# Sigma Commutators

hadronic 'Sigma-term'

$$\Sigma_h = \langle h|[Q_i^A,[Q_j^A,H_{QCD}]]|h\rangle = m\langle h|\bar{\psi}\psi|h\rangle$$

$\Sigma_h/m$ scalar density inside a hadron

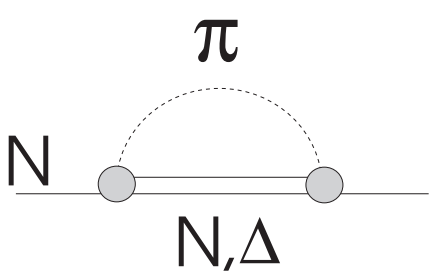
Feyman-Hellmann Theorem:

$$H = H_0 + H' = H_0 + \lambda h'$$

$$\langle\Phi(\lambda)|H'|\Phi(\lambda)\rangle = \lambda\frac{\partial E(\lambda)}{\partial\lambda} \quad \rightarrow \quad \Sigma_h = m\frac{\partial M_h}{\partial m}$$

pion: $(H_\chi = \frac{1}{2}m_\pi^2\Phi^2)$

$$\Sigma_\pi = m_\pi/2 = 70 \text{ MeV}, \; \Sigma_\pi/m = 12!$$

nucleon : $\pi N$-scattering

$$\Sigma_N = 45 \text{ MeV}$$