Status of EW Results

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(for the LEP EW Working Group)

19 Nov 1996

- $R_{b\bar{b}}$, $R_{c\bar{c}}$
- $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$
- Higgs mass

The LEP EW Working Group:
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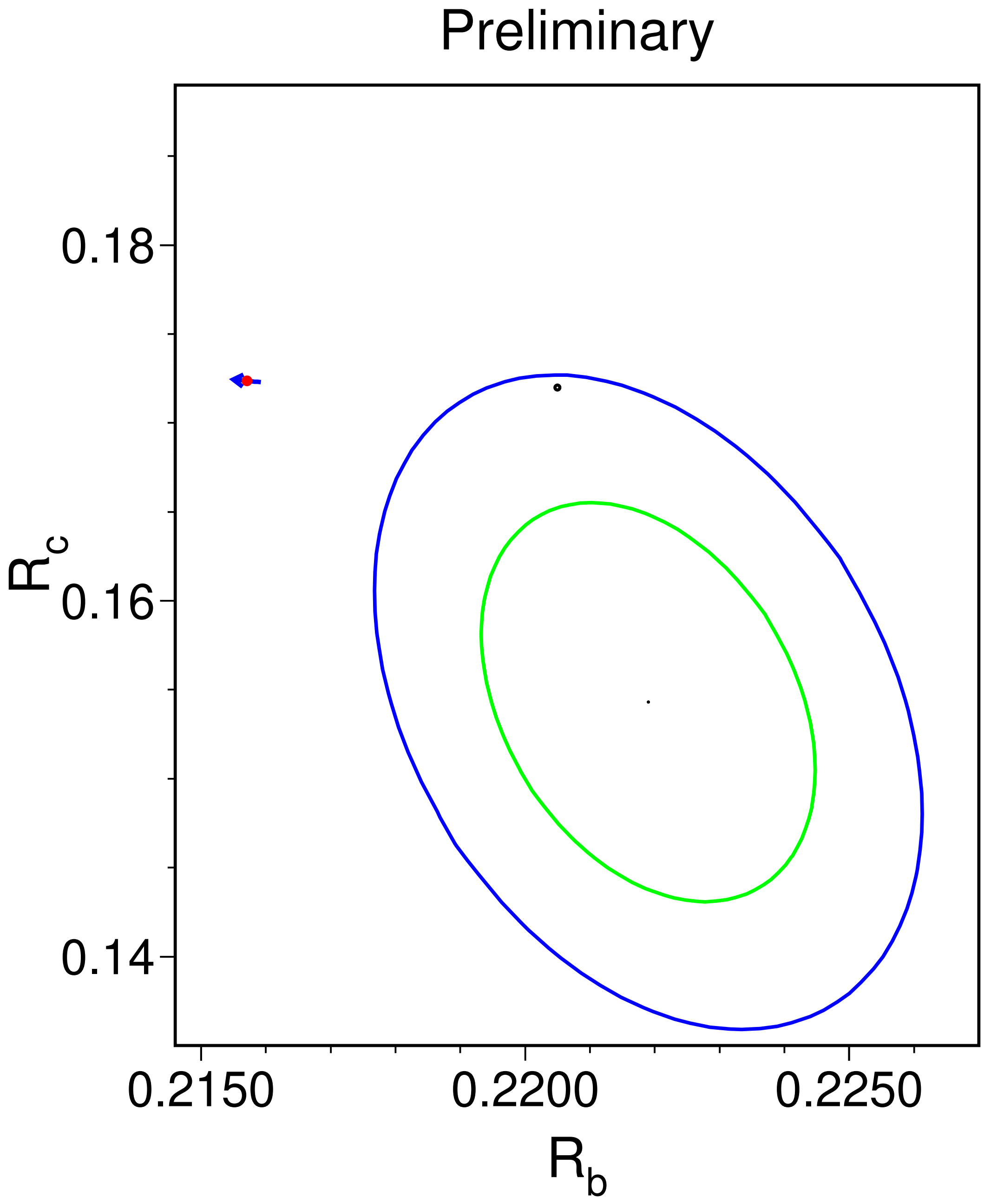
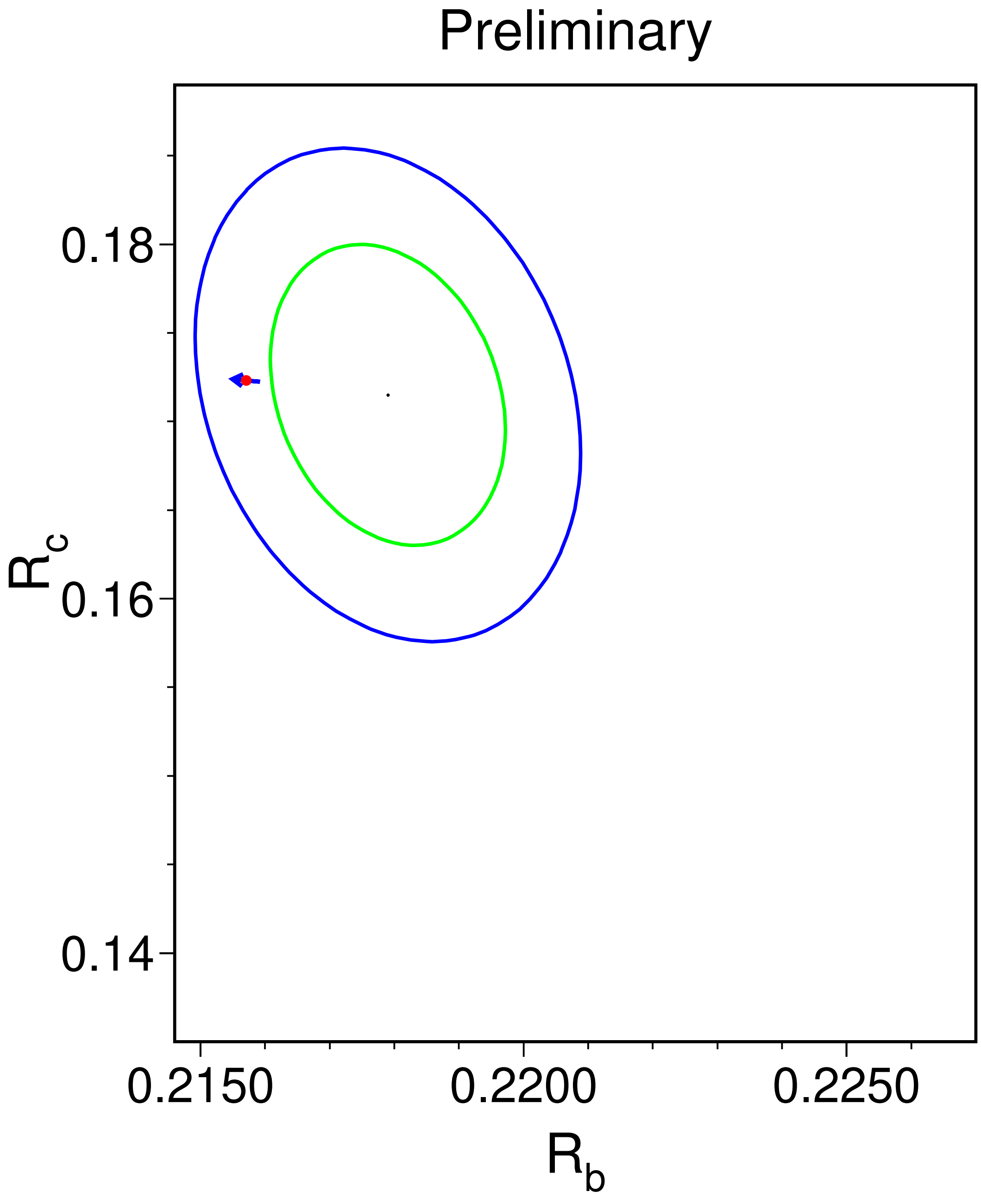
$R_{b\bar{b}}$, $R_{c\bar{c}}$ in Beijing

last year...



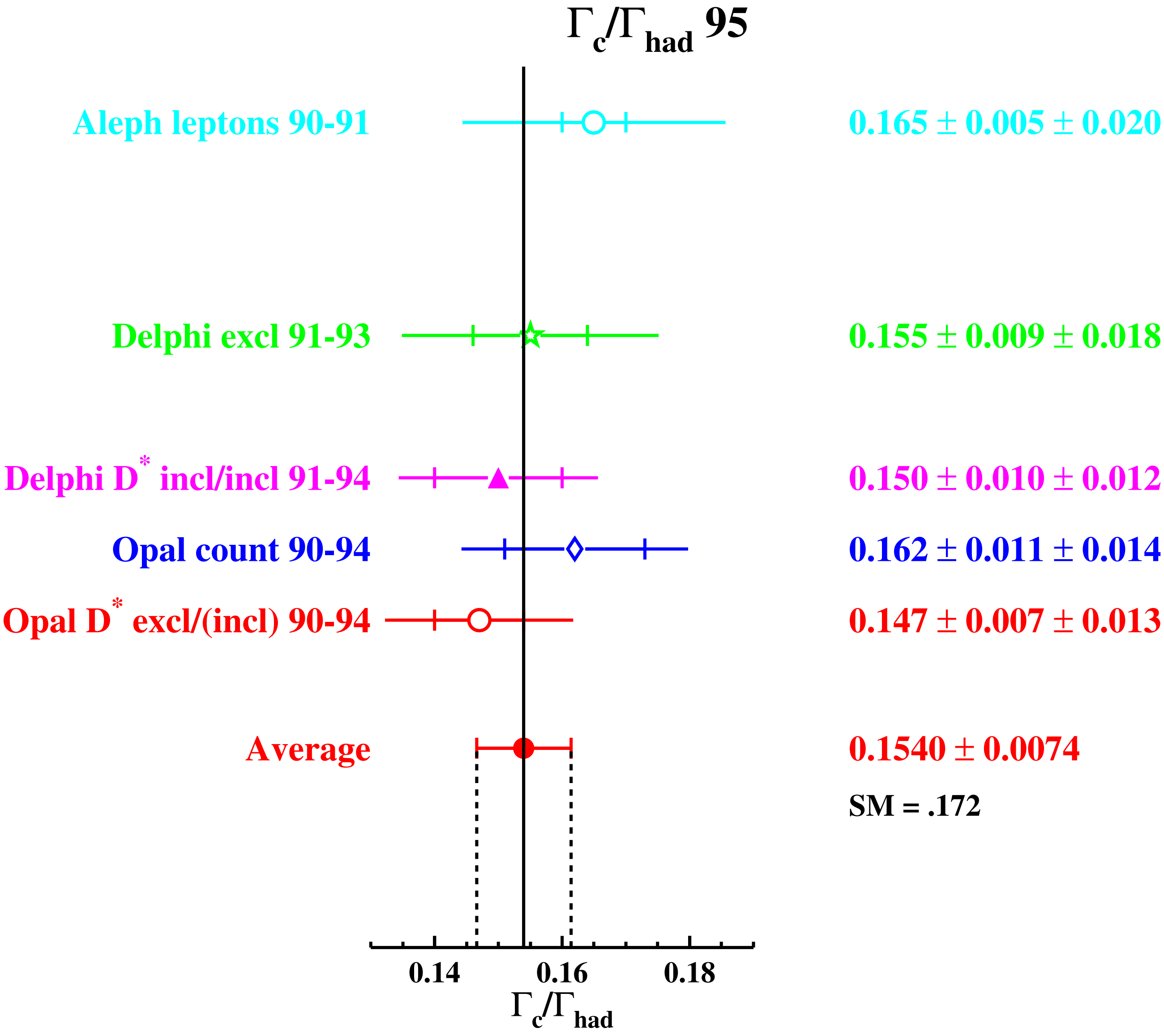
. . . this year



What happened?

