DUSTING FOR SUSY'S FINGERPRINTS IN PRECISION DATA

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MAX-PLANCK-GESELLSCHAFT

PHENO 07 - May 2007

INTRODUCTION

Electroweak precision calculations,
why bother?

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	central value	absolute error	relative error
M_W[GeV]	80.398	± 0.025 TEV/LHC: $\pm 0.020/0.015$ ILC:± 0.007	$\pm 0.03\%$
$\sin^2 \theta_{\text{eff}}$	0.23153	± 0.00016 ILC: ± 0.000013	$\pm 0.07\%$

- Negligible errors for α, G_F, M_Z, ...

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- Theory predictions sensitive to new physics via quantum corrections.

$\Rightarrow$ Probe new physics with current data.

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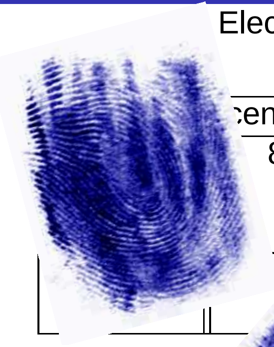

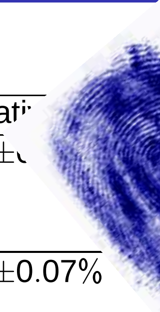

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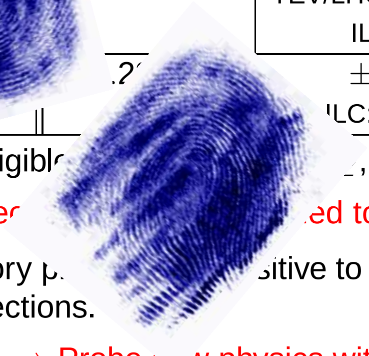

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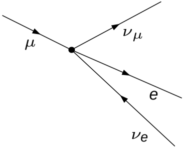
SUSY's fingerprints can already be observed...

W boson mass from μ-decay

Born level



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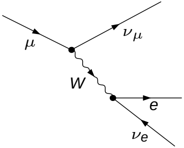

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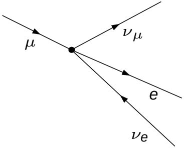

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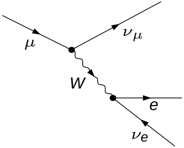

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- Summarise electroweak radiative corrections by Δr.

[Marciano,Sirlin]

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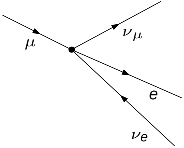

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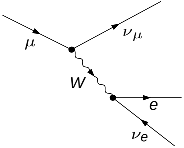

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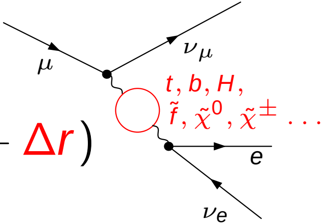

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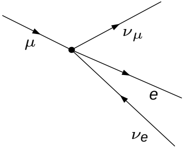

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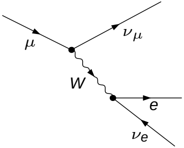

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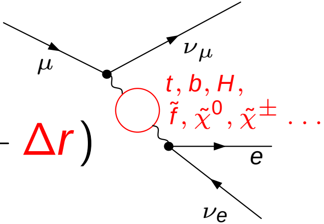
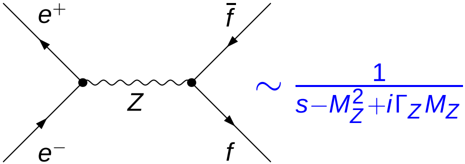


$$\Delta r = \Delta r(M_W, M_Z, m_t, \alpha, \alpha_s, M_h, M_A, m_{\tilde{f}}, m_{\tilde{\chi}^{0,\pm}} \ldots)$$

Z pole observables

- LEP1 / SLC / GigaZ: $e^+e^- \to f\bar{f} @ s \sim M_Z^2$.



