New fits to inclusive electron scattering from p, n, and d at low Q^2

P. Bosted

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- **Motivation**
- **Proton fit for F_1 and F_2**
- **Deuteron fit for F_1 and n/p ratios**
- **Example: Q^2 dependence of Baldin Sum Rule**
- **Outlook: R for deuteron and A>2 fits**

Motivation

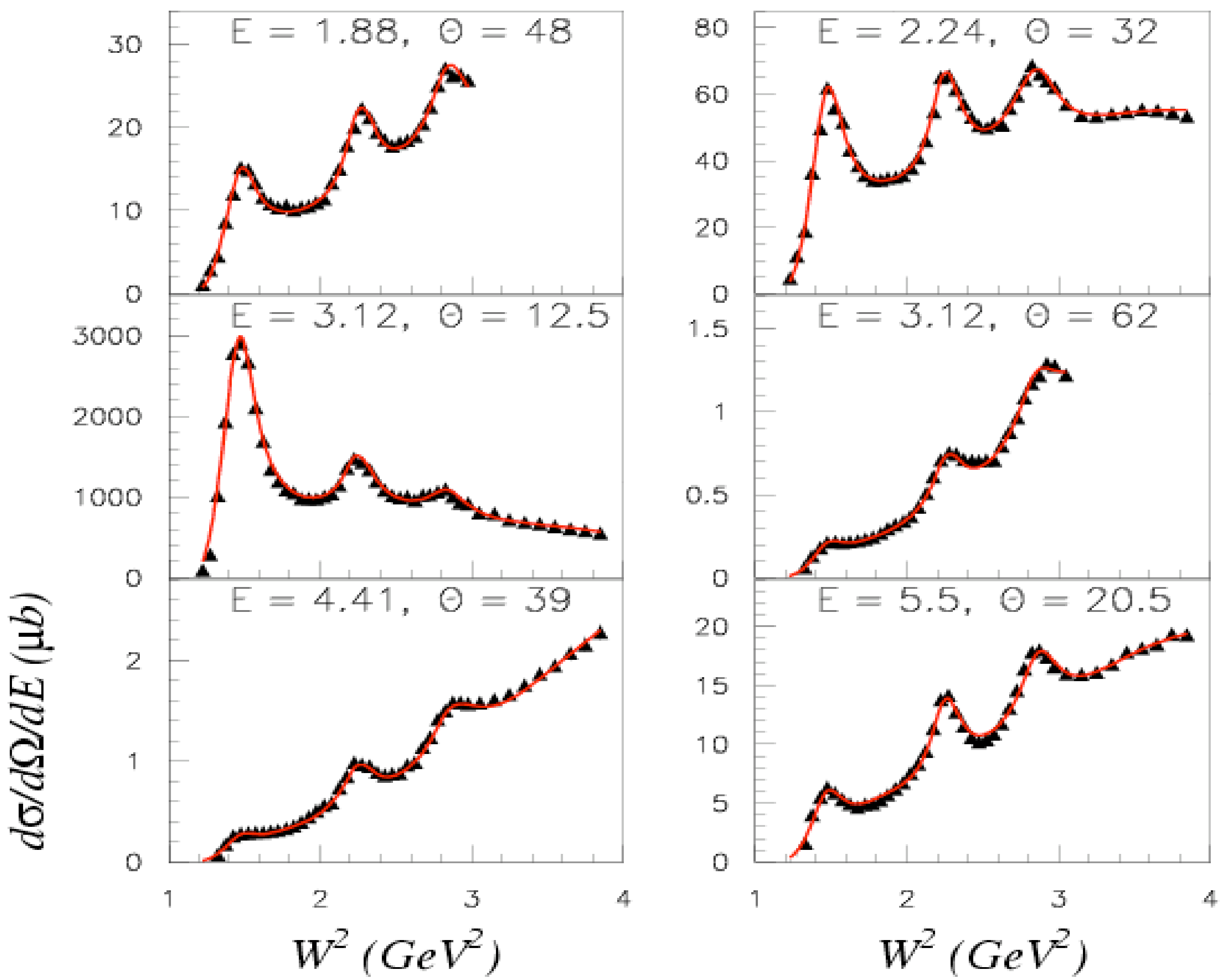
- Replace 1000’s data points with smooth function
- Needed for reliabel radiative corrections
- Dilution in (g_1, g_2) experiments using ammonia
- Predictions DIS PV at low Q^2
- Modeling for neutrino scattering experiments
- Needed to get g_1 from $A_{1.}$
- Helpful in sum rule evaluations.
- Study of higher twist, QCD evolution low Q^2

