Search for MSSM Higgs Bosons in the bb channel

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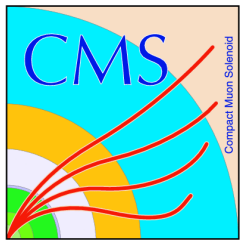

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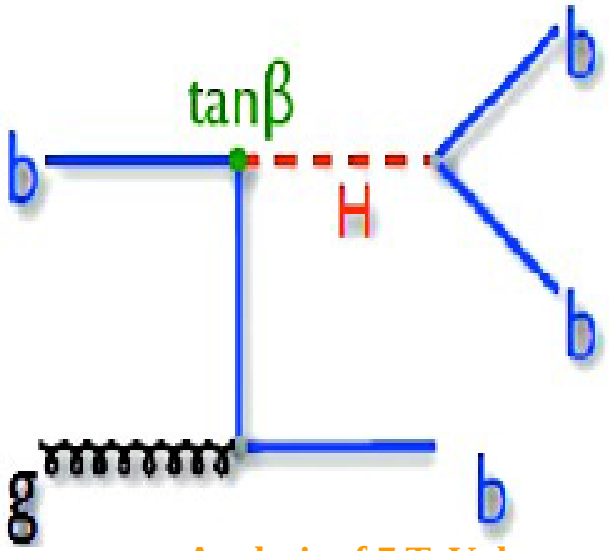
DPG Meeting

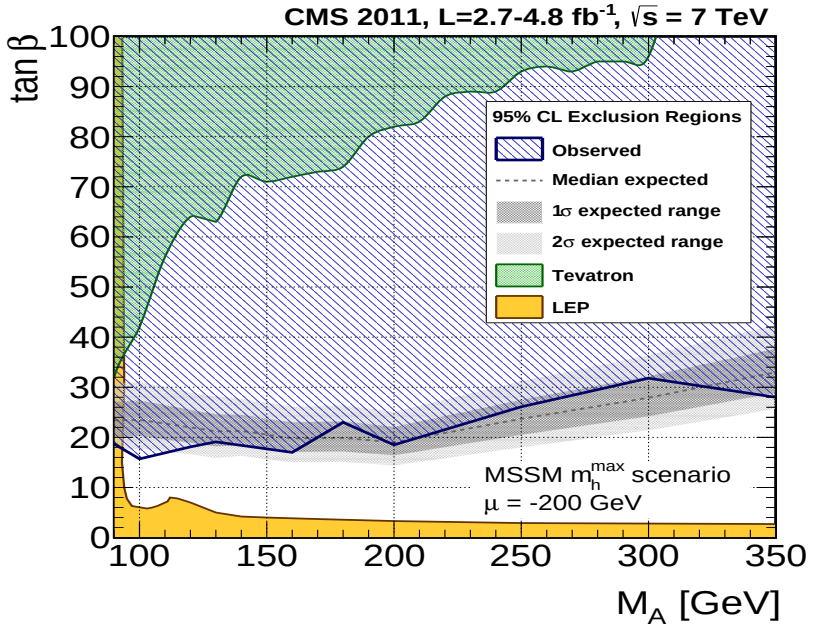
Outline

MSSM $\Phi \to b\bar{b}$ search

- Higgs sector of MSSM
  - 5 scalars: 2 **CP-even** (h/H); 1 **CP-odd** (A)**; 2 charged** $(H^{\pm})$
  - **only two parameters at tree level:** $tan\beta$, M_A
- Heavy neutral Higgs boson H/A: mass degenerate
- Production rate enhanced by $\tan^2\beta$
- Br $(h/H/A \to b\bar{b}) \simeq 90\%$



Analysis of 7 TeV data
Phys. Lett. B 722 (2013) 207



Analysis Strategy (1/2)

Signal signature

- 3 b-tagged jets
- Peak in dijet mass distribution of first 2 leading jets

Main Background: multijet QCD

- bbb or bb + 1 mistagged jet
- $t\bar{t}$, Zbb, non-bb $\rightarrow$ small

Analysis of 8 TeV data

- Main challenges due to increased luminosity and $\sqrt{s}$
  - Pile-up interactions
  - Large trigger rates $\rightarrow$
  - Required: tighter cuts on the jet p_T, η + additional $\Delta\eta(jet1, jet2)$ cut

