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Spectator Tagging for Deep Virtual Compton Scattering on a Bound Nucleon in Deuterium $D(e,e'\gamma pn_S)$ and $D(e,e'\gamma np_S)$

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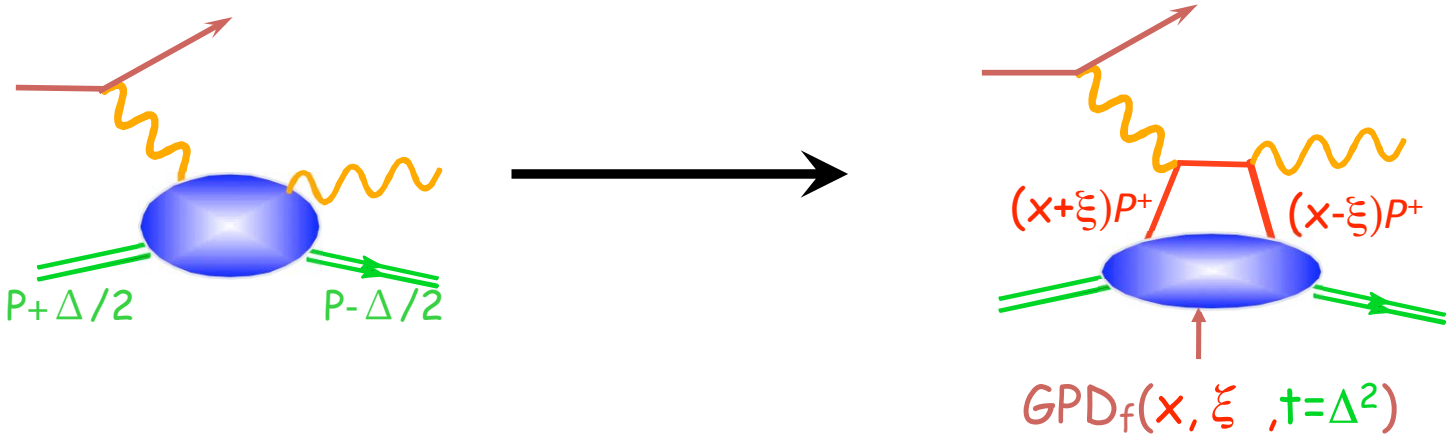
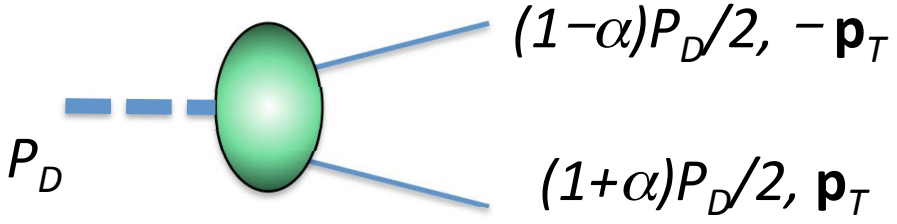
DVCS on a Nucleon