New fit to inclusive electron-proton scattering for $0<Q^2<8$ GeV^2, W<3 GeV

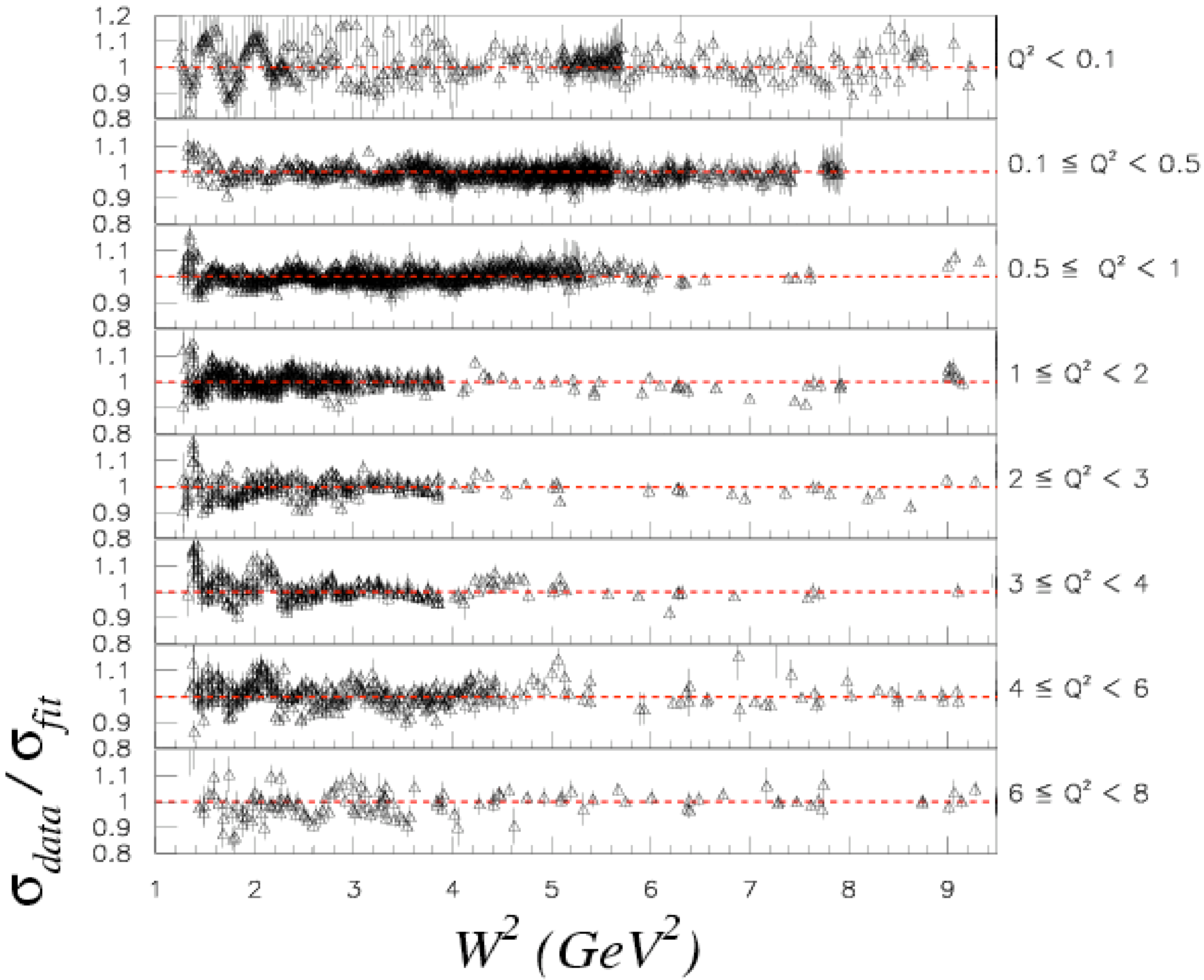
M.E. Christy and P.E. Bosted, arXiv:0711.0159)2007)

- **Baed on new Jefferson Lab Hall C data.**
- **Fit to both F_1, F_2 (or F_2, R)**
- **Includes Q^2=0 photo production data**
- **SLAC data added for smooth transition DIS region**
- **Fit varaiables are Q^2, $W^2 = M^2 + Q^2 (1/x - 1)$**
- **Polynominal non-resonant background**
- **Relativistic Breit-Wigner shapes for 6 resonances**
- **Total of 100 free parameters in fit**

