Hypercharged Anomaly-Mediated Supersymmetry Breaking at the LHC

PHENO '09

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Homer L. Dodge Dept. of Physics and Astronomy

May 12, 2009

Introduction

authors

- Hypercharged Anomaly Mediation

  Radovan Dermisek, Herman Verlinde, Lian-Tao Wang

  Phys.Rev.Lett.100:131804,2008

  arXiv:0711.3211 [hep-ph]

- Prospects for Hypercharged Anomaly-Mediated SUSY Breaking at the LHC

  H. Baer, R. Dermisek, S. Rajagopalan, H. Summy

  On arXiv soon

Introduction

Overview

- Describe the HCAMSB model
- Look at the mass spectrum
- (preliminary) Event generation for the LHC

HCAMSB

Anomaly Mediation

HCAMSB

Anomaly Mediation

Soft Parameters in SUGRA Models

HCAMSB

Anomaly Mediation

Soft Parameters in SUGRA Models

Visible Sector
(MSSM)

Hidden Sector
(SM Gauge Singlets)

HCAMSB

Anomaly Mediation

Soft Parameters in SUGRA Models

Visible Sector (MSSM)	- - - - - - - - - -	Hidden Sector (SM Gauge Singlets)

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Anomaly Mediation

Soft Parameters in SUGRA Models

Visible Sector
(MSSM)

tree-level
- - - - - - - - - -
gravitational int.

Hidden Sector
(SM Gauge Singlets)

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Anomaly Mediation

Soft Parameters in SUGRA Models

Visible Sector (MSSM)	tree-level - - - - - - - - - - gravitational int. + additional 1-loop contribution (super-Weyl anomaly)	Hidden Sector (SM Gauge Singlets)

HCAMSB

Anomaly Mediation

Soft Parameters in SUGRA Models

Visible Sector (MSSM)	tree-level - - - - - - - - - - gravitational int. + additional 1-loop contribution (super-Weyl anomaly)	Hidden Sector (SM Gauge Singlets)

Tree-level suppression $\Longleftrightarrow$ *ExtraDimensions*

HCAMSB

Anomaly Mediation

AMSB is nice because. . .

HCAMSB

Anomaly Mediation

AMSB is nice because...

- all soft terms depend on single parameter: $m_{3/2}$
- solves SUSY flavor and CP problems
- soft contributions are scale invariant

HCAMSB

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However AMSB alone is problematic:

HCAMSB

Anomaly Mediation

AMSB is nice because...

- all soft terms depend on single parameter: $m_{3/2}$
- solves SUSY flavor and CP problems
- soft contributions are scale invariant

However AMSB alone is problematic:

- well known that sleptons are tachyonic: $m^2_{sleptons} < 0$
- Adhoc m_0 bumps up those masses
  $\Rightarrow$ soft terms no longer RGE invariant

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minimal AMSB

Soft Contributions in AMSB Models

Parameter Space:

$$(m_0,)\ m_{3/2}, tan\beta, sign(\mu)$$

RGE's:

$$M_a = \frac{b_a g_a^2}{16\pi^2} m_{3/2}, \quad a = 1, 2, 3$$

$$m_i^2 = -\frac{1}{4}\{\frac{d\gamma}{dg}\beta_g + \frac{d\gamma}{df}\beta_f\} m_{3/2}$$

$$A_f = \frac{\beta_f}{f} m_{3/2}$$

HCAMSB

Hypercharged Mediation

HCAMSB

Hypercharged Mediation

This mediation of SUSY-breaking relies on a few things:

HCAMSB

Hypercharged Mediation

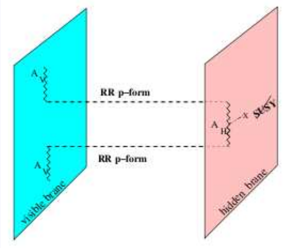
This mediation of SUSY-breaking relies on a few things:

- MSSM & hidden sectors separated by bulk
- hidden brane in strongly-warped region of manifold
  $\Rightarrow$ filters tree-level gravitational effects
- visibile (V) & hidden (H) branes carry U(1) charges
  $\Rightarrow$ gauge bosons: A_V and A_H
- F-type SUSY breaking happens on the hidden U(1) brane

