Beam Test Results for the SuperB - SVT Thin Striplet Detector

SuperB-SVT Project

The SuperB B-factory is expected to deliver luminosity in excess of 10^{36} cm^{-2} s^{-1} using a new beam steering technique that implies a reduced center-of-mass boost with respect to previous B-Factories (BaBar and Belle). This forces the SuperB detector to improve on typical vertex resolution.

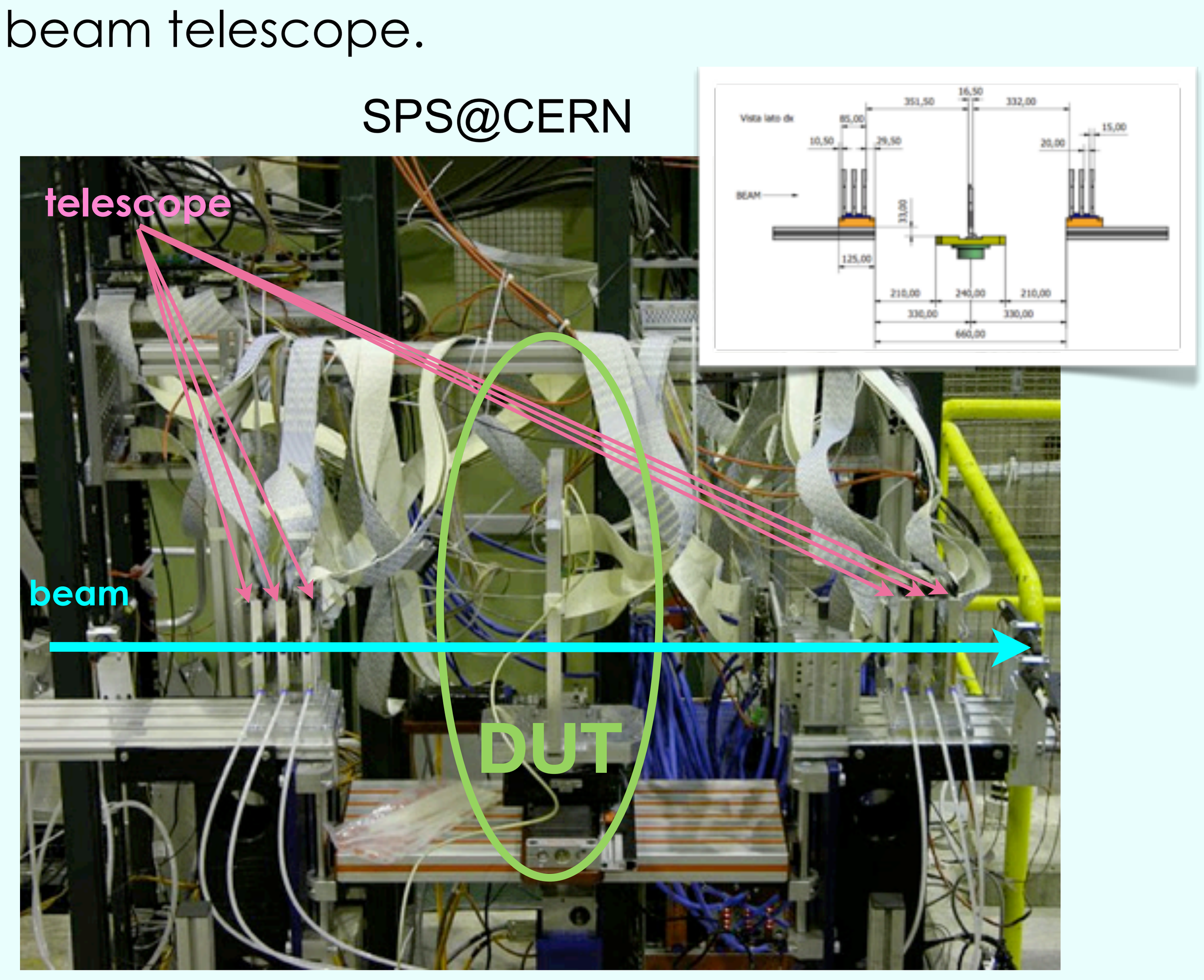
In order to achieve precise measurements near the interaction point, the SuperB Silicon Vertex Tracker (SVT) will need a first layer very close to the beam pipe (Layer0). The requirements for the Layer0 will thus be very stringent in terms of granularity, readout speed, material budget and radiation tolerance. Several options have been considered and in the baseline choice the Layer0 will be based on high resistivity sensors, with a thin silicon substrate (200 μm) and short double-sided strips (striplet detector or "Striplets") at ± 45° angle to the detector's edge.

