Unraveling the spin of the gluino at the LHC

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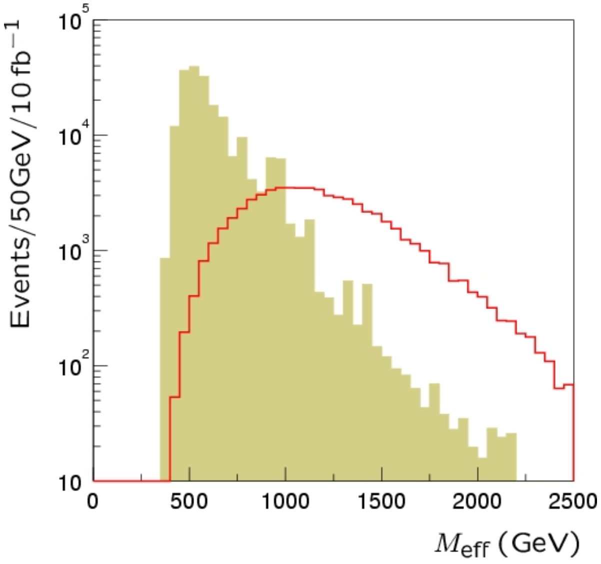
Inclusive searches



- LHC has a large yield of strongly interacting new particles
- $\sigma_{\rm SUSY}(\mathbf{1}\ \text{TeV}) \simeq \mathcal{O}(\mathbf{10}\ \text{pb})$
- SUSY conserving R parity $\Longrightarrow$ jets and missing $\not\!\!E_T$

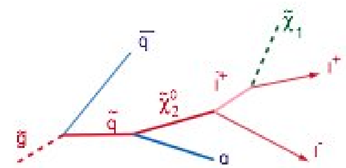
- Rather simple to rule out/discover gluinos and squarks up to $\simeq \mathbf{2.5}$ TeV

➪ We'd like as much information as possible (masses, spin, etc) to reconstruct the low energy SUSY breaking parameters

Exclusive SUSY search

❄ Particle masses can be determined using edges of invariant mass distributions in decay chains, *e.g.*

$$\tilde{\mathbf{g}} \rightarrow \bar{\mathbf{b}}\tilde{\mathbf{b}}_{\mathbf{L}} \rightarrow \bar{\mathbf{b}}\mathbf{b}\tilde{\chi}^{\mathbf{0}}_{\mathbf{2}} \rightarrow \bar{\mathbf{b}}\mathbf{b}\mathbf{l}^{\pm}_{\mathbf{2}}\tilde{\mathbf{l}}^{\mp}_{\mathbf{R}} \rightarrow \bar{\mathbf{b}}\mathbf{b}\mathbf{l}^{\pm}_{\mathbf{2}}\mathbf{l}^{\mp}_{\mathbf{1}}\tilde{\chi}^{\mathbf{0}}_{\mathbf{1}}$$



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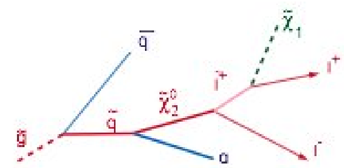
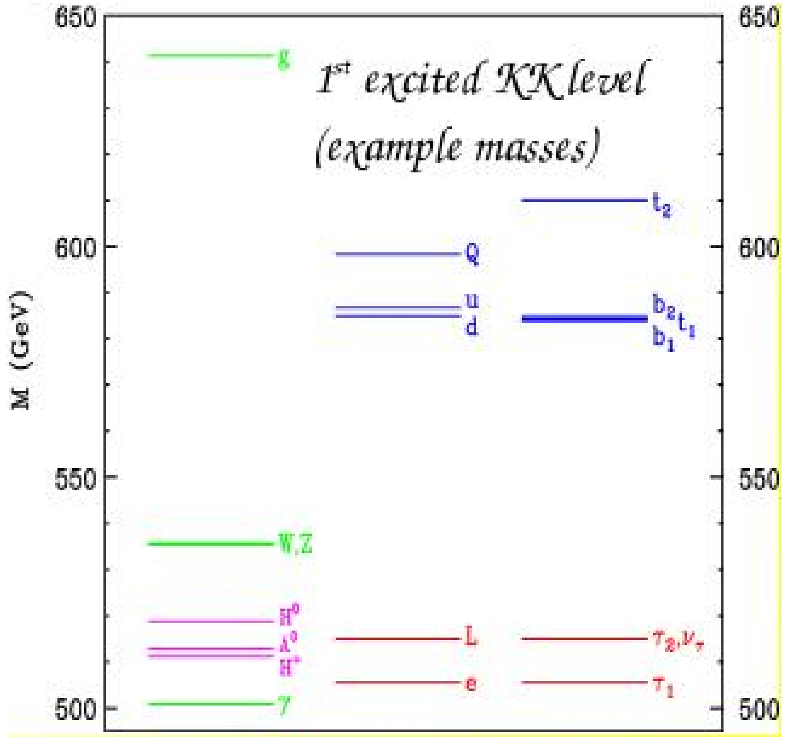


