

DIAGNOSTIC SYSTEM FOR THE LLS. BEAM POSITION MONITORS

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Abstract

An overview of the diagnostic instrumentation foreseen for the LLS synchrotron radiation source is presented. After this, more detailed attention is addressed to the storage ring beam position monitors. In particular, the electrodes' diameter and their optimum arrangement, in two feasible transverse sections of the electron vacuum pipe, are defined with regard to the button's intrinsic resolution obtained and to the monitor's sensitivity provided for each transverse dimension.

1 INTRODUCTION

The design stage of the LLS, a proposed synchrotron radiation source for Spain, has been completed [1]. What follows is a summary of the different devices that, distributed around the accelerator complex, will aid commissioning and guarantee its efficient running, providing a good quality and stable photon beam at the user's experiments. The LLS parameters relevant to the beam diagnostic system are shown in table 1.

Table 1: LLS parameters relevant to beam diagnostics.

Parameter	Storage Ring		Booster	
	Single Bunch	Multi Bunch		
Mode	Single Bunch	Multi Bunch	-	
Energy	GeV	2.5	2.5	0.1 - 2.5
Max. average current	mA	10	250	2
Single Bunch current	mA	10	0.9	0.04
RF frequency	MHz	500	500	500
Number of bunches	1	300	50	50
Harmonic number	420	210	210	210
Revolution frequency	MHz	1.19	2.38	2.38
Repetition rate	Hz	-	10	10
Synchrotron frequency	kHz	15.7	12.4	-
Bunch length 2σ	ps	44	47	172
Q_x, Q_y	14.3, 8.2	-	-	-
Emittance	nm rad	8.48	-	-
Minimum size σ_x, σ_y	μm	74, 38	-	-

2 DIAGNOSTIC DEVICES FOR THE LLS

Several types of detectors, mainly current transformers, will be used for beam intensity and related measurements: The total charge coming from the pre-injector will be measured with a Faraday cup (FC). A second Faraday cup will permit the determination of the energy distribution of the electron beam from the linac. In transfer lines and in

the booster, charge measurements will be delivered by Integrating Current Transformers (ICT). For observing the longitudinal profile of the bunched beam in transfer lines, Fast Current Transformers (FCT) will be used. Besides that, a wall current monitor (WCM) in each transfer line, will monitor the amplitude and duration of the bunches from the injector and from the booster respectively. The average beam current will be measured with a high precision D.C. Current Transformer [2] (DCCT) in the storage ring and with a modular parametric current transformer (MPCT) in the booster

Several fluorescent screens and CCDs will provide a direct visualisation of beam position, transverse distribution of particles and intensity during the commissioning stage. They will also be especially useful to obtain fast qualitative information from single shots in transfer lines and during the first turn. Furthermore, the injection process could be controlled by having one of them after the septum magnet, one at the end of the injection bump and one well away from it.

An accurate characterisation of the transverse position of the circulating electron beam will be provided by the many Beam Position Monitors (BPM) arranged in the machine. Besides the position, they will be used to infer other information concerned with lattice functions and beam dynamics. In transfer lines, where the impedance increase is not so critical, striplines are preferred and will be used to allow measurements of the horizontal and vertical trajectory. Striplines in the booster will be used for examination of time structure and for other routine diagnostic purposes. In the ring they will serve tune measurements

One bending magnet beamline will be dedicated to machine diagnostics. A common CCD will be used to measure the transverse beam size and shape. However, the bunch length measurement requires a faster system such as a streak camera that is also a particularly important diagnostic tool in detecting bunch cleanliness and instabilities. A pickup electrode, with appropriate signal amplification and fast data recording, will also provide measurements of the bunch length.

A pair of horizontal and vertical scrapers will be used to measure the position and beam profile in the outer part of the density distribution during the first turns after injection. An annular stripline right after the injection point into the storage ring will provide valuable non-destructive measurements independent of beam position.

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Beam loss monitors will indicate when and where the beam or part of it was lost.

Lattice functions and other machine and beam parameters could be directly extracted or inferred making use of the devices already mentioned and summarised in table 2.

