Experimental status of Supersymmetry

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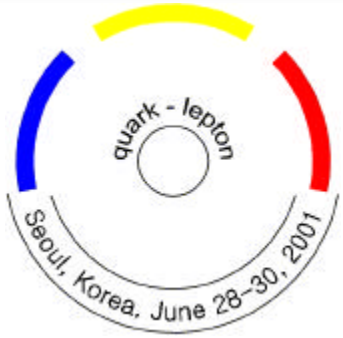
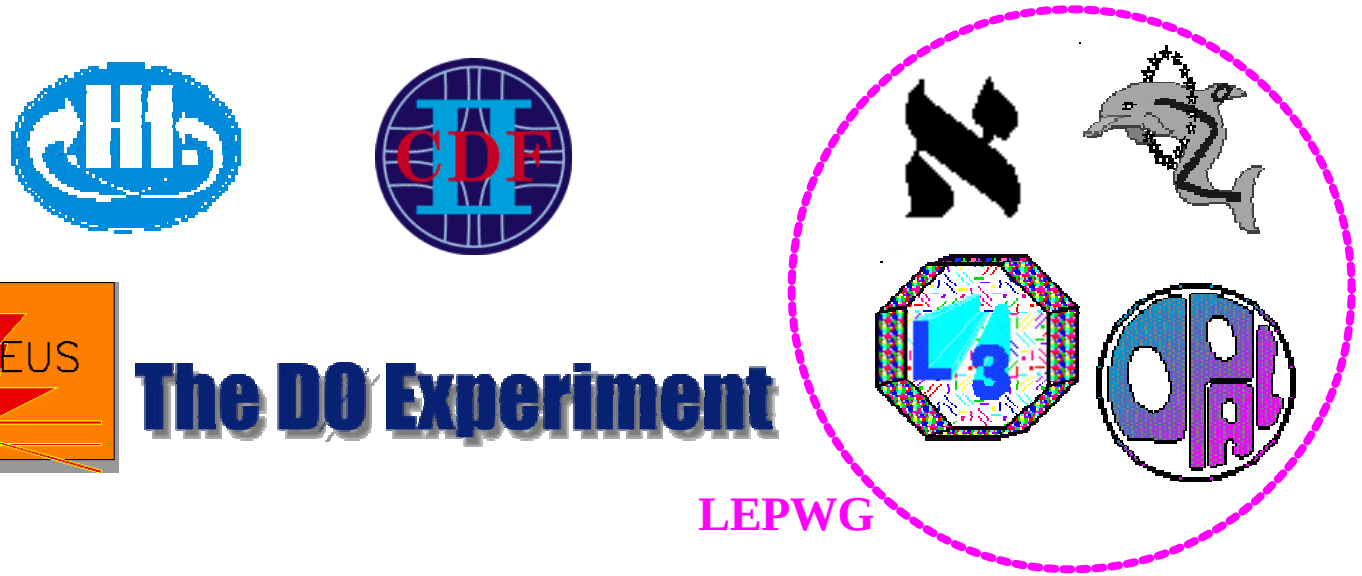


Overview

- Introduction
- SUSY in a nutshell
- Experimental searches
  - LSP, Charginos and Neutralinos
  - Sgoldstinos
  - Gluinos, Squarks (incl. Stop)
  - Sleptons and gravitinos
  - R-parity violating SUSY
  - SUSY Higgs
- Prospects and conclusions

Introduction

- I present some recent results from:



- I won't discuss the theory in much detail!
- NB! I will not discuss detectors—see following talks! (they are all following…)

SUSY on two slides

- SUSY symmetrizes SM fermion and boson particle content: just add tildes (mostly)
- SUSY is broken (no light selectron) but we don't know how.
- MSSM—parameterize ignorance of SUSY breaking with many "soft" terms
  - LSP is *N1*
  - Signature is *nl+mj+MET*
- mSUGRA—breaking transmitted to visible particles by grav. interactions. Only 4.5 parameters:

m_0 Common scalar mass

$m_{1/2}$ Common gaugino mass

$sign(m)$ Higgs mass parameter

$\tan b$ Ratio of Higgs VEVs

A_0 Trilinear coupling

LSP can be N1 or sneutrino

Signature as in MSSM, stop can be light

SUSY, 2nd slide

- GMSB—gravitino (LSP) mass related to SUSY breaking scale.
  Relevant mass range:

  $O(10^{-2} < M(\tilde{G}) < 10^{4})$ eV

  – Phenom. depends on NLSP, e.g.:

  $N1 \to g\tilde{G},\ \tilde{l} \to l\tilde{G}$

  – NLSP lifetime can be appreciable.

- AMSB—Super Weyl anomaly generates gaugino and scalar masses.
  – *C1, N1* near mass degenerate.
- RPV—*L* and/or *B* number violating couplings non-zero:
  – Sparticles can be singly produced and the LSP is unstable.
  – Signature: more leptons, less MET

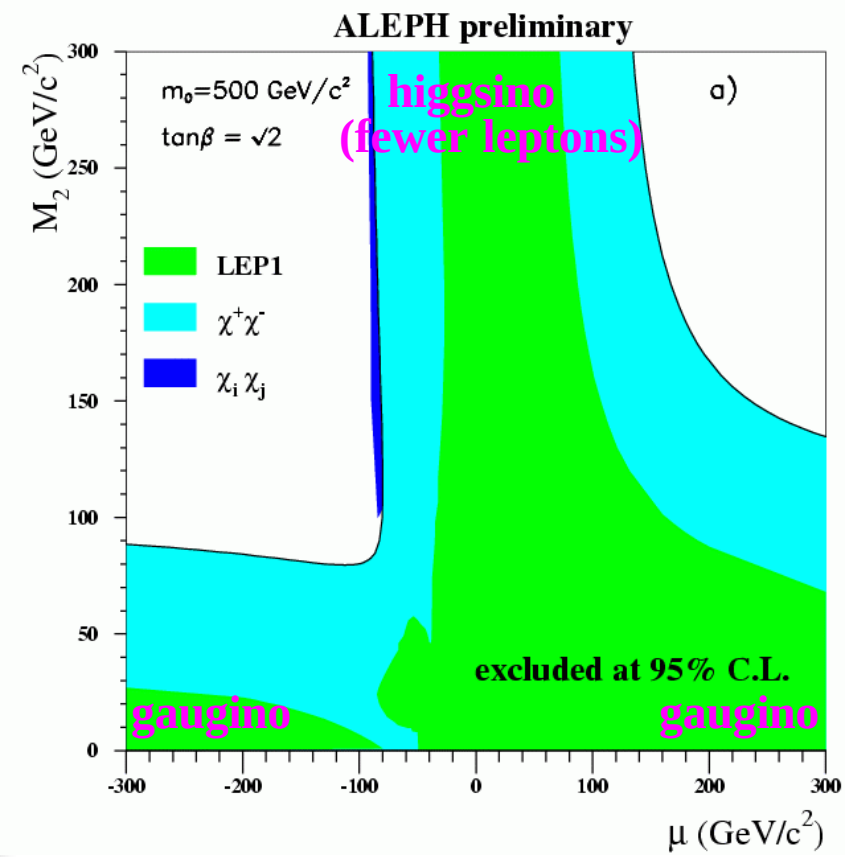
LSP, Charginos and Neutralinos

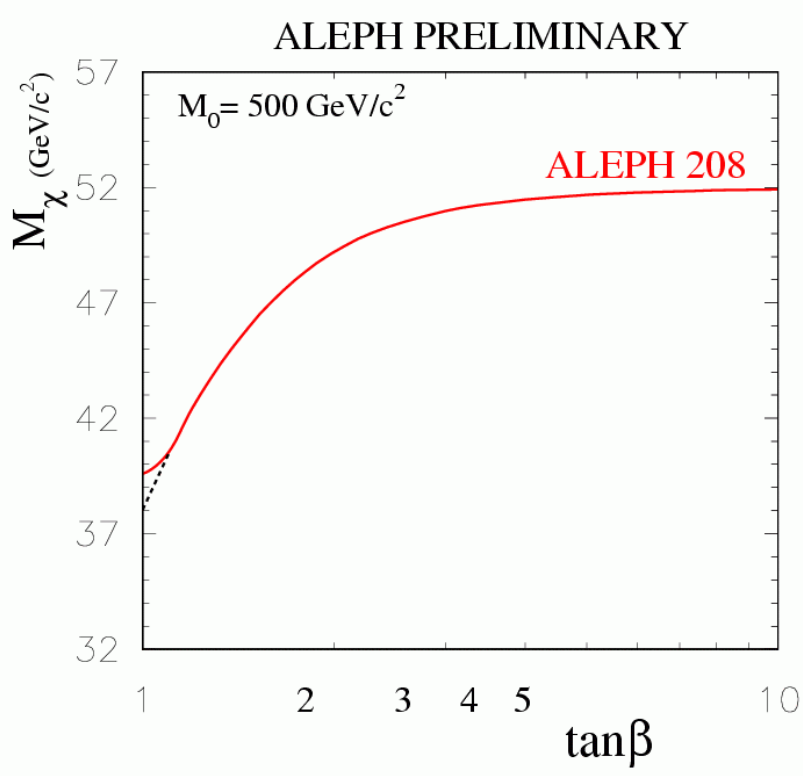
- Cosmology: LSP is neutral, colorless, weakly interacting (e.g. $\tilde{c}_1^0 \equiv N_1$)
- LEP1 : $\sqrt{s} = M(Z^0)$ look at Γ_{invis}

  $M(N_1) > 25\ GeV$, for $\tan b > 2$
- LEP2 : $\sqrt{s} \leq 208$ GeV
  - ALEPH: assume gaugino mass unification and look for

$e^+e^- \to C_1C_1, N_iN_j \to nl + mj + MET$

Limits on Neutralino LSP





Similar results from D, L and O!

LEP-SUSY WG Chargino results

- Assume gaugino unification

$$M_1 = (5/3) \cdot M_2 \tan^2 q_W$$

- Chargino pair production, decay via *W** to leptons, leptons+jets, jets
- Efficiencies, backgrounds, and candidates summed over A,D,L and O : all in agreement
- Compute CL for No Excess (CL for obtaining a less background-like result than observed)
- Compute CL for No Deficit (CL for obtaining a more background-like result than observed)

LEP-SUSY Chargino results (ii)

Gaugino-like chargino
(large sneutrino mass)

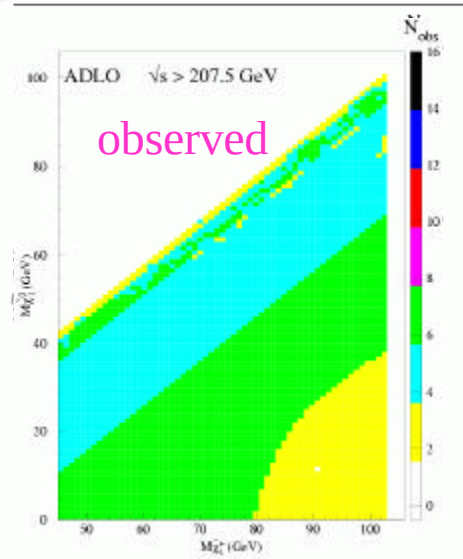
$BR(\tilde{\chi}^+_1 \to W^+\tilde{\chi}^0_1)$: 100%

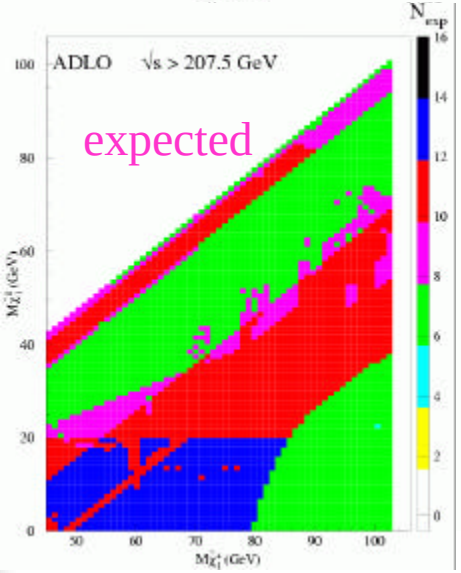
$\sqrt{s} \geq 207.5$ GeV

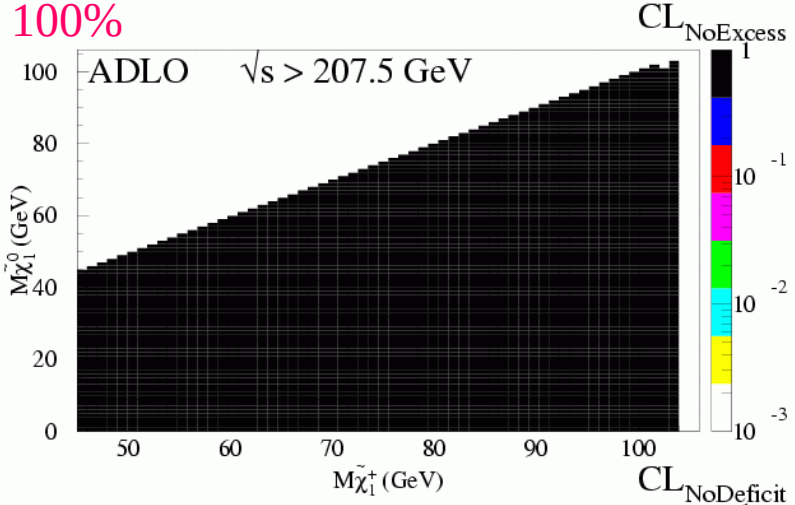
$L = 35.2\ pb^{-1}$

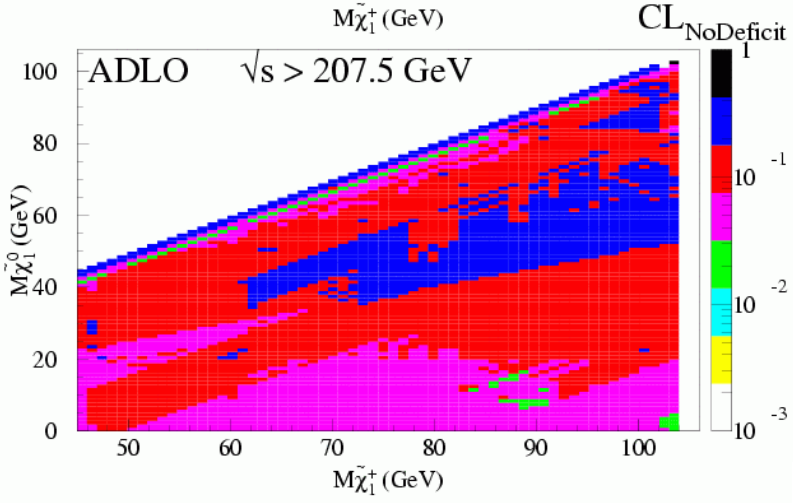
Small deficit

Leptons,
leptons+jets, jets



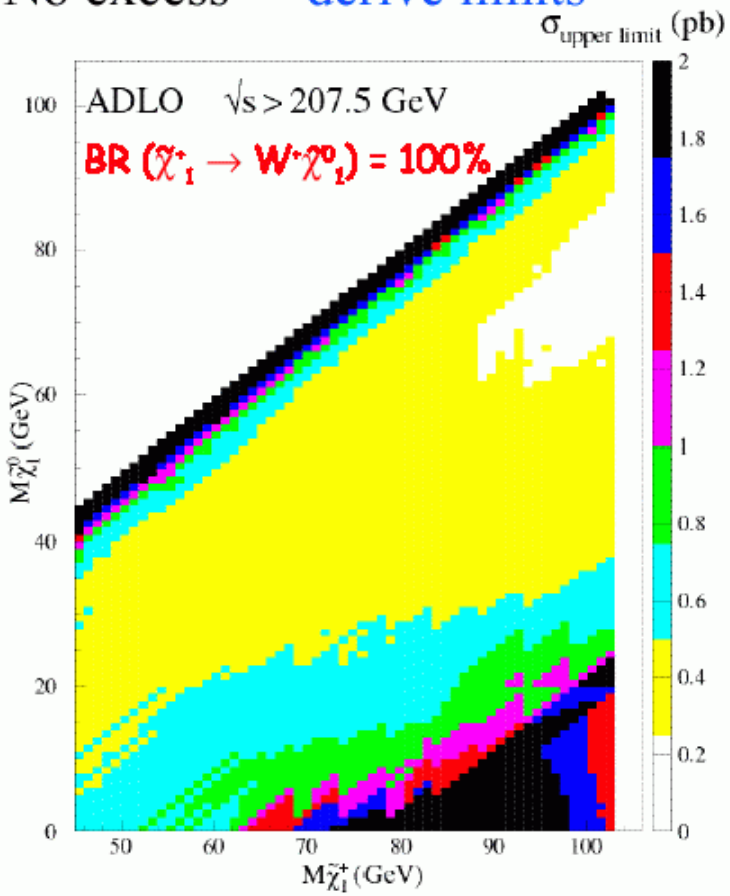


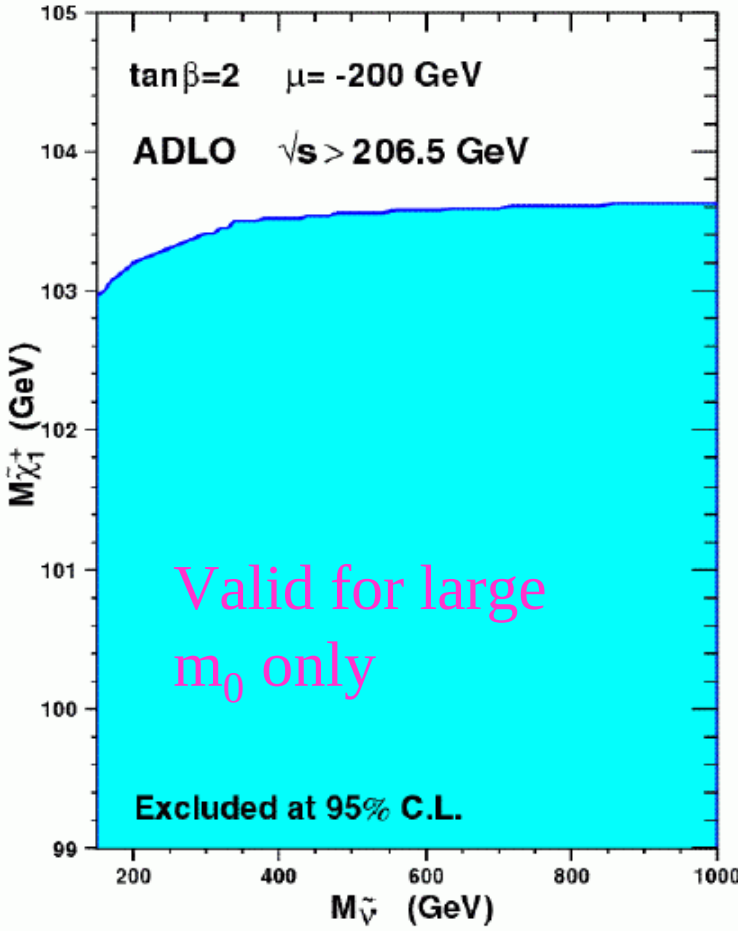




LEP-SUSY Chargino results (iii)

No excess ⇨ derive limits





$m_{\tilde{\chi}^+_1} \geq 103.5\ (103.3)$ GeV at 95% CL for $m_{\tilde{\nu}} > 300$ GeV

obs. exp.

