Analysis of E94010
GDH on ^{3}He

presented by

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Summary of the Experiment

$$e + {}^3\text{He} \rightarrow e' + X$$

- **Beam** : Polarized electron beam at Jefferson Lab.

Energy	:	6 beam energies from 0.86 GeV to 5.1 GeV
Current	:	5 to 15 μA
Polarization	:	$>$ 70% (GaAs crystal)

- **Target** : Polarized ^{3}He target (Optical pumping)

Polarization	:	average 34%
Density	:	$\sim$ 10 atm
Length	:	40 cm with window thickness of 0.1 mm

- **Scattering angle** : 15.5°
- **Detectors** : JLab Hall-A Spectrometers

Analysis Schematics

$$\vec{e} + {}^{3}\vec{\mathrm{He}} \rightarrow e' + X$$

$\sigma_{\downarrow\Uparrow}$ $\sigma_{\uparrow\Uparrow}$ $\sigma_{\downarrow\Rightarrow}$ $\sigma_{\uparrow\Rightarrow}$

$$A_{\parallel} = \frac{1}{P_b P_t f}\frac{\sigma_{\downarrow\Uparrow} - \sigma_{\uparrow\Uparrow}}{\sigma_{\downarrow\Uparrow} + \sigma_{\uparrow\Uparrow}}$$

$$A_{\perp} = \frac{1}{P_b P_t f}\frac{\sigma_{\downarrow\Rightarrow} - \sigma_{\uparrow\Rightarrow}}{\sigma_{\downarrow\Rightarrow} + \sigma_{\uparrow\Rightarrow}}$$

σ_0

σ_{TT}

$$\Downarrow$$

$$I^{\mathrm{GDH}} = \int_{\nu_{\mathrm{th}}}^{\infty} \frac{2\sigma_{\mathrm{TT}}}{\nu} d\nu$$

Extraction of σ_{TT}

$$\sigma_{\mathrm{TT}} = \frac{2\pi^2 Q^2}{\alpha K} \frac{1}{(1-y)(2-y)} \sigma_0 \left[A_{\parallel} - (1-y)(A_{\parallel} \cos\theta + A_{\perp} \sin\theta)\right]$$

$$\sigma_{\mathrm{LT}} = \frac{2\pi^2 Q^2}{\alpha K} \frac{\sin(\theta/2)}{\sqrt{1-y}} \sigma_0 \left[A_{\parallel} + \frac{1-(1-y)\cos\theta}{(1-y)\sin\theta} A_{\perp}\right]$$

$$g_1 = \frac{MQ^2}{2\alpha^2} \frac{y}{(1-y)(2-y)} \sigma_0 \left[A_{\parallel} + \tan\frac{\theta}{2} A_{\perp}\right]$$

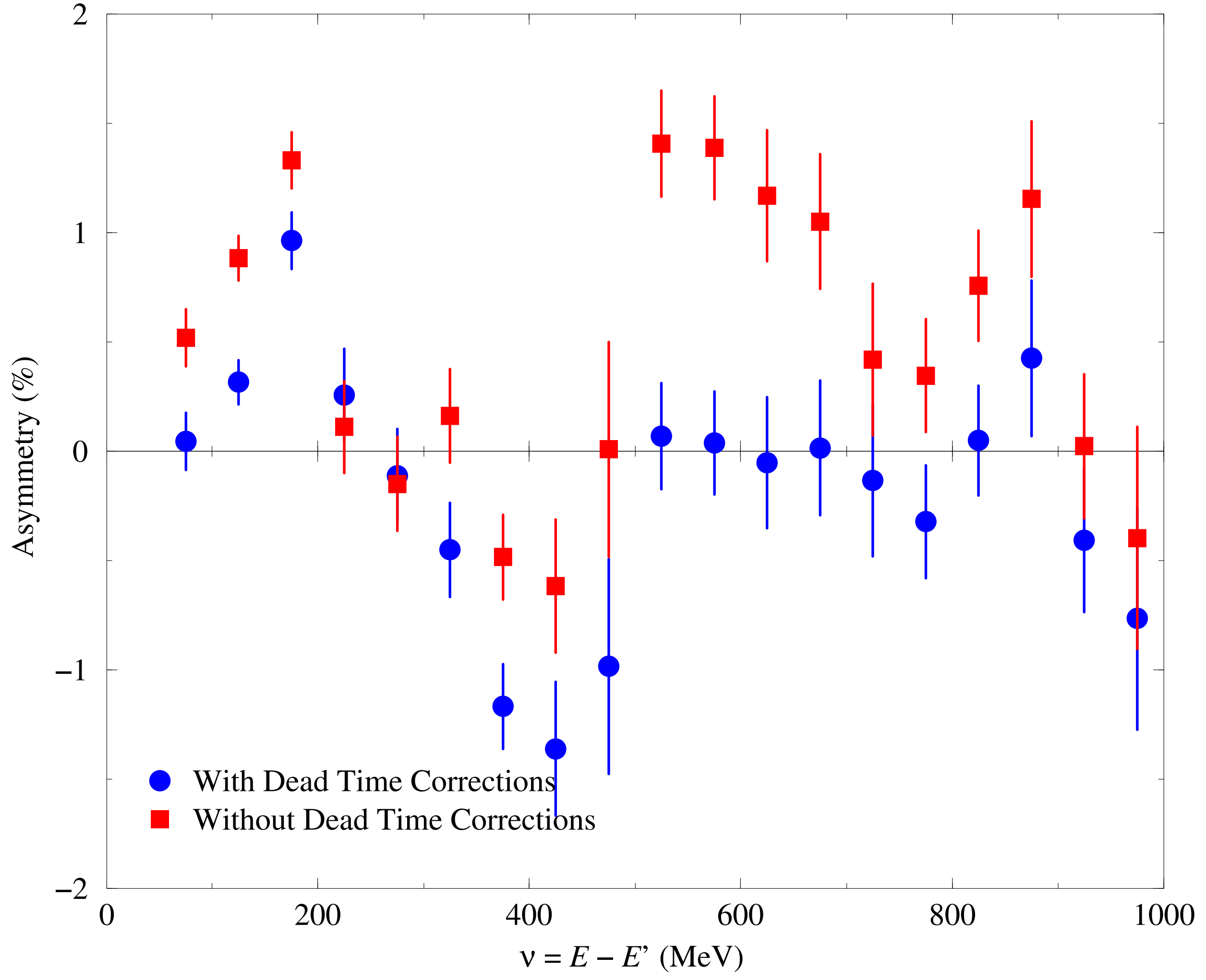
$$g_2 = \frac{MQ^2}{2\alpha^2} \frac{y^2}{2(1-y)(2-y)} \sigma_0 \left[-A_{\parallel} + \frac{1+(1-y)\cos\theta}{(1-y)\sin\theta} A_{\perp}\right]$$

