ALEPH Status Report

LEPC Mar 7 2000

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Imperial College, London

Shutdown Operations
LEP1 Analyses
Higgs Searches
SUSY Searches
2-fermion Production
WW Production

Shutdown Work

Not a great deal

Remove short from TPC

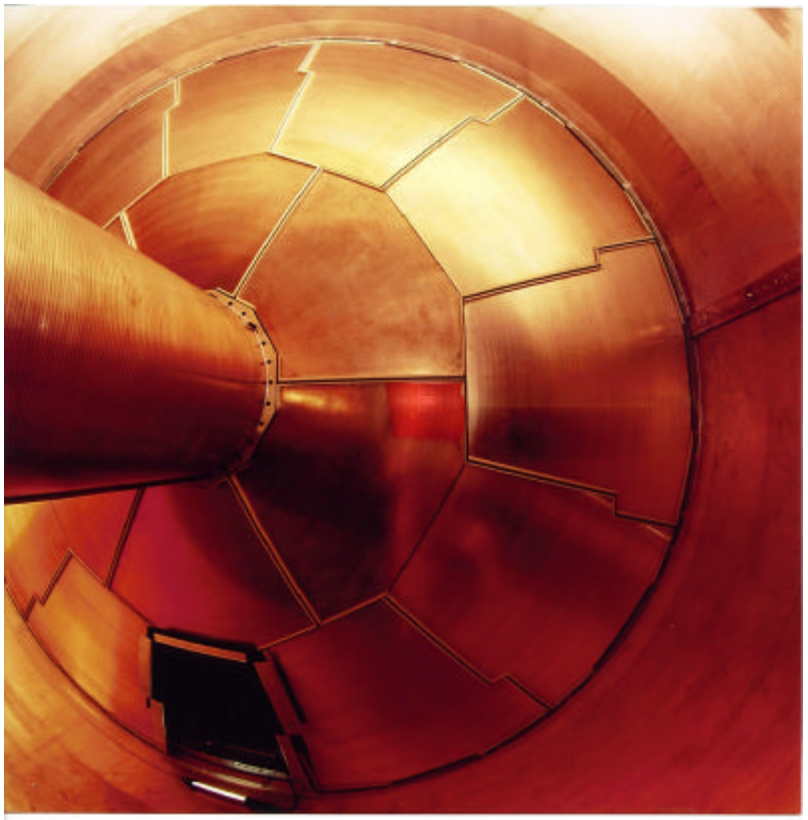
Examine 'LEP1' Cryogenics at Pit 4

No problem found

ALEPH is ready for the new data

Successful TPC Repair

Short removed from inside of TPC



Luminosity Used

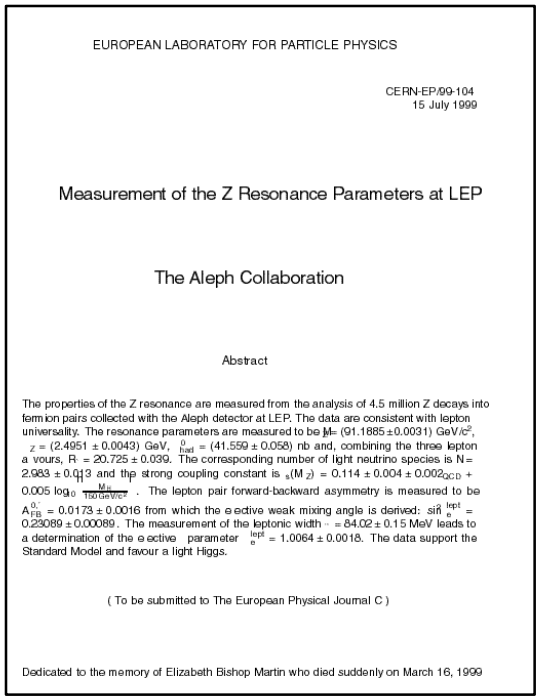
Year – Nominal Energy	Energy	Luminosity
1997 - 183	182.66	56.81 ±0.11
1998 - 189	188.62	174.20 ± 0.20
1999 - 192	191.58	28.93 ± 0.08
1999 - 196	195.52	79.86 ± 0.16
1999 - 200	199.52	82.28 ± 0.15
1999 - 202	201.63	41.89 ± 0.11

1999 was another excellent year for LEP and ALEPH

Congratulations to LEP

LEP1 Results

Final Results on Z Lineshape



EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CERN-EP/99-104
15 July 1999

Measurement of the Z Resonance Parameters at LEP

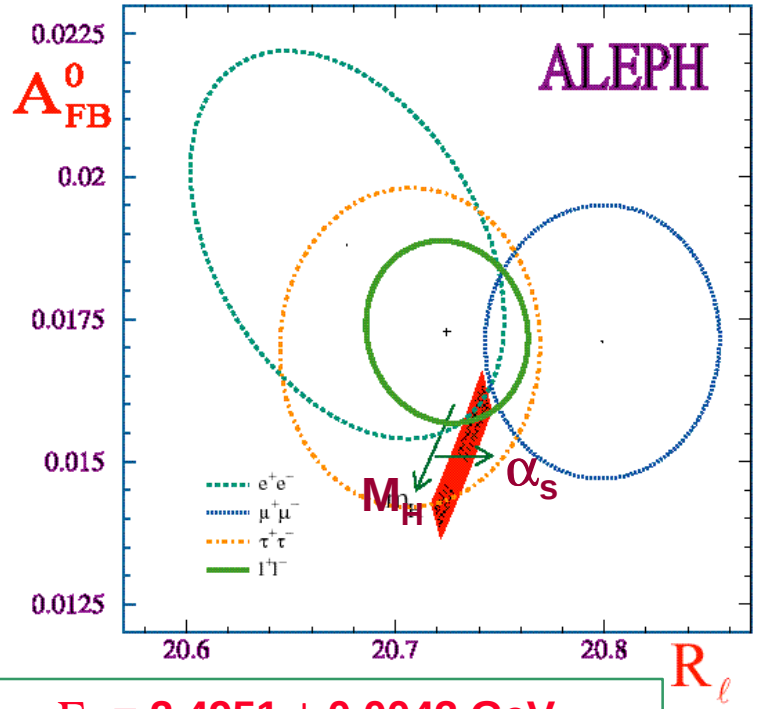
The Aleph Collaboration

Abstract

The properties of the Z resonance are measured from the analysis of 4.5 million Z decays into fermion pairs collected with the Aleph detector at LEP. The data are consistent with lepton universality. The resonance parameters are measured to be M_Z = (91.1885 ± 0.0031) GeV/c^2, Γ_Z = (2.4951 ± 0.0043) GeV, σ^0_{had} = (41.559 ± 0.058) nb and, combining the three lepton flavours, R_ℓ = 20.725 ± 0.039. The corresponding number of light neutrino species is N_ν = 2.983 ± 0.013 and the hadronic strong coupling constant is $\alpha_s(M_Z)$ = 0.114 ± 0.004 ± 0.002_{QCD} + 0.005 $\log_{10}\frac{M_H}{150\,GeV/c^2}$. The lepton pair forward-backward asymmetry is measured to be $A^{0,\ell}_{FB}$ = 0.0173 ± 0.0016 from which the effective weak mixing angle is derived: $\sin^2\theta^{lept}_{eff}$ = 0.23089 ± 0.00089. The measurement of the leptonic width $\Gamma_{\ell\ell}$ = 84.02 ± 0.15 MeV leads to a determination of the effective parameter σ^{lept}_{had} = 1.0064 ± 0.0018. The data support the Standard Model and favour a light Higgs.

(To be submitted to The European Physical Journal C)

Dedicated to the memory of Elizabeth Bishop Martin who died suddenly on March 16, 1999



$M_Z = 91.1885 \pm 0.0031$ GeV/c^2 $\quad\quad$ $\Gamma_Z = 2.4951 \pm 0.0043$ GeV

$N\nu = 2.983 \pm 0.013$ $\quad\quad$ $\sin^2\theta_{eff} = 0.23098 \pm 0.00089$

$\alpha_s(M_Z) = 0.114 \pm 0.004 \pm 0.002_{QCD} + 0.005\ \log_{10}[M_H/150\ \text{GeV}/c^2]$

B Fragmentation Function

Uses B decays to $D^{(*)}\ell$

Good B Momentum reconstruction

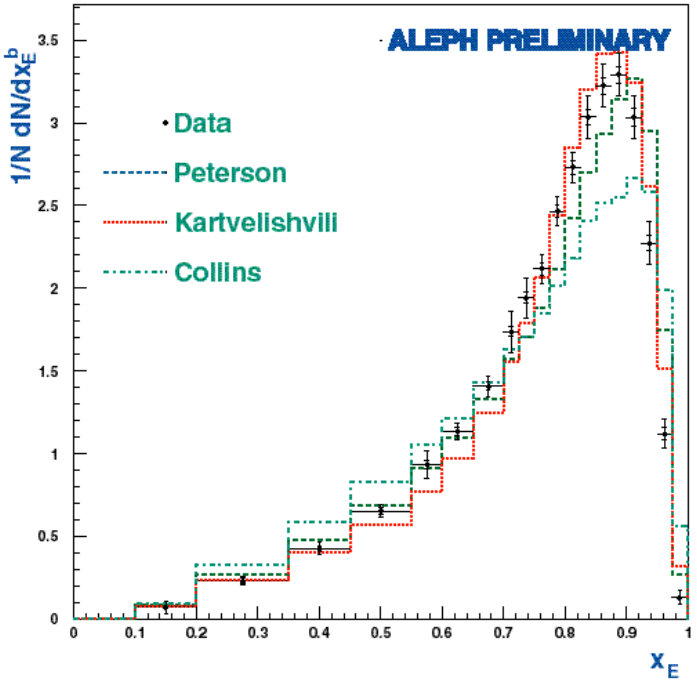
Results

For leading B hadron

$\langle x_E \rangle = 0.739 \pm 0.005 \pm 0.006$

For weakly decaying B hadron

$\langle x_E \rangle = 0.720 \pm 0.005 \pm 0.005$



x_E for leading B hadron

Latest B_s Mass Difference, ΔM_s

Aim for improvement at high frequency

Require good proper time reconstruction

Two New Analyses

- *Repeat of the D_s-lepton analysis*

  Efficiency 20-30% better

  - but better understanding of backgrounds limits the benefit

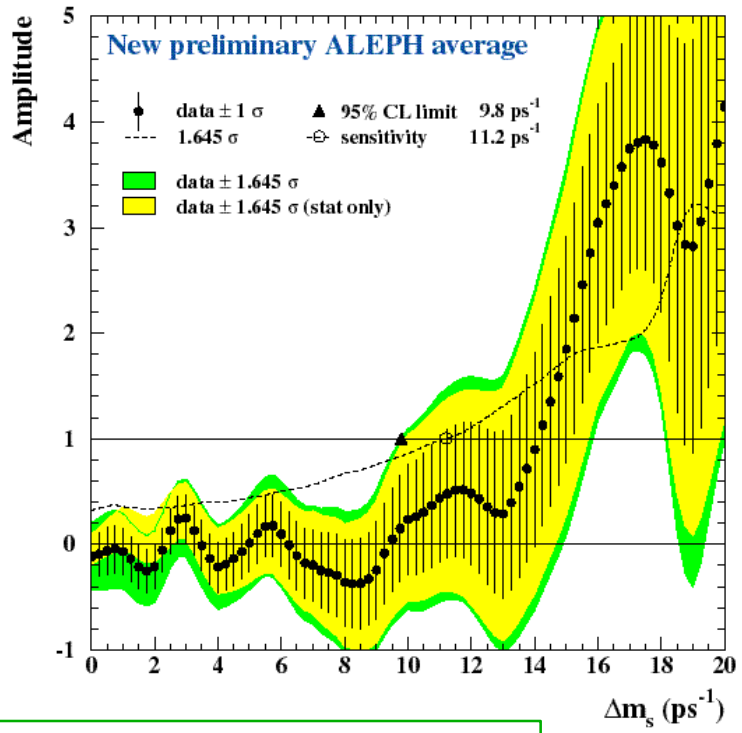
- *Fully reconstructed B_s* w

  New Analysis

  20 Bs candidates above a background of 30

Combination yields benefit

Latest ALEPH Combination



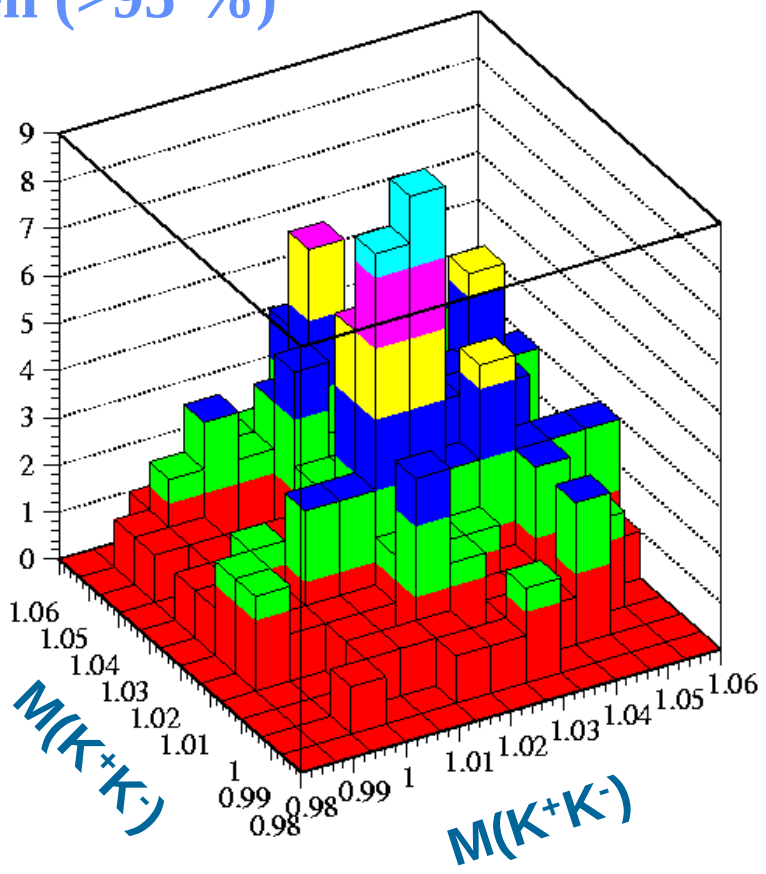
Latest ALEPH Lower Limit 9.8 ps^{-1} - Sensitivity 11.2 ps^{-1}