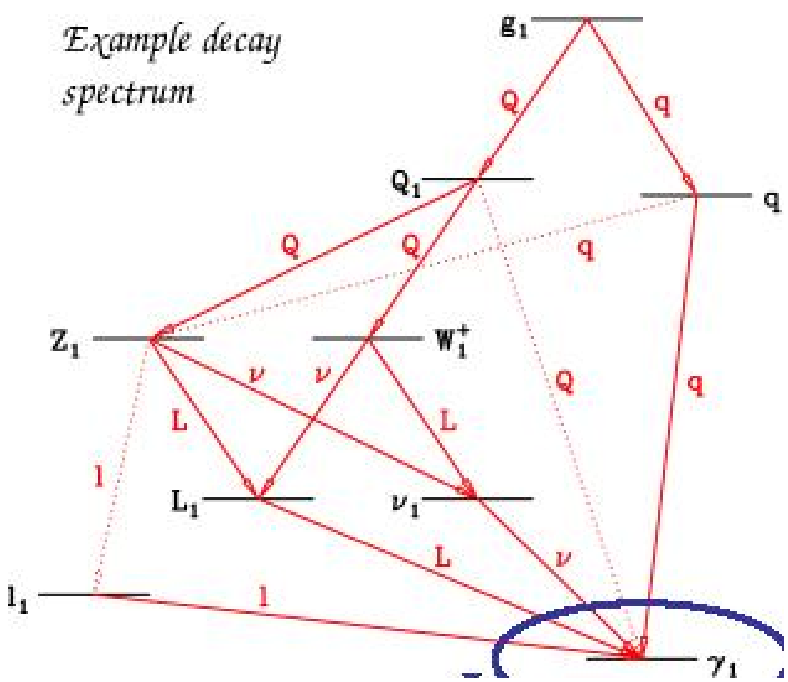
❄ Like sign dileptons can be a signal for a Majorana gluino:

- $\mathbf{qq} \to \tilde{\mathbf{q}}\tilde{\mathbf{q}}$ via a $\mathbf{t}$–channel gluino (Barger, et al; Barnett et al.; Tata et al.)
- $\mathbf{gg}\ (\mathbf{q}\bar{\mathbf{q}}) \to \tilde{\mathbf{g}}\tilde{\mathbf{g}}$ with $\tilde{\mathbf{g}} \to \mathbf{q}\tilde{\mathbf{q}}^*$ or $\bar{\mathbf{q}}\tilde{\mathbf{q}}$

Loop hole

- UED: KK tower with same spin as in the SM
- UED lead to "similar signals" $\Longrightarrow$ we must probe the spin!





Basic idea: (hep-ph/0605067)

- Study the decay chain used to measure the gluino mass

$$\tilde{g} \to b\tilde{b}^*/\bar{b}\tilde{b} \;\oplus\; \tilde{b} \to \tilde{\chi}^0_2 \to \tilde{\ell} \to \tilde{\chi}^0_1$$

- compare SUSY with UED

- structure of interactions and spins lead to correlations between particles

- UED and SUSY with same spectrum and σ

- trade angles for invariant masses that are Lorentz invariant.

