Project "Spectroscopy of Baryon Resonances and Photoproduction of Neutral Mesons"

Realized in the framework of the German scientific program "TRANSREGIO-16"

Experiments on the photoproduction of neutral mesons are carried out at the tagged photon beam of the electron accelerator ELSA (Bonn University) in the framework of the German scientific program "TRANSREGIO-16". One of main goals – a search for so called "missing" resonances, which cannot be extracted from the pion-nucleon data because their small πN coupling, Investigations of the photoproduction processes are complementary to experiments on πp scattering and are anticipated to give a new valuable contribution to spectroscopy of nonstrange baryons.

The experimental tool for studying these topics is the systematic measurement of photoproduction of single and multiple mesons off proton and neutron (with the use of a deuterium target) in various kinematical conditions. The experimental program is based on the unique combination of a photon beam with energy covering the completed resonance range and the photon spectrometer Crystal Barrel having almost 4π acceptance and high energy and angular resolutions for the final-state particles. This device, called now as CB–ELSA, with its excellent opportunities of detecting several photons and with the solid angle close to 4π, is an ideal instrument allowing to study simultaneously processes of the photoproduction of different neutral mesons: $\gamma p \to \pi^0 p$, $\gamma p \to \eta p$, $\gamma p \to \pi^0\pi^0 p$, $\gamma p \to \pi^0\eta p$ *et al*. by detecting from two to eight photons originated after decaying mesons produced in the above reactions.

The spectrometer CB–ELSA has a granular structure, it consists of 1380 CsI(Tl) crystals; the large angular acceptance allows to reconstruct multi-photon final states. To provide a possibility to detect and identify also charged particles (protons, deuterons), the detector made of scintillating fibres was inserted into the inner cavity of the Crystal Barrel.

During years 2000–2003, numerous runs of data taking were performed at energies of the incident electrons of 1400, 2600 and 3200 MeV; the energies of tagged bremsstrahlung photons are determined by characteristics of the tagging system and cover the diapason from 25% to 95% relatively to the incident electron energy. Main components of the tagging system are a photon-production target (radiator), a dipole magnet deflecting electron emitted the bremsstrahlung photons, in accordance with the momentum of this electron, and a detector for the reconstruction of electron's trajectory. The detecting part of the tagging system consists of 14 scintillation counters and two multi-wire proportional chambers. Besides, last time the tagging system was equipped additionally with an array of 500 scintillating fibres allowing to "tag" with a high efficiency photon fluxes up to 10^7 1/s.

During rather long period of data acquisition, a huge amount of valuable information was obtained. Processing and analysis of these data are underway, first publications started to appear since 2005.

But of especial importance are data obtained in experiments using both a polarized photon beam and a polarized target since polarization of beam and target play a key role in disentangling the high-mass spectrum of N^* and Δ resonances and different combinations of beam and target polarization provide the tools to identify different partial wave contributions. To realize such possibility, a serious upgrade of the experimental setup was performed during 2005–2006. The spectrometer Crystal Barrel, into the inner cavity of which a polarized target "with frozen spin" was inserted, was moved to another (DGH) beam-line; this allowed to put near the Crystal Barrel the cryogenic system for "pumping" the polarization. While upgrading, the Crystal Barrel was equipped with two additional forward detectors (Forward Plug made of 90 CsI(Tl) crystals and Mini-TAPS consisting of 216 BaF_2 crystals) which provide a high angular resolution when detecting particles emitted from the Crystal Barrel target at small angles. Also improved was the tagging system – owing to installing new scintillation counters as well as a new detector made of scintillating fibres the dynamic diapason of this system was widened and its energy resolution became higher. It is planned to start experiments at the upgraded setup at the first half of 2007.

Another advantage which will be got after moving the experimental setup to the DGH beam-line is a capability to combine the Crystal Barrel with the Bonn magnetic spectrometer; being set at zero degree (with a bore for passage of the photon beam) this spectrometer will be used for detection of charged particles and triggering, mainly in threshold reactions. The high momentum and position resolution allows one to use a high intensity untagged bremsstrahlung beam because in selected reactions the photon energy can be reconstructed from the complete observation of two body final state. In another mode of operation, this spectrometer will be used to detect electrons scattered at small angles in electroproduction experiments.