Diffractive Slope Extraction of Exclusive ρ^0_L and ρ^0_T at HERMES

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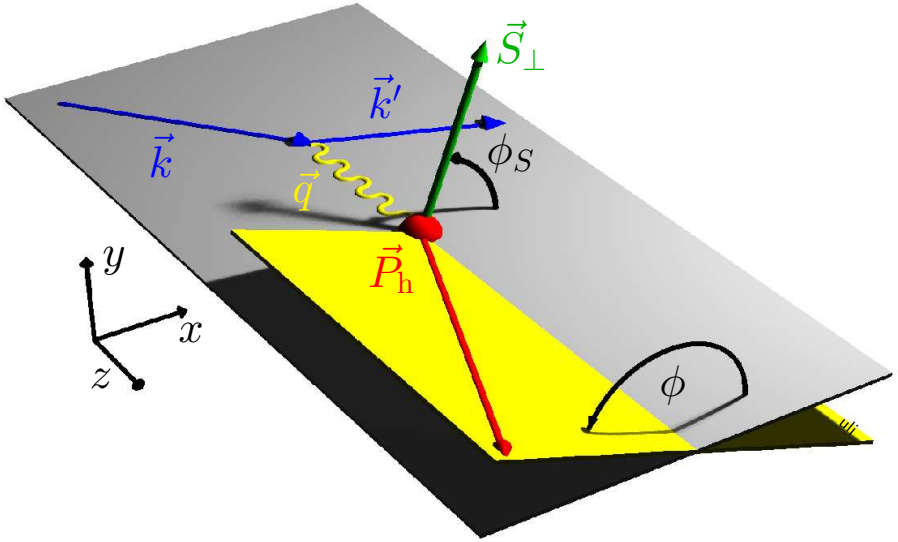
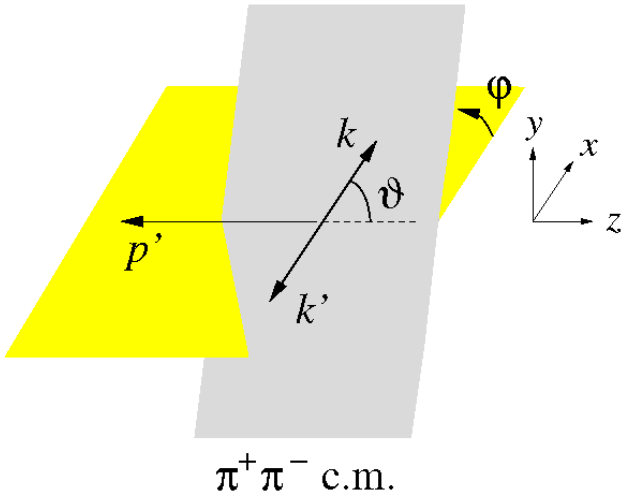
Motivation

- Observing ρ^0 electroproduction ($ep \rightarrow e'p'\rho^0$) through decay channel $\rho^0 \rightarrow \pi^+\pi^-$.
- ρ^0 meson shrinks at higher values of Q^2.
  - Effect known as shrinkage and is a precondition for color transparency, or the ability to scatter off small targets with reduction of color interaction.
- Transverse size of ρ^0 reflected in cross-sectional slope parameter b.
- b fairly well understood.
- Very little known about dependence on helicity of ρ^0.

