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NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

GOVERNING BOARD

Recommendations by the Physics Committee concerning

Bubble Chamber Film Analysis Equipment

by J. D. Cockcroft

The Physics Committee have begun a review of the needs of university departments for equipment for the measurement and analysis of film from bubble chamber experiments. The principal circumstances as reported to the Committee are summarised in Appendix 1. Bubble chamber experiments are among the most important to be carried out with the C.E.R.N. proton synchrotron and Nimrod. Large quantities of excellent bubble chamber film from C.E.R.N. are already available to British university teams, and film from Nimrod will be available from 1965. The total number of events to be measured is estimated to reach 1,000,000 per year in 1966, whereas the measuring capacity of the equipment already available will not be more than 300,000 events per year in 1966. If the recommendations at 1 and 2 below are put into effect, the equipment provided will allow each of four groups to measure an additional 100,000 events per year initially and perhaps 200,000 per year eventually.

1. The Committee recommended that one installation consisting of three scanning and measuring projectors (SMP's) and an IBM 7044 computer should be provided by the Institute immediately, sited at a university. Action to implement this recommendation has been taken by the G.P.C. and the Director of the Rutherford Laboratory, in whose budget the money required in 1964-65 is included. The Committee set up a panel consisting of Professors Butler, Flowers and Merrison and Dr. Pickavance to recommend on the siting of this first unit. The panel have recommended that the unit should be sited at the University of Glasgow, and I concur with this recommendation.
2. The Committee recommend that the Institute should provide increased measuring capacity as soon as possible to at least three other university departments. The equipment might differ from that to be provided as recommended at 1 above because of local requirements, or technical developments. The total expenditure on these three further installations might be £200,000 to £300,000 in 1965-66 and eventually £300,000 p.a. (See Appendix II). This cost is not provided for in the Rutherford Laboratory estimate.

The Committee recommend that these further installations should be given high priority in the Institute's programme, which should if necessary be revised to accommodate them.

The Committee expect to make more detailed recommendations on the nature, siting and timing of these further installations at a later date.

Bubble Chamber Film Analysis Equipment for UniversitiesSummary of the Position as reported to the Physics Committee

by J. A. V. Willis

1. General

For the foreseeable future bubble chamber experiments will be among the most important experiments on the C.E.R.N. proton synchrotron and Nimrod. The films can be sent to a participating university department, where the measurement and analysis can be done if the necessary equipment is available.

2. Responsibility for providing Equipment

The film will come partly from C.E.R.N. and partly from N.I.R.N.S. Laboratories. It would have been impracticable for D.S.I.R. to provide measuring equipment for the former and the N.I.R.N.S. for the latter, because each university group will use film from both sources. A working agreement was therefore made in August, 1963 that the D.S.I.R. would provide the "first generation" measuring equipment, and the Institute would provide the "second generation" equipment, i.e. equipment requiring on-line connection to a computer.

At the time of this working agreement, it was thought that the cost of the "on-line" computer equipment would be quite small. The large computers required for analysing the measurements were not included in the working agreement. (They were expected to be provided under separate arrangements).

3. British Bubble Chamber Groups

There are well-established bubble chamber physics groups at eight centres:-

University of Birmingham
University of Cambridge
University of Glasgow
Imperial College, London
University of Liverpool
University of Oxford
Rutherford Laboratory
University College, London

and groups at two more centres are being formed:-

University of Bristol
University of Durham

4. Source and Quantity of Film

The combined facilities of C.E.R.N. and N.I.R.N.S. can be expected to produce by 1966 3,000,000 pictures per year for the British groups. The number to be measured will be smaller, and is estimated at 500,000 per year in 1965 and 1,000,000 per year in 1966.

5. Present Measuring Capacity

The eight centres in the first list in paragraph 3 each have one or more manual and "national" automated measuring machines, and Imperial College and the Rutherford Laboratory have "second generation" machines of the Hough-Powell type now coming into use. The combined capacity of all these machines is estimated to provide for the measurement of 200,000 events per year in 1965 and perhaps 300,000 per year in 1966.

