THE ALICE TOF SYSTEM IN CONTINUOUS READOUT: COMMISSIONING – ONLINE DATA QUALITY MONITORING – PID PERFOMANCE

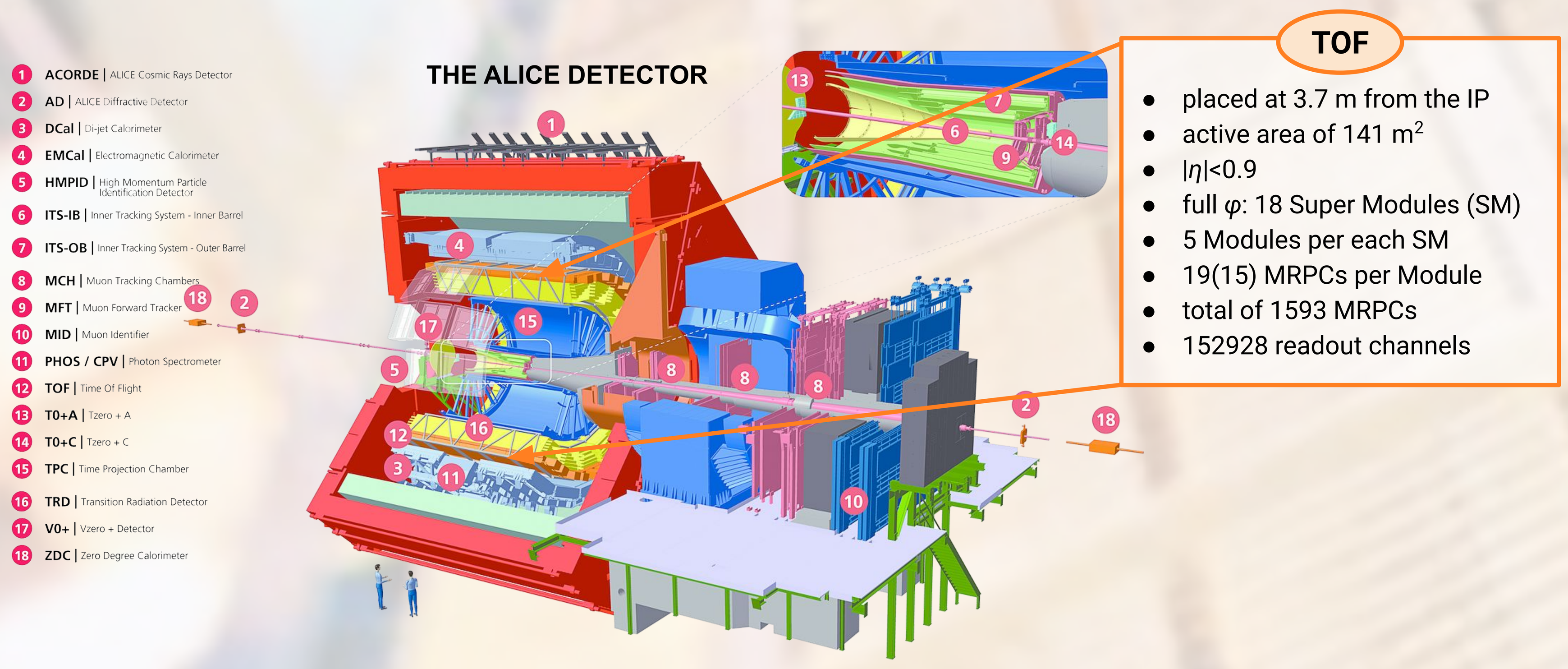
Francesca Ercolessi[1] and Giovanni Malfattore[1] *on behalf of the ALICE Collaboration*

[1]*University of Bologna and INFN Bologna, Italy*

The ALICE TOF System

The main physics goal of the **ALICE** experiment is the study of the dense and hot matter created in ultra-relativistic heavy-ion collisions: the **Quark-Gluon-Plasma**.
The excellent **Particle IDentification** (PID) capabilities of ALICE allow to identificate particles produced in hadronic collisions down to very low transverse momentum (~100 MeV/*c*) exploiting different complementary techniques.

