Some preliminary thoughts on theory uncertainties

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On Z resonance (leading pole term):

$$A_4 = \frac{\sum_q X_q \, 8 \frac{v_\ell}{a_\ell} \frac{v_q}{a_q}}{\sum_q X_q \left(1 + \frac{v_\ell^2}{a_\ell^2}\right)\left(1 + \frac{v_q^2}{a_q^2}\right)} \qquad X_q = f_q(x_1) f_{\bar{q}}(x_2) + f_{\bar{q}}(x_1) f_q(x_2)$$

$$\frac{v_\ell}{a_\ell} = 1 - 4 s_\ell^2, \qquad s_\ell^2 \equiv \sin^2 \theta_{\text{eff}}^\ell$$

$$\frac{v_q}{a_q} = 1 - 4|e_q|(s_\ell^2 + \Delta_q) \qquad \Delta_q = \underbrace{\Delta_{q(1)}}_{\text{implemented}} + \underbrace{\Delta_{q(2)}}_{\text{missing}}$$

$$\frac{\delta A_4}{A_4} \approx \frac{\sum_q X_q \, (-4|e_q|\Delta_{q(2)})}{\sum_q X_q \, (1 - 4|e_q| s_\ell^2)} + \frac{\sum_q X_q \, 8|e_q| \, (1 - 4|e_q| s_\ell^2) \Delta_{q(2)}}{\sum_q X_q \, [1 + (1 - 4|e_q| s_\ell^2)^2]}$$

$\Delta_{q(2)}$ is known (in SM) for leading Z pole term

Off Z pole: need to include non-res. terms, *estimate* their missing 2-loop terms

Comments on mass/width scheme

- Pole expansion scheme (PS) and complex-mass scheme (CMS):
  Gauge-invariant (GI), consistent to all orders (at least conceptually)
- Factorization scheme (FS):
  Gauge-invariant (GI), not extendable beyond NLO
- Naive scheme (NS) and other gauge-dependent (GD) schemes:
  can lead to completely wrong results

- Difference GI–GD is meaningless, cannot be used for theory error estimate
- Difference PS–FS, PS–CMS, CMS–FS is of higher order (NNLO)
  $\rightarrow$ Can be used as indication for theory error, but may not fully capture it