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*News from  $\sim 1\text{fb}^{-1}$  of  $e^+e^-$  data  
at  $E_{cm}=192\text{-}202\text{ GeV}$*



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UC Santa Cruz

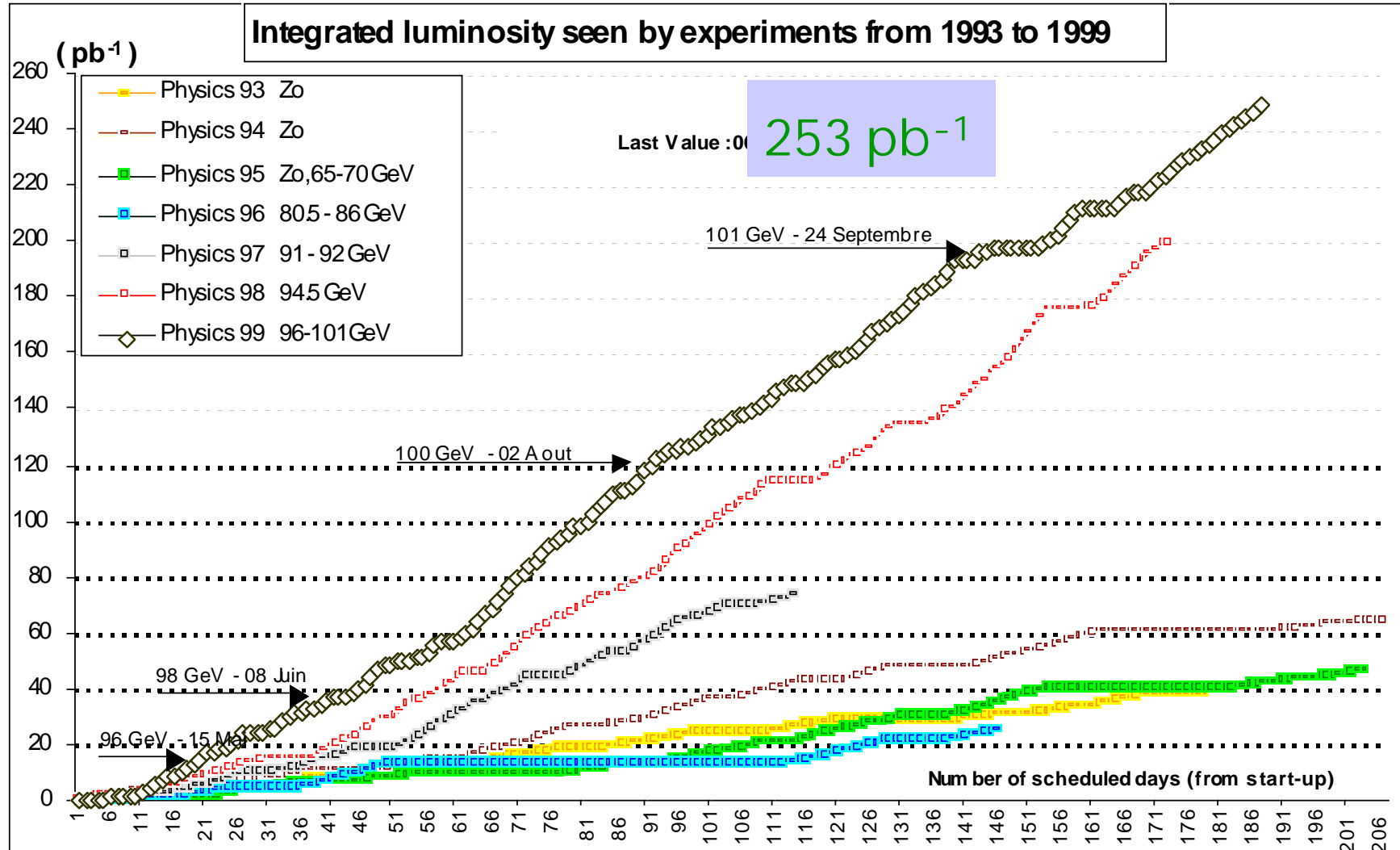
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# Outline

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- New physics in SM processes
  - photons, WW, ZZ...
- Direct searches
  - Higgs and SUSY
- The future
  - LEP at Y2K, after LEP?

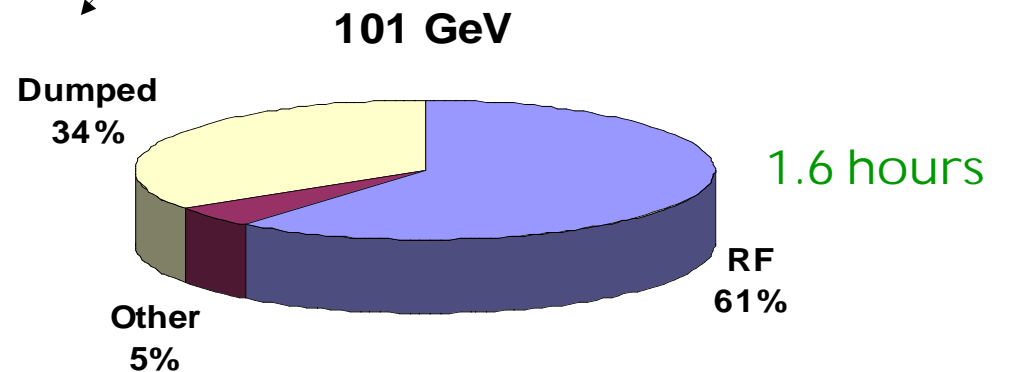
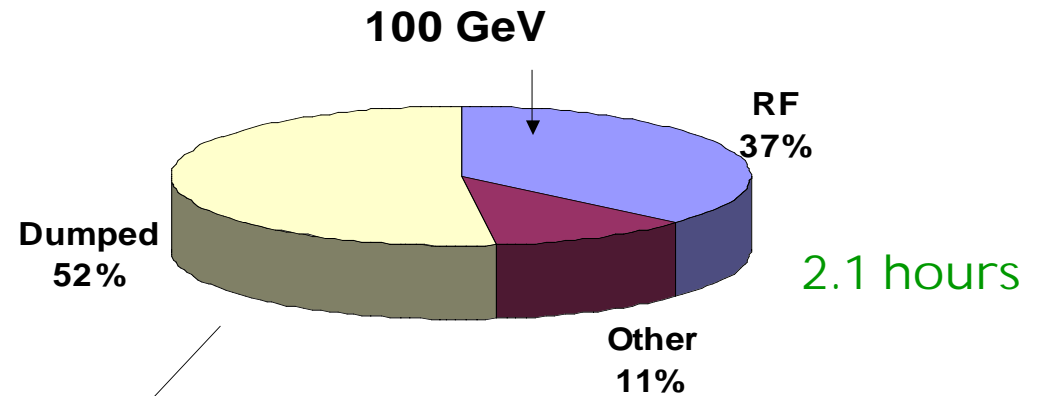
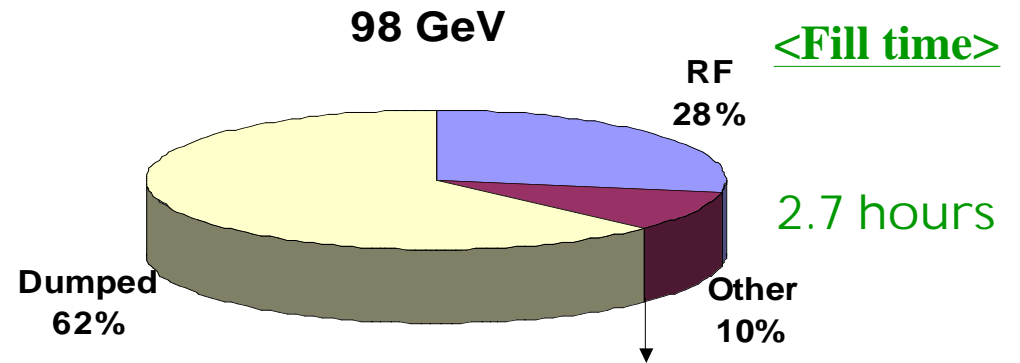
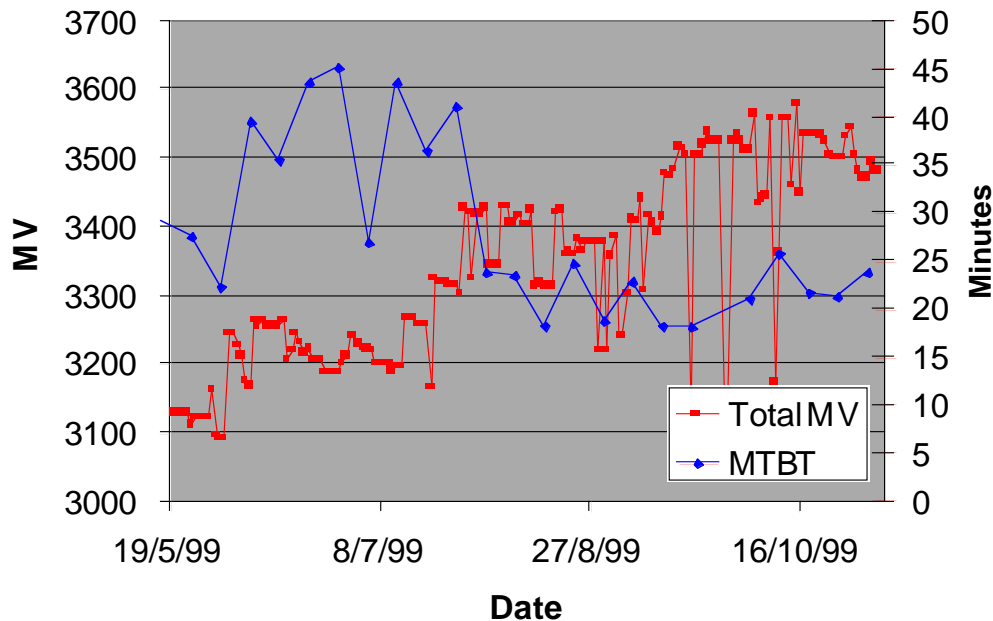
# LEP in 1999 - A story of success!