Table 2 Diagnostic devices and their use

Diagnostic device	Applications
Faraday cup	Beam charge; time structure in transfer lines.
Fluorescent screen	Transverse profile, position, current.
DCCT	Average beam intensity, beam lifetime in rings.
WCM	Longitudinal structure of the beam. Position.
FCT	Observing short beam pulses in transfer lines.
ICT	Charge in a pulse in transfer lines. Injection efficiency
BPM button PU	Transverse Position. Closed orbit. Tune.
Stripline	Position. As kicker and receivers for tune meas.
Scraper	Dynamic aperture. Beam profile.
Beam loss monitor	To minimize radiation level.
Photon monitors, CCD	Transverse distributions. Emittance.
Streak camera	Bunch shape. Instabilities.

An outline drawing of the diagnostics for the LLS is shown in figure 1. It provides an overview of the arrangement of the diagnostic devices that will be used in the accelerator complex. They are summarised in the table 3.

Table 3. Summary of LLS accelerator instrumentation

Device	LTB	Booster	BTS	Storage Ring
Faraday Cup	2	-	-	-
FCT	1	-	-	-
ICT	2	1	3	-
BPM	5	42	8	96
Stripline	1	2	2	3
Scraper	-	-	-	2
Fluorescent screens	3	3	5	6
WCM	1	-	1	1
DCCT	-	1	-	1
BLM	4	12	4	50
Streak camera	-	-	-	1

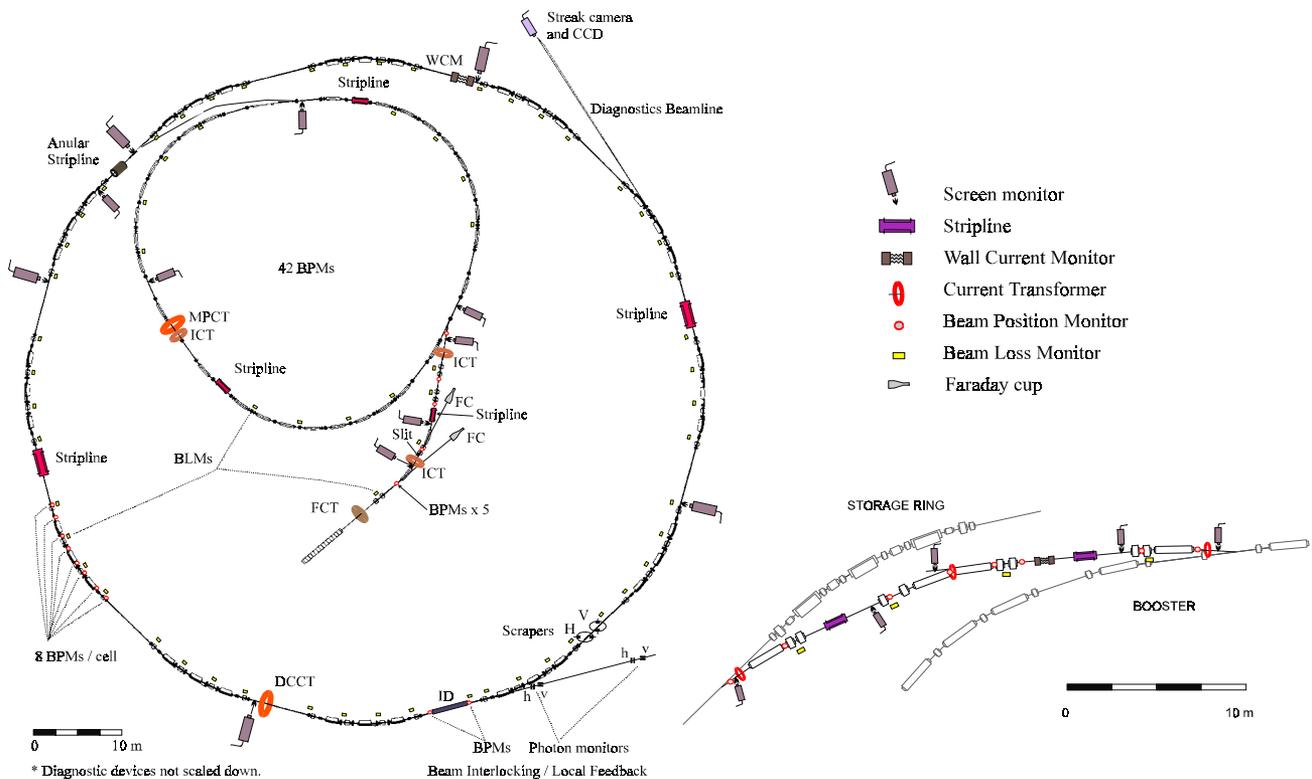


Figure 1. Layout of beam diagnostic devices for the LLS

2 BEAM POSITION MONITORS

Each detector of the beam position monitor (BPM) system is composed of four button style pickups (PU) capacitively coupled to the beam. Their position in the

storage ring, close to the quadrupoles, see fig 2, and the position of the correction dipoles, was verified with a closed orbit correction simulation. We will have eight monitors per cell and at the entrance and exit of the insertion devices. The main use of the last will be for beam interlocking to avoid damage to the vacuum

chamber if the electron beam becomes miss-steered. Only some of the BPMs will also have single turn capability.

