New particles hints

- in loops
- mediators of interaction
- ...

New particles produced directly

Low energy → **High energy**

BSM NEW FUNDAMENTAL INTERACTIONS

New particles hints

- in loops
- mediators of interaction
- ...

New particles produced directly

Low energy → **High energy**

- ★ **Effective field theories for low energy**
  - ➡ **New (heavy) dof integrated out**
- ★ **Consider all Dirac bilinears for EW interactions**
  - ➡ $1, \gamma_5, \gamma_\mu(1+\gamma_5), \sigma_{\mu\nu}$
  - ➡ **Define ``*Wilson coefficient*" for new interaction**

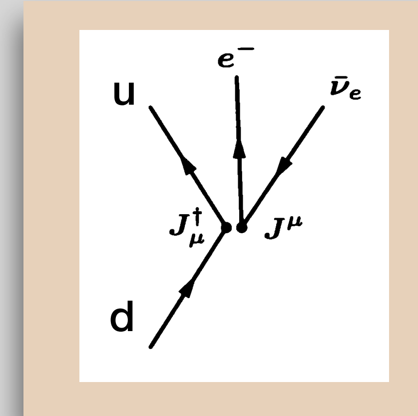
Read "Beyond V-A"

Includes scalar and tensor bil.

BSM NEW FUNDAMENTAL INTERACTIONS

EFT AT THE QUARK LEVEL $d_j \to u_i l^- \nu_l$

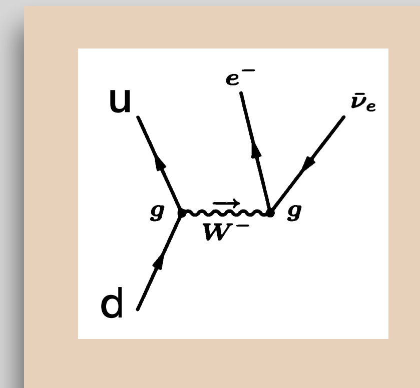
$$\mathcal{L}^{(\mathrm{eff})} = \mathcal{L}_{\mathrm{SM}} + \sum_i \frac{1}{\Lambda_i^2}\mathcal{O}_i$$



4-fermion interaction

$$\mathcal{L}_{d_j\to u_i\ell^-\bar{\nu}_\ell} = \frac{-g^2}{2m_W^2}V_{ij}\Big[\big(1+[v_L]_{\ell\ell ij}\big)\bar{\ell}_L\gamma_\mu\nu_{\ell L}\bar{u}^i_L\gamma^\mu d^j_L + [v_R]_{\ell\ell ij}\bar{\ell}_L\gamma_\mu\nu_{\ell L}\bar{u}^i_R\gamma^\mu d^j_R$$
$$+ [s_L]_{\ell\ell ij}\bar{\ell}_R\nu_{\ell L}\bar{u}^i_R d^j_L + [s_R]_{\ell\ell ij}\bar{\ell}_R\nu_{\ell L}\bar{u}^i_L d^j_R$$
$$+ [t_L]_{\ell\ell ij}\bar{\ell}_R\sigma_{\mu\nu}\nu_{\ell L}\bar{u}^i_R\sigma^{\mu\nu}d^j_L\Big] + \mathrm{h.c.},$$

right



Tensor

$\varepsilon_T \equiv t_L$

Scalars

$\varepsilon_S \equiv s_L + s_R$

SM

$$\langle p(p_p)|\bar{u}\gamma_\mu d|n(p_n)\rangle = \bar{u}_p(p_p)\Big[g_V(q^2)\gamma_\mu + \frac{\tilde{g}_{T(V)}(q^2)}{2M_N}\sigma_{\mu\nu}q^\nu + \frac{\tilde{g}_S(q^2)}{2M_N}q_\mu\Big]u_n(p_n)$$

$$\langle p(p_p)|\bar{u}d|n(p_n)\rangle = g_S(q^2)\bar{u}_p(p_p)u_n(p_n)$$

Hadronic Form Factors

$$\langle p(p_p)|\bar{u}\sigma_{\mu\nu}d|n(p_n)\rangle = \bar{u}_p(p_p)[g_T(q^2)\sigma_{\mu\nu} \text{ + induced }]u_n(p_n)$$

BETA DECAY IN EFT

[Bhattarchaya et al., PRD85]

[Cirigliano et al., NPB 830]

$$e^q(x) = e^q_{\rm loc}(x) + e^q_{\rm gen}(x) + e^q_{\rm mass}(x)$$

$$\int_{-1}^{1} dx\, e^q(x, Q^2) = \int_{-1}^{1} dx\, e^q_{\rm loc}(x, Q^2) = \frac{1}{2M} \langle P|\bar{\psi}_q(0)\psi_q(0)|P\rangle(Q^2) = \sigma_q(Q^2)$$

The scalar charge is here too!