B_s Width difference, $\Delta\Gamma_s$

$B_s \rightarrow D_s^{(*)+} D_s^{(*)-}$ is mostly CP even (>95 %)

Other defined CP modes have a BR < 1% J/ψ φ, J/ψη, J/ψπ, ψ(2S)φ, ππ, ηπ,

Select via φφ in same hemisphere



$\Delta\Gamma_s$ using two methods

- $\tau\,(B_s)_{short}$ from lifetime fit
- $\Delta\Gamma$ from $B(D_s D_s)$

B_s Width difference, $\Delta\Gamma_s$

Lifetime

$\tau_s(\text{short}) = 1.27 \pm 0.33_{\text{stat}} \pm 0.07_{\text{syst}}$ ps

gives

$\Delta\Gamma/\Gamma = (22\ ^{+38}_{-51})\%$

Branching Ratio

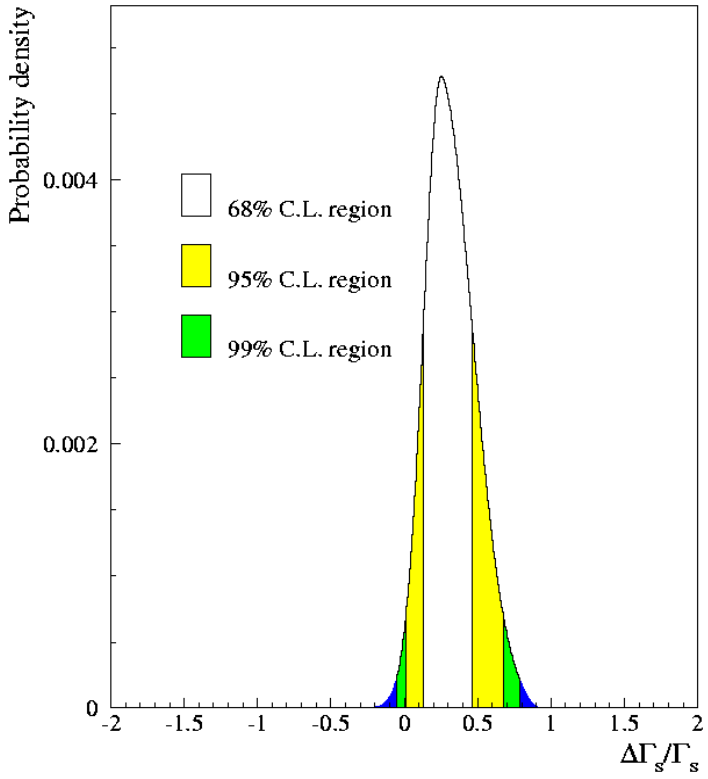
$\text{Br}(\text{Bs(short)} \rightarrow D_s D_s) = 23 \pm 10_{\text{stat}}$

gives

$\Delta\Gamma/\Gamma = (26\ ^{+30}_{-15}\ ^{+19}_{-9})\%$

Combining these

$\Delta\Gamma/\Gamma = (25\ ^{+21}_{-14})\%$



Higgs Searches

SM Higgs Online Analysis

Online Analysis

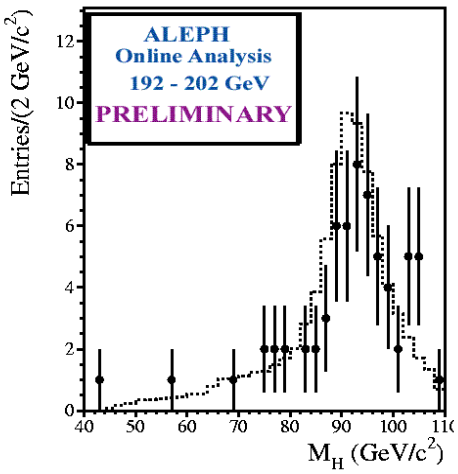
Run during 1999

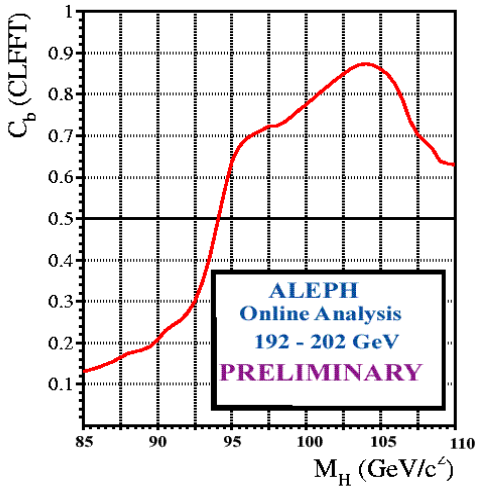
Based on 189 GeV analysis

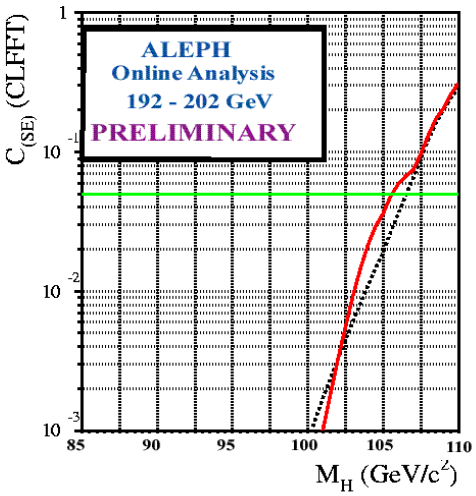
Frozen during the run

Results presented at November LEPC

M_H > 105.6 at 95% CL







Current Higgs Analyses

Two Mainly Independent streams NN and Cuts

	NN - Analysis	Cuts - Analysis
4 –jet	NN	Cuts
Hνν	NN	Cuts
Hll	Cuts	Cuts
Tau channels	NN	NN

Changes since November

1999 data reprocessed

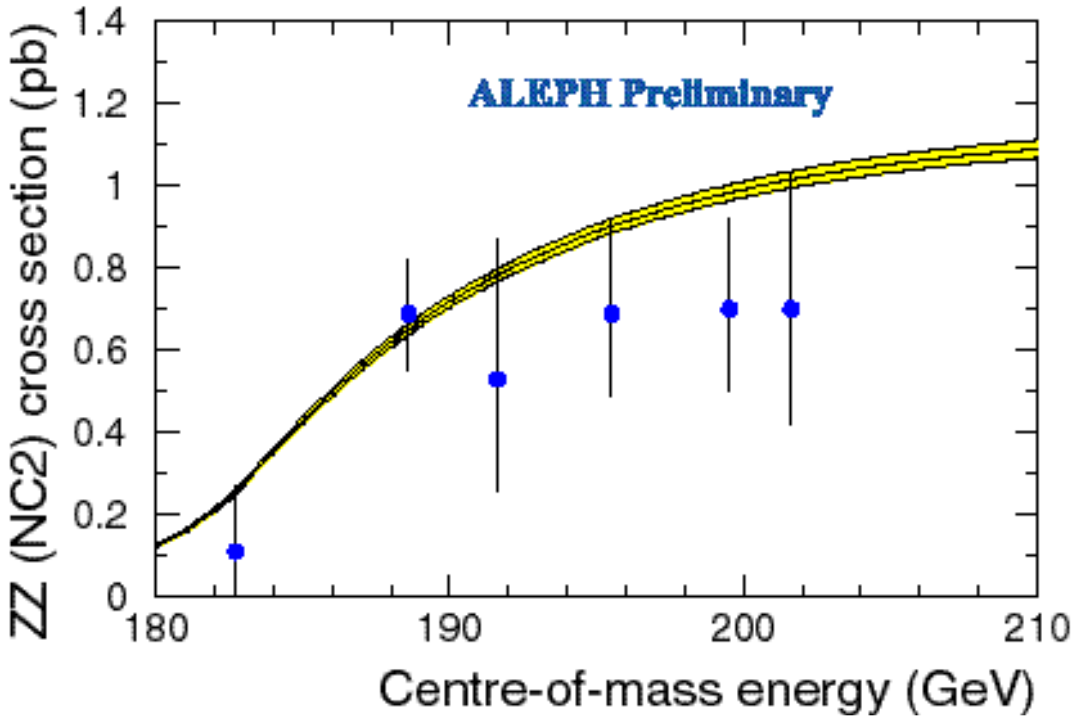
Analyses improved

- use of kinematic fit in 4 jet channel
- different treatment of hZ - hA overlap

Analyses re-optimised for energy and luminosity taken in 1999

ZZ Cross Section

Lower than prediction between 192 and 202 GeV

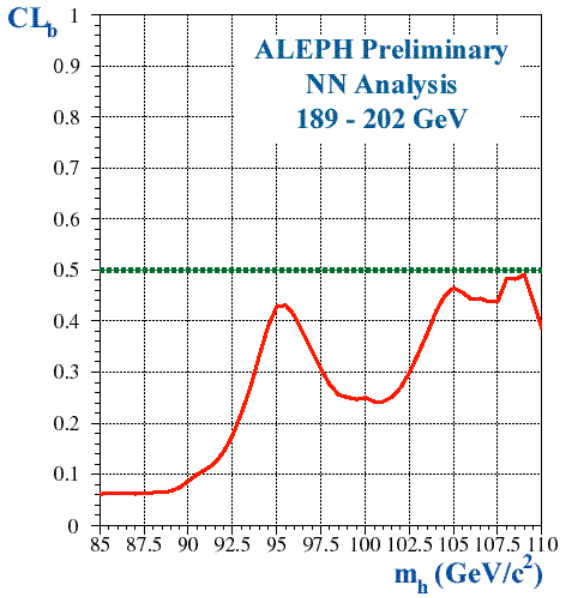


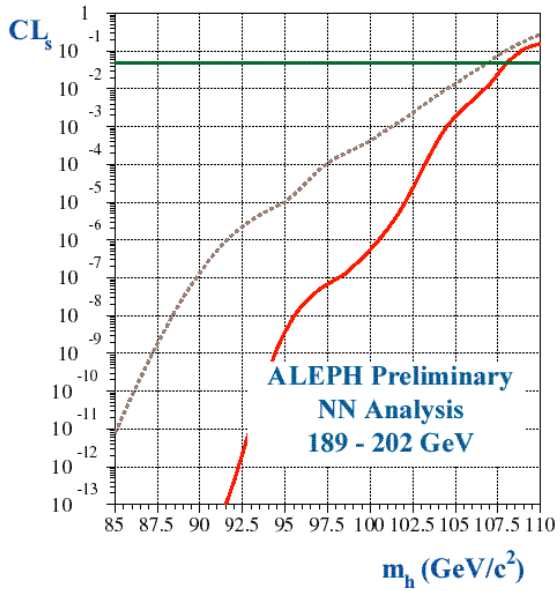
SM Higgs - Present Limits

From the NN Analyses 189 - 202 GeV data

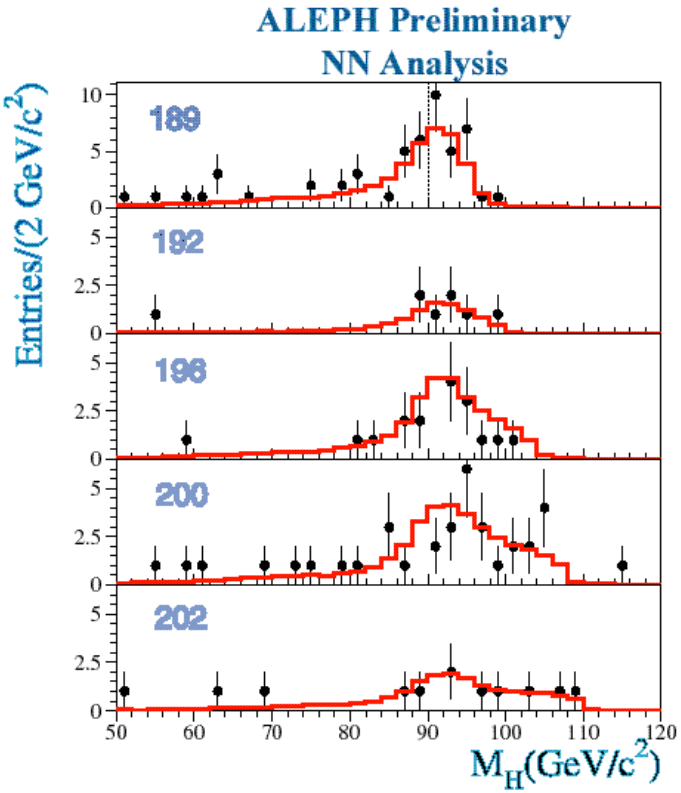
Limits at 95% CL

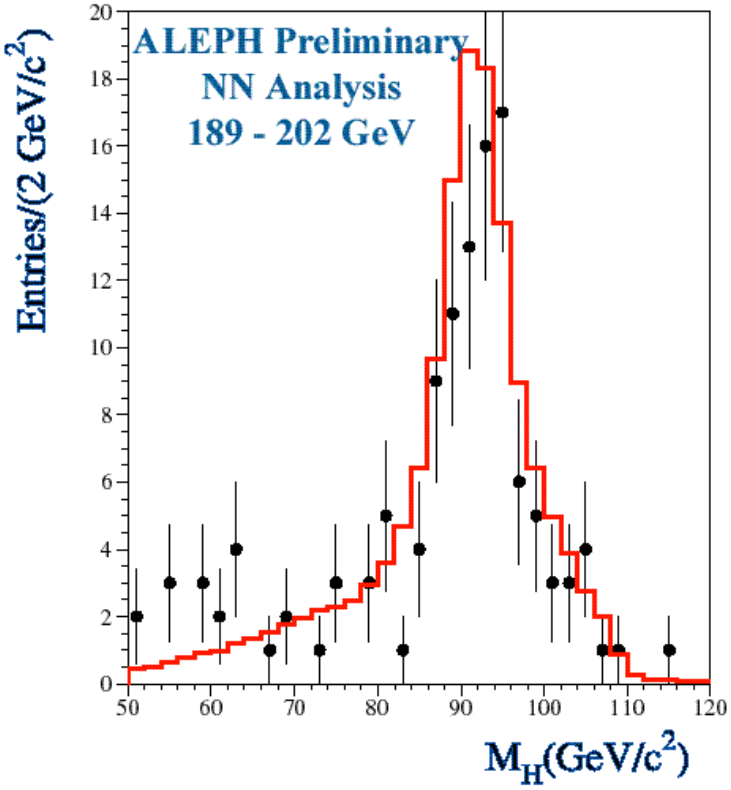
Observed 107.7 GeV/c^2 **Expected 106.8 GeV/c^2**





