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DESENVOLVIMENTO DE UM SISTEMA TOMOGRÁFICO COMPUTADORIZADO APLICADO A ENSAIOS NÃO DESTRUTIVOS UTILIZANDO-SE ÉCRANS E CÂMERA CCD

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Considerando o elevado custo de um sistema multicanal de detecção de raios-X para um tomógrafo de terceira geração, foi construído um sistema tomográfico, aplicado a ensaios não destrutivos (END), o qual utiliza como detector de raios-X, uma câmera CCD,espelho e écran, e ainda, toda a parte de software computacional envolvida na aquisição de dados e reconstrução das imagens. O sistema de detecção consiste em um écran de filme radiográfico [1] da Kodak (sua finalidade é converter raios-X em luz visível), colado na parede interna de uma caixa escura,um espelho com alta reflexividade colocado a 45^0 em relação à base da caixa e uma camera CCD com lente convergente de 4mm, da Pacific Corporation, modelo VPC510 B/W 12V 200mA montada no topo da caixa protegida com chumbo (conforme ilustrção) devido a incidência direta de raios-X o que poderia danificar a camera. Os raios-X incidem sobre o écran, que emite luz em direção ao espelho e por reflexão à camera CCD, sendo o sinal captado por uma placa de aquisição (pixel-view). O espelho tem dupla finalidade:a de direcionar a luz emitida pelo écran para a camera CCD e eliminar os raios-X resultantes da não interação com o écran radiográfico o que poderia danificar a camera. Realizam-se diversas projeções e em seguida reconstrói-se a imagem através de um programa escrito em linguagem C++ utilizando-se como algoritmo o método das retroprojeções filtradas [2]. As projeções são efetuadas por uma mesa giratória com um motor de passo [3] controlado por um circuito eletronico (interface) ligado a um computador comum tipo PC. São realizadas 90 projeções sendo que a mesa efetua 2 graus por projeção. A fonte de raios-X possui feixe em cone colimado o qual permite obter-se diversas fatias tomográficas, sendo possível posteriormente a reconstrução 3D das imagens. A tensão utilizada no tubo de raios-X é de 80 kV e a corrente de 7 mA. Este projeto foi financiado em parte pelo CNPq, FINEP e PETROBRAS.

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$\gamma\gamma$ angular correlation experiments performed with a multi-detector system

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$\gamma\gamma$ angular correlations performed in systems composed by various detectors needs different solid angle corrections for each independent pair of detectors. The fit of the angular correlation function depends on other two main points, which are (1) the combined efficiencies of the independent detector pairs and the (2) effects the fast electronics has on these efficiencies, mainly due to the energy resolution of the fast amplifiers and on the behavior of the logic circuitry. We present here a way to treat the problem, that allows the determination of the nuclear properties usually produced in such experiments. The use of a multi-detector system, where a number n of detectors results on $n(n-1)/2$ independent detector pairs, represents an important improvement in the measuring time, over systems with only two detectors, one of them movable over the angular range. The time reduction factor is the number of independent pairs. We must choose the angles in order to minimize ambiguities, since the correlation function (when no polarization observables are measured) is usually expanded in Legendre polynomials of even order in $\cos\theta$. This produces a function with period π, also showing reflection symmetry around its half-period.

$\pi/2$. For instance, the setup presently under use at the Linear Accelerator Laboratory of IFUSP is composed by four Ge detectors of volumes ranging from 50 up to 150 cm^3 at the following positions: $\pi/6$, $\pi/2$, π and $3\pi/2$. The angles between independent pairs are, respectively, $\pi/3$, $5\pi/6$, $4\pi/3$, $\pi/2$, π and $\pi/2$. Due to the correlation function properties, we actually have the angles (in the second quadrant): $\pi/2$ (twice), $2\pi/3$ (twice), $5\pi/6$ and π. This choice is enough to produce a detailed angular correlation function. The differences in the efficiencies affect the data in such a way that they do not form a set joined by a smooth function of the angles. The usual function is $W(\phi) = \sum_{k \text{par} \geq 0} A_{kk} P_k(\cos\phi)$ where $W(\phi)$ is the angular correlation between two γ radiations emitted by the nucleus on a fast succession, forming the angle ϕ between them. The $A_{kk}$are the correlation coefficients. associated to the Legendre polynomials of order k, $P_k(\cos\phi)$. $W(\phi)$ is normalized such that $A_{00} = 1$ and $dP(\phi) = W(\phi)\frac{d\Omega_1}{4\pi}\frac{d\Omega_2}{4\pi}$ is the emission probability of the pair $\gamma_1\gamma_2$ inside $d\Omega_1$ and $d\Omega_2$ respectively, whose axes make the angle ϕ. When we extend the calculation to a real situation, with finite detector sizes, the result is