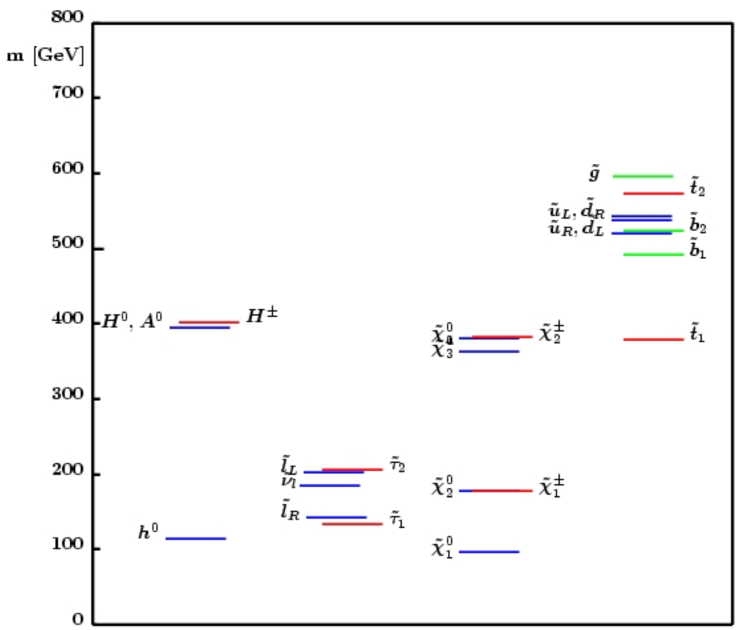
- We chose the signal processes

$$pp \to \tilde{g}\tilde{g} \to jjb\bar{b}\ell^+\ell^- + \not{p}_T \quad \text{or} \quad pp \to \tilde{q}\tilde{g} \to jb\bar{b}\ell^+\ell^- + \not{p}_T$$

Reference point

- Parameter point SPS1a

$$m_{\tilde{q}} = 608 \text{ GeV},\ m_{\tilde{b}_1} = 517 \text{ GeV}, \ldots$$



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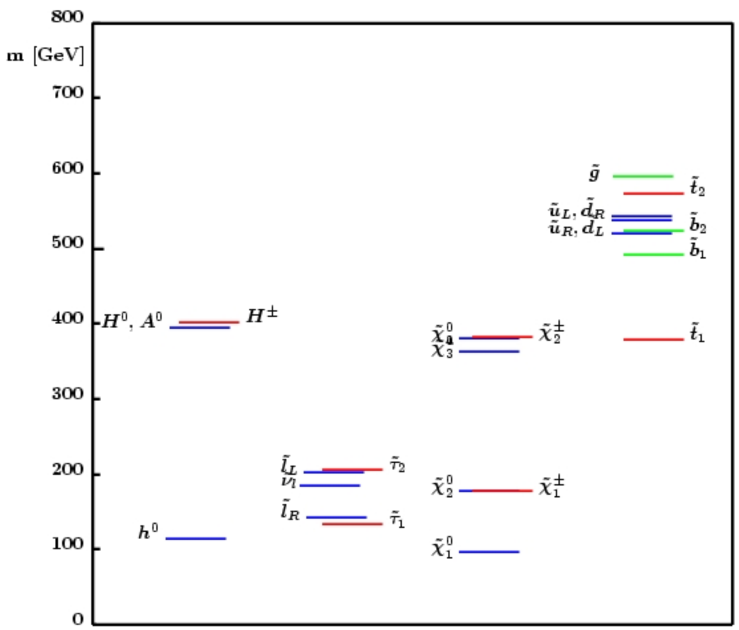
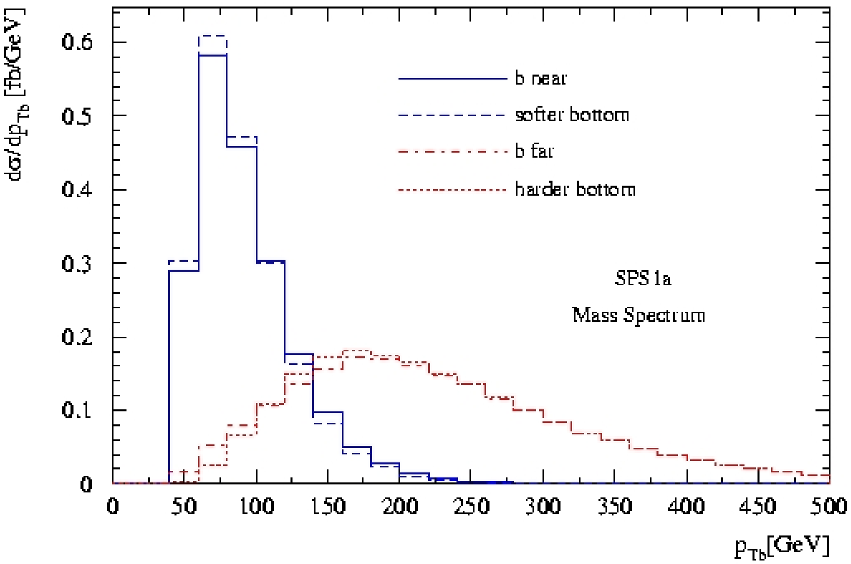


