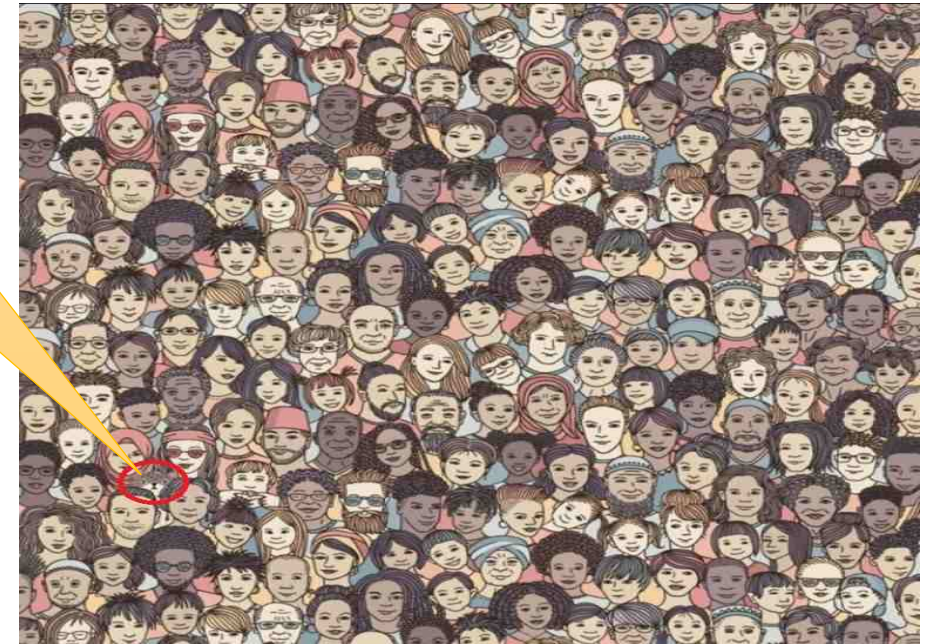
Particle Identification

Can you
see a cat
here?



Particle Identification

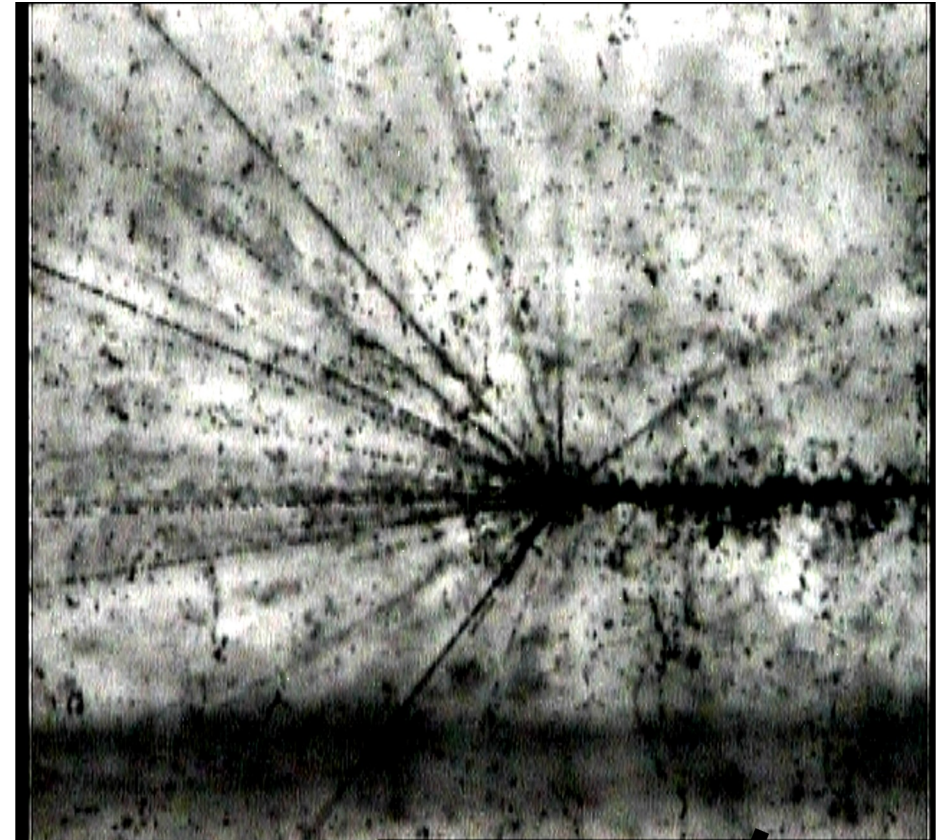
Here I am



Particle Identification

- A real photograph of an event of HIC.
- Limited particles.

