Strangeness photoproduction at the BGO-OD experiment

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The BGO-OD experiment at the University of Bonn's ELSA accelerator facility in Germany is ideally suited to investigate photoproduction at extreme forward angles. It combines a highly segmented BGO electromagnetic calorimeter at central angles and an open dipole magnetic spectrometer in the forward direction. This allows the detection of forward going kaons, and complex final states of mixed charge from hyperon decays.

Current projects at the BGO-OD experiment include strangeness production of $\gamma p \to K^+\Lambda/\Sigma^0$ at forward angles, $K^0\Sigma^0$ with a deuteron target and $K^+\Lambda(1405)$ line shape and cross section measurements.

Keywords: $\Lambda(1405)$; BGO-OD ; strangeness photoproduction.

1. Introduction

Hadron spectroscopy is used to investigate the degrees of freedom of the constituents of the nucleon. Since the conception of the quark model, there have been descriptions of baryons and mesons with more than three and two valence quarks respectively. Such hadrons could manifest as penta- and tetraquarks, or as meson-meson and meson-baryon molecular like states. Candidates for such exotic matter were found in recent years in the charm sector[1,2], and there is evidence that similar configurations may exist in the light, strange sector[3]. To study such effects in photoproduction experiments, access to a low momentum exchange region, where the meson is produced at forward angles is crucial.

The BGO-OD experiment at the University of Bonn's ELSA accelerator facility in Germany is ideally suited for this endeavor. It combines a highly segmented BGO electromagnetic calorimeter at central angles and an Open Dipole magnetic spectrometer in the forward direction. This allows the detection of forward going kaons, and complex final states of mixed charge from hyperon decays (see section 2). Preliminary results in current projects are shown in section 3 for $\Lambda(1405)$ production, in section 4 for $\gamma n \to K^0\Sigma^0$ and in section 5 cross section measurement of $\gamma p \to K^+\Lambda/\Sigma^0$ in the extreme forward regime. The presented results are only a handful of currently pursued projects.

2. The BGO-OD experiment

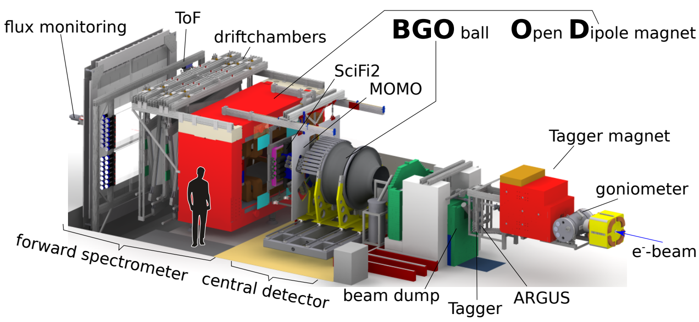
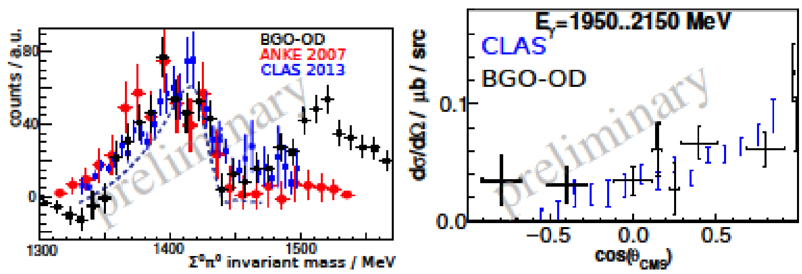


Fig. 1. Overview of the BGO-OD experiment.

The BGO-OD experiment, shown in figure 1, is located at the **E**lectron **S**tretcher **A**ccelerator (ELSA) facility in Bonn. ELSA is an electron accelerator with a quasi continuous beam up to 3.2 GeV[4]. The electron beam hits a radiator inside the goniometer tank, which creates a real photon beam via bremsstrahlung. The energy of the photons is determined by a measurement of the bremsstrahlung electron with the Tagger detector. The photon beam interacts with the target cell inside the BGO ball, which is filled with liquid hydrogen or deuterium. The final state particles of the reaction are detected with the BGO calorimeter using bismuth germinate oxide crystals between polar angles 25° to 155°. Charged particles traveling in $\theta < 12°$ are detected in the forward detector. The track trajectory before the open-dipole magnet is measured with the MOMO and SciFi2 scintillating fibre detectors, and the drift chambers measure the trajectory after the magnet. The measured track curvature is used to determine the momentum, while the ToF walls at the end of the experiment measure the velocity via time of flight.