$$K \equiv \frac{W^2 - M^2}{2M} = \nu - \frac{Q^2}{2M}$$

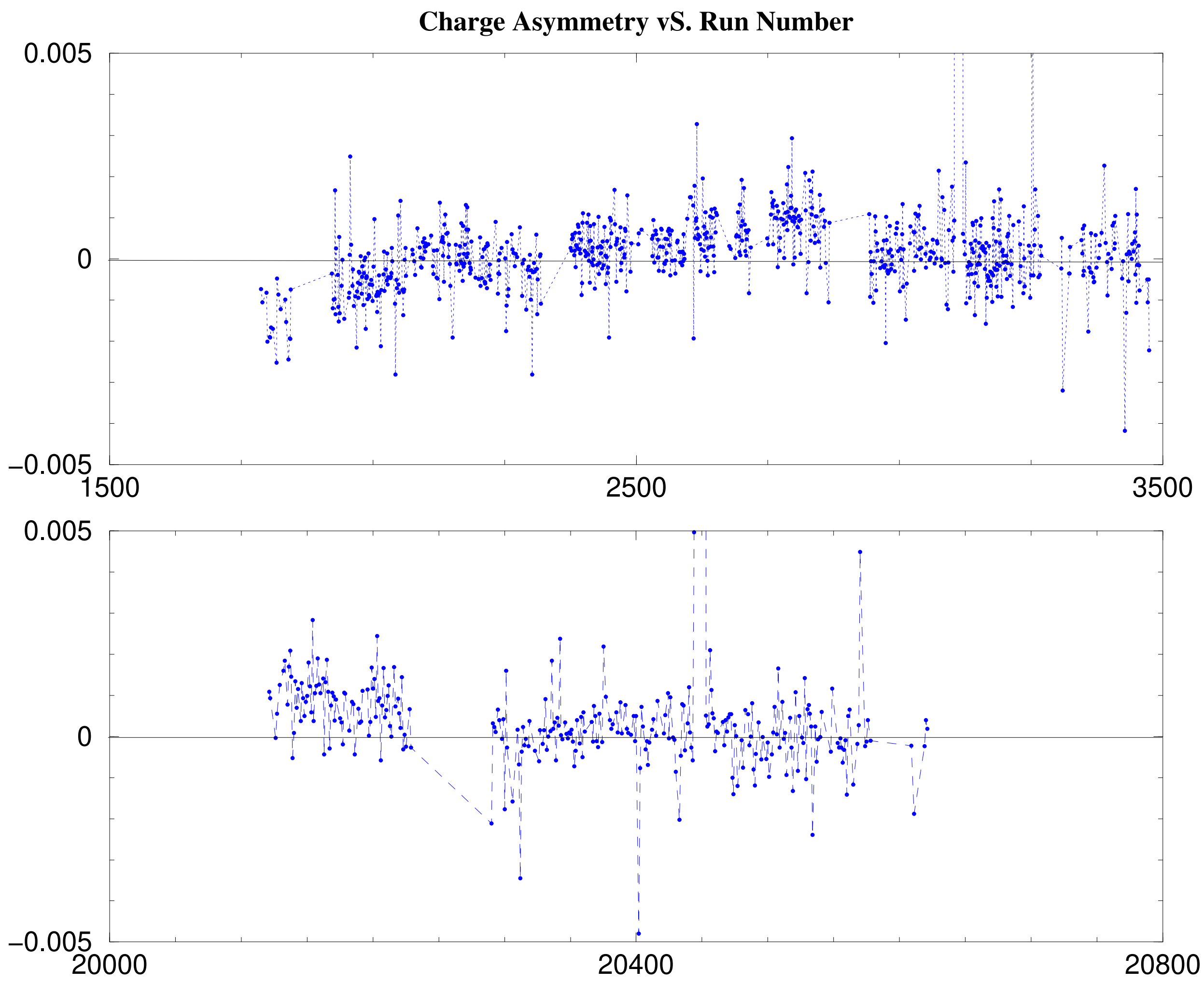
Some Issues in the Analysis

- Helicity dependent dead time corrections
  - Mostly computer dead time while copying files
- Control of charge asymmetry
  - Most of the runs with $Q_{\rm asym} < 2000$ ppm
- "Almost" identical two arms
  - Different particle ID package
  - Slightly different optics
  - Understanding spectrometer acceptance
- Polarized radiative corrections (Modified POLRAD)
  - Realistic quasi-elastic shape
  - Use of experimental data for structure functions
- Different acceptance cuts for asymmetries and cross section
  - Careful treatment of statistical error since they are correlated
- Interpolation/Extrapolation to constant Q^2 for GDH integral

