BES results

and the Standard Model

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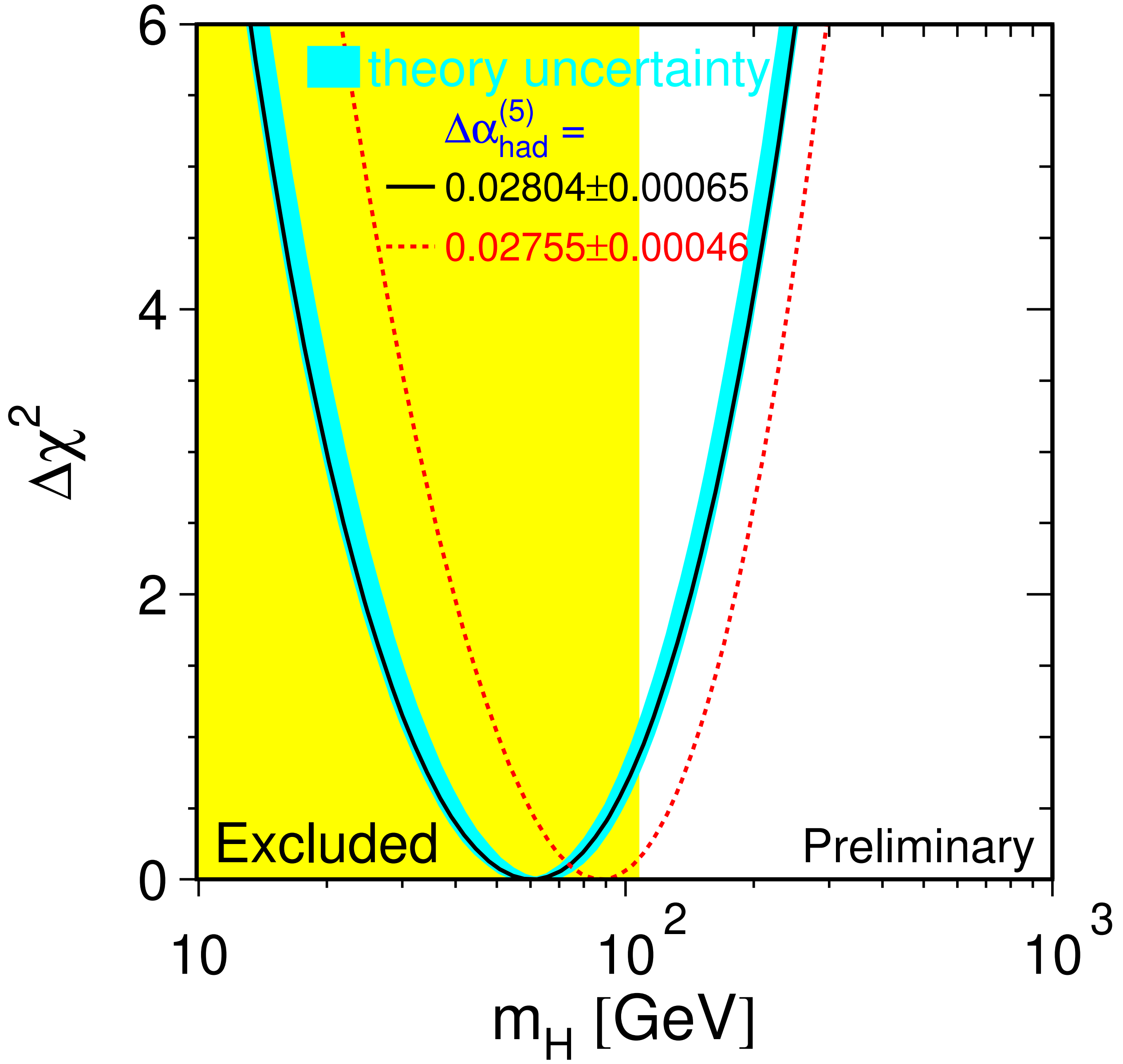
FRANCE

IHEP, Beijing, October 27, 2000

log m_H - blue band plot

summer 2000



$m_H = 60^{+52}_{-29}$ GeV

The one-sided 95%CL (90% two-sided) upper limit on m_H is
. 165 GeV

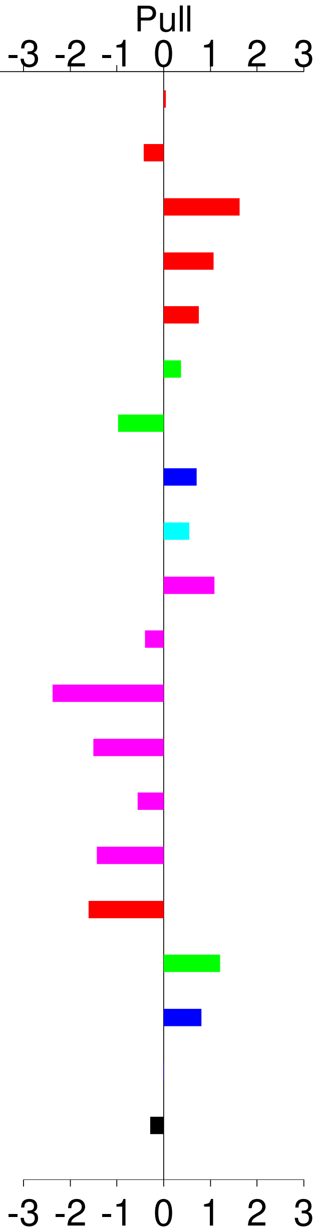
was $66.5\pm^{+60}_{-33}$ GeV in Moriond (spring 2000)

red dashed line use BES results !!!

fits of LEP EWWG: pulls

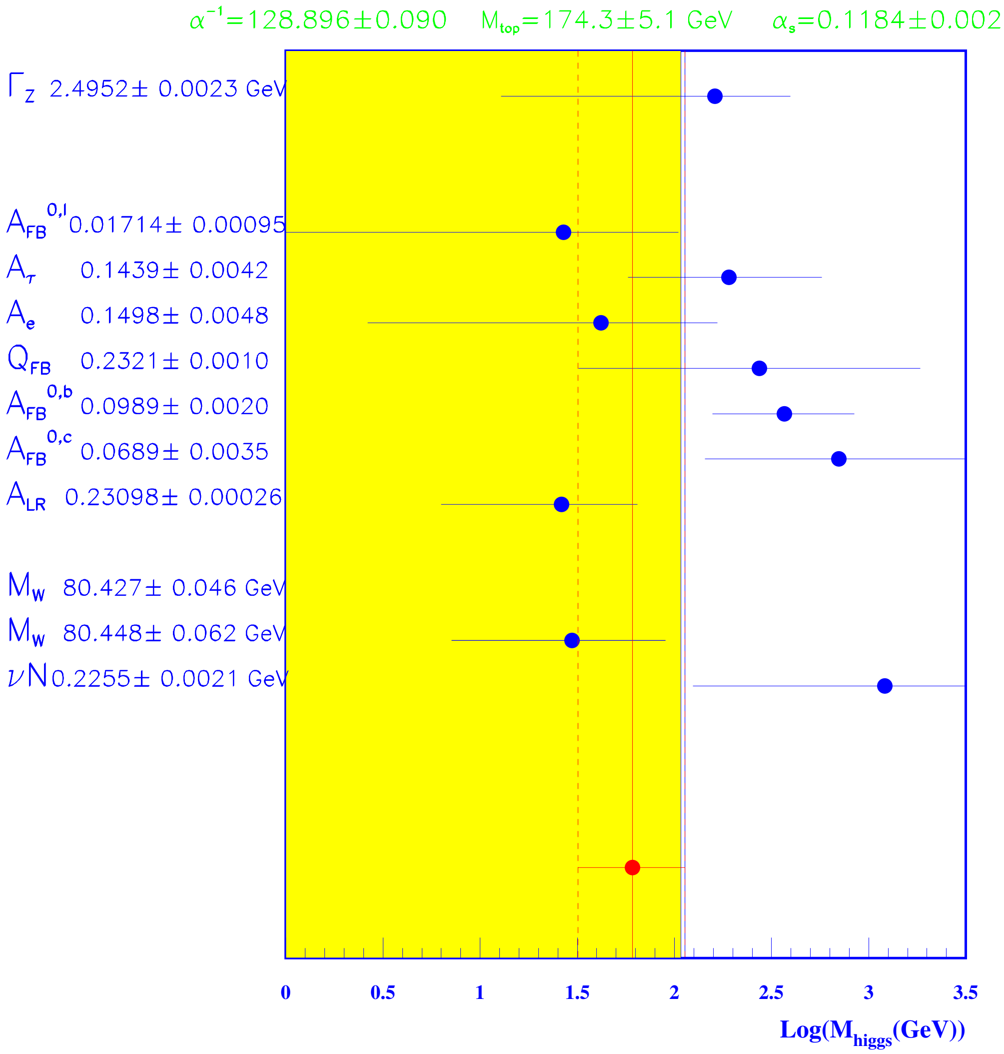
Osaka 2000

	Measurement	Pull
m_Z [GeV]	91.1875 ± 0.0021	.05
Γ_Z [GeV]	2.4952 ± 0.0023	-.42
σ^0_{hadr} [nb]	41.540 ± 0.037	1.62
R_l	20.767 ± 0.025	1.07
$A^{0,l}_{fb}$	0.01714 ± 0.00095	.75
A_e	0.1498 ± 0.0048	.38
A_τ	0.1439 ± 0.0042	-.97
$\sin^2\theta^{lept}_{eff}$	0.2321 ± 0.0010	.70
m_W [GeV]	80.427 ± 0.046	.55
R_b	0.21653 ± 0.00069	1.09
R_c	0.1709 ± 0.0034	-.40
$A^{0,b}_{fb}$	0.0990 ± 0.0020	-2.38
$A^{0,c}_{fb}$	0.0689 ± 0.0035	-1.51
A_b	0.922 ± 0.023	-.55
A_c	0.631 ± 0.026	-1.43
$\sin^2\theta^{lept}_{eff}$	0.23098 ± 0.00026	-1.61
$\sin^2\theta_W$	0.2255 ± 0.0021	1.20
m_W [GeV]	80.452 ± 0.062	.81
m_t [GeV]	174.3 ± 5.1	-.01
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02804 ± 0.00065	-.29



χ^2/d.o.f. = 21/15 12% probability

log m_H for different measurements



three measurements : $A_{FB}^{0,l}$, A_{LR} and m_W give central value of m_H of about 30 GeV

