Prospect for search of neutral SUSY Higgs h

bb h$\longrightarrow \mu^+\mu^-$ UP-TO-DATE

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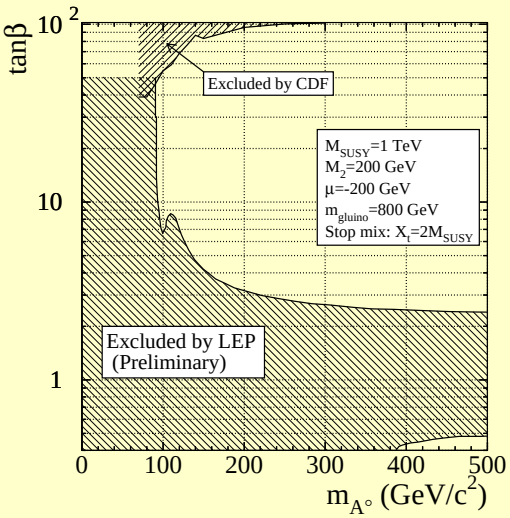
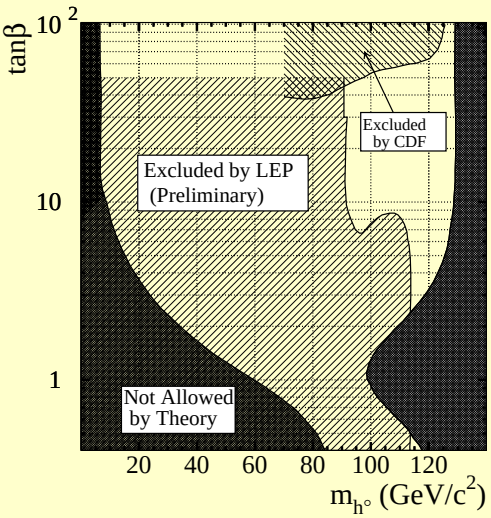
December 12, 2002
Higgs meeting





PDG, Phys. Rev. D 66 0100001 (2002),updated by P. Igo-Kemens.

No indication of of h and A signal found at LEP

$$m_h > 91.0 \text{ GeV} \qquad m_A > 91.9 \text{ GeV}$$

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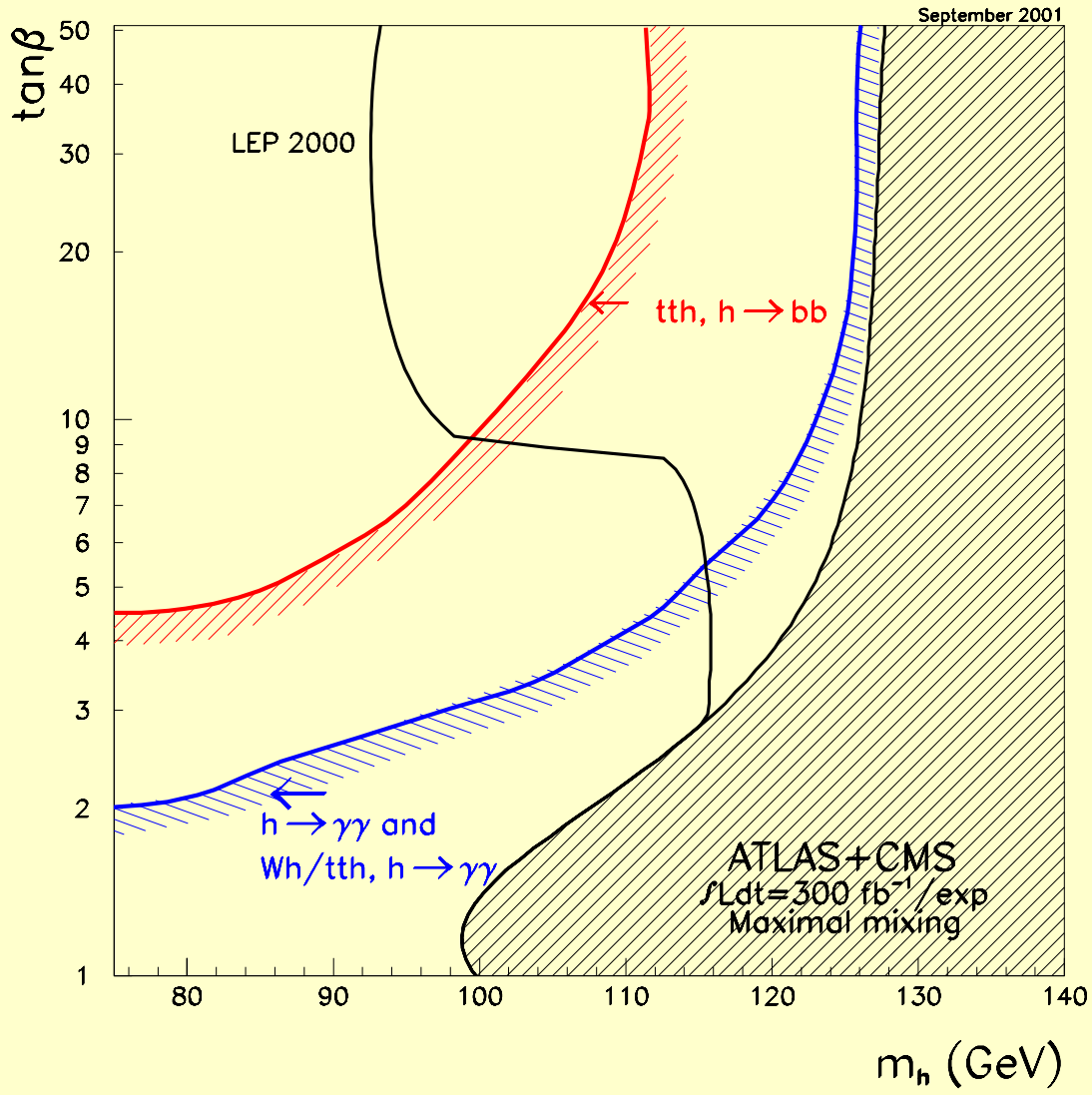
Motivation: Perspective of LHC search

From the others channel search at LHC :



Region to study

$m_h \approx 100$ **GeV** and **tanβ** > 10.

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Motivation: Channel $\mathbf{h \to \mu^+\mu^-}$

A channel to explore this region is:

$$\mathbf{h \to \mu^+\mu^-}$$

- decay channels of h boson.
- $^+\boldsymbol{\mu}^-\boldsymbol{\tau}^+\boldsymbol{\tau}^-$ and $\boldsymbol{H}^{\pm}$

A second channel in case of discovery will be an essential proof of the validity of model.

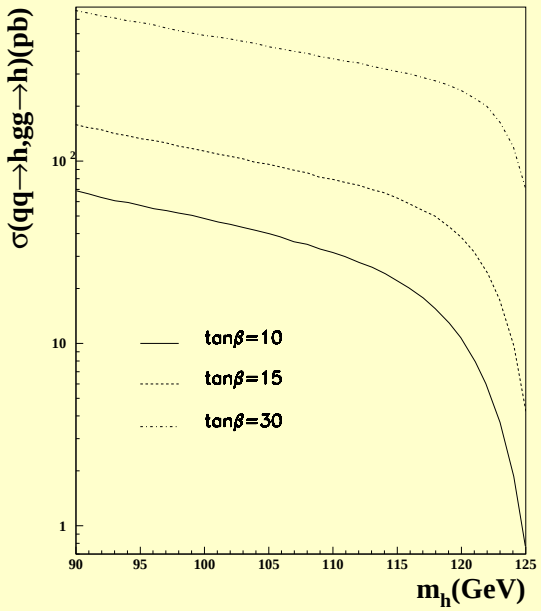
The correction factors to Higgs SM boson of MSSM higgs are proportional to:

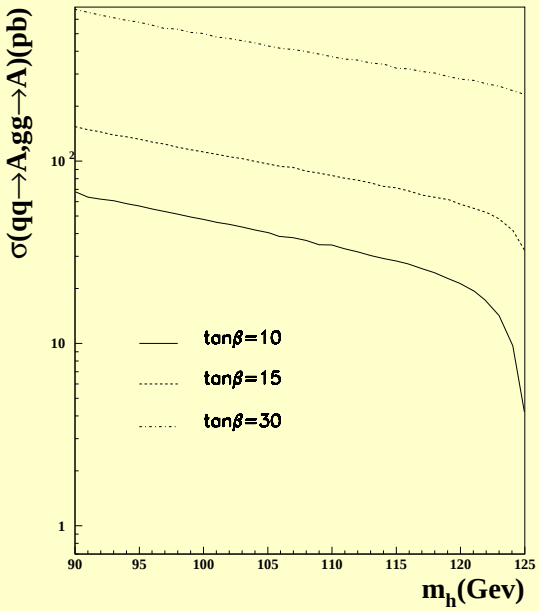
MSSM	$\boldsymbol{d\bar{d}, s\bar{s}, b\bar{b}}$ $\boldsymbol{e^+e^-, \mu^+\mu^-, \tau^+\tau^-}$	$\boldsymbol{u\bar{u}, c\bar{c}, t\bar{t}}$	$\boldsymbol{WW, ZZ}$
h	$\mathbf{-\sin\alpha/\cos\beta}$	$\mathbf{\cos\alpha/\sin\beta}$	$\mathbf{\sin(\beta-\alpha)}$
H	$\mathbf{\cos\alpha/\cos\beta}$	$\mathbf{\sin\alpha/\sin\beta}$	$\mathbf{\cos(\beta-\alpha)}$
A	$\mathbf{-i\gamma_5\tan\beta}$	$\mathbf{-i\gamma_5\cot\beta}$	$\mathbf{0}$