# LEP operator: Not an easy job!

Cryogenics operated at limit capacity!

RF cavities operated at  $\sim \langle 7 \text{ MV/m} \rangle$  well above their design gradient ( $\sim 6 \text{ MV/m}$ )



# *For what follows...*

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30 pb<sup>-1</sup> at 191.6 GeV  
80 pb<sup>-1</sup> at 195.5 GeV  
85 pb<sup>-1</sup> at 199.5 GeV  
40 pb<sup>-1</sup> at 201.6 GeV

} 235 pb<sup>-1</sup>/expt

Results very *preliminary!!!*  
(presented one day after the end of run)

Emphasis on  open questions after the ADL0 presentations  
implications of the latest results

Limits at 95% C.L. - Discoveries at 5 $\sigma$

# *Final states with photons*

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## Topology

## SM process

## New processes

Single photon

Single ISR

Anomalous TGC's  
Extra dimensions

Two acoplanar  
photons

Double ISR

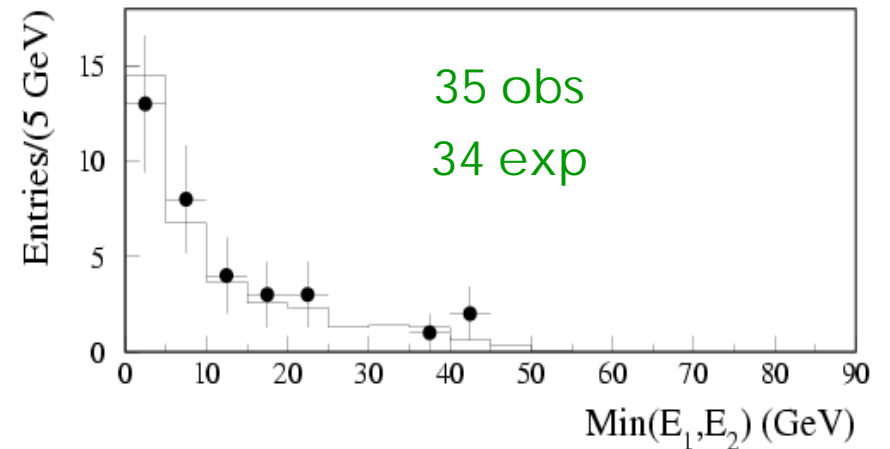
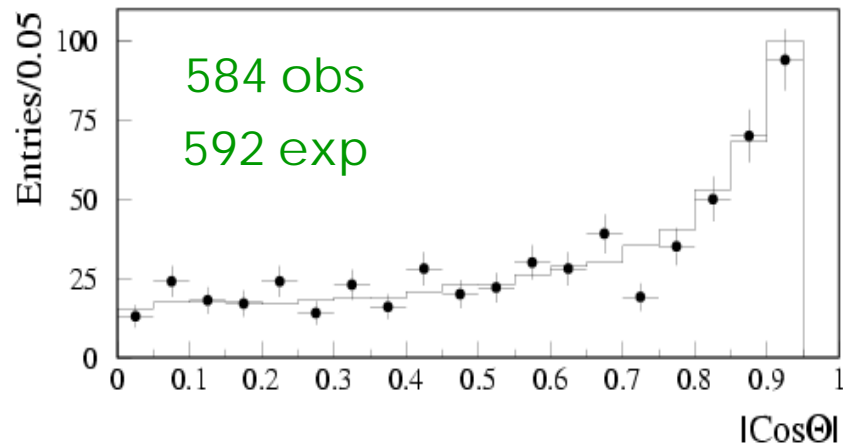
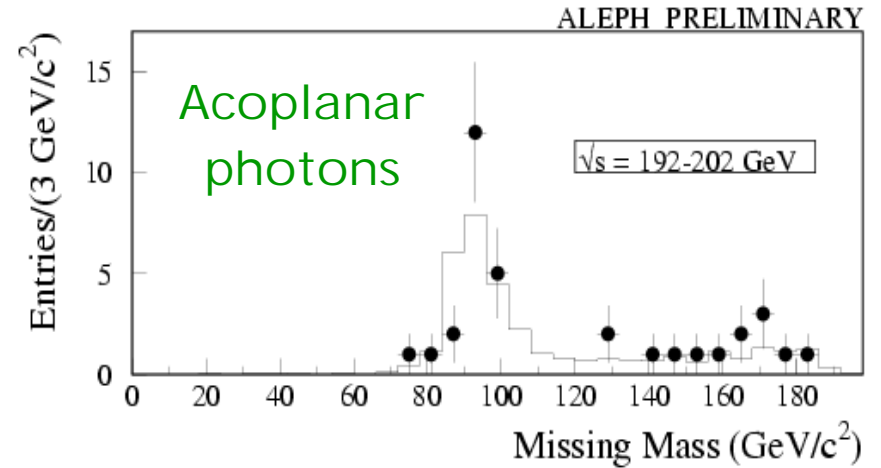
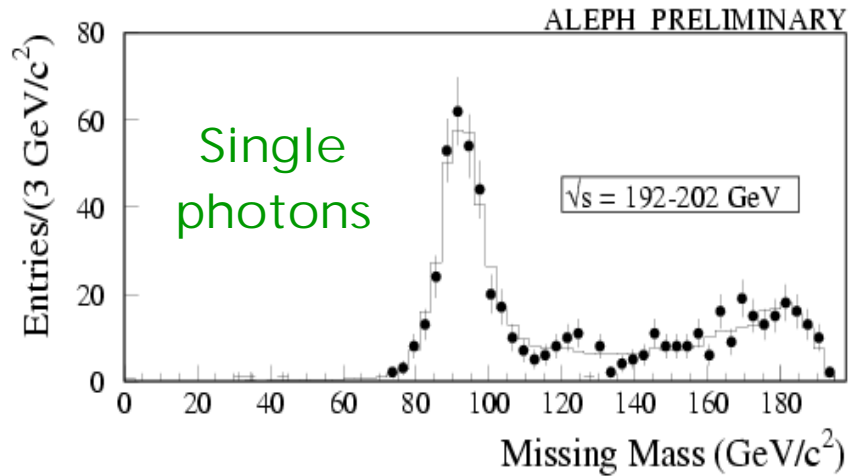
SUSY (GMSB)

