

SM and QCD Reviews

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Outline:

Electroweak Model review

QCD review

Both topics won **Nobel Prizes** for the theory

Electroweak Model (or Standard Model)

- **Glashow, Salam, Weinberg**

Quantum Chromodynamics

- **Gross, Politzer, Wilczek**

10. Electroweak Model and Constraints on New Physics

Revised March 2018 by J. Erler (U. Mexico) and A. Freitas (Pittsburgh U.).

- 10.1 Introduction
- 10.2 Renormalization and radiative corrections
- 10.3 Low energy electroweak observables
- 10.4 W and Z boson physics
- 10.5 Precision flavor physics
- 10.6 Experimental results
- 10.7 Constraints on new physics

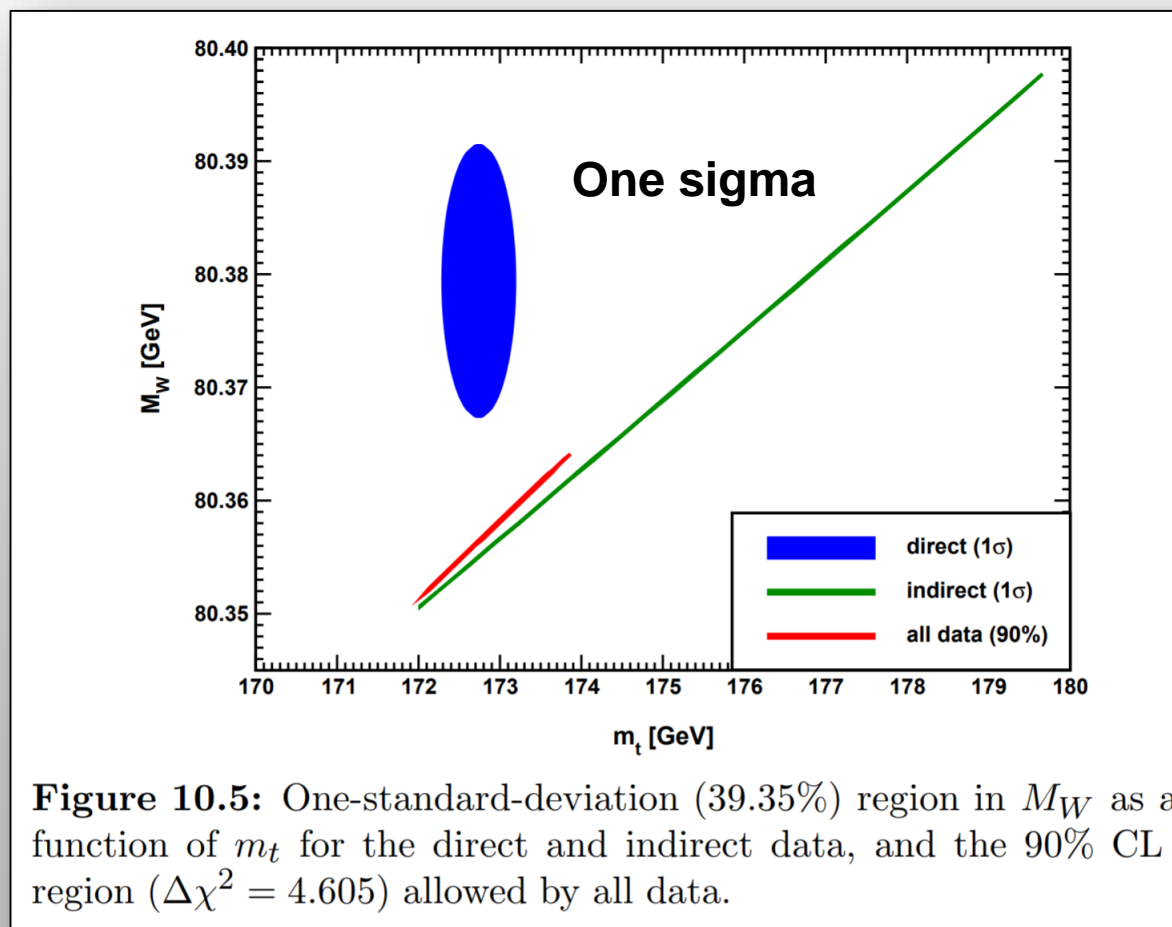
A large part are extensive **fits** to the electroweak data **and** examining for signs of inconsistencies and evidence for physics beyond the standard model.

