Alignment and Calibration report

14/09/2016 Claire Prouve - University of Bristol

on behalf of the Alignment & Calibration group

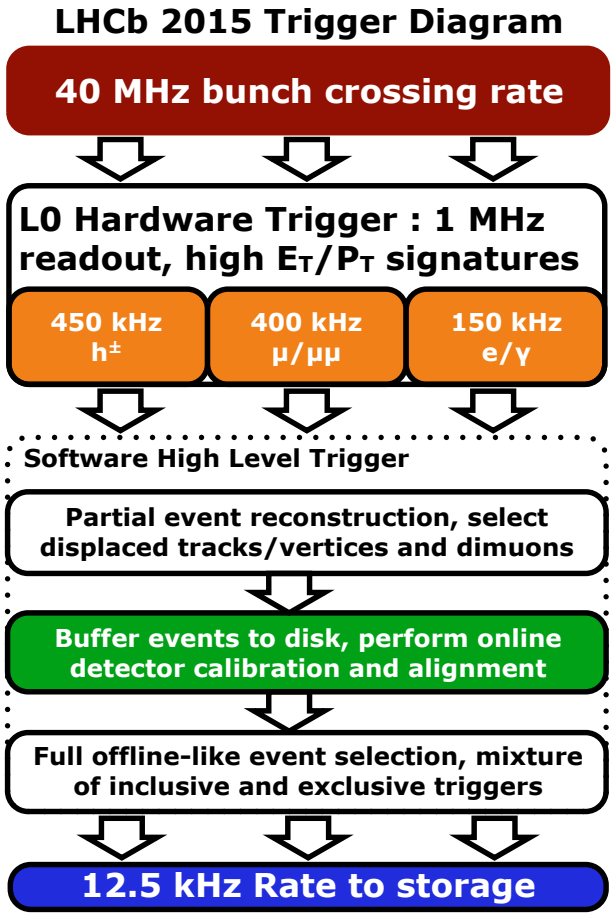
Overview

- Perform alignment and calibration of subdetectors 'in real-time'
  - ➔ Same constants in trigger and offline reconstruction
  - ➔ Use of PID information in HLT2
  - ➔ Best possible trigger performance

- Requirements: fast + evaluated in real-time

- <u>Alignments + π^0 calibration:</u>
  Use HLT farm with ~1800 nodes
  Collect results on single node and evaluate the alignment constants
- <u>Calibrations:</u>
  Run on monitoring histograms

- Manual, offline, hardware alignments



Alignments

VELO Alignment

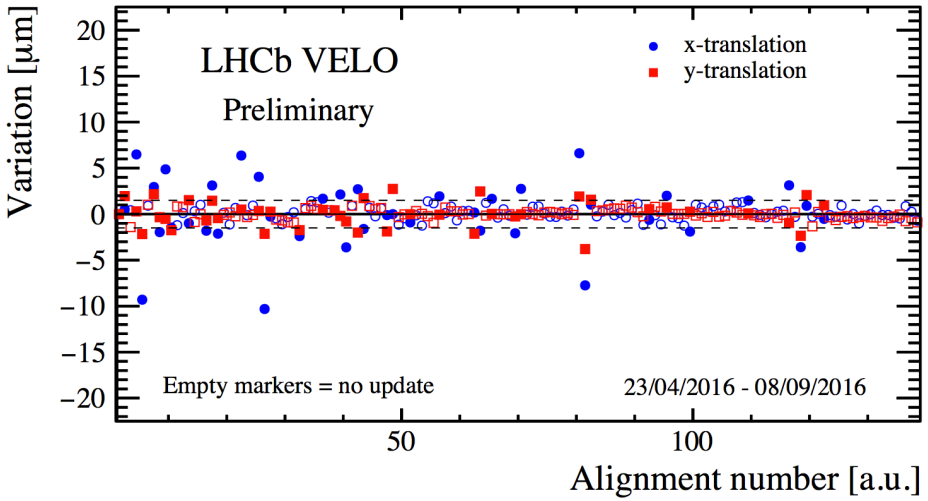
Giulio, Silvia

Alignment of both halves for translations and rotations in x, y and z.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Automatic	Per fill	Min. bias + beam gas events	< 1 min.	2 min.

- Running since beginning of Run II
- Alignment constants updated every 3-8 fills
- Stability studies:
  - Threshold for automatic update of alignment constants
  - Dependence on initial alignment

[LHCb Week March 2016]



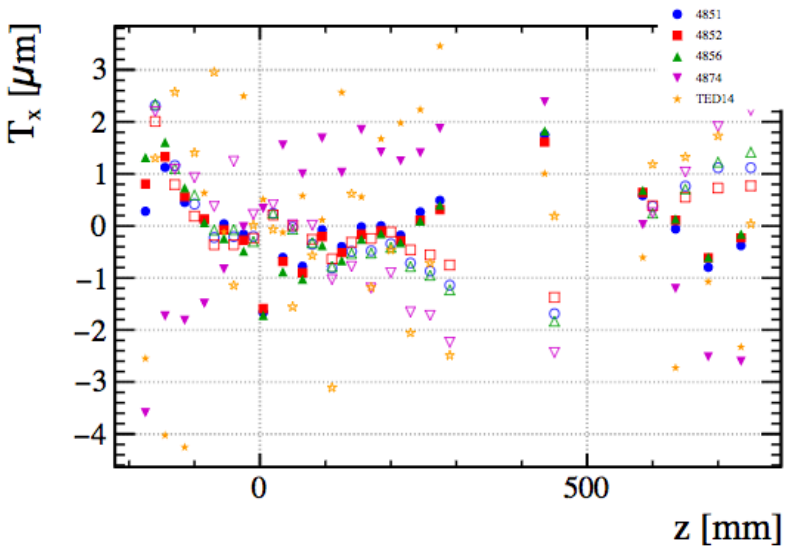
VELO Alignment

Giulio, Silvia

Study on alignment of individual modules:

- Module misalignment degrades alignment
- Align modules for main DOF: T_x, T_y and R_z