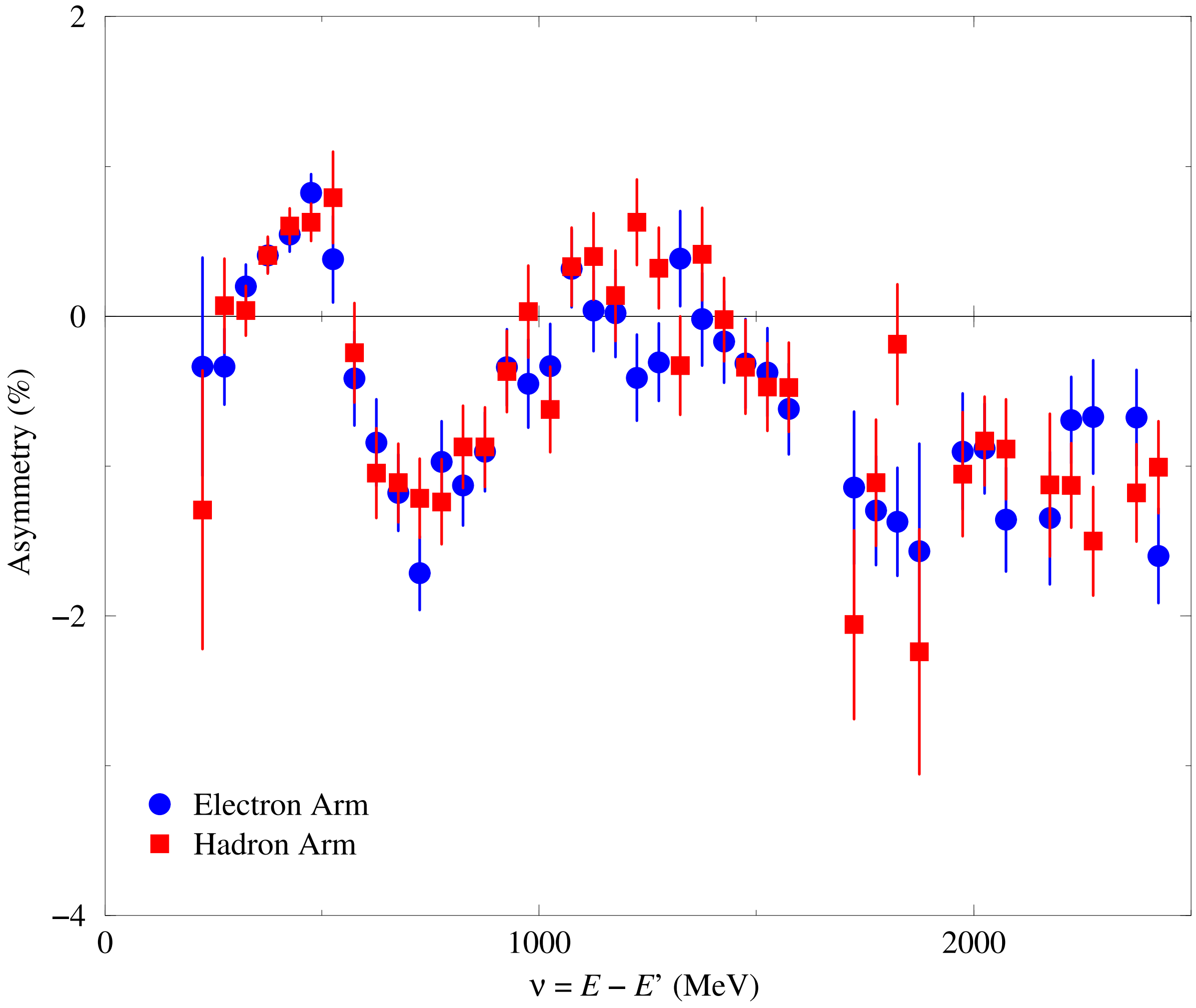
Effect of Dead Time



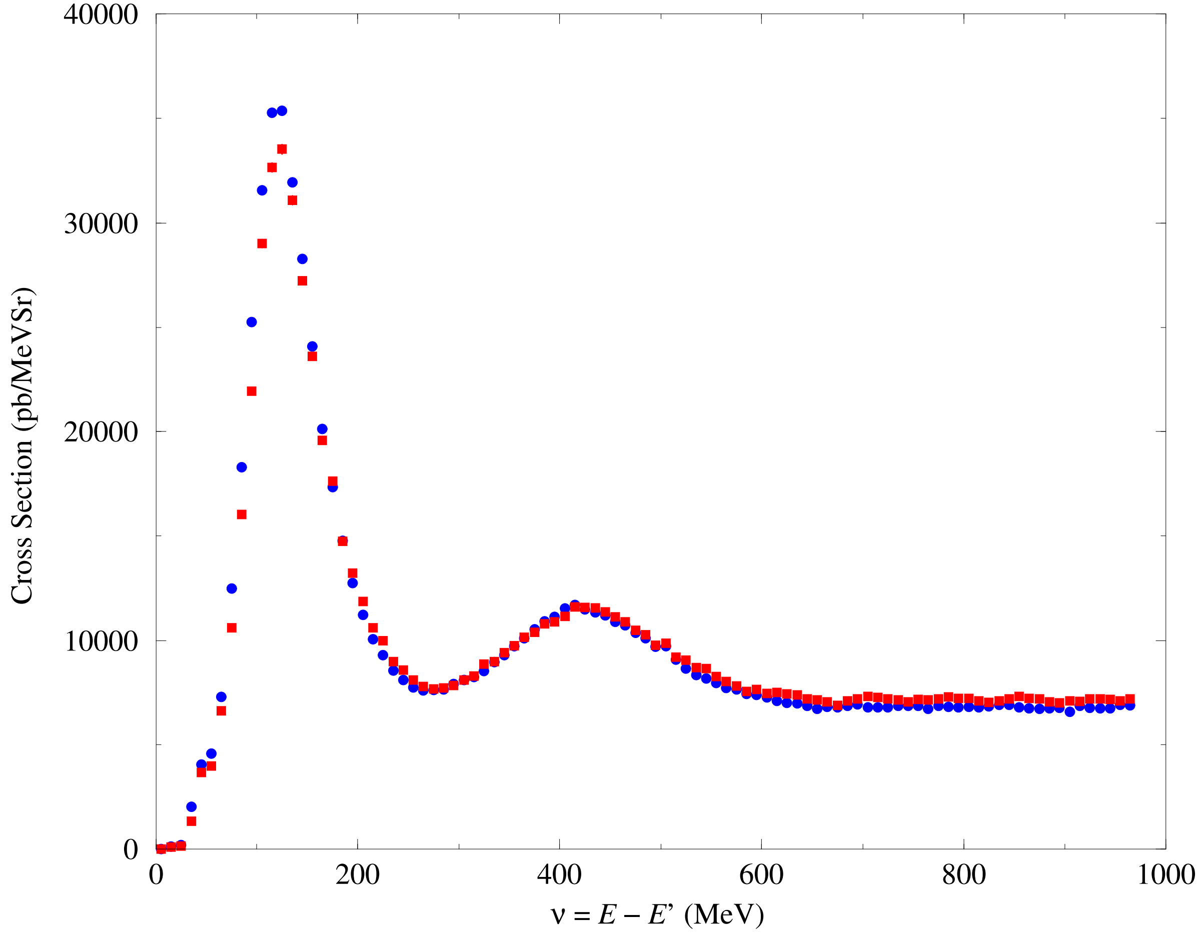
Charge Asymmetries



Comparison of the Two Arms

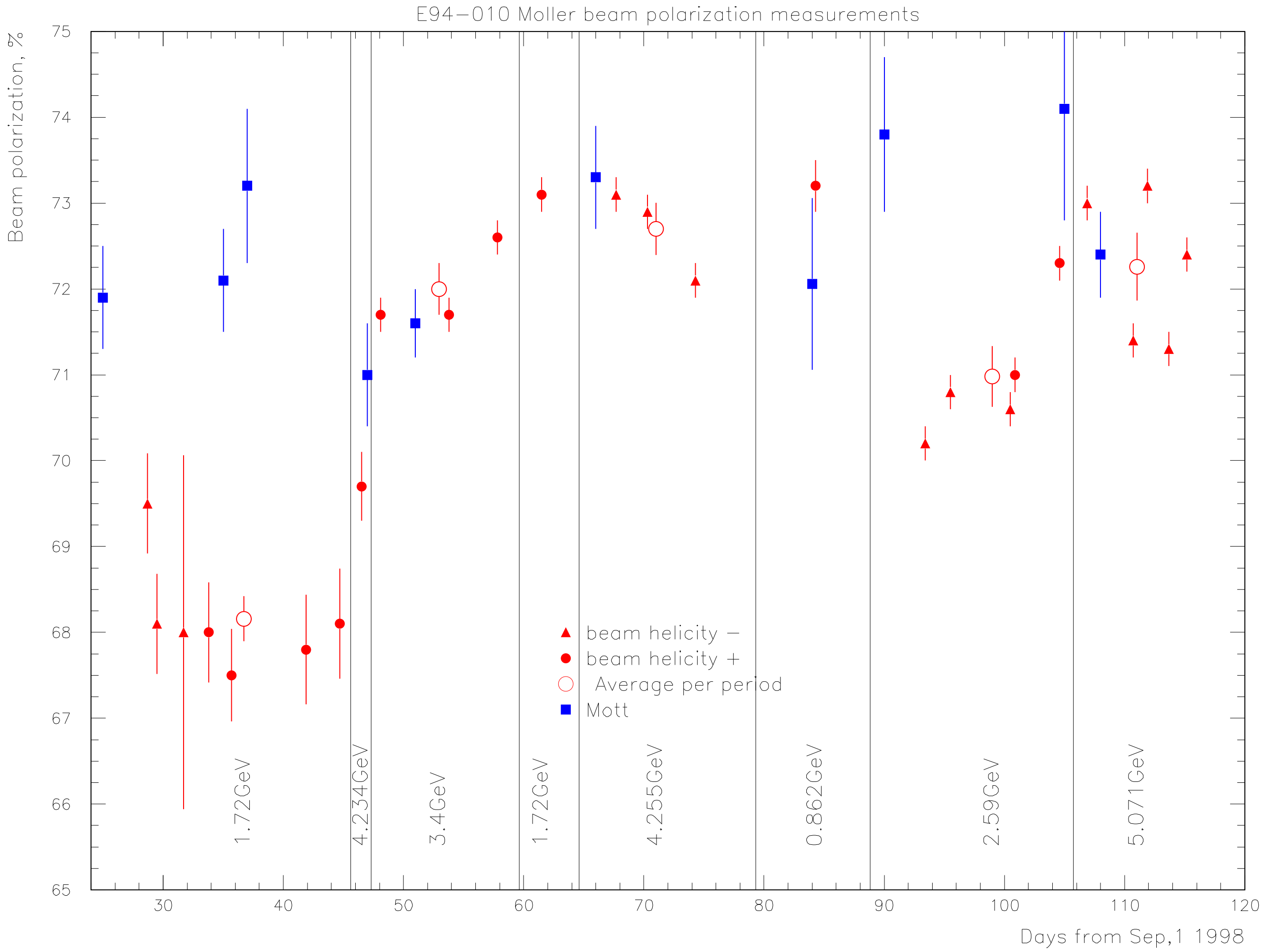


Comparison of the Two Arms

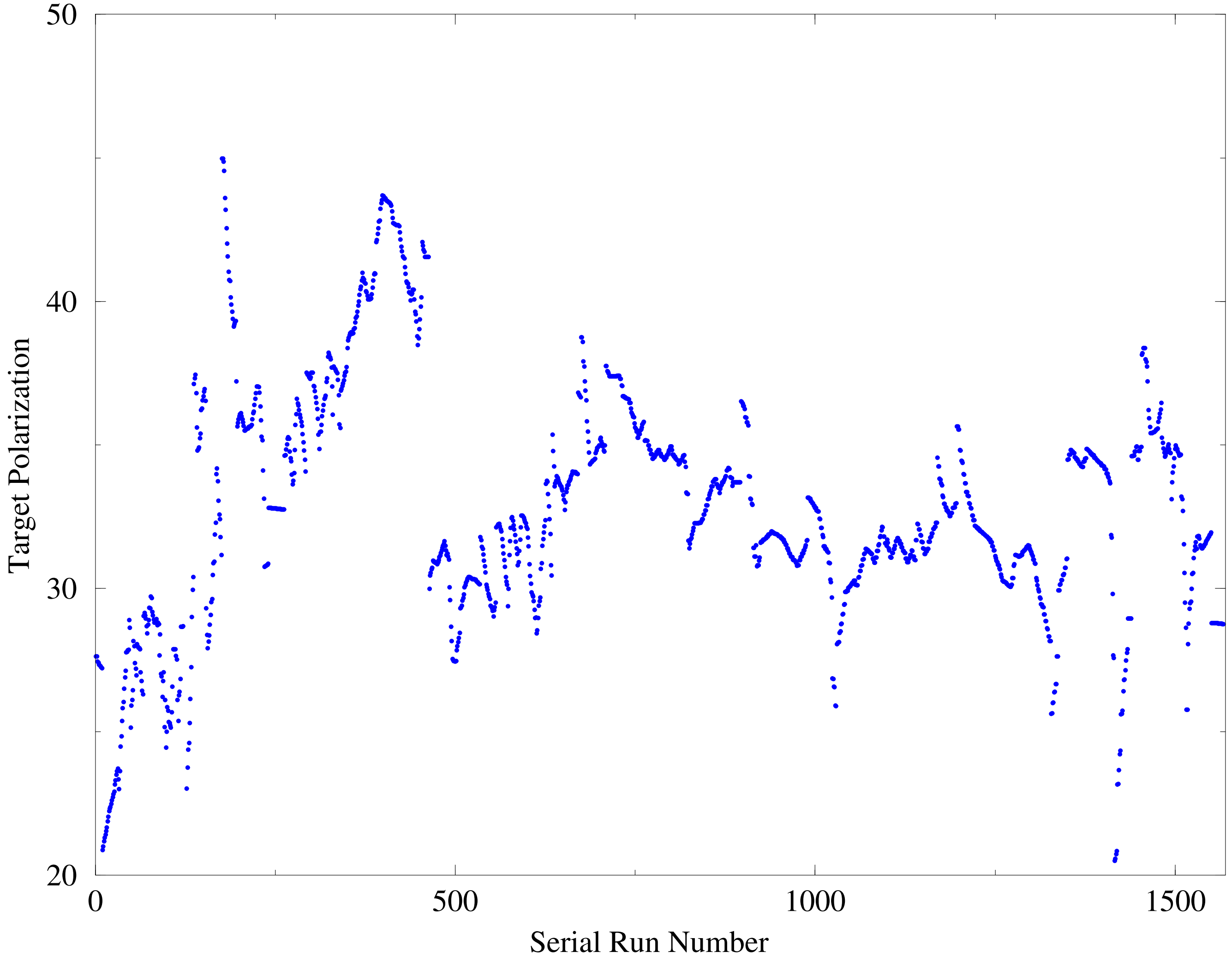


