LEPC 9-Nov-1999

DELPHI Status Report

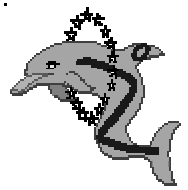
Presented by Jesús Marco
IFCA Santander

OPERATION @200-202 GeV

PRELIMINARY RESULTS: SM OVERVIEW & SEARCHES

PROSPECTS FOR 2000

Operation at 200-202 GeV

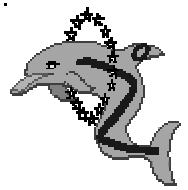


- Luminosity on tape:
  - 125.4 pb^{-1} collected with efficiency ~93%
  - 84.3pb^{-1} @200 GeV + 41.1pb^{-1} @202 GeV

    (+ 0.04 pb^{-1} @ 204 GeV)
- Total collected luminosity in 1999: 232.2 pb^{-1}
  - 25.9 pb^{-1} @192 GeV
  - 76.9 pb^{-1} @196 GeV
  - plus 3.95 pb^{-1} at Z^0 peak

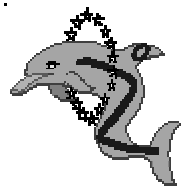
THANKS TO THE LEP GROUP!

Operation at 200-202 GeV



- *Thanks to LEP extremely good background conditions, a gain in efficiency is obtained:*
  - *starting before PHYSICS*
  - *earlier ramping volts*
  - *reduced "run paused"*
- *Major events:*
  - *incident with control system of our magnet (only 3 fills lost)*
  - *suffered a lot from quality of electricity distribution (broken control card in HV transformer affected electronics...)*
    CLEAR WORRY!

Luminosity



Detector Performance

- *Detector was not opened during 98/99 shutdown, alignment very good after 2.5 pb^{-1} at Z^0 peak, so since the beginning of high energy data taking!*
- *VD stable and efficient!*

Average efficiencies:

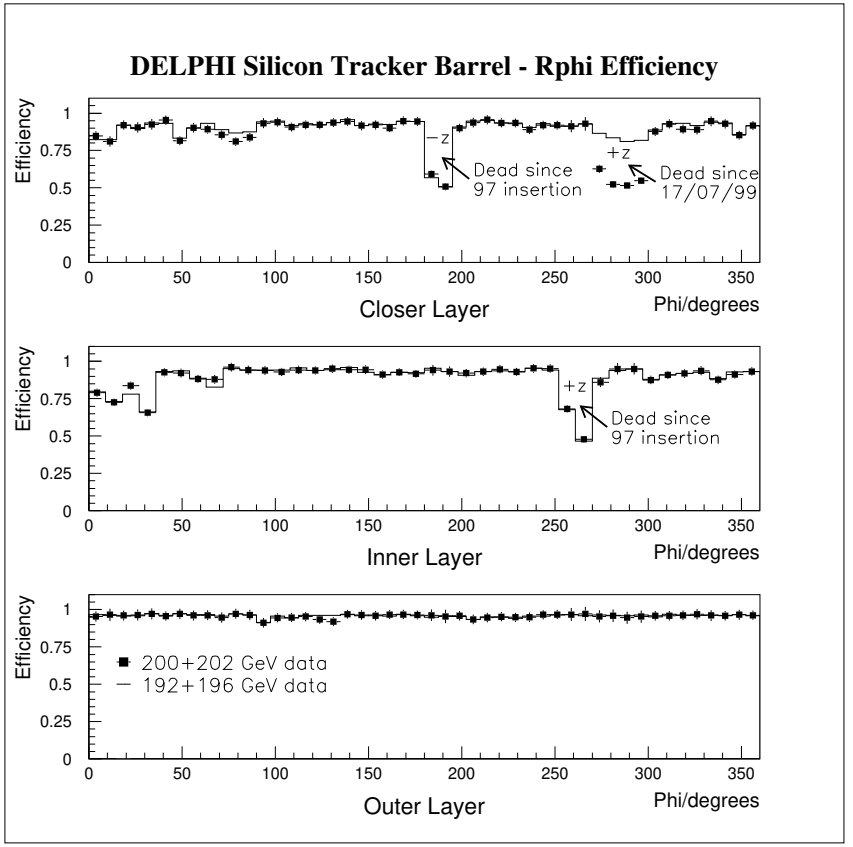
Rϕ:Closer layer 86%

Inner layer 89%

Outer layer 96%

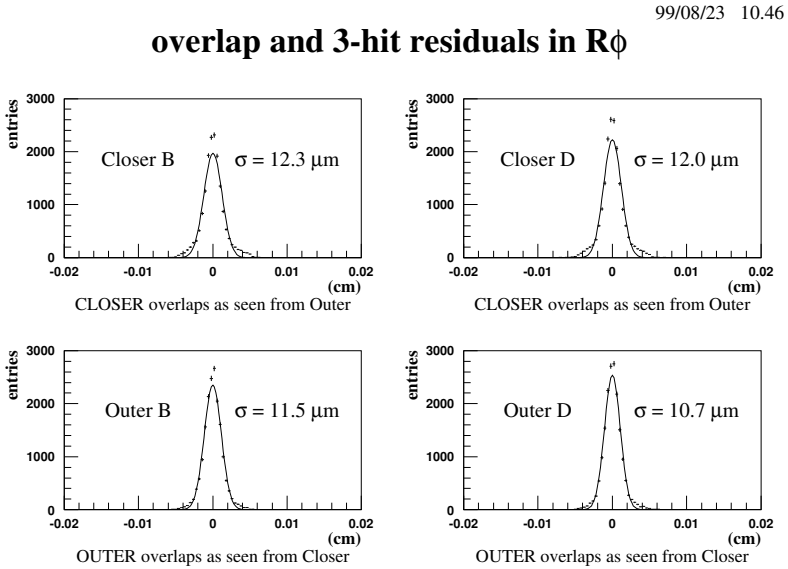
z: Closer layer 79%

Outer layer 85%

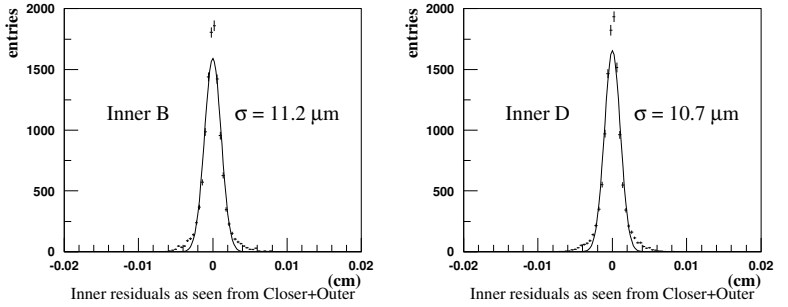


VD Resolution

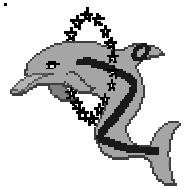
- *Excellent!*



→ *intrinsic resolution/layer ~9 μ*

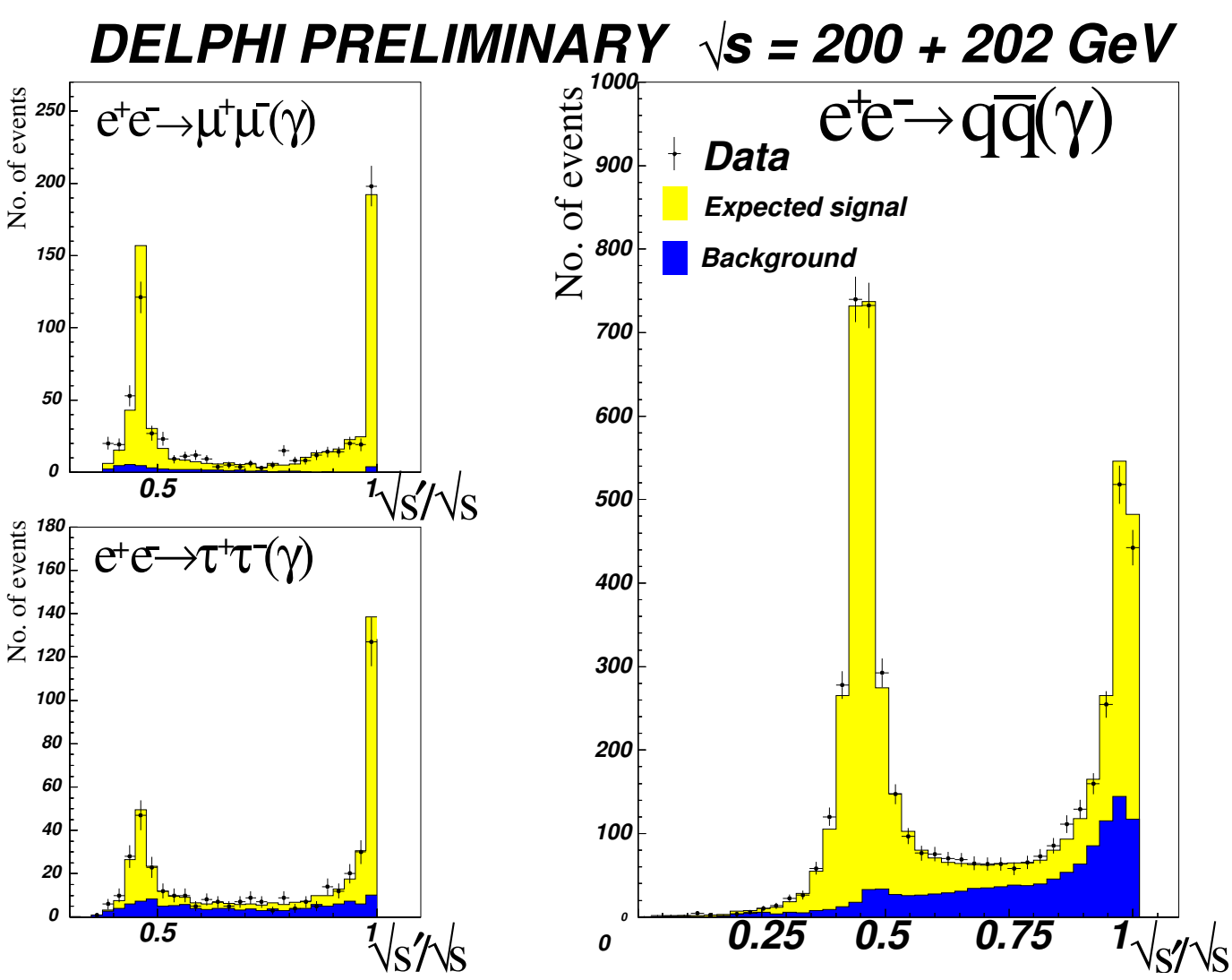


SM Overview @192-202 GeV

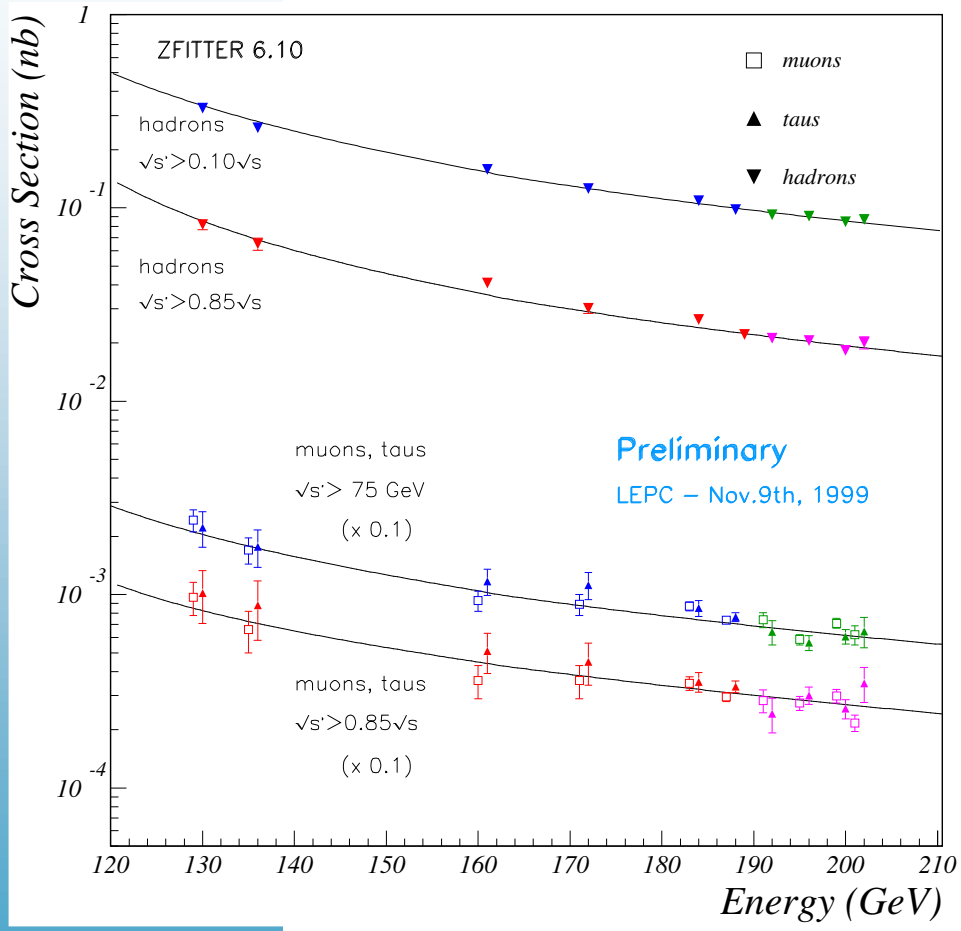


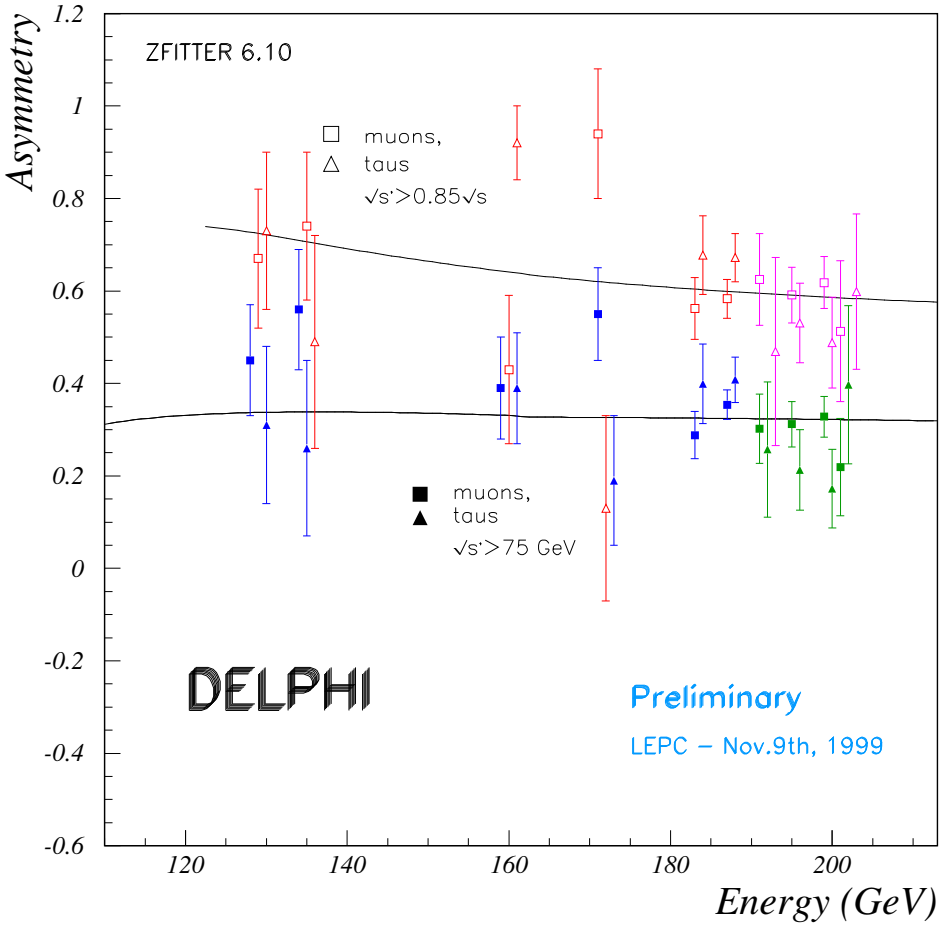
- Fermion-pair production
- Coplanar photons
- Double radiative return
- WW cross section and mass spectrum
- Four-fermion events:
  - ZZ cross section
  - eeqq events

