Measurement of antiproton - proton elastic cross section below 100 MeV/c

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Very recent results obtained by the OBELIX Collaboration [1] have revealed a quite puzzling situation concerning the low energy $(\bar{N} - N)$ interaction. In particular the presence of a dip in the total $\bar{n}p$ cross section $\sigma_T(\bar{n}p)$ around 80 MeV/c, attributable to a dip in the elastic $\bar{n}p$ cross section $\sigma_{el}(\bar{n}p)$, not directly measured, seems not explained by present models nor parametrizations of the $(\bar{N} - N)$ interaction (see Fig. 1).

Briefly, the experimental situation below 200 MeV/c for the $(\bar{N} - N)$ system is as follows:

i) there is a complete set of data for $\sigma_T(\bar{n}p)$ and $\sigma_{ann}(\bar{n}p)$ from 50 MeV/c [1]
ii) there are data, in particular below 100 MeV/c, for $\sigma_{ann}(\bar{p}p)$, but not with a regular scan [2]
iii) there are no data for $\sigma_T(\bar{p}p)$

We remind that the $(\bar{n}-p)$ system is a pure I = 1 state, whereas the $(\bar{p}-p)$ one is a mixture of I = 0 and I = 1 states. Another conclusion from the experiment of Ref. [1] is that below 100 MeV/c the channel I = 0 dominates over the I = 1 one by at least a factor 2.

It is quite surprising that there are no measurements of $\sigma_T(\bar{p}p)$ below 200 MeV/c in spite of 13 years of operation of LEAR, a machine approved and built just with the aim of supplying a full set of data in the low energy region. The reason is that probably the first round of experiments at LEAR, even if not complete, did not show relevant anomalies even though an unexpected

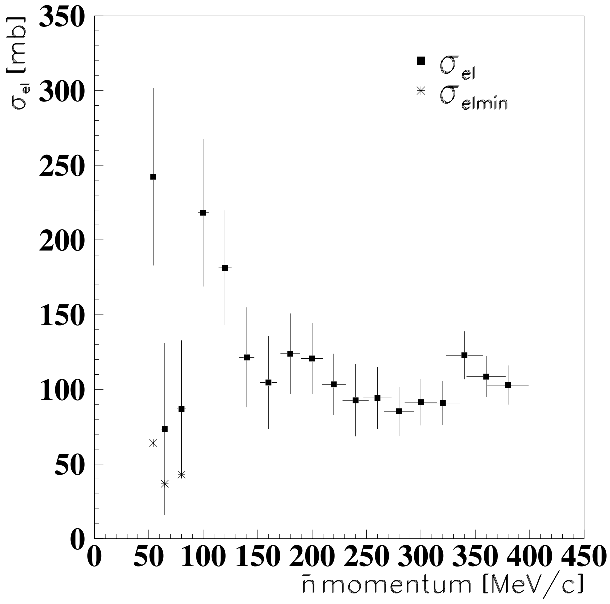

Fig. 1. Elastic $\bar{n}p$ cross section (■) as a function of the $\bar{n}$ momentum; the asterisks represent the lower limits of the elastic cross section due to the unitarity constraints.

behavior of the elastic channel in the $(\bar{p}-p)$ system appeared in the real-to-imaginary ratio of the forward scattering amplitude [3]. Measurements of $\sigma_{el}(\bar{p}p)$ and $\sigma_T(\bar{p}p)$ are also not easy at such low energies and unfortunately the analysis of the data on $\sigma_T(\bar{n}p)$ was completed after the shut-down of LEAR.

Stimulated by the interest of these new data, we have investigated whether it is possible to perform some relevant measurement at AD.

Clearly the investigation of the I = 1 channel ($\bar{n}-p$ system) is impossible, since the upper momentum of $\bar{p}$ from AD is 100 MeV/c and the threshold for the $\bar{n}$ production is 98 MeV/c.

The investigation of the $(\bar{p}-p)$ system seems too difficult at first sight, taking into account the conditions of extraction of the $\bar{p}$ beam from AD, ($\geq 10^6\bar{p}$'s in a time of 500 ns at maximum and a repetition rate of some 10^{-2} Hz) and the consequent possibility of using any beam detector for coincidence or timing purposes.

The upgrade of AD to a slow extraction operation could help considerably the design of a detector able to measure $\sigma_{el}(\bar{p}p)$ below 100 MeV/c, but this option seems not scheduled in the near future.

A new way of measuring $\sigma_{el}(\bar{p}p)$ at AD in fast extraction mode has been recently envisaged, even if many experimental conditions have to be checked.

We are indeed investigating an experimental device based on the following options:

i) a small target (radius $\simeq 1.5$ mm, thickness $\leq 10\mu m$) made of CH_2
ii) a detector of reduced size (essentially a box $\approx 6 \times 6 \times 6cm^3$) with the four sides made by six layers of scintillating fibers, $\approx 1mm^3$ each, viewed by multianode photomultipliers
iii) a read-out system of the scintillating fibers based on 100 MHz FADCs
iv) the beam energy might be varied by absorbers of suitable thickness
v) a carefully studied and designed beam dump.

Concerning the rates we estimate to obtain ≈ 1 ev/pulse for $(\bar{p} - p)$ elastic scattering, ≈ 3 ev/pulse for $\bar{p} - p$ annihilation, ≈ 3 ev/pulse for $\bar{p} - C$ annihilation, by assuming $10^6 \bar{p}$/pulse.

$\sigma_{el}(\bar{p}p)$ could be measured in 1-2 days at 1 energy setting and $\sigma_{ann}(\bar{p}p)$ too, provided a background measurement with a C target of equivalent thickness is performed in the same amount of time.

Before submitting a formal proposal we intend to explore the following steps of our preliminary study of feasibility:

i) to study the response of the scintillating fibers to low energy (0.5 - 5 MeV) protons. This test will be performed at the Van der Graaf machine CN of Legnaro
ii) to perform an accurate simulation of the detectors response, by optimizing the dimensions, the granularity ...
iii) to perform an accurate study of the beam dump, to minimize the background
iv) to understand, having advice from the AD machine staff, the best beam line that could fulfill the experimental requirements.

Last but not least, if we could convince ourselves that the experiment is feasible, we will enlarge the Group of interested physicists.

References

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