Precision and stability of the automatic Velo Alignment in 2015

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Introduction

- In 2015 commissioned automatic alignment procedure
- Still a couple of things to finalise
- Possible to exploit information from 2015 run

Automatic alignment procedure

- At each fill a new alignment is evaluated
- HLT1 lines collect dedicated samples for each alignment (VELO, Tracker, Muon)
- Run the alignment as soon as enough data are collected
- Update only if new alignment is significantly different from the old one
- Check significance based on variation of χ^2 and of alignment constants
- If alignment procedure does not converge or proposed variation unphysically large then alignment is not updated and experts should investigate
- Time requested: few minutes after the enough data have been collected

Setting the thresholds

- Need to set the thresholds on the variation of the constants to determine when a new alignment is significantly different from the previous one
- For 2015 run determined accuracy and precision from MC and data from 2012
- Now possible to use data taken in 2015 to study more in depth the precision and optimise the thresholds

Thresholds used in 2015

- too small: statistical fluctuation
- too big: unexpected behaviour

dof	Min variation	Max variation
T_x T_y [µm]	2	10
T_z [µm]	4	10
R_x, R_y [µrad]	3.5	25
R_z [µrad]	15	100

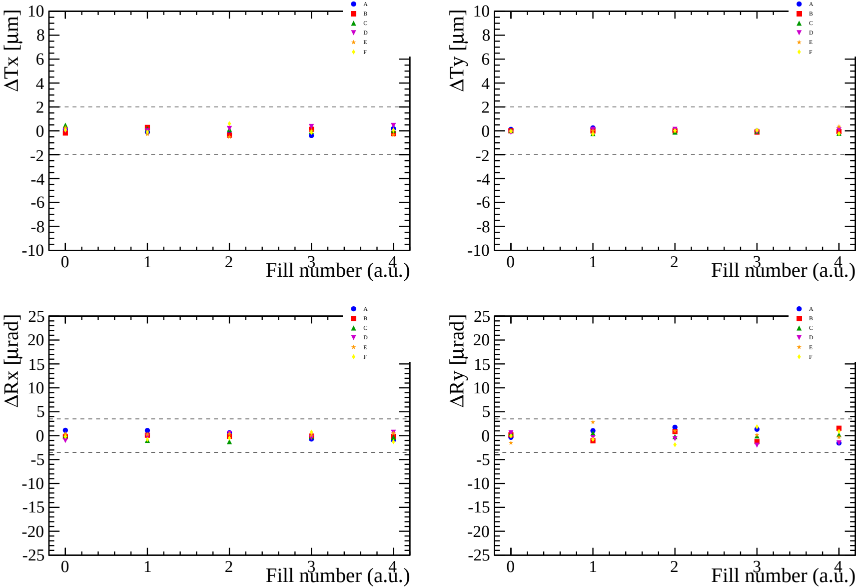
Setting the thresholds for 2016

- To study precision considered 5 runs, for each of them:
- divide data available for alignment in 6 independents datasets ($\sim 8k$ events)
- run using only a dataset per time the alignment procedure starting always from the same optimal alignment (obtained using the full dataset)
- the difference wrt the initial alignment is a proxy of the dependence of the alignment on the dataset and hence of the precision of the method

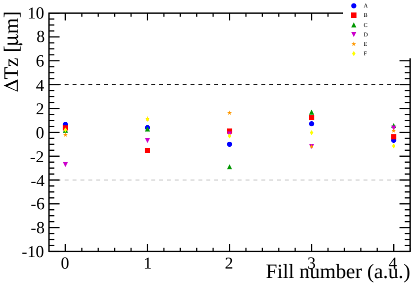
Max variations

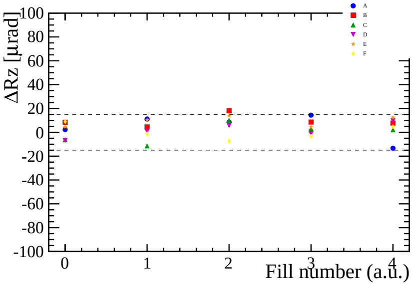
$$T_x, T_y \sim 1\,\mu\text{m} \qquad T_z \sim 4.5\,\mu\text{m}$$
$$R_x, R_y \sim 3.5\,\mu\text{rad} \qquad R_z \sim 25\,\mu\text{rad}$$