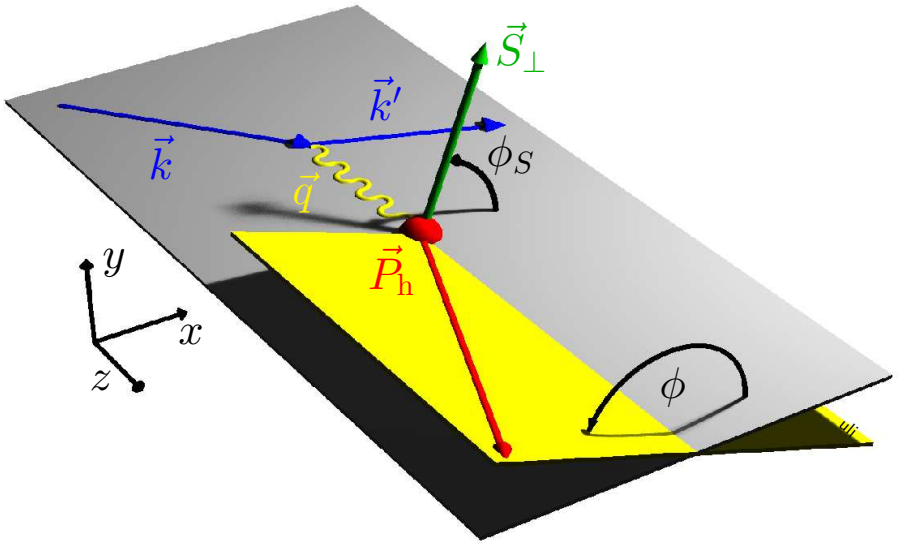


Lab Frame

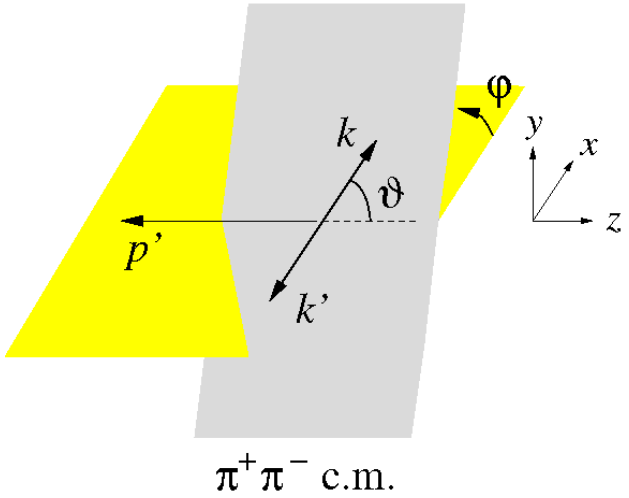


M. Diehl (arXiv:0704.1565v2)

- Q^2 is the absolute value of the magnitude of the four-momentum of the virtual photon involved in the *ep* collision.
- $-t'$ is the momentum transfer above the minimum required for the reaction to take place.
- ϵ is the virtual photon polarization parameter.