Chargino results in CMSSM

- MSSM: 105 (or is it 124?) new parameters!
- Too much to scan. Add some boundaries
- LEP2 (often) employs Constrained MSSM:
  1. m_0 SU(2) gaugino mass param. at EW scale
  2. M_2 VEV Common scalar mass at Planck scale
  3. $\tan b$ ratio of two Higgs doublets
  4. m Higgsino mass parameter
  5. A_0 Common trilinear coupling
  6. m_A Pseudoscalar Higgs mass at EW scale
- Note similarity to mSUGRA:

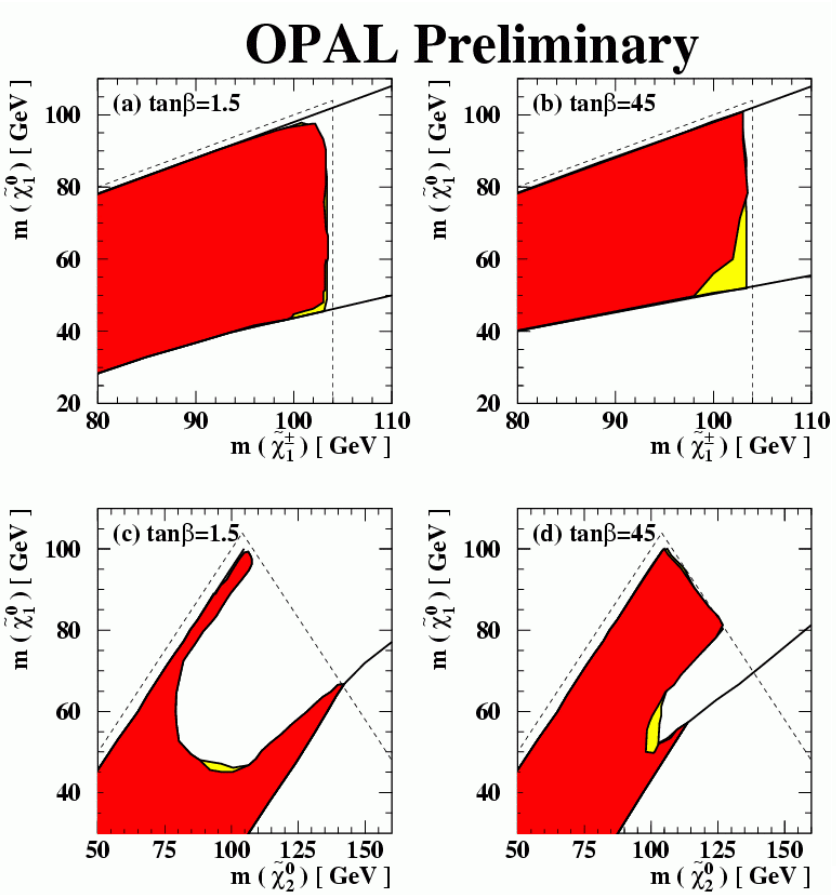
  $m_{1/2} \leftrightarrow M_2, sign(m) \leftrightarrow m, \otimes \leftrightarrow m_A$
- Typical scan: $0 \le M_2 \le 2000, |m| \le 500, m_0 \le 500, A_0 = \pm M_2, \pm m_0, 0$

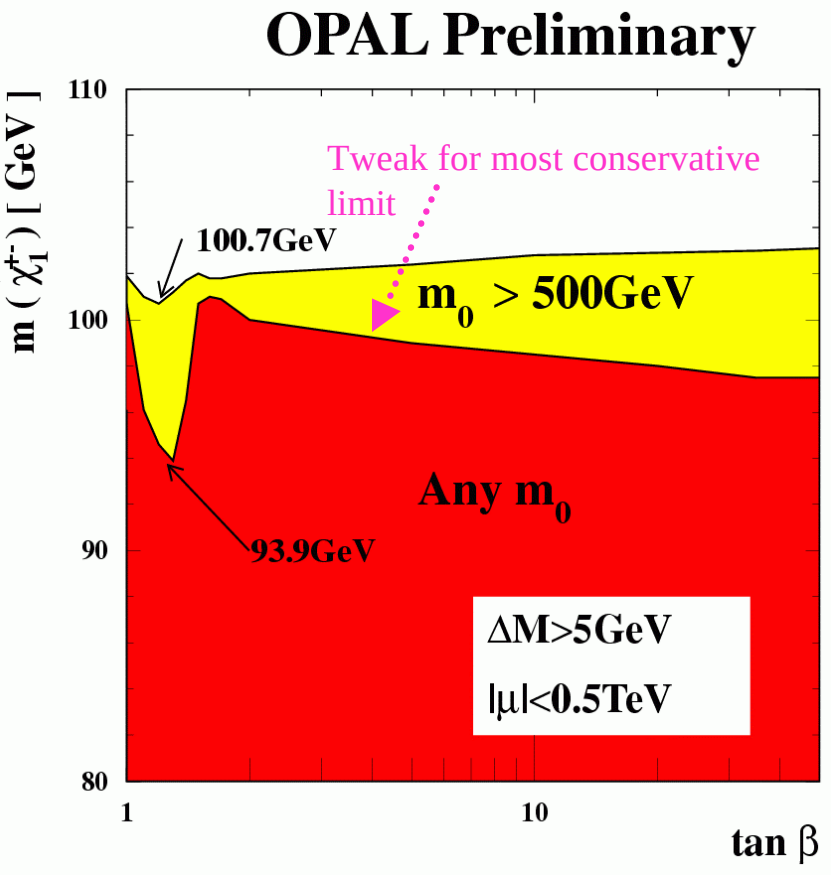
Chargino results in CMSSM (ii)

OPAL 2000 data

Small Δm large Δm

Category	Region	I a	I b	II	III	IV	WW-like
A (0 leptons)	total bkg.	2.8±0.9		2.8±0.3	15.1±0.9	20.8±1.0	9.5±0.4
	observed	8		7	18	23	14
B (>0 leptons)	total bkg.	9.1±2.4		4.9±1.8	5.3±0.3	13.4±0.4	37.3±0.7
	observed	7		7	5	16	32
C (0 leptons, $N_{ch} \leq 4$)	total bkg.	20.4±4.2	22.0±4.2	17.1±2.0	29.8±1.8	47.4±1.3	–
	observed	24	28	14	29	34	–

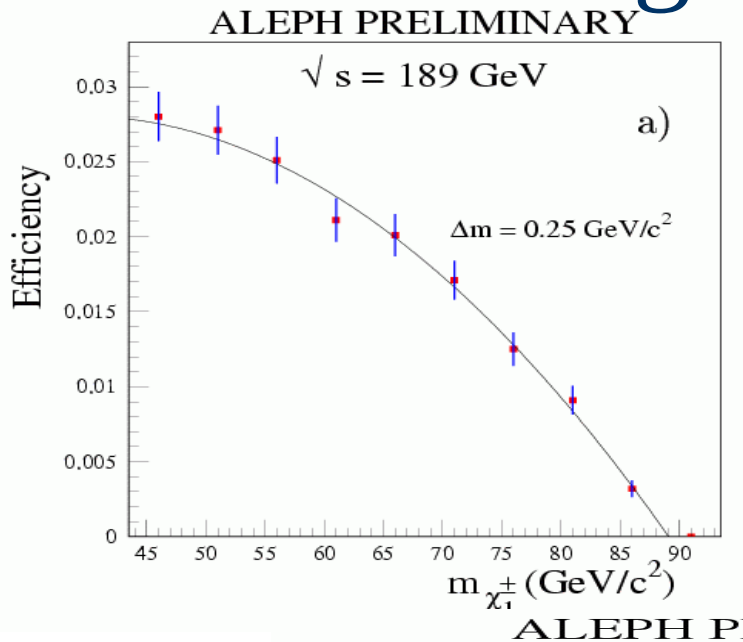


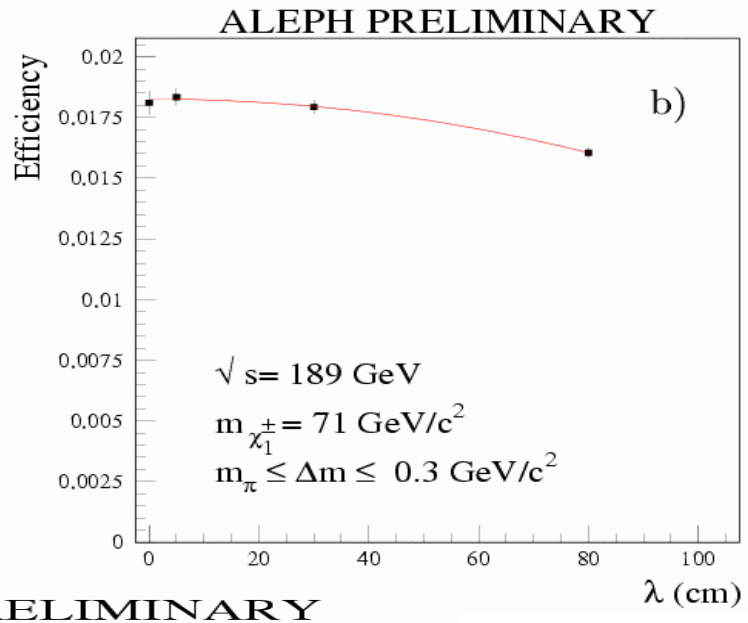


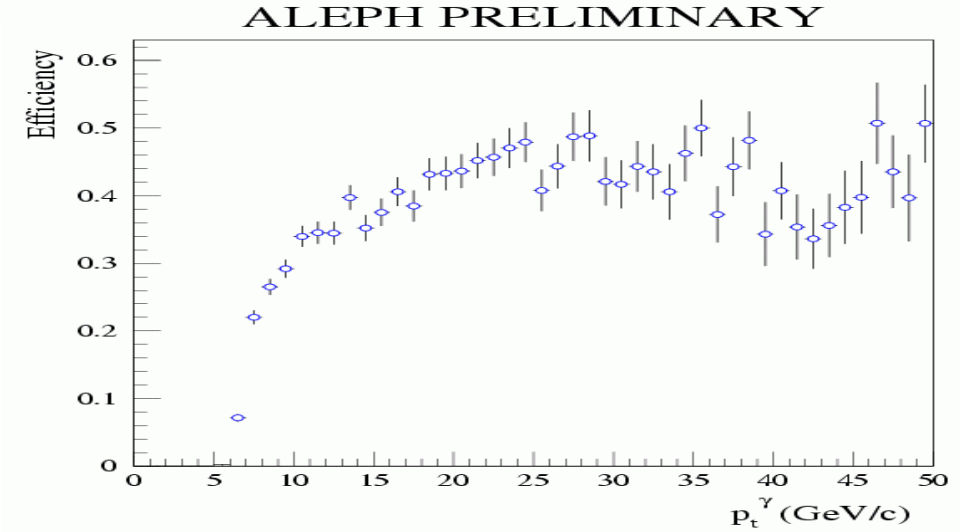
Near mass-degenerate *C1*, *N1*

- $m_p \leq \Delta m \equiv m_{C1} - m_{N1} \leq 5\ GeV$
- Occurs in MSSM: 1) for large *M1,M2* (higgsino); 2) in gaugino region if *M1-M2* unification relaxed; 3) in AMSB since *M1/M2*>>1
- Small Δm implies long decay length for *C1*. Examine $0\ \mathrm{cm} < l < 80\ \mathrm{cm}$
- Little hadronic activity, lots of MET
  - Require isolated ISR photon for tag (cuts gg bg)

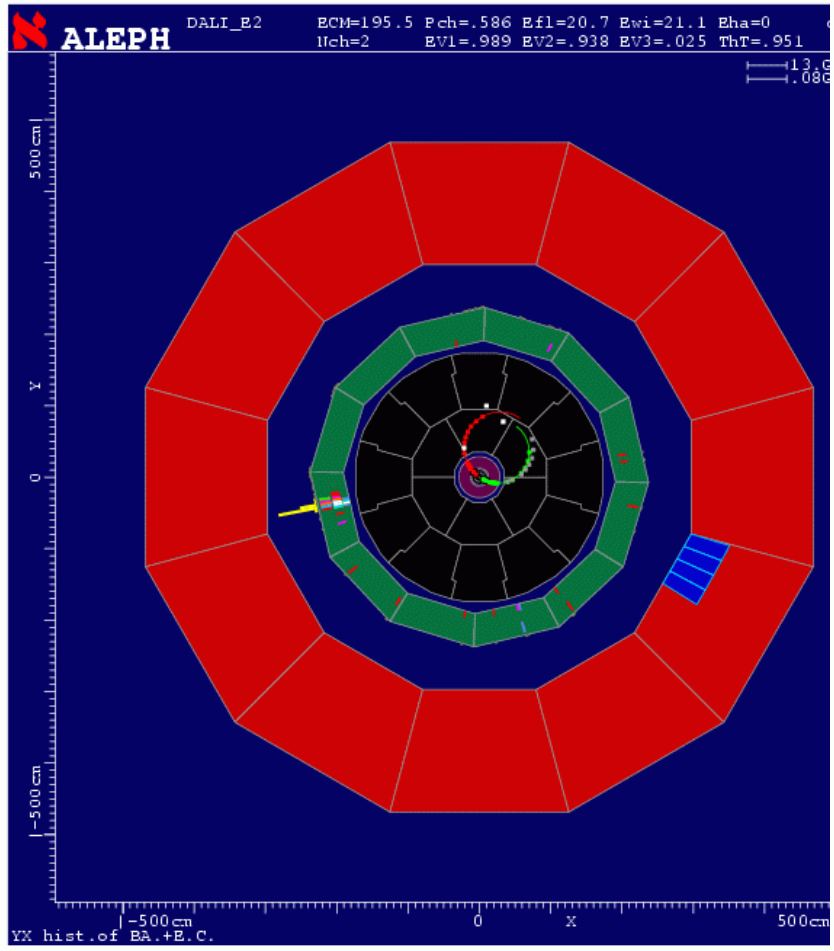
Near mass-degenerate *C1*, *N1* (ii)

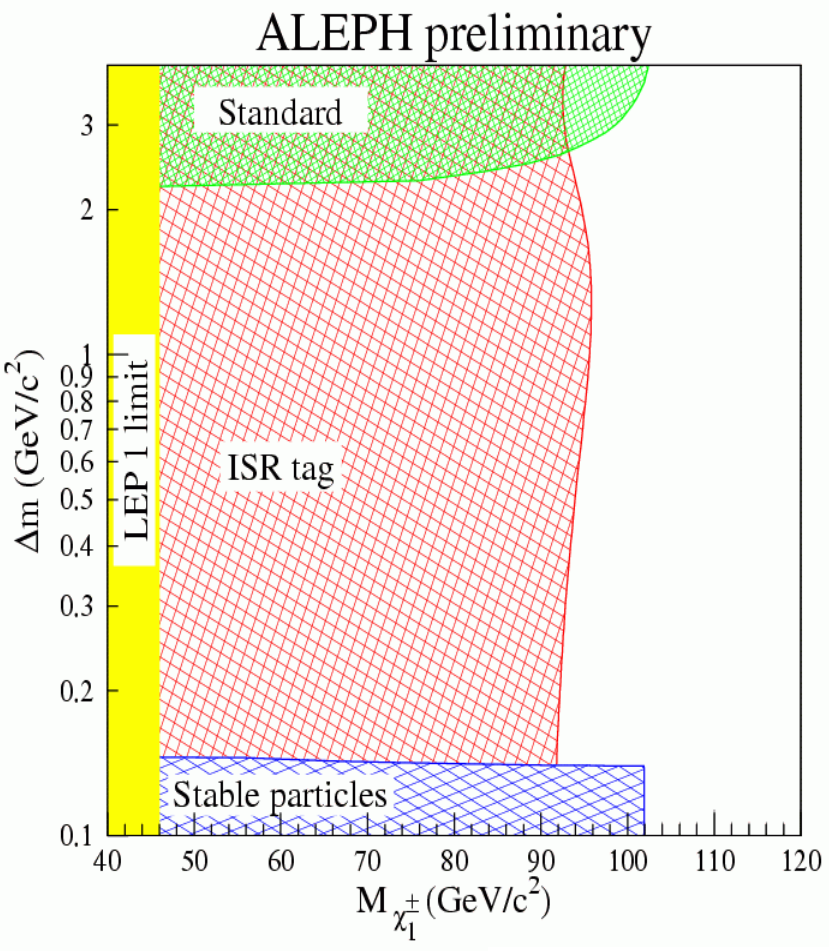






Near mass-degenerate C1 (iii)





