Fits to Inclusive cross sections

Eric Christy

Hampton University

γ-Z Boxing Workshop @ JLab - December 16, 2013

Precise knowledge of nucleon resonance region inclusive cross sections are important input for:

1. Radiative corrections,
2. F_1 and R needed for extraction of spin structure functions from spin asymmetry measurements.
3. Interpolating functions for structure function moment determinations
4. Estimation of backgrounds for Parity Violating measurements such As Qweak.

Inclusive cross section modeling formalism:

Fit reduced cross section in Rosenbluth form:

$$\frac{1}{\Gamma}\frac{d\sigma}{d\,\Omega\,\mathrm{dE'}} = \sigma_T\left(\mathrm{x},\mathrm{Q}^2\right) + \varepsilon\sigma_L\left(\mathrm{x},\mathrm{Q}^2\right)$$

Cross section is sum of Resonant + non-resonant contributions.

$$\sigma_T\left(W^2,Q^2\right) = \sigma_T^R\left(W^2,Q^2\right) + \sigma_T^{NR}\left(W^2,Q^2\right)$$

$$\sigma_L\left(W^2,Q^2\right) = \sigma_L^R\left(W^2,Q^2\right) + \sigma_L^{NR}\left(W^2,Q^2\right)$$

** It is assumed that all sums are incoherent.*

=> no interference between resonance and non-resonance states

Resonant contribution:

$$\sigma_T\left(W^2,Q^2\right)=W\sum_{i=1}^{7} BW_T^i\left(W^2\right)\cdot\left[A_T^i\left(Q^2\right)\right]^2$$

BW^i: relativistic Breit-Wigner with Q^2 dependent width.

A^i_T : resonance transition amplitude.

$$A_T^i(Q^2) = \frac{A_T^i(0)}{(1+Q^2/0.91)^{c_i}} \cdot \left(1+\frac{a_i Q^2}{1+b_i Q^2}\right)$$

In terms of transverse helicity amplitudes: $\left[A_T^i\right]^2=\left[A_{1/2}^i\right]^2+\left[A_{3/2}^i\right]^2$

$$A_L^i(Q^2) = A_L^i(0)\cdot\frac{Q^2}{(1+d_i Q^2)}e^{-e_i Q^2}$$

We have included the possibility of the resonant states with the largest photo-couplings

I	State	$\beta_{1\pi}$	$\beta_{2\pi}$	β_{η}
1	$P_{33}(1232)$	1.0	0.0	0.0
2	$S_{11}(1535)$	0.45	0.10	0.45
3	$D_{13}(1520)$	0.65	0.35	0.0
4	$F_{15}(1680)$	0.65	0.35	0.0
5	$S_{15}(1650)$	0.4	0.5	0.1
6	$P_{11}(1440)$	0.65	0.35	0.0
7	($l = 3$ assumed)	0.5	0.5	0.0

*Note that the helicity amplitudes are *not* fixed to those determined from exclusive processes...

These are allowed to be whatever best reproduces the cross sections.

Fit high precision cross section data covering range of Q^2, W^2, ε: $Q^2 < 9$ and $W < 3$

Data Set	Q^2_{Min} (GeV^2)	Q^2_{Max} (GeV^2)	# Data Points
E94-110 [5]	0.18	5	1259
E00-116 [14]	3.6	7.5	256
E00-002 [15]	0.06	2.1	1346
SLAC DIS [16]	0.6	9.5	296
Photoproduction (Old) [17–19]	0	0	242
Photoproduction (DAPHNE) [20]	0	0	57

