MEASURING THE GLUINO SPIN AT THE LHC

Tilman Plehn

MPI München & University of Edinburgh
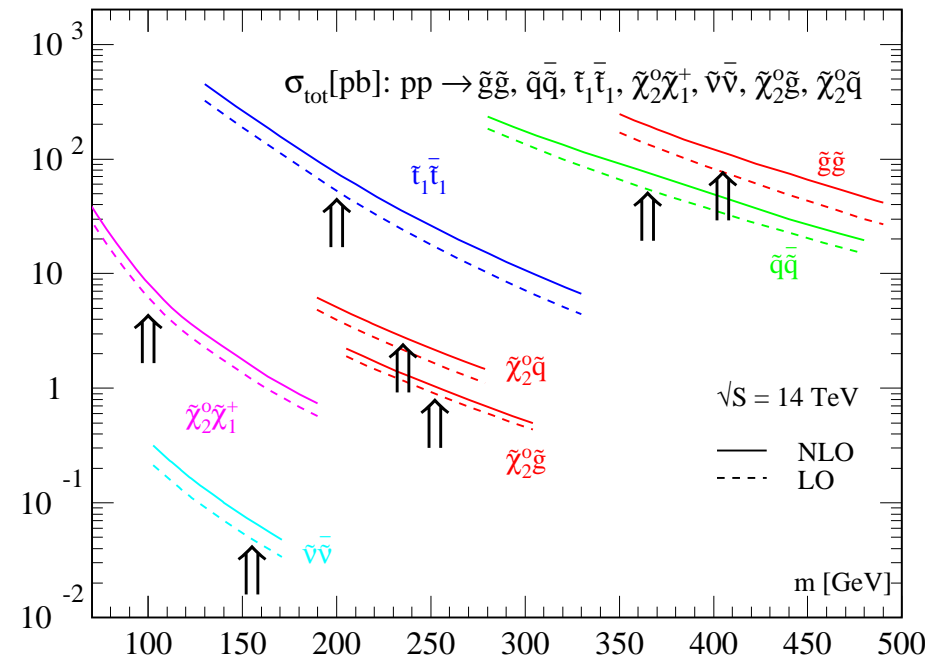
- – SUSY cascade decays
- – Spin measurements and UED straw man
- – Gluino spin from different correlations

with Alexandre Alves & Oscar Eboli

Signals mostly squarks and gluinos [Prospino2]
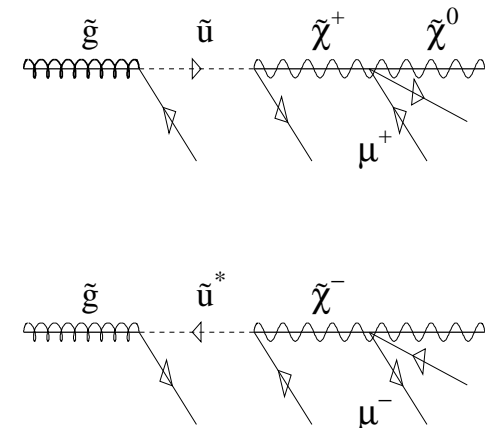
- QCD coupling g$\tilde{q}\tilde{q}$, q$\tilde{g}\tilde{q}$, g$\tilde{g}\tilde{g}$

- jets and $\not{E}_T$: pp $\to$ $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{q}^*$, $\tilde{g}\tilde{g}$, $\tilde{q}\tilde{g}$

- jet might be bottoms,
  additional leptons likely

- cross sections comfortably large

σ_{tot}[pb]: pp $\to$ $\tilde{g}\tilde{g}$, $\tilde{q}\bar{\tilde{q}}$, $\tilde{t}_1\bar{\tilde{t}}_1$, $\tilde{\chi}_2^0\tilde{\chi}_1^+$, $\tilde{\nu}\bar{\tilde{\nu}}$, $\tilde{\chi}_2^0\tilde{g}$, $\tilde{\chi}_2^0\tilde{q}$

$\sqrt{S} = 14$ TeV

—— NLO
---- LO

m [GeV]

How to tell it is SUSY–QCD?

- remember: gluinos Majorana fermions

- jet in gluino decay: q or $\bar{q}$

$\Rightarrow$ final–state leptons with both charges   [SPS1a: BR = 0.4%]

$\Rightarrow$ like–sign dileptons from $\tilde{g}\tilde{g}$ [Barger,...; Baer,...; Barnett,...]

