



## VXD Alignment: Phase II

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May 25, 2018



# Outline

VXD Alignment of Phase II

Results of alignment procedure

Alignment validation using collision and cosmic data

Summary



## Status of VXD alignment

- First calculated VXD alignment is done and published in "Calibration\_Offline\_Development".
- It can be used for reprocessing.
- We are using it for validation on collision and cosmic data.
- We are working on (semi-)automatic alignment and validation procedure.
- We are calculate VXD alignment separately to check alignment parameters.
- The both alignment are discussed.



# VXD Alignment procedure

## Cosmic rays

- (Experiment 2) Runs 904, 905, 906, 919, 920, 938, 1107 and 1110 are used for alignment and validation.
- We collected more than 70 0000 cosmic tracks.
- Tracking information of cosmic rays looks very good.
- Applied PXD and SVD masking procedure during reconstruction.

## Beam collision datasets

- (Experiment 3) Runs 577, 578, 579, 580, 674, 677, 686, 782, 783, 785 and 786 are used for alignment and validation.
- We collected more than 70 0000 cosmic tracks.
- Applied PXD and SVD masking procedure during reconstruction.



## VXD alignment procedure

- We are fixing CDC. It is dependent of CDC alignment
- We are using magnetic fields depends on experimental number.
- We are fixing all half-shells and ladders (in alignment hierarchy).
- The Millepede algorithm calculates 108 ( $18 \text{ sensors} \times 6$ ) parameters

### Alignment studies using cosmic rays

- The Millepede algorithm is using 50 krecords.
- Alignment validation are used too.

### Alignment studies using collision data

- The Millepede algorithm is using 30 krecords.
- RecoTracks composed via CDCHits and (PXDHits or SVDHits).
- VXDHits more or equal to 3.
- Alignment validation are used too.

## VXD Alignment of Phase II

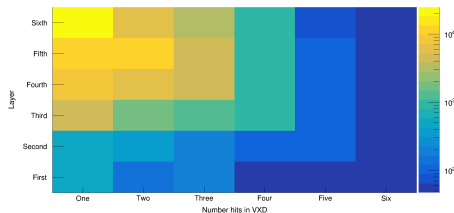
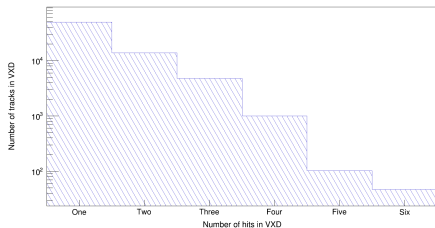
### Results of alignment procedure

Alignment validation using collision and cosmic data

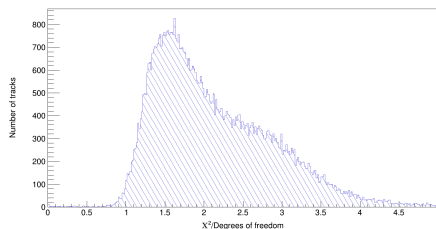
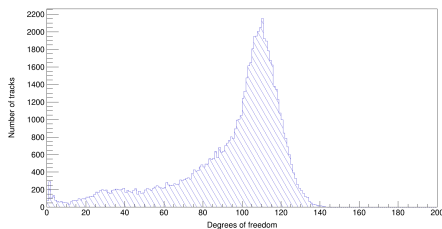
Summary



# Occupancy and tracking quality of cosmic rays



Number of VXD hits in tracks (left) and occupancy of VXD layers (right).



Number degrees of freedom (NDF) on track (left) and  $\chi^2/NDF$  of tracks (right).



