Simple Estimation of Single Pion Production Parity Violation Asymmetry

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Introduction

- Two Contributions needs to be considered:
  - Gamma-Z interferences term:
    - e- + N → Z + gamma →e- + Pi + X
  - W- exchange:
    - e- + N → W- →ν + X + Pi-
- Kinematics considered:
  - Negative Pions at 12.9 degrees @ 3.66 GeV

Neutral Current

- The Asymmetry for PVDIS electron is about 100 ppm * Q^2 ~ Q^2/Mz^2
- So one also expected that for the single pion production, the asymmetry is about Q^2/Mz^2
- Then the central question is to calculate the average Q^2 for the eletro-pion production.

For Electro-Pion Production

- One can use equivalent photon flux

$$\frac{d\sigma}{d\Omega_e dP_e} = \Gamma \sigma(\gamma N)$$

$$\Gamma \sim \frac{\alpha}{2\pi^2} \frac{E_e^{'}}{E_e} \frac{\nu}{Q^2}$$

- The average Q2 can be obtained as

$$< Q^2 >= \frac{\int Q^2 \Gamma d\Omega_e dP_e}{\int \Gamma d\Omega_e dP_e}$$

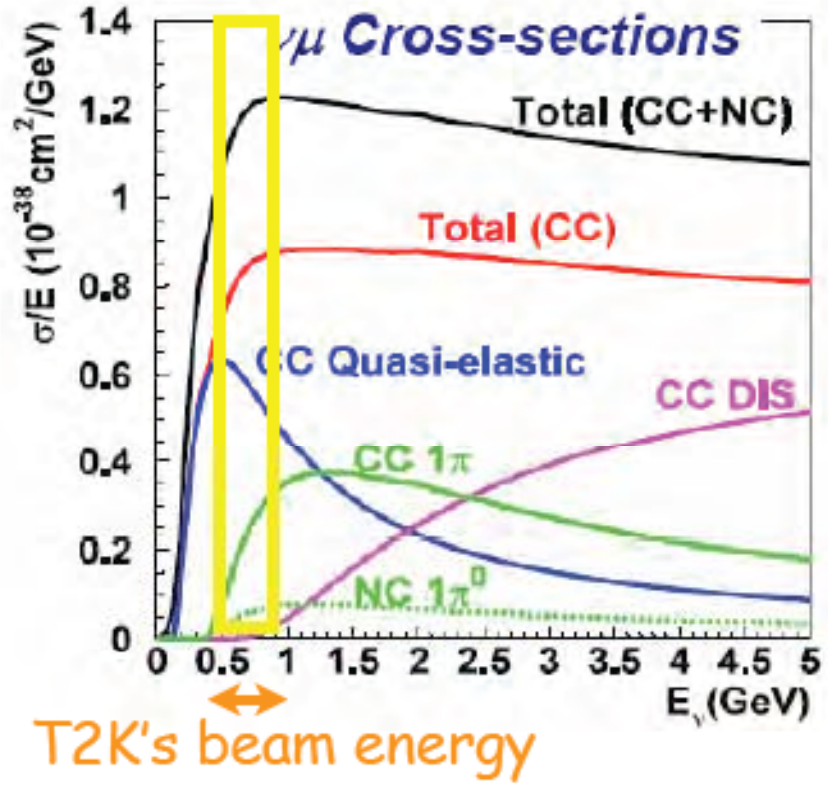
- Here, we assume the same photon-N scattering total cross section.

Simulation

- Uniform sample electron momentum and solid angle.
- Make sure the kinematics permit a pion to reach the desired kinematics:
  - 12.9 degrees @ 3.66 GeV
- Weighted by Gamma Flux and calculate average Q2.
  - Obtained <Q2> ~ 0.264 ~ 32 ppm
  - Assuming a 120 pm in PVDIS electron for Q2 @ 1 GeV^2.

