Measuring the Fifth Structure Function in $d(\vec{e}, e'p)n$

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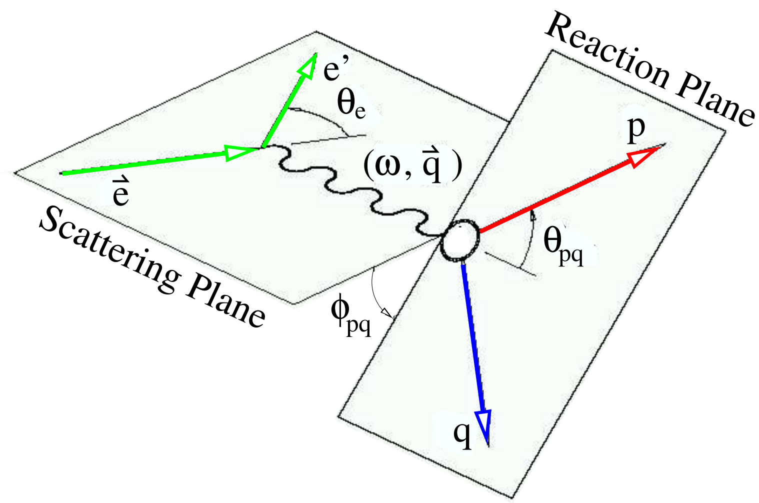
1. Introduction and Background.
2. Event Selection and Corrections.
3. Extracting the Fifth Structure Function.
4. Measuring the Background Structure Functions
5. Preliminary Comparison with Theory.
6. Conclusions.

Introduction - 1

- Goal: Measure the imaginary part of the LT interference term of $d(\vec{e}, e'p)n$ to test the hadronic model at low Q^2 ($\approx 1\ (GeV/c)^2$).

- Use the out-of-plane production to extract the fifth structure function.



- Cross section:

$$\frac{d^3\sigma}{d\omega d\Omega_e d\Omega_p} = \sigma^{\pm} = \sigma_L + \sigma_T + \sigma_{LT}\cos(\phi_{pq}) + \sigma_{TT}\cos(2\phi_{pq}) + h\sigma'_{LT}\sin(\phi_{pq})$$

Introduction - 2

- Asymmetry

$$A'_{LT} = \frac{\sigma_{90}^{+} - \sigma_{90}^{-}}{\sigma_{90}^{+} + \sigma_{90}^{-}} \approx \frac{\sigma'_{LT}}{\sigma_L + \sigma_T} = \langle \sin\phi_{pq} \rangle_{+} - \langle \sin\phi_{pq} \rangle_{-}$$

Subscripts - ϕ_{pq}. Superscripts - beam helicity.

- Analyze data from the E5 run period in Hall B.
  - Recorded about 2.3 billion triggers, $Q^2 = 0.2 - 5.0 (GeV/c)^2$.
  - Dual target cell with liquid hydrogen and deuterium.

Event Selection and Corrections

For electrons:	Good CC, EC, SC status	$cc > 0, ec > 0, sc > 0, stat > 0$
	Energy-momentum match	$0.325p_e - 0.13 < E_{total} < 0.325p_e + 0.06$
	Reject pions	$ec\_ei \geq 0.100$ and $nphe \geq 25$
	EC track coordinates fiducial	$\lvert dc\_ysc \rvert \leq 165(dc\_xsc - 80)/280$
	EC fiducial	No tracks within $10\ cm$ of the end of a strip
	Egiyan threshold cut	$p_e \geq (214 + 2.47 \cdot ec\_threshold) \cdot 0.001$
	Electron fiducial	Same method as D. Protopopescu, *et al.*, CLAS-Note 2000-007.
	Quasi-elastic scattering	$0.92\ GeV \leq W \leq 1.0\ GeV$
	Select target	$-11.5\ cm < v_z < -8.0\ cm$
	Momentum corrections	Pitt (CLAS-Note 2001-018) and elastic-scattering methods
For protons:	Proton fiducial cut	Same method as R. Nyazov and L.Weinstein, CLAS-NOTE 2001-013.
	ep vertex cut	$\lvert v_z(e) - v_z(proton) \rvert \leq 1.5\ cm$
	Momentum corrections	Pitt (CLAS-Note 2001-018) method
For neutrons:	Missing mass cut	$0.84\ GeV^2 \leq MM^2 \leq 0.92\ GeV^2$
Beam charge asymmetry:	2.6 GeV, reversed field:	0.9936 ± 0.0007
	2.6 GeV, normal field:	0.9944 ± 0.0007
	4.2 GeV, normal field	0.9987 ± 0.0009
Radiative corrections:	EXCLURAD	Adding helicity dependent model
Beam polarization:	All Runs	0.736 ± 0.017

