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MONTE-CARLO SIMULATION OF *VOLUCAM*, A NEW 3D TOF-PET CAMERA: A SENSITIVITY STUDY.

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VOLUCAM, is a new 3D Time Of Flight (TOF) Positron Emission Tomograph (PET) under investigation at LETI. As an aid to design this PET camera we developed a Monte Carlo simulation to study its sensitivity performances.

Our simulation program is based on ITS 3.0, a general coupled electron-photon transport code, that we adapted to obtain the results specific of our PET design. The simulation follows each gamma ray, from creation in the phantom to detection in crystals or final escape by scoring every interaction, either in the phantom or in the crystals. The simulation stops in the crystals, so effects of photomultipliers (PMT) are not included.

ITS original file has been transformed to describe the contemplated geometry of our PET camera. The model includes the following elements:
the phantom is a sphere of 20 cm diameter, filled with water.
two opposite crystals, the shape and material of wich are freely choosen by the user.
the drift space between the two crystals is supposed to be void of air.

Sensitivity has been studied with respect to the energy threshold and geometrical parameters: shape and area of detection, distance between the two opposite crystals. Every simulation is the result of 400,000 annihilations and is performed with 25 mm deep cesium fluoride (CsF) crystals.

We have tested two opposite crystals 90 cm apart, of a constant area of 600 cm^2 and of different shapes: a square and 3 rectangulars having respectively a width-to-lengh ratio of 0.84, 0.67, 0.50. Results are very close for the 3 first shapes, but sensitivity of the last shape is about 15% lower, both for the unscattered and scattered coincidences. Then, following results will always deal only with the 3 first shapes.

We have simulated 10 areas of detection from 150 to 1350 cm^2 with every combination of distance between crystals and energy threshold corresponding to the following values:
distance (cm): 60, 70, 80, 90.
energy threshold (keV): 0, 150, 250, 350.

Results are qualitatively very similar in every of those cases. Single events rate varies linearly with respect to the area; coincidence events rate, both true and scattered, varies as a 2nd degree polynomia. As an example Fig. 1 & 2 plot the case of an energy threshold of 350 keV and a distance between crystals of 90 cm. With an area of detection of 600 cm^2, we obtain a scatter fraction {Scatter / (Scatter + True)} of 18%. Assuming a timing coincidence window τ of 5 ns and calculating Randoms as $Singles^2 . \tau$, we obtain a random fraction {Random / (Scatter + True)} of 11%.

For every test, the reduction of counts due to the energy threshold is strictly independant from the geometrical parameters. On the contrary scatter fraction, as a function of the energy threshold depends strongly on the geometrical parameters.

We have developed a Monte-Carlo simulation as a design tool for PET. First results provide qualitative informations on the effects of geometrical parameters in connection with the energy threshold. We plan to continue this study of sensitivity by including in the simulation both the effects of PMT and those of septa designed to reduce the angular acceptance. We are also working on a spatial resolution simulation in order to generalize our program.

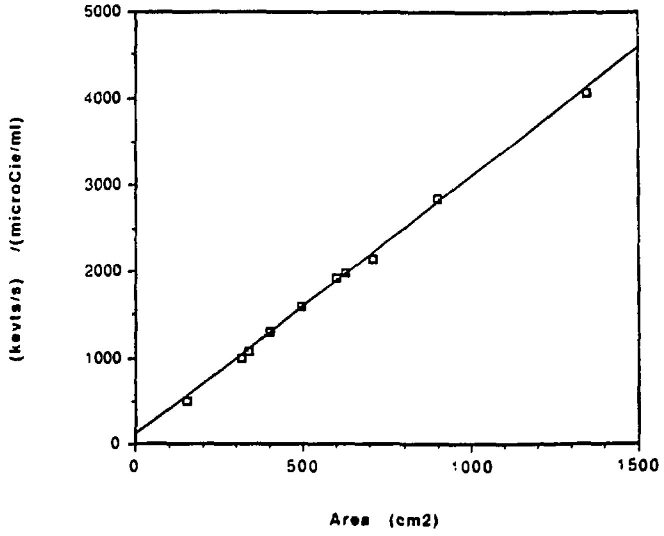

Figure 1: Single counts.
Threshold = 350 keV. Distance = 90 cm.

