ANGULAR RESOLUTION OF LASER STREAMER DETECTOR

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It is well-known [1] that discrepancy in low energy pion-proton elastic scattering data does not allow to obtain a reliable estimate of chiral symmetry breaking in non-strange hadron sector. New data on elastic cross section in wide ranges of energies and scattering angles might eliminate this discrepancy. We have designed a laser streamer detector [2] consisting of a hydrogen streamer chamber illuminated by laser light and a set of the scintillation counters built into the lateral walls of the chamber. This detector enables to measure π–p elastic cross section even in the energy range from 5 MeV to 20 MeV which looks unachievable with an alternative technique. Angular acceptance of the device ranges from 60° to 150°. While the π–p differential cross section shows a fairly weak angular dependence in this region, nevertheless, angular resolution of the detector should be rather high — on the level of (0.1°–0.2°). This is a price to pay for the simplicity of the trigger system designed to register only a coincidence between an incident particle and scatterred ones and not to measure angles or energies.

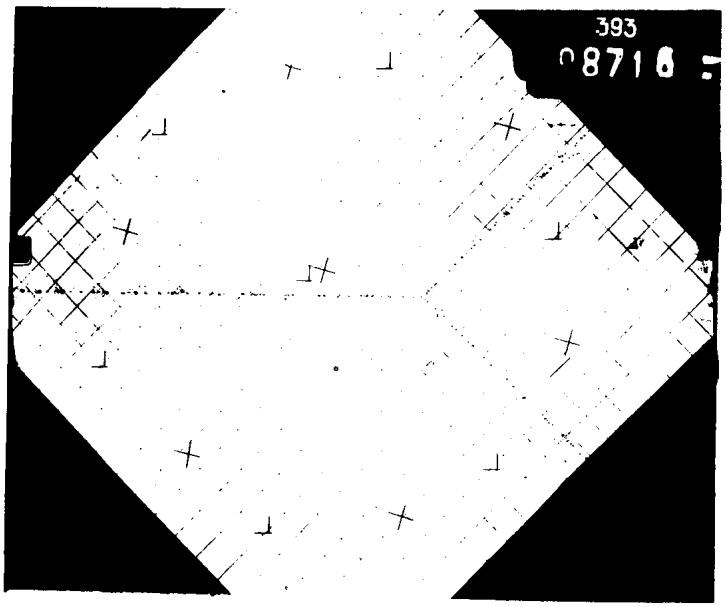

Fig.1. Picture of pp elastic scattering at $T = 47$ MeV in hydrogen streamer chamber

Because of a muon component in the incident low energy beam high angular resolution is crucial to discriminate π–p from μ–p scattering at the stage of the data processing. Estimate of the angular resolution on the order of 0.4° immediately follows from the naive expectations considering the spatial resolution in the hydrogen streamer chamber (150 microns [2]) and the length of a track.

To check this estimate we have had a short run at the low energy ($T = 47 \pm 10$ MeV) proton beam. One of the registered 140 pp elastic scatterings is shown in Fig.1.

It is known that the opening angle θ in the two-body equal mass elastic scattering is confined by

$$\arccos(T/(T+4m)) \leq \theta \leq 90°$$

giving the range 89.28°–90° for θ if the kinetic energy of the incident protons is equal to 47 MeV. The geometric efficiency of our detector $\varepsilon[\vartheta]$ for the pp scattering (Fig.2) reduces the upper border of this interval. At the same time the dispersion of the beam energy should result in some broadening. Taking into account the distribution of the beam energy $P(T)$ and the geometric efficiency of the detector $\varepsilon[\vartheta(\theta, T)]$, one may obtain the estimate of the angular resolution from the fit of the calculated distribution

$$N(\theta) = N_0 \cdot \int P(T)\varepsilon\left[\vartheta(T,\theta_1)\right] \exp\left[-\frac{(\theta_1-\theta)^2}{2\delta\theta^2}\right] dT d\theta_1$$

to the experimental one (Fig.3). Such a procedure gives the mean opening angle equal to 89.3° and the value $\delta\theta = 0.27°$.