Fermion-pair production



Fermion-pair production

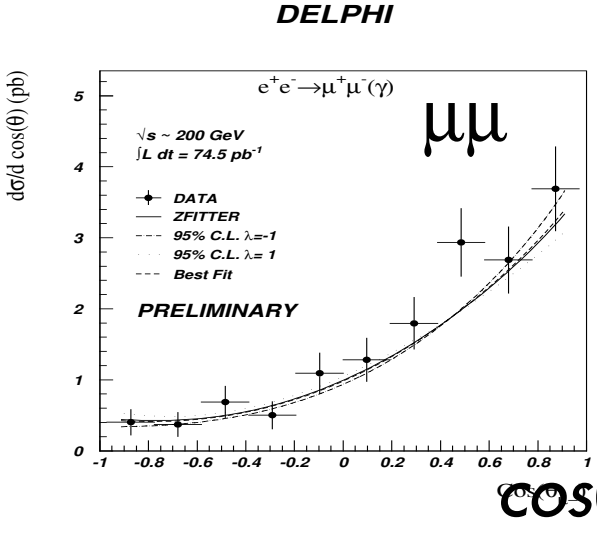


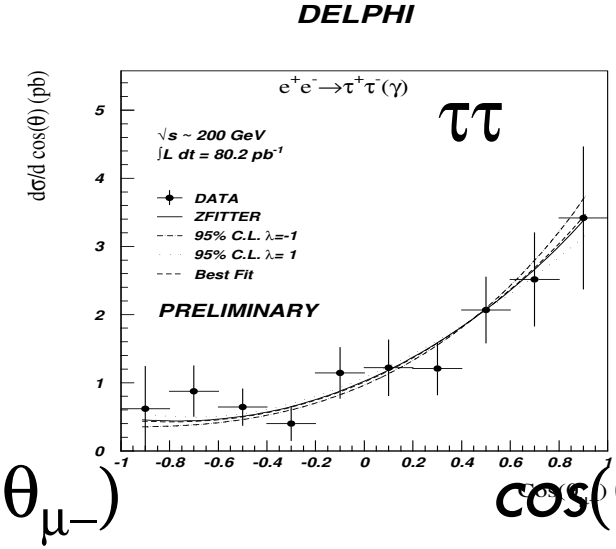


- Cross-section
- F-B Asymmetry

Fermion-pair production: μμ,ττ

Gravity in Extra Dimensions





Fit $\mu^+\mu^-$, $\tau^+\tau^-$ angular distributions at all 1999 energies.

Differential cross section

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\cos\theta} = A(\cos\theta) + B(\cos\theta)[\frac{\lambda}{\mathrm{M_s^4}}] + C(\cos\theta)[\frac{\lambda}{\mathrm{M_s^4}}]^2,$$

Limits on $\mathrm{M_s}$

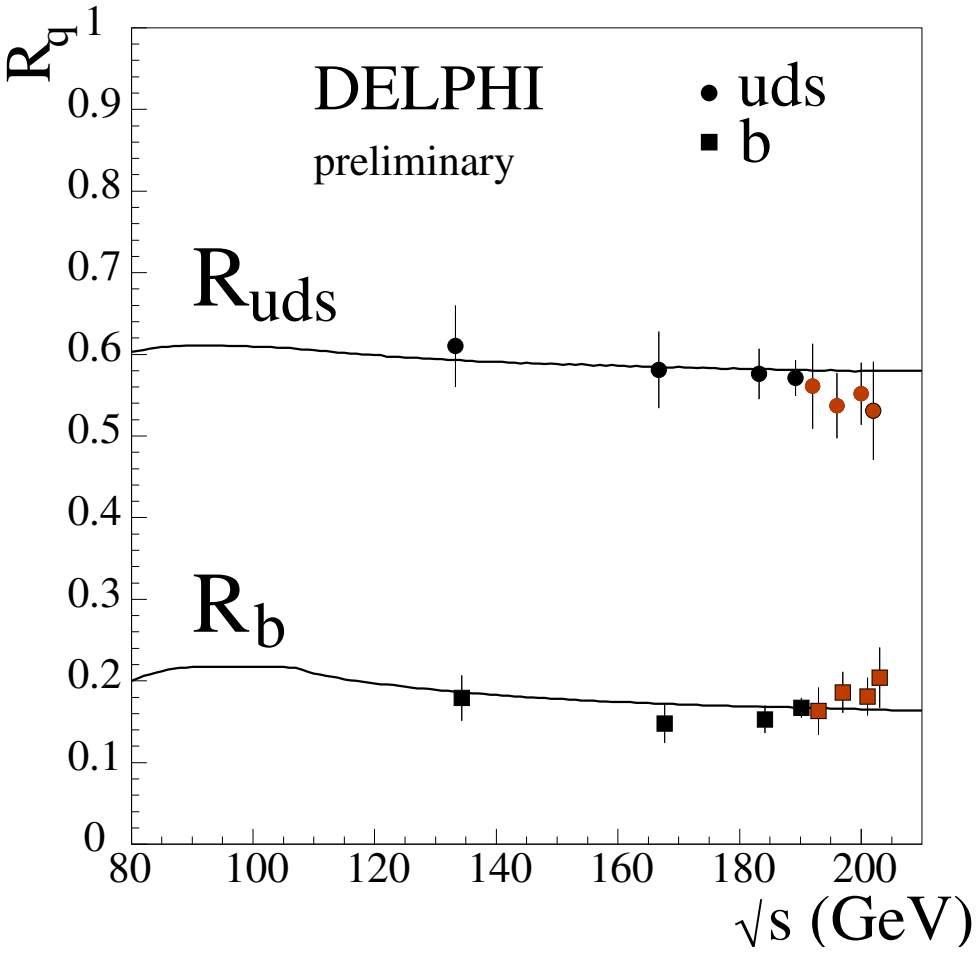
$\mathrm{M_s} > 667\mathrm{GeV} \quad (\lambda = -1)$

$\mathrm{M_s} > 707\mathrm{GeV} \quad (\lambda = +1)$

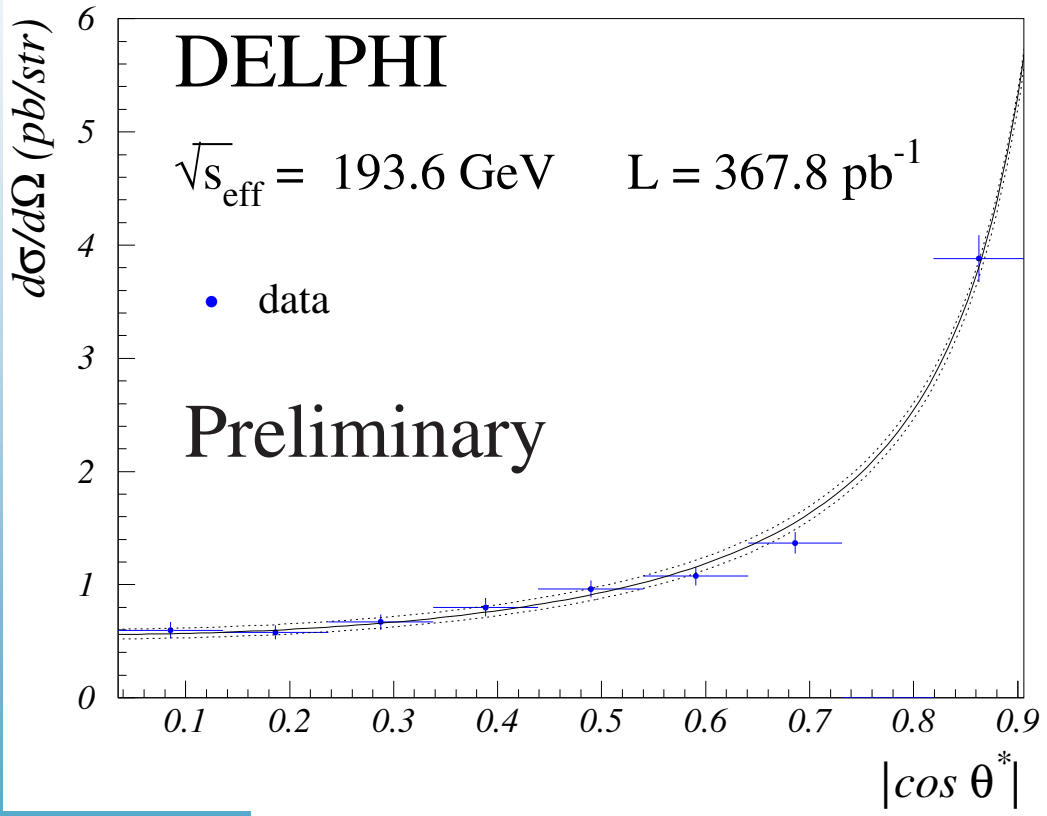
M_s eff.Planck scale

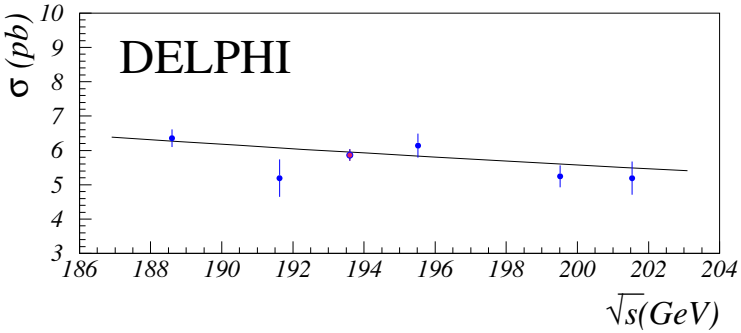
λ interference parameter

Fermion-pair flavour tag



Coplanar Photons





Good agreement with QED prediction

Limits on gravity in extra-dimensions:

M_S >615 GeV/c^2 (λ=+1)

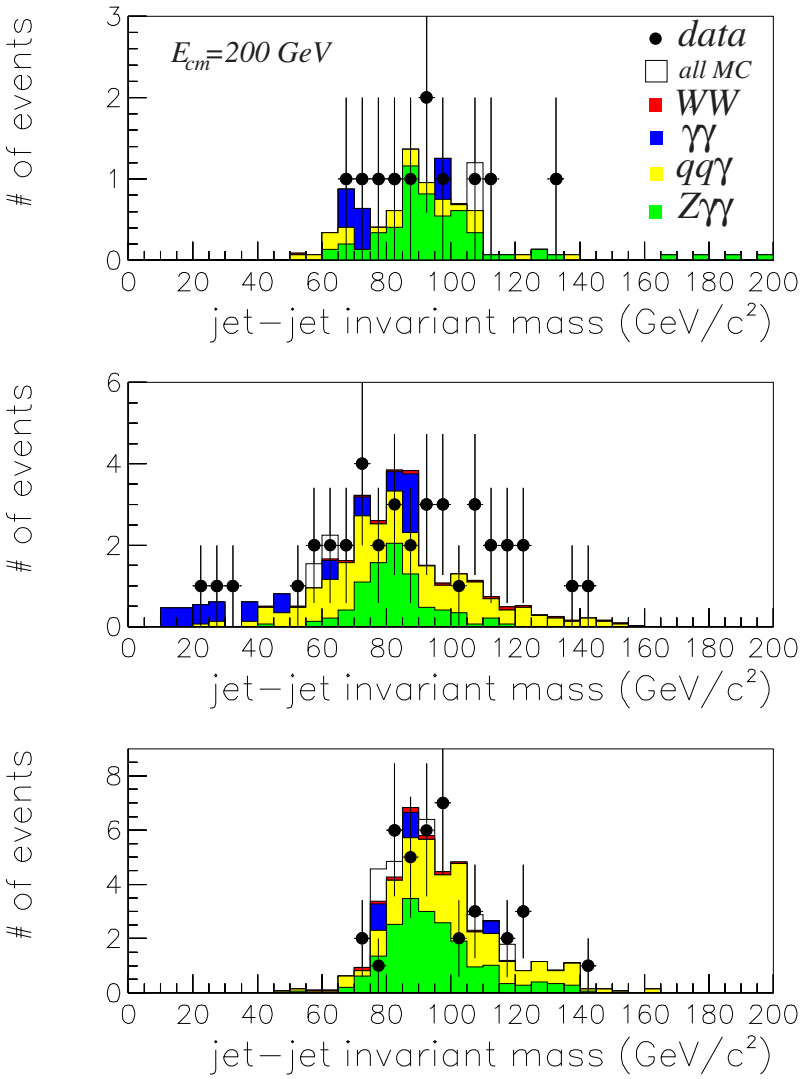
M_S >703 GeV/c^2 (λ=-1)

Double radiative return to Z

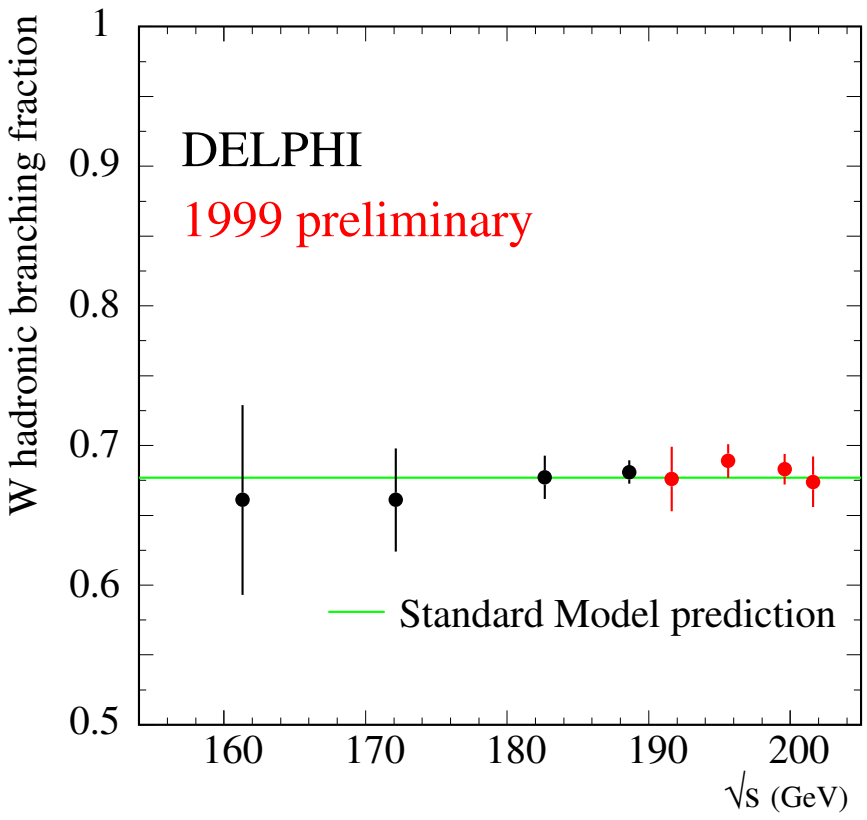
Three cases for symmetric double radiative return

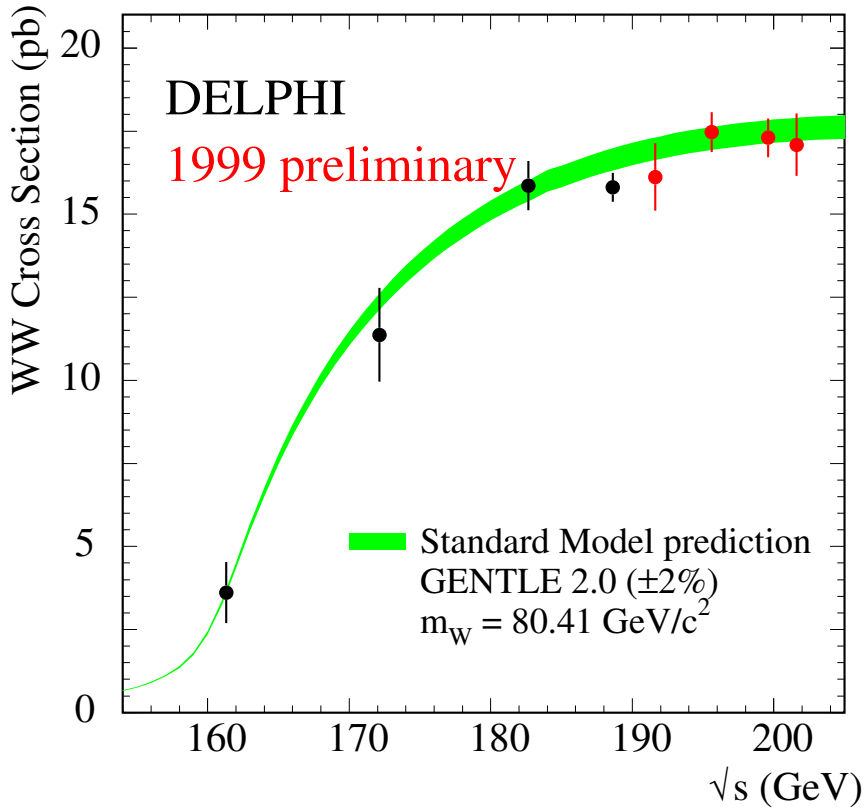
- *Both photons detected*
  ($3^\circ<\theta_\gamma<177^\circ$)
  $\sigma=0.27\pm0.06$ pb
- *Only one photon seen*
  $\sigma=1.03\pm0.27$ pb
- *Both photons lost in the beam pipe*
  $\sigma=1.59\pm0.31$ pb
  ($\sigma_{th}=1.29$ pb *)

