Summary status for the paper on beam test results for the SuperB SVT thin striplet detector

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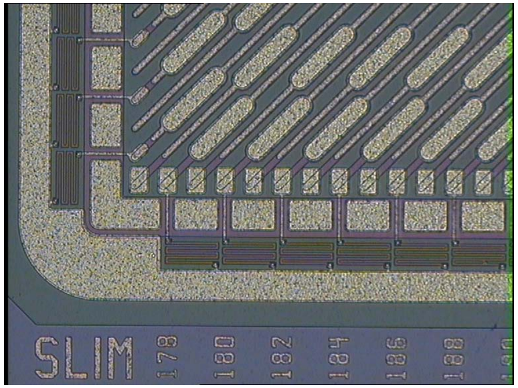
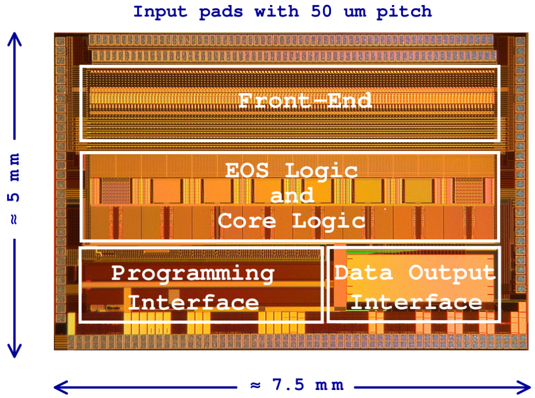


Outline



Introduction

- SuperB layer0
- The Setup of 2011 September Beam Test at Cern
- The Analysis Results: Efficiencies, Cluster Size and Spatial Resolution
- Steps for the publications and remaining issues

Introduction and short history

- Some results were already presented by:
  - Laura Poster @Pisa Conference May 2012 and short proceedings (global efficiency, RMS residuals and cluster size vs angle)

  - Afterwards several improvements in the analysis (better alignment, some bug fixes, better cluster position)
  - Carlo presented almost final numbers @ SIF in September 2012 (no proceedings)
  - Lorenzo few slides too @ VERTEX in September 2012 (proceedings with few details on)

- Now the goal is to collect all the details and write a longer paper (8? pages)

Francesco suggested J.INST

Super B Silicon Vertex Tracker

- The SuperB is expected to deliver luminosity of 10 ^{36} cm^{-2} s^{-1} with a reduced beams asymmetry with respect to previous B-Factories

- This forces the SuperB detector to improve on typical vertex resolution, with a first layer very close (about 1.5 cm) to the beam (Layer0)

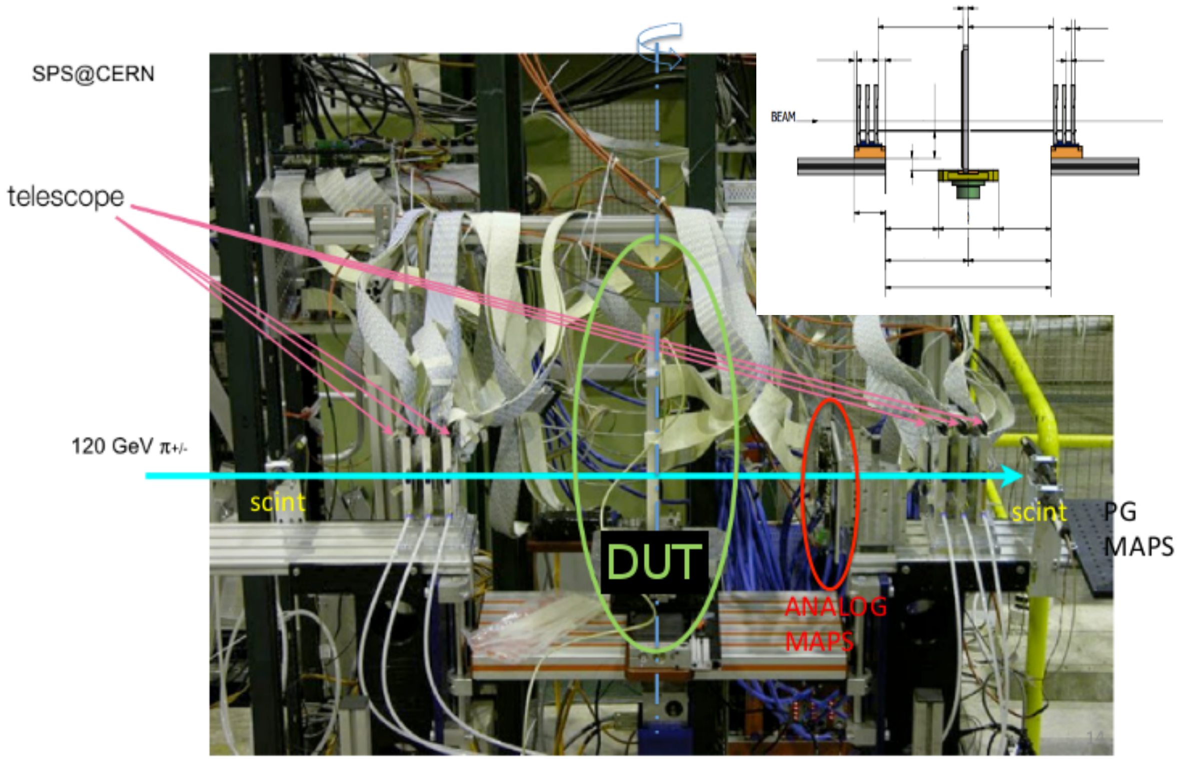
- The baseline option for the Layer0 will be a high resistivity sensor, with a thin silicon substrate (200 μm) and short (20 mm) double-sided strips (”Striplets”) at ± 45° angle to the detector's edge.

