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RESEARCH GROUP MANAGEMENT BOARD

Initial Installation of the AEA/SRC Joint Laser Centre at Harwell

W M Lomer

Summary

1. In July 1974, the proposals in RGMB(74)36 for a high power laser research programme at Harwell, to be run in close collaboration with SRC, were approved in principle by the AEA. The Council of the SRC approved in principle the provision of high power laser facilities subject to availability of funds, and to agreement of appropriate arrangements with the AEA.

2. In the intervening period studies have been made of the present achievements in both laser-beam plasma interactions and laser compression and a more detailed assessment has been made of the laser requirements and of the commercial availability of high power lasers.

3. The requirements and specifications have been determined and agreed through detailed discussions with SRC and University representatives: this paper is the AEA companion paper to match the definitive SRC request for expenditure given approval by the Council in December 1974. The initial construction of the Joint Laser Centre will require capital expenditure of about £3.8M.

4. This paper outlines the total case, but asks for specific approval against cost estimates for only that part of the project which can be immediately housed in temporary accommodation: this Part I requires a capital approval in the rounded sum of £2.4M, to be shared equally between SRC and AEA. The costed case for Part 2, covering the new permanent building and certain additional equipment, will be prepared when design has proceeded further.

The General Proposal

5. The Aim, Objectives and Scope of the Joint Laser Project remain as described in RGMB(74)36 and detailed discussions between AEA, SRC and University staff have resulted in the following definition of the proposed joint project.

6. It is proposed that high power laser systems should be provided by the UKAEA and SRC at a Joint Laser Centre on the Harwell/Chilton site. These facilities will serve the research programme of the UKAEA and UK universities: the

programmes will comprise research on laser beam - matter interactions and the development of new high power laser systems which might be used to extend or replace the systems provided initially.

7. The AEA will discharge its policy and executive management through its membership of the joint management committees which will control the Joint Laser Centre. Appendix I notes the proposed initial structure and its relation to Research Group structure. This skeleton structure has been agreed with SRC, but its connection with SRC committees is not yet final. All AEA Capital expenditure will flow through the hands of our Project Officer supported at each level by Finance and Contracts Officers. Dr Lomer will be the RGMB member responsible for this project, and the Project Officer will be Dr Whitehead, of Nuclear Physics Division. When the scientific policy and programme of the Centre is to be discussed, the Main Project Committee will be expanded into a Scientific Council, with University and Culham representation, and a Security Sub-Committee - see para 8 - inserted into the AEA line of command.

8. Parts of the work, particularly on the theoretical and computational side, may approach classified areas. Within the project, the AEA will (in collaboration with MoD) take responsibility for the security classification of programmes, will assume sponsorship of the sensitive parts of the work, and will be responsible for implementation of the necessary security control mechanisms. In order that these responsibilities can be effectively discharged, the AEA will have full administrative control of all accommodation which may be used for classified or sensitive work. In this connection a Special Security Committee will be set up under AEA chairmanship, with representatives from AEA and MoD only, to examine all proposed programme developments at the Joint Laser Centre and to determine their security classification.

9. A new building, to be owned by AEA, to house the main central facilities will be designed and sited so that both classified and unclassified work may be carried out in it: the arrangements for segregation and control of classified work will not be activated until the necessity for them is clear. The building would be of floor area of about 3000m^2, would be sited on the Rutherford Laboratory side of the Harwell site and will be designed so that it can be extended if required. This building is of demanding specification in air conditioning and antivibration arrangements: the designs will not be ready for approval for some months and construction will take, say, two years. In the interim, B.488 at Harwell will be utilised to launch the project. It is expected that some occupancy of B.488 will persist for three years.

10. The capital and operating costs of the project will be shared equally by SRC and AEA. Equivalent staff contributions will be made by the two organisations who will pay their own staff: it is estimated to reach a total of about 66 Direct

staff (all grades) by the end of the first two years.

11. The capital cost of Part I of the proposal, which will be installed and operated temporarily in B.488, is estimated at £2411K (including contingencies) and approval for the Authority's share of this sum of £1205K is now sought.

12. Part II of the proposal comprises the new building, and an intense electron beam system; the global estimate for this is £1400K of which the AEA will be expected to contribute half. More detailed estimates will shortly be put in hand, and the whole of the initial expenditure should be completed in 3/4 years.