ChiPT gets it at the Chern-Dashen point.

We could get it straight at 0 mmt transfer!

Very indirect though…

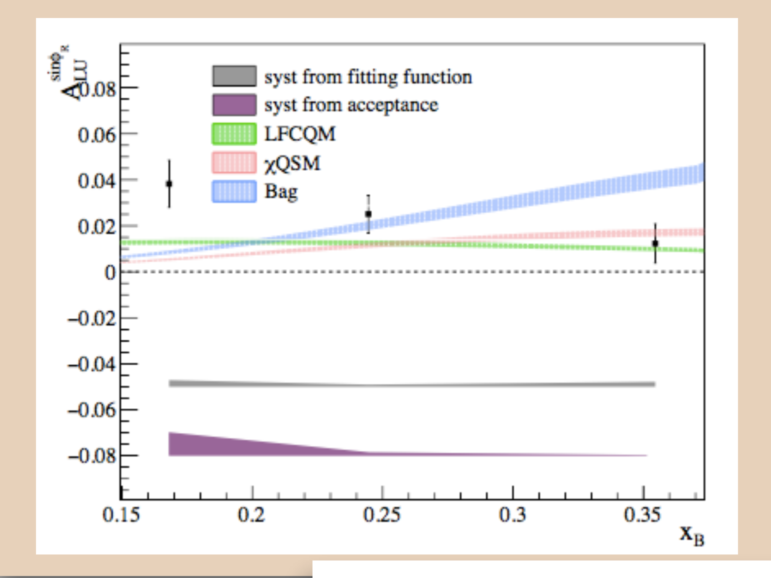
$$F_{LU}^{\sin\phi_R} = -\sum_q e_q^2\, x \frac{|R|\sin\theta}{Q}\left[\frac{M}{m_{hh}}\, x\, e^q(x)\, H_1^{\sphericalangle\, q}\big(z, \cos\theta, m_{hh}\big) + \frac{1}{z}\, f_1^q(x)\, \widetilde{G}^{\sphericalangle\, q}\big(z, \cos\theta, m_{hh}\big)\right]$$

CHIRAL-ODD TWIST-3 PDF

[AC, arXiv:1405.7659]

DIHADRON ASYMMETRY FOR UNPOLARIZED TARGET INVOLVING SCALAR PDF (subleading)

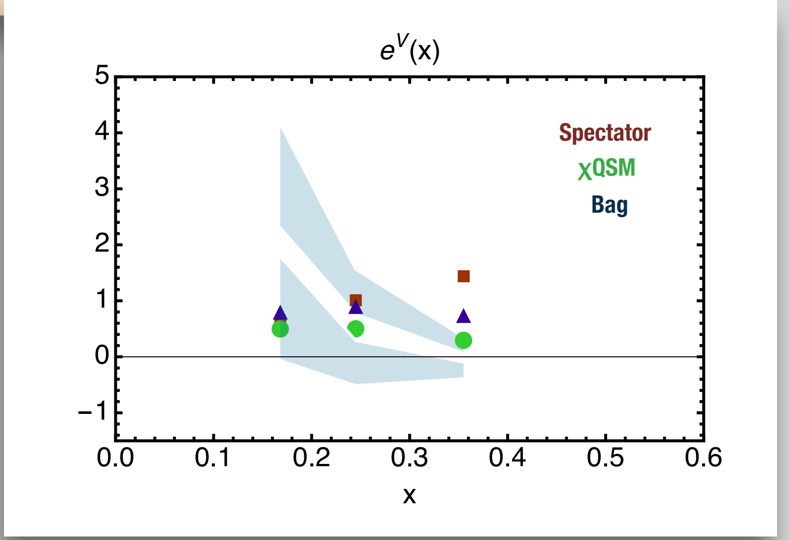
Jefferson Lab



CLAS collaboration

S. Pisano et al., to be published¿?

A.C. et al. 1405.7659



SCALAR CHARGE related to e(x=0)

lots of things to think of...

FIRST STEP OF A LONG WAY TOWARDS THE SCALAR CHARGE