An electron scatterer's view of neutrino physics

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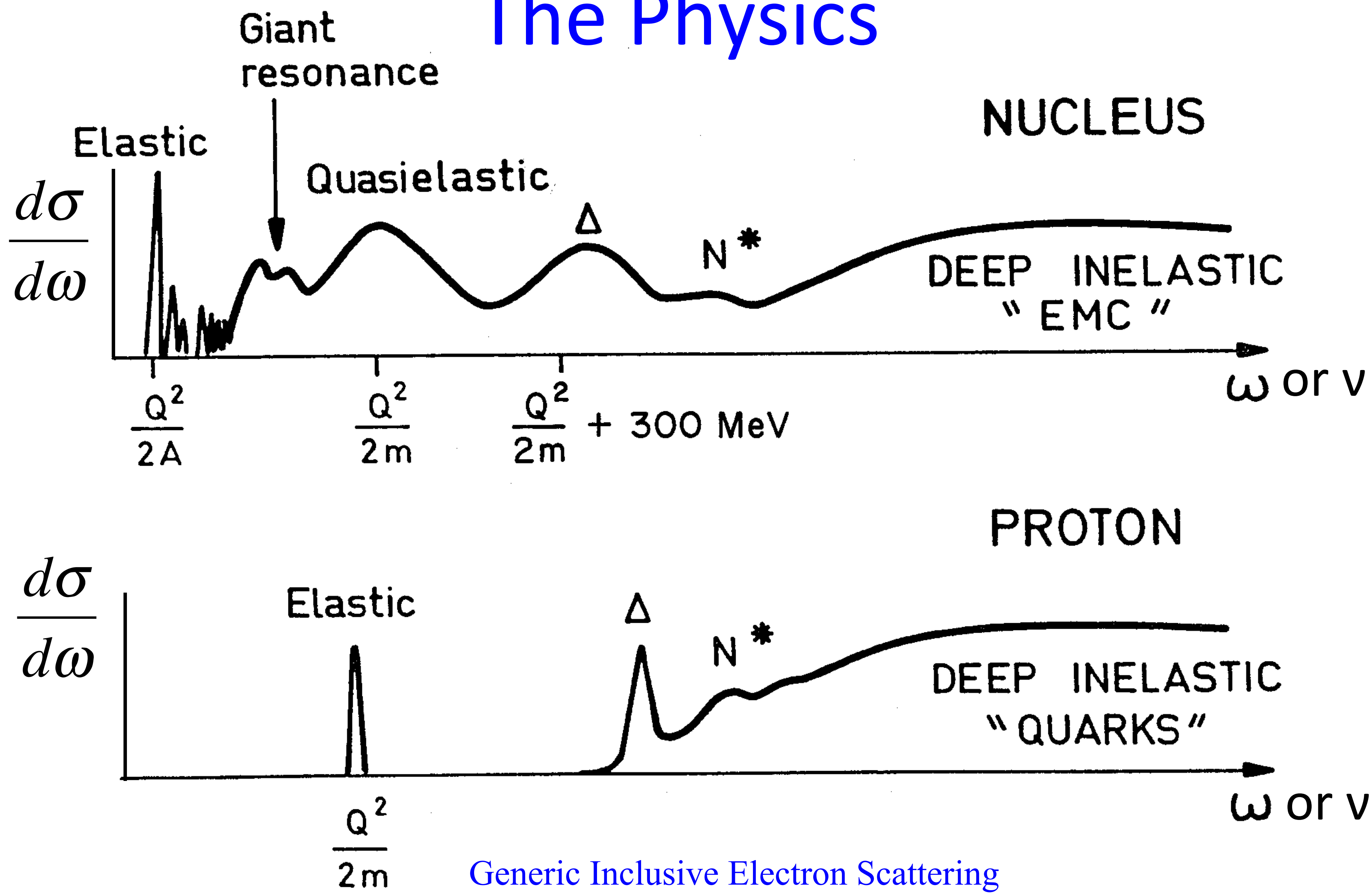
The problems

- Complicated beams
  - Non-monochromatic
  - Not pure
- Simplistic detectors
  - Crude granularity
  - Often non-magnetic
  - Optimized for tiny cross sections
  - Assumed the nuclear physics was known
- Need to reconstruct the incident neutrino from the detected outgoing particles

