Covering the Standard Model in the LHC era

Wei-Ming Yao

LBNL Director's Review May 8 2013

Executive Summary

- The data evaluation and review articles have been essential for progress in particle physics, will continue so in the future.
- Search for new physics (BSM) is the primary goal of the LHC, but the SM measurements will provide precision tests in the regions never explored before.
- All discrepancies of the past are either gone or getting close to the SM predictions.
- The discovery of Higgs boson may complete the SM picture.
- But reasons for new physics are remaining (dark matter, naturalness, etc.).
- New focus of SM will be on newly discovered Higgs boson (EWSB) and deviations from overall consistency of SM.

SM Responsibilities

Listings

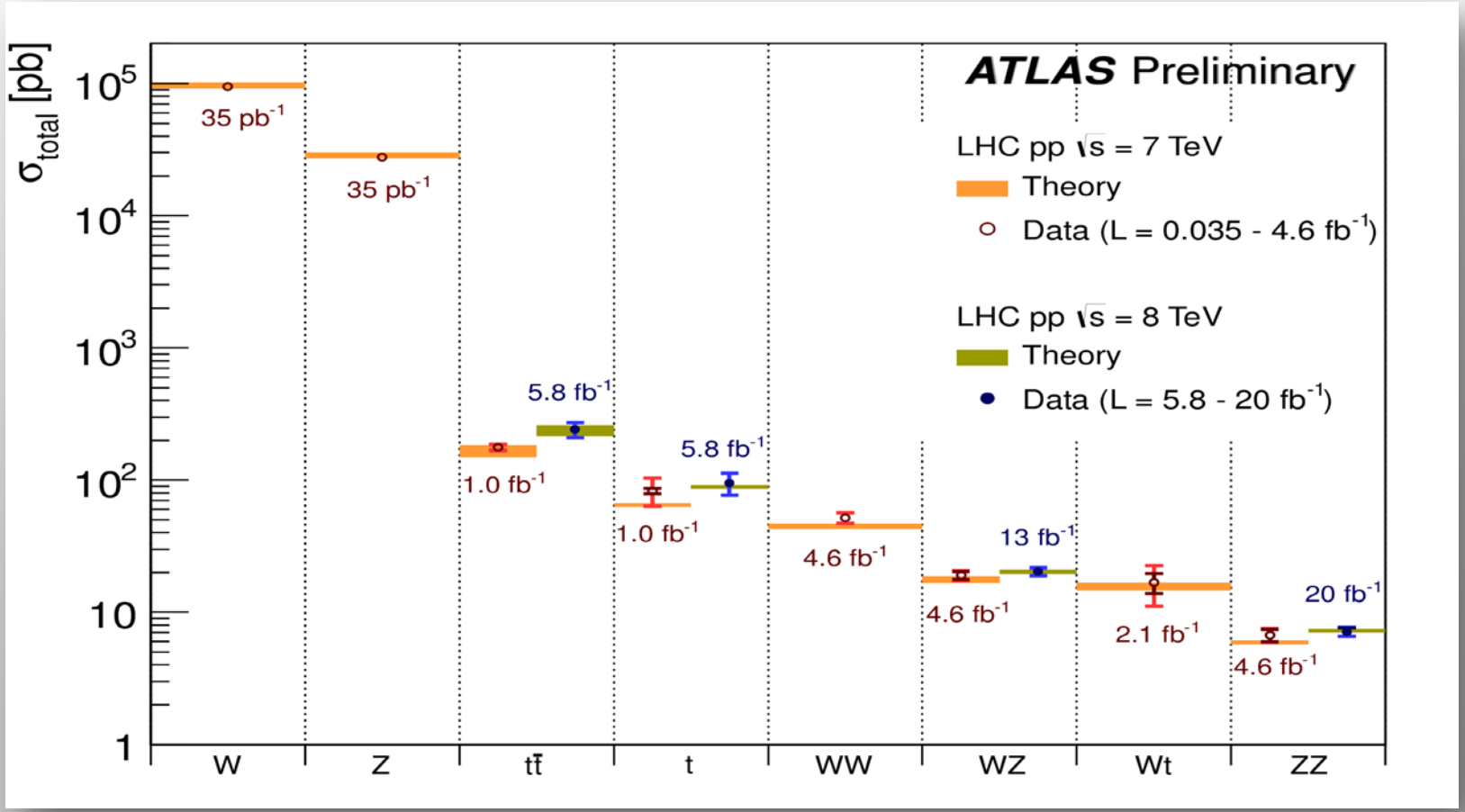
- Gauge and Higgs bosons (C. Grab, D.E. Groom*, A. Gurtu*, M. Grunewald, K. Hikasa, G. Weiglein*)
- Leptons (C. Grab, K.G. Hayes, K. Monig, neutrio team)
- Quarks (R.M. Barnett*, A.V. Manohar, W.-M. Yao*, K. Hagiwara)
- Mesons and Baryons (many authors)