Variations due to different dataset



Variations due to different dataset





New thresholds for 2016

- too small: statistical fluctuation
- too big: unexpected behaviour

dof	Min variation	Max variation
T_x T_y [μm]	1.5	10
T_z [μm]	5	10
R_x, R_y [μrad]	4	25
R_z [μrad]	30	100

Dependence from initial alignment

- For computing a new alignment we start from an input alignment, usually the one from the previous fill
- How much the input alignment matters?

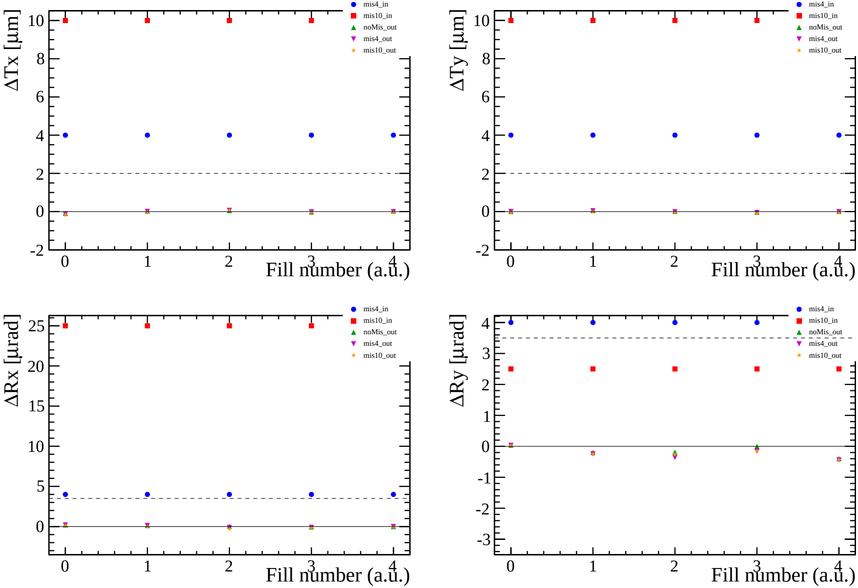
- Consider 5 fills and for each of them align starting from 3 different alignment:
  - the optimal alignment for that run
  - the optimal alignment plus a small misalignment
  - the optimal alignment plus a big misalignment
- Subtract the optimal alignment and compare

Max variations after alignment

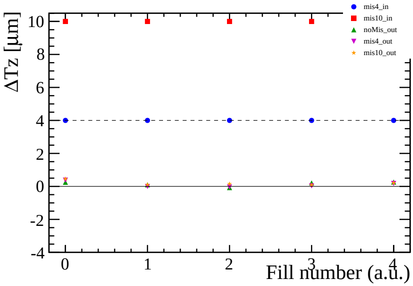
$T_x, T_y \sim 0.07\ \mu\text{m}$ $\quad$ $T_z \sim 0.2\ \mu\text{m}$

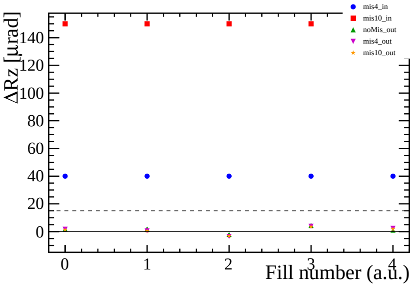
$R_x, R_y \sim 0.3\ \mu\text{rad}$ $\quad$ $R_z \sim 1.5\ \mu\text{rad}$