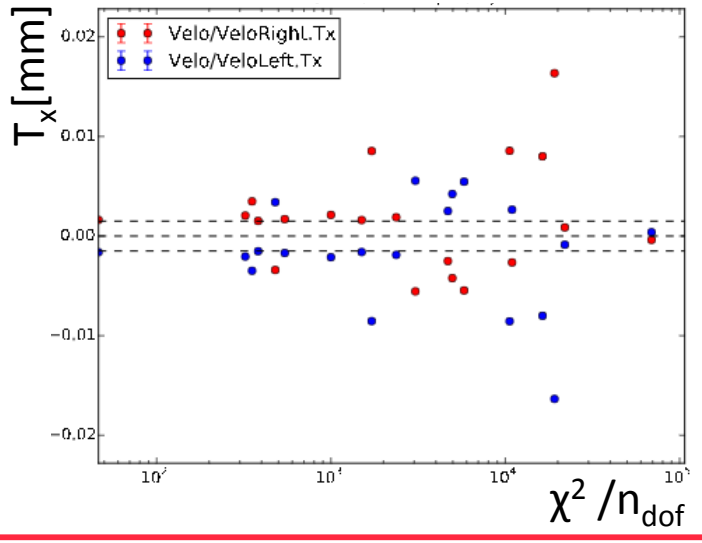
➔ **Compatible with statistical fluctuations, no frequent modular alignment needed.**



Study on χ^2 convergence criteria:

- Convergence if $\chi^2 / n_{dof} < 2$
- Update of constants dependent on variation
- Plot the variation against χ^2 / n_{dof}

➔ **All triggered updates have $\chi^2 / n_{dof} > 200$**



MC study on the impact of residual mis-alignment on physics ongoing [Matej Roguljic's talk]

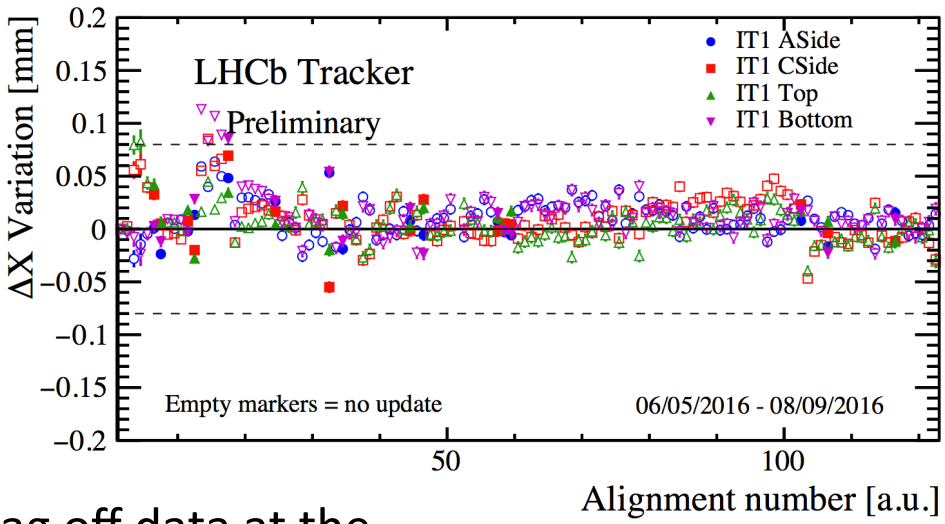
Tracker Alignment

Francesca, Lucia, Maurizio, Wouter

Alignment of each IT box, TT and OT modules for translations in x and z, rotations in x , IT boxes for rotations in z.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Automatic	Per fill	D^0 sample	< 1 min.	7 min

- Running since beginning of Run II
- Alignment constants updated every 5-12 fills
- Studies:
  - Optimisation of thresholds for automatic update
  - Optimisation of DOF used online



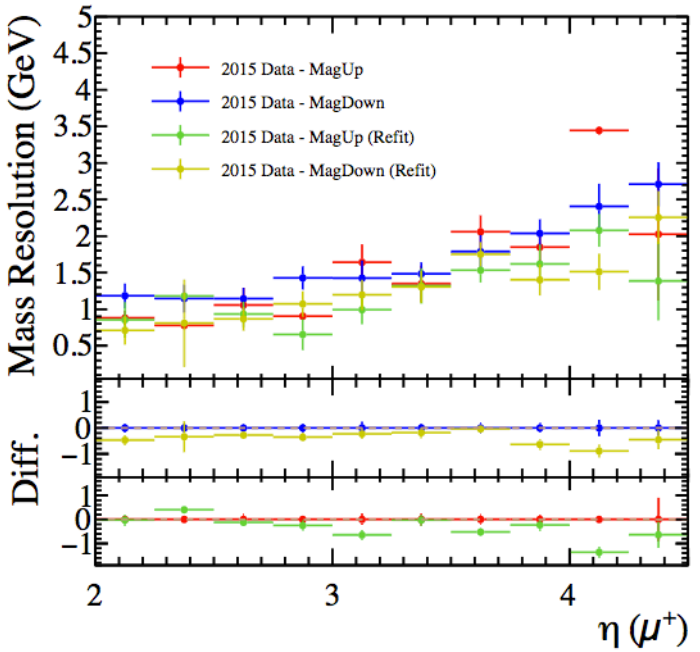
- Offline alignment for T_y performed on mag off data at the beginning of the year [LHCb Week June 2016]

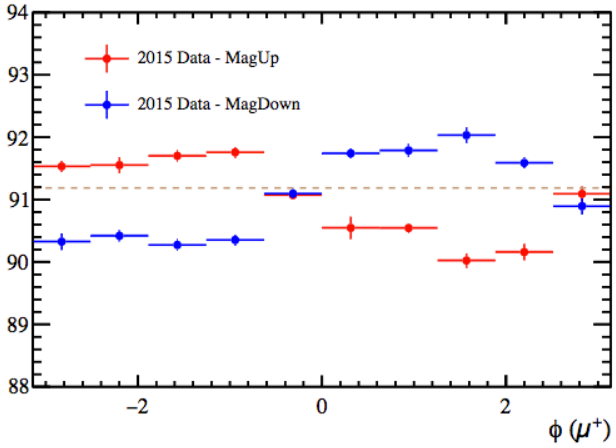
Tracker Alignment

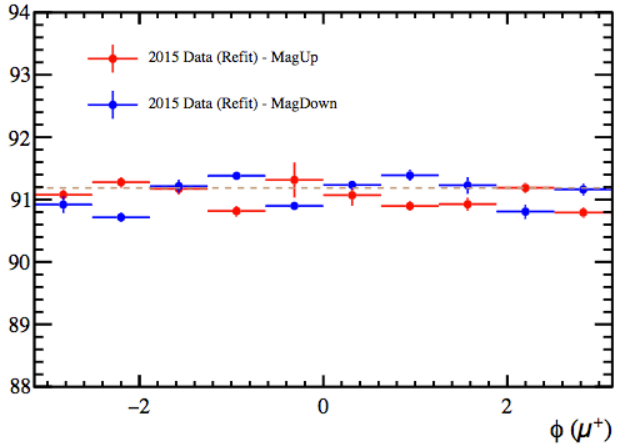
Stephen, Wouter

Study on using Z → μμ for internal alignment:

- OT modules split above/below the beam pipe, OT C-frames in z, split TT modules, IT boxes, IT layers and ladders
- Performed on full 2015 Z → μμ sample
- Using CALIBOFF database (ttitot-20151228) in DaVinci prepared by Wouter [Wouter's talk] on 2015 data [Stephen's talk]
- **15% improvement in Z mass resolution**
- Smaller variation of Z mass with Φ(μ)







Hardware Tracker Alignment

Fred, Pavol
Artur, Niels

Using light + mask/reflector + camera to track points

BCAM: [Pavol's talk]

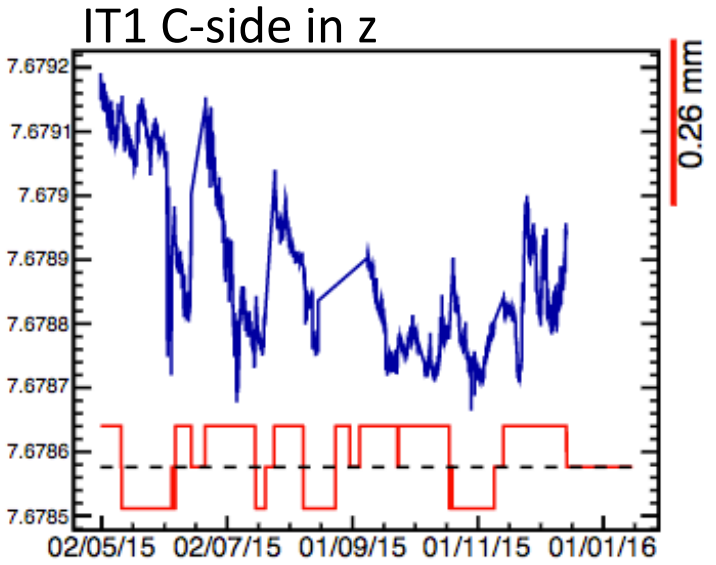
- 1 per C-frame of each IT station
- every 18 sec
- Integrating over 1h ➔ 5µm precision

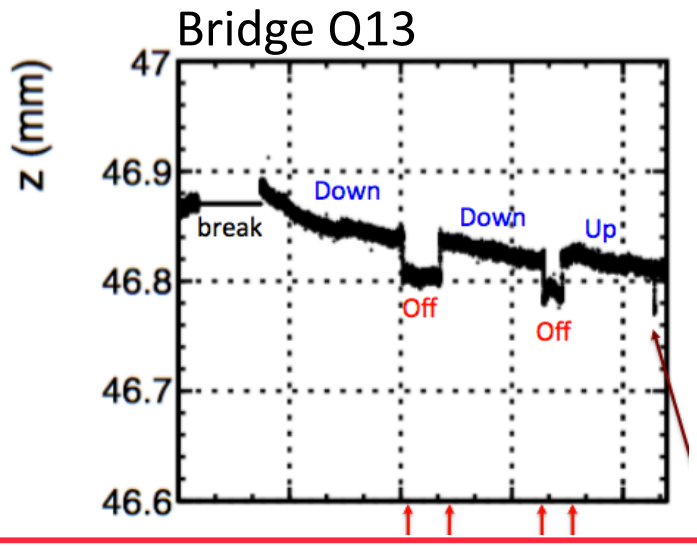
RASNIK: [Artur's talk]

- 4 per C-frame of each OT station + 2 on bridge
- Precision up to 5µm

- Movement seen also by software alignment
  ➔ **real movement of the bridge**

- Work on relating BCAM with RASNIK with software alignment ongoing
- Use BCAM/RASNIK as constraints for software alignment(?)





RICH Mirror Alignment

Anatoly, Claire, Paras

Alignment of each mirror for rotations about local y and z axes.

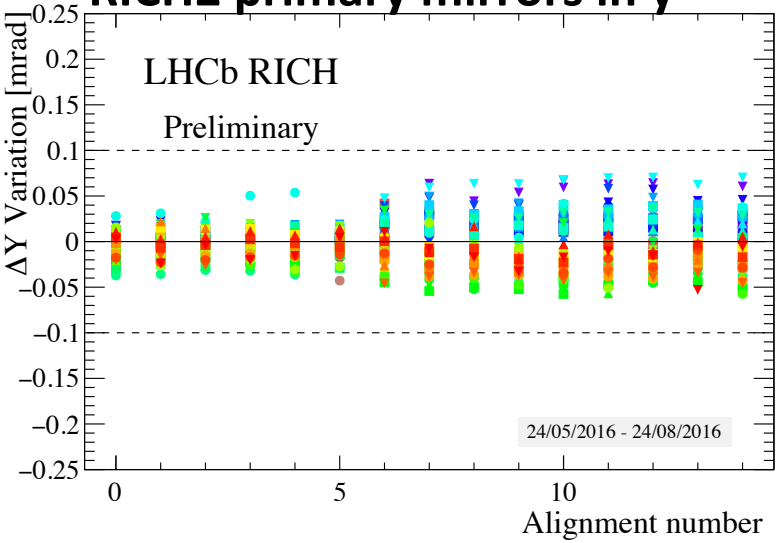
Update of constants	Frequency	Data sample	Time to collect data	Time to run
Monitoring mode only	Per fill	HLT1 line	5 hours (due to prescale)	30 min (both RICHs)

- Manual running since mid 2015
- Automatic running since beginning of 2016
- Improvements during Run II:
  - Increase in speed from 4 hours to 15 min per alignment
  - Increase in stability
    [LHCb Week March 2016]
- First alignment 2016 into new condDB release

