Beam Test Results for the SuperB-SVT Thin Striplet Detector

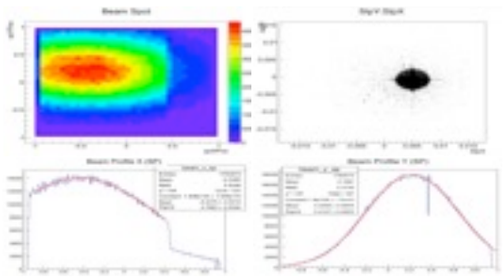
In order to achieve precise measurements near the interaction point, the SuperB Silicon Vertex Tracker (SVT) will need a first layer very close to the beam pipe (Layer0) with very stringent requirements in terms of granularity, readout speed, material budget and radiation tolerance.

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 ulterior requirement.

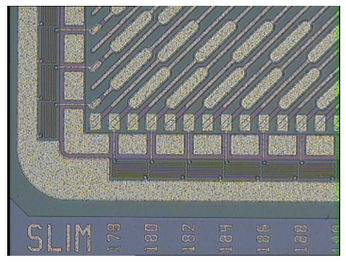
Beam test setup

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.



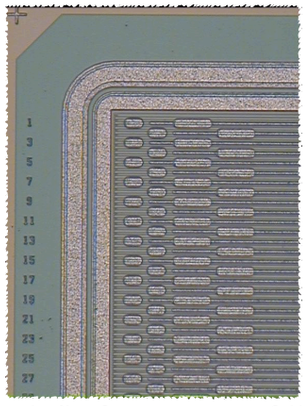
Beam: 120 GeV/c charged pions;
spills lasting 9.5s any 40s, widths of about 8 and 4 mm rms on the horizontal and vertical planes respectively.

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.

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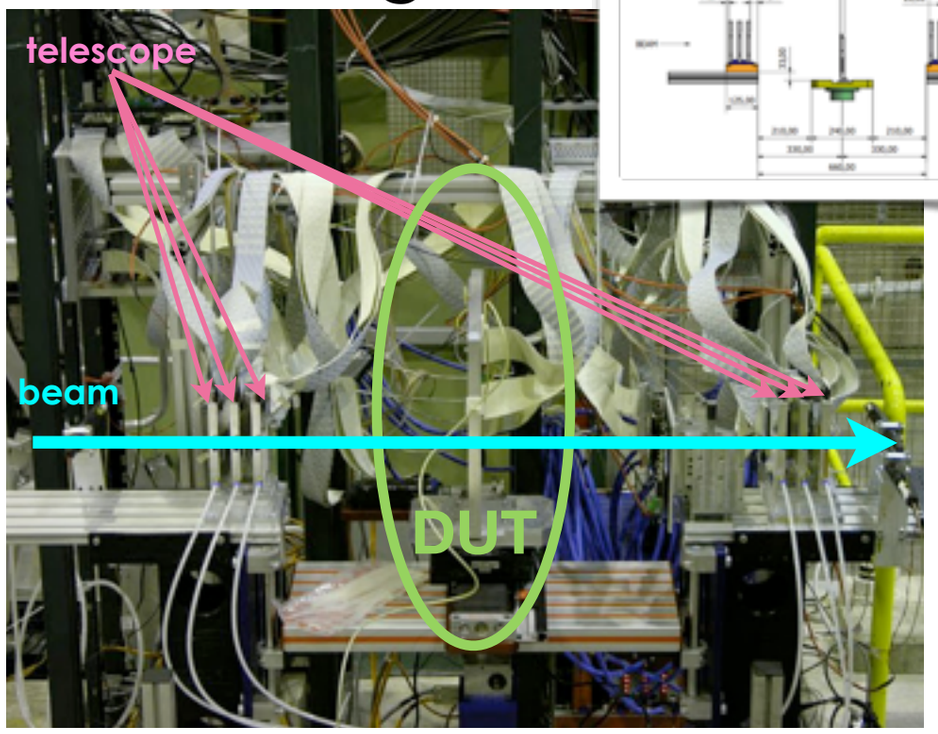
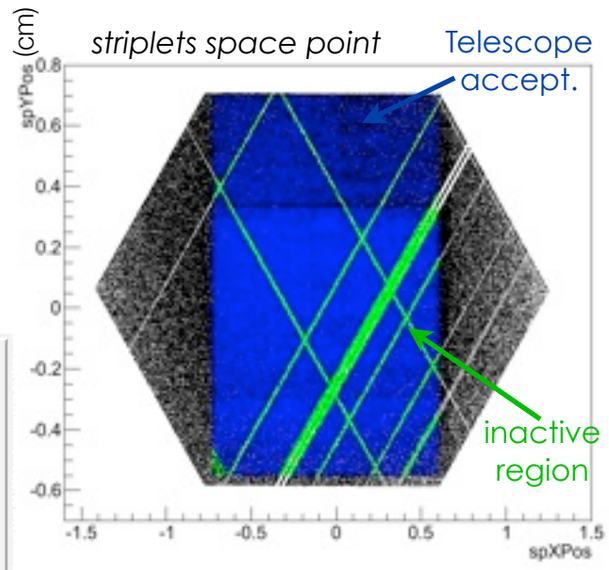