I think first such fit done by M. Barnett and L. Abbott in 1978.

Since 1988 written by **Paul Langacker** and later joined by **Jens Erler**. Paul retired two editions ago, so to maintain and improve the review, we recruited **Ayres Freitas** to join Erler.

Freitas is a professor at the University of Pittsburgh and is one of the world experts on multi-loop EW radiative corrections.

I have asked them to update this figure to include two sigma bounds to show that the inconsistency is only two sigma.



Weinberg
angle,

α_s ,

$m(t)$,

$m(H)$,

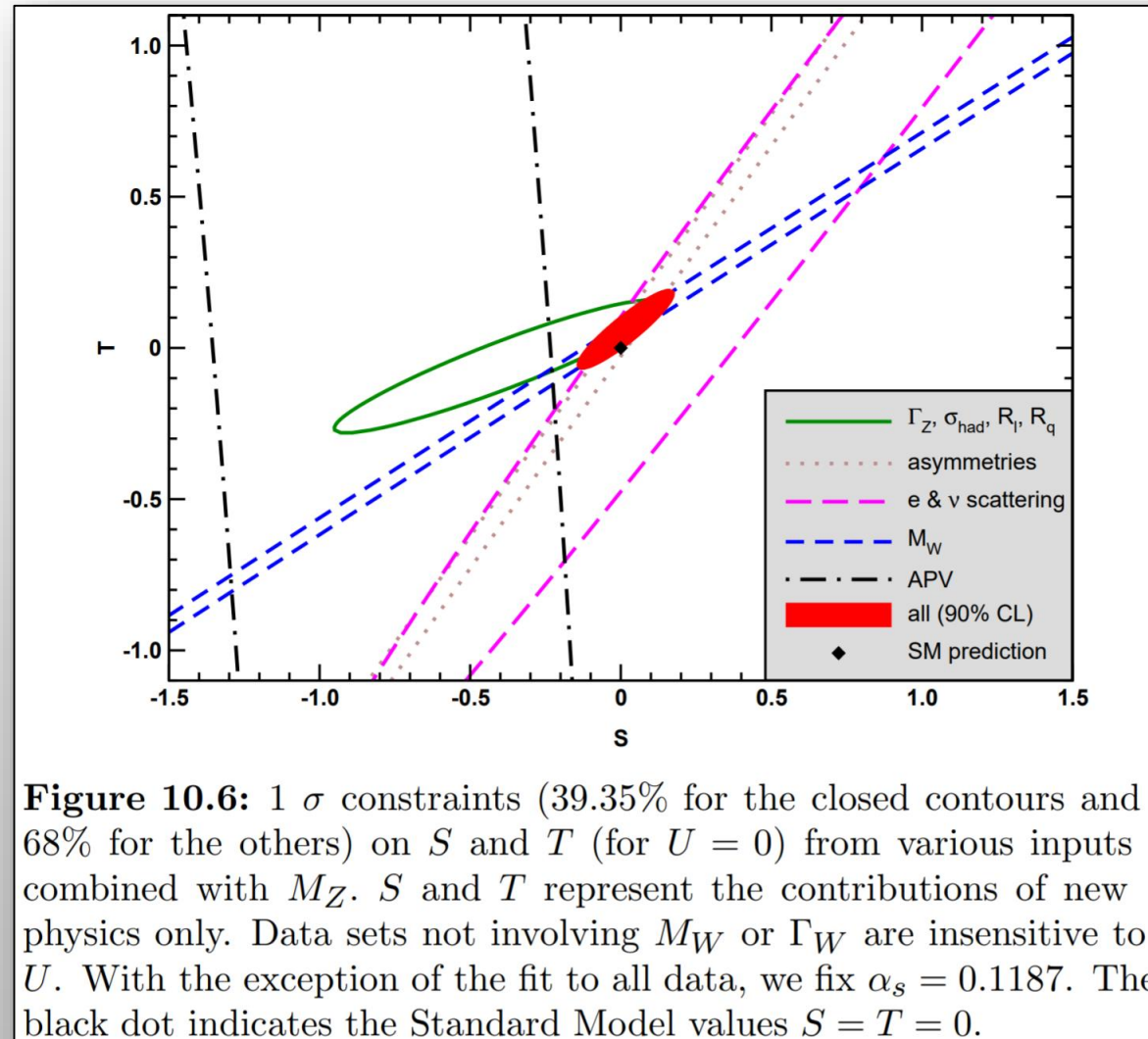
etc.

