Sources of difference in the $a_i$ extractions
- f1-th order extraction $\to$ kinematics $\frac{Q^2}{A}$ $\to$ see N^3LO 3N force
- 3N vs. NN: different kinematics $3N$ pom, on shell $E^2 m_1$
  $NN$: pom virtual

order-range N^3LO 3N force

$$V_{3N,\pi}^{(3)} = \sum_{i\neq j\neq k} \left( -D \frac{g_A^2}{g_{\pi NN}} \frac{q_i \cdot q_j}{q_i^2 + m_i^2} \frac{q_i \cdot q_k}{q_k^2 + m_k^2} \right) \cdot q_i \cdot q_j \cdot q_k$$

$$V_{3N,calc}^{(1)} = \sum_{i\neq j\neq k} \frac{E}{2} \frac{q_i \cdot q_j}{q_i^2} \frac{q_i \cdot q_k}{q_k^2}$$

Convention: dimensionless coupling $C_D = D f_H^2 \Lambda \chi$ $\quad$ and $\Lambda \chi \approx 700 \text{ MeV}$

$C_E = E f_H^4 \Lambda \chi$ $\quad$ (choice)

N^3LO 3N force only have 2 LECs: $C_D, C_E \to$ fit to $A = 3.4$ $\quad$ Why light nucleon?

usually fit $B(3H) + a_{n-d}$

or $n \to p(4He)$

$a \to ^3H$ $\beta$-decay half-life $\to$ see Thursday

$\rightarrow$ predict structure + scattering/reaction $\to$ N^3LO (NN + 3N)

Majority of calculations with N^3LO NN + N^3LO 3N became full N^3LO 3N force, only derived recently

N^3LO 3N force: $Q^4$, no new contact interactions! $\rightarrow$ parameter free $\quad$ $\rightarrow$ 3N topology

N^3LO 4N force: $Q^4$, all motion $\Delta_i = 0$ (no cancellation like for NLO 3N)

also parameter-free

4N contact only at N^5LO $\quad$ $V = -4 + 2.4 + 0 + \Delta_1 = 6$

$\Delta_i = 0 + \frac{g_\pi}{\Lambda} - 2$
$N^3LO$ 3N topology

one-loop contributions $\nu = -4 + 2N + 2L + \sum_i \Delta_i$; all $\Delta_i = 0 \Rightarrow \nu = 4$ and $L = 1$

operators like $N^3LO$ 3N + small res

$\delta c_1 = -\frac{g_A^2 m_T}{64 \pi f^2}$

$\delta c_3 = -\delta c_4 = \frac{g_A^4 m_T}{16 \pi f^2}$