Trigger Performance of the ALICE Silicon Pixel Detector

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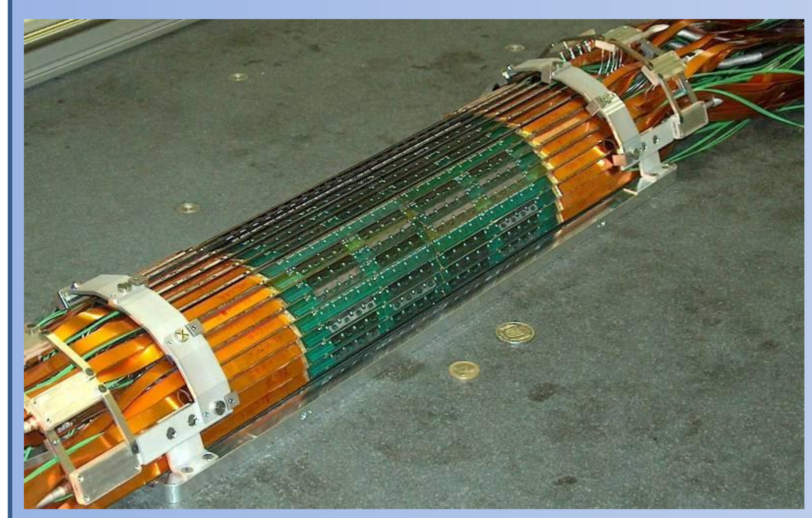
ABSTRACT

The ALICE Silicon Pixel Detector (SPD) forms the two innermost layers of the ALICE Inner Tracking System (ITS). It consists of two-layer barrel of hybrid silicon pixel detectors, The unique feature of the SPD among the vertex detectors of LHC experiments is the prompt trigger capability , called Fast-Or, which allows it to contribute to the experimental first level trigger decision. The SPD data stream includes 1200 digital signals (Fast-Or) promptly asserted on the presence of at least one pixel hit in one of the detector readout chips. The off-detector Pixel Trigger system elaborates in real time the 1200 Fast-Or signals continuously received from the detector in order to generate a pre-processed signal for the ALICE first level trigger. All the Fast-Or signals are written in the data and available for offline analysis. In this contribution it is presented the methodology used to evaluate performances of the Fast-Or. The methods are entirely based on offline data analysis. Results are given for a sample of data of proton-proton collisions at $\sqrt{s}$ = 7 TeV and Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV.

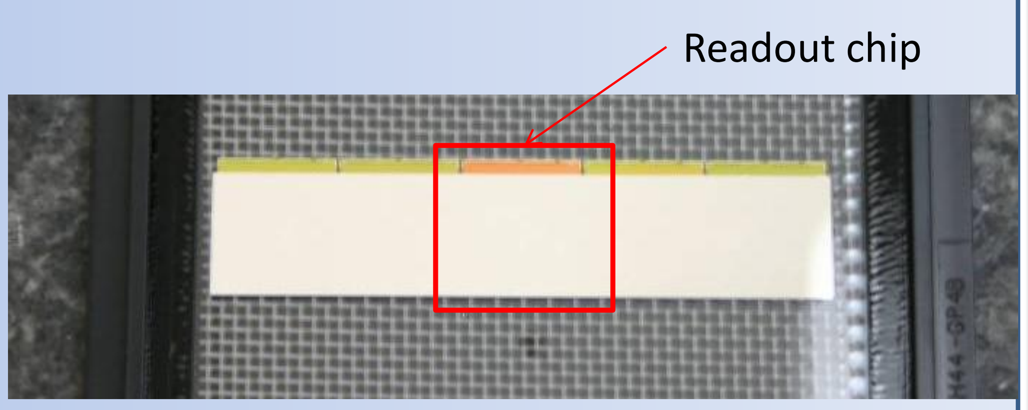
ALICE Silicon Pixel Detector



The Silicon Pixel Detector (SPD)[1] is the innermost detector in Alice. It consists of two cylindrical layers of hybrid silicon pixel detectors at radii of 3.9 cm and 7.6 cm.

