

# *TPC ExB and V drift calibration and alignment*

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# *Outlook*

- Requirements
- Space point resolution - (Lars Bozyk)
- Calibration strategy:
  - ExB (Magnus Mager)
  - Drift velocity (GOOFIE -2008 +CE - 2006 ) - (Juan Castillo, Martin Siska, Stefan Rossegger, Jens Viechula)
  - Alignment (Magnus Mager, Jens Viechula)
- Impact of mis-calibration - misalignment (Pt resolution, DCA resolution)
- Status – Ready for first collision

# Requirements – Statistical error

Covariance Matrix -

Extrapolation 0

$$\begin{bmatrix} \frac{9s^2}{L} & -\frac{36s^2}{L^2} & \frac{30s^2}{L^3} \\ \frac{36s^2}{L^2} & \frac{192s^2}{L^3} & -\frac{180s^2}{L^4} \\ \frac{30s^2}{L^3} & -\frac{180s^2}{L^4} & \frac{180s^2}{L^5} \end{bmatrix}$$

Covariance Matrix -

Interpolation middle

$$\begin{bmatrix} \frac{9s^2}{4L} & 0 & -\frac{15s^2}{L^3} \\ 0 & \frac{12s^2}{L^3} & 0 \\ -\frac{15s^2}{L^3} & 0 & \frac{180s^2}{L^5} \end{bmatrix}$$

Covariance matrix at X=x0

L – Level Arm

Sigma – error of measurement

Constrain	Plane	Resolution (cm)
0	Vertex	0.102
1	Vertex	0.019
0	TPC in	0.020
1	TPC in	0.011
0	TPC mid	0.012
1	TPC mid	0.009
0	TPC out	0.029
1	TPC out	0.023
0	TRD in	0.086
1	TRD in	0.049

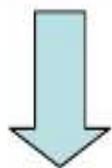
Constrain	Plane	Resolution (mrad)
0	Vertex	1.349
1	Vertex	0.329
0	TPC in	0.639
1	TPC in	0.131
0	TPC mid	0.175
1	TPC mid	0.174
0	TPC out	0.744
1	TPC out	0.373
0	TRD in	1.234
1	TRD in	0.537

Constrain	Plane	Resolution (1/m)
1	TRD in	0.00027
0	TRD in	0.00082

- TPC standalone resolution (hpt tracks)
  - TPC in 0.110 mm, 0.130 mrad
  - Vertex 1 mm, 0.3 mrad
- Strong requirement - mean pull position at entrance of TPC
  - Maximal rotation ~ 0.1 mrad
  - Maximal translation- 100 microns
- Physic performance requirement can be weaker
  - The systematic error to be added to the track covariance matrix

# Requirement – Influence of misalignment

$$\vec{P} = \vec{S}_y S_x^{-1}$$
$$C = S_x^{-1}$$



$$y = y + \Delta y + k_y x + \dots$$
$$\vec{S}_y = \vec{S}_y + \vec{S}_{Dy}$$
$$\vec{P} = \vec{S}_y S_x^{-1}$$
$$\vec{P} = (\vec{S}_y + \vec{S}_{Dy}) S_x^{-1} = \vec{P} + \Delta \vec{P}$$

- Ideal case:
  - P – parameter vector at reference point X0
  - C covariance matrix
  - Sy, Sx - sum vector and matrix
- Misaligned case
  - Delta of parameters – linear combination of missalignment parameters
- In parabolic approximation the introduction of the linear distortion of space points leads to the additional distortion of the track parameter vector
- To estimate the influence of misalignment, miscalibration (see following slides) only residuals fitted

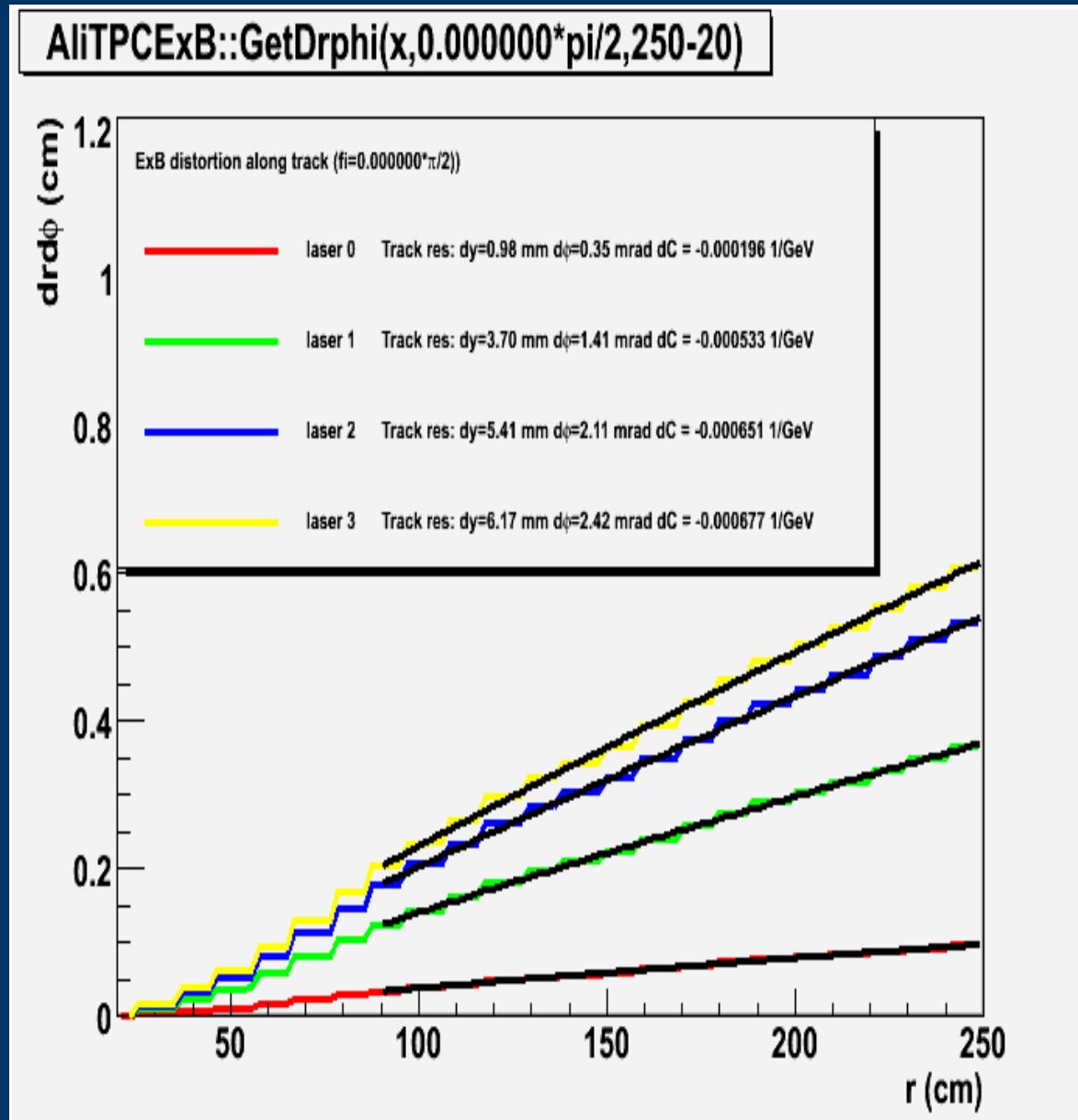
# ***ExB effect***

$$\mathbf{u} = \frac{e}{m} \tau E \frac{1}{1 + (\omega\tau)^2} \left( \hat{\mathbf{E}} + \omega\tau [\hat{\mathbf{E}} \times \hat{\mathbf{B}}] + (\omega\tau)^2 (\hat{\mathbf{E}} \cdot \hat{\mathbf{B}}) \hat{\mathbf{B}} \right)$$

- The Alice TPC omega-tau at 0.5T ~ 0.33
- The typical Bx/Bz ratio ~+0.01 (z, r and fi dependent)
  - In first approximation radial symmetry
- The dominant correction part follow ExB vector
  - The deviation from ideal position given by E vector ~ 0.6 cm
  - 250 cm drift x 0.01 (ExB) x 0.33 (omega-tau)

