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NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

GOVERNING BOARD

Comments on the Expenditure of the Rutherford Laboratory and comparison with CERN

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A. Introduction

We were asked by the General Purposes Committee of NIRNS to examine the expenditure of the Rutherford Laboratory and in particular to relate the annual budgets of the Laboratory to those of CERN, Geneva, and to report our findings to the Governing Board of the Institute.

We have attempted to do this by a direct comparison of similar items of expenditure in the two laboratories in the current financial year, and by considering the way in which the CERN expenditure has grown after the initial operation of the CERN proton synchrotron in 1960, we have made some general comments on the future budgets of the Rutherford Laboratory. This study was made possible by the very willing co-operation of the Director of the Laboratory, Dr. T. G. Pickavance, the Assistant Director, Mr. L. B. Mullett, and Dr. G. H. Stafford. We thank Dr. M. G. N. Hine of CERN for making available to us information on CERN's budgets and for discussions on many problems.

B. A comparison between CERN and Rutherford Laboratory expenditure and staff allocations

(1) Operating expenditure and staff of the high energy accelerators

	Staff	Expenditure (£'000)
C.P.S.	242	1,000
Nimrod	255	1,120

Comments

(a) Staff includes local engineering design and workshop support, beam layout groups, operating, maintenance and machine development staff.

(b) Expenditure includes operating and capital expenditure incurred by the above groups, including shielding for the machine and the experiments. Nimrod costs omit payments during the year on the capital construction of the machine and initial shielding.

(c) The C.P.S. has been in operation three years and is now running 120 hrs. per week. Nimrod has only just operated for the first time. When the C.P.S. first worked, the machine design and construction staff was about 250.

(d) It seems likely that Nimrod running on the same schedule as the C.P.S. will need similar operating staff numbers and a similar operating budget.

(2) Operating expenditure and staff of the low energy accelerators

	Staff	Expenditure (£'000)
C.S.C.	83	370
P.L.A.	89	430

Comments

(a) Staff and expenditure cover the same items as (1)(a) and (b) above.

(b) Both machines are running on similar schedules.

(c) Local engineering design and workshop staff also support nuclear physics teams using the machine in both cases.

(d) As with the larger machines, it seems that the C.S.C. and the P.L.A. need roughly the same operating staff and hence about the same operating budgets. Both groups contain a large development effort, which partly accounts for the higher staff and expenditure figures compared with similar machines at universities.

(3) Beam equipment and staff for the high energy machines (excluding ejection equipment and shielding)

	Staff	Expenditure (£'000 - capital only)
C.P.S.	66	480
Nimrod	51	500

Comments

(a) The high capital expenditure on Nimrod beam equipment is partly due to payment of bills this year for apparatus ordered some time ago.

(b) The C.P.S. expenditure is now roughly the same each year.

(c) It is expected that both the staff and expenditure on this item will be lower for Nimrod than the C.P.S. due to the difference in beam energy.

(d) In a year or two one would expect the capital expenditure on Nimrod beam equipment to fall to about £300,000 per annum.

(4) Bubble chamber construction, operation and research

	Staff	Expenditure (£'000)
CERN	130	880 (440 is capital for 2m. bubble chamber)
Rutherford Lab.	50	310

Comments

(a) The CERN groups are building a 2-metre hydrogen chamber and using a 1-metre propane chamber. Also on site at CERN are an 80 cm. hydrogen chamber, a 100 cm. propane chamber and a 1.5 m. hydrogen chamber, all belonging to and operated by visiting groups. The operating costs of the latter fall on the CERN budget (except staff costs and major maintenance).

(b) At any one time CERN has set up 2 to 3 of these bubble chambers for which the operating costs are paid by CERN. Hence £440,000 per annum may be taken as typical of operating expenditure for this amount of use. However, not all the staff expenditure falls to CERN, since the visiting research staff and the operating staff for visiting chambers fall to other laboratories.

(c) At Rutherford Laboratory it is not at present planned to run more than one bubble chamber at a time. In these circumstances the operating expenditure is thought likely to be around £300,000 per annum. If all three bubble chambers (hydrogen, helium, heavy liquid) were to be kept simultaneously in an operational state, the annual expenditure would be likely to rise to £500,000.

(d) The staff shown for Rutherford Laboratory above includes 27 university staff paid by Rutherford Laboratory, but not the 20 staff to be taken over with the National Bubble Chamber now at CERN.