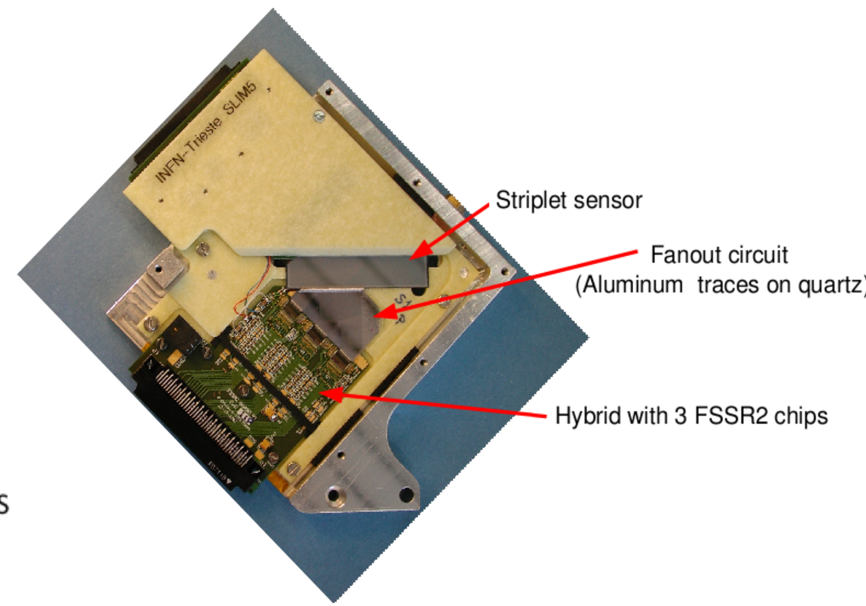
- Futhermore a good spatial resolution at angle up to 70° is an additional requirement

Test Beam

In September 2011 the SuperB collaboration submitted a striplets prototype to test the performance at different incident angle with 120 GeV/c pions' beam, at the SPS-H6 test-beam line at CERN.

The same prototype, with the same readout (data-driven FSSR2 chip), was already tested in a previous test beam in September 2008.





Active area 27 x 12.9 mm^2

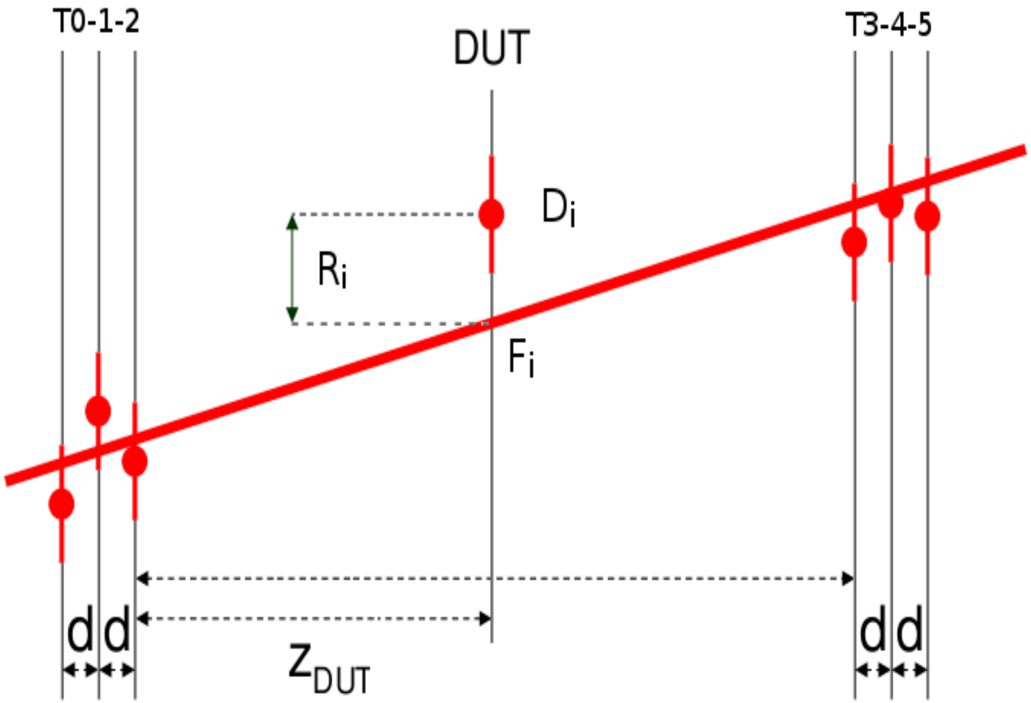
Test Beam: Setup

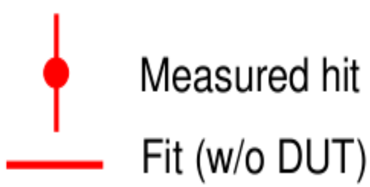
In the previous test beam first thresholds (hit, no-hit) were conservatively set to a rather high value ~ 4400 (6300) e-, ~ 27 (40)% MIP, respectively for p(n) striplets sides, causing a drop of efficiency in the full cluster measurement at large angles.