HCAMSB

Hypercharged Mediation

RR p-forms traverse the bulk



They couple to gauge fields by linear C-S-couplings

HCAMSB

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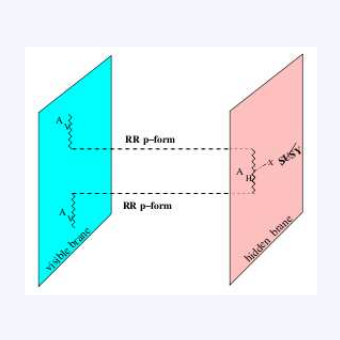

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KK reduction

$$\Downarrow$$

$$\mathcal{L}_{RR} = C \wedge (dA_V + dA_H) + \frac{1}{2\mu^2}|dC|^2$$

equivalent to Stuckelberg mass;

$\mu \sim$ string scale

$$\Downarrow$$

$$(A_V + A_H)$$

integrates out

HCAMSB

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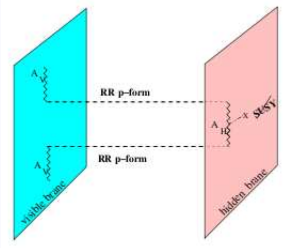

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Low-energy combination:

$$A_1 = (A_H - A_V)$$

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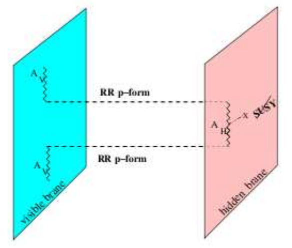

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Low-energy combination:

$$A_1 = (A_H - A_V)$$

A_1 is the Hypercharge Boson

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Hypercharged Mediation

F-terms give mass of visible sector bino:

HCAMSB

Hypercharged Mediation

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- 1-loop bino mass contrib. to hypercharged particles
- 2-loop to other gauginos (no direct coupling)

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- Correction to M_1 RGE

$$\to M_1 = \tilde{M}_1 + \frac{b_1 g_1^2}{16\pi^2} m_{3/2}$$

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Hypercharged Mediation

F-terms give mass of visible sector bino:

- 1-loop bino mass contrib. to hypercharged particles
- 2-loop to other gauginos (no direct coupling)
- Correction to M_1 RGE

$$\rightarrow M_1 = \tilde{M}_1 + \frac{b_1 g_1^2}{16\pi^2} m_{3/2}$$

Parameterize Hypercharged contrib. relative to AMSB's

$$\alpha = \frac{\tilde{M}_1}{m_{3/2}}$$

Anomaly and HC Mediation

Things to note:

Anomaly and HC Mediation

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Pure Anomaly Mediation

some problems gone:

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- RGE running to TeV scale $\Rightarrow m_{\tilde{t}_1} < 0$

Anomaly and HC Mediation

Things to note:

Pure Anomaly Mediation

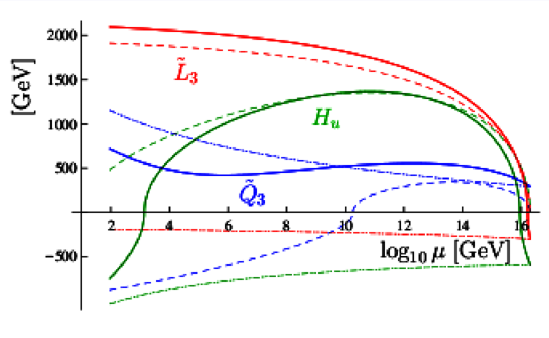
some problems gone:

- tachyonic sleptons
- fixed by *anomalous dimension*

Pure HC Mediation

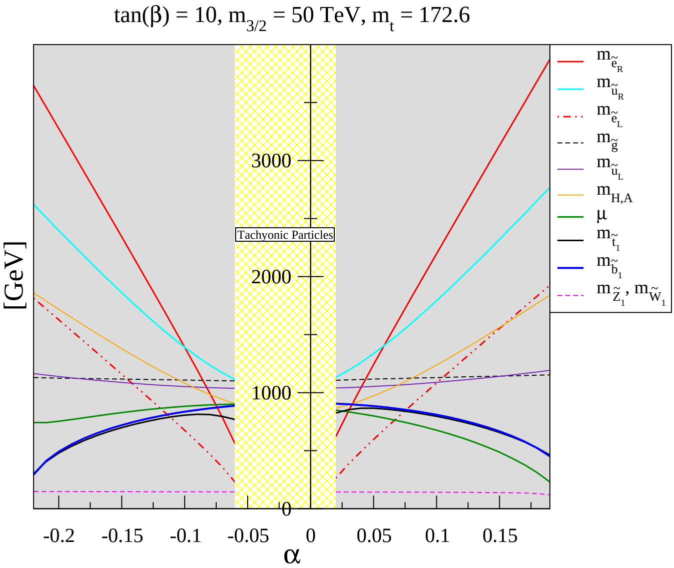
- bino mass can fix this
- RGE running to TeV scale $\Rightarrow m_{\tilde{t}_1} < 0$

