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JÜLICH FORSCHUNGSZENTRUM

Error Estimation for the Trapezoidal Sensors of the MVD

March 5, 2012 | Dariusch Deermann

Contents

- Motivation, why study the wedge sensor precision?
- GEANE propagation and needed resolution
- Use eta distribution for better point reconstruction
- Results

Motivation

Minimize material budget

Material budget increases with number of readout channels and therefore with the resolution of the sensors.

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Multiple scattering on the material in front of the strip sensors distorts the track.

Resolution of the sensors

Resolution of the sensors does not need to be better than the deviation produced by multiple scattering.

GEANE propagator

With the GEANE track propagator it is possible to calculate the deviation from the original path.

It ranges from 35 μm to 100 μm for 10 GeV muons in front of the first strip sensor disc.

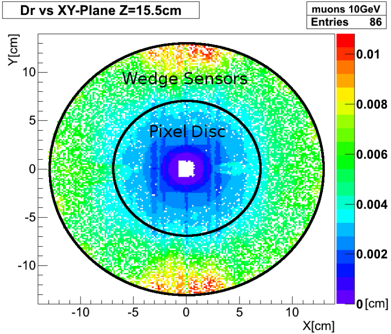

Figure: Position deviation from the original path.

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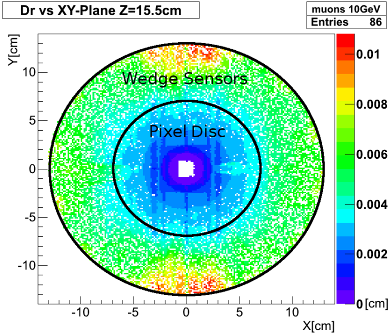

Figure: Position deviation from the original path.

Desired resolution

We want to resolve distances of about 35 μm.

Current sensor design

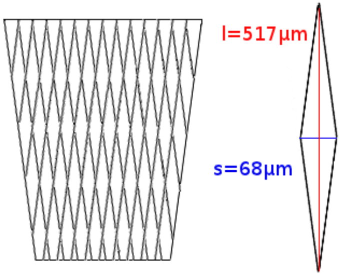

Figure: Shape of the trapezoidal sensors

- Skew angle between front- and backside strips is 15°

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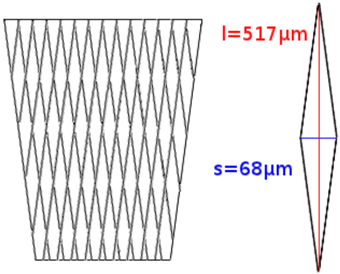

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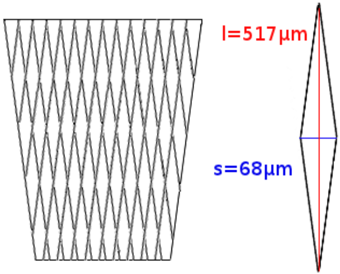

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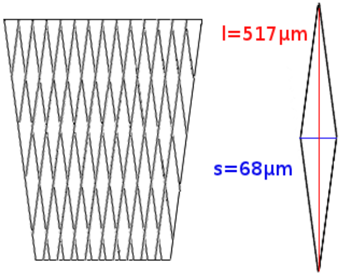

Figure: Shape of the trapezoidal sensors

- Skew angle between front- and backside strips is 15°
- 512 strips per side with a pitch of 67.5 µm
- Rhombus shaped cells with a long axis *l* and a short axis *s* between the strips
- Long axis *l* always points in radial direction
- Short axis *s* always points in tangential direction

Options for reconstruction

One strip fired

No options to improve resolution, the reconstructed position is the strip position.

