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JRA2 SITRA Forward Tracker Prototype

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Abstract

The SITRA Forward Tracker Prototype is a prototype for a tracker module that can be used in test beams for identifying tracks of particles passing the test setup. It consists of new front end and readout electronics chips produced in 2008 in 130nm technology coupled to specially designed Hamamatsu silicon strip sensors.
This prototype is a completion of a EUDET deliverable No. JRA2-D15.

1 Introduction

During 2008 the work on the forward tracker prototype (deliverable No JRA2-D12) was accomplished. The forward tracker prototype comprises of Hamamatsu silicon strip sensors mounted together with FE chips at the mounting structures. Several modules are equipped with the novel specially treated sensors that allow using infra-red laser to align the detection modules. The modules are now under tests in LPHNE and will be tested at the beams in 2009.

2 Sensors

2.1 Basic parameters

Dedicated silicon strip sensors have been designed by HEPHY Vienna and manufactured in Hamamatsu (see Fig. 1). The wafer was approximately 320 micron thick and a resistivity of 6.7 kΩcm of the bulk material was chosen such that the full depletion voltage of the sensor fell between 50 and 100V. The sensors are single sided AC coupled and their dimensions are 91.5 x 91.5 mm^2. They have 1792 readout strips with a strip pitch of 50 µm. The strips are connected to the bias line using poly-silicon resistors with a resistance of 20MΩ. More details about the sensors can be found at [1].

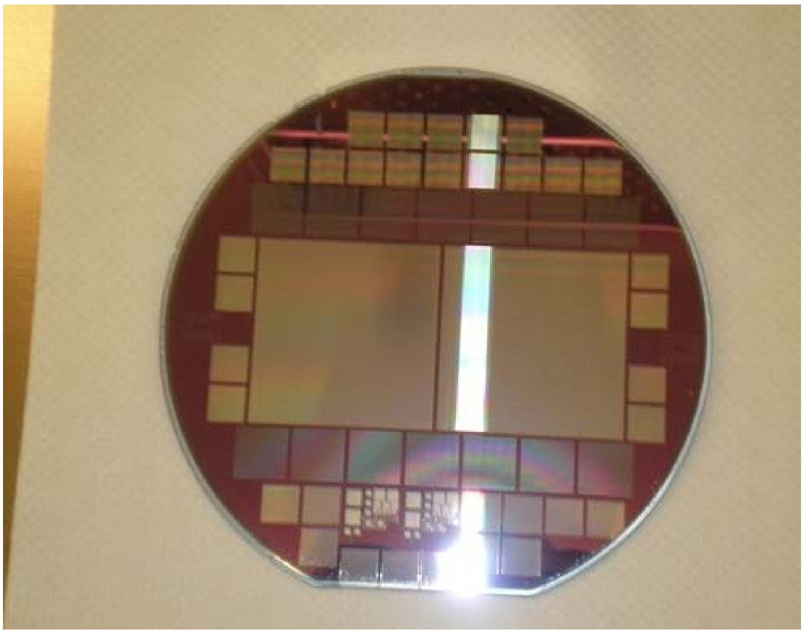

Figure 1: Hamamatsu silicon wafers

Fig. 2 shows test results of the sensors achieved in HEPHY Vienna.

