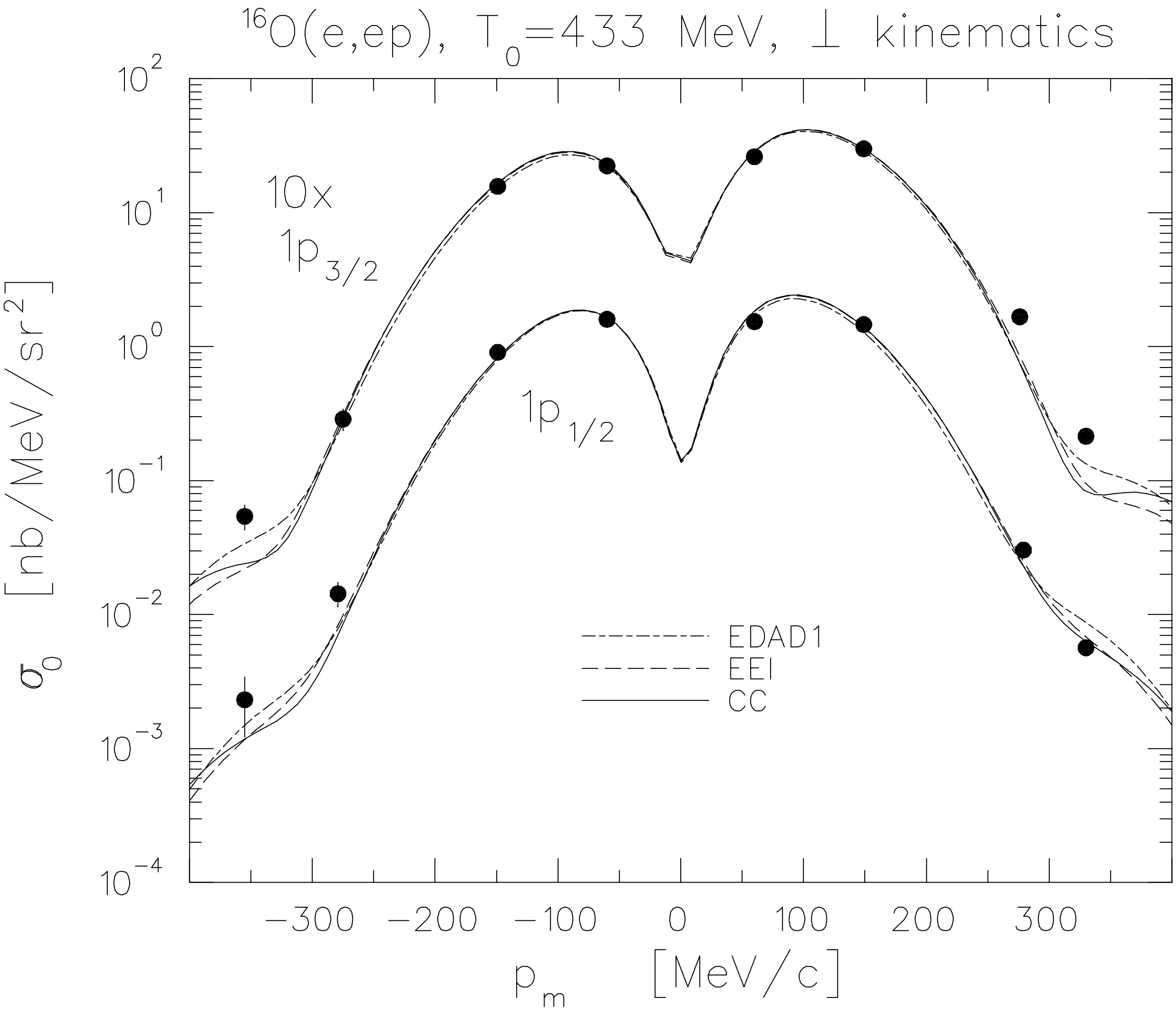
Physics Issues for Quasifree $^{16}\mathbf{O}(e, e'p)$

- FSI
- Gauge/Gordon ambiguities
- Relativistic dynamics
- Effective response functions