$R_{c\bar{c}}$

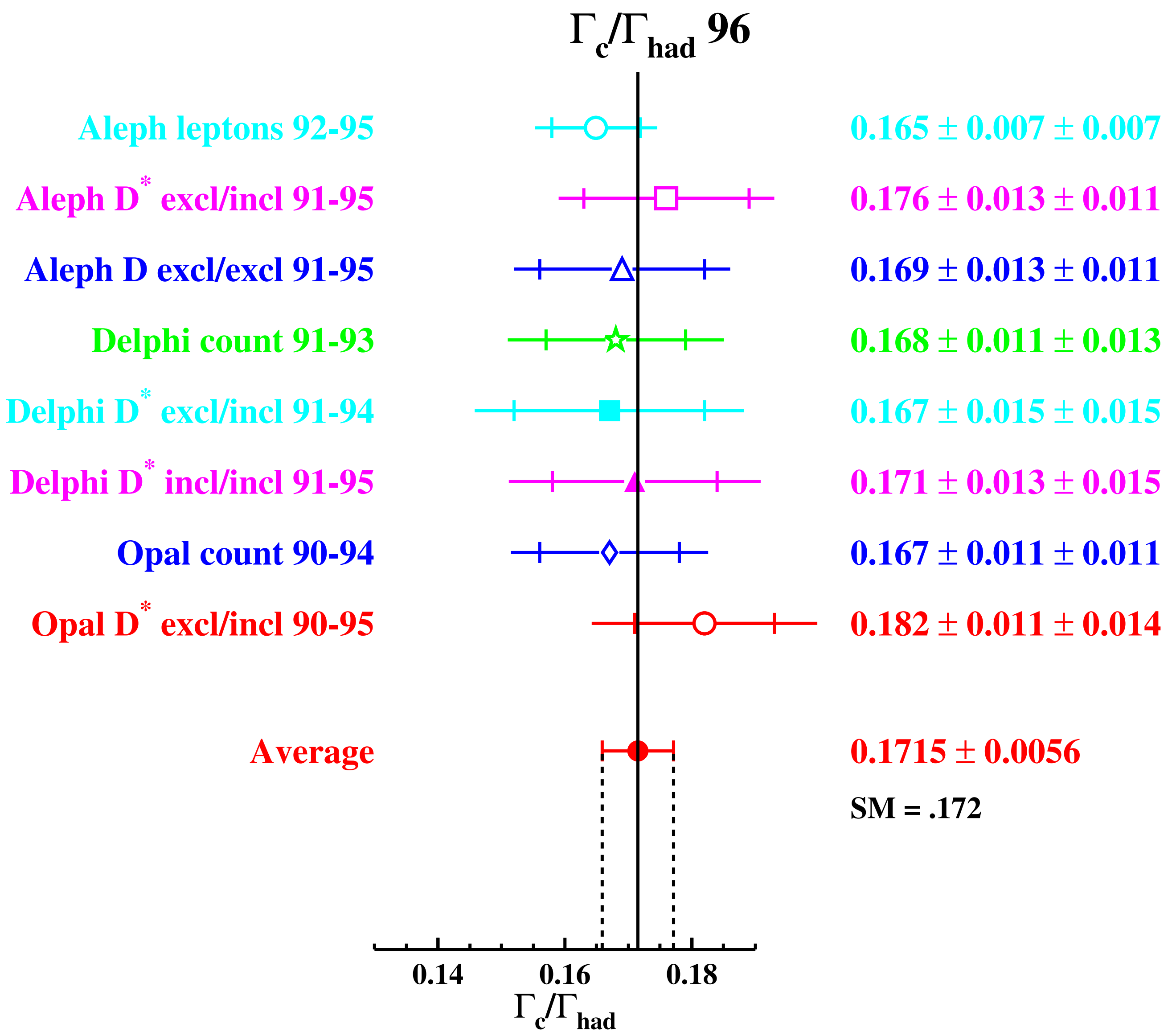
Don't quote: modified results![1]



[1] For the purposes of these graphical comparisons, the results have been modified by hand to common input parameters. The averages quoted have been correctly determined with the complete combination procedure.

$R_{c\bar{c}}$

Don't quote: modified results!



The differences:

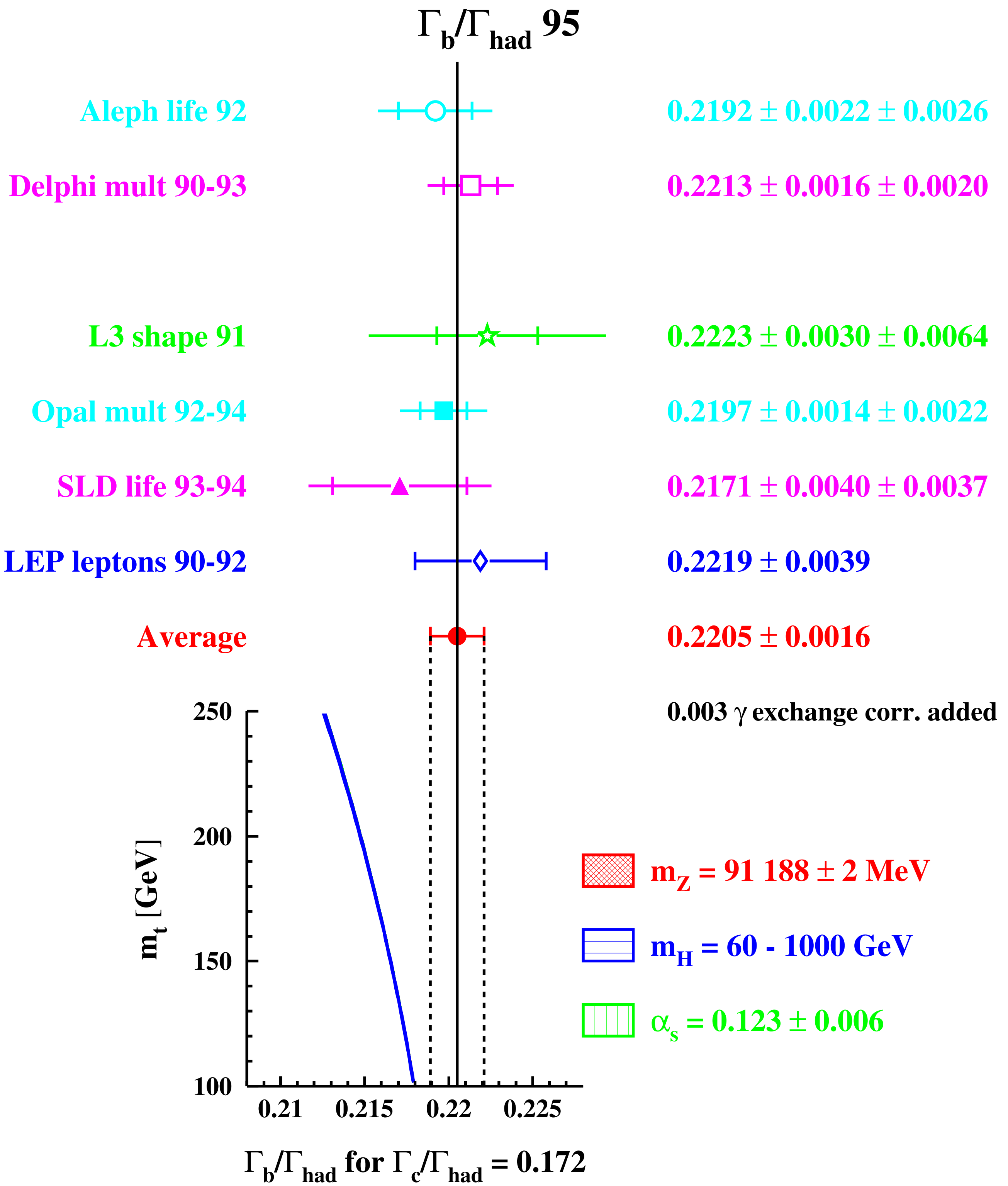
- Several results depend on the value of $P(\mathrm{c} \to \mathrm{D}^{*+}) \times BR(\mathrm{D}^{*+} \to \pi^{+}\mathrm{D}^{0})$. Last year the low energy result (0.178) was used; this year the result from LEP (0.163) is used. This is the largest systematic effect. (The current average of 0.1715 would change to 0.1637).
- Several input parameters have changed (*e.g.*, branching ratios and gluon splitting).
- Several analyses have been improved.
- The data sample has increased significantly.

Dominant errors:

$$\left.\begin{array}{ll} \text{Statistics:} & 0.0037 \\ \text{Uncorrelated systematics:} & 0.0029 \\ BR(\mathrm{c} \to \ell) & 0.0022 \\ BR(\mathrm{D_s} \to \phi\pi) & 0.0011 \end{array}\right\} 0.0053$$

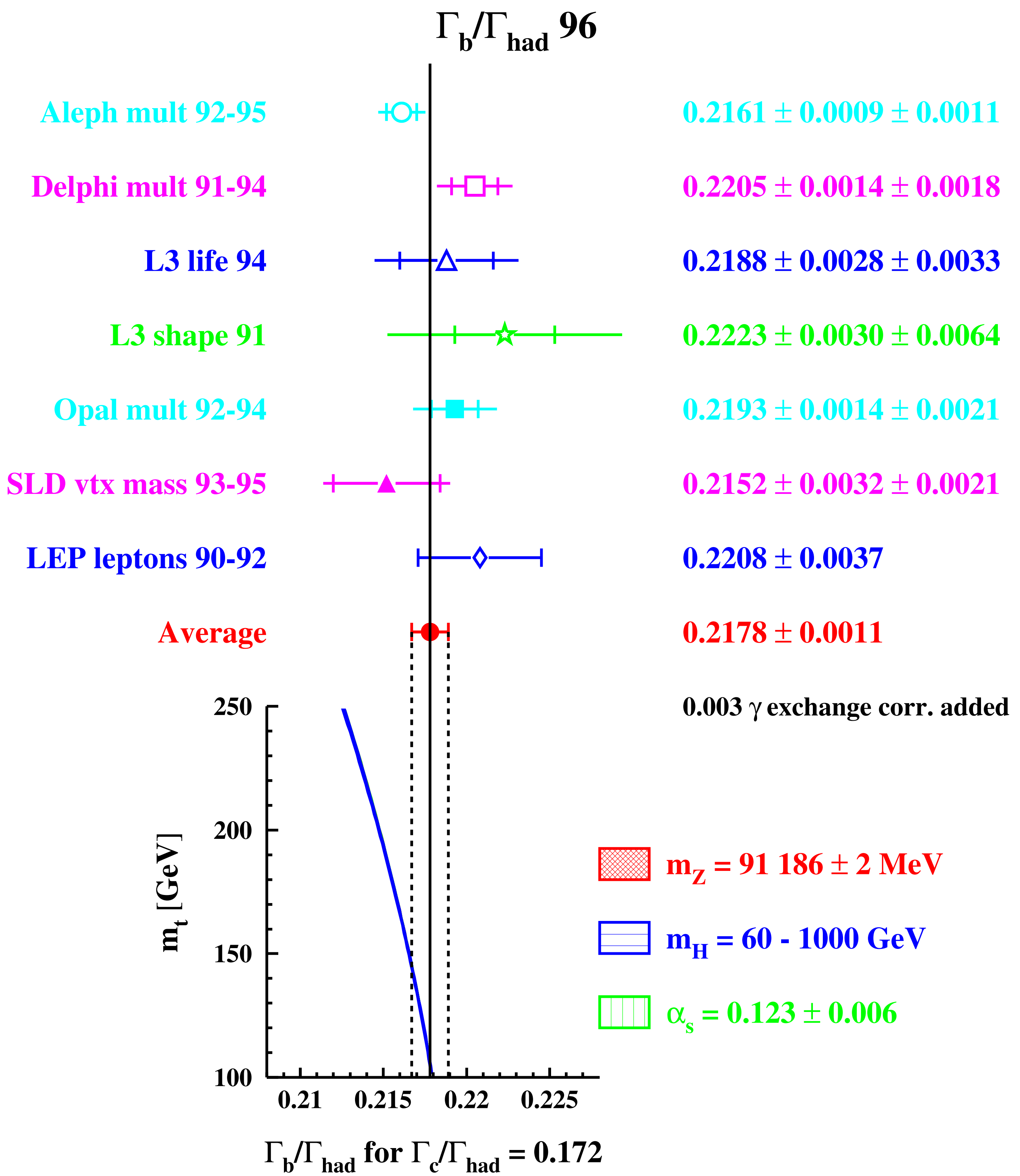
$R_{b\bar{b}}$

Don't quote: modified results!