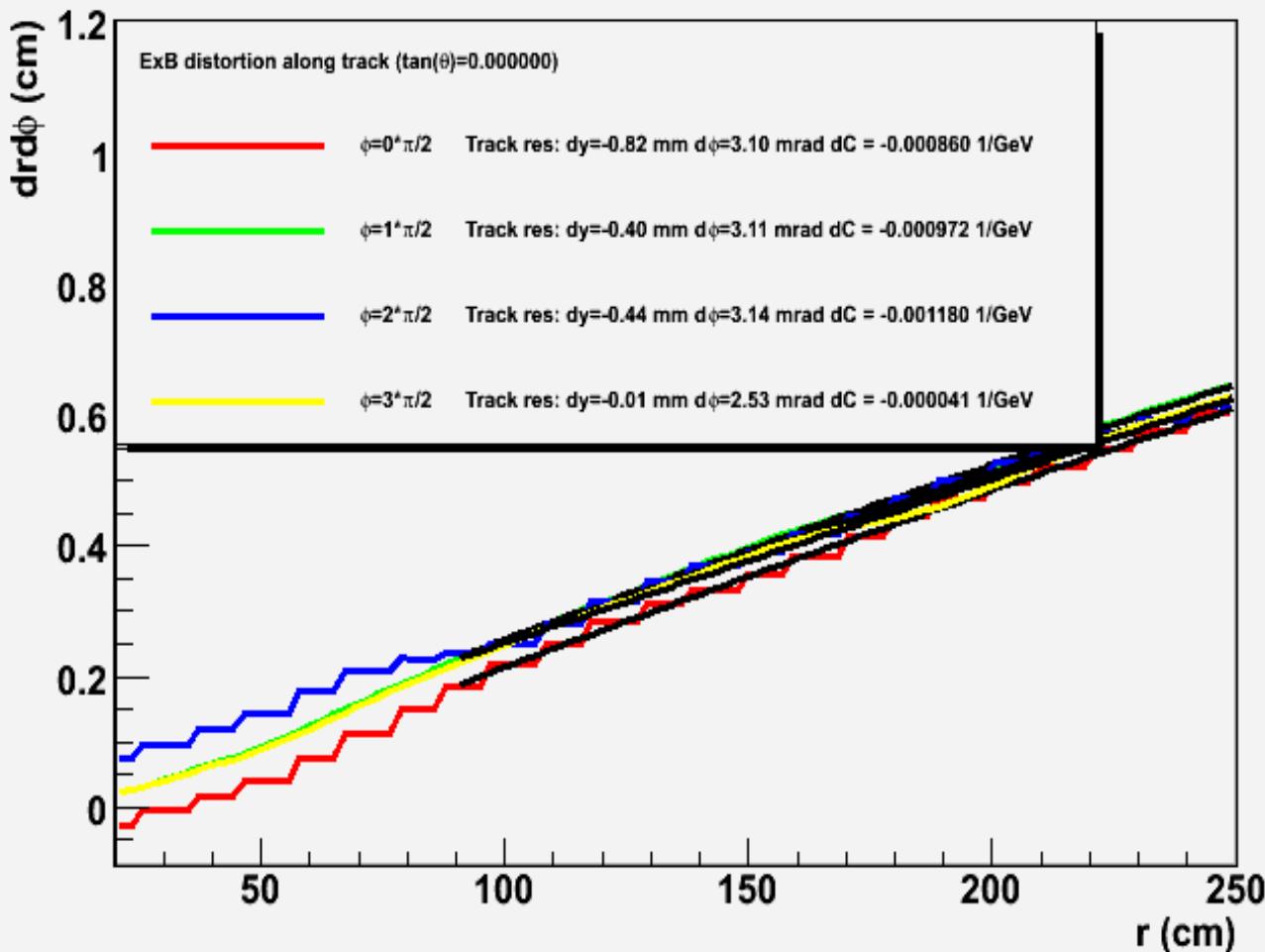
# *ExB effect correction*

- ExB correction estimated integrating correction drift velocity vector along full trajectory to readout plane
  - ExB correction object stored in the OCDB and used in simulation, reconstruction
- B field input MC, or measured field map
- Distortion proportional to the B field
- Example: r- $\phi$  distortion of the laser tracks at 4 different z position ( $B=0.5$  T)



# *ExB effect - Impact to DCA, angular momentum resolution (Theta=0)*

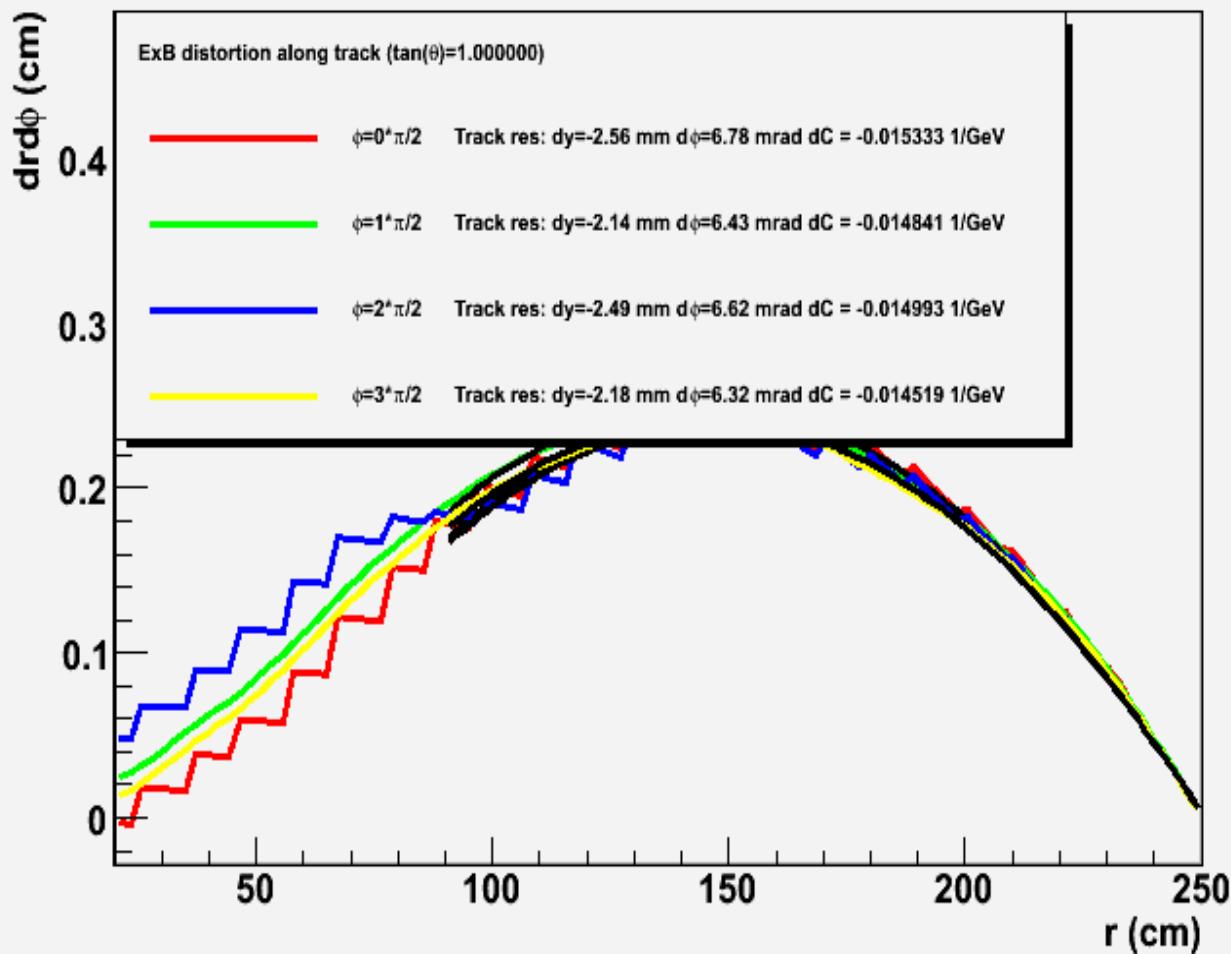
AliTPCExB::GetDrphi(x,0\*pi/2,0.000000\*x)



- DCA dist.
  - 0 – 0.8 mm
- Angle dist.
  - 2.5 – 3.14 mrad
- Curvature dist.
  - -0.0004 -0.001 1/GeV

# *ExB effect - Impact to DCA, angular and momenta resolution (Theta=1)*

AliTPCExB::GetDrphi(x,0\*pi/2,1.000000\*x)



- DCA dist.
  - $\sim -2.56$  mm
- Angle dist.
  - $\sim 6.5$  mrad
- Curvature dist.
  - $-0.014$  1/GeV

