Polarized Cross Sections and Systematic Errors

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Compiling the Systematic Error

• ASYMMETRY:
  – Beam Polarization: 1.7% -> [http://hallaweb.jlab.org/equipment/moller/e08-027.html](http://hallaweb.jlab.org/equipment/moller/e08-027.html)
  – Target Polarization: 2.5%-4% -> A few runs higher.
  – Pion Contamination: Negligible (Melissa’s study)
  – Dilution (PF): ~7% (~4%) -> Does not include 3350 GeV.
  – Out-of-Plane Systematic: 0.5-1.5%-> Will discuss on next slides how I calc. this
    • I showed this before but it never hurts to see it again

  – If I missed something, let me know!
Summary of Cuts

- **Good electron cuts used to generate asymmetries:**
  - Helicity Error: hel.(L/R).error/0x2f
  - BPM Error: (L/R)rb.bpmavail == 1
  - Event type: D(L/R).evtypebits&(1<<3)>0
  - VDC Track: (L/R).tr.n =1 and (L/R).vdc.(u1/u2/v1/v2).ncluster = 1
  - PID cuts from Melissa’s analysis and MySQL database
  - DP Cut: +/- 4% (L/R).rec.dp
  - Target Phi: -0.04 < (L/R).tr.tg_ph < 0.04
  - Target Theta: -.04 < (L/R).tr.tg_th < 0.08
  - Loose Tracking Cuts: -0.08 < (L/R).tr.r_y < 0.08 and -0.8 < (L/R).tr.r_x < 0.8
Out-of-Plane Systematic

• Instead of doing complicated error propagation with vectors and cross-products, use a simple Monte-Carlo

Relevant Vectors for calculation (in lab coordinate system):

Incoming e-: \( \vec{k} = [\tan(\phi_b), \tan(\theta_b), 1] \)

Outgoing e-: \( \vec{k'} = [\sin(\theta_r)\cos(\phi_r), \sin(\theta_r)\sin(\phi_r), \cos(\theta_r)] \)

Proton spin: \( \vec{s} = [\pm 1, 0, 0] \) Sign depends on pos/neg polarization

• The component of each vector has an associated uncertainty
• Generate Gaussians around mean value of each angle with uncertainty as width of the Gaussian
  – Take mean value as Histo->GetMean() in ROOT
• Calculate out-of-plane angle with these Gaussian generated values
• Run \( 1E6 \) times and take STD of the out-of-plane angles as uncertainty

Root Tree Variables

\[ \begin{align*}
\theta_b &= \text{Lrb.tgt.0.theta} \\
\phi_b &= \text{Lrb.tgt.0.phi} \\
\theta_r &= \text{L.rec.l.theta} \\
\phi_r &= \text{L.rec.l.phi}
\end{align*} \]
Out-Of-Plane Uncertainty

- BPM uncertainty: use updated numbers from Jie (10/12/2016)
  - $\Theta, \Phi = 1$ mrad
- Reconstructed target uncertainty use numbers from Chao
  - $\Theta, \Phi = 2$ mrad
- Don’t have numbers for uncertainty in target field
  - I’ve asked but waiting to hear back
  - Did check assuming an angle off by $\approx 5^\circ$ and it had small affect
- Dominated by BPM uncertainty, but overall effect is $\pm 0.5^\circ$
  around central angle
- Uncertainty has very small effect on the data
Updated Toby Dilutions

Model Calculation:

Tune Bosted nitrogen model to saGDH data
Average difference now ~7% across all settings
Check tune by comparing radiated tuned model to radiated saGDH data

Rest of systematics (blue bands at +/- 12%):
20% for He4 model, 20% for Al model, 10% for H model, PF 4.5% (over-estimate)

Inner error bars are statistical and outer are total error bars
Updated Toby Dilutions

Model Calculation:
Tune Bosted nitrogen model to saGDH data
Average difference now ~7% across all settings
Check tune by comparing radiated tuned model to radiated saGDH data

Rest of systematics (blue bands at +/- 25%):
20% for He4 model, 20% for Al model, 10% for H model, PF 20%

Currently used tuned model dilution for 3350 MeV data set, but with large systematic uncertainty

Inner error bars are statistical and outer are total error bars
Radiated Physics Asymmetries
Generating the Polarized DS