numerical results

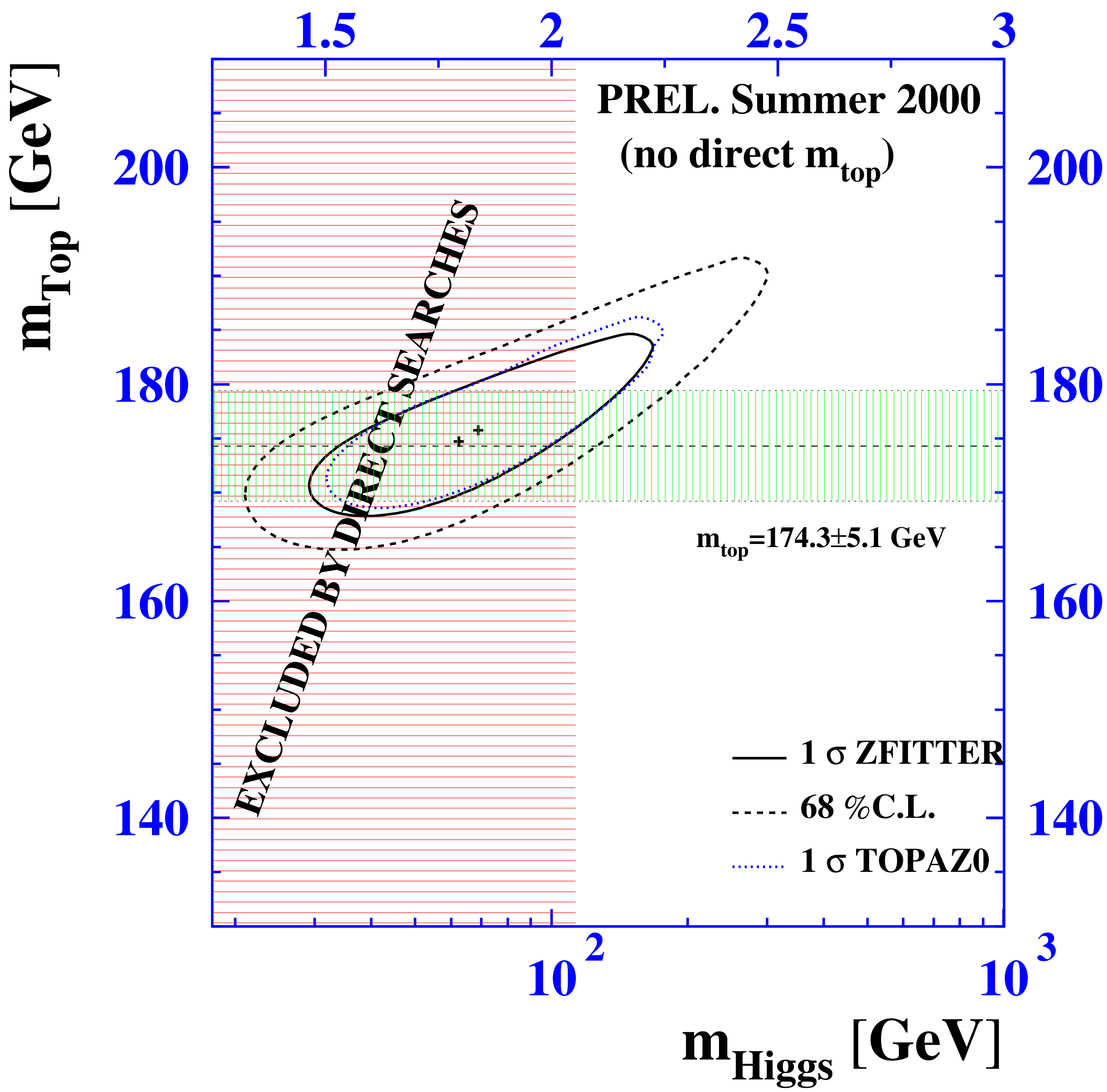
Fit results presented in Osaka 2000

	LEP including LEP-II m_{W}	all data except m_{W} and m_{t}	all data except m_{W}	all data
m_{t} [GeV]	178^{+13}_{-10}	169^{+10}_{-8}	173.2 ± 4.6	174.5 ± 4.3
m_{H} [GeV]	135^{+262}_{-83}	59^{+84}_{-29}	75^{+69}_{-37}	62^{+53}_{-30}
$\log(m_{\mathrm{H}}/\mathrm{GeV})$	$2.13^{+0.47}_{-0.41}$	$1.77^{+0.39}_{-0.29}$	$1.88^{+0.28}_{-0.30}$	$1.79^{+0.27}_{-0.28}$
$\alpha_s(m_{\mathrm{Z}}^2)$	0.120 ± 0.003	0.119 ± 0.003	0.119 ± 0.003	0.118 ± 0.003
χ^2/d.o.f.	$13/9$	$20/12$	$20/13$	$21/15$
$\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$	0.23167 ± 0.00020	0.23147 ± 0.00017	0.23147 ± 0.00017	0.23140 ± 0.00016
$1 - m_{\mathrm{W}}^2/m_{\mathrm{Z}}^2$	0.2229 ± 0.0006	0.2231 ± 0.0007	0.2229 ± 0.0005	0.2226 ± 0.0004
m_{W} [GeV]	80.383 ± 0.029	80.376 ± 0.034	80.387 ± 0.025	80.402 ± 0.020

after Osaka new Tevatron m_W and Heavy Flavour results from SLD (not available before the Conference) have been introduced to the fit input

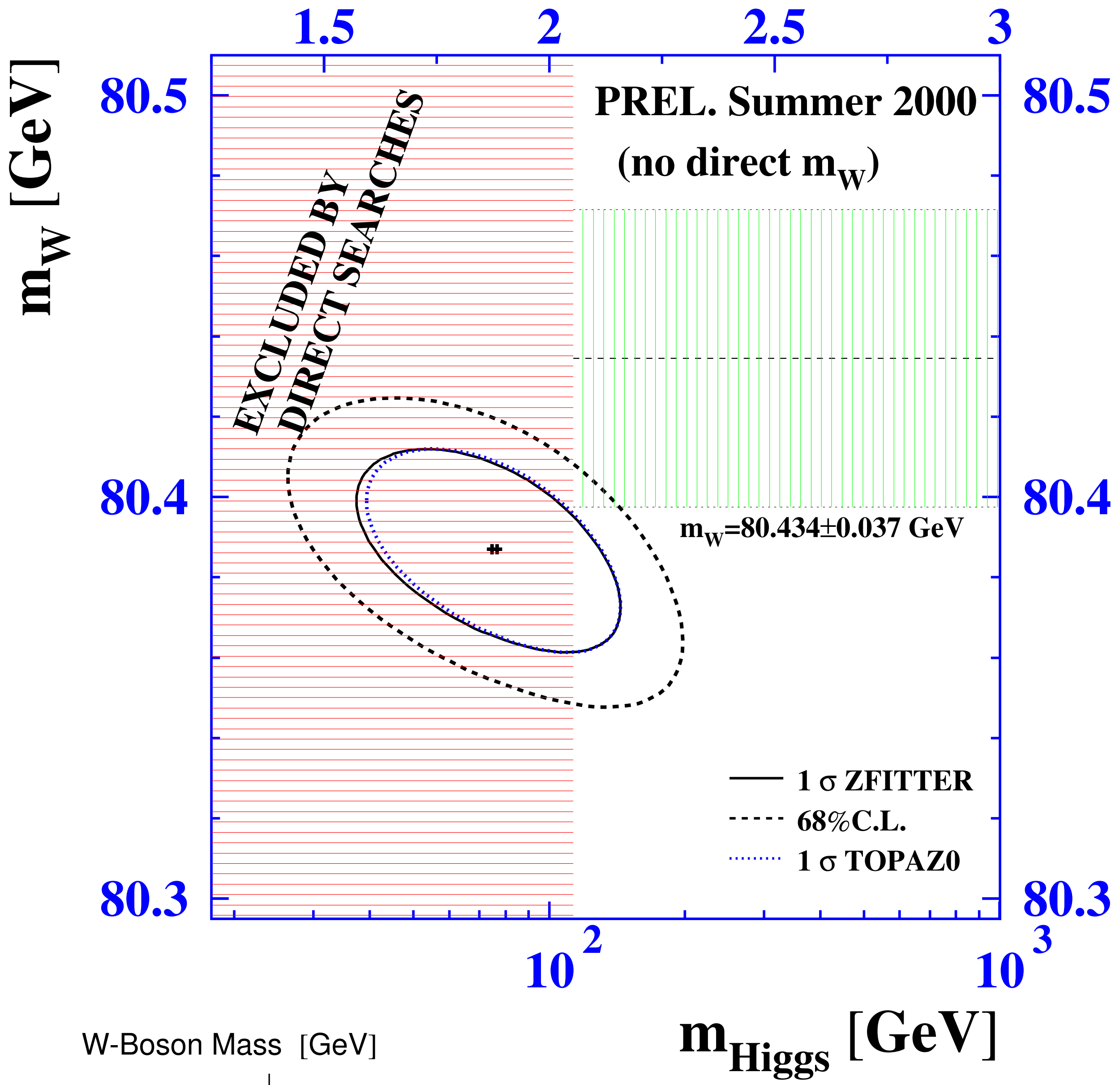
	LEP including LEP-II m_{W}	all data except m_{W} and m_{t}	all data except m_{W}	all data
m_{t} [GeV]	179^{+13}_{-10}	169^{+10}_{-8}	173.0 ± 4.6	174.3 ± 4.2
m_{H} [GeV]	135^{+262}_{-83}	56^{+75}_{-27}	74^{+68}_{-37}	60^{+52}_{-29}
$\log(m_{\mathrm{H}}/\mathrm{GeV})$	$2.13^{+0.47}_{-0.41}$	$1.75^{+0.37}_{-0.29}$	$1.87^{+0.28}_{-0.30}$	$1.78^{+0.27}_{-0.28}$
$\alpha_s(m_{\mathrm{Z}}^2)$	0.120 ± 0.003	0.119 ± 0.003	0.119 ± 0.003	0.118 ± 0.003
χ^2/d.o.f.	$13/9$	$19/12$	$20/13$	$21/15$
$\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$	0.23167 ± 0.00020	0.23147 ± 0.00017	0.23147 ± 0.00017	0.23140 ± 0.00016
$1 - m_{\mathrm{W}}^2/m_{\mathrm{Z}}^2$	0.2229 ± 0.0006	0.2231 ± 0.0007	0.2229 ± 0.0005	0.2226 ± 0.0004
m_{W} [GeV]	80.383 ± 0.029	80.374 ± 0.034	80.386 ± 0.025	80.402 ± 0.020

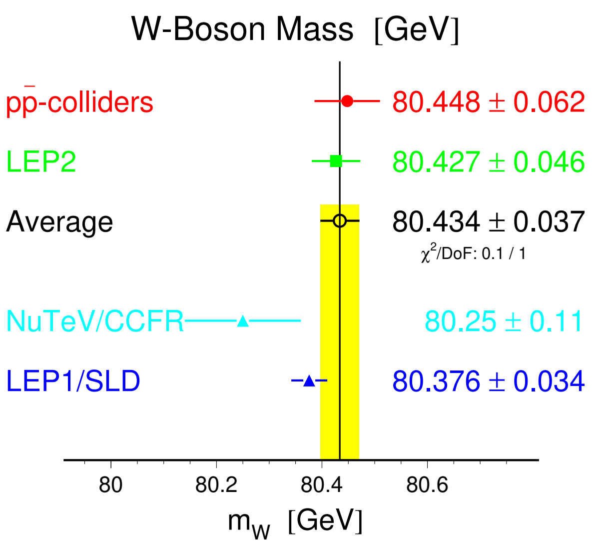
using $\Delta\alpha_{had}^{(5)}(s)$ 0.02755 ± 0.00046
(obtained using BES results) :
$m_{\mathrm{t}} = 174.6 \pm 4.4$, $m_{\mathrm{H}} = 88\ ^{+60}_{-37}$



PREL. Summer 2000
(no direct m_top)
m_Top [GeV]
m_Higgs [GeV]
EXCLUDED BY DIRECT SEARCHES
m_top=174.3±5.1 GeV
1 σ ZFITTER
68 %C.L.
1 σ TOPAZ0
1.5
2
2.5
3
200
180
160
140
10 2
10 3