- Spectator Kinematics

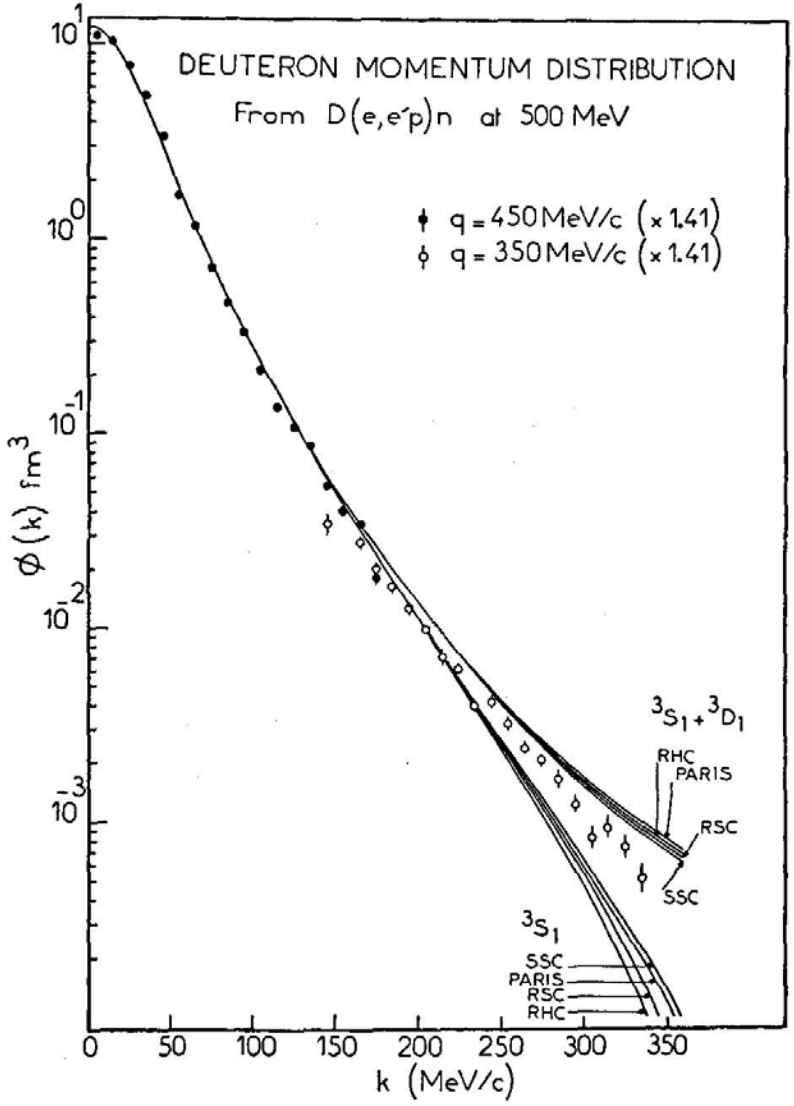


$$\alpha = \frac{\vec{P}_D \cdot \vec{p}}{\left|\vec{P}_D\right| E_D}$$

Deuteron Momentum Distribution

- Beam divergence at IP of 60 GeV/c Deuteron is ≈ 0.3 mr
- Intrinsic uncertainty in transverse momentum of neutron in deuteron:

  $P_T(n)$ ≈ (0.3 mr)(30 GeV/c)
  ≈ 10 MeV/c



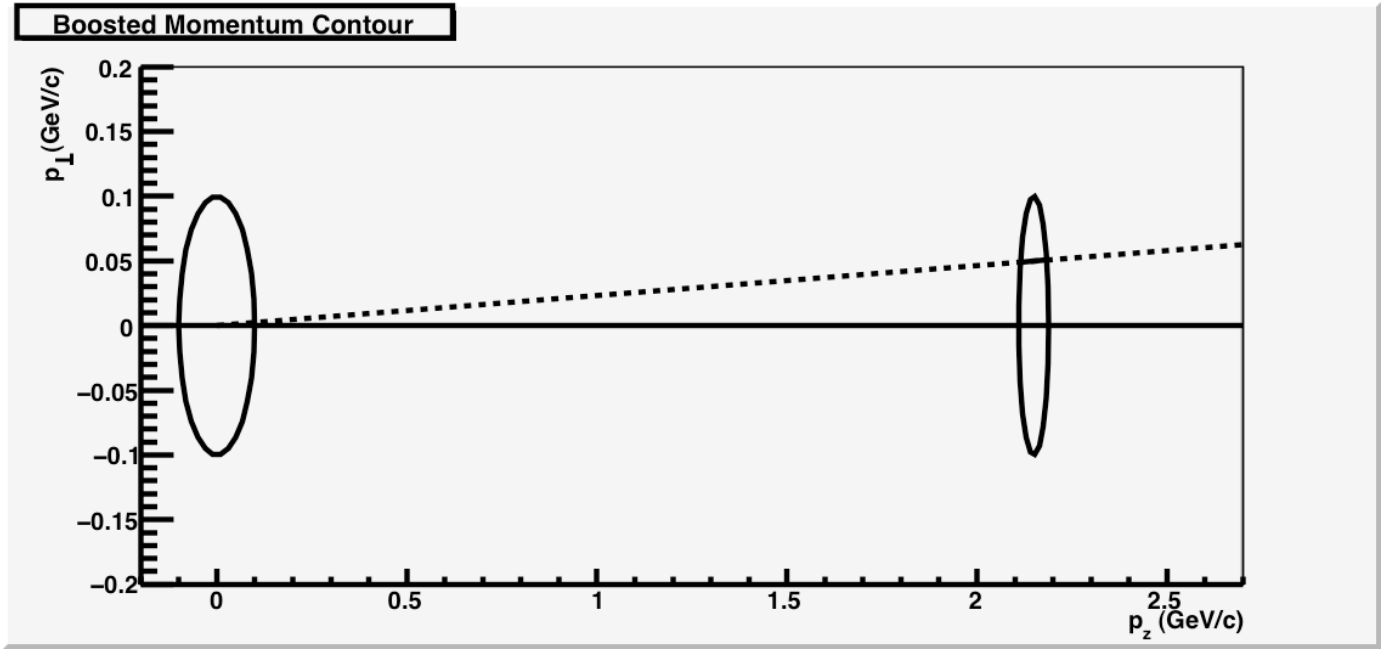
Quasi-Free Kinematics-Neutron

- Spectator Proton
  - Final state momentum $P_p = (1+\alpha)P_D/2,\ p_T$
  - Proton has one half of deuteron rigidity
    - Detect in dipole spectrometer
- DVCS neutron,
  - Δ_T > 300 MeV/c
    - Negligible overlap with initial state momentum distribution
    - Detect in Hadron Calorimeter
- Reaction is over complete even without |p| measurement of neutron.

Quasi-Free Kinematics-Proton

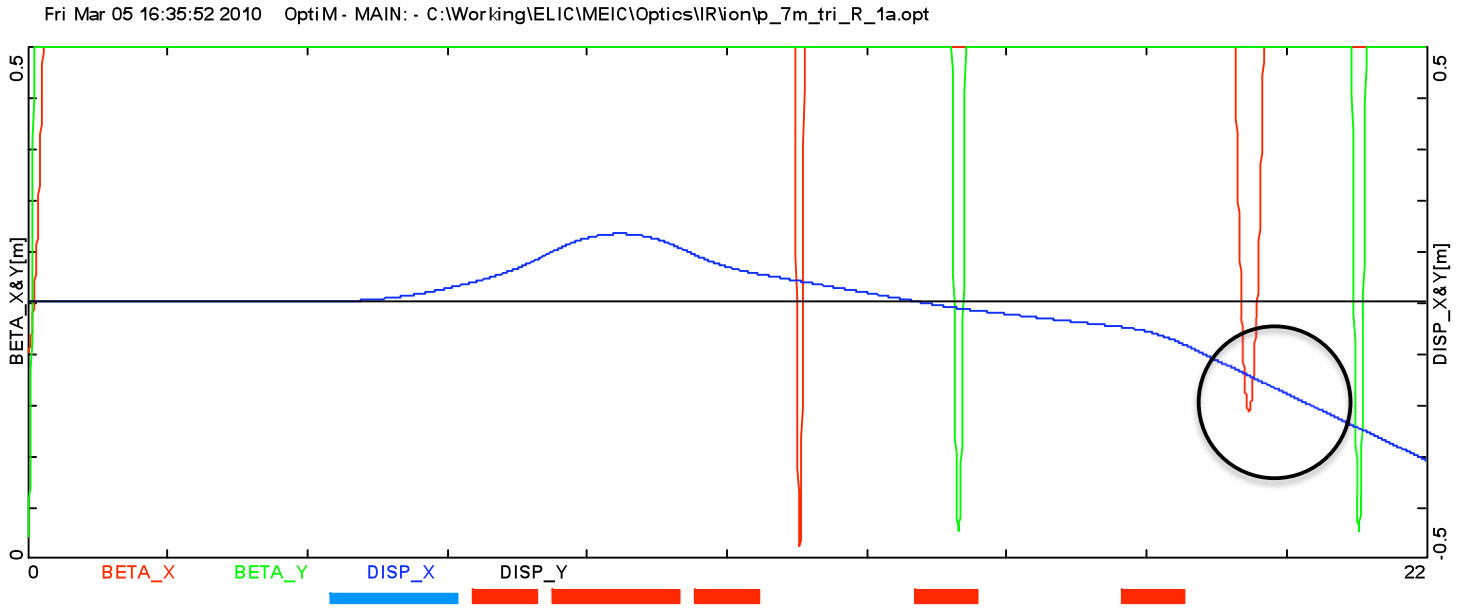
- Spectator Neutron
  - Final state momentum $P_n = (1+\alpha)P_D/2,\ p$
  - Hadron Calorimeter at 0° downstream of dipole
    - Angular resolution ≈ 1 cm/ 10 m ≈ 1 mr
    - Nominal transverse momentum (30 GeV/c) θ_n ± 30 MeV/c
    - Partially Occluded by FF Quads, Acceptance > 50%
- DVCS Proton,
  - $P_p = (1+\alpha-2\xi)P_D/2,\ -p+\Delta_T$
  - Δ_T > 300 MeV/c
    - Negligible overlap with initial state momentum distribution
  - Forward tracking outside FF-Quads even without forward dipole
    - θp>(300 MeV/c)/(30 GeV/c) = 10 mr
    - Quad shadow ≈ 10 mr.
- Reaction is over complete even without |p| measurement of 2 of final state particles.
  - Test of exclusivity