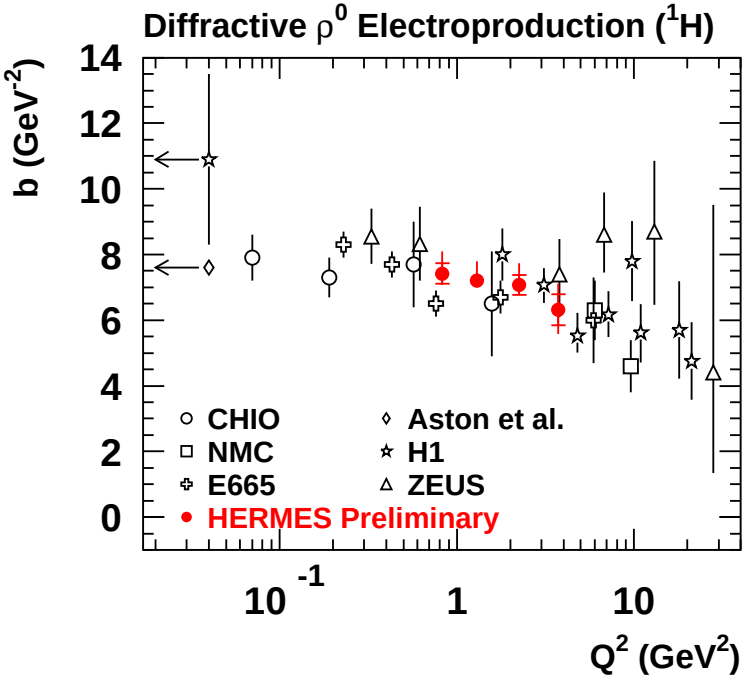


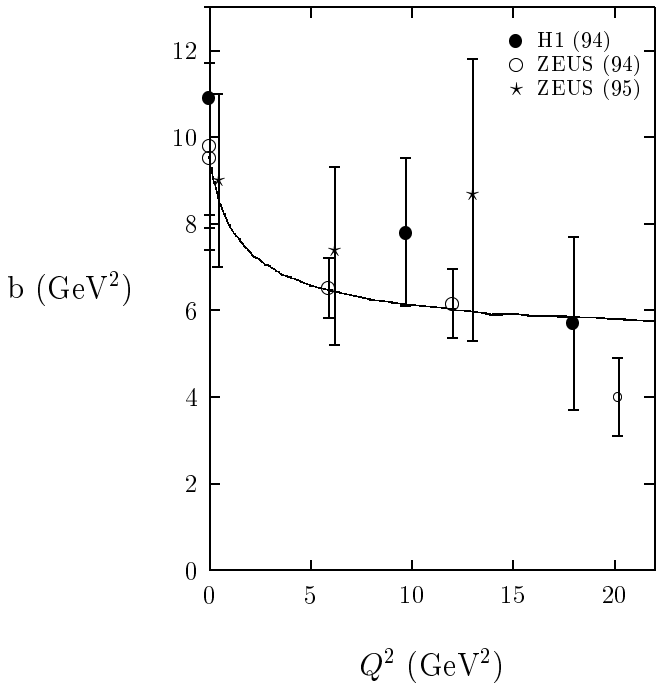
Lab Frame



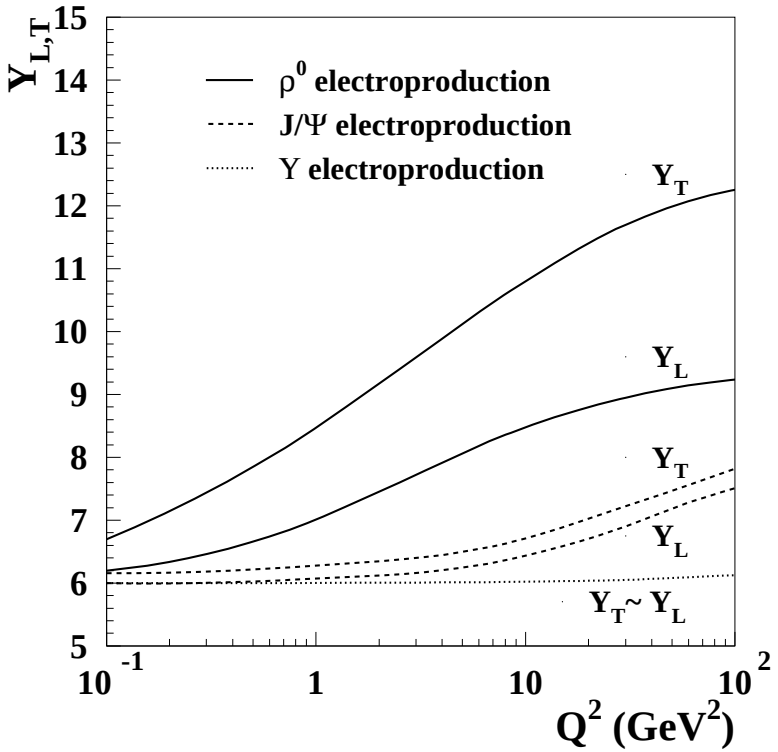
M. Diehl (arXiv:0704.1565v2)

- ϕ is the angle between the scattering plane and the production plane.
- ϕ_S is the angle between the scattering plane and the target polarization.
- φ and ϑ spherical angles between the forward direction of π^+ and forward direction of ρ^0 in the ρ^0 rest frame.