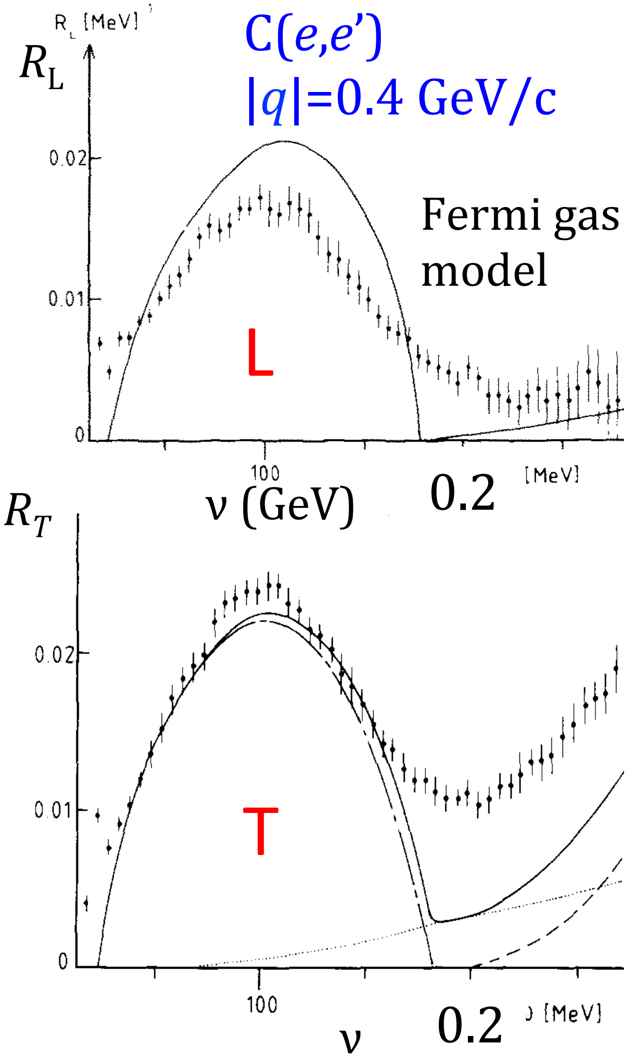
The Physics



Generic Inclusive Electron Scattering
at fixed momentum transfer

Fermi Gas Model: Too good to be true?

$$\frac{d\sigma}{d\Omega d\nu} = \sigma_M \frac{E'}{E}\left[\frac{Q^4}{\vec{q}^4} R_L(Q^2,\nu) + \left(\frac{Q^2}{2\vec{q}^2} + \tan^2\frac{\theta}{2}\right) R_T(Q^2,\nu)\right]$$



y = minimum initial nucleon momentum

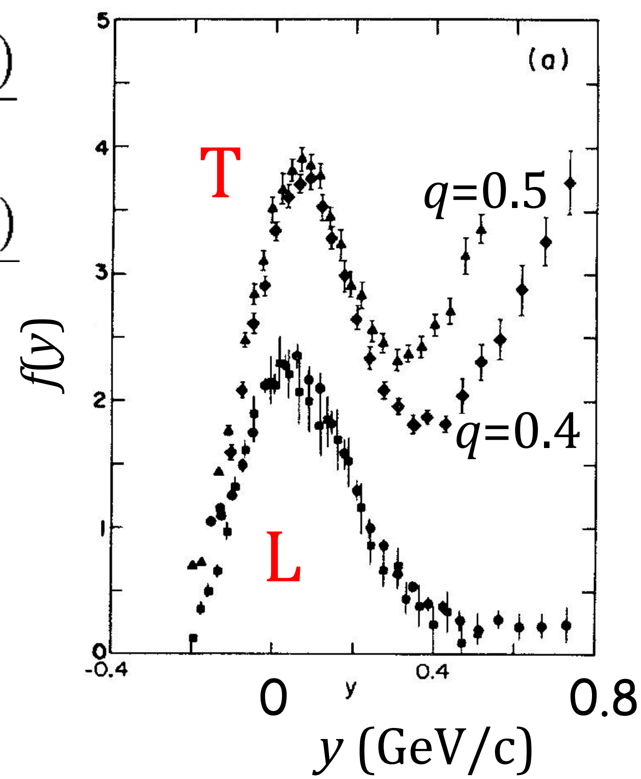
= *m*ν/*q* – *q*/2 (nonrelativistic only!)