*A.B.Arbuzov's preliminary result (quasi-real electron approximation and ZFITTER)



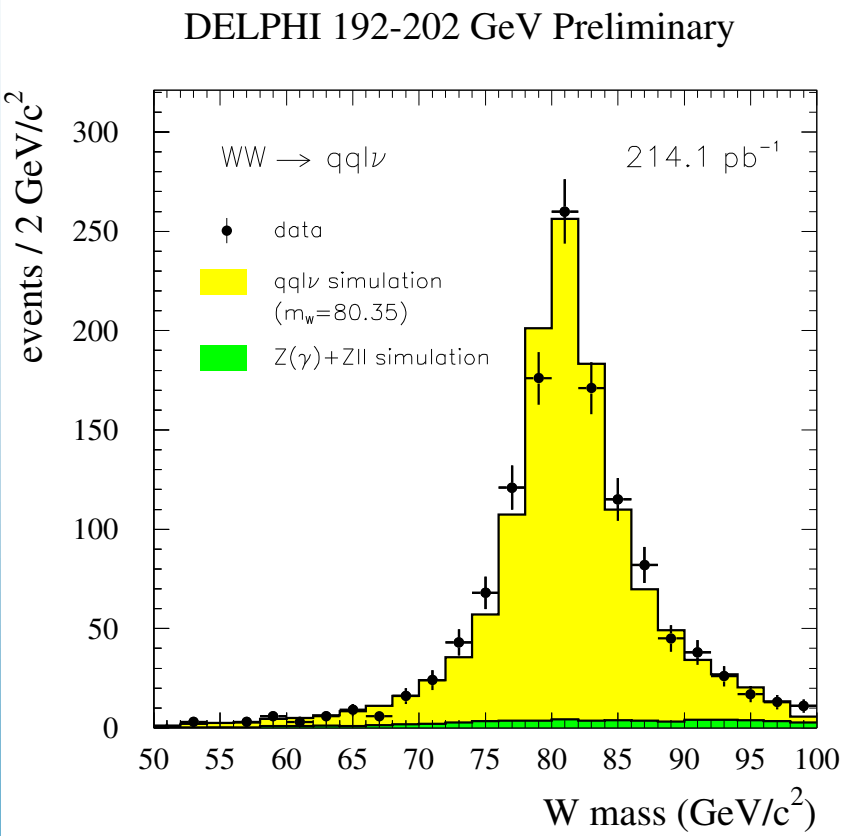
WW cross section

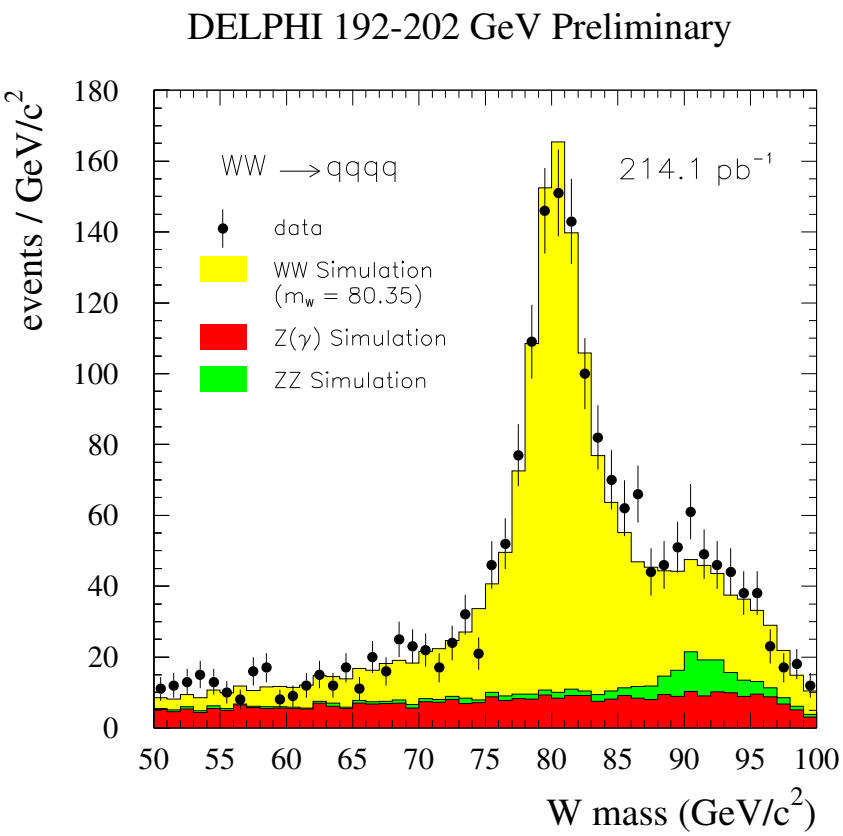




- W hadronic BR
- WW cross section

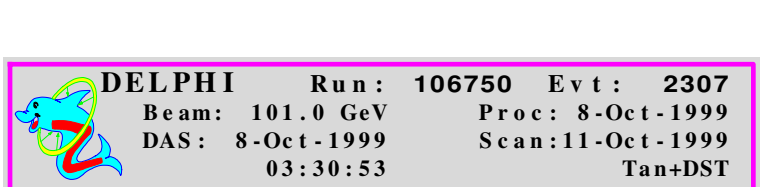
W mass spectrum

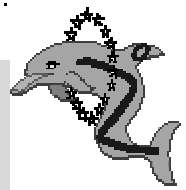


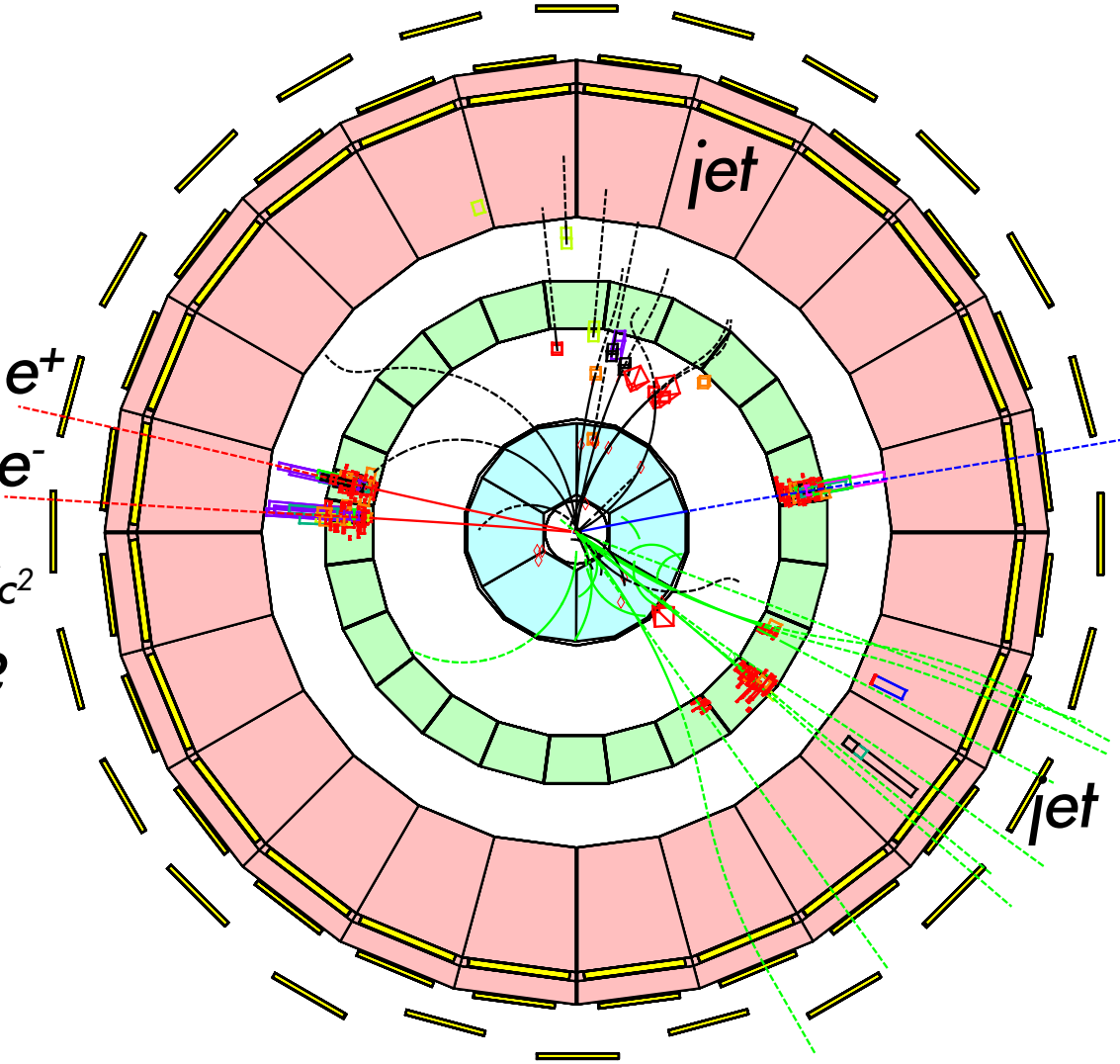


- *Semileptonic channel*
- *Fully hadronic channel*

A NICE EVENT







$E=29$ GeV e^+

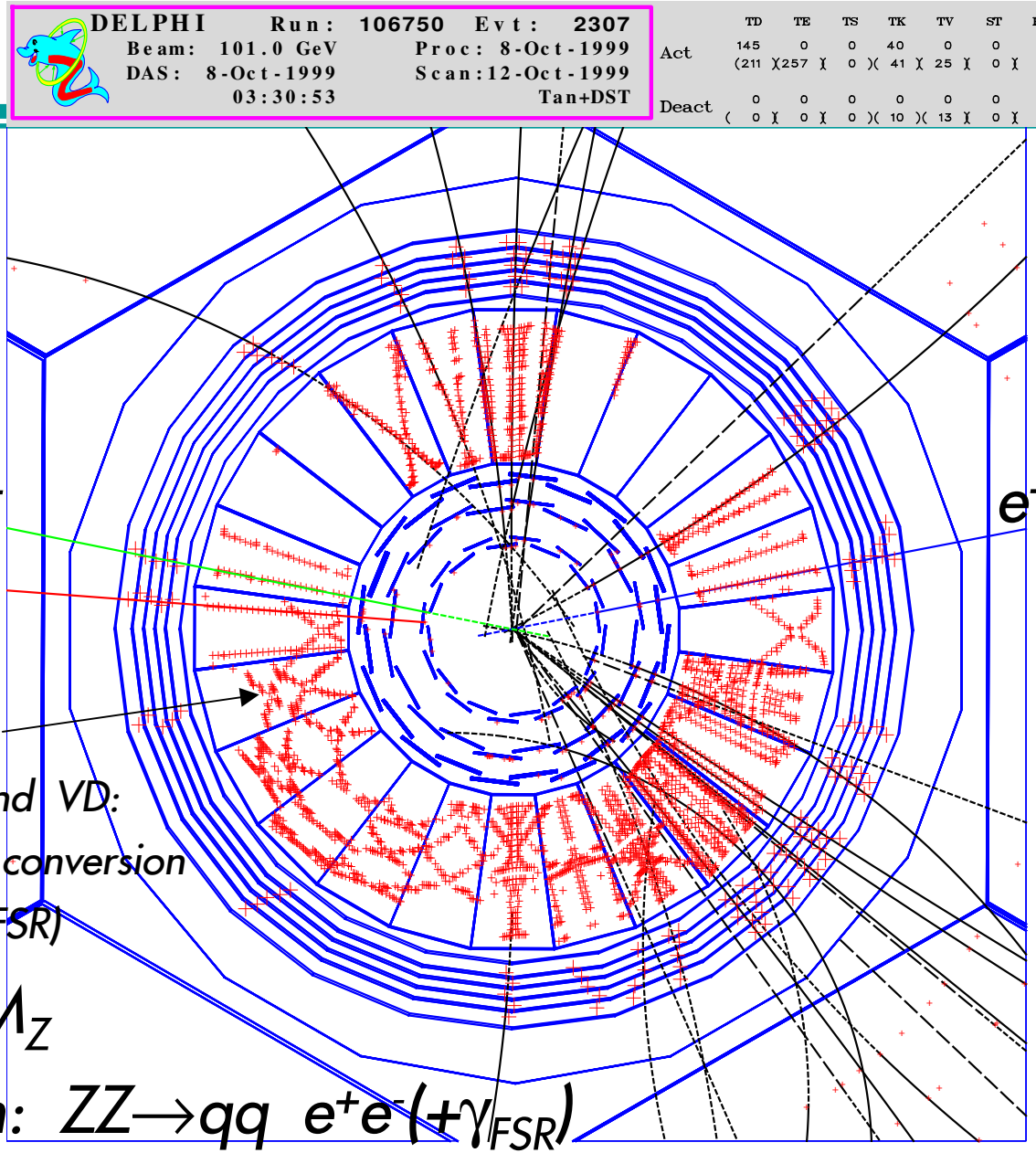
$E=42$ GeV e^-

$M(e^+e^-)=3.8$ GeV/c^2

γ^* ?

e^+ $E=30$ GeV

A ZZ EVENT



E=29 GeV e^+

E=42 GeV e^-

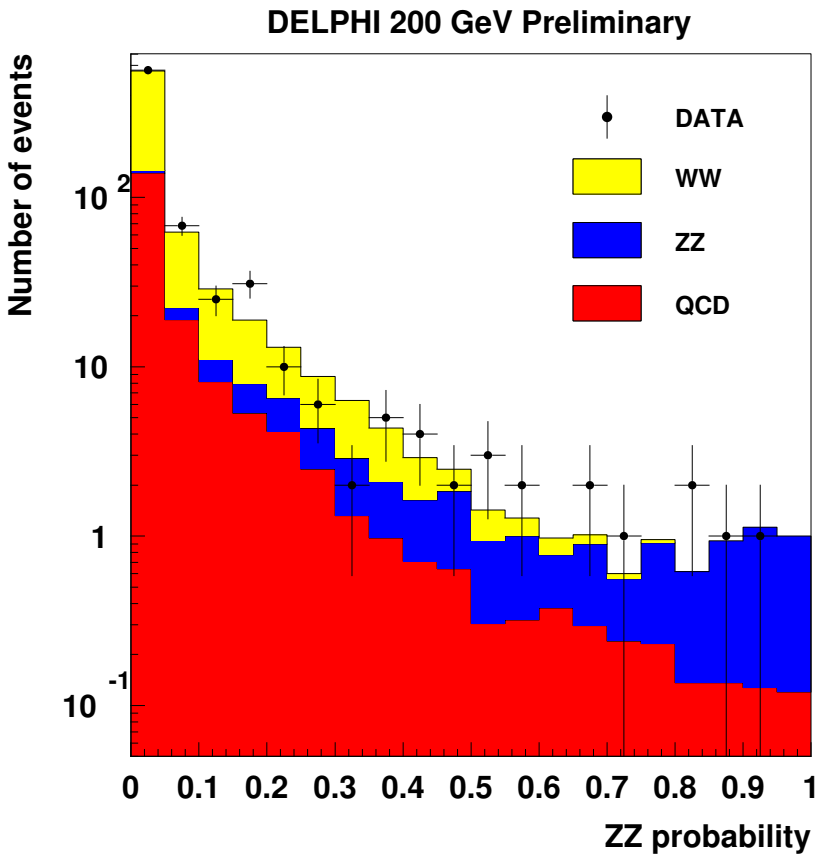
e^+ *E=30 GeV*

low energy electron only visible in ID and VD: asymmetric gamma conversion in the beam pipe (FSR)