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Two strips fired

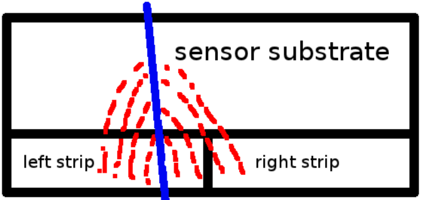
- Center of gravity: Calculate the position as charge weighted mean stripvalue.
- η method: Use the sensor dependent η distribution to reconstruct the position.

η distribution

The η distribution is a helpful tool to reconstruct the original hit point from two strip entries.

Definition of η

$\eta = \frac{q_r}{q_r + q_l}$, where q_r and q_l are the deposited charges in the right strip and left strip.



$$q_l = 20000e\,,\ q_r = 5000e\,,\ \eta = \frac{5000}{25000} = 0.2$$

Figure: Two strips getting hit by a particle and resulting η value

Before the η value can be used for hit reconstruction it is necessary to determine the distribution of η values for evenly spread hits on the sensor.

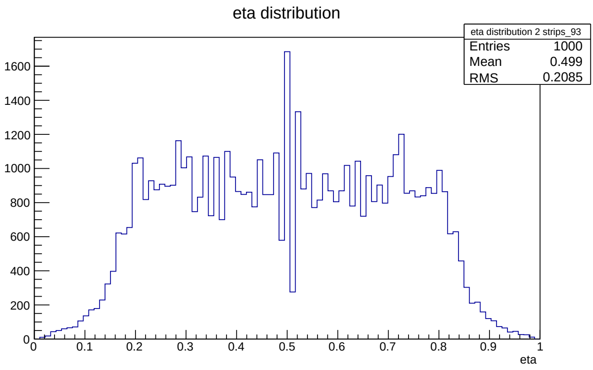


Figure: η distribution, created with 100000 muons of random energies

How to reconstruct the hit point with η?

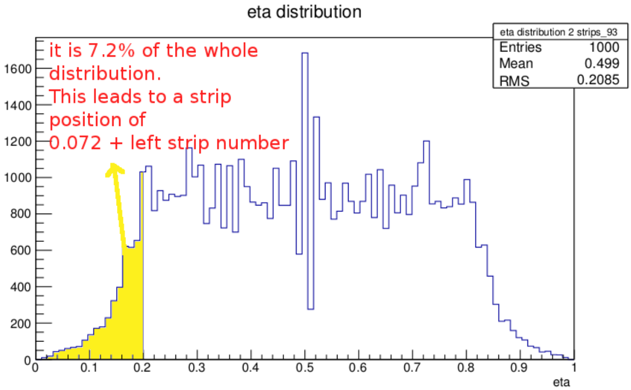


Figure: Integrate from 0 to η over the η distribution

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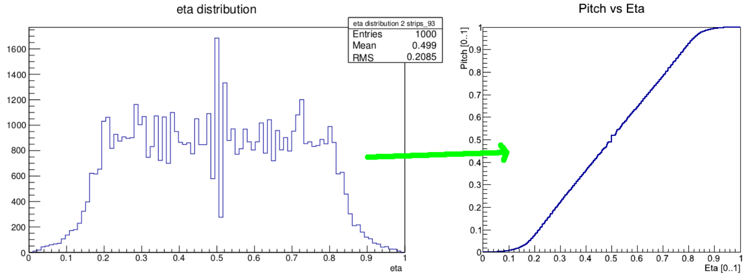

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How to reconstruct the hit point with η?

The hit position x as strip number can be calculated as:

$$x = x_l + \frac{1}{N_0} \int\limits_0^{\eta} \frac{dN}{d\eta}$$

In that equation x_l is the left strip number and N_0 is the number of entries in the η distribution.

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η distribution created with evenly distributed hits?

This only works well if the η distribution was created with evenly distributed hits on the sensor plane!