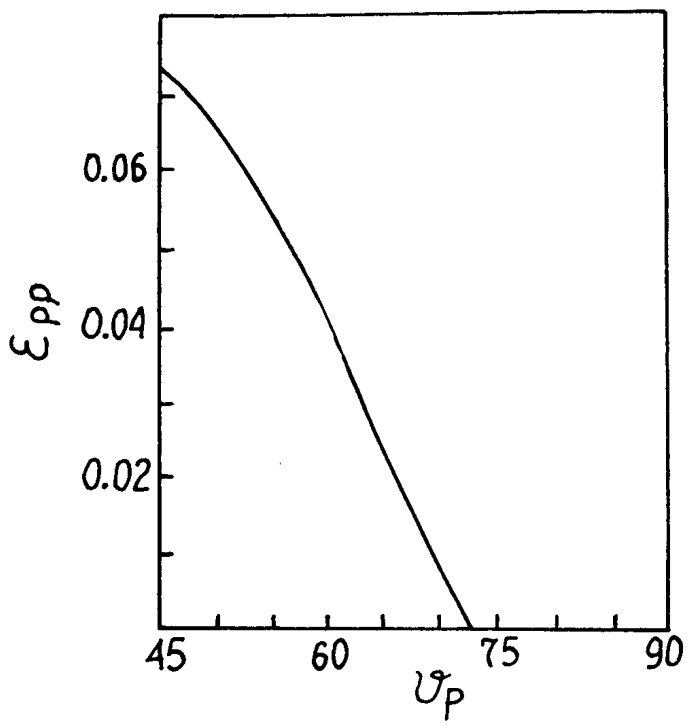

Fig.2. Geometric efficiency of laser streamer detector for elastic *pp* scattering versus angle of recoil proton

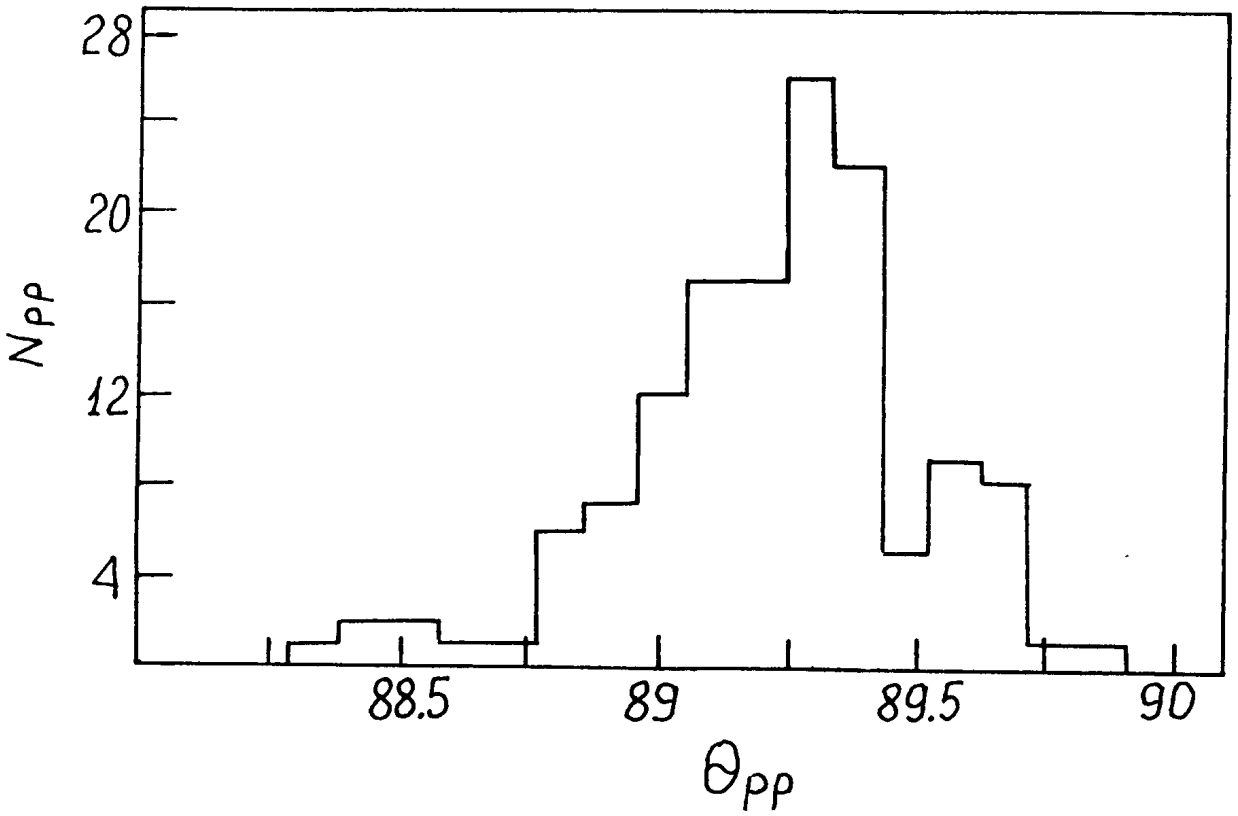

Fig.3. Distribution of 140 *pp* elasic scattering events versus opening angle

On the other hand we have obtained an independent estimate of $\delta\theta$ when the real track events were simulated by a pattern of thin crossed strings placed into the volume of the chamber. It appears that the quantity $\delta\theta$ does not exceed 0.2° in this case. The discrepancy of the order 0.07° can be explained by a simple way. Evidently, the spatial distribution of the incident proton beam in the volume of the chamber should be taken into account when comparing the experimental data to the results of calculations.

Moreover, one can expect that, the value $\delta\theta$ of the order 0.1°–0.15° can be obtained by improving the model of geometric reconstruction. To record the event we have used a shadowgraph method [3] but treated both the illuminating and the optical systems as the ideal ones. In a refined model of the event reconstruction actual path of light rays should be considered.

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