Update on Alignment and Calibration

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on behalf of the Alignment & Calibration group

Overview alignments

Alignments

1. **VELO alignment**: Alignment of both halves for translations and rotations in x, y and z.
2. **Tracker alignment**: Alignment of TT, IT and OT for translations in x, rotations and translations in z (online) and translations and rotations in y (offline).
3. **RICH mirror alignment**: Alignment of all individual mirrors for rotations around x and y.
4. **Muon alignment**: Alignment of both halves of each station for translations in x and y.

Automatic update of alignment constants

Monitoring mode only

- **Run on the HLT-farm at the beginning of every fill in the same order as above.**

Overview calibrations

Calibrations

- **OT calibration:** Global time alignment for all modules, extract the global time delay t_0 caused by a difference in collision time and the phase of the LHC clock received at LHCb.
- **RICH calibration:**
  - **Refractive index calibration**: correct the refractive index calculated from hardware sensors.
  - **HPD Image calibration**: calibration of the image for each anode element.
- **Calorimeter calibration:** Occupancy method and LED monitoring system, adjust the high voltage to compensate for the aging of the detector
- **Run on the monitoring histograms for ~every run (OT and RICH) or every fill (Calorimeter).**

- **π^0 calibration**: Calibrate the gain in each cell using the π^0 mass distribution with $\pi^0 \rightarrow \gamma\gamma$

  Run on the alignment farm during TS.

VELO alignment (1/2)

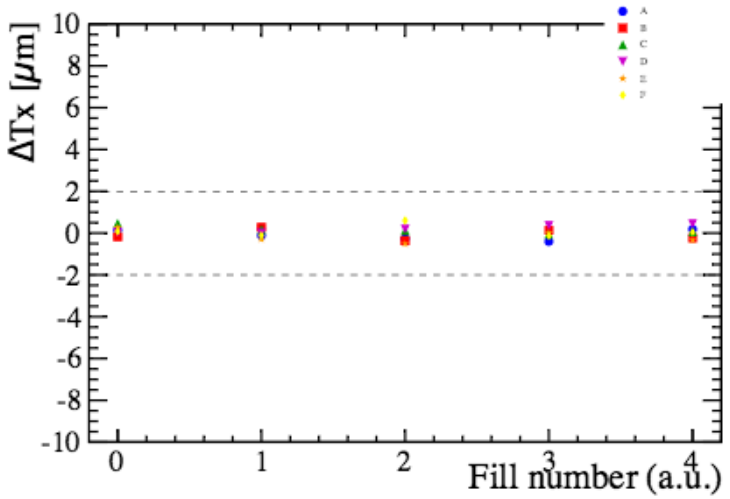
Giulio, Silvia

Work during WS [Giulio's talk]

Threshold for automatic update of alignment constants:

- accuracy and precision used in 2015 taken from 2012 MC and 2012 data
- If too small: sensitive to statistical fluctuations
  If too big: unexpected behaviour
- new stability study with data taken in 2015: several alignments made on different events from same fill

➔ **New thresholds determined.**



	2015		for 2016	
dof	Min variation	Max variation	Min variation	Max variation
T_x T_y [μm]	2	10	1.5	10
T_z [μm]	4	10	5	10
R_x, R_y [μrad]	3.5	25	4	25
R_z [μrad]	15	100	30	100

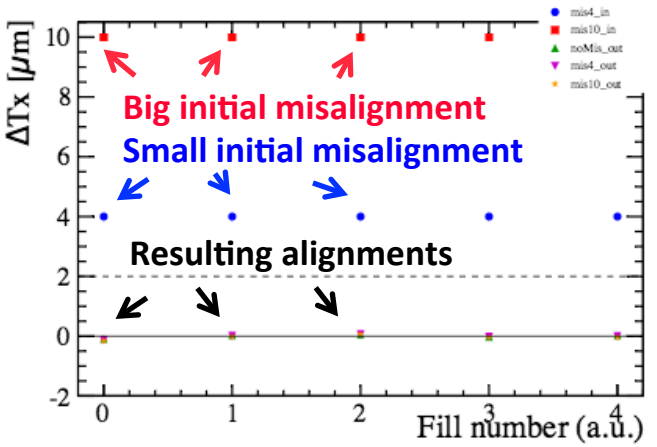
VELO alignment (2/2)

