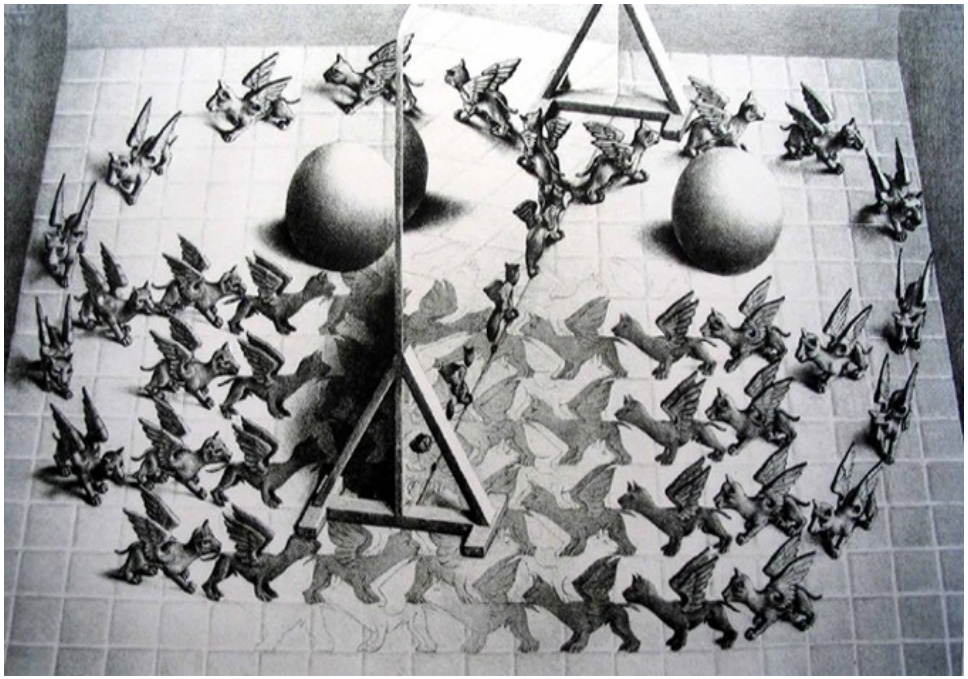
Physics at LHC:
SUperSYmmetry

Pedrame Bargassa

LIP



LIP 15/06/2012

Outline

- *Example of Chargino search*
- *Example of Neutralino search*
- *Example of Squar/Gluino search*

Chargino search

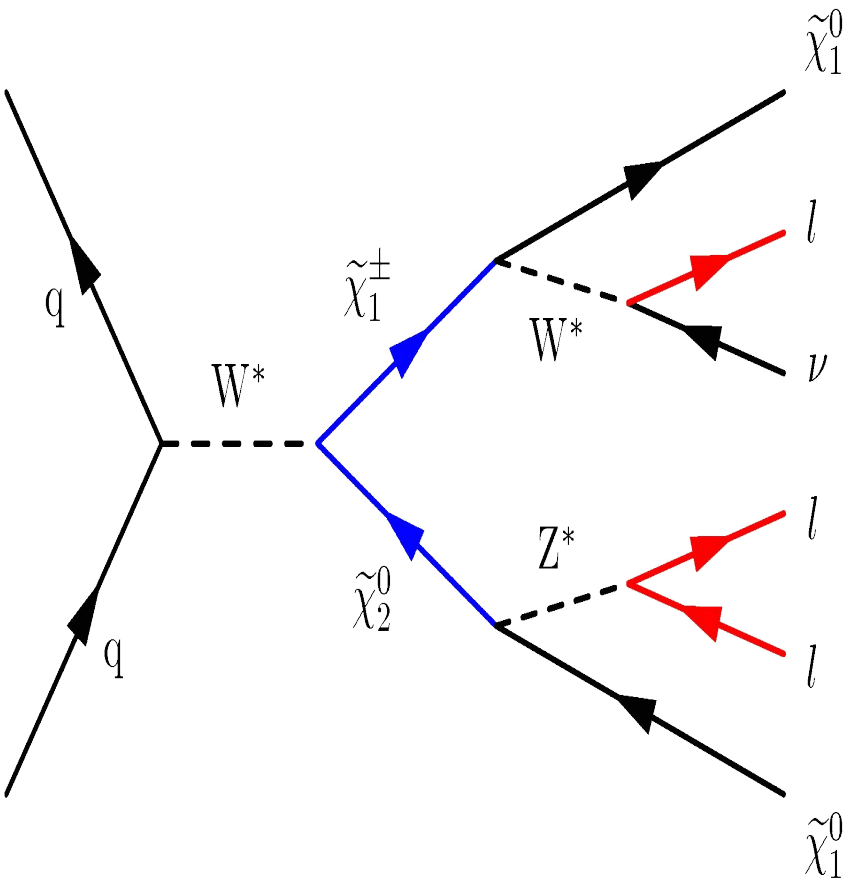
Try to come up with diagrams for production of a chargino at a hadronic machine

