The present and the uncertain future of the ElectroWeak fit

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Outline

The ElectroWeak fit: what is it?

The present status.

- ☞ high energy colliders results.
- ☞ our best knowledge of the SM Higgs boson mass (updated after the Winter Conferences 2007). **New**

Are we satisfied?

- ☞ the Chanowitz argument (is still there).

What and where can we improve in the near future?

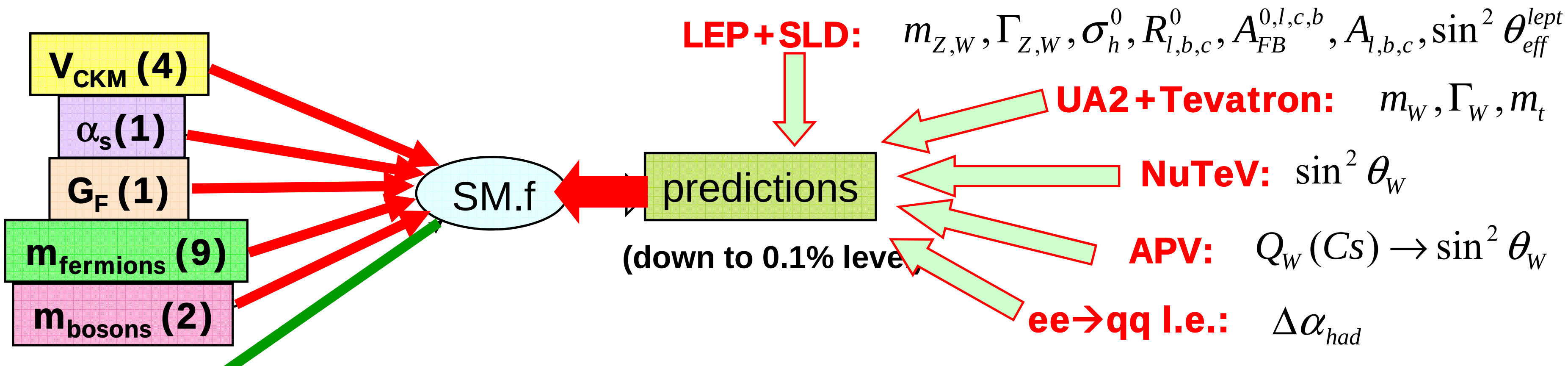
- ☞ W, top and Higgs boson at the Tevatron.
- ☞ an “optimist’s” viewpoint revisited.

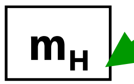
The LHC: will it all still make sense?

- ☞ constraining new physics.

The EW fit in a nutshell

What we (think we) know



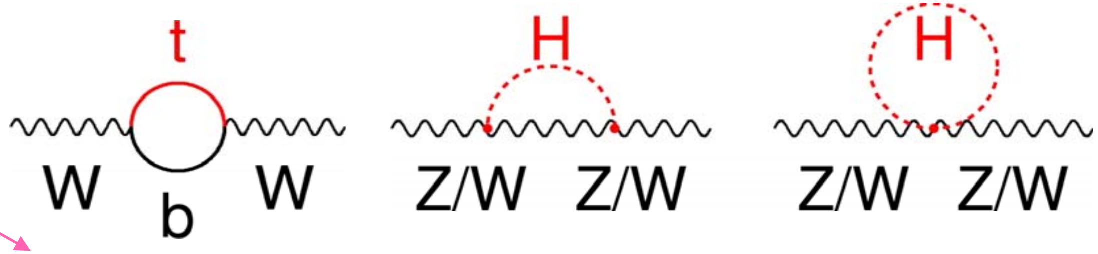


No observable directly related to m_H. However the dependence can appear through radiative corrections.
$\Rightarrow$ tree level quantities are changed

$$\frac{m_W^2}{m_Z^2\cos^2\theta_W} = 1 + \Delta\rho$$

$$m_W^2 = \frac{\pi\alpha}{\sqrt{2}\sin^2\theta_W G_F}(1+\Delta r)$$

$$\alpha(m_Z^2) = \frac{\alpha(0)}{1-\Delta\alpha} \qquad \Delta\alpha = \Delta\alpha_{lept} + \Delta\alpha_{top} + \Delta\alpha_{had}^{(5)}$$



$\Delta\rho$, Δr = f [log(m_H/m_W), m_t^2]

The uncertainties on m_t, m_W are the dominating ones in the electroweak fit

By making precision measurements (already interesting per se):

- one can get information on the missing parameter m_H
- one can test the validity of the Standard Model

A global fit?

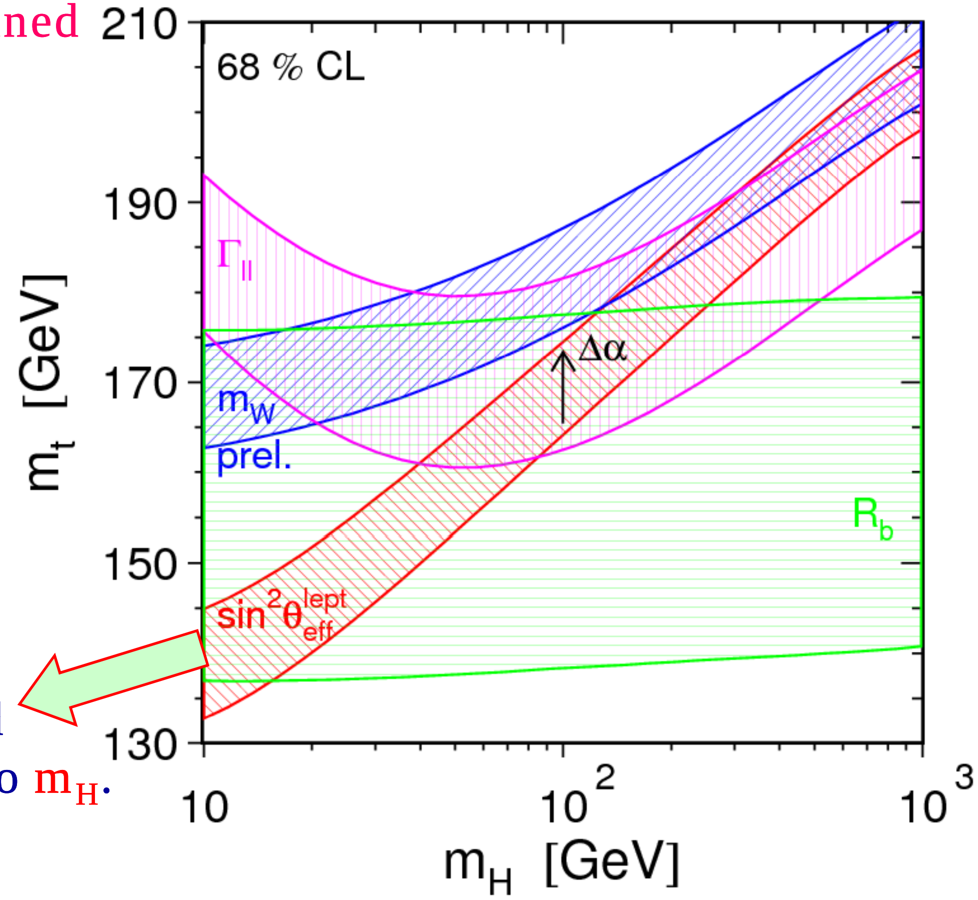
All precision "observables" in the SM fit are calculated in terms of a small set of input parameters: m_Z, G_μ, $\alpha(m_Z)$, m_l, m_q, m_t, m_H, α_s. They constitute the fit parameters.
Both observables and input parameters are constraints in the fit and are subject to their experimental uncertainties.
Theory errors in the expressions of the "observables" introduce further uncertainties
m_Z, G_μ, $\alpha(0)$, m_l are the most precisely measured input parameters –can be seen as fixed in the fit-, $\alpha_s(m_Z)$ is very well constrained

$\Rightarrow$ the dominant uncertainties come at present from:

- The top mass m_t
- The hadronic contribution to the fine structure constant $\Delta\alpha_{had}$
- The Higgs mass itself m_H

$\Rightarrow$ the dominant theory errors involve:

- $\sin^2\theta_{eff}$
- The W mass m_W



Amongst the experimental measurements leading to precision "observables", m_W and $\sin^2\theta_{eff}$ are the most sensitive parameters to m_H.

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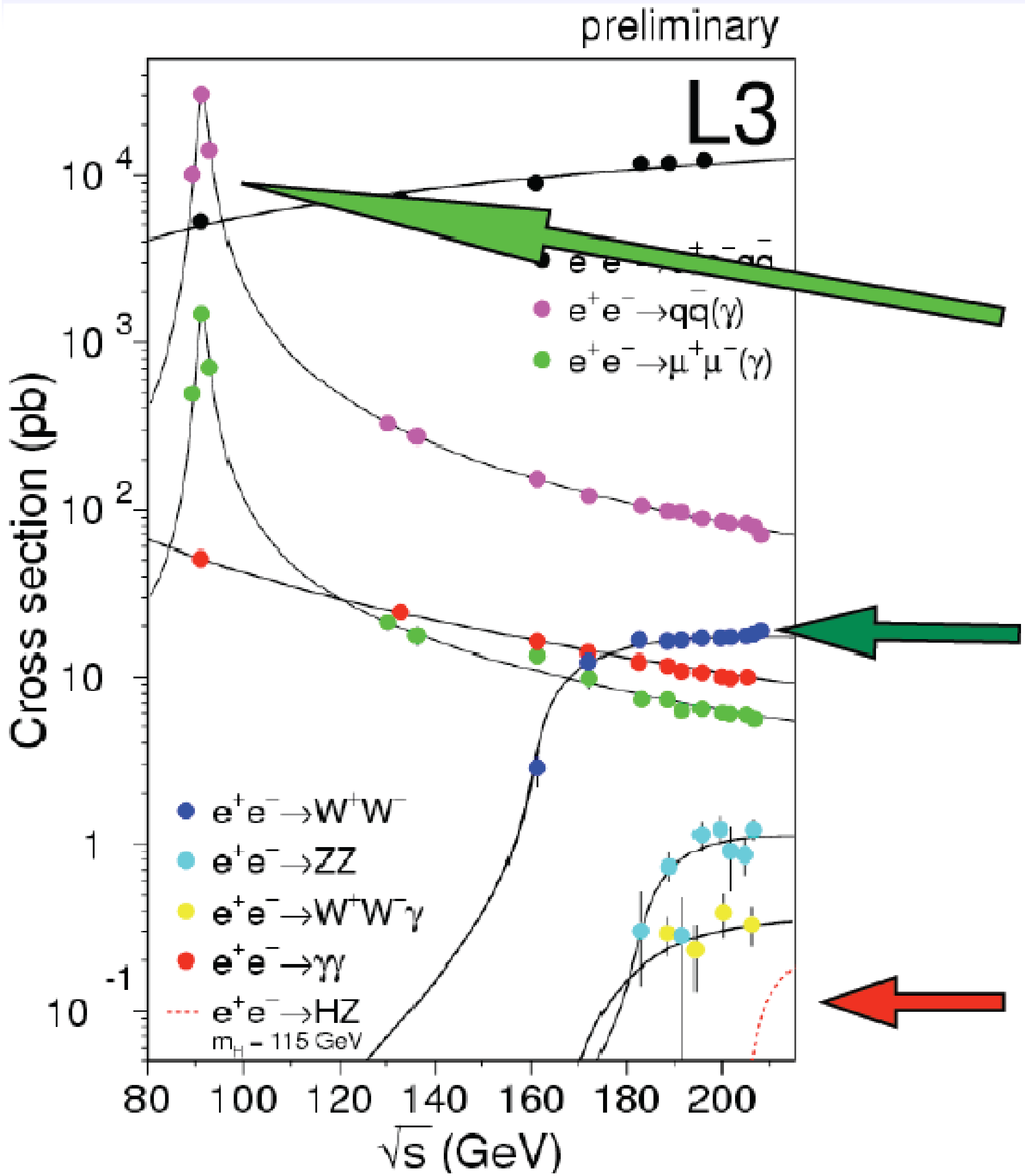
High energy precision measurements

High energy e^+e^- data at the Z pole



LEP1, SLD
20M Z
(10 days at the LHC)

LEP2
40000 WW
(15 days at the LHC for 40K WW)
(10 minutes for 80K W)

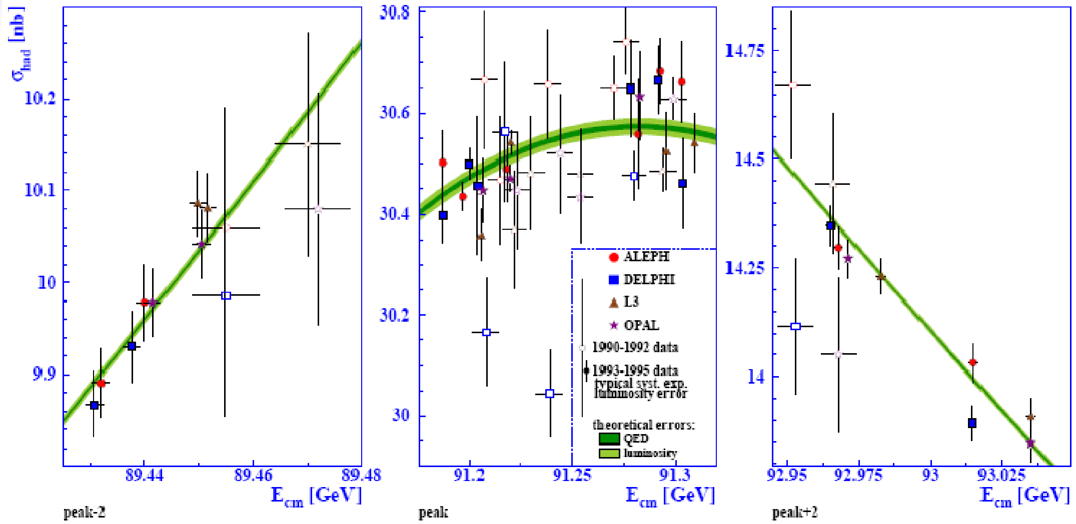
LEP, SLD
No Higgs bosons

Final Z pole report (LEP1, SLD)

LEP+SLD, hep-ex/0509008

LEP era precisely established the SM.
Of enormous relevance for the EW fit:
m_Z, Γ_Z, σ^0_{had}, R_f, asymmetries

m_Z=91.1875 ±0.0021(exp) GeV/c^2
Γ_Z=2.4952 ±0.0023(exp) GeV
$\sin^2\vartheta_W$=0.23153 ±0.00016(exp)

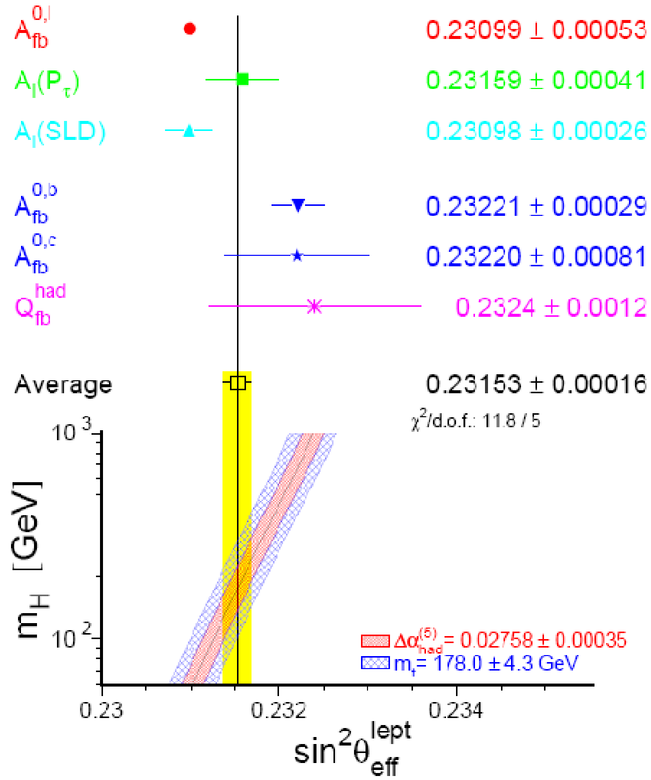


Assuming lepton universality:

$$\frac{\chi^2}{ndf}(lept) = \frac{1.6}{2} \qquad P\sim 44\%$$

$$\frac{\chi^2}{ndf}(hadr) = \frac{0.02}{2} \qquad P\sim 98\%$$

$$\frac{\chi^2}{ndf}(tot) = \frac{11.8}{5} \qquad P\sim 4\%$$



Hadrons vs leptons: 3.2 σ
2.9 σ between two most precise quantities: A_l and $A_{FB}^{0,b}$

