DEVELOPMENT OF TRACK CHAMBER PICTURE PROCESSING SYSTEMS AT THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

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Some information on the bubble and spark chamber picture processing system at JINR has been presented at previous conferences[1,2]. The present configuration of the system and plans for development are given in this report. During the next 2-3 years, the main sources of film at the Joint Institute for Nuclear Research will be:

from the JINR synchrophasotron:

- the 1 m hydrogen bubble chamber with two 50 mm films,
- the 1 m propane bubble chamber with two 80 mm films,
- film from spark chambers.

from the Serpukhov accelerator:

- the 2 m hydrogen bubble chamber with 3 or 4 50 mm films,
- the 2 m propane bubble chamber with six 50 mm films,
- the 5 m magnet spark chamber spectrometer with one 35 mm film,
- some large streamer chambers in a magnetic field.

A part of these films will be analysed by physics groups from the laboratories of the JINR member countries or will be processed in large collaborations, but because of the limited possibilities of these laboratories the major part of this film will probably be processed on the JINR devices. A processing system is being developed which will be able to handle these various films effectively.

A brief survey of the data processing system status is given below.

1. STATUS OF THE TRACK CHAMBER PICTURE PROCESSING SYSTEM

1.1 Semi-automatic measuring devices (PUOS) on-line to the BESM-4 and MINSK-22 computers (Fig. 1)

At present, the work of attaching 11 PUOS's on-line to a BESM-4 computer is in the last stages of completion[3,4]. Production measurement has already started with 5 GeV/c (πp) interactions in the 1 m hydrogen bubble chamber. Measurements are carried out by operators in accordance with the scanning information provided. The BESM-4 computer reads in and checks the data from the measuring devices, and those measurements which satisfy all criteria are recorded on magnetic tape. The operators communicate with the computer via switches and indicator lamps. The system operates for six hours per day, with the operators working 3.5 hours on the scan-tables and 3.5 hours on the measuring devices. To achieve maximum efficiency these PUOS's will be divided into three sub-groups: one for processing hydrogen bubble chamber pictures, one for processing propane bubble chamber pictures, and the third one for various work with spark chamber pictures and for tests.

The PUOS's now in use for measuring the pictures from the 1 m propane chamber which are on-line to the MINSK-22, will be taken out of service. These devices will then be connected to the BESM-4 computer. Thus finally the number of PUOS's on-line to the BESM-4 computer will be increased to 16.

1.2 HPD on-line to the CDC-1604A computer

The Road Guidance programs for measuring hydrogen bubble chamber pictures on HPD are near completion[5,6]. It is expected that processing real events for the purpose of checking out the entire system can be started in the second part of the year.

Scanning and pre-measurement of events will be done on scanning-measuring tables of the type BPC-1 and BPC-2 connected to a small TPA computer (8 K, 12 bit, 8 μsec). Two tables are presently being connected on-line. Next year there will probably be six tables on-line. Measured data will be stored on magnetic tape and will serve as input to the normal sequence of film processing programs MIST, GATE, FILTER, SMOG and THRESH on the CDC-1604A.

In future, the pictures from the JINR 2 m hydrogen bubble chamber will be processed on the BESM-6 by a geometry program which takes into account both energy loss as a function of a particle's mass and the inhomogeneity of the magnetic field. Work on the use of HPD to analyse film from the ITEP 6 m magnet spark chamber spectrometer operating at the 40-60 GeV Serpukhov accelerator is going on simultaneously with the work of getting the HPD to run. It seems that it will be the first experiment to be processed using the HPD. It is planned to define the approximate position of the event by measurement on the BPC-2 scanning tables; the remainder of the processing will then be automatic. At the same time this work will serve to develop the processing methods for the pictures from the JINR 5 m magnet spark chamber spectrometer.