Reviews

- Quantum Chromodynamics (S. Bethke, G. Dissertori, G.P. Salam)
- Electroweak model and constrains on BSM(J. Erler, P. Langacker)
- The CKM quark-mixing matrix(A. Ceccucci, Z. Ligeti, Y. Sakai)
- CP Violations (T. Gershon, D. Kirkby, Y. Nir)
- Heavy-Quark & Soft-Collinear Eff. Theory (C. Bauer, M. Neubert)
- Lattice QCD (S. Hashimoto, J. Laiho, S.R. Sharpe)
- Much more at http://pdg.lbl.gov

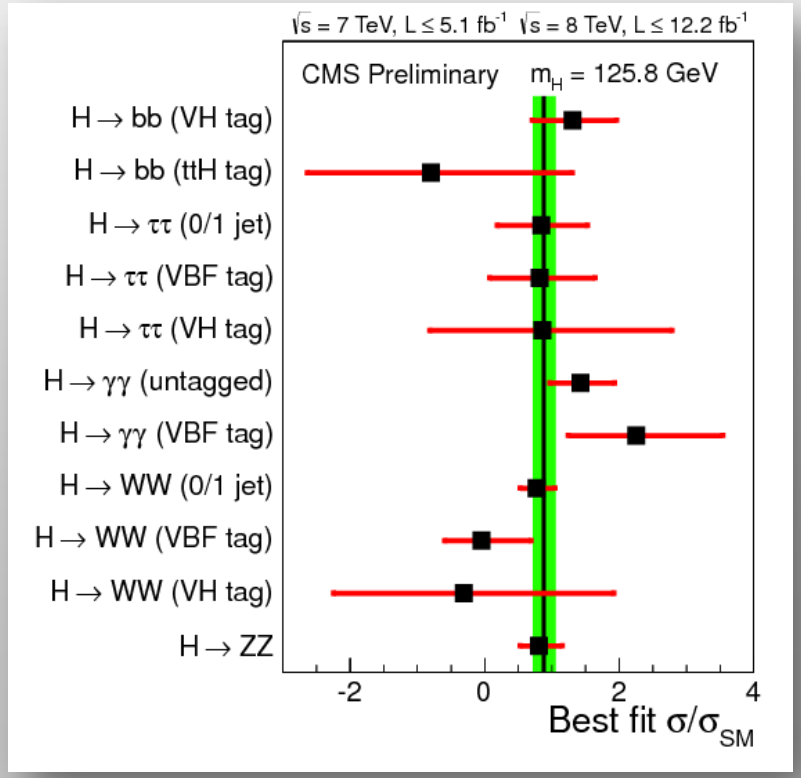