Anomaly and HC Mediation



HCAMSB Spectrum

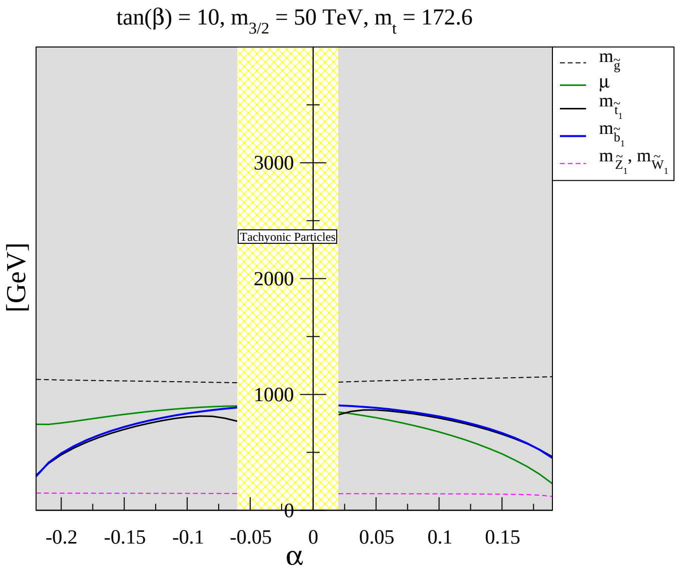
ISAJET 7.79



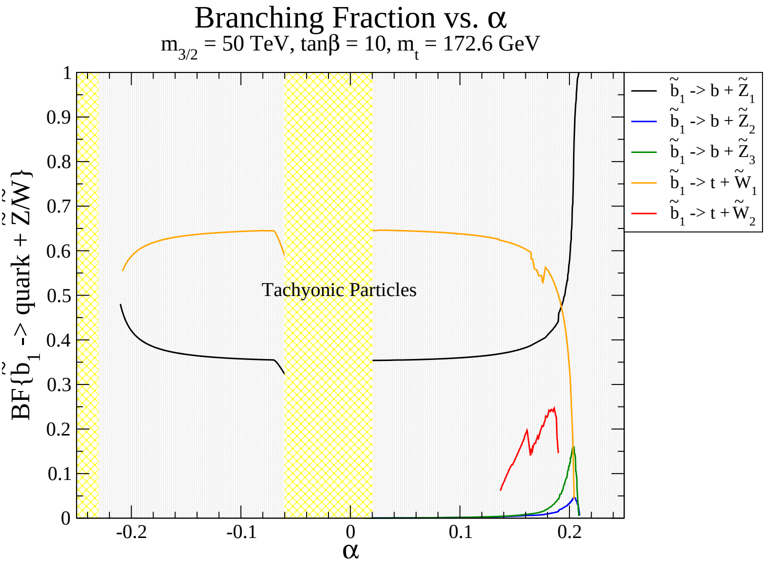
*left-right split AMSB

HCAMSB Spectrum

ISAJET 7.79



HCAMSB at the LHC



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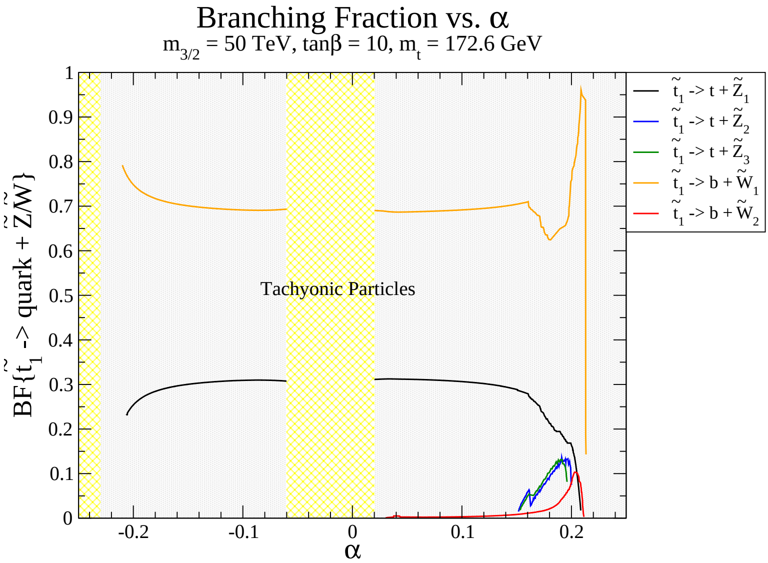
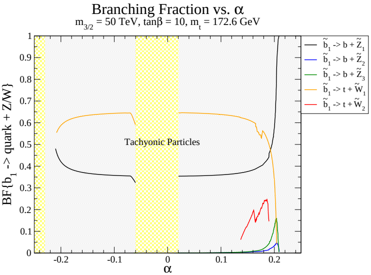
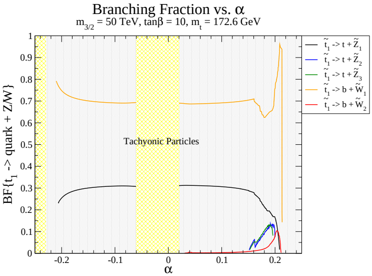


HCAMSB at the LHC

signatures





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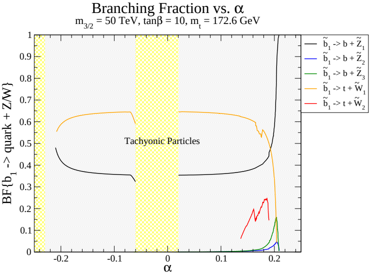
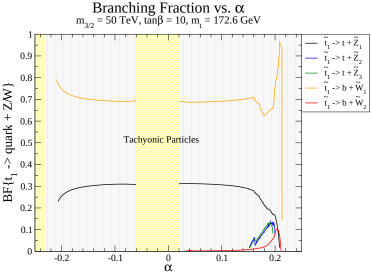


$\tilde{b}_1$ decays:

$$\tilde{b}_1 \longrightarrow b + \tilde{Z}_1, \tilde{Z}_2, \tilde{Z}_3$$
$$\tilde{b}_1 \longrightarrow t + \tilde{W}_1$$

$\tilde{t}_1$ decays:

$$\tilde{t}_1 \longrightarrow t + \tilde{Z}_1, \tilde{Z}_2, \tilde{Z}_3$$
$$\tilde{t}_1 \longrightarrow b + \tilde{W}_1$$



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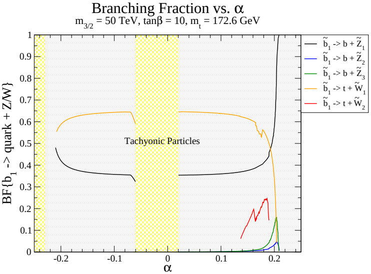

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high b-jet mult.

E_T^{miss}

isolated leptons

$\tilde{W}_1$ *tracks*

$\tilde{t}_1$ decays:

$$\tilde{t}_1 \to t + \tilde{Z}_1,\ \tilde{Z}_2, \tilde{Z}_3$$
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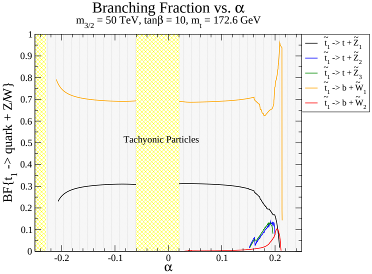
high b-jet mult.