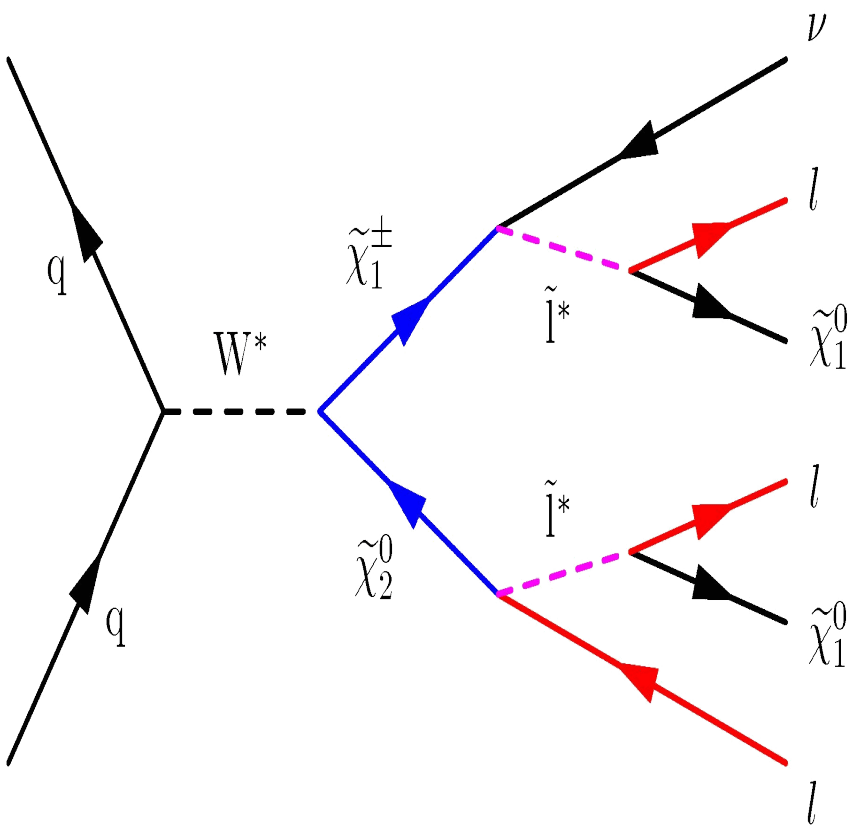
Chargino search

Production mode: Think about W production @ hadronic machine

2 decay scenarios:

- M(slept) » M(χ^0_2): Z/W exchange dominates: Br(χ^{+-}_1,χ^0_2 -> lept.) low
- M(slept) ~ M(χ^0_2): Slepton exchange dominates: Br(χ^{+-}_1,χ^0_2 -> lept.) maximal





Chargino search

Think about experimentally:

What are the background processes to such a signal/signature ?

What are the inconvenients of such a processes ?

How would-you design a selection ?

Chargino search

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WZ production
ZZ production where 1 lepton is lost
(Z)
(ttbar → Dilepton)
→ It's basically a low-background processes !

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Low cross-section → High (integrated) luminosity type of search
WZ background is irreducible

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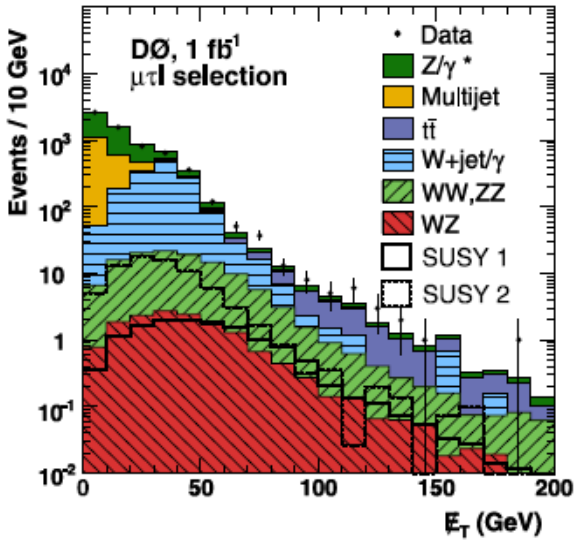
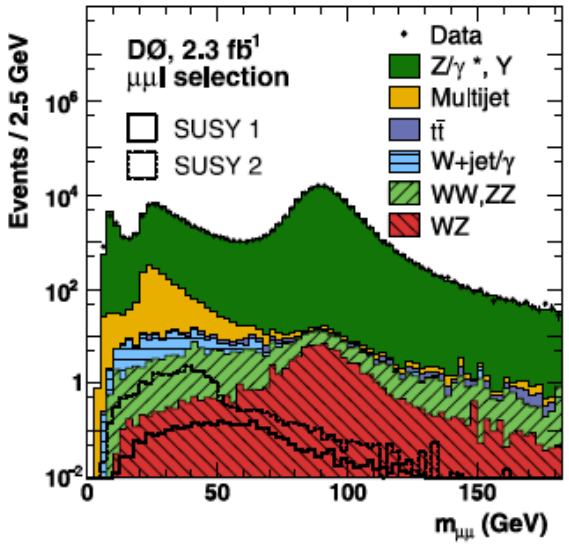
WZ background is irreducible

