

# MSSM BR Report and Plans for YR4

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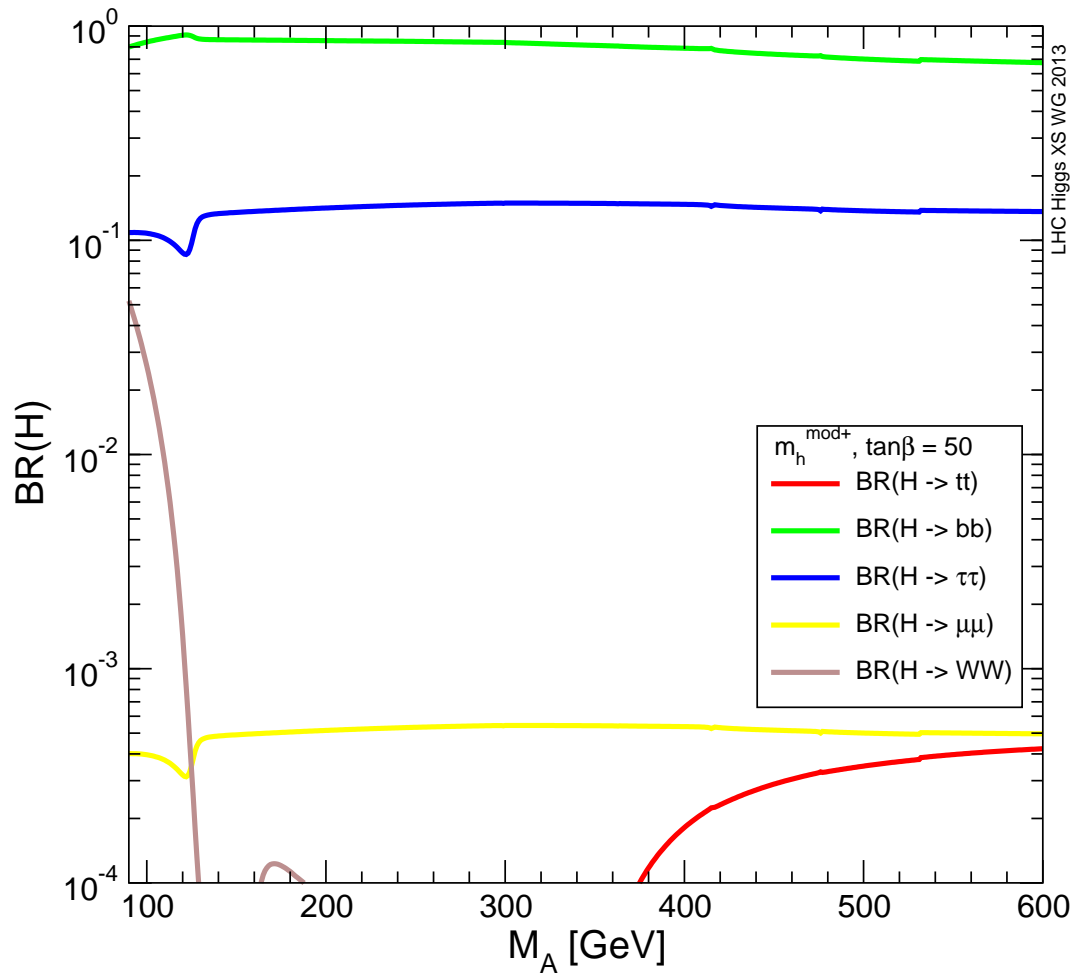
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other contributors: Michael Spira

- MSSM Higgs decays
- Exotic MSSM Higgs decays
- Plans for YR4

# MSSM Higgs Decays



Status:

Predictions for MSSM decay channels based on [FeynHiggs](#) and [Hdecay](#)

Results: “classic benchmarks”

- $m_h^{\text{max-up}}$
- $m_h^{\text{mod+}}$
- $m_h^{\text{mod-}}$
- light-stop
- light-stau
- tau-phobic
- low- $M_H$

## Previous new additions:

- $H \rightarrow hh$  (FH) and  $A \rightarrow hZ$  (FH) included  
→ request by ATLAS/CMS
- Extended range of  $M_A = 5 \dots 90$  GeV included  
→ request for light charged Higgs searches
- Extended range of  $\mu = \pm 1000, \pm 500, \pm 200$  GeV  
→ request by the  $\phi \rightarrow b\bar{b}$  group

## New additions:

- $H \rightarrow ZA$  (FH),  $h/H \rightarrow AA$  (FH),  $H \rightarrow W^\pm H^\mp$  (HD) included
- Extended range of  $M_A = 1 \dots 2$  TeV included  
⇒ everything recalculated with FH2.11.2 and HD6.3.1
- New scenarios for low  $\tan \beta$   
→ request by ATLAS/CMS to have a scenario valid at low  $\tan \beta$   
to get large  $\text{BR}(H \rightarrow hh)$ ,  $\text{BR}(A \rightarrow hZ)$   
→ evaluated for “low-tb-high” (“hMSSM” based on Hdecay)  
⇒ see Pietro’s talk yesterday!