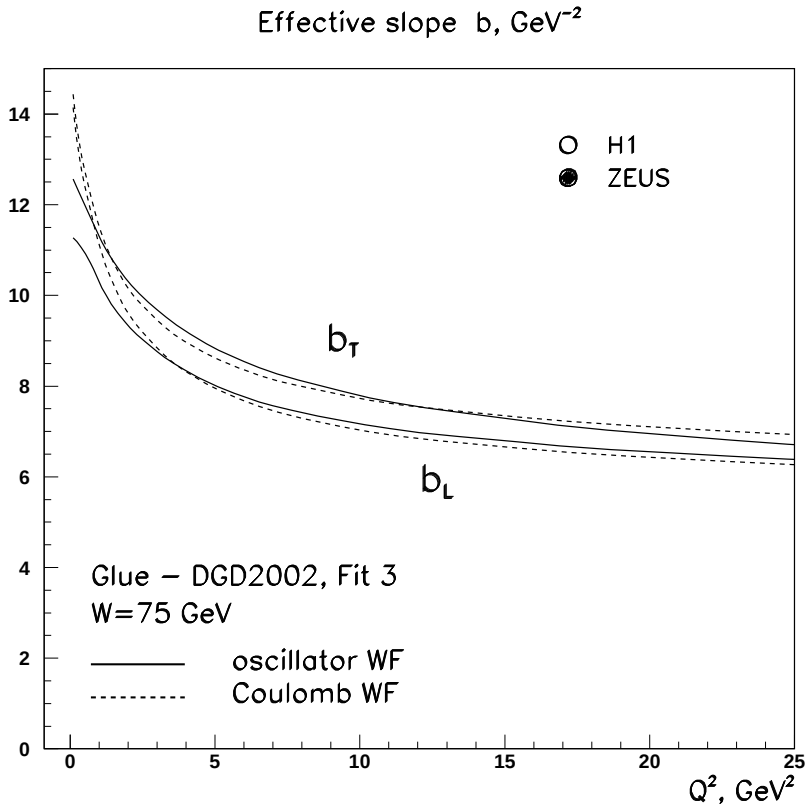


- World data with old HERMES results from M. Tytgat, "Diffractive Production of ρ^0 and ω Vector Mesons at HERMES", PhD. thesis, University Gent, Belgium (2001).
  - Agreement with other experiments very good.
- Theoretical curve matches experimental results (I. Royen and J.-R. Cudell, hep-ph/9807294).
- Going one step further in the analysis: *L*–*T* separation.



Theoretical curve of $Y_{L/T}$ from Kopeliovich et al. (B.Z. Kopeliovich, J. Nemchik, and Ivan Schmidt, hep-ph/0703118)

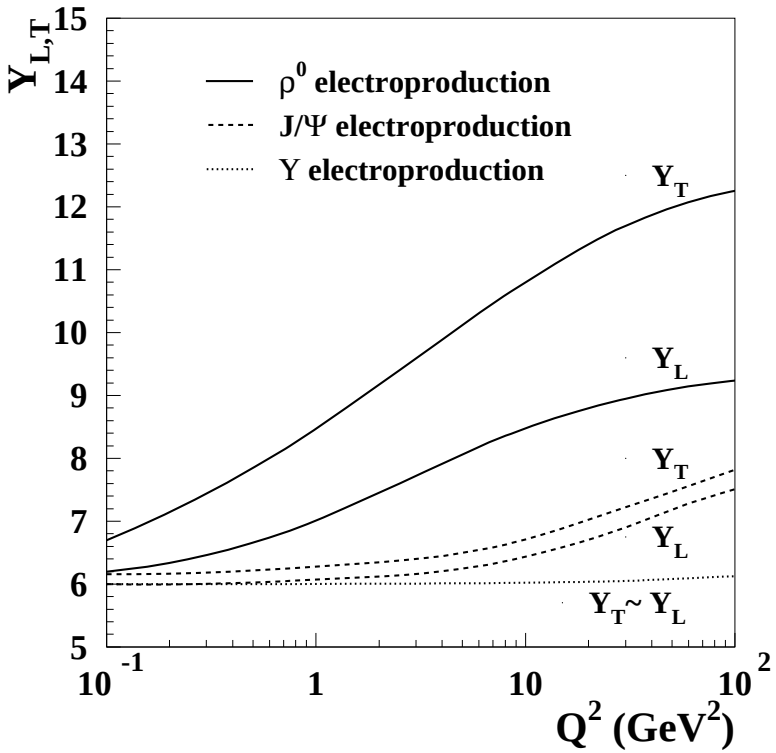
- $b_{L/T}(Q^2) \propto b_N + const \frac{Y^2_{L/T}}{Q^2+m_V^2}$
  - b_N contribution from nucleon
  - $Y_{L/T}$ relates the size of the $q\bar{q}$ pair to Q^2
- Several specific values computed in the paper
  - $b_T - b_L = 0.7$ GeV^{-2} at $Q^2 = 0.7$ GeV^2
  - $b_T - b_L = 0.4$ GeV^{-2} at $Q^2 = 5$ GeV^2