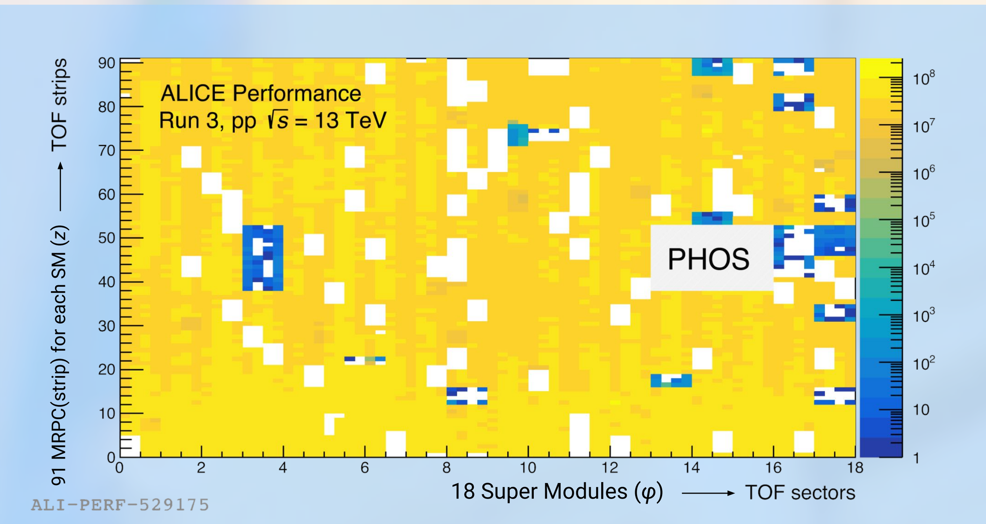
In the intermediate p_T interval [0.3-5] (GeV/*c*) this task is mainly accomplished using the **Time Of Flight** (**TOF**) detector, based on **Multigap Resistive Plate Chambers** (MRPC) technology.



Data Quality Monitoring

In order to cope with the a large amount of data expected in Run 3, ALICE deployed a new Online and Offline Computing system (O[2]). One of the key software components of the system is the data **Quality Control** (QC) that replaces the existing online and offline Data Quality Monitoring.

All the commissioning phases of the TOF detector were followed by a set of quality assurance procedures using the QC framework, composed of specialized "modules" which **monitor** the **TOF raw data stream** in all the steps along the reconstruction chain, i.e. before and after data reduction/compression.



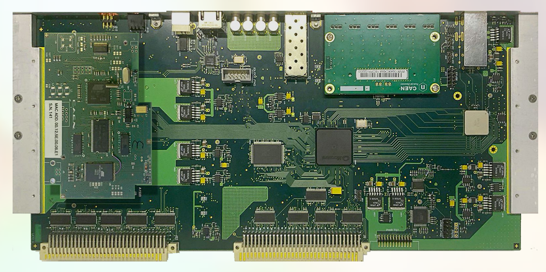
TOF Hip Map, 1 bin = 1 electronic front-end board.

TOF Quality Control ensures:

- **Online monitoring**: to quickly detect faulty conditions or bad detector configurations during data-taking
- **Asynchronous monitoring**: to ensure good quality of reconstructed data

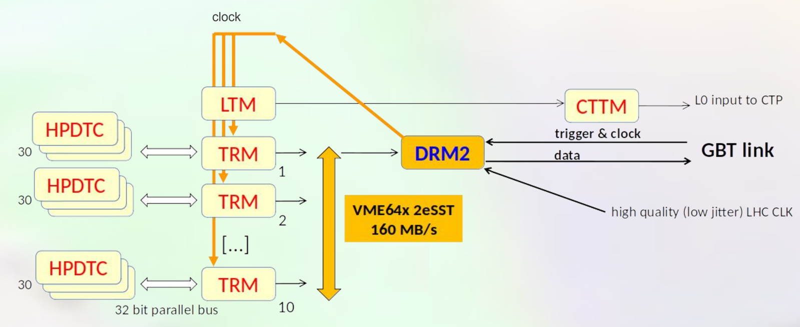
TOF Upgrade

Each of the 18 sectors of the TOF detector is read out by four VME crates, each containing 9/10 Time-to-Digital Converter Readout Modules boards (TRM) housing 30 HPTDC (High Performance TDC) each and one Data Readout Module (DRM).



DRM2 board.

In order to cope with the increase of interaction rate expected in Run 3 a new readout board was designed, the **DRM2**, equipped with a faster link (data bandwidth up to 4.48 Gb/s) towards the DAQ system using the **GBTx ASIC** and the VTRX transceiver



Run 3 TOF read-out scheme.

