Gauge-mediated SUSY with tau slepton NLSP at the ILC

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Based on works in collaboration with:

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Contents

- LHC results + muon g-2
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Introduction

Discovery at LHC:
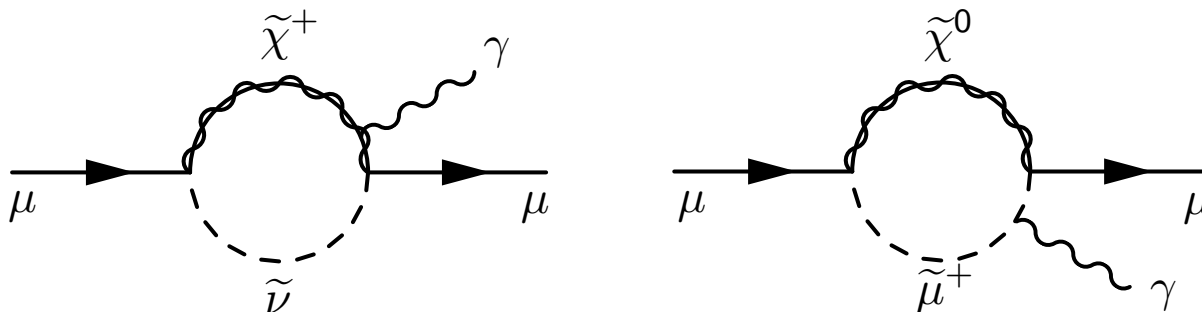
Higgs mass is **126 GeV**

Implications for SUSY:
The scalar top is heavy O(10-100) TeV or there is large left-right mixing of the scalar tops in the MSSM
… or require NMSSM

Muon g-2:
Suggests sleptons, higgsino, wino, and bino are in the O(100) GeV range.
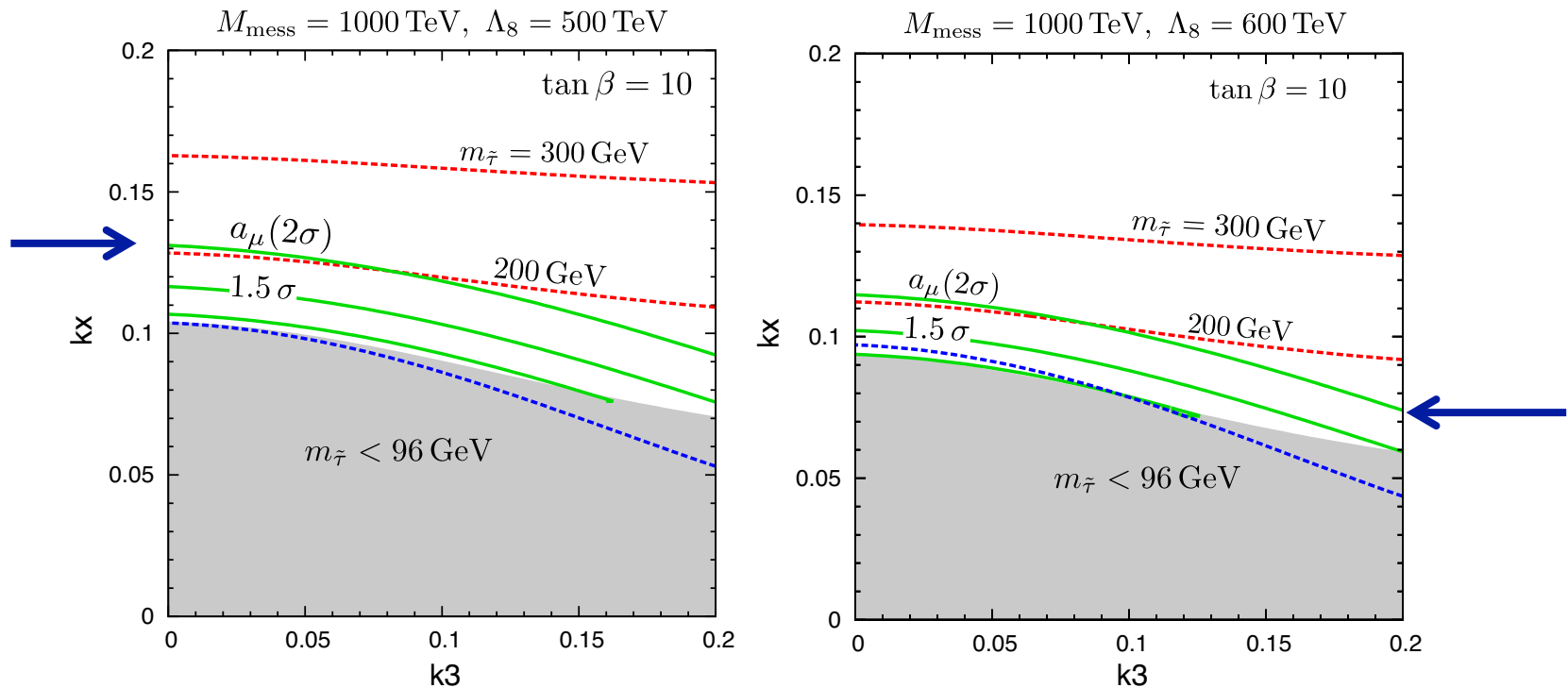
Leading contributions to muon g-2:

Models with light sleptons

Models with heavy squarks and light sleptons which are compatible with muon g-2 can be realized e.g.

[Ibe, Matsumoto, Yanagida, Yokozaki, arXiv:1210.3122]

NB) Consistent with GUT; GMSB → no SUSY flavor/CP problem.

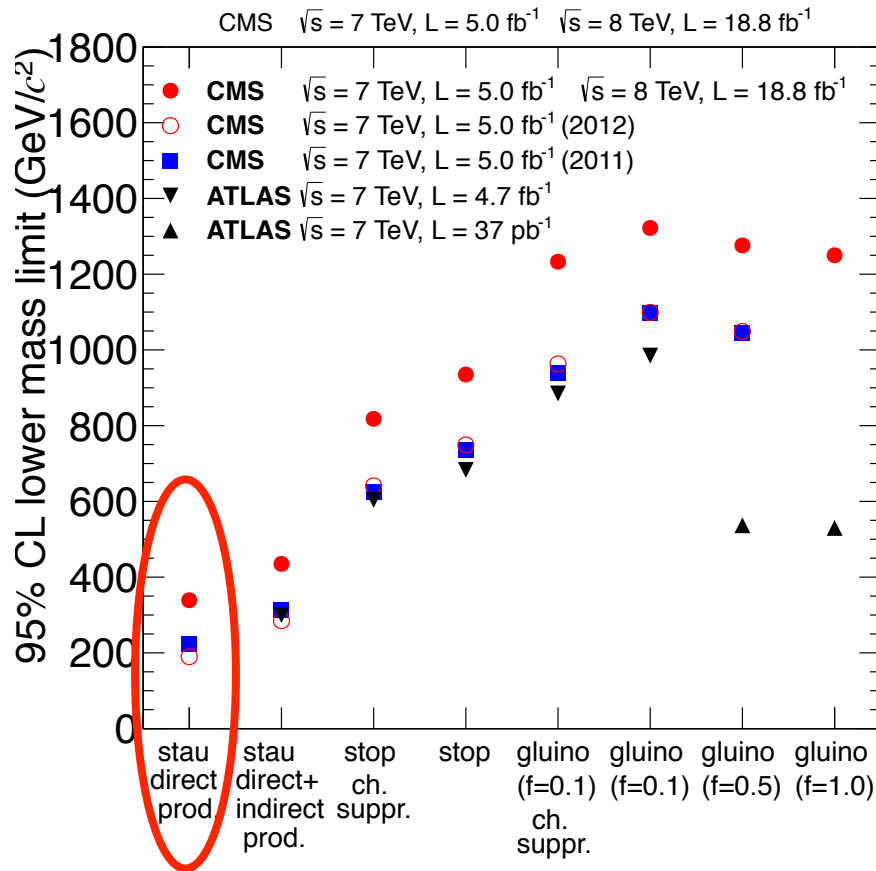$M_{\mathrm{mess}} = 1000\,\mathrm{TeV},\ \Lambda_8 = 500\,\mathrm{TeV}$

