# Status of the Fast Interaction Trigger detector of ALICE

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The Fast Interaction Trigger (FIT) is one of the detectors installed in the ALICE experiment during the second Long Shutdown (LS2) of the LHC to cope with the new collision rates of 50 kHz for Pb–Pb and up to 1 MHz for pp collisions. FIT comprised of the FT0, FV0, and FDD sub-detectors that use Cherenkov and scintillator technologies. The sub-detectors are placed in the forward regions on both sides of the interaction point. FIT delivers fast triggers and determines online vertex, luminosity, multiplicity and centrality. FIT also contributes to beam-background monitoring in ALICE and provides feedback on the beam quality to the LHC. This work presents an overview of the FIT detector and its performance with pp and heavy-ion collision data collected during 2022 and 2023.

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## 1. Introduction

In the current Run 3 of the Large Hadron Collider (LHC) at CERN, the LHC delivers much more luminosity to ALICE with respect to the previous Run 1 and Run 2. The increase in collision rates goes from 200 kHz to 1 MHz for pp and from 8 kHz to 50 kHz for Pb–Pb [1]. A major upgrade was done in ALICE during the long shutdown 2 (2019-2021) to cope with the new conditions. Three new detectors were installed: the Inner Tracking System (ITS), the Muon Forward Tracker (MFT), and the Fast Interaction Trigger (FIT) [2]. In addition, the Time Projection Chamber (TPC) underwent a major upgrade; a new Online-Offline (O2) computing infrastructure was developed, and continuous readout was implemented [3].

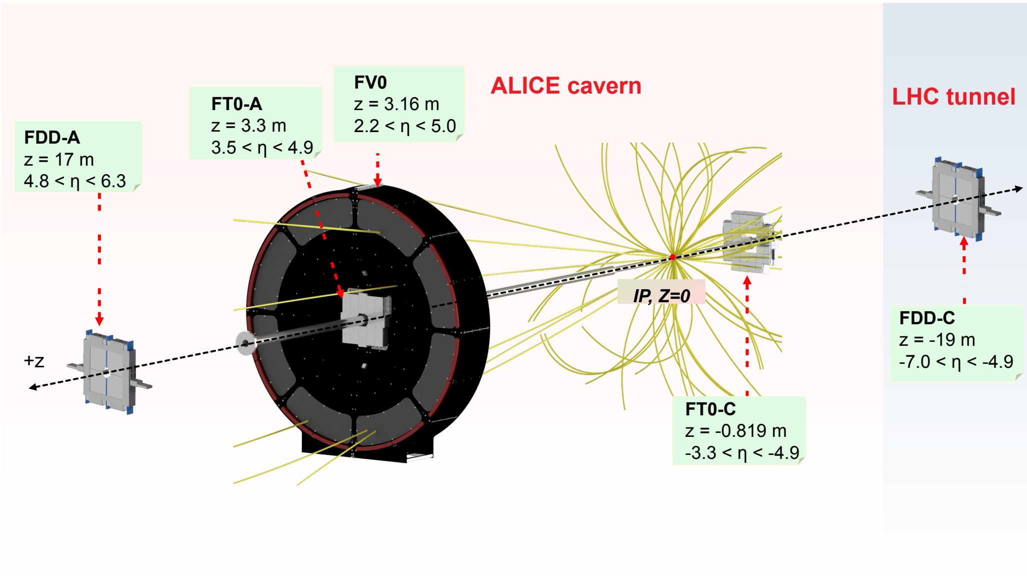


**Figure 1:** FIT components and their positions with respect to the nominal interaction point. From left to right: FDD-A, FT0-A, FV0, FT0-C and FDD-C.

## 2. The Fast Interaction Trigger

FIT consists of three sub-detectors: FV0, FT0, and FDD, that are placed in the forward direction with respect to the nominal interaction point. Their placement and pseudorapidity coverage are shown in Fig. 1. FDD and FT0 are divided into two matrices: FDD-A, FDD-C, FT0-A and FT0-C. The names follow the LHC convention, where A side is towards the ATLAS experiment, and C is towards CMS. Since FV0 is placed only on the A side, its name does not change.

FV0 is a large area detector and is composed of 5 concentric plastic scintillator wheels divided into eight cells. Each cell is read with a novel optical-fibre readout system [4] and one fine-mesh photomultiplier (FM-PMT). Because of its large size, the outer ring is read out by two FM-PMTs. FV0, with a total of 48 channels, is optimized to calculate multiplicity, provide a low-level trigger, and determine the event plane.

FT0 use Cherenkov quartz radiators, read out by modified MCP-PMTs [5] totalling 208 channels: 96 and 112 channels in FT0-A and FT0-C, respectively. FT0 is the fastest detector in ALICE, providing less than 20 ps time resolution for minimum ionizing particles and delivering online triggers with latency below 425 ns. The triggers include minimum bias, centrality, and vertex. FT0 determines high-precision collision time and is crucial in luminosity determination and background monitoring.