Rediscovery SM @LHC

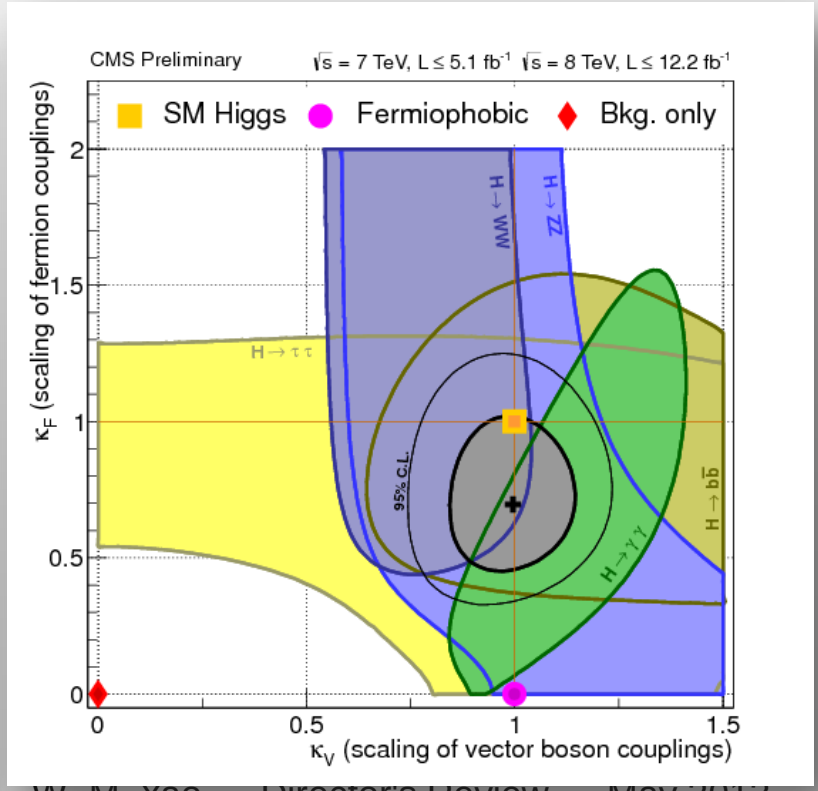
LHC is doing extremely well and will provide precision tests of SM predictions at the unprecedented level.



Higgs Boson

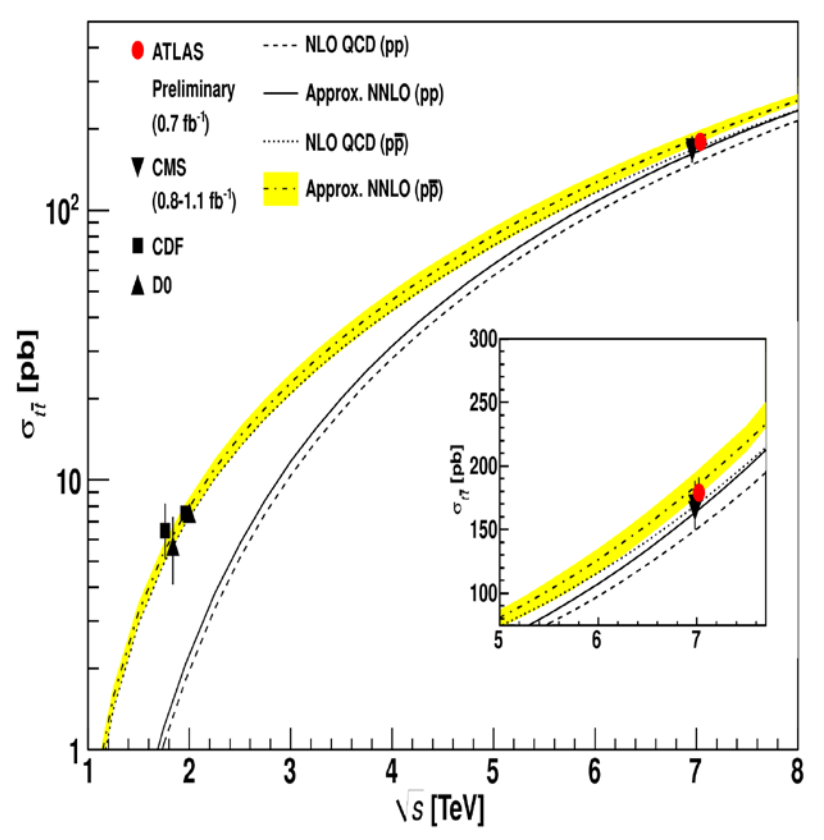
- The observation of a Higgs boson at 125 GeV marks an important step towards understanding of EWSB.
- The new boson seems SM-like, but we want to measure precisely its mass, spin-parity, coupling, and decays.

