



DELPHI Y2K PHYSICS

- Searches Updates -

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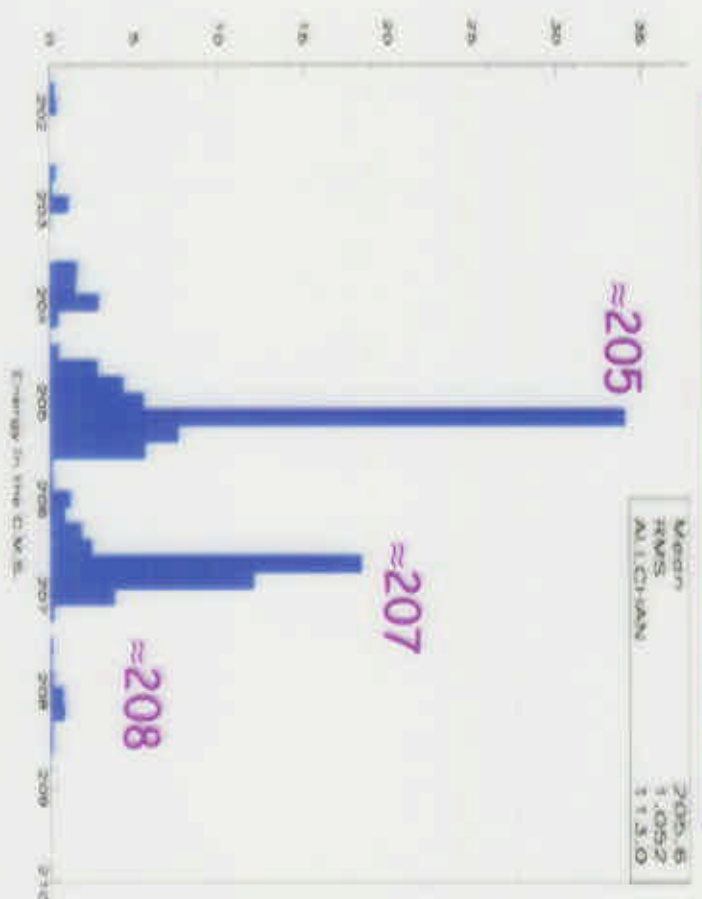
LEP & DELPHI

- LEP: a very special year



\sqrt{s} miniramps

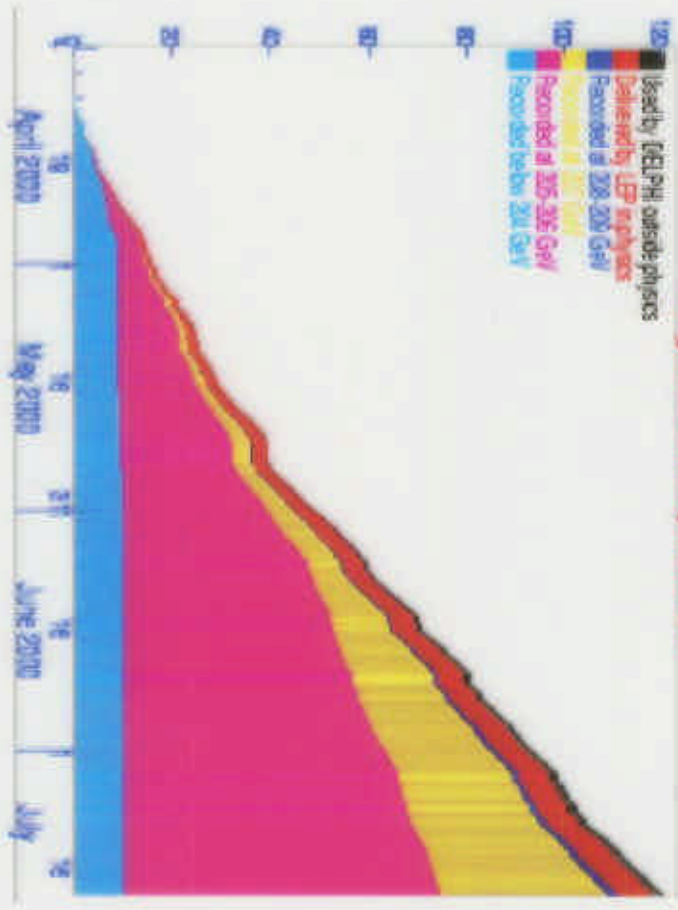
$$\sqrt{s} = 200-209 \text{ GeV}$$



- DELPHI: a successful running

$$\begin{aligned} &\bullet 93\% \text{ efficiency} \\ &\bullet L \approx 120 \text{ pb}^{-1} \end{aligned}$$

Integrated Luminosity in DELPHI



Used by DELPHI outside physics
 Delivered by LEP engineers
 Recorded at 208, 200 GeV
 Recorded at 205, 206 GeV
 Recorded below 204 GeV

... This is the first look at the Y2K data

... We try to look everywhere!

Model independent (topologies)

Systematic exploration of model(s)

some "golden" topologies:

- acoplanar jets and leptons → susy
- 4 jets → Higgs
- photons only → gmsb and ...

What did we gain this year?

- Energy! → Threshold channels
- Phase-space and cross-section...?
- Statistics! → Lum

-
- do we understand the data?
 - any hints of New Physics?



DELPHI Y2K UPDATES

SUSY:

- Sparticles
 - gauginos $\tilde{\chi}^0, \tilde{\chi}^\pm, \tilde{g}$
 - sleptons $\tilde{e}, \tilde{\mu}, \tilde{\tau}$
 - squarks $\tilde{b}, \tilde{t}, \tilde{f}$
- Scenarios:
 - MSUGRA
 - GMSB
 - RPV

EXOTICS:

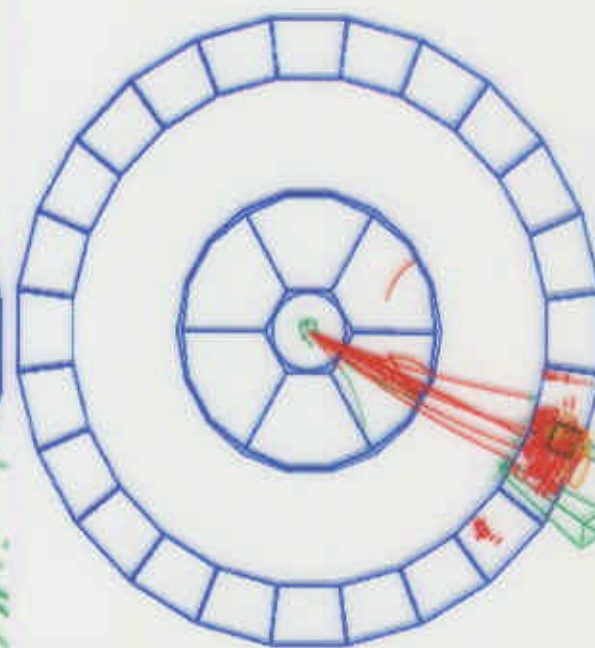
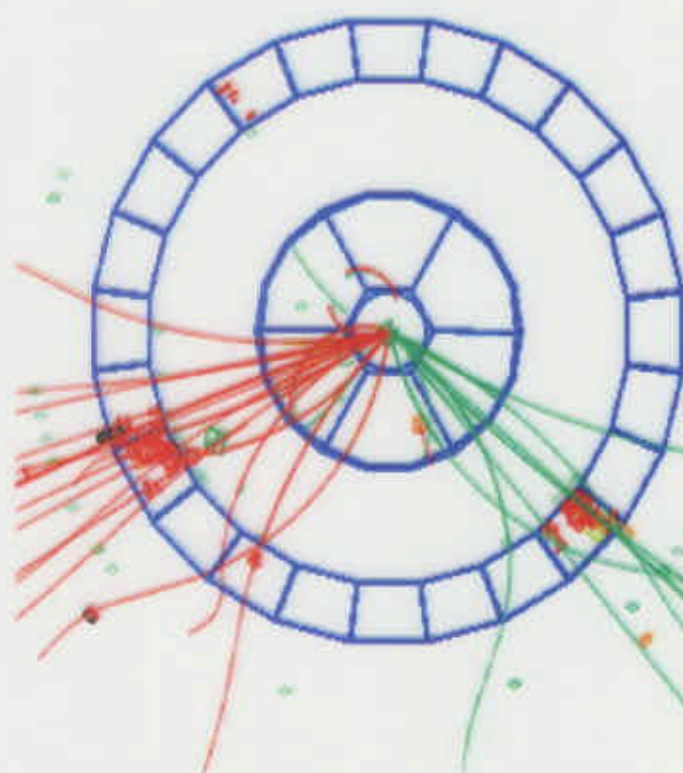
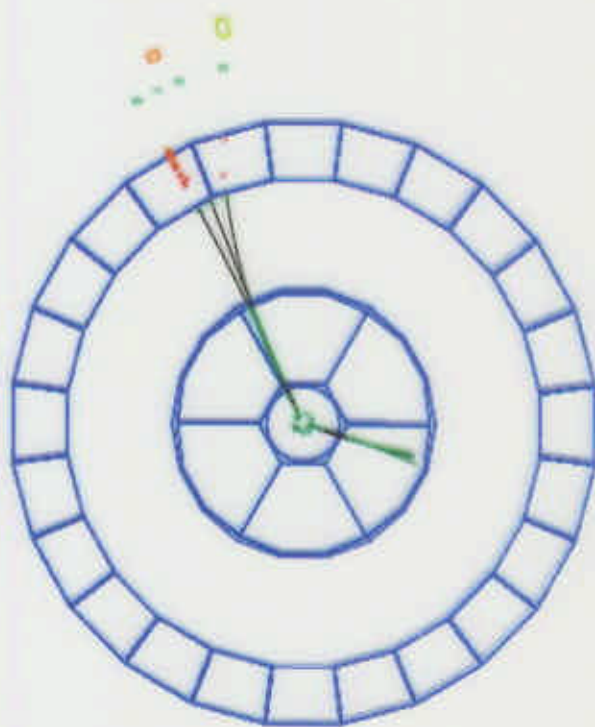
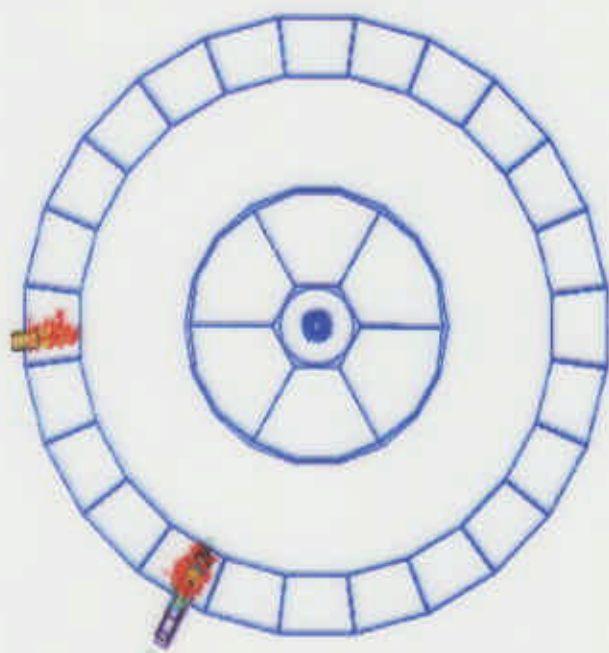
- Excited leptons
 - direct & indirect
- Technicolor
- FCNC

