VXD alignment study: Status & Plans

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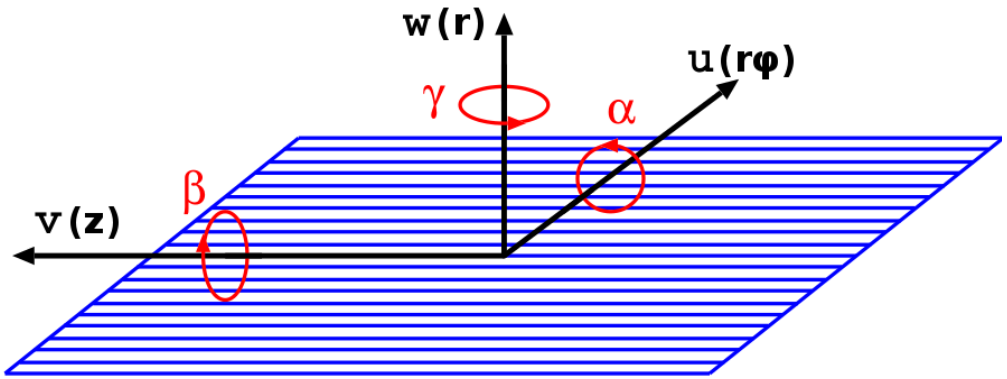
Outline

Alignment of vertex detector

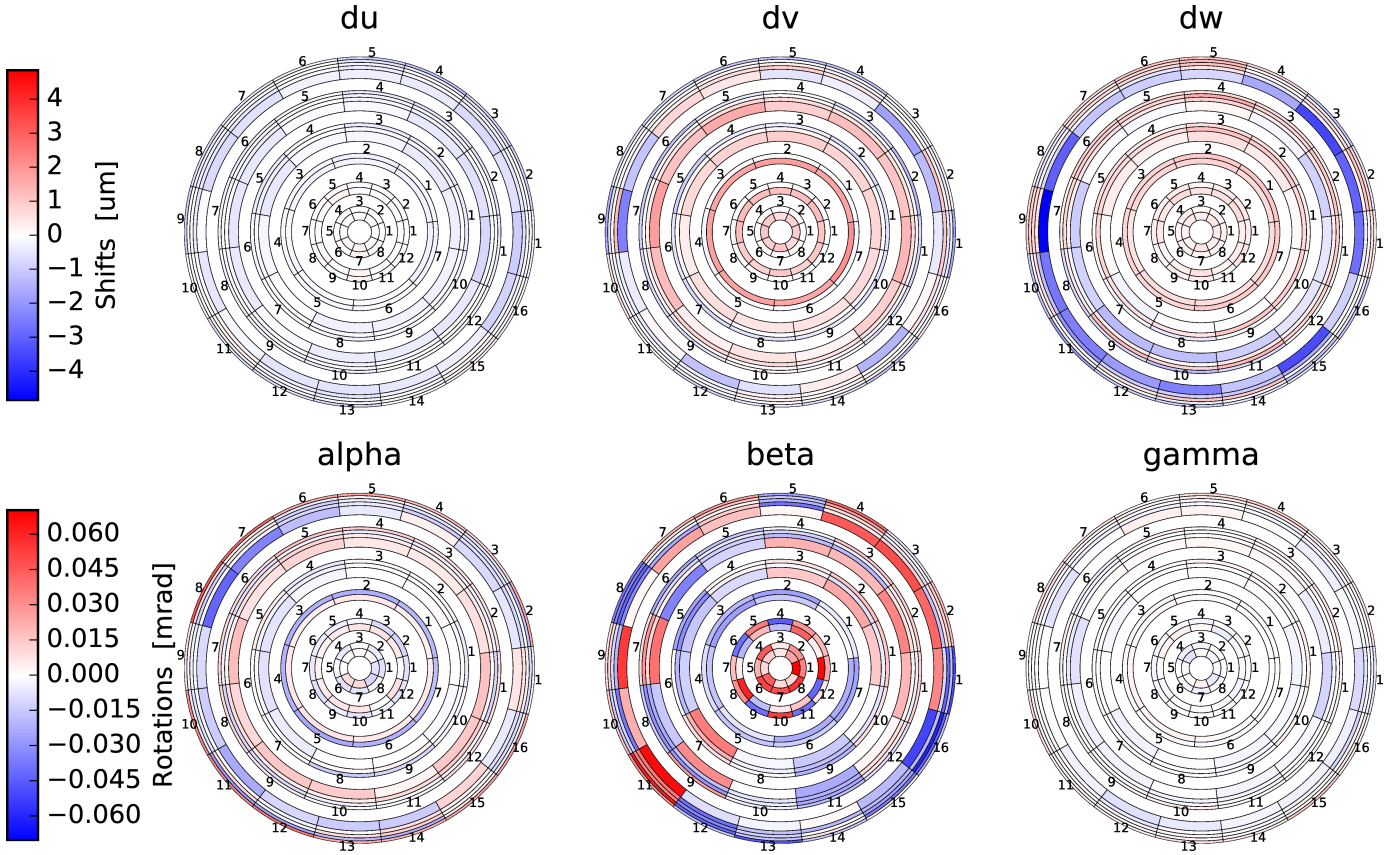
- Position of sensors estimated from tracks
- Local parameters for each sensor:
  Shifts: u, v, w
  Rotations: α, β, γ
- 212 sensors $\times$ 6 parameters = 1272 alignment parameters + deformation of sensors
- χ^2 invariant modes are combination of alignment parameters, that cannot be estimated from given set of tracks
- For better result we define simple constraints: *The sum of alignment corrections of per each rigid body parameter is zero.*