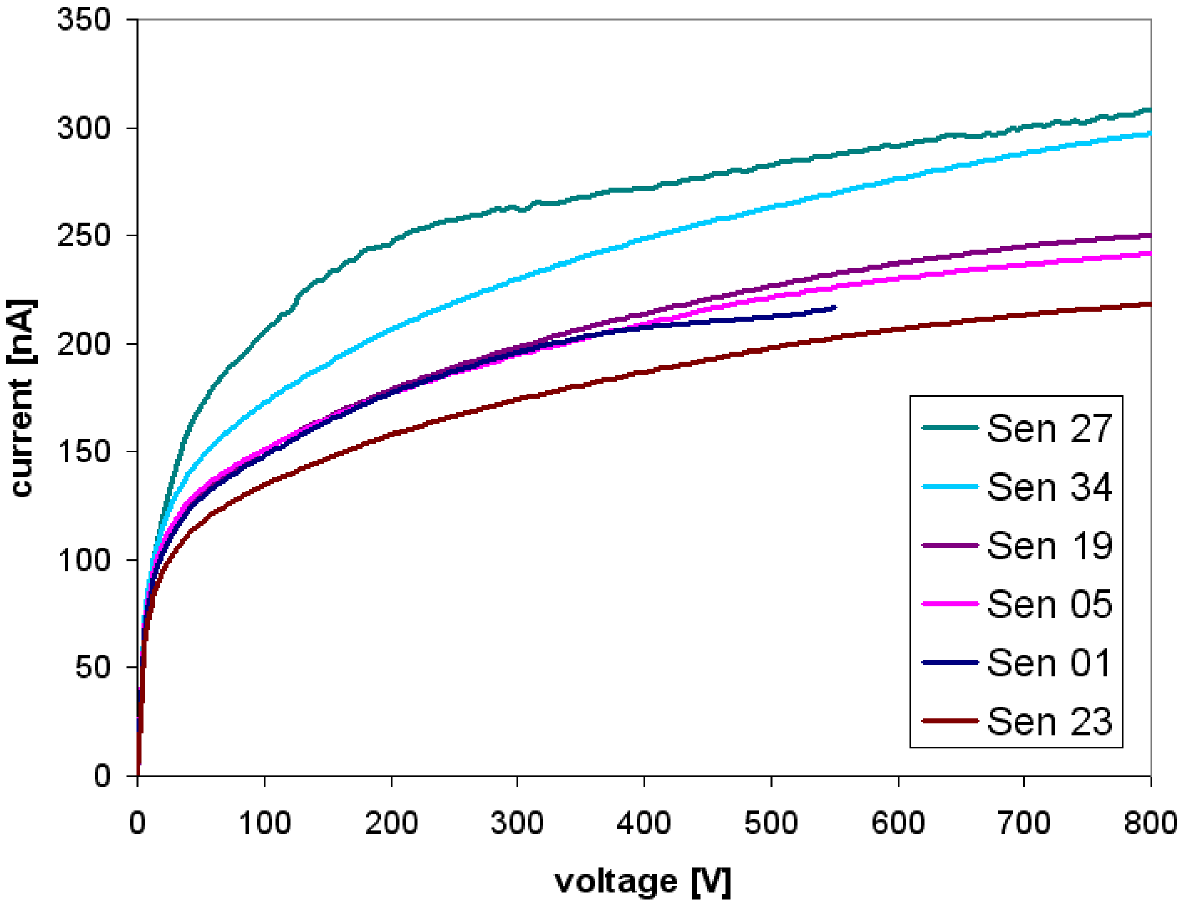

Figure 2: IV curves of Hamamatsu sensors

2.2 Optical treatment

Three of the sensors integrating the forward tracker prototype were special alignment sensors. These are normal HPK detectors with a 1 cm diameter hole in the Al back plane. The hole is placed at the same position across the three modules. Since infrared (IR) light is partially absorbed in Si (a fraction is reflected and the rest transmitted), an IR beam can be used to produce a pseudo-track crossing several consecutive modules. Note that, if the 3rd detector is still transparent, the 4th module can also be aligned with the same laser beam.
We equipped the prototype with 3 such sensors and chose a 1060 nm diode laser coupled to a fibre as light source. From the 2 detectors that make the module, only one is an alignment sensor. The chosen modules are the 2nd to 4th beamwise. The IR beam is delivered via optical fibre. Only the fibre and its collimator are placed inside the detector box. The diode itself plus associated electronics are conveniently placed out of the box. The transmittance of the modules to the chosen wavelength was measured in the laboratory, before the detectors were mounted in the modules. We obtained a mean value of T[λ=1064 nm]=16% with a spread below 1%. Since the sensors were not anti-reflection coated, we tilted the 3 modules by 1 deg to avoid the back-reflection to travel along the forward-going beam.
The built-in alignment system can then be used to monitor the internal stability of the ensemble. The system is only operated during particle beam off. The signal produced by the laser can be readout using the own detector electronics, so no special needs for special front-end electronics or DAQ is needed.