f = reduced response function

$$f_L(Q^2,\omega) \propto \frac{R_L(Q^2,\omega)}{\tilde{G}_E^2(Q^2)}$$

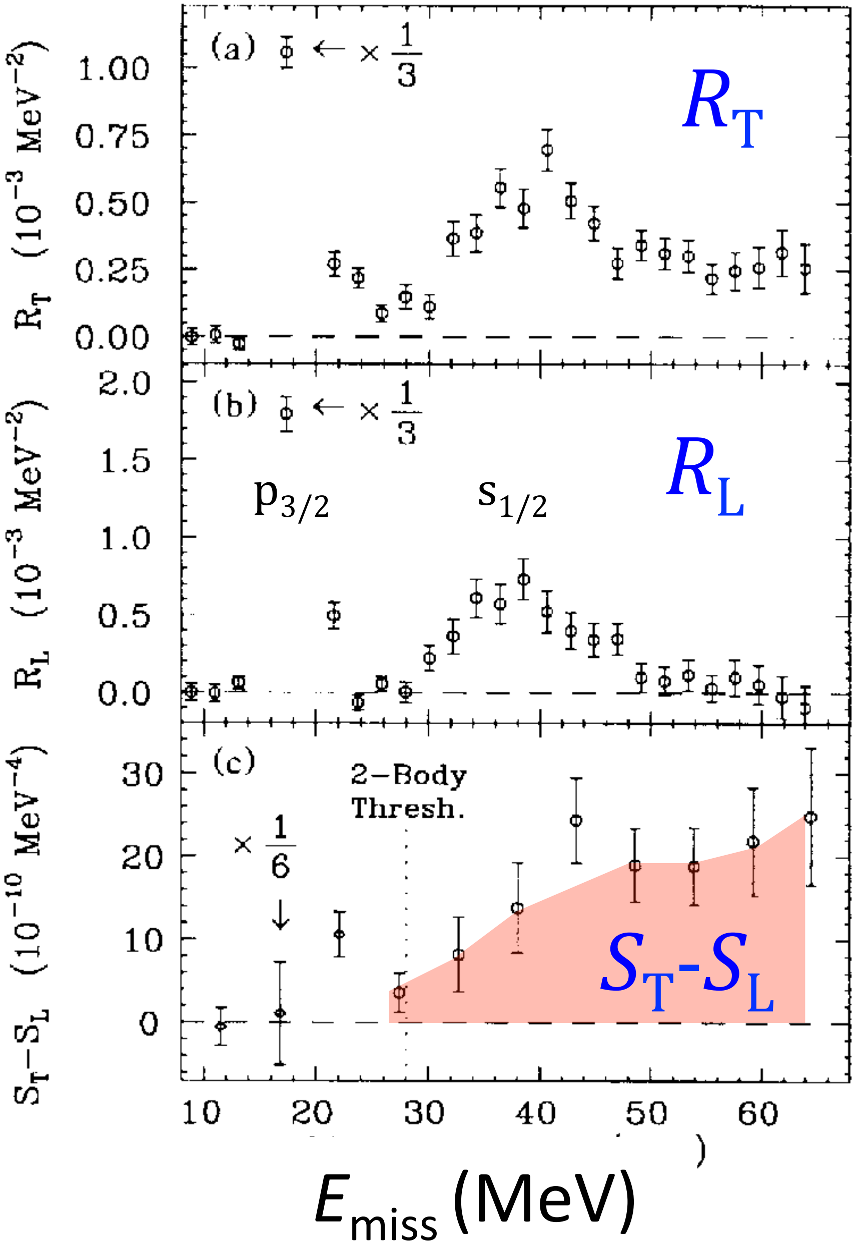
$$f_T(Q^2,\omega) \propto \frac{R_T(Q^2,\omega)}{\tilde{G}_M^2(Q^2)}$$

- L scales
- T scales
- T≠L!!



