Prospects for future measurements of GPDs using COMPASS at CERN

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Abstract

The COMPASS collaboration has expressed the interest for pursuing an experiment dedicated to the measurement of the Generalized Parton Distributions (GPD). The GPDs can be accessed through the reactions of Deeply Virtual Compton Scattering and Hard Exclusive Meson Production. The experiment will use the existing COMPASS spectrometer with a new target, a new recoil detector and an extended calorimetry. Simulations for different models have been performed and the beam charge asymmetry accessible at COMPASS has a great sensitivity to the GPD models. A prototype of recoil detector was tested and shows a timing resolution slightly above the required precision.

Key words: nucleon structure, Generalized Parton Distributions, COMPASS, recoil detector

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1. Motivations

The COMPASS collaboration has expressed the interest for pursuing an experiment dedicated to the measurement of the Generalized Parton Distributions (GPD) [1,2]. The GPD formalism provides a link between the spatial and the momentum distributions of partons inside the nucleon. Moreover, the second moment of GPDs gives access to the total angular momentum carried by partons through the Ji sum rule [3]. Hence, it can bring new insight on the nucleon spin puzzle.

2. Physics observables

The GPDs can be accessed through Deeply Virtual Compton Scattering and Hard Exclusive Meson Production. The use of the 100-190 GeV muon beam of the CERN SPS will give access to the kinematical domain where both valence, sea quarks and gluons are involved ($0.01 < x_{Bj} < 0.3$). The goal of the experiment is to measure the cross section as well as spin and charge asymmetries as a function of x_{Bj}, Q^2 and t, the squared momentum transferred to the proton. At 190 GeV, the DVCS process is dominant over the competing Bethe-Heitler process and the cross section can be measured. At 100 GeV, the possibility to use muon beams of opposite charge and polarization will allow to measure the charge and spin asymmetries arising from the interference between the DVCS and the Bethe-Heitler process. These observables have great sensitivity to GPD models [4,5]. Hard exclusive meson production cross sections will also be measured providing a different quark flavor content.

3. Experimental realisation

The experiment will use the existing COMPASS spectrometer although several new detectors will have to be added. The interaction will take place in a 2.5 m long target filled with either liquid hydrogen or liquid deuterium. The target will be surrounded by a time-of-flight measuring device for the detection of recoiling particles such as protons and pions. It will consist of two concentric barrels of scintillator counters read at both sides. Additional layers of lead scintillator sandwich shall also be added for the detection of photons and improved neutrons detection. This detector will ensure the exclusivity of the process with particle identification capability. It will also provide a measurement of the recoiling proton momentum to a precision of a few percent.

In the case of DVCS, the photon will be detected in the existing forward calorimeters. A wide-angle calorimeter covering lab angles up to 20 degrees will be added in order to improve the acceptance at high x_{Bj} and to insure a better separation between single photon and neutral pion productions.

The background induced by the passage of the beam through the target will yield rates of the order of a few MHz in the scintillator counters. This prevents the use of a hardware trigger. A possible solution is to use the existing DIS inclusive trigger and to sample and record the information of the waveform of the recoil detector PMTs with a 1GHz frequency over a 150 ns long window. Simulations have shown that an efficiency for proton detection of 90% can be achieved with a purity of 80% under COMPASS nominal beam intensity. The sampler module has to be designed with the strong requirement that it does not add dead-time to the data acquisition.

4. Prototype tests

A recoil detector prototype was built and tested on the COMPASS beam line in order to validate the detection concepts. It is a 30 degree sector of the full detector. The length of the scintillator counters is 280 cm for the inner ring and 400 cm for the outer ring. With this device, a TOF resolution of 315 ps was achieved for particles hitting the central zone of the scintillator, while on the edge the resolution increases up to 380 ps. This resolution is higher than required for the experiment. It is mainly due to the low number of photons produced in the 4 mm thin A counter. In order to overcome this effect we are now looking into the possibility to use the timing of the incident and scattered muons and the vertex reconstruction. This method could also be used for the detection of slow recoiling neutron when a deuterium target is used.

5. Conclusions

The COMPASS collaboration has expressed the interest for pursuing an experiment dedicated to the measurement of the Generalized Parton Distributions (GPD). The GPDs can be accessed through the reactions of Deeply Virtual Compton Scattering and Hard Exclusive Meson Production. The experiment will use the existing COMPASS spectrometer with a new target, a new recoil detector and an extended calorimetry. Simulations for different models have been performed and the beam charge asymmetry accessible at COMPASS has a great sensitivity to the GPD models. A prototype of recoil detector was tested and shows a timing resolution slightly above the required precision.

A proposal for the experiment is being written and further studies are in progress. After approval, the construction phase will last 2-3 years and data taking could be started with the full set-up around 2010.

References

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