Now the threshold was set to ~ 3300 (4800) e-, ~ 20 (30)% MIP , respectively for p(n) striplets sides (at normal incidence 1 MIP is ~ 16000 e- in 200 μm).

Moreover the relative low beam energy (12 GeV) produced a larger multiple scattering than in September 2011 test beam.

Analysis results: Residual & Efficency

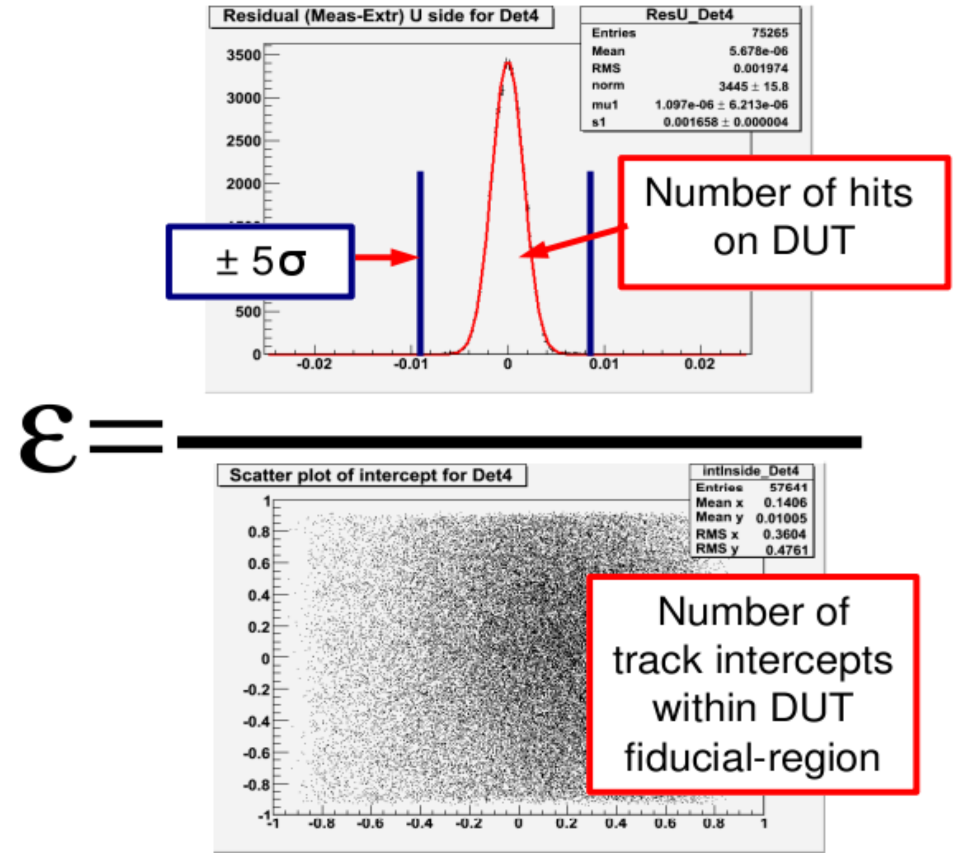




Ri = Residual associated with i-hit on DUT

Fi = Geometrical point obtained from telescope hits fit

Di = i-hit on DUT



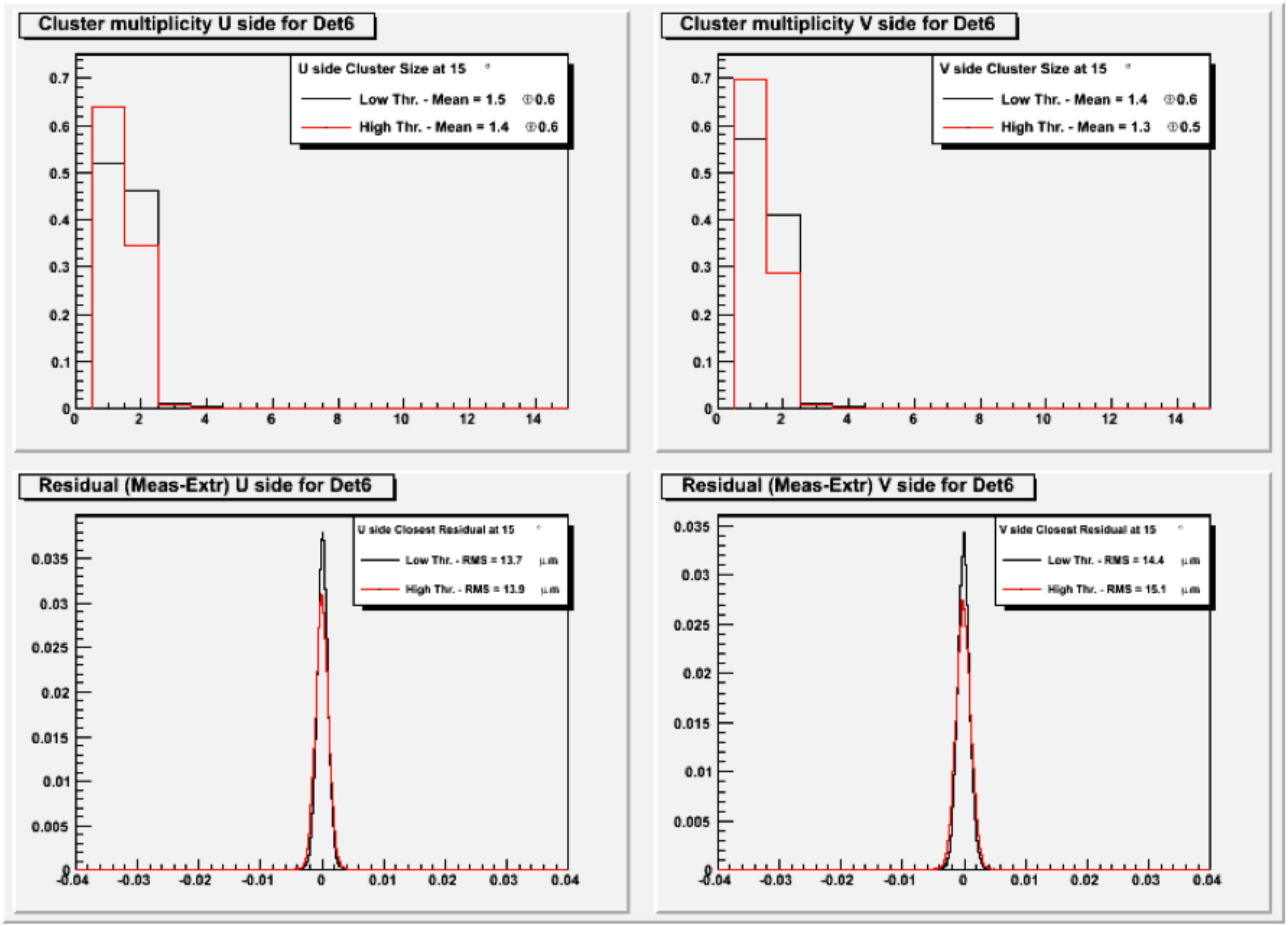
We cut at 80 μm/cosϑ (~5σ) on residuals

Results from different runs are consistent within 0.2%. Both for low and high threshold an efficiency better than 99.4% is measured.

Efficiencies (%) within 80/cosϑ vs incident angle

Incident angle	Eff_P Low thr.	Eff_P High thr.	Eff_N Low thr.	Eff_N High thr.
0	99.5	99.4	99.5	99.3
15	99.4	99.4	99.4	99.4
30	99.6	99.5	99.6	99.4
45	99.6	99.7	99.6	99.3
60	99.6	99.8	99.6	99.3
70	99.8	99.9	99.8	99.7

Comparisons Low/High thr.: 15˚ - Cluster size/Residuals



Cluster size vs incident angle

