Searches for sleptons and squarks at LEP

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on behalf of the 4-LEP experiments

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- Introduction
- Squarks
- Sleptons (in particular staus)
- Conclusion

The LEP e^+e^- collider

E_{CM} (GeV)	Year	$\int$Ldt (pb^{-1}/exp)
88-95	'89-'95	~175
130,136	'95,'97	~10
161,172	'96	~10, ~10
181-184	'97	~55
189	'98	~170
192,196,200,202	'99	~(30,80,80,30)
205,207,->208.9	2000	>(56, 36, 2.6)

Results based on samples $E_{CM} \leq 202$ GeV (~0.5x4 fb^{-1})
(@ $E_{CM} > M_Z$)

Squarks searches

$m_t >> m_q$ ⇒ $\tilde{t}$ expected to be the lightest $\tilde{q}$ and with a large mixing (large top mass)

relation with Higgs sector $\Delta m_h^2 \sim \frac{m_t^4}{m_w^2} \log\left(\frac{m_{\tilde{t}}^2}{m_t^2}\right)$

production x-section depends on mass and mixing angle

Topology depends on $\Delta m = m_{\tilde{f}} - m_{LSP}$

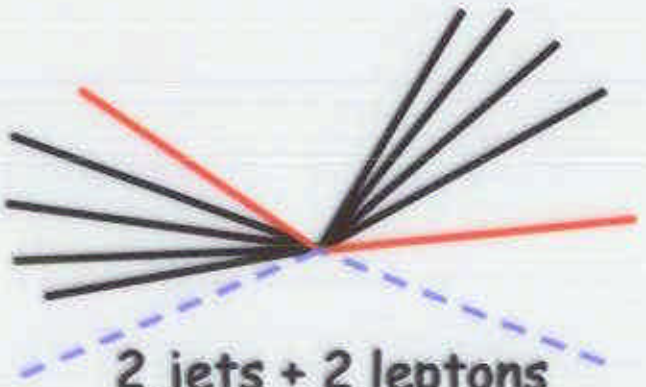
$\tilde{t} \rightarrow c/u\ \chi$ (FCNC)

