

ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ  
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ  
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**MAGNETIC SPECTROMETER OF THE  
«DEUTERON-2» SET-UP**

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**ԸՆԹՅՈՒՆ-2՝ ՍԱՐՔԱՎՈՐՄԱՆ ՍԱԳՆԻՍԱԿԱՆ ՍՊԵԿՏՐԱԶՈՓ**

Աշխատանքում նկարագրված է Երևանի ֆիզիկայի ինստիտուտի երկթե  
ԷՒԵյտրոն-2՝ փորձառական սարքի հիմնական բաղադրիչը՝ մագնիսական  
սպեկտրաչափը (ՄՍ)։ Ցույց է տրված, որ էլեկտրոնները և  
 $\pi^-$ -մեզոնները տարալուծվում են  $10^{-2} \div 10^{-3}$  գործակցով։ 1.5 ԳէՎ-ից  
փոքր իմպուլսով դրական լիցքավորված մասնիկները տարալուծվում են  
իմպուլսի և թռիչքի տևողության չափման միջոցով։ ՄՍ-ի հիմնական  
բևութագրերն են. իմպուլսի և անկյան չափումների ընդգրկման  
տիրույթները, համապատասխանաբար՝  $\Delta p/p=46\%$  և  $\Delta\theta=4^\circ$ , մարմնային  
անկյունը՝  $\Delta\Omega=2.75 \cdot 10^{-9}$  ստերադիան, իմպուլսի և անկյան չափման  
լուծունակությունը՝  $\delta p/p=1.5\%$ ,  $\delta\theta=0.6^\circ$ ,  $\delta\varphi=2^\circ$ , իմպուլսի և անկյան  
չափման սահմանները կազմում են  $0.5 \div 3.0$  ԳէՎ/c և  $10 \div 30^\circ$  ու  $68 \div 90^\circ$ ,  
համապատասխանաբար:

Երևանի ֆիզիկայի ինստիտուտ

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#### MAGNETIC SPECTROMETER OF THE "DEUTERON-2" SET-UP

A magnetic spectrometer of the two-arm "Deuteron-2" set-up is described, which is intended for investigation of  $(e,e'p)$  type reactions at the Yerevan electron synchrotron. The scattered electron identification was executed by means of the  $\pi/e$  rejection system with the rejection factor  $10^{-2} \div 10^{-3}$ . The hadron identification in the momentum range up to 1.5 GeV/c was realized by momentum and time-of-flight measurements. The main characteristics of the spectrometer are: momentum acceptance  $\Delta p/p=46\%$ , solid angle  $\Delta\Omega=2.75\text{msr}$  (i.e. the total acceptance  $\Delta S=1.26 \cdot 10^{-3}\text{sr}$ ), momentum resolution  $\delta p/p=1.5\%$ , angular resolutions  $\delta\theta=0.6^\circ$ ,  $\delta\varphi=2^\circ$ . The intervals of measured momentum and the polar scattering angle were  $0.5 \div 3$  GeV/c and  $10 \div 30^\circ$ ;  $68 \div 90^\circ$ , respectively.

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МАГНИТНЫЙ СПЕКТРОМЕТР УСТАНОВКИ "ДЕЙТРОН"

В работе описывается магнитный спектрометр (МС) установки "Дейтрон-3" Ереванского физического института. Показано, что электроны и  $\pi$ -мезоны режетируются с коэффициентом  $10^{-2} \div 10^{-3}$ . Положительно заряженные частицы с импульсом меньше 1,5 ГэВ/с идентифицируются измерением импульса и времени пролета. Основные характеристики МС: интервал захвата импульсов и углов  $\Delta p/p=46\%$ ,  $\Delta\theta=4^\circ$ , телесный угол  $\Delta\Omega=2,75 \cdot 10^{-3}$  ср, импульсное и угловое разрешение  $\delta p/p=1,5\%$ ,  $\delta\theta=0,6^\circ$ ,  $\delta\varphi=2^\circ$ , импульсный и угловой интервал  $0,5 \div 3,0$  ГэВ/с,  $\theta_e=(10 \div 30^\circ, 68 \div 90^\circ)$ , соответственно.

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## 1. Introduction

The "Deuteron-2" set-up is intended for investigations of electro- and photonuclear reactions. It is located [1] on the  $e^-$  electron and  $\gamma$ -1 photon beams of the Yerevan electron synchrotron. One of the main units of the set-up is the magnetic spectrometer (MS) intended for detection and identification of secondary forward particles (at angles up to  $30^\circ$ ). The MS is constructed on the basis of the standard SP-57 magnet.