P. Barreau et al, NPA 402, 515 (1983)
Finn et al, PRC 29, 2230 (1984)

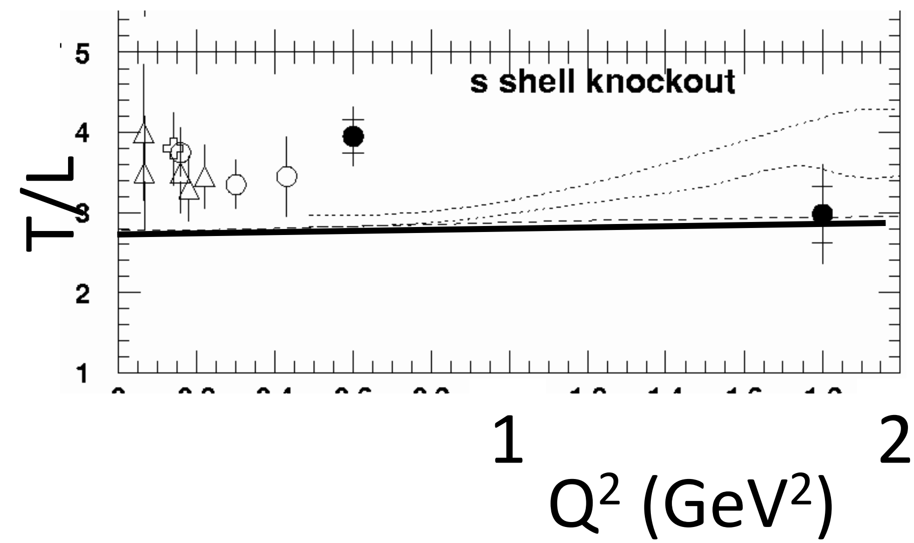
Extra Transverse even at x = 1



$^{12}C(e,e'p)$

q=0.4 GeV and x=1

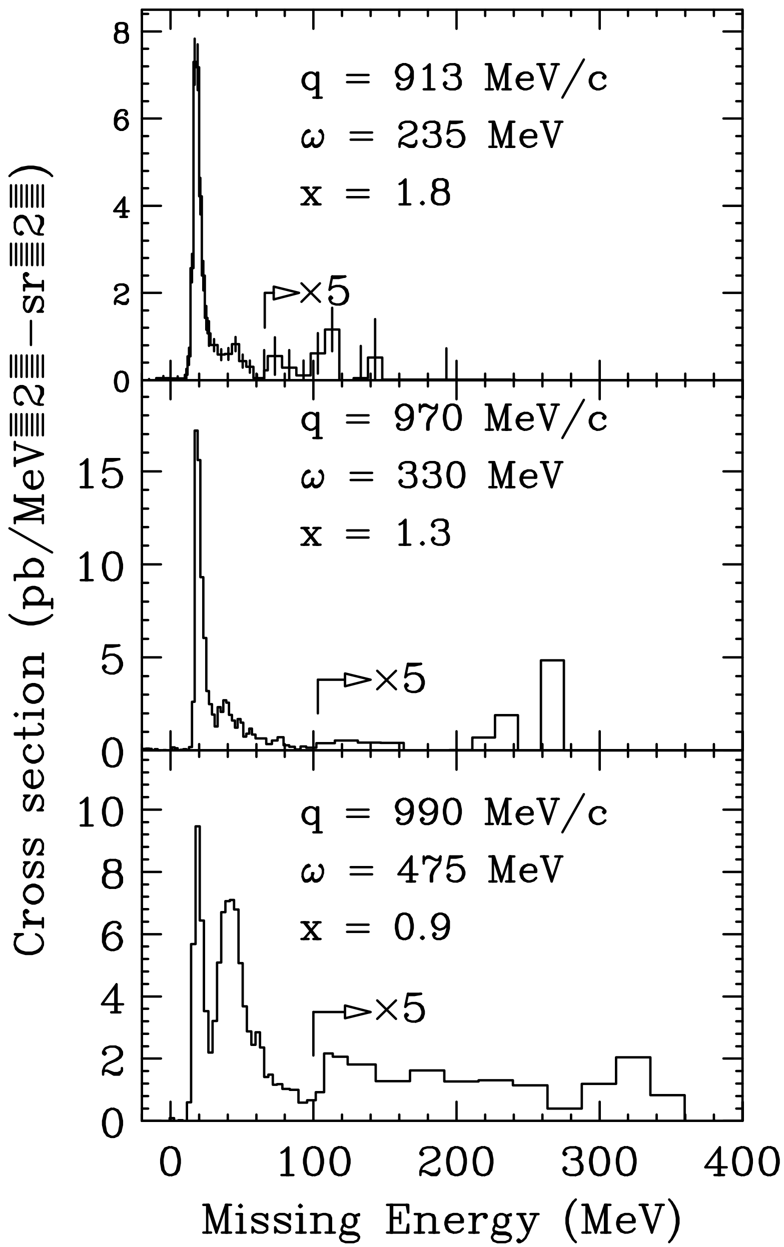
extra transverse strength starting at the 2N KO threshold