In a large region of the interesting parameter space

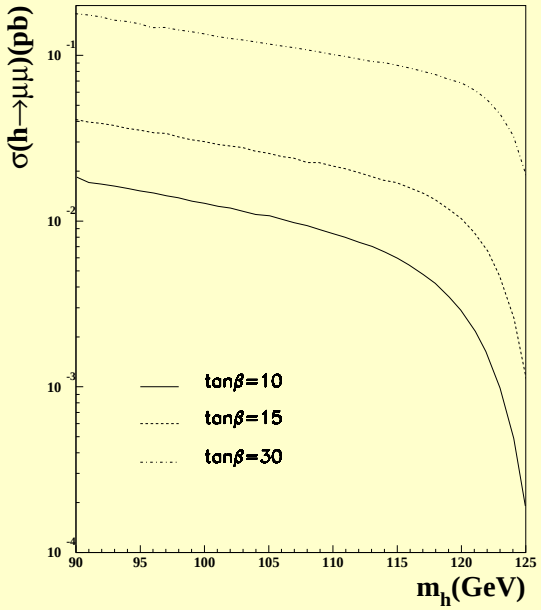
A and h are indistinguishible

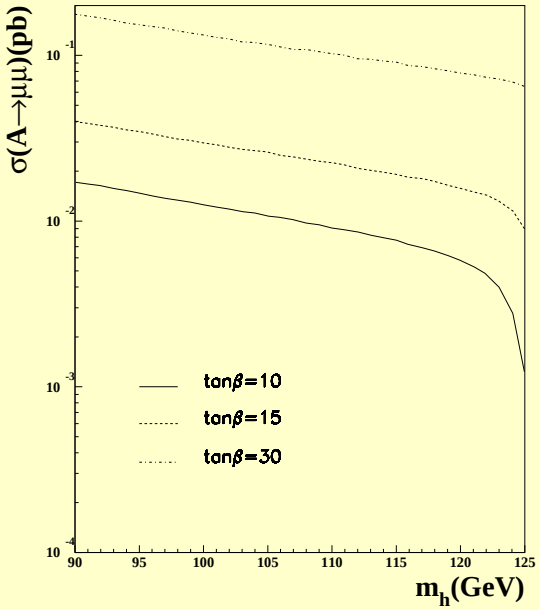
h and A production cross section





h and A decay branching ratio x cross-section in $\mu^+\mu^-$





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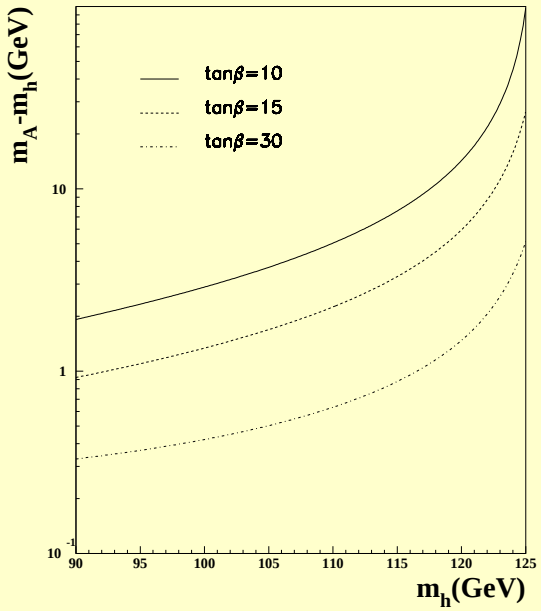
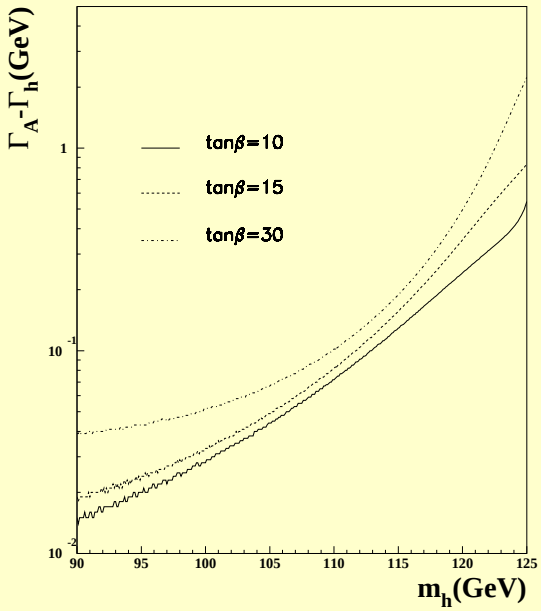
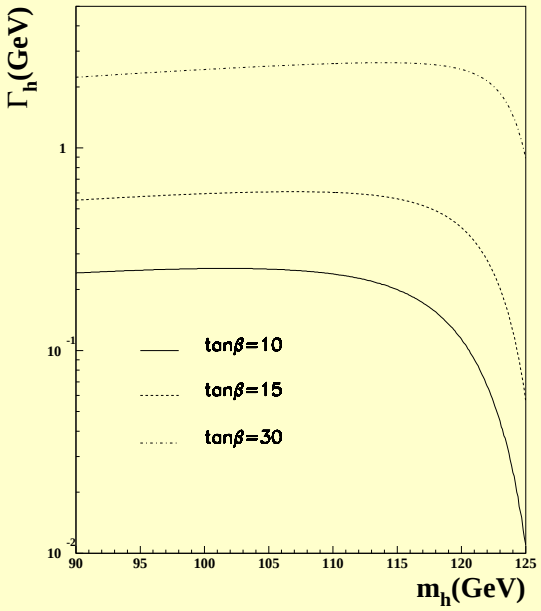
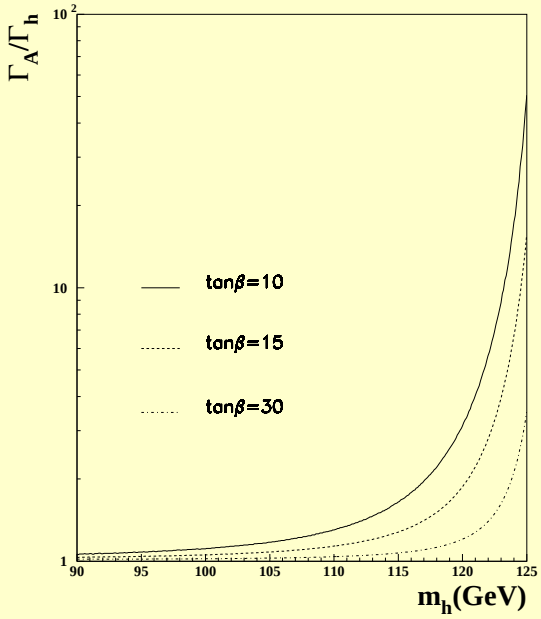
Difference of mass and width neutral boson h and A





h width





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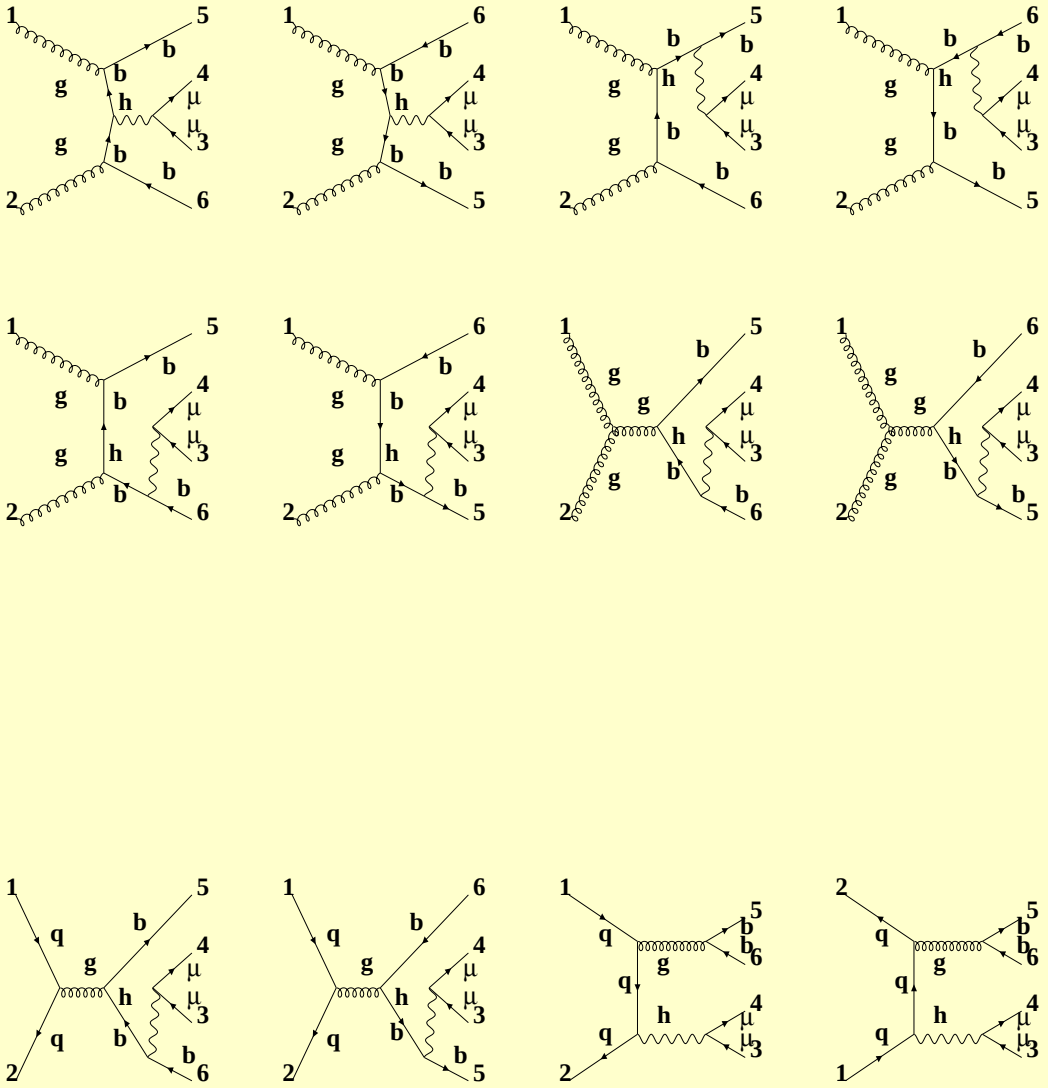
Signal: $gg \longrightarrow h_0 bb \longrightarrow \mu\mu bb$ *and* $q\bar{q} \longrightarrow h_0 bb \longrightarrow \mu\mu bb$



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Signal: $\mathbf{h \longrightarrow \mu^+\mu^-}$ and $\mathbf{b\bar{b}}$

- $^+\mu^-$ and $\mathbf{b\bar{b}}$:
  $\boldsymbol{\sigma}\cdot$ Br ($h \longrightarrow \mu^+\mu^-$) $\approx$ **0.1** pb, at $\mathbf{\tan\beta} = 30$ and $m_{\mathbf{h}}$ = 110 **GeV**.

- $^* \longrightarrow \mu^+\mu^-$ and $\mathbf{b\bar{b}}$
  - $\boldsymbol{\sigma}\cdot$ Br ($\mathbf{Z} \longrightarrow \mu^+\mu^-$)$\approx$ 1500 **pb**.
- $^+\mu^-\mathbf{b\bar{b}}$:
  $\boldsymbol{\sigma}\cdot$ Br ($Z \longrightarrow \mu^+\mu^-$)$\cdot$ Br ($Z \longrightarrow \mathbf{b\bar{b}}$) $\approx$ **0.15pb**.
  $\Rightarrow$ Same order of magnitude of signal.
  Reduced by kinematical cuts.
- $\mathbf{\bar{t} \longrightarrow W^+W^-b\bar{b} \longrightarrow b\bar{b}\mu\nu\mu\nu}$.
  $\boldsymbol{\sigma(t\bar{t})}\cdot$ Br ($t \longrightarrow b\ W$)$\cdot$ Br ($W \longrightarrow \mu\nu$) Br ($t \longrightarrow b\ W$) $\cdot$ Br ($W \longrightarrow \mu\nu$) $\approx$ **5.84pb**.

$\Rightarrow$ Missing energy in the event.Used to reduce this background.

♠ The two b-jets are more energetics $\longrightarrow$ easier identification by b-tag.

$\Rightarrow$ Using ONLY one b-jet identification might improve signal/background ratio.

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Data taking scenario: high luminosity.
Expected total integrated luminosity:
$\int \mathcal{L}\, dt = 300\ \mathbf{fb^{-1}}$.

Generation: PYTHIA Version 6.203

- $^{+}\mu^{-}$ and $\mathbf{b\bar{b}}$:
  8 points $\tan\beta$ [15,50]
  7 points m_A [95 GeV,125 GeV]
- $^{+}\mu^{-}$ and $\mathbf{b\bar{b}}$: $\Leftarrow$ (NEW)
  8 points $\tan\beta$ [15,50]
  7 points m_A [95 GeV,125 GeV]
- $^{+}\mu^{-}$ and $\mathbf{b\bar{b}}$
  in the high P_t region ($P_t > 80$ GeV).
- $^{+}\mu^{-}\mathbf{b\bar{b}}$:
- $\bar{t} \rightarrow W^{+}W^{-}\mathbf{b\bar{b}} \rightarrow \mathbf{b\bar{b}}\mu\nu\mu\nu$.