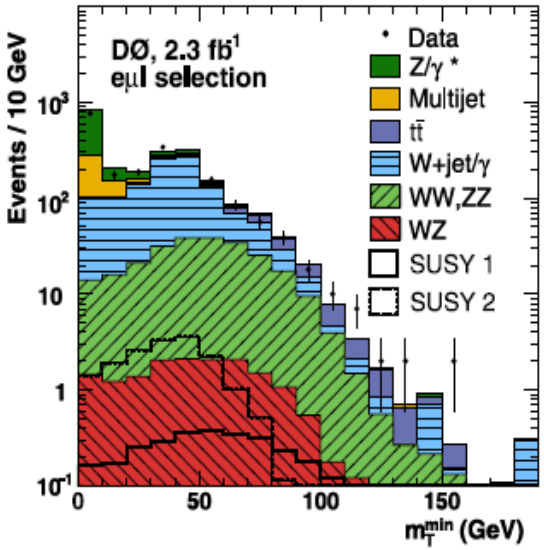
How would-you design a selection ?
Require 3 leptons, 2 of them with opposite charge
Increase statistics: The 3rd lepton can be a “track”: Enough to beat dilepton SM background w/o paying price of lepton identification
Minimal MET to beat down the ZZ processes

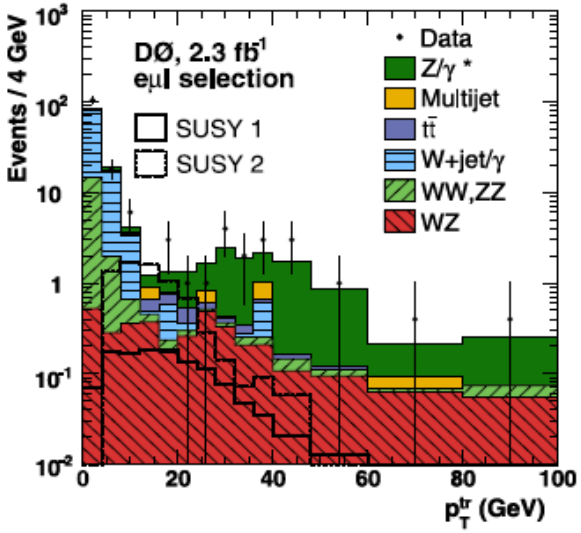
Chargino search

D0 RunII **Trileptons:** eμl, eel, $\mu^{+-}\mu^{-+}$l, $\mu^{+-}\mu^{+-}$l, eτ l, μτ l