if Δm very low

-> lifetime no longer negligible

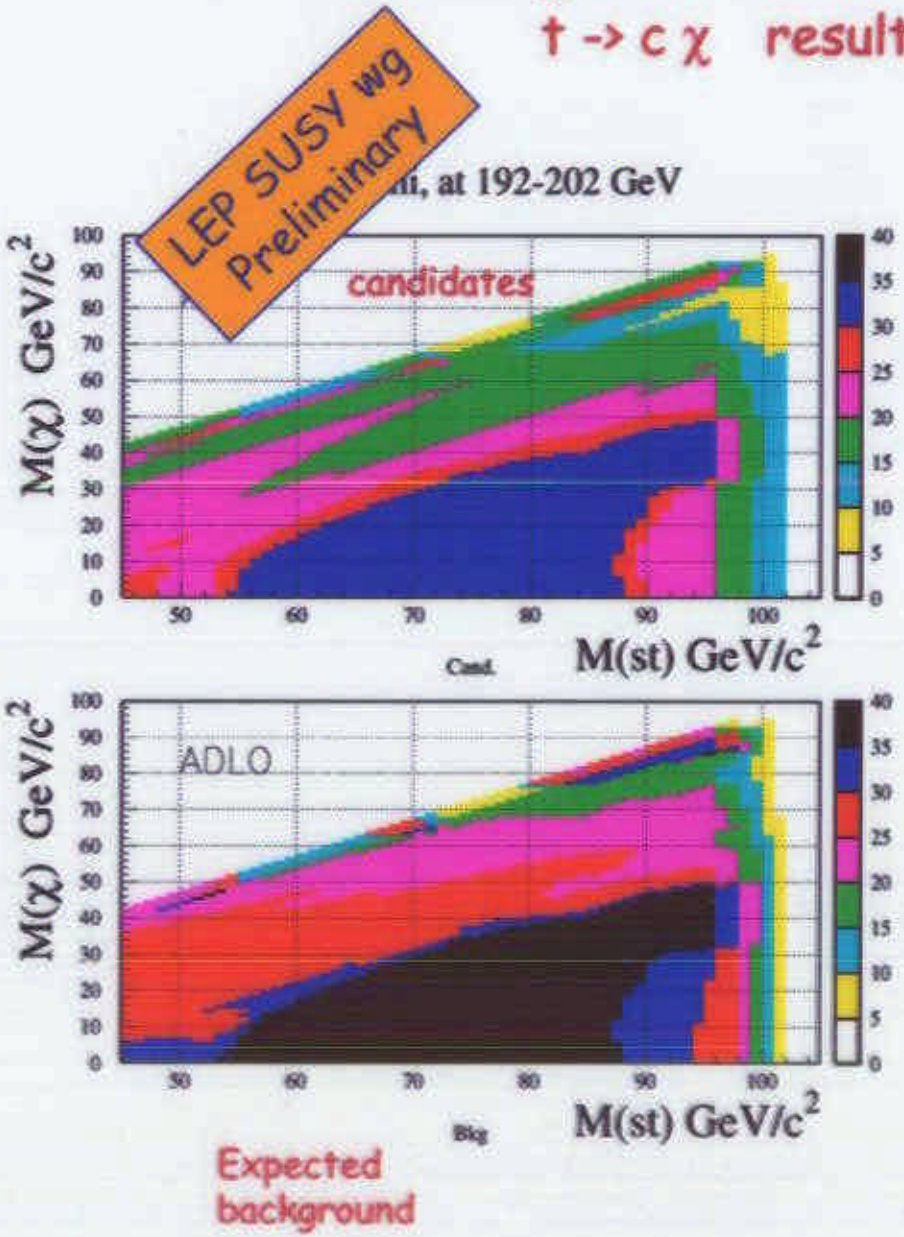
2 jets and missing energy

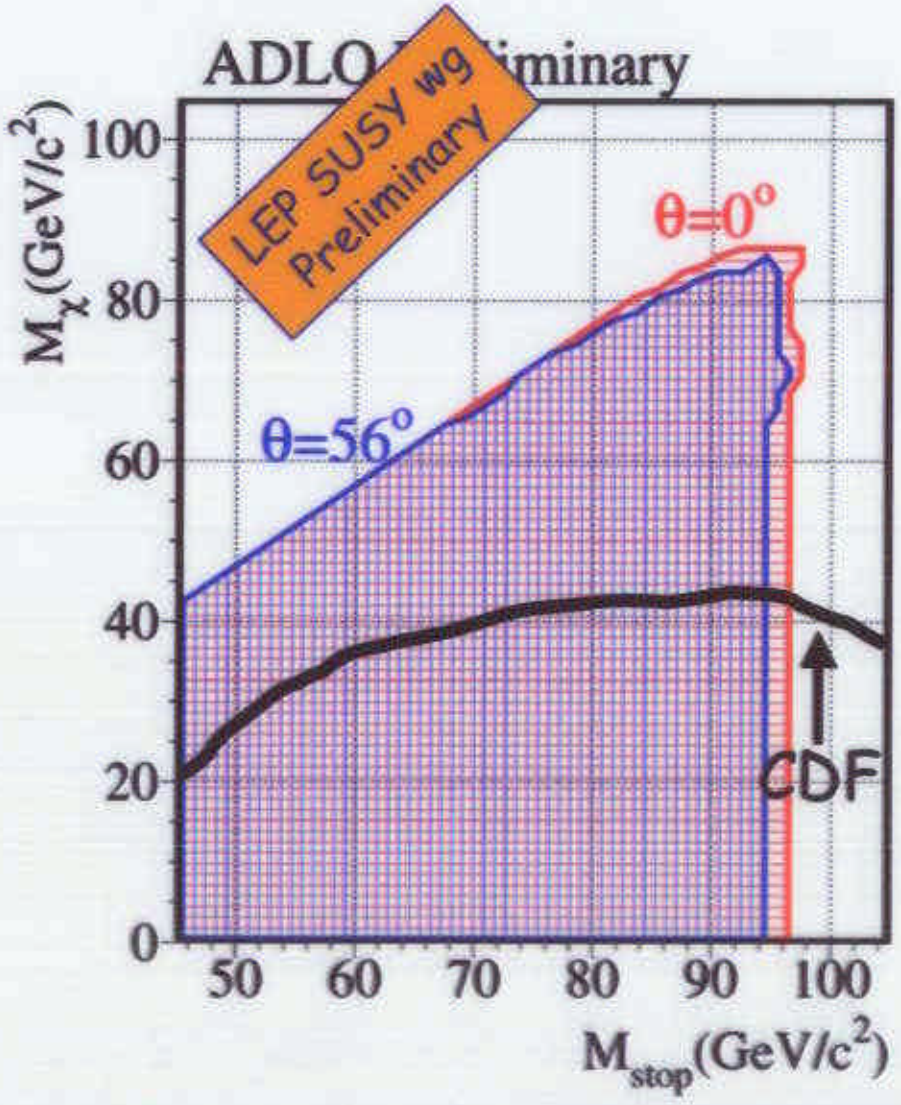
$\tilde{t} \rightarrow b l\ \nu$



2 jets + 2 leptons and missing energy

$\tilde{t}$ -> c χ results ADLO (no lifetime)





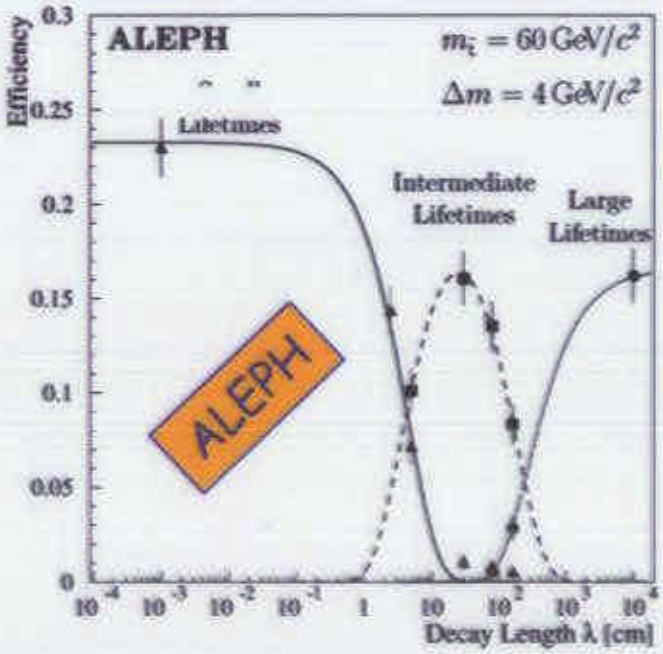
NEW: $\tilde{t}$ -> c/u χ searches at low Δm (lifetime) ALEPH

3 different topologies:

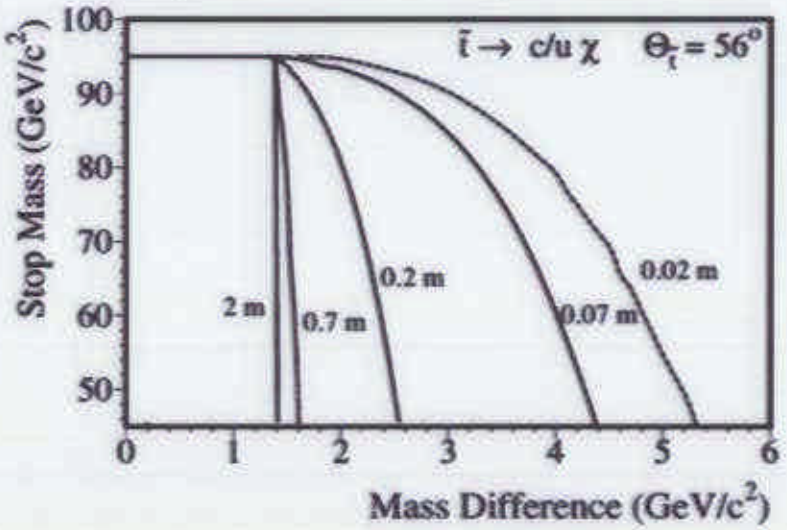
small lifetime (see previous studies)