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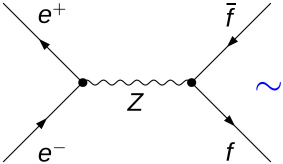

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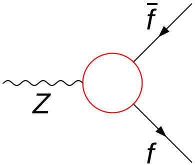

$$\Longrightarrow \mathcal{M}_{\mathrm{eff}} = \bar{u}_f \gamma_\alpha [\mathcal{G}_V^{\mathrm{eff}} - \gamma_5 \mathcal{G}_A^{\mathrm{eff}}] v_f \epsilon_Z^\alpha$$

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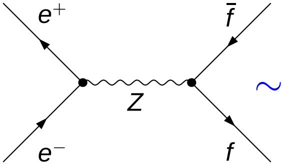

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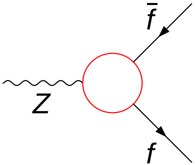

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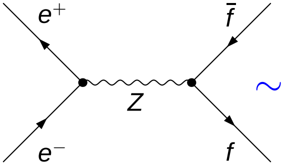

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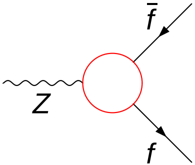

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- Partial widths: $\Gamma_f := N_c^f \frac{\alpha}{3} M_Z \left(|\mathcal{G}_V^{\text{eff}}|^2 R_V^{QED} + |\mathcal{G}_A^{\text{eff}}|^2 R_A^{QED}\right)$

CALCULATIONS

Status of M_W & $\sin^2\theta_{\mathbf{eff}}$ calculation

[Heinemeyer, Hollik, Stöckinger, Weiglein, AMW] – JHEP08(2006)052 & forthcoming pub.

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$\delta M_W^{\text{th}} \approx 4 \ldots 8$ MeV $\qquad \delta\sin^2\theta_{\text{eff}}^{\text{th}} \approx (5.1\ldots7.3)\times10^{-5}$

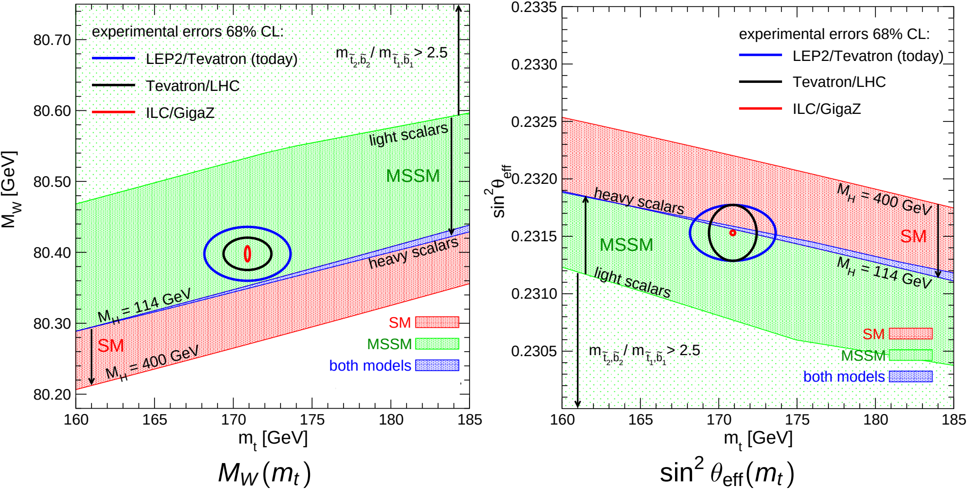
ANALYSES

Scatter plots

- SUSY parameters:

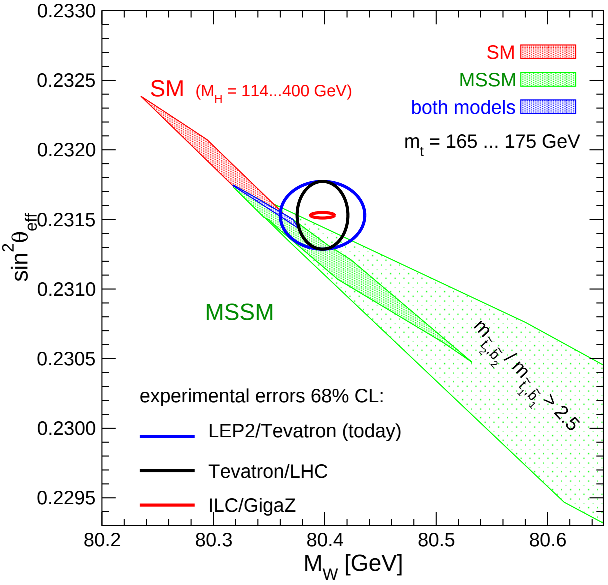
sleptons	:	$M_{\tilde{F},\tilde{F}'} = 100 \ldots 2000$ GeV
light squarks	:	$M_{\tilde{F},\tilde{F}'_{\text{up/down}}} = 100 \ldots 2000$ GeV
$\tilde{t}/\tilde{b}$ doublet	:	$M_{\tilde{F},\tilde{F}'_{\text{up/down}}} = 100 \ldots 2000$ GeV
		$A_{t,b} = -2000 \ldots 2000$ GeV
gauginos	:	$M_{1,2} = 100 \ldots 2000$ GeV
		$m_{\tilde{g}} = 195 \ldots 1500$ GeV
		$\mu = -2000 \ldots 2000$ GeV
Higgs	:	$M_A = 90 - 1000$ GeV
		$\tan\beta = 1.1 \ldots 60$

