Running EW Couplings

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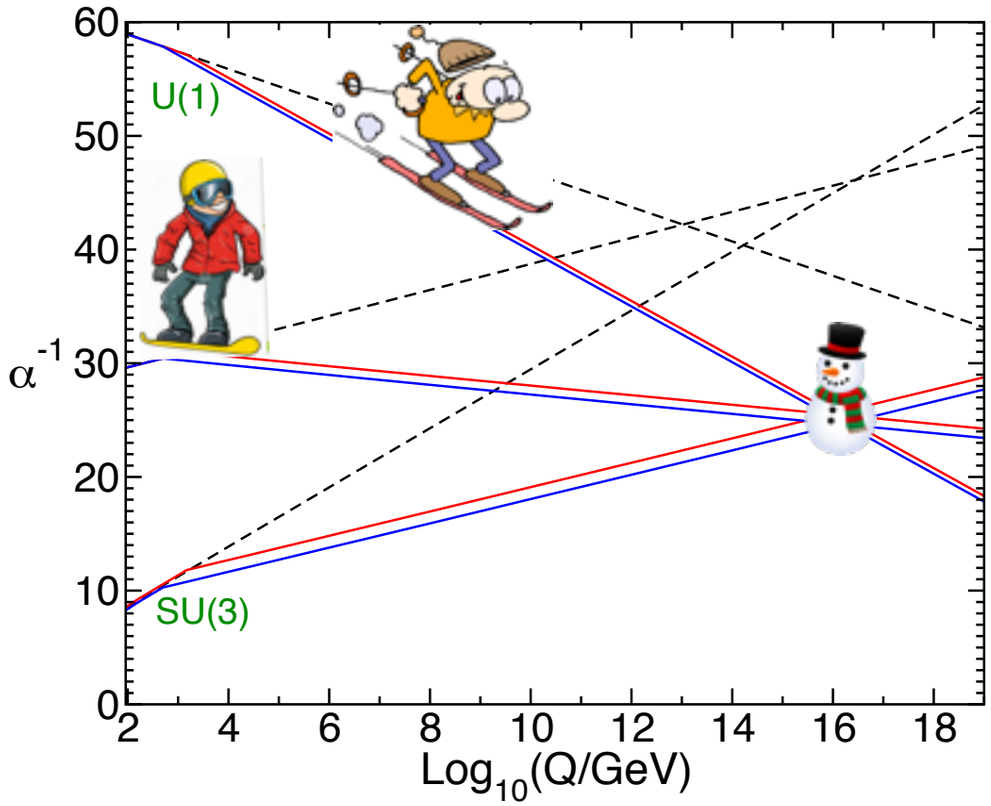
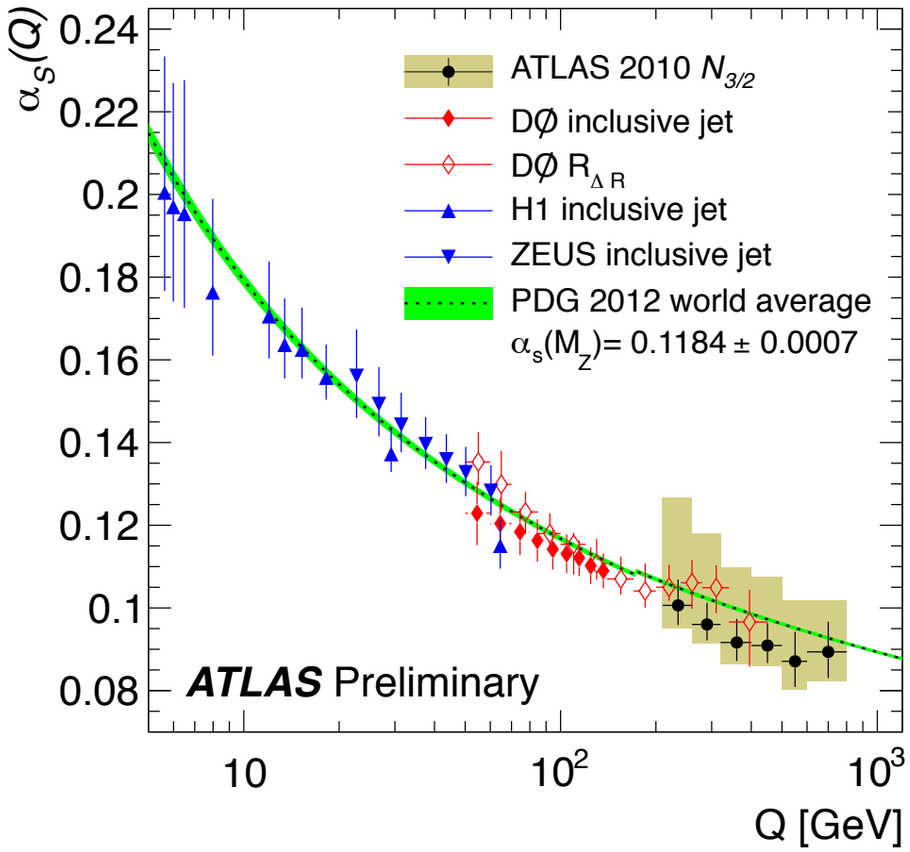
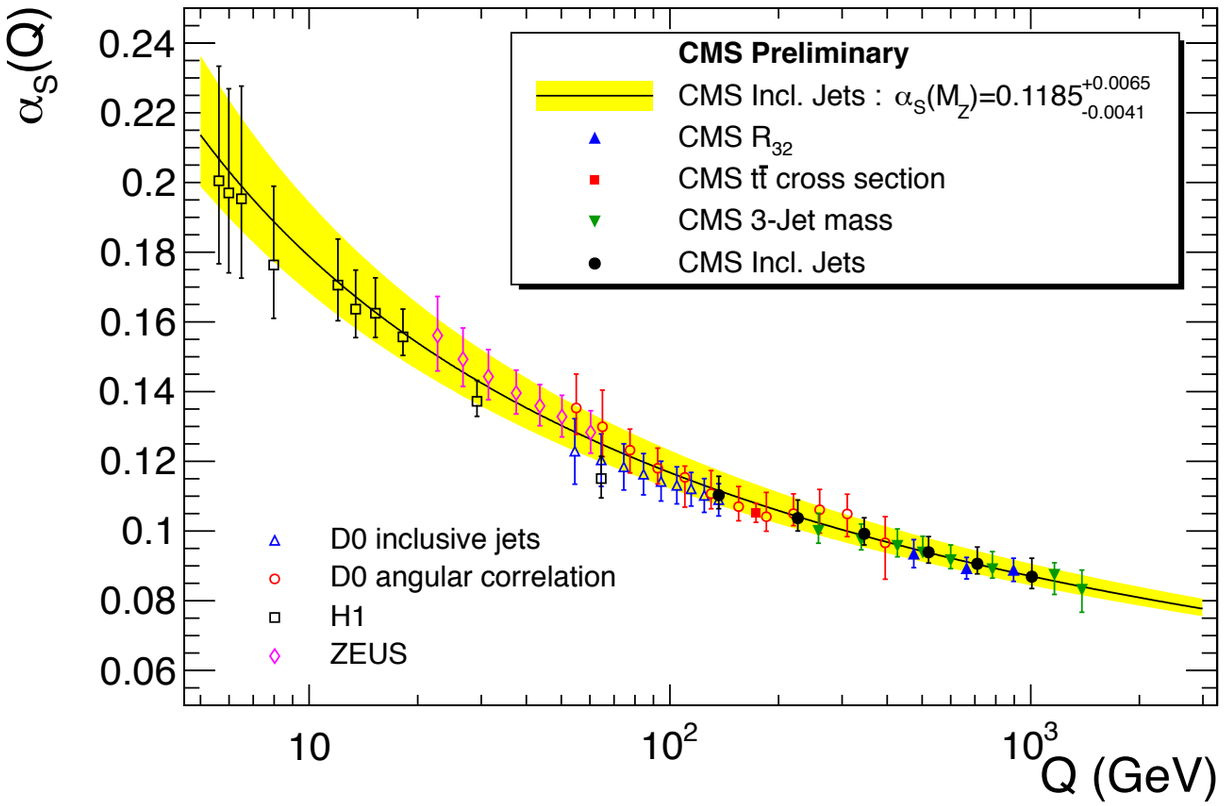