• **Systematic Errors:**
  
  – Uncertainty in radiating the Bosted model: 3%
  
  – Uncertainty in the Bosted model: 10%
  
  – Uncertainty in the reconstructed angle: ~1-2%
    
    • Use same Monte-Carlo method for out-of-plane systematic
    
    • Corresponds to a Mott systematic: ~4-8%
  
  – For longitudinal I assume uncertainty in reconstructed angle from pointing measurement
    
    • From Min’s tech-note: ~0.7% ->
      
      [http://hallaweb.jlab.org/experiment/g2p/collaborators/mhuang/technote/pointingSummary.pdf](http://hallaweb.jlab.org/experiment/g2p/collaborators/mhuang/technote/pointingSummary.pdf)
    
    • Corresponds to a Mott Systematic of: ~3%
Scattering Angle Reconstruction

From previously defined acceptance cuts
Weight calculated angle by 1/Mott to help remove physics dependence on angle

Use following functional form to fit: $\theta \, (\text{deg}) = \exp (p_0 + p_1*P_0) + p_2 + p_3*P_0$

P0 in GeV
Use initial parameters for p0,p1,p2,p3 from Jixie ELOG Post 110: https://hallaweb.jlab.org/dvcslog/g2p/110

Color bands are systematic error: +/-2%

Shift RHRS manually up by 0.3 degrees for fit
This approx the shift seen in 2.2 GeV data

P0 = 3.535, P1 = -2.363, P2 = 10.551, P3 = -1.464

P0 = 2.667, P1 = -1.723, P2 = 9.124, P3 = -0.876
Scattering Angle Reconstruction

From previously defined acceptance cuts
Weight calculated angle by 1/Mott to help remove physics dependence on angle
Can test how well Mott weighting works by comparing reconstructed angle at longitudinal with the pointing result

Red/Blue color bands are systematic error: +/-2%
Greg band is systematic error of 0.7%

![Graph showing scattering angle reconstruction](image-url)
Polarized DS and Tail Subtraction

- Data lower than pion threshold should be mostly radiative tail
- Confirms I got the sign correct in calculating the tail

- Abs. magnitude of stat. error bars on radiated DS are carried through from here on out

- Tail subtraction systematic is 2.5-4%.
- Systematic on tail subtracted DS on average ~10% (Gets bigger where tail and data are closer in value)
Polarized DS and Tail Subtraction

- Abs. magnitude of stat. error bars on radiated DS are carried through from here on out.
- Tail subtraction systematic is 2.5-4%.
Inelastic Radiative Corrections

- Inelastic radiative corrections systematics are broken up two ways:
  - Procedure systematic (interpolation/extrapolation dependence on input models)
  - Theory systematic (how accurate are the assumptions made in the calculations)
- Previously discussed both of these BUT a general rule of thumb:
  - At low nu (around the delta) theory systematics dominate (2-3%)
  - At high nu the procedure systematics dominate

Procedure systematic relatively constant across nu
When DS get’s smaller, relative systematic gets bigger!
Inelastic Radiative Corrections

- Use Hall B model run at overall inputs scale of 0.40/0.65/0.90 for procedure systematics
- Using modified version of RADCOR/POLRAD where angle is not necessarily constant!
- For 2254 5T Transverse:
  - Born Systematic: ~13% (Gets closer to 20/25 at nu above 1050 MeV)
- For 3350 5T Transverse:
  - Born Systematic: ~20%
Inelastic Radiative Corrections

- Use Hall B model run at overall inputs scale of 0.40/0.65/0.90 for procedure systematics
- Using modified version of RADCOR/POLRAD where angle is not necessarily constant!
- For 2254 5T Longitudinal:
  - Born Systematic: ~6-7%

![Graph showing data and model predictions](image-url)
Going Forward

• Dominate source of systematic error is unpolarized cross section model and Mott/scattering angle uncertainty
  – Model uncertainty could be reduced in the future with our data
  – Mott is probably here to stay?
• 3350 GeV data is dominated by dilution/PF systematic.
• How to treat statistical error bars when doing RC’s?
  – Options: Keep absolute value constant, Keep relative value constant, Other???
• Will soon look at g1/g2 extraction and moment calculations
• Questions/comments/concerns?