Christy

Jefferson Lab Experiment 94-110

Measurement of $R = \sigma_L/\sigma_T$ In The Nucleon Resonance Region

spokes institution → *Hampton University, Hampton, VA*

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University of Colorado, Boulder, Colorado

Florida International University, University Park, FL

Florida State University, Tallahassee, FL

George Washington University, Washington, DC

University of Illinois, Champaign-Urbana, IL

University of Maryland, College Park, MD

Massachusetts Institute of Technology, Cambridge, MA

University of Michigan, Ann Arbor, MI

Mississippi State University, Mississippi State, MS

New Mexico State University, Las Cruces, NM

North Carolina A & T University, Greensboro, NC

Ohio University, Athens, OH

Oregon State University, Corvallis, OR

Rutgers University, New Brunswick, NJ

Rensselaer Polytechnic Institute, Troy, NY

Thomas Jefferson National Accelerator Facility, Newport News, Virginia, VA

University of Virginia, Charlottesville, VA

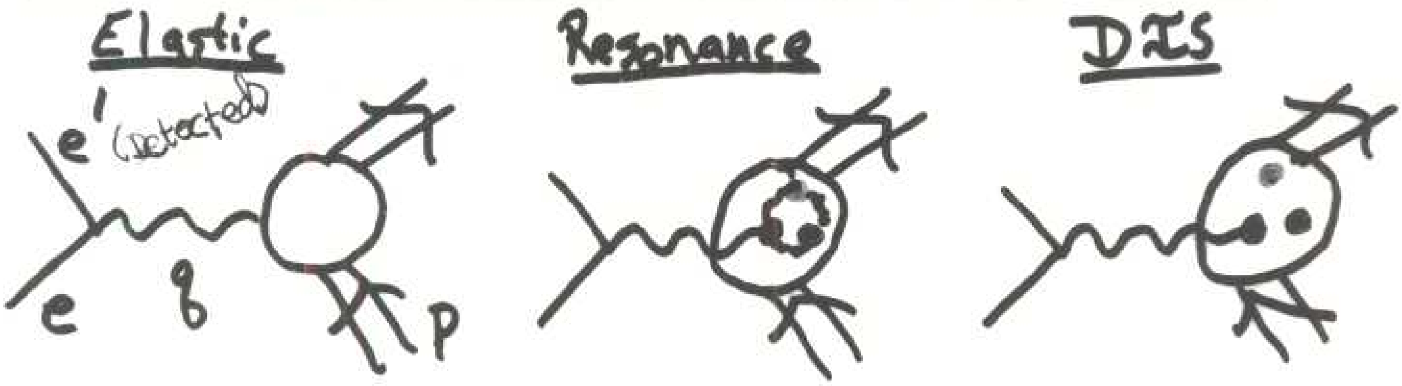
Vrije Universiteit, Amsterdam, Netherlands

College of William and Mary, Williamsburg, VA

Yerevan Physics Institute, Armenia

$p(e,e')X$

R is a Fundamental Structure Function



$$\frac{d\sigma}{d\Omega dE'} = \Gamma[\sigma_T(x,Q^2) + \epsilon\sigma_L(x,Q^2)] \quad \text{(OPEA)}$$ (spin Averaged)

$$= \Gamma \frac{4\pi^2\alpha}{2xM(Q^2+\nu^2)^{1/2}}\left[2xF_1(x,Q^2) + \epsilon F_L(x,Q^2)\right]$$

Γ: virtual photon flux

ϵ: virtual photon longitudinal polarization

$$R(x,Q^2) \equiv \sigma_L(x,Q^2)/\sigma_T(x,Q^2)$$

$$= \frac{F_L(x,Q^2)}{2xF_1(x,Q^2)}$$

$$= \frac{F_2(x,Q^2)}{2xF_1(x,Q^2)}\left(1 + \frac{4M_p^2x^2}{Q^2}\right) - 1$$

$R = \sigma_L/\sigma_T$

Elastic	Resonance	Deep Inelastic
($Q^2 < 8.83$ GeV^2/c^2)		($Q^2 < 50$ GeV^2/c^2)
$R = \frac{2M}{Q}\frac{G_E(Q^2)}{G_M(Q^2)}$	$R = ?$ $\downarrow$	$R = \frac{M^2x^2}{Q^2}$ (NPM)
Charge-Current Structure of Nucleon		$R \to 0$ as $Q^2 \to \infty$ (Spin-1/2 partons)

→ Lacking data on R in the Resonance Region ←

> We propose to perform a model-independent global survey of the longitudinal strength across the entire resonance region.

Phase I : $1 < Q^2 < 4$ $(\text{GeV}/c)^2$

Phase II : $4 < Q^2 < 7.5$ $(\text{GeV}/c)^2$

Benefits of a precise measurement of R

- Gain knowledge about fundamental nucleon structure
  - ▹ R might be small (Duality)
  - ▹ R might be large (scattering from interacting quarks)
  - ▹ Map out Q^2 dependence of R for each resonance region
- Duality Studies
- Access to Higher Twists?

Also need precision measurement of R for ...