Incident angle	Cluster size P Low thr.	Cluster size P High thr.	Cluster size N Low thr.	Cluster size N 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	5.3	5.4	3.3	7.8

Resolution from Residuals

The resolution of the DUT can be estimated from the residual distribution, but the track extrapolation to the DUT position and the Multiple Scattering must be subtracted.

$$\sigma^2_{resolution} = \sigma^2_{residual} - \sigma^2_{extr\text{-}track} - \sigma^2_{MS\ on\ DUT}$$

Residual on DUT = measured pos. – extrapolated pos.

depends on $(z_{DUT}, reso_T, MS_T)$

Resolution from Residuals

To estimate the sigma residuals three independent ways were followed:

RMS (solid, but too rough estimate for the resolution)

Fits of Gaussians (best to model strip lost)

FWHM/2.35 (alternative, used as a cross check)

Resolutions from RMS Residuals

Incident angle	**Reso_U Low thr.** RMS (μm)	**Reso_U High thr.** RMS (μm)	**Reso_V Low thr.** RMS (μm)	**Reso_V High thr.** RMS (μm)
0	14.6	15.9	14.2	16.5
15	13.2	13.9	13.6	15.1
30	14.1	14.7	14.1	15.4
45	17.7	17.3	18.5	20.7
60	24.2	28.1	30.1	38.7
70	37.4	51.6	50.8	60.0

Resolutions from fit of Residuals

To estimate the sigma residuals several fits were tried.