Giulio, Rosen

Dependence on initial alignment: Giulio's talk

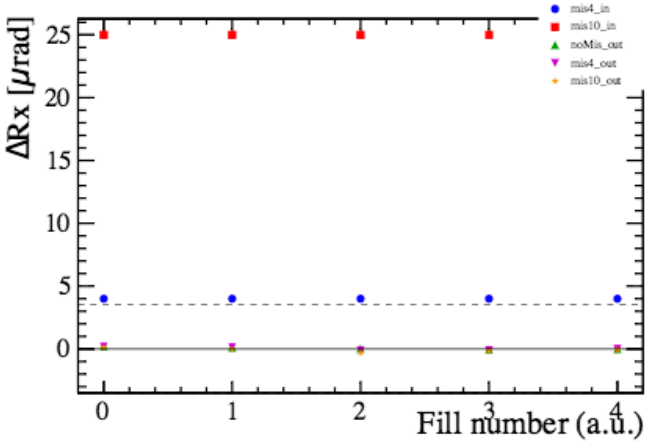
- stability study with data taken in 2015: several alignments made on same events starting from different alignments (optimal, small misalignment, big misalignment)

➔ **New alignment does not significantly depend on the initial alignment.**



To be done:

- optimization of the rate between collision and beam gas events in the HLT1 line (same HLT1 line as for the luminosity studies) to get more beam gas events



Plans for 2016 data-taking

- Apply the new thresholds for automatic update of alignment constants
- Adjust the rate of beam-gas events to collision events
- Continue running automatically as during the end of 2015

Tracker alignment

Wouter, Maurizio, Francesca, Lucia

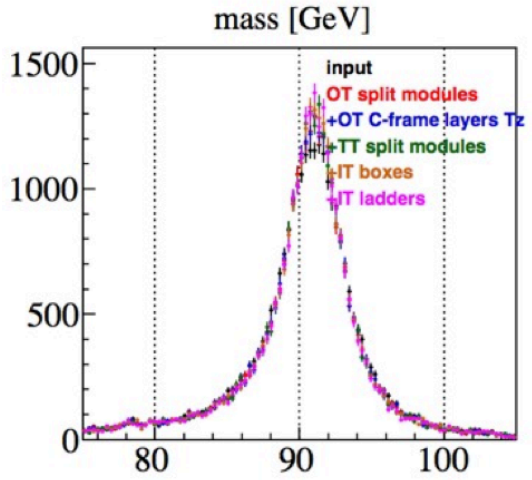
Work during WS

Z→ μμ decays + additional degrees of freedom: Wouter's talk

- Z→μμ decays collected in 2015
- OT modules split above/below the beam pipe, OT C-frames in z, split TT modules, IT boxes, IT layers and ladders