Daniele Alves, Jamison Galloway, JTR, Jon Walsh 1410.6810

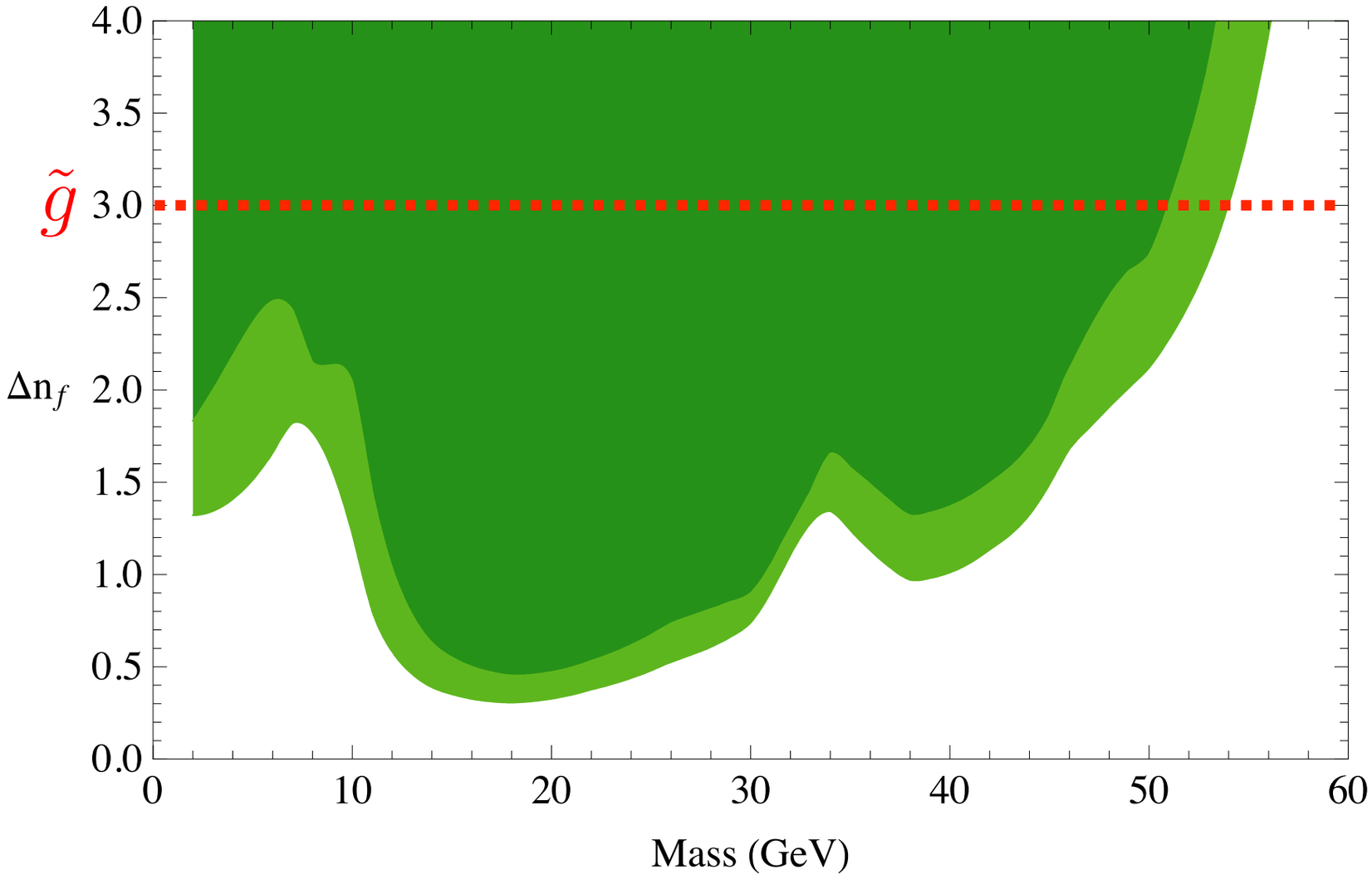
running α_3





model-independent limits on colored states

LEP

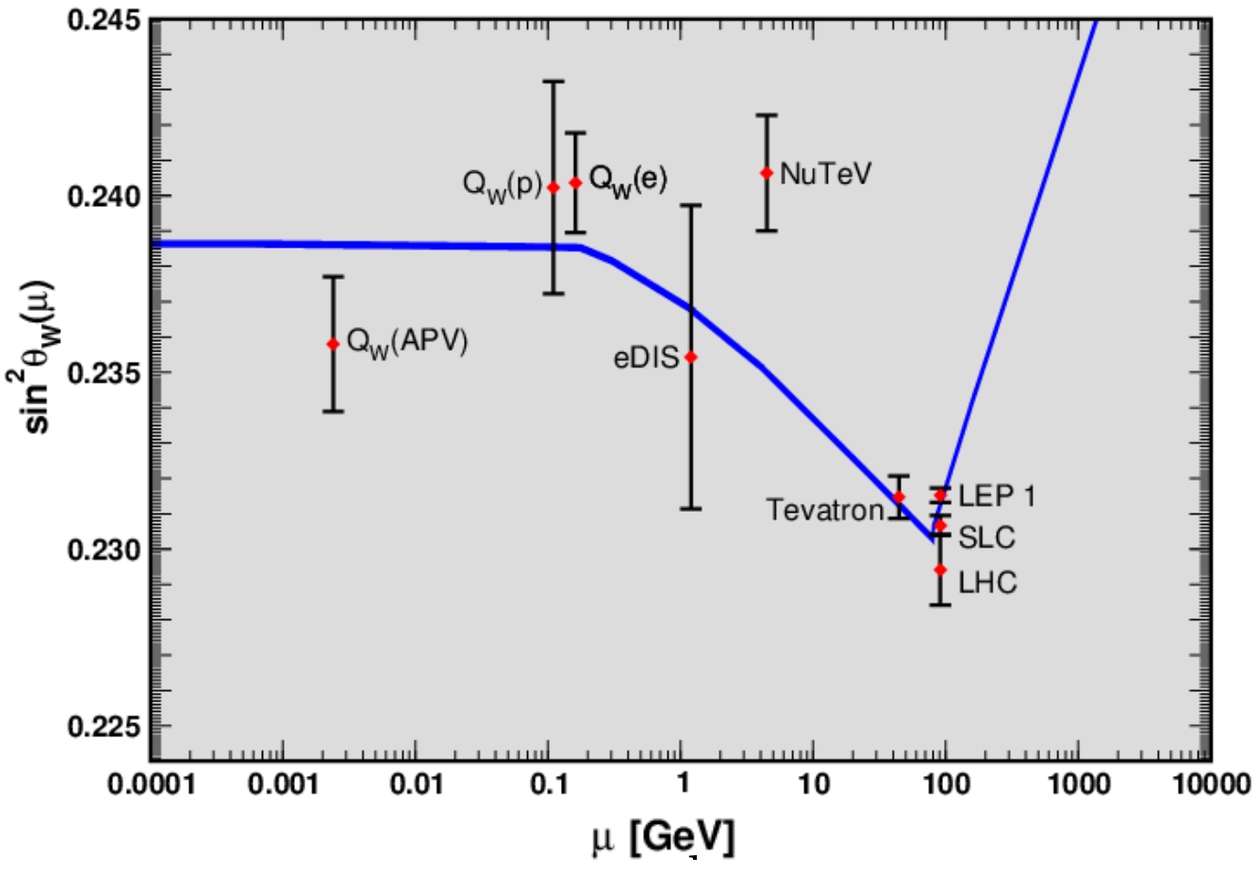


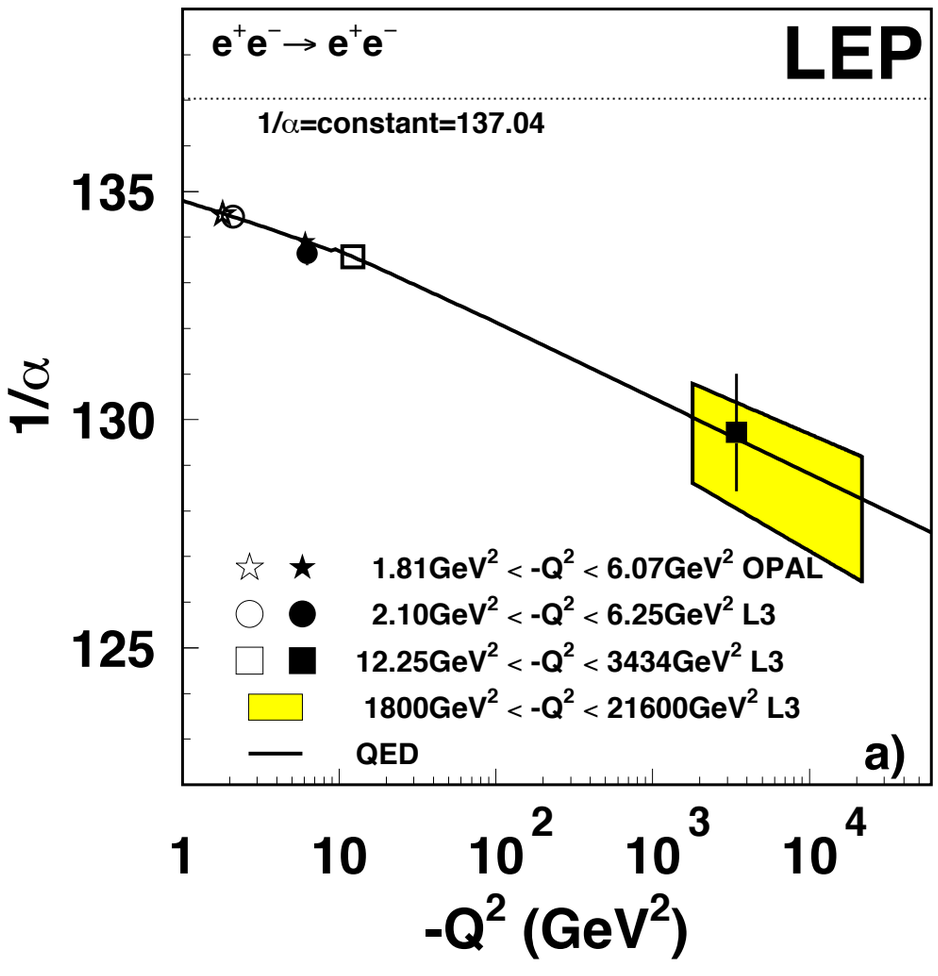
Kaplan and Schwartz 0804.2477

running weak couplings

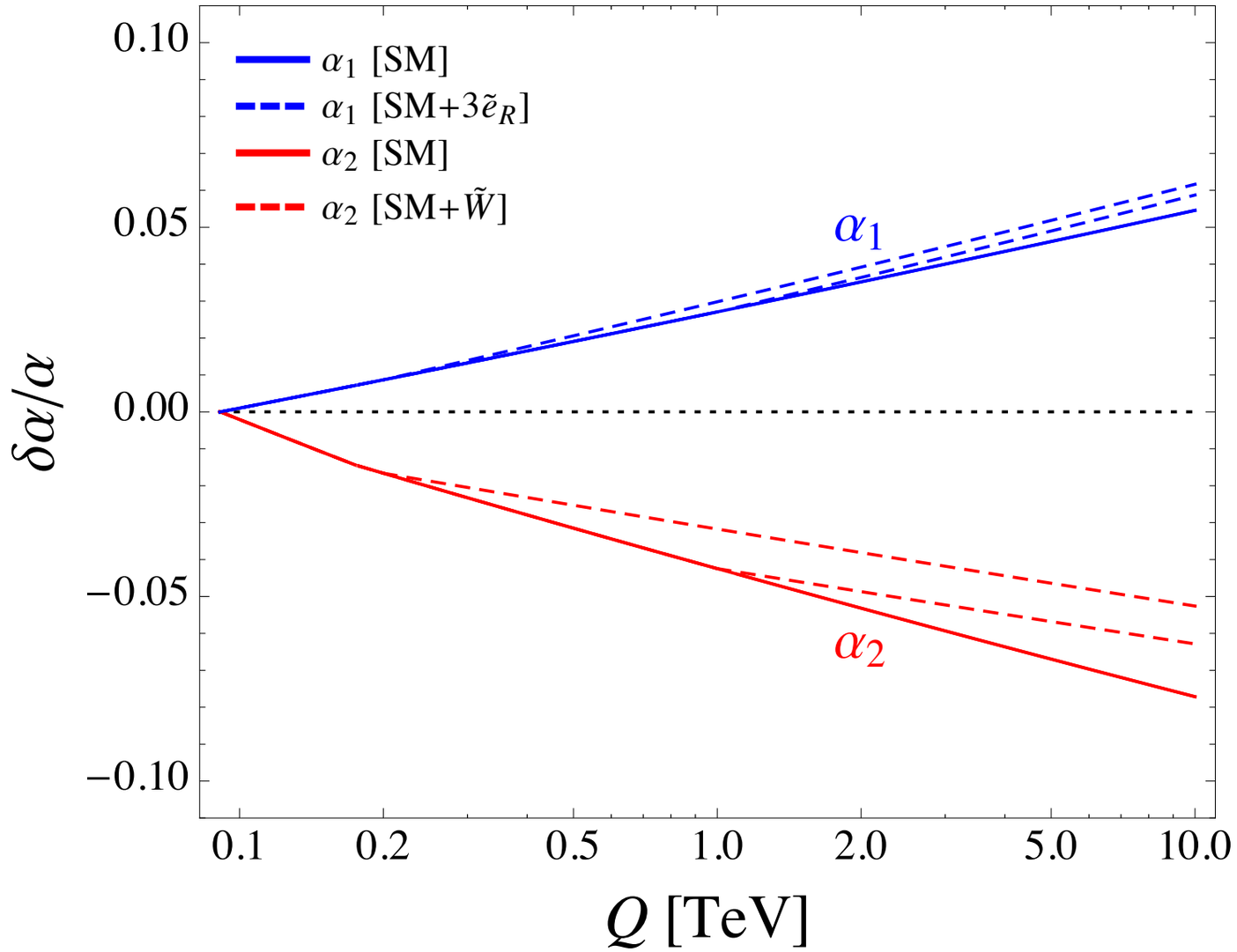
so far only measured in the broken regime:

$$Q \lesssim m_Z$$





running weak couplings

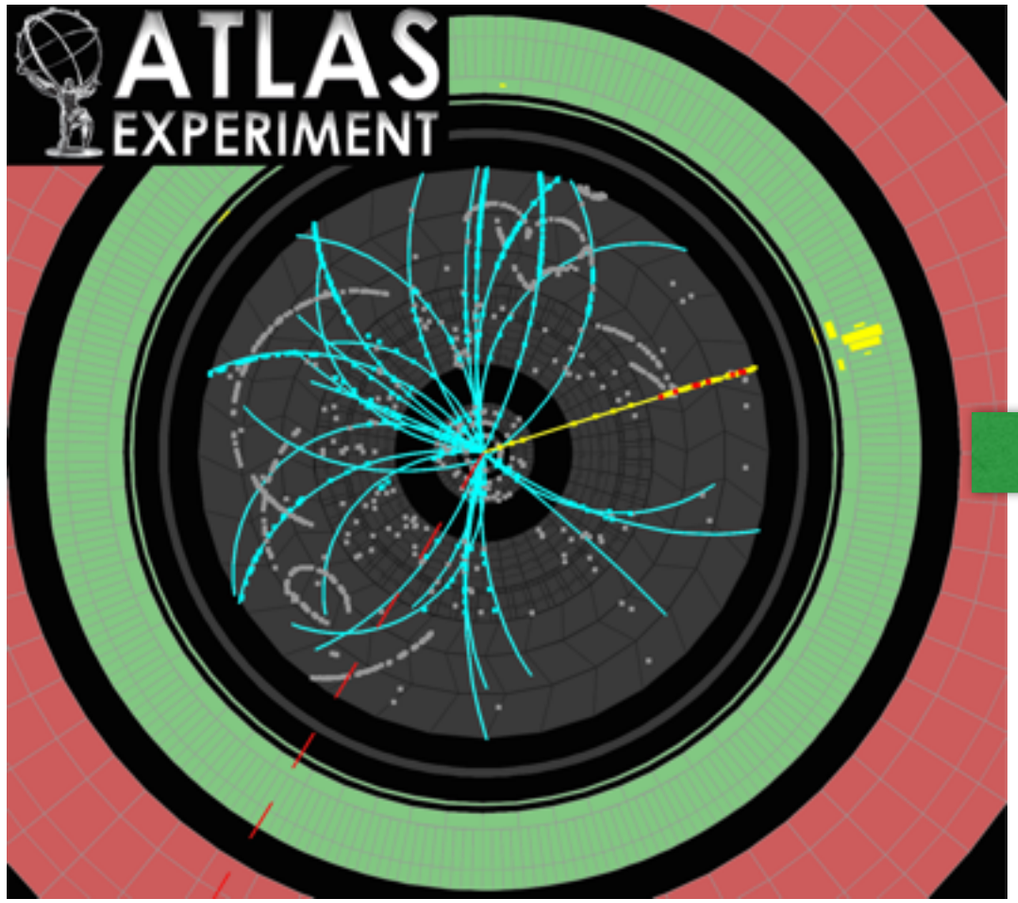


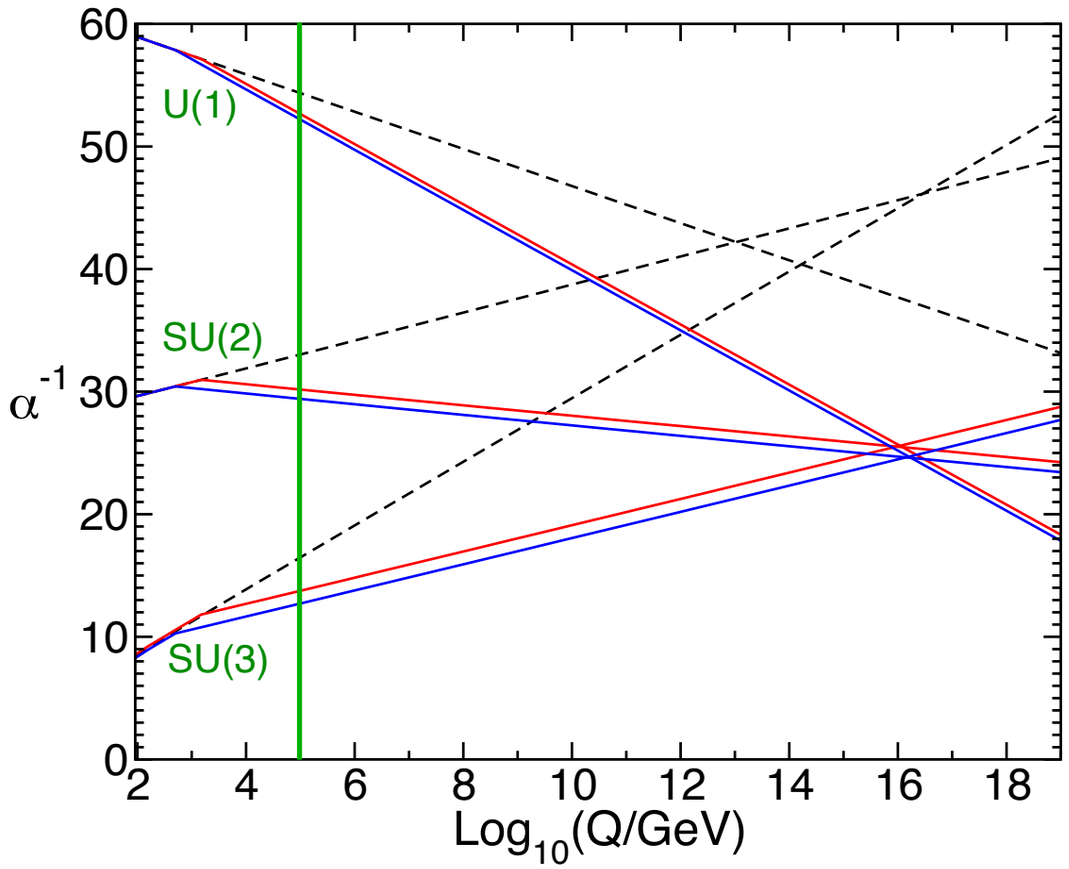
SM: $\dfrac{\delta\alpha_2}{\alpha_2}(1\ \text{TeV}) \approx -3\%$ $\dfrac{\delta\alpha_2}{\alpha_2}(10\ \text{TeV}) \approx -7\%$

plan

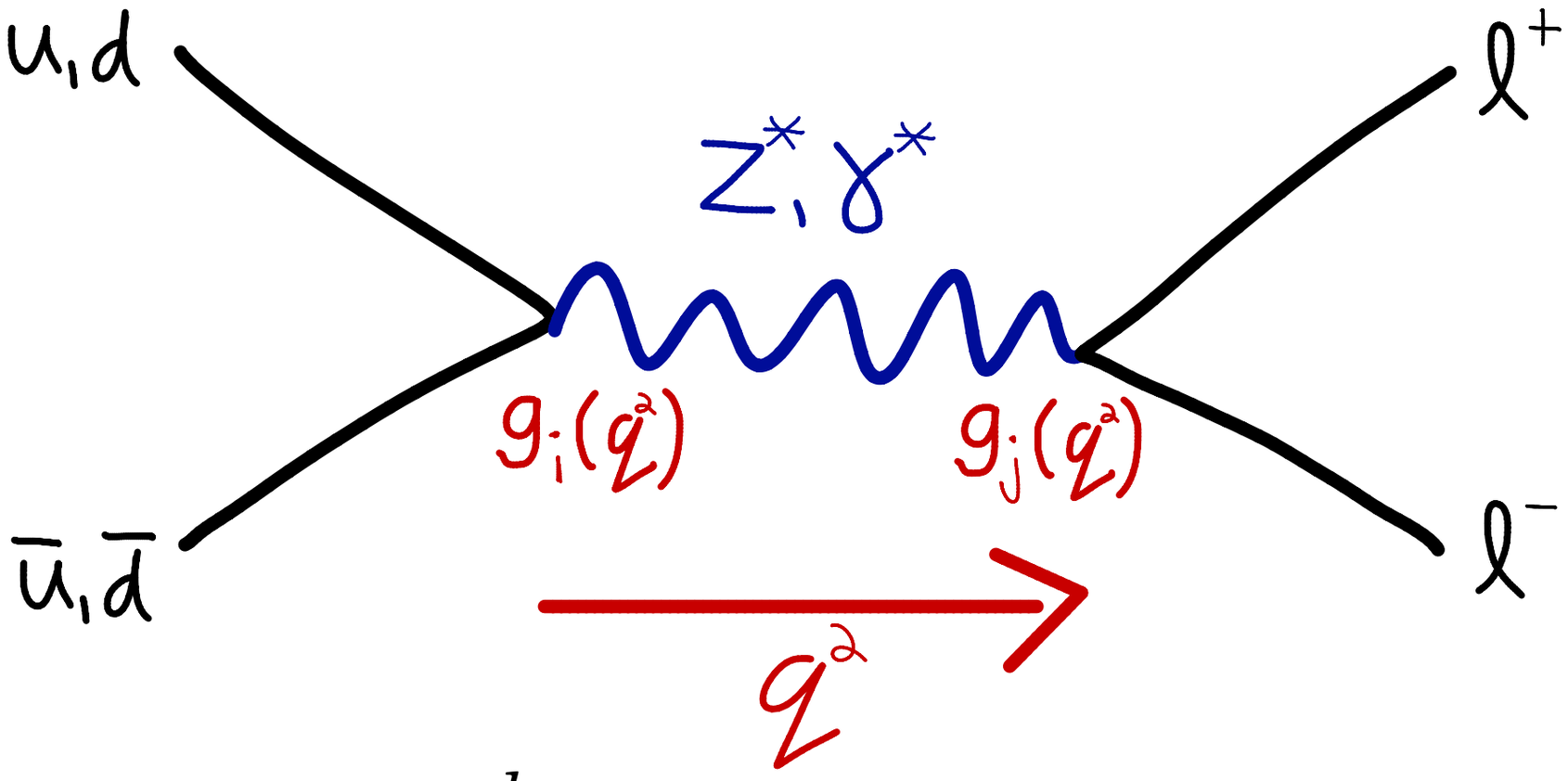
1. measuring $\alpha_{1,2}(Q)$ at a pp collider
2. LHC limits and 14/100 TeV reach
3. measuring other running parameters