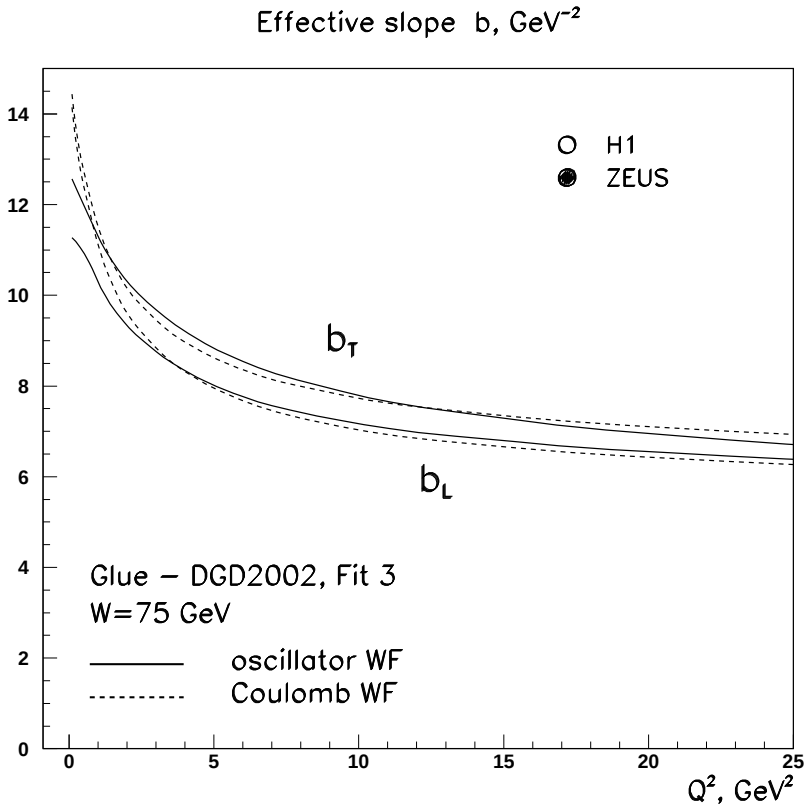


Theoretical curve of b_T and b_L from Ivanov (I. Ivanov Ph.D. Dissertation, Bonn 2002. hep-ph/0303053)

- Coulomb wave function has $b_T - b_L = 0$ at low Q^2.
- Oscillator wave function has $b_T - b_L = 0$ at high Q^2.
- Legend has ZEUS and H1 points, but none on graph
  - No results from any experiment as of yet.
- HERMES kinematics range: $0.5\ \text{GeV}^2 < Q^2 < 7.0\ \text{GeV}^2$

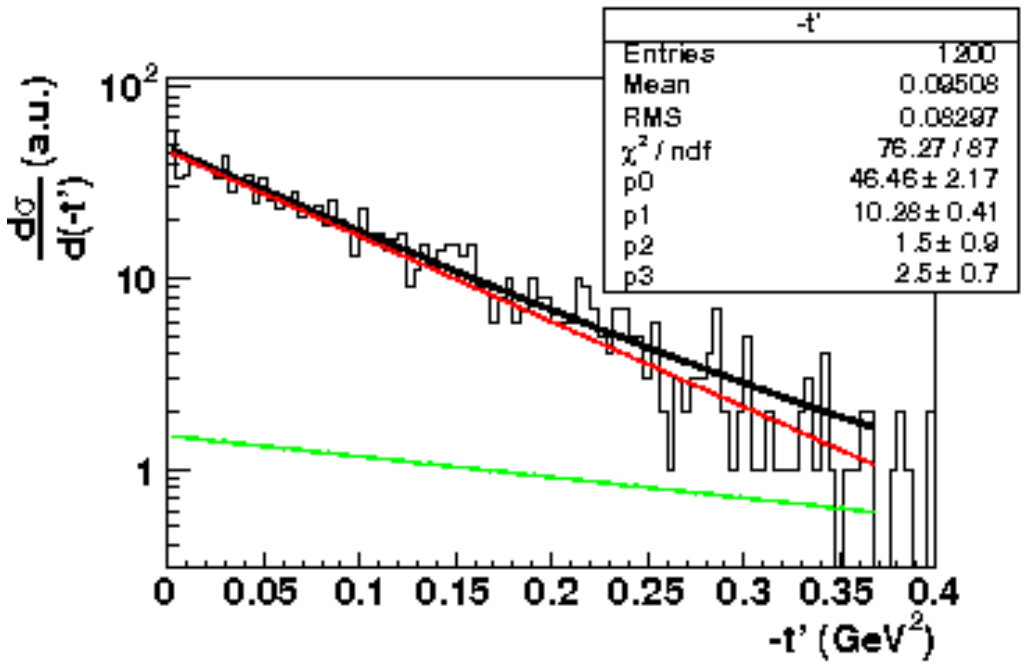
Comparison of theories





- Exact values disputed, but in general $|b_L - b_T| \approx 1$ GeV^{-2}.
- Dispute over $b_L <> b_T$.
- Shrinkage seen for both $b_{L/T}$.

