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LPI CONSOLIDATION PROGRAMME

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After two and half years of running-in and operation, a consolidation programme is necessary to make from the LPI complex a reliable injector in the LEP injector chain.

It mainly consists of expensive capital investments which cannot be covered by the exploitation budget :

- modernisation of the LIL front end (Appendix 1)
- equippment of the LPI key elements with spares (Appendices 2, 4, 5 and 6)
- complement of the high-frequency instrumentation for beam observation (Appendix 3).
- improvement of the short circuiting system of the PS 114 MHz cavity (Appendix 7)
- installation of a 3 GHz high power test stand (Appendix 8)

A method to repair the leaking LIL sections is presently under test. The corresponding cost is not included. In fact, if the repair of the whole sections can be realized by the CERN Central Workshop, it should not be too expensive and could be covered by the exploitation budget.

The requested project spending profile spread over three years is given in Table 1. Three of the eight main programme lines have already been started this year due to the urgency of the consolidation programme and in anticipation of a project proposal.

- front-end of LIL
- spare LIL accelerating section
- instrumentation

<u>Distribution</u>
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APPENDIX 1

THE FRONT-END OF LIL

1. Introduction

Contract No 590 289/ISR-LEP "Supply of equipment for the experimental front-end of an electron linear accelerator" was agreed upon with Thomson GCR-MEV on 25.01.1980. The total cost was 1.5 MFS (1980).

Equipment concerned:

i) an e^- gun and its modulator

ii) the pre-buncher, the buncher and the associated focusing coils

The final acceptance tests on the front-end took place in July 1982 at LAL, Orsay.

Following a number of improvements, the "experimental" front-end was considered suitable for use during the commissioning of LIL. The beam performance of the front-end turned out to be adequate to achieve the nominal beam performance of LIL.

A number of problems were encountered with regard to the exploitation of the front-end equipment. At present, the interface with the controls system is still missing.

This proposal concerns:

i) A complete rebuilt of the e^- gun modulator, a reconstruction of the area between the e^- gun outlet and the prebuncher.

ii) A spare solution for the prebuncher, buncher and associated solenoids.

2. Modernisation of the e^- gun modulator and its outlet

The exploitation of the modulators is hampered by the lack of standardisation and modularity of the equipment. Consequently, maintainability of the equipment is poor. For the modernisation of the e^- gun modulator we will use commercially available power supplies interfaced to standard PS--controls hardware. Data transmission to and from the HV platform will be via fiber optical links. Another modernisation concerns the shielded enclosure of the modulator and its interlock key-systems. Finally, two operational e^- gun modulator assemblies will be constructed.

The area between the gun anode and the prebuncher (on-axis about 20 cm) is crowded; it contains three water-cooled solenoids, a beam intensity monitor and two moving mechanisms (vacuum valve and a beam stopper/ diaphragm). Repairs in this area are time consuming as was experienced recently when a current feed cable of a solenoid was burnt out. The area will be reconstructed.

3. <u>The prebuncher, buncher and associated solenoids</u>

The equipment used to bunch the beam from the e^- gun and to accelerate it to relativistic velocities is clearly indispensable for the operation of LIL and thus of LEP.

Possible risks with the standing wave structure of the buncher: air--vacuum leaks, as encountered on other LIL accelerating sections, can not be excluded. Repairs in situ may be feasible but difficult due to access constraints.

The in house manufacture of a spare for the present buncher and solenoids is possible but not easy as not all execution drawings required are available. Hence, a spare system should be bought from industry.

4. <u>Summary and Cost Estimate</u>

4.1 Reconstruction of the gun modulator and construction of a complete spare unit:

power supplies	100 kFS
interfaces	90 "
optical links	60 "
amplifier	20 "
shielded enclosure and HV checks	90
Subtotal	360 kFS

4.2 Reconstruction of the area between the gun anode and the prebuncher:

solenoids, vacuum chamber, other mechanical work 50 kFS

4.3 Prebuncher, buncher and solenoids

Spare of existing equipment	600 kFS
Total	1010 kFS

APPENDIX 2

A SPARE FOR THE FIRST ACCELERATING SECTION OF LIL-W (ACS25)

1. Introduction

We have installed sixteen LIL accelerating sections, and only one spare section is available.