1. measuring $\alpha_{1,2}(Q)$ at a pp collider





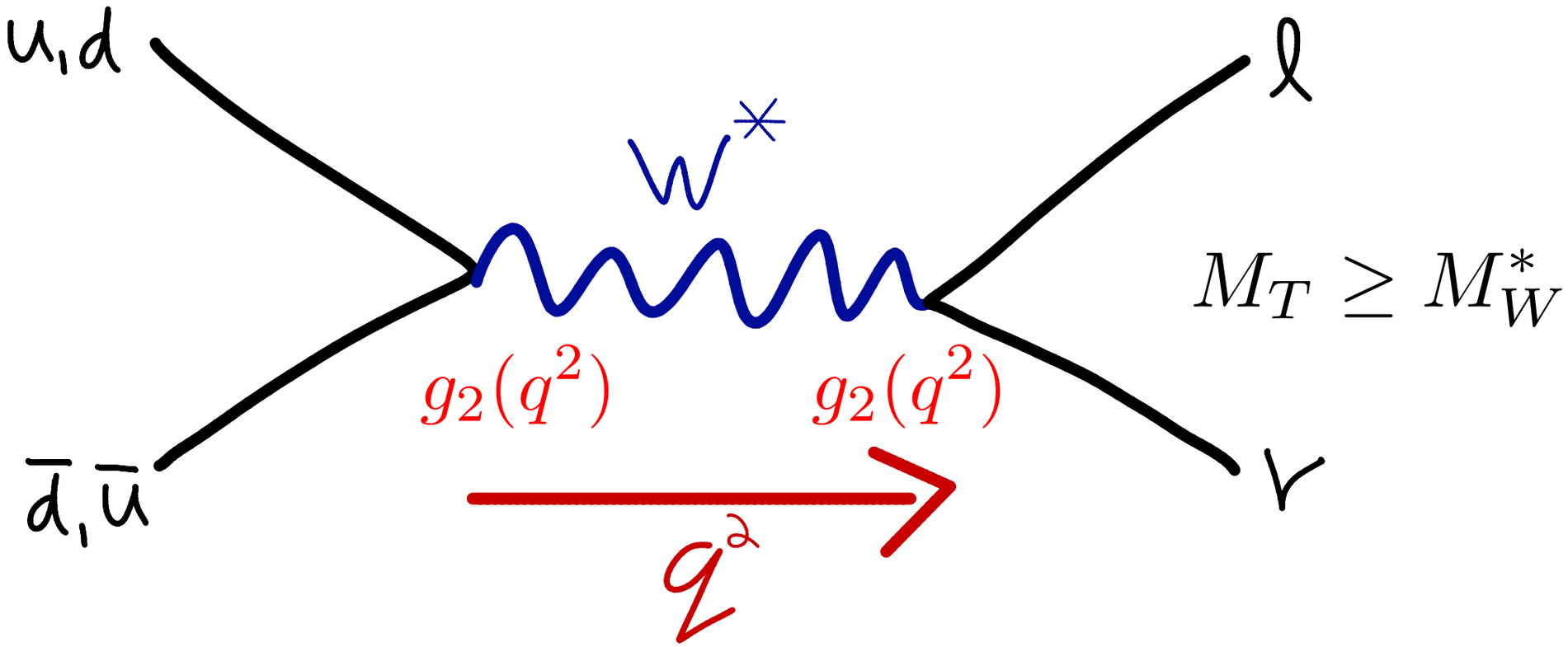
off-shell Drell-Yan



$$\frac{d\sigma}{dM_{ll}} \propto \alpha_i(M_{ll})\alpha_j(M_{ll}) \qquad i,j = 1,2$$

- Rainwater and Tait hep-ph/0701093
- Dittmaier and Huber 0911.2329

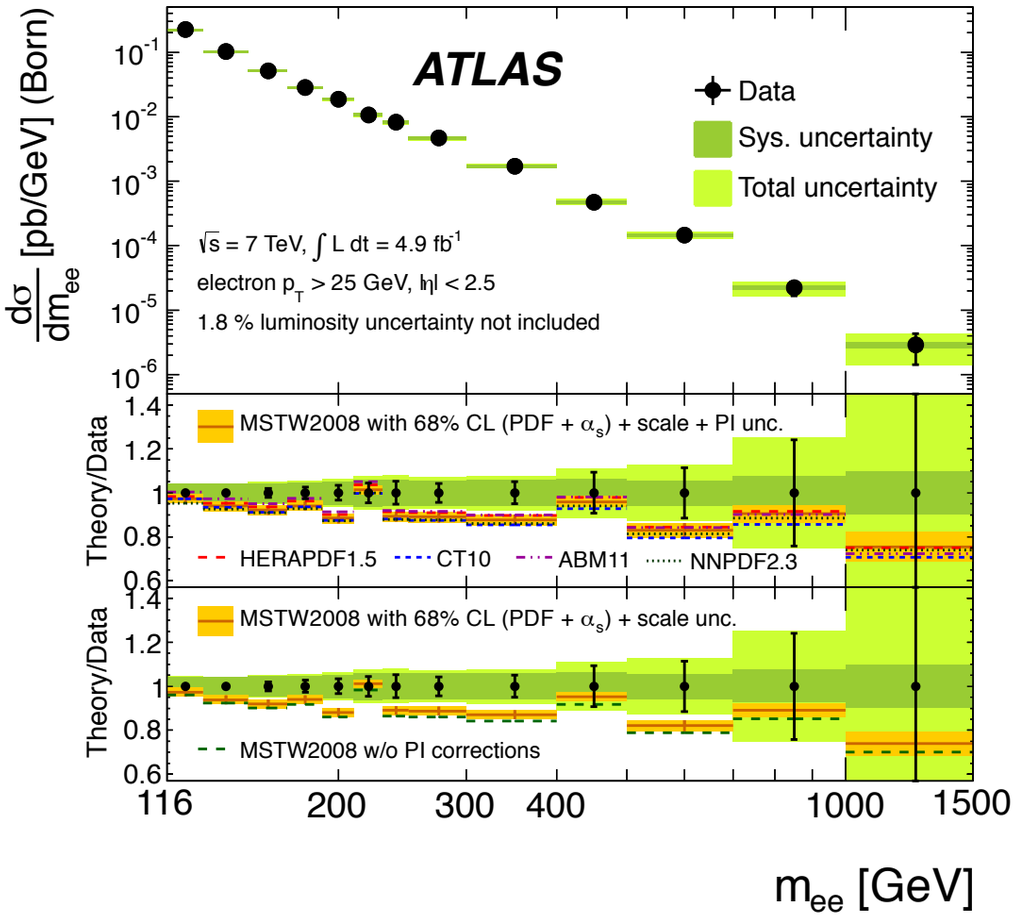
off-shell Drell-Yan

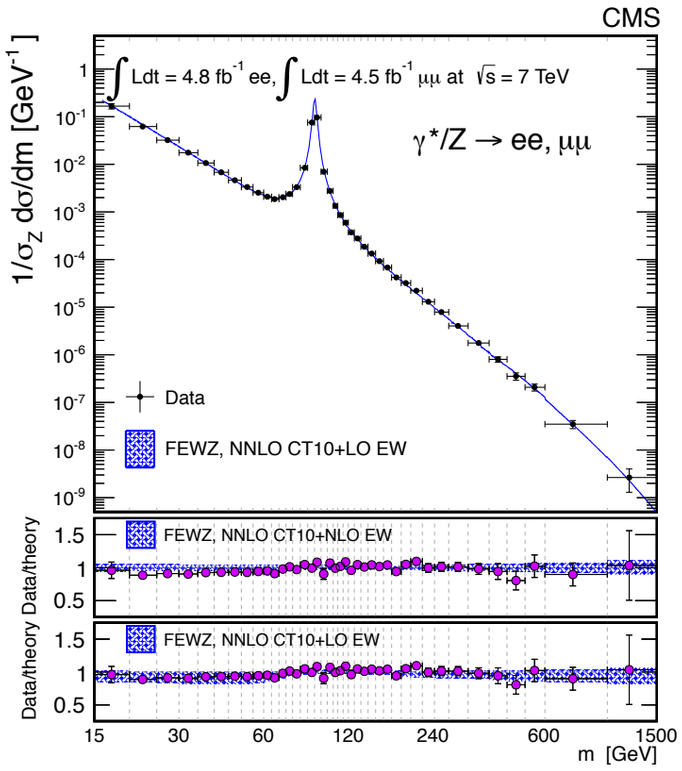


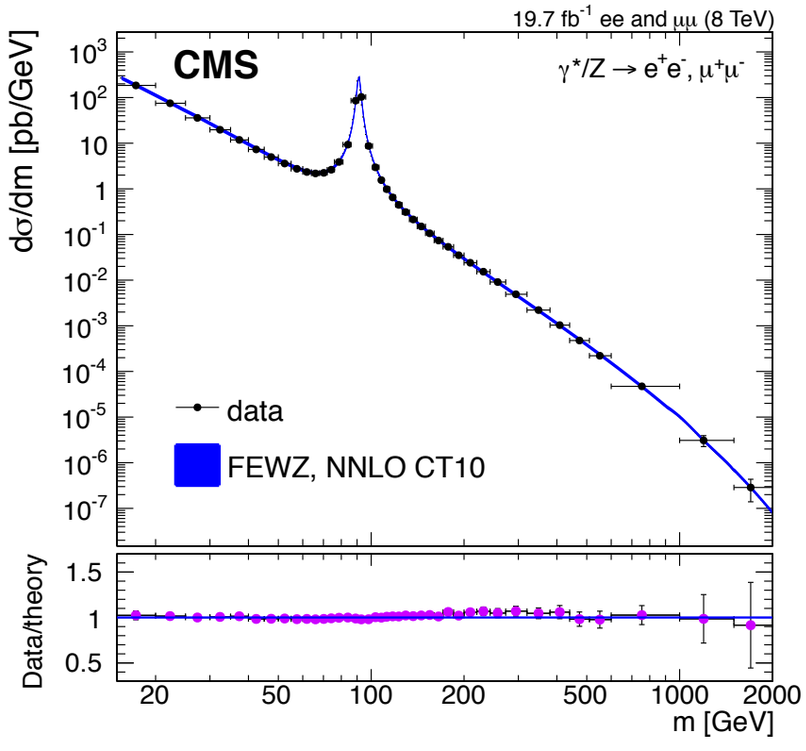
$$\frac{\mathrm{d}\sigma}{\mathrm{d}M_T}(pp \to W^* \to \ell\nu) \equiv \int_{M_T}^{\infty} \mathrm{d}M_{\ell\nu} \frac{\mathrm{d}\sigma^{W^\pm}}{\mathrm{d}M_T \mathrm{d}M_{\ell\nu}}\big(\alpha_2(M_{\ell\nu})\big)$$

- Rainwater and Tait hep-ph/0701093
- Brensing, Dittmaier, Kramer, Muck 0710.3309

