ESRF	Experiment title: EFFECTIVE ATOMIC NUMBER IMAGING BY MEASUREMENT OF THE COHERENT-COMPTON RATIO	**Experiment number:** MI 113
Beamline: ID15 / BL25	**Date of experiment:** from: **04** June 1996 to: 07 June 1996	**Date of report:** **02** October 1996
Shifts: 12	**Local contact(s):** THOMAS TCHENTCHER	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Duvauchelle Philippe * INSA Lyon **CNDRI**
Zhu Pei * INSA Lyon **CNDRI**
Dupuis Olivier * INSA Lyon **CNDRI**
Kleuker Ulf * ESRF

Report:

Coherent-Compton ratio measurement allows to characterize industrial materials and body tissues. We propose to apply this technique to elaborate images of human brain where each point corresponds to the effective atomic number (Z_{eff}). To perform this measurement, we absolutely need a monochromatic beam because the coherent (Rayleigh) and Compton photons are discriminated by their energy. In addition, the photon flux must be very high (about 10^{10} photons. $s^{-1}.mm^{-2}$) to permit a low counting time and a good spatial resolution. The experiment, detained in the next paragraph, was realized on beamline ID 15 / BL 25.

The experiment

At first, we have to define the best experimental parameters. We have set incident beam energy at 60 keV because, for medical applications, this value is a good compromise between absorbed dose and attenuation. Concerning the measurement volume, it is defined as the intersection of incident and scattered beams. The spatial resolution depends directly of its dimensions. We have chosen slits of 1 millimeter width and height for both incident and scattered beam. This is the result of another compromise between resolution and acquisition time (5 seconds by point). Moreover, a lessening of these dimensions would imply also to decrease the scan step. Another parameter to set is the scattered angle. Figure 1 shows different spectra when the scattered angle varies. We have set this angle at 35° which is the best compromise between the magnitude and the separation of the two peaks. Concerning the sample, we use representative phantoms of human brain made up with polyethylene (PE) cylinders with nine drilled holes. Each hole contains a different concentration of the eight specific elements we planed to test (K, I, Ca, Zn, Al, Cu, Gd and Fe). A scan of this sample consists of two displacements : one along the X axis (35 points) and one rotation α (71 lines). Thus, a half turn of the phantom allows to measure the whole cylinder. To perform an image as we can see on figure 4, we have to compute, for each point of this image, the areas corresponding to Compton peak and Rayleigh peak from each spectrum, as these shown on figure 2. We also can see in figure 2, these areas varies in such a way that the ratio Rayleigh-Compton increases with concentration value.

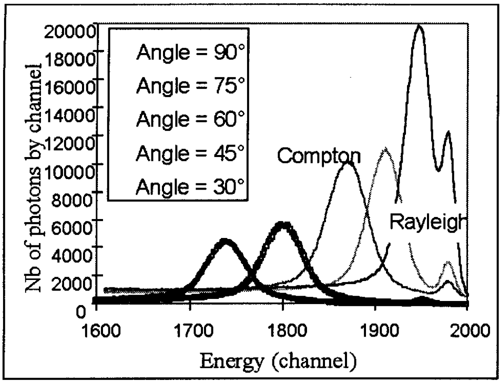

Fig. 1 : Spectra obtained for 5 scattered angles

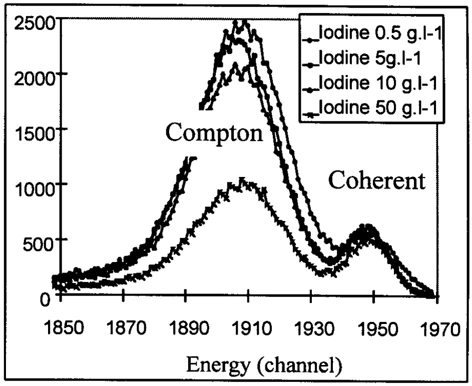

Fig. 2 : Spectra corresponding to 4 concentrations

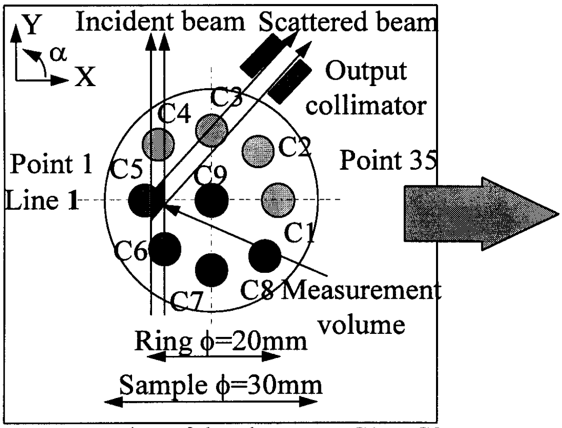

Fig. 3 : Cross section of the phantoms. C1 to C9 correspond to increasing concentrations

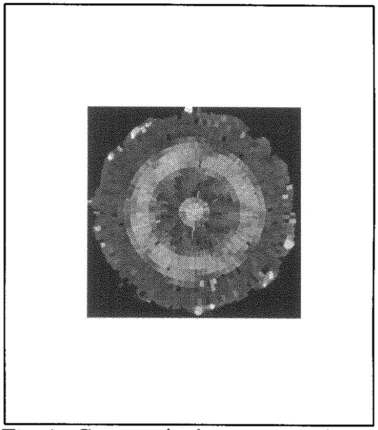

Fig 4 : Geometrical reconstruction. A high value of Z_{eff} correspond to a white area.

Discussion

The purpose of this first experiment is to show feasibility and capabilities of this technique. Even if we have to progress in different way these preliminary results (figures 2 and ***4) are very*** encouraging. As we could see on the image figure 4, the central hole (white area) is well seen but the other eight holes situates on the ring cannot be distinguished. To understand the problem, we can report to figure 3 where we can see the measurement volume over the sample. The spatial resolution is not the same along the two directions X and Y because of the geometry of the measurement volume. In particular, we can see that along Y axis, this volume stretches both in PE and in two neighboring holes, which leads to a blurred zone. However, we can see a difference between aqueous solutions and PE in spite of close values of the Z_{eff}.

Improvements

To increase the spatial resolution, we must reduce the slit on the output collimator in such a way to improve the spatial resolution along the Y axis. However, the scattered photon flux will be insufficient to preserve our measurement statistic for a counting time of 5 seconds by point. A solution consists to increase the beam height because the value of spatial resolution along Z axis is less critical than in the XY layer.

Future prospects

Beam time is required on ID15 / BL25 for the beginning of 1997, to perform new images with our new specific collimator recently machined (0.3 mm width x 6 mm height). Thus, we will reach a spatial resolution of 1 mm by 1 mm in the XY layer without changing counting time.