Linear Track Fitter Detector Alignment and Application on Data Beam Test

31. August 2010 | T. Randriamalala, J. Ritman, T. Stockmanns and H. Xu

Outline

- Linear Track Fitter
- Detector Alignment
- Conclusion

Linear Track Fitter

Reconstructed track is obtained by minimizing:

$$\chi^2 = \delta^T V^{-1} \delta$$

$$\delta = (\delta_j) = (\delta_{x,j}, \delta_{y,j}) = ((x_m - x)_j, (y_m - y)_j)$$

$$x = x_0 + a_x . (z - z_0)$$

$$y = y_0 + a_y . (z - z_0)$$

x_0, y_0, a_x, a_y are the variables to be optimized.

The elements of the covariance matrix: $V_{i,k} = r_{i,k} \sigma_i \sigma_k$

$r_{i,k}$ is the correlation coefficient between δ_i and δ_k

σ_i is the error on δ_i

Errors σ_i

σ's are the result of the digitization process and the scattering.

In simulation, define :

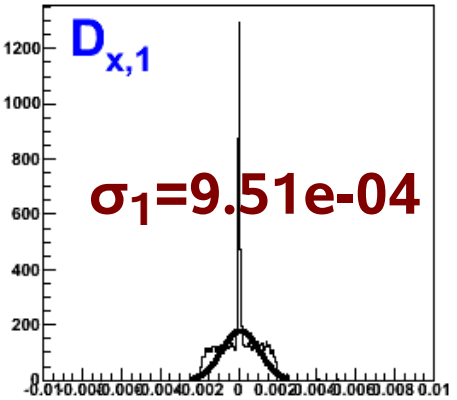
$$\vec{D} = \overrightarrow{X_{reco}} - \overrightarrow{X_{proj}}$$

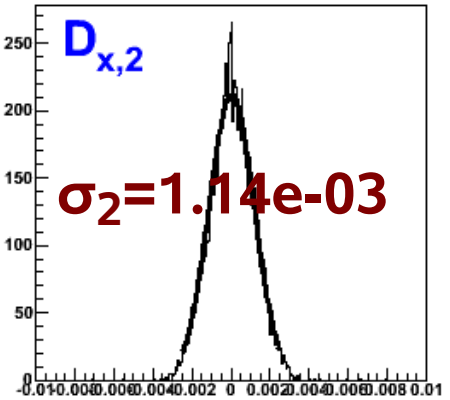
$\overrightarrow{X_{proj}}$ is the position of the fitted line based on the information at z_0 and one MC hit. It can be from:

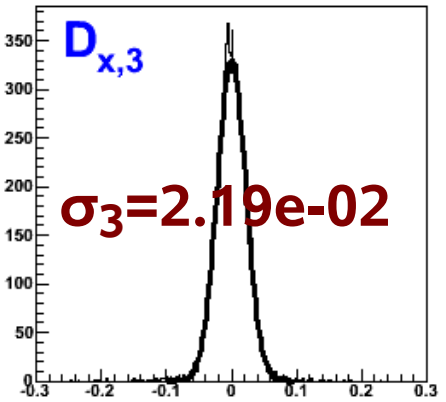
- vertex position & MC hit at 1st plane, or
- MC hit at the 2nd plane & MC hit at 1st plane (in abscence of the vertex, scattering in the 1st layer can be ignored), or
- additional point & MC hit at 1st plane.

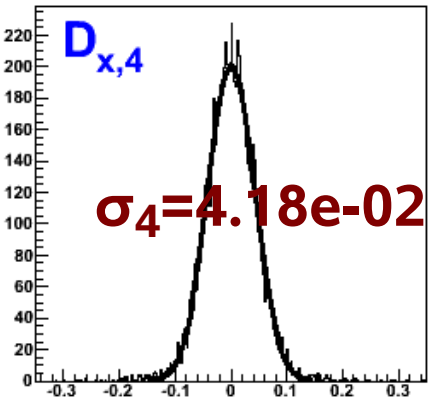
Simulation :

- 6 layers of silicon sensor:(D,SS,SS,D)
- proton beam of 2.95GeV/c momentum
- unknown vertex