$\tan\beta = 10$

$m_{\tilde{\tau}} = 300\,\mathrm{GeV}$

$a_\mu(2\sigma)$

$1.5\,\sigma$

$200\,\mathrm{GeV}$

$m_{\tilde{\tau}} < 96\,\mathrm{GeV}$

$M_{\mathrm{mess}} = 1000\,\mathrm{TeV},\ \Lambda_8 = 600\,\mathrm{TeV}$

$\tan\beta = 10$

$m_{\tilde{\tau}} = 300\,\mathrm{GeV}$

$a_\mu(2\sigma)$

$1.5\,\sigma$

$200\,\mathrm{GeV}$

$m_{\tilde{\tau}} < 96\,\mathrm{GeV}$

< 2σ deviation in muon g-2 → m(stau) < 200 GeV
Motivates search for light stau!

Stau search at LHC

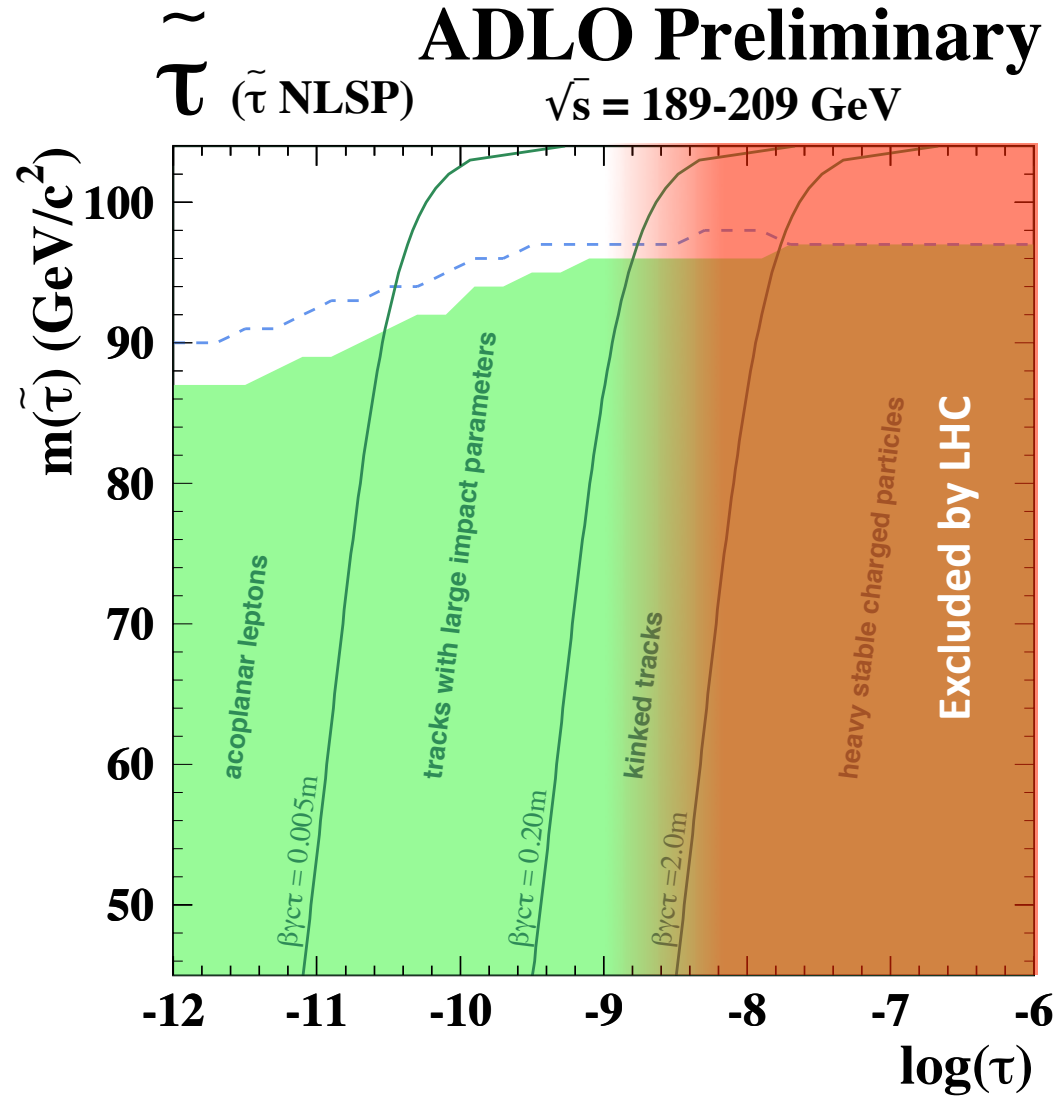If the stau lifetime is sufficiently long, it appears as a Heavy Stable Charged Particle.