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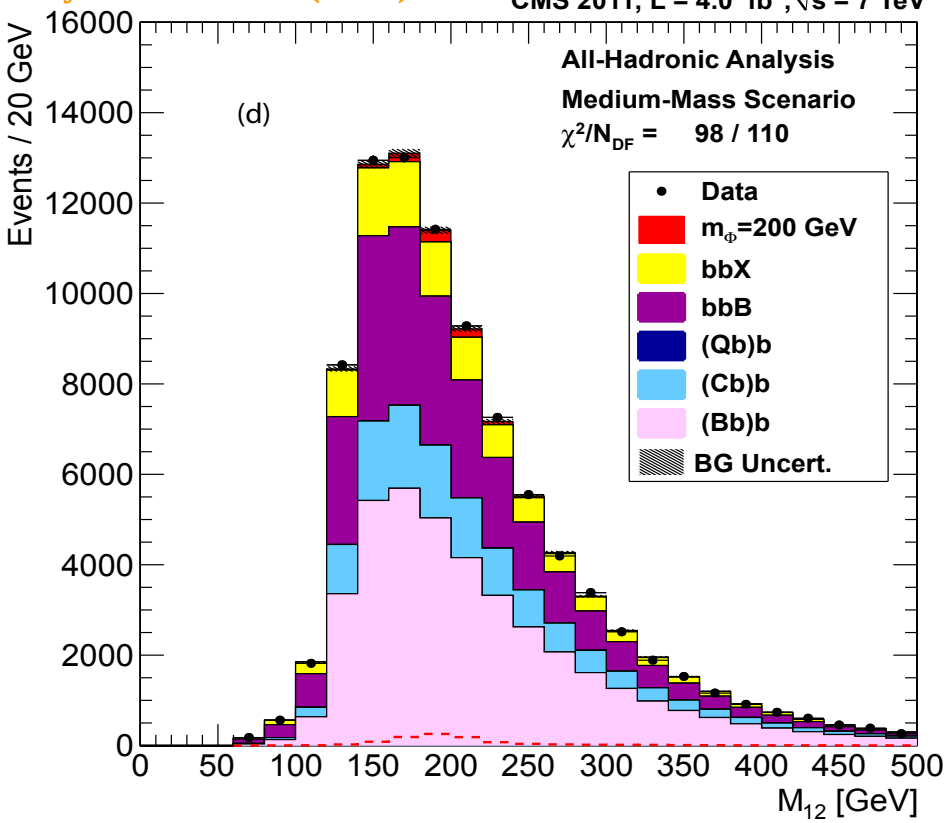
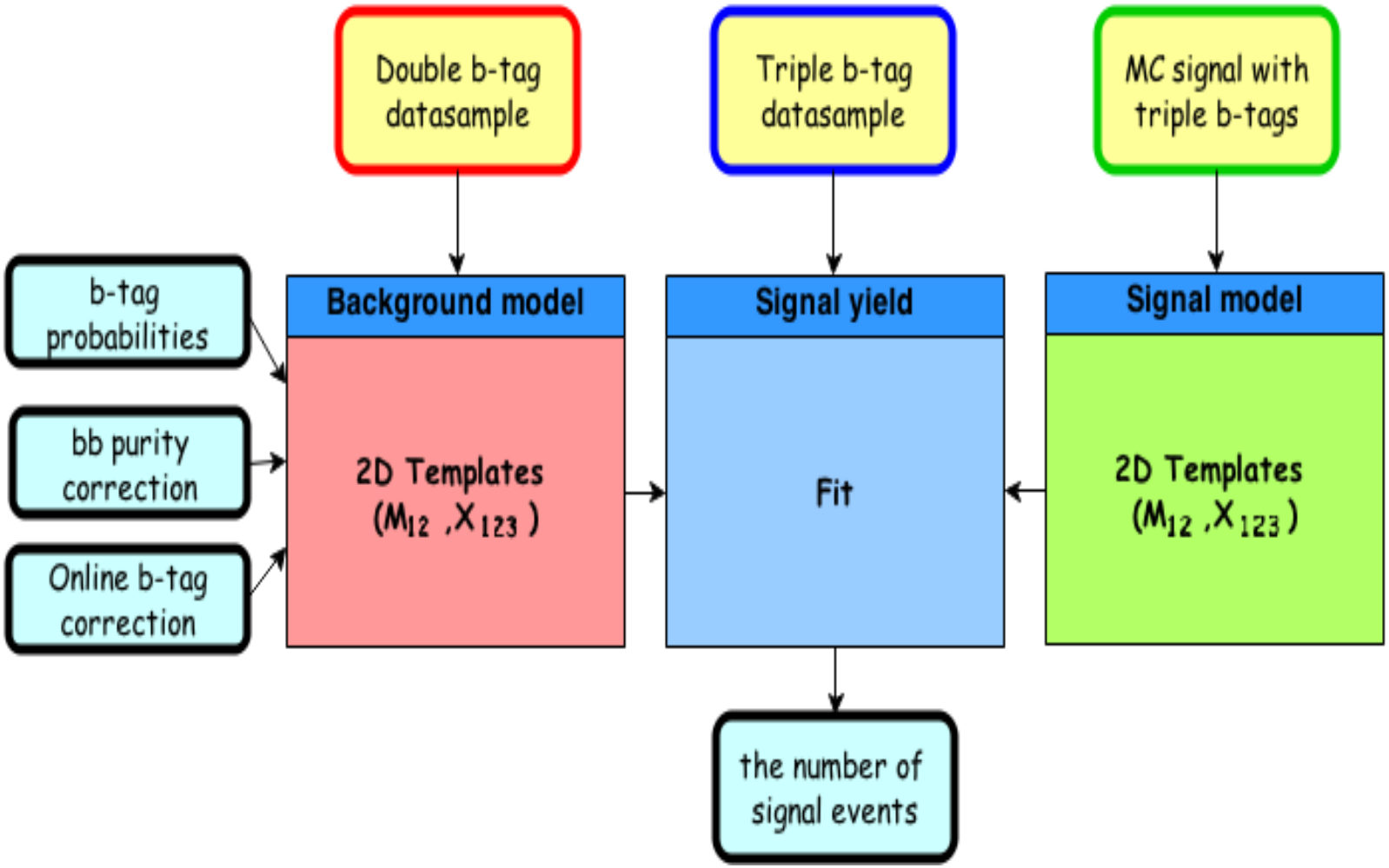


- Data-driven background model
  - Background templates from double-b-tag data
  - Normalization from the fit to triple-b-tag data

Analysis Strategy (2/2)



Trigger & Event Selection

- Dedicated triggers to cope with large hadronic interaction rate
  - Online b-tagging based on the impact-parameter significance
- Three scenarios defined according to triggers employed

Scenario	Medium-Mass	High-Mass	Very-High-Mass
Luminosity	4.05 fb^{-1}	19.71 fb^{-1}	19.71^{-1}
Selection of jets:			
jet1	p_T >60 GeV	> 80 GeV	>160 GeV
jet2	p_T > 53 GeV	> 70 GeV	>120 GeV
jet3	p_T > 20 GeV	> 20 GeV	> 20 GeV
at HLT	$\lvert\eta^{jet1,jet2,jet3}\rvert < 1.7$	<1.7	<2.4
and offline	$\Delta\eta(jet1, jet2) < 1.7$	<1.7	

- Offline: b-tagged 3 leading jets

Background Modeling

2D Templates

- M_{12}: Invariant mass of 2 leading jets
- $EvtBTag(X_{123})$: Constructed from the sum of Secondary Vertex (SV) masses, M_{SV}, of 3 leading jets
  - Additional separation power between templates of different flavour