Furthermore, due to the device geometry, charged particles will form very high incident angles with the detector. A good spatial resolution at angles up to 70° is an additional requirement.

Beam test setup

In September 2011 the SuperB collaboration submitted low material budget silicon demonstrators to test with 120 GeV/c pions, at the SPS-H6 test-beam line at CERN. Three different types of detectors were placed as DUTs inside a high-resolution and fast-readout beam telescope.

SPS@CERN



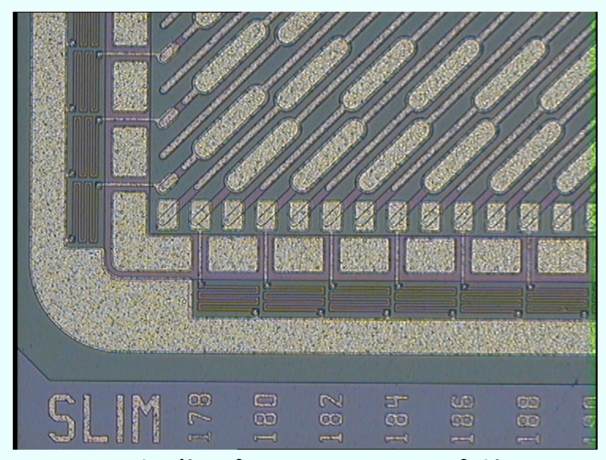
The first DUT was a high resistivity double sided silicon detector, with short strips ("striplets") at 45° angle to the detector's edge, readout by a data-driven FSSR2 chip.

An other DUT was a prototypes of a new hybrid pixel detector with a 200 μm thick sensor and 4096, 50μm x 50μm pixels (SuperPix0).

Finally, a small (18 pixels) Monolithic Active Pixel Sensor (MAP) was also tested.

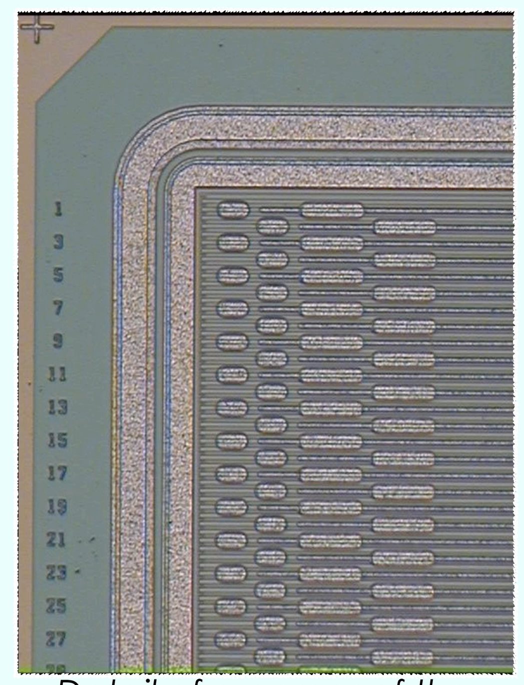
This poster is focused on preliminary results concerning the striplets devices.

Striplets detector:
Strips are tilted by 45°
50 μm pitch
active area
27 x 12.9 mm^2 and
200 μm thick.
Strip cap. ~4 pF



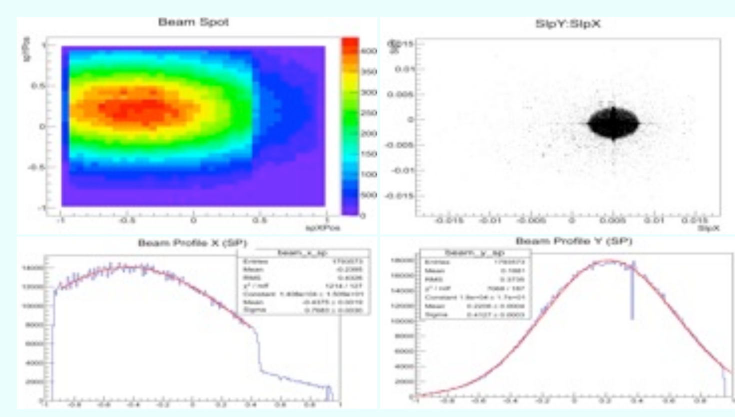
Detail of a corner of the striplet detector.

