WP2 Alignment Task: Status Report

Introduction

Alignment Monitoring – LHCb VELO

Weak Modes – LHCb VELO

AIDA Alignment Web page

AIDA Telescope (WP9)

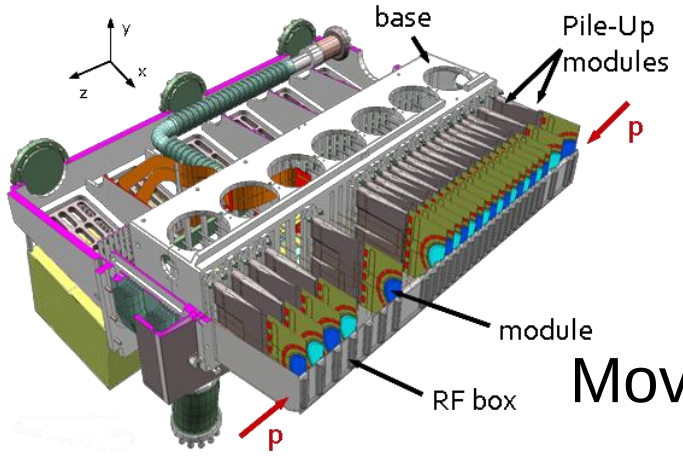
Resolution – GEANT4 Material Description

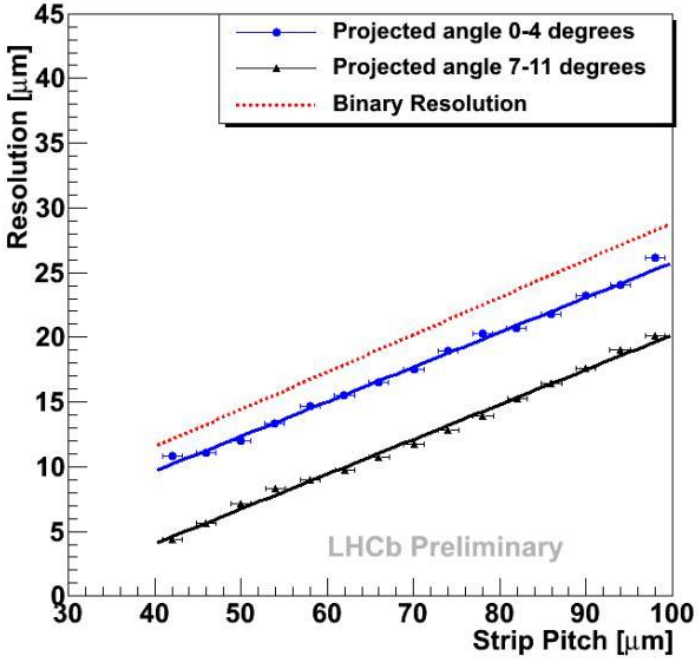
Chris Parkes, Silvia Borghi, Christoph Hombach

LHCb VELO

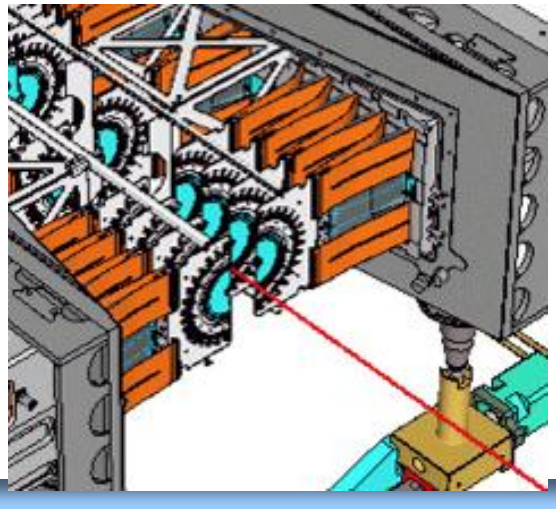
- Highest precision vertex detector at LHC

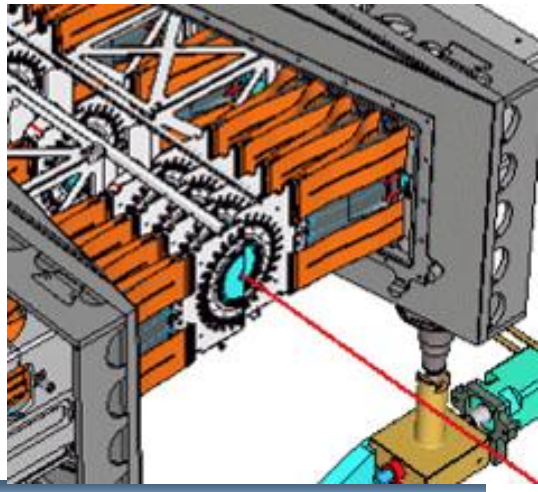
VELO Resolution vs pitch for 2 projected angle bin