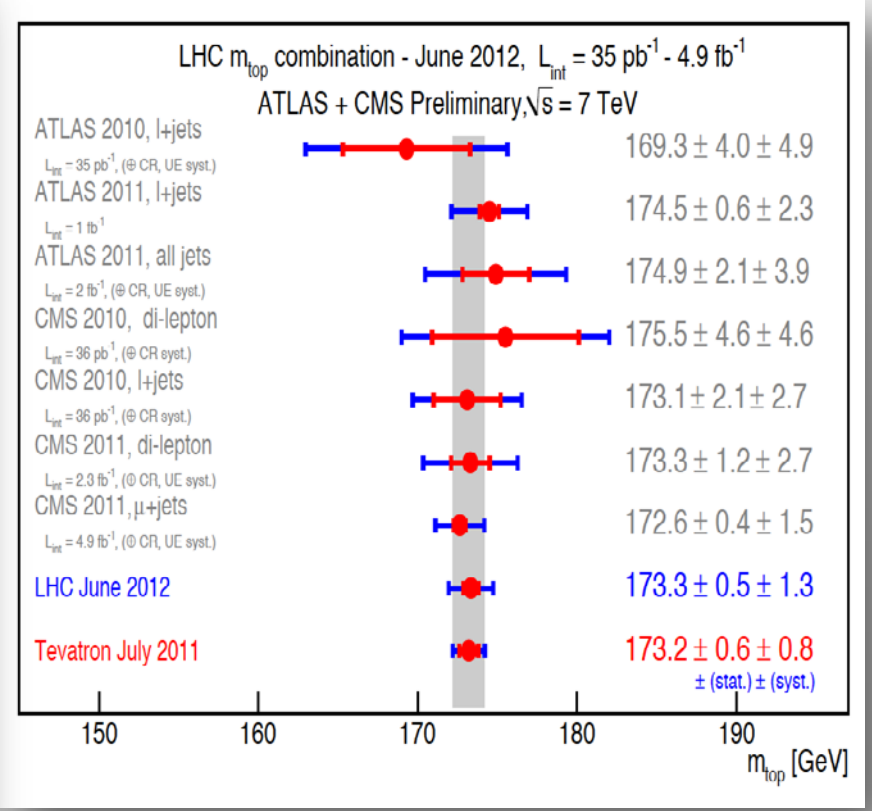




Top Quark

- As heaviest quark, top quark may play special role in EWSB.
- LHC will provide precision test of top production and decay.
- Top quark review is under major revision in post-Higgs era.