# New SVD alignment

layer 6 ladder 1				
$u = -33.71404 \text{ } \mu\text{m}$	$u = -62.40701 \text{ } \mu\text{m}$	$u = 115.03165 \text{ } \mu\text{m}$	$u = 293.5339 \text{ } \mu\text{m}$	$u = 623.98253 \text{ } \mu\text{m}$
$v = 1264.2411 \text{ } \mu\text{m}$	$v = 1401.3783 \text{ } \mu\text{m}$	$v = 1400.30803 \text{ } \mu\text{m}$	$v = 1389.77761 \text{ } \mu\text{m}$	$v = 1405.5495 \text{ } \mu\text{m}$
$w = 748.1956 \text{ } \mu\text{m}$	$w = -86.21158 \text{ } \mu\text{m}$	$w = -86.7122 \text{ } \mu\text{m}$	$w = -281.3629 \text{ } \mu\text{m}$	$w = -98.2731 \text{ } \mu\text{m}$
$\alpha = -2.51509 \text{ mrad}$	$\alpha = 1.993 \text{ mrad}$	$\alpha = -2.62172 \text{ mrad}$	$\alpha = -0.15357 \text{ mrad}$	$\alpha = 2.49757 \text{ mrad}$
$\beta = 6.8963 \text{ mrad}$	$\beta = 9.43731 \text{ mrad}$	$\beta = 4.28242 \text{ mrad}$	$\beta = 0.31371 \text{ mrad}$	$\beta = -4.56417 \text{ mrad}$
$\gamma = 2.75465 \text{ mrad}$	$\gamma = -1.29721 \text{ mrad}$	$\gamma = -1.5226 \text{ mrad}$	$\gamma = -1.4522 \text{ mrad}$	$\gamma = -0.04307 \text{ mrad}$

layer 5 ladder 1			
$u = -220.7334 \text{ } \mu\text{m}$	$u = -68.53501 \text{ } \mu\text{m}$	$u = 238.53304 \text{ } \mu\text{m}$	$u = 610.86129 \text{ } \mu\text{m}$
$v = 1305.7779 \text{ } \mu\text{m}$	$v = 1481.26957 \text{ } \mu\text{m}$	$v = 1492.39488 \text{ } \mu\text{m}$	$v = 1434.18921 \text{ } \mu\text{m}$
$w = 515.8123 \text{ } \mu\text{m}$	$w = -211.02487 \text{ } \mu\text{m}$	$w = -375.2288 \text{ } \mu\text{m}$	$w = -46.66411 \text{ } \mu\text{m}$
$\alpha = -2.34351 \text{ mrad}$	$\alpha = -4.52472 \text{ mrad}$	$\alpha = 0.91889 \text{ mrad}$	$\alpha = 4.14148 \text{ mrad}$
$\beta = 8.68049 \text{ mrad}$	$\beta = 10.53553 \text{ mrad}$	$\beta = 5.50777 \text{ mrad}$	$\beta = 1.34236 \text{ mrad}$
$\gamma = 2.71428 \text{ mrad}$	$\gamma = -2.83053 \text{ mrad}$	$\gamma = -2.1763 \text{ mrad}$	$\gamma = -1.4508 \text{ mrad}$

Results of alignment procedure using cosmic rays and collisions.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .





# New SVD alignment

layer 4 ladder 1			
$u = 96.1088 \text{ } \mu\text{m}$	$u = 483.29323 \text{ } \mu\text{m}$	$u = 660.08936 \text{ } \mu\text{m}$	
$v = 1205.7636 \text{ } \mu\text{m}$	$v = 1378.63313 \text{ } \mu\text{m}$	$v = 1293.4936 \text{ } \mu\text{m}$	
$w = 692.62254 \text{ } \mu\text{m}$	$w = 165.0378 \text{ } \mu\text{m}$	$w = 280.4235 \text{ } \mu\text{m}$	
$\alpha = 1.70054 \text{ mrad}$	$\alpha = -3.01974 \text{ mrad}$	$\alpha = 2.91041 \text{ mrad}$	
$\beta = 3.68286 \text{ mrad}$	$\beta = -1.20568 \text{ mrad}$	$\beta = -4.2961 \text{ mrad}$	
$\gamma = 0.2498 \text{ mrad}$	$\gamma = -1.53046 \text{ mrad}$	$\gamma = -1.2852 \text{ mrad}$	

$u = 395.52083 \text{ } \mu\text{m}$	$\alpha = -0.06854 \text{ mrad}$	$u = 665.4539 \text{ } \mu\text{m}$	$\alpha = -0.34611 \text{ mrad}$
$v = 1520.9022 \text{ } \mu\text{m}$	$\beta = 3.96816 \text{ mrad}$	$v = 1480.972 \text{ } \mu\text{m}$	$\beta = -2.04194 \text{ mrad}$
$w = 130.77893 \text{ } \mu\text{m}$	$\gamma = -2.20055 \text{ mrad}$	$w = 101.61113 \text{ } \mu\text{m}$	$\gamma = -1.61025 \text{ mrad}$

**layer 3  
ladder 1**

Results of alignment procedure using cosmic rays and collisions.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .



# New PXD alignment

## layer 2 ladder 1

$u = 1279.8057 \text{ } \mu\text{m}$	$\alpha = 1.1749 \text{ mrad}$	$u = 1122.5584 \text{ } \mu\text{m}$	$\alpha = 1.14043 \text{ mrad}$
$v = 2511.1409 \text{ } \mu\text{m}$	$\beta = -5.11015 \text{ mrad}$	$v = 2055.2759 \text{ } \mu\text{m}$	$\beta = -9.06401 \text{ mrad}$
$w = -133.3009 \text{ } \mu\text{m}$	$\gamma = -16.10861 \text{ mrad}$	$w = -131.3294 \text{ } \mu\text{m}$	$\gamma = 10.17553 \text{ mrad}$

## layer 1 ladder 1

$u = 562.2949 \text{ } \mu\text{m}$	$\alpha = -1.00498 \text{ mrad}$	$u = 603.2556 \text{ } \mu\text{m}$	$\alpha = 5.19397 \text{ mrad}$
$v = 2482.1325 \text{ } \mu\text{m}$	$\beta = -0.38789 \text{ mrad}$	$v = 2000.0123 \text{ } \mu\text{m}$	$\beta = -9.92172 \text{ mrad}$
$w = -347.0658 \text{ } \mu\text{m}$	$\gamma = -3.24455 \text{ mrad}$	$w = -422.475 \text{ } \mu\text{m}$	$\gamma = 1.73578 \text{ mrad}$

Results of alignment procedure using cosmic rays and collisions.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .

## VXD Alignment of Phase II

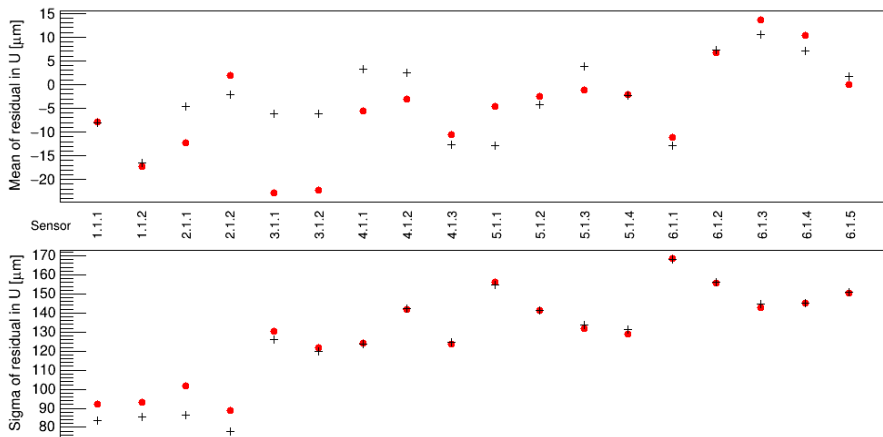
Results of alignment procedure

Alignment validation using collision and cosmic data

Summary



# VXD alignment validation using cosmic rays



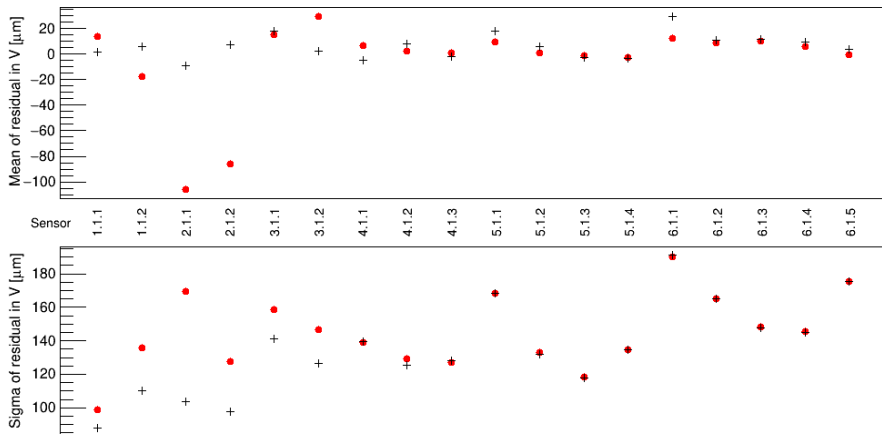
Unbiased residuals for all VXD sensors in phase 2 in U side.

Results calculated using **GT** are marked as **red dots**.

Results calculated using **new alignment** are marked as **black crosses**.