Properties of alignment

There are used 1 200 000 tracks:

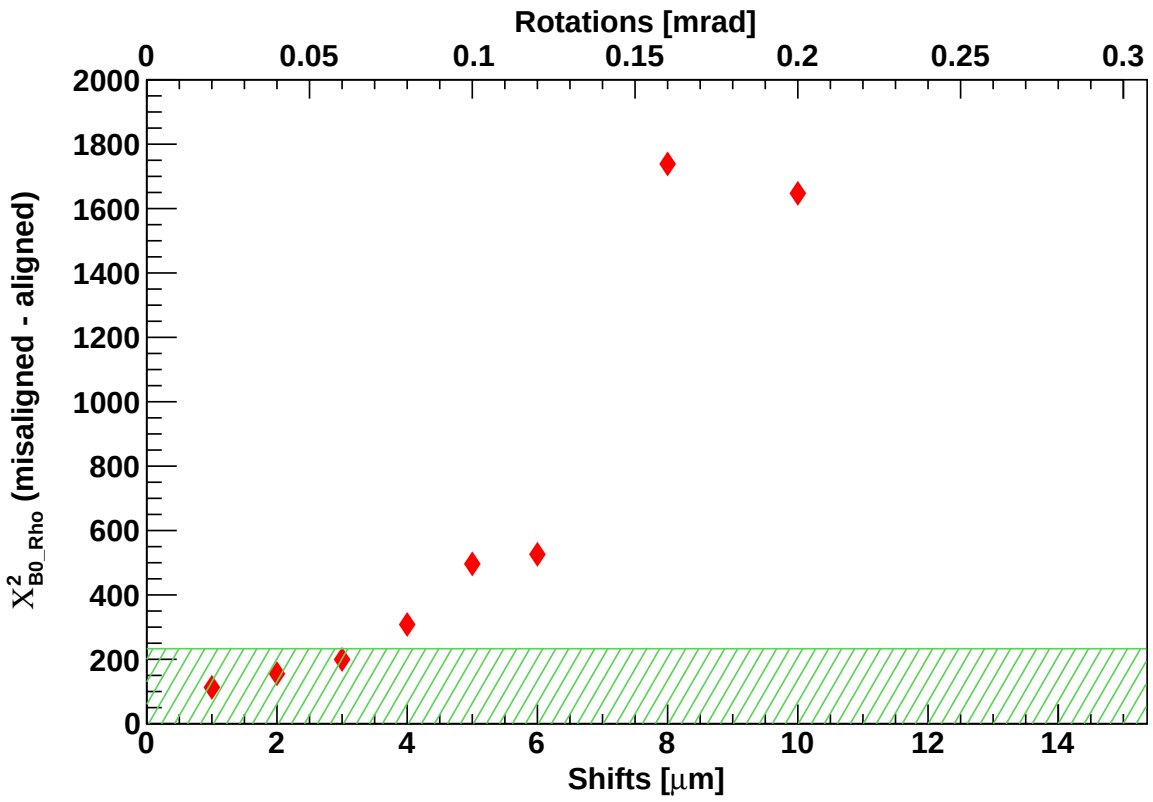
- 55 % of Υ(4S) resonance decay
- 35 % of muon pairs
- 10 % of cosmic muons