N_{ev} generated corresponding to 5 times the expected integrated luminosity

Detector simulation: ATLFAST version 2.60

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*Full simulation in ATLSIM framework**

Event generation: MSSM m_h^{max} scenario

PYTHIA 6.203 release 13 Nov. 2001

Detector simulation: Inner Detector/Calorimeters/Muon System

GEANT3 v. 21/08 release 23 June 1997
DICE-03-21-55-64 geometry configuration
3D non linear magnetic field from bmagatlas02.data
Muon Spectrometer layout from amdb_simrec.p.03

Event reconstruction: Inner detector & Muon System

Inner Detector: xKalman++ 11 June 2002
Muon Spectrometer: MuonBox v. 6.03.07
Combined: STACO algorithm by J.F. Laporte

* version 01-02-07 release 27 July 2002

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$$m_h^{nom} = 100\ GeV \quad \Gamma_h^{nom} = 1\ GeV \quad \tan\beta = 20$$

	Reconstruction efficiency	Mass resolution* (GeV)
Muon Spectrometer ($\|\eta\| < 2.7$)	85%	2.54 ± 0.04
Inner Detector ($\|\eta\| < 2.5$)	92%	1.78 ± 0.06
Combined ($\|\eta\| < 2.5$)	74%	1.58 ± 0.02

* nominal width subtracted

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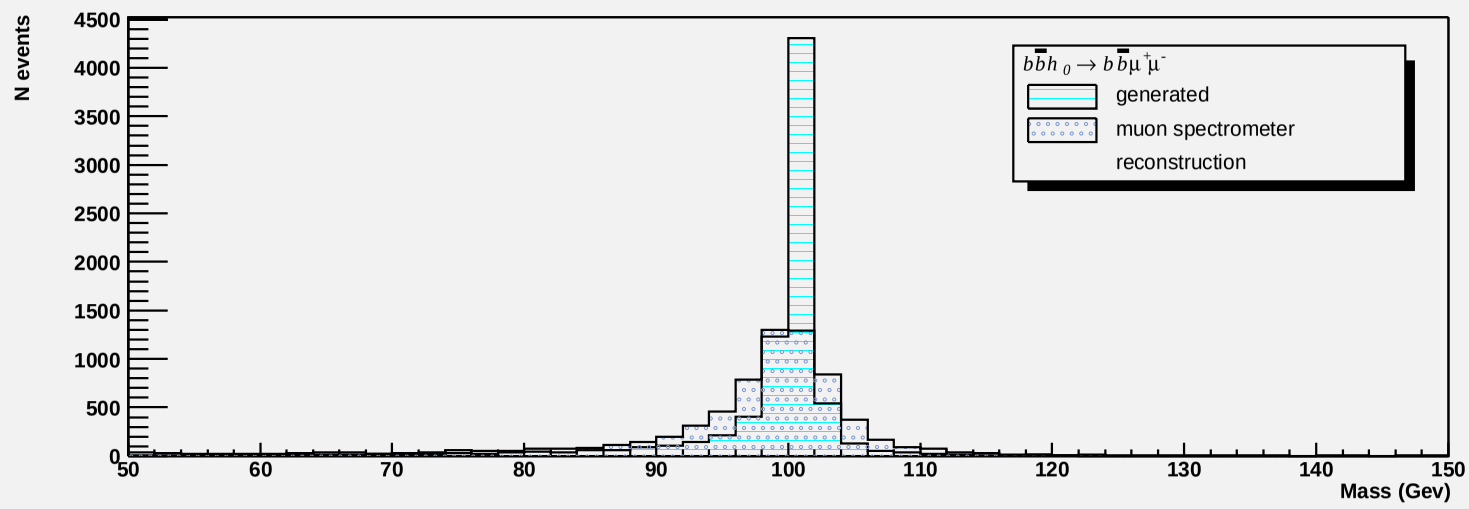
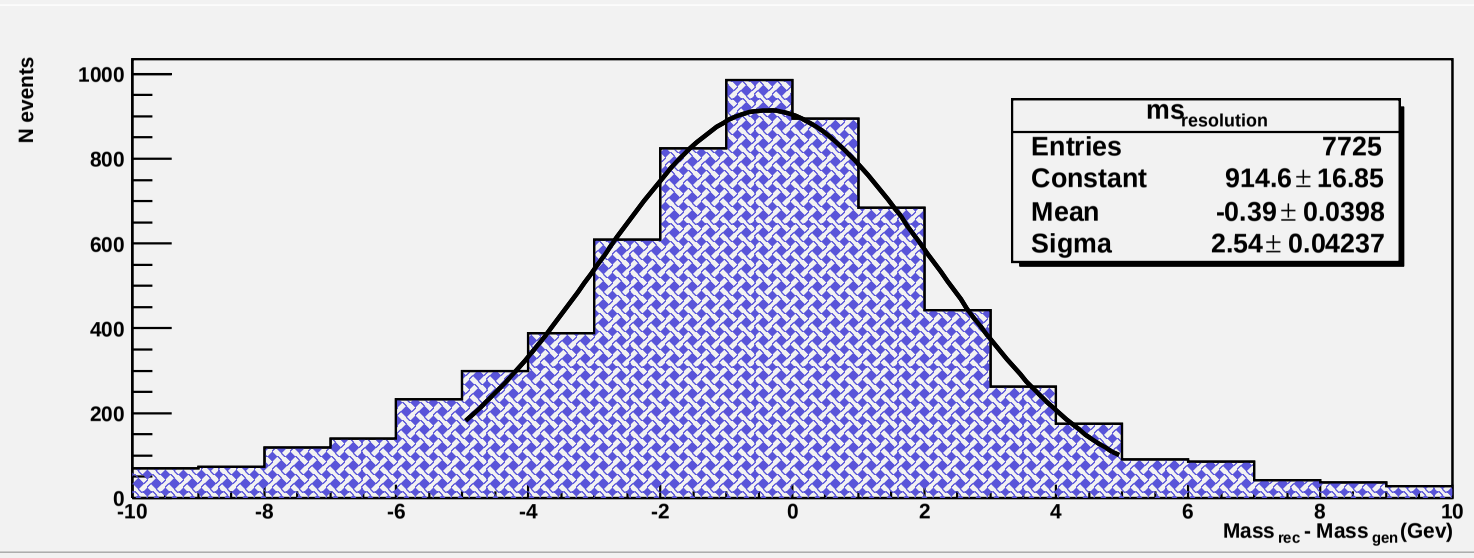
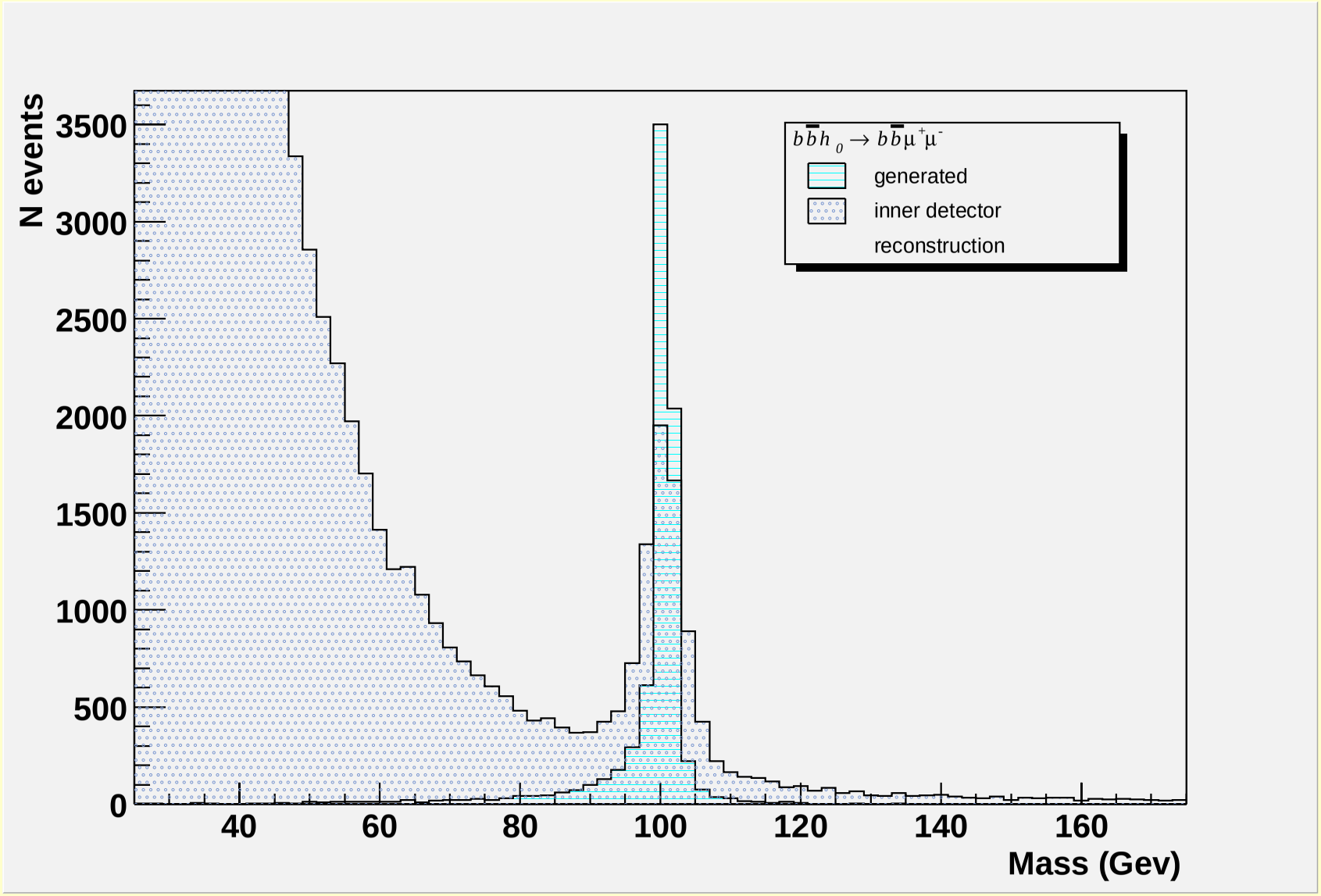
Muon Spectrometer reconstruction





