I. The HIP Alignment

II. A Linear Fit

July 15th 2010 | T. Randriamalala, J. Ritman ,T. Stockmanns, H. Xu and

Outline

I. The HIP Alignment
II. A Linear Fit
III. Outlook

The HIP alignment

The **"Hits and Impact Points (HIP) Alignment"** is a track based alignment method .

It is consisting on finding the correct transformation by minimizing of the hit residuals $q_m(u_m,v_m,0)$ of the measured point and $q_x(u_x,v_x,0)$ of the track impact point in ***LCS*** ($\hat{w}$, the 3rd component unit vector, is perpendicular to the detector plane).

$$\chi^2 = \sum_{j}^{Ntrack} \varepsilon_j^T V_j^{-1} \varepsilon_j \qquad \varepsilon = \begin{pmatrix} \varepsilon_u \\ \varepsilon_v \end{pmatrix} = \begin{pmatrix} u_x - u_m \\ v_x - v_m \end{pmatrix}$$

V_j is the sum of measured and impact point positions covariance matrices of track j.

Basic Formalism

The correct total transformation from the GCS to the LCS:

$$q = \Delta R R \left(r - r_0\right) - \Delta q$$

where: $q\left(u,v,w\right)$: point coordinates in LCS,

$r\left(x,y,z\right)$: point coordinates in GCS,

$r_0\left(x_0,y_0,z_0\right)$: origin coordinates of LCS in GCS,

$R = R_\alpha R_\beta R_\gamma$: (ideal) rotation matrix,

$\Delta R = R_{\Delta\alpha} R_{\Delta\beta} R_{\Delta\gamma}$:corrective rotation matrix,

$\Delta q = \Delta R R \Delta r = \left(\Delta u, \Delta v, \Delta w\right)$:corrective translation.

With the approximation that the total corrective is small:

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

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

where : θ is the angle between uw-plane and the track

ψ is the angle between vw-plane and the track

p* = *(Δu, Δv, Δw, Δα, Δβ, Δγ) is the alignment parameter.

Simulation and results

Geometry: 4 layers of Silicon Strip Sensors parallel to xy-plane and have axis the z-axis

Introduce misalignment at the 4^{th} layer

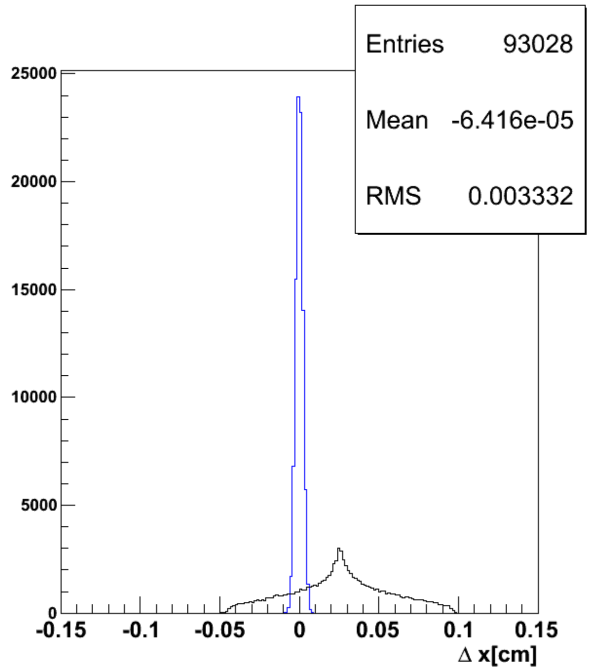
- x-shift : -0.0284 cm
- y-shift : 0.0279 cm
- ϕ = 50 mrad
- θ = 20 mrad
- ψ = 25 mrad

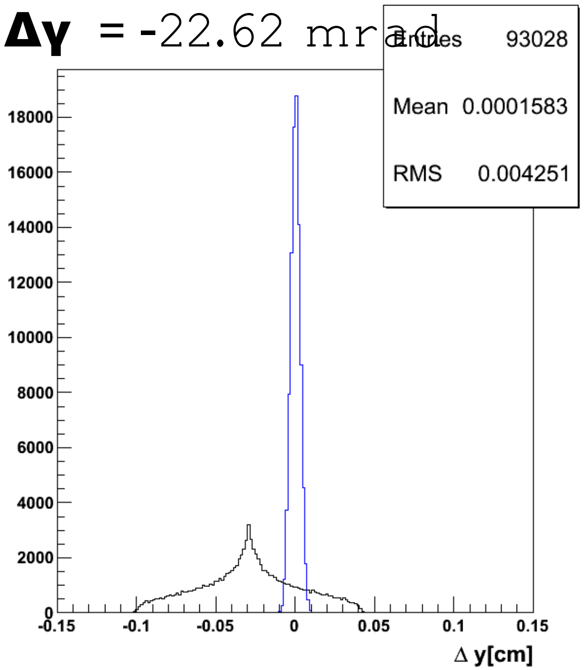
After alignment process

- **Δu** = 0.0277 cm
- **Δv** = -0.0274 cm
- **$\Delta\alpha$** = -49.99 mrad
- **$\Delta\beta$** = -19.32 mrad
- **$\Delta\gamma$** = -22.62 mrad