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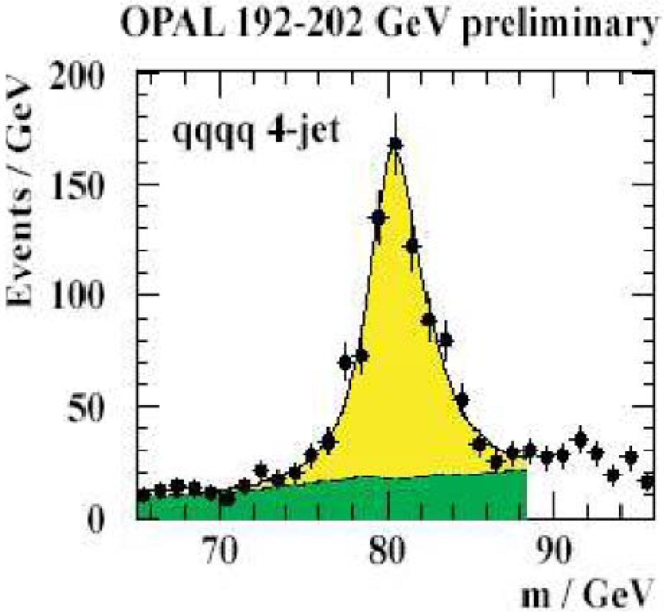
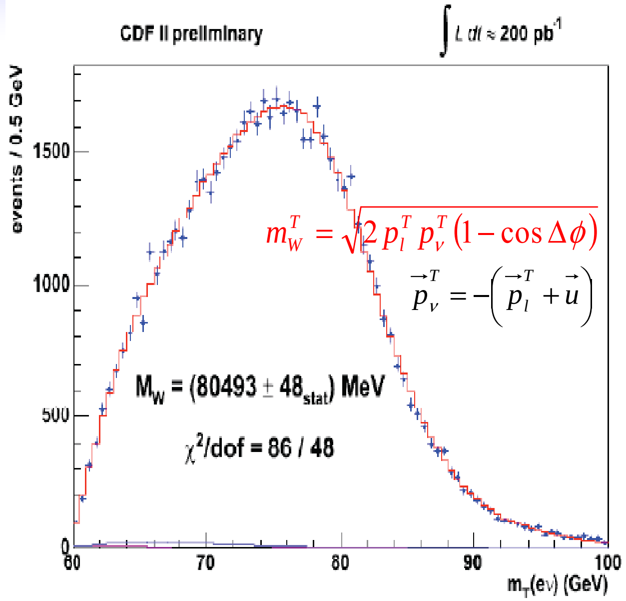
LEP2+Tevatron era: m_W

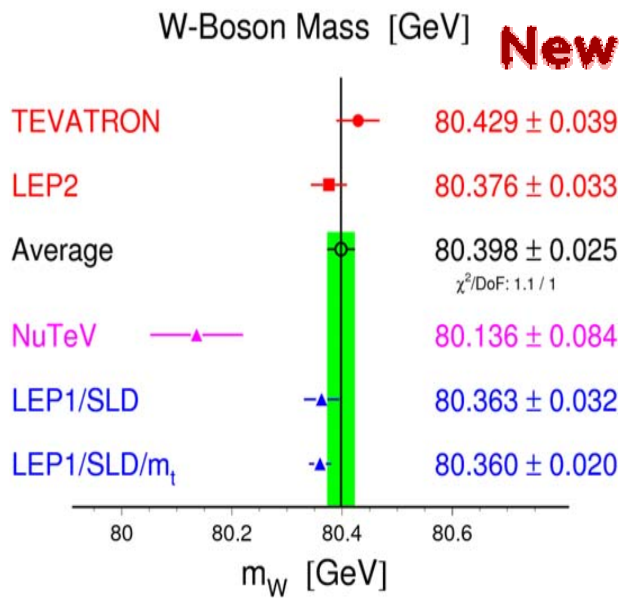


LEP still preliminary (as in 2006)

Tevatron final Run I, new preliminary Run II, with best single measurement from CDF.



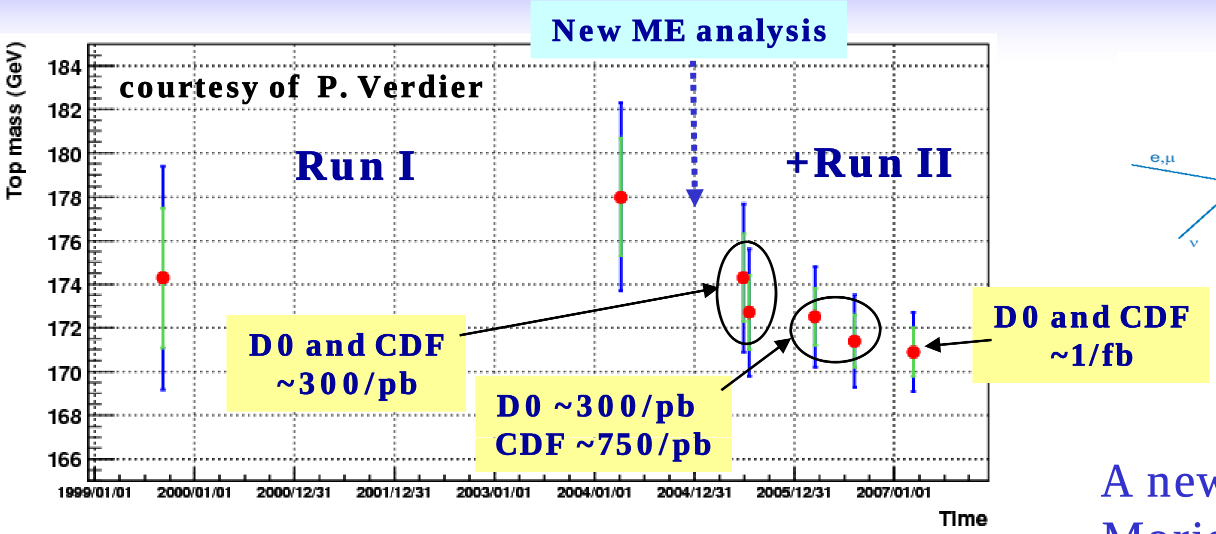
Source	Systematic Error on m_W (MeV)		
	$q\bar{q}\ell\bar{\nu}_\ell$	$q\bar{q}q\bar{q}$	Combined
ISR/FSR	8	5	7
Hadronisation	13	19	14
Detector Systematics	10	8	10
LEP Beam Energy	9	9	9
Colour Reconnection	–	35	8
Bose-Einstein Correlations	–	7	2
Other	3	11	4
Total Systematic	21	44	22
Statistical	30	40	25
Total	36	59	33

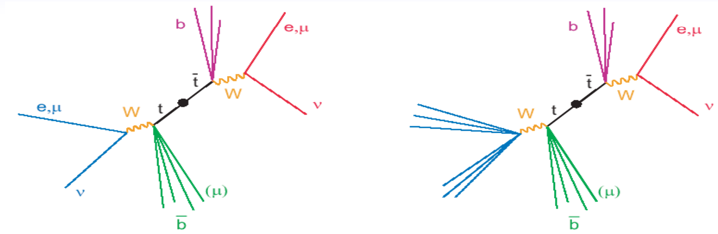


LEP : weight of the qqqq channel now 23%

m_W=80.398 ±0.025(exp) GeV/c^2

Tevatron era: m_t



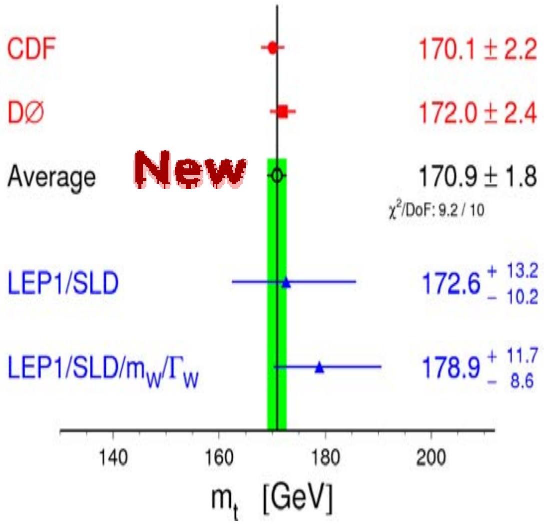


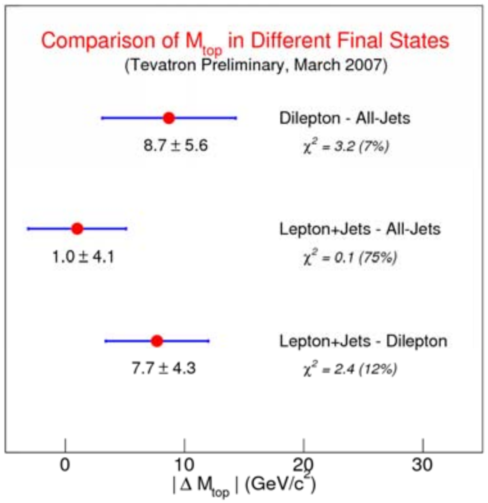
A new preliminary top mass for Moriond 2007 corresponding to 1/fb

For the first time the world combined error goes below 2 GeV

Some analyses start to be dominated by the systematic contributions

	Run-I published					Run-II preliminary					
	CDF			DØ		CDF				DØ	
	all-j	l+j	di-l	l+j	di-l	l+j	di-l	all-j	lxy	l+j	di-l
Syst.	5.7	5.3	4.9	3.9	3.6	1.9	3.9	3.2	5.6	2.0	5.6
Stat.	10.0	5.1	10.3	3.6	12.3	1.6	3.9	2.8	14.8	1.8	5.8
Total	11.5	7.3	11.4	5.3	12.8	2.5	5.6	4.3	15.8	2.7	8.0





m_t=170.9 ±1.8(exp) GeV/c^2

Putting all together

What we measured

Not a very healthy fit ?

- **Anomaly #1**

$\sin^2\theta_{eff}$ from quark asymmetries agree each other and point towards a heavy Higgs
$\sin^2\theta_{eff}$ from lepton asymmetries agree each other and prefer a light Higgs

- **Anomaly #2 (nobody worries…)**

NuTeV measures $\sin^2\theta_W$ from NC/CC νN DIS cross sections, and its measure is 3σ away from the predictions
(feeling is that TU are largely underestimated)

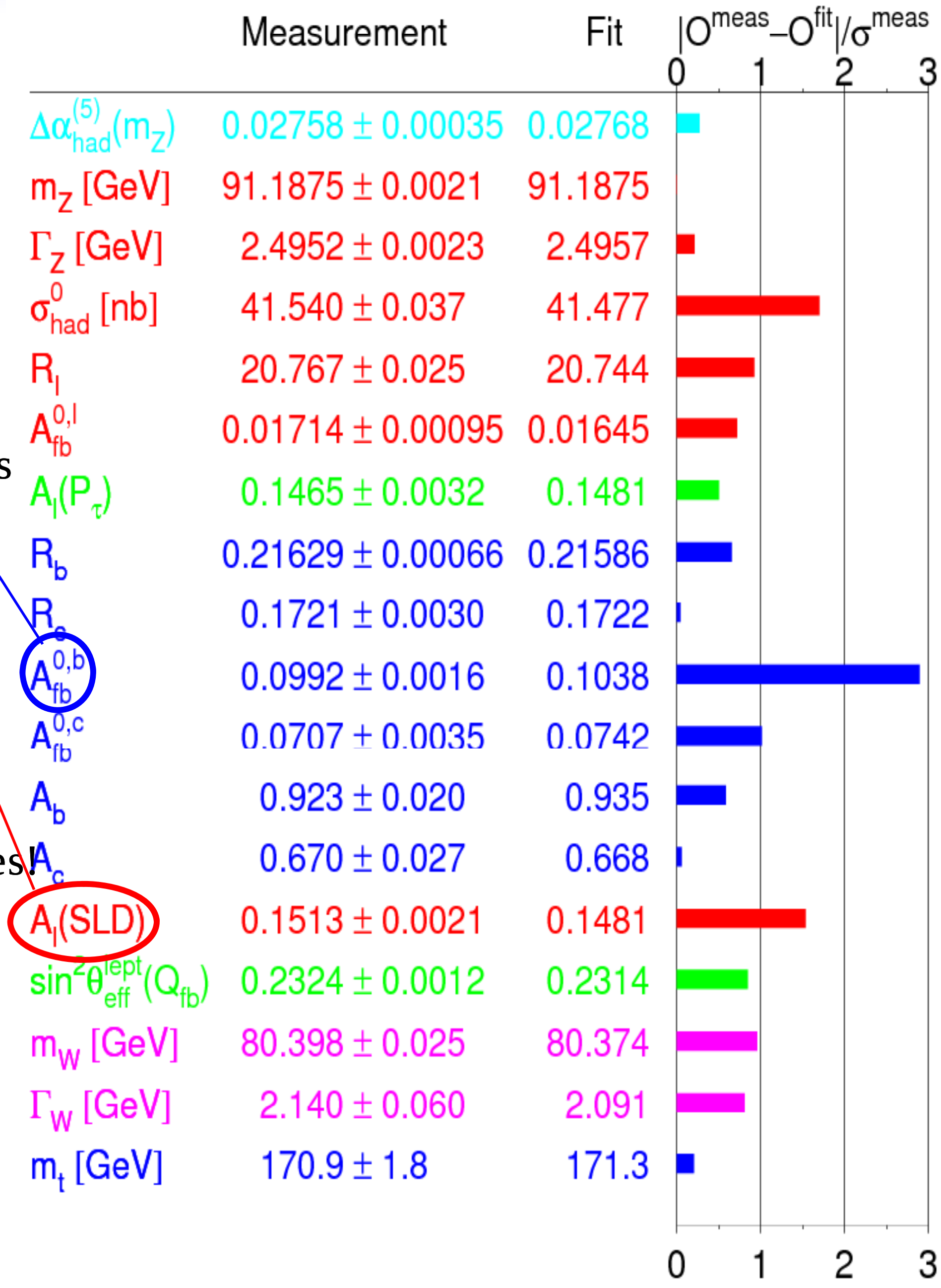
- **Anomaly #3**

The Higgs boson is not found yet

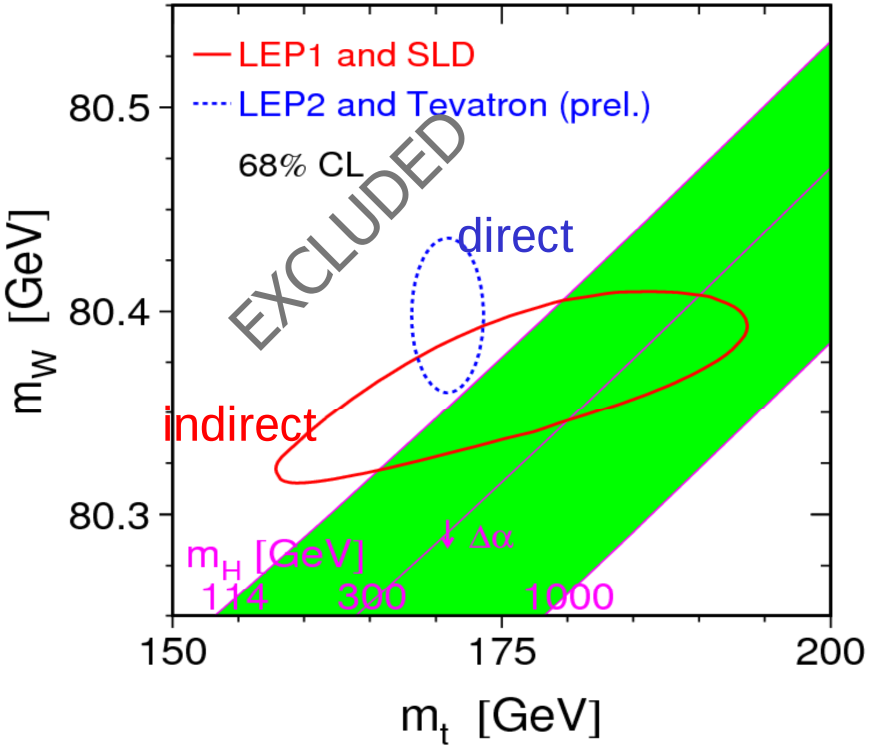
All "anomalies" concern very m_H sensitive variables!