Weak fixing β parameter and wedge sensors. χ^2 modes are eliminated.

Effects of misalignment on physical analysis

- Vertex position of $B^0 \rightarrow J/\Psi + K^0_{short}$
- Misalignment generated by zero-mean normal distribution and standard deviation as measure of size of misalignment



Critical misalignment has standard deviation over than 3.0 μm in shift and 0.06 mrad in rotations.

Status of alignment

Convergence of alignment

- Residual misalignment as comparison between initial and aligned geometry

Initial shifts [μm]	0.00	10.2	157.7	0.0	0.0	215.7
Initial rotations [*mrad*]	0.000	0.000	0.000	0.247	3.040	3.467
Residual shifts [μm]	4.62	4.11	4.06	4.15	4.09	4.35
Residual rotations [*mrad*]	0.086	0.106	0.106	0.104	0.104	0.104

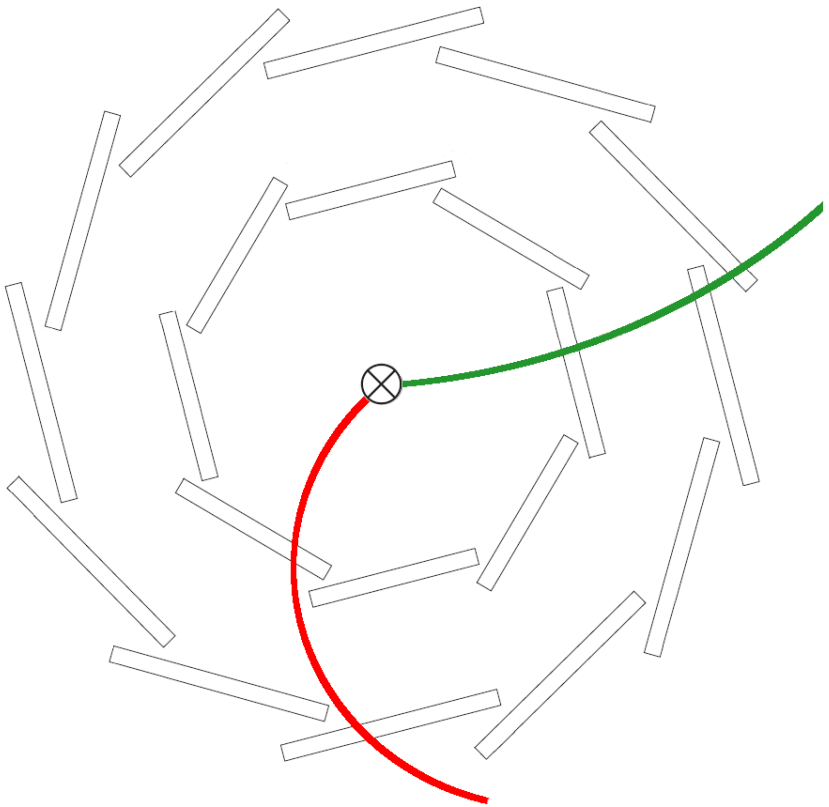
The present alignment is good enough to suppress the effect of geometry misalignment on physical studies.