HIGGS:

- Invisible
- $H \rightarrow \gamma\gamma$
- SM Higgs
- MSSM Higgs
 - neutral & charged

- Lum $\approx 90\text{-}100 \text{ pb}^{-1}$
- All results are preliminary
- All limits are 95% CL

У 7 + 0 3 3 У 5 7 0 8 8 5



SUPERSYMMETRY

- Many searches, scenarios and parameters...
- Current assumptions in the analyses:

all

- minimal particle content (MSSM)
- soft Susy breaking

many

- R parity conservation $R_p = (-1)^{3B-L+2S}$
- gravity or gauge mediated susy breaking
- gaugino mass unification $M_1 = \frac{5}{3} \tan^2 \theta_w M_2 \approx 0.5 M_2$
- assumptions on scalar masses

some

- GUT scale Unification $m_0, m_{1/2}, A_0, \tan \beta, \text{sign}(\mu)$

Charginos

- Prod:



- negative interference
- is $\tilde{\nu}$ light?

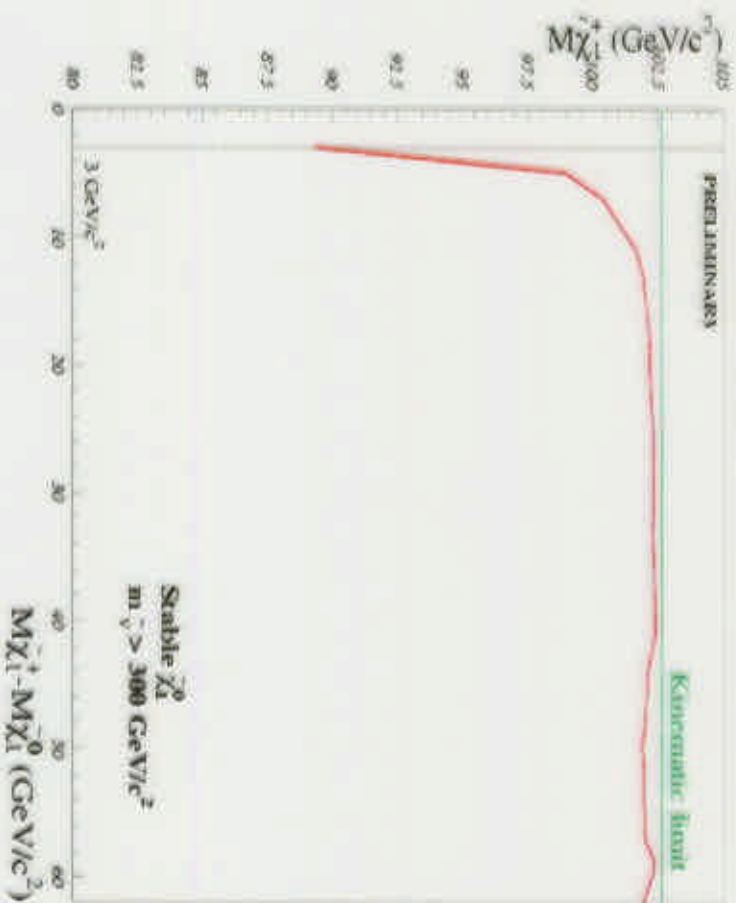
- Decay: $\tilde{\chi}_1^\pm \rightarrow \tilde{\chi}_1^0 jj, \tilde{\chi}_1^0 \ell \nu$

- leptonic BR enhanced if sleptons light
- cascades $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 \gamma$

- Mass difference:

$$\Delta M = M_{\tilde{\chi}_2^\pm} - M_{\tilde{\chi}_1^0}$$

DELPHI $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ limits at 205.32 GeV



ΔM	$M_{\tilde{\nu}}^{\min}$	$M_{\tilde{\chi}_1^\pm}^{95}$	σ^{\max}
20	300	101.8	0.28
3	$M_{\tilde{\chi}_1^\pm}$	89.3	1.80

Neutralinos

- Prod:

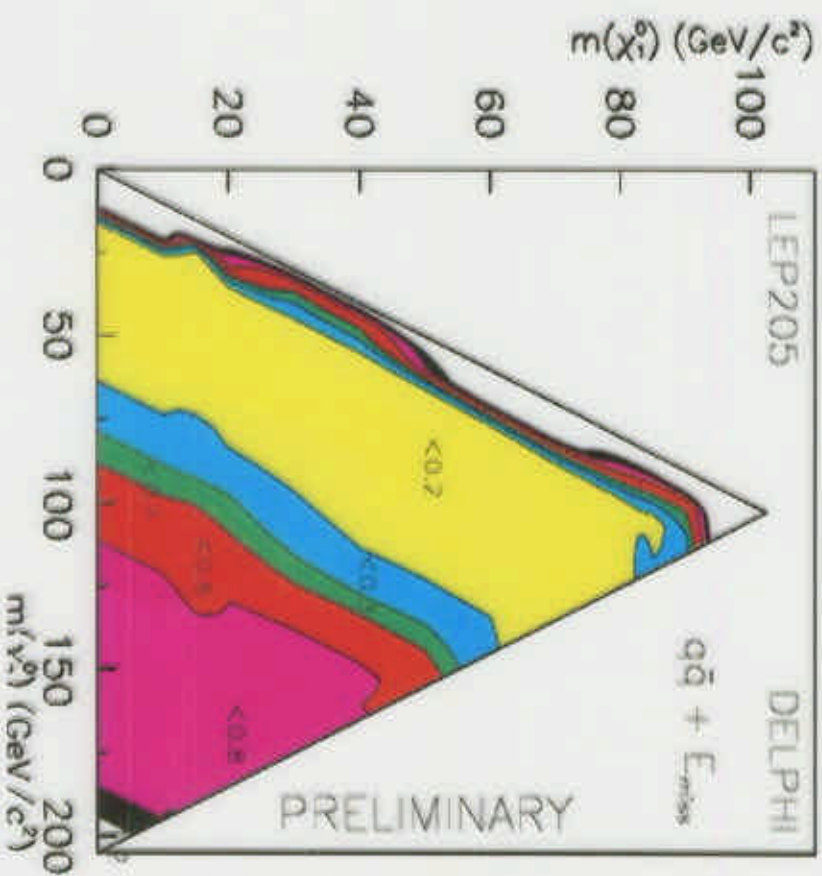


- positive interference
- is \tilde{e} light?

- topologies: $jj, ee, \mu\mu$
- eff depend on ΔM
- Cross-section limits
 $0.1 - 0.8 \text{ pb}^{-1}$

...combination with previous data
implies further assumptions

Topology	Data	MC
jj	24	29.1
ee	26	27.7
$\mu\mu$	28	23.0



Global Msugra exclusions

- Combining searches for:

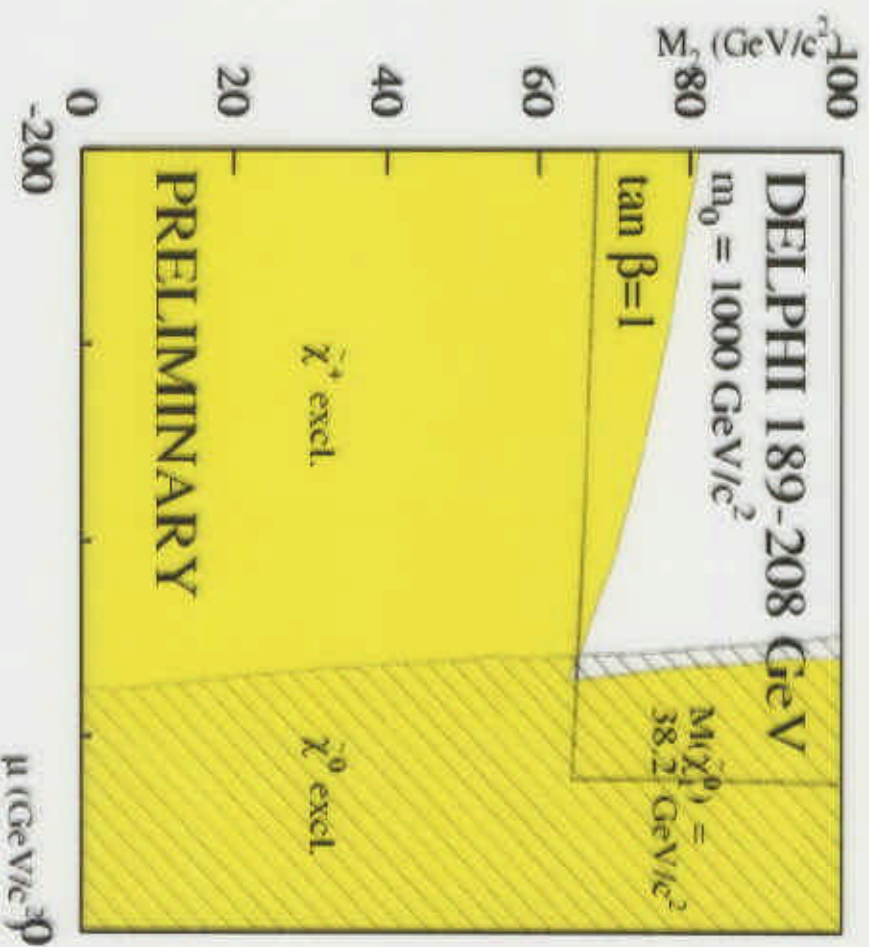
- Charginos
- Sleptons
- Neutralinos^(*)

we can constrain:

- (M_2, μ) plane regions
- smasses (M_{LSP})



- high m_0 :
 $M_{LSP} > 38.2 \text{ GeV}/c^2$
(at $\tan \beta = 1$)