## Exotic MSSM Higgs decays

New, interesting decays/scenarios?

From my email with Stefania :-)

Stefania:

For the specific case of the MSSM, we are thinking to decays of the type  $h \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 \rightarrow (\gamma \tilde{G}) (\gamma \tilde{G})$  (with  $\tilde{G}$  the gravitino and  $\tilde{\chi}_1^0$  mainly bino).

$\Rightarrow$  “GMSB type” scenario

Sven:

I understand that  $\text{BR}(\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}) = 1$  is assumed, but that the parameters  $m_{\tilde{\chi}_1^0}$ ,  $m_{3/2}$  and the neutralino mixing matrix are still relevant. The longer the life time the better? Probably up to a certain limit that gives you displaced photons (with a decay length  $c\tau$ ). What are your preferred values?

$\text{BR}(h \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0)$  is in principle evaluated in our machinery. So far it did not play a role, because in the benchmark scenarios so far  $m_{\tilde{\chi}_1^0} > M_h/2$ .

## How to find an interesting scenario?

Scenario needed with  $M_1 \neq M_2$  at the GUT scale, equivalent to  $M_1 \neq M_2/2$  at the EW scale. The easiest would be to treat  $M_1$  and  $M_2$  independent parameters.

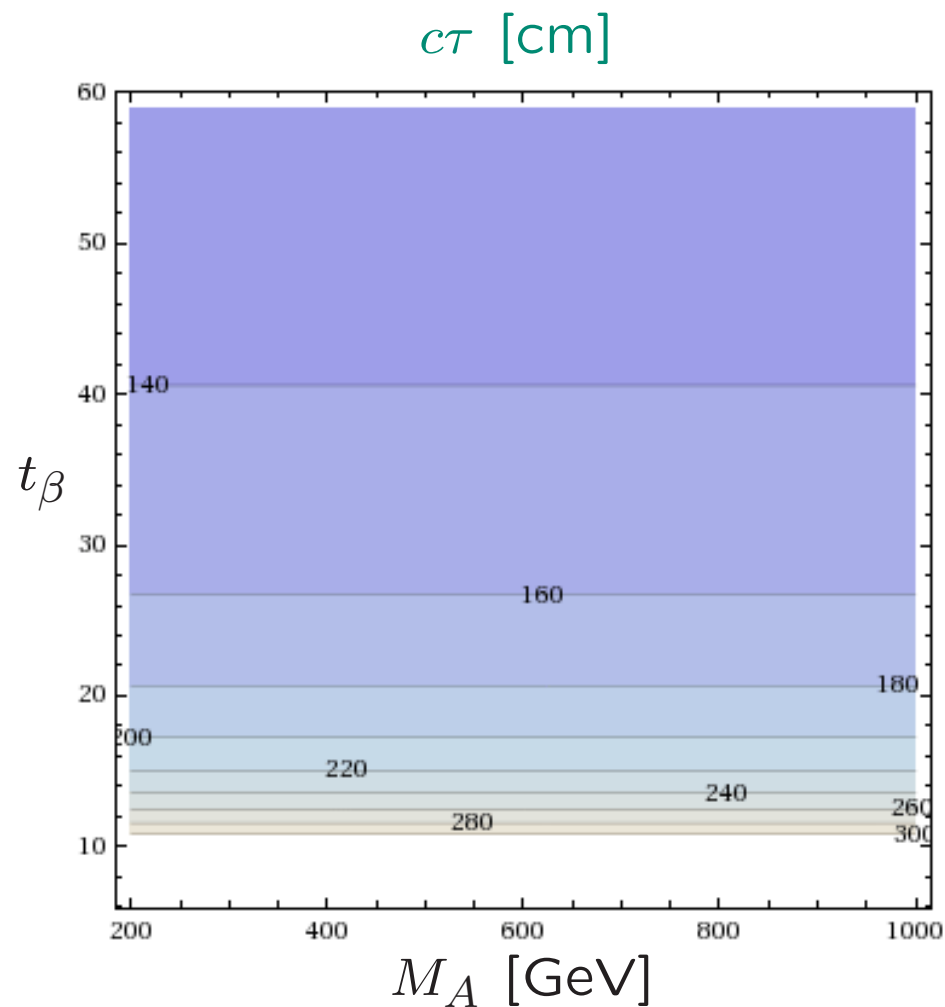
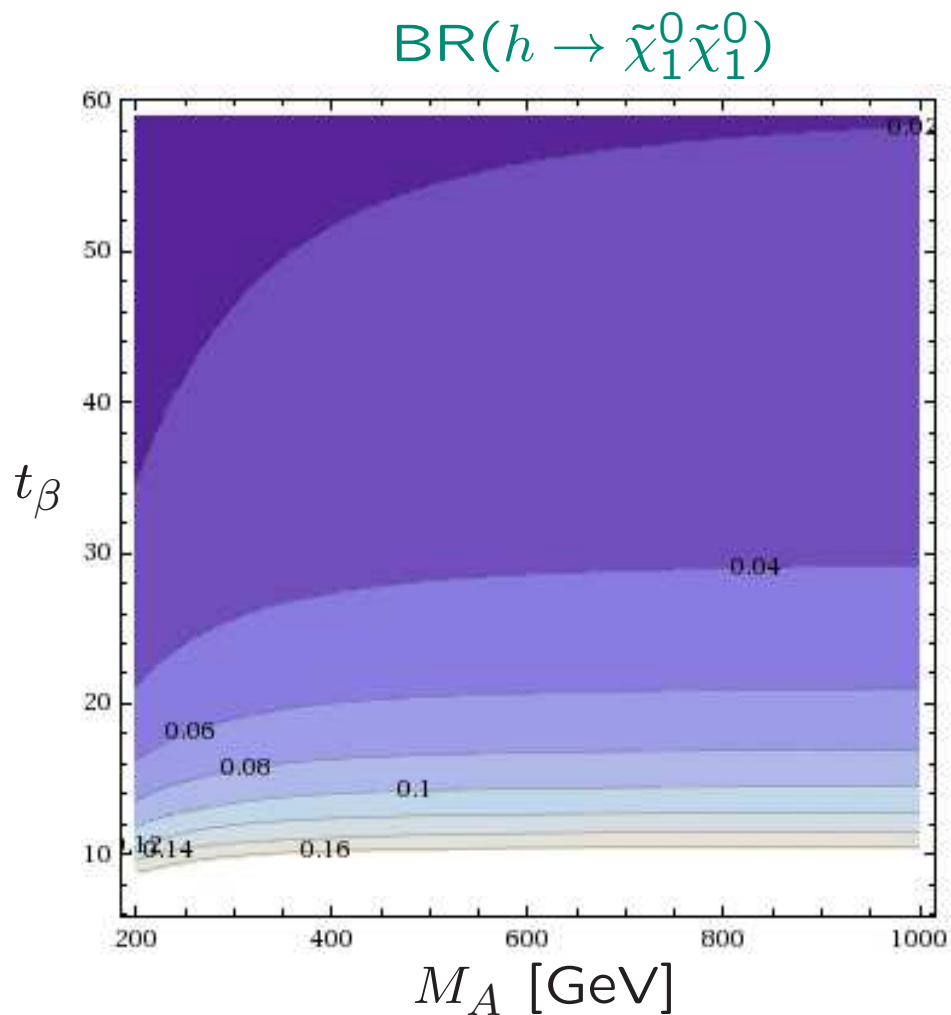
- start with a known benchmark scenario: [mhmod+](#)
- Treat  $M_1$  as independent parameter  
⇒ scan over  $M_1, M_A, \tan \beta$   
→  $M_1 \sim M_2/2$  is connection to original mhmod+ scenario
- Evaluate:  $m_{\tilde{\chi}_1^0}, \text{BR}(h \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0), \text{decay length } c\tau$  [arXiv:0909.3523]