Spectator Neutron tagging at angle θ_n



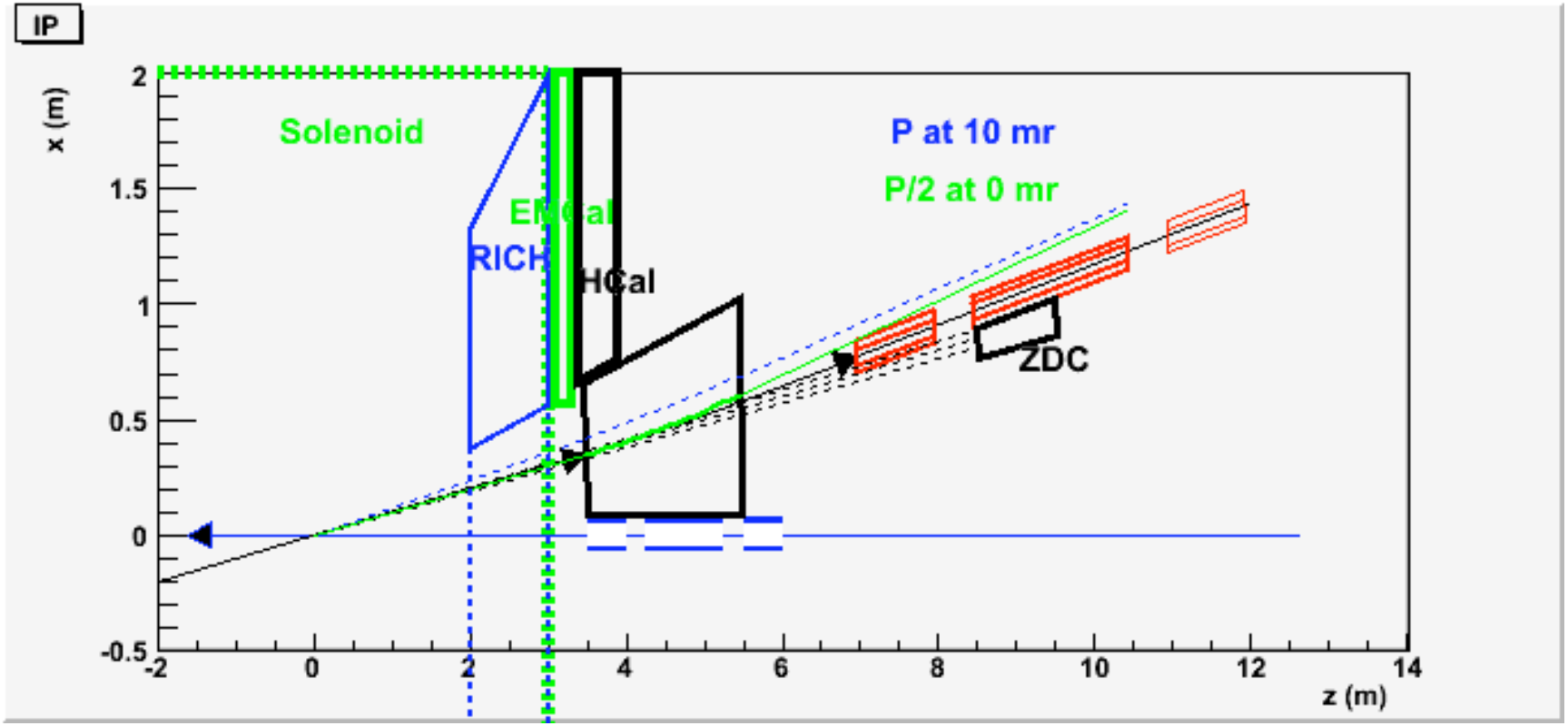
- Contour at p = 100 MeV/c
  D at rest (left) or boosted (right, small boost for clarity)
- Spectator Neutron θ_n integrates over slice of momentum distribution.
  - Dominated by $p_T = (P_D/2)\tan\theta_n$