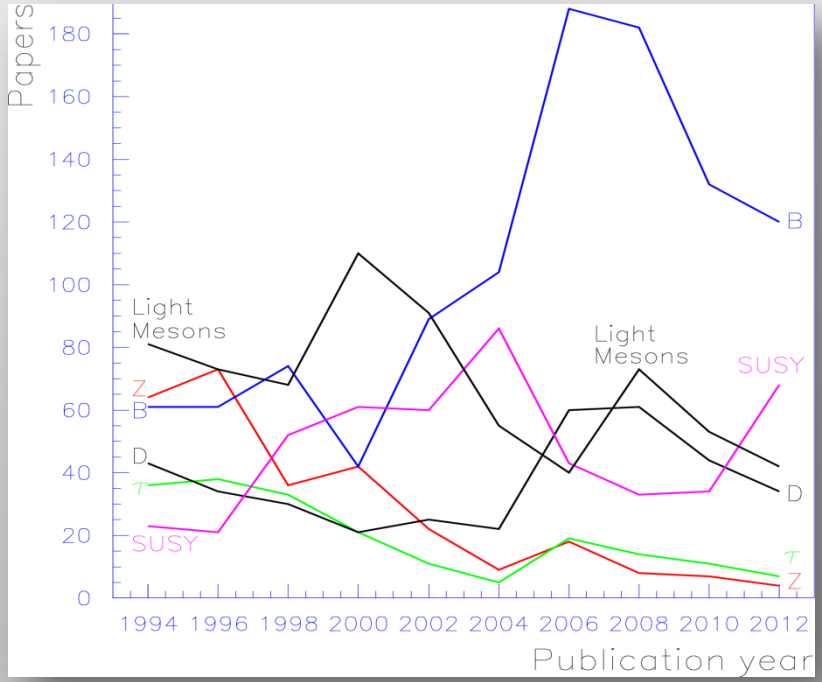


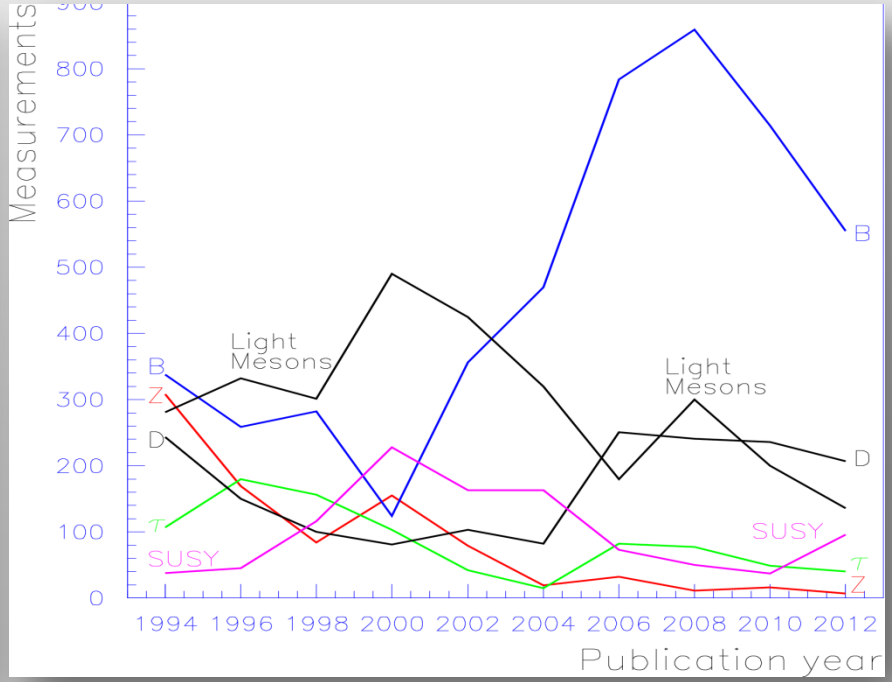


Heavy Flavor Physics

B physics continues to be the most productive field in RPP.

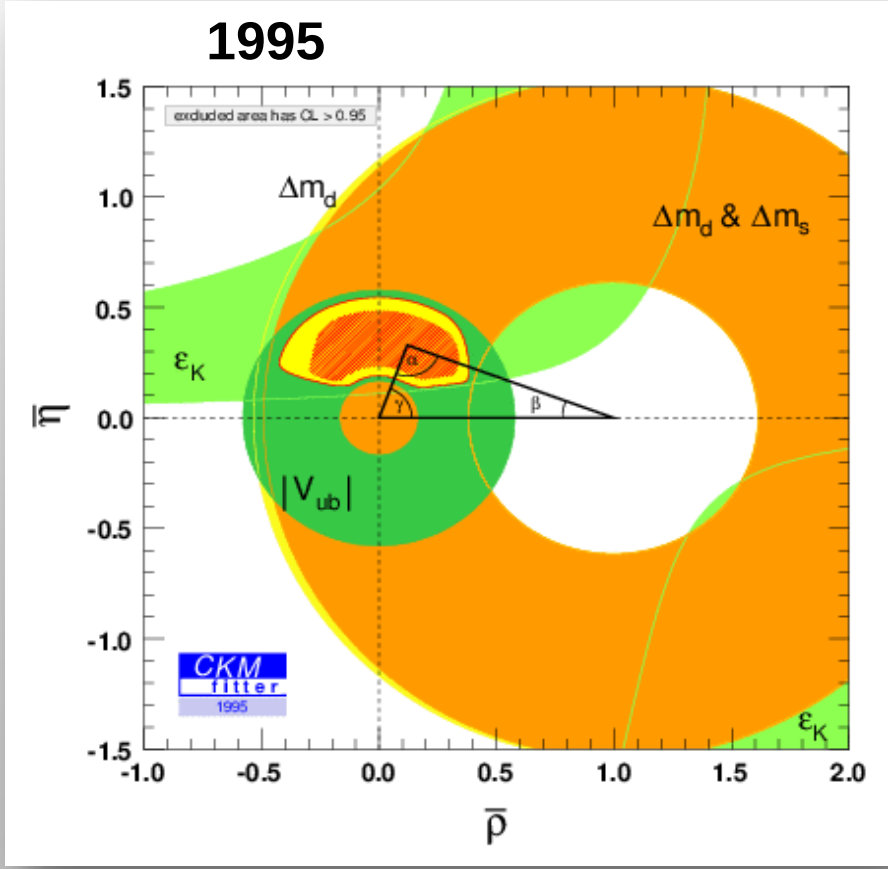
- Including first LHCb results, the first evidence of $B_s \rightarrow \mu^+\mu^-$.
- Much more precise measurements and fewer anomalies.
- All data are consistent with SM so far.

