Path forward: theory vs experiment needs, QE discussion input

Comments/Observations:

R. Tayloe,
Nuint'09

Path forward: theory vs experiment needs, QE discussion input

Comments/Observations:

- Desperately seeking:
  model-independent cross section measurements
- M_A , what the ...?
- κ , RFG-blasphemy?

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Desperately seeking:
model-independent cross sections

- **IMHO, best approach to providing xsections needed for oscillations is to develop a solid understanding of theory**

- Requires, from experiments, unbiased, model-independent observables: cross sections!
    - need fluxes (with errors) to do this, no xsection based tuning

Jon Link, Nov. 18, 2005
Fermilab Wine & Cheese seminar

E 23, NUMBER 11 1 JUNE 1981

Quasielastic neutrino scattering: A measurement of the weak nucleon axial-vector form factor

N. J. Baker, A. M. Cnops,* P. L. Connolly, S. A. Kahn, H. G. Kirk, M. J. Murtagh, R. B. Palmer, N. P. Samios, and M. Tanaka
Brookhaven National Laboratory, Upton, New York 11973
(Received 12 February 1981)

Brookhaven AGS
7ft D_2 Bubble Chamber

The quasielastic reaction $\nu_\mu n \to \mu^- p$ was studied in an experiment using the BNL 7-foot deuterium bubble chamber exposed to the wide-band neutrino beam with an average energy of 1.6 GeV. A total of 1138 quasielastic events in the momentum-transfer range $Q^2 = 0.06-3.00$ $(\text{GeV}/c)^2$ were selected by kinematic fitting and particle identification and were used to extract the axial-vector form factor $F_A(Q^2)$ from the Q^2 distribution. In the framework of the conventional $V-A$ theory, we find that the dipole parametrization is favored over the monopole. The value of the axial-vector mass M_A in the dipole parametrization is 1.07 ± 0.06 GeV, which is in good agreement with both recent neutrino and electroproduction experiments. In addition, the standard assumptions of conserved vector current and no second-class currents are checked.

We have used a maximum likelihood method to extract M_A from the shape of the Q^2 distribution for each observed neutrino energy. This likelihood function $\mathcal{L}^I$ is independent of the shape of the neutrino spectrum . . .

They didn't even try to determine their ν flux from pion production and beam dynamics.

Phys. Rev. D **25**, 617 (1982)

The distribution of events in neutrino energy for the 3C $\nu d \to \mu^- p p_s$ events is shown in Fig. 4 together with the quasielastic cross section $\sigma(\nu n \to \mu^- p)$ calculated using the standard $V-A$ theory with $M_A = 1.05 \pm 0.05$ GeV and $M_V = 0.84$ GeV. The absolute cross sections for the CC interactions have been measured using the quasielastic events and its known cross section.[4]

In subsequent cross section analyses the theoretical ("known") quas-ielastic cross section and observed quasi-elastic events were used to determine the flux.

Desperately seeking:
model-independent cross sections

- **IMHO, best approach to providing xsections needed for oscillations is to develop a solid understanding of theory**