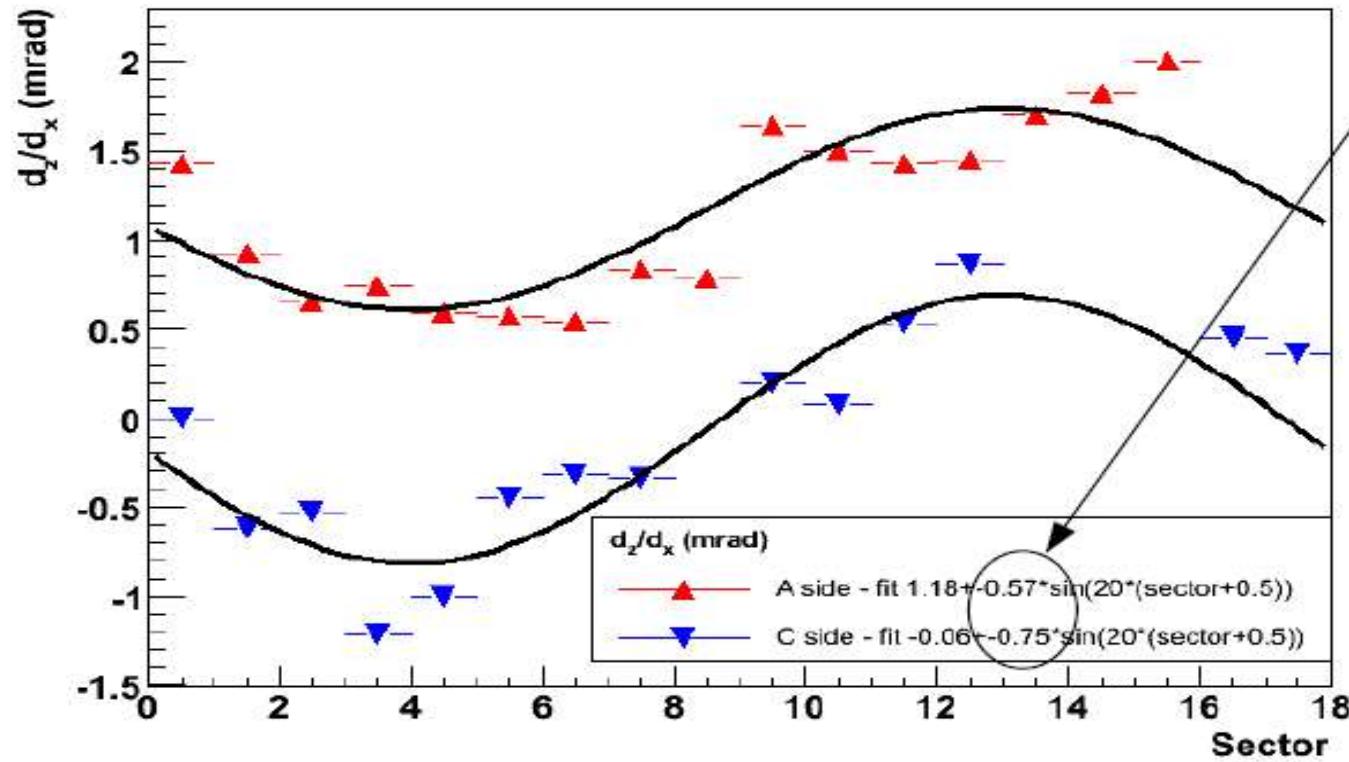
# ***ExB effect -Calibration strategy***

- 1)Construct ExB correction table using measured magnetic field – Done
- 2)Verify correction table using laser scan with different B fields (-0.5 .. -0.2 .. 0 ..0.2 0.5 T)
  - 1)To be done
- 3)Adjust omega-tau factor (uncertainty ~20 %)
- 4)Fit the mean angle between E and B vector (2 order correction)
- 5)Estimate systematic effects
  - 1)Systematic effect to be added to the Covariance matrix of the track

# *Drift velocity*

- Drift velocity - function of environment variables (T,P, gas composition, Electric field)
- Environment variables - space and time dependent
- TPC statistical limit
  - Resolution  $v_d \sim 0.004\%$  ( $0.01\text{ cm}/250\text{ cm}$  drift length)
- Physics requirement
  - Resolution at vertex 1 mm - 0.3 mrad ==>Resolution  $v_d \sim 0.04\%$

# Drift velocity – space dependence



Major ~ 0.7 mrad  
difference in vertical  
direction (**top to  
bottom**) of the TPC

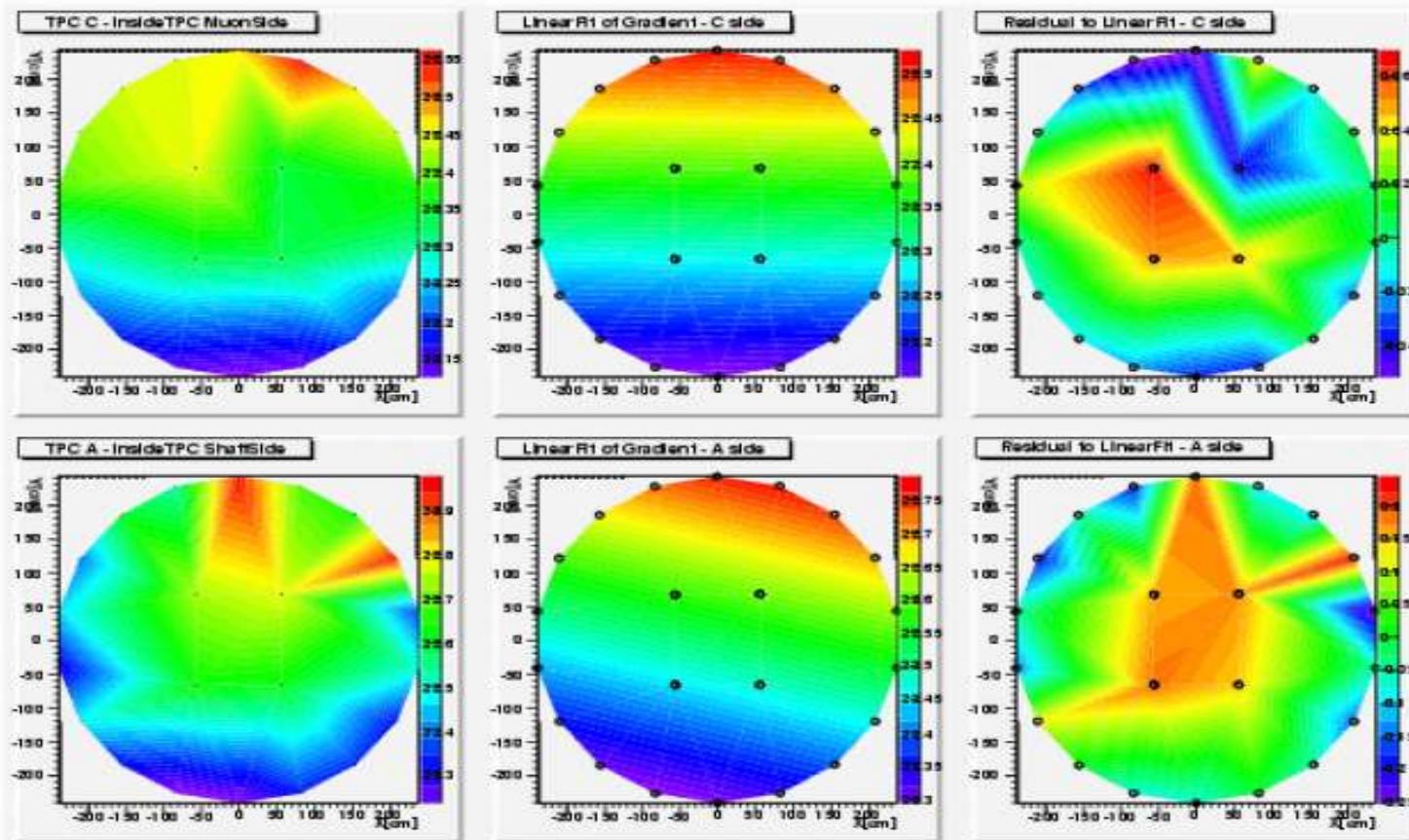
-> corresponds to  
 $\Delta z \sim 3.5\text{mm}$   
-> corresponds to  
 $\Delta v_d \sim 0.14\%$

Previous suggestion:  
**Pressure drop?**

- Parameters like E, C<sub>CO2</sub>, C<sub>N2</sub> assumed to be constant in vertical direction (top/bottom of the TPC)
- Pressure drop over 5m  $\Delta p = \rho * g * h = 0.34 \text{ TORR}$   
->  $\Delta v_d \sim 0.046\% \dots$  not significant!
- A combination with  **$\Delta T \sim 0.4\text{K}$  would cause**  
 **$\Delta v_d \sim 0.14\%$**

# *Drift velocity – space dependence*

## Vertical TempGradient within the TPC



### C side

LinearFit:  $T_0 + p1 X + p2 Y$   
 $T_0 | 22.3415$

$p1 | 1.86722e-05$   
 $p2 | 0.000759867$

$$dT/dY =$$

**0.38 K per 500cm**

Residual to data  
[min -0.04 | max 0.07 ]

