ELKE: A GRID GUIDANCE PROGRAM FOR THE RAPID MEASUREMENT OF BUBBLE CHAMBER FILM ON A PEPR FILM SCANNER CONNECTED TO A PDP-10 COMPUTER

H.-J. Grimm,

Institut für Hochenergiephysik,
Universität Heidelberg,
Heidelberg, Germany.

1. INTRODUCTION

A newly developed grid guidance program to measure bubble chamber photographs on the PEPR device is described. Emphasis has been put on high measuring speed.

2. DATA PREPARATION AND OUTPUT OF MEASUREMENTS

In order to obtain measuring rates of more than 300 events/h, it was decided to have no operator intervention of any kind. Prior to measurement, only the scanning of the events is required recording the frame-number, the topology, and the grid position of the vertex to an accuracy of about 5×5 mm^2 on film. With only this scanning information, completely automatic measurement of bubble chamber film is obtained. The output from this measuring program consists of all the line elements (=LE) of tracks terminating in the scanning area. These LE's are spaced 1 mm apart along the direction perpendicular to the sweep. On special request the number of bubbles along the LE's can be obtained, providing an estimate of the ionization of the track.

3. EVENT FINDING

At Heidelberg the ELKE program will replace the Yale University PEPR program[1] in the near future. From that program the same underlying idea for the pattern recognition of bubble chamber events is used, namely that tracks belonging to the actual event can be distinguished from the non-interacting background because they terminate at the vertex.

4. HARDWARE/SOFTWARE INTERFACE

The ELKE program uses the film as a random access memory, thus enabling one to apply more and more refined techniques as soon as abnormal conditions arise, e.g. the program rescans several times at the place of an expected LE, lowers the threshold for the signal detection or jumps over gaps and confused regions on the track. In addition the program finds the end points of tracks stopping in the liquid using the PEPR spot. Moreover, no time is spent in doing precision and/or bubble density measurements on tracks that do not belong to the event and which will be rejected later on. All software was designed to work concurrently with the PEPR device. The synchronization of the data transfers from the PEPR to the CPU is achieved by the interrupt facility of the system.

5. PROGRAMMING TECHNIQUES

The program has been completely rewritten, 90% in PDP-10 assembler language, the remaining part in FORTRAN IV. In the interest of speed, integer arithmetic is used throughout. The program takes 12 K words of core storage in the PDP-10 computer. The peripheral requirements are kept to a minimum for the program to run in a multi-programing environment. Three I/O devices are used for: the scanning card input -, the log- and the output-file. A display unit was used only in the debugging stage and is not needed during production. No changes to the computer's operating system are required until the priority interrupt system is used. Then the program will occupy a lower interrupt level.

6. PROGRAM CONTROL

The event processing is done in five major steps. After the film transport has positioned the film, one finds the position of the picture in the CRT coordinate system. The data box is encoded to find the roll and frame number, and the fiducials are found. All LE's are gathered in an enlarged scanning area of 9×9 mm^2 (so as to find events close to the edge) (Figs. 1 and 2). In the track-following part, the tracks belonging to the event are recognized. Track-following is done using the slope defined by the last two LE's and only once, at the start of the tracks, is the less accurate angle information used. All the LE's found in the scanning area are used in turn to start track following. During track following one tries to collect those LE's in the area that belong to the track. Reaching the boundary of the scanning area the direction of track-following is reversed. If one reaches on reversal the opposite boundary of the scanning area, this track is dropped because it is a non-interacting one just passing through the scanning area. If, on the other hand, one cannot reach the opposite boundary, this track must end inside the region possibly at the vertex of the bubble chamber event. Once again the track is reversed to follow away from the vertex through the whole illuminated region of the chamber or until the track stops in the liquid. If the track stops, one determines precisely the location of the last bubble. The resulting LE's associated with tracks can be seen in Fig. 3. These LE's and the LE's from the fiducial search are corrected. Together with their corresponding pointers, they are written onto magnetic tape. The calibration and the output is overlapped with the film transport movement to the next required frame.

7. FURTHER PROCESSING

As one can see in Fig. 3, one is left with about 20 tracks instead of just 3 belonging to the two-prong event due to the loose criteria applied so far. A further reduction to the required number of tracks is needed. This can be done using a modified and more powerful version of the Berkeley match program[2]. This match program can run on the PDP-10 during the time when the film transport moves or while changing film rolls. At Heidelberg we can also use an appropriate entry into the BERTA program[3] which at a certain level copes with exactly the same problem of vertex finding and track matching.