- Extraction of other structure functions
  - ▹ F_2: $\frac{\sigma(x,Q^2,\epsilon)}{\sigma_{Mott}} \nu = F_2(x,Q^2)\left[1 + \frac{1-\epsilon}{\epsilon}\frac{1}{1+R(x,Q^2)}\right]$
  - ▹ g_1: $A_1 = \frac{\sigma^T_{1/2} - \sigma^T_{3/2}}{\sigma^T_{1/2} + \sigma^T_{3/2}} = \frac{g_1 - (Q^2/\nu^2) g_2}{F_1}$
- Input for radiative corrections

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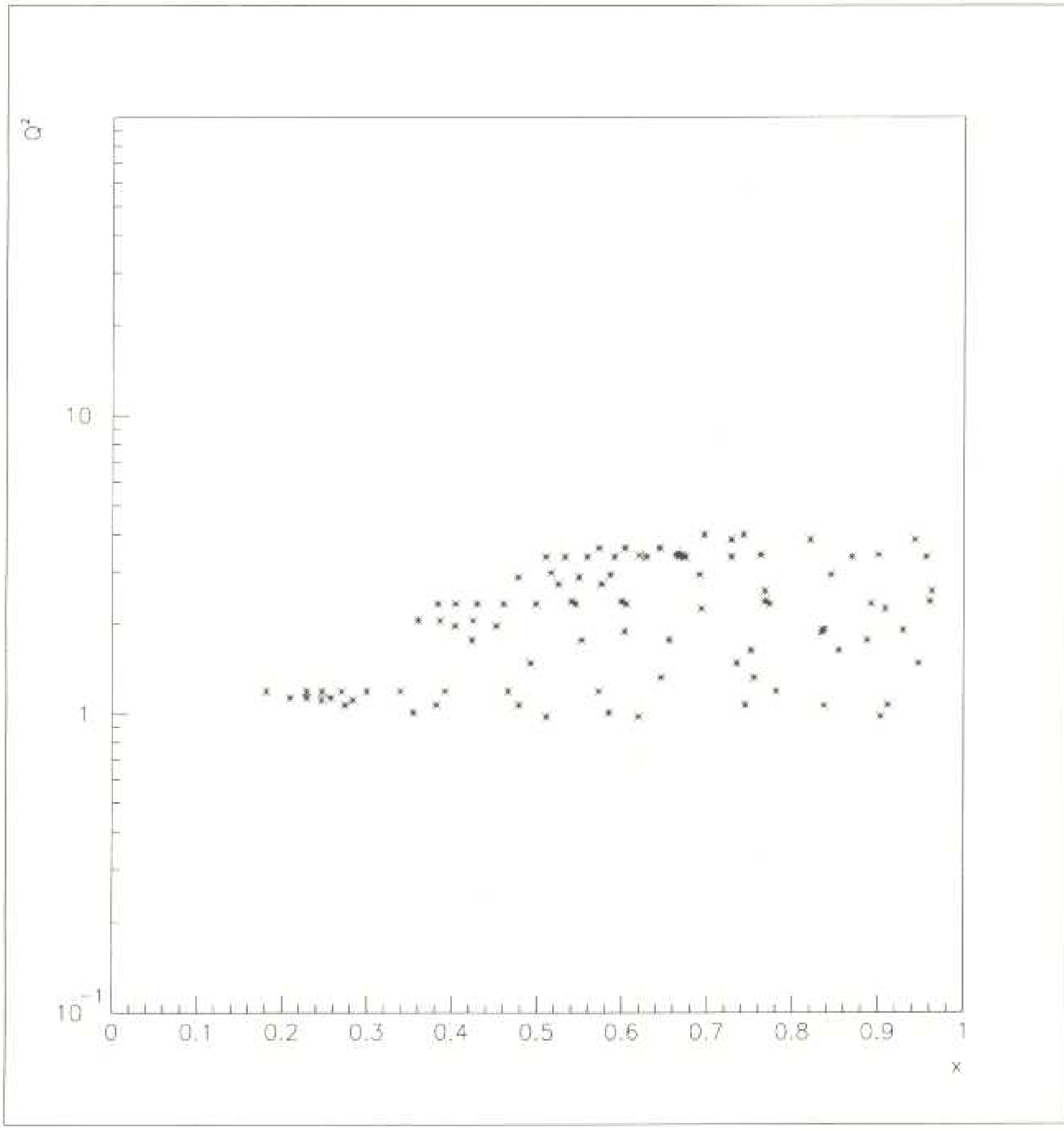
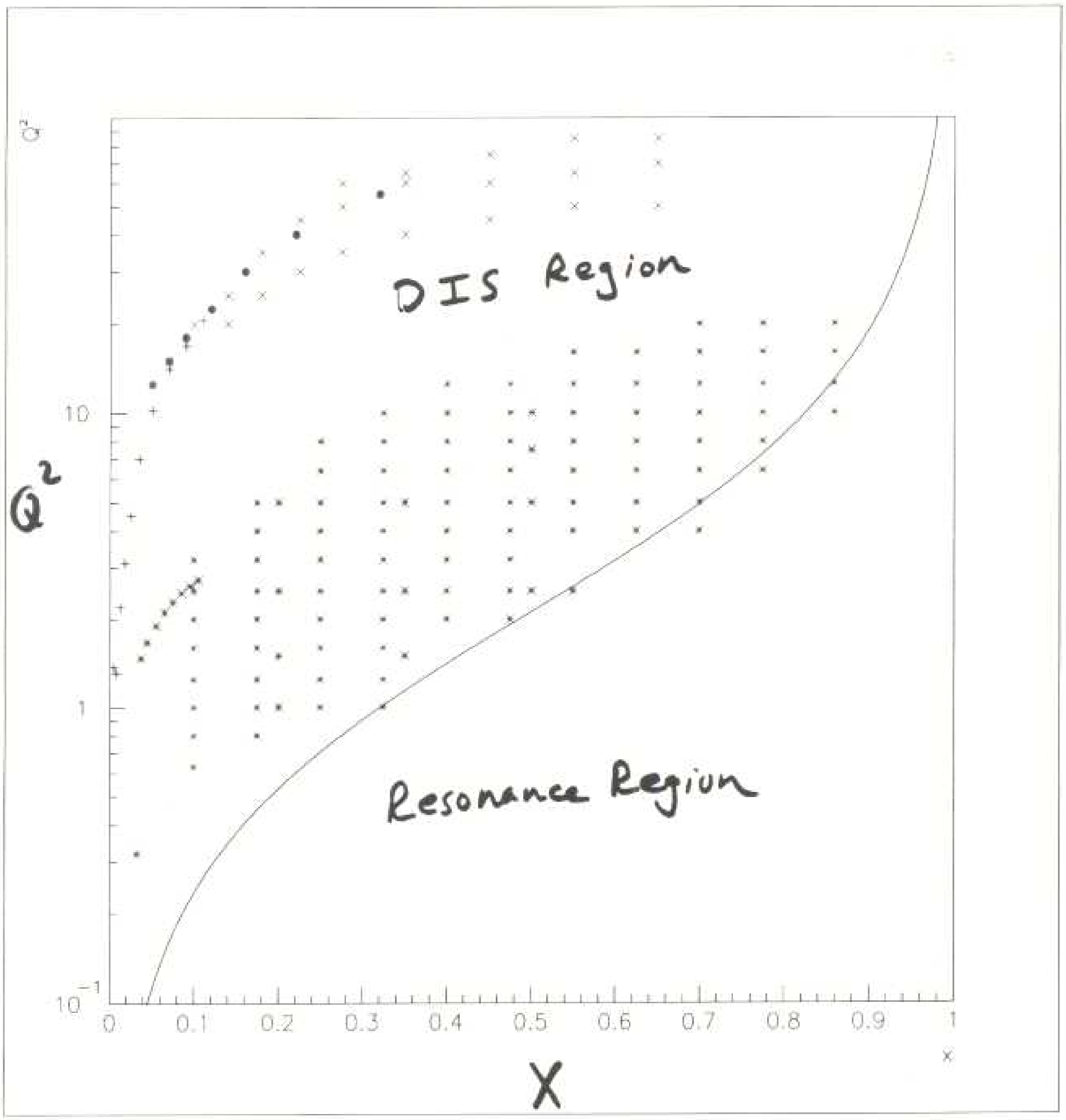
>50 kinematic points for 'Direct' L-T Separations