LHC limit for direct stau pair production:

m(stau) > 340 GeV, if stau is (pseudo-)stable.

If the stau is light, it must decay!

[CMS-EXO-12-026, arXiv:1305.0491]

Stau search at LEP

ADLO Preliminary
√s = 189-209 GeV

~τ (~τ NLSP)

LEP limit for stau (GMSB)
m(stau) >~ 90 GeV

→ Stau parameter range at the **ILC** with large impact parameters:

Lifetime: 10 μm – 10 cm
Mass: 90 GeV – 250 GeV

Stau decays

Stau search strategy is applicable in many models:

Decay to gravitino (GMSB) $\quad \widetilde{\tau} \to \tau \widetilde{G}$

Decay to axino $\quad \widetilde{\tau} \to \tau \widetilde{a}$

R-parity violation $\quad \widetilde{\tau} \to \tau \nu_e, \; \tau \nu_\mu$

$$\to \mu \nu_e, \; \mu \nu_\tau$$

$$\to e \nu_\mu, \; \mu \nu_\tau$$

Common signature: tau + missing

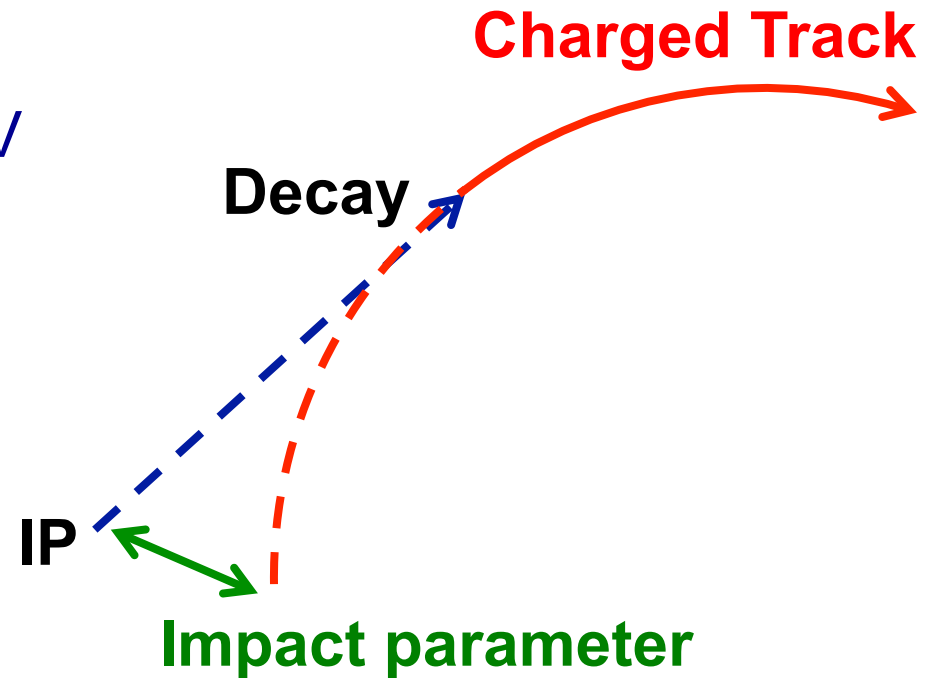# Stau search at the ILC

CM energy: 500 GeV
Stau mass: 90 GeV – 250 GeV
Stau lifetime: 10 μm – 10 cm

Search strategy:
Use track impact parameters
to find stau

[Matsumoto, Moroi, **PLB** 701, 422 (2011)]