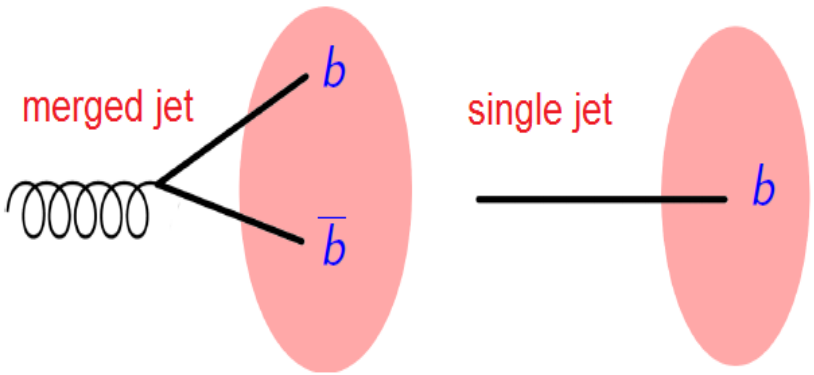
In selected double-b-tag data

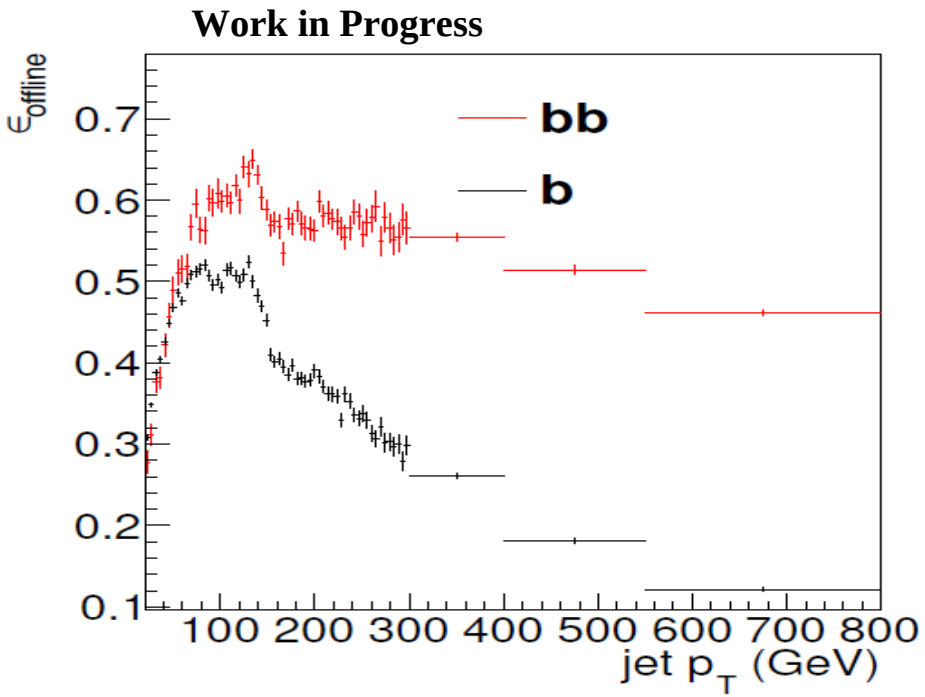
1. Consider possible flavor configurations of 3 leading jets
   - bbX, bXb, Xbb
2. Assume flavour for untagged jet, X=Q,C and B
3. Weight event according to b-tag probability for assumed flavour
4. Weight event according to probability for assumed M_{SV}

Extension of the Background Templates (1/2)

- Larger jet p_T values considered in 8 TeV data $\rightarrow$
  - Significant extension of b-tag probability functions to higher p_T ($\sim$ 800 GeV)
  - Large contribution of events with hard gluons splitting, e.g $g \rightarrow b\bar{b}, c\bar{c}$, merged in one jet
  - Probability to tag these merged jets significantly larger than for single jets

