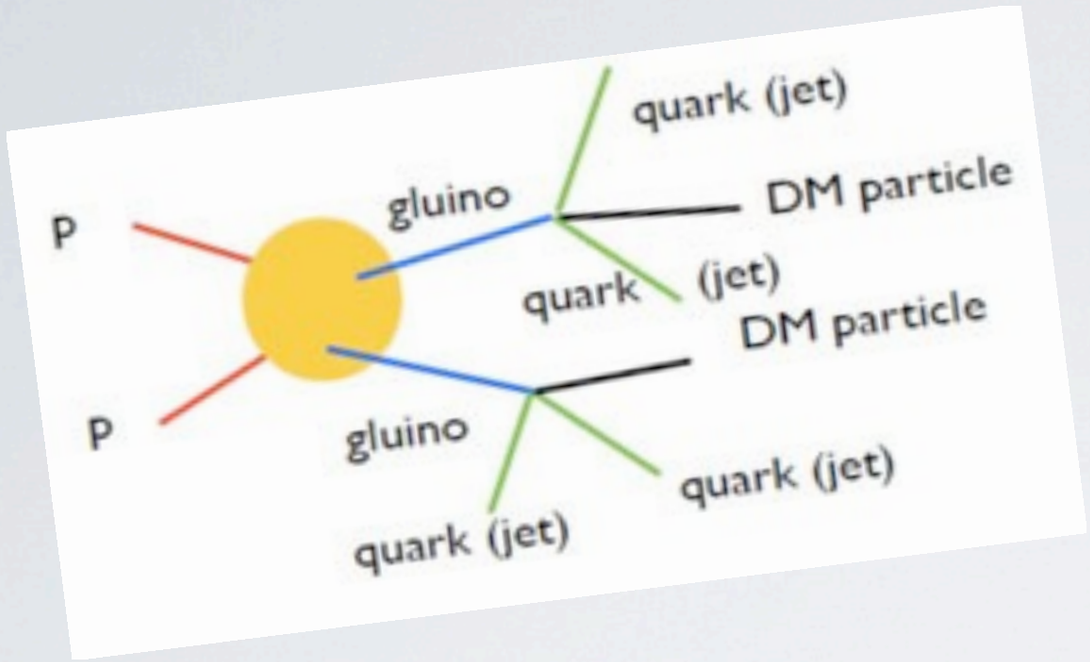
A FAT GLUINO IN DISGUISE



Jürgen R. Reuter, DESY (and somewhere over the rainbow ...)

with D. Wiesler, arXiv:1212.xxxx

Terascale-Workshop 2012, DESY 04.12.2012

MOTIVATION

- BSM models: mostly weakly coupled, discrete parity (DM),

  $\Longrightarrow$ narrow resonances
- fulfilled in the SUSY paradigm

- Exception: some Higgses ..... **Gluino**

- Mass-to-width ratio **Γ/M** $\sim$ few to 15-20 % theoretical upper limit

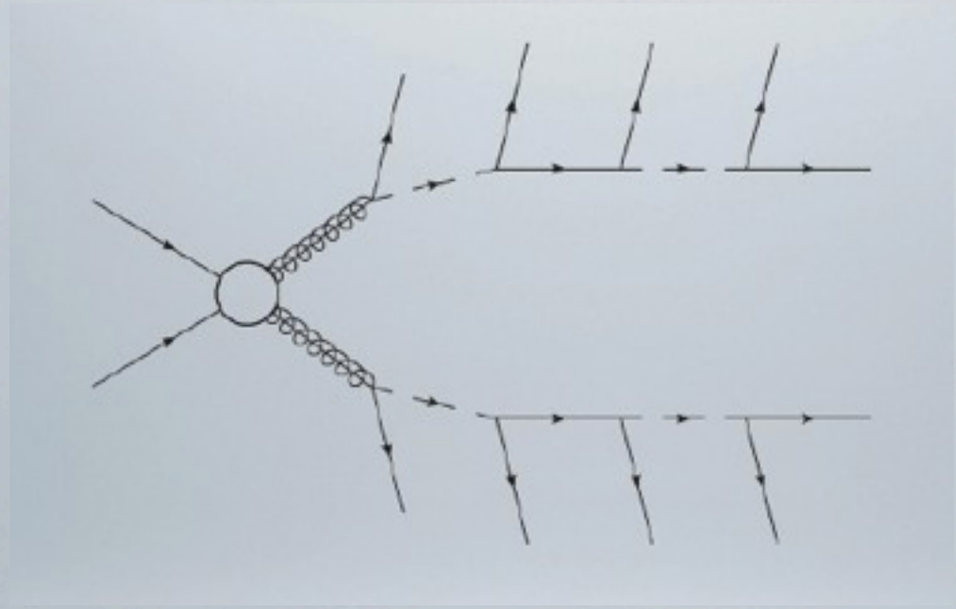
  Γ/M $\sim$ 32 % (without invisible or exotic decays)

- Example realization: GMSB $M_{\tilde{g}} \sim 2\,\mathrm{TeV} \qquad \Gamma_{\tilde{g}} \sim 240\,\mathrm{GeV}$

- Plan: scan over "fat gluinos" in "full" simulation

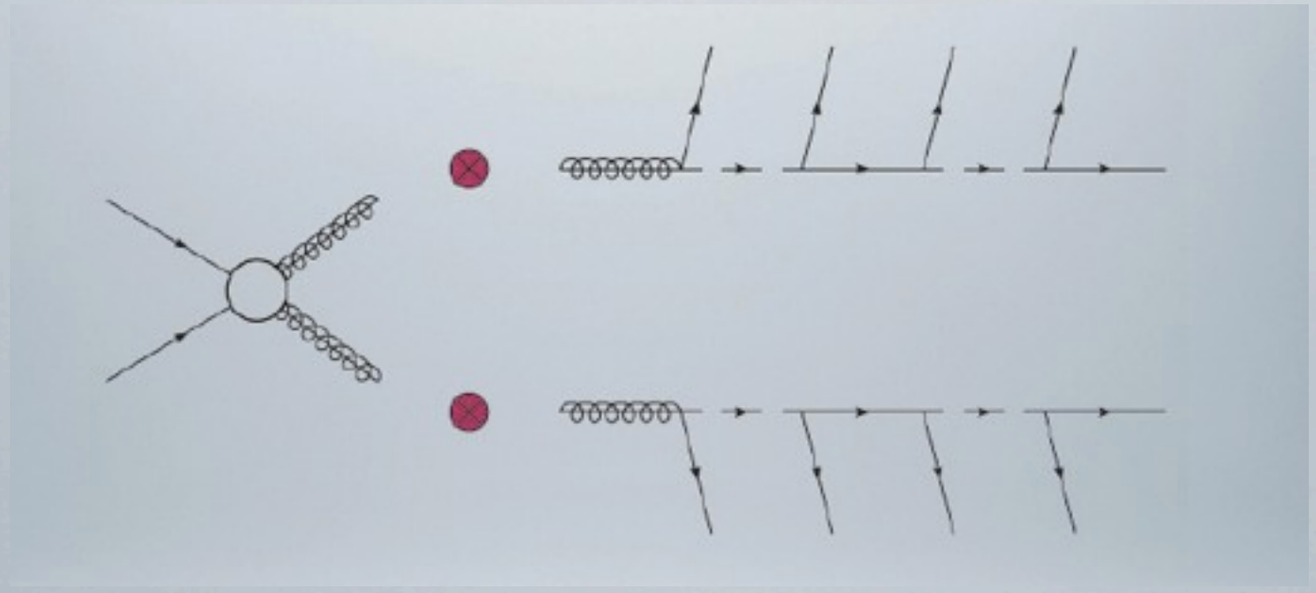
GLUINOS BEYOND FACTORIZATION

★ Standard Gluino Cascade: 2 → 10 process (numerically challenging)



