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ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

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GEOMETRICAL EFFICIENCY FOR THE TRIGGERED HIGH PRESSURE STREAMER CHAMBER OF THE JINR

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Monte Carlo computation technique [1] is often used to correct cross sections in the experiments in which triggering systems are improving the efficiency for selecting events with a given topology.

In this work we present one method of computation of the geometrical efficiency in detecting events in which the triggering system selects one charged particle scattering at a given angle. The target is a volume of gas of a given shape, the detecting counters are cylindrically set up arround the target and the beam has a given divergence, the method is particularly suitable for computers with high speed and relatively small memory field length.

1. In order to calculate differential cross sections for elastic $\pi\, ^4He$ events in the JINR high pressure streamer chamber [2,3] it has been necessary to compute the solid angle within which useful events were registered.

Let us define the geometrical efficiency as the ratio between the effective solid angle and the whole solid angle in detecting scattered pions in the angular interval

$$\epsilon_\theta = \frac{\Delta\Omega_{eff}(\theta)}{2\pi\sin\theta\Delta\theta} = \frac{\Delta\Omega_{eff}(\omega)}{\Delta\Omega(\theta)} .$$

The differential cross section is given by

$$\frac{\Delta\sigma}{d\Omega} = \frac{1}{N_\pi \, n \, L \, \bar{\epsilon}_\theta} \cdot \frac{\Delta N}{d\Omega} ,$$

where ΔN - the number of events corresponding to $\Delta\theta$, N_π - the number of pions in the beam, n - the number of the nuclei in 1 cm^3 , L - the length of the effective volume, $\bar{\epsilon}_\theta$ - the geometrical efficiency at the angle θ averaged over the whole effective volume.

2. A scheme of the triggering system of the streamer chamber is shown in fig. 1. Events are registered when the scattered pion falls into one of the counters 8 ÷ 14 or 15 ÷ 21 while no incident pion has been registered by the counter 1. The uneffective region in the xy plane is 30 degrees forward and 10 degrees backward. The height of the counters is 11.6 cm and the radius of the counter hodoscope is about 30 cm.

The beam is collimated so as to pass through the streamer chamber into a cylindrical region of about 2.5 cm radius.

3. We used in computing the geometrical efficiency three methods based on different approximations in order to find the corrections on the cross section due to some factors and the better way to take them into account with a small computation time.

The factors examined are the dimensions of the effective volume, the divergence of the beam, the efficiency of different counters.

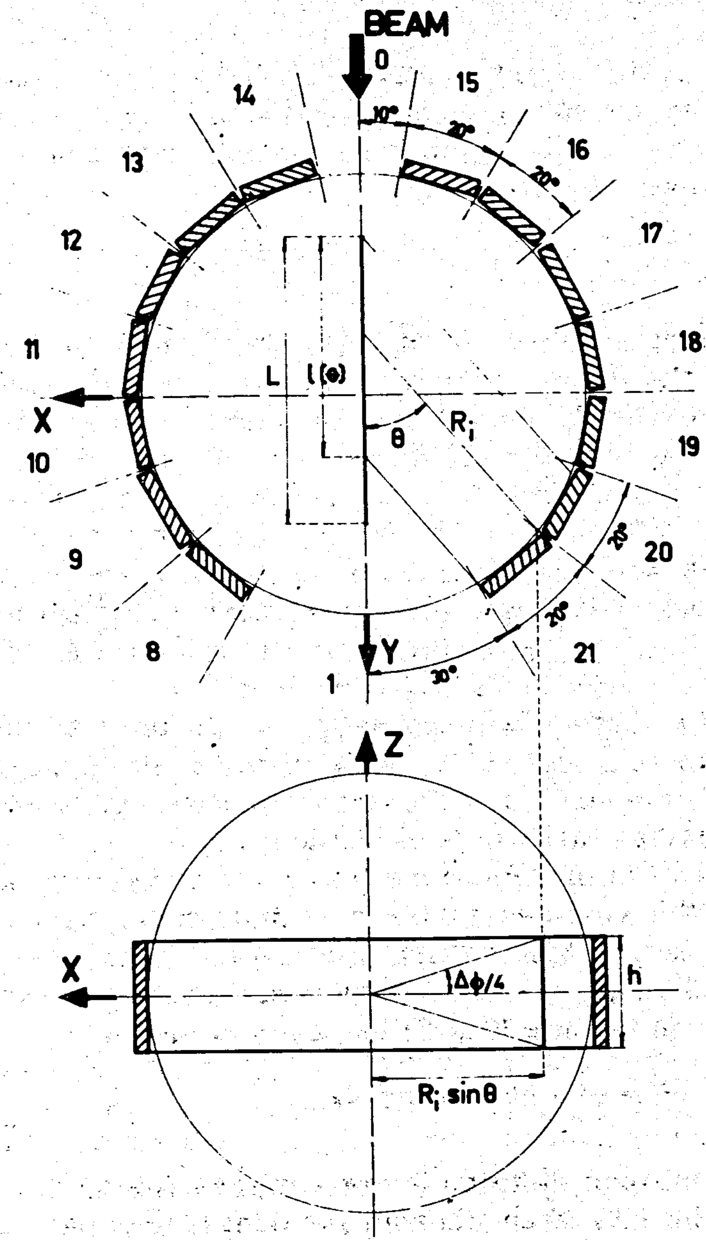

Fig. 1. Experimental set up and some notations used in the analytical version of the program.