1.3 CRT automatic scanner on-line to the BESM-4 computer

The scanner is intended for the measurement of spark chamber pictures[7]. In 1969, 100,000 events were measured to investigate the polarization of secondary protons in the reactions $pp \to pn\pi^+$ and $pp \to pp\pi^0$ (the energy of the secondary protons being about 380 MeV). The pictures were of a 32-gap spark chamber $36 \times 36 \times 83$ cm^3 on a frame of 18×22 mm^2. After 3 months of operation we have obtained the following breakdown of the scheduled time:

measuring	75%
input of programs (adjustments of the CRT-BESM-4 and change of films)	9%
computer malfunction	8%
device malfunction (defocusing of the light spot, instability of discrimination levels for photo-multiplier signals and others)	5%
accidental failures	3%

1.4 Bubble and spark chamber picture processing programs

BESM-6, CDC-1604A, BESM-4, MINSK-22 and TPA computers are all used by the bubble and spark chamber picture processing system in the JINR. Of these the BESM-4, MINSK-22, TPA and to some extent the CDC-1604A are involved in the measurement systems. The data processing programs are

run on the CDC-1604A and BESM-6. One must also mention that these computers are used for the off-line processing of experimental data received by data links from remotely located computers in the Institute; BESM-4, BESM-3M, and MINSK-2 computers are used for these purposes. Altogether these computers make up the measuring-computing complex of the JINR which is intended to handle both bubble and spark chamber picture processing and also data from filmless experiments[8].

The 1 m hydrogen bubble chamber data processing is done on the CDC-1604A by the PRIT, THRESH, GRIND programs. The PRIT program is used for preparing magnetic tape in the format which is necessary for THRESH. THRESH, GRIND, SLICE and SUMX programs have been modified to the JINR requirements (computer, chamber, measuring system) from the well-known CERN programs with similar titles[9].

The geometry and kinematics programs are ready for processing the 2 m propane bubble chamber data on the BESM-6. The geometry program is based on algorithms developed for the program on the BESM-4 for heavy-liquid chambers[10]. In that program multiple scattering, kinks, and inhomogeneity of the magnetic field are taken into account. The kinematics program for heavy liquids has been developed from and uses the same general organization as the GRIND program.

The 2 m hydrogen bubble chamber data processing programs on the BESM-6 are based upon the corresponding geometry and kinematics programs developed in CERN (including the mass-dependent treatment of energy loss).

Versions of such programms developed in the JINR have to include the possibility of measuring film from large magnet spark chamber spectrometers (ITEP, JINR). At the end of 1970 it is also planned to start using the SLICE and SUMX programs on the BESM-6.

2. DEVELOPMENT OF THE BUBBLE AND SPARK CHAMBER
   PICTURE PROCESSING SYSTEM

Within the next few years most attention will be given to the HPD. There will be both hydrogen bubble chamber pictures and large streamer chamber pictures to be processed on it. The development of this device will be in two directions:

- overcoming limitations affecting device efficiency arising from the CDC-1604A computer, and

- the use of a display with a light-pen for the recovery of rejected events (possibly in real time).

The PUOS's on-line to the BESM-4 will be used for propane bubble chamber picture processing once the HPD device is in operation and the system will be developed to increase efficiency.

At present the CRT is being used for the processing of cylindrical spark chamber pictures. Much attention is being given to the use of a display with a light-pen to provide effective man-machine interaction in the process of recognizing and measuring events.

A device of the "SPIRAL READER" (SR) type is being developed in the JINR in collaboration with some other laboratories. It is planned to put it into operation in 1971. Together with the High Energy Physics Institute in Zeuthen we are studying the possibility of using the SR, possibly in modified form for processing pictures from the large chambers. Also, one would like to be able, with such a machine, to measure ionization in the region of the relativistic rise if that should prove feasible.