$M(e^+e^-e^+) \sim M_Z$

Interpretation: $ZZ \rightarrow qq\ e^+e^-(+\gamma_{FSR})$

ZZ analysis



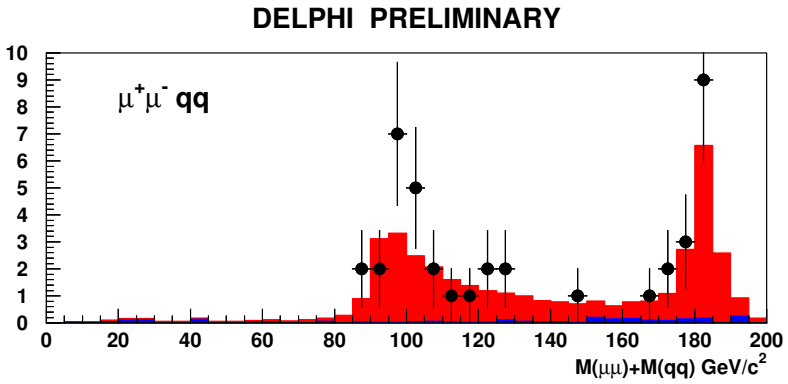
- *ZZ probability in qqqq analysis*

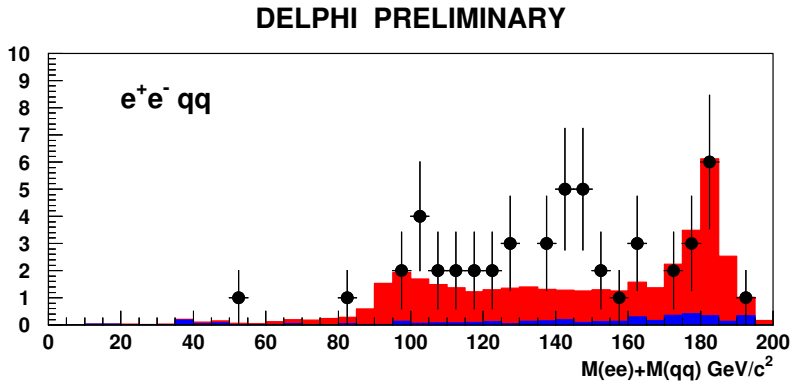
- *ZZ mass region*
- *Improved qqqq*
  - *probabilistic analysis based on ideogram techniques*
  - *sensitive to all flavours*
  - *four or five jet configurations*
- *qqνν I.D.A.*
- *$l^+l^-l^+l^-$: 1 event (4-μ event)*
- *llνν*

ZZ analysis

- *qqll channel is clean and efficient:*

	data	MC	signal	(efficiency)
qqμμ	5	5.6	5.2	87%
qqee	6	5.4	4.8	71%

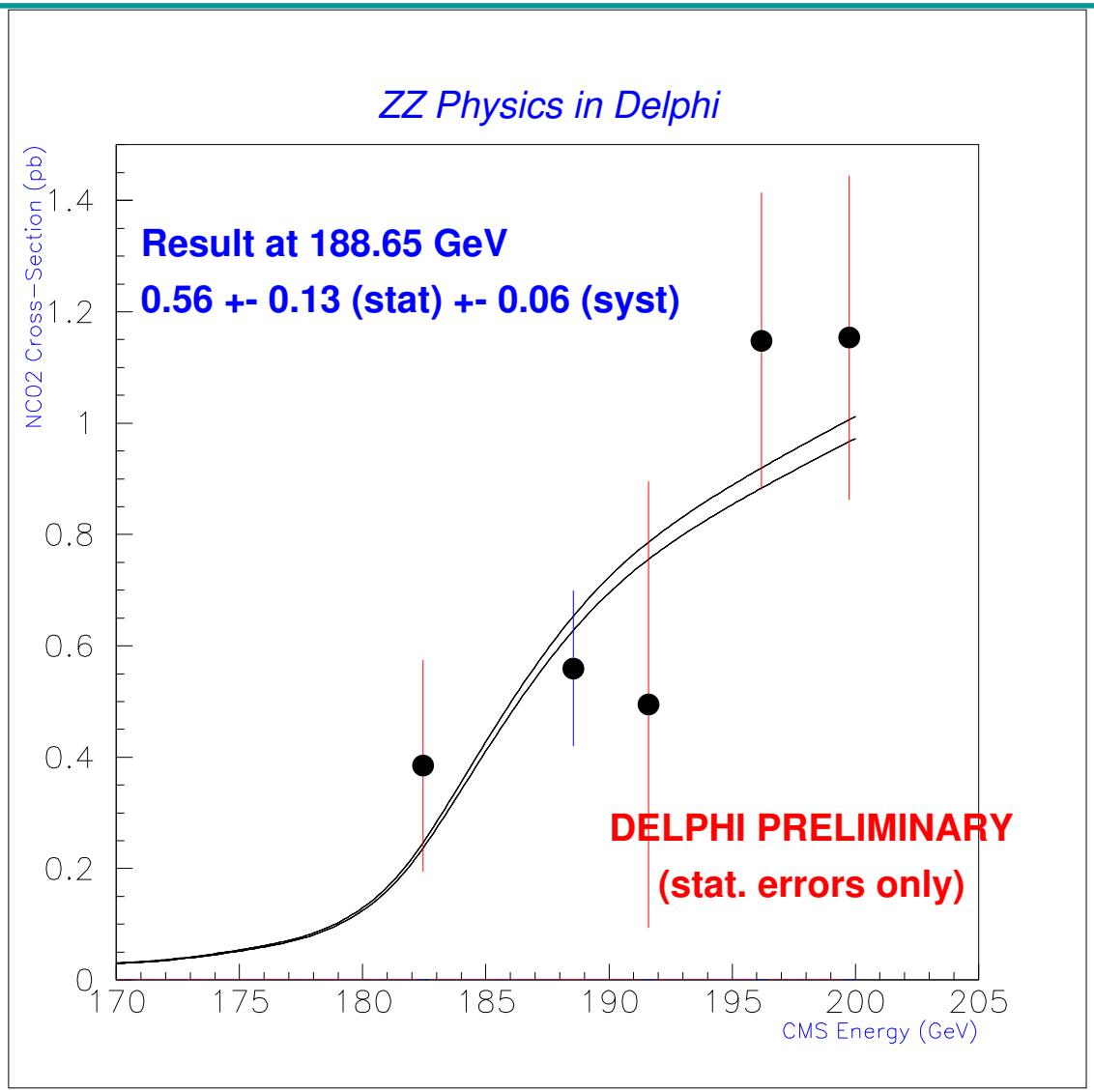




" ZZ+Zγ* "

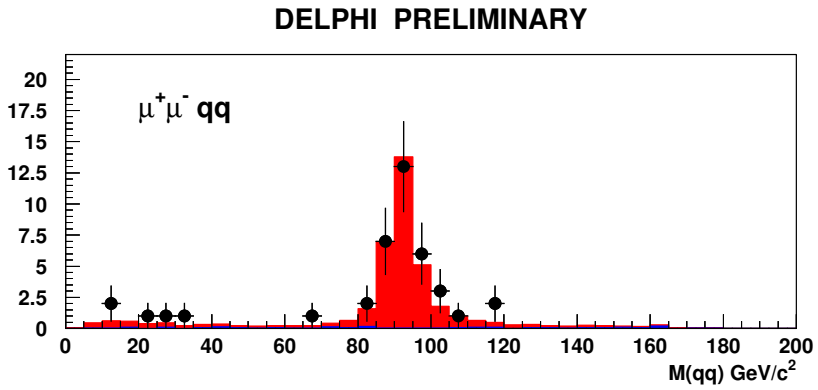
" ZZ+Zγ*+Zee "

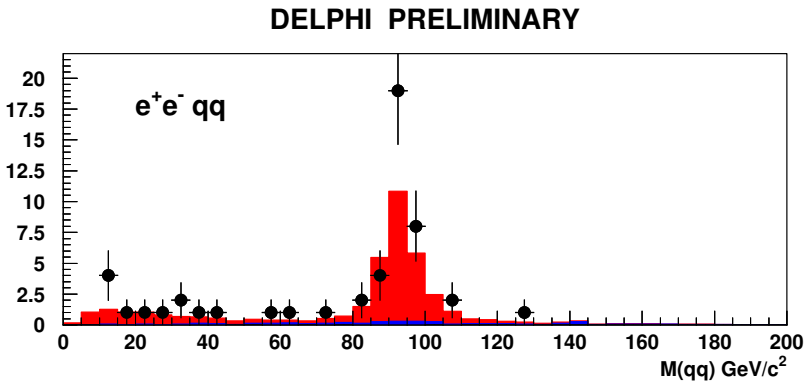
ZZ cross section



llqq events at LEP2

- DELPHI has more than 400 pb^{-1} collected at LEP2
- Check of the mass spectrum:

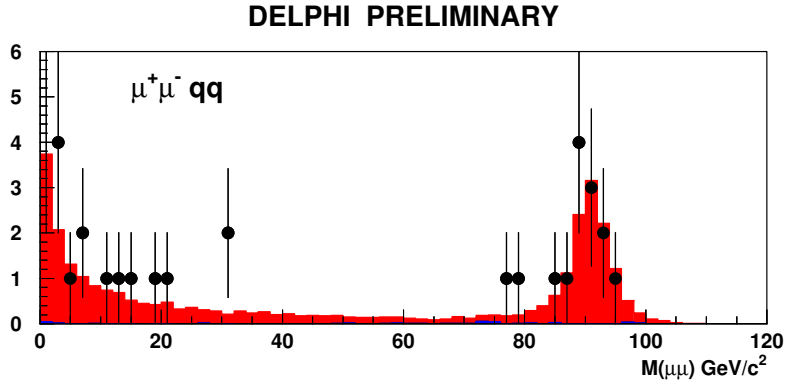


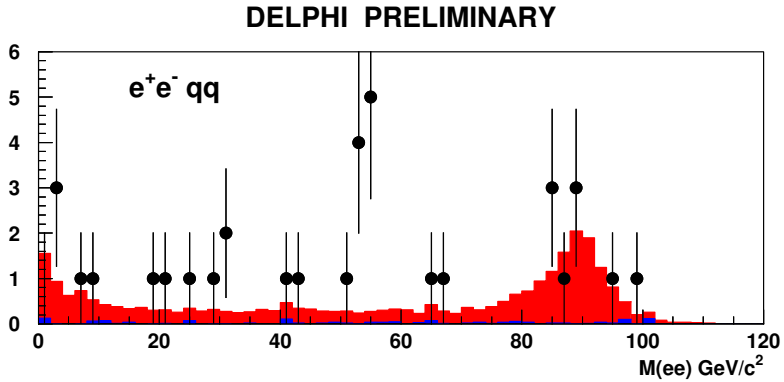


M_{qq} (after 4C-fit)

llqq events at LEP2

- *Excess in eeqq, when $M_{qq} \sim M_z$: check M_{ee}*





M_{ll} *(with* M_{qq} *in Z region)*

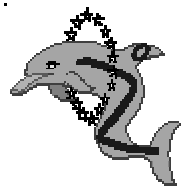
eeqq events at LEP2

M_{ll} window	μμqq		eeqq	
(GeV/c^2)	data	MC	data	MC
0-20	15	11.8	7	6.2
20-80	5	6.2	19	9.7
80-120	12	12.4	9	11.6

- Resolution in M_{ee} (after 4C-fit) is ~1.7 GeV/c^2
- 10 events seen in three neighbouring mass bins [50-56] GeV/c^2 (with contribution from different years)
- Expected background is 0.79±0.06 events

But...

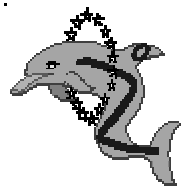
eeqq events at LEP2



- Angular distribution and charge asymmetry follow expected Standard Model behaviour
- Work and cross-checks are going on...

DELPHI sees this effect as a good example where a collaborative LEP effort can help to progress, having in mind next year situation.

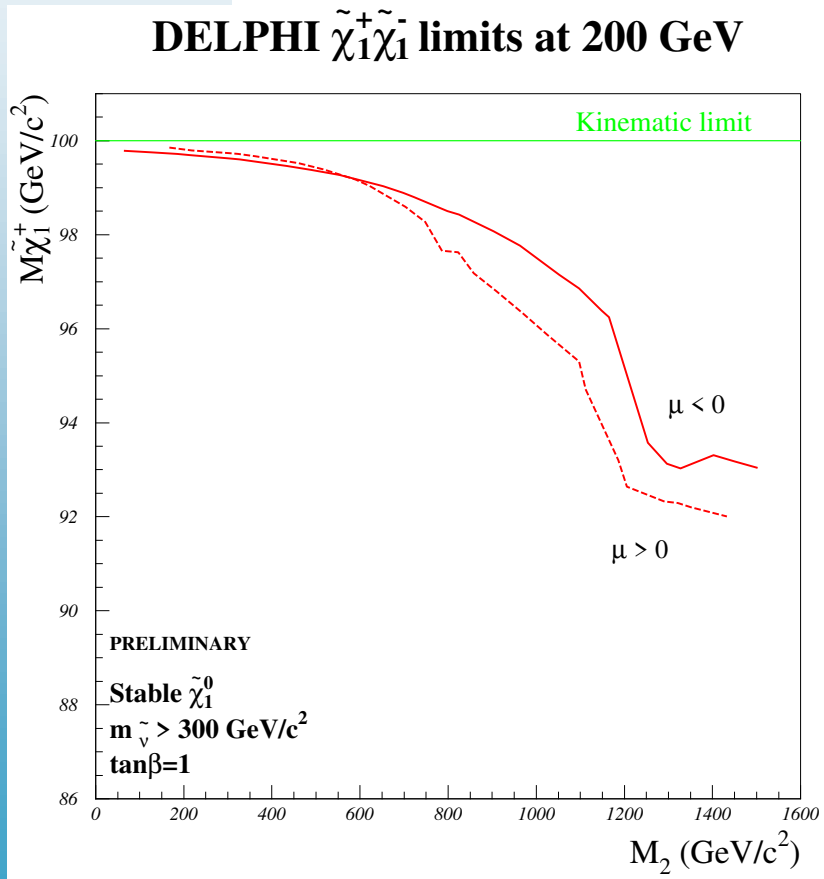
Searches: preliminary results



- Charginos
- s-top & s-bottom
- s-leptons
- Asymmetric τ pairs
- Photon events with missing energy
- Higgs search:
  - hZ channel and limit on the SM Higgs
  - hA search
  - Charged Higgses analysis