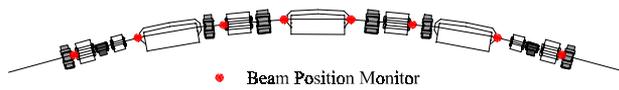


Figure 2. Scheme for the positioning of BPMs in the LLS cell

Analytical formulae [3] have been used to demonstrate that, for a circulating current of 10 mA, an intrinsic resolution of $1\mu\text{m}$ can be achieved with button's radius greater than 5 mm, if they are closer than 25 mm to the center of the vacuum chamber (pipe radius). Results are shown in figure 3.

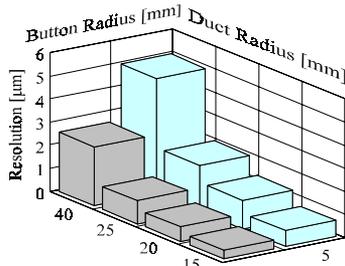


Figure 3. Intrinsic button's resolution versus pipe and button radius.

Part of the work was dedicated to determine whether a particular geometry, in combination with an optimum placement of the PU electrodes, could significantly improve the resolution and sensitivity of the detector or not. This study, together with vacuum chamber conductance considerations, allowed us to define the optimum dimensions for two possible electron pipe shapes. See figure 4

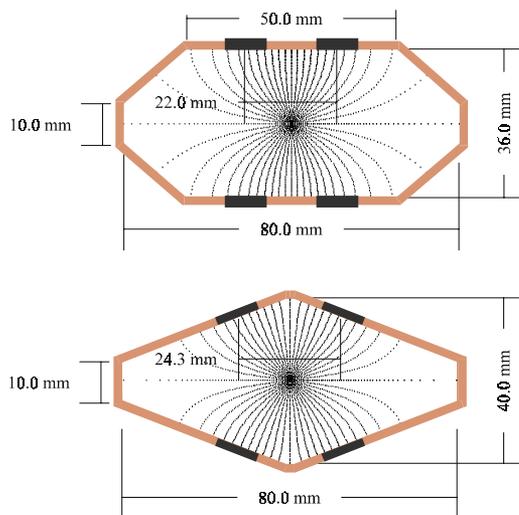


Figure 4. Two possible cross-sections of the electron pipe, showing the position of the buttons and the electric field lines created by an on-center beam.

The button's arrangement in figure 4 provides the same sensitivity in both, vertical and horizontal, planes. The theoretical calibration curves, assuming the difference over sum algorithm, are shown in figure 5. The value of the sensitivity is the slope of the curve at the origin. This value can be used while the deviation from linearity of the BPM response is lower than 1%. In our design this occurs for off-center beams of less than 4 mm, for buttons of 10mm diameter.

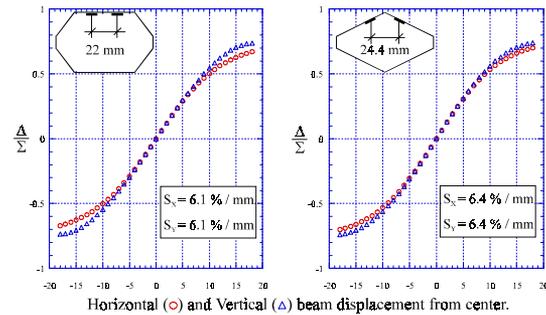


Figure 5. Difference over sum signal, Δ/Σ , versus beam displacement.

Both arrangements give similar results. The final choice will rely on mechanical stability and cost considerations.

3 CONCLUSIONS

The instrumentation devices that will be used to speed up the LLS commissioning, as well as to insure that it operates efficiently, with a minimum down time, have been presented.

The optimum dimensions, as well as the best button's arrangement, for two feasible designs of the electron beam pipe have been defined. The results of the vacuum chamber conductance and monitor performance study do not favour one design over the other.

4 ACKNOWLEDGMENTS

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