### A side

LinearFit:  $T_0 + p1 X + p2 Y$   
 $T_0 | 22.5388$

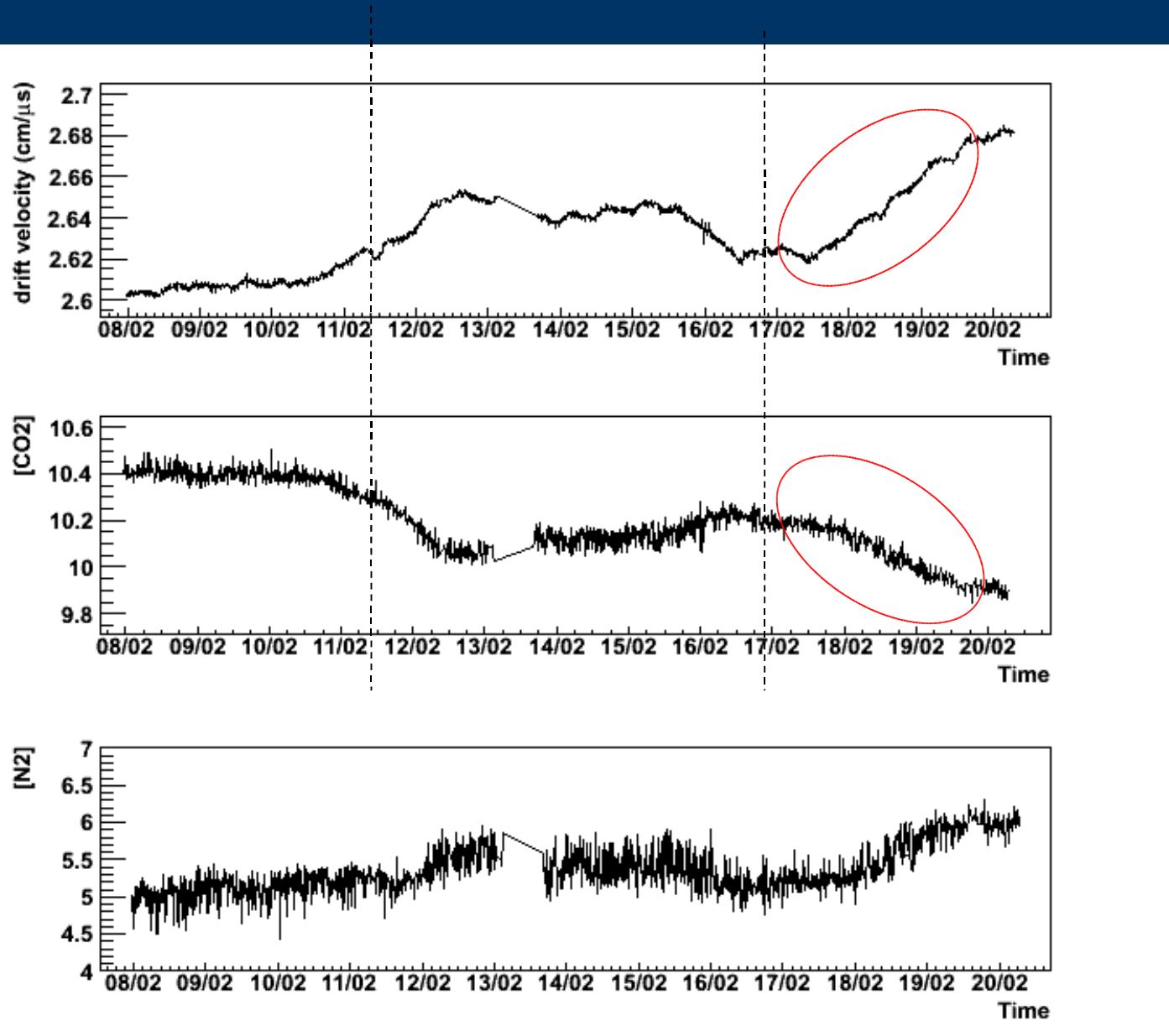
$p1 | 0.000267293$   
 $p2 | 0.000983088$

$$dT/dY =$$

**0.49 K per 500cm**

Residual to data  
[min -0.27 | max 0.26]

