ESRF	**Experiment title:** **Effect of synchrotron radiation on image quality and dose in mammography**	**Experiment number**: LS-1240
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Report:

Introduction

The aim of the experiment was to continue 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 quality of the beam has been greatly improved by the ID17 staff. Simultaneously, we have developed a method which allows to remove an important part of the local homogeneities due to phase contrast on the image. As a result, the objective evaluation of image quality became feasible. The results clearly demonstrate the advantage of a monochromatic synchrotron irradiation to a conventional spectrum in mammography.

Material and method

Test object and detector

The test object simulates an average dense breast of 50 mm thickness. Its surface is 12 x 15 cm^2 (Hessler 1985).The detector used was a Kodak MinR 2190 - MinR 2000 screen-film system.

Synchrotron set-up

The harmonics were rejected by means of a Platinum mirror (resulting in a harmonics percentage less than 1 %). The beam width was cm and its height was varied between 0.3 and 2 mm, depending on the energy used. The images were obtained by scanning vertically the detector and the test object, which were separated by a Copper slit of 12 cm width and 3 mm height to reduce scatter. The energy was varied between 18 and 22 keV.

Conventional mammography set-up

Conventional mammographic images were obtained on a CGR DMR unit which allowed the following radiation spectrum: Molybdenum anode with 30 µm Molybdenum and Rhodium anode with 25 µm Rhodium filtration. High voltage was varied between 24 and 32 kV. An antiscatter grid with a ratio of 5:1 was used.

Digitisation

The data needed for the objective assessment of image quality were obtained by digitising the films. The film digitiser used was a Tango unit developed by the firm Heidelberg (Heidelberg, Germany). A quality control program is applied, to guarantee a good stability of the scanning process (Moeckli 1998). In this study, the scanning resolution was set to 100 pixels per millimetre with an optical opening of 15.9 µm.

Image quality assessment

The image quality assessment of the films obtained with our test object is based on the statistical decision theory (Wagner 1985). It calculates the size of the smallest spherical microcalcification detectable with a 99.7 % confidence on the mammogram by a non-prewhitening matched filter observer (Bochud 1997). This quantity is given in millimetre and is called "Image Quality Index" (IQI) (Desponds 1991). According to its definition, the smaller the IQI computed, the better the image quality. The method consists to calculate the signal to noise ratio (SNR) by taking into account the shape of the object. In the Fourier space, the SNR is given by equation (1).where S(f) is the Fourier spectrum of a sphere, MTF(f) is the modulation transfer function of the system, W(f) is the Wiener spectrum of the image noise and C is the radiographic contrast. A threshold SNR value of 5.4 was used in the calculation of the sphere diameter.

Details concerning the measurement method of the image quality parameters have been published elsewhere (Bochud 1997, Desponds 1991).

A good correlation between the IQI and radiologists ranking has already been observed in a comparative study of mammographic screen film systems (Hessler 1985).

Dose measurements

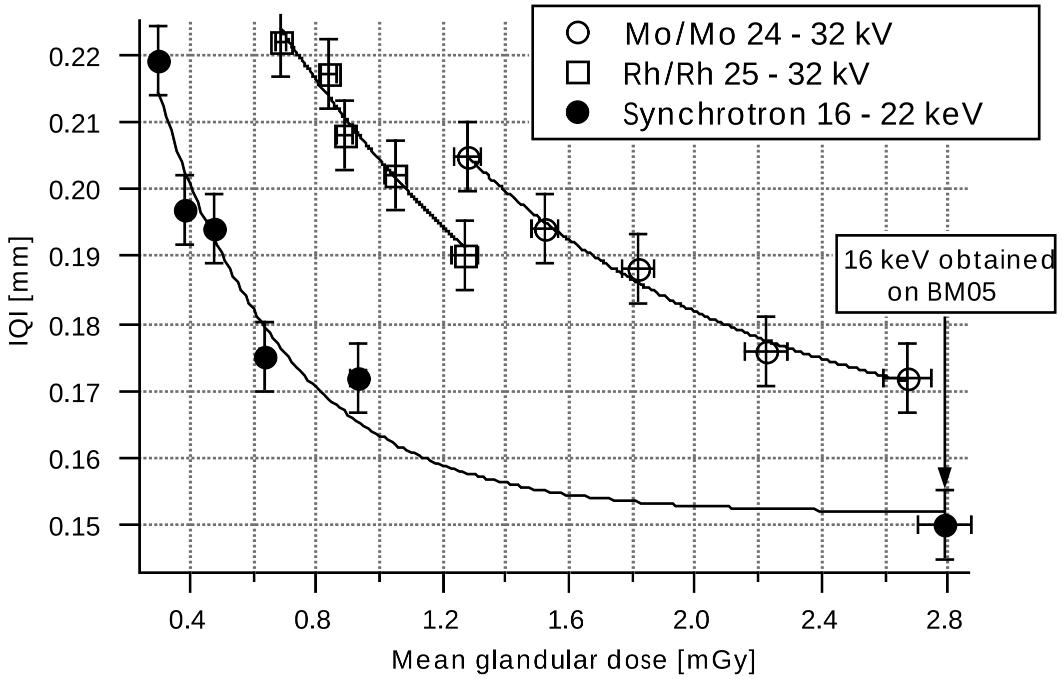
The doses have been measured with LiF thermoluminescent dosimeters (TLD) of 0.38 mm thickness. The measured dose was the mean glandular dose (MGD) which is the best indicator of risk in mammography (Hammerstein 1979). It is defined by equation (2) where D(x) is the dose at depth x, L is the breast thickness and a is the adipose thickness.

$$SNR = \frac{\sqrt{2\pi}\, C \int S^2(f) MTF^2(f) f\, df}{\sqrt{\int S^2(f) MTF^2(f) WS(f) f\, df}} \quad (1)$$

$$MGD = \frac{1}{L-2a} \int_a^{L-a} D(x)\, dx \quad (2)$$

Results and conclusion

The results obtained during this experiment are summarised in the following figure.



One can clearly see that the image quality is much better for the same dose when using synchrotron radiation. Conversely, the same image quality is obtained with much less dose when using synchrotron radiation. This behaviour seems to be due to the difference of scatter rejection between the two configurations. The scatter to primary ratio has to be measured in order to verify this assumption.

<u>These results demonstrate clearly the advantage of a synchrotron monochromatic beam to a conventional irradiation in mammography.</u>

References

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