Plans

Tracks & constraints

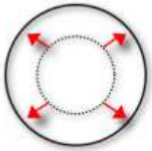
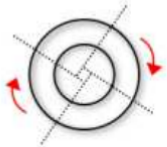
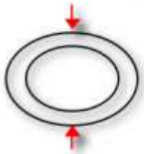
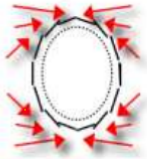
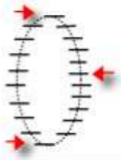
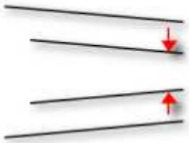
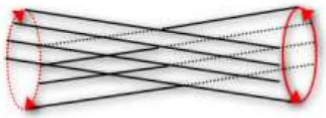
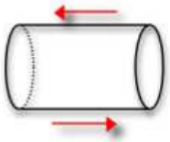
For better and faster alignment:

- Selection of tracks:
  - More hits in same layer
  - Low p_t
  - ...
- Optimization number of tracks
- Development more sophisticated constraints



χ^2 invariant (weak) modes

Potential weak modes and their potential impact on physics as 3 $\times$ 3 matrix [1]:

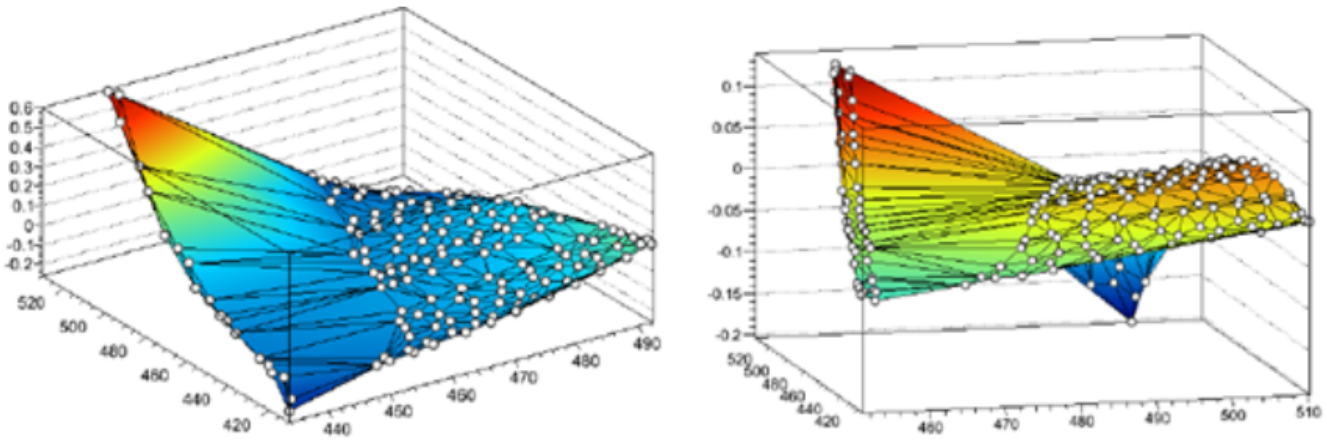
	ΔR	Δϕ	ΔZ
R	**Radial Expansion** (distance scale) 	**Curl** (Charge asymmetry) 	**Telescope** (COM boost) 
ϕ	**Elliptical** (vertex mass) 	**Clamshell** (vertex displacement) 	**Skew** (COM energy) 
Z	**Bowing** (COM energy) 	**Twist** (CP violation) 	**Z expansion** (distance scale) 

Transformations of module global coordinates (ΔR, $\Delta\phi$, ΔZ) as function of module R, ϕ or Z.

[1] ATLAS note: ATL-COM-INDET-2009-003-1

Deformation of sensors

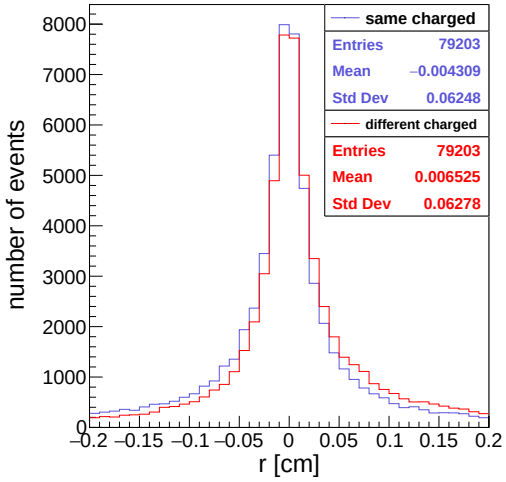
- Expected mechanical offsets of sensors are smaller than 100 μm
- What is effect of planar deformation on physical analysis?
- How to minimize this effect using software?
  - Mapping and fitting surface of sensors
  - Simulation typical slopes and scales of deformation
  - Applying in alignment procedure (basf2)

