CHARM PRODUCTION AT HERMES

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Charm production in polarised lepton nucleon scattering is believed to be a clean probe of the nucleon spin contribution ΔG carried by gluons. An extensive search for charm signals has been carried out in the HERMES data of the years 1995 to 1997. Clean signals for both hidden and open charm could be extracted. A preliminary measurement of the J/ψ cross section near threshold is presented. In the shutdown of 1997/98 major detector upgrades have been implemented, which will significantly improve the physics potential of HERMES in the charm sector.

Presently, a direct measurement of the gluon contribution ΔG to the nucleon spin is one of the most urgent tasks in high energy spin physics. In polarised lepton nucleon scattering a measured asymmetry $A_{LL}^{\gamma g}$ for the photon gluon fusion process can be related to $\Delta G/G$ via

$$A_{LL}^{\gamma g} = \frac{N_{\uparrow\downarrow}^{\gamma g} - N_{\uparrow\uparrow}^{\gamma g}}{N_{\uparrow\downarrow}^{\gamma g} + N_{\uparrow\uparrow}^{\gamma g}} = \frac{1}{DfP_bP_t}\,\hat{a}_{QCD}^{\gamma g}\frac{\Delta G}{G}$$

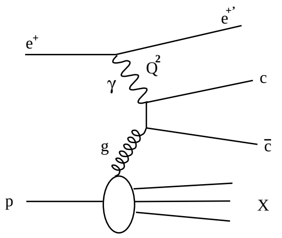

Figure 1: Charm production in leading order QCD via photon gluon fusion.

with $\hat{a}_{QCD}^{\gamma g}$ being the analysing power of the elementary QCD process. The effective polarisation of the experiment is determined by the product of beam and target polarisation $P_b{\cdot}P_t$, the photon depolarisation factor D and a possible target dilution f. Charm production proceeding via photon gluon fusion (Fig.1) can be used to access $\Delta G/G$, since the mass of the charm quark provides the hard scale of the process. For open charm production the two c-quarks fragment into $D(c\bar{q}, q\bar{c})$ mesons. In case of the $J/\psi(c\bar{c})$ several processes have to be distinguished. The inelastic production is described by the Colour Singlet Model [1], where a colour neutral state is formed by the emission of a second hard gluon. Additionally, a significant contribution from elastic J/ψ vector meson production has to be considered. From s-channel helicity conservation one would expect no dependence on ΔG for this process. Small asymmetries are predicted by models describing the hard elastic process as exchange of two gluons [2].

An extensive search for charm signals has been carried out in the data of the years 1995 to 1997 to evaluate the capabilities of the HERMES experiment to provide information on $\Delta G/G$.

The HERMES spectrometer [3] is well suited in terms of particle identification and trigger to detect the decay $J/\psi \to e^+e^-$. The decay particles of the J/ψ generate a trigger even in the absence of the scattered positron; the $e^{\pm}$ vs. hadron separation is very good. The decay channel $J/\psi \to \mu^+\mu^-$ became accessible only after a trigger upgrade, tested in 1996 and fully implemented in 1997. Up to 1998 muon identification could be achieved only by requiring minimum ionising signals in the calorimeter and the preshower detector. A clear signal in both di–leptonic J/ψ decay channels has been extracted from the 1995–1997 data. Figure 2 shows the invariant mass spectrum for the combined signal of ~140 events over a background of ~ 40. The signal is small, since HERMES is not designed for the detection of charmed final states and is restricted to J/ψ production near threshold by the beam energy of 27.5 GeV. The acceptance for J/ψ is as low as 10%. Data have been collected on various target gases; two thirds of the statistics are from unpolarised targets. The J/ψ's are dominantly produced at low Q^2 with the scattered positron remaining inside the beam pipe, preventing the full reconstruction of the event kinematics and the separation of different production mechanisms.

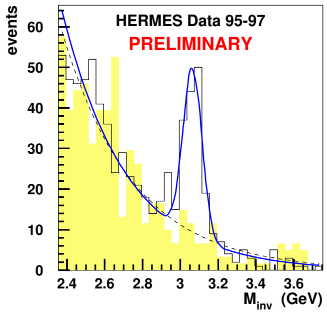

Figure 2: Invariant mass spectrum combined for $J/\psi \to e^+e^-$ and $J/\psi \to \mu^+\mu^-$.

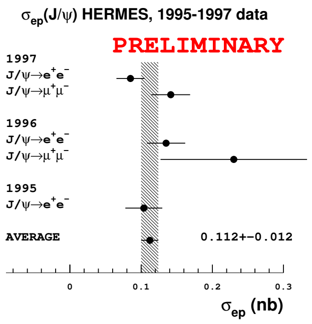

Figure 3: J/ψ electroproduction cross section separated by decay channel and year.

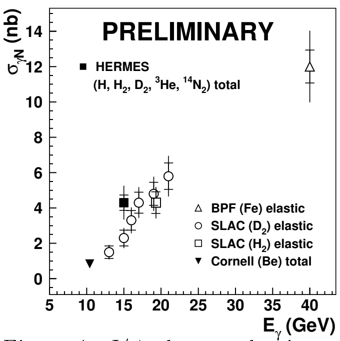

Figure 4: J/ψ photoproduction cross section compared to other experiments.

The behaviour of the charm production cross sections near threshold is an intrinsically interesting subject. Figure 3 shows the total electroproduction cross section separated by year and decay channel. Despite the different trigger and particle identification, the two decay channels agree very well within errors. The preliminary average is $\sigma_{ep}^{J/\psi}[E_e = 27.5 \text{ GeV}] = (0.112 \pm 0.012)$ nb. This value can be converted into a photoproduction cross section $\sigma_{\gamma p}^{J/\psi}[E_\gamma = 15 \text{ GeV}] = (4.3 \pm 0.5)$ nb [4]. The preliminary systematic uncertainty is 20%. In figure 4 this result is compared to world data near threshold, mainly for elastic J/ψ production from experiments using real photon beams.[5 6 7 8]

The analysis of open charm production to extract $A_{LL}^{\gamma g}$ is preferable for several reasons. The fragmentation to charmed mesons is well understood. A higher cross section and decay channels with sufficient branching ratio allow larger signals to be detected. However, due to the high combinatorial background and the so far limited hadron identification, no clean signal was found in $D^0 \rightarrow K\pi$ or in semileptonic D^0 decays. Still, a small but significant signal could be extracted for the decay $D^\star \rightarrow D^0\pi$ by tagging the missing mass (fig. 5).

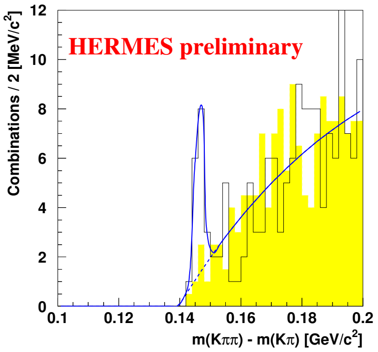

Figure 5: Missing mass spectrum $M(K\pi\pi) - M(K\pi)$ for the process $D^\star \rightarrow D^0(\rightarrow K\pi)\,\pi$.

In summary, the present HERMES charm data samples are small, but well understood. Several detector upgrades have been introduced for the 1998 running. Clean $\pi/K/p$ separation by a RICH allows direct $D^0 \rightarrow K\pi$ reconstruction. Semileptonic $D^0 \rightarrow \mu\nu K$ decays may be accessible by a muon detector. A small angle detector enhances the acceptance of the scattered electron at low Q^2. With the help of these upgrades, charm production at HERMES may allow access to information on $\Delta G/G$.

References

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