intermediate lifetime -> tracks with IP

long lifetime -> heavy stable hadrons

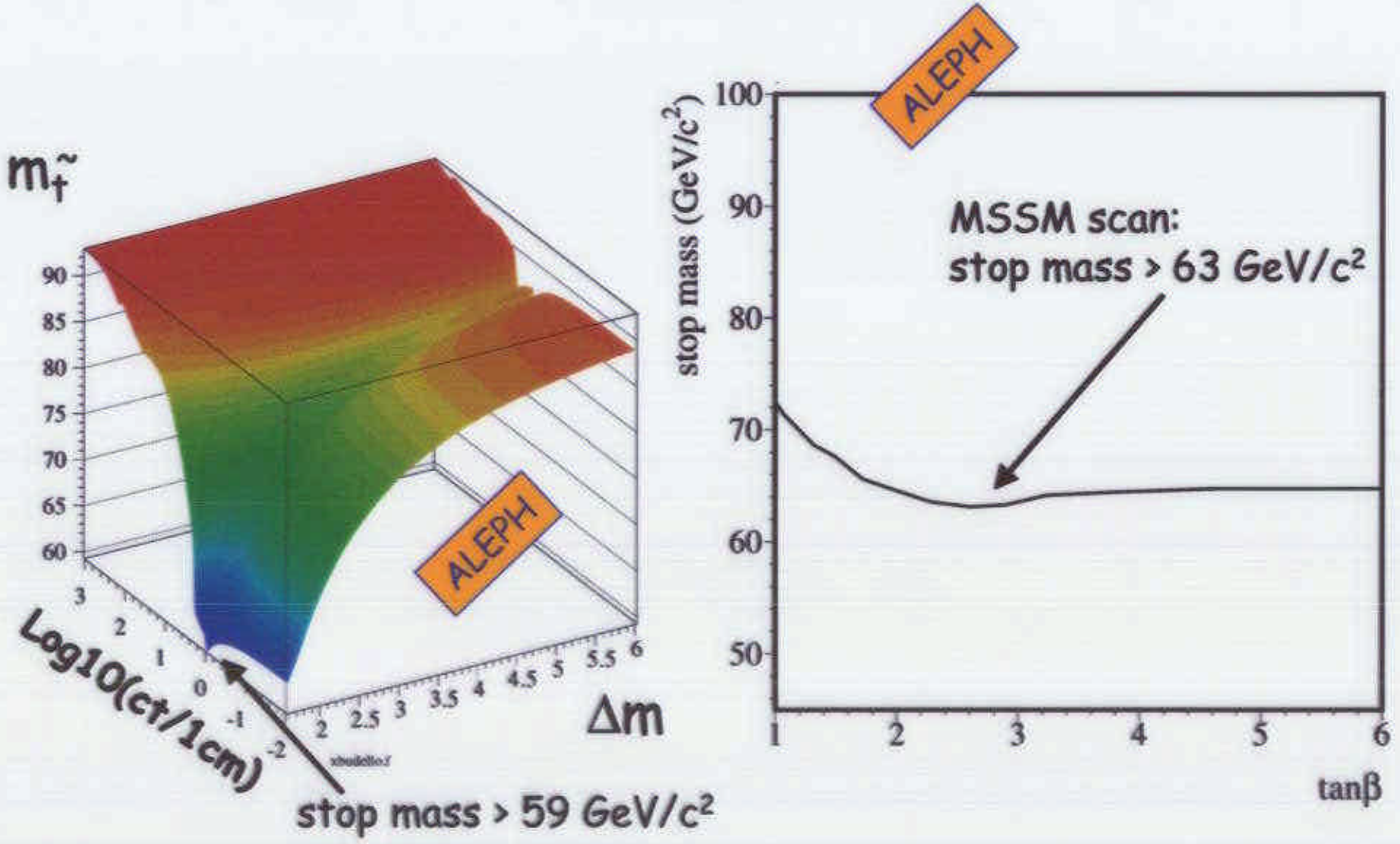


tanβ=1.5 ; θ=56° ; μ=-100 GeV

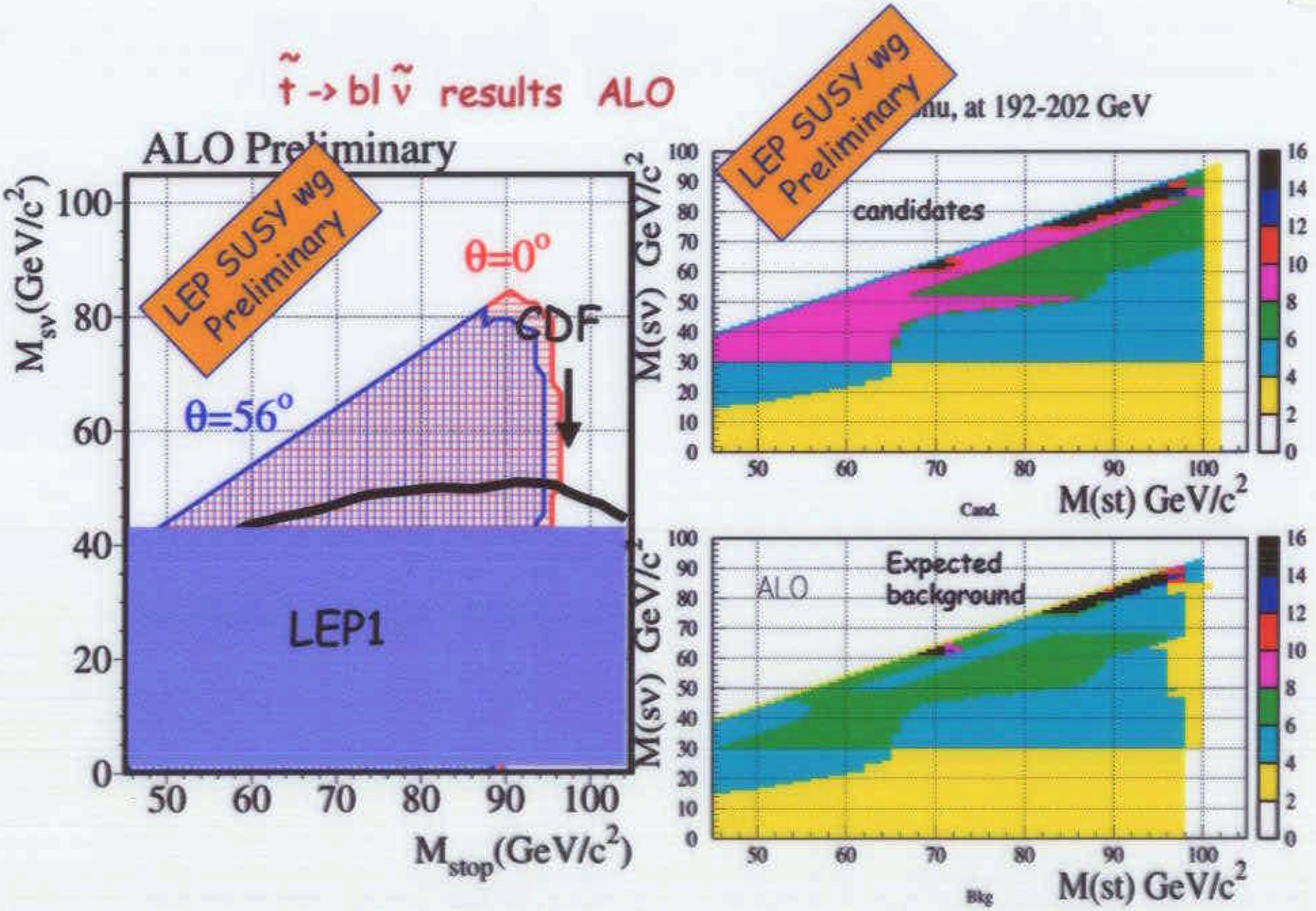


Candidates in agreement with SM expectation

$\tilde{t} \to c\,\chi$ searches at low Δm ALEPH: 189 -202 GeV



$\tilde{t} \to b l \tilde{\nu}$ results ALO



$\tilde{b} \rightarrow c\,\chi$ searches

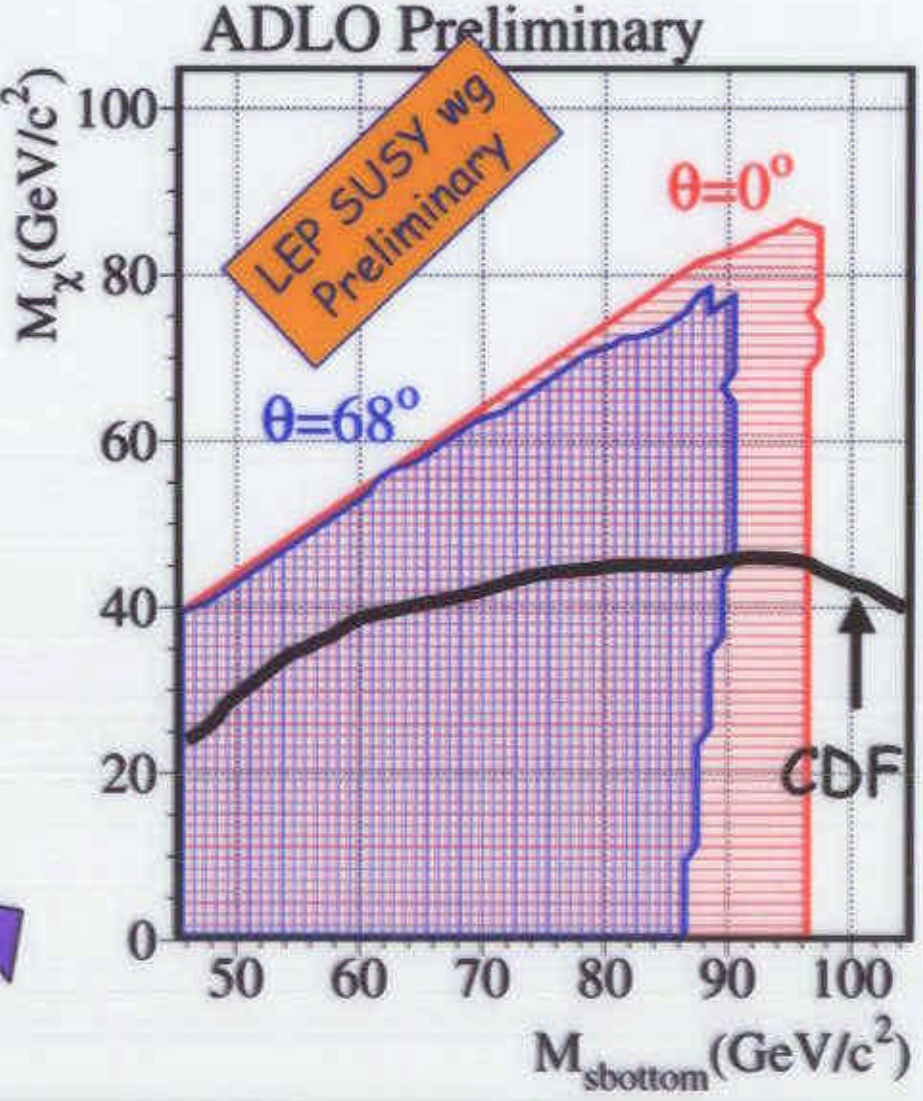
sbottom expected to be light at large tanβ (mixing)

small x-section
for Z decoupling

Topology:
2 acoplanar b-jets

Typical backgrounds:
~30-20(low-Δm) (γγ)
~15-5(high-Δm) (4-f)
Typical efficiency:
10(low-Δm)-60(high-Δm)

No-excess found



Slepton searches in MSUGRA

Decay: $\tilde{l} \rightarrow l \chi$

Signature: acoplanar leptons Background: ww-> lvlv , $\gamma\gamma$ ->ll

