Subthreshold $\bar{p}$ production at COSY energies?

V. I. Komarov[a] and H. Müller[b]

Subthreshold particle production in a nuclear interaction is defined as production below the energy threshold in a free nucleon-nucleon collision. It is thus a nuclear phenomenon which may be explained either in terms of high-momentum components of the nuclear wave function or by a cooperative behavior of several target nucleons during the interaction process. So far no final distinction between different assumptions is possible.

At COSY-Jülich a research program is in progress which is devoted to the systematic investigation of this phenomenon. COSY-proposal #18 [1] deals with the investigation of subthreshold production of K^+ mesons, while in proposal #21 [2] the extension of the research program to K^- mesons was suggested.

Following this line we consider the question whether the investigation of subthreshold $\bar{p}$ production is feasible at COSY energies. The highest energy of 2.8 GeV reached so far is far below the threshold energy of 5.63 GeV. This makes the measurements a real challenge due to the low cross section for $\bar{p}$ production and the high background of other negatively charged particles. From the physical point of view, however, deep subthreshold production far below the threshold becomes especially interesting, because the collective aspects of the phenomenon should become more and more dominating.

In this contribution the cross sections for negatively charged particles are estimated from ROC model [4, 5] calculations in order to get a basis for a decision about the feasibility of a $\bar{p}$ measurement at ANKE. We start from known data and compare in Fig. 1 the momentum spectra of anti-protons with the data of Ref. [3] over a large energy interval. The agreement of the model calculations carried out with the same parameter set at all energies is satisfactory. Subsequently, the much lower bombarding energy of 2.8 GeV is considered again using the same parameters. Figure 2 shows a ROC-model estimate of the anti-proton spectrum averaged over a polar angle $\Theta < 10°$. In order to emphasize the experimental difficulties of a possible measurement at such a deep subthreshold energy the spectra of the other negatively charged stable particles are depicted too. About nine orders of magnitude more π^- mesons than $\bar{p}$'s must be expected. The calculated total cross section for $\bar{p}$ production, $\sigma_{\bar{p}} \approx 5\,\text{pb}$, may serve as a starting point for a counting-rate estimate. Further calculations with the aim to improve the statistical accuracy are in progress.

References:

[1] W. Borgs et al., *COSY Proposal #18*, Jülich (1990).
[2] T. Kirchner et al., *COSY Proposal #21*, Jülich (1996).
[3] Y. Sugaya et al., Nucl. Phys. **A634**, 115 (1998).
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[a] Joint Institute for Nuclear Research, LNP, 141980 Dubna, Russsia
[b] Forschungszentrum Rossendorf, Postfach 510119, 01314 Dresden, Germany

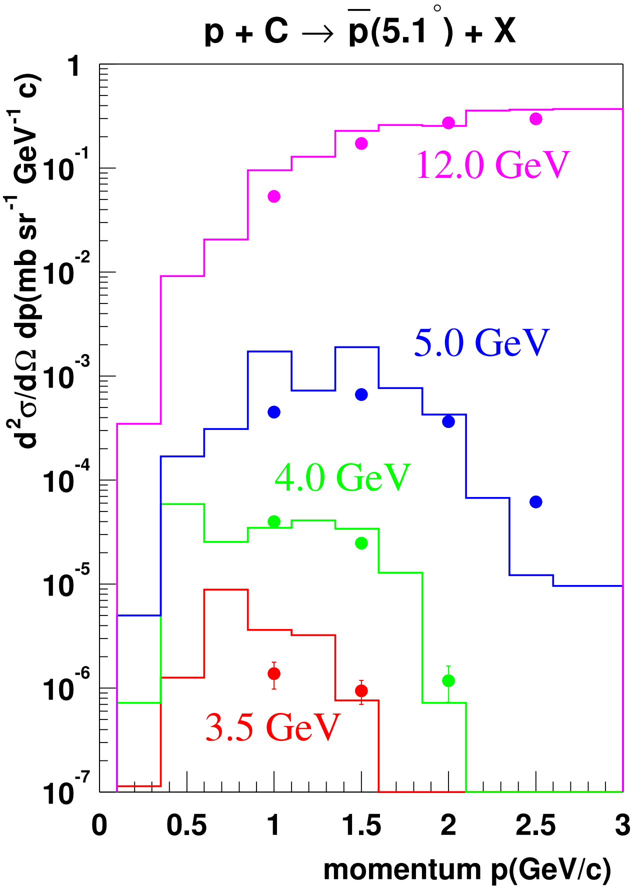

Fig. 1: Momentum spectra of $\bar{p}$ measured at 5.1° [3] (dots) compared with ROC-model calculations (histograms) at incident energies between 3.5 and 12.0 GeV.

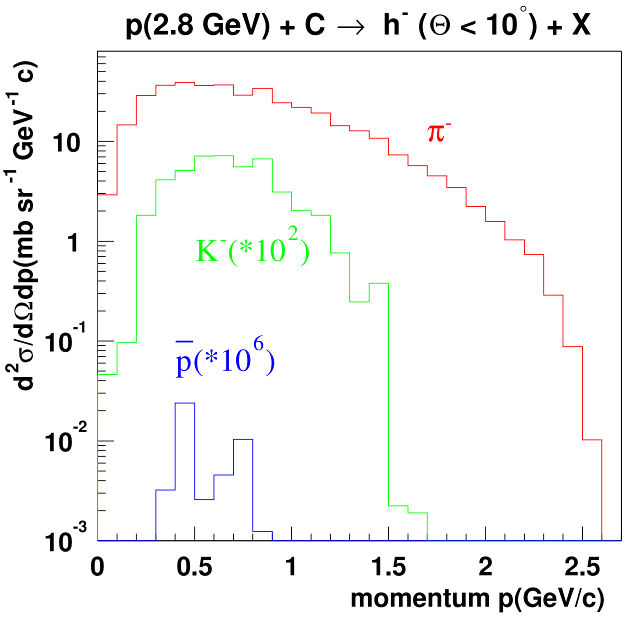

Fig. 2: Momentum spectra of negatively charged hadrons calculated with the ROC model. K^- and $\bar{p}$ spectra are multiplied by the factors indicated in the figure.