Table 10.7: Values of \hat{s}_Z^2 , s_W^2 , α_s , m_t and M_H [both in GeV] for various data sets. In the fit to the LHC (Tevatron) data the α_s constraint is from the $t\bar{t}$ production [204] (inclusive jet [205]) cross-section.

| Data | \hat{s}_Z^2 | s_W^2 | $\alpha_s(M_Z)$ | m_t | M_H |
|--------------------------------------|---------------|-------------|-----------------|-----------------|---------------------|
| All data | 0.23122(3) | 0.22332(7) | 0.1187(16) | 173.0 ± 0.4 | 125 |
| All data except M_H | 0.23107(9) | 0.22310(19) | 0.1190(16) | 172.8 ± 0.5 | 90_{-16}^{+17} |
| All data except M_Z | 0.23113(6) | 0.22336(8) | 0.1187(16) | 172.8 ± 0.5 | 125 |
| All data except M_W | 0.23124(3) | 0.22347(7) | 0.1191(16) | 172.9 ± 0.5 | 125 |
| All data except m_t | 0.23112(6) | 0.22304(21) | 0.1191(16) | 176.4 ± 1.8 | 125 |
| M_H, M_Z, Γ_Z, m_t | 0.23125(7) | 0.22351(13) | 0.1209(45) | 172.7 ± 0.5 | 125 |
| LHC | 0.23110(11) | 0.22332(12) | 0.1143(24) | 172.4 ± 0.5 | 125 |
| Tevatron + M_Z | 0.23102(13) | 0.22295(30) | 0.1160(45) | 174.3 ± 0.7 | 100_{-26}^{+31} |
| LEP | 0.23138(17) | 0.22343(47) | 0.1221(31) | 182 ± 11 | 274_{-152}^{+376} |
| SLD + M_Z, Γ_Z, m_t | 0.23064(28) | 0.22228(54) | 0.1182(47) | 172.7 ± 0.5 | 38_{-21}^{+30} |
| $A_{FB}^{(b,c)}, M_Z, \Gamma_Z, m_t$ | 0.23190(29) | 0.22503(69) | 0.1278(50) | 172.7 ± 0.5 | 348_{-124}^{+187} |
| $M_{W,Z}, \Gamma_{W,Z}, m_t$ | 0.23103(12) | 0.22302(25) | 0.1192(42) | 172.7 ± 0.5 | 84_{-19}^{+22} |
| low energy + $M_{H,Z}$ | 0.23176(94) | 0.2254(35) | 0.1185(19) | 156 ± 29 | 125 |

Red area is 90% CL and consistent with $S=T=0$ (SM).

Black dot
is SM.



**Written by Sigi Bethke, Guenther Dissertori, and Gavin Salam
for ten years**

9. Quantum Chromodynamics

Revised September 2017 by S. Bethke (Max-Planck-Institute of Physics, Munich),
G. Dissertori (ETH Zurich), and G.P. Salam (CERN).¹

Bethke, Dissertori, and Salam requested to “retire” after ten years.