Typical performances at high Δm:

	Efficiency	Background
$\tilde{e}\tilde{e}$	(25-60)%	(25-140)fb
$\tilde{\mu}\tilde{\mu}$	(50-65)%	(50-140)fb
$\tilde{\tau}\tilde{\tau}$	(25-55)%	(95-190)fb

LEP SUSY wg Preliminary

Selectron searches

Final state: e^+e^- + missing energy

LEP SUSY wg Preliminary

	High ΔM		Low ΔM	
E_{cm}	N_{cand}	N_{exp}	N_{cand}	N_{exp}
183	14	17.4	2	2.3
189	56	59.2	8	6.5
192	9	10.1	2	1.8
196	34	32.4	2	5.2
200	33	31.5	7	4.9
202	13	16.1	1	2.3
all	162	166.7	22	23.0

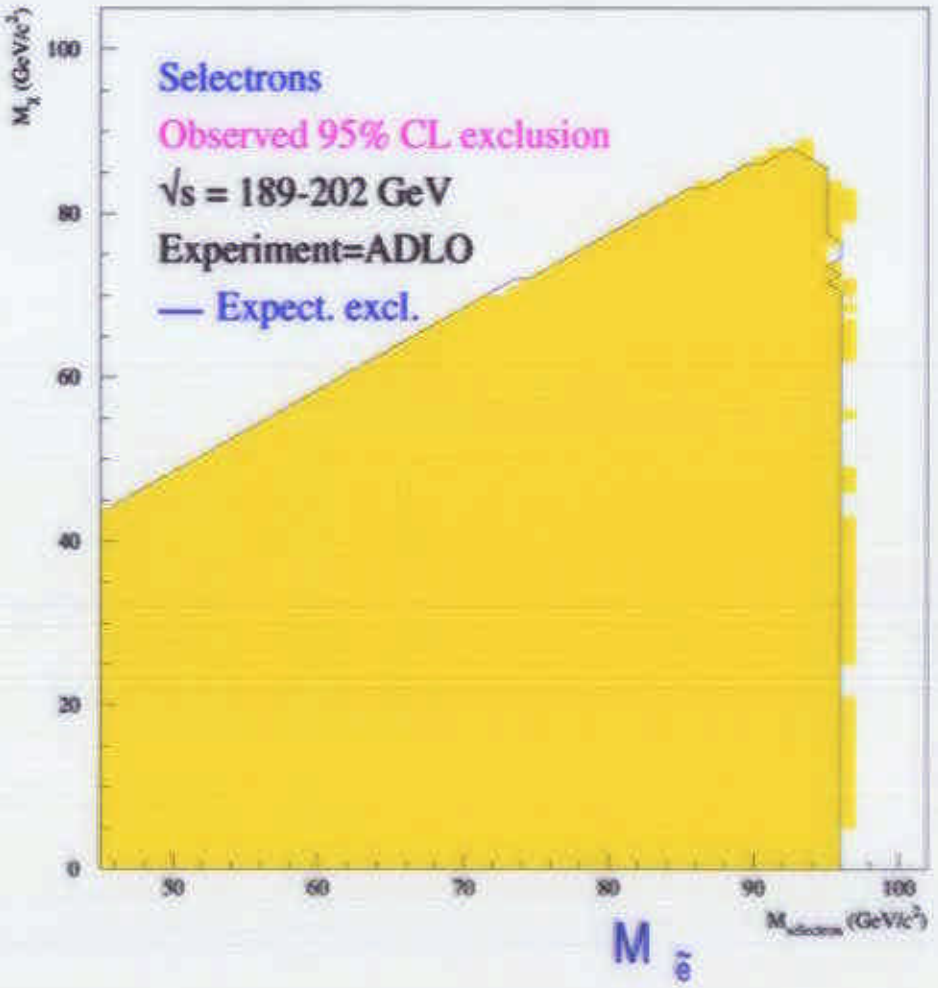
Selectron limits

ADLO: no excess
➧ set constraints

$\sigma_{ee} <\sim 0.05 \div 0.1$ pb
(@ $\sqrt{s} = 202$ GeV)

$M_{\chi_1^0}$

tanb=1.5, m=-200



$M_{\tilde{e}}$

Exclusion in the plane $(M_{\tilde{e}}, M_{\chi_1^0})$

$M_{\tilde{e}} > 95$ GeV/c²
(exp. 95 GeV/c²)
($\Delta M > 15$ GeV/c²)

(95% C.L.)