Search for Charginos

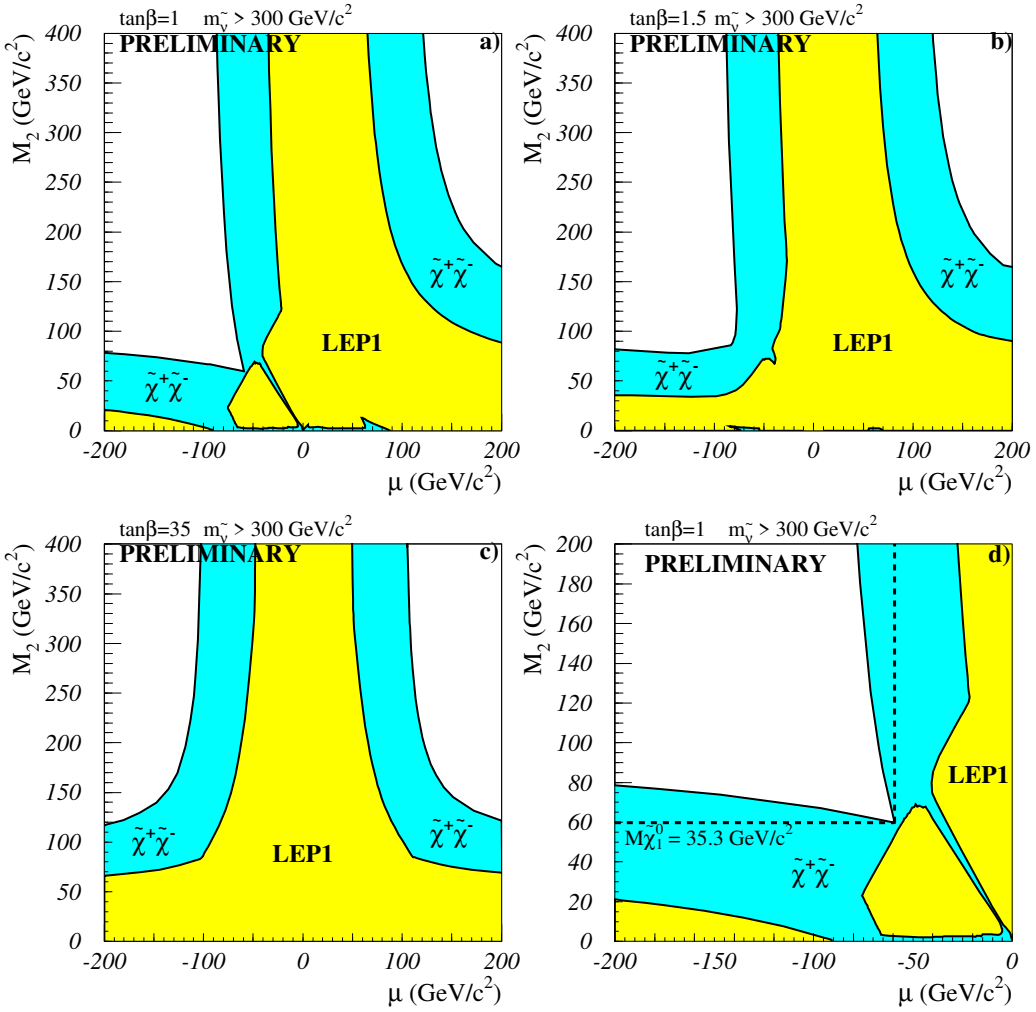
- *Analysis in stable and unstable neutralino scenarios at E_{cm}=192, 196, 200 and 202 GeV. No evidence of signal.*



Case	$m_{\tilde{\nu}}$ (GeV/c^2)	$M^{min}_{\tilde{\chi}^\pm}$ (GeV/c^2)	σ^{max} (pb)
STABLE $\tilde{\chi}_1^0$ Ecm=196-200 GeV			
ΔM>20 GeV/c^2	>300	99.6	0.20
ΔM>10 GeV/c^2	>300	99.4	0.26
ΔM>3 GeV/c^2	>41	92.0	1.45
UNSTABLE $\tilde{\chi}_1^0$ Ecm=202 GeV			
ΔM>10 GeV/c^2	>300	99.7	0.44
ΔM=1 GeV/c^2	>41	100.4	0.24

Search for Charginos

DELPHI MSSM limits at 200 GeV

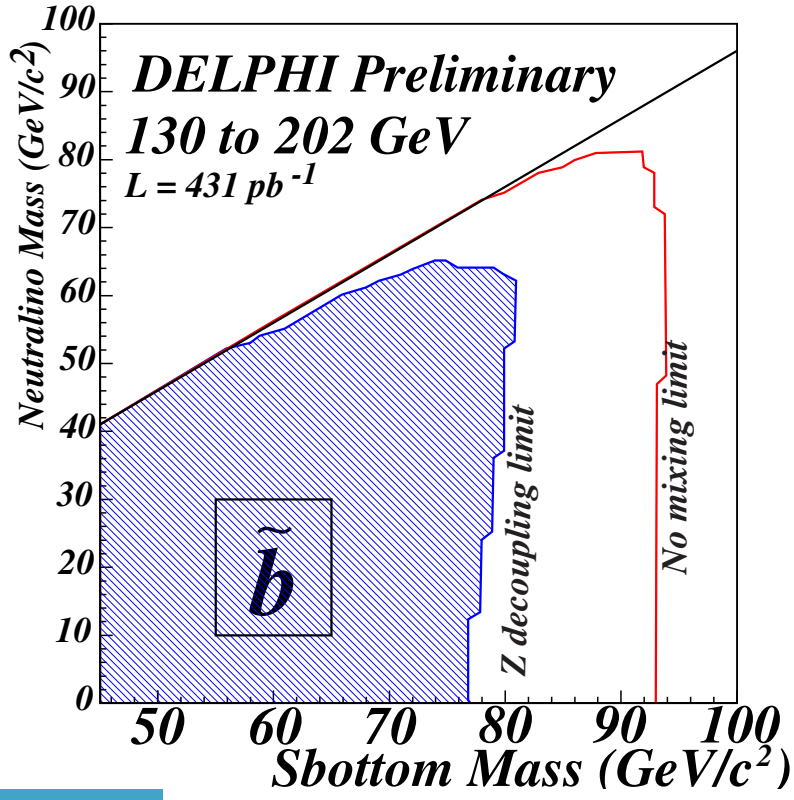


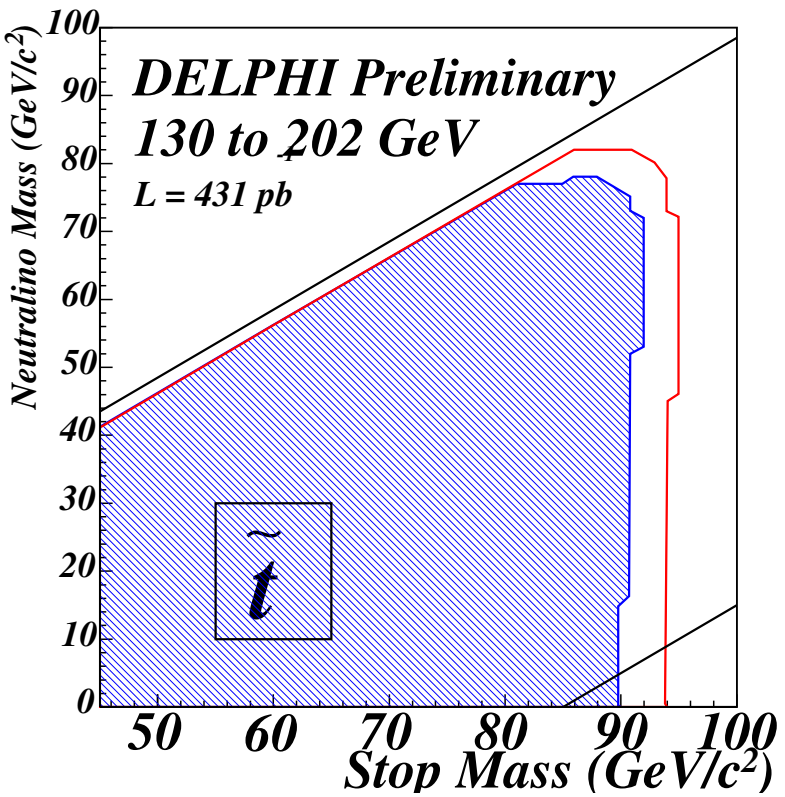
Regions excluded at 95% C.L.in the (μ,M_2)plane at E_{cm}=200 GeV under the assumption of a heavy sneutrino

$$M(\tilde{\chi}_1^0) > 35.3 GeV/c^2$$

Squarks

- Both analyses ($\tilde{t}\to c\tilde{\chi}^0$, $\tilde{b}\to b\tilde{\chi}^0$) optimized for cases $\Delta M<10$ and $\Delta M>10$
- No excess of selected events, limits improved.

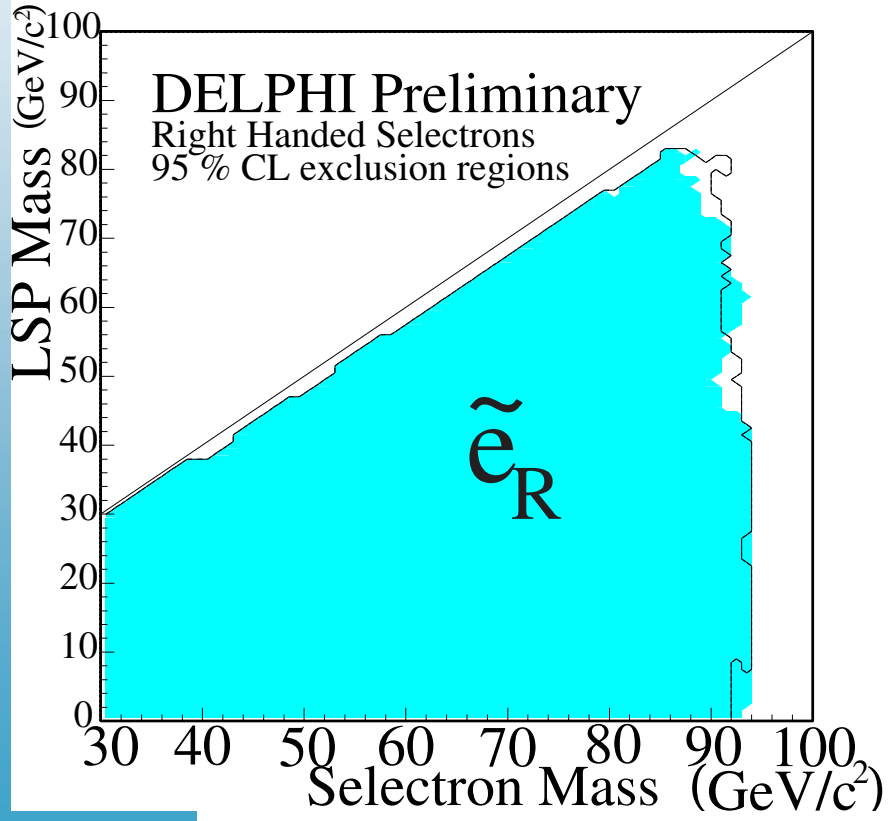


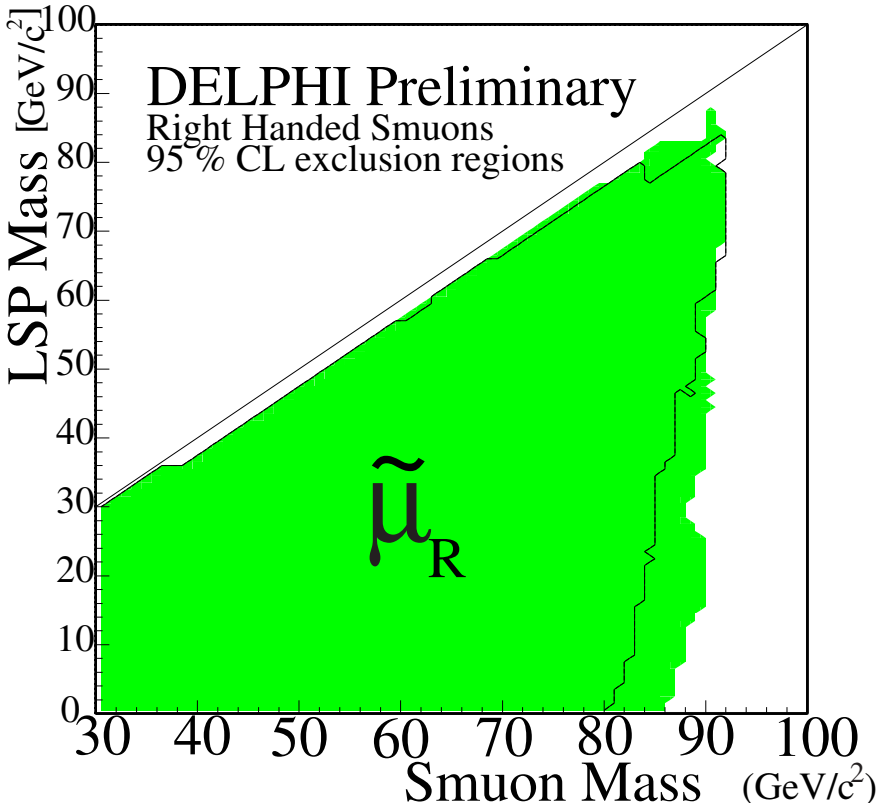


Sleptons

- Number of selected events in agreement with SM predictions
- New limits: LSP mass -Slepton mass plane (for tanβ=1.5 and μ=-200)

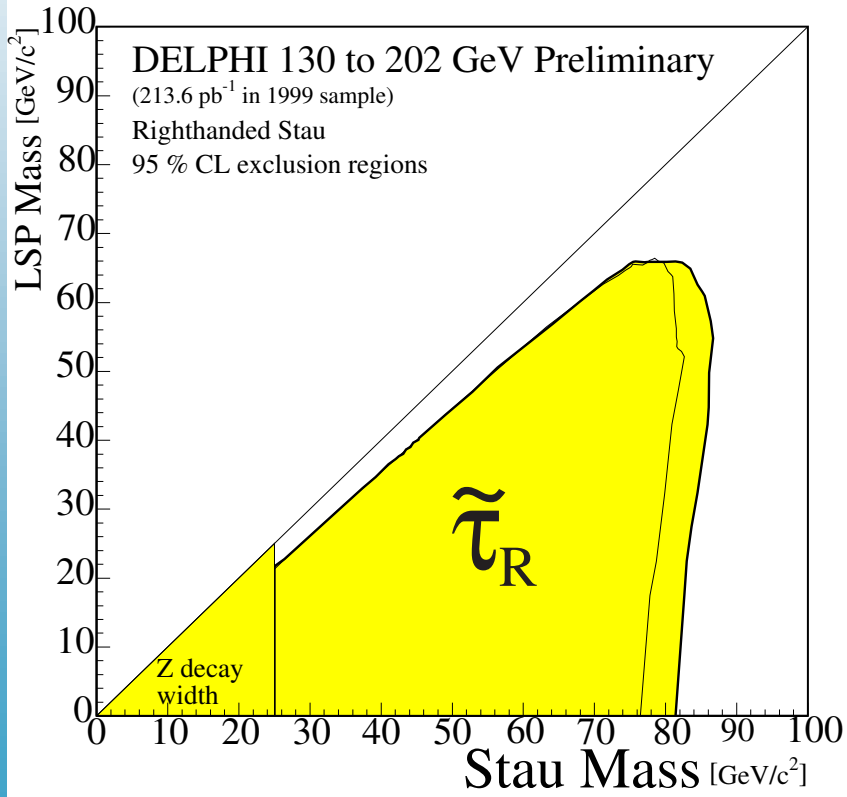
$M_{\tilde{e}_R} > 91$ GeV/c^2 (for $\Delta M > 10$ GeV/c^2) $M_{\tilde{\mu}_R} > 85$ GeV/c^2 (for $\Delta M > 6$ GeV/c^2)

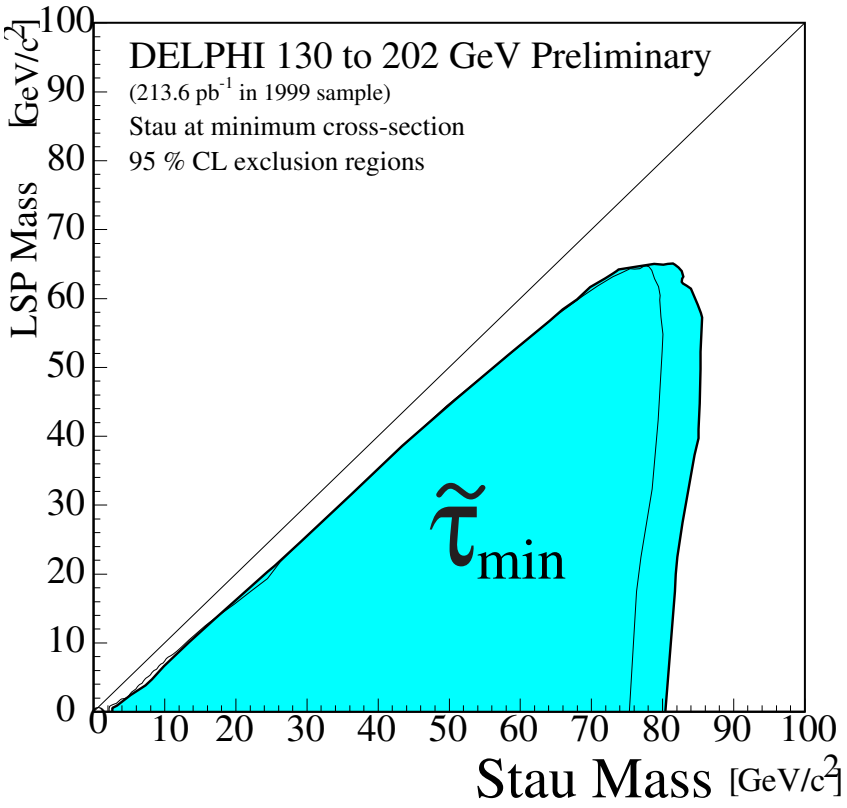




Staus

- *Number of observed events as expected from SM background*
- *Limits for right-handed and minimal mixing stau production*