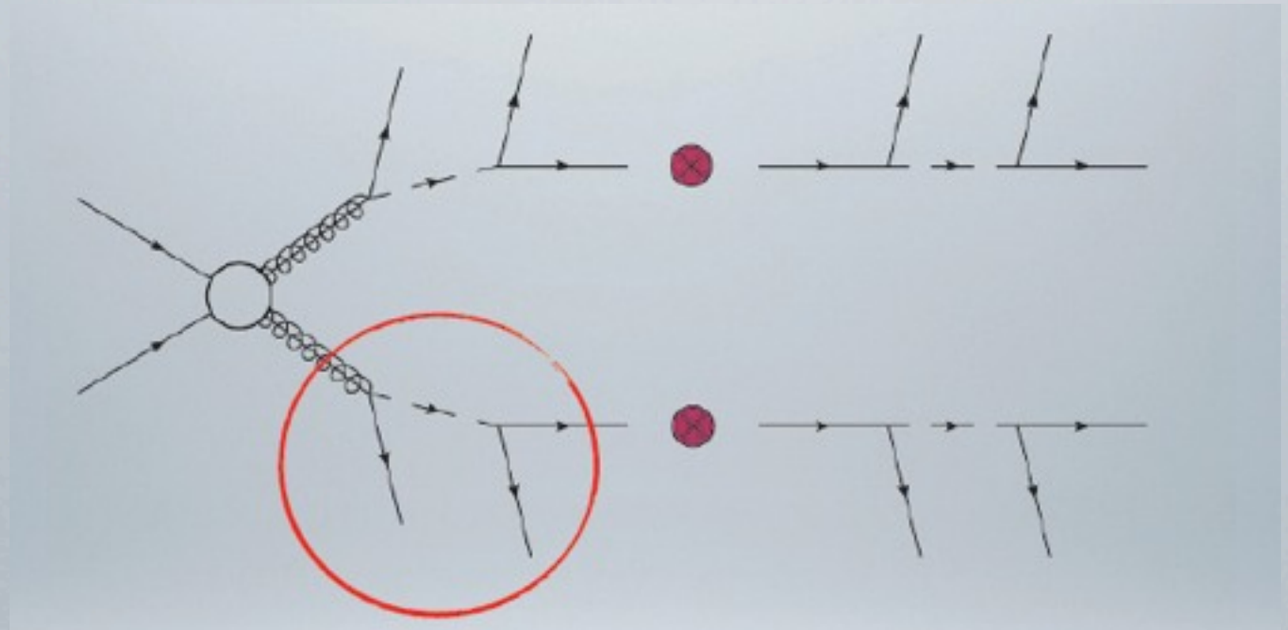
GLUINOS BEYOND FACTORIZATION

★ Factorization in Narrow-Width Approximation (NWA)



GLUINOS BEYOND FACTORIZATION

★ Tradeoff Accuracy/Speed: First decay with full ME



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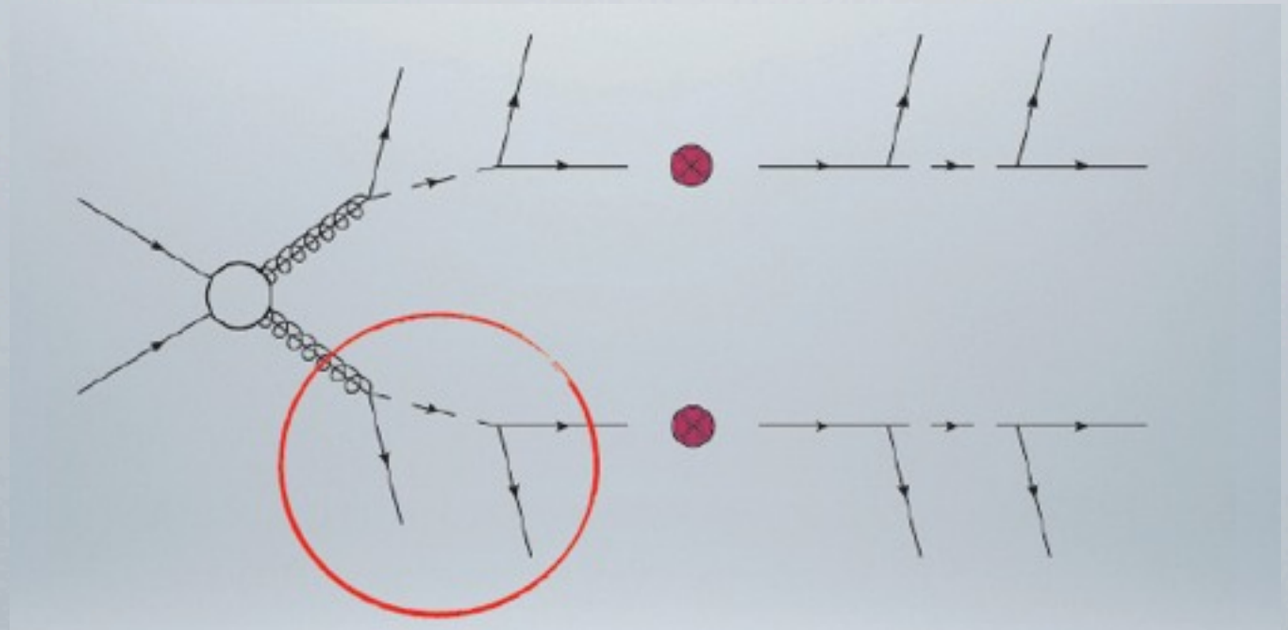


Setup of our study

- Comparison of SUSY vs. UED
- Generic scan over 5 values: $\Gamma/M \in \{ 0.5\%, 2.5\%, 5\%, 10\%, 15\% \}$
- Look for impact on mass and spin observables

SIMULATION SETUP

- Parton level studies with WHIZARD Kilian/Ohl/JRR, 0708.4233
- Study on ISR, combinatorics, detector eff. Pietsch/JRR/Sakurai/Wiesler,1206.2146
- For each point (UED and SUSY) normalized sets (5k events)
- Considered LHC 14 TeV
- pMSSM benchmark scenario

