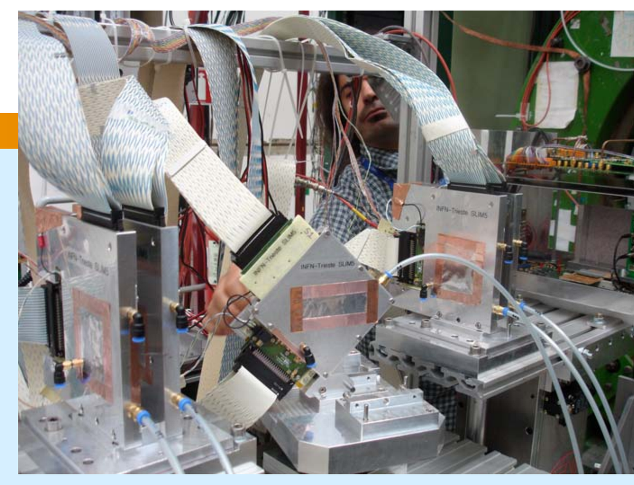
# SLIM5 Beam Test Results for Thin Striplet Detector and Fast Readout Beam Telescope




## Lorenzo Vitale on behalf of SLIM5 collaboration

Università degli Studi and INFN Trieste, ITALY



## Abstract

In September 2008 the **SLIM5** collaboration submitted a low material budget silicon demonstrator to test with 12 GeV/c protons, at the PS-T9 **test-beam** at CERN. Two different detectors were placed as DUTs inside an high-resolution and fast-readout beam telescope.

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 the data-driven FSSR2 chip.

The other one was a 4k-Pixel Matrix of Deep N Well **MAPS**, developed in a 130 nm CMOS Technology, providing digital sparsified readout.

In the following I present the **striplets** and also the beam **telescope** characteristics, with some details about the frontend readout (based on the FSSR2 chip) and some preliminary results.
A paper is in preparation.


## SLIM5 project

**S**ilicon detectors with **L**ow **I**nteractions with **M**aterial by INFN group **5** & eight Italian Universities

### Aim

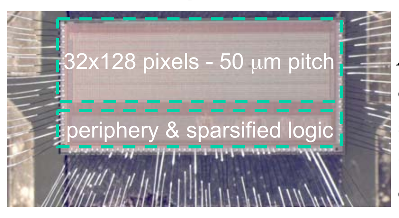
The SLIM5 was a project aiming to develop highly-segmented silicon tracking detectors, with low material budget, fast readout and data-driven architecture, and self-triggering capability.

### Detector options

The collaboration identified two detector options to reach this goal:

➔A new and challenging triple well CMOS Monolithic Active Pixel Sensor (**MAPS**) with in-pixel signal processing and sparsified capabilities.

Pixel cell is 50x50 μm$^2$,
active area close to 90%
and 100-200 μm thick.
For more details, talk by M. Villa

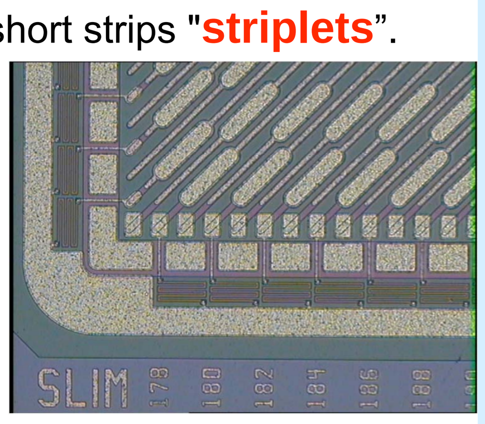



*The APSEL4D chip bonded to the chip carrier.*

➔A more traditional, but **thin** high resistivity double-sided silicon detector with short strips "**striplets**".