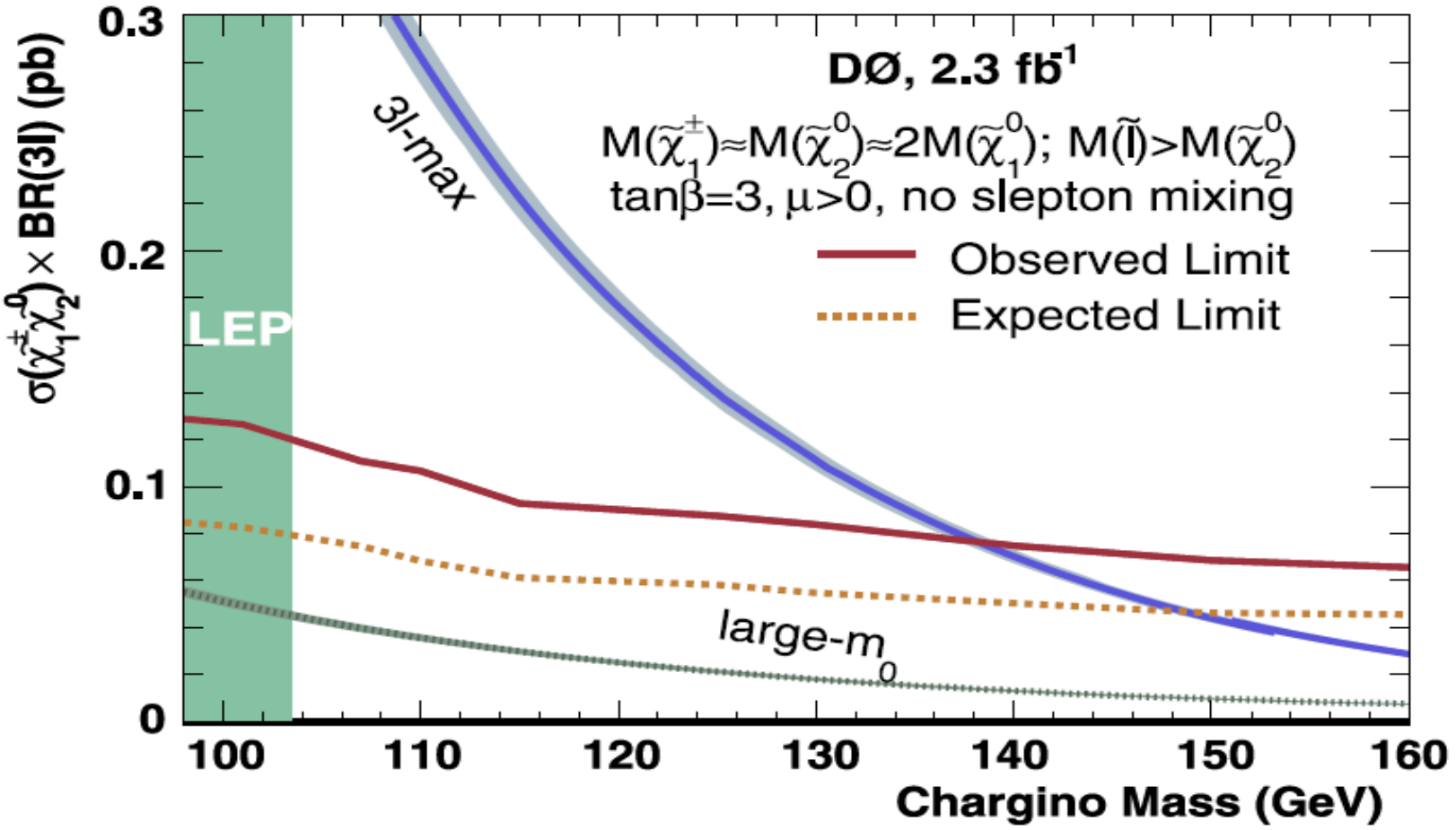








Chargino search



$M(\chi^{\pm}_1) \geq 141$ GeV/c^2

For large scalar mass: No limit yet !

→ And this is only within mSUGRA interpretation

Neutralino search

Try to come up with diagrams for production of a neutralino at an ee machine

Neutralino search

LEP II **Production $\chi^0_1 \chi^0_2$, χ^0_2 -> $Z^* \chi^0_1$**

2 production channels in interference :

- Large m_0: s : e^-e^+ -> Z^* -> $\chi^0_1 \chi^0_2$
- Small m_0: t : e^-e^+ -> ~l -> $\chi^0_1 \chi^0_2$

Large m_0 : **$M(\chi^0_1) \geq 51$ GeV/c^2**

For all m_0 : **$M(\chi^0_1) \geq 46$ GeV/c^2**

Squark/Gluino search

Try to come up with diagrams for production of:
Squark pair
Gluino pair
associated Squark-Gluino
at a hadronic machine

Let's try to think things as function of the mass of the proponents...

Squark/Gluino search

3 SUSY cases:

- **Small m_0 : $M_{\tilde{g}} > M_{\tilde{q}}$**
  - qq , gg -> ~q ~q
  -
- **Large m_0 : $M_{\tilde{q}} > M_{\tilde{g}}$**
  - qq , gg -> ~g ~g
  -
- **Intermediate m_0 : $M_{\tilde{q}} \sim M_{\tilde{g}}$**
  - qg -> q g qq , gg -> ~g ~g
  -

Now experimentally:

What are the main backgrounds ?
-> Which “basic” selection would-you apply ?

How to distinguish ~q~q from Standard Model (QCD) qq ?
-> Think about the decay of ~q