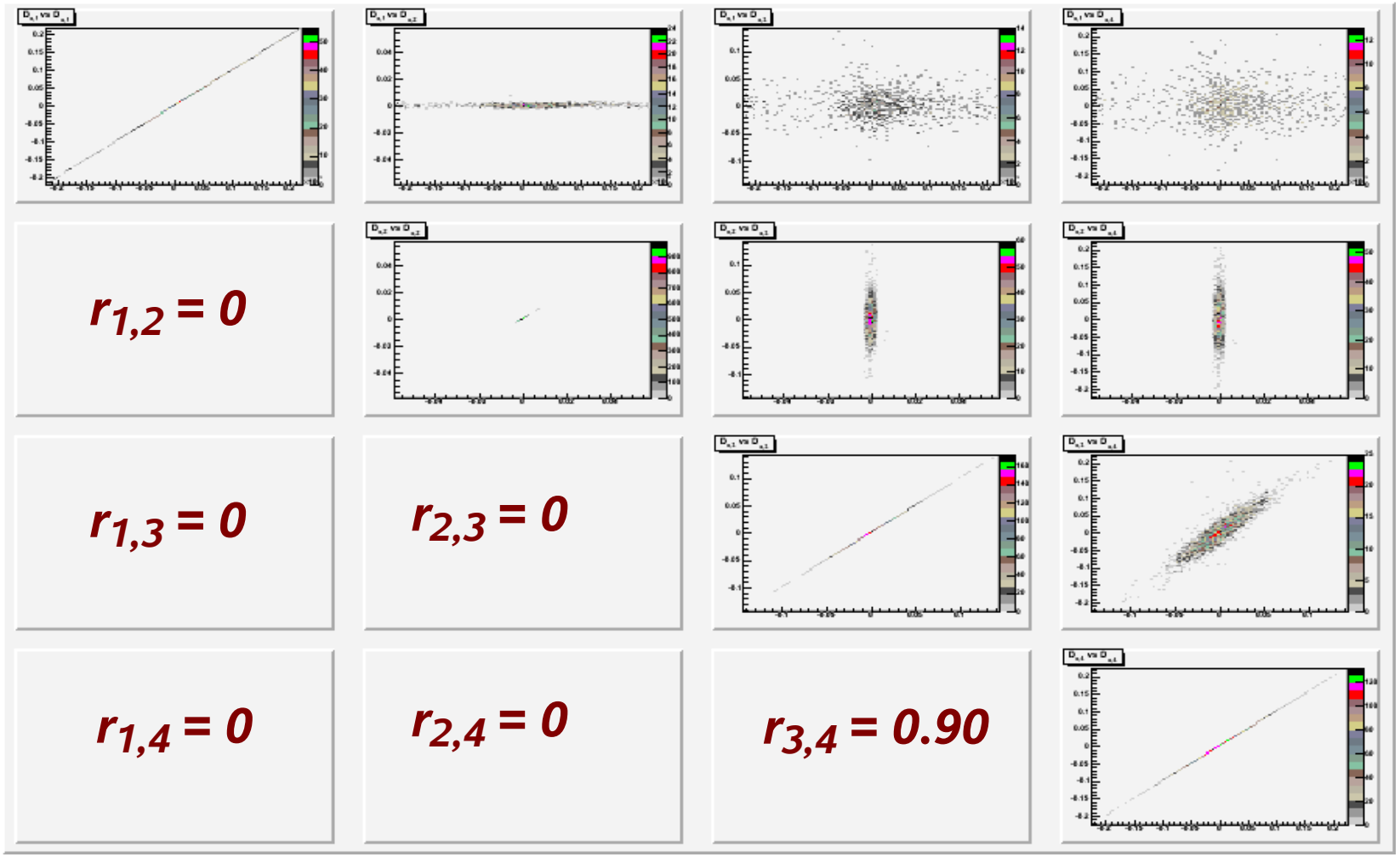




$\sigma_{x,i} = \sigma_{y,i}$

Correlation Coefficient $r_{i,k}$

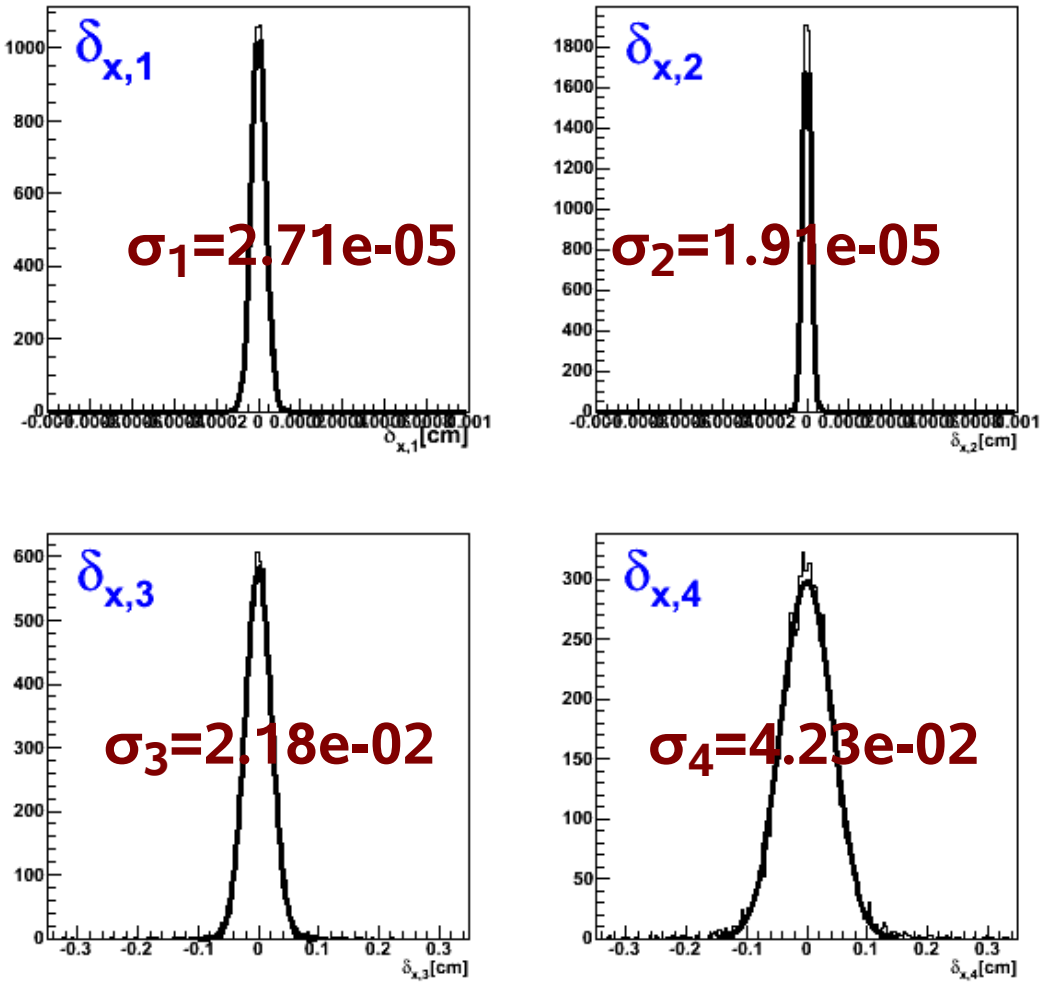
Scatter plots representing correlation between residuals on x-coordinate