Standard NRIA Calculations

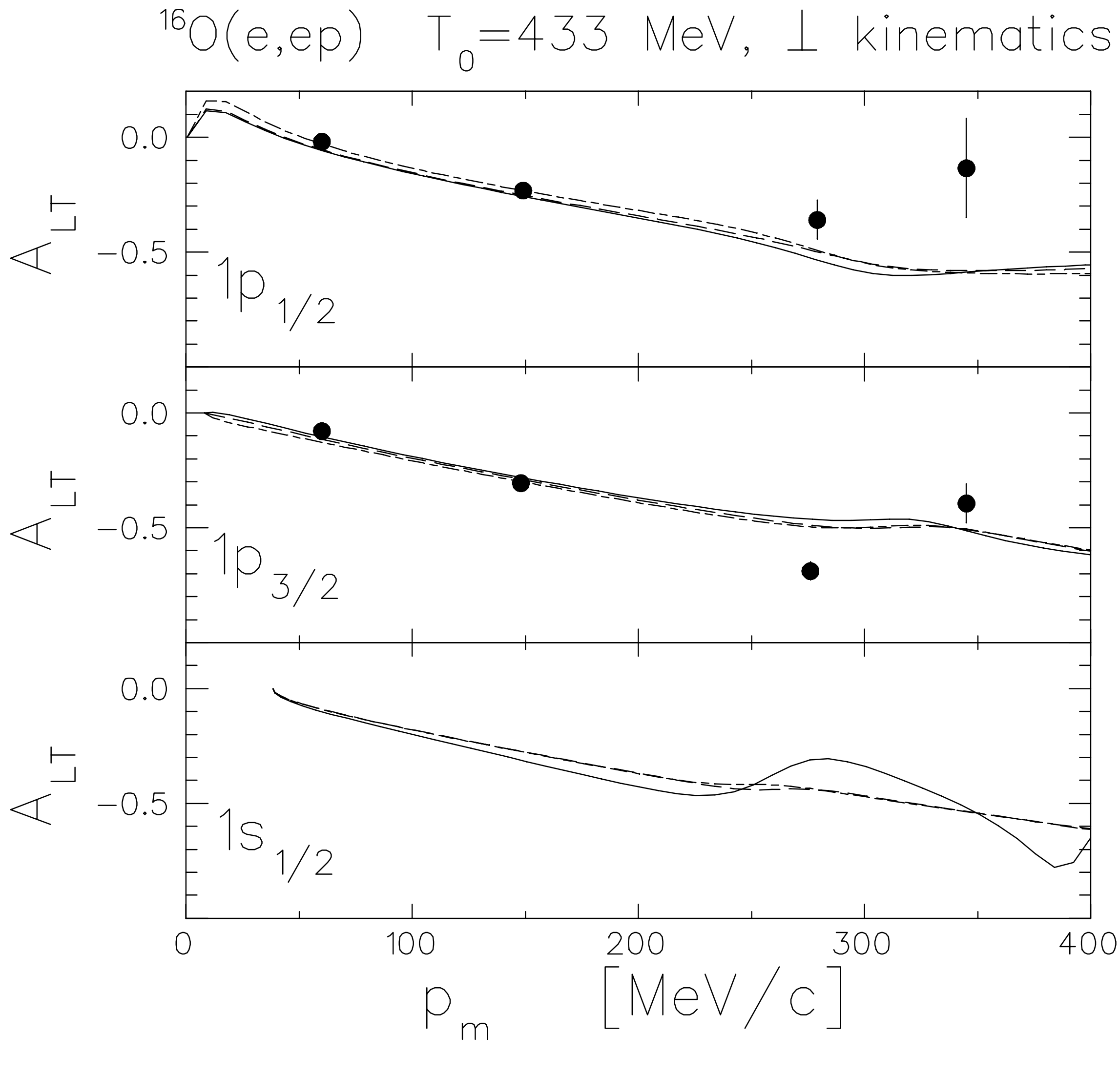
- Overlap functions: fitted to Leuschner data using Paris-Melbourne effective interaction for FSI.
- Current operator: $\bar{\Gamma}_{cc1}$ in EMA using MMD form factors
- Gauge: Coulomb
- FSI: based on EEI. Calculations with channel coupling include all possible couplings in IPM (including elastic reorientation, inelastic scattering, and charge exchange).
- Electron distortion: included in EMA

