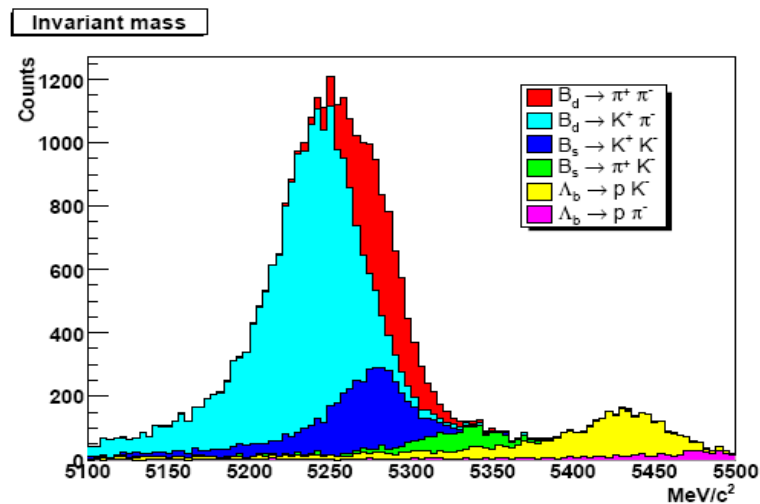# B → hh studies: physics case(s) and requirements

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- *The B → hh family*

- *Physics case(s) & requirements*

- *HLT2 selection or selections?*

- *Mass window cuts*

The B → hh family

"Standard" modes:

- ❑ $B^0 \to \pi\pi$, $B_s \to KK$

- ❑ $B^0 \to K\pi$, $B_s \to \pi K$

> A total of
> 10 B decays !

Rare modes:

- ❑ $B^0 \to KK$, $B_s \to \pi\pi$,   **not yet found experimentally**

Related modes:

- ❑ $\Lambda_b \to pK, p\pi$,   **recently discovery by CDF**

Baryonic "cousins":

- ❑ B^0 , $B_s \to$ p pbar   ,   **not yet found experimentally**

- ❑   **(could also look for final states with a Λ)**

Physics case(s) – rather rich!

□ $B^0 \to \pi\pi$: time-dependent asymmetry

- so far inconsistency in direct CP contribution ($C_{\pi\pi}$) between BaBar and Belle

□ $B^0 \to K^+\pi^-$: direct CP violation measurement

□ $B_s \to \pi^+K^-$: direct CP violation, branching ratio measurement

□ $B_s \to KK$: time-dependent asymmetry, branching ratio measurement, lifetime measurement

□ Gronau, Lipkin and Rosner relation

$$\left| A\left(B_s \to \pi^+K^-\right)\right|^2 - \left| A\left(\overline{B}_s \to \pi^-K^+\right)\right|^2 = \left| A\left(\overline{B}^0 \to \pi^+K^-\right)\right|^2 - \left| A\left(B^0 \to \pi^-K^+\right)\right|^2$$

□ $B^0 \to K^+\pi^-$, $B^+ \to K^+\pi^0$: $\neq$ in CP asymmetry hard to understand theoretically

□ $B^0 \to \pi\pi$, $B_s \to KK$: determination of the CP angle γ exploiting U-spin symmetry

□ Rare $B \to h^+h'^-$: h = π, K … but also a baryon such as p, Λ

□ $\Lambda_b \to pK$, $p\pi$: lifetime ratio measurements (wrt B^0)

□ Etc. List non exhaustive

Requirements to carry out our physics goals

❑ **We want a selection as efficient as possible**
   ⇒ cuts as loose (and clever!) as possible

❑ **We want an inclusive selection, to pick up our cocktail of modes**
   ⇒ in particular: mass window cut as broad as possible

❑ **We want the best out of the detector**
   ⇒ the largest possible allocated bandwidth

❑ **All in all: a complex and serious optimisation problem …**

❑ **… not to mention the "competition" with the rest of the LHCb benchmark B-decays, and trigger constraints**

HLT2 selection or selections?