Moves for each LHC fill





Monitoring

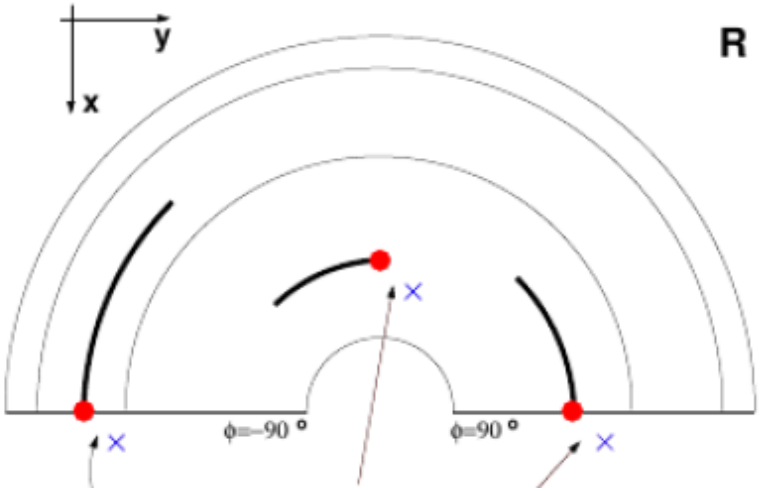
Alignment monitoring

- Variation of alignment, e.g.
  - Temperature effect
  - Mechanical variation

- Monitoring in DQ offline procedure:
  - residual bias
  - Other physics parameters (PV, IP, etc.)

Monitoring of sensor alignment

- Residual along radial and azimuthal direction
- Misalignment for x, y, z translation and rotation around x, y, z axis



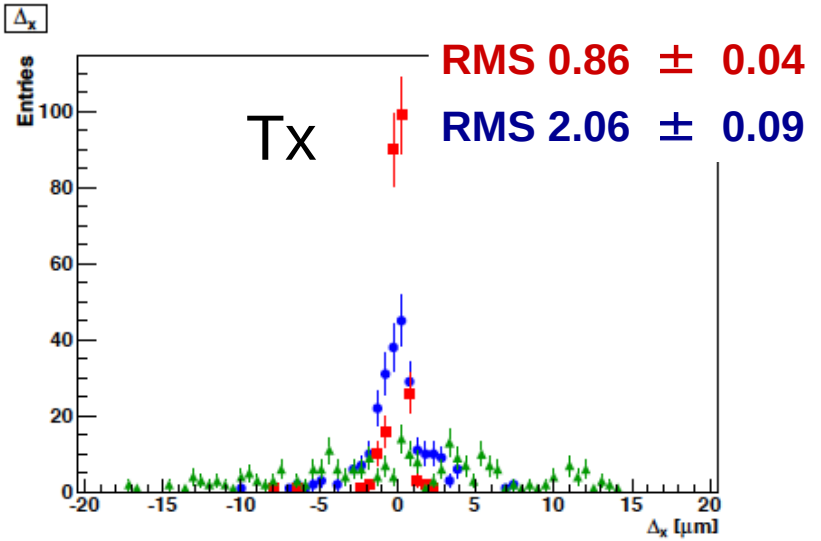
- Geometrical consideration to extract misalignment from the residual bias distribution