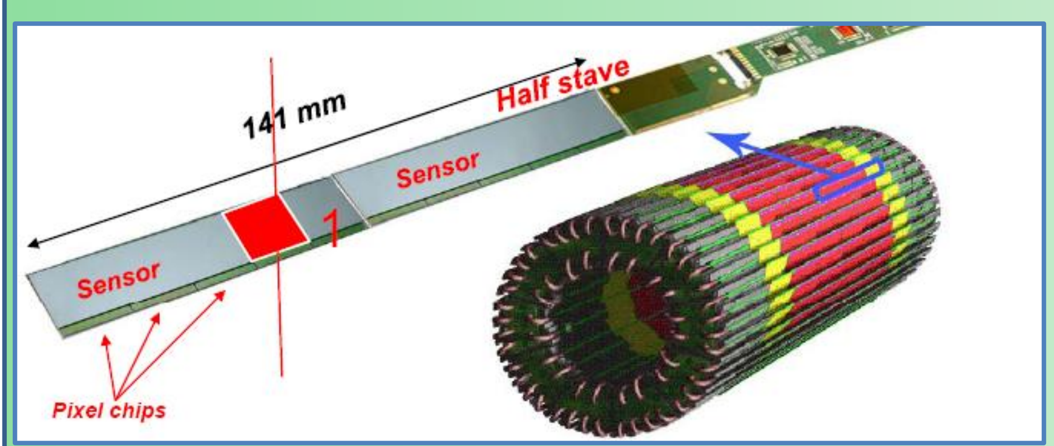
SPD has a key role in the determination of the primary vertex and in the measurement of the impact parameter of the secondary tracks originating from the weak decays of strange, charm and beauty particles. The basic building block is a module consisting of a pixelized, reverse biased silicon sensors bump-bonded to 5 front-end chips.

- The pixels are 50μm (rϕ plane) x 426 μm (along beam axes).
- Each front-end chips has 8192 pixel channels arranged in a 32x256 matrix.
- The SPD contains about 10^7 pixels and 1200 readout chips.

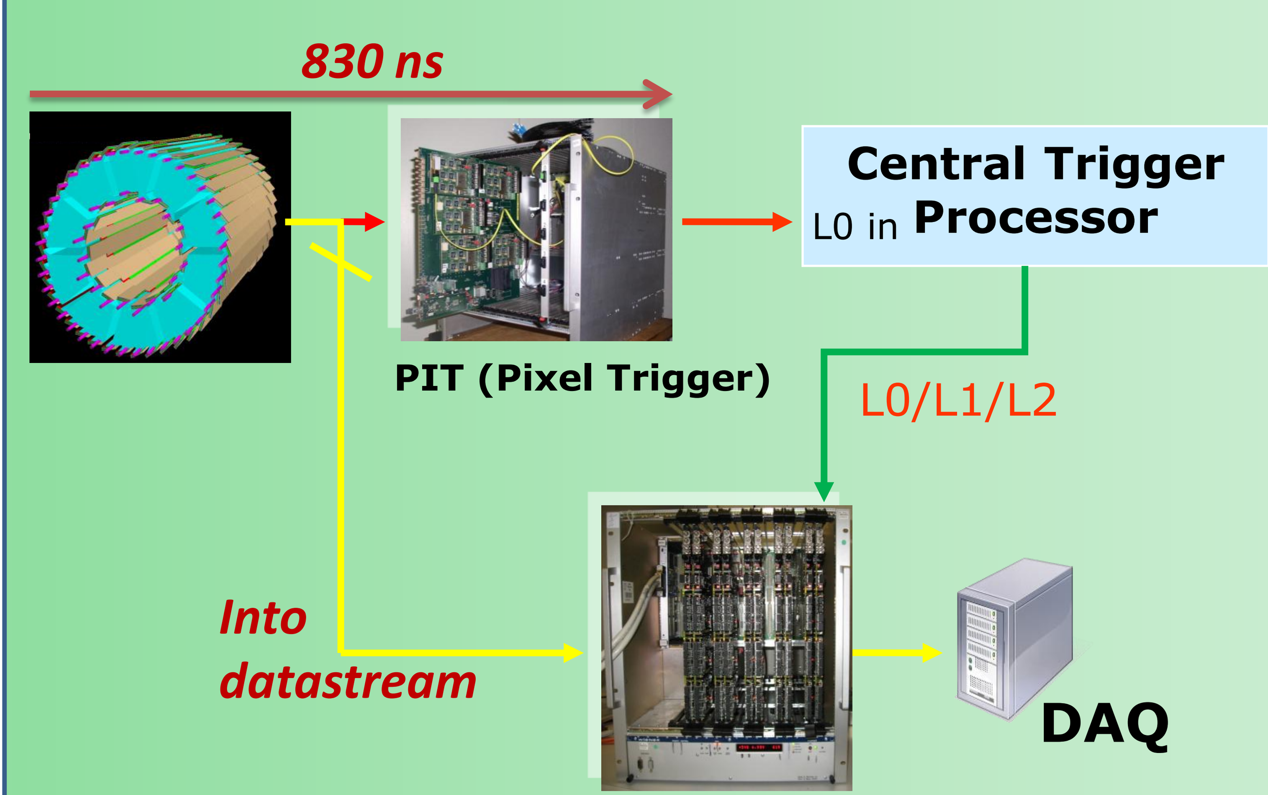


The unique feature of the SPD among the vertex detectors of LHC experiments is the prompt trigger capability called Fast-Or. The Fast-Or trigger has been used in the ALICE first level trigger decision for the whole cosmic, p-p and Pb-Pb data taking periods.