# *Drift velocity – time dependence*



Zone C

-CO<sub>2</sub> 10.2 % -> 10%

-V<sub>drift</sub> 2.62 cm/us-> 2.68cm/us

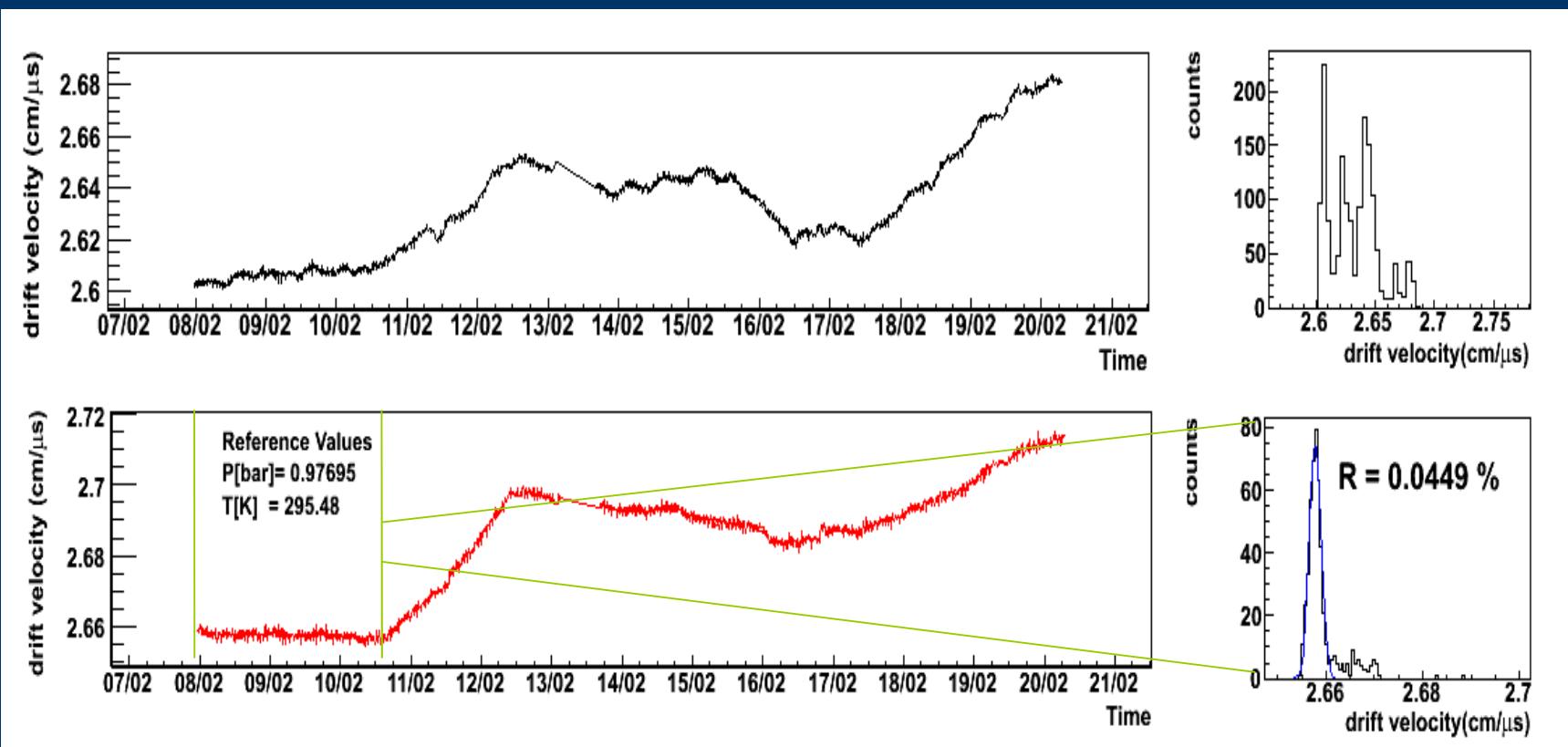
- V<sub>drift</sub> < 2.2%

Zone A and Zone B

-shows the stability of gas composition for 5 days

# *Drift velocity – time dependence*

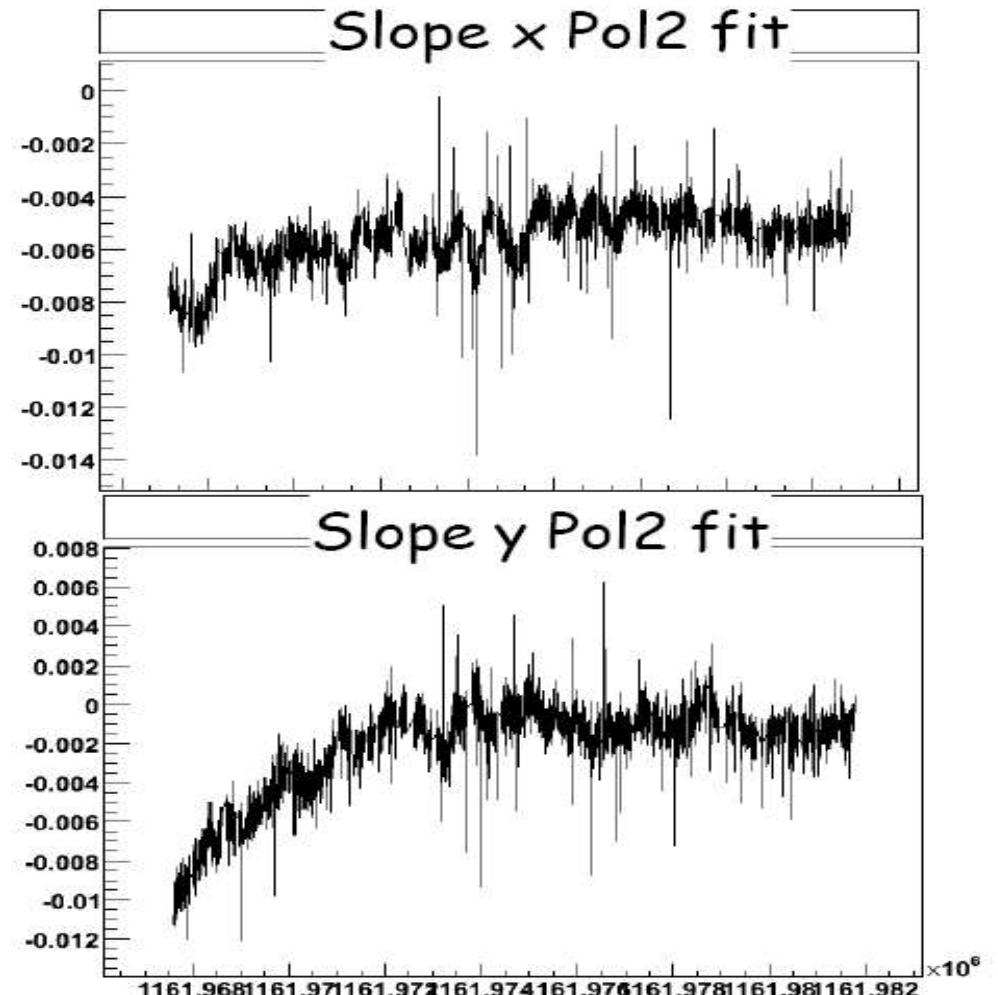
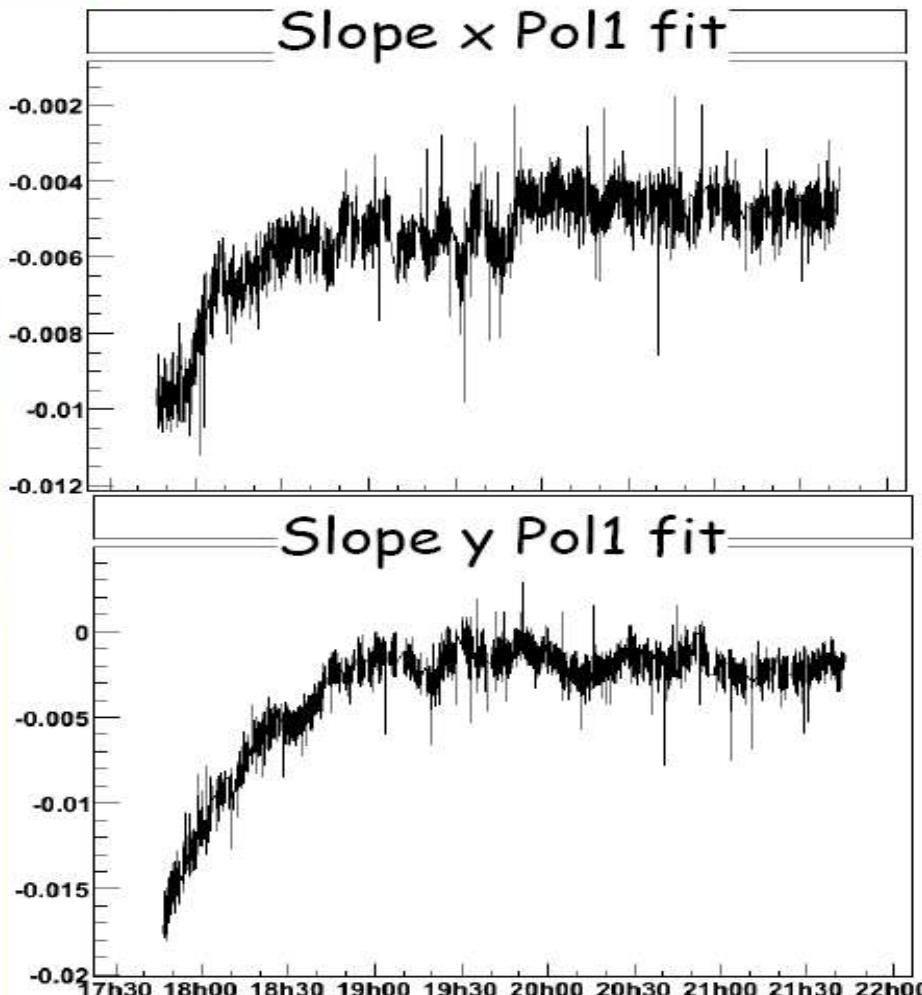
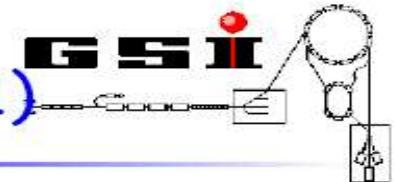
- top: raw velocity measurement depend on time
- bottom: velocity corrected with Temperature and Pressure,  
NO with gas composition
- resolution of Vdrift is 0.05% (500 data points, range of stable gas composition)



# *Drift velocity – Time dependence*



CE time dependence (examples OrocA11)



# *Drift velocity – calibration strategy*

- Options:
  - Goofie calibration + DCS values (T, P) - (ONLINE)
    - Time dependence (Goofie) - to be corrected for the T and P at TPC (
    - Space dependence DCS values (T,P) – linear fit
    - Relative precision 0.05% (1 mm at vertex)
  - Laser Central electrode - (ONLINE)
    - Space and time dependence of drift velocity
    - Relative precision  $\sim 0.01 \text{ cm}/250\text{cm} \sim 0.004 \%$
  - Calibration using tracks – (OFFLINE)
    - Track crossing central electrode
    - Reconstructed primary vertex position using the tracks from A and C side of the TPC
    - Relative precision  $\sim 2 \text{ mm} / \sqrt{N_{\text{events}}}$

# *Drift velocity – calibration strategy*

- All 3 methods to be cross-checked
- Calibrate 1 (GOOFIE +DCS) method using laser calibration
- The offline calibration as a quality assurance
- Estimate systematic

# *Alignment*

- Precision given by surveyor measurement ~  
sigma ~ 0.1- 0.15 mm

# *Track and CE plane based alignment for ALICE TPC*

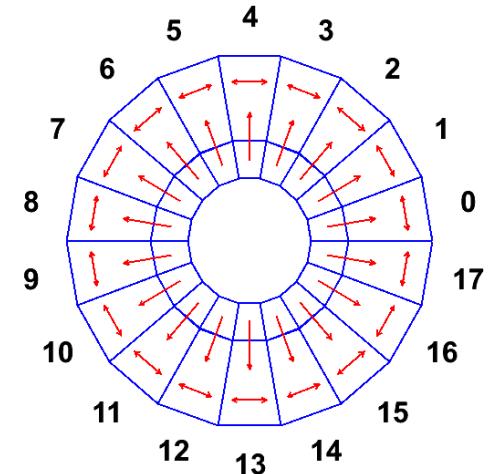
- Strategy:
  1. Relative alignment of pairs of sectors – minimization of the chi2 distance between track (plane) extrapolation from sector k to track (plane) at sector i ( $K_{ik}$ )
  2. Find the set of correction constants  $C_i$  for each sector