Relative position between two strips

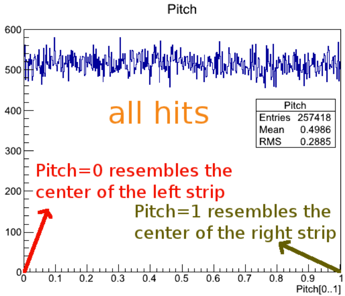

Figure: Hit distribution relative to the strip position

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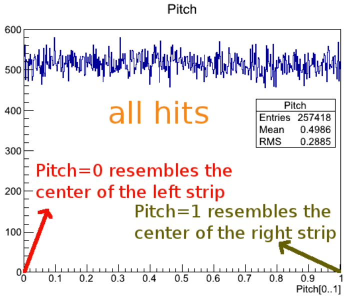

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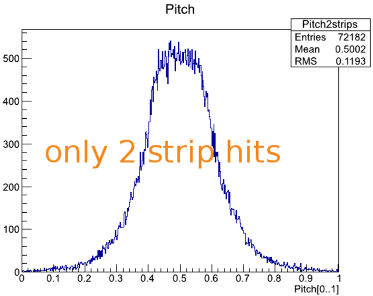

Figure: Hit distribution for hits with 2 entries, relevant for η

Correction of η method with respect to pitch distribution

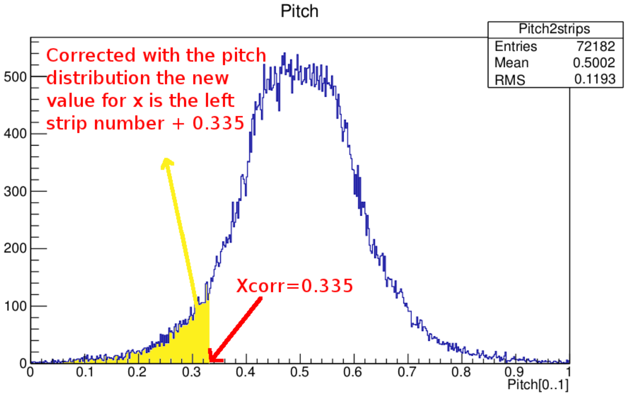

Figure: Integrate from 0 to $x_{corr.}$ so that we fill the same area as in the integral on the η distribution.

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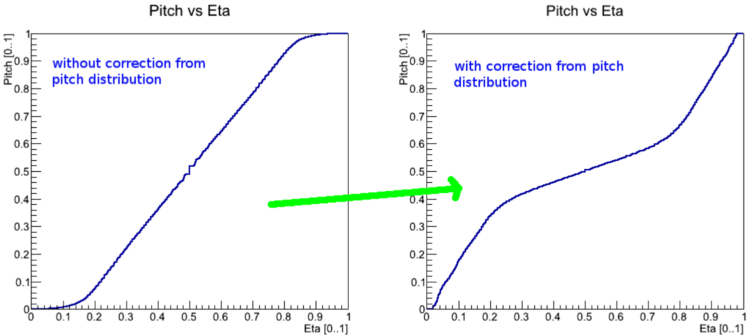

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Correction of η method with respect to pitch distribution

$x_{corr.}$

$$\frac{1}{N_{\eta,0}} \int\limits_0^{\eta} \frac{dN}{d\eta} = \frac{1}{N_{x,0}} \int\limits_0^{x_{corr.}} \frac{dN}{dx}$$

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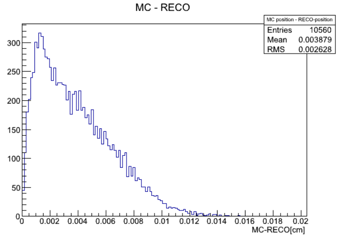

Figure: reconstruction error with center of gravity method

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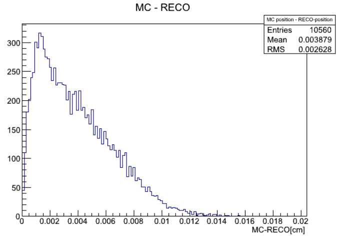