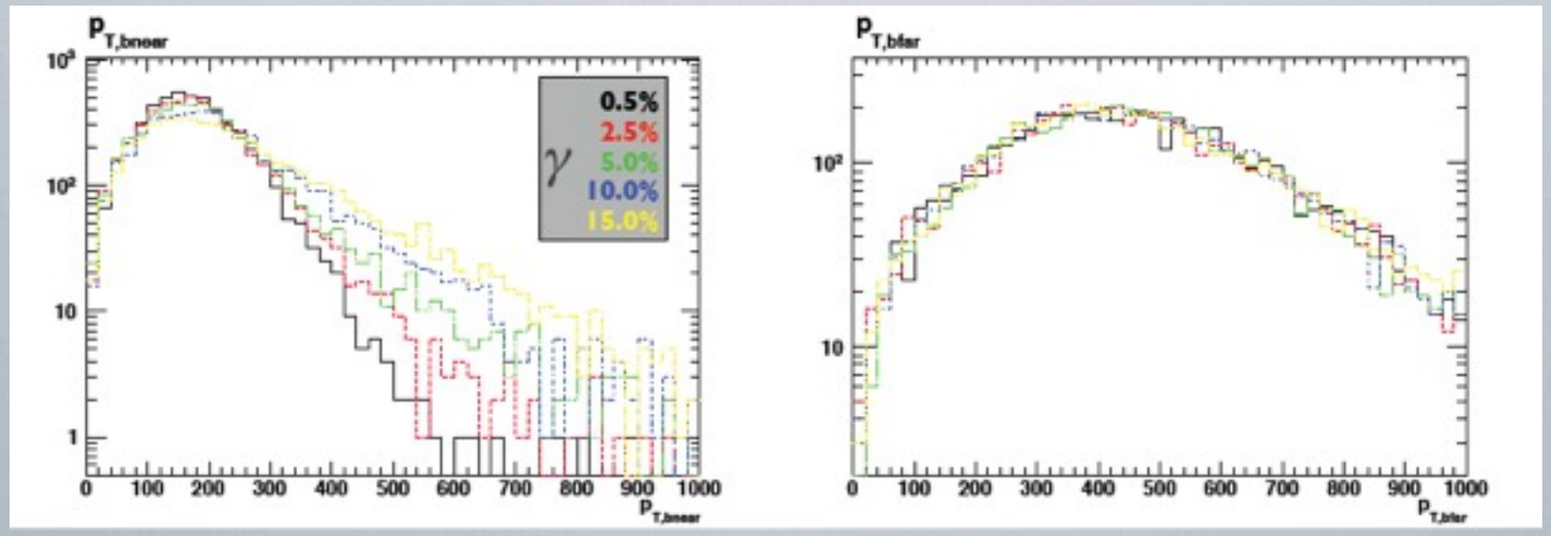
M_1	M_2	M_3	A_t	A_b	A_τ	μ	M_A	$m_{\tilde{l}_I}$	$m_{\tilde{\tau}_L}$
150	250	1200	4000	4000	0	1500	1500	1000	1000
$m_{\tilde{l}_R}$	$m_{\tilde{\tau}_R}$	$m_{\tilde{q}_L}$	$m_{\tilde{q}_L^3}$	$m_{\tilde{q}_R^u}$	$m_{\tilde{q}_R^d}$	$m_{\tilde{t}_R}$	$m_{\tilde{b}_R}$	$\tan\beta$	
200	1000	1000	1000	1000	1000	4000	1000	10	

- ... and similar datapoint for UED (for spin determination)
- Setup of (exclusive) decay chains

$$\tilde{g}[1] \to b\bar{\tilde{b}}_i \to b\bar{b}\tilde{\chi}_2^0 \to b\bar{b}\ell^\pm\tilde{\ell}_R^\mp \to b\bar{b}\ell^\pm\ell^\mp\tilde{\chi}_1^0$$
$$\tilde{g}[2] \to d\bar{\tilde{d}}_L \to d\bar{d}\tilde{\chi}_1^0$$

MASS DETERMINATION

- Decay chain $\tilde{g}[1] \to b\bar{b}_i \to b\bar{b}\tilde{\chi}_2^0 \to b\bar{b}\ell^\pm\tilde{\ell}_R^\mp \to b\bar{b}\ell^\pm\ell^\mp\tilde{\chi}_1^0$