Fast-Or signal

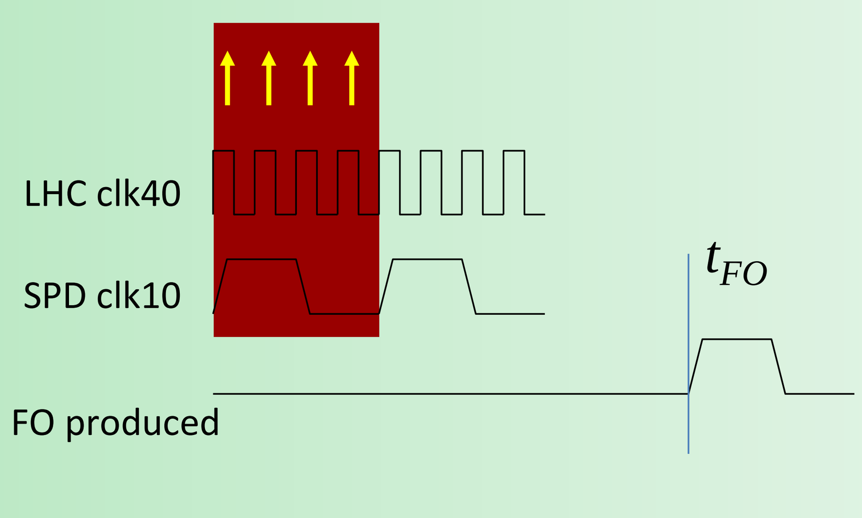


A digital signal called Fast-Or (FO) is promptly asserted on the presence of at least one pixel fired by each readout chip. A dedicate circuit generates the FO signal in each chip, in parallel of the pixel hit one. The 1200 FO signals are sent to DAQ for every triggered event by the readout electronics (yellow path in figure below).



The off-detector Pixel Trigger system (PIT)[2] elaborates in real time the 1200 FO signals continuously received from the detector in order to generate a pre-processed signal for the ALICE first level trigger. The PIT combines the 1200 FO signals by predefined algorithms. The algorithms can be based on coincidence logic and on a counting based logic. Multiplicity thresholds can be set on the number of chips asserting a FO.