The CSIC-Santander group (IFCA) is currently developing a transparent microstrip detector which introduces minor changes to the layout but manages to boost transmittance beyond 70% at a design wavelength. Further details can be found in reference [2]

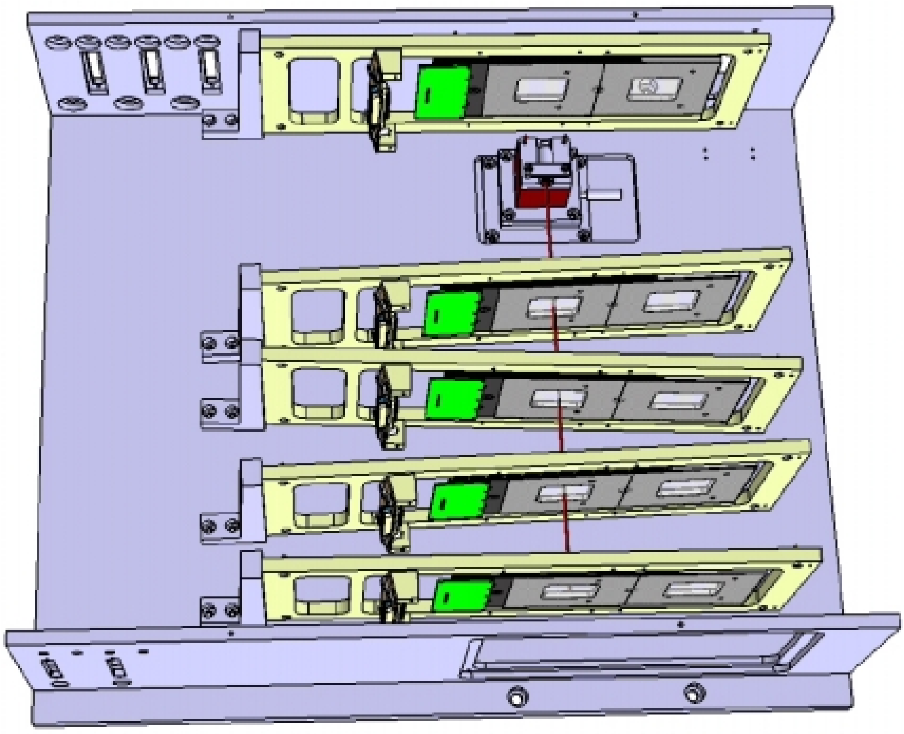

Figure 3: Extruded view of the Faraday cage showing the 5 modules, 3 of them modified for IR beam transmission. A block containing the laser beam collimator can be seen between 1st and 2nd modules.

3 Electronics

In the context of the Silicon for a Linear Collider (SiLC) R&D, a highly compact 88-channels mixed-signal chip has been designed in 130nm CMOS technology intended to read Silicon Strip detectors for the experiments at the future International Linear Collider. The chip is designed in collaboration between the Paris High Energy Physics Laboratory (LPNHE Paris) and the Electronic Department at the University of Barcelona. Optimized for a detector capacitance of 10pF, it could be configured according to the detector to be implemented. It includes eighty eight channels of a full analog signal processing chain and analog to digital conversion, with the corresponding digital controls and readout channels. The chip is 5x10mm^2 where the analog implementation represents 4/5 of the total silicon area.
Key part of the schematics is displayed in Fig. 4.
The chip parameters as well as the achieved chips performance is described in a detail in [3].