I. For events with a scattering angle θ and the interaction vertices along the axis in an effective region L, the geometrical efficiency can be approximated by the formula

$$\frac{\Delta\phi}{2\pi} = \frac{1}{2\pi}\cdot\frac{1}{m}\sum_{i=1}^{m_1} 4\,\mathrm{arctg}\left(\frac{h}{2R_i\sin\theta}\right),$$

where $m = L/PAS$, $m_1 = \ell(\theta)/PAS$, PAS is the step of the computation. For notation see fig. 1. R_i is analytically computed. The choice of a step (PAS) of 1 cm for the numerical integration leads to errors of about 0.3% on the average. A systematical difference between the efficiency computed in this way in comparison with the other methods appears at small and big scattering angles (θ) due to the fact that in this approximation all interaction points were taken on the axis.

A better approximation is difficult to obtain with this method because of the rapid increase of the dimensions of the program when averaging for vertices taken outside the axis.

II. In order to take into account the distribution of the vertices inside a cylindrical or cone trunk region, a Monte Carlo method has been used. For each angle θ an average over the effective interaction volume (fig. 2) has been computed

$$\overline{\frac{\Delta\phi}{2\pi}} = \frac{1}{2\nu\nu}\int_x\int_y\int_z \Delta\phi\,dx\,dy\,dz.$$

A uniform distribution of vertices inside the cone trunk has been chosen. Incident tracks have been taken parallel to the y axis. The total number of

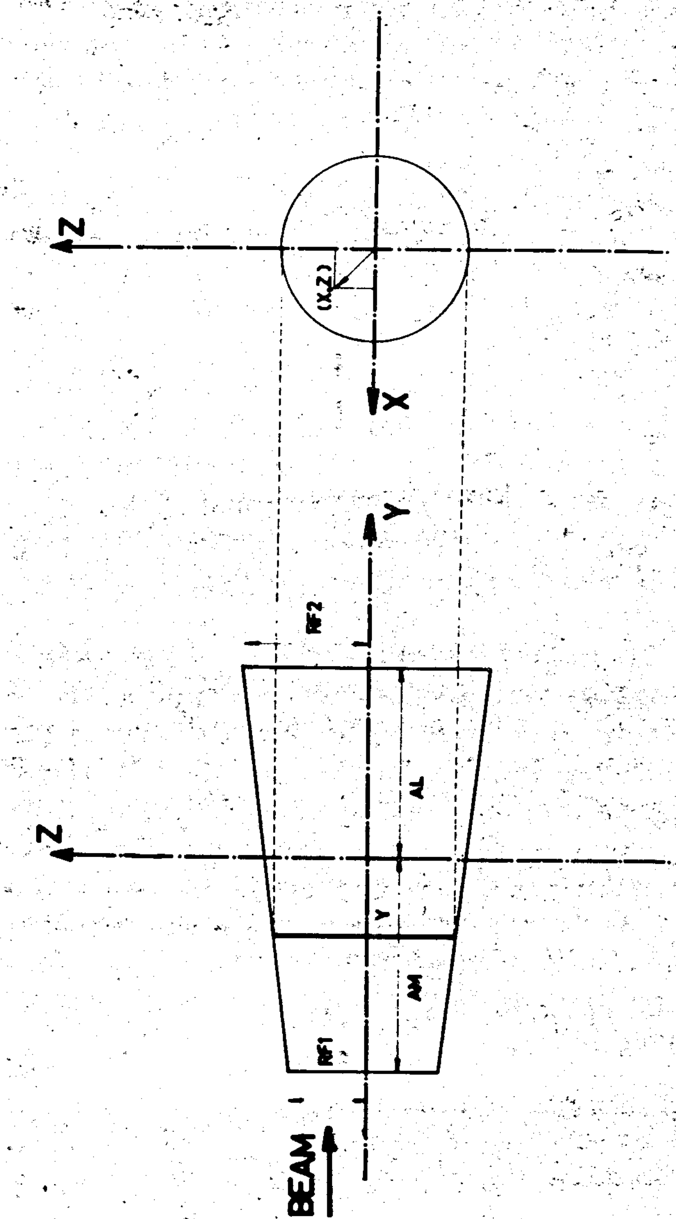

Fig. 2. The effective volume chosen for the second version of the program. Events are generated uniformly over the whole volume.

random events generated for a given scattering angle θ has been 20.000. Such a sample gives errors of about 0.7% * on the average. Fluctuations are seen (fig. 4b) but the increase of the number of generated events is limited by the increase of the computation time.