Two coplanar  
photons

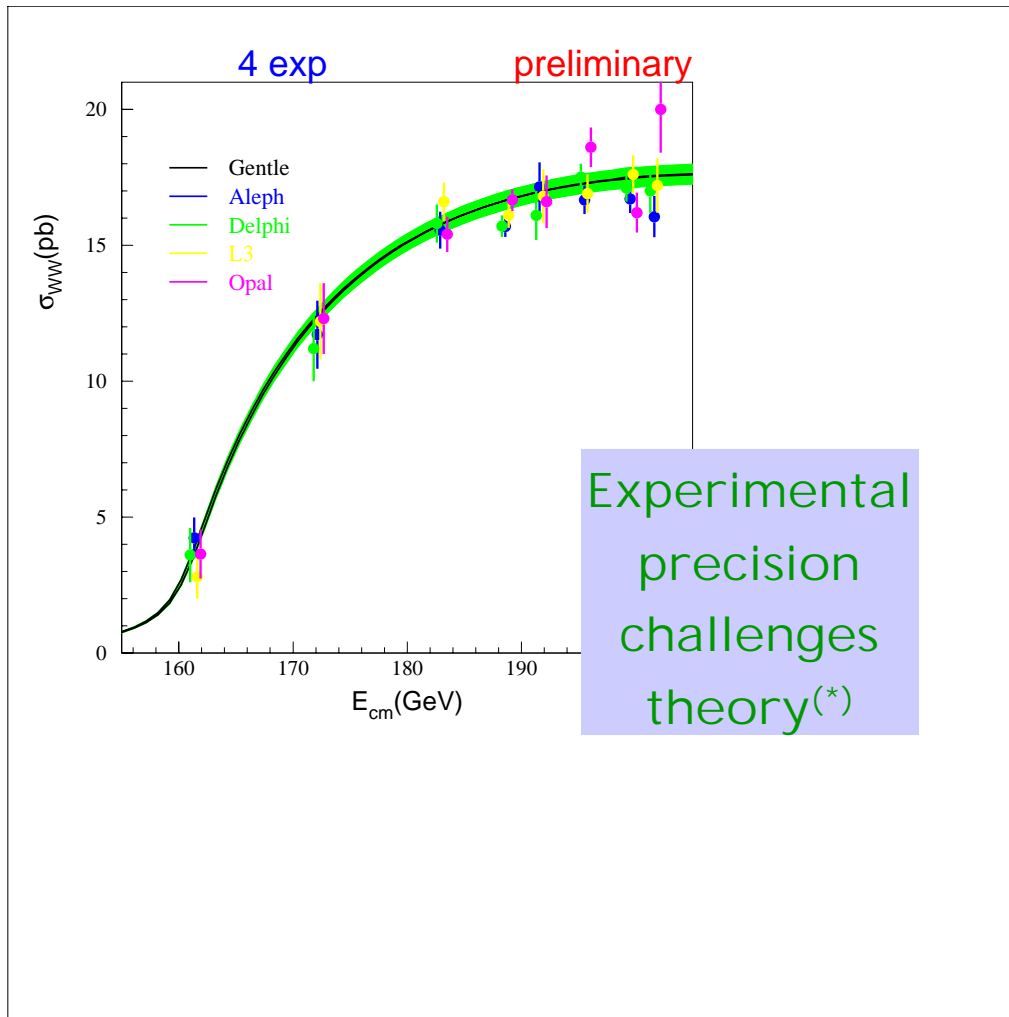
QED t-channel  
electron exchange

Extra dimensions  
Excited leptons  
Contact interactions

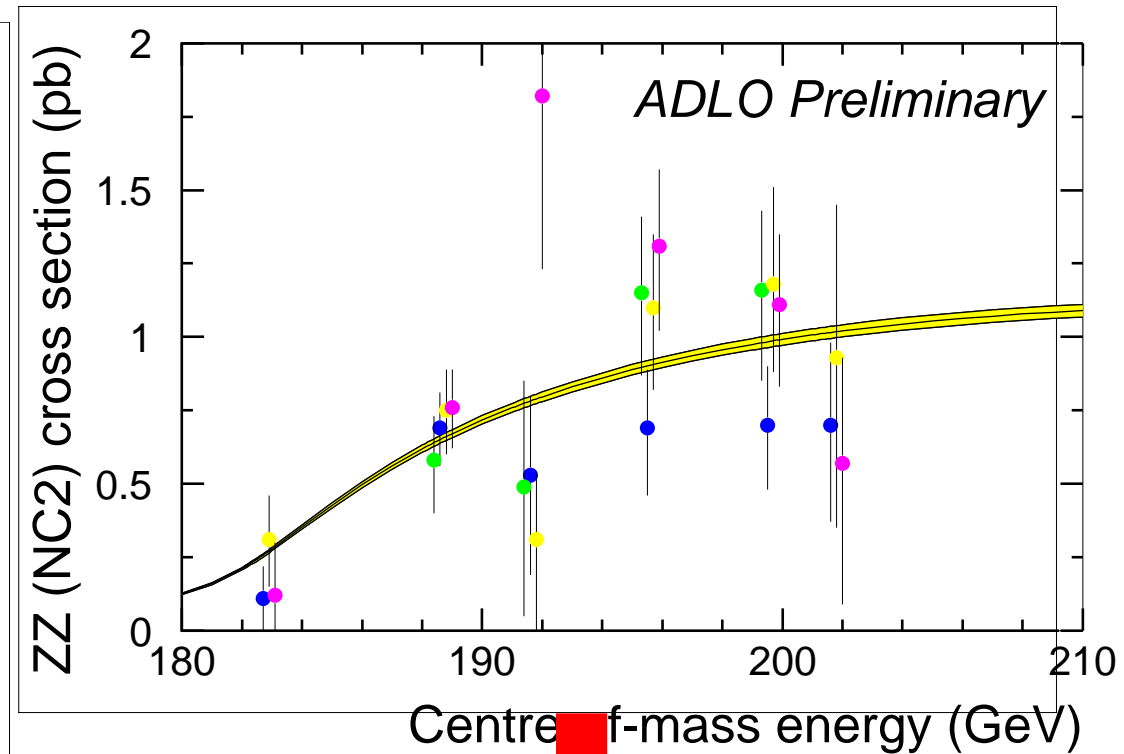
# Results with photons



# *W/Z pair production*



(\*) hep-ph/9907436  
hep-ph/9909363

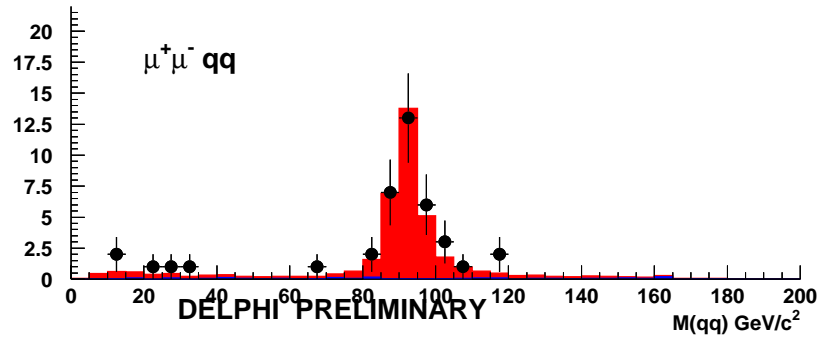


Limits on  
anomalous neutral  
vector boson couplings  
and extra dimensions

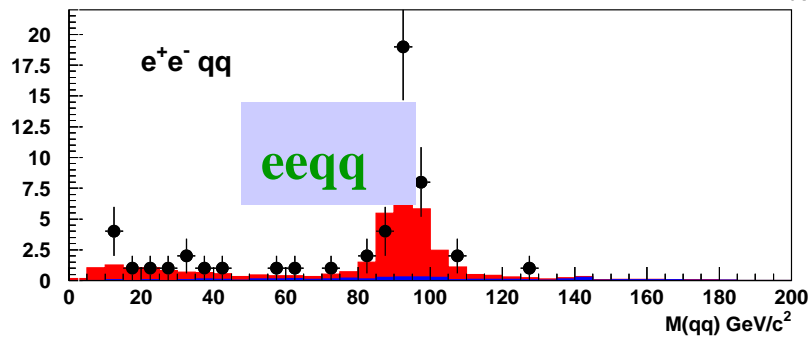
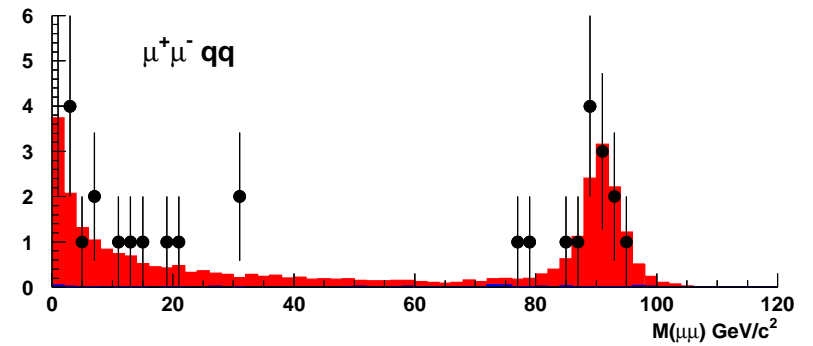


# DELPHI $eeqq$ excess

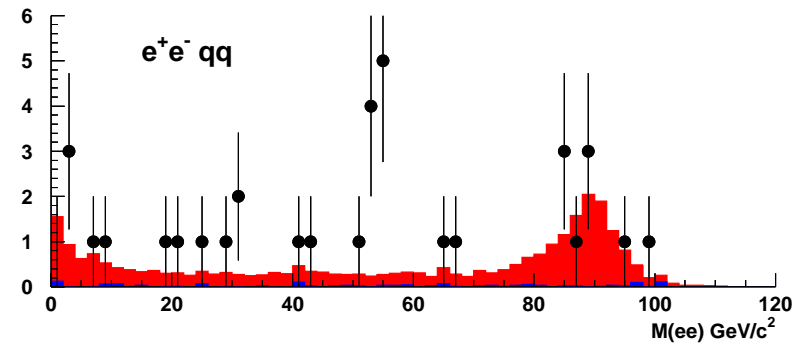
DELPHI PRELIMINARY



DELPHI PRELIMINARY



DELPHI PRELIMINARY



# ...not confirmed by others

ALEPH  $llqq$  mass spectrum  
already studied before the  
DELPHI announcement:

No excess!

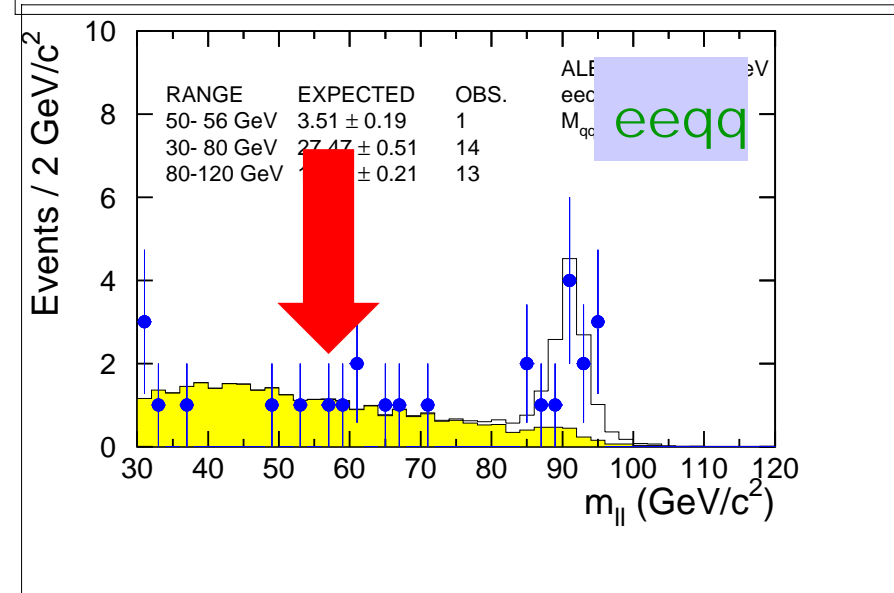
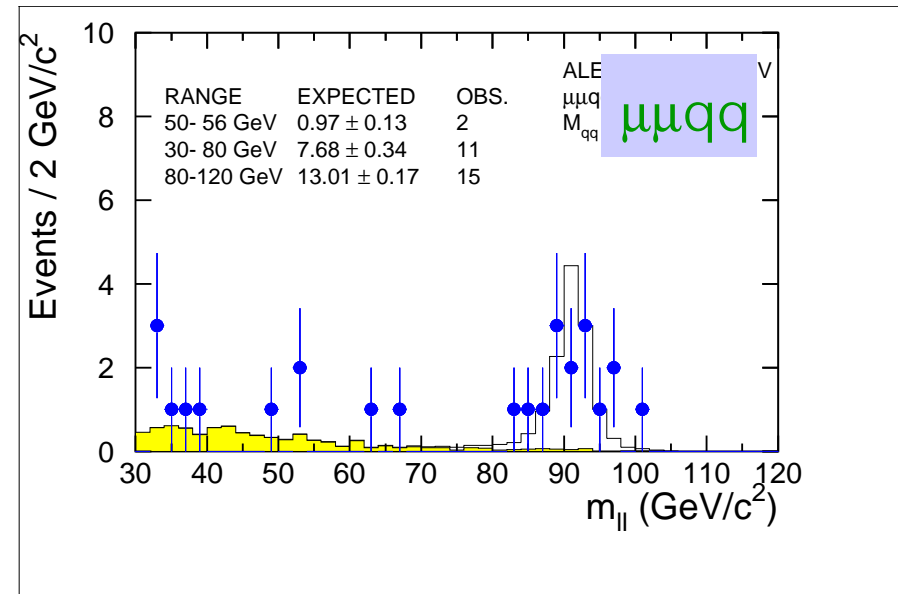
Specific modifications to  
approach the DELPHI analysis:

Still no excess!