Charged Track

Decay

IP

Impact parameter

1. Full simulation study at several benchmark points
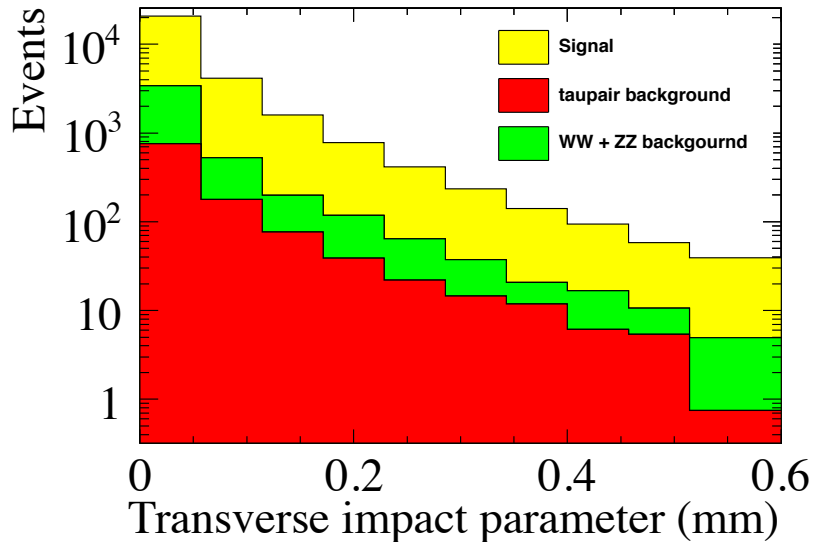2. Parameter scan with fast simulation

Full simulation study at the ILC

[Katayama, Mori, Fujii, Matsumoto, Suehara, TT, Yamashita, **LC-REP-2013-010**]
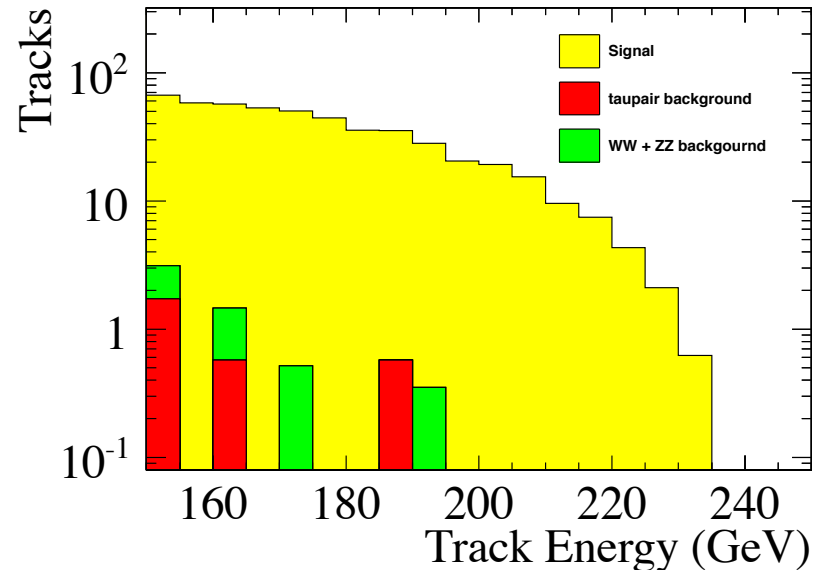
Stau mass: 120 GeV
Stau lifetime: 100 μm
CM energy: 500 GeV
Beam pol: $P(e^+, e^-) = (+0.8, -0.3)$
Integrated lumi: 500 fb^{-1}

Assumptions:
selectron is heavy
stau1 is partner of right-handed tau

Stau pair cross section: 136 fb

Impact parameter analysis:
Δlifetime / lifetime = 1.4%

Kinematic edge analysis:
Δm / m = 1.4%

Summary and prospects

- Search for light sleptons is ever more important in the wake of the Higgs discovery at 126 GeV

- It is possible to build models compatible with 126 GeV Higgs and muon g-2

- LHC limits → stau must decay if light

- ILC sensitivities in the O(1)% level for stau mass and lifetime

- ILC studies will continue to probe the different stau mass and lifetime ranges.

Thank you!