FSI



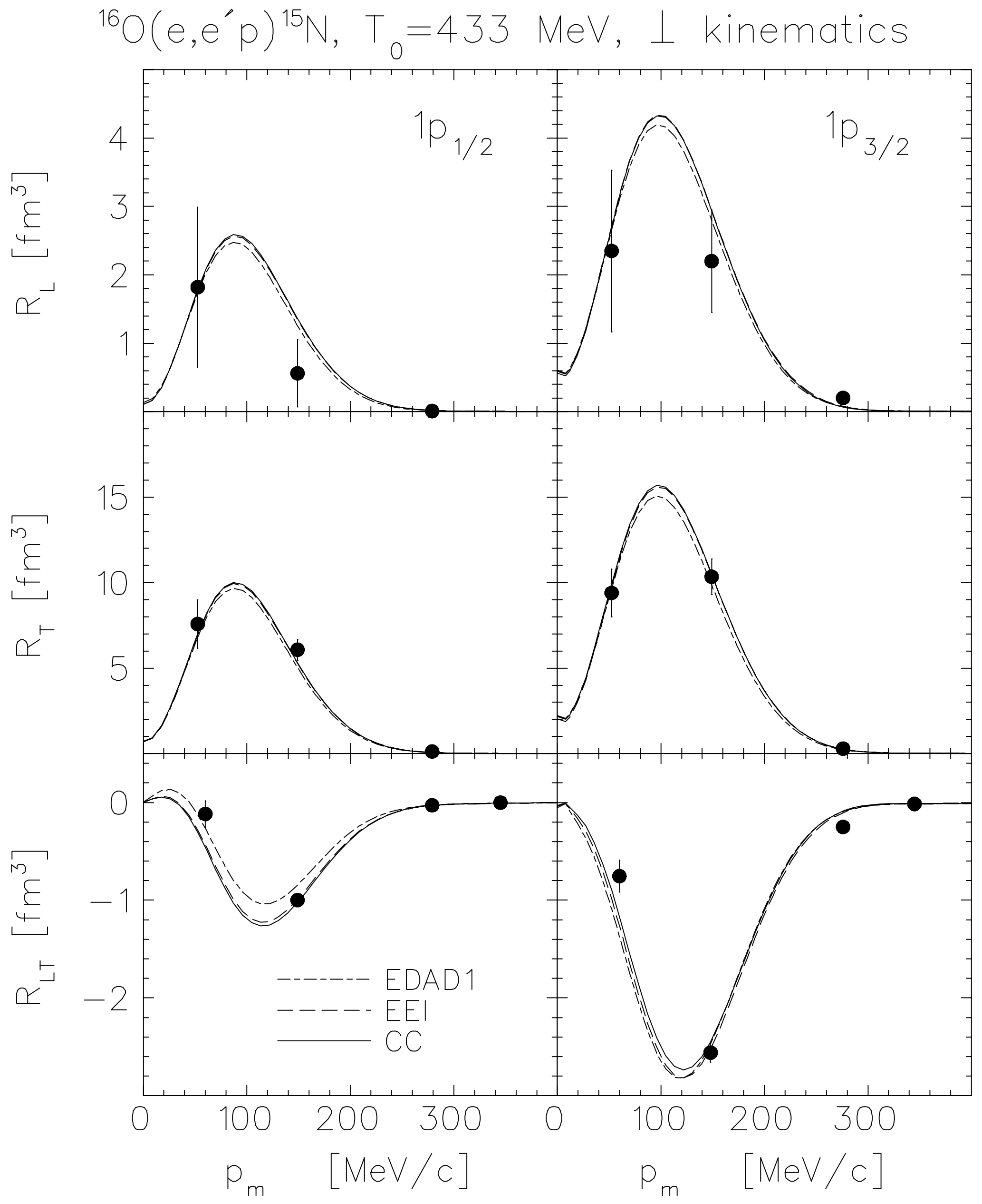
- Accurate peak cross sections with normalization factors similar to those for Leuschner data.
- Mainz data for $T_0 \sim 200$ MeV disagree by factor of 2, while JLab and NIKHEF data are consistent with each other and with trend for other nuclei. Therefore, Mainz normalization appears to be incorrect.
- Problems develop for $p_m > 200$ MeV/c, but many effects can produce significant variations at large p_m.