FDD [6] is made of two arrays of plastic scintillator pads with two fast wavelength-shifting bars attached on the sides. The light from the bars is transported through optical fibres to fine mesh PMTs. Each array has eight pads divided into two layers of four quadrants, giving a total of 16 channels. FDD covers the region of large rapidities, relevant for studying photon-induced and diffractive processes. FDD also provides luminosity, minimum bias trigger, and background information.

All FIT sub-detectors have a common front-end electronic (FEE) operating continuously (in a triggerless mode) and processing signals with the rate matching the 25 ns LHC bunch crossings intervals [7]. Each sub-detector has one Clock Module (TCM) and multiple Processing Modules (PM) connected to it. TCMs are connected to O2 [8] via one GigaBit Transceiver (GBT). FEE is configured and monitored by control server software integrated into the Detector Control System (DCS) [9] for slow control. Through the DCS, the detector's high voltage (HV) and the FEE can be controlled, configured, monitored, and operated by experts and the central ALICE crew. In addition, the three sub-detectors have laser calibration systems, also used for ageing, time alignment, and performance studies.

## 3. Performance

The FIT detector has been operating since October 2021, providing commissioning, pp and Pb–Pb collision data [10] with all three FIT sub-detectors. In 2023, ALICE collected a large sample of pp collisions and is taking Pb-Pb data since the end of September.

### 3.1 Performance in pp collisions

The FT0 detector showed an excellent time resolution of around 18 ps on 13.6 TeV pp collisions, as shown in the left plot of Fig. 2. There is a good correlation between the FT0 primary vertex and the primary vertex from ITS. It is worth mentioning that the FT0 vertex is an online signal sent to the central trigger of ALICE, whereas the ITS is reconstructed offline.

The FV0 detector provided charge measurement from one side of ALICE shown in Fig. 3. An example of the charge distribution measured by FV0 is presented in the left panel from Fig. 3, which is used as an input for the determination of centrality classes based on multiplicity. The right panel of Fig. 3 presents the correlation between FV0 and FT0-C sub-detectors, since they are on opposite sides with respect to the interaction point is an interesting comparison because it shows that they are correlated; the higher charges to FV0 are due the larger size of this detector with respect to FT0-C.

The FDD detector measured the vertex position and the collision time in pp collisions at 13.6 TeV. The correlation between these quantities is shown in Fig. 4. Thus, FDD provides additional trigger information for events, creating signals only at very large rapidities and corroborating FT0 information for the rest of the events.

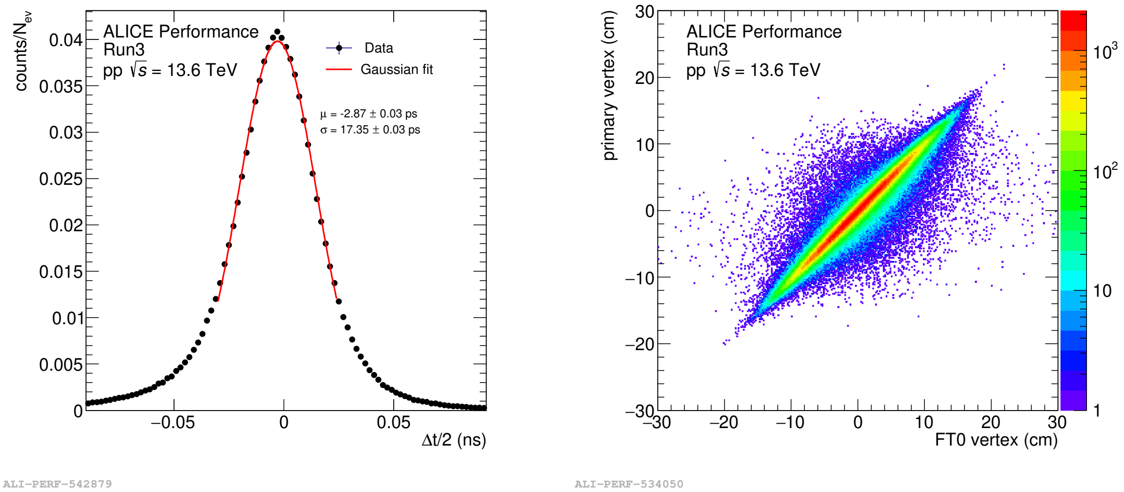


**Figure 2:** Performance of FT0 in 13.6 TeV pp collisions. Left: FT0 distribution of the vertex time. Right: correlation of the vertex position along the beam line obtained with FT0 and ITS.