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

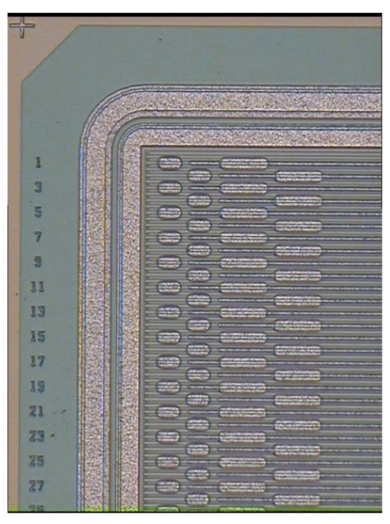
For more details, see Poster by I. Rashevskaya



*Detail of a corner of the SLIM5 striplet detector.*

### Telescope strip detectors

300 μm thick double-sided silicon strip detector with orthogonal strips
•384 ch. read per 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



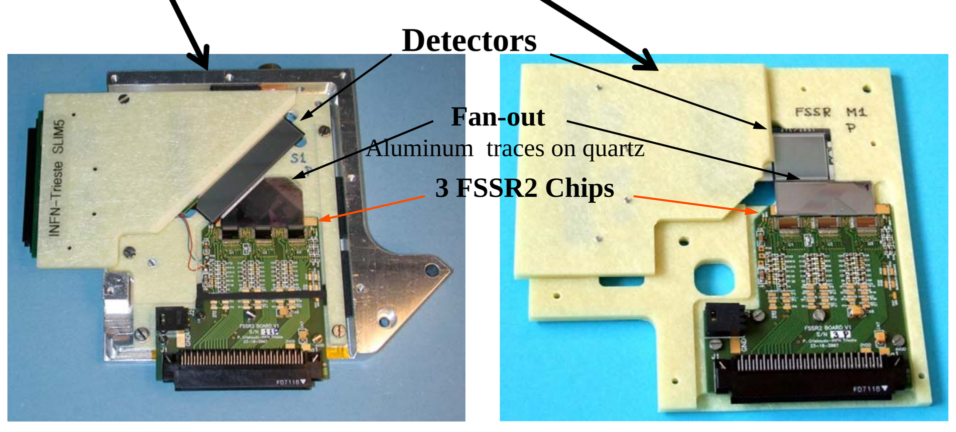
*Detail of a corner of the SLIM5 telescope strip detector.*

All devices provide directly timestamp info on hit.

### Applications

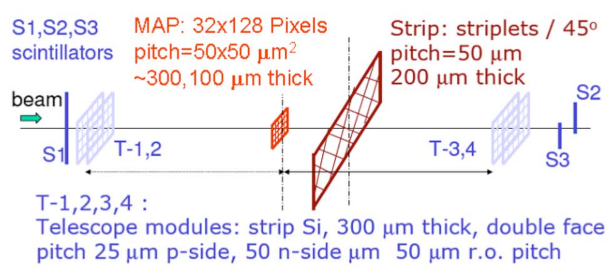
Such detectors can be used for the layer 0 in a future high-luminosity collider, such as the **Super B-factory** or the **International Linear Collider**.

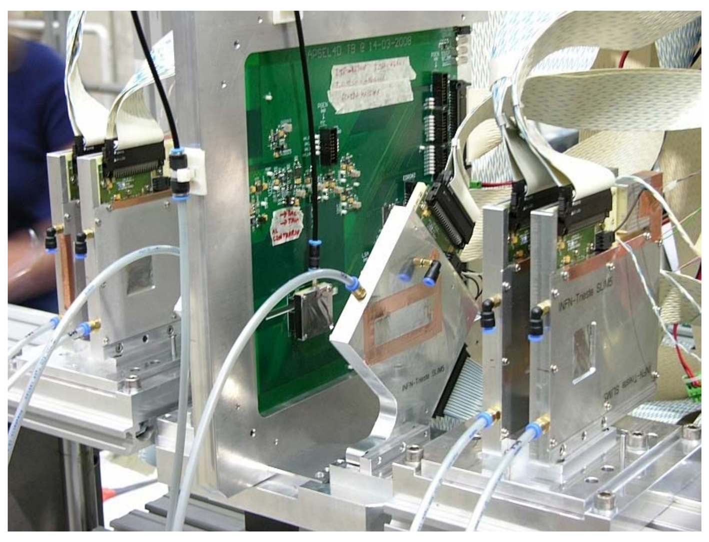
## Striplets and Telescope assembly




## SLIM5 Beam test

3-16 Sep. 2008 @ PS-CERN with 12 GeV/c protons



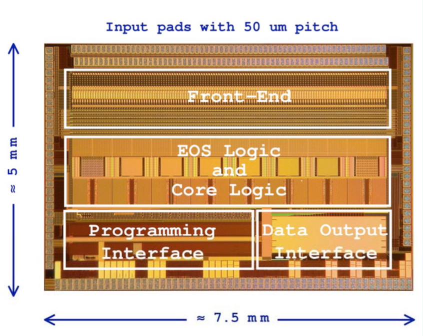



*Schematic view of the SLIM5 beam test and picture of the experimental setup*

## Strip readout and Calibration Studies

Both the telescope strips and the striplets are readout by the second release of the Fermilab Silicon Strip Readout Chip (**FSSR2**), originally designed for the BTeV experiment.