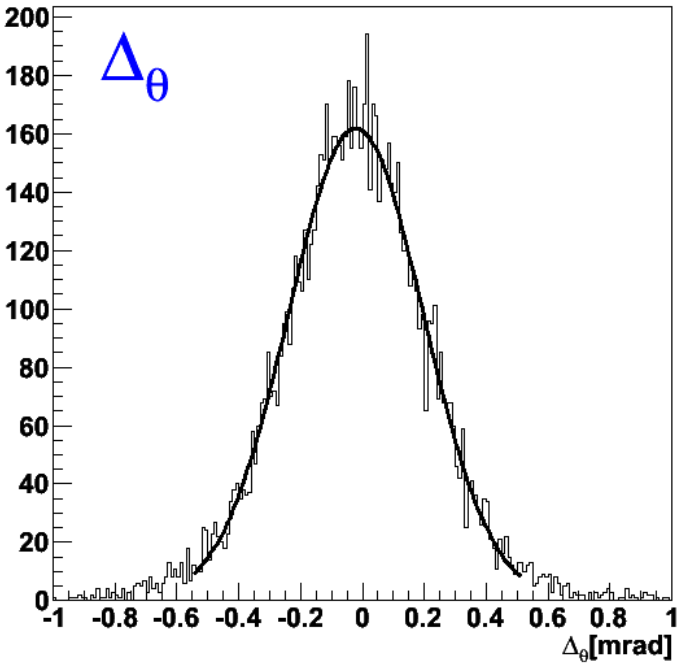
$$r_{x,i,k} = r_{y,i,k}$$

Result of the track fitter

Residual δ_i (RecoHit-RecoTrackPos) at the ith plane on x coordinate



$\Delta_\theta = \theta_{reco} - \theta_{MCTrue}$



Angular resolution σ_θ = 0.21 mrad

Detector Alignment

The alignment procedure consists of minimizing :

$$\chi^2 = \sum_{j}^{Ntrack} \epsilon_j^T W_j^{-1} \epsilon_j \qquad \epsilon = \begin{pmatrix} \epsilon_u \\ \epsilon_v \end{pmatrix} = \begin{pmatrix} u_x - u_m \\ v_x - v_m \end{pmatrix}$$

is the residual vector expressed in LCS *(u,v,w)*

W_j is the covariance matrix of the track j

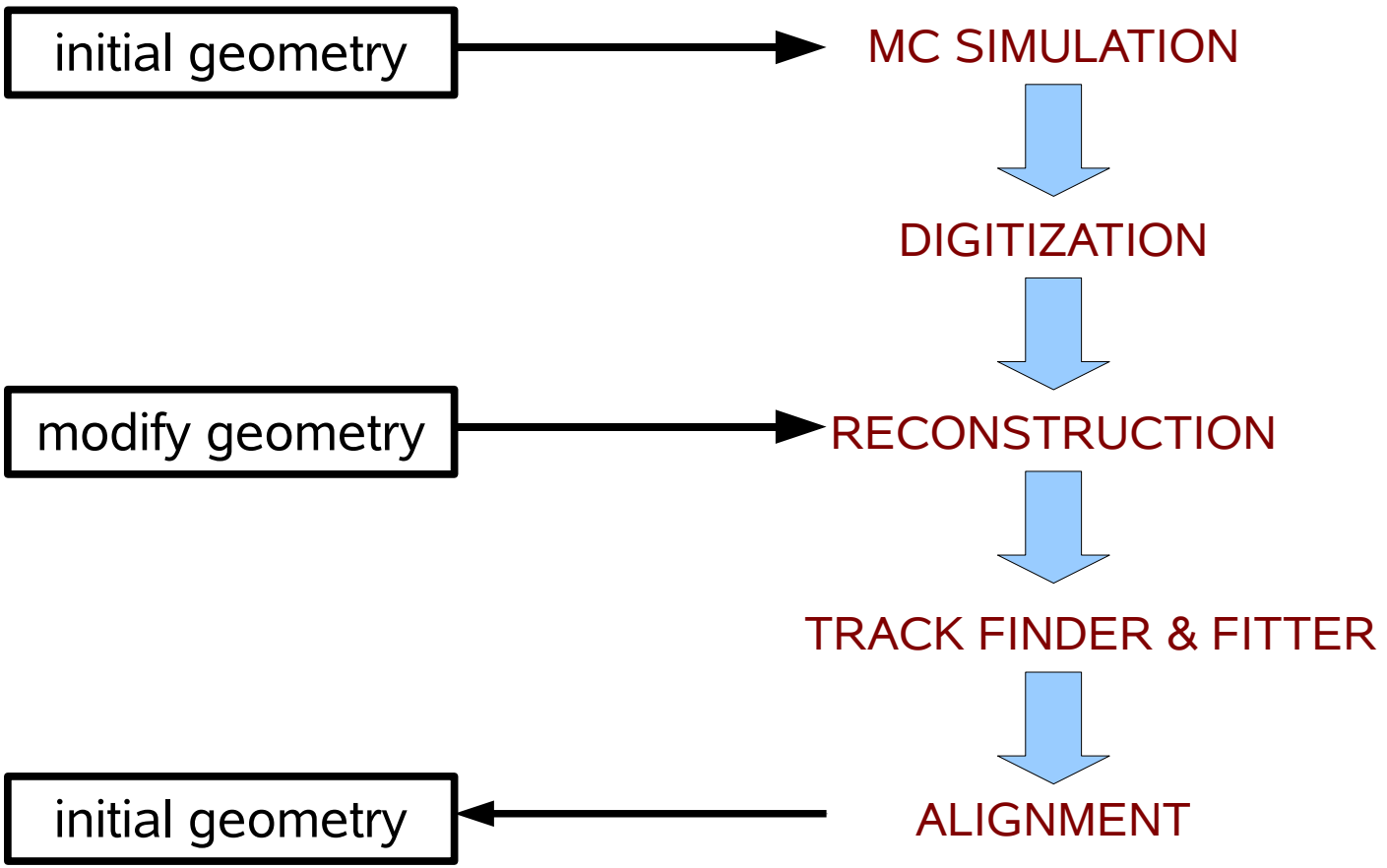
Explicitily, by assuming that the misalignment is small:

$$\epsilon_u = u_x - \Delta u + (\Delta\gamma + \Delta\alpha) v_x + (\Delta w + \Delta\beta v_x) \tan\psi - u_m$$

$$\epsilon_v = v_x - \Delta v - (\Delta\gamma + \Delta\alpha) u_x + (\Delta w + \Delta\beta v_x) \tan\theta - v_m$$

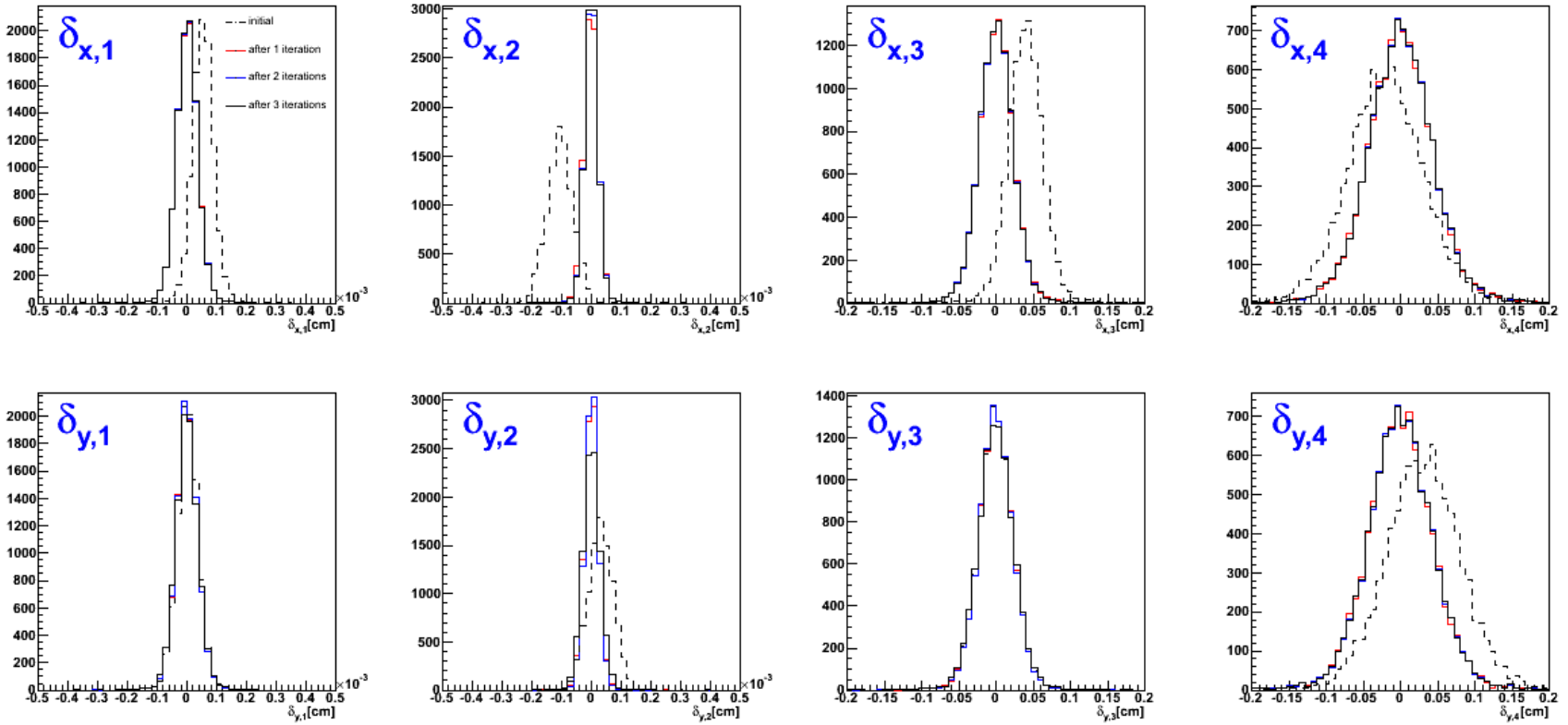
θ is the angle between the *uw*-plane and the track,
ψ is the angle between the *vw*-plane and the track and
Δu, Δv, Δw, $\Delta\alpha$, $\Delta\beta$ and $\Delta\gamma$ are the correction parameters.