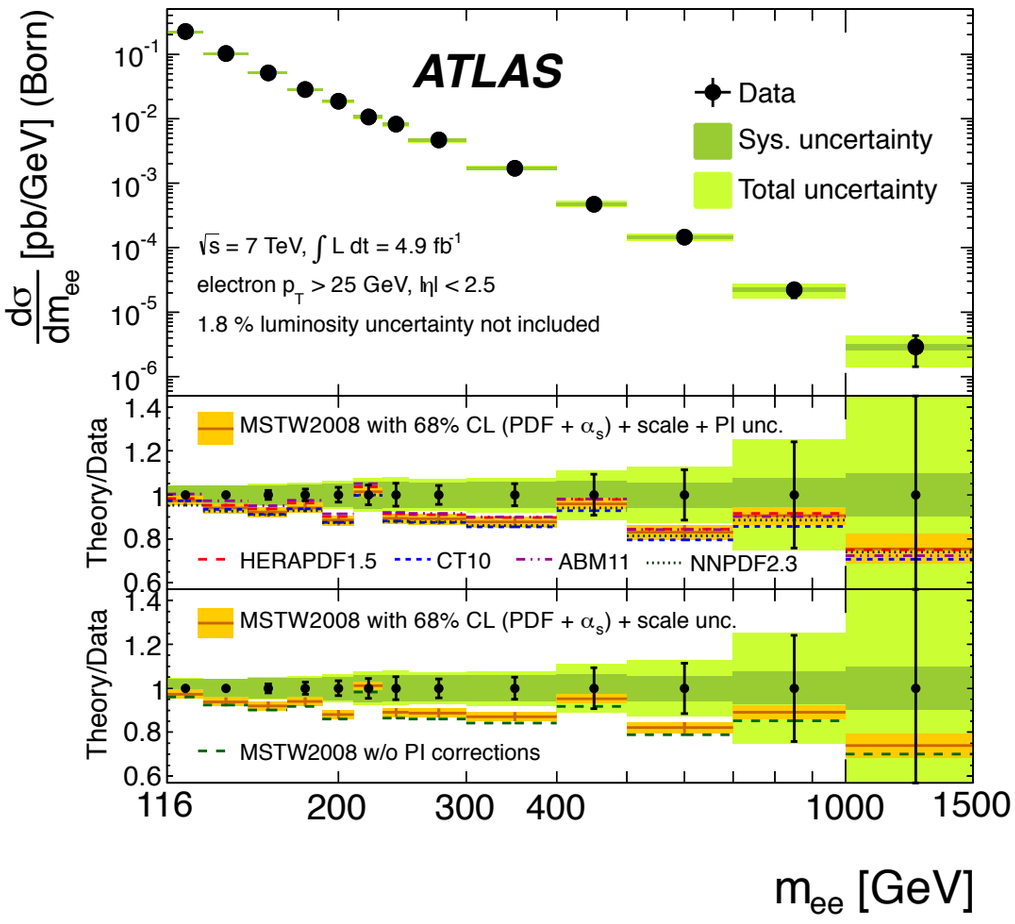
existing Drell-Yan measurements

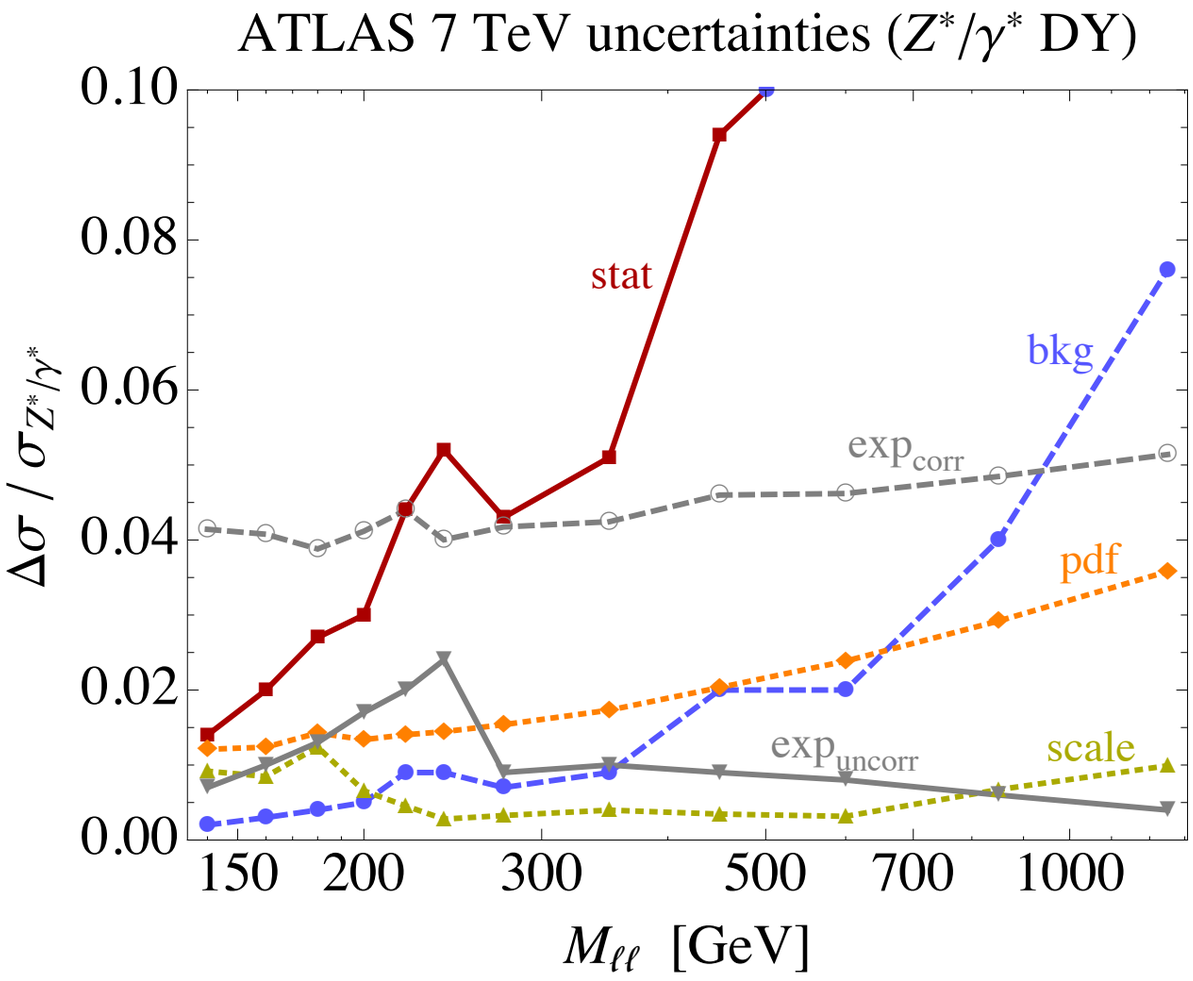






existing Drell-Yan measurements





technical specs

what we include:

- current PDF uncertainties (NNPDF2.3)
- NNLO QCD scale uncertainty
- new states @ LO EW ($\alpha_{1,2}(m_{ll})$, leading log)

to do:

- new states @ NLO EW

(in progress Alves, Galloway, Li, Petriello, JTR, Walsh)