- Impact of the SPS1a mass hierarchy



Basic acceptance cuts

$$p_{T,b} > 50 \text{ GeV} \qquad p_{T,\ell} > 10 \text{ GeV}$$

$$p_{T,j}^{\text{min}} > 40 \text{ GeV} \qquad p_{T,j}^{\text{max}} > 150 \text{ GeV}$$

$$|\eta_i| < 2.4 \qquad \Delta R_{ik} > 0.4$$

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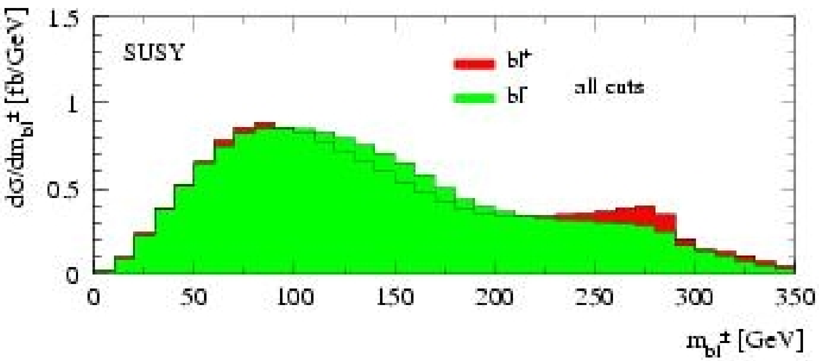
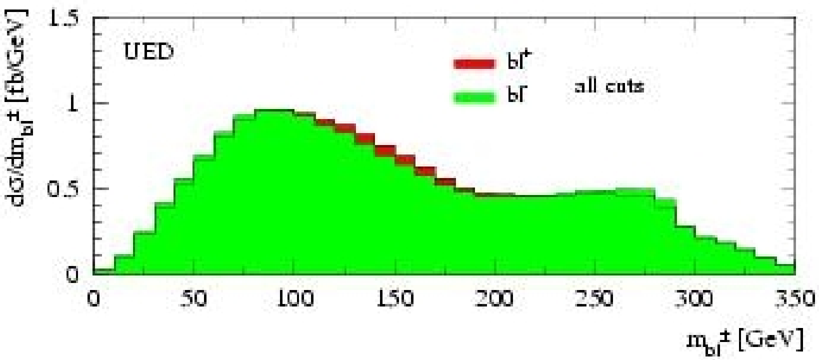
- Background rejection cuts

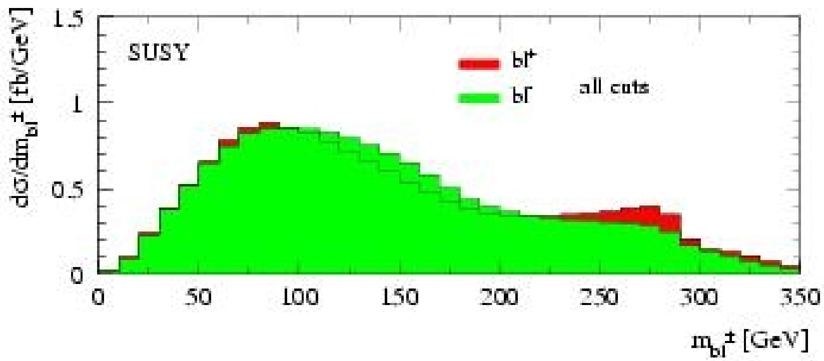
$$m_{\ell\ell} < 80 \text{ GeV} \qquad m_{jj} < 300 \text{ GeV}$$

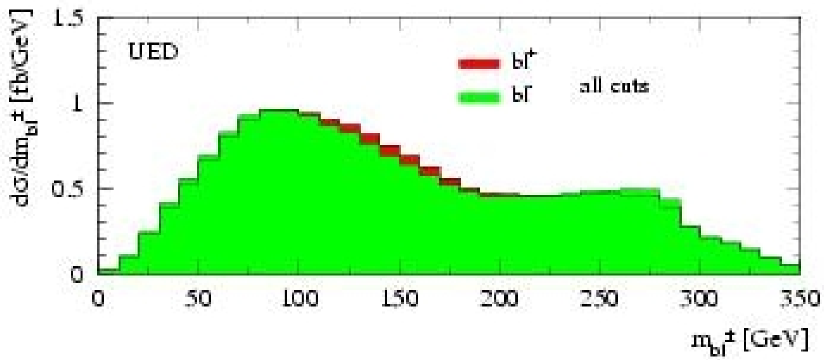
$$\tilde{M}_{\text{eff}} > 450 \text{ GeV}$$