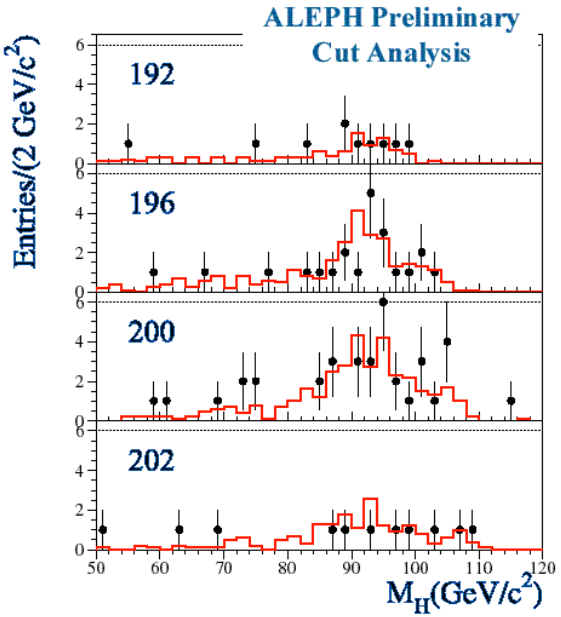
SM Higgs Candidates
NN Analysis

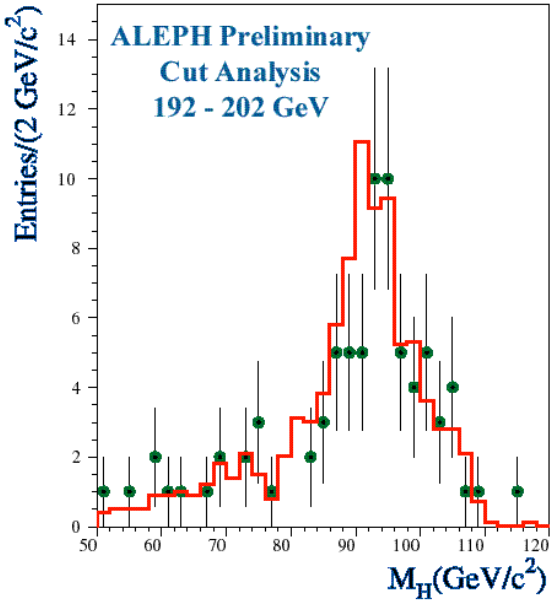




SM Higgs Candidates
Cuts Analysis

192 - 202 GeV Data



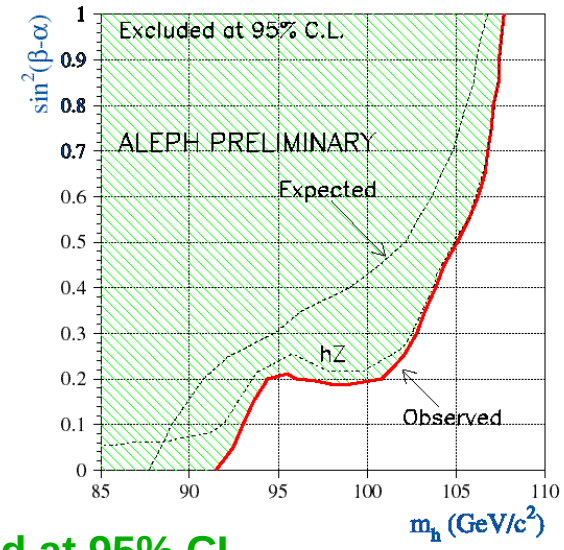


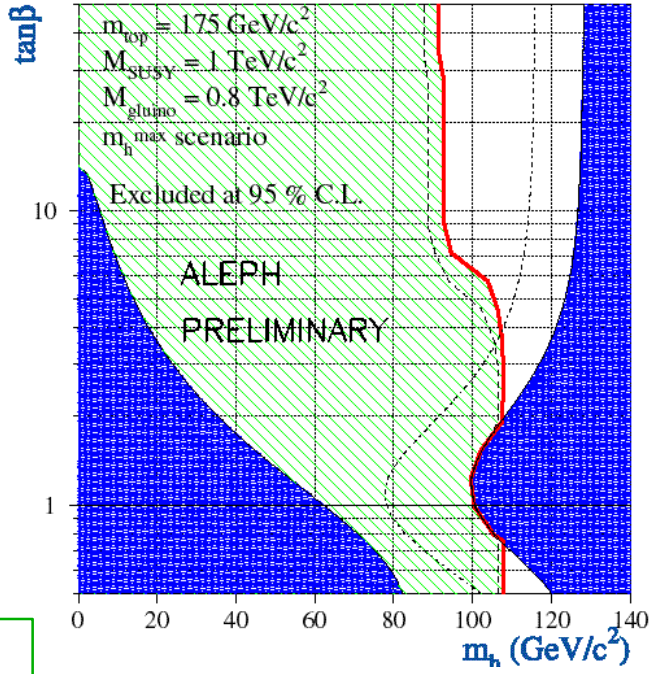
Lower limit on M_H from the Cuts Analysis

Observed 105.1 GeV/c² **Expected 105.7 GeV/c²**

Higgs Bosons in the MSSM

Combine hZ searches with hA -> bbbb Analyses





Limits obtained at 95% CL

For M_h, Observed 91.5 GeV, Expected 87.7
For m_A, Observed 91.9 GeV, Expected 88.1

tanβ excluded from 0.8 to 1.9 (for M_{top} = 175 GeV, m_{SUSY} = 1 TeV

Charged Higgs

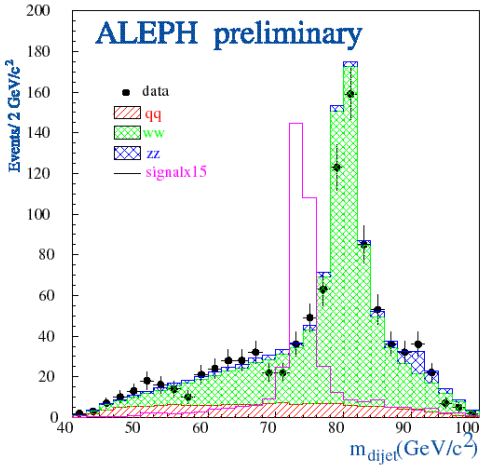
Assume decay 100% to τν, cs

3 Analyses

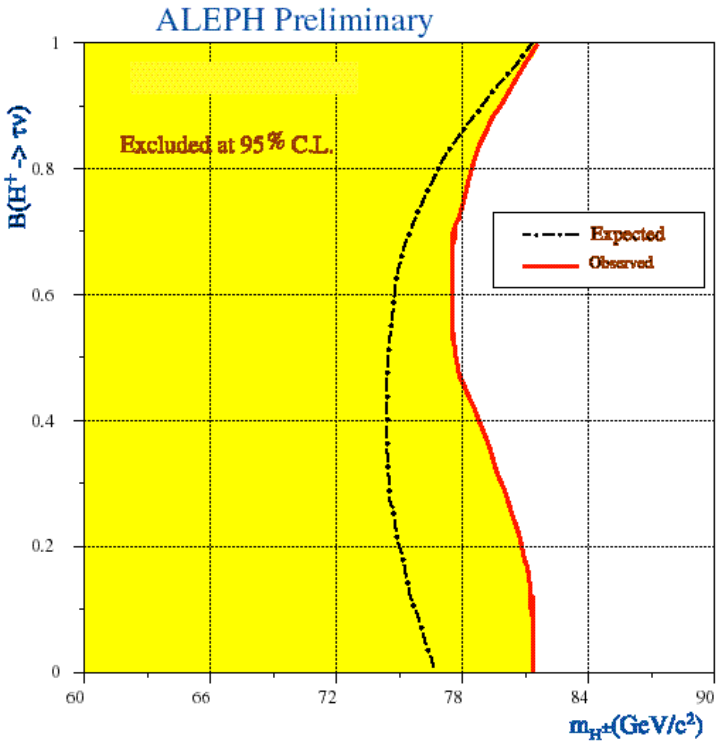
H^+H^- –> τντν

–> τνcs

–> cscs



$H^+H^- \rightarrow$ cscs channel



M(H^+) Lower limit = 77.7 GeV/c^2

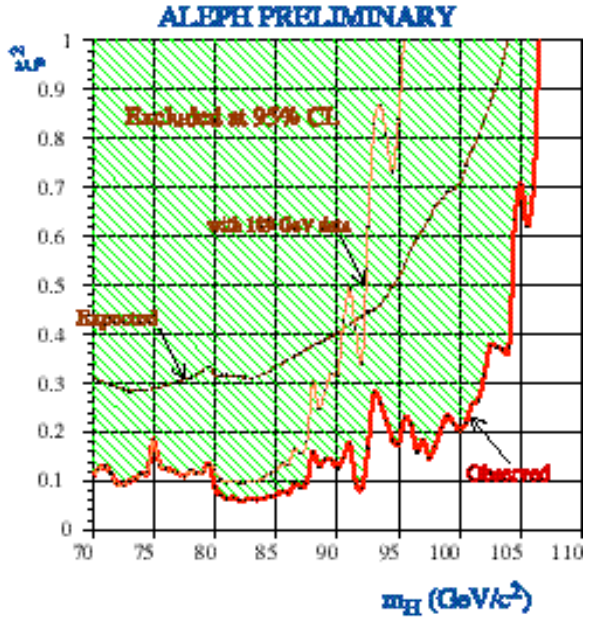
Exotic Higgs Decays

Invisible Decays e.g. $h \rightarrow \chi\chi$

Assume

$\sigma(h \rightarrow \text{Invisible}) = \xi^2 \sigma(h_{SM})$

Exclusion in (ξ^2, m_h) Plane

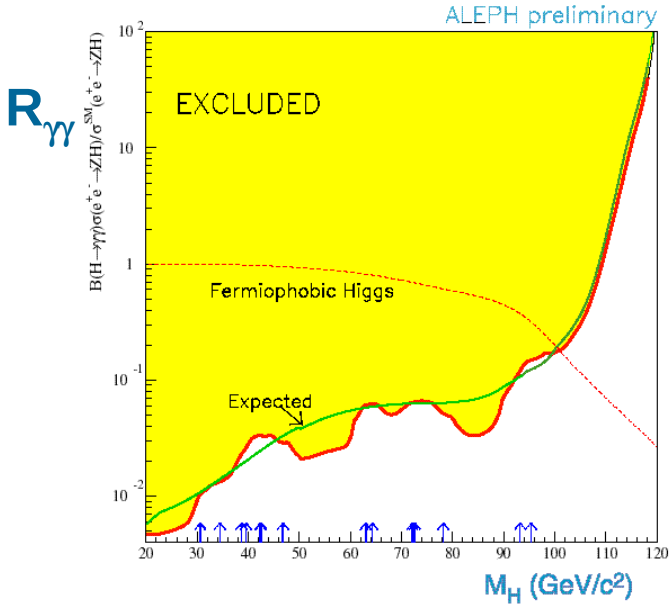


For $\xi^2 = 1$, $M_h > 106.4$ GeVc^2

Fermiophobic Higgs $h \not\rightarrow ff$

Look for $h \rightarrow \gamma\gamma$

$$R_{gg} = \frac{Br(H \rightarrow gg)\, s(e^+e^- \rightarrow ZH)}{s^{SM}(e^+e^- \rightarrow ZH)}$$