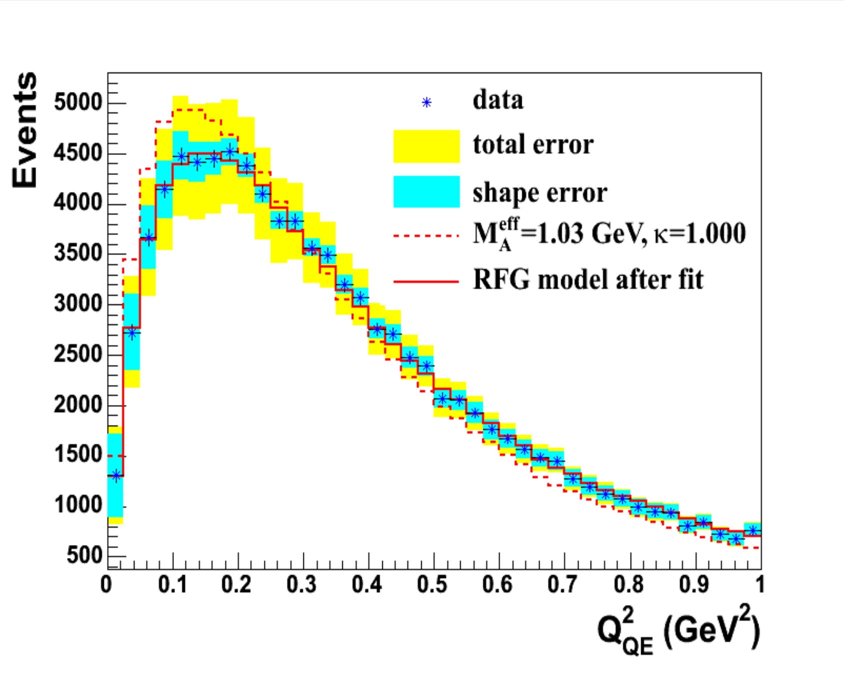
- Requires, from experiments, unbiased, model-independent observables: cross sections!
  - need fluxes (with errors) to do this, no xsection based tuning
  - careful with model-dependent kinematics (eg: E_ν, Q^2), model-ind variables best (eg: T_μ, θ_μ or similar)
  - Careful with background subtraction. This can add more model-dependence (and uncertainy) than is needed. Perhaps one should not subtract? (eg: bckgd to CCQE: CCpi+pi abs subtracted? or not?) Some (many?) theorists prefer no subtraction.
  - M_A is not a model-ind. observable

- Requires, from theory, models for ν interactions...
  - if to be as serious event generator, also need:
    - complete kinematics (eg: down to low-Q^2)
    - adjustable parameters (knobs to tune), or exps will add their own...

- M_A , what the ...?

Higher value for M_A (CCQE) in some recent experiments (compared to older results)

- Data excess in ~0.3-0.8 GeV^2 range when compared to RFG model with M_A=1.0 GeV
- K2K, MiniBooNE, MINOS from shape-only fits
- MiniBooNE, MINOS rate (xsection) is high as well. Coincidence?
- nuclear effects? not yet clear...?
    - Q^2 shape does change with nuc. effects, but enough?
    - total xsection is always suppressed with nuc. effects alone.
- is old M_A smaller because of light targets?
    - since nuc effects small, then no?
- NOMAD result
    - C target, lower M_A value, but higher energy?
- SciBooNE will weigh in very soon, Mineva also.



MiniBooNE CCQE data
T, Katori Nuint09

- Experiments should produce model ind results (xsections, not just MA) so data may be fully explored by modelers

κ , RFG-blasphemy?

κ has proved useful in tuning RFG to explain low-Q^2 data

- for MiniBooNE Similar effects seen in other experiments
- latest MiniBooNE CCQE data consistent with κ=1.0
- still a useful parameter for better fit at low Q^2
- and is supported by e-scattering data (next slides, from Teppei Katori)

4. Pauli blocking parameter “kappa”, κ

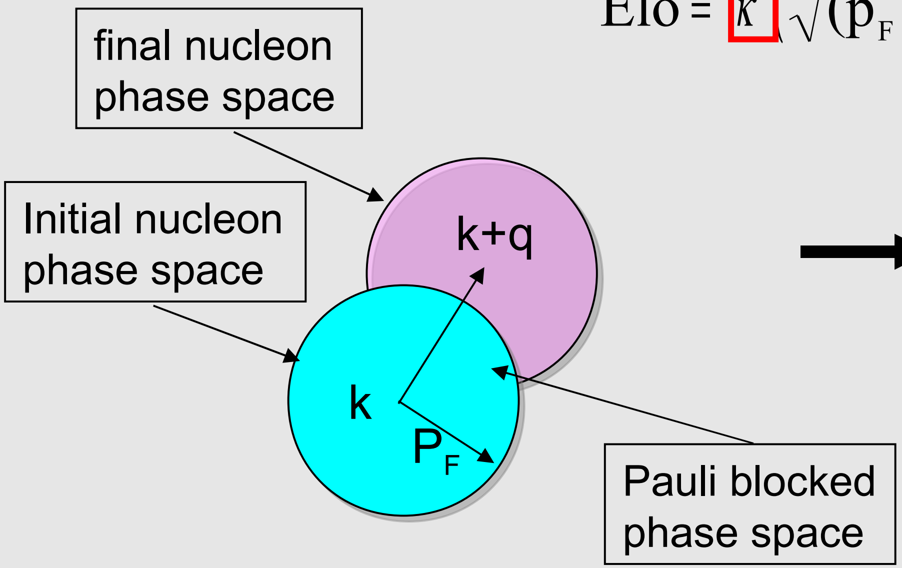
We performed shape-only fit for Q^2 distribution to fix CCQE shape within RFG model, by tuning M_A^{eff} (effective axial mass) and κ

