PS/LP Note 92-10
16. 3. 1992

Activity Programme of Klystron and Modulators Section Production and Leptons Group (LP)

P. Pearce

M. Guillon

G. McMonagle

G. Rentier

G. Curri

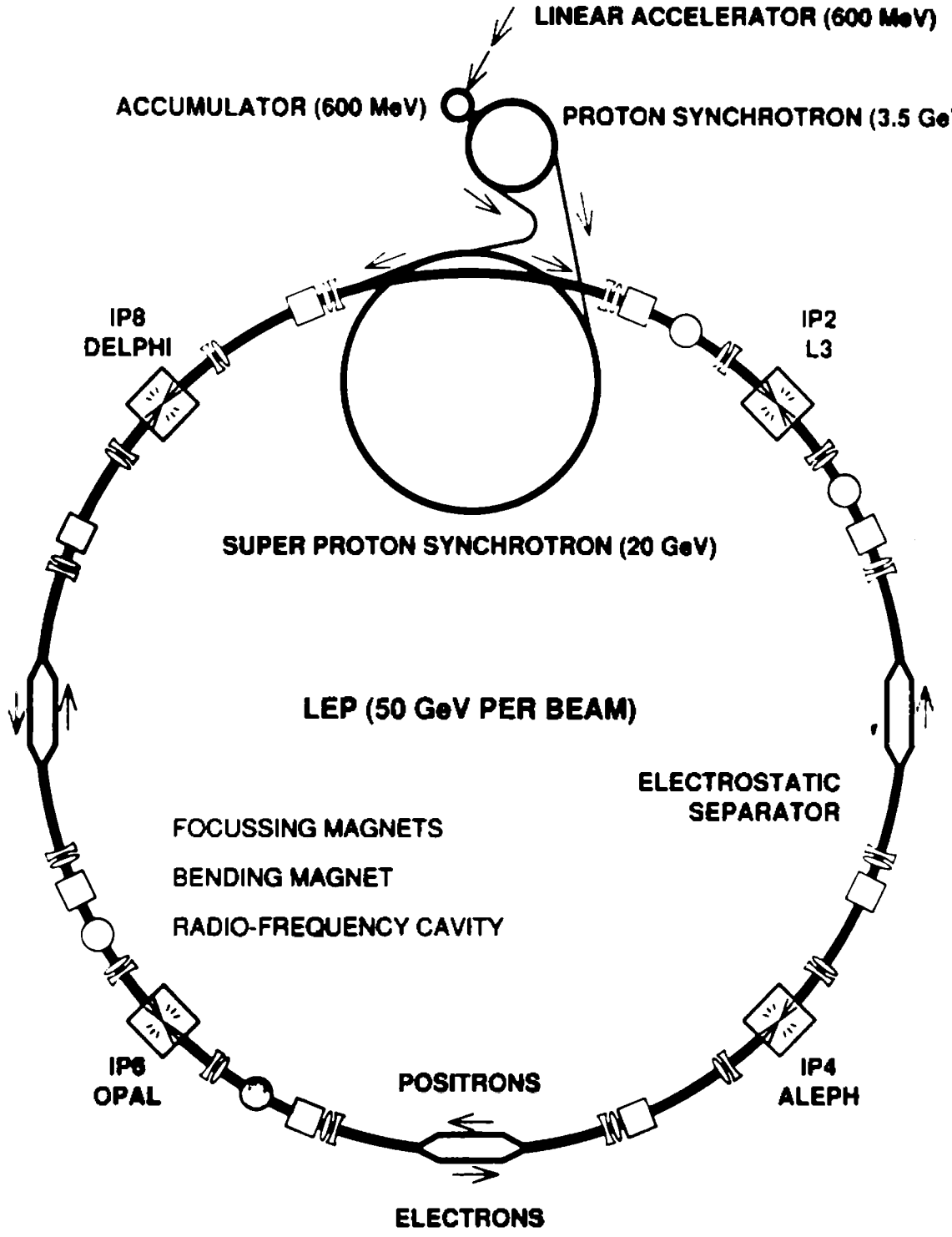
Transparencies presented
at the LP Group Meeting

