Alignment Results

Estimated uncertainty on alignment by error propogation

Beam centre measured to +/-1 pixels
Uncertainty from stage angle rotation precision negligible.

Phi (rotation around the X axis) gives uncertainty +/- 0.88 degrees,
Theta (rotation around the Y-axis) uncertainty +/- 0.27 degrees, this is in good agreement with the result from multiple measurements (with a less accurate technique) of an rms of 0.35 degrees.

Measurments Organised by Detector

J03-W0026 (n-bulk)

Theta – measurement 1. 0.38 degrees, dodgy measurement.
Theta - measurement 2. 0.003 degrees.
Phi - measurement 1. 0.435 degrees, dodgy measurement
Phi - measurement 2. -0.753 degrees

Acccuracy compatible with estimated uncertainty.

F09-W0015 (p-bulk)

Measurement 1.
Theta - 0.000
Phi – 0.009
Whole set of measurements of theta, see below, average -0.22 degrees, rms 0.35 degrees
Phi measurement 2. 0.811 degrees.

Accuracy compatible with estimated uncertainty.

Planar Detector

Check of Phi alignment misalignment is -0.009 degrees.
Check of Theta Alignment misalignment -0.002 degrees.

No second measurement after data taking, but other results during setup are compatible with estimated uncertainty.

Organised by day for following log book

Day 2

Device J03-W0026 MXR3D (n-bulk), first attempt at alignment procedure.

Record of PositionsDay2.xls, Measurement 1 Phi
Theta – obtain correction 0.19 degrees, possibly applied sign wrong, so alignment 0.38 degrees
Record of PositionsDay2.xls, Measurement 1 Theta

Phi - initially obtained correction 0.065 degrees, possibly applied sign wrong and definitely applied rotation angle wrong. With correct rotation number was 0.37 degrees. If sign wrong also misalignment is 0.37+0.065=0.435 degrees.

Day 3

Device J03-W0026 MXR3D, check of alignment before dismounting

Measurements in

Day 3 n-bulk 3D Record of Positions.xls

Measurement 1 Phi / Measurement 1 Theta are measurements from Day 2.

New measurements are labelled Measurement 2

Theta - misalignment 0.003 degrees.

Phi - misalignment is -0.753 degrees.

Device F09 W0015 (p-bulk),

Measurements in

Day 3 p-bulk F09 3D Record of positions.xls

Theta - 0.000

Phi – 0.009

Day 4

Record of positions_day4_F09.xls

Measurements messed up as L not kept constant, but should be possible to recalculate something from recorded numbers.

Revised calculations using L not constant, from Beta+theta=acos(L1/D1)

1.

Theta1 -0.042

Theta2 -0.006

2.

Theta 1 -0.612

Theta2 -0.060

3.

Theta1 -0.662

Theta2 -0.150

4.

Theta 1 0.019

Theta 2 2.902 . exclude, assume error in values.

An uncertainty of one pixel in centre position gives 0.37 degrees.

RMS of these values 0.35 degrees.

And for Phi

1.

Phi 1 0.093

Phi 2 1.688

An uncertainty of one pixel in centre position gives 1.60 degrees using this technique

L was constant for this measurement – so using standard technique
Phi 0.811

Planar device Ntype, I03-W0047
Measurements in
Record of positions_day4_Planar.xls
Check of Phi alignment misalignment is -0.009 degrees.
Check of Theta Alignment misalignment -0.002 degrees.

Previous measurements while setting up look compatible with estimated uncertainty.
No measurement taken at the end of data taking.

Draft Text for Paper

Alignment

This paper presents a measurement of the non-uniformity of charge collection in the 3D detectors across a pixel, this requires an accurate alignment of the detectors perpendicular to the beam. The detectors were aligned perpendicular to the Diamond beam using the following procedure. The detector was mounted on a motorised stage with six degrees of freedom mounted on an optical table, see Figure 1. Translations could be adjusted with 1µm precision and rotations with 5µrad precision. A right handed co-ordinate system was defined with Z along the beam, Y vertically upwards and X horizontal.

The detector was positioned approximately perpendicular to the beam and rotated by β degrees (typically 45º) around the Y-axis. The pixel registering the peak intensity of counts from the beam was then located on the detector. The detector was then moved a known distance along X using the automated stage, and the peak intensity pixel again recorded. The distance between the two beam positions on the detector is D1, see Figure 2. The detector was then rotated in the opposite sense by the same angle (-β) from the nominal perpendicular position and the process repeated to determine a distance D2. If the detector is well aligned D1 and D2 should be equal, if not a correction angle can be calculated using the following equation

$$\tan\theta \tan\beta = \frac{D1 - D2}{D1 + D2}, \qquad (1)$$

where θ is the correction angle. Having applied the correction the process was then repeated to check the alignment.