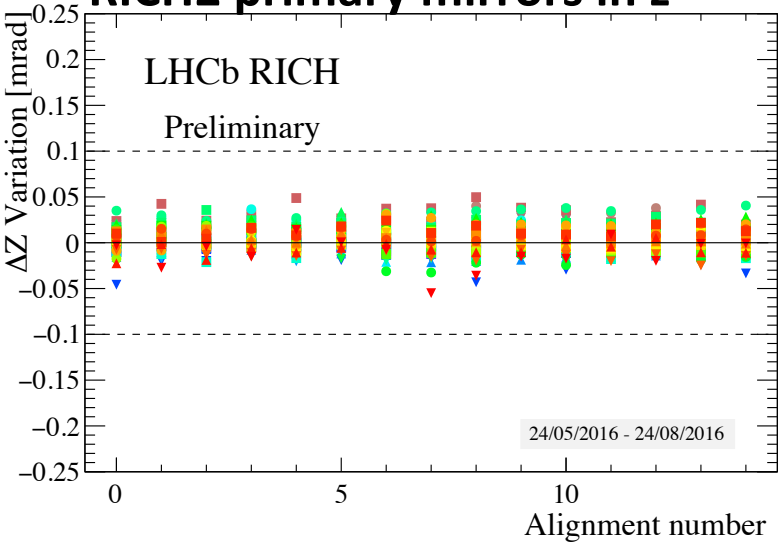
RICH Mirror Alignment

Anatoly, Claire, Paras

RICH2 primary mirrors in y

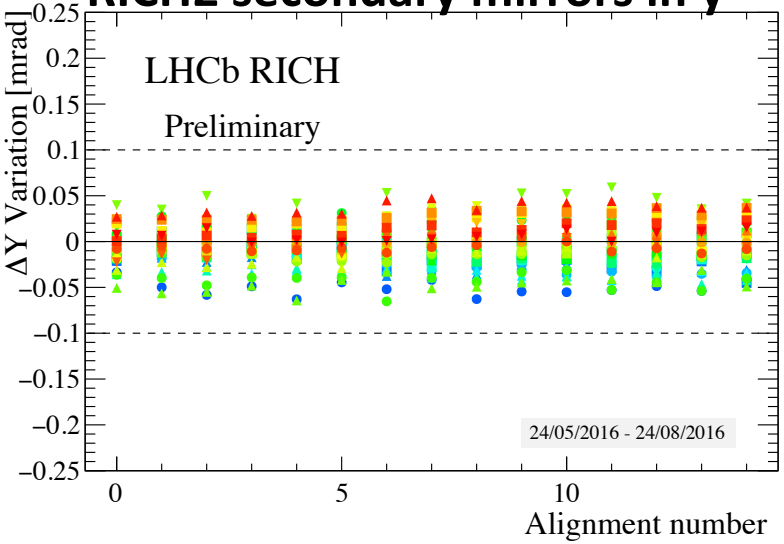


RICH2 primary mirrors in z

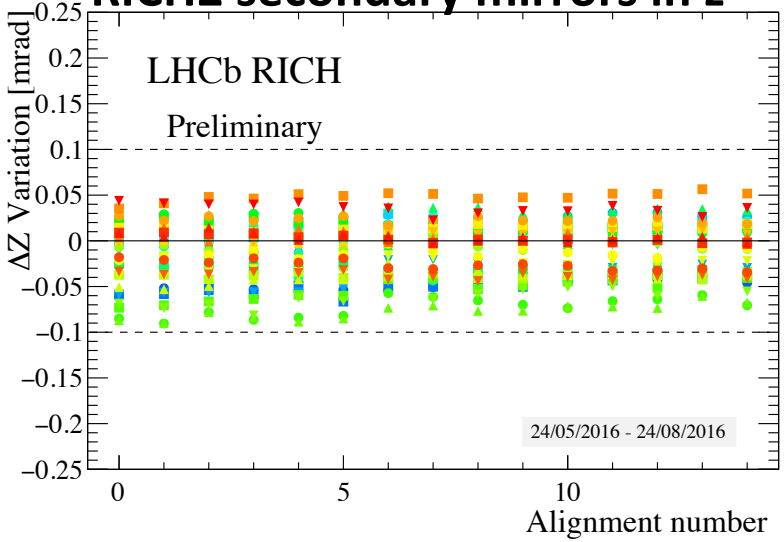


Well within required precision!