$b\bar{b} : \Delta R < 0.3$

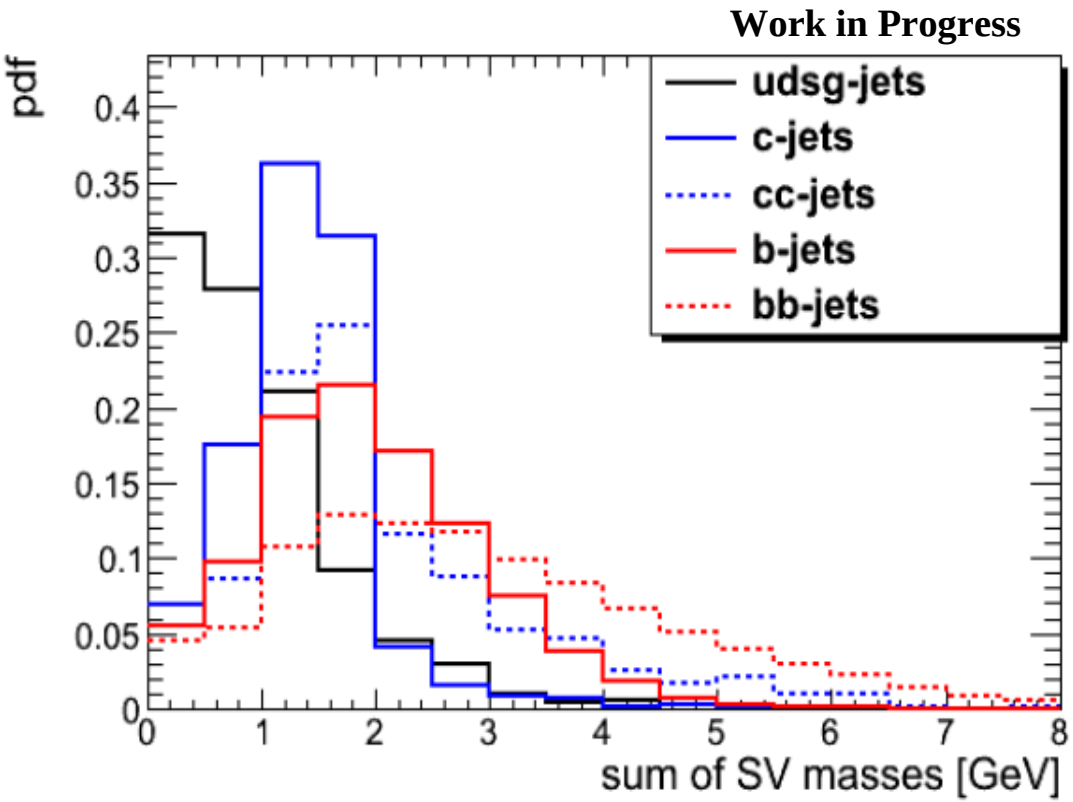




Extension of the Background Templates (2/2)

How to deal with new “flavours”: cc and bb?

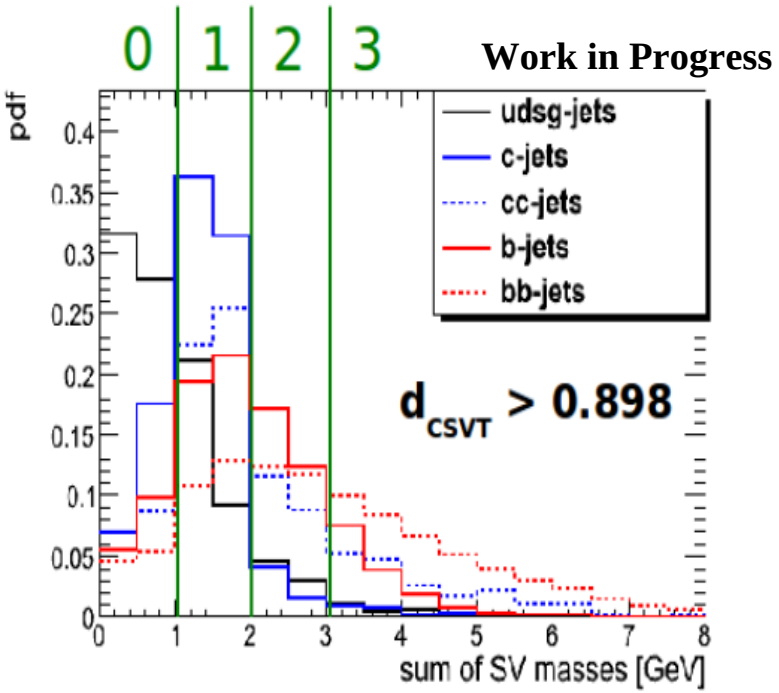
- 15 background templates in total
- Can we distinguish bb (cc) and b (c) templates?



- b-tagged 3 leading jets in b-enriched QCD MC
- Good discrimination of merged and single jets