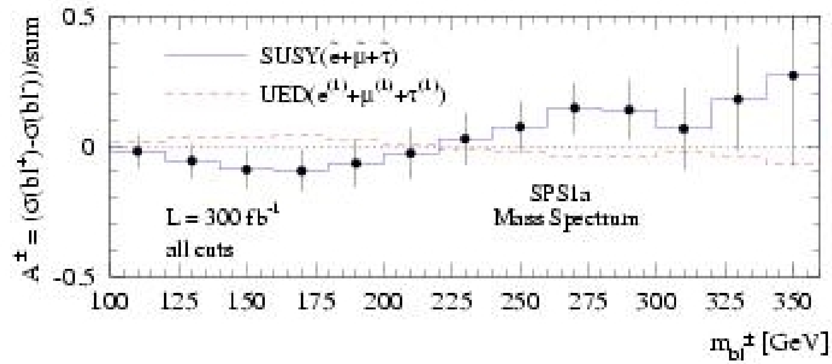
- $\sigma(\tilde{g}\tilde{g}) = 8.6$ fb
- $\sigma(\tilde{q}\tilde{q}) = 85$ fb
- $S/B \simeq 1$
- subtract opposite flavor dileptons
- we use that we can identify b vs. $\bar{b}$ with ab efficiency of 49%

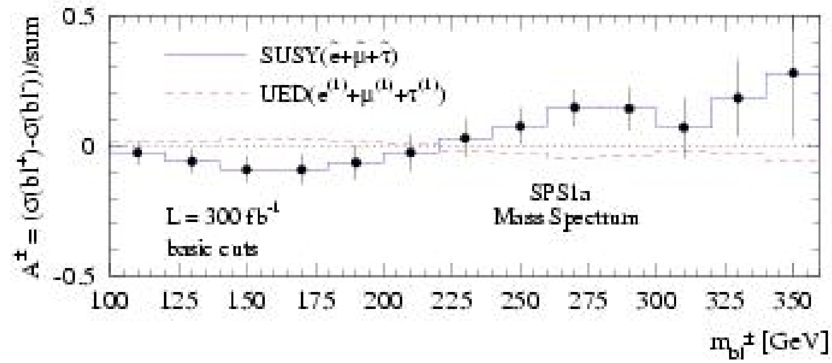

SUSY
bl+
bl-
all cuts
dσ/dm_bl± [fb/GeV]
m_bl± [GeV]

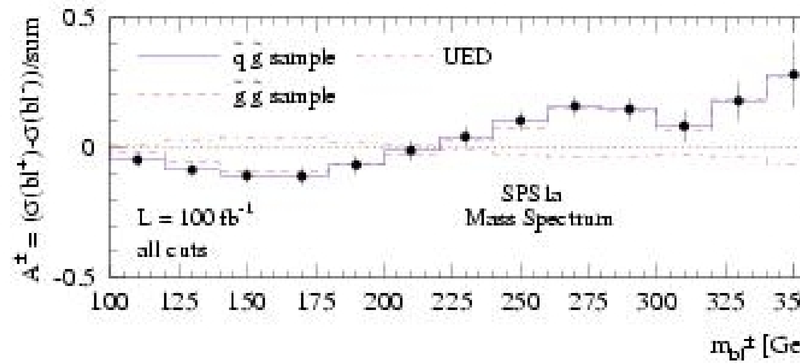

UED
bl+
bl-
all cuts
dσ/dm_bl± [fb/GeV]
m_bl± [GeV]











