Insertion Device alignment for the Diamond Light Source

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ABSTRACT

This paper covers the survey and alignment techniques selected for the build & pre-alignment of the Insertion Devices, together with the alignment of the integrated 3-axis Hall probe bench magnetic measurement system, currently situated at Diamond Light Source.

Insertion Device assembly consists of a main sub frame, upper and lower magnet arrays and two horizontal beams, which are currently assembled and surveyed prior to their magnetic field alignment.

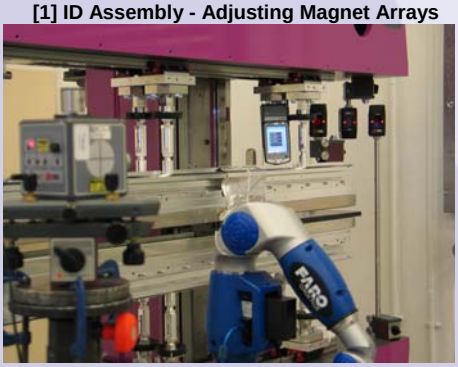
Instrument selection and measurement uncertainty is also covered on the assembly of the Insertion Devices and survey monument positions, prior to their installation within the storage ring.

COMPANY BACKGROUND

Diamond is a new synchrotron radiation source in the final stages of construction in Oxfordshire, UK. Diamond is the largest scientific research facility to be built in the UK for 30 years, and will produce ultra-violet and X-ray beams of exceptional brightness, allowing pioneering experiments to be carried out which probe deep into the basic structure of matter and materials. The facility will comprise a 3 GeV electron storage ring, injected from a 100 MeV linac through a full energy booster synchrotron, and an initial complement of seven beamlines.

The facility will be constructed, owned and operated by Diamond Light Source Ltd. (DLS), a private company formed under a Joint Venture Agreement between the UK Government and the Wellcome Trust.

[1] ID Assembly - Adjusting Magnet Arrays

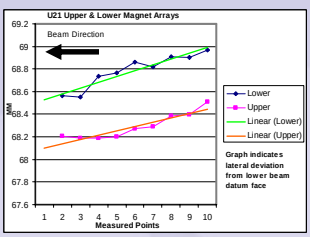


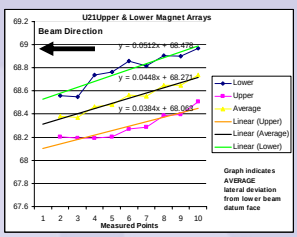
The ID's lower beam is set level to gravity with the Hamar system. Capturing the live data, columns are adjusted to bring the upper magnet array parallel and level to within 20 µm of the lower beam working surface (datum plane).

Due to small working areas, the Faro Gage Arm is then introduced by locally aligning perpendicular of the datum plane, to set the lower magnet array parallel and level to each other.

When the two magnet arrays are parallel the unit is then placed onto the measuring bench where it is levelled **[8]**. The physicist can then take preliminary measurements of the magnet alignment and on completion of this, pre-alignment survey's can take place.

[2] U21 Transverse Installation Reference





Measured Data **Average Bestfit Line**

To establish the transverse alignment reference for the ID installation the average position of the upper and lower magnet arrays are used. Points are measured on each of the arrays using a Faro laser tracker which are then projected onto a common plane perpendicular to the gravity vector. A line of best fit through the 2 data sets is then used to define the beam axis for installation. The above graphs indicate typical results for this process.