Will fit to cover entire kinematic range



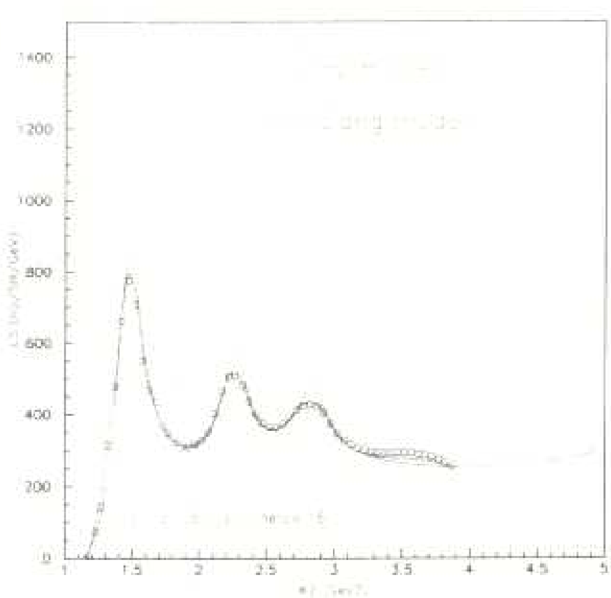
Kinematics of World's Data Set

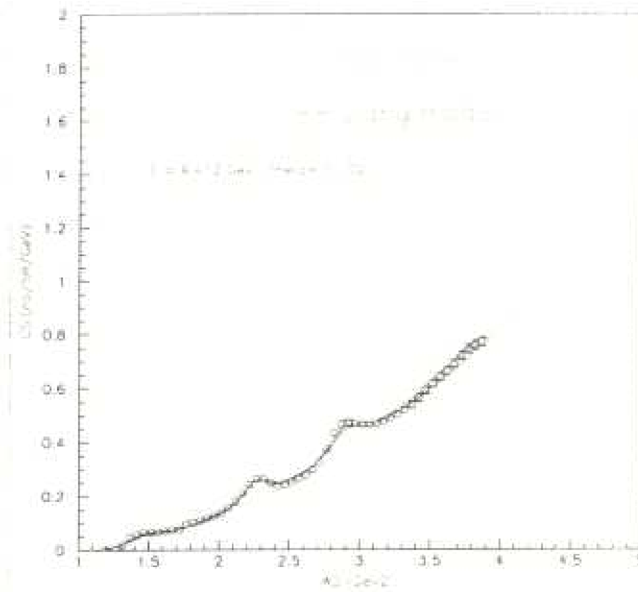


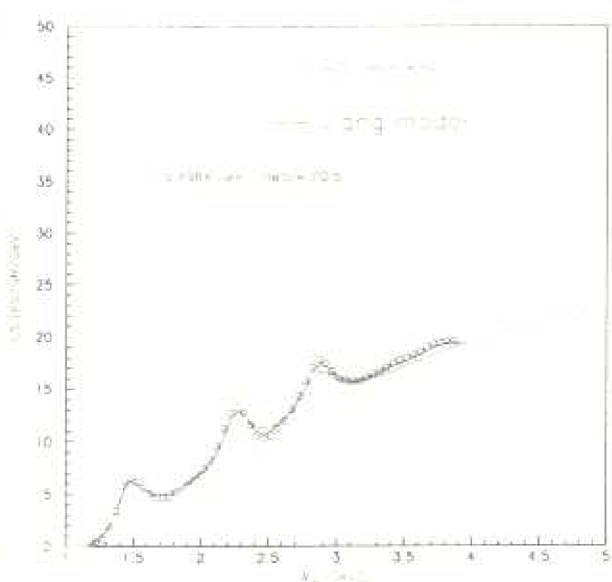
E94-110 Cross Sections

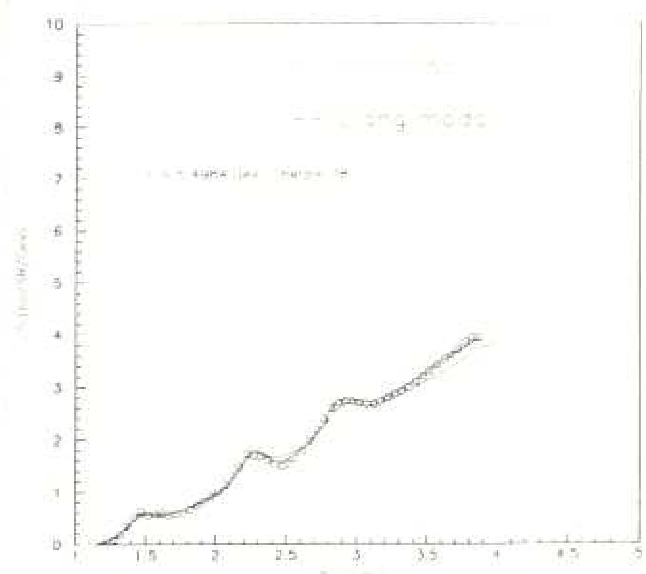
- Statistical uncertainties are included (typically < 1 %)
- Current fit (Liang Model) reproduces data cross section well

Fix energy of beam and θ_{spect} — Q^2 varies within a setting









Model Iteration Procedure

*

Model is used for radiative corrections and bin-centering the data in θ.

Extract σ^{exp} from data.

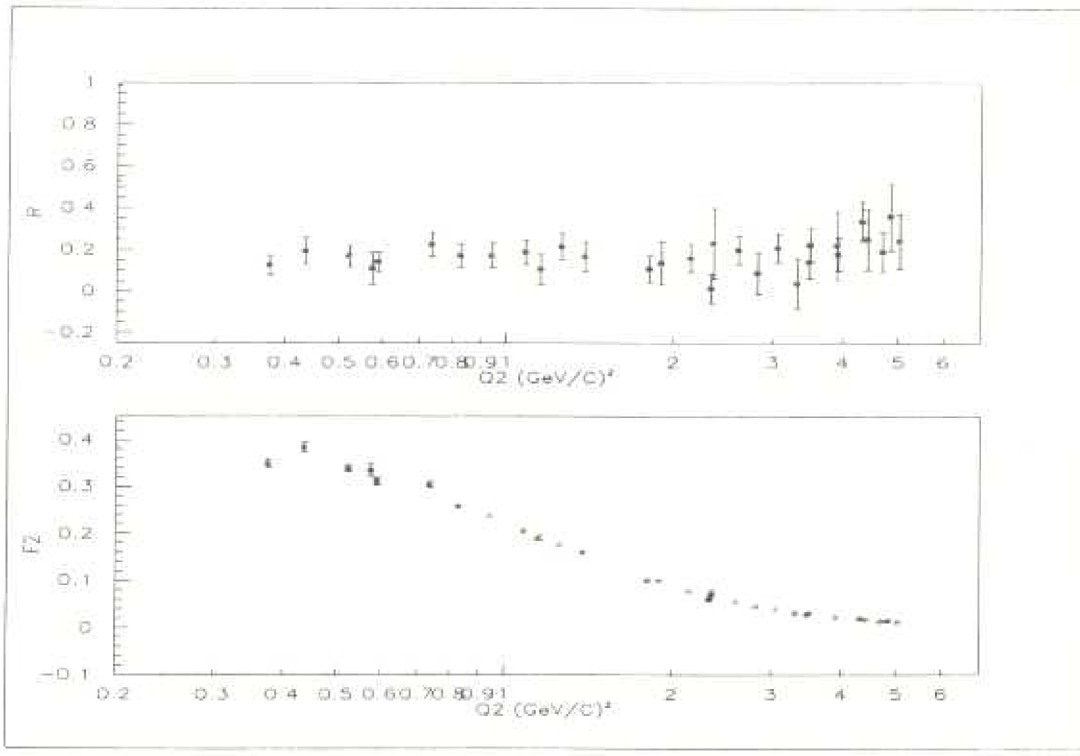
Use model to decompose σ^{exp} into F_2 and R.