FSI



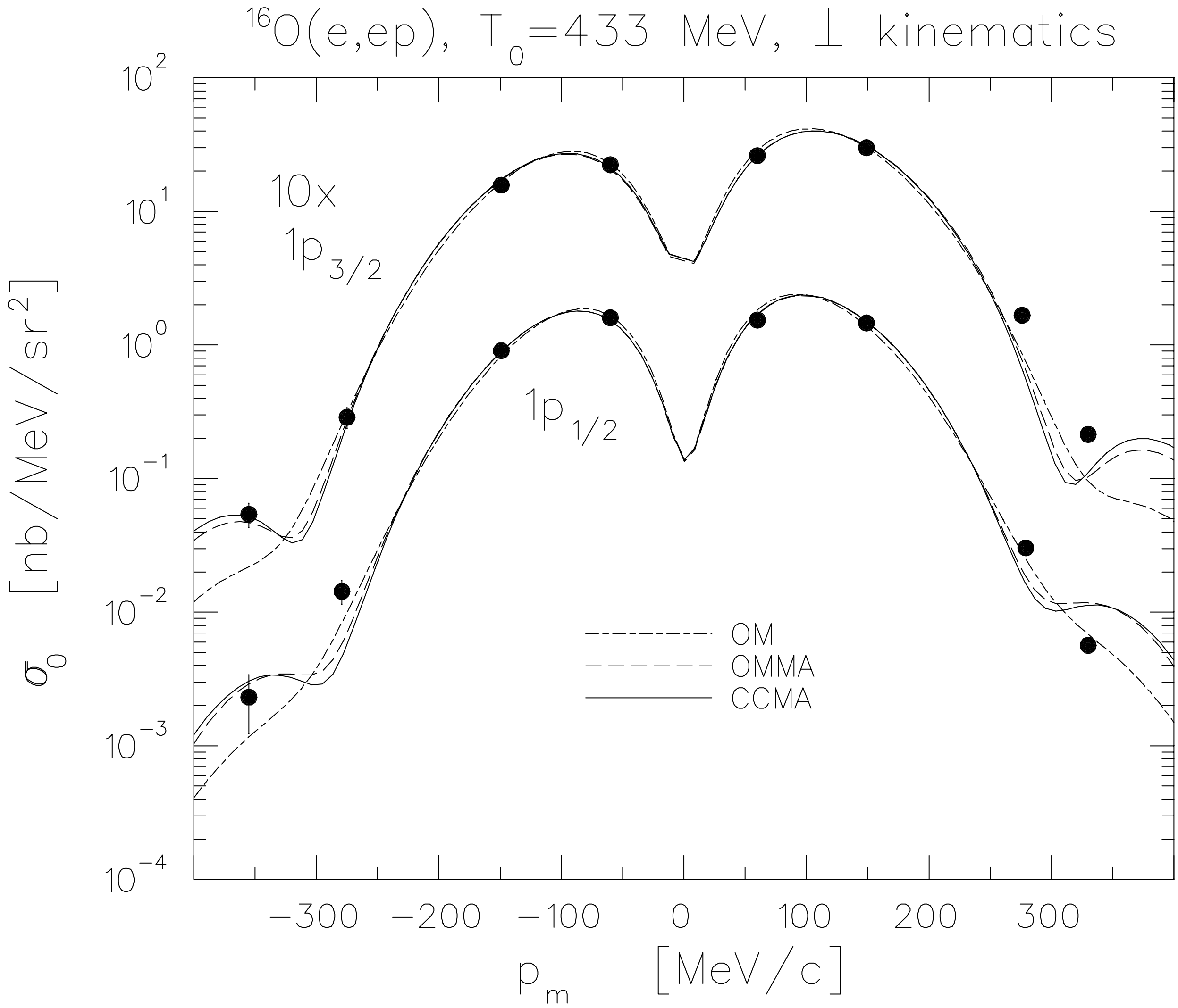
- A_{LT} tests effective current operator while minimizing uncertainties in missing momentum distribution.
- Very little sensitivity to optical potential.
- Channel coupling affects s-shell at large p_m, but is unimportant for p-shell A_{LT}.