- Completely data-driven
- Each chip serves 128 strips
- Only digital output providing:
  - o address
  - o time stamp
  - o 3 bit amplitude
- Can be readout up to 70 MHz readout clock; Operated at 20 MHz, allowing a max data transmission rate of 240 Mbit/s over six lines.




A total of 384 channels were readout on each side of the sensor by three FSSR2 chips, here used for the first time to process also negative signals.

Among the several programmable options we have chosen to operate the chips at
- low gain, base line restorer selected,
- 125 ns shaping time,
- ≈1/5 MIP threshold.

For **calibration** purposes, an internal square-wave pulser provides voltage steps on the integrated injection capacitance of 40 fF whose discharge feeds the amplification chain.

At fixed threshold, input amplitude was increased and fraction of pulses-over-threshold recorded. The result is fitted with an erf function, where σ is the estimated noise:

| Detector | Polarity | Noise (ENC) | S/N | Threshold Dispersion | Gain (mV/fC) |
|---|---|---|---|---|---|
| Striplet | p | 636 | 25 | 640 | 96 |
| | n | 1023 | 16 | 670 | 67 |
| Telescope | p | 502 | 48 | 640 | 97 |
| | n | 802 | 30 | 670 | 67 |

## Data Analysis

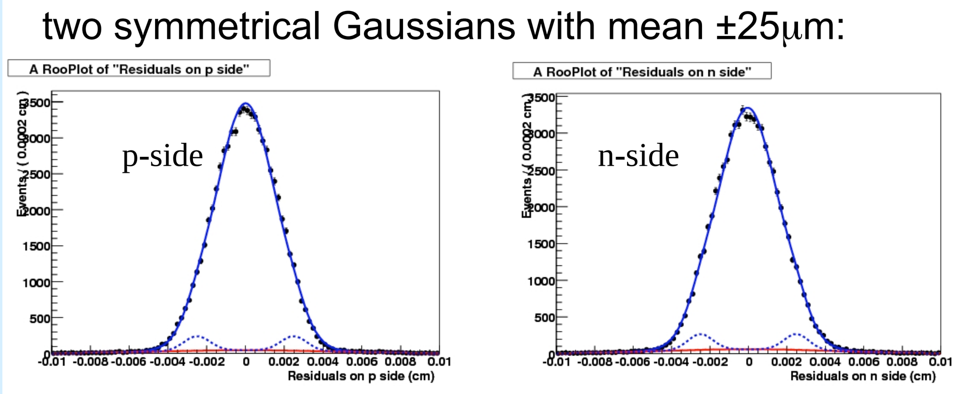
**Pattern Recognition**: Used a very simple algorithm : start from combining space point (p cluster + n cluster) on L0, L3 (outer telescope modules) to generate a pseudo track. Add space points on the inner telescope modules (L1, L2) if distance from pseudo track is within a fiducial road width, typically 0.1-0.2 cm before alignment and 0.05 cm after alignment.

**Track fit**: Least Square Method to extract track parameters. Multiple scattering not accounted in track fit. Prob($\chi^2$) is flat tuning errors for space points according to pitch, cluster size and pulse height.

