$B \longrightarrow hh$ misalignment studies

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CP WG Meeting,
CERN, 19 December 2007

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Outline

- Motivation and Overview
- VELO Misalignments
- IT/OT Misalignments
- Plans and Conclusions

Motivation

- Study effects of a misaligned tracking system on measurements with $B \longrightarrow hh$.
- Chapter 1 (presented here)
  - Systematically study effect of misalignments purely based on their size.
  - Does not involve any assumptions on quality of metrology or alignment software.
  - Gives a good overview and shows critical alignment DOFs.
- Chapter 2 (future studies)
  - Study remaining misalignment effects after application of alignment algorithms.
  - Use alignment challenge data.
  - Detect potential bias coming from alignment software.

Chapter 1

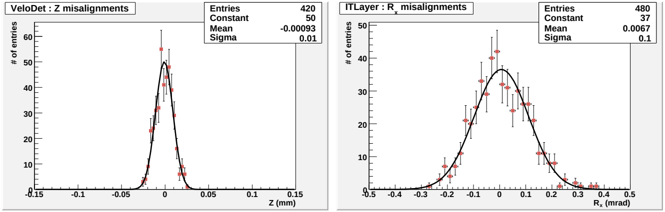
- Create random misalignments for VELO sensors/modules and IT/OT layers.
- Choose scale (Gaussian sigma) to be ≈ 0.3 of the detector's single hit resolution. (called 1σ)
- Generate 10 sets of '1σ' misalignments and apply each to $2k$ $B_d \longrightarrow \pi\pi$ events[1].
  $\Rightarrow$ This gives a $20k$ sample suppressing potentially 'friendly' or 'catastrophic' misalignment sets.
- Create other sets with misalignment scales increased by factors 3 (3σ) and 5 (5σ).

[1] Misalignment are applied at reconstruction level (Brunel v31r11) to events generated with perfect geometry.

Misalignment scales

- Scales shown here are for the 1σ set (in $\mu\mathrm{m}$ and mrad).

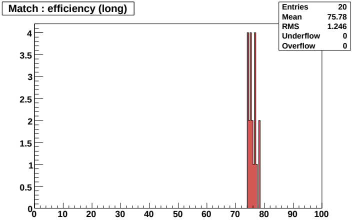
	translations			rotations		
	Δ_x	Δ_y	Δ_z	Δ_α	Δ_β	Δ_γ
VELO sensor	3	3	10	1.00	1.00	0.20
VELO module	3	3	10	1.00	1.00	0.20
IT layer	15	15	50	0.10	0.10	0.10
OT layer	50	0	100	0.05	0.05	0.05



VELO results

- Event numbers and pattern recognition efficiencies after standard $B \to hh$ selection.

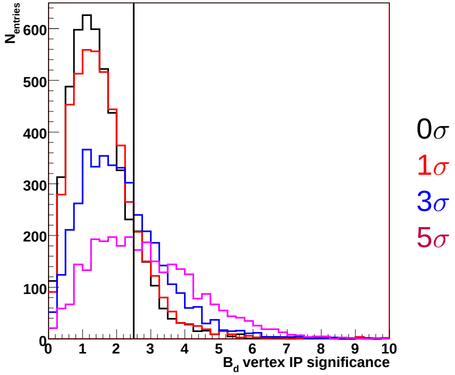
	N_{sel}	$\epsilon_{forward}$	ϵ_{match}
0σ	4185	0.86	0.81
1σ	3978	0.86	0.80
3σ	2617	0.84	0.78
5σ	1355	0.81	0.76



ϵ_{match} for 5σ sample

- Effect on PR is small
  $\Rightarrow$ loss of events has to come from selection

Effect on selection

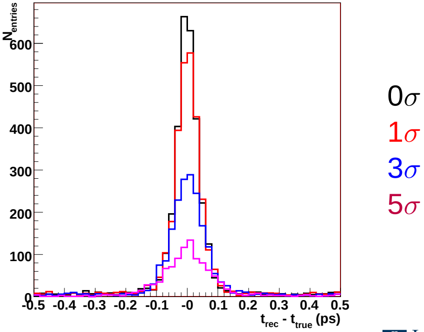


- Biggest effect comes from tight upper cut on B impact parameter significance ($IPS(B_d) < 2.5$).
- Additional effect on lower IPS cut of daughters.