The dipoles and/or quadrupoles mounted on fourteen sections can be dismounted relatively quickly, and if one of these sections has to be replaced by the spare one, then we need about four days (including opening/closing of the shielding walls to get access to the exchange operation.

The situation is different for the two first sections of LIL-W which are equipped with large solenoids and dipoles. To remove the solenoids, the r.f. connecting waveguide to the coupler and the end flange must be taken off and the numerous connections must be undone. For the whole operation, we will require about two months, according to Mr. Dabin from LAL (Laboratoire de l'Accélérateur Linéaire at Orsay) who was in charge of the mounting of the sections. Even if we shorten this time by extending the hours worked per week, this exchange operation will still last several weeks.

Interrupting a LEP run for such a long period is considered to be inadmissible and for this reason it is proposed to purchase one spare section equiped with solenoids and dipoles.

2. Probability of a breakdown requiring a section exchange

Over the past two years air-vacuum leaks appeared on the end plate of six sections. The repair was done in-situ either by welding (three) or by sealing-off with a varnish (three). The repair by welding involves a certain risk and the duration is many hours, possibly days. The radiation level 40 cm from the end plate of the first LIL-W sections after a 24 hours' machine stop is at present approx. 100 mrem/hr but will increase in the future.

Moreover, there is the risk of other faults which might require a section exchange, i.e. leak on one of the cooling pipes which are brazed on the accelerating structure, a burn-out of some of the solenoids and, of course the not-thought-of event.

Being concerned by the frequent repairs to be done on the sections we were lead to propose to purchase a spare section for ACS25.

3. Section components and cost estimates

3.1 Section with solenoids

- accelerating structure		250 kFS
- envelope		20 "
- support, stainless		30 "
- end plates, connection		20 "
- ion pumps		10 "
- assembly, transports		100 "
	Subtotal	430 kFS

3.2 Solenoids and dipoles

- 18 solenoids		150 kFS
- dipoles		20 "
- assembly, connections		50 "
	Subtotal	220 kFS
	Total	650 kFS

APPENDIX 3

INSTRUMENTATION

1. Introduction

The LPI construction budget included the purchase of rack-mounted and thus for the routine running required instruments only. As the general PS exploitation budget left no margins, the LPI machines are poorly equiped in instrumentation for exploitation and beam observation.

Furthermore, from the experience obtained with the LPI commissioning, we concluded that instrumentation for beam and equipment observation has to be enlarged. As an example: we still have no instrumentation to compare the phase of the LIL beam pulse with the one on the r.f. reference line. Such a measurement is needed for the ongoing investigation on the source of the LIL energy variations.

Instruments costing around 10 kFs or less are in general purchased with exploitation funds.

2. Instruments and estimated cost

2.1 Observation of beam signals

fast scope Tek. 7104		70 kFS
digital scope		20 "
console Gould storage scope 2 x		80 "
transient digitizer		80 "
	Subtotal	250 kFS

2.2 Observation of 3 GHz signals and networks

network analyser		75 kFS
digital scope		20 "
3 GHz burst generator and freq. counter		45 "
	Subtotal	140 kFS
	Total	390 kFs

APPENDIX 4

SPARES FOR THE LIL RF SYSTEMS

1. Introduction

The high-power r.f. distribution networks consist of waveguide sections (straight and bents) and different components: power splitters, measurement couplers, windows, variable phase shifters and attenuators, vacuum pumping ports, r.f. loads, a special high-power isolator and one r.f. switch. Only the strict minimum of spares has been purchased for all items with an expected indefinite life time, such as power splitters (11 splitters installed, 1 spare). The spare situation for items of limited life time such as windows is better but the frequent interruptions of the vacuum in the waveguides (repair of sections) shortens this life time.

