# $F_1$, $F_2$ Models for electron scattering

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- **Needed for radiative correction calculations.**
- **Needed to get "dilution factor" in experiments using $NH_3$ or $ND_3$ targets to measure $g_1$ and $g_2$**
- **Needed to predict PV asymmetry in ep inelastic scattering (background to Moller scattering test of Standard Model).**

# Nucleon elastic scattering

- Good fits to ep elastic now exist (Kelly, Arrington, Bosted) up to $Q^2$=5 $GeV^2$.
- Same fits also give e-n elastic: pretty accurately up to $Q^2$=3 $GeV^2$. Will be improved in near future with more data.
- Main uncertainty is in $G_{EP}$ . For most applications, doesn't matter if use Rosenbluth results or polarization transfer results since $G_{EP}$ small part of cross section at high $Q^2$.

# Inelastic scattering on proton

- The recent (March 2006) fit of Eric Chirsty works very well for $0<Q^2<5$ GeV$^2$ and W<3 GeV.
- Fit is to both $F_2$ and R (or $F_L$ and $F_1$)
- Fit used photoproduction data to ensure good behavior at very low $Q^2$
- Results for $F_2$ similar (at 20% level) to previous fits (SLAC Bodek/Atwood, SLAC Rock, E665, F2 NMC for W>2 GeV).