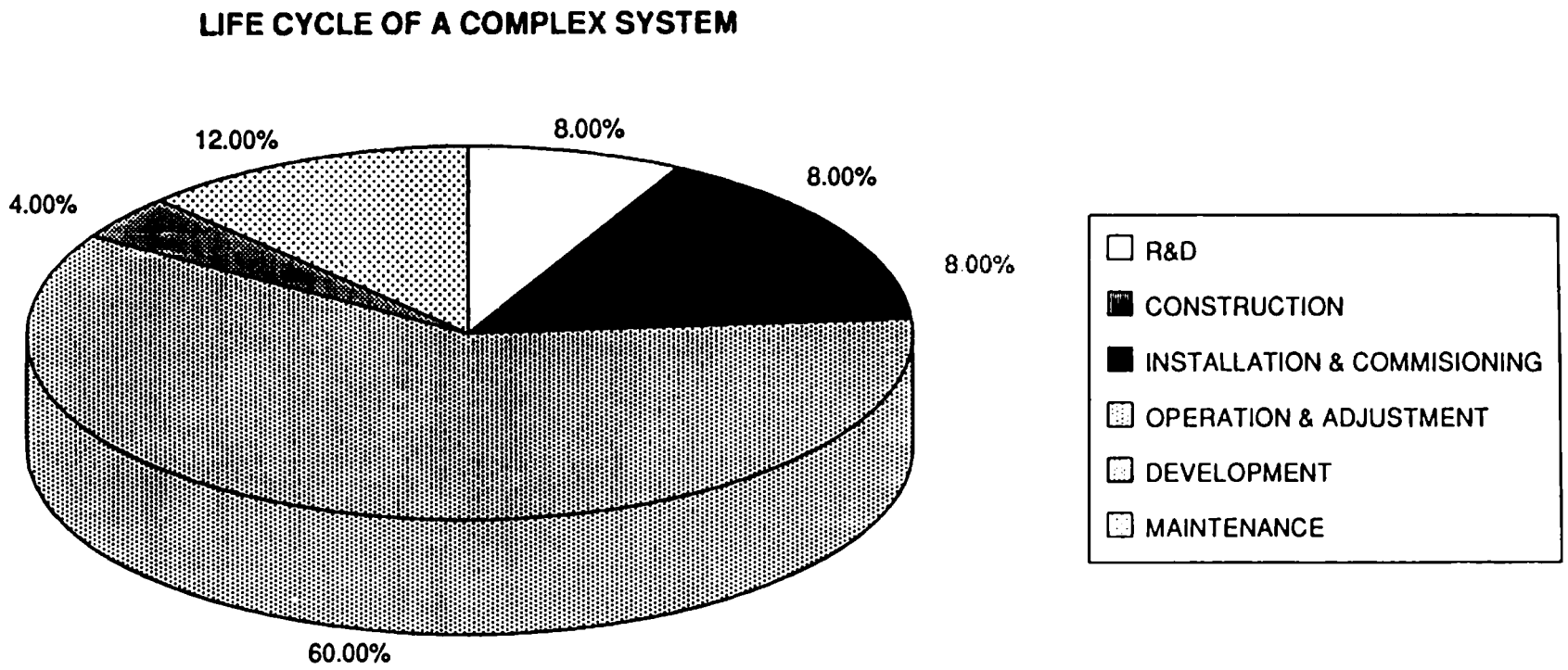
Distribution:

LP Group

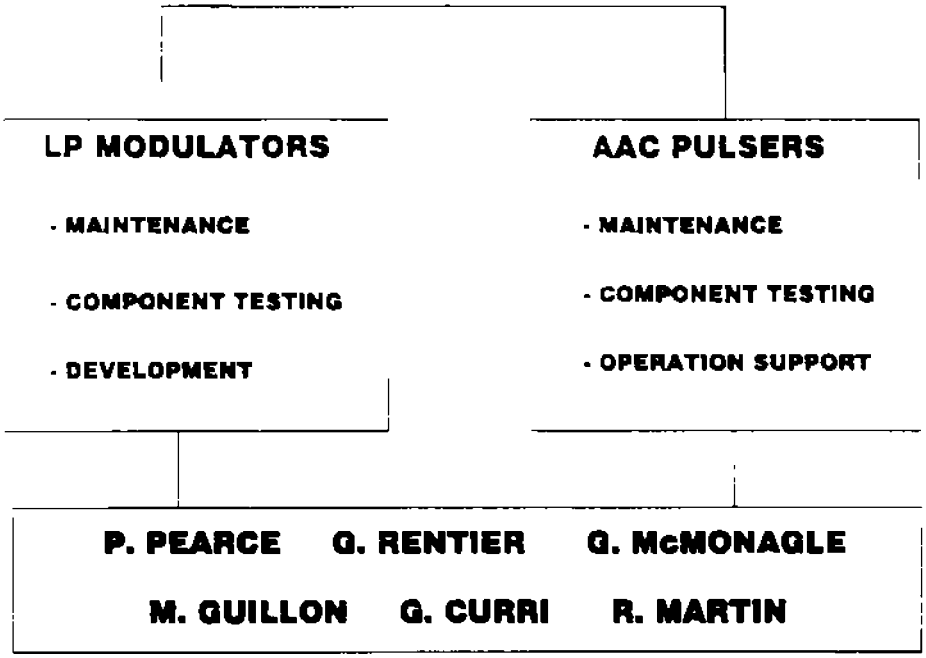
X857-11-85

THE LEP COMPLEX

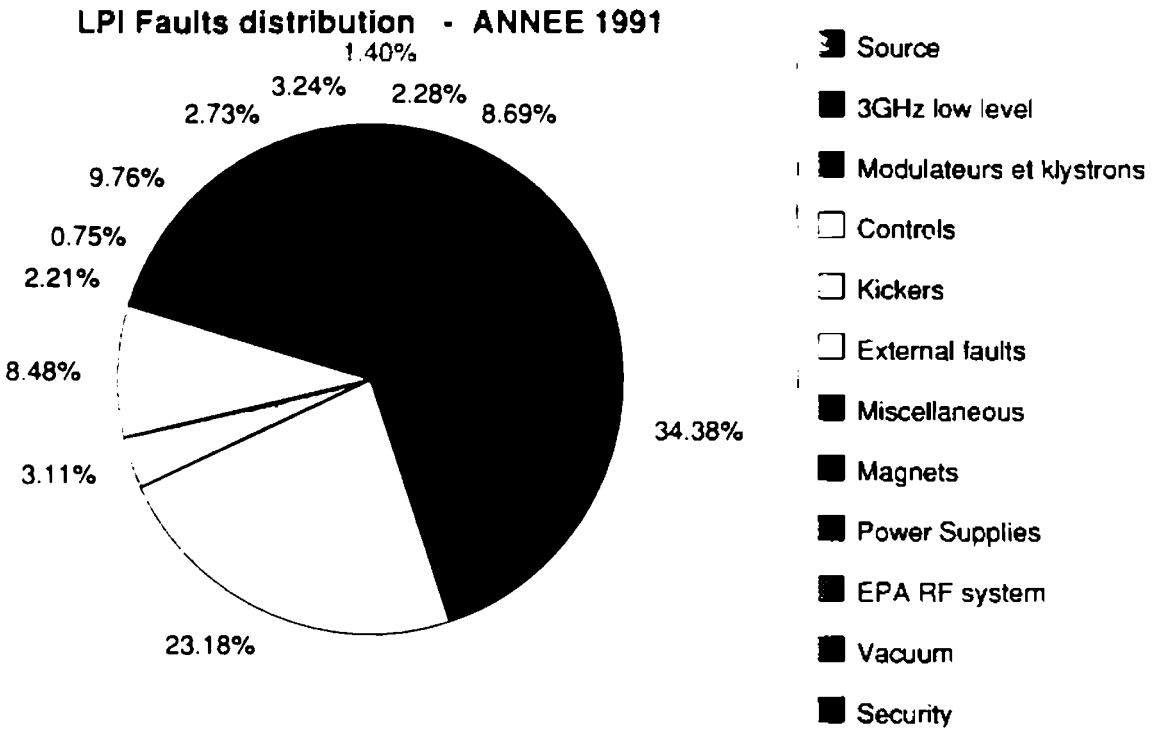


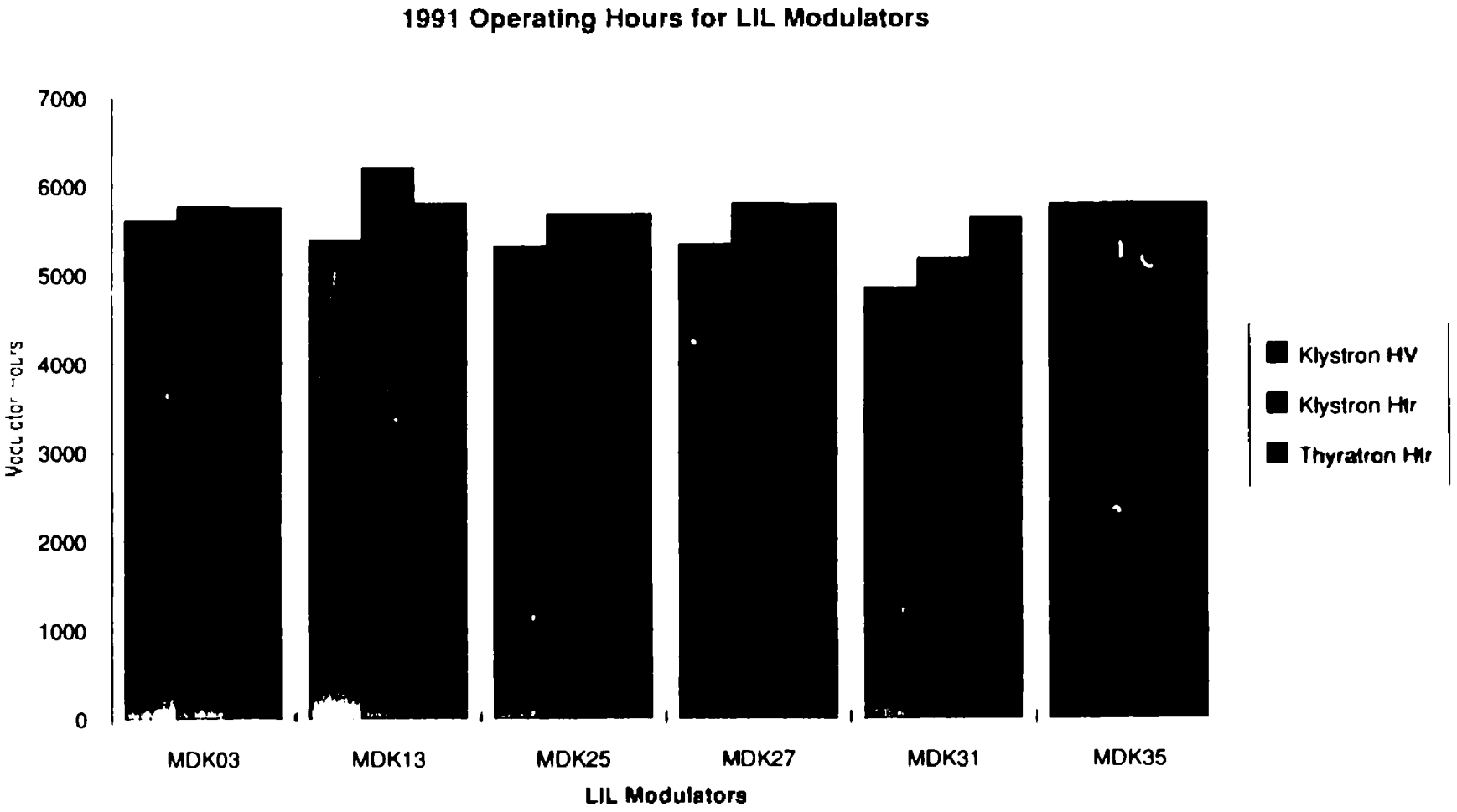

LIFE CYCLE OF A COMPLEX SYSTEM
12.00%
8.00%
8.00%
4.00%
8.00%
60.00%
R&D
CONSTRUCTION
INSTALLATION & COMMISIONING
OPERATION & ADJUSTMENT
DEVELOPMENT
MAINTENANCE