$$\frac{\chi^2}{ndf}(all) = \frac{28.0}{17} \quad P\sim4.5\%$$

$$\frac{\chi^2}{ndf}(only-high) = \frac{18.2}{13} \quad P\sim15\%$$

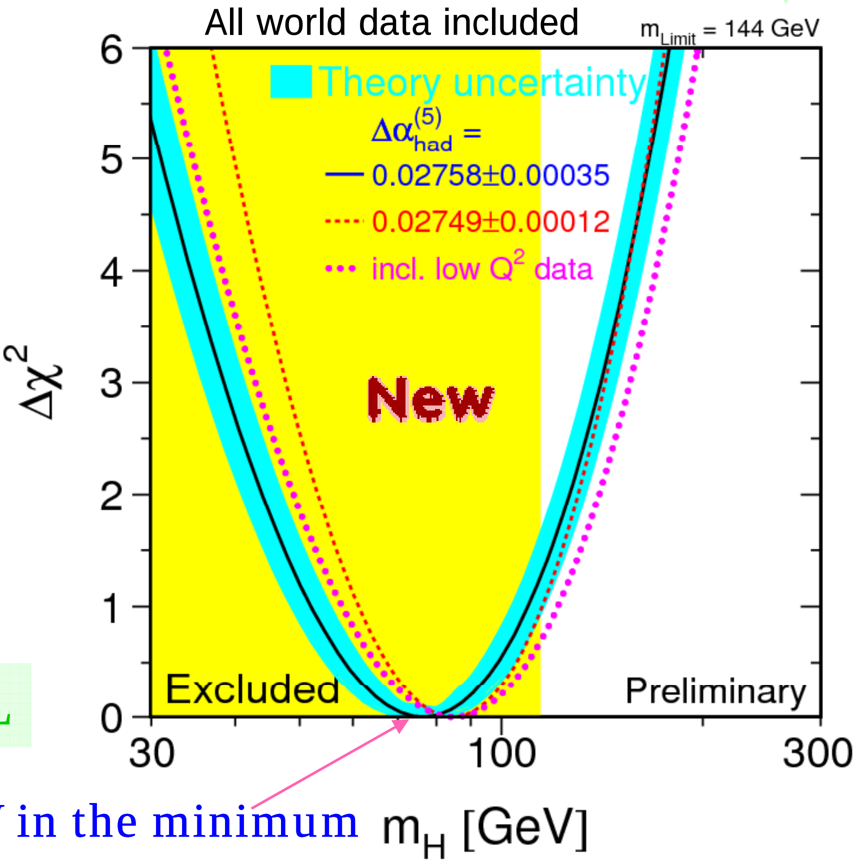


Where we are



Summary of inputs:
m_t=170.9 ±1.8(exp) GeV/c^2
m_W=80.398 ±0.025(exp) GeV/c^2
m_Z=91.1875 ±0.0021(exp) GeV/c^2
Γ_Z=2.4952 ±0.0023(exp) GeV

SM predictions from ZFITTER 6.42
(complete two-loop calculations for m_W and fermionic two-loop calculations for $\sin^2\vartheta_{eff}$)



Direct and indirect data favour a very light SM Higgs boson !

m_H(best)=76 GeV/c^2 ($\delta m_H/m_H \approx$ 37%)

m_H<144 GeV/c^2 @95% CL

Bayesian limit: m_H<182 GeV/c^2 @95% CL

Small impact of NuteV in the minimum

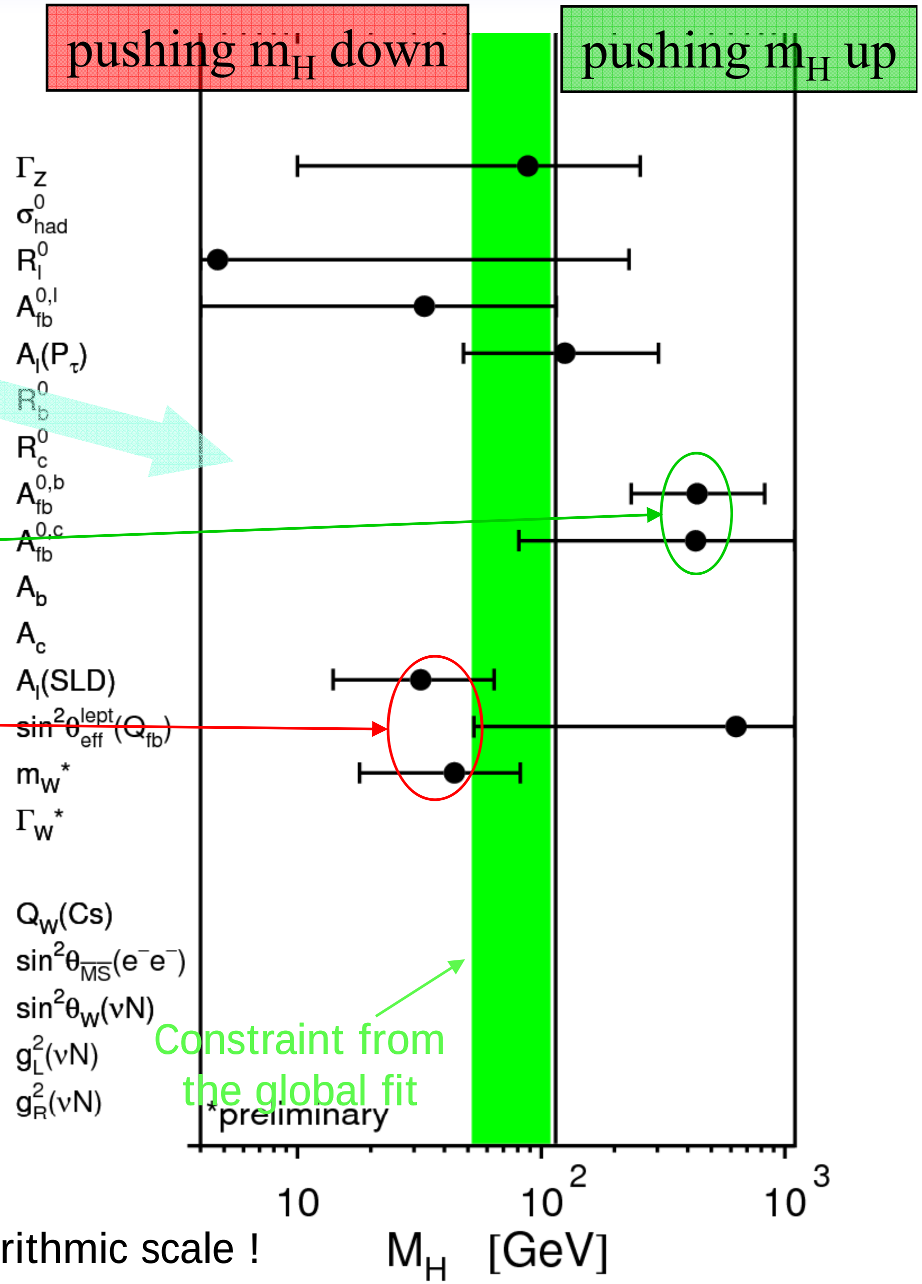
Are we satisfied?

A global fit can sometimes hide striking discrepancies...
(see the asymmetry problem)

Constraint on m_H from each pseudo-observable from a 5 parameter fit where $\Delta\alpha_{had}$, $\alpha_s(m_Z)$, m_Z, m_t are fixed

There are only the hadronic asymmetries (and the NuTeV result) that are pushing for a high Higgs mass

They seem to contradict the result from other measurements like A_l or m_W.



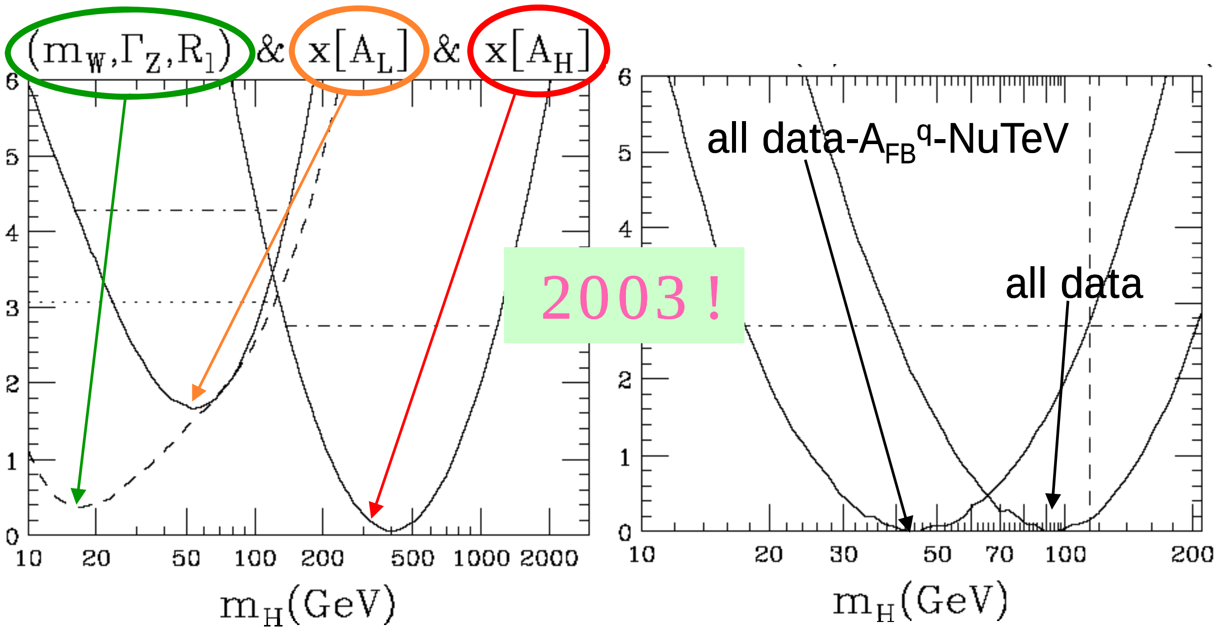
beware: logarithmic scale !

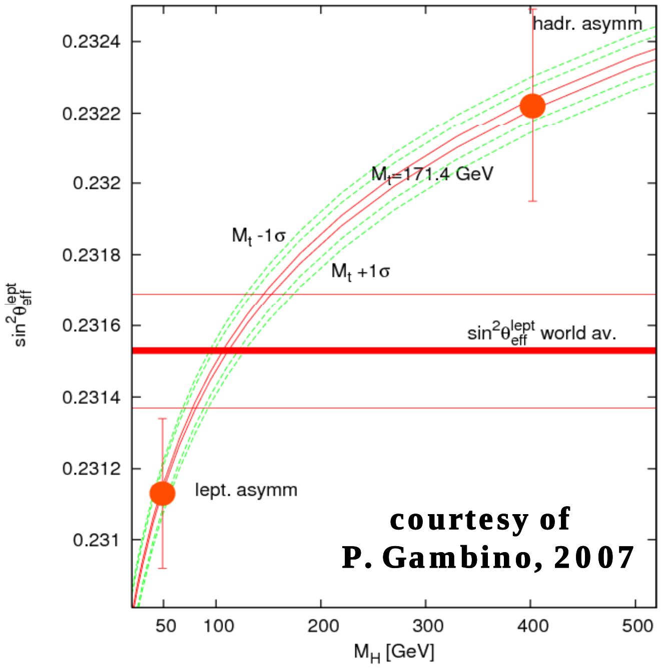
The Chanowitz point of view

The poor consistency of the m_H sensitive sector (m_W,A_{LR},A_{FB}^b) is cause for concern in assessing the reliability of the SM predictions of m_H.

	90% CL m_H (GeV/c^2)
m_W	$10<m_H<161$
A_{LR}	$10<m_H<122$
A_{FB}^b	$130<m_H<1200$

- statistical fluctuation?
- new physics?
- underestimated correlated systematic? In A_{FB}^q ?





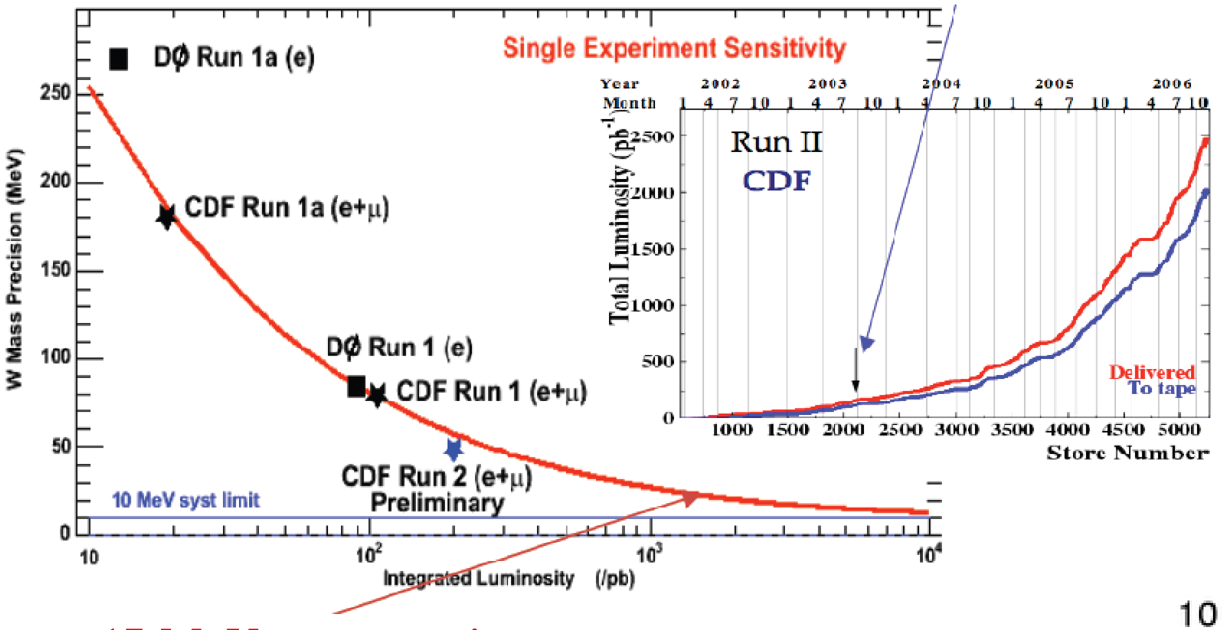
Removing the hadronic asymmetries from the fit (i.e. one assumes there is an unknown large systematic error) makes the fit very good, but inconsistent with direct search data ! This is still valid today...

