Tests of Strip Detectors for ATLAS Upgrade

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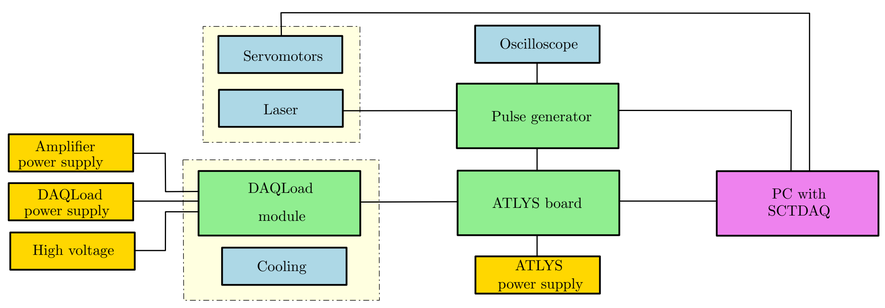
Introduction

There are several options for testing detection properties of a silicon strip detector. We can use a source of β-particles, laser or test beam. However test beam best simulates conditions in real experiment, it is quite expensive and also it is not that easily accessible with respect to the first two mentioned methods. Advantage of laser tests with respect to the β-source tests is that laser beam can be precisely positioned and so hit only specific part of the detector. Spot of a well focused laser on the detector is a few microns in diameter (which is smaller than the gap between two strips). Presented work is dedicated to laser testing of strip detectors at laboratories of Institute of Particle and Nuclear Physics in Prague.

Experimental setup

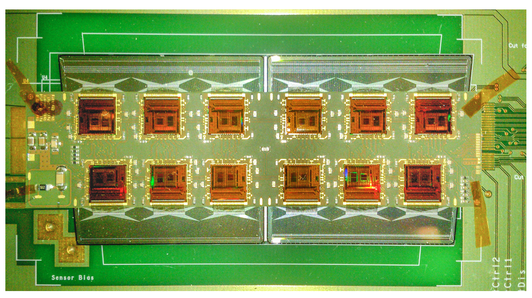
For all measurements performed within presented work we used following experimental setup. Computer is the part of the experiment where all measurements are controlled from and SCTADQ is a software used for acquisition, visualisation and analysis of measured data.



- Computer - provides control of whole setup
- Pulse generator - used for pumping of active medium in laser
- DAQLoad module - data acquisition module containing control/readout hybrid and strip detector
- ATLYS board - communication interface between computer, DAQLoad module and pulse generator

Silicon strip detectors

Silicon strip detectors work on a principle of collection of charge generated by particle passage. During our tests, we were using binary readout (as in real experiment) where we have information only about whether a signal detected on a strip is higher or lower than defined threshold.

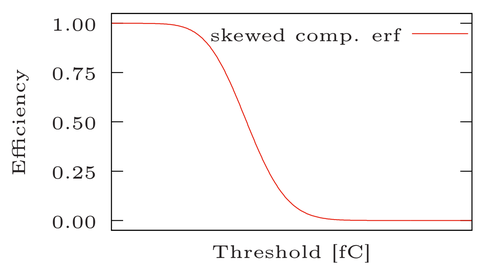


Detector info: 300 μm thick n-type Si bulk, 2.38 – 4.78cm long strips.

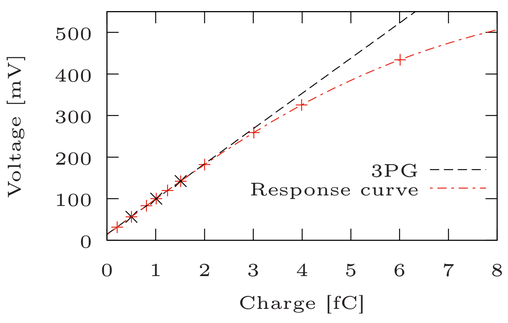
Types of tests

In this part we present types of tests we used during our measurements.

Threshold scan is a basic test in which we study relation between number of detected hits from set of trials and threshold. Result of threshold scan is skewed complementary error function (see the figure).



Response curve and 3PG are relations between signal from the detector given in mV and collected charge in fC. Sometimes we do not need whole response curve (RC), but only its part which can be approximated by liner fit of three points on RC. This fit is called three point gain (3PG).

