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TESTING OF AN ASSEMBLY OF SPARK CHAMBERS WITH FERRITE RINGS INTENDED FOR EXPERIMENTS AT THE SYNCHRO-CYCLOTRON

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The present paper deals with the study of some characteristics of an assembly of wire spark chambers with ferrite rings in connection with its preparation for experiments in the JINR synchrocyclotron.

The spark chamber assembly was prepared in the form of a set of modules with working dimensions of 256 x 256 mm^2. The module has a fibre-glass frame. Both electrodes of the module consist of 256 parallel copper 0.1 mm diameter wires stretched at 1 mm intervales. The wires of the ground and high voltage electrodes are arranged perpendicular to each other. The distance between electrodes in the working region is 8 mm, increased at the edges to 10 mm to reduce fringe effects. The windows of the module are sealed with 0.1 mm polyethylene film.

Each electrode is connected to a matrix with 0.7 watt type ferrite rings with an external diameter of 3 mm. In the matrix of the high voltage electrode teflon-insulated conductors are used for the connection with the chamber wires and the rings are coated with epoxy resin. The capacitance of the module is 400 pf.

The pulsed power supply of the assembly uses a high-voltage pulse generator [1], with a discharge device consisting of VIR-14 dischargers. The discharge capacitance for the spark gap is 1 nf. The discharger is connected to two spark gaps and the discharge circuit includes current-limiting resistors (R = 82 ohm). The rise time constant of the high voltage pulse in the spark gap is 30 nsec. The total time lag of the high-voltage pulse with reference to the triggering pulse from the coincidence circuit is 120 nsec.

Tests in a charged particle beam extracted from the synchrocyclotron were carried out using an assembly of 8 modules arranged in series one behind the other. A neon-helium mixture was blown through the modules. The voltage in the discharge capacitances was 6 kV and the voltage of the clearing field was 50 V.

A block diagram of the set-up is given in Fig. 1.

Information from the matrix was read out by the device described in (2). For the readout the modules were divided into sets of four, namely: first the matrices of the ground electrodes of the first four modules were searched, and then the matrices of the high-voltage electrodes of these modules and so on.

From the readout the information is transmitted to the store of one of the AI-4096 analysers, which are components of the storage and processing centre [3]. The serial number of the ferrite rings set by the spark current occupies one 18-digit word. If several neighbouring rings are set, only the serial number of the first of them is recorded and the total number of rings set is indicated in the same word.

The digits of each word are allocated as follows:

1 - 8 for the serial number of the set ring in the matrix
9 - 10 for the serial number of the module in the set of four
11 for the serial number of the matrix in the module
12 - 15 for the serial number of the set of four modules
16 - 17 for the total number of neighbouring rings set
18 for recording the sign of the beginning of the event.

Recording in the store of the analyser can also be carried out by another programme, when the code of the number transmitted by the readout (more precisely the first 12 digits of the word mentioned above) is the reference of the channel whose contents increase by one with each operation.

The contents of the store can be transferred to an oscillograph tube for the observation of separate events and for obtaining qualitative information on the efficiency of separate modules in the first recording programme, or on the particle beam profile in the second programme.

Fig. 2 gives an example of a transfer on the tube screen of information recorded by the first programme when only the first 8 digits of the words were extracted. The serial number of the analyser channels is plotted on the X co-ordinate and the serial number of the set rings in the modules on the Y co-ordinate. The order of transfer corresponds with that described above. The figure shows two events recorded successively.

The information stored in the analyser was transferred to magnetic tape and then transmitted through a buffer store for processing in the Minsk-22 computer(3). It was processed according to the PORISK programme (spark chamber tuning programme) as described in paper (4). The programme is in three parts.

The first part of the programme successively selects separate events from the information received, interprets them, condifies them into suitable form for subsequent analysis and records on magnetic tape the three-dimensional matrices representing the separate events, indicating the serial numbers of the modules, matrices and set rings. In addition, this part of the programme calculates the average number of rings set for one spark and the average number of sparks in the module for one triggering.