^(*) Cascades are crucial:

$$e^+ e^- \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_3^0, \tilde{\chi}_2^0 \tilde{\chi}_4^0$$

topologies:

jj, ee, $\mu\mu$, multijets, multileptons,
tau cascades, low E_τ

Selectrons & Smuons

- Prod:



- Decay: $\tilde{\ell} \rightarrow \ell \chi_1^0, \ell \chi_2^0$

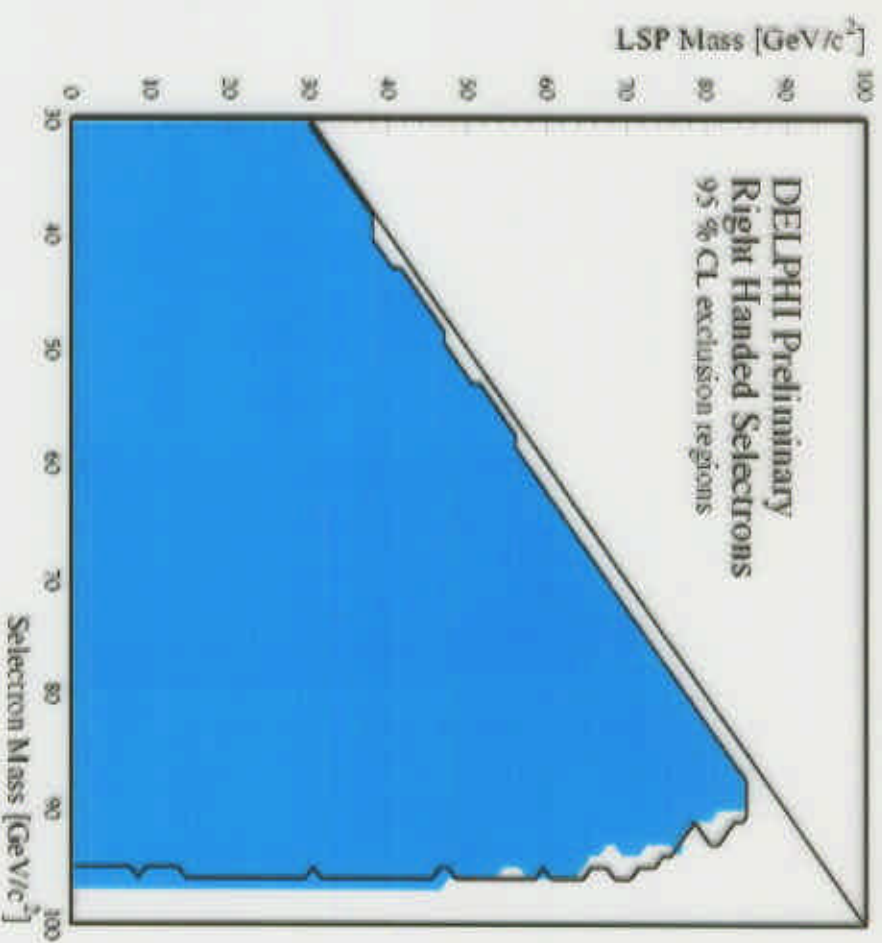
- Mass difference:

$$\Delta M = M_{\tilde{\ell}} - M_{LSP}$$

- $\mu = -200$, $\tan \beta = 1.5$:
- \tilde{e} cross-section
- BR's

Slepton | Data | MC |

\tilde{e}	22	23
$\tilde{\mu}$	4	7.5



$$M_{\tilde{e}} > 90 \text{ GeV}/c^2$$

$$M_{\tilde{\mu}} > 89 \text{ GeV}/c^2$$

(...If $\Delta M > 5 \text{ GeV}/c^2$)

Staus

- 3rd family mixing

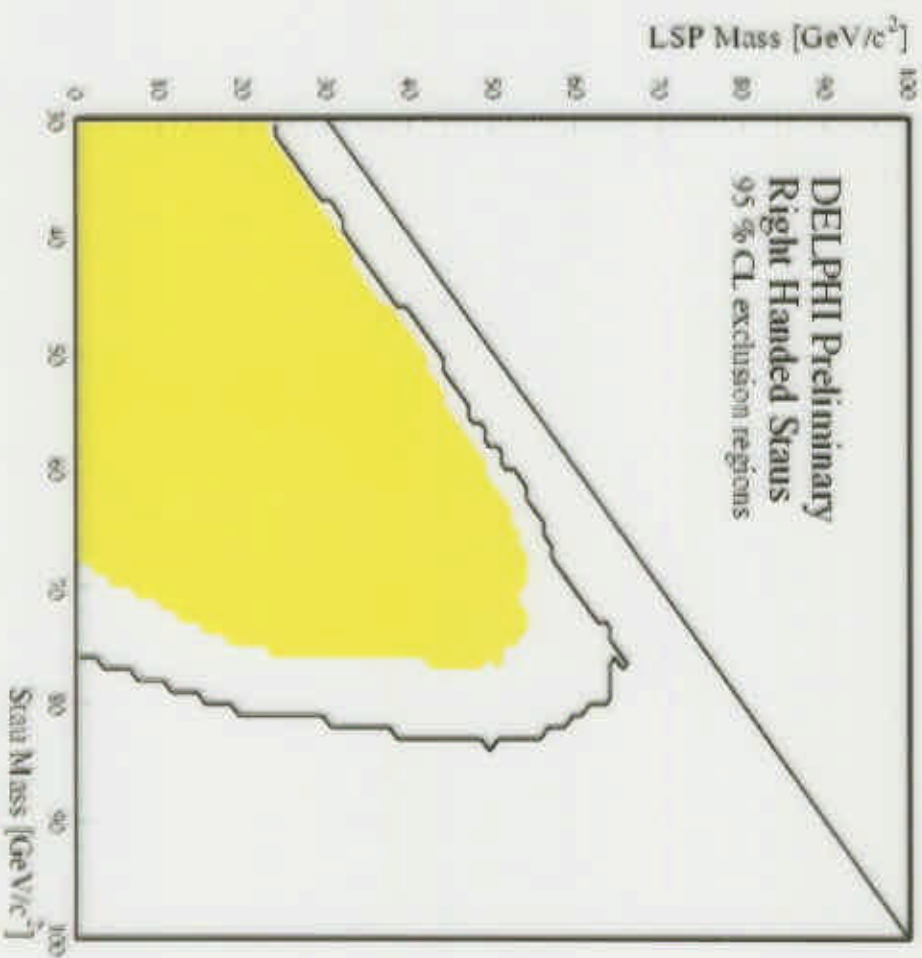


- Lightest states could be

$L^{\text{Charged}}SP$

- 2 scenarios:
 - no mixing $\theta=0$
 - minimal cross-section
- 2 analyses (cross-check)
- the backgrounds:
 - low ΔM : " $\gamma\gamma$ "-collisions
 - high ΔM : leptonic WW

Data | MC |
18 19.7



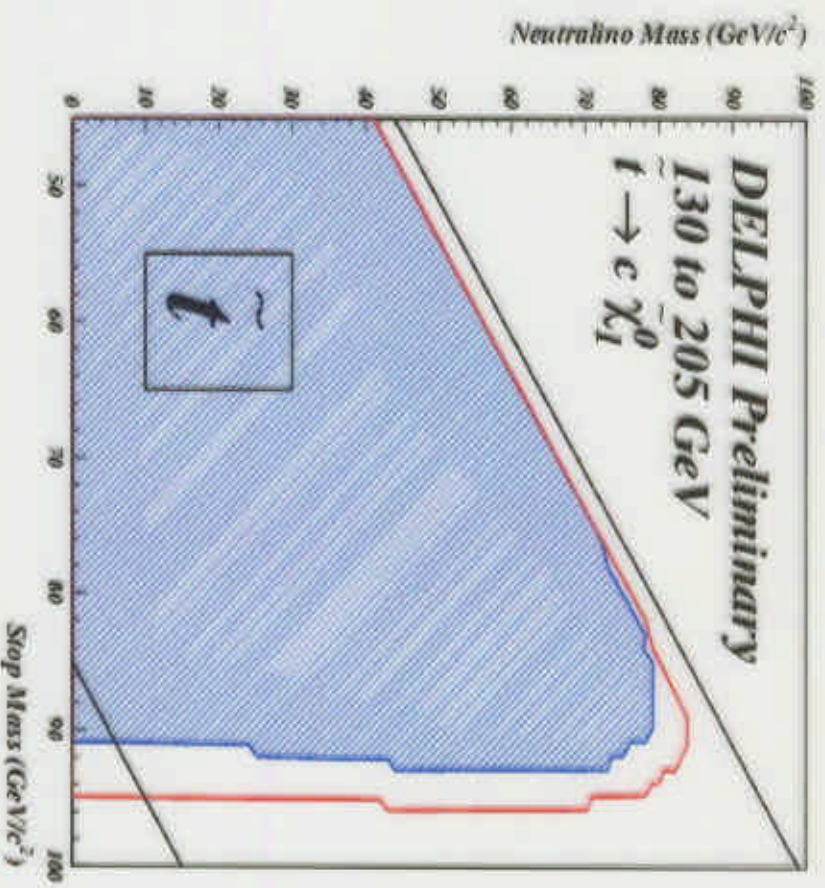
Squararks

- Mixing \Rightarrow possible light states
- topology: 2jets+Emiss
- $\tilde{b} \rightarrow b\tilde{\chi}_1^0$ b-tag
- $\tilde{f} \rightarrow c\tilde{\chi}_1^0$ \tilde{f} hadronization

Squark | Data | MC |

\tilde{b}	4	3.8±0.4
\tilde{f}	6	5.3±0.4

$$\Delta M = M_{\tilde{q}} - M_{LSP}$$



• Mass limits for $\Delta M > 15 \text{ GeV}/c^2$

Squark | $\theta=0$ | θ_{min} |

\tilde{b}	96	83
\tilde{f}	95	91

Other scenarios considered...