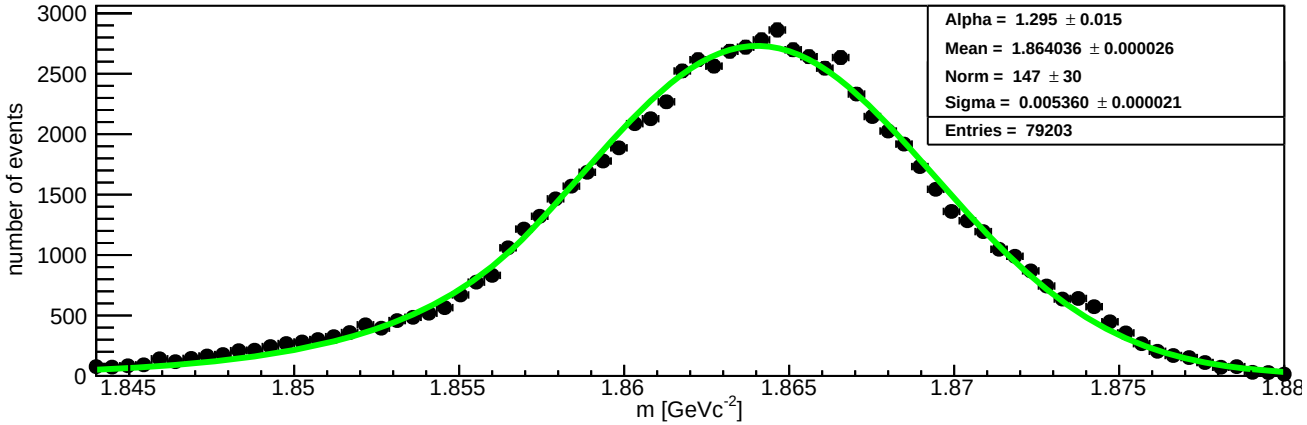


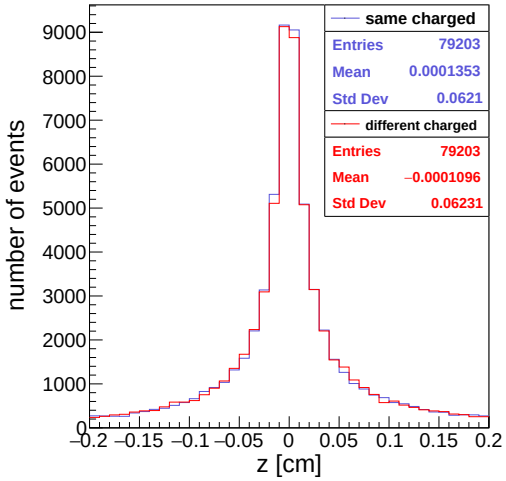
Illustrated figures of L4 from B2GM (February 2016)

Monitoring and validation tool

- It is based on:
  1. Process with high counting rate
  2. Cosmic rays
- Effects of misalignment on physics for VXD (vertex positions) and CDC (momenta)
- Development and optimization tool for data taking







Validate plots from analysis of process with high counting rate.