RICH2 secondary mirrors in y



RICH2 secondary mirrors in z



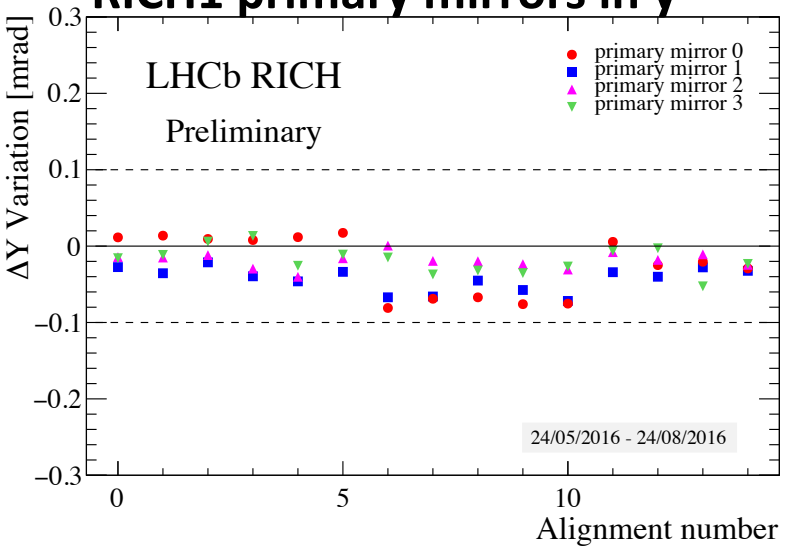
Run I: 0.68 mrad

Run II: 0.66 mrad

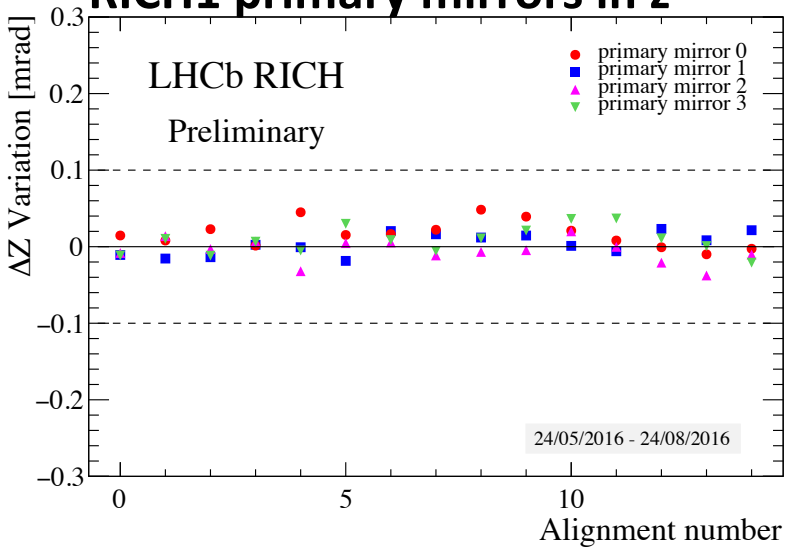
RICH Mirror Alignment

Anatoly, Claire, Paras

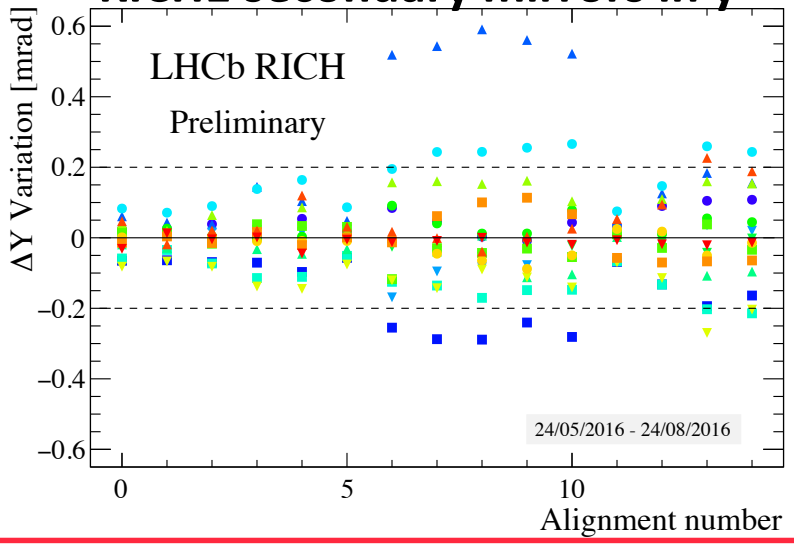
RICH1 primary mirrors in y



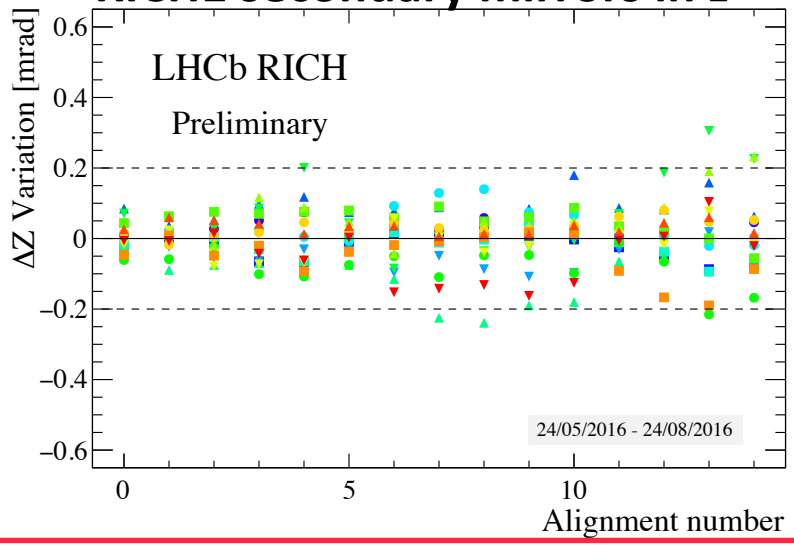
RICH1 primary mirrors in z



RICH1 secondary mirrors in y



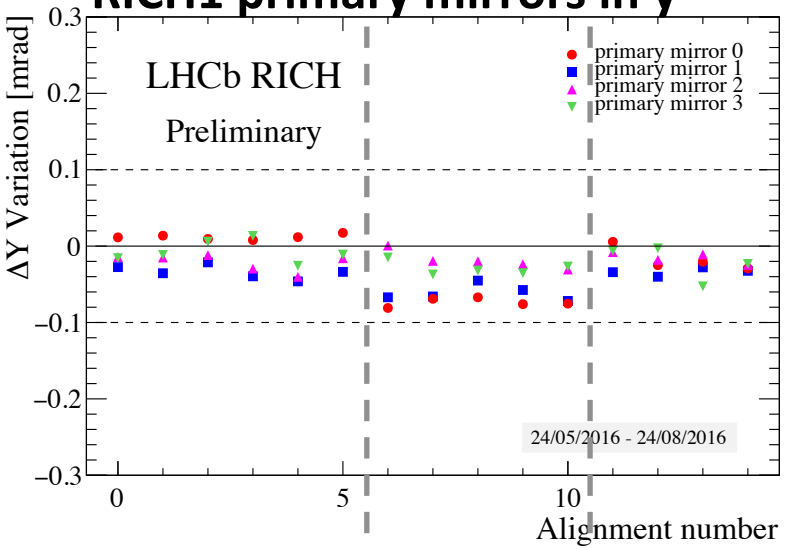
RICH1 secondary mirrors in z



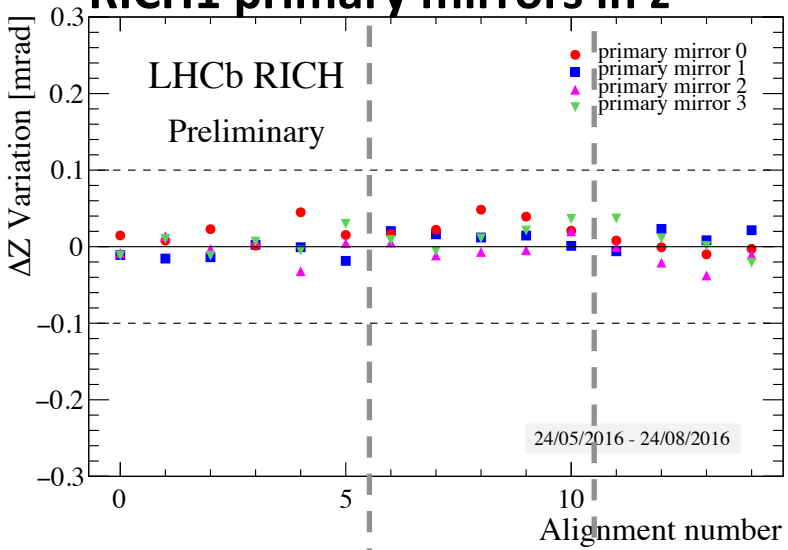
RICH Mirror Alignment

Anatoly, Claire, Paras

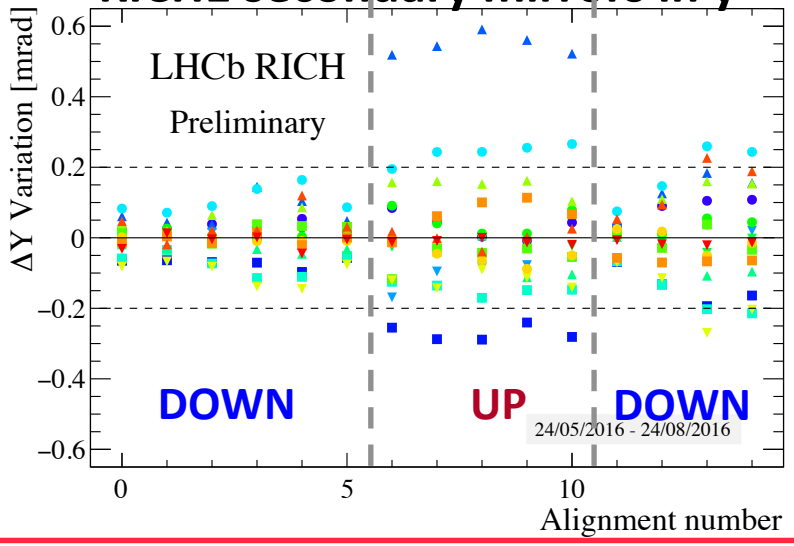
RICH1 primary mirrors in y



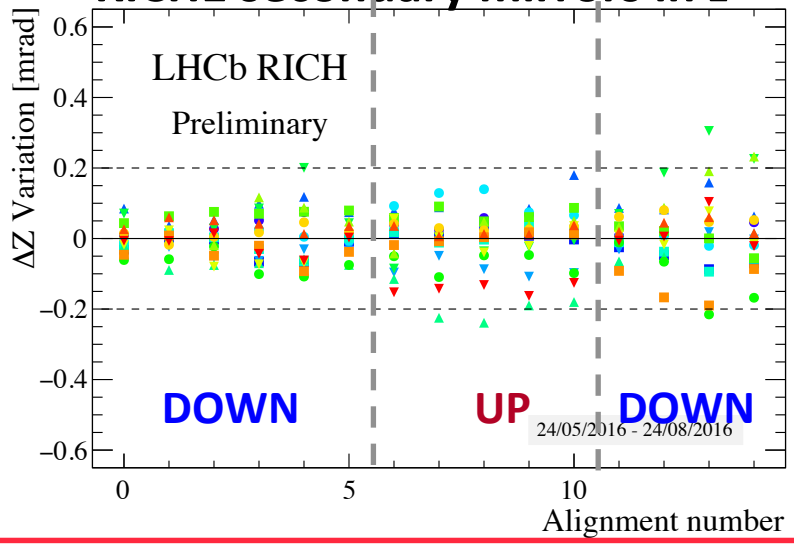
RICH1 primary mirrors in z



RICH1 secondary mirrors in y



RICH1 secondary mirrors in z



Small difference due to mag polarity.

➔ No visible impact on overall resolution/ performance