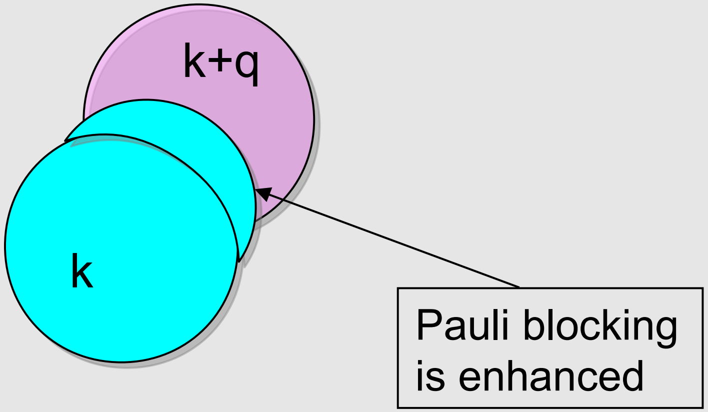
Pauli blocking parameter "kappa”, κ

Smith and Moniz, Nucl.,Phys.,B43(1972)605

To enhance the Pauli blocking at low Q^2, we introduced a new parameter κ, which is the energy scale factor of lower bound of nucleon sea in RFG model in Smith-Moniz formalism, and controls the size of nucleon phase space

$$Elo = \kappa\left(\sqrt{(p_F^2 + M^2)} - w + E_B\right)$$

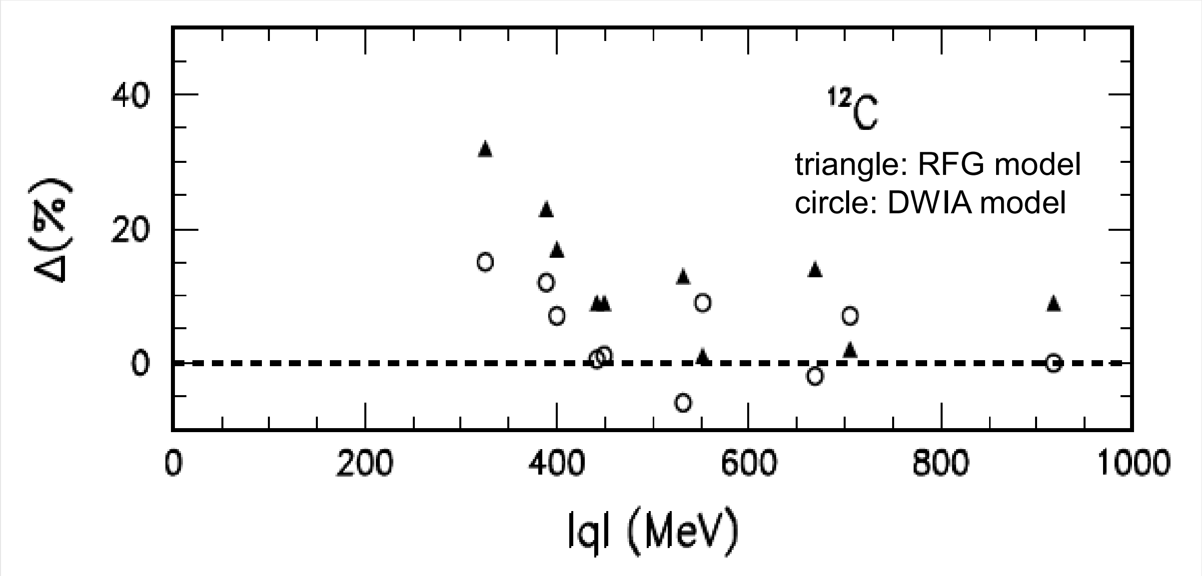




4. Kappa and (e,e') experiments

In low |q|, The RFG model systematically over predicts cross section for electron scattering experiments at low |q| (~low Q^2)