Residuals

black: before alignment
blue: after alignment





Remarks

This simulation has been done for 1000 GeV/c proton tracks: small scattering effect

$$V_j = V = \begin{pmatrix} \sigma_x^2 + \sigma_m^2 & 0 \\ 0 & \sigma_x^2 + \sigma_m^2 \end{pmatrix} = \begin{pmatrix} \sigma_m^2 & 0 \\ 0 & \sigma_m^2 \end{pmatrix} \qquad \sigma_m = pitch/\sqrt{12}$$

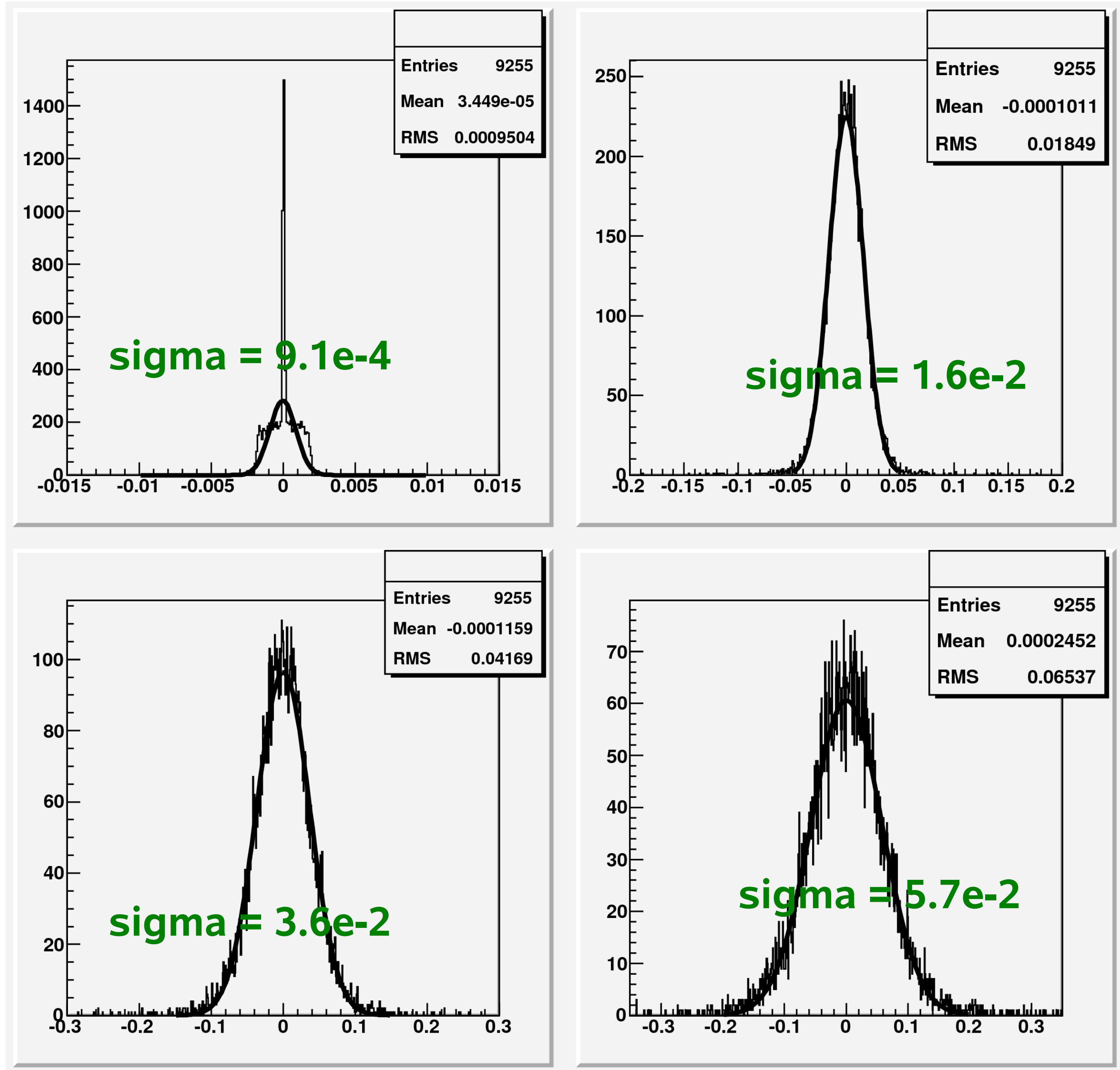
Hits lie in a straight line and the track impact positions are well measured.