$$K_{ik} I_i X_{li} - I_k X_{lk} = 0$$

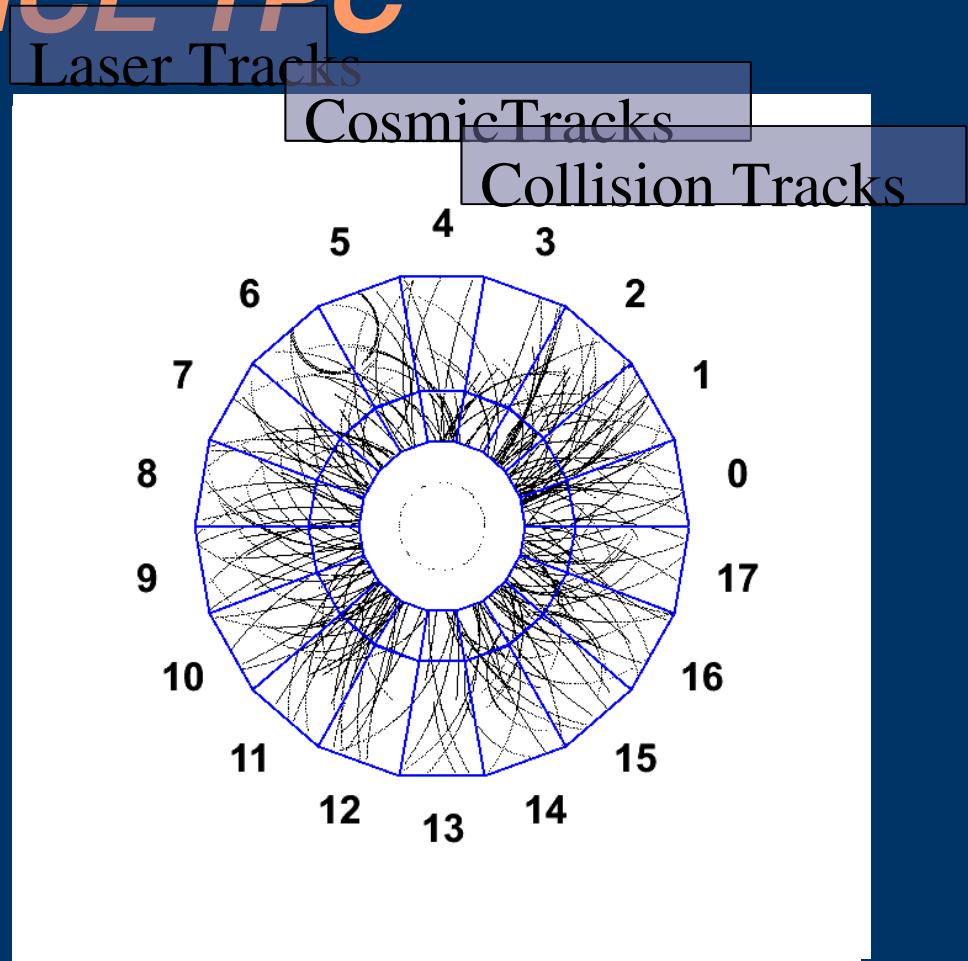
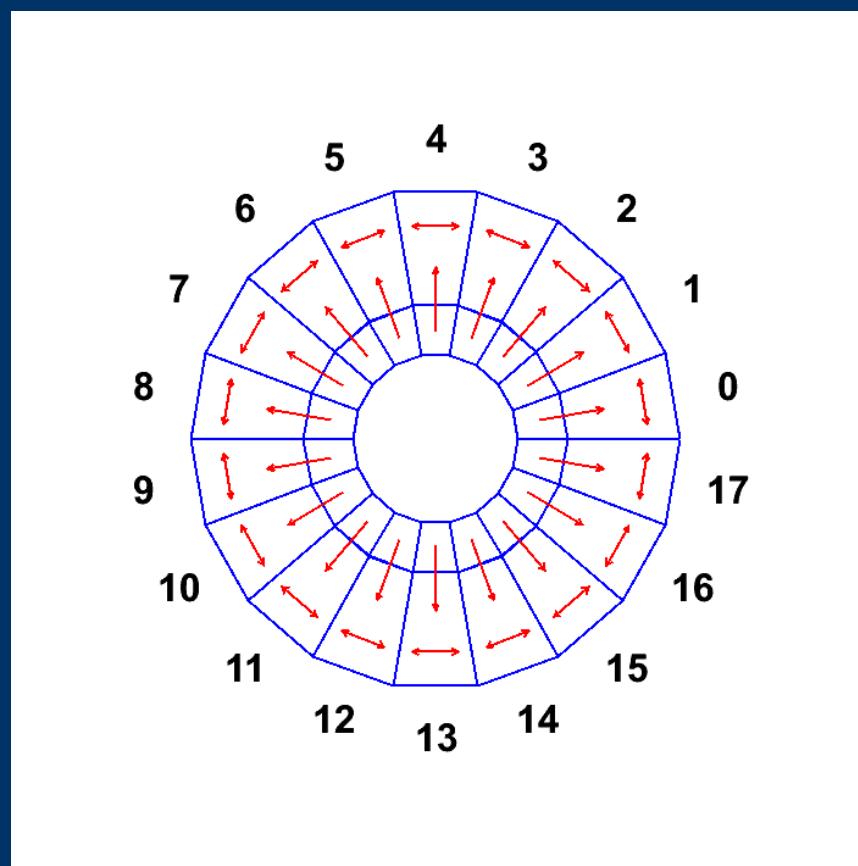
• K and C  
transformation - 6  
alignment parameters

- translations  $\delta x \ \delta y \ \delta z$
- rotations-tilting  $\alpha x \ \alpha y \ \alpha z$

$$\begin{aligned} K_{ik} &= C_k^{-1} C_i \\ X_g &= C_i I_i X_{li} \\ C_i I_i X_{li} - C_k I_k X_{lk} &= 0 \end{aligned}$$



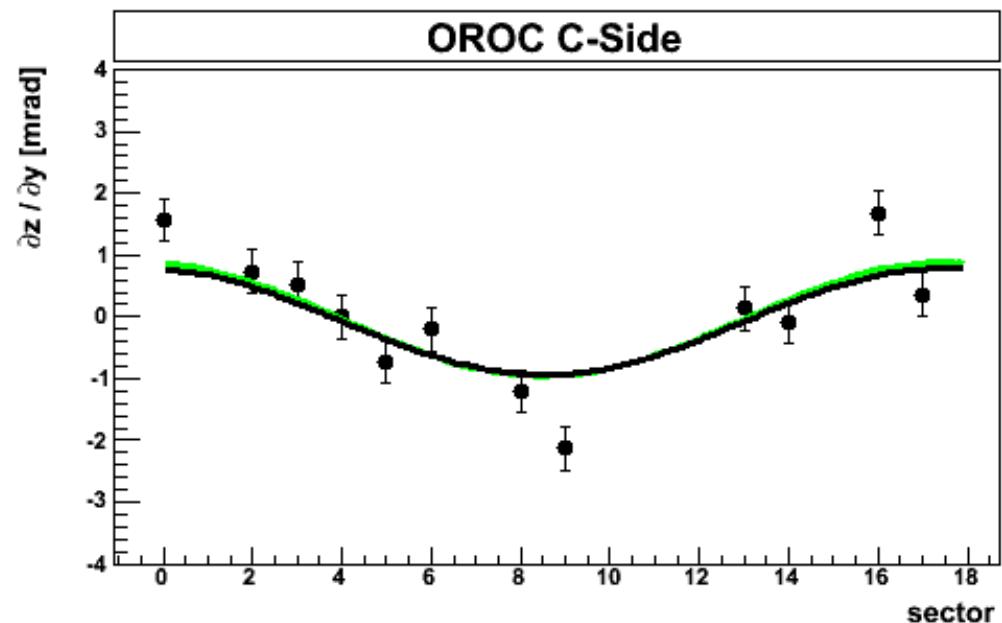
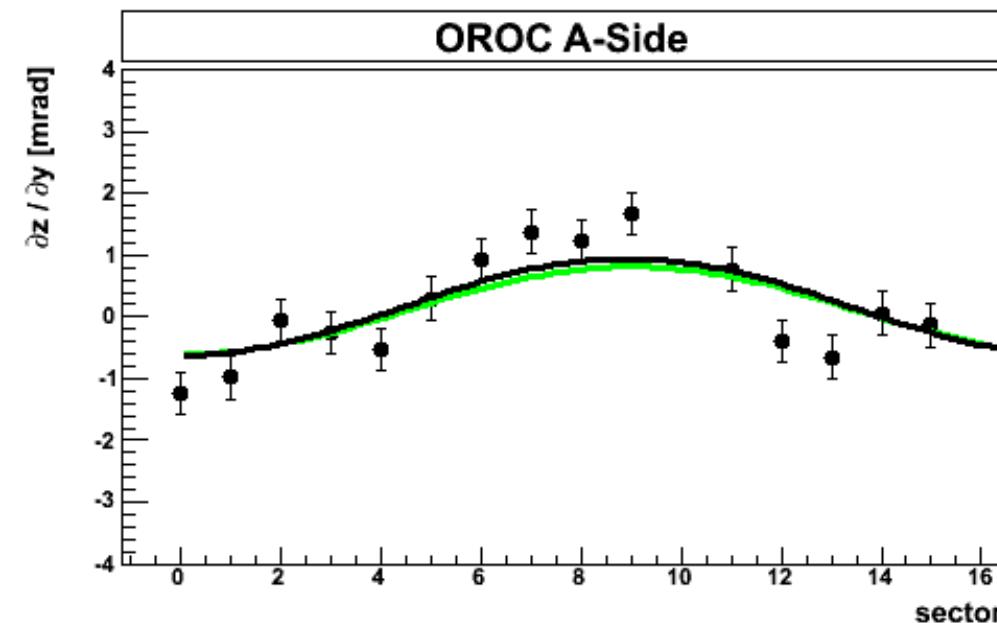
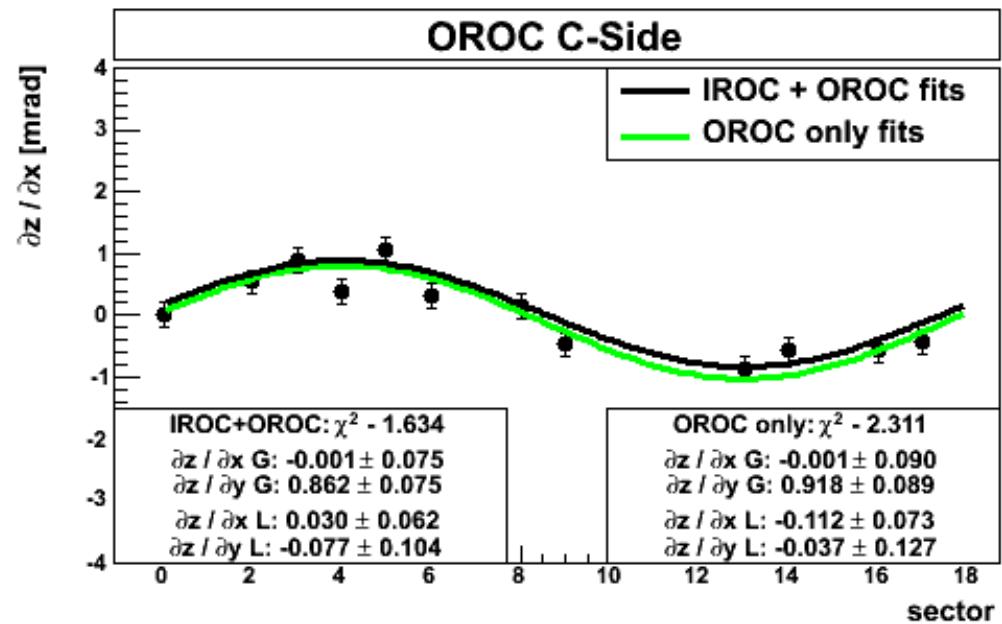
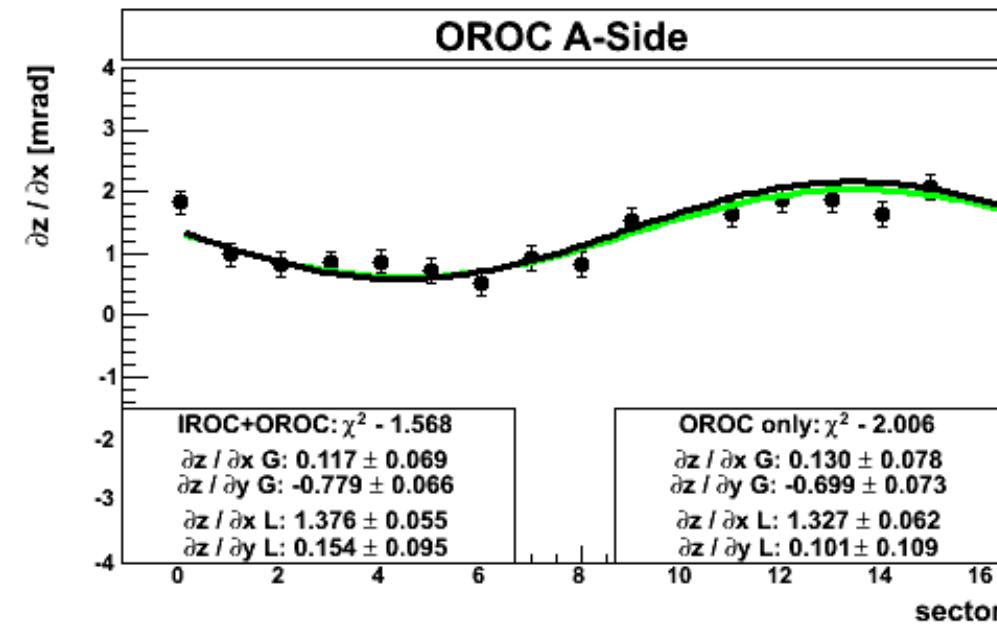
# *Track and CE plane based alignment for ALICE TPC*



