B→DX Stripping

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Outline

→*Long introduction*
(repeating several slides from previous talk)

Talk in two parts

→ *Pre-scaling the mass windows*
→ *HLT1 & Stripping*

Requirements

→ *Trigger delivers 2kHz*

→ *Stripping has to deliver 200Hz*

→ *Stripping selection has to stay within 5Hz, for any signal channel we are looking at*

→ *It should be ~100% efficient for offline selected events*

→ *For both signal and control channels*

Channels under study …and software details

→ B^0 → $D^0 K^{*0}$

→ B_s → $D^0 \varphi$

→ $B^\pm$ → $D^0 K^\pm (\pi^\pm)$

→ B_s → $D_s^\pm K^\mp (\pi^\mp)$

→ B^0 → $D^\pm \pi^\mp$

D^0 → 2 charged tracks

$D^{+/-}$ → 3 charged tracks

Boring software details

→ DaVinci V22r0p2 with L0 patch from Patrick K.

→ 25k signal events for every channel

→ 1M L0-yes mbias events

$B \rightarrow D^0 X$ Selection

$B^{\pm} \rightarrow D^0 K^{\pm}$; $B^{\pm} \rightarrow D^0 \pi^{\pm}$; $B^0 \rightarrow D^0 K^{*0}$; $B_s \rightarrow D^0 \varphi$

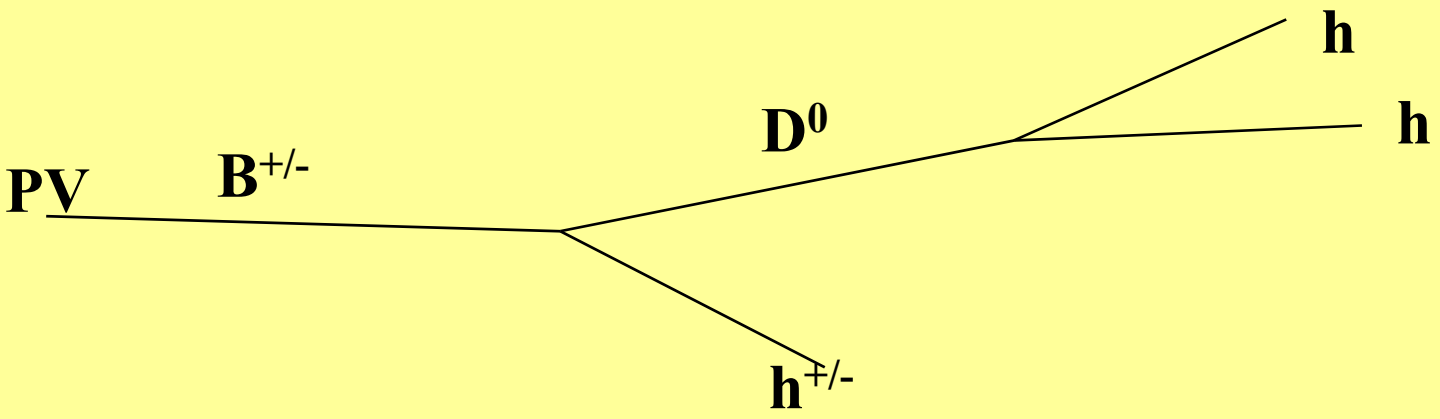
1) $B \rightarrow D^0 X$. We'll have

a common D^0 selection;

a common set of cuts for the B^0;

two separate set of cuts → for the bachelor

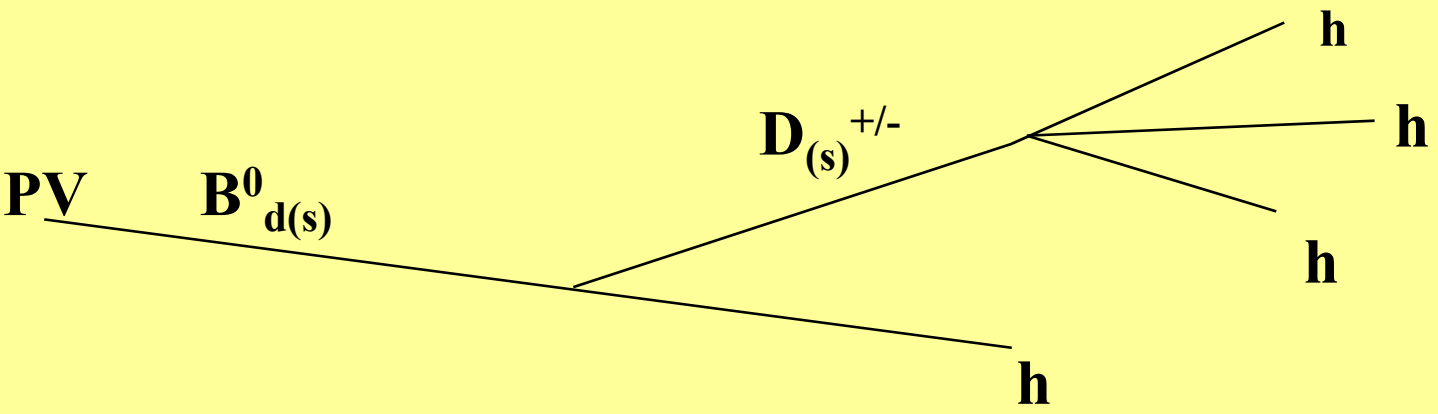
→ for the K^{*0}/φ → hh



$B^0 \rightarrow D^{+/-} h^{-/+}$ selection

2) $B_{(s)}^0 \rightarrow D_{(s)}^{\pm} h^{\mp}$ meant to catch the following channels