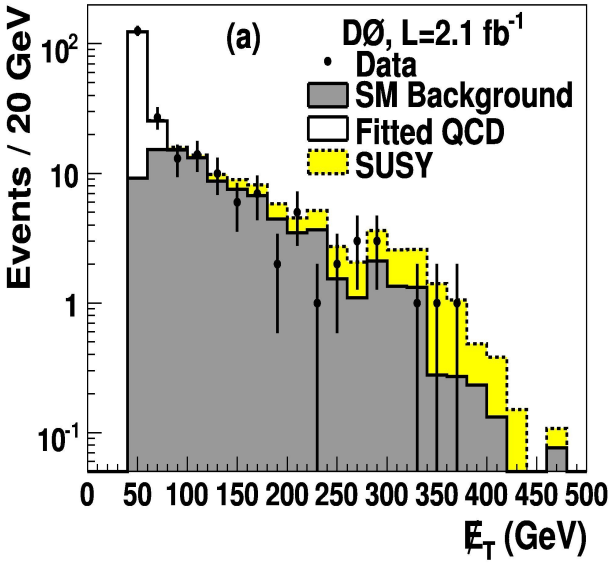
Squark/Gluino search

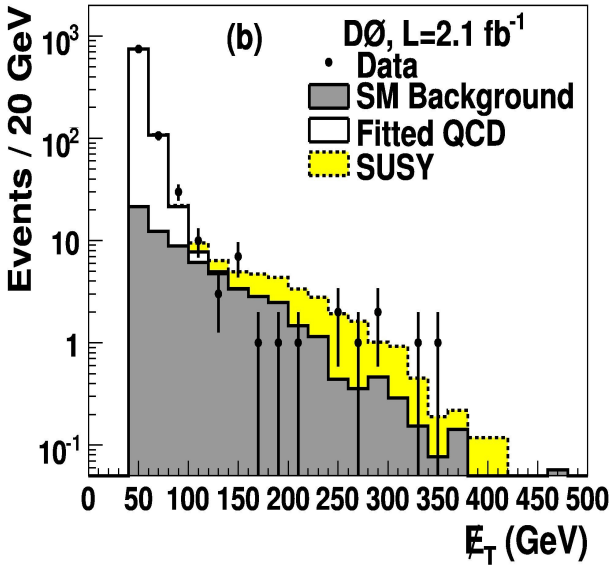
D0 RunII

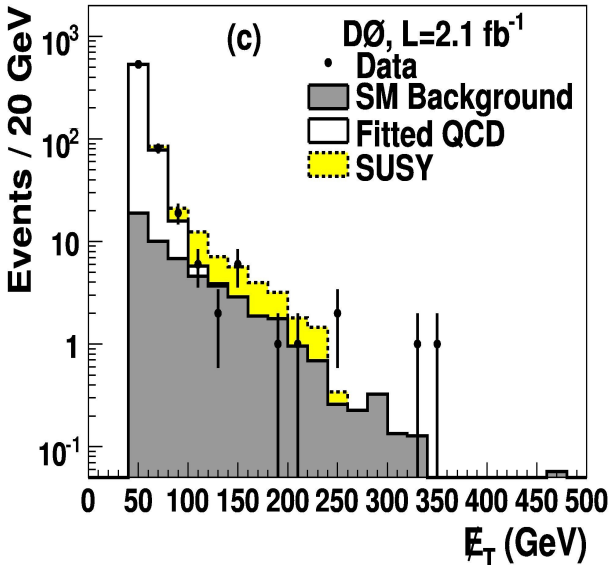
3 signal selections
for 3 Susy cases:

- **Small m_0 : $M_{\tilde{g}} > M_{\tilde{q}}$**
  - qq , gg -> ~q ~q
  - Signature: 2 acoplanar jets
- **Large m_0 : $M_{\tilde{q}} > M_{\tilde{g}}$**
  - qq , gg -> ~g ~g
  - Signature: N(jets) > 3
- **Intermediate m_0 : $M_{\tilde{q}} \sim M_{\tilde{g}}$**
  - qg -> ~q ~g qq , gg -> ~g ~g
  - Signature : N(jets) > 2

Usage of MET of course !
Why would QCD have low MET ?