Central Kr-Ag/Br event at 950 MeV/A

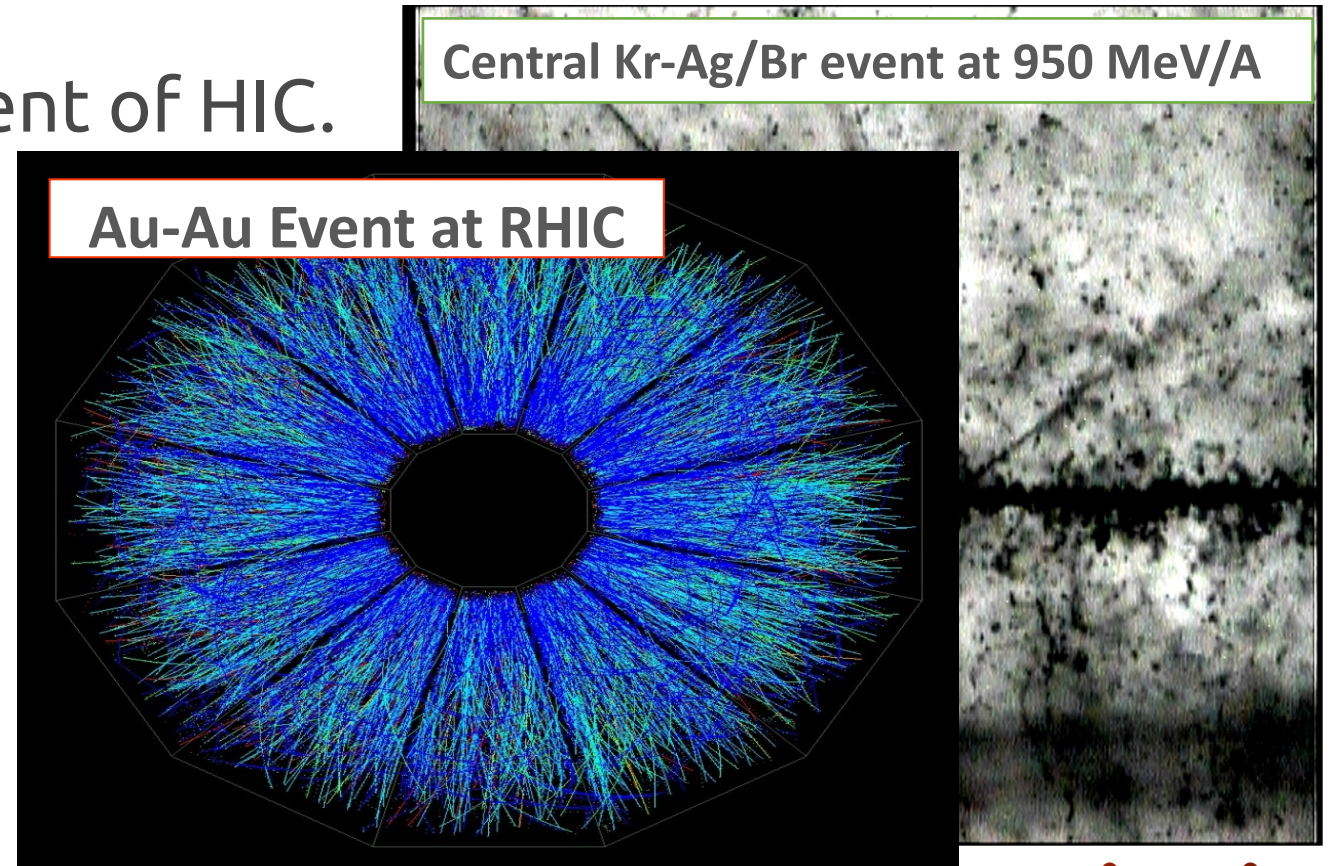


Few particles only



Particle Identification

- A real photograph of an event of HIC.
- Thousands of particles
- No microscope to measure their properties.

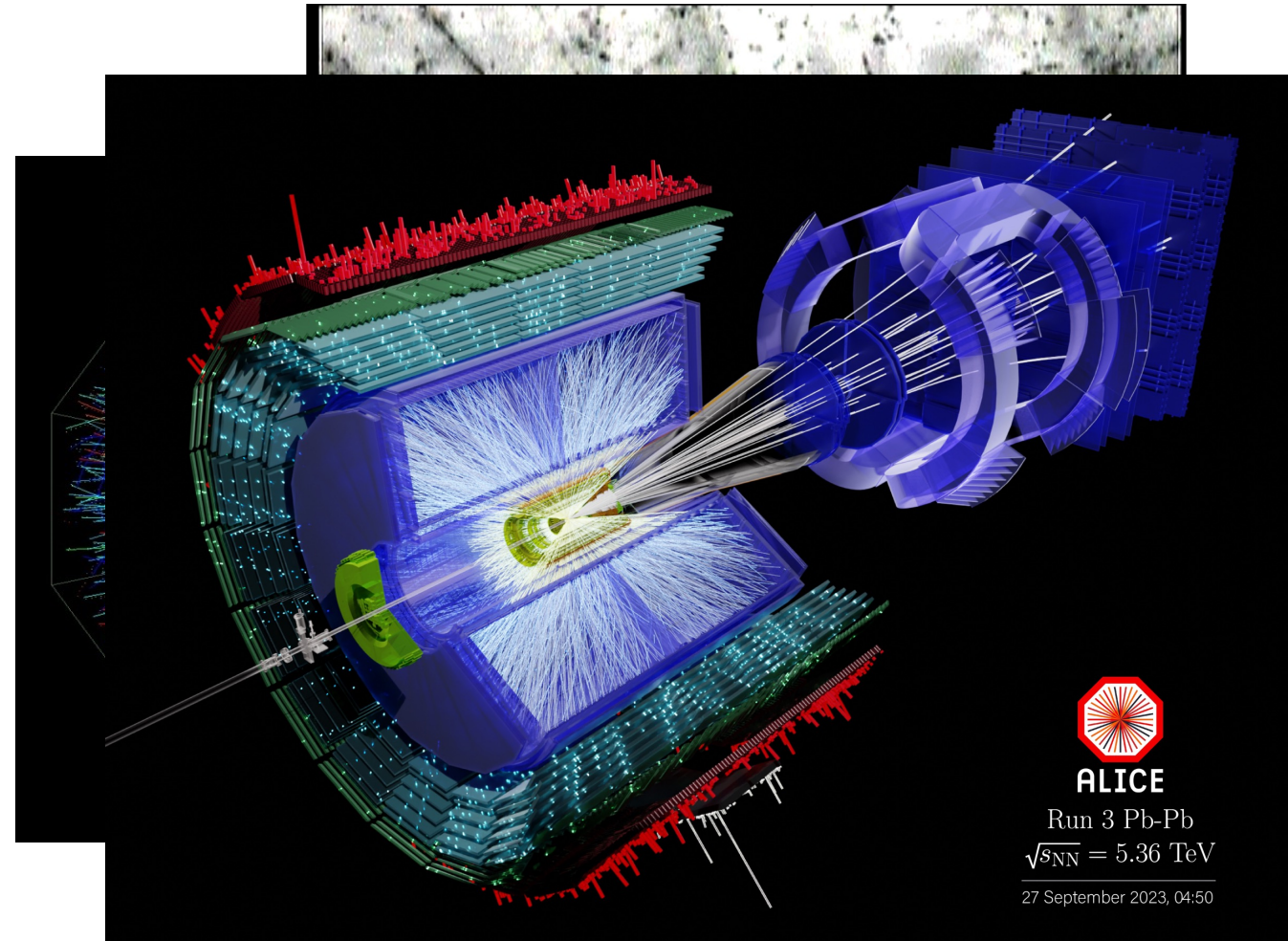


Thousands of particles!