$\langle \sin\phi_{pq}\rangle_{\pm}$ Moments Analysis For A'_{LT}

Recall

$$\sigma^{\pm} = \sigma_L + \sigma_T + \sigma_{LT}\cos(\phi_{pq}) + \sigma_{TT}\cos(2\phi_{pq}) + h\sigma'_{LT}\sin(\phi_{pq})$$

Let

$$\begin{aligned}\langle \sin\phi_{pq}\rangle_{\pm} &= \frac{\int_{-\pi}^{\pi}\sigma^{\pm}\sin\phi_{pq}d\phi}{\int_{-\pi}^{\pi}\sigma^{\pm}d\phi} = \frac{\sum_{\pm}^{\phi}\sin\phi_i}{N^{\pm}} \\ &= \pm\frac{\sigma'_{LT}}{2(\sigma_L+\sigma_T)} \approx \pm\frac{A'_{LT}}{2}\end{aligned}$$

For a sinusoidally-varying component to the acceptance

$$\langle \sin\phi_{pq}\rangle_{\pm} = \pm\frac{A'_{LT}}{2} + \alpha_{acc}$$

so

$$\langle \sin\phi_{pq}\rangle_{+} - \langle \sin\phi_{pq}\rangle_{-} = A'_{LT} \quad \text{and} \quad \langle \sin\phi_{pq}\rangle_{+} + \langle \sin\phi_{pq}\rangle_{-} = 2\alpha_{acc}$$

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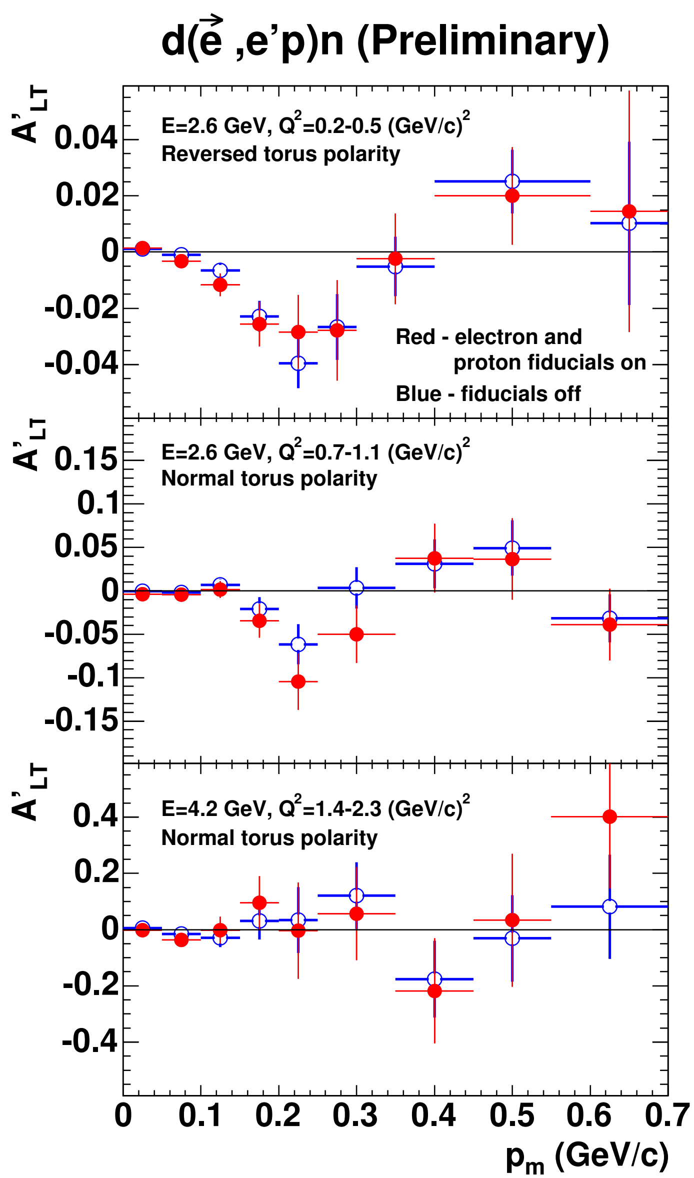
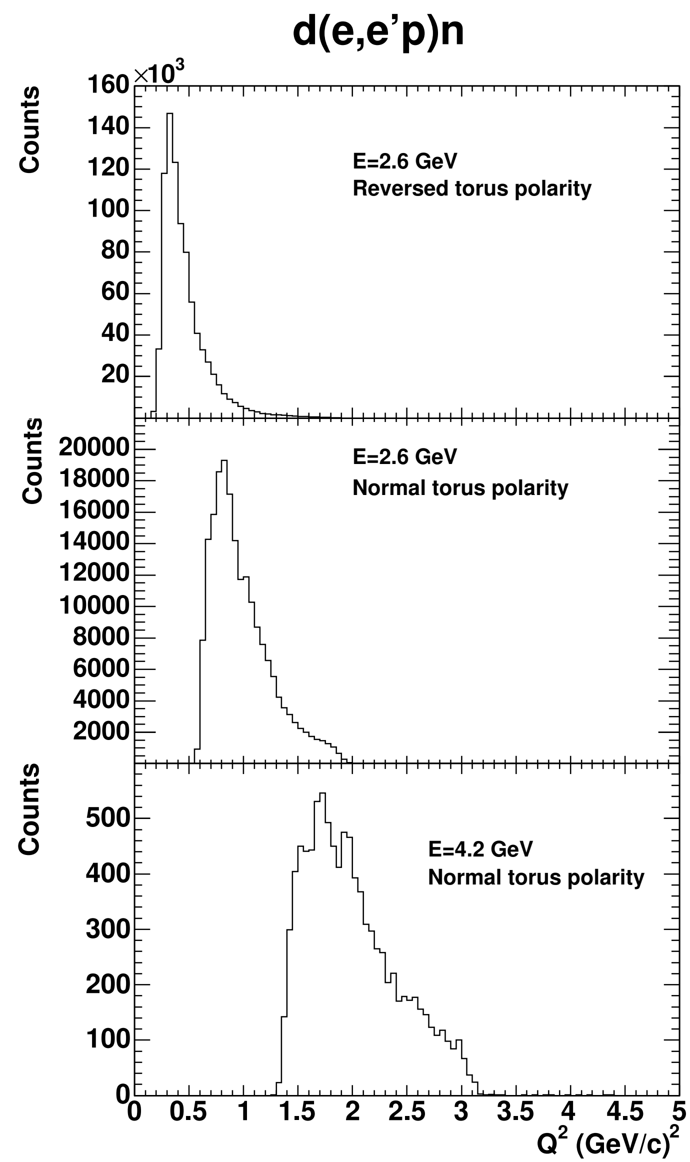
A'_{LT} Results for $d(\vec{e}, e'p)n$