# VXD alignment validation using cosmic rays



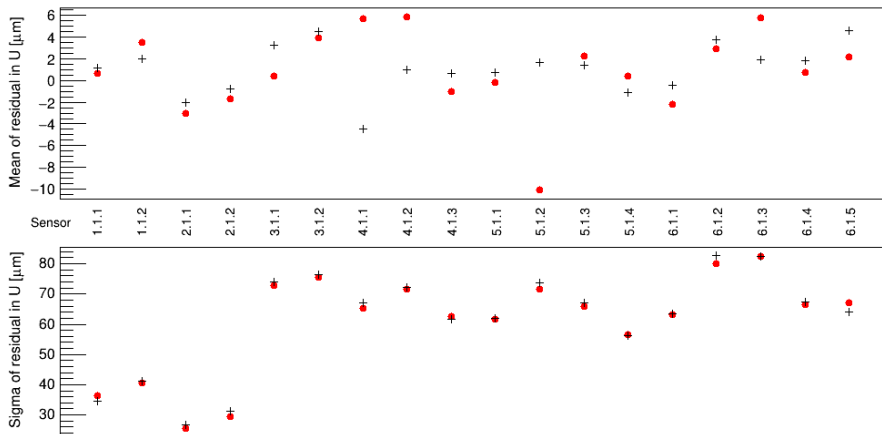
Unbiased residuals for all VXD sensors in phase 2 in V side.

Results calculated using **GT** are marked as **red dots**.

Results calculated using **new alignment** are marked as **black crosses**.



# VXD alignment validation using collision data



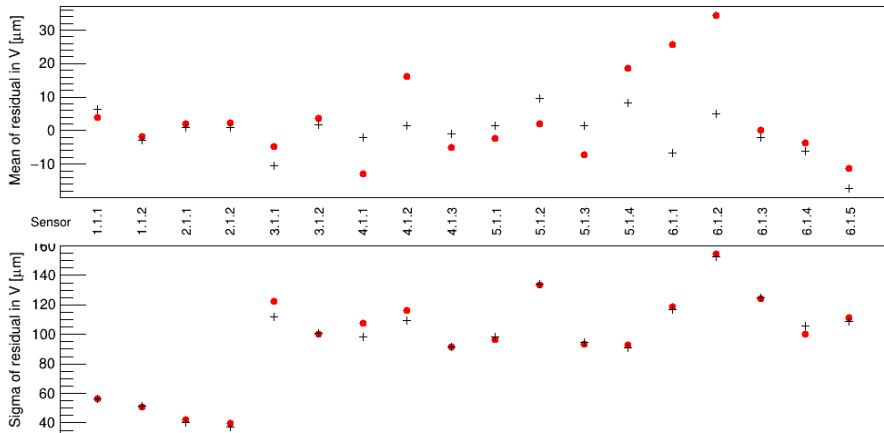
Unbiased residuals for all VXD sensors in phase 2 in U side.

Results calculated using **GT** are marked as **red dots**.

Results calculated using **new alignment** are marked as **black crosses**.



# VXD alignment validation using collision data



Unbiased residuals for all VXD sensors in phase 2 in V side.

Results calculated using **GT** are marked as **red dots**.

Results calculated using **new alignment** are marked as **black crosses**.



## Summary

- We were calculate two independent alignment for checking alignment procedure.
- One of them is published in GT "Calibration\_Offline\_Development" (back-up)
- Second is stored locally only

`/home/belle2/jkandra/basf2/beam/alignment/phase2/data/cosmicAndBeam/database.txt`

- Systematic and statistical errors are  $\approx 100 \mu\text{m}$  and  $1.0 \text{ mrad}$ .
- Alignment constants are validated using cosmic rays and collisions.
- The alignment and validation procedure are semi-automatic.

## Plans for next weeks

- Time dependent analysis of validation variables (residuals).
- Developed full automatized procedure to validate and calculate alignment.
- The second alignment parameters will be updated to GT soon.