E(γ) = 21 GeV

Assumes $m_0 > 500\ GeV$

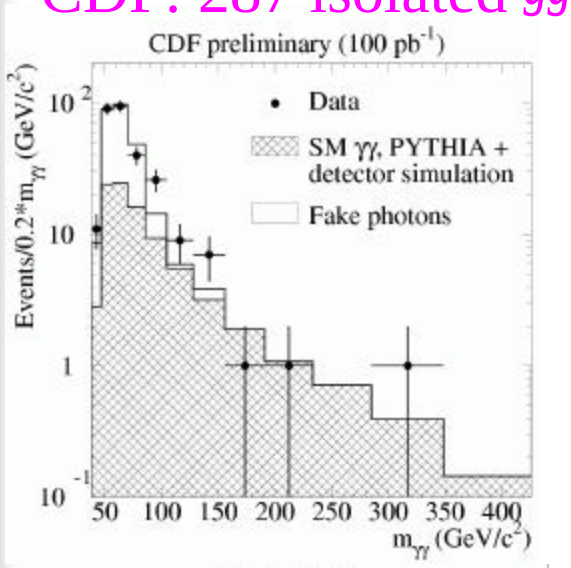
Valid for all tan β

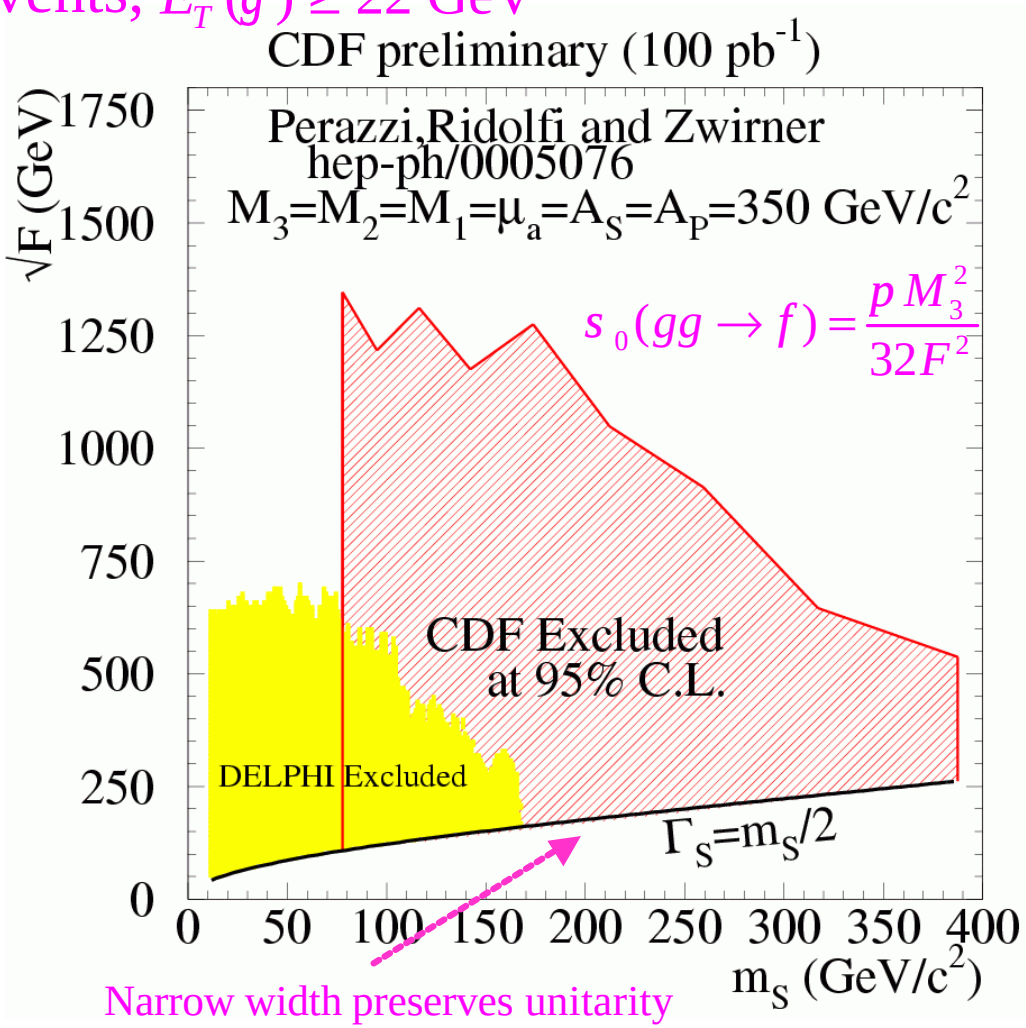
Search for Sgoldstino

- Spontaneous breaking of global SUSY implies the existence of massless fermions: goldstinos. "Spartner" is sgoldstino (f).
- Light f unstable theoretically, motivates search for M(f) ~ O(100 GeV)
- Production: gg fusion
  - Assume all other SUSY particles heavy. Then $s\,(p\bar{p} \to f)$ depends only on $M(f), \sqrt{F}$
- Decay: $gg, gg, WW, ZZ, f\bar{f}$ Diphoton good choice for clean signal (*Br*~1-2%).
  - $Br(H_{SM} \to gg) \sim 1‰$; larger for bosophilic Higgs

Search for Sgoldstino (ii)

CDF: 287 isolated $\gamma\gamma$ events, $E_T(\gamma) \geq 22$ GeV





Gluino LSP

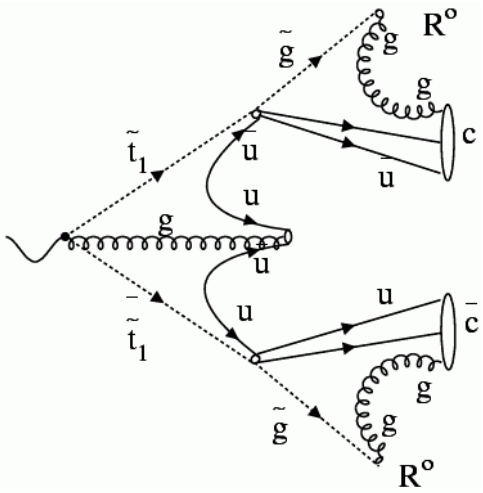
- In some SUSY models, the gluino can be light and stable.
  - Forms R-hadrons that trundle through detector.
- Standard MET+jets: loses MET !
- DELPHI searches:
  1. LEP1: $e^+e^- \rightarrow \tilde{g}\tilde{g}q\bar{q}$ Exclude: 2-18 GeV
  2. LEP2: $\tilde{q} \rightarrow R$ decays. Look in:

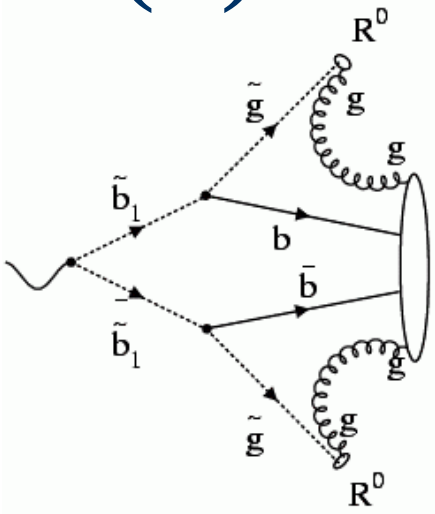
$$\begin{cases} e^+e^- \rightarrow q\bar{q}g \rightarrow q\bar{q}\tilde{g}\tilde{g} \\ e^+e^- \rightarrow \tilde{t}_1\bar{\tilde{t}}_1 \rightarrow c\tilde{g}\bar{c}\tilde{g} \\ e^+e^- \rightarrow \tilde{b}_1\bar{\tilde{b}}_1 \rightarrow b\tilde{g}\bar{b}\tilde{g} \end{cases}$$

2 jets+2 gluino jets

$\tilde{g} \rightarrow R^0, R^{\pm}$

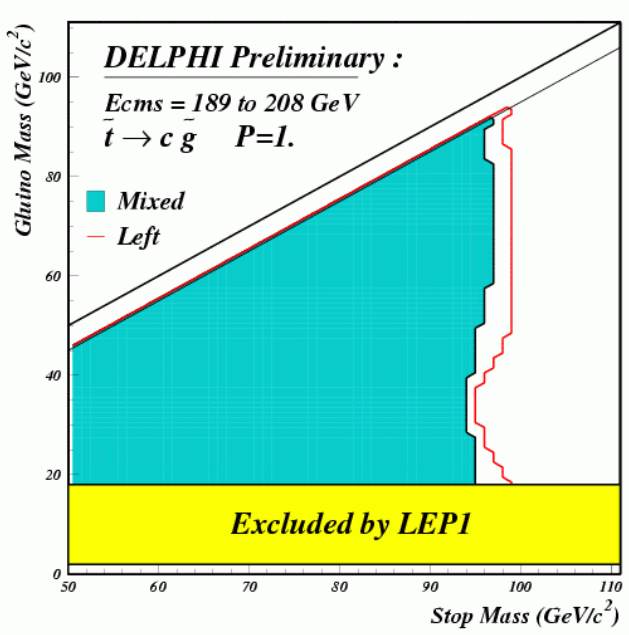
Gluino LSP (ii)

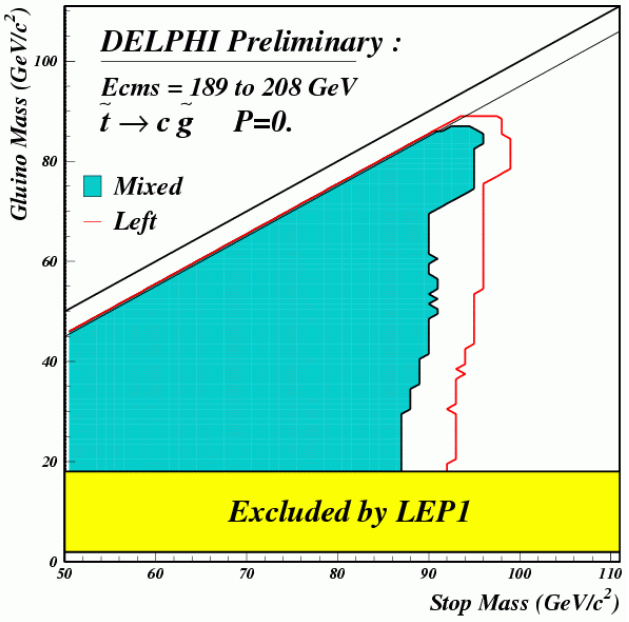




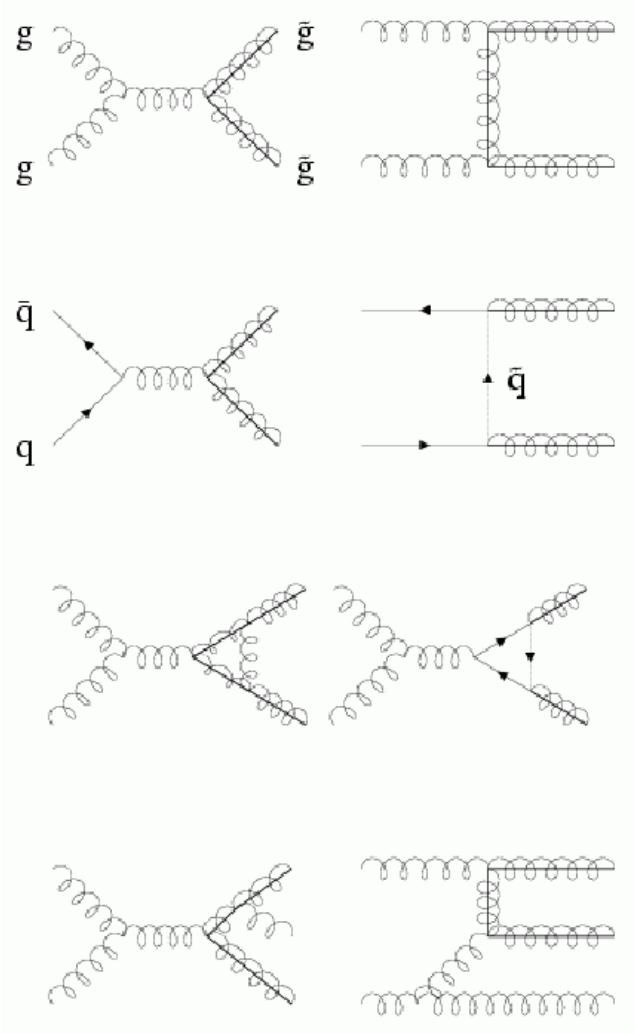
P=1 $\tilde{g} \rightarrow R^{\pm}$ { dE/dx in tracker; Treat as heavy μ

P=0 $\tilde{g} \rightarrow R^{0}$ { ΔE in CALO, Treat as heavy K_L with ~4 interactions





Gluino search in like-sign top



- CDF's scenario:

$$p\bar{p} \to \tilde{g}\tilde{g},$$

$$\tilde{g} \to t\tilde{t}^{(*)},$$

$$t \to bW \to bl\nu$$

- Top-dilepton with LS
- Assume:

$$Br(\tilde{t} \to c\tilde{c}_1^0) = 100\%$$

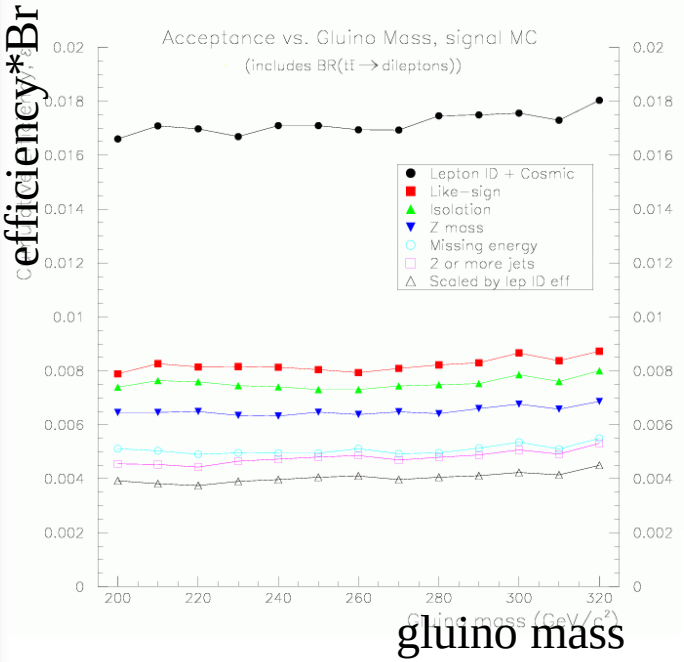
Gluino search in like-sign top (ii)

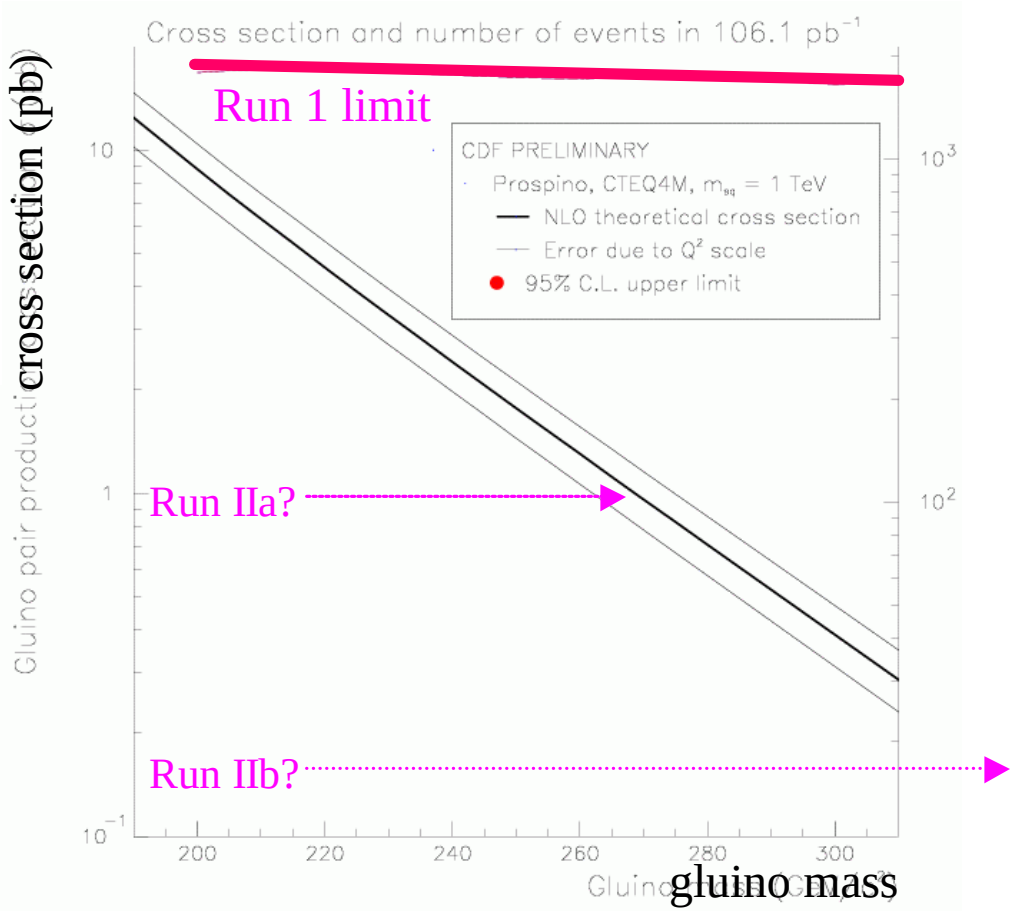
+Reinterpret tt results

+LS cut removes ~all bg

-Runs out of cross section!

Obs: 9 OS/ 3 LS events

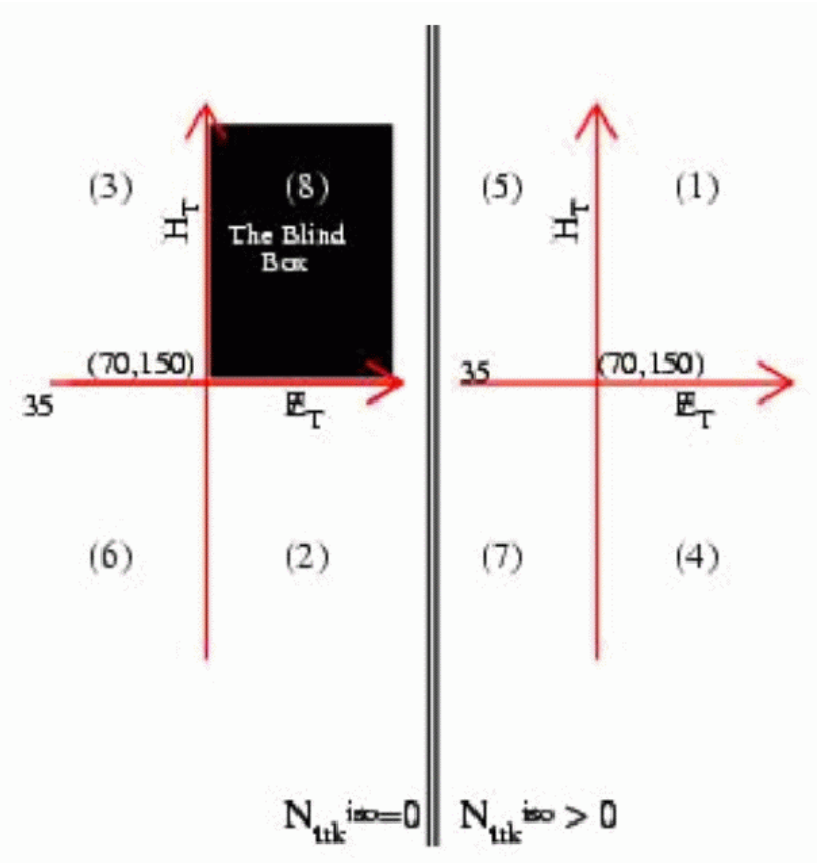




Looks good for Run II, already in progress!