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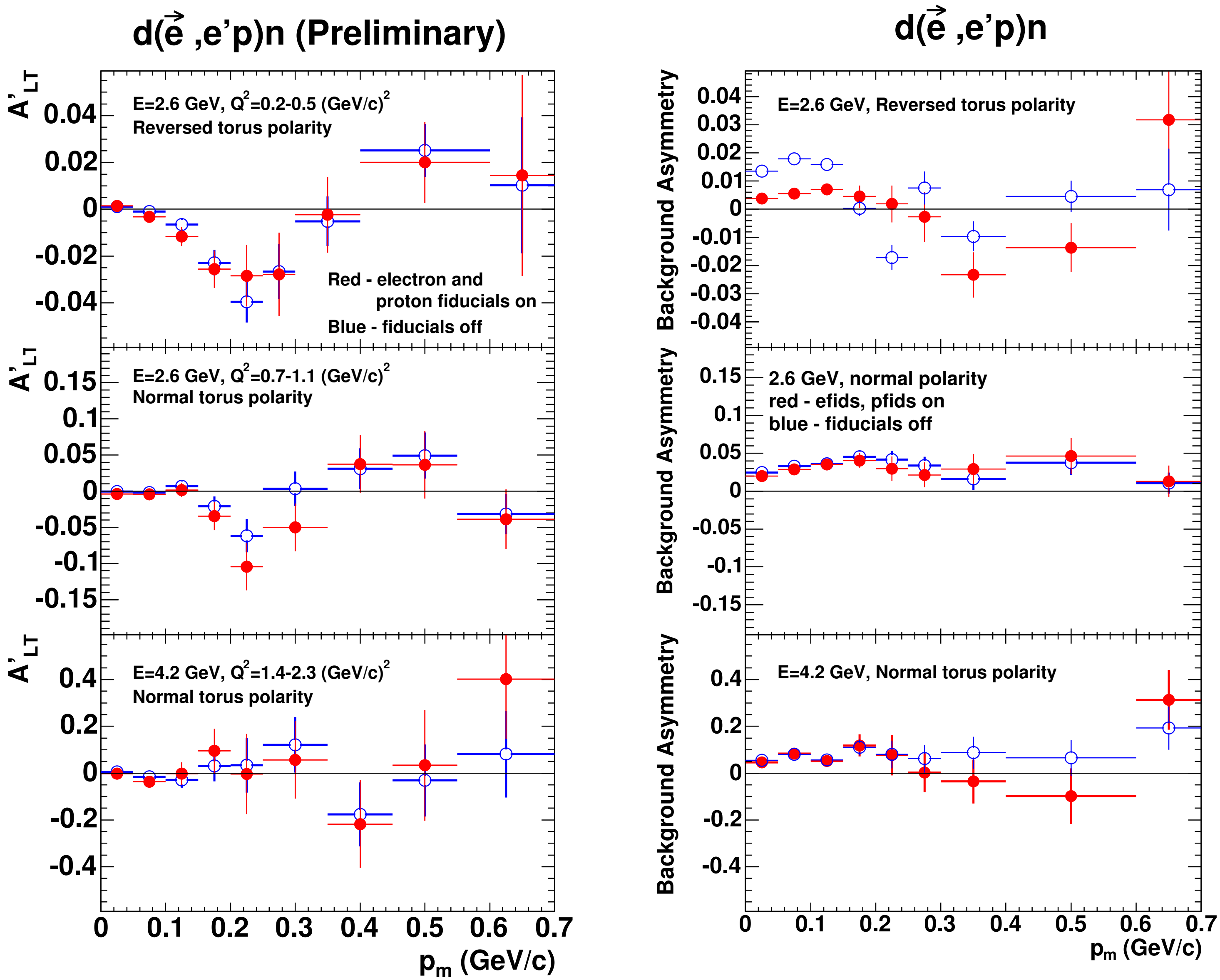
Asymmetry Background Results