FSI



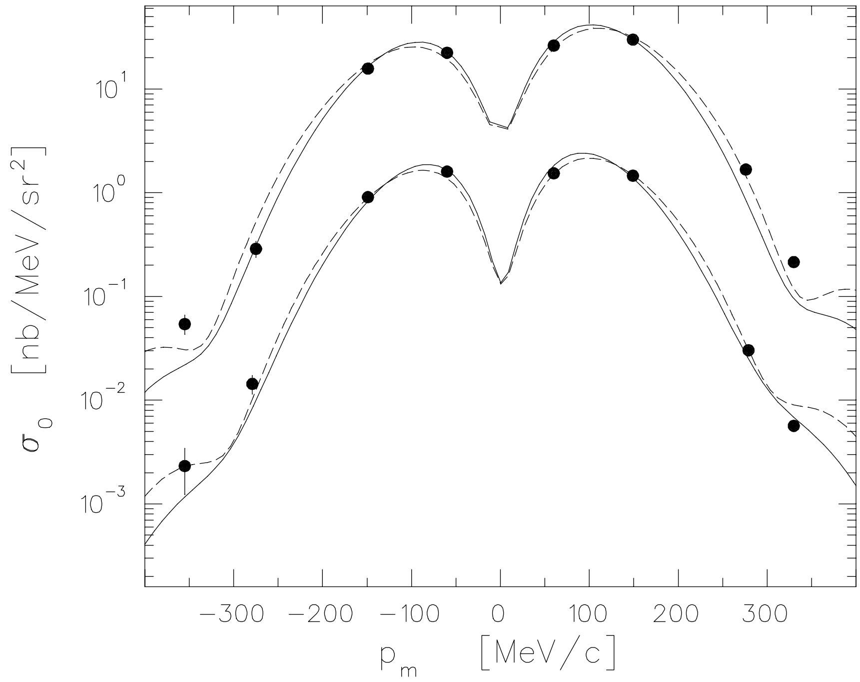
- Agreement between calculations and data for response functions generally quite good.
- Discrepancies in R_{LT} much smaller than at lower Q^2.
- R_{LT} shows some sensitivity to optical potential, with EDAD1 better for $1p_{1/2}$ and EEI better for $1p_{3/2}$. Lack of consistency here, but optical potential probably not primary issue.