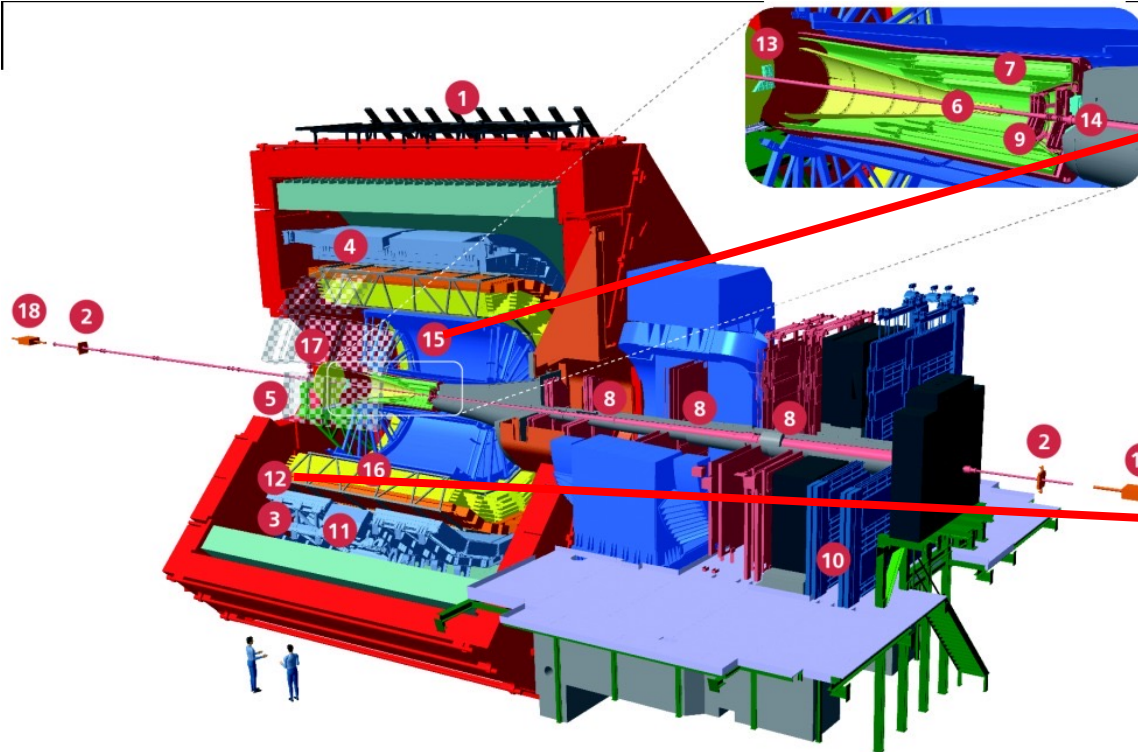


Particle Identification

- 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 In Run 3



- 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 TPC-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

TPC

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

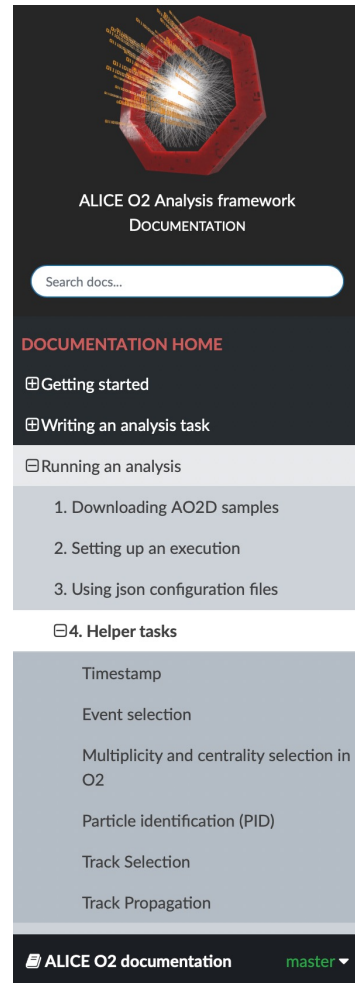
TOF

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

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:

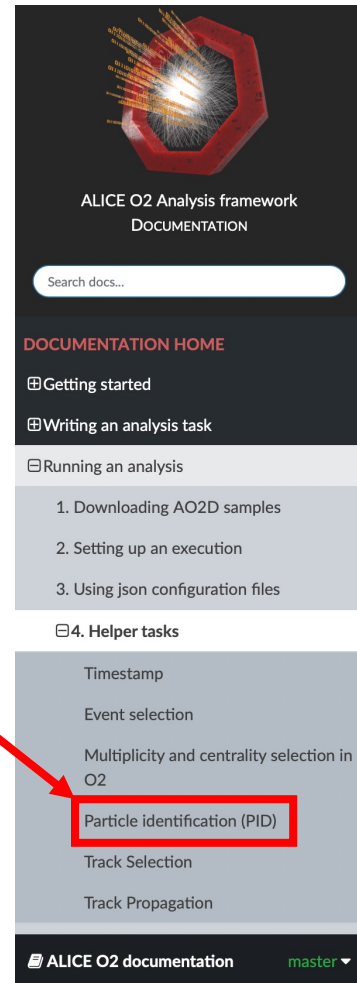
- [Concept](#)
- [Basic usage in user tasks](#)
- [Trigger aliases](#)
- [Event selection criteria](#)
- [Event selection decisions](#)
- [Found bunch crossings](#)
- [Configurables](#)
- [Remarks](#)

Concept

Get familiar with helper tasks

- **Helper task** are for carrying out advance analysis.
- **Particle identification** section.

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



Helper tasks

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Timestamp

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Event selection

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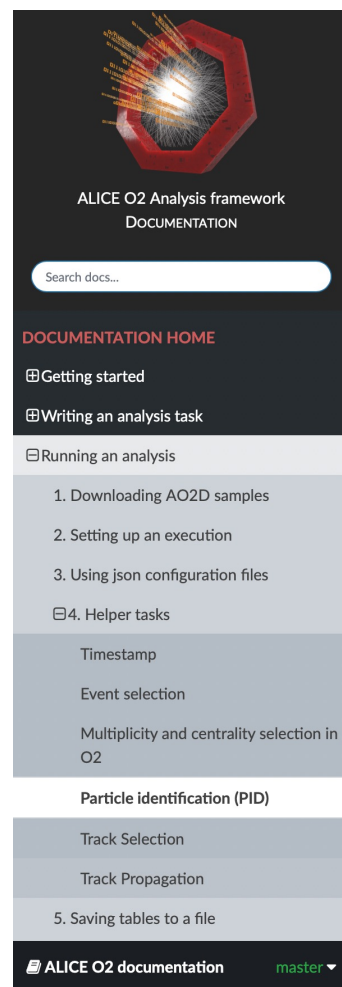
Concept

Get familiar with helper tasks

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

➤ **Particle identification** section.

➤ **Guide for PID**



Particle identification (PID)

Table of contents:

- [Introduction](#)
- [Usage in user tasks](#)
- [Task for TOF and TPC PID](#)
- [Example of tasks that use the PID tables \(and how to run them\)](#)

Here are described the working principles of Particle Identification (PID) in O2 and how to get PID information (expected values, nSigma separation et cetera) in your analysis tasks if you plan to identify particles.

Introduction

PID is handled in analysis by filling helper tables that can be joined to tracks (propagated or not). The parameterization of the expected detector response (e.g. signal, resolution, separation) is used in the PID tasks to fill the PID tables. These parameterizations are detector specific and handled by the detector experts; usually, they are shipped to the PID helper tasks from the CCDB to match the data-taking conditions. The interface between the detector and the Analysis Framework (i.e. your tracks) is fully enclosed in [PIDResponse.h](#). Here are the defined tables for the PID information for all the detectors.