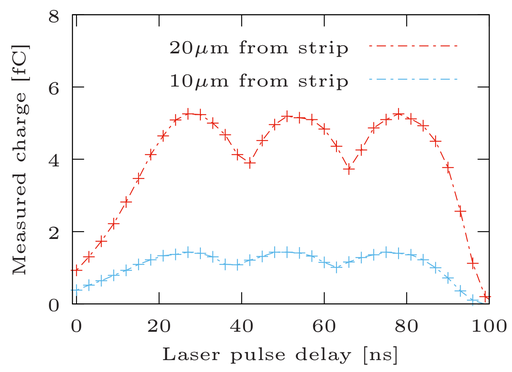


In **Trigger delay scan** we measure relation between detector response and time delay of laser pulse with respect to the readout.

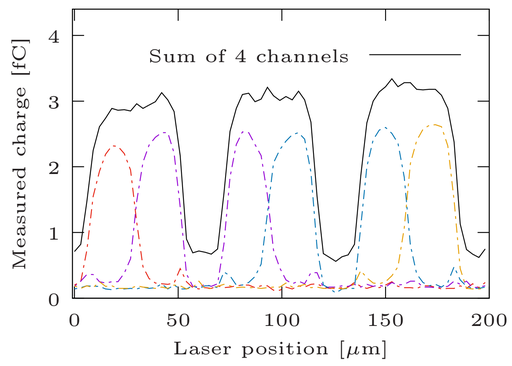
Interstrip scan is a type of measurement where we study the relation between the response of a detector and a position of laser beam. It is an important test of a detector, thanks to which we can study the way in which the collected charge is distributed between strips.

Results

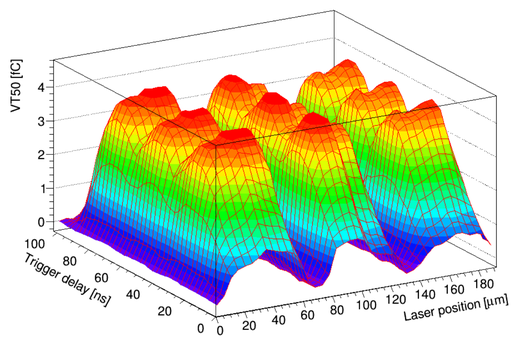
- One of the tests we performed was **trigger delay scan**. From this measurement, we could estimate values of trigger delay when the signal from the detector is the highest. It can be also seen that not only timing but also position of the laser directly influences strength of the signal, i.e. amount of collected charge.



- Further we did **interstrip scan**. We studied signal from individual strips and also the sum of signals from all the strips. Based on this measurement we can decide whether the charge is collected properly (e.g. does not get lost).

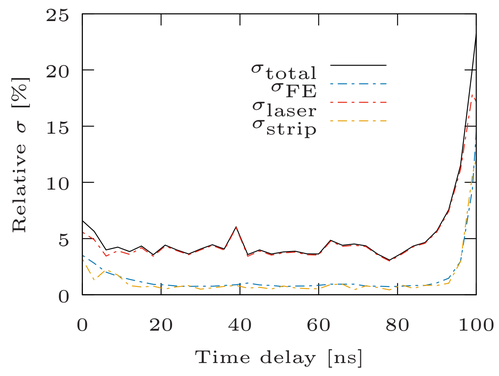


- Finally we performed **two-dimensional scan** where we changed both, the trigger delay and the laser position. This measurement helped us to better study relation between these two parameters and a signal strength.



- Additionally we tried to estimate contribution of different effects on total uncertainty of measurements. We extracted these pieces of information by combining results from several measurements of detector response with and without laser and the fact that holds

$$\sigma^2_{\text{total}} = \sigma^2_{\text{strip}} + \sigma^2_{\text{FE}} + \sigma^2_{\text{laser}}.$$



Comments

Two effects affecting our measurements are presented here. One effect are thermal changes in clean room during measurements. Those changes mainly influence power of the laser. Even though we measured mostly during the night when there is nobody in the clean room and thermal changes should be small, it is important to be aware of this problem. Our tests seem to observe also dependencies of air humidity.

Conclusion

Presented work helped to refine the testing procedure of response from the detector as a function of trigger delay parameter and laser position. Performed measurements contributed to certain extent to understanding the detection properties of newly produced pieces of strip detectors which will be placed in the ATLAS Upgrade experiment.