Without the hadronic asymmetries (only $A_{fb}^{0,b}$) from the fit yields a 95% CL upper limit of 106 GeV. (Un)fortunately, this cannot be done.

Short time improvements (read: before the LHC)

m_W and m_t at the Tevatron

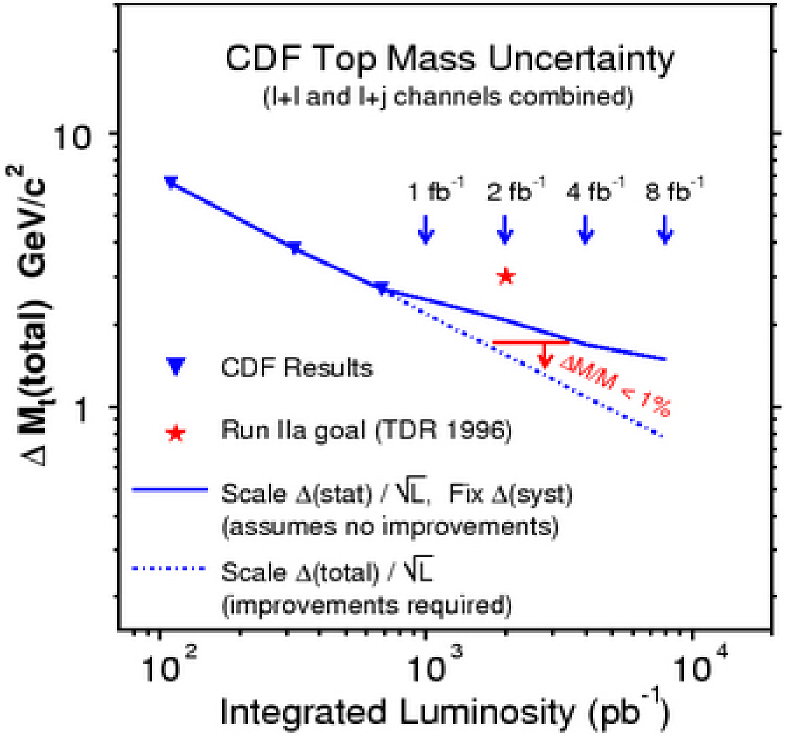
CDF: only 200/pb used so far



20 MeV world error on m_W at the start of the LHC?

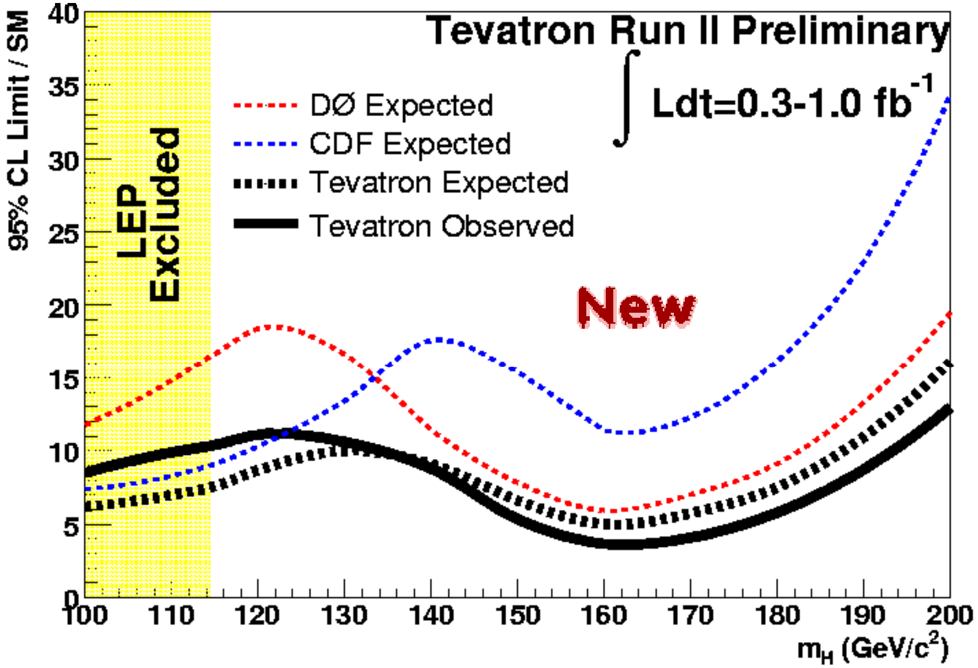
~15 MeV asymptotic

m_t: perspectives from CDF extrapolated to the Tevatron combined result say that δmt=1.2–1.6 GeV with 2/fb analyzed.



Can Tevatron do as well as the LHC?

Higgs boson and the Tevatron



The direct hunt to a SM like Higgs boson continues at the Tevatron:

- $qq \rightarrow ZH \rightarrow \ell\ell bb$, $\nu\nu bb$
- $qq \rightarrow WH \rightarrow \ell\nu bb$
- $gg \rightarrow H \rightarrow WW^* \rightarrow \ell\nu\ell\nu$

New limits presented at Moriond 2007.
They are in terms of R=95% CL limit/σ_{SM}

- R<1 indicates model exclusion at that mass

Just statistics does not seem to be sufficient to get to 1 in a short time scale

Many improvements in the analyses expected however:

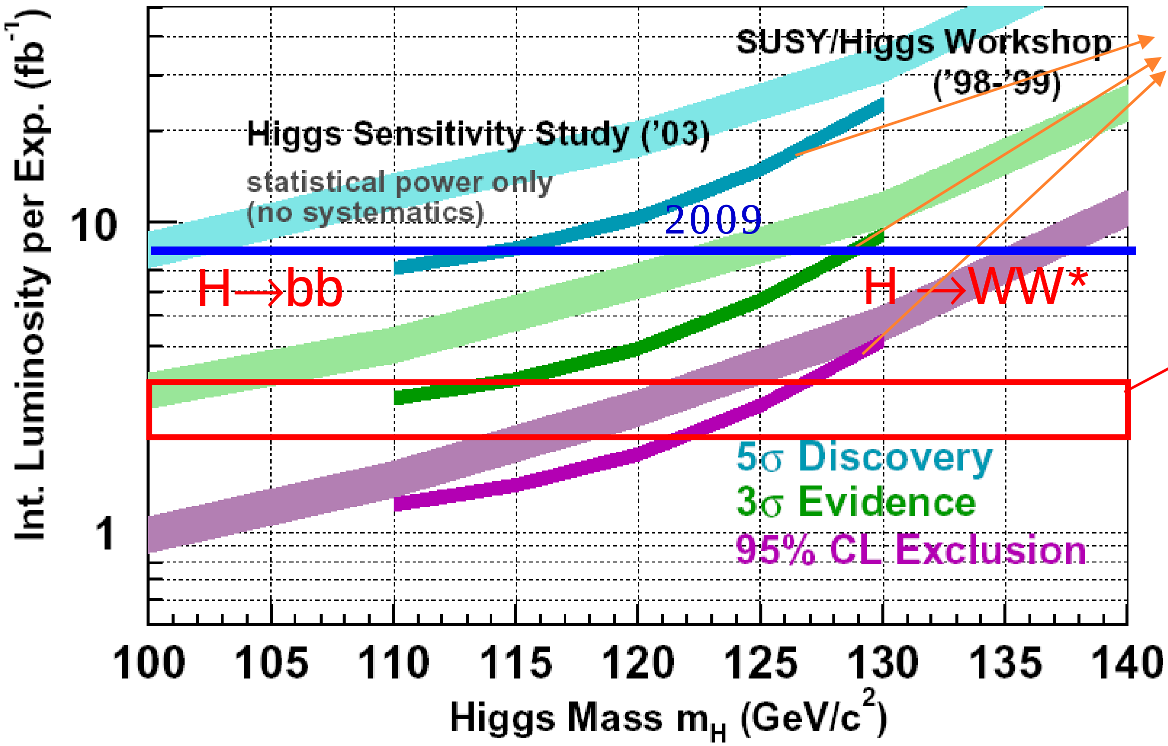
- more advanced analysis techniques
- new channels will increase sensitivity
- many systematics limited by statistics

R=1 when lumi ~ 3/fb for m_H=115 GeV and lumi ~ 5.5/fb for m_H=160 GeV seem feasible

D. Cho, Aspen 2007

What is the discovery potential instead?

Discovery potential at the Tevatron

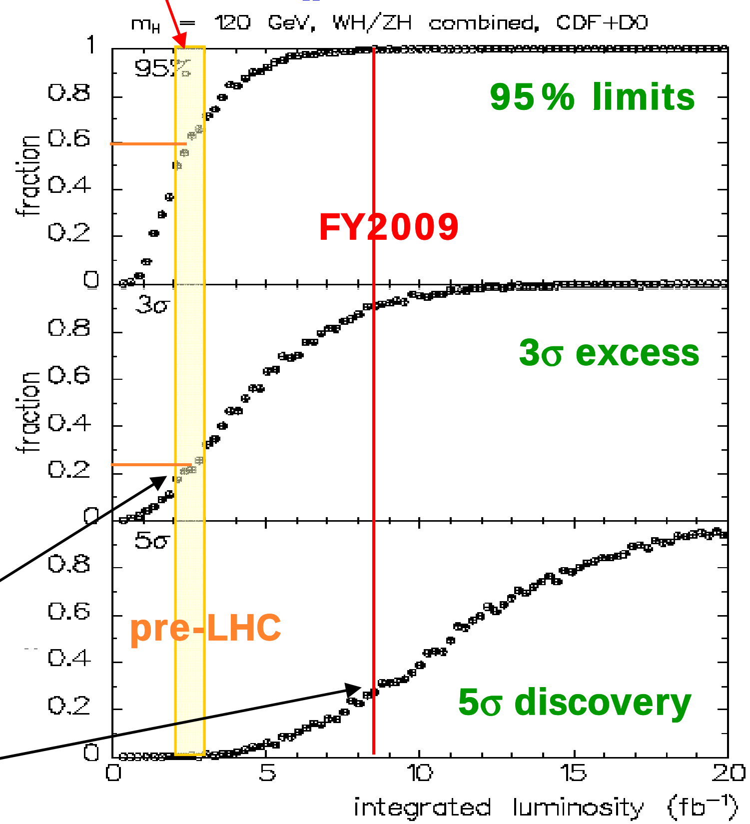


- 2003 curves with updated analyses and detectors.
- No update since.
- No systematics included.

(maximum effect estimated to be 20%)

Assume 2-3/fb analyzed data prior to LHC

Fraction of pseudo-experiments for m_H=120 GeV/c^2.



In the pre-LHC scenario, the 95% exclusion limit can reach 125 GeV/c^2, a 3σ excess could be visible if m_H<115 GeV/c^2

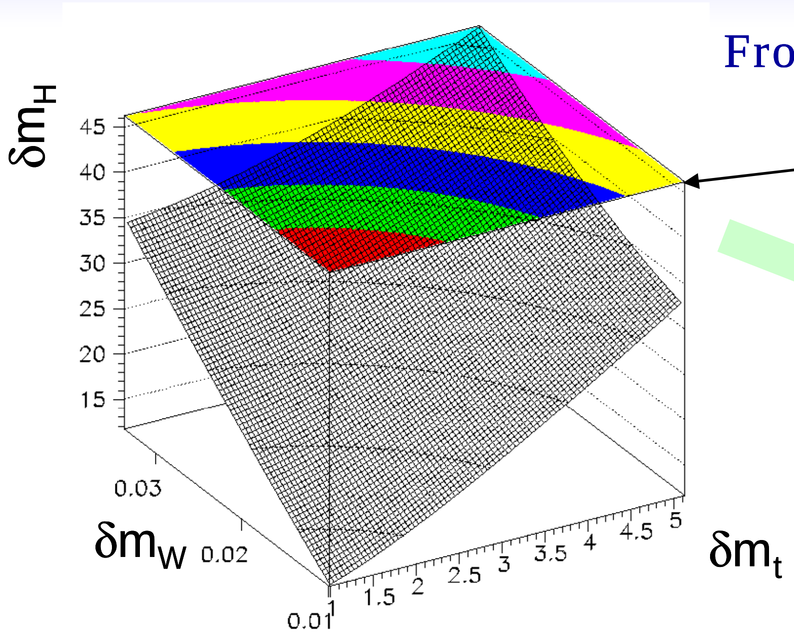
A 5σ discovery seems out of range, but the improvements in the analysis cannot be accounted for (see the top mass)...

Example: there is a probability of 20 and 30% that Tevatron will have at least a 3σ excess before LHC if the Higgs mass is 120 GeV/c^2.

Example 2: there is a probability of 30% that Tevatron will discover the Higgs with the full data sample if the Higgs mass is 120 GeV/c^2.

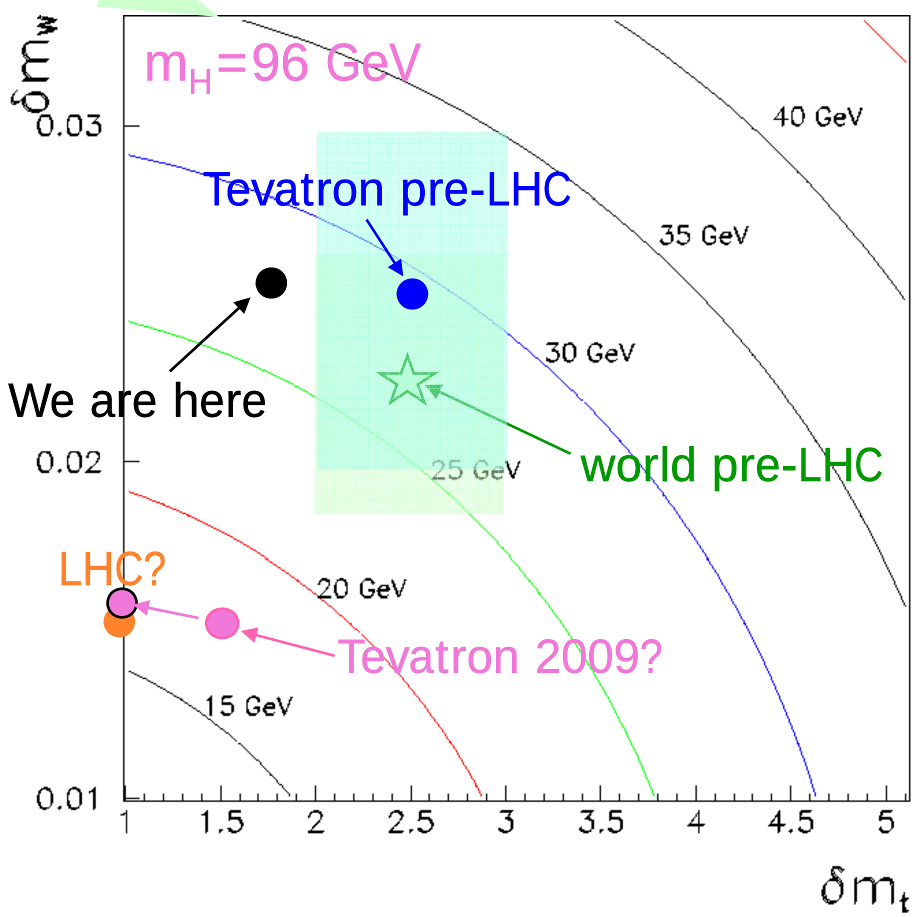
What next?