Inner Detector reconstruction



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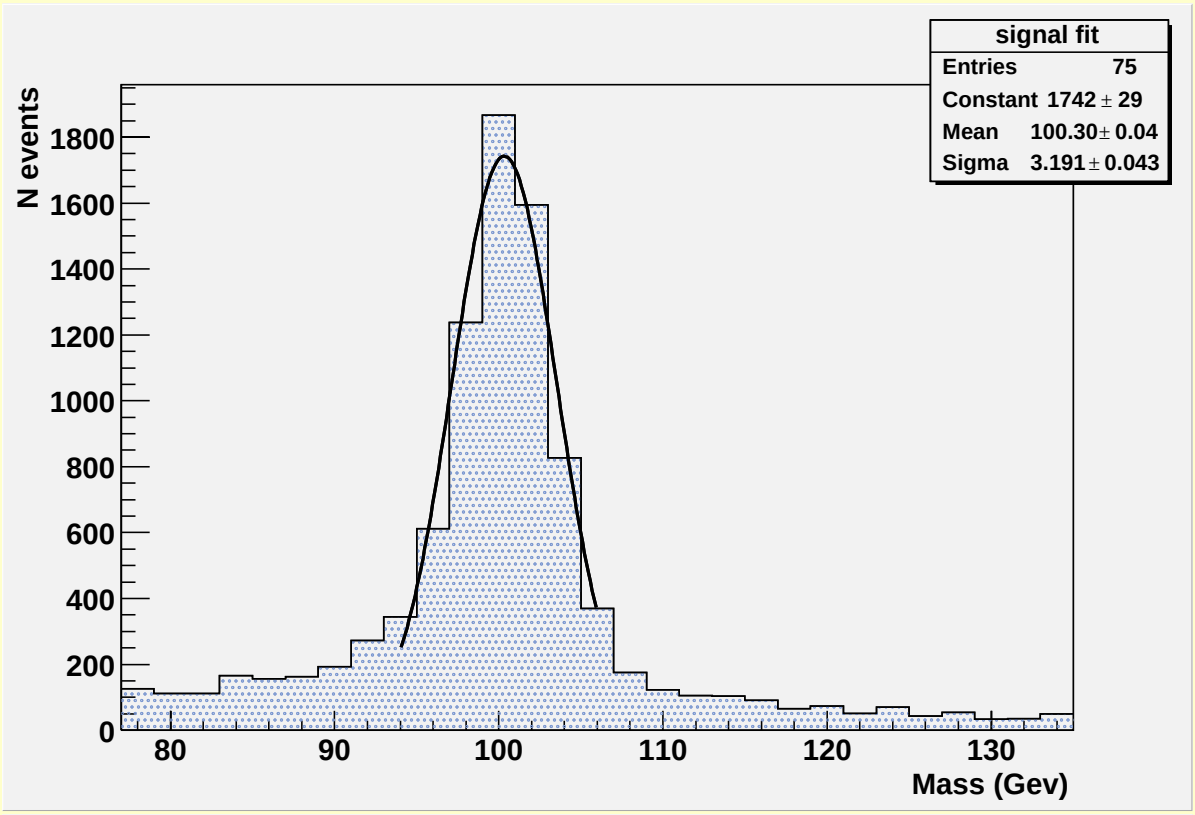
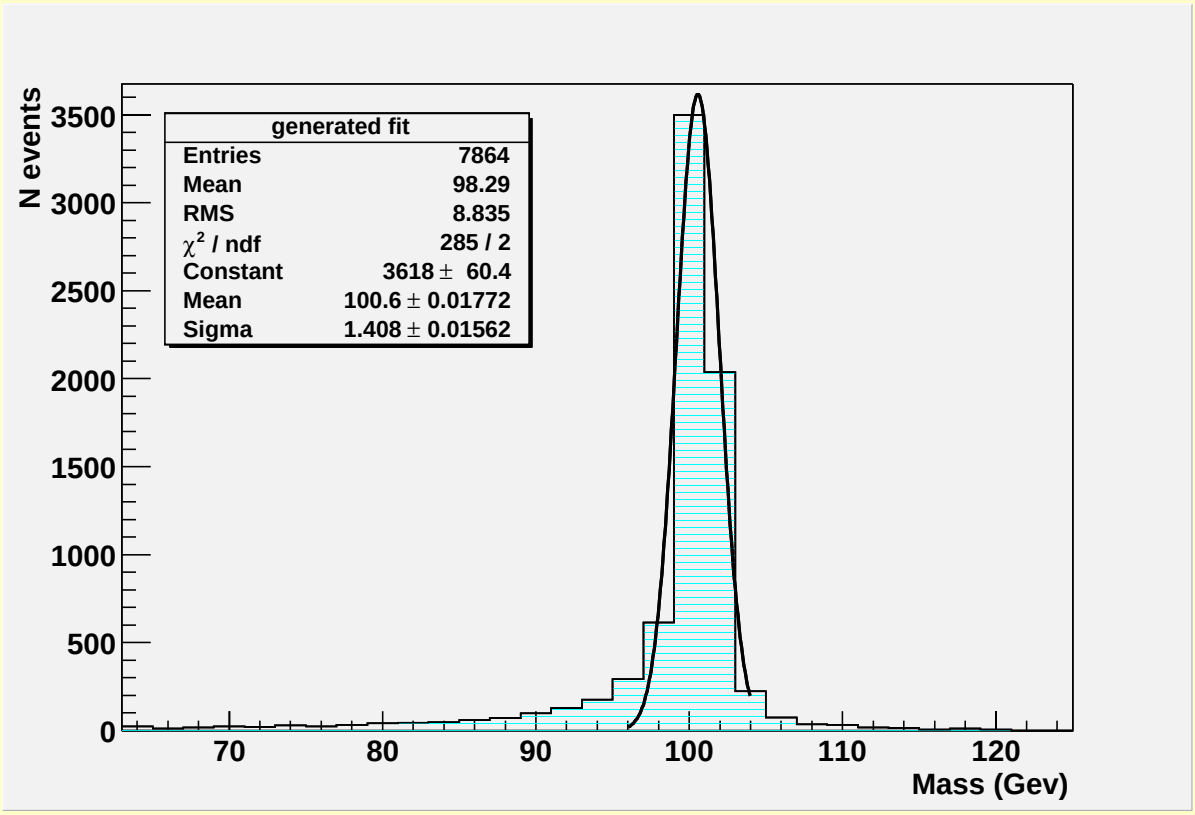
Inner Detector reconstruction bckg subtracted





$bb\,h \longrightarrow \mu^+\mu^-$

UP-TO-DATE

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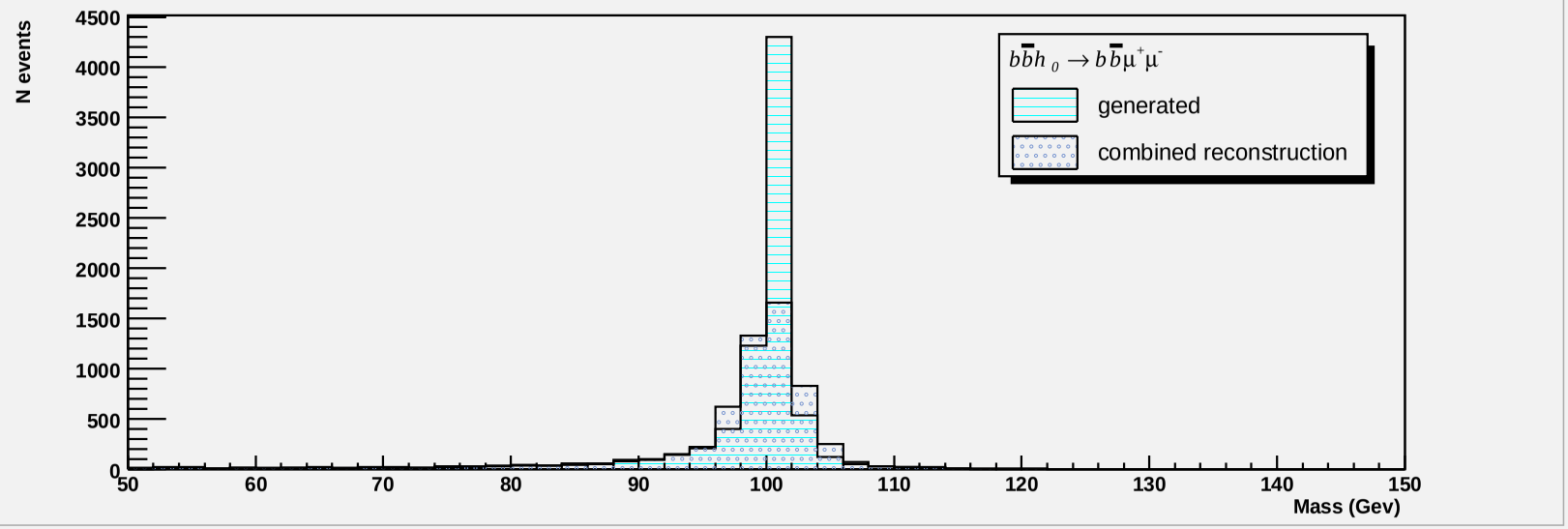
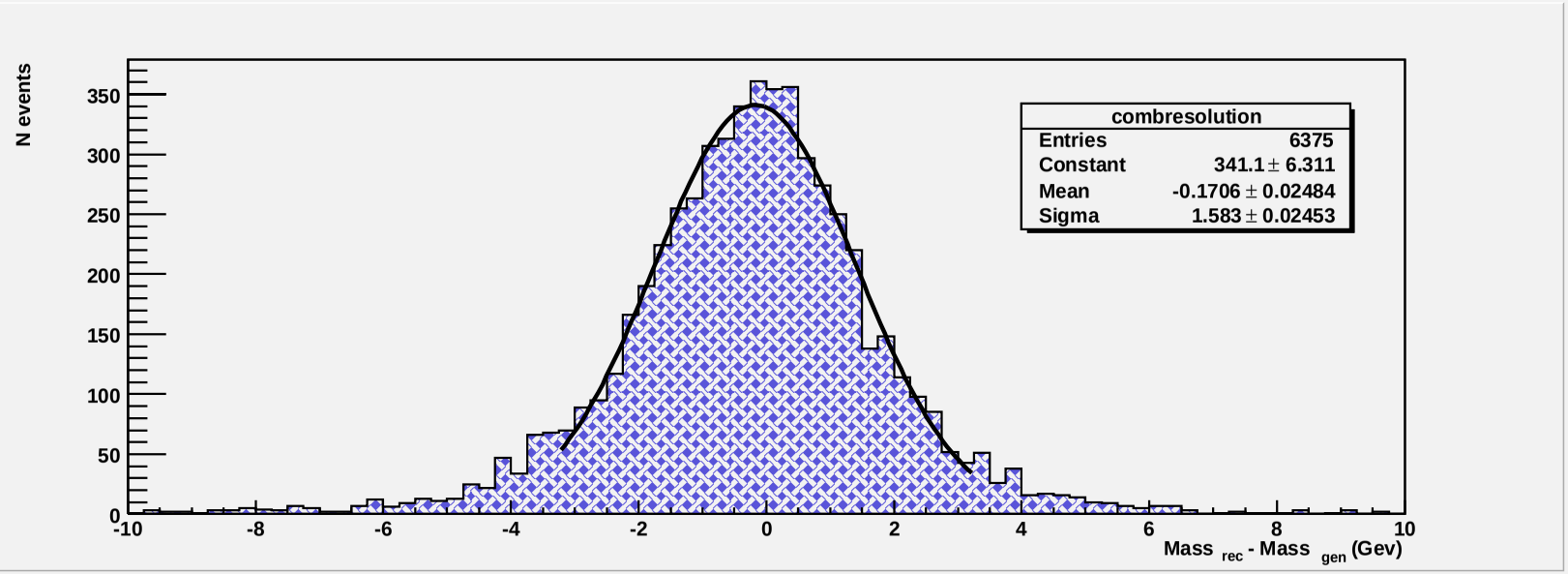
Combined reconstruction





Selection cuts

Preselection

- $\mathbf{P_T > 10\ GeV, |\eta| < 2.5}$
- $\mathbf{_T > 15\ GeV}$ e $\mathbf{|\eta| < 2.5}$

Selection:

- $\mathbf{^{\mu 1}_{t}} \in \mathbf{[25, 100]}$ GeV
- $\mathbf{^{\mu 2}_{t}} \in \mathbf{[25, 60]}$ GeV
- $\mu^+\mu^- \in \mathbf{h^0_{mass} \pm 2.5}$ GeV
- $\mathbf{^{b1}_{t} < 60}$ GeV
- $\mathbf{^{b2}_{t} < 55}$ GeV
- $\mathbf{^{miss}_{t}}$ missing $\mathbf{< 80}$ GeV

SAMPLES

Three different event samples are defined according the b-tag :