$R_{b\bar{b}}$

Don't quote: modified results!



$R_{b\bar{b}}$

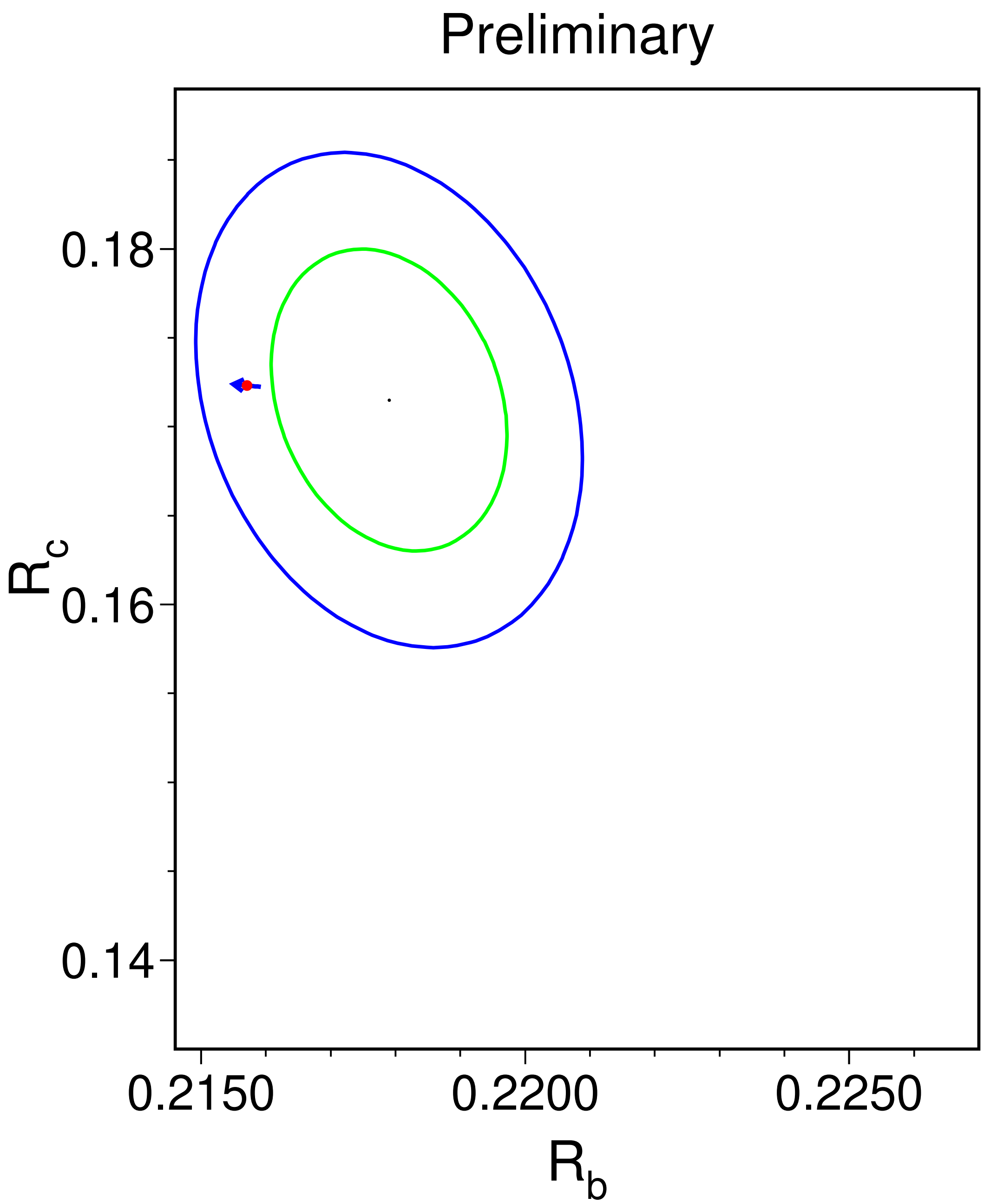
The differences:

- New data:
  - ALEPH: 92 $\rightarrow$ 92-95
  - DELPHI: 90-93 $\rightarrow$ 90-94
  - L3: new 94 result
- New analyses:
  - SLD: vertex mass tag: VERY high purity (97% pure at 37% eff)
  - ALEPH: multi-tag including vertex mass tag $\Rightarrow$ VERY small systematics
- Some minor changes to input parameters (*e.g.*, g$\rightarrow$ $b\bar{b}$, $c\bar{c}$).

Dominant errors:

Statistics	0.00067	0.0011
Uncorrelated systematics	0.00053	
gluon splitting	0.00044	
QCD hemisphere correlations	0.00031	
D decay multiplicity	0.00029	
$BR(D \rightarrow K^0X)$	0.00022	