Summary

Status of alignment

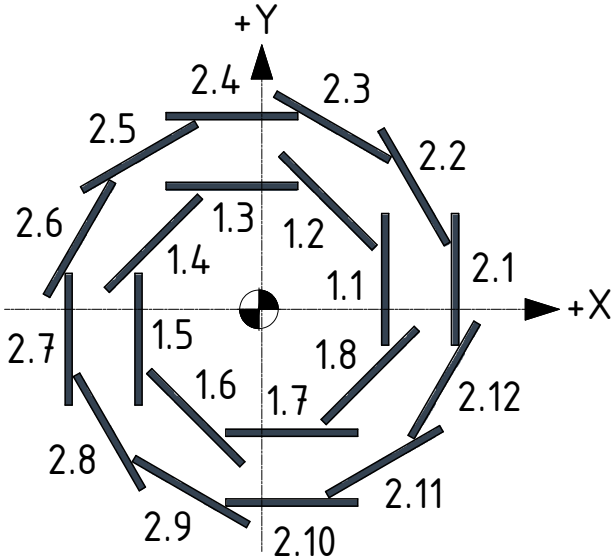
- 1 200 000 tracks of 3 different datasets, simple constraints
- Result in $\pm$ 4.62 μm in shifts and $\pm$ 0.086 mrad in rotations
- Weak fixed parameters or sensors
- Non critical effect on physics analysis
- Working for different initial misalignments

Plans

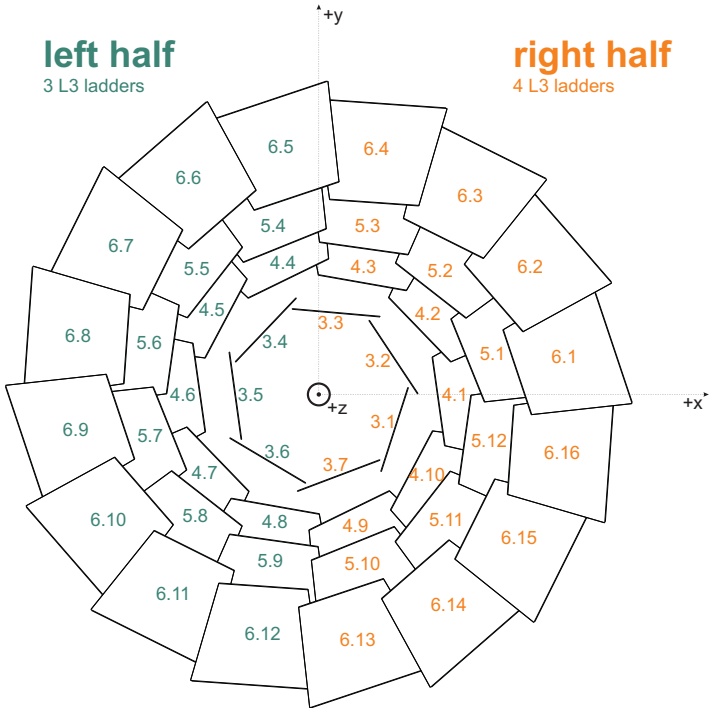
- Selection of tracks and development of constraints
- Study of χ^2 invariant modes
- Study of planar deformation of sensors
- Development monitoring and validation tool