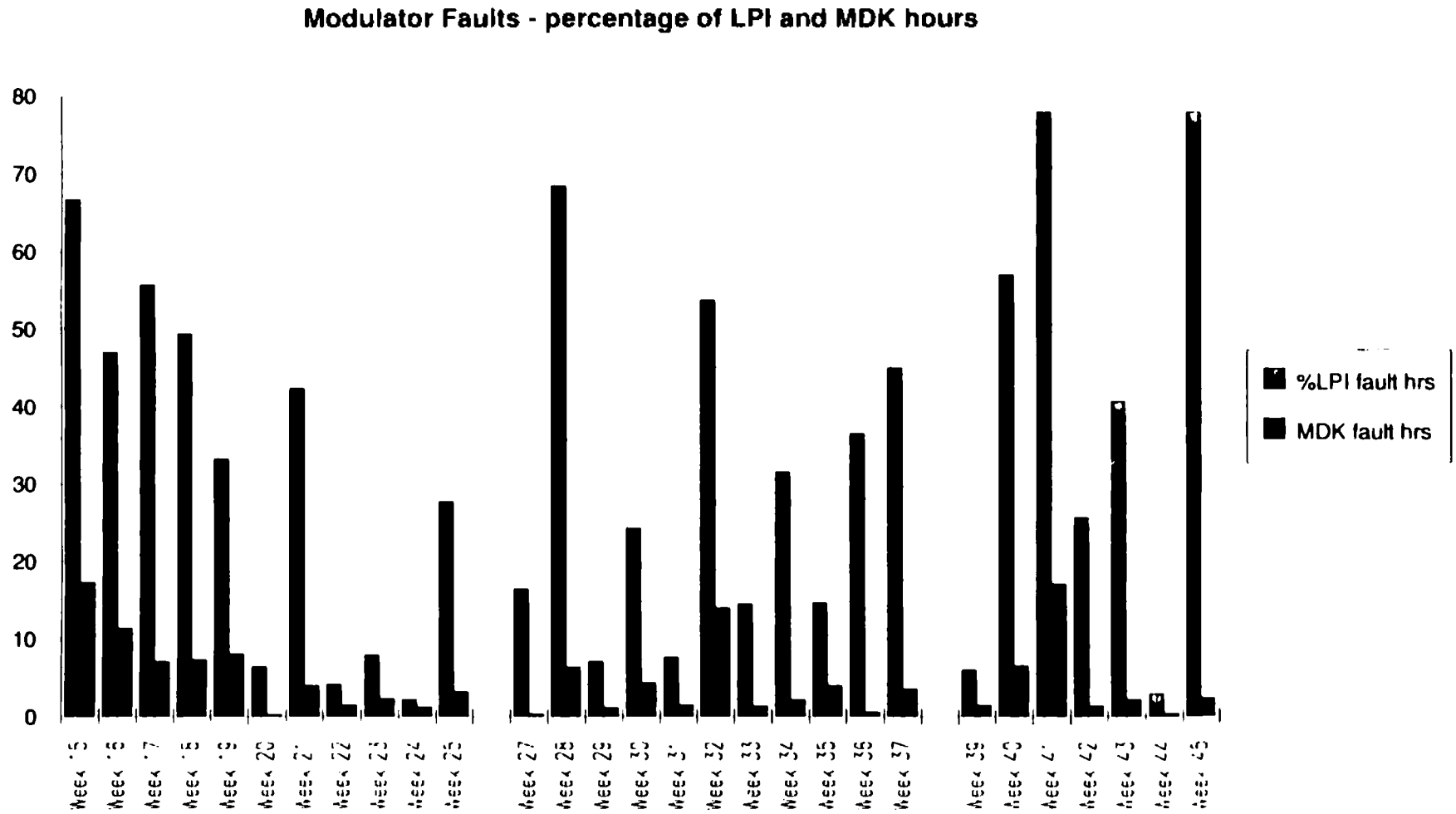
KLYSTRON MODULATOR-PULSER SECTION

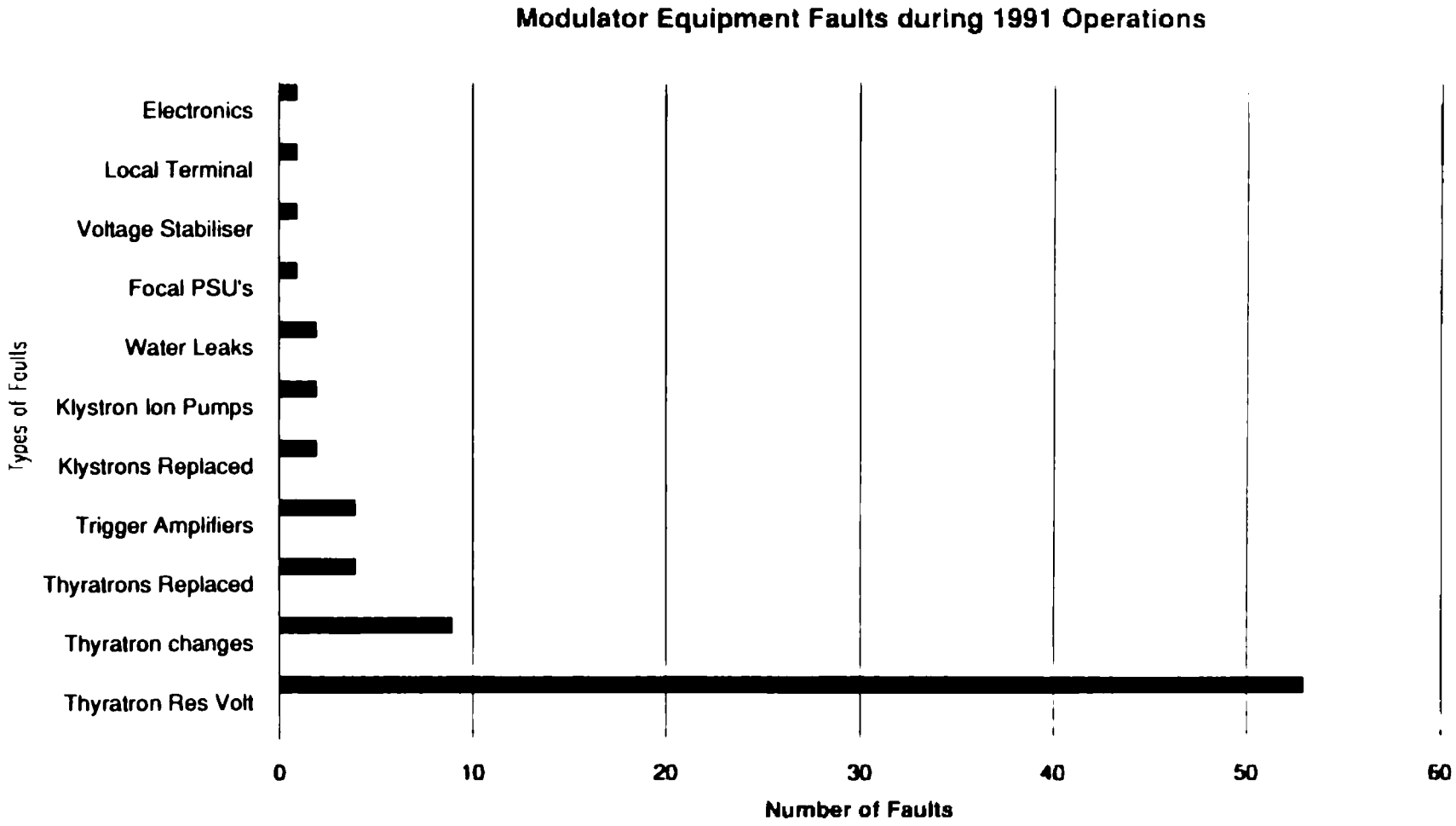


	LP MODULATORS	AAC PULSERS	MDK Elect/Mech	AAC Elect/Mech
P. PEARCE	●	●	●	●
G. RENTIER	●		●	
G. McMONAGLE	●	●		●
M. GUILLON			●	●
G. CURRI			●	●
R. MARTIN		●		


LPI Faults distribution - ANNEE 1991
1.40%
3.24%
2.28%
2.73%
8.69%
9.76%
0.75%
2.21%
8.48%
34.38%
3.11%
23.18%
Source
3GHz low level
Modulateurs et klystrons
Controls
Kickers
External faults
Miscellaneous
Magnets
Power Supplies
EPA RF system
Vacuum
Security


1991 Operating Hours for LIL Modulators
7000
6000
5000
4000
3000
2000
1000
0
MDK03
MDK13
MDK25
MDK27
MDK31
MDK35
LIL Modulators
Klystron HV
Klystron Htr
Thyratron Htr


Modulator Faults - percentage of LPI and MDK hours
80
70
60
50
40
30
20
10
0
%LPI fault hrs
MDK fault hrs


Modulator Equipment Faults during 1991 Operations
Types of Faults
Electronics
Local Terminal
Voltage Stabiliser
Focal PSU's
Water Leaks
Klystron Ion Pumps
Klystrons Replaced
Trigger Amplifiers
Thyratrons Replaced
Thyratron changes
Thyratron Res Volt
0
10
20
30
40
50
60
Number of Faults

LP MODULATOR WORK achieved in 1991

1. Maintain the klystron modulators during 5500 hours operation including MDK97 for the CTF.
2. Test and install klystrons and thyratrons into modulators.
3. Design and test a new Peak Power reading system.
4. Design and test interlock memorisation modifications.
5. Install klystron heater economy mode operation.

6. The moving of MDK35 collaboration.

7. Klystron waveguide elbow investigation and action.
8. Building a complete spare Valvo klystron tank.

9. Manufacture and implantation of MDK29 (test modulator).