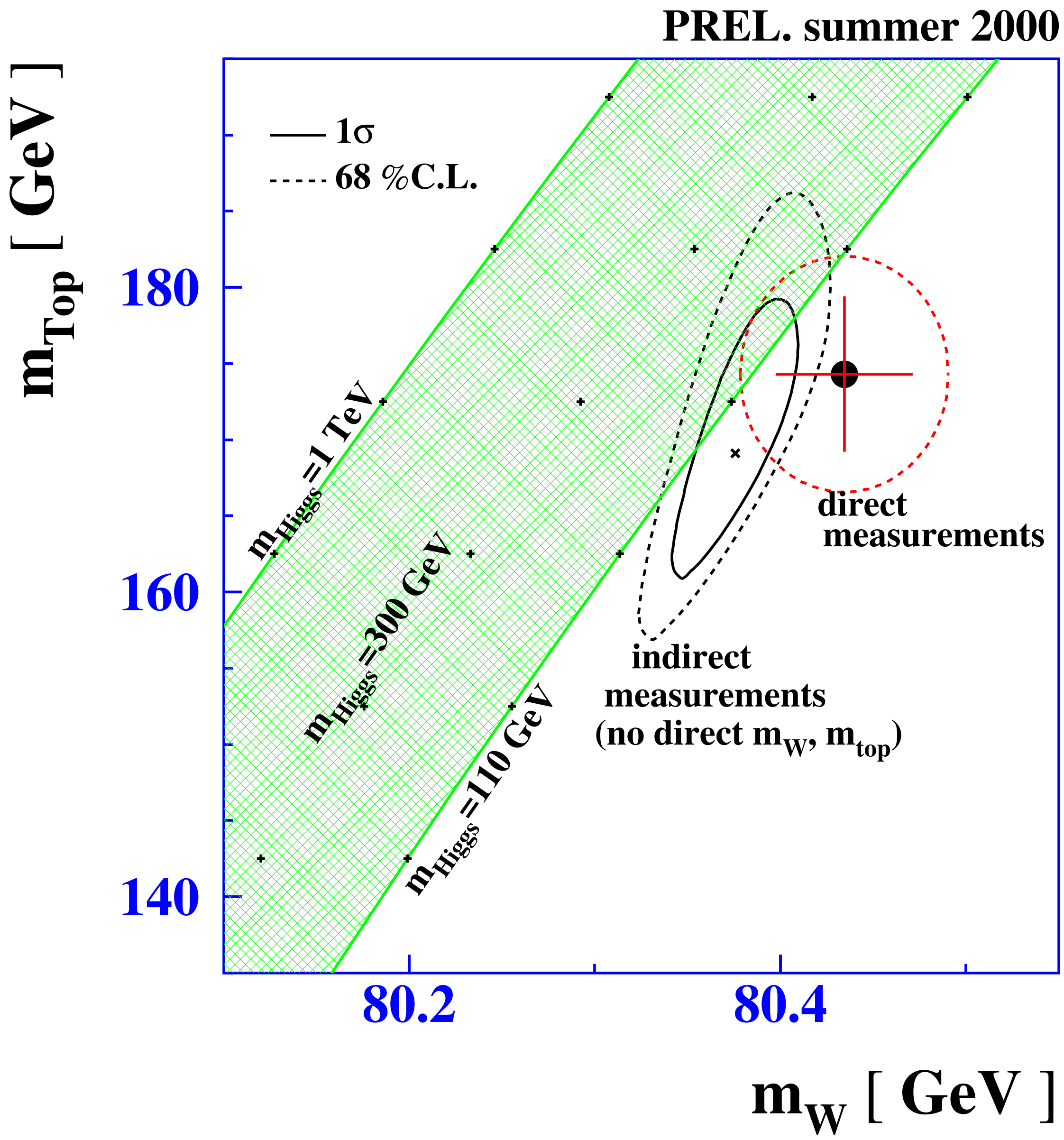
m_W vs m_H

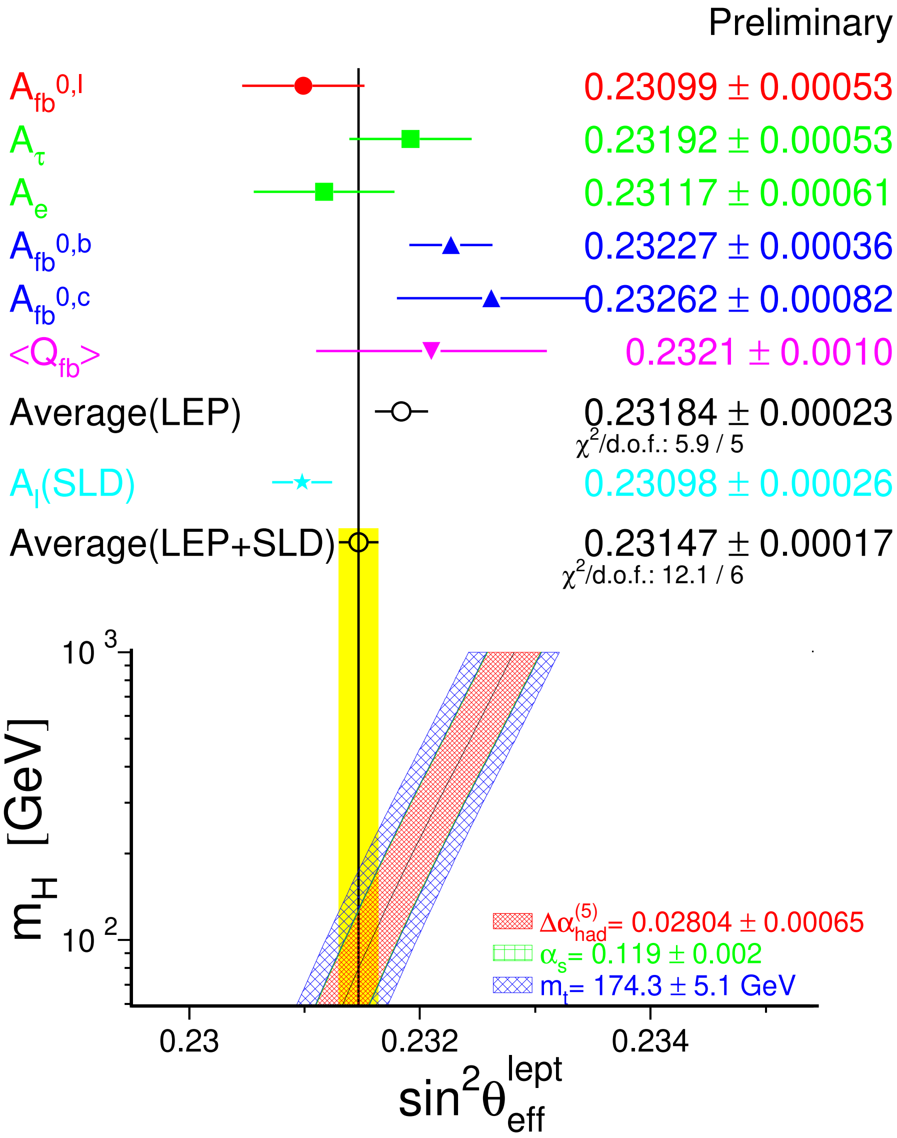

1.5
2
2.5
3
80.5
80.4
80.3
m_W [GeV]
PREL. Summer 2000
(no direct m_W)
EXCLUDED BY DIRECT SEARCHES
m_W=80.434±0.037 GeV
1 σ ZFITTER
68%C.L.
1 σ TOPAZ0
10^2
10^3
m_{Higgs} [GeV]


W-Boson Mass [GeV]
$p\bar{p}$-colliders 80.448 ± 0.062
LEP2 80.427 ± 0.046
Average 80.434 ± 0.037
χ^2/DoF: 0.1 / 1
NuTeV/CCFR 80.25 ± 0.11
LEP1/SLD 80.376 ± 0.034
80
80.2
80.4
80.6
m_W [GeV]