Extraction Method



- Sample histogram of b extraction (b is p1).
  - Black curve is full fit.
  - Red curve is signal.
  - Green curve is background.
- b for unpolarized ρ^0: $\frac{d\sigma}{d(-t')} = Ae^{-b(-t')}$.

- Use M. Diehl formalism (arXiv:0704.1565v2) for base angular distributions: cross section parameterized by $W_{XY}()$
  - $W_{XY}(\phi,\varphi,\vartheta) = \frac{3}{4\pi}[cos^2(\vartheta)W^{LL}_{XY}(\phi) + \sqrt{2}cos(\vartheta)sin(\vartheta)W^{LT}_{XY}(\phi,\varphi) + sin^2(\vartheta)W^{TT}_{XY}(\phi,\varphi)]$
  - X, Y = U, L
  - Additional dependencies for X, Y = T on ϕ_S
    - $W^{LL}_{UU}(\phi) = (u^{00}_{++} + \epsilon u^{00}_{00}) - 2cos(\phi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{00}_{0+}) - cos(2\phi)\epsilon u^{00}_{-+}$
    - $W^{LT}_{UU}(\phi,\varphi) = cos(\phi+\varphi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{0+}_{0+} - u^{-0}_{0+}) - cos(\varphi)\mathrm{Re}(u^{0+}_{++} - u^{-0}_{++} + 2\epsilon u^{0+}_{00}) + cos(2\phi+\varphi)\epsilon\mathrm{Re}(u^{0+}_{-+}) - cos(\phi-\varphi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{0-}_{0+} - u^{+0}_{0+}) + cos(2\phi-\varphi)\epsilon\mathrm{Re}(u^{+0}_{-+})$
    - $W^{TT}_{UU}(\phi,\varphi) = \frac{1}{2}(u^{++}_{++} + u^{--}_{++} + 2\epsilon u^{++}_{00}) + \frac{1}{2}cos(2\phi+2\varphi)\epsilon u^{-+}_{-+} - cos(\phi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{++}_{0+} + u^{--}_{0+}) + cos(\phi+2\varphi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{-+}_{0+}) - cos(2\varphi)\mathrm{Re}(u^{-+}_{++} + \epsilon u^{-+}_{00}) - cos(2\phi)\epsilon\mathrm{Re}(u^{++}_{-+}) + cos(\phi-2\varphi)\sqrt{\epsilon(1+\epsilon)}\mathrm{Re}(u^{+-}_{0+}) + \frac{1}{2}cos(2\phi-2\varphi)\epsilon u^{+-}_{-+}$
  - etc.
  - u^{AB}_{CD} are SDME's where $A,B,C,D = +,-,0$

- We chose to modify angular distributions by $e^{-b_{L/T}(-t')}$ in appropriate places.
  - $W_{XY}(-t', \phi, \varphi, \vartheta) = \frac{3}{4\pi}[e^{-b_L(-t')}cos^2(\vartheta)W_{XY}^{LL}(\phi) + e^{-b_{interference}(-t')}\sqrt{2}cos(\vartheta)sin(\vartheta)W_{XY}^{LT}(\phi, \varphi) + e^{-b_T(-t')}sin^2(\vartheta)W_{XY}^{TT}(\phi, \varphi)]$
  - $b_{interference}$ chosen to be $\frac{b_L + b_T}{2}$
- A WORD OF CAUTION: Simply using the ϑ angular distributions is not sufficient to correctly characterize the distributions in order to extract $b_{L/T}$.
  - $\frac{d\sigma}{d(-t')d(cos(\vartheta))} = A_L cos^2(\vartheta)e^{-b_L(-t')} + A_T sin^2(\vartheta)e^{-b_T(-t')}$
  - $A_{L/T}$ proportionality constants.

- Results have not been released yet.
- Current status:
  - All data sets prepared for extraction.
  - Monte Carlos generated to test extraction procedure.
  - Systematic studies chosen.
  - Working on fitting programs.
    - Maximum Likelihood fit method in Minuit.