Example of Far-Forward Tagging



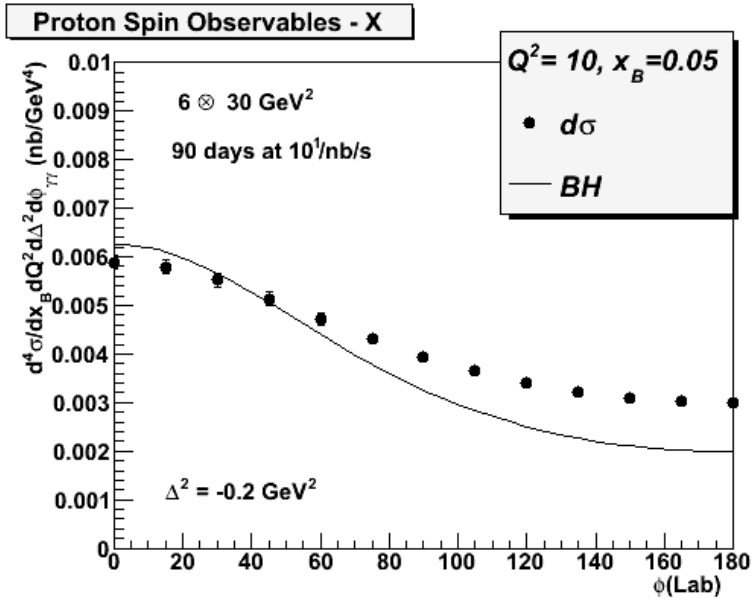
- After first FODO cell after FF Triplet
  - Dispersion ≈ 20 cm
  - $\beta_x \approx 20$ cm
- Momentum Resolution $\delta p/p \approx 2 \bullet 10^{-3}$.
  - Detectors more than 1 cm from beam.
- Additional Bend of > 100 mr downstream to straighten out beam line