Variations due to initial alignment



Variations due to initial alignment

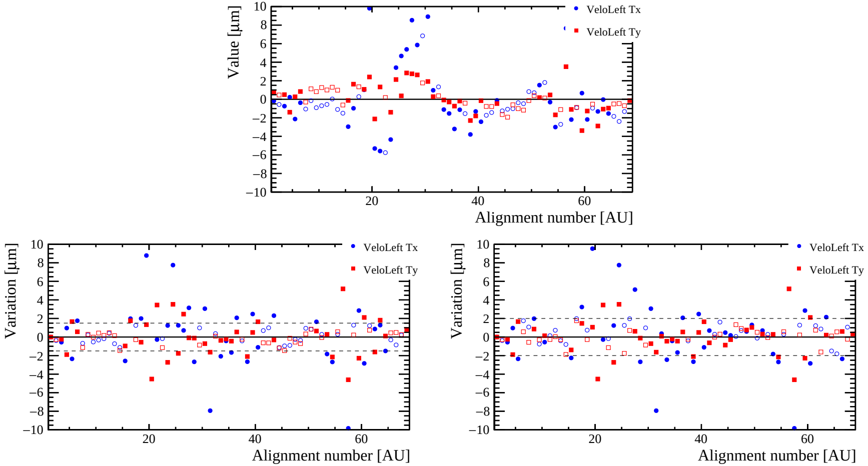




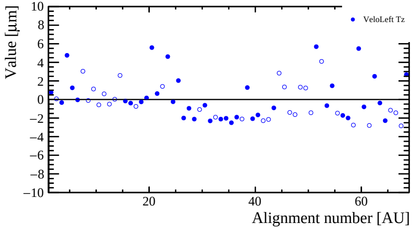
Studying stability

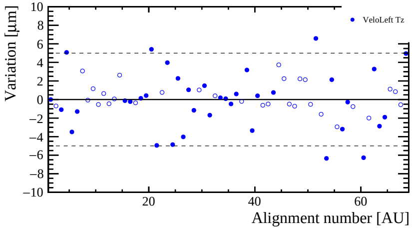
- As the new alignment does not depend significantly on the input alignment I can see the effect of applying the new thresholds without having to run again all the alignments :)
- Considered 68 runs in COLLISION15
- With old thresholds 40 updates, (9 for R_z alone, 7 for T_x alone ...)
- With old thresholds 38 updates, (13 for T_x alone, 4 for Ty alone ...)