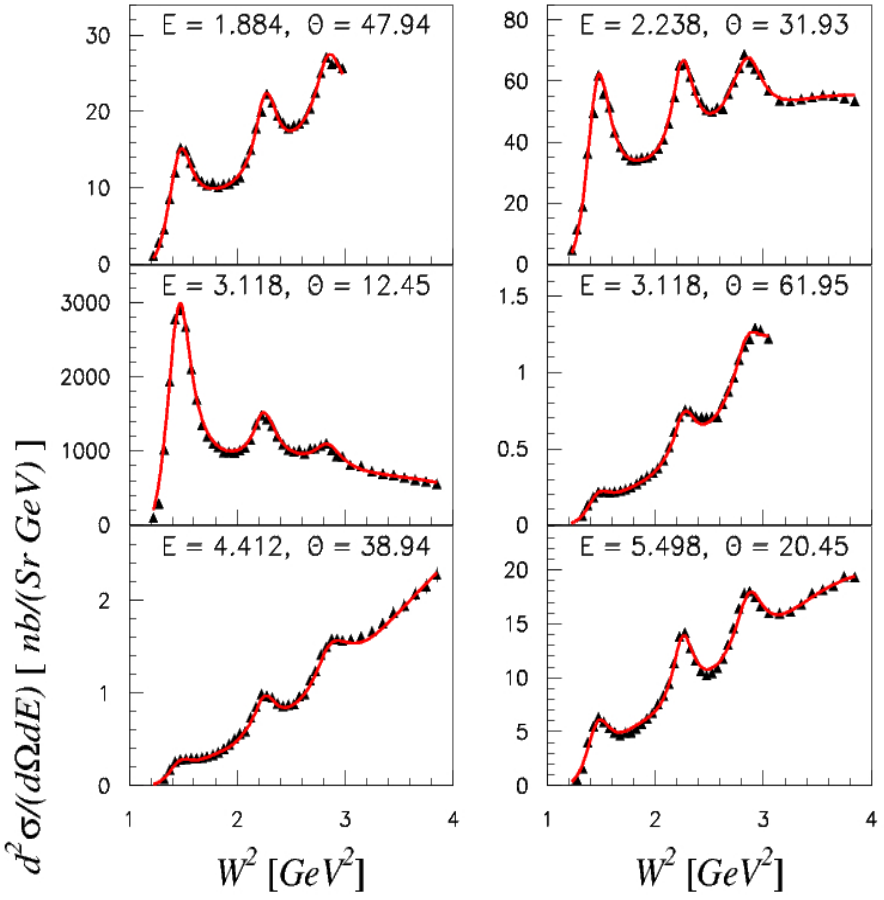
Kinematic range of fit: $Q^2 < 9$ and $W < 3$

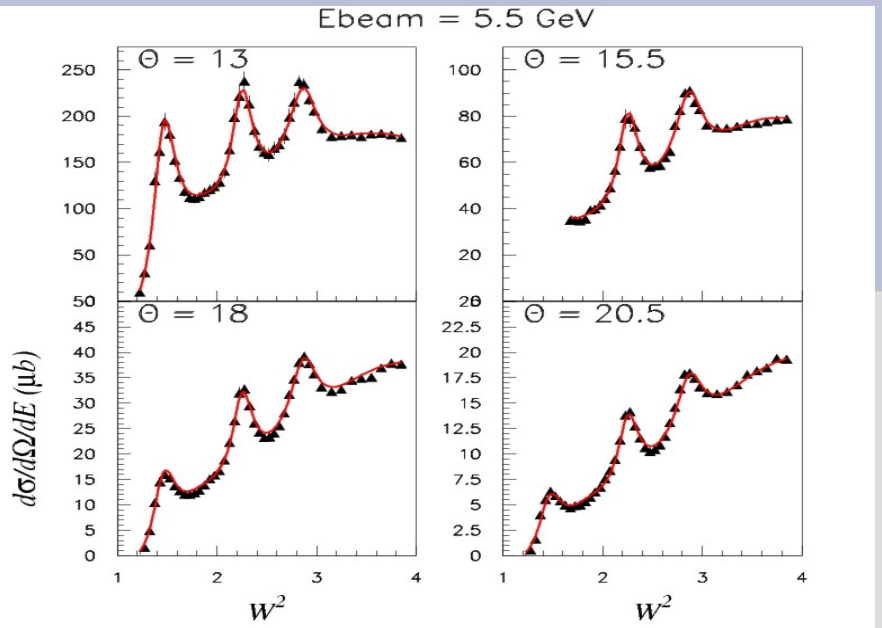
- **reproduces cross section data to ~3%**
- **Fit to both σ_T and σ_L**
- **Similar fit to deuteron (smeared n+p)**