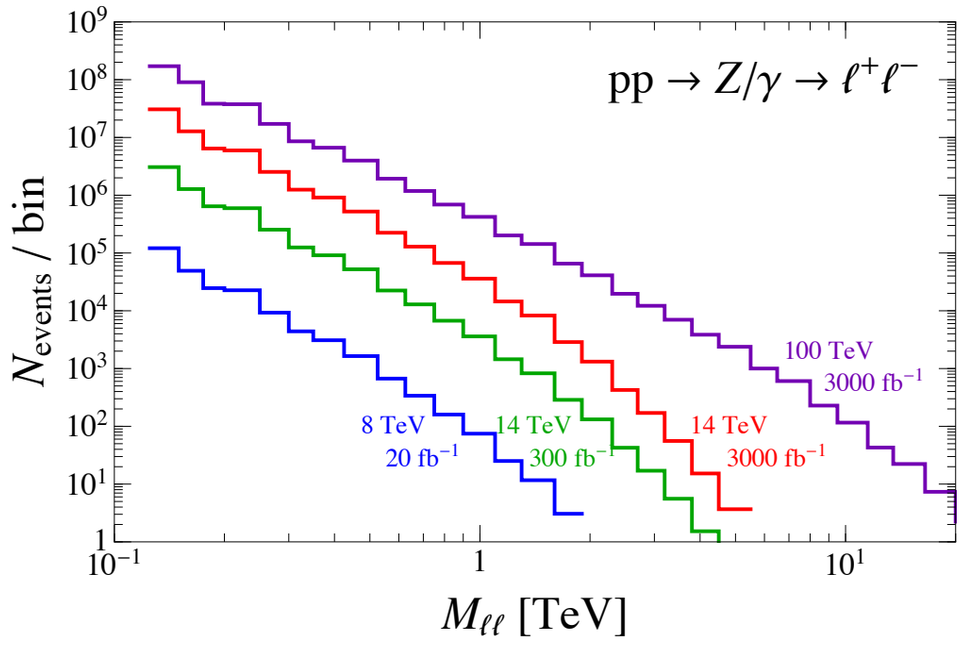
- EW logs

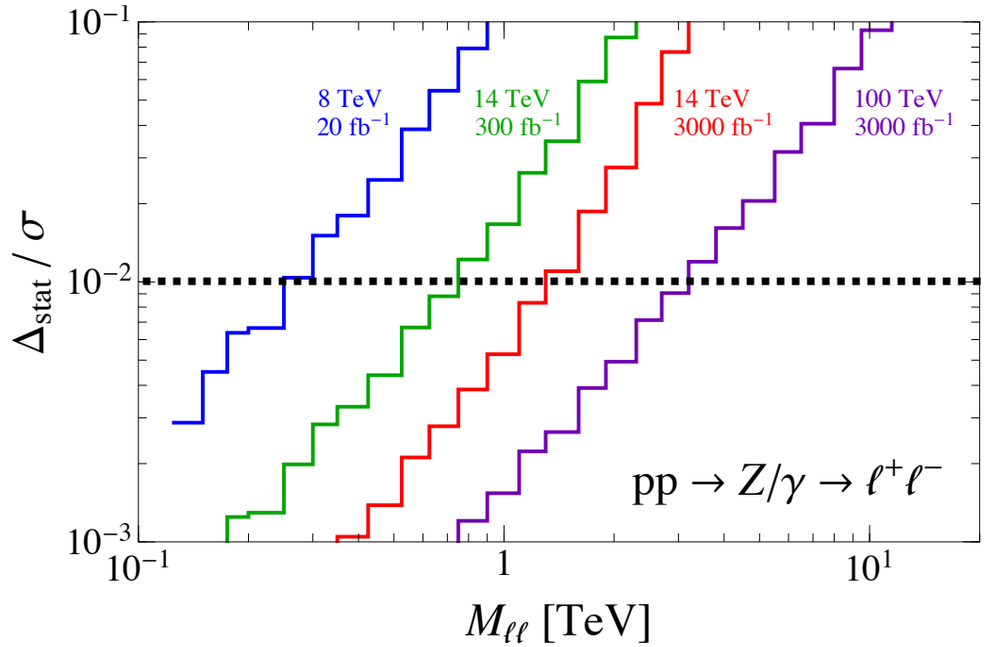
cross section

σ

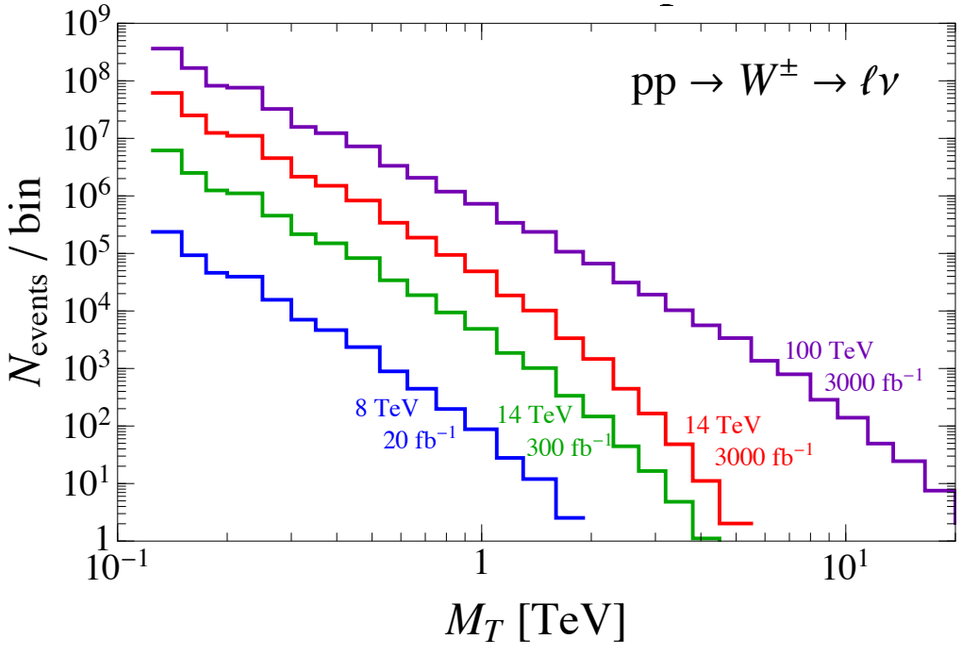
stat uncertainty

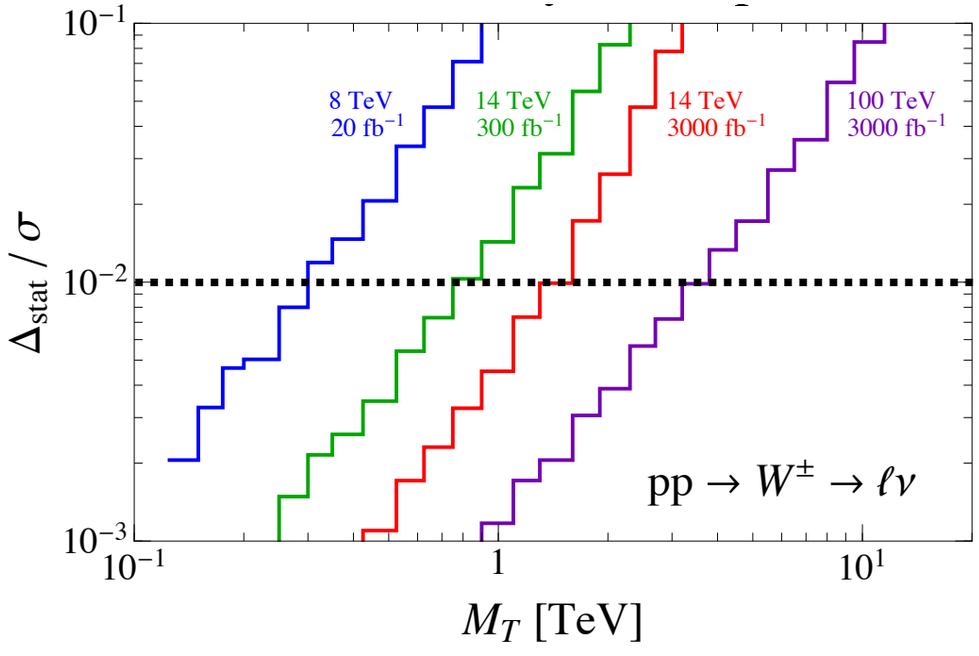
Z^*





W^*

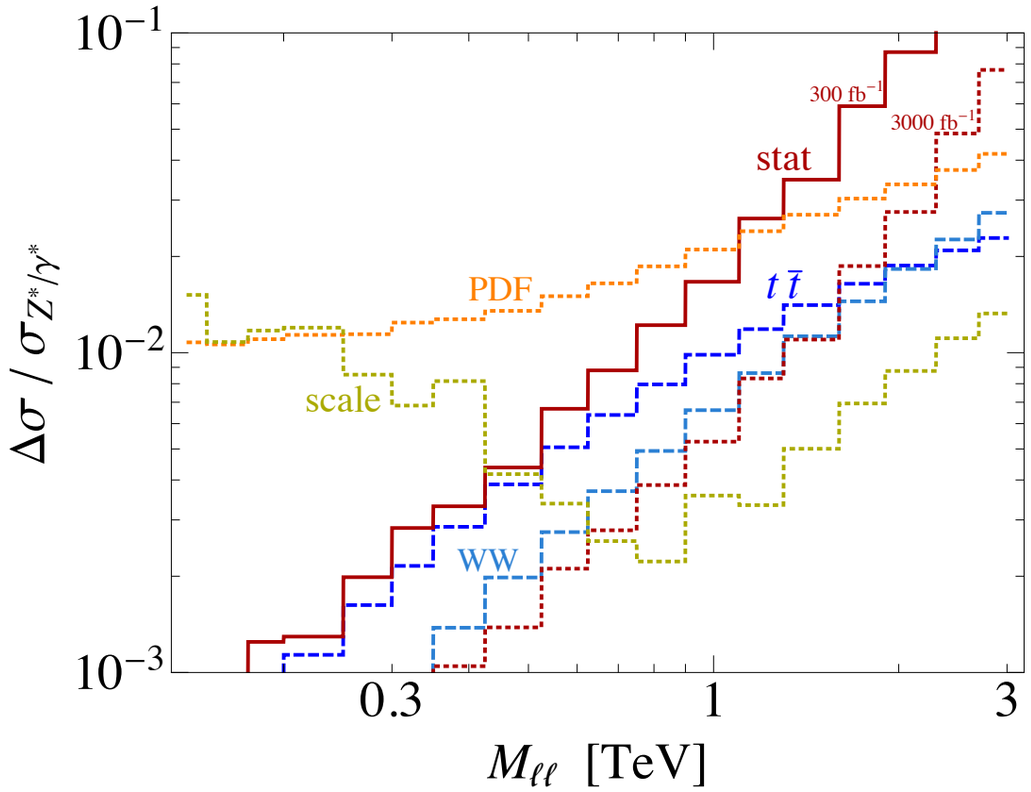




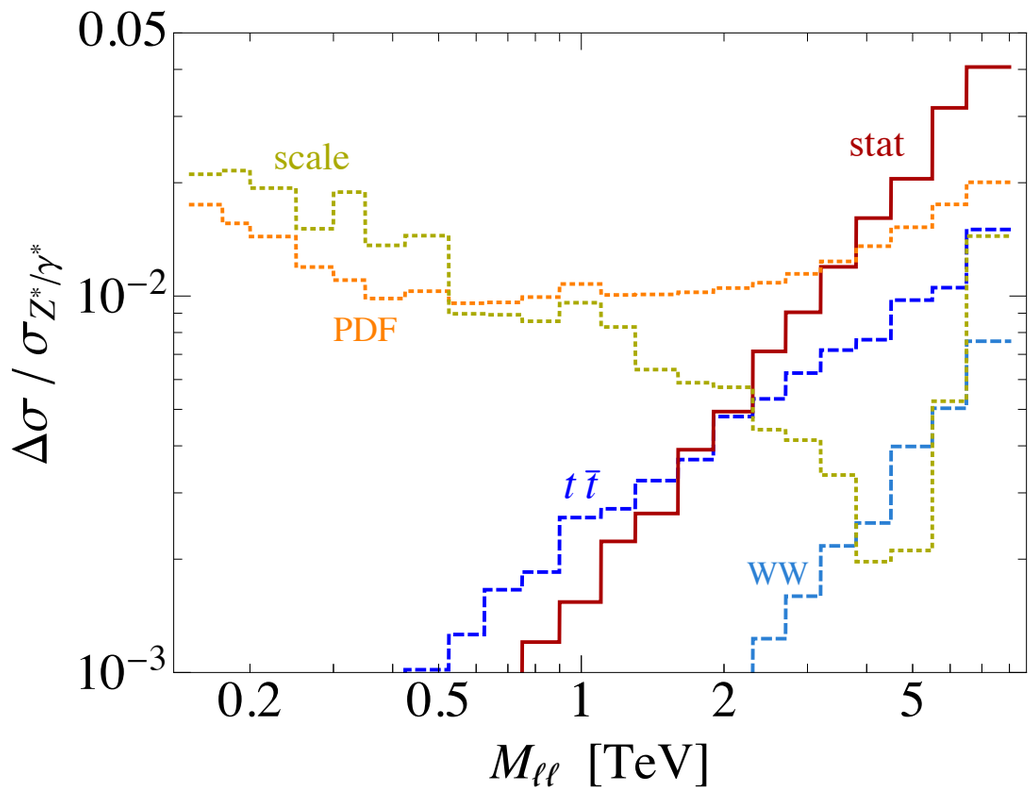
theoretical uncertainties

Z^*

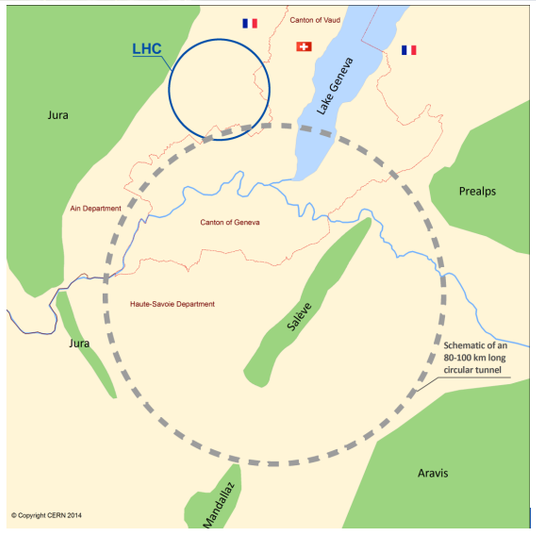
14 TeV



100 TeV

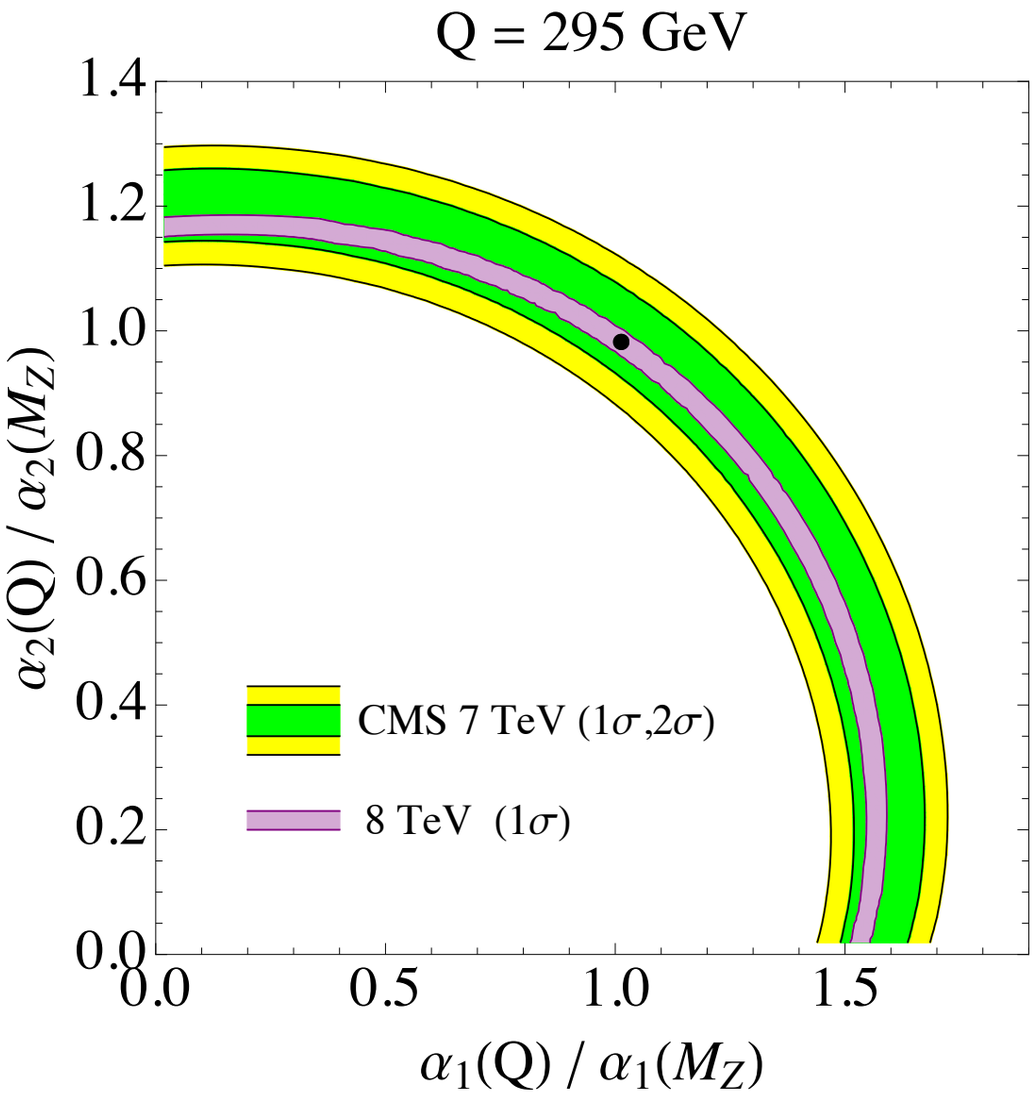


2. LHC measurements and 14/100 TeV reach

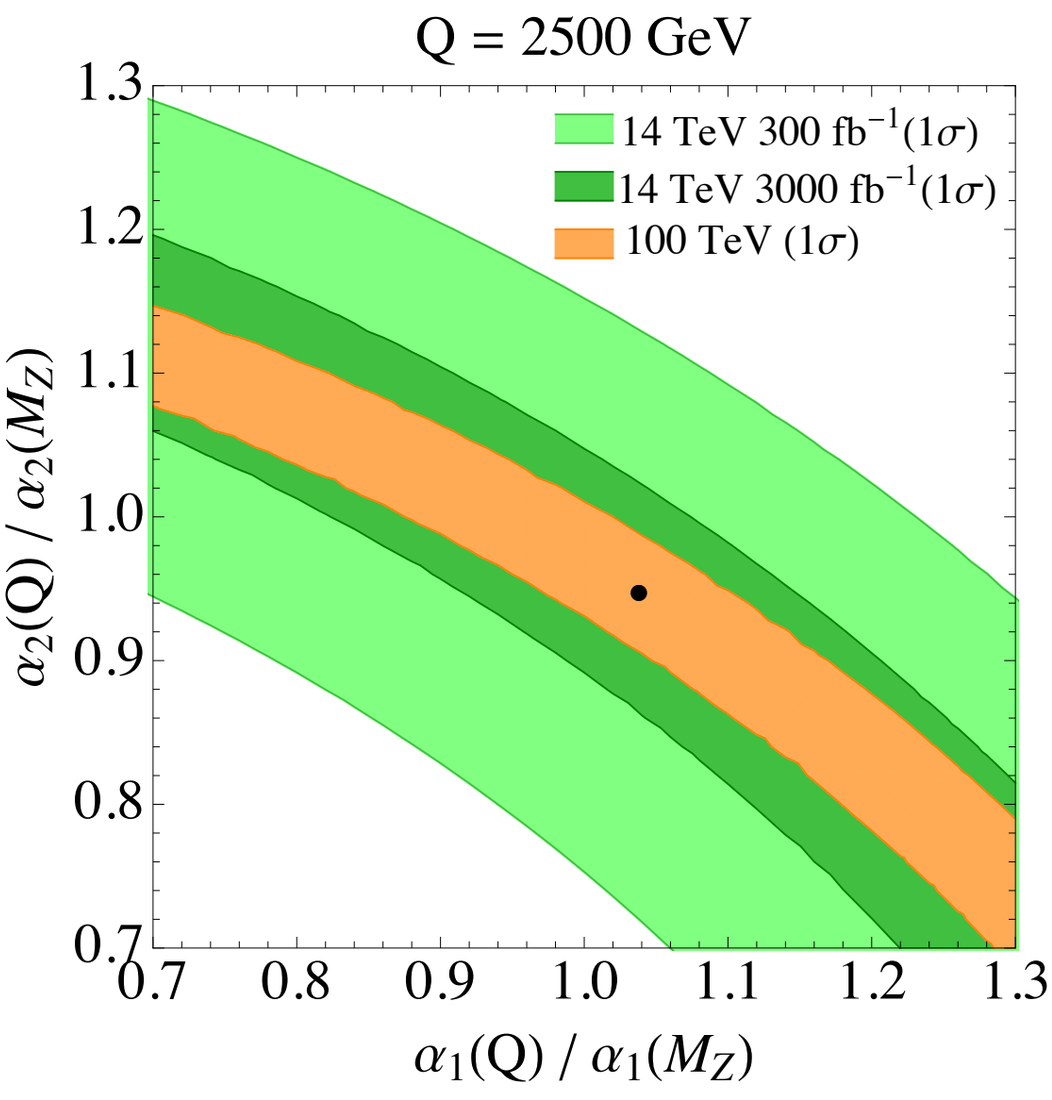


measuring $\alpha_{1,2}(Q)$

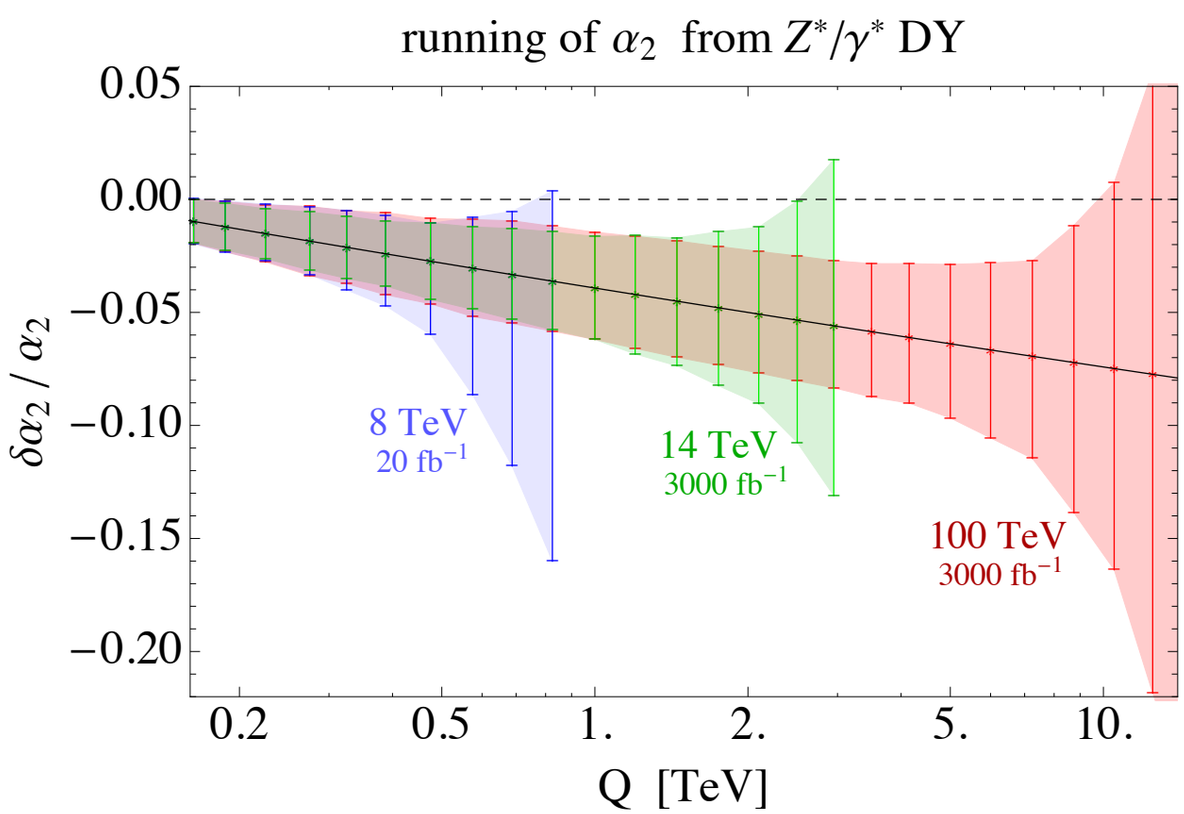
now

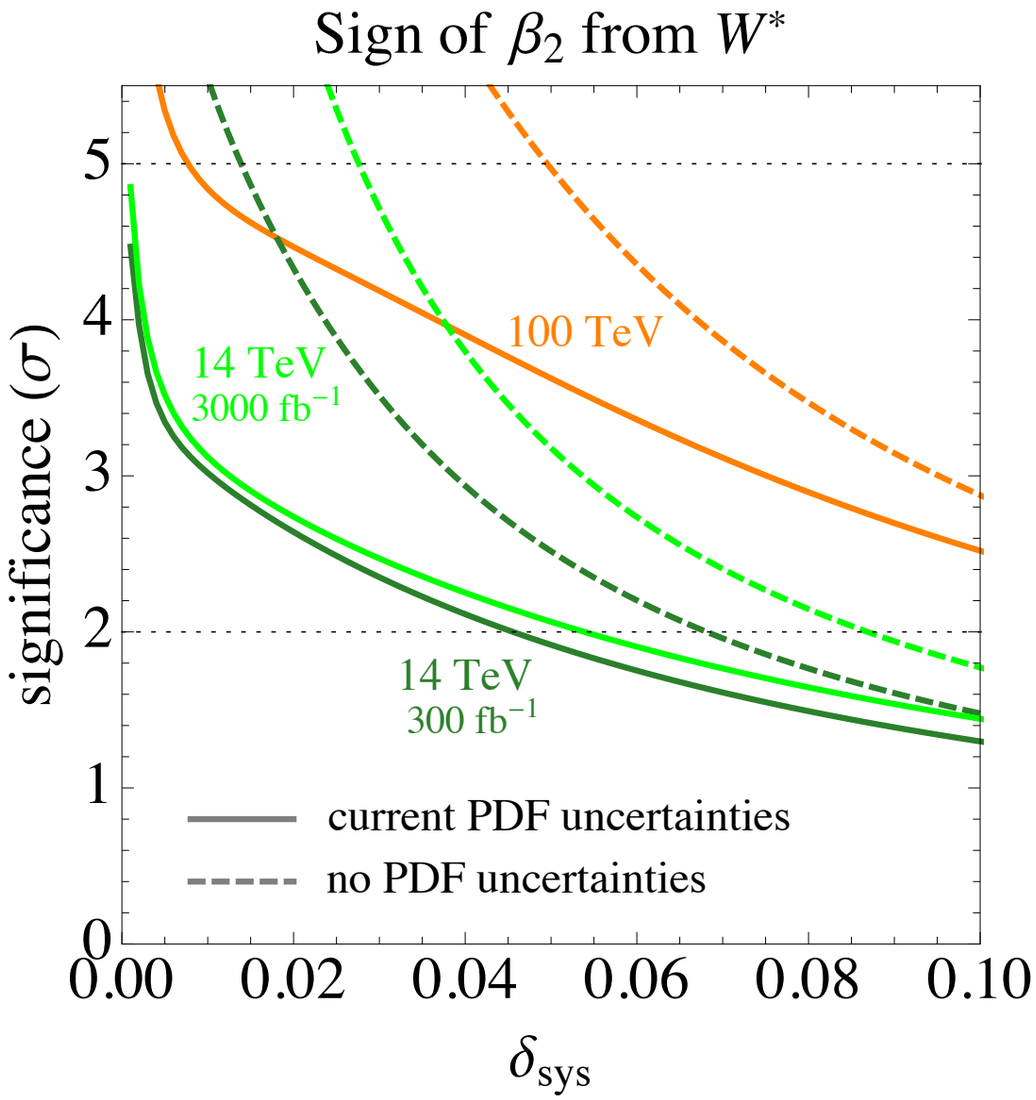


later



measuring $\alpha_2(Q)$



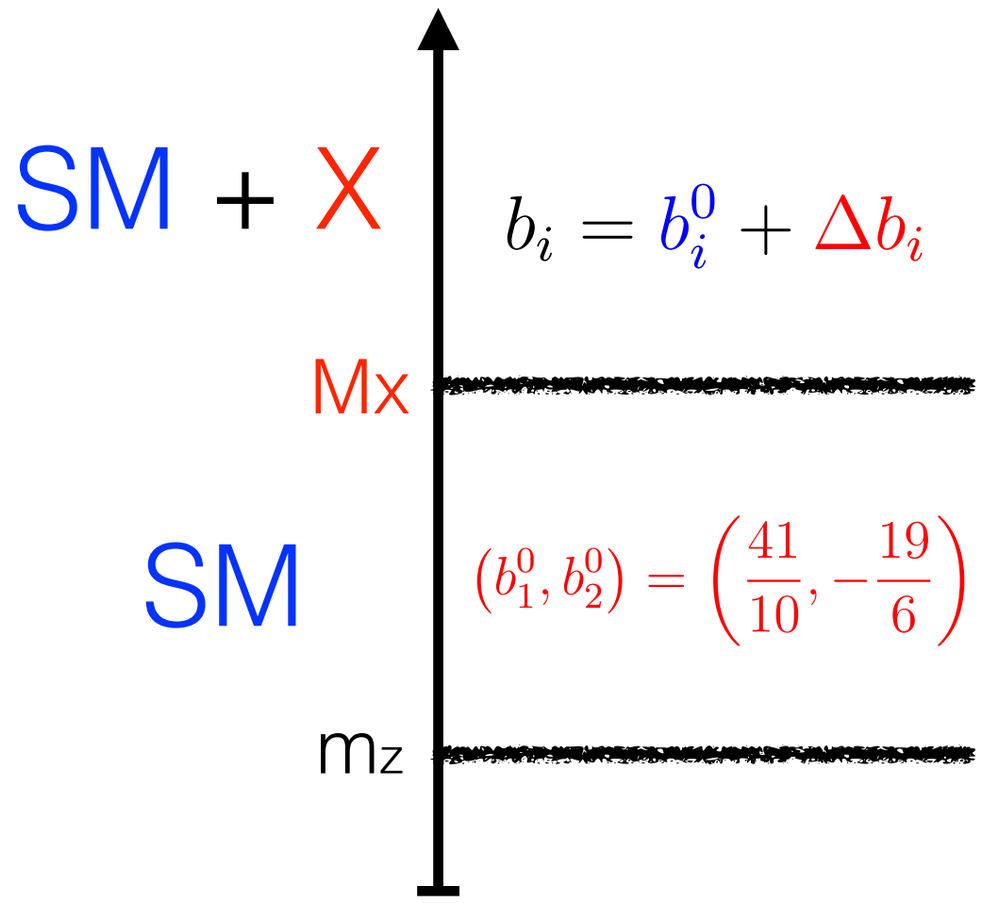


one-scale simplified model

parameters:

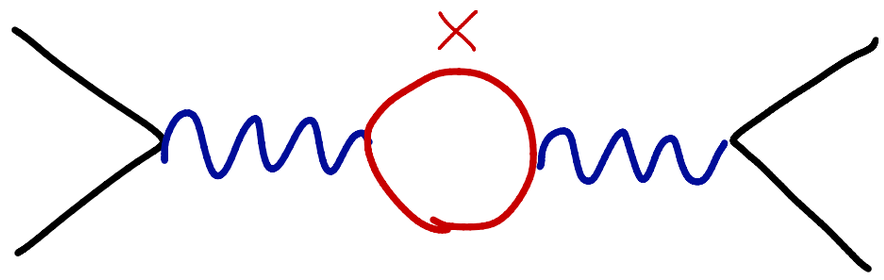