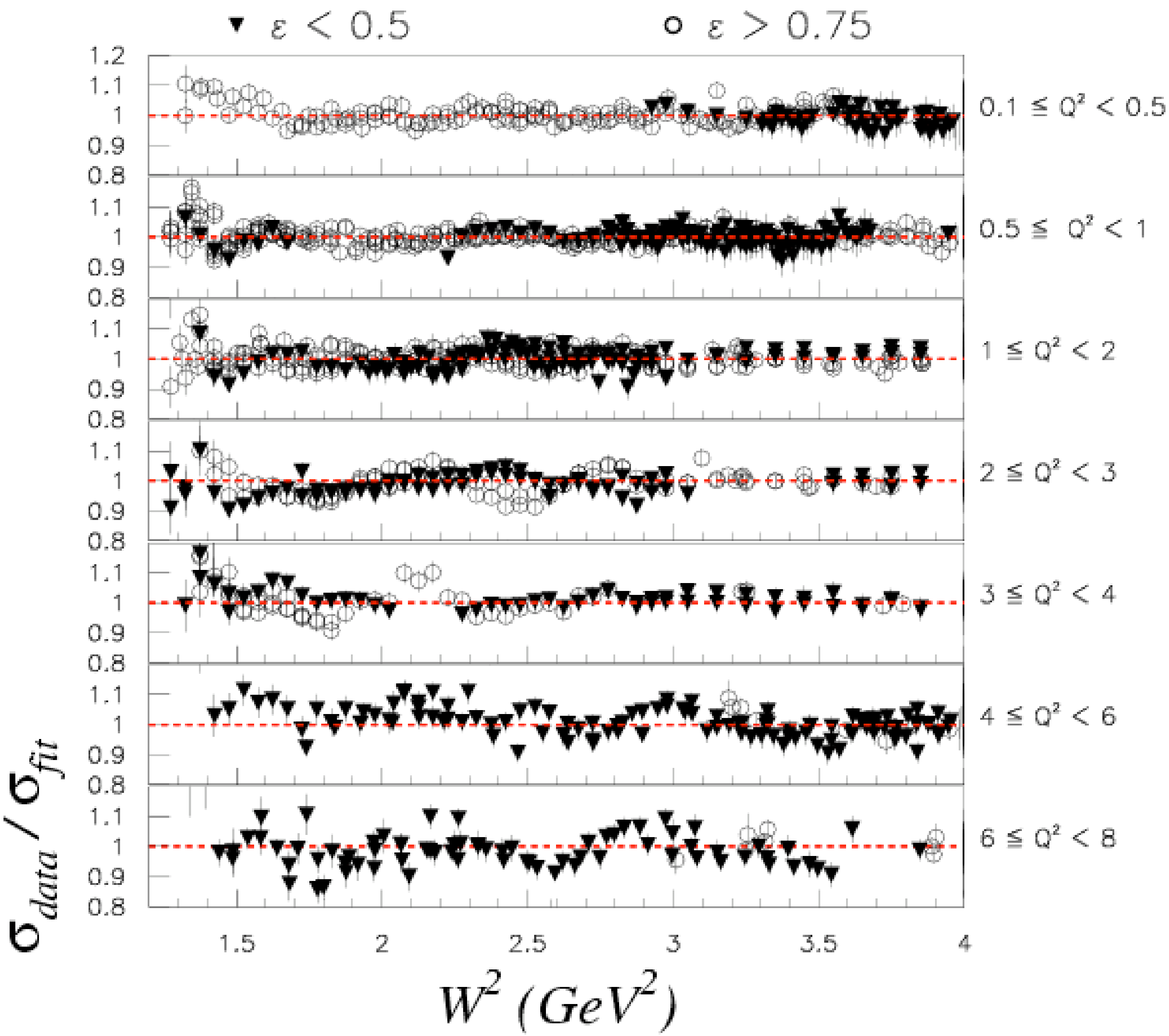
Proton Cross Sections: a few examples



Ratio of data to proton fit

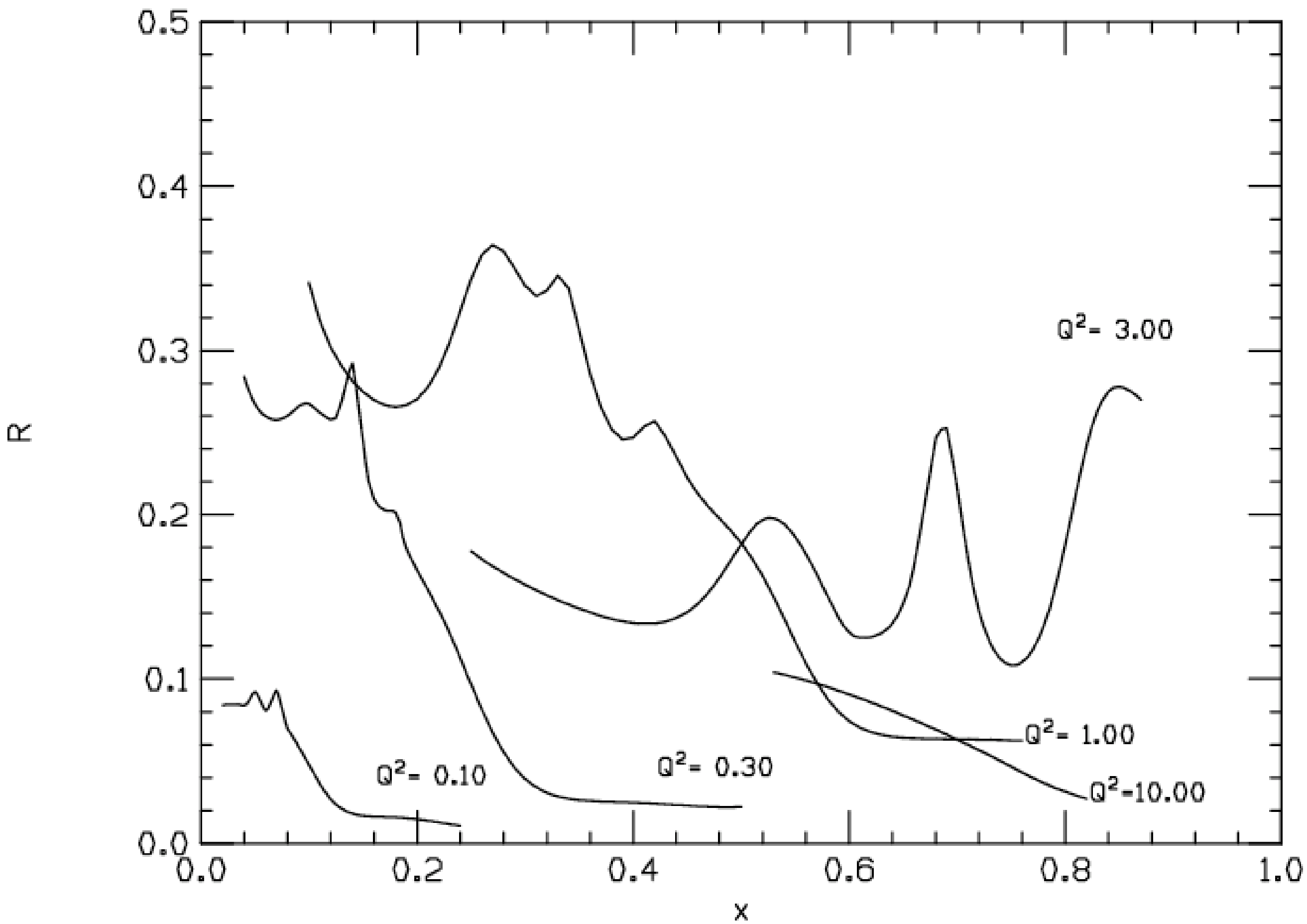


Ratio of data to proton fit at low, high ε



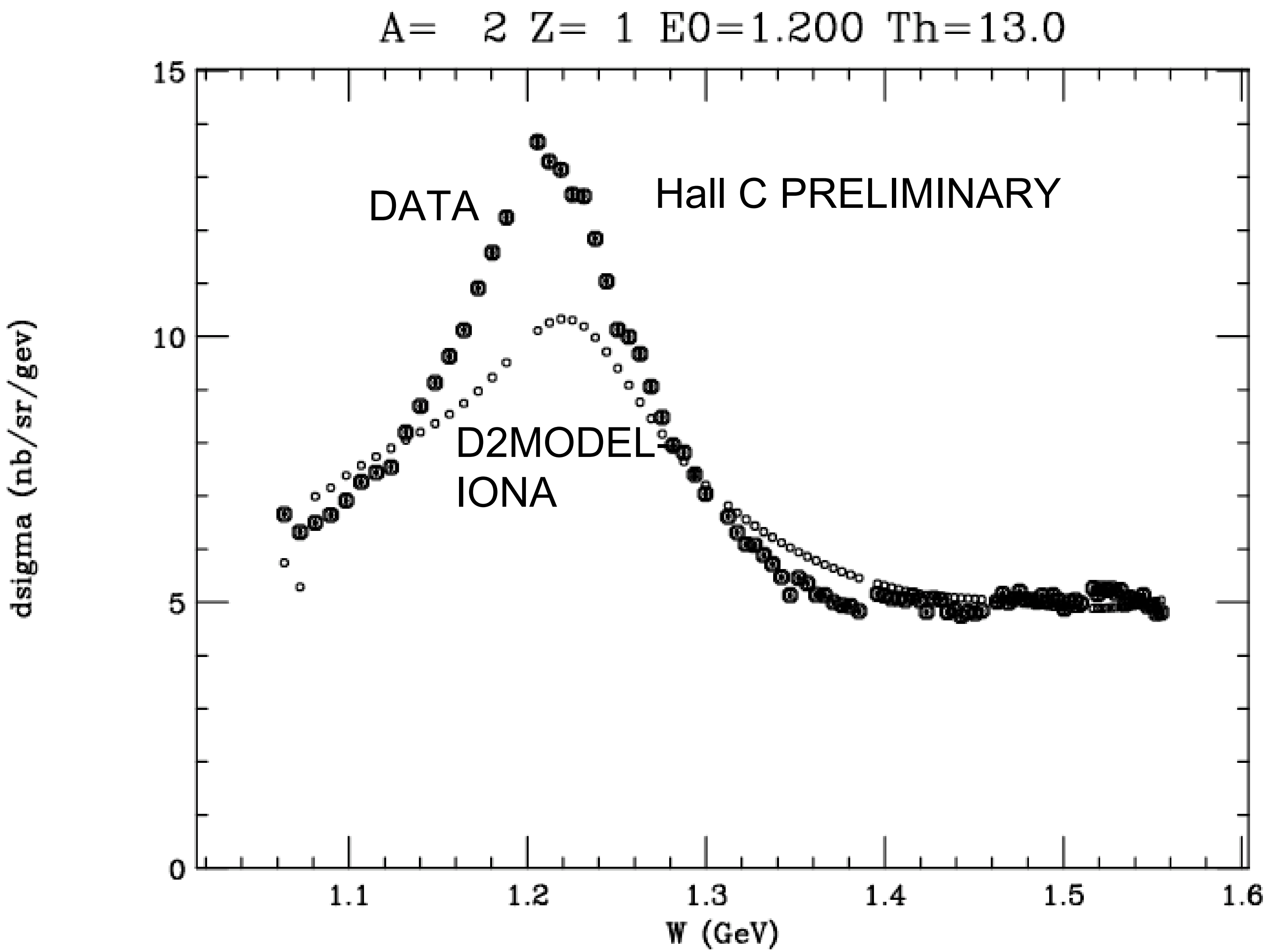
Ratios $R=\sigma_L/\sigma_T$ versus x

Clear oscillations seen due to resonances
Largest at modeerate Q^2



Inelastic scattering on deuteron

- Previous fits did not specifically include Fermi smearing effect : fixed widths of resonances were used rather than ones that increase with q.
- 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 PRELIMINARY
D2MODEL-
IONA
dsigma (nb/sr/gev)
W (GeV)
0
5
10
15
1.1
1.2
1.3
1.4
1.5
1.6