-
-
-

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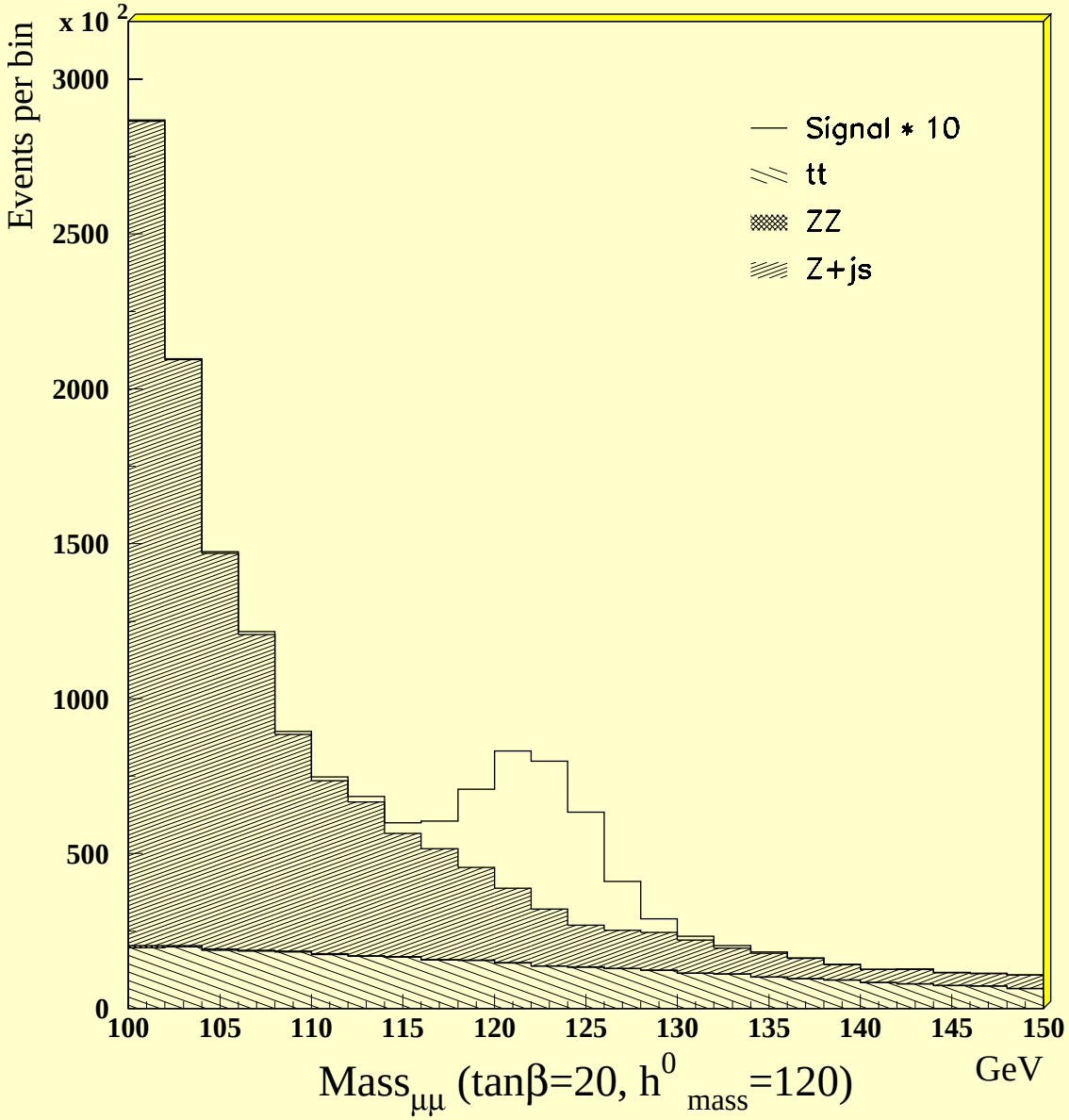
Analysis at $\tan\beta = 20$ *and* $m_h = 120$ *GeV (one b-tag sample)*

	$N_{h\to\mu\mu}$	N_{tt}	N_{zz}	N_{z+jets}
N_{gen}	34620	8544000	174000	2.412e+09
presel	5621	5128006	61682	1.621e+07
$P_t^{\mu 1}$	4623	3643464	46874	1.340e+07
$P_t^{\mu 2}$	3354	1989820	33759	1.024e+07
$M_{\mu^+\mu^-}$	2313	67743	98	24920
P_t^{b1}	2142	37990	82	22925
P_t^{b2}	1860	15880	69	20340
P_t^{miss}	1860	12234	69	20340

Table 1: Analysis step by step

$\tan\beta = 20$ *and* $m_h = 120$ *GeV (sigle b tag)*



Signal : neutral h and A bosons

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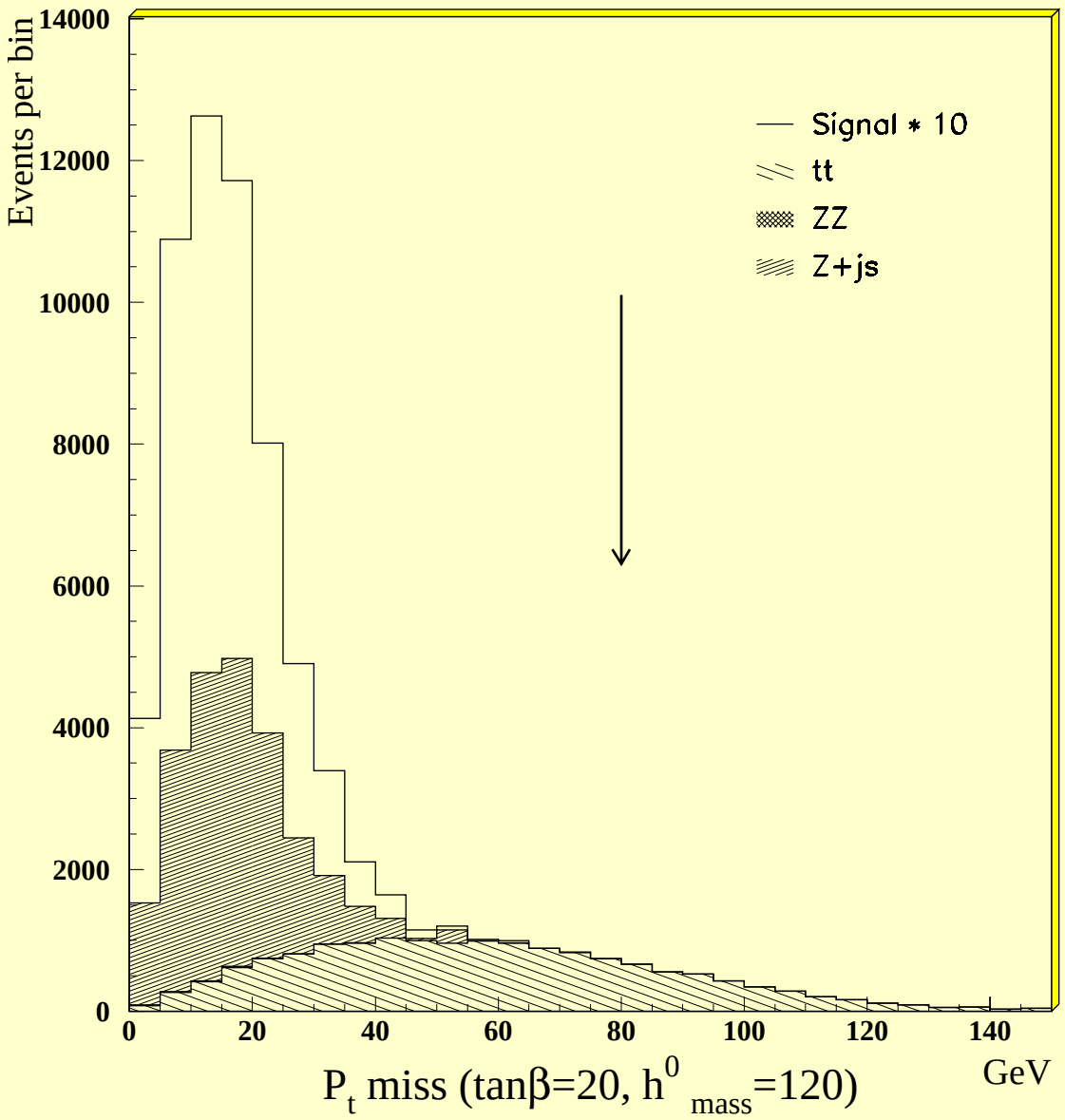
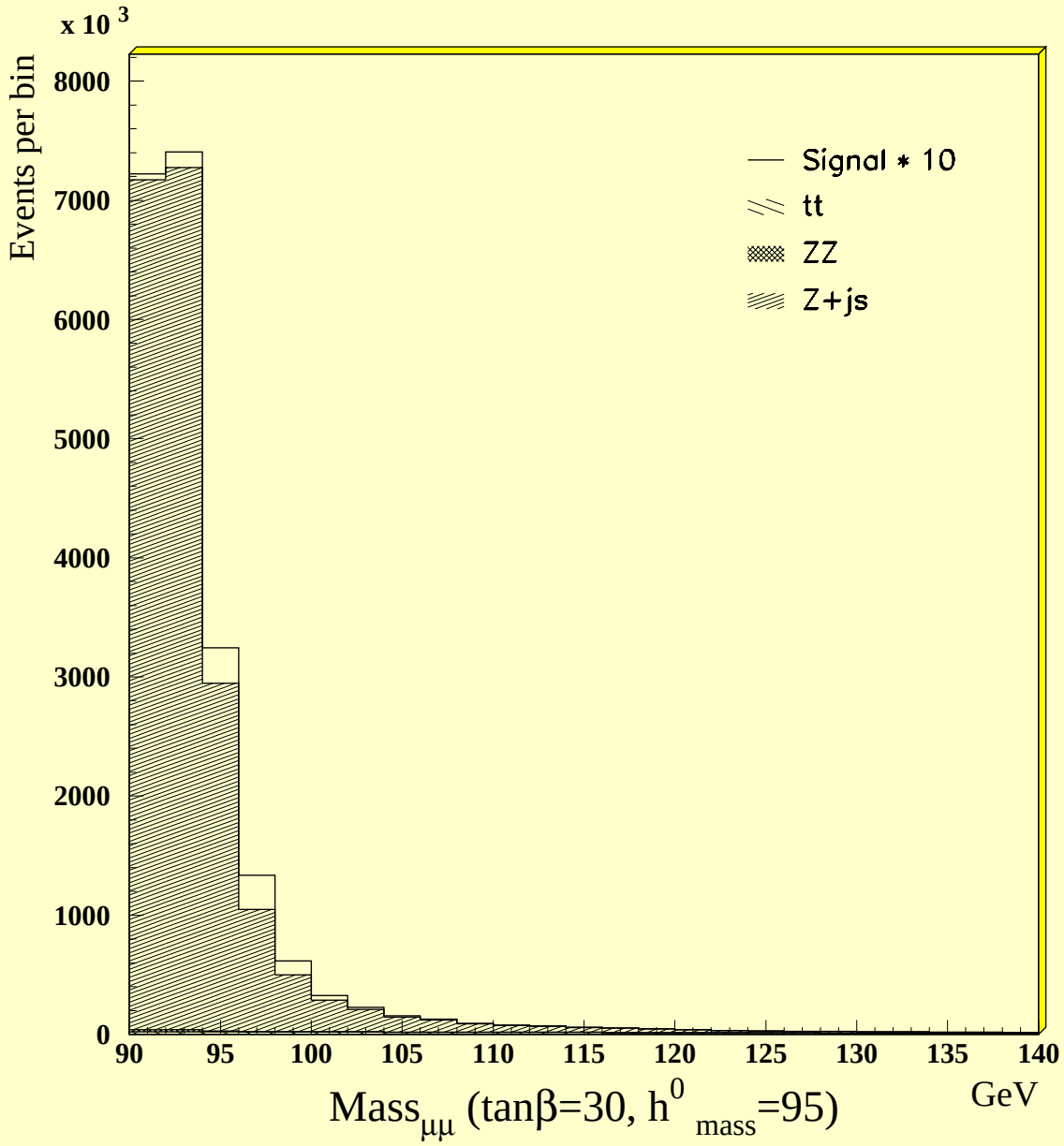
$\tan\beta = 20$ *and* $m_h = 120$ *GeV (single b tag)*