✳ To discriminate SUSY ⊗ UED

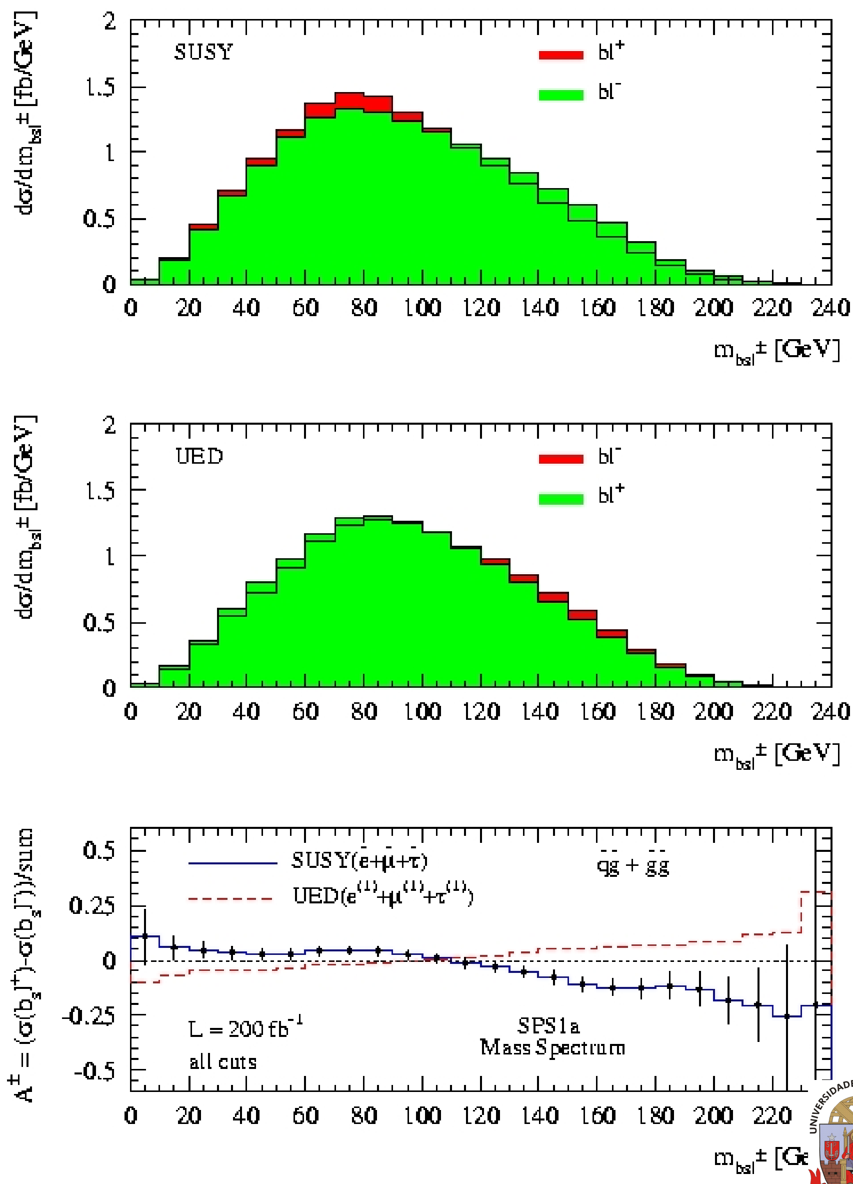
$$A^{\pm}(m_{b\ell}) = \frac{d\sigma/dm_{b\ell^+} - d\sigma/dm_{b\ell^-}}{d\sigma/dm_{b\ell^+} + d\sigma/dm_{b\ell^-}}$$

Using the near b

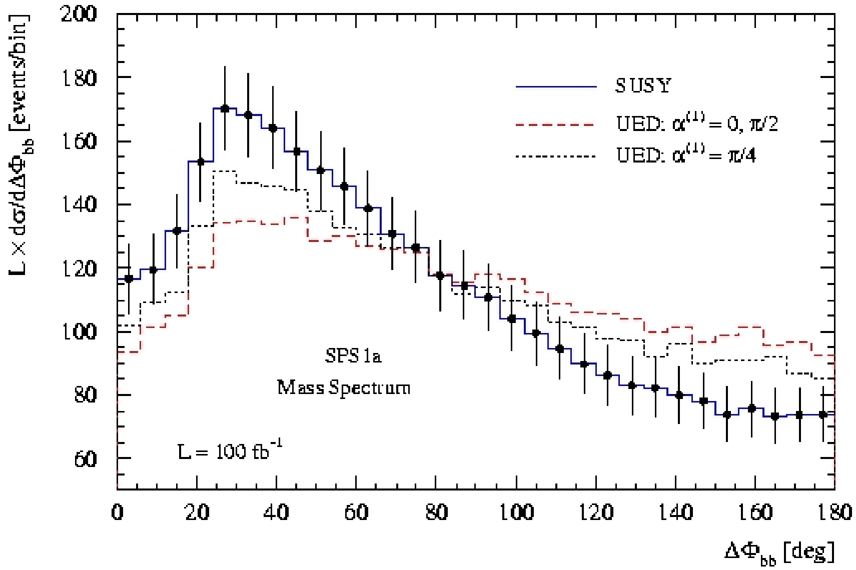
➤ For SPS1a it is possible to identify the near b

