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AN AUTOMATIC DEVICE FOR COUNTING A LARGE NUMBER OF TRACKS IN CR39

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ABSTRACT

In order to perform an indoor survey of internal exposure to radon and its short life daughters using track etching passive detectors, it is necessary to analyze a large amount of information without spending a lot of time and manual work. For this purpose, the possibility of utilizing PEPR (Precision Encoding and Pattern Recognition) normally used in the digitization of high energy particle tracks recorded on Bubble Chamber film has been studied. A special subroutine has been set up for a PDP 11/45 Computer to guide PEPR in studying the tracks of α-particles in CR39.

KEYWORDS

Solid state track detector; track counting, computerized image analysis; PEPR for particle recognition; automatic method for particle counting.

1. - INTRODUCTION

While measuring indoors environment radioactivity in a region of central Italy using solid-state track detectors, the need for a rapid, low-labour, reproducible way of estimating high numbers of dosimeters, which would also eliminate the background caused in various ways, becomes evident. As is well known, in fact, the recognition of a charged particle using a solid state track detector, takes place in the following stages: 1) formation of the trail; 2) increasing the damage using, for example, chemical etching; 3) observation of the tracks (recognition, measurement of their shape and size, counting). Considering the small dimensions of the tracks (for α-particles in CR39 in the order of micron), an enlargement is required. The most direct and elementary method useful for comparison, is to perform the observation using an optical microscope with a calibrated grid lens. This method however implies a heavy man-hour commitment and a certain subjectivity in the recognition and classification of the events. In the case of tracks caused by an arbitrary spatial distribution of particles this problem becomes particularly delicate, as for example is the case with α-particles of radon and its daughters collected in a dosimeter. Automatic methods could also be very useful when the number of tracks for unit surface is low and when the contrast between the tracks and the background is limited. For this reason many semi-automatic and automatic scanning methods have been set up in last years(1-6).

To analyze the CR39 American Acrylics detector, the utility of the PEPR(7), of the National Laboratory of the INFN at Frascati was looked onto. With this aim in mind, specific codes for calculation have been worked out and the detectors exposed to the indoor building radioactivity have been directly analyzed.

2. - THE SYSTEM OF AUTOMATIC TRACK MEASUREMENTS

The Frascati PEPR was constructed in 1977 for the study of particle tracks in bubble chamber for high energy experiences. Fig. 1 shows a schematic block diagram of the PEPR system.

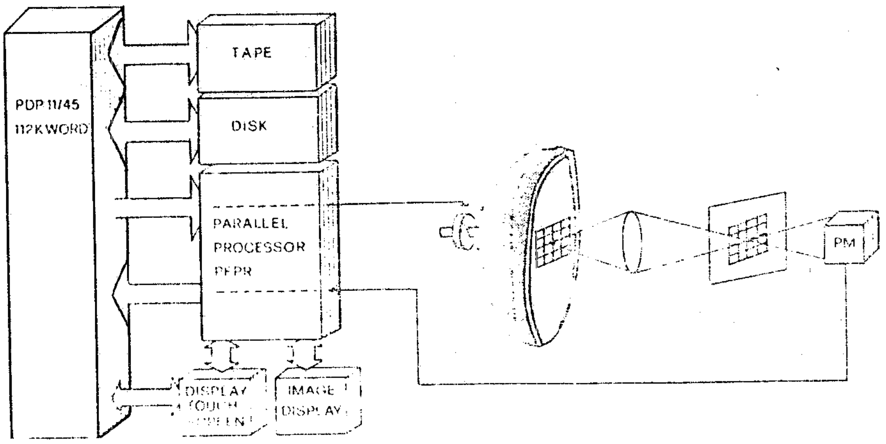

FIG. 1 - Schematic block diagram.

The PEPR is an apparatus entirely controlled by computer, used for the first time at MIT(8). The scanning element is a light spot (or line element) produced on a CRT (Cathod Ray Tube) with magnetic focusing and deflection of the electron beam. The system has two logically separate functions. The first is to localize and recognize a track. This function is called Pattern Recognition (PR) Mode of the system. The second function is to measure the position co-ordinates of this track, and is called Precision Encoding (PE) Mode. The point/line under the computer's control is focalized by an optical system on the film which is fixed onto a special support.

When the point/line crosses an object on a film, the variation at the transmitted light is detected with a photomultiplier on the back side of the film. The resulting signal is divided in an analog divider by the output signal of the reference photomultipliers looking directly at the light output of the CRT. Thus the output of the divider is directly a measure of the image density at the sampled points.

Recently, new hardware was added to detect "local maximum" within the scan cell, rather than working uniquely with a threshold logic. Subsequently, the number of maxima accepted in that particular area is recorded and for each, the centre, the angle at which it was obtained and the maximum value of the signal is registered.

The computer - a PDP 11/45 with a memory of 112K - connects to a digital parallel processor with 32 registers of 16 bit, which is the heart of the PEPR electronics. The processor accepts relatively simple commands. The results , of the measurement operations are stored in its special registers.

The principal characteristics of the PEPR can be summarized in the following points: total flexibility of the apparatus, elaborate software for acquisition and processing and speed of execution. The flexibility of the apparatus lies in the possibility of working either interactively (between the operator and the machine) or completely automatically. In the present work a nearly 100% interactive mode is operated.