## 2. The MS Structure

The MS is constructed by a usual principle (without focusing) according to two considerations: i) the size and equipment of load-carrying facilities in the experimental hall - the low-background hall of YERPHI - allow to apply neither extensive magnetic systems of many magnetic modules (dipoles and quadrupoles), nor special focusing magnets (see, e.g. [2]); ii) insofar as the spectrometer is to be used to study the processes with small yields, then solid angle of the MS must be chosen maximal. This naturally results in an increase of the angular acceptance. The version without focusing offers a simple possibility to verify (see below) the input angle of detected particles without use of special hodoscope systems located before the magnet. And this is very

important for the "Deuteron-2" set-up, since the distance between the target and input plane of the magnet is only 1 meter (again because of the small size of the hall). At such a distance the operation of any detector from the viewpoint of background loads is extremely difficult at least at small angles and at luminosity  $L \geq 10^{32} \text{ cm}^{-2} \text{ sec}^{-1}$ . The horizontal bend of particles in the magnetic field should be based on an important circumstance. This is stimulated by the magnet structure and by the necessity to make measurements in the scattering angle region practically from 0 to  $30^\circ$  (see fig.1). In case of choice of vertical bend a minimally possible angle (other conditions being equal) would be  $45^\circ$ .

The spectrometer is located on a platform able to turn around the general axis of the set-up. In its turn, the turning platform of the spectrometer (and the whole set-up) is assembled on a common moveable truck enabling by special rails to displace the whole set-up for a distance of 9 meters to shift the set-up from one beam to another. The height of the set-up median plane is maintained to the accuracy of 1mm.

### 3. Detecting System

The charged particles in the MS are detected by scintillation counters (SC)  $C_1+C_4$ , a Čerenkov gas-filled threshold counter (Č) [3] and a shower detector (SD) [4]. A block-diagram of the detecting system (DS) is shown in fig.2. The DS allows to simultaneously detect events "electron"

("e") by switching the  $\check{C}$  in coincidence, and events "hadron" ("h"), when  $\check{C}$  is in anticoincidence. However, the selection of events "electron" or "hadron" is not restricted to coincidence of  $\check{C}$ . For a final selection we further use data from the SD spectrometric channel. The combined use of the  $\check{C}$  and SD ensure a minimum value of the  $\pi/e$  rejection factor in the interval  $10^{-2} \div 10^{-3}$  [5], the efficiency of electron detection at the ends of this interval varying within  $90 \pm 80\%$ , respectively. Under the mode of detection of positive-charged hadrons the identification of particles (protons, pions, etc.) is extended by measuring the time of flight using the counters  $C_1$  and  $C_4$  on the basis of 4.5m. Such method of identification is effective up to 1.5 GeV/c. So long as in electro- and photonuclear reactions the yield of hadrons with momenta larger than 1.5 GeV/c (at primary energies up to 4.5 GeV) becomes insignificant, the MS makes no provision for identification of higher-energy hadrons. Fig.3 shows a typical curve of time-flight distribution under electron detection mode. The total time resolution  $\Delta\tau$  of the system, according to fig.3, is  $\pm 1.5\text{ns}$ . It is mainly due to the large dimensions of the scintillators  $C_1$  and  $C_4$  ( $20 \times 20 \text{ cm}^2$  and  $45 \times 35 \text{ cm}^2$ , respectively) leading to time-of-flight spreads  $\sim 2\text{ns}$ . We can diminish the  $\Delta\tau$  to  $1\text{ns}$  using the compensation method, i.e. by measuring the time of flight with the use of two PEM from the both ends of the scintillators  $C_1$  and  $C_4$ . However, this approach complicates essentially the system (four channels of measurement). Meanwhile, the obtained resolutions,  $\Delta\tau = \pm 1.5\text{ns}$  and real pulse spreads in the MS (see

below) allows us to separate, quite reliably, the  $\pi$ -mesons from the protons with the  $\pi/p$  rejection coefficient  $\sim 10^{-2}$ . The rejection of k-mesons from protons and  $\pi$ -mesons is not considered by us because of the small yield of k-mesons.

#### 4. Momentum Measurement

The principle of momentum measurement in a "not focusing" MC is rather simple - it is necessary to determine the particle trajectory, to calculate the curvature radius  $R$  in the magnetic field, and by the formula

$$p = 300 RH_{\text{off}} \quad (1)$$

to determine the momentum  $p$ .