3. Λ(1405) photoproduction

Since years it is speculated that the Λ(1405) has a molecular like structure of $N\bar{K}$[5,6]. Lattice QCD calculations give more support for the molecule like structure compared to a genuine three quark state[7,8]. BGO-OD is ideally suited to detect the $\Lambda(1405) \rightarrow \pi^0\Sigma^0$ decay. The preliminary results on the line shape of the $\pi^0\Sigma^0$ decay are compared to other experimental results in figure 2a, while figure 2b shows an energy bin of the measured differential cross section. The line shape and cross section agrees to the other experimental data within statistics, while the forward spectrometer allows the extension of the CLAS cross section to more forward angles.



(a) Line shape results for E_γ = 1500..2300 MeV. The dashed blue line marks the predictions by J.C.Nacher[6].

(b) differential cross section

Fig. 2. Preliminary results on $\gamma p \rightarrow K^+\Lambda(1405) \rightarrow K^+\pi^0\Sigma^0$. (a) shows the line shape, while (b) the differential cross section. Black points show the results of the full topology reconstruction and magenta for the K^+ in the forward detector. The blue data points were take from the CLAS experiment[9,10] and the red data from the ANKE experiment[11].

4. $K^0\Sigma^0$ with deuterium target

Previous measurements of the $\gamma p \to K^0\Sigma^+$ cross section showed a cusp over the K^*Y thresholds [12]. Similar models which predicted the pentaquark at LHCb, predict a rise in the $K^0\Sigma^0$ cross section at the exact same energy [3]. In these models a K^* is created below threshold, feeding the $K^0\Sigma^+$ cross section. At BGO-OD deuteron data was analyzed on the $\gamma n(p) \to K^0\Sigma^0(p)$ reaction by K. Kohl. The preliminary results are shown in figure 3. They show consistency with the predicted structure of the interaction.

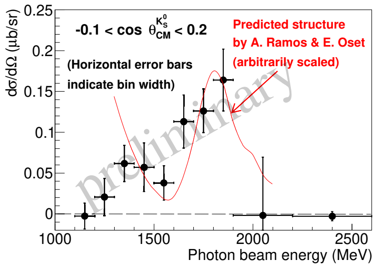
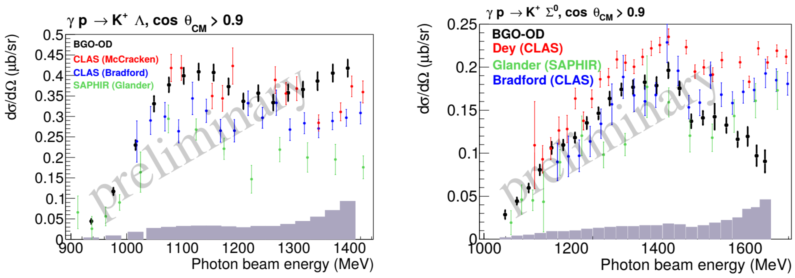


Fig. 3. Preliminary differential cross section on $\gamma n(p) \to K^0\Sigma^0(p)$ using a deuterium target. The red line shows the predictions for the total cross section [3].

5. K^+ at extreme forward angles

The $\gamma p \to K^+\Lambda$ cross section at forward angles is virtually unconstrained by data, which correspond to low transfer momentum, t [13]. Preliminary results on the $K^+\Lambda$ and $K^+\Sigma^0$ cross section in this kinematic regime were analyzed by T.C. Jude at BGO-OD and are shown in figure 4. BGO-OD experiment shows a high statistics compared to other experimental results in the forward region. The high angular resolution of the forward spectrometer allows to map out crucial regions at low t. The $K^+\Sigma^0$ cross section shows a apparent cusp close to multiple thresholds, which is still under investigation.



(a) $\gamma p \to K^+\Lambda$. Red data shows the CLAS results of McCracken [14].

(b) $\gamma p \to K^+\Sigma^0$. Red data shows the CLAS results of Dey [15].

Fig. 4. Differential cross section for γp to $K^+\Lambda$ (a) and $K^+\Sigma^0$ (b) for forward going K^+. Blue data shows the CLAS results of Bradford [16], while green shows the SAPHIR data [17].

6. Summary and Outlook

Current projects at BGO-OD investigate strangeness photoproduction. The here presented $\gamma p \rightarrow K^+\Lambda$, $\gamma p \rightarrow K^+\Sigma^0$, $\gamma p \rightarrow K^+\Lambda(1405)$ and $\gamma n(p) \rightarrow K^0\Sigma^0$ analyses are only a subset of the projects to come. The future projects will include K^* and hypernucleus production. Also non-strange analyses like the $\gamma p \rightarrow \eta' p$ are currently pursued.

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