$B_{(s)} \rightarrow D_{(s)}^{\pm} h^{\mp}$; $B^0 \rightarrow D^{\pm} \pi^{\mp}$



Strategy

→ *Keep wide mass windows and pre-scale them*
→ *No PID cuts*
→ *Write a selection which resembles the offline, but with looser cuts*
→ *Try to avoid to create inefficiencies with respect to the offline selections*
→ *Show results with & without HLT1*

Pre-scaling details

B→D(3h)h

→Keep without pre-scaling ± 30 MeV both around the D mass and around the D_s mass. And ± 50 MeV both around the B and B_s mass

→Pre-scale the rest with factor 5% (at this stage arbitrary)

B→D(hh)X

→Keep without pre-scaling ± 30 MeV around the D mass; keep ± 50 MeV around the B mass and -150/+200 MeV around the K*0 (to include also the φ)

→ Pre-scale the rest with factor 5% (at this stage arbitrary)

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$B \rightarrow D^0X$ stripping selection

LHCb

Selection cut	Stripping
D daughters	IPS > 2 ; Pt > 0.3
K* daughters	IPS > 2 ; Pt > 0.3
Bachelor IPS wrt PV	> 2 σ
Bachelor P/ Pt (Gev)	Pt > 0.3
Daughters track χ2	< 100
D mass	± 150 MeV
B mass	± 500 MeV
K* mass	± 250 MeV
Flight distance B/D	> -3 mm
Cos(θ)	> 0.9995
Flight Significance B	> 8 σ
IPS B → PV	< 6 σ
χ2 K* / D / B vertex	< 12 / 12 / 12

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Offline comparison: $B \rightarrow D^0X$ stripping selection

LHCb

Selection cut	Offline (D^0K^{*0})	Offline (D^0K^+)	Stripping
D daughters	StandardD0	StandardD0	IPS > 2 ; Pt > 0.3
K* daughters	StandardTightK*	NN	IPS > 2 ; Pt > 0.3
Bachelor IPS wrt PV	NN	> 3.5 σ	> 2 σ
Bachelor P/ Pt (Gev)	NN	2< P < 100; Pt > 0.4	Pt > 0.3
PID Kaons $dll_{K\pi}$	> 2	> -1	Not applied
Daughters track χ2	Not applied	Not applied	< 100
D mass	± 25 MeV	± 21 MeV	± 150 MeV
B mass	± 50 MeV	± 50 MeV	± 500 MeV
K* mass	± 150 MeV	NN	± 250 MeV
Flight distance B/D	> -1 mm	> -1 mm & < 7mm	> -3 mm
Cos(θ)	> 0.9998	> 0.9999	> 0.9995
Flight Significance B	> 10 σ	> 16 σ	> 8 σ
IPS B → PV	< 3.5 σ	< 3.0 σ	< 6 σ
χ2 K* / D / B vertex	< 9 / 6 / 9	< NN // 4 / 4	< 12 / 12 / 12
Vertex isolation cut	< 12 tracks with 2 σ	Not applied	Not applied

What comes out ?

→ *In the $D^0K^{*0}(\varphi)$ selection* ***efficiency drops to 98 %***

→ ***mbias 35 Hz without HLT1***

→ ***mbias 4 Hz with HLT1***

→ *This are arbitrary numbers and to some extent meaningless, since I have not optimized any cut and I have just picked a number for the pre-scaling factor. My only point is that I have implemented the pre-scaling within the already existing framework*

$B_{(s)}^{0} \rightarrow D_{(s)}^{\pm} h^{\mp}$ Stripping selection

Selection cut	Stripping
D daughters	Pt > 0.25 ; P > 2 ; IPS >2 σ
Bachelor P & Pt (Gev)	P > 2 ; Pt > 0.4
Bachelor IPS wrt PV	> 2.0 σ
Daughters track χ2	< 100
D mass	- 100 / + 150 MeV
B mass	± 500 MeV
D IPS wrt PV	> 2 σ
D FS wrt PV	> 9 σ
χ2 D vertex	< 15
IPS B → PV	< 6.0 σ
χ2 B vertex	< 15
Cos(θ)	> 0.9995

Offline comparison: $B_{(s)}^{0} \rightarrow D_{(s)}^{\pm} h^{\mp}$

Selection cut	Offline ($D_s K$)	Offline ($D\pi$)	Stripping
D daughters	Pt > 0.3 ; P > 2 ; IPS >3 σ	Pt > 0.3 ; P > 2 ; IPS >3 σ	Pt > 0.25 ; P > 2 ; IPS >2 σ
Bachelor P & Pt (Gev)	2< P <100 ; Pt > 0.5	P > 2 ; Pt > 0.5	P > 2 ; Pt > 0.4
Bachelor IPS wrt PV	> 3.0 σ	> 3.0 σ	> 2.0 σ
Daughters track χ2	Not applied	Not applied	< 100
D mass	± 21 MeV	± 21 MeV	- 100 / + 150 MeV
B mass	± 50 MeV	± 50 MeV	± 500 MeV
D IPS wrt PV	> 3 σ	> 3 σ	> 2 σ
χ2 D vertex	< 15	< 15	< 15
IPS B → PV	< 4.0 σ	< 4.0 σ	< 6.0 σ
χ2 B vertex	< 10	< 10	< 15
Cos(θ)	> 0.9999	> 0.9999	> 0.9995
D FS wrt PV	> 10 σ	> 10 σ	> 9 σ
Flight Significance B	> 8σ	> 2.5 σ	Not applied

What comes out ?