10. Organised a 2 day klystron modulator workshop.
11. Analysis of modulator fault data to guide improvements.
12. Take over responsibility for AAC pulser operations.

1.3 Yearly work checklist

The following tests should be made on a yearly basis to enable a "trouble free" operation during the rest of the year. These checks will not cure equipment faults, but will ensure that the known failure areas are looked at regularly and preventive maintenance can be used to avoid major problems.

- CHECKLIST

Clean the Faraday cage, Thyratron and PFN assemblies.

Inspect the HV filter for burnt end contacts and/or resistors.

Inspect the HV Triaxial plug/socket for contact burning etc.

Take a sample of the Diala B oil and get it measured from each tank.

Empty each tank and clean, and inspect all connections/components.

Re – adjust pulse shape, working in diode mode at operational voltage.

Re – calculate klystron voltage to check calibration/scaling factor.

Check the klystron current calibration from CT signal.

Check the trip levels and timing of all dynamic interlocks.

Make a final power test into waterload or machine cavity loads.

Check the security RF protection system at each modulator.

Check the tightness of all 3 phase busbar connections(PO group).

After all maintenance and setting up has been completed the following data must be taken and entered into each modulators log book.

- Waveform photos with amplitude and timebase scales.
- Modulator operating parameters screen photo.
- Klystron/Thyratron hours run data.
- RF output power level from HP peak power meter.
- Calculate and note the klystron perveance.