A spare modulator-klystron assembly is under construction in the LIL klystron gallery. Network components must however be provided to permit connecting the klystron to components we would like to test as, for example, the spare LIPS or the spare accelerating section.

Spares for all other systems, i.e. the r.f. reference line with its drive power amplifier, the phasing systems, the r.f.-level detection, will all be charged on the LP-exploitation budget.

2. Components for the high-power networks

It is proposed to purchase all components for constructing a network permitting the testing of a spare LIPS and the spare section. Furthermore, we want to double the spares for the "indefinite life time" items and to purchase replacements for the high-power (35 Mw) r.f. windows which have been exposed to air more than three times (the manufacturer does not guarantee the operation of the window above this figure).

For the power isolator in the network feeding the bunching system no spare is available. This isolator has caused quite some problems in the past; the r.f. loads overheated which resulted in a serious pollution of the network. After replacing them with loads with much higher power rating no problems were encountered. Nevertheless, if this isolator breaks down (ferrites cracked or other causes) LIL will be out of action.

3. A deflecting structure for LIL-V

The structure serves to measure the micro-bunch phase distribution and to trim the tail in the phase distribution.

The structure installed was borrowed via LAL from LURE, Orsay and must be given back. Although this structure is not indispensable for the production of nominal beams for LEP, not replacing it would mean that the bunch length in LIL can no longer be measured. Given that this is one of the basic parameters which has to be observed when optimizing the buncher, we propose to construct a copy of the present structure.

4. Summary and cost estimate

4.1	Components for the high-power networks:	
	windows, loads, power splitters, couplers, waveguide sections	200 KFS
	isolator	100 kFS
4.2	Deflecting structure	50 kFS
	Total	350 kFS

APPENDIX 5

HIGH-POWER 3 GHZ RF

1. Introduction

The LIL modulator-klystron assembly (MDK97) presently under construction in the klystron gallery will serve in emergency situations as a source of spare parts for the six operation modulator-klystrons and be used to test new parts. In order to conserve the high availability of tested spares ready-to go-in, it is proposed to purchase another klystron tank, fully equiped. We would then have for each of the two types of tanks (Thomson and Valvo) one ready with its klystron in the gallery.

A number of improvements on the modulators are being implemented and when finished should render the equipment more reliable. However, long term problems may appear and effects like that of the ambient temperature on the voltage stability remain to be investigated. The environmental conditions in the klystron gallery are not suited for research on equipment. It is proposed to construct a modulator test station in hall 174. The building blocks of this modulator can in emergency cases be used as spares for LIL.

2. Summary and cost estimates

2.1	Additional klystron tank fully equiped	100 kFS
2.2	Modulator test station	400 kFS
	Total	500 kFS

APPENDIX 6

THE E^-/E^+ CONVERTER: UPGRADING AND COMPLETING SPARES

1. Introduction

The converter was designed following the principles developed by DESY in Hamburg. However, as LPI has to switch rapidly and regularly from the e^+ to the e^- mode and vice versa, the moving mechanism is of a more sophisticated design. Experience with this mechanism has been satisfactory and it only blocked once during operation.

2. The small focusing solenoid

The small solenoid mounted just behind the tungsten target causes some concern. The nominal peak excitation current for the solenoid - 5 kA - has not been used as above about 4 kA the windings are vibrating. Above all we want to avoid a crack in the solenoid as it takes time to recover from water entering the accelerating sections. (In 1987, due to an interlock error, a solenoid burned out resulting in a flooding.) The e^+ yield per impinging e^- on the target depends on magnetic fields created by the solenoid and therefore operation at nominal current is desirable. With one pulsed power supply available the research on the solenoid is slowly progressing. It is proposed to construct a spare power supply which can then be used for tests outside the klystron gallery, a laboratory will have to be installed.