- Collision, cosmics and laser tracks populate different parts of global covariance matrix

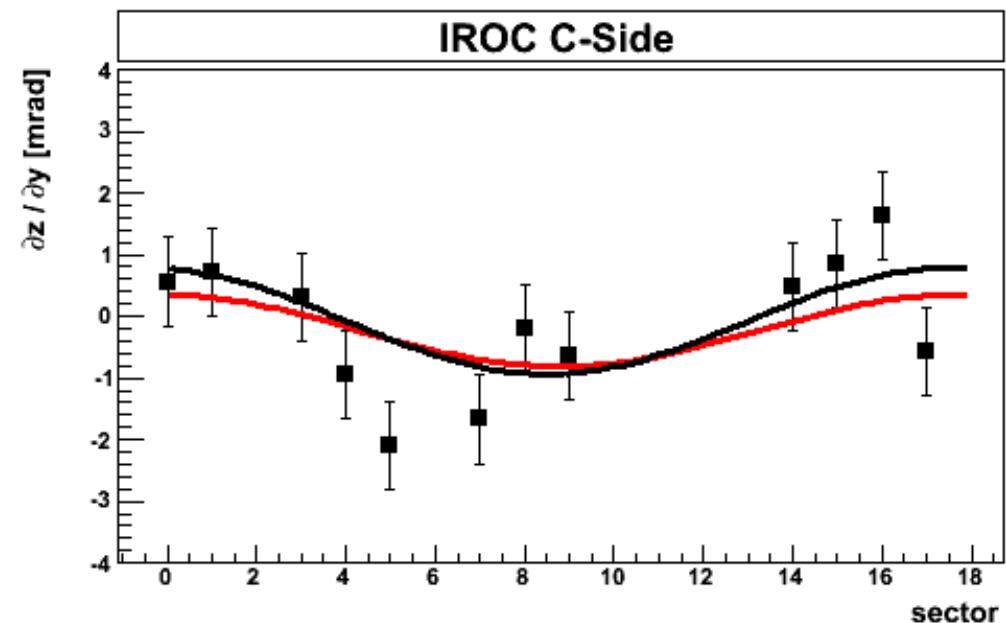
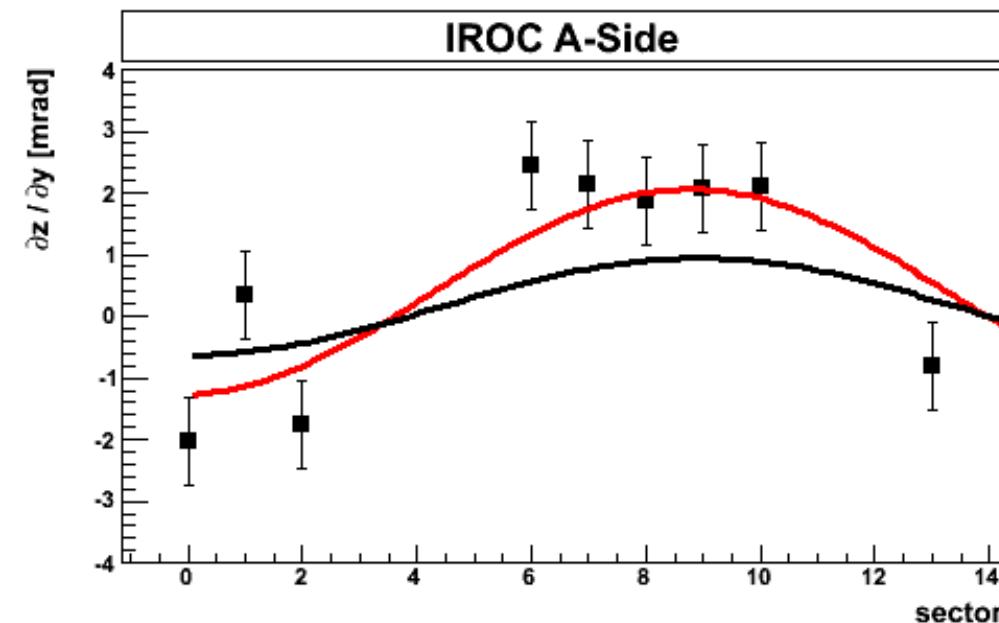
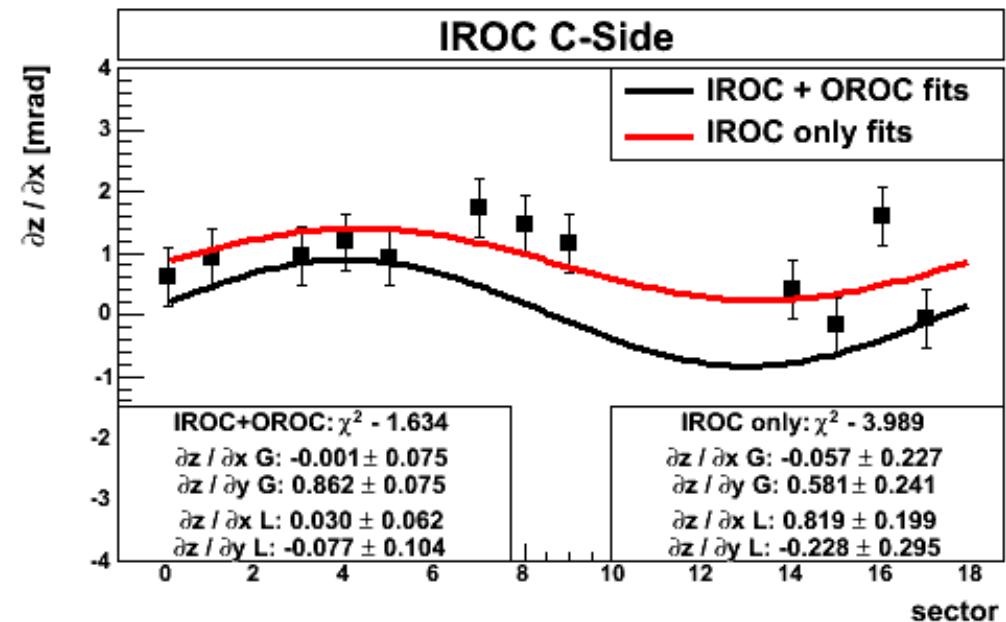
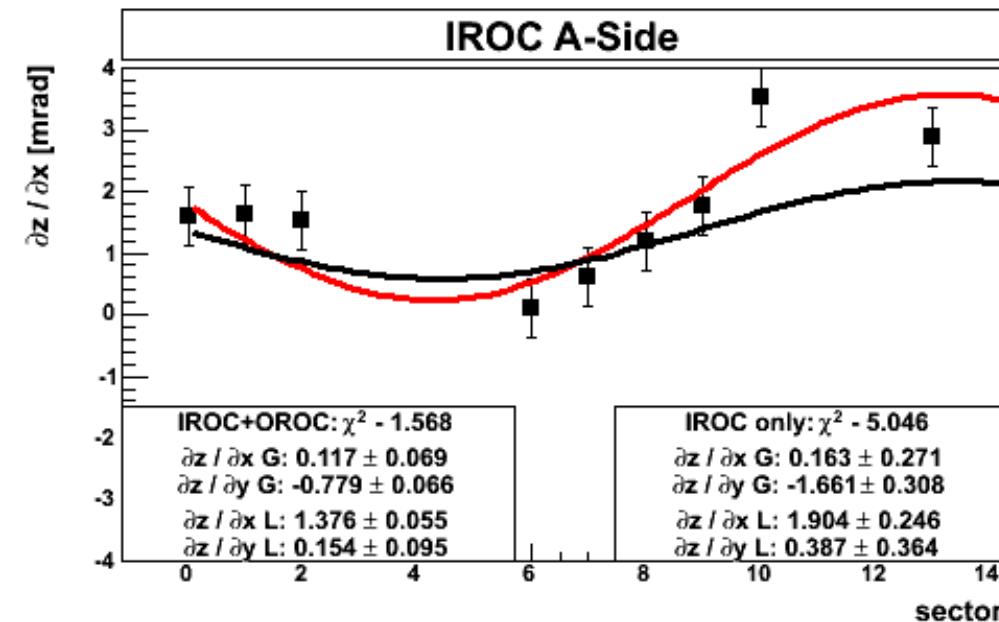
# Global alignment (fit OROCs):