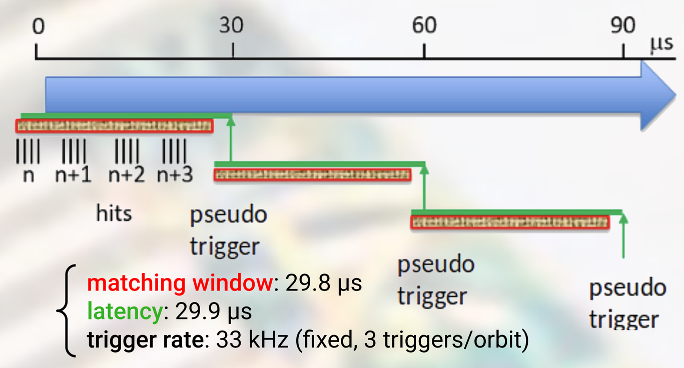
During the Long Shutdown 2 the DRM2 board replaced the old DRM1, moreover the VME64 readout (40 MB/s) was also upgraded to VME64 2eSST protocol yielding to a **data throughput** of **160 MB/s** over the VMEbus.

TOF in Continuous Readout

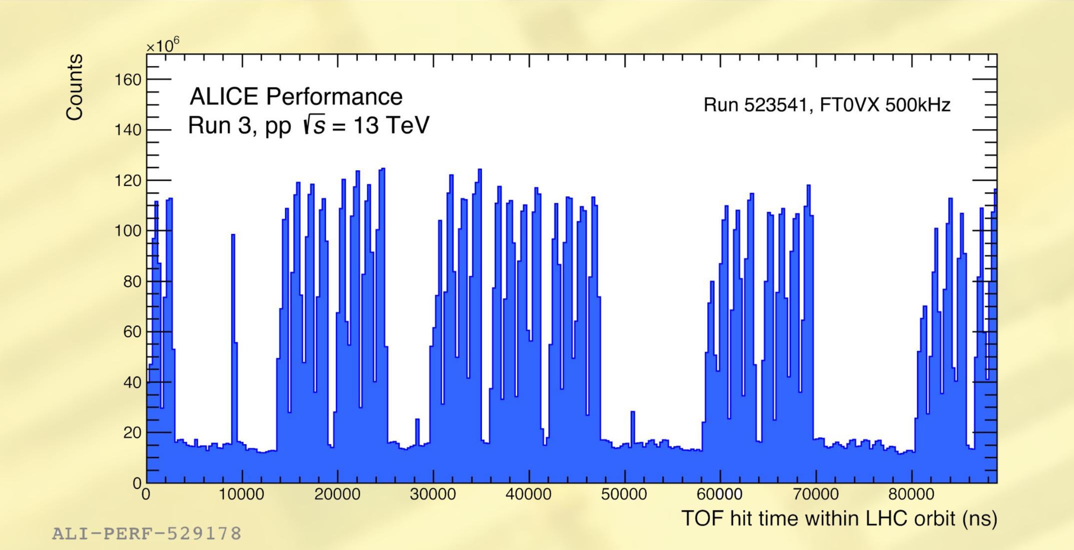
The read-out of the ALICE experiment was designed to work with the input trigger of the Central Trigger Processor (CTP). In Run 1 and 2 the TDC selected matching window was just 600 ns and included only one collision event. The trigger from CTP was received with a 6800 ns latency.

In order to cope with the enhanced luminosities reached in **Run 3**, the TOF detector is now operating in **continuous readout**.

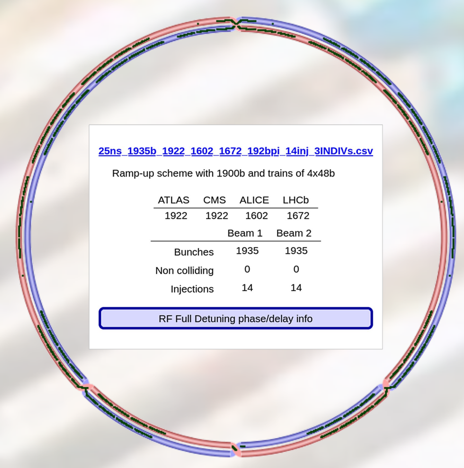
To achieve this condition the internal buffering capabilities of the HPTDC are fully exploited, using a **matching window** of **~30 μs** and a pseudo-**trigger** at **fixed frequency** of **33 kHz**.