Indirect error on m_H



From the improved expected errors on m_W and m_t

Awramik, Czakon, Freitas, Weiglein, hep-ph/0311148 (analytical expression of m_W as a function of m_t and m_H with two-loop corrections. Valid at the 0.5 MeV/c^2 scale)



Thumb-rule for similar impact on m_H:

$$\delta m_W \approx 0.7\times 10^{-2}\,\delta m_t$$

The LHC will be able to measure m_W at the 15 MeV scale and m_t at 1 GeV (better, I believe).
But will we make use of all this precision?

A new meaning to the EW fit: MSSM

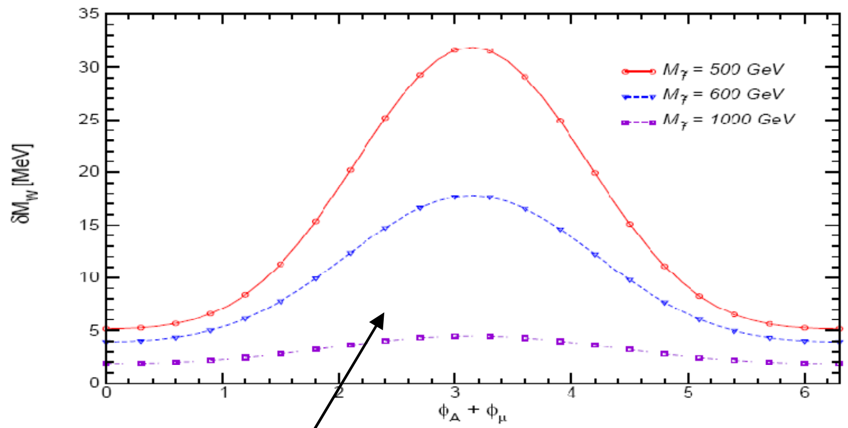
Use the EW fit to constrain new physics as well. Need precise calculations.

- MSSM loop effect on high energy observables may be similar to SM in size.
- Main contributions to one-loop SUSY corrections come from $\tilde{t}, \tilde{b}$ doublets.
- One loop MSSM for the m_W prediction are now available.
- Remaining MSSM uncertainties below 10 MeV.

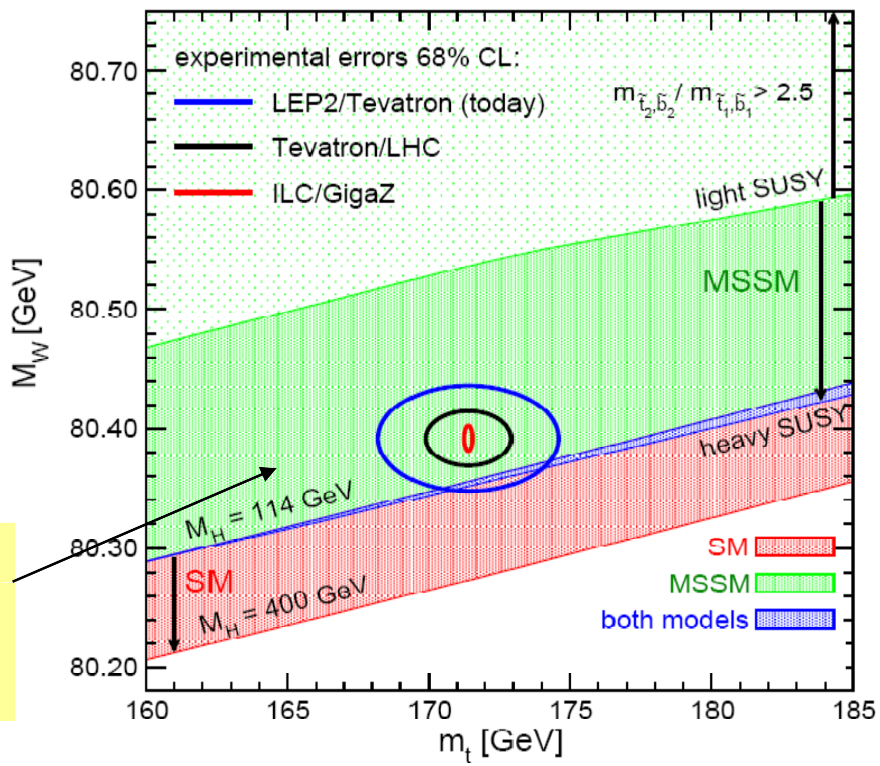
$$\delta m_W = -\frac{m_W^{ref}}{2} \frac{\sin^2\theta_W}{\cos^2\theta_W - \sin^2\theta_W} \Delta r^{SUSY}$$

Data slightly prefer MSSM to SM. More importantly, large regions of the MSSM parameter space are ruled out already…

Weiglein, Heinemeyer et al., hep-ph/0611371



Squarks contribution to m_W as a function of the phase



Squarks and slepton masses: 100 GeV→2 TeV
μ: -2 TeV→2 TeV
M_A: 90 GeV→1 TeV

Conclusions

The ElectroWeak fit is a good way to summarise the work of generations of experimental and theoretical physicists in the effort of constraining or ruling out the SM.

Anomalies and problems in the fit have always been there since I was undergraduate.
Still, the SM is ruling in the 100 GeV energy scale.

Now eagerly awaiting for the LHC. It will bring down δm_W^{world} to less than 15 MeV and δm_t^{world} to (much?) less than 1 GeV
The TeV range will bring us the SM Higgs boson and/or 'new' physics.
A new future for the 'EW' fit in the constraining of such new physics?

In the meanwhile, we should carefully look at the Tevatron.
Chances are (tiny, but finite) they can close the hunt to the Higgs boson.

SM m_H<144 GeV/c^2 @95% CL

Backup

Parametric and theory uncertainties

In the SM fit all "observables" are expressed in terms of a few input parameters
⇒ two sources of errors come into play in the fit

- Errors on the input parameters themselves (from data) propagate in the fit and give origin to the parametric uncertainties.
  - dominated by the error on m_t
- Unknown higher orders in the predictions (truncation errors) also add uncertainties which are genuine theory uncertainties.
  - dominated by errors on m_W and $\sin\theta_{eff}$.

	$\delta\sin\theta_{eff}(10^{-4})$	$\delta m_W(\mathrm{MeV}/c^2)$
PU m_t	3	30
PU $\Delta\alpha_{had}$	1	6
TU	0.5	4

The blue band in the m_H χ^2 curve includes the effect of all theory uncertainties

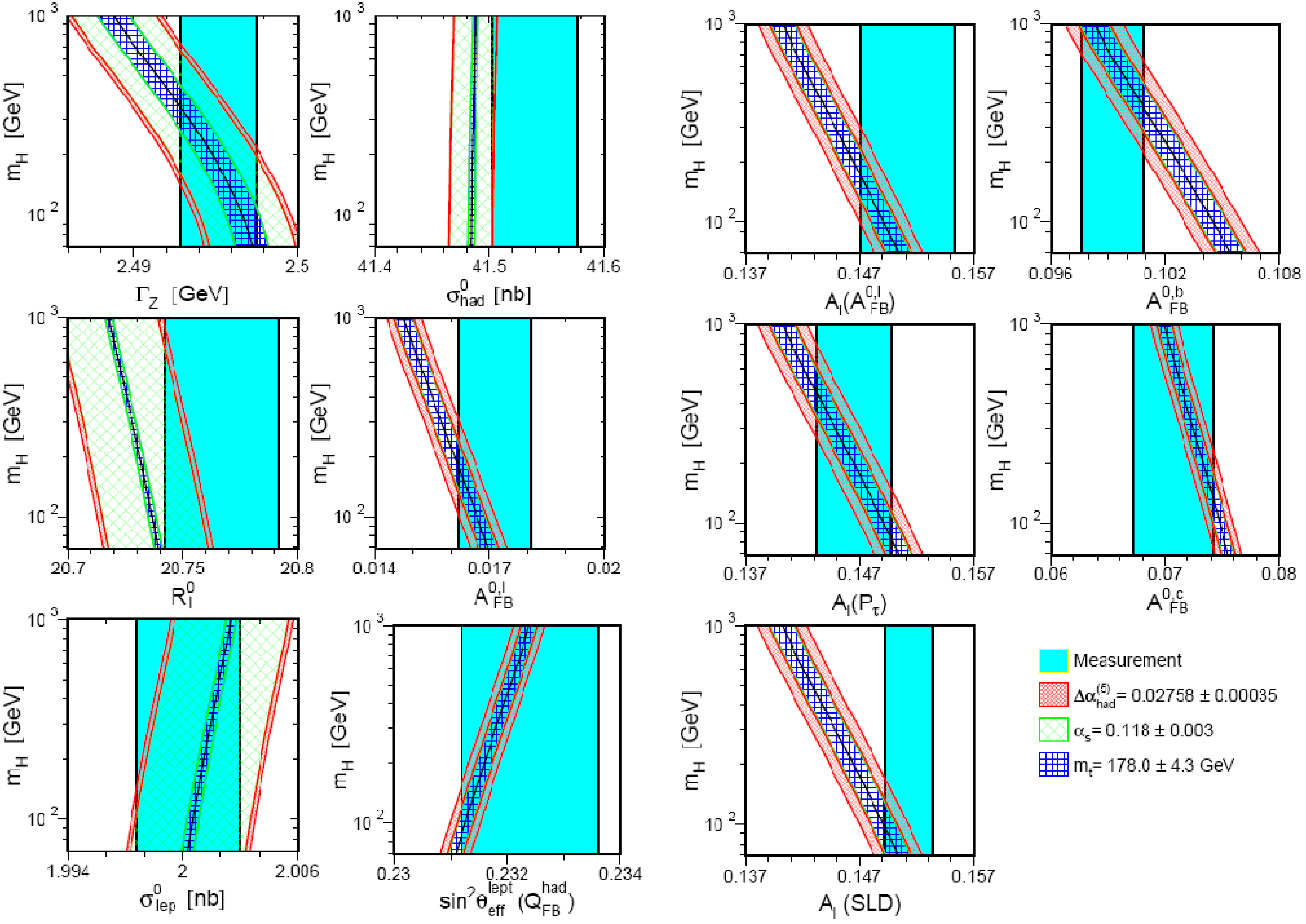
There is a general consensus that it can be determined by comparing codes with different, but equivalent, factorisation schemes or resummation techniques...a reasonable shortcut

The inclusion of higher order corrections in the codes improves the theory error:

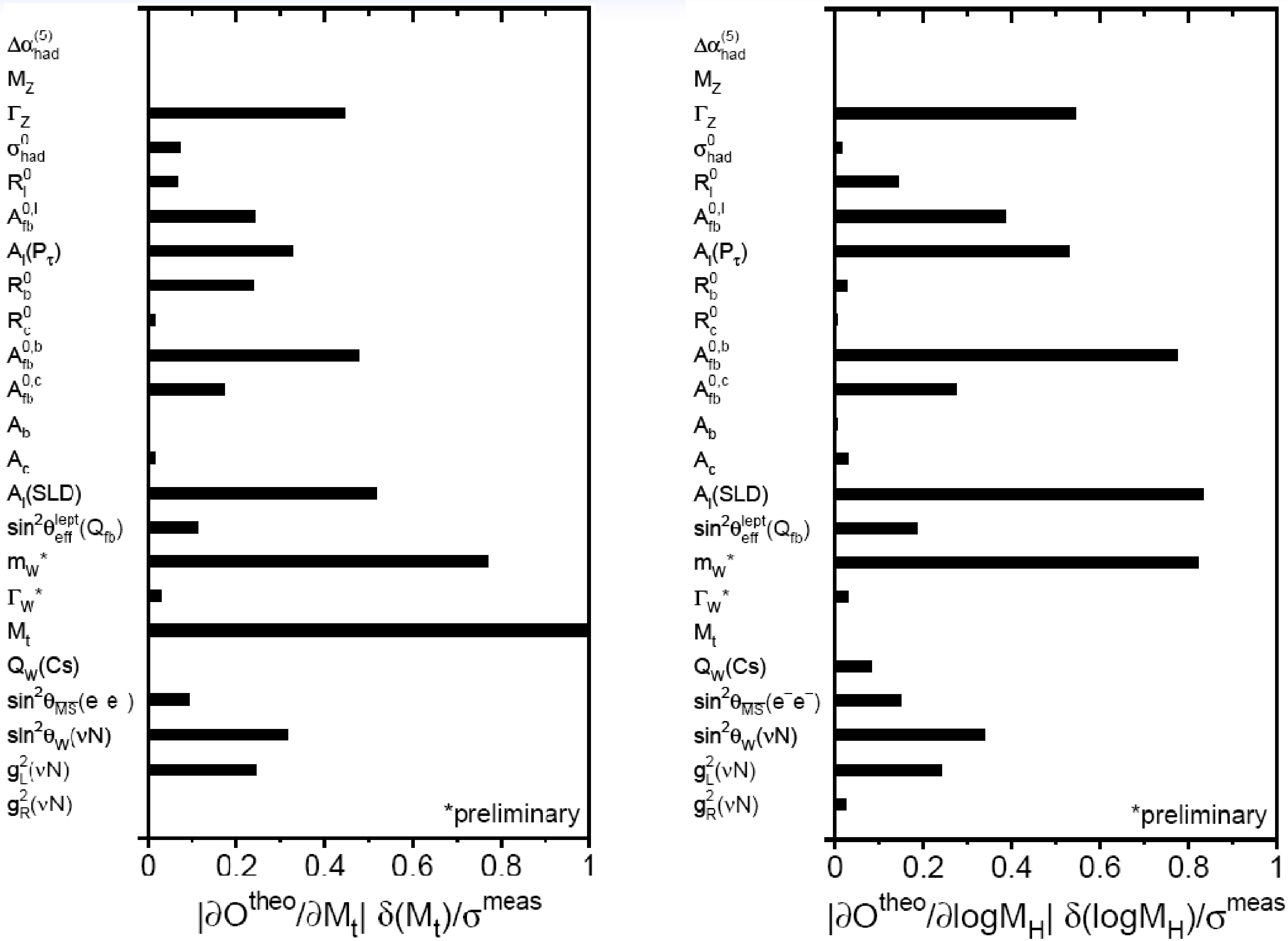
- $\Delta\alpha_{had}$ –largest uncertainty to $\alpha(m_Z)$- is used in two different estimations, data driven (0.02761±0.00036 ⇒ δm_W~7 MeV/c^2) or theory driven (0.02747±0.00012)
- m_w with fermionic and bosonic two loops correction ⇒ δm_W~4 MeV/c^2

Perspectives pre-LHC:
$\sin^2\theta_{eff}=(1+\Delta k)\sin^2\theta_W$ at the two-loops (fermions and bosons) is close (Awramik et al)

Sensitivities (I)



Sensitivities (II)



The precision observables

Are the ones that at tree level depend only on a_{em} ,G_F, M_Z, and $\sin q_W$

At tree level:

$G_F = \pi\alpha / \sqrt{2}\, m_W^2 \sin^2\theta_W$ relation between EM and Weak constants

$\rho \equiv m_W^2 / m_Z^2 \cos^2\theta_W = 1$ relation between neutral and charged weak coupling

The interaction of the Z with fermions is given by the left- and right- handed couplings g_L and g_R:

$g_L = \sqrt{\rho}\,(I_3 - Q \sin^2\theta_W)$ left fermions couple with Z and γ

$g_R = \sqrt{\rho}\,(Q \sin^2\theta_W)$ right fermions couples with γ

or alternatively Vector and Axial couplings:

$g_V = g_L - g_R$, $g_A = g_L + g_R$

$$\begin{cases} g_v = \sqrt{\rho}\,(I_3 - 2\,Q \sin^2\theta_W) \\ g_A = \sqrt{\rho}\, I_3 \end{cases}$$

$$A_{LR} = \sigma_{LR} / \sigma_{TOT} = A_e = 2\, g_{Ae}\, g_{Ve} / (g^2_{Ae} + g^2_{Ve})$$

$$A_{pol} = \sigma_{pol} / \sigma_{TOT} = A_f = 2\, g_{Af}\, g_{Vf} / (g^2_{Af} + g^2_{Vf})$$

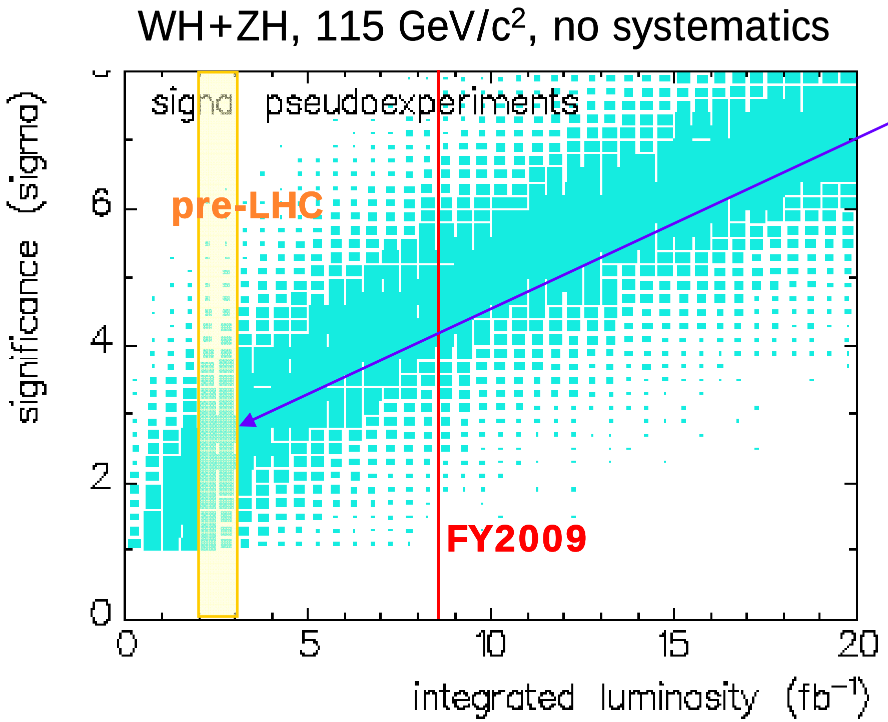
$$A_{FB} = \tfrac{3}{4}\, \sigma_{FB} / \sigma_{TOT} = \tfrac{3}{4} A_e A_f$$

σ_{LR} difference between σ for Left and Right handed incoming fermions

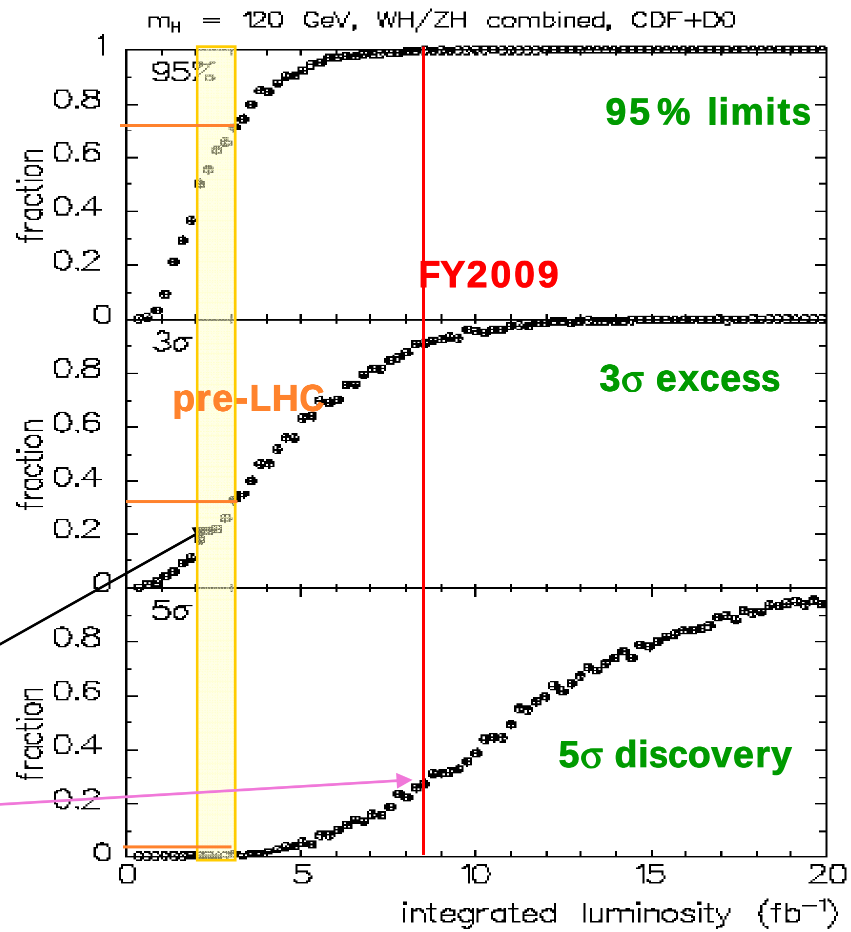
σ_{pol} difference between σ for Left and Right handed outgoing fermions

σ_{FB} difference between σ for outgoing fermions going Forward or Backward

Around-the-corner SM Higgs



If the Higgs is very close to 115 GeV/c^2,
A 3σ excess can be seen with only 3/fb.
8/fb or more needed for a 5σ discovery.



Fraction of pseudo-experiments satisfying a certain criteron for m_H=120 GeV/c^2.

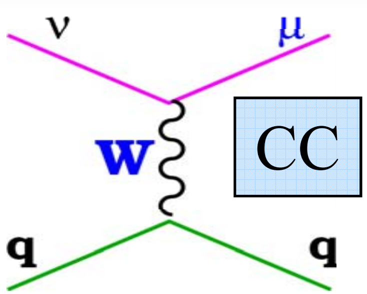
Example: there is a probability between 20 and 30% that Tevatron will have at least a 3σ excess before LHC if the Higgs mass is 120 GeV/c^2.

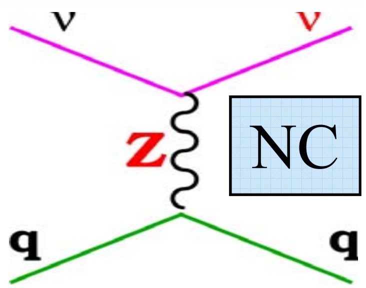
Example 2: there is a probability of 30% that Tevatron will have discovered the Higgs when the full data sample will have been analysed if the Higgs mass is 120 GeV/c^2.

Assume 2-3/fb analyzed data prior to LHC !

$\sin\theta_W$:NuTeV

$$R = \frac{\sigma(\nu N \to \nu X) - \sigma(\bar{\nu} N \to \bar{\nu} X)}{\sigma(\nu N \to \mu^- X) - \sigma(\bar{\nu} N \to \mu^+ X)} = g_L^2 - g_R^2 = \frac{1}{2} - \sin^2\theta_W$$





$\Rightarrow \sin\theta_W = 0.2277 \pm 0.0013(\mathrm{stat}) \pm 0.009(\mathrm{syst})$

Global SM fit: 0.2227 ± 0.00037

$\sin^2\theta_W \equiv 1 - m^2_W/m^2_Z \Rightarrow m^2_W = 80.14 \pm 0.08$ GeV/c^2

- PDFs at ~LO, should be updated (work ongoing...)
- Asymmetries: s^-~0.002 agrees with theory and with the re-analysis of old DIS νN data, could explain 1/3 of the discrepancy
- Isospin violations ($u_p(x) \neq d_n(x)$) within the experimental reach could also explain 1/3 of the discrepancy

$$R = \frac{1}{2} - \sin^2\theta_W + K(u^- - d^- + c^- - s^-)$$

($u^- - d^-$: ≠ 0?; s^-: ≠ 0?)

$$q^- = \int_0^1 x[q(x) - \bar{q}(x)]dx$$

- Nuclear shadowing and other nuclear effect under study, though less convincing
- New physics/supersimmetry cannot easily account for this (f.i. Gambino hep-ph/0211009)
- EW corrections should be small (small sensitivity)

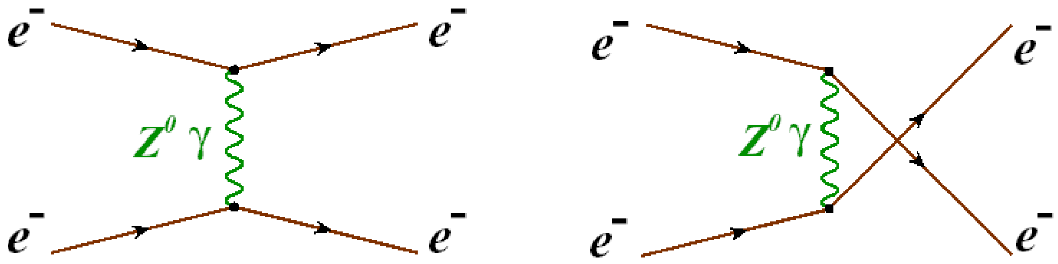
"MRST has performed a global analysis including possibility of isospin violation [...] this could potentially reduce NuTeV discrepancy by 1-1.5σ, although range of allowed isospin violation could also remove discrepancy altogether or make it worse [...] conclusion is that existing data allows level of isospin violation which could either solve NuTeV discrepancy or make it worse"

⇒If the theory error associated to the measurement does not account for this, it is underestimated

⇒Stay tuned for an update

http://home.fnal.gov/~gzeller/nutev.html#NLOQCDCorrections, linked from the main NuTeV page

$\sin\theta_W$: SLAC E158



$$A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$$

$$A_{PV} \propto (1 - 4\sin^2\theta_W)$$

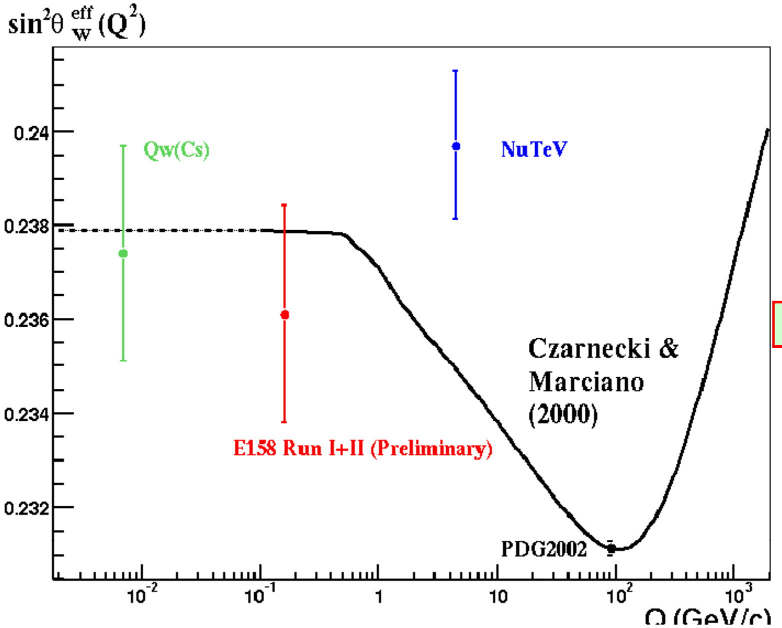
$$A_{PV}^{meas} = P_e \cdot A_{PV}$$

Parity violation in Moller scattering: at tree level $A_{PV}=-3\ 10^{-7}$

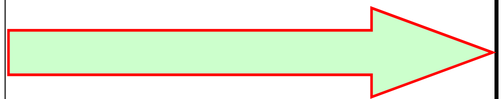
E158 goal: $\delta\sin^2\theta_W \sim 0.001$

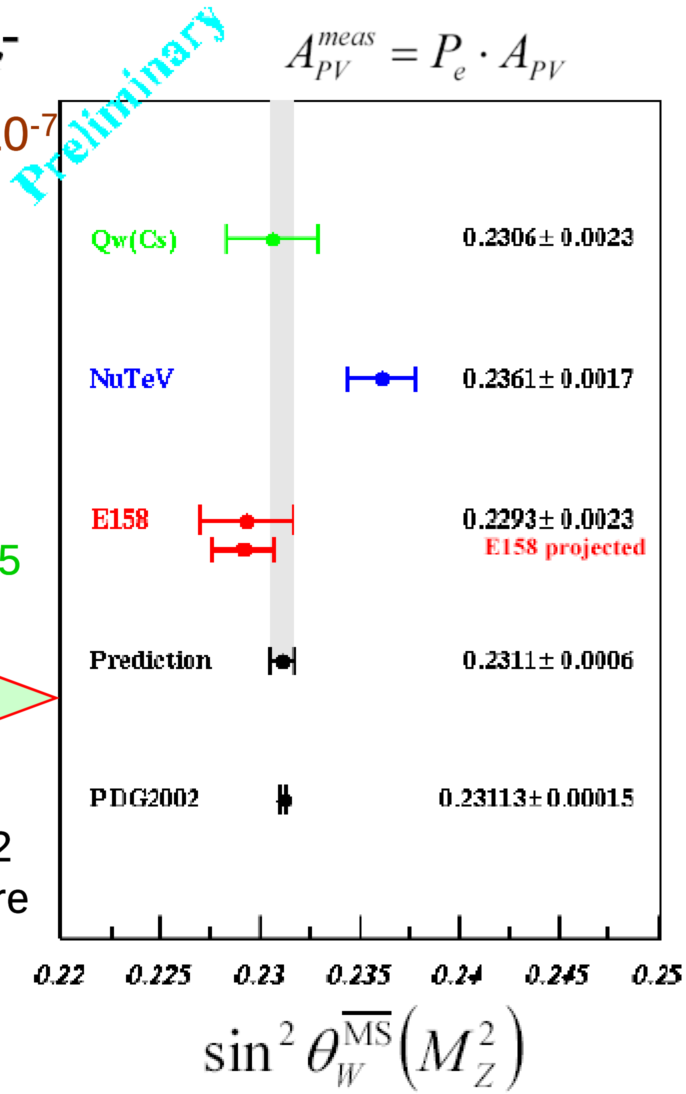
Best measurement of θ_W away from the Z pole

($E=48$ GeV; $Q^2=0.03$ GeV^2, beam polarisation ~ 85%)



Run III data being analysed: expect $\delta\sin^2\theta_W(m_Z^2) \sim 0.0015$ by Summer 2004