The charged particle trajectory can be determined by measuring coordinates in at least three points lying either inside the circle or on two tangentials to this circle. These three points are chosen: two of them are the points  $(x_2, y_2)$  and  $(x_3, y_3)$  on the tangential after the magnet, and one of them is the point  $(x_1, y_1)$  on the tangential before the magnet. As point  $(x_1, y_1)$  we took the centre of the beam spot on the target, because, as was mentioned above, the measurement of particle coordinates in the gap between the target and the magnet is practically unrealizable due to large background loads. The points  $(x_2, y_2)$ ,  $(x_3, y_3)$  after the magnet are measured by multiwire proportional chambers (MWPC) [6] with a distance between the wires 2mm.

The radius  $R$  is calculated with the use of input and output angles

$$R=h/(\sin \alpha_1 + \sin \alpha_2) \quad (2)$$

where  $h$  is the length of poles of the magnet. Angles  $\alpha_1$  and  $\alpha_2$ , in turn, are determined by measurement of coordinates of the chosen points as follows:

$$\alpha_1 = \arctg \left\{ \left[ x_2 - x_1 + \left( y_2 - h/2 \right) \operatorname{tg} \alpha_2 \right] / \left[ y_M + h/2 \right] \right\} \quad (3)$$

$$\alpha = \arctg \left\{ \left[ x_3 - x_2 \right] / \left[ y_3 - y_2 \right] \right\}$$

where  $y_M$  is a coordinate of the central point of the magnet input plane.

Note that as far as changes of the  $z$  coordinate are small (because the magnet gap is only 100mm), then the theoretical consideration of the problem on plane with the resultant formulae (2) and (3) is valid with a good accuracy (errors of such approximation are by an order of magnitude lower than the spectrometer momentum resolution).

In order to determine by (1) the particle momentum  $P$  (in eV), it is necessary, besides the radius  $R$  (in cm) also to determine the effective field in the magnet,  $H_{\text{off}}$  (in gauss), not coinciding with the experimentally measured strength of the magnetic field in the gap of the magnet. To calculate  $H_{\text{off}}$ , we used the current-carrying wire. For the Yerevan altitude we have a relation  $p=2.94 m/i$ , where  $p$  is momentum,  $m$  is mass of compensating load,  $i$  is current in the wire. The wire coordinates were measured in three points of the trajectory, the radius  $R$  was determined by the formulae (2) and (3), and from the relation (1) the effective field was

calculated. We obtained the dependence of  $H_{\text{eff}}$  on the magnetic field strength  $H_u$  in the homogeneous region measured. Fig.4a presents dependences of the  $H_{\text{eff}}/H_u$  ratio on  $H_u$  (for the central trajectory in the median plane). The decrease of  $H_{\text{eff}}$  at large values of  $H_u$  is due to the saturation effect. Such dependences were obtained for the whole aperture of the spectrometer. In the region of uniform distribution of the magnetic field we observed neither deviations in the shape of dependence on  $H_u$  nor in the absolute value of  $H_{\text{eff}}$ . Therefore, in all the measurements, to determine the absolute value of momentum by formula (1) (the curve in fig.4a) was used.

#### 5. The momentum Resolution

The most important characteristic of MS is, of course, its momentum resolution. From relation (1) we have

$$\frac{dp}{p} = \left\{ \left[ \frac{dH_{\text{eff}}}{H_{\text{eff}}} \right]^2 + \left[ \frac{dR}{R} \right]^2 \right\}^{1/2} \quad (4)$$

The errors of  $dH_{\text{eff}}/H_{\text{eff}}$  depend on the spreads of many parameters used for determination of  $H_{\text{eff}}$  (measurement of: current in the wire, mass of compensating load, magnetic field strength, wire coordinates in three planes, etc.). Knowing these spreads, we can, in principle, analytically determine  $dH_{\text{eff}}/H_{\text{eff}}$ . However, it can be determined experimentally as well. With this aim, at the given value of magnetic field (current in the magnet) we determined the value of  $H_{\text{eff}}$  via multiple measurements by given parameter at