For each W^2 bin, fit F_2^{exp} and R^{exp} vs Q^2 to get new model.

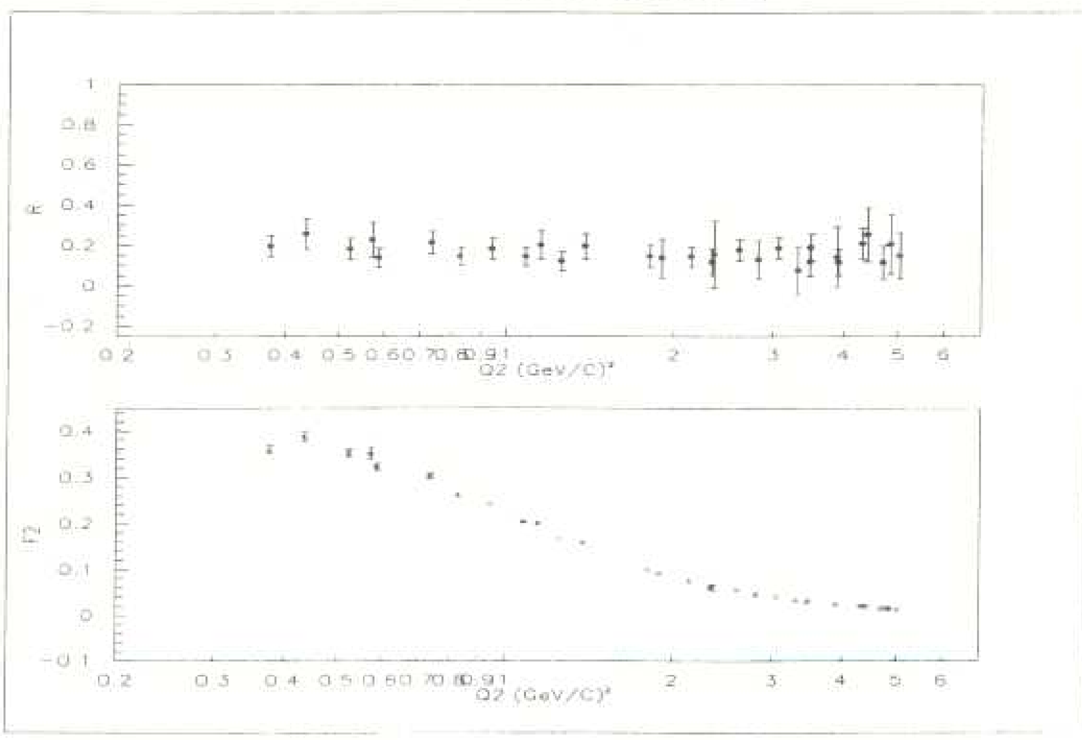
* σ^{exp} is first corrected for eff + HMS Accept + C.S. background.

Structure Function Extraction via Model Iteration

Δ Peak, Iteration 0:

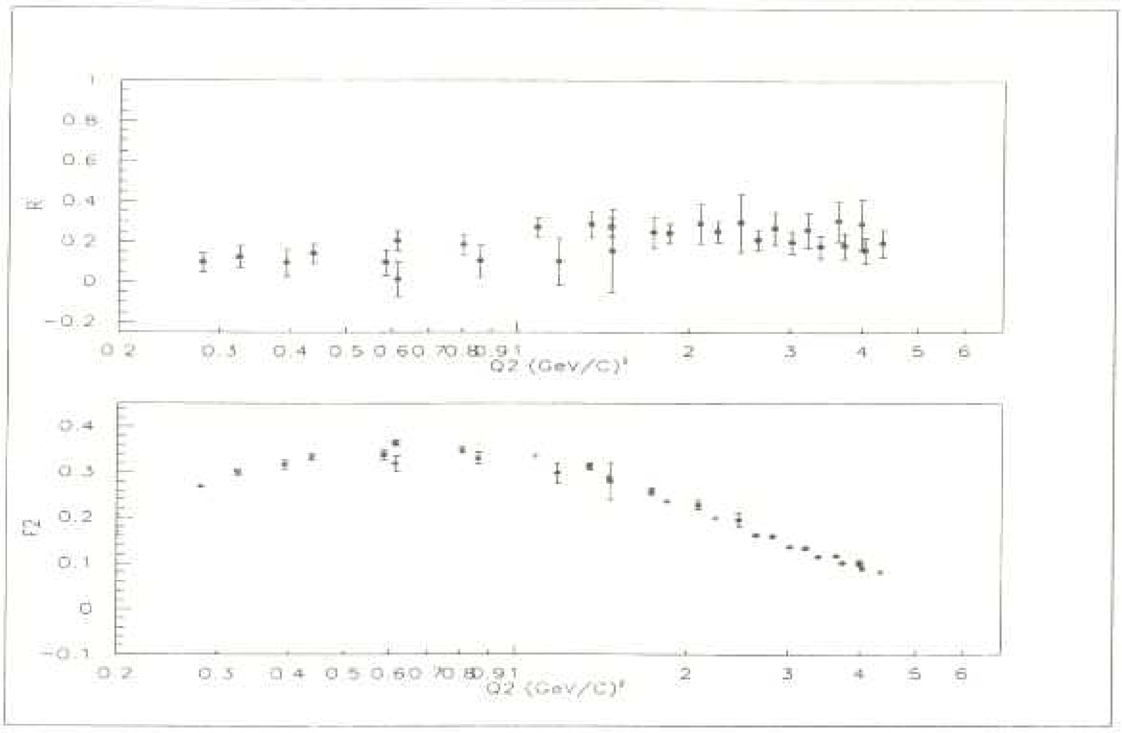


Δ Peak, Iteration 2:



Structure Function Extraction via Model Iteration

$\mathbf{F_{15}}$ Peak, Iteration 0:



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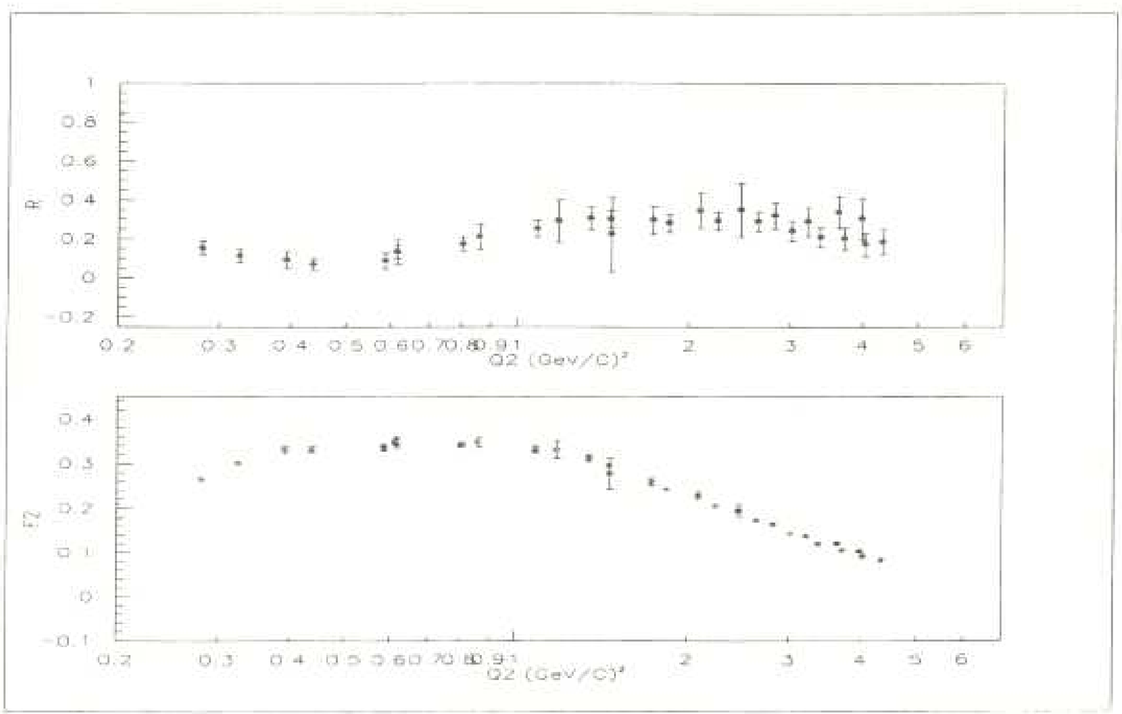
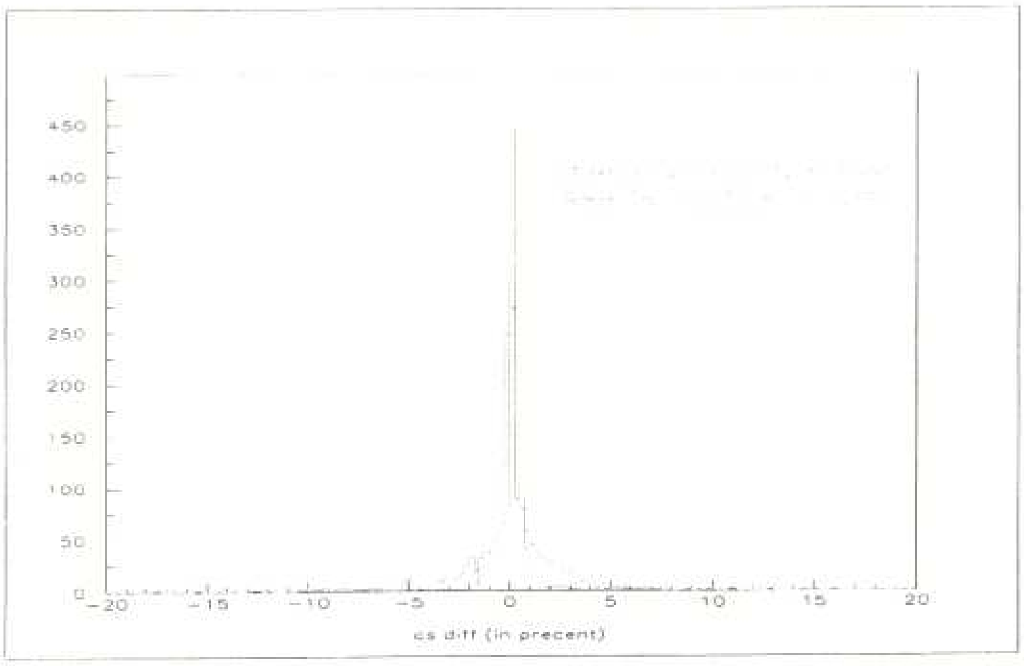
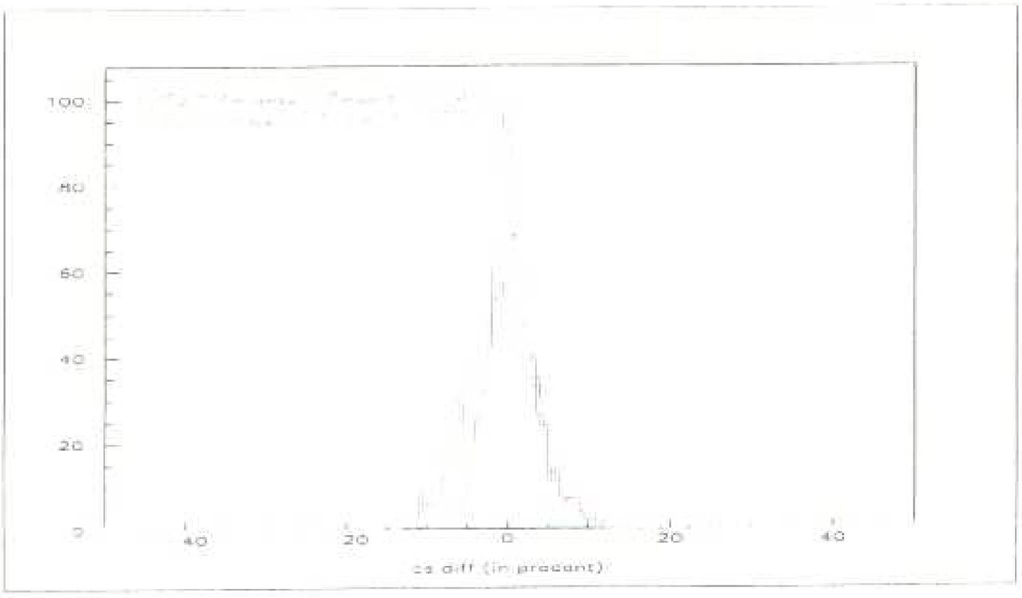