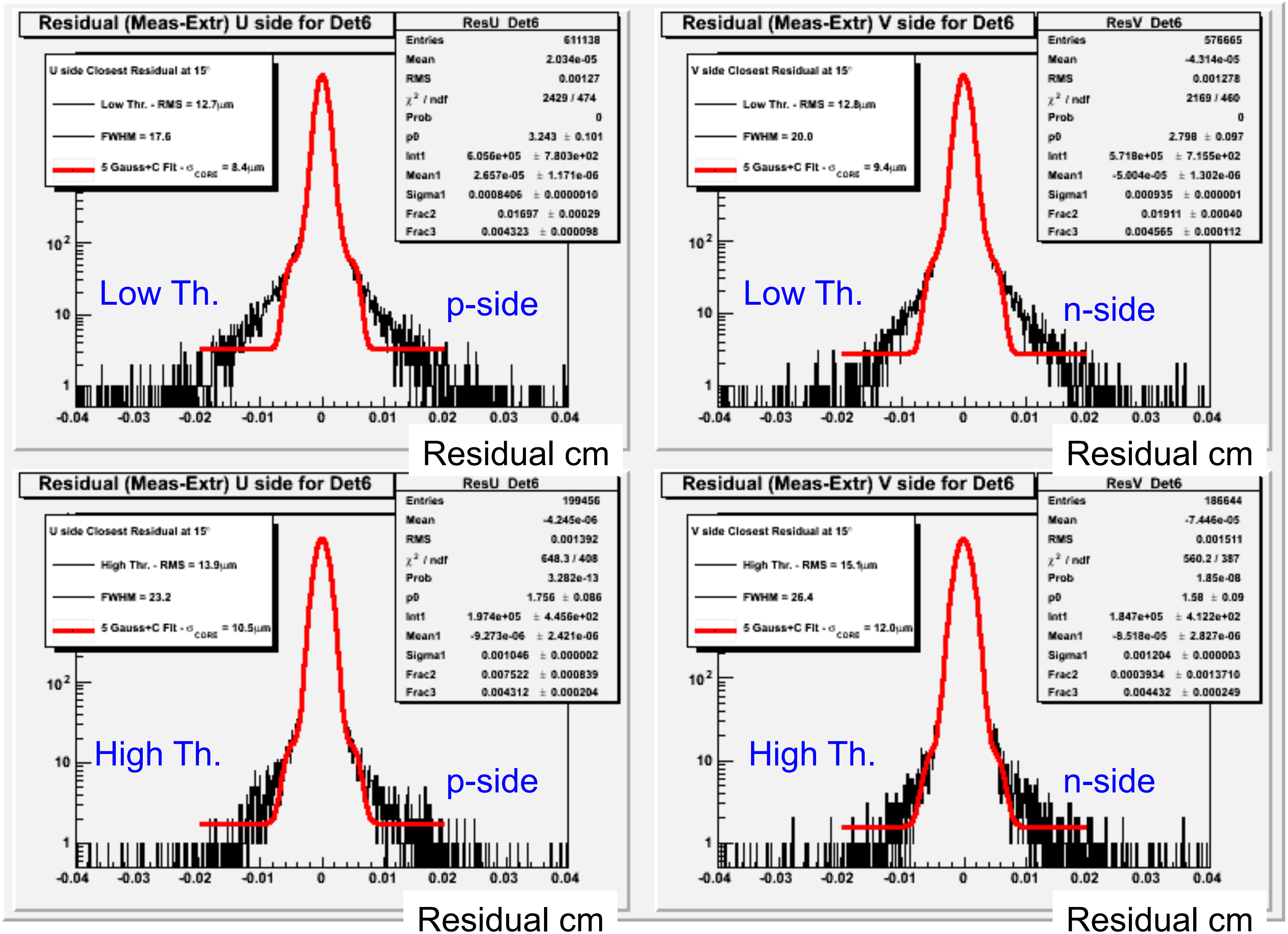
The best results were given by 5 Gauss + Const:

Core Gauss 3 free parameters (Ntot, Mean, Sigma)

2 Gauss +-25μm 1 free parameter (same Mean, Sigma as Core)

2 Gauss +-50μm 1 free parameter (same Mean, Sigma as Core)

15˚ - 5Gauss Fit of Residuals



Fraction of the Core Gaussian

From this fit (5 Gauss + Const) we extract the Parameter in RED:

Core Gauss 3 free parameters (Ntot, Mean, Sigma)