constant values of other parameters. This procedure being done for all parameters. We found average values of relative deviations of  $H_{\text{eff}}$  in all parameters. Results of such measurements are given in fig.4b, whence it follows that  $\delta H_{\text{eff}}/H_{\text{eff}} \leq 0.25\%$ . As far as this quantity was considerably smaller than the second term in (4) (see below), then in what follows we neglected it and took  $\delta P/P = \delta R/R$ . The errors of  $\delta R/R$  can be determined in three ways: analytically by formulae (2) and (3), by the Monte-Carlo simulations and experimentally using the elastic electron-proton scattering. All the three methods were used and the results came out very close. Fig.5 presents, e.g., the determined by the Monte-Carlo simulation two dependences of  $\delta p/p$  on the horizontal dimensions of the beam spot on the target, i.e. on the spreads of  $\Delta x_1$  at two values of the radius  $R$  (the MS was exploited mainly in the interval of the mentioned radii). One can see, that there is a sensitive dependence of  $\delta p/p$  on  $\Delta x_1$  (at fixed values:  $\Delta x_2 = \Delta x_3 = 2\text{mm}$ ). In the ideal case, when  $\Delta x_1 = 0$ , a minimum value of  $\delta p/p$  (in the given configuration of the spectrometer) is  $\leq 1\%$ . Practically, the MS can be exploited at  $\Delta x_1 = 5\text{mm}$ , which provides  $\delta p/p \leq 1.5\%$ .

## 6. The Spectrometer Acceptance

An important characteristics of the spectrometer is the acceptance  $\Delta S = \Delta \Omega \Delta p/p$ , where  $\Delta \Omega$  is the solid angle,  $\Delta p/p$  is the momentum acceptance. The acceptance is one of the important factors both for determination of the time of

performance of the experiment (hence, of the statistical errors) and for determination of the absolute values of measured cross sections (hence, of the absolute errors). Therefore, we studied the MS acceptance in detail. Fig.6 shows the obtained by the Monte-Carlo simulation dependence of  $\Delta\Omega$  on the curvature radius. Arrows point to the interval of radii  $R=4.20\pm 6.70\text{m}$  (see also fig.5 used in real physical measurements. To such interval of  $\Delta R$  corresponds, for example, for the maximum possible value  $H_{\text{off}}=1.6$  kgauss  $p=2.0$  GeV/c, ( $p=2.6$  GeV/c), . i.e.  $\Delta p=1.2$  GeV/c, hence  $\Delta S=1.26 \cdot 10^{-3}$  sr, since  $\Delta\Omega=2.75$  msr and  $\Delta p/p \approx 0.46$  (see fig.6).

## 7. The Spectrometer Efficiency

The total efficiency of the MS consists of two components: the efficiency of the detecting system including the MWPC and the efficiency of selection of events. As to the first component, its value was determined in a classical way: as the DS efficiency we took the product of efficiencies of its separate elements determined by the method of "three counters" (the counter under study was placed between two auxiliary counters, and we determined the ratio of the number of three-fold coincidences to the number of two-fold ones). It was found that the detection of, e.g., electrons by four scintillation counters, SD,  $\check{C}$  and at least four MWPC was  $\sim 71\%$ .

Much more difficult is to determine and provide high level of efficiency of selection of required events. The

events with a trajectory passing through the homogeneous region of the magnetic field and which has the form of a straight line, are selected as useful. Obviously, the event selection efficiency essentially depends on the background conditions which are responsible for the so-called average number of operations (ANO) in the MWPC and its distribution by wires in the MWPC. The experiment has shown that the selection efficiency starts to decrease if the ANO becomes more than 3 (the ANO corresponds to the number of wires producing electric signals during one trigger master).

Another important circumstance responsible for the selection efficiency is the quality of the PC adjustment. We performed the so-called programmed adjustment of individual chambers: two chambers (most distant ones) were taken as basic and were adjusted geometrically (using the optical devices). Errors in their adjustment affect mainly the determination of the absolute value of the measured momentum. So long as the value of deviations of trajectories in the places of disposition of these chambers are sufficiently large ( $\sim 360\text{mm}$  for chamber No.1 and  $\sim 600\text{mm}$  for the chamber No.7), then the real errors of the adjustment,  $0.8\text{mm}$ , do not essentially affect the determination of the average value of momentum and the momentum resolution. The adjustment of the other (intermediate) chambers was executed as follows: if we construct a line passing through the operated wire in the basic chambers, then determine the calculated coordinates of that line in the intermediate chambers and find the difference between the obtained coordinates and those of

really selected wires in these chambers, then at correct adjustment the distribution of events with respect to these differences must have a maximum at zero. At deviation from zero by means of programmed shift of the chamber coordinate as a whole by the required value, we can attain "zero" distribution. Fig.7 shows such (real) distribution, for five intermediate chambers. One can see that we succeeded in adjusting all the chambers. The resultant efficiency of selection of events was ~86%.

Thus, the MS total efficiency was ~64% (this value can be made more precise only via physical measurements, e.g. of (e,e')-scattering on hydrogen (see below)).