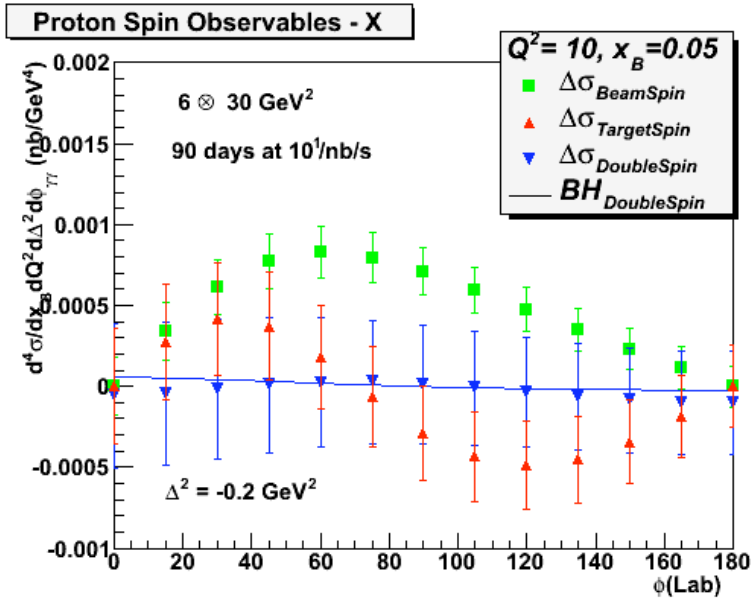
Interaction Point Region

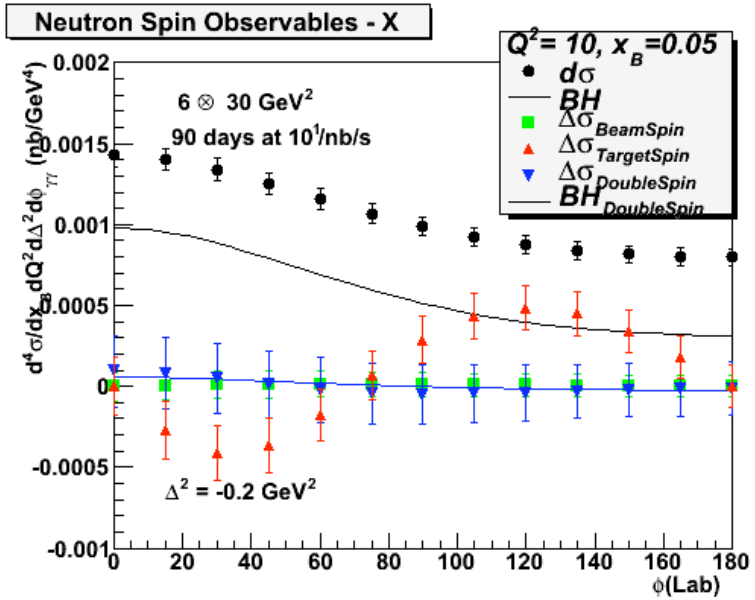


- Neutron spectators in ZDC
- Proton spectators tracked with Dipole

Sample Count Rates

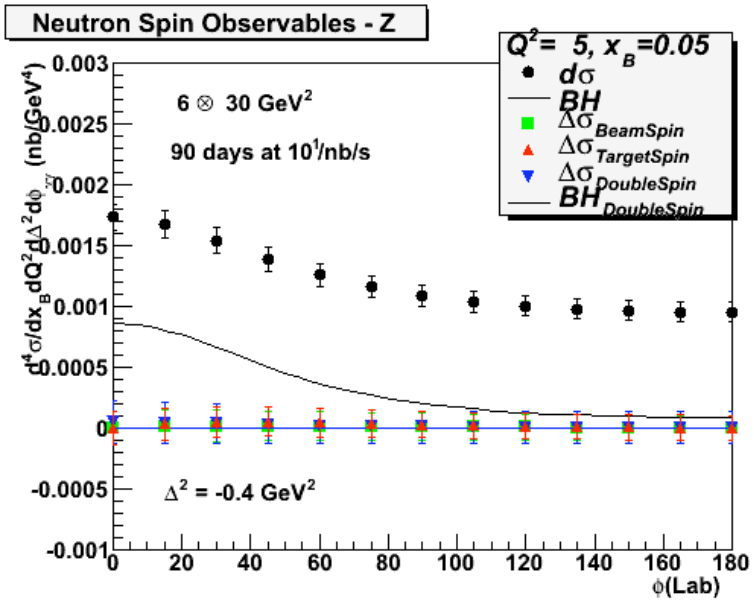