➔ **Z peak ~15% narrower, and improved track χ^2 after alignment**

➔ **Improved internal IT alignment**

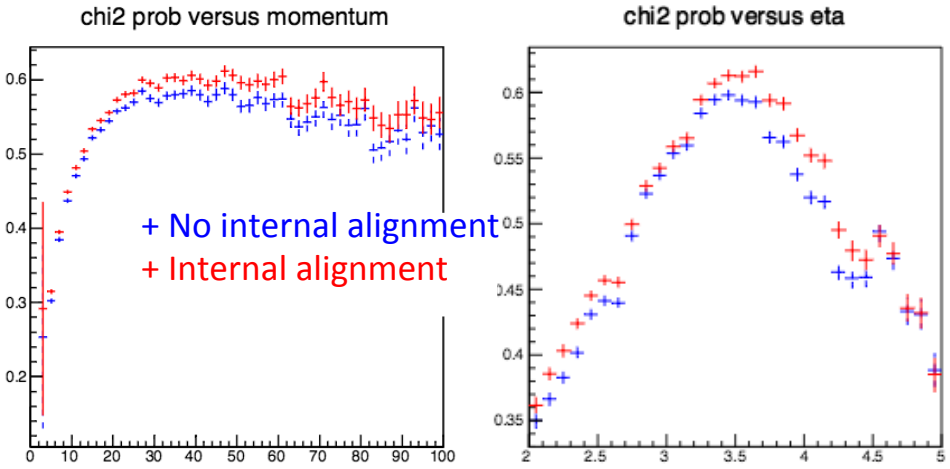


D^0 decays + additional degrees of freedom: Maurizio's talk

- Default D^0 decays
- Same configuration as for Z alignment for OT and IT

➔ **Same improvements in track χ^2 and overlap-residuals as on Z sample**

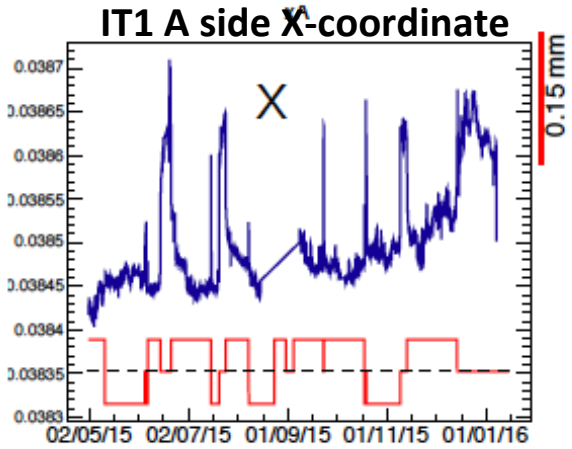
➔ **No improvement in D^0 mass resolution**

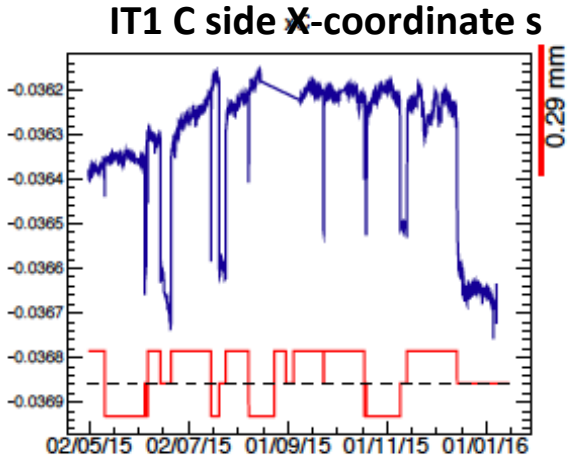


Tracker alignment

To be done:

- Evaluation of alignment with high momentum tracks and tracks from J/Ψ events
- Study different alignment configurations
- Stability study for IT: correlation between movement seen by BCAM (Pavol's talk) and tracker alignment under study
- Stability study for OT and TT: stability of alignment constants of the different elements





Plans for 2016 data-taking

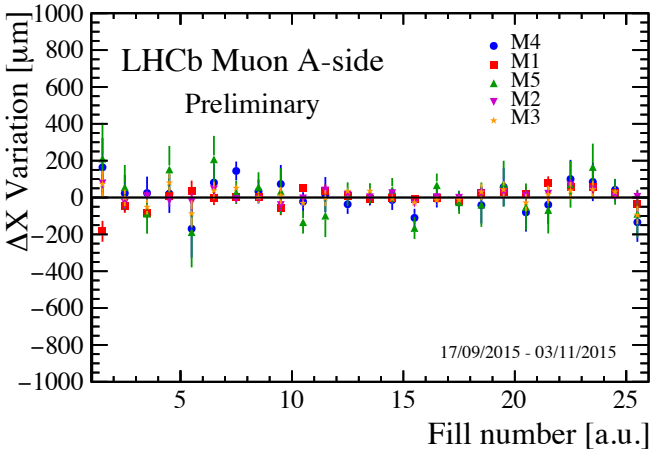
- Detector was opened and IT2C box was moved (~1mm in x,y)
  ➔ expect significant misalignment at the start
- 1st alignment with big data-sample and all degrees of freedom at the beginning of data-taking
- Alignment in y with magnet-off data
- Use D^0 events plus high-momentum tracks (and possibly J/Ψ events)

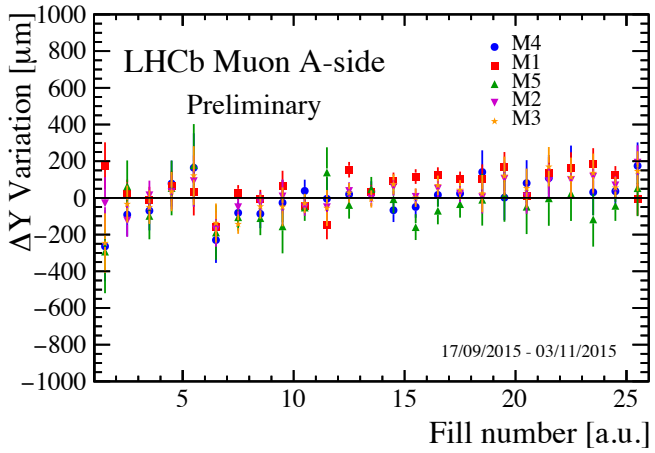
Muon alignment

Silvia, Stefania

Work during WS

No work necessary, alignment was already stable in 2015.