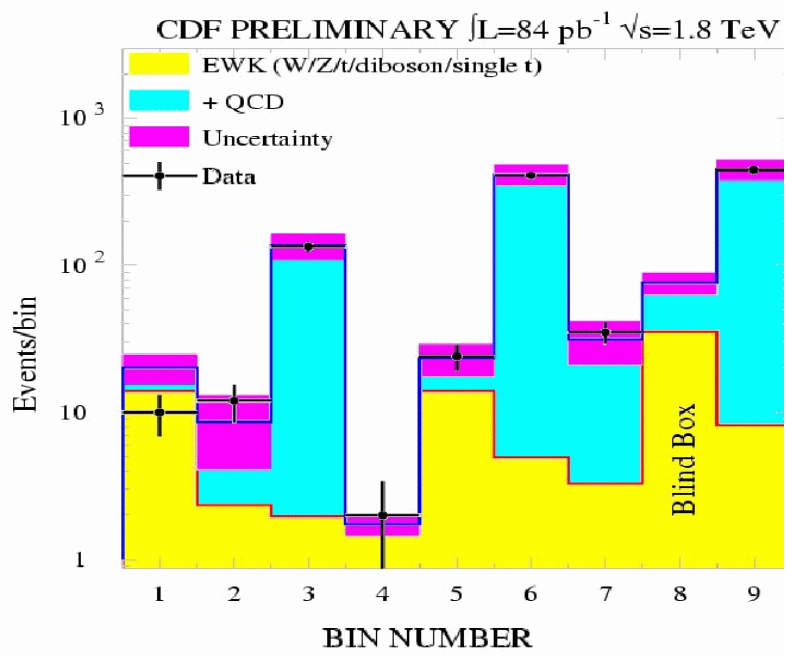
Search for squarks and gluinos

- At Tevatron,
  $p\bar{p} \rightarrow \tilde{g}\tilde{g}, \tilde{g}\tilde{q}, \tilde{q}\bar{\tilde{q}}$
  typically dominate.
- Classic search is for MET+jets from hadronic decays in RPC scenario. CDF Requires (in the box):
  - $E_t(j_{1,2,3})$>(70,30,15) GeV
  - MET>70 GeV
  - No isolated tracks
  - $E_t(j_2)+E_t(j_3)$+MET>150 GeV
- BG: QCD,Z+jets,W+jets,tt
- Perform analysis "blind"



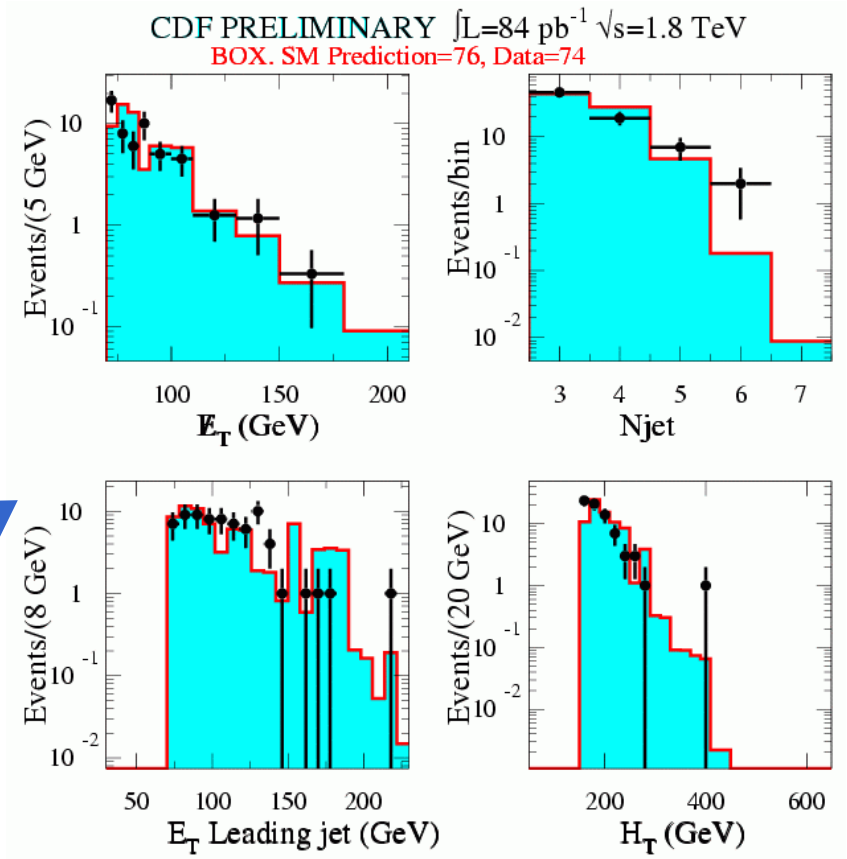
Other boxes available for cross checks

Search for squarks and gluinos (ii)

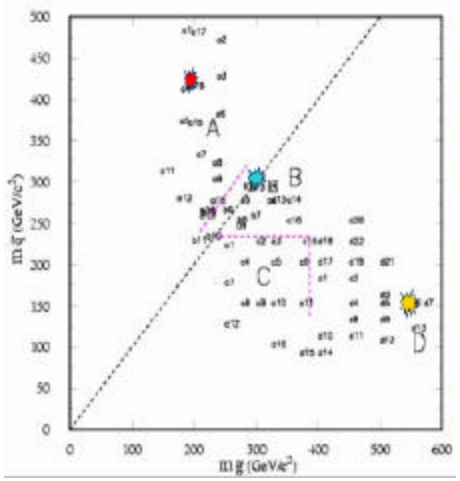


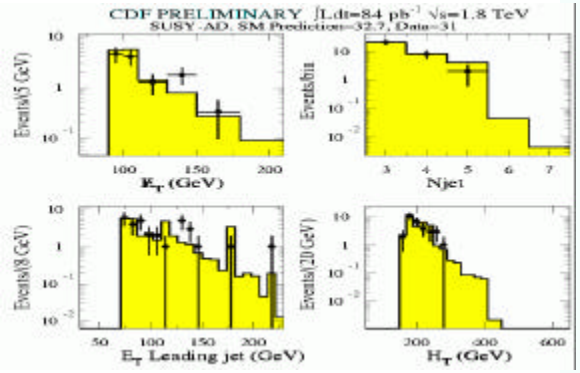
Backgrounds in good shape

So check inside the box

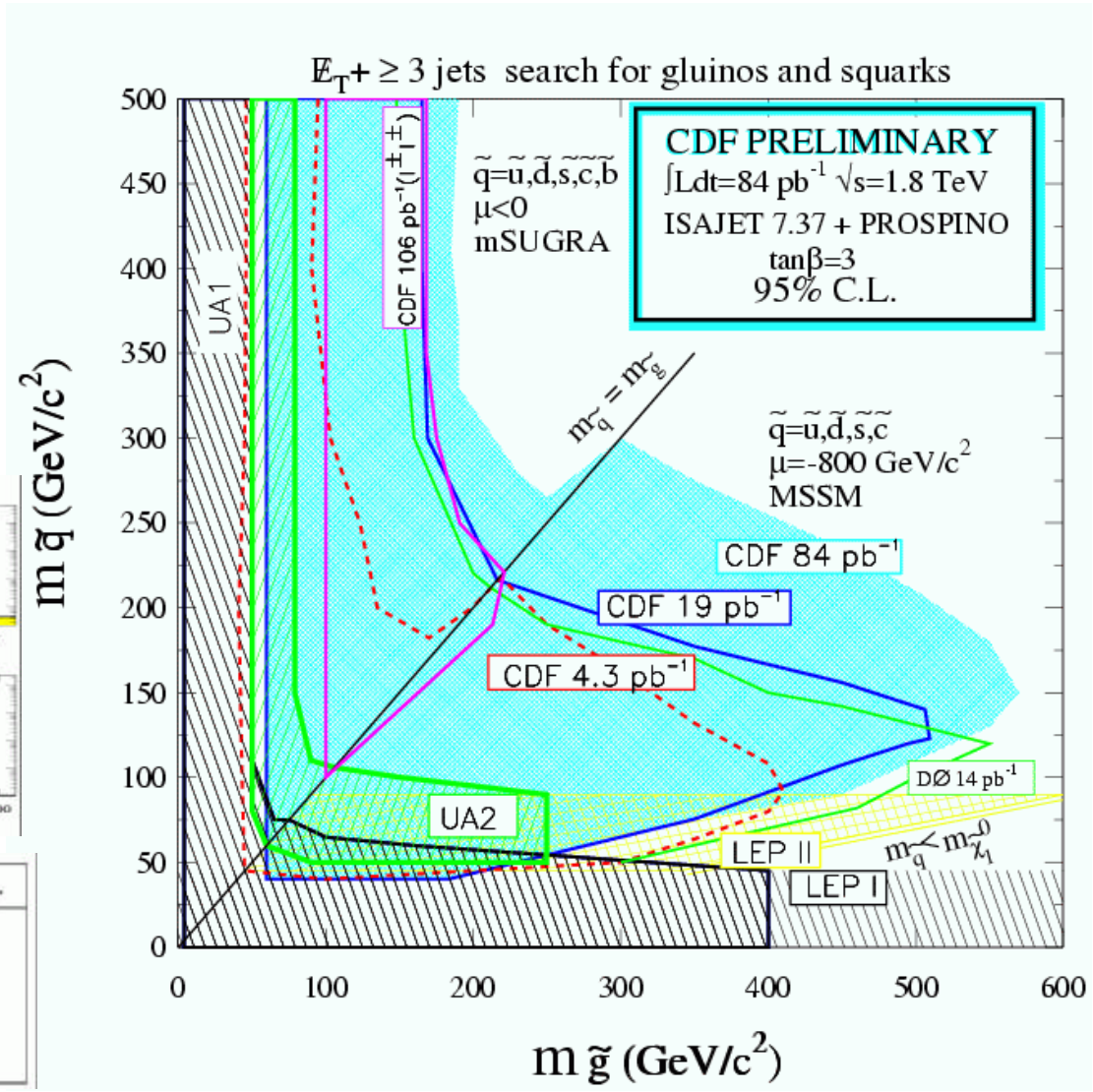


Search for squarks and gluinos (iii)





Box	MET,HT	Expected	Observed	$N_{95\%C.L.}$
A	90,160	32.7 ± 6.7	31	17.7
B	110,230	3.7 ± 0.5	5	7.4
C	110,170	10.6 ± 1	14	11.9
D	90,160	32.7 ± 6.7	31	17.3



Search for Top squark

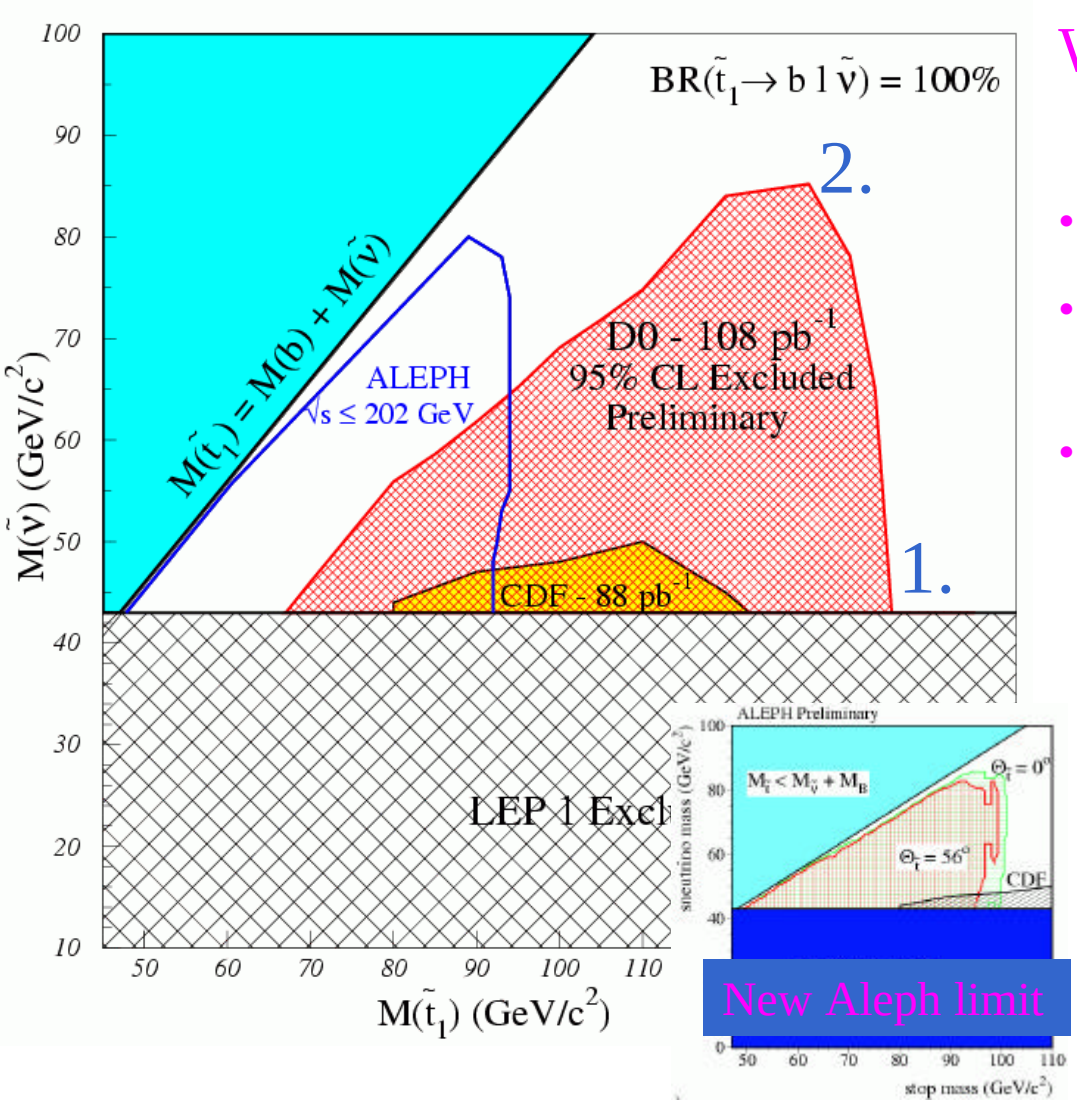
- Heavy top, mixing -> stop can be light
- Dzero performs search:

$$p\bar{p} \to \tilde{t}_1\bar{\tilde{t}}_1, \quad \tilde{t}_1 \to bl\tilde{n}, \ \{l = e, m \ 33\% \text{ ea}\}$$

- Require $e + m + MET$ (15,15,15) GeV, acoplanar
- BG: Fakes, $Z^0 \to t\,t$, $t\bar{t}$, WW, WZ^0
- BG: 13.4±1.5 expected, 11 observed

Set limits in stop-sneutrino mass plane

Search for Top squark (ii)



Why so much better than CDF?

- Didn't use b-tag!
- Instead, required e+μ to reduce SM backgrounds
- Lower MET cut

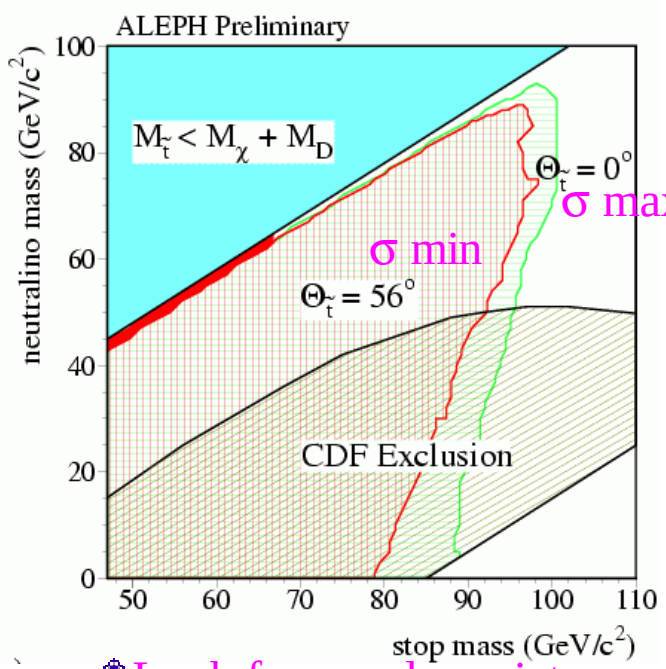
Moral?

Dzero excludes:

1. (140,43) GeV
2. (130,85) GeV

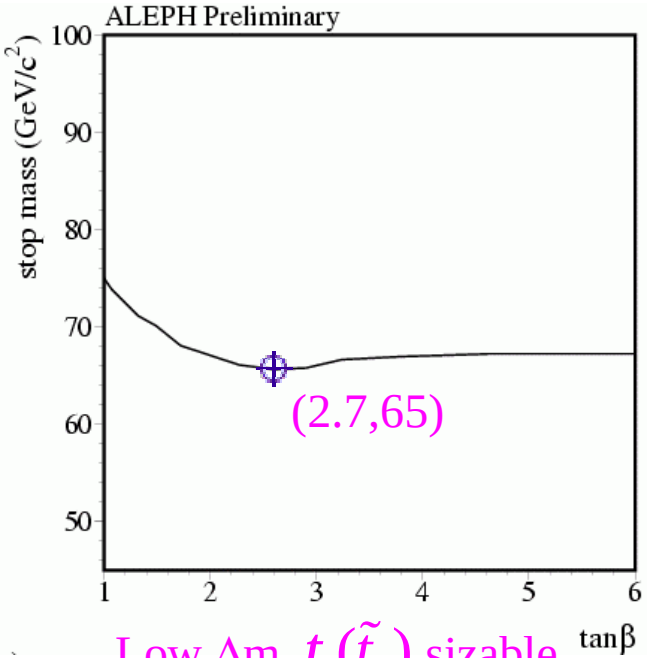
Search for Top squark (iii)

- $\tilde{t}_1 \to c\tilde{c}_1^0$ channel:



Look for acoplanar jets:

13 events obs., 10.7 exp.