13. There will be periodic reassessments with the SRC of the cost sharing arrangements, and of the forward development programme of the Centre. This forward development has been indicated by SRC as involving further capital expeniture on their part over the next three years - 1978-81 - of about £½M per annum. No corresponding provision has been made in the AEA five year forecast. The timetable for the presentation of further cases for approval will depend on technical and financial developments.

The Proposed Installations

14. These proposals have been formulated by taking account of the programme requirements of the UKAEA, the SRC and of university scientists. Joint visits have been made to major American and European laser laboratories and manufacturers to establish the "state of the art" situation. The detailed technical proposals are given in Appendix II.

15. The proposed installations are presented in two parts. Part 1 is concerned with the capital costs which will be incurred whilst the project is housed temporarily in B.488 and Part 2 is concerned with the provision of a new building and its occupancy during the third year of the joint project.

PART 1

Glass Lasers

16. It is proposed to purchase two complementary neodymium glass lasers, each giving beams of high optical quality capable of achieving power densities on target exceeding 10^{15} watts/cm². In its most straight-forward form the high power compression laser is designed to produce a total of 500 joules in two beams with a tailored pulse of 300 psec duration to irradiate 100μm diameter spheres with a power density exceeding $4.5.10^{15}$ watts/cm². A second, intermediate power, single beam laser is designed to produce at least 10 joules in 100 psec which could be focussed to achieve power densities in excess of 10^{15} watts/cm². A major use of this second laser will be component testing, diagnostic development and calibration and as a driver for the development of higher energy systems.

17. It is probable that the first laser will be purchased from the General Electric Company, Syracuse, New York, with the development of the pulse shaping part of the system pursued within the project, and that the second laser will be purchased from Quantel, Orsay, Paris. The costs based on budgetary estimates given by the General Electric Company are given in Table I. (The General Electric Company is the only one to have supplied a complete laser amplifier system of the type required, which is at the limit of current technology). The basic contingency noted in Tables I and II is small because the firms concerned will carry the main technical responsibility.

Diagnostics and Experiments

18. A wide range of optical and electronic instrumentation will be needed for measuring and monitoring laser performance and for laser alignment. An extensive range of instrumentation is also required for target experiments. In general the instrumentation is characterised by the wide range of electromagnetic radiation to be detected and measured - from the infra-red to hard x-rays, by the variety of particle energies - from electron volts to MeVs, by the temporal range and resolution of many phenomena - from picoseconds to microseconds and by the spatial resolution of microns demanded by many studies.

19. An initial list of diagnostic equipment is given in Appendix II: Table I summarises the estimated costs.

Modifications to B.488

20. It is intended to house the joint programme initially in B.488 (North Bay and laboratories) whilst a new building is designed and constructed. It is expected that B.488 which though small has existing facilities for the provision of a filtered air supply, will house the project satisfactorily for two to three years by which time the major part of the equipment and staff will have transferred to the new building. A number of relatively minor structural alterations are required to B.488 together with the appropriate redistribution of services. The major expense arises from the overhaul and extension of the existing clean air system and building redecoration with dust-control paints. The HMC have already approved the allocation of B.488 (North Bay and laboratories) to this project.

21. The capital costs of modification and up-grading of B.488 are given in Table I together with the estimated consequential capital costs of rehousing present occupiers.

PART 2

The New Laser Building

22. The special environmental needs of the high power glass lasers require that particular attention should be paid to

the design of a building for this project so that the maximum performance can be obtained from the lasers, so that experimental reproducibility can be achieved and relied upon and so that maintenance and repair of the systems can be minimised in cost and down time.

23. Two major aspects of design dominate this problem. The first is that of space conditioning: the lasers must be operated in an environment supplied with filtered air which is also temperature controlled and stabilised. Humidity control is desirable in some areas. The second aspect concerns the mechanical stability and freedom from vibrations. Note has been taken of experience in these matters obtained at other laboratories with existing installations: detailed considerations will be given to the design criteria adopted by laboratories constructing new buildings to house similar laser installations.

24. The space estimates of the major, functionally identifiable areas are given in Appendix II. A token cost estimate of £1M is taken at present, based on architect and engineering advice. The time to initial occupancy, from Instruction to Proceed, is not likely to be less than two years.