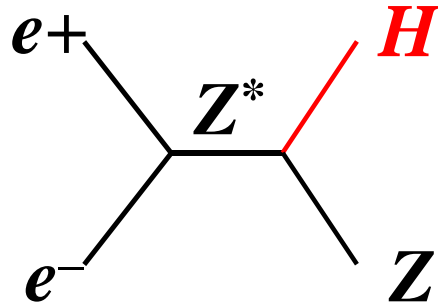
50-56  $\text{GeV}/c^2$ :

3.5 expected

1 observed

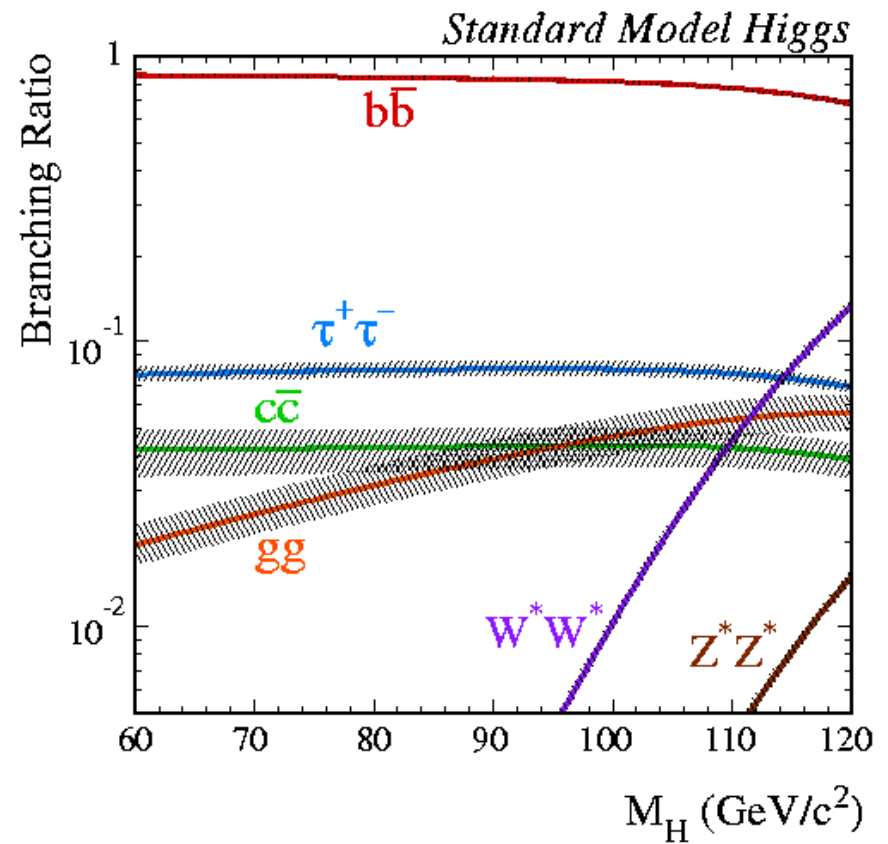


# SM Higgs - A new regime

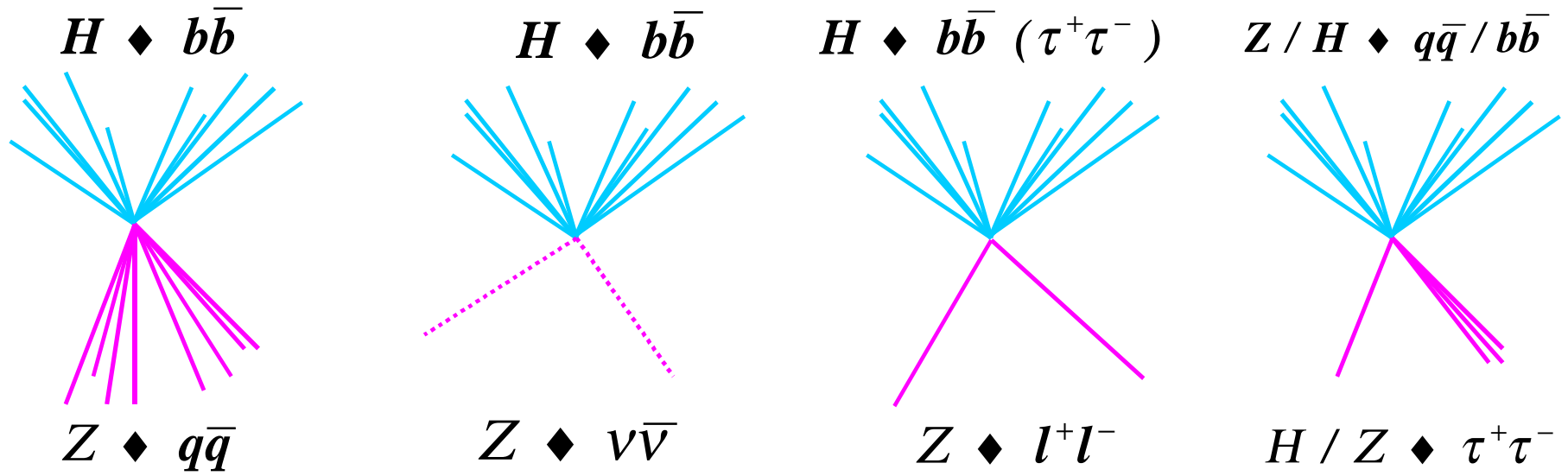


New in 1999:

- Moving away from  $M_Z$
- Covering an exciting mass range



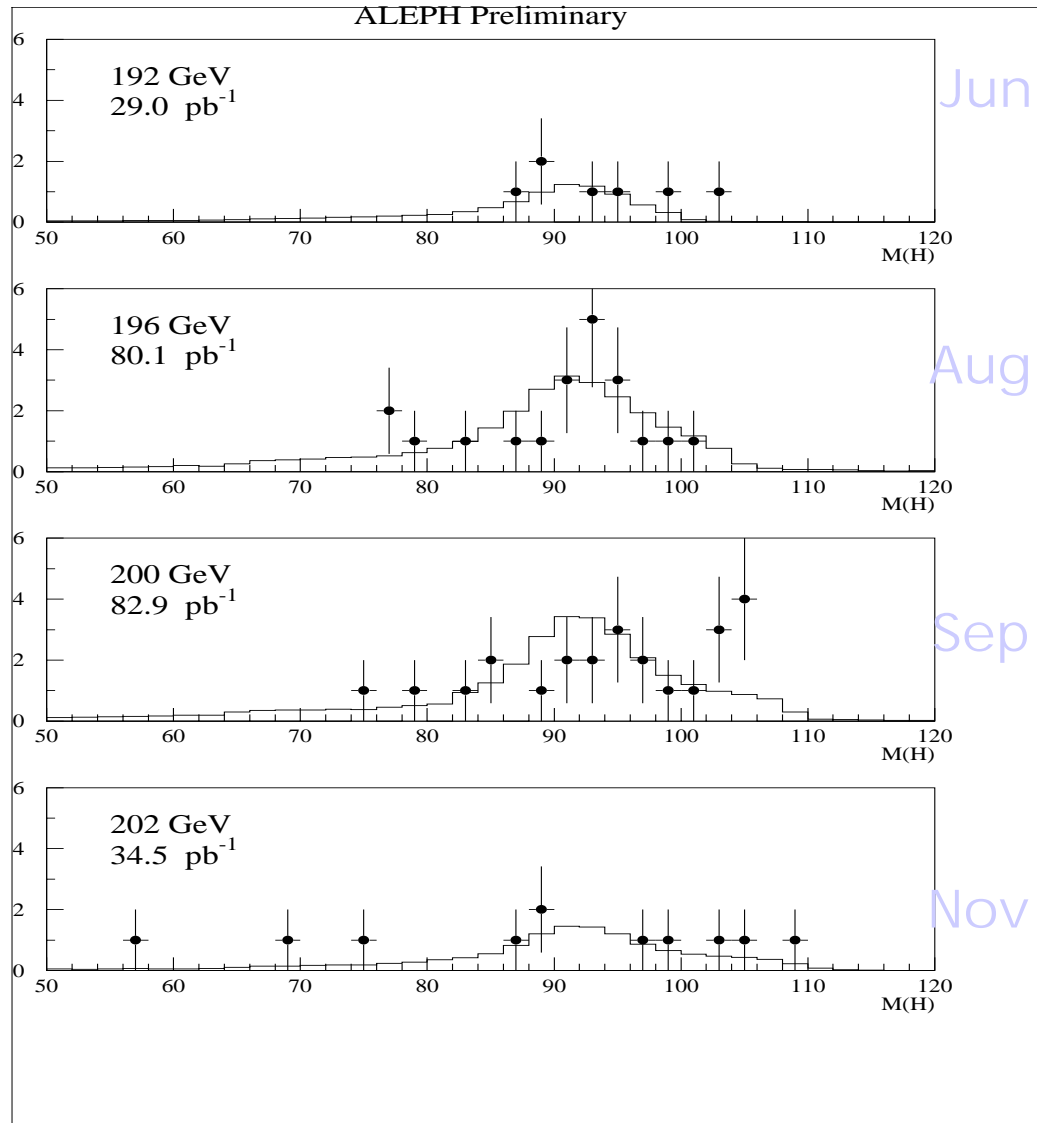
# $e^+e^-$ ♦ *HZ* - Topologies



BR (%)	60	17	6	9
eff (%)	40	40	70	30
Bkg's:	ZZ,qq,WW	ZZ,WW,qq	ZZ,Zee	ZZ,WW

Handles: b-tagging      Acoplanarity      lepton-ID      tau-ID  
 4 jet topol.       $M_{\text{mis}} = M_Z$       + isolation      b-tagging  
 b-tagging       $M_{\text{ll}} = M_Z$