TOF strategy for continuous readout.



TOF hit time distribution within LHC orbit (88.92 μs).



LHC filling scheme for Run 523541.

TOF PID performance

The **TOF-PID** is extensively exploited in a vast number of ALICE analyses.

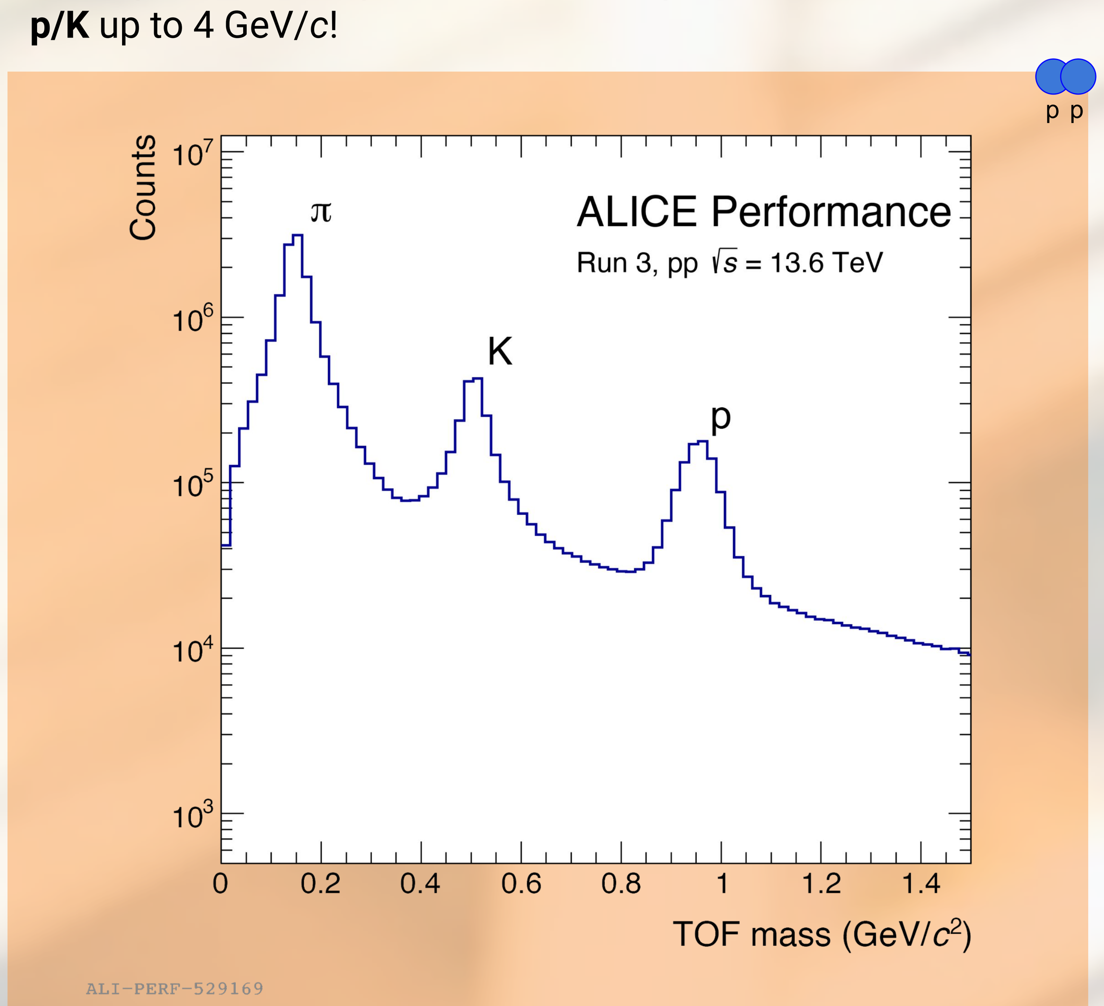
Particle Identification (PID) within the TOF detector is performed through time of flight measurements.