Fermi-smearing

- **Nucleons move in nuclei with characteristic "Fermi" momentum controlled by nuclear density.**

- **Typical values are 0.05 GeV for D, 0.15 GeV for ^{3}He, 0.2 GeV for 3<A<12, and 0.25 GeV for A>12.**

- **In inclusive electron scattering, "smears" out invariant mass W by:**

$$W^2 = M^2 + 2M\nu - Q^2 + 2\vec{q}\cdot\vec{p_f}$$

More on Fermi smearing

- So ture W and measured W differ by magnitude of momentum transfer vector times struck nucleon momentum
- For deuteron, use Paris wave function to estimate probability of finding a nucleon with a given value of p*cos(θ), where θ is angle between q and p.

Basic structure of deuteron fit

P.E. Bosted and M.E. Christy, arXiv: 0711.0159 (2007)

- **Subtract off quasi-elastic contributions using PWIA calculation, Paris wave function.**
- **Next, extract F_1 from cross section using proton fit for $R=\sigma_L/\sigma_T$, assuming R is same for proton and neutron.**
- **Underlying fit parameters describe F_1 from the sum of a free proton plus a free neutron. Functional from similar to proton fit (relativistic Breit-Wigner resonances plus polynomial non-resonant background).**

Basic structure of the fit

- Underlying fit is Fermi-smeared using 20 bins of equal probability in dW, for comparison with actual data. Crucial step is very efficient coding of Fermi smearing.