Event-B-Tag (X_{123}) Variable

sv-mass-sum bin B_j of jet j



Event-b-tag $= T_{12} + T_3$

$T_{12} = 0$ if $B_1 + B_2 \leq 1$

$T_{12} = 1$ if $2 \leq B_1 + B_2 \leq 3$

$T_{12} = 2$ if $B_1 + B_2 \geq 4$

$T_3 = 0$ if $B_3 \leq 1$

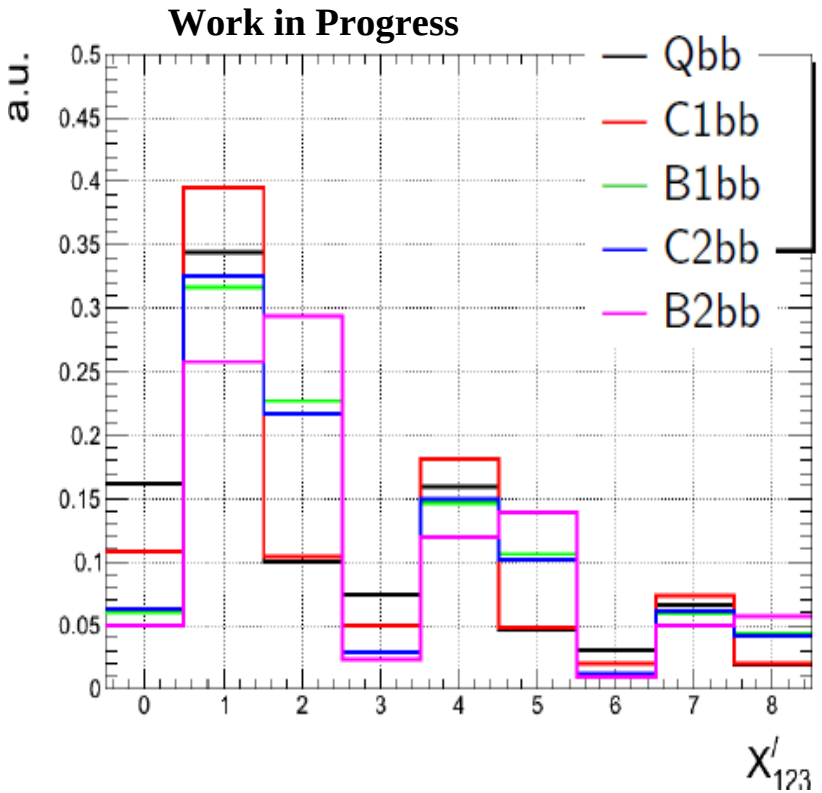
$T_3 = 3$ if $B_3 = 2$

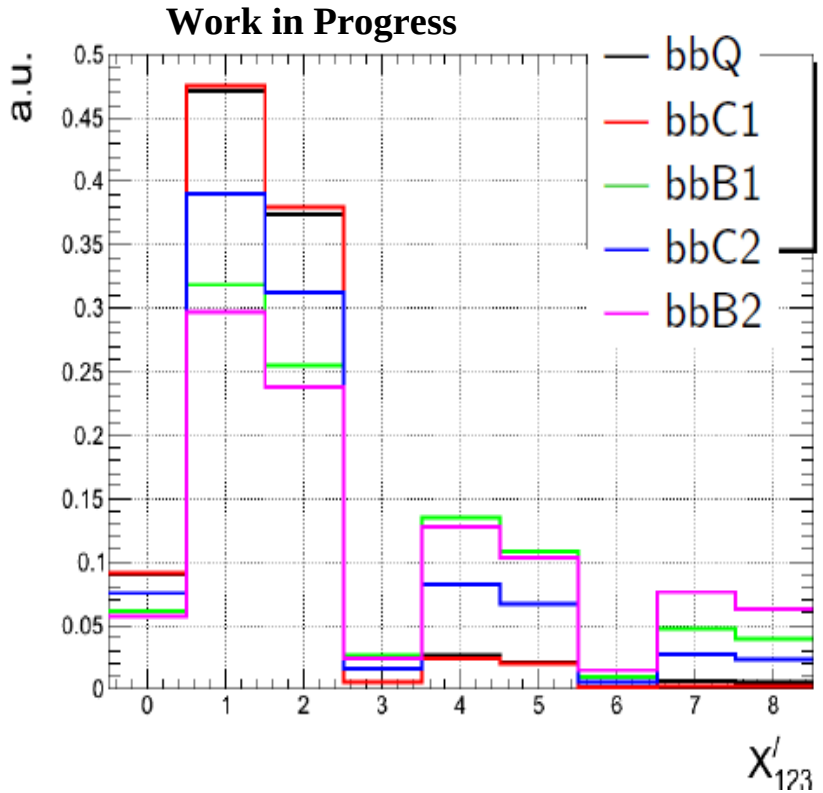
$T_3 = 6$ if $B_3 = 3$

- 4 B_j bins of the sum of M_{SV} to distinguish single and merged jets
  - b and bb flavor
  - c and cc flavor

Event-B-Tag background Templates

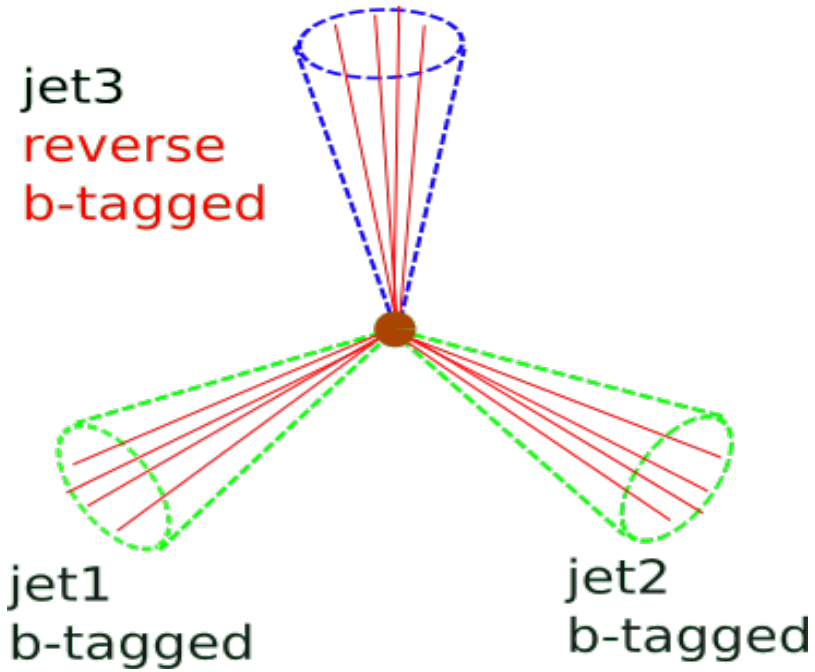
- Derived from double-b-tag data sample
  - Event-by-event basis
  - According to the sum-M_{SV} probability obtained from MC
- Here, example of Medium-Mass scenario