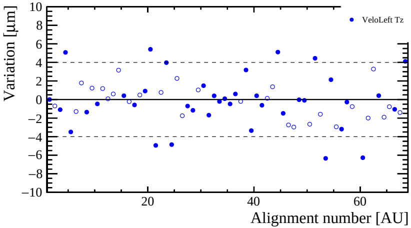
Stability T_x T_y



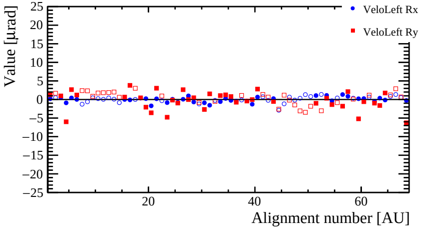
Stability T_z

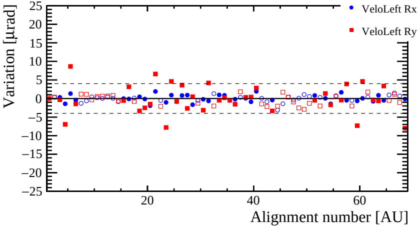


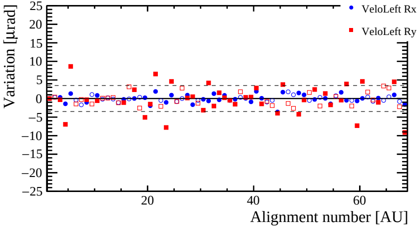




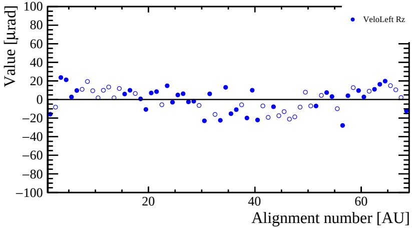
Stability R_x R_y

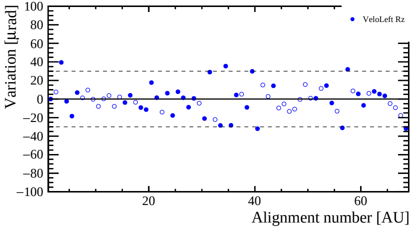


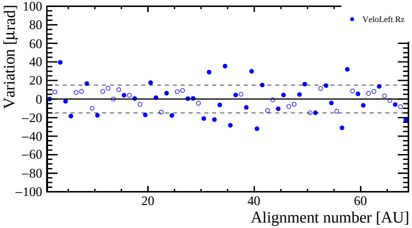




Stability R_z



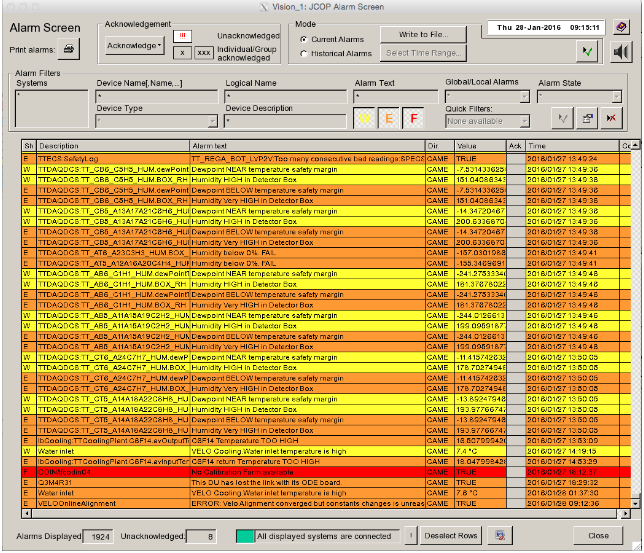




Alarms when something goes wrong

- In the procedure if the automatic alignment procedure does not converge or the variation is unphysically large an expert should investigate
- but the error was lost in log files not checked regularly so it was hard to spot
- Now a error message can appear on the alarm screen and an email sent to lhcb-onlinealignmentcalibration@cern.ch
- For details see the twiki