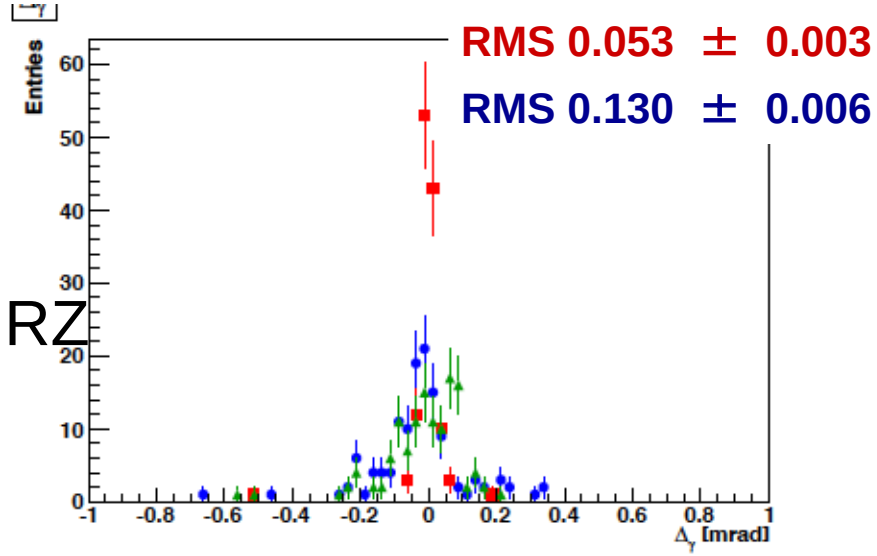
Simplified formula

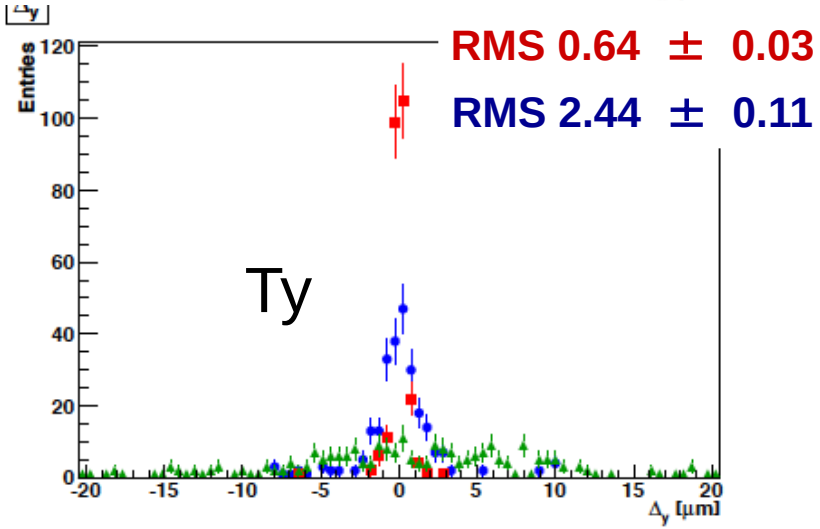
$$\epsilon_R = -\Delta_x \cos(\phi_{strip}) - \Delta_y \sin(\phi_{strip})$$
$$\epsilon_\Phi = +\Delta_x \sin(\phi_{strip}) - \Delta_y \cos(\phi_{strip}) - \Delta_\gamma r$$

Monitoring of Sensor Alignment

- Misalignment evaluated:
  - Survey measurements
  - Alignment based on 2010 data
    - Alignment based on 2011 data







Alignment stability on 2011 data

- 2011 alignment
  - 3 period considered: June, July and August

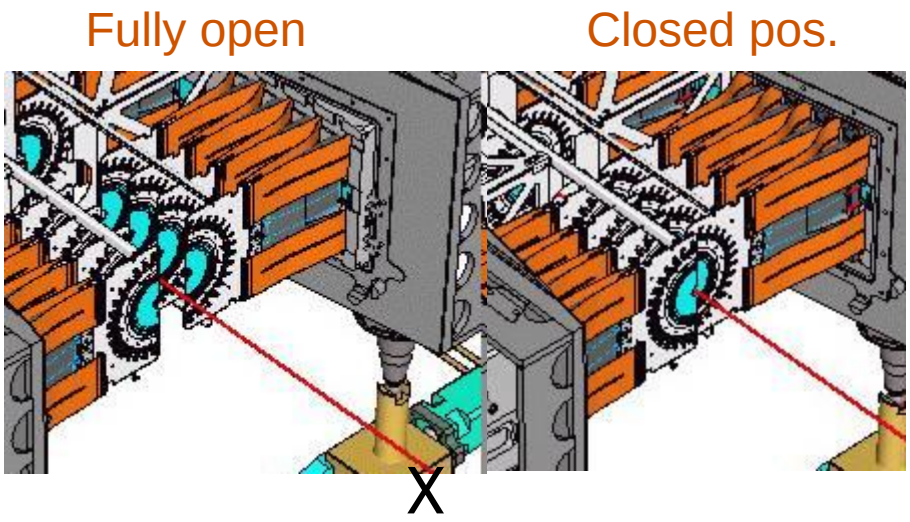
	June	July	August	Precision
Tx [μm]	0.4 ± 0.1	1.0 ± 0.1	1.0 ± 0.1	0.5 ± 0.1
Ty [μm]	0.5 ± 0.1	0.9 ± 0.1	0.5 ± 0.1	1 ± 0.1
Tz [μm]	31 ± 3	30 ± 3	35 ± 4	7 ± 1
Rx [μrad]	380 ± 40	380 ± 40	420 ± 50	580 ± 60
Ry [μrad]	1560 ± 170	1710 ± 190	1790 ± 200	630 ± 70
Rz [μrad]	19 ± 2	37 ± 4	80 ± 9	20 ± 2