The filling of the PID tables is delegated to dedicated tasks in [Common/TableProducer/PID/](#). Examples of these tasks can be found in [pidTOF.cxx](#) and [pidTPC.cxx](#) for TOF and TPC tables, respectively.

Usage in user tasks

Tables for PID values in O2 are defined in [PIDResponse.h](#). You can include it in your task with:

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

In the process functions, you can join the table to add the PID (per particle mass hypothesis) information to the track. In this case, we are using the mass hypothesis of the electron, but tables for nine (9) stable particle species are produced ([EL](#), [Mu](#), [Pi](#), [Ka](#), [Pr](#), [De](#), [Tr](#), [He](#), [AL](#)).

- For the TOF PID as:

```
void process(soa::Join::iterator const& track) {
    track.toNSigmaEL();
}
```

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

Accessing 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(³He), Al

Accessing PID Data Formats

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

- After including the **header**.
- Need to **subscribe** for each particle for each detector separately.

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

TPC Pion



TOF Pion



- 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

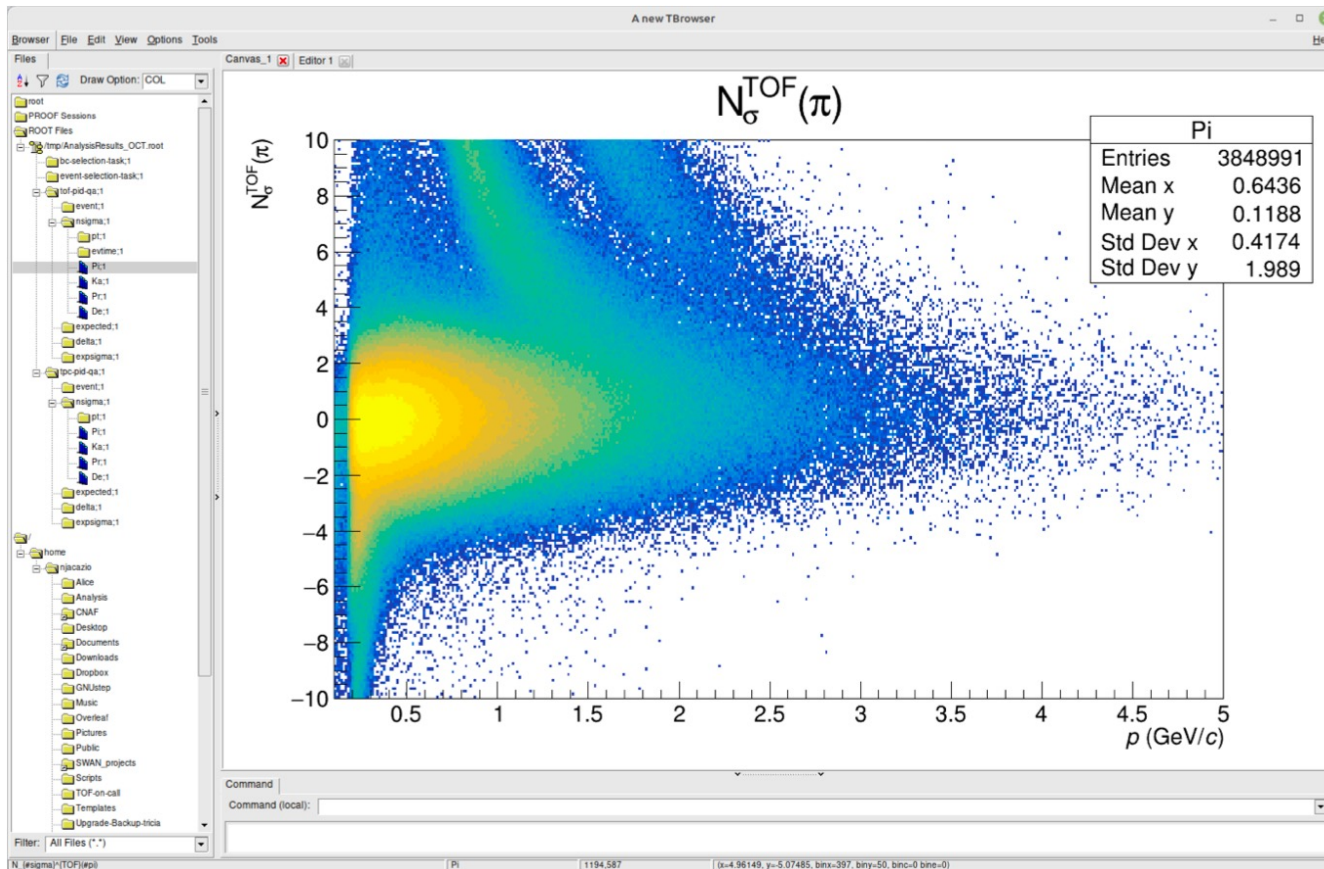


Dependencies

- 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



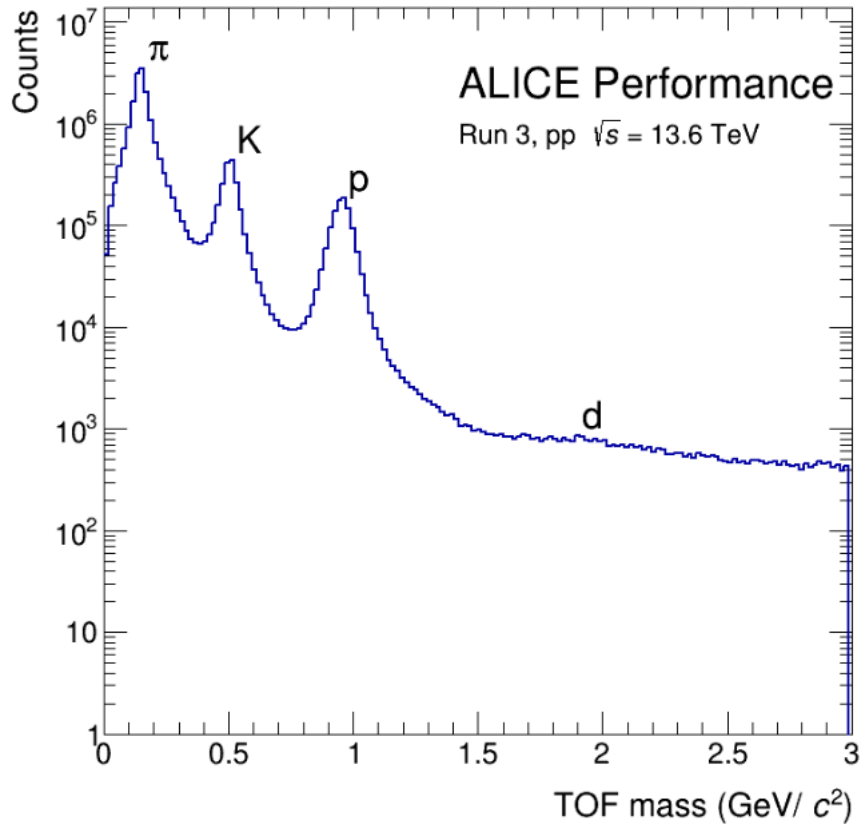
o2-analysis-pid-tpc-qa
o2-analysis-pid-tof-qa