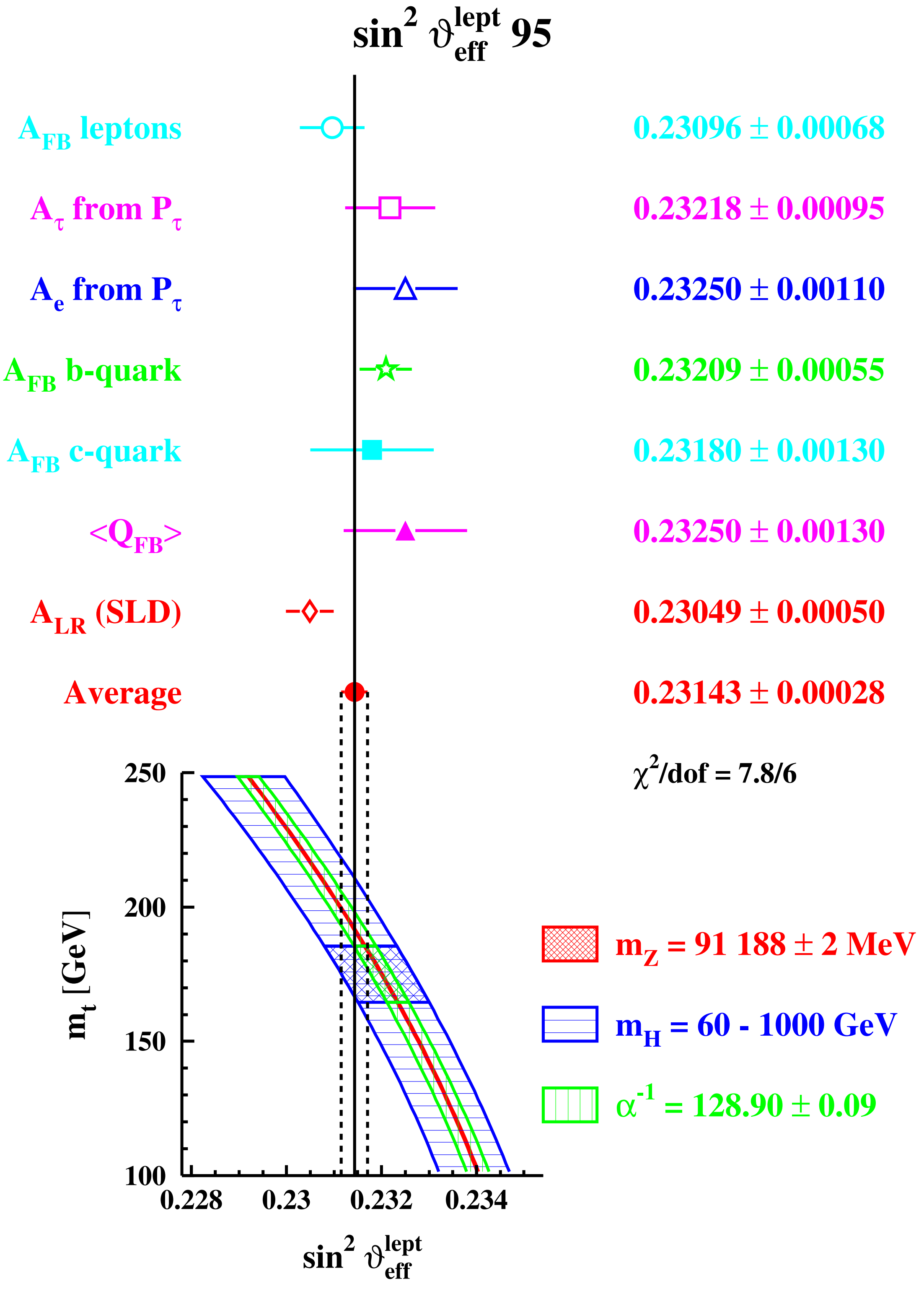
$R_{b\bar{b}}$ *vs.* $R_{c\bar{c}}$



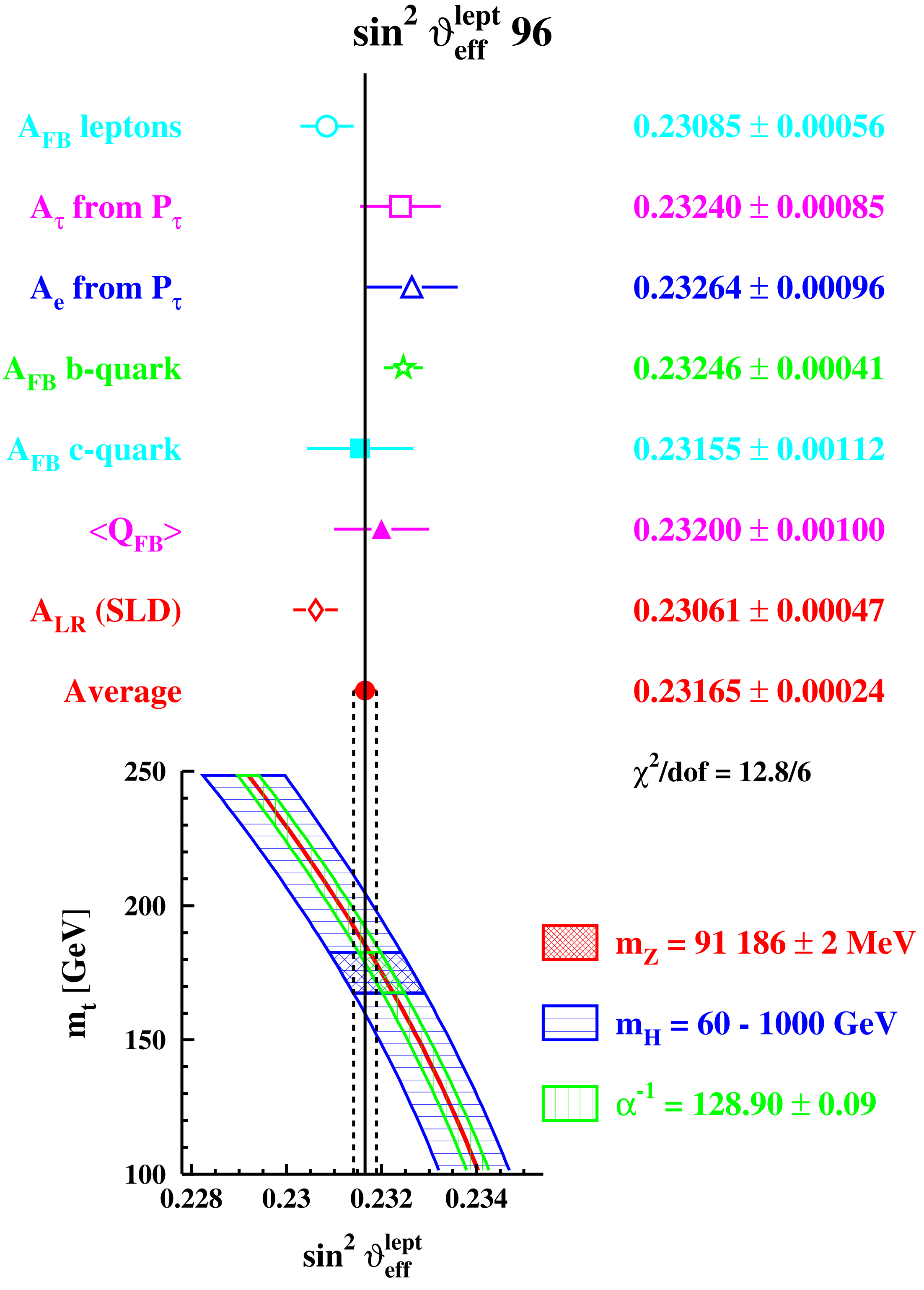
Changes understood and are due to:

- **New data**
- **New techniques**

$\sin^2\theta_{eff}^{lept}$

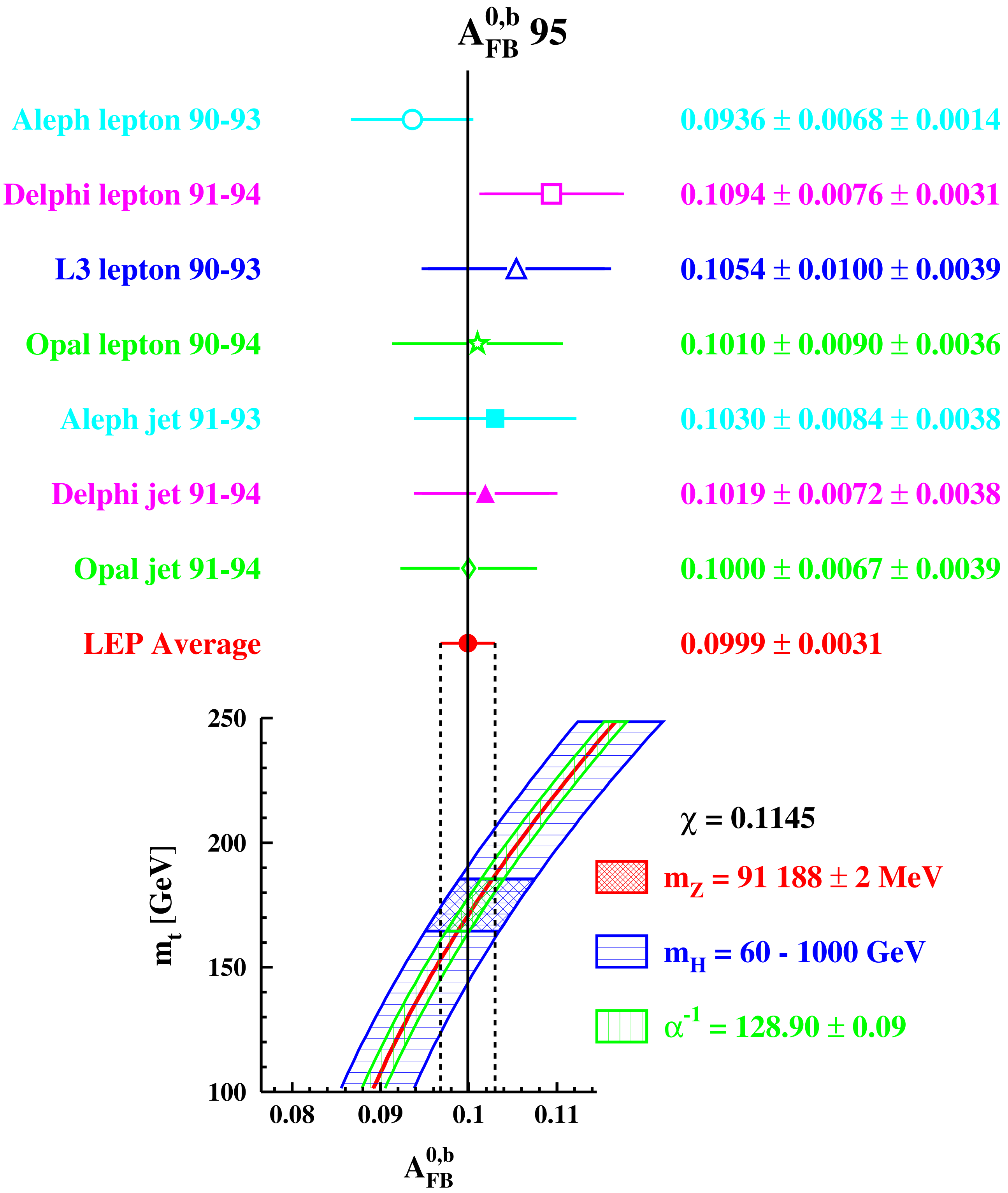


$\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$



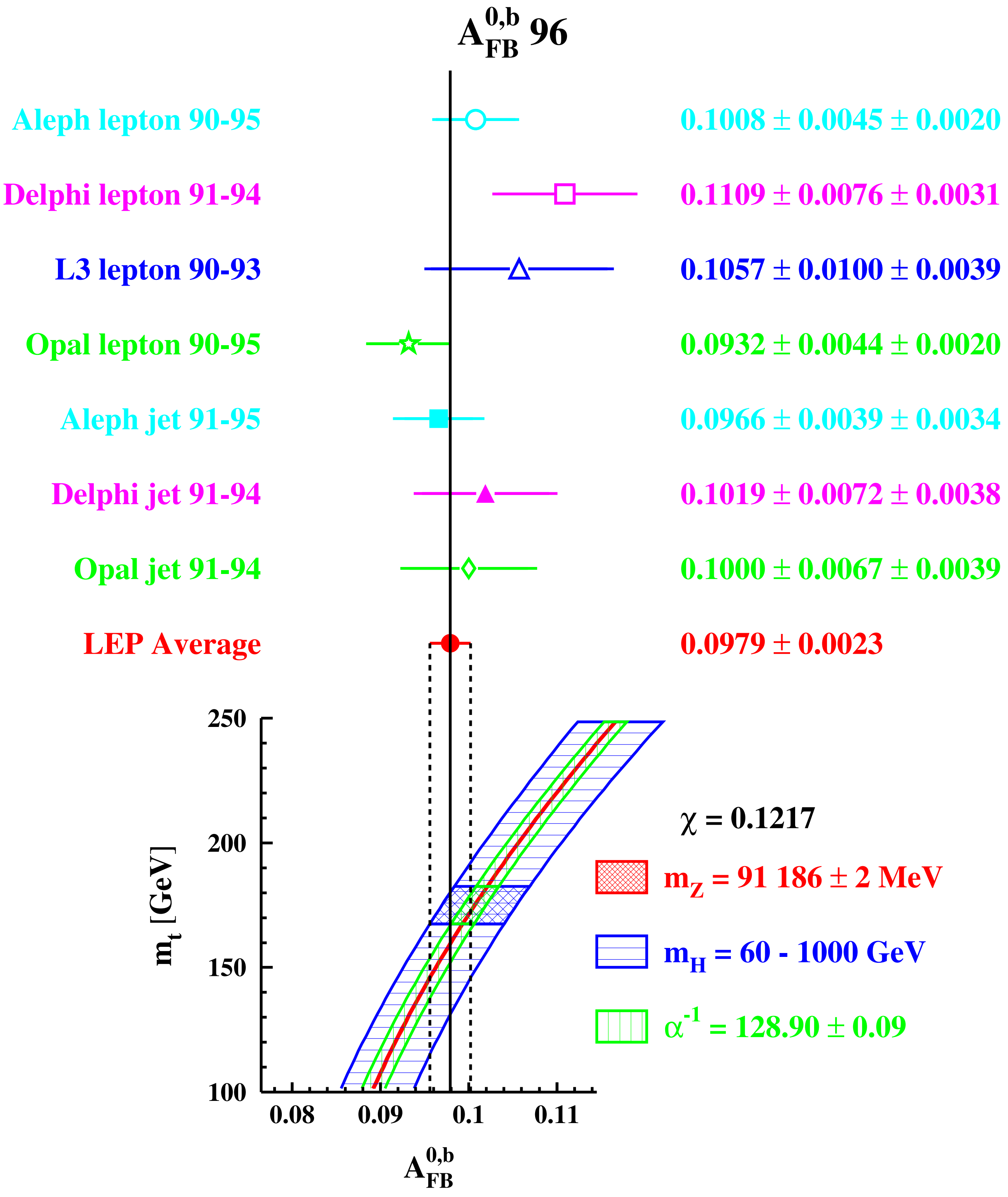
A^{b}_{FB}

Don't quote: modified results!



A^{b}_{FB}

Don't quote: modified results!