(5) Data analysis, including computing

	Staff	Expenditure (£'000)
CERN	95	450
Rutherford Lab.	38	228

Comments

(a) CERN staff includes those engaged on this work in the Data Handling Division, the N.P.A. Division and the Track Chamber Division.

(b) CERN work includes considerable research into new methods of data analysis appropriate to an international centre, but not necessary on the same scale at a national one.

(c) Both staff figures include a programming and computing group (709 at CERN and Orion at Rutherford Laboratory). Rutherford Laboratory will have available the Atlas facility later on (not costed against Rutherford Laboratory), but CERN will have to buy or hire new larger facilities (costed against CERN).

(d) The CERN expenditure of £450,000 includes about £140,000 for the hire of their computers. (This year extra expenditure is being incurred by the hire of external computing time estimated at another £140,000.)

(e) The Rutherford Laboratory expenditure includes the hire of CEGB computing facilities but not the capital sum for Orion which is £200,000 in this year but not repeated in subsequent years.

(f) The Rutherford Laboratory staff of 38 must increase if Rutherford Laboratory undertakes the same amount of data analysis as CERN. This will increase the expenditure. However, it is intended that the university groups will use Atlas. Thus although some of the groups will have their own computers, data analysis equipment and operating staff, they will certainly call on Rutherford Laboratory for support, both financial and staff, to help with data analysis. This is likely to cause the present £228,000 expenditure to rise to £350,000 per annum. (For example, part of the present £228,000 expenditure this year goes to university groups to enable them to analyse photographs now coming from CERN.)

(6) Theoretical physics

	Staff	Expenditure (£'000)
CERN	38*	116
Rutherford Lab.	0	0

(*including 23 Fellows)

Comments

(a) The present practice of the Rutherford Laboratory is that theoretical physics is carried out in the universities and that university theorists are encouraged to interact strongly with the experiments by frequent visits to the Laboratory. For example, Professor Dalitz, who has recently taken a Chair at Oxford, is a consultant of the Laboratory and spends a great deal of his time there.

(7) High energy physics other than bubble chamber research

	Staff	Expenditure (£'000)
CERN	150*	700
Rutherford Lab.	66	620

(*including Fellows)

Comments

(a) To the CERN staff of 150 (55 research physicists) must be added the visiting scientists and teams (not paid by CERN).

(b) To the Rutherford Laboratory staff of 66 (13 research physicists) must be added the university physicists and support staff; (some paid by Rutherford Laboratory and all of their apparatus paid for by Rutherford Laboratory).

(c) Both CERN and Rutherford Laboratory supply and pay for a considerable amount of support in men and equipment for the visiting scientists.

(d) Rutherford Laboratory aims at a rather higher ratio of visitors to local staff than CERN now have.

(e) Even allowing for the above points, the high expenditure of £620,000 at Rutherford Laboratory as against £700,000 at CERN needs explanation. A large fraction is going into initial electronic equipment for Nimrod experiments (about £270,000). It is likely that the present expenditure by Rutherford Laboratory will increase only slightly in the next few years. In support of this prediction, it is noted that the CERN expenditure on this item was around £600,000 at the time the C.P.S. first came into service.

(8) Physics research with low energy machines

	Staff	Expenditure (£'000)
C.S.C.	44*	180
P.L.A.	17	225

(*including Fellows)

Comments

(a) The low staff figure of 17 for the P.L.A. reflects Rutherford Laboratory policy of leaving the major use of the facilities to university groups.

(b) It is noted that £70,000 is being spent this year by Rutherford Laboratory on two large anlysing magnets.

(c) Both CERN and Rutherford Laboratory pay for the research equipment used by visiting physicists.

(9) Administration, Engineering and Site Services

These can best be compared as fractions of the total laboratory staff in both cases.

(1) Administration and Finance

	Staff	% of total staff	Expenditure (£'000)
CERN	258	19%	630
Rutherford Lab.	142 (162*)	15% (17%)	530*

(*including AERE services)

(2) Central Workshops and Site Services

	Staff	% of total staff	Expenditure (£'000)
CERN	273	20%	2050
Rutherford Lab.	156	17.5%	1037

Comments

(a) CERN Administration includes Directorate, Library, Finance and General Administration, Patrol Service, Purchasing Office and cleaning services.

(b) Rutherford Laboratory Administration includes Library, Finance and General Administration, Central Stores and Transport Section. (Oxford Purchasing Office figures have been added to Rutherford Laboratory figures, see*) If the definition is adjusted to correspond with CERN the additions and subtractions virtually cancel out.