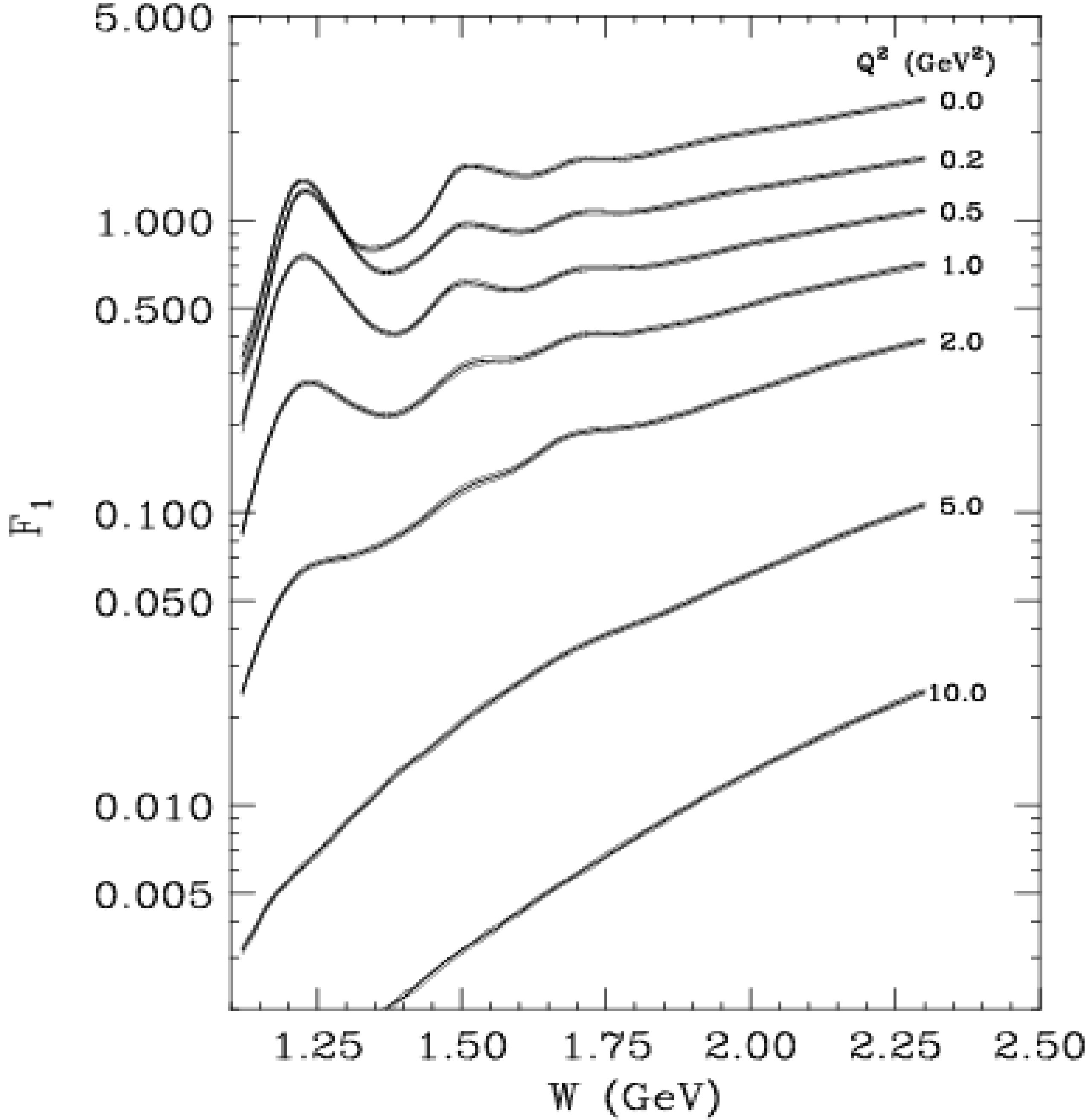
- Additional parameters are used to describe effects beyond Fermi-smearing such as Final State Interactions (FSI) and Meson Exchange Currents (MEC). This fills in the “dip” between quasi-elastic and Delta(1232).

Basic structure of the fit

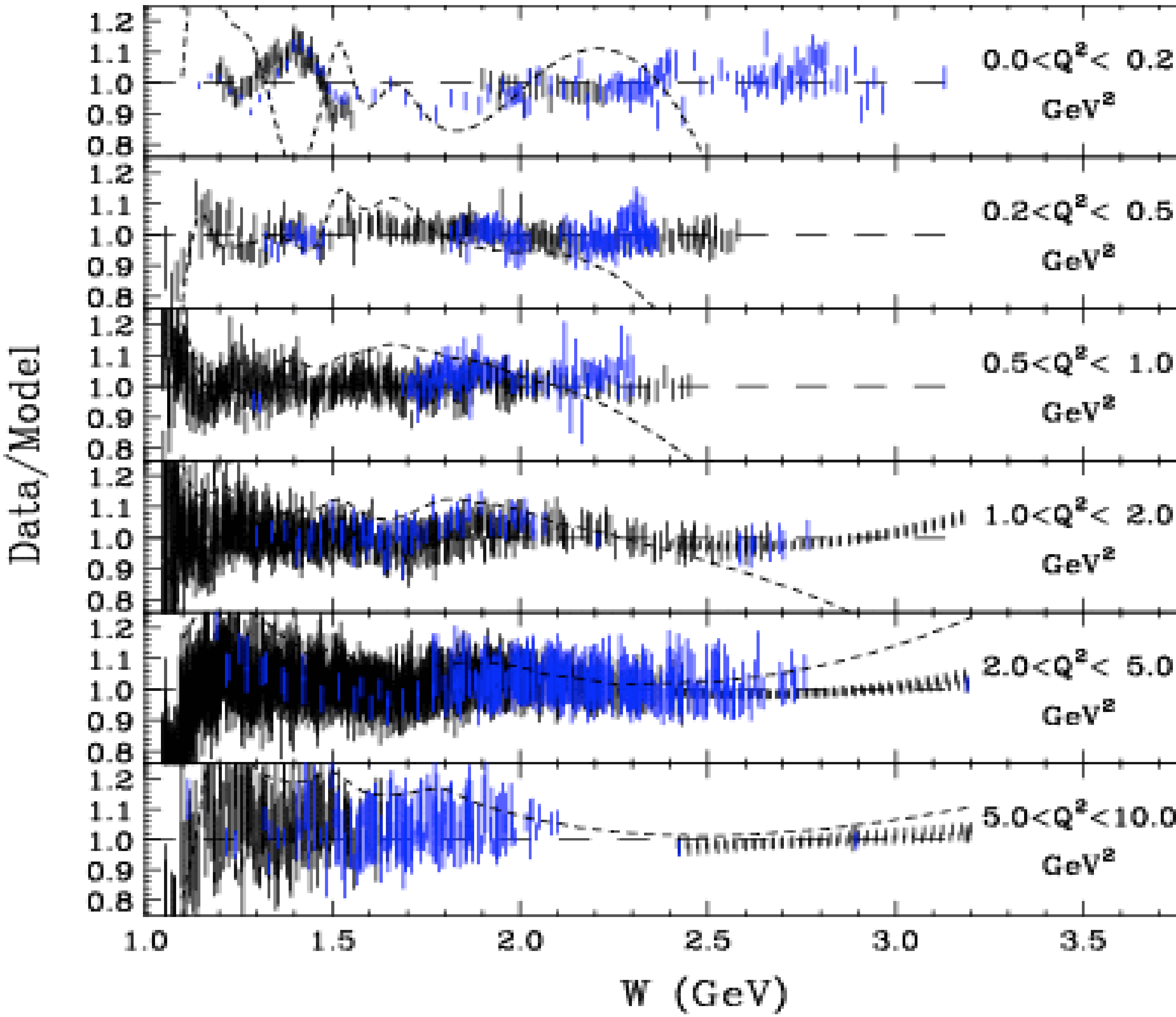
- **Also speeded up code by pre-calculating resonance parameters (for example branching ratios for single pion, double pion, or eta) as a function of W and storing for later use.**