Smuon searches

LEP SUSY wg Preliminary

Final state: $\mu^+\mu^-$ + missing energy

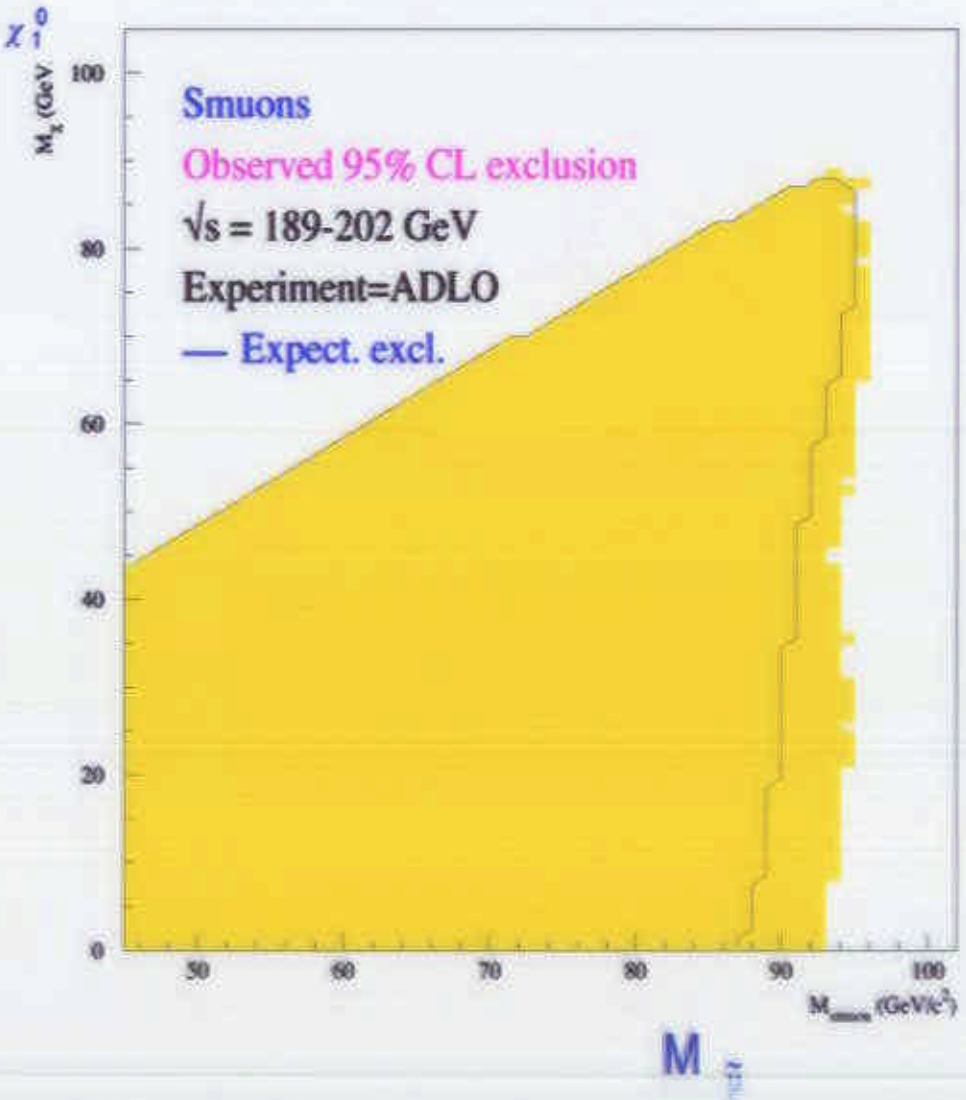
	High ΔM		Low ΔM	
E_{cm}	N_{cand}	N_{exp}	N_{cand}	N_{exp}
183	20	13.2	1	3.4
189	29	34.6	10	13.2
192	9	10.6	2	2.0
196	26	28.1	5	5.3
200	24	29.3	8	5.5
202	10	14.7	3	2.6
all	118	130.5	29	32.0

Smuon limits

ADLO: no excess
➧ set constraints

$\sigma_{\mu\mu} <\sim 0.25 \div 0.05$ pb
(@ $\sqrt{s}$=202 GeV)

tanb=1.5, m=-200



Exclusion in the plane $(M_{\tilde{\mu}}, M_{\chi_1^0})$

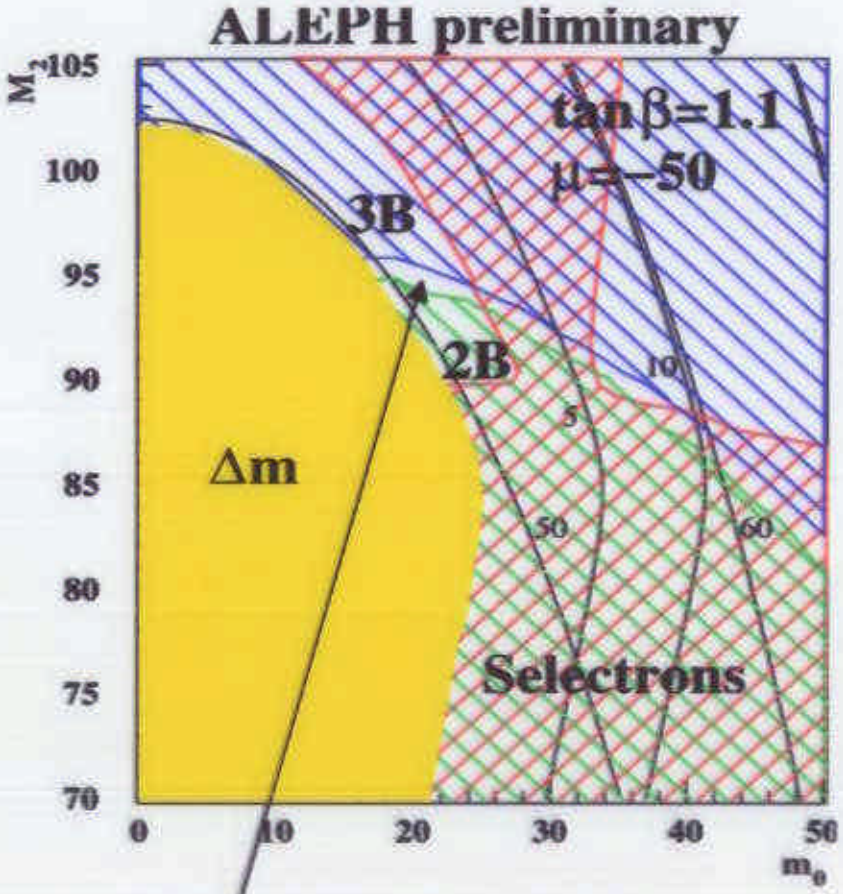
$M_{\tilde{\mu}} > 92$ GeV/c

(exp. 88 GeV/c²)

($\Delta M > 15$ GeV/c²)

(95% C.L.)