Beam Polarization

99/07/16 22.23

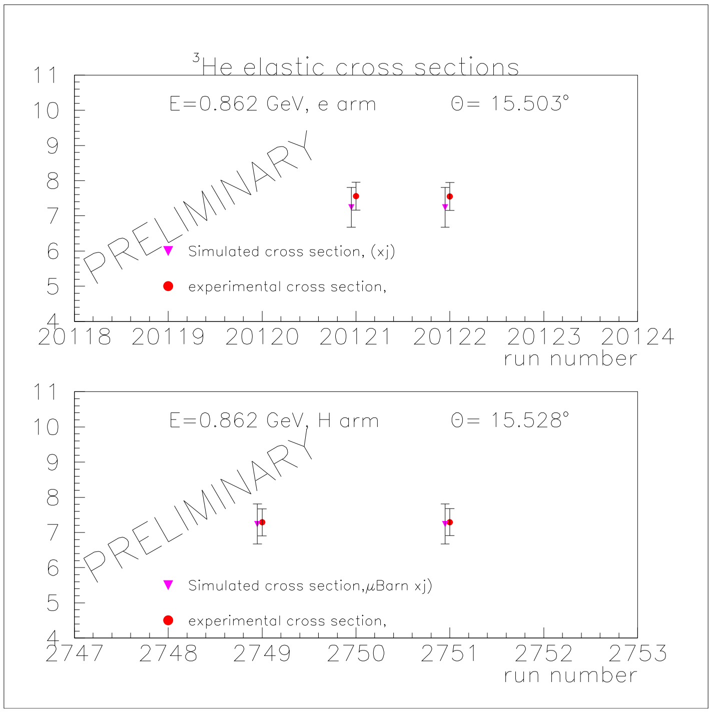


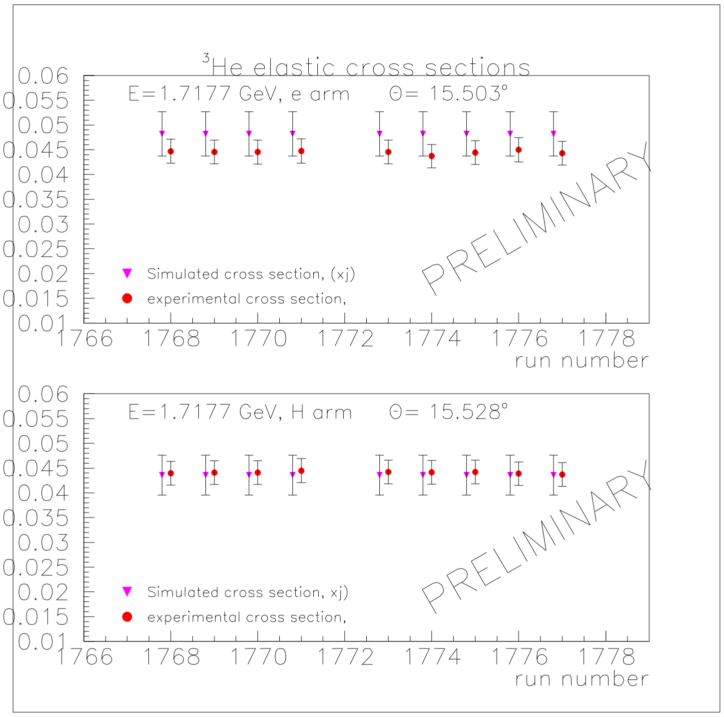
Target Polarization



Elastic Cross Sections

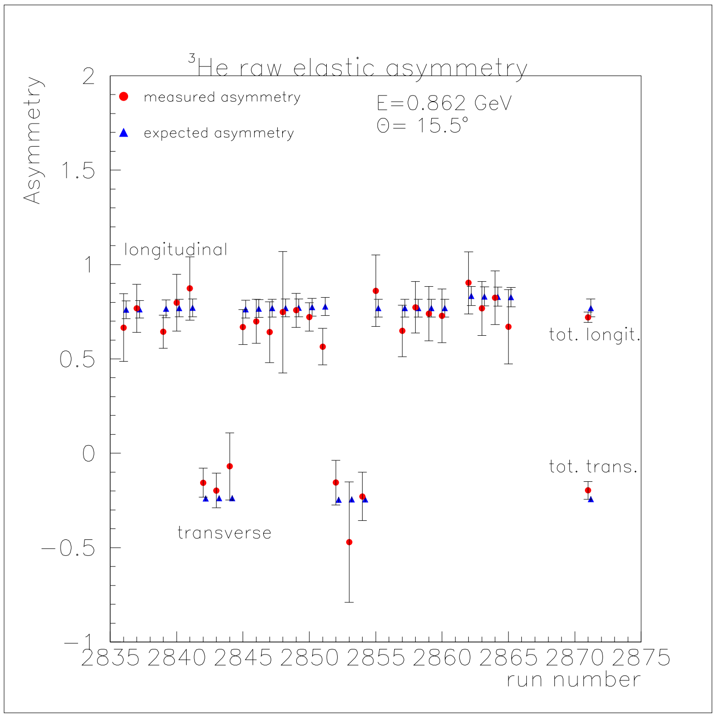
- Overall check of the target density and the acceptance