8. TIMING

Figure 4 shows the distribution of the time used for the complete processing of one stereo view. The time was taken running in a non-overlapped mode so that the sweeping time adds on to the CPU time. The time for the film transport is included. It is felt that the total time can be reduced to $\sim$ 3 to 4 sec on adjusting our film transport and by the use of film of better quality. This will result in a measuring rate of $\sim$ 300 to 400 three-view events/h. In Fig. 5 the approximate usage of the three hardware components -- PEPR, CPU, FILM TRANSPORT -- in relation to each other is shown; the data came from 10 measurements only. Success rates on events passing geometry cannot yet be given.

9. APPLICATION IN A PHYSICS EXPERIMENT

At Heidelberg we will use the system described to measure K^- film just taken in the 81 cm Saclay hydrogen bubble chamber in the momentum region of 0.6 to 0.8 GeV/c. It is planned to measure two-prong + $V^{\pm 0}$ events, some of which have the peculiarity of short protons. Some 200,000 events will be measured with their ionization.

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REFERENCES

1) H. Taft, D. Bogart and P. Lucas, Proceedings of the Nimegen PEPR Conference, 1968.

2) P. Berge, private communication.

3) K. Brokate et al., these proceedings.

Figure captions

Fig. 1 : Photograph of the 81 cm Saclay HBC during a K^- exposure at 0.793 GeV/c.

Fig. 2 : LE's found in the scanning region.

Fig. 3 : LE's found for the data box, fiducials and output from the track following routine.

Fig. 4 : The distribution of the time taken to measure one view.

Fig. 5 : Approximate usage of system components.