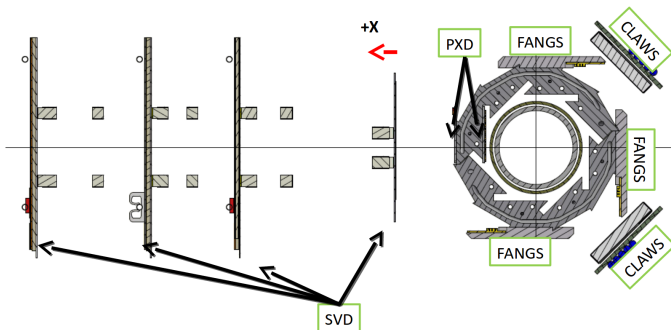
# Backup





## Geometry of Phase II

- ECL, CDC, VXD and Beast will be used.
- VXD: One ladder in each layer
- VXD: 4 sensors of PXD and 14 sensors of SVD
- Beast: Dedicated radiation monitors (FANGS, CLAWS, PLUME)
  - $\phi_{FANGS} = \{90^\circ, 180^\circ, 270^\circ\}$
  - $\phi_{CLAWS} = \{135^\circ, 225^\circ\}$
  - $\phi_{PLUME} = \{135^\circ, 225^\circ\}$

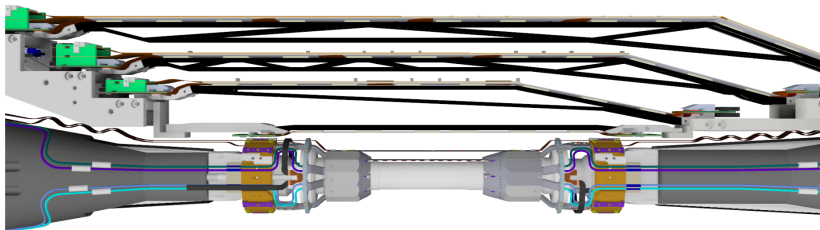


VXD and Beast Geometry of VXD.



## Geometry of Phase II

- Similar geometry as in VXD DESY TestBeam 2017
- Difference between Phase II and VXD DESY TestBeam 2017:
  - VXD TB 2017: narrow beam of  $e^-$
  - VXD TB 2017: beam is perpendicular to planes of sensors
  - VXD TB 2017: low beam background and no cosmic rays
  - Phase II: particles from collisions
  - Phase II: particles fly out from the IP to all  $\theta$  directions
  - Phase II: realistic beam background and cosmic rays



Geometry of Phase II in XZ direction.



Horizontal plane for highest background sensitivity (+X direction).

# SVD alignment in GT

layer 6 ladder 1				
$u = -4.34918 \text{ } \mu\text{m}$	$u = -50.4268 \text{ } \mu\text{m}$	$u = 136.42895 \text{ } \mu\text{m}$	$u = 311.5788 \text{ } \mu\text{m}$	$u = 654.37054 \text{ } \mu\text{m}$
$v = 1046.9279 \text{ } \mu\text{m}$	$v = 1659.6045 \text{ } \mu\text{m}$	$v = 1431.0185 \text{ } \mu\text{m}$	$v = 1387.232 \text{ } \mu\text{m}$	$v = 1325.956 \text{ } \mu\text{m}$
$w = 704.03985 \text{ } \mu\text{m}$	$w = 246.77537 \text{ } \mu\text{m}$	$w = 121.30378 \text{ } \mu\text{m}$	$w = 89.32574 \text{ } \mu\text{m}$	$w = 81.46937 \text{ } \mu\text{m}$
$\alpha = -4.84061 \text{ mrad}$	$\alpha = 4.38908 \text{ mrad}$	$\alpha = -1.68932 \text{ mrad}$	$\alpha = -0.76658 \text{ mrad}$	$\alpha = -0.20989 \text{ mrad}$
$\beta = 2.42327 \text{ mrad}$	$\beta = 8.84796 \text{ mrad}$	$\beta = 8.64943 \text{ mrad}$	$\beta = 2.29149 \text{ mrad}$	$\beta = 0.74706 \text{ mrad}$
$\gamma = 2.85472 \text{ mrad}$	$\gamma = -0.99817 \text{ mrad}$	$\gamma = -1.38374 \text{ mrad}$	$\gamma = -1.49464 \text{ mrad}$	$\gamma = -0.16583 \text{ mrad}$

layer 5 ladder 1			
$u = -172.99837 \text{ } \mu\text{m}$	$u = -61.87318 \text{ } \mu\text{m}$	$u = 259.11277 \text{ } \mu\text{m}$	$u = 642.88932 \text{ } \mu\text{m}$
$v = 1001.7106 \text{ } \mu\text{m}$	$v = 1481.808 \text{ } \mu\text{m}$	$v = 1511.667 \text{ } \mu\text{m}$	$v = 1461.3939 \text{ } \mu\text{m}$
$w = 490.4122 \text{ } \mu\text{m}$	$w = -67.62527 \text{ } \mu\text{m}$	$w = -68.37548 \text{ } \mu\text{m}$	$w = 117.13722 \text{ } \mu\text{m}$
$\alpha = -4.27649 \text{ mrad}$	$\alpha = -5.08138 \text{ mrad}$	$\alpha = 2.2043 \text{ mrad}$	$\alpha = 1.09933 \text{ mrad}$
$\beta = 6.96077 \text{ mrad}$	$\beta = 11.70694 \text{ mrad}$	$\beta = 5.77772 \text{ mrad}$	$\beta = 3.83877 \text{ mrad}$
$\gamma = 2.95413 \text{ mrad}$	$\gamma = -2.75858 \text{ mrad}$	$\gamma = -2.2851 \text{ mrad}$	$\gamma = -1.51593 \text{ mrad}$

