FIRST RESULTS FROM THE ANTINEUTRON EXPERIMENT AT LEAR

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ABSTRACT

We describe the experimental lay-outs and the first results obtained in an experiment under way at LEAR whose aims are: a measurement of the 0° excitation function for the $\bar{p}p \to \bar{n}n$ reaction from 550 MeV/c down to the threshold, a measurement of the angular distribution for the same reaction below 200 MeV/c and a study of a tagged $\bar{n}$ beam.

We give a short account of the measurements performed at LEAR during the past month. The purpose of the experiment[1] (PS 178) is that of studying the interactions and the properties of the antineutron ($\bar{n}$) by taking advantage of the unique possibilities[2] offered by the LEAR facility. The starting point of the above program is a careful study of the methods best suited in order to obtain good $\bar{n}$ beams and the measurement of poorly or not known cross-sections. Several arguments convinced us[2] that the best method of producing high-quality $\bar{n}$ beams is that of using the charge-exchange (CEX) reaction $\bar{p}p \rightarrow \bar{n}n$ on an external LH_2 target. The production of $\bar{n}$ at 0° may be most useful for some experiments, the production at different angles with the simultaneous detection of the associated neutron (n) most powerful for other measurements.

The ($d\sigma / d\Omega$) for the CEX reaction in the forward direction was not measured in previous experiments[3], nor in running ones[4]. We have then performed a measurement of the 0° cross-section with the experimental lay-out shown by Fig.1. The $\bar{p}$ beam, defined by a thin (1mm) scintillator, impinges on the LH_2 target, 15 cm long and with a radius of 1.5 cm, enclosed in a scintillator's veto box.
A straightforward logic defines the events candidates for the CEX reaction. A bending magnet, located immediately downstream the target sweeps the non-interacting $\bar{p}$'s out from the $\bar{n}$ detector, located at ~

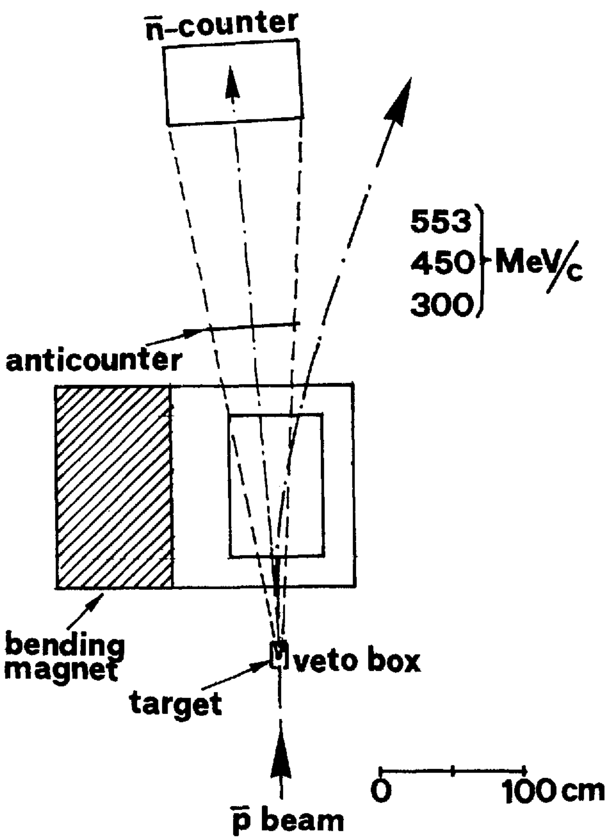

Fig. 1 - Experimental lay-out used for the measurement of the forward cross-section for the CEX reaction.

3.5 m from the target. An anticounter at the exit of the magnet vetoes charged particles produced by neutrals generated in the target and converted elsewhere.

The $\bar{n}$ detector consists of ten equal modules: each one is made of an iron slab (the converter), 100x100x1 cm^3, a scintillator wall, 100x100x1 cm^3 and a plane of x-y limited streamer tubes, 96x100 cm^2 with 1 cm pitch; the limited streamer tubes give the track coordinates needed for pattern recognition. The trigger conditions can be chosen according to the number of annihilation prongs that have to be selected. The minimal condition is that at least two subsequent elements of scintillator be activated, corresponding to one prong at least in the final state. The performances of this detector, in a slightly modified configuration, were previously studied in some parasitic runs[5)]. Fig.2 (left) shows an event produced by an $\bar{n}$ annihilating in the third module with the emission of two charged prongs.