- Unconstrained scan, but:
  - Higgs mass in agreement with LEP searches.
  - Direct search bounds for SUSY particles.



⇒ Preference of MSSM over SM from M_W.

⇒ MSSM and SM equally good for $\sin^2\theta_{\text{eff}}$.



⇒ Combination of M_W and $\sin^2\theta_{\text{eff}}$ slightliy favours MSSM.

Global mSUGRA fits & forecasts

[Allanach, Lester, AMW] – JHEP12(2006)065 & arXiv:0705.0487 [hep-ph].

- Application of Markov Chain Monte Carlo techniques & Bayesian stats as extension of previous analyses.
  [Allanach, Lester], [Baltz, Gondolo], [Ellis, Heinemeyer, Olive, Weiglein]

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- MSSM spectrum from `SOFTSUSY2.0.10`.
  [Allanach]
- SM input varied in 4σ range (χ^2 penalty).
- mSUGRA parameter space constrained by
  - Dark matter relic density $\Omega_{DM}h^2$.
    `[microOMEGAS1.3.6]`
  - Branching ratios $BR(b \to s\gamma)$, $BR(B_s \to \mu^+\mu^-)$.
    `[microOMEGAS1.3.6]`
  - Higgs mass m_h.
    `[SOFTSUSY2.0.10]`
  - Anomalous magnetic moment $\delta a_\mu \equiv \delta\frac{(g-2)_\mu}{2}$.
    [`microOMEGAS1.3.6,` *Stöckinger]*
  - W boson mass M_W and effective leptonic mixing angle $\sin^2\theta_{\text{eff}}$

- mSUGRA parameters:
  - Before EW symmetry breaking

$$A_0, m_0, M_{1/2}, B, \mu$$

  - After EW symmetry breaking

$$A_0, m_0, M_{1/2}, \tan\beta, \mathrm{sign}(\mu), M_Z^{\mathrm{exp}}$$

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- Application of different priors:
  - Flat priors on $A_0, m_0, M_{1/2}, \tan\beta$.
  - Flat priors on $A_0, m_0, M_{1/2}, B, \mu$ & favour mSUGRA parameters within same order of magnitude.

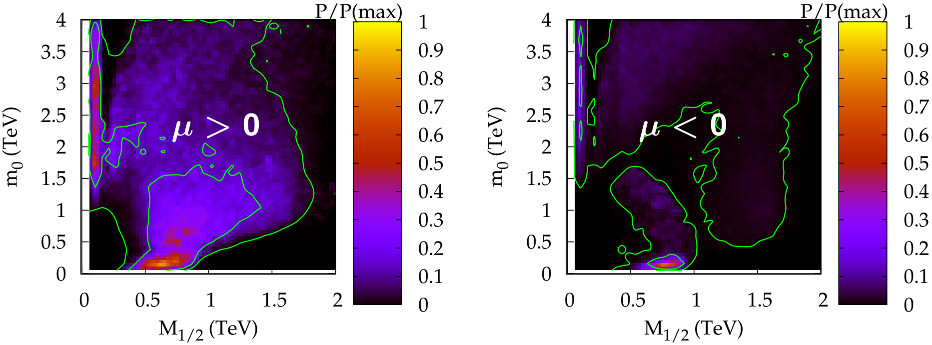
same order prior: e.g. $p(m_0|M_{\text{SUSY}}) = \frac{1}{\sqrt{2\pi w^2} m_0} \exp\left(-\frac{1}{2w^2}\log^2(m_0/M_{\text{SUSY}})\right), \, w = 1, 2\ldots$

$$\log(m_0/\text{MSUSY}) \text{ within } \pm w \quad @\ 68\%\text{CL}$$

$\Rightarrow$ Flat prior before EWSB “natural”.

Posterior probability maps, flat priors on $A_0, m_0, M_{1/2}, \tan\beta$ after EWSB

Stringent constraints from DM relic density.



