§18. Calculation of Geometry Matrix for Optimization of Fields of View for Imaging Bolometers in LHD

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In order to compare imaging bolometer (IRVB) data to impurity transport code results it is necessary to calculate the geometry matrix of each IRVB. The geometry matrix, T_{ij}, mathematically relates the radiated power, P_i, detected by each IRVB channel, i, to the radiated power density, S_j, of each arbitrarily defined plasma subvolume, j, by Eq. 1

$$P_i = \sum_j \frac{\Omega_{ij}}{4\pi} V_{ij} S_j = \sum_j T_{ij} S_j \qquad (1)$$

where T_{ij} is the product of the solid angle, Ω_{ij}, of the ith detector with respect to the jth plasma subvolume and the intersecting volume, V_{ij}, between the field of view (FoV) of the ith detector and the jth plasma subvolume divided by 4π. The LHD plasma volume is divided up into subvolumes using a cylindrical grid having the dimensions of major radius, 2.5 m $< R < 5$ m, vertical distance from midplane, -1.3 m $< Z < 1.3$ m, and toroidal angle, $0° < \phi < 18°$, or one half field period by assuming helically periodic symmetry. The grid size in each dimension is $\Delta R = 5$ cm, $\Delta\phi = 1°$ and $\Delta Z = 5$ cm. By eliminating subvoxels where no plasma exists the total number is reduced from 46,800 to 13,161.

A computer code has been written which calculates the geometry matrix by starting at the center of each IRVB pixel and stepping towards the plasma in 1 cm steps along the sight line of the IRVB pixel determined by the aperture and foil camera geometry[1]. As the FoV expands, moving further away from the aperture, the FoV is subdivided to keep each subvoxel below 1 cm in dimension to maintain the accuracy of the calculation. Then for each subvoxel of the FoV the effective volume and the respective solid angle of the IRVB pixel are calculated and T for that subvoxel is added to the appropriate geometry matrix element corresponding to the position in the plasma grid. A separate subroutine is used to determine when a sightline hits the LHD vacuum vessel wall and any subsequent FoV sub voxels are not added to T. This program is applied to three different IRVBs (ports 6-T, 10-O and 6.5-U) having a total of 1968 pixels. Using the program the FoVs for the imaging bolometers at 6-T and 10-O were optimized to reduce the number of non-visible plasma subvolumes from 108 to 12 as seen in Fig 1. In the Future the IRVB at 6.5-U will be optimized by bringing the foil closer to the plasma and IRVBs are planned to be added at Ports 6.5-L and 8-O in order to view the unseen plasma subvolumes in the x-point regions of the diagonal cross-sections.

1) B. J. Peterson et. al, to be published in Plasma Fusion Res. (2012).

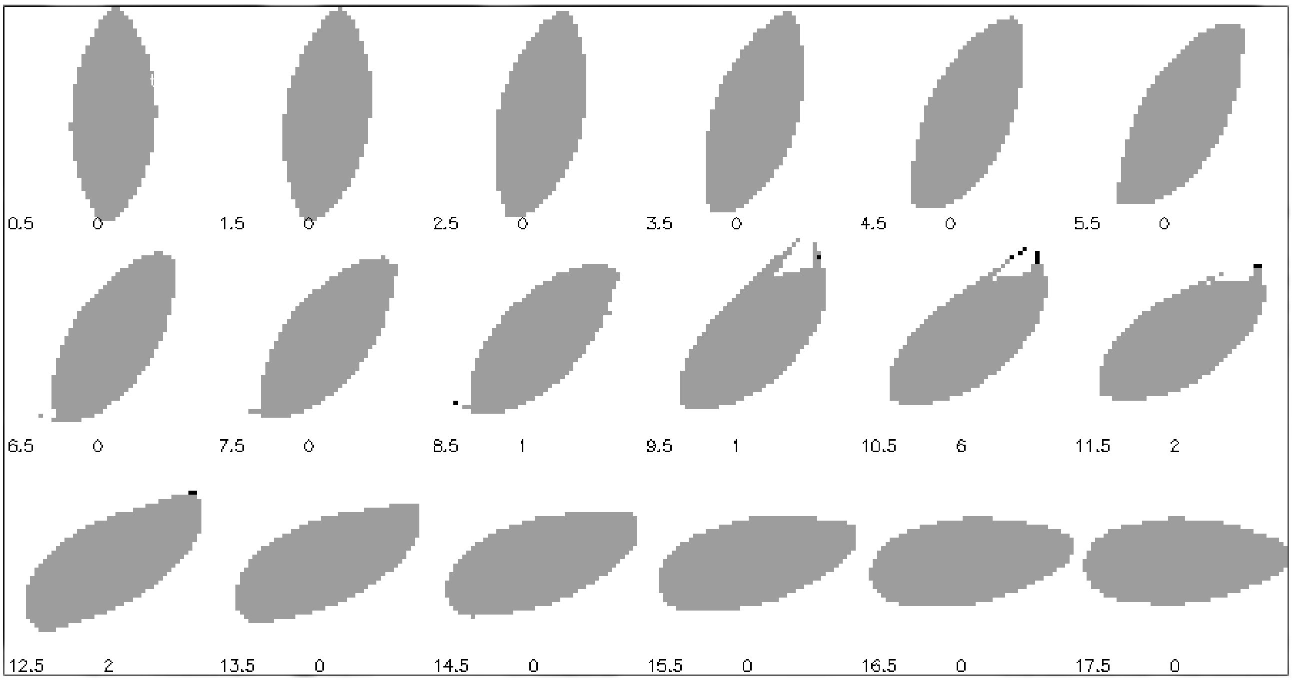

Fig. 1 Plasma subvolumes not viewed by any IRVB channel. Each of the 18 subfigures shows the 50 (R) x 52 (Z) grid cross-section at one toroidal angle, which is indicated in the lower left hand corner of each subfigure. The color code is zero IRVB channels (black), one or more IRVB channels (gray), no plasma (white). The number of plasma voxels which are not viewed viewed by IRVBs is given in the lower center of each cross-section.