Simulation Studies



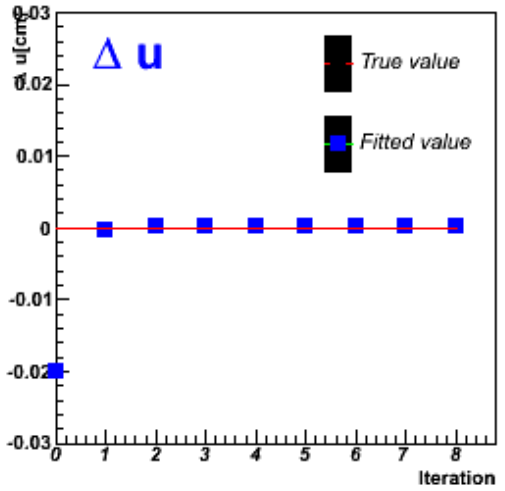
- The displacements have been introduced by hand for the 3 last planes.
- Δw = 0

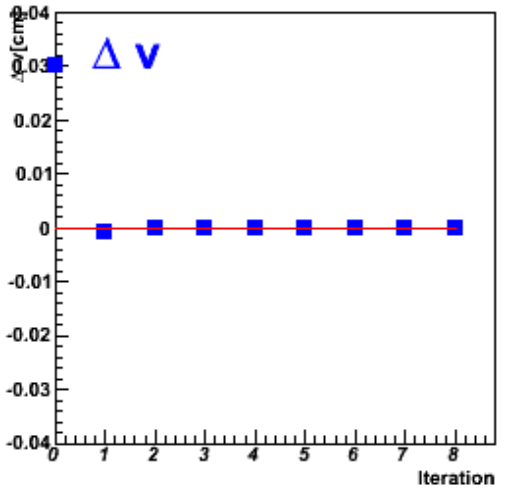
Residual δ_i at the ith plane on x and y coordinate after each iteration



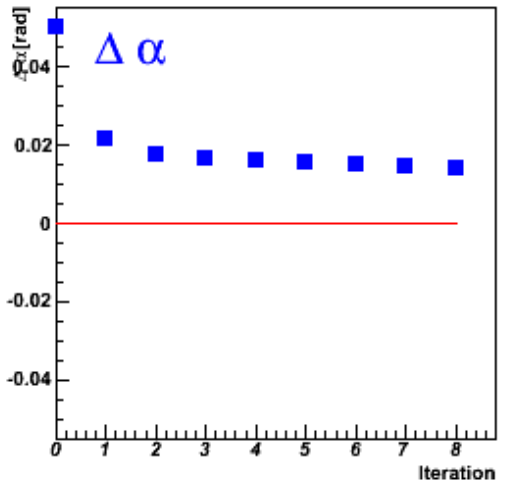
Alignment achieved after 2 iterations.

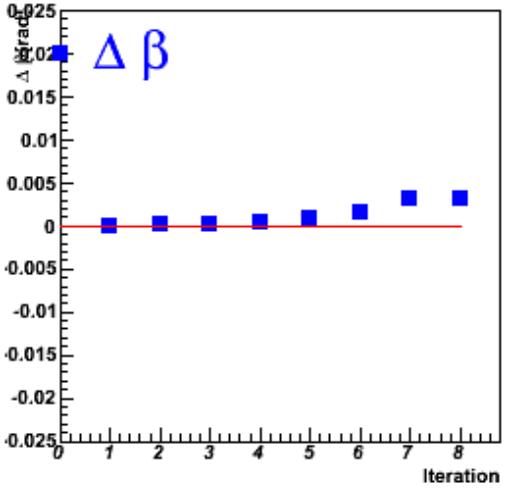
Values of the parameters after each iteration for the last plane