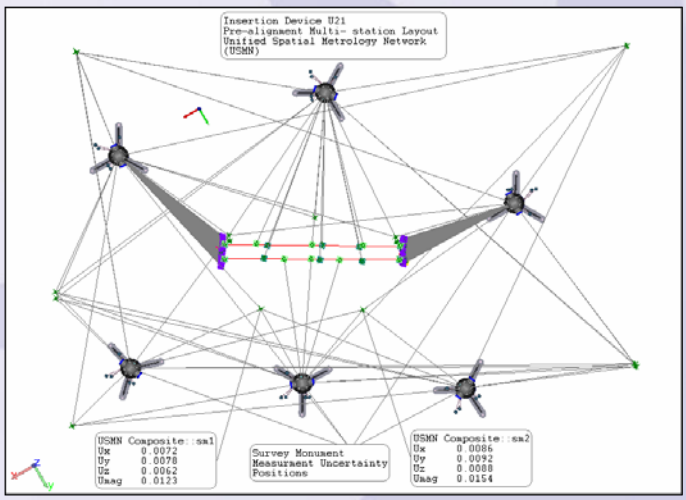
[3] Diamond Light Source Ltd

Aerial View

Survey & Alignment Group

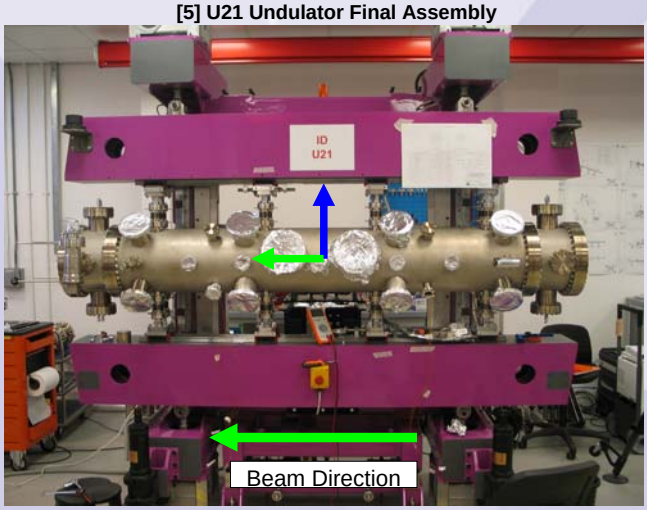
Oxfordshire, United Kingdom

[4] U21 Unified Spatial Metrology Network (USMN)



Typical instrument geometry and network configuration for the pre-alignment of both in and out of vacuum Insertion Devices. Uncertainty values of 12 to 15 microns (2.0 sigma) achieved for the positions of the survey monuments within the controlled network.

[5] U21 Undulator Final Assembly



Final Assembly of Undulator 21, awaiting installation and final positioning inside the storage ring on ID Straight I03.

The co-ordinate system used for installation is defined by:

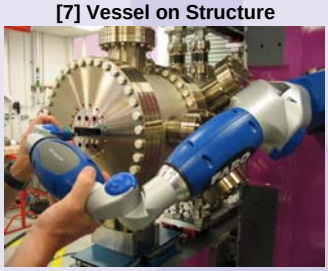
- the best-fit plane centred between the upper and lower beams for pitch, elevation and roll **[1]**.
- the best-fit line defined by the as-built magnet arrays positions for transverse position and yaw **[2].**
- mid point between the vacuum vessel end flanges for longitudinal position.

Once the co-ordinate system is established, a multi-station laser tracker survey is used to value the survey monuments **[4]**. These are then used in conjunction with a precision level during installation.

[6] U21 Storage Ring Final Alignment On Straight I03

Faro Laser Tracker booked into Storage Ring controlled Network for final positioning of ID21. Careful adjustments are made to finally locate survey monument positions within 50µm against nominal data.

[7] Vessel on Structure



For in-vacuum ID's the vacuum vessel is aligned for roll an elevation using the Faro Gauge co-ordinate measuring arm mounted on the main structure of the ID via a magnetic base. A co-ordinate frame is then established from measured points on the lower beam datum, vertically translated to the nominal beam axis. The vacuum vessel is then adjusted so that points measured on the top and bottom of the entry and exit flange apertures are equi-distant from the beam axis. The transverse and longitudinal position of the vacuum chamber is determined using a laser tracker during the final survey.

[8] Hall Probe Transducer & Integrating Coil

Integrated 3-axis measurement/positioning system (Hall Probe), along with the 2 axis's positioning Coil system situated at Diamond. Insertion Devices are moved to the measuring bench for the final adjustments of its magnetic field alignment.

The Hall Probe Bench was aligned so that its main axis (s) was perpendicular to gravity and its 2 remaining axes (x & z) were mutually perpendicular. The supports at each end of the integrating coil are mounted on translation stages which were orthogonally aligned with respect to the axes of the hall probe bench. All alignments were carried out using a laser tracker referenced to gravity via its internal gyro.

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