THE HPD - CDC 3200 SYSTEM AT AMSTERDAM

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1. INTRODUCTION

In this paper we want to present results obtained with an HPD system, with the special feature that an abnormal scan is not required. After a short discussion of the hardware configuration and of the digitizing method the main features of the Minimum Guidance program will be described and some figures on the performance will be given. Preliminary results of the ionization measurements and future developments like BEBC and Zero Guidance will be discussed.

2. MAIN FEATURES OF THE HARDWARE

The main features of the system are summarized in Fig. 1. The HPD is on-line to a medium size computer (CDC 3200, 32 K of 24 bit words, cycle time of 1.25 µs). The external equipment consists of 4 magnetic tape units, a diskfile (capacity 33 M words), a card reader, a line printer and a console typewriter. Part of the system is a Tektronix 611 storage scope of which the 'write thru' mode is used to measure points on the displayed picture directly in HPD coordinates.

The advantages and disadvantages of not using an abnormal scan have been extensively discussed by Harting in Argonne [1]. We will therefore give only a short description of the digitizing method, which is illustrated in Fig. 2. Instead of finding along each scanline the centre of the dark spots encountered, a sampling technique is used. Only a normal scan is made with a scanline distance of 25 µm and the track signal is sampled with the grating pulses, occurring at intervals corresponding to 12.5 µm on the film. Sample pulses are defined as the 'and' of the track pulses and the grating pulses. The number of sample pulses in the "track pulse" is sent to a buffer memory together with the y coordinate of the centre of the spot. In this way a 50 x 120 mm^2 picture is covered by 4000 x 4800 measuring points, the position of each point being known with an accuracy of ± 2 μm.

3. MINIMUM GUIDANCE

3.1 The program chain

The program chain consists of the programs MIST - GATE - FILTER THRESH.

The program MIST controls the premeasurement of the vertex, which is done on three on-line Enetra film plane digitizers, that are normally used for hand measurements. In each frame three fiducials and the vertices are measured in 2 views and the third view is computed. If the error in the spatial reconstruction of the point is too large MIST asks the operator to measure the third view. The final accuracy is 5 - 10 μ on the film. The output is written on a tape in a blocked format, as proposed by the CERN MG group.

This tape is used as input tape for the program GATE, which controls the HPD and which transfers the digitizings from the HPD to the disk. Immediately after the scan is finished the picture number is decoded, the fiducials are found and FILTER is executed. The masterpoints and the ionization information are written on the output tape together with the information from the input tape. We therefore do not need a merge program like SMOG.

Our version of FILTER has been adapted from the CERN Minimum Guidance FILTER. The techniques used for track finding and following have been described elsewhere [2], we therefore report only on the main changes necessary to adapt the program to our HPD and computer.

1. The abnormal scan is simulated in the program: the original information on the black grid points is obtained from the y coordinate of the centre of the black spot and the number of sample points along the y direction. For abnormal tracks the points are grouped together in the x direction and represented by the x coordinate of the centre and the number of points in the x direction (Fig. 3).

2. The search for outgoing tracks (subroutine WEDGE) is done over the full 360° at one time.
3. Due to the limited core size the program had to be split into overlays and segments.
4. The digitizings cannot be stored in core memory all at the same time. Only those digitizings required by the program for the next section of the followed track are read in from the disk. This transfer is done in parallel with the execution of the FILTER program.
5. In clear regions of the picture a fast track following routine is used.

The geometry program is a combination of a THRESH version already in use on our computer and a rather old CERN version of MATCH, which has been put into THRESH as an independent overlay. Failures of MATCH are corrected afterwards in THRESH by trying all combinations of track-views, which did not already give a good 3 dimensional fit. THRESH does not get information about the expected number of tracks.

The THRESH output tape also contains ionization information, corrected for geometrical effects. This information will be used in GRIND for automatic decision making.

3.2 Results of geometry and kinematics

With this program chain we are now measuring 15 hours a week on a sample of 1600 4-prongs and V^0's from a 4.2 GeV/c K^-p experiment in the 2 m CERN HBC. The results of this sample will mainly be used to optimize the program chain. Until now 1000 events have been measured and processed through GRIND. As measurement and analysis are still in progress we are not able to give accurate figures about success and failure rates. The results obtained so far indicate that 55% of the events have a GRIND error $<$ 100 and give a fit or a missing mass fit in GRIND.