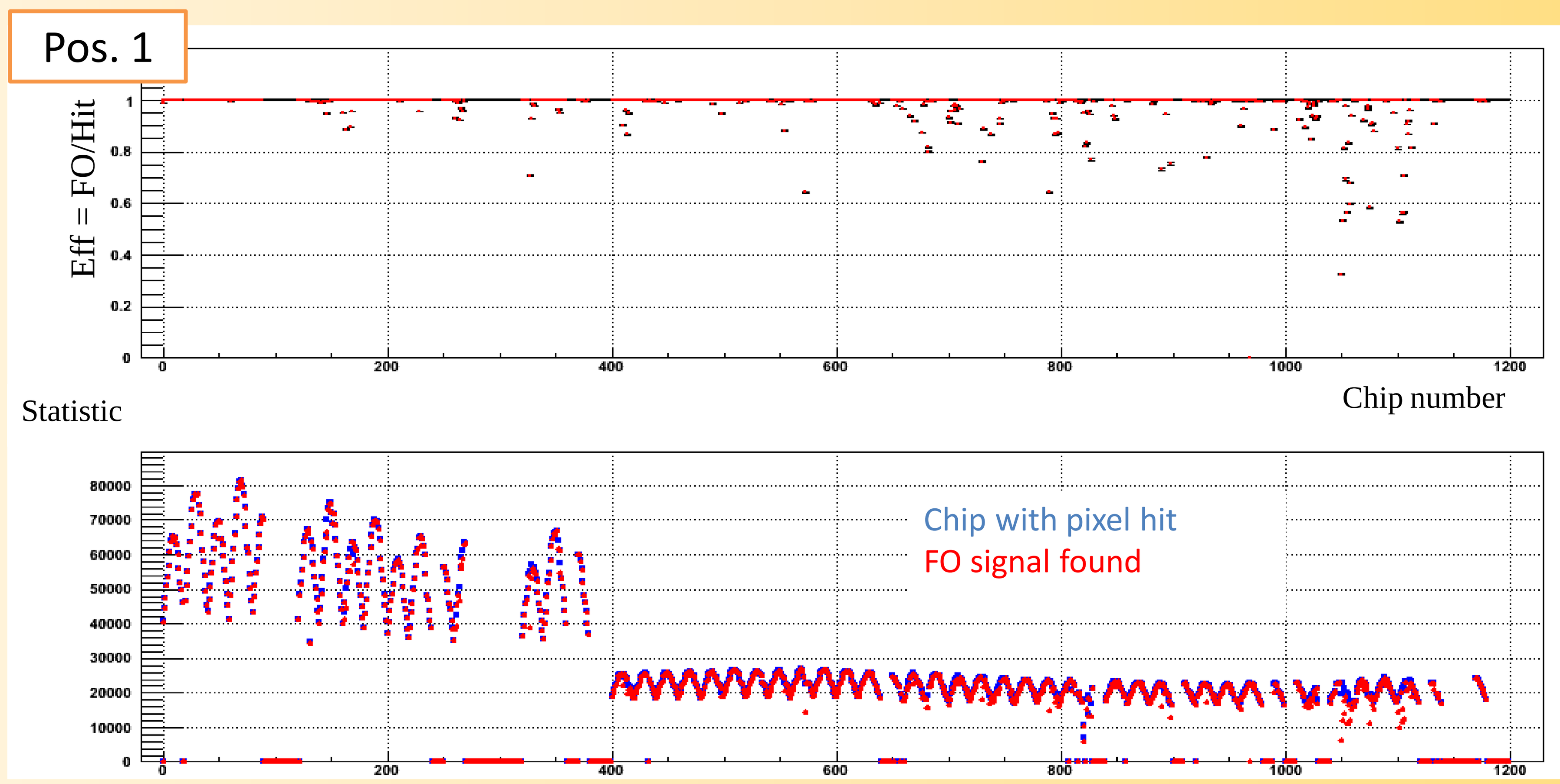
The ALICE Silicon Pixel Detector electronics works with a 10 MHz clock. The Fast-OR signals are synchronous to the internal clock. The LHC bunch crossing frequency is 40MHz. The SPD clock integrates 4 consecutive bunch crossing as showed in the figure by the red region. The yellow arrows are the positions where the interaction can occur, they are counted from 1 to 4, left to right respectively. The FO signal associated to all of them is the same and produced at the same time t_{FO}.