# ALEPH Higgs Rumors

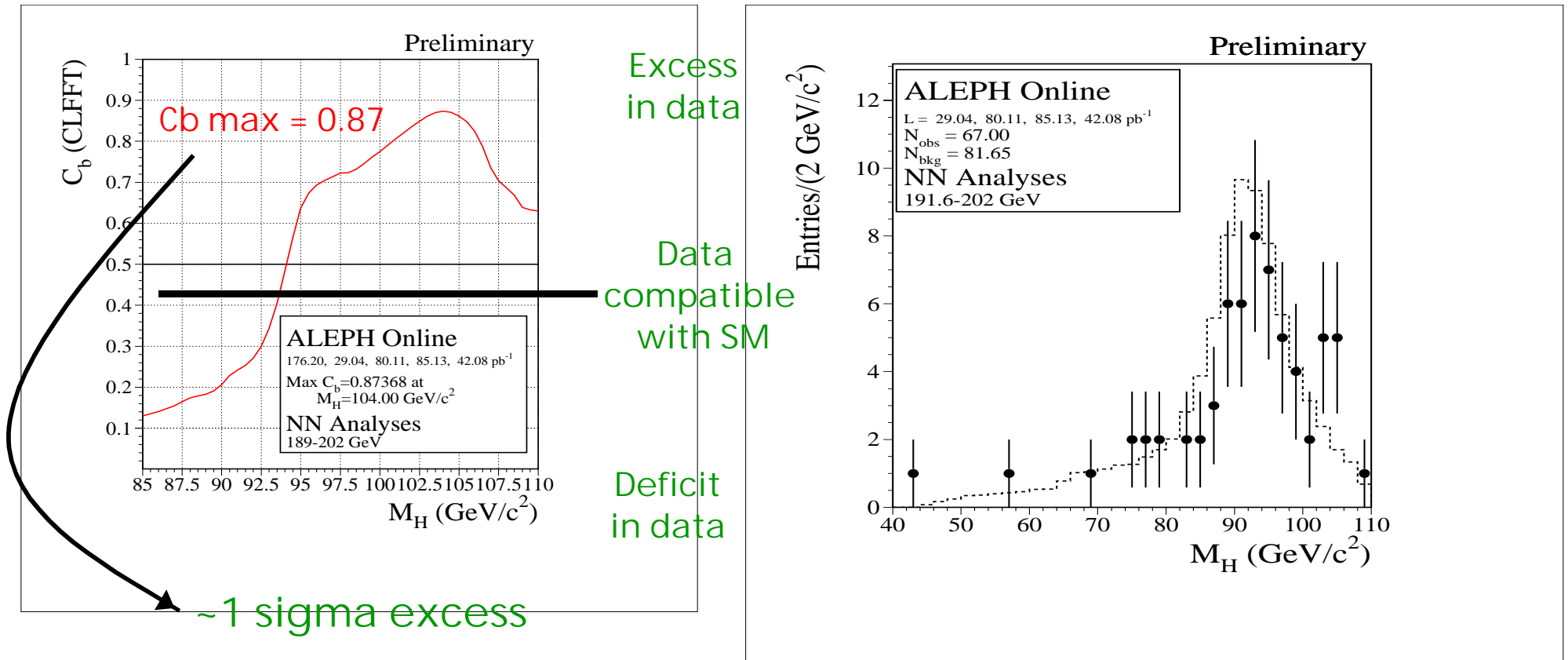


Shown to summer  
conferences

Rumors start here...

... and end here!

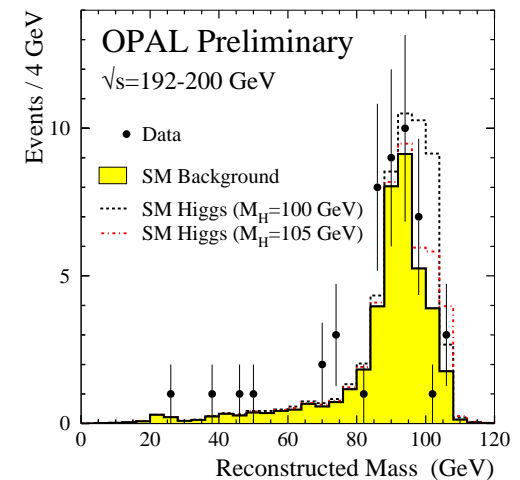
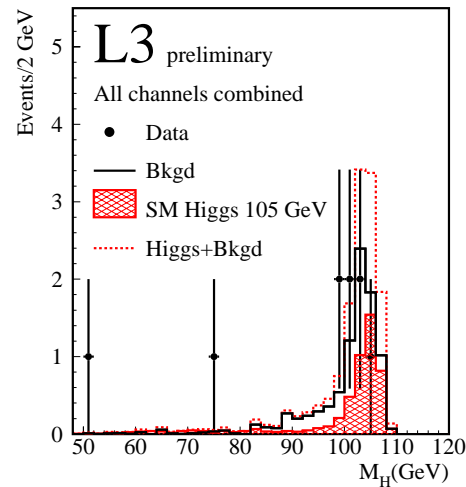
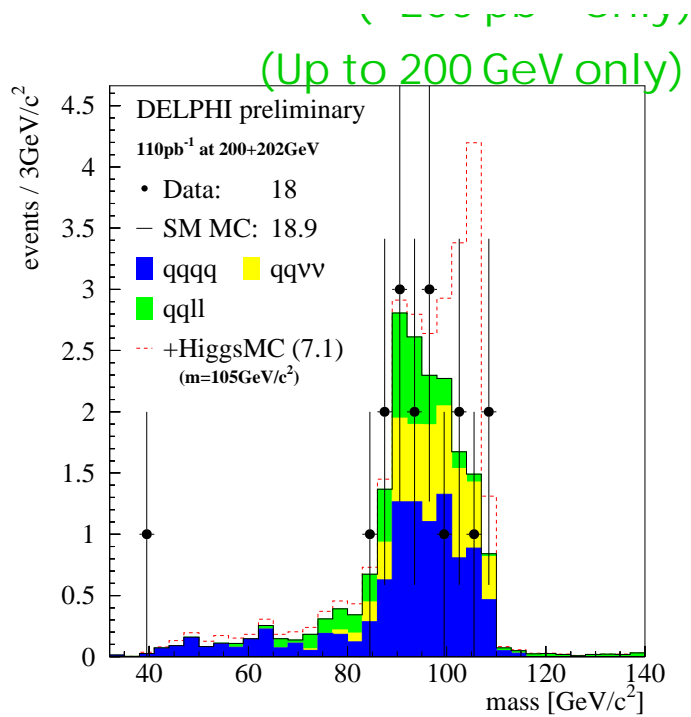
# ALEPH Higgs Search



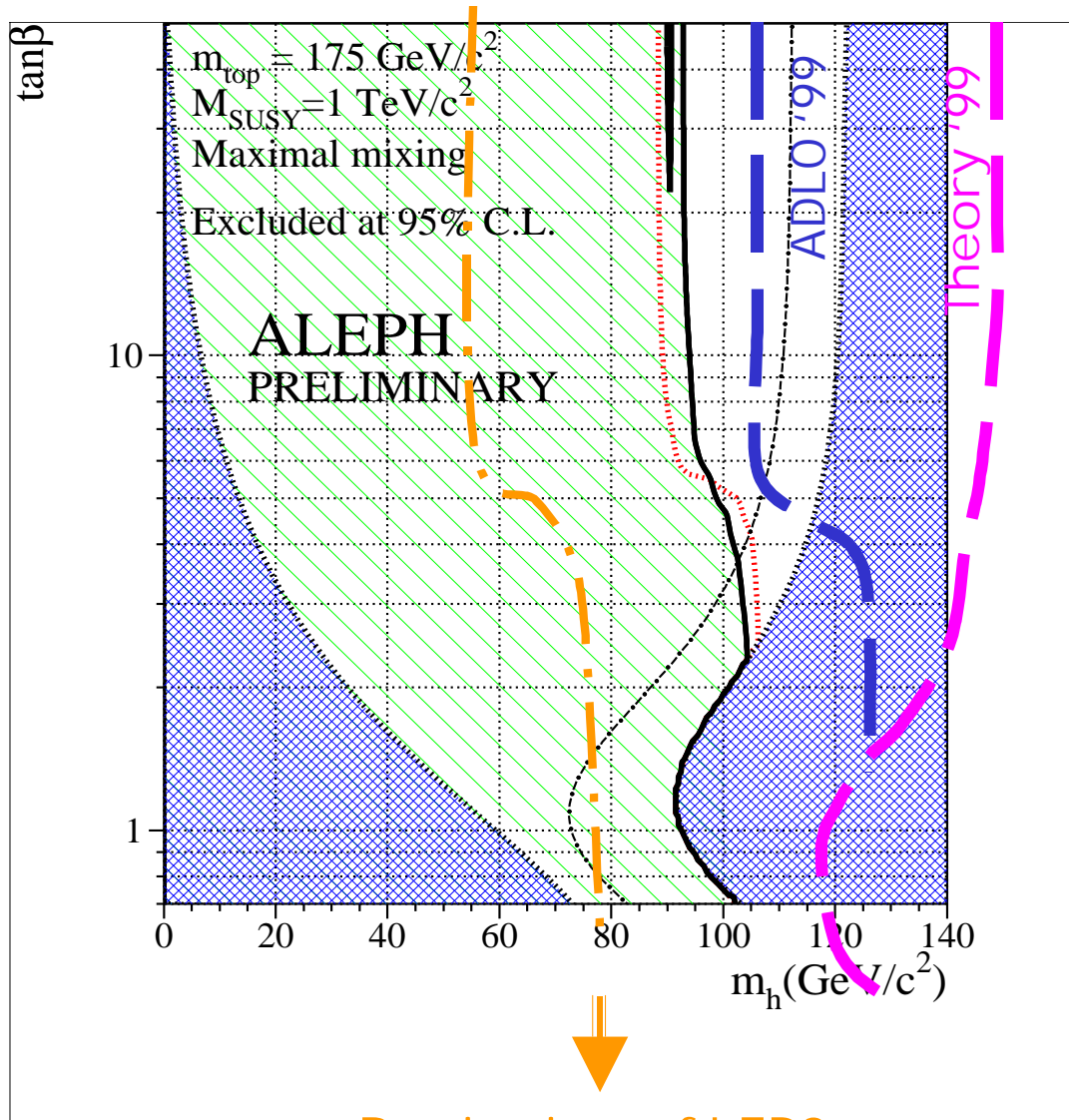
**C<sub>b</sub>**: The compatibility with SM background.