m_W vs m_t

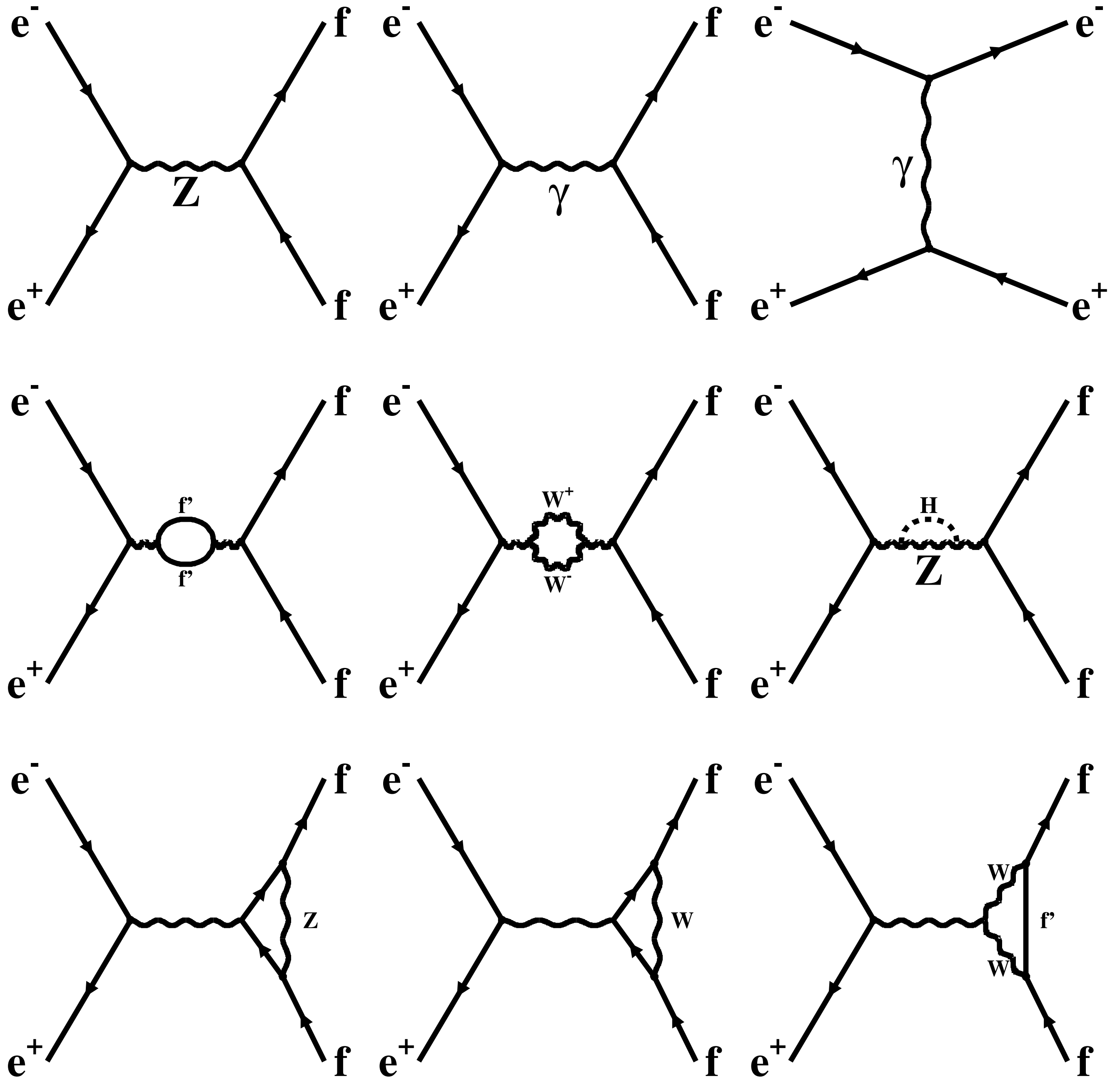
no m_t, no m_W in the fit input



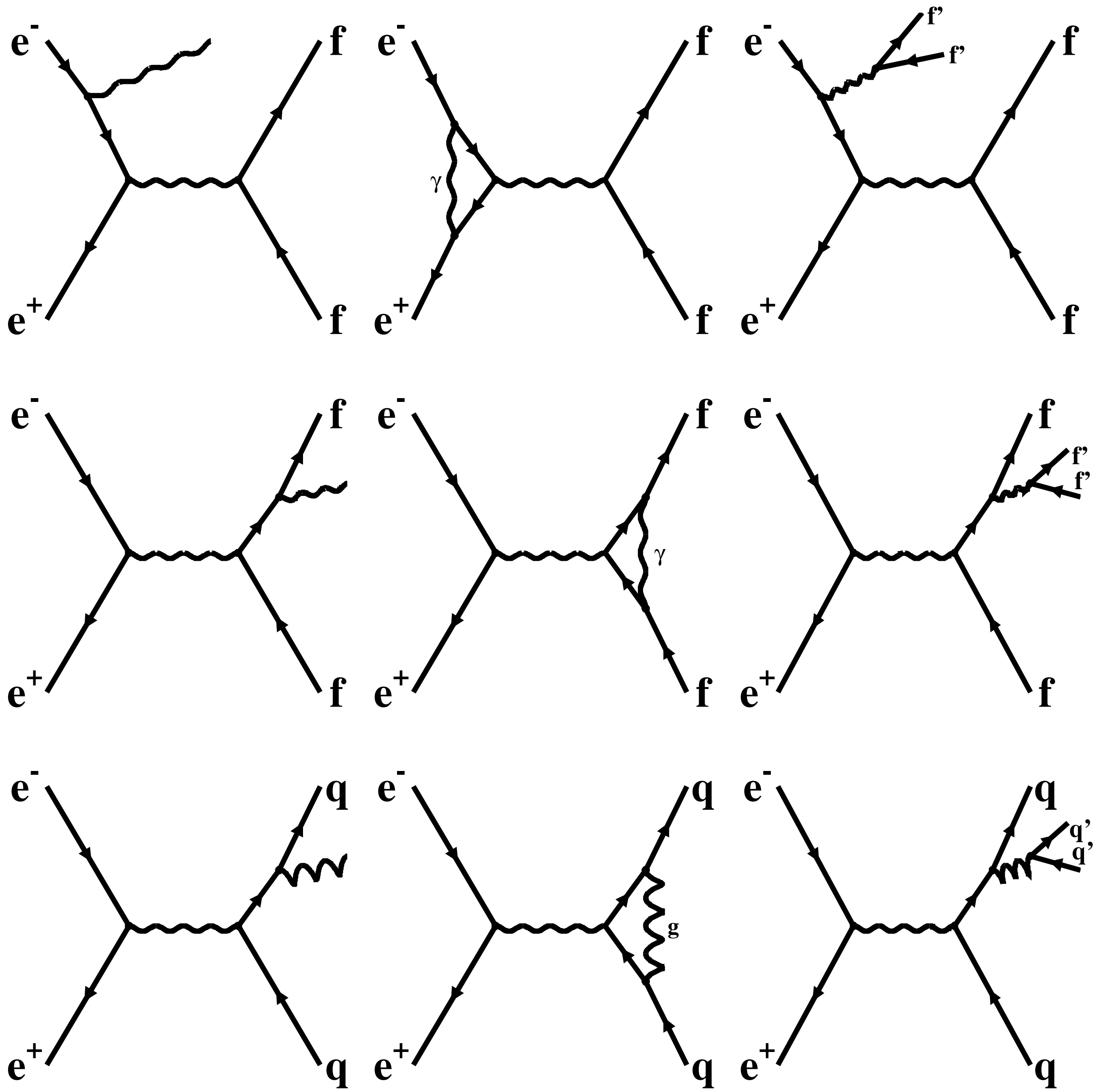


2.9σ between
A_{lr}(SLD) and $A_{fb}^{0,b}$(LEP)

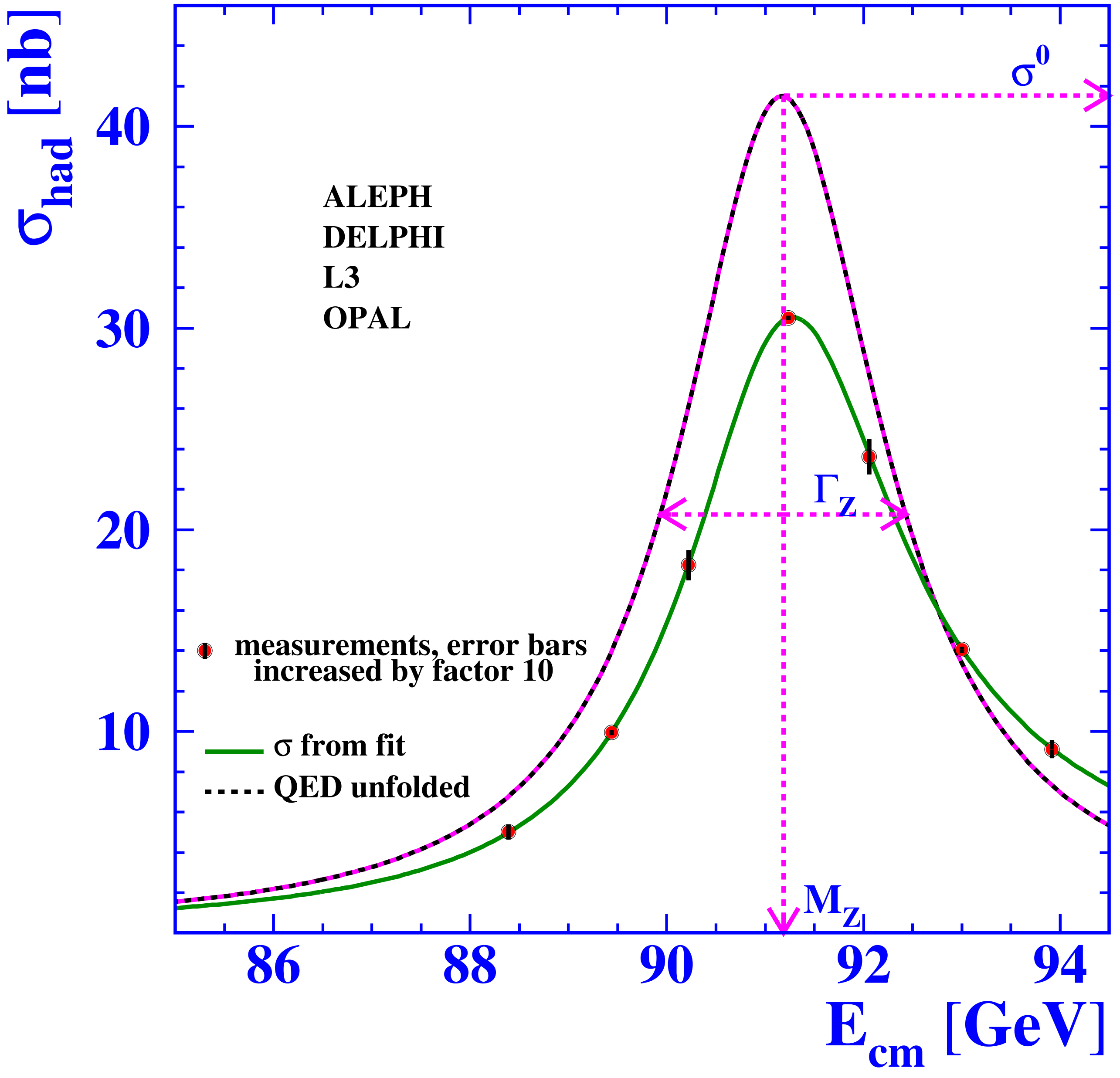
Radiative corrections



Radiative corrections

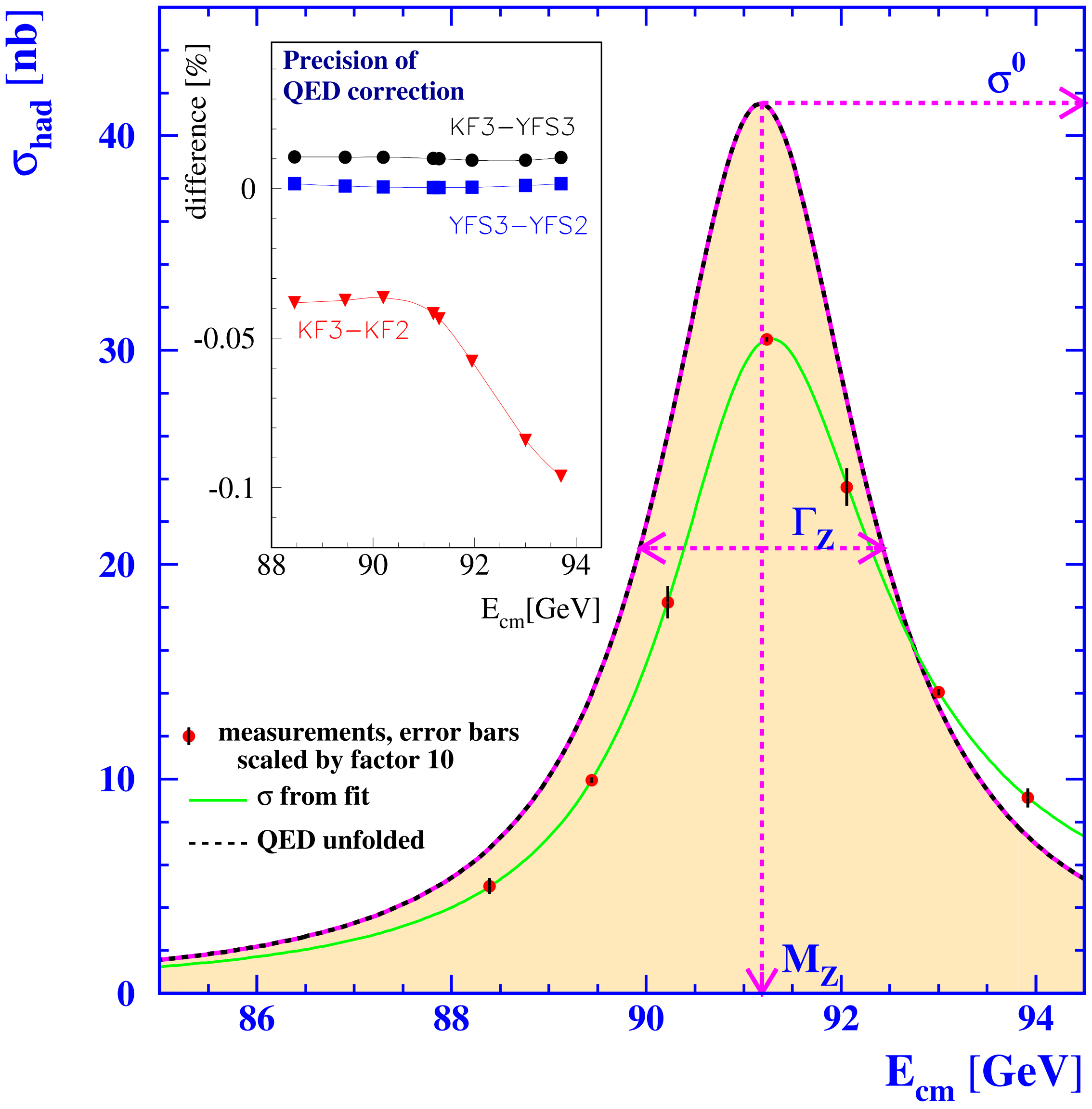


Z lineshape



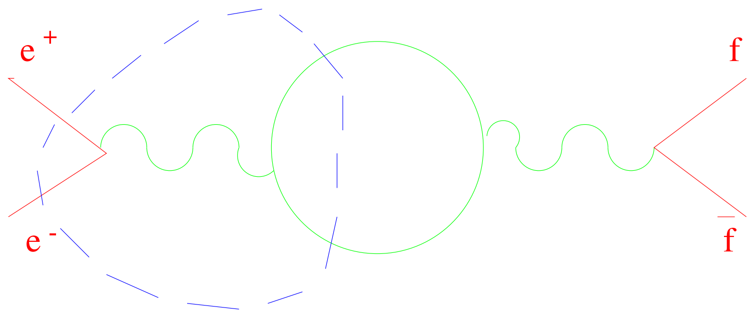
σ_{had} [nb]
40
30
20
10
σ^0
ALEPH
DELPHI
L3
OPAL
Γ_Z
measurements, error bars increased by factor 10
σ from fit
QED unfolded
M_Z
86
88
90
92
94
E_{cm} [GeV]