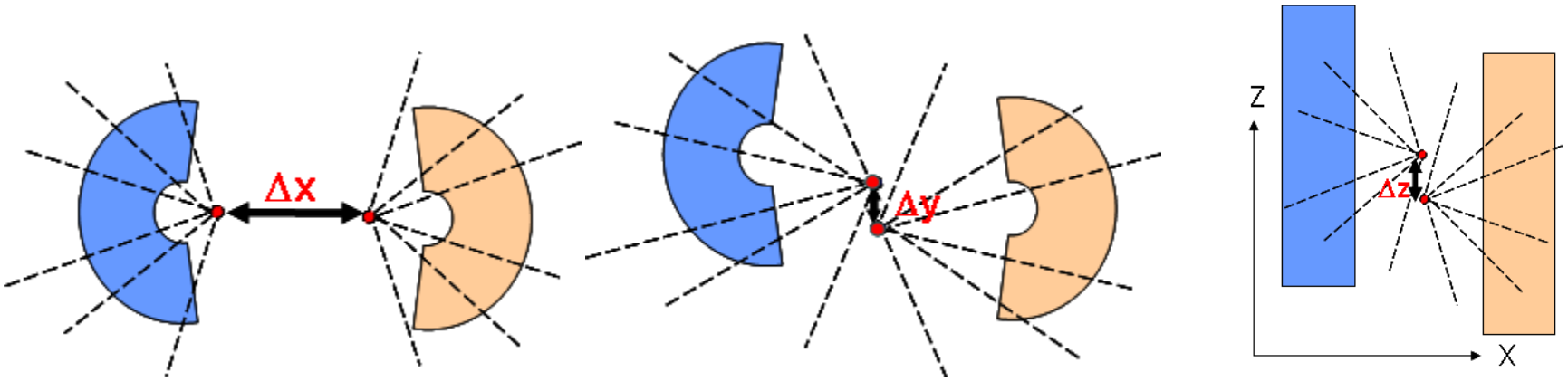
- VELO alignment stable in the considered period.
- Method is used to monitor routinely the alignment stability

Monitoring: 2 half alignment

- VELO centred around the beam for each fill when the beam declared stable

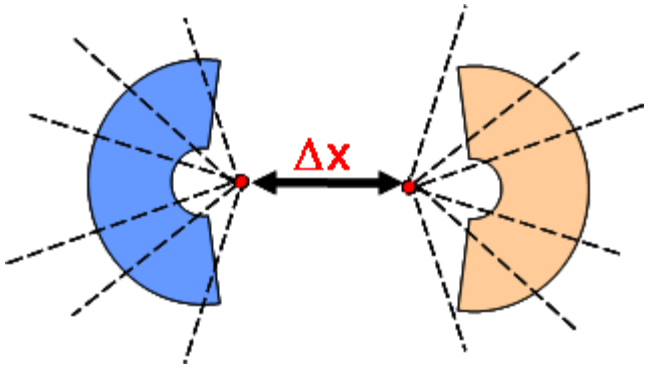
- Primary Vertex method:
  - Reconstruct PV using tracks in left or in the right side
  - Evaluation of misalignment by the distance between the two vertices