$A_{\mathrm{FB}}^{\mathrm{b}}$

The differences:

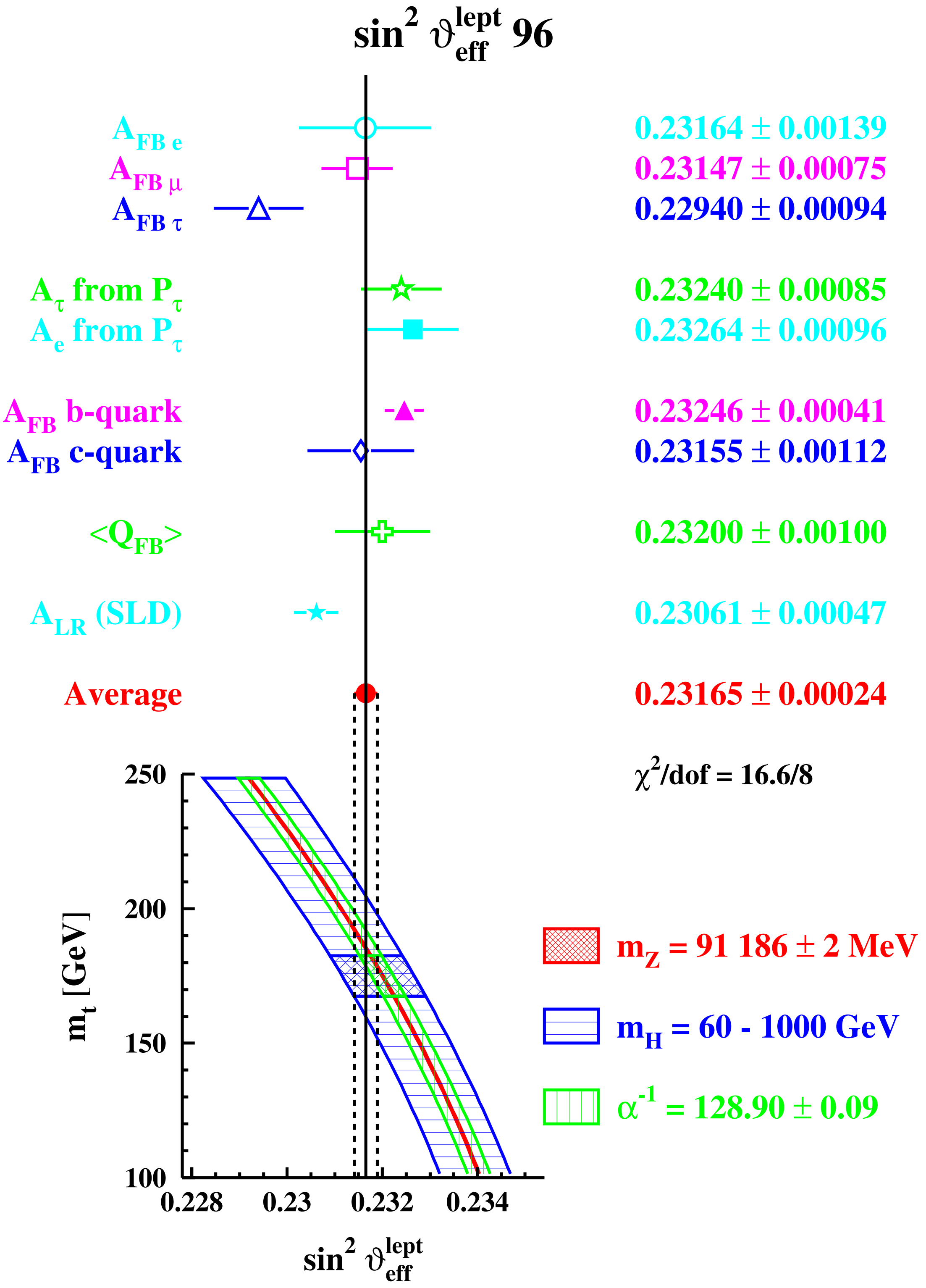
- **improved OPAL lepton analysis with new data**
- **improved ALEPH jet charge analysis with new data**
- **improved QCD corrections (high momentum lepton reduces effects of gluon emission)**
- **new value for $\mathrm{B}^0\bar{\mathrm{B}}^0$ mixing (0.1145 changed to 0.1217)**

These last two effects essentially cancel, leaving the major effect due to new data.

Dominant errors:

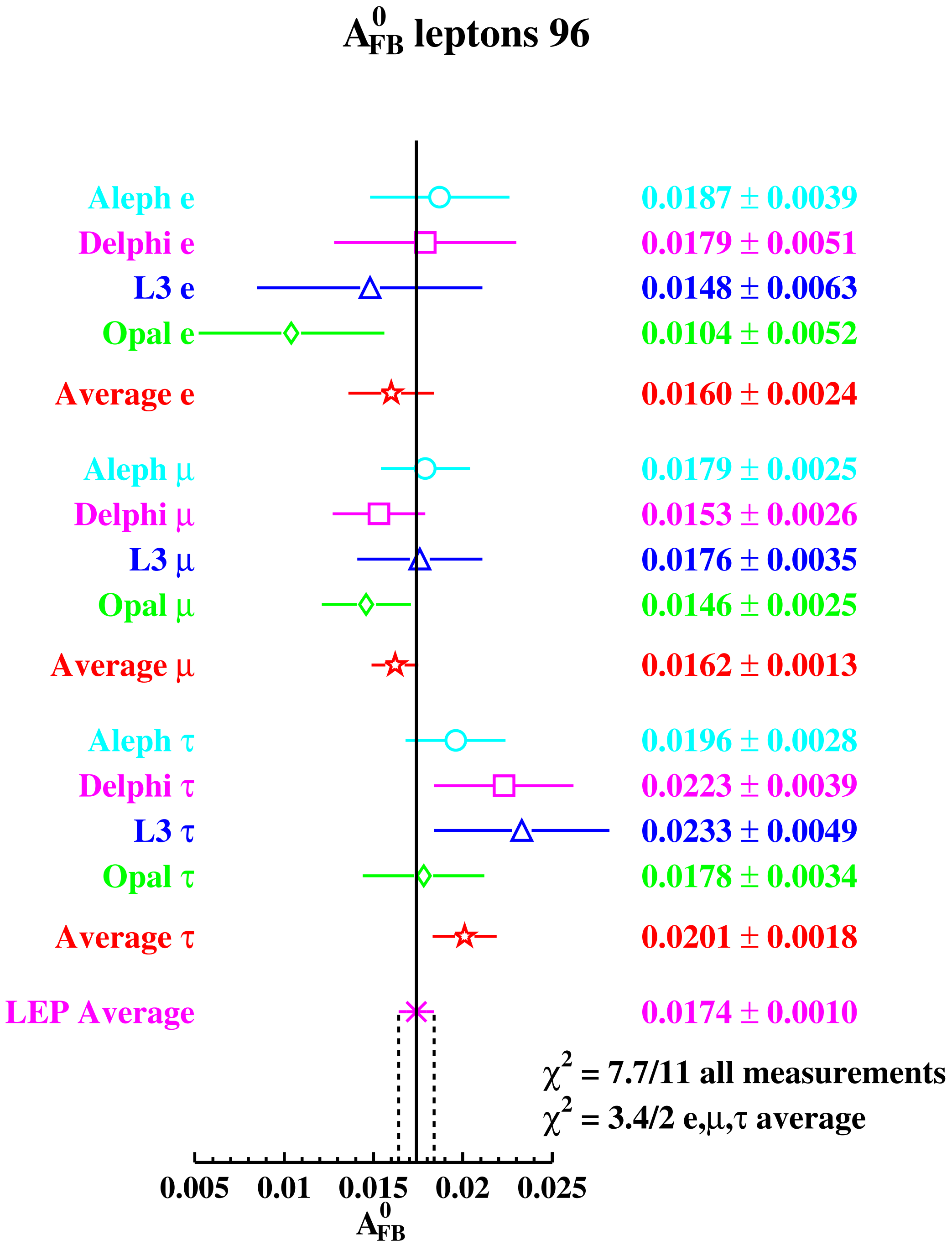
$$\left.\begin{array}{ll}\textbf{Statistics:} & \mathbf{0.0020}\\ \textbf{Uncorrelated systematics:} & \mathbf{0.0008}\\ \textbf{Common systematics:} & \mathbf{0.0006}\end{array}\right\}\mathbf{0.0023}$$

More 2 s.d. effects



$A_{\rm FB}^{0,\tau}$

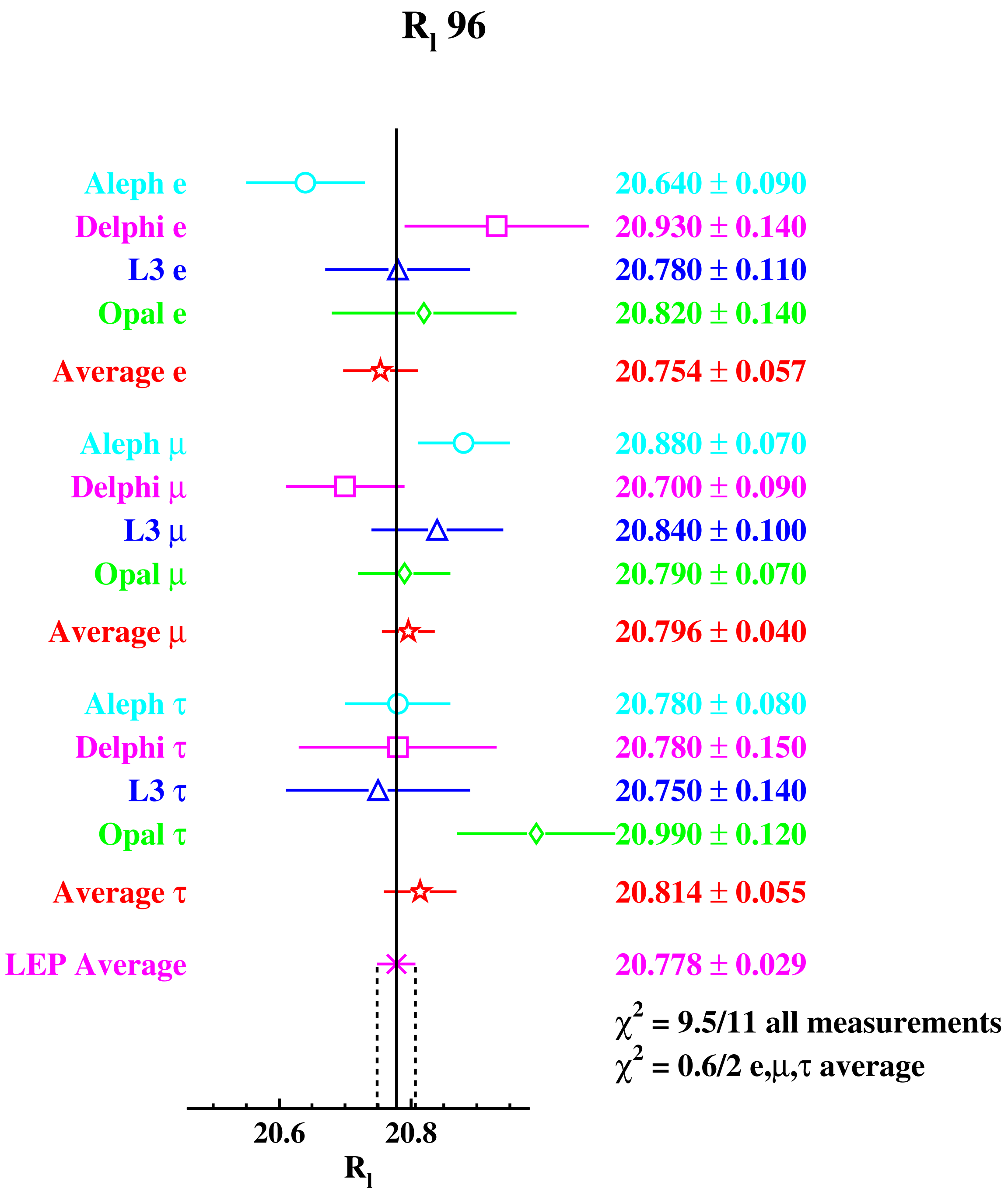
Common to all experiments:



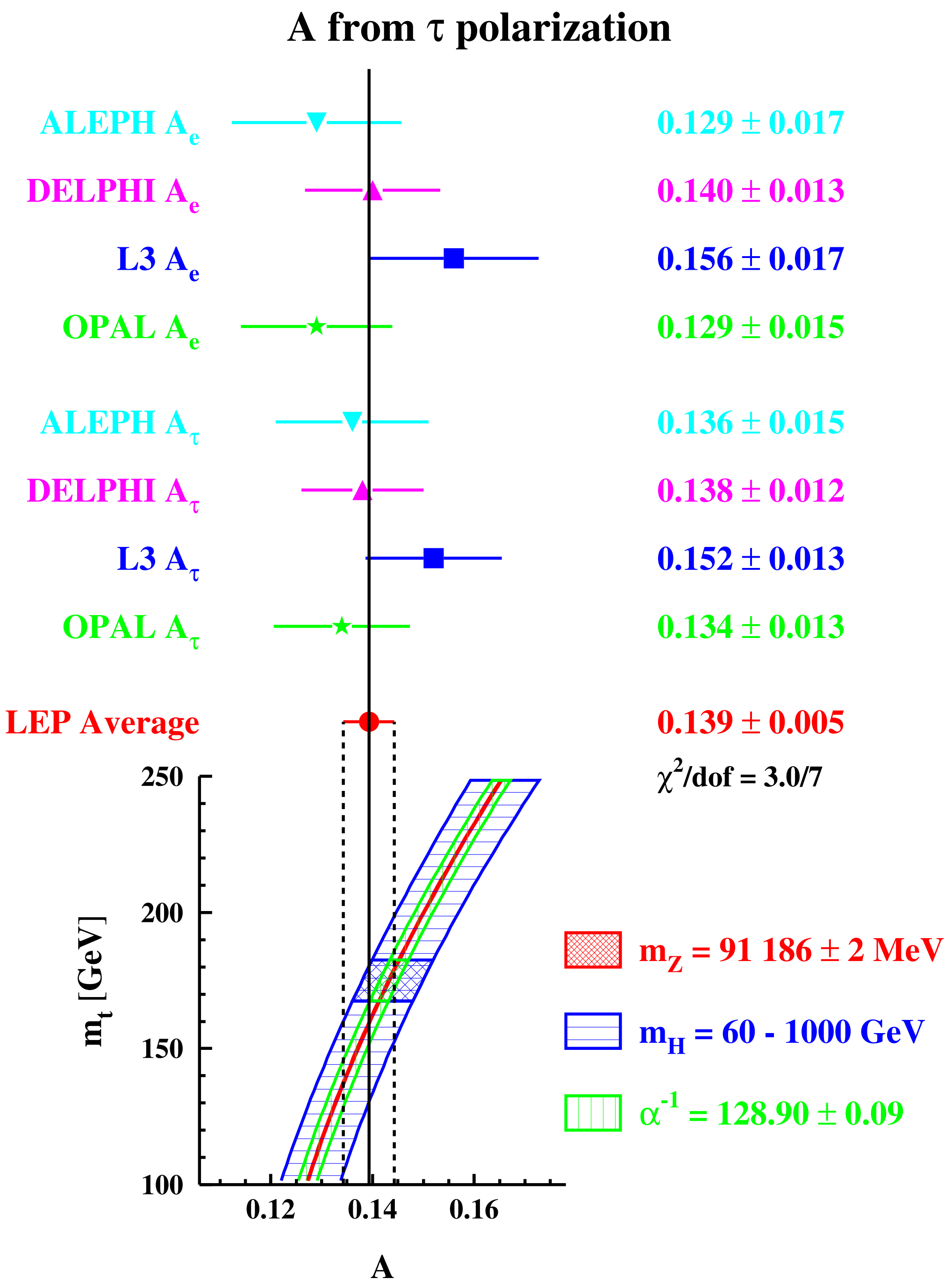
NB: $\chi^2 = 3.4/2 \Rightarrow 18\%$ probability!

Widths

The leptonic widths ($R_\ell = \Gamma_{had}/\Gamma_{\ell\ell}$) look OK:



Tau polarization is also OK:

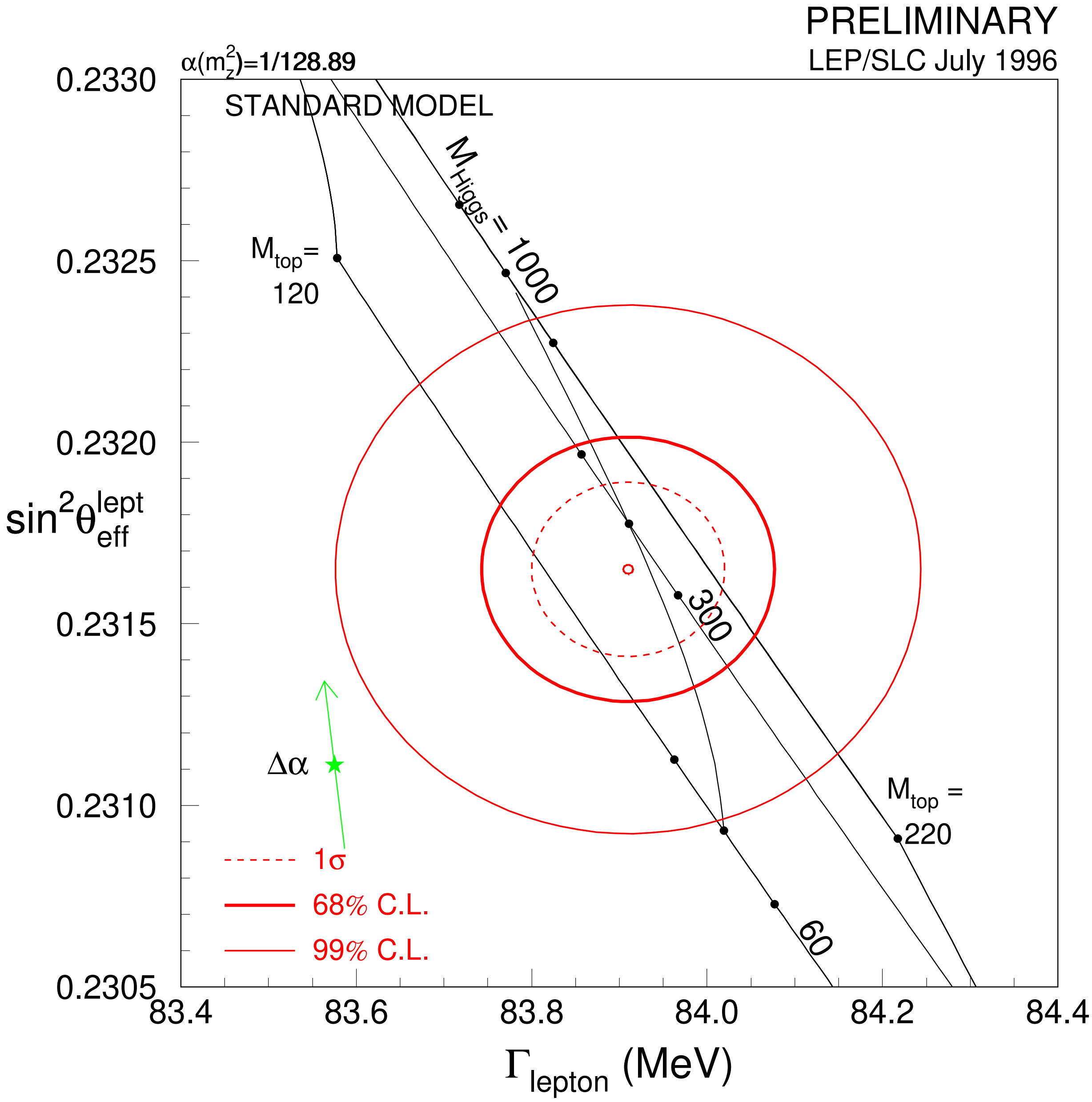


Summary of data

	96	95
$\alpha(m_Z^2)^{-1}$	128.896 ± 0.090	128.896 ± 0.090
LEP		
m_Z [GeV]	91.1863 ± 0.0020	91.1884 ± 0.0022
Γ_Z [GeV]	2.4946 ± 0.0027	2.4963 ± 0.0032
σ^0_{had} [nb]	41.508 ± 0.056	41.488 ± 0.077
R_ℓ	20.778 ± 0.029	20.788 ± 0.032
$A_{FB}^{0,\ell}$	0.0174 ± 0.0010	0.0172 ± 0.0012
+ corr. matrix		
$\mathcal{A}_\tau$	0.1401 ± 0.0067	0.1418 ± 0.0075
$\mathcal{A}_e$	0.1382 ± 0.0076	0.1390 ± 0.0089
$R^0_{b\bar{b}}$	0.2179 ± 0.0012	0.2219 ± 0.0017
$R^0_{c\bar{c}}$	0.1715 ± 0.0056	0.1543 ± 0.0074
$A_{FB}^{0,b}$	0.0979 ± 0.0023	0.0999 ± 0.0031
$A_{FB}^{0,c}$	0.0733 ± 0.0049	0.0725 ± 0.0058
+ corr. matrix		
$\sin^2\theta_{eff}^{lept}$ $(\langle Q_{FB}\rangle)$	0.2320 ± 0.0010	0.2325 ± 0.0013
SLD		
$\sin^2\theta_{eff}^{lept}$ (A_{LR})	0.23061 ± 0.00047	0.23049 ± 0.00050
$R^0_{b\bar{b}}{}^{(a)}$	0.2149 ± 0.0038	0.2171 ± 0.0054
$\mathcal{A}_b$	0.863 ± 0.049	0.841 ± 0.053
$\mathcal{A}_c$	0.625 ± 0.084	0.606 ± 0.090
$p\bar{p}$ and νN		
$\sin^2\theta_W(\nu N)$	0.2244 ± 0.0042	0.2257 ± 0.0043
m_W [GeV] $(p\bar{p})$	80.356 ± 0.125	80.26 ± 0.16
m_t [GeV] $(p\bar{p})$	175 ± 6	180 ± 12

What can be said about m_H?