$\tan\beta = 30$ *and* $m_h = 95$ *GeV (sigle b tag)*



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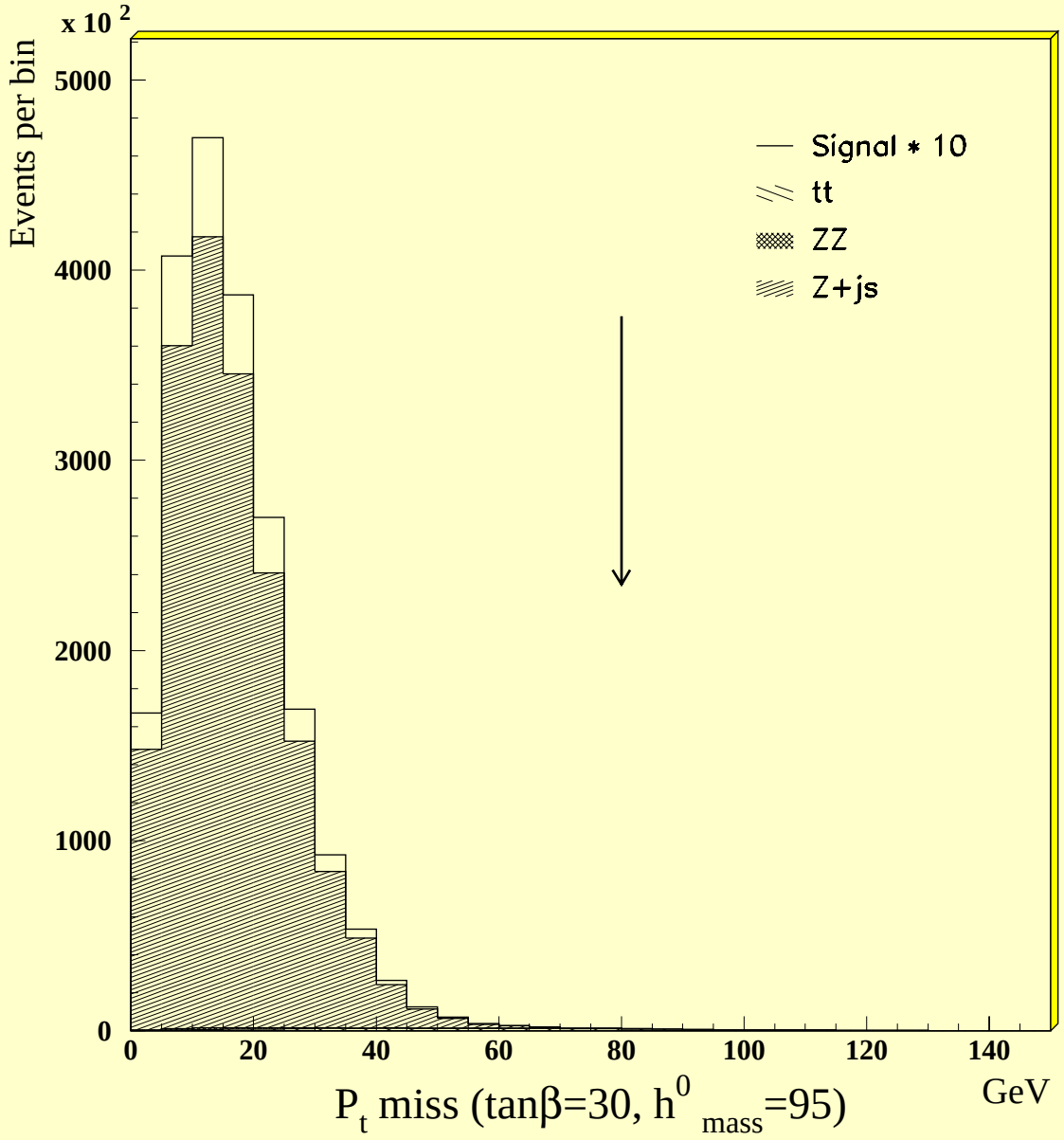
$\tan\beta = 30$ *and* $m_h = 95$ *GeV (single b tag)*



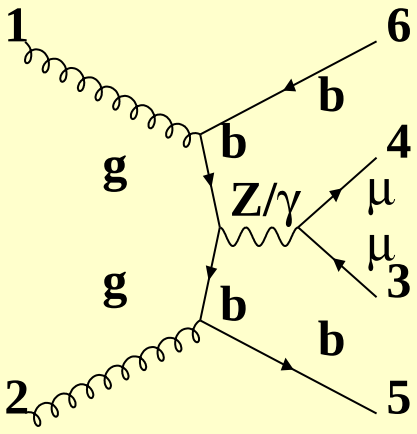
Difficulty in neutral h boson search:

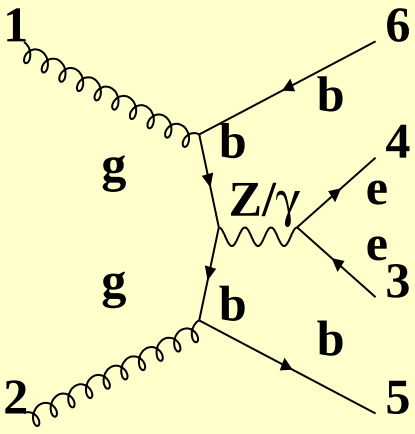
Precise knowledge of background.

in particularly:

$$Z \to \mu^+\mu^-$$

- $Z \to \mu^+\mu^-$ $\qquad$ $Z \to e^+e^-$





- boson: Br(h $\to e^+e^-$) negligible.

The final state for the background determination could be:

two b-jets + $\mathbf{e^+e^-}$

- decays.

BUT .....

- $^+\boldsymbol{\mu}^-$ and Z$\longrightarrow \mathbf{e^+e^-}$ have different inner-bremmstralung (ATLAS-PHYS-95-075).

- generator level. Detector performance is not implemented.

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- modifies in different way the shapes invariant mass of electrons and muons.

  $M_{e^+e^-}$ and $M_{\mu^+\mu^-}$

  difference up to $\approx 40\ \%$

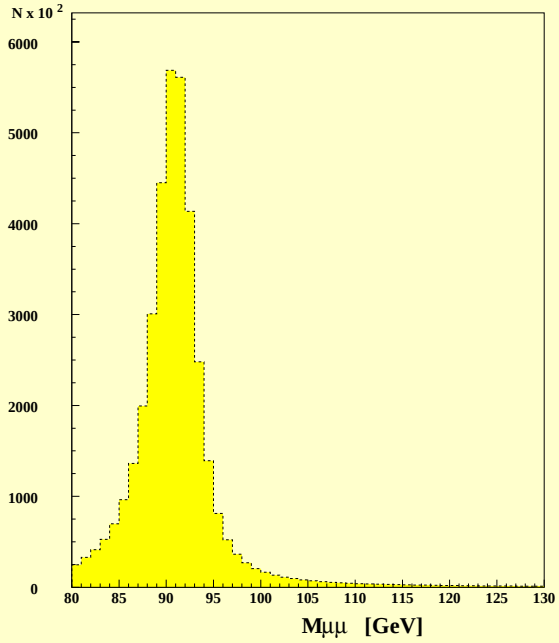
- $T > 7$ GeV or
- track.

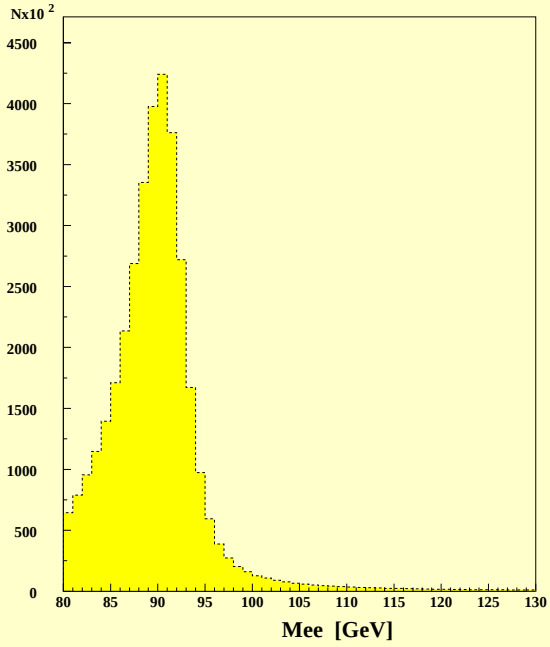
  added to four-momentum of electron $\mathbf{p}$.

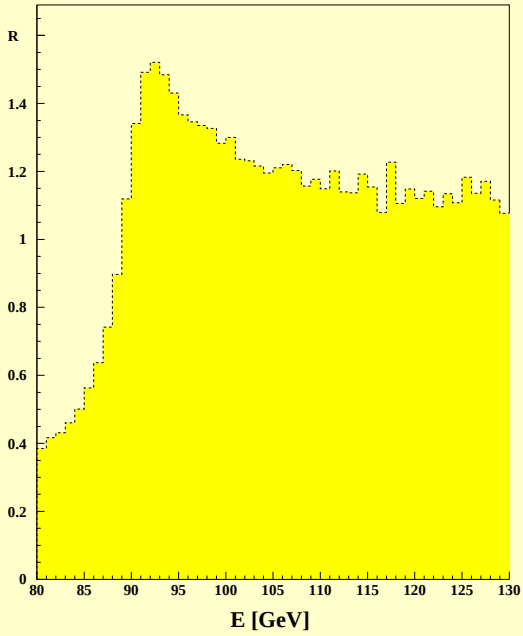
  $M_{e^+e^-}$ and $M_{\mu^+\mu^-}$

  difference reduced to $\approx 10\ \%$

$Z \longrightarrow e^+e^-$ *and* $Z \longrightarrow \mu^+\mu^-$







$$\mathbf{R} = \frac{M_{\mu^+\mu^-}}{M_{e^+e^-}}$$

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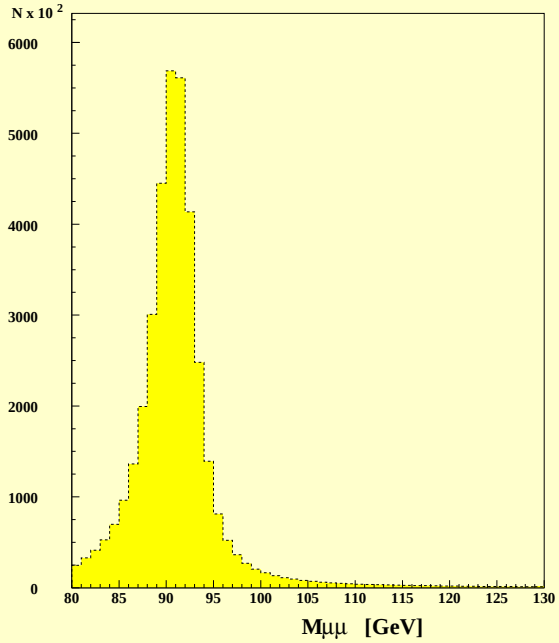
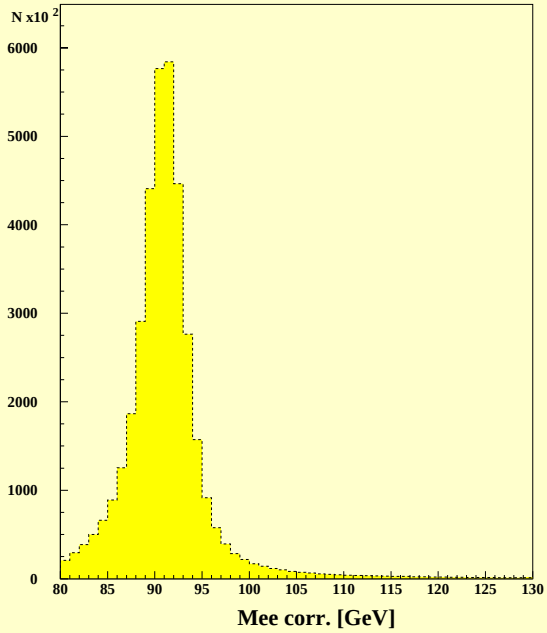
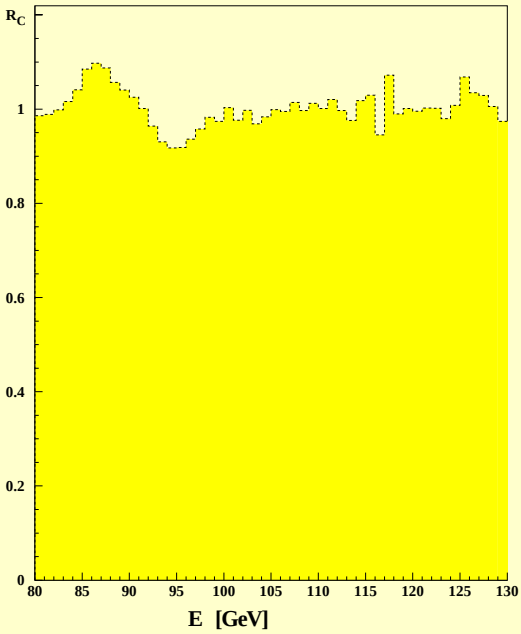
$Z \longrightarrow e^+e^-$ *and* $Z \longrightarrow \mu^+\mu^-$