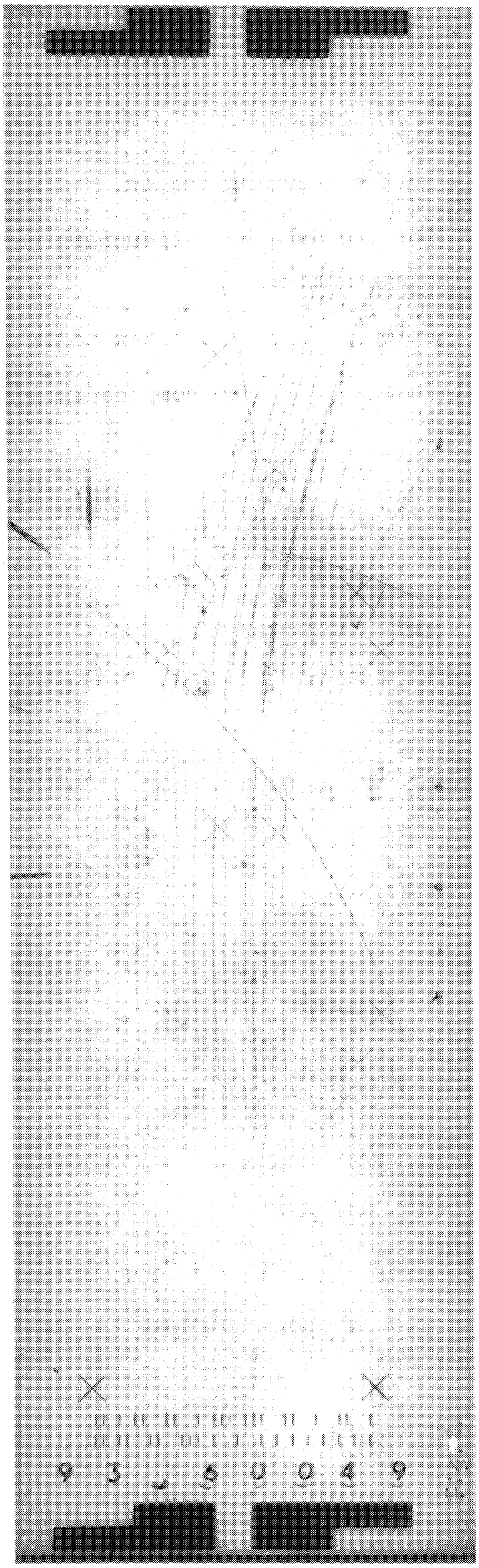


FIG. 1