#### 8.Spectrometer Calibration by Electron-Proton Scattering

The most effective way to calibrate the spectrometer is to measure the cross section of some well-calculable or experimentally already studied process. We took electron scattering on free protons. The 1.947 GeV electrons were scattered at  $15 \pm 2^\circ$  on  $^{12}\text{C}$  and  $\text{CH}_2$  equithick targets.

Fig.8 shows a spectrum of electrons scattered on a  $^{12}\text{C}$  target with thickness 0.012 rad units. One can see a pronounced peak from quasi-elastic scattering and a wide maximum in the region of  $\Delta$ -resonance. Fig.9 presents a similar spectrum obtained on the  $\text{CH}_2$  target. The difference between data from  $\text{CH}_2$  and  $^{12}\text{C}$  is also given in fig.9 (open circles). The curve in fig.9 refers to the result of

theoretical calculations by the Rosenblut formula with dipole form factor. We took into account the radiative corrections according to ref.[7] by the "folding" procedure, i.e. in order to compare theory with experiment, the radiative corrections were introduced into the theoretical data.

Experimental and theoretical data will become equal to the normalization coefficient 0.66, i.e. the spectrometer efficiency will be  $\approx 66\%$ , which is in good agreement with the above-given value of efficiency (0.64).

The width of distribution of scattered electrons on protons allows to determine experimental momentum resolution of the MS. If the effect introduced by the final value of the angular acceptance is taken into account, then the momentum resolution is  $\delta p/p = (3.1 \pm 0.1)\%$  at 1.8 GeV/c and  $\Delta x_1 = 10\text{mm}$ . In the momentum range  $p < 1.8$  GeV/c  $\delta p/p$  will be lower, since to similar momenta there correspond small curvature radii, and following fig.5, this leads to a decrease in  $\delta p/p$ . The experimentally found value  $\delta p/p$  is in good agreement with the calculated ones (see Sect.5).

Above (see Introduction) we mentioned that the spectrometer allows to make more precise the input polar angle in the angular acceptance region ( $\sim 4.5\%$ ). With this aim, using the measurements of the trajectory after the magnet, we determined the particle coordinate on the magnet input and with the known central coordinate of the target we determined the input angle  $\theta_e$  with spreads  $\delta\theta_e = 0.6^\circ$ . Fig.10 presents distributions of events given in fig.8 by the

coordinate on the magnet input, and fig.11 shows electron spectra for four values of input angle (for four regions of spectrum in fig.10). One can see that in the angular acceptance the spectra have different characteristics. The sum of all these spectra integral spectrum is that shown in fig.8.

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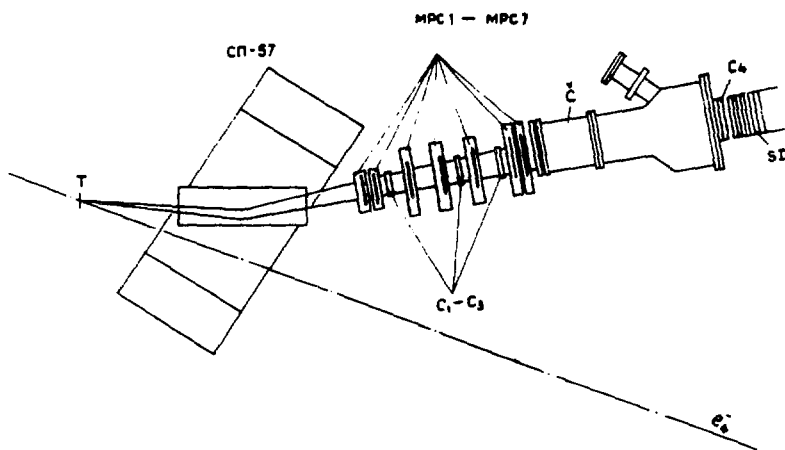