$\partial z / \partial x_i$  and  $\partial z / \partial y_i$  as a function of the sector

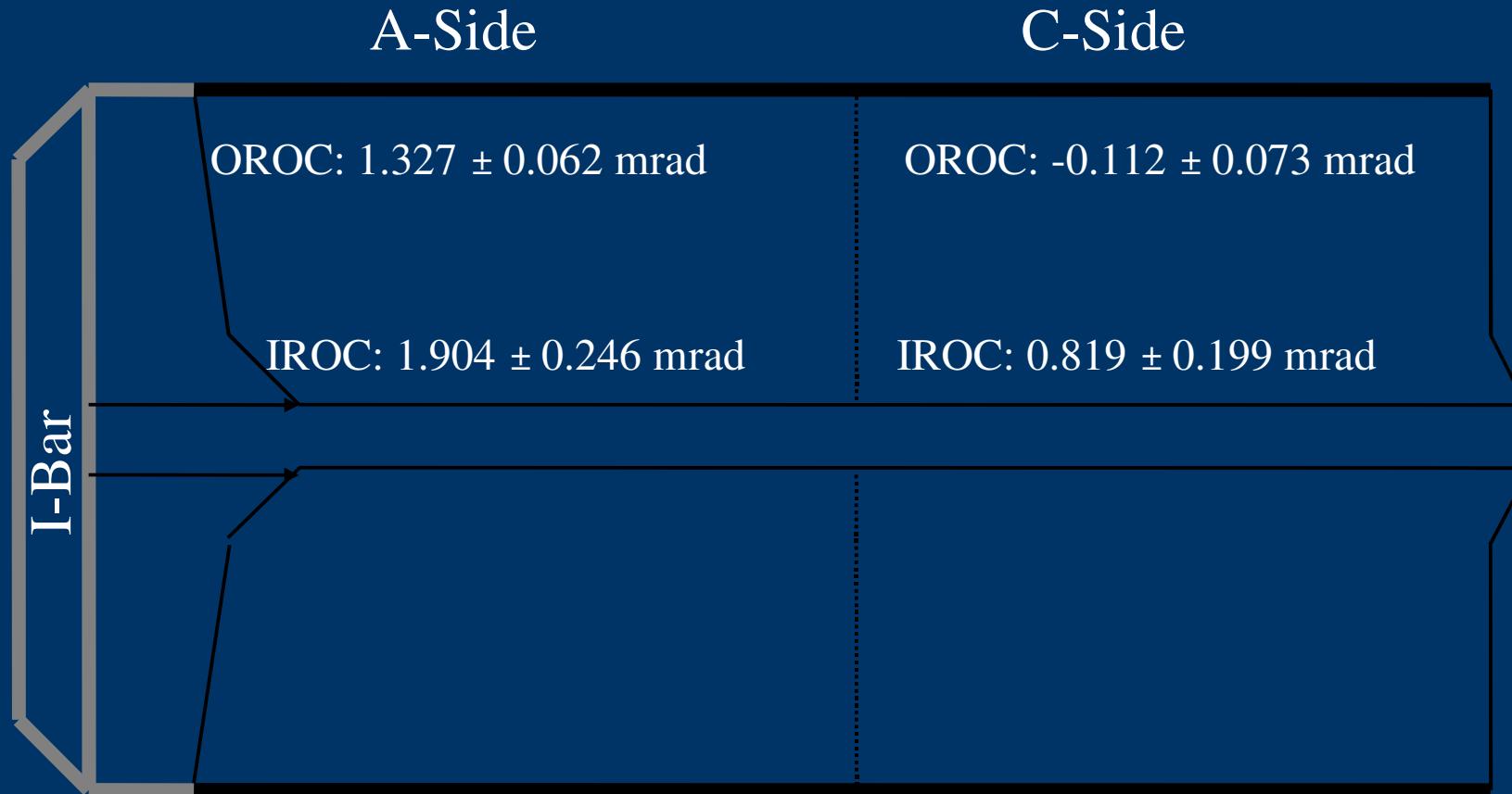


# Global alignment (fit IROCs):

$\partial z / \partial x_i$  and  $\partial z / \partial y_i$  as a function of the sector



# *Results suggest the following picture*



Assume CE is perp. to z

# *Systematic effect - Summary*

	Full mis-calibration	Day 0
ExB effect	$\Delta y \sim 0\text{-}3\text{mm}$	$\Delta y \sim 0\text{-}0.3\text{ mm}$
	$\Delta k_y \sim 3\text{-}6\text{ mrad}$	$\Delta k_y \sim 0\text{-}0.6\text{ mrad}$
	$\Delta C \sim 0.01\text{ }1/\text{GeV}$	$\Delta C \sim 0.001\text{ }1/\text{GeV}$
Drift velocity	$\sigma_z \sim 5\text{cm}$	$\sigma_z \sim 1\text{mm}$
	$\sigma_{kz} \sim 2\% * k_z$	$\sigma_{kz} \sim 0.04\% k_z$
	$\Delta k_z \sim 0.7\text{ mrad}$	$\Delta k_z \sim 0\text{ mrad}$
Alignment	$\sigma_y \sim 0.15\text{ mm}$	$\sigma_y \sim 0.10\text{ mm}$
	$\Delta z \sim 0.5\text{ mm}$	$\Delta z \sim 0\text{ mm}$
	$\sigma_z \sim 0.15\text{ mm}$	$\sigma_z \sim 0.10\text{ mm}$
	$\Delta k_z \sim 1\text{ mrad}$	$\Delta k_z \sim 0\text{ mrad}$
	$\sigma_{kz} \sim 0.2\text{ mrad}$	$\sigma_{kz} \sim 0.2\text{ mrad}$

- To achieve mentioned residual mis-calibration
  - Scan with laser tracks (ExB, v drift $\leftrightarrow$  DCS, alignment) - plan April 2008