At present

❖ **Every B-decay channel is typically related to an HLT2 selection**
  - exclusive, inclusive, common to a group of B-decays

❖ **Plan A in a nutshell: we optimize for a B $\rightarrow$ hh HLT rate of R Hz, R ~ 10, and estimate an efficiency ε**

Thinking about the future …

❖ **All our estimates have been based on MC studies**
  $\Rightarrow$ we are likely to get it wrong :S

❖ **If the real-experiment rate turns out to be ~R, we are in business.**
  But if the actual rate is > R, we will be simply downscaled!
  $\Rightarrow$ we then loose statistics (efficiency) proportionally to the downscale factor (!): $\varepsilon_{real} = \varepsilon_{MC}$ / (downscale factor)
  Clearly not optimal, even acceptable

❖ **Plan B:**
  - introduce a tigher B $\rightarrow$ hh HLT2 selection that reduces the minimum bias rate by, say, a factor 1.5 or 2, while keeping (hopefully ;-)) the efficiency on signal > 80% w.r.t. our present HLT2 selection

Comments on mass window cuts (1/3)

What we have as standard in CVS:

❑ **Offline: ± 600 MeV mass window**

❑ **HLT2 : ± 300 MeV mass window**

❑ **⇒ this is inconsistent; does not make sense**

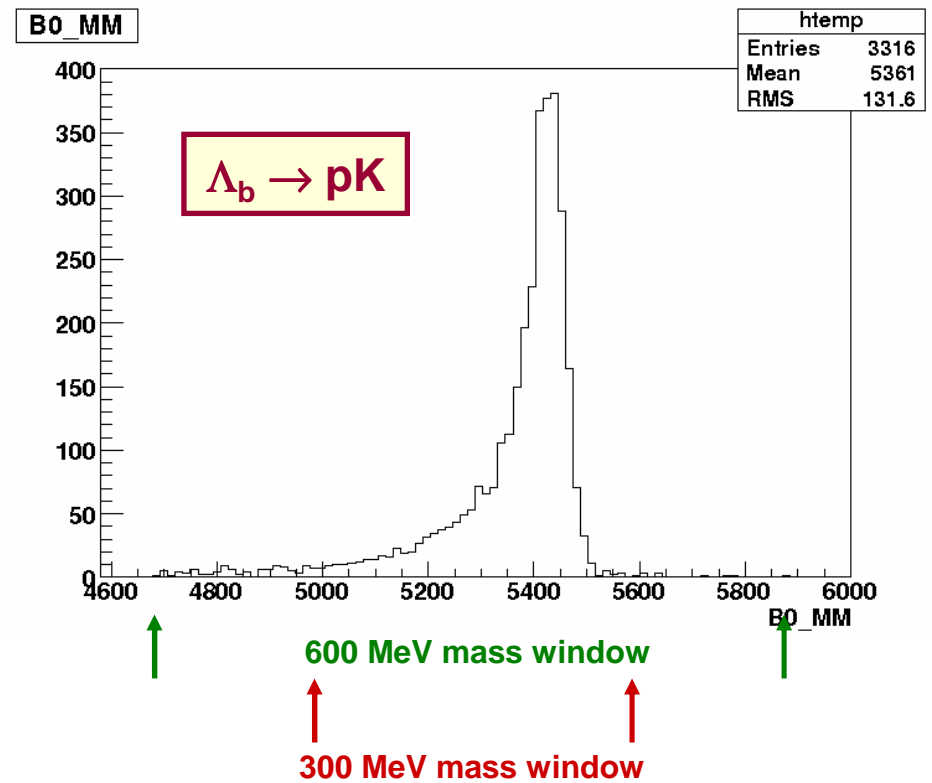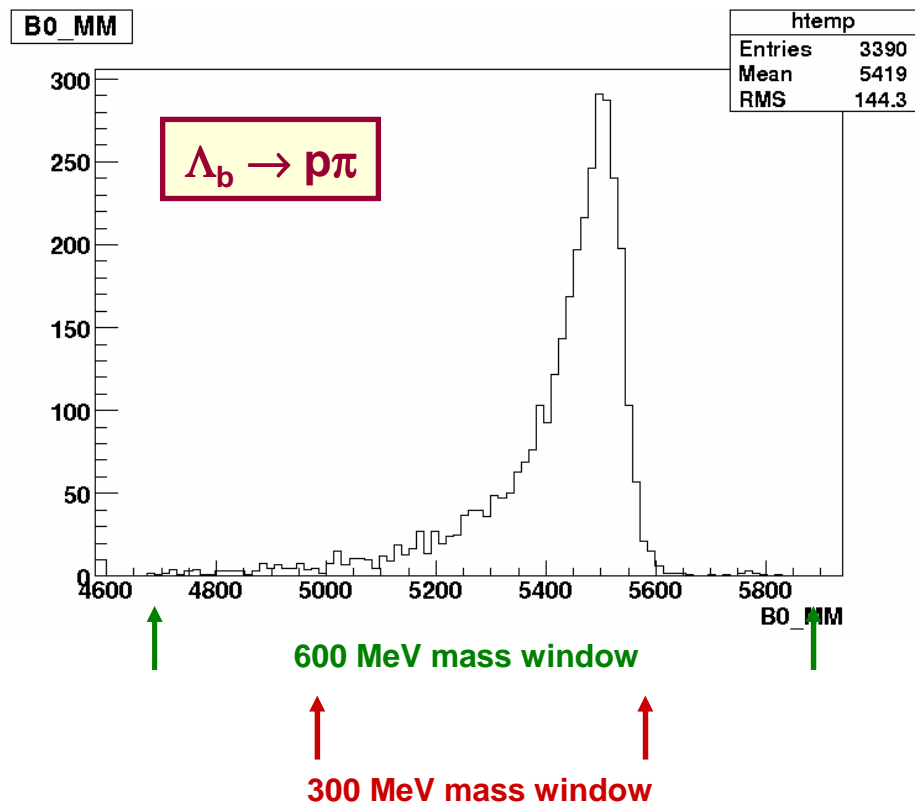❑ **Most importantly: it will also suppress
a lot the rare baryonic modes**
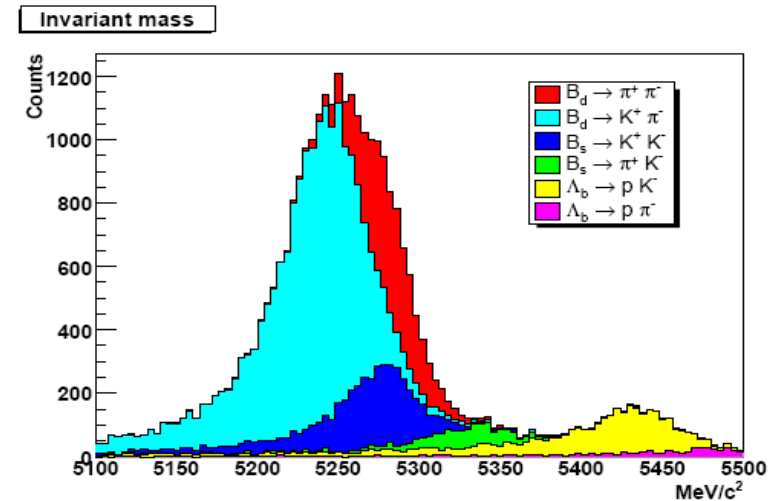
Mass window: (m_B= 5280 MeV) ± X MeV