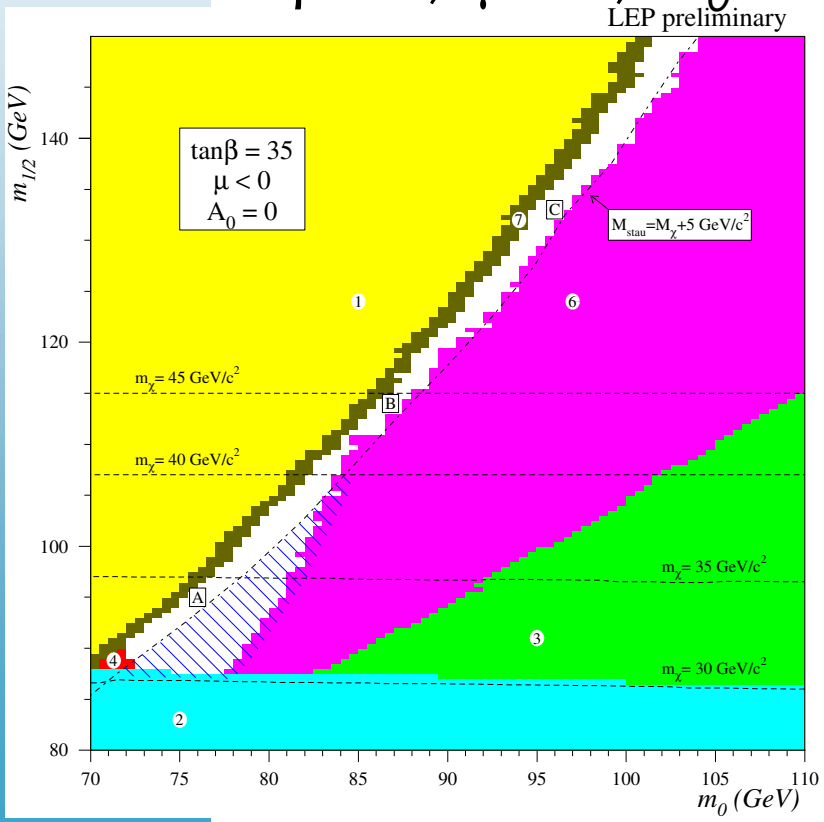




Asymmetric τ pairs

- *Interpretation in Minimal SUGRA (LEPSUSY WG):*

  ex: tanβ=35, μ<0 , A_0=0



- $\tilde{\tau}$ *mixing caveats at large tanβ*

$$\tilde{\chi}_1^+ \rightarrow \tilde{\tau}^+ \nu_\tau$$
$$\tilde{\tau}^+ \rightarrow \tilde{\chi}_1^0 \tau^+$$

- *If* $M(\tilde{\tau}) - M(\tilde{\chi}^0) < 5 GeV/c^2$

searches for charginos and staus are blind! and if tanβ large, selectron cannot help

- *How to cover this unexplored strip at large tanβ in mSUGRA?*

Asymmetric τ pairs

- Use: $e^+e^- \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0$

$$\tilde{\chi}_2^0 \rightarrow \tilde{\tau}_1^+ \tau^-$$
$$\hookrightarrow \tilde{\chi}_1^0 \tau^+$$

$$M(\tilde{\chi}_2^0) - M(\tilde{\tau}_1) >> M(\tilde{\tau}_1) - M(\tilde{\chi}_1^0)$$

- Search for a pair of asymmetric τ:

  $10 < E_1 < 50$, $E_2/E_1 < 0.15$

  Acoplanarity > 20°

- Analysis at 189 GeV:

  4 events selected

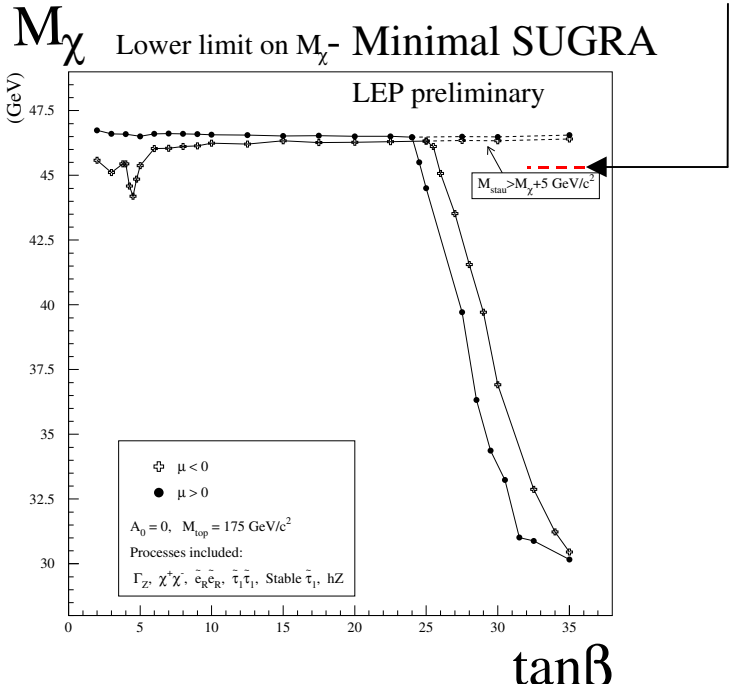
  2.8±0.7 expected

  mean eff~17%

- DELPHI limit at 95% CL:

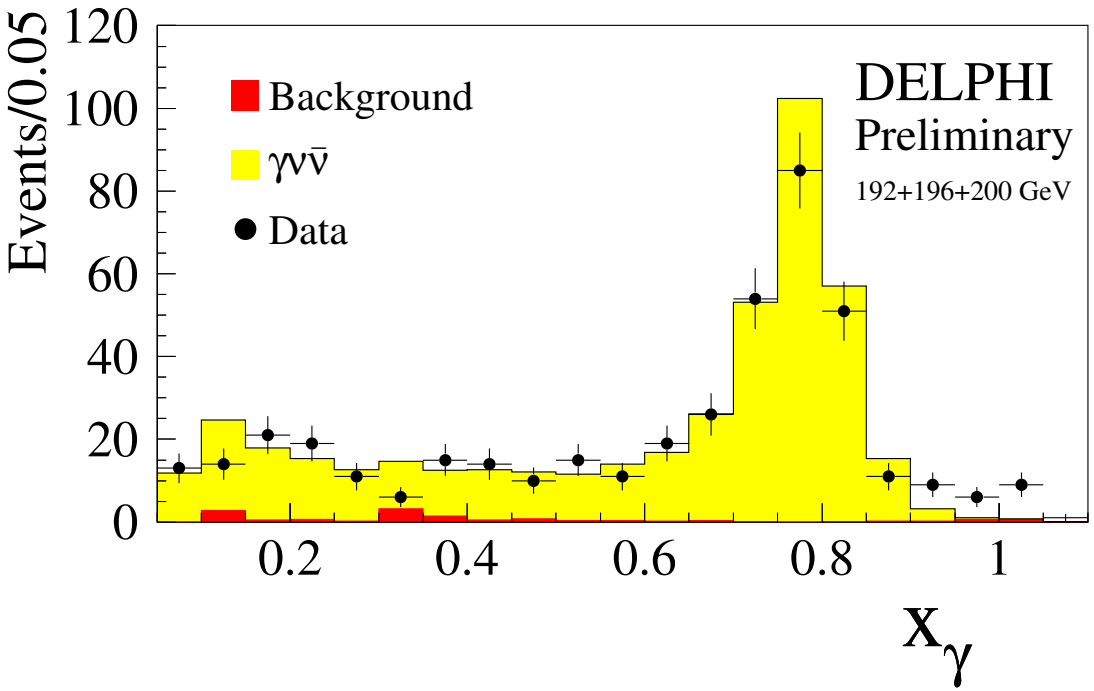
$$\sigma(e^+e^- \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^0) < 0.25\,pb$$

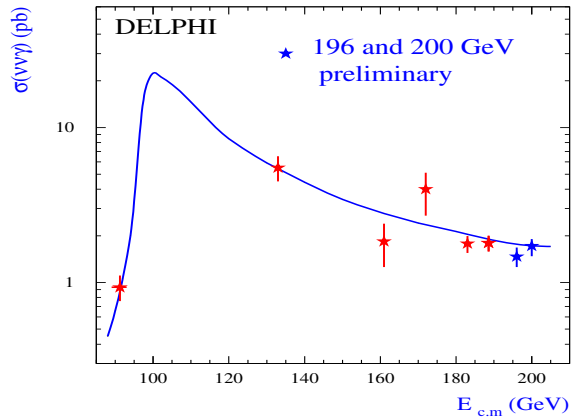
in the strip, translates into a lower limit $M_{LSP} > 45.5$ GeV/c^2

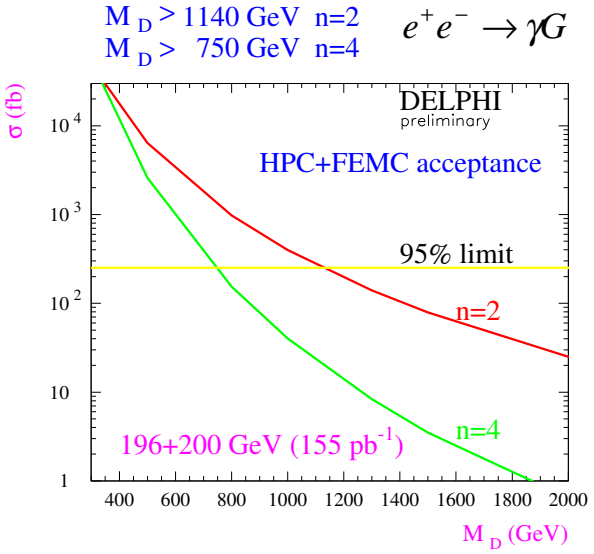


Single Photon Events

- *Check ννγ cross section and derive limits on new physics*



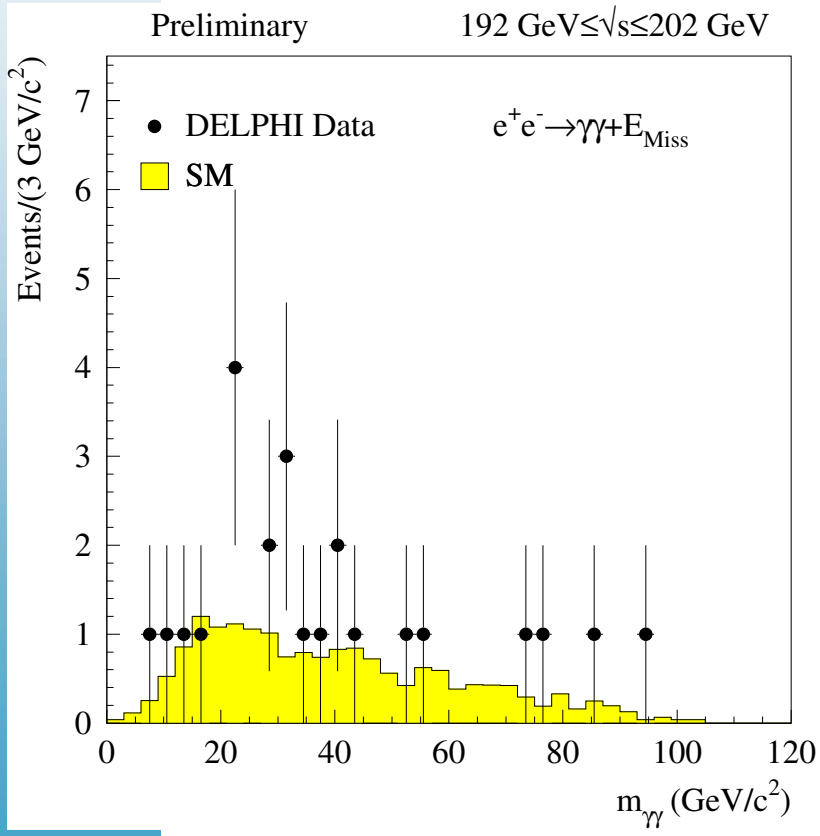


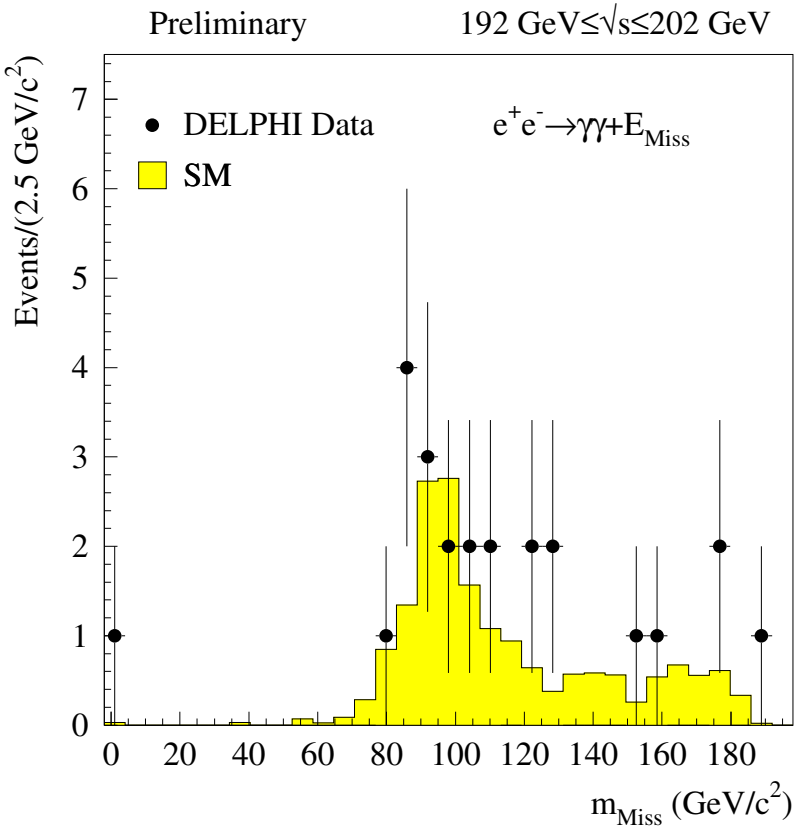


- *STIC + FEMC + HPC*

Two Photons + Missing Energy

- *Preselection level: at least two acoplanar γ with x_γ>0.05*
  (check agreement with SM ννγγ(γ) prediction from KORALZ)

