

# saGDH Analysis

## *Radiative Corrections*

**Jaideep Singh**

**University of Virginia**

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# Introduction

Goal: “Transform” measured cross sections  $\rightarrow$  Born cross sections:

$$\left[ \frac{d^2\sigma(\nu)}{dE \cdot d\Omega} \right]_{\text{raw}} \times f_{\text{RC}}(\nu) = \left[ \frac{d^2\sigma(\nu)}{dE \cdot d\Omega} \right]_{\text{Born}}$$

Corrections arise from two sources:

1. Higher order diagrams that contribute to measured cross section
2. Energy lost by the scattered electron

Higher order diagrams result in an overall multiplicative factor. On the other hand, corrections due to energy loss are more convoluted.

# Energy Loss Mechanisms

The scattered electron can lose energy in two ways:

1. Collisions (Ionization) - shifts spectrum
2. Radiation (Bremsstrahlung) - smears peaks

Radiation losses have the largest effect on our data and are classified in two groups:

1. External - loss of energy in the field of a foreign nucleus
2. Internal - loss of energy in the field of the target nucleus

The target nucleus is the one from which the electron scatters, whereas, the foreign nuclei are simply bypassed by the scattered electron. Therefore, the key distinction between internal and external corrections is that internal corrections are independent of the material thickness.

# Synthesis

$$\left[ \frac{d^2\sigma(\nu)}{dE \cdot d\Omega} \right]_{\text{raw}} = \int dx \cdot d\nu_{\text{bef}} \cdot d\nu_{\text{aft}} \cdot (1 + \delta_{\text{HO}}) \cdot \left[ \frac{d^2\sigma(\nu)}{dE \cdot d\Omega} \right]_{\text{Born}} \\ \times \left( \begin{array}{l} \text{probability of losing } \nu_{\text{bef}} \text{ at } x \\ \text{per unit energy loss bin} \end{array} \right) \\ \times \left( \begin{array}{l} \text{probability of losing } \nu_{\text{aft}} \text{ at } x \\ \text{per unit energy loss bin} \end{array} \right)$$

Where the observed energy loss  $\nu$  is equal to the sum of the energy lost before, during, and after scattering:

$$\nu = \nu_{\text{bef}} + \nu_{\text{scatter}} + \nu_{\text{aft}}$$

# Radiation Prescription

## 1. Radiative Corrections to Elastic and Inelastic $ep$ and $\mu p$ Scattering

L.W. Mo and Y.S. Tsai

*Reviews of Modern Physics* **41**, 205-235 (1969)

## 2. Radiative Corrections to Electron Scatterings

Yung-Su Tsai

SLAC-PUB-848, 59 pages with 7 figures, January 1971

## 3. Electron scattering at $4^\circ$ with energies of 4.5-20 GeV

S. Stein, W.B. Atwood, E.D. Bloom, R.L.A. Cottrell, H. DeStaebler, C.L. Jordan, H.G. Piel, C.Y. Prescott, R. Siemann, and R.E. Taylor  
*Physical Review D* **12**, 1884–1919 (1975)

## 4. POLRAD 2.0 FORTRAN code for the Radiative Corrections Calculation to Deep Inelastic Scattering of Polarized Particles

I. Akushevich, A. Ilyichev, N. Shumeiko, A. Soroko, and T. Tolkachev  
arXiv:hep-ph/9706516 v1 26 Jun 1997

# Algorithm

1. Form raw cross sections
2. Subtract contribution from  $N_2$
3. Subtract radiative tail due to  $^3\text{He}$  elastic scattering
4. “Smooth” the raw data (fit, spline, etc.)
5. Guess an initial Born cross section based on smoothed data
6. “Radiate” the guess for the Born cross section
7. Compare radiated Born cross section to smoothed data
8. Improve guess for Born cross section based on differences
9. Iterate until radiated Born cross section converges to smoothed data
10. Ratio of converged Born cross section to smoothed data is “the radiative correction”

# Implementation

The elastic tail is calculated using **ROSETAIL.F** :

1. It appears to be a line by line translation of **Stein, et. al.**
2. Includes a crude finite acceptance calculation (implemented by Karl)
3. Can generate polarized radiative tails (implemented by Karl)

Radiative corrections in the “inelastic” regime are generated by:

<b>RADCOR.F</b>	<b>POLRAD.F</b>
unpolarized cross sections External corrections based on <b>Mo &amp; Tsai</b>	polarized cross sections Internal corrections based on <b>Shumeiko, et. al.</b>

# Progress

1. Pretty much understand most of what I just said (thanks to Karl)
2. Checked most equations in **ROSETAIL.F**
3. Cleaned up code for **ROSETAIL.F** (accepts inputs from a file)
4. Can more or less reproduce most of Table III in **Mo and Tsai**
5. Collected most of the information I need for the radiation lengths
6. Having a closer look at **ROSETAIL.F** and **Mo and Tsai** to see if saGDH satisfies all approximations
7. Will soon be looking at elastic tails for saGDH kinematics