Fig.1

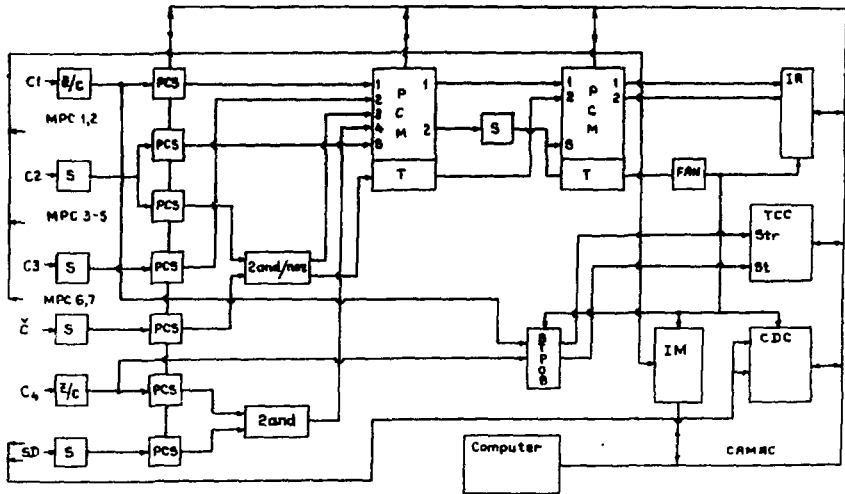


Fig.2

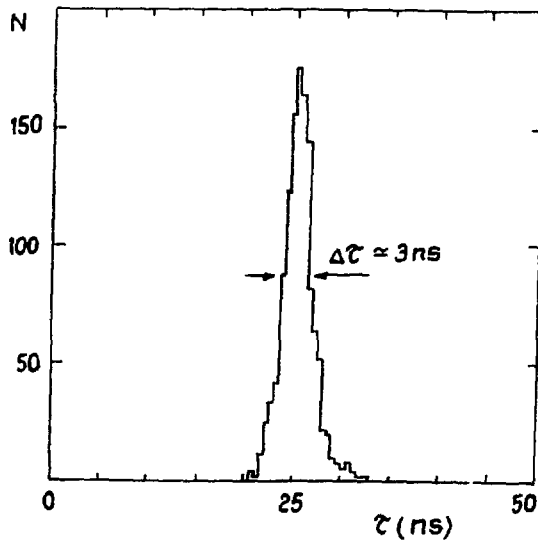


Fig.3

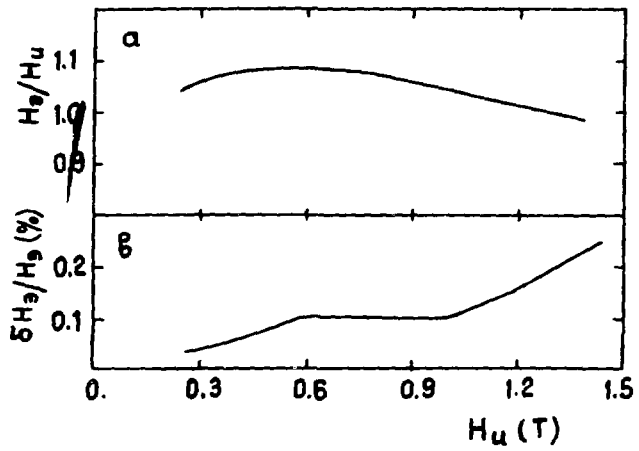


Fig.4

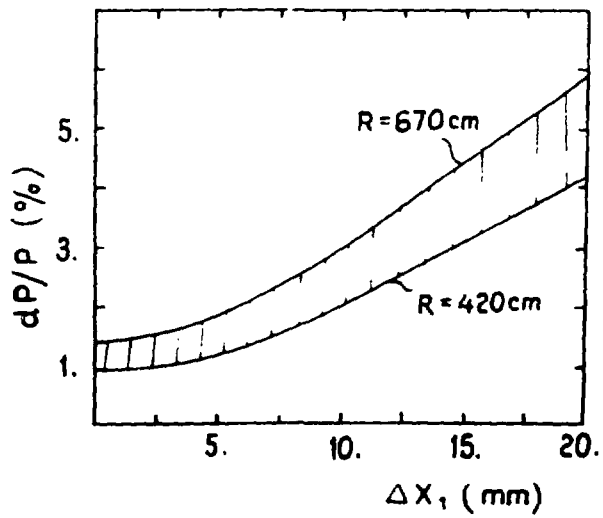


Fig.5

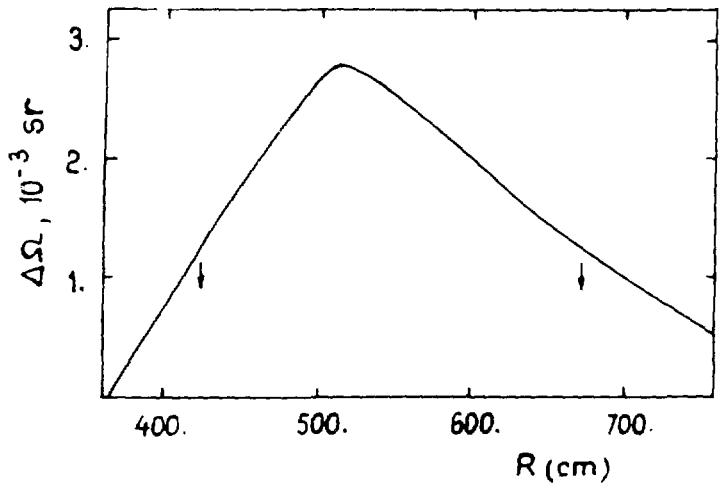


Fig.6

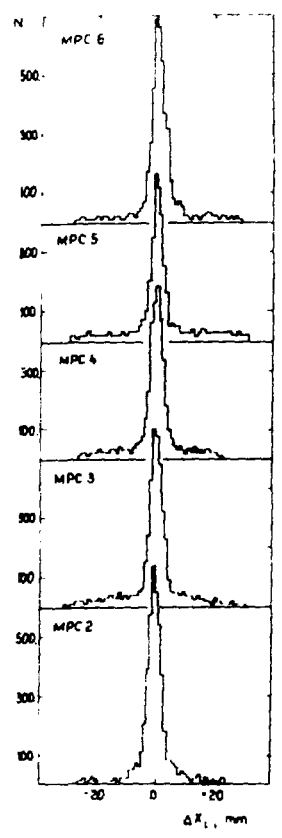


Fig.7

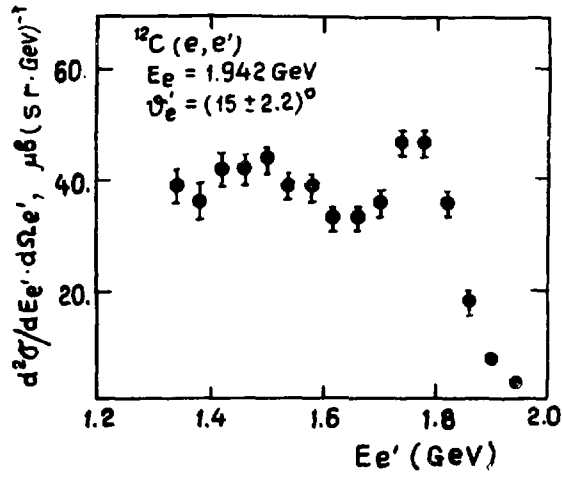


Fig.8

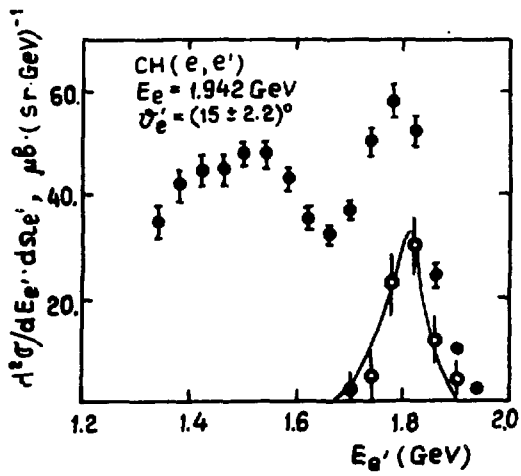


Fig.9

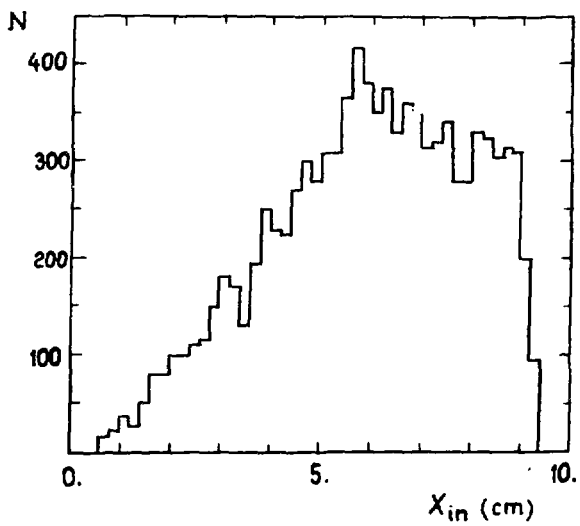


Fig.10

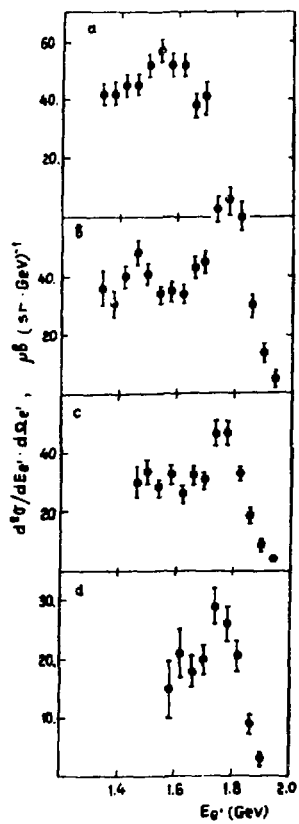


Fig.11

## FIGURE CAPTIONS

- Fig.1 Magnetic spectrometer of the "Deuteron-2" set-up. T-target, SP-57 - magnet, C<sub>1</sub>-C<sub>4</sub> - scintillation counters, Č-Čerenkov gaseous threshold counter, SD-shower detector, MWPC-multiwire proportional chambers.
- Fig.2 Block-diagram of MS electronic logic. F $\bar{\Phi}$ -discriminator, z/c - zero-crossing discriminator, PSC-program-controlled discriminator, 2Y/ND- two-fold coincidence, PCM- programmed coincidence matrix, S-strob coincidence, F- fan-out, IM- interrogation module, IR- input register, TCC- time-to-code converter, CDC- charge-to-digital converter.
- Fig.3 The time-of-flight distribution of e<sup>-</sup> and  $\pi^-$ -mesons with momenta  $p \approx 2$  GeV/c on the basis of 4.5m in the MS.
