

Silicon Strips and Pixel Technologies

Hands-on: Operate a mini HEP experiment

Aim

Operate a pixel detector system as in a real experiment, estimating the rate of cosmic ray rate with an array of ALICE pixel detector modules. A sample of cosmic ray events will be collected exploiting the self-triggering capability of the detector. A preliminary evaluation of the detector efficiency could also be done.

Introduction

An LHC experiment is a complex system of hardware and software components. For instance the detectors are underground in the cavern and when the beams are circulating the access to the underground area is forbidden. A Control System that works remotely is then necessary to operate and control the detector from the surface area.

In the next sections the detector and the software subsystems : the DCS, the DAQ and the Online monitoring will be briefly described. At the end a summary on how to operate a mini high energy physics tracker will be provided.

The participants at this session will be divided into 3 sub-groups to operate the detector and software sub-systems.

- mini HEP experiment components -

Detector: The detector of the mini-HEP experiment resembles the ALICE Silicon Pixel Detector. Its basic component is the half-stave, which consists of two ladders and one Multi-Chip Module (MCM). The former consists of a silicon sensor matrix which includes 250×160 cells (measuring $50 \mu\text{m} \times 425 \mu\text{m}$ each) and that is bump bonded to 5 front-end chips as shown in Figure 1. The latter is the device responsible of the half-stave readout.



Figure 1 : Sketch of the half-stave assembly: the two ladders (5 readout chips each) and the MCM.

Each chip, then, contains 32 (160 channels divided by 5) \times 256 channels. In summary our detector will have 3 half-staves of 10 chips each for a total of about 3×10^5 read out channels

(327680=256*160*2*4). On top of the pixel signal, the HS provides the FastOr signal which is a digital signal as well. A FastOr signal is generated by a chip if at least one pixel inside it provides an hit (please note the different granularity of the two signals).

Detector Control System (DCS) : In a control room the switching on/off of the detector and its Front End Electronics (FEE) configuration must be done by means of the DCS. The SPD DCS is a distributed control software whose main control panel is shown in figure 2.

