Energy dependence of the cross section for $pp \to \{pp\}_s\gamma$ at intermediate energies at ANKE*

D. Tsirkov[1,2], T. Azaryan[1], S. Dymov[1,2], V. Komarov[1], A. Kulikov[1], V. Kurbatov[1],
G. Macharashvili[1,3], Yu. Uzikov[1] for the ANKE collaboration.

The deuteron photodisintegration $\gamma d \to pn$ is a testing ground of the existing models of NN interaction, see refs. in [1]. Much less is known on the similar reaction of diproton photodisintegration $\gamma\{pp\}_s \to pp$, where $\{pp\}_s$ is a proton pair in $^1S_0$ state. This reaction is more sensitive to the short range NN interaction because the $M1$ transition, which dominates $\gamma d \to pn$ via the $\Delta(1232)$ isobar excitation, is forbidden. Since two protons cannot form a nucleus, the diproton photodisintegration has only been observed with a diproton bound in ^{3}He and heavier nuclei, having large contamination from many-nucleon absorbtion.

The reaction $pp \to \{pp\}_s\gamma$ has been observed with the ANKE spectrometer at COSY-Jülich. It can be considered as inverse photodisintegration of a free $^1S_0$ diproton for photon energies $E_\gamma \approx T_p/2$. A cut on $E_{pp} < 3$ MeV was made to ensure that proton pairs are mainly in the $^1S_0$ state. Missing mass squared distributions show a clear peak at zero mass for proton beam energies of $T_p = 0.353$, 0.500 and 0.550 GeV [1]. Beam energies of 0.318, 0.625 and 0.800 GeV suggest much less confidence in the existence of the photon peak, but knowing the fact that $\{pp\}_s\gamma$ production actually takes place, these data were analyzed to get energy dependence of the cross section. The integral cross section of the reaction was determined in the range of c. m. angles $0° < \theta_{pp} < 20°$ according to the setup acceptance (see fig. 1).

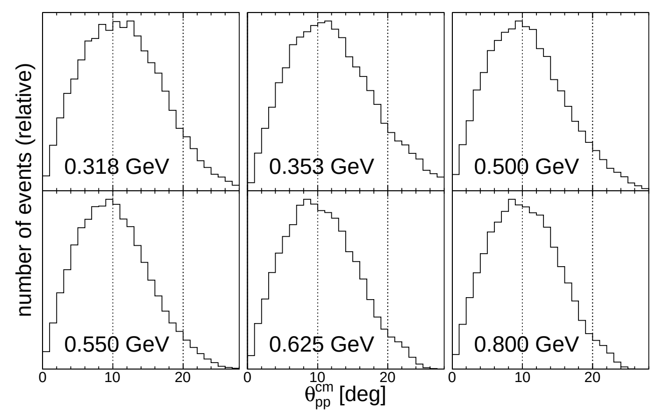

Fig. 1: Simulated setup acceptances for $pp \to \{pp\}_s\gamma$ for 0.318, 0.353, 0.500, 0.550, 0.625 and 0.800 GeV as a function of the diproton c. m. s. angle.

The number of $pp \to \{pp\}_s\gamma$ events was obtained by analyzing the missing mass spectra of the diproton. The procedure of obtaining these spectra is similar to that described in [1,2]. At the beam energy of 0.318 GeV very low statistics is available, allowing us to obtain only the upper limit of the cross section. Extraction of the photon peak for 0.625 and 0.800 GeV is much more complicated compared to [1], since the π^0 peak, which gives the main background, becomes wider, due to kinematical reasons, with increase of the energy. Pion and photon peak shapes were obtained by the Monte-Carlo simulation using program package GEANT3. An example for the procedure of extraction is shown in fig. 2. It is seen, that at 0.625 GeV introducing a photon peak significanly improves χ^2/ndf of the fit in the region around the zero mass: from 62/27 to 24/26. There is no such clear improvement for 0.800 GeV, therefore only the upper limit of the cross section can be estimated for this energy.

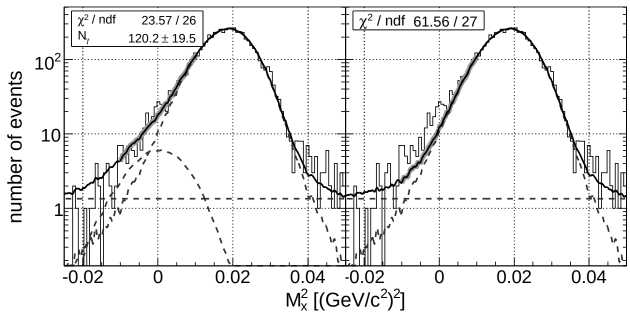

Fig. 2: Example of fitting the missing mass squared distribution for 0.625 GeV (left). Fit without the photon peak (right) is shown for comparison.

Energy dependence of the cross section integrated in the $0° \le \theta_{pp}^{cm} < 20°$ angular range is shown in fig. 3. Luminosities needed for the cross section calculation were taken from [2]. Data for $T_p = 0.353$, 0.500 and 0.550 GeV originated from [1].

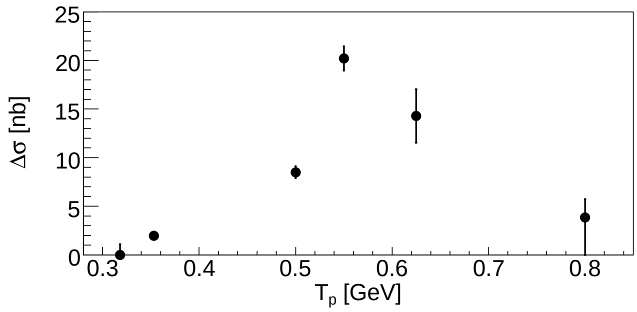

Fig. 3: Energy dependence of the integral cross section in the $0° \le \theta_{pp}^{cm} < 20°$ angular range.

The spectrum obtained shows a clear bump around $T_p = 0.5$–0.6 GeV, which may reflect the influence of the $\Delta(1232)$ excitation, even though this channel is suppressed compared to the similar $np \to \gamma d$ reaction. The Δ-peak would mean that the expected short-range effect is weak.

References:

[1] V. Komarov et al., Phys. Rev. Lett. **101** 102501 (2008).

[2] V. Kurbatov et al., Phys. Lett. B **661** 22 (2008).

[1] LNP JINR, 141980 Dubna, Russia
[2] IKP FZJ, 52425 Jülich, Germany
[3] HEPI TSU, 0186 Tbilisi, Georgia

* supported by COSY-FFE