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HERMES EXPERIMENT AT HERA COLLIDER

PNPI participants of HERMES collaboration:
S. L. Belostotski, G. E. Gavrilov, O. G. Grebenyuk, A. A. Izotov,
A. A. Jgoun, A. Yu. Kisselev, A. G. Krivshich,
S. I. Manayenkov, O. V. Mikloukho, Yu. G. Naryshkin

The experiment HERMES was designed to measure spin-dependent structure functions g_1 and g_2 of the proton and the neutron in deep inelastic scattering of the polarized 27 GeV electrons (positrons) of the HERA collider on a polarized gas target.

Experimentally, g_1 and g_2 can be separated by measuring two spin asymmetries related to the longitudinal and transverse target polarizations. Precise determination of g_1 and g_2 is of particular importance for verification of the Ellis-Jaffe [1] and fundamental Bjorken [2] sum rules.

The double spin asymmetries in the semi-inclusive hadron electroproduction are also measured with the help of the HERMES detector in order to directly separate the different quark flavour contributions to the nucleon spin. In semi-inclusive measurements, HERMES is superior to the other spin experiments. Thus the SLAC experiments E-142 and E-143 have no possibilities for semi-inclusive measurements and SMC in CERN has a very limited statistics in these measurements.

The most important and direct method of studying the helicity distributions of valence quarks makes use of the spin asymmetry differences for the production of the positive and negative pions in the reactions

$$\vec{e} + \vec{p} \rightarrow e' + \pi^{\pm} + X. \qquad (1)$$

Under assumption that the fragmentation process and the hard electron-quark collision are factorized and using the approximation of the independent quark fragmentation, all the fragmentation effects are ruled out in the measured pion asymmetries [3], [4] and spin-dependent u and d valence quark distributions can be deduced from the data.

In addition to the reactions with charged pions and kaons detected in coincidence with the scattered positrons, the reactions in which decaying particles are produced with a mean lifetime less than the time needed to pass through the detector, like π^0, ρ^0, K^0_S, ϕ and J/ψ mesons and Λ-hyperon, can be investigated.

The HERMES setup is described in [5], [6], [7]. The target is a thin-walled storage cell which is fed by a high intensity source of polarized H, D, and ^{3}He atoms providing the

target thickness of 10^{14}–10^{15} atoms/cm^2. Electron (positron) beam transverse polarization is typically 60% due to the Sokolov-Ternov effect [8]. Longitudinal electron beam polarization of 50% is obtained with the help of the HERA spin rotators.

