Flavor separation of quark densities

- 6 flavors needed ($u, \bar{u}, d, \bar{d}, s, \bar{s}$)
- At LO with light quarks, $ep$ DIS gives only one combination

$$2xF_1 = F_2 = \frac{4}{9}x[u(x) + \bar{u}(x)] + \frac{1}{9}x[d(x) + \bar{d}(x) + s(x) + \bar{s}(x)]$$

Other forms of DIS can be used.
- Nuclear target $\rightarrow$ extraction of neutron target
  - By isospin symmetry
    $$f_{u/n}(x) \simeq f_{d/p}, \quad f_{d/n}(x) \simeq f_{u/p}, \quad \text{etc}$$
  - On isosinglet target (e.g., deuteron), per nucleon:
    $$2xF_1 = F_2 = \frac{5}{18}x[u(x) + \bar{u}(x) + d(x) + \bar{d}(x)] + \frac{1}{9}x[s(x) + \bar{s}(x)]$$
- Neutrino and antineutrino (mostly nuclear targets)
Neutrino DIS

- Also have $F_3$. (Coefficient of $-i\epsilon^{\mu\nu\alpha\beta}q_\alpha p_\beta/(2p \cdot q)$ in $W^{\mu\nu}$.)
- Show graphs
- Parton model formulae

\[
2xF_{1W}^+ = F_{2W}^+ = x[d(x) + \bar{u}(x) + s(x)],
\]

\[
F_{3W}^+ = 2[d(x) - \bar{u}(x) + s(x)],
\]

\[
2xF_{1W}^- = F_{2W}^- = x[u(x) + \bar{d}(x) + \bar{s}(x)],
\]

\[
F_{3W}^- = 2[u(x) - \bar{d}(x) - \bar{s}(x)],
\]

- Also try detecting decays of charm particles in final state, to pick out strange-quark induced processes
- Correct for quark mixing.

Flavor dependence of parton densities

(J. Beringer et al. (Particle Data Group), Phys. Rev. D86, 010001 (2012). Fig. 18.4.)