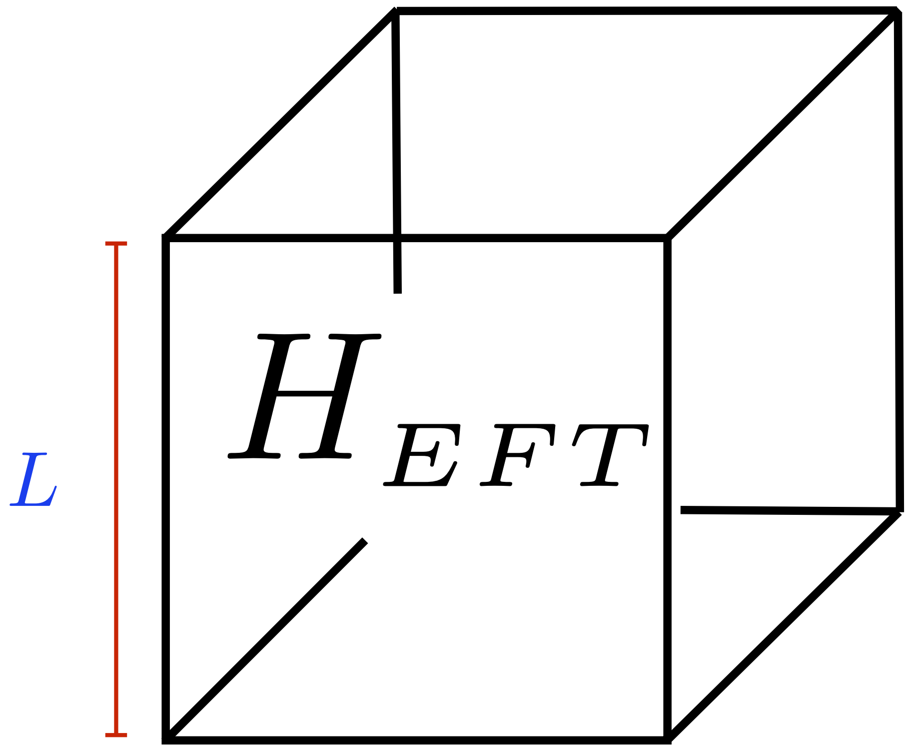
Alternate method: match to the potential



Effective field theory Hamiltonian in a finite volume with periodic BCs

$$V(\mathbf{r}) = V(\mathbf{r} + \mathbf{m}L)$$

$$\psi(\mathbf{r}) = \psi(\mathbf{r} + \mathbf{m}L)$$

$$V(\mathbf{r}) = \int \frac{d^3\mathbf{k}}{(2\pi)^3}\, e^{i\mathbf{k}\cdot\mathbf{r}}\, \tilde{V}(\mathbf{k}) \;\rightarrow\; V_L(\mathbf{r}) = \frac{1}{L^3}\sum_{\mathbf{n}} e^{i2\pi\mathbf{n}\cdot\mathbf{r}/L}\, \tilde{V}(\frac{2\pi}{L}\mathbf{n})$$

$$\psi(\mathbf{r}) = \int \frac{d^3\mathbf{k}}{(2\pi)^3}\, e^{i\mathbf{k}\cdot\mathbf{r}}\, \tilde{\psi}(\mathbf{k}) \;\rightarrow\; \psi_L(\mathbf{r}) = \frac{1}{L^3}\sum_{\mathbf{n}} e^{i2\pi\mathbf{n}\cdot\mathbf{r}/L}\, \tilde{\psi}_L(\frac{2\pi}{L}\mathbf{n})$$

3-dimensional Schrödinger equation in finite volume

$$\boxed{\frac{-\hbar^2}{2\mu}\boldsymbol{\nabla}^2\psi_L(\mathbf{r}) \;+\; V_L(\mathbf{r})\psi_L(\mathbf{r}) \;=\; E\;\psi_L(\mathbf{r})}$$