→ *Efficiency drops to 98 %*
→ *mbias 25 Hz without HLT1*
→ *mbias 2 Hz with HLT1*
→ *This are arbitrary numbers and to some extent meaningless, since I have not optimized any cut and I have just picked a number for the pre-scaling factor. My only point is that I have implemented the pre-scaling within the already existing framework*

Second part:
HLT1 & Stripping, what's going on ?

Introduction

→ *What is the problem ? As summarized by Marta:*

	After L0	L0+HLT1
B→D(3h)h	223 Hz	12 Hz
B→D(2h)h	111 Hz	13 Hz

→*For simplicity I will next studies on the B→D(3h)h selection*

Trying to identify the problem

What can be done to try to identify the problem

1. ***Will try to look at a few variables with/without HLT1 and see if anything can be spotted***
   In other words is there a specific HLT1 cut, not applied in the stripping –or offline- which kills the mbias rate ?

2. ***Will try to re-produce some HLT1 cuts in the stripping and see if they can help to explain this ~factor 10***

All that follows is meant as material for discussion and new ideas are welcome.

Intermezzo

Cut in HLT1 hadron lines

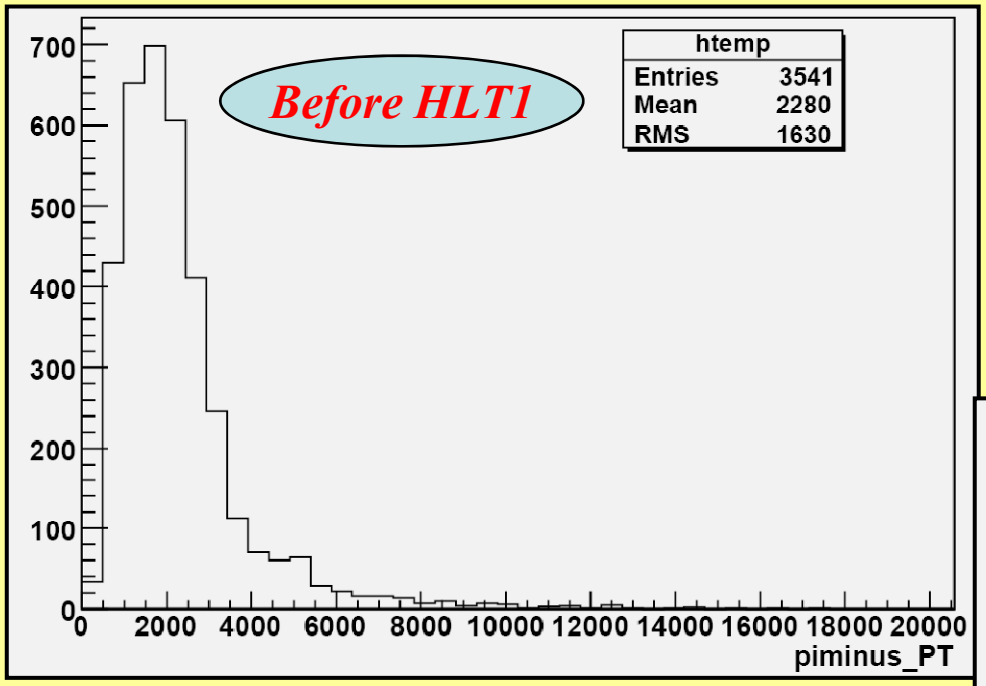
1. Et Cut	> 3500
2. Min Et Cut	> 2500
3. SingleHadPtCut	> 5000
4. HadMainIPCut	> 0.1
5. HadMainPtCut	> 2500
6. HadMainTrackFitChi_2Cut	< 10
7. HadVERTEXDocaCut	< 0.2
8. HadVERTEXDzCut	> 0
9. HadVERTEX_MinIPCut	> 0.1
10. HadVERTEX_MinPtCut	> 1000
11.HadVertexPointingCut	< 0.4

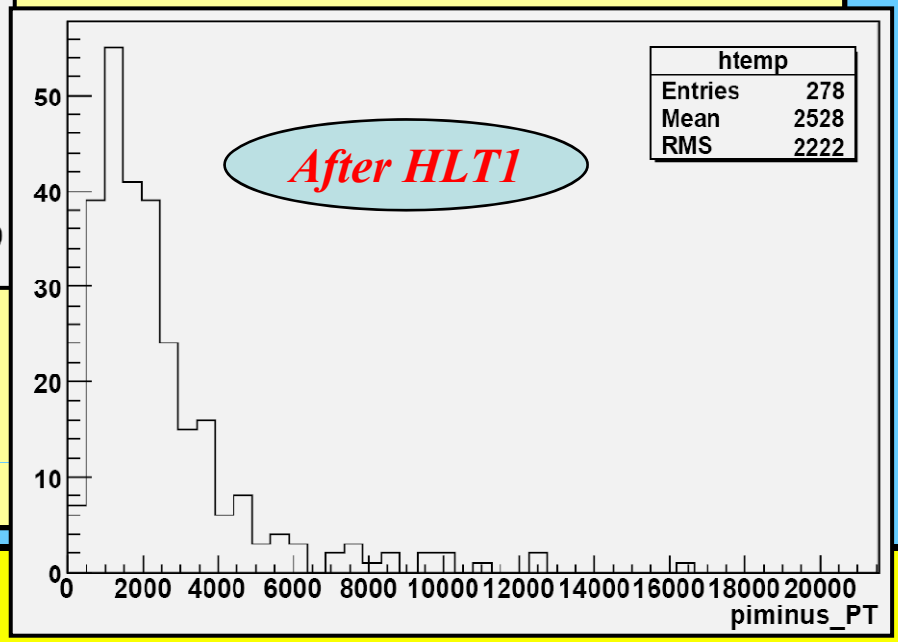
As taken from HltConf/python/HltConf/HltHadronLines.py