Z lineshape - ISR precision



Effective couplings

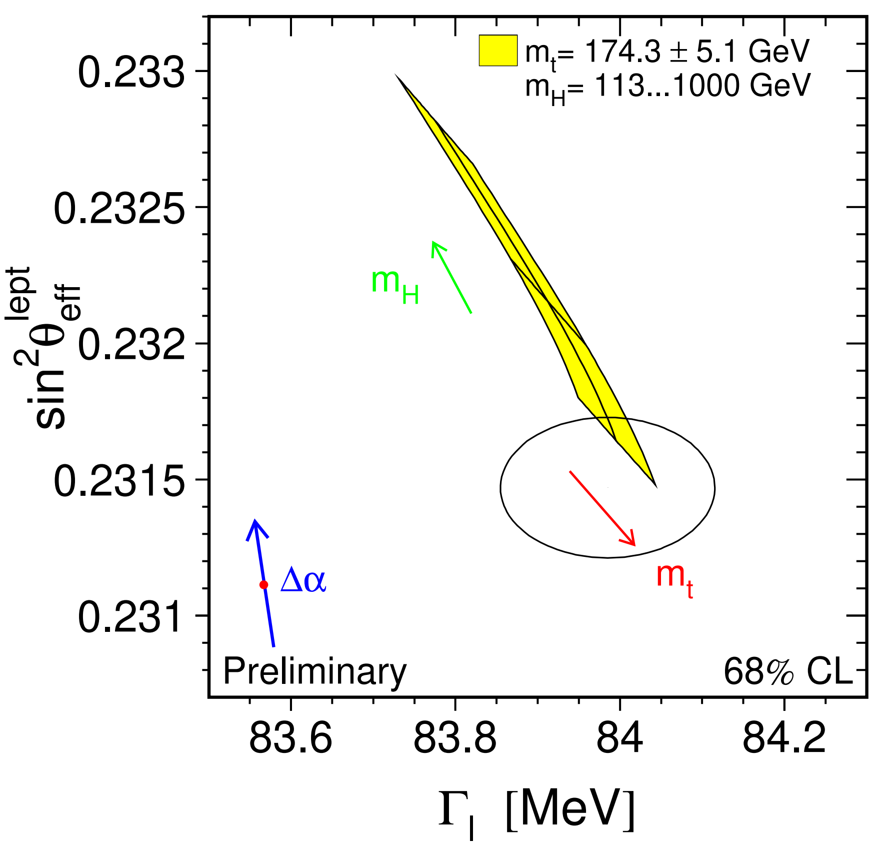
$$\sin^2\theta^{lept}_{eff} \equiv \frac{1}{4}(1 - \frac{g_{Vl}}{g_{Al}})$$



$\uparrow$ effective couplings

- include propagator corrections m$_t$, m$_H$, ... new physics (?)
- include vertex corrections

EW radiative corrections

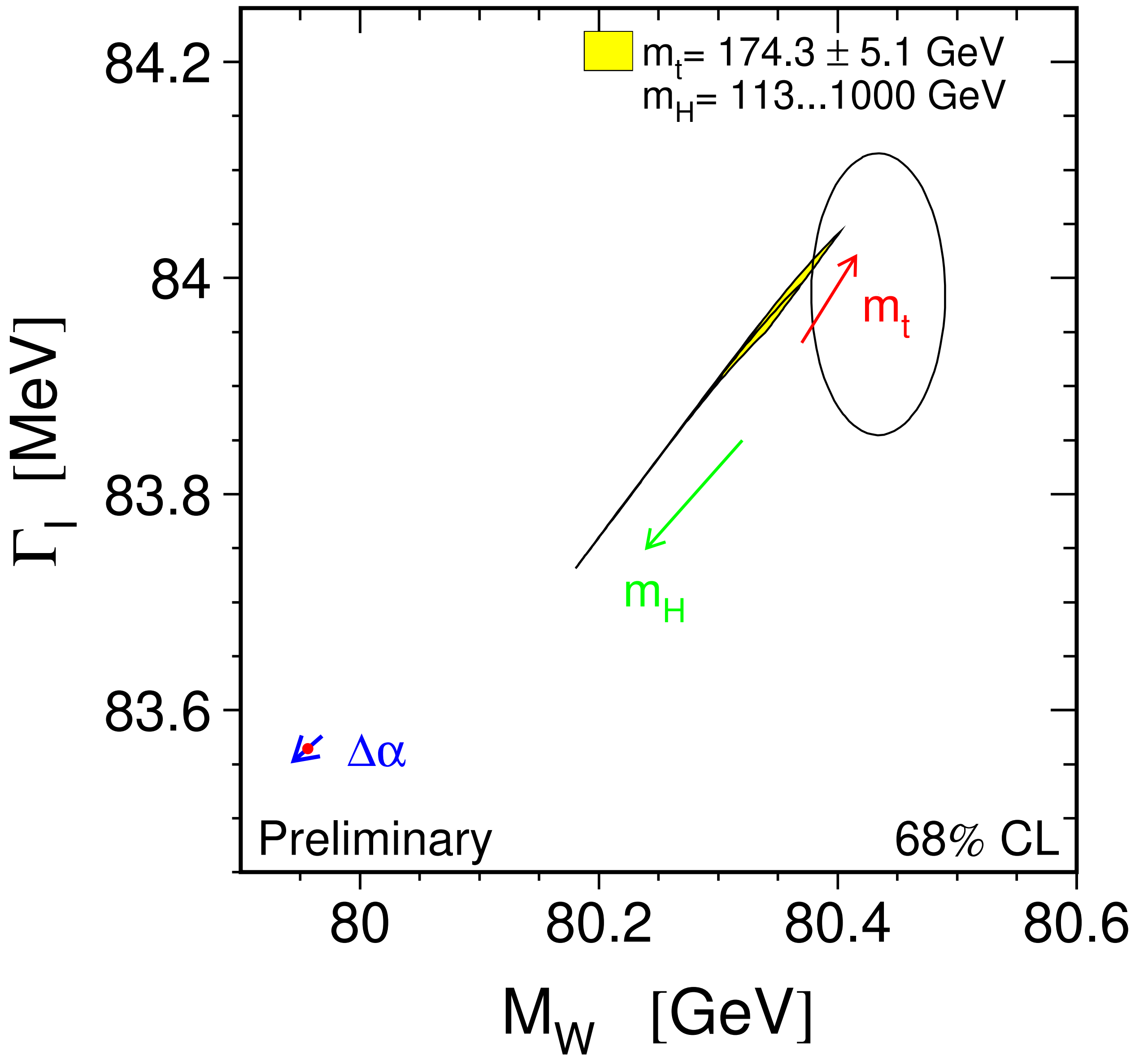


L. Okun, summary talk of the Marseille (1993) conference:

...before July 93...no genuinely electroweak radiative corrections have been observed experimentally. The electroweak radiative corrections turned out to be unexpectedly small. ... a consequence of the cancelation of two large contributions .... heavy top-quark loops, the other from all other particles.

$$\alpha_{QED}(m_Z^2) = \frac{1}{128} \qquad \frac{\alpha_W}{\pi} = \frac{\alpha(m_Z^2)}{\pi sin^2\Theta} \sim 1\% \qquad \frac{\alpha_Z}{\pi} = \frac{\alpha(m_Z^2)}{\pi sin^2\Theta cos^2\Theta} \sim 1.3\%$$

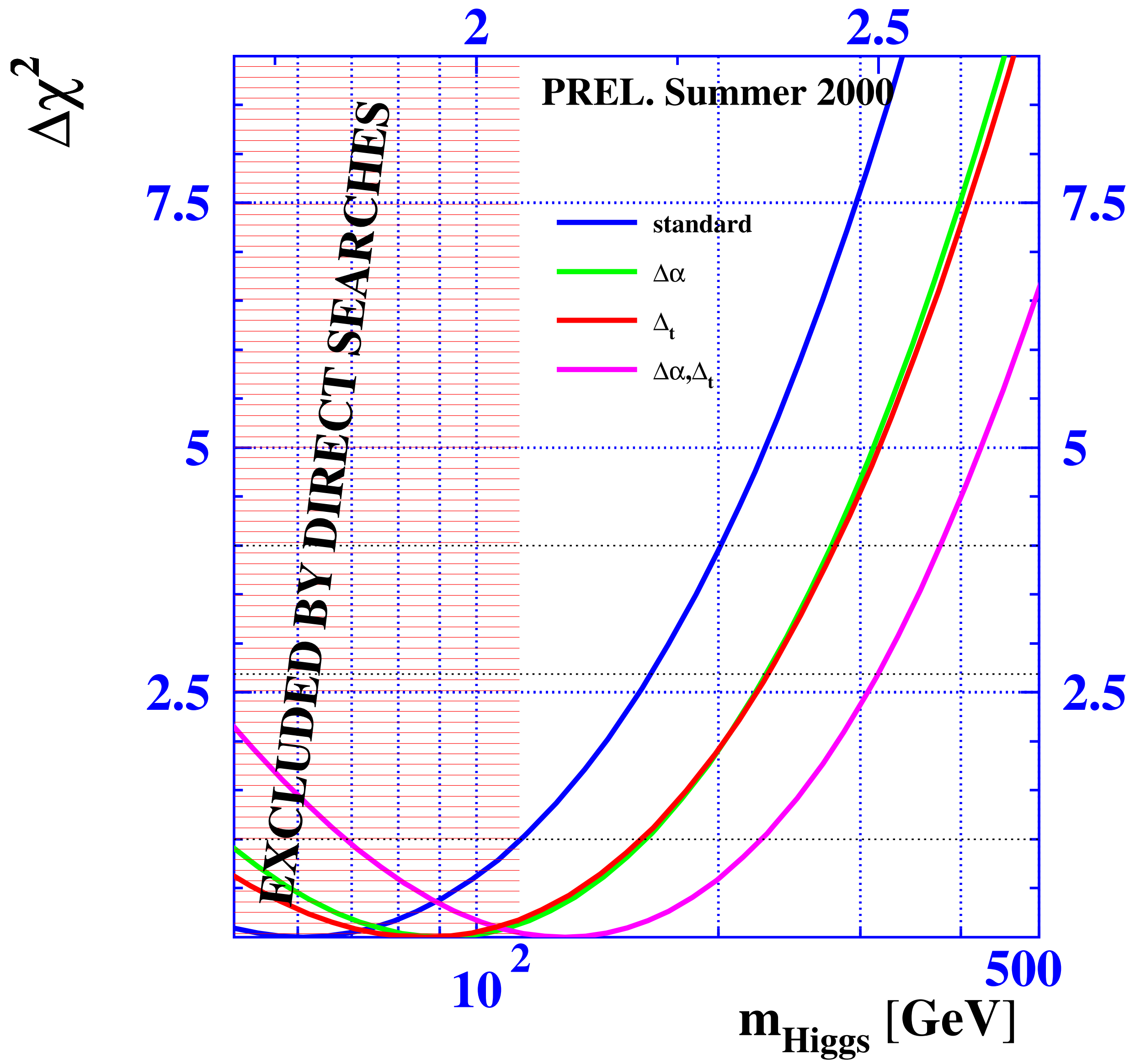
experimental precision $\sim$ 10 times better.



$$\Delta r = \Delta\alpha + \Delta r_w(m_t, m_H, \ldots.)$$

Sensitivity to $\Delta\alpha$ and Δ m$_t$

repeat the fit by changing the input value of
α^{-1} by 0.09 (1σ)
m$_t$ by 5.1 GeV (1σ)
both



Variation of Standard Model predictions

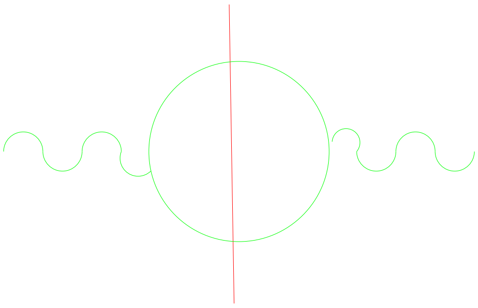
$$\alpha_{QED}^{-1}(m_Z^2) = 128.89 \pm 0.09$$
$$m_t = 174.3 \pm 5.1 \text{ GeV}$$

	value	Δ_{ex}	$\Delta\alpha$	Δm_t
$\Gamma_{\ell\ell}$(MeV)	83.96	0.09	0.0011	0.047
$\sin^2\theta_{eff}^{lept}*10^4$	2315.1	1.7	2.5	1.6
m_W(MeV)	80419	38	12	31.3

Variation of Standard Model prediction of value of different observables related to the error $\Delta\alpha$ of $\alpha_{QED}^{-1}(m_Z^2)$ and Δm_t of m_t compared to the experimental error.

