CERN/SI/Int. BR/72-6
9.10.1972

THE PSB BEAM LOSS MONITOR SYSTEM

R. Stubbs

GENERAL

The Beam Loss Monitor (BLM) system was required for real time observation of beam losses at the 800 MeV PSB. Basically it was considered simplest to locate radiation detectors at various parts of the machine and transfer line. The fact that the PSB has four rings complicated the matter as it would have been not really possible to monitor every beam at all the desired points. Consequently, for the machine, one detector per two rings at all interesting positions was considered a satisfactory compromise, the detectors being mounted symmetrically between rings one and two, and three and four.

Requirements for such a detector were versatility, simplicity, low price (due to large number) and a reasonable bandwidth (~ 50 MHz). Because of the two detectors per position around the machine, it was thought an advantage to be able to observe any two at a time. Then, taking into account the various positions on the machine and transfer line where beam loss might occur. Also the fact that two selectors would be needed (i.e. a system for routing the high voltage and signal output from the MCR to only the detector under observation and hence saving the need for continuous powering of all BLM's), a system comprising 45 BLM's combined with two parallel selectors of 48 channels each, was decided upon.

DETECTOR

The type of detector chosen was similar to that used by Awschalon et al.(1), consisting of a photomultiplier in a can of liquid scintillator. The scintillator used here was NE 224 because of its sensitivity of γ-rays and fast neutrons, and its high light output relative to other liquid scintillators. The photomultiplier selected was the RCA 931A, its "squirrel cage" construction rendering it more insensitive to magnetic fields than other types, and also for its cheapness and ease of availability. Fig. 1 shows a cross-section of one such detector (the cost per detector is estimated at ~ 80 Sw.Fr.).

In its can the photomultiplier is adequately cooled by the surrounding liquid. The supply voltage is of negative polarity with a maximum value of 1250 volts, when the current drawn is ~ 5 mA. This is the maximum possible when considering heat dissipation and safety factors.

Tests at the PS using a secondary emission monitor as a comparison indicated that the BLM was considerably more sensitive and would probably not have to be operated at voltages much above 500 - 600(2). Consequently, the type of photomultiplier dynode chain was decided so as to give the greatest linear dynamic range, despite a small loss in overall gain.

Fig. (2) shows two curves of tube gain as a function of anode voltage, from which the normal type of power law relationship is seen to hold. Gain variation for different tubes at the same voltage is no higher than ~ 15%, however by adjustment of the voltage a total gain variation of $> 10^4$ can easily be achieved.

MOUNTING

The mounting of a BLM at the Booster is achieved by suspending it by a metal arm bolted to the machine. The design of the arm was so as to allow versatility in fixing to almost anywhere on the machine. Along the transfer line where such a support would have been abnormally long or cumbersome, vertical stands are used.

SIGNAL SELECTOR

The signal and high voltage selectors are divided into three units, each unit housing both selectors for sixteen monitors. The signal selector had to have a bandwidth comparable to that of the 500 metres of cable between each detector and the MCR (~ 7.5 db at 50 MHz :- ~ 100 m RG214 + ~ 400 m 3/8" "Flexwell"). Hence a "relay tree" construction was adopted using miniature reed relays. Each signal selector unit consists of two parallel trees (for the two signal paths) in the form 16 → 4 and 4 → 1 with each output from one selector going into a further 3 → 1 selector (separate chassis), and hence to the MCR. The overall performance of the signal selector is 2.5 db at 50 MHz (Fig. 3). It is therefore the cabling that limits the useful bandwidth.

HIGH VOLTAGE SELECTOR

The high voltage selector is a considerably simpler structure housed in the same unit as the signal one. It comprises a double bank of high voltage reed relays switching onto any one monitor, power from one or other of the high voltage supplies.

CONTROLS

Complete control of the system is gained from the MCR where the two continuously variable high voltage supplies are located, along with the control unit and signal outputs. By means of the two Contraves (chain A and chain B) any two of the 45 detectors can be observed simultaneously (if the same two are selected logic negates the command, in order to stop one power supply trying to drive the other, and an error signal is given). The gains of the two detectors so chosen can then be controlled by the high voltage supplies. The signal system is of 50 Ω impedance terminated in the MCR.

PERFORMANCE

Performance tests using radiation losses at the PSB have shown that the system behaves certainly as well as expected. However, as also expected for very high losses and high signal gain, distortions can occur. Although the onset of such distortions is easily noticeable and they appear to follow a pattern consistant with space charge effects in the photomultipliers, care is necessary to ensure that observations are not unintentionally made in this region.