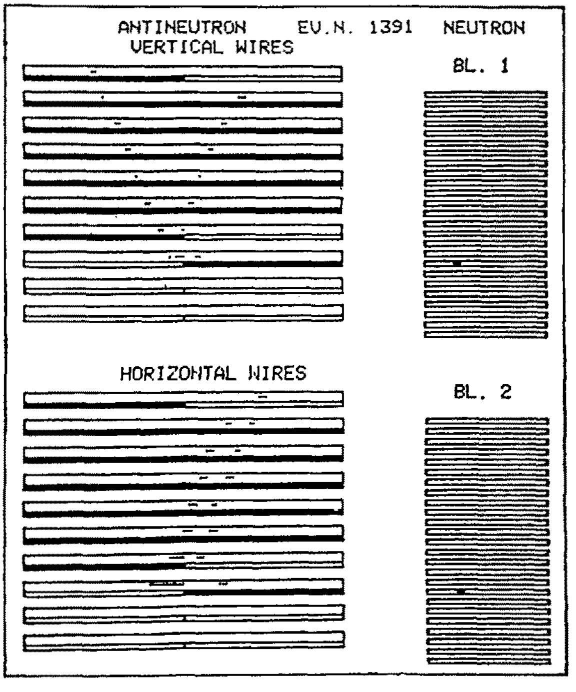

Fig. 2 - Pictorial view of the detectors response for a $\bar{n}$-n correlated event.

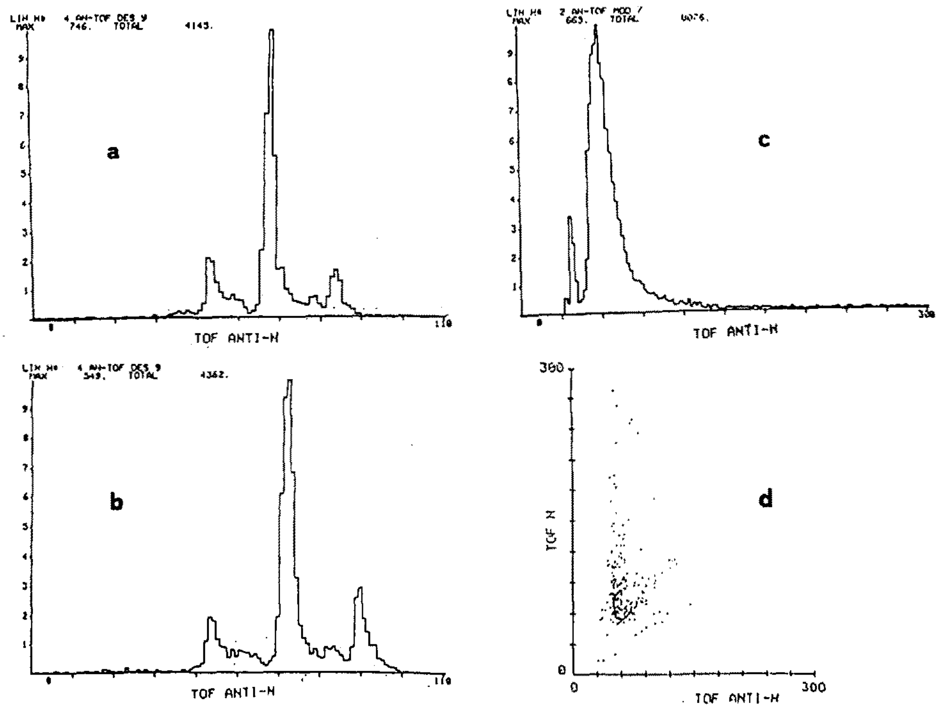

Fig. 3 - On-line spectra showing a) the TOF measured by the $\bar{n}$ detector at 550 MeV/c; b) the same at 450 MeV/c; c) the same at 300 MeV/c; the abscissa scale is in ns; d) scatter plot of the $\bar{n}$ and n TOFs in the tagged beam configuration.

The energy of the $\bar{n}$'s is determined by means of the measurement of their time-of-flight (TOF). Fig.3 shows on-line TOF spectra measured with p of 550 (a) and 450 MeV/c (b). The larger peak at the center corresponds to the $\bar{n}$'s. At 450 MeV/c it is broader since the momentum loss of the $\bar{p}$, and then the momentum range of the produced $\bar{n}$, is larger. The weaker peak at the left is due to π's or γ's from the target, whereas the peak at the right corresponds to particles produced by the unspent $\bar{p}$ beam in a shielding concrete wall, not shown by Fig.1. Both peaks clearly reflect some inefficiency of the veto box. Fig.3 c) shows the TOF spectrum measured with $\bar{p}$ of 300 MeV/c, which are brought at rest along the length of the target and produce $\bar{n}$ via CEX up to 98 MeV/c (threshold of the reaction) $\bar{n}$ of all momenta between 70 and 290 MeV/C are then produced and give the broad peak with the long tail extending towards large TOF's. The narrow peak at the beginning of the spectrum is again due to π's or γ's produced in the target and is partially cut down due to a different timing in the trigger. The above spectra, rather clean, will be analyzed taking into account the pattern of the annihilation stars, that are an unambiguous signature of the $\bar{n}$'s.