Data and predicted xs difference for ^{12}C



Butkevich and Mikheyev
Phys.Rev.C72:025501,2005

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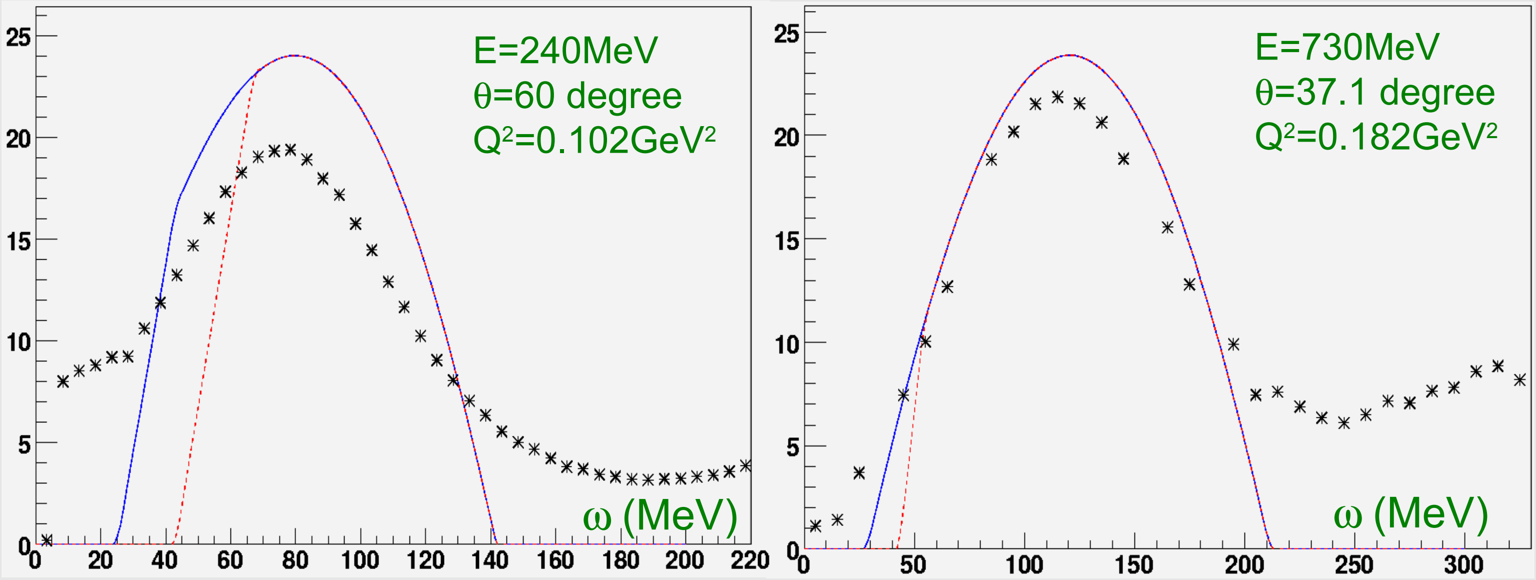
We had investigated the effect of Pauli blocking parameter "κ" in (e,e') data. κ cannot fix the shape mismatching of (e,e') data for each angle and energy, but it can fix integral of each cross section data, which is the observables for neutrino experiments. We conclude κ is consistent with (e,e') data.

black: (e,e') energy transfer data
red: RFG model with kappa (=1.019)
blue: RFG model without kappa



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RFG prediction-(e,e') data ratio in Q^2 (GeV^2)