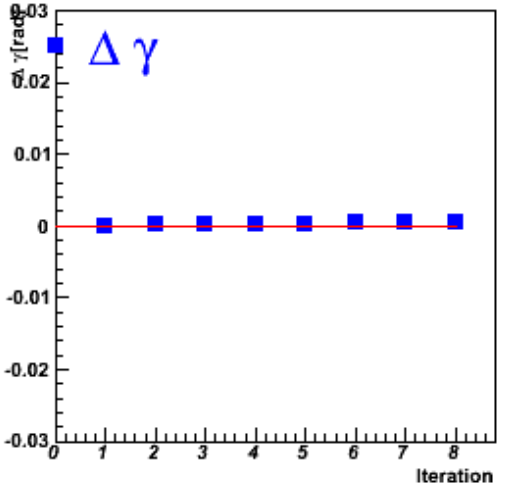




Very fast convergence for all parameters apart from Δα

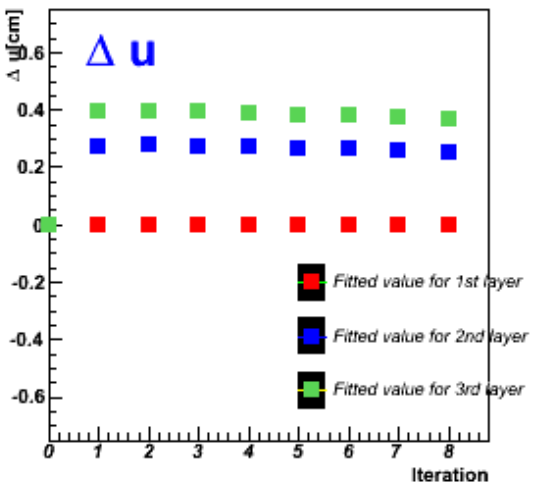


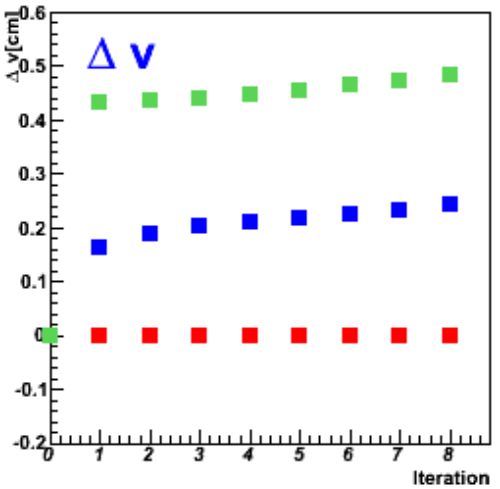




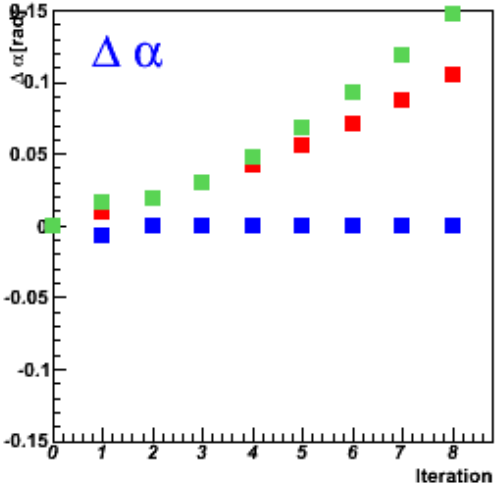
Alignment of the Tracking Station

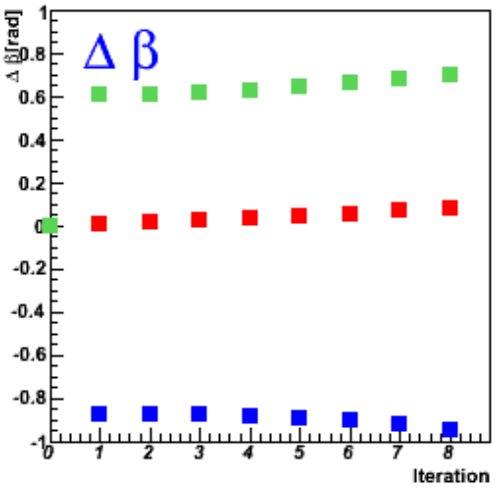
Constraintes : $\Delta u_1 = \Delta v_1 = 0$

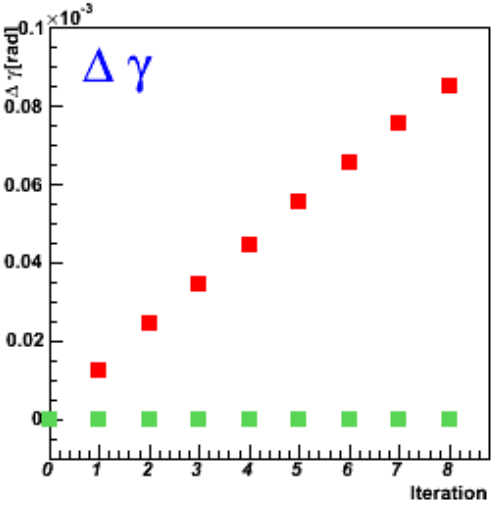




Convergence of Δα ?