Squark/Gluino search

D0 RunII

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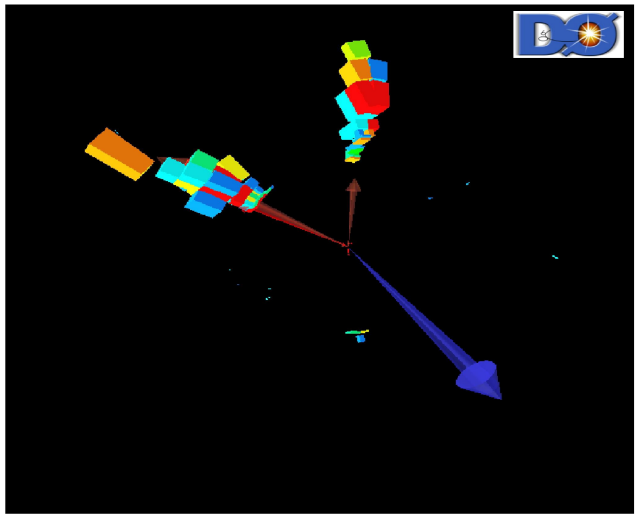
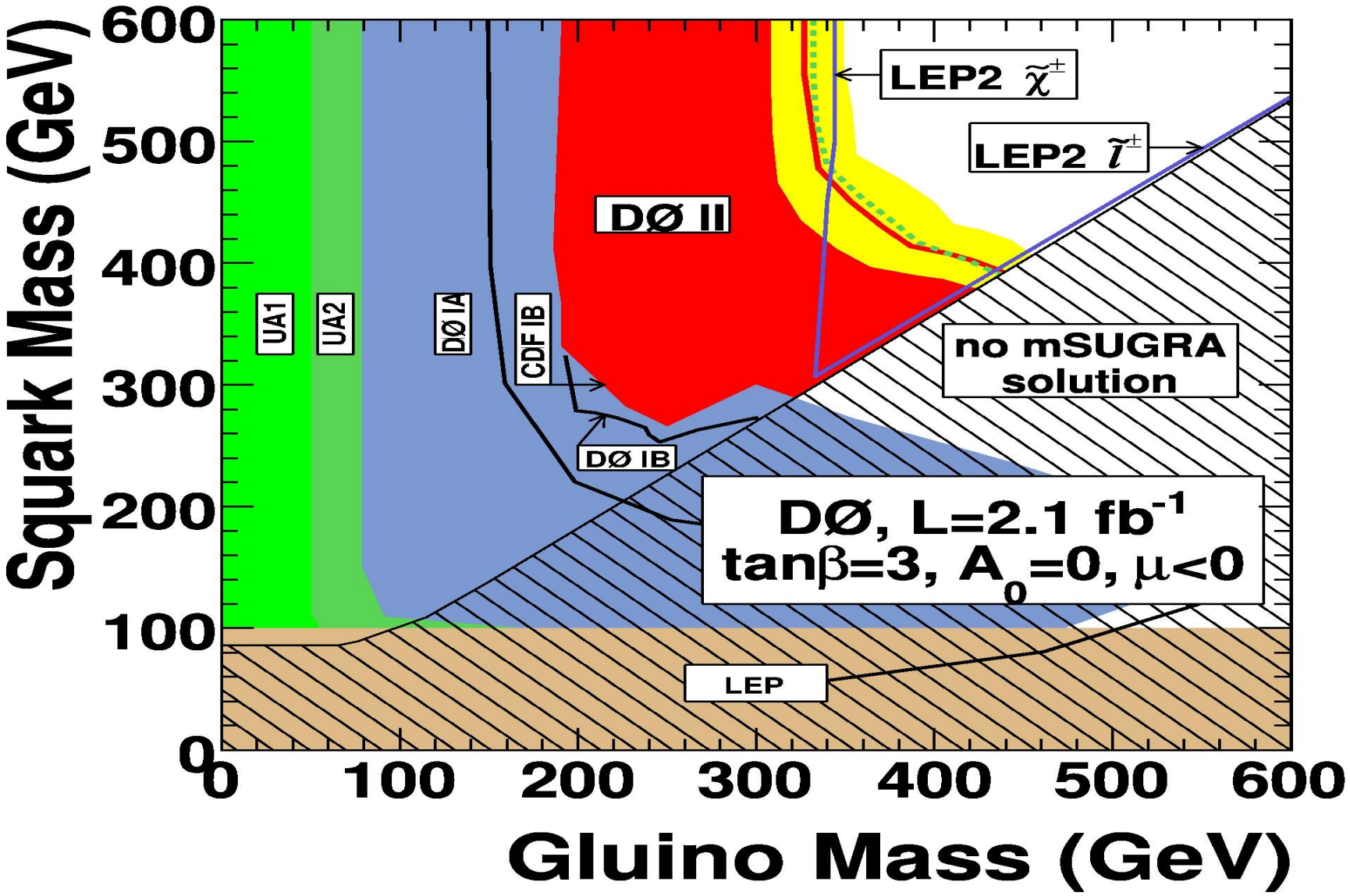


$\tilde{q}\,\tilde{q}$ event ?

MET = 350 GeV
E_T (j1,j2) = 264, 106 GeV

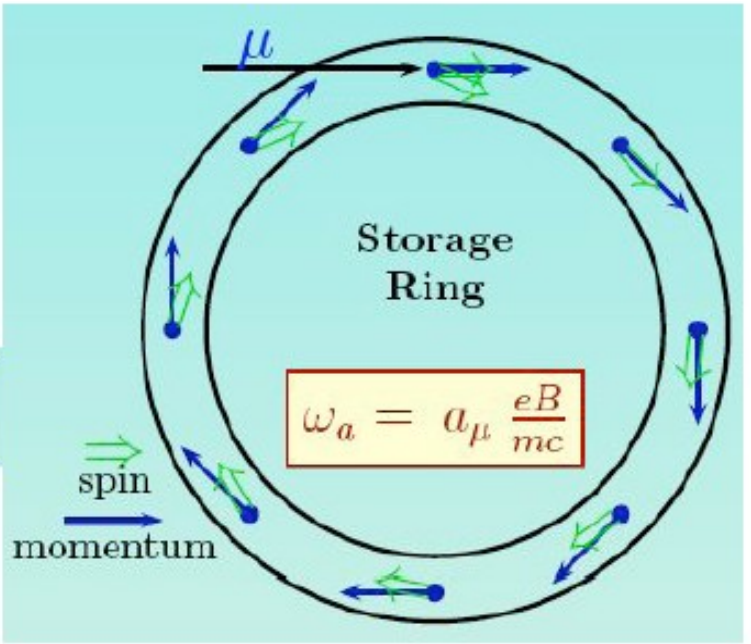
Squark/Gluino search



g-2 muon anomaly

$$\vec{\mu} = g_\mu \frac{e\hbar}{2m_\mu c}\vec{s} \; ; \quad g_\mu = 2\,(1 + a_\mu)$$