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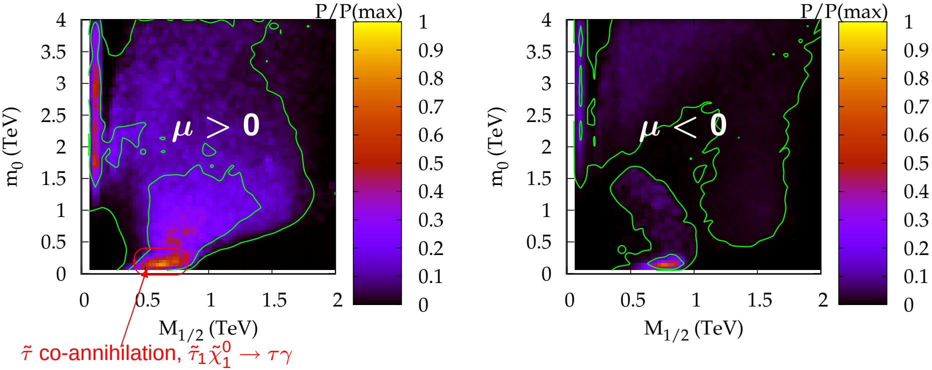

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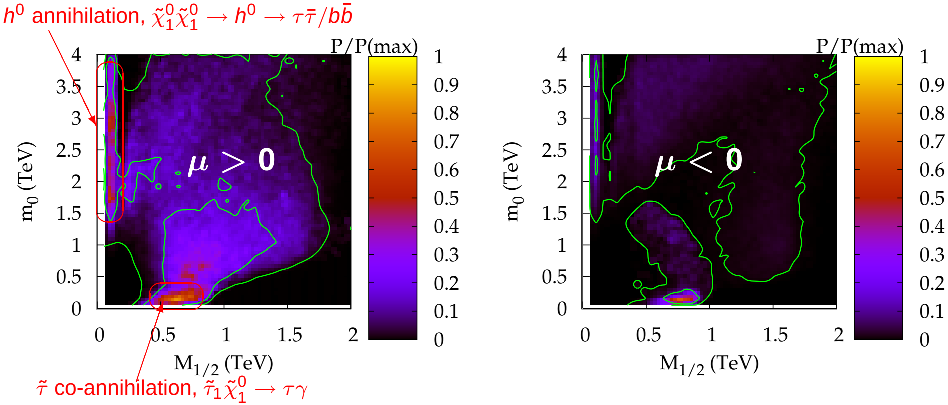

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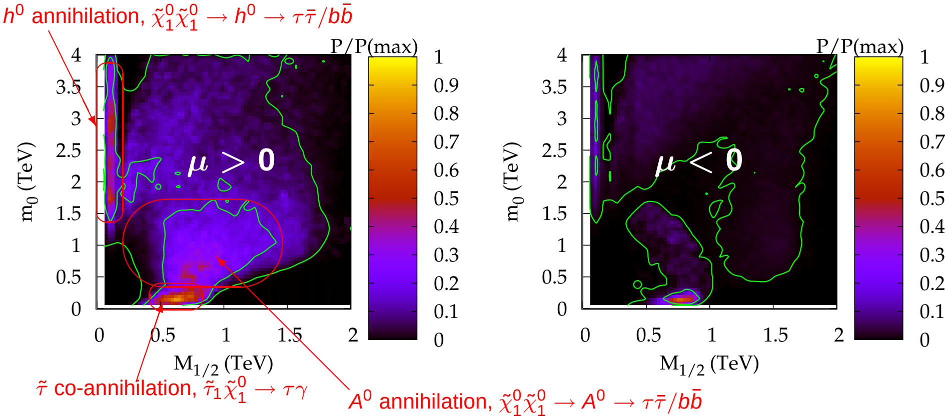