- Fig.4 a) The dependence of the ratio of the value of effective magnetic field  $H_{\text{eff}}$  to the value of measured field strength  $H_u$  (in the median plane).  
 b) The dependence of relative errors of determination of  $\delta H_{\text{eff}}/H_{\text{eff}}$  on  $H_u$ .
- Fig.5 The calculated dependence of relative errors of  $\delta p/p$  on the horizontal dimension of the beam spot on the target ( $\Delta x_1$ ).
- Fig.6 The dependence of the solid angle  $\Delta\Omega$  on the curvature radius R. Arrows point to the interval of curvature radii used in the MS.

Fig.7 Event distributions on differences between the coordinates of the operated wire and the coordinate of the trajectory in MWPC2+MWPC6.

Fig.8 Scattered electron spectrum in the reaction  $^{12}\text{C}(e,e')$ . Primary electron energy is  $E_e=1.942$  GeV, the scattering angle  $\theta_e=15\pm 2^\circ$ .

Fig.9 The same as in fig.8. ●-for  $\text{CH}_2(e,e')$ , ○-the  $\text{CH}_2-^{12}\text{C}$  difference spectrum. Solid curve is the calculated spectrum of electrons scattered on protons.

Fig.10 Distribution of events in  $^{12}\text{C}(e,e')$  reaction over the input coordinate of the magnet  $x_{in}$ .