$$c\tau = 48\pi \frac{m_{3/2}^2 M_{\text{Pl}}^2}{m_{\tilde{\chi}_1^0}^5} \frac{1}{|P_{1\gamma}|^2}$$

$$P_{1\gamma} = N_{11}c_W + N_{12}s_W$$

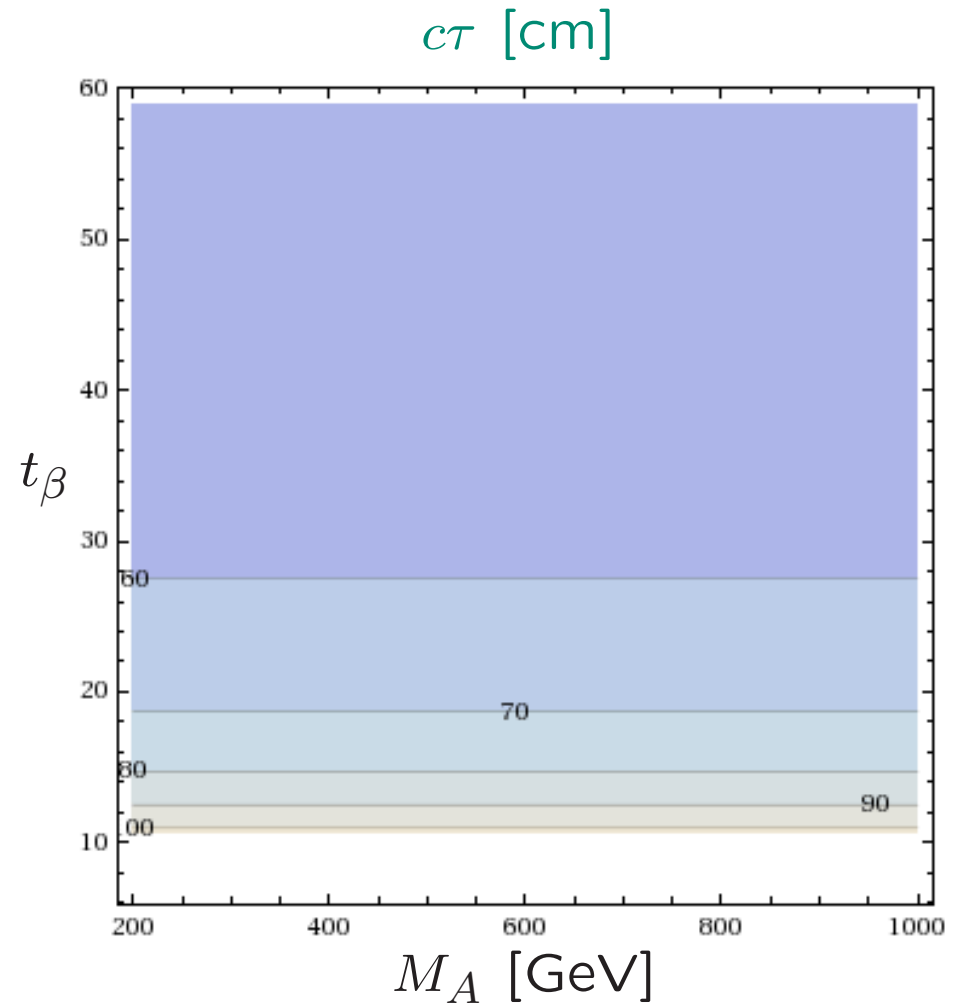
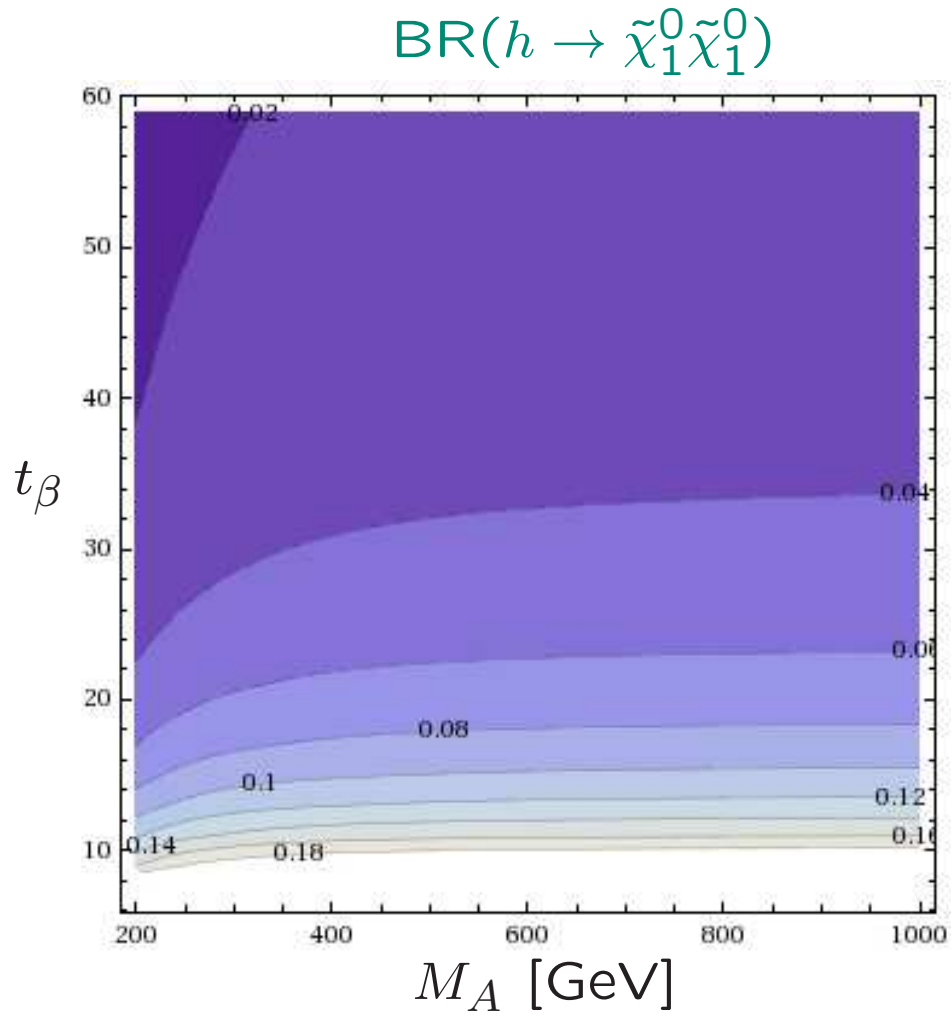
- $m_{3/2} = 0.6\text{eV}$ : gravitino mass
  - $M_{\text{Pl}}$ : Planck mass
  - $N_{ij}$ : neutralino mixing matrix
- evaluated with FH2.11.2

mhmod+ with  $M_1 = 10$  GeV:



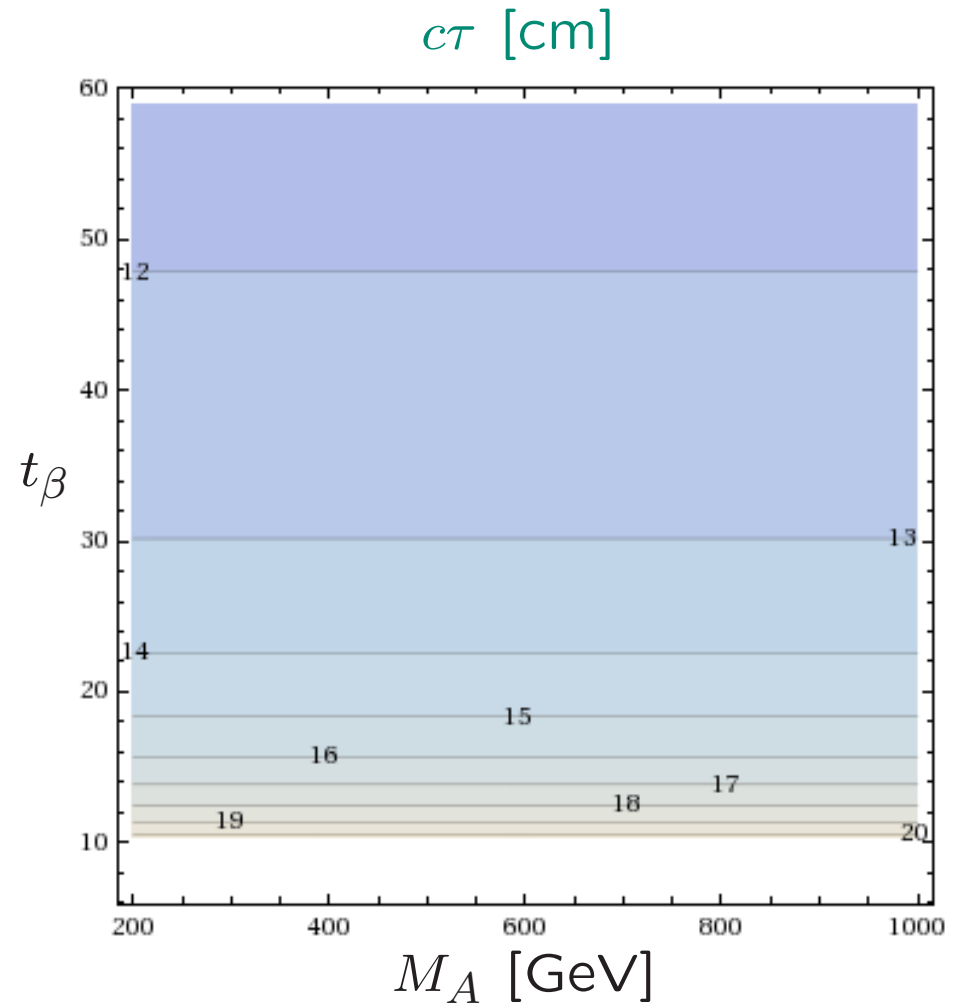
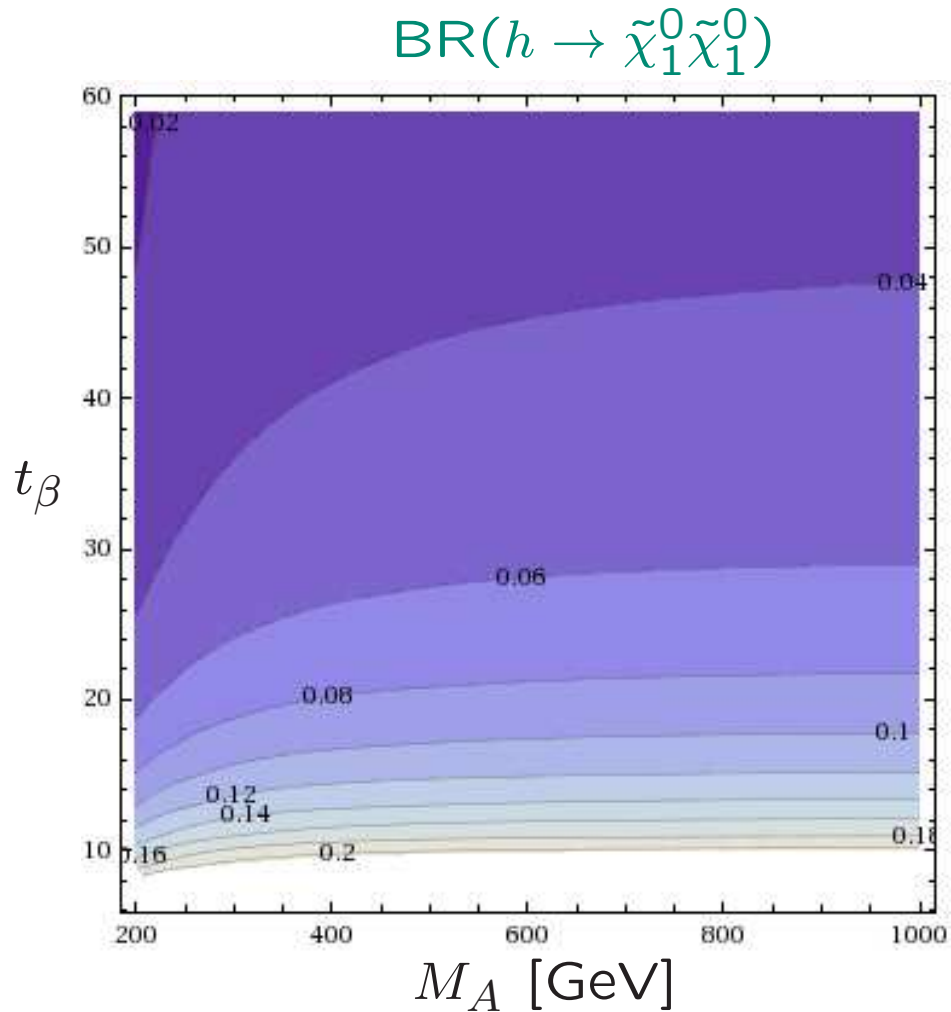
$\Rightarrow$  decay length of  $\mathcal{O}(1\text{m})$