- 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

My Analyses All Analyses Dashboard		AliHyperloop 
PIDTPC		
PIDTPC_APass3_deprecated		
PIDTPC_Run2		
PIDTPC_withTPCOnly		
PIDTPCBase		
PIDTPCBase_Run2		
PIDTPCFull		
PIDTPCFull_APass3_deprecated		
PIDTPCFull_Run2		
PIDTPCFull_withTPCOnly		
PIDTPCFullINN		
PIDTPCFullINN_withTPCOnly		
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		

Helper task on Hyperloop

Take as reference

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

The screenshot displays the Hyperloop web interface. On the left is a sidebar with a list of tasks. The task 'PIDTOFRun3' is selected and highlighted. The main panel shows the configuration for 'PIDTOFRun3'. It has tabs for 'Wagon settings', 'Configuration 1', 'Derived data', and 'Test Statistics'. The 'Configuration 1' tab is active, showing a 'tof-pid' section with several parameters:

Parameter	Value
processWoSlice	0
processWSlice	1
ccdb-timestamp	-1
ccdb-url	http://alice-ccdb.cern.ch
enableParticle	# Enable

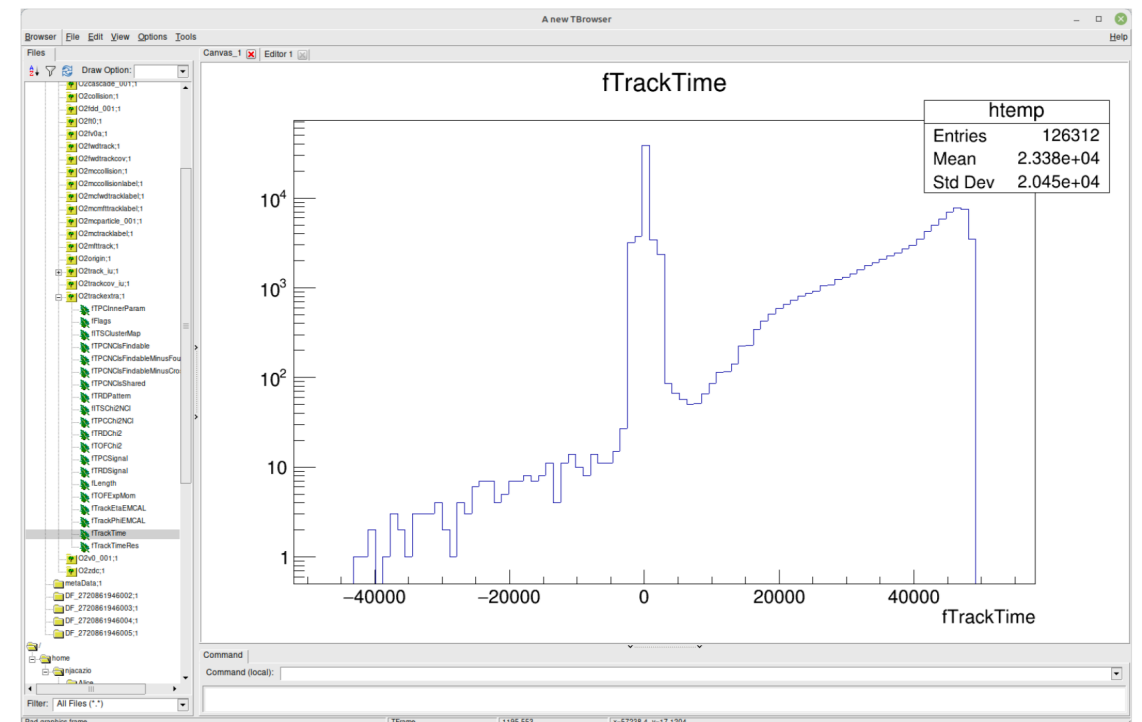
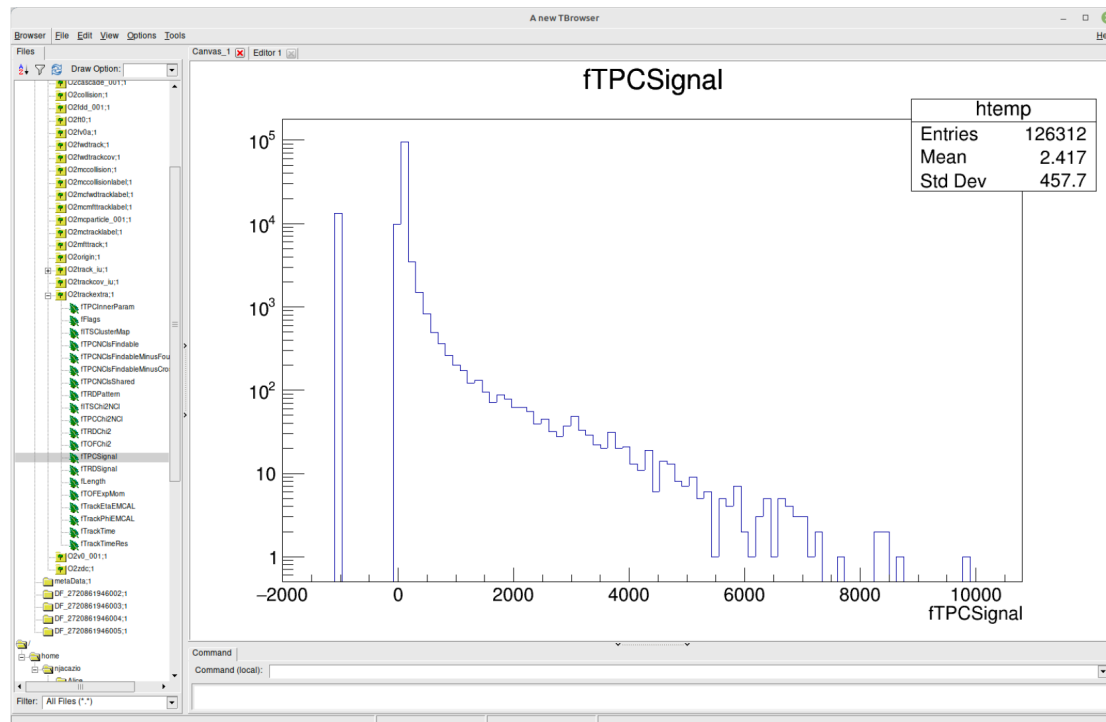
Below the 'enableParticle' parameter, there is a table with particle types and their corresponding values:

Particle	Value
El	-1
Mu	-1
Pi	-1
Ka	-1
Pr	-1
De	-1
Tr	-1
He	-1
Al	-1

At the top right of the configuration panel, it says 'Latest change by ddozbrigg at 22/06/23, 17:06 GMT+5:30'. A yellow warning box on the right states: 'Subwagons cannot be used for workflows which have derived data output.'