Both the telescope strips and the striplets are read out by the FSSR2 Chip, completely data-driven. Each chip reads 128 strips. Digital output providing: address, time stamp, 3 bit amplitude
Can be read out up to 70 MHz readout clock, but operated at ~20 MHz, allowing a max data transmission rate of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

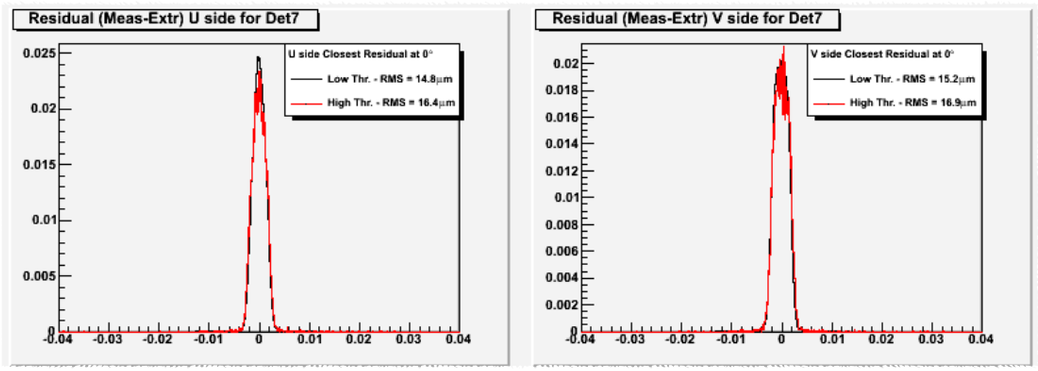
Analysis results

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).

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.

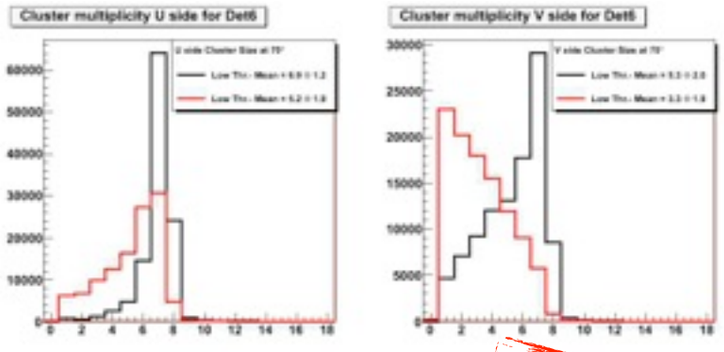


ϑ	ε_U Low thr.	ε_U High thr.	ε_V Low thr.	ε_V High thr.
0	99.6	99.6	99.6	99.4
15	99.6	99.6	99.7	99.5
30	99.7	99.6	99.7	99.5
45	99.7	99.8	99.7	99.4
60	99.7	99.8	99.7	99.2
70	99.9	99.9	99.9	99.7

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

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

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



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

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

PRELIMINARY

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