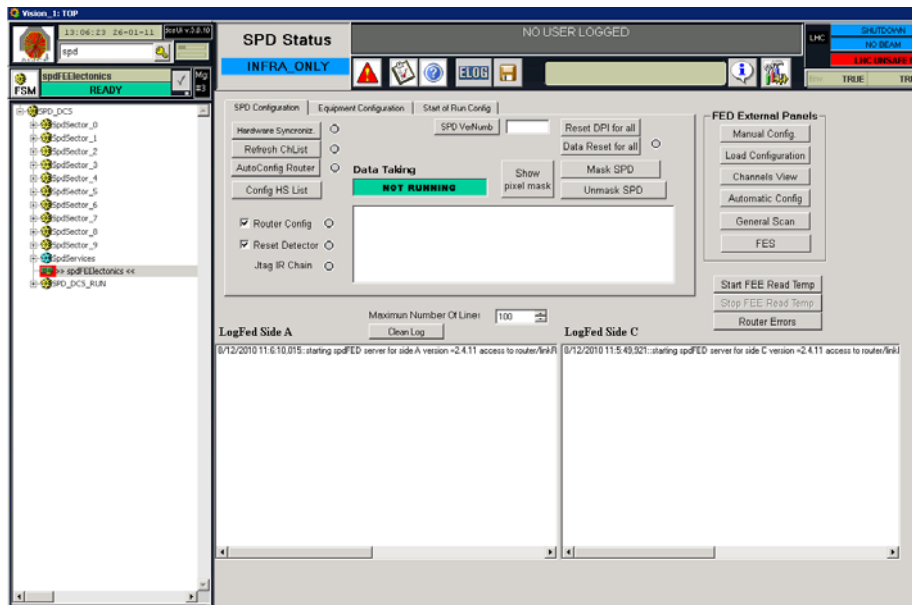


Figure 2 : The Detector Control System main panel

Data Acquisition (DAQ) : Every data acquisition requires a configuration and the definition of parameters and options. The acquisition itself is driven by the Trigger. The trigger consists of a complex of logic operations among detector responses (e.g.: coincidence between forward detectors when the beam is passing through the experiment) or by a clock pulse at a specific rate which is used for detector calibrations. The main system which centrally manages the experimental trigger is called Central Trigger Processor (or CTP). The trigger settings play a crucial role in an experiment, therefore the laboratory experience will allow the operators to configure it as a function of the measurements to be done. Then, by means of some interactive programs, the operator chooses the running conditions and can control the setting of the machines involved in the data acquisition (e.g.: max file size). The main panel of the DAQ run Control User Interface looks like the one in figure 3.

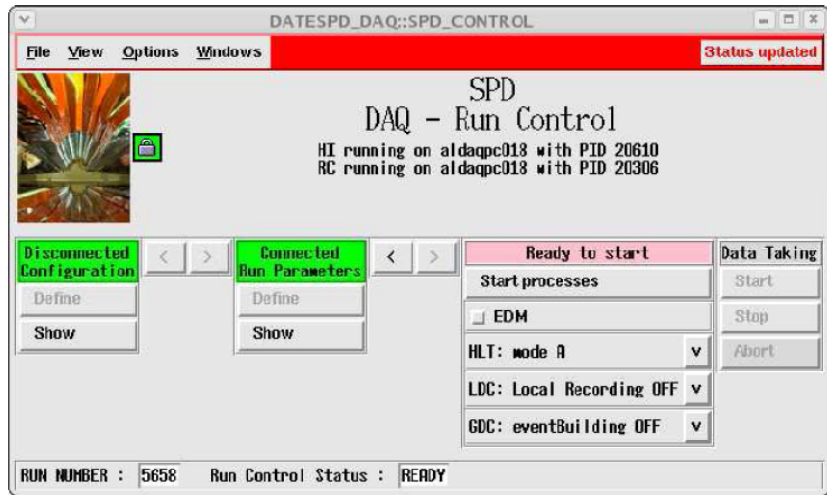


Figure 3 Run Control panel for the DAQ

Online Monitoring : the aim of the Online monitoring is to look at the data coming out of a detector as soon as they are read out and to provide the first feedback on the data quality. A set of meaningful histograms should be defined first and automatic checks should be decided to drive the operator attention towards the proper histogram to be looked at. LHC experiments have developed specific frameworks to monitor both detectors and central services (e.g.: read out rate, trigger rate, data size, etc). SPDMOOD will be the monitoring tool of the laboratory experience and the figure 4 shows an example of its pixel hitmap as taken during the detector commissioning phase. Please note that there are more than 2000 histograms hidden in SPDMOOD!