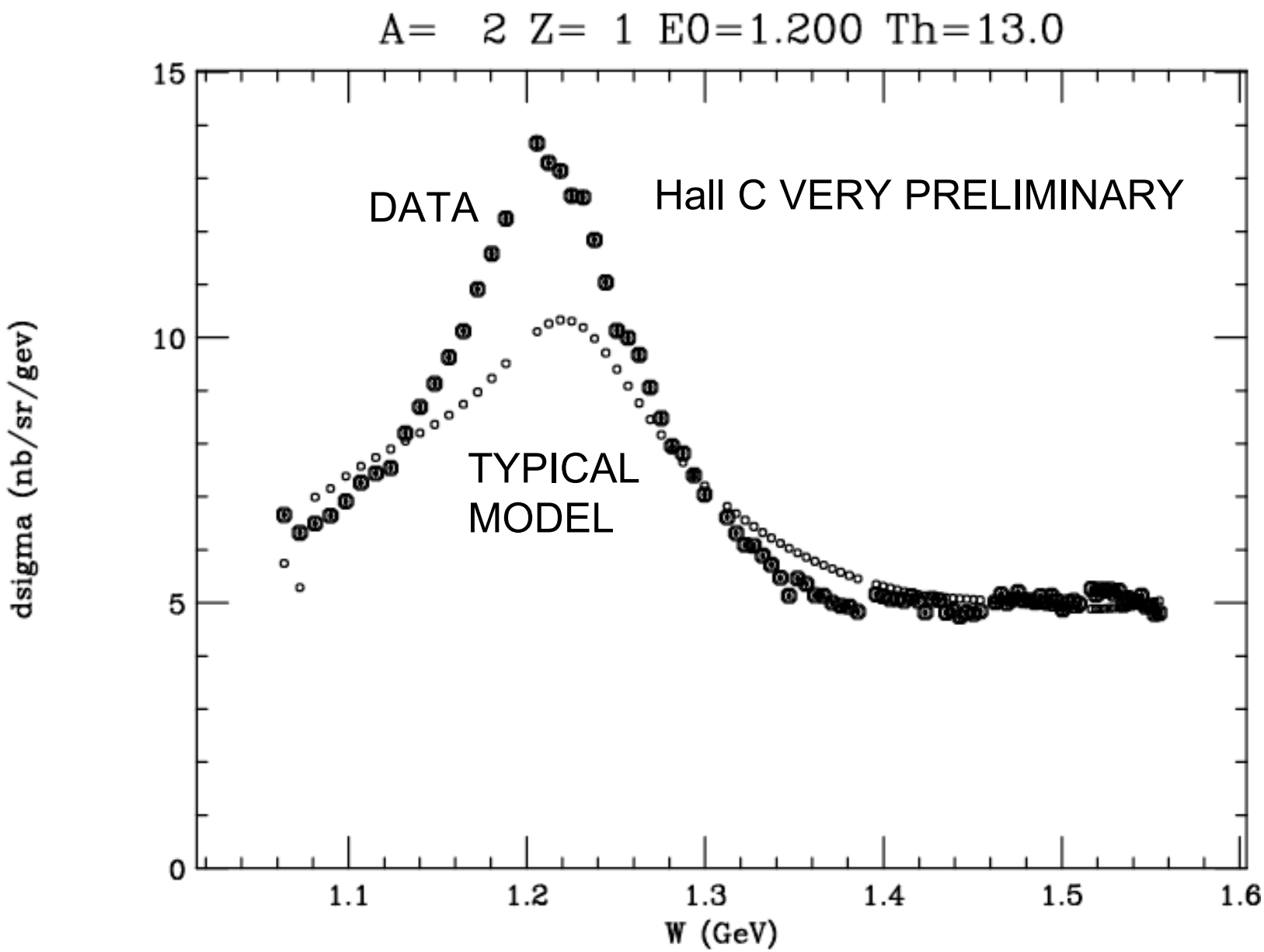
# Inelastic scattering on deuteron

- At low $Q^2$ and W<2 GeV (resonance region), most existing fits do NOT reproduce data (width of resonances is too wide).

- Recall $dW^2 = q\,(p_f)^2$, so Fermi smearing on deuteron is less than typical resonance width (sigma) of 40 MeV. At W=1.5 GeV, dW ranges from 10 to 30 MeV as $Q^2$ increases from 0.1 to 1 $GeV^2$.

# Inelastic scattering on deuteron

- **Fits that did not specifically include Fermi smearing effect and use data with $Q^2>1$ GeV$^2$ will have washed-out resonance structure at low $Q^2$.**
- **This can be seen on next slide for the lowest $Q^2$ (about 0.1 GeV$^2$) preliminary radiated cross section data from the recent Jlab January 2005 experiment.**


A= 2 Z= 1 E0=1.200 Th=13.0
DATA
Hall C VERY PRELIMINARY
TYPICAL
MODEL
dsigma (nb/sr/gev)
W (GeV)