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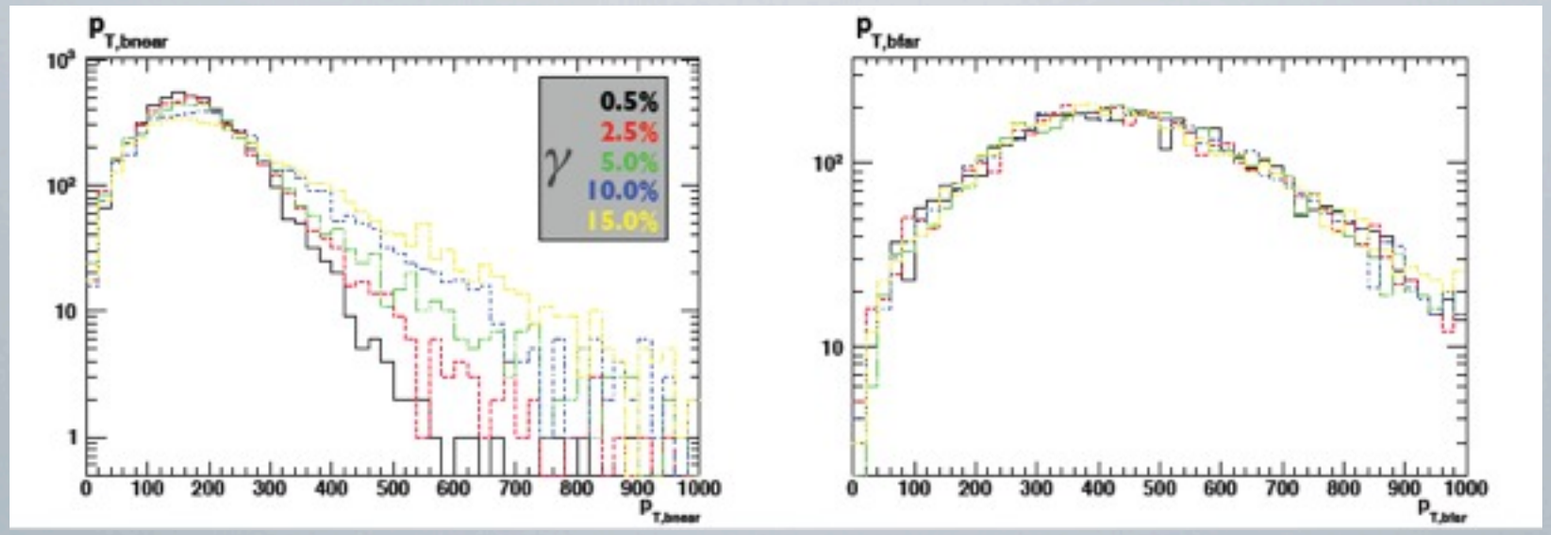
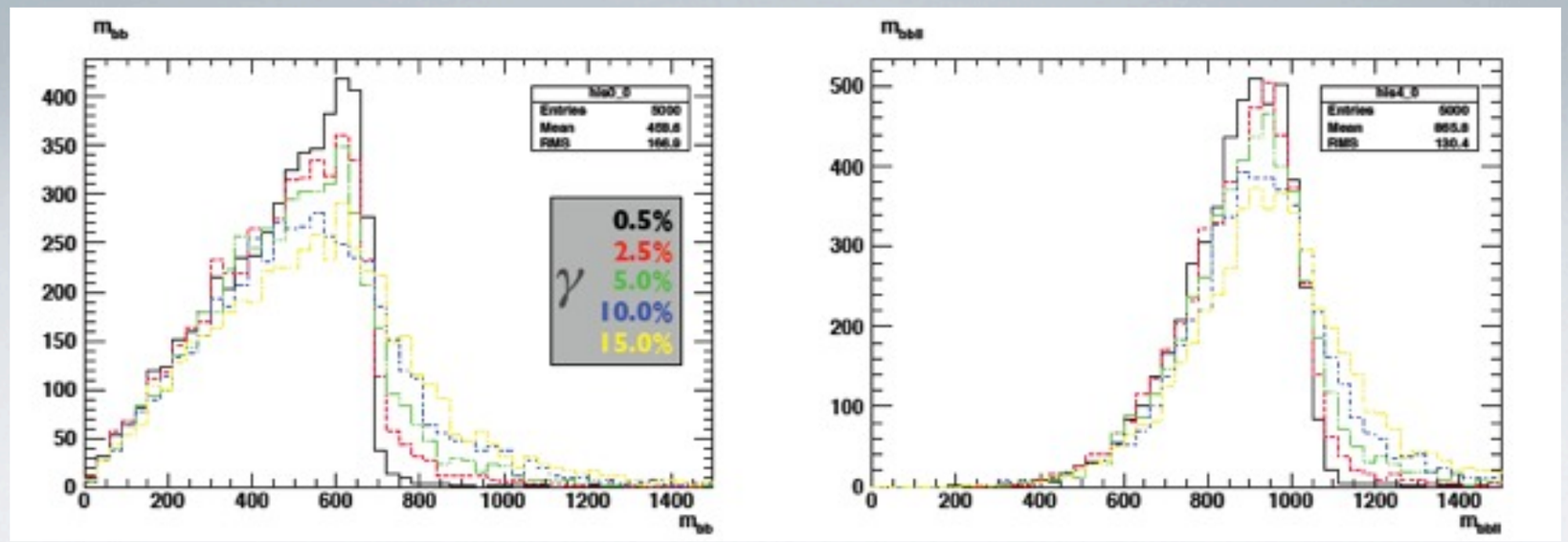


- **Mass edges:** two *b*s ... or ... two *b*s/two leptons



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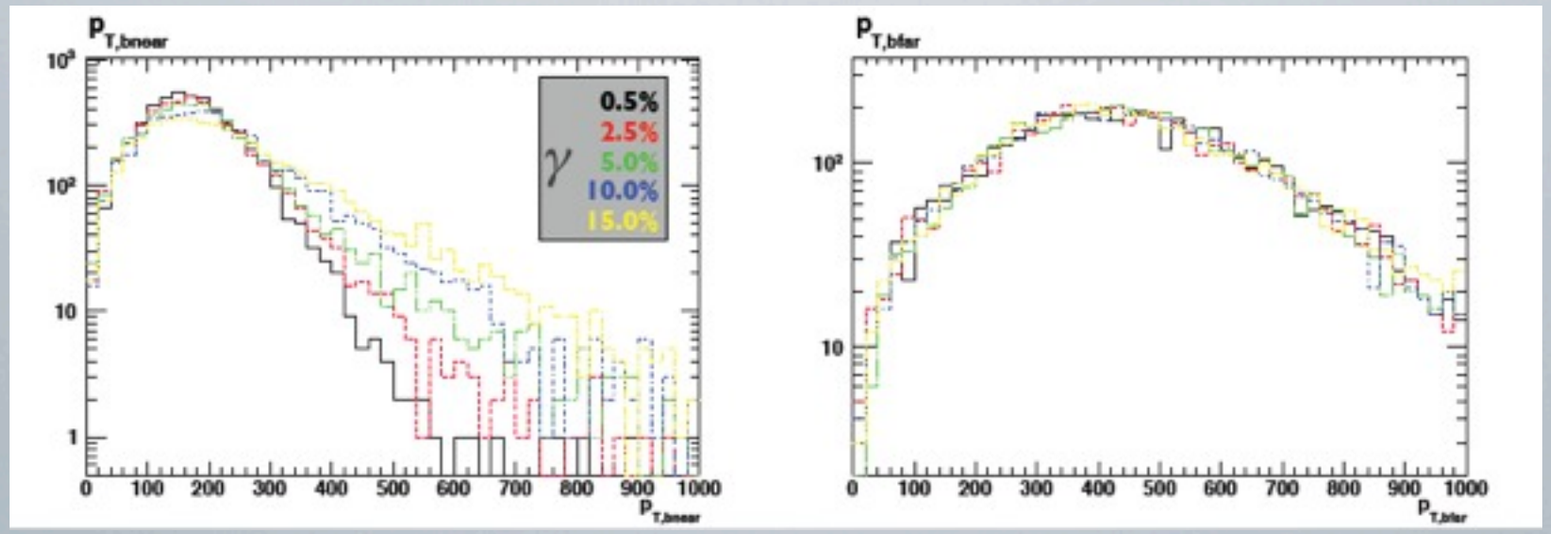