$(M_x, \Delta b_1, \Delta b_2)$

$$\frac{d}{dt} g_i = \frac{1}{(4\pi)^2} b_i \, g_i^3$$



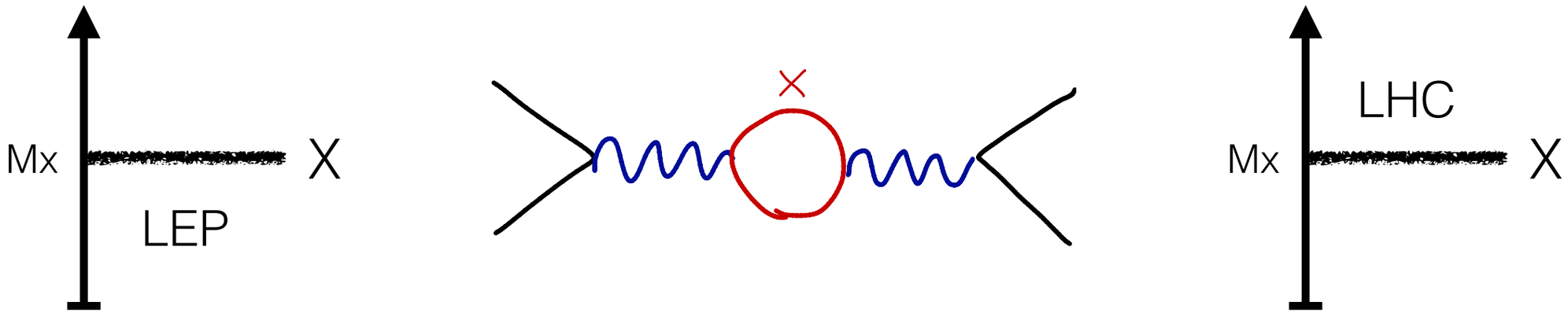
$$\Delta b_1 = \frac{2}{5} Y_i^2$$

	Δb_2
2	1/3 = 0.33
3	4/3 = 1.33
5	20/3 = 6.67
7	56/3 = 18.7



Precision Electroweak

below threshold vs. above threshold



$$\frac{\left(D_\rho W^a_{\mu\nu}\right)^2}{2g^2} \qquad \frac{\left(\partial_\rho B_{\mu\nu}\right)^2}{2g'^2}$$

$$W = \Delta b_2 \, \frac{\alpha_2}{20\pi} \, \frac{m_W^2}{M^2} \qquad Y = \Delta b_1 \, \frac{\alpha_1}{20\pi} \, \frac{m_W^2}{M^2}$$

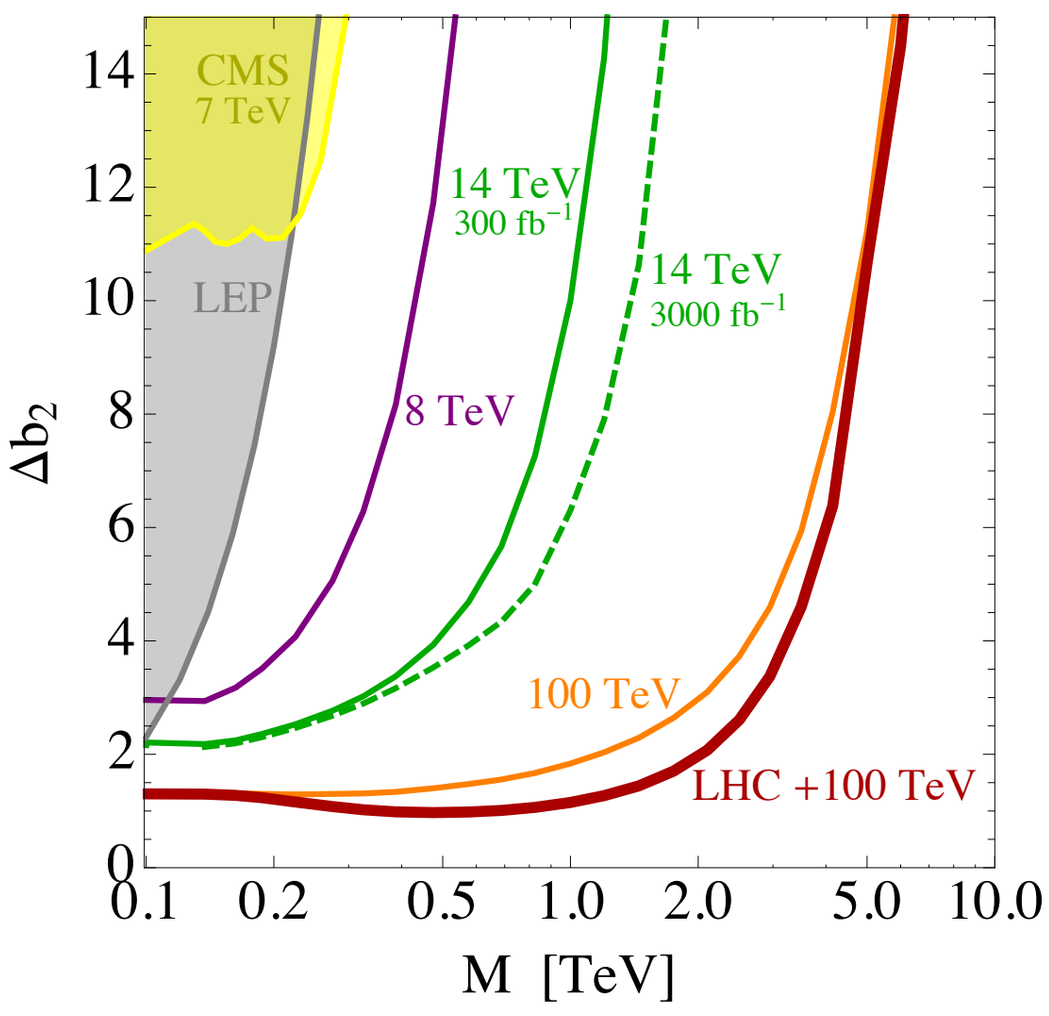
$$W, Y \lesssim 10^{-3}$$

see for ex: Barbieri, Pomarol, Rattazzi, Strumia 0405040

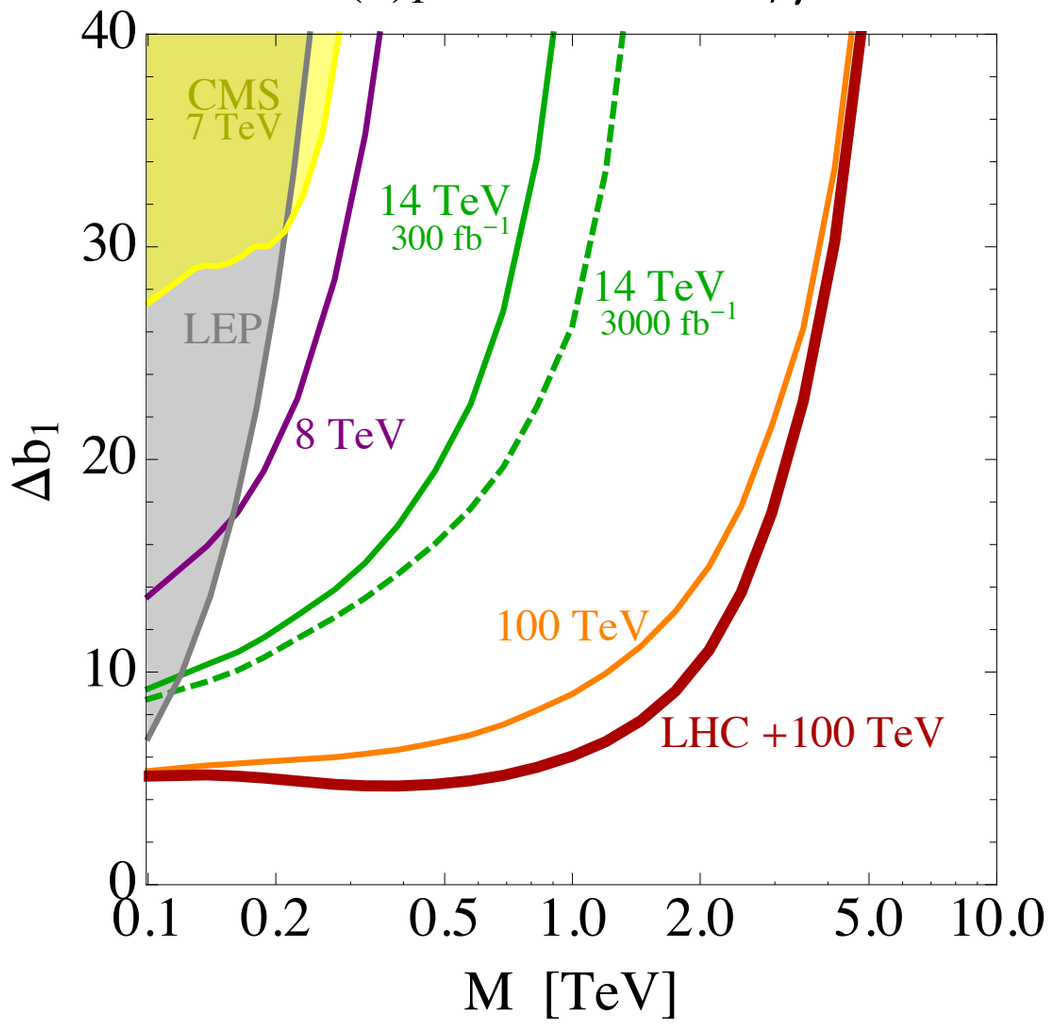
$$\frac{\delta\sigma}{\sigma}(Q) \propto \Delta b_{1,2} \, \frac{\alpha_{1,2}}{\pi} \log\left(\frac{Q}{M}\right)$$