(c) CERN Site Services include the Central Workshops, Transport Section, site maintenance and a building planning and design group (equivalent to the SWO group at Rutherford Laboratory).

(d) Rutherford Laboratory Site Services include Central Workshops and site maintenance.

(e) The smaller percentage of Site Services at Rutherford Laboratory can be explained by the fact that UKAEA provides some site services to Rutherford Laboratory (and is paid for them).

(f) Expenditure on Site Services includes the cost of building works

(g) The figures given above should give no cause for worry at Rutherford Laboratory, since they are understandably less than those at CERN. We were not able to compare the quality of the staff in each laboratory.

Recapitulation of Staff Figures

		Rutherford Lab.	CERN
1.	Operating groups for high energy machine	255	242
2.	Operating groups for low energy machine	89	83
3.	Beam equipment groups	51	66
4.	Bubble chamber groups	50	130
5.	Data analysis and computing	38	95
6.	Theoretical Physics	0	38
7.	High energy physics groups (other than bubble chamber groups)	66	150
8.	Low energy physics groups (P.L.A.)	17	44
9.	Administration	142	258
10.	Site Services and Central Workshops	156	273
11.	Not included in the above	29	
12.	TOTALS	893	1,379

Comments

(a) Rutherford Laboratory figures exclude the Cyclotron Group (26) and the group working on the Oxford project (16), but include some design and construction of bubble chambers and film measuring machines in universities (34). The net total for the Rutherford Laboratory strength is 901.

(b) CERN figures exclude the Accelerator Research Group but include Fellows.

(c) No better than ±5% accuracy is claimed for any of the above figures in respect of breakdown against equivalent headings.

(d) No attempt is made to account for the hundreds of visiting scientists and support staff who use both CERN and Rutherford Laboratory and whose costs are in varying degrees borne by these laboratories. It should, however, be noted that Rutherford Laboratory aims at having a higher ratio of visiting physicists to local physicists than CERN has at present.

Recapitulation of Expenditure (£'000)

		Rutherford Lab.	CERN
1.	Operating groups for high energy machine	1,120	1,000
2.	Operating groups for low energy machine	430	370
3.	Beam equipment groups	500	480
4.	Bubble chamber groups	310	880
5.	Data analysis and computing	228	450
6.	Theoretical Physics	0	116
7.	High energy physics groups (other than bubble chamber groups)	620	700
8.	Low energy physics groups (P.L.A.)	225	180
9.	Administration	530	630
10.	Site Services and Central Workshops	1,037	2,050
	TOTALS	5,000	6,856
	Items not included above:		
	Nimrod capital	740	
	Nimrod Shielding and Extraction Equipment	245	
	Nimrod beams - recurrent costs	230	
	Orion capital	200	
	Radiation Protection	42	
	Minor building works	56	
	Residue of Extra Mural and Experimental Agreements	90	
		6,603	7,540
	Accelerator Research		310
	V.E. Cyclotron	137	
	Oxford Project	76	
	Research Reactors	110	
		6,926	7,850
	Less Receipts	69	
		6,857	

Comments

(a) The present estimated out-turn at the Rutherford Laboratory is (NI/63/18): £7.243 m.

Deduct special allowance to pay DSIR for the National Bubble Chamber £ .375

net estimated out-turn £6.868 m

(b) No better than ±5 per cent accuracy is claimed for the figures under particular headings in the comparison.

C. Conclusions on the present expenditure of the Rutherford Laboratory

(a) The most important conclusion from this comparison is that Nimrod has not only cost as much as the CERN Proton Synchrotron to build, but it will also cost as much to operate as a machine each year. This conclusion is reasonable when the relative complication of the installations is considered, and is also confirmed by the staff and expenditure figures of the Bevatron group at L.R.L. Berkeley and the Synchrophasotron group at Dubna, Moscow.

(b) Similarly the P.L.A. at Rutherford Laboratory and the Synchro-cyclotron at CERN also cost roughly the same to operate and use each year although in this case the fields of research are quite different.

(c) The expenditure on bubble chambers at Rutherford Laboratory, now less than half that at CERN, would rise substantially in the next few years if the three bubble chambers available were fully used with Nimrod. It is important to formulate a policy for the use of these three bubble chambers now if this item of research expenditure is to be kept in control.

(d) Expenditure on beam transport equipment is understandably high this year at Rutherford Laboratory. It is expected to level out at just over half the present figure.