Contains much more information than a mass plot!

# SM Higgs results up to 202 GeV



# MSSM - Neutral Higgs bosons



	$M_h$ limit (GeV)	
	Expected	Observed
<b>A</b>	<b>88.3</b>	<b>89.9</b>
<b>D</b>	<b>84.9</b>	<b>84.5</b>
<b>L</b>	<b>~84</b>	<b>~81</b>
<b>O</b>	<b>83.1</b>	<b>77.1</b>

ADLO: ~90 GeV

Low  $\tan\beta$  region slowly covered:

ADLO:  $\tan\beta > \sim 2$

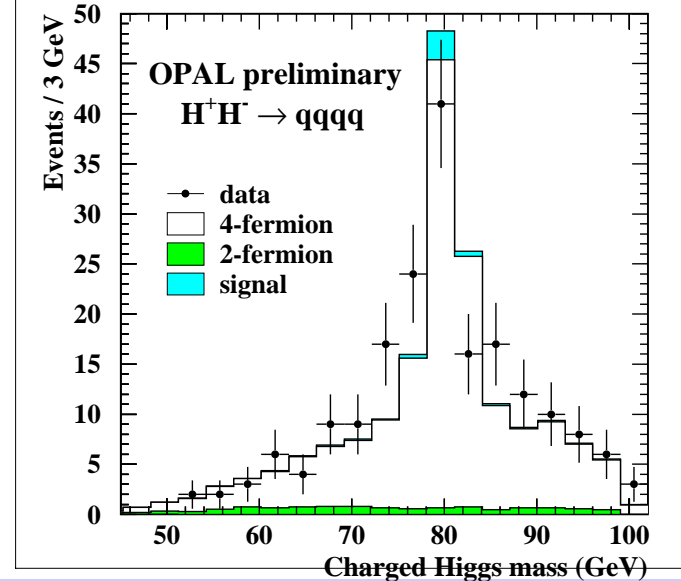
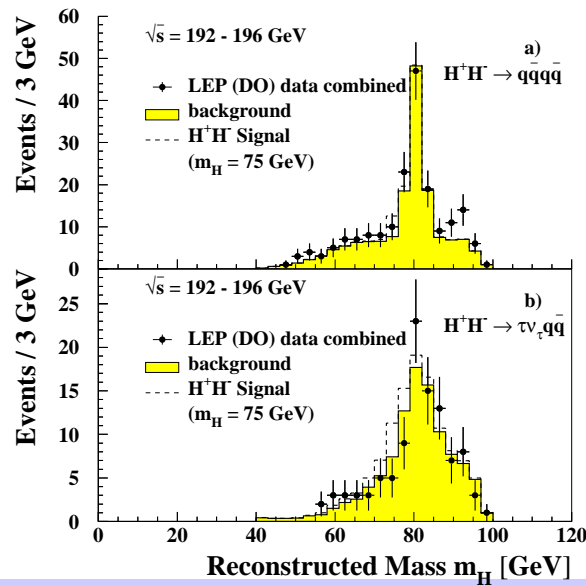
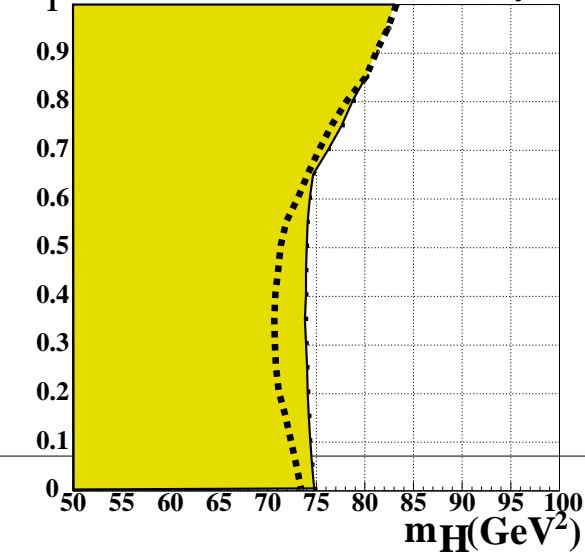
MSSM scans show  
no pathological points