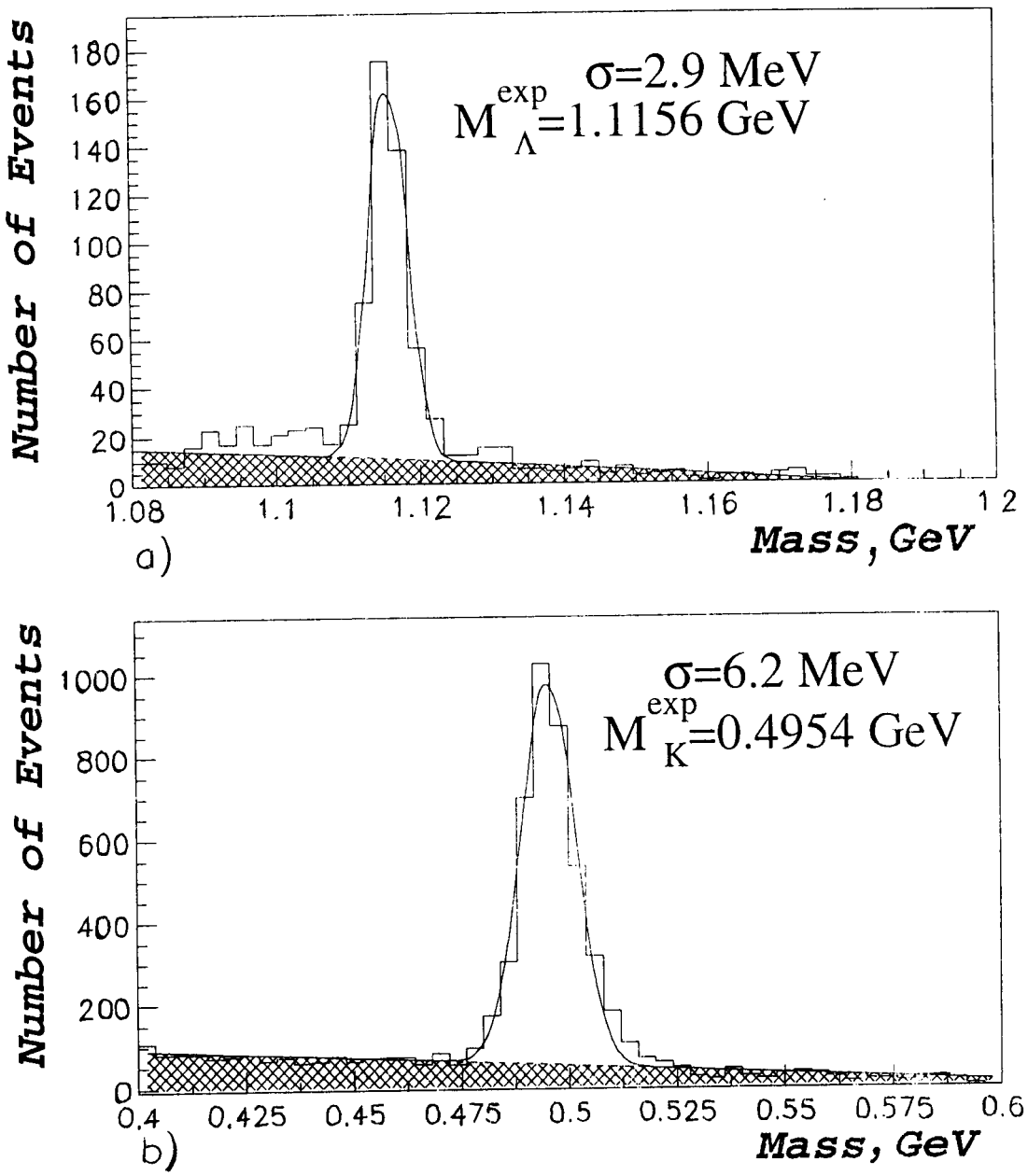

Fig. Invariant mass distribution for $\Lambda^0 + \tilde{\Lambda}^0$ (a) and K^0_S (b) production

The HERMES detector consists of a spectrometer magnet, tracking chambers, a transition radiation detector, trigger hodoscopes, and a calorimeter. The influence of the magnetic field of the HERMES magnet on the electron and proton beam dynamics has been minimized by the magnet mid-plane screening steel plate and in addition compensated for.

PNPI group in the HERMES experiment was responsible (together with INFN, Rome and MEA DESY) for the design and fabrication of the HERMES spectrometer magnet and for the proportional chambers situated in the magnet gap. Tracking information obtained by means of the proportional chambers is used for reconstruction of low momentum hadron tracks which is of particular importance for the reactions with Λ and K_S production.

The HERMES experiment was commissioned in May 1995. More than 10^7 deep inelastic scattering (DIS) events has been collected mostly using ^{3}He target with relatively high atom density of $\approx 10^{15}$ atoms/cm^2 and polarization of 50% .

In the analysis we (PNPI group) made our focus on the semi-inclusive DIS reactions

$$\vec{e} + \vec{p} \rightarrow e' + \Lambda^0(\tilde{\Lambda}^0, K_S^0) + X \qquad (2)$$

with $\Lambda^0(\tilde{\Lambda}^0, K_S^0)$ decay products proton and pion (antiproton and pion, two pions) detected in coincidence with HERMES trigger positrons. Three-track events were chosen with one track associated with the detected positron and two others with hadrons. The selection of $\Lambda^0(\tilde{\Lambda}^0)$ and K_S^0 has been mainly done by the requirement of the distance between positron interaction point in the target and the decay vertex to be larger than 3 cm, an averaged decay length being about 30 cm for Λ^0 and 25 cm for K_S^0. Narrow peaks (Fig.) in the hadron invariant mass distributions have been observed positioned at 1.1156 and 0.4954 GeV for $\Lambda^0(\tilde{\Lambda}^0)$ and K_S^0 respectively in a very good agreement with the Particle Data Group values. Having analyzed the data set taken during the 1995 year run of the HERMES experiment, we obtained 827 $(\Lambda^0 + \tilde{\Lambda}^0)$ events. The Λ^0 to $\tilde{\Lambda}^0$ ratio is found to be 3 to 1. The number of K_S^0 is 4818. The yields of Λ^0, $\tilde{\Lambda}^0$ and K_S^0 are expected to be increased by a factor of 3 each by including the events with low energy pions which do not give full tracks through the HERMES spectrometer. An attempt is undertaken to estimate longitudinal polarization transferred from the primary positron to the Λ-hyperon by measuring forward–backward asymmetry in its rest frame. The spin asymmetries related to the ^{3}He target polarization are also planned to be deduced from the 1995 year data for the above semi-inclusive reactions.

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