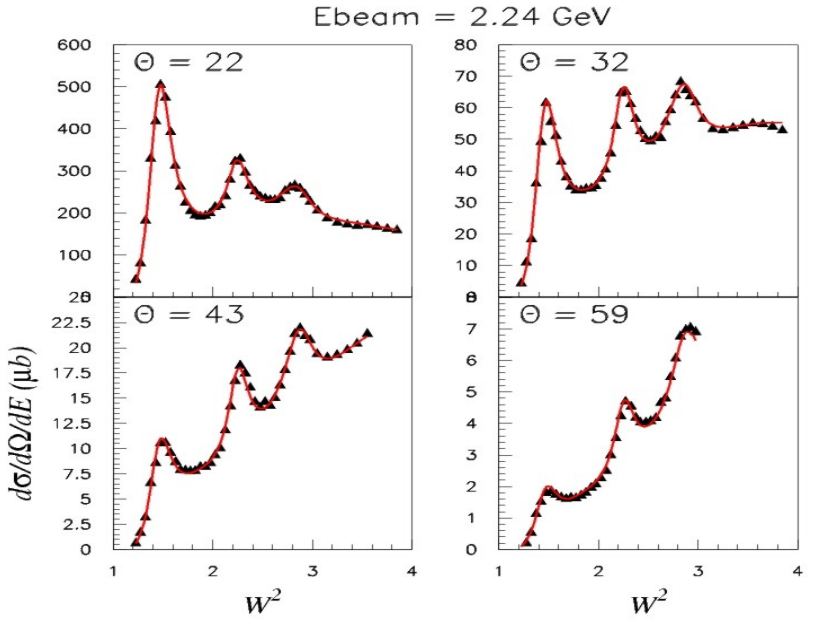
P.E. Bosted and MEC , PRC 77, 065206

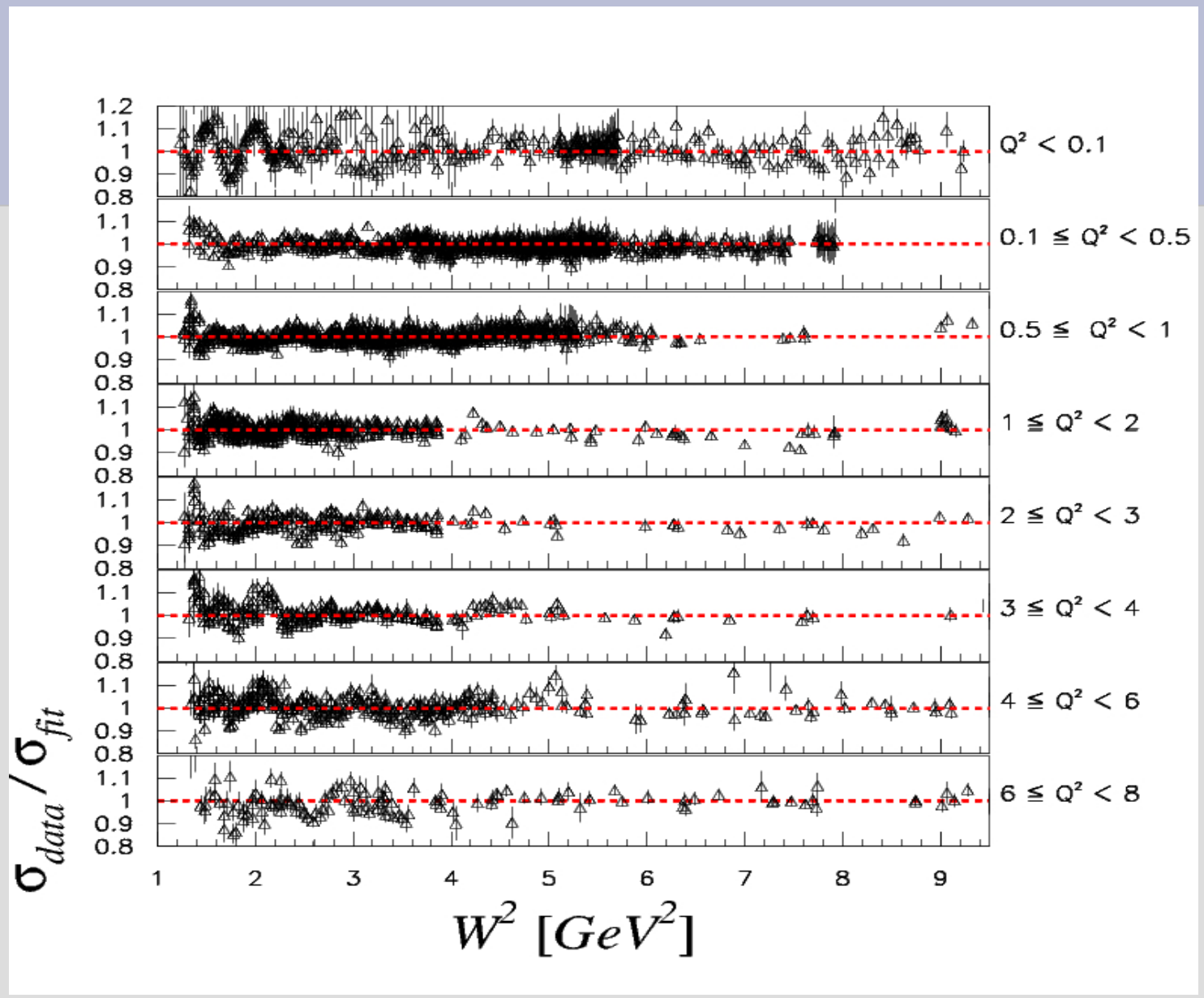
Resonance Region Fit Results (E94110 data)