0
5
10
15
1.1
1.2
1.3
1.4
1.5
1.6

# Inelastic scattering on deuteron

- To study problem further, used large sample (about 10 billion scattered electrons) of data from CLAS Eg1b experiment using CLAS in Hall B at Jlab.
- Targets filled with $ND_3$ or $NH_3$ (plus some liquid helium) were alternated frequently (so acceptance cancels) and electrons were detected $10<\theta<40$ degrees for beam energies 1.7, 2.5, 4.2, 5.7 GeV.

# Inelastic scattering on deuteron

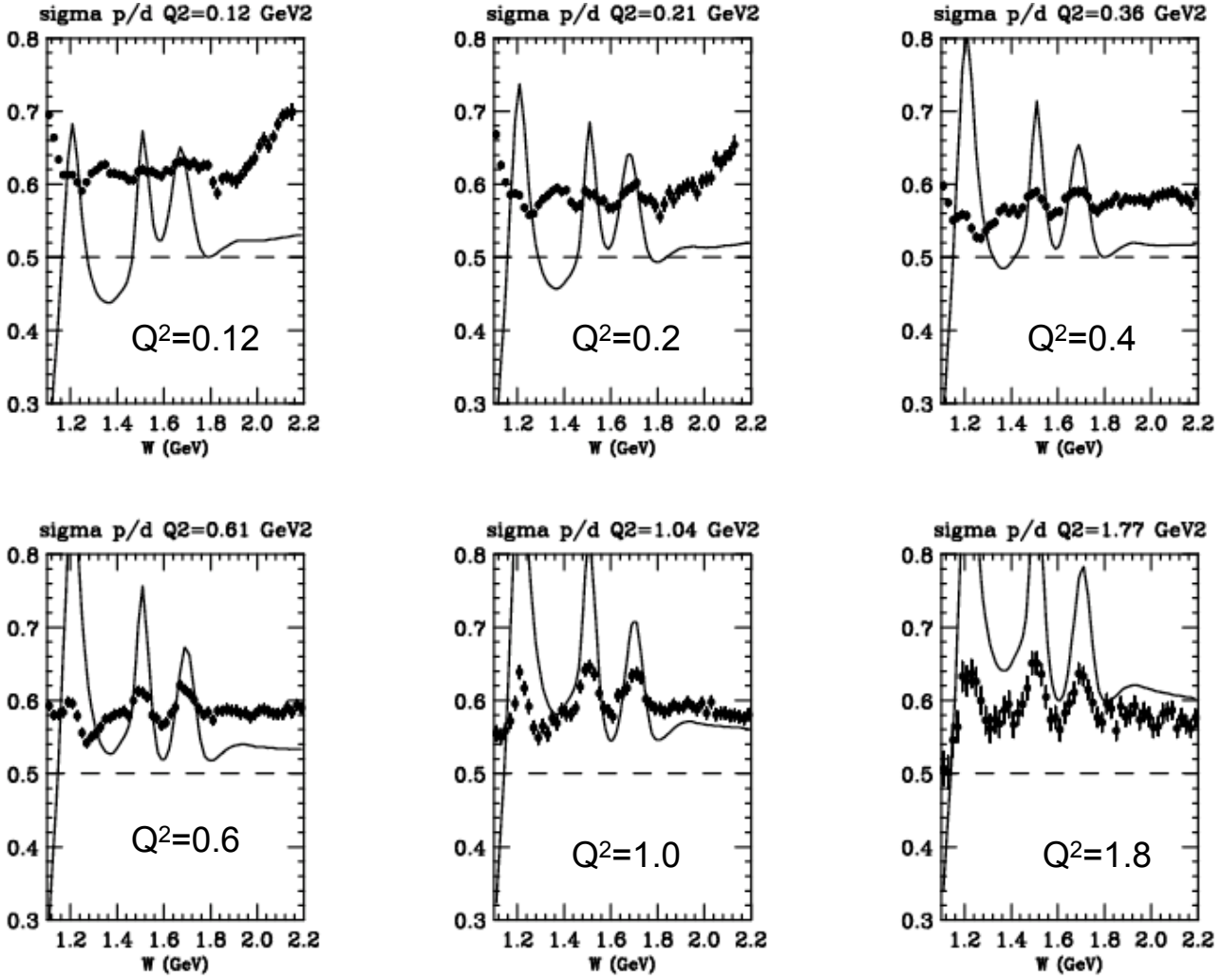
- Discarded 5.7 GeV data because experimental W resolution >30 MeV.
- Discarded $Q^2<0.1$ GeV$^2$ data due to large (>10%) tails from $^{15}$N elastic.
- Discarded $Q^2>1.5$ GeV$^2$ data (Fermi smearing in deuteron >30 MeV).
- Normalized data to give expected p/d ratio in DIS region ($W>2$, $Q^2>1$ GeV$^2$)
- Extraced p/d ratios in resonance region