decreases with Q^2

Ulmer et al, PRL 59, 2259 (1987);
Dutta et al, PRC 61, 061602 (2000)

Fixed q

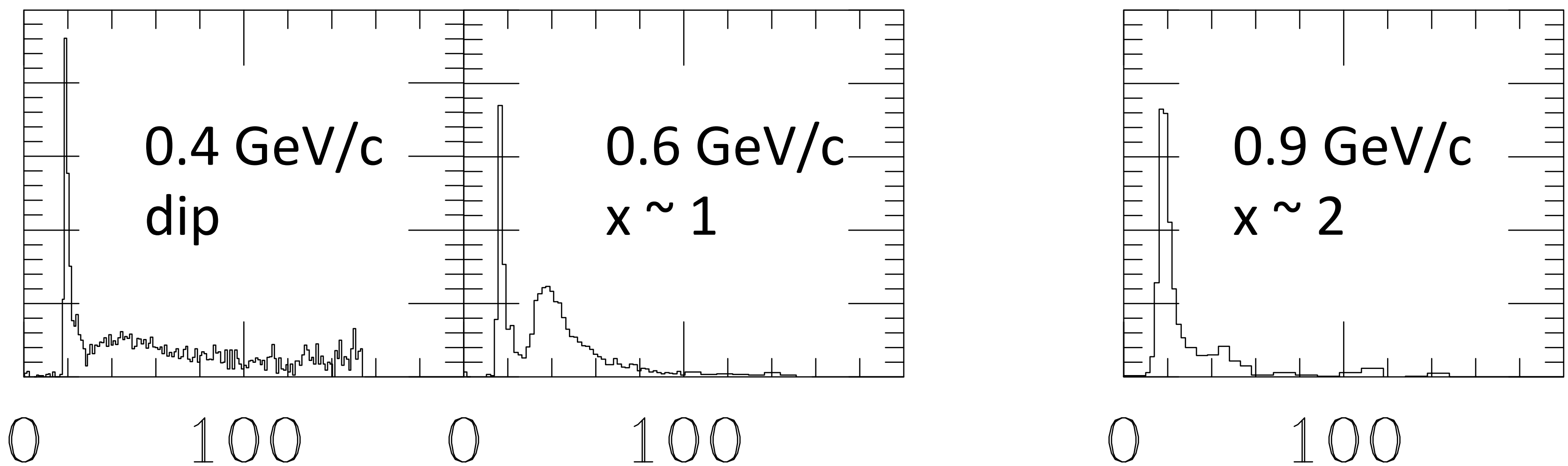


$^{12}C(e,e'p)$ Bates
q ~ 1 GeV/c

Non-QE reactions increase with ω

S. Penn, unpublished
