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 identify particles produced in hadronic collisions down to very low transverse momentum (~100 MeV/c) exploiting different complementary techniques.

In the intermediate phase, different complementary techniques were pursued to produce in hadronic collisions down to very low transverse momentum (\( p_T \)).

The excellent PID performance of ALICE is the basis for a vast number of ALICE analyses.

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 (TRM) housing 30 HPTDC (High Performance TDC) each and one Data Readout Module (DRM).

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 GTX 580 and the VTRX transceiver.

During the Long Shutdown 2 the DRM2 board replaced the old DRM1, moreover the VME64 readout (40 MB/s) was also upgraded to VME64 2x1SST 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.

Data Quality Monitoring

In order to cope with the large amount of data expected in Run 3, ALICE deployed a new Online and Offline Computing system (O2). 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 Quality Control ensures:

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

TOF PID performance

The TOF detector allows the measurement of the \( \beta \) 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 \( m \) of a particle from its momentum measurement:

\[
\frac{m}{p} = \frac{1}{\beta} = \sqrt{1 - \frac{1}{\beta^2}}
\]

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

\[
\Delta t = \frac{m_{1,2} \sigma}{p}
\]

and given the resolution \( \sigma \) the separation can be quantified (in standard deviations) as:

\[
n_{\text{sep}}(m_{1,2}, \sigma) = \frac{\Delta t}{\sigma}
\]

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 \( \sqrt{s_{NN}} = 5.58 \) 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.