25. The siting of the new building will be chosen to facilitate access for university users, to allow for future expansion, to conform with Research Group site expansion policy and to minimise access costs.

The Electron Beam System

26. An essential tool in the area of basic research into new lasers is the electron beam generator. E-beams are used to pump chemical lasers (e.g. HF) or to excite quasi-molecular lasers, high power CO_2 and gas excimers. It is proposed to provide an electron beam generator for installation in the new building. The generator will be capable of delivering a 30 ns, 100,000 ampere pulse of electrons of energy above 1 MeV. The electrons pass through a thin foil into the lasing medium, held in chambers which would be easily interchangeable and engineered to meet the requirements of specific programmes. The global cost estimate of such a system is taken in Table I as £260K.

Extension of Facilities

27. Since the initial provision of high powered lasers is limited to those of the neodymium glass type we must expect that later submissions will introduce new lasers of other varieties. No specific provision is now sought.

Staff Estimates

28. It is estimated that before the end of the project's third year 66 Direct staff will be needed, drawn in equal number from the SRC and the Authority. The Direct Authority provision is estimated at 16 Category A and 17 Category B

and others. The staff will have to be found mainly by transfers from other (mainly Underlying) projects, although recruitment of up to three specialists will be needed. Collaboration with existing laser and plasma diagnostic expertise at Culham will greatly speed up progress and efficiency.

29. The capital cost of this project is to be allocated to the Underlying Programme. Provision in estimates and forecasts is as shown in Table II. Provision is being made in PM 11 82 00 - Laser Studies (Project FZ 8/20/01).

30. Capital charges are to be shared equally between SRC and AEA, and 'effort to be equally contributed'. Details and mechanisms of sharing capital and operating costs and of ownership nevertheless still remain to be negotiated with the SRC.

31. The expenditure on this project will be controlled by the Directors of the Rutherford Laboratory and of Harwell through a Project Committee, on which the AEA representatives will be

Dr WM Lomer	Programme Director responsible
Mr EJS Clarke	or nominee for Research Group Finance Branch
Dr C Whitehead	AEA Project Officer

Explicit approval for individual contracts within the envelope approval sought in this paper will be authorised under normal delegated powers provided no deviation from the overall plan here presented is implied. Analogous arrangements are planned by the SRC.

Recommendations

32. The Board is invited to:

(a) approve the launching of the Joint Laser Centre

(b) note the skeleton committee structure and the proposals for regular review of projects

(c) approve capital expenditure of £1.2M for Part I of the scheme

(d) note that approval for capital expenditure to an estimated total of £0.7M for Part 2 of the scheme will be sought shortly

(e) note the Project Officer, Project Committee arrangements and allocation to Harwell Projects.

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Table I

	Capital Costs		AEA Share Sanctionable	AEA Share Associated
	£000		£000	
Part 1				
GE 1.5 TW system *($2.53M @ $2.3 = £1)	1100			
Pulse stacker and oscillator	100			
Computer	45			
Supports	50			
		1295	647	
Quantel 100 GW system *(1.5M FF @ 10FF = £1)	150			
Optical isolation	10			
		160	80	
Diagnostics				
Laser diagnostics	56			
Input beam diagnostics	90			
Alignment	45			
Optical hardware	55			
Oscilloscopes	70			
Target area diagnostics	240			
		556	278	
Building 488				
Structural modifications and overhaul of plant	40 (+ 5 asstd)		20	2.5
Consequential moves	50 (+ 10 ")		25	5
		90	45	7.5
Contingency	210		105	
TOTAL	2311		1155	7.5
Additional contingency (see footnote to Table II)	100		50	
GRAND TOTAL	2411		1205	

		556	278	
Building 488				
Structural modifications and overhaul of plant	40 (+ 5 asstd)		20	2.5
Consequential moves	50 (+ 10 ")		25	5
		90	45	7.5
Contingency	210		105	
TOTAL	2311		1155	7.5
Additional contingency (see footnote to Table II)	100		50	
GRAND TOTAL	2411		1205	

Part 2: Token estimates

The New Laser Building Construction, services and access	1000 (+200 asstd)	500	100
Electron beam system	260	130	
Contingency	140	70	
GRAND TOTAL	1400	700	100

Note: This paper assumes that no import duties will be payable. The Authority, but not the SRC, will be exempt from VAT.