III. Geometrical efficiency was computed also for every event taking into account the incident track direction:

$$\frac{\overline{\Delta\phi}}{2\pi} = \frac{1}{L_V}\int_{L_{eff}} \frac{\Delta\phi}{2\pi},$$

where L_V is the length of the incident track going through the effective volume of the chamber; L_{eff} is the part of this length which contributes in recording events (fig. 3). 10.000 random events have been used for the computation of the average for a scattering event.

These computations are done in a subroutine of the program for the geometrical reconstruction of events. The method allows the evaluation of systematical errors introduced in the above approximative method, by requiring the beam to be parallel to the y axis in the chamber. The subroutine can be used for the computation of the average geometrical efficiency on the whole range of scattering angles by generating at random incident tracks but the extremely long computation time is prohibitive.

* For the angular region 70÷110 ° the average value of the efficiency is $\bar{\epsilon}_\theta = 0.132 \pm 0.001$.

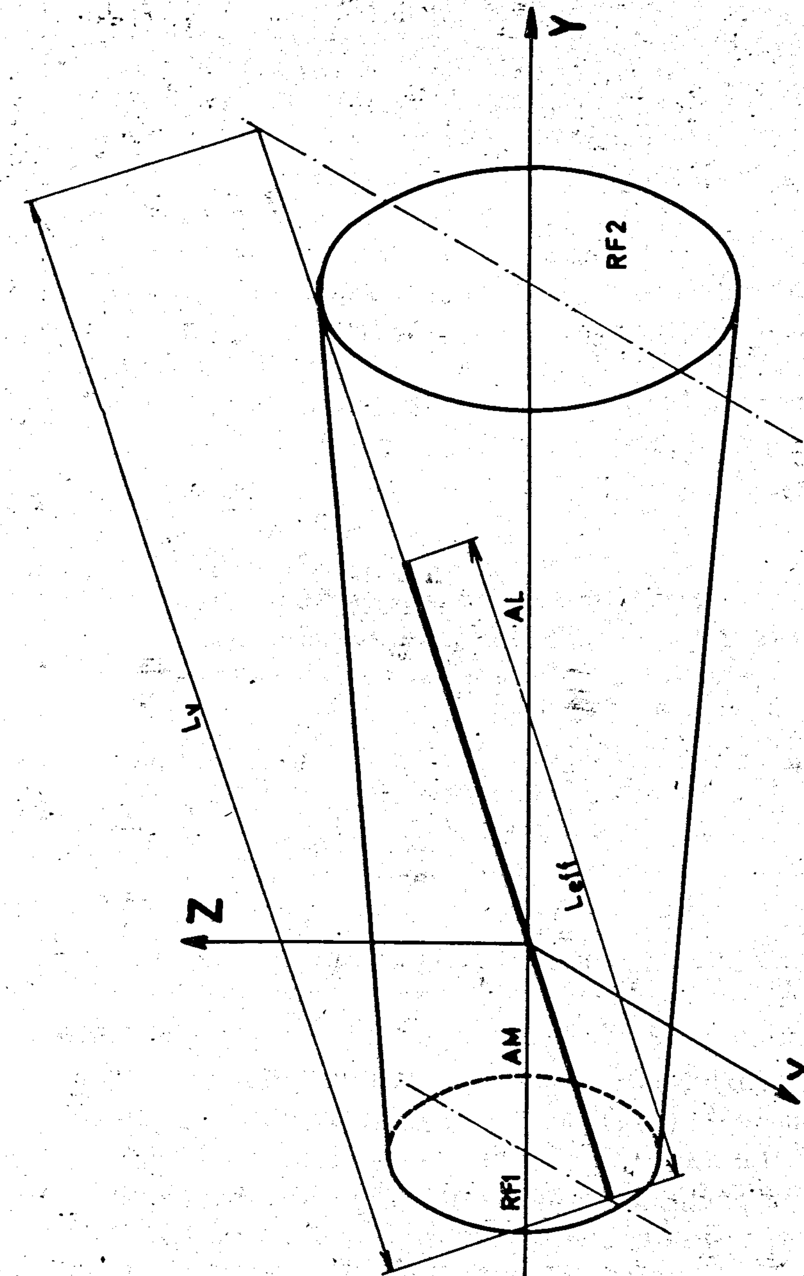

Fig. 3. The notations used in the third version of the program. Events are uniformly generated along the incident on the length L_V .