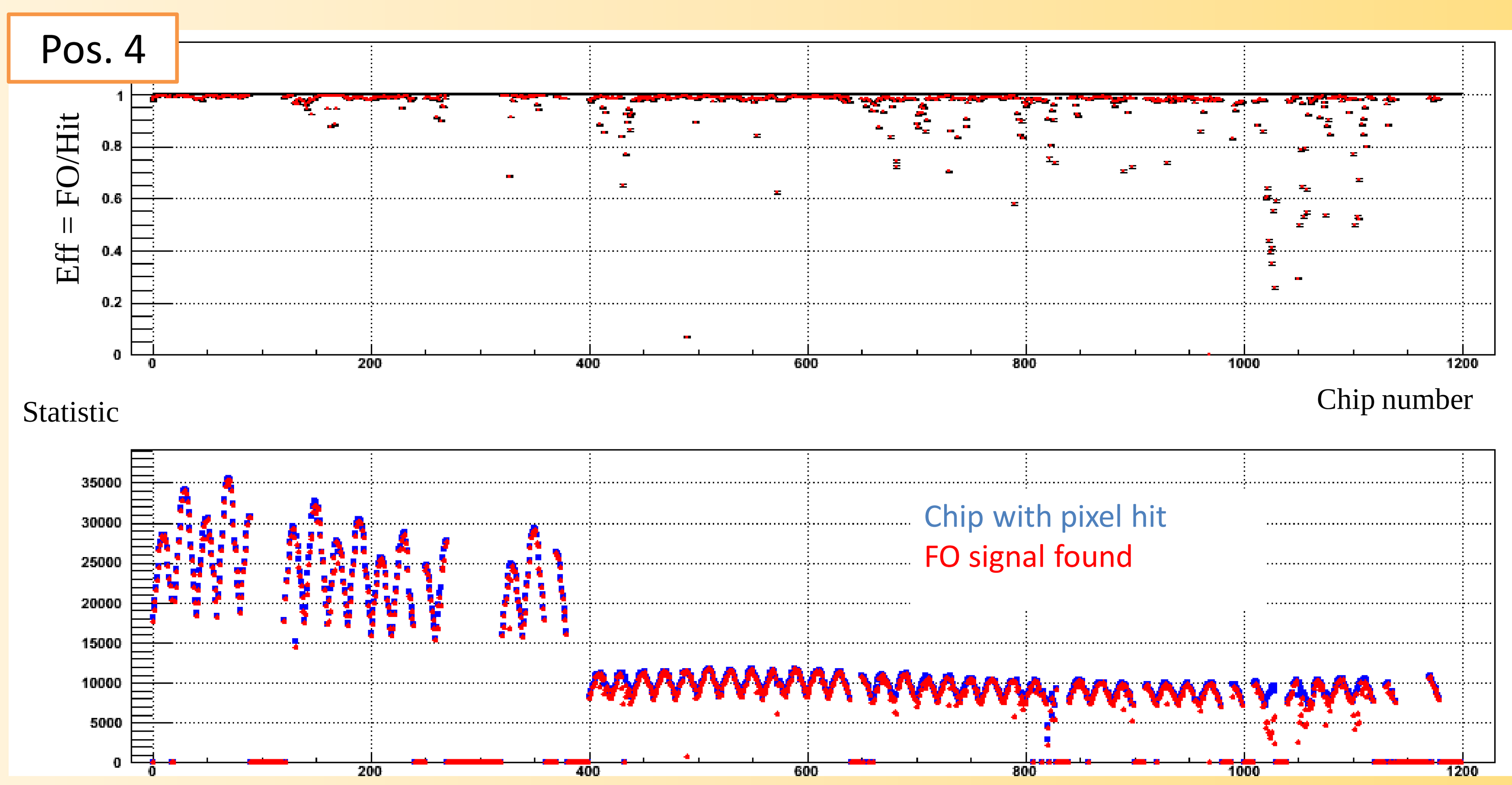
Data Analysis and Results

A method has been developed to evaluate the efficiency performance of the Fast-Or signal production for each of the 1200 readout chips. The method is entirely based on offline data analysis. It consists in checking whether a Fast-Or signal is produced or not when the chip matrix has been fired by at least one pixel hit. If the FO is found active the chip is considered efficient. The method is continuously used to monitor the quality of the FO performance. Data showed here were obtained from a sample of proton-proton collisions at $\sqrt{s}$ = 7 TeV.

In the figure below, top part, the chip by chip efficiency is shown. In the bottom part the statistic per chip when a pixel was fired (blue points) and a FO signal has been found (red points) is displayed. The efficiency is the ratio of these numbers.



The plot above has been obtained selecting events occurring in position 1 of the clock phase relationship. The same efficiency distribution is obtained when treating events in position 2 and 3. Position 4 is the one closest to the rising edge of the SPD clock. A reduction of efficiency is observed for this position: FO signals loose the correct timing and mismatch the corresponding hit data.



The table below summarizes the results of the integrated efficiency for all the 4 positions.

Eff. % Pos. 1	Eff. % Pos. 2	Eff. % Pos. 3	Eff. % Pos. 4
98,77	98,74	98,65	96,84

The method has been used to check the FO efficiency during the Pb-Pb run at $\sqrt{s}$=2.76 TeV. The same behavior per position has been observed. The higher density track enhances the overall FO efficiency. The table below summarizes the results of the integrated efficiency for all the 4 positions in lead-lead collisions.

Eff. % Pos. 1	Eff. % Pos. 2	Eff. % Pos. 3	Eff. % Pos. 4
99,23	99,22	99,17	98,46

The offline analysis developed is continuously used in ALICE to check also the correct online processing of the Pixel Trigger system. The PIT logic is applied offline on the data. The online information is then compared to the data and found to be in excellent agreement.

The studies of the Fast-Or signals efficiency has been taken into account to correct proton-proton data[3][4][5].

[1] The ALICE Silicon Pixel Detector, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 582, Issue 3, 1 December 2007,Pages 728-732

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[2] G. Aglieri Rinella et al., "The Level 0 Pixel Trigger system for the ALICE experiment", JINST 2 P01007, 2007

[3] ALICE collaboration, "First proton–proton collisions at the LHC as observed with the ALICE detector: measurement of the charged particle pseudorapidity density at $\sqrt{s}$ = 900 GeV", Eur. Phys. Journ. C, Vol.65, I.1, pp.111-125, 2010

[4] ALICE collaboration, "Charged-particle multiplicity measurement in proton-proton collisions at sqrt(s) = 0.9 and 2.36 TeV with ALICE at LHC", Eur. Phys. Journ. C68, pp.89-108, 2010

[5] ALICE collaboration, "Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s}$ = 7 TeV with ALICE at LHC", Eur. Phys. Journ. C68, pp.345-354, 2010

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