We collected between 10^4 and 10^5 events at each $\bar{p}$ momentum setting. The region between 550 and 300 MeV/c was scanned in steps of 25 MeV/c by using suitable degraders upstream the target. Around 500 MeV/c we did a scan in steps of 12 MeV/c in oreder to detect the possible presence, in the CEX exclusive channel, of the resonance called the S(1936) meson, a baryonium candidate whose existence is still rather controversial[6]. In conclusion, we will produce in the near future a full study of the $d\sigma/d\Omega$ (0°) for the CEX reaction from 550 MeV/c to the threshold with a good accuracy.

In a second series of measurements we used the layout shown by Fig.4. The $\bar{n}$ detector was located at ~2.5 m from the target, at different angles between 20° and 45°. In addition we installed at ~ 2.5 m and at angles between 35° and 60° a n detector consisting in 2 arrays of 25 scintillators, 100x2x5 cm^3 each, viewed by photomul-

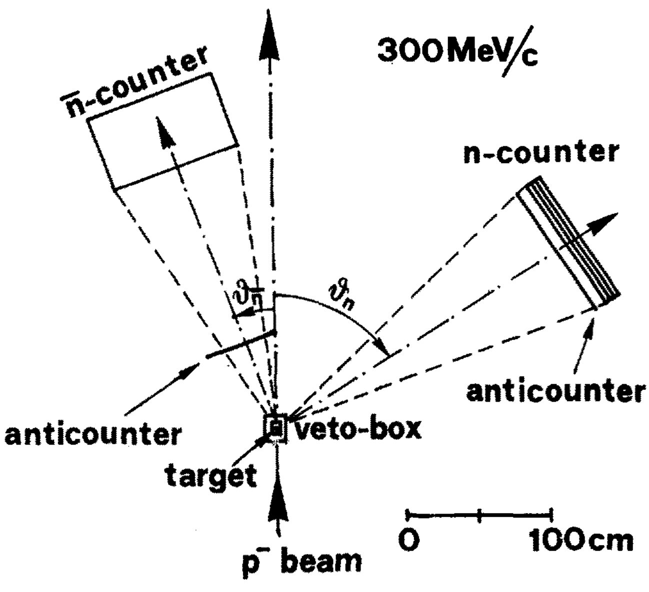

Fig. 4 - Experimental lay-out used for the measurement of the angular distribution of the CEX reaction and for the tagged $\bar{n}$ beam study.

tipliers (PM) on both sides in order to obtain a good measurement of the TOF and of the impact position. The scintillators strips were connected to the PMs by light guides arranged following a particular coding system that allows a considerable reduction in the number of PMs and associated electronic channels[7,8]. The absolute efficiency of detection of this hodoscope was measured in a separate experiment performed at the CN Van der Graaf accelerator of the Laboratori Nazionali di Legnaro. Two anticounters in front of the $\bar{n}$ and n detectors respectively vetoed charged particles produced by neutrals generated in the target and converted in the mechanical surroundings.

The purpose of the layout described above was twofold;

1) to measure the angular distribution of the CEX reaction from 200 MeV/c to the threshold in order to ascertain even at low energies the dip-bump structure observed by Nakamura et al.[3] at higher $\bar{p}$ momenta. We remind that another experiment (PS 173) running at LEAR with a completely different apparatus[4], does not plan to extend the measurements the CEX reaction below 200 MeV/c.
2) to test the performances of the "tagged" $\bar{n}$ beam and to measure the efficiency of the $\bar{n}$ detector. The measurement of the n TOF and position allows the determination of the momentum and direction of the tagged $\bar{n}$, that may be used for further measurements (total and elastic cross sections of $\bar{n}$ on protons and nuclei). A full account of the expected performances of the tagged $\bar{n}$ beam is given in Ref.1)

Fig.2 shows a correlated $\bar{n}$-n event. On the left we may observe the pattern of the n detectors. The n detected by the first hodoscope (BL.1) through n-p scattering is also interacting in the second one (BL.2). Fig. 3d) shows a scatter plot of the $\bar{n}$ TOF versus the n TOF. The correlated events must cover a band parallel to the axis of the ordinates, as expected by a Monte Carlo simulation of the experiment, and are clearly visible in the on-line plot (no cuts were applied at this level). We have taken also data with a Graphite target installed midway between the production LH_2 target and the $\bar{n}$ detector, with the aim of measuring the cross-section for interaction of $\bar{n}$ on ^{12}C.

In conclusion we have performed the first measurements foreseen in our program of $\bar{n}$ physics. The results that we have obtained, even if not yet analyzed, look very promising. For the next future we plan to measure the cross-sections for $\bar{n}$ on protons (tagged beam configuration) and for the CEX reaction at 0° on some selected nuclei, in collaboration with groups from the Tel Aviv and Indiana Universities that have stressed the importance of the measurement[9].

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