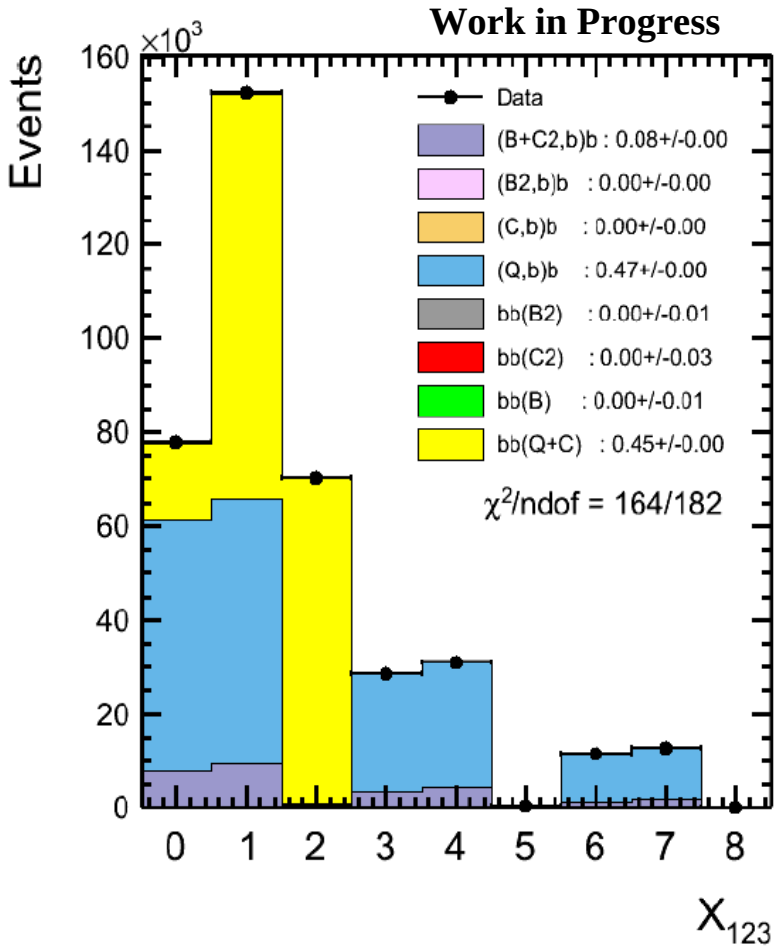
Commissioning the Background Model

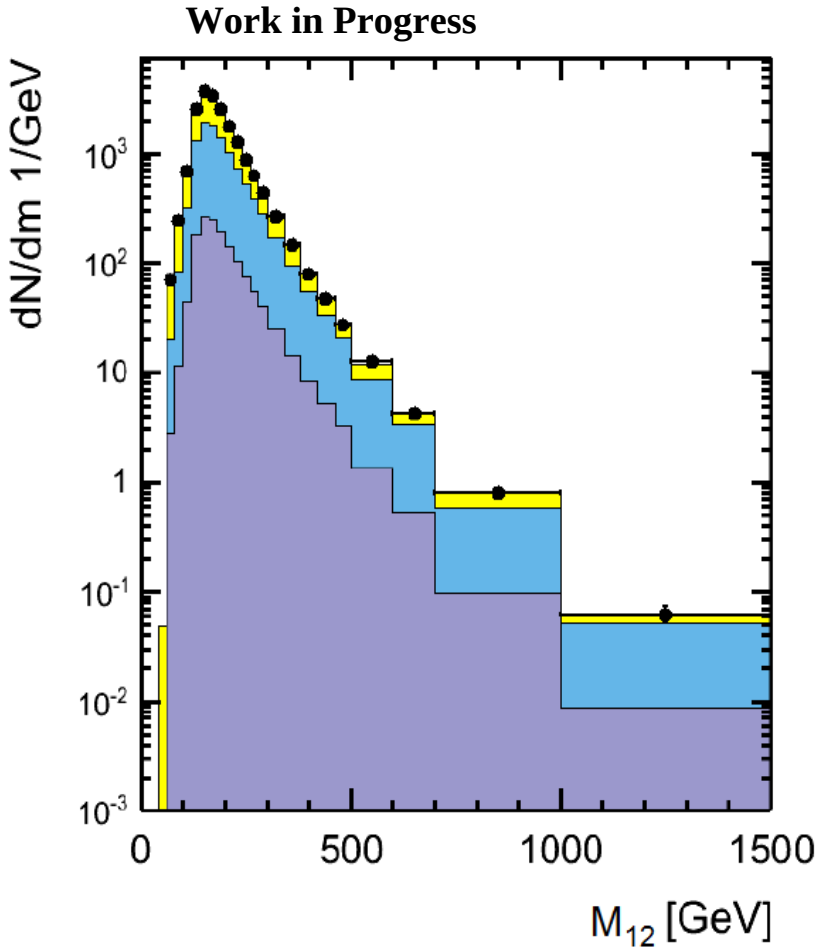
1. Fit in Reverse-B-Tag sample
   - Required: 2 b-tagged jets and one reverse b-tagged jet, failed b-tagging criteria
2. Maximum Likelihood fit of 2D templates
   - Only stat. errors of data are taken into account $\rightarrow$
   - No stat. or system. uncertainties of templates yet