Plans for 2016 data-taking

- Muon system was opened during WS
- misalignment in muon system can create asymmetry in L0Muon

➔ initial alignment needed

1. software alignment
2. if misalignment is big move the chambers mechanically and perform new alignment
3. produce new LUT for L0Muon

- Run in monitoring mode

RICH Mirror Alignment (1/3)

Anatoly, Claire, Paras

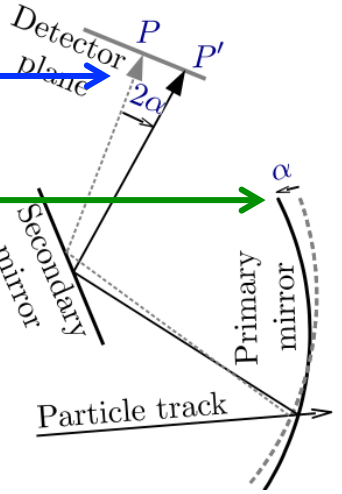
Work during WS

Studies on increase of speed

1. Magnification coefficients:

- translate the misalignment-on-the-detector-plane into actual mirror tilts
- Previously calculated for every alignment for each iteration on data
- Tested using the same set for all alignments and all iterations

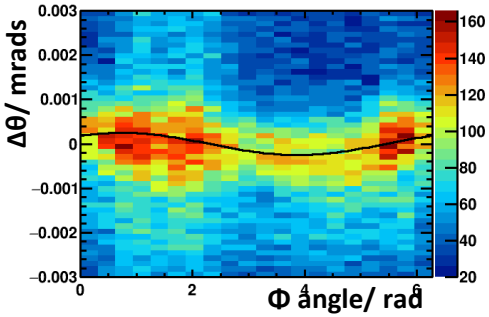
➔ No significant difference in resulting mirror tilts and **procedure 9 times faster!!!**



2. New method for fitting histograms:

- use same Gaussian width for each slice in phi

➔ Same resulting mirror-tilts and **3 times faster**



3. New method for determining individual mirror misalignments:

- No more fixed mirrors + align all mirrors at the same time

➔ **Fewer iterations needed** obtaining the same Cherenkov angle resolution.

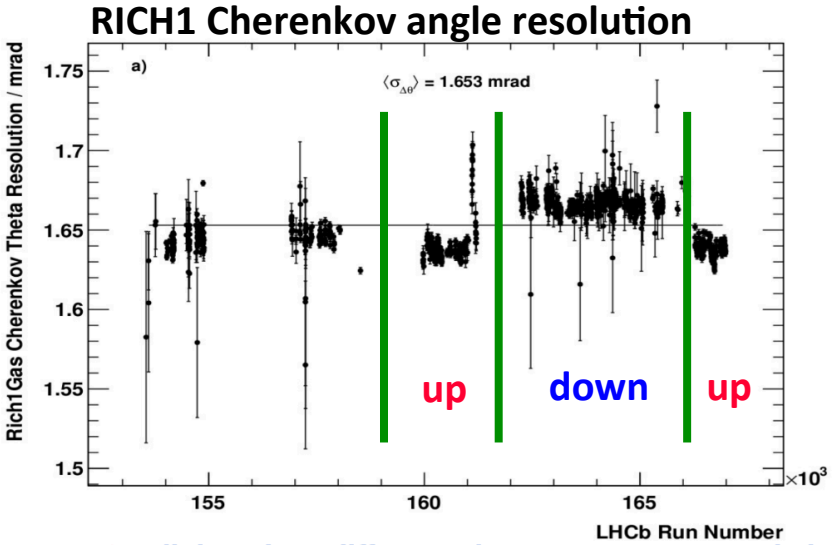
RICH Mirror Alignment (2/2)

Anatoly, Claire, Paras

Number of events needed for stable alignment:

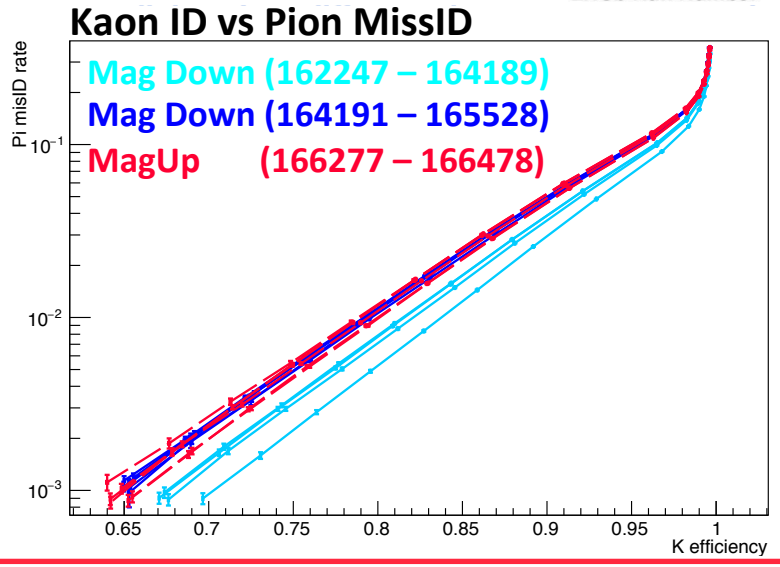
- several alignments made on different runs from same time-period

➔ 1M events for RICH1, 2M events for RICH2



Magnet polarity:

- Different Cherenkov angle resolution for different magnet polarities in RICH1
- Increase in energy required to pass L0 between Mag Down and Mag Down
- **See no evidence that the PID suffers if we use the same alignment for both polarities**
- More studies ongoing



RICH Mirror Alignment (3/3)

Anatoly, Claire, Paras

Plans for 2016 data-taking

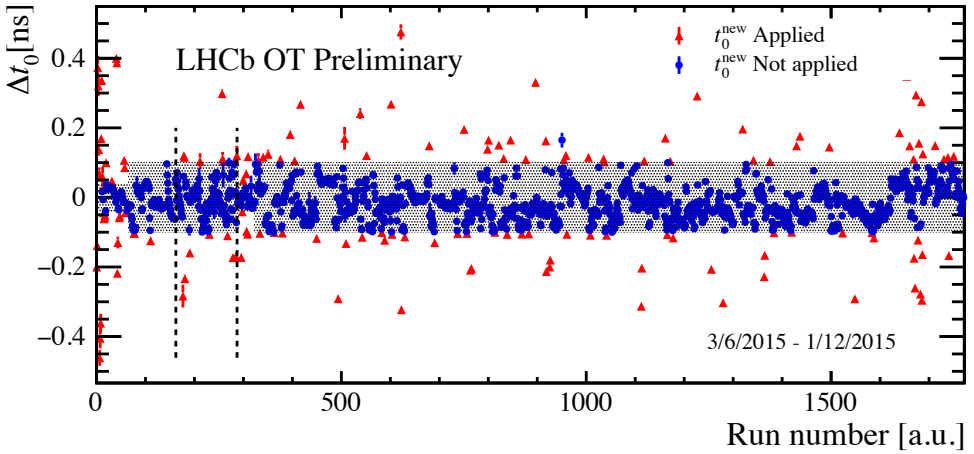
- Adjust HLT1 prescale for RICH1 to get desired number of events for both RICHs in same amount of time
- 1st alignment with big data-sample at the beginning of data-taking
- Run every fill if possible to have more stability studies
  - Stability of alignment constants
  - Stability of Cherenkov angle resolution
- Revisit in September if we can run less often

OT global t_0 calibration

Philippe, Lucia

Work during WS

- No conceptual work necessary, calibration already worked well in 2015.
- Some work on the monitoring.



Plans for 2016 data-taking

Continue running automatically on ~every run as during 2015.