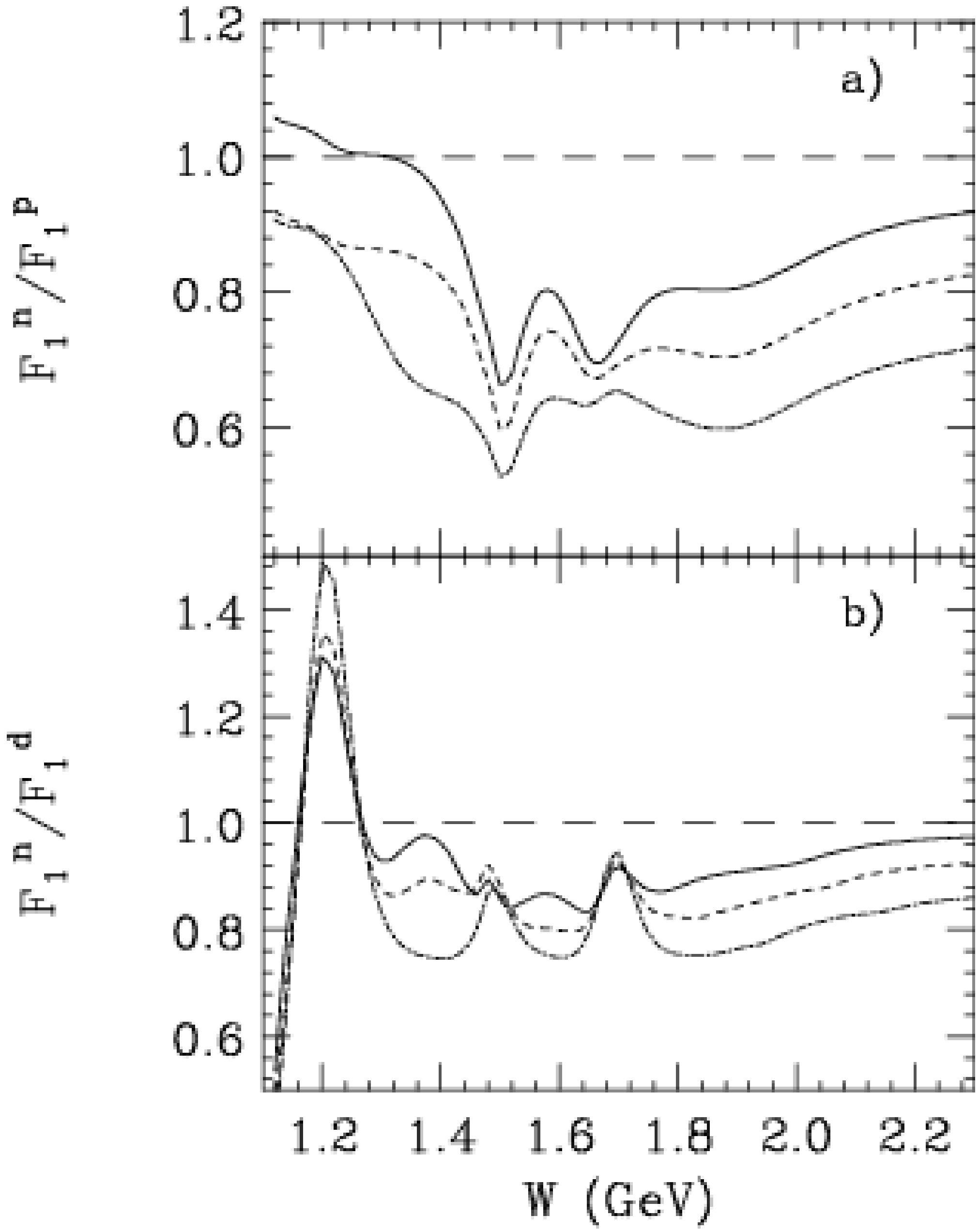
- **Used 1/10 of data to get starting parameters, then full data to refine results.**

