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MONITORING OF FAST TIMING OF LIL

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The tolerances on the timing in LPI have been evaluated (ref.1) and it was shown that the following resolution for the timing settings relative to the RF of EPA are required

Gun	1 ns	
Bunchers	500 ns	
Pulsed solenoid	800 ns	positron operation
	3 ns	electron operation
RF (no LIPS)	120 ns	RF on pulse
RF (LIPS)	10 ns	RF on,phase jump
Inj.kickers	3 ns	

During the running-in with electrons we can operate with 1kA instead of 6kA in the pulsed solenoid (SNP25). Then the timing resolution can be relaxed from 3 ns to 24 ns still providing a 1% resolution in pulsed solenoid field.

In order to check the timing it was proposed to monitor key signals via independent cables (ref.2). It was suggested to use cables of the same electrical length between the signal source and the monitoring point in EB1 so that the sequence of signals available in the control room is a true picture of the sequence of events occurring in LIL.

This concept of timing monitoring is used at DESY and at LAL. Its application to LIL has been recommended (ref.3,4). The different possibilities and their cost implications are reconsidered in this note in view of the stringent timing requirements and our desire to hand over to the heavily loaded PS operations crew a "transparent" machine which can be easily adjusted and where mistiming can quickly be diagnosed.

Table 1 gives all key points to be monitored: one WCM at the beginning of each linac and the WL.WCM 37 preceding the injection kickers as beam references; the voltage applied to the klystrons by the modulators (MDK); the RF signals as discussed with J.C.Bourdon and P.Brunet; the injection kickers because intimately related to the linac timing.

The signals arrive via cables at the patch panels RA022 (WCMs) and RA023 (all others) in EB1 just behind the console where the delays can be adjusted via the computer system. The signals can be observed on a scope which is triggered by one of the standard delay units well in advance of injection into EPA. It may be possible to use a digital "stop-watch" later on for this purpose once more experience has been gained.

The RF signals are taken from the incident wave couplers. The cable length is given from the couplers to "boite C" (C) via "boite A" (A) and from C to RA023 in EB1. Nomenclature:

BV	buncher V
BW	buncher W
Section	input coupler of first section seen by beam of all sections fed by one RF station
Kl.in	klystron input
Kl.out	klystron output

Fig.1 shows were these couplers are in the RF networks.

As suggested by D.Grier the kickers are monitored by looking at the sum signal of the two terminating resistances which are contained in one kicker. If the two kicker modules forming the kicker are out of synchronism, the sum signal deteriorates discernibly providing therefore also the check of synchronism.

Note all the signals are also available to the operator via the SOS system but which unfortunately does not have a sufficient time resolution.

We now look at the different scenarios determining each time cable length and cost. Table 1 gives the detailes lengths, Table 2 the cable parameters and Table 3 the total lengths and the cost estimate.

Scenario 0 (cf.column lmin)

All cables minimum length, only 1 cable from C to EB1. Difficult trouble shooting because incomplete information to operator on RF in EB1.

Scenario 1 (cf.column l1)

Cable lengths the same for all signals of a given RF station so that pulse pattern can be monitored on a scope in the klystron gallery. Still tedious to relate to beam because simultaneous observation in the gallery and in the control room needed.

Scenario 2 (cf.column l2)

All signals are available in EB1 and all cable lengths in LIL are the same. The cables of the kickers are still non-standard.

Scenario 3 (cf.column l3)

All cable lengths are the same and all signals are available in EB1.

Since the cost for the scenario 3, which has all the desirable features, is modest, the decision was made to implement the system according to scenario 3 (ref.5).

As there is only one output at the modulator indicating the klystron voltage, I.Kamber proposes that the cables from these outputs to the SOS village in EB1 are interrupted at the patch panel RA023 in EB1, where a high impedance probe can be connected for observation. Later, buffer amplifiers may be added there.

Although the cable length given in Table 1 are sufficiently precise for the cost estimate, they must not be taken as the real lengths as input for the cabling. In order to get these lengths right, a practical procedure is being worked out with V.Glaus. The cables for the WCMs are already laid. The unknown cable lengths from the WCMs to RA041 in EB1 must be measured with the reflectometer so that the short cable linking RA041 and RA022 can be replaced by a cable of appropriate length.

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References

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4) J.C.Bourdon, P.Brunet, E.Plouviez, LAL PI 84-44/T (1984)

P.Brunet, priv.comm. (Oct.1985)

5) LIL-RF meeting, 30.10.85

Table 1, Length and cost of timing monitoring cables
length in m, , cost in sfr

Signal source	Path of cable	l_{min}	l_1	l_2	l_3	Cable type
VL. WCM 11	→ EB1	90	90	120	120	B
	Cable delay (ns)	367	367	490	490	
MDK 03	MDK → EB1	69	97	97	97	C
RF 03	BV → C	9	35	35	35	D
	BW → C	35	35	35	35	D
	Kl.in → C	6	35	35	35	D
	Kl.out → C	10	35	35	35	D
	C → EB1	69	69	4 × 69	4 × 69	C
	Cable delay (ns)	~~unequal~~	490	490	490	
MDK 13	MDK → EB1	64	79	97	97	C
RF 13	Section → A → C	19	19	19	19	A
	Kl.in → C	18	19	19	19	D
	Kl.out → C	18	19	19	19	D
	C → EB1	64	64	3 × 82	3 × 82	C
	Cable delay (ns)	~~unequal~~	400	490	490	
WL. WCM 221	→ EB1	60	60	120	120	B
	Cable delay (ns)	245	245	490	490	
WL. SNP 25	→ EB1	36	36	97	97	C
	Cable delay (ns)	182	182	490	490	
MDK 25	MDK → EB1	79	94	97	97	C
RF 25	Section → C	18	18	18	18	A
	Kl.in → C	6	18	18	18	D
	C → EB1	79	79	2 × 88	2 × 88	C
	Cable delay (ns)	unequal	475	490	490	

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Table 2, Cable parameters

Type	Cable	Cost/m	Installed/m cost	β
A	Suhner SA 17272	7,26	9,46	0,816
B	Suhner SA 12272	2,41	4,61	0,816
C	RG 214	1,75	3,95	0,66
D	Suhner SA 07272	1,43	3,63	0,816
Connectors of cable Type C 18,88/cable				

Table 3, Cost		Scenario			
		ℓ_{min}	ℓ_1	ℓ_2	ℓ_3
length type A		89	89	89	89
length type B		253	253	343	360
length type C		1128	1229	2354	2422
length type D		136	282	282	282
Total length		1606	1853	3068	3153
# of cables C		17	17	28	28
Cost cable	A	842	842	842	842
	B	1166	1166	1581	1660
	C	4456	4855	9298	9567
	D	494	1024	1024	1024
Connectors of cables C		321	321	528	528
Total cost		7279	8208	13273	13620
Cost difference		0	975	6040	6387

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