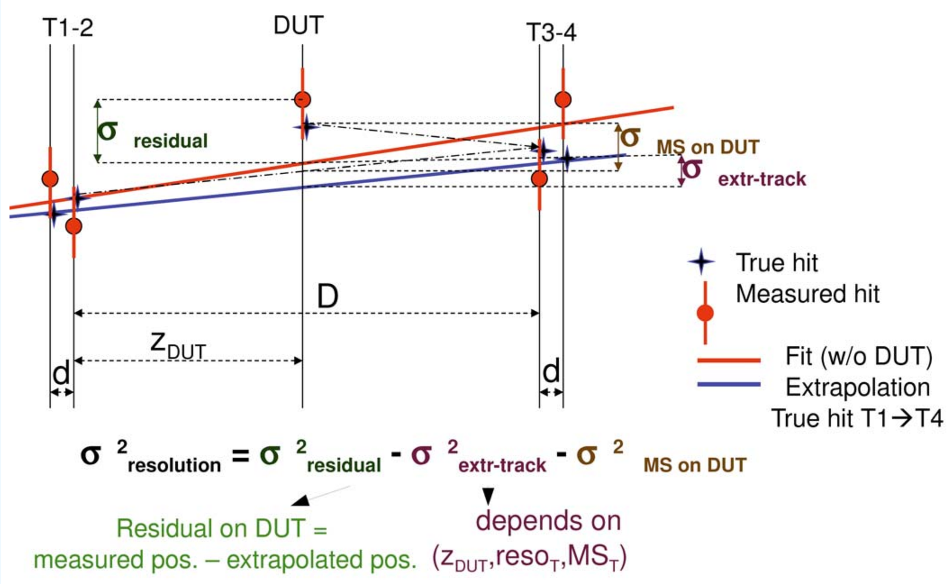
**Alignment** and **DUT Residuals**: select events with only one track passing from DUT active area, compute residual for DUT space points, perform iterative alignment minimizing residuals vs p,n translations and rotations.

## Results

Besides the striplets, a telescope extra module was used as a DUT to evaluate resolution and efficiency. Cluster size is typically 1-2 in both cases. Residuals are fitted with narrow Gaussian + outlier Gaussian + two symmetrical Gaussians with mean ±25μm:




**Resolution**: the space point resolution is obtained from the fitted σ, after subtracting the 3.9 μm track error (1.75 and 5.3 μm for Telescope p and n side respectively) and the multiple scattering evaluated from MC: 6.0 (7.0) μm for 200 (300) μm of Si.




– **13.6 (7.2) μm for p side** (pitch/√12 = 14.2-7.2 μm)
– **14.1 (10.7) μm for n side** (pitch/√12 = 14.4 μm)

**Efficiency 98.3±0.1 (99.4)%**
Efficiency:= #Clusters>0/#tracks in a ±80μm region


## Contacts:

**Lorenzo Vitale**
Email: vitale@ts.infn.it
Web: http://www.pi.infn.it/slim5



## SLIM5 collaboration

G. Batignani[1,2], S. Bettarini[1,2], F. Bosi[1,2], G. Calderini[1,2], R. Cenci[1,2], A. Cervelli[1,2], F. Crescioli[1,2], M. Dell'Orso[1,2], F. Forti[1,2], P.Giannetti[1,2], M. A. Giorgi[1,2], A. Lusiani[2,3], G. Marchiori[1,2], M. Massa[1,2], F. Morsani[1,2], N. Neri[1,2], E. Paoloni[1,2], M. Piendibene[1,2], G. Rizzo[1,2], L.Sartori[1,2], J. Walsh[2], C. Andreoli[4,5], E. Pozzati[4,5], L. Ratti[4,5], V. Speziali[4,5], M. Manghisoni[5,6], V. Re[5,6], G. Traversi[5,6], L.Gaioni[4,5], M. Bomben[7], L. Bosisio[7], P. Cristaudo[7], G. Giacomini[7], D. Iugovaz[7], L. Lanceri[7], I. Rachevskaia[7], G. Venier[7], L. Vitale[7], M. Bruschi[8], R. Di Sipio[8], B. Giacobbe[8], A. Gabrielli[8], F.Giorgi[8], C. Sbarra[8], N. Semprini[8], R. Spighi[8], S. Valentinetti[8], M. Villa[8], A. Zoccoli[8], D. Gamba[9], G. Giraudo[9], P. Mereu[9], G.F. Dalla Betta[10], G. Soncini[10], G. Fontana[10], L. Pancheri[10], G. Verzellesi[11]

[1]Università degli Studi di Pisa, [2]INFN Pisa, [3]Scuola Normale Superiore di Pisa,
[4]Università degli Studi di Pavia, [5]INFN Pavia,
[6]Università degli Studi di Bergamo,
[7]INFN Trieste and Università degli Studi di Trieste
[8]INFN Bologna and Università degli Studi di Bologna
[9]INFN Torino and Università degli Studi di Torino
[10]Università degli Studi di Trento and INFN Padova
[11]Università degli Studi di Modena e Reggio Emilia and INFN Padova