After long discussions and consultations, we recruited:

- Joey Huston (ATLAS),
- Klaus Rabbertz (CMS),
- Guilia Zanderighi (theory)

Large part is determination of α_s and the review examines this in great detail.

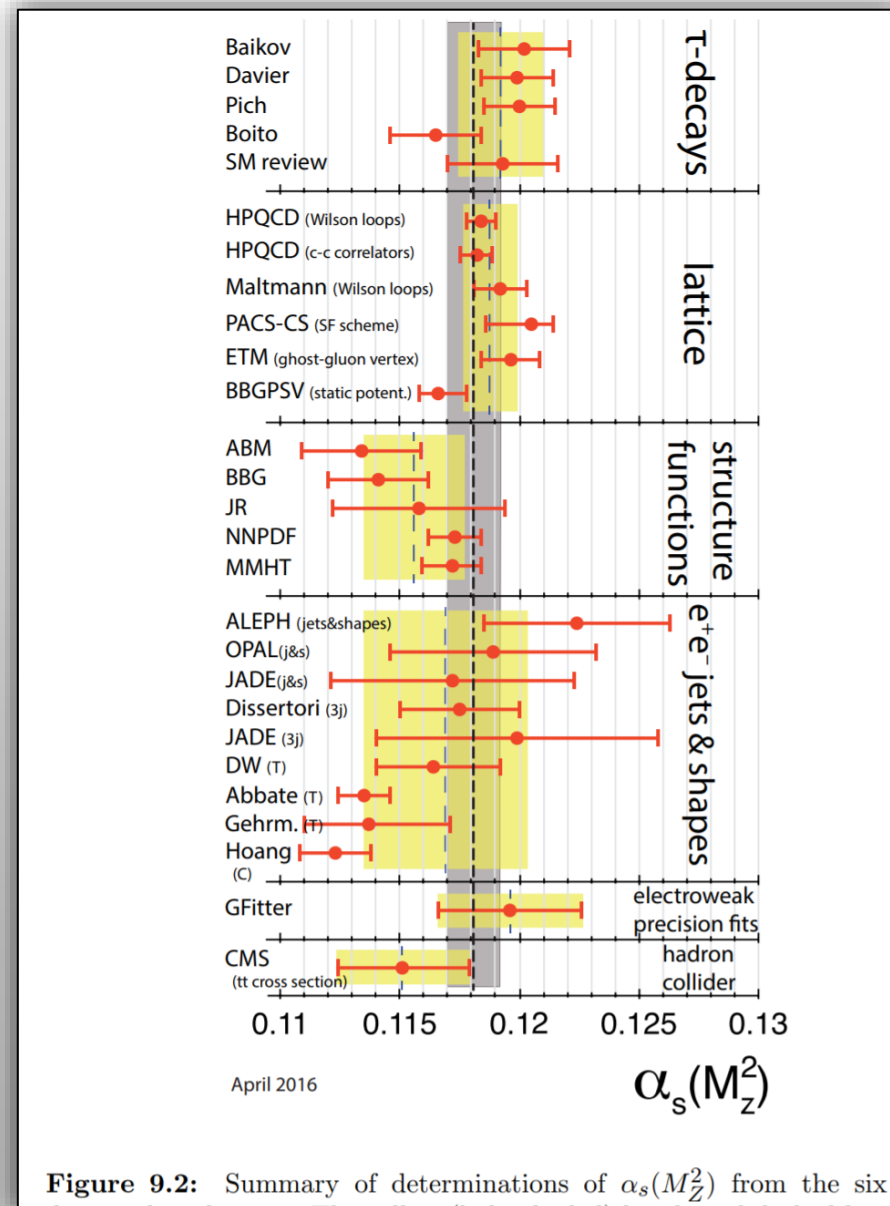
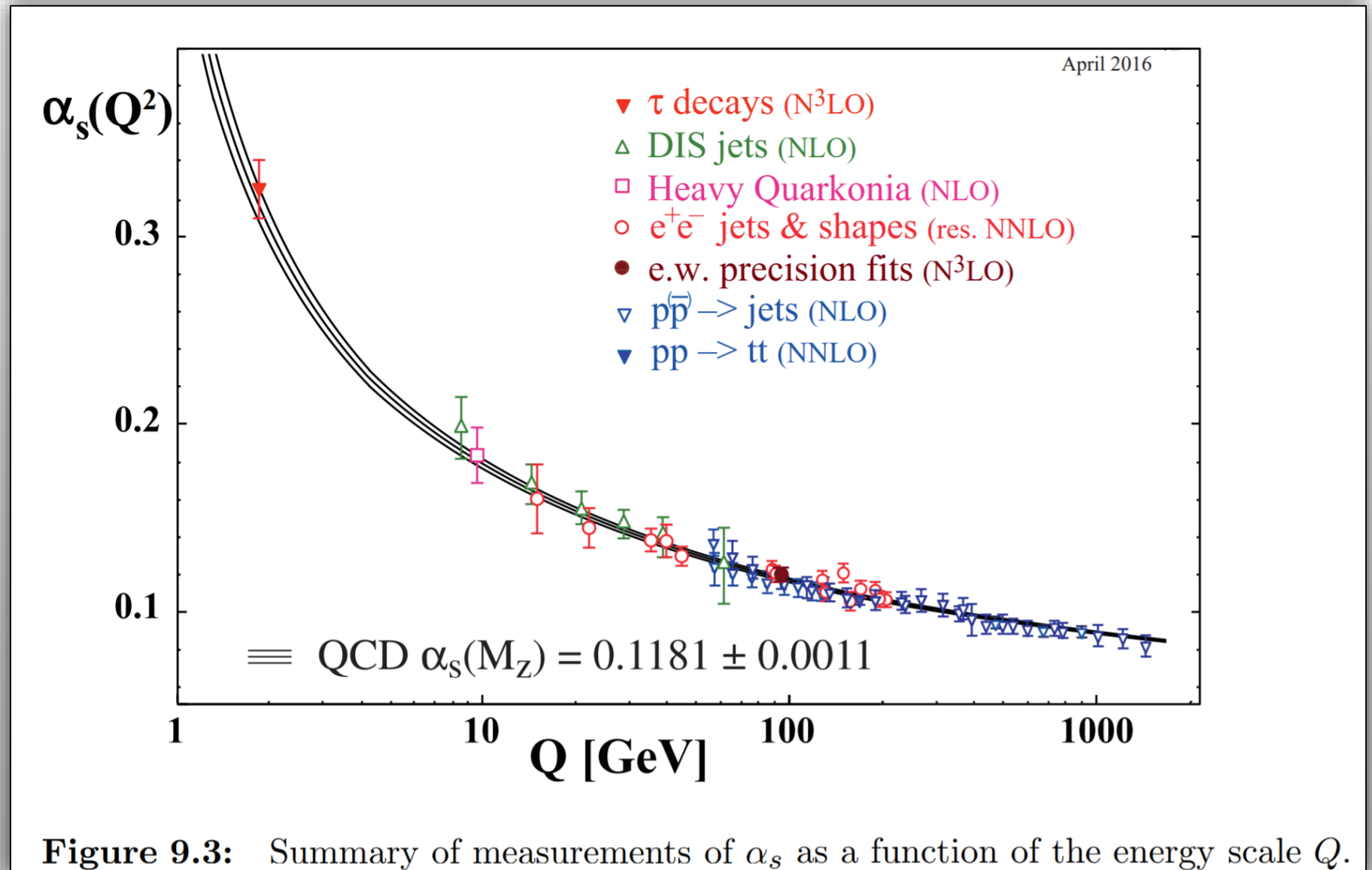


Figure 9.2: Summary of determinations of $\alpha_s(M_Z^2)$ from the six

Running of α_s



Electroweak review

- In good shape, almost no complaints.
- A little fine tuning is coming.
- Adding a new author was helpful.

Quantum Chromodynamics review

- Previous authors did excellent job for ten years.
- New authors for next edition after dedicated search.