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ITkPix Read-out Chip Software Emulator for the ITk Pixel Online DAQ Software

Curiosity has pushed humankind to higher and higher extremes. One place where those extremes are reached is the Large Hadron Collider (LHC) at CERN. To push those extremes even further, the LHC will be upgraded to the High-Luminosity Large Hadron Collider (HL-LHC).

As one of the experiments performed at the LHC, ATLAS, will be upgraded as well. One of the upgrades is that the current Inner Detector will be replaced by the all-silicon Inner Tracker (ITk). In particular, the ITk pixel part will be composed of about 30 thousand ITkPix read-out chips. As a front-end chip, the ITkPix is responsible for reading out the connected 150 thousand sensor pixels. This includes both digitising the analogue signal, as well as providing information where on the chip the measurement was taken. The Data Acquisition (DAQ) read-out system is responsible for acquiring the data from all of the front-ends, and making the data available for further processing. Due to the high amount of read-out channels as well as the high radiation environment, the DAQ system faces tremendous challenges in both data bandwidth and signal integrity. As such the DAQ system needs to be validated before the commissioning of the new ITk. With the read-out software as the head of the chain, it needs to be running reliably to acquire data and test other components of the DAQ chain, ideally at a large-scale system level.

To help with the development and debugging of the read-out software, a software model of the on-detector hardware is needed. As such, this project focuses on developing a standalone C++ software emulator of the ITkPix front-end, which can be used for that purpose. The software emulator faithfully replicates the behaviour of the ITkPix-V2 chip, which is the final production read-out chip. For validation of the emulator, an already existing read-out chain operating a small setup connected real ITkPix front-end chip. With this, the read-out functioning of the emulator was proven to be perfectly accurate, compared to that of the real ITkPix FE chip. Following the validation the emulator will be integrated in the new Pixdaq software, allowing system-level development and debugging, but could also be later used during actual data taking for validation purposes.