INSTALLATION TEST OF KLYSTRON

(P_{in})	(P_{out})	Gain
30 W	3.6 MW	50.8 dB
100	9.2	49.6
150	12.1	49.0
200	14.2	48.5
250	15.9	48.0
310	17.4	47.5
350	18.3	47.2
400	18.9	46.7
450	19.3	46.3
500	19.7	46.0

Thomson TH2094 SN°94009

- 48 HOURS OF PULSING IN DIODE MODE UP TO 270 KV WITH CORRECT FOCAL CURRENTS.
- 48 HOURS OF TEST WITH RF INTO WATERLOAD WITH 220 KV, 240 KV AND 260 KV

FOCAL POWER SUPPLIES

Ripple Peak to peak = 0.3%

HISTORY

(a) TESTED VEL124 13/12/89 OK
(b) RECEIVED CERN 5/08/91
(c) TEST FOR SEALING 15/10/91 AND AFTERWARDS, FOUND OUT OF SPECIFICATION — WITH NO ABNORMAL OPERATION BEING MADE.

① VELIZY — INPUT = 180 W
OUTPUT = 24.7 MW
GAIN = 51.4 dB
240 KV $V_{KLYSTRON}$

② CERN — INPUT > 500 W
OUTPUT ≃ 20 MW
GAIN ≃ 46 dB
240 KV $V_{KLYSTRON}$

VSWR (TOS) Measured at Klystron input
(a) PULSING = 2% (10 W REFL. WITH 500 W INCID.) (b) NOT PULSING ≃ 30%

MDK 97 PARAMETERS

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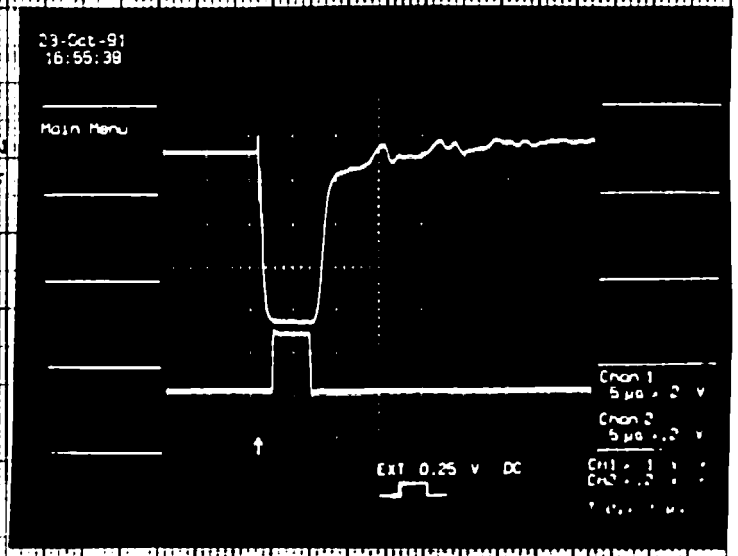
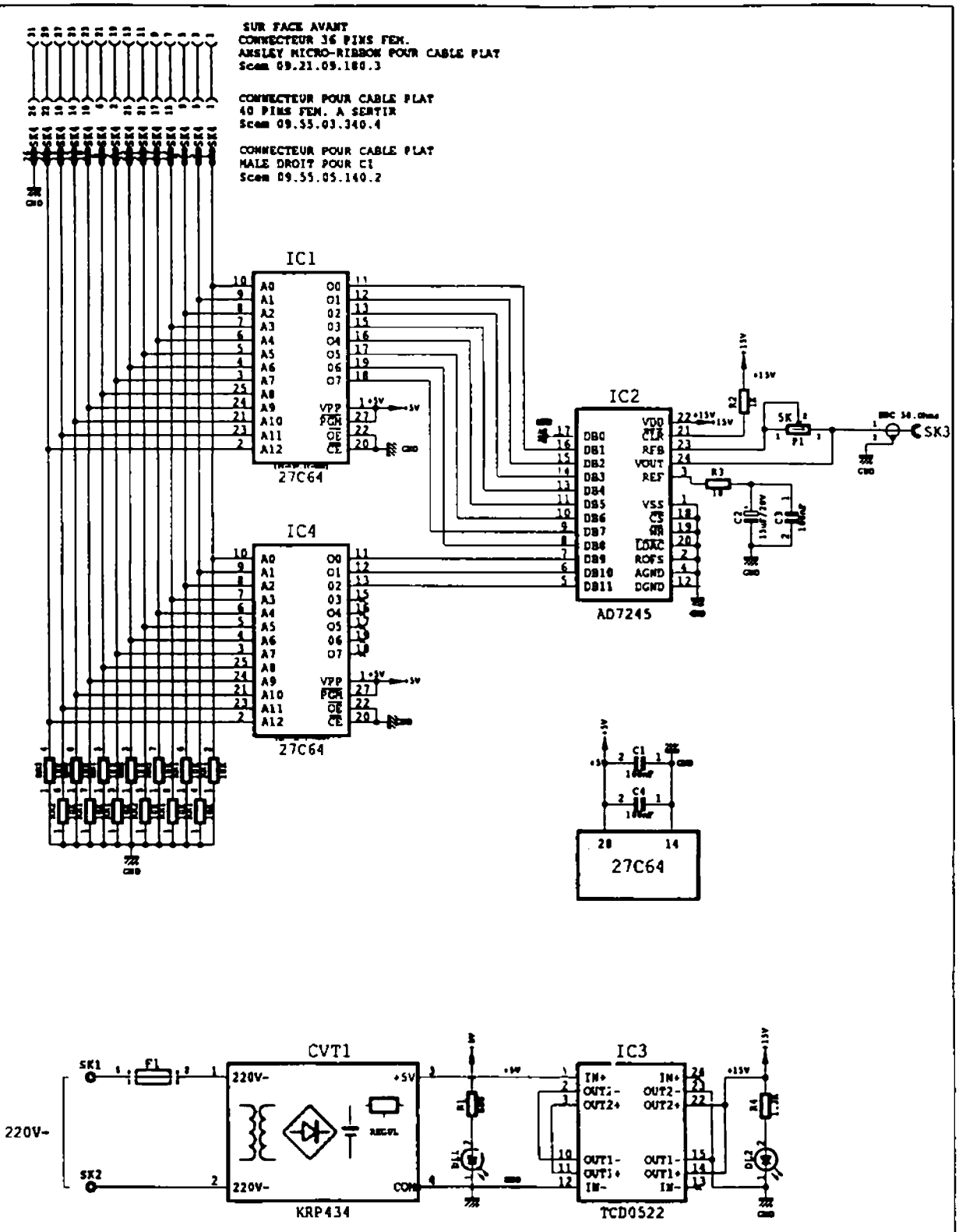
KLY BODY WATER IN TEMP	28.7 oC	THYR. RESERVE VOLTAGE	4.75 V
KL BODY WATER OUT TEMP	21.8 oC	THYR. RESERVE CURRENT	14.7 A
KLY TANK TEMPERATURE	30.9 oC	THYR. RESERVE POWER	68.4 W
SPARE		THYR. KEEP ALIVE VOLT	22.5 V
SPARE		THYR. KEEP ALIVE CUR	375 mA
SPARE		SPARE	
KLY FOCAL. A CURRENT	171.2 A	SPARE	
KLY FOCAL. B CURRENT	169.1 A	SPARE	
KLY FOCAL. C CURRENT	175.1 A	SPARE	
SPARE		SPARE	
KLY HEATER VOLTAGE	24.34 V	SPARE	
KLY HEATER CURRENT	22.5 A	SPARE	
KLY HEATER POWER	528 W	KLY. RF FORWARD POWER	4895.6MW
SPARE		PFN REF. VOLTAGE	33.8KV
PREMAGN CURRENT	16.8 A	KLYSTRON VOLTAGE	237 KV
KLY ION PUMP VOLTAGE	3.4kV	KLYSTRON CURRENT	238 A
KLY VACUUM PRESSURE	BE-9 Torr		
THYR. HEATER VOLTAGE	6.38 V		
THYR. HEATER CURRENT	65.8 A		
THYR. HEATER POWER	411 W		