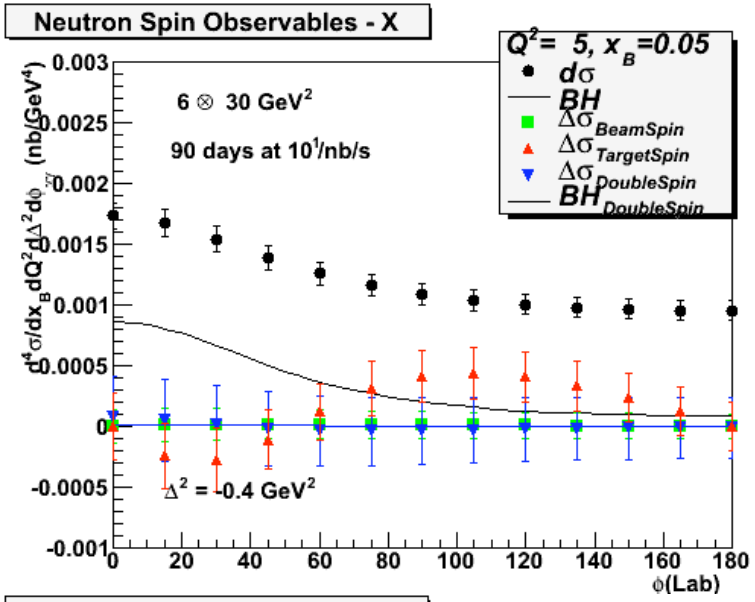


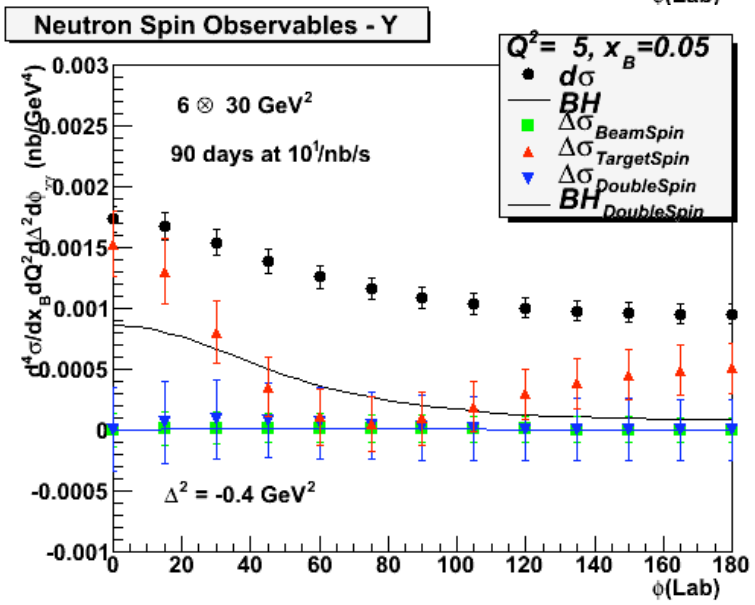


- L=10^{34}/cm^2/s
- $\Delta Q^2 = 0.4\ Q^2$
- $\Delta x_B = x_B/\sqrt{2}$
- Δt = 0.1 GeV^2.
- VGG code M. Guidal
  - Twist-2 only

