World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:6, No:3, 2012

Alignment of Emission Gamma Ray Sources with Nai(Ti) Scintillation Detectors by Two Laser Beams to Pre-Operation using Alternating Minimization Technique

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***Abstract*—**Accurate timing alignment and stability is important to maximize the true counts and minimize the random counts in positron emission tomography So signals output from detectors must be centering with the two isotopes to pre-operation and fed signals into four units of pulse-processing units, each unit can accept up to eight inputs. The dual source computed tomography consist two units on the left for 15 detector signals of Cs-137 isotope and two units on the right are for 15 detectors signals of Co-60 isotope. The gamma spectrum consisting of either single or multiple photo peaks. This allows for the use of energy discrimination electronic hardware associated with the data acquisition system to acquire photon counts data with a specific energy, even if poor energy resolution detectors are used. This also helps to avoid counting of the Compton scatter counts especially if a single discrete gamma photo peak is emitted by the source as in the case of Cs-137. In this study the polyenergetic version of the alternating minimization algorithm is applied to the dual energy gamma computed tomography problem.

***Keywords*—**Alignment, Spectrum, Laser, Detectors, Image

I. INTRODUCTION

THE alignment between the radiation source and detecting devices is critical in gamma ray imaging [1] and 2] .Several techniques for alignment using lasers and other methods have been devised [3], such as the combination of a laser projector and reflectors to indicate the correct relative position between the subject, the detector, and the x-ray beam, the combination of laser positioning and pinhole focal-spot radiography to provide precise alignment , the use of a single laser that points to the focal spot position to help the a lignment of an x-ray spectrometer [4] . Other methods that provides two coinciding laser beams. The advantage of the two laser configuration is that it provides a highly accurate method to form a visible indicator of the incident ray from both directions. The alignment process of the target for imaging system by [5]. Alternating minimization technique used based on a statistical model for measuring gamma ray counts data. The reconstruction problem is formulated as an optimization problem in statistical estimation theory [6] and [7] .Many image reconstruction algorithms tomography for medical imaging have been developed that model the polyenergetic nature, there by capturing the physics of the transmission process.

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The prime motivation for a model that accounts for the energy of the photons is to reduce beam hardening artifacts that occur in the reconstructed images when a monoenergetic (ME) model is used for spectrum. This artifact appears especially if the domain has high attenuating materials like bone or metallic implants that are typical in medical imaging.

The polyenergetic algorithm applied that it accounts for the energy of the gamma photons by scintillation detectors. Ascintillator is material which exhibits scintillation which is the property of luminescence [8] .When excited by ionizing radiation, luminescent materials when struck by an incoming particle absorb its energy and scintillate or reemit the absorbed energy in the form of light [4].

Sometimes, the excited state is metastable, so the relaxation back out of the excited state is delayed depending on the type of transition and the wavelength of the emitted optical photon [9]. A scintillation detector or scintillation counter is obtained when a scintillator is coupled to an electronic light sensor such as a photomultiplier tube or a photodiode. photomultiplier tube absorb the light emitted by the scintillator and reemit it in the form of electrons via the photoelectric effect. The multiplication of electrons results in an electrical pulse which can then be analyzed and yield meaningful information about the particle that originally struck the scintillator.

II. THE ALIGNMENT PROCEDURE BASED ON LASER BEAM POSITIONING DEVICE

In the dual tomography, there are 30 detectors being used, 15 detectors are set up to detect Cs-137 activity of 100mCi and 15 detectors are to detect Co-60 with 50mCi. In transmission measurement geometry, the arrangements of the detectors are made such that they form two sets of curved detector arrays. With this arrangement, it is expected that the dual source computed tomography could perform CT scan for an 18 inch column. For smaller columns sizes like 10- 12 inch may need 9 or 11 detectors. Equal number of detectors should be taken out from left side and right side so as to keep the fan beam measurement. With odd number of detectors, it is convenient to identify the center of detectors that is directly opposite to source point. Accurate timing alignment is important to maximize the true counts.