Let's look at the data

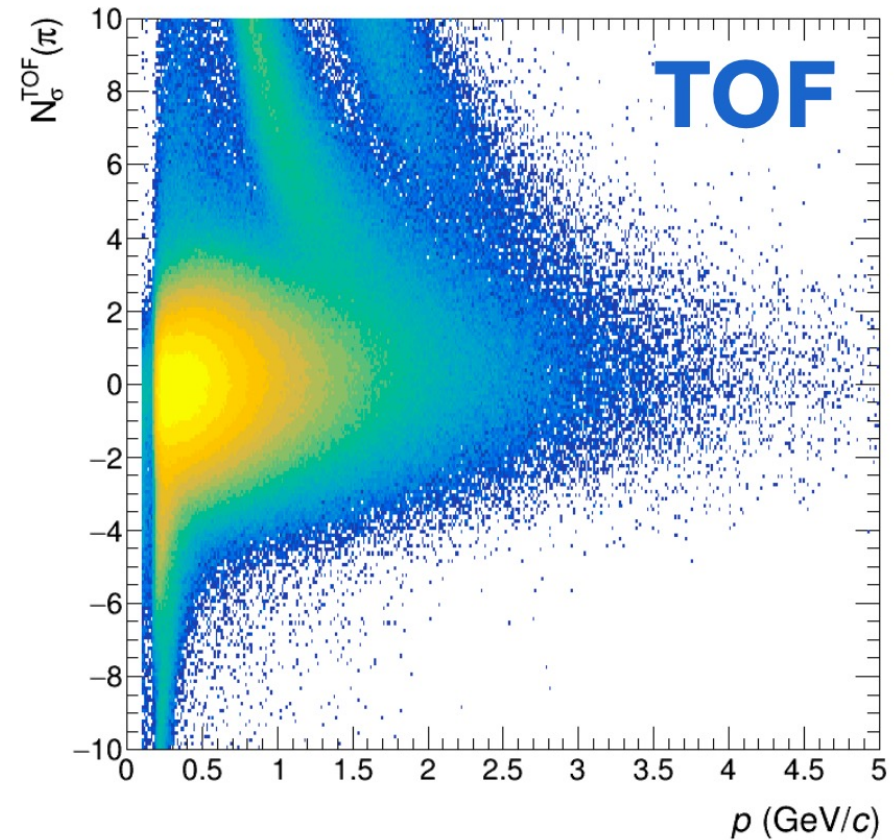
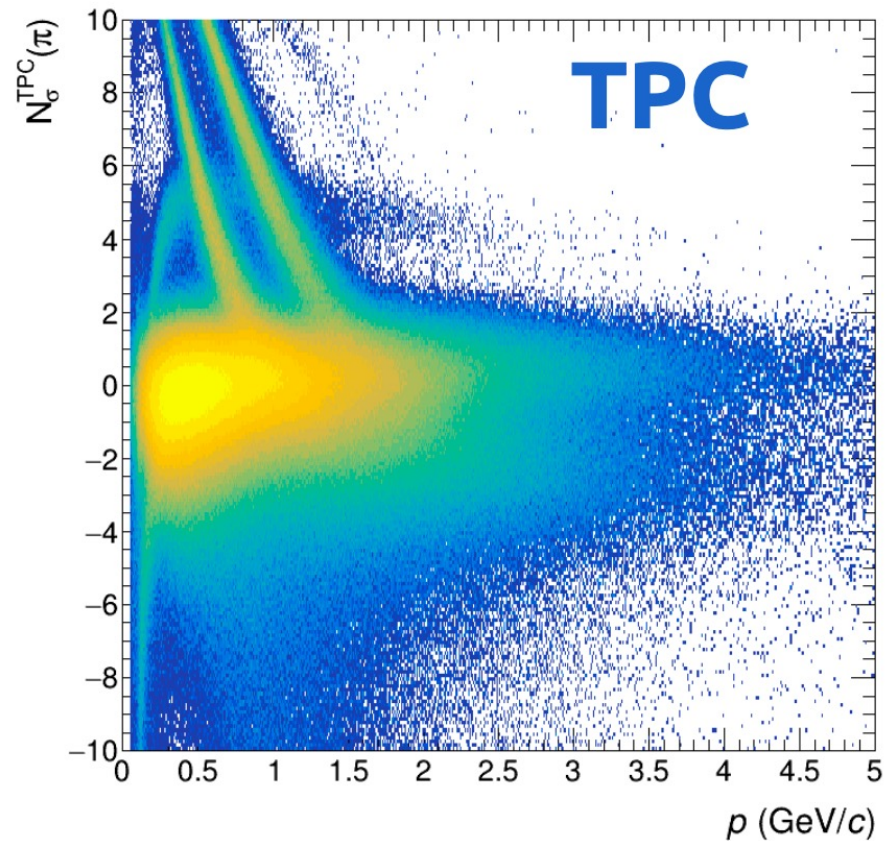
Raw Data
AO2D.root