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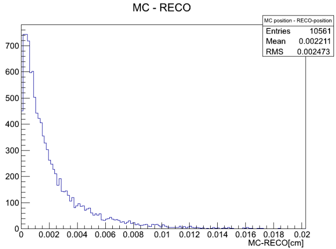


Figure: Reconstruction error with η method

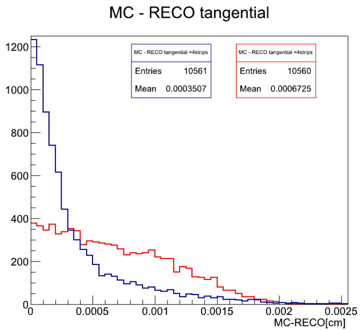
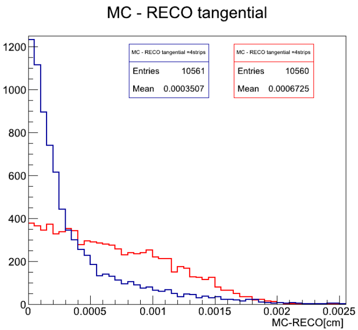


Figure: Tangential error with center of gravity in red and η method in blue



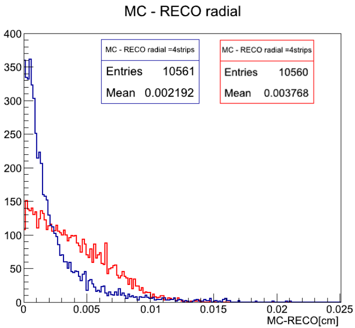


Figure: Tangential error with center of gravity in red and η method in blue

Figure: Radial error with center of gravity in red and η method in blue

Not all hits will result in two strip entries on both sides of the sensor.
So the resolution of hits with less entries should be considered too.

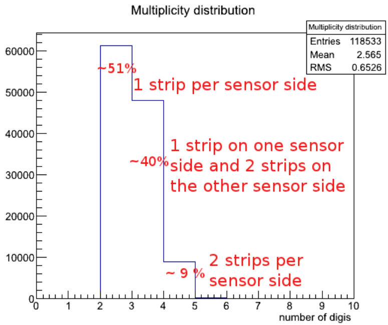


Figure: Number of strip entries for a hit point

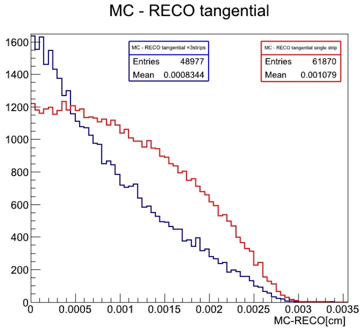
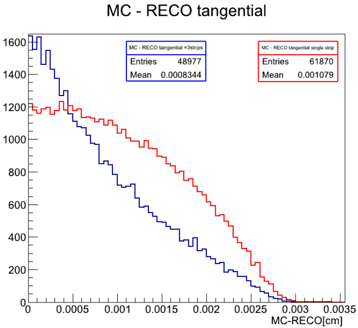
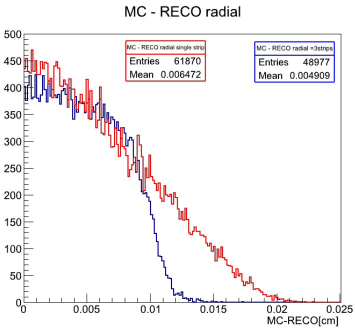


Figure: Tangential error for single strip hits in red and single + double strip hits in blue





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Result

	single strip	center of gravity	η method	single + η method
overall	66.7 μm	38.8 μm	22.1 μm	50.2 μm
tangential	10.8 μm	6.7 μm	3.5 μm	8.3 μm
radial	64.7 μm	37.7 μm	21.9 μm	49.1 μm

Summary

- Resolution of 35 μm can be achieved for the strip discs.
- η distribution can help to increase the reconstruction performance.

Thank you for your attention!