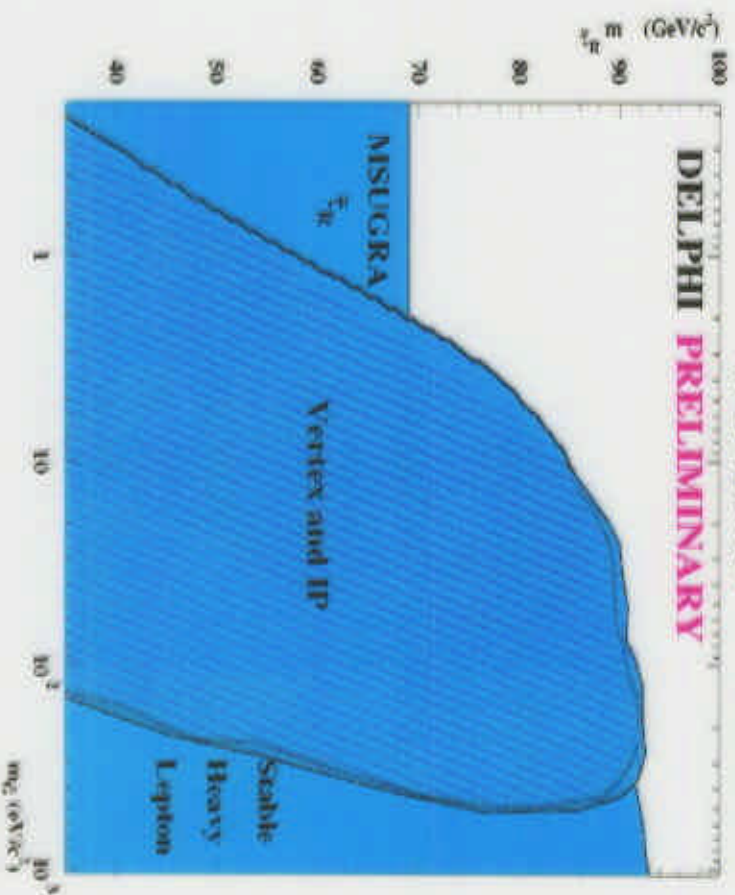
- **GMSB** $\tilde{\tau} \rightarrow \tau \tilde{G}$

- signature depends on decay length \rightarrow \tilde{G} mass

$$M_{\tilde{G}} \in [10, 100] \text{ eV}/c^2$$

$\sqrt{s} = 130\text{-}208 \text{ GeV}$

Kink or displaced vertex



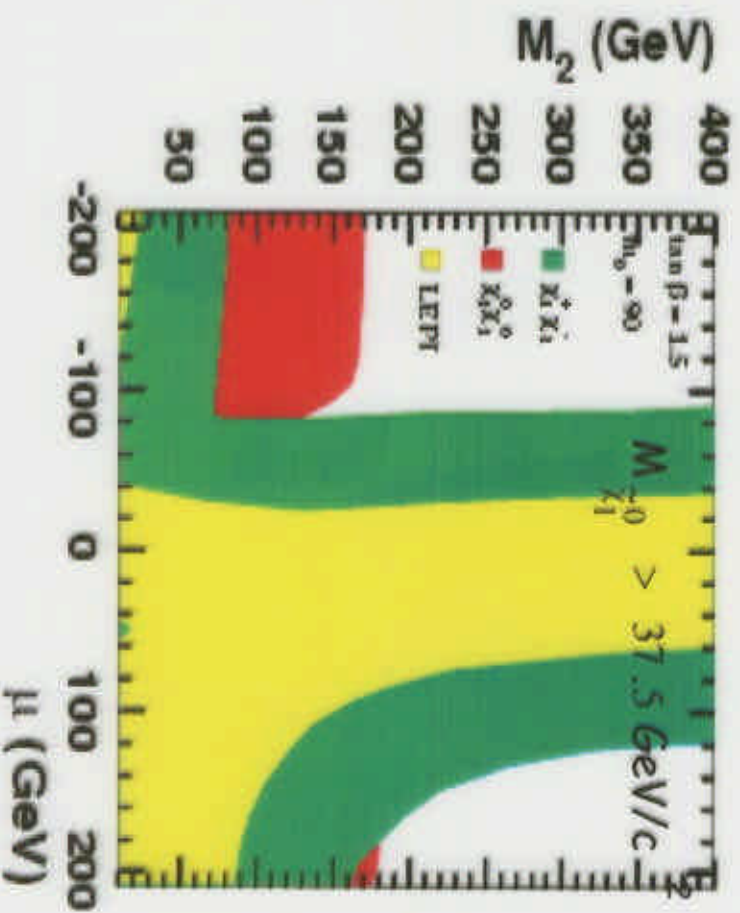
- **R-parity violation**

- UDD term

$$\tilde{\chi}_1^0 \rightarrow \tilde{q}^* q \rightarrow qqq$$

- Signatures of χ pair production:

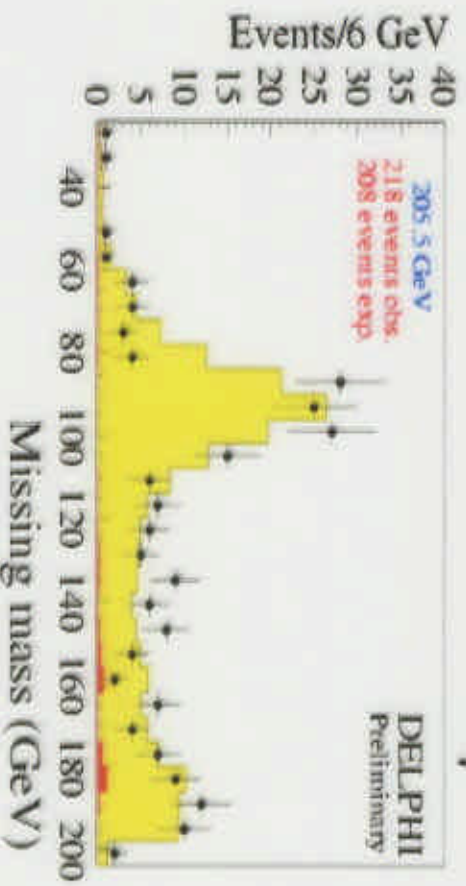
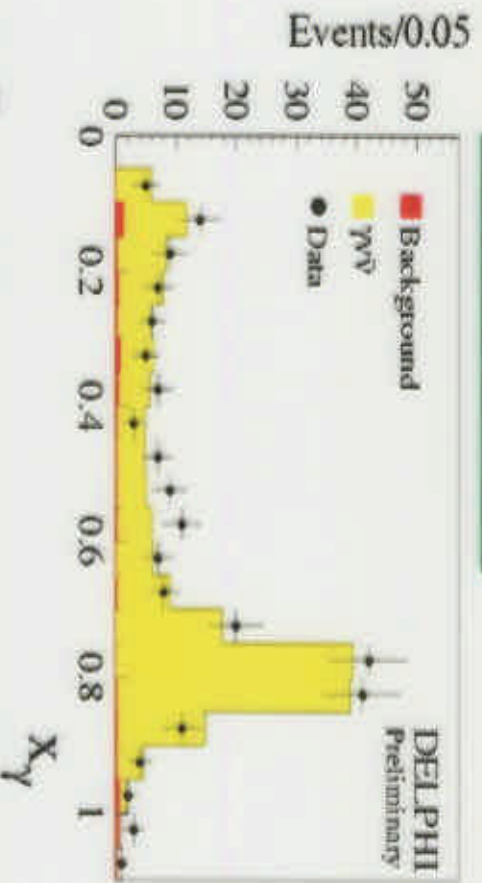
6 to 10 jets



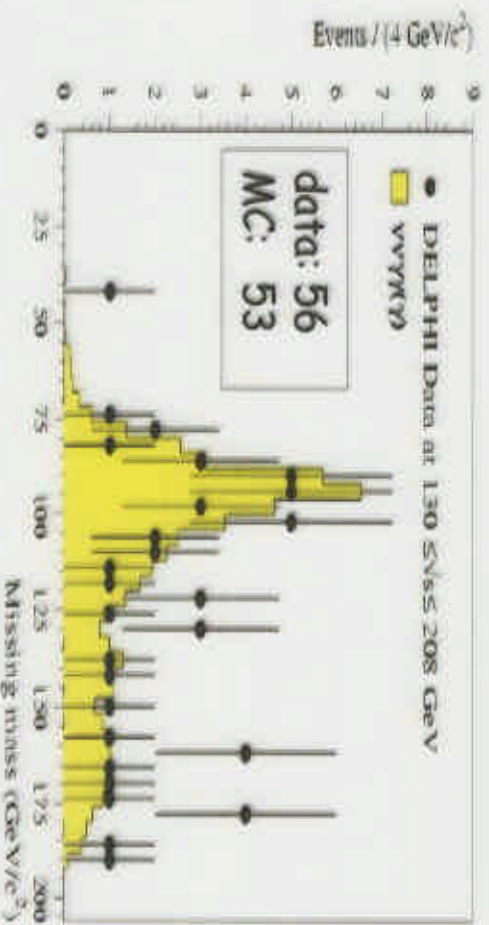
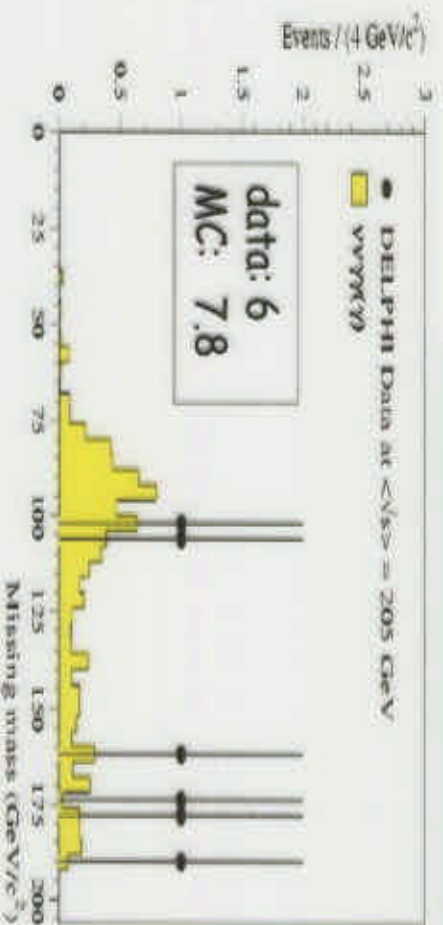
Photons only

