DESIGN OF X-RAY DIAGNOSTIC BEAMLINE FOR INDUS-2 STORAGE RING

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Abstract

Indus-2 is a 3rd generation light source with 2.5 GeV energy and 300mA current. The r.m.s beam sizes are in the range of few hundred micrometers (~250µm). Two independent diagnostics beamlines have been designed and are under development for Indus-2 storage ring viz. visible diagnostic beamline and X-ray diagnostic beamline. Generally, former beamline is used for longitudinal measurements whereas latter for transverse measurements. In X-ray diagnostic beamline (X-DBL) pinhole camera will image 8-18keV dipole radiation on a phosphor screen to measure the beam size, beam divergence, beam emittance and beam stability. By selecting harder part of synchrotron radiations, it's possible to improve resolution for better tuning of machine for low coupling. This paper briefly reviews the various design issues of pinhole array based diagnostic beamline. Calculated results for total horizontal angular acceptance, optimum pinhole diameter, matrix size of pinhole array, metal energy filters, phosphor screen and planned mechanical layout X-DBL have been discussed.

INTRODUCTION

Beamline BL-24 at 10° port of bending magnet (DP-10) of Indus-2 storage ring will be used for X-ray diagnostic beamline. Pinhole array will have total horizontal angular acceptance of $\theta_H = 2.5 mrad$. It is designed to cover up to ±2.0 mm movement of source point or up to ±0.4mrad divergence change in vertical plane. Actually there will be combined effect of both source shift and divergence change.

In design study, detailed comparison of major working diagnostic beamline such as BESSY II, ALS (BL 7.2), Canadian Light Source, Australian Light Source, NSLS, and Diamond Light Source was carried out ref. [1-5]. From the operating experience of working X-ray diagnostic beamlines, spatial resolution of 20-25 micron is generally obtained by using pinhole with diameter of 20-22 micron. Similarly resolution in beam stability measurements is found to be of few microns depending upon integration time and the electronics applied. Different type of pinhole arrays are used for X-ray imaging. In a pinhole array, the intensity variation on either side of the central beam provides measure of divergence of the beam. The spacing between pinholes in pinhole array ranges from 0.5 to 1mm along vertical direction. For X-DBL vertical spacing of 1mm between the pinholes will be used. Schematics of pinhole imaging for SR source is shown below in fig.1

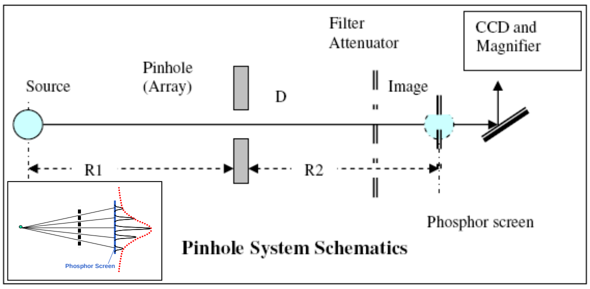

Fig.1. Schematics of pinhole imaging for SR source. Imaging of source point by multiple pinholes (Inset).

X-RAY DIAGNOSTIC BEAMLINE

Pinhole Array

We will use pinhole array for imaging because it will not only cover the alignment issues but further Gaussian fitting of peaks will give information of opening angle along with position of source point too, as shown in fig.1 (inset). Further, source point to pinhole distance (R1) is fixed at 8m; by selecting this R1 space constraints for placing pinhole array inside tunnel would be fulfilled without any modification in front end.

Optimum value of pinhole size and theoretical spatial resolution was decided based on two major factors such as diffraction errors and geometric errors ref. [6-7] and results are shown in fig 2

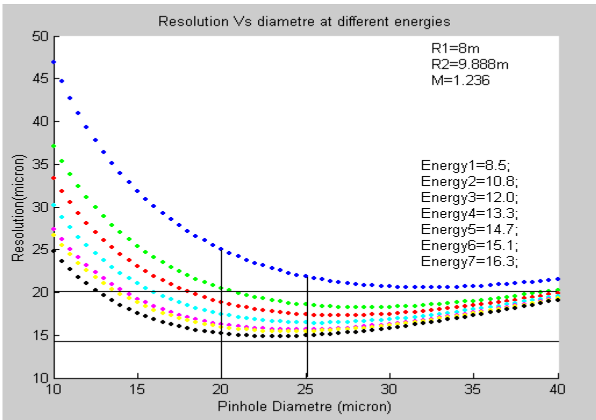

Fig 2: Plot for expected theoretical resolutions at different pinhole diameter corresponding to different photon energies (KeV)

Beryllium Window

Beryllium window will be used at the end of beamline for extraction of X-ray. This also provides vacuum isolation to beamline. Transmission curve for 'Be' at different thickness values was studied. Calculations for flux density, power density and brilliance were carried out using SPECTRA 8.0[8].

Energy Filters

In case of pinhole imaging generally metallic energy filters are used for selection of X-ray energy for its imaging on phosphor screen. Remotely controlled filter will reduce intensity of the X-ray beam at high beam current and further by selecting harder part of synchrotron radiations will improve the resolution of the measurements.

Phosphor Screen

In pinhole imaging, X-ray to visible conversion is carried out using phosphor screen. A comparative study was carried out for commonly used phosphors for diagnostics purpose ref. [9]. We will use P-43 in first phase and P-46 in second phase for fast online studies.

Expected Intensity Pattern

The expected intensity pattern of incident X-rays on the phosphor screen I(x, y) was calculated by using design parameters of X-DBL. Results at 8KeV and at 18KeV are shown below in fig.3

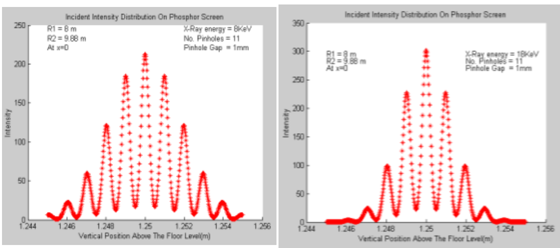

Fig.3.Expected intensity pattern for 8 KeV (left) and 18KeV (right) on phosphor screen with Indus-2 source parameters.

PARAMETERS TO BE MEASURED USING PINHOLE ARRAY

Beam Size and Beam Emittance

The beam spot will be imaged on thin phosphor screen and this image will be fitted with Gaussian curve to get horizontal and vertical beam sizes (σ_x & σ_y). Emittance can be measured by using measured beam size and beta functions of SR source

Beam Stability and Beam Dispersion

Beam stability of electron beam will be measured by using CCD camera to monitor centroid of the image. Further, one significant advantage of the X-ray pinhole camera over the UV/visible imaging is the stability of its image, since the latter is susceptible to mirror vibrations in long transport line. This feature of X-DBL will be used to measure dispersion function at the source point.

Beam Divergence

By Gaussian fitting to the intensity distribution of the peaks of vertical beam spots, one can measure beam divergence.

ACKNOWLEDGEMENTS

We would like to acknowledge the guidance and support provided by Shri C. P. Navathe, Dr. S. K. Deb, Dr. G. S. Lodha, Shri V. K. Raghuvanshi, Shri Sanjay Chouksey, Shri Sendhil Raja and Dr. G. Haridas in designing these beamlines. We are thankful to Shri R. K. Yadav for doing all drawing related work of these beamlines.

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