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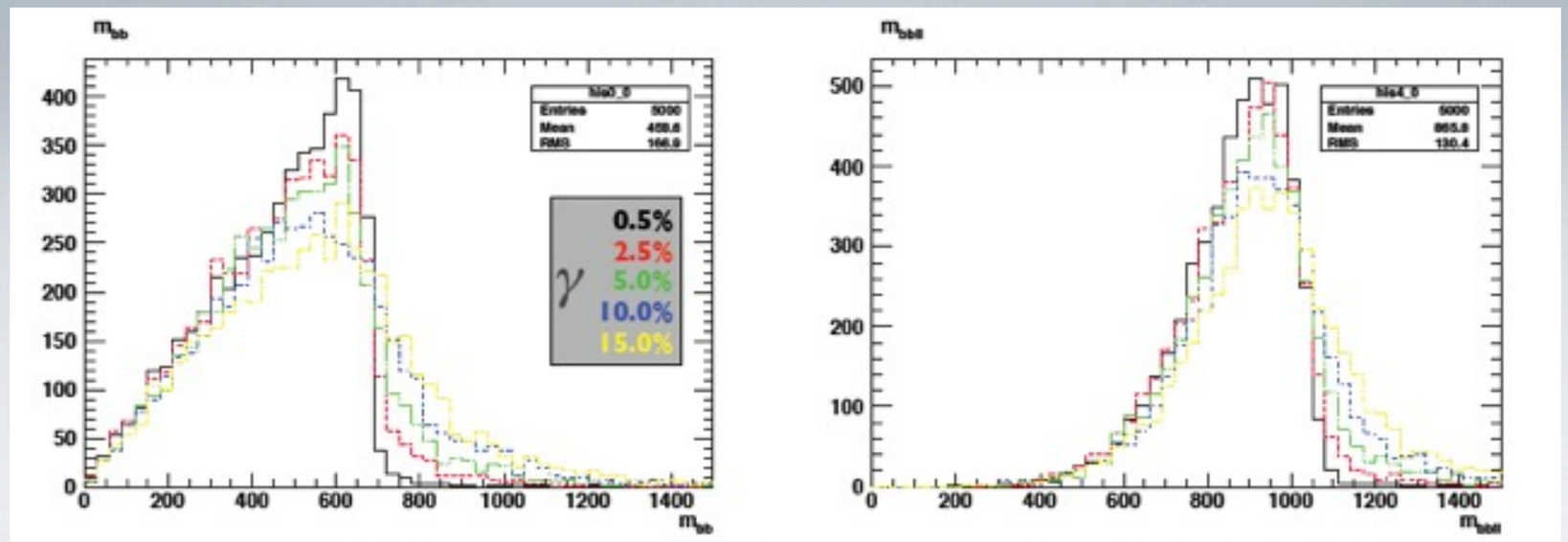


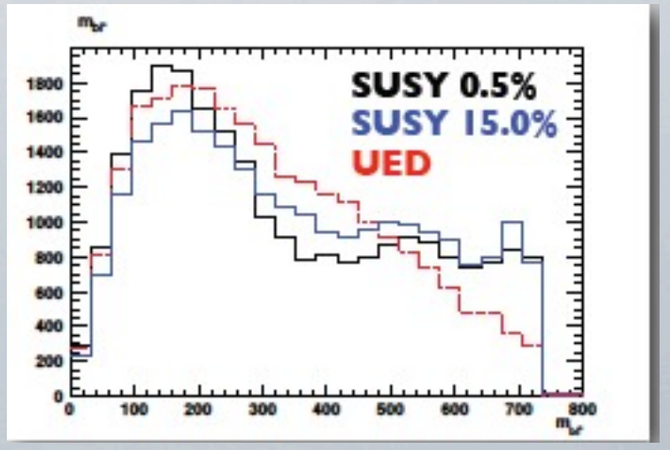
- **Uncertainties of several hundred GeV !!**

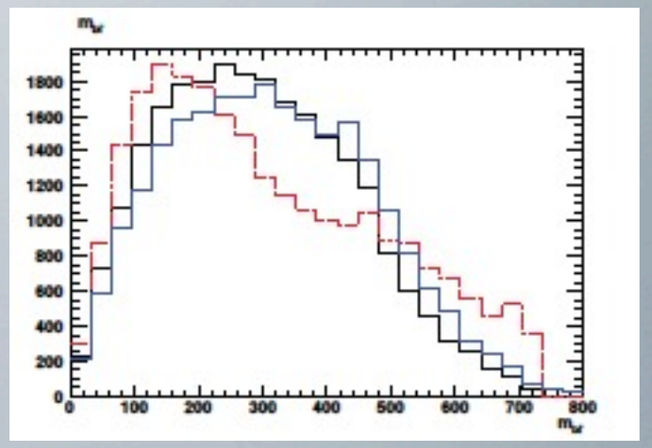
SPIN DETERMINATION (I)

Method 1: Shape asymmetry of $m_{b\ell}$

Alves/Eboli/Plehn, 2006

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





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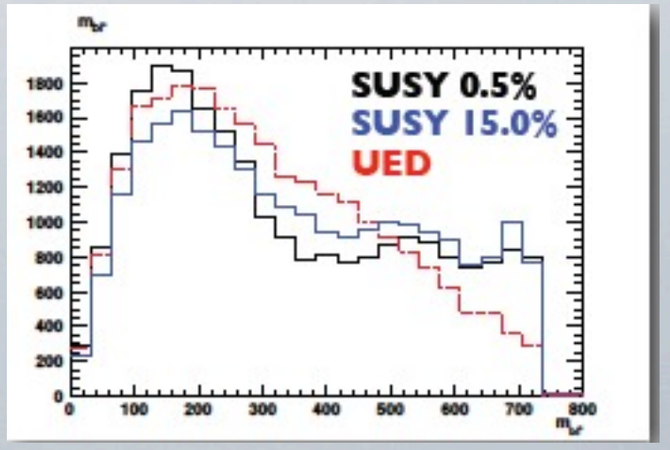