$$\mathbf{R} = \frac{M_{\mu^+\mu^-}}{M^{\mathrm{corr}}_{e^+e^-}}$$

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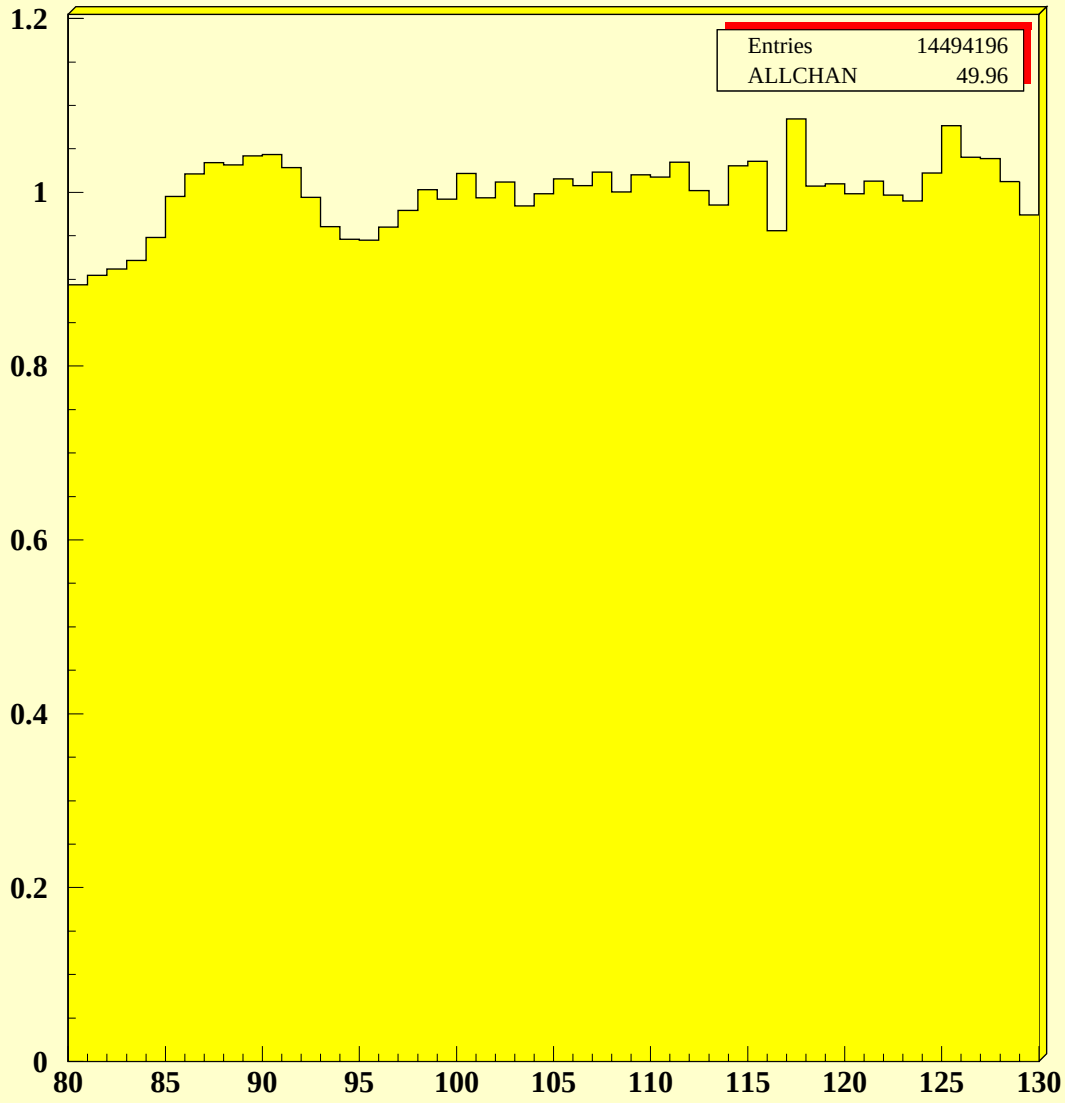
$Z \to e^+e^-$ *and* $Z \to \mu^+\mu^-$



$$\mathbf{R} = \frac{M^{\mathbf{corr}}_{\mu^+\mu^-}}{M^{\mathbf{corr}}_{e^+e^-}}$$

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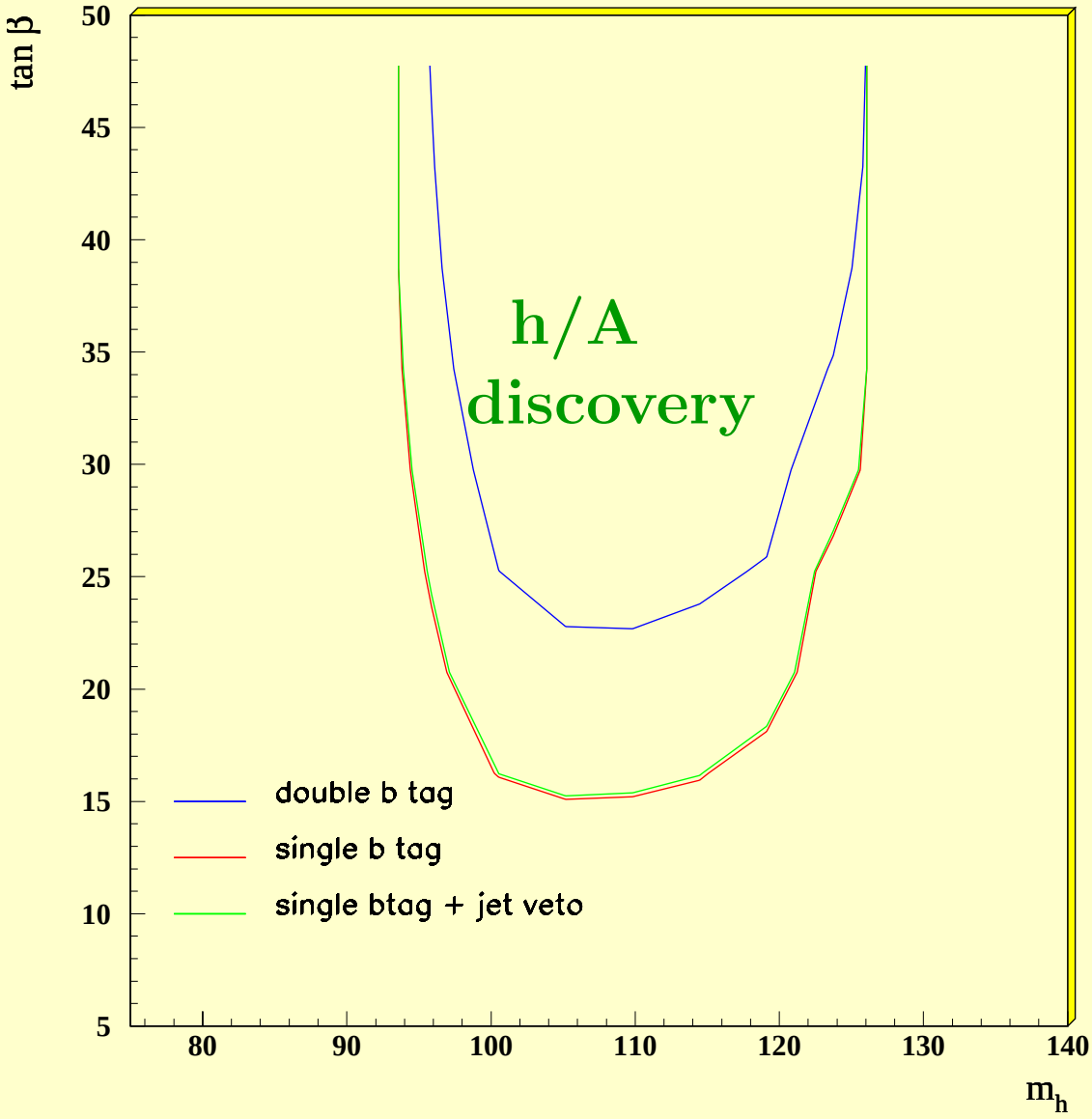
Discovery plot at $S/\sqrt{B} = 5$ with 300 fb^{-1}



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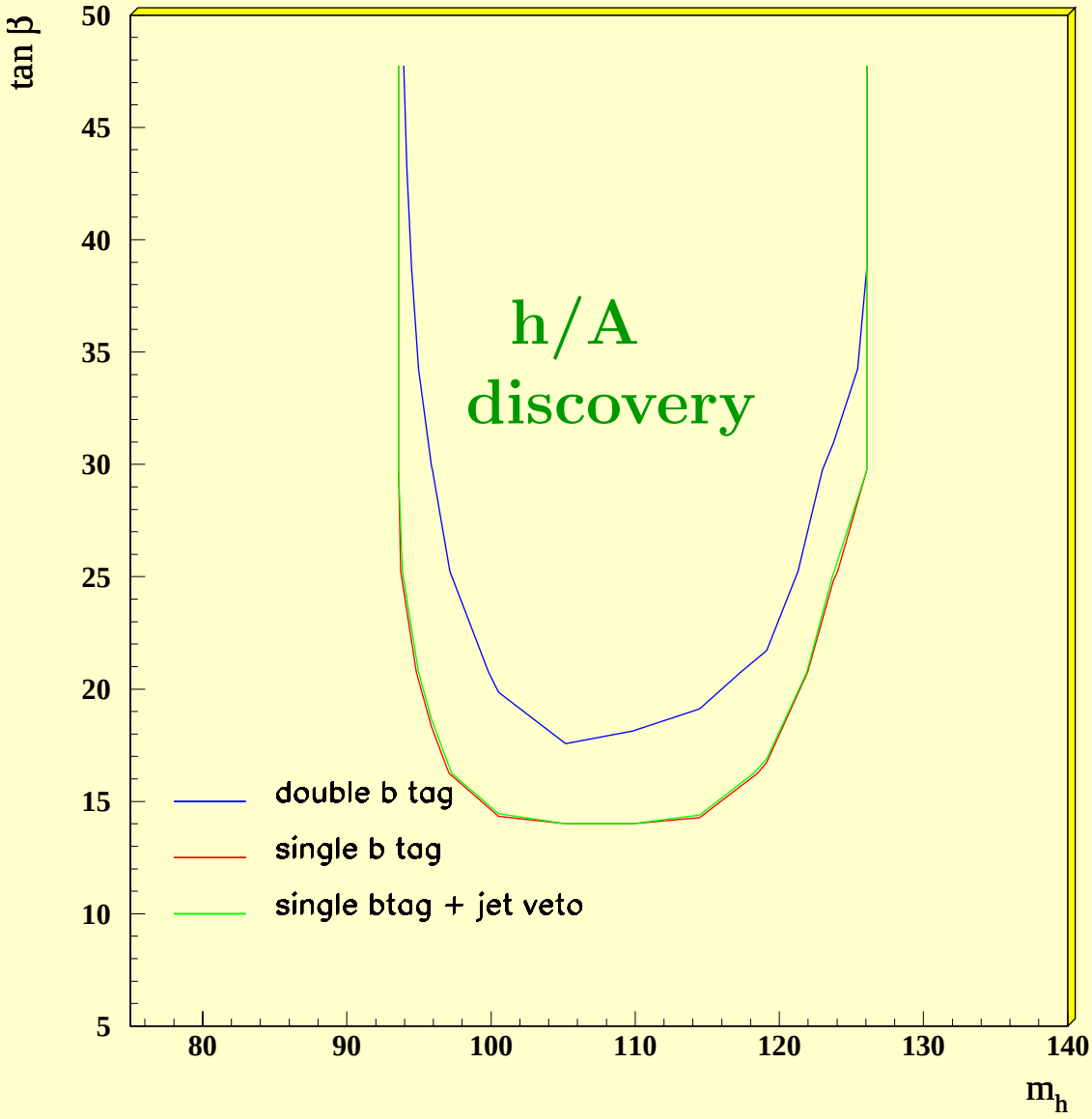
Discovery plot at $S/\sqrt{B} = 3$ with 300 fb^{-1}