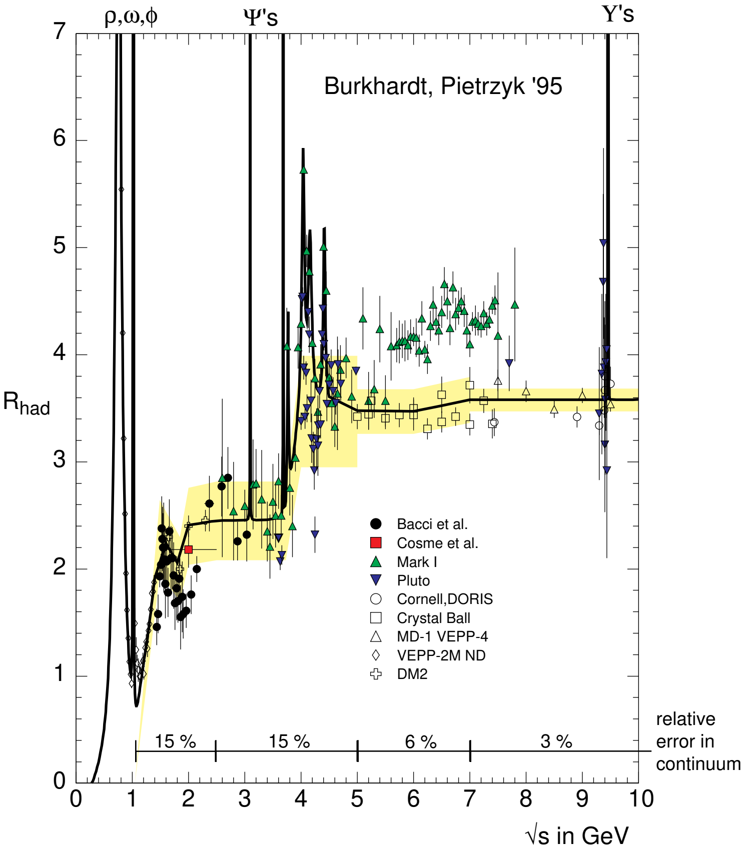
$$\Delta r = \Delta\alpha + \Delta_{weak}(m_t, m_H)$$

$$\alpha(s) = \frac{\alpha(0)}{1 - \Delta\alpha_l(s) - \Delta\alpha^{(5)}_{had}(s) - \Delta\alpha_{top}(s)}$$



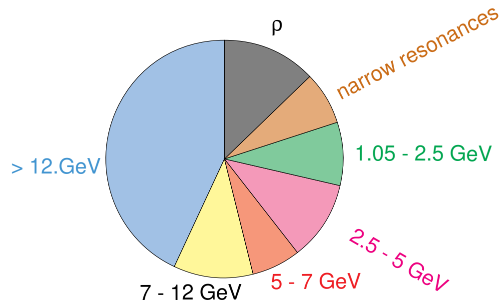
$$\text{Re}\,\Pi_{\gamma\gamma}(s) = \frac{\alpha\ s}{3\pi}\ \ P\int_{4m_\pi^2}^{\infty} \frac{R_{had}(s')}{s'(s'-s)} ds'$$

$\Delta\alpha^{(5)}_{had}(s)$ was evaluated (using exp. data) by
S. Eidelmann and F. Jegerleher, Z. Phys. C67(1995)419
H. Burkhardt and B. Pietrzyk, Phys. Lett. B356(1995)398

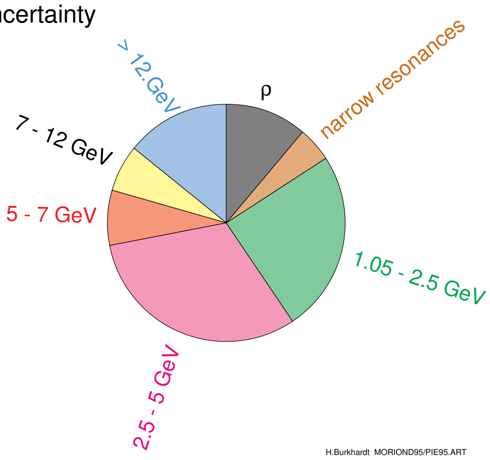


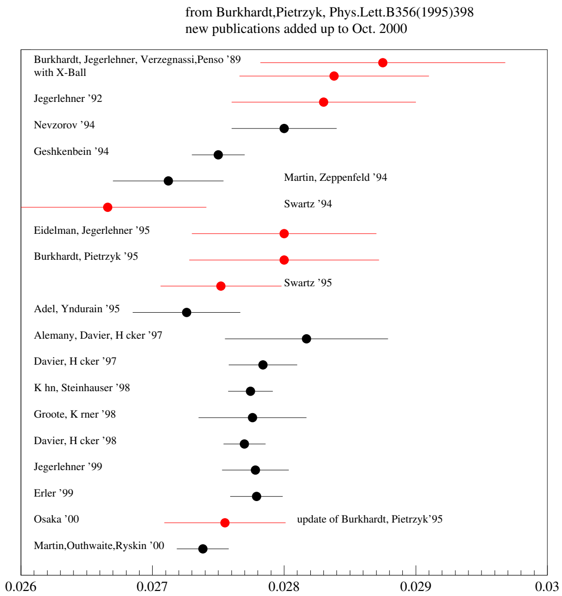
Burkhardt, Pietrzyk '95

relative contributions to $\Delta\alpha_{had}(M_Z)$



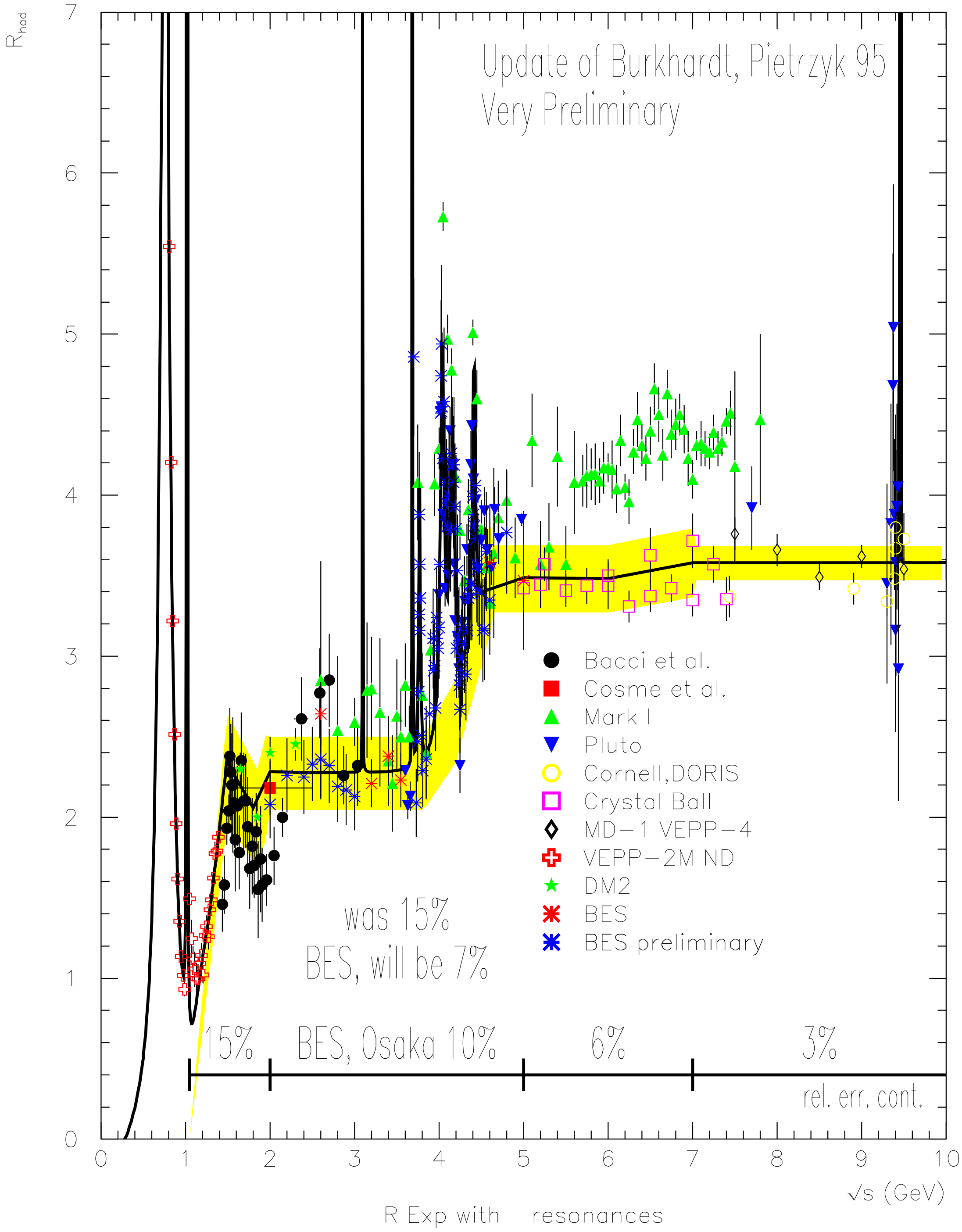
in uncertainty





... and now BES results come

α_{QED} with new BES measurements



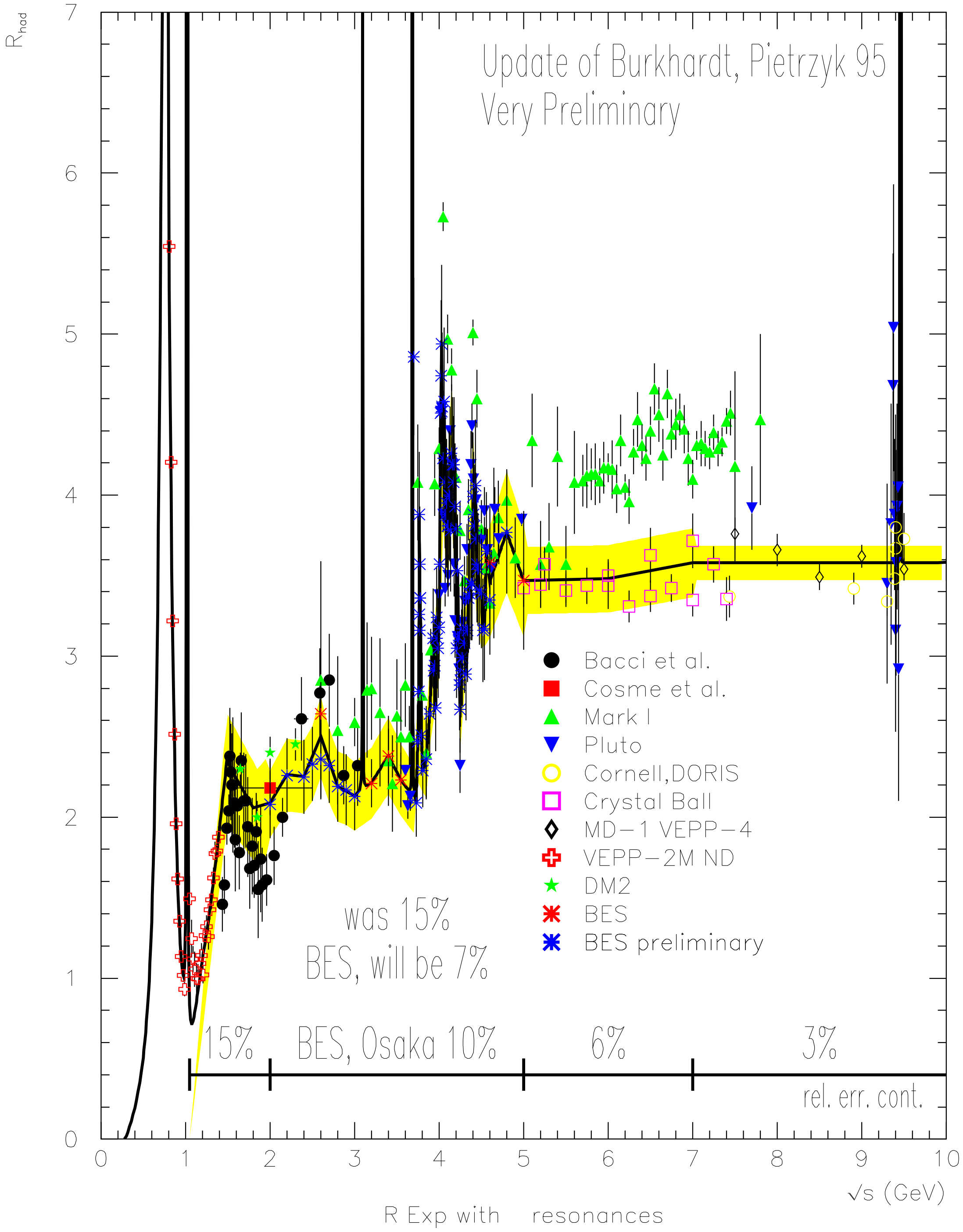
$$\Delta\alpha^{(5)}_{had}(s) = 0.02755 \pm 0.00046 \leftarrow \text{very preliminary}$$

was 0.0280 ± 0.0007, central value changed by 0.7σ

$\rightarrow \alpha^{-1} = 128.945 \pm 0.060$

α^{-1} does not contain top contirubution (as needed for SM fit programs)

