FORWARD SPECTROMETER FOR SPES-4π EXPERIMENT

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Study of Roper resonance excitation of the proton allows to get information on radial excitation modes of baryons [1]. This information may be used for testing different theoretical approaches existing for description of baryon properties. From the data obtained from the Roper resonance excitation one may extract information on the proton compressibility. Alpha–proton scattering at intermediate energies offers an exceptional opportunity for studying the Roper resonance since the background spin–isospin modes of baryon excitation in inelastic α–particle forward scattering are depressed, and non-spin-flip (T=S=0) mode should be dominant.

Such an experiment is under preparation at the National Laboratory Saturne (LNS) in Saclay, France. Alpha–particles with the momentum of about 7 GeV/c from the accelerator Saturne II will be scattered by a small angle ($\theta_\alpha = 0.4 \pm 0.8°$) on a liquid hydrogen target and will be analyzed by the existing high-resolution spectrometer SPES-IV. The Roper resonance decay products will be registered by a large acceptance non-focusing magnetic spectrometer in coincidence with SPES-IV. This spectrometer consists of two arms: Lateral Spectrometer (LS) and Forward Spectrometer (FS), see Fig.1. The PNPI responsibility is to design, fabricate and test the FS.

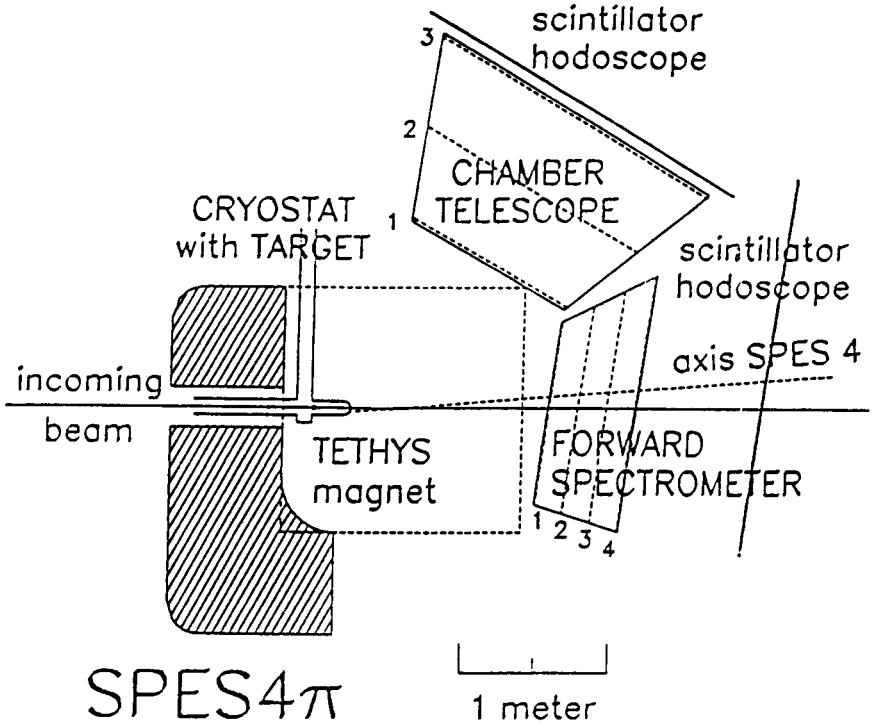

Fig.1. General layout of the SPES-4π experiment

The Roper resonance decays to the ground state of the nucleon with emission of one or two pions. The Monte Carlo simulation of this process shows that the angular distribution of protons is concentrated in the forward direction. The aim of the FS is to register protons arising in the decay of the Roper resonance, to select them from pions and other background particles, and to measure the proton kinematical parameters.

FS consists of a system of drift chambers and a scintillation hodoscope. Protons will be selected from pions by time-of-flight and energy loss measurements by means of the scintillation counter hodoscope. The outgoing angles as well as the momenta of the particles are measured by the above mentioned drift-chambers telescope which determines the particles trajectories and their bending in the magnetic field. The requirements to the accuracy in measuring the angles and momenta of the protons spring from the requirement to obtain a good enough missing mass resolution, so that one could distinguish between one- or two-pion decays of the Roper resonance. According to the Monte Carlo simulation the momentum resolution should be about (2-3)%. To reach such resolution one needs to work with the maximum magnetic field (1.2 T) and to measure the X-coordinate in the first and the last drift chambers with the accuracies of about 1 mm (FWHM). The momentum and the angle of the scattered proton being measured with the required accuracy and knowing also the angle and the momentum of the scattered α-particle, one can determine the missing mass and separate the channels of one- and two-pion decays of the Roper resonance.

FS is supposed to work with the counting rate induced by a beam intensity of 5×10^8 particles per burst of 0.5 s incident on a liquid hydrogen target with the length up to 10 cm. The drift chambers and the scintillation hodoscope each have a hole to let through the outcoming α-particle beam.