Telescope: 6 modules 300 μm thick double-sided silicon strip detector with orthogonal strips,
384 channels / side.
Area ~ 19 x 19 mm^2
25 μm pitch on p-side with 50 μm readout
50 μm pitch on n-side
Strip cap. 4.3 pF,
Fanout cap. 0.7÷1.3 pF



Detail of a corner of the telescope strip detector.

Beam: 120 GeV/c charged pions; spills lasting 9.5s any 40s, widths of about 8 and 4 mm rms on the horizontal and vertical planes respectively.



Both the telescope strips and the striplets are read out by the FSSR2 Chip, completely data-driven. Each chip reads 128 strips. Digital output providing: address, time stamp, 3 bit amplitude
Can be readout up to 70 MHz readout clock, but operated at ~20 MHz, allowing a max data transmission rate of 240 Mbit/s over six lines.

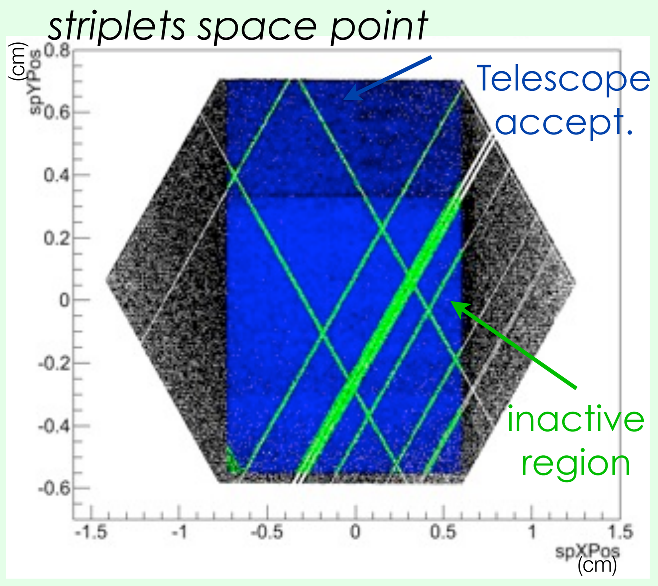
Analysis results

Two striplets detectors are tested. For each device several sets of thresholds are used. In the first one the highest threshold (hit - no hit) is set to 20 ADC counts, corresponding to ~20% MIP, and it is compared to the lowest (15 ADC counts).

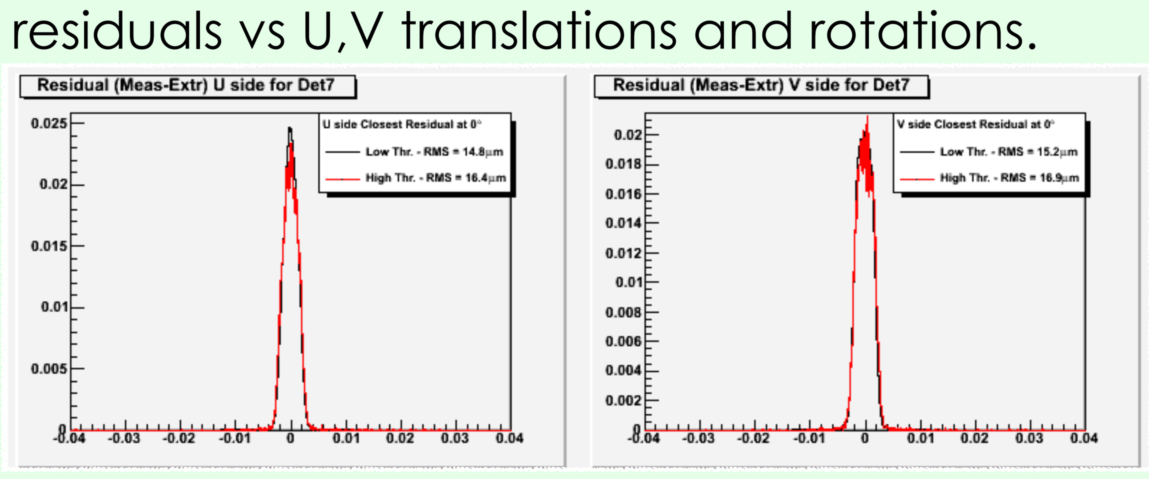
To check the performance at different angles of incidence several angular scans are carried out up to 70° w.r.t. beam axis.