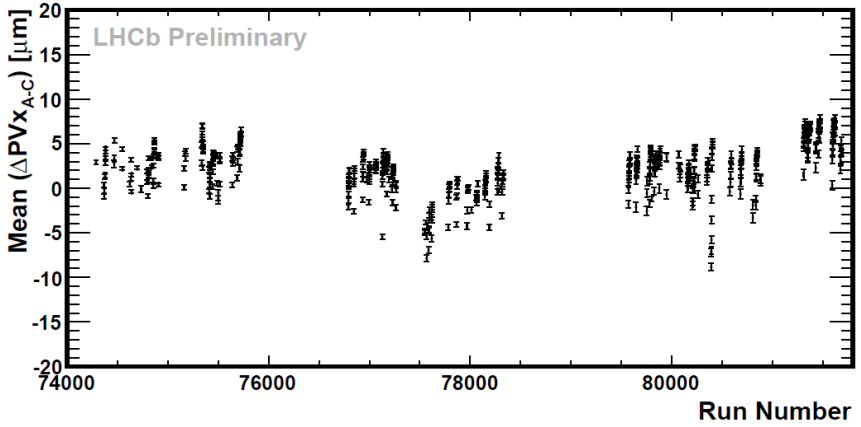


Monitoring: 2 half alignment

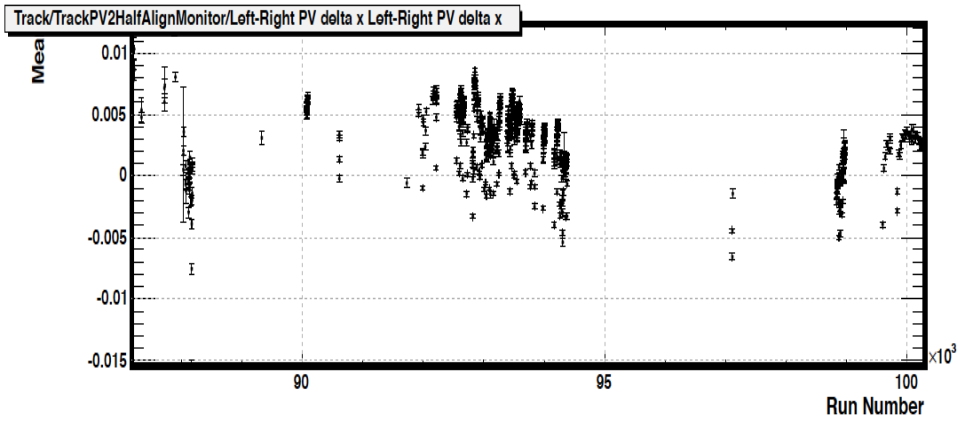
- Stability of 2 half alignment by PV method:
  - within ± 5 μm for Tx



2010 data



2011 data



Alignment Automation

- Automatic running of alignment for monitoring
- For 2012 run for data from each fill

- This year, will use as a monitoring tool
  - Updates by hand

- Longterm – updates automatically ??
  - Stability, performance improvements….

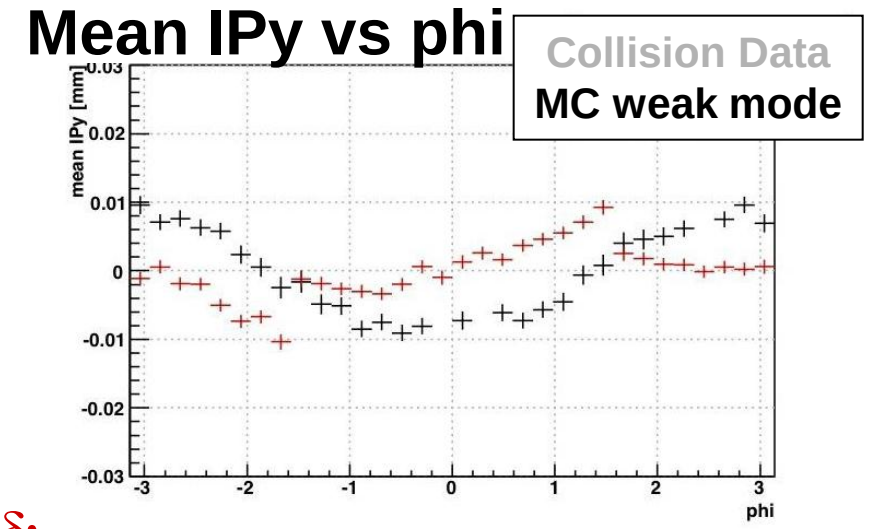
Weak Mode

VELO: weak mode study

- Weak mode:
  - Negligible effect on residuals and χ^2
  - Alignment procedure not sensitive to weak mode

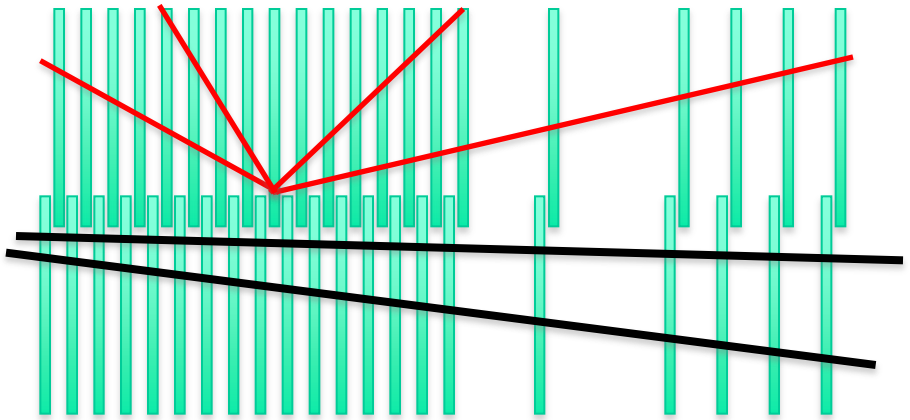
- Distortions on IP or other physics quantities