# Inelastic scattering on deuteron

- Radiative corrections not applied (although checked small in kinematic region selected, since $ND_3$ and $NH_3$ targets very similar).
- Fermi smearing effects not included (in particular for the $^{15}N$), but not large in region studied.
- Possible differences in pair-symmetric background not included
- Results are VERY PRELIMINARY.

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using SLAC Bodek/Attwood for p and d

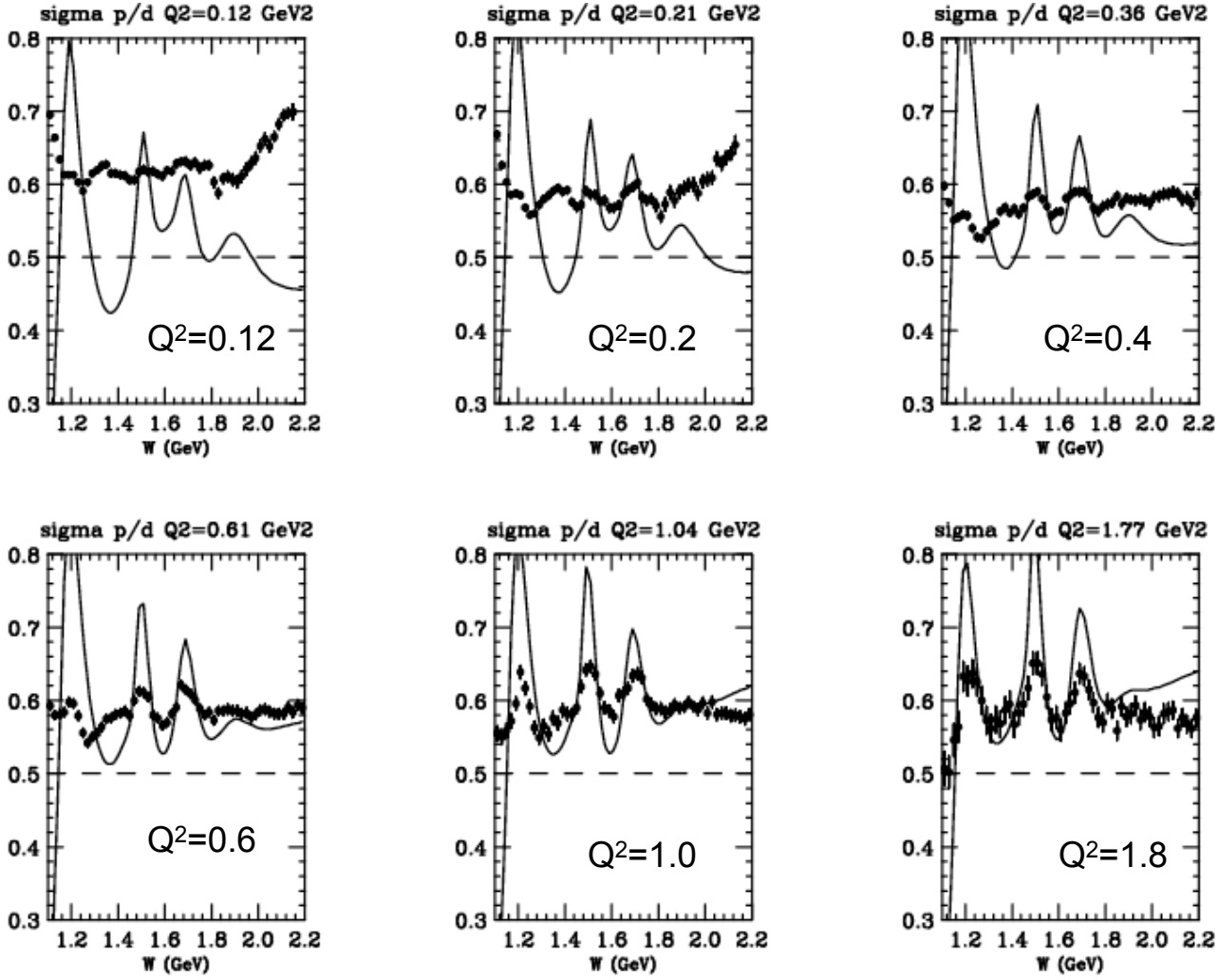





Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using Christy for p and SLAC Bodek/Attwood for d