One of the TOF-PID estimator for a given mass hypothesis m_i (i = e, μ, π, k, p, d, t, ^{3}He, ^{4}He) is the $N\sigma_{\mathrm{TOF}}$ quantity:

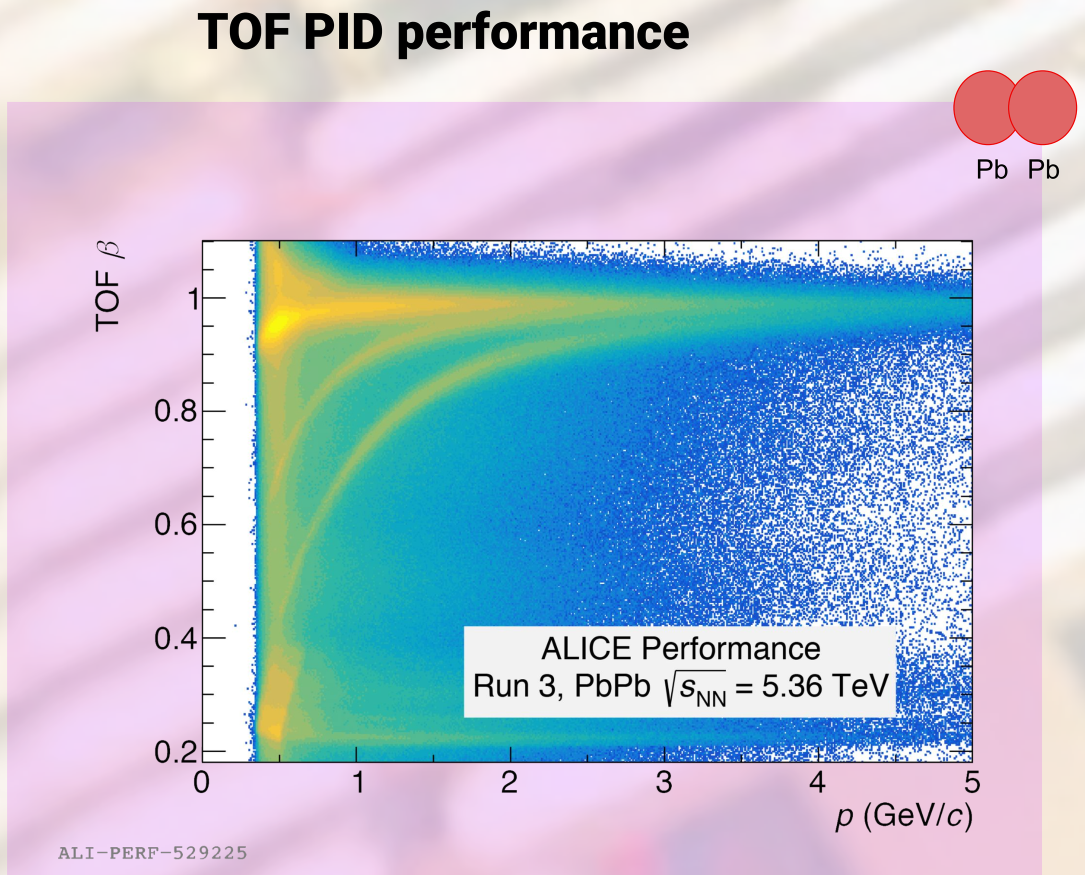
$$N\sigma_{\mathrm{TOF},i} = \frac{t - t_0 - t_{\mathrm{exp}}(m_i, p, L)}{\sigma_{\mathrm{PID}}(m_i, p, L)}$$

where σ_{PID} is the TOF PID resolution, $\mathbf{t_0}$ is the event collision time and $\mathbf{t_{exp}}$ is the expected time-of-flight for a particle of mass $\boldsymbol{m_i}$, momentum $\boldsymbol{p}$ and track length $\boldsymbol{L}$.

The TOF detector provides excellent **particle separation** over species: 3σ separation on **K/π** up to 2.5 GeV/c and on **p/K** up to 4 GeV/c!



Distribution of $\boldsymbol{m_{\mathrm{TOF}}}$ in the kaon hypothesis in Run 3 pp at 13.6 TeV collision.