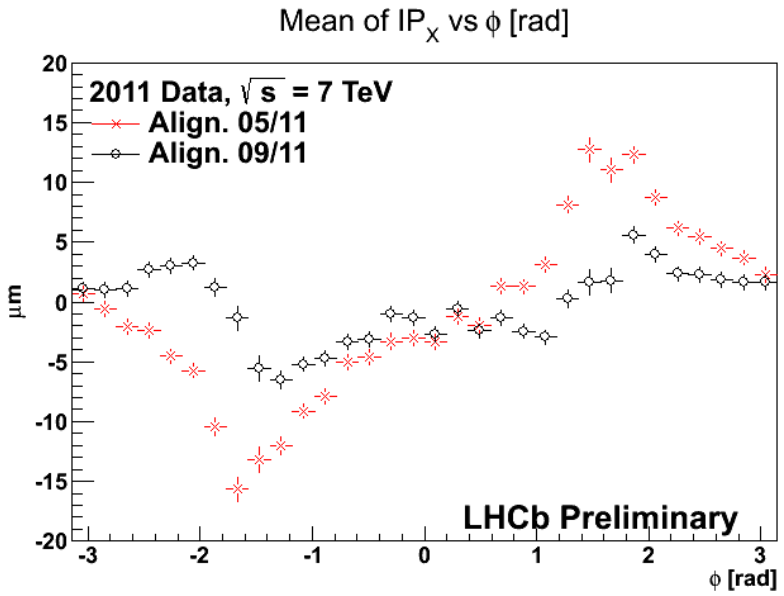
- Main weak modes (strong dependence on detector geometry):
  - Twist around the z axis: $R'_z = Rz + \delta\gamma \cdot z$
  - z- scaling
  - x or y shearing

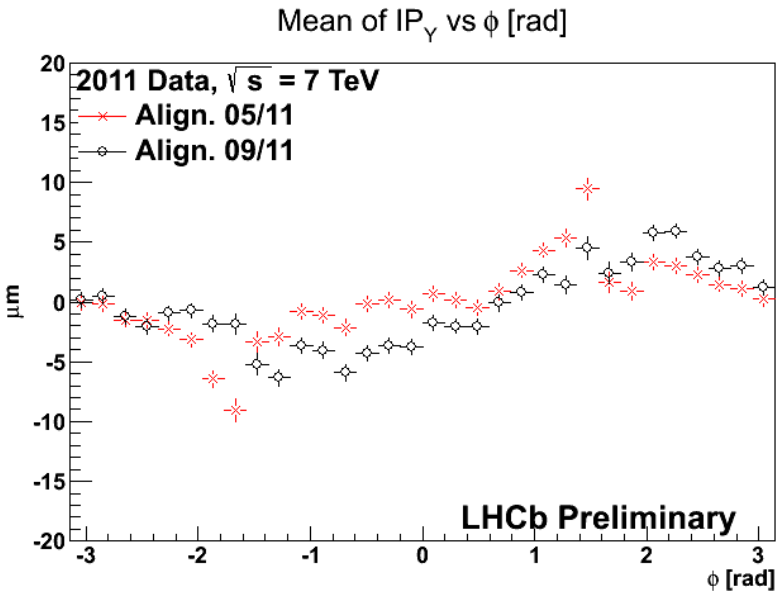


VELO: weak mode study

- Different constraints for different track samples
  - Collision data
  - Beam gas events
- Sensitivity to some of this mode selecting the proper type of tracks







Communication

AIDA Alignment Web Page

- Collect Alignment Contacts & Literature

AIDA Common Software Tools

Home » Documentation

Alignment

Links

Methods

Millepede webpage

Methods based on kalman: method1, method2

Experiments using:

- Methods based on Millepede: CDF, HERA-B, LHCb, CMS, ALICE, BELLE
- Residual minimisation: DELPHI, NOMAD, CMS
- Methods based on Kalman Filter: LHCb, CMS
- Other methods: ALEPH, ATLAS, SLD, P238

LHC experiments' web page:

LHC Detector Alignment Workshop

3rd LHC Detector Alignment Workshop - 15-16 June 2009

2nd LHC Detector Alignment Workshop - 2, June 25-26, 2007

1st LHC Detector Alignment Workshop - 1, Sept 4-6 2006 ; Proceedings

References

Methods

- W. Hulsbergen, *The global covariance matrix of tracks fitted with a Kalman filter and an application in detector alignment*, Nucl.Instrum.Meth.A600 (2009) 471 - Preprint
- V. Blobel, *Software alignment for tracking detectors*, Nucl. Instrum. Meth. A 566 (2006) 5-13
- R. Frühwirth, T. Todorov and M. Winkler, *Estimation of detector alignment parameters using the Kalman filter with annealing*, J. Phys. G: Nucl. Part. Phys. 29 (2003) 561–574

LHC experiments:

Alice

- ALICE Collaboration, *Alignment of the ALICE Inner Tracking System with cosmic-ray tracks*, J. Instrum. 5 (2010) P03003
- A. Rossi for ALICE Collaboration, *Alice Alignment, Tracking and Physics Performance Results*, arXiv:1101.3491. (2011)
- J. Y. Grossiord, G. Jacquet and Yu L. Margaryan, *The RELCAM an optical transparent sensor for geometry alignment and monitoring systems* ALICE-INT-2002-19 (2002)
- Other notes

