ESRF	Experiment title: EFFECTIVE ATOMIC NUMBER IMAGING BY MEASUREMENT OF THE COHERENT-COMPTON RATIO	**Experiment number:** MI 184
Beamline: ID15 / BL25	**Date of experiment:** from: 22 January 1997 to: 25 January 1996	**Date of report:** 20 June 1997
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Names and affiliations of applicants (* indicates experimentalists):

Duvauchelle Philippe * INSA Lyon CNDRI
Kaftandjian Valerie * INSA Lyon CNDRI
Cendre Emmanuelle * INSA Lyon CNDRI
Joly Alexandre * INSA Lyon CNDRI
Dupuis Olivier * INSA Lyon CNDRI
Peix Gilles * INSA Lyon CNDRI

Report:

Coherent-Compton ratio measurement allows to characterize materials by their effective atomic number (Z_{eff}). The applications concern industrial field (composite material) or medical field (soft tissues or bone). Our project applies this technique to the human brain imaging in order to establish a relation between presence of specific neurological elements and tumors appearance. The principle of this technique consists in counting photons which are scattered in a little volume of matter, in the direction θ from the incident beam. This volume, called measurement volume, is defined by the intersection of the incident and the scattered beams, obtained with two collimators. The photons are counted by a cooled germanium detector resolved in energy in order to separate the Compton photons from the Rayleigh ones. The Coherent-Compton ratio is a value only depending on the Z_{eff} . To perform this measurement, we need a high monochromatic photons flux. Imaging is possible if we move the measurement volume, point by point, throughout the sample or by using a multi point original technique. The experiment, detailled in the next paragraph, was realized on beamline ID15 / BL 25.

The experiment

The experimental conditions have been defined in the precedent experiment which was realized in june 1996 (MI1 13). The incident beam energy has been set at 60 keV. The scattered angle θ is set at 35” and the counting time at 5 seconds per point. The spatial resolution is defined by the collimators, specifically machined to reach a resolution of 1 mm^2 in the tomographic slice. The choice of all these parameters are the result of a compromise. The samples are made up with polyethylene (PE) cylinders with drilled holes. Each hole contains a concentration ranging from $0.5 g.l^{-1}$ to $50 g.l^{-1}$ of the eight specific elements we studied (K, I, Ca, Zn, Al, Cu, Gd, Fe). We have scanned these eight phantoms using a point by point acquisition mode, and another phantom, with three holes, using a multislits collimator. In the two cases, the grey level of a pixel is related to the quantitative value of Z_{eff} , with an accuracy better than 1.8%.

1. **Single slit collimator**

In this mode, the thickness of the slice is 2 mm. For each point of the scan, we acquire a spectrum which represents the number of photons detected as a function of their energy. After fitting by a gaussian function, we extract the Rayleigh and Compton components by measuring the areas of these two peaks (Fig. 1). Results concerning the R/C ratio variation versus Z_{eff} for nine different concentrations of zinc are shown in figure 3. On figure 2, we can see a Z_{eff} image obtained with a simple geometrical reconstruction.

2. **Multi slits collimator**

In this mode, the thickness of the slice is 0.3 mm for the same counting time. This original technique consists in replacing the one slit output collimator by a collimator with 28 parallel slits of 0.3 mm width. Thus, we acquire simultaneously data coming from the 28 measurement volumes along the incident beam. The counted photons on the detector correspond to the sum of the two kinds of photons scattered in the whole elementaries volumes. So, in order to perform an image, we have to reconstruct two sinograms where each point corresponds to the areas of the fitted spectra. A classical transmission tomography algorithm is. used to perform our reconstruction. Results are shown on figure 4.

Discussion

According to the images on figures 2 and 4, it is easy to see a difference between the PE cylinder and the differents holes even when the densities are very similar ($\approx$ 1%). In addition, even if it is not visible on the image in figure 2, it is possible to measure significant differences between holes as shown in figure 3. The multi slits acquisition mode is very interesting because, in these conditions, it is possible to decrease the counting time or the slice thickness without decreasing the measurement accuracy.

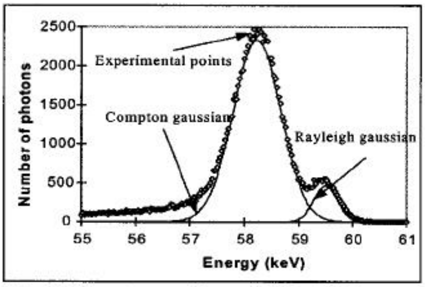

Fig 1. Spectrum of one point of a scan

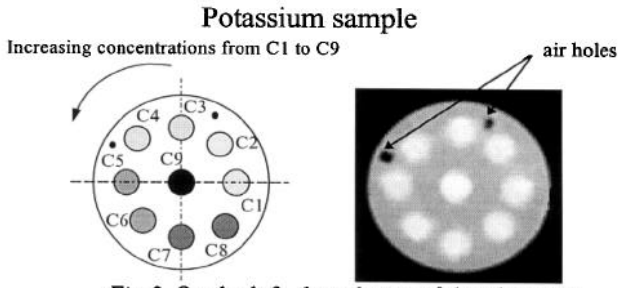

Fig 2. On the left, the scheme of the phantoms. On the right, the corresponding image

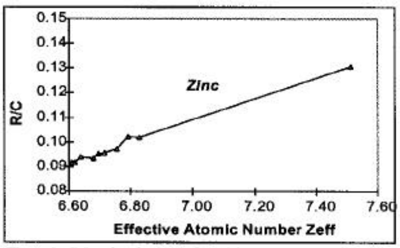

Fig 3. Variation of R/C as a function of Z_{eff}

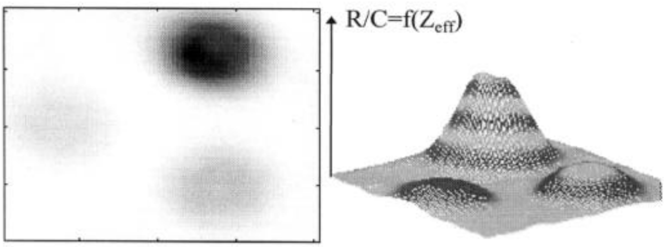

Fig 4. Image obtained with a multislits collimator. The phantom is a 3 drilled holes full of iodine solutions (0.5, 10, 50 $g.l^{-1}$). On the left, the image in grey levels. On the right, Z_{eff} is represented by the height of the curves.

Future prospects

We will test our technique on brain of little animals, in which we could inject tumors. These measurement will allow to characterize, in vivo, the capabilities of the coherent-Compton ratio method.