E_T^{miss}

isolated leptons

$\tilde{W}_1$ *tracks*



HCAMSB at the LHC

chargino tracks

$$m_{\tilde{W}_1} \sim m_{\tilde{Z}_1} :$$

HCAMSB at the LHC

chargino tracks

$m_{\tilde{W}_1} \sim m_{\tilde{Z}_1}$:

Wino-like $\leftrightarrow$ light

nearly degenerate: $\Delta m \sim 200 MeV$

$\tilde{W}_1^+ \rightarrow \pi^+ + \tilde{Z}_1$

HCAMSB at the LHC

chargino tracks

$m_{\tilde{W}_1} \sim m_{\tilde{Z}_1}$:

Wino-like $\leftrightarrow$ light

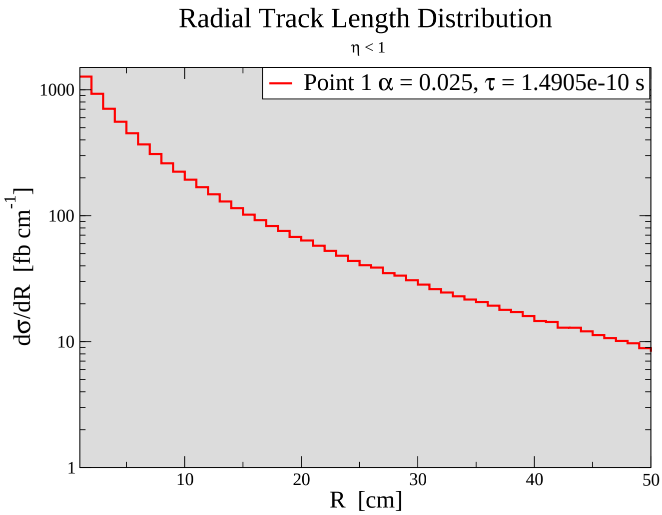
nearly degenerate: $\Delta m \sim 200 MeV$

$$\tilde{W}_1^+ \rightarrow \underset{\substack{\downarrow \\ soft}}{\pi^+} + \underset{\substack{\searrow \\ E_T^{miss}}}{\tilde{Z}_1}$$

possible track with no calorimeter signal

HCAMSB at the LHC

chargino tracks



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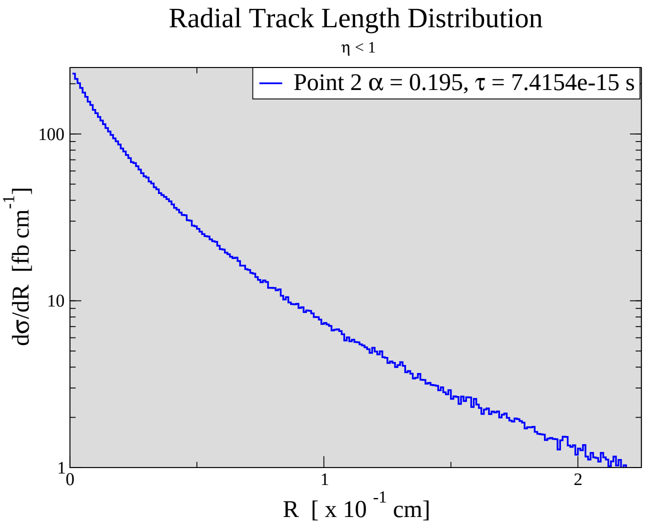

HCAMSB at the LHC

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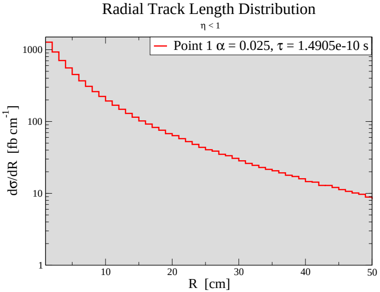
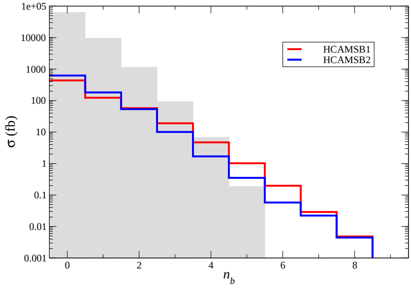