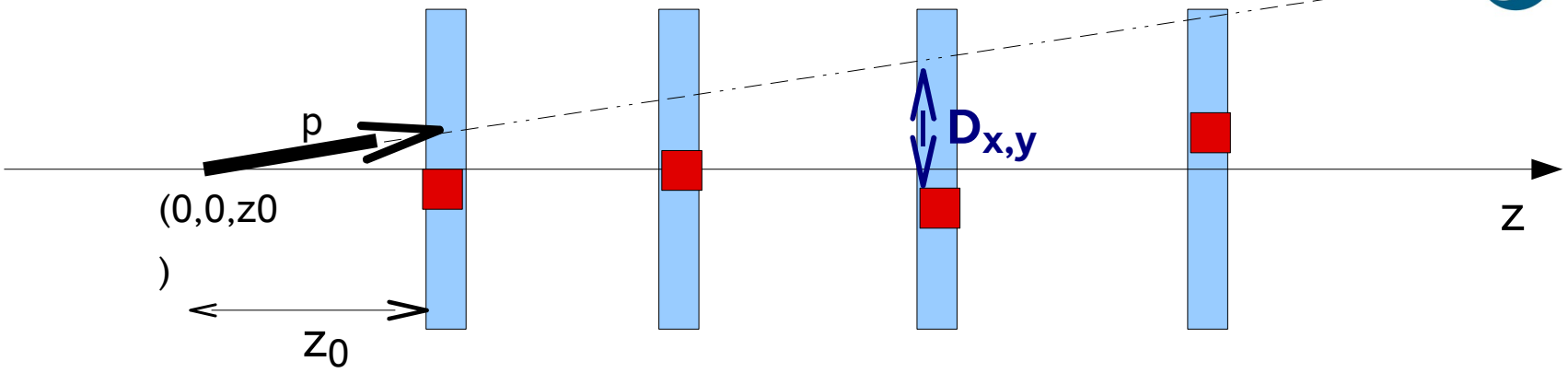


Conclusion

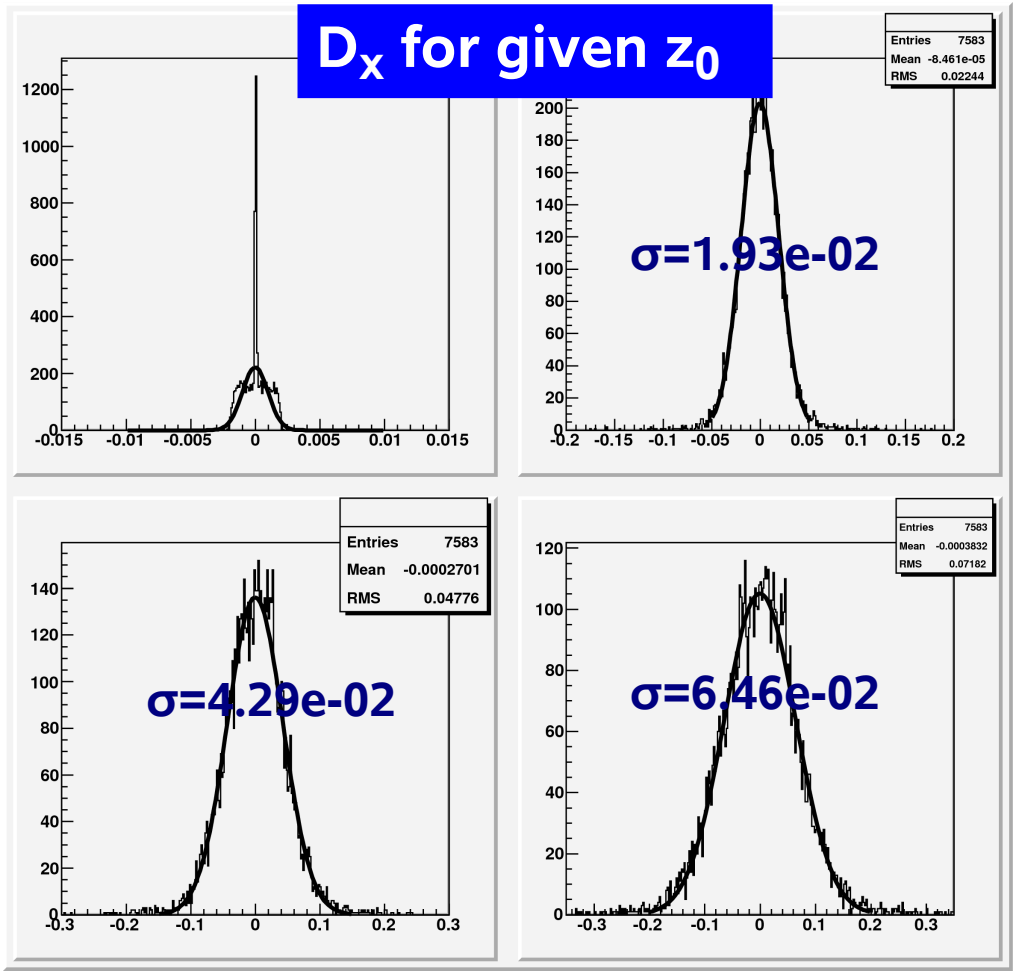
- A track fitter that takes into consideration the correlation between detector plane have been developed.
- A method of detectors alignment based on reconstructed tracks has been presented. Alignment can be acheived for less than 3 iterations.
- The relative position of the sensors of one of the setup of the BonnTS during the beam test at COSY in Julich was been determined by this alignment procedure.

THANK YOU!