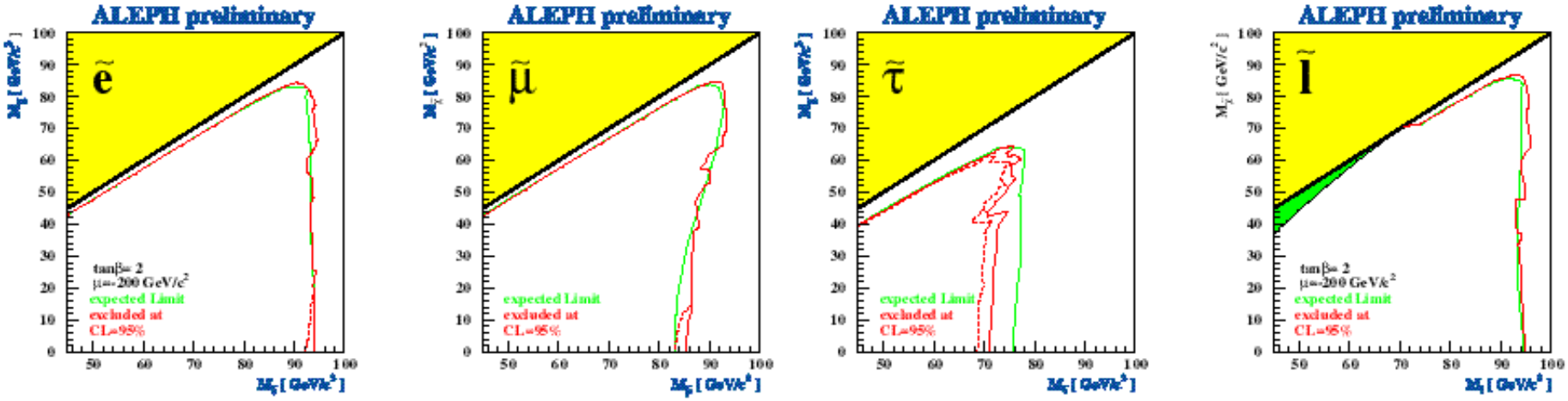


For $R_{\gamma\gamma} = 1$, $M_h > 109.1$ GeVc^2

SUSY Searches

Sleptons in the MSSM

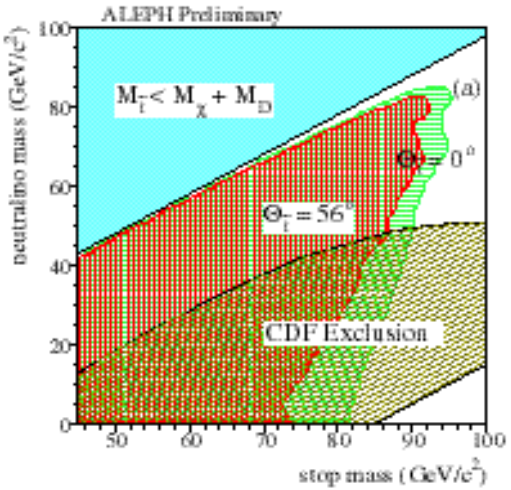
	192 – 202 GeV			
	Selectrons Acoplanar e	Selectrons Single e	Smuons Acoplanar μ	Staus Acoplanar τ
Number. of Candidates	42	22	39	46
Expected Background	48.1	34.2	43.4	34.2
95% Lower Limits for Δm > 10 GeV	92	-	85	68 (worst mixing)

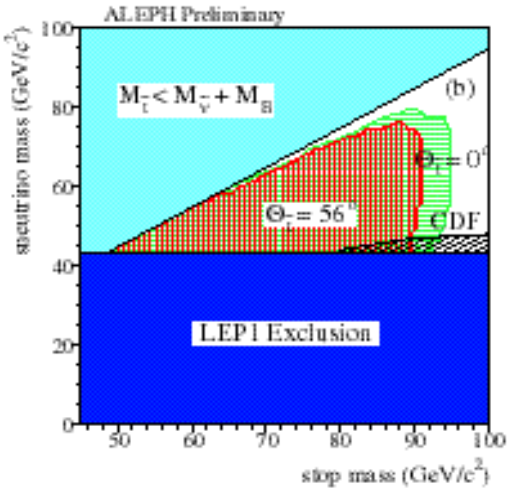


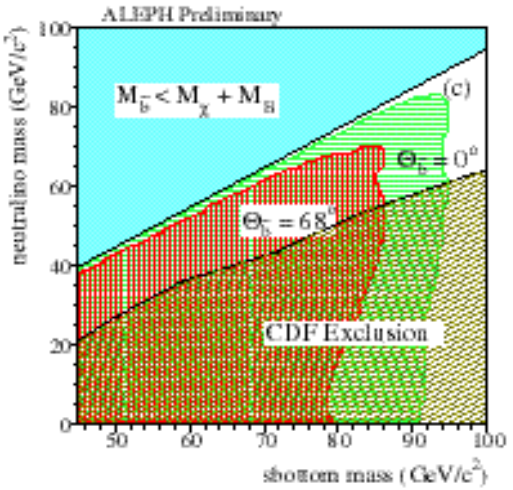
Stop, Sbottom, Squark

192 – 202 GeV

	$t \to c\mathrm{c}$	$t \to b\ell\mathrm{n}$	$b \to b\mathrm{c}$	$q \to q\mathrm{c}$
Number. of Candidates	**10**	**5**	**2**	
Expected Background	**8.4**	**3.1**	**2.7**	
Lower Limit GeV/c^2	**87** (6 < ΔM < 40)	**88** (ΔM > 10)	**91** (ΔM > 8)	**97** (ΔM > 6)





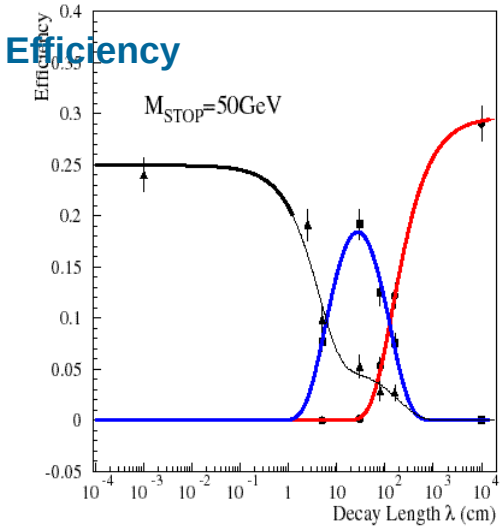


Stop at Low ΔM

New Analyses for $M_{stop} - M\chi < 6$ GeV

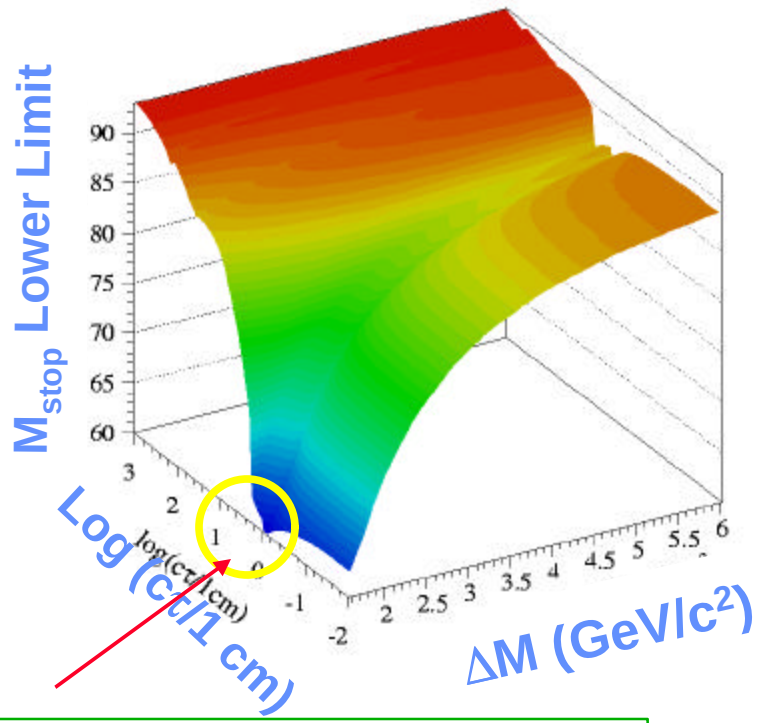
Small ΔM - finite Lifetime
decays in detector

$\Delta M < M_{charm}$ - long lifetime
exits detector



Efficiency

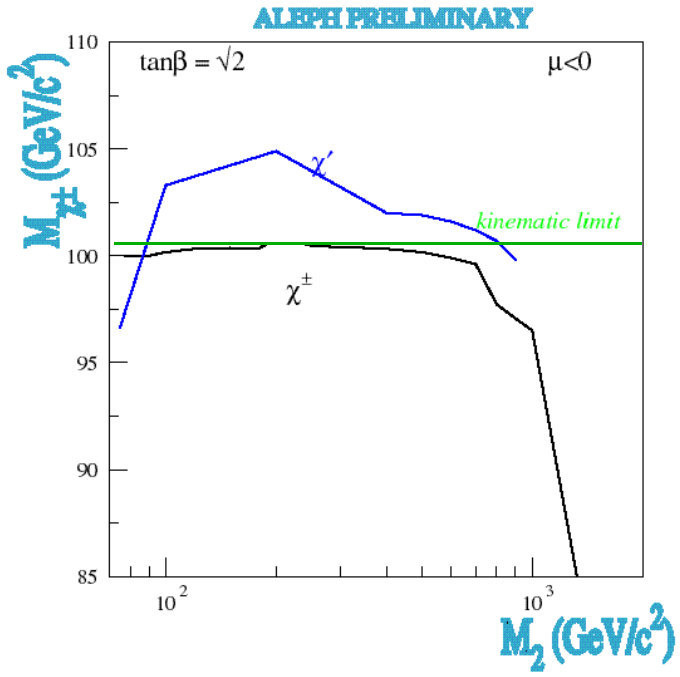
Decay Length

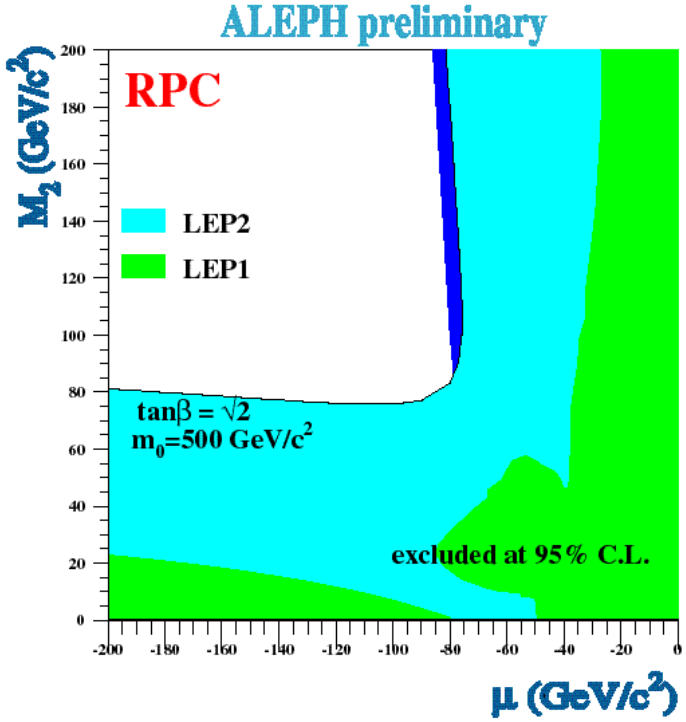


Lower Limit $M_{stop} > 59.3$ GeV/c²

Assuming MSSM relation between Δm and decay length
$M_{stop} > 63$ GeV/c²

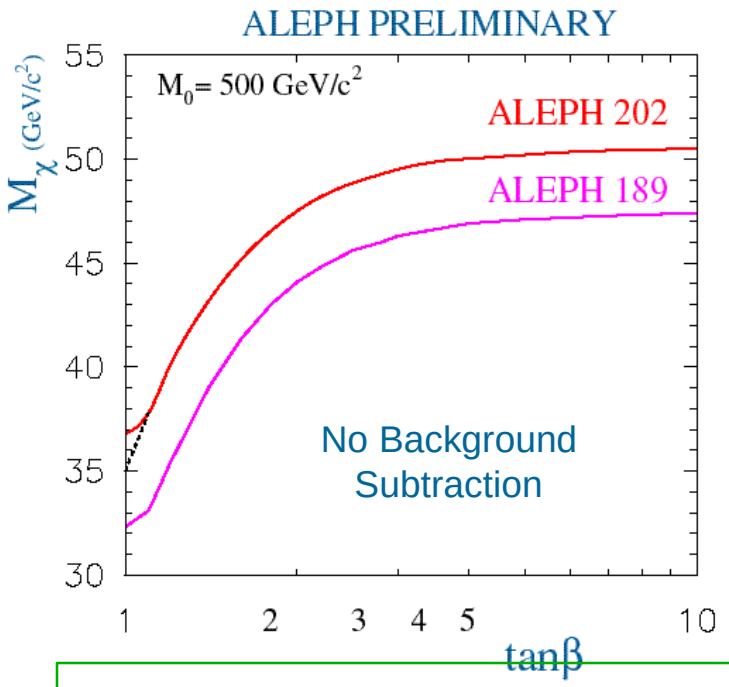
Charginos





Charginos at or above kinematic limit

Lightest Neutralino - LSP



M(χ) > 36.8 GeV/c²(M_0 > 500)