The image processing is usually split into two phases: the analysis of the image, and the elaboration of the resulting data. In PEPR system it has been found important to insert a sufficient part of elaboration into the acquisition algorithm, so as to exhaust the full process of analysis for each single image. In this way the moving and storage of intermediate data is avoided.

The above-mentioned characteristics of the PEPR mean that it should be useful also in the biomedical field, for the study of cell structures (analysis and counting of chromosomes etc.).

3. - EXPERIENCE WITH THE SYSTEM

The algorithm used with the PEPR in analyzing photogrammes of CR39 using standardized etching procedures is based on the investigation of local maxima. If the found maximum passes the tests, the outline and the area of the corresponding object are determined. The radius corresponding to the area and an estimation of eccentricity with ellipsoidal hypothesis is obtained. Timing figures are as follows (without any optimization attempted but with extra diagnostic loads for learning purpose): 0.1 s/mm^2: hardware time on empty dosimeter; 4 s/mm^2: software time (testing-histogramming); 0.5 s for each object that enters to the form analysis (operator decision: ~15% rejection).

During the first experiments, dosimeters were irradiated with α-sources, and the particle tracks were analyzed. When loose criteria are used on the detected local maxima, two distinct grouping appear in the histogram on the radius. These groupings are more evident in a bidimensional histogram of the radius versus the maximum of the photographic density. A strong positive correlation is found between the two parameters. The nature of the two groupings is immediately evident by comparison between the irradiated and non-irradiated area: small-grey objects being due to artefacts. Strong variability of these from a plastic to other is also evident.

From these kind of tests we determine a set of cuts to be applied in the local maxima search stage. During the same series of measurements, the circular tracks were separated - first manually, and then using a single algorithm - from the elliptical ones.

At this preliminary stage the measurement system was applied to some photographs of CR39 irradiated inside radon diffusion dosimeters specially designed and placed in the buildings in the Umbria region under observation. In Fig. 2 and Fig. 3, the number of tracks per mm^2 versus minor diameter is shown; the graphs refer to events with circular and elliptical tracks respectively. The events attributed to the α-particles of radom and its daughters are compared with those in a non-irradiated part of the dosimeter. The latter events can be attributed to various causes (background particles, defects in the plastic, etc.) and therefore require further research.

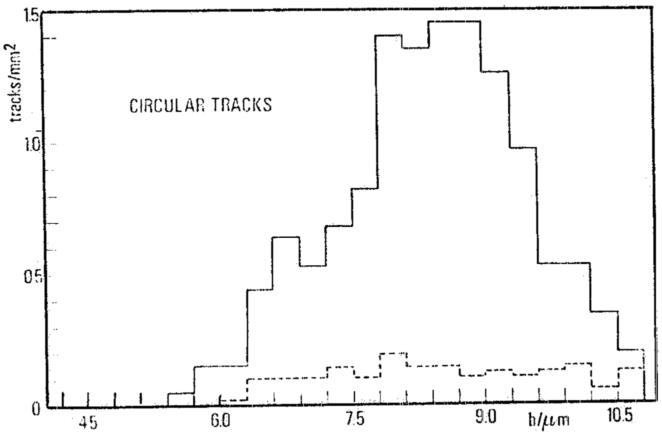

FIG. 2 - Tracks per mm^2 versus minor diameter: —— irradiated area ---- non-irradiated area.

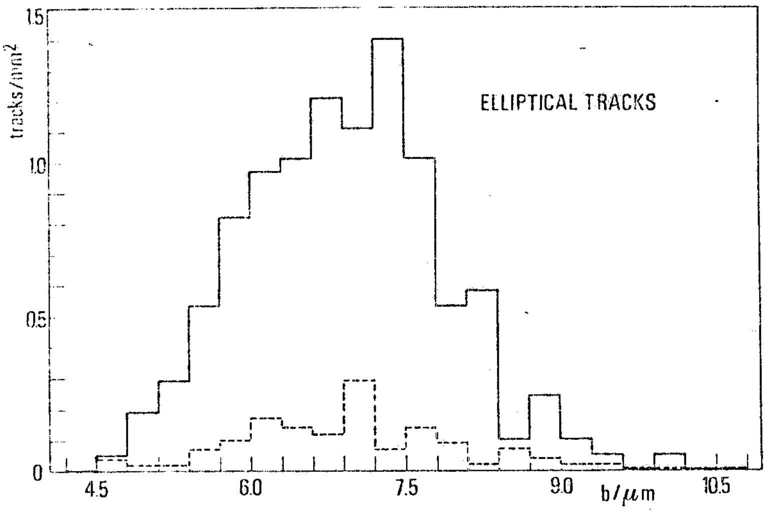

FIG. 3 - Tracks per mm^2 versus minor diameter: —— irradiated area ---- non-irradiated area.

3. - CONCLUSIONS

From the experiment carried out, one can conclude that the PEPR system is definitely competitive in terms of speed of analysis, although it has to pass through the photographic stage.

The software should be improved by carrying over two tested procedures from the high energy physics production programs. The first would be the use of the line-element scan to find the direction of the major axis, characterized by the maximum signal, to improve the eccentricity estimate by measuring the distance between the tangents at the ellipse parallel to the major axis (and thus determining the minor axis). The second imrpovement should be to substitute threshold operations with determination of the flex points at the track density profile, thus helping to free the system from the additional problems due to the photographic process.

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