In Fig. 4 the THRESH residuals for the helix fit are shown. To study the effect of the absence of the abnormal scan we grouped the tracks into three categories according to the angle between track and x-direction ($0^\circ - 30^\circ$, $30^\circ - 60^\circ$, $60^\circ - 90^\circ$). The peak values of the residues are 2.5 μ, 3.5 μ and 3.5 μ respectively.

3.3 Speed

The speeds of the different programs are listed in Table 1. The speed of FILTER depends very strongly on the event type, the film quality and the number of beamtracks, which is reflected in the number of digitizings. The speed of 20 events/hour is obtained for 4-prongs on a picture with 20 incoming tracks, giving 150 000 digitizings. The time for the display is needed because we want to save the digitizings of 1 cm^2 around the vertex for debugging purposes. Time can be gained by decoding the picture number and finding the fiducials during the scan.

3.4 Ionization

The V^o's in the sample are used to test the ionization measurements. For each track segment the ratio of the number of hits along the track and the corresponding number of scanlines is measured. These ratios are corrected for the angle between track and scanline. From the resulting numbers the bubble density and the error are calculated.

Table 1

Time analysis of program chain

		Time per event per view	Time per frame	Time per event
MIST				150 s
GATE	scan		16 s	
	picture number decoding fiducial finding		7 s	
	tape handling		3 s	
FILTER	computations	24 s		
	waiting time for disk	5 s		87 s
	display	8 s		24 s
THRESH				20 s
GRIND				20 s

The average of the bubble densities in the three views - after geometrical corrections - is taken as the ionization density of the track. In Fig. 5 the ratio of the bubble densities of the 2 tracks of the V^o is compared with the same quantity as computed in GRIND. In 80% of the events the agreement is within 20%.

In future the information on the track width will be used to correct for differences in the apparent bubble size in the three views.

4. FUTURE DEVELOPMENTS

4.1 BEBC

Some effort has been made to digitize pictures from the BEBC model at CERN [3]. As in these pictures the particle tracks show up light against a dark background, AC coupling was used instead of DC coupling and the signal was passed through a high pass filter with a cut-off of 200 kHz to eliminate background variations. It was proved that good digitizings can be obtained from these pictures and that the tracks can be followed by our MG FILTER.

4.2 Zero Guidance

The HPD system at Amsterdam is intended eventually to operate in the Zero Guidance mode. A vertex finding routine based on picking up and following all beamtracks simultaneously has been written. This program will be used to scan small angle scattering of K^+ in hydrogen.

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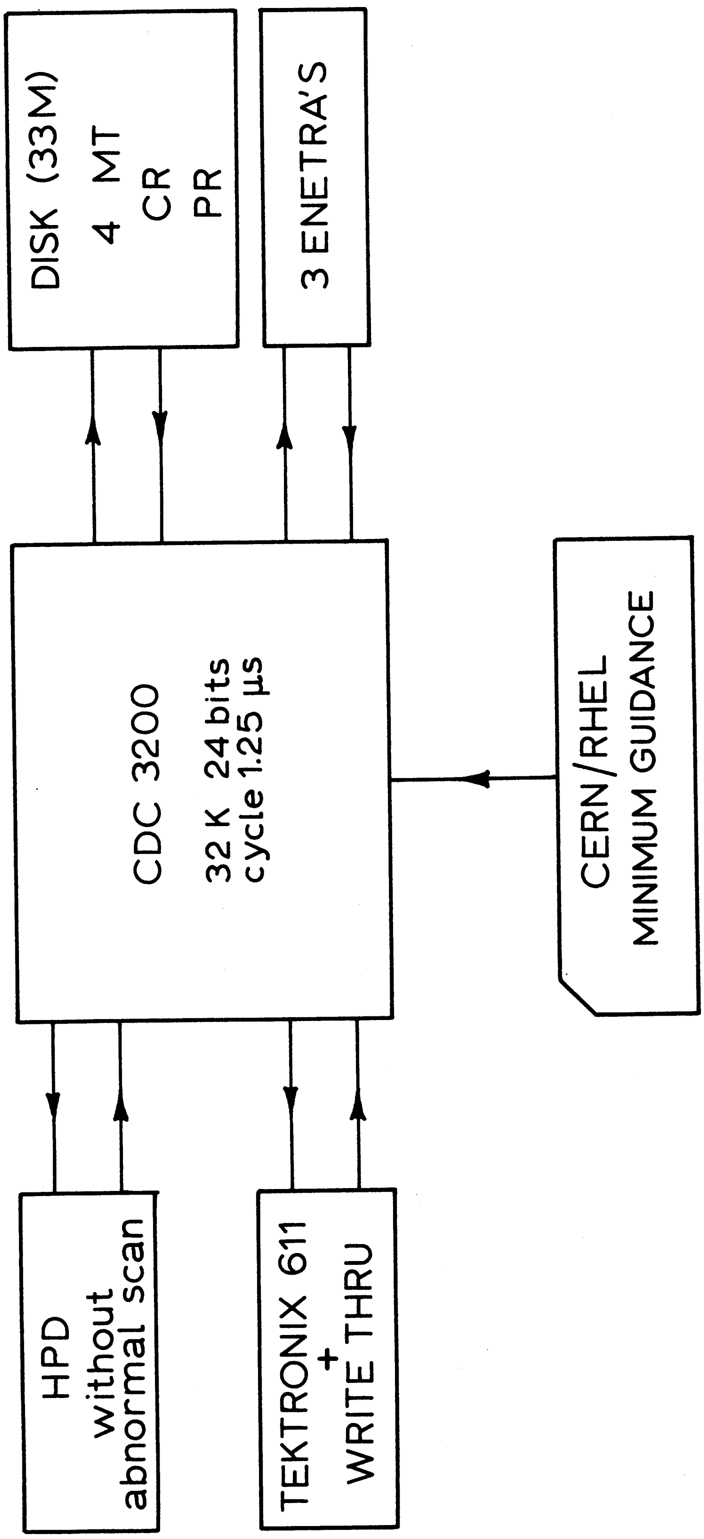