Fit in Reverse-B-Tag sample

- Medium-Mass scenario



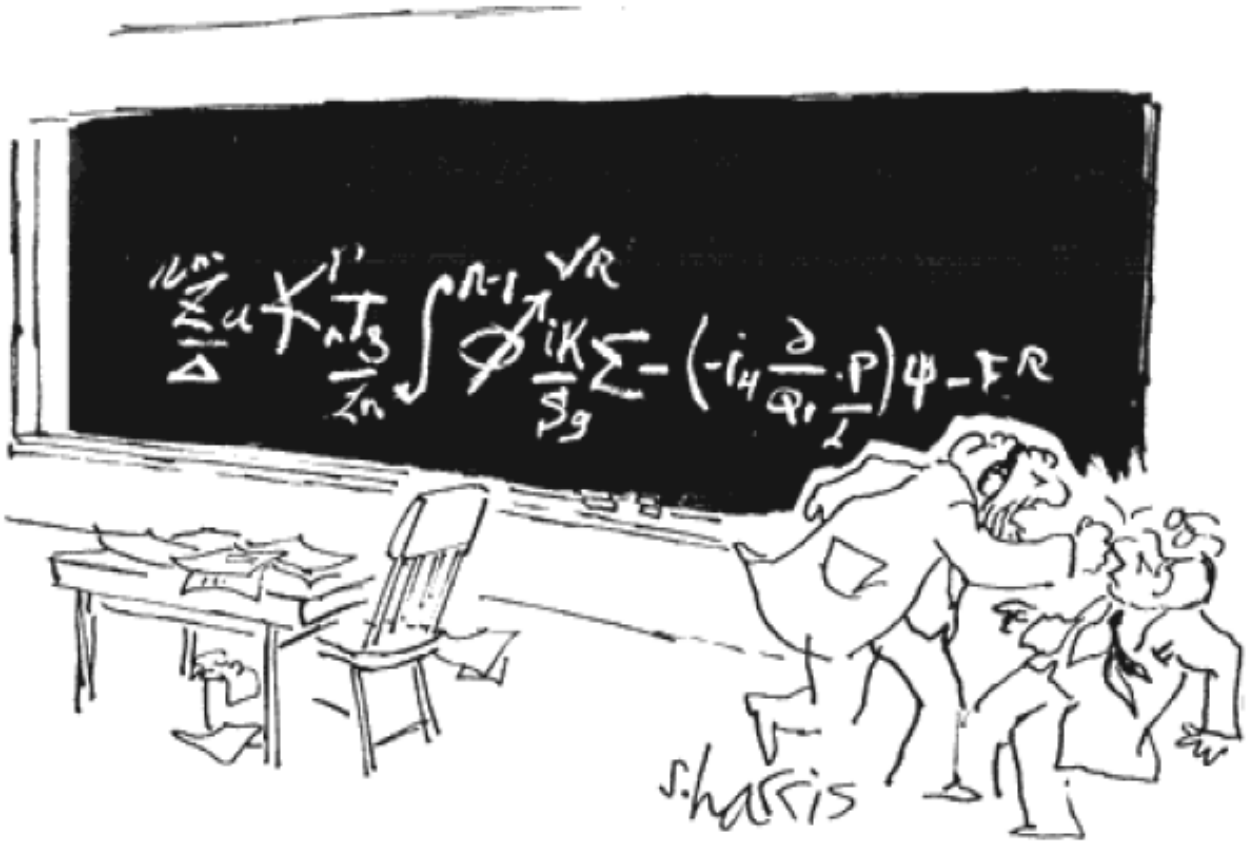


- Similar templates merged, e.g (Q,b)bb =Qbb +bQb
- Good description of data, as expected light-flavor templates dominate

Summary

- Status of the search for the neutral $\Phi \to b\bar{b}$ reported
- Study of expected the signal and background yields
- Study of single and merged jets
- Commissioning the background model
  - Fit in Reverse-B-Tag sample
- **Analysis in progress**
- **Stay tuned!**

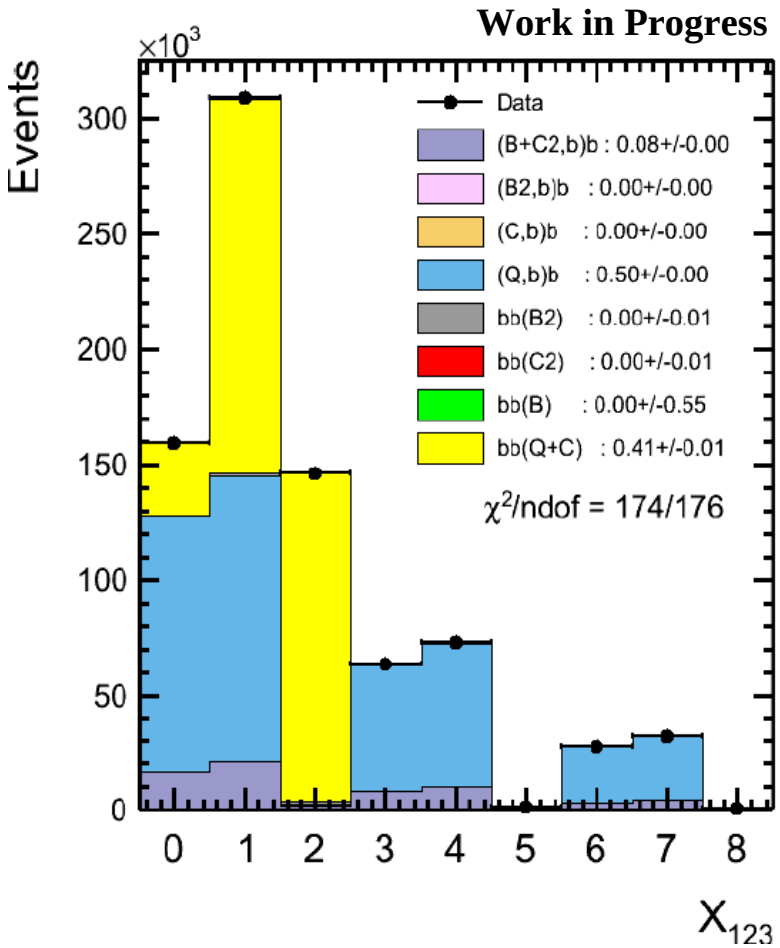
Backup slides

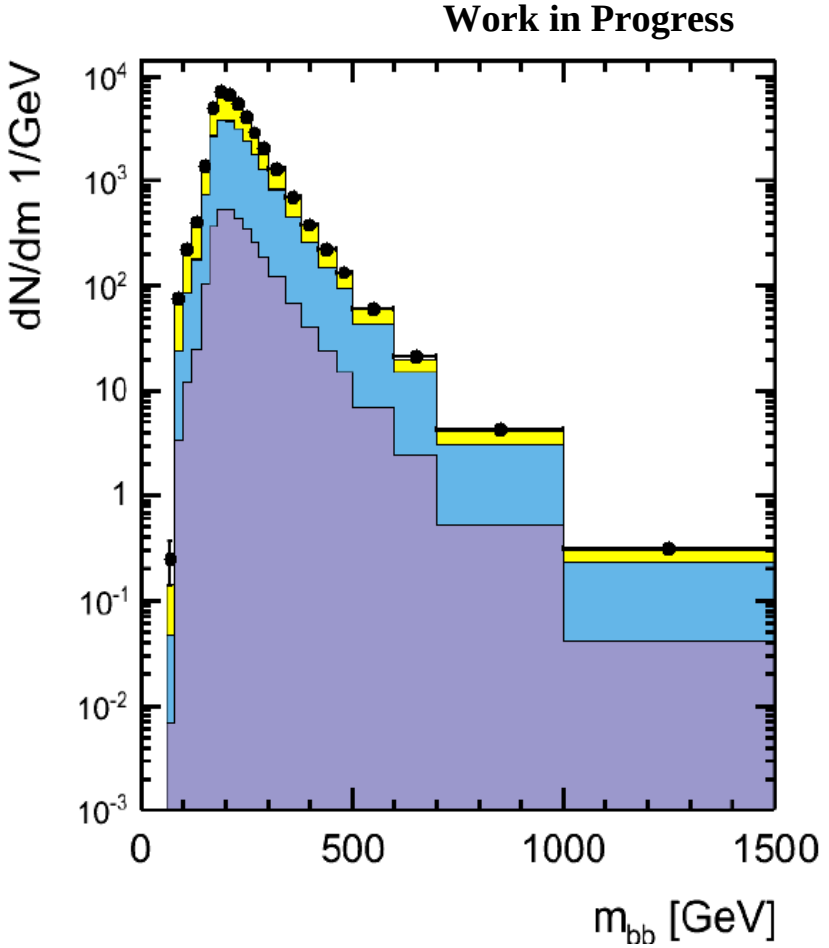


"You want proof? I'll give you proof!"