Results of alignment procedure published in GT.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .



# SVD alignment in GT

layer 4 ladder 1			
$u = 138.52709 \text{ } \mu\text{m}$	$u = 506.07306 \text{ } \mu\text{m}$	$u = 692.97678 \text{ } \mu\text{m}$	
$v = 1010.1974 \text{ } \mu\text{m}$	$v = 1418.477 \text{ } \mu\text{m}$	$v = 1361.044 \text{ } \mu\text{m}$	
$w = 742.675 \text{ } \mu\text{m}$	$w = 385.0448 \text{ } \mu\text{m}$	$w = 454.76654 \text{ } \mu\text{m}$	
$\alpha = 0.79538 \text{ mrad}$	$\alpha = -0.46819 \text{ mrad}$	$\alpha = 0.69029 \text{ mrad}$	
$\beta = -1.19958 \text{ mrad}$	$\beta = -0.93372 \text{ mrad}$	$\beta = -1.64907 \text{ mrad}$	
$\gamma = 0.72706 \text{ mrad}$	$\gamma = -1.61563 \text{ mrad}$	$\gamma = -1.31721 \text{ mrad}$	
layer 3 ladder 2			
$u = 442.36924 \text{ } \mu\text{m}$	$\alpha = -0.83024 \text{ mrad}$	$u = 702.36336 \text{ } \mu\text{m}$	$\alpha = -1.47463 \text{ mrad}$
$v = 1561.861 \text{ } \mu\text{m}$	$\beta = 2.0391 \text{ mrad}$	$v = 1555.3394 \text{ } \mu\text{m}$	$\beta = -2.65391 \text{ mrad}$
$w = 364.54434 \text{ } \mu\text{m}$	$\gamma = -1.58169 \text{ mrad}$	$w = 366.49898 \text{ } \mu\text{m}$	$\gamma = -1.87602 \text{ mrad}$

Results of alignment procedure published in GT.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .



# PXD alignment in GT

## layer 2 ladder 1

$$u = 1317.8714 \text{ } \mu\text{m} \quad \alpha = 0.45302 \text{ mrad}$$

$$v = 2581.377 \text{ } \mu\text{m} \quad \beta = -11.3945 \text{ mrad}$$

$$w = 113.1393 \text{ } \mu\text{m} \quad \gamma = -15.43234 \text{ mrad}$$

$$u = 1163.3531 \text{ } \mu\text{m} \quad \alpha = 0.10156 \text{ mrad}$$

$$v = 2144.773 \text{ } \mu\text{m} \quad \beta = -8.74658 \text{ mrad}$$

$$w = 131.6313 \text{ } \mu\text{m} \quad \gamma = 9.43878 \text{ mrad}$$

## layer 1 ladder 1

$$u = 605.435 \text{ } \mu\text{m} \quad \alpha = -1.43431 \text{ mrad}$$

$$v = 2576.434 \text{ } \mu\text{m} \quad \beta = -10.1762 \text{ mrad}$$

$$w = -82.33036 \text{ } \mu\text{m} \quad \gamma = -2.1086 \text{ mrad}$$

$$u = 650.1355 \text{ } \mu\text{m} \quad \alpha = 4.67683 \text{ mrad}$$

$$v = 2092.916 \text{ } \mu\text{m} \quad \beta = -11.42998 \text{ mrad}$$

$$w = -164.10026 \text{ } \mu\text{m} \quad \gamma = 0.69078 \text{ mrad}$$

Results of alignment procedure published in GT.

The largest shift is in  $v(z)$  alignment parameters.

Sum of systematic and statistic errors for shifts are  $\approx 100 \text{ } \mu\text{m}$ .

Sum of systematic and statistic errors for rotations are  $\approx 1.0 \text{ mrad}$ .