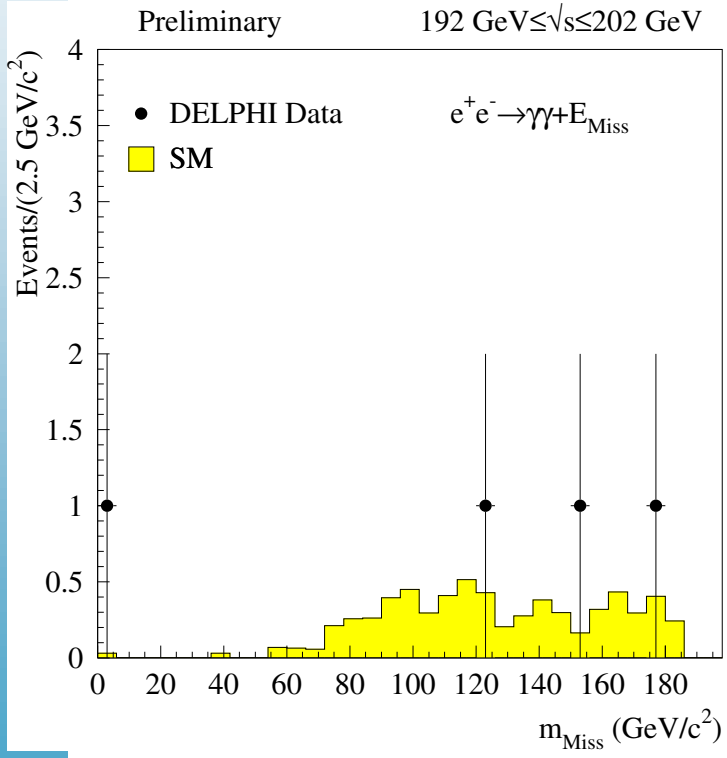


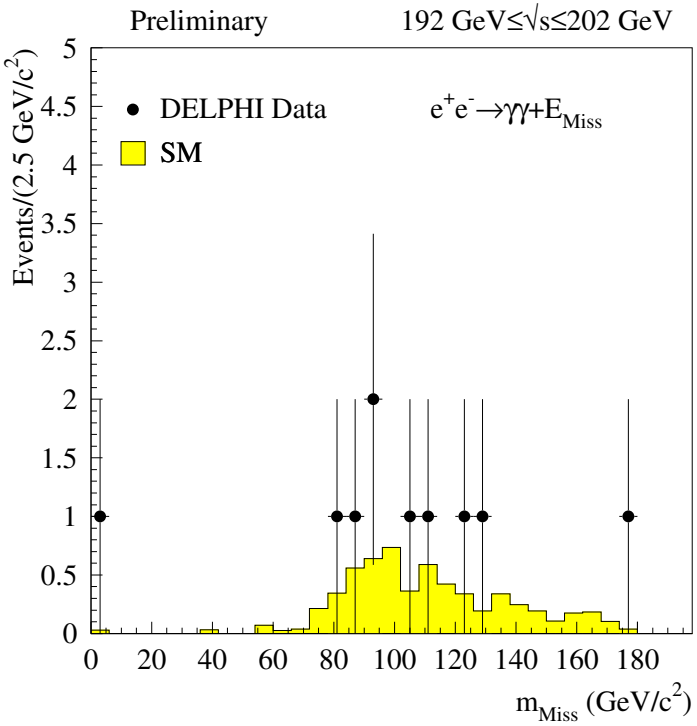


Two Photons + Missing Energy

- *After kinematical selection according to final state,*

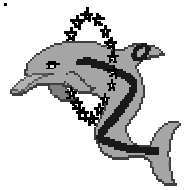
$$e^+e^- \to \tilde{\chi}_2^0\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\gamma\tilde{\chi}_1^0\gamma \qquad e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to \tilde{G}\gamma\tilde{G}\gamma$$





Good agreement data-SM prediction in both cases

Higgs search: SM HZ



- Current LEP combined limit: $m_H > 102.6$ GeV/c^2
- Sensitivity to a 105 GeV/c^2 Higgs:

E_{cm}	Lum.(pb^{-1})	σ(pb)	# events
195.6	76.9	0.04	3.2
199.6	81.3	0.15	12.2
201.6	33.9	0.19	6.4
TOTAL:	192.1		**21.8**

- Main background ZZ, but now better mass discrimination

Hll channels

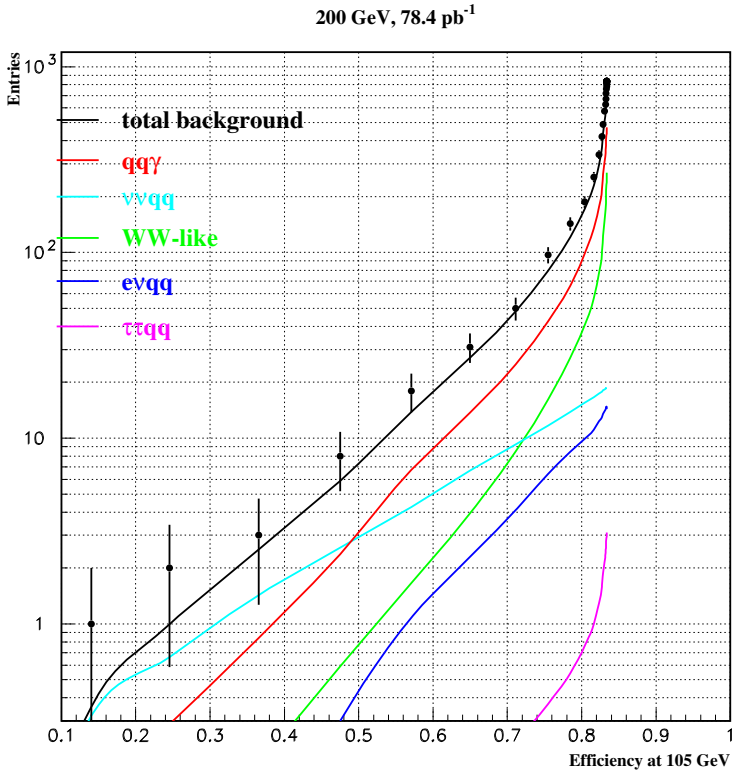
- *Performance:*

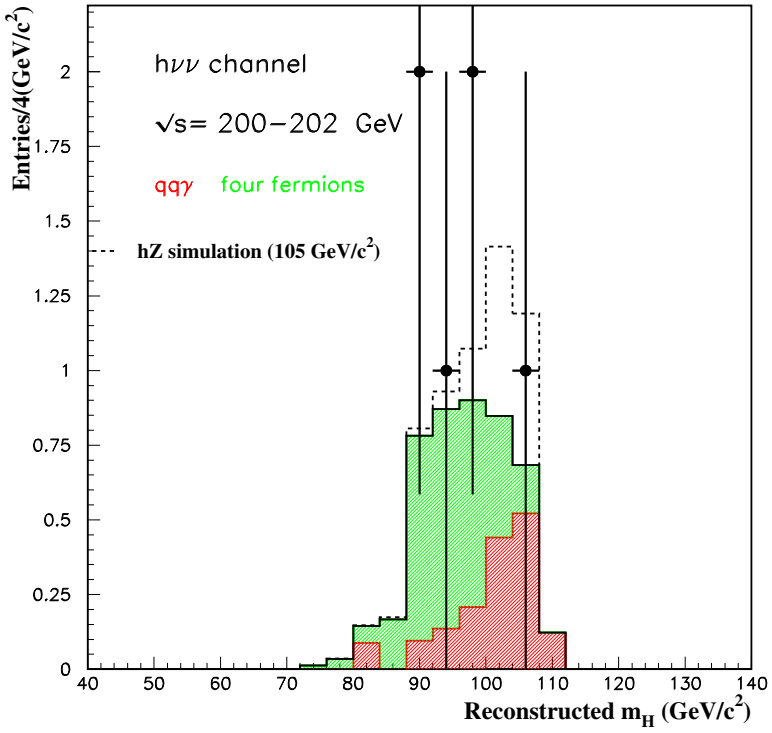
Channel	Data			Background	Signal (M_H=105)
	200	202	Total		
Hee	1	0	1	2.52	50% eff
Hμμ	2	0	2	0.97	51% eff
ττqq	0	0	0	0.53	14% eff.
Total:	3	0	**3**	**4.02**	**0.4 evts**

- *No golden candidate (M_H>100 GeV/c^2)!*

Hnn channel

- Preselection improved, likelihood variable used



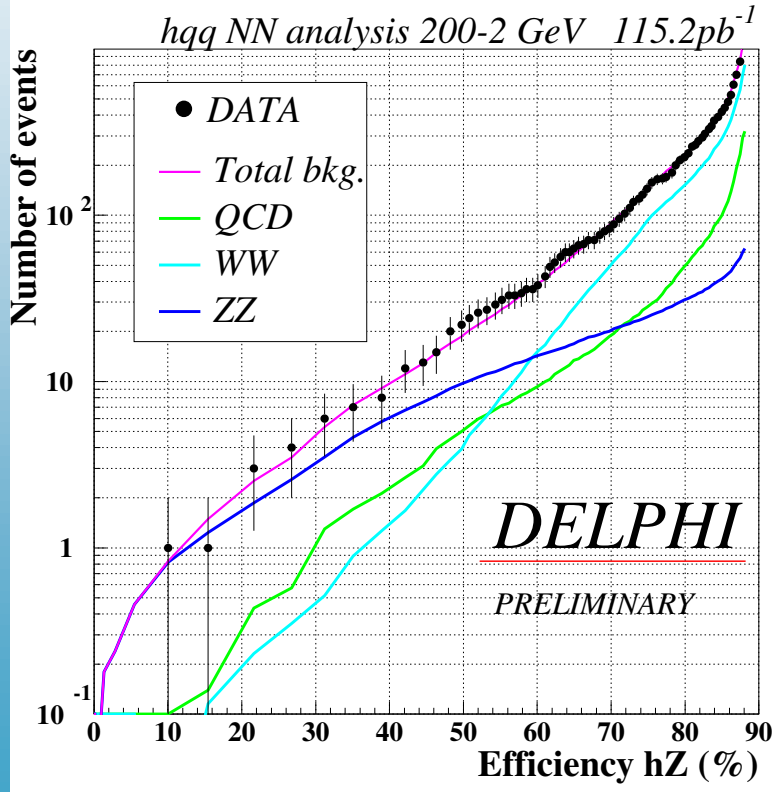


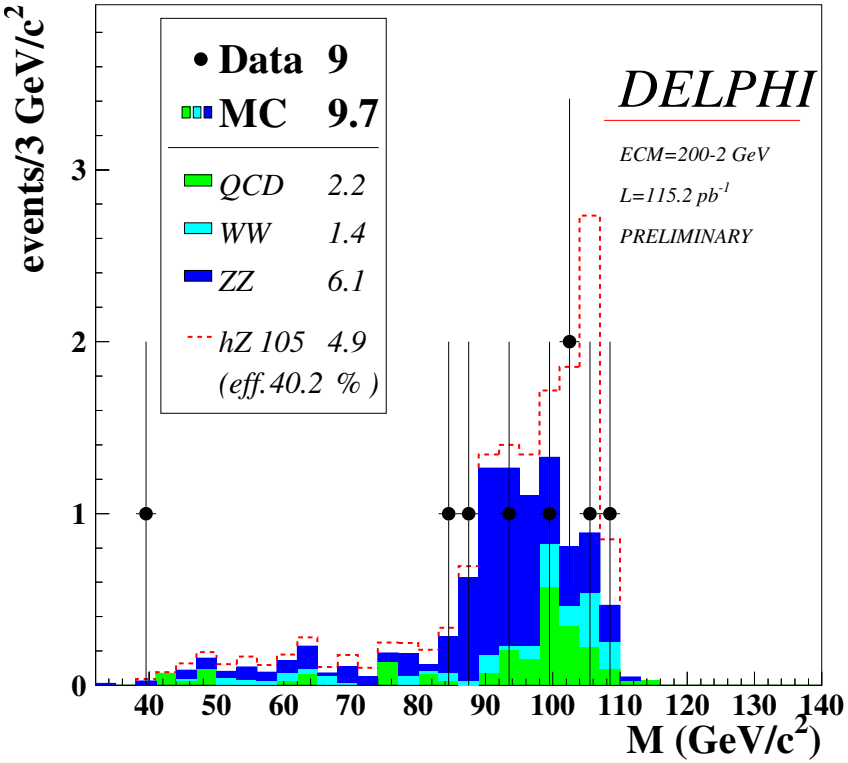
Efficiency vs background curve

Mass plot at 40% efficiency

Hqq channel

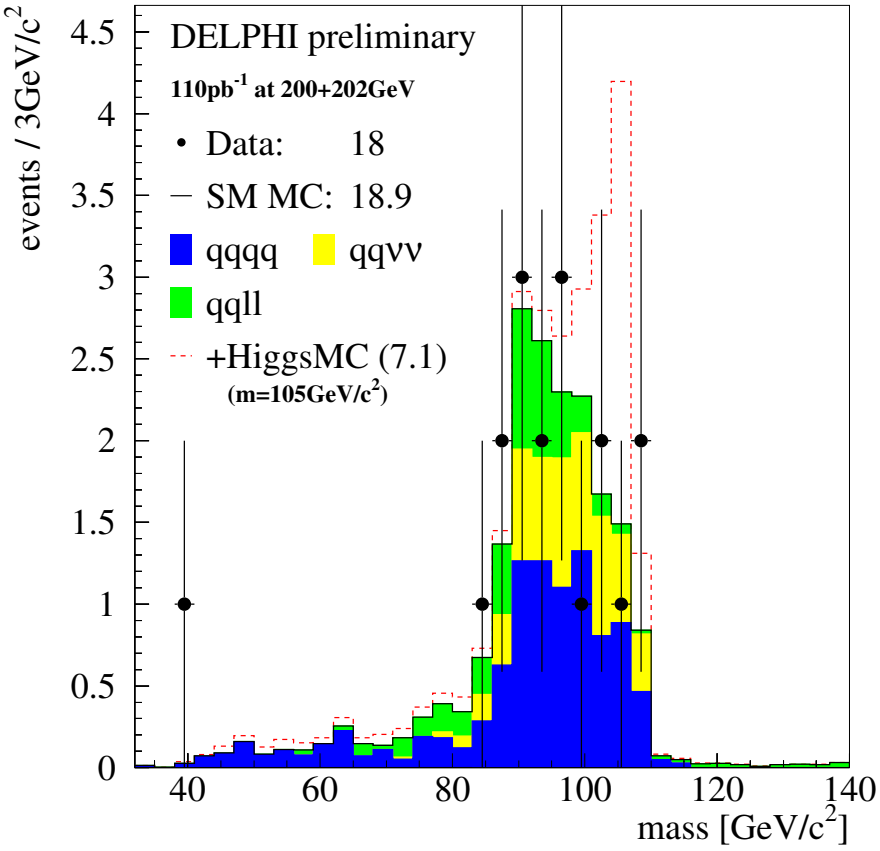
- Combined variable (NN output) using b-tag, antiQCD, and mass-compatibility with WW