Assumptions

No stau mixing

Gaugino Mass unification

Slepton mass unification

For M_0 < 500 GeV/c²

- **Scan SUSY space**

  7 points out of 1500 not excluded with M_0 ~ 150 GeV/c²

  Lowest has M(χ) = 35.4 GeV/c²

  Estimate M(χ) > 35 GeV/c²

- **Use Higgs Limit**

LSP using Higgs limits

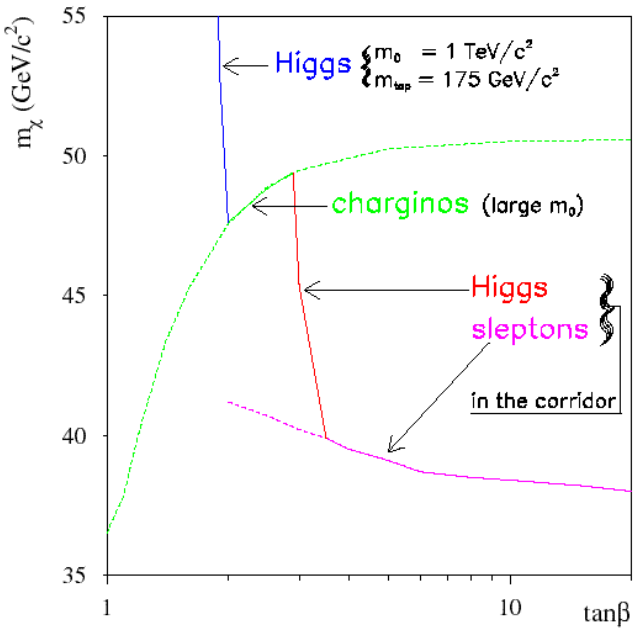
Assume slepton-squark unification

M_{top} = 175 GeV/c^2

M_0 < 1 TeV

No $h \rightarrow tt$ decays

(OK with low Δm stop results)



Limit

M(χ) > 38 GeV/c^2 (All M_0)

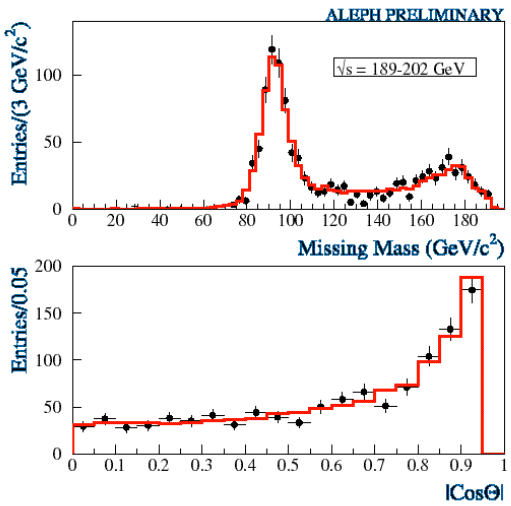
Reached at high tan β

For tanβ < 3

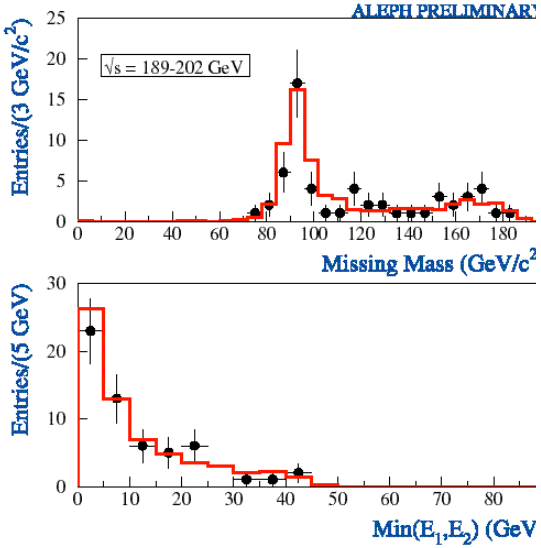
M(χ) > 45 GeV/c^2 (All M_0)

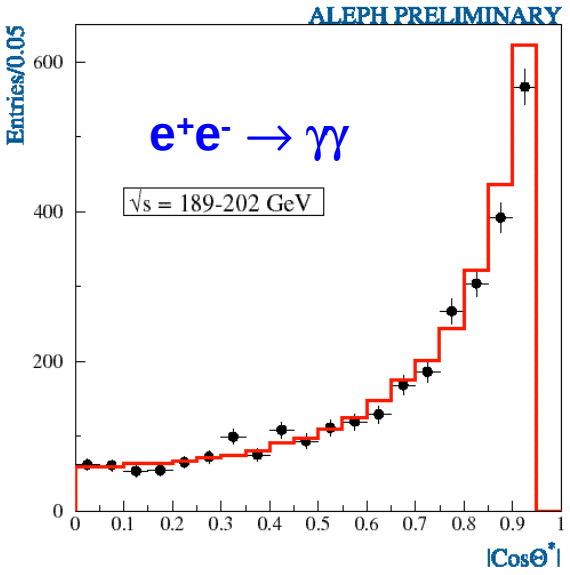
Single & Double Photons

Single Photons



Double Photons





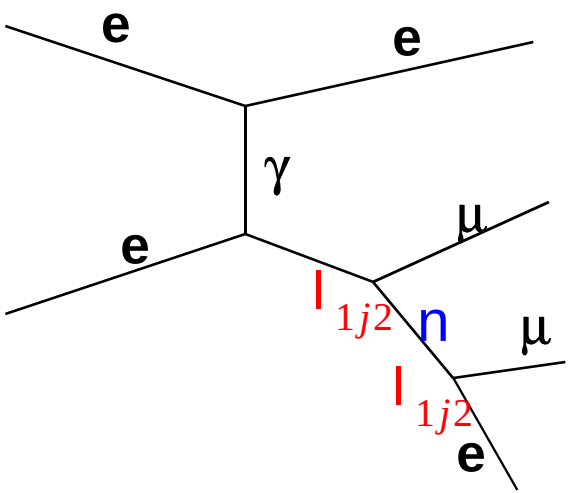
All in very good agreement with SM predictions

No evidence for MSSM neutralinos, GMSB gravitinos, TeV scale quantum gravity gravitons, eeγγ contact interactions, *t*-channel excited electrons

RPV SUSY

‘Normal’ searches for pair produced states updated

New Analysis - Single sneutrino each



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Preview:
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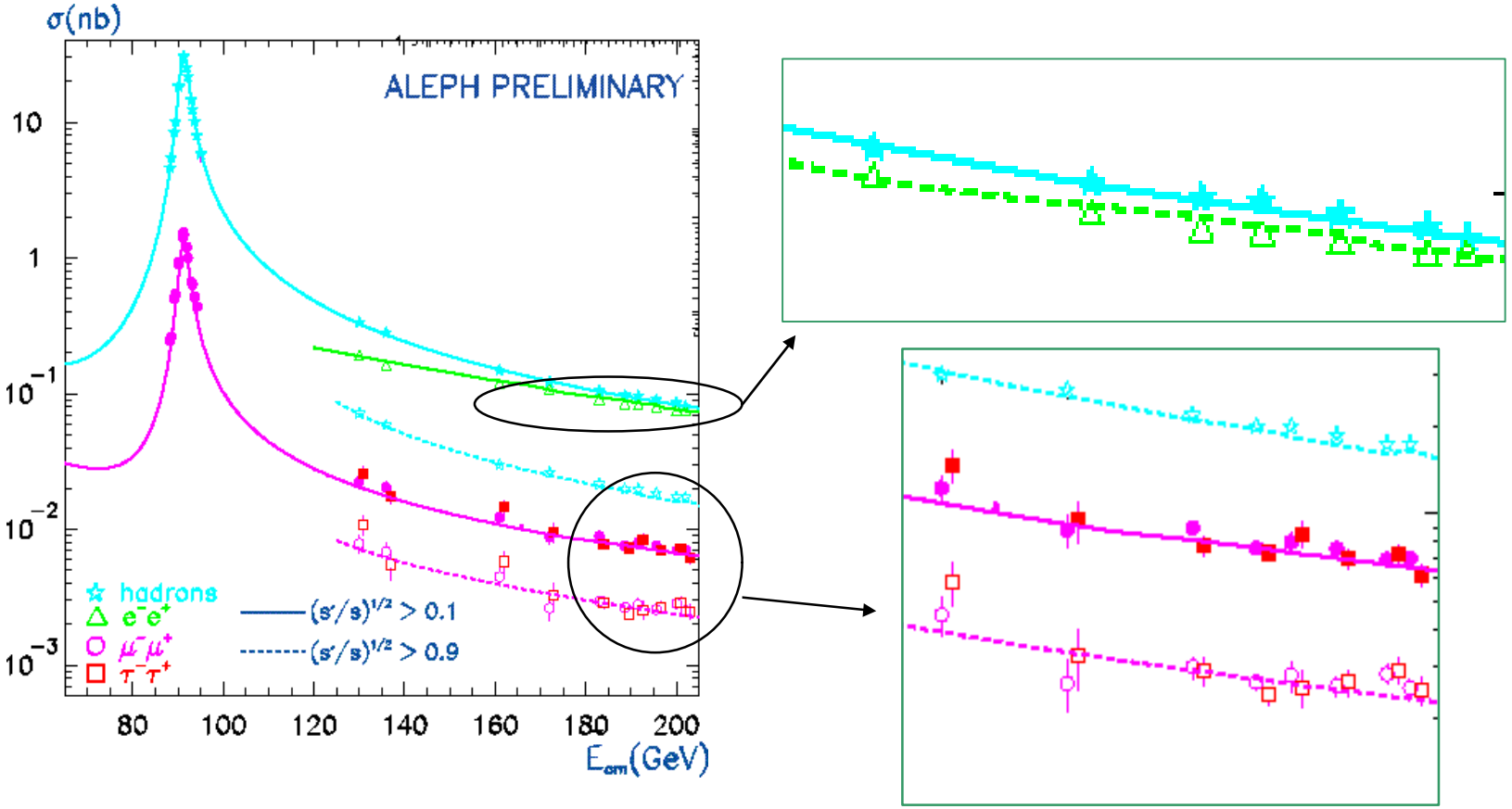
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Look for μμe