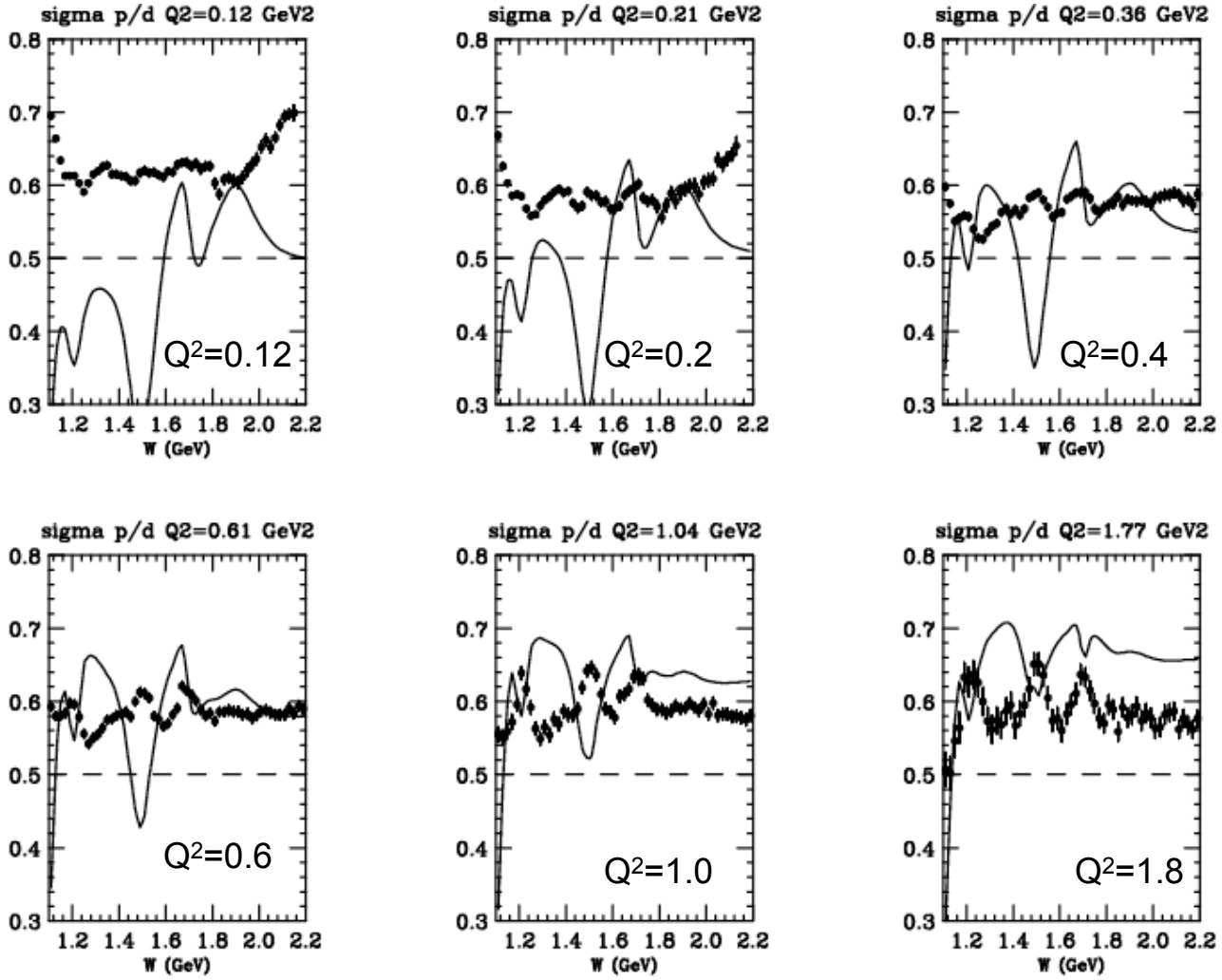





Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using Eric Christy for p and Steve Rock fit d

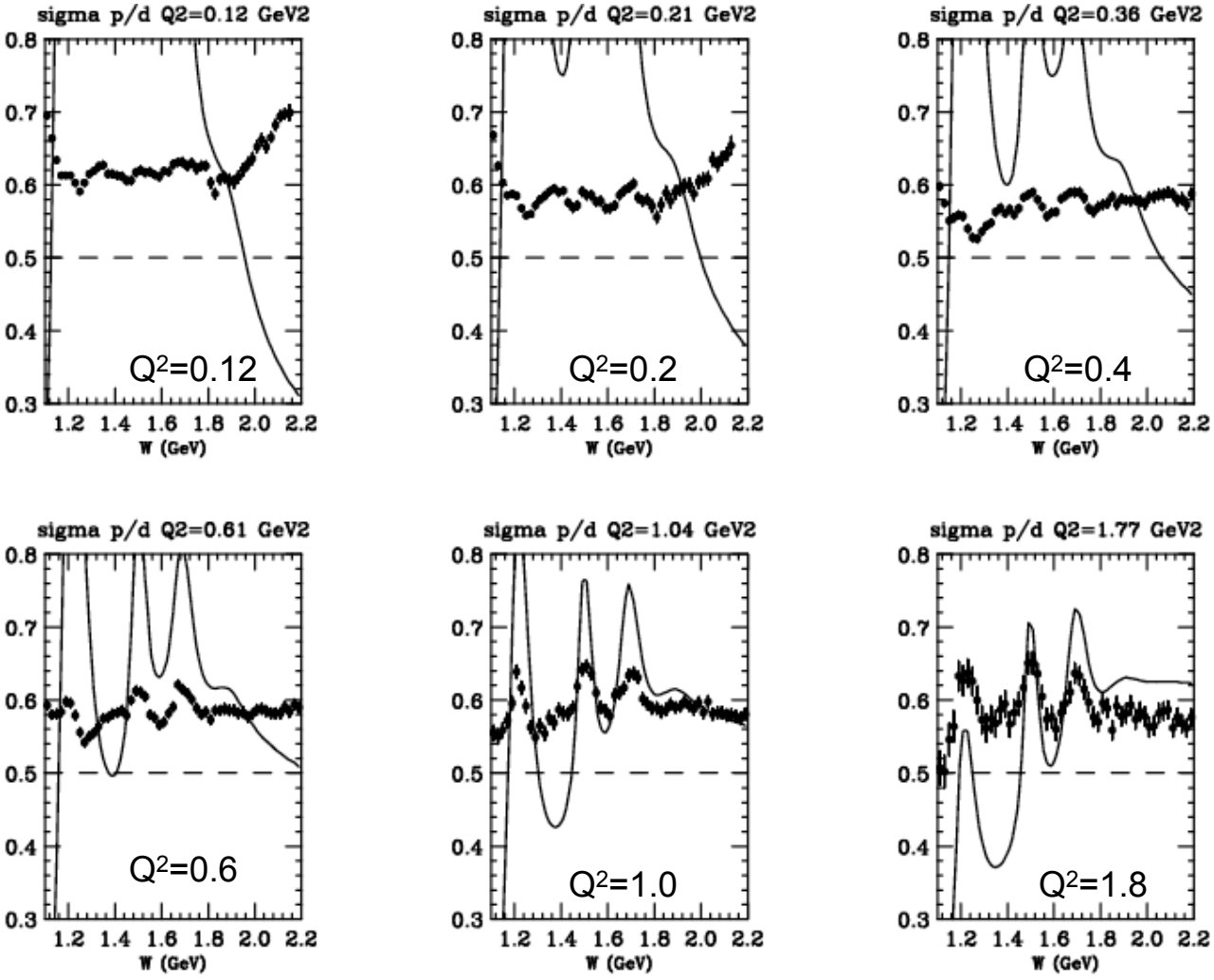





Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using Eric Christy for p and D2MODEL_IOANA fit d