Before/After HLT1

Here looking at mbias passing a loose B→D(3h)h stripping selection

These are events stripped with the B→D(3h)h selection.
Looking now at the bachelor Pt distribution

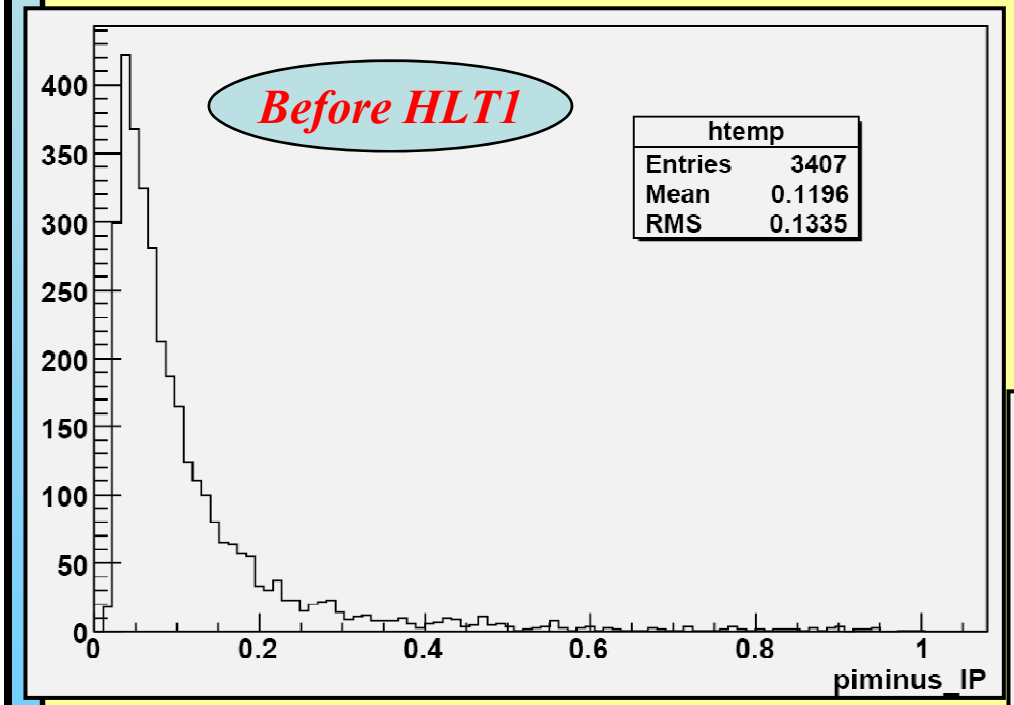


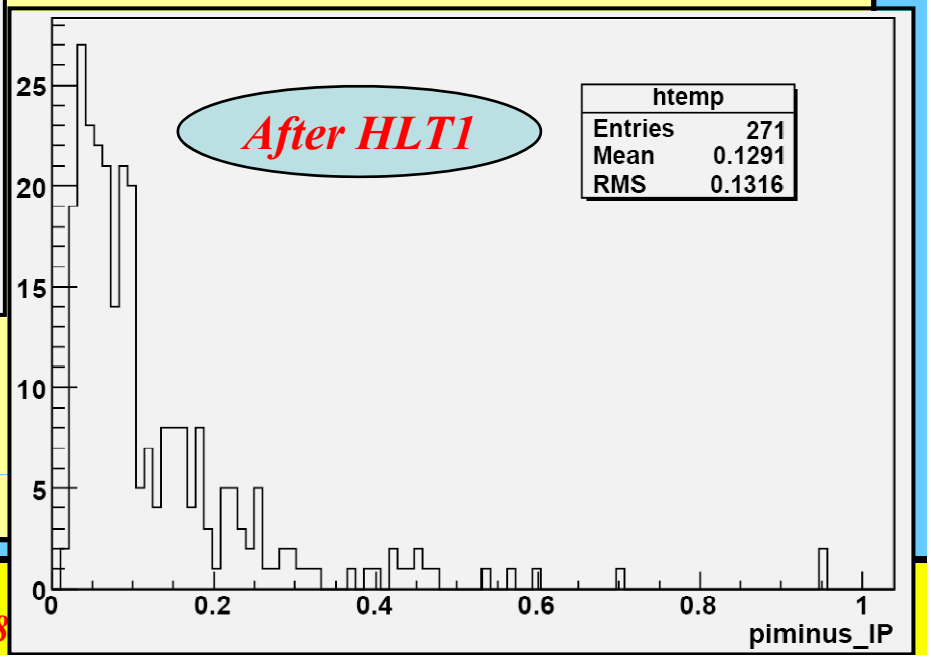


Before/After HLT1

Here looking at mbias passing a loose B→D(3h)h stripping selection

These are events stripped with the B→D(3h)h selection.
Looking now at the bachelor IP distribution

