



Ab initio calculations of electroweak response: a status report

- The ANL/JLAB/LANL quantum Monte Carlo team

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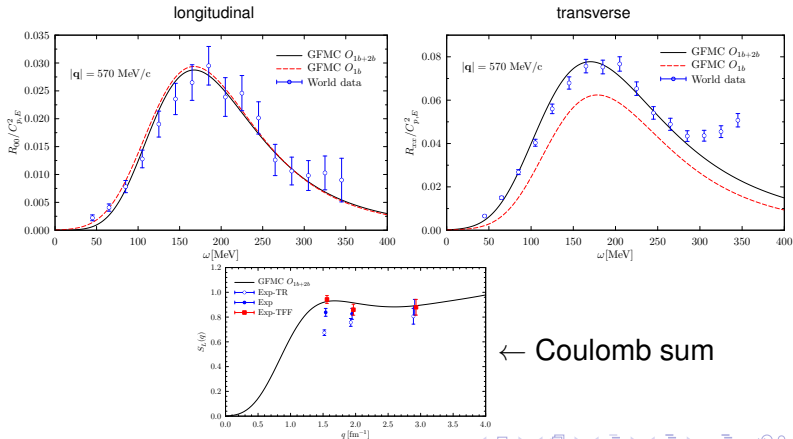
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- Computational resources from *ANL LCRC*, *LANL Open Supercomputing*, and *NERSC*
- JLab Theory Center support for August 2017 collaboration meeting
- Saori Pastore's FNAL travel grant to interact with event generator developers

- GFMC calculations of EM, NC, and CC response of ^{12}C in quasielastic regime
- Short-time approximation to response of ^{12}C and beyond:
 - *Relativistic kinematics and dynamics at two-body level*
 - *Inclusion of pion production channels*
- PWIA-inspired approaches based on N and $2N$ momentum distributions (and spectral functions)

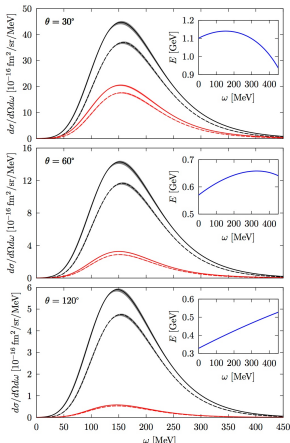
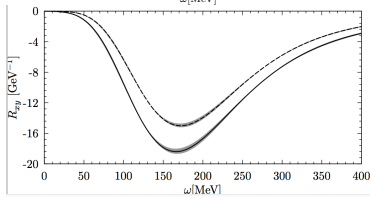
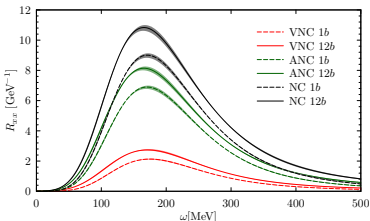
$$\int_0^\infty d\omega e^{-\tau\omega} R_{\alpha\beta}(q, \omega) = \langle i | j_\alpha^\dagger(\mathbf{q}) e^{-\tau(H-E_i)} j_\beta(\mathbf{q}) | i \rangle$$

- Inversion back to $R_{\alpha\beta}(q, \omega)$ by maximum entropy methods



- Inclusive $\nu/\bar{\nu}$ ($-/+$) cross section given in terms of five response functions

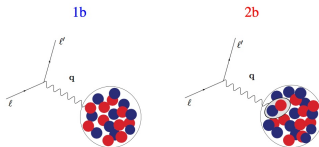
$$\frac{d\sigma}{d\epsilon'_l d\Omega_l} \propto \left[v_{00} R_{00} + v_{zz} R_{zz} - v_{0z} R_{0z} + \overbrace{v_{xx} R_{xx} \mp v_{xy} R_{xy}}^{\text{dominant}} \right]$$

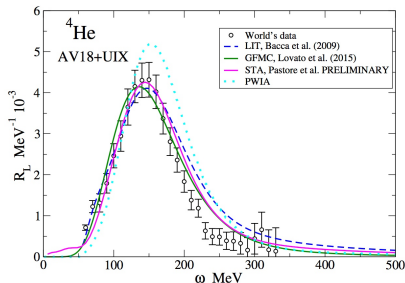


$$\begin{aligned}
 R_{\alpha\beta} &= \sum_f \delta(\omega + E_0 - E_f) \langle 0 | O_{\alpha}^{\dagger}(\mathbf{q}, \omega) | f \rangle \langle f | O_{\beta}(\mathbf{q}, \omega) | f \rangle \\
 &= \frac{1}{2\pi} \int dt \langle 0 | O_{\alpha}^{\dagger}(\mathbf{q}, \omega) \underbrace{e^{-i(H-E_0-\omega)t}}_{P(t)} O_{\beta}(\mathbf{q}, \omega) | 0 \rangle
 \end{aligned}$$

- Include two-body physics by expanding $P(t)$ and keeping up to two-body terms

$$\begin{aligned}
 H &\sim \sum_i t_i + \sum_{i<j} v_{ij} \\
 O_i^{\dagger} P(t) O_i &+ O_i^{\dagger} P(t) O_j + O_i^{\dagger} P(t) O_{ij} + O_{ij}^{\dagger} P(t) O_{ij}
 \end{aligned}$$



Longitudinal Response function at $q = 500$ MeV

- STA is in excellent agreement with GFMC results for $q > 0.5$ GeV/c
- STA extension to NC and CC response and applications to ^{12}C are in progress



JLab experiments in support of ν program

- The $^{40}\text{Ar}(e, e' p)$ experiment and ^{40}Ar “spectral function” (analysis phase, report by Mariani)
- PR12-17-06 *Electrons for Neutrinos: Addressing Critical Neutrino-Nucleus Issues* (conditionally approved by PAC45, 07/2017)

Summary: The committee overall finds the proposed physics is well motivated, but the actual measurements are in need of significant optimization. We are glad to see that neutrino and electron scattering physicists are working together on this proposal, which should lead to a better joint interpretation and use of the data. The committee was also impressed with the preliminary work done with CLAS6 data and with the plan discussed in the open session for evaluating neutrino simulation models using the proposed running. We would like to see a preliminary application of the CLAS6 data (and possibly projected CLAS12 data) to neutrino models and comparison of the improved models with one of the existing neutrino data samples (such as T2K, MINERvA, NOvA, or MiniBooNE). We believe the collaboration is more than capable of doing this before the next PAC meeting and that this would lead to a better optimized run plan. We therefore recommend C2 conditional approval.