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Report on Doctoral Thesis by Ms. Marketa Peskova, "Proton structure studies using hard exclusive processes at COMPASS experiment."

It's my great pleasure to review and evaluate Ms. Marketa Peskova's Doctoral thesis titled, "Proton structure studies using hard exclusive processes at COMPASS experiment." It's an excellent piece of work and a well-written thesis. The main objective of the thesis is to study the 3-dimensional structure of the nucleon by extracting the differential cross-section of the hard exclusive π^0 production as a function of the four-momentum transfer $|t|$ and the azimuthal angle ϕ in the kinematic domain of average $x_B \sim 0.134$ using the muon beam momentum of 160 GeV and unpolarized liquid hydrogen target with the COMPASS spectrometer at CERN. The measurement employed the recoiled proton time-of-flight detector CAMERA surrounding the target combined with the spectrometer, which detected the scattered muon and the π^0 from its decay into two photons.

One of the major goals of this thesis work is to study Generalized Parton Distributions (GPDs) which help understand the three-dimensional (3D) structure of the nucleon in terms of its quark and gluon fields. During the past decade, the handbag mechanism has become the leading theoretical approach for extracting nucleon quark and gluon structure from exclusive reactions, such as deeply virtual Compton scattering (DVCS) and hard exclusive meson production (HEMP). In this approach, the quark distributions are parameterized in terms of GPDs, which contain information about the distributions of both the longitudinal momentum and the transverse position of partons in the nucleon. Most of the reactions studied, such as DVCS or hard exclusive vector meson production, are, at leading order, primarily sensitive to the chiral even GPDs. The chiral- odd GPDs are difficult to access, since subprocesses with a quark helicity-flip are suppressed. However, a complete description of nucleon structure requires the knowledge of the chiral-odd GPDs as well as chiral-even GPDs. Exclusive hard pseudoscalar meson production, and in particular π^0 meson production in the reaction $\mu p \rightarrow \mu' p' \pi^0$, is especially sensitive to the quark helicity-flip subprocesses.

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In this thesis, she performed the calibrations on the electromagnetic calorimeters, and discussed and reported the issues that were raised during the process. She reported the luminosity determination, selection criteria for the π^0 candidates in the experimental data, and simulations used to estimate the background. She presented the procedure of inspecting the data quality, the selection of the events, and the steps of the analysis including acceptance corrections. Then, she extracted the exclusive π^0 differential cross sections, evaluated the systematic errors, and fitted the ϕ-modulation of the differential exclusive π^0 production cross section to extract the structure functions $\sigma_T + \varepsilon\sigma_L$, σ_{TT} and σ_{LT}. One comment I would like to make is about lack of discussions on radiative corrections, especially its impact on ϕ modulations of differential cross sections when σ_{TT} is very strong. The strong contribution of the transverse cross section amplitude σ_{TT}, observed at COMPASS in the 2012 pilot run and CLAS 6 GeV at Jefferson Lab was confirmed. The primary focus is its interpretation within the framework of the handbag model, and its sensitivity for accessing the chiral-odd (quark helicity flip GPDs). Within the handbag interpretation, the results appear to confirm the expectation that pseudoscalar, and in particular hard exclusive π^0 production is a uniquely sensitive process to access the chiral odd GPDs.

In summary, the thesis contains an original contribution to knowledge in the field. The argument is clear, logical and coherent. She demonstrated a critical understanding of the problems. The methodology she used is sound, appropriate for the research subject she tackled, and applied correctly. She performed the accurate and precise error assessment and produced the impressive quality of the results. The thesis is well-written, with clear language and proper citation style. Figures, tables, and other elements are clear and well-presented. I recommend the thesis for acceptance by the faculty and grade it as excellence (summa cum laude).

Sincerely yours,

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