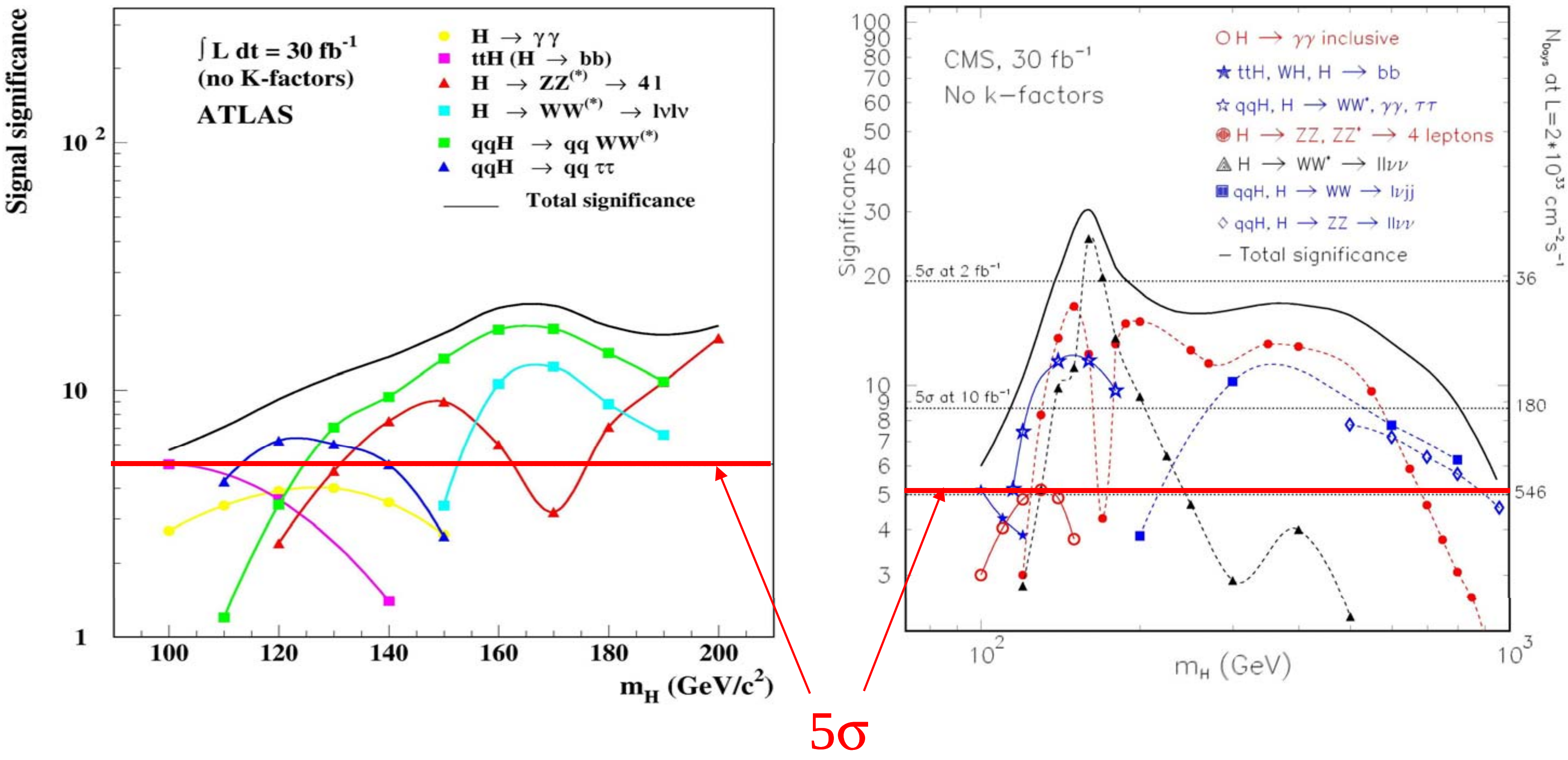




Other ideas for $\delta\sin^2\theta_W(Q^2 \sim 0) \sim 0.002$ at nuclear reactors are around...

$\sin^2\theta_W(Q^2=0.026\text{GeV}^2) = (0.2367 \pm 0.0017(\text{stat}) \pm 0.0014(\text{syst}))$

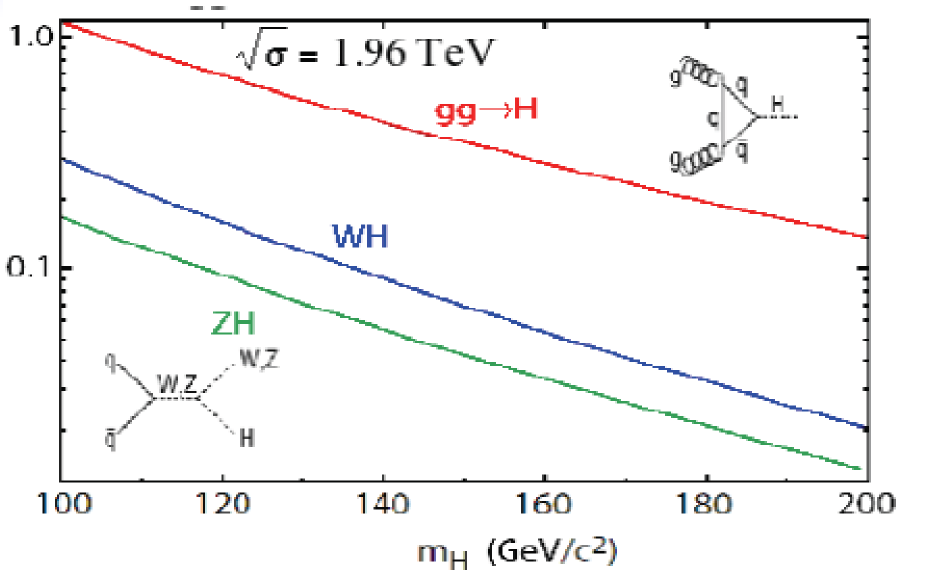
SM Higgs search at the LHC

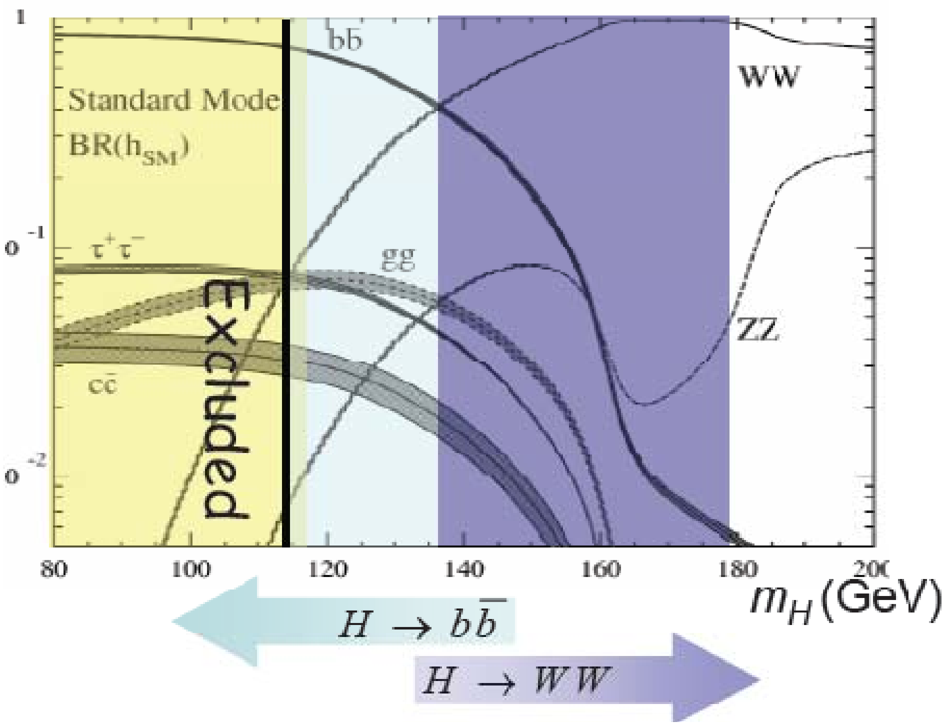


No holes in m_H coverage !

Discovery happens early in the game (the plots are for 30/fb)

Higgs boson branching ratios





The top mass case

Errors per experiment* (in GeV)

10 fb^{-1}, low lumi → qqbblν, qqbblν (high p_T), bblνlν, σ_{tt}

50 fb^{-1}, high lumi → qqbblν (+J/ψ)

	qqbbqq	qqbblν	qqbblν (high p_T)	bblνlν	σ_{tt}	qqbblν (+J/ψ)
statistical	0.2	0.1	0.3	0.5	<0.05	0.5
light jet E scale/res	2.0	0.8	<1.0?	-	1.0	negl.
b-jet E scale/res	0.8	0.8	0.6	0.7	1.0	negl.
Lepton E scale/res	-	negl.	?	negl	0.5	0.4
b-tagging	0.3	0	?	0.3?	1.3	-
background	2.0	0.1	0.1	0.1?	negl.	0.2
ISR/FSR	2.3	<1.0?	0.2?	1.0	0.8	0.6
b/q-fragmentation	0.9	0.3	0.1	0.7	1.6	0.7
Underlying Event	0.6	0.3	1.3	?	2.0	0.6
pdfs uncertainty	1.4	0.1	negl.	negl.	3.5	0.3
Total	<3.0?	<2.0?	<2.0?	<2.0?	<4.0?	<1.5?

(*) From the ATLAS PTDR and the CMS PTDR

Systematics will dominate our measurements
The ones from theory/modelling are very important

After one year of LHC

	Run IA	
Source	**Δm_W (CDF)**	**Δm_W (ATLAS)**
Statistics	145 MeV	< 2 MeV
E-*p* scale	120 MeV	15 MeV
Energy resolution	80 MeV	5 MeV
Lepton identification	25 MeV	5 MeV
Recoil model	60 MeV	5 MeV
W width	20 MeV	7 MeV
Parton distribution functions	50 MeV	10 MeV
Radiative decays	20 MeV	< 10 MeV
$p_T{}^W$	45 MeV	5 MeV
Background	10 MeV	5 MeV
TOTAL	230 MeV	25 MeV

Uncertainties per experiment per year and per lepton

The real improvement

Internal calibration from Z data mainly.
Need excellent control of energy flow+ momentum scale

15 MeV LHC combined will then be reached... still all is very challenging !!!

Constraining pdfs at the LHC

How? For an s-channel process (W, Z, W/ZW/Z, tt) $m^2=sx_1x_2$ and $y=1/2\ln(x_1/x_2)$

$$\frac{dN_X}{dy} = \frac{d\sigma_{qq,gg\to X}}{dy} \bullet L \bullet pdf_{qq,gg}(x_1,x_2;Q^2)$$

$\Rightarrow x_{1/2} = e^{\pm y}\, m/\sqrt{s}$

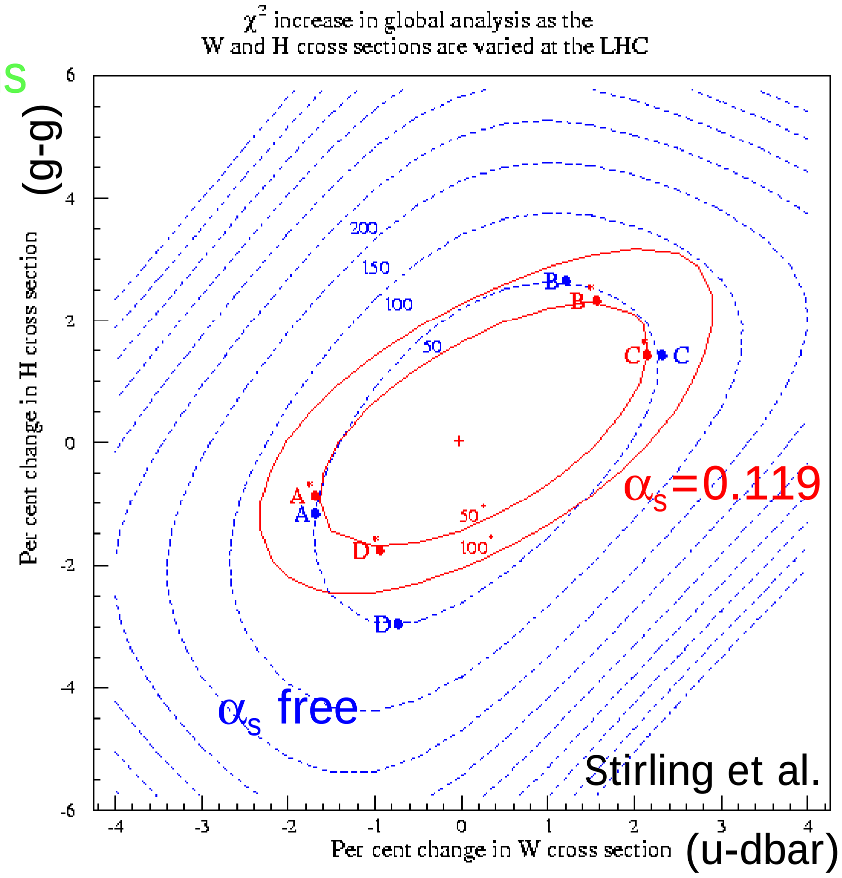
From the shape of y differential cross-sections we can constraint different pdfs
(one can measure L•pdf)

$\Rightarrow$ Single W, Z, W/ZW/Z can bring info on regions of x close to tt production
(q-antiq x range between 3 10^{-4} and 0.1)

$\Rightarrow$ γ or Z+jet can help in the q-g case
(g x range between 5 10^{-4} and 0.2)
($x_{b,c}$ range between 10^{-3} and 0.1)

$\Rightarrow$ W+jet can help for x_s

$\Rightarrow$ $d\sigma/dy(W^-)/d\sigma/dy(W^+) \approx d(x_1)/u(x_1)$ at large y



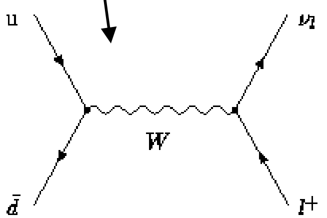
$\Rightarrow$ All the high Q^2 region is covered !
A few % on g and light quarks -syst. » stat.
And 5-10% on s, c, b might be reached

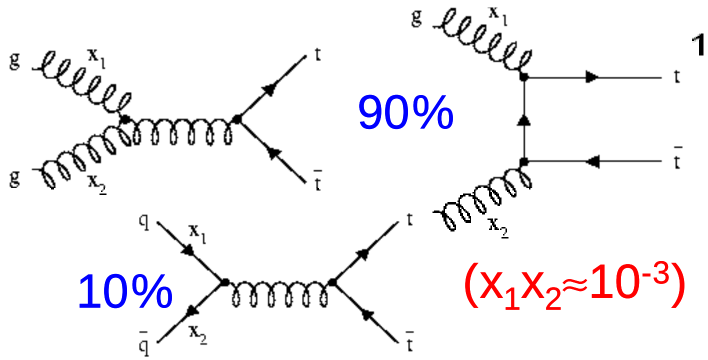
To which extent can we extrapolate from q-q $\leftrightarrow$ g-g?