FIG.1 HPD-CDC 3200 system

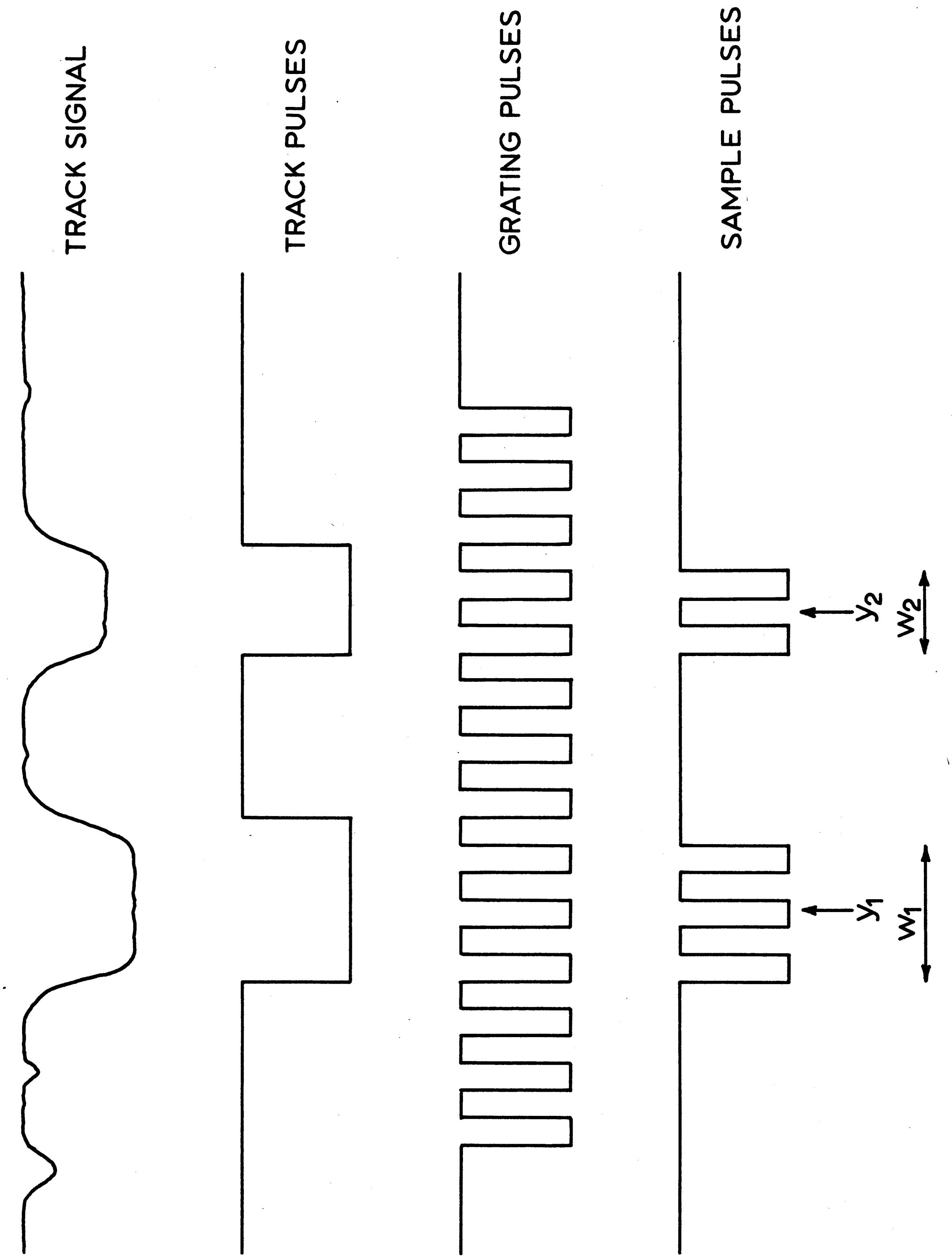

FIG.2 DIGITIZING METHOD

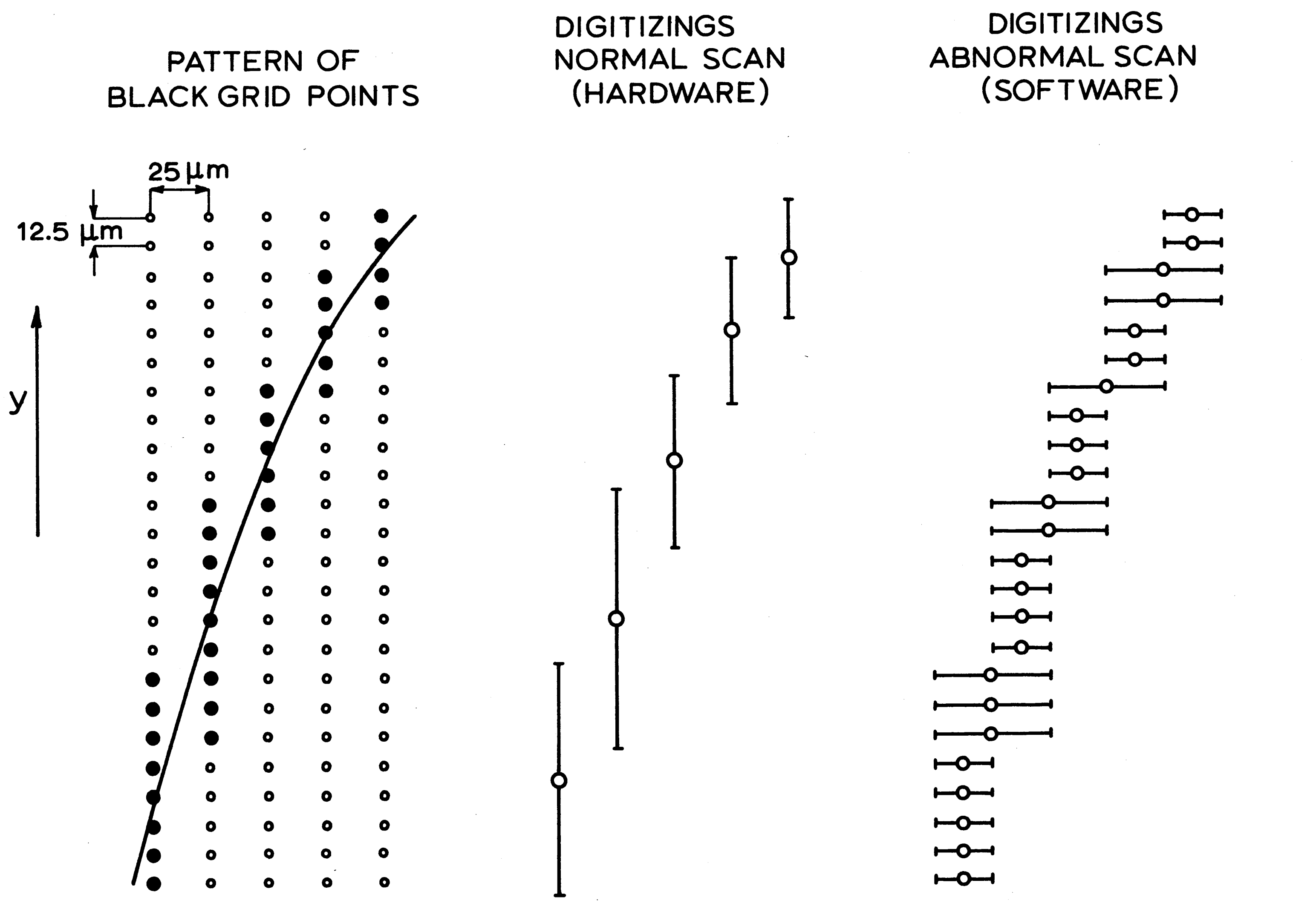

FIG.3 SIMULATION OF ABNORMAL SCAN