Absolute limit on slepton mass



$\chi^{\pm}\ \tilde{\nu}$ ~ mass degenerate

General problem: $m_{\tilde{l}} > m_{\chi 2} > m_{\chi 1}$
-> slepton cascade decays

Partially covered by chargino searches: $\chi, \tilde{\nu}$ LSP

some region not excluded

Absolute limit on slepton mass

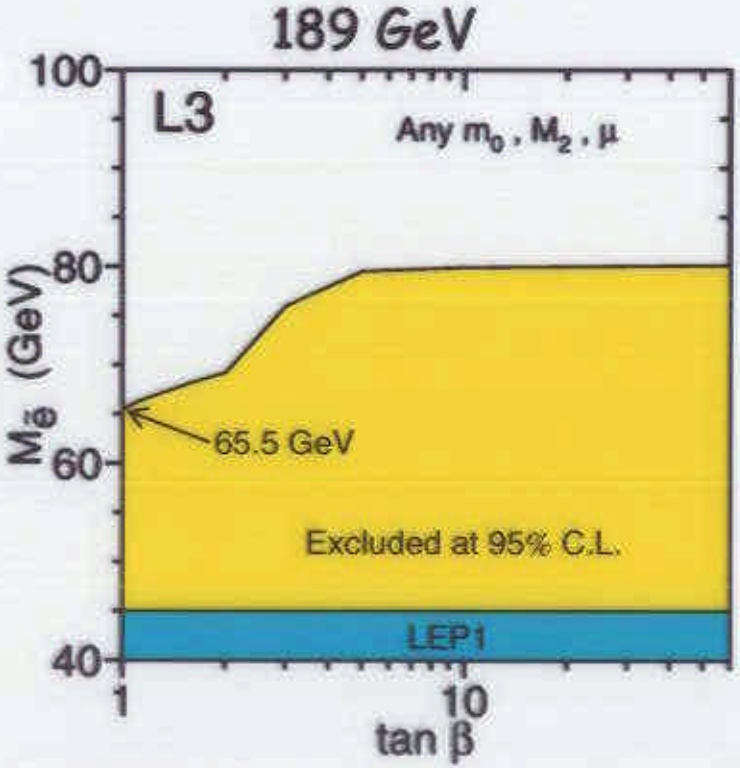
Use production of:

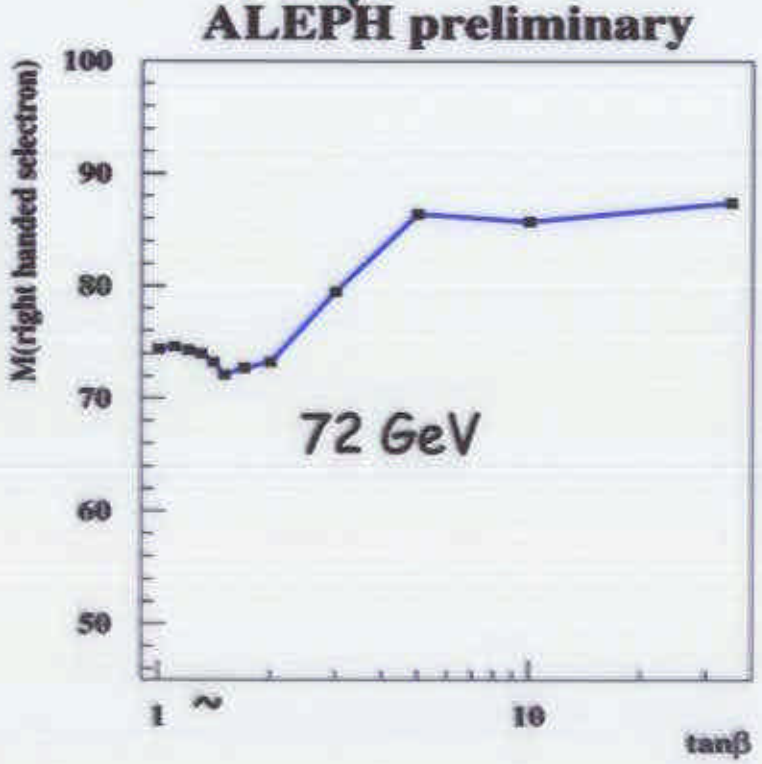
$\tilde{\nu}\tilde{\nu} \rightarrow \chi^2\chi^1\nu\nu \rightarrow ll\chi^1\chi^1\nu\nu$ (acop lep.)

$\tilde{e}\tilde{e} \rightarrow \chi^2\chi^2 ee \rightarrow \tilde{g}ee\gamma\gamma\chi^1\chi^1$ (acop. e +γ)

$\chi^1\chi^3 \rightarrow (\chi^3 \rightarrow l\,l \rightarrow l\chi^1)$ (single lep.)

no excess





Stau searches

LEP SUSY wg Preliminary

Final state: $\tau^+\tau^-$ + missing energy

	High ΔM		Low ΔM	
E_{cm}	N_{cand}	N_{exp}	N_{cand}	N_{exp}
183	21	29.9	7	5.2
189	113	96.4	9	11.4
192	26	17.1	12	15.5
196	62	43.7	43	39.8
200	50	42.3	45	37.8
202	17	21.9	16	17.3
183-202	289	251.7	132	127.0
189-202	268	221.8	125	121.8

If threshold > 183 GeV:

$\Delta N = 46.2$ => + ~20%

=>Poisson prob $\{N \geq N_{cand}; N_{exp}\} = 0.15\%$

Statistical errors only!