6. Types of Measuring Equipment

In British "national" measuring machines, a human operator selects the tracks to be measured, and traces it roughly by a mechanical device. The machine measures the track accurately and records it in digital form (as do all the other machines that will be mentioned) for later geometrical and kinematical analysis in large computers.

Very rapid development of faster-operating machines, using computers, is at present taking place. There are three main types:-

(a) The SMP (Scanning and Measuring Projector) developed at Berkeley, in full use there and coming into use at other centres. Measurements are controlled by a human operator but the computer checks each measurement as it is made and immediately rejects faulty measurements. The scanning of pictures to select events for measurement is done on the same machine, not as a preliminary operation on a separate scanning device.

(b) The HPD (Hough-Powell Device) developed jointly by Berkeley, Brookhaven, C.E.R.N. and (latterly) the Rutherford Laboratory; in use at Berkeley, Brookhaven and C.E.R.N., and coming into use at the Rutherford Laboratory, Imperial College and elsewhere. With this device the pictures are first scanned to select events for measurement, and the tracks to be measured are roughly indicated by a human operator. The film is then fed into the HPD, which scans the picture electronically, accurately measuring the chosen tracks.

(c) PEPR (Precision Encoding and Pattern Recognition) under development at M.I.T. This device differs from the HPD in that it is intended eventually to measure pictures without preliminary human identification of the track to be measured.

7. Choice of machine

An installation consisting of three SMP machines coupled to an IBM 7044 computer was recommended to the Committee as the best present equipment to supply to the first university centre, on the ground that this equipment is well-proved and successful and is available commercially.

This installation can be expected to process 100,000 events per year initially, and perhaps 200,000 per year eventually.

APPENDIX IIEstimates 1965-66Universities Film Measurement and Data Processing Unitsby L. B. Mullett

1. At a meeting on 14th July of the Physics Committee of the N.I.R.N.S. a proposal was considered for University Bubble Chamber Film Measurement and Data Processing Units. The Committee are addressing a recommendation to the Board of the N.I.R.N.S. that equipment for at least four university film analysis groups should be provided.
2. The proposed equipment for each group consists typically of three scanning and measuring projectors (S.M.P.'s) and one hired IBM 7044 computer with a recurrent cost (for each group) of £100,000 per annum, an initial capital cost (for each group) of £75,000, and associated building costs (for each group) in the range £10,000 to £30,000 depending upon whether conversion or new construction is required.
3. Provision for one such installation can be obtained within the R.L. section of the Five Year Forecast 1965-1970, and the General Purposes Committee has already approved immediate action. A siting committee has met and commitment now waits on comment from the Department of Education and Science.
4. The Draft Estimates for 1965-66 includes specific provision for this first unit in the Rutherford Laboratory section. However, the scale of this equipment is considerably greater than was envisaged, particularly in respect of the associated computer, and only a contribution to one of the three further installations might be possible without substantially exceeding the Five Year Forecast figures.
5. Almost certainly, the university departments concerned with the three further installations would not all specify SMP's, since other developments are progressing, but the cost of the SMP installation may be taken as typical. For these, given early approval, the capital cost could all fall into 1965-66, and the computers could be available for about October, 1965, thus requiring rental for six months in 1965-66 at a rate of £70,000 each. The cost for one such installation could therefore be:-

	<u>1st year</u> <u>(1965-66)</u>	<u>2nd and subsequent</u> <u>years</u>
Buildings (up to)	£30,000	-
Capital plant (3 S.M.P.'s)	£70,000	-
Computer rental	£35,000	£70,000
Recurrent	£15,000	£20,000
Modifications & improvements	£150,000	£100,000

The ultimate recurrent cost for three installations might therefore be £300,000 p.a. and the expenditure in 1965-66 would be in the range £200,000 to £300,000 depending on the starting dates of the projects.