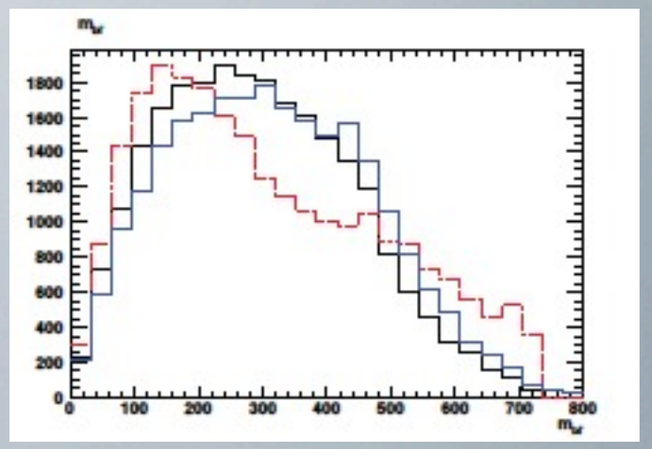

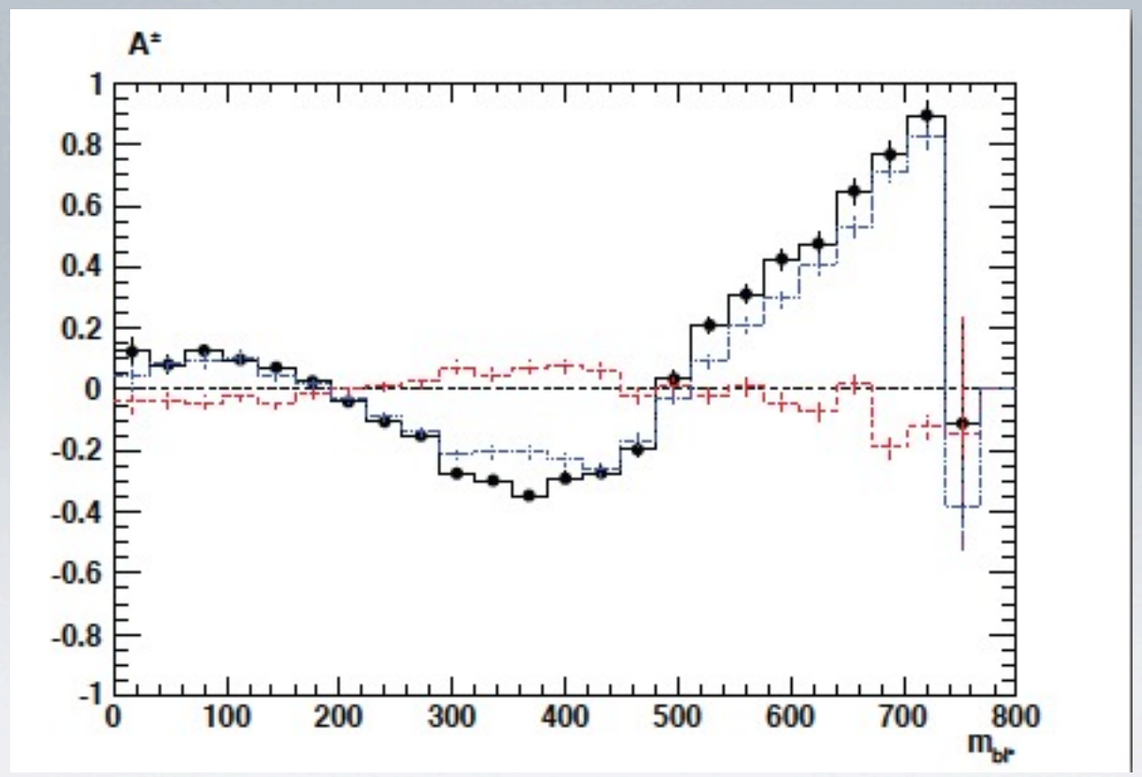

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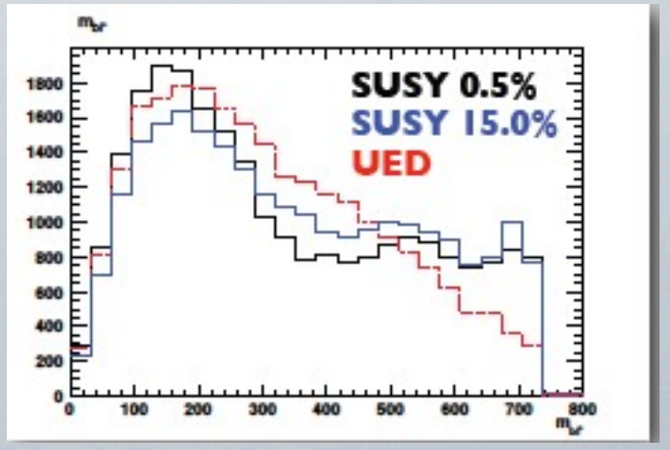
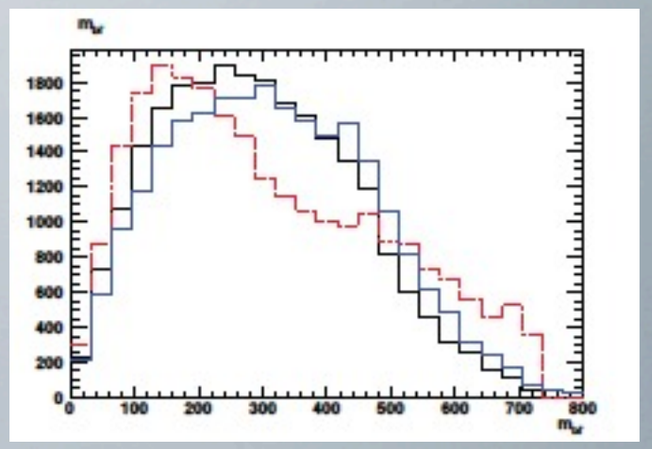
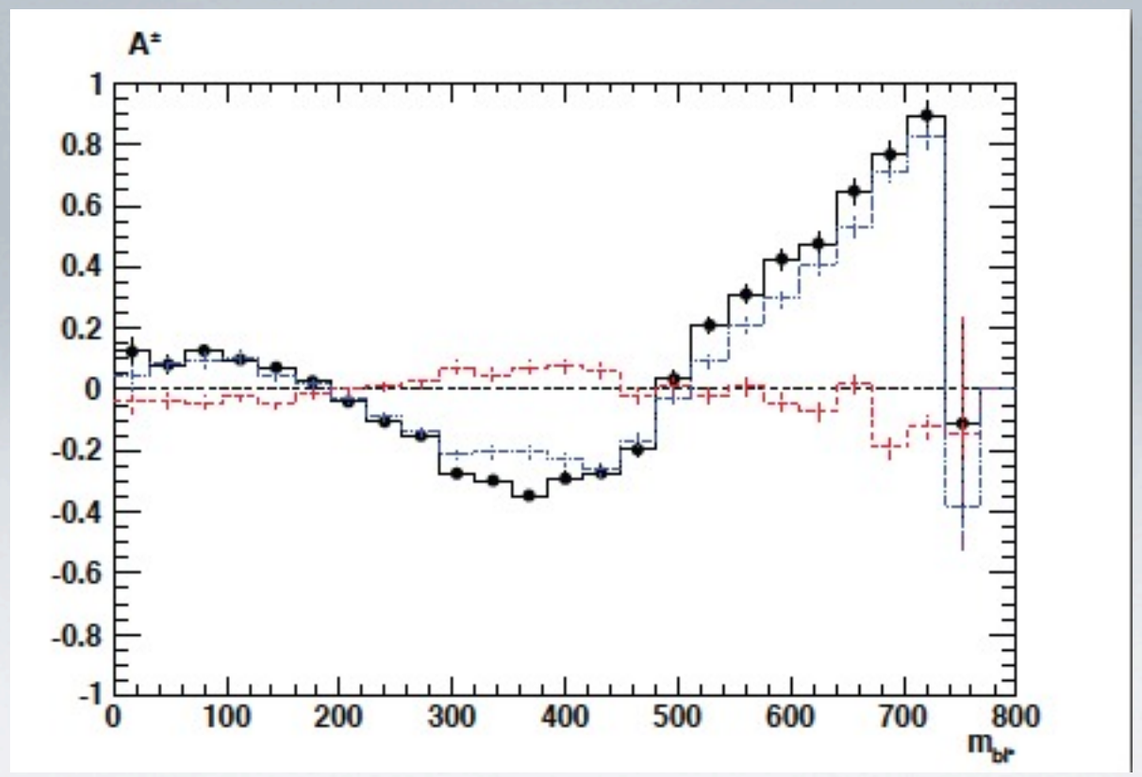






Shape Asymmetry not affected by fat gluino!