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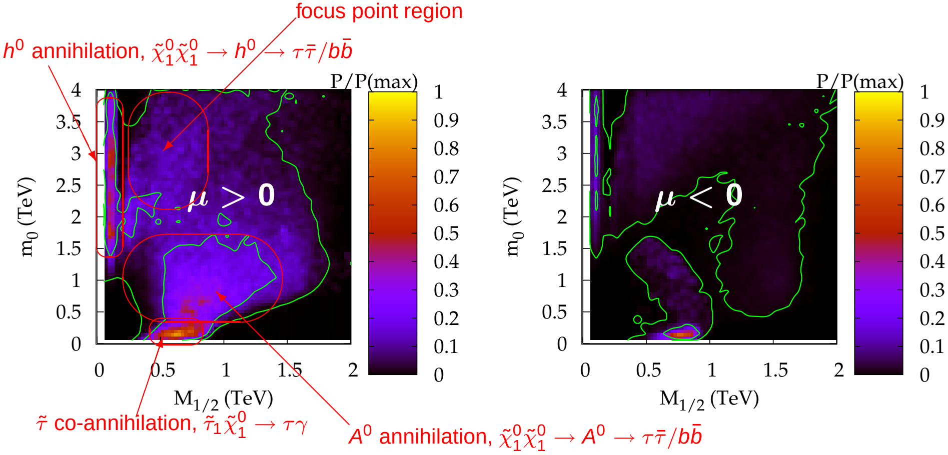

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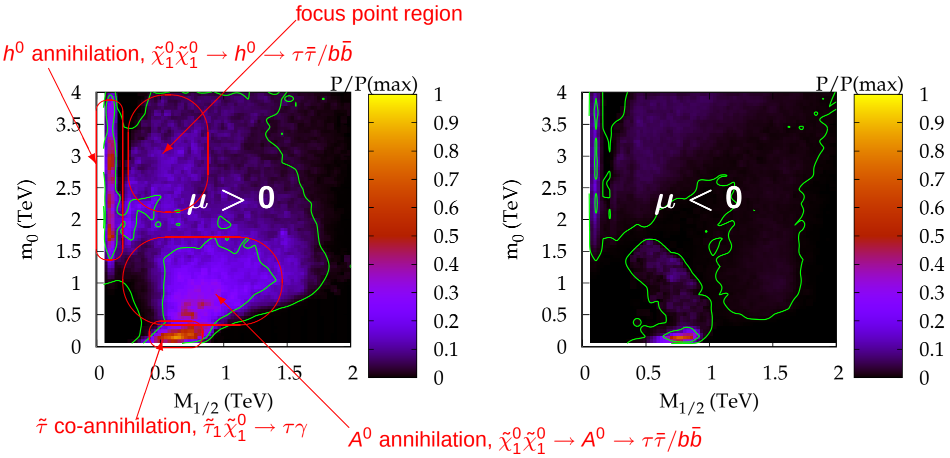

$P(\mu < 0)/P(\mu > 0) = 0.07 - 0.16$

$\Rightarrow \mu < 0$ not completely ruled out by $(g-2)_\mu$ as often assumed
(for flat priors on $A_0, m_0, M_{1/2}, \tan\beta$).

Now: flat priors on $A_0, m_0, M_{1/2}, B, \mu$ before EWSB
& mSUGRA parameters of same order

$\Rightarrow$ large $\tan\beta$ disfavoured $\Rightarrow$ A^0 pole region suppressed
$\Rightarrow$ large values of A_0 disfavoured $\Rightarrow$ h^0 pole region suppressed
$\Rightarrow$ large m_0 disfavoured $\Rightarrow$ focus point region suppressed

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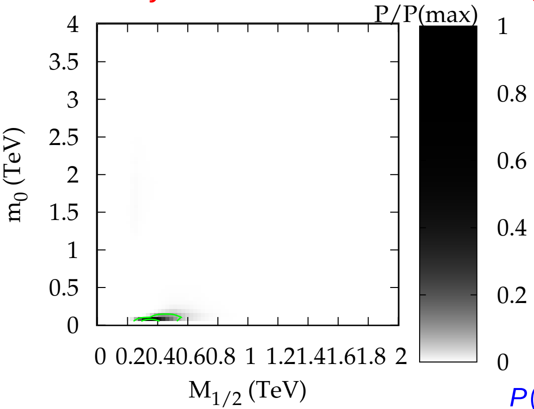
$\Rightarrow$ large m_0 disfavoured $\Rightarrow$ focus point region suppressed

$\Rightarrow$ Good fit only for stau co-annihilation region.



$\Rightarrow$ Light SUSY spectra.

$P(\mu < 0)/P(\mu > 0) = 0.002 - 0.006$

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  - Preference for light SUSY for natural priors.

Outlook

- Paper on Z observables.
- Extension to non-minimal models.
- Further studies in constrained MSSM scenarios (NUHM, AMSB,$\ldots$).
- Preparation of public computer code ($\Rightarrow$ LHC analyses).
- How light can the neutralino be? ($\Rightarrow$ O.Kittel PHENO 07)