*These figures are based on an order of cost proposal from the firms mentioned, expressed in dollars and French francs, provided in October/November 1974. These costs were accepted for approval purposes by SRC, with a small corresponding contingency.

Table II

Spend Profile (AEA share) £000

	75/76	76/77	77/78	78/79	Total 75/79 inclusive
Part 1 (Capital costs)					
1.5 TW laser system	330	270	47	-	647
100 GW laser system	80	-	-	-	80
Diagnostics	60	96	122	-	278
B.488 mods*	45	-	-	-	45
Contingency	30	45	30	-	105
Part I Total	545	411	199	-	1155
Additional contingency≠	-	25	25	-	50
Part 1 Grand Total	545	436	224	-	1205
Part 2 (Capital costs)					
New Laser Building**	-	175	175	150	500
Electron Beam system	-	74	56	-	130
Contingency	-	25	25	20	70
Part 2 Total	-	274	256	170	700
Grand Totals Pts 1 & 2	545	710	480	170	1905
Estimates & FYF Provision***	420	650	400	200	1670

*This figure was not identified in the SRC submission

**Specific provision for a new building was not made in the FYF but an amount of £200K for modification to existing buildings was included

***Although the total estimate for 1975/76 is £125K in excess of the estimates provision it should be possible to provide for this difference when the final breakdown of the 1975/76 capital grant is advised to London Office at the end of March 1975. It should also be possible to accommodate the differences in the Forecast years by re-phasing on other schemes and possibly by the use of internal labour.

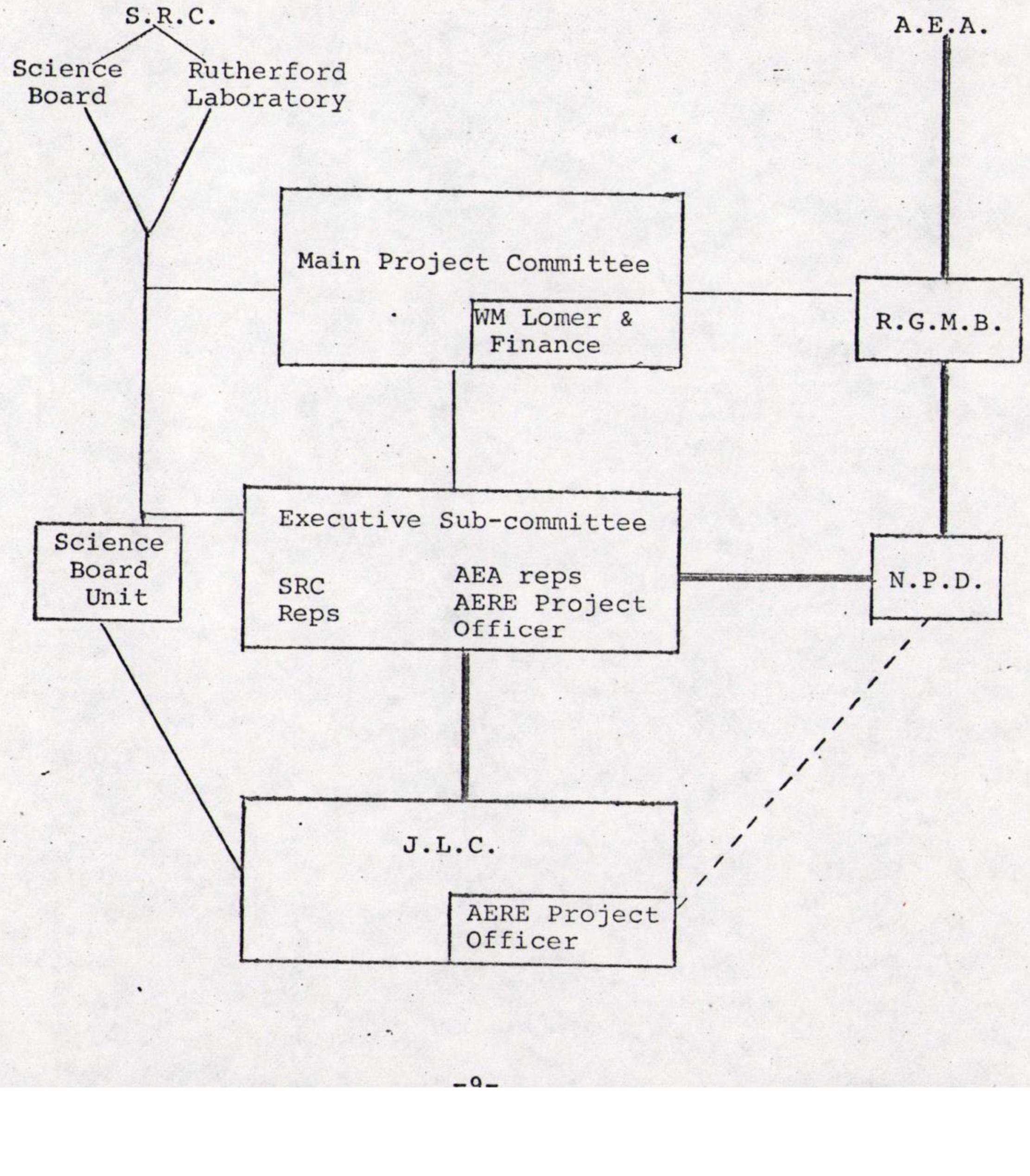
≠ To cover the aggregated uncertainties which arise from the possibilities of currency fluctuations and technical variations between the order of cost and tender calculation stages an additional contingency is included in this AEA submission. The contingency level shown within the Part 1 total is that used by the SRC.

Appendix I

Management Organisation

Joint Committees will have balanced SRC and AEA representation, and a joint Secretariat provided by Harwell and the Rutherford Laboratory. We note in the appropriate boxes in the chart below only those officers essential to financial control of the project. On the AEA side heavy lines indicate the executive financial control line of command, light lines advisory and general guidance, and dashed lines the normal flow of Divisional overhead support.

When the scientific programme is discussed the Main Project Committee will be enlarged by, e.g. Culham and University representation, and a Security Sub-committee with MoD representation, inserted into the AEA line of command.



Appendix II

THE JOINT LASER CENTRE FACILITIES

Glass Lasers

1. It is proposed to provide two Nd Glass Lasers, each capable of achieving power densities of greater than 10^{15} watts cm^{-2} on targets. An intermediate energy laser would deliver $>2.5 \times 10^{15}$ watts cm^{-2} to a plane target 64 μm diameter: the compression laser would have two beams and irradiate a 100 μm diameter sphere with a power density of $>4.5 \times 10^{15}$ watts cm^{-2}. These high power densities will be required to initiate the scientific programmes.

2. The purpose of the lasers is to achieve a high power density accurately delivered on target in a controlled way. Both spatial and temporal structure of the beam are important: as well as being focussed on the target, the energy must be delivered in accordance with a chosen time dependent law. Since temporal modulation is necessary it is unlikely that pulse durations much less than 100 ps can be handled. The power density in the final amplifying elements of the laser is limited by material damage considerations to ~ 5 GW cm^{-2}. This then defines the size of each laser, the maximum energy being determined from the target requirement, i.e. for the flat target the requirement is

$$\geqslant (2.5 \times 10^{15} \text{ watts/cm}^2) \times (3.22 \times 10^{-5} \text{cm}^2)$$
$$\geqslant 80 \text{ GW} \geqslant 8 \text{ joules in 100 psec}$$

and for spherical targets

$$\geqslant (4.5 \times 10^{15} \text{ watts/cm}^2) \times (3.15 \times 10^{5} \text{ cm}^2)$$
$$\geqslant 1.4 \text{ TW} \geqslant 140 \text{ joules in 100 ps}$$

These two lasers will be identified for future discussion as the 100 GW and 1.5 TW lasers.

3. Since focussing of the beam into a small spot is a most important requirement of both lasers it is important to maintain beam quality. Beam quality can be degraded by obvious optical defects in the design such as uncorrected aberrations and inhomogeneous or poor quality glass components. Experience in high power laser laboratories has shown that these defects can be controlled so that they make a negligible contribution to image quality deterioration: however, as yet, the non-linear effects in the laser cannot be eliminated.

4. The refractive index of a medium is more correctly represented by an expression of the form $n = n_o + n_2 E^2$ where n_o is the normal linear refractive index and $n_2 E^2$ is the non-linear index dependent on the square of the electric field in the radiation. The refractive index of the medium is thus intensity dependent and any intensity fluctuations present in the beam result in uncorrectable refractive effects which lead to beam quality degradation. The total non-linearity introduced as the beam traverses the medium is a product of n_2, E^2 (or I) and the length traversed (I = beam intensity in GW cm^{-2}).

5. The overall performance of the laser as a generator of high quality beam can be characterised by the integral $B = k\int_0^{\ell} n_2 I dl$. This integral must be minimised in order to control the uncorrectable beam divergence. As B is allowed to increase, non-linear effects in the glass increase until the beam may suffer self-focussing, leading to massive damage to the laser glass. It is intended that the glass lasers that are the subject of this proposal will have laser B integrals chosen to ensure that 90% of the output power in the collimated beam will be contained in a cone with a full angle of 1 milliradian. These lasers are characterised by a very short total glass length distributed in large diameter components operating at high gain.

6. The laser amplifiers will be operated in the linear regime of amplification so that distortion of the temporally shaped driving pulse is minimised. After the passage of the 100 ps transient the amplifier glass still contains a large fraction of its original stored energy: for this reason, the laser must be protected against target reflections. The reflected pulse could be propagated back through the laser with high gain until early stages of the laser are destroyed. The designs incorporate Faraday rotator isolators to protect against 30% retro-reflected intensity at the targets.

<u>1.5 TW Laser</u>

7. The 1.5 TW laser design can be considered in three parts.

(a) the oscillator and pulse shaping section. A YAG oscillator produces a short ~30 ps pulse which is the basic building brick from which the output pulse is synthesised by delaying and summing techniques. This section of the laser also contains preamplifiers to generate an output energy of ~100 millijoules.

(b) Lower power amplifier section. In this section, glass rod amplifiers are used to increase the energy to ~10 joules. Amplifiers of increasing diameter are used to maintain an approximately constant power density.

(c) High power section. For power levels >150 GW, disk amplifiers using established technology would be used. The laser would be split into two beams in this section each of which would be separately amplified and focussed on to the target. The beam diameter in each branch after the final amplifier would be 140 mm giving a power density of ~5 GW cm^{-2} as the final components.

(d) The proposed design of the 1.5 TW laser is conservative and uses established technology and components throughout. A major consideration in the design is that the laser could be uprated by adding more beams or larger diameter disk amplifiers to achieve energies in excess of 1 kJ, in 300 psec or less, without significant loss of beam quality.

100 GW Laser

8. It is intended that the 100 GW laser should broadly follow the specification of the first two sections of the 1.5 TW laser. No pulse stacking would be used: the YAG oscillator would generate a single pulse ~100 ps in length. The precise duration of the pulse would be controlled in the range 30-500 ps by the use of inter-cavity etalons. Rod amplifiers would be used up to a maximum diameter of 64 mm or perhaps 80 mm, the output energy would be ~10 joules at 100 ps, and again, as in the 1.5 TW laser, 90% of this energy would be in a 1 mradian full angle cone. The 100 GW laser could be used as an alternative driver stage for the main two channel disk amplifiers.

9. This laser is a necessary part of the central facility, where, in addition to its use as a stand alone interaction facility, it would be used for component testing, diagnostic development, calibration and as a driver stage in any new high power amplifier development programmes.

Electron Beam System

10. An important part of the work of the centre will be in the area of basic research into new lasers. An essential tool in this field is the electron beam generator. The e-beam would be used to trigger chemical lasers (e.g. HF) or to excite quasi-molecular lasers (e.g. Xe-Ar, Xe-Ne), high power CO_2 and gas excimers (eg Xe_2^*, $K_{r^2}^*$). It is proposed to provide an electron beam generator capable of delivering a 30 ns, 100 KA pulse of 1 MeV electrons. The electrons would pass through a thin foil into the laser chamber. Matching lines and laser chambers would be easily interchangeable and engineered to meet the requirements of specific proposals.

Extension of Facilities

11. It was originally proposed to provide a CO_2 laser of approximately 500 GW power but the state of laser interaction physics research in the world at the present time suggests it is inappropriate to make a firm commitment at this stage to provide a CO_2 laser in the central facilities. Development of Iodine, HF, or other new lasers may well make one of these the right choice and it is possible that during Part II of the period covered by this paper we may decide that at the next stage of the project the glass lasers should be complemented or replaced by one of these alternative systems.

Experimental Equipment

12. In addition to the lasers, the centre must be provided with comprehensive sets of diagnostic and experimental instrumentation. In Table I the principal items are identified and cost estimates are given. The equipment is listed under six headings:

Laser Diagnostics

This category covers equipment that in principally concerned with monitoring the performance of the laser. Pulse shapes are measured by fast photo-diodes, power after each stage of amplification by calorimeters and pulse duration by two-photon fluorescence cameras. This information provides the control room with important data related to the laser's pulse to pulse repeatability and the behaviour of individual stages of amplification.

Input Beam Diagnostics

This equipment is provided to monitor the beam from the oscillator preamplifier at the input to the power amplifier. The power amplifier gain characteristic is expected to be linear: the quality of the final 1.5 TW beams is almost wholly dependent on the quality of the preamplifier output.

Alignment

Visible light and 1.06 μ CW YAG lasers will be used for alignment of the main chain. In a laser of this complexity, daily alignment checks will be necessary and hence alignment equipment is permanently built into the system. Normal high precision surveying instruments will also be used for initial alignment of components and target systems.

Optical Hardware

Beam splitters, mirrors and lenses will be used to pick up sample fractions of the laser beam for diagnostic purposes. These will be held on magnetic clamp stands with micrometer adjustment. It is anticipated that monitoring arrangements will change and flexibility of operation demands that a good stock of the various components is held. This category is not to be confused with the principal optical components that form part of the main laser chain.

Instrumentation

Nearly all the signals arising from monitors on the laser and target region are fast transients that must be observed directly on cathode ray oscilloscopes or indirectly via fast digitisers and D to A convertors. Some signals where peak values only are important may be dealt with digitally in the main laser data logger. Numbers of slow ~100 MHz, fast ~ 1 GHz and storage oscilloscopes have been estimated.

Target Area

The greatest concentration of instrumentation occurs in the target area. It is proposed to install a comprehensive array of monitoring and diagnostic equipment to monitor radiation and particles produced in the laser-matter interactions, to monitor the properties of the compressed plasma and to make observations of scattered and reflected incident radiation. Remote controlled micromanipulators will be will be used to position the targets which will be viewed by high magnification TV systems using 1.06 μ CW YAG illumination.

It is in this area that the needs of individual experimenters will most modify the configuration of the equipment. The list presented in Table I is intended to represent basic essential requirements. Specific additional requirements will be met from the running operational budget.

TABLE I to Appendix II

Experimental Equipment	Cost in £000
Laser Diagnostics	
Photo-diodes	
Calorimeters	
Streak camera	
Two-photon fluorescence cameras (TPF)	
Spectrometers	
Beam profile cameras	56
Input Beam Diagnostics	
Far field camera with vidicon readout	
Near field camera	
Pulse shape real time digitiser	
Energy monitor (calorimeter)	
Streak camera	
Spectrometer	
TPF camera	90
Alignment	
Argon ion laser	
CW YAG laser	
HeNe lasers	
Auto-collimators	45
Optical Hardware	
Mirrors	
Lenses	
Stands	
Beam splitters	
Alignment targets	55
Instrumentation (oscilloscopes etc)	
Slow CROs	
Gigahertz CROs	
Storage CROs	
Real time digitisers	70
Target Area	
Target chamber and vacuum system	
Focussing optics	
Target alignment monitors and manipulators	
Neutron detectors	
X-ray detectors	
X-ray crystal spectrometers	
Normal incidence spectrometer	

continued

Target Area (contd)	Cost in £000
Pulsed laser interferometry	
Scattered light grating spectrometer	
Ion collectors	
Ion spectrometers	
Data handling computer	
X-ray streak camera	
Visible streak camera	
UV spectrometer (grazing incidence)	
Screened rooms	
Cabling	240
Total:	556

TABLE II to Appendix II

Estimate of Laser Building Requirements

		Area in m²
Laser 1	100 GW Nd glass	120
Laser 2	1.5 TW	560
	Target	90
	Data acquisition	30
	Control room	30
	Capacitors	60
Laser 3	CO_2, I, HF	200
	Target room	20
Laser 4	e-beam	160
Laboratory support		300
		1570
Offices, conference rooms etc.		1400
	Total building area	2970 m²