RICH calibrations

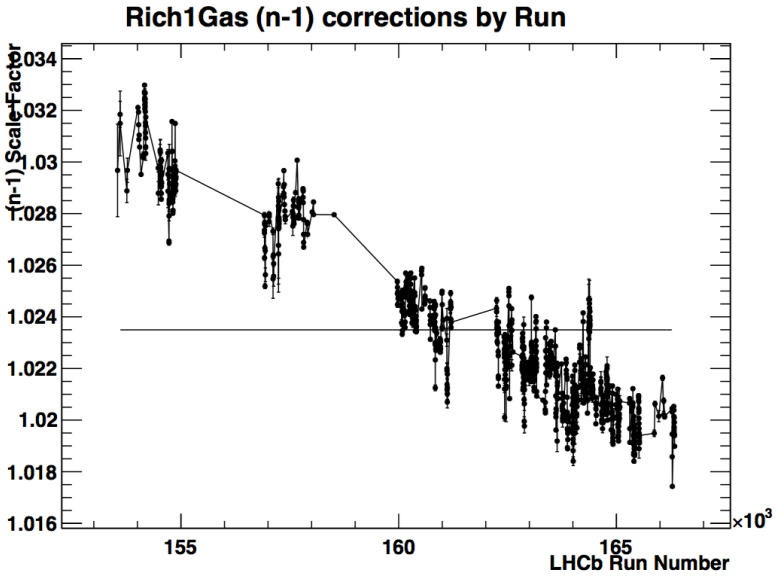
Chris, Jibo

Work during WS

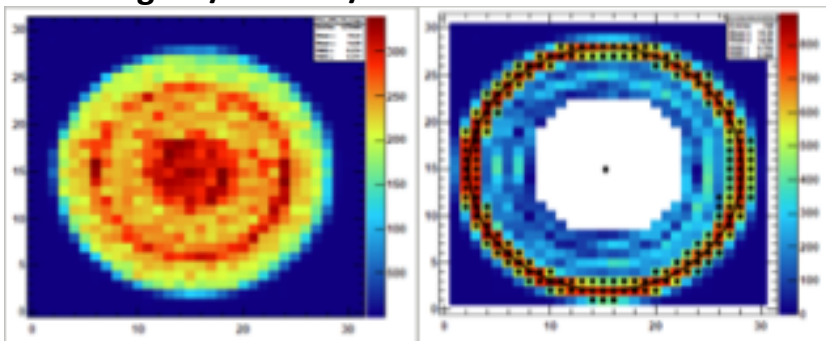
- No work conceptual necessary, calibration already worked well in 2015.

Plans for 2016 data-taking

Continue running automatically on ~every run as during 2015.



HPD image w/o and w/ Sobel filter



Calorimeter calibrations

Marie-Noelle, Jean Francois

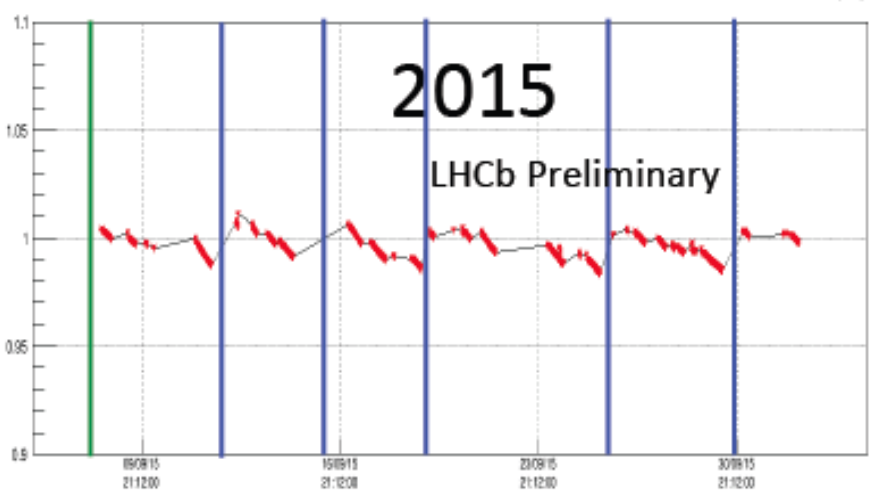
Work during WS

LED method:

- Worked well in 2015
- Failing LED were replaced during WS

Occupancy method:

- Noticed dependency on the beam conditions
- Study still ongoing



Plans for 2016 data-taking

- Run LED method for both ECAL and HCAL automatically at the start of each fill
- Run occupancy method for each fill (without applying the results) to study the dependency on the beam conditions

