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TM-887
2110.000

SPEEDING UP SAMM MEASUREMENT OF E-310 SPARK CHAMBER FILM

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June 1979

ABSTRACT

Recent improvements to SAMM hardware and software that have resulted in a 45% improvement in speed are described. Further modifications for yet better performance are suggested.

One of the first things that struck an observer in the old SAMM spark measurement program (henceforth referred as SPARK-I) was the slowness of its fiducial measurement. E-310 spark chamber film has 138 fiducials in the three views and fiducial measurement took up roughly 50% of the total measurement time. Yet the fiducials were being measured by SPARK-I very slowly, much slower than comparable measurements on 30" bubble chamber film. An examination of the problem led to the following conclusions.

(a) 30" bubble chamber film had much narrower fiducial arms than E-310 spark chamber film.

(b) While scanning for the fiducial arm, it was possible to obtain a hardware histogram of the fiducial arm (as the scan was being performed) using the existing hardware histogrammer (which had 256 channels) for the 30" film but this could not be done for the E-310 film since the fiducial arms were much wider.

(c) The program then had to resort to a software histogram of the scan output in order to find the peak. This took computer time and resulted in a slower fiducial measurement.

The Extended Hardware Histogrammer

It was decided to construct a larger hardware histogrammer with 4096 channels, (as compared to the 256 channels of the previous one). This histogrammer would accumulate hits reported by the SAMM slice scan and report the location and contents of the largest bin, in the first word and the contents of all the bins in sequence, packed 3 to a word.

A program SPARK II was written to utilize the new histogrammer. Timing tests were performed on the fiducial measuring routines in both SPARK I and II and the two results were compared.

Table I gives the result of the comparison. All the major time-consuming routines are listed. Assuming that SAMM spends the same time on routines uneffected by the new histogrammer, it is clear that SPARK II is faster than SPARK I by ~20%.

The major gain was made in routine ANLHIS which in SPARK I generates the histogram by software addition whereas in SPARK II it reads the contents of the extended hardware histogrammer. Some of the time gained this way is lost in routine UNPBHS which has to unpack the new histogram words for subsequent use.

It is clear from Table I that the routine PEAKS is the main time consumer with a massive 25% of the total time. It is also clear that an improvement in peaks of δ% will improve SAMM performance by 4/3 δ%. If PEAKS can be made to take up 12% of SAMM's time, SAMM will speed up by 17%. This in conjunction with the gain in ANLHIS will result in an improvement of ~50% in SAMM's speed.

<u>Possible Ways of Improving PEAKS'</u>

The routine PEAKS has the software function of extracting the best value for the position, height and width of all peaks in the histogram, taking care that noise fluctuations are not reported as signal. The hardware histogrammer only reports the position of the highest peak. There may be several peaks in a 4096 bin histogram, the biggest of which need not necessarily be the signal of interest. (A spark or dirt close to a fiducial may give a signal larger than the fiducial arm.).

TABLE I

		% of time spent in routine	
Routine	Function	SPARK I	SPARK II
LINE		9.1%	8.9%
ANLHIS	Generates histogram	19.5%	4.2%
PEAKS	Finds all the peaks present	22.2%	25.2%
FTLNSS	Fits line to slice scan hits	7.6%	5.8%
UNPBHS	Unpacks SPARK II histogrammer	-	5.9%
TOTAL		58.4%	50.3%
Time spent on rest of routines		41.6%	49.7%

PEAKS arrives at its result by examining each of the 4096 bins in turn. It does a thorough job in extracting signal and rejecting noise but the price is paid in speed of execution.

Instead of finding peaks by examining each bin in turn, there exist fast algorithms which are optimized in speed for finding peaks. The FIBONACCI type search is one of them. A routine was written which utilized the FIBONACCI numbers which found peaks rapidly. But alas, the discrimination between signal and noise was now poor. At this point it became evident that peak finding had to be incorporated into the hardware.

The Peak Finding Hardware Histogrammer

The problem in finding peaks is to make sure that only solid signals and not fluctuations due to noise are reported. The new peak finding histogrammer was designed so that it reported a peak if and only if the contents of a bin exceeded a threshold T1 (see Fig. 1). All succeeding bins are assigned to that peak until the signal dips below a threshold T2. Then the remaining bins are candidates for the 2nd peak. The second peak is deemed to exist if the signal again exceeds T1, and so on. A maximum of 12 peaks are catered for . The histogrammer reports the addresses of the locations where the signal exceeds T1 for each peak, followed by the contents of the histogram. T1 and T2 are variable by software. By merely examining the initial addresses of peaks, it is possible to quickly determine if there are any. If not, no more time is wasted and the scan is tried elsewhere.

If a peak is present, the software reads in the histogram bins in the neighborhood of the peak only. The routine PEAKS is used to locate the position of the maximum: It is now able to do this rapidly since the range of bins it has to examine is limited .