➤ We define

$$A^{\pm}(m_{b_s\ell}) = \frac{d\sigma/dm_{b_s\ell^+} - d\sigma/dm_{b_s\ell^-}}{d\sigma/dm_{b_s\ell^+} + d\sigma/dm_{b_s\ell^-}}$$



Purely hadronic correlations

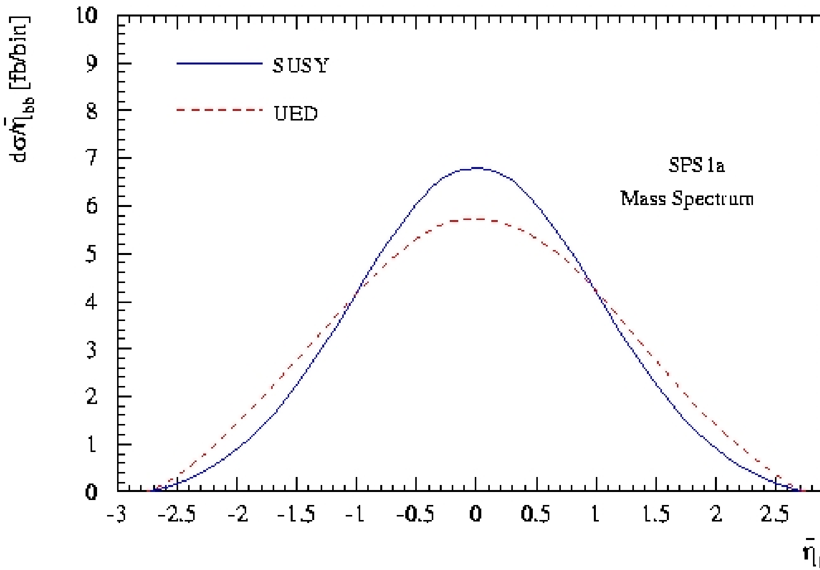


- Let's explore b–$\bar{b}$ correlations
- They are independent of $\tilde{\chi}_2^0$ decay
- We can use the b–$\bar{b}$ azimuthal angle separation:

$$\frac{\sigma(\Delta\Phi_{bb} < 90^o) - \sigma(\Delta\Phi_{bb} > 90^o)}{\sigma(\Delta\Phi_{bb} < 90^o) + \sigma(\Delta\Phi_{bb} > 90^o)}$$

that is 0.08 ± 0.02 for UED and 0.24 ± 0.02 for SUSY.