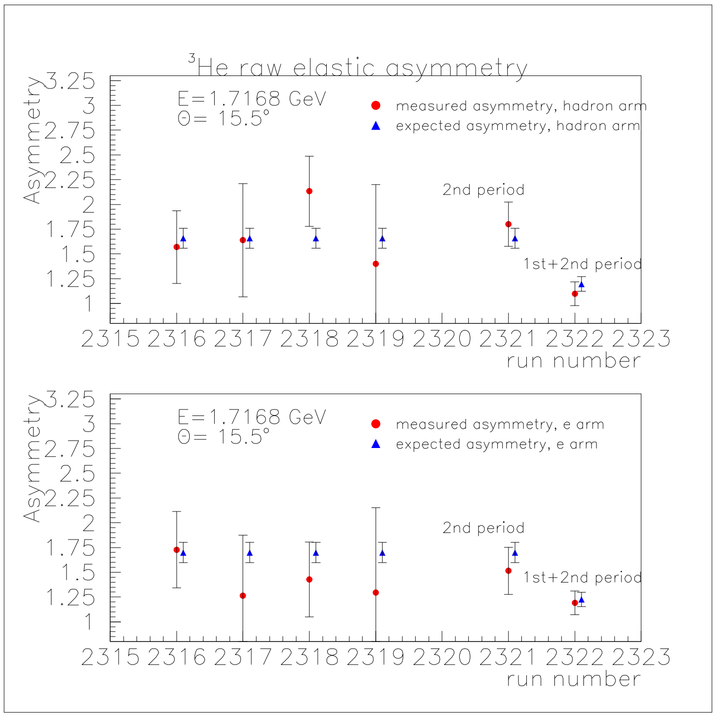




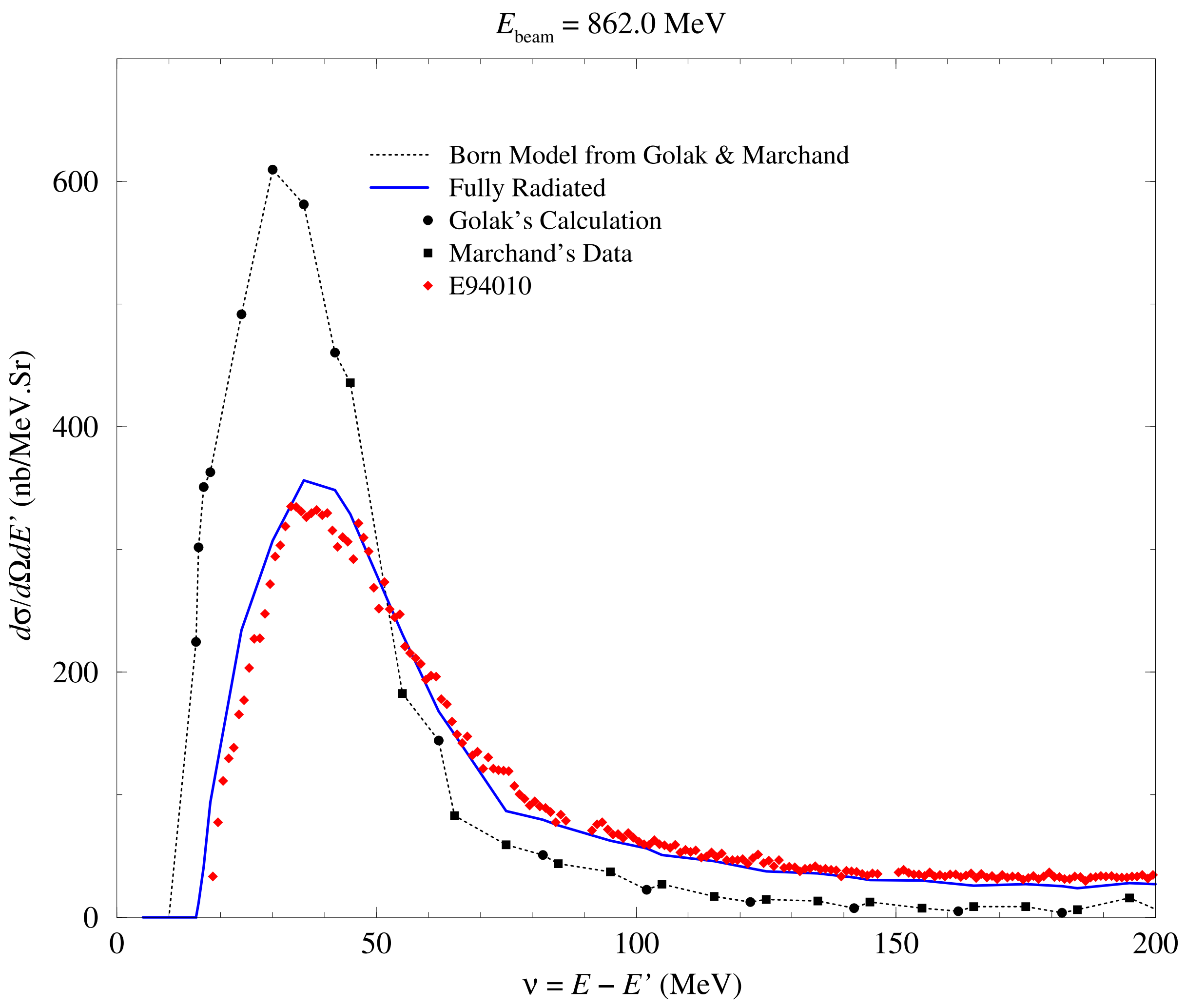
Elastic Asymmetries

- Independent check of the target polarization