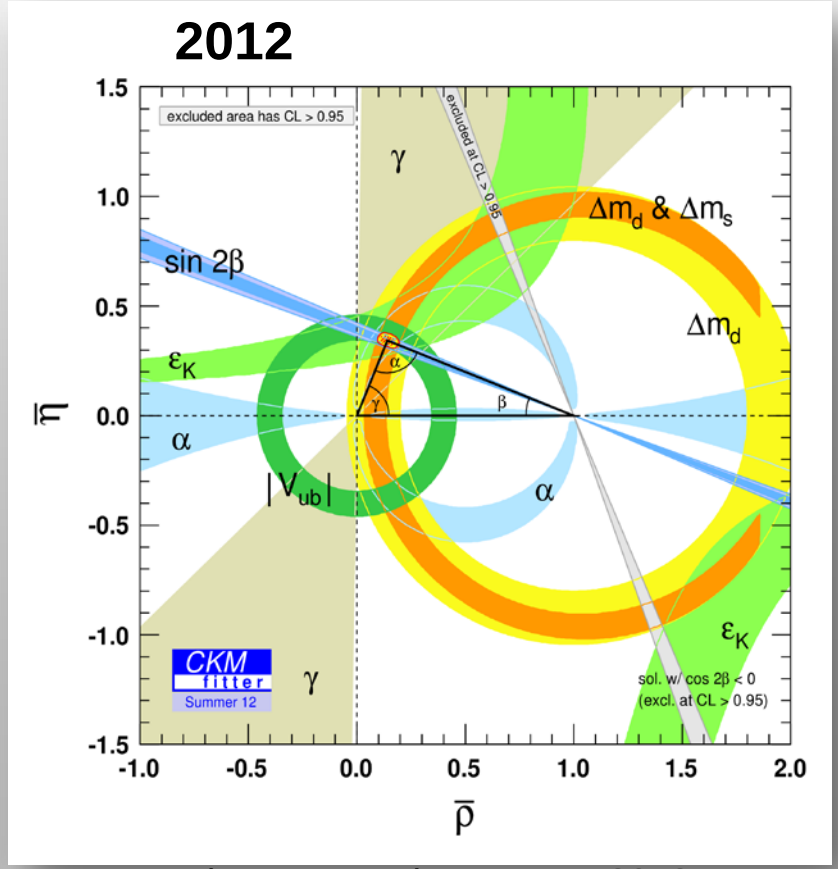




CKM Matrix Elements

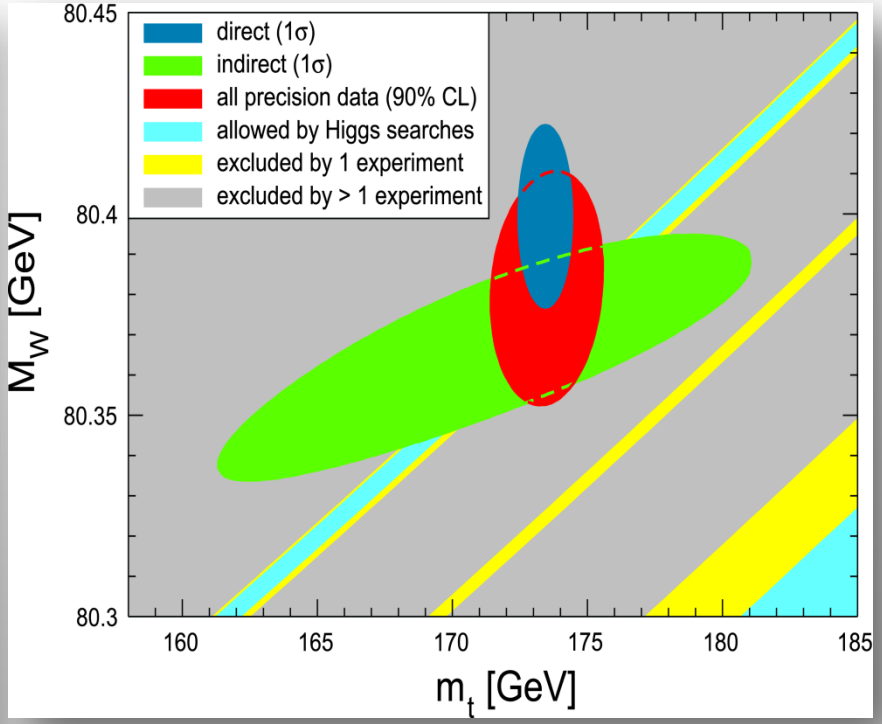
- All CP-violation manifestations in decays are from one single complex phase in flavor-changing transitions of quarks.
- There is huge progress made from 1995 to 2012.