During the initial stages of the "running-in" of the Booster, the monitors proved themselves very useful in enabling the discovery and correcting of timing errors, etc., especially at injection. In this connection, the high bandwidth was at a premium. Fig. 4 shows such a case; observations were being made in the injection line and the losses show very clearly the effects of the 3 MHz chopper superimposed on the slow chopper. Also, at ejection, the coherent bunch to bunch oscillations between bunches and their incoherent oscillations within the bunches can be observed in the losses on the septum.

A list of the positions of the detectors on the PSB corresponding to their MCR selector number is given in Table 1.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the help given by R. Guerin in the construction and testing of the system and to L. Petty for his assistance in the mounting of the monitors.

REFERENCES

(1) Awschalon, M. et al. TM-274, 1105-12, Oct. 70.

(2) Agoritzas, V. et al. "Beam Loss Detector Tests" MD of 18.11.71.

TABLE 1

List of BLMs and Position on Booster

One BLM covers rings (1 + 2) and another , rings (3 + 4) for each position.
Unless otherwise stated detector is mounted at the upstream end of position shown.

DETECTER No.	POSITION			DETECTOR No.	POSITION.		
1	1 L 1	(1+2)		25	9 L 1	(3+4)	DOWN STREAM
2	I K S	(1+2)		26	10 L 1	(3+4)	
3	3 L 1	(1+2)		27	11 L 1	(3+4)	
4	4 L 1	(1+2)		28	12 L 1	(3+4)	
5	5 L 1	(1+2)		29	13 L 1	(3+4)	
6	6 L 1	(1+2)		30	14 L 1	(3+4)	
7	7 L 1	(1+2)		31	15 L 1	(3+4)	
8	8 L 1	(1+2)		32	16 L 1	(3+4)	
9	9 L 1	(1+2)	DOWN STREAM	33	I S H	(1+2)	DOWN STREAM
10	10 L 1	(1+2)		34	I S H	(3+4)	DOWN STREAM
11	11 L 1	(1+2)		35	15 (E-S)	(1/2)	DITTO
12	12 L 1	(1+2)		36	15 (E-S)	(3/4)	DITTO
13	13 L 1	(1+2)		37	T-SV 1	(1/2)	DITTO
14	14 L 1	(1+2)		38	T-S V 1	(3/4)	DITTO
15	15 L 1	(1+2)		39	K 1		DITTO
16	16 L 1	(1+2)		40	S V 2		DITTO.
17	1 L 1	(3+4)		41	K 2		DITTO
18	I K S	(3+4)		42	TS-B H		DITTO
19	3 L 1	(3+4)		44	TS-DET		DITTO
20	4 L 1	(3+4)		43	TS-DUMP		
21	5 L 1	(3+4)		45	LINAC(ISST)		DOWN STREAM
22	6 L 1	(3+4)		46			
23	7 L 1	(3+4)		47			
24	8 L 1	(3+4)		48			

CROSS SECTION OF A BEAM LOSS MONITOR FIG 1.

