Neutral Pion DIS Multiplicity with CLAS12 Data

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Outlook

- Multiplicity: Brief Motivation
- CLAS12: Detector Overview
- Data Selection.
- Preliminary analysis Multiplicity vs z
- Preliminary analysis Multiplicity vs PT
- Future plans
**Semi Inclusive Deep Inelastic Scattering (SIDIS):**

The four-vector of the measured hadron can give us information on the proton’s structure.

\[ \sigma^{ep\rightarrow ehX} = \sum_{q} DF \otimes FF \]

**Structure Function:**  \( F \propto DF \otimes FF \)

**Partonic Distribution Function**  
**Fragmentation Function**
Observable: Multiplicity

Multiplicity:

\[ m^h(Q^2,x,z,P_{hT}^2) = \frac{d\sigma^h_{\text{SIDIS}}/dQ^2 \, dx \, dz \, dP_{hT}^2}{d\sigma^h_{\text{DIS}}/dQ^2 \, dx} \]

SDIS:

\[ e(l)P(P) \rightarrow e(l')h(P_h)X \]

hadron production plane

lepton scattering plane

Kinematics factors drops in the ratio. Information on the FF can be extracted from it.

Assuming Gaussian distributions in \( k_T \) and \( p_T \)

\[ m_N^h(x,z,P_{hT}^2) = \frac{\pi}{\sum_a e_a^2 f_1^a(x)} \sum_a e_a^2 f_1^a(x) \frac{D_{1-h}^a(z)}{\pi(z^2(k_{1,a}^2) + (P_{1,a-h}^2))} e^{-P_{hT}^2/(z^2(k_{1,a}^2) + (P_{1,a-h}^2))} \]
At large $x$ (sea contribution can be neglected) the multiplicity should follow $z$-dependance of FF (after PT integration).

Fragmentation function for $u$ and $d$ quarks are the same at first approximation.

Suppression of spin-dependent fragmentation function for $\pi^0$ since Collins FF has roughly equal magnitude but opposite sign in up and down quarks.

Suppression of higher-twist contributions at larger energy fraction (important at Jlab energy where small $z$ are contaminated by target fragmentation).

Absence of $\rho^0$ production that complicates the interpretation of charged single pion data.

In exclusive production the longitudinal photon contribution is suppressed with respect the transverse photon contribution which is higher twist. This suggest that longitudinal photon contribution to SIDIS will be also suppressed.
CLAS12 Detector Overview

Forward Detector:
- Torus magnet
- Drift Chamber system
- Forward ToF System
- LT Cherenkov Counter
- HT Cherenkov Counter
- RICH
- Preshower calorimeter
- E.M. calorimeter (EC)
- Forward Tagger (FD)

Central Detector:
- Solenoid magnet
- Barrel Silicon Tracker
- Central Time-of-Flight
- Micromegas
- Neutron detector

Number of readout channels ~100,000

https://www.jlab.org/Hall-B/clas12-web/
CLAS12 Detector Overview

Installation Completed at the end of 2017

Target used: Unpolarized Liquid Hydrogen. Polarized electron beam (85% of polarization) E = 10.6 GeV

\( L = 10^{35} \text{ cm}^{-2} \text{ s}^{-1} \)

For this analysis: **Forward Detector**

- \( e' \) ID: Track, FTOF, HTTC, PCAL
- \( \gamma \) ID: \( \beta \) PCAL

Very preliminary results based on < 1% of the data collected. The data were processed with a preliminary reconstruction algorithm. The collaboration has improved and updated these algorithms and is processing a large data sample. In the future weeks I will extend this analysis to 10% of RUN- Group A.

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Data Selection: Scattered Electron Cuts

FIDUCIAL CUTS:

- EC Included
- EC Excluded
- DC Included
- DC Excluded

Data Sample:

SIDIS: \( eP \rightarrow e' \pi^0 X \)

DIS: \( eP \rightarrow e' X \)

Forward Calorimeter sampling fraction for electrons
Data Selection: Scattered Electron

\[ Q^2 > 1 \text{ GeV}^2 \]
\[ W > 2 \text{ GeV} \]
\[ y < 0.80 \]

**MC:**
CLASDIS LUND Generator
Based on LEPTO-PEPSI

Hadronization:
Lund String Model

Reconstructed electrons kinematics
Data vs MC Kinematics

- Electron $Q^2$ distribution
- Electron $W$ distribution
- Electron $x$ distribution
- Electron $y$ distribution

Preliminary
Reconstructed photons

Photon selections

- Photon Energy $> 400$ MeV
- Photon with angle $> 2^\circ$ with respect e’

Cal. Sector Uniformity

Photons invariant mass for each CLAS sector (Data)

- Sector 1
- Sector 2
- Sector 3
- Sector 4
- Sector 5
- Sector 6

Cal. Sector Uniformity

$\sigma = 11.5$ MeV
Data divided in z bin (size 0.1)
0.2 < z < 0.9
Each bin has been fitted with: Gauss + Poly 3rd
π0 s obtained from the gaussian integral

Two methods:
- Combination of all photons pair in event
- The 2 most energetic photons of the event

π0 Reconstruction in Z bins

Efficiency w. Acceptance:
π0s reconstructed from MC (within the cuts)

π0s generated (4π)

Combination of all photons pair in event
The 2 most energetic photons of the event
Statistical uncertainty

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Multiplicity of Neutral Pions Electroproduction

Preliminary Neutral Pion Multiplicity (0.1% of the statistic)

- Combinatory
- Statistical uncertainty
- DSS LO
- DSS NLO

No systematics in the plot!
π0 Reconstruction in Pt bins

Data divided in Pt bin from 0.2 to 1GeV/c
Each bin has been fitted with: Gauss + Poly 3rd
π0 s obtained from the gaussian integral

Efficiency w. Acceptance:
π0s reconstructed from MC (within the cuts)
π0s generated (4π)

![Graphs showing acceptance vs. Pt for different bins](image)
π0 Reconstruction in PT bins

π0 Multiplicity vs Pt

Gaussian Fit

<table>
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<th>Name: $f_{1d}$</th>
<th>$a$</th>
<th>$s$</th>
<th>$\chi^2/\text{ndf}$</th>
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PRELIMINARY

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Next Steps: Towards Multi Dimensional Analysis

- Getting more statistic.
- Improving the fits

Obtained on <1% of the data sample. We will have statistics for a truly multidimensional analysis.

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Conclusions

Both the $Z$ and PT distribution of neutral pion multiplicity look reasonable even if very preliminary data have been used for this analysis.

In the next months the analysis will be done with better quality data and higher statistics. Results will be obtained in multi dimensional bins.

By the end of this year I am planning to conclude this analysis and move to charged particles.