Let's look at the data

Raw Data
AO2D.root

PID Helper task
do their job

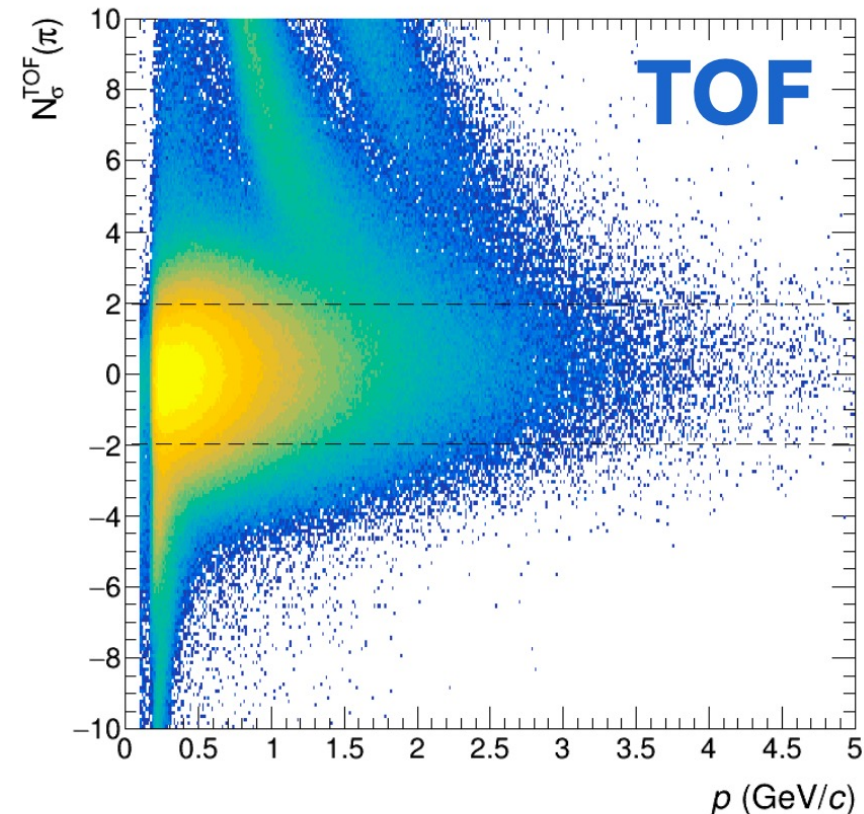
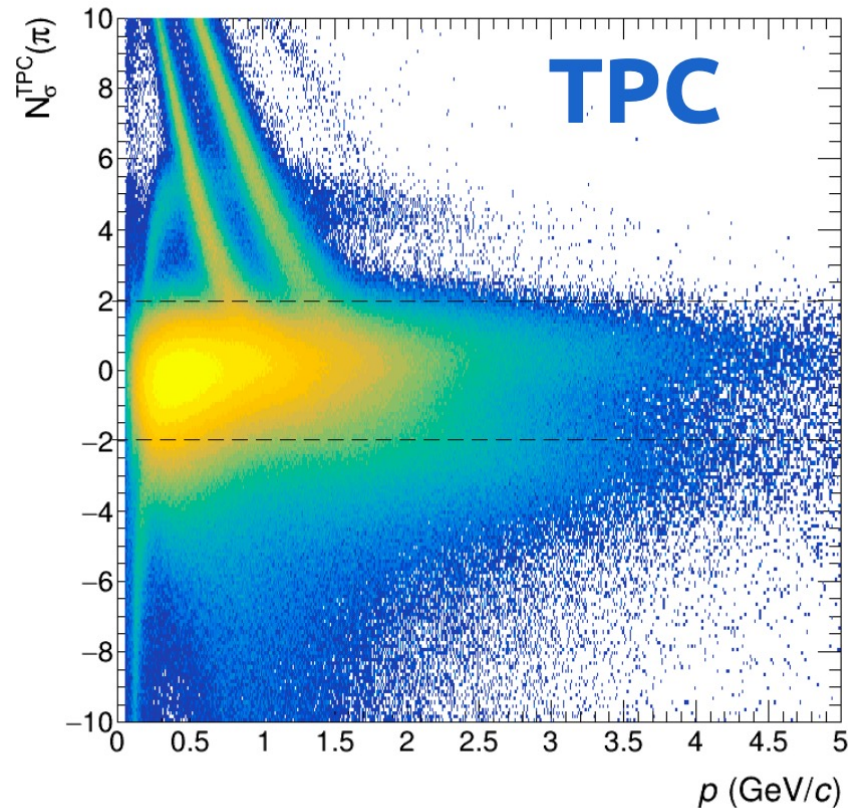


Let's look at the data

Raw Data
AO2D.root

PID Helper task
do their job

Use 2σ cut
(filters or partitions)