Hartmuth Arenhoevel calculations of A'_{LT}

1. Numerical solution of the Schroedinger equation using some parameterization of the NN interaction like the Paris potential (NORMAL).

2. Additional components are then added to this starting point.

   (a) Meson exchange currents (MEC).

   (b) Isobar configurations (IC).

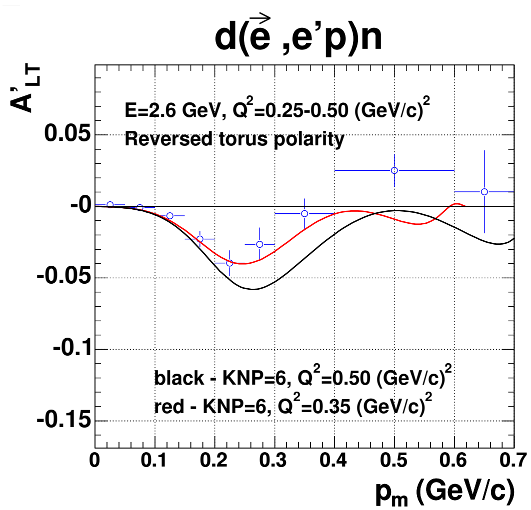
   (c) Final state interactions (FSI).

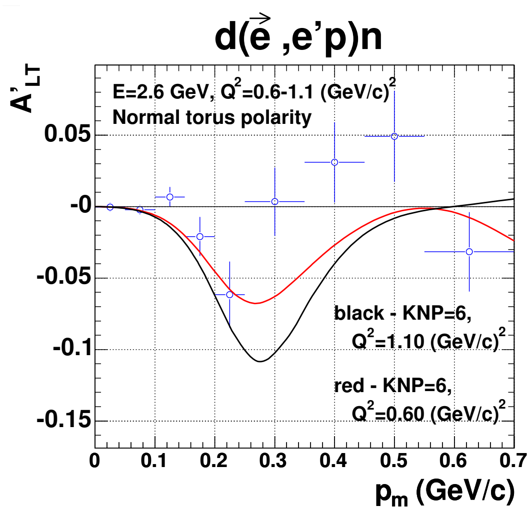
3. Relativistic corrections (RC) are also made to the nucleon charge and current densities.