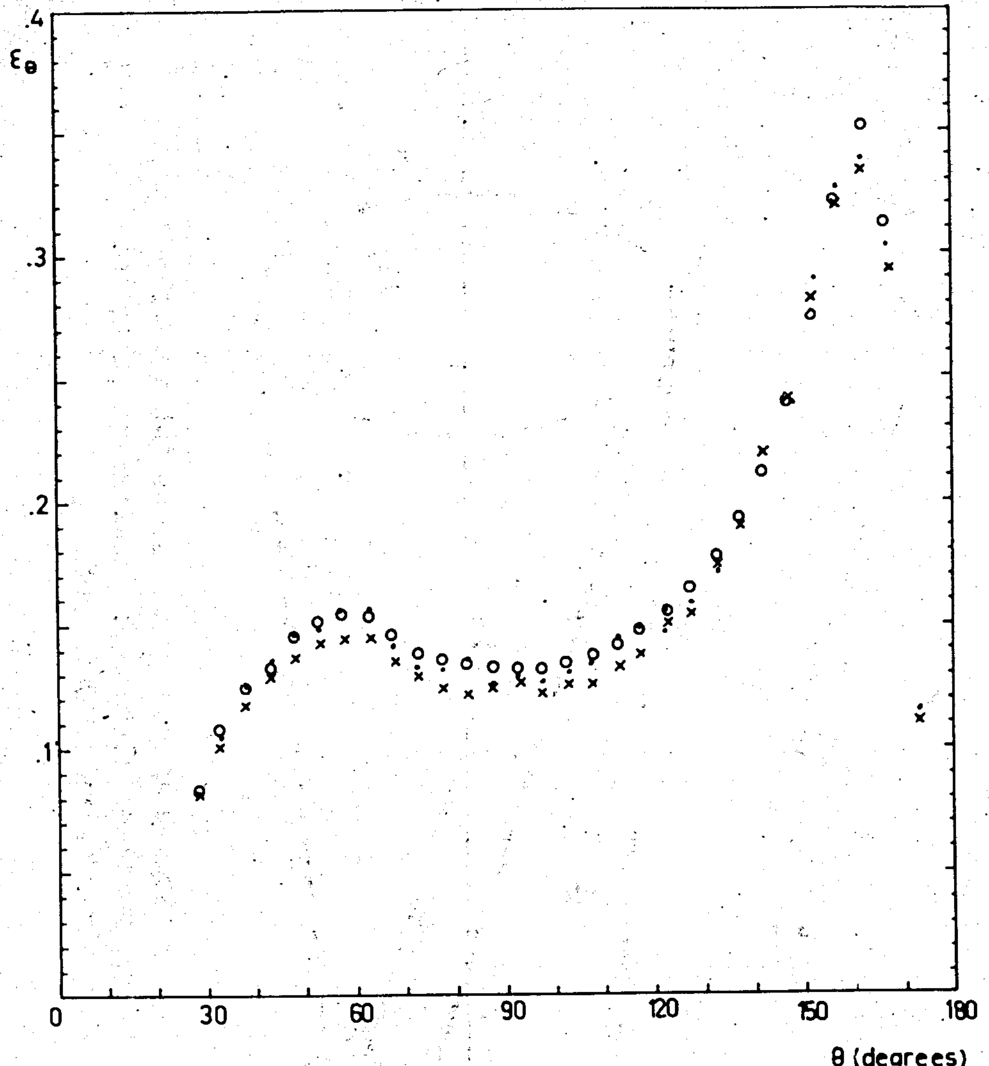

Fig. 4. Efficiency $\bar{\epsilon}_\theta$ versus the pion scattering angle θ (degrees). ∘– a) analytical computation on the axis (AL=17 cm, AM= 15 cm). · – b) Monte Carlo for a cylinder (AL =17 cm, AM = 15 cm, RF1 = RF2 = 3 cm). ×– c) Monte Carlo for the same cylinder. (Counter 20 with 0.86 efficiency and the other counters with 0.95 efficiency).

4. The values of the geometrical efficiency as a function of the scattering angle θ are given in fig. 4. Due to the small divergence of the beam, small deviations from these values are to be expected from a better approximation.

From fig. 4 it is seen that the efficiency of the streamer chamber is approximatively constant for a large interval of scattering angles, increases for small and high scattering angles and falls down at 30° and 170°. For the region 40° ÷ 140° analytical approach (1) is very good. For small and big angles Monte Carlo evaluations (II) are necessary. In these regions deviations due to the beam direction are also to be expected.

Small samples should be corrected by the average value, while for large samples (1000 events) a correction for every event (third method) should be used.

If the efficiency of a counter of the triggering system is low, the geometrical efficiency is falling down over a rather large region of angles (fig.4c).

The Monte Carlo computation (fig. 4b) has been used for the cross section calculations [4].

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