For relative lower beam momenta, multiple scattering becomes stronger.

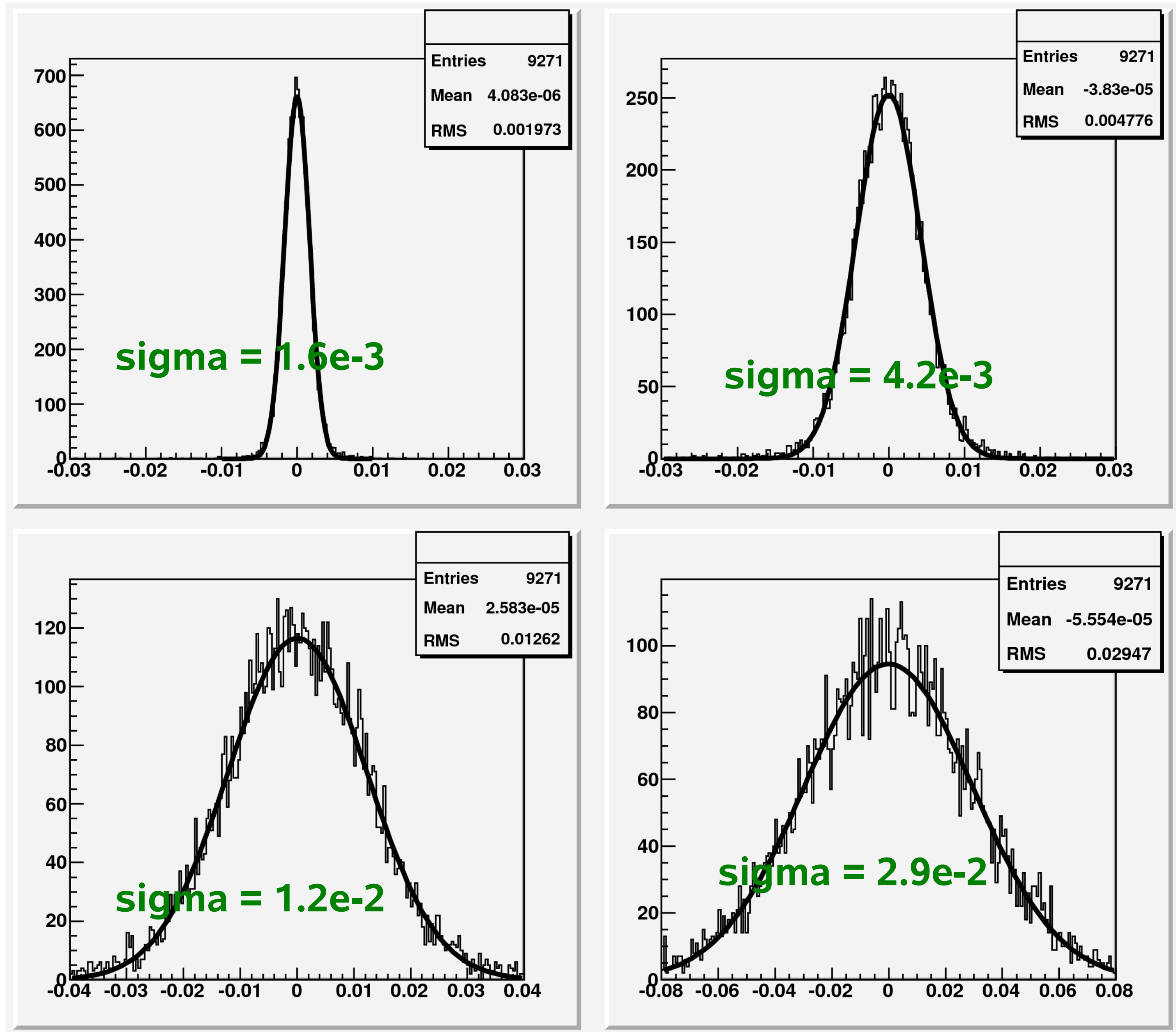
Linear Fit

@ 2.95 GeV/c

MC true – RecoHit



Result
from the
existing
linear track
fitter



Linear fit by minimizing:

$$\chi^2 = \sum_{j}^{NHit} \delta_j^T V_j^{-1} \delta_j$$

$\delta_j = (\delta x_j, \delta y_j)$

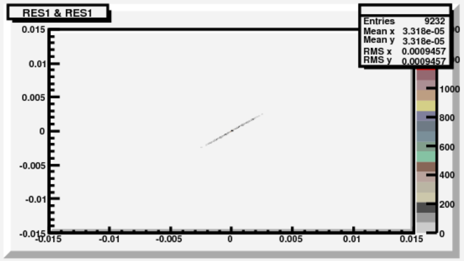
$\delta x = x_{reco} - (x_0 - a_x z)$, $\delta y = y_{reco} - (y_0 - b_x z)$

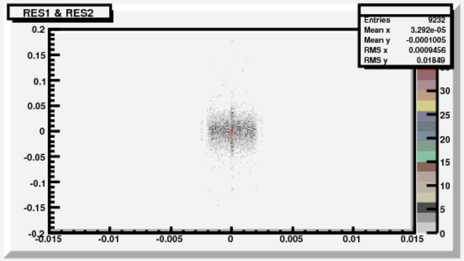
V_j is 8x8 covariance matrix

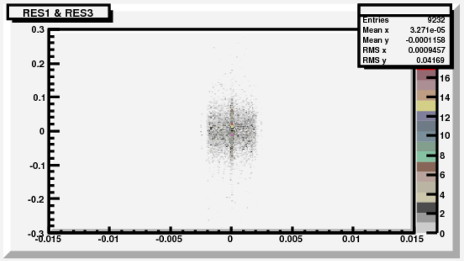
x_0, y_0, a and b are the output parameter from the minimization

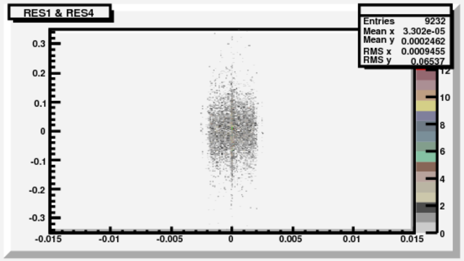
Covariance matrix involves correlation coefficients determination