More studies following!

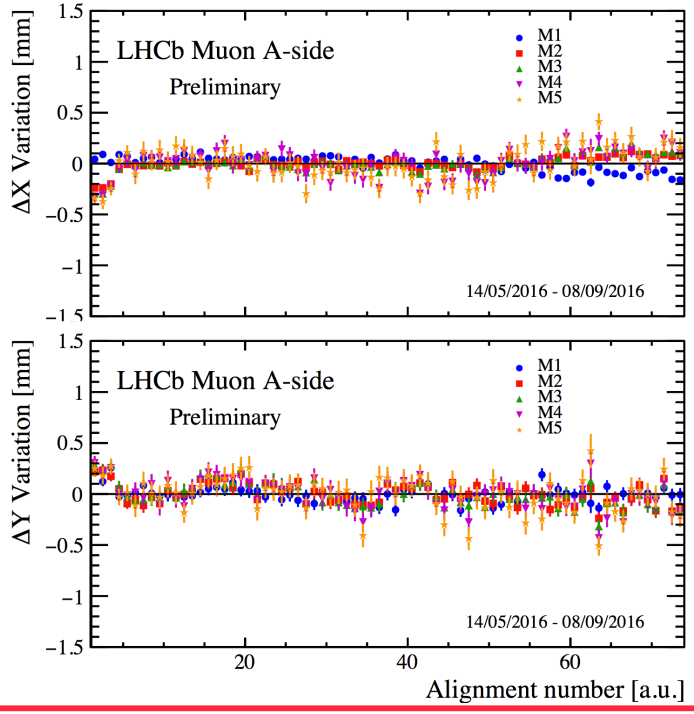
Muon Alignment

Giulio, Stefania

Alignment of both halves of each station for translations in x and y.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Monitoring mode only	Per fill	J/ψ sample	3 hours	7 min

- Running since beginning of Run II
- First alignment 2016:
  - Misalignment of M1 of ~2mm in T_x
    ➔ mechanically moved
  - New condDB release and LUT for L0 produced
- Stable conditions with variations well below required precision of 1mm
  [Stefania's talk]



Calibrations

OT Calibration

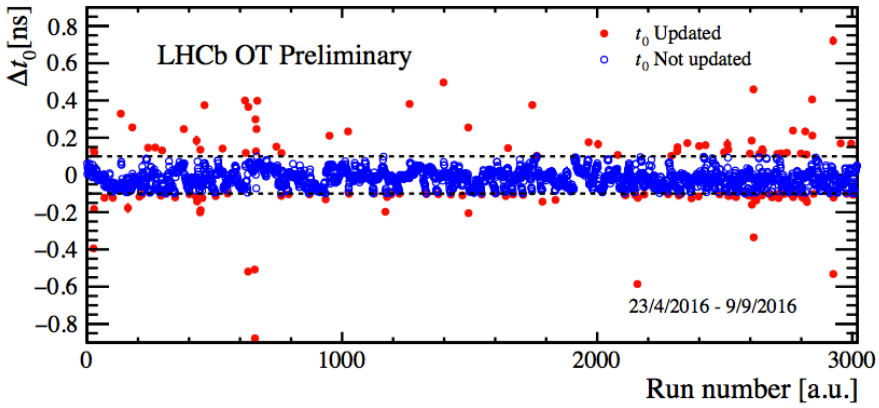
Philippe, Lucia

Calibration of global time delay t_0 caused by a difference in collision time and the phase of the LHC clock received at LHCb.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Automatic	Per run	Mon. histogram	15 min	O(min)