model-independent limits

W^*

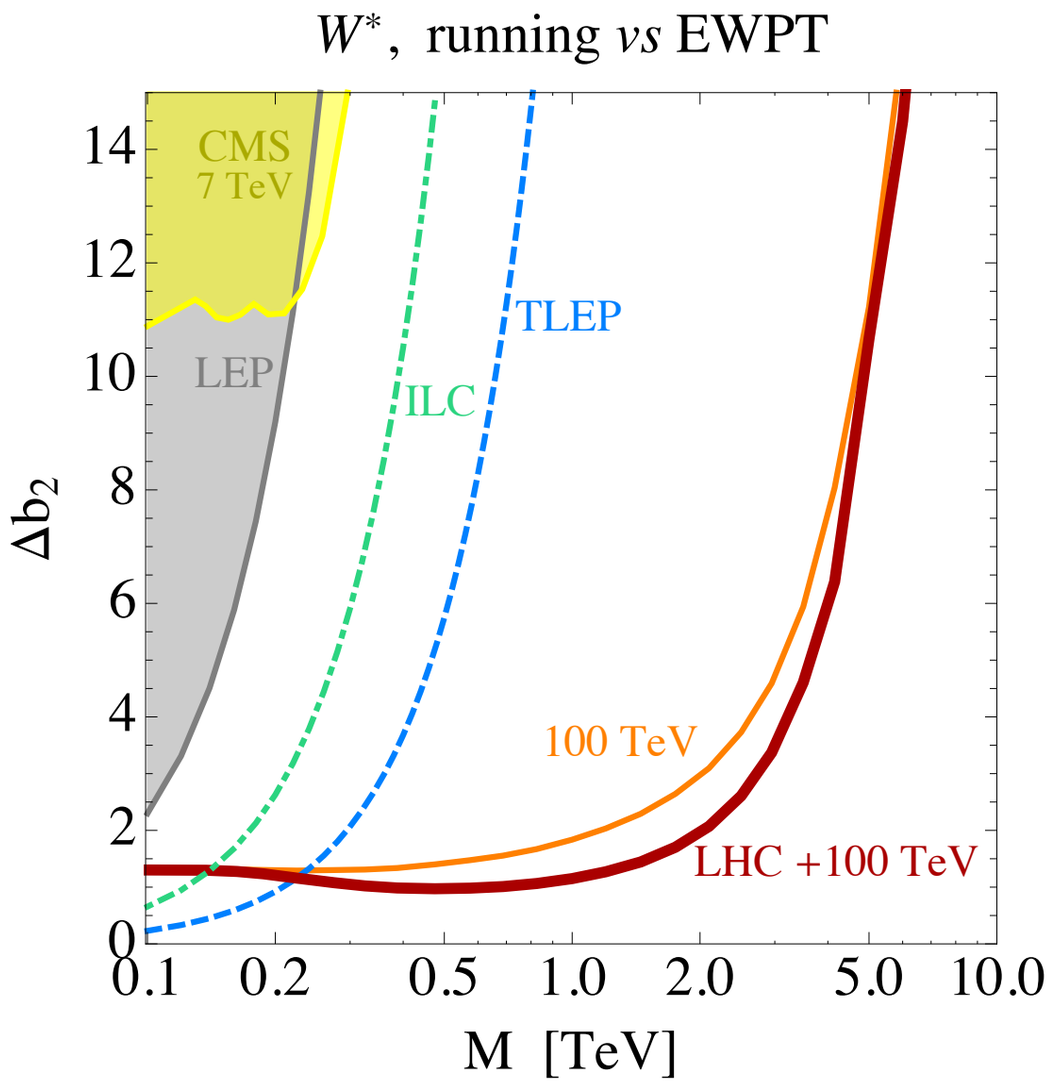


Z^*

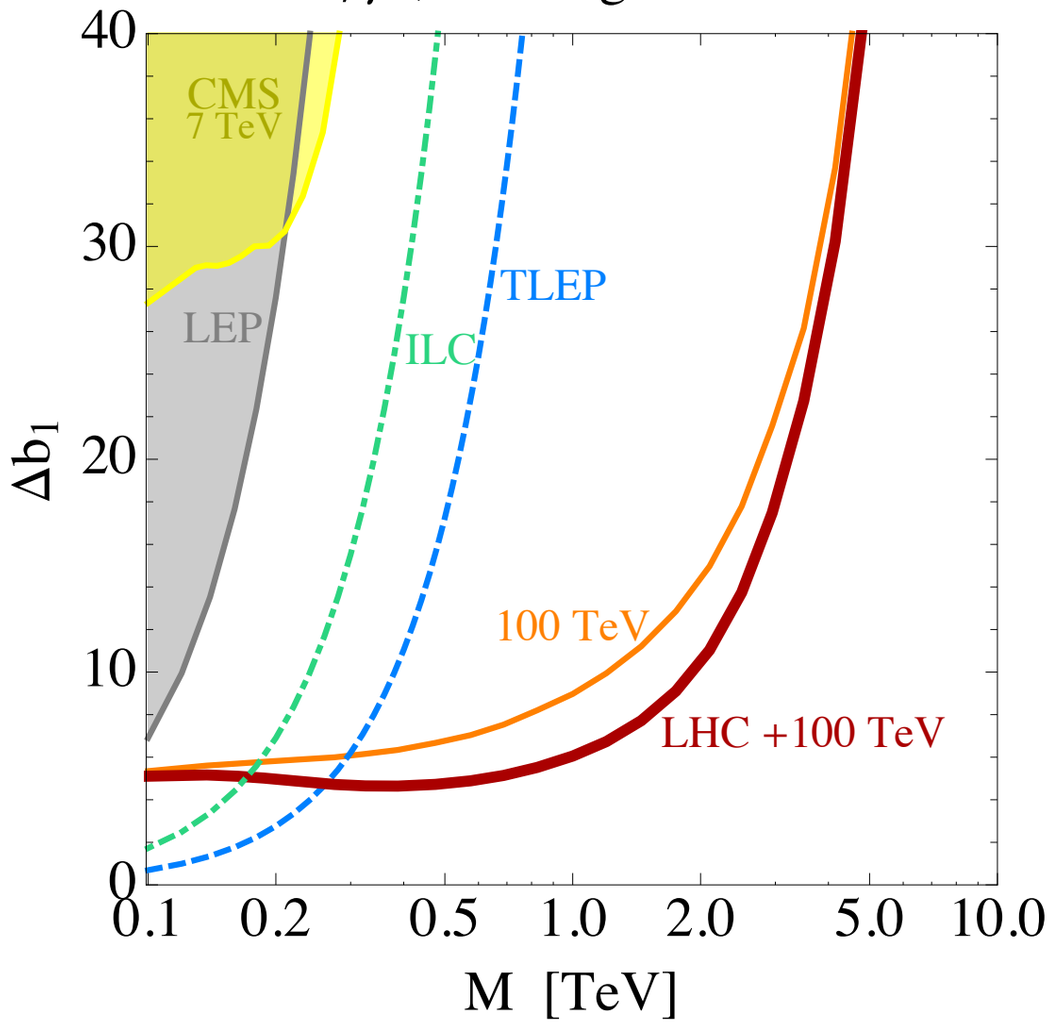


model-independent limits

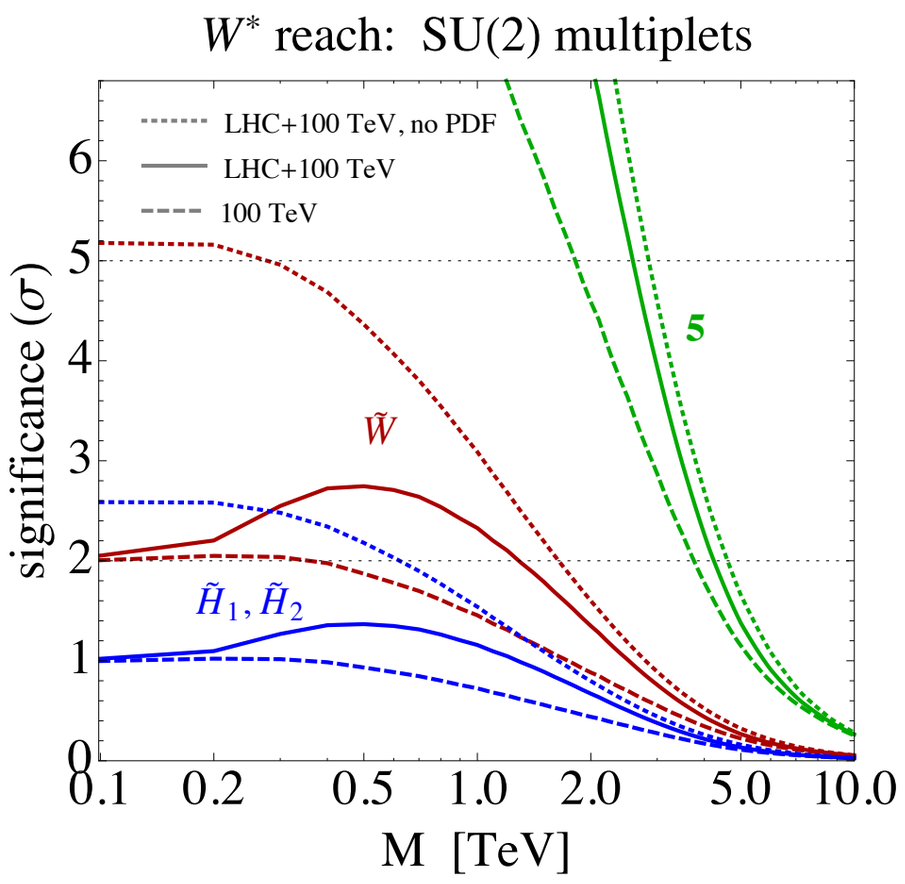
W^*

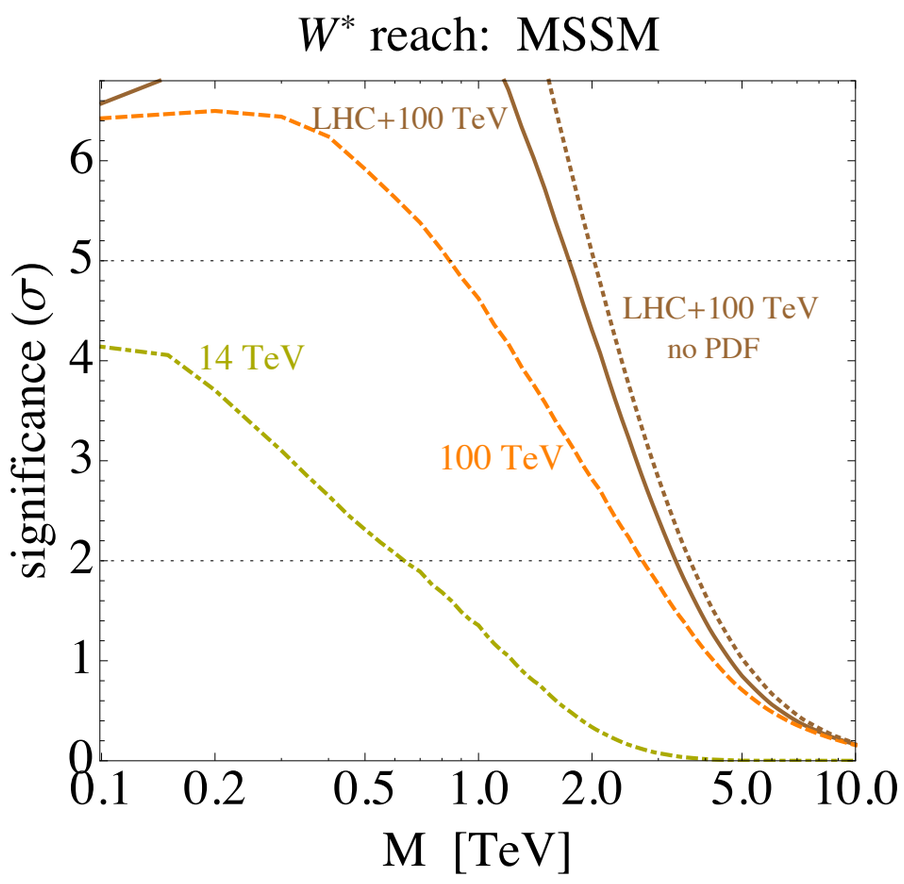


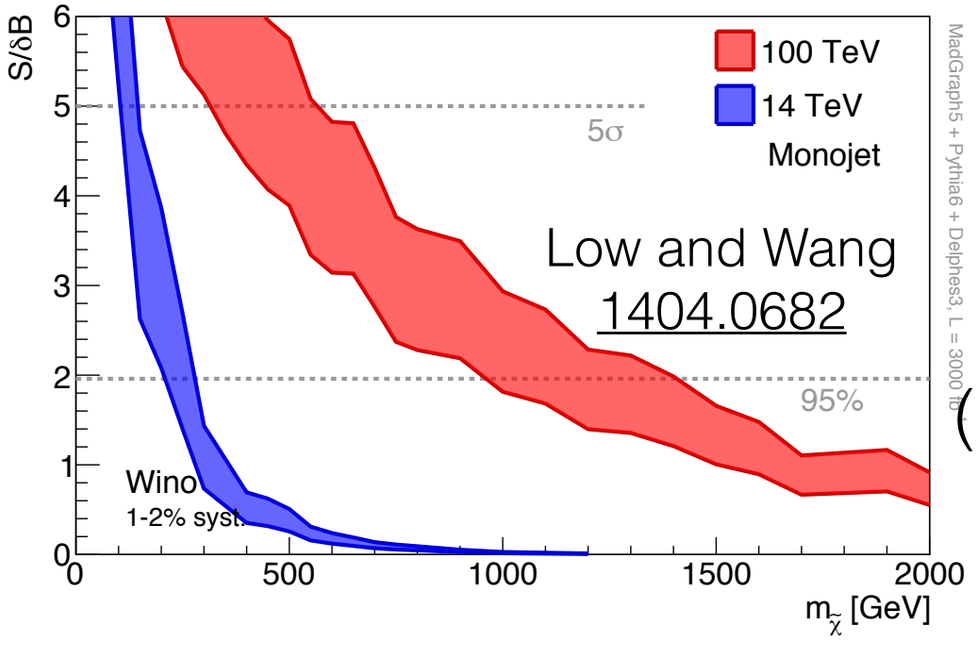
Z^*



applications

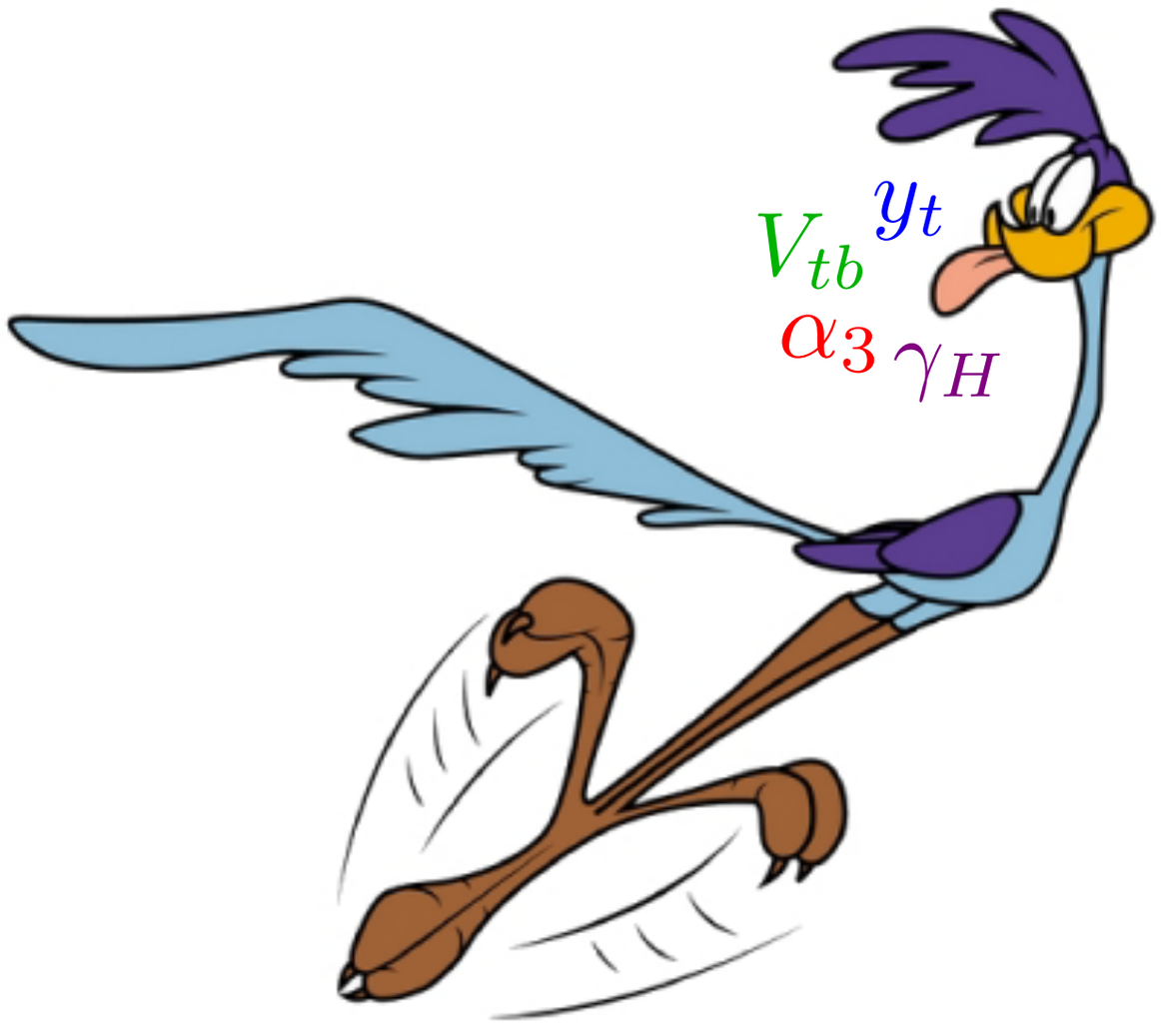






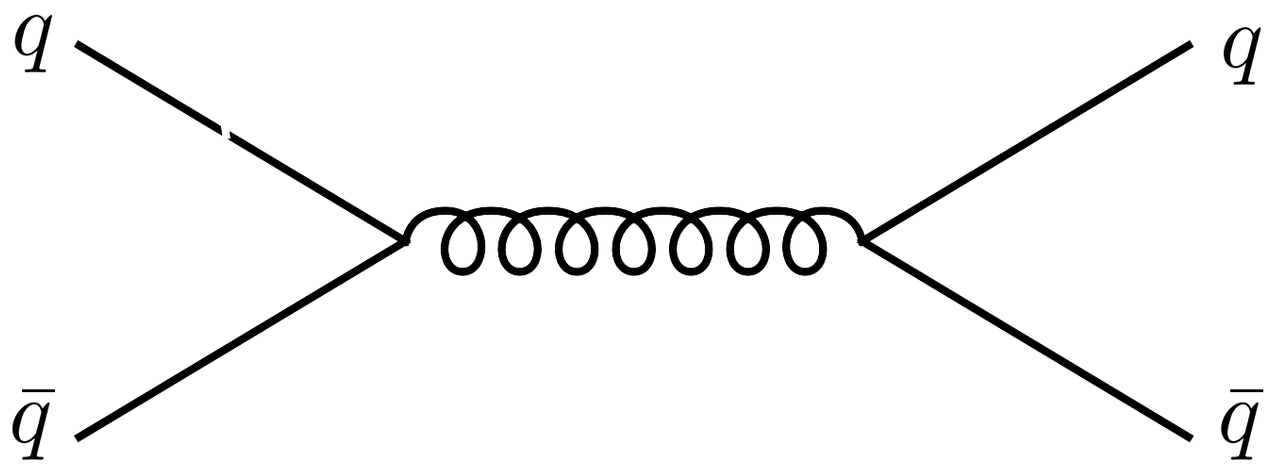
(no disappearing track)

3. measuring other running parameters?

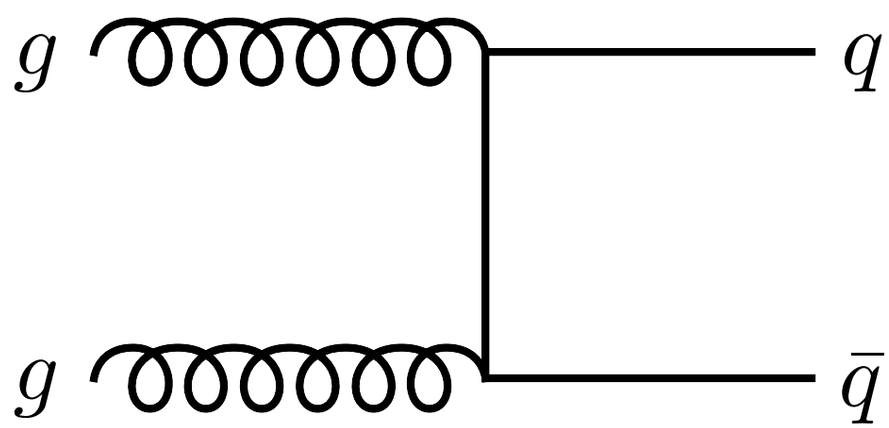


running α_3

event-by-event scale choice is ambiguous:

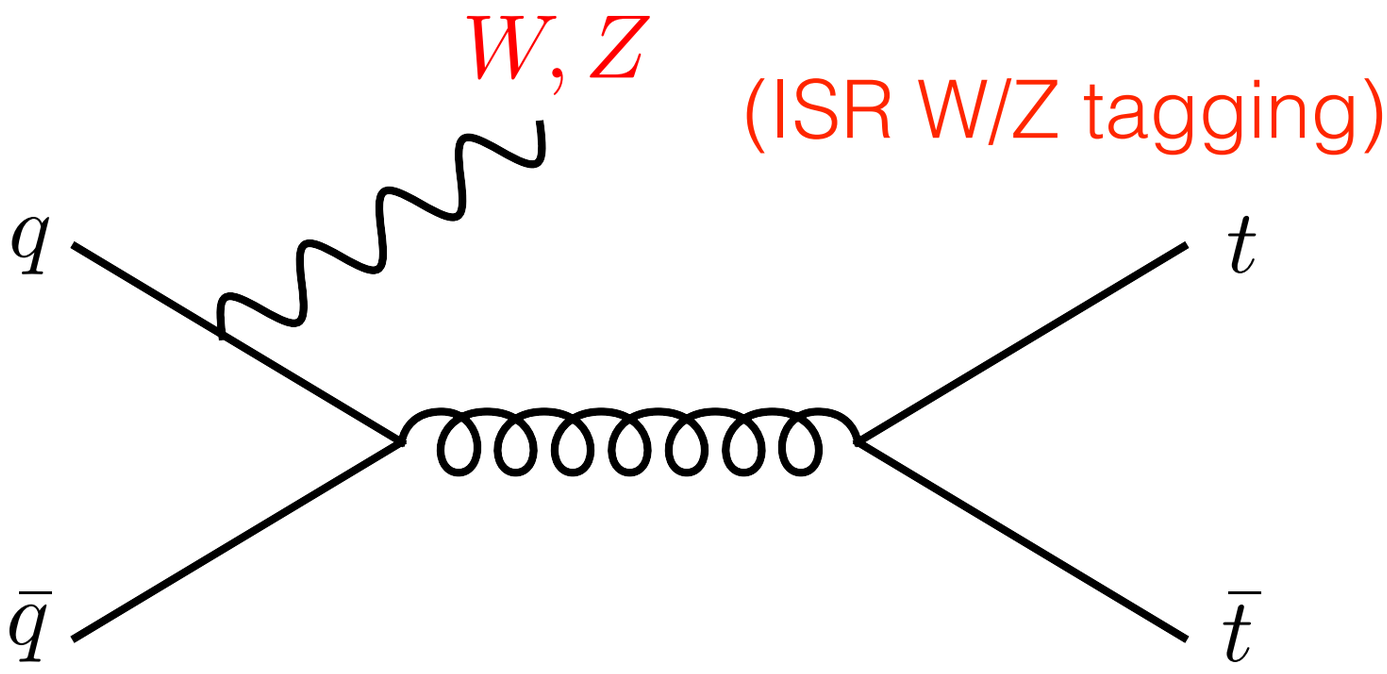


$\alpha_3(s)$ $\mathcal{M} \sim \frac{1}{s}$