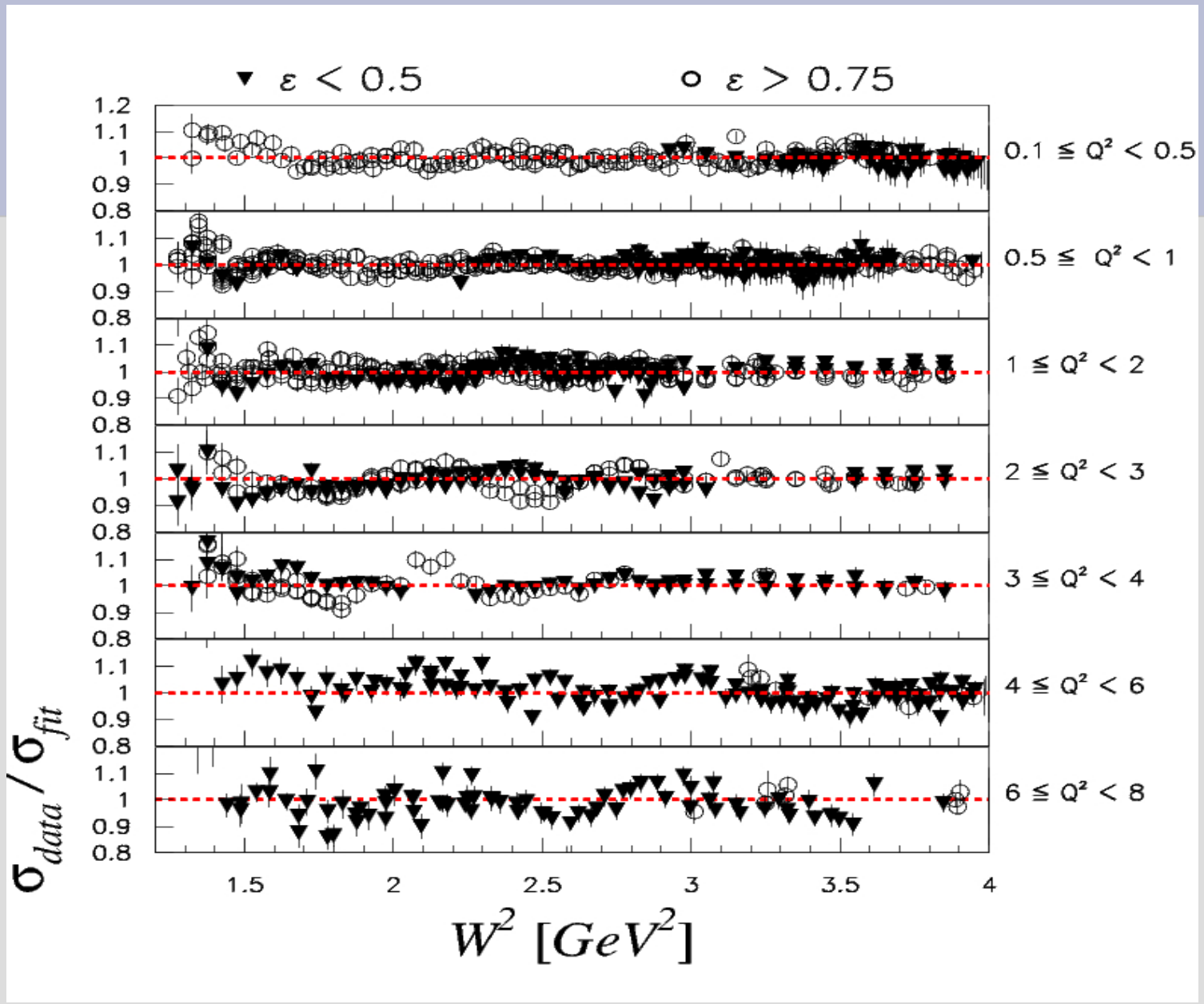
M.E.C. and P.E. Bosted, PRC 81,055213



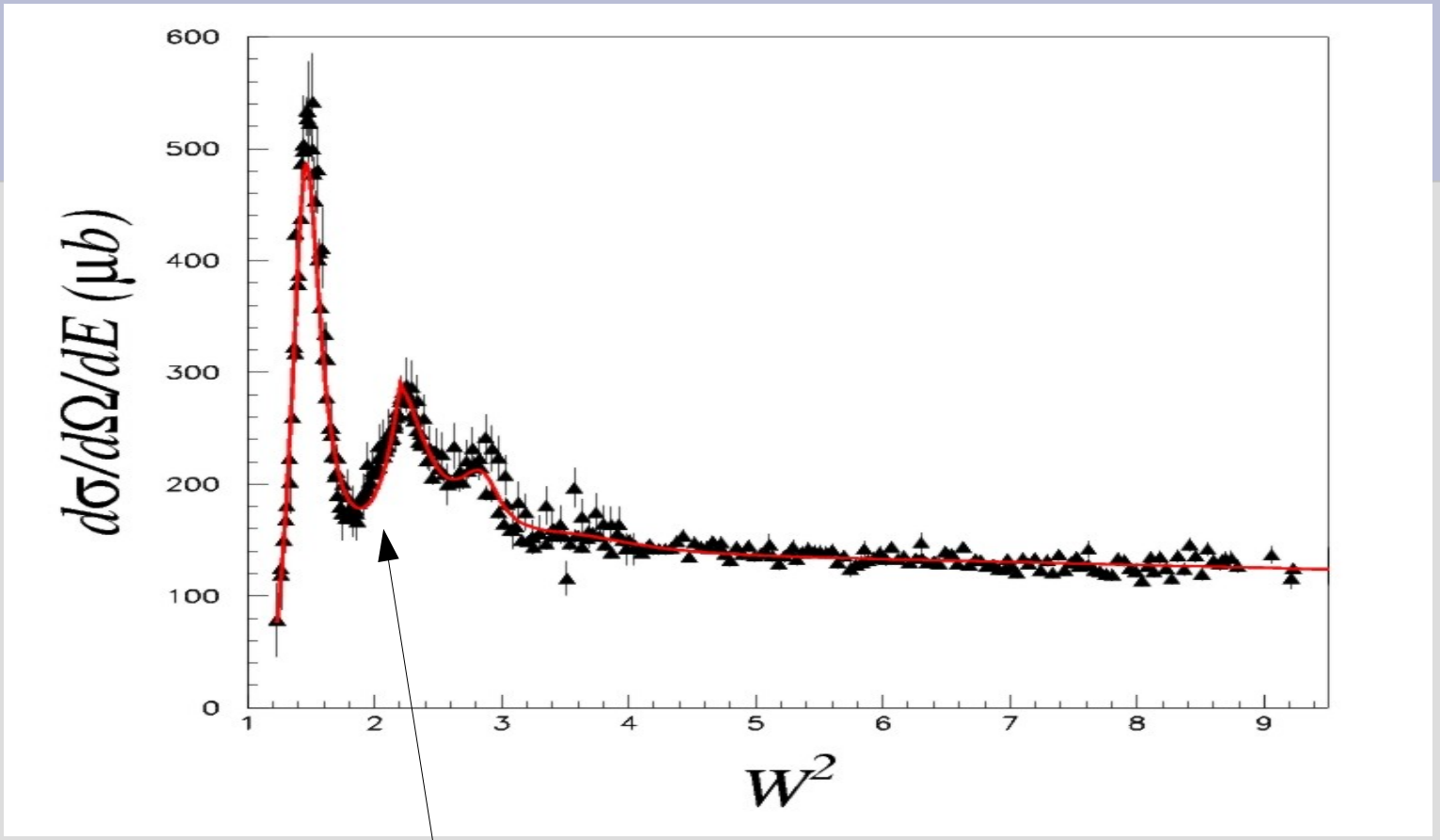





$Q^2 < 0.1$
$0.1 \leq Q^2 < 0.5$
$0.5 \leq Q^2 < 1$
$1 \leq Q^2 < 2$
$2 \leq Q^2 < 3$
$3 \leq Q^2 < 4$
$4 \leq Q^2 < 6$
$6 \leq Q^2 < 8$
$\sigma_{data} / \sigma_{fit}$
W^2 [GeV^2]