(e) The expenditure on counter experiments is already high this year, but the comparison with CERN suggests that it should not increase very much over the next few years. Control of this expenditure, though essential, is complicated by the Institute's policy of maximum university use of the machines. In view of the number of competing accelerators around 7 GeV, the best value for money is likely to be obtained by concentrating on a few lines of research and pursuing them vigorously. The Rutherford Laboratory policy on scheduling has made a good start in this direction.

(f) In general we did not find any great discrepancies in making this comparison, but even minor variations of a few per cent here and there can materially affect the amount of research possible in a laboratory. No doubt the Rutherford Laboratory staff will continue their enquiries along the general lines adopted in this report, and we recommend that the annual budget figures be presented to the Board in the same form (as well as in the normal administrative form).

(g) One matter which arose during the discussions needs special comment. The Rutherford Laboratory cooperates with universities in many research programmes; appreciable Institute funds are involved. Any shortfall in the funds made available to universities from other sources will inevitably lead to an increase in this load on the Rutherford Laboratory budget.

D. The future annual expenditure of the Rutherford Laboratory

With this background comparison in mind, and the experience at CERN, we considered the way in which the expenditure of the Rutherford Laboratory is likely to vary in subsequent years. Various estimates made by Rutherford Laboratory were shown to us and our comments are directed at these estimates.

1. 1964/65

With the help of the detailed comparison with CERN summarised above, we worked out a minimum budget for the Rutherford Laboratory for 1964/5 without reference to existing estimates. This took into account the large payments still to be made on existing capital schemes, and allowed for the growth of approximately 5 per cent in staff numbers and the corresponding growth of non-capital expenditure seen to be necessary from the present state of progress under the headings considered in the comparison. Only £150,000 of new capital expenditure was included (of which £120,000 will be needed for urgent building items deferred during the budgetary difficulties this year). Thus we made no provision for new capital investment in the larger kinds of equipment, and for this reason did not include a "shadow cut". The result was £6.45 million.

We understand that the maximum amount likely to be available to the Rutherford Laboratory for 1964/65 is £6.5 m., and that the allocation of the NIRNS shadow cut may reduce this to about £6.25m. Next year's budget is therefore likely to be tight. A detailed review of the estimate totalling £6.5 m. (NI/63/18) confirms that no provision can be made for capital expenditure on the larger kinds of equipment. This is a situation which may be tolerable for one year, but for no longer.

2. 1965/66 and later years

Experience in other laboratories shows that, once the initial major capital construction is complete and paid for, budgets must increase by about 5 per cent per annum in real terms if the same research effort is to be maintained. This is simply due to the fact that research equipment steadily becomes more elaborate and costly as time goes on. The starting date from which such a formula should operate on the total budget is affected by the tail end of payments on expensive installations such as Nimrod, but at the Rutherford Laboratory we would expect 1965/66 to be the first year needing an increase of this order. Minimum budgets for 1965/66 and 1966/67 would then be about £6.8 m. and £7.1 m. But as we have seen, there will be no scope for capital investment in new equipment during 1964/65, and to avoid the danger of a serious shortage of equipment in the second full year of operation we would prefer a higher figure, say £7.0 m., in 1965/66, followed by £7.1 m. as the minimum figure for 1966/67.

We understand that the Director has estimated "rational" budgets for these years of £7.0 m. and £7.3 m., and we support him. However, we fear that his estimate of £7.5 m. for 1967/8 may be too low.

We must emphasise again that 5 per cent per annum growth of budgets will only maintain a constant research effort in the Laboratory, while allowing the research apparatus to be kept up-to-date. It does not allow for major innovations in high energy physics at 7 GeV. A possible example might be the development of neutrino physics at this energy, which would need major new building construction and a big investment in shielding and detection equipment. Similarly, there is no allowance for major Capital development of the accelerators to improve their performance. But we would not expect such major additions, of either kind, to be necessary in the next three years.

3. Number of research physicists

Experience at CERN and other similar research laboratories shows that an annual expenditure of £7m will support about 200-250 research physicists, and that they would need a total supporting staff of about 1100. A research physicist in this context means a physicist carrying out experiments on the machines; physicists designing and building apparatus are included in the supporting staff. These numbers are consistent with the Rutherford Laboratory's predictions for 1966. However, if the number of university physicists demanding facilities at the Laboratory is allowed to increase much beyond 200, either more money must be found or the research programmes will be starved. It is clear that the Director will need support in controlling the growth of demands on the Laboratory to match available budgets. CERN is in trouble of this kind, and this year finds itself with too many physicists for the money and staff available for their support.