Low Δm, $t\,(\tilde{t}_1)$ sizable

Tiny Δm, $\tilde{t}_1 \to u\tilde{c}_1^0$

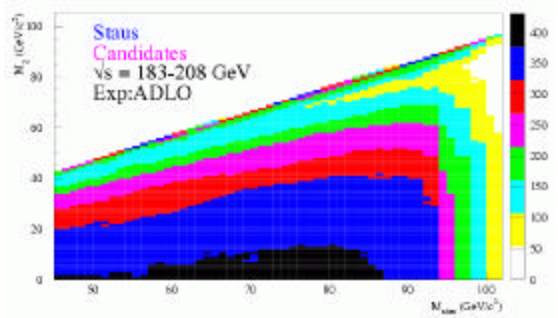
Look for **long-lived hadrons**

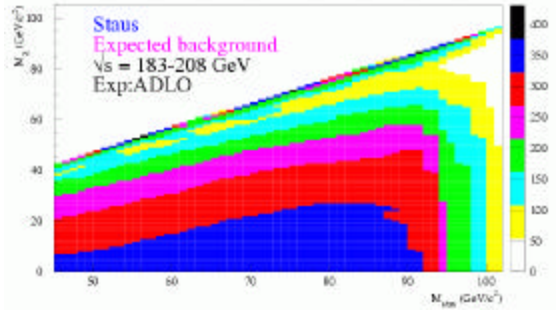
0 events obs., 0.6 exp.

Slepton Searches

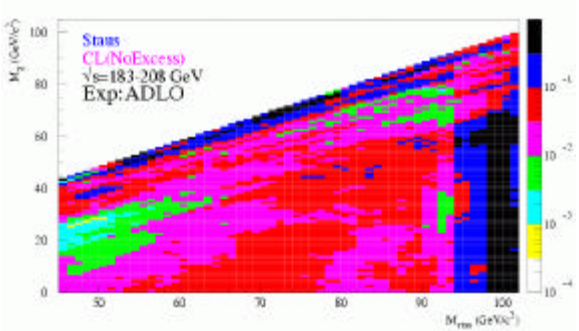
- **Simplest case: smuon NLSP**
  - **mSUGRA inspired models:** $m(\tilde{m}_L) > m(\tilde{m}_R)$ **and mixing is negligible**
  - **Production:** $e^+ e^- \xrightarrow{s-chan} \tilde{m}_R^+ \tilde{m}_R^-$
  - **Decay:** $\tilde{m}_R \rightarrow m\tilde{c}_1^0$
  - **∴ Search for acoplanar muon pairs**
- **Stau NLSP**
  - **Mixing can contribute (at large tan beta)**
- **Selectrons: t-channel neutralino exchange enhances s**

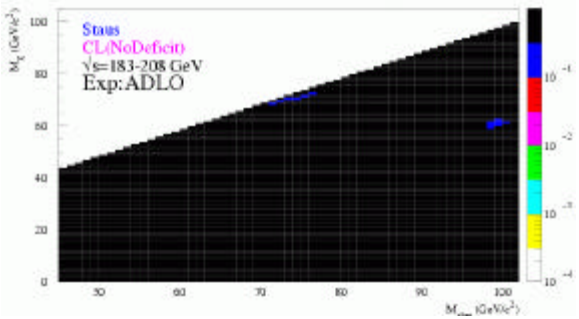
Channel	Neutralino Mass	Observed Slepton Mass Lower Limit	Expected Slepton Mass Lower Limit
Selectron	0 GeV 40 GeV	100.5 GeV 99.4 GeV	99.1 GeV 99.3 GeV
Smuon	0 GeV 40 GeV	95.4 GeV 96.4 GeV	91.0 GeV 91.7 GeV
Stau	0 GeV 40 GeV	80.0 GeV 87.1 GeV	85.1 GeV 89.3 GeV





Earlier excess unconfirmed !



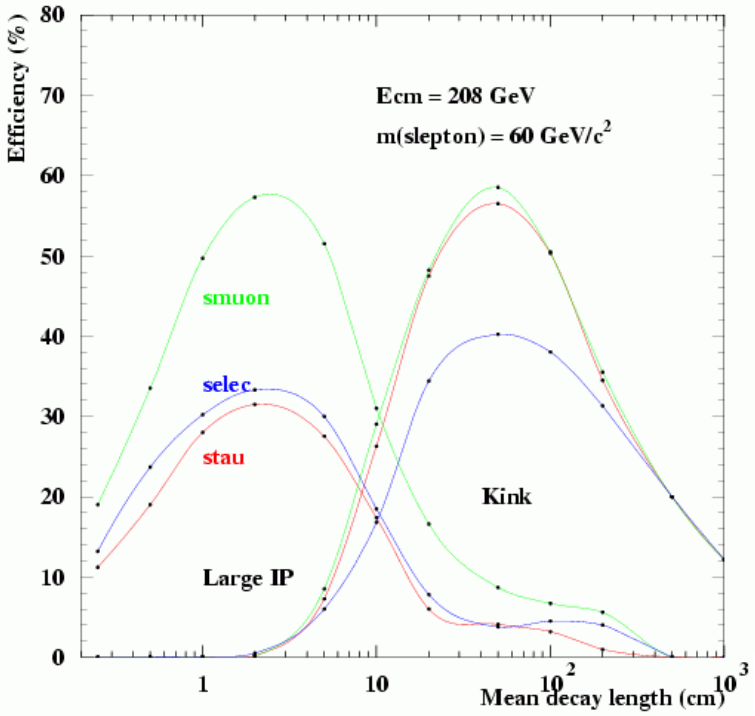


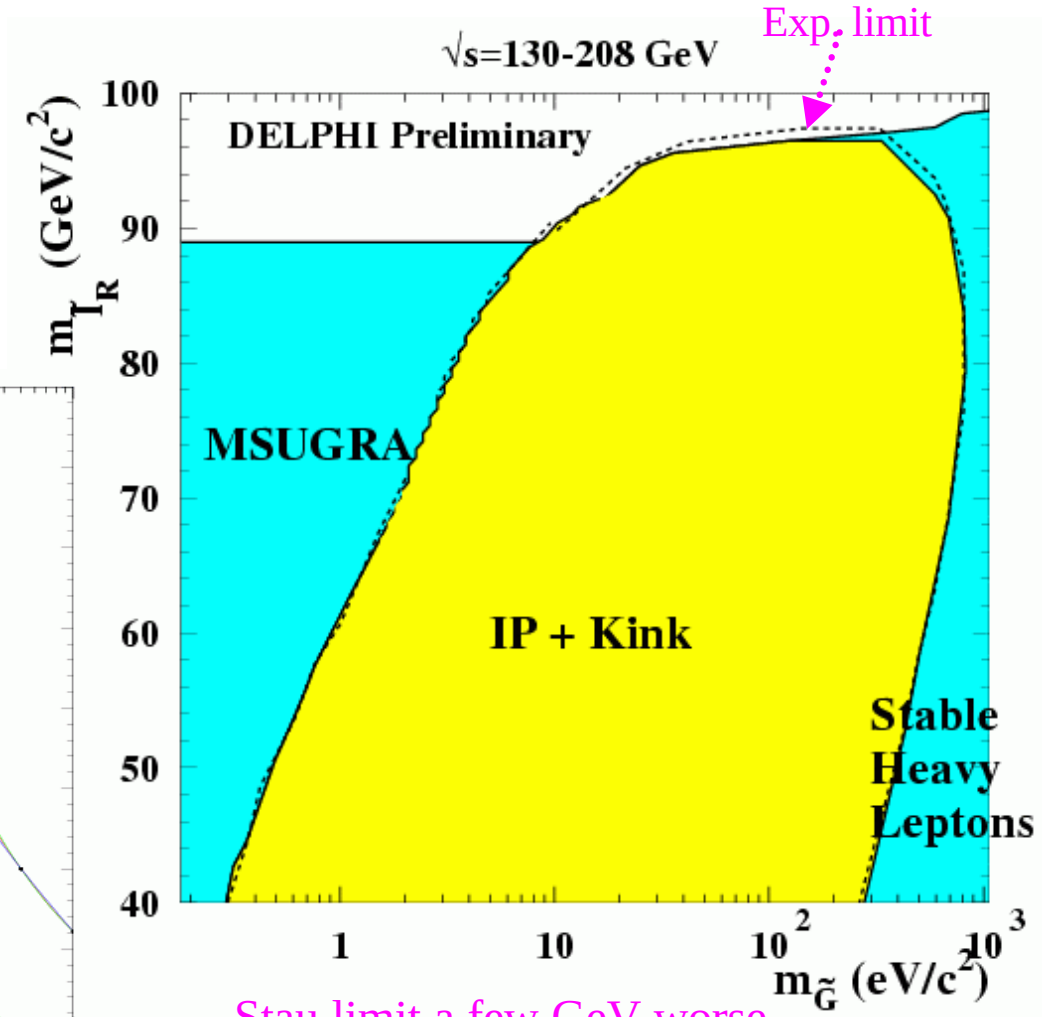
Sleptons in GMSB (long-lived)

- Delphi considers slepton NLSP
  1. Stau, with $\tilde{t}_1 \to t\tilde{G}$
  2. Slepton co-NLSP, with $\tilde{l}_R \to l\tilde{G}$
- Avg. decay length $\sim \sqrt{(E_{\tilde{l}} / m_{\tilde{l}})^2 - 1} \bullet m_{\tilde{G}}^2 / m_{\tilde{l}}^5$

Grav. Mass (eV)	Search method	#exp/#obs
<1	IP	3.3/4
1-10	IP	2.4/2
10-1000	Kinked tracks	0.94/2
>1000	Large dE/dx	0.25/0

Sleptons in GMSB (ii)



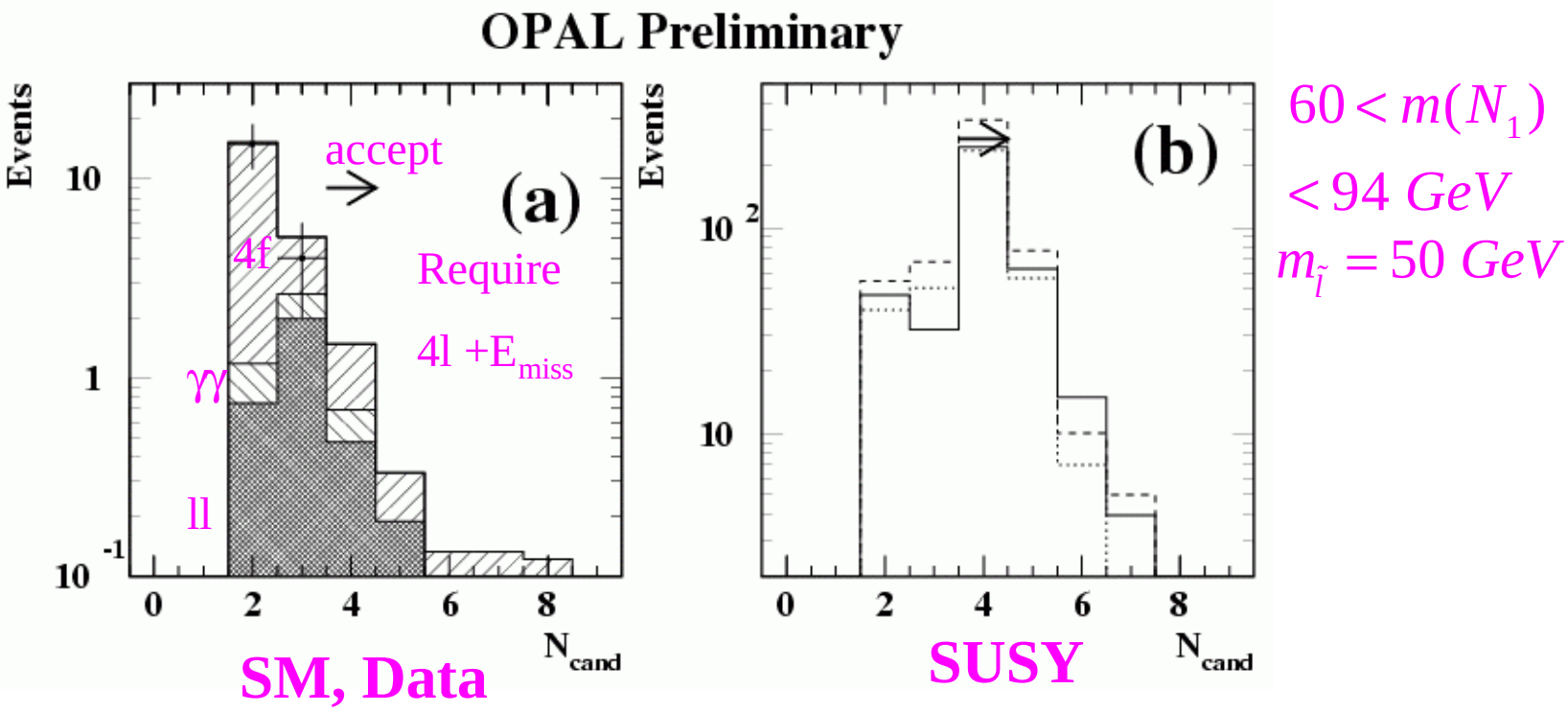


Stau limit a few GeV worse

Sleptons in GMSB (iii)

- OPAL performs related searches

$$e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to (\tilde{\ell}\ell)(\tilde{\ell}'\ell') \to (\ell\ell\tilde{G})(\ell'\ell'\tilde{G})$$



$60 < m(N_1) < 94\ GeV$

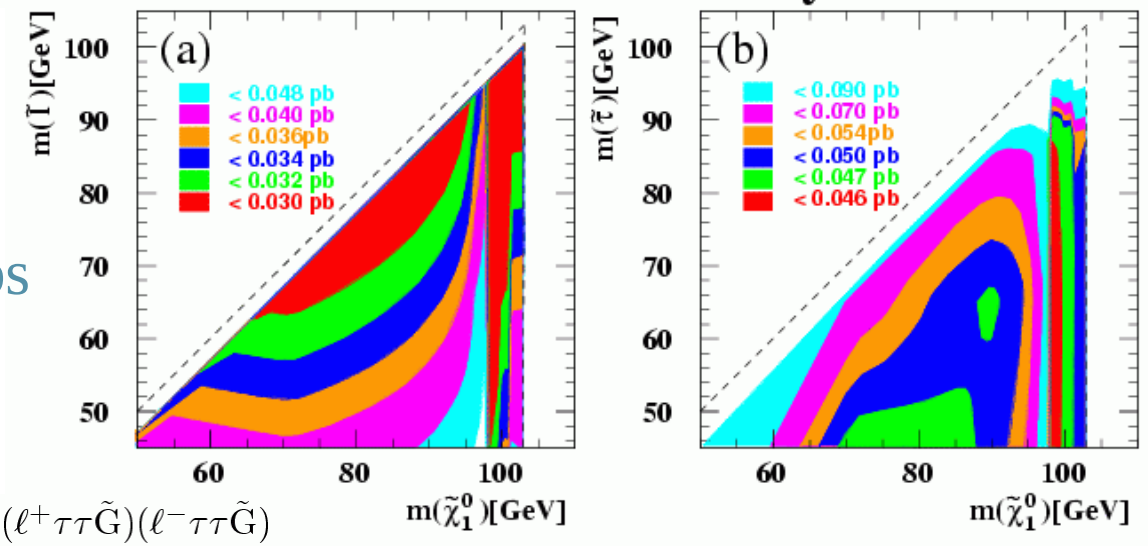
$m_{\tilde{l}} = 50\ GeV$

Sleptons in GMSB (iv)

$e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to (\tilde{\ell}\ell)(\tilde{\ell}'\ell') \to (\ell\ell\tilde{G})(\ell'\ell'\tilde{G})$

Require 4l +E_{miss}

Result: 1.5 exp, 0 obs



$e^+e^- \to \tilde{\ell}^+\tilde{\ell}^- \to (\ell^+\tilde{\tau}\tau)(\ell^-\tilde{\tau}\tau) \to (\ell^+\tau\tau\tilde{G})(\ell^-\tau\tau\tilde{G})$

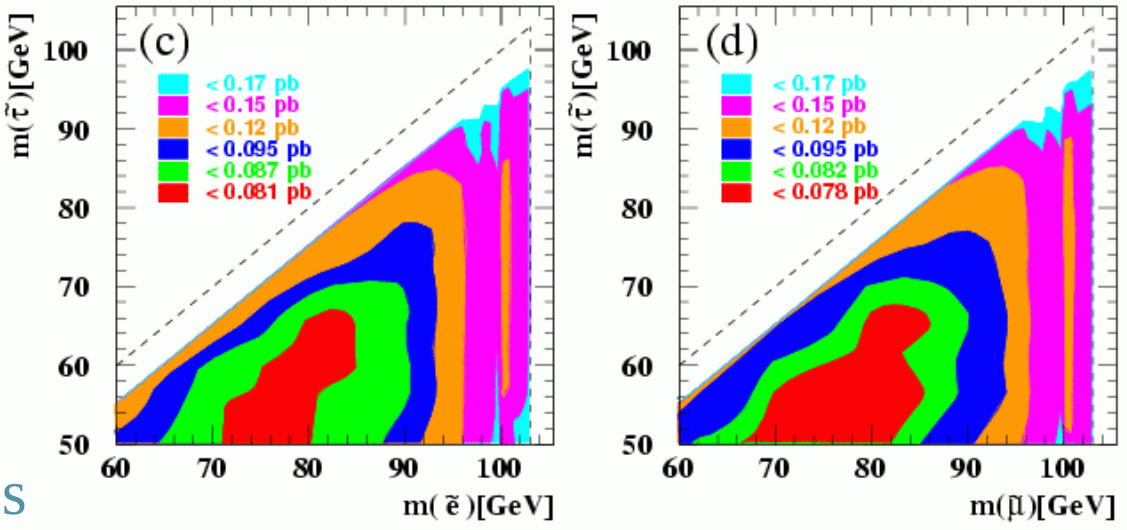
Require $e, m,$ or t_h

5-10 ch. tracks

Appreciable E_{miss}

Veto $WW \to qq'\ell n$

Result: 5.2 exp/10 obs



HERA R-parity violation searches

- At HERA, resonant squark production via λ' coupling: $e^+ p \Rightarrow \tilde{q}$

Cross section small as proton antiquark must participate

Decays to:

$e^+ + \bar{u}^j$ or $\bar{\nu}_e + \bar{d}^j$

λ'_{1jk}	production process	
111	$e^+ + \bar{u} \to \overline{\tilde{d}_R}$	$e^+ + d \to \tilde{u}_L$
112	$e^+ + \bar{u} \to \overline{\tilde{s}_R}$	$e^+ + s \to \tilde{u}_L$
113	$e^+ + \bar{u} \to \overline{\tilde{b}_R}$	$e^+ + b \to \tilde{u}_L$
121	$e^+ + \bar{c} \to \overline{\tilde{d}_R}$	$e^+ + d \to \tilde{c}_L$
122	$e^+ + \bar{c} \to \overline{\tilde{s}_R}$	$e^+ + s \to \tilde{c}_L$
123	$e^+ + \bar{c} \to \overline{\tilde{b}_R}$	$e^+ + b \to \tilde{c}_L$
131	$e^+ + \bar{t} \to \overline{\tilde{d}_R}$	$e^+ + d \to \tilde{t}_L$
132	$e^+ + \bar{t} \to \overline{\tilde{s}_R}$	$e^+ + s \to \tilde{t}_L$
133	$e^+ + \bar{t} \to \overline{\tilde{b}_R}$	$e^+ + b \to \tilde{t}_L$

Cross section scales as

$$l'^{\,2}_{1j1} \cdot d(x), \qquad x = M^2_{\tilde{q}} / s$$

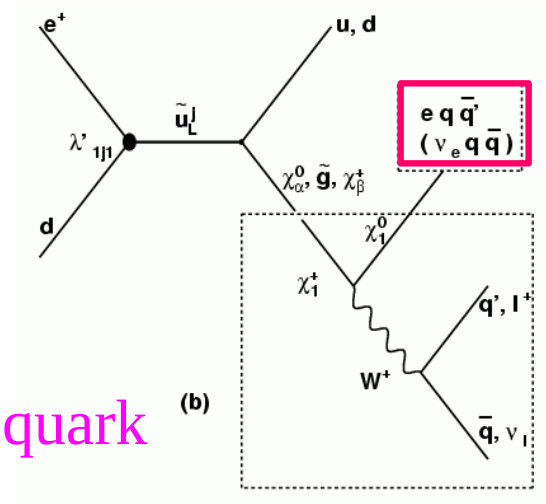
Decays to:

$e^+ + d^k$

HERA RPV searches (ii)

- Search assumptions:
  - Only one RPV coupling dominates
  - Squarks undergo RPV and RPC decays
  - LSP can be $\tilde{c}_1^0$, $\tilde{c}_1^{\pm}$, or $\tilde{g}$ which decays

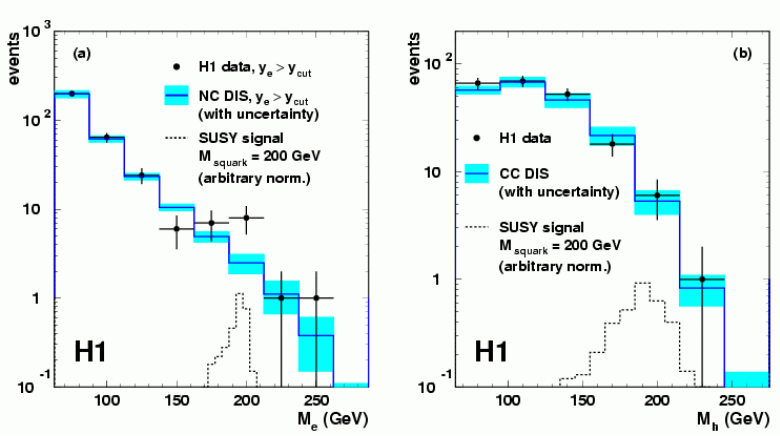
    $LSP \Rightarrow q\bar{q}'l$
  - Sparticle lifetimes neglected

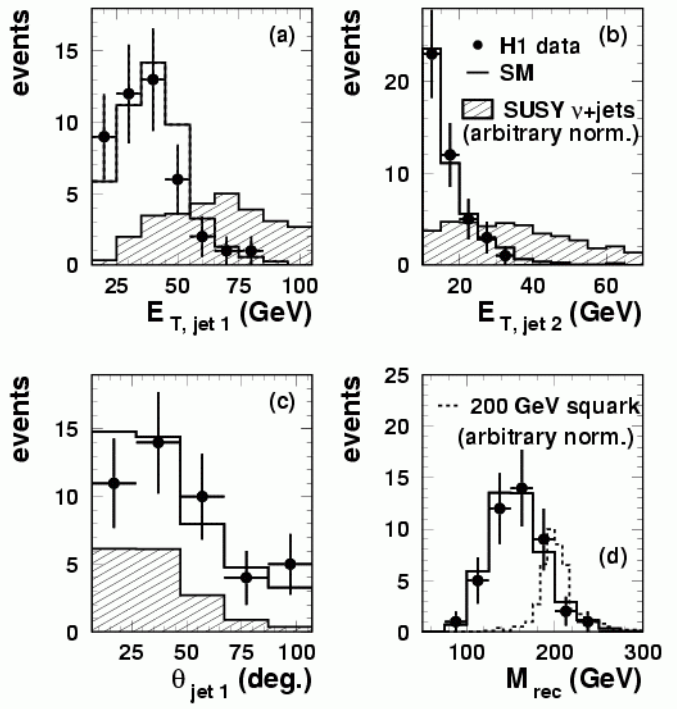


Example gauge decay of squark

H1 RPV searches: 1994-97 data

Channel	Decay processes	Signature
LQe	$\tilde{q} \xrightarrow{\lambda'} e^+ \; q$	high P_T e^+ + 1 jet
$LQ\nu$	$\overline{\tilde{d}^k_R} \xrightarrow{\lambda'} \bar{\nu}_e \; \bar{d}$	missing P_T + 1 jet
eMJ	$\tilde{q} \longrightarrow q \; X \hookrightarrow^{\lambda'} e^+\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow q\bar{q} \; Y \hookrightarrow^{\lambda'} e^+\bar{q}q$	e^+ + multiple jets
e^-MJ	$\tilde{q} \longrightarrow q \; \chi^0_\alpha, \tilde{g} \hookrightarrow^{\lambda'} e^-\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow q\bar{q} \; Y \hookrightarrow^{\lambda'} e^-\bar{q}q$	e^- (i.e. wrong sign lepton) + multiple jets
νMJ	$\tilde{q} \longrightarrow q \; X \hookrightarrow^{\lambda'} \nu\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow q\bar{q} \; Y \hookrightarrow^{\lambda'} \nu\bar{q}d'$	missing P_T + multiple jets
$e\ell MJ$	$\tilde{q} \longrightarrow q \; X \hookrightarrow \ell\nu_\ell \; Y \hookrightarrow^{\lambda'} e^\pm\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow \ell^+\ell^- \; Y \hookrightarrow^{\lambda'} e^\pm\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow e^+e^- \; Y \hookrightarrow^{\lambda'} \nu\bar{q}q$	e + ℓ (e or μ) + multiple jets
$\nu\ell MJ$	$\tilde{q} \longrightarrow q \; X \hookrightarrow \ell\nu_\ell \; Y \hookrightarrow^{\lambda'} \nu\bar{q}q$ $\tilde{q} \longrightarrow q \; X \hookrightarrow \mu^+\mu^- \; Y \hookrightarrow^{\lambda'} \nu\bar{q}q$	ℓ (e or μ) + missing P_T + multiple jets

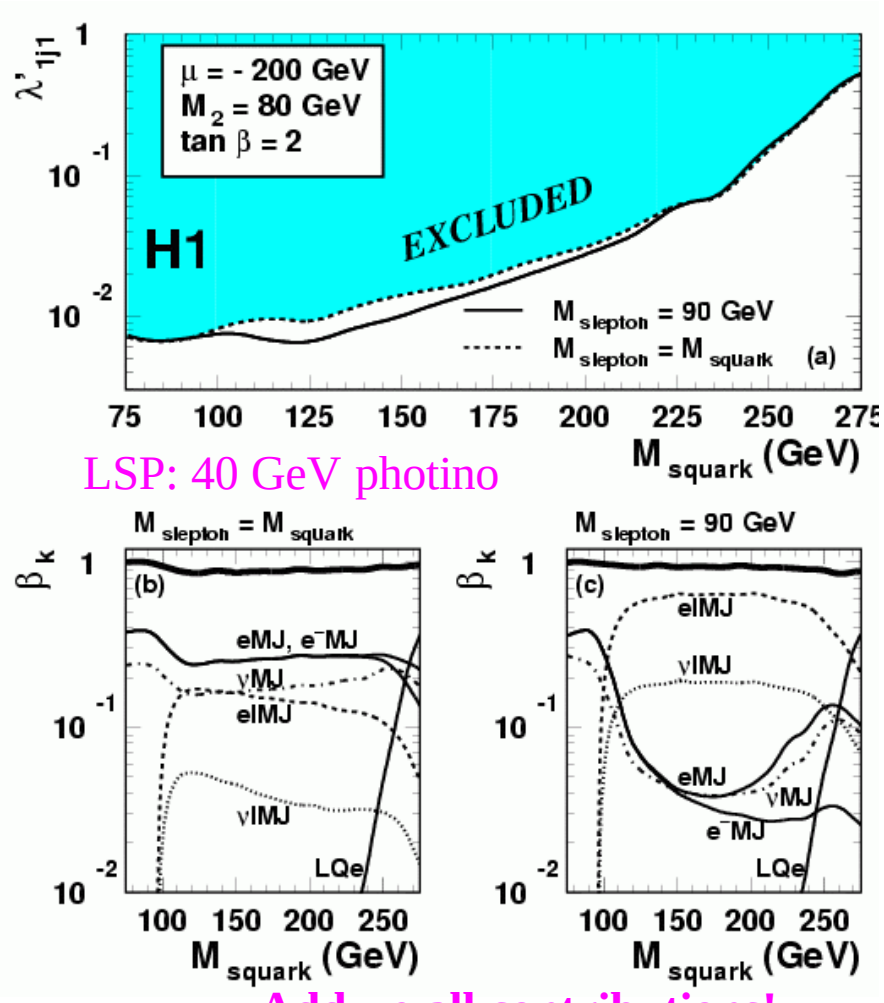




RPV searches at H1 (ii)

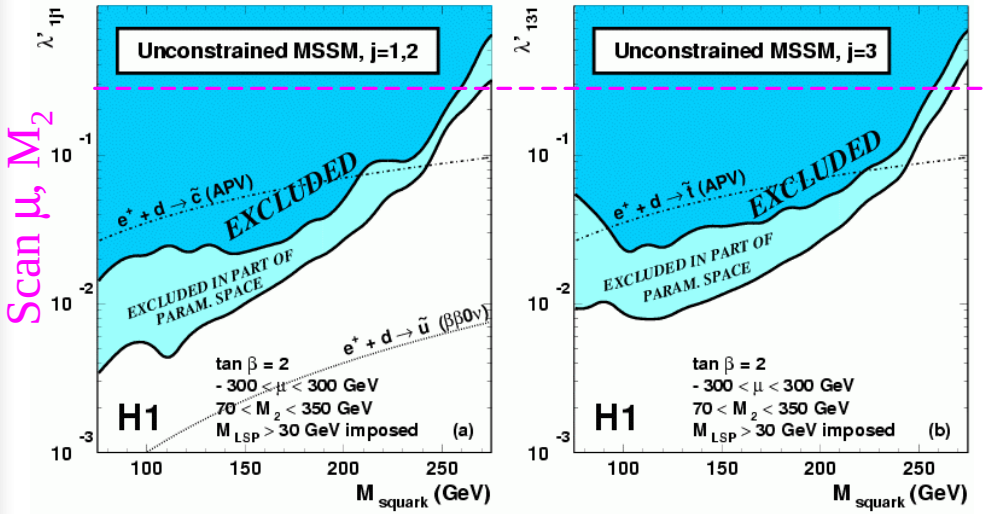
Channel	Selection Cuts	Efficiency	N_{obs}	N_{exp}
DIS-like channels: $Q^2 > 2500$ GeV^2, $y < 0.9$				
LQe	$E_{T,e} > 15$ GeV $P_{T,miss}/\sqrt{E_{T,e}} \leq 4\sqrt{\text{GeV}}$ $40 \leq \sum(E - P_z) \leq 70$ GeV optimised lower y-cut	40–70 %	310	301 ± 23
$LQ\nu$	$P_{T,miss} > 30$ GeV no electron $E_{T,e} > 5$ GeV	30–80 %	213	199 ± 12
channels with: e + multijets + X				
e-preselection: $E_{T,e} > 5$ GeV; ≥ 2 jets: $E_{T,jet\,1,2} > 15, 10$ GeV; high y_e; angular cuts				
eMJ	$P_{T,miss} < 20$ GeV $40 \leq \sum(E - P_z) \leq 70$ GeV	35–50 %	159	151 ± 17
e^-MJ	eMJ criteria + "wrong" charge of e	$\approx 30\%$	0	1.3 ± 0.5
$eeMJ$	second e with: $E_{T,e2} > 5$ GeV $5° < \theta_{e2} < 110°$	$\approx 30\%$	0	0.7 ± 0.4
$e\mu MJ$	$P_{T,\mu} > 5$ GeV $10° < \theta_\mu < 110°$	35–50%	2	4.2 ± 1.2
νeMJ	$P_{T,miss} > 15$ GeV $y_e(y_e - y_h) > 0.05$	$\approx 30\%$	1	3.2 ± 1.2
channels with: ν + multijets + X				
ν-preselection: $P_{T,miss} > 25$ GeV; ≥ 2 jets: $E_{T,jet\,1,2} > 15, 10$ GeV				
νMJ	$E_{T,jet2} > 15$ GeV $\sum(E - P_z)_h < 55$ GeV	20–60 %	21	23 ± 4
$\nu\mu MJ$	$P_{T,\mu} > 5$ GeV $10° < \theta_\mu < 110°$	$\approx 40\%$	0	0.5 ± 0.2

No excesses. Proceed to set limits:



Add up all contributions!

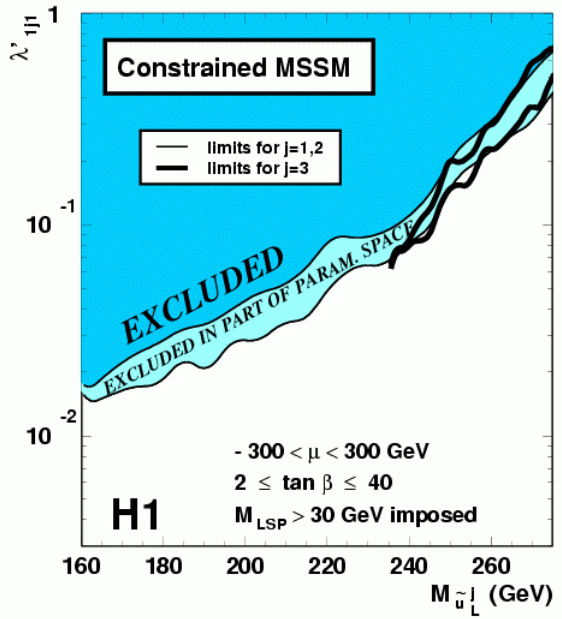
More RPV limits from H1



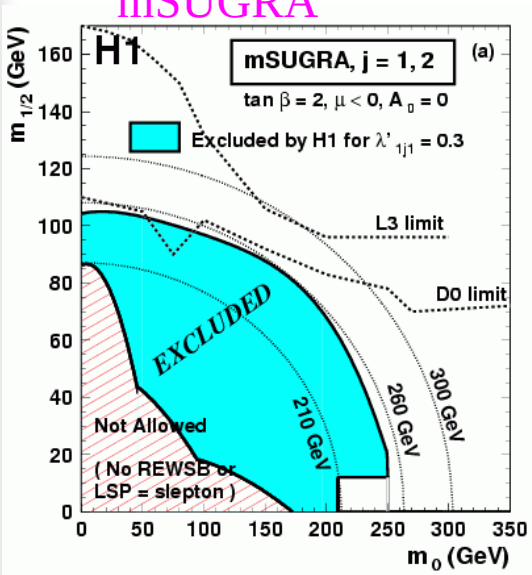
Scan μ, M_2

EM strength coupling:
Exclude squarks
below 260 GeV

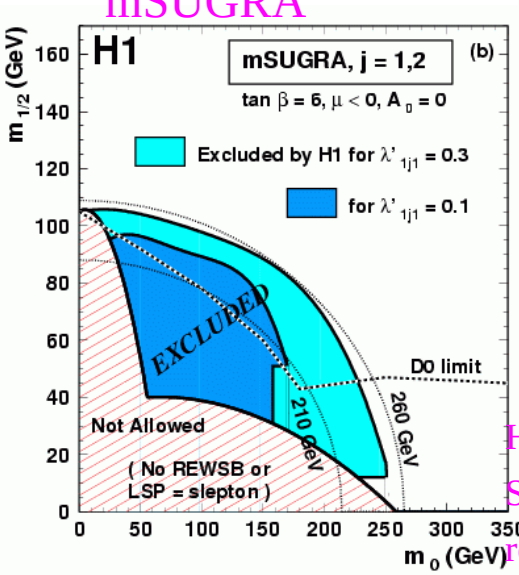
CMSSM



mSUGRA

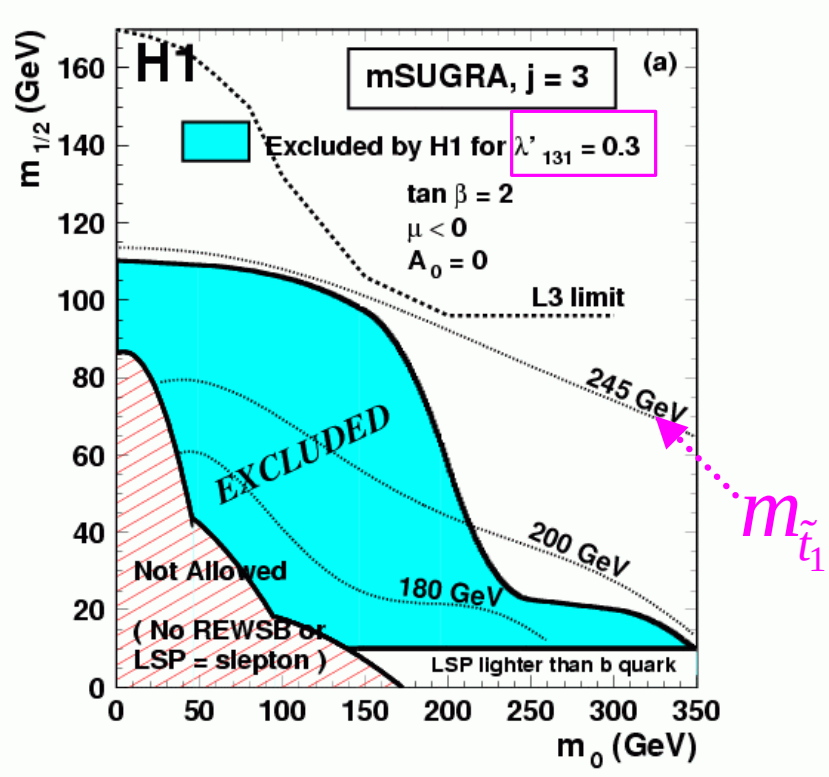


mSUGRA

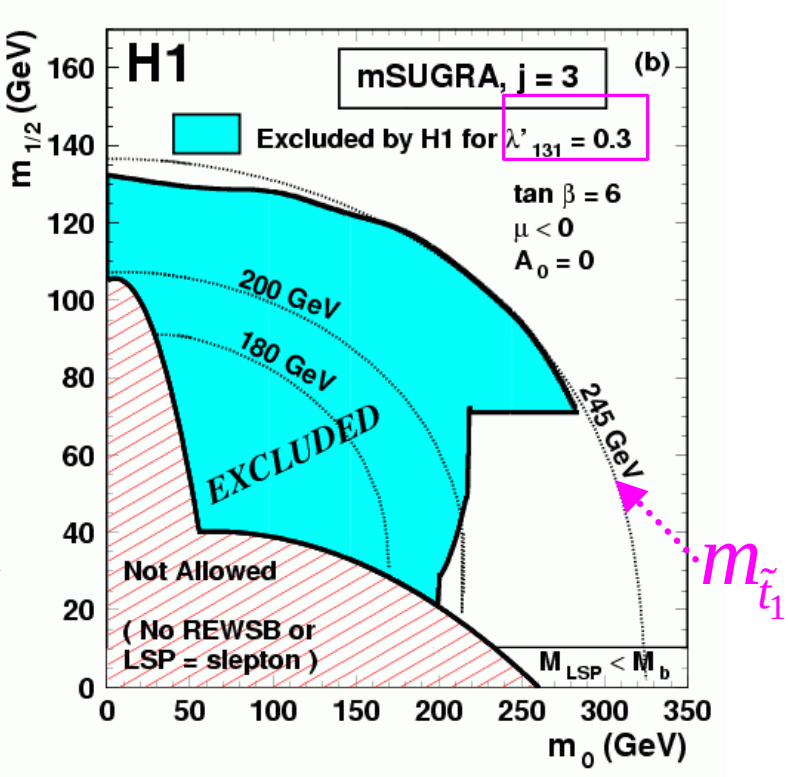


High tan beta: LSP is Zino:
Suppresses positron decay, while H1
retains sensitivity with neutrino channels