Error on alarm panel



Sh	Description	Alarm text	Dir.	Value	Ack	Time	Cc
E	TTECS:SafetyLog	TT_REGA_BOT_LVP2V:Too many consecutive bad readings:SPECS	CAME	TRUE		2016/01/27 13:49:24	
W	TTDAQDCS:TT_CB6_C5H5_HUM.dewPoint	Dewpoint NEAR temperature safety margin	CAME	-7.531433625		2016/01/27 13:49:36	
W	TTDAQDCS:TT_CB6_C5H5_HUM.BOX_RH	Humidity HIGH in Detector Box	CAME	151.04086343		2016/01/27 13:49:36	
E	TTDAQDCS:TT_CB6_C5H5_HUM.dewPoint	Dewpoint BELOW temperature safety margin	CAME	-7.531433625		2016/01/27 13:49:36	
E	TTDAQDCS:TT_CB6_C5H5_HUM.BOX_RH	Humidity Very HIGH in Detector Box	CAME	151.04086343		2016/01/27 13:49:36	
W	TTDAQDCS:TT_CB5_A13A17A21C6H6_HU	Dewpoint NEAR temperature safety margin	CAME	-14.34720467		2016/01/27 13:49:36	
W	TTDAQDCS:TT_CB5_A13A17A21C6H6_HU	Humidity HIGH in Detector Box	CAME	200.6336870		2016/01/27 13:49:36	
E	TTDAQDCS:TT_CB5_A13A17A21C6H6_HU	Dewpoint BELOW temperature safety margin	CAME	-14.34720467		2016/01/27 13:49:36	
E	TTDAQDCS:TT_CB5_A13A17A21C6H6_HU	Humidity Very HIGH in Detector Box	CAME	200.6336870		2016/01/27 13:49:36	
E	TTDAQDCS:TT_AT6_A23C3H3_HUM.BOX_	Humidity below 0%. FAIL	CAME	-157.0301986		2016/01/27 13:49:41	
E	TTDAQDCS:TT_AT5_A12A16A20C4H4_HU	Humidity below 0%. FAIL	CAME	-155.3469691		2016/01/27 13:49:41	
W	TTDAQDCS:TT_AB6_C1H1_HUM.dewPoint	Dewpoint NEAR temperature safety margin	CAME	-241.2753334		2016/01/27 13:49:46	
W	TTDAQDCS:TT_AB6_C1H1_HUM.BOX_RH	Humidity HIGH in Detector Box	CAME	181.37678022		2016/01/27 13:49:46	
E	TTDAQDCS:TT_AB6_C1H1_HUM.dewPoint	Dewpoint BELOW temperature safety margin	CAME	-241.2753334		2016/01/27 13:49:46	
E	TTDAQDCS:TT_AB6_C1H1_HUM.BOX_RH	Humidity Very HIGH in Detector Box	CAME	181.37678022		2016/01/27 13:49:46	
W	TTDAQDCS:TT_AB5_A11A15A19C2H2_HUM	Dewpoint NEAR temperature safety margin	CAME	-244.0126613		2016/01/27 13:49:46	
W	TTDAQDCS:TT_AB5_A11A15A19C2H2_HUM	Humidity HIGH in Detector Box	CAME	199.0959187		2016/01/27 13:49:46	
E	TTDAQDCS:TT_AB5_A11A15A19C2H2_HUM	Dewpoint BELOW temperature safety margin	CAME	-244.0126613		2016/01/27 13:49:46	
E	TTDAQDCS:TT_AB5_A11A15A19C2H2_HUM	Humidity Very HIGH in Detector Box	CAME	199.0959187		2016/01/27 13:49:46	
W	TTDAQDCS:TT_CT6_A24C7H7_HUM.dewP	Dewpoint NEAR temperature safety margin	CAME	-11.415742632		2016/01/27 13:50:05	
W	TTDAQDCS:TT_CT6_A24C7H7_HUM.BOX_	Humidity HIGH in Detector Box	CAME	178.7027494		2016/01/27 13:50:05	
E	TTDAQDCS:TT_CT6_A24C7H7_HUM.dewP	Dewpoint BELOW temperature safety margin	CAME	-11.415742632		2016/01/27 13:50:05	
E	TTDAQDCS:TT_CT6_A24C7H7_HUM.BOX_	Humidity Very HIGH in Detector Box	CAME	178.7027494		2016/01/27 13:50:05	
W	TTDAQDCS:TT_CT5_A14A18A22C8H8_HU	Dewpoint NEAR temperature safety margin	CAME	-13.89247946		2016/01/27 13:50:05	
W	TTDAQDCS:TT_CT5_A14A18A22C8H8_HU	Humidity HIGH in Detector Box	CAME	193.97766747		2016/01/27 13:50:05	
E	TTDAQDCS:TT_CT5_A14A18A22C8H8_HU	Dewpoint BELOW temperature safety margin	CAME	-13.89247946		2016/01/27 13:50:05	
E	TTDAQDCS:TT_CT5_A14A18A22C8H8_HU	Humidity Very HIGH in Detector Box	CAME	193.97766747		2016/01/27 13:50:05	
E	lbCooling:TTCoolingPlant.C6F14.avOutputT	C6F14 Temperature TOO HIGH	CAME	16.50799942		2016/01/27 13:53:09	
W	Water inlet	VELO Cooling.Water inlet temperature is high	CAME	7.4 °C		2016/01/27 14:19:15	
E	lbCooling:TTCoolingPlant.C6F14.avInputTer	C6F14 return Temperature TOO HIGH	CAME	18.04799842		2016/01/27 14:53:29	
F	ODIN/tfcodin04	No Calibration Farm available	CAME	TRUE		2016/01/27 18:12:37	
E	Q3M4R31	This DU has lost the link with its ODE board.	CAME	TRUE		2016/01/27 18:29:32	
E	Water inlet	VELO Cooling.Water inlet temperature is high	CAME	7.6 °C		2016/01/28 01:37:30	
E	VELOOnlineAlignment	ERROR: Velo Alignment converged but constants changes is unreas	CAME	TRUE		2016/01/28 09:12:36	