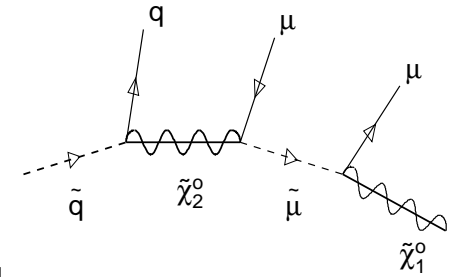$\Rightarrow$ gluinos indeed Majorana fermions, if fermions

Gluino mass from cascade decay   [Gjelsten, Miller, Osland]

– decay $\tilde{g} \rightarrow \tilde{b}\bar{b} \rightarrow \tilde{\chi}_2^0 b\bar{b} \rightarrow \mu^+\mu^- b\bar{b}\tilde{\chi}_1^0$ [SPS1a: 0.4%]

– largest cross section $\tilde{q}\tilde{g}$ [27 fb instead of 8 fb for pairs]

– thresholds & edges $m_{\ell\ell}^2 < (m_{\tilde{\chi}_2^0}^2 - m_{\tilde{\ell}}^2)(m_{\tilde{\ell}}^2 - m_{\tilde{\chi}_1^0}^2)/m_{\tilde{\ell}}^2$

– detector resolution, calibration, systematic errors, shape analysis, cross sections as input?   [Cambridge; Hinchliffe...; Nojiri...; Polesello...]

– Sfitter: Lagangian parameters directly from endpoints   [Fittino; Arkani-Hamed...]

$\Rightarrow$ spectrum information in decay kinematics

LOTS OF CREDIT

Identify squarks   [Barr; Athanasiou, Lester, Smillie, Webber; Datta, Kong, Matchev]

– masses from endpoints, shapes still available

– boost in intermediate rest frames impossible   [McElrath at Pheno06]

⇒ invariant masses and azimuthal angles available

Straw man: universal extra dimensions   [Appelquist, Cheng, Dobrescu; Macesanu, Gustavo Burdman's talk]

– typical spectrum degenerate → ignored   [Cheng, Matchev, Schmaltz]

– rates larger for same masses → ignored   [Dicus, McMullen, Nandi]

– higher excitations → ignored

⇒ only angular correlations and threshold behavior

Squark–slepton cascade   [other processes: David Miller's talk]

– compare with first KK Z and ℓ

– typically largest pp → $\tilde{q}\tilde{g}$ [$\tilde{q} : \tilde{q}^* \sim 2 : 1$]

⇒ $\hat{m} = m_{j\ell}/m_{j\ell}^{max}$ asymmetry best: $\mathcal{A} = [\sigma(j\ell^+) - \sigma(j\ell^-)]/[\sigma(j\ell^+) + \sigma(j\ell^-)]$
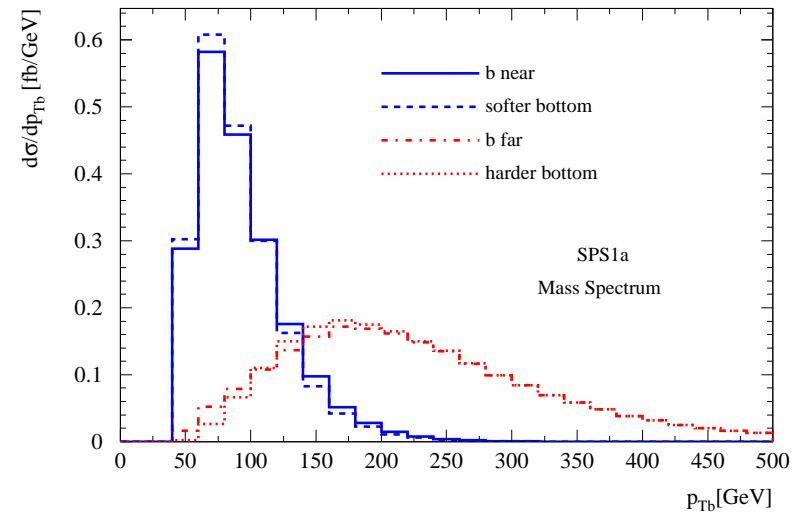
⇒ works for hierachical spectrum

GLUINO SPIN

Given like–sign dileptons, check gluino

- mass cascade: outgoing fermions identified

- Smadgraph: all intermediate states   [also $\tilde{\tau}_{1,2}$]

$\Rightarrow$ compare with UED straw man   [in UED–Madgraph]

Bottom–lepton correlation

- near/far $\equiv$ soft/hard bottom   [ignored for now]