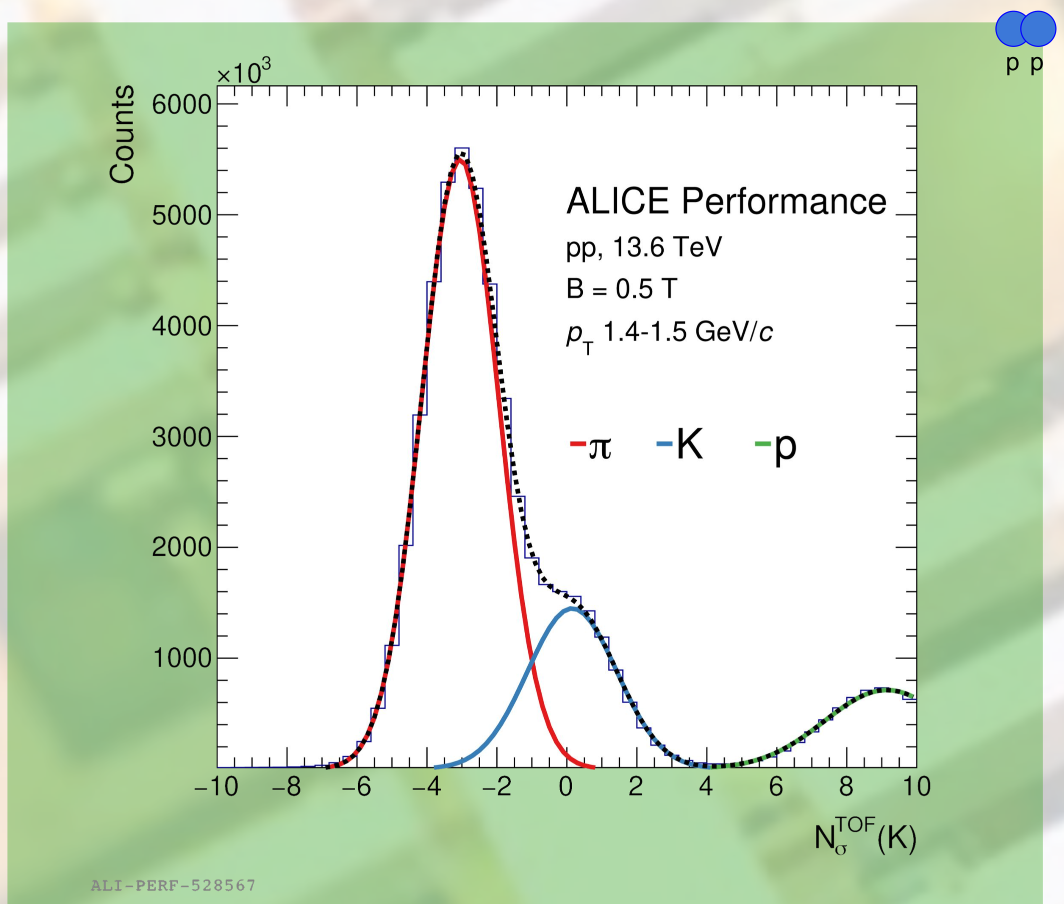


Distribution of $\boldsymbol{\beta}$ as measured by TOF detector as a function of **momentum** for particles reaching the TOF in Run 3 PbPb at $\sqrt{s_{NN}}$ = 5.36 TeV collisions.

The TOF detector allows the measurement of the β of a detected particle measuring the length L of the particle trajectory and the time of flight t.

It is possible to deduce the **mass of a particle** from its momentum measurement:

$$m^2 = \frac{p^2}{c^2}\left(\frac{c^2t^2}{L^2} - 1\right)$$



Distribution of $\mathbf{N_\sigma^{TOF}}$ in the momentum range p_T ∈ (1.4 - 1.6) GeV/c in the kaon mass hypothesis in Run 3 pp at 13.6 TeV collisions.

For two different mass hypothesis $m_{1,2}$ the expected time of flight difference for a particle with a given momentum p is

$$\Delta t \sim \frac{L}{2c}\frac{m_1^2 - m_2^2}{p^2}$$

and given the resolution σ the **separation** can be quantified (in standard deviations) as:

$$n_\sigma(m_1, m_2) = \frac{\Delta t}{\sigma} = \frac{L(m_1^2 - m_2^2)}{2\sigma p^2 c}$$

Conclusions

- The ALICE-TOF detector is now operating in **continuous readout** and efficiently recorded ~99% of Run 3 500kHz pp collisions at 13.6 TeV and PbPb collisions at $\sqrt{s_{NN}}$ = 5.36 TeV
- **Detector operations** during data-taking **are monitored** through the Quality Control framework allowing to spot issues in real time and to keep the readout efficiency high during the run
- In July-November 2022, after 14 years of operation, TOF showed **very stable conditions** and is already providing an **excellent PID performance**