PoS PROCEEDINGS OF SCIENCE

The COMPASS-II program

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The COMPASS experiment at CERN uses either muon or hadron beams with a longitudinally or transversely polarized solid target, liquid hydrogen or heavy nuclear targets for study of hadron structure and hadron spectroscopy. The COMPASS Collaboration has recently submitted a proposal for additional measurements in the next years and the proposal was approved by the CERN Research Board. The proposal consists of three main parts: 1) nucleon structure study via Drell-Yan process using a negative pion beam and transversely polarized proton target 2)nucleon structure study in exclusive positive and negative muon beam scattering off the unpolarized proton target 3)test of the chiral perturbative theory predictions via reactions of Primakoff scattering using hadron beam.

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1. The COMPASS experiment

COMPASS is a high-energy physics experiment at the secondary beams of Super Proton Synchrotron at CERN [1].The purpose of the experiment is the study of hadron structure and hadron spectroscopy with high intensity muon and hadron beams [2]. The COMPASS detector consists of two spectrometers built around dipole magnets in order to detect particles scattered at large and small angles, respectively. It is equipped with a large number of precise tracking detectors, two electromagnetic calorimeters, two hadron calorimeters and particle identification system including RICH and two muon walls. Layout of a target region can be optimized for particular measurement. COMPASS operates with muon and hadron beams with momentum up to 280 GeV/c. During the first phase (2002-2011) of the experiment the longitudinal and transverse nucleon spin structures were studied via deep inelastic scattering with muon beam of high intensity. Production of hadron resonances via diffractive scattering, central production and photon exchange using pion and proton beams and hydrogen, tungsten, lead and nikel targets were also studied. Possible extension of COMPASS physic program is described in the COMPASS-II Proposal [3] which was approved by the CERN Research Board for the period of three years starting since 2012. It consists of three general directions: tests of chiral perturbative theory, GPD program and Drell-Yan program.

2. GPD program

The recently developed theoretical framework of Generalized Parton Distributions (GPDs) embodies both form factors and PDFs, such that GPDs can be considered as momentum- dissected form factors which provide information on the transverse localization of a parton as a function of the fraction it carries of the nucleon's longitudinal momentum. Obtaining such a "3-dimensional picture" of the nucleon is sometimes referred to as "nucleon tomography". At COMPASS GPDs can be accessed by measuring the cross section of exclusive deeply virtual Compton scattering (DVCS), $\mu + p \to \mu + \gamma + p$, or deeply virtual meson (M) production (DVMP), $\mu + p \to \mu + M + p$. For this study COMPASS plans to use $\mu^{\pm}$ beam of 160 GeV/c and 2.5 m long LH_2 target surrounded by a recoil proton detector. Two already existing electromagnetic calorimeters will be supplemented by a new calorimeter with large aperture. After 70 days of data taking with μ^+ and 210 days with μ^- beam accumulated statistics will correspond to integrated luminosity L$= 10^{32}$ cm^{-2}. The kinematic domain accessible at COMPASS cannot be explored by any other facility in the nearest future. High-statistics data on semi-inclusive deep inelastic scattering (SIDIS) on the proton will be recorded simultaneously with the DVCS and DVMP measurements.

3. Drell-Yan program

The transverse momentum of partons inside nucleons is a central element in understanding the 3-dimensional structure of the nucleon. When this intrinsic transverse momentum is taken into account, several new parton distribution functions (PDFs) are required to describe structure of the nucleon. The Drell-Yann (DY) process provides possibility to access convolution of PDFs of beam and target hadrons (in contrast to SIDIS where the cross section contains convolutions of PDFs and fragmentation functions). Of particular interest are the correlations between quark transverse momentum and nucleon transverse spin, and between quark transverse spin and its transverse momentum in an unpolarized nucleon, which are encoded in the so-called Sivers and Boer-Mulders functions. The Sivers and Boer-Mulders PDFs are T-odd functions, therefore when measured in DY they should have the same values but opposite signs than in SIDIS. COMPASS provides unique opportunity to test this QCD prediction because SIDIS and DY measurements can be done at the same setup and in intersecting kinematic ranges. For Drell-Yan studies COMPASS will operate with 190 GeV/c π^- beam of high intensity (up to 10^8 s^{-1}) and transversely polarized NH_3 target. Hadron absorber will be installed just downstream the target to stop both secondary hadrons and unscattered beam pions to prevent their decay into muons. J/ψ peak can be used as a monitoring signal. Safe range for dimuon masses, separated from $J\psi$ and Υ peaks is 4-9 GeV/c^2. In COMPASS kinematics the most of observed DY events correspond to annihilation of valence quarks into dileptons with p_t about 1 GeV and for these events TMD effects are dominant. Two years of data taking will allow to collect enough statistics (more than 200 000 DY events) to extract TMD PDFs and test the QCD prediction concerning the signs of Sivers and Boer-Mulders functions measured in DY. J/ψ production mechanism can also be studied in parallel.

4. Tests of chiral perturbation theory

The electric α and magnetic β dipole polarisabilities characterize the response of a meson, as a composite $q\bar{q}$ system, to external electromagnetic fields in the low-frequency limit. Clearly these are fundamental structure parameters of any meson, and the comparison between theoretically predicted and directly measured values provides a stringent test for various theoretical approaches, like χPT, dispersion sum rules, QCD sum rules and quark confinement models. COMPASS can access polarizabilities of charged pion and kaon via differential cross section of a Primakoff reaction $(\pi^-,K^-)+Z \to (\pi^-,K^-)+\gamma$. For this one plans to use a beam of negative hadrons (mainly pions and 3% of kaons) of 190 GeV/c and nickel target of 0.3 X_0 thickness. The COMPASS setup has silicon tracker to measure meson scattering angle precisely, electromagnetic calorimeter for a photon detection and for triggering and cherenkov threshold detector for K/π separation. Muon beam of the same momentum will be used as reference. After 90 days of data taking the values of $\alpha_\pi - \beta_\pi$ and $\alpha_\pi + \beta_\pi$ will be measured with statistical accuracy $< 0.3\times 10^{-4}$ fm^3 and $< 0.02\times 10^{-4}$ fm^3 correspondently. Quadrupole polarizabilities of the pion also will be probed. Kaon polarizability α_K can be measured for the first time under assumption $\alpha_K + \beta_K = const$ with accuracy about 0.04×10^{-4} fm^3. Study of other Primakoff reactions will provide strong test of χPT like $\pi^- + Z \to \pi^- + \pi^0 + Z$, $\pi^- + Z \to \pi^- + \pi^0 + \pi^0 + Z$, $\pi^- + Z \to \pi^- + \eta + Z$ can be performed in parallel.

References

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