Full Spin Observables

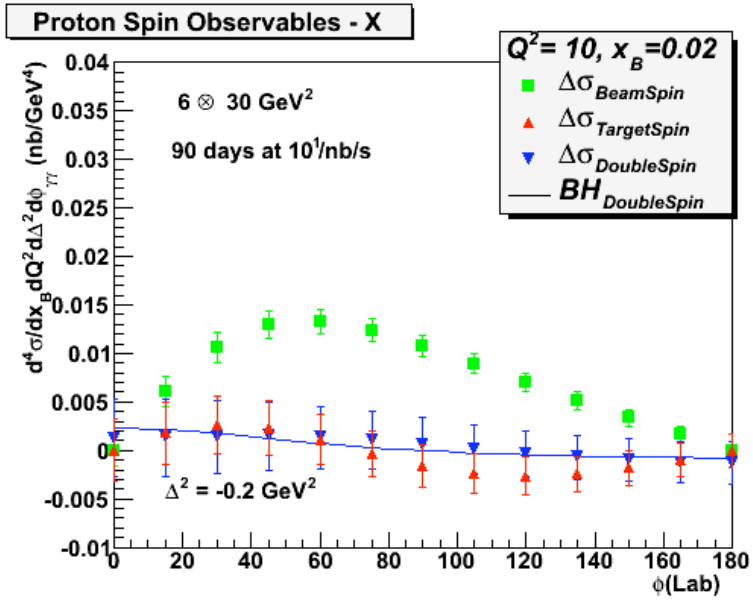


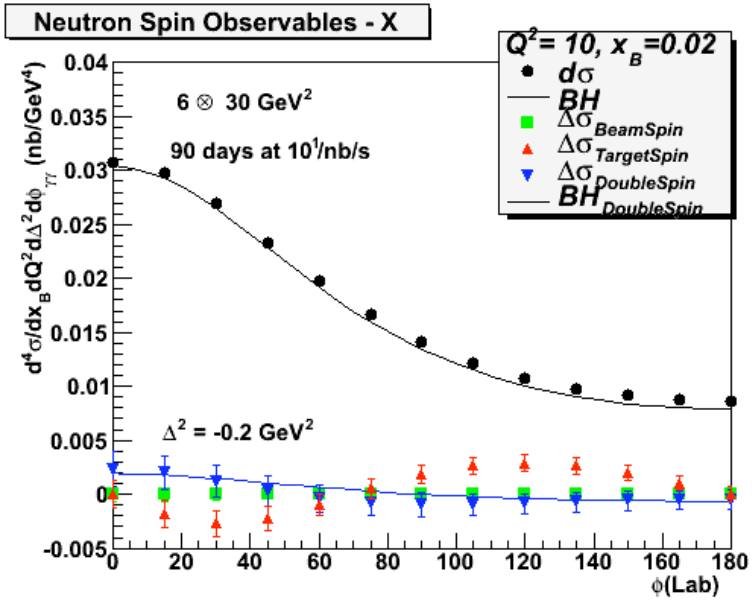


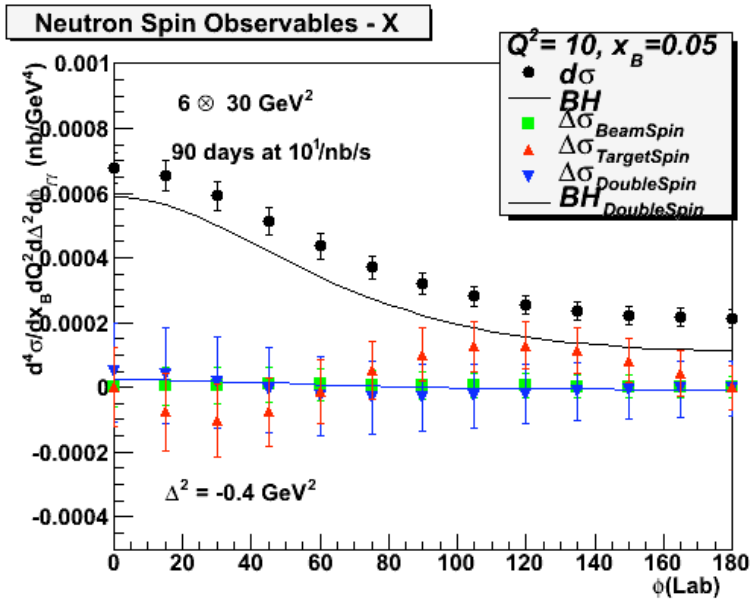


- Neutron
- Δ^2=−0.4 GeV^2.
- Count rates larger on bound proton

x_B dependence







- Spin observables are very model dependent
- "Zero" is an artifact of GPD parametrization.
- proton and neutron unpolarized cross sections dominated by BH at low x
  - Test for binding effects?

Conclusions

- Extensive program of DVCS on tagged protons and tagged neutrons is possible.
  - Complete spin observables
  - Fully differential cross sections.
- Design of forward tracking and Calorimetry needed
  - PID is less important for exclusive reactions, more important for SIDIS
- Need studies differential in initial momentum
  - (α, p_T)
- 10^{34} luminosity is minimum useful for $x_B \geq 0.02$