DELPHI status report on 1998 data taking

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Outline :

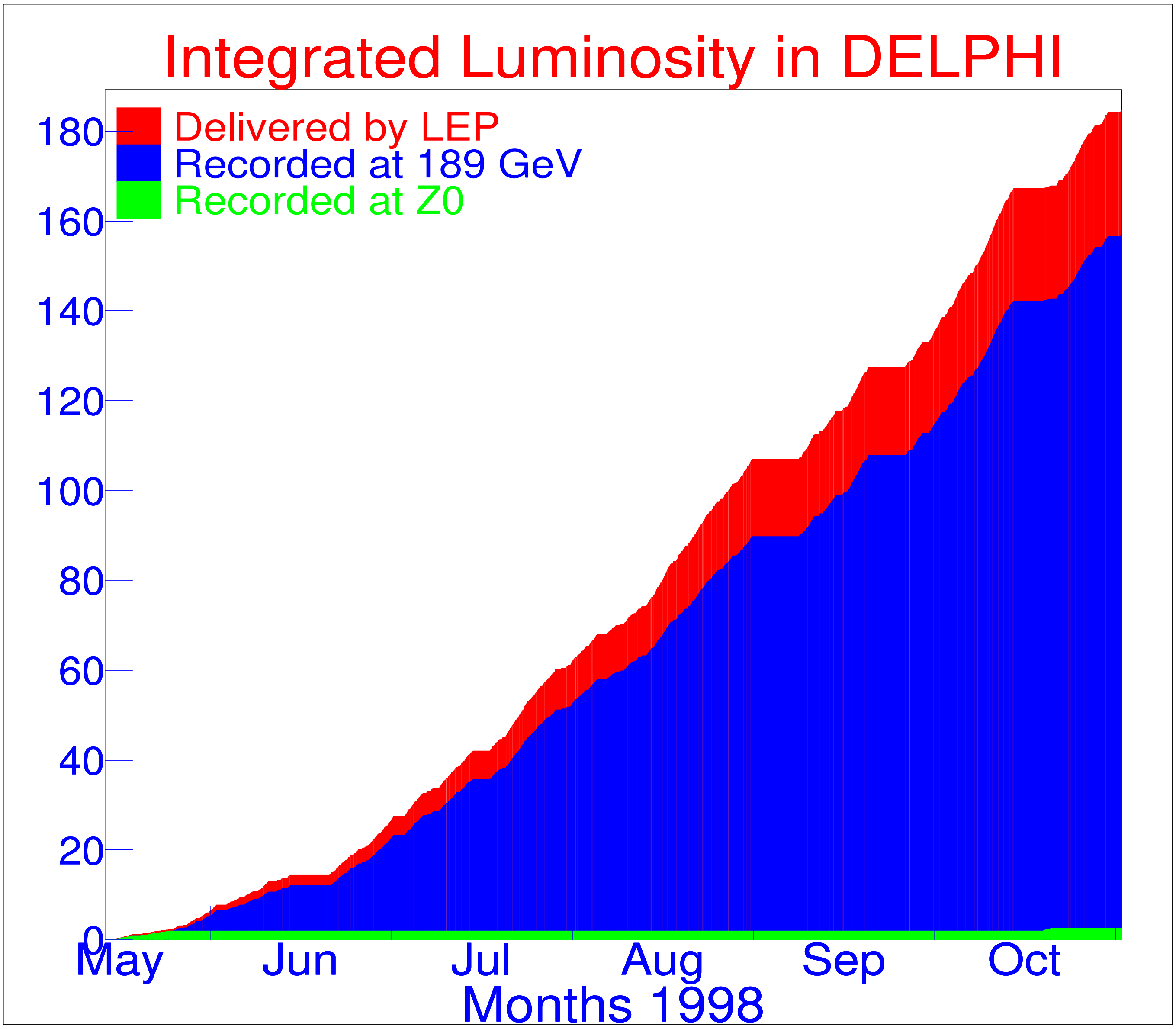
- DELPHI operation
- Detector performance
- Preliminary results at 188.7 GeV :
  - EW measurements
  - Highlights from searches
- Summary and prospects for 1999

DELPHI operation

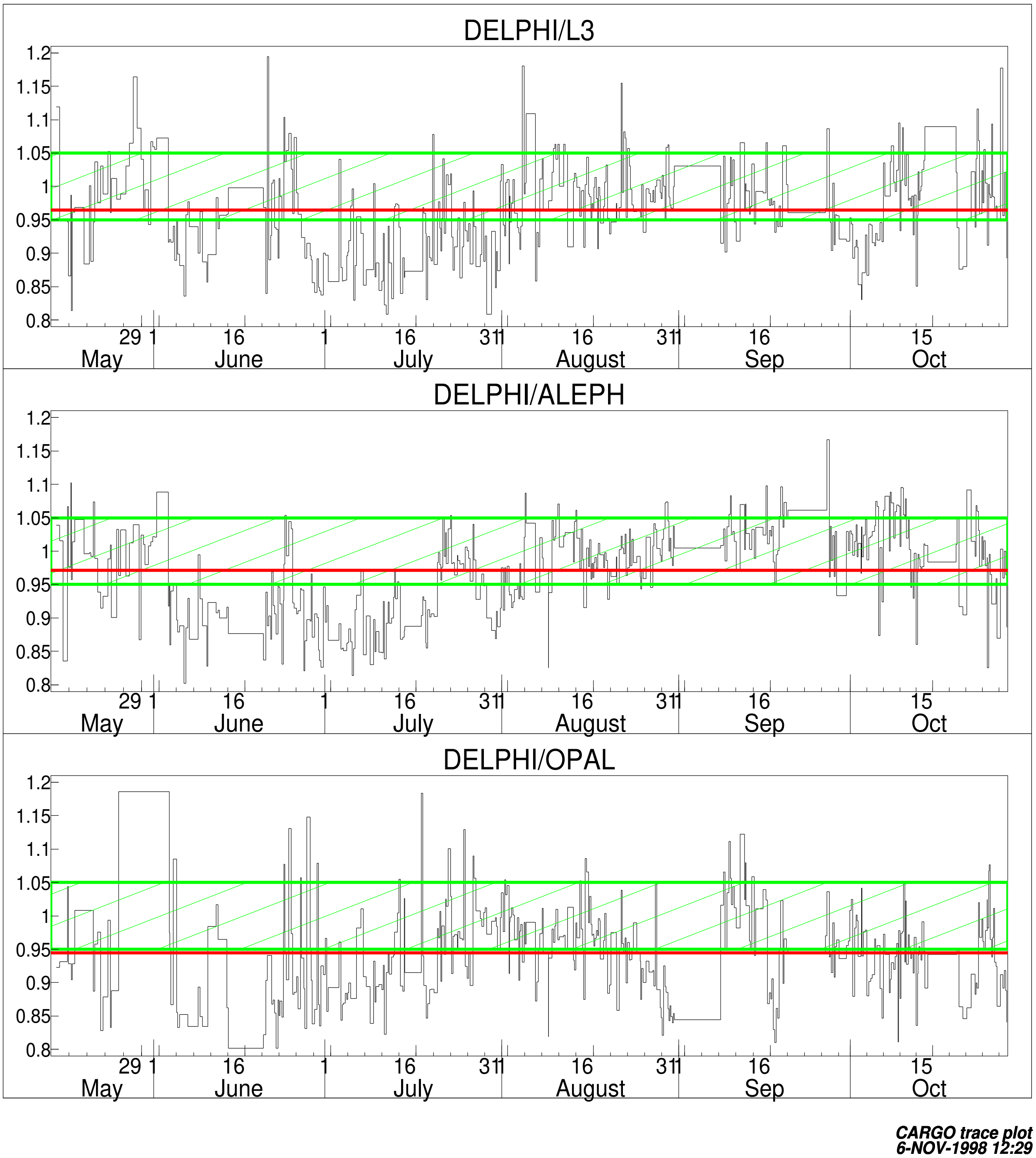
Integrated luminosity at 188.7 GeV:

delivered $\mathcal{L}$: 181.7 (+5) pb^{-1} collected $\mathcal{L}$: 158.0 pb^{-1}

all figures: up to Oct. 28 before cryogenic problems at IP8



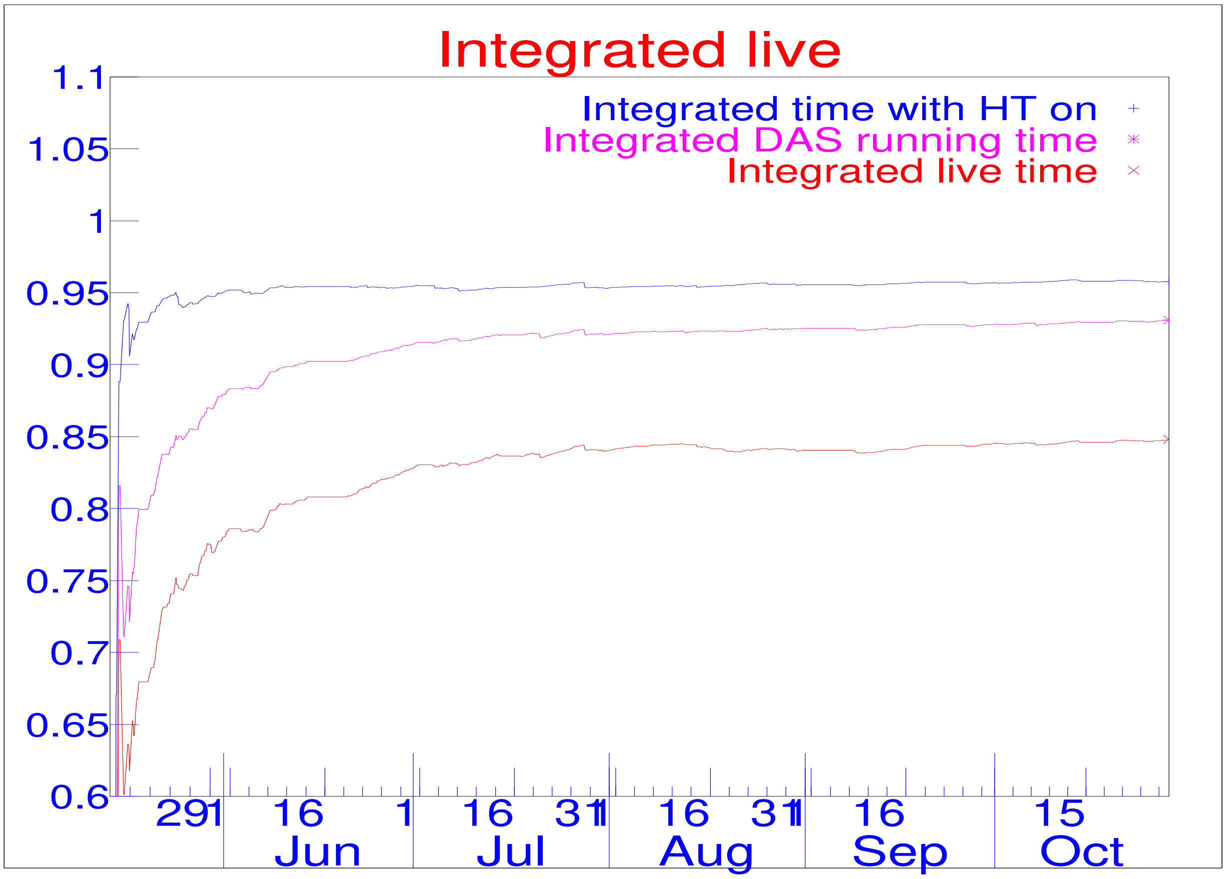
Luminosity delivered fill-by-fill:



⇒Less luminosity delivered to DELPHI ($187\mathrm{pb}^{-1}$ vs $200\mathrm{pb}^{-1}$)

Running efficiency at 188.7 GeV:

overall efficiency : 84.9 % (lumi)   85.7 % (time)



breakdown of losses (in time):

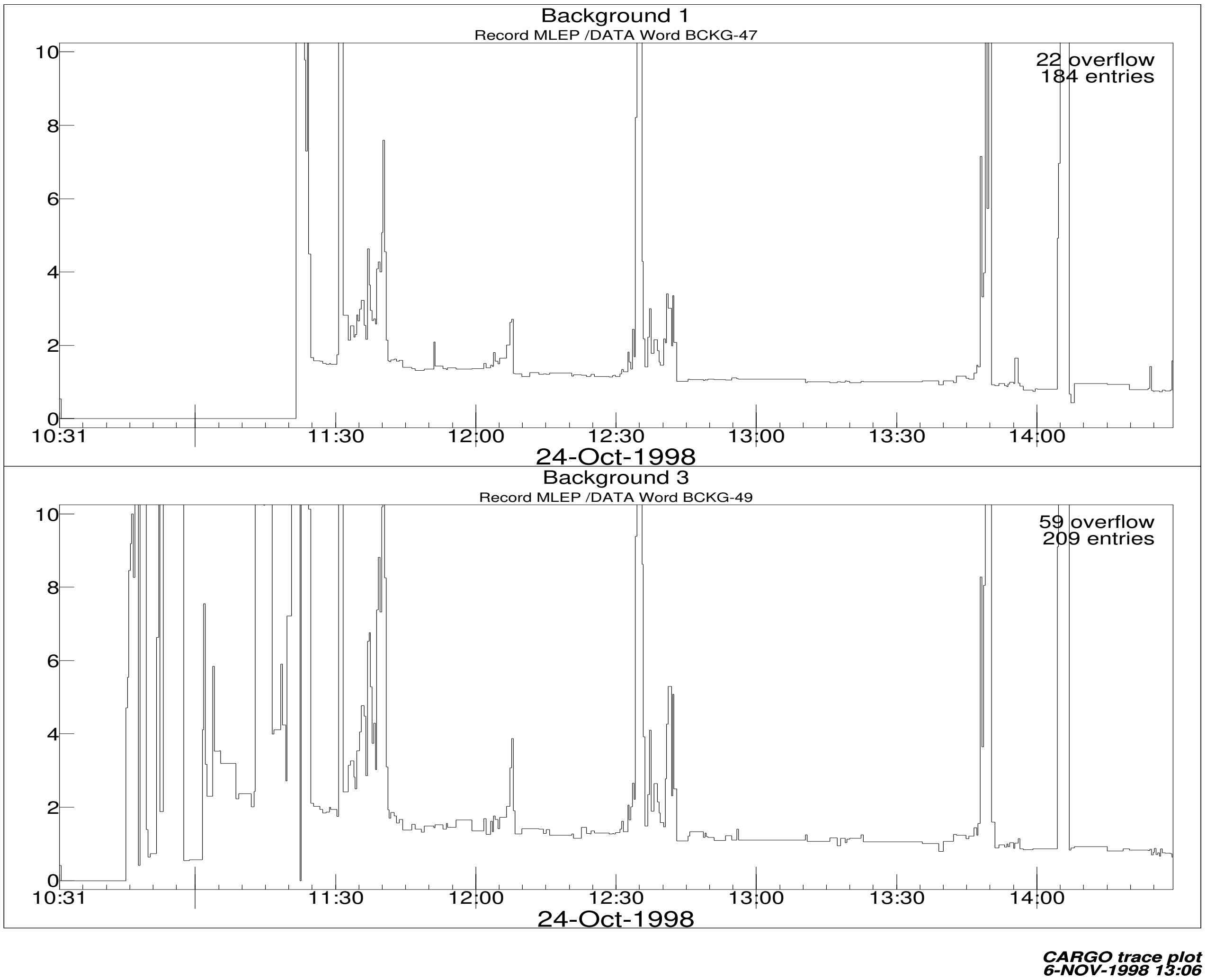
Start-up fill :	bkg: 1.3 %	2.6 %	('97 : 4.3 %)
	oth: 1.3 %		
Run paused :	bkg: 1.4 %	3.0 %	('97 : 2.3 %)
	techn: 1.6 %		
DAS crashed :		3.7 %	('97 : 6.3 %)
Data rejected :		2.2 %	('97 : 3.2 %)
Trigger deadtime :		2.8 %	('97 : 2.3 %)

Radiation background at 188.7 GeV:

Wrt '97: average background level was lower but DELPHI suffered from more frequent and more severe background storms and spikes (from radiation γ).

An example (fill 5368, 24/10/98):

bkg 1: TPC bkg 3: Si γ monitor



Start-up:10%, Run paused: 19%, ϵ : 66%

⇒frequent TPC trips (189, in '97: 79) mostly at EOF (60%)
⇒background spikes are a real WORRY for us

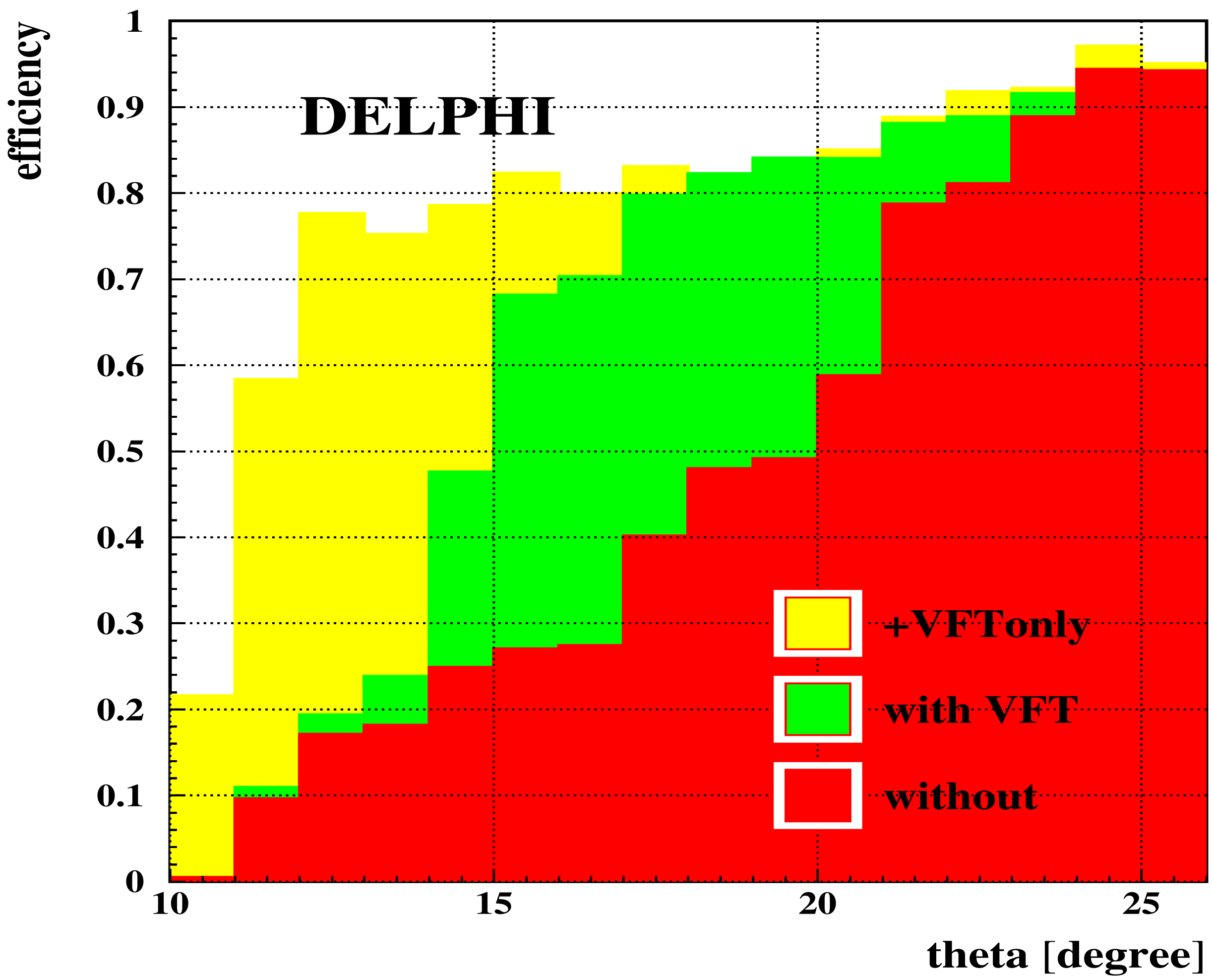
DELPHI performance

Alignment and stability:

- 2.5 pb^{-1} of Z^0 data in May: $\Rightarrow$very good alignment
  missing $\mu\mu$ dist in $R\phi$: 34μm, in z: 58μm (as good as final '97 alignment)
- Stability: OK in z, within 10μm in $R\phi$ $\rightarrow$ figs.