- decay asymmetry: b vs. $\bar{b}$

$\Rightarrow$ independent of production process
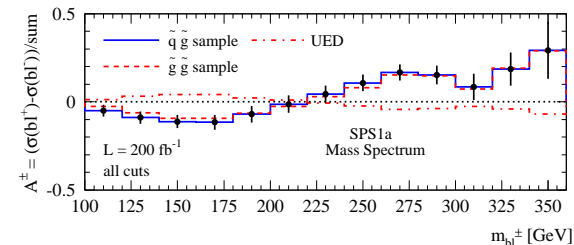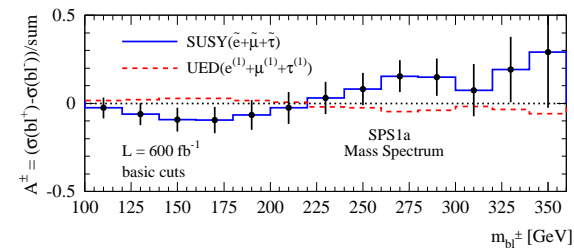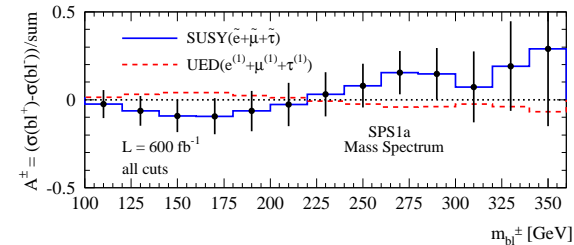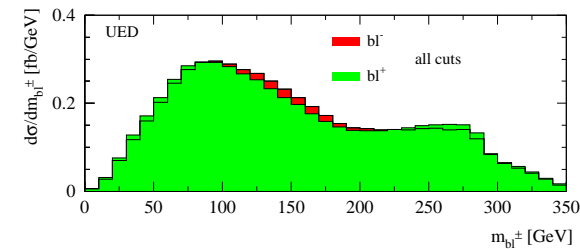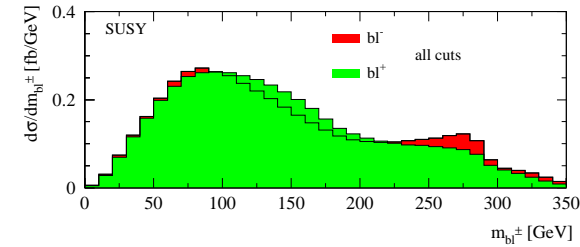
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Decay asymmetry after cuts
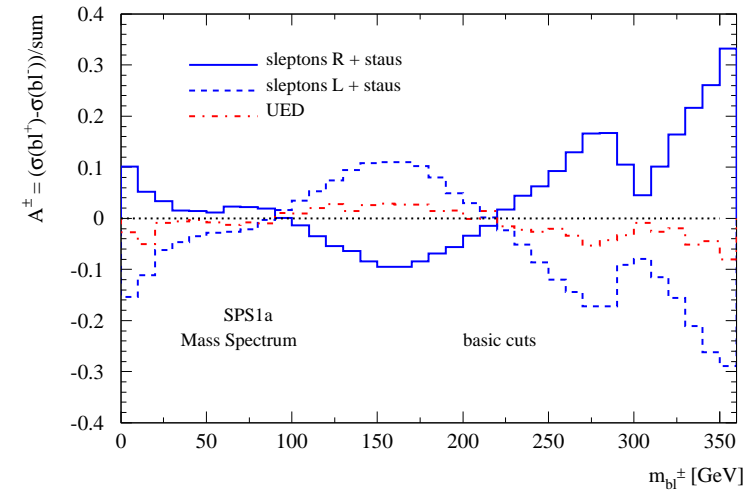
- $\tilde{g}$ produced with $\tilde{q} \to q\tilde{\chi}_1^0$

- $t\bar{t}$+jets background flavor-subtracted

- $\mathcal{A} = [\sigma(b\ell^+) - \sigma(b\ell^-)]/[\sigma(b\ell^+) + \sigma(b\ell^-)]$