More on staus

- Observed by the 4 experiments

	ALEPH	DELPHI	L3	OPAL
N_{cand}	50	82	70	66
N_{exp}	40.0	71.4	54.7	57.7
Prob	7.0%	11.7%	2.6%	15.2%

(numbers @189-202 GeV)

- Background estimation:

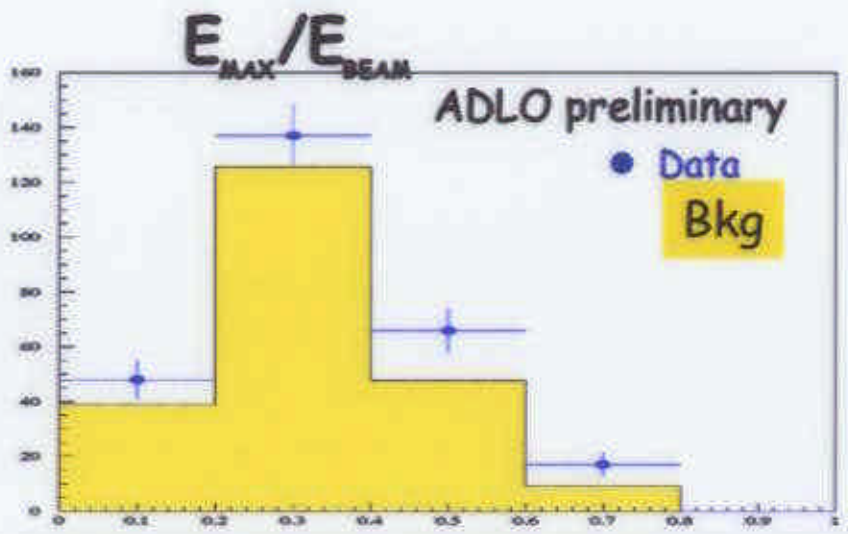
Composition at high ΔM =>

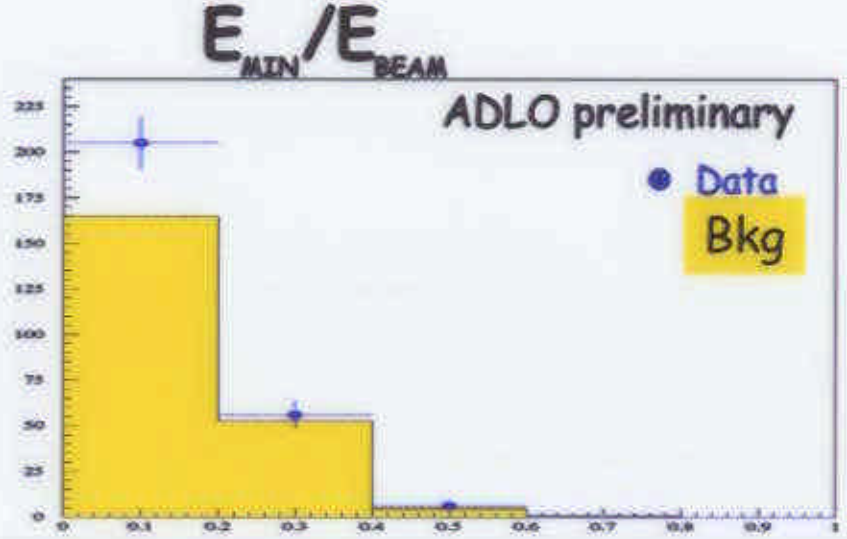
$W^+W^- \to l^+l^-\nu\nu$	80%
$\gamma\gamma \to l^+l^-$	12%
$\gamma\gamma \to$ hadrons	2%
$\tau\tau(\gamma)$	5%
Other 2 fermions	1%

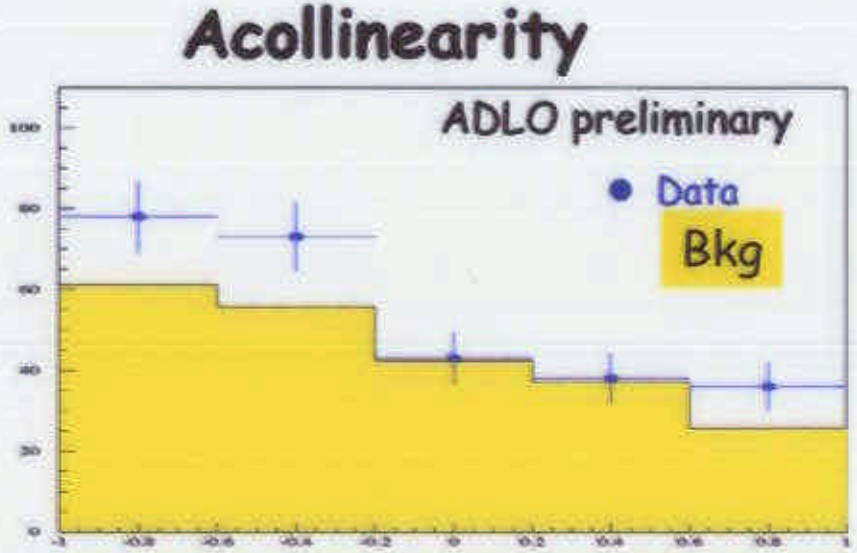
From a detailed study of systematic effects

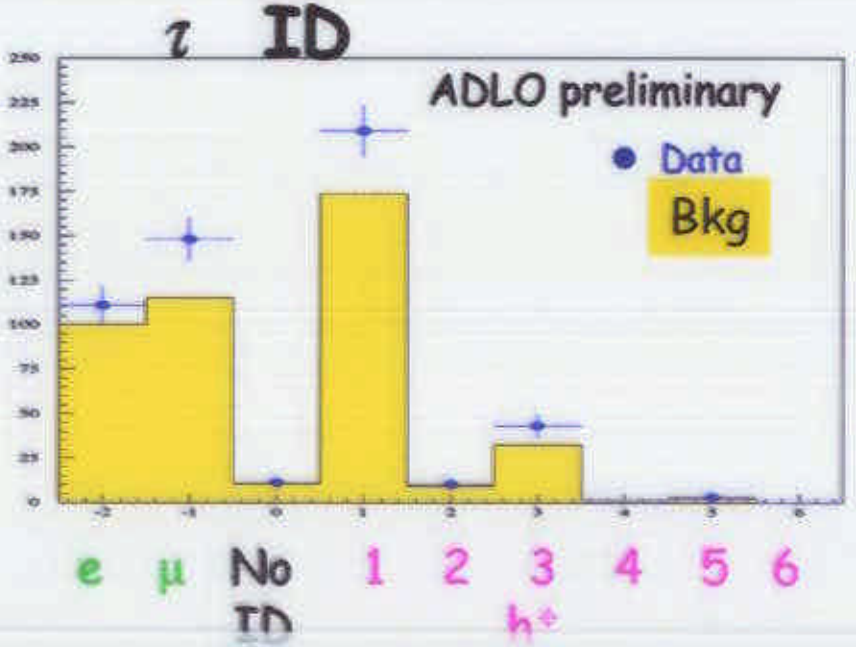
- total combined systematics ~ 2.5% to 3%
- unlikely to explain the excess of ~20%

Staus: Some distributions (ADLO)