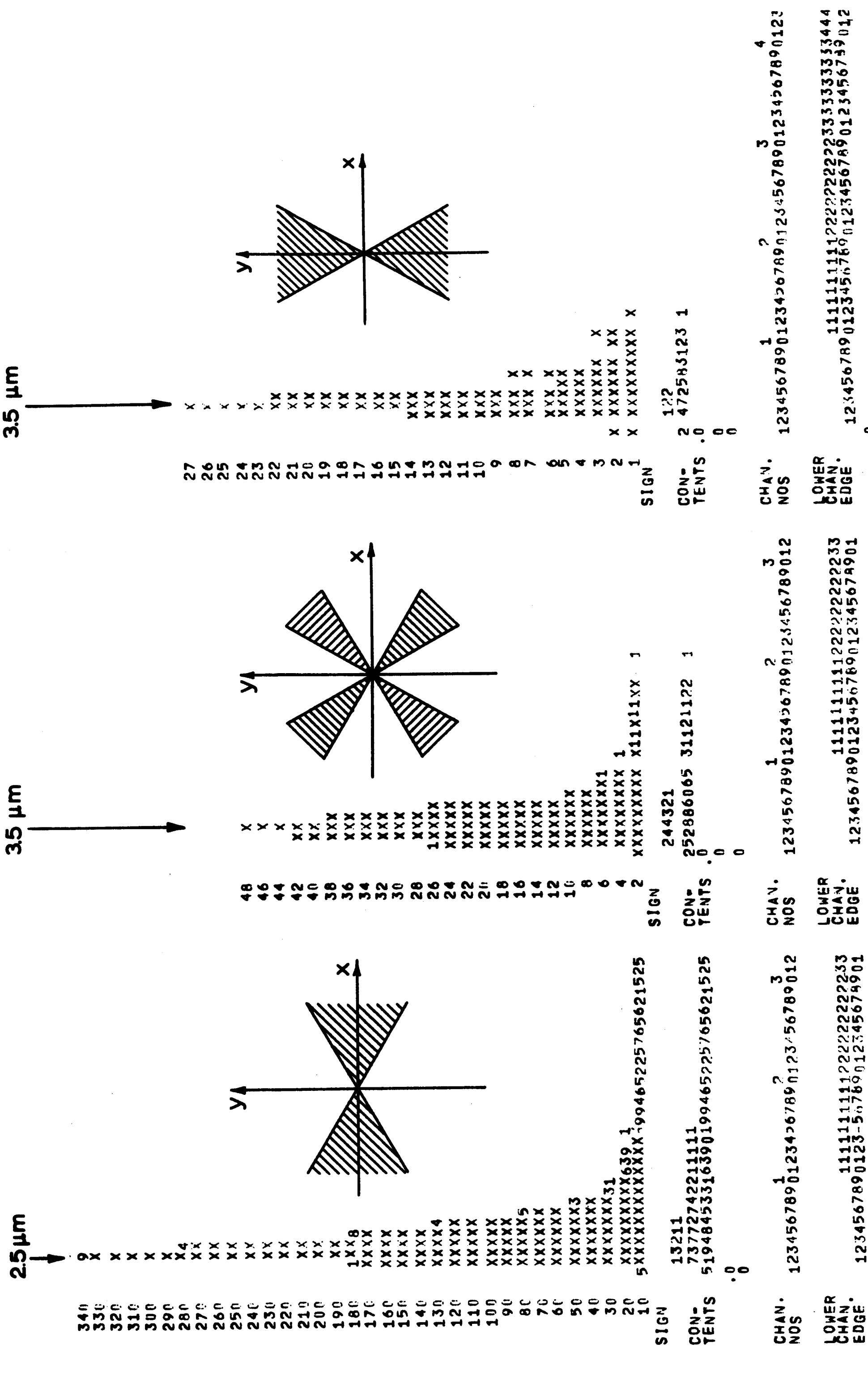

FIG.4 THRESH RESIDUALS

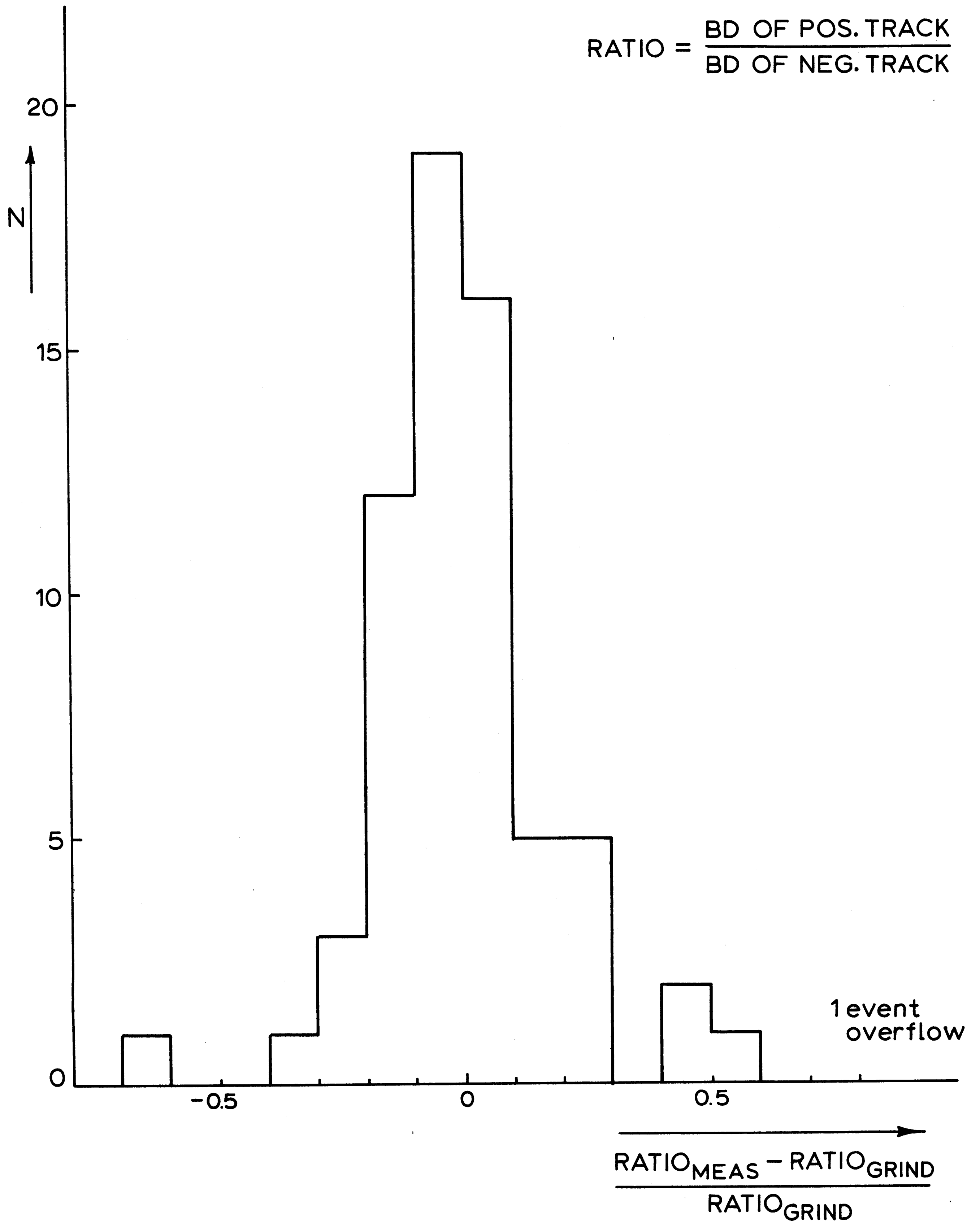

FIG. 5 IONIZATION OF V^0's

DISCUSSION

W. BLAIR *(CERN):* Do you need the accuracy of the ENETRA in pre-digitizing the vertex?

W. van LEEUWEN: The ENETRA are there and also they are on-line. At present their accuracy is needed but later we might do with lower precision.

D. HOLTHUIZEN *(Amsterdam):* An accurate vertex measurement is not strictly necessary. However, it saves computer time because one can recognize passing tracks as not belonging to the vertex in less time.