BACKUP

Accuracy and precision of alignment procedure from Run I

Accuracy from MC: evaluated with 50 different misalignments over the same data sample

Precision from MC: evaluated with 8 different samples (misaligned and not misaligned scenario compatibles)

Precision from Data: evaluated from 8 different samples from the same fill

Variation 3 fills 2012: evaluated difference of 3 fills (2520, 2855, 3316) taken on April, July and November 2012

Accuracy and precision of alignment procedure

2 halves				
dof	Accuracy from MC	Precision from MC	Precision from Data	Variation 3 fills 2012
T_x T_y [μm]	<1	<1	2	up to 6
T_z [μm]	3	4	1	0.5
R_x, R_y [μrad]	3	2	3	4
R_z [μrad]	10	15	40	up to 25
Modules				
T_x T_y [μm]	<1	<1	2	2
R_z [μrad]	30	50	100	60

Updates with old tresholds

[(('VeloLeft.Rz',), 9), (('VeloLeft.Tx',), 7), (('VeloLeft.Ry', 'VeloLeft.Rz', 'VeloLeft.Tx'), 3), (('VeloLeft.Ry', 'VeloLeft.Tx', 'VeloLeft.Ty', 'VeloLeft.Tz'), 2), (('VeloLeft.Ry',), 2), (('VeloLeft.Tx', 'VeloLeft.Ty'), 2), (('VeloLeft.Tz',), 2), (('VeloLeft.Rz', 'VeloLeft.Tx'), 2), (('VeloLeft.Rx', 'VeloLeft.Ry', 'VeloLeft.Tz'), 1), (('VeloLeft.Rz', 'VeloLeft.Ty', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Rz', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Rz', 'VeloLeft.Tx', 'VeloLeft.Ty'), 1), (('VeloLeft.Rz', 'VeloLeft.Ty'), 1), (('VeloLeft.Ry', 'VeloLeft.Ty', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Rz', 'VeloLeft.Tx', 'VeloLeft.Ty', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Tx'), 1), (('VeloLeft.Ry', 'VeloLeft.Ty'), 1)]

Updates with new tresholds

[(('VeloLeft.Tx',), 13), (('VeloLeft.Ty',), 4), (('VeloLeft.Tx', 'VeloLeft.Ty'), 3), (('VeloLeft.Ry', 'VeloLeft.Tx', 'VeloLeft.Ty'), 3), (('VeloLeft.Ry', 'VeloLeft.Tx', 'VeloLeft.Ty', 'VeloLeft.Tz'), 2), (('VeloLeft.Rz',), 2), (('VeloLeft.Tx', 'VeloLeft.Tz'), 2), (('VeloLeft.Rz', 'VeloLeft.Ty'), 2), (('VeloLeft.Ry', 'VeloLeft.Ty'), 2), (('VeloLeft.Rz', 'VeloLeft.Tx', 'VeloLeft.Ty'), 1), (('VeloLeft.Ty', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Ty', 'VeloLeft.Tz'), 1), (('VeloLeft.Ry', 'VeloLeft.Rz'), 1)]