SPIN DETERMINATION (II)

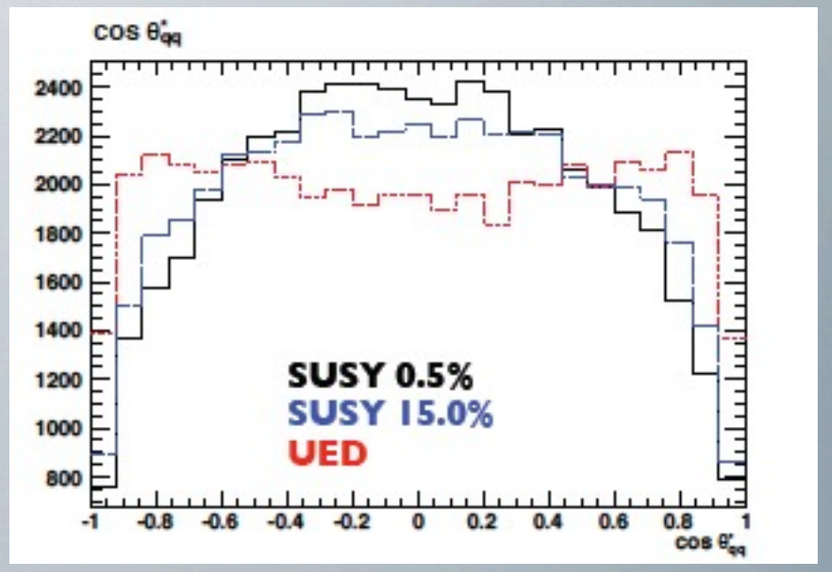
★ Angular correlations and asymmetries

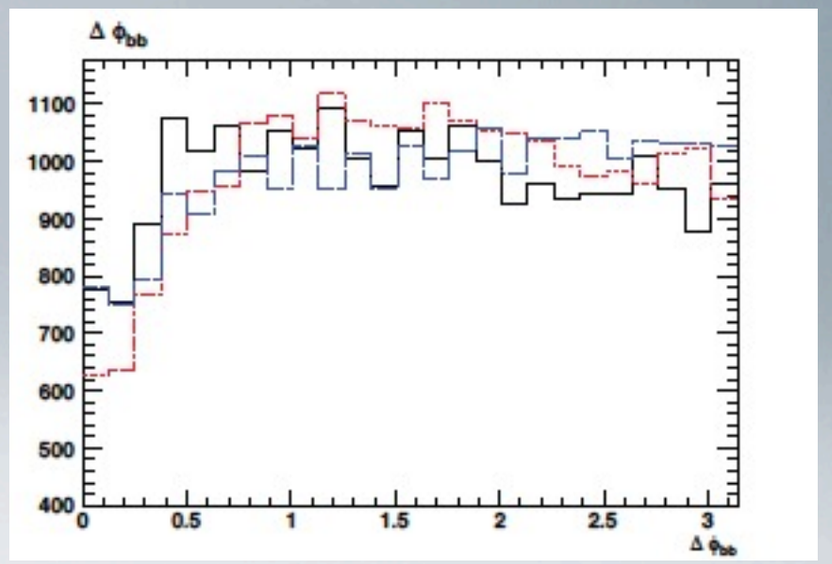
$$\cos\theta^*_{jj} = \tanh\left(\frac{\Delta\eta_{jj}}{2}\right)$$

Gudi M/Rolbiecki/Tattersaal, 2011

$$\Delta\phi_{bb}\,|\phi(b_1) - \phi(b_2)|$$

Alves/Eboli/Plehn, 2006

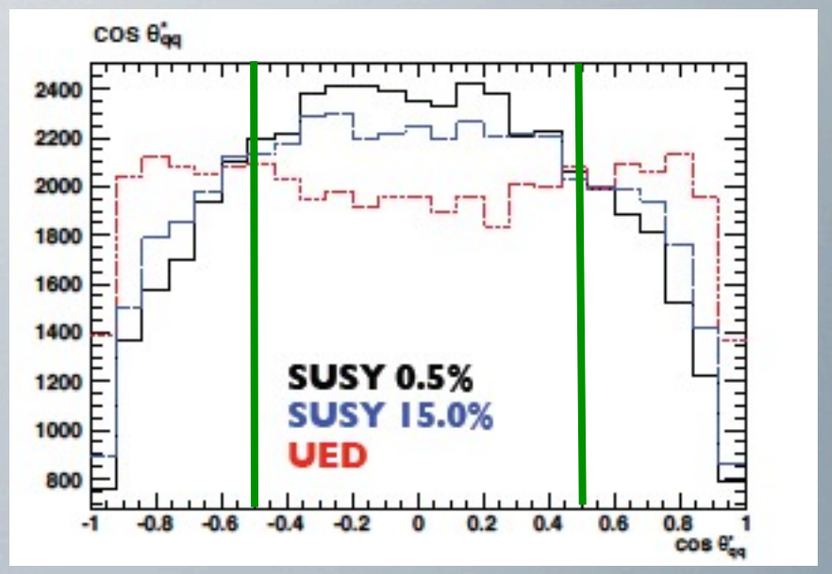




SPIN DETERMINATION (II)

★ Angular correlations and asymmetries

$$A_{ct}^{\pm} = \frac{N(|\cos\theta^*_{qq}| < 0.5) - N(|\cos\theta^*_{qq}| > 0.5)}{N(|\cos\theta^*_{qq}| < 0.5) + N(|\cos\theta^*_{qq}| > 0.5)}$$



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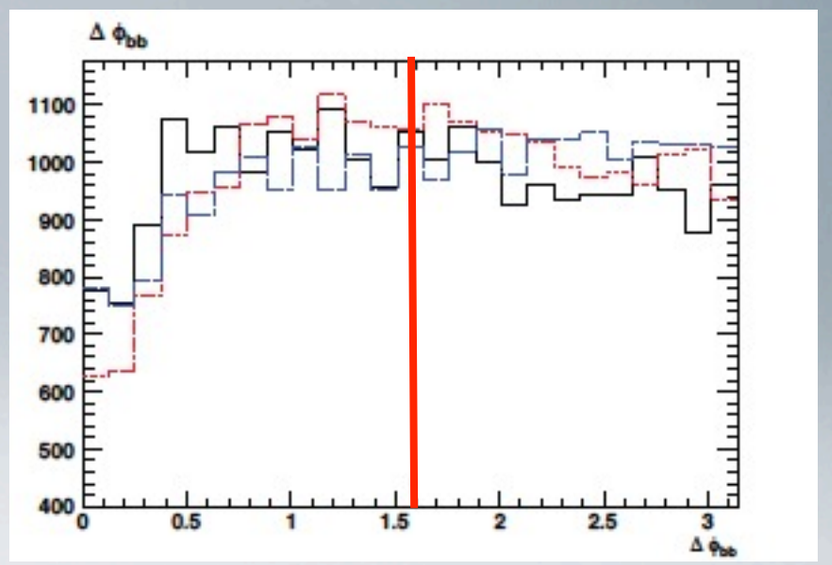