- Running since beginning of Run II

- Offline calibration for each t_{OTIS} applied, change only due to hardware interventions
  ➔ perform ~once a year



- Resolution from 3ns in Run I to:
  2.43 ns (Monolayer alignment + global t_0 calibration)
  2.40 ns (Monolayer alignment + global t_0 calibration + offline t_{OTIS} calibration)

➔ DB update for condDB and simulation with new resolution planned

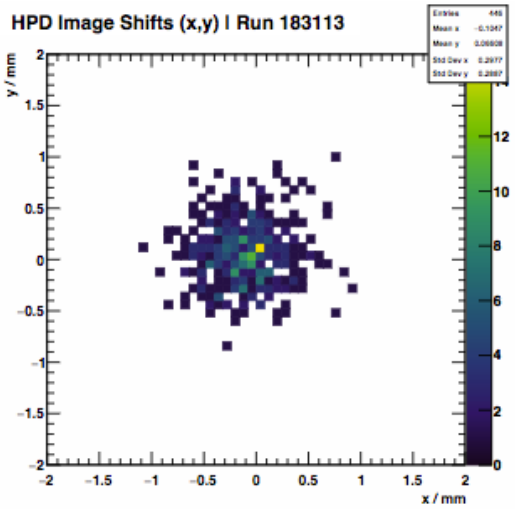
RICH calibrations

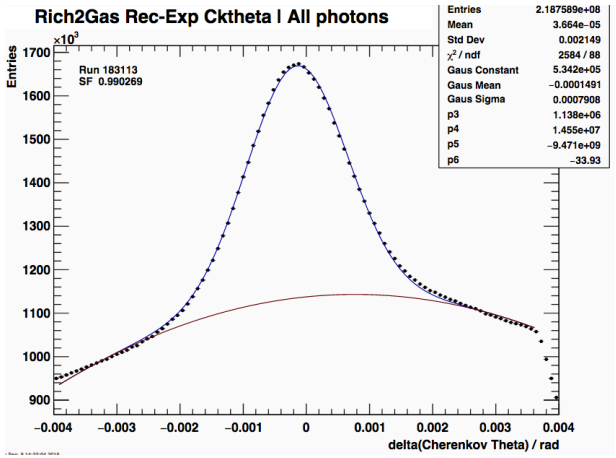
Chris, Jibo, Mike

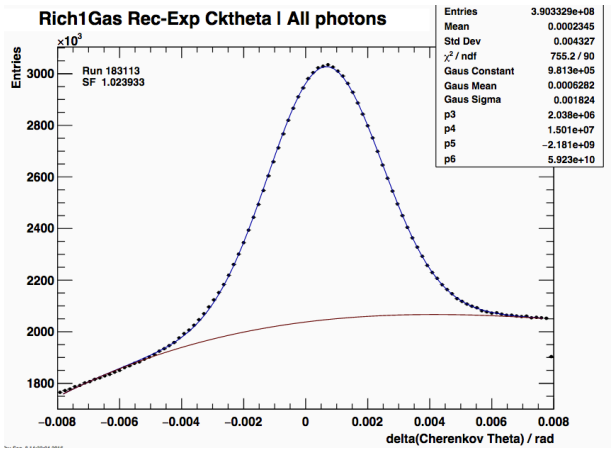
Calibration of refractive index and HPD image shift.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Automatic	Per run	Mon. histogram	15 min	O(min)

- Stable running since beginning of Run II
- Web resources for easy monitoring: https://lbrich.cern.ch







Calorimeter Calibration

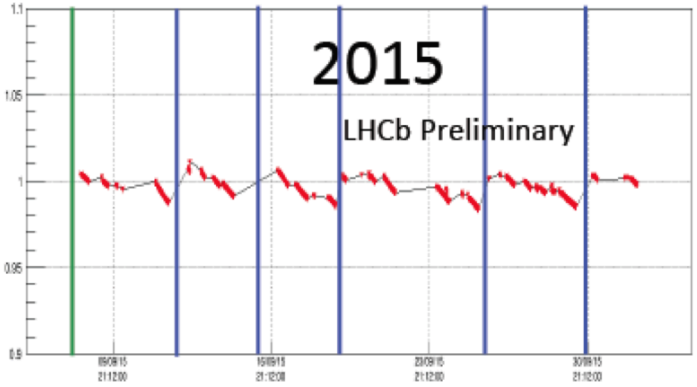
Marie-Noelle, Jean Francois

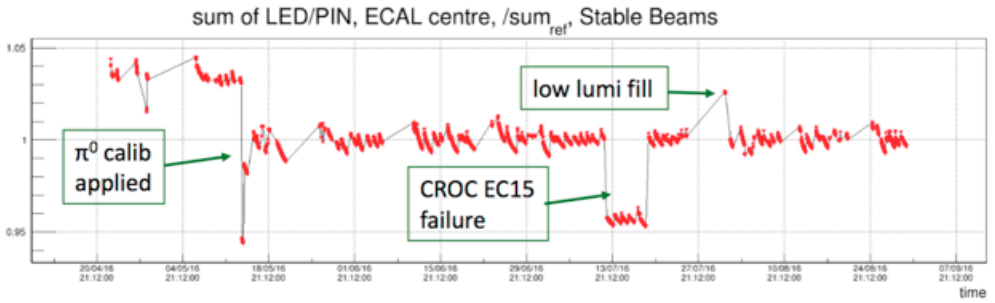
LED calibration of the gain of the photomultipliers.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
Automatic	Per fill	LED data	O(1h)	O(min)

- Running per few fills since beginning of Run II
- Running per fill since beginning of 2016