$e^+e^- \rightarrow ff(\gamma)$

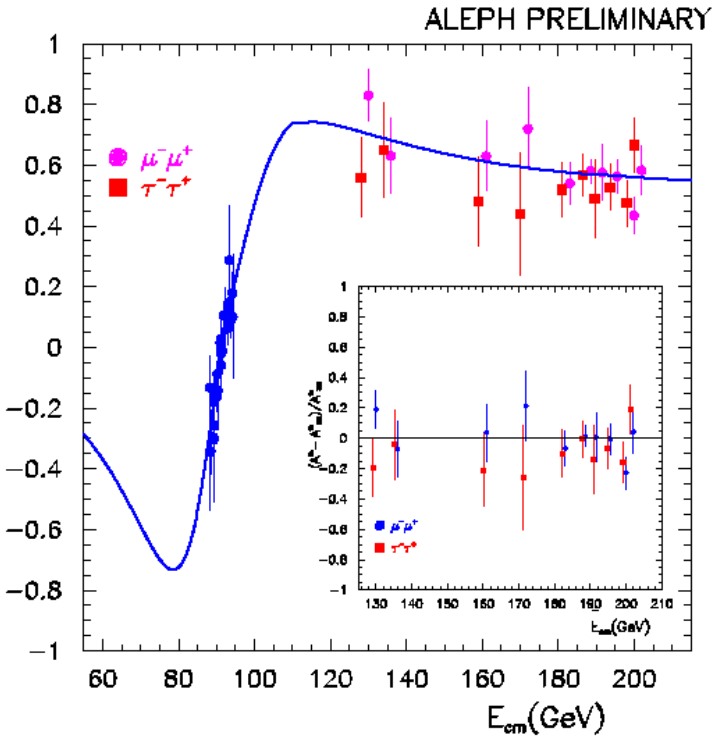
2-fermion Production

Measurement Accuracy - and predictions now at the few % level

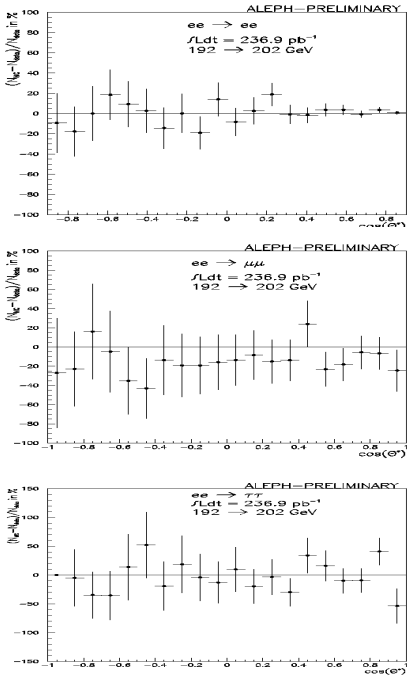


Lepton Asymmetry

No deviations from Standard model



MC - Data Differences



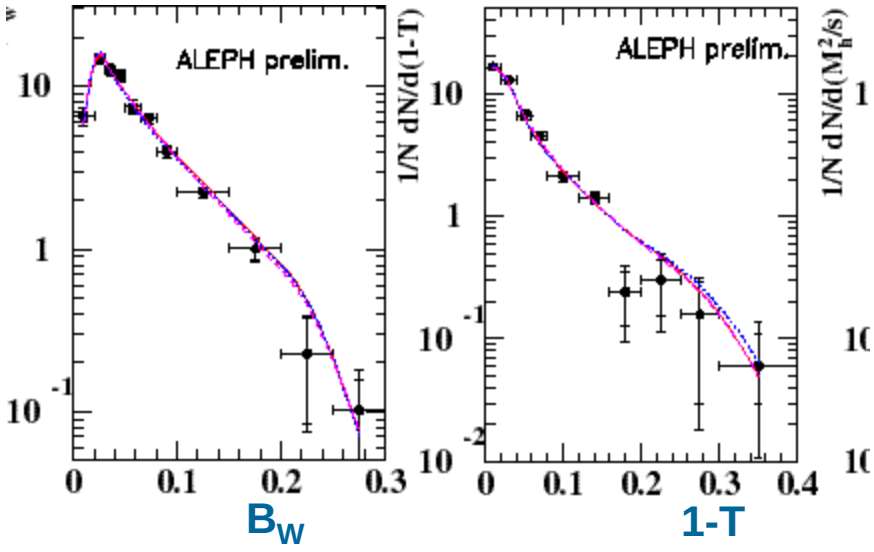
ee

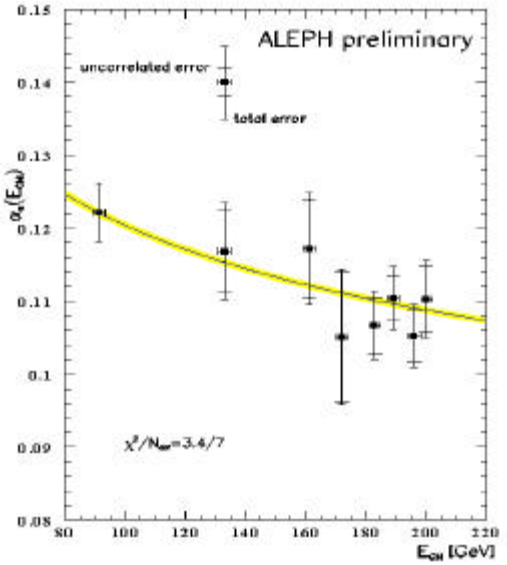
μμ

ττ

cos θ

Event Shapes & a_s





Excellent Agreement with predictions from PYTHIA, HERWIG and ARIADNE

α_s v. E_{CM}

W Physics

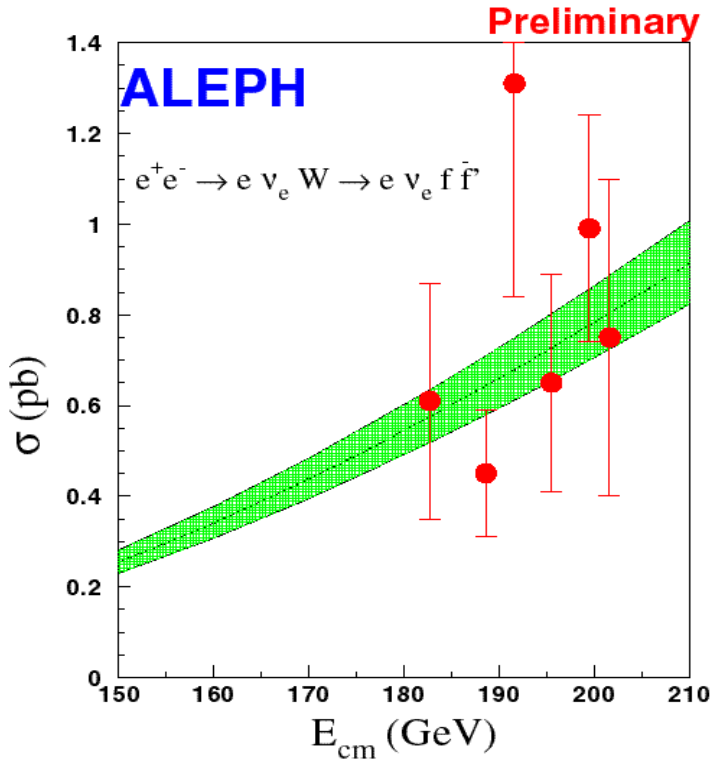
Single W Production

$e^+e^- \rightarrow We\nu$

All W decay modes

Cross section relative to SM

$R = 0.94 \pm 0.14_{stat} \pm 0.09_{syst} \pm 0.10_{th}$

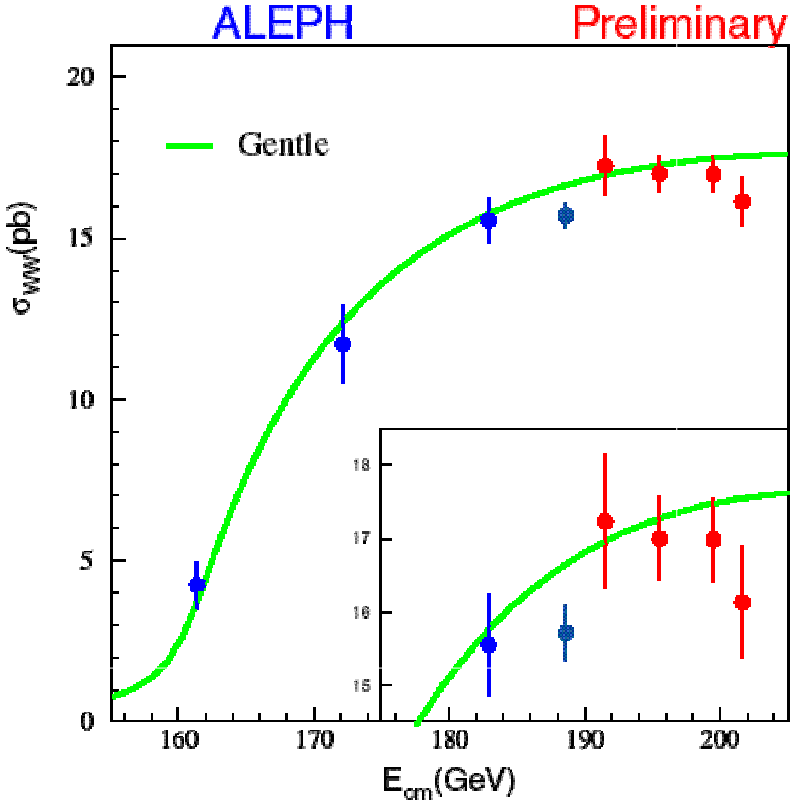


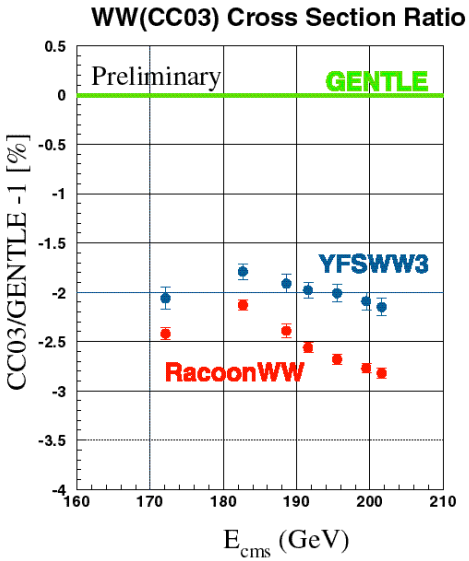
WW Cross Section

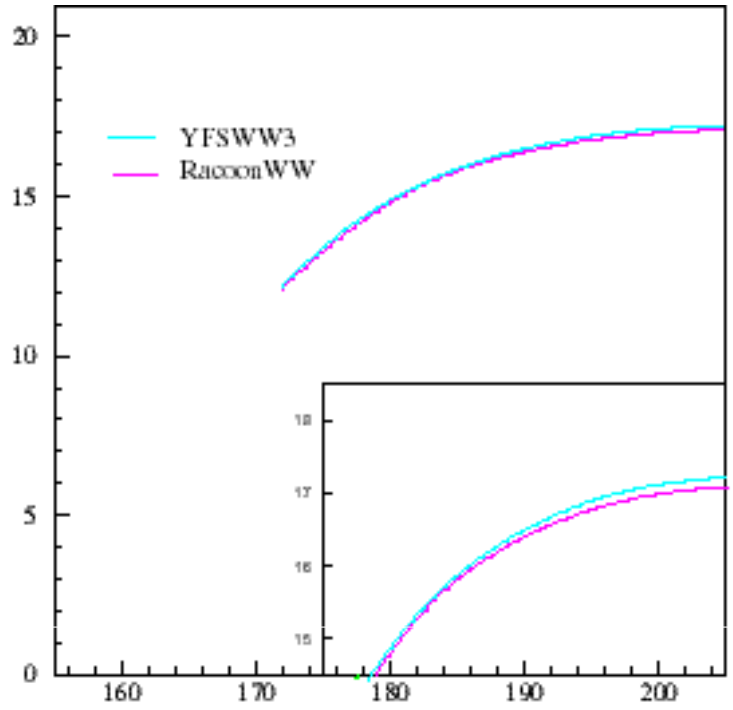
At 189 GeV ALEPH had a lower cross section than GENTLE prediction

Also low 192 - 202 GeV

New Calculations yield cross section 2-3% lower than GENTLE




WW(CC03) Cross Section Ratio
Preliminary
GENTLE
YFSWW3
RacoonWW
CC03/GENTLE -1 [%]
E_cms (GeV)


YFSWW3
RacoonWW

WW Cross Sections & BR

Energy GeV	Cross section pb
172	$11.71 \pm 1.23 \pm 0.28$
183	$15.57 \pm 0.62 \pm 0.29$
189	$15.71 \pm 0.34 \pm 0.18$
192	$17.23 \pm 0.89 \pm 0.18$
196	$17.00 \pm 0.54 \pm 0.18$
200	$16.98 \pm 0.53 \pm 0.18$
202	$16.16 \pm 0.74 \pm 0.18$

Branching Ratios %

$B(W \to e\nu) = 11.26 \pm 0.36$
$B(W \to \mu\nu) = 10.99 \pm 0.34$
$B(W \to \tau\nu) = 10.63 \pm 0.45$

$B(W \to qq) = 67.09 \pm 0.56$

$|V_{cs}| = 0.956 \pm 0.021 \pm 0.015$

Triple Gauge couplings

3 CP Conserving TGC's $\Delta g_1^Z,\ \Delta\kappa_\gamma,\ \lambda_\gamma$

16 C, P or CP Non-Conserving TGC's

Re and Imag parts of

$$g_4^\gamma, g_5^\gamma, \tilde{\kappa}_\gamma, \tilde{\lambda}_\gamma,\ g_4^Z, g_5^Z, \tilde{\kappa}_Z, \tilde{\lambda}_Z$$

Standard Couplings

1, 2 and 3 parameter fits at 183 and 189 GeV

Uses WW ->lνqq, qqqq, lνlν, single W and single γ

1 parameter fits for 183 - 202 GeV

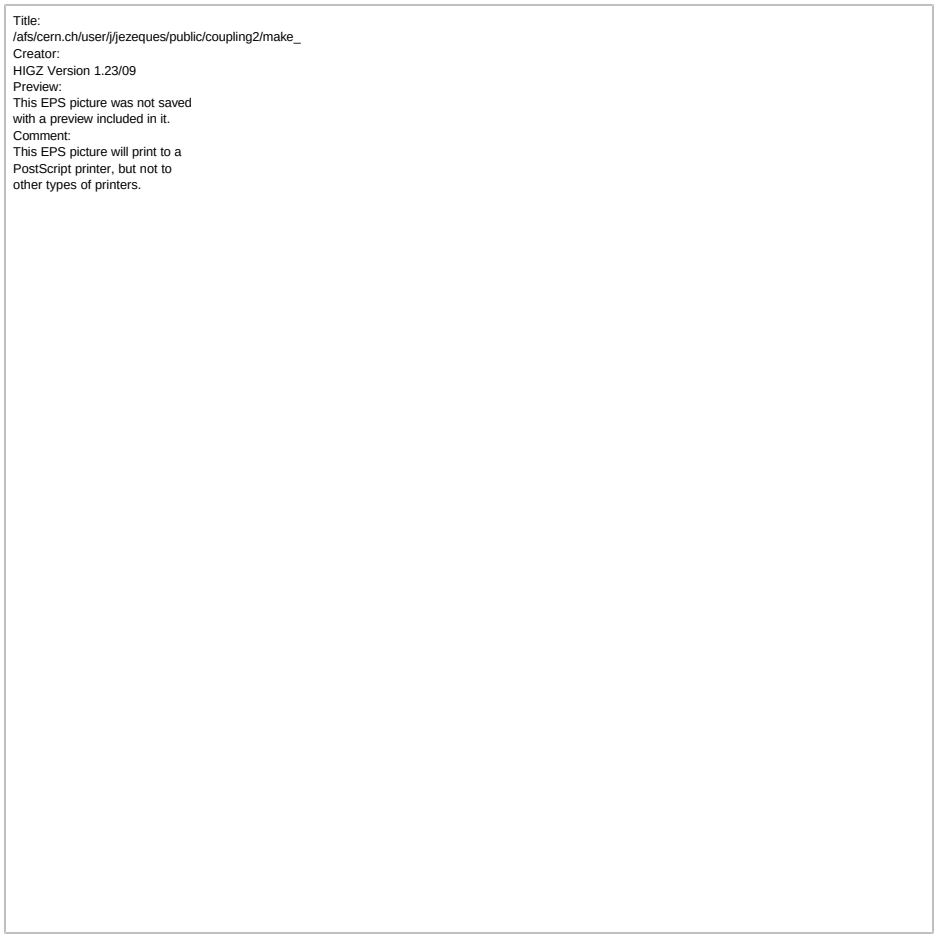
Uses WW ->lνqq from 192 - 202 GeV

C, P or CP violating couplings

1 parameter fits for 183 - 202 GeV

Uses WW ->lνqq from 183 - 202 GeV

3-Parameter Fit for 'Standard' Couplings



183 - 189 GeV

All 3 Couplings free to vary

Combines WW results with single W and single γ

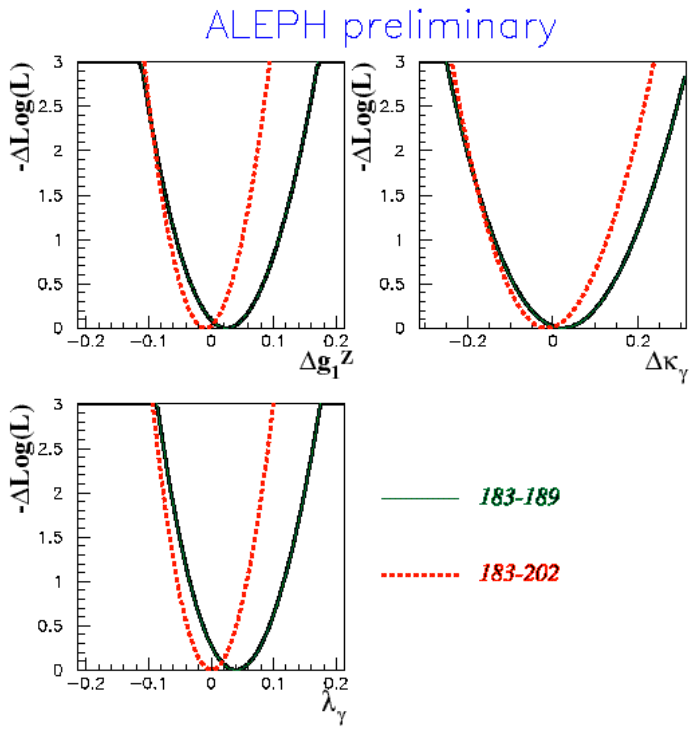
$$\Delta g_1^Z = 0.013^{+0.133}_{-0.134}$$