Charge Current Part

- We know the neutrino charge exchange total cross section 0.7 Ebeam (GeV) * 10e-38 (cm^2/GeV) = 4.2 * 10e-14 barn @ 6 GeV

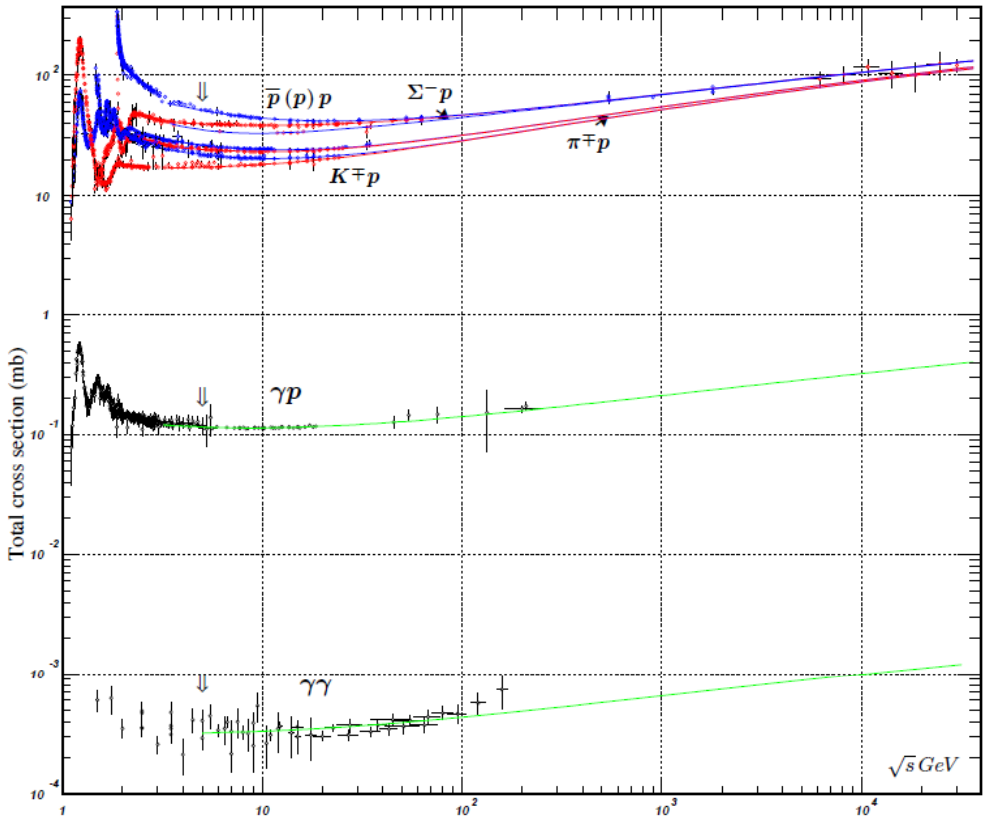


For Electro-Pion Cross Section

$$\frac{d\sigma}{d\Omega_e dP_e} = \Gamma \sigma(\gamma N)$$

$$\Gamma \sim \frac{\alpha}{2\pi^2} \frac{E_e^{'}}{E_e} \frac{\nu}{Q^2}$$

- Total gamma-N Pion production total cross section is about 0.9e-4 barn.



Based on the same simulation

- We can calculate the expected virtual photon flux

$$< \Gamma >= \frac{\int \Gamma d\Omega_e dP_e}{\int d\Omega_e dP_e}$$

- Average Gamma = 4.67e-5
- Total flux is 4.67e-5 * 6. * 4. * 3.1415926
  - After multiply solid angle = 3.5e-3

Combine all the numbers together

$$A = \frac{N_{CC}}{2N_{eN}} \sim \frac{2 \cdot \sigma^{\nu}_{CC}}{2 < \Gamma > 4\pi E_e \sigma_{\gamma N}}$$

- A_PVDIS = 2 * 4.2e-14 / 0.9e-4 / 3.5e-3 / 2. ~ 0.13 ppm
  - Here the first 2 takes into account that 2 interaction for neutrino can happen in both proton and neutron. And photon production probably dominated by neutron.
  - Here the last two is taken into account the factor that sum of two states in the denominator of the asymmetry.
  - We did not take into account the possible effect from phase space, but the estimation is probably good to order magnitude estimation.

Summary

- Based on this simple estimation:
  - We conclude that the contribution from charge exchange is about 0.1 % level of PVDIS electron asymmetry. (probably also negligible after taking into account amplitude).
    - 0.15 ppm vs. 120 ppm.
  - We conclude that the contribution from neutral current exchange is about 27% of PVDIS electron @ 1 GeV2
    - 32 ppm vs. 120 ppm.