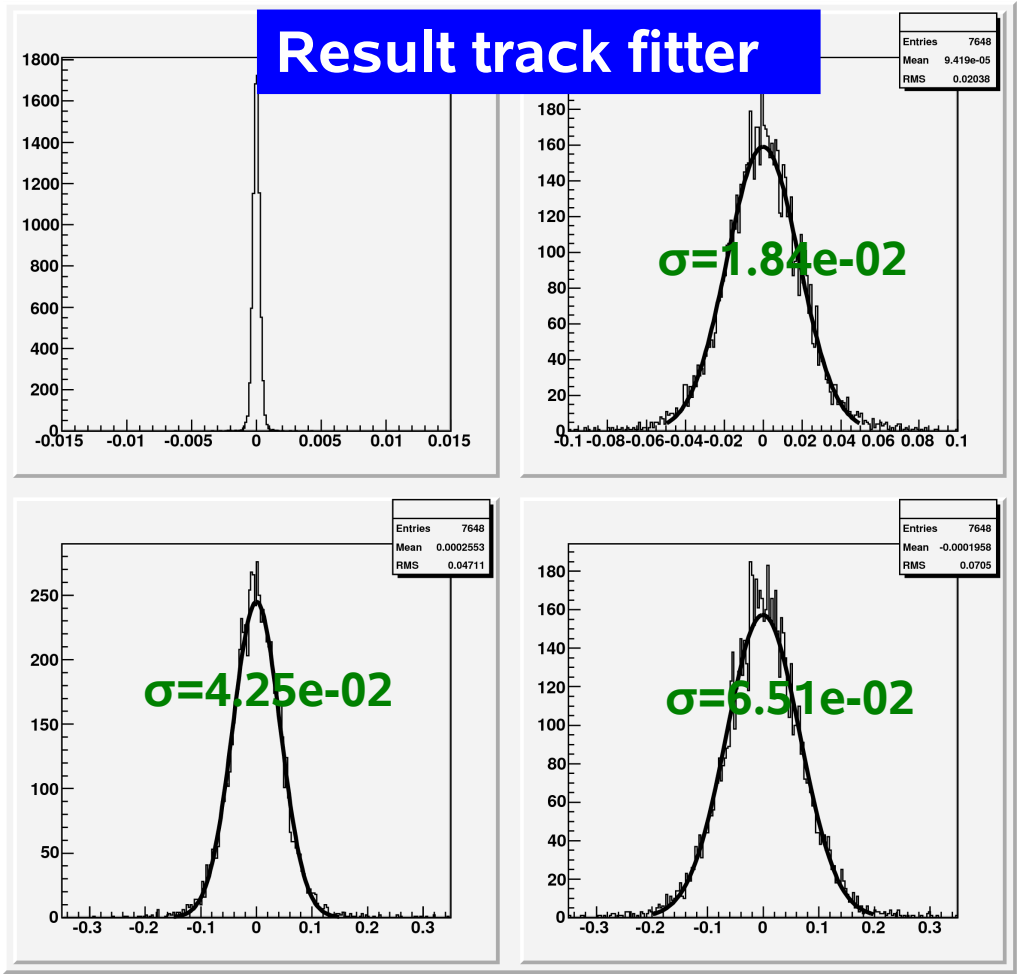
TRACK FITTER PROBLEM



D_x for given z_0

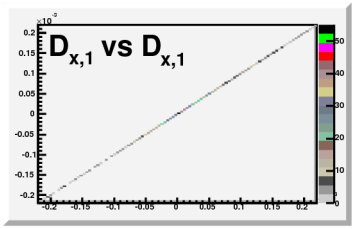


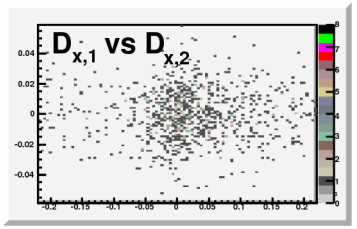
Result track fitter

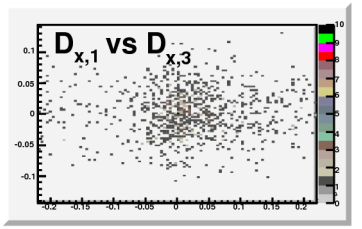


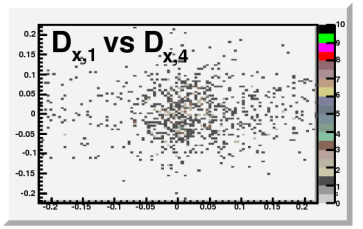
Correlation Coefficient $r_{i,k}$

Scatter plots representing correlation between residuals on x-coordinate

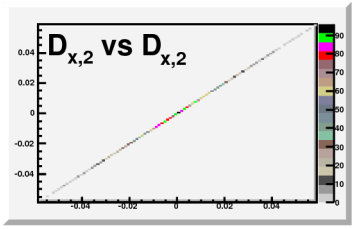


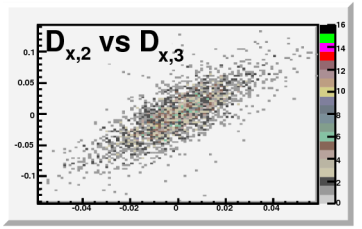


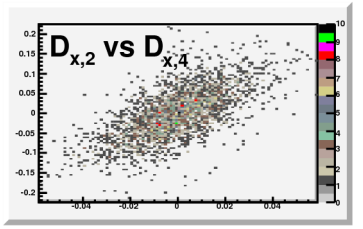




$r_{1,2} = 0$

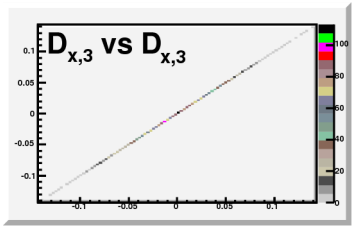


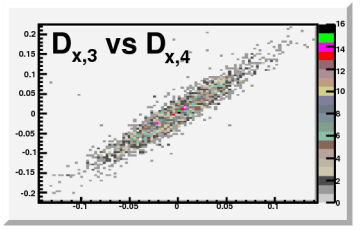




$r_{1,3} = 0$

$r_{2,3} = 0.76$

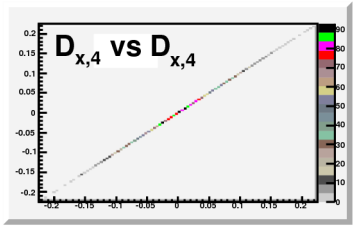




$r_{1,4} = 0$

$r_{2,4} = 0.64$

$r_{3,4} = 0.93$



$$r_{x,i,k} = r_{y,i,k}$$