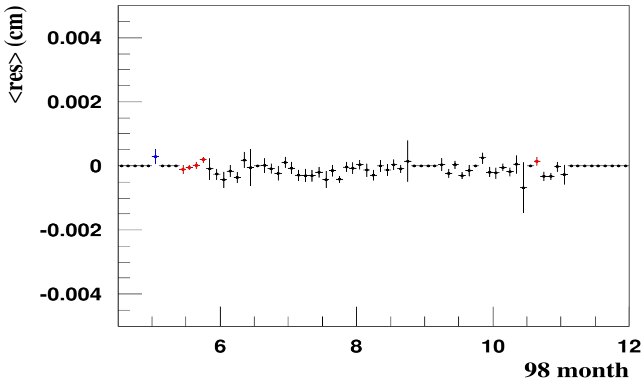
Tracking:

New wrt '97: new forward tracking (new algorithms, VFT points included in track search)

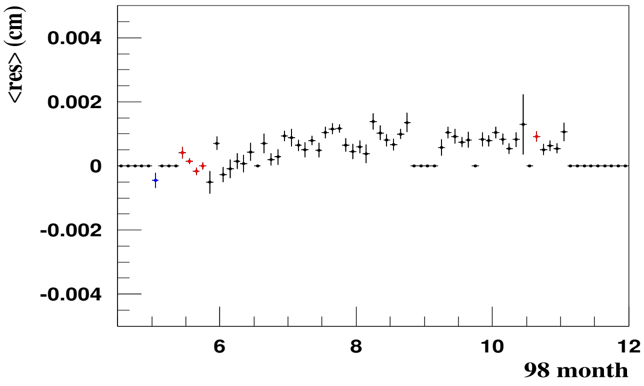


VD alignment stability in Rϕ: <VD residuals> vs time

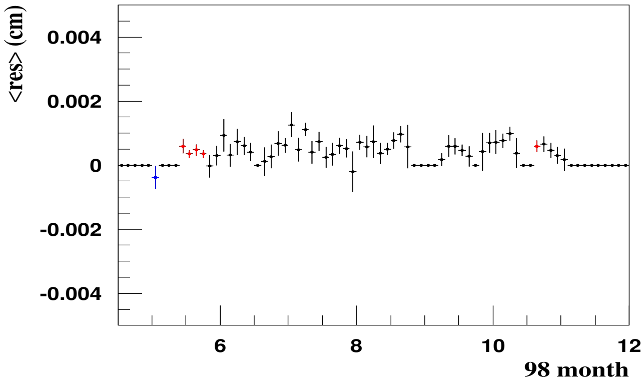
VD 98 STABILITY IN Rϕ



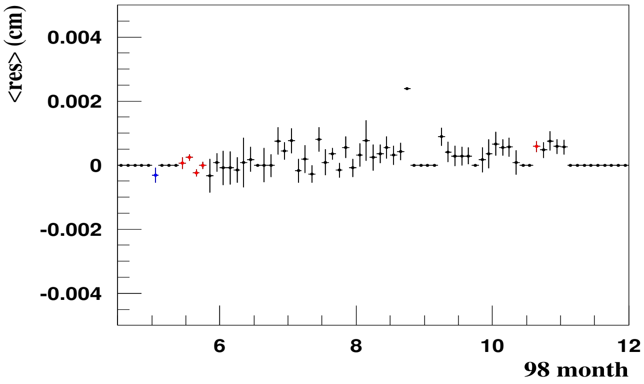
OUTER Bottom half-shell overlap Rϕ



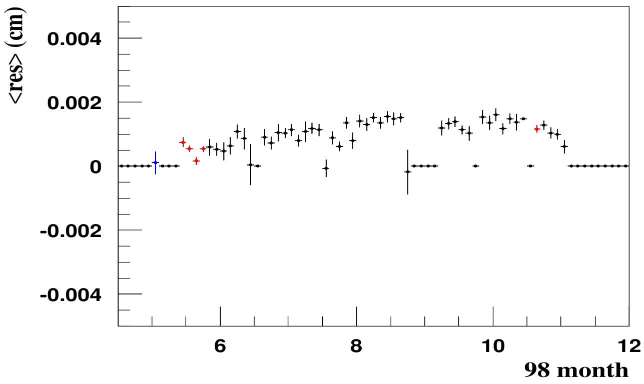
OUTER Top half-shell overlap Rϕ



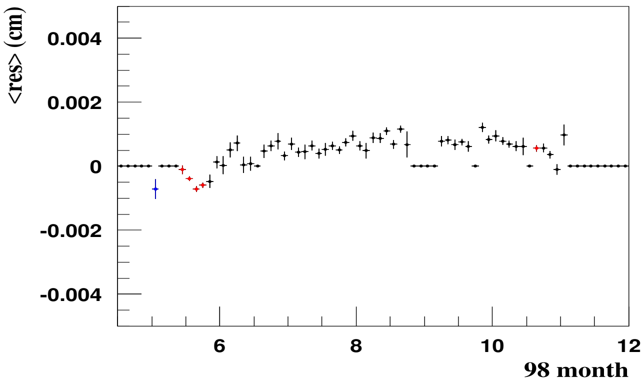
INNER Bottom half-shell overlap Rϕ



INNER Top half-shell overlap Rϕ



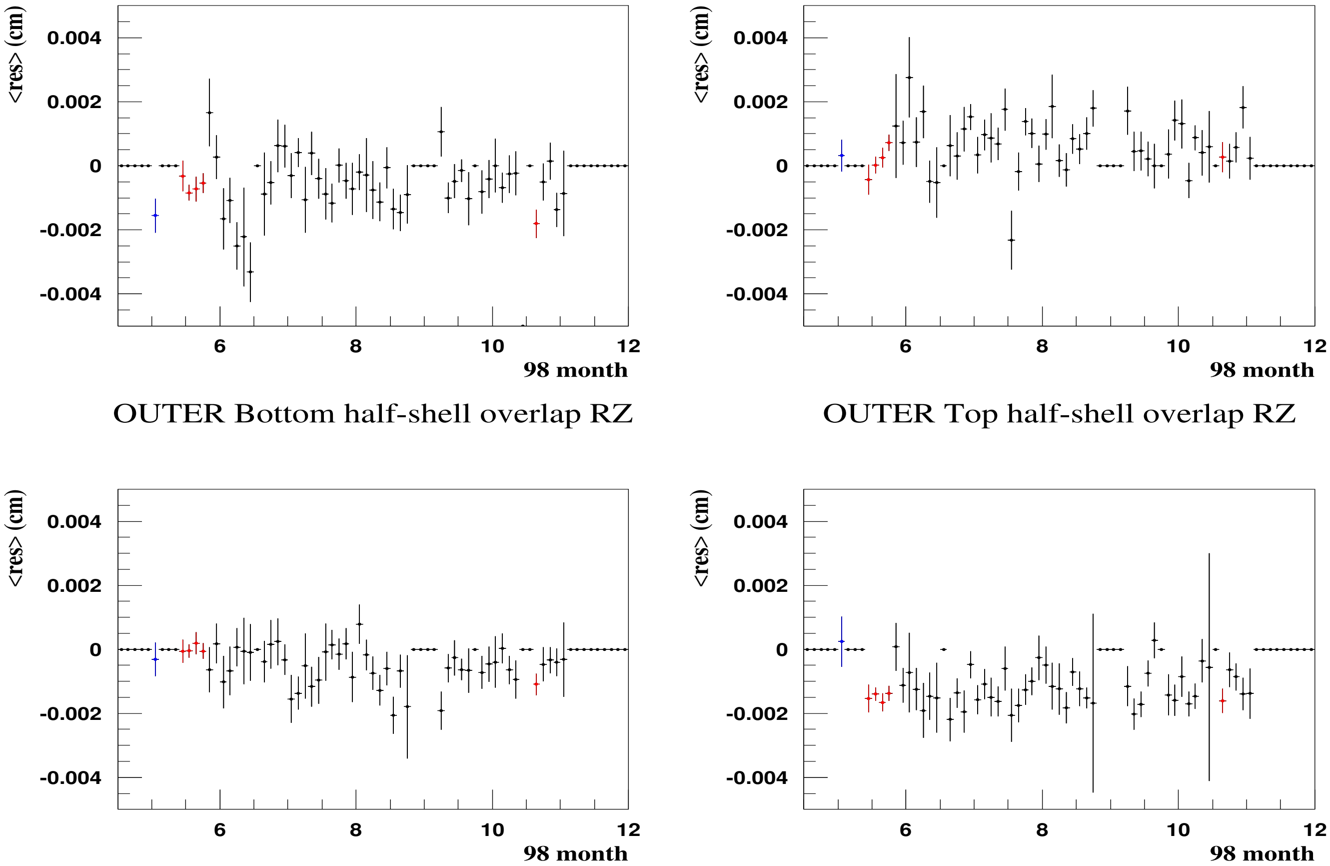
CLOSER Bottom half-shell overlap Rϕ



CLOSER Top half-shell overlap Rϕ

VD alignment stability in Rz: <VD residuals> vs time

VD 98 STABILITY IN RZ



OUTER Bottom half-shell overlap RZ

OUTER Top half-shell overlap RZ

CLOSER Bottom half-shell overlap RZ

CLOSER Top half-shell overlap RZ

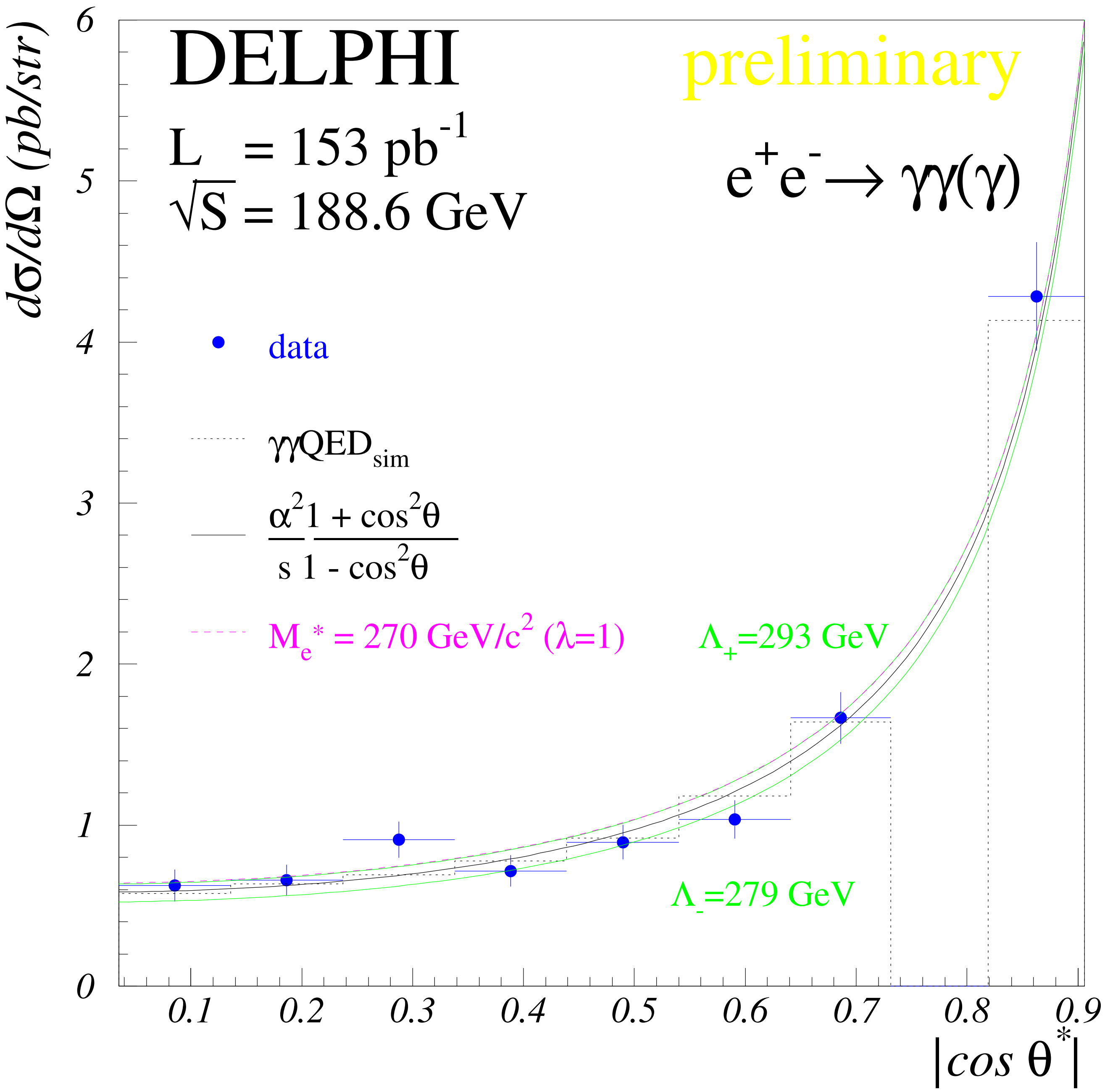
DELPHI physics results at 188.7 GeV

I) EW measurements:

- coplanar $\gamma\gamma$ production
- fermion-pair production
- W mass
- WW cross-section
- ZZ production

All results are PRELIMINARY !

EW measurements: coplanar $\gamma\gamma$ production



Limits on:

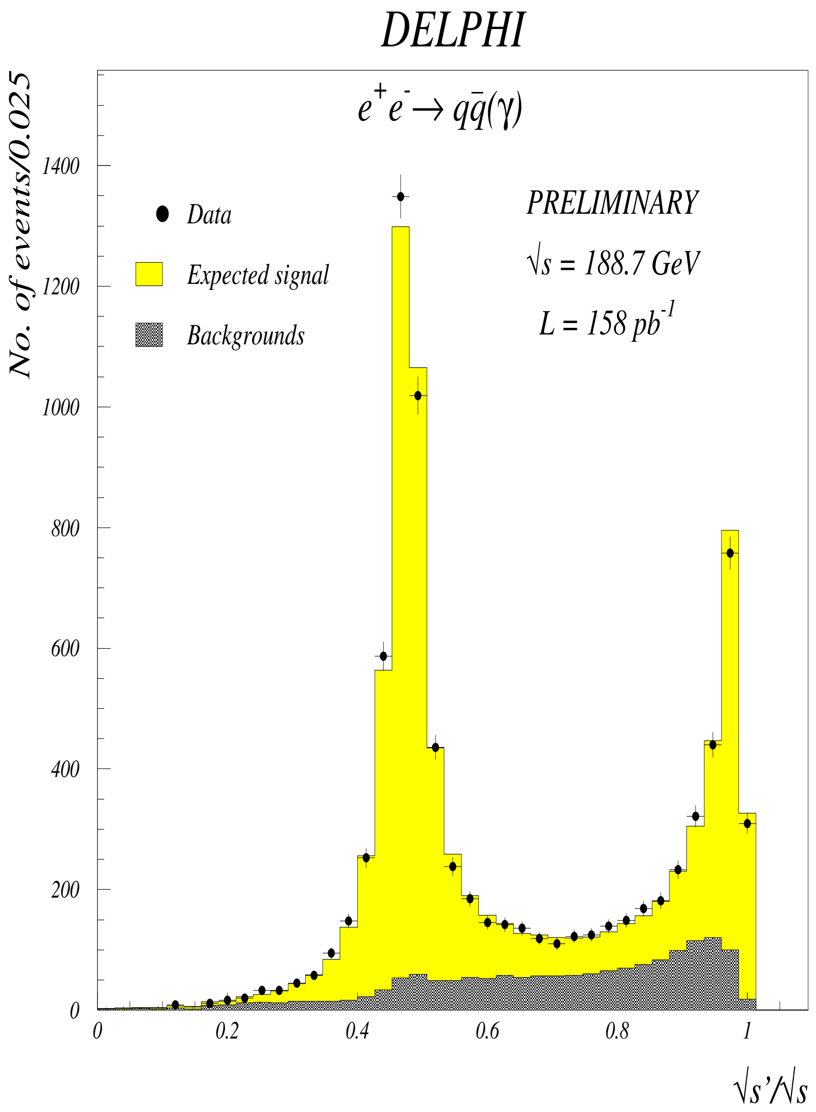
compositeness: $\Lambda^+ > 293$ **GeV,** $\Lambda^- > 279$ **GeV**

excited electron: $\mathbf{M}_e^* > 270$ **GeV**

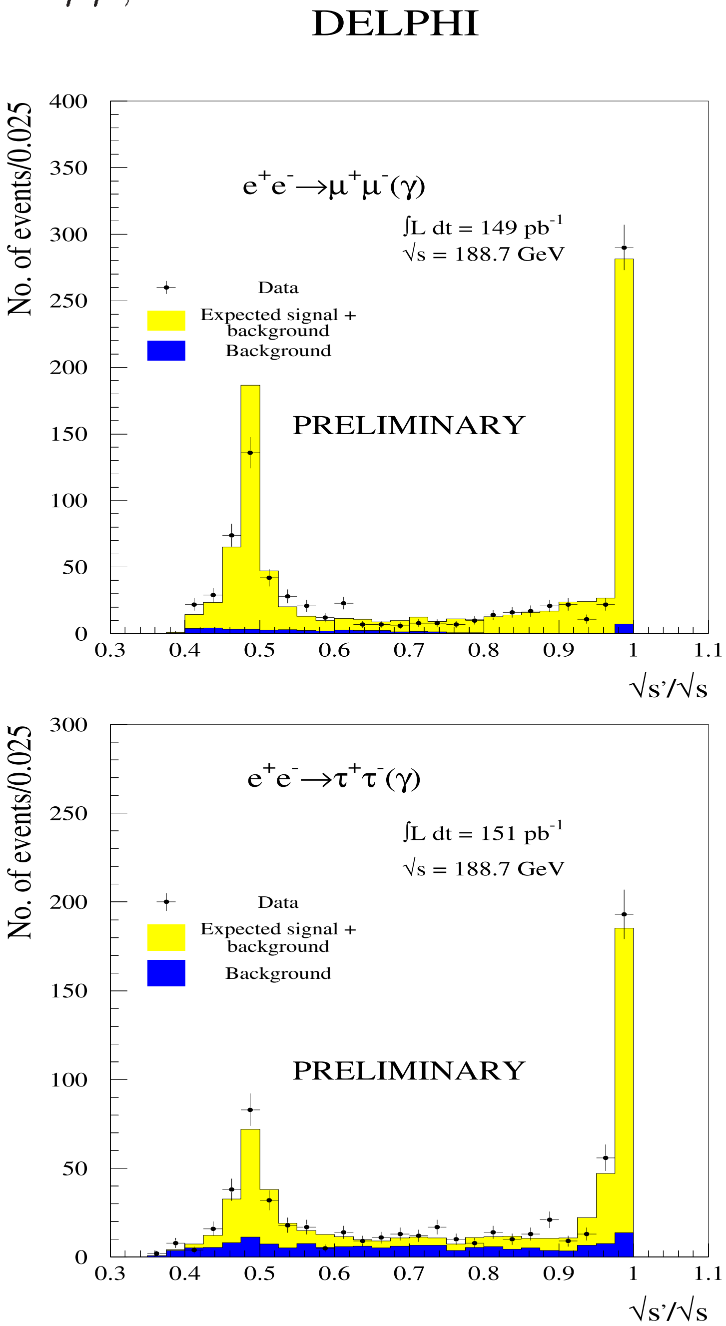
EW measurements: fermion-pair production

- $\sqrt{S'}$ distributions in hadronic and leptonic final states:

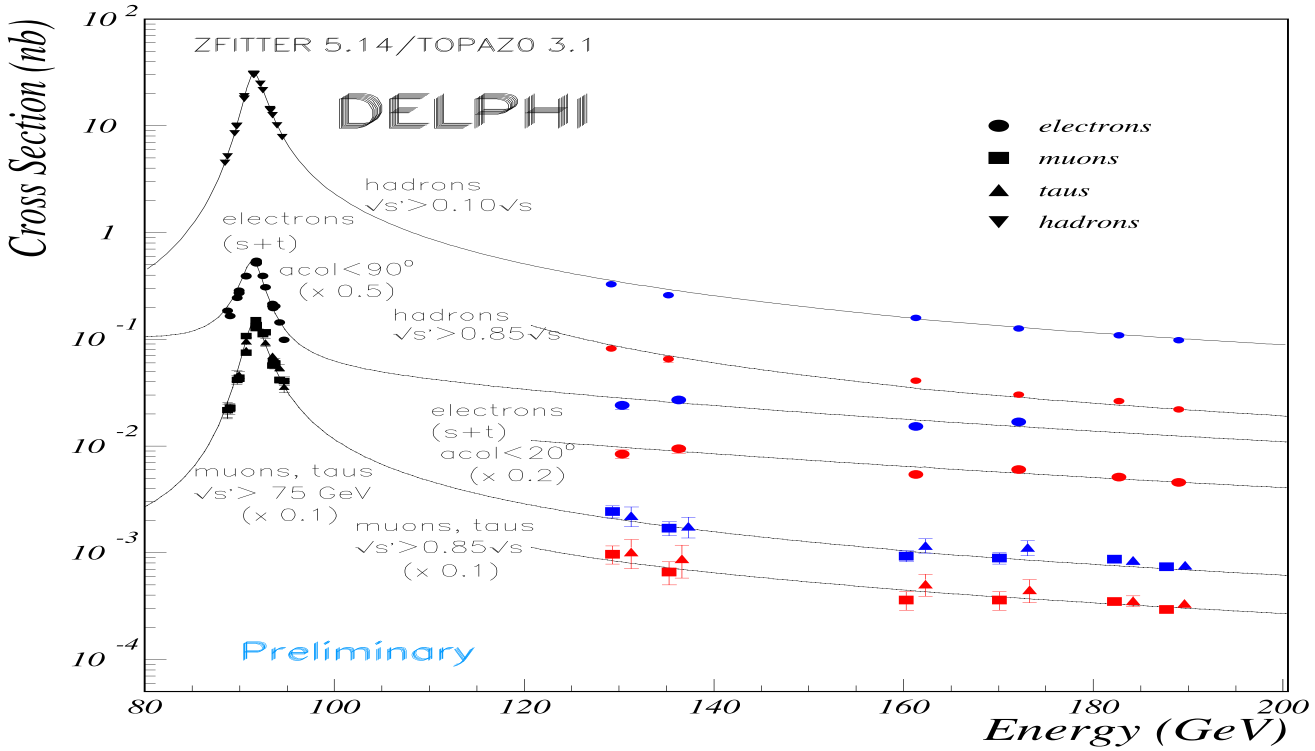
$q\bar{q}$: data vs PYTHIA

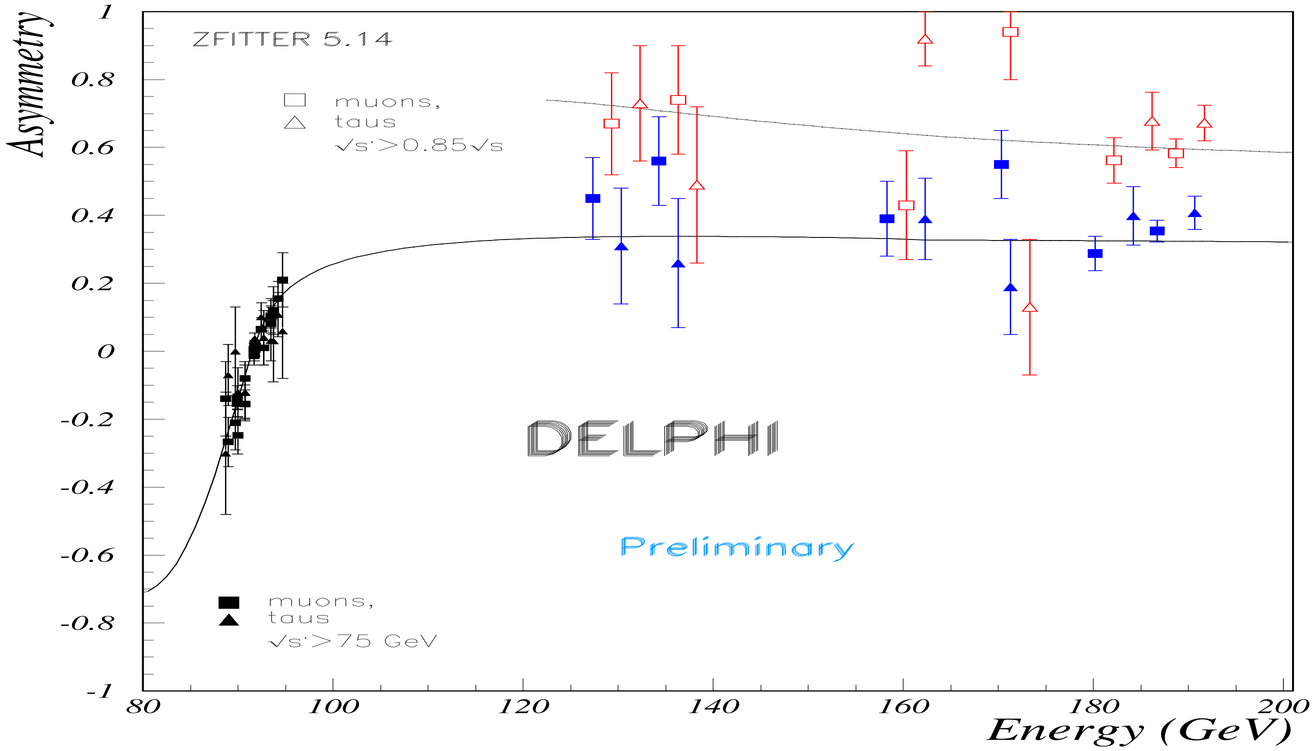


$\mu\mu, \tau\tau$: data vs KORALZ



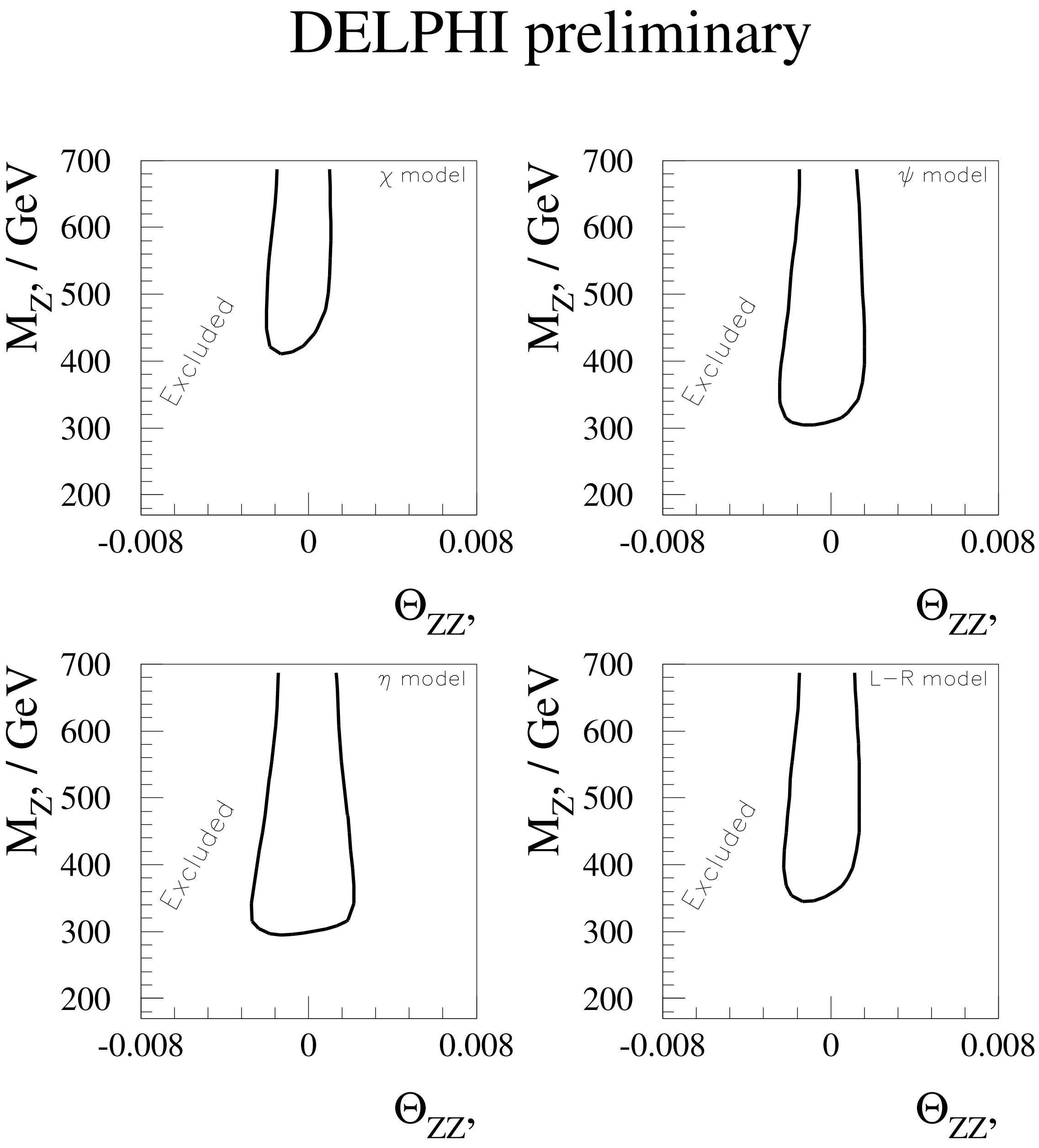
•Cross-sections and FB asymmetries:





⇒NO substantial departure from SM predictions

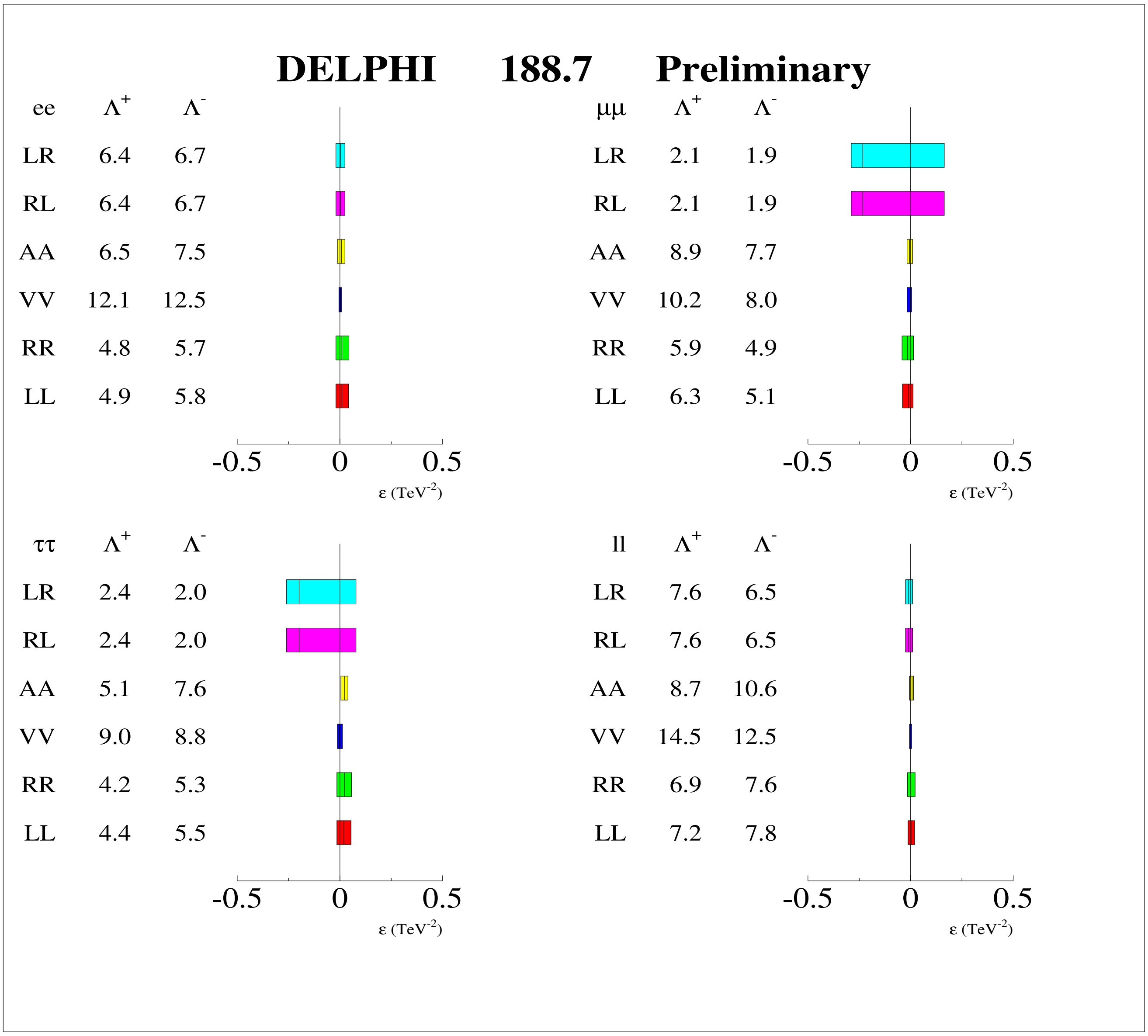
• Fits to physics beyond the SM: additional Z' bosons



$\mathbf{M}_{Z'} > 300$ **GeV**

•Fits to physics beyond the SM: 4-fermion contact interactions

Using the leptonic final states: allowed ranges for the fitted parameter $\epsilon = 1/\Lambda^2$ and corresponding 95 % lower limits (in TeV) on Λ for different helicity couplings, for constructive (+) and destructive (-) interference with the SM (ll = lepton universality assumed).



gain of 2 to 6 TeV over our previous results

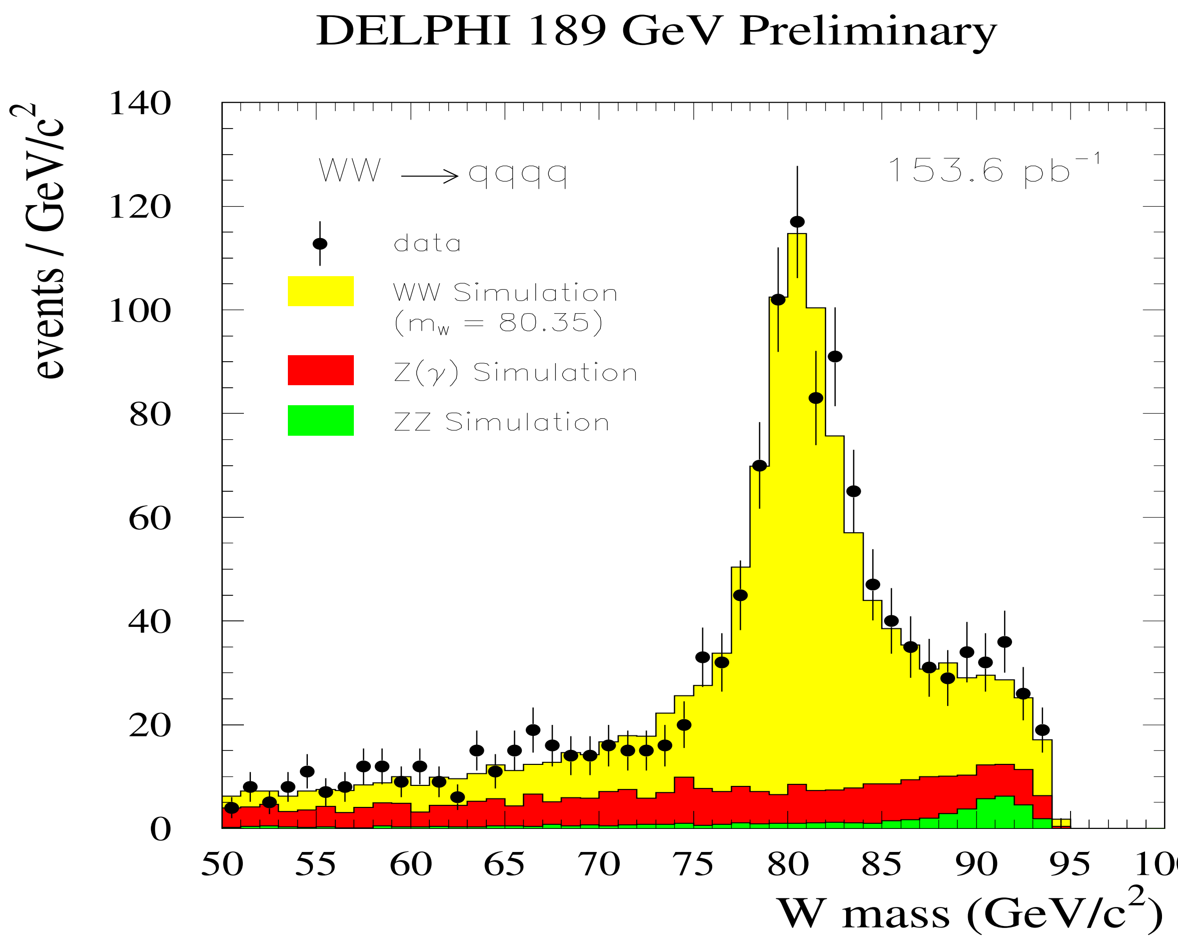
EW measurements: W mass

- Event selection at 188.7 GeV:

channel	$\mathcal{L}(\mathrm{pb}^{-1})$	observed	expected (purity)
$q\bar{q}q\bar{q}$	153.6	1316	1291.0 (75%)
$e\nu q\bar{q}$	153.6	227	250.5 (91%)
$\mu\nu q\bar{q}$	153.6	299	308.7 (95%)

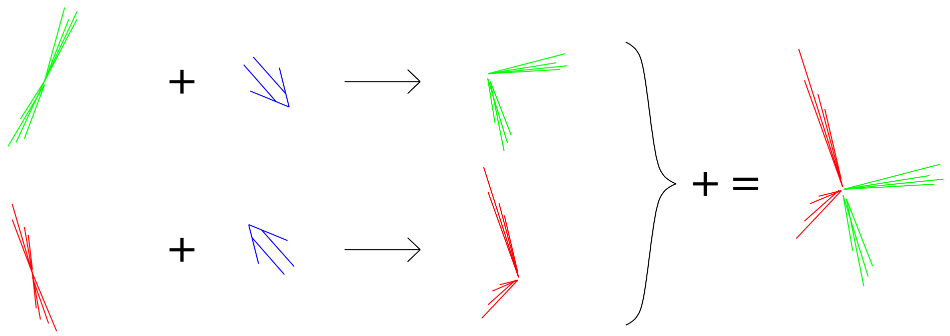
$\Rightarrow$we expect $\delta(\mathrm{M}_W)_{stat} \sim 100$ MeV (first result: '99 winter conf.)

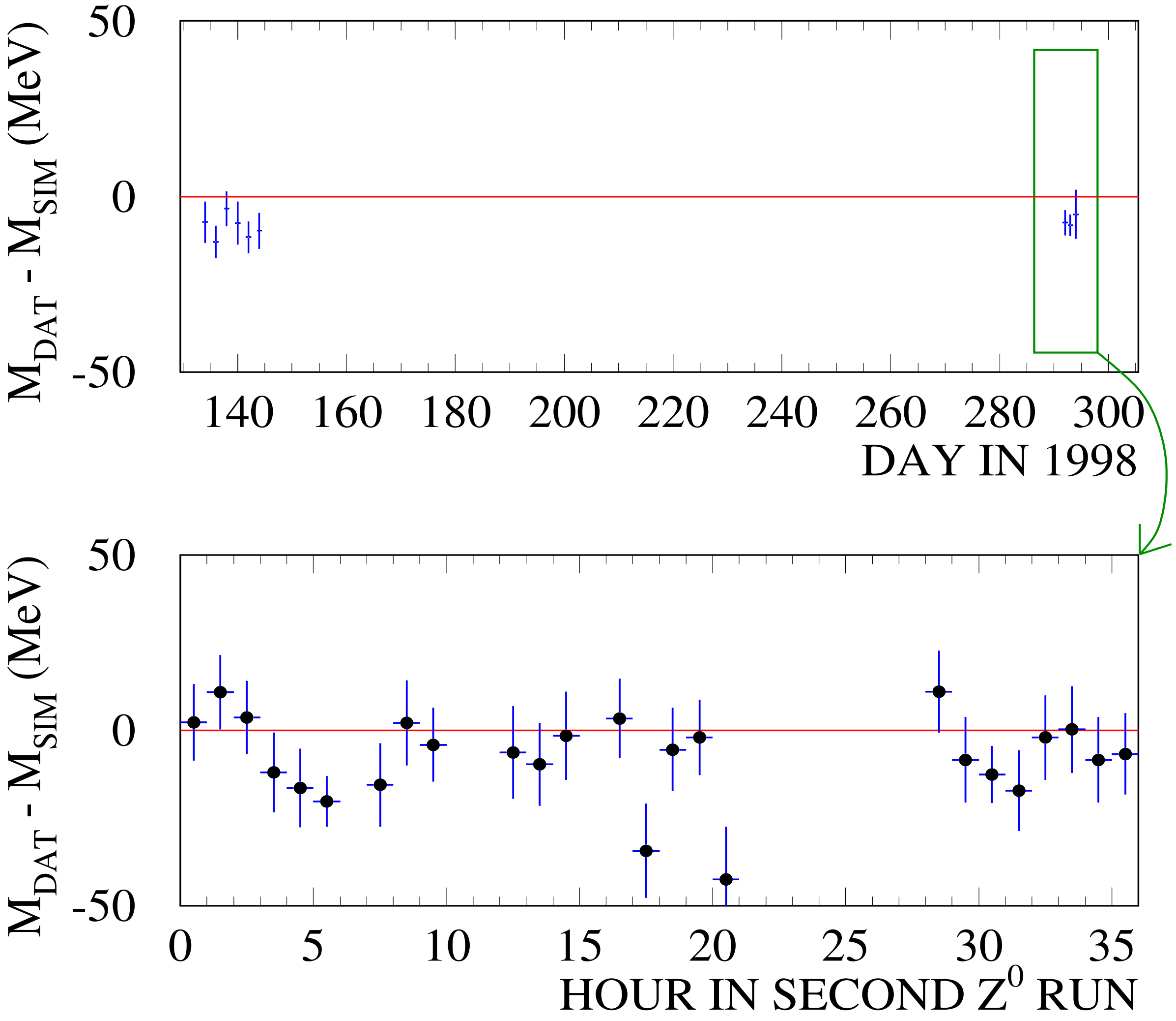
- W mass distributions at 188.7 GeV: $q\bar{q}q\bar{q}$ channel



data vs simulation (PYTHIA two-fermions and four-fermions)

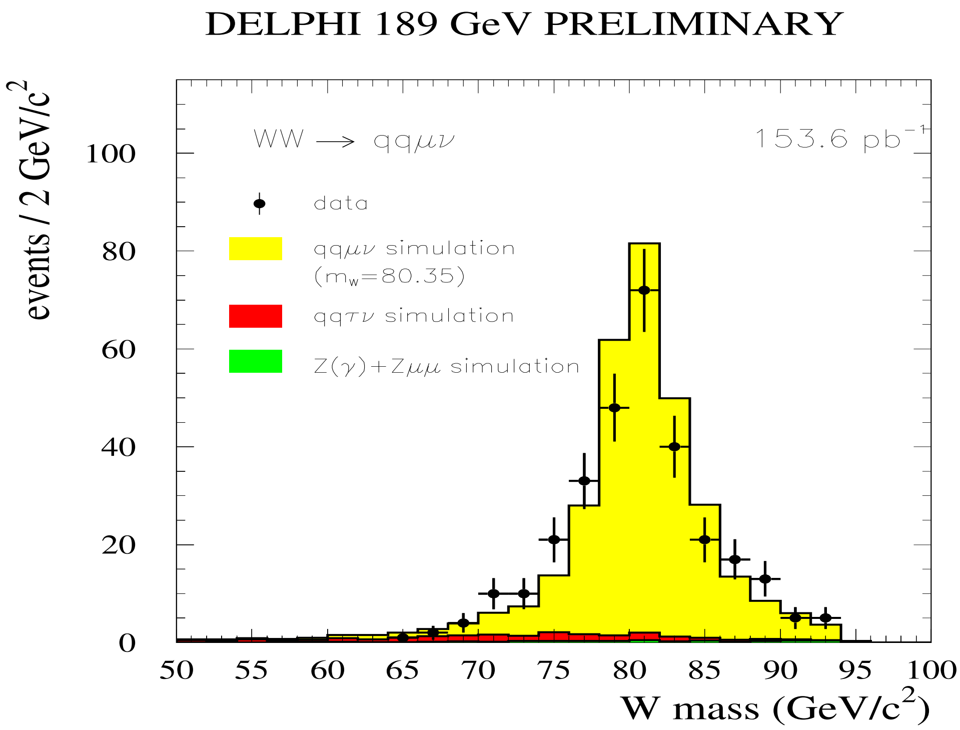
• Checking detector stability and systematics on M_W with Z^0 events:

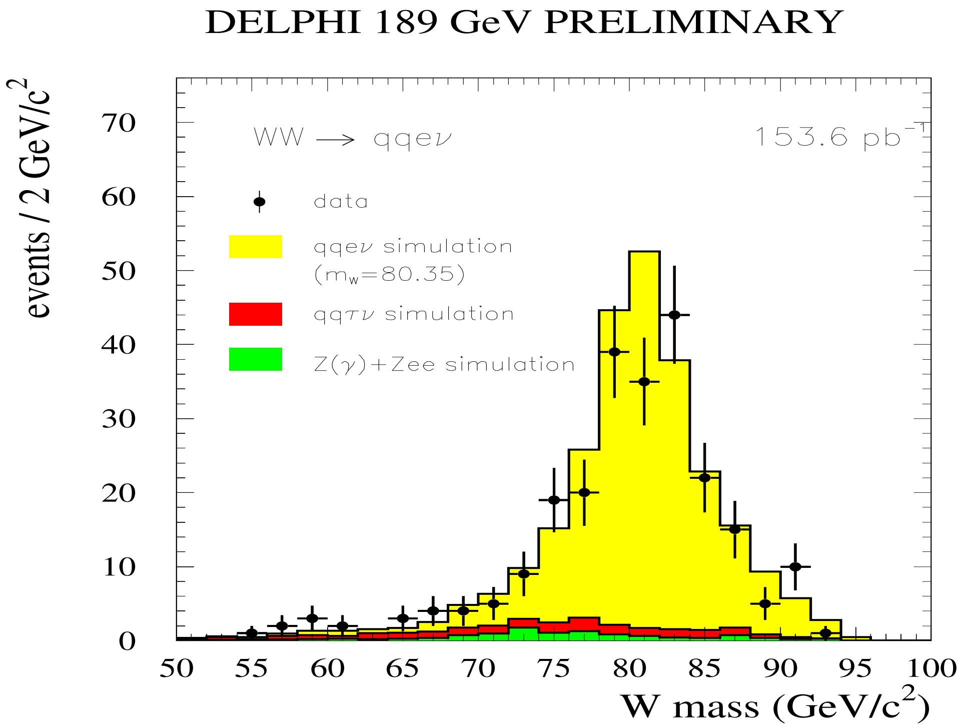




Detector stability is OK for M_W measurement

• W mass distributions at 188.7 GeV: semi-leptonic channels





data vs simulation (PYTHIA two-fermions, EXCALIBUR four-fermions)