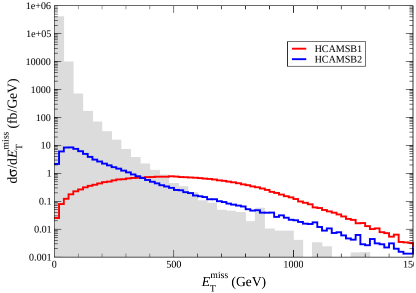
Atlas Detector

- innermost system
  3 pixel layers
  5,8,12.5 cm
- intermediate system
  4 barrel layers
  30 - 50 cm

HCAMSB at the LHC

Event Generation - ISAJET





Cuts:

n(jets) $\geq$ 4

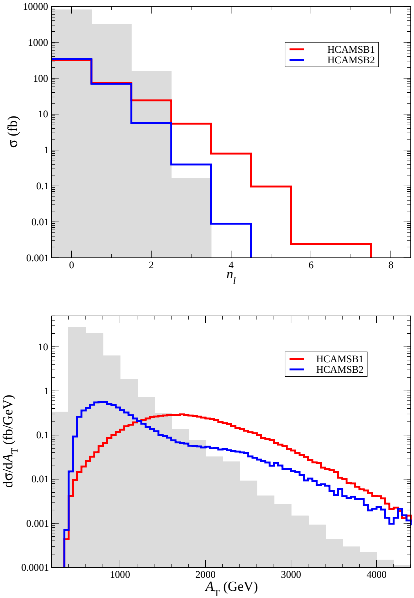
$E_T^{miss} > max(100 GeV, 0.2_{Meff})$

$E_T(j_1, j_2, j_3, j_4) >$ 100,50,50,50 GeV

$S_T > 0.2$

HCAMSB at the LHC

Event Generation - ISAJET



$A_T =$

$E_T^{miss} + \Sigma E_T(jets) +$
$\Sigma E_T(isolated\ leptons)$

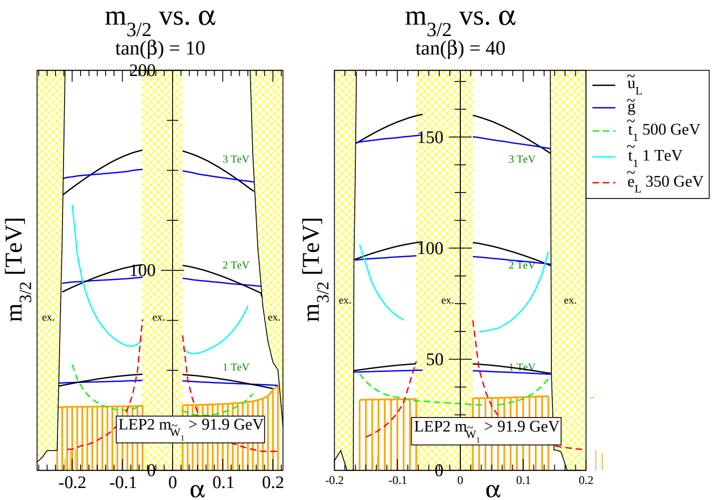
Summary

- Described hypercharged anomaly mediation
- HCAMSB spectrum: lead to decay channels and signatures
- Working on event generation:
  cut optimization
  invariant mass distributions
  reach