▼ ε < 0.5
○ ε > 0.75
0.1 ≦ Q² < 0.5
0.5 ≦ Q² < 1
1 ≦ Q² < 2
2 ≦ Q² < 3
3 ≦ Q² < 4
4 ≦ Q² < 6
6 ≦ Q² < 8
σdata / σfit
W² [GeV²]

Results comparison to Photoproduction data



Largest discrepancies in 2nd resonance region:

S11(1520), D13(1520), Roper P11(1440)

Notes on Proton Fit Results

1. Fit typically reproduces cross section data to ~3%

2 Gap in data utilized for published fit between $0 < Q^2 < 0.1$

updated (unpublished) fit utilizing additional low Q^2 data provided to Qweak for inelastic background studies.

3. $R = \sigma_L / \sigma_T = F_L / 2xF_1$ reasonable well reproduced

4. Transition form factors from fit in 2nd resonance region do *not* match those from exclusive experiments.

From publication

"It is certainly true that the individual transverse transition form factors in the second resonance region are *not* consistent with those extracted from exclusive analysis, although there is consistency in the overall transverse resonance strength in this region."

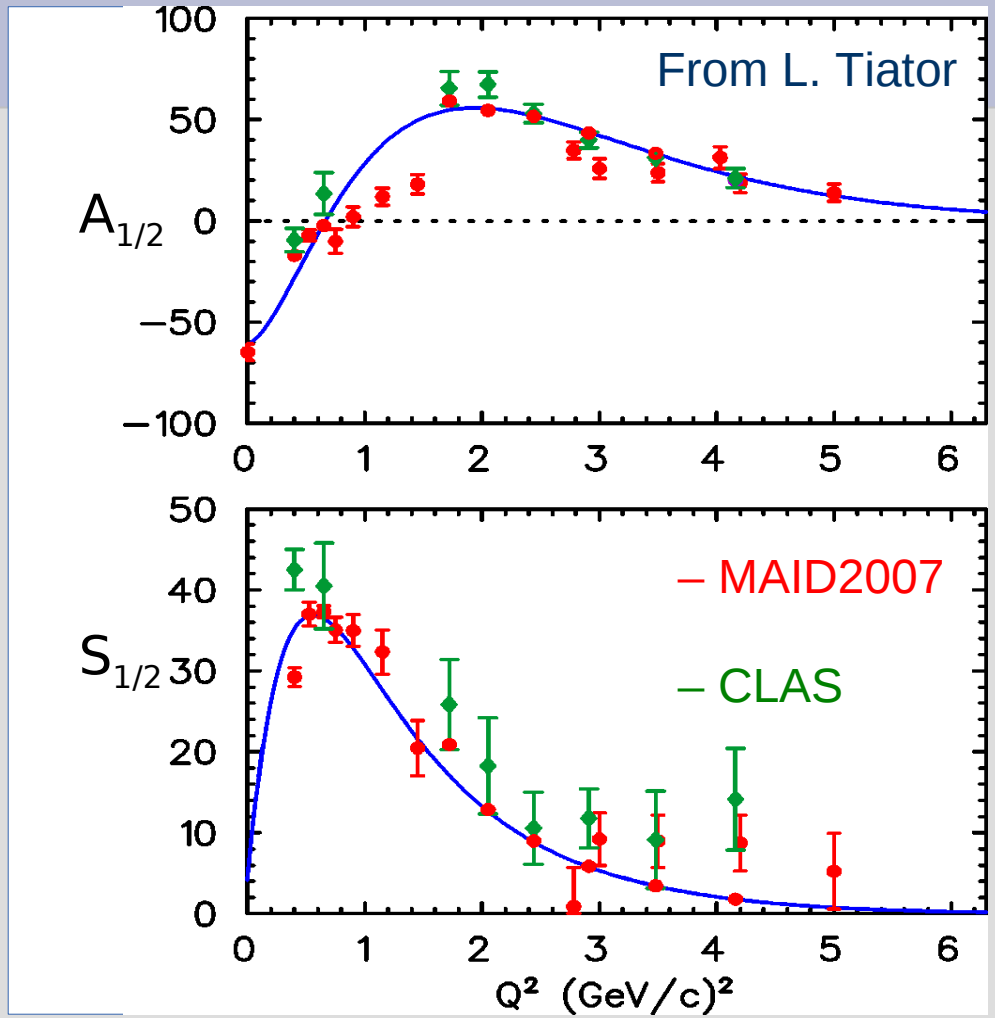
"Part of this inconsistency could be caused by the chosen form for the Roper amplitude...".