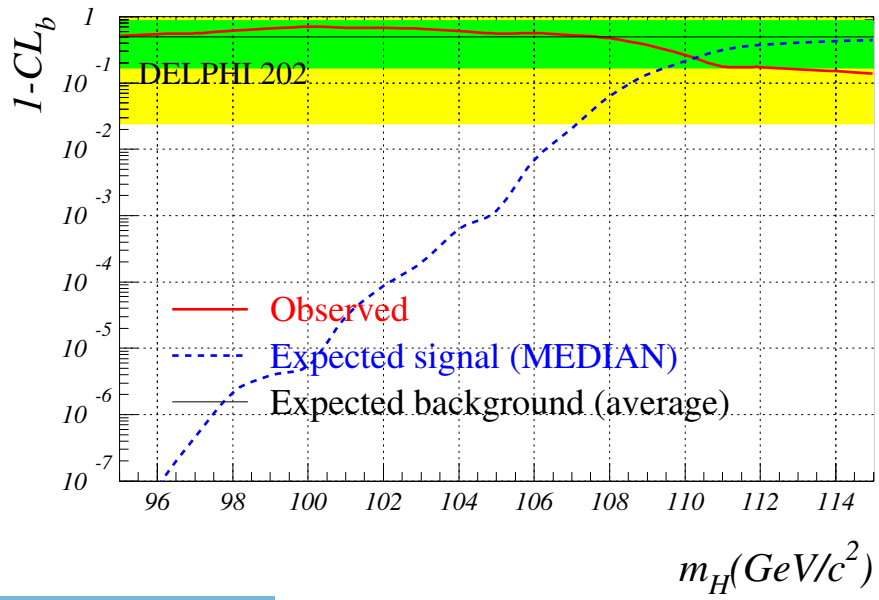
HZ mass plots

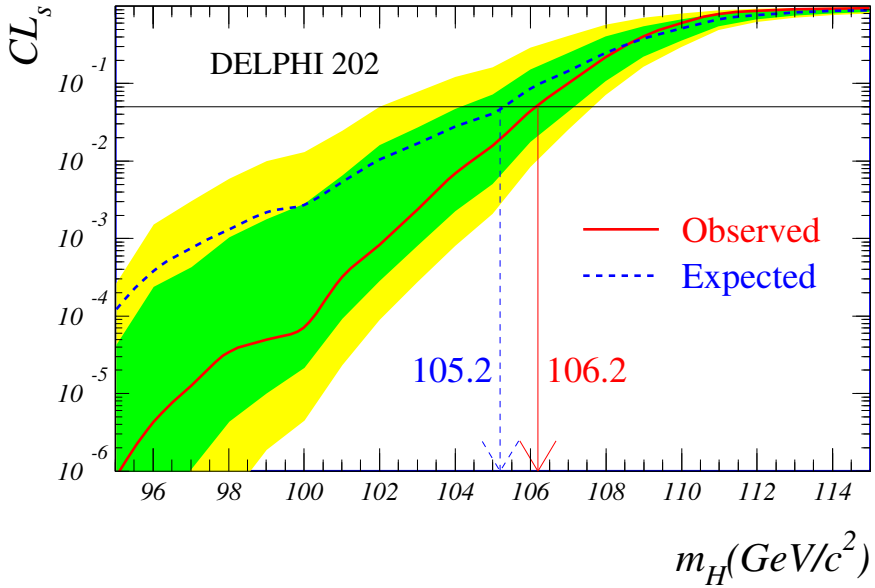
- Combined mass plot: 200 + 202 GeV



HZ mass limit

- *PRELIMINARY LIMIT* *(using 2D info: mass-discriminant variable)*





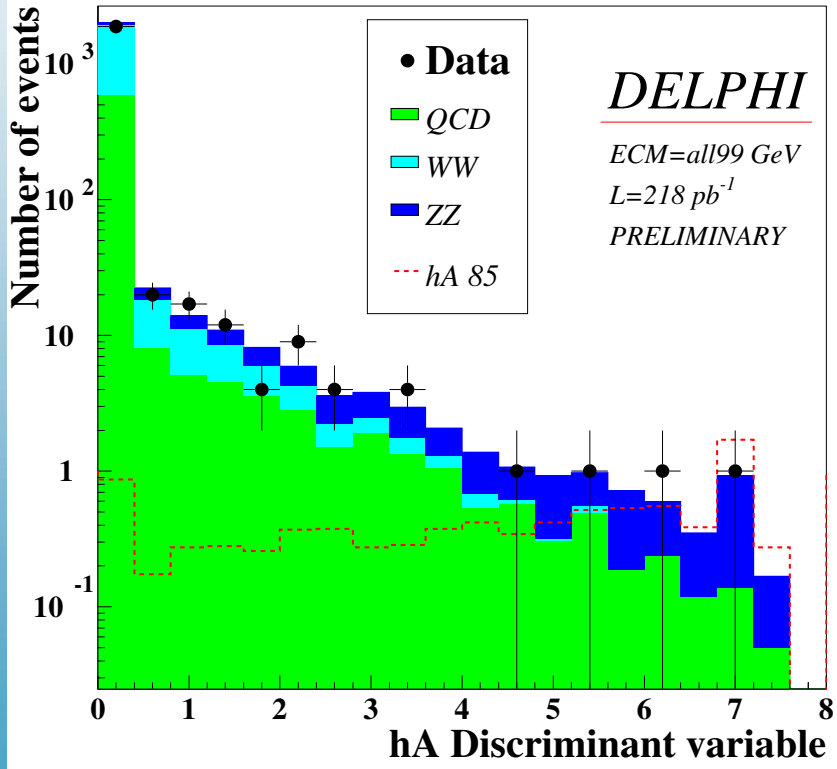
Observed limit: $m_H > 106.2$ *GeV/c²*

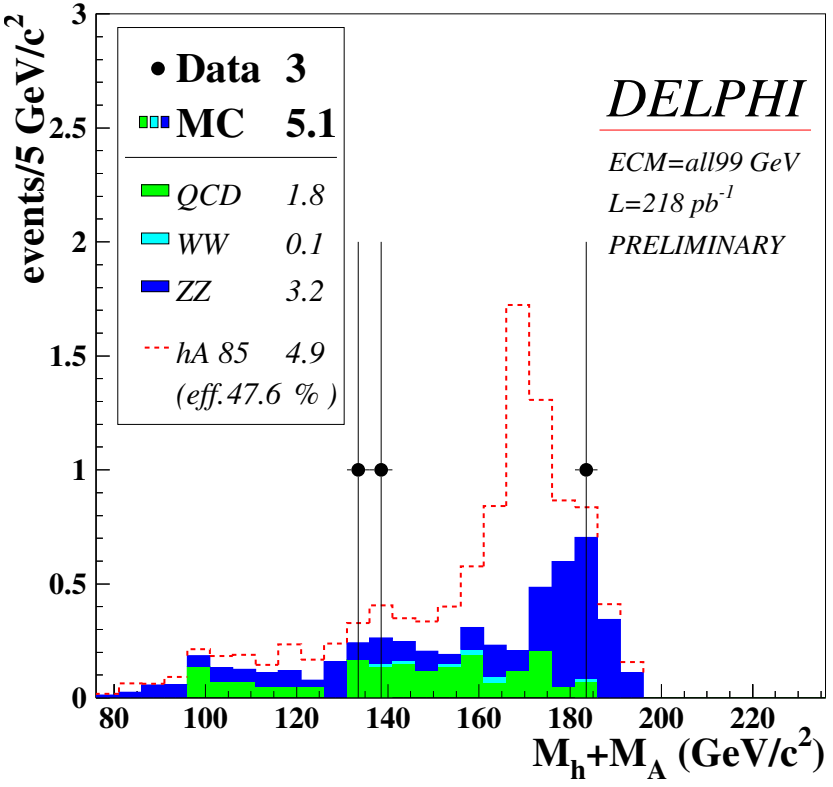
Expected: $m_H > 105.9$ *GeV/c²* *(median)* *(105.2 GeV/c² mean)*

Discovery sensitivity: 97.2 GeV/c²

hA search

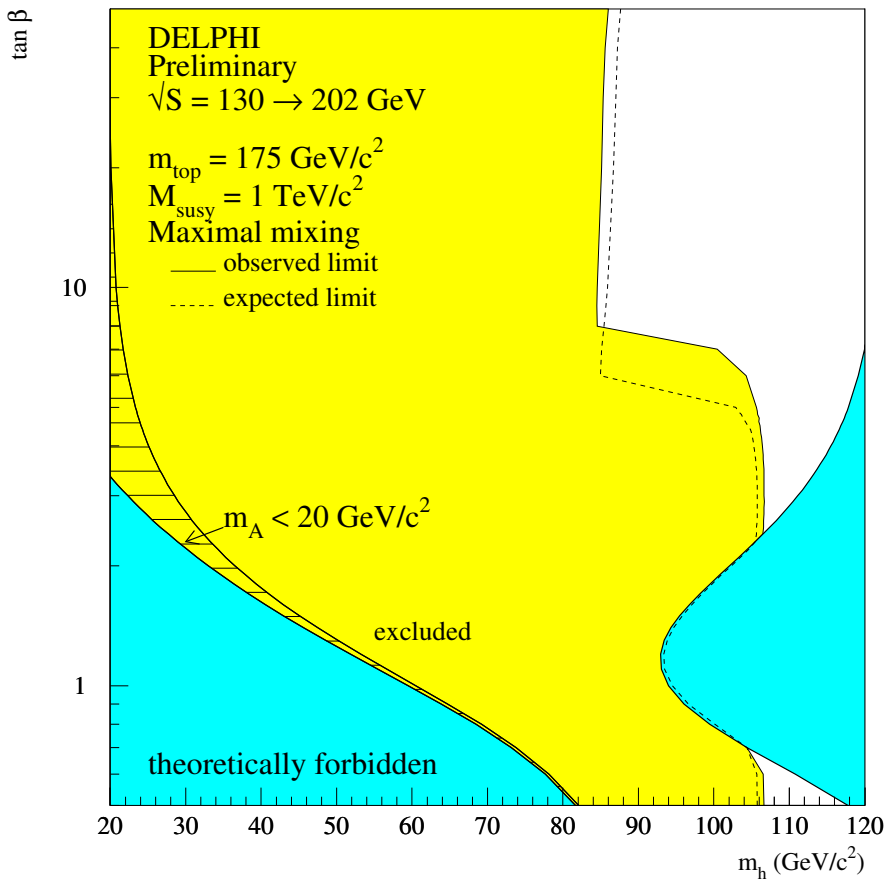
- Discriminating likelihood used in the bbbb channel

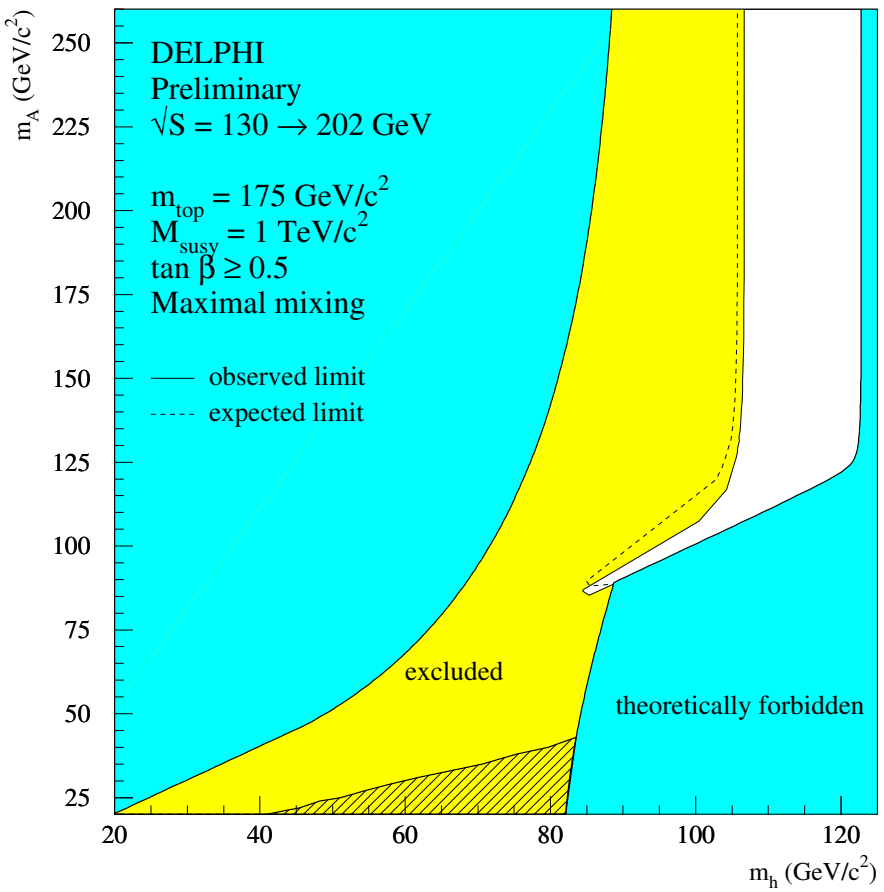




MSSM limits

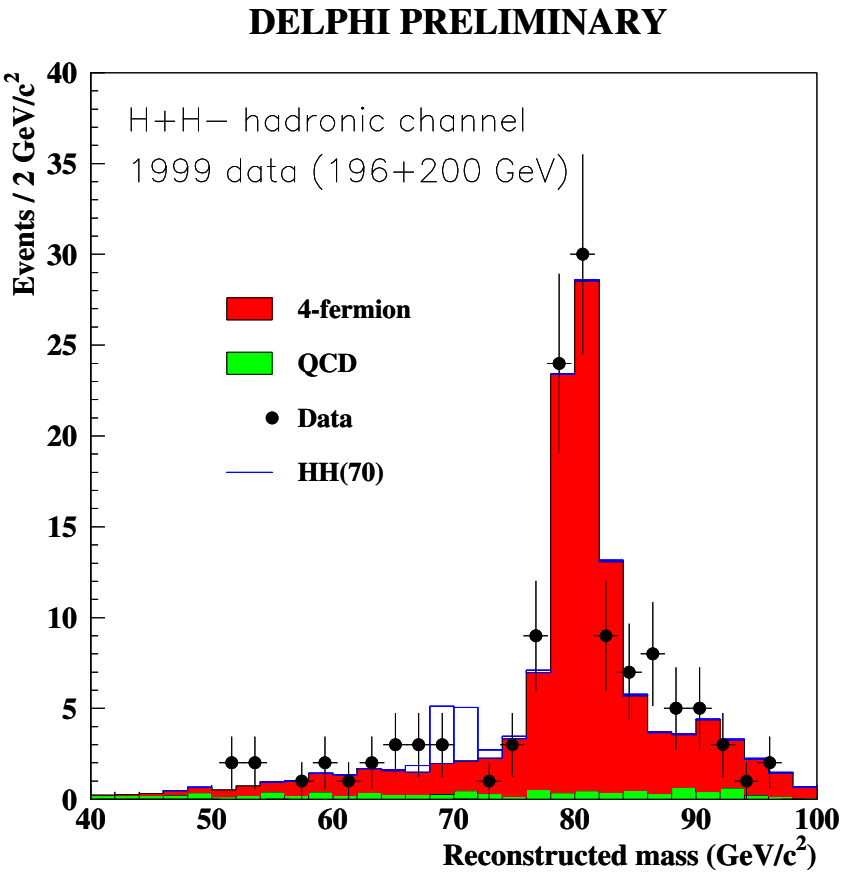
Combine hZ + hA search (all LEP2 data)

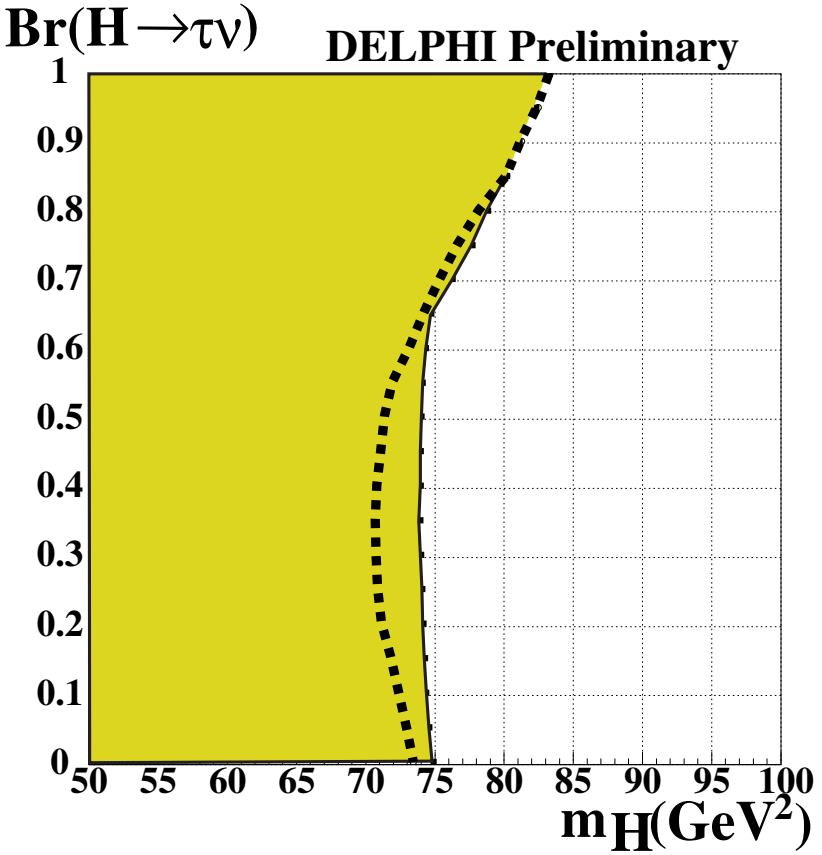




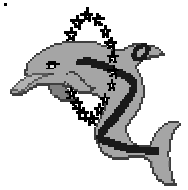
Charged Higgs

- *All three channels (cscs, csτν,ττν) analyzed*



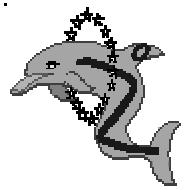


Conclusions:



- *Excellent year for DELPHI:*
  - *Very good detector performance*
  - *Large luminosity collected: thanks to the LEP group!*
  - *Many interesting physics analysis (including some new)*
- *Good agreement with SM predictions: preliminary estimates for cross sections at high energies, including fermion-pair production, coplanar photons, WW and ZZ*
- *Understanding of excess in eeqq, would like to compare!*
- *Searches analysis updated, new limits on SUSY*
- *Good performance for the Higgs search, but...*

Prospects:



- *...it may be waiting for the new millenium to appear; joint LEP effort will be needed to discover it !*

- *Expect highest as possible collision energy for LEP in 2000, with a reasonable luminosity (>150 pb^{-1})*
- *Should study in detail the possibility of the Higgs fusion*
- *Need additional info on the possibility to run at lower energies if not possible at the maximum one*

- *No major intervention expected during shutdown,*

DELPHI will be ready!