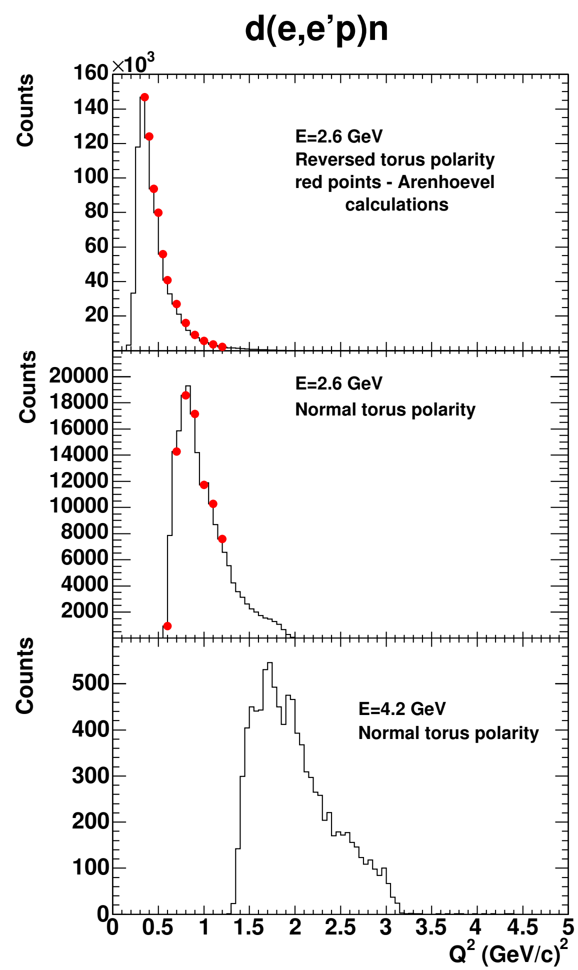
4. In the figures to follow, all of the ingredients listed above are included (KNP=6).