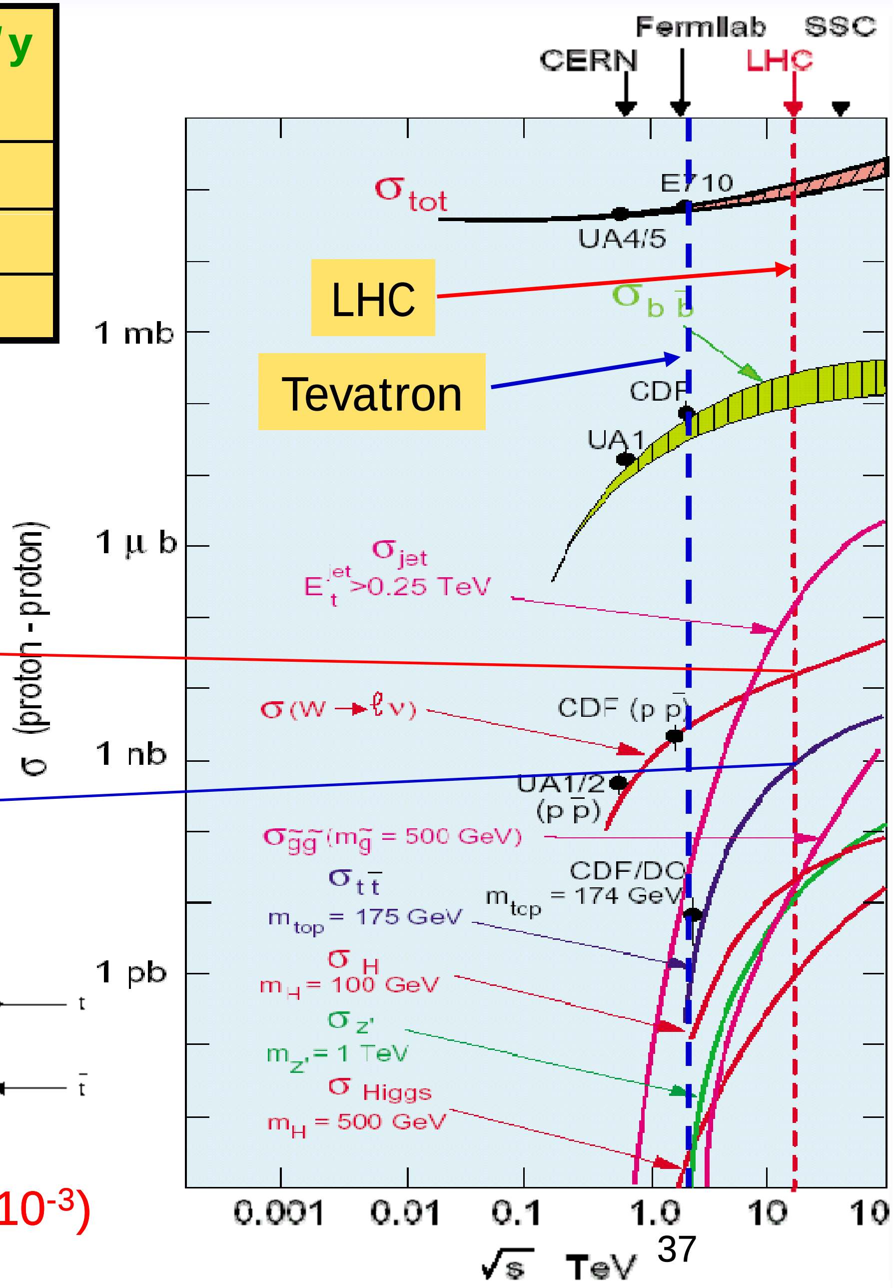
Expected statistics

	E_{CM} TeV	Lumi $cm^{-2}s^{-1}$	Int. Lumi/y fb^{-1}
TeVatron	2	$<10^{32}$	0.3
LHC(low lumi)	14	2×10^{33}	10
LHC(high lumi)	14	10^{34}	100

process	σ(pb)	Events/s	Events/y
bb	5×10^{8}	10^{6}	10^{12}
Z→ee	1.5×10^{3}	~3	10^{7}
W→eν	1.5×10^{4}	~30	10^{8}
WW→eνX	6	10^{-2}	6×10^{3}
tt	830	~2	10^{7}
H(700 GeV)	1	2×10^{-3}	10^{4}

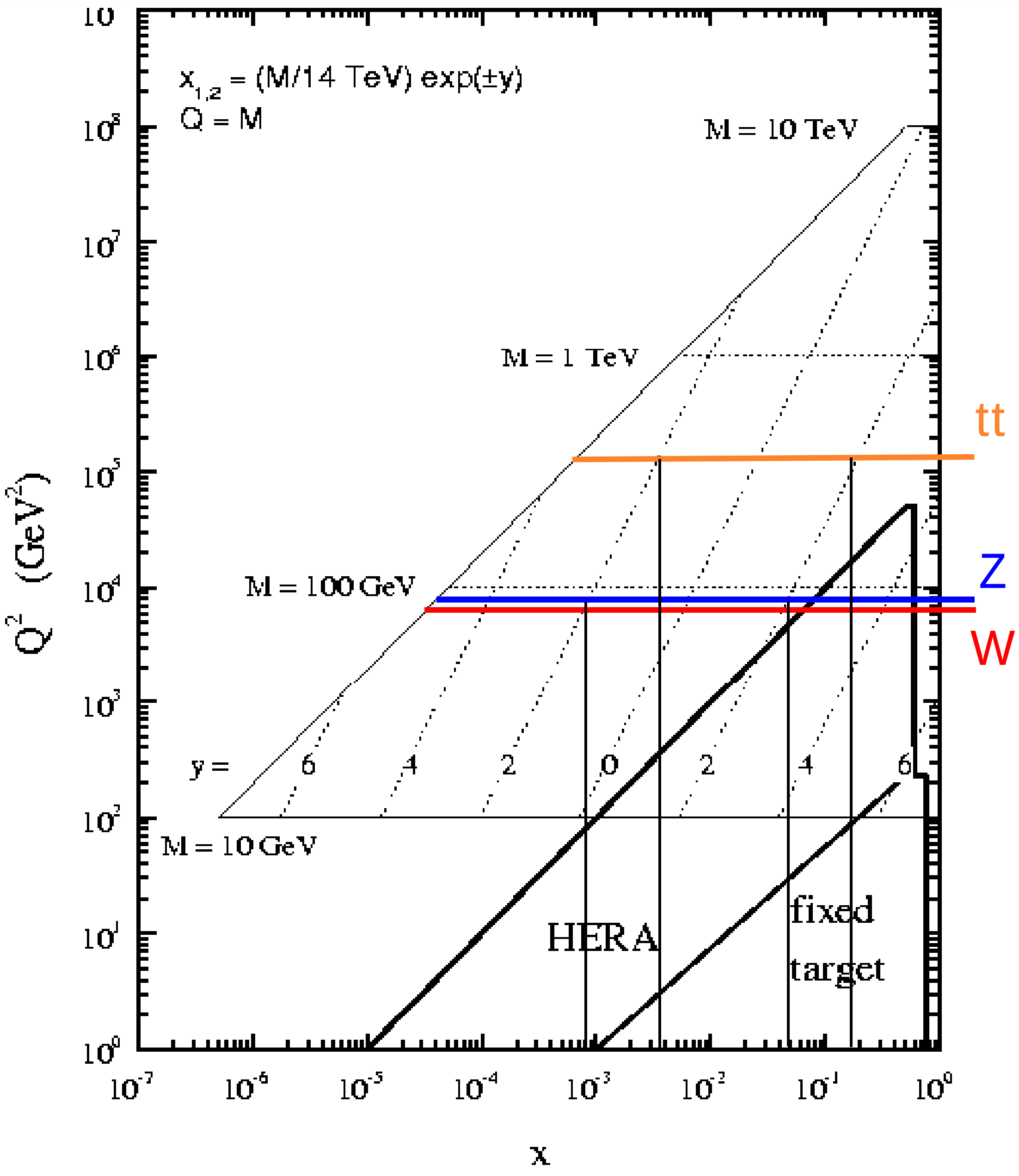


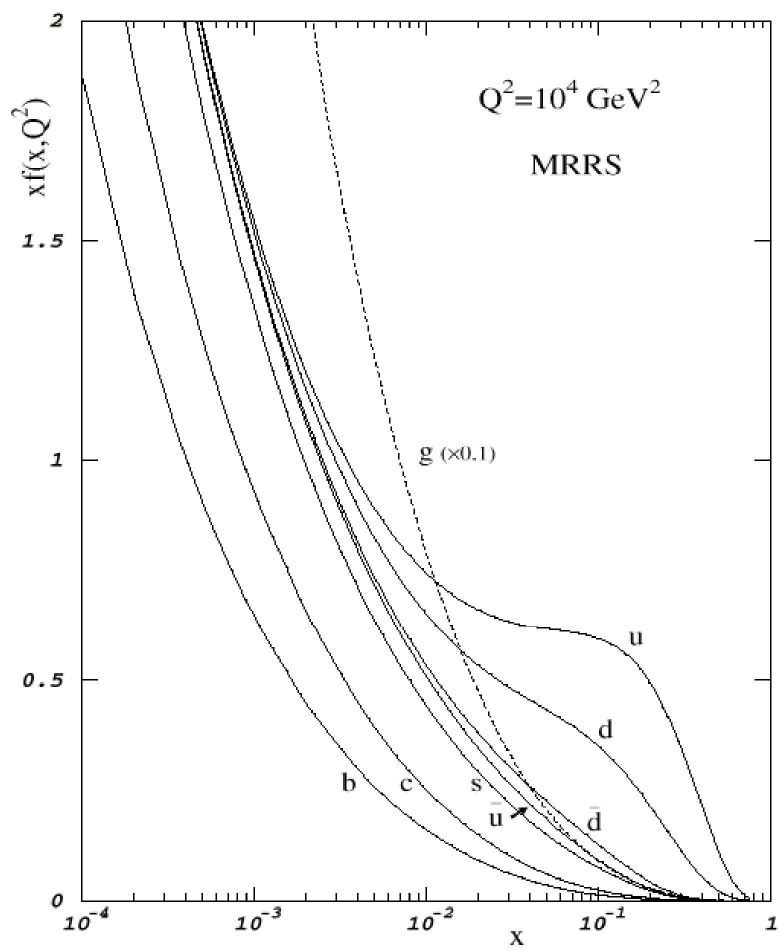




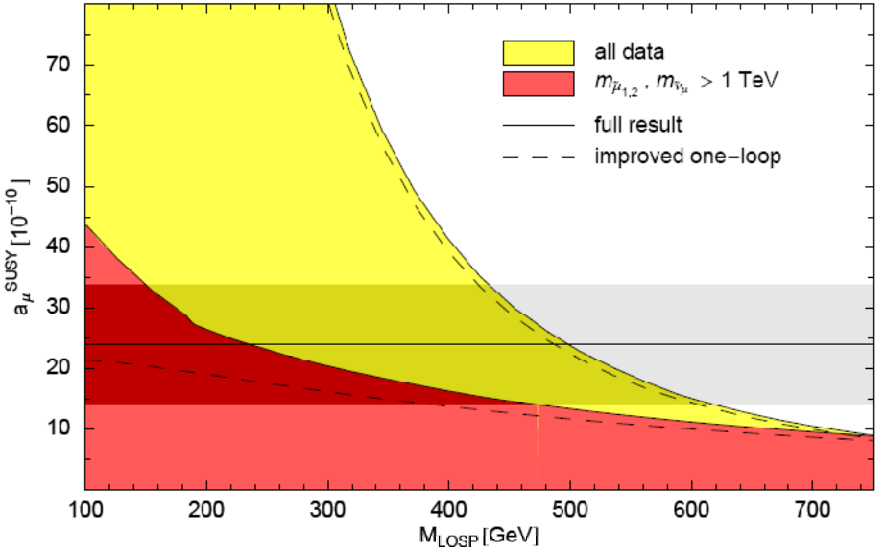
Roberto Chierici

LHC parton kinematics

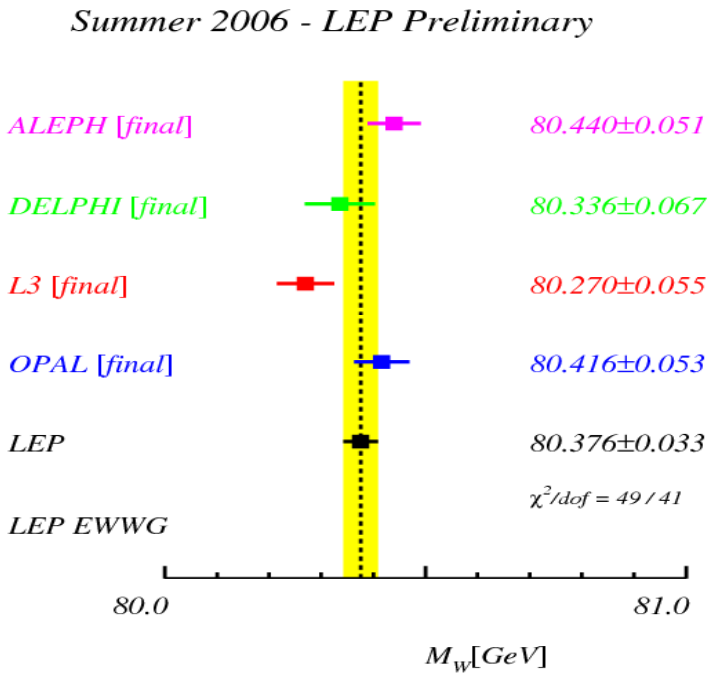




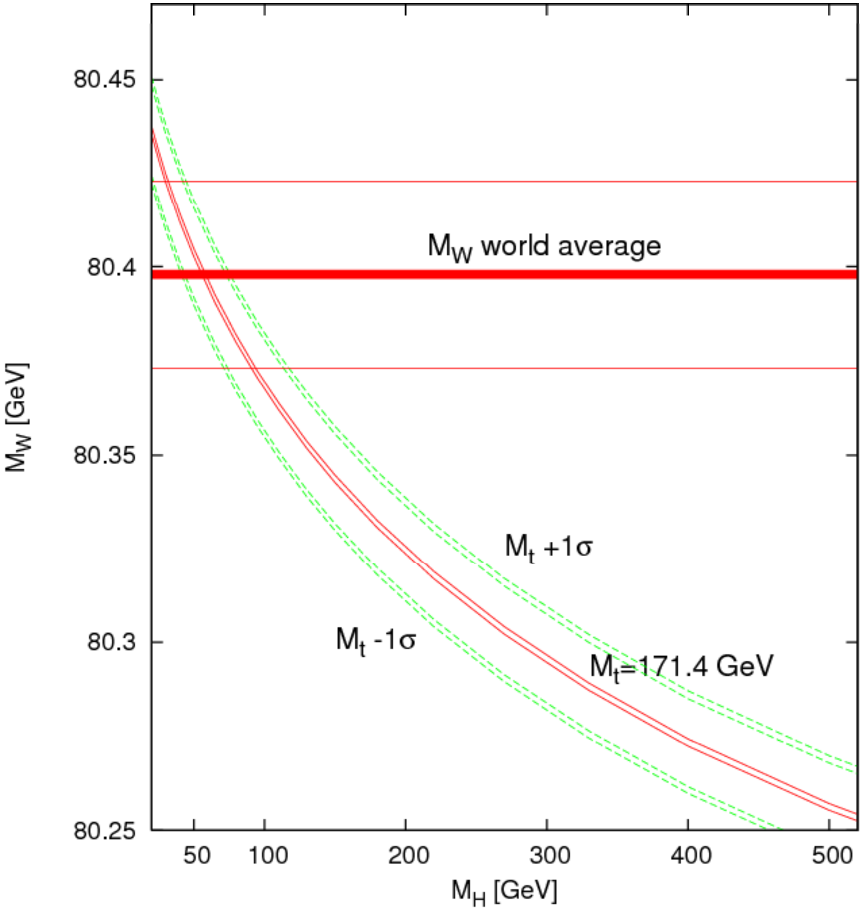
Plots...



all data
$m_{\tilde{\mu}_{1,2}}, m_{\tilde{\nu}_\mu} > 1$ TeV
full result
improved one−loop
a_μ^{SUSY} [10^{-10}]
70
60
50
40
30
20
10
100
200
300
400
500
600
700
M_{LOSP} [GeV]



Summer 2006 - LEP Preliminary
ALEPH [final]
80.440±0.051
DELPHI [final]
80.336±0.067
L3 [final]
80.270±0.055
OPAL [final]
80.416±0.053
LEP
80.376±0.033
$\chi^2/dof = 49/41$
LEP EWWG
80.0
81.0
M_W[GeV]



M_W world average
M_t +1σ
M_t -1σ
M_t=171.4 GeV
80.45
80.4
80.35
80.3
80.25
M_W [GeV]
50
100
200
300
400
500
M_H [GeV]