- A clear signature in many models...
(msugra, GMSB, graviton prod)

single photon



2 acoplanar photons



Monojets

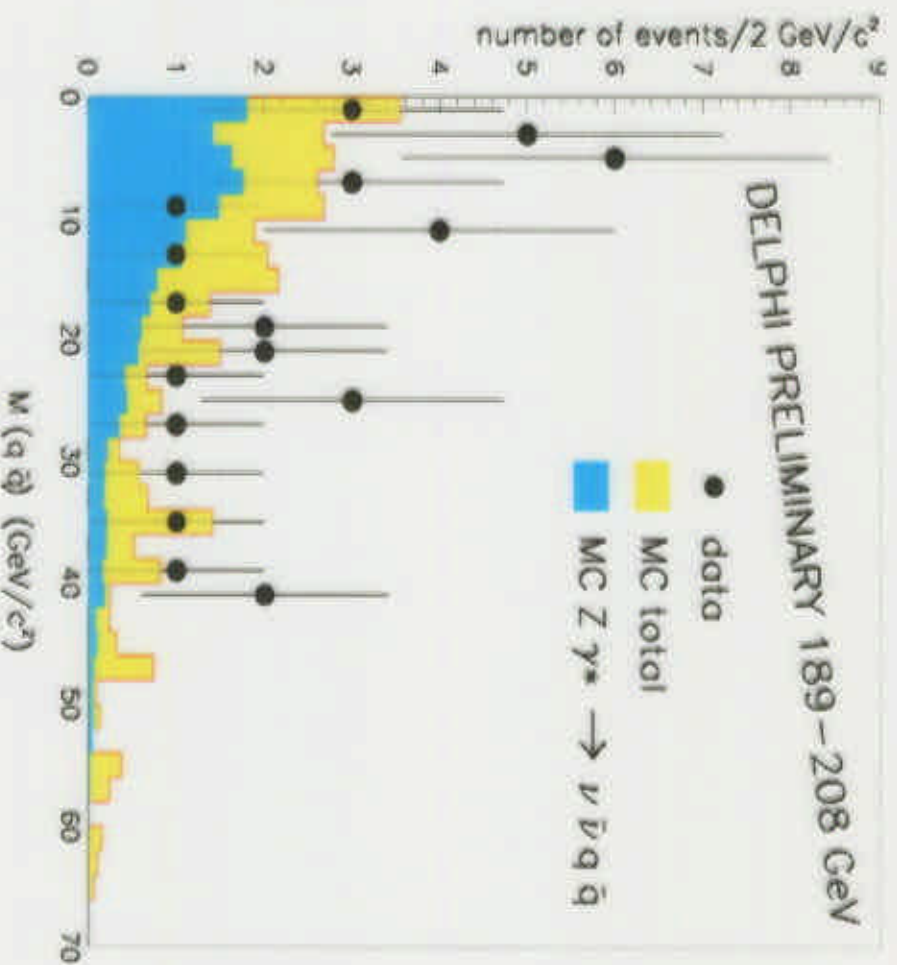
- A clear signature in many (susy) scenarios...

- In the SM:

$$e^+e^- \rightarrow Z\gamma^* \rightarrow q\bar{q}\nu\bar{\nu}$$

Data | MC |

9 8.2



$$\sigma(Z\gamma^* \rightarrow q\bar{q}\nu\bar{\nu}) = 0.190 \pm 0.058 \text{ (stat)} \pm 0.024 \text{ (syst)} \text{ pb}$$

EXOTIC SEARCHES

Excited leptons

- single production

$$e^+e^- \rightarrow \ell\ell^*$$

- decay

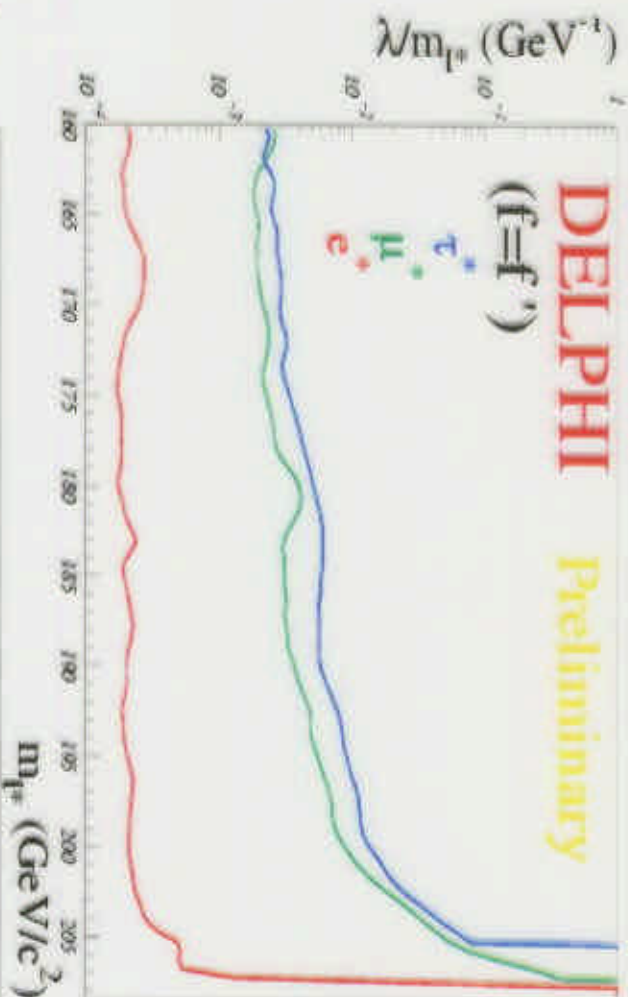
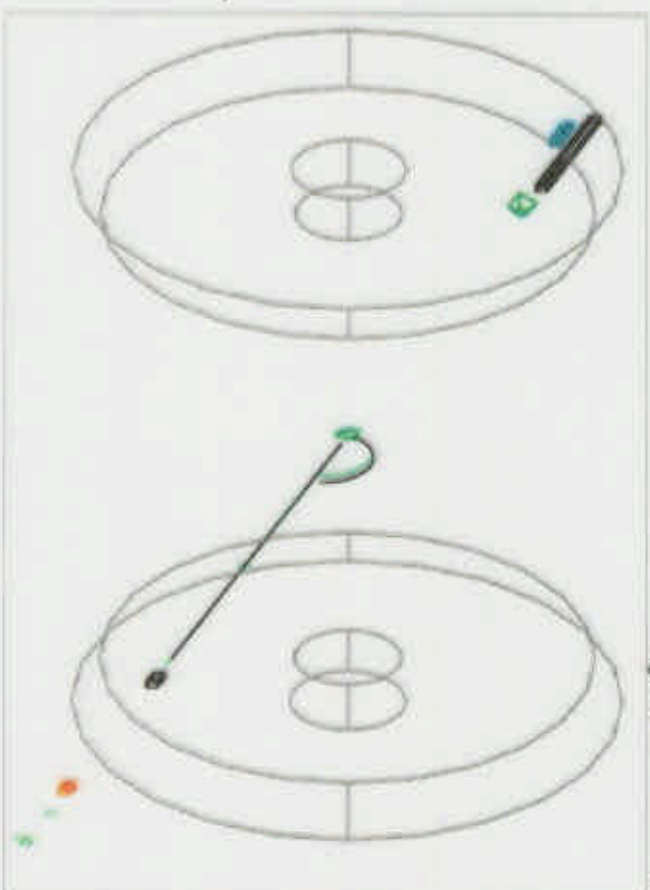


... many topologies

$\ell\ell\gamma, \gamma, j\ell, j\bar{\ell}, j\ell\ell, \dots$

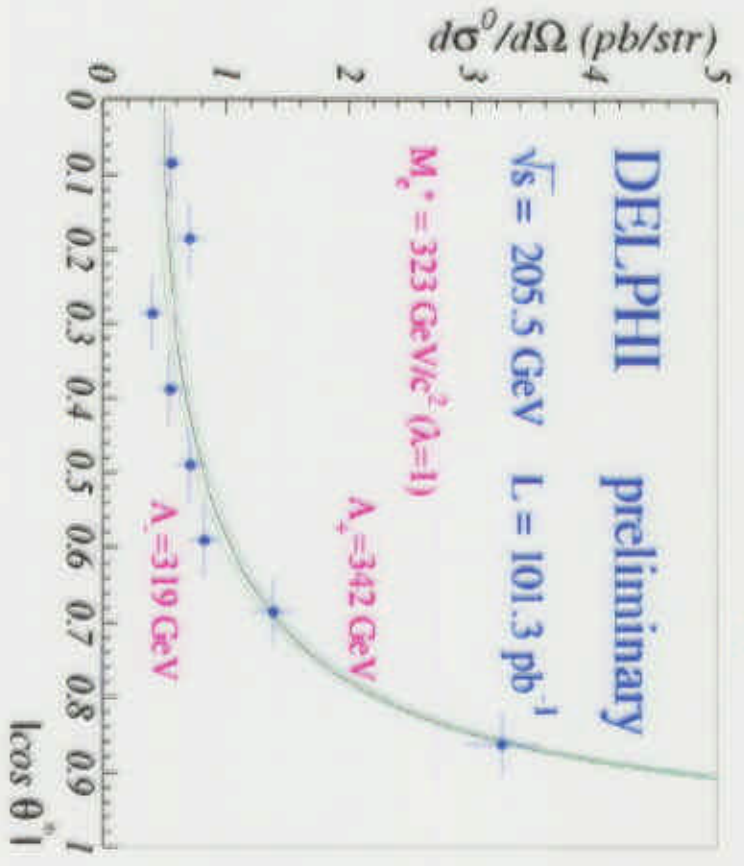
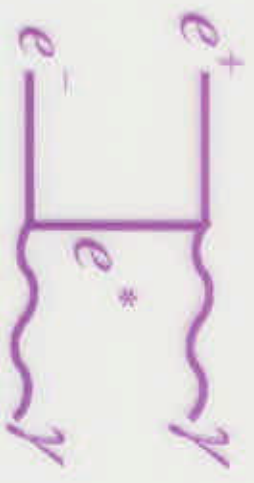
- ... at threshold:

$$e^+e^- \rightarrow (\mu)\mu^* \rightarrow (\mu)\mu\gamma$$



Excited leptons

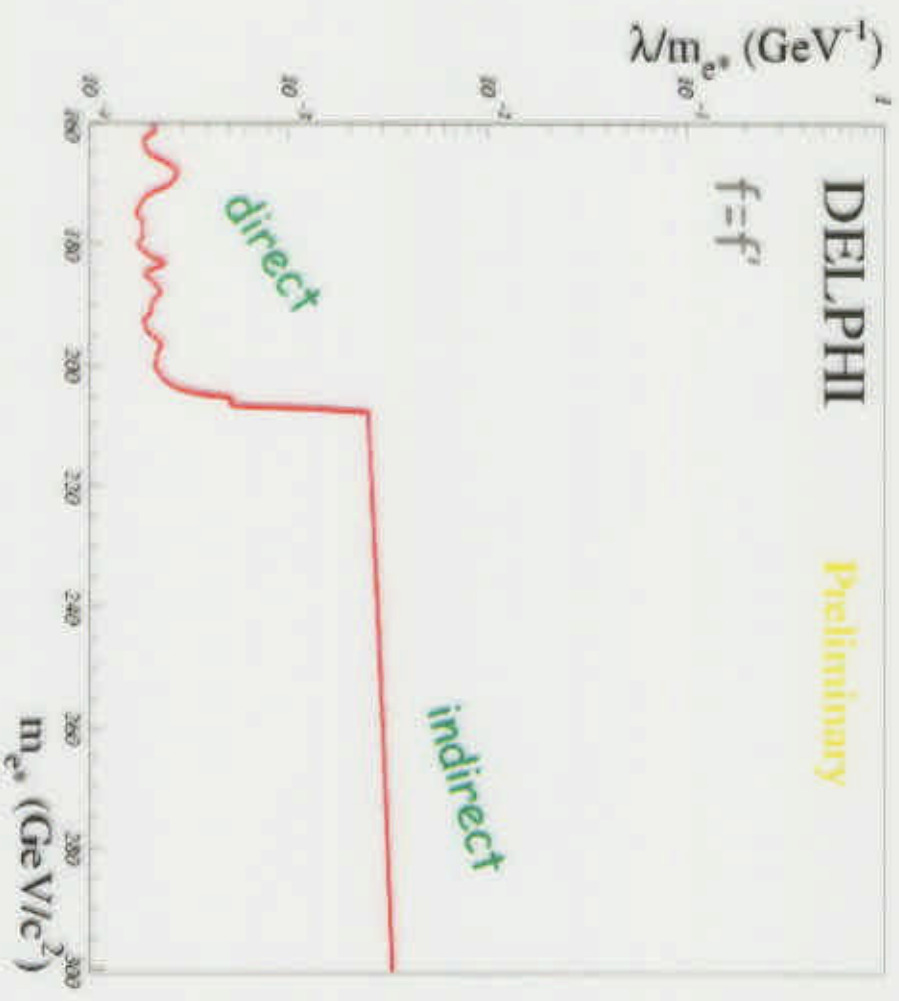
- Indirect search



- deviations from QED are searched for

DELPHI Preliminary

$f=f'$



Technicolor

- Final states @ LEP:



- channels

$M_\rho < \sqrt{s}$:
 $\mu\mu(\gamma)$ (resonant), $\pi_T^0\gamma$

$M_\rho > \sqrt{s}$:
 $\pi_T^+\pi_T^-, W_L^+\pi_T^-, W_L^+W_L^-$

- decays

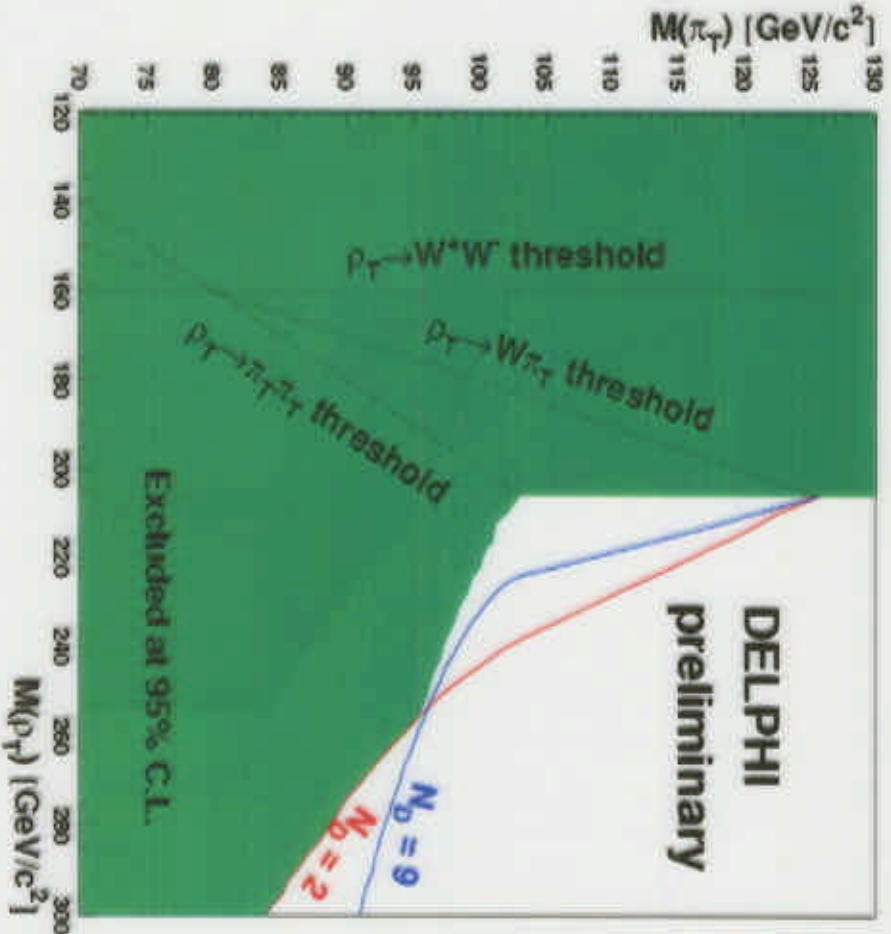
$\pi_T^+ \rightarrow b\bar{c}, \pi_T^0 \rightarrow b\bar{b}$

- Parameters

$M_{\pi_T}, M_{\rho_T}, \sin^2 \chi = 1/N_D$

- Main signatures:

4 jets
 B-tagging



Single top production

- FCNC ...?



.. Much suppressed in the SM (10^{-13})

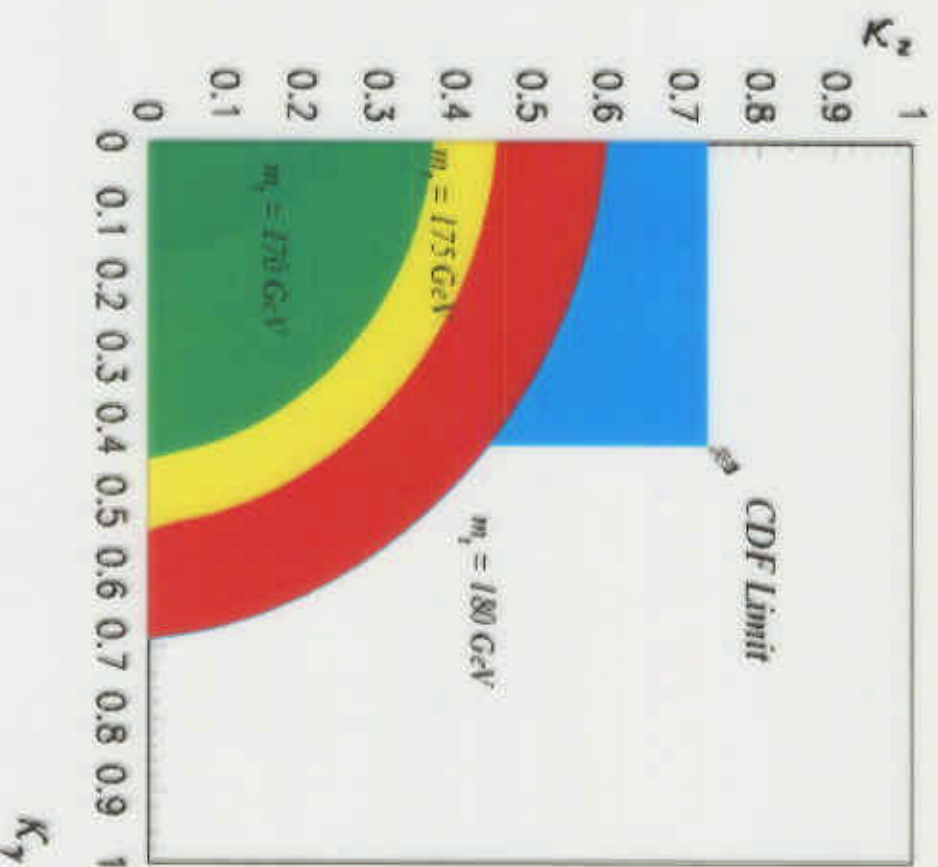
- Final states:

- jets (Btag)
- 1 isolated lepton, jets (Btag)



Channel	Data	MC
hadronic	4	3.3
leptonic	11	8.9

- Anomalous top couplings (k_{γ}, k_z)



HIGGS BOSONS

Exotic

Standard

Supersymmetric



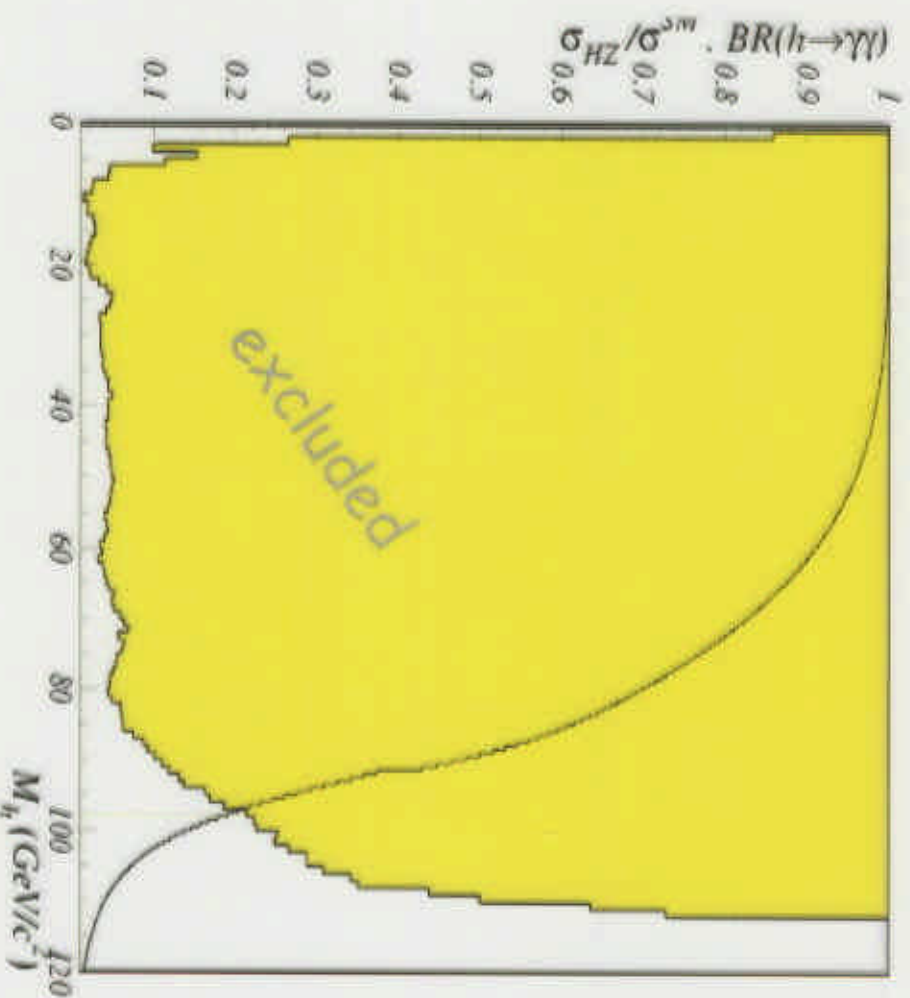
- SM-like production
 $e^+e^- \rightarrow HZ$