Backup

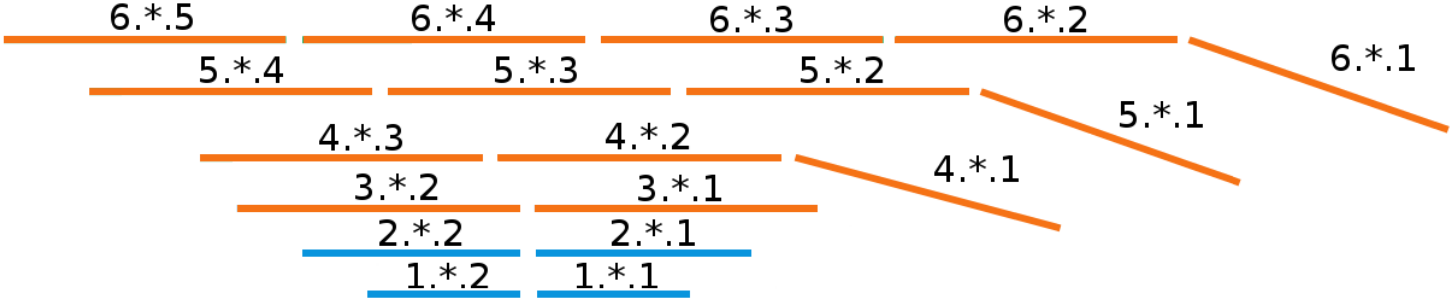
Numbering of VXD



Numbering of PXD ladders

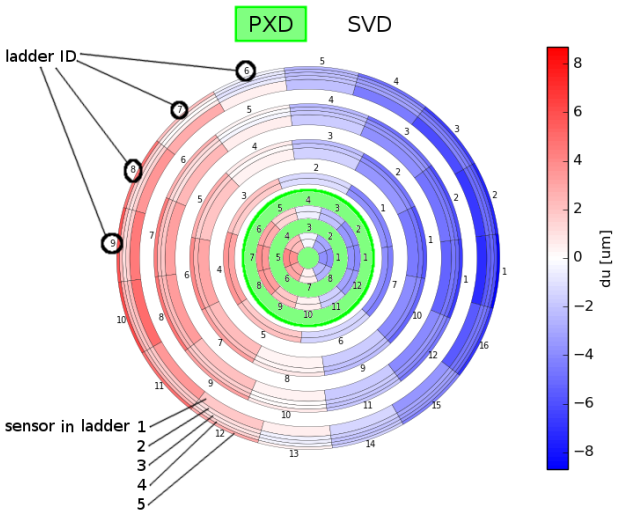


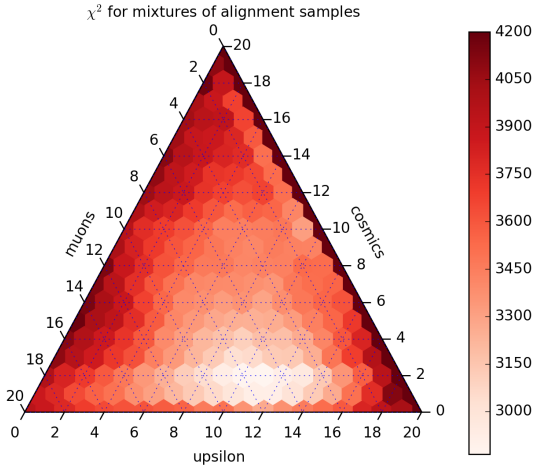
Numbering of SVD ladders



Numbering of VXD sensors. PXD a SVD sensors

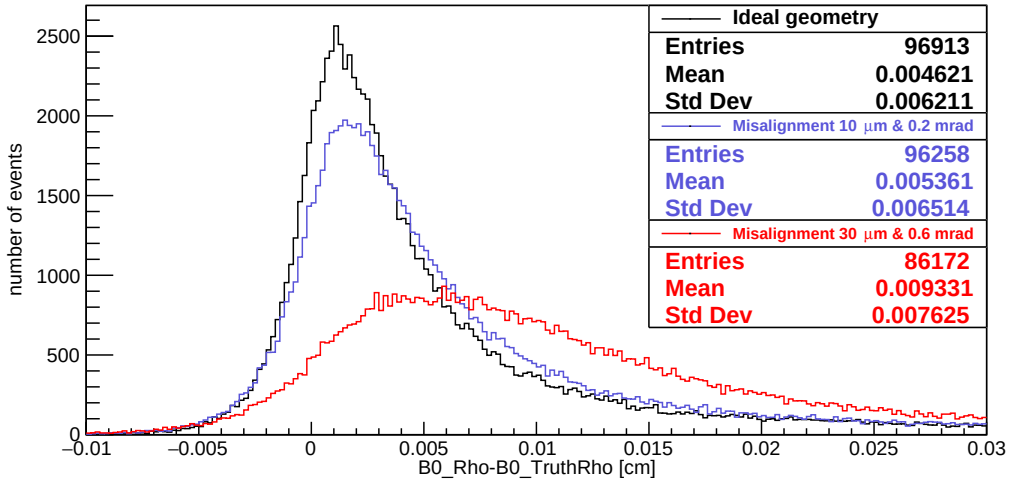
Alignment study of VXD





The arrangement of ringplot

Mixing triangle for all mixtures of 3 datasets.



Effects of misalignment on the distribution of ρ coordinate of vertex B^0