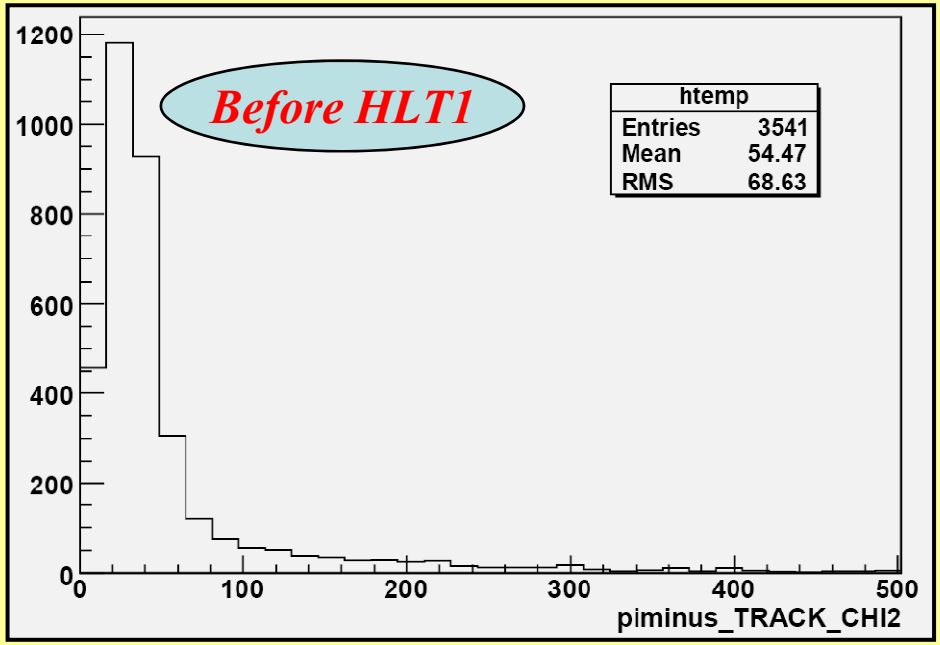


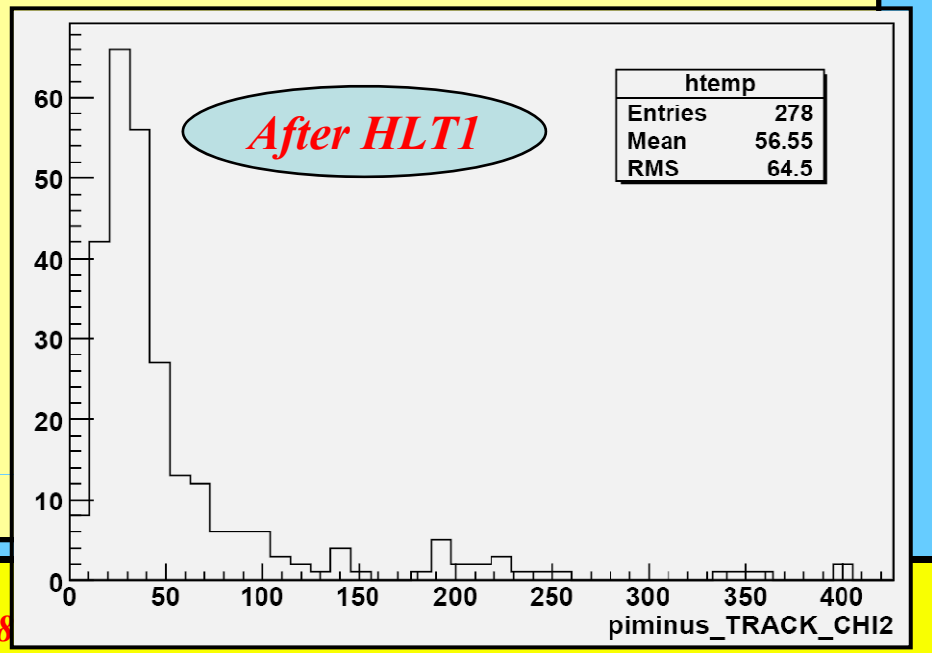


Before/After HLT1

Here looking at mbias passing a loose B→D(3h)h stripping selection

These are events stripped with the B→D(3h)h selection.
Looking now at the bachelor track χ2 distribution





Distributions before/after HLT1

→ *No major differences are observed, an effect is seen in the Pt distribution*

→ *Was this expected ? To some extent yes. For various reasons:*

1. *Environment is completely different On/Offline.*
   The cuts in the HLT1 do not directly produce an effect on variables reconstructed offline.

2. *We are not looking at the same particles/tracks.*
   We do not know what triggered HLT1

3. *It is likely that this ~factor 10 is a combination of various effects.*

Now try something different: try to put some HLT1 cuts in the stripping.

HLT1 cuts in the stripping

How ?

→ *Keep few very loose stripping cuts*

→ *Add one by one some stripping cuts and see if this factor ~ 10 goes away or not*

→ *By creating a stripping selection more directly correlated with the HLT1 cuts*

HLT1 cuts in the stripping

The reduction factor

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5

HLT1 cuts in the stripping

The reduction factor

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5

Now re-starting from scratch and removing almost all cuts

Removing almost all the cuts and the pre-scaling	19.1 (Bigger cause I removed all the cuts)

HLT1 cuts in the stripping

The reduction factor: Pt

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5

Now re-starting from scratch and removing almost all cuts

Removing almost all the cuts and the pre-scaling	19.1 (Bigger cause I removed all the cuts)
+ 2.5 Gev Pt cut on one of daughters	8.8
+ 5.0 Gev Pt cut on one of daughters	5.4

HLT1 cuts in the stripping

The reduction factor : pointing cut

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5

Now re-starting from scratch and removing almost all cuts

Removing almost all the cuts and the pre-scaling	19.1 (Bigger cause I removed all the cuts)
No Pt cuts + pointing cut @ < 0.4	17.4
Pt on one daughter > 2.5GeV + pointing cut @ < 0.4	8.7

HLT1 cuts in the stripping

The reduction factor : track χ2

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5

Now re-starting from scratch and removing almost all cuts

Removing almost all the cuts and the pre-scaling	19.1 (Bigger cause I removed all the cuts)
No Pt cuts + No pointing cut + track χ2 cut at < 10	18.1