★ We could use also the average b–$\bar{b}$ rapidity



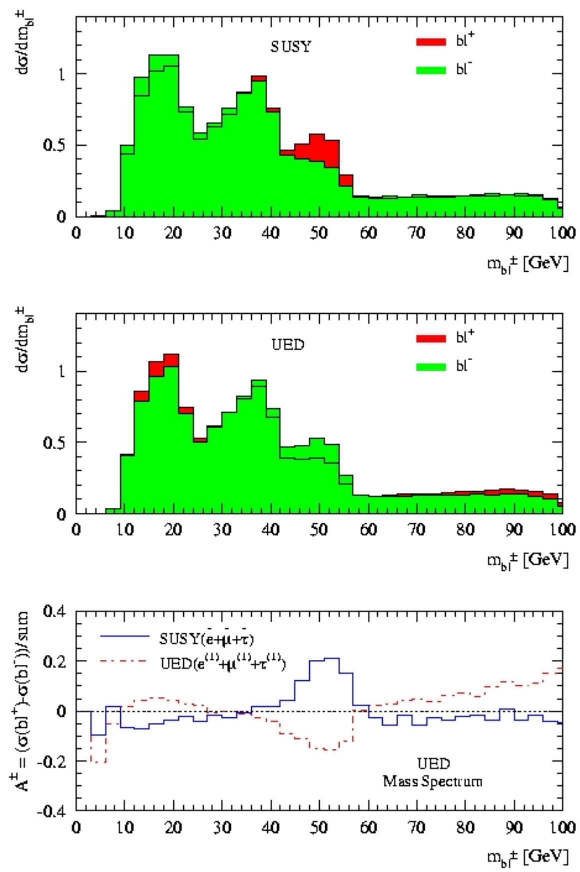
Final remarks

- Separating the UED and SUSY decay chains is hard for a "typical" UED spectrum
- We are comparing decay chains $\Longrightarrow$ there is a dependence on other particles/interactions
- Hadronic correlations are rather insensitive to L and R nature of $\tilde{b}$
- This gluino decay chain can give information on the R–L nature of the first– and second–generation sleptons
- The LHC can lead to important information on the gluino spin

Backup slides

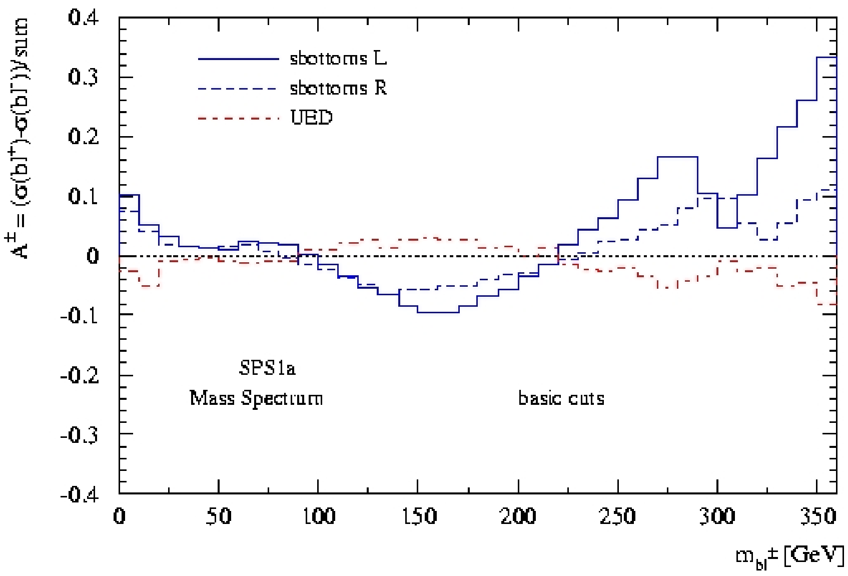
Degenerate UED spectrum

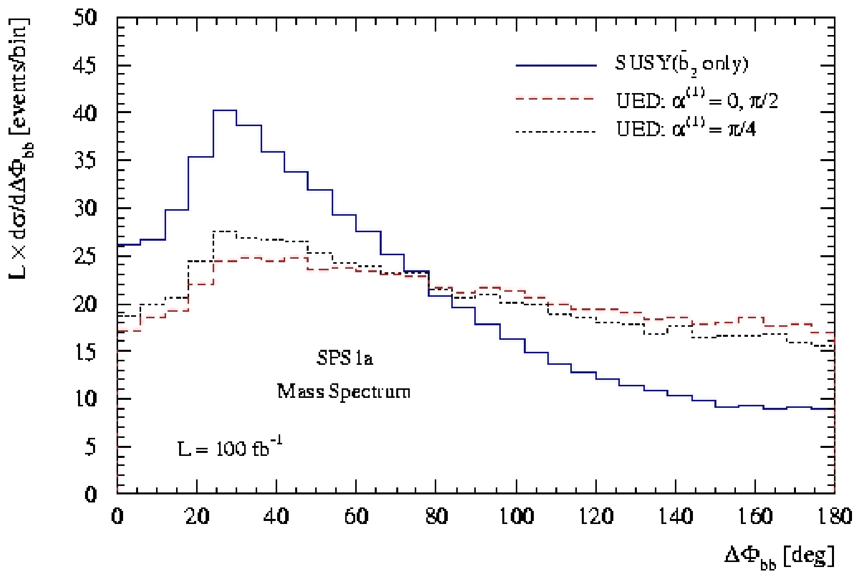
➡ masses in the 500–600 GeV rage



Backup slides

Left and right sbottoms: $\tilde{b}_1 \simeq \tilde{b}_L$ and $\tilde{b}_2 \simeq \tilde{b}_R$





Backup slides

Left and right sleptons: $\tilde{\ell}_1 \simeq \tilde{\ell}_R$ and $\tilde{\ell}_2 \simeq \tilde{\ell}_L$