More RPV limits from H1 (ii)



$m_{\tilde{t}_1}$



$m_{\tilde{t}_1}$

L3 limit is independent of magnitude of RPV coupling

large $\tan b$ **dependence**

RPV searches at ZEUS

- Assumptions for this scenario:
  - At most one lambda' coupling non-zero
  - LSP is *N1*, gluino heavier than squark
  - Set $M_1 = (5/3) \cdot M_2 \tan^2 q_W$
  - M_0=0, trilinear couplings=0
  - All 1st gen. sfermions assumed mass degenerate

Search for $l'_{1j1} > 0$ with 1994-1997 e^+p data: 48 pb^{-1}

RPV searches at ZEUS (ii)

Analysis classes

class	circularity cut	signal topologies	backgrounds	variables
ν	$c > 10^{-3}$	$\nu qq\bar{q}, \nu qq\bar{q}q\bar{q}$	CC-DIS, γp	M, ℓ_c, y
e^+ low-c	$c < 10^{-3}$	e^+q	NC-DIS, γp	M, y
e^+ high-c	$c > 10^{-3}$	$e^\pm qq\bar{q}, e^\pm qq\bar{q}q\bar{q}$	NC-DIS, γp	M, ℓ_c, y
e^-	$c > 10^{-3}$	$e^- qq\bar{q}, e^- qq\bar{q}q\bar{q}$	NC-DIS, γp	M, ℓ_c, y

- *M* = reconstructed mass for event
- *lc*=log(circularity)
- *y~E-Pz* transfer from e+ to hadronic final state

Dramatic background rejection with final cuts!

	preselection			after R cut		
class	$\mathcal{A}_C$	B_C	N_C^{presel}	$\mathcal{A}_C^{\text{final}}$	B_C^{final}	N_C^{obs}
ν	12.8%	137	162	10.2%	0.9	3
e^+ low-c	0.2%	88	66	0.0%	0.0	0
e^+ high-c	14.0%	441	439	9.0%	0.5	2
e^-	6.2%	0.08	0	6.0%	0.01	0
	Acc	#bg	#obs	Acc	#bg	#obs

Opt for each:

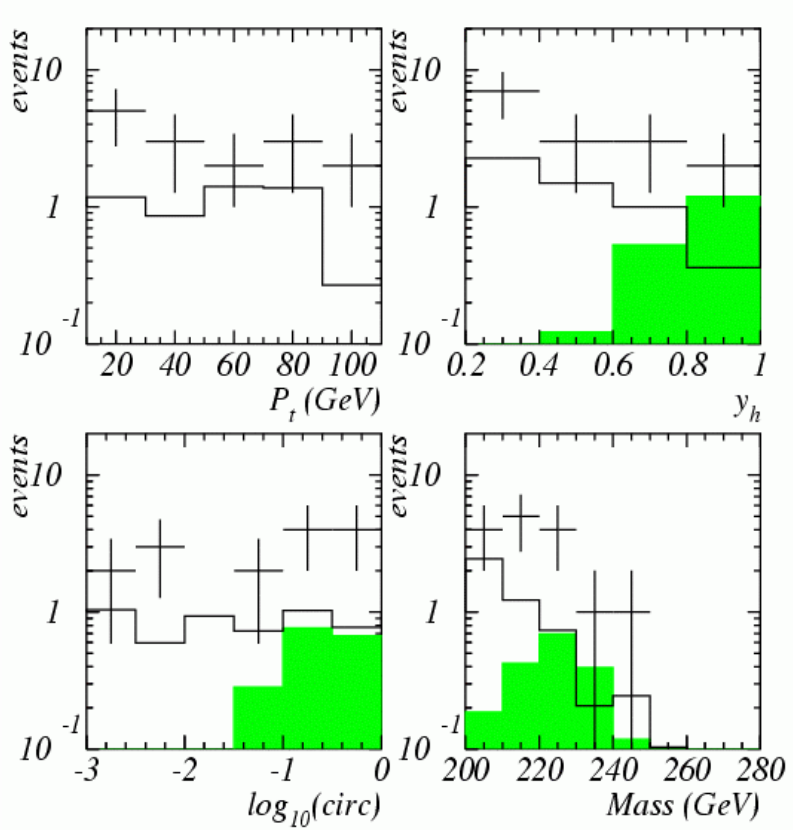
$m_{\tilde{q}} = 220\ GeV,$

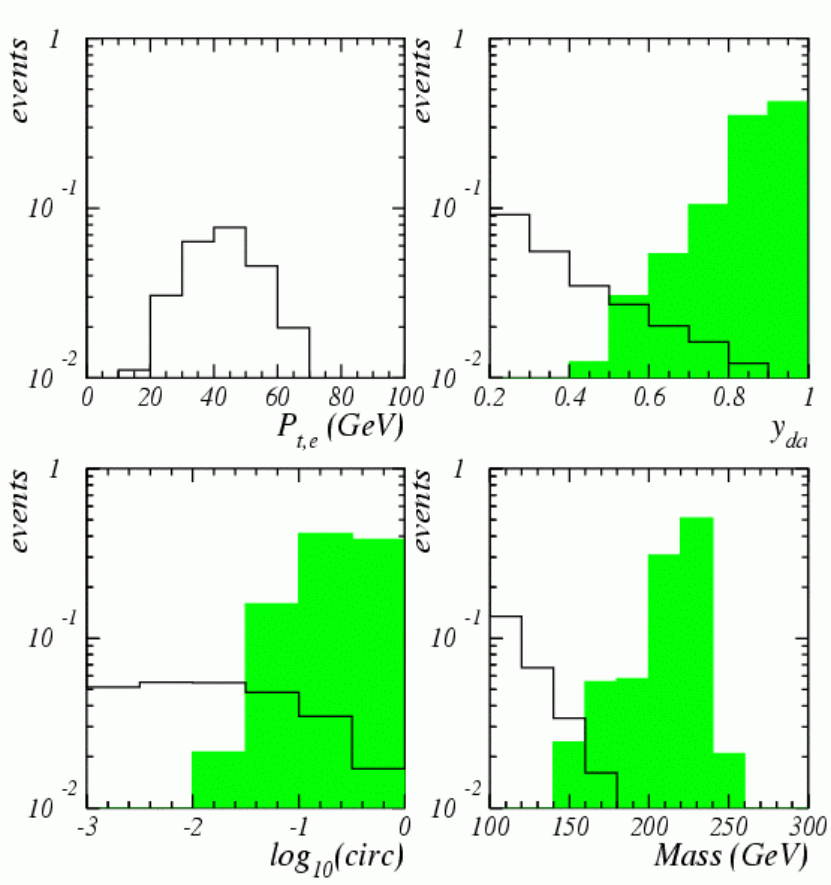
$m = -180\ GeV,$

$M_2 = 100\ GeV,$

$\tan b = 2$

RPV searches at ZEUS (iii)





Neutrino sample, *M>200 GeV*

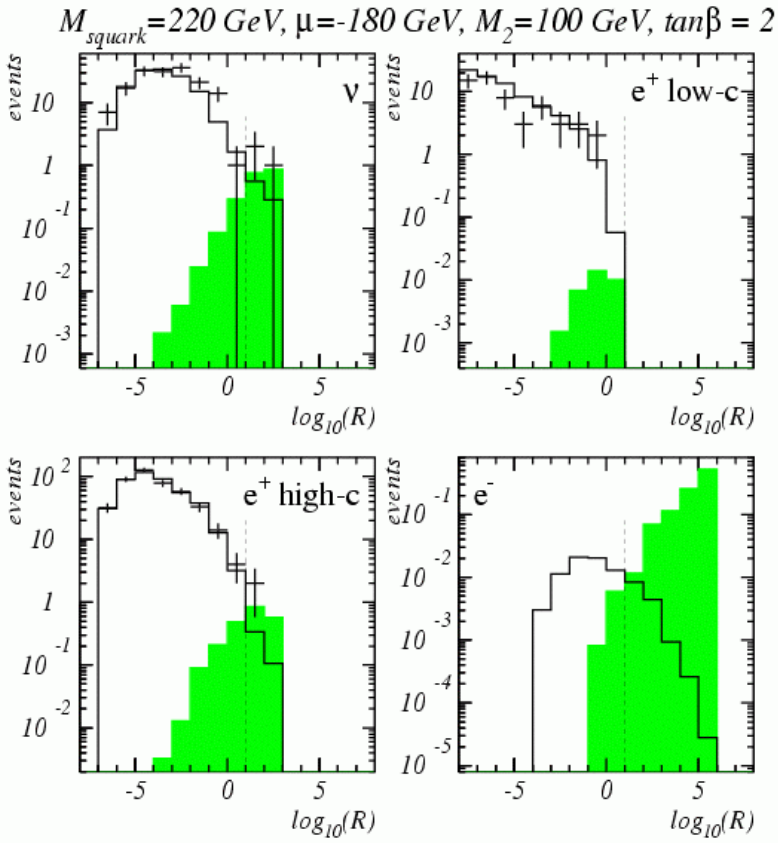
Discrepancy believed understood!

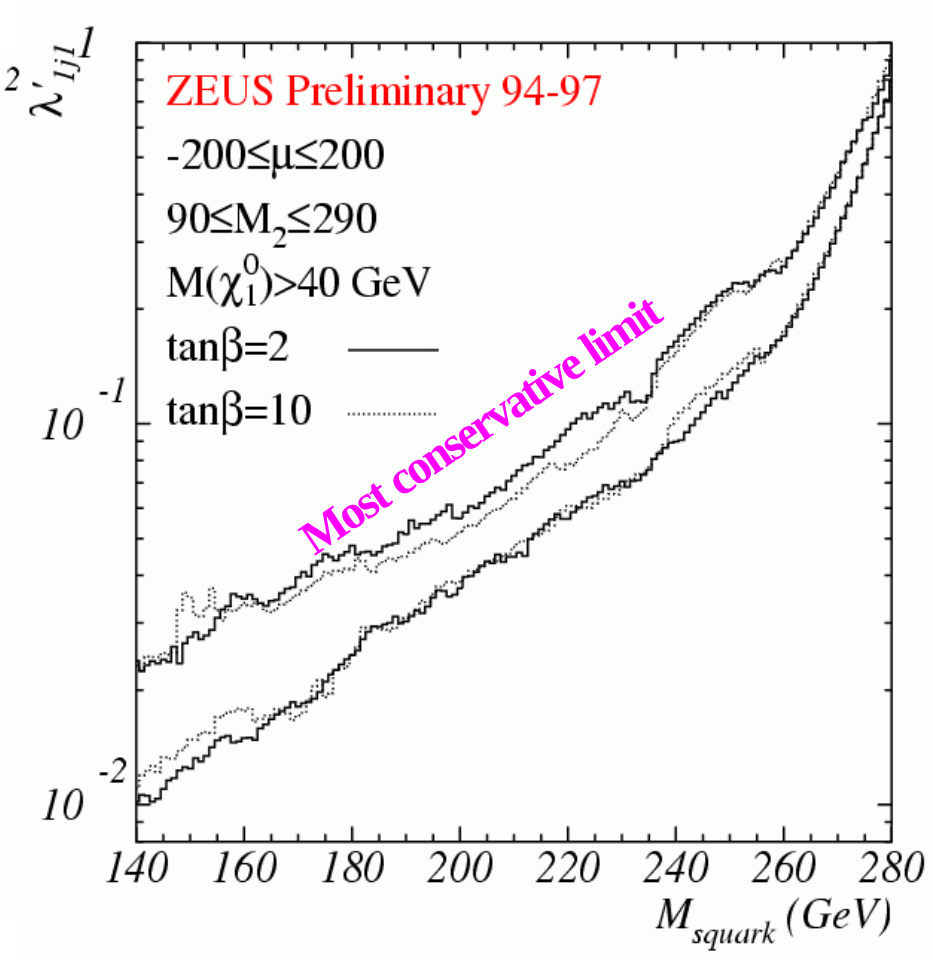
Electron sample, *M>100 GeV*

(no events pass selection)

Green is SUSY, M(squark)=220 GeV

RPV searches at ZEUS (iv)





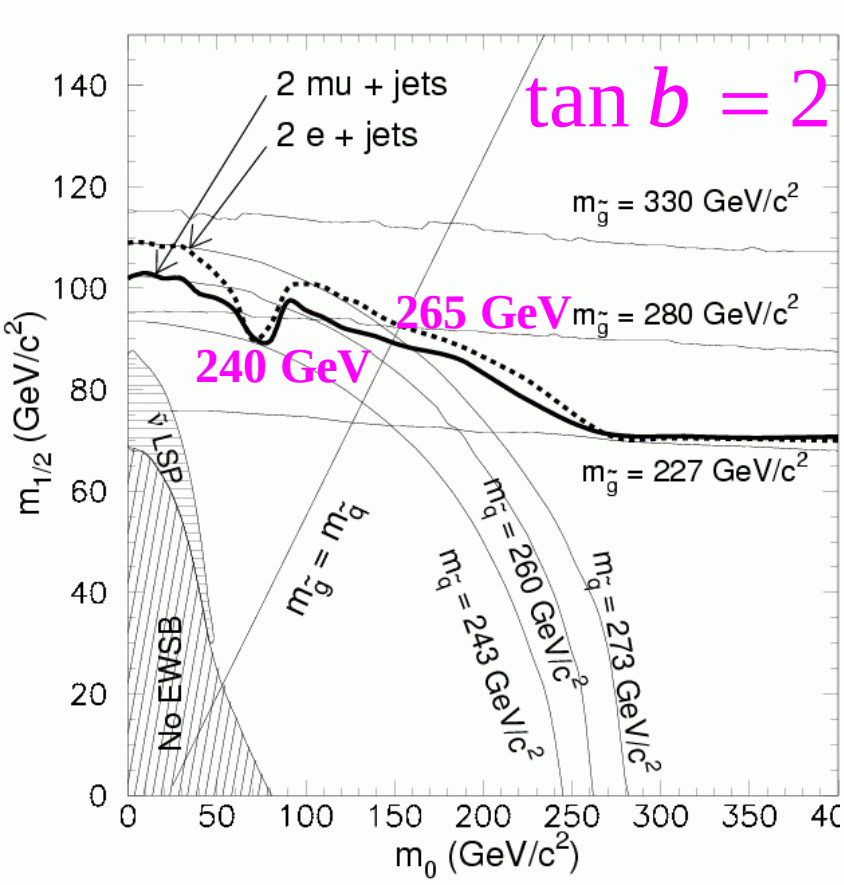
Green is SUSY,
M(squark)=220 GeV

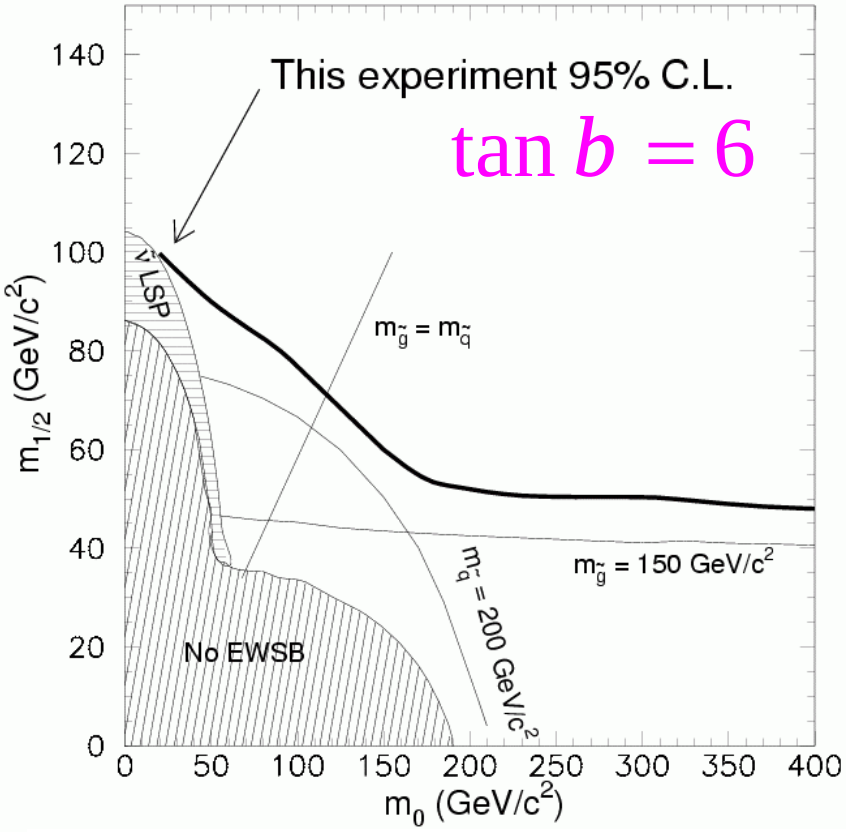
R-parity violation search at DZero

- Search for non-zero $l'_{2jk}, (j = 1, 2; k = 1 - 3)$
  - LSP decays $\tilde{c}_1^0 \Rightarrow mqq'$
  - Require 2 m (15,10) + 4 j (15), H_t >150, aplanarity cuts
  - Complementary to ee+jets search
  - 0.18 events expected, 0 observed
  - Set limits in mSUGRA framework:

$$\tan b = 2,\ A_0 = 0,\ m < 0,\ scan:\ (m_0, m_{1/2})$$

RPV search at Dzero (ii)



