EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** X-Ray Microbeam characterisation of high-precision silicon dosimeters for Microbeam Radiation Therapy (MRT)	**Experiment number**: MI-1223
Beamline:	**Date of experiment**: from: 25.11.2015 to: 28.11.2015	**Date of report**: 24.02.2016
Shifts: 9	**Local contact(s)**: Herwig Requardt	*Received at ESRF:*

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Report:

Report

Aim of the studies performed on ID17 was the characterization of silicon microbeam monitors for MRT. Specifically we were interested in assessing the behavior of the beam monitors in the presence of tissue-equivalent material (PMMA) and furthermore in their radiation tolerance.
The sensors were read out through the AFE DAQ, developed by the Wollongong members of the 3DMiMic project. The readout daughterboard was directly connected to the sensor board, and the both were mounted in a metallic support box, in front of the microbeam exit (Fig. 1).

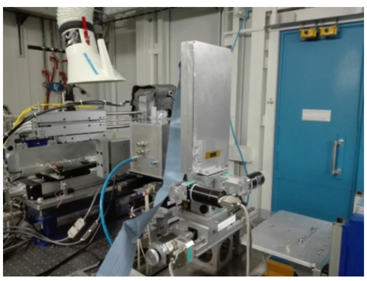

Figure 1 – Left: the AFE readout daughterboard, connected to the sensor testboard, as mounted in the support frame. right: The complete support frame mounted on the ID 17 beamline.

The tests covered three different aspects:

Response of the sensor to microbeams.
The sensor was exposed to microbeams, using a 400 um pitch collimator. The data was taken employing a multichannel readout. We employed two sensors, collecting several datasets at different gap settings, ranging from 24.8 to 50 mm. The employed sensors had both a variable pitch geometry (Fig. 2), with three strips spaced by 24 um each and sorrounded by individual steering rings, in order to collect the whole charge also when the microbeams have a slightly different pitch from the detector pitch. The distance between the collimator and the sensor induced a slight beam divergence, with an effective pitch measured in ~401.25 um. Fig. 3 (left) shows the results obtained on a 50 um strip length sensor, with a 24.8 mm wiggler gap. The peaks are clearly defined and no charge is observed in the valleys, proving the successful containment of the charge to the strip cluster. The observed "beatings" can be used to define the pitch mismatch. The plot also shows (red squares) the centre of mass and average charge for each cluster. The observed profile is compatible with physical effect, as the noise (Fig. 2, right) is contained within a sigma of <0.5% of the full range.

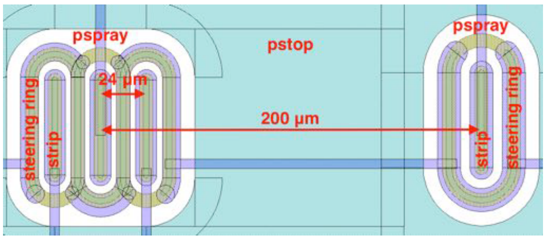

Figure 2: variable pitch sensor geometry

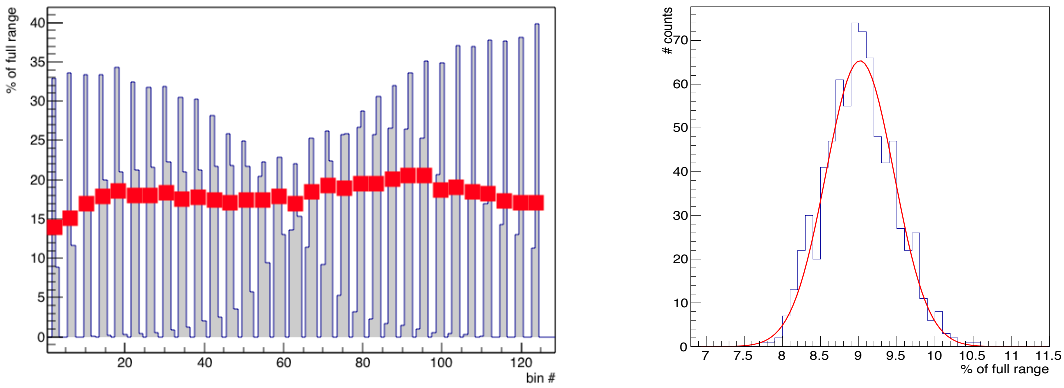

Fig 3: Left: microbeam profile as observed with the 50 um pitch sensor. Red squares show the centre of mass and average charge for each triplet. Right: amplitude distribution during one single exposure for one single channel.

Response of the sensor to microbeams.
We interposed, between the sensor and the collimator, a PMMA block (10 mm thick), at a distance of ~6 mm from the sensor itself – as close as allowed by the detector support. The resulting profile observed was compatible with the one observed without PMMA. However, in this case, a small signal was visible also in the valleys, likely attribuable to beam scatering within the PMMA block. The observed peak-to-valley signal ratio was in the order of ~90.

Radiation damage.
After performing the above mentioned measurements, the two tested sensors (variable pitch, 50 and 250 um strip length) were irradiated and re-tested following different dose steps. The irradiation was performed employing a micro-beam array in bursts of few to several MRads, obtained with a 24.8 mm gap. Following each step we performed a multichannel measurement with the AFE readout. The first detector (50 um strip length) stopped being operational at a dose of 25 Mrad. However this detector had been previously employed in test campaigns at ID17, where it was already exposed to an undefined radiation dose. For this reason we have repeated the tests employing the 250 um strip-length detector, previously unirradiated. The detector survived the highest dose we delivered (234 Mrad), without showing visible changes in its behavior. Moreover, after being left to rest overnight, the measurement was repeated and, also in this case, no change in the detector behavior was observed, showing no evidence of annealing effects.

Conclusions and outlook
The successful tests allowed to test the variable pitch geometry sensors with MRT beams. This specific geometry has proven effective in monitoring beams even in the presence of a slight divergence. New 3D sensors with a pitch of 100.5 um are currently being produced and should further address this issue. As one of the parameters to be monitored in MRT is the peak-to-valley dose ratio, the preliminary measurements performed with the AFE readout employing a PMMA block were successful in determining an energy deposit in valleys. Further tests will likely be required with an upgraded readout to increase the dynamic range of the readout and determine a calibration factor between live tissue and energy deposit in silicon. Finally, the sensors were proven to be radiation hard, characteristic that would make their employment feasible in MRT beam monitoring.