➔ more stable gain





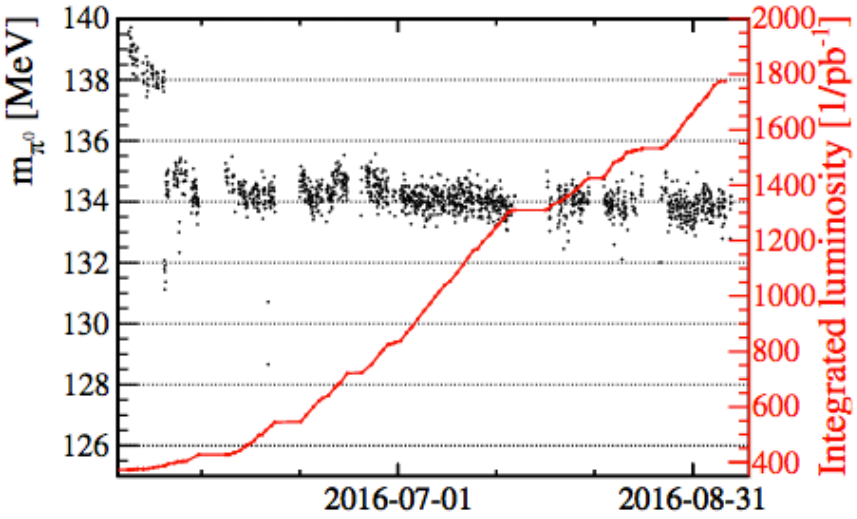
Calorimeter π^0 Calibration

Dasha, Jean Francois

Calibration by fitting the π^0 mass for each calorimeter cell.

Update of constants	Frequency	Data sample	Time to collect data	Time to run
No	~1 per month	Min. bias	3-4 days	5 hours

- Last calibration applied in May
- Automatisation of online fmDST production
- Debugging/ understanding calibration code
- Work on PreShower calibration ongoing



Conclusion

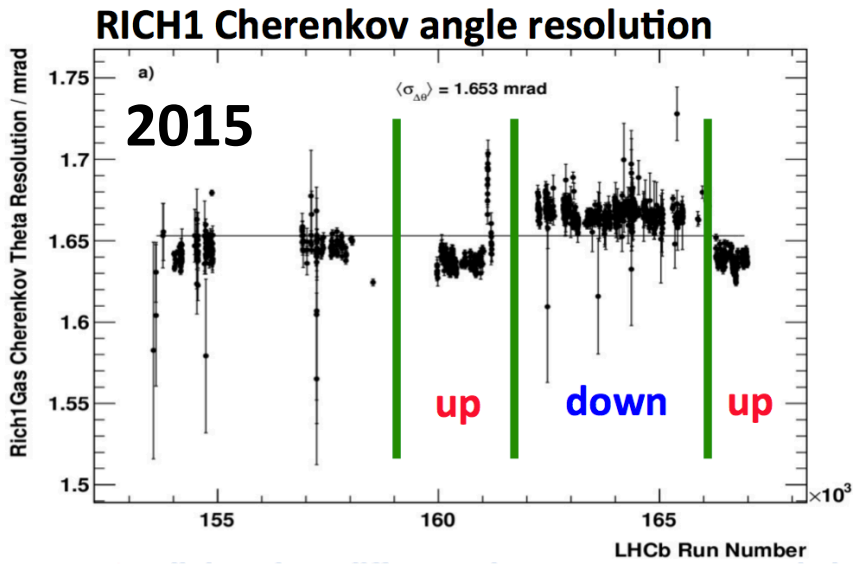
- Very successful automatic calibration and alignment system!
- Additional offline and hardware alignments
- Many studies done during the last year
- Optimisations in performance and speed
- Better understanding of our detector
- More things to be studied and understood

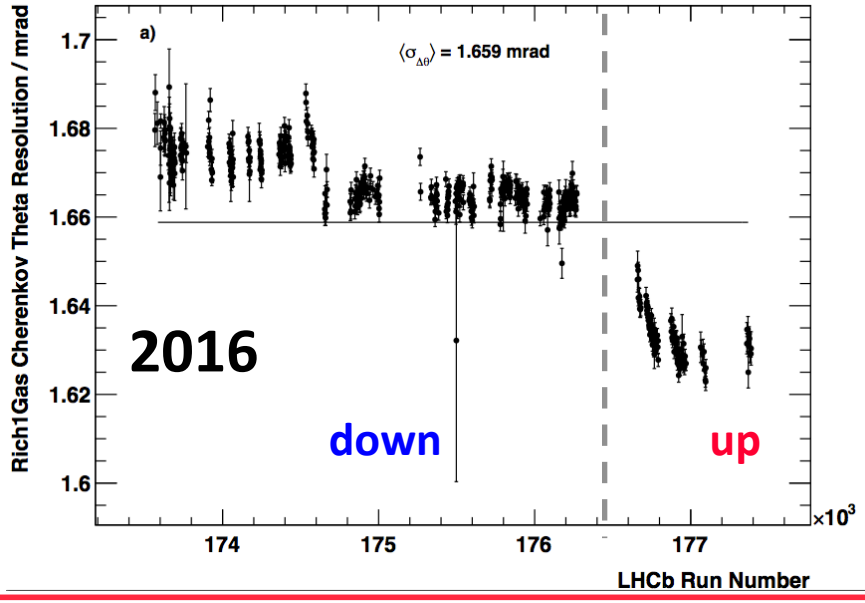
Special thanks to the online team!!!

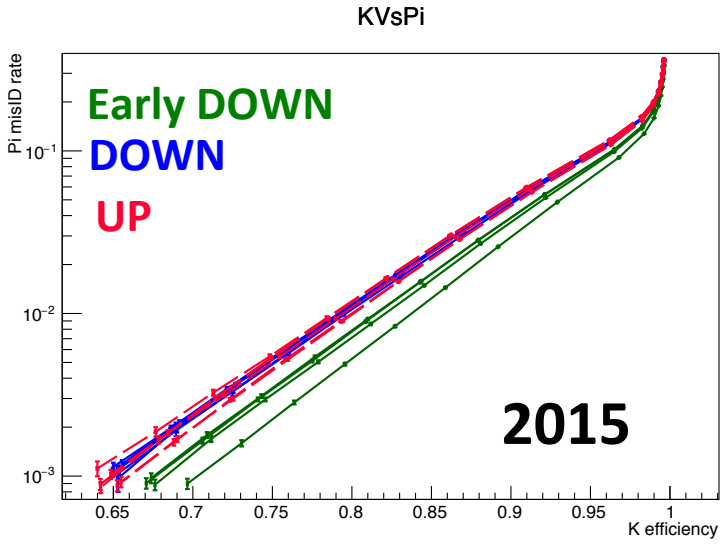
Backup

RICH Mirror Alignment

Anatoly, Claire, Paras







- Still difference in Cherenkov angle resolution between mag. polarities
- No difference in overall PID performance in 2015 ➔ waiting for PID samples for 2016
- More investigations underway