J. Morrison, PRC **59**, 221, (1999)

Fixed ω = 0.2 GeV

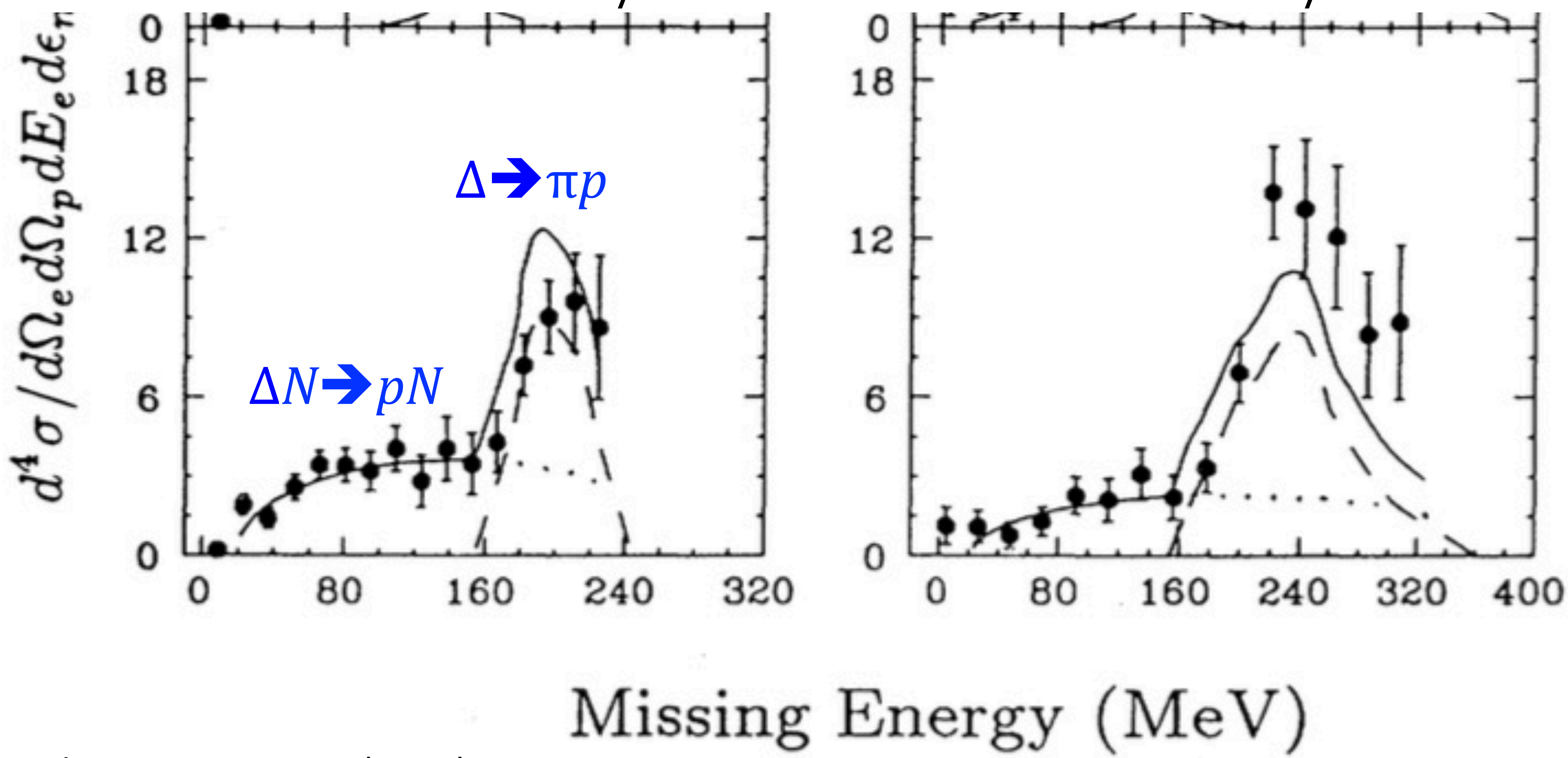


R. Lourie, PRL **56**, 2364 (1986)
L. Weinstein, PRL **64**, 1646 (1990)
S. Penn, unpublished

^{12}C(e,e'p) Delta Region