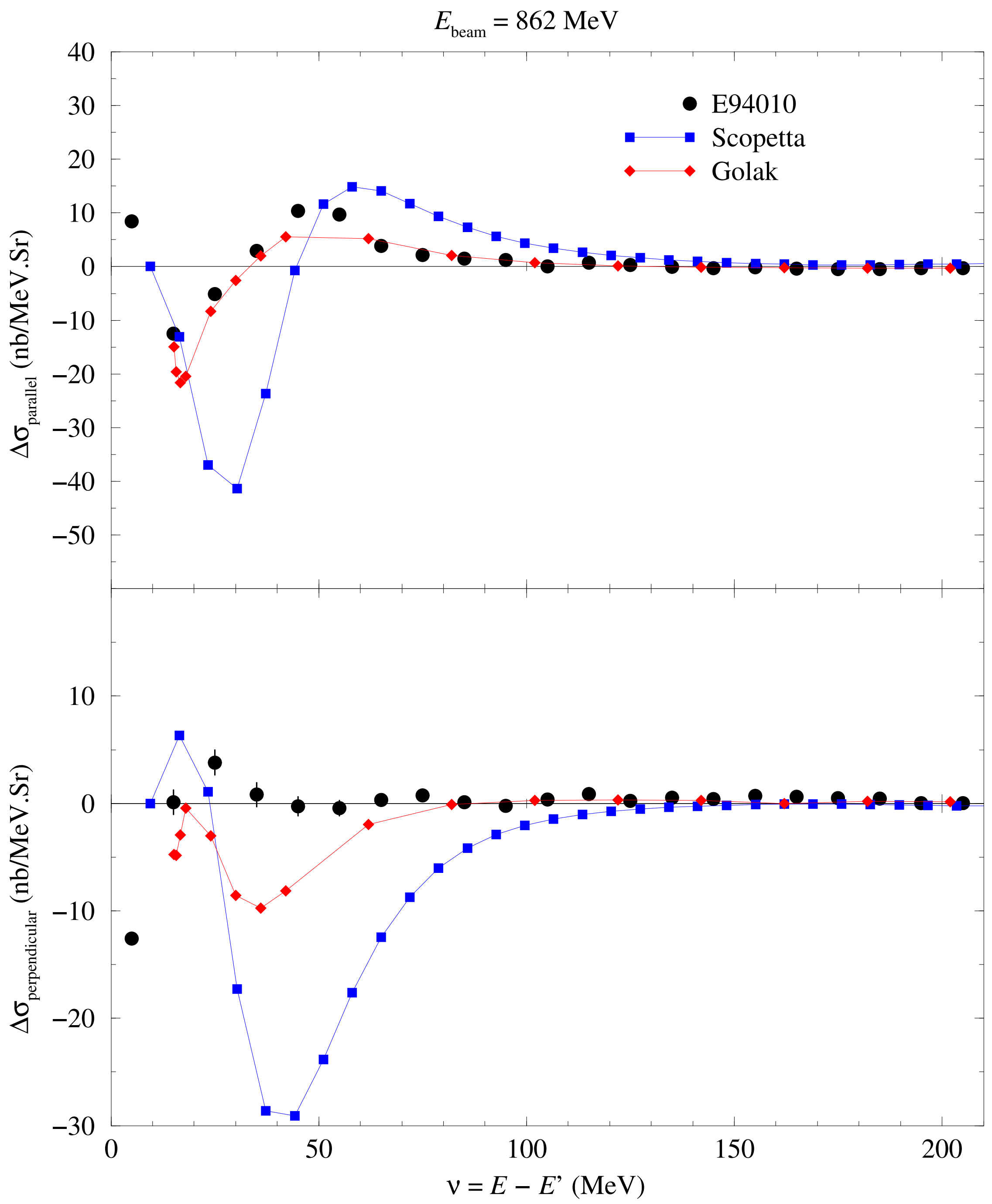




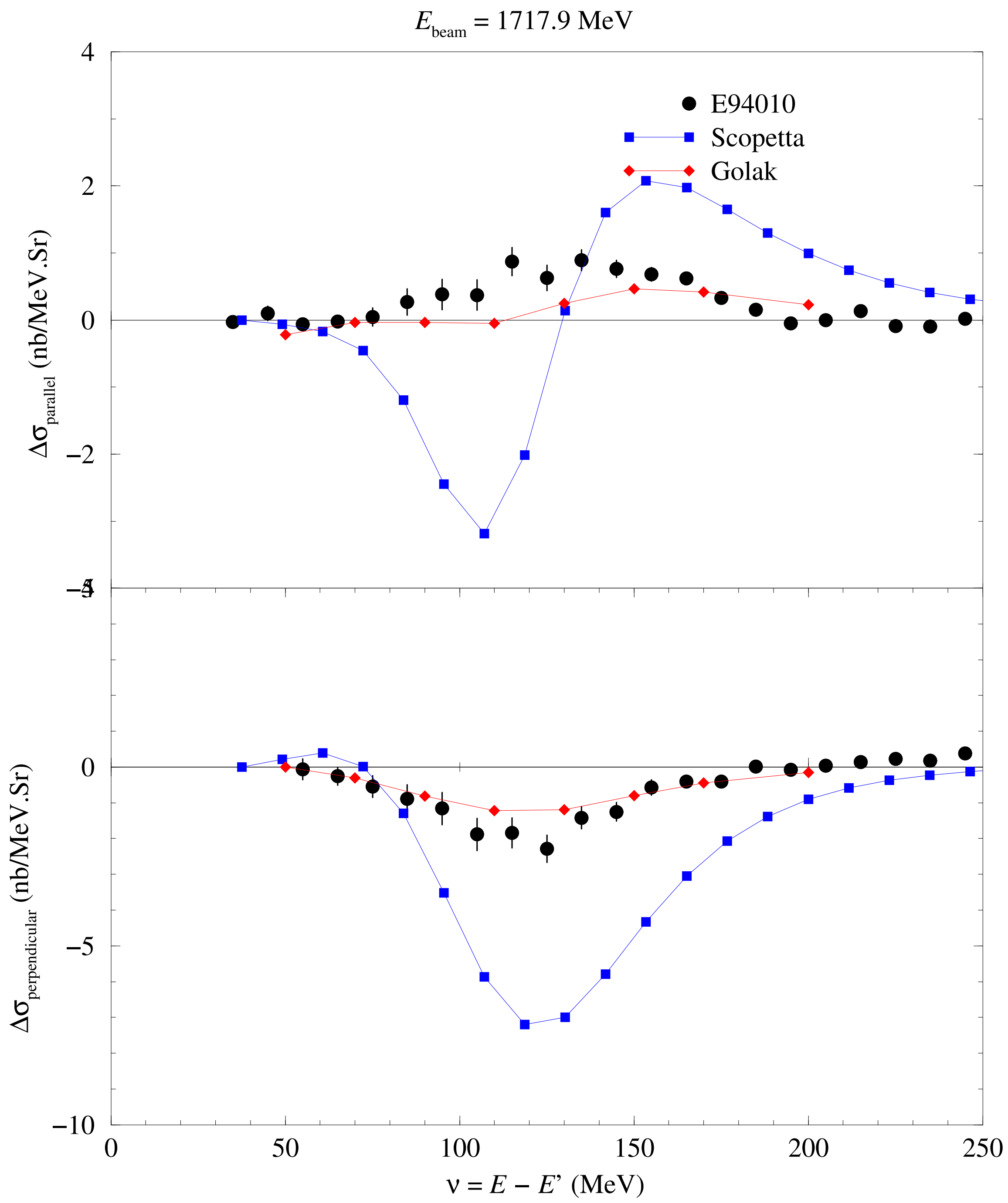
Comparison with Theory



Comparison with Theory (Cont.)