2 Gauss +-25μm Normalization (same Mean, Sigma as Core)

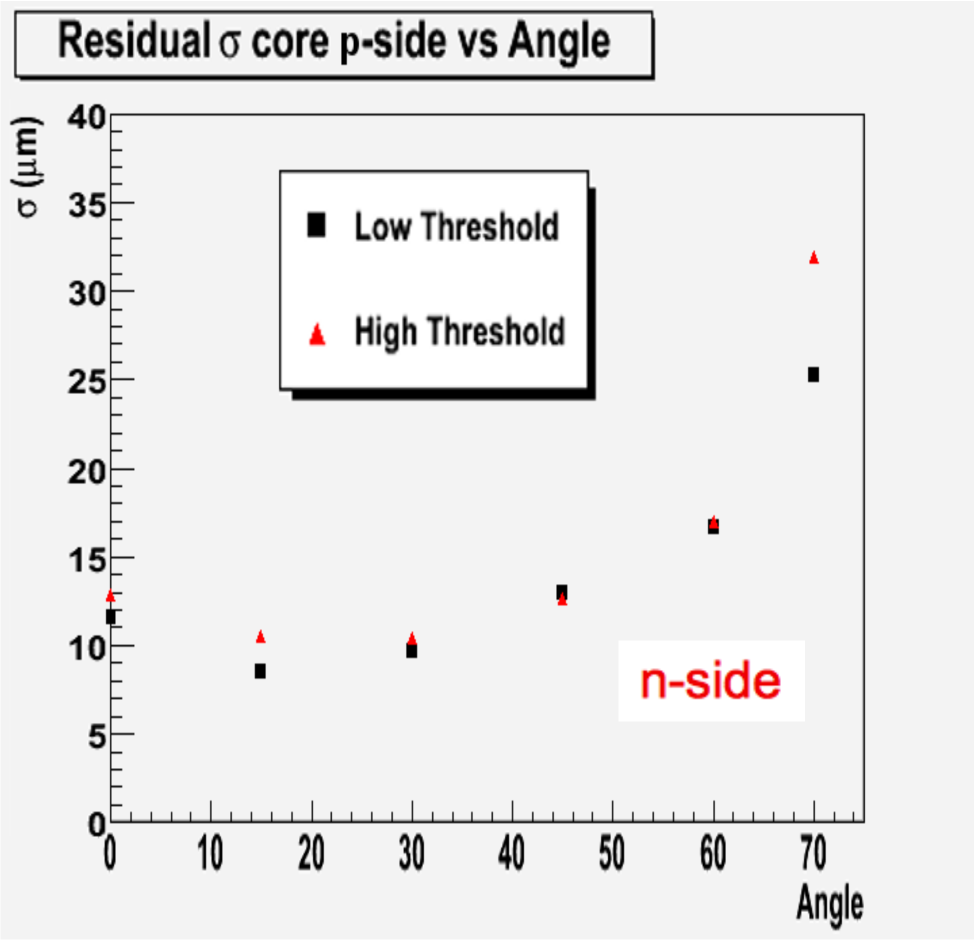
2 Gauss +-50μm Normalization (same Mean, Sigma as Core)

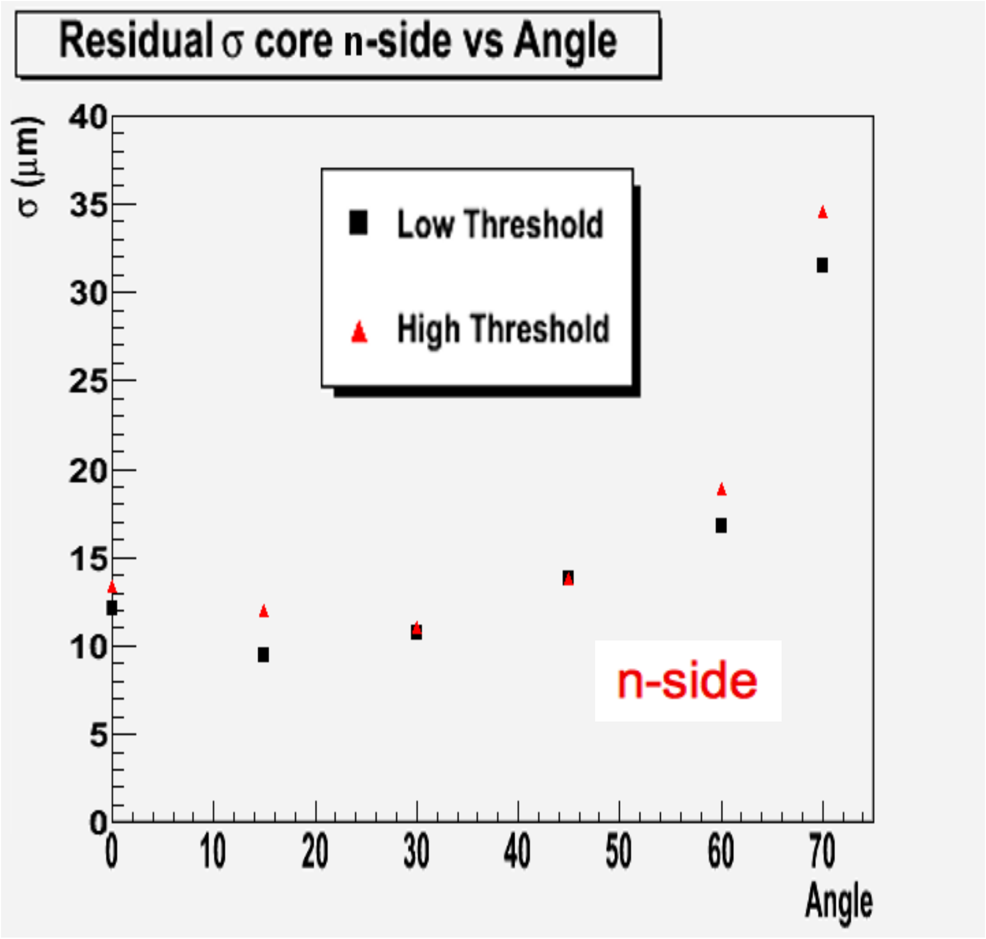
The core Gaussians accounts for 99.6% at normal incidence and, as expected, decreases with angle, worse for n-side and higher thr see next slide (FracCore).