ElectroWeak Global Fit: Present and Future

Quantity	Value	Standard Model	Pull	Dev.
M_Z [GeV]	91.1876 ± 0.0021	91.1874 ± 0.0021	0.1	0.0
Γ_Z [GeV]	2.4952 ± 0.0023	2.4961 ± 0.0010	−0.4	−0.2
Γ(had) [GeV]	1.7444 ± 0.0020	1.7426 ± 0.0010	—	—
Γ(inv) [MeV]	499.0 ± 1.5	501.69 ± 0.06	—	—
$\Gamma(\ell^+\ell^-)$ [MeV]	83.984 ± 0.086	84.005 ± 0.015	—	—
$\sigma_{\rm had}$[nb]	41.541 ± 0.037	41.477 ± 0.009	1.7	1.7
R_e	20.804 ± 0.050	20.744 ± 0.011	1.2	1.3
R_μ	20.785 ± 0.033	20.744 ± 0.011	1.2	1.3
R_τ	20.764 ± 0.045	20.789 ± 0.011	−0.6	−0.5
R_b	0.21629 ± 0.00066	0.21576 ± 0.00004	0.8	0.8
R_c	0.1721 ± 0.0030	0.17227 ± 0.00004	−0.1	−0.1
$A_{FB}^{(0,e)}$	0.0145 ± 0.0025	0.01633 ± 0.00021	−0.7	−0.7
$A_{FB}^{(0,\mu)}$	0.0169 ± 0.0013		0.4	0.6
$A_{FB}^{(0,\tau)}$	0.0188 ± 0.0017		1.5	1.6
$A_{FB}^{(0,b)}$	0.0992 ± 0.0016	0.1034 ± 0.0007	−2.6	−2.3
$A_{FB}^{(0,c)}$	0.0707 ± 0.0035	0.0739 ± 0.0005	−0.9	−0.8
$A_{FB}^{(0,s)}$	0.0976 ± 0.0114	0.1035 ± 0.0007	−0.5	−0.5
$\bar{s}^2_\ell(A_{FB}^{(0,q)})$	0.2324 ± 0.0012	0.23146 ± 0.00012	0.8	0.7
	0.23200 ± 0.00076		0.7	0.6
	0.2287 ± 0.0032		−0.9	−0.9
A_e	0.15138 ± 0.00216	0.1475 ± 0.0010	1.8	2.1
	0.1544 ± 0.0060		1.1	1.3
	0.1498 ± 0.0049		0.5	0.6
A_μ	0.142 ± 0.015		−0.4	−0.3
A_τ	0.136 ± 0.015		−0.8	−0.7
	0.1439 ± 0.0043		−0.8	−0.7
A_b	0.923 ± 0.020	0.9348 ± 0.0001	−0.6	−0.6
A_c	0.670 ± 0.027	0.6680 ± 0.0004	0.1	0.1
A_s	0.895 ± 0.091	0.9357 ± 0.0001	−0.4	− 0.4



- Present precision is limited by M_W.
- ILC/TLEP would improve M_W, M_{top}, M_H significantly and provide precision test of EWSB.

Prospects for 2014 Edition

- Continue to work with outsider working groups for providing the world best averages.
  - Newly formed LHC working groups: Higgs, top, etc
  - Tevatron Electroweak Working group (TEVEWWG)
  - Heavy Flavor Averaging Group (HFAG)
- Planning for most updated reviews and mini-reviews:
  - Higgs, EWK, QCD, CKM, CPV
  - Heavy Flavor Physics (top, B, D, Mixing, Vub, Vcb)
- All data are consistent with SM and BSM may show up soon!
- Will continue to meet the challenges in the LHC era.