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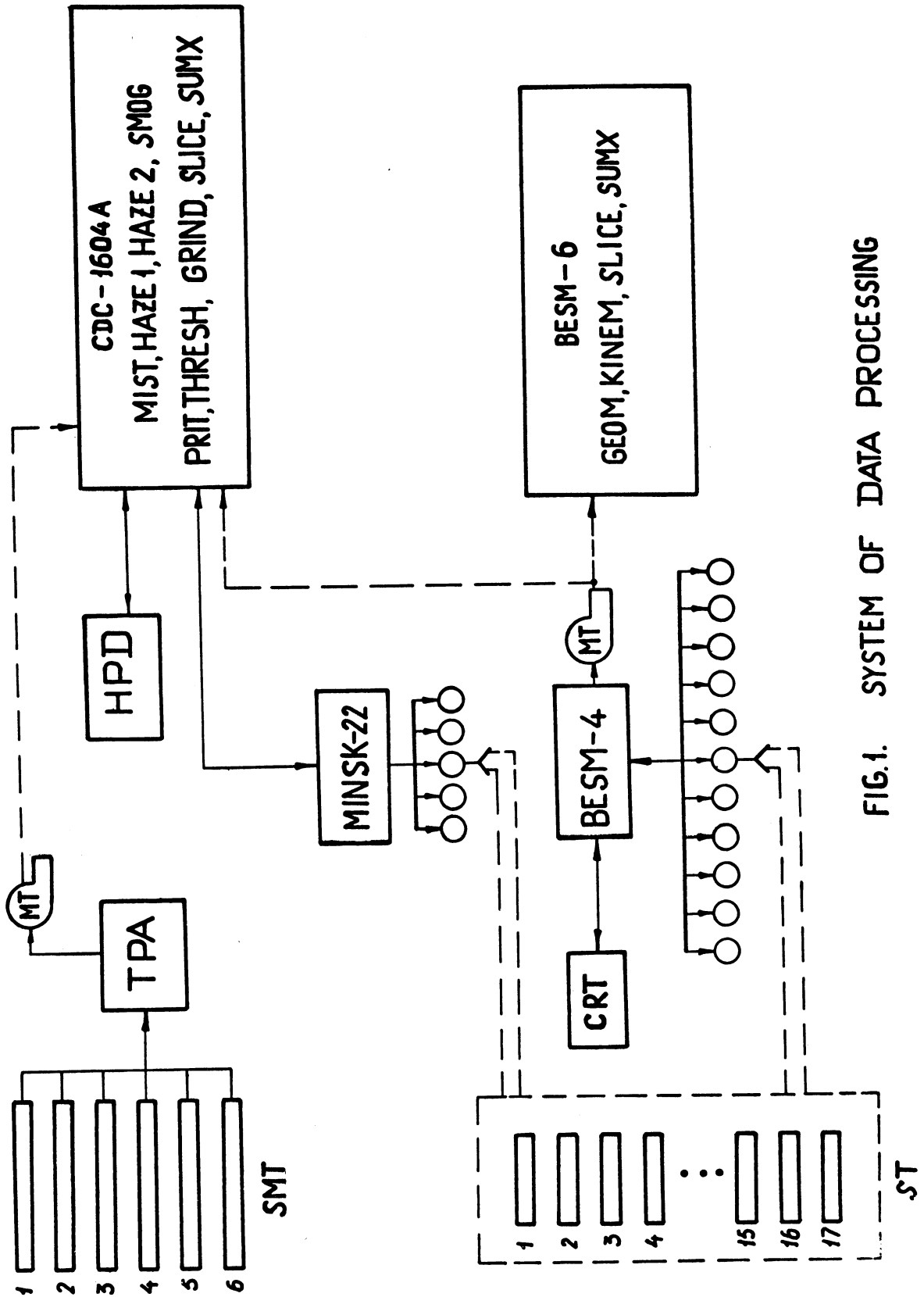10) N.F. Markova, V.I. Moroz, V.I. Nikitina, A.P. Stel'mah and G.N. Tentyukova, JINR preprint, R10-3768, Dubna, 1968.

FIG.1. SYSTEM OF DATA PROCESSING

DISCUSSION

W. BLAIR *(CERN)*: You have not said anything about measuring film from large bubble chambers, for example, Mirabelle. Would you like to comment on this?

R. POSE: We are just tackling this problem but we have not yet put very much work into it.

W. SLATER *(UCLA)*: What are the main characteristics of your computers?

R. POSE: The BESM 4 is a 3 address computer with a core memory of 8 K 45-bit words and a 600 K word drum.   It operates at about 20,000 instructions per second.

The MINSK 22 is a two-address machine, with a core memory of 8 K 37-bit words and a memory cycle time of 24 μsec.

The BESM 6 computer works at a speed of one million one-address instructions per second, has a 32 K word core memory of 48-bit word length and a 512 K word drum.

For the small TPA computer I gave some information in the morning session.

M. THOMPSON *(Wisconsin)*: Can you run FORTRAN of the BESM 6?

R. POSE: Yes.

K. SMITH *(Glasgow)*: Have you made any attempts to analyse streamer chamber film?

R. POSE: No, not yet. We are, however, building streamer chambers in Dubna, therefore at the beginning of 1971 we have to do something for them.

H. NAGEL *(Bonn)*:   The Bonn-Hamburg HPD measured about 300 events from the DESY 1 m streamer chamber (set up by Dr. Ladage and co-workers) as a test using the Full Guidance system. 90% of the tracks were successfully reconstructed by THRESH. The track residuals peak at 6-7 μ.