Going ever more inclusive:

❑ **Seems to be the trend for us – c.f. latest info from Hans**

❑ **Should we envisage this asap? And try and merge our inclusive selection
with e.g. $B^+ \rightarrow hhh$? And …?**

❑ **Or potentially dangerous in our case?**

❑ **Look at FIDEL?**

❑ **Not completely clear to me at this point – needs studies and comparisons**

Comments on mass window cuts (2/3)

❏ **Invariant mass distributions
after pre-selection assuming pion hypothesis**

$\Lambda_b \rightarrow p\pi$

htemp	
Entries	3390
Mean	5419
RMS	144.3

600 MeV mass window

300 MeV mass window

$\Lambda_b \rightarrow pK$

htemp	
Entries	3316
Mean	5361
RMS	131.6

600 MeV mass window

300 MeV mass window

> **The new mass window
> seems to have been chosen
> to "fit as a glove" ;-) !**
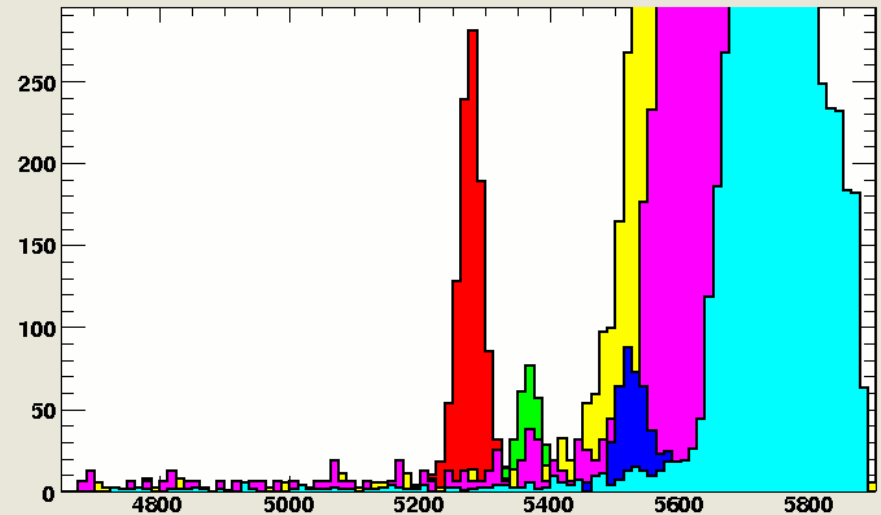
(thanks to Marco G. for histos)

Comments on mass window cuts (3/3)

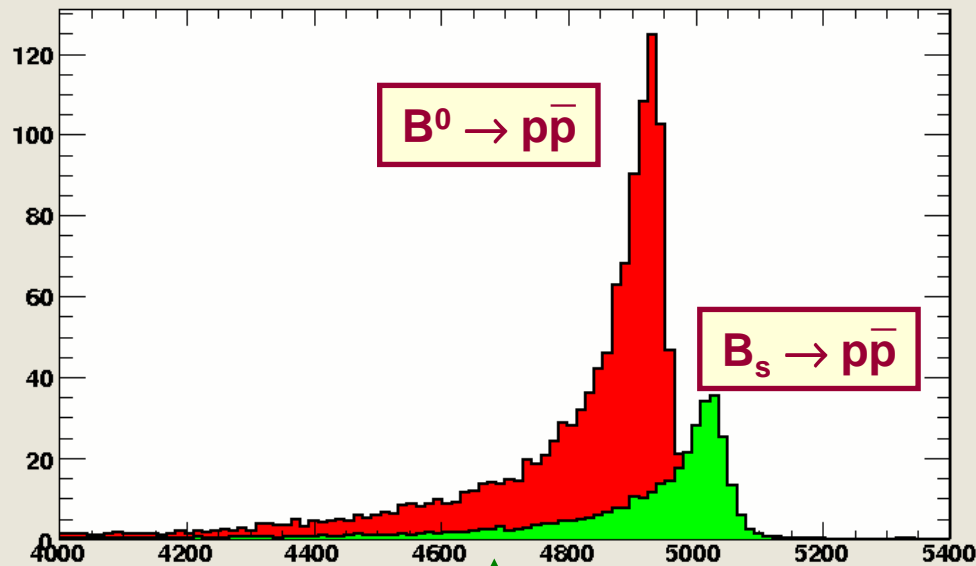❑ **Invariant mass distributions after pre-selection assuming pion hypothesis**

➢ **600 MeV window looses ~15% of signal**

Mass Distribution for B2hh Channels after Preselection

Mass Distribution for Bd2ppbar and Bs2ppbar

$B^0 \to p\bar{p}$

$B_s \to p\bar{p}$

The new 300 MeV mass window eliminates most of the signal !

600 MeV mass window

300 MeV mass window

(thanks to Laurence for histos)

Remarks, in short

❑ **Important message to the outside world – not to undersell:
"B2HH" stands for a big family of benchmark channels – 10 B-decays!**

❑ **We should introduce a tighter HLT2 selection "for safety reasons"**

  - I plan to make a "Hlt2TightSelB2HH"

❑ **The topics collected under the B2HH umbrella will suffer if we go for
too narrow a mass-window. Suggest (a) this is revisited and
(b) an appropriate B2HH bandwidth is negotiated**

**P.S.: If you understood I have strong feelings on these matters,
then I succeeded in passing the message across ;-)**