Atlas

- *Alignment of the ATLAS Inner Detector Tracvking System with 2010 LHC proton-proton collisions at sqrt(s)= 7 TeV*, ATLAS-CONF-2011-012
- *Alignment Performance of the ATLAS Inner Detector Tracking System in 7 TeV proton-proton collisions at the LHC*, ATLAS-CONF-2010-067
- Preprints
- Other notes

CMS

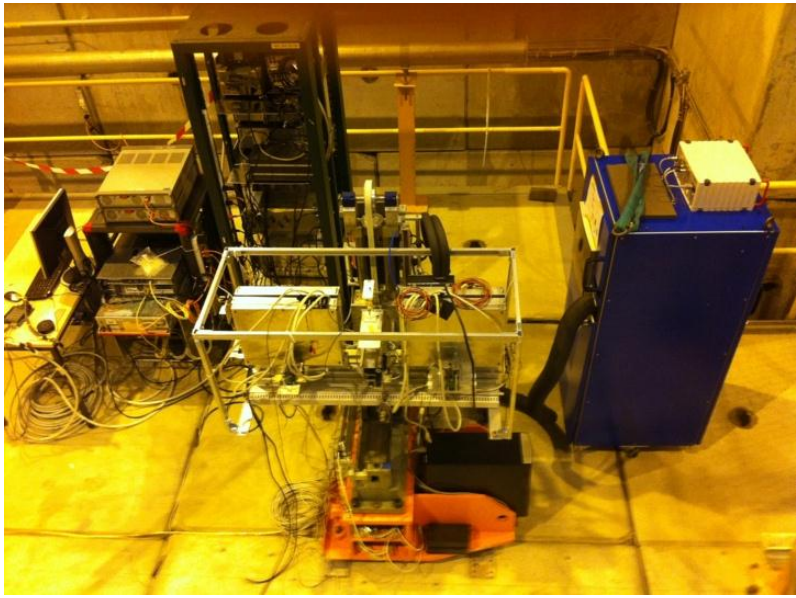
- CMS Collaboration, *Aligning the CMS Muon Chambers with the Muon Alignment System during an Extended Cosmic Ray Run* J. Instrum. 5 (2010) T03019, preprint
- CMS Collaboration, *Alignment of the CMS Muon System with Cosmic-Ray and Beam-Halo Muons*, J. Instrum. 5 (2010) T03020, preprint
- CMS Collaboration, *Alignment of the CMS Silicon Tracker during Commissioning with Cosmic Rays*, J. Instrum. 5 (2010) T03009, preprint
- W. Adam et al., *Alignment of the CMS silicon strip tracker during stand-alone commissioning*, 2009 JINST 4 T07001

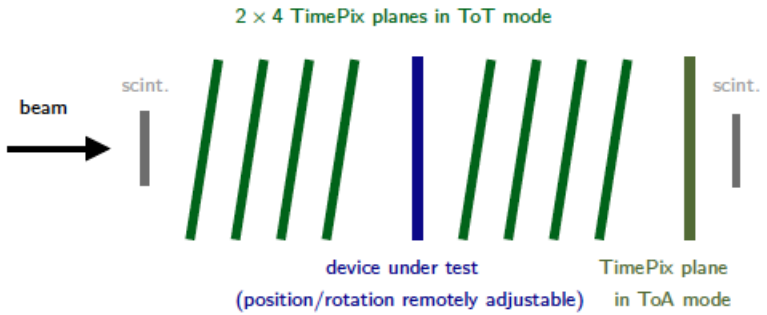
AIDA Connections

WP9.3 TimePix Beam Telescope

AIDA Collaborators: Daniel Hynds, Paula Collins, Abraham Gallas, Martin van Beuzekom…

- Infrastructure upgrade in 2011, including
  - Improved DAQ
  - New portable CO_2 cooling system
- "semi-permanent" installation in H8.A CERN area





Features:

Spatial resolution ~ 2 μm

Time tagging with ~ 1 ns precision

~ 15 kHz trigger rate

2011 devices: LHCb, ATLAS, Medipix,

Plans and Summary

Work towards AIDA Aims:

Alignment Stability Monitoring

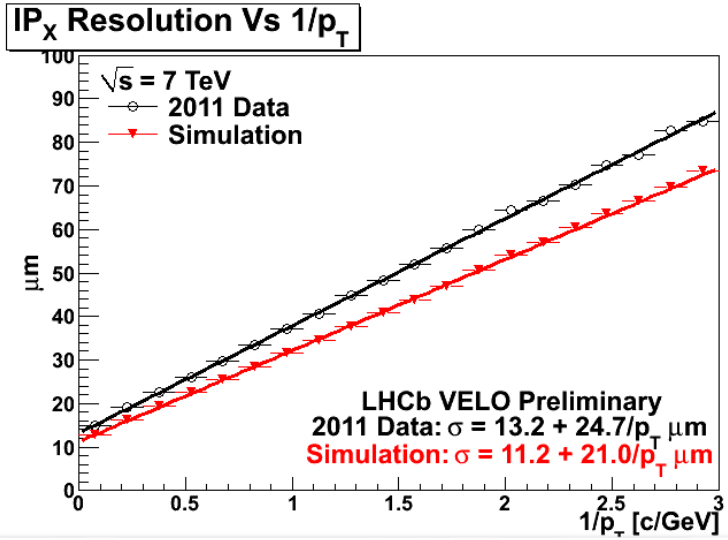
Weak Modes Study

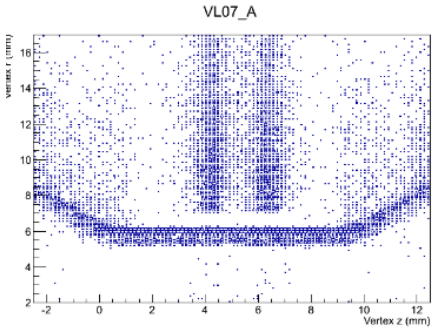
Web Page

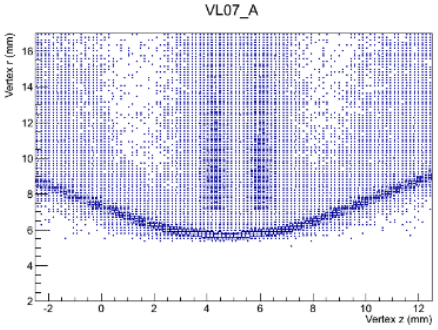
- Dedicated PhD Student (Christoph)
- Generalise Alignment work for AIDA
  - Common setups (forward/barrel, silicon/fibres…)
- Apply software to pixel testbeam (WP9)
- Forge links other expts

Material Description

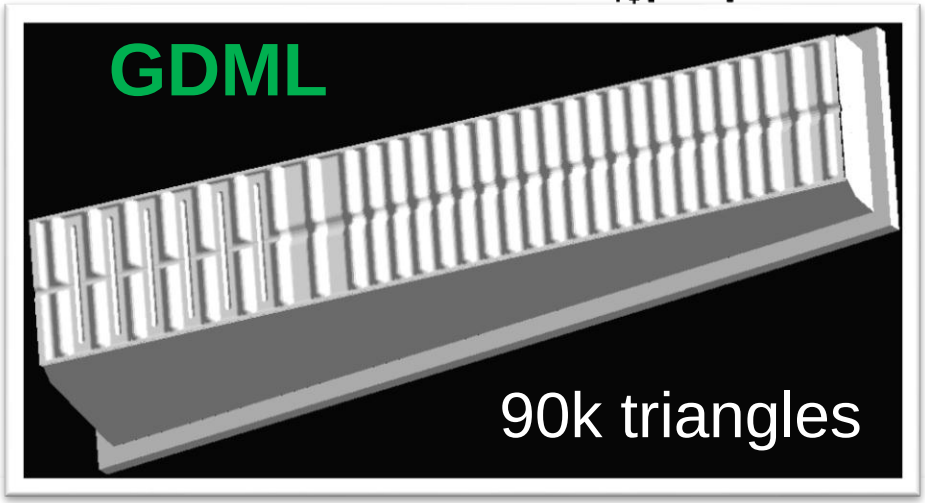
Matt Reid et al.

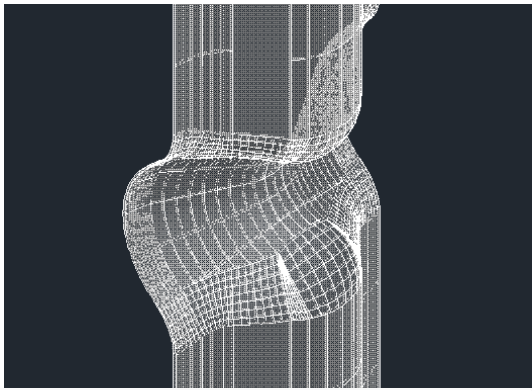






- IP: Data / Simulation discrepancy at low P_T
- Disagreement foil shape with XML





300μm Aluminium foil – very complex shape

CAD Drawings ➔ GDML, using Blender

Thanks to Norman Graf, also John Apostolakis, Gabriele Cosmo