- Final states:



- BR could be enhanced:
 - Anomalous couplings
 - 2HDM models

↪ Fermiophobic



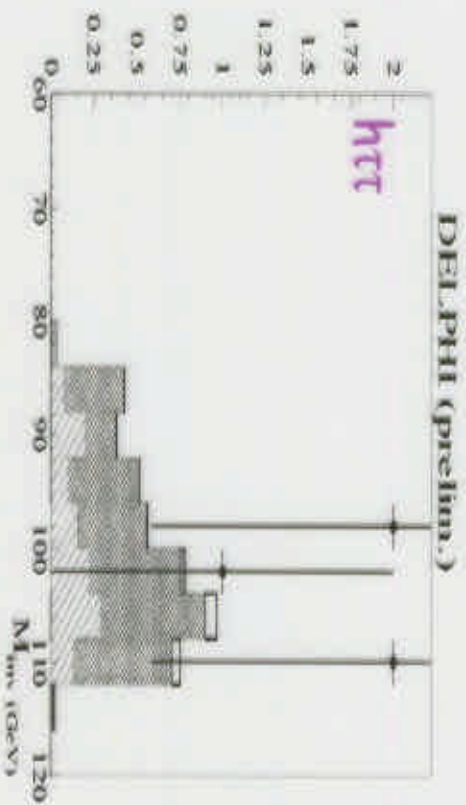
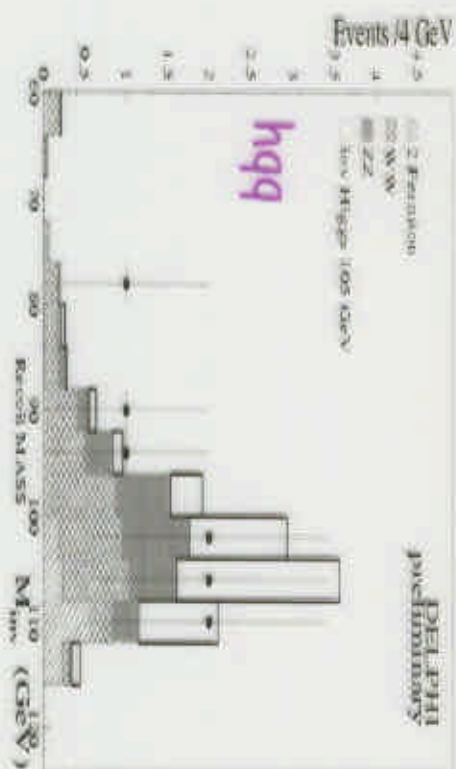
BR=1 $M_h > 112 \text{ GeV}/c^2$
 BR=0.21 $M_h > 97 \text{ GeV}/c^2$

Invisible Higgs

- The Higgs could have important invisible decay modes... e.g.

$H \rightarrow LSP LSP$

channel	data	MC
hqg	9	8.8
hee	2	2.3
h $\mu\mu$	0	2.2
htt	5	4.3



$M_H > : 104.3 \text{ GeV}/c^2$
 expected: 107.0

SM Higgs

- Higgstrahlung



- Fusion



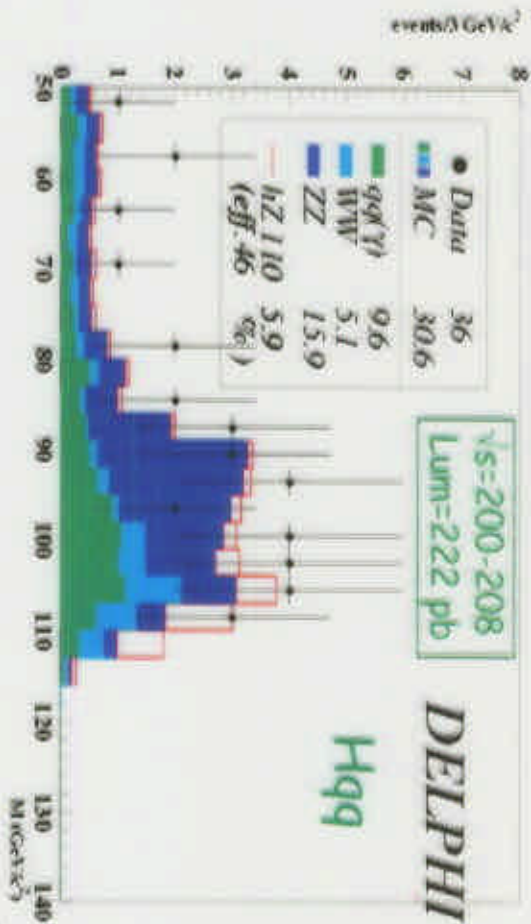
High mass

	data	MC	Eff. (%)
Hqq	18	14	48
Hvv	1	2.2	30
Hee	0	1.6	47
Hμμ	3	4.2	71
qqττ	3	3.2	25

- Some excess in hqq
- good agreement in other channels

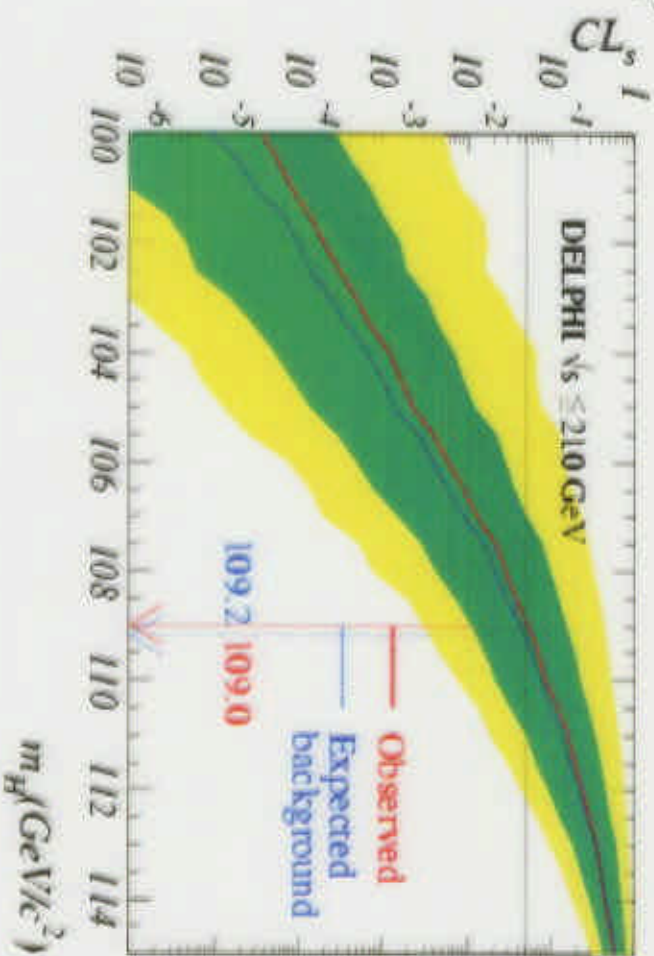
SM Higgs

- Mass plots (S/B=1)



M_H (95% CL)
obtained: 109.0 GeV/c²
expected: 109.2

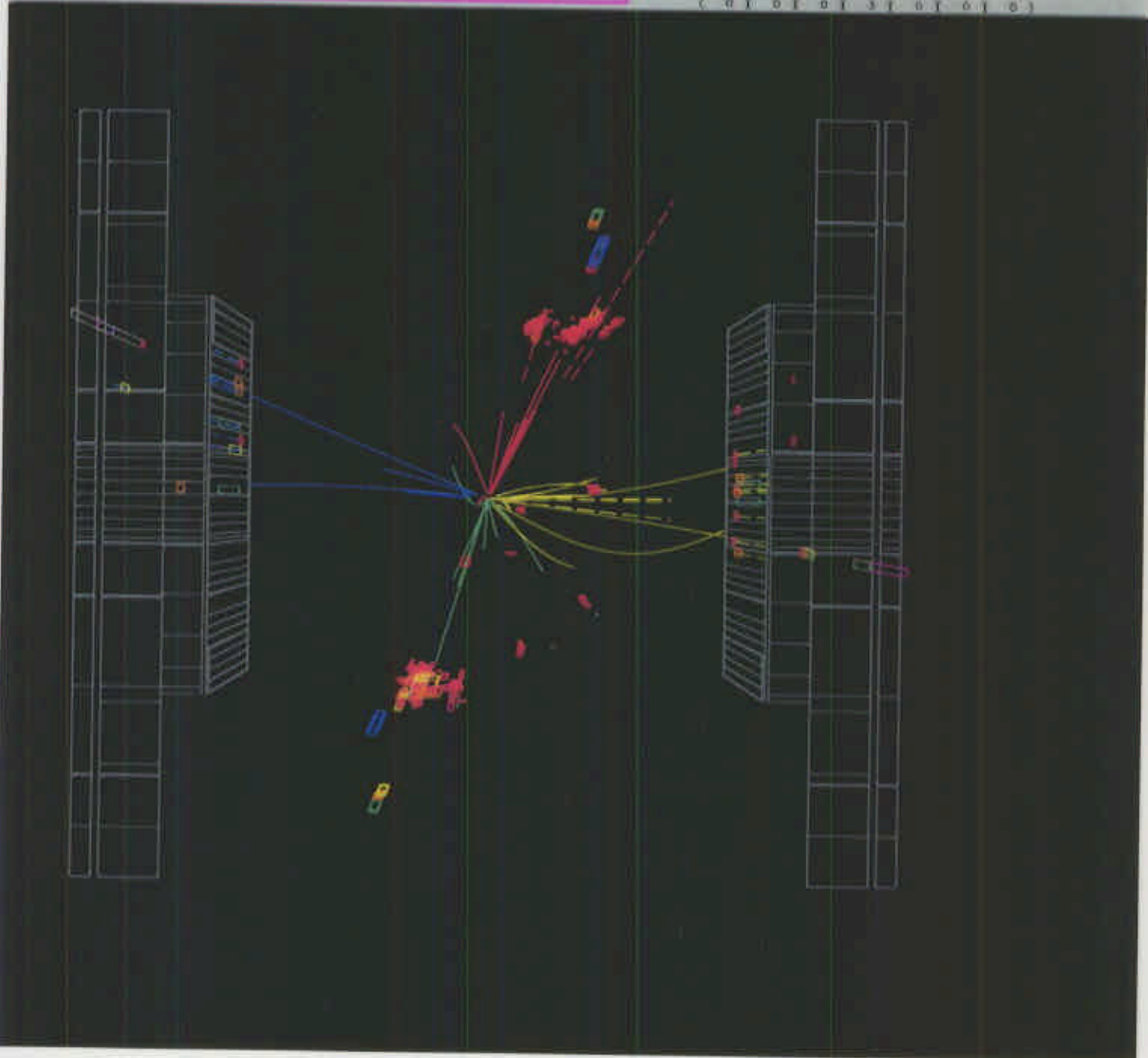
- Signal CL





DELPHI Run: 113070 Evt: 2410
Beam: 103.4 GeV Proc: 24-Jul-2000
DAS: 24-Jul-2000 Scan: 25-Jul-2000
13:09:42 Tan+DST