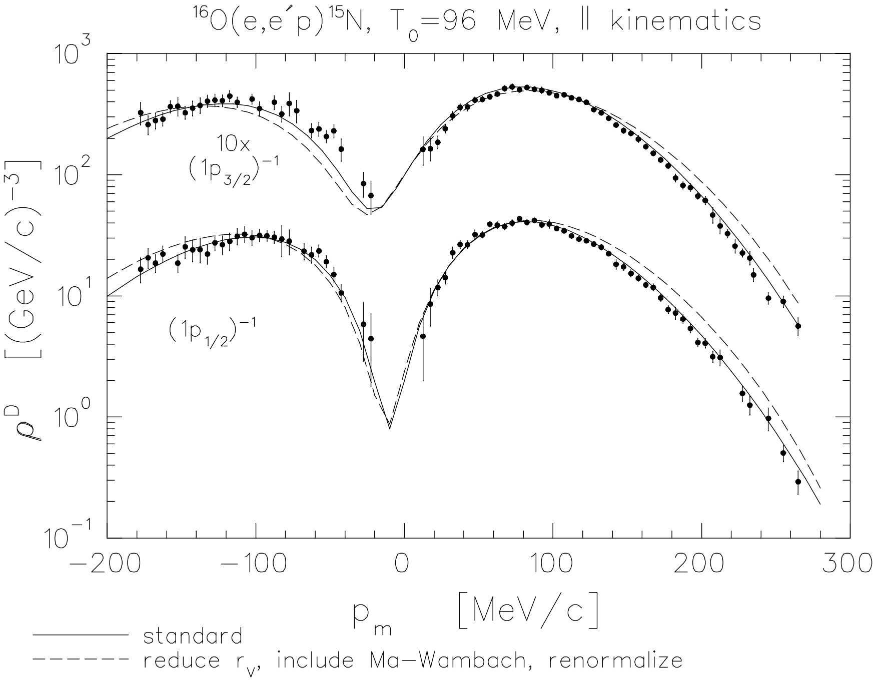
Overlap Functions



- Nonlocality factor enhances cross sections at large p_m, but has practically no effect on A_{LT}.
- Nonlocality factor seems to reduce relative importance of channel coupling.
- Nonlocality factor improves σ_0 for $p_m < 0$, but has ambiguous effect for $p_m > 0$.

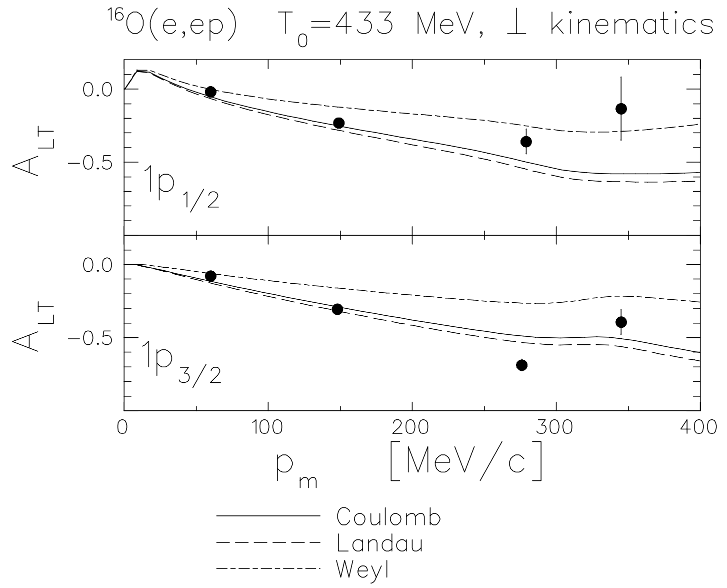
Overlap Functions

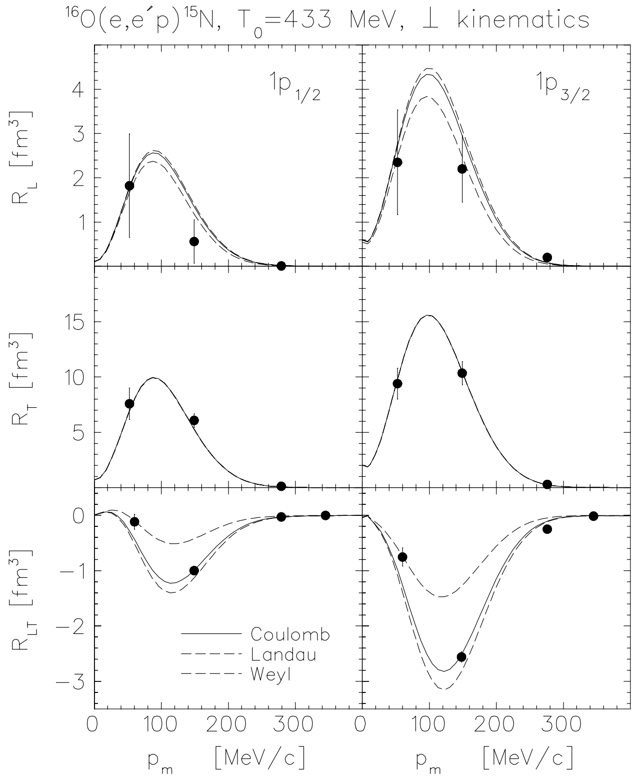




- Could argue that because $p_m \gg 0 \Longrightarrow x \ll 1, Q^2 \sim 0$, data in parallel kinematics for small T_0 might not give reliable momentum distribution because off-shell and gauge/Gordon ambiguities become more important.
- Although fit to $\sigma_0(p_m)$ improved, there is little effect on A_{LT}.