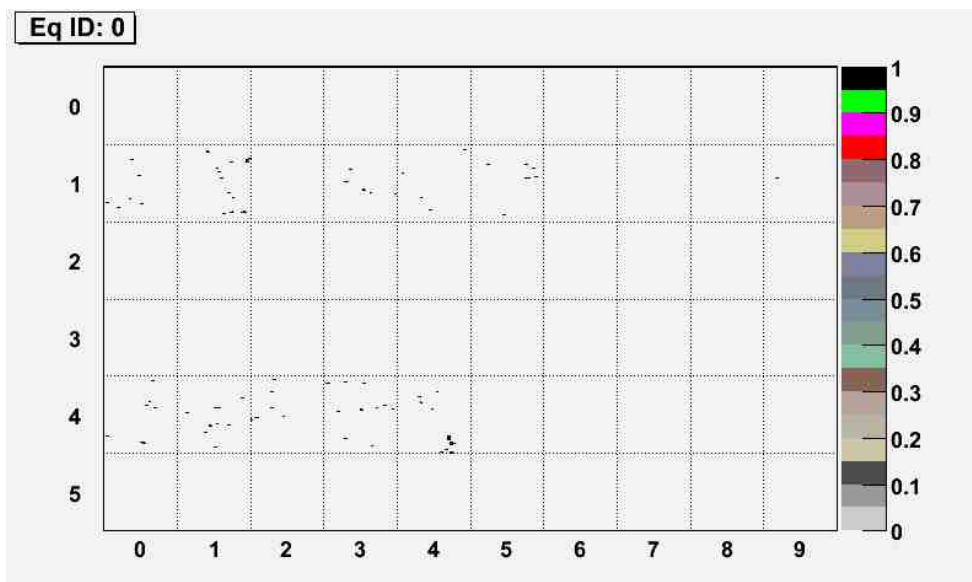


Figure 4 : Pixel hitmap from SPDMOOD, the online monitoring tool. A couple of Half Saves were put in coincidence for cosmic ray rate measurement

Apparatus



Figure 5 : A schematic view of the apparatus. 1) DAQ station, 2) DCS station, 3) Online monitoring station and 4) Planes containing the ALICE pixel detector half-staves. The bottom left picture shows a detail of the 4 planes with the 4 half-staves and the cooling (black box).

- How to operate an HEP experiment -

LHC experiments have several components which should interplay with each other to provide data for the physics analysis : detectors, services as cooling systems and power supplies, the DCS, the DAQ and the Online monitoring. To take data the first step is to configure the detectors and the acquisition. As soon as the runs starts people devoted to the monitoring procedure control the data flow by means of the available online monitoring tools. Given the complexity of a HEP experiment a Run Coordinator is also necessary to coordinate the activities among the various subsystems, every brave student is welcomed to play such a role!. The Run Coordinator is in contact with the physics board members and the experiment is run as a function of the priorities chosen by the physics board itself. The physics board of the mini-HEP experiment has decided to measure the cosmic rate in the experimental area to test the level of the detected background, so please start the measurement!.

Experiment configuration

Detector : to operate the ALICE silicon pixel detector the first steps consist in applying the proper voltages to the sensors (2 step procedure) and to the FEE. This is done by means of the DCS system.

The list of actions to be taken is the following one (please mark the “Done” cell if the operation was done correctly or add a comment) :

| Action | Done | Comment |
|--|------|---------|
| 1) Bring each HS to the “MCM_ONLY” state | | |
| 2) Bring each HS to the “STBY_CONFIGURED” state | | |
| 3) Click on “Config HS list” on the main SPD DCS panel [Check that T < 40°C] | | |
| 4) Bring each HS to “READY” state (Click on “GO_READY”) | | |

List of actions to check the read out configuration (please mark the “Done” cell if the operation was done correctly or add a comment):

| Action | Done | Comment |
|---|------|---------|
| 1) Check the channels view | | |
| 2) Click on “Manual Config”, then check the “Router settings” tab and compare the active channels | | |
| 3) Click on Autoconfig Router | | |

Data Acquisition : an important role is played by the choice of the trigger for the measurements. The first runs are necessary to calibrate the detector, therefore at the beginning a pulse at a predefined frequency is chosen. Later on a self triggering mode will also be used. The trigger configuration is chosen by means of the CTP emulator system.

List of actions to configure the DAQ (please mark the “Done” cell if the operation was done correctly or add a comment):

| Action | Done | Comment |
|---|------|---------|
| 1) Set the trigger mode to BC in the CTP emulator | | |
| 2) Start the run and then the emulation | | |
| 3) Stop the emulation and then the run | | |

Online Monitoring : The tool should be configured by checking its input data source (it must correspond to the LDC defined in the DAQ Run Control panel) and the file format (it must be a *date* file). As soon as the run starts the data is decoded and the histograms start filling. In calibration runs the pixel hitmap is always open as event display during data taking. SPDmood is also able to search for noisy pixels and to print them on the screen. List of actions to configure the monitoring system (please mark the “Done” cell if the operation was done correctly or add a comment) :

| Action | Done | Comment |
|---|------|---------|
| 1) Set the input data source | | |
| 2) Get the pixel hitmap histogram (plus other histograms if it helps) | | |
| 3) Click on “RUN” in the SPDmood main panel | | |