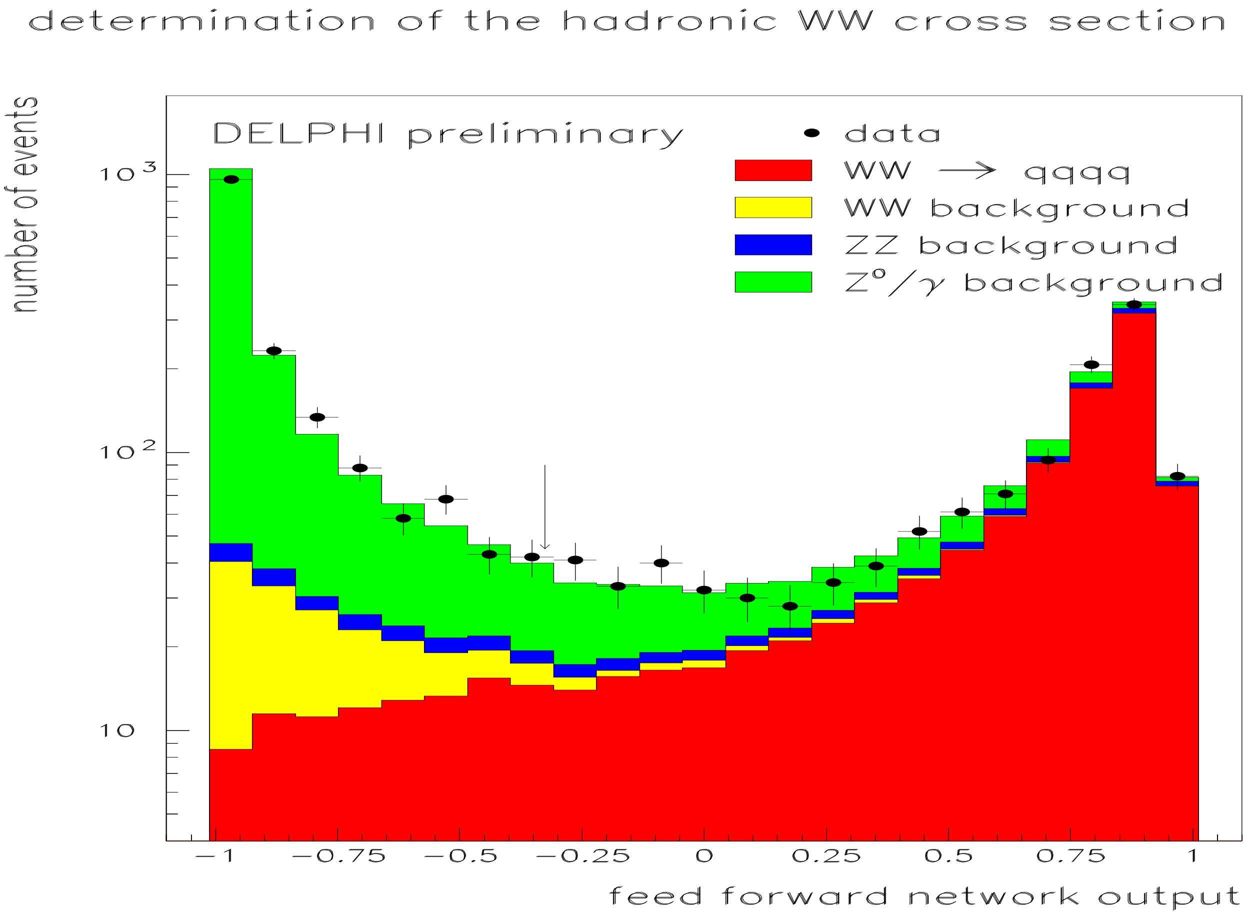
EW measurements: WW cross-section

- Event selection at 188.7 GeV:

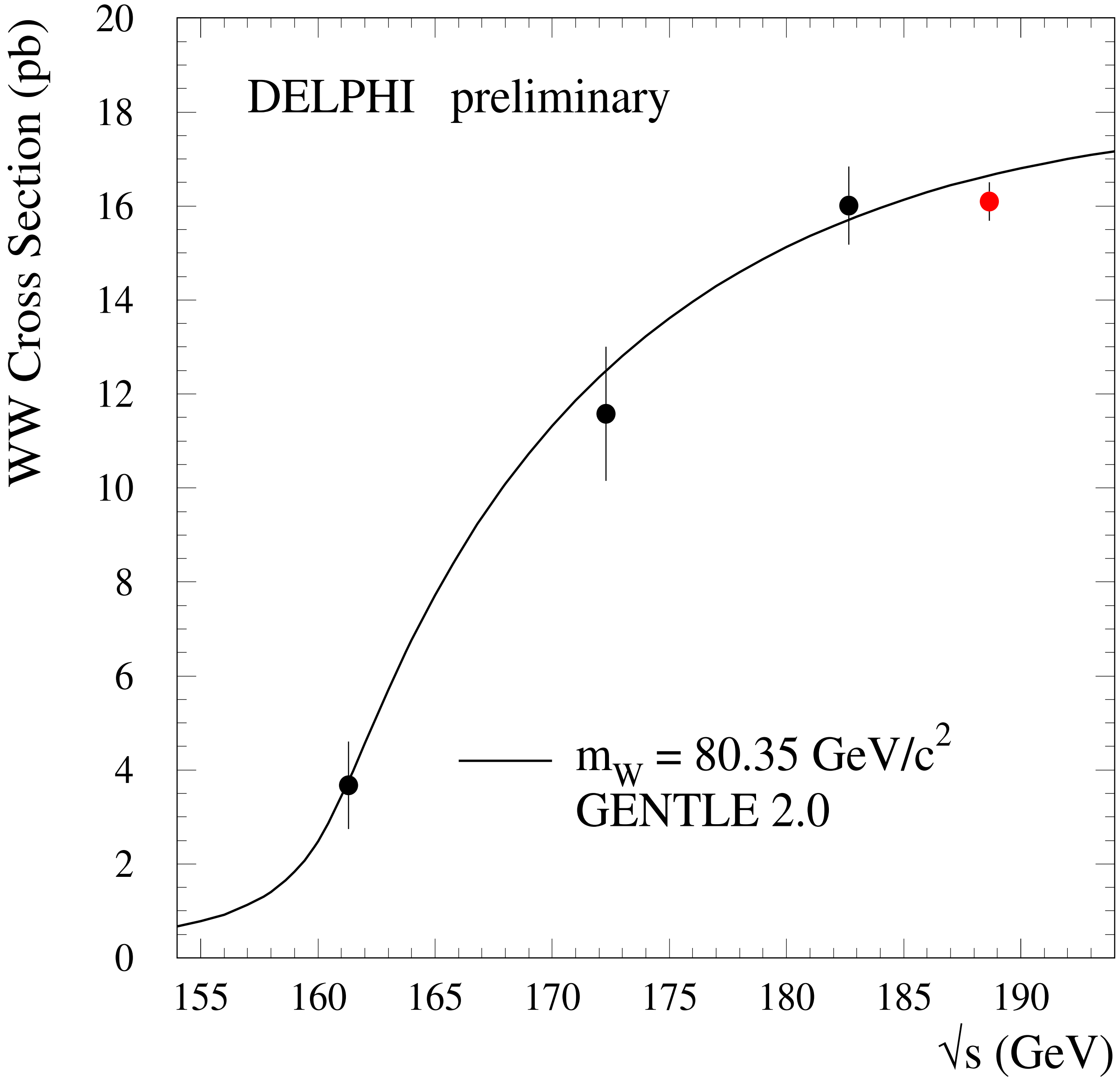
channel	$\mathcal{L}(pb^{-1})$	observed	efficiency	purity
$l\nu l\nu$	149	151	60%	82%
$q\bar{q}l\nu$	149	861	70%	88%
$q\bar{q}q\bar{q}$	155	1308	88%	79%

Data/simulation comparison :

Example of the $q\bar{q}q\bar{q}$ channel



•WW cross-section at 188.7 GeV:



NB: Error at 189 GeV is statistical only

⇒No departure from SM prediction

EW measurements: ZZ production

• At 188.7 GeV, we expect:

$$\sigma_{ZZ}^{on-shell} = 0.7\,\mathrm{pb} \text{ where: on-shell} \equiv |M_Z - 91.2| < 20\,\mathrm{GeV}$$

• Event selection at 188.7 GeV:
Most final states are common with hZ searches

BUT

The ZZ analyses are designed to select on-shell ZZ signal and do not require b-tagging (except in the four-jet channel).

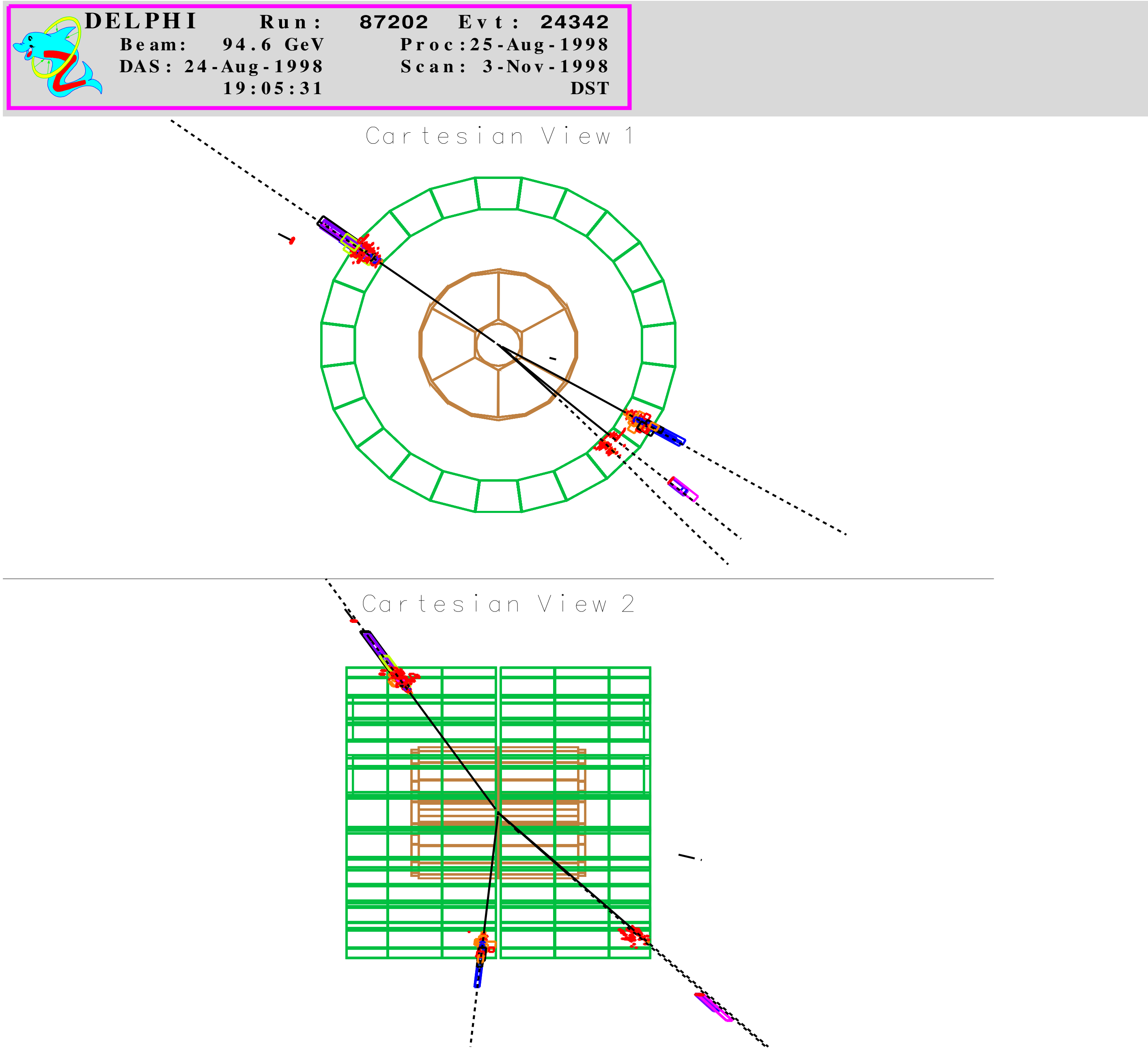
⇒Independent analysis of the same final states

channel	$\mathcal{L}(\mathrm{pb}^{-1})$	observed	exp. signal	exp. bkg.	ϵ
$q\bar{q}b\bar{b}$	158.0	6	3.7	1.1	21.7%
$q\bar{q}\nu\nu$	155.4	8	9.8	2.5	34.7%
$q\bar{q}\mu^+\mu^-$	158.0	5	3.7	0.2	78.2%
$q\bar{q}e^+e^-$	158.0	3	3.9	0.6	57.4%
total	-	22	21.1	4.4	-

⇒Good agreement with SM predictions

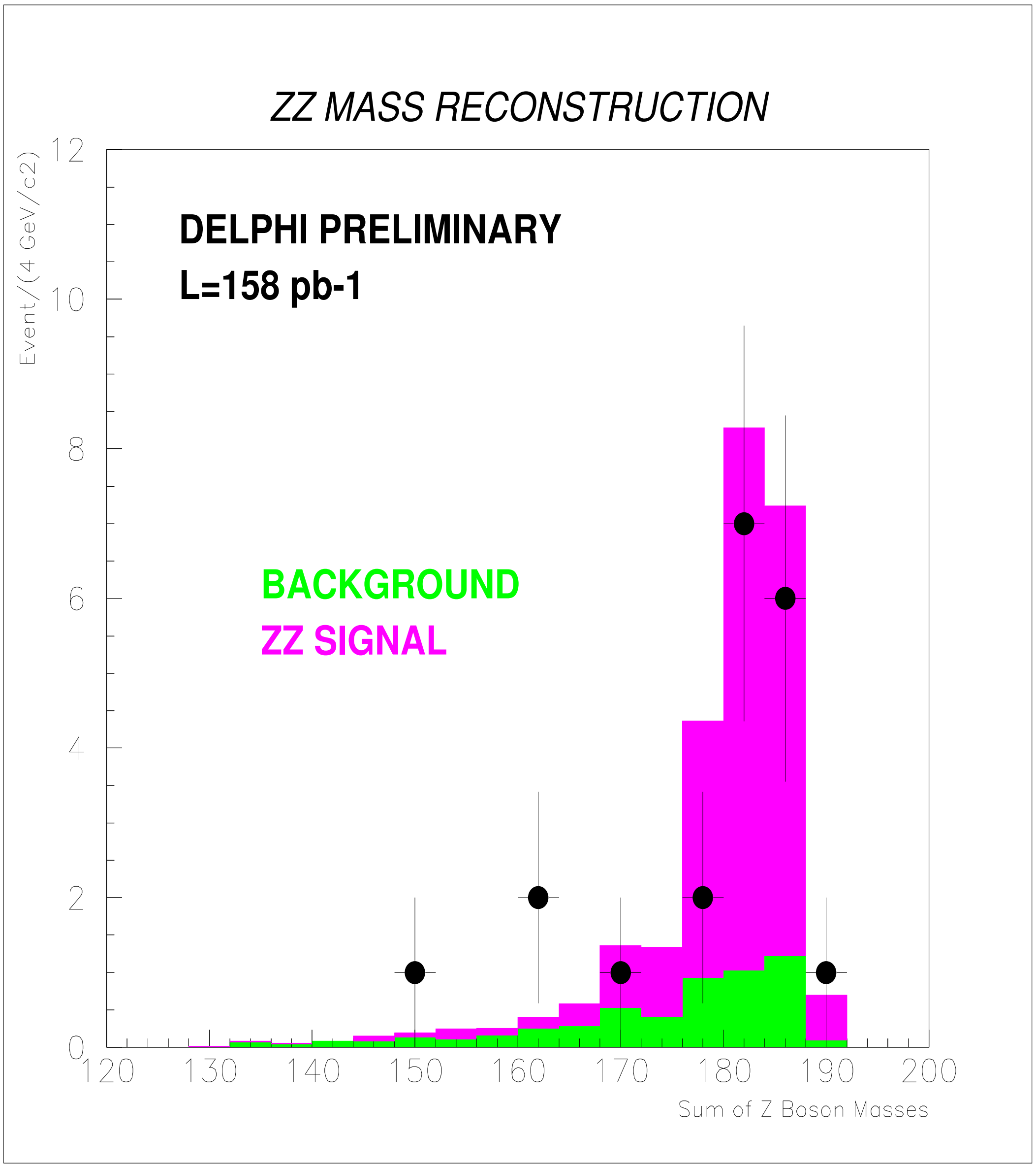
NB: No on-shell ZZ→llll event found but the leptonic analyses provide a nice study of the Zγ^* process.
Example: a Z$\gamma^* \to e^+e^-\rho(\to \pi^+\pi^-)$ event

A $Z\gamma^* \rightarrow e^+e^-\rho(\rightarrow \pi^+\pi^-)$ event



$$M_{ee} = 87.6 \text{ GeV} \qquad M_{\pi\pi} = 0.80 \text{ GeV}$$

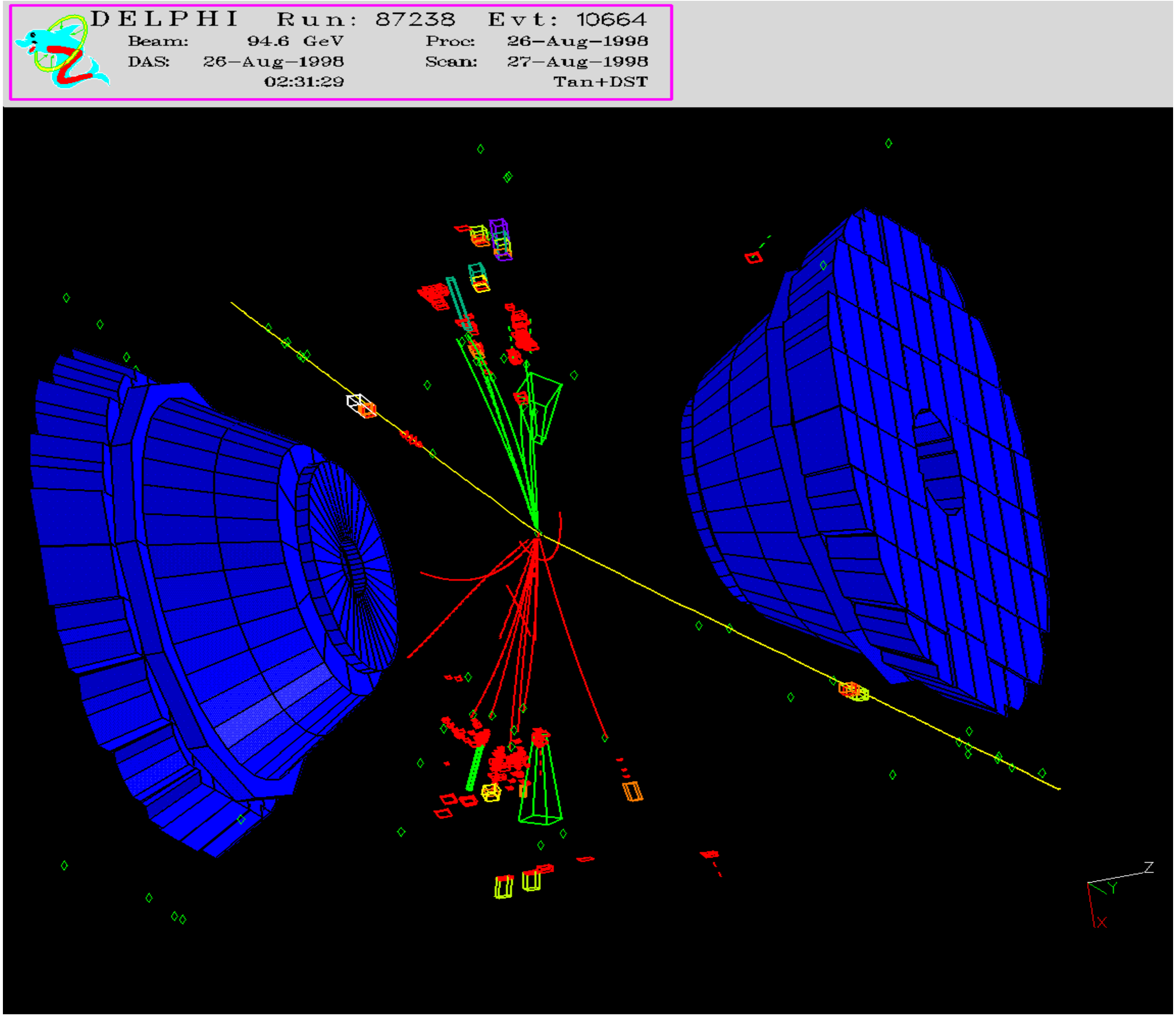
•Mass distribution: data vs simulation



•Graphic displays of a few events consistent with on-shell ZZ production:

a $b\bar{b}\mu^+\mu^-$ event, a $q\bar{q}e^+e^-$ event, a $q\bar{q}b\bar{b}$ event.