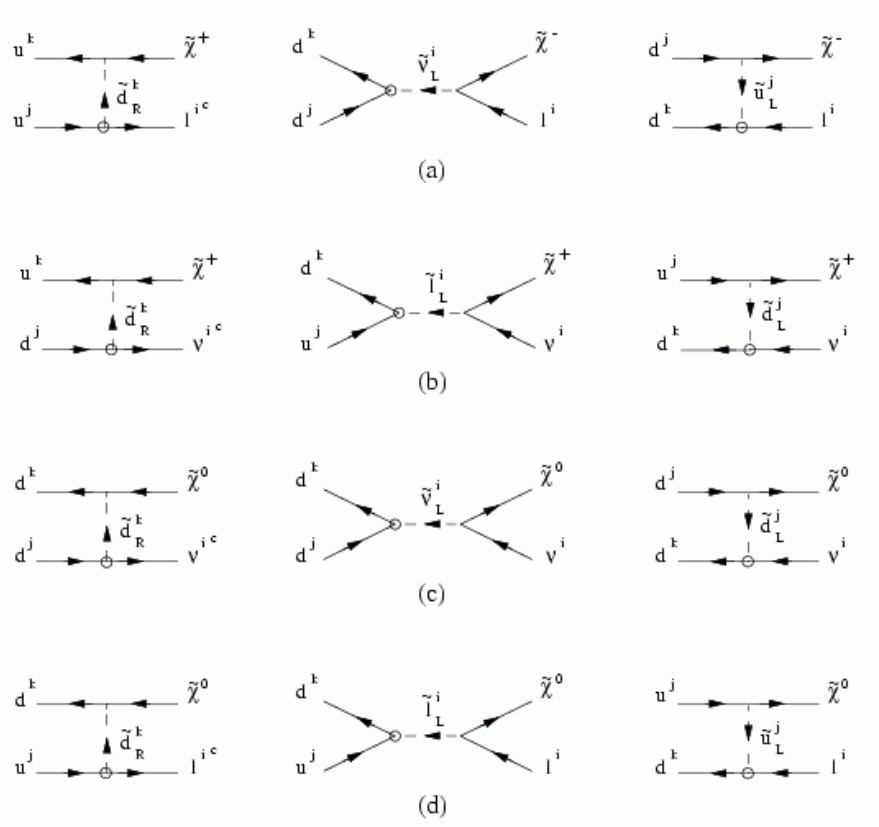


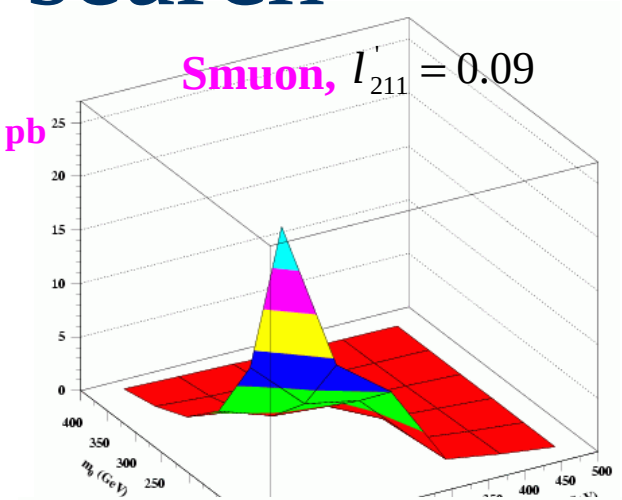
tan b dependence: gauginos become light-> soft muons+jets

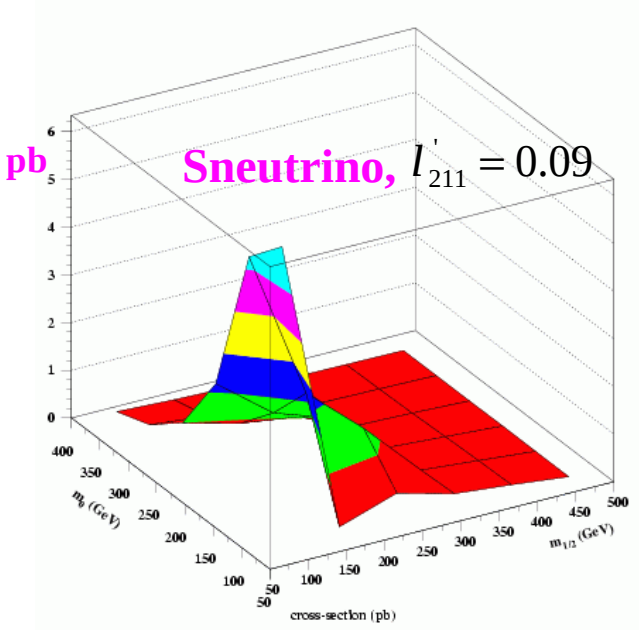
($m > 0$ would reduce limits: LSP photino content diminished)

Dzero RPV Slepton search

- **Look for smuons and sneutrinos from**
- **non-zero l'_{211} resonant production**



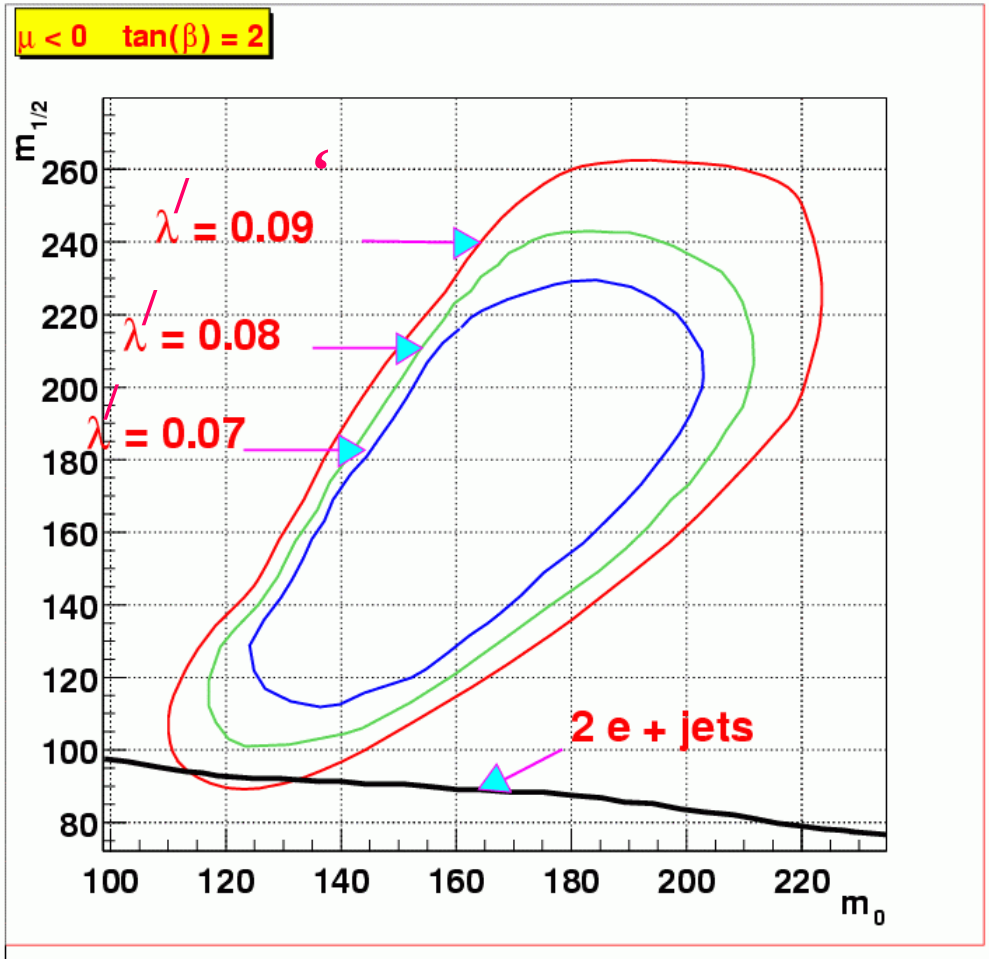




Dzero RPV Slepton search (ii)

- Signature is 2 muons + 2 jets.
- Backgrounds:
  - top, WW+jets, Z+2jets
  - Drell-Yan, W+jets negligible
- Perform NN analysis. Variables:
  - Et(j), Pt(μ), M(μμ), ΔR, sphericity, aplanarity
- Reference point: $m_0 = 200, M_2 = 200, \tan b = 2, m < 0$
  - Result: 6.4 signal evt, 1 bg evt, 2 observed

Dzero RPV Slepton search (iii)



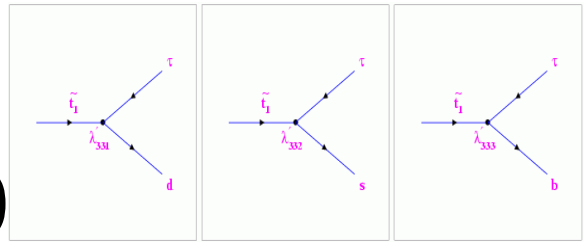
looks exactly the same with smuon mass on x-axis

R-parity violation search at CDF

- Idea: test 3rd gen. RPV coupling:

$$p\bar{p} \to \tilde{t}_1\bar{\tilde{t}}_1,\ \tilde{t}_1 \Rightarrow bt$$

$$\to (bl\nu_l\bar{n}_t)(bt_h)$$



- Final state "looks like" LQ3 analysis.
  Improvements:
  1. Lower P_T electron cut, $P_T > 10\ GeV$
  2. Track-based t_h id, include p^0 reconstr.

Significantly improves acceptance for $Z^0 \to t\,t$

RPV search at CDF (ii)

- After baseline selection, remaining BG:

$$Z^0 \to t\,t,\ W + jets,\ QCD$$

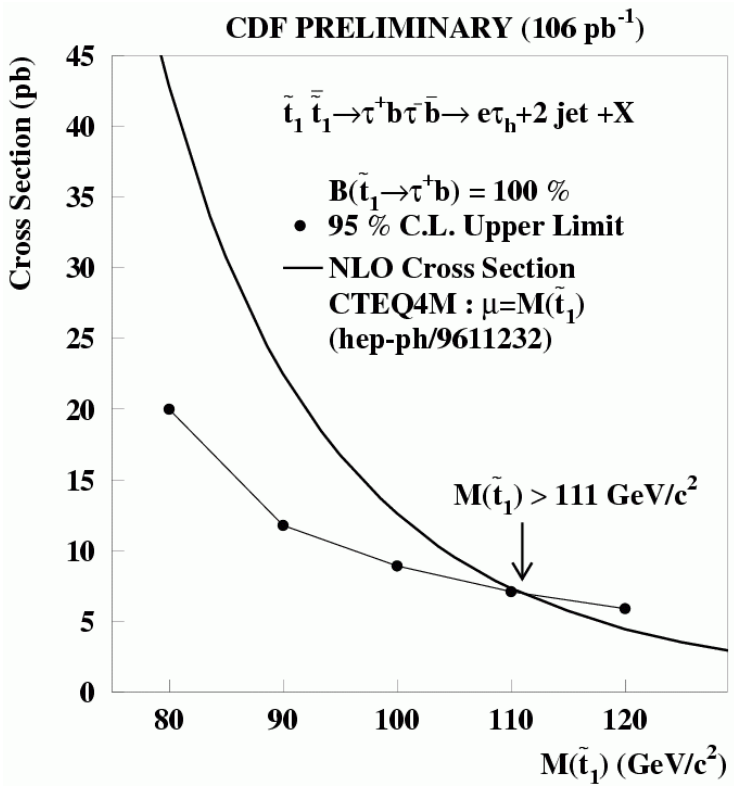
  - Final cuts require:

$$M_T(e, \not\!\!E_T) \le 35\ GeV,$$
$$E_T(e) + \not\!\!E_T + P_T(t_h) \ge 75\ GeV,$$
$$N_j \ge 2$$

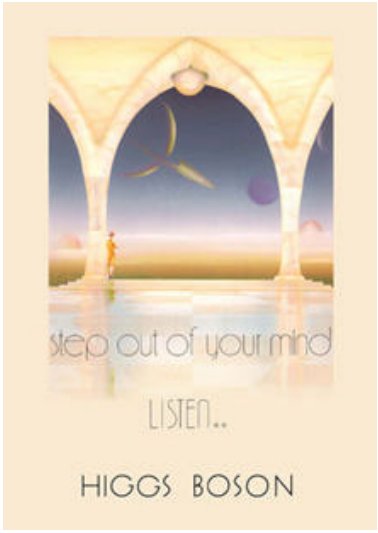
No b-tag!

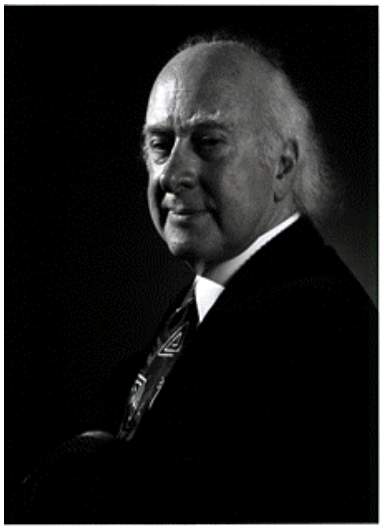
  - Result:
    - 1.9 expected
    - 0 observed

Also have cross section limits for $t \to mn\bar{n}$



SUSY Higgs



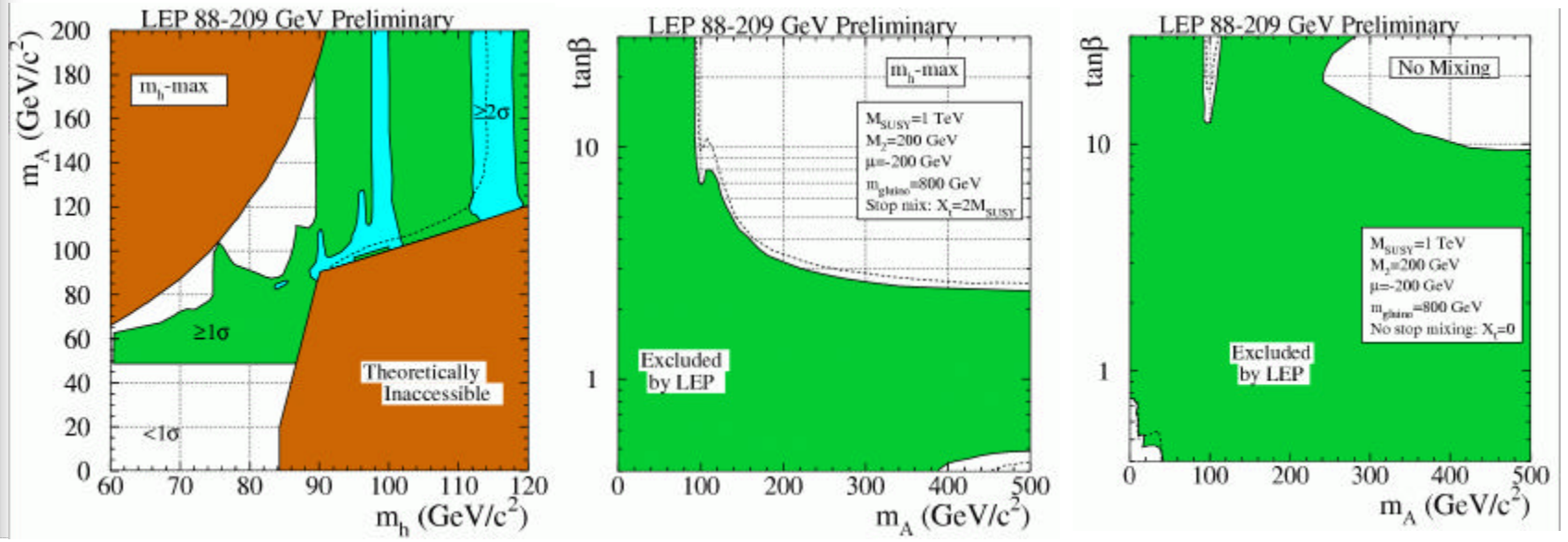


- LEP2 (WG) looked
- at $e^+e^- \to h^0 A^0$
  $\to (b\bar{b})(b\bar{b}, t\bar{t})$
- Constrained model: $M_{SUSY}, M_2, m, A, \tan b, m_A, m_{\tilde{g}}$
- L3 results, e.g.:

decay	background	signal $m_h = m_A = 90\ GeV$	observed
$A^0 \to b\bar{b}$	7.8	3.2	12
$A^0 \to t\bar{t}$	3.2	0.4	2

SUSY Higgs (ii)

- Examine 3 scenarios:
  1. no mixing (top squarks)
  2. m_h-max: gives heaviest *h*, (conservative)
  3. large $m = 1\ TeV$ (alt. decays of higgs)



Prospects and conclusions

- I didn't have time to cover it all! Vast field at present and foreseeable future
  - LEP2 final results soon: RPV, GMSB
  - Tevatron Run II underway. Major detector and machine upgrades. First physics results early in 2002. CDF-D0 WGs!
  - H1 and Zeus will take much more data, polarized lepton beam, etc.

LOOKING FORWARD TO IT!

See following talks for details.