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HLT1 cuts in the stripping

The reduction factor : all together

Configuration	Reduction from HLT1 (factor X)
Previous loose configuration	12.6
After the cuts	12.5
Removing almost all the cuts and the pre-scaling	19.1 (Bigger cause I removed all the cuts)
+ 2.5 Gev Pt cut on one of daughters	8.8
+ 5.0 Gev Pt cut on one of daughters	5.4
No Pt cuts + pointing cut @ < 0.4	17.4
Pt on one daughter > 2.5GeV + pointing cut @ < 0.4	8.7
No Pt cuts + No pointing cut + track $\chi 2$ cut at < 10	18.1

Summary

→ *Pre-scaling is now implemented within the framework*

→ *An investigation on the HLT1/Stripping problem has started*

→ *Looking at the some distributions with/without the HLT1 a small increase in the mean of the Pt distribution is seen*

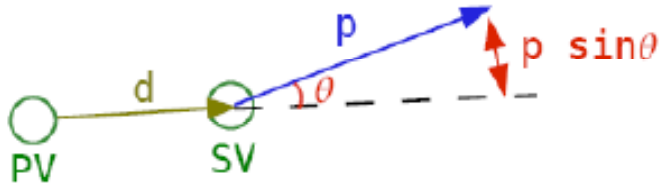
→ *Have tried to re-produce the HLT1 cuts into the stripping 1 by 1, in order to have a stripping selection more directly correlated with the HLT1*

→ *So far have tried with pointing cut → no particular effect seen*
with track χ2 cut → no particular effect seen
with Pt cut → a drop can be seen indicating the correlation of this cut with what done in HLT1

Spares

POINTING CUT DEFINITION

POINTING



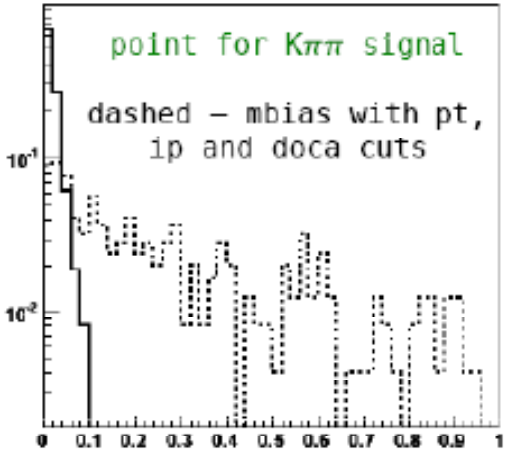
p = vector sum of daughters 3-momenta

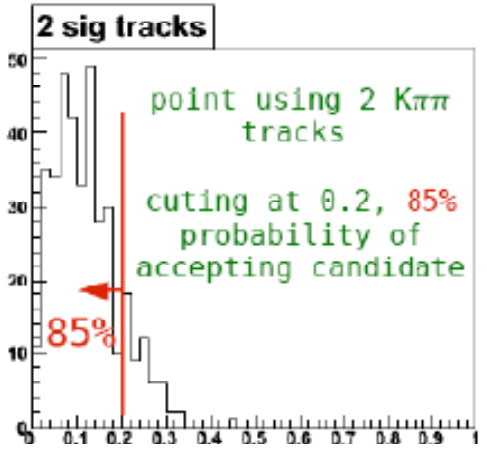
ptdaus = pt sum of B daughters

$$\text{POINT} = \left(1 + \frac{\text{PTDAUS}}{p \sin\theta}\right)^{-1}$$

- distribution range 0 – 1
  signal < 0.1
- used in HLT1 hadron alley
- cutting at 0.2 is a good strategy to select events which loose 1 track

  n-1 recovers 85% of candidates which loose one track





Thanks Gabriel!

DiHadron line: mb rate, candidates and L0xHLT1 TOS efficiencies

	mb rate (kHz)	mb candidates	Bs2PiK	Bs2PhiPhi	Bs2DsPi	Bd2D0Kstar
L0ΣT>3500.0	582.13	1.27	37.90	18.80	29.10	31.90
Calo2DChi2<4	555.09	4.81	38.00	18.30	28.60	32.10
Velo	552.70	4.89	37.90	18.30	28.60	32.10
IP>0.1	407.05	2.74	36.30	16.40	28.00	30.60
Calo3DChi2<4	290.84	2.17	36.00	15.80	27.10	28.60
VeloCalo	290.84	2.30	35.90	15.70	26.90	28.40
GuidedForward	66.47	1.35	35.70	14.80	26.00	26.60
PT>2500.0	27.04	1.36	34.80	13.30	24.50	24.90
Velo1	27.04	58.38	43.70	21.60	34.80	34.00
IP>0.11	27.04	33.49	35.50	14.40	25.60	26.00
MatchIDsFraction<0.9	27.04	32.25	31.00	13.90	25.40	25.80
DOCA<0.2	26.29	15.85	34.50	13.20	24.30	24.90
VertexDz>0.0	25.84	9.08	34.30	13.10	23.90	24.70
Forward	23.75	5.46	33.30	13.10	23.80	24.70
VertexMinPT>1000.0	7.77	1.96	33.30	12.70	23.00	23.60
VertexPointing<0.4	4.48	1.87	33.30	12.60	23.00	23.60
FitTrack	4.48	1.87	33.30	12.60	23.00	23.60
FitVertexMinIP>0.1	4.18	1.82	33.10	12.10	22.70	23.40
FitVertexMaxChi2OverNdf<10.0	1.79	1.75	32.30	11.90	22.50	23.20

DaVinci v22r0p2 (+patch from Diego)

100k minbias events, 1k signal

Example of reducing the rate:
Rate without (with) HLT1

Selection cut	MBias rate without (with) HLT1 [Hz]	% of ghosts
Previous configuration	1216 (109)	(53 ± 5) %
Pt cut on daughters and bachelor > 300 MeV	547 (52)	(47 ± 8) %
With BFS cut at > 8	131 (12)	(63 ± 15) %
Adding B/D/K* $\chi 2$ cut at < 12	111 (10)	(60 ± 16) %
With cut on B IPS < 6	95 (7)	(53 ± 19) %
Daughter track $\chi 2$ < 100	35 (4)	(43 ± 28) %

→ Pre-scaling allows us to reduce the rate and have almost 'acceptable' values of rate without the HLT1.