	TR	TK	TV	ST	PK
Act	0 53	0 60	0 0	0 0	0 0
Detct	0 0	0 0	0 0	0 0	0 0

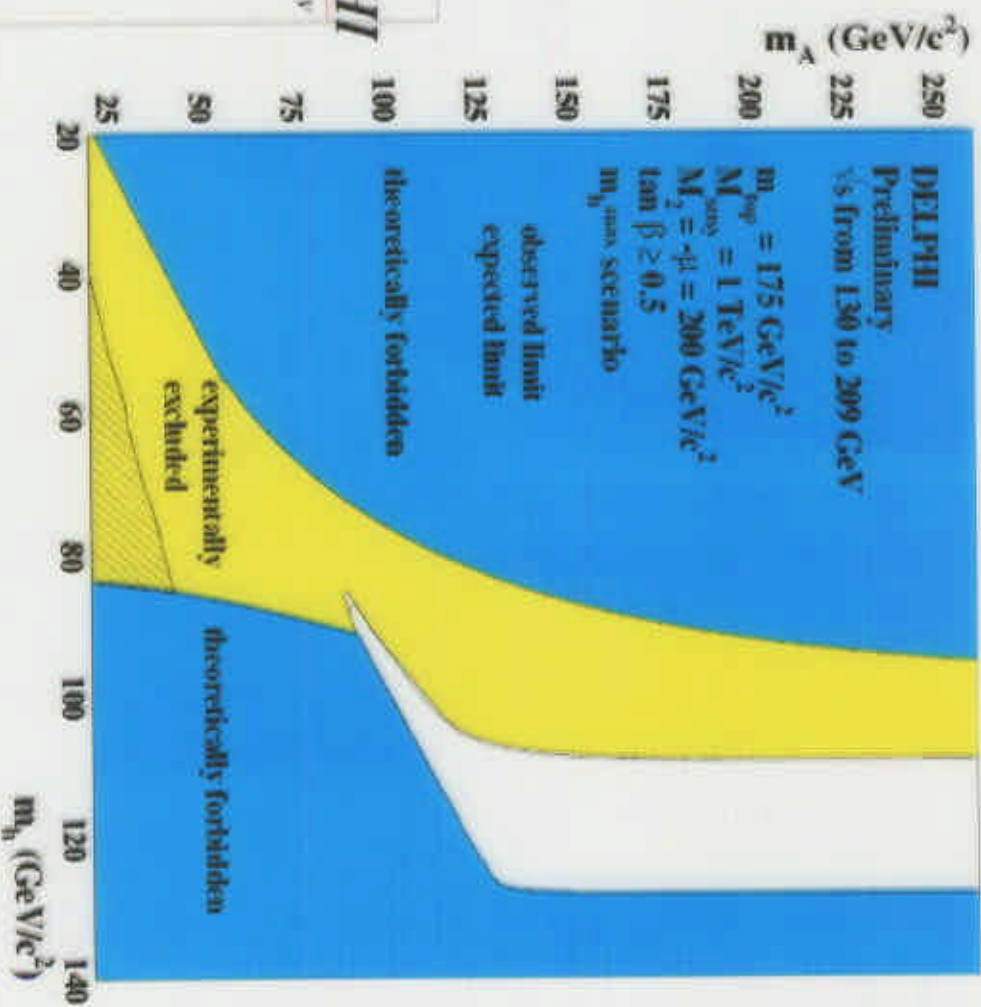
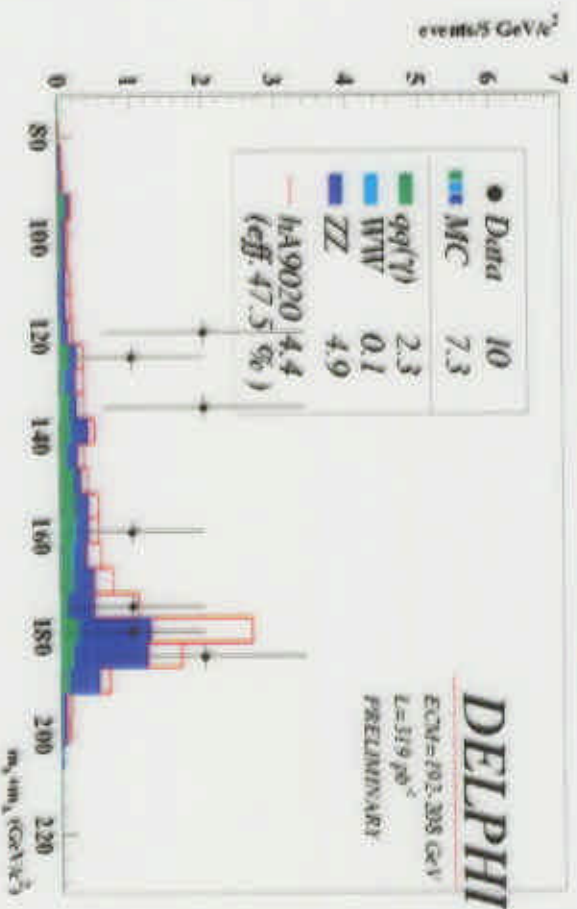


MSSM neutral Higgs

- Associate production



- 4b final state: basically same observations as in hZ ...



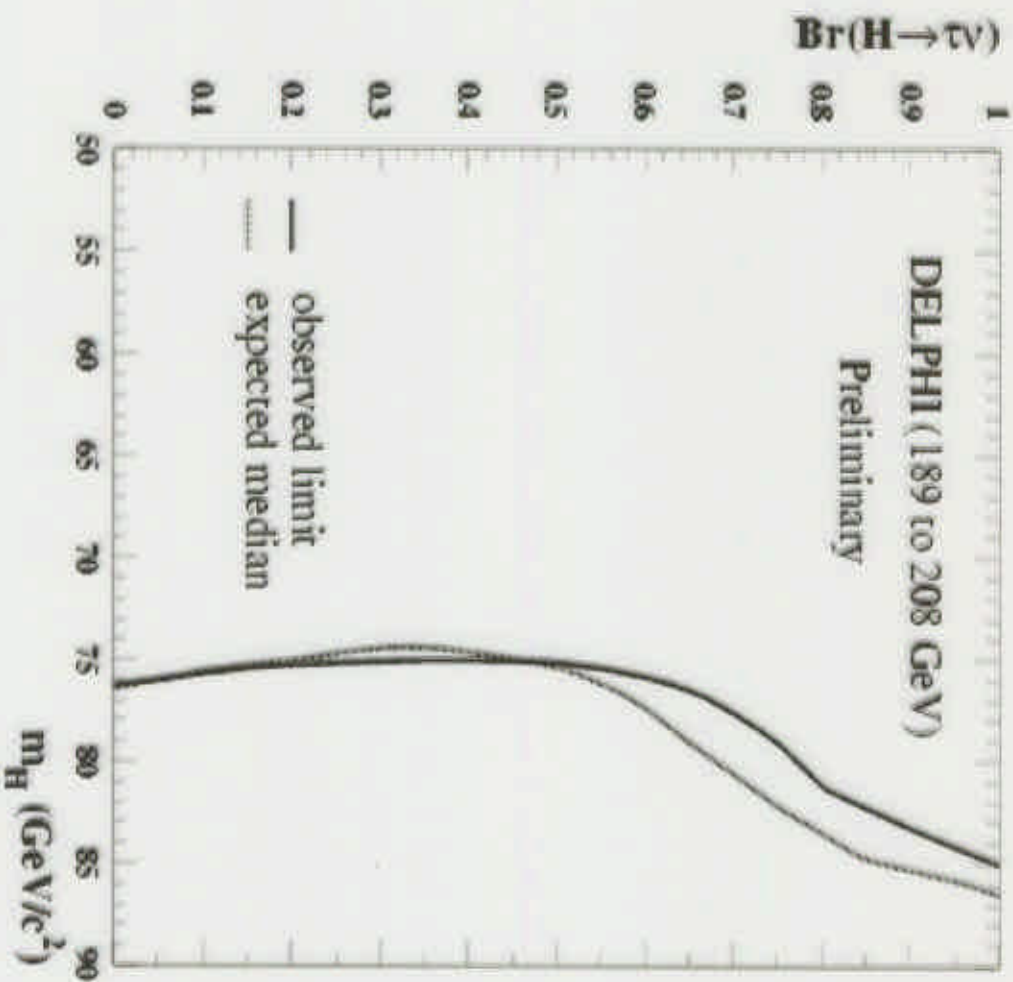
MSSM charged Higgs



- 2 main decay modes:
 - $H^+ \rightarrow c\bar{s}, \tau\nu$
- WW: irreducible background

- leptonic channel:
 - polarisation info
(W spin 1, H spin 0)

channel	data	MC
$c\bar{s} \ c\bar{s}$	147	127
$c\bar{s} \ \tau\nu$	59	73
$\tau\nu\tau\nu$	12	8.8



- "WW Wall" will not be broken for all BR...

Outlook

- The (successful!) LEP running is coming to an end...



- Preliminary look at Y2K data:
 - do we understand the data?
 - any hints of new physics?



- ... A long way to go:
 - more detailed analyses
 - further interpretations
 - LEP COMBINATIONS

- LEP still running...