Dirac: $g_\mu = 2$, $a_\mu = \frac{\alpha}{2\pi} + \cdots$ muon anomaly



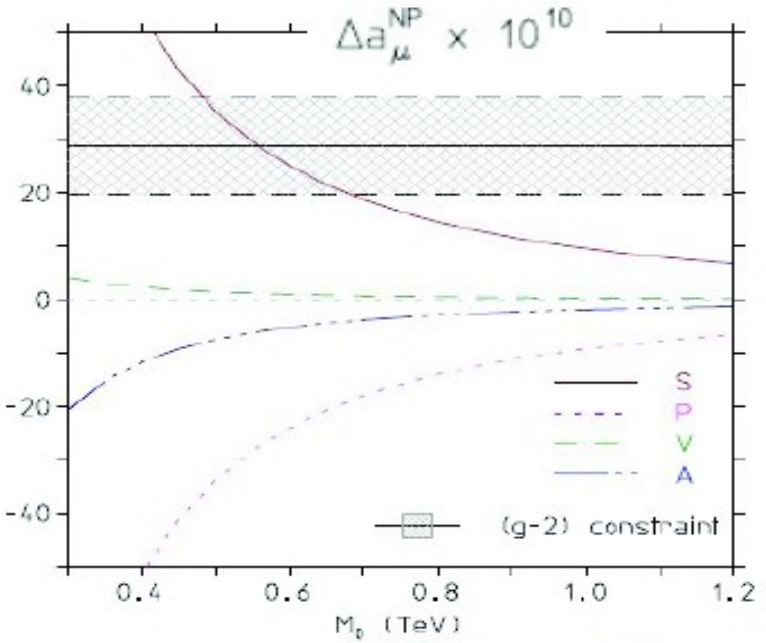
$$a_\mu^{\text{Exp.}} = 1.16592089(63) \times 10^{-3} \qquad a_\mu^{\text{The.}} = 1.16591797(61) \times 10^{-3}$$

$$\delta a_\mu^{\text{NP?}} = a_\mu^{\text{Exp.}} - a_\mu^{\text{The.}} = (292 \pm 88) \times 10^{-11} \,,$$

$3.3\,\sigma$

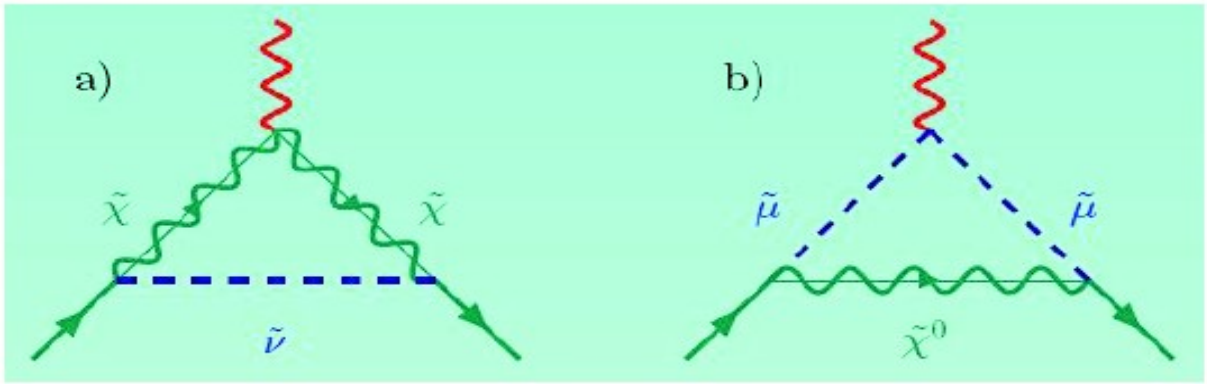
1

Possible SUSY explanations...



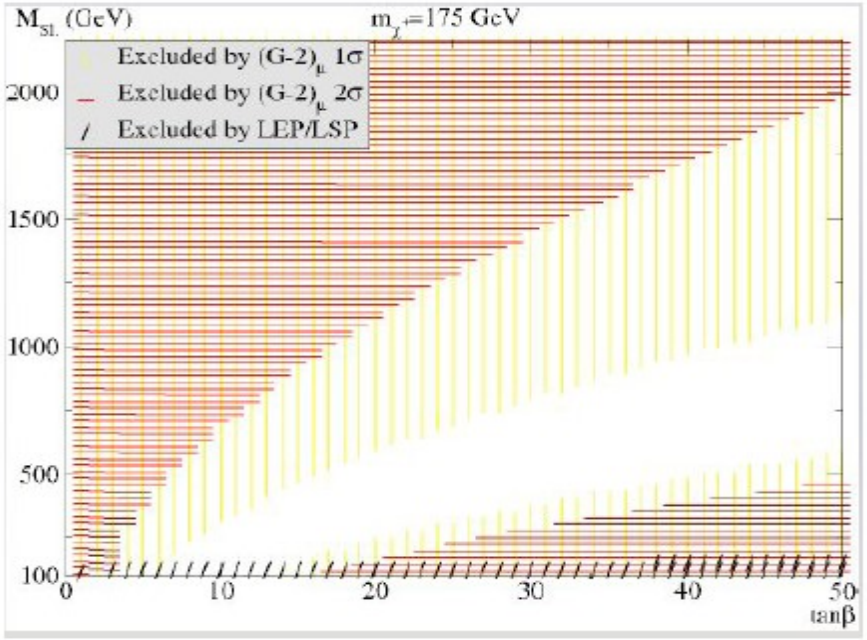
$$(\delta a_\mu)_{1L}^{MSSM} \sim \frac{\alpha}{2\pi}\left(\frac{m_\mu}{M_{SUSY}}\right)^2 \tan\beta \,\mathrm{sign}(\mu M_2)$$