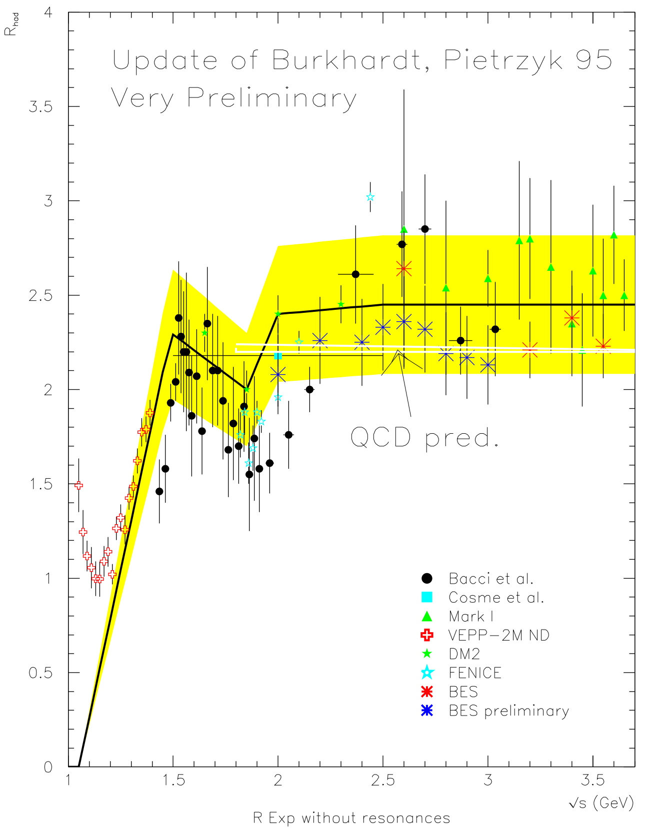
α_{QED} with new BES measurements - integral



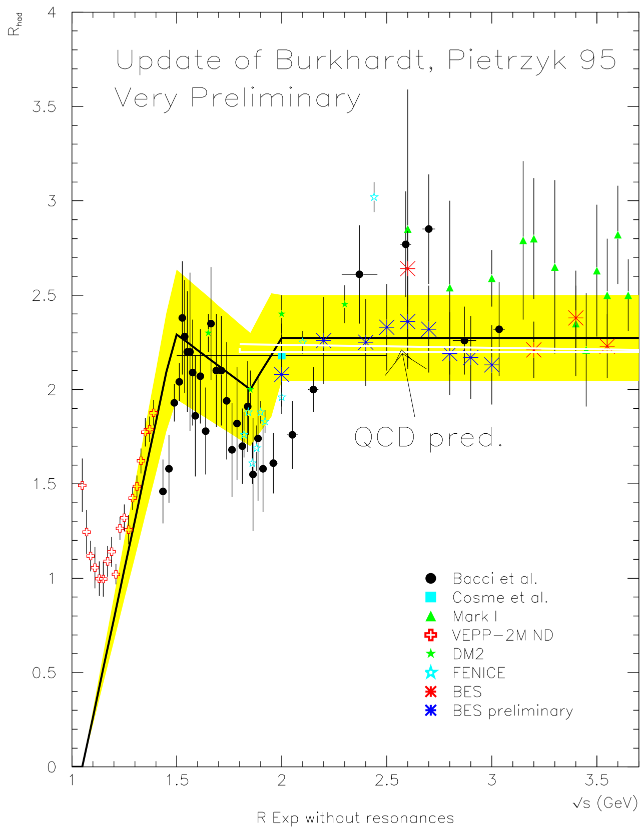
$\Delta\alpha^{(5)}_{had}(s)$ practicly did not changed