Gauge/Gordon ambiguities





- Gauge ambiguity, which is an artifact of nonconservation of single-nucleon current, complicates interpretation of A_{LT} and R_{LT}.
- Data tend to exclude Weyl gauge, but not strongly.
- Gordon ambiguity much smaller.

Relativistic Dynamics

Question: Why does van Orden calculation produce large difference in A_{LT} for $1p_{3/2}$ versus $1p_{1/2}$ for large p_m while NRIA does not?

Hypothesis: Most important relativistic effect is enhancement of lower components of **bound state** wave function.

$$\hat{J}^{\mu}_{eff} = \Lambda^{\dagger}_{c}(r)\gamma^{0}\Gamma^{\mu}\Lambda_{b}(r)$$

$$\Gamma^{\mu} = F_1\gamma^{\mu} + F_2\frac{i\kappa}{2m}\sigma^{\mu\nu}q_{\nu}$$

$$\Lambda_{\alpha} = \begin{pmatrix} 1 \\ \frac{\boldsymbol{\sigma}\cdot\boldsymbol{p}}{E_{\alpha}+m+S_{\alpha}(r)-V_{\alpha}(r)} \end{pmatrix} D^{1/2}_{\alpha}(r)$$

$$D(r) = 1 + \frac{S(r)-V(r)}{E+m}$$

- $S-V$ is large and negative, thereby enhancing lower component.
- $\boldsymbol{\sigma}\cdot\boldsymbol{p}$ gives a spin-orbit coupling that depends upon $S'-V'$. Therefore, this term can produce difference between A_{LT} for $1p_{1/2}$ and $1p_{3/2}$.
- Relativistic effect *decreases* as energy increases $\Longrightarrow$ enhancement of lower components probably more important for bound state than for ejectile.
- This effect can be included in EMA, but will take time.
- Spin-orbit dependence of A_{LT} may be important test of relativistic dynamics for ground state that is related to spin-orbit splitting of binding energy and saturation.
- Pesky caveat: gauge/Gordon ambiguity

Other Issues

- Effective response functions
  - Electron distortion destroys simple response-function decomposition, introducing additional dependencies upon beam energy and azimuthal angle.
  - Must construct *effective response functions* by analyzing calculations like data.
    * Perform Rosenbluth separation on calculated cross sections for two energies to incorporate distortion effects.
    * Extract effective $\tilde{R}_{LT}$ from left-right asymmetry. Electron distortion contributes to asymmetry by shifting $\vec{q}$.
  - Contribution of R_{TT} is not entirely negligible. R_{TT}/R_L about -10% for $1p_{1/2}$ or +10% for $1p_{3/2}$ and $V_{TT}/V_L \sim 1/2$.
- Conventions
  - Juncai plots σ_0 with opposite sign for p_m.
  - Nilanga shows R_{LT} for s-shell with opposite (positive) sign.
- Inclusion of quasifree data for s-shell.
  - I would like to include these data, both A_{LT} and normalization factor, because the physics is the same.
  - Is momentum distribution available? Is A_{LT} available?
- Data analysis
  - Show spectra?
  - Are we sure that background or 2s1d peak do not affect A_{LT} for $1p_{3/2}$ at large p_m?
  - Is there data for higher p-shell fragments?
- Additional measurements

– Momentum distribution too sparse for direct comparison with NIKHEF data for $p_m \lesssim 250$ MeV/c. Present kinematical conditions should be more reliable.

– Test of relativistic dynamics hinges on A_{LT} for one point, $p_m \sim 280$ MeV/c. Better coverage of p_m would make a more convincing case.