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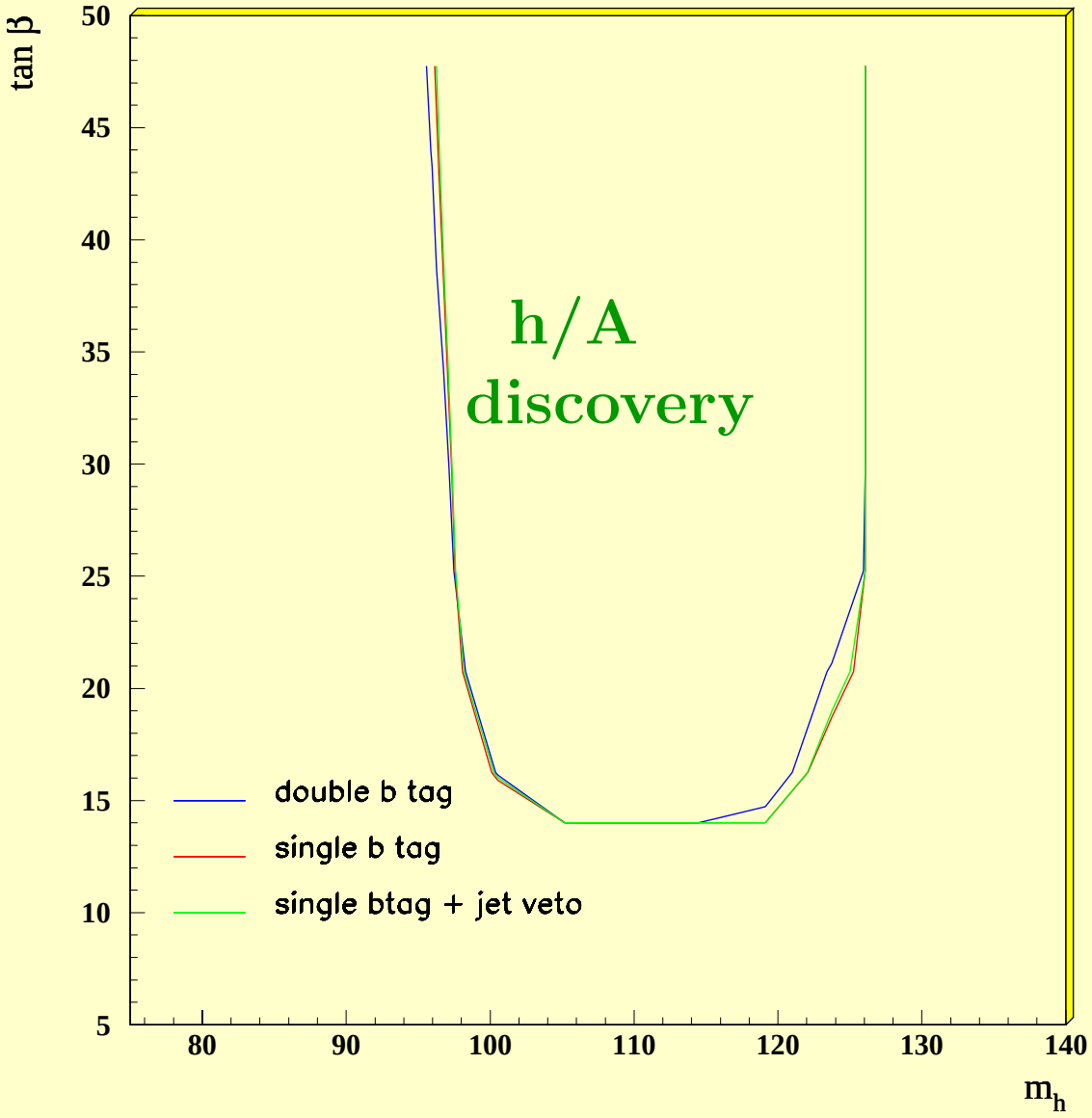
S/B plot at S/B = 0.01 with 300 fb^{-1}



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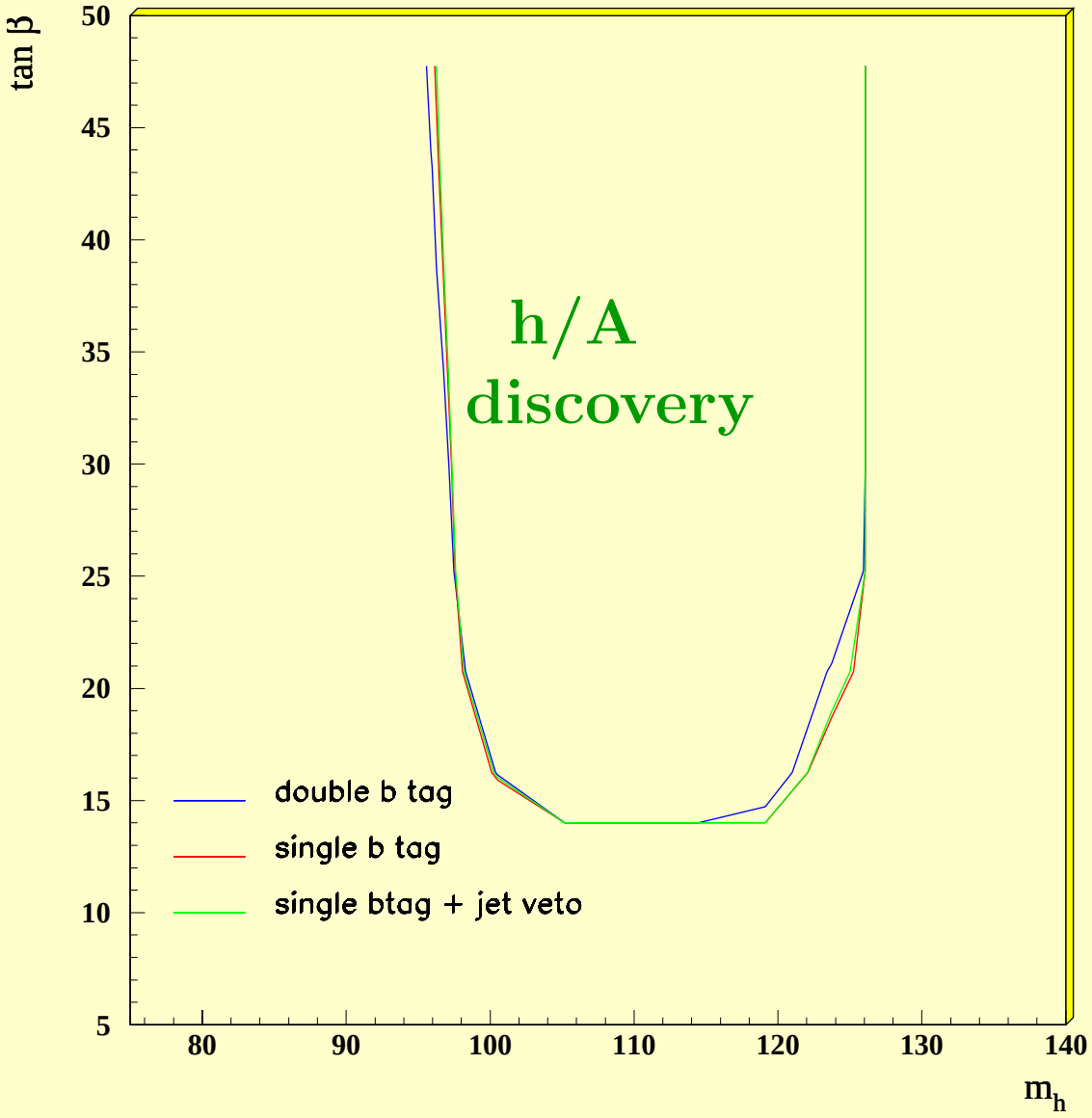
S/B plot at S/B = 0.01 with 300 fb^{-1}



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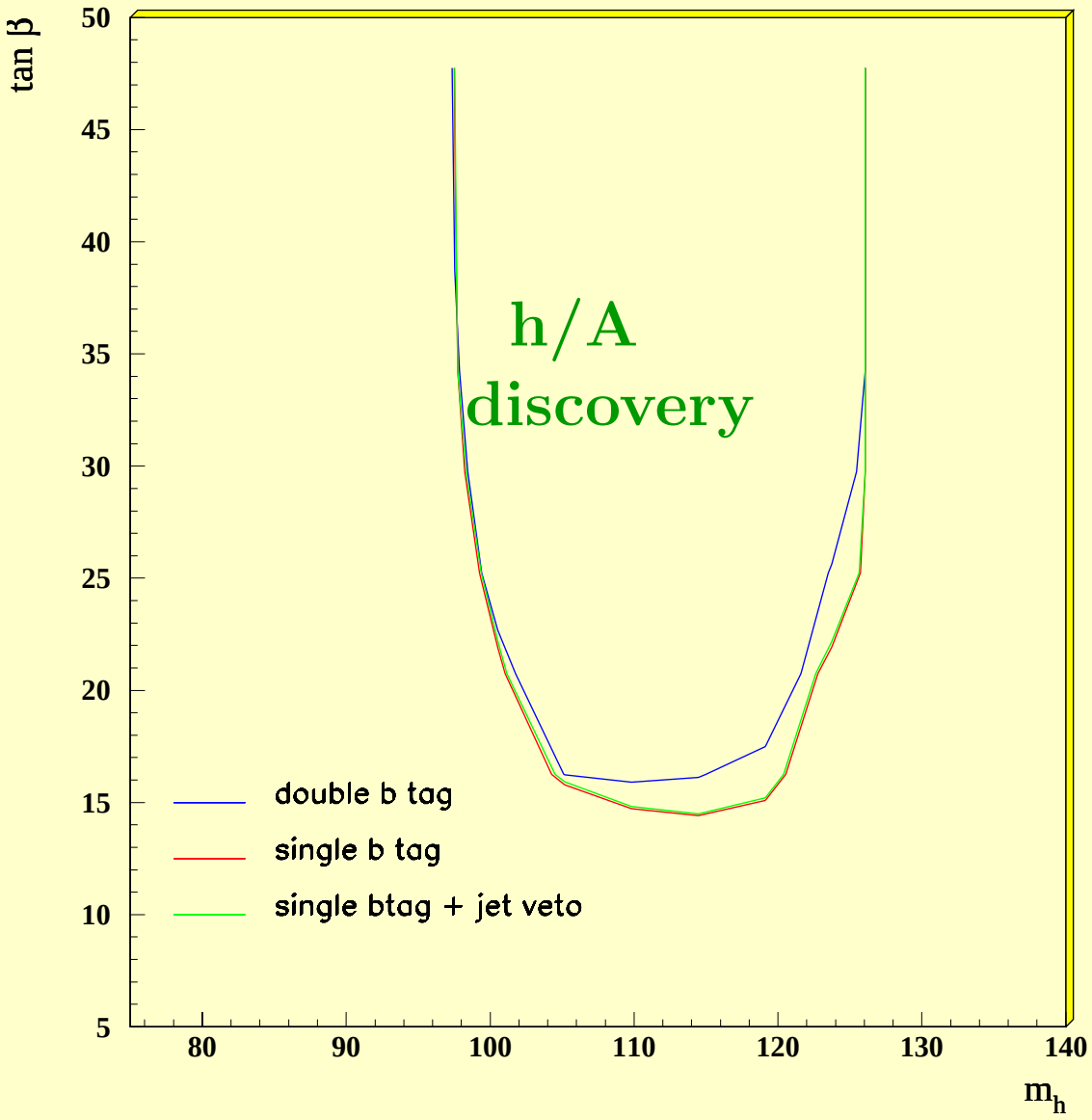
S/B plot at S/B = 0.02 with 300 fb^{-1}



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Conclusions

- $\tan\beta$ and $m_h \approx 100$ GeV has been studied using $h \longrightarrow \mu^+\mu^-$ with 2 jets production.
- $\sqrt{B} = 5$ is reached at $\tan\beta \simeq 20$ and $m_h \simeq 100$ GeV.
- request of a single b-jet identified in the event.
- for an efficient background subtraction.