backup

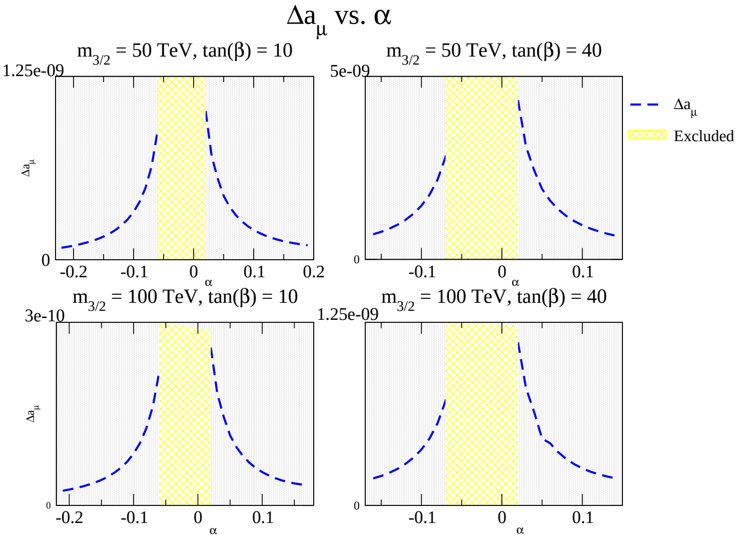
HCAMSB Spectrum

Constraining α and $m_{3/2}$



Constraining α and $m_{3/2}$

indirect limits



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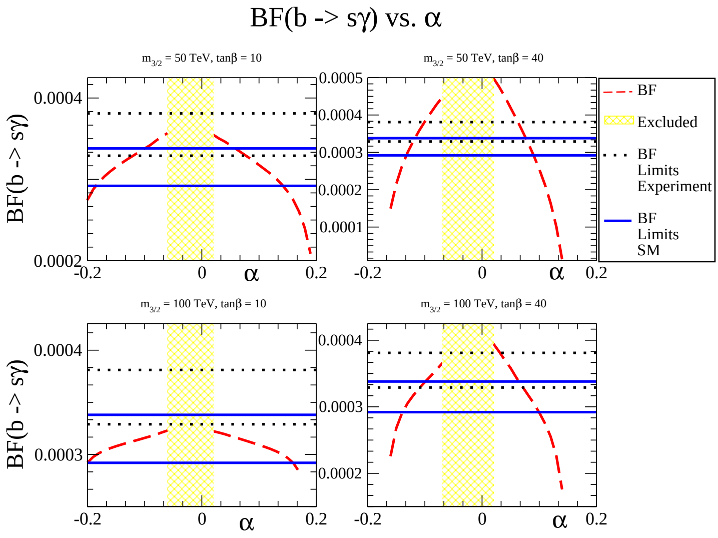
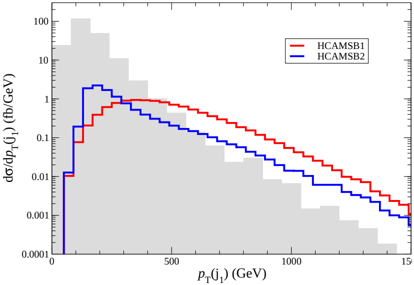
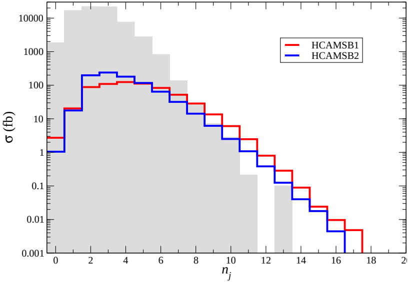
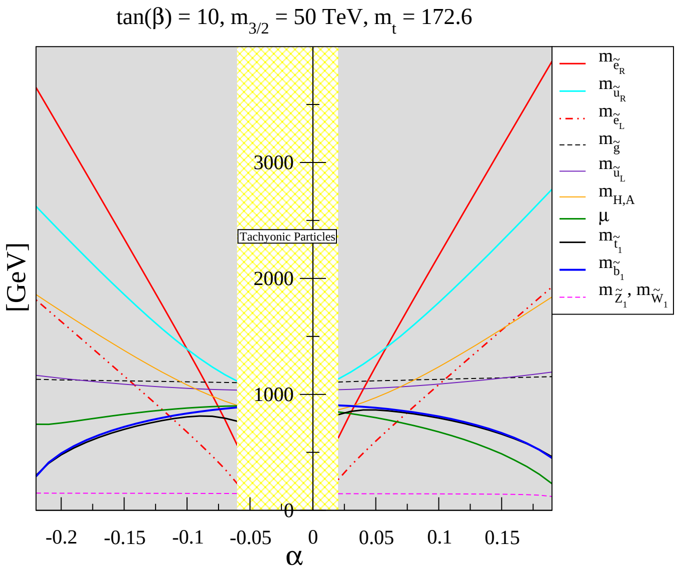


HCAMSB at the LHC





HCAMSB Spectrum



HCAMSB Spectrum