α_{QED} - comparison of 95 and Osaka analysis
low energy region

95 analysis

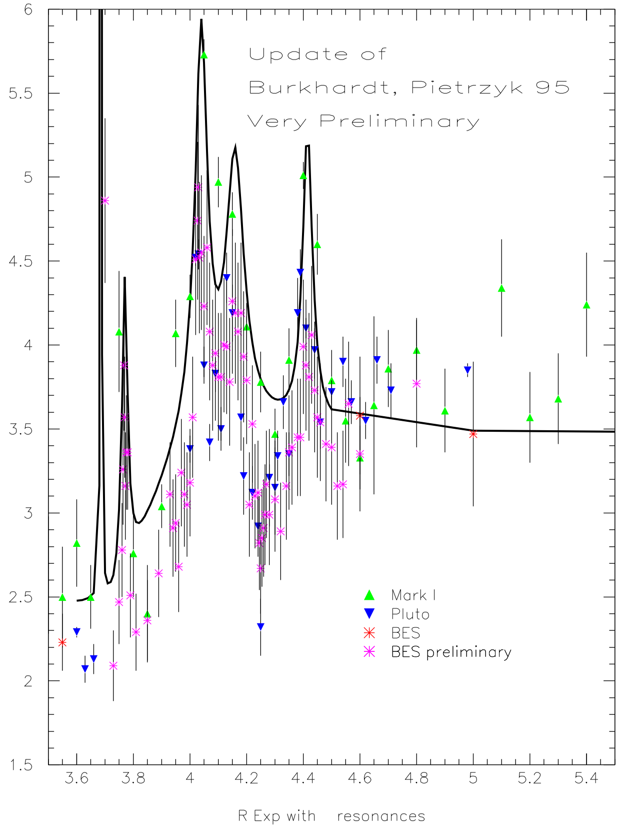


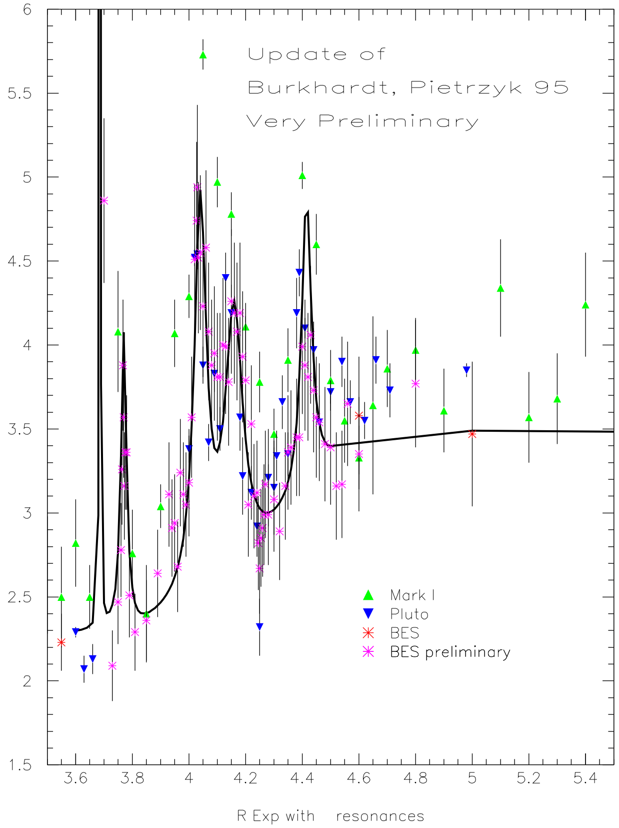
Osaka analysis



α_{QED} - comparison of 95 and Osaka analysis
charmonium region

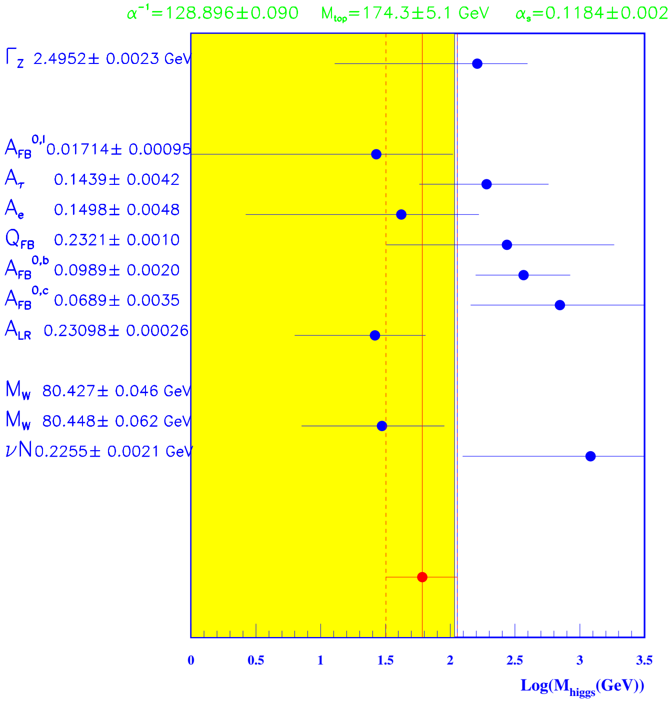
95 analysis | **Osaka analysis**



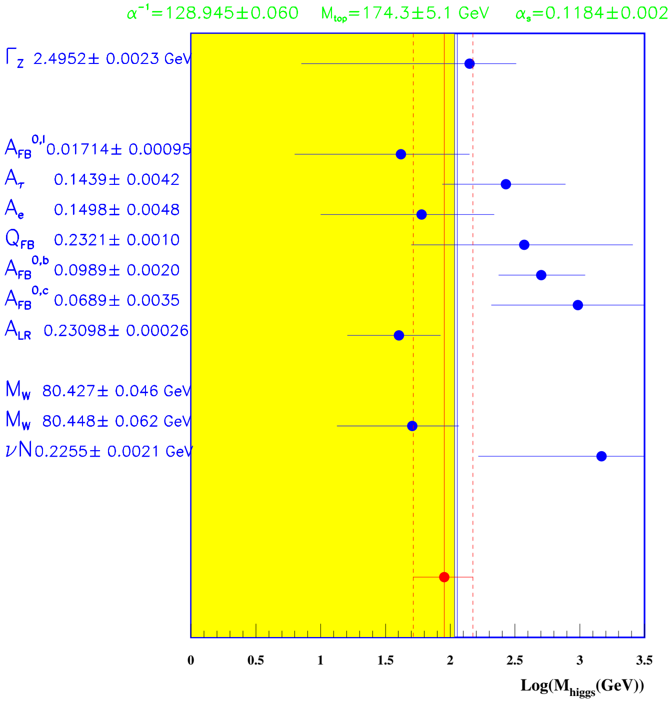


comparison log m$_H$ fits

before BES

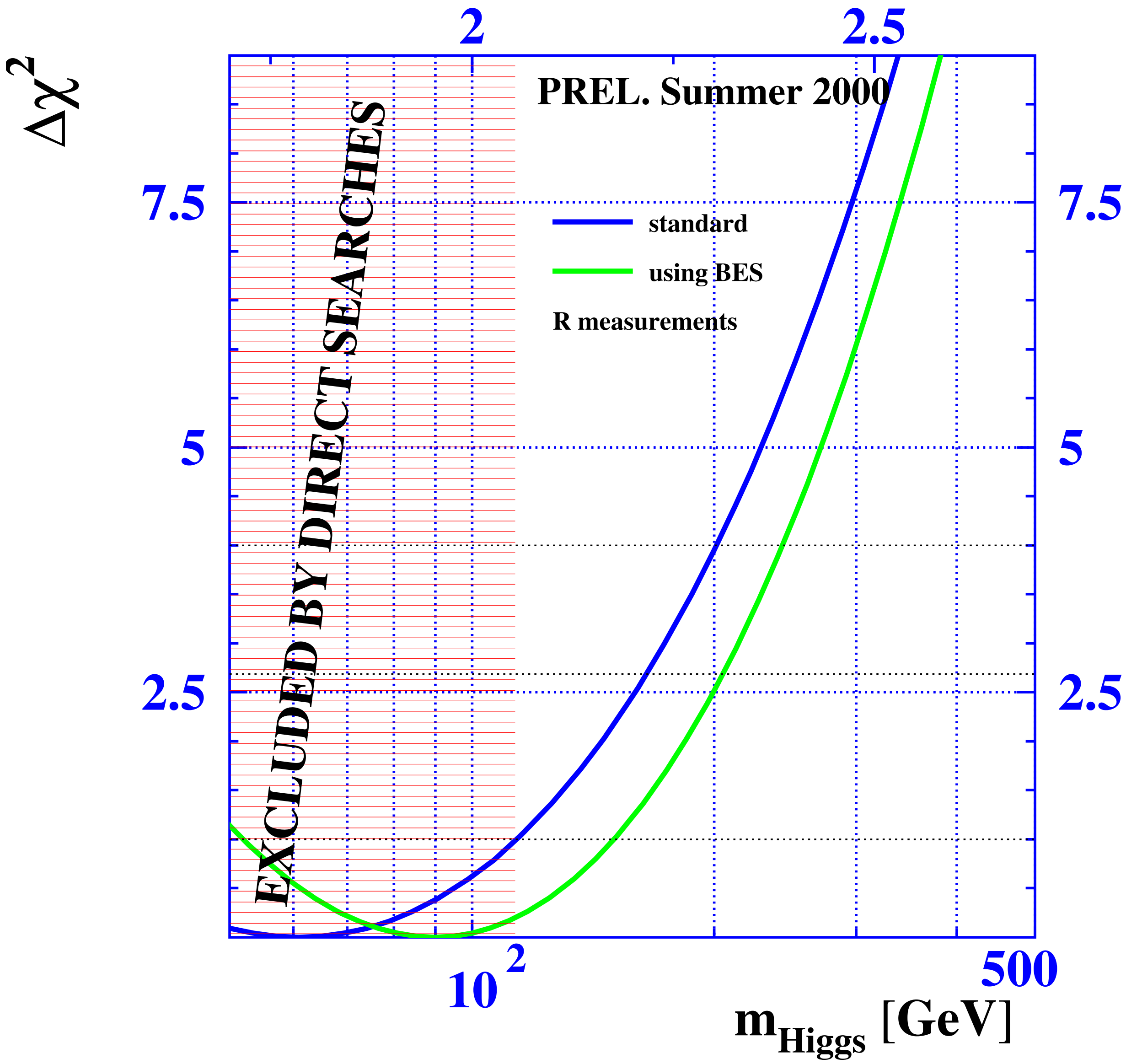


with BES results



with BES results, three measurements $A_{FB}^{0,l}$, A_{LR} and m_W, give higher central values of m_H (40 - 50 GeV)

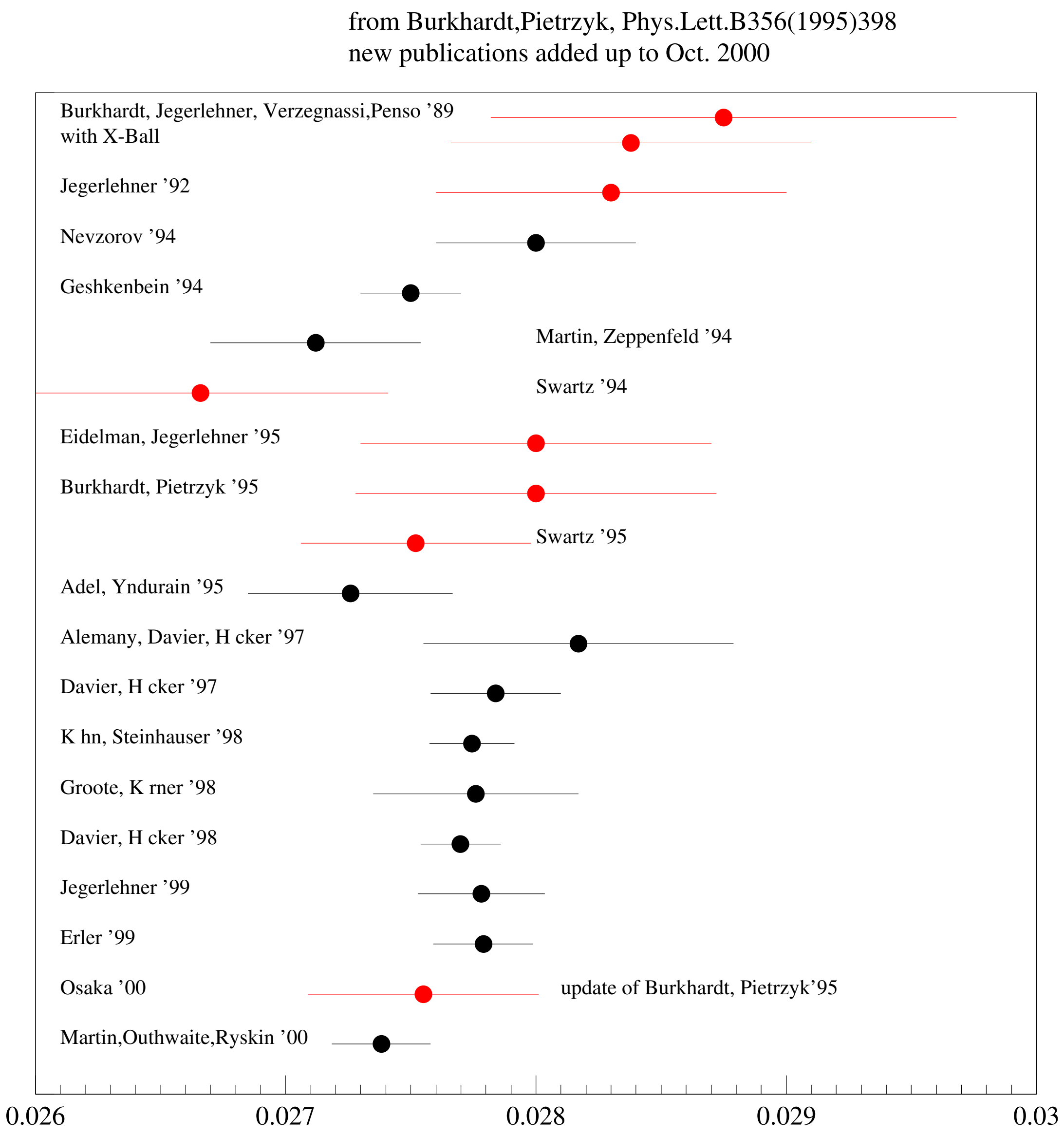
log m_H - consequence of BES R measurements



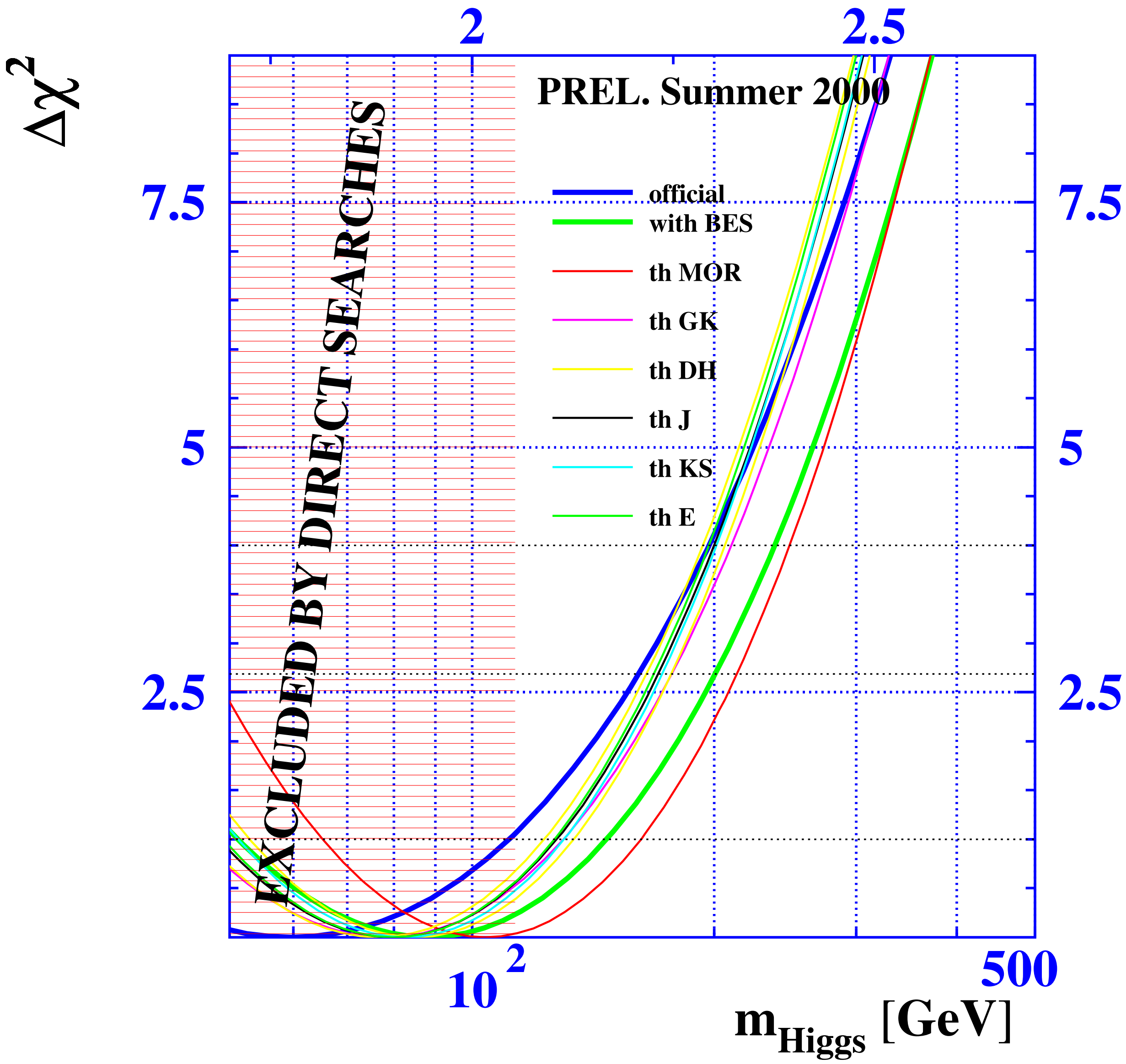
minimum moves to 88 GeV, upper limit moves to 210 GeV

↑ very preliminary ↑

Different evaluations of $\Delta\alpha^{(5)}_{had}(s)$



Different Higgs mass upper limits



Conclusions, comments

- Standard Model is still in a good shape
- Standard Model is consistent
  - indirect $m_t = 169^{+10}_{-8}$ GeV, direct $m_t = 174.3 \pm 5.1$ GeV
  - indirect $m_W = 80.374 \pm 0.034$ GeV,
    direct $m_W = 80.434 \pm 0.037$ GeV
- most significant changes :
  - BES R measurements, not yet included in the official fit results
  - m_W from LEP
  - Z lineshape now final, but preliminary numbers were already very good
- data prefer low Higgs mass

  official fit results $\rightarrow m_H = 60^{+52}_{-29}$ GeV, $m_H < 165$ GeV
- using BES R measurements, data still prefer low m_H, but less low

thanks to
Gunter Quast with his ZF package
Zhengguo Zhao and his BES team
LEPP EWWG with Martin Gruenewald and Bob Clare
LEP Collaborations