Comparison with Theory - Limiting Curves

Hartmuth Arenhoevel calculations

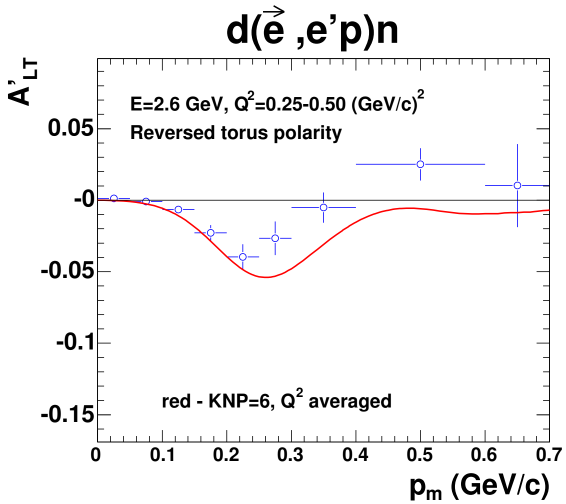


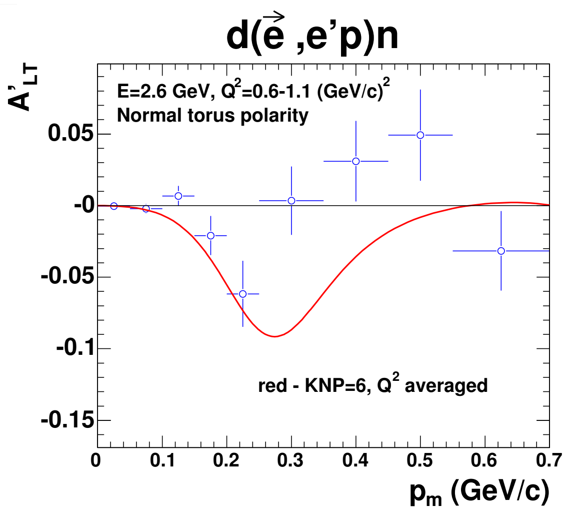


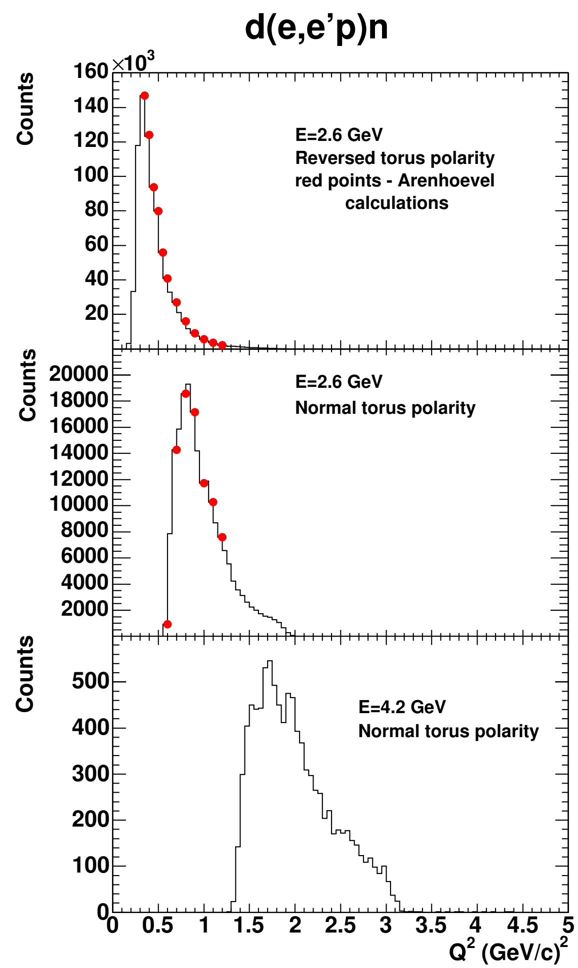


Comparison with Theory - Q^2-Averaged Curves

Hartmuth Arenhoevel calculations

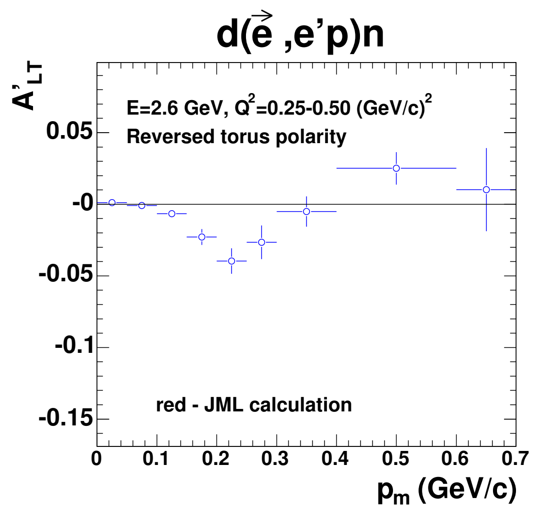


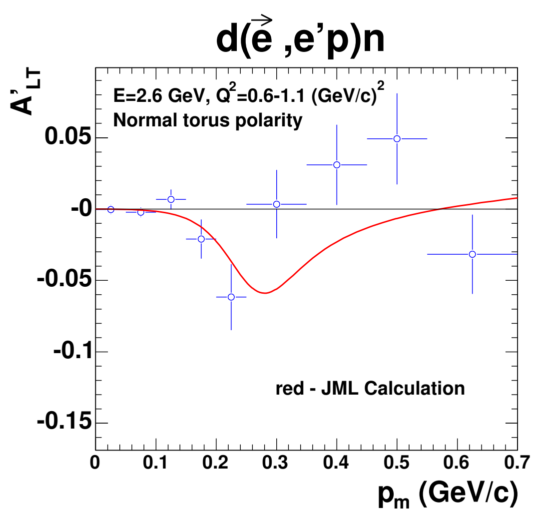


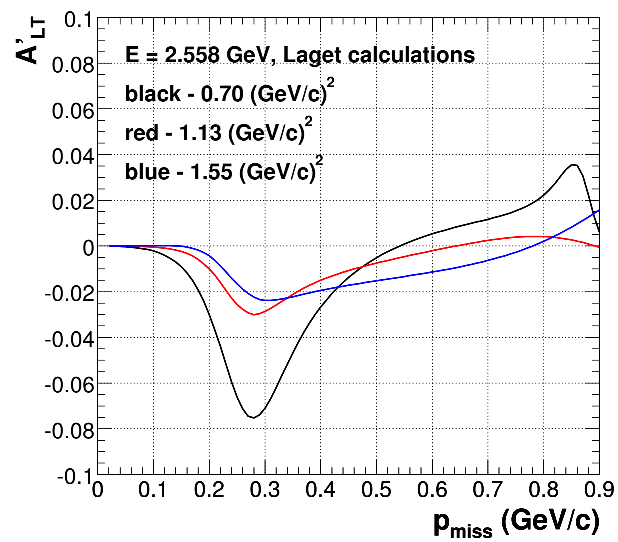


Comparison with Theory - Q^2-Averaged Curves

Jean-Marc Laget calculations



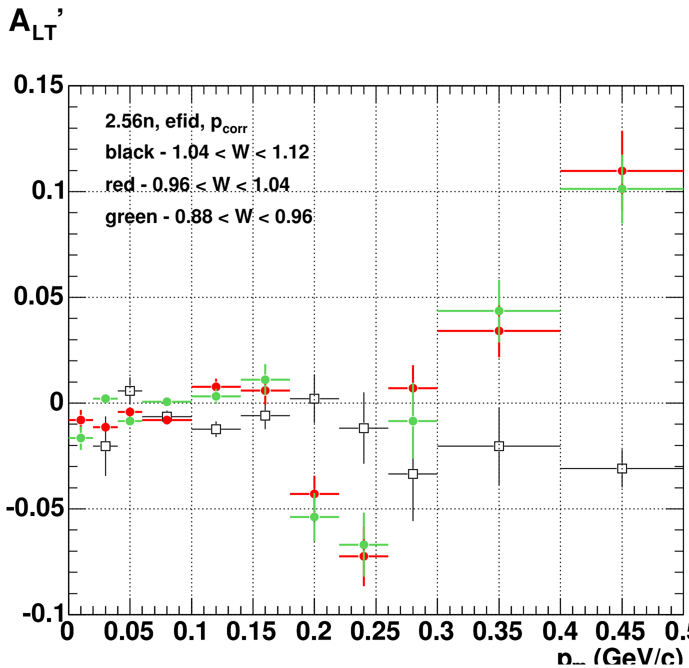


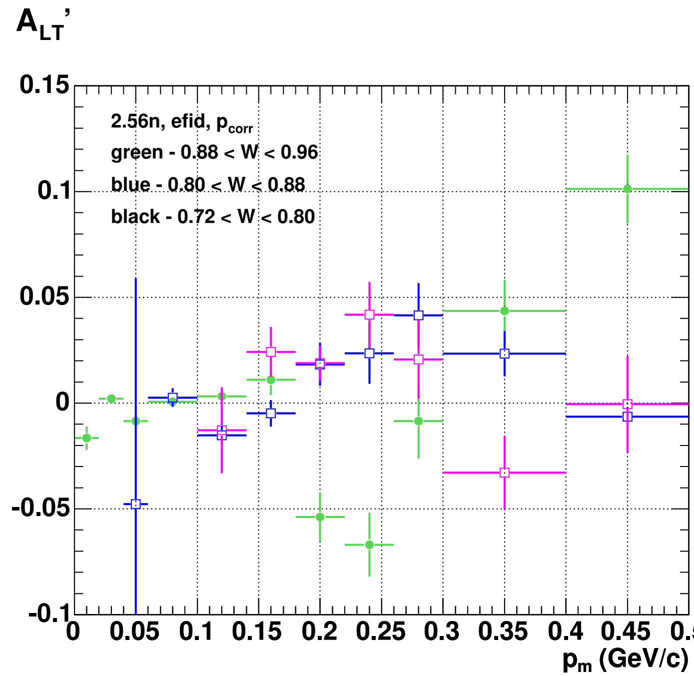


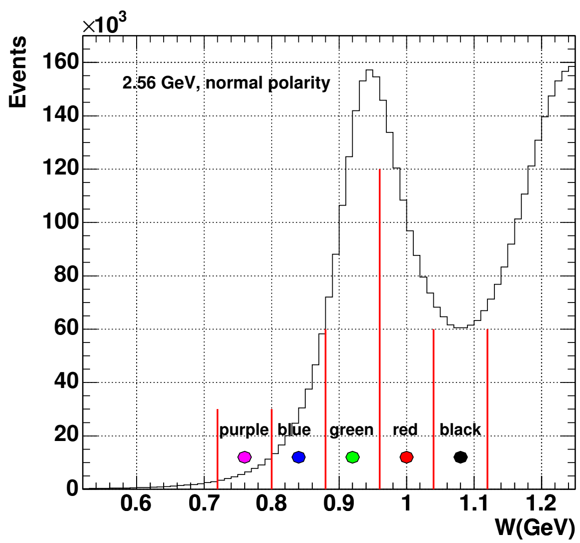
Conclusions

- We observe a 4-6% dip in A'_{LT} at $p_m \approx 220\ MeV/c$ in the lower Q^2 data sets. At higher energy, we can't draw conclusions because of the large statistical uncertainties.
- The $\langle \sin(\phi_{pq} \rangle$ technique works well including the subtraction of the two different beam helicities to eliminate acceptance effects.
- The background asymmetry is sensitive to the fiducial cuts for the reversed torus polarity running conditions, but not for the normal torus polarity running (within statistics).
- At low missing momentum p_m, the calculations by Arenhoevel and Laget reproduce the data, but diverge (they're too negative) above $p_m = 250\ MeV/c$. The dip we observe in A'_{LT} is not well understood.
- The source of the background asymmetry is under investigation.