24/10/91 PPearce

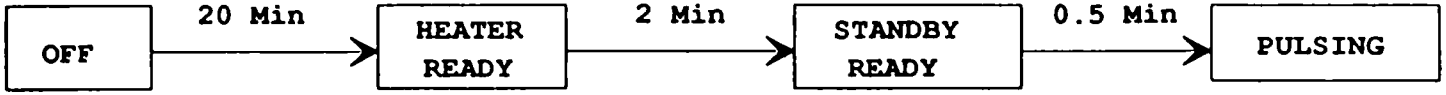


LIL7EL 1098 CONVERTER 12 BITS BCD-DA	RESP: RENTIER	32-80	
	DRAW: CEGELEC JMW	25-57	25-09-91
1098P J14836	JOB : J11836		
CONVERTER 12 BITS BCD - DA	MODA: Cegelec C.JL	2557	5/11/91
	MODB		
	MODC		

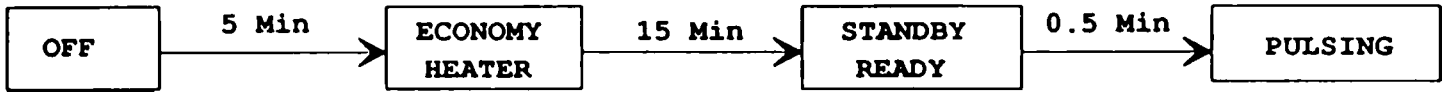
CERN-PS	LIL7EL 1098/2	4	b

Klystron Economy Mode Operation

OLD CYCLE



NEW CYCLE



This was originally tried out with both Klystrons and Thyratrons. Reducing Thyratron heater voltage destabilises its operation and therefore we do not gain lifetime but only problems.

AR PULSERS

DESCRIPTION

Repetition rate for all pulsers is 2.4 or 4.8 secs

1. 20mm Lithium Lens power supply B.195------> TARGET ZONE
   Stored energy 17.5 kJ peak primary current 21.7 kAmps
   Time to peak 260 uSecs
   Peak current in lens 500 kAmps Capacitor voltage 5 kV

2. 20mm Lithium Lens test power supply B.195 -> TEST ZONE B.195
   (specification as above)

3. Magnetic Horn power supply B.195-------> TARGET ZONE
   stored energy 18 kJ peak current in horn 400kAmps time to peak 20 uSecs. Capacitor voltage 5 kV

4. 34mm Lithium Lens power supply B.195 -> B.195---->TARGET ZONE or TEST ZONE. Available stored energy 200 kJ, peak lens current 1 M amp, peak primary current 40 kamps. Time to peak 1 mSec. Possibility of producing 1.5 M amps in lens but, lens failed at 1.3 M amps

5. Plasma lens/ 400 kAmp horn pulser B.174 -> B.174 TEST ZONE
   available stored energy 83 kJ peak current in horn 400 kAmps time to peak 15 uSecs. Capacitor voltage 7 kV. Pinch current in plasma lens400K amps peak currnet in lens 480 kAmps. Time to pinch current10 uSecs. Capacitor voltage 13 kV.