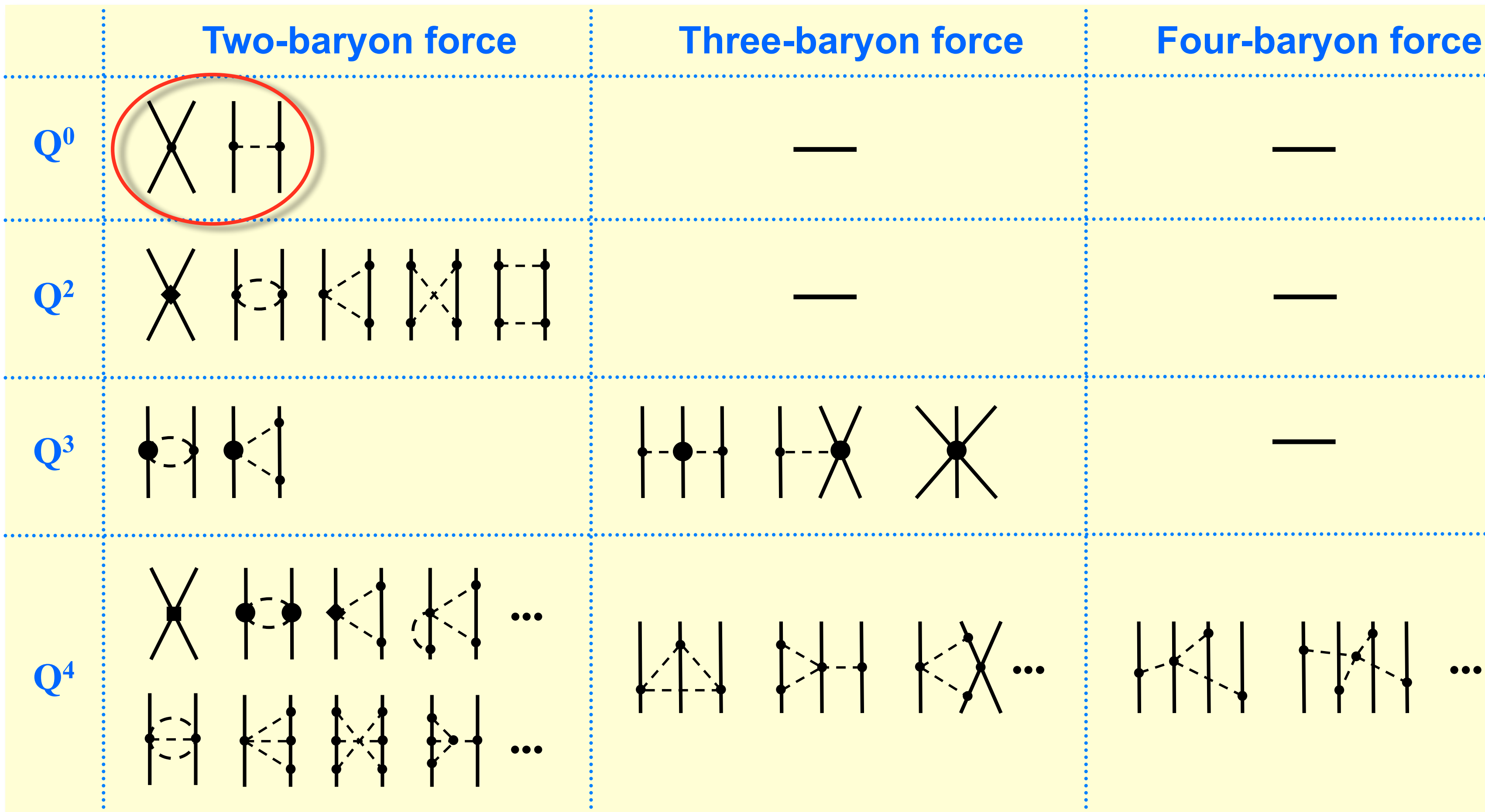
$$\Downarrow$$

$$\frac{\hbar^2}{2\mu}\left(\frac{2\pi}{L}\right)^2 |\mathbf{n}|^2\;\tilde{\psi}_L(\frac{2\pi}{L}\mathbf{n}) \;+\; \sum_{\overline{\mathbf{n}}}\tilde{V}(\frac{2\pi}{L}(\mathbf{n}-\overline{\mathbf{n}}))\;\tilde{\psi}_L(\frac{2\pi}{L}\overline{\mathbf{n}}) \;=\; E_L\;\tilde{\psi}_L(\frac{2\pi}{L}\mathbf{n})$$

$$\boxed{\hat{H}_{\mathbf{n},\mathbf{n}'} \;=\; \frac{2\pi^2\hbar^2}{\mu L^2}\;|\mathbf{n}|^2\;\delta_{\mathbf{n},\mathbf{n}'} \;+\; \tilde{V}(\frac{2\pi}{L}(\mathbf{n}-\mathbf{n}'))}$$

Diagonalize large symmetric matrix

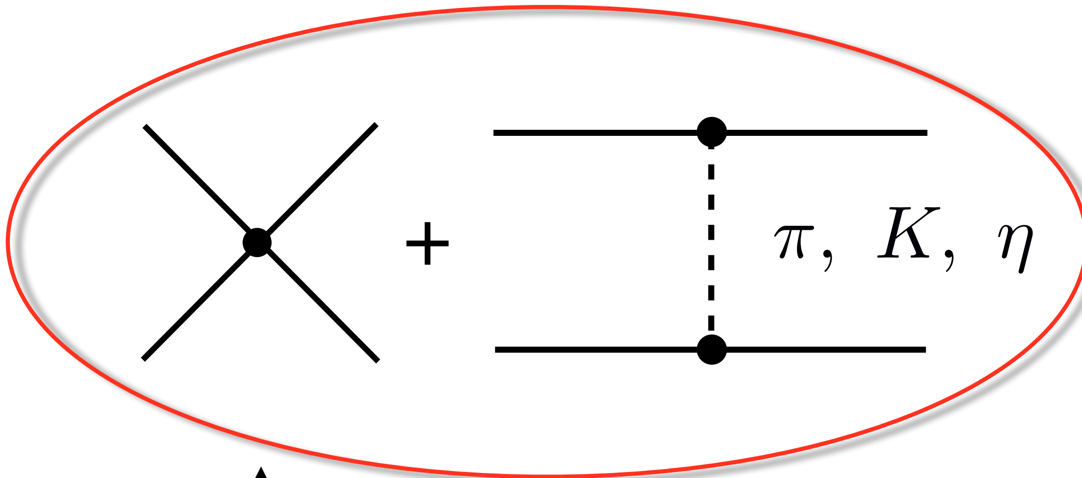
Nuclear Effective Field Theory



2 baryon force ≫ 3 baryon force ≫ 4 baryon force . . .

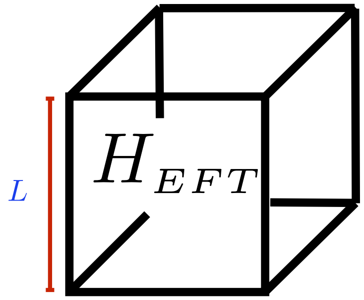
Match to Effective Field Theory!

LO potential:



Fit coupling to match energy levels

Now we have LO potential at ALL pion masses!



vs.

$$p\cot\delta = \frac{1}{\pi L}\mathcal{S}(\tilde{p})$$