mhmod+ with  $M_1 = 12$  GeV:



$\Rightarrow$  decay length of  $\mathcal{O}(0.5\text{m})$

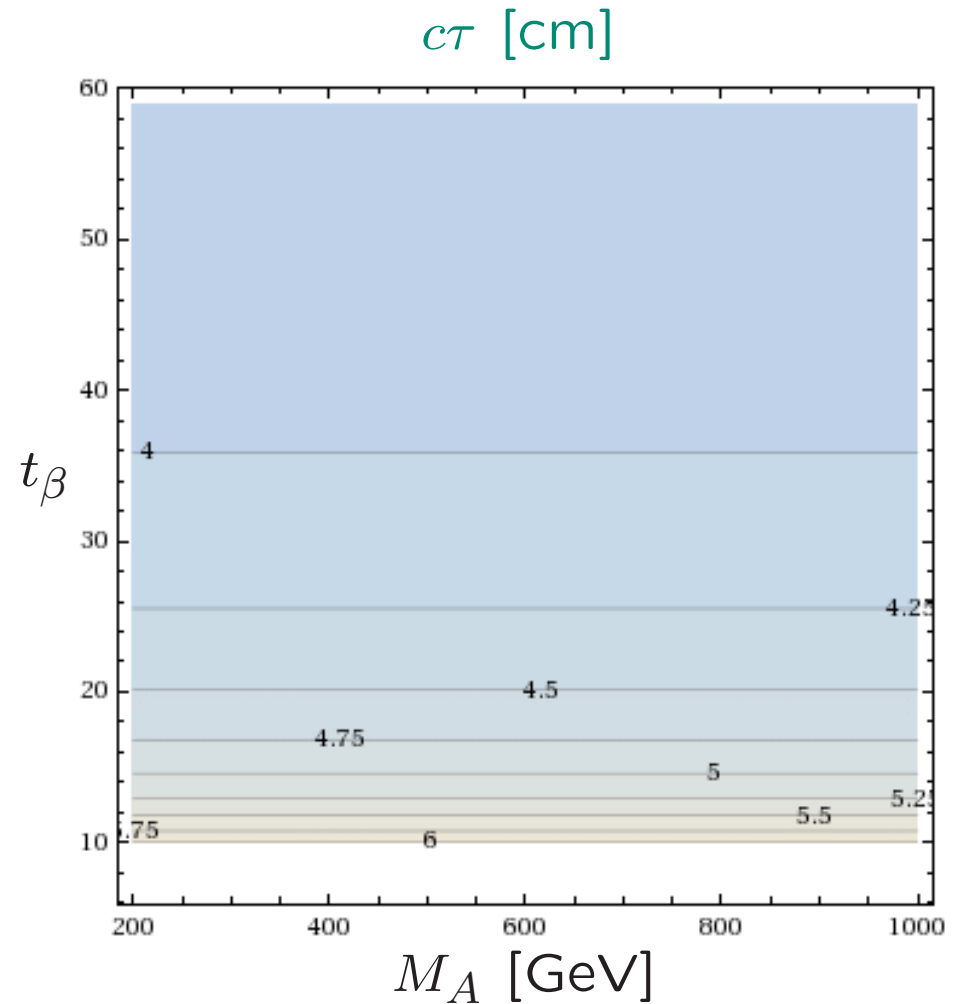
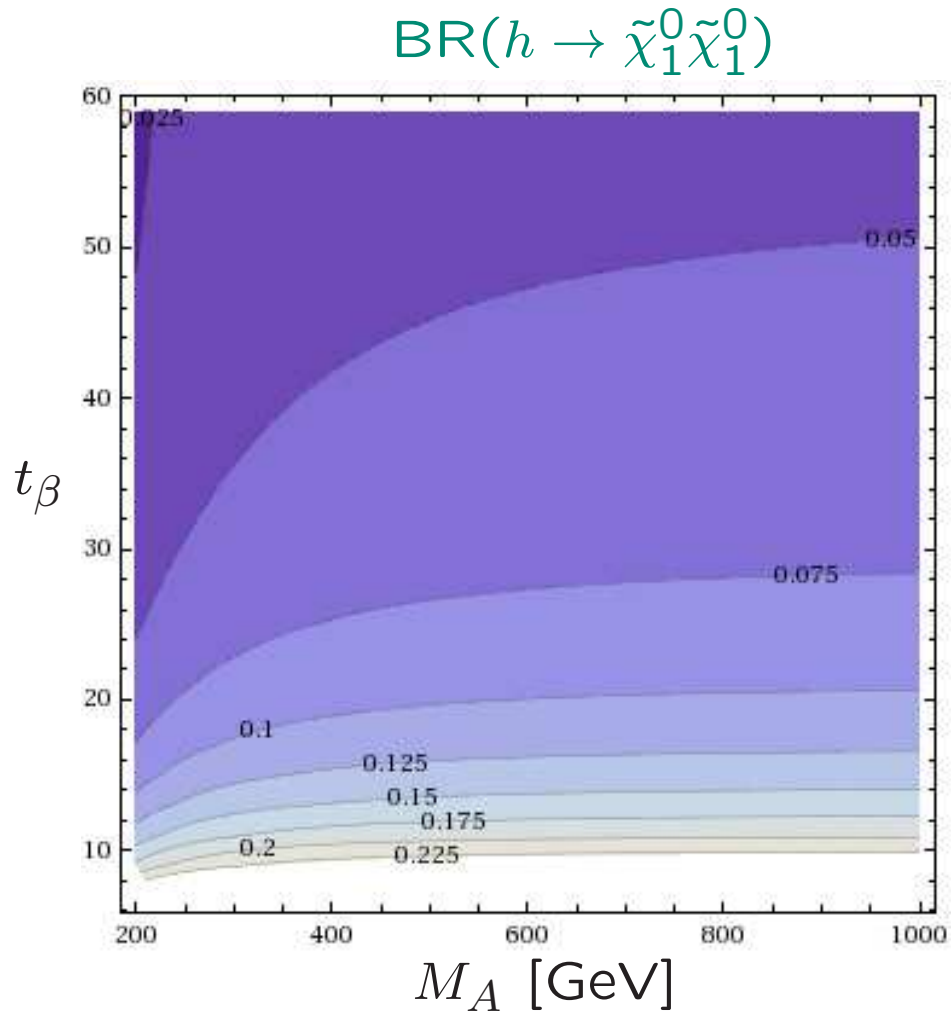
mhmod+ with  $M_1 = 16$  GeV:



$\Rightarrow$  decay length of  $\mathcal{O}(10\text{cm})$

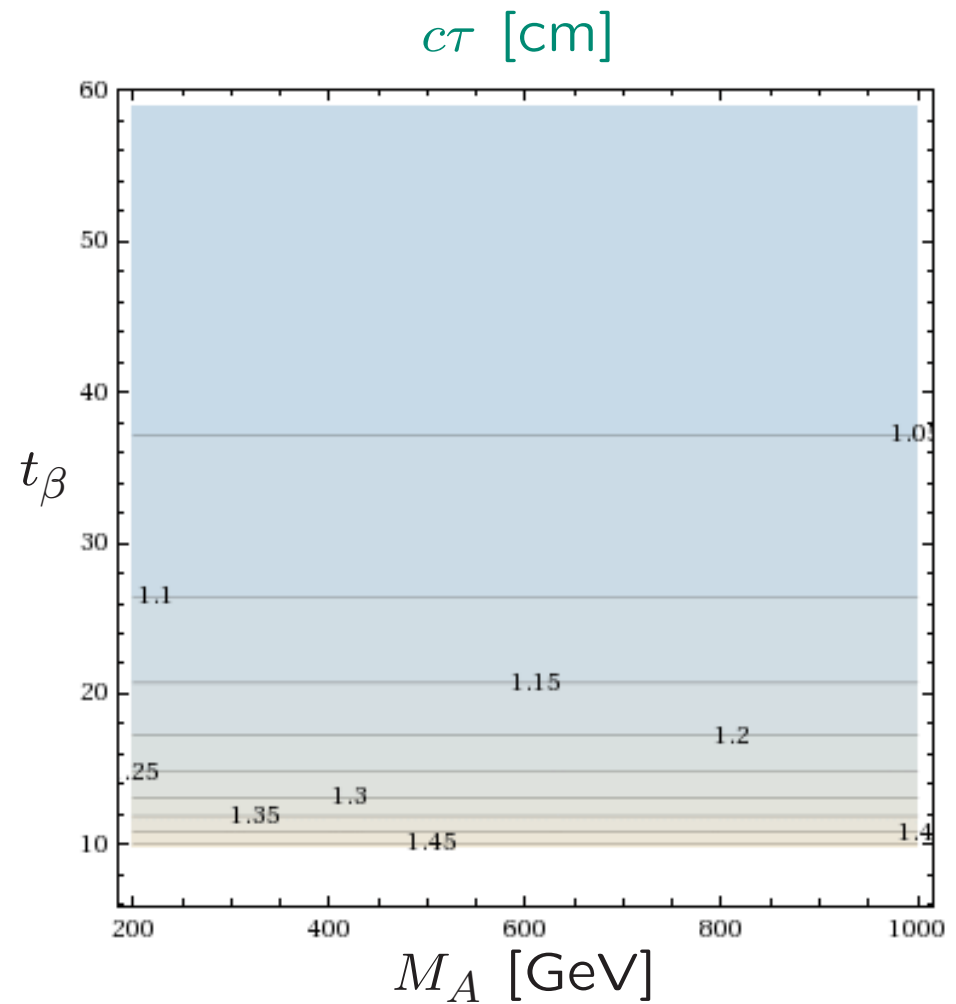
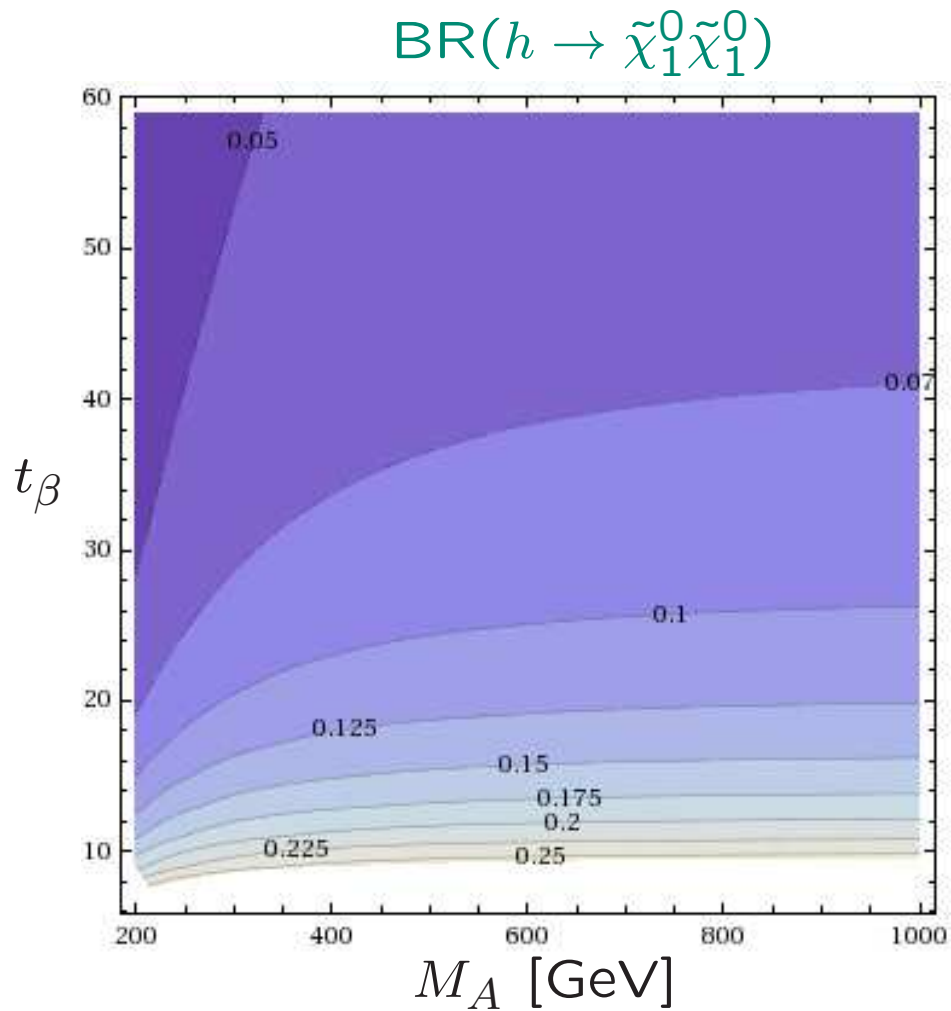


mhmod+ with  $M_1 = 20$  GeV:



$\Rightarrow$  decay length of  $\mathcal{O}(5\text{cm})$

mhmod+ with  $M_1 = 26$  GeV:



$\Rightarrow$  decay length of  $\mathcal{O}(1\text{cm})$

$\Rightarrow$  strong  $M_1$  dependence!

## Plans for YR4

- SM BR update (see Michael Spira's talk)
  - concentrate on  $M_H = 122 \dots 128$  GeV?!
  - later for “full” mass range (for interpretation of extended searches)?!
- Dalitz decays (see Michael Spira's talk)
  - include a recommendation if agreement between ATLAS and CMS is found
- Update of MSSM BRs  
(additional channels, very brief . . . )
- Description of exotic decay evaluation?!
  - coordinate with Exotic decay group!

Back-up