The drift chamber telescope consists of six chambers: X1,Y1,X2,Y2 - chambers to measure X and Y coordinates of the trajectory at different Z (in the direction along the beam), U and V chambers (with $\pm 10^\circ$ wires inclination) to resolve many-events ambiguity. The active surface of the chambers increase from 0.5×1.2 m^2 for the first plane to 0.7×1.7 m^2 for last one. The particle coordinates are determined from drift time measurements. The basic element of the drift chambers is a hexagonal drift cell with a wire cathode. There are two layers of such cells in each chamber. The spacing between two anode wires in one layer is 8.66 mm. The anode wires are made from gold plated tungsten wire which diameter is 0.025 mm. The drift chambers are filled with 50% of Ar and 50% of C_2H_6 gas mixture. The high voltage between the anode and cathode wires varies between 2.2 and 2.6 kV. Within these conditions, according the results of Garfield type calculation there exists practically linear dependence between the particle coordinate and the measured drift time.

The area above and below the beam hole is covered with three layers of the plastic straw-tube drift chambers. Each of these tubes has the diameter of 8 mm.

For registration of signals from sense wires of the drift chambers, 16-channel preamplifier, shaper and discriminator modules (ASD-16) were fabricated. These modules are based on integral chips designed in University of Pennsilvania (USA). The main ASD-16 parameters are: input impedance - 110 Ω, shaping time - 12 ns, threshold charge - 4 fC and double pulse resolution - 25 ns. Equivalent noise is 2000 electrons. CROS2 read-out system was used for fast read-out of the information from the drift chamber detector. The read-out system consists of an input register, controlable delay and read-out module. CROS2 contains a 256 deep fast memory delay for each wire. The maximum clock rate is 53 MHz for a total delay of 4.8 μs in 19 ns step. This allows to measure a drift time with a precision of 19 ns. The

read–out speed via CAMAC-DATAWAY is one 32–bit word per 100 ns.

The scintillation hodoscope of FS is installed at the distance of about 3 m from the target behind the drift chamber detector. The hodoscope consists of 16 scintillator vertical bars 120 cm long and 1.5 cm thick. The width of the bars changes from 5 to 20 cm. The narrow bars are installed closer to the the beam line in view of higher expected counting rate in this area. Ten additional scintillation counters cover the area above and below the beam line. The full size of the hodoscope active surface is 1.2×2.5 m^2. All scintillation counters are assembled on a single supporting frame. The photomultipliers FEU–87 and FEU–97 are used. The magnetic shielding of the counters is provided.

The completion of all this work at the Forward Spectrometer is planned in the middle of 1996. In 1995 the scintillation hodoscope, two drift chambers (X1 and Y1), 2 straw–tube chambers and the read–out CROS2 system were ready. All this equipment was transported to Saclay and succesfully tested on the accelerator Saturne-II proton beam. The coordinate resolution of the drift shambers was shown to be about $\sigma = 0.15$ mm (Fig.2). The resolution in the real measurement conditions will be limited by the CROS2 system by $\sigma = 0.4$ mm. The dE/dx and time–of–flight resolution (σ) of the scintillation hodoscope were measured to be about 1 MeV and 1 ns, respectively, in an agreement with the technical requirements.

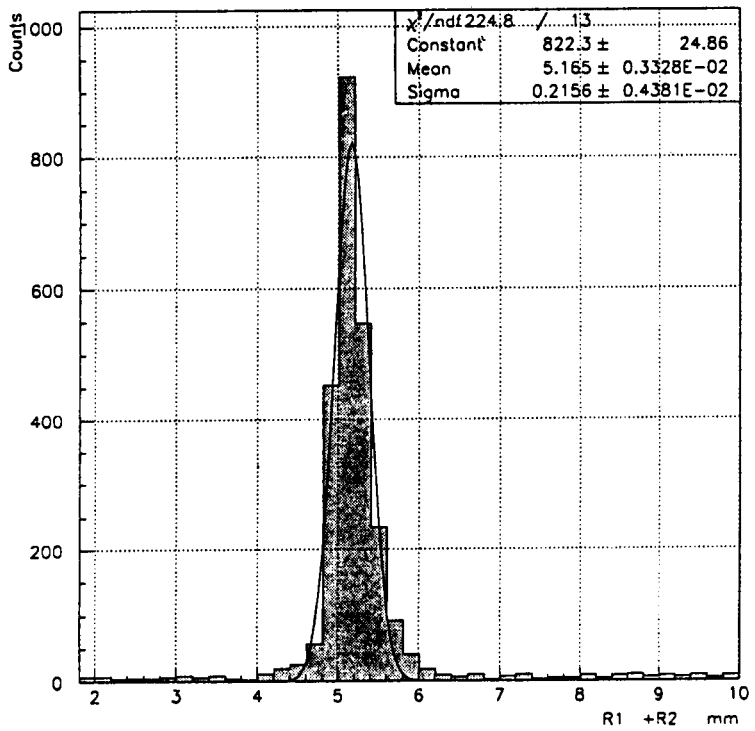

Fig.2. The distribution of the sum of distances measured in two adjacent cells of the drift chamber for the proton beam approximately perpendicular to the chamber. For a strictly parallel beam of particles this sum should be equal to the distance between the sense wires. The width of the measured distribution ($\sigma = 0.22$ mm) corresponds to the proper drift–chamber resolution of $\sigma = 0.15$ mm

REFERENCE

1. *Morsh H.P. et al.* //Phys.Rev.Lett., 1992. V.69. P.1336.