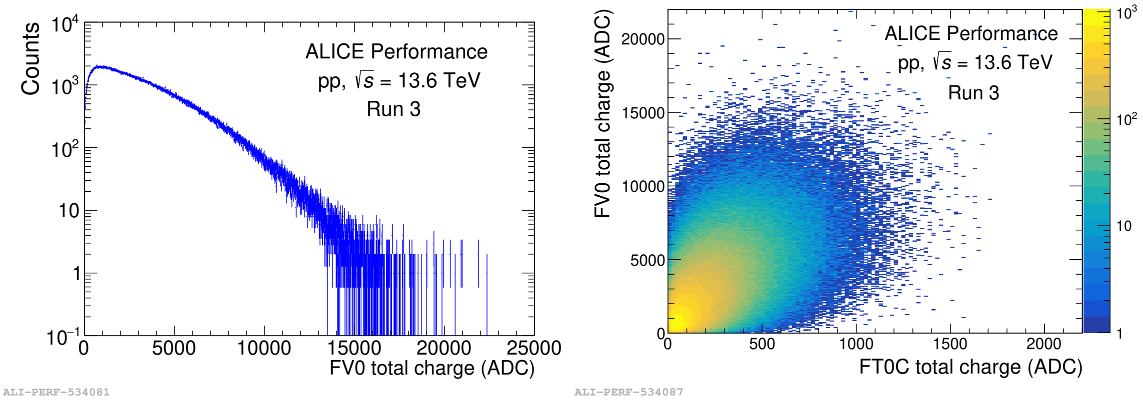


**Figure 3:** Performance of FV0 at 13.6 TeV pp collisions. Left: FV0 total charge. Right: charge correlation of FV0 and FT0-C.

### 3.2 Performance in Pb–Pb collisions

During the Pb–Pb pilot run in 2022 at the LHC, we successfully collected data to evaluate the detector's performance.

With the data collected, FIT verified that the FT0 sub-detector can provide charge information and, therefore, measure multiplicity, as is shown in Fig. 5, which is an expected performance. Due to the enhanced time resolution, it can also determine the precise position of the interaction vertex, which is improved further at higher multiplicities due to the higher charges in heavy-ion collisions.

Among other results, it was shown that FT0 can provide charge information for the determination of centrality in Pb–Pb collisions, see Fig. 5, left panel. There is also an excellent correlation between the position of the interaction vertex determined with the timing capabilities of FT0 and with ITS tracking as depicted in the right panel of Fig. 5.

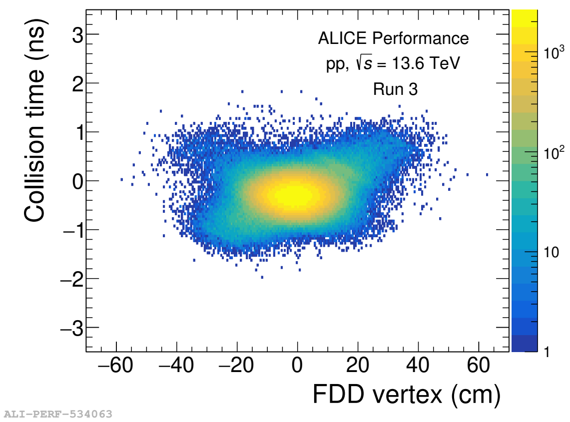


**Figure 4:** Vertex and collision time correlation from the FDD with pp collisions at 13.6 TeV.

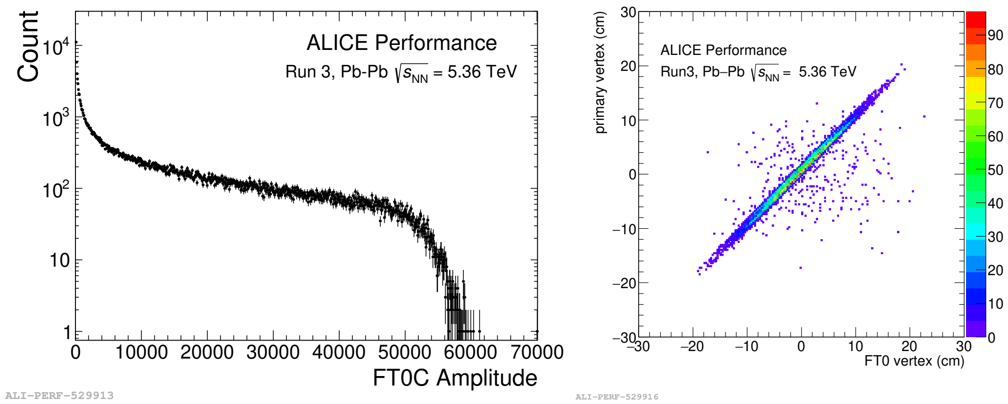


**Figure 5:** Performance of FIT in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.36 TeV. Left: FT0-C total charge. Right: correlation of the vertex position along the beam line obtained with FT0 and ITS.

Additionally, the FIT detector is the main luminometer of ALICE. Fit also provides the LHC with rates of inelastic interactions and background estimation. This information is used to monitor the beam quality by the LHC.

## 4. Conclusions

The three FIT sub-detectors were installed and commissioned successfully and have been working and participating with almost 100% efficiency during the data taking. FIT was successfully tested up to a 4 MHz interaction rate on pp collisions and showed excellent performance during the Pb–Pb pilot beams from 2022.

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