In spectral measurements, The two collimators are commonly used to limit the flux of the incident gamma ray .In the spectral experiments performed in this study, NaI(TI) was employed. The alignment of the two collimators and detectors with respect to the direction of the incident beam remains a difficult task. This is due to the fact that the two collimators must be aligned concentrically with respect to each other, as well as the direction of the incident beam, in order to reduce the beam filtration .By using laser alignment approach, this problem could be adequately solved. Laser beam utilized as a visible substitute for the incident gamma ray beam in the spectral measurements. See Figures 2 and 3. So precise alignment is essential in certain measurements and imaging tasks, although it often requires arduous efforts and is therefore very time consuming. In order to ease the difficulty and to improve the accuracy of the alignment tasks, laser pointer used to establish a visible indicator of the incident gamma ray beam. During the alignment process, the laser facing the gamma ray source, The laser beam constantly pointed towards the output window of the gamma ray tube when the position of the laser was adjusted along the optical rail. This verified that the laser beam was parallel to the direction along which the components were positioned, which was the direction of the supporting optical rail, see Figures 1 and 2.

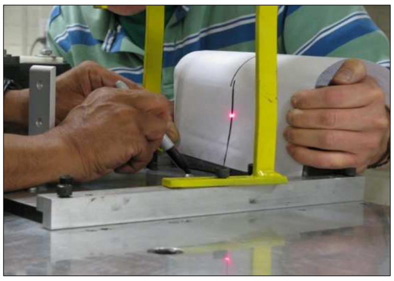


Fig. 1 Laser beam adjustment with collimator device

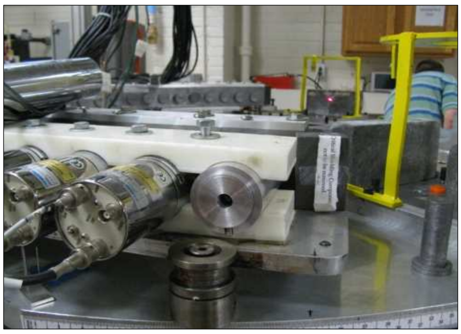


Fig. 2 Arrangement of laser beam system through adjustment with other detectors of tomography unit

III. Results

A. Alignment position between source and detector

Good alignment produces good spectrum ,so from the excel sheet we need range of the energies at which the peaks of cesium and cobalt exist, these energies are needed as input in the scan program called (biomass). Cesium sheet consisting of 3 columns because of one peak detected, while cobalt sheet consisting four columns because of the two peaks detection. The spectrum of good and bad alignment, see Figures 3 and 4. The spectrum of Figures 3 and 4 indicates the following peaks , a- Low energy of radiation due to internal conversion of the gamma ray, b- Backscatter at the low energy end of the compton distribution, the compton interaction is a pure kinematic collision between gamma ray photon and a free electron in the NaI(Tl) crystal. By this process, the incident gamma ray gives up only part of its energy to the electron. The amount given to recoil electron depends on whether the collison is head on or glancing. For a head on collision, the gamma ray imparts the maximum allowable energy for the compton interaction . c- Photopeak at an energy of 662 keV .

B. Imaging of sonogram after and before alignment

The aim of centering is to ensure detectors are well aligned to the collimated source point. Firstly, remove the first and last detectors like, Detector #1 and Detector #15 and replace it with two units of highly directed laser. The laser device is placed in an aluminum holder that has the same dimensions as the detector, which can easily replace the detector position. In a perfectly aligned source-detector positions, the two beams from the two lasers should overlap flawlessly on the source point. Adjust projection plate position by hand-adjustment of horizontal ball screw so that beams align.