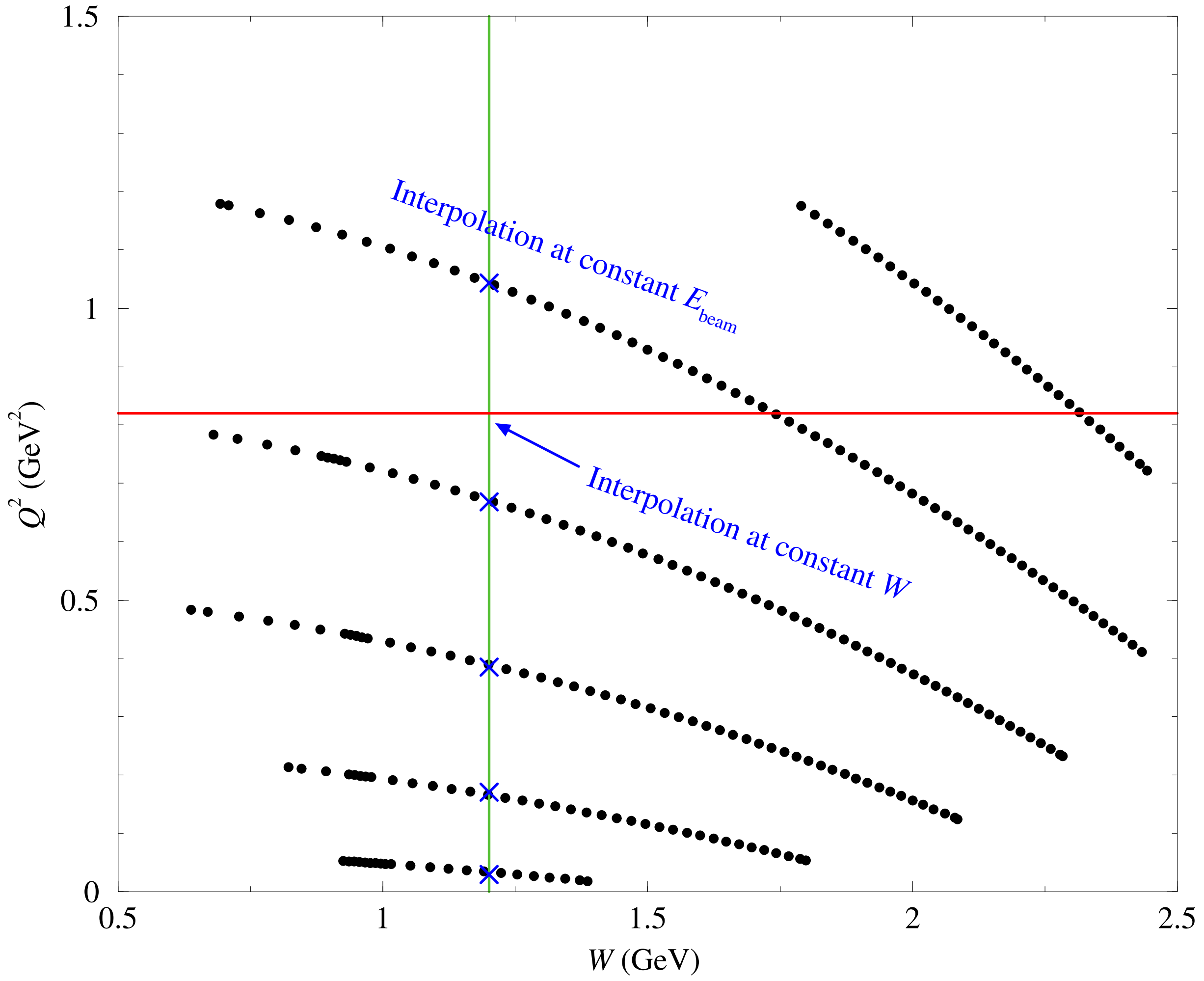
Comparison with Theory (Cont.)