The second part of the programme defines the geometrical shift of the modules in relation to each other. For this the events are successively retrieved from the magnetic tape and those fulfilling the following conditions are selected:

1. Sparks are recorded in all the modules.
2. In the first and last module only one spark is recorded.
3. In the remaining modules sparks are recorded whose co-ordinates deviate from the straight line running through the co-ordinates of the spark in the end modules, by no more than the specified distance (8 mm).

In the events selected the least squares method is used to compute the parameters of the straight line approximating to the particle track and the distance from the spark in each module to this straight line is determined. The calculation is made for a given number of events (in the present case 120). Then the mean shift of the sparks from the approximating straight lines is found.

Calculation shows that one iteration is sufficient, since the magnitude of the shifts obtained in the second iteration is in the majority of cases less than the accuracy of determination of the shifts themselves, which in the present cases was 0.05 mm.

The spark shifts found correspond to the relative shifts of the modules and are corrections to the recorded co-ordinates of the passage of the particle through the chamber. It should be noted that as a result of this method the relative shifts of a module can be as it were "established" only on a straight line defined in more than one way (for example, crossing through their geometric centres and making an arbitrary angle with the electrodes).

The calculated corrections to the relative shift of the modules are given in Table 1.

The third part of the programme computes the recording efficiency and the three-dimensional resolution for each module. For this purpose, taking into consideration the corrections to relative shifts of the modules, the parameters of the straight lines approximating to the tracks were determined by the least squares method and then for each module the r.m.s. deviation of the sparks from the tracks was found.

The distribution of the distances from the spark to the track for one of the modules is given in Fig. 3. The r.m.s. values of these deviations for both matrices of all the modules is given in Table 2. For the ground electrodes of all the modules this value lies between 0.33 - 0.50 mm and for the high voltage electrodes between 0.44 - 0.62 mm.

The same table shows the recording efficiency when one charged particle is passing through the module and also the average numbers $\bar{n}$ of rings set by one spark, as determined in the first part of the programme. The average number of sparks in the module for one triggering varied from 1.0 to 1.8 depending on the beam intensity and the background conditions.

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References

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TABLE I

Corrections to the relative shift of the modules (mm)

No. of module	Ground electrode		High-voltage electrode	
	Iteration 1	Iteration 2	Iteration 1	Iteration 2
1	-0.16	0.01	-0.60	0.00
2	0.06	-0.04	1.30	0.10
3	-0.57	0.01	0.14	-0.04
4	-1.12	0.00	-1.56	-0.11
5	3.83	0.10	0.32	0.06
6	0.44	-0.02	1.13	0.00
7	-0.86	-0.02	0.05	0.00
8	-1.62	-0.03	-0.78	0.00

TABLE II

Recording efficiency ε, average number of set rings $\bar{n}$ and accuracy σ of determination of the co-ordinates of the passage of the particle through the modules.

No. of module	Ground electrode			High-voltage electrode		
	ε(%)	$\bar{n}$	σ(mm)	ε(%)	$\bar{n}$	σ(mm)
1	97.4	1.69	0.44	99.7	1.08	0.48
2	99.5	1.77	0.34	99.2	1.17	0.44
3	96.4	1.48	0.42	96.0	1.27	0.48
4	98.8	1.59	0.46	100.0	1.15	0.59
5	99.0	1.81	0.50	99.2	1.29	0.62
6	93.6	1.62	0.44	98.9	1.21	0.58
7	97.1	1.48	0.33	98.7	1.29	0.44
8	99.2	1.94	0.46	99.2	1.50	0.59