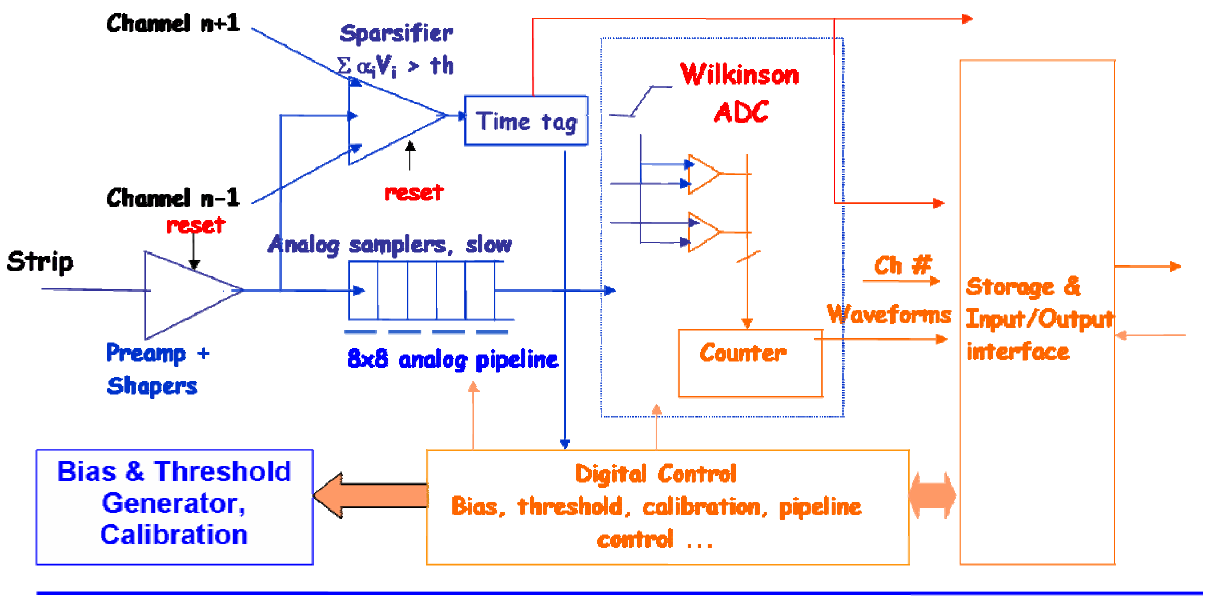

Figure 4: Schematics of the SITR chip

4 Mechanics

Sensors with electronics have been mounted on a special frame, which provided both sufficient mechanical stability and good thermal performance. The module drawing can be seen at Fig. 5.

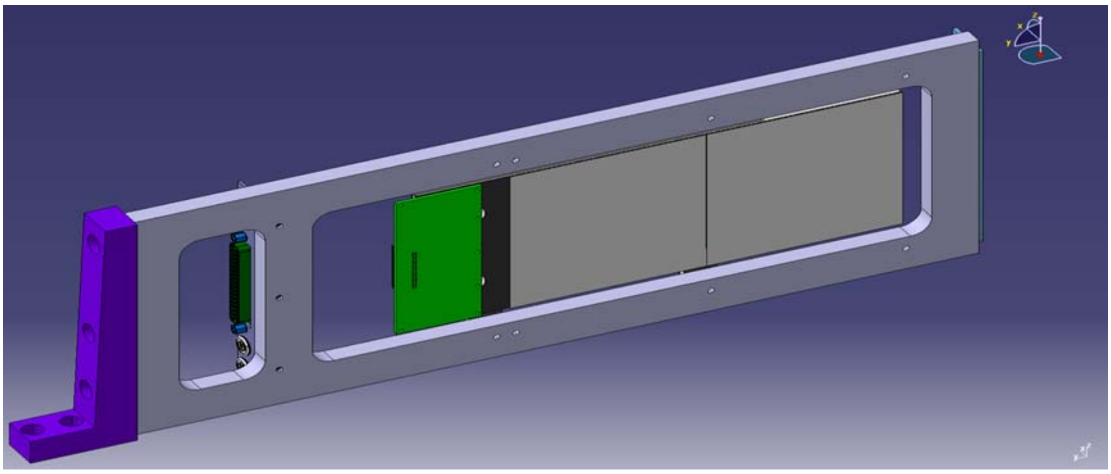

Figure 5: Drawing of the tracker prototype

The module prototypes have been produced in LPNHE Paris. Fig. 6 shows the tooling for module production.

Figure 6: Tooling for prototype production in Paris

Final prototype can be seen at the next Fig. 7.

Figure 7: Final tracker prototype

5 Conclusion

A forward tracker prototype, made of silicon strip sensors, dedicated front end chips and support structure has been completed by the institutes of the JRA2-SITRA task of EUDET.

Acknowledgement

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References

[1] T. Bergauer et.al.:Generic Silicon Strip Detector R&D, EUDET-Memo-2007-27

[2] M. Fernandez et at.: Experimental validation of optical simulations for microstrip detectors, EUDET-Memo-2008-37

[3] J-F. Genat et al.: Silicon Strips Detectors Readout ASICs in Sub-Micron CMOS Technology, EUDET-Memo-2008-28