Measurement 1 : Calibration

The first measurement is actually a calibration procedure which consists in the noisy pixel search and their masking. To this aim one has to set the BC mode (clock pulse at 40 MHz) in the CTP emulator. The run should start first and the CTP emulation follows. After a while the operator should stop the run, go to the SPDmood main panel, click on “Operations” and follow the instructions. Eventually the operator should print the found noisy pixels and ask to the DCS colleague to set them in the Pixel Mask.

List of actions to start the calibration (please mark the “Done” cell if the operation was done correctly or add a comment) :

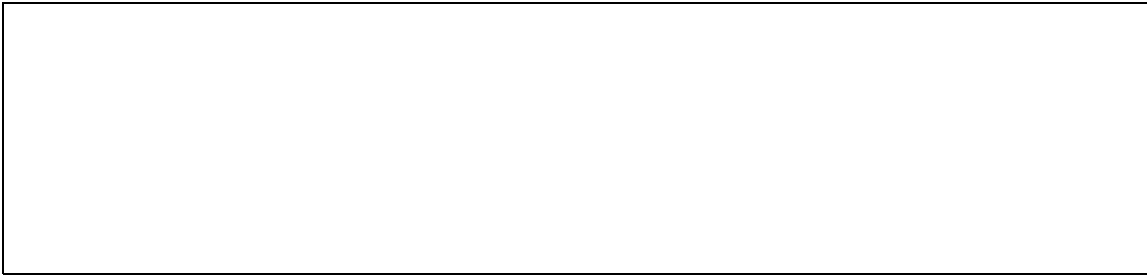
| Action | Done | Comment |
|---|------|---------|
| 1) General Reset : “AutoConfig Router”, “Reset DPI for all”, “Data Reset for all” | | |
| 2) Check DB version number. In the calibration phase it should be 53 | | |

Please take note now :

| Run Number | Trigger mode | # events | Min. # hits | # noisy pixels | Threshold |
|------------|--------------|----------|-------------|----------------|-----------|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Question: What if the threshold (pre_VTH) increases to 210 or decreases to 170 ?

Question : What if the self triggering mode is chosen?



Measurement 2 : Cosmic ray rate

The main measurement of the course assumes that the apparatus has no relevant noise contribution and its efficiency is known. The noisy pixels have been removed and the FastOr signals are not noisy, therefore the first assumption is correct. The second assumption would mean that the *triggering* HS are fully efficient and for “sake of time” we believe it. The signal coincidence between the outermost half-staves, then, is a good trigger signal to take a cosmic ray event. The data acquisition should be in self triggering mode and the SPDmood will provide the event display so that the passage of the cosmic ray will be observed really online.

Once the run is started, the number of triggered events and the run duration time will estimate the cosmic ray rate. Since the cosmic rate is expected to be around $8 \cdot 10^{-3}$ Hz some time is needed to reduce the statistical error.

List of actions to start the physics run (please mark the “Done” cell if the operation was done correctly or add a comment) :

| Action | Done | Comment |
|---|------|---------|
| 1) Check DB version number. In the calibration phase it should be 54 | | |
| 2) Configure the PIT trigger algorithm | | |

Please take note :

| Run Number | # events | # time duration (s) | rate |
|------------|----------|---------------------|------|
| | | | |

| | | | |
|--|--|--|--|
| | | | |
| | | | |

Question: What is the effect of the presence of noisy pixels?

(Optional)

It is also possible to measure the efficiency of the middle HS just counting the number of events with 3 clusters (one cluster per plane). If time allows it, the efficiency will be then the ratio of the number of such events over the number of triggered events.

| Run Number | # events | # events (#clusters >= 3, 1 per plane) | efficiency |
|------------|----------|--|------------|
| | | | |
| | | | |
| | | | |