Resolutions Residual vs incident angle
Sigma CORE (Frac CORE)

Incident angle	Resolutions P Low thr. σ (μm) Frac%	Resolutions P High thr. σ (μm) Frac%	Resolutions N Low thr. σ (μm) Frac%	Resolutions N High thr. σ (μm) Frac%
0	11.6 99.5	12.9 99.9	12.1 99.5	13.4 99.9
15	8.5 97.9	10.5 98.8	9.5 97.7	12.0 99.2
30	9.7 97.2	10.4 96.9	10.7 97.0	11.0 96.2
45	13.0 96.6	12.6 93.8	13.8 92.2	13.8 78.9
60	16.7 92.1	17.0 70.2	16.8 68.3	18.9 41.8
70	25.2 82.5	31.9 43.2	31.5 48.8	34.6 14.8

Striplets Beam Test results





Resolutions Residual vs incident angle Sigma CORE & FWHM/2.355

An alternative estimate of the resolution can be taken from on the distribution FWHM

Incident angle	Resolutions P Low thr. σ (μm)	Resolutions P Low thr. FWHM/2.355 (μm)	Resolutions N Low thr. σ (μm)	Resolutions N Low thr. FWHM/2.355 (μm)
0	11.6	13.6	12.1	13.6
15	8.5	7.6	9.5	8.5
30	9.7	9.2	10.7	10.2
45	13.0	12.6	13.8	13.9
60	16.7	16.1	16.8	19.2
70	25.2	25.5	31.5	42.0

Resolution from Residuals

The resolution of the DUT can be estimated from the residual distribution, but the track extrapolation to the DUT position and the Multiple Scattering must be subtracted.

$$\sigma^2_{resolution} = \sigma^2_{residual} - \sigma^2_{extr\text{-}track} - \sigma^2_{MS\ on\ DUT}$$

Residual on DUT = measured pos. – extrapolated pos.

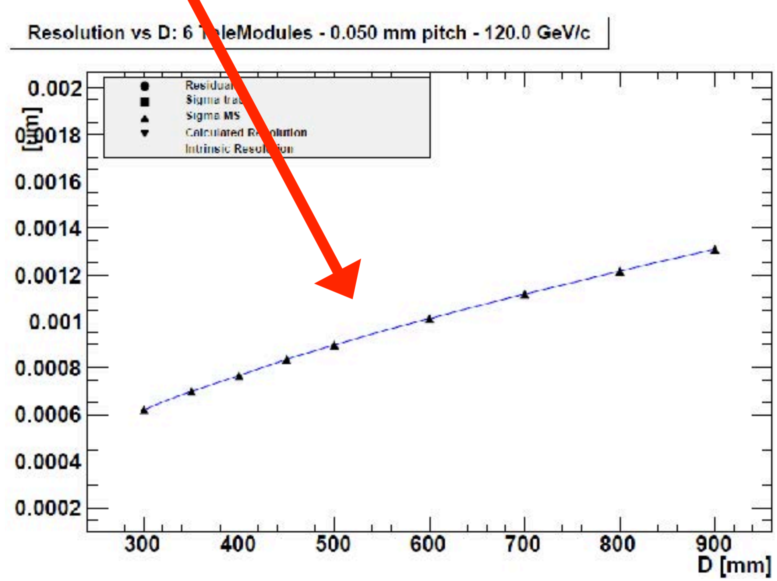
depends on $(z_{DUT}, reso_T, MS_T)$

Typical values at normal incidence are:

σ residual ~ 12 μm

σ extr-track ~ 7 μm

σ MS ~ 1 μm

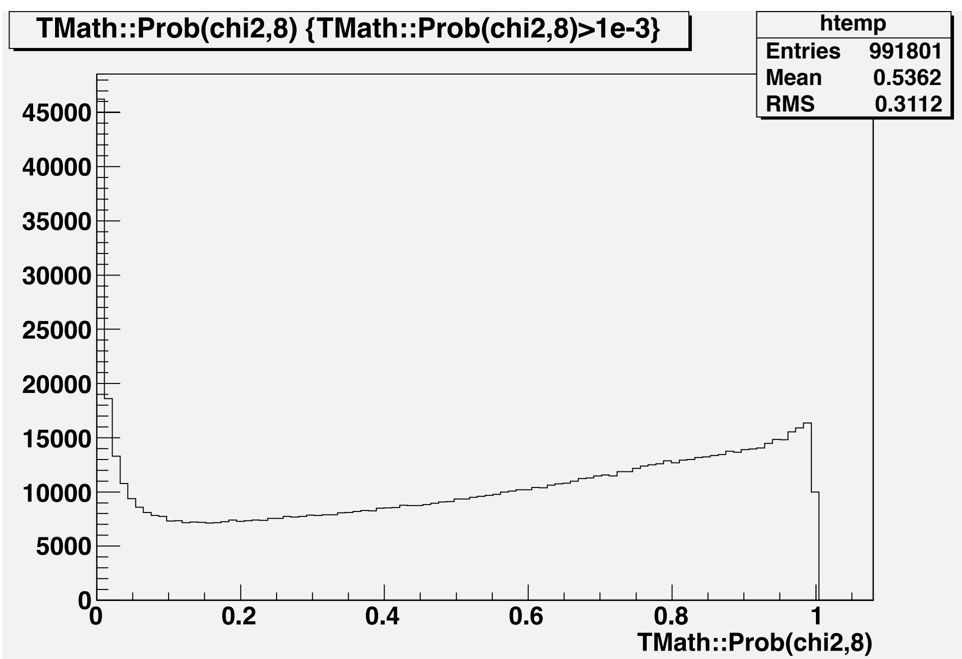


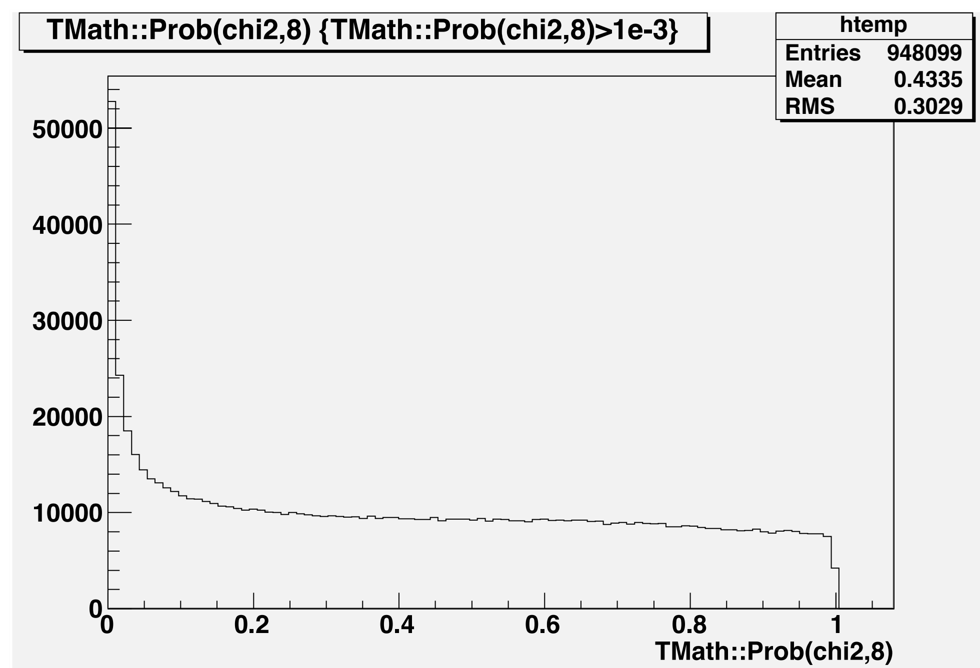
Contribution from track

Default values were 10 μm both for p and n sides, but in this way error matrix was largely overestimated.
After correction for a bug in SbtSpacePoint.cc,
input error for the telescope hits have been tuned until Prob(Chi2) was flat.

σ_p=7 μm; σ_n=10 μm

σ_p=6 μm; σ_n=9 μm OK!





Then the error matrix was used to propagate to the DUT position:

Some Formulas

$x = a + bz \qquad \rightarrow \text{similarly for } y: \quad y = a + bz$

$z_{DUT} = 434mm$

$x_{EXT-DUT} = a + bz_{DUT}$

$\sigma_{x_{EXT-DUT}} = \sqrt{\sigma_a^2 + (z\sigma_b)^2 + (b\sigma_z)^2 + 2zc_{ab}} = 5.21\mu m$

with $\sigma_a = 3.535\mu m \quad \sigma_b = 5.315 \cdot 10^{-6} \quad c_{ab} = 1.398 \cdot 10^{-5}$

Assume (from RMS angle) $b \approx 10^{-6} \quad \sigma_z = 1mm$

For $y \quad \sigma_a = 5.392\mu m \quad \sigma_b = 7.972 \cdot 10^{-6} \quad c_{ab} = 3.146 \cdot 10^{-5}$

$\sigma_{y_{EXT-DUT}} = 8.27\mu m$

Resolution from Telescope

The extrapolated track resolution on the DUT can be estimated from the telescope resolution using this formula:

$$\sigma_{EXT-DUT} = \frac{1}{2}\sqrt{\frac{\sigma^2_{xEXT-DUT}}{\cos^2\vartheta} + \sigma^2_{yEXT-DUT}}$$

With:

$\sigma_{x\text{-track}}$ the resolution in x of telescope extrapolated track

$\sigma_{y\text{-track}}$ the resolution in y of telescope extrapolated track

ϑ the DUT rotation angle

At normal incidence $\sigma_{extr\text{-}track}$ = 7.03 μm

Resolutions Residual vs incident angle
Sigma CORE Low Threshold

Incident angle	Resolutions P Low thr. σ_{mis} (µm)	Resolutions P Low thr. σ_{cal} (µm)	Resolutions N Low thr. σ_{mis} (µm)	Resolutions N Low thr. σ_{cal} (µm)
0	11.6	9.2	12.1	9.8
15	8.5	4.5	9.5	6.2
30	9.7	6.2	10.7	7.7
45	13.0	10.1	13.8	11.2
60	16.7	13.5	16.8	13.6
70	25.2	21.7	31.5	28.7

Remaining issues

Procedure of evaluating the track contribution should be ok, but since we use the Core Gaussian for the best estimate of the σ of the residual, the subtraction is probably too optimistic…

My proposal is to quote all the three estimate for the residual anyway.