Fit in Reverse-B-Tag sample (2/3)

- High-Mass scenario

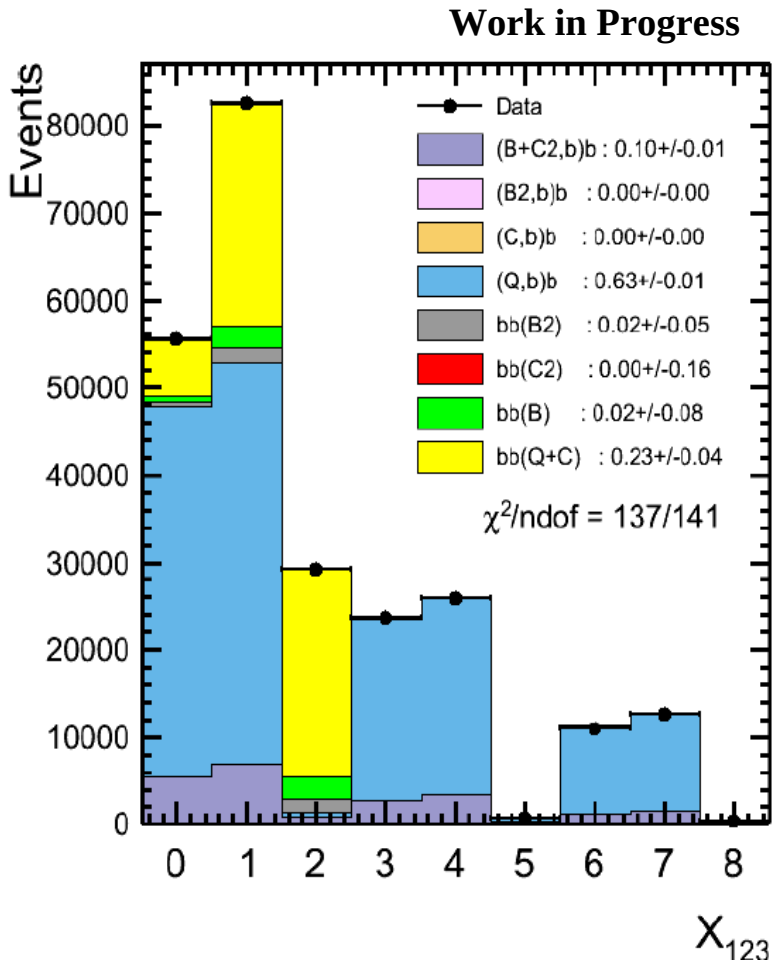


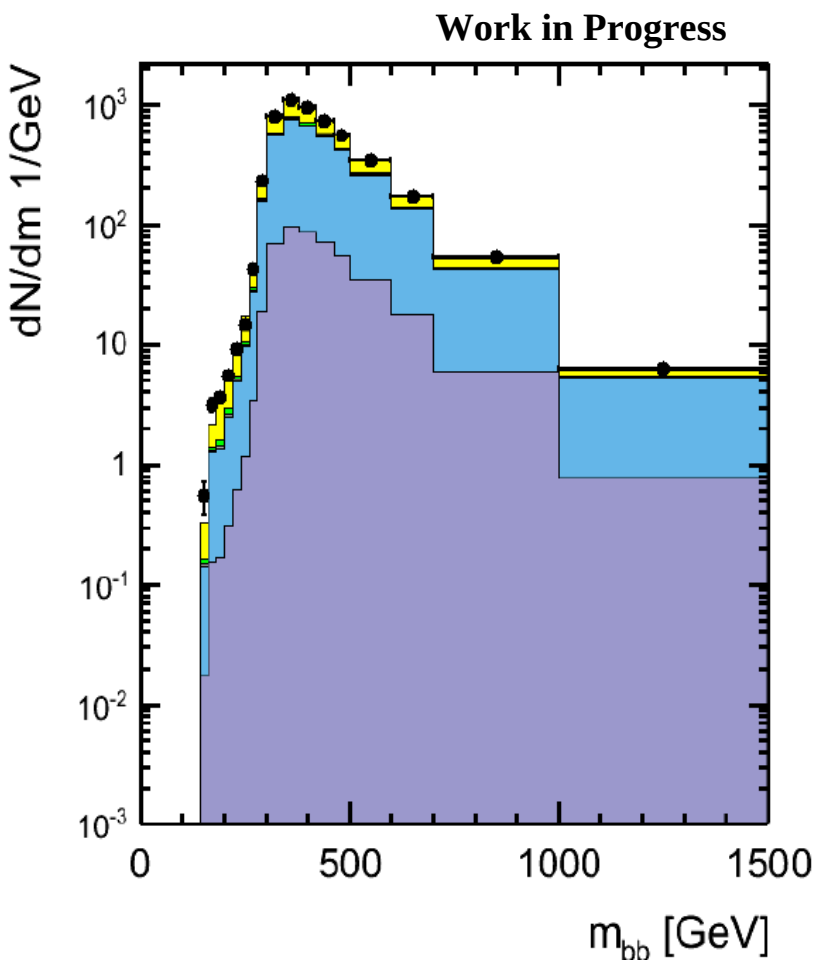


- Good description of data, as expected light-flavor templates dominate

Fit in Reverse-B-Tag sample (3/3)

- Very-High-Mass scenario





- Good description of data, as expected light-flavor templates dominate