E_0 = 460 MeV
q = 400 MeV/c
ω = 275 MeV/c

E_0 = 647 MeV
q = 473 MeV/c
ω = 382 MeV/c

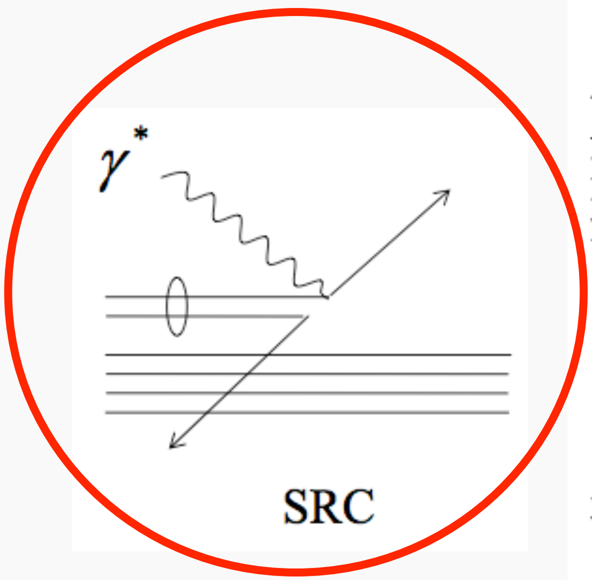


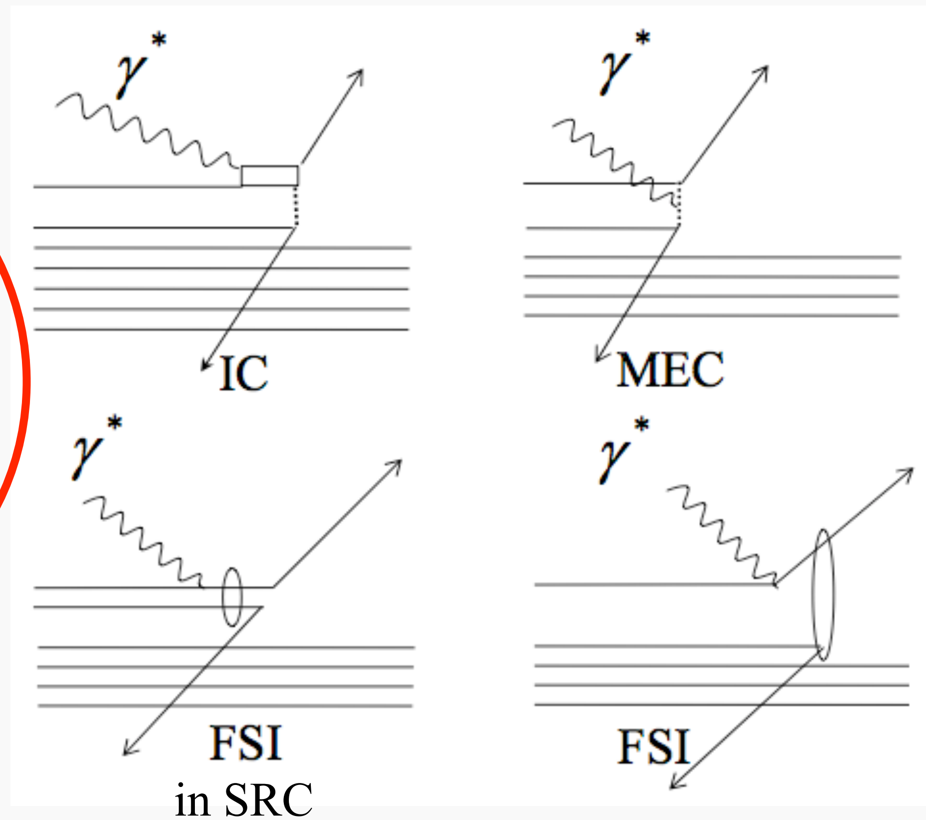
Baghaei, PRC **39**, 177 (1989)

What are correlations?