Deuteron F_1 fit results



Ratios deuteron data to fit (blue is low ε)



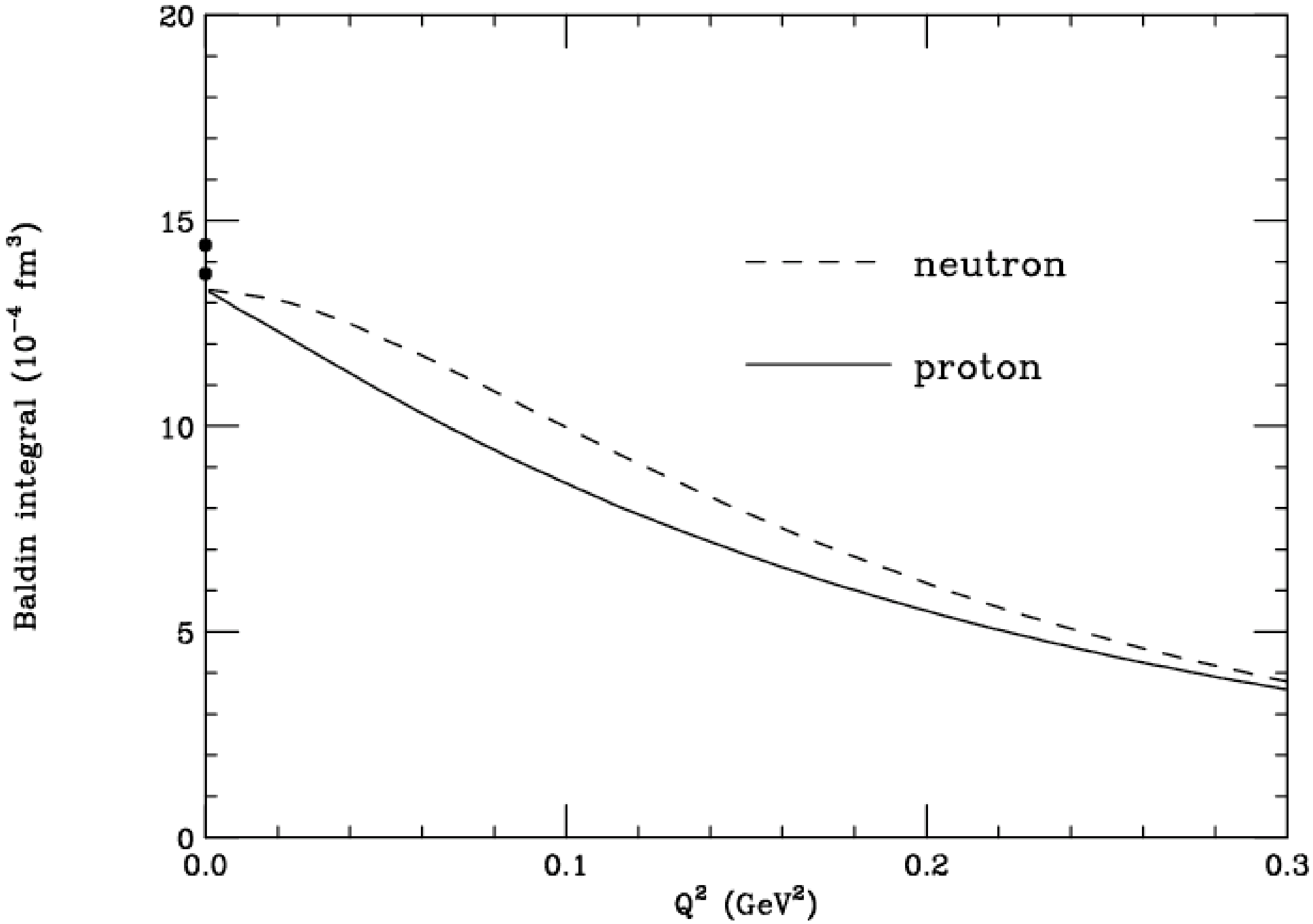


n/p ratios at Q^2=0.5, 1, 2 GeV^2

n/d ratios at Q^2=0.5, 1, 2 GeV^2 (see BONUS exp. talk C. Keppel)

Application to extended Baldin sum rule

Relates nucleon polarizability to integral of $2xF_1$ from zero to pion threshold. Q^2 dependence should be calculable (analog of GDH sum rule).



Outlook

- **Fit both F_1 and F_2 (or F1 and R) for d, n**
- **Include "free neutron" data from BONUS experiment in fitting.**
- **Extend to higher Q^2 with 12 GeV JLab.**
- **Extend to A>2 (in progress)**

Fit A>2 includes new data from CLAS for $^{15}N/C$ and $^{4}He/C$

(CLAS Collaboration, P.E. Bosted, R, Fersch et al., arXiv: 0712.2438 (2007)