$$\Delta k_g = 0.043^{+0.234}_{-0.222}$$

$$\lambda_g = 0.023^{+0.151}_{-0.149}$$

1 σ errors

One parameter fit for 183 - 202 GeV data



183 - 202 GeV

Current overall ALEPH Values

$$\Delta g_1^Z = 0.003^{+0.048}_{-0.047}$$

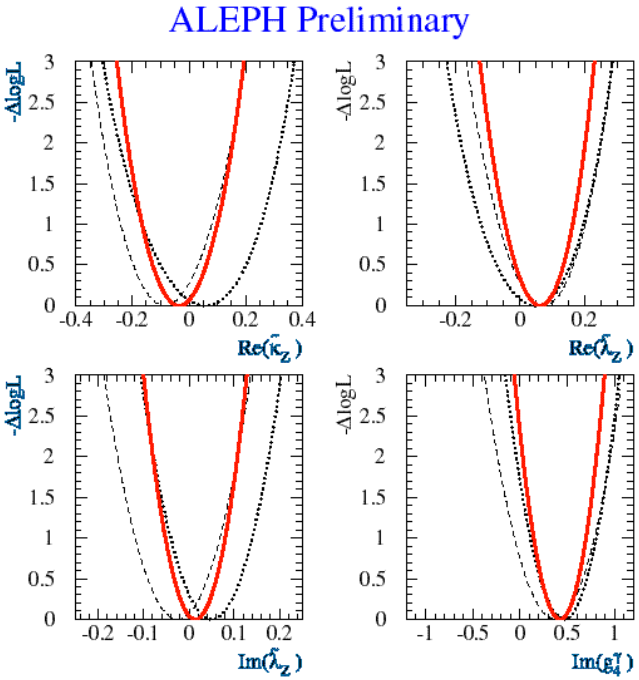
$$\Delta k_g = 0.001^{+0.108}_{-0.103}$$

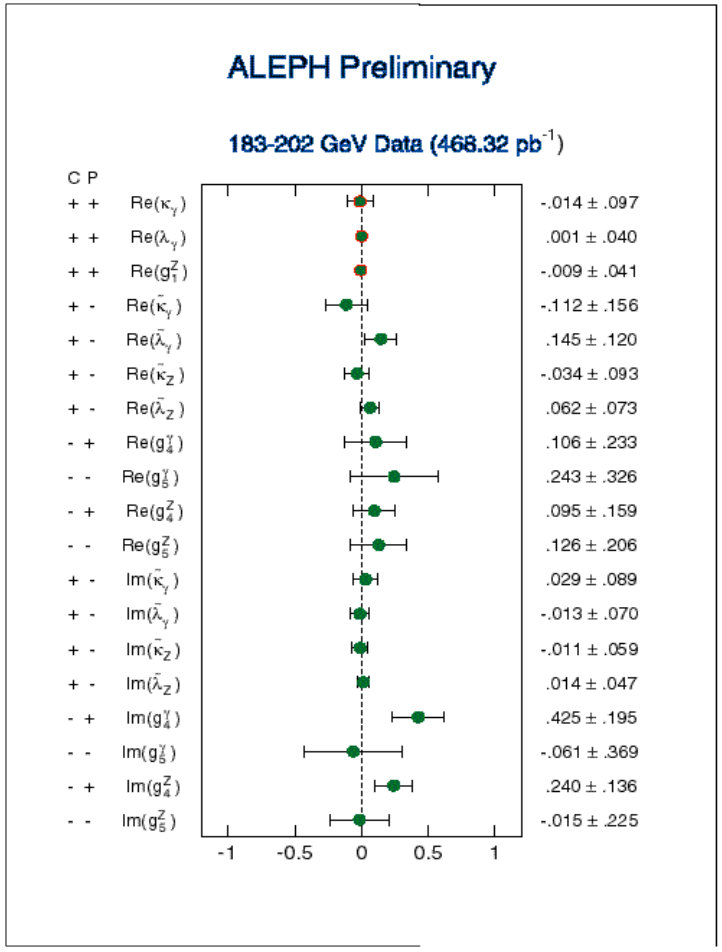
$$\lambda_g = 0.004^{+0.045}_{-0.044}$$

1 σ errors

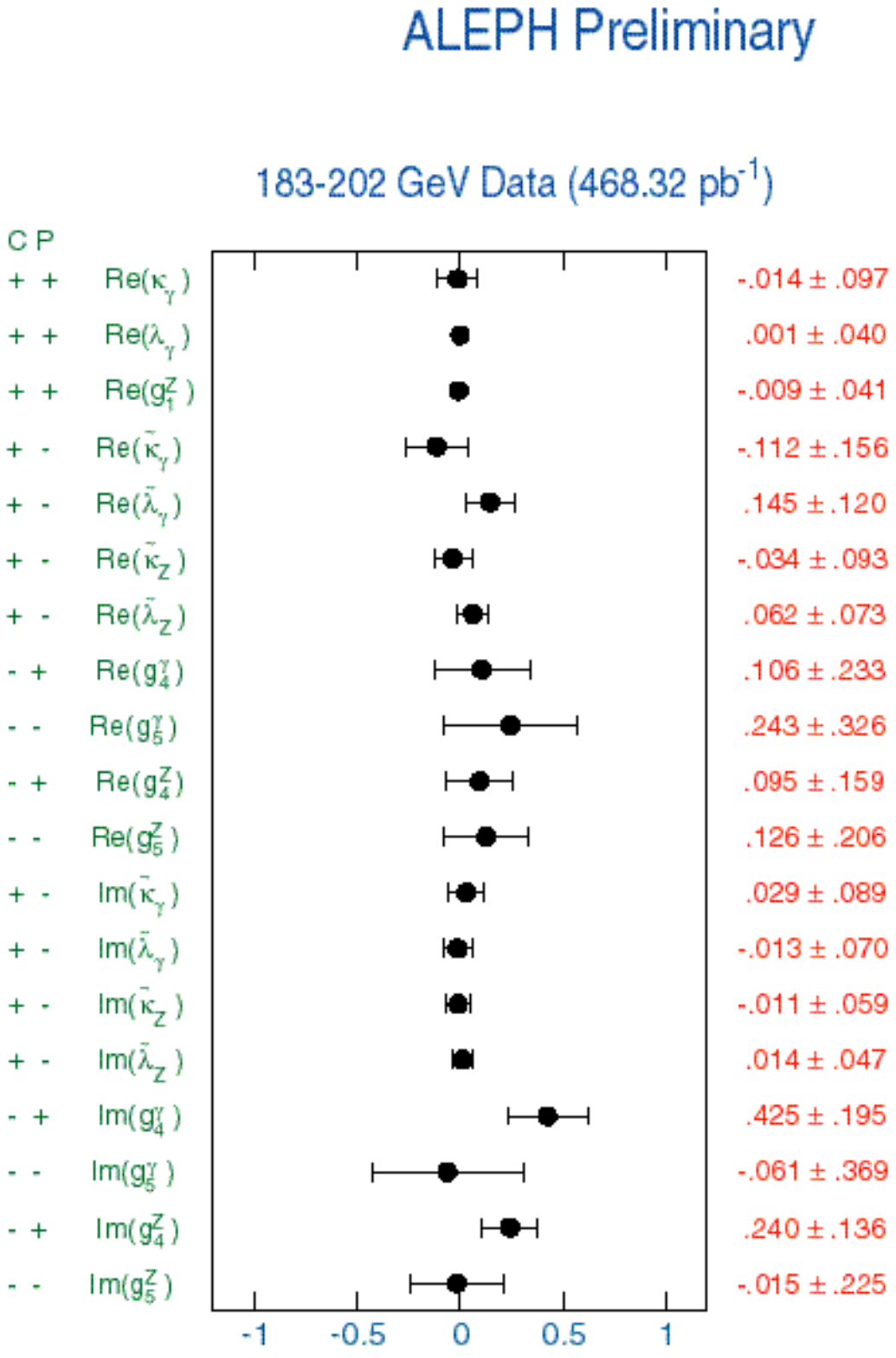
C,P or CP violating couplings, 183 - 202 GeV

Maximum Likelihood Analysis





C, P or CP Non-Conserving Couplings



W Mass

Statistical Accuracy now approaching present understanding of the systematics

- but this should improve
- present estimates believed to be 'conservative'

Main sources of systematics (model dependent)

Fragmentation - All channels

30 MeV for qqqq channel, 40 for lνqq

Final State Interactions - four jet channel

Colour Reconnection

30 for qqqq

Bose-Einstein Correlations

30 for qqqq

Bose-Einstein Effect

Interaction between like-sign pions from the two W's

Examined by 2 procedures

- Tune models on the Z data

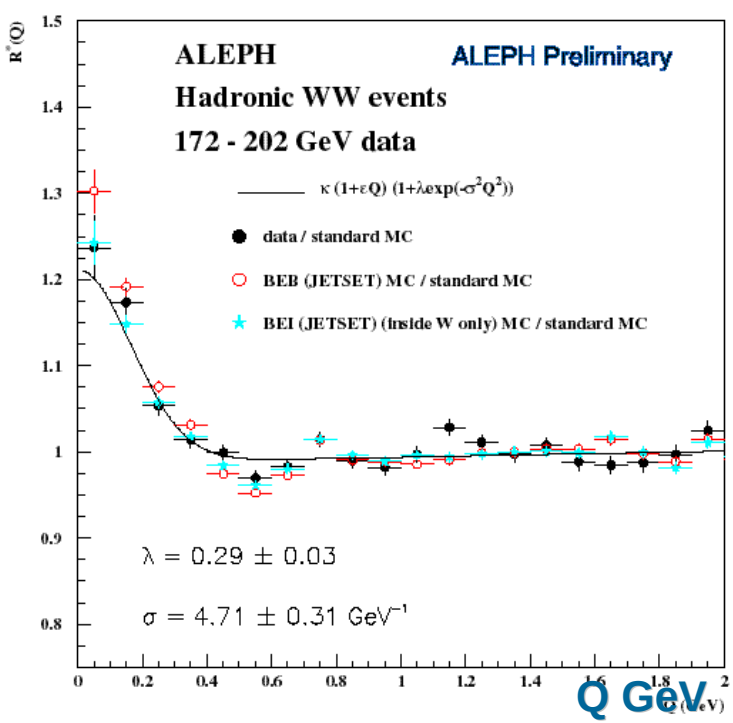
  Verify on lνqq

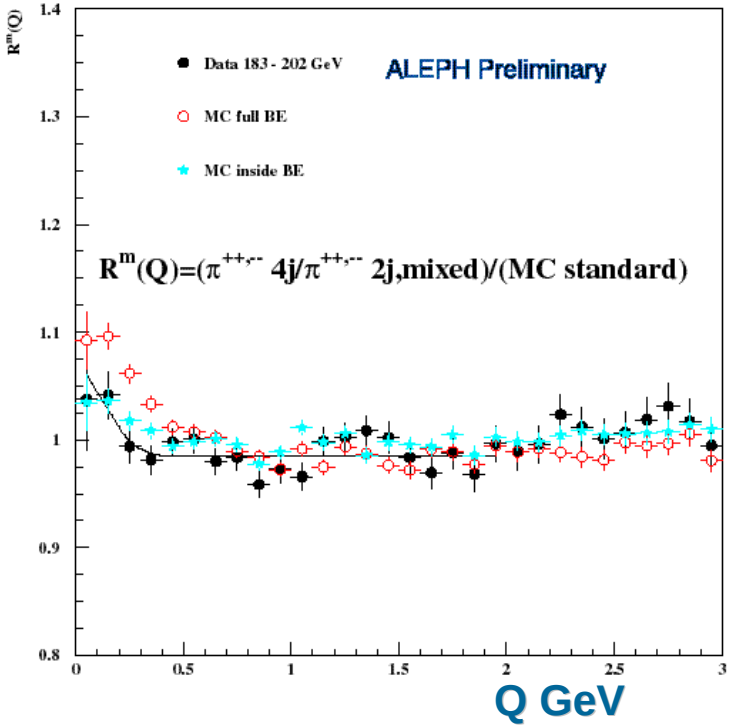
  Compare model prediction on qqqq data with/without correlations between W's

- Compare like-sign pairs in qqqq events with those from mixed events from lνqq final states