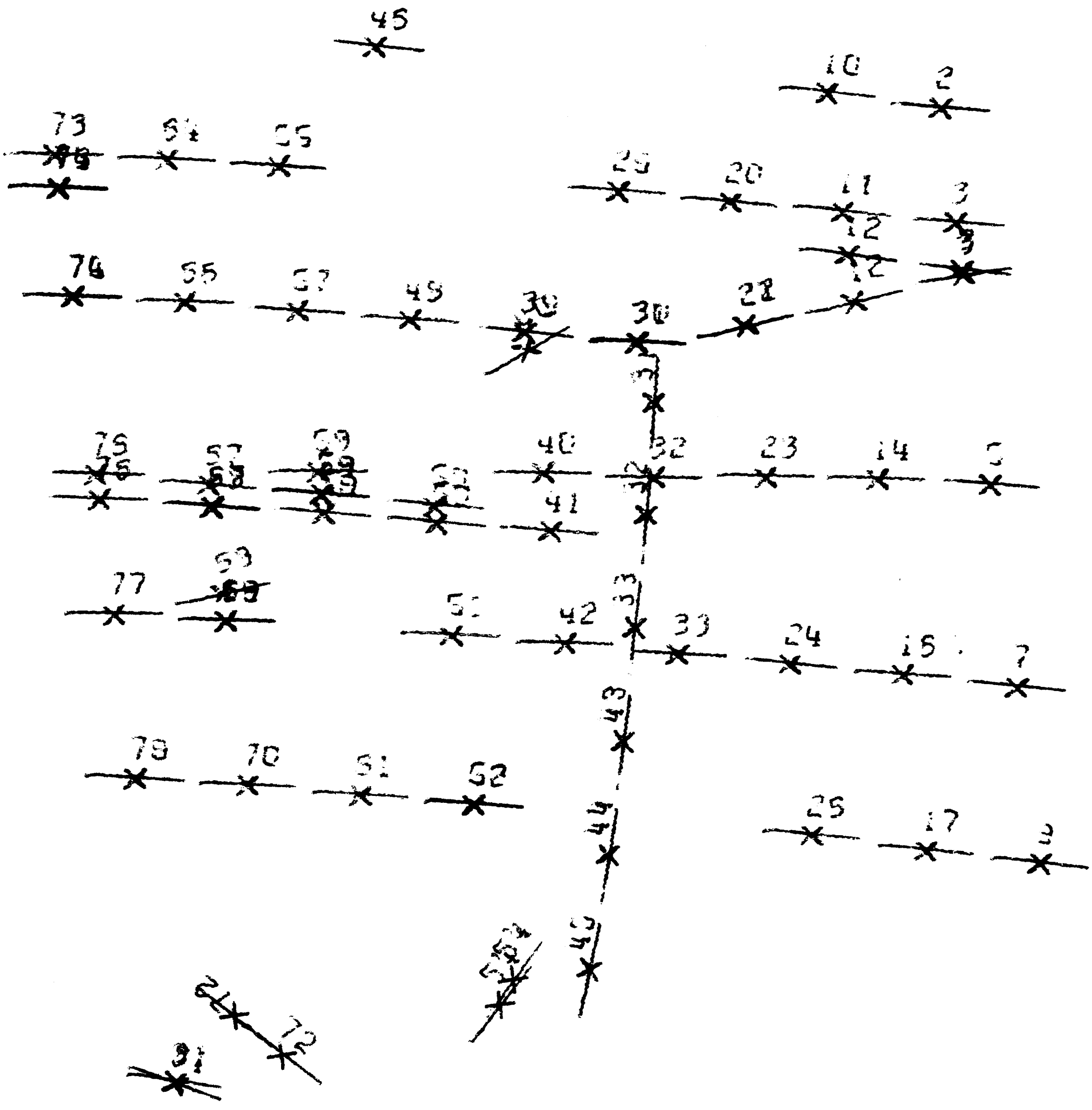
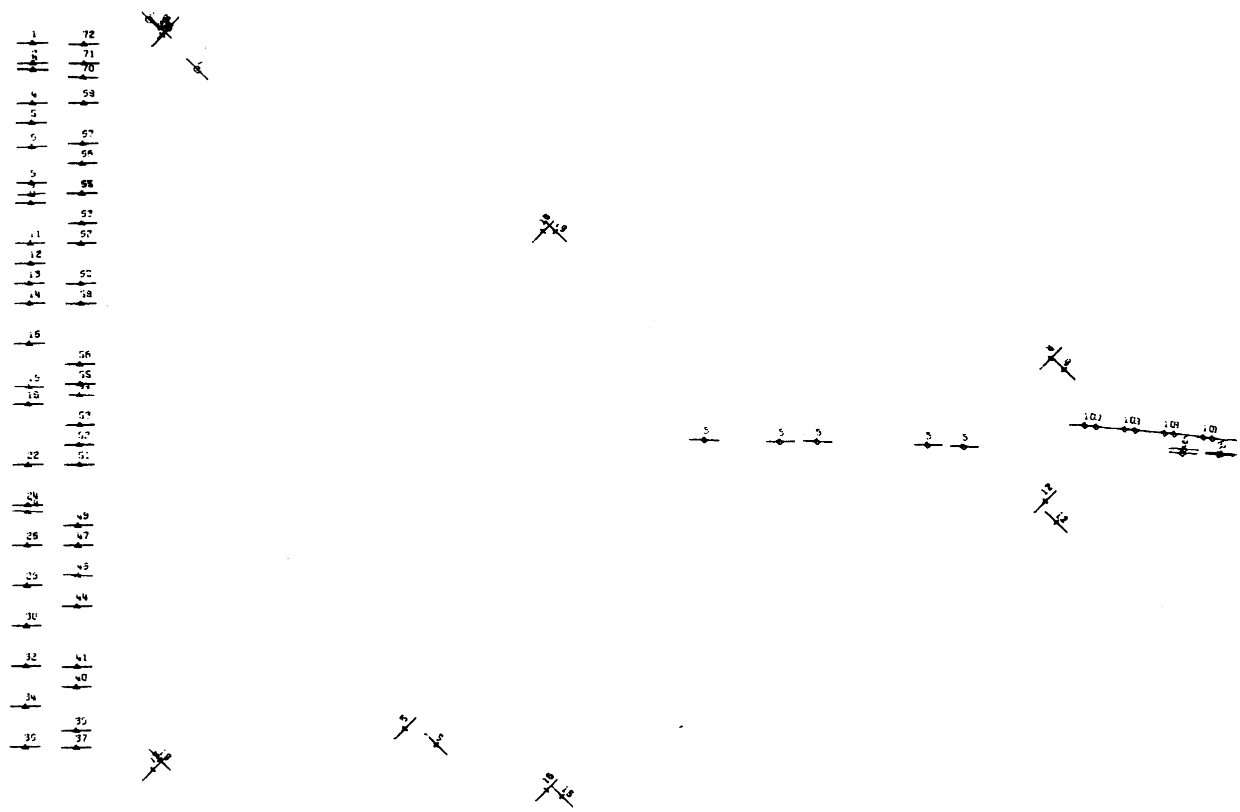