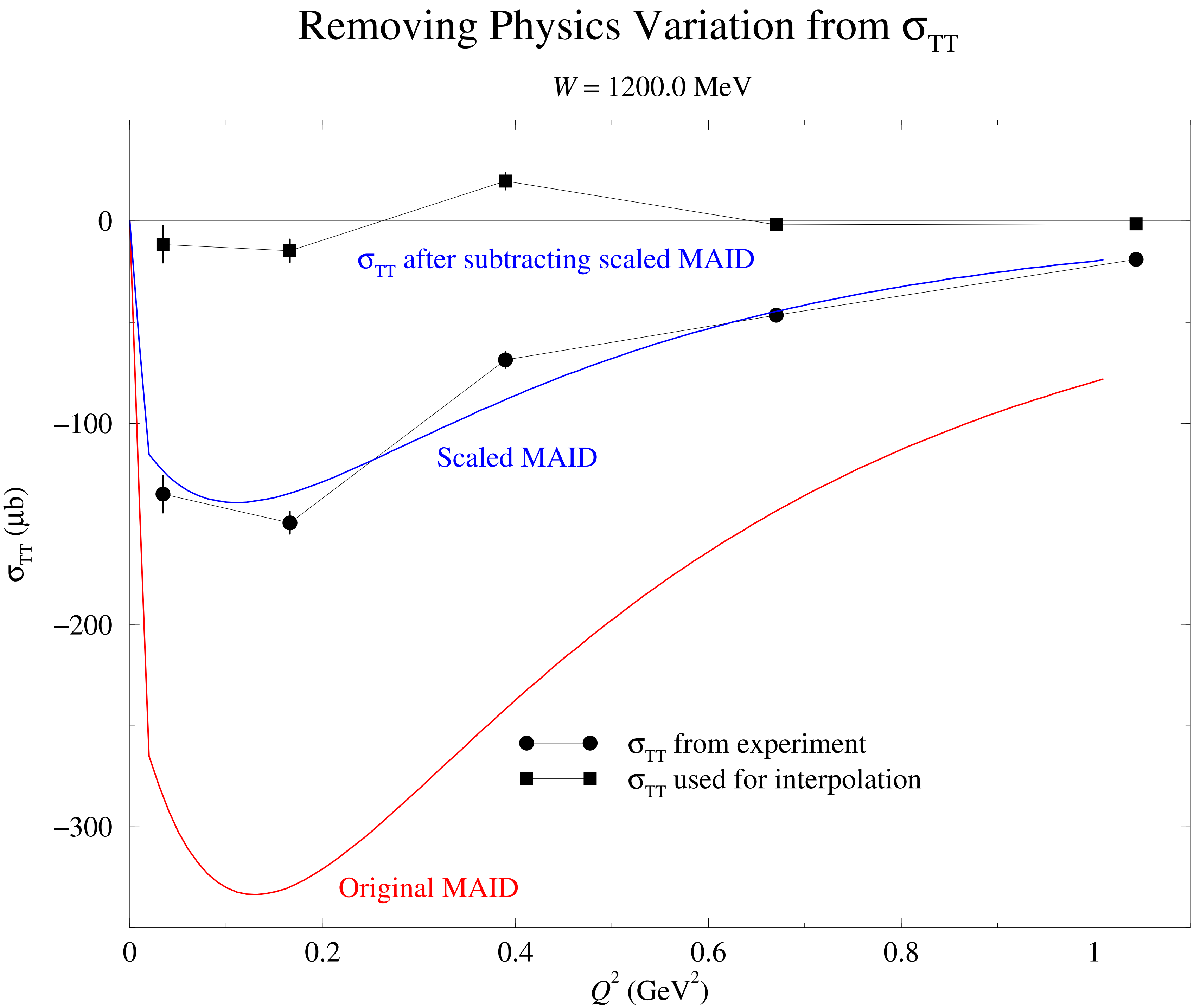


Interpolation to Constant Q^2

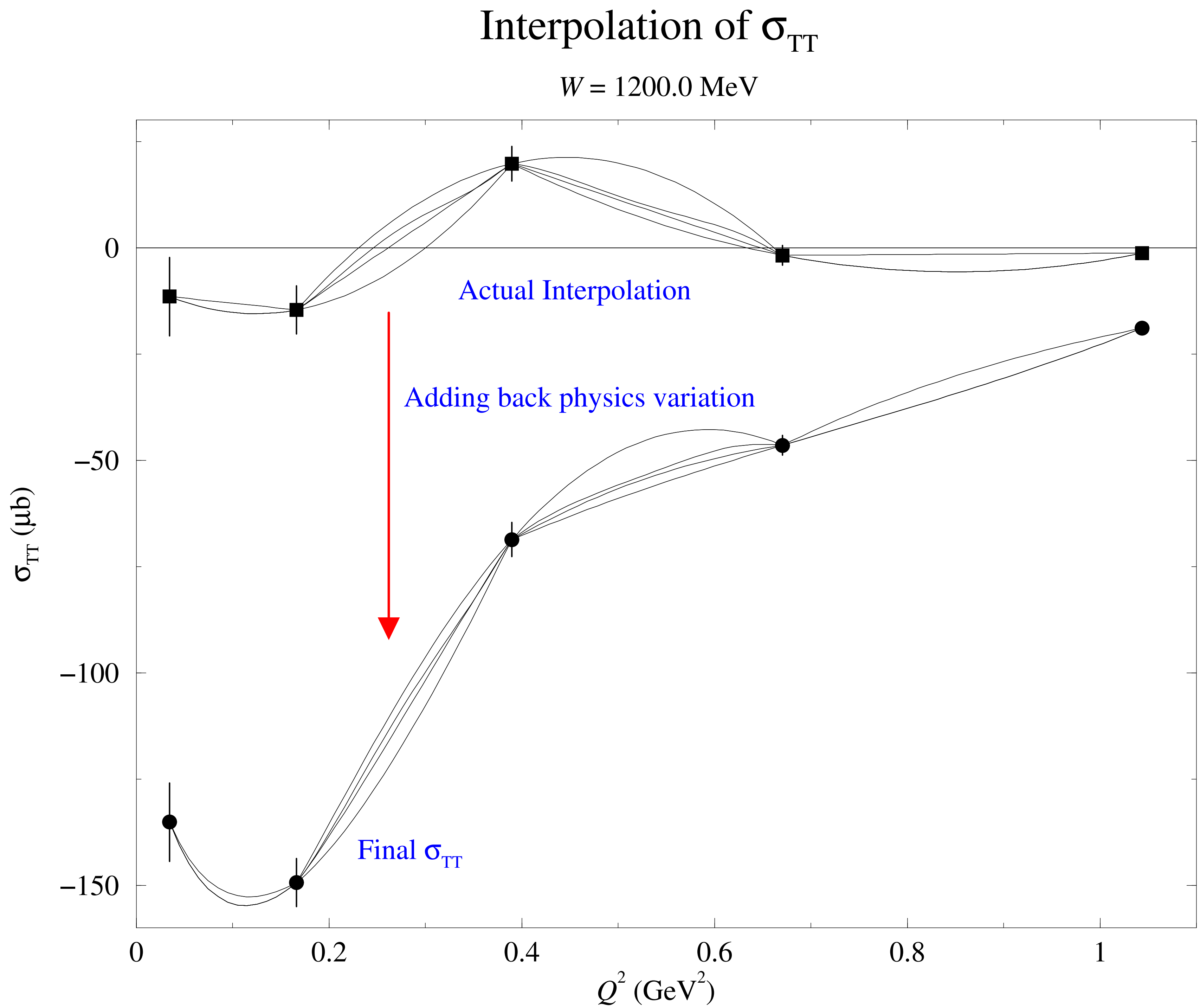
- First, interpolation at constant E_{beam} for all 6 beam energies
- Second, interpolation at constant W as a function of Q^2
  - Due to large variation as a function of Q^2, interpolation gives large systematic errors
  - Based on adjusted MAID cross sections, major part of the variation has been removed.
  - Interpolation performed on smaller variation
  - Physics variation added back

Interpolation to Constant Q^2 (Cont.)



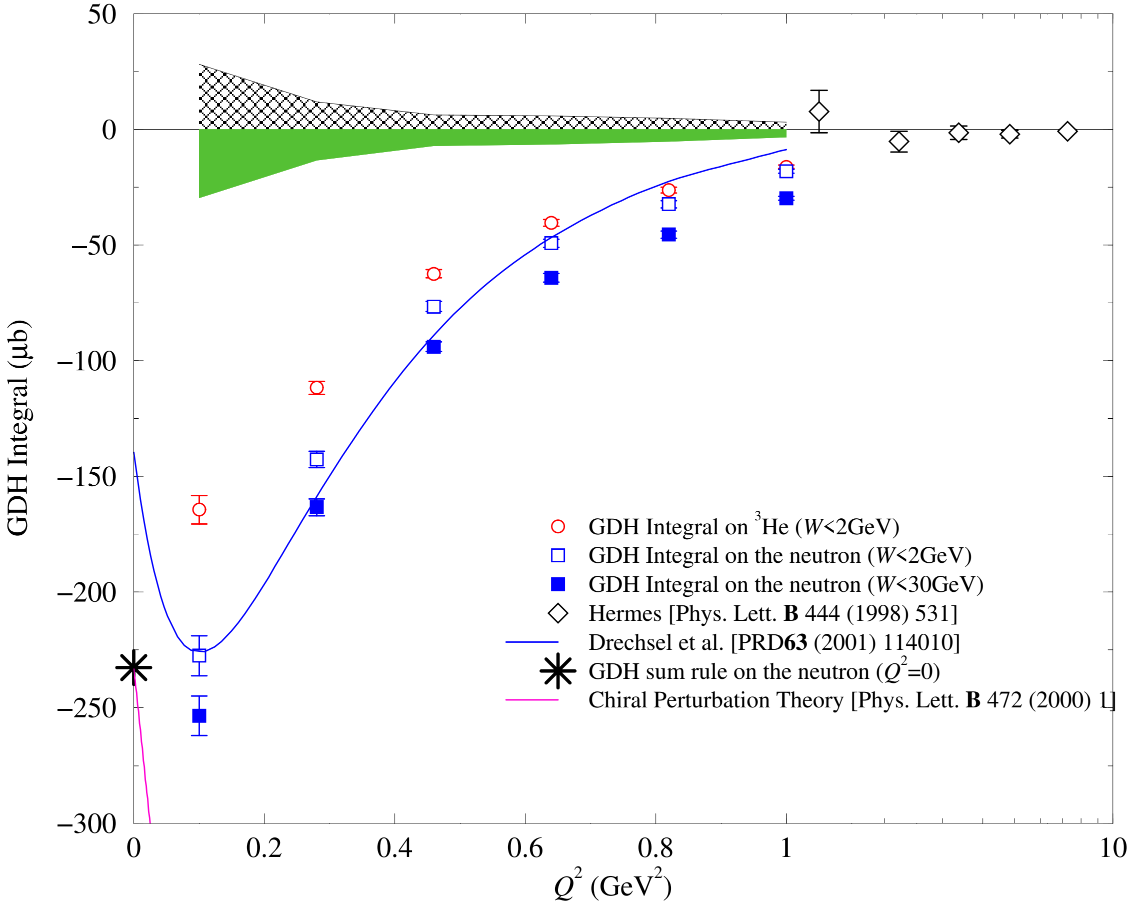


Removing Physics Variation from σ_{TT}
W = 1200.0 MeV
0
−100
−200
−300
σ_{TT} (μb)
σ_{TT} after subtracting scaled MAID
Scaled MAID
Original MAID
σ_{TT} from experiment
σ_{TT} used for interpolation
0
0.2
0.4
0.6
0.8
1
Q^2 (GeV^2)



Interpolation of σ_{TT}
W = 1200.0 MeV
Actual Interpolation
Adding back physics variation
Final σ_{TT}
σ_{TT} (μb)
0
−50
−100
−150
0
0.2
0.4
0.6
0.8
1
Q^2 (GeV^2)

Final Result



Conclusion

- ➜ The experiement involved measurement of asymmetries and absolute cross sections.
- ➜ Overall consistency of the analysis
  - Comparison of elastic asymmetries and cross section
  - Comparison of quasi-elastic asymmetries and cross section
- ➜ Lessons
  - Better control of charge asymmetry
  - Better control of helicity dependent dead time
  - Better understanding of both arms (Particle ID, acceptance)