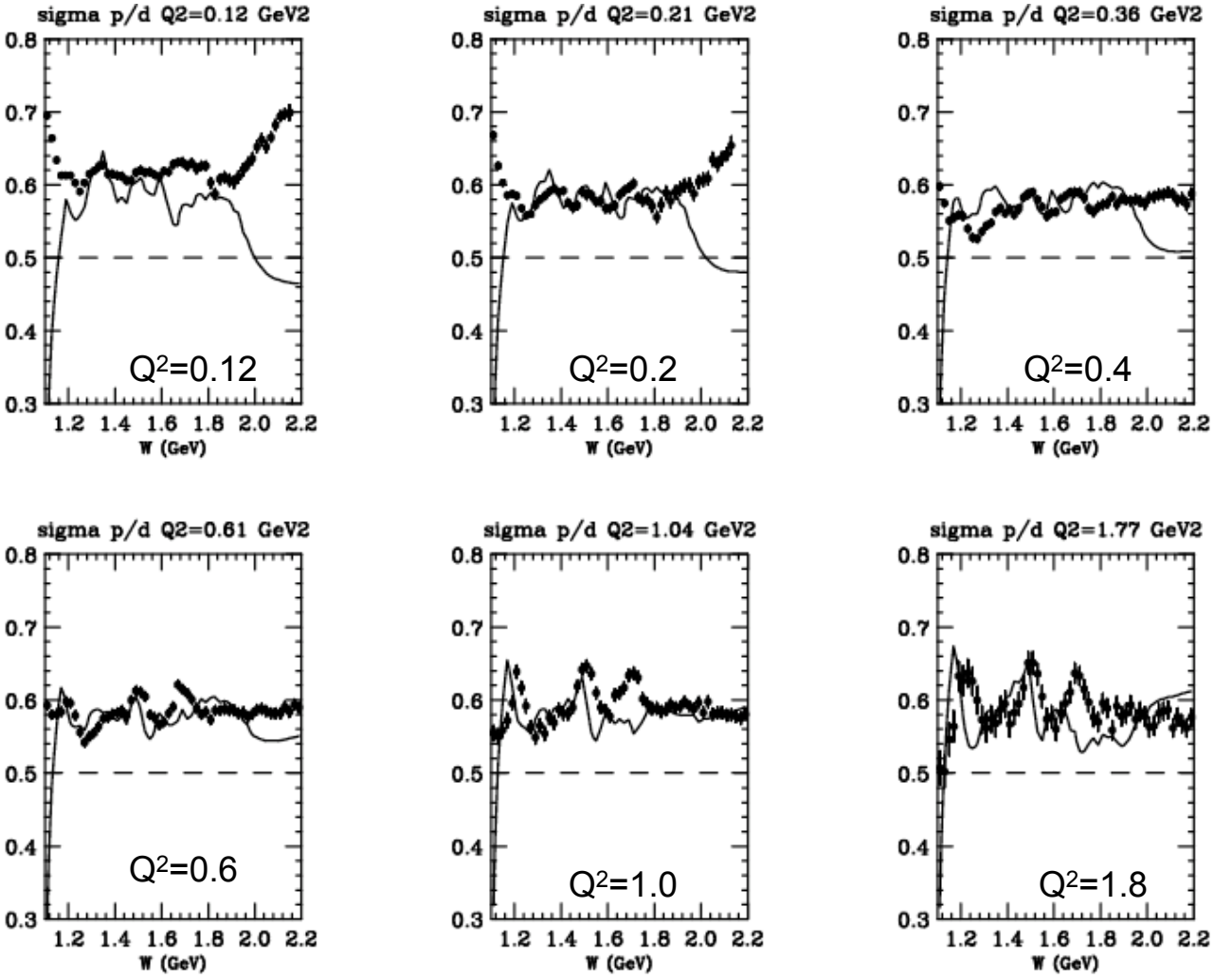





Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using Eric Christy for p and E665 fit for d