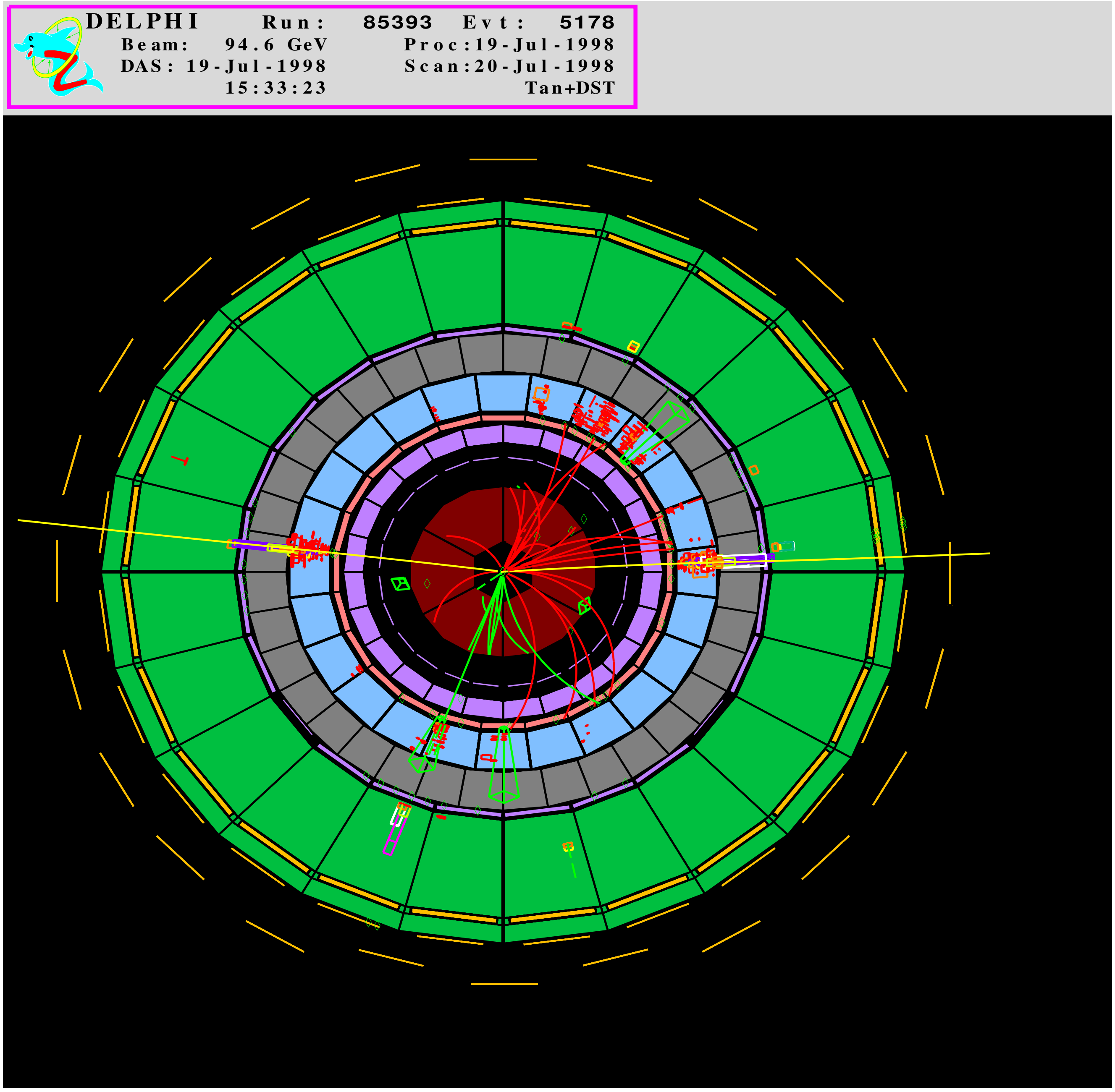
A $b\bar{b}\mu\mu$ event



$\mathrm{M}_{\mu\mu} = 92.3$ GeV $\quad$ $\mathrm{M}_{rec} = 93.4$ GeV

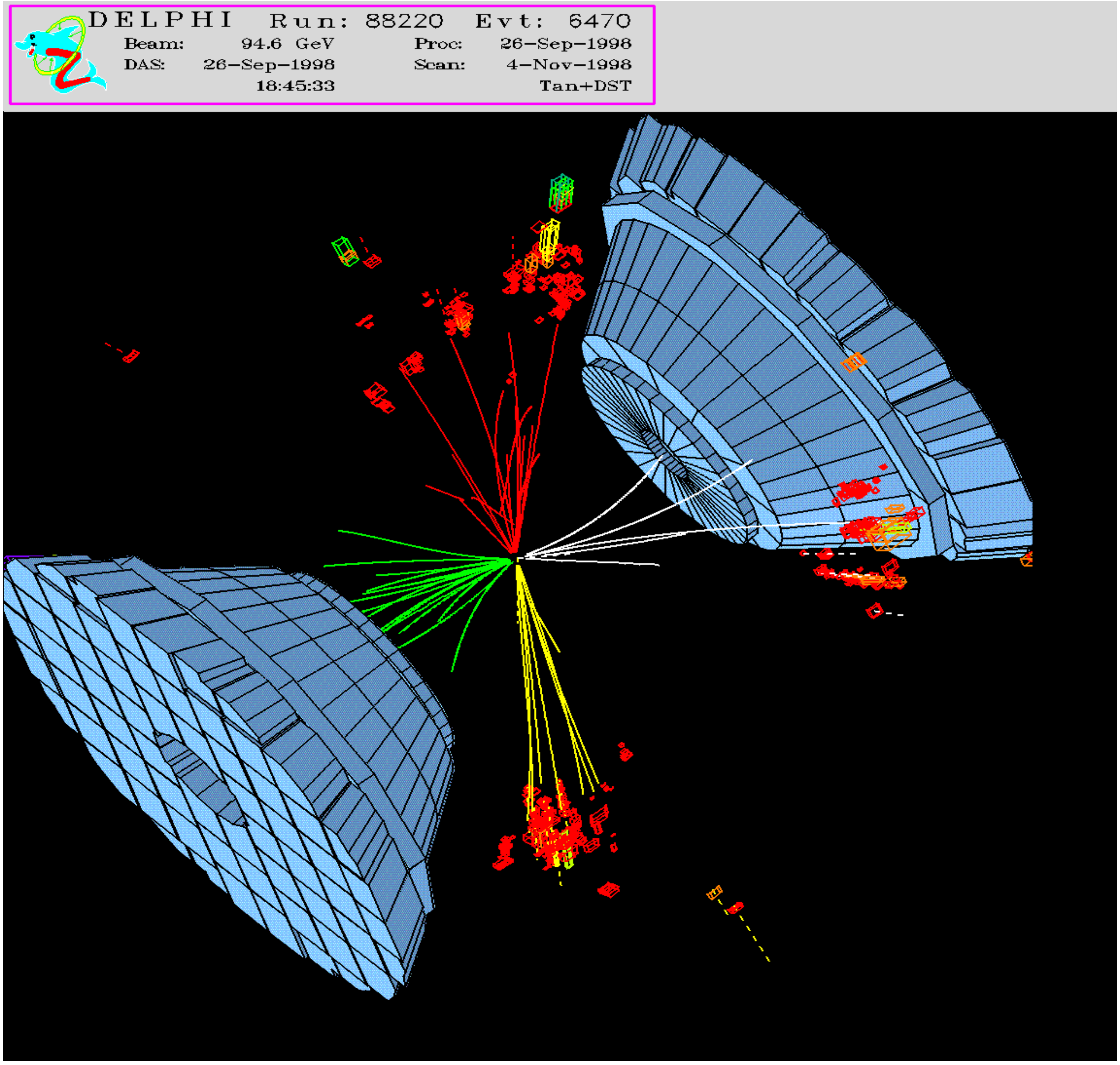
Tightly b-tagged

A $q\bar{q}e^+e^-$ event



$M_{ee} = 91.2$ GeV $M_{rec} = 90.3$ GeV Not b-taggged

A $q\bar{q}b\bar{b}$ event



$\mathrm{M}_{jj} = 92.9$ GeV $\quad \mathrm{M}_{jj} = 91.1$ GeV

Tightly b-taggged

DELPHI physics results at 188.7 GeV

II) Searches:

- Higgs bosons - hZ channels
- Higgs bosons - hA channels
- stop $\rightarrow c\tilde{\chi}_1^0$
- Single photons
- Acoplanar photon pairs
- Stau searches

All results are PRELIMINARY !

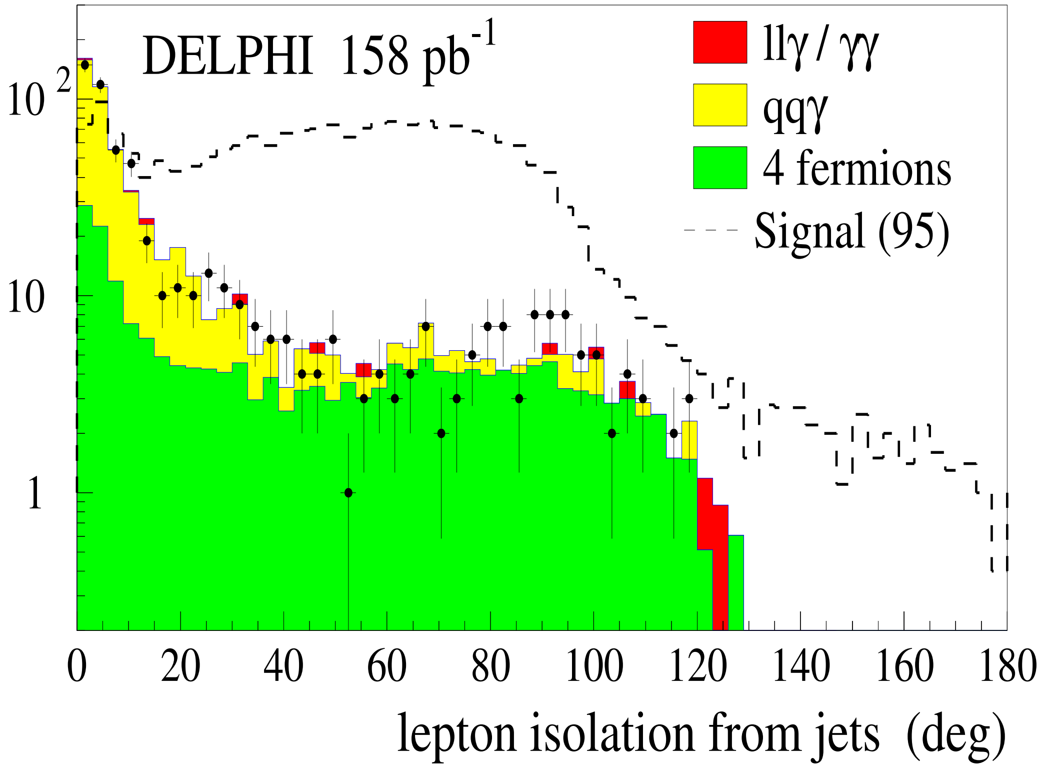
Searches: Higgs bosons - hZ channel

- Event selection:

hZ channel	$\mathcal{L}(\mathrm{pb}^{-1})$	obs.	exp. bkg.	$\epsilon_{95}(\%)$	exp. sig$_{95}$
h ee	155.4	0	1.91±0.41	44.8	0.39
h $\mu\mu$	158.0	2	1.90±0.20	59.4	0.52
h $\nu\nu$	153.3	2	4.11±0.48	24.7	1.27
h $\tau\tau$	158.0	0	0.55±0.15	12.8	0.10
$\tau\tau hadr$	158.0	1	2.50±0.29	15.6	0.23
$hadr\ q\bar{q}$	158.0	21	20.31±2.09	44.5	7.56
total	-	26	31.3 ±2.2	-	10.1

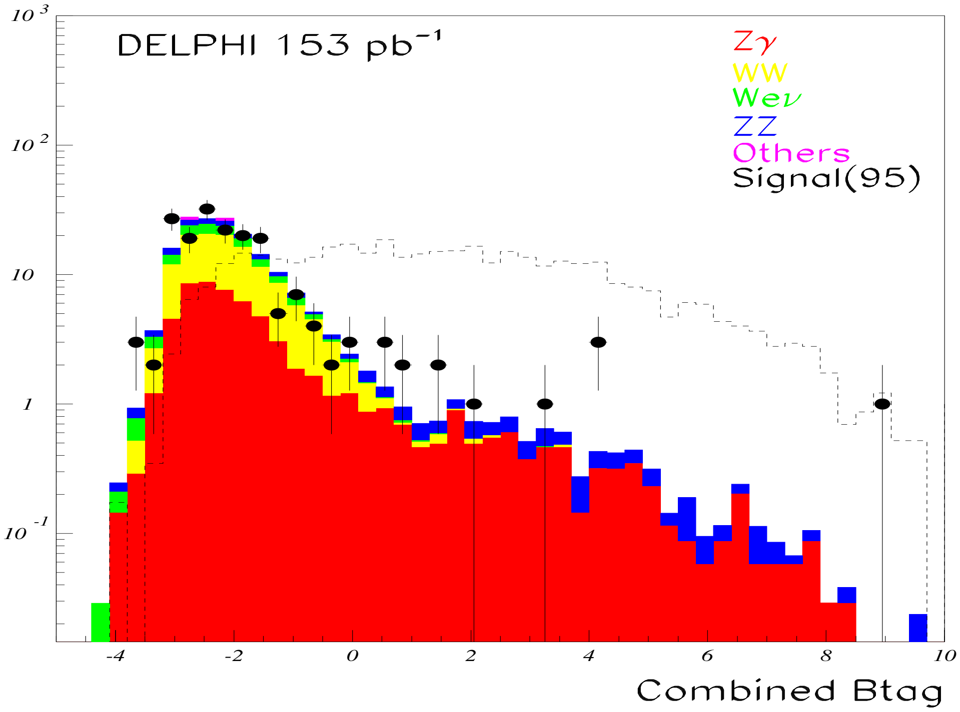
⇒Good agreement with SM predictions

- Data vs simulation: the h$\mu\mu$ channel

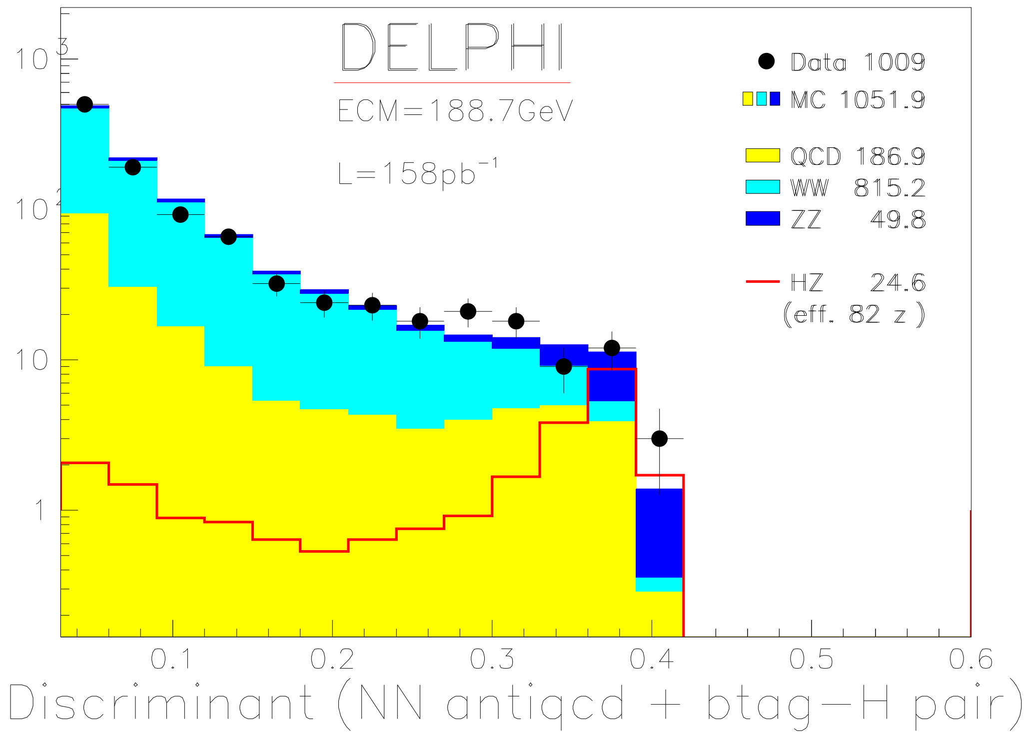


- Data vs simulation, cont'nd:

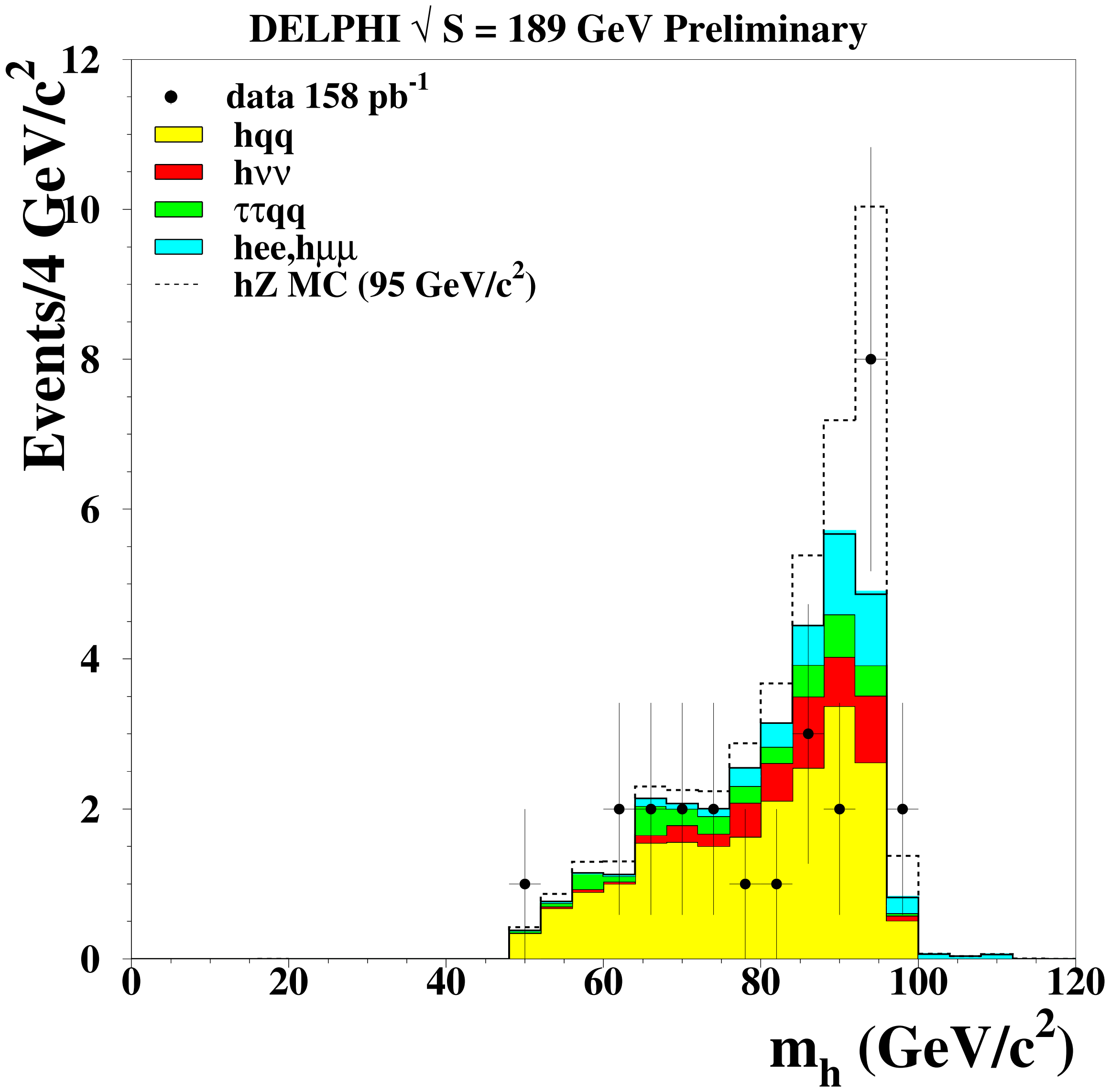
h $\nu\bar{\nu}$ channel



4-jet channel



•Reconstructed M_h spectrum:



•95% Exclusion limit on the SM Higgs boson:

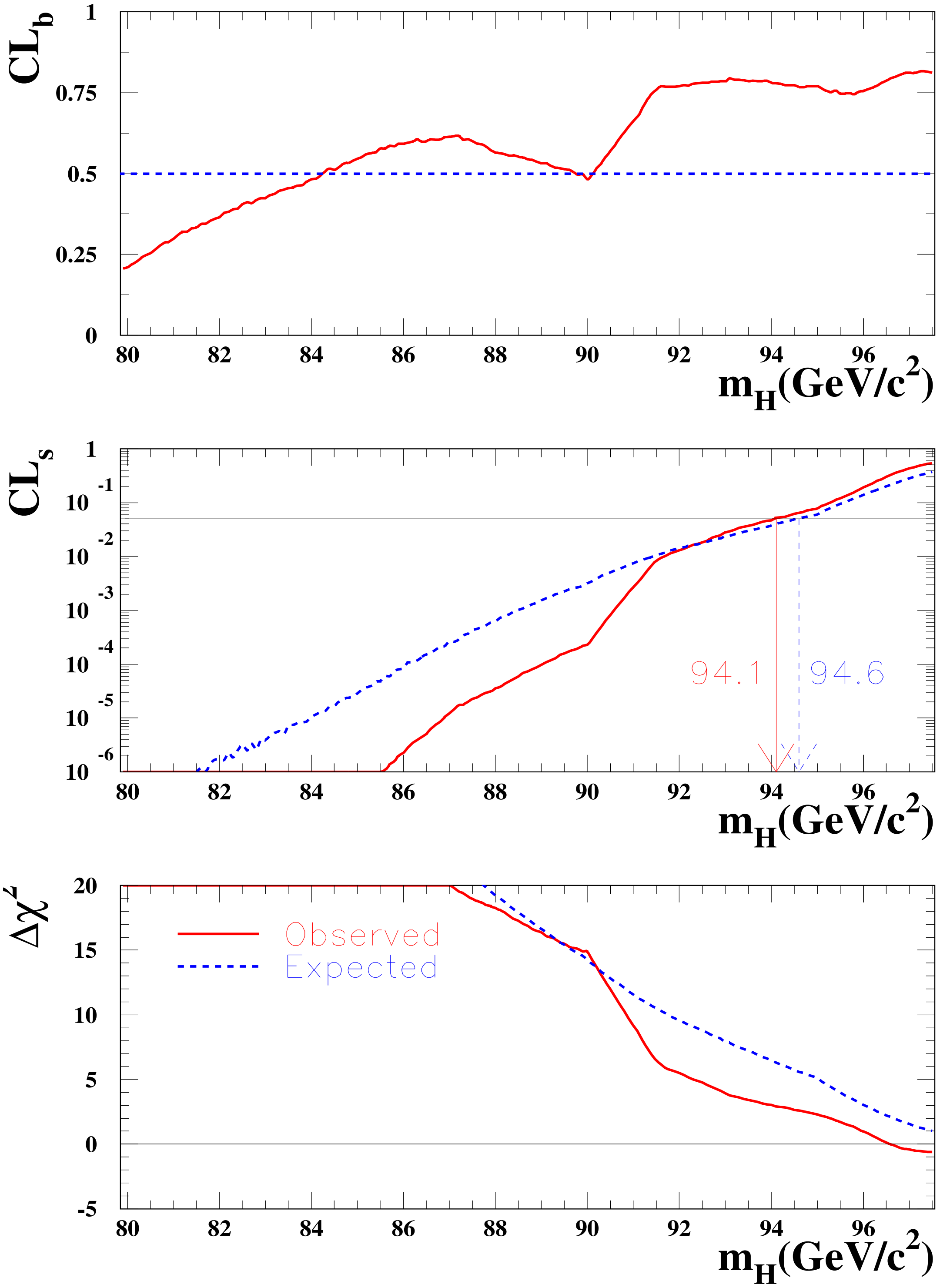
Statistical method:

•based on likelihood ratio test-statistics

•takes into account rates and reconstructed M_h spectrum in each channel

•uncertainties on efficiencies and background rates included

DELPHI 189 GeV Preliminary - SM Higgs boson



observed: M_h >94.1 GeV

expected: 94.6 GeV (mean), 95.2 GeV(median)

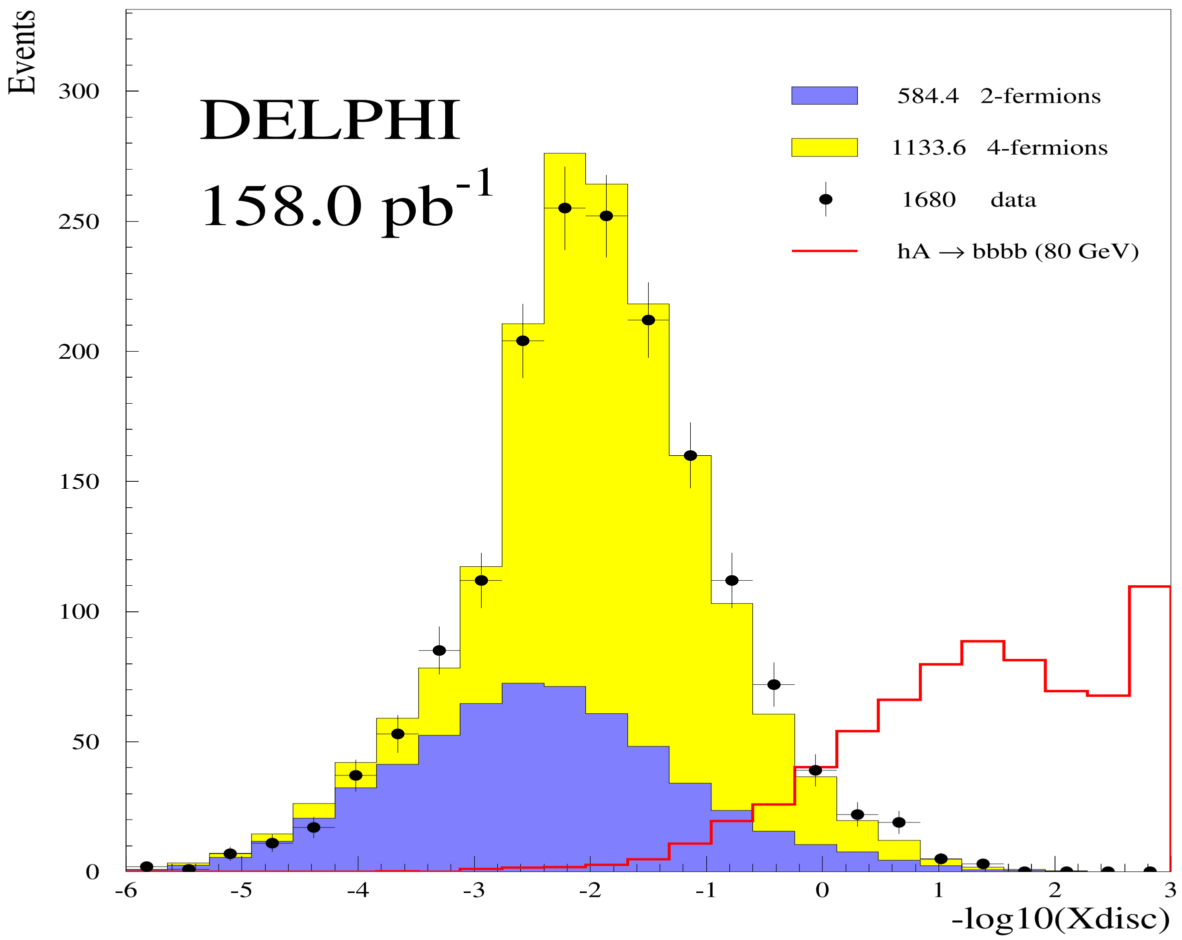
Searches: Higgs bosons - hA channel

- Event selection:

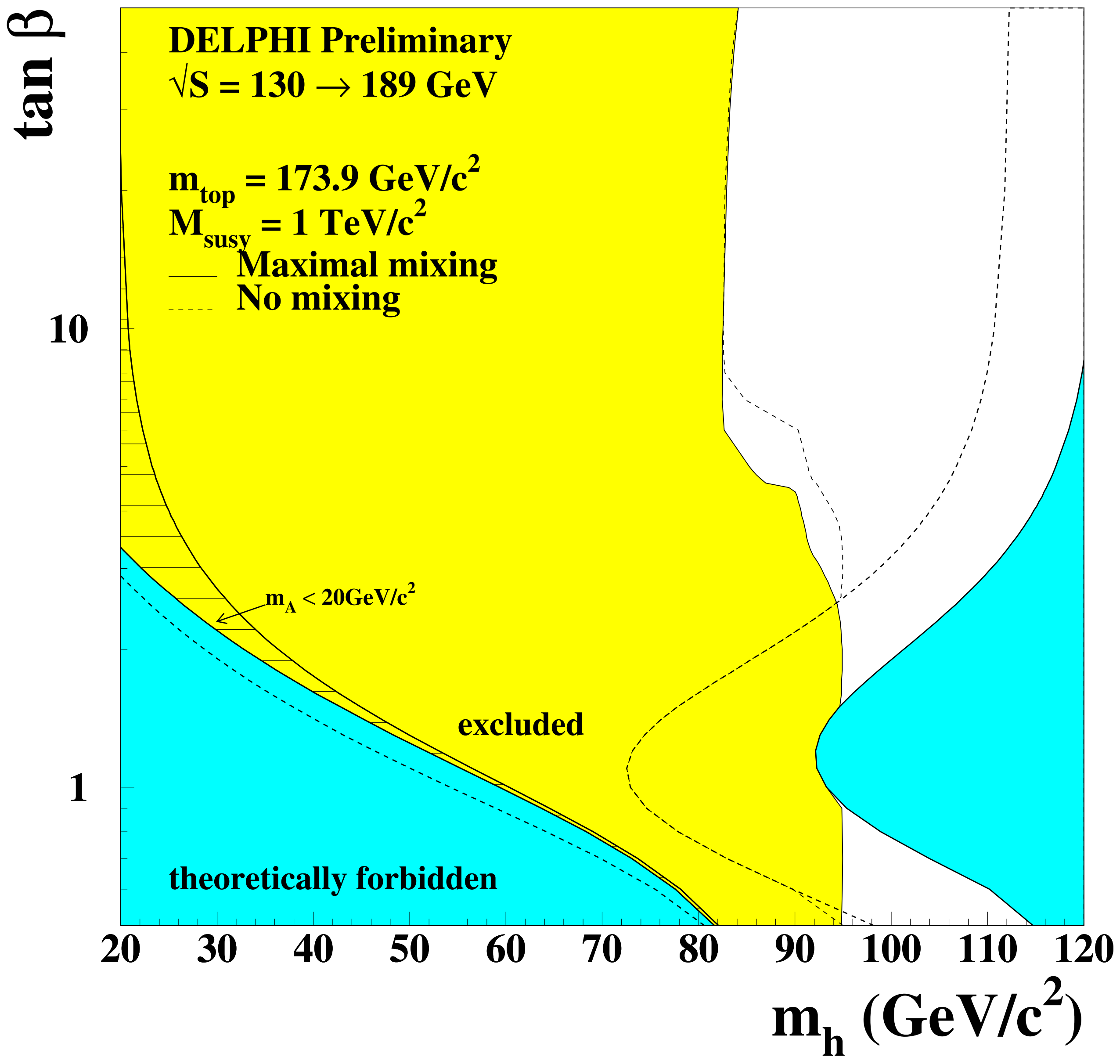
hA channel	$\mathcal{L}(pb^{-1})$	obs.	exp. bkg.	$\epsilon_{80}(\%)$	exp. sig$_{80}$
$\tau\tau b\bar{b}$	158.0	0	0.55 ± 0.15	18.3	0.31
$b\bar{b}b\bar{b}$	158.0	3	4.25 ± 0.40	52.4	5.19
total	-	3	4.8 ± 0.4	-	5.5

$\Rightarrow$Good agreement with SM predictions

- Data vs simulation: example of the $b\bar{b}b\bar{b}$ channel



•95% MSSM exclusion limits (benchmark scans): tanβ vs M_h plane

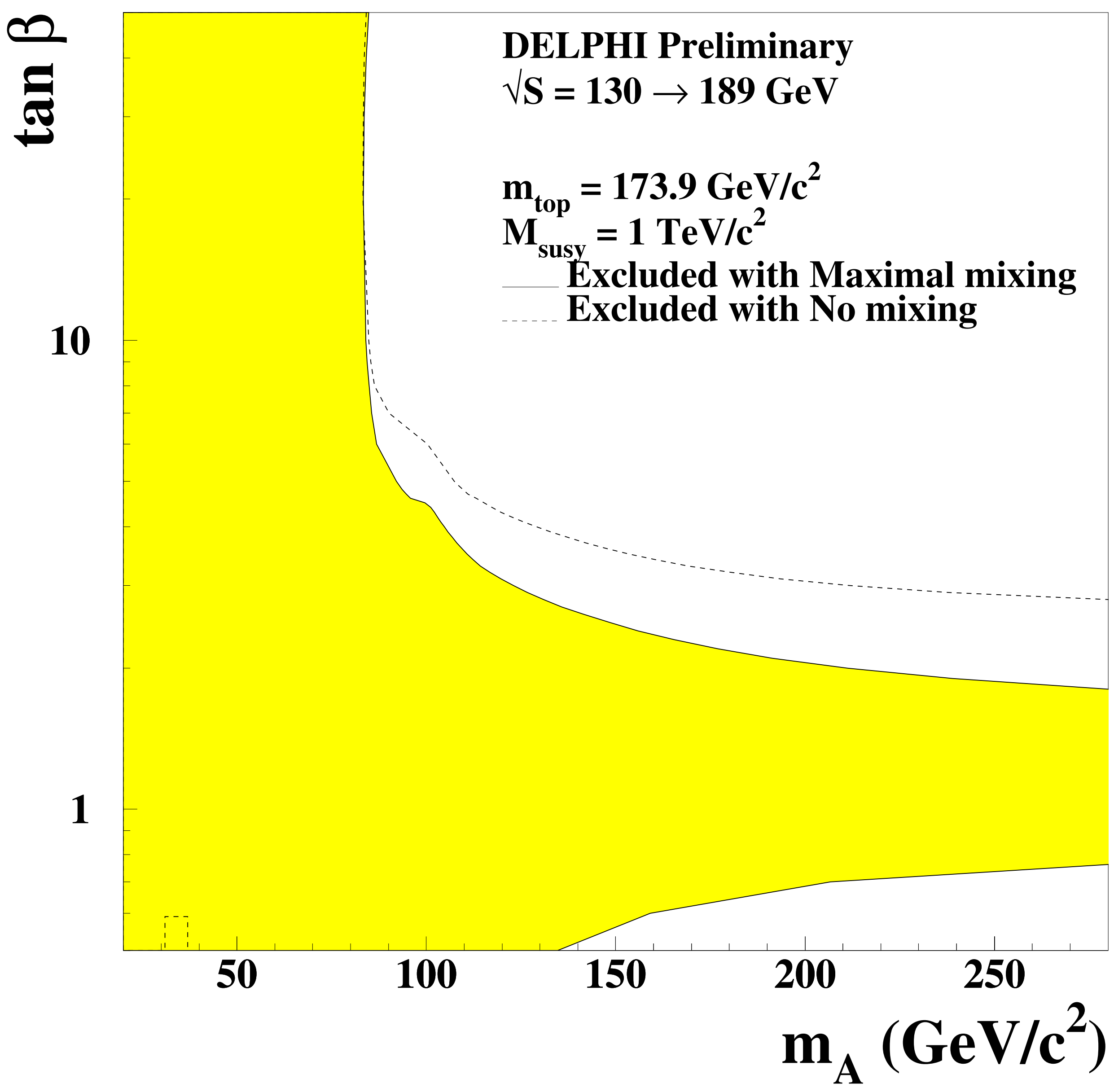


$M_h > 82.4$ GeV (exp. 80.3 GeV) for all tan$\beta > 0.6$

$0.6 <$ tan$\beta < 2.5$ excluded for no mixing

$1.0 <$ tan$\beta < 1.5$ excluded for maximal mixing

•95% MSSM exclusion limits (benchmark scans): tanβ vs M_A plane



$M_A > 83.3$ GeV (exp. 81.4 GeV) for all tan$\beta > 0.6$

Searches: stop $\rightarrow c\tilde{\chi}_1^0$

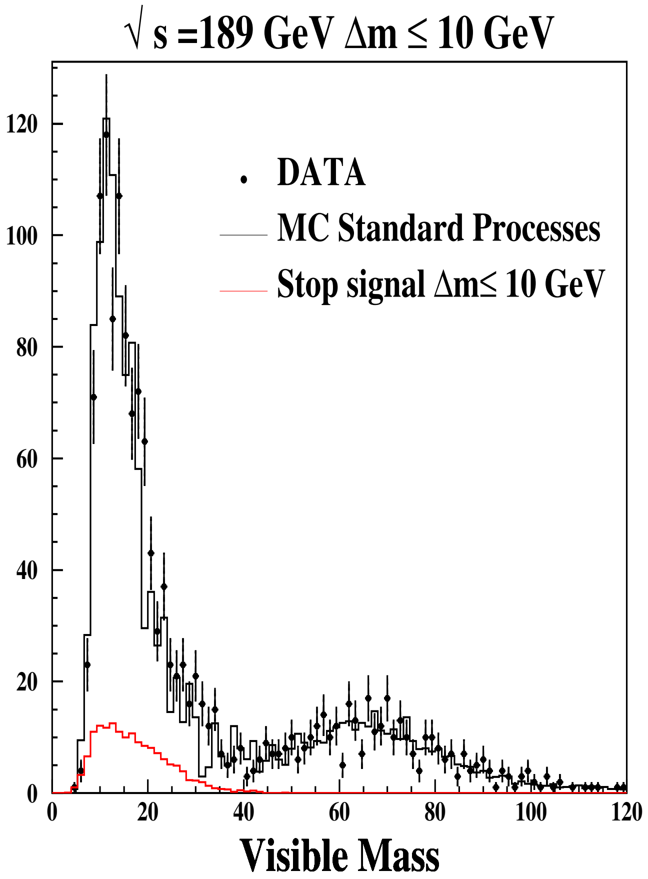
• Event selection ($\Delta M = M_{\mathrm{stop}} - M_{\tilde{\chi}_1^0}$):

case	$\mathcal{L}(\mathrm{pb}^{-1})$	obs.	exp. bkg.	main bkg.
$\Delta M > 10GeV$	158.0	5	7.0 ± 0.9	$q\bar{q}(\gamma)$
$\Delta M < 10GeV$	158.0	3	3.3 ± 0.8	$\gamma\gamma \rightarrow had$
total	158.0	8	9.3 ± 1.2	

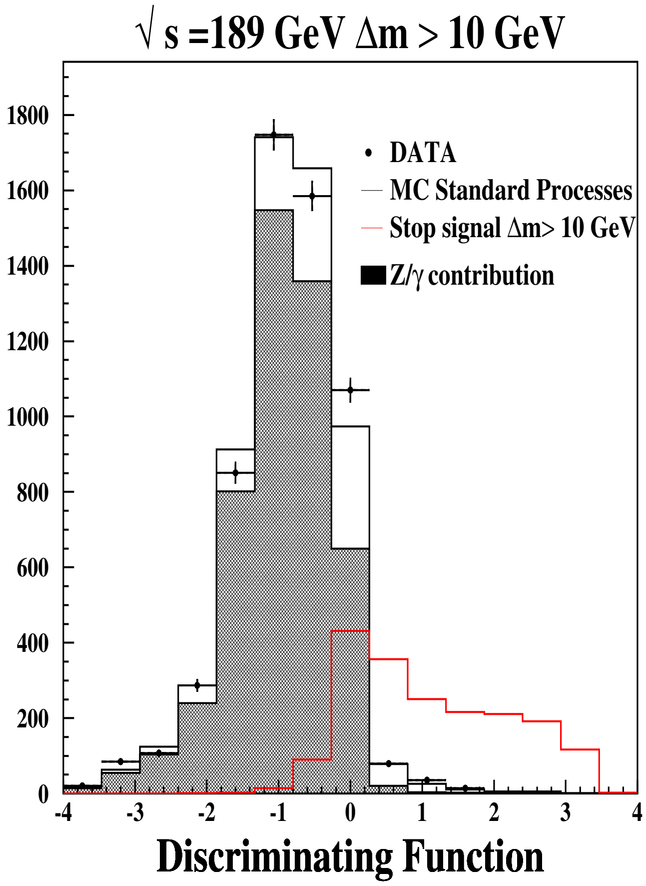
$\Rightarrow$Good agreement with SM predictions

• Data vs simulation:

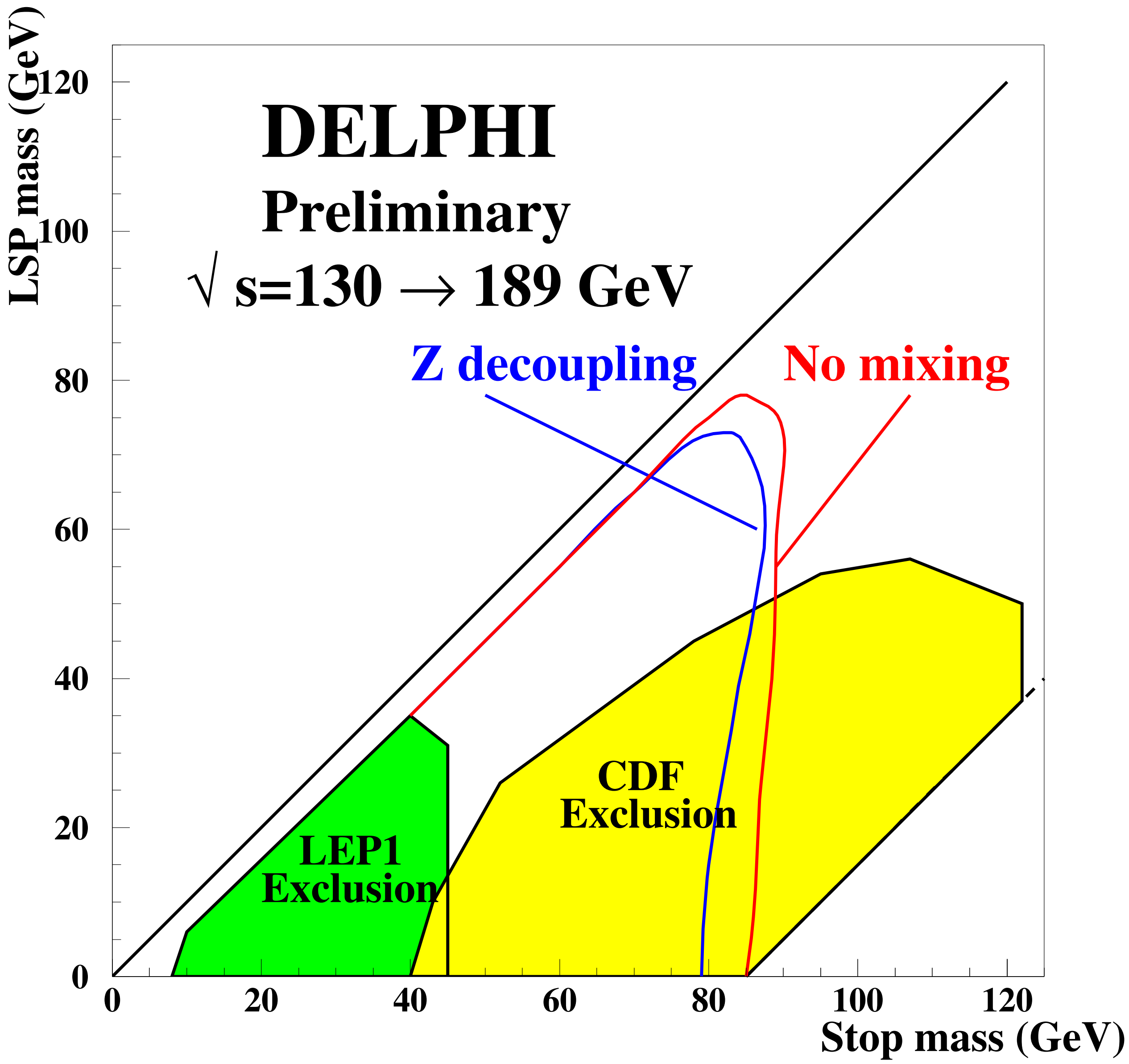
degenerate case



non-degenerate case

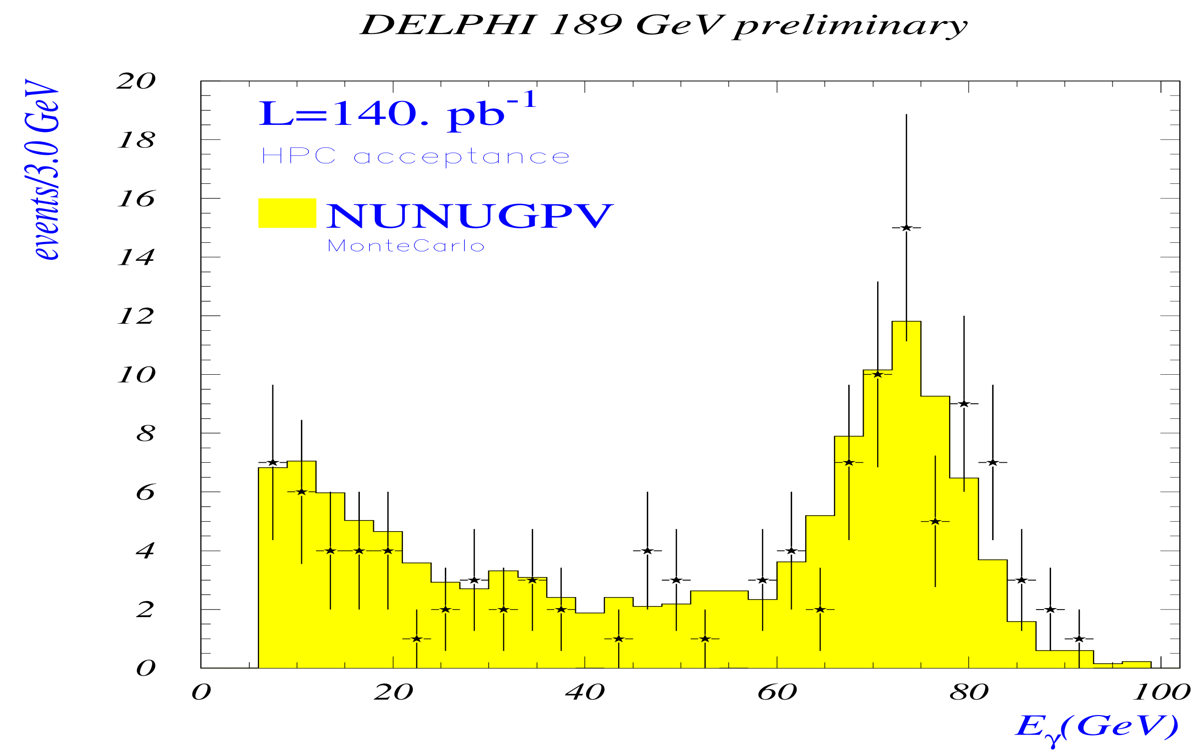


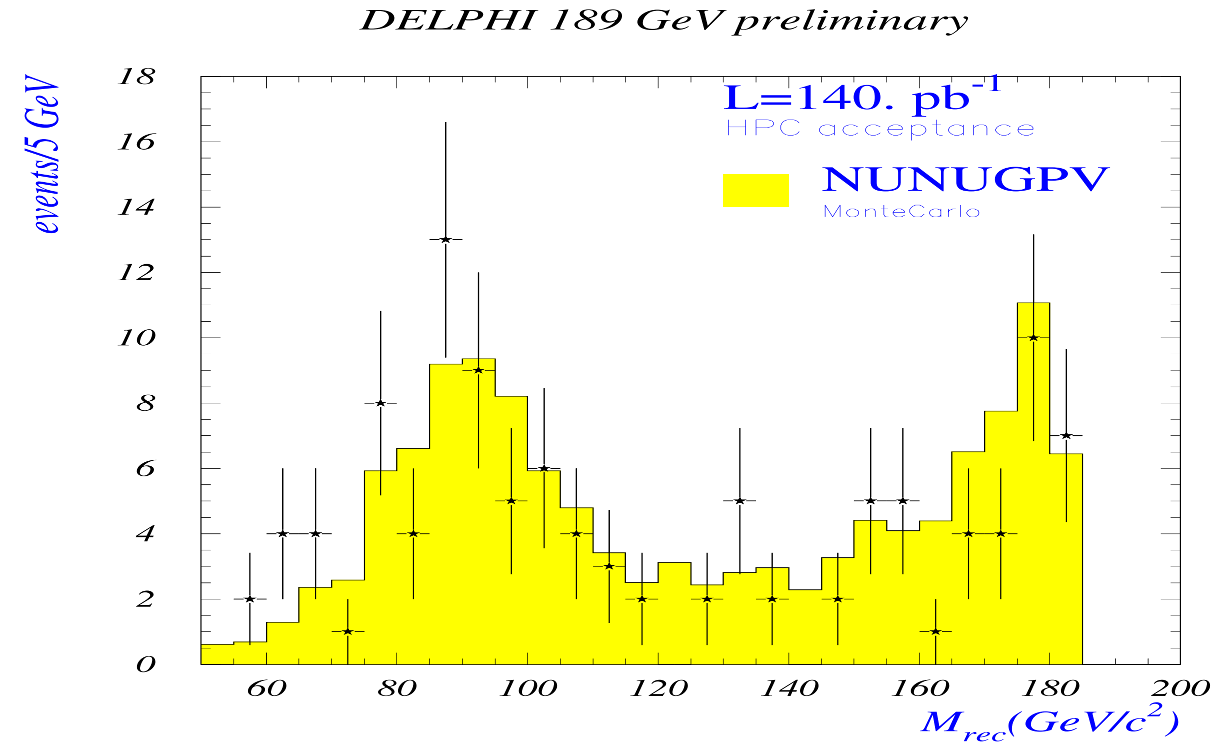
•95% Exclusion limit on stop:



⇒Gain of ∼ 10 GeV over our previous results

Searches: single photons



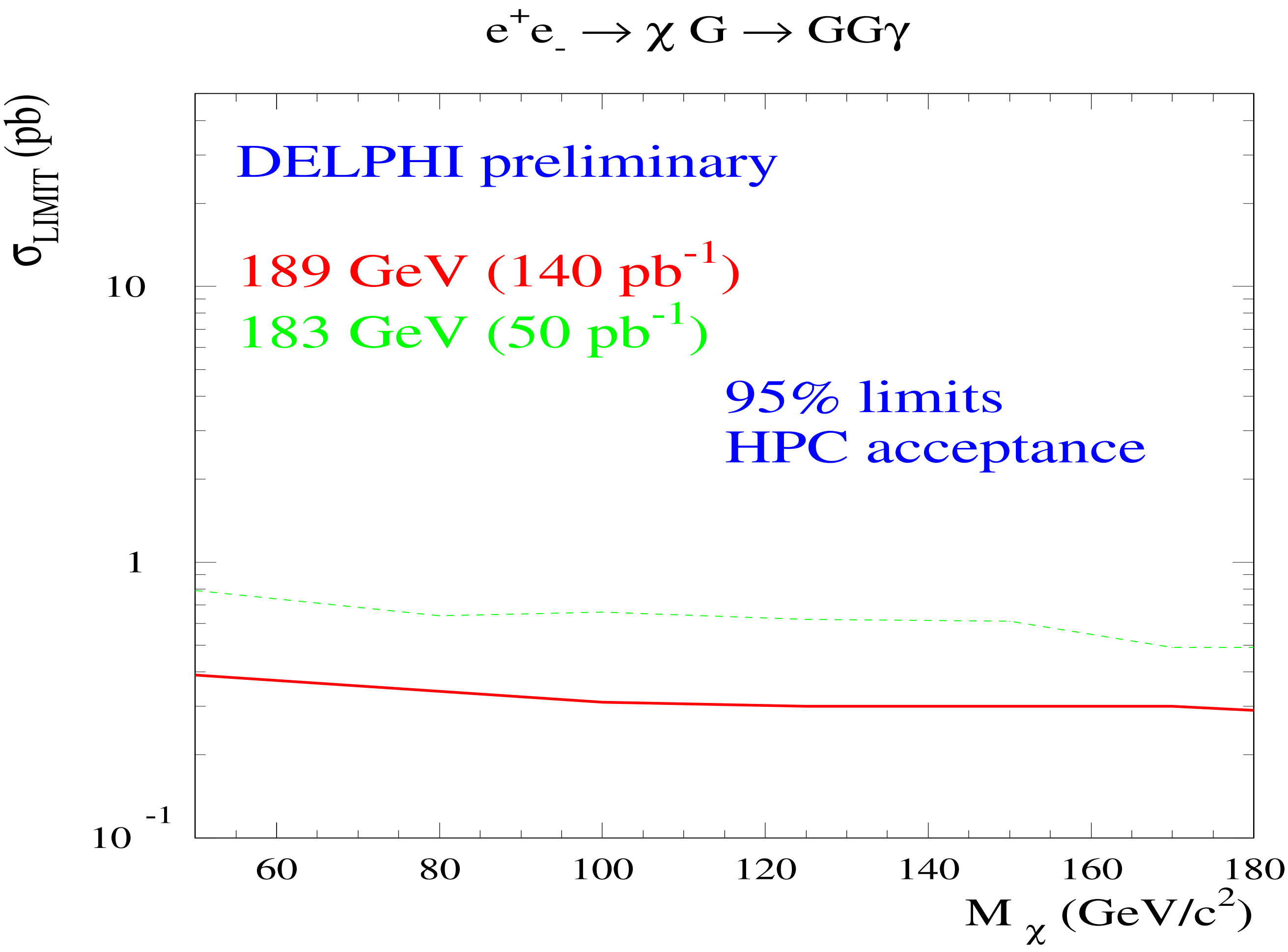


$\Rightarrow$number of ν species from LEP2 data:

$$N_\nu = 2.80 \pm 0.13(stat.)\ \text{(LEP1 result :}N_\nu = 2.89 \pm 0.32)$$

•Constraints on the SUSY process: $e^+e^- \to \tilde{G}\tilde{\chi}_1^0 \to \tilde{G}\tilde{G}\gamma$ (GMSB)

- Limit on neutralino production:



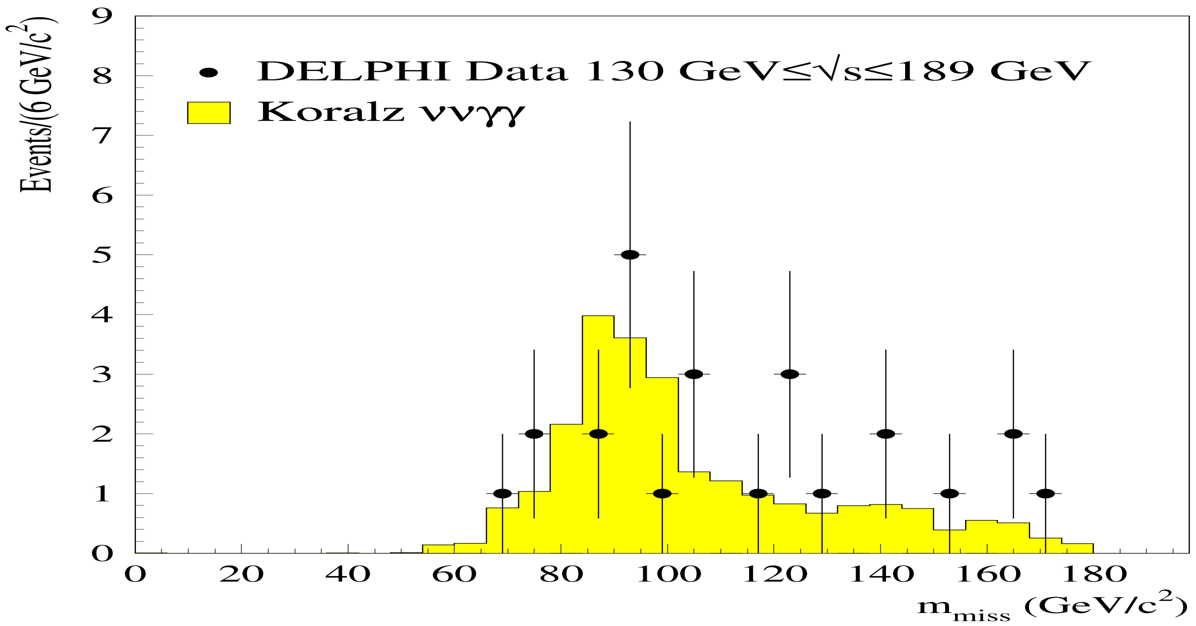
- Limit on the gravitino mass, assuming very large masses for all other SUSY particles:

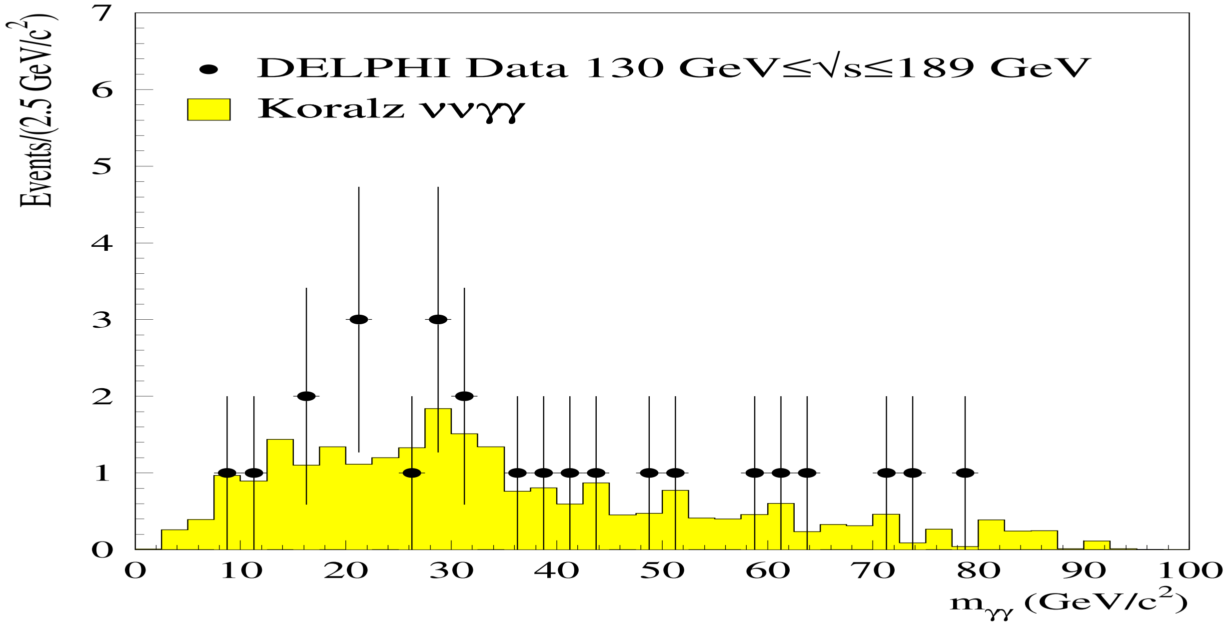
$$\sigma < 0.2\text{pb} \;\Rightarrow\; \mathbf{M}_{\tilde{G}} > \mathbf{8.7\ 10^{-6}\ eV}$$

Searches: acoplanar photon pairs (pointing γ)

- Event preselection:

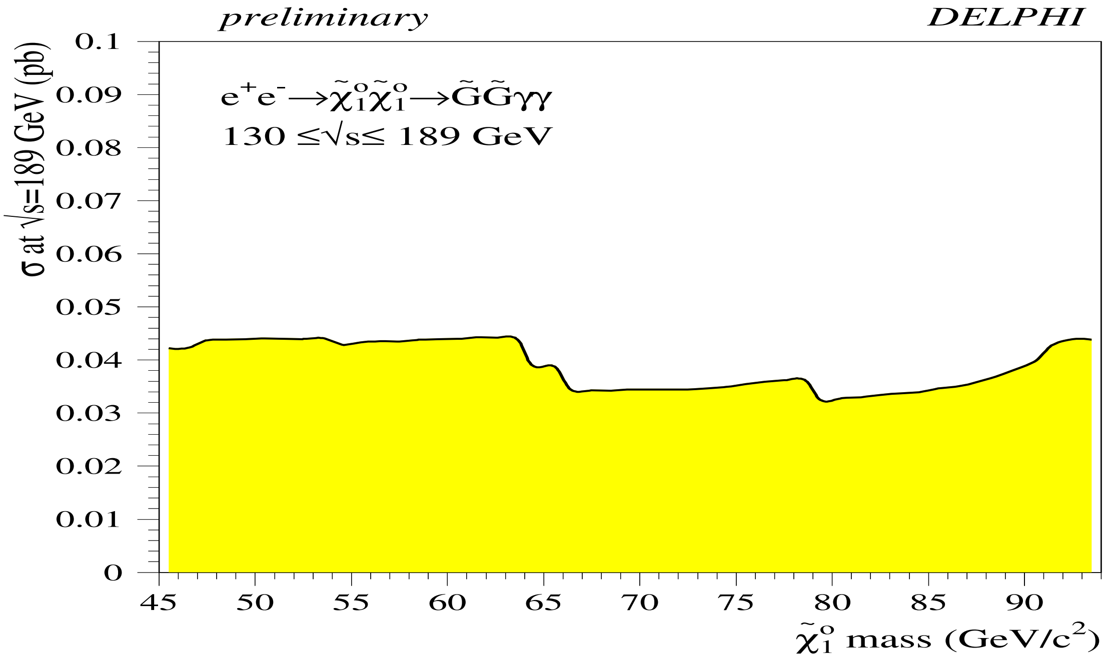
at 188.7 GeV:	SM exp: 14.0	obs: 15
tot. LEP2:	SM exp: 24.2	obs: 25

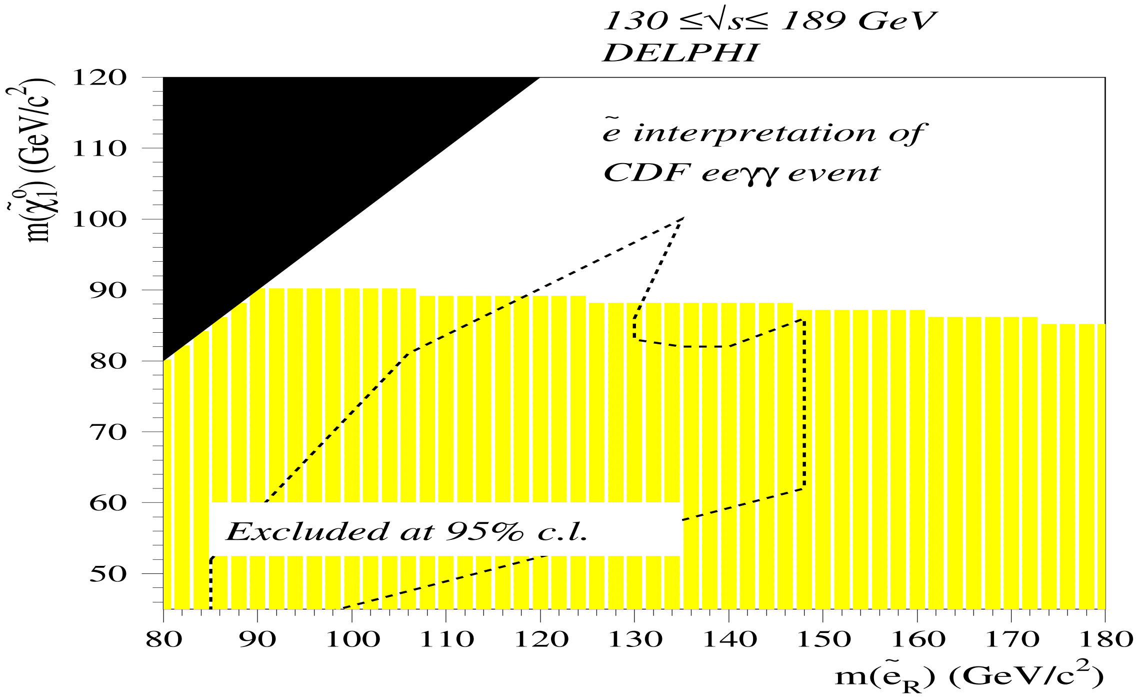




•Constraints on SUSY processes: $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to \tilde{G}\gamma\tilde{G}\gamma$ (GMSB)

Final cuts: SM exp: 8.0 obs: 6 $\Rightarrow$95% upper lim. on σ(pb) vs $M_{\tilde{\chi}_1^0}$

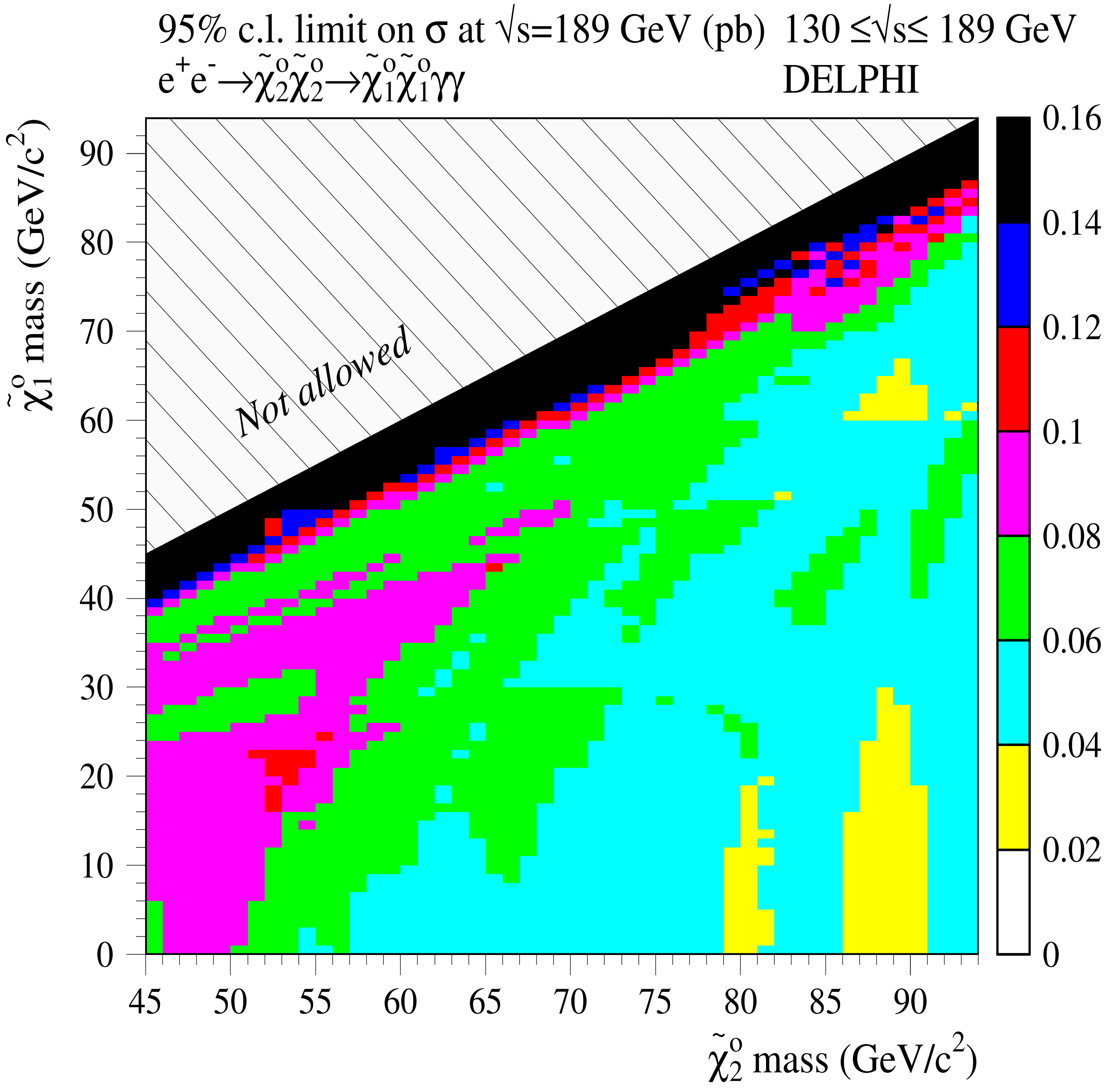




•Constraints on SUSY processes: $e^+e^- \to \tilde{\chi}_2^0\tilde{\chi}_2^0 \to \tilde{\chi}_1^0\gamma\tilde{\chi}_1^0\gamma$ (MSSM)