Checking the Iteration Procedure

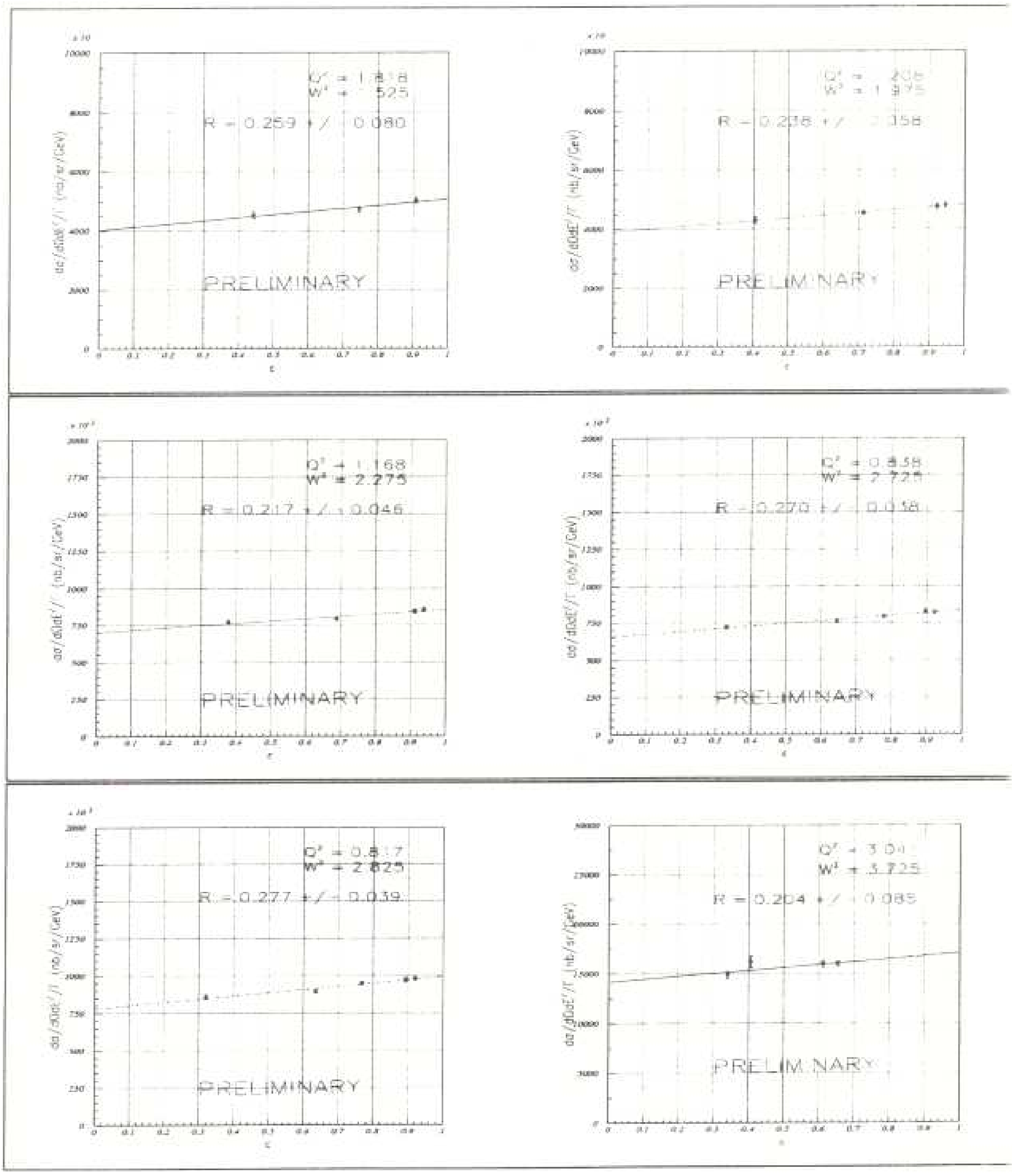
- Test convergence by calculating residuals or the extracted cross section from the previous iteration.