Fig. 2



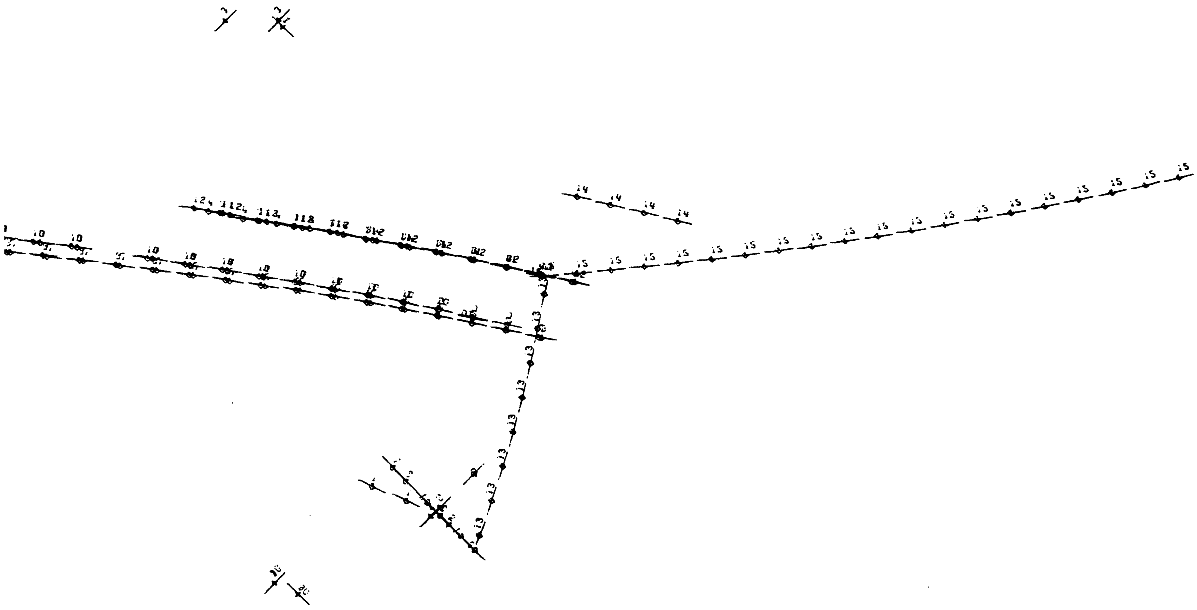


Fig. 3

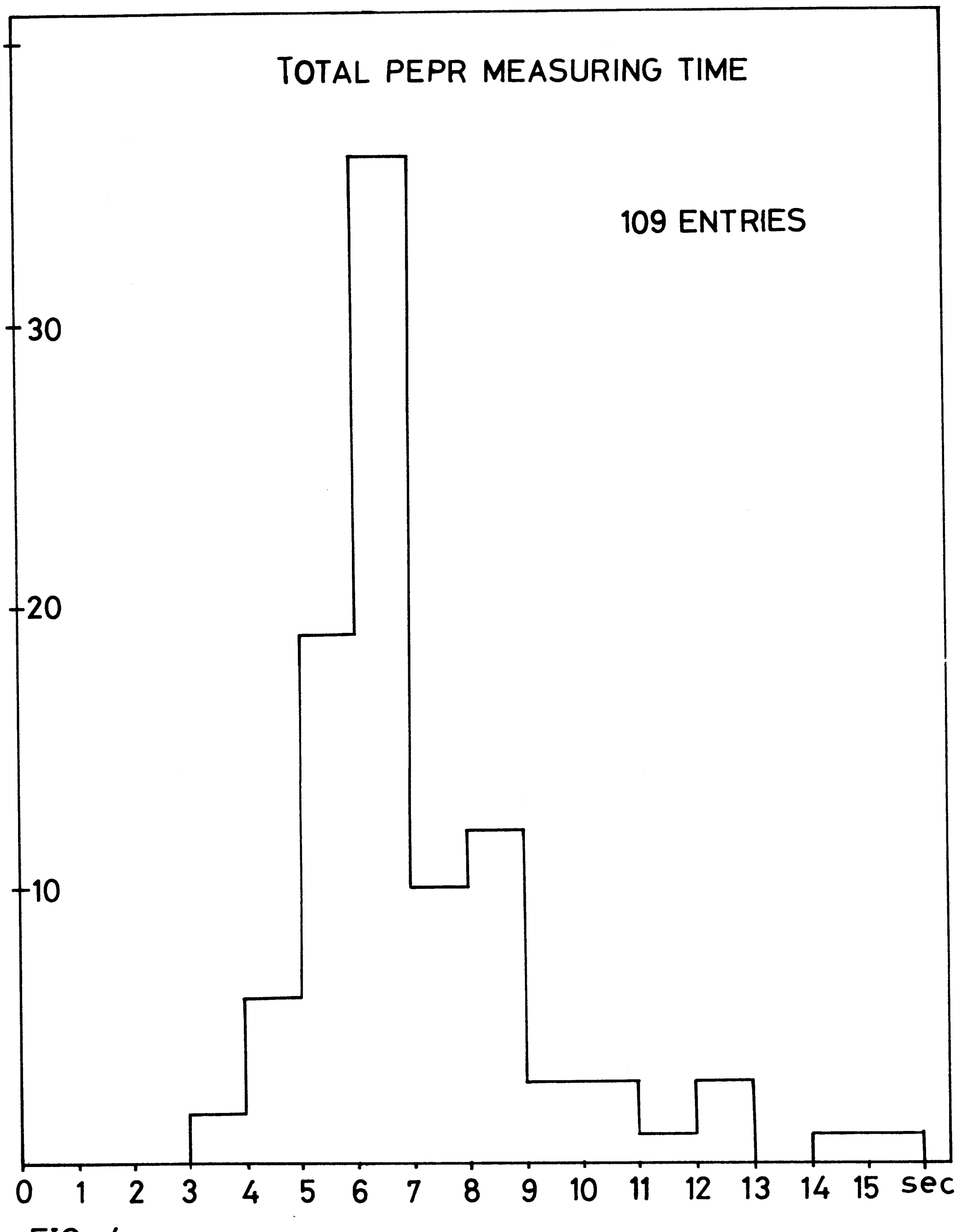

TOTAL PEPR MEASURING TIME
109 ENTRIES
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
sec