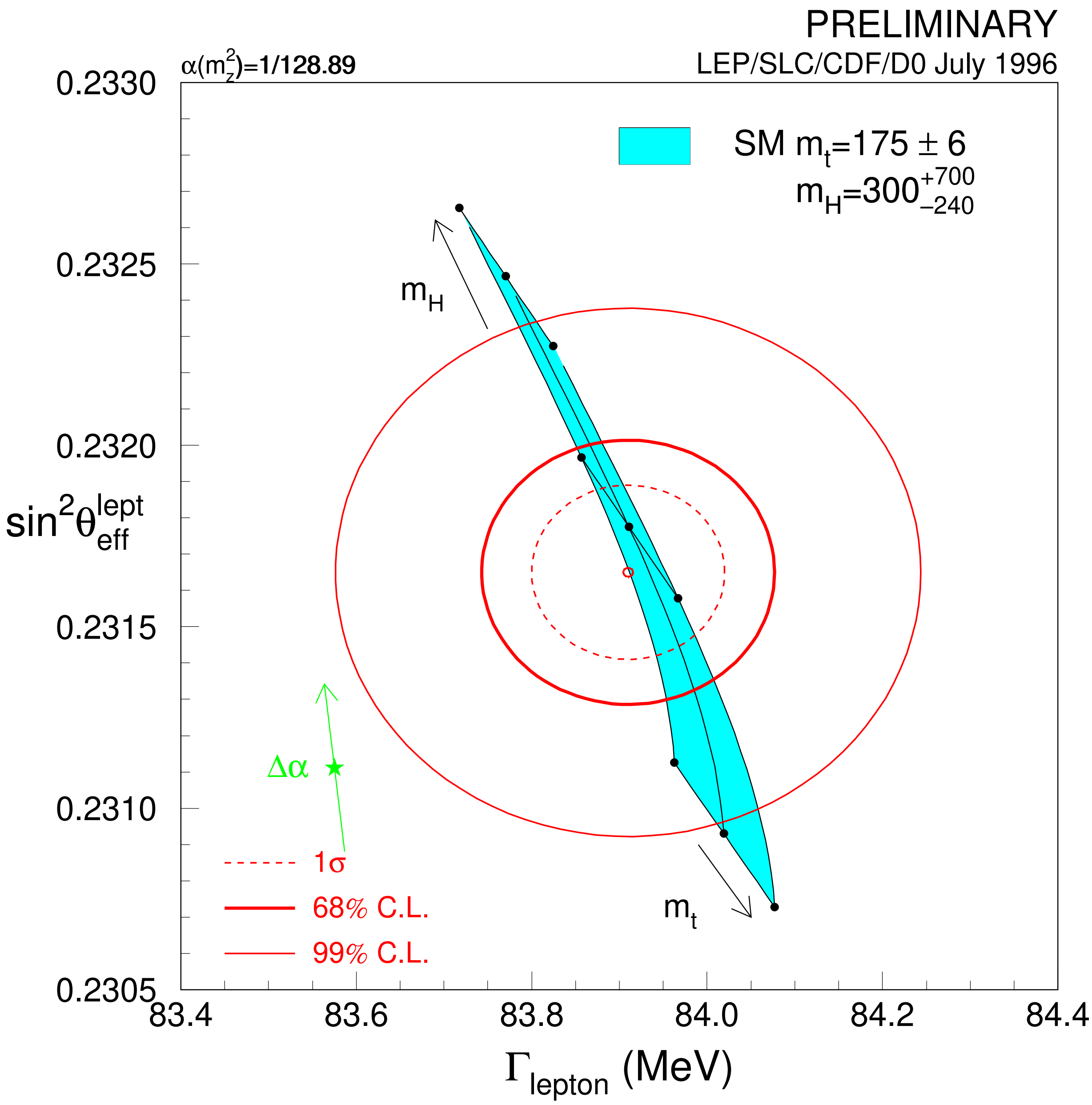
No fit yet, just asymmetries and widths:



Not much to learn without m_t!

What can be said about m_{H}?

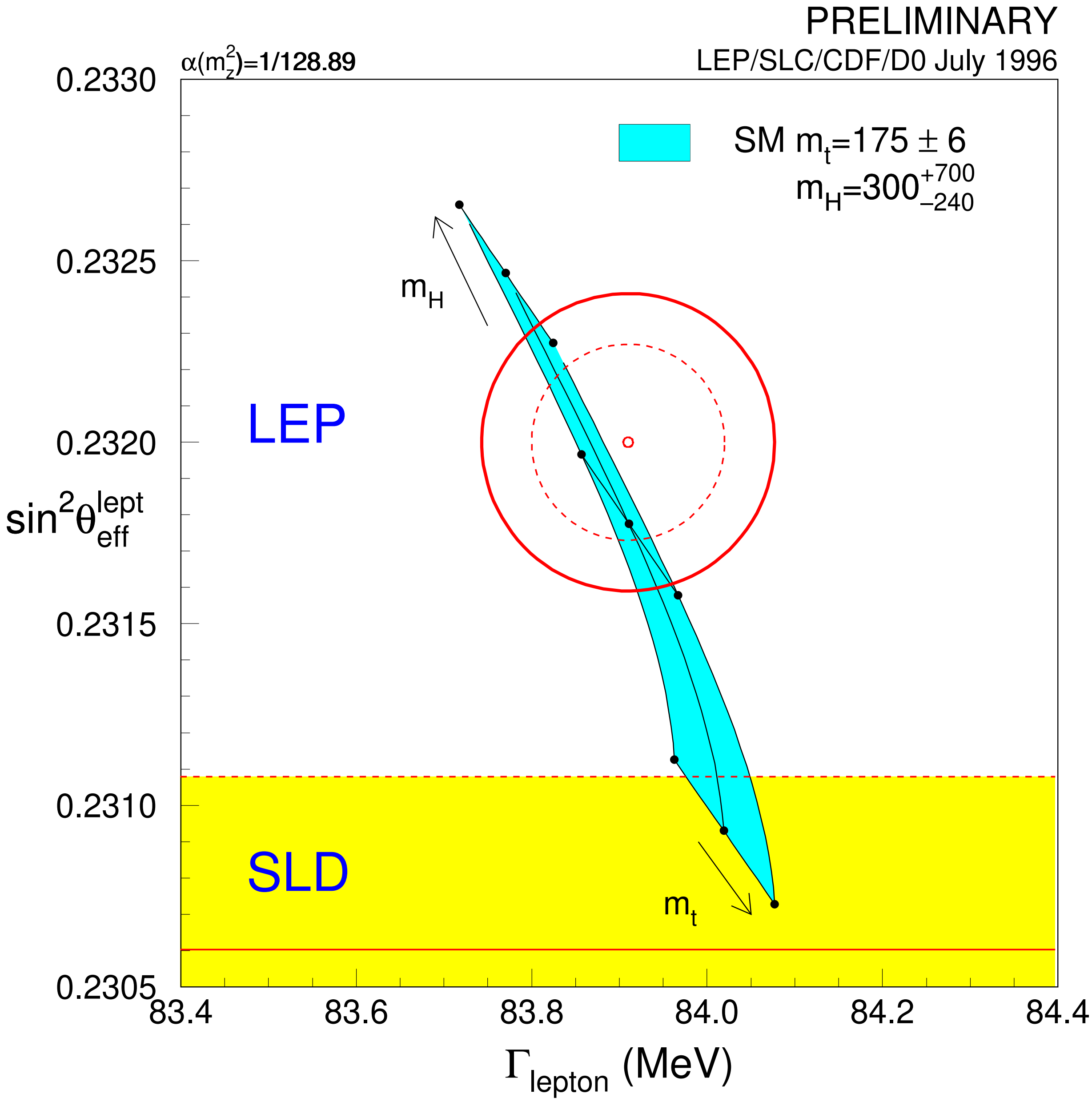
No fit yet, just asymmetries and widths:



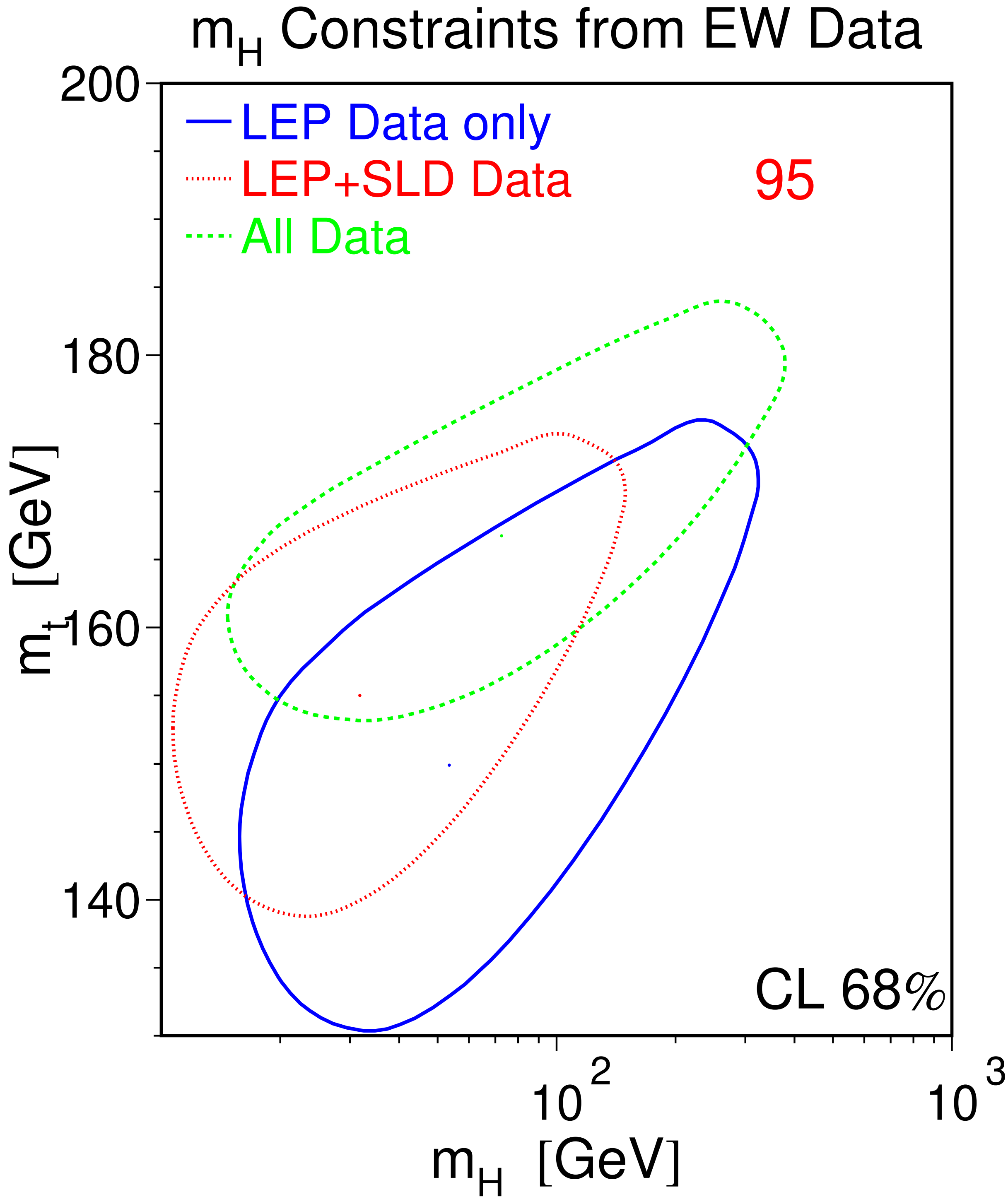
But with m_{t} it starts getting interesting!

Short aside

LEP *vs.* SLD comparison:

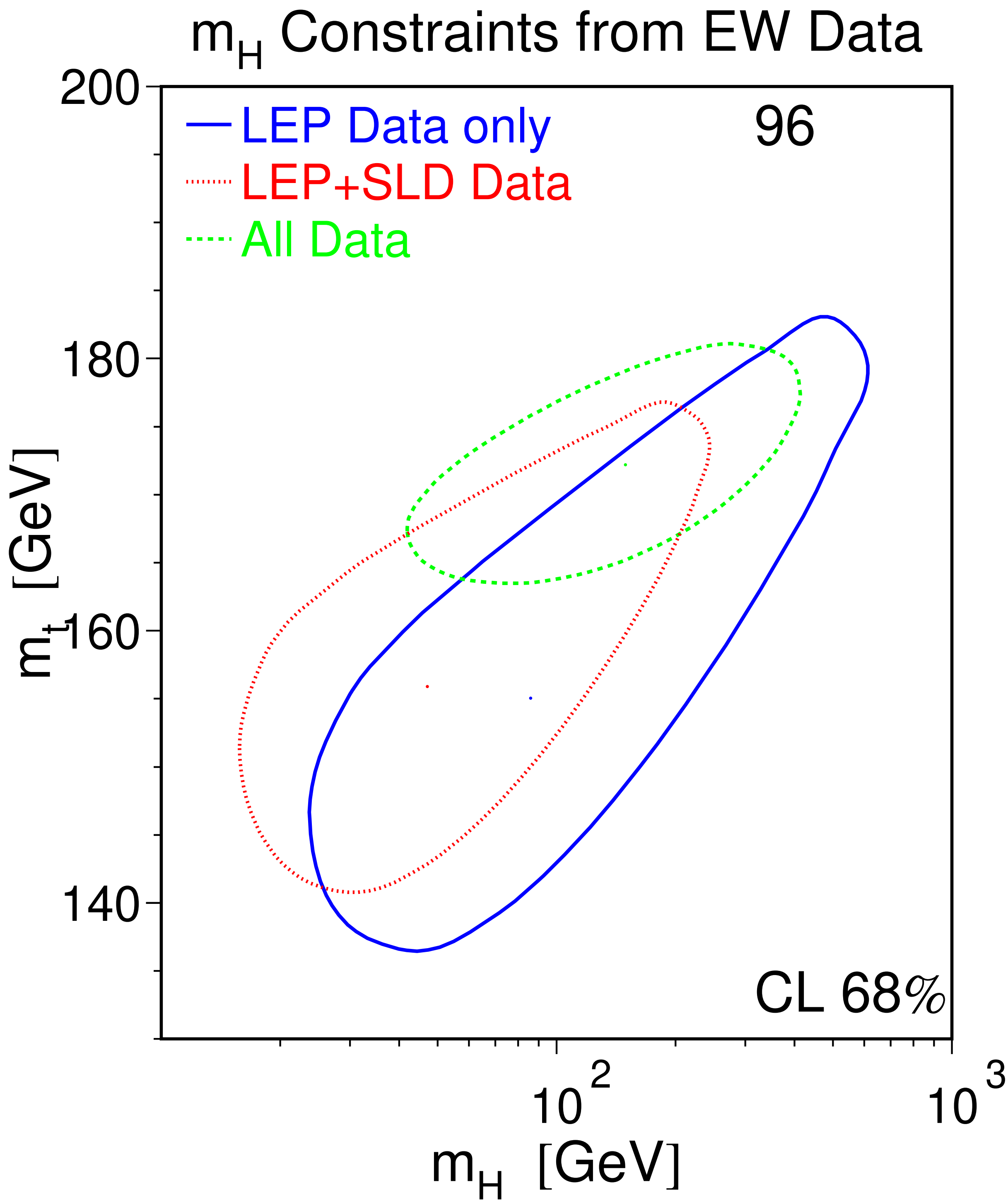


last year...


m_H Constraints from EW Data
LEP Data only
LEP+SLD Data
All Data
95
CL 68%
200
180
160
140
m_t [GeV]
10^2
10^3
m_H [GeV]

m_H *vs.* m_t

this year...



SM fit

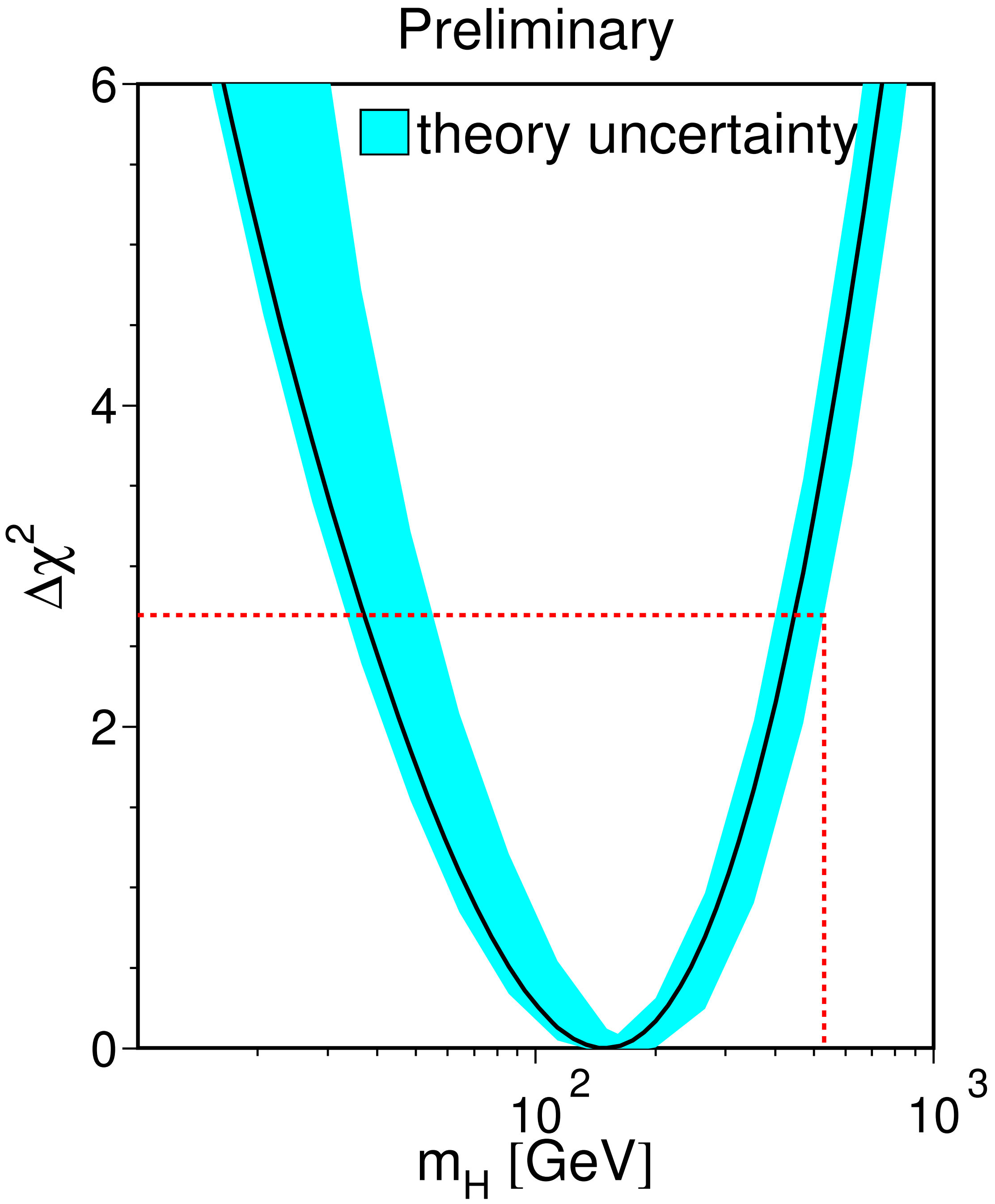
	LEP	LEP +SLD + $p\bar{p}$ and νN data + m_t
m_t [GeV]	155^{+18}_{-13}	172 ± 6
m_H [GeV]	86^{+202}_{-51}	149^{+148}_{-82}
$\alpha_s(m_Z^2)$	0.121 ± 0.003	0.120 ± 0.003
χ^2/d.o.f.	9/8	19/14

Values derived from the above:

$\sin^2\theta_{eff}^{lept}$	0.23198 ± 0.00026	0.23167 ± 0.00023
$\sin^2\theta_W$	0.2249 ± 0.0009	0.2235 ± 0.0006
m_W(GeV)	80.278 ± 0.049	80.352 ± 0.033

Comments:

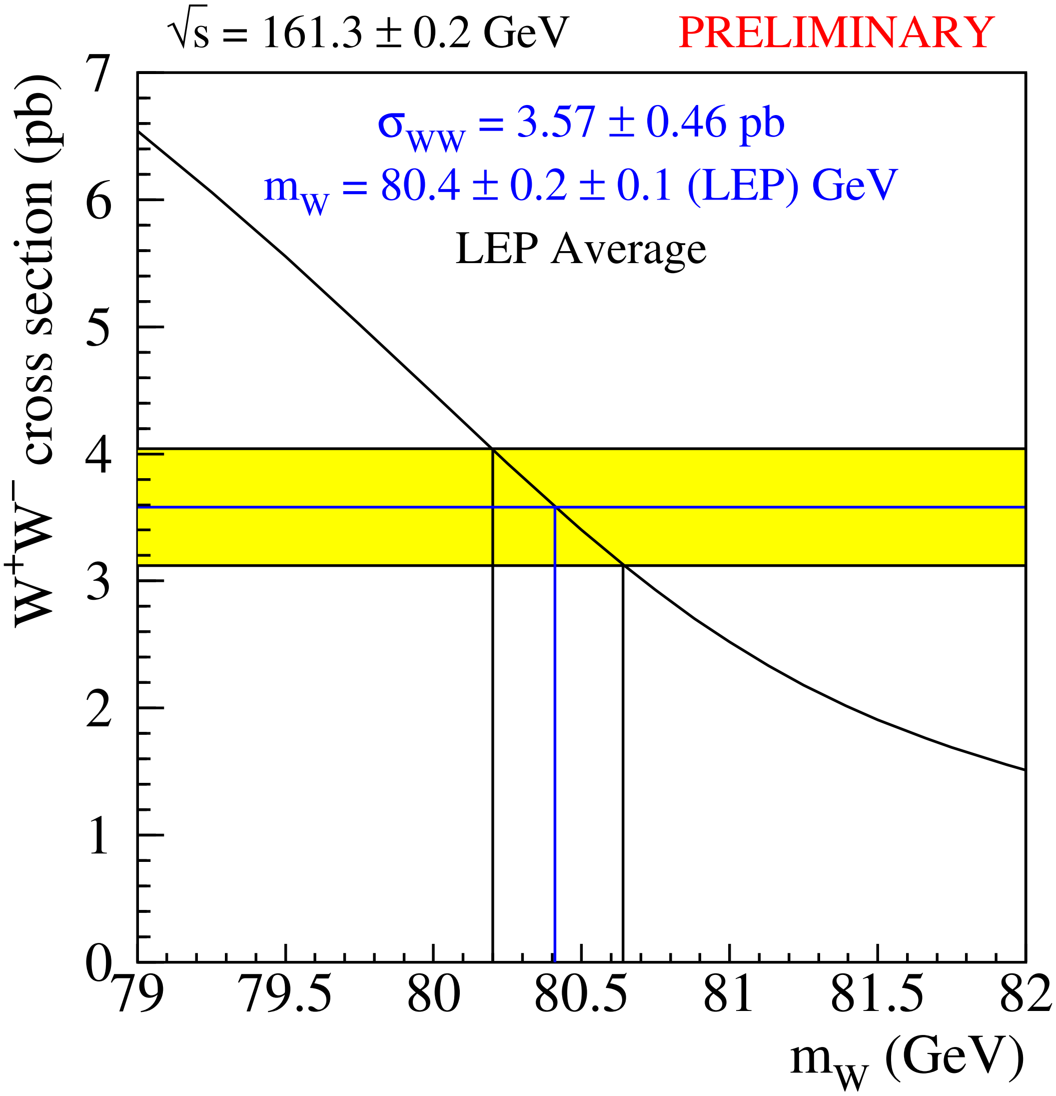
- $\alpha_s(m_Z^2)$ is as good as all other measurements together (0.118 ± 0.003)
- The error on m_W is an excellent goal for LEPII!



95% CL upper limit: 550 GeV.

m_W

At last LEPC:



Update is pending:

- **final LEP energy**
- **publication by all 4 LEP experiments**

In addition, we will soon have comparable direct reconstruction results.

Conclusions

- Last year $R_{b\bar{b}}$ and $R_{c\bar{c}}$ ruled out the SM at the 99.9% CL.
- This year they are only about 1.7σ off.

- Last year only SLD caused problems with $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$.
- This year $A_{b\bar{b}}$ is causing its share.

- Last year we started seeing hints of m_{H} sensitivity.
- This year it's looking somewhat more impressive (even with a lower $R_{b\bar{b}}\ldots$).

- We now know what error we need on m_{W} from LEPII. (And thus how much luminosity!)