- Test validity of model by calculating %diff of model from data.

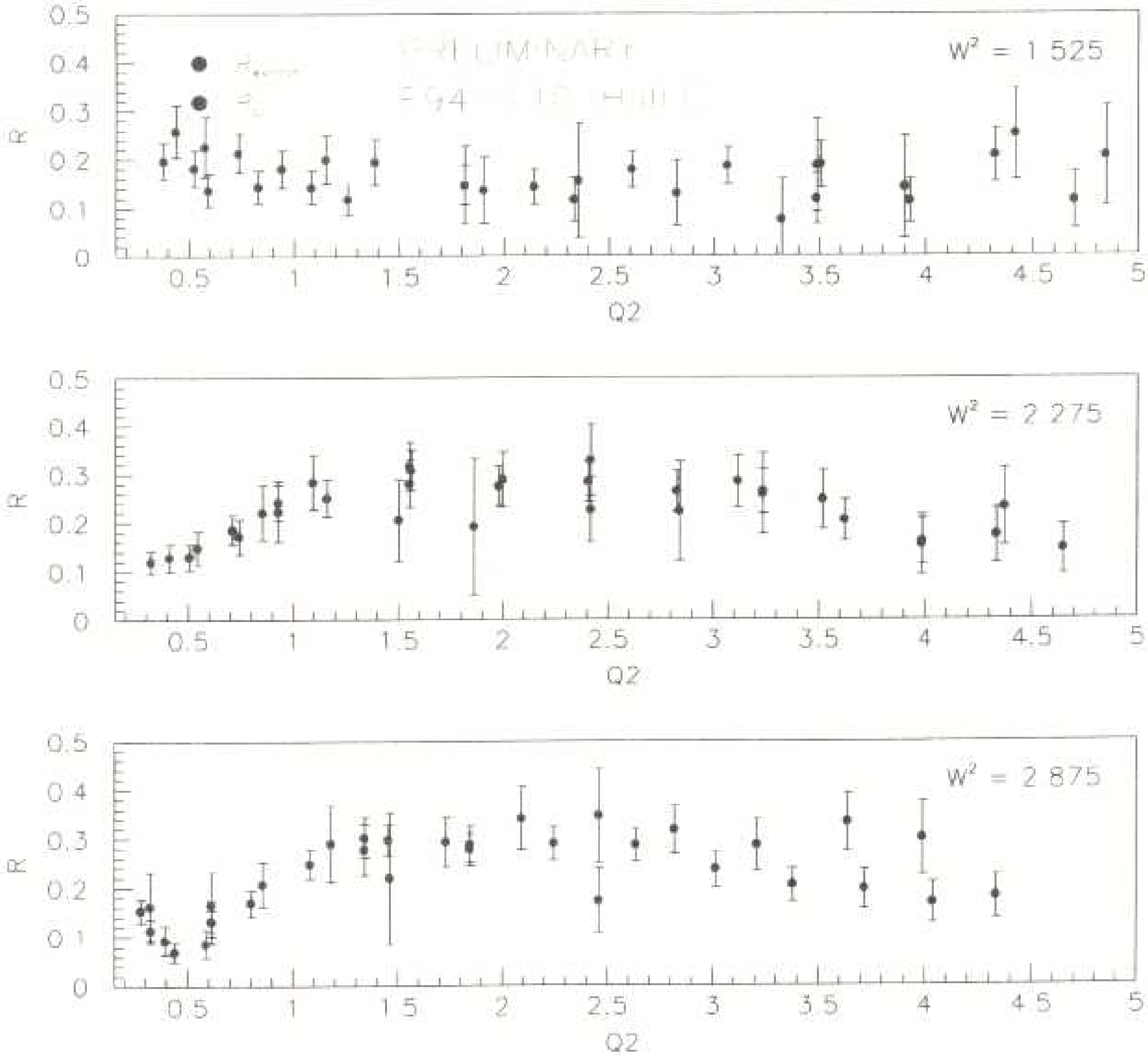


• Subset of L-Ts (~60 total)



Resonance R vs. Q^2 for fixed W^2 bins

- R is extracted via model iteration method - good agreement with limited L-Ts.
- Uncertainties include statistical, systematic, and estimated uncertainties on the model fit from the previous iteration.



* S_{11} + F_{15} look to have similar Q^2 dependence – Different from Δ!

Resonance R vs. Q^2 for fixed x bins

- R is extracted via L-T separations
- Error is given by fit with statistical and 1% pt-pt systematics included
- Remarkable agreement with previous SLAC DIS extractions!

(Duality in R ?)