PEAKS was modified to use the packed histogram words directly to save space and time. A program SPARK III was assembled to utilize these new features. There was an immediate dramatic improvement in performance as indicated by Fig. 2. SAMM now measures faster by 45%. All the improvement resulted from faster fiducials. The algorithm to find sparks can also utilize the new histogrammer. When this is implemented another 20% improvement is to be expected.

Comments on the New Histogrammer

The peak finding histogrammer, apart from speeding up SAMM has greatly enhanced its power to pattern recognize. It will henceforth play a key role in all further SAMM applications (including the program being currently developed for Lou Hand and collaborators) since it facilitates rapid area scans searching for signals whose locations are not even approximately known.

FIGURE CAPTIONS

Figure 1: Only peaks B and C will be found by the hardware histogrammer. Peak A does not drop below T2. Peak D does not rise above T1. Peak A is clearly noise. If the user is interested in signals of the level of Peak D, he must set a lower T1.

Figure 2: SAMM performance as a function of time. Major changes in the operating modes are denoted.

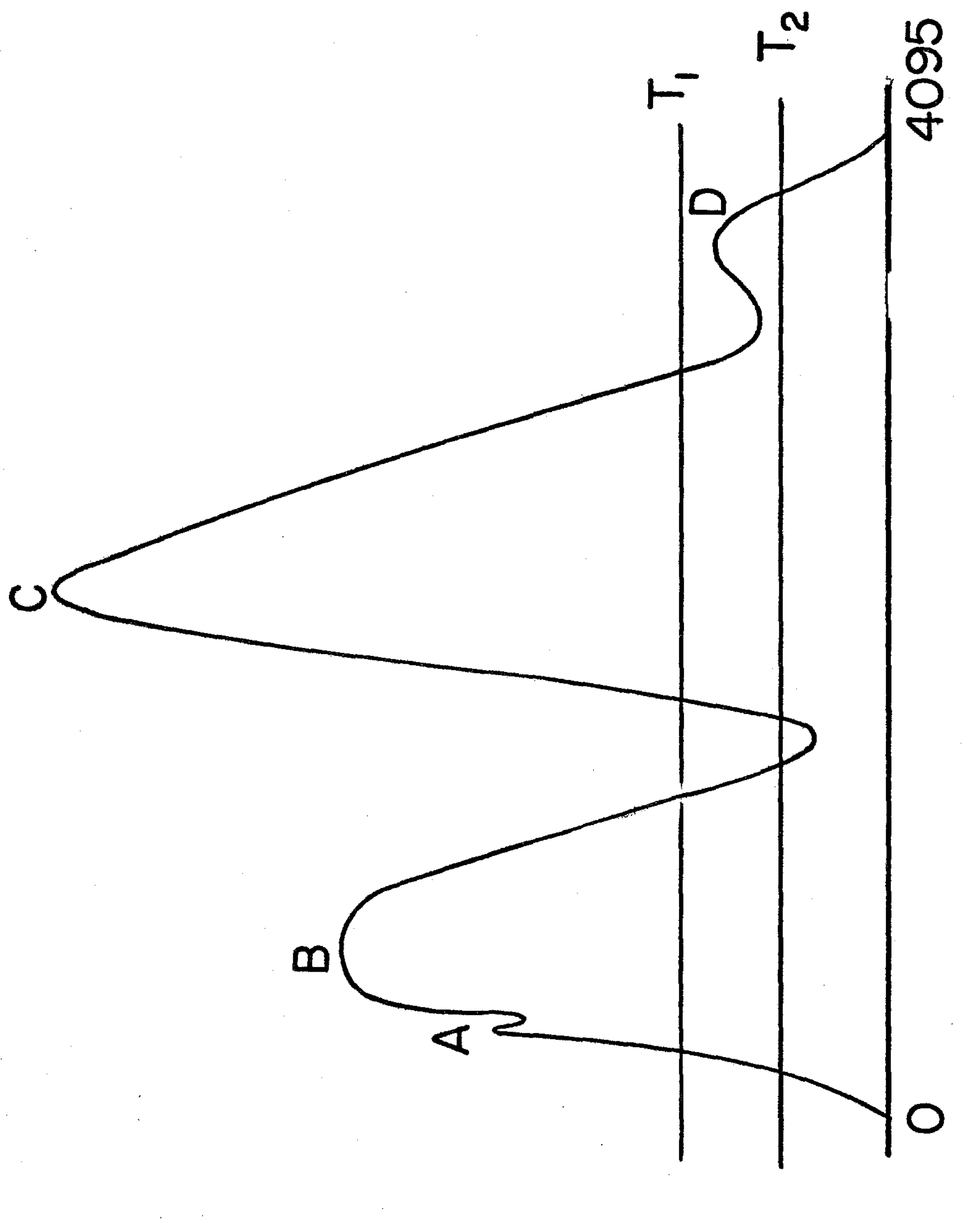

FIGURE I

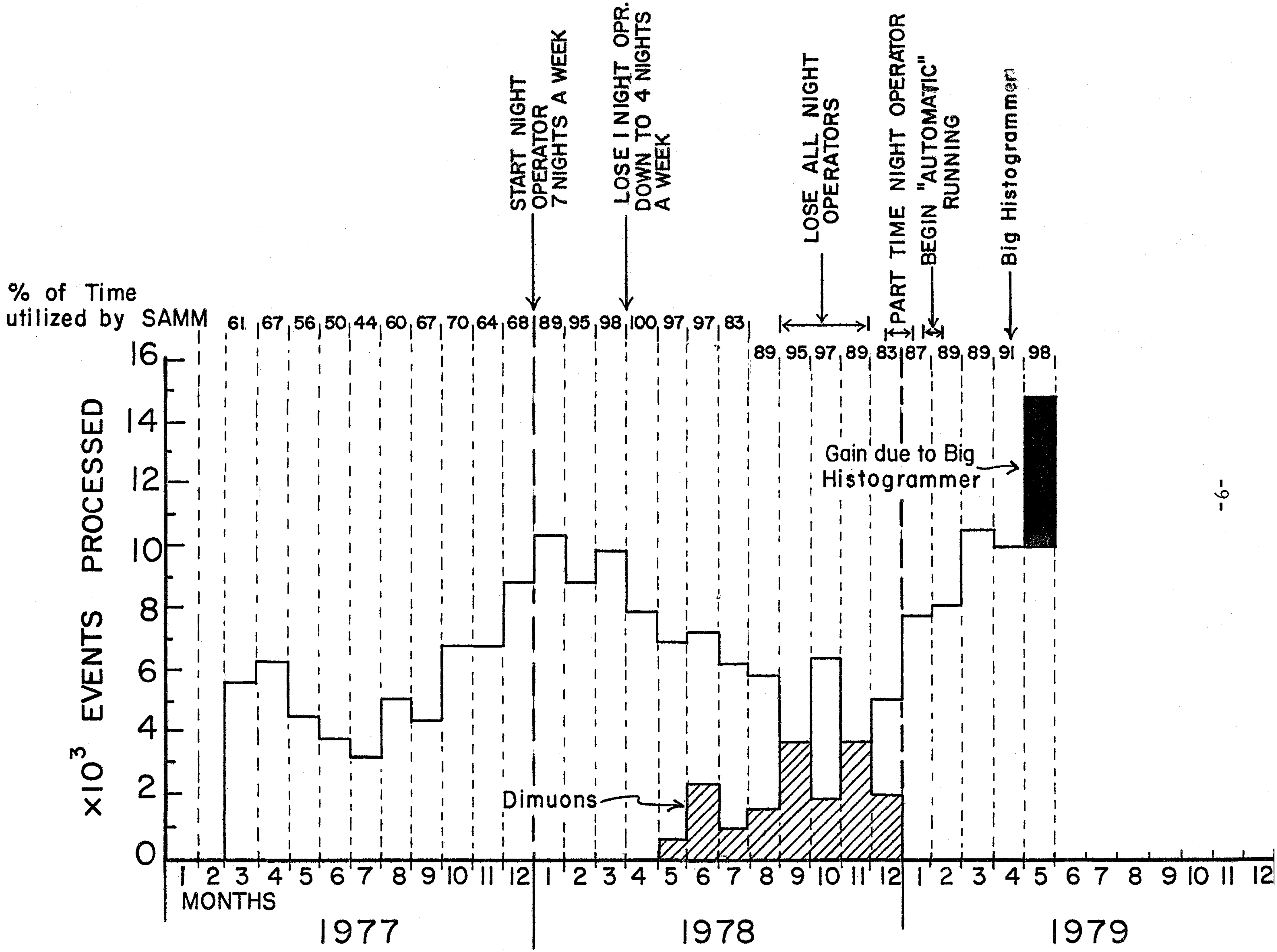
% of Time utilized by SAMM
61 67 56 50 44 60 67 70 64 68 89 95 98 100 97 97 83 89 95 97 89 83 87 89 89 91 98
START NIGHT OPERATOR 7 NIGHTS A WEEK
LOSE I NIGHT OPR. DOWN TO 4 NIGHTS A WEEK
LOSE ALL NIGHT OPERATORS
PART TIME NIGHT OPERATOR
BEGIN "AUTOMATIC" RUNNING
Big Histogrammer
Gain due to Big Histogrammer
Dimuons
×10³ EVENTS PROCESSED
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
MONTHS
1977
1978
1979

FIGURE 2