Fig.11 Spectrum of electrons scattered on  $^{12}\text{C}$  at  $E_e=1.947$  GeV, for four values of scattering angle:  
a)  $\theta_e=13.6\pm 0.3^\circ$ , b)  $14.6\pm 0.3^\circ$ , c)  $15.6\pm 0.3^\circ$ ,  
d)  $16.6\pm 0.3^\circ$ .

## REFERENCES

1. Alanakyan K.V., Amaryan M.J., Asryan G.A. et al. The Characteristics of the Electron Beam Extracted onto the Set-up "Deuteron-2" of YERPHI. Preprint YERPHI-1035(85)87.
2. Afanas'ev N.G., Visotskaya A.B. et al. The Magnetic Spectrometer for 100MeV Electrons. PTE 1964, vol.5, p.48 (in Russian).
3. Alanakyan K.V., Amaryan M.J. et al. The Gas Threshold Čerenkov Counter for "Deuteron-2". Preprint YERPHI-1034(84)-87.
4. Bojakhchyan E.M., Keropyan I.A., Nikitin N.I. Some Data on Fluctuations of Energy Loss in a Shower Detector. Preprint EPI-333(58)-78.
5. Alanakyan K.V., Amaryan M.J., Asryan G.A. et al.  $\pi/e$  Rejection System of "Deuteron-2" Set-up. Preprint YERPHI-1042(92)-89.
6. Apresyan A.N., Asatryan P.A., Ajvazyan P.B. et al. The Results of Construction of Multiwire Proportional Chamber in YERPHI. Preprint YERPHI-486(29)-81.
7. Tsai Y.S. Radiative Corrections of Electron Scatterings. SLAC-PUB-848, 1971.

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