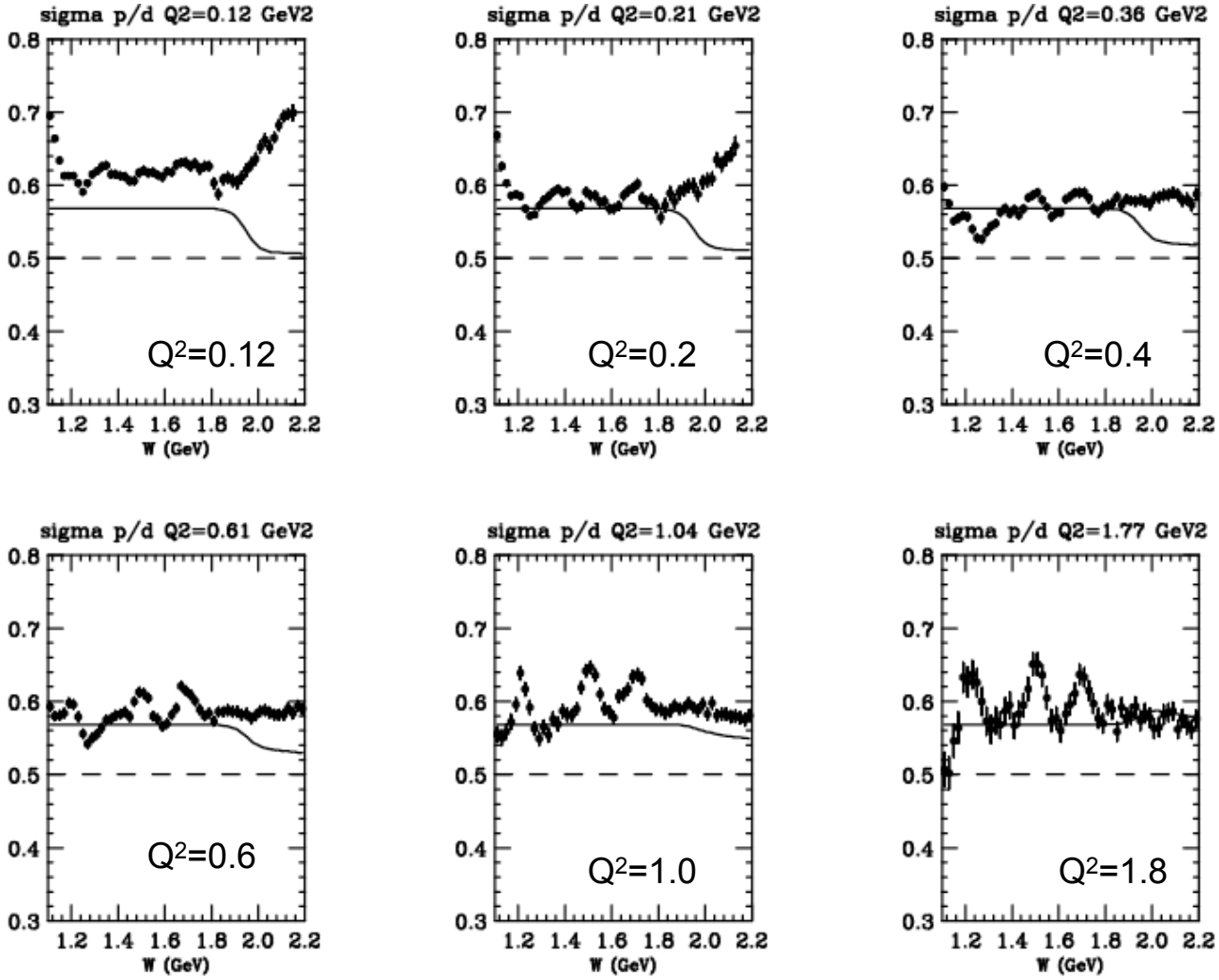





Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic proton/deuteron ratio in Resonance Region

## Curves using E665 fit for both p and d






Data: CLAS Eg1b VERY PRELIMINARY from NH3/ND3

# Inelastic scattering on deuteron

- **Looks like what works best among available models is E665 fit (A. V. Kotwal, January 1994), which makes assumption n=0.76p in the resonance region.**
- **Next step: add Fermi smearing for deuteron.**
- **Next step: study best transition to DIS region (W>2 GeV): clearly n/p=(1-0.8x) inadequate: need to consider using (1-0.8xi) and also make shadowing corrections.**

# Inelastic scattering on nuclei

- **Presently, apply simple y-scaling-based Fermi smearing model to free neutron and proton fits, plus a Steve Rock fit to "EMC" ratio for x<0.8 to take into account binding and shadowing.**
- **This prescription predicts ratio of $^{15}$N to C essentially independent of W in the resonance region.**
- **This seems to be born out by very preliminary ratios measured in CLAS.**