→ Factor 10 given by HLT1 always there

All these cuts are looser or the same as in the offline apart from the track $\chi 2$ → In the $D^0K^{*0}(\varphi)$ selection efficiency drops to 98 %

Example of reducing the rate:
Rate without (with) HLT1

Selection cut		MBias rate without (with) HLT1 [Hz]	% of ghosts
Previous configuration		795 (63)	(60 ± 6) %
With DFS cut at	> 9 σ	133 (10)	(55 ± 16) %
Adding B/D/ χ2 cut at	< 15	81 (7)	(55 ± 25) %
Daughter track χ2	< 100	25 (2)	(45 ± 30) %

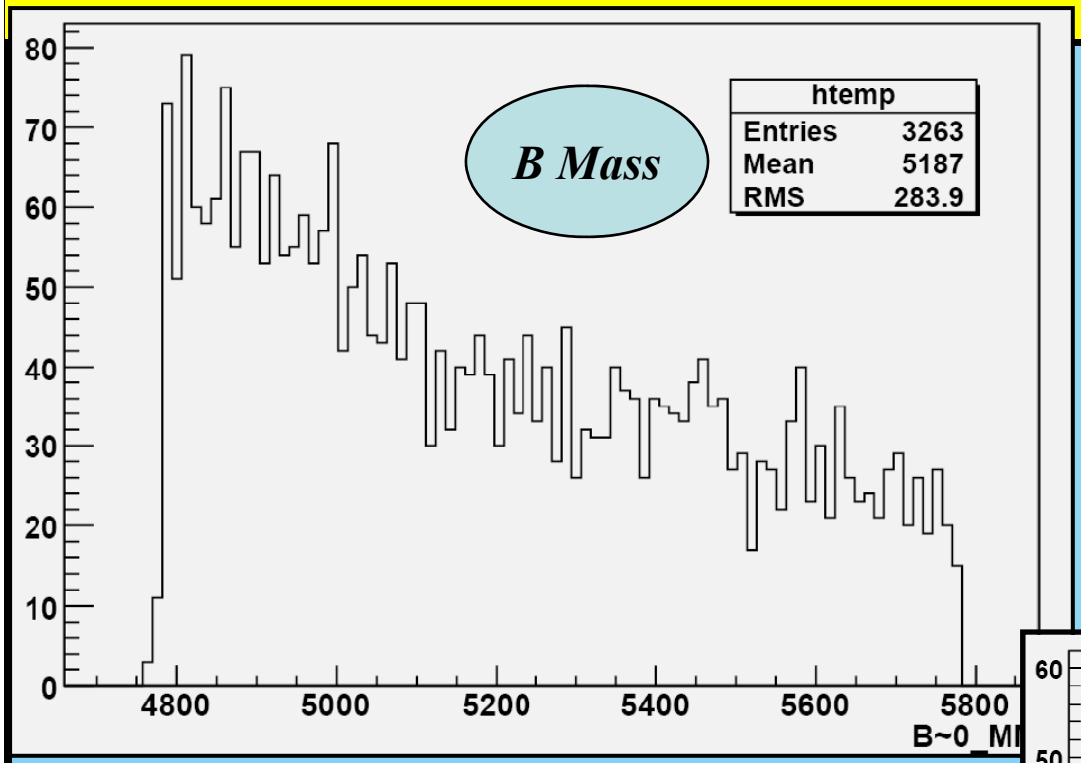
→ Pre-scaling allows us to reduce the rate and have almost 'acceptable' values of rate without the HLT1.

→ Factor 10 given by HLT1 always there

All these cuts are looser or the same as in the offline apart from the track χ2 → Efficiency for offline selected events drops to 98 %

These 90% of events

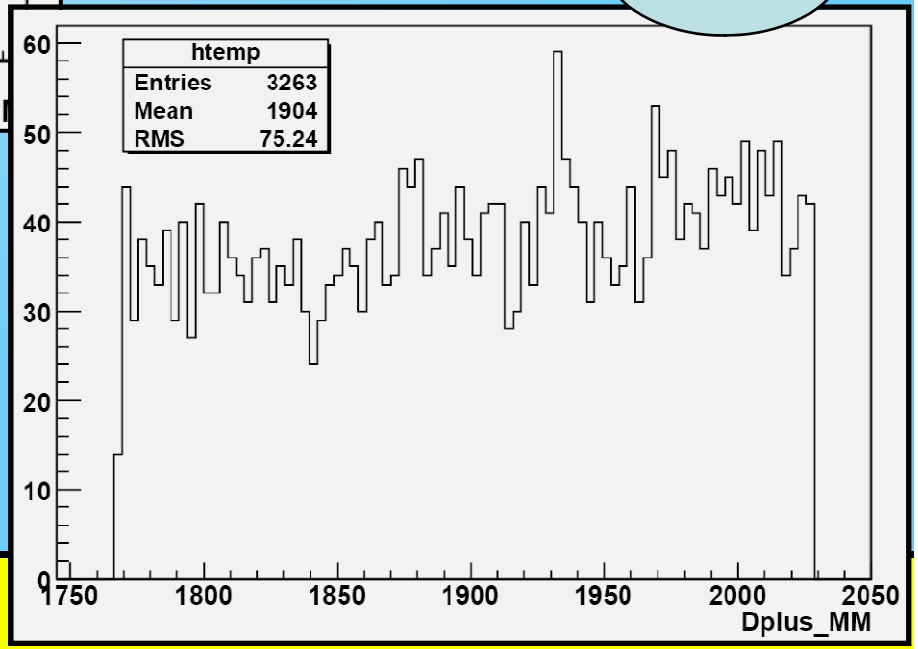
Here looking at mbias passing a loose B→D(3h)h stripping selection