Scale 1/2

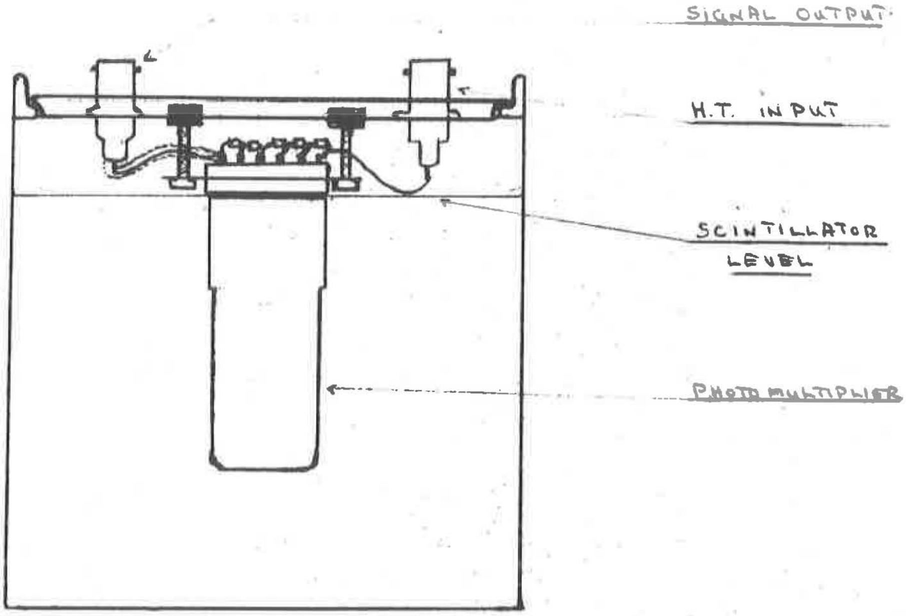
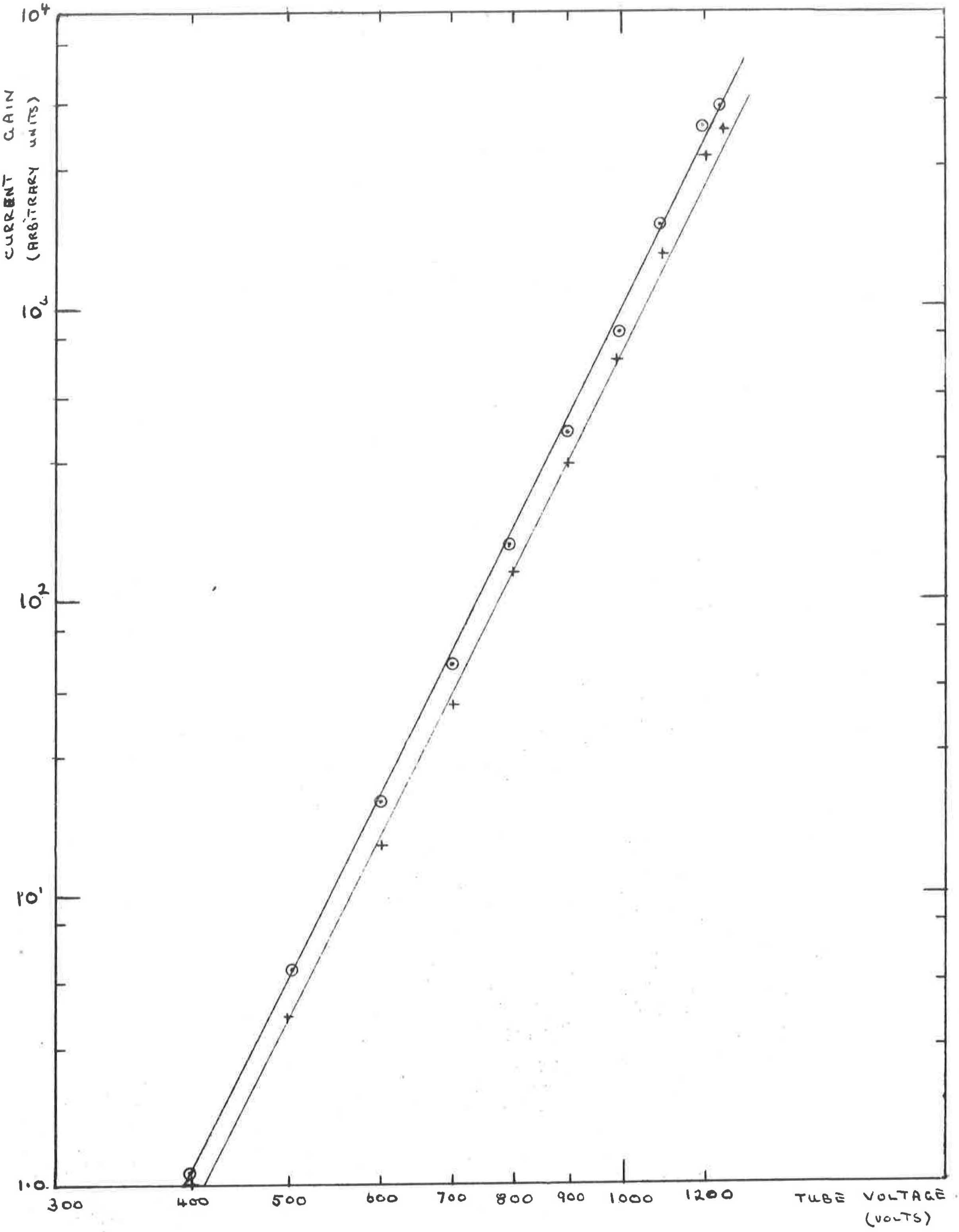


FIG 2

GAIN AS A FUNCTION OF TUBE VOLTAGE FOR TWO B.L.M.s.



SIGNAL ATTENUATION OF B.L.M. SYSTEM

Fig (3)