For all the collected runs, single side and total efficiency, clusters size and resolution are studied.

Event selection: Trigger requires at least one hit on 4 telescope modules. Least Square Method to extract track parameters is used. Events with more than one track are skipped. Events with tracks hitting inactive or hot strips and their closest channels are excluded from efficiency calculation.



Alignment and DUT Residuals: select events with only one track passing from DUT active area, compute residuals for DUT space points, perform iterative alignment minimizing residuals vs U,V translations and rotations.



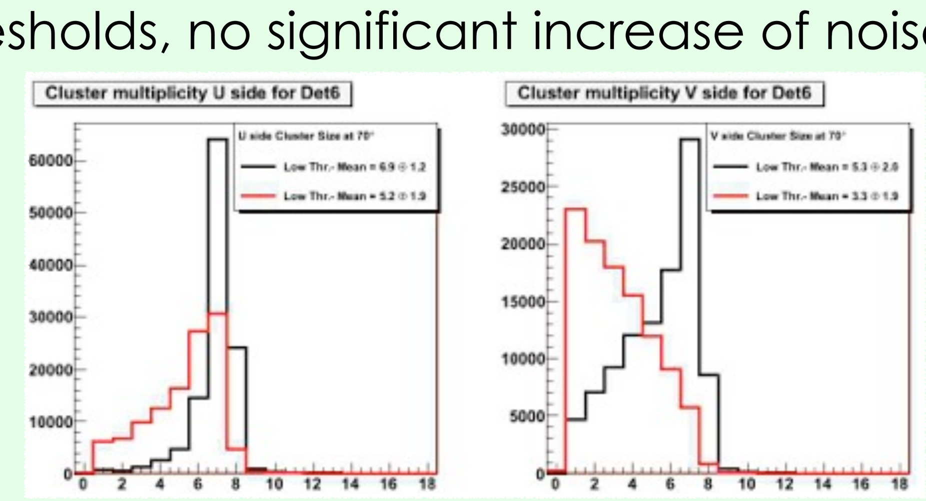
Efficiency: percentage of events in the DUT active region within 112μm/cosϑ to the reconstructed track (ϑ = angle of incidence).

ϑ	ε_U Low thr.	ε_U High thr.	ε_V Low thr.	ε_V High thr.
0	99.6	99.6	99.6	99.4
15	99.6	99.6	99.7	99.5
30	99.7	99.6	99.7	99.5
45	99.7	99.8	99.7	99.4
60	99.7	99.8	99.7	99.2
70	99.9	99.9	99.9	99.7

Results from different runs are consistent within 0.1%. Both for low and high threshold an efficiency better than 99% is measured.

ϑ	Cluster size U Low thr.	Cluster size U High thr.	Cluster size V Low thr.	Cluster size V High thr.	Expected by geom.
0	1.3	1.2	1.2	1.2	>1
15	1.5	1.4	1.5	1.3	>1
30	2.0	1.8	1.9	1.7	>1.6
45	2.9	2.6	2.7	2.3	~2.8
60	4.6	3.9	4.0	3.0	~4.9
70	6.9	5.2	5.3	3.3	~7.8

Cluster size: increases with the angle of incidence. Close to expectations at low thresholds, no significant increase of noise.



Resolution: the estimate of resolution is taken from fit of residuals.

ϑ	Reso_U Low thr. σ(μm)	Reso_U High thr. σ(μm)	Reso_V Low thr. σ(μm)	Reso_V High thr. σ(μm)
0	12.0	12.8	12.8	13.4
15	8.6	10.6	10.9	12.4
30	10.2	9.4	10.3	11.0
45	13.7	12.8	16.8	16.4
60	16.5	17.3	21.0	20.3
70	23.8	32.6	34.9	37.0

PRELIMINARY

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