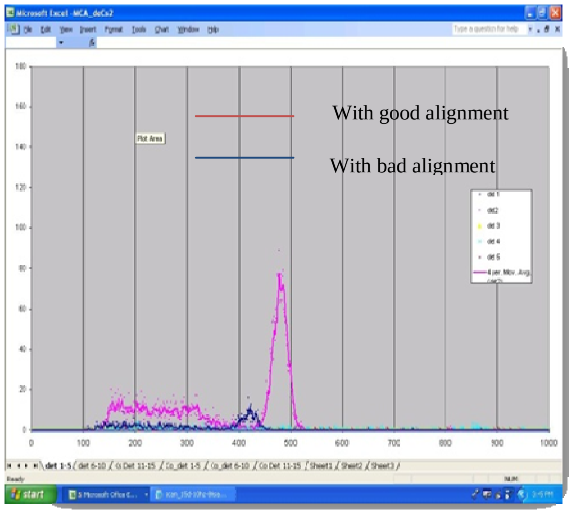


Fig. 3 Gamma ray spectrum measured with NaI (TI) detector at a good alignment position of tungsten collimator compared with the spectrum obtained with a collimator tilted away from the good alignment position

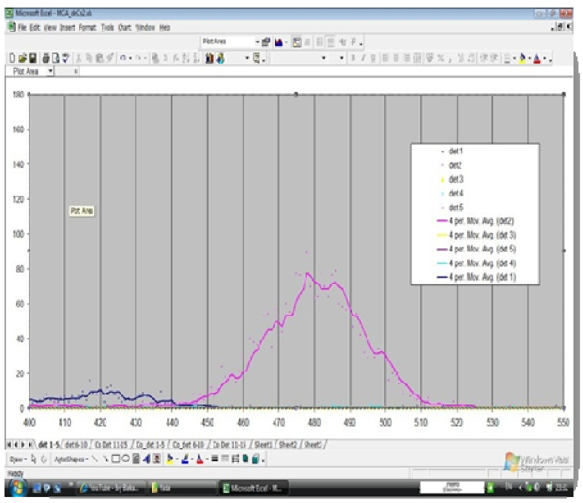
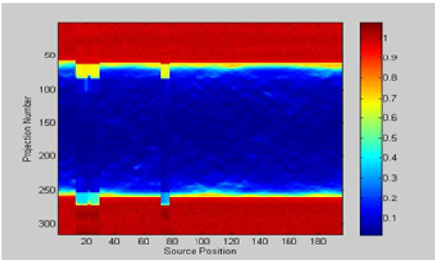
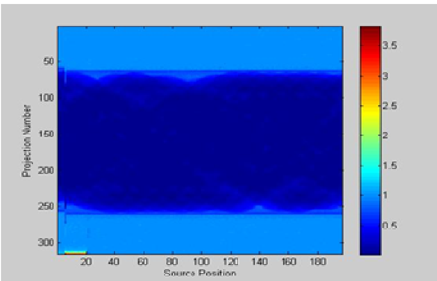


Fig. 4 Spectrum obtained or isotope Cs-137 with another position of alignment

When completed, make visible markings so that the source device collimator could be placed in and out with ease at the calibrated line point. Laser device is Class of IIIA type. Data taken by detectors after alignment transfer to analyze by MATlab prog .The results indicate that for the same transmission data, the polyenergetic approach gives far superior results to the monoenergetic approach. The monoenergetic approach is sensitive because of the attenuation of the materials at the gamma ray photon energies. The polyenergetic approach based on the alternating minimization technique shows promising potential for determining the phase holdup using dual source gamma ray tomography .Image of sonogram for pebblebed reactor with 1ft heigt and 12in diameter after 500 iterations with Hz = 5, Marbles diam=2in .Senogram image after and before alignment , see Figure 5, a and b.



a- Image of senogram beforer alignment



b- Image of senogram after alignment

Fig. 5 Image of senogram after and before aligment

IV. Conclusion

This paper reports a convenient laser alignment by which the positioning of the imaging can be achieved. The laser was positioned a distance from the source with its beam adjusted to constantly point towards the output collimator window of gamma ray source and parallel to the direction along which the components are placed. The main advantage of the this alignment was illustrated in gamma ray spectral measurements in which the two collimators of sources and the detectors could be conveniently aligned with respect to the direction of incident gamma ray based on the laser beam. The alignment process is suitable for facilitating accurate image acquisition , as it provides a simple method for ensuring the alignment of various components with respect to the direction of gamma ray. After alignment , senogram image generated by using the alternating minimization technique .For materials with high attenuation ,the alternating minimization algorithm is more stable and produces senogram image that have a greater degree of accuracy and lower levels of noise.

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