3. Handling the converter

The radiation level at a distance of 40 cm from the end plate of the first LIL-W section, thus next to the converter, after a machine stop of 24 hrs. amounts presently to approx. 100 mrem/hr. but will increase in the future.

Quick dismounting and remounting of the converter target, the small solenoid or the entire converter assembly, should be possible. Certain modifications must be made to achieve this objective.

4. Summary and cost estimates

4.1 Focusing solenoid all including:

solenoid development	20 kFS
pulsed power supply	150 kFS
laboratory equipment	50 kFS
Subtotal	220 kFS
4.2 Handling: modifications	100 kFS
Total	320 kFS

APPENDIX 7

IMPROVEMENT PROJECT FOR THE SHORT-CIRCUITING SYSTEM OF THE 114 MHZ CAVITY

R. Garoby

1. Introduction

The present 114 MHz system installed in the PS has been able to provide SPS and LEP with above nominal lepton beams, in the summer 88. The voltage developped in the cavity during lepton acceleration is up to the specifications, and the parasitic cavity resonances are properly damped.

But, during proton acceleration cycles, 2 short-circuiting arms have to be moved in, to reduce the impedance seen by the beam, and many problems have been experienced with that system (damaged contacts, vacuum leaks, mechanical drifts). Its reliability is clearly not yet up to the necessary standard. On top of that, the impedance at the lowest resonance, when the short-circuit is established, is still of 20 Kohms, which might explain some of the instabilities experienced at high beam intensities.

A work program is proposed, which consists of :

- building a test bench where arms could be easily tested under vacuum, while moving.
- improving the equipments controling the arm movement.
- modifying some of the high order mode dampers, to damp further the resonance of the short-circuited cavity.

2. Summary and cost estimates

Test bench construction and setting-up	50 kFS
Dampers and arm control system modification	50 kFS
Total	100 kFS

APPENDIX 8

GENERAL INSTALLATION OF THE 3 GHZ HIGH-POWER TEST STAND

1. Introduction

The facility will permit to test with beam a modernized electron gun, a spare bunching system, a spare accelerating section and the associate rf equipment at high power. For reasons of economy, we intend to make use of the already existing high-power RF source at LIL and therefore the test stand will be accommodated along side the LIL building. In addition, the test stand could also be used as a CLIC Injector Test Facility. (CTF) whose proposal is described in the CLIC Note 65.

The staff working on LIL consolidation, maintenance and improvement could thus also work on CTF. The expertise and skill gained through the participation in CTF will have a positive impact on the availability and performance of LIL.

2. Cost estimates

2.1 The blockhouse (shielding blocks are free)	150 kFS
Connection LIL-CTF	70 kFS
Sub-Total civil engineering	220 kFS
2.2 Utilities : water, electricity, compressed air, smoke detection, cabling, etc..	60 kFS
2.3 Air conditioning of blockhouse.	80 kFS
2.4 Access (no remote control) and radiation monitoring	40 kFS
Total	400 kFS

TABLE 1 (ESTIMATED YEARLY PAYMENTS)

LPI CONSOLIDATION

	'89	'90	'91	Total
<u>Front-end of LIL</u>				
Gun : modernisation and spare	210	200		410
Spare bunching system V	50	250	300	600
<u>Spare LIL accelerating section (ACS 25)</u>				
Section	240	190		430
Solenoides, dipoles	150	70		220
<u>Instrumentations</u>				
Observation of nsec beam signals	100	90	60	250
Observation of 3GHz and networks	70	70		140
<u>Spares for the LIL RF systems</u>				
Network components	100	100		200
Isolator		100		100
Deflecting structure		50		50
<u>High-power 3GHz RF</u>				
Spare klystron tank	100			100
Modulator test station	100	200	100	400
<u>The e^-/e^+ converter</u>				
Spare pulse power supply	50	100		150
Coils	20	50		70
Handling facilities	50	50		100
<u>PS 114 MHz cavity</u>	50	50		100
<u>Installation of the 3 GHz high-power test stand</u>	400			400
Total in kFS	1690	1570	460	3720