- Linear dependance on $\tan\beta$;
- Same sign as the SUSY parameter μ: $\mu > 0$ favoured;
- Light chargino/Sneutrino required.



2

And with a 125 GeV Higgs?



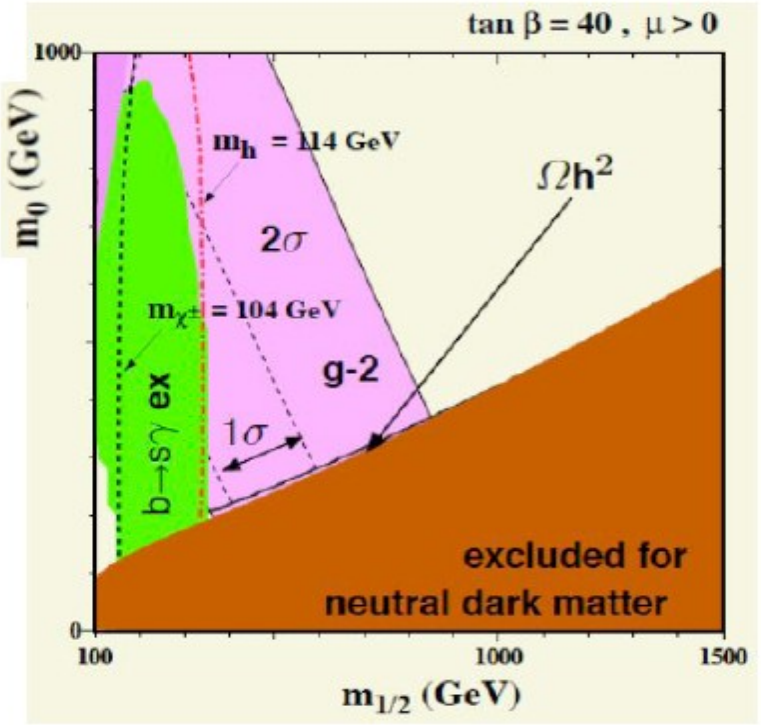
Model	Minimum χ^2/d.o.f.	Fit Probability	$m_{1/2}$ (GeV)	m_0 (GeV)	A_0 (GeV)	$\tan\beta$
CMSSM						
$M_h \simeq 125$ GeV, $(g-2)_\mu$	30.6/23	13%	1800	1080	860	48
NUHM1						
$M_h \simeq 125$ GeV, $(g-2)_\mu$	29.7/22	13%	830	290	660	33

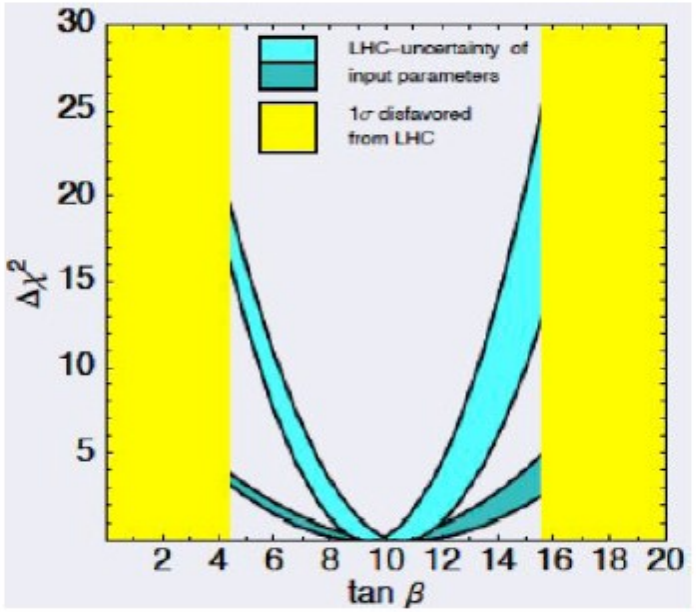
3

Complementarity btw g-2 and LHC

- $(G-2)_\mu$: essentially sensitive to 2nd generation sleptons $(\tilde{\nu}_\mu, \tilde{\mu})$;
- Higgs mass: essentially sensitive to 3rd generation squarks $(\tilde{T}, \tilde{B})$;

putting things together... the g-2 translates into the direct **tanβ** measurement





4