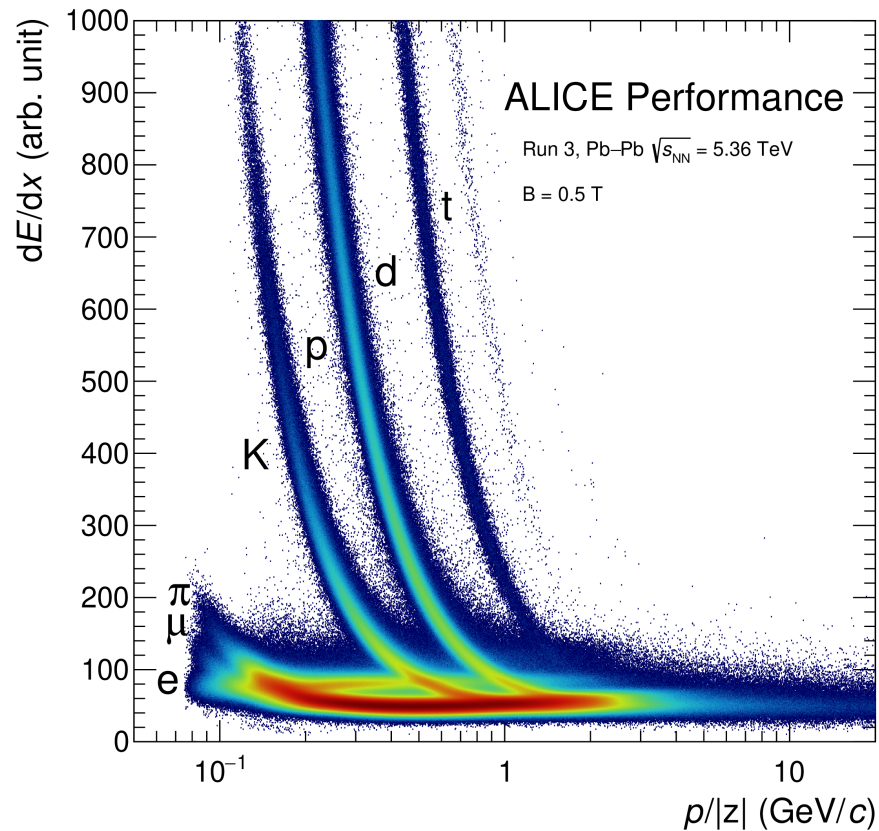


Let's look at the data

Raw Data
AO2D.root

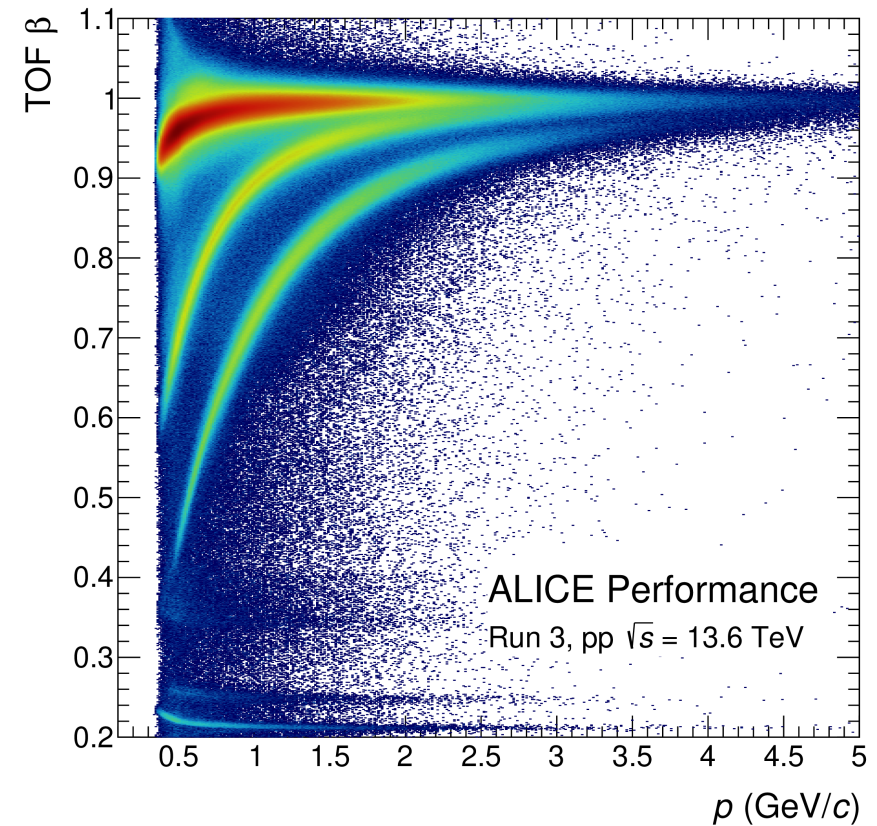
PID Helper task
do their job

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ALI-PERF-529714

07/11/23



ALI-PERF-528116

O2AT Banajit Barman (GU)

25

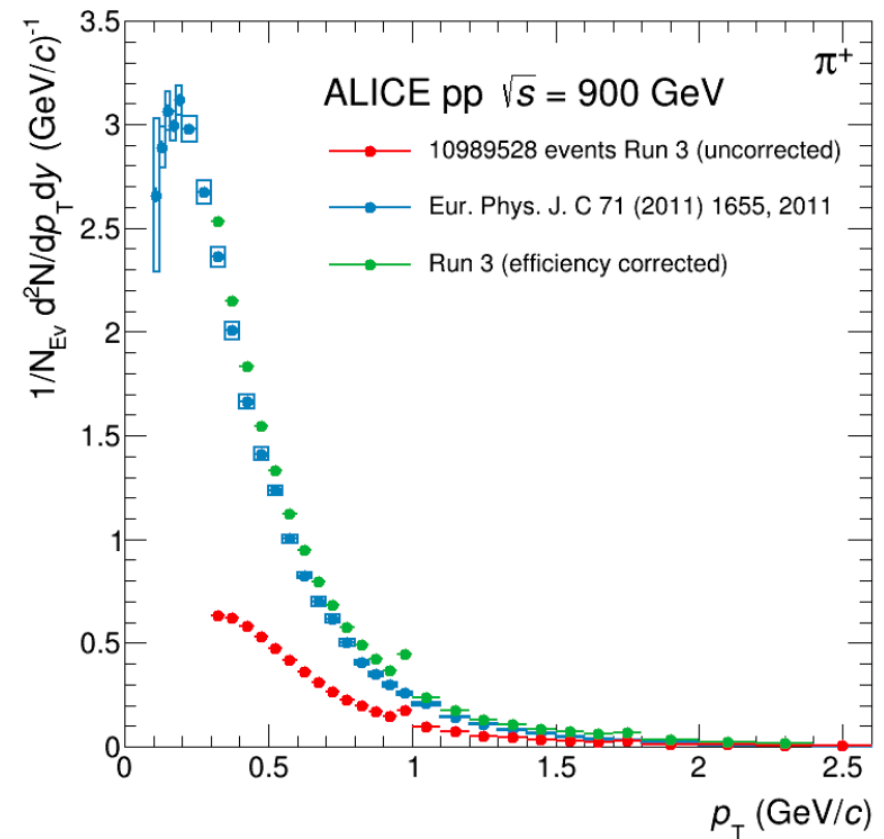
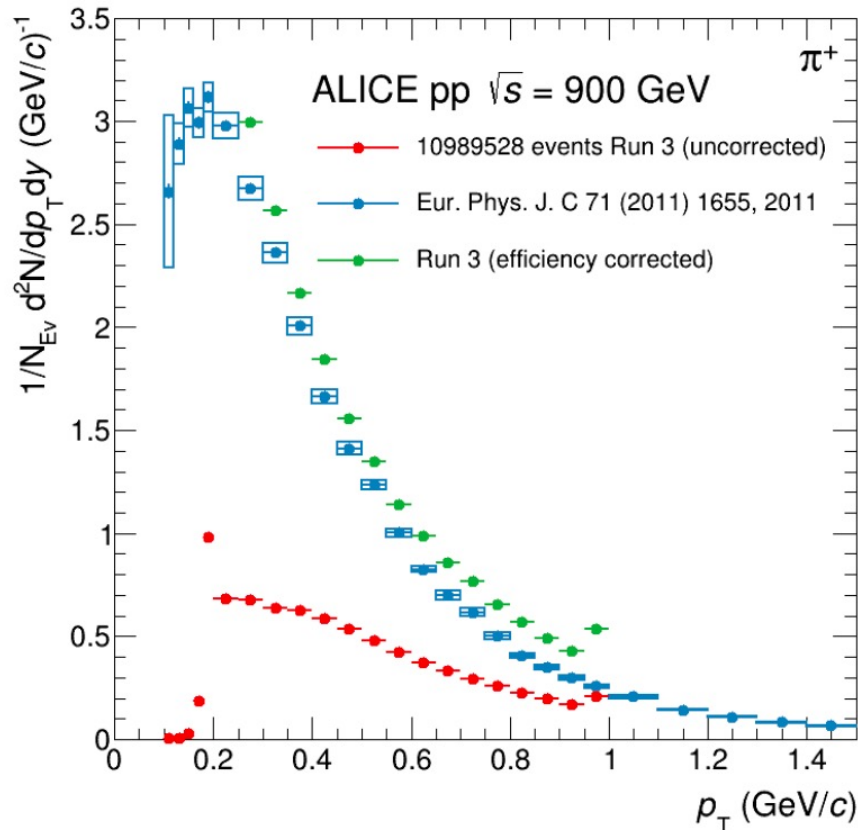
Let's look at the data

Raw Data
AO2D.root

PID Helper task
do their job

Use 2σ 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:



Mattermost

- 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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