Effect on proper time resolution

- Proper time resolution after standard $B \to hh$ selection.

	proper time resolution (in fs)
0σ	38.1
1σ	40.3
3σ	54.3
5σ	73.6



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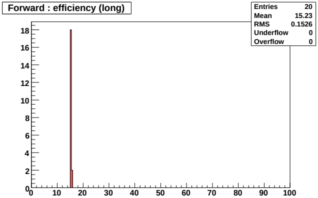
IT/OT results

- Event numbers and pattern recognition efficiencies after standard $B \to hh$ selection.

	N_{sel}	$\epsilon_{forward}$	ϵ_{match}
0σ	4185	0.86	0.81
1σ	3510	0.15	0.81
3σ	3344	0.15	0.80
5σ	2975	0.15	0.77



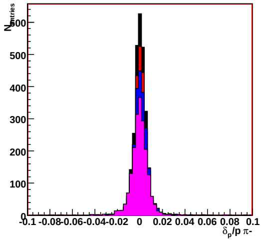
$\epsilon_{forward}$ for 5σ sample

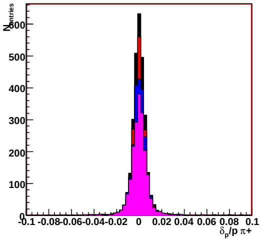
- Forward pattern recognition seems to collapse under the weight of the misalignments.
  Forward is the only PR used in the trigger!
- Effect on trigger will also be followed by Eduardo's studies on $B \to hh$ & HLT.

Effect on momentum resolution

- Momentum resolution after standard $B \to hh$ selection.

	momentum resolution (in %)
0σ	0.50
1σ	0.51
3σ	0.54
5σ	0.61



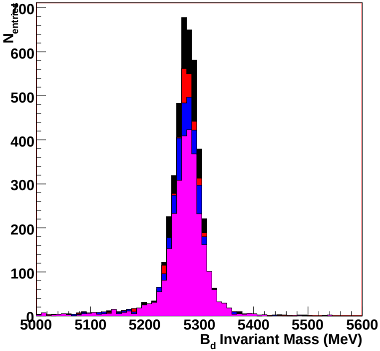


0σ
1σ
3σ
5σ

Effect on mass resolution

- Mass resolution after standard $B \to hh$ selection.

	mass resolution (in MeV)
0σ	23.2
1σ	23.3
3σ	24.5
5σ	26.8



0σ
1σ
3σ
5σ

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Plans

- Look at combined VELO and T station misalignments
  (First look didn't show any surprises)
- Look at more variables
  Towards `B2hhFit`: What input variables have to be changed? (σ_m, B/S, σ_τ, ...)
- *Chapter 2*: Study the 're-aligned' case in the alignment challenge
- Study other effects like z-scaling
- Any wishes for particular variables to be checked?

Conclusions

- VELO misalignments strongly affect $B \longrightarrow hh$ selection and proper time resolution.
- T station misalignments critically affect forward PR.
  $\Rightarrow$ very bad for trigger! To be followed up...
- If software alignment is better than our '1σ' case things look fine.
- Looking forward to chapter 2!

VELO results

- Pattern recognition efficiencies in $B \to hh$ study and LHCb alignment challenge.

	ϵ_{Velo3D}	ϵ_{TSA}	ϵ_{match}	$\epsilon_{forward}$
B2hh 0σ	0.97	0.92	0.81	0.86
B2hh $T5\sigma$	0.97	0.90	0.77	0.15
MisAlCh1	0.67	0.80	0.48	0.41
MisAlCh2	0.33	0.53	0.12	0.07

	$\epsilon_{match} / (\epsilon_{Velo3D} \times \epsilon_{TSA})$	$\epsilon_{forward} / \epsilon_{Velo3D}$
B2hh 0σ	0.91	0.89
B2hh $T5\sigma$	0.88	0.15
MisAlCh1	0.89	0.61
MisAlCh2	0.71	0.21