Beginning of LEP2



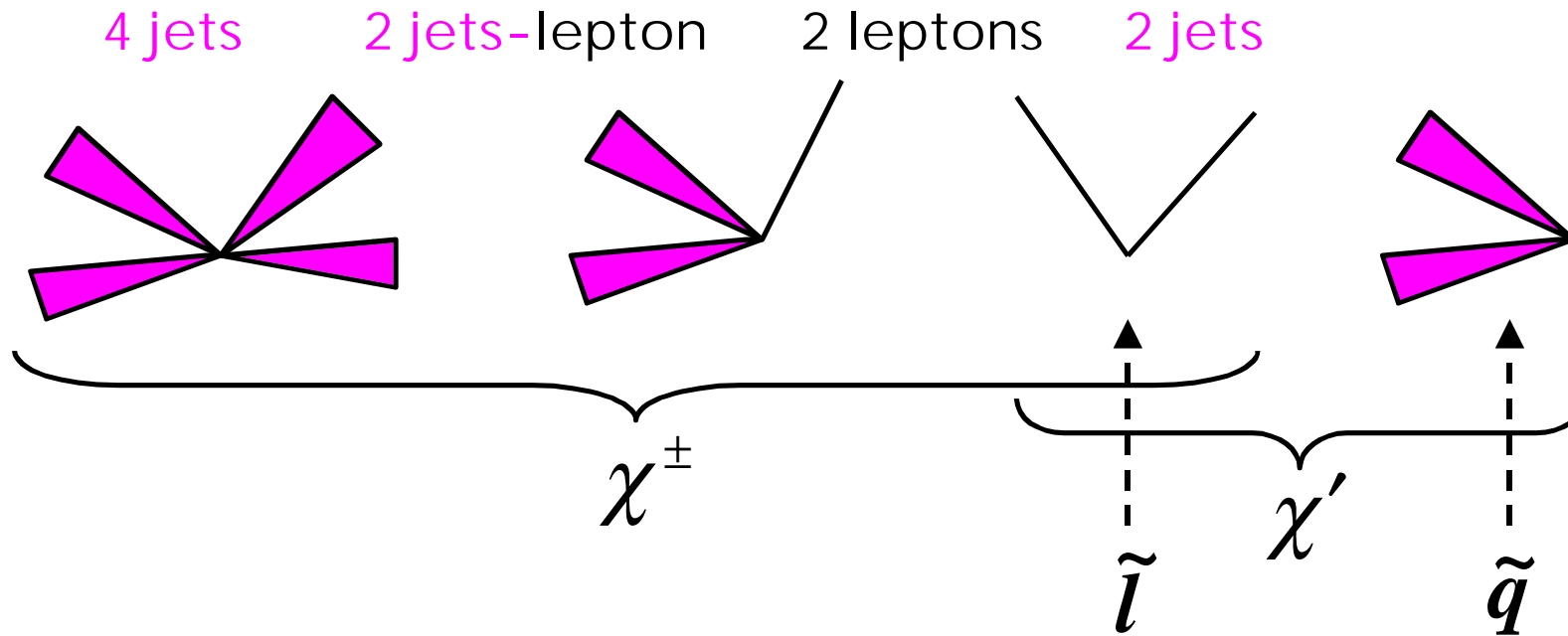
# Charged Higgs

**DELPHI Preliminary**  
 $\text{Br}(H \rightarrow \tau\nu)$

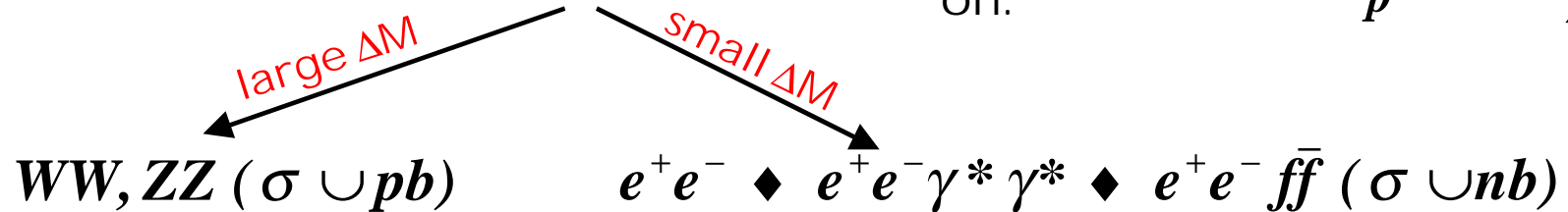


# SUSY topologies and backgrounds

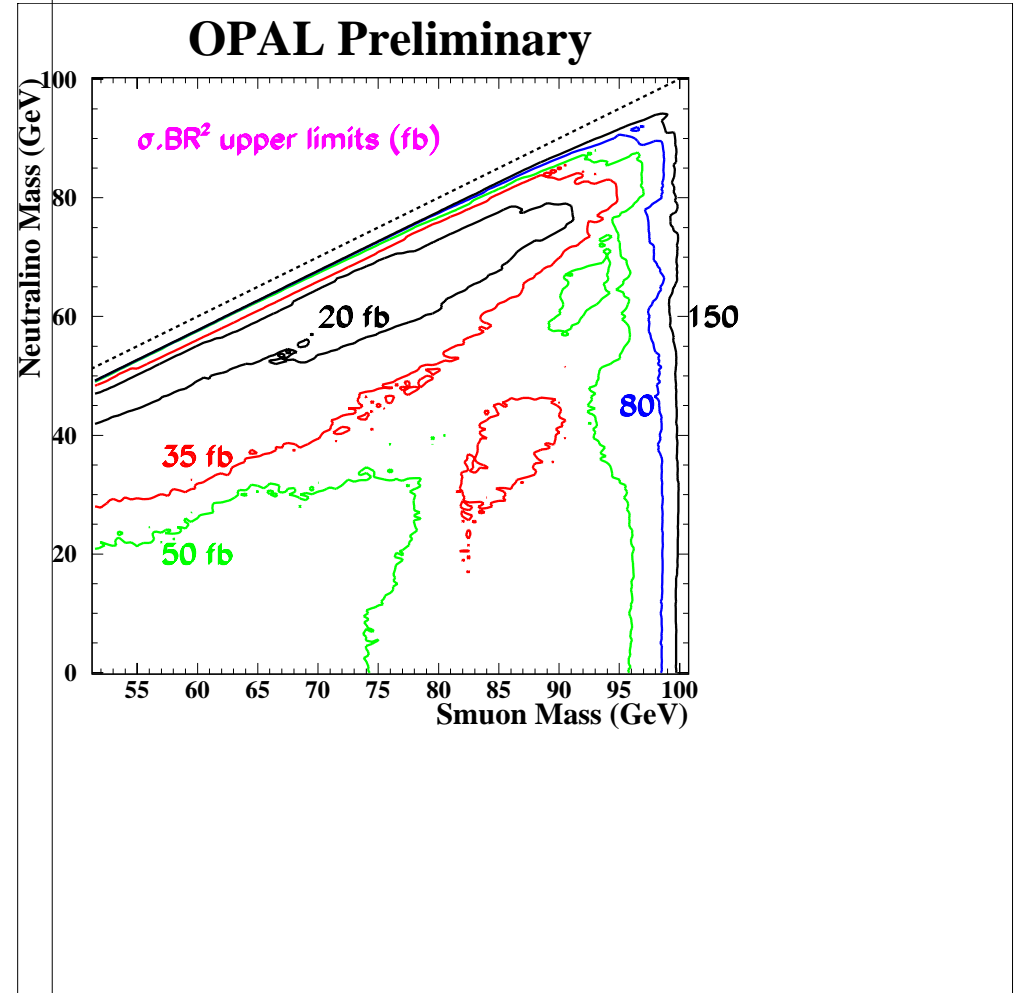
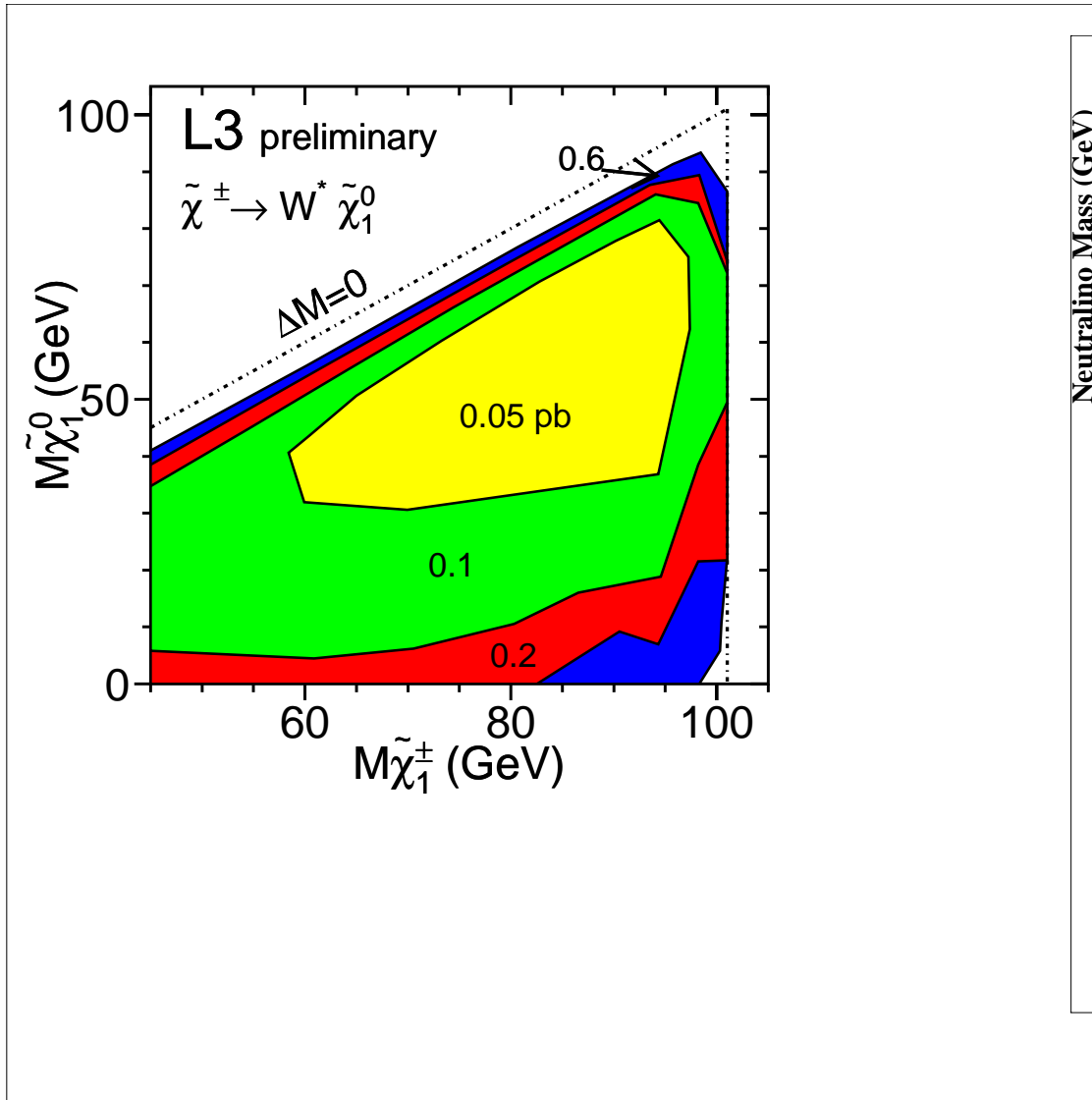
R-parity conserved: Missing energy +



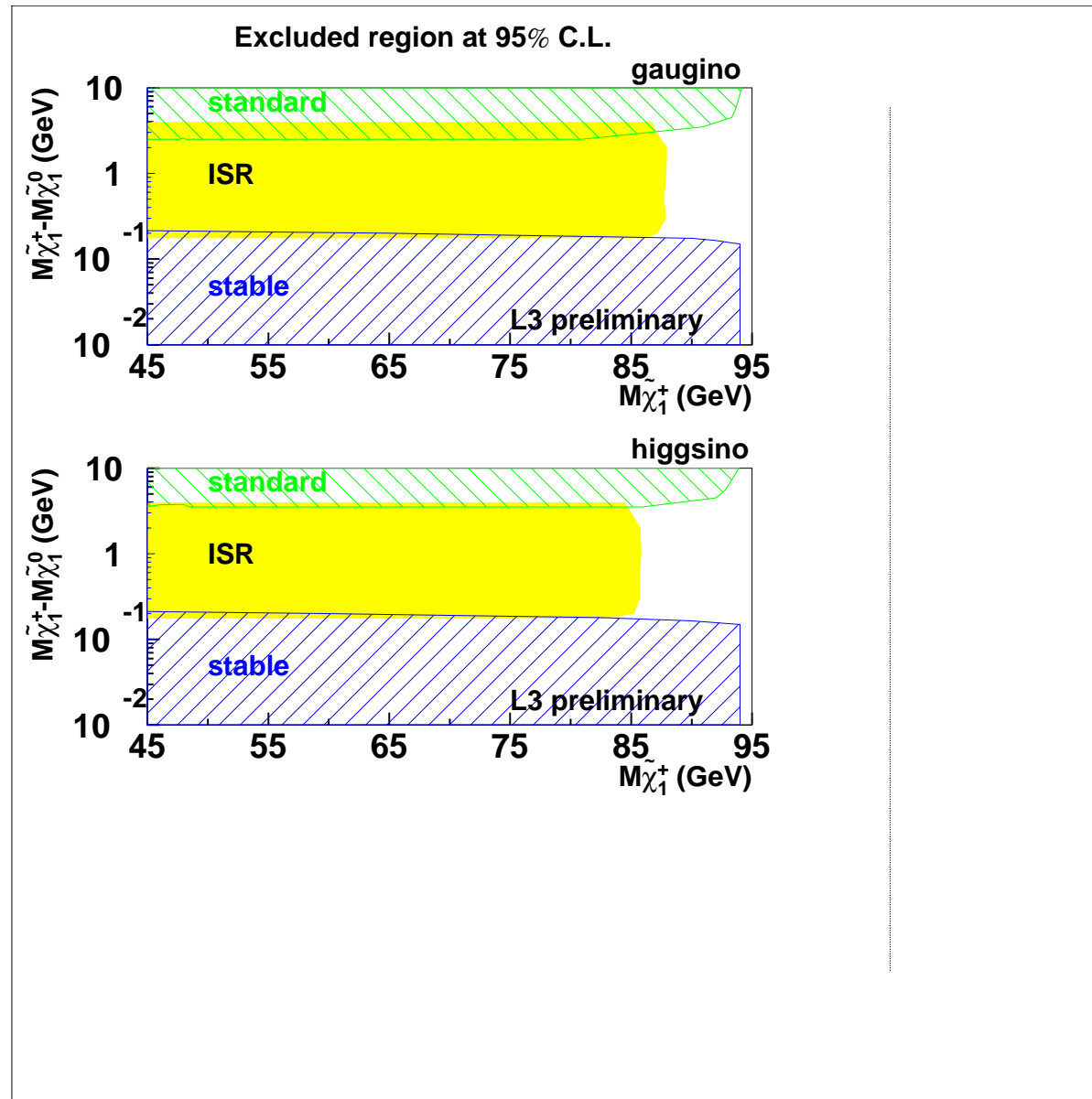
Signal event properties and backgrounds depend on:  $\Delta M = M_{\tilde{p}} - M_{\chi}$



