ESRF	**Experiment title:** **Effect of synchrotron radiation on image quality and dose in mammography**	**Experiment number**: LS - 1249
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Report:

Introduction

The aim of the experiment was to extend the study of the effect of monochromatic x-ray beams on image quality and dose in a context of patient dose optimisation in the field of mammography. The high quality of the BM05 beam and its great coherence allowed us to continue the work previously done on ID17 (see experiment report LS-1240). The comparison of image quality and dose obtained with conventional mammography units and with synchrotron radiation have been performed for set-ups with and without tools to eliminate scatter (a grid for conventional units and a slit for synchrotron radiation). Furthermore, the study of the improvement of image quality with phase contrast has been continued and the results show great possibilities in this field in the future.

Materials and methods

Synchrotron set-up

The harmonics were rejected by slightly tuning the second crystal of the monochromator. The remaining harmonics were calculated for each energy used by measuring the effective energy of the beam. They were less than 1% in each case.

A tungsten slit was placed at the output of the beam. It was possible to define precisely the height of the slit between 50 µm to 1.5 mm. The images were obtained by scanning vertically the detector and the test object, which were separated (or not) by a copper slit of 12 cm width and 3 mm height to reduce scatter. In the phase contrast set-up, the in-line holography method was employed (Cloetens 1999), i.e. only a gap of about 1 meter was added between the detector and the test object (Fresnel zone – edge enhancement).

Phase contrast test objects

A first set of test objects was composed of two plates of 1 mm thickness containing sharp edges of 200 µm thickness. One of the test objects was composed of PMMA and the other of Teflon. After digitisation, an average profile of the edges was obtained and allowed to measure the edge enhancement by calculating the difference of maximum and minimum optical density.

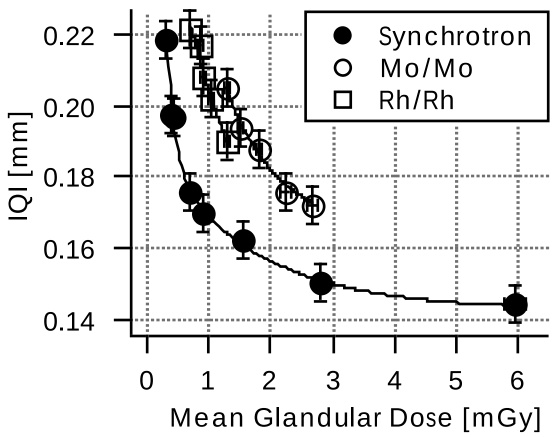
The second test object was a pork liver placed in a plastic box. It was about 8 cm thick.

Other materials and methods

Other useful information concerning this experiment can be found in the experiment report LS-1240 or in the following references: Moeckli 98 (digitisation); Bochud 97 and Desponds 91 (image quality); Hammerstein 79 and Desponds 91 (dose assessment); Moeckli 99 (test objects, material, experiment and results); Cloetens 99 (phase contrast).

Results of attenuation contrast imaging

The comparison between conventional units with (respectively without) an anti-scatter grid and synchrotron radiation with (resp. without) a copper slit is summarised in figure 1 (resp. in figure 2). It is clearly seen on figure 1 that the synchrotron set-up is better in any case than the conventional set-ups (the lower the IQI the better the image quality). Figure 2 shows that the difference between the two configurations is less important when the anti-scatter tools (grid or slit) are removed. The reason of that behaviour is probably that the transmission factor of the primary X-rays through a slit is almost 1 whereas the one through an anti-scatter grid in mammography is generally about 0.7 (Säbel 1996). Further measurements must be carried out in order to characterise clearly the different factors that define an anti-scatter tool.



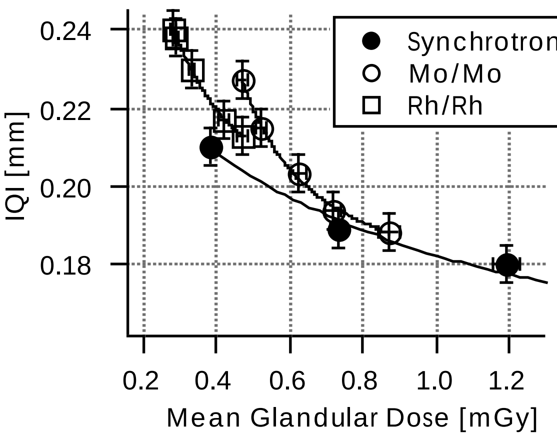
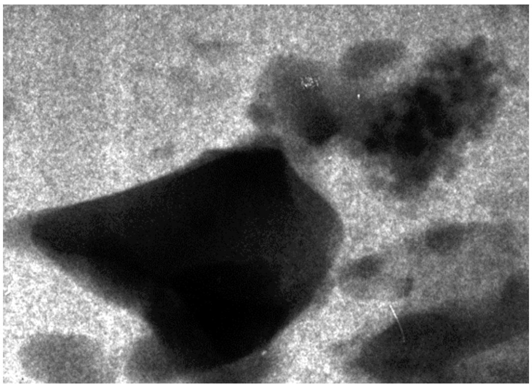


Figure 1: Comparison with an anti-scatter tool. Figure 2: comparison without the tool.

Results of phase contrast imaging

The improvement of phase contrast in a mammography set-up has been demonstrated for the gap and the energy variation. Nevertheless, many more measurements needs to be performed in order to obtain an objective assessment of image quality with phase contrast. The pork liver has been imaged at 18 keV without air gap (figure 3) or with an air gap of 1 metre (figure 4). The real images size are 9.5 mm x 13.2 mm. One can clearly see the improvement of the structures visibility due to the edge enhancement. It must be pointed out that these images have been obtained with the same dose.



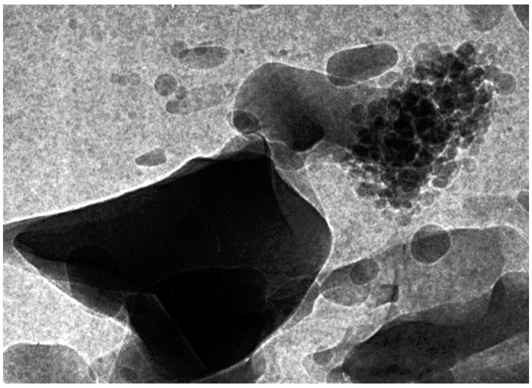


Figure 3: Image of a liver pork without phase contrast. Figure 4: Image of a liver pork with phase contrast.

Conclusion

The image quality - dose relationship is better for synchrotron radiation with a slit than for a conventional mammography unit with an anti-scatter grid, probably due to the fact that the slit has a higher primary transmission factor. Further measurements must be done in order to confirm these results.

Preliminary measurements of phase contrast imaging have been performed. A pork liver has been imaged with the in-line holography concept, showing the powerful possibilities of image quality enhancement with phase contrast imaging. Measurements must be done to obtain an objective description of phase contrast image quality.

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