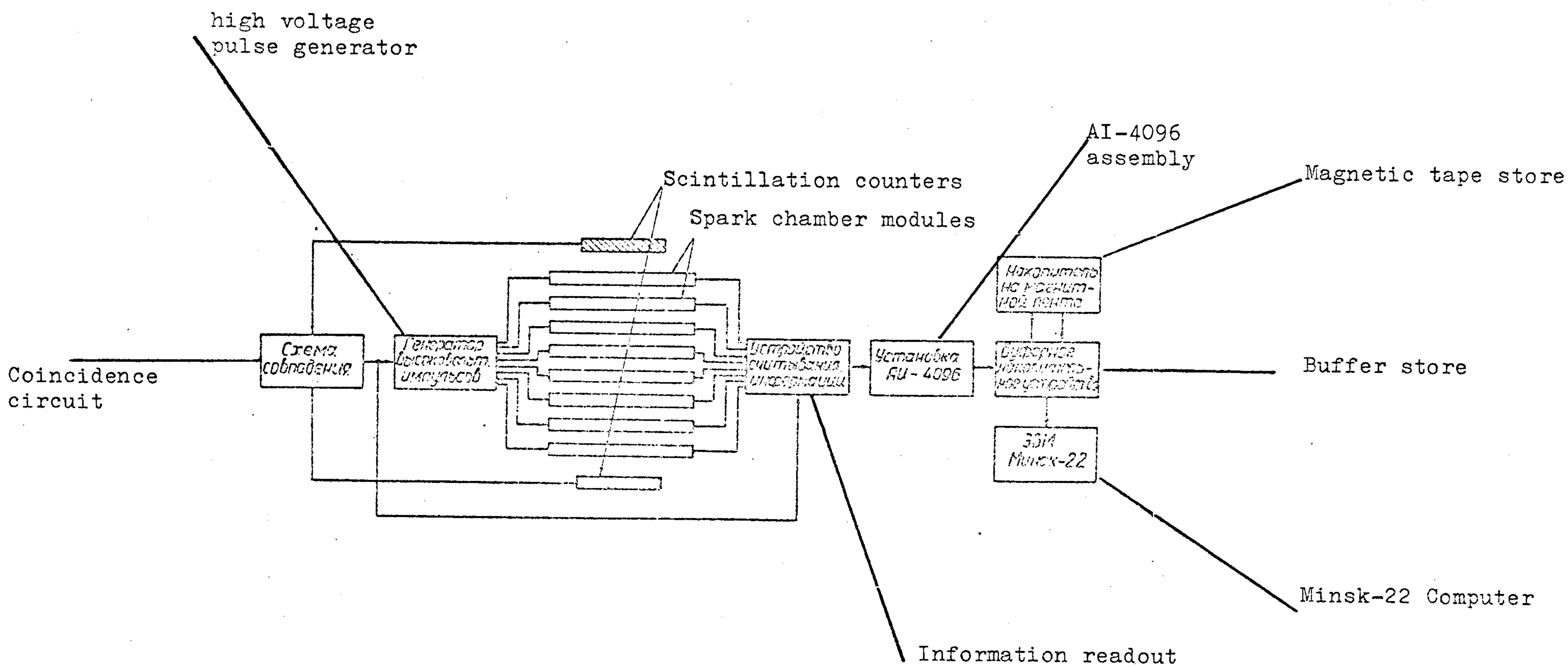
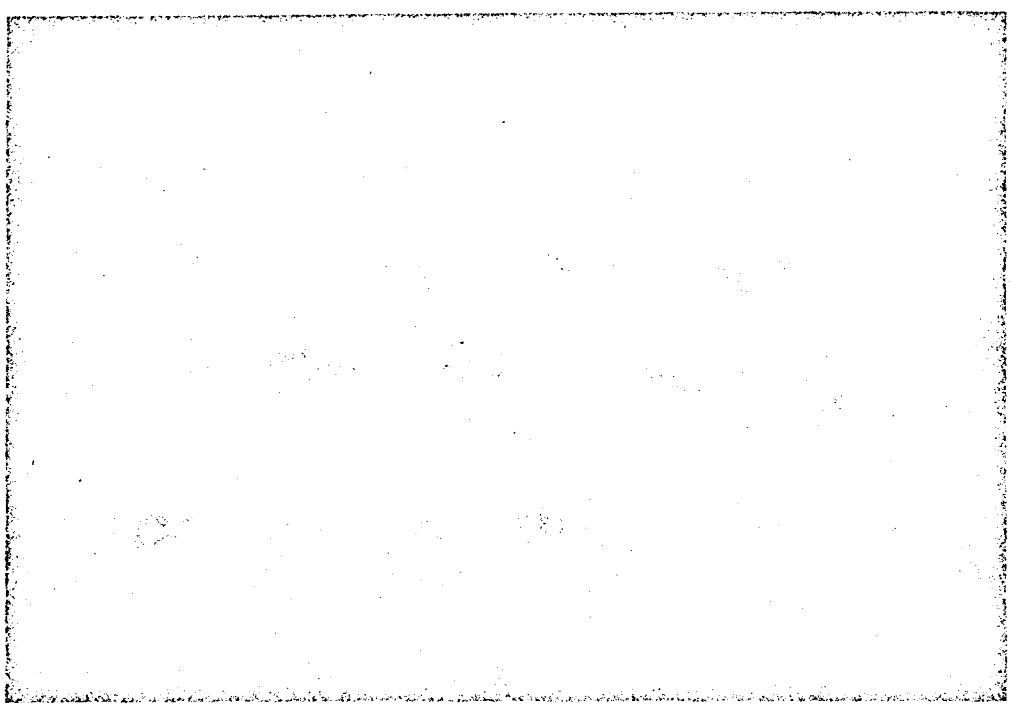
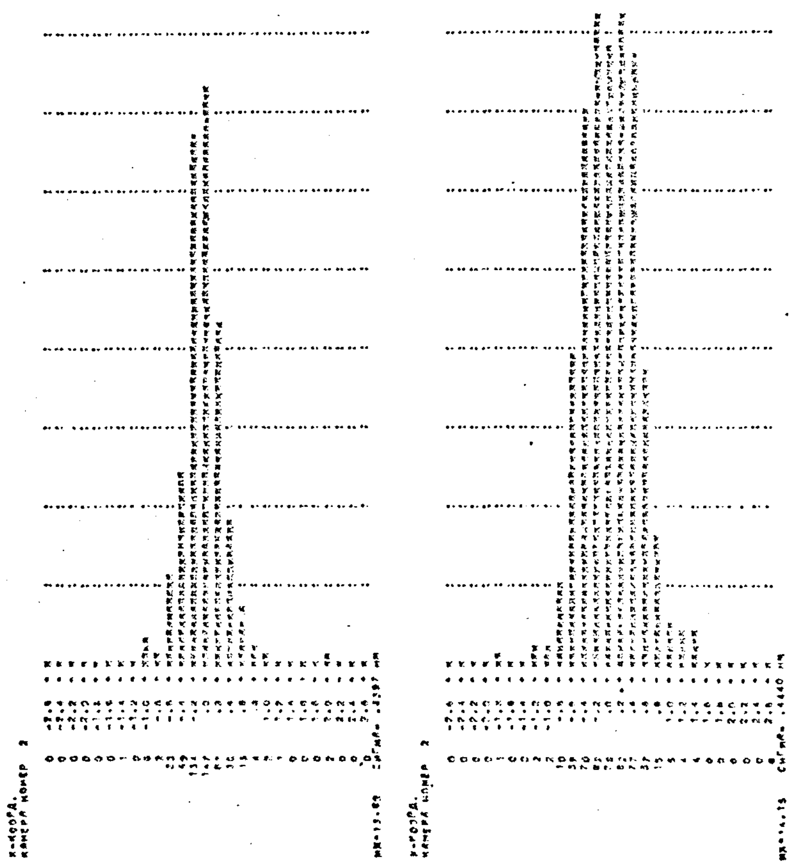


Fig. 1 Block diagram of the experiment with spark chamber system.



<u>Fig. 2</u> Information transferred to the oscillograph tube of the AI-4096 analyzer. Bottom line of spots - null line (X co-ordinate); middle line of spots - spark co-ordinates for the high voltage electrodes; top line of spots - spark co-ordinates for the ground electrodes.



<u>Fig. 3</u> Distribution of the distances between the spark and the straight line approximating to the track. Spacing of histogram - 0.2 mm. On the left - ground electrode, on the right - high-voltage electrode. Vertical scale: on the left: 1 reading = 2 events, on the right: 1 reading = 1 event.