  Normalise with similar Monte Carlo ratio

Bose-Einstein Effect

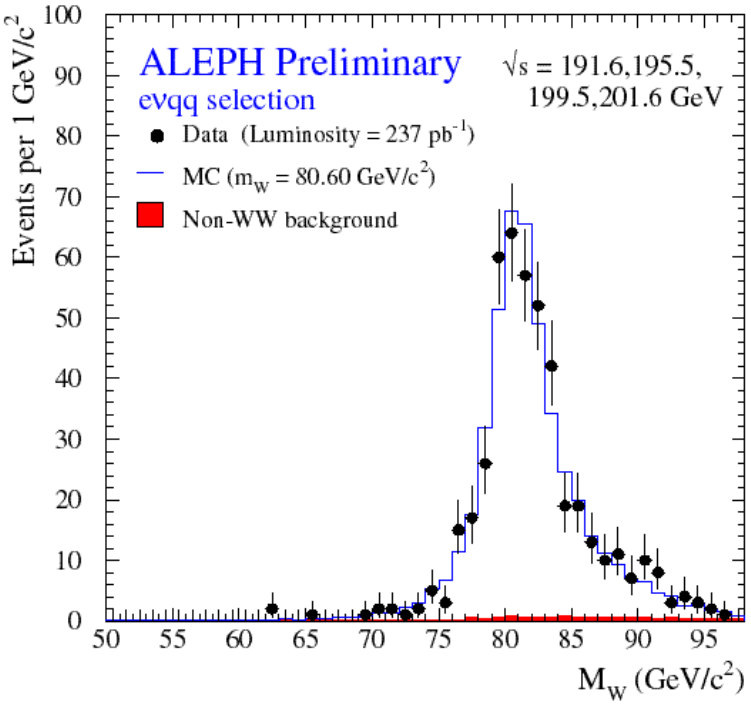


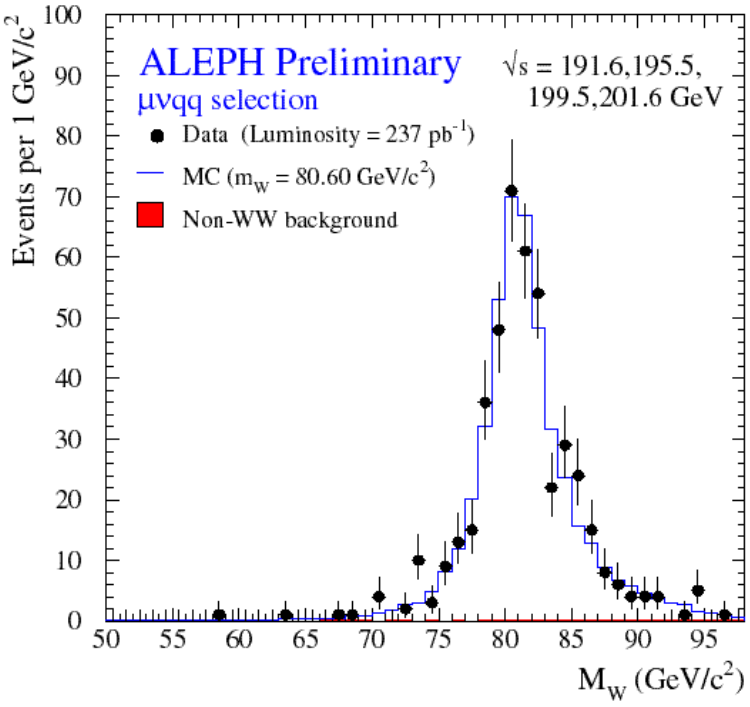


By integrating curves BE effects between W's disfavoured by 2.2σ

Both methods favour NO strong effect between W's

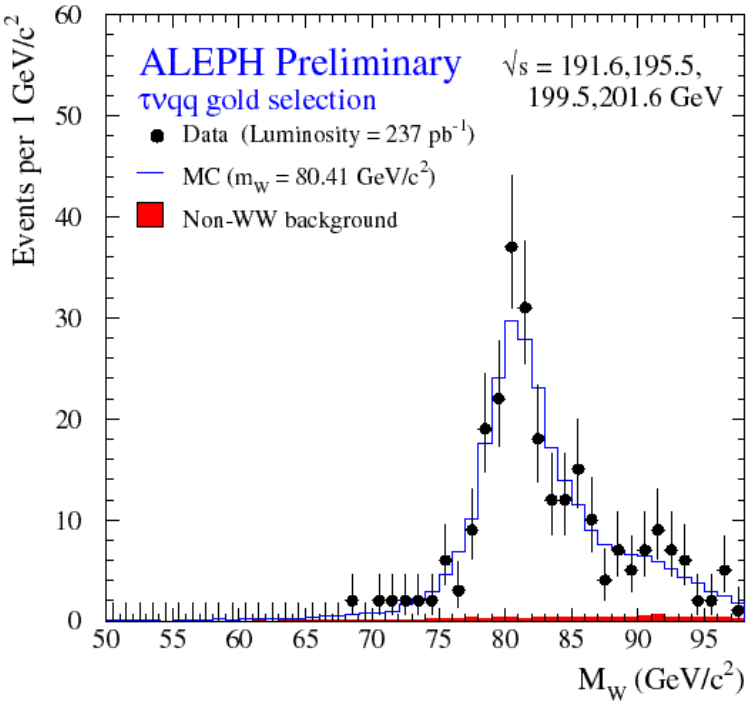
W Mass Plots eνqq and μνqq Channels



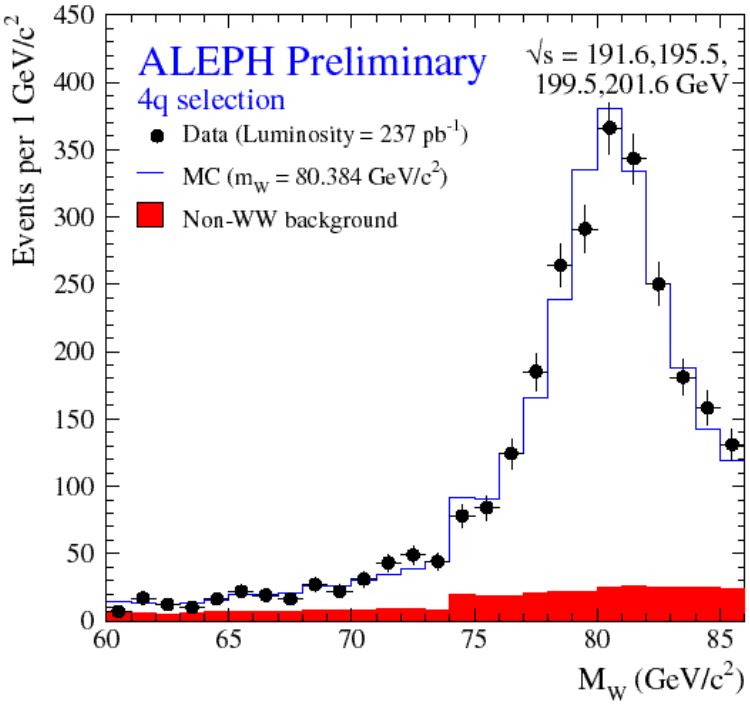


M(eνqq) = 80.596 **Γ(lνqq) = 2.052** **M(μνqq) = 80.600**

W Mass Plots - tn qq and qqqq Channels

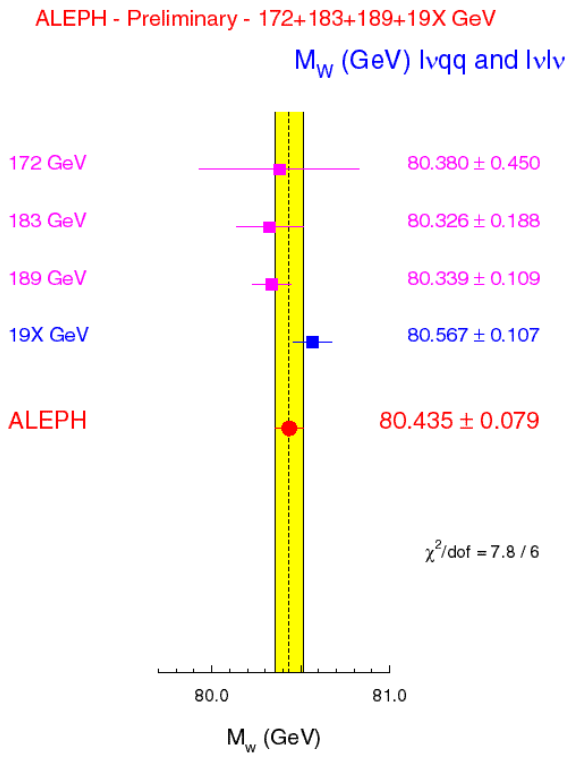


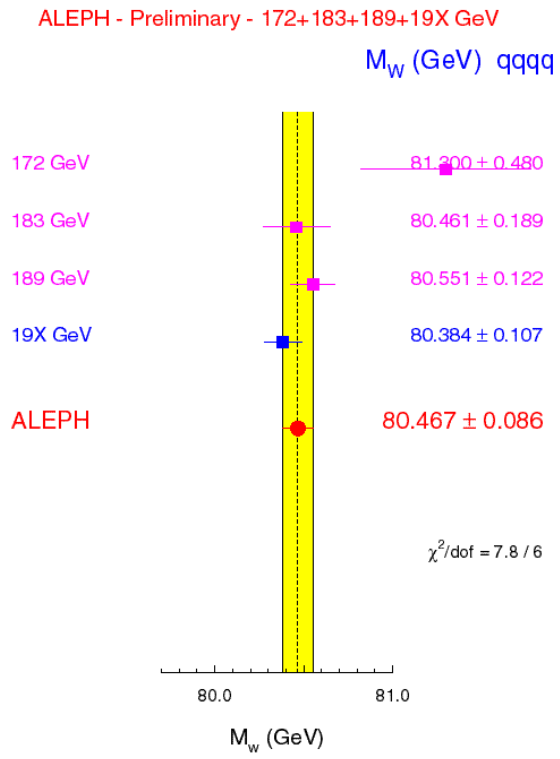
M(τνqq) = 80.408



M(qqqq) = 80.384

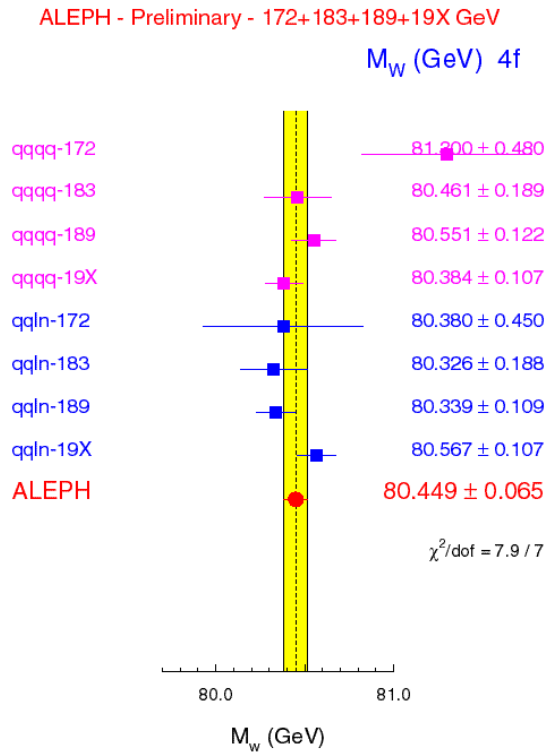
W Mass Values

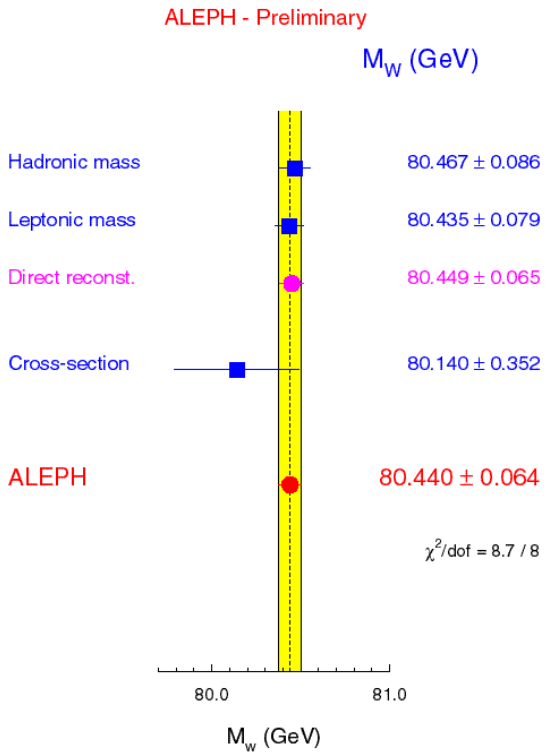




$W_{mass}(qqqq) - W_{mass}(l\nu qq) = 32 \pm 91$ MeV/c^2

Overall Values





Present ALEPH Preliminary Value = 80.440 ± 0.064 GeV/c²

W Mass & Width Summary

Combining all Energies

Mass from qqqq channels

$80.467 \pm 0.064(\text{stat}) \pm 0.035(\text{syst}) \pm 0.042(\text{thy}) \pm 0.017(\text{LEP})\ \text{GeV}/c^2$

Mass from lνqq channels

$80.435 \pm 0.063(\text{stat}) \pm 0.045(\text{syst}) \pm 0.017(\text{LEP})\ \text{GeV}/c^2$

M(qqqq) - M(lνqq) = $32 \pm 91\ \text{MeV}/c^2$

ALEPH Combined W Mass and W Width

$M_W = 80.440 \pm 0.044 \pm 0.045\ \text{GeV}/c^2$

$\Gamma_W = 2.168 \pm 0.158 \pm 0.116\ \text{GeV}$

Summary

1999 was another excellent year for ALEPH

Data taking efficiency and quality remained high throughout the year

There is a rich physics output

ALEPH is ready for this year's data taking and look forward to even higher energies - and hopefully a discovery

Our belief is that all emphasis should be on maximizing the high energy performance for the Higgs search