$$N_{[\mathsf{ab}]}(\theta) = C_{[\mathsf{ab}]}\left\{1 + \sum_{k_{\text{par}}=2}^{4} A_{kk} Q_{kk}^{[\mathsf{ab}]} P_k(\cos\theta)\right\}$$

where N is the number of coincidences registered between the detectors a and b, and the symbol [ab] means that the two independent data sets were summed up, in the manner of Camp and van Lehn [1]. $Q_{kk}^{[\mathsf{ab}]}$ are the solid angle correction coefficients, calculated as in [1]. The normalization constant $C_{[\mathsf{ab}]}$ also depends on the particular pair of detectors, through their efficiencies. We propose the following theoretical function to be fitted to the data

$$\boldsymbol{W}_{\text{theo}} = C_0 \epsilon \cdot \mathbf{R} \cdot \mathbf{X}$$

where C_0 is the universal part of $C_{[\mathsf{ab}]}$, which will be fitted, and the diagonal matrix ϵ is composed by sums of bilinear combinations of the detection efficiencies of each detector pair. The matrix $\mathbf{R}$ contains products of $Q_{kk}^{[\mathsf{ab}]} P_k(\cos\theta)$ and the column-vector $\mathbf{X}$ contains the multipole mixing ratios of the two transitions under study, in the A_{kk} form.

The minimization procedure is a covariant one, $\chi^2 = \mathbf{\Delta}^t \mathbf{M}^{-1} \mathbf{\Delta}$ where $\mathbf{\Delta}$ is the difference column-vector $\mathbf{\Delta} = \boldsymbol{W}_{\text{exp}} - \boldsymbol{W}_{\text{theo}}$ where $\boldsymbol{W}_{\text{exp}}$ are the counts obtained and $\mathbf{M}$ is the complete covariance matrix of the problem. $\mathbf{M}$ is composed by two pieces, one coming from the data and the from the efficiencies, $\mathbf{M} = \mathbf{M}_{\text{exp}} + \mathbf{M}_\epsilon$. Tests were made by fitting angular correlation data from the decay of ^{193}Os. The authors acknowledge support of FAPESP and CNPq.

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The Mathematical Model of Gammographic Study for FCC Riser

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The Fluid Catalytic Decomposition (Craqueamento Catalíco Fluído - FCC) is a very promising way of fuel production, which industrial application is under development now in Brazil. This process is going under the initial conditions of high temperature and pressure of all ingredients, injected into the Riser Column of FCC. The speed of fluid motions through the reaction area is extremely high too (up to 7 - 8 m/s). Thus, the direct diagnostics of the spatial distribution for the FCC parameters along the reaction volume is connected with some significant troubles.

One of the indirect methods usually used to do FCC diagnostics is the γ-ray tomography. However, this method has some principal limitations, mainly due to the small density of fluid in the central part of the reaction volume in comparison with the steel of thick Riser Column walls. The preliminary computer modeling of the diagnostic process permits to analyze these limitations and to chose the optimal properties of the γ-source and detector with the aim to achieve the maximum spatial and density resolution during reasonable data collecting time, which is supposed to be of the order of minutes.

The mathematical model of γ-ray tomography scanning for a FCC Riser had been worked out and the corresponded software was elaborated. The computer code permits to simulate the 2D Riser Column cross-section image for various geometry of the γ-ray source and detector collimators, various energies of γ-rays and various