→ These are the events which do not pass the HLT1

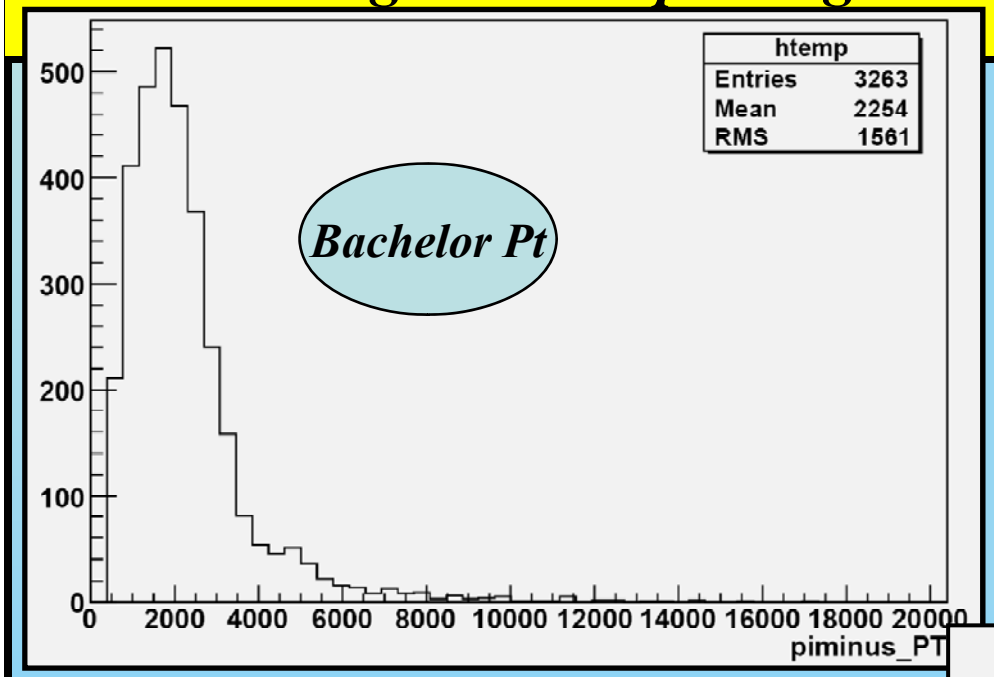
→ Can something easy be spotted about them ?

D+ Mass



These 90% of events

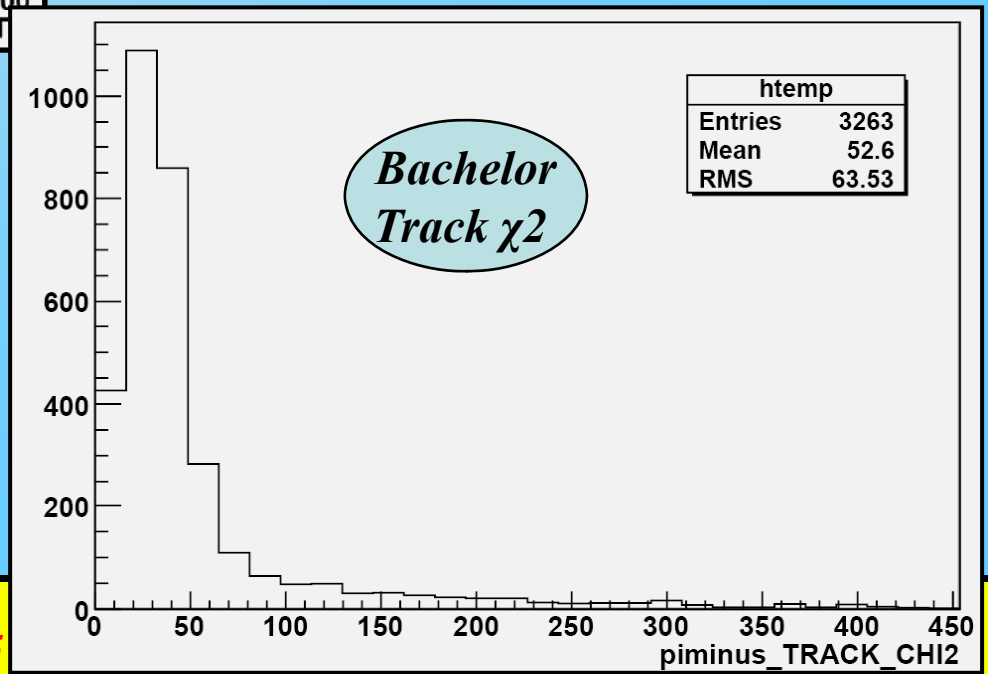
Here looking at mbias passing a loose B→D(3h)h stripping selection



→ There are the events which do not pass the HLT1

→ Can something easy be spotted about them ?

I looked at more distributions and I am afraid the answer is NO



What line triggered hlt1

→ 278 Events total

Numbers do not quite add up

→ 75 diHadron

→ 65 SingleHadron (25 of these are shared with diHadron)

→ 40 photonDecision

→ 10 XpressDecision

→ 12 ElectronTrackDecision

→ ~50 from various muon related decision