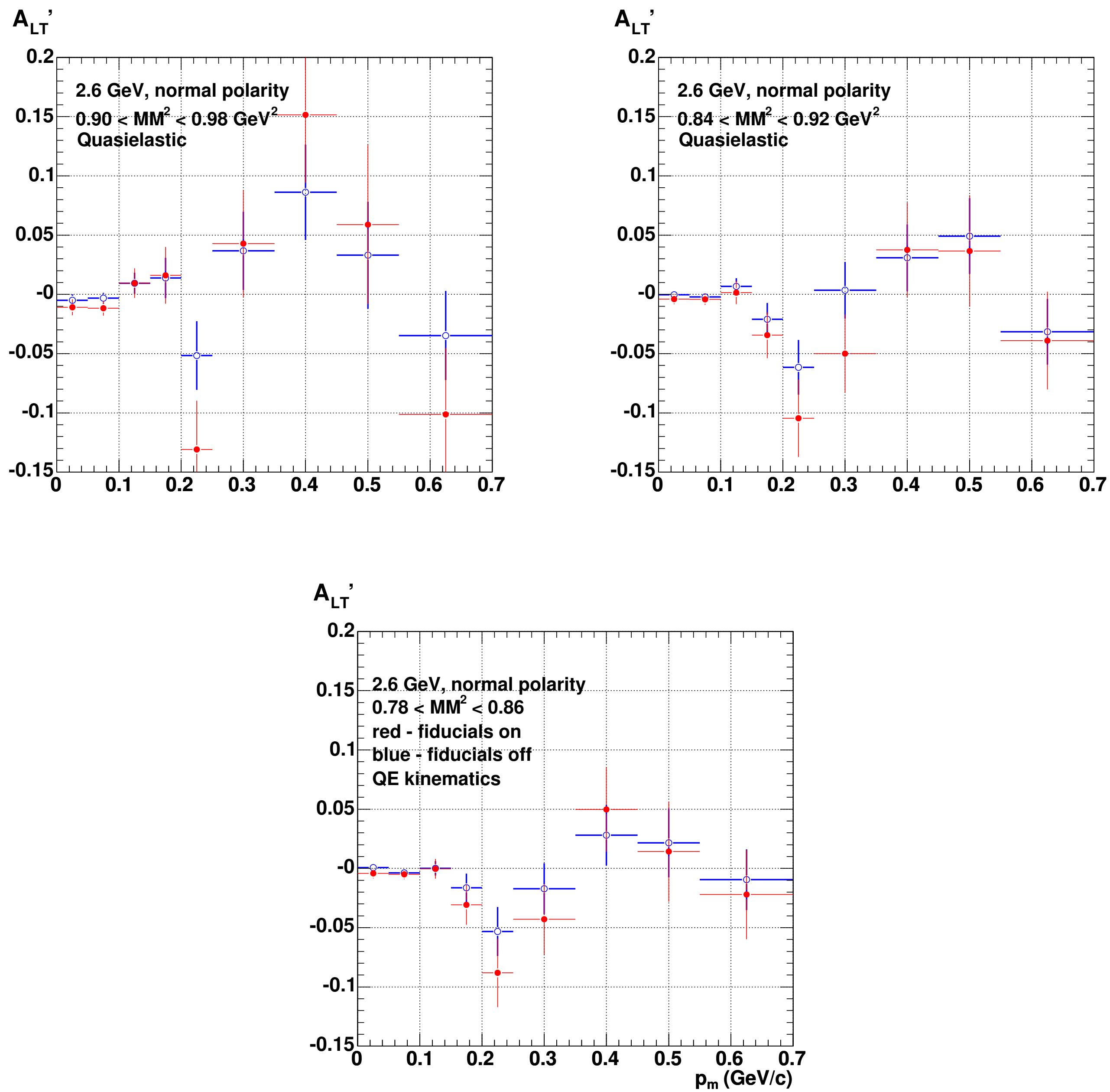
W dependence of A'_{LT} at the Quasi-elastic Peak







MM^2 dependence of A'_{LT} at the Quasi-elastic Peak



Fifth Structure Function Asymmetry for $d(\vec{e}, e'p)n$

- Measured A'_{LT} for the $d(\vec{e}, e'p)n$ reaction for the E5 running period.
- See a dip in A'_{LT} at $p_m \approx 220\ MeV/c$ in the lower Q^2 data.
- Background asymmetry extracted for each set of running conditions. We see significant difference for reversed torus polarity running.
- Existing calculations from Arenhoevel and Laget diverge from the data at $p_m > 2$