$\Rightarrow$ **gluino spin accessible just like sbottom**
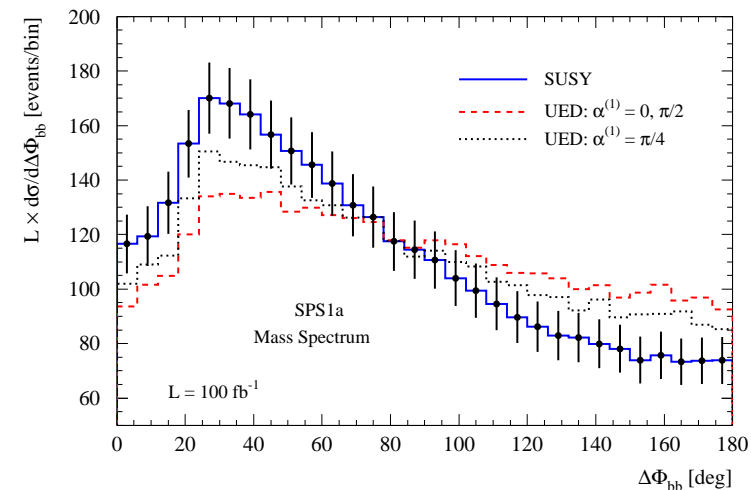
COMPLICATIONS

Problems with neutralino decay

- $\tilde{\tau}_{L,R}$ opposite to $\tilde{\mu}_{R,L}$ [Harvard degeneracies vs. Sfi tter]

- neutralino coupling unknown [bino-wino-higgsino]

- KK-weak mixing suppressed/unknown

- other decays possible... [Wang, Yavin]

$\Rightarrow$ jet–jet observables preferable for gluino
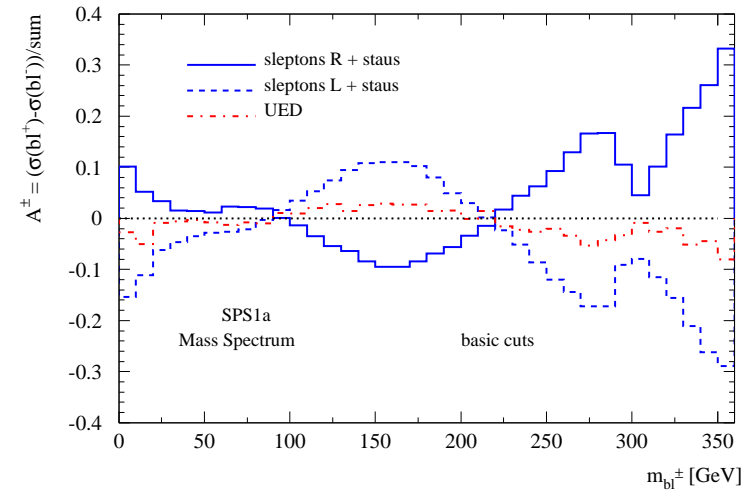
Hadronic angular correlations

- left with azimuthal angle ϕ_{bb} and rapidity [Barr]

- SUSY behavior dominated by boost

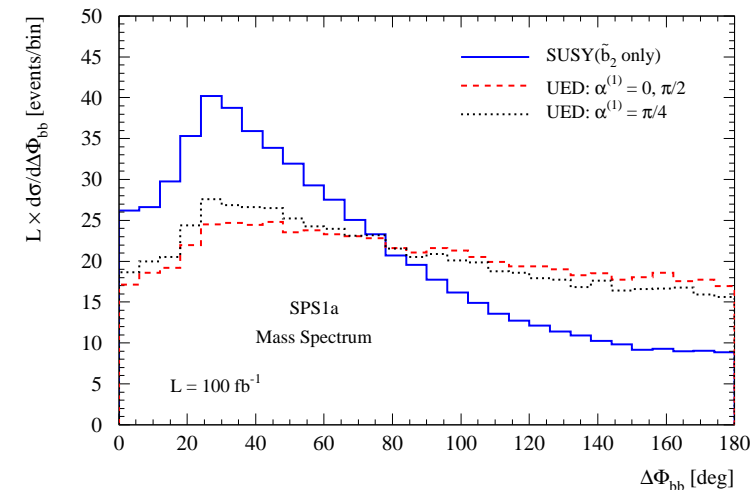- UED singlet–doublet mixing to mimick SUSY?

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Hadronic angular correlations

- left with azimuthal angle ϕ_{bb} and rapidity   [Barr]

- SUSY behavior dominated by boost

- UED singlet–doublet mixing to mimic SUSY?

- SUSY sbottom mixing: $\tilde{b}_2$ only?

$\Rightarrow$ gluino spin without neutralino complication

Cascade decays at the LHC

- – spins, masses, couplings all linked
- – it might be hard
- – we can do it, provided masses hierarchical
- – join in, LHC physics is fun!