$\alpha_3(t)$ $\mathcal{M} \sim \frac{1}{t}$

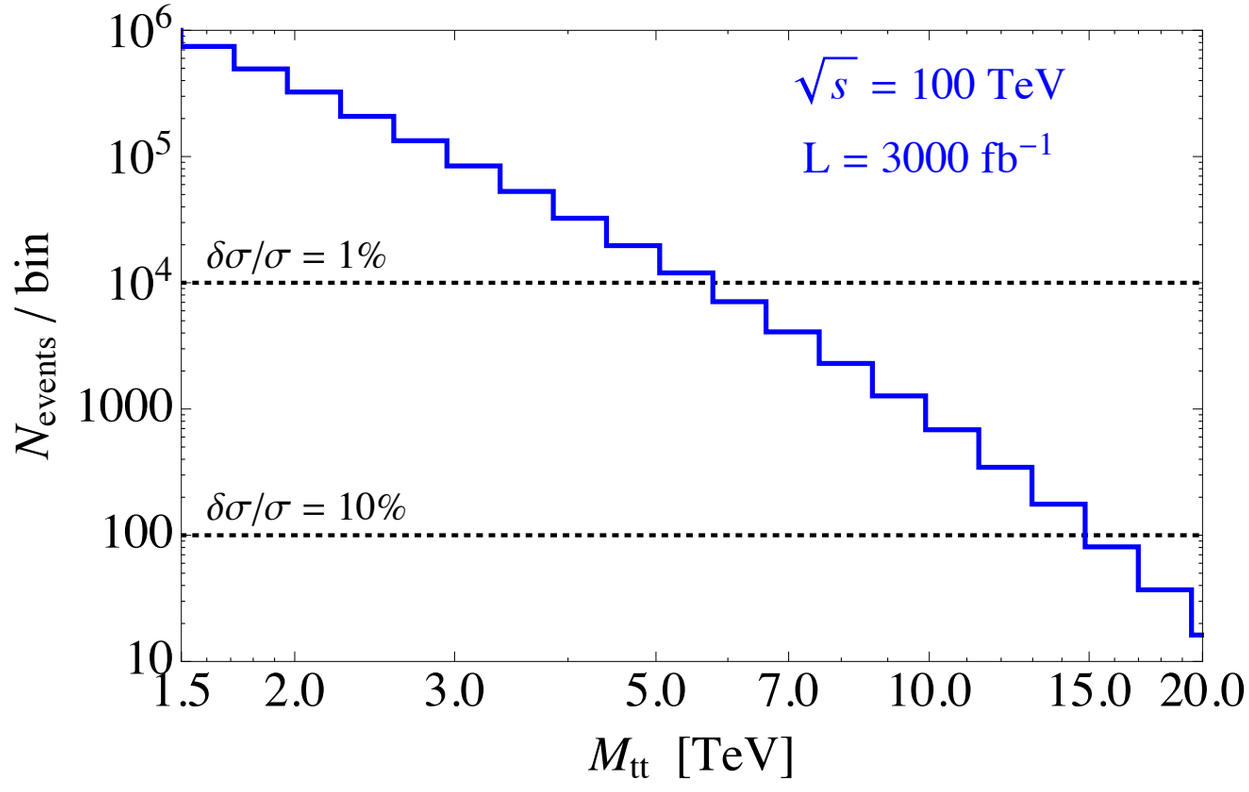
running α_3 at 100 TeV



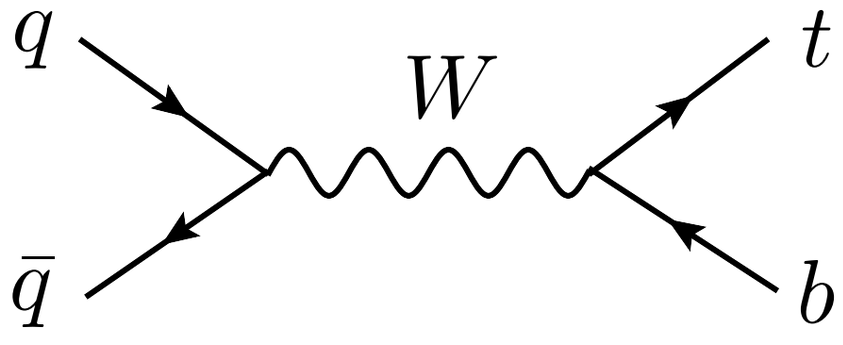
$\alpha_3(M_{tt})$

Galloway, JTR, Schwaller, Stolarski, Walsh

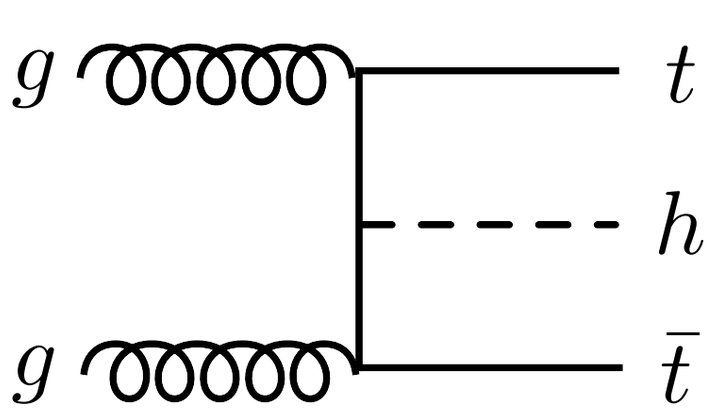
$\sigma_{t\bar{t}V_{\rm ISR}}$



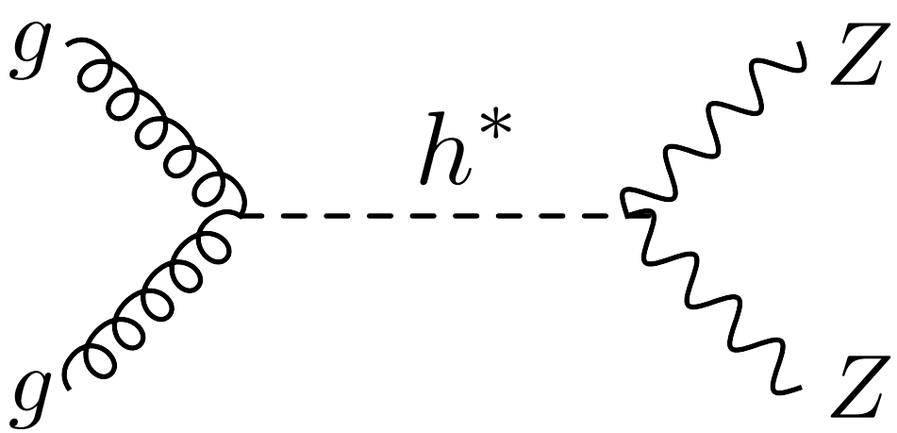
other running parameters @ 100 TeV?



$V_{tb}(Q)$



$y_t(Q)$



$\gamma_H(Q)$

take away

- running EW couplings can be measured using Drell-Yan now at the LHC and a 100 TeV collider

- model-independent limits on EW states await

- other running parameters should be explored at 100 TeV

ex: $\alpha_3(Q)$ from ttV_{ISR}