LP MODULATOR WORK for 1992

1. Commissioning and using MDK29 for testing LIPS, Klystrons, Thyratrons and Electronics.
2. Follow up recommendations from Klystron-Modulator Workshop (see list).
3. Test the new spare Valvo klystron tank.

4. Klystron acceptance testing at manufacturers.

5. Test and evaluate an EEV replacement thyratron in a modulator (MDK29).
6. Complete the design and making of a klystron tank that accepts both Valvo and Thomson tubes
7. Look at possibilities for a separate RF gun modulator in the CTF.
8. Complete the new thyratron Trigger Amplifier design and make tests with it.
9. Test out and manufacture the 100Hz internal timing modification for MDKs.
10. Develop test software, controls and measurement procedures for use with MDK29.
11. Maintain and adjust regularly LP modulators.

12. Maintain and run the AAC pulsers (see list).

Klystron Modulator

Workshop Comments and Recommendation List

1. Interlock data recording by computer for intermittent faults over a period of time.

2. Review Thyratron reservoir tracking method.

3. Compare interlock system philosophy to SLAC's

4. Replace Klystrons and Thyratrons more often to reduce downtime due to worn out tubes.

5. The Test modulator is a key to maintaining reliable equipment operations.

6. Test and condition all spare and repaired parts thoroughly for 48 hours.

7. Oil quality to be tested regularly and tanks fitted with silica-gel breathers with air sealing.

8. Improve control rack screening and eliminate spurious tripping on electrical noise.

9. Prompt repair and testing of faulty equipment.

10. Continue to collect and analyse tube data to aid decision taking for klystron/thyratron changing.

pdp/mdk

KLYSTRON AND THYRATRON TUBE LIFETIMES

KLYSTRONS: Thomson TH2094 (Cost 130KFrs)
Valvo YK1600 (Cost 165KFrs)

- 2 Thomson and 2 Valvo tubes have been replaced so far

- 1Thomson tube is due to be replaced in the shutdown

- The lifetimes obtained from those replaced have been

  between 13000 and 18000 heater hours.

An analysis done last year, and repeated this year with the latest data shows that we need to replace klystrons at a rate of between 2 and 3 tubes per year based on the figure of 18000 hours per year.

This can be done by purchasing new klystrons, or getting the old ones repaired. The repair is economically done only once in practice. This has longterm financial implications on the group budget.

The ratio of prices for purchase or repair from our two suppliers is quite wide!

(new) VALVO/THOMSON = 127%
(repair) VALVO/THOMSON = 147%

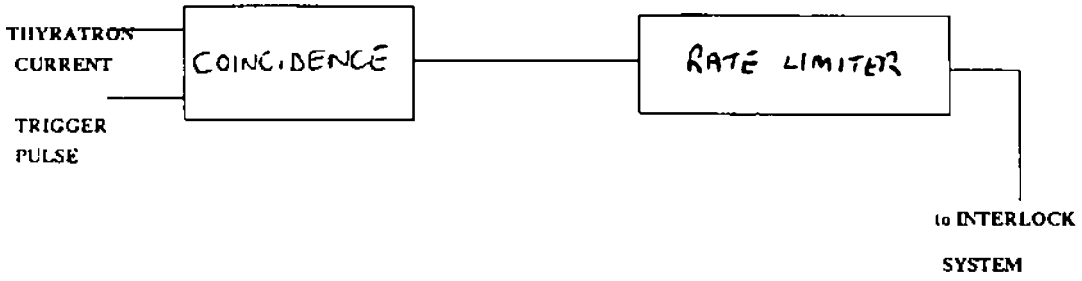
THYRATRONS: ITT type KU275C (Cost per tube 16KFrs)

All tubes have been replaced at least once. The lifetimes obtained vary between 16000 and 20000 heater hours. Repair seems to be difficult when dealing with ITT (USA). A European manufacturer will soon offer the same tube!

The replacement rate (new tubes) will be about the same as klystrons since the hours run and observed lifetimes are comparable.
That is 2 or 3 new tubes per year.

INTERLOCKS - MONITORING - OIL

Faulty shot detection:
To detect the coincidence of
Thyratron current and trigger pulse



The present system looks at amplitudes but one channel could be modified for coincidence detection (Fault 1)

Voltage monitoring.

The 30,000:1 cap. divider should be made lower in ratio to give more precision and better S/N ratio. It can be made 10,000:1 and use a small 3:1 divider to provide the electronic signals for the interlocks.

OIL in Klystron tanks.
All tanks to be fitted with silica-gel breathersand making semi vacuum tight. We should be able to live with oil of 30kV rms (lowest in Sept 1991)

TANKS.
We have 1 spare Thomson tank complete with focal coils (waiting for a klystron)..

We also have the new Valvo tank with coils and has a newklystron(needs testing)

There is a test tank, it will need focal coils

START UP SITUATION FOR THE KLYSTRONS AND THYRATRONS

6 March 1992

Modulator	Klystron Type	Klystron Htr hours	Thyratron S No.	Thyratron Htr hours
MDK 03	V/006	20,416	2353	1207
MDK 13	V/003	9674	2354	217
MDK 25	T/009	0	2355	602
MDK 27	T/008	15,934		
MDK 31	V/007	0	2347	12,664
MDK 35	T/007	872	2356	2842
MDK 97	V/005	21,129	2176	20,571
MDK 29	V/008	0		

	KLYSTRONS	THYRATRONS
Spare Tubes	2 Valvo, 1 Thomson	3
In Repair	2 Thomson	0
New-On Order	1 (2) Valvo, 1 Thomson	0