Correlation Coefficients between residuals at each plane

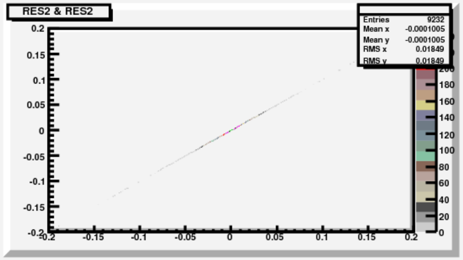


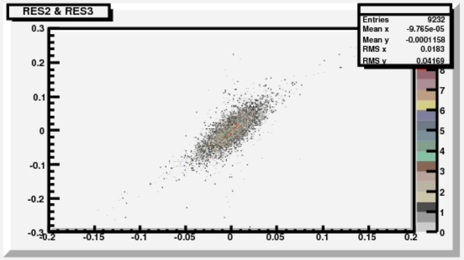


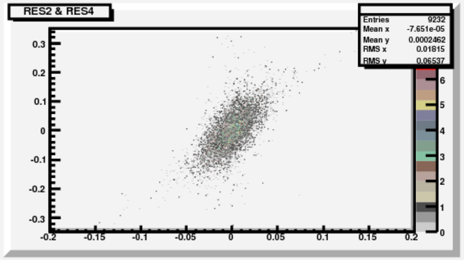




r12 = 0.0040803

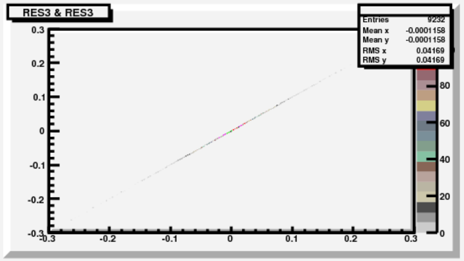


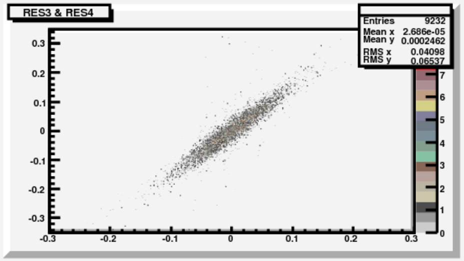




r13 = 0.0109865

r23 = 0.792915

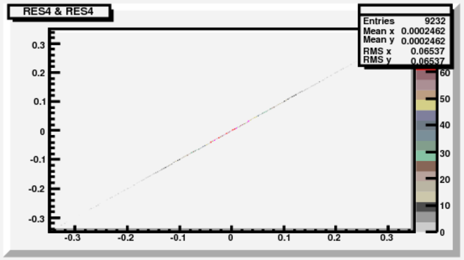


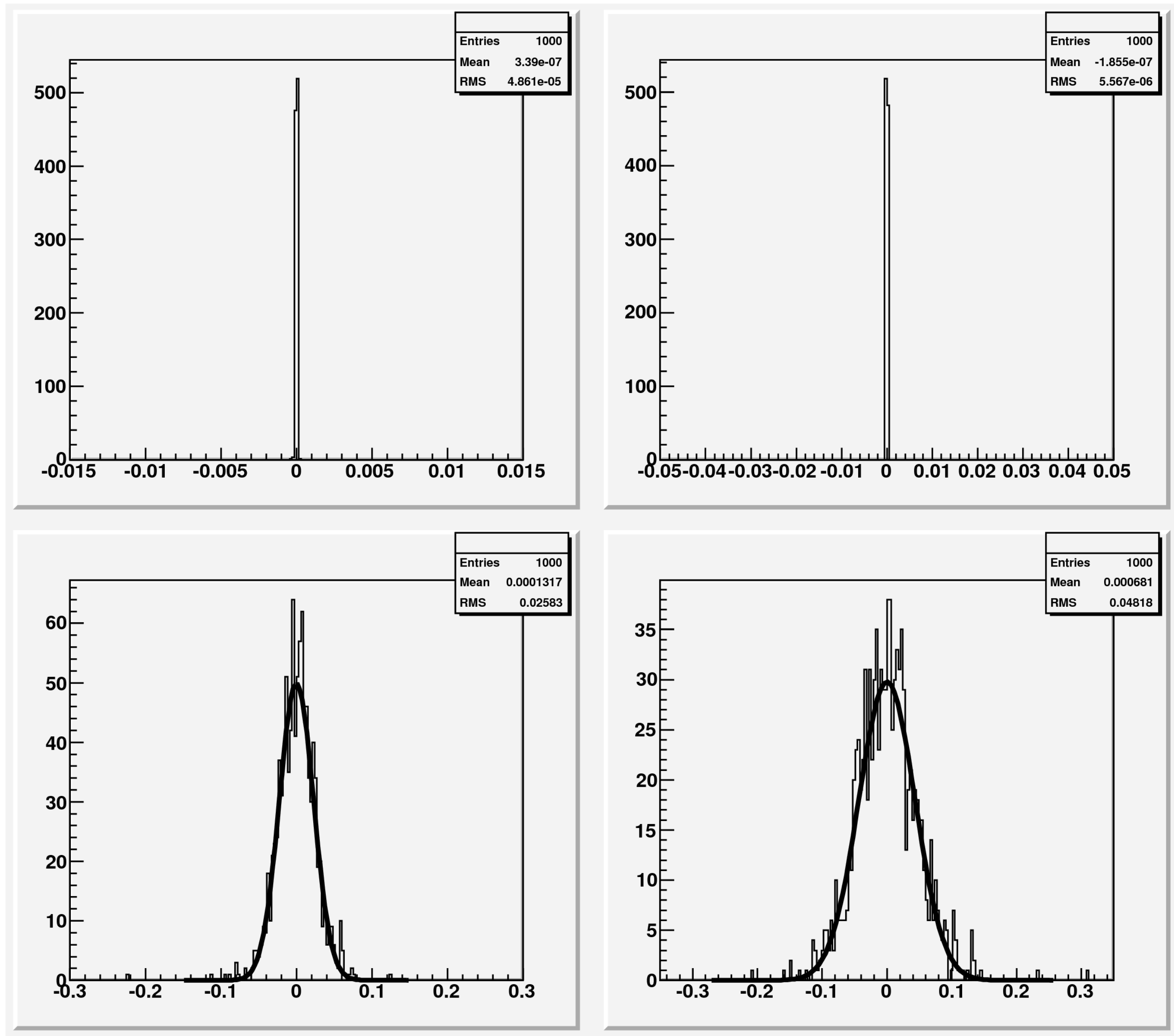


r14 = 0.0157063

r24 = 0.59982

r34 = 0.847575




Entries 1000
Mean 3.39e-07
RMS 4.861e-05
Entries 1000
Mean -1.855e-07
RMS 5.567e-06
Entries 1000
Mean 0.0001317
RMS 0.02583
Entries 1000
Mean 0.000681
RMS 0.04818

Outlook

More investigation on the correlation coefficient

Get the alignment works for more than 2 planes adjustment.