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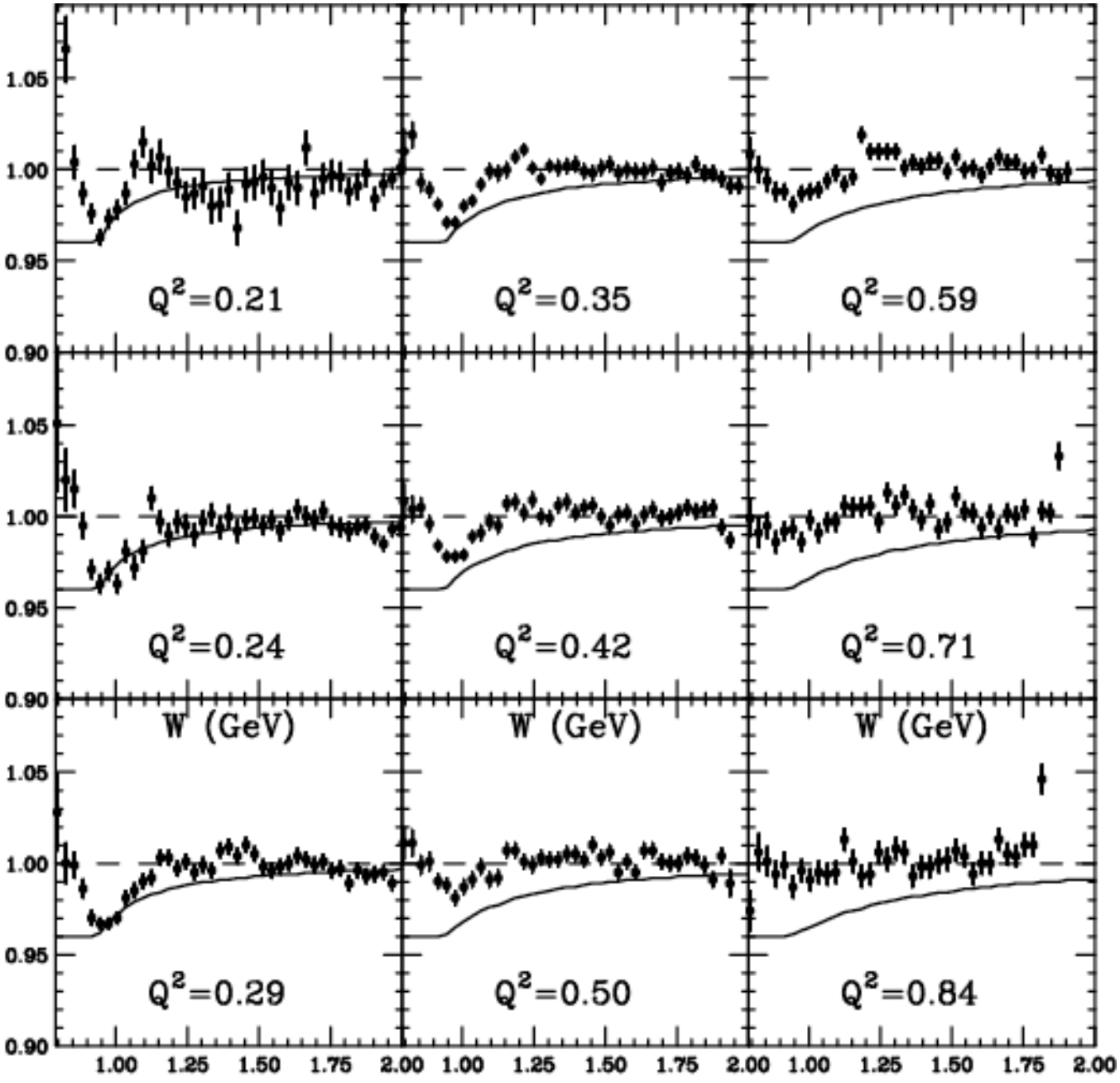
- **This prescription predicts ratio of $^{15}$N to C essentially independent of W in the resonance region (BUT, not quasielastic!).**
- **This seems to be born out by very preliminary ratios measured in CLAS.**

# Very preliminary ratios 15N/C (per gm) from CLAS Eg1b




Curve use
DIS limit
n/p=(1-0.8x)

# CONCLUSIONS

- **Neutron / Proton ratio almost constant in the nucleon resonance region.**
- **New data from CLAS and Hall C will soon pin down vector current for proton, neutron, carbon, 15N, and heavier targets from quasi-elastic region up to W-3 GeV and for 0.05<Q2<5 GeV2**
- **Better emipirical fits needed for modeling radiative corrections, neutrino interactions, and many other applications.**