CERN/TC/COM 62/4

Geneva, January 19, 1962.

M E M O R A N D U M

To: Members of Track Chamber Committee

From: R. Budde

Please find enclosed the draft of a report on equipment for analysis of track chamber pictures in European laboratories. This draft will be discussed at the next meeting on January 24th, 1962.

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D R A F T

Equipment available in Europe for the measurement of bubble chamber photographs

This brief report presents the information requested at the Nuclear Physics Committee of November 29th, 1961, on the facilities available or in preparation in Europe for the measurement of bubble chamber photographs.

1. Classical methods

The equipment of the European laboratories for the measurement of bubble chamber photographs started some 5 years ago. In many laboratories, scanning projectors and digitized measuring instruments to record coordinates along the reprojected tracks, of different types, were designed and progressively built. Following a suggestion of Prof. Amaldi, representatives of the interested laboratories met in Geneva in September 1958 and in February 1959, and agreed on specifications of measuring instruments to be built by industrial firms. Apparatus were thus built by industry in France and England, several of them are already delivered and in use.

A first survey of the available apparatus was prepared by the Secretary of the Track Chamber Committee in 1960. It indicated that, by the end of 1961, there would be in Europe 37 groups working on bubble chamber photographs, using 57 scanning projectors and 28 measuring machines.

More recent data was collected from the members of the Track Chamber Committee, in order to obtain a more definite view of the situation for 1962.

Outside of CERN, there will be about 10 major groups and 23 smaller ones. The larger groups count of the order of 10 physicists, they have already worked on experiments involving large number of photographs, they can be expected to play a major role in future experiments. The smaller groups have about 4 physicists, their activity is usually more fruitful in association with other groups. Several of the smaller groups show signs of vigorous growth, the number of autonomous groups may appreciably increase by the second half of the year.

These groups and CERN will be amply provided with scanning tables and scanners, they will be operating 65 ± 5 digitized measuring instruments by the second half of 1962. Each machine can measure up to 50 events per day in optimum conditions, but the yield is of course smaller in the less experienced laboratories, say, 20 events per day.

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2. Programming and computing

Practically all the laboratories working on bubble chamber photographs have access to a large size digital computer. The computations to be performed can be roughly divided into three successive steps:

a) The geometric reconstruction of the event in space, with the relevant optical corrections, etc...

b) The kinematic analysis of the event on the basis of momentum and energy conservation, with the aim of identifying the physical process giving rise to the observed track configuration.

c) The statistical analysis of a population of events, to evaluate spectra, angular distributions, etc.

In most European laboratories, computer programmes exist for the computations of type a and b that apply to individual events. These vary in refinement and flexibility, affecting the type of experiments that the various groups can tackle with efficiency.

Furthermore, the statistical analysis of type c is still done by hand computation in most laboratories, and this imposes a practical upper limit of about one thousand to the number of events that can be handled in a single experiment. Efforts are under way to develop the so-called "event-library programmes" that will further eliminate the hand computations and increase this upper limit. Correspondingly, improvements must be brought to the other phases of the analysis, to insure that the systematic errors due to scanning bias, measurement errors etc. are reduced at the same time as the statistical errors.

3. New measuring instruments

Several laboratories are working on the improvement of the now classical measuring methods, for instance, a Baby-Iep project, at Imperial College, aims at measuring curvatures and angles by an optical method that directly fits a curved line to the reprojected tracks.

A more ambitious apparatus, the Flying Spot Digitizer (also sometimes called HPD or Hough Powell Device) is under development in a collaboration between CERN, the Rutherford Laboratory, Brookhaven and Berkeley. This instrument transmits directly the measurements of coordinates made on the photograph to the memory of the computer. A selection or gating of the relevant information is made by the computer, using rough measurements performed at the scanning table.

Tests were made on a first prototype in April 1961, and the very encouraging results are contained in the report CERN 61-31. Work is in progress now in CERN for the construction of a new machine, which will be suitable, it is hoped, for use for actual experiments and which will start operation in the first half of 1962. In parallel, the design of an instrument suitable for manufacture by industry is under way, in a collaboration between CERN and the Rutherford Laboratory.

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Some figures on the expected speed of measurement of this new instrument are contained in the CERN report already mentioned. They indicate that a single instrument attached to a computer of type 709 could measure 320 events per 8 hour shift, and that two digitizers working in tandem could double this yield.

4. Conclusions

In 1962, there will be in Europe about 200 physicists working on the analysis of bubble chamber photographs. They will have scanning and classical measuring machines capable of measuring of the order of 250.000 events, which corresponds to about 2.500.000 bubble chamber photographs for the type of events considered in the present experimental programmes. It is likely that about 2/3 of this effort will be applied to bubble chamber runs taken at CERN, while other photographs will come from the accelerators in the Member States or America. Ten major groups, in collaboration with smaller ones, can be expected to take the leadership of one bubble chamber run each.

The matching between the measuring capacity and the bubble chamber output can be considered to be good, although some temporary limitations may occur, due to insufficient experience, lack of computer programmes, etc. in some groups.

It is not the scope of the present report to present a forecast of the situation in 1963, but it may be useful to point out some of the factors which will produce changes.

- The type of experiments will gradually shift towards higher accuracy and resolution, requiring larger number of events.
- The complexity of some of the events to be measured will increase, slowing down the rate of measurement.
- There may be a tendency to further exhaust the information contained in the films, by investigating the events not included in the first experiments.
- Several of the smaller groups will become large ones, able to take the leadership in bubble chamber experiments.
- The total measuring capacity will be increased by the acquisition of new instruments, by an overall increase in efficiency of operation, and by the HPD. The increase may well be by a factor of two, or more.

Y. Goldschmidt-Clermont
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