FIG. 4

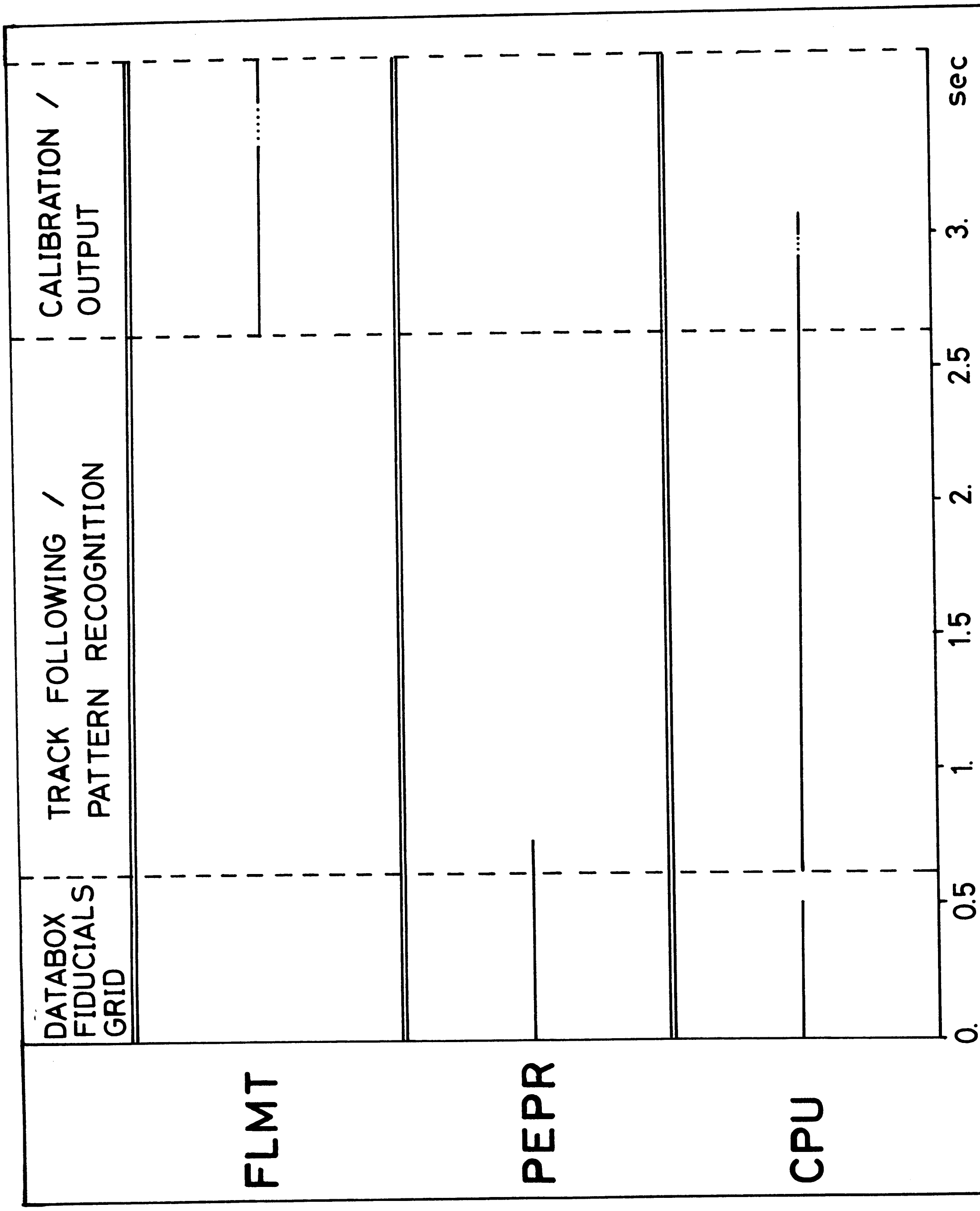

DATABOX
FIDUCIALS
GRID
TRACK FOLLOWING /
PATTERN RECOGNITION
CALIBRATION /
OUTPUT
FLMT
PEPR
CPU
0.
0.5
1.
1.5
2.
2.5
3.
sec

FIG. 5

DISCUSSION

J. LOKEN *(Oxford):* What is the total time per frame for your system?

H. GRIMM: Including the film transport, the time is 3.2 seconds per view.