Final cuts: SM exp: 8.9 obs: 11

⇒95% upper limits on σ(pb) in $M_{\tilde{\chi}_1^0}$ vs $M_{\tilde{\chi}_2^0}$ plane



Searches: staus

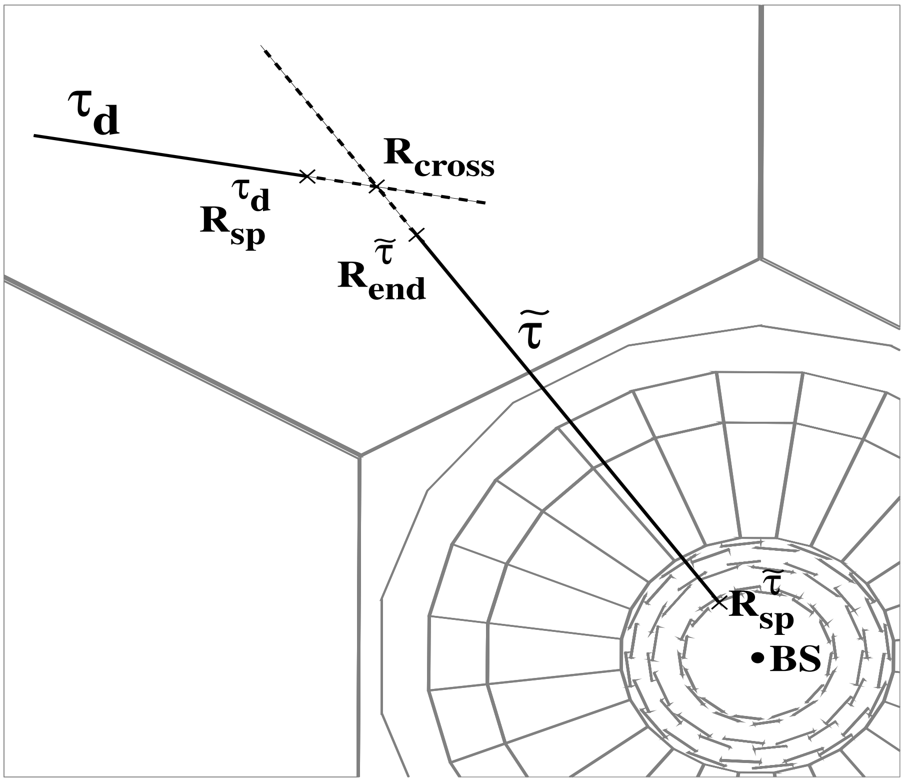
•Final states investigated and related SUSY processes:

•$\tau\tau+$ missing energy:
$\Rightarrow e^+e^- \to \tilde{\tau}\tilde{\tau} \to \tilde{\chi}_1^0\tau\tilde{\chi}_1^0\tau$ in MSSM (LSP $= \tilde{\chi}_1^0$)

$\Rightarrow e^+e^- \to \tilde{\tau}\tilde{\tau} \to \tilde{G}\tau\tilde{G}\tau$ in GMSB (LSP = massless $\tilde{G}$, NLSP $= \tilde{\tau}$)

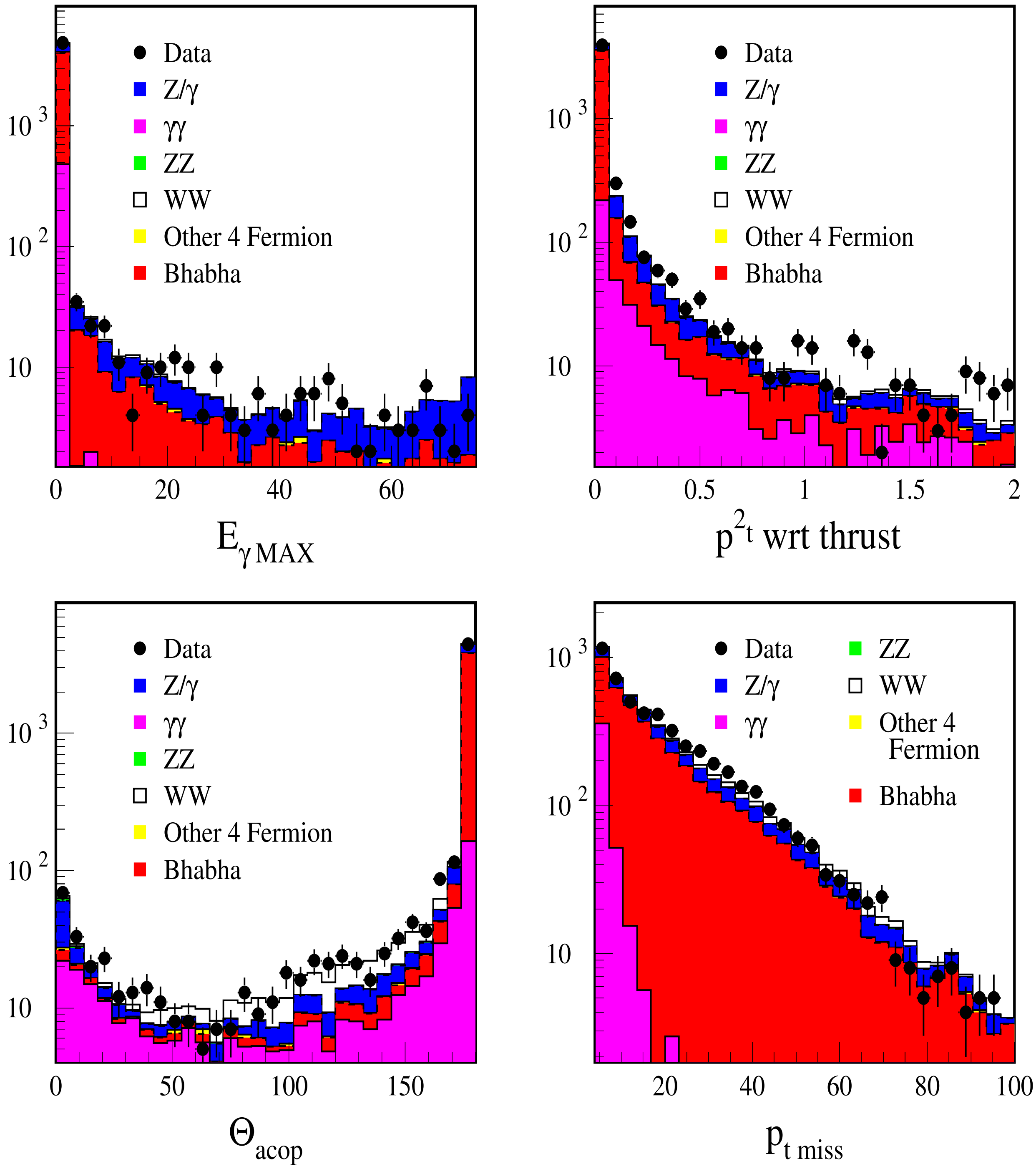
•$\tau\tau\tau\tau+$ missing energy:
$\Rightarrow e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to \tilde{\tau}\tau\tilde{\tau}\tau \to \tau\tau\tilde{G}\tau\tau\tilde{G}$ in GMSB (LSP = massless $\tilde{G}$, NLSP $= \tilde{\tau}$, NNLSP $= \tilde{\chi}_1^0$)

•$\tau\tau+$ missing energy, kinks or large impact parameters:
$\Rightarrow e^+e^- \to \tilde{\tau}\tilde{\tau} \to \tau\tilde{G}\tau\tilde{G}$ in GMSB (LSP = massive $\tilde{G}$, NLSP $= \tilde{\tau}$)

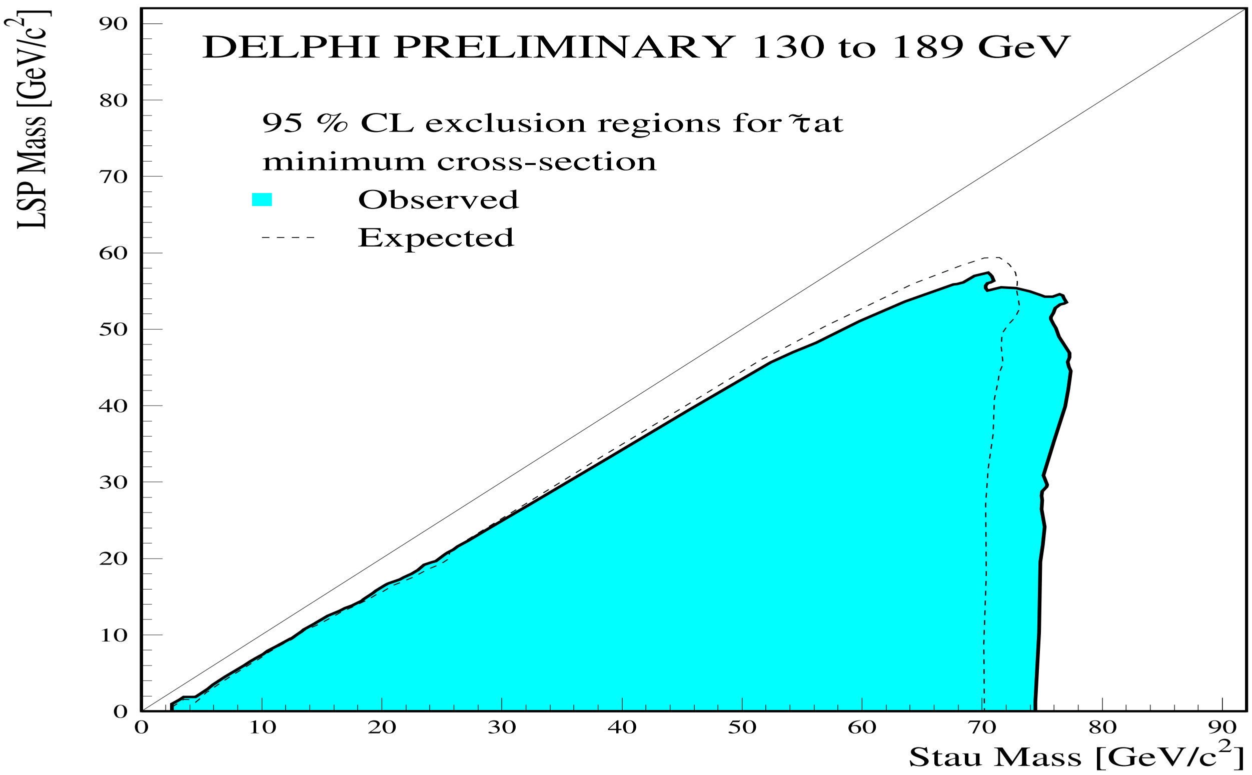


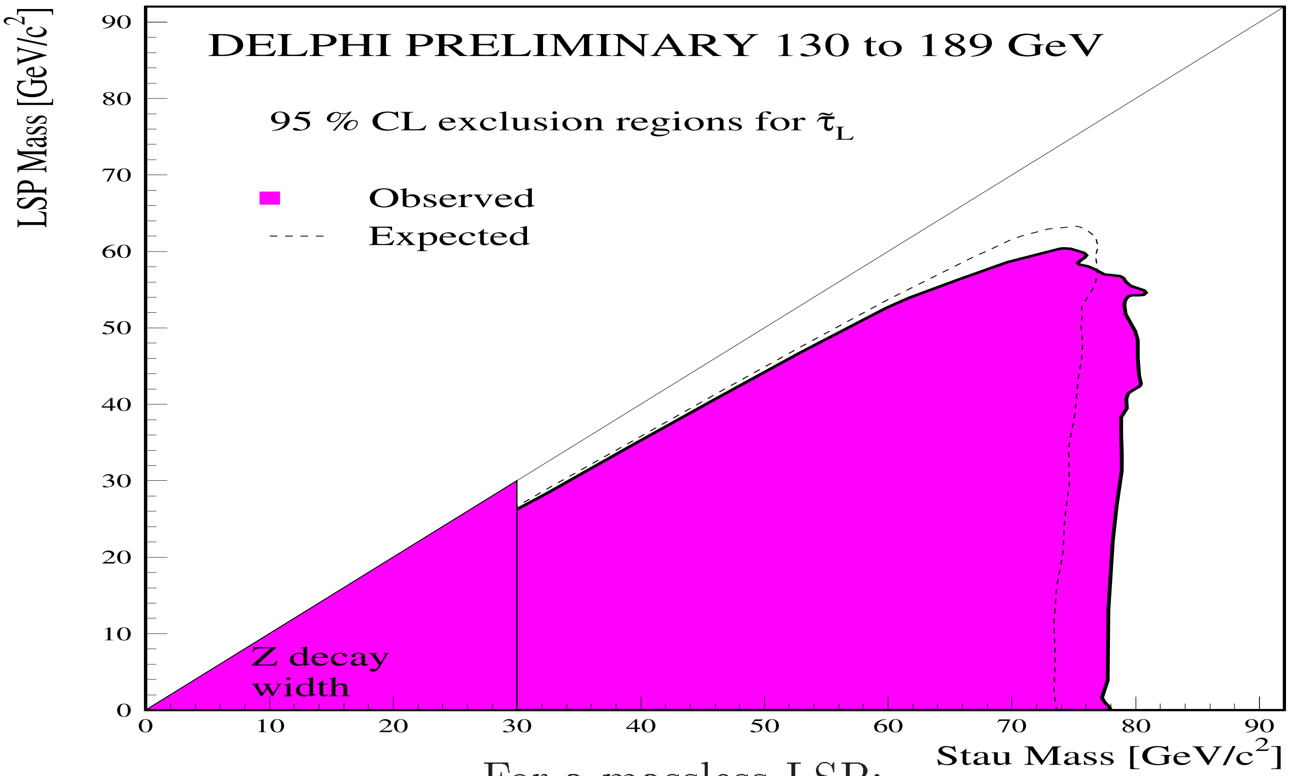
• Data vs simulation: example of the $\tilde{\tau}$ pair search

DELPHI preliminary



•Limits on $e^+e^- \to \tilde{\tau}\tilde{\tau} \to \tilde{\chi}_1^0\tau\tilde{\chi}_1^0\tau$ (MSSM, LSP $= \tilde{\chi}_1^0$):



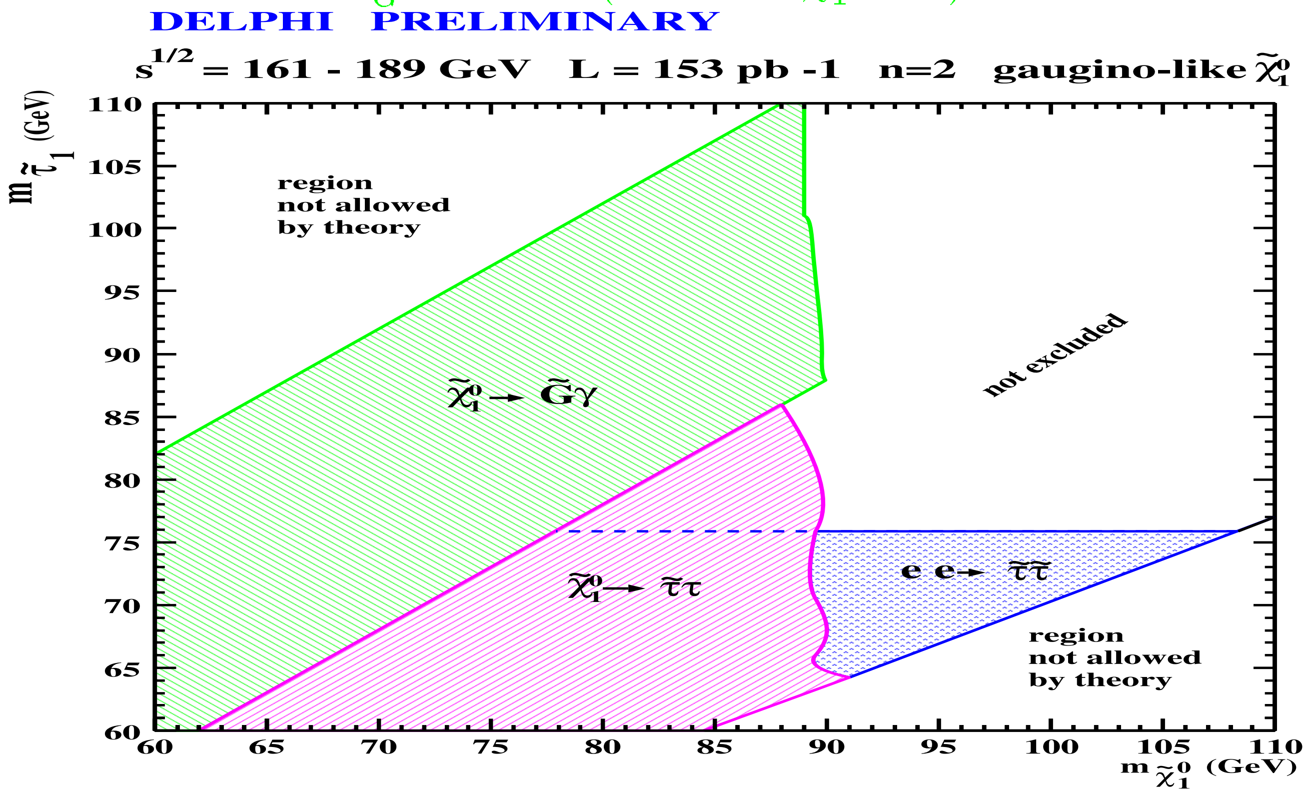


For a massless LSP:

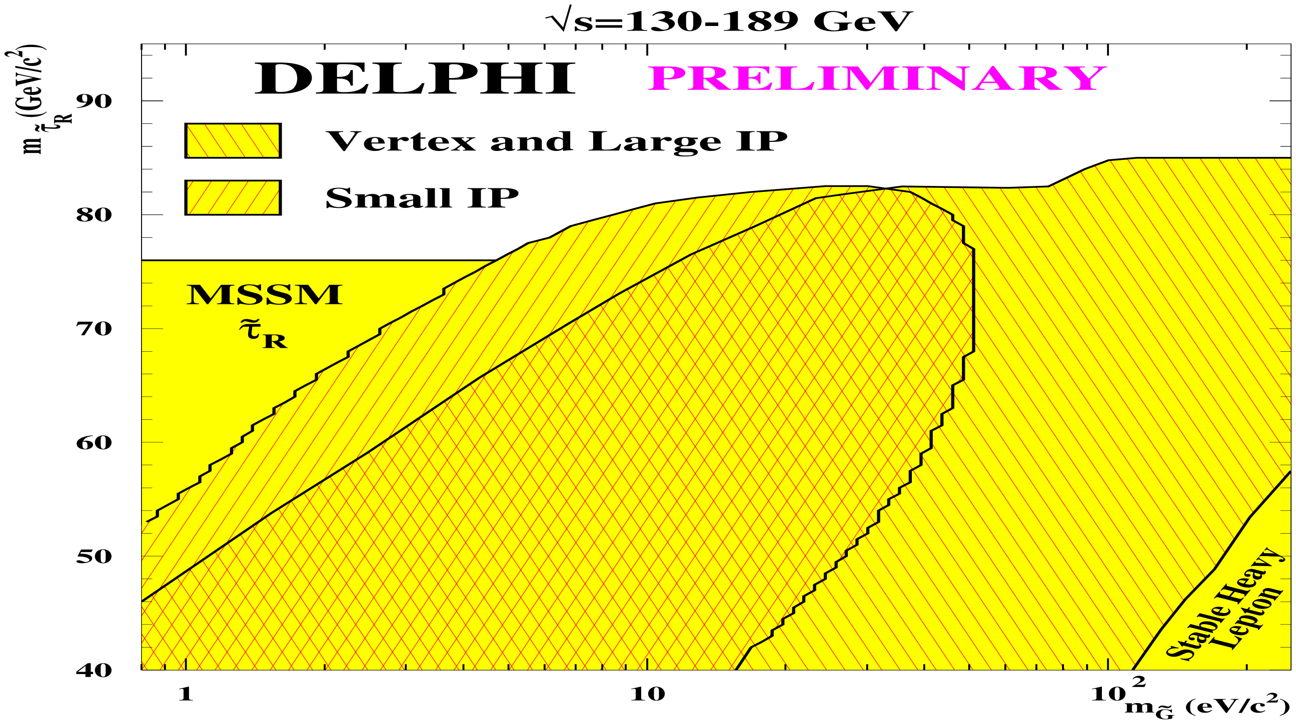
$M_{\tilde{\tau}} > 74$GeV (min), $M_{\tilde{\tau}} > 76$GeV (R), $M_{\tilde{\tau}} > 78$GeV (L)

•Constraints on GMSB models (LSP = $\tilde{G}$):

$M_{\tilde{G}} < 10$ eV (NLSP = $\tilde{\chi}^0_1$ or $\tilde{\tau}$)



Massive $\tilde{G}$ (NLSP = $\tilde{\tau}$)



Summary ...

- Despite difficult conditions, '98 operating was great with 158 pb^{-1} collected: thanks to the LEP group !
- EW measurements: data agree with SM, $\delta(M_W)_{stat}$ will decrease, ZZ production can be studied.
- Searches: no hint of new physics, substantial gain in exclusion limits (O(10 GeV)).

... and '99 prospects

- Shutdown plans: no major interventions (end caps kept in beam position), closure by end of January '99.
- Beam requests: OK for any scenario of energy raising PROVIDED highest energy is achieved as soon as possible.
- HOPE to have better operating conditions ($\mathcal{L}$, bkg).