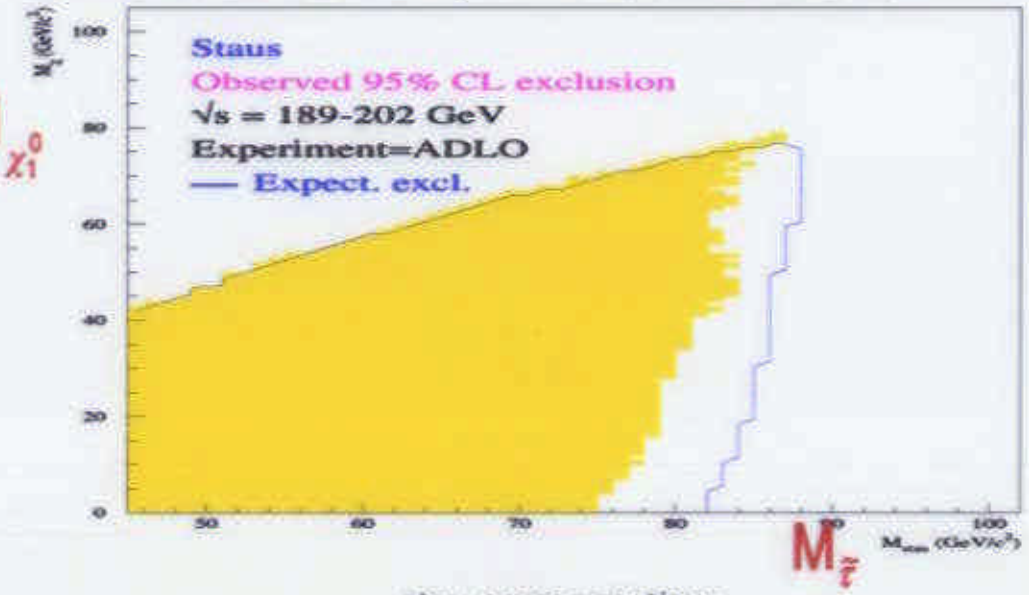




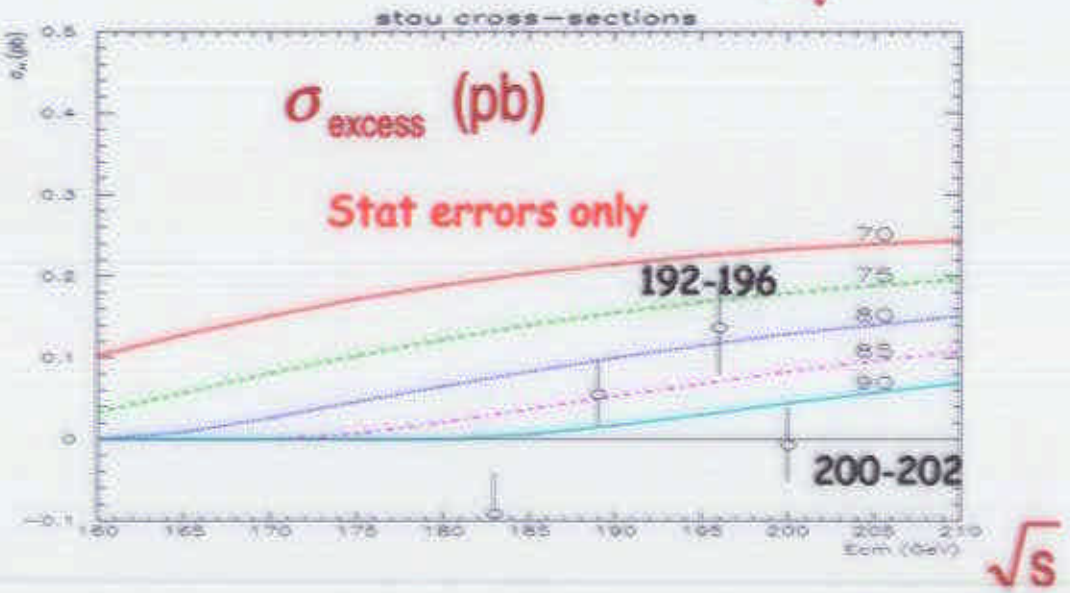


Staus: exclusion and "measurement"

Assuming a statistical fluctuation, the mass limit can be derived ...



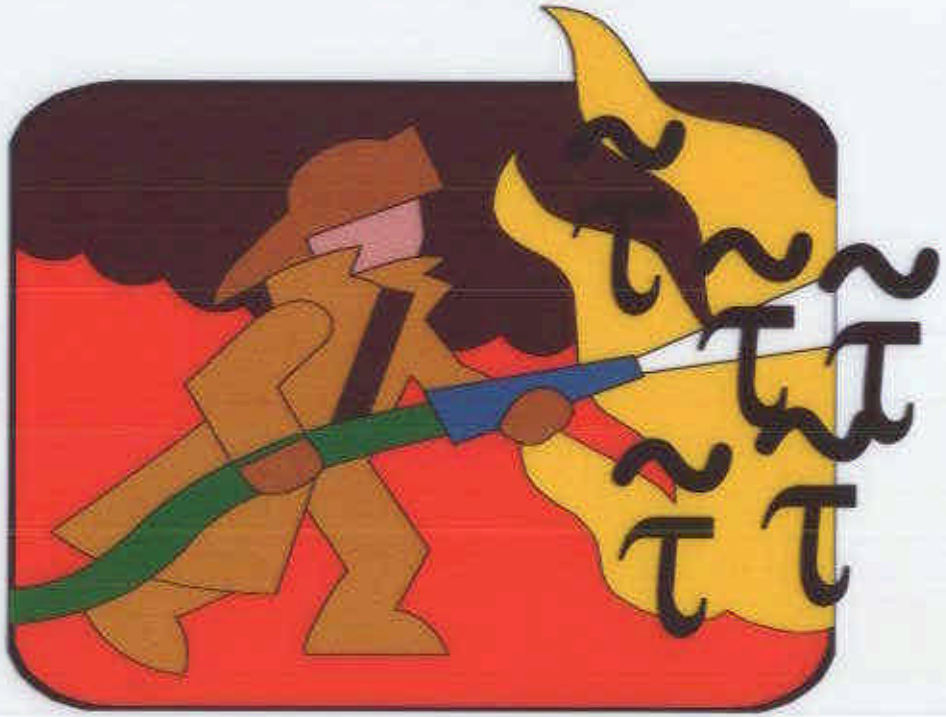
... or the cross section for the excess can be measured



Curves are $\sigma_{\tilde{\tau}_R\tilde{\tau}_R}$ for different stau masses

Staus: future

- future is ..... $\sqrt{s}$>202 GeV



tomorrows talk: M. Maggi

Conclusions

- Sfermions thoroughly searched for with the 1.6 fb^{-1} luminosity collected at LEP at $E_{cm} < 202$ GeV
- Numbers and properties of the events selected generally in agreement with expectation
- Strong constraints in the space of the MSSM parameters are derived
- An anomaly is observed in the acoplanar tau channel, whose statistical significance is of the order of %; more data already available..... please came to the tomorrows talk