Average Two-Nucleon Properties in the Nuclear Ground State

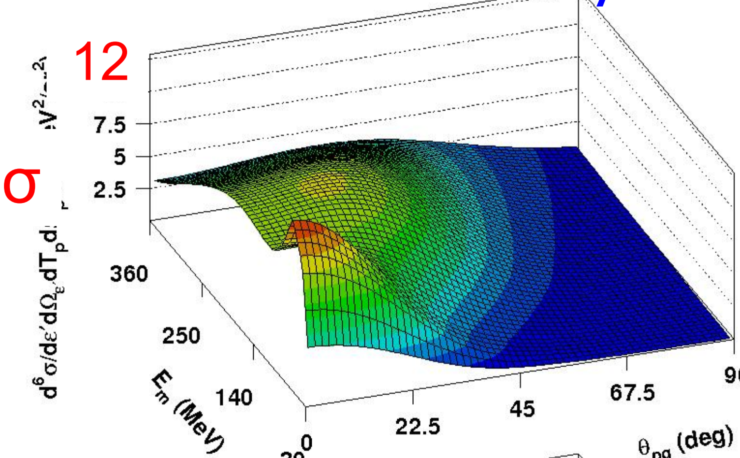
Two-body currents are not Correlations
(but add coherently)



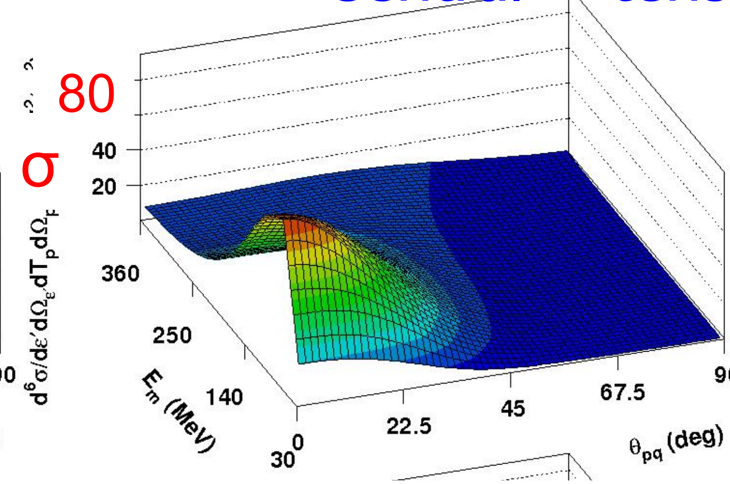


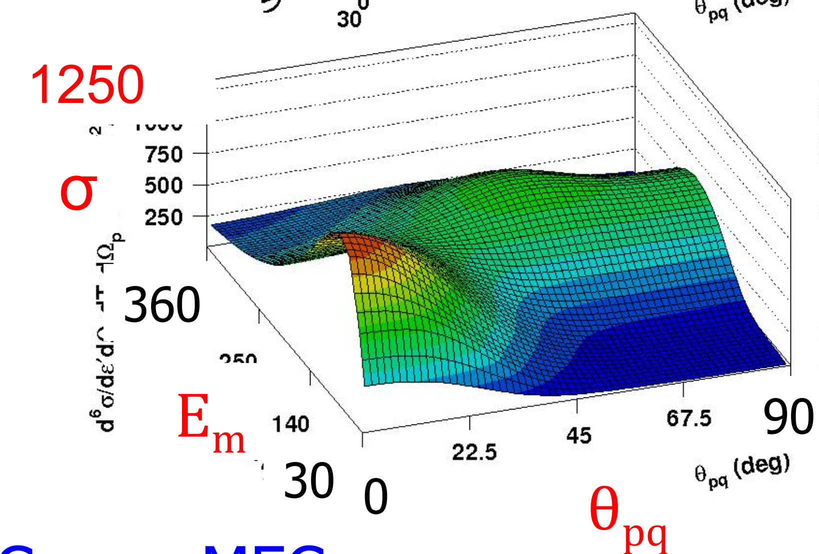
2N currents enhance correlations

Central correlations only



Central + tensor corr





Corr + MEC

MEC changes the magnitude of the cross section,
not the distribution in E_{miss} vs $Theta_{pq}$

O(e,e'p) Ryckebusch

Summary

- Electron scattering:
  - Monochromatic beam
  - Choose kinematics to minimize "uninteresting" reaction mechanisms
  - Calculate cross sections after the fact
- Neutrino interactions
  - Continuous mixed beams
  - Must include all reaction mechanisms
  - Need good models in event generators
    - Correct initial state
    - MEC, IC
    - FSI (not discussed here)