This could also be due to a breakdown in our assumption of incoherency.

Q^2 dependence of Roper A_T is inconsistent with fit form utilized.

→ $A_{1/2}$ goes from negative to Positive at $Q^2 \sim 0.6$

=> node in A_T^2



Summary of Proton fit

→ Christy-Bosted proton resonance region fit provides good description of inclusive cross section including both longitudinal and transverse parts.

→ Best fit gives Individual transition form factors in 2^{nd} and 3^{rd} resonance region which are *not* consistent with those measured in exclusive processes.

Some of these can possibly be constrained, but will likely lead to a moderately worse fit to the data.

Investigations of this have begun.

Deuteron / Neutron fitting

→ Bosted-Christy deuteron fit provides description of deuteron data Comparable to the proton fit. **PRC 77, 065206**

→ This fit:

1. *assumes* $R_n = R_p$ => Only σ_T is fit.

2. Fermi smears with Paris wavefunction

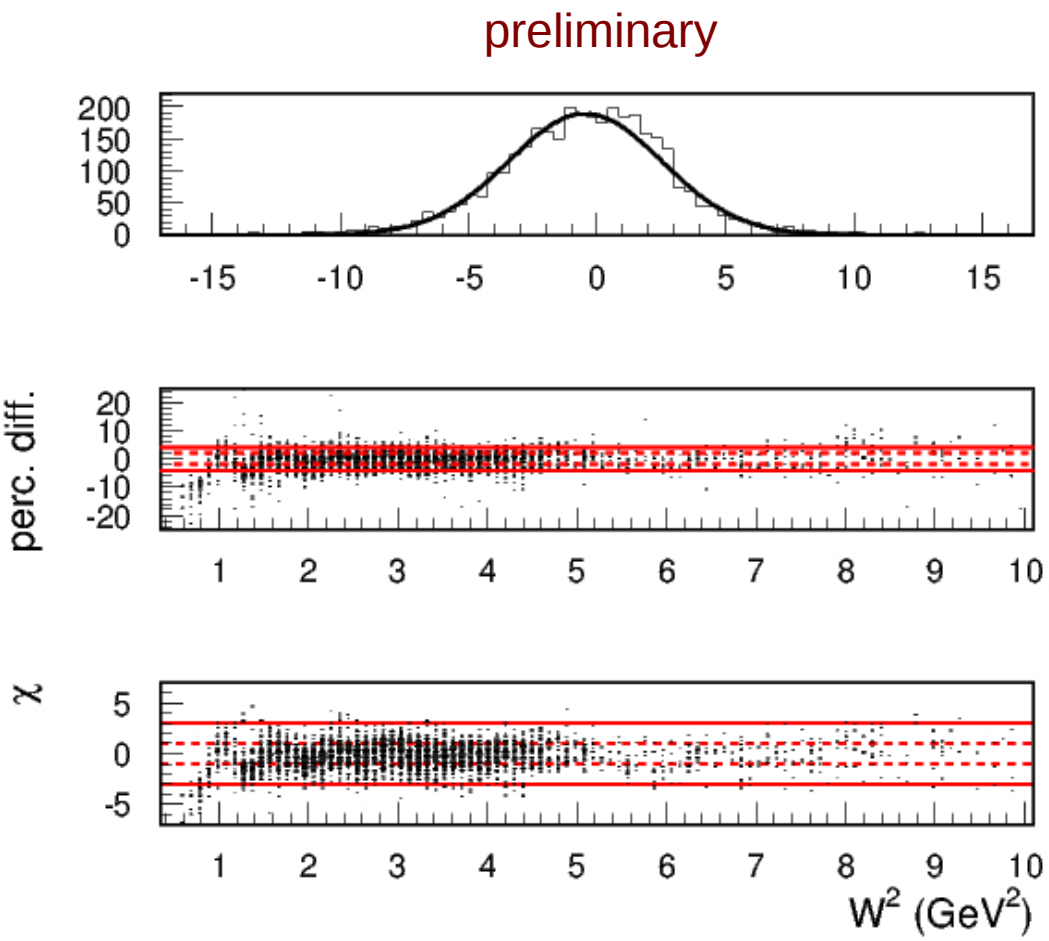
3. Parametrizes neutron σ_T

Currently finalizing new fit which:

1. includes parametrization of neutron σ_L

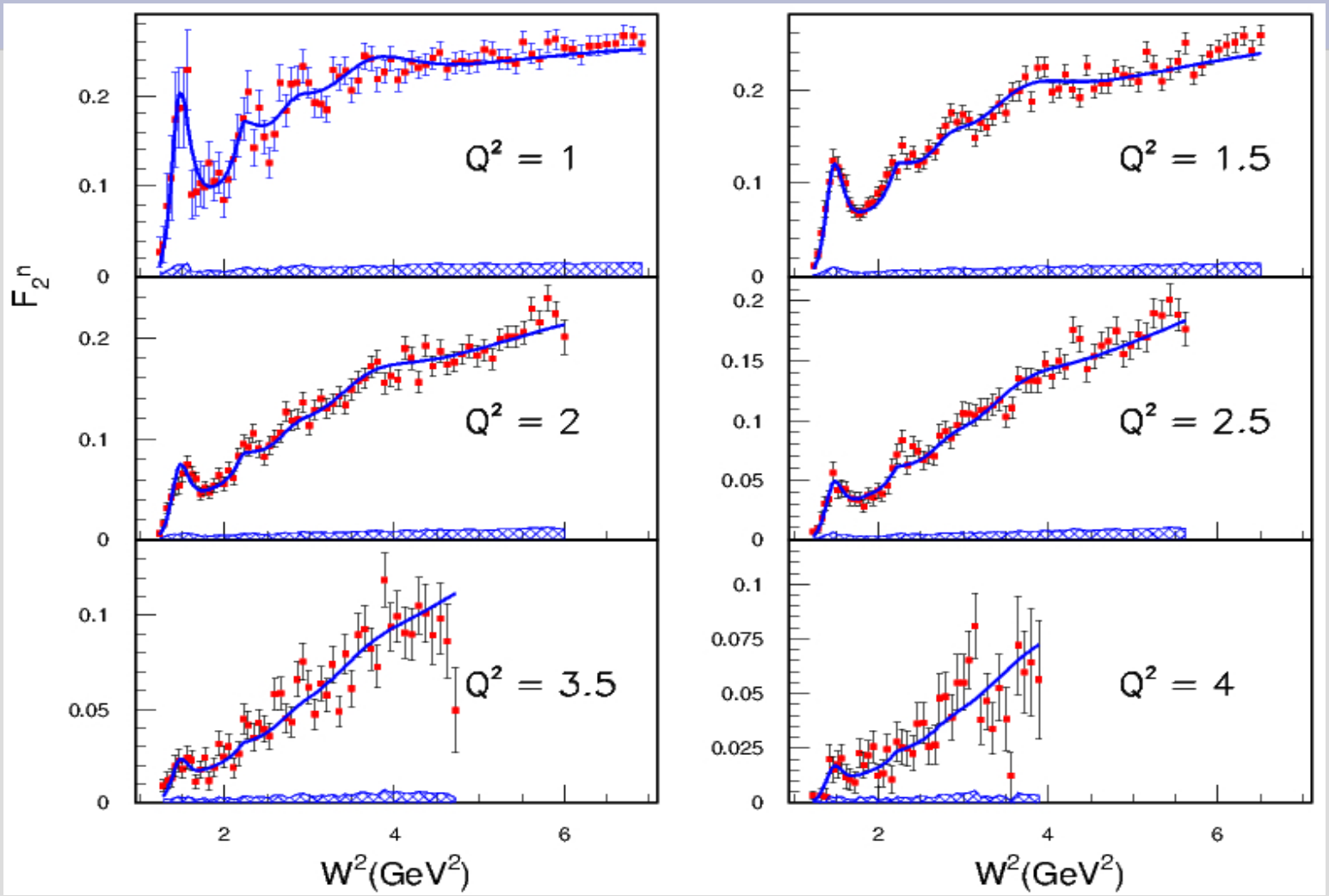
2. improved smearing based on WBA convolution (W. Melitchouk)

Recent deuteron fitting



New data available from BONUS spectator tagging experiment.

This data is *not* currently included in the fit.



New d/n fit will provide neutron cross sections and structure functions from both deuteron inclusive cross sections and BONUS tagged ratios (n/d).

Studies of tension between these data sets will Also be studied within the WBA.

… FIN