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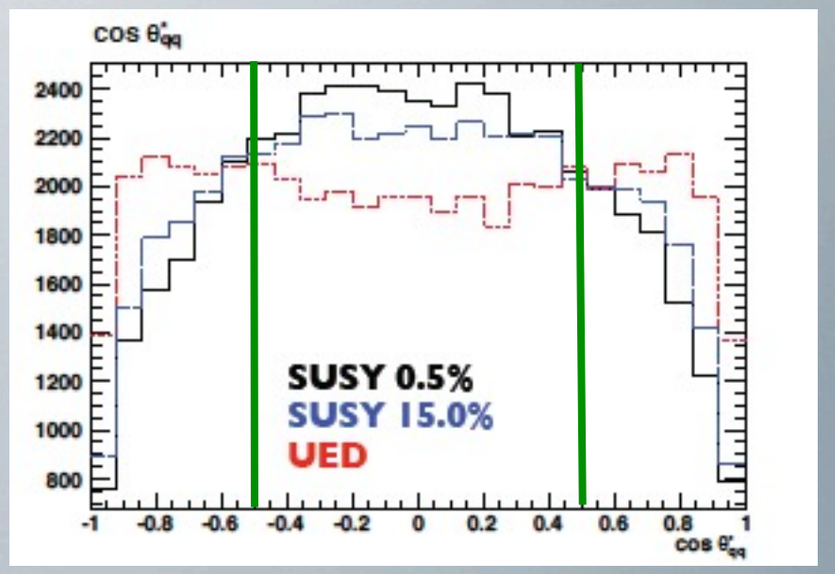

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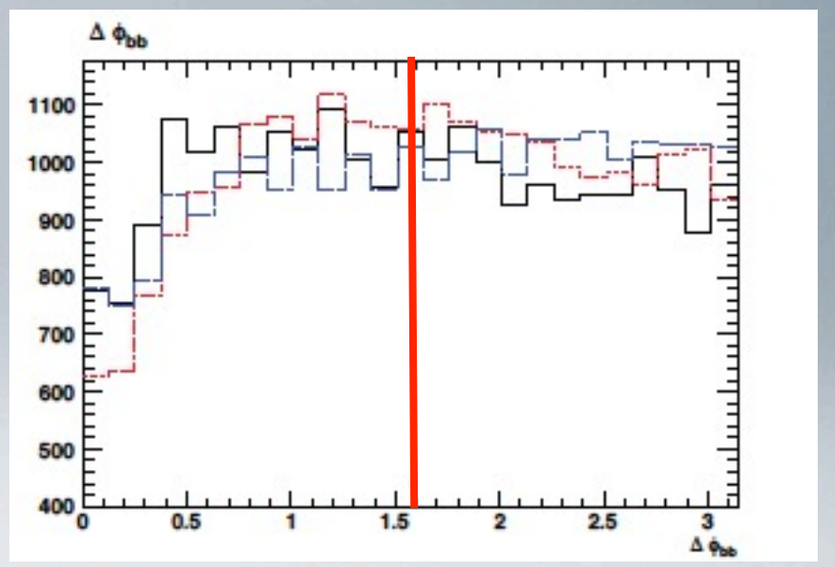

sample	5k
$A_{ct}^{\pm}$ (std)	0.194 ± 0.015
$A_{ct}^{\pm}$ (ofs)	0.125 ± 0.014
$A_{ct}^{\pm}$ (ued)	0.003 ± 0.014
$A_{\phi}^{\pm}$ (std)	0.014 ± 0.014
$A_{\phi}^{\pm}$ (ofs)	-0.047 ± 0.014
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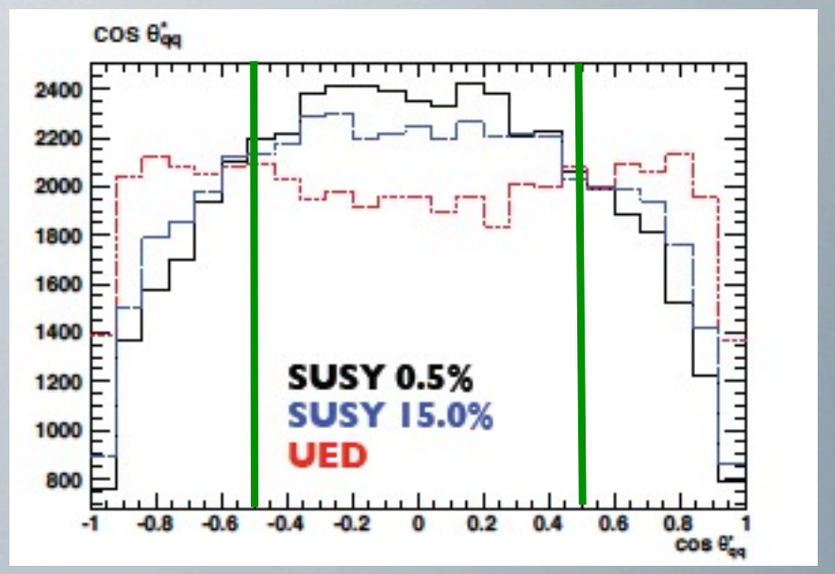

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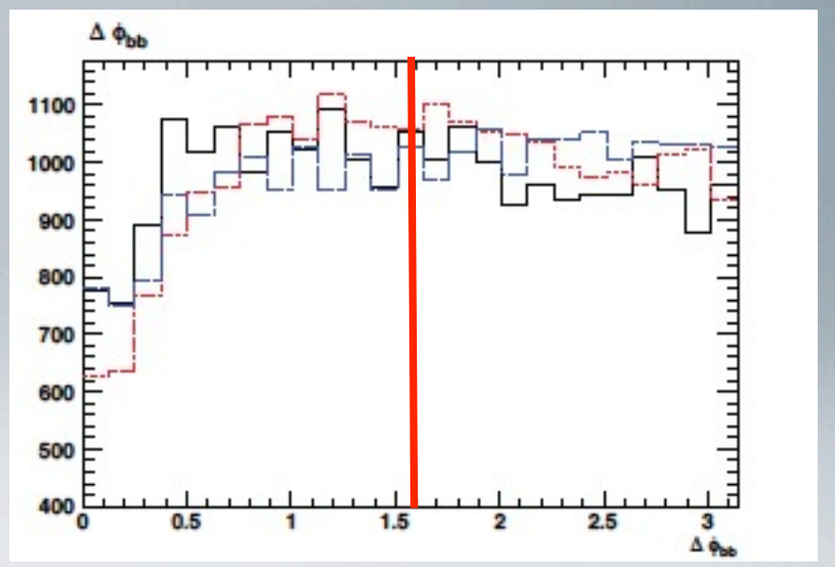

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SUMMARY/CONCLUSION

- Gluinos can have considerable **Γ/M** ≲ 20 %
- Physics example: GMSB with heavy gluinos
- Investigation with full matrix elements for gluino decay
- **Spin determination**: failure of one method, but **not endangered**
- **Mass determination**: **much higher uncertainties** due to washed out edges!
- *"En attendant Gluino"*

DID WE MISS THE ORDER DATE?