π^0 calibration

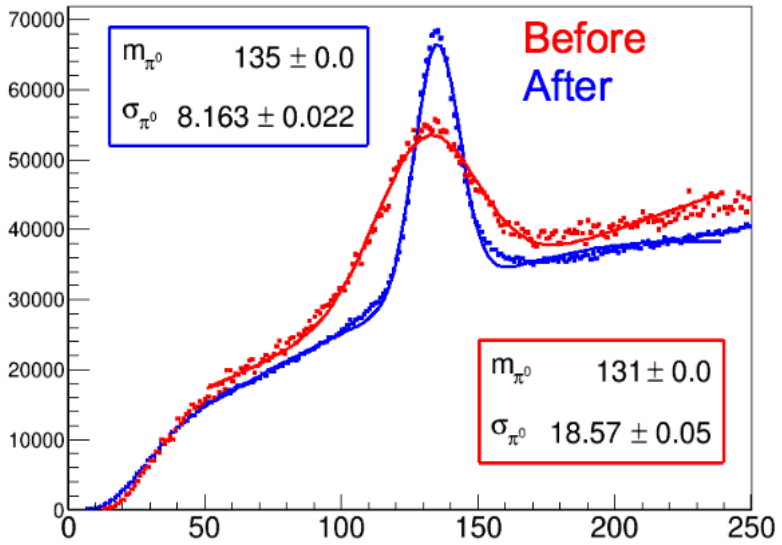
Dasha, Jean Francois

Work during WS

- Dedicated conddb provided for September data that was affected by a π^0 mass shift (local tag calo-20160104, included into a global tag cond-20160123)

Ongoing work:

- Speed up the procedure
- Investigate over- and under-calibration of ECAL cells in the central region
  - ➔ Improve event selection



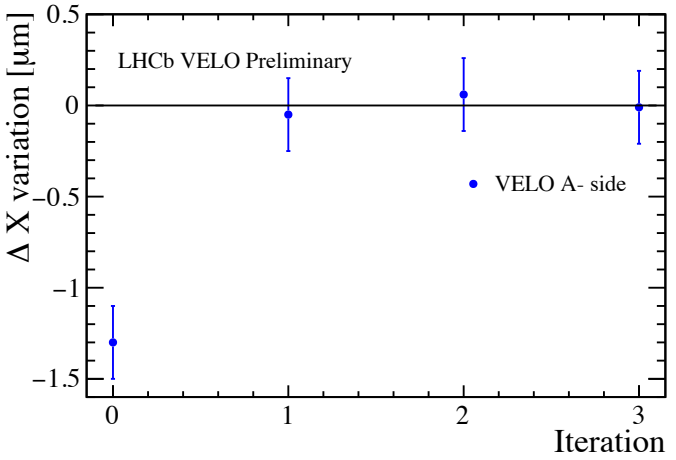
Plans for 2016 data-taking

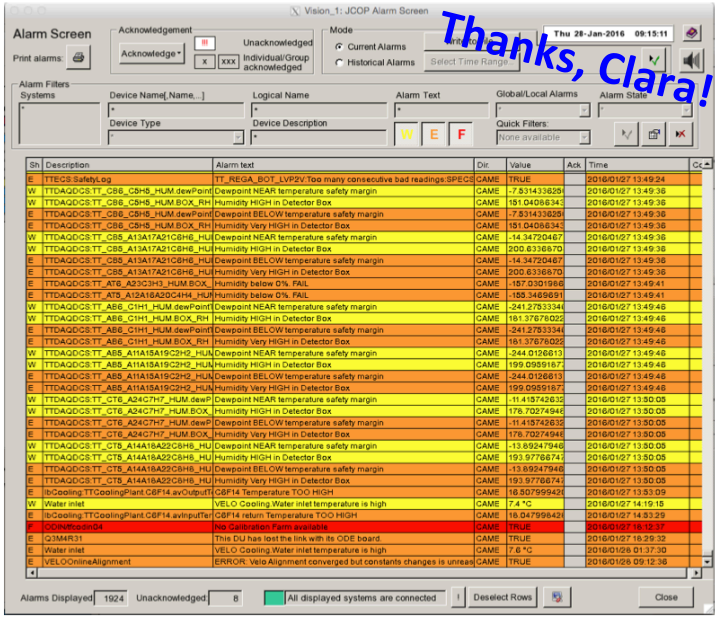
- Before data-taking correct for the over-/under calibration of central cells by using MC
- Perform calibrations during the TS

Monitoring and Alarms

Work in progress:

- Show development of alignment constants during the alignment procedure in presenter
- Show the stability of the alignment constants over time in presenter
- Alarm if something goes *wrong*: change in constants too large, no convergence was reached…
- **Developing procedure for case of alarms**





Conclusion

- Many studies done during WS
- Improvements in performance
- Improvements in speed
- Some small improvements/studies still to be made
- Further work on the monitoring required
- Getting ready for data-taking!