# Cross section limits

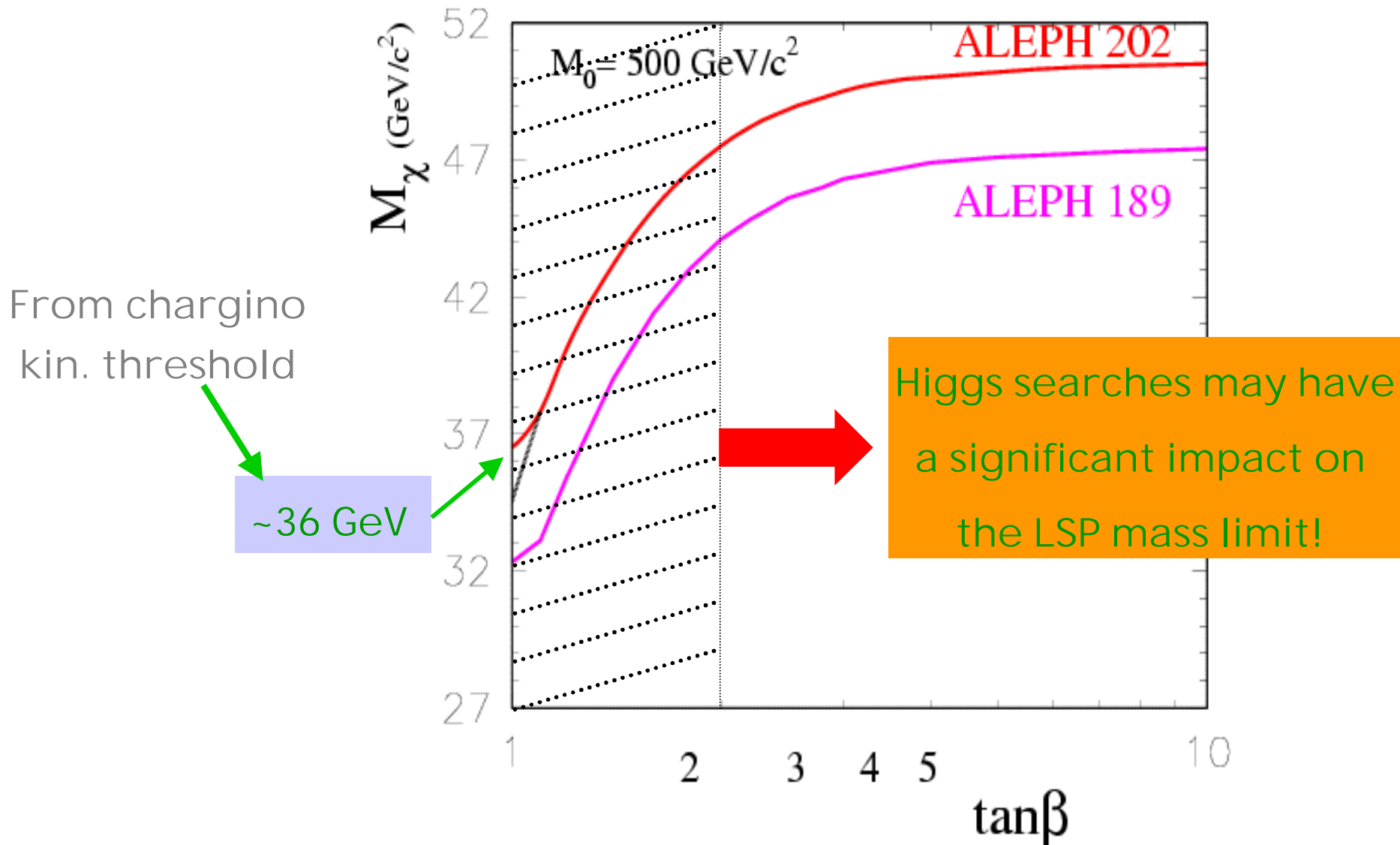


# Covering the small $\Delta M$ region



# The LSP mass limit

ALEPH PRELIMINARY



## *Other searches...*

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- Invisible Higgs decays, fermiophobic Higgs
- Squarks/sleptons, GMSB with stau as NLSP
- Heavy stable particles
- Excited leptons
- Deviations from SM in 2-f processes
- Anomalous TGC's

# LEP in Y2K - Ultimate reach

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202 GeV : Successful operation in 1999

204 GeV : Pilot run ( $\sim 10\text{nb}^{-1}/\text{expt}$ ) in 1999

206 GeV : Seems possible in 2000 (obtained in tests)

208 GeV : Optimistic? (but not out of question...)

>210 GeV : forbidden by French law!!!

- Standard Model Higgs

Sensitive up to  $\sim (E_{\text{cm}} - M_Z) \rightarrow 114 \text{ GeV}/c^2$

- Charginos

Sensitive up to  $\sim E_{\text{cm}}/2 \rightarrow 104 \text{ GeV}/c^2$

- MSSM Higgs

$h, A$  close to  $95 \text{ GeV}/c^2$

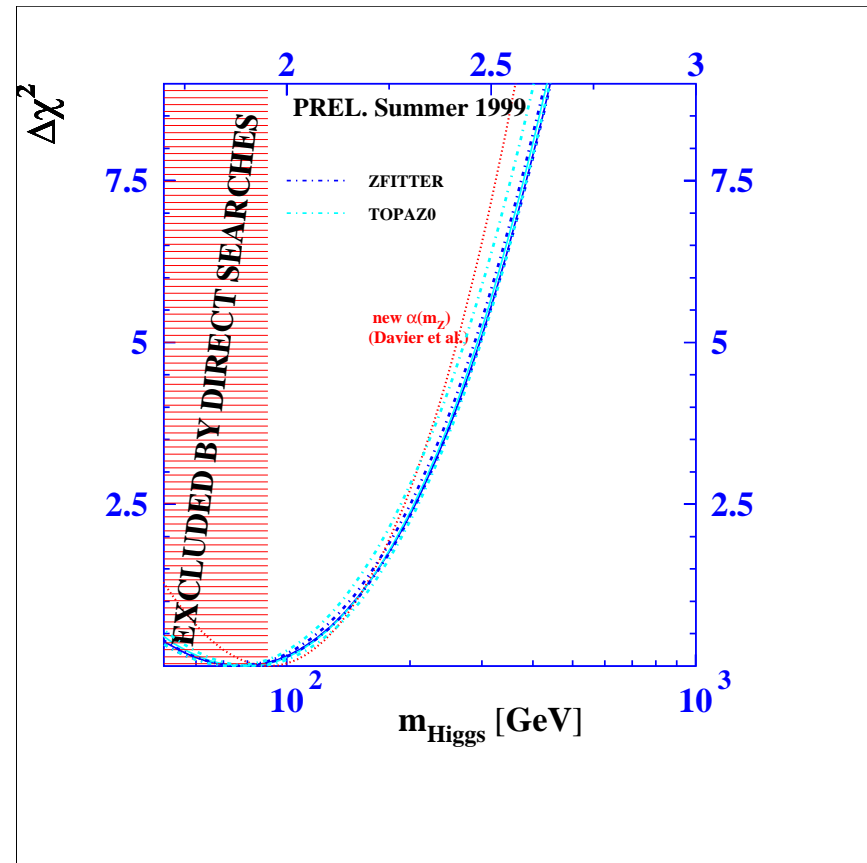
charged Higgs: sensitivity above  $M_W$

# If no Higgs at LEP?

LEP's last contribution to the Higgs search is the indirect determination of its mass using the most precise W mass to that date!



"Ball" passed to Fermilab!



If central value of  $M_H$  stays as is now, strong motivation for both Tevatron and LHC to prepare for the most difficult Higgs hunt:

$$M_H \sim 130 \text{ GeV}/c^2$$



# Summary

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- 1999: a year of excitement and good results
- ... but negative results!

An outstanding year for LEP concludes  
a decade of a successful experimental program  
of leading research!!!

Not too late to reward  
it with a discovery!!!