Having performed the alignment around the Y axis, the process was repeated for the alignment around the X axis. The rotation angle around the X axis was limited by the stage and a β of typically 10º was used.

This alignment measurements in both axes were repeated at the end of the data taking of each detector to check that the detector had not moved during the measurements.

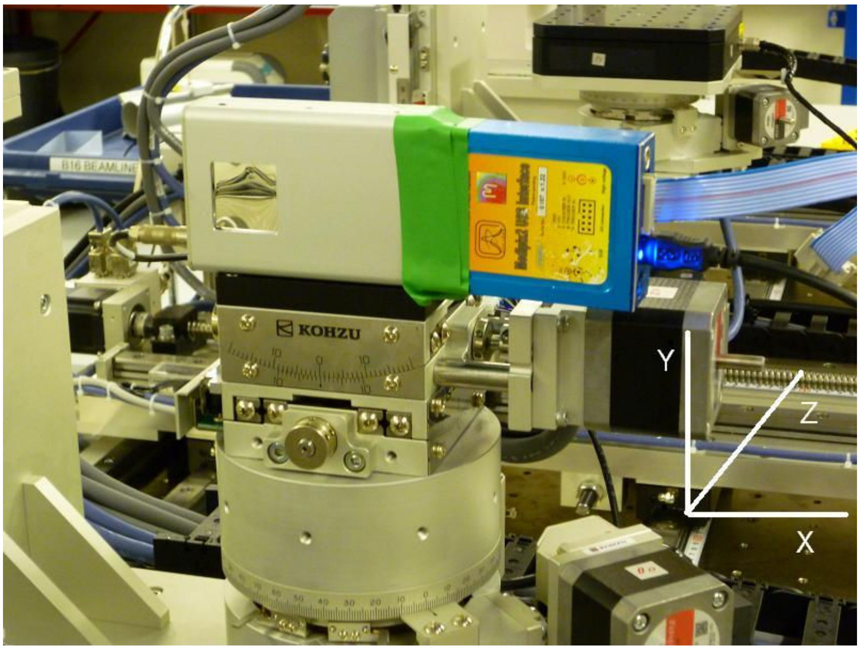

Figure 1: Detector in its housing box with readout card, mounted on the motorised stage. The co-ordinate system is indicated. The stage rotation mechanism about the Y-axis and Z-axis is clearly visible. (picture needs converting to b/w for publication)

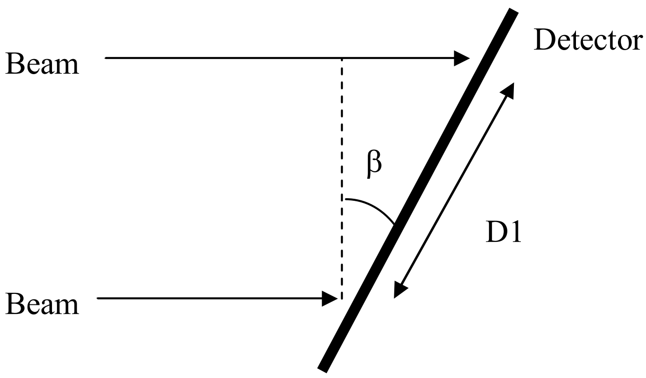

Figure 2: Illustration of alignment procedure. The detector was rotated by angle β, and the two beam central positions are measured as a distance D1 apart on the detector.

The accuracy of the alignment was estimated by two methods. Eight repeated measurements of the alignment were made using the method discussed above for one detector and the rms calculated. The uncertainty on the alignment was calculated by error propagation due to the uncertainty arising from mismeasuring the beam position by one pixel; the accuracy of the movement of the stage made a negligible contribution. The results from both methods were in excellent agreement.

An alignment accuracy of 0.3 degrees on rotations about the Y-axis and 0.9 degrees on rotations about the X-axis were achieved. This alignment accuracy corresponds to a deviation of 2 to 5µm from a perpendicular line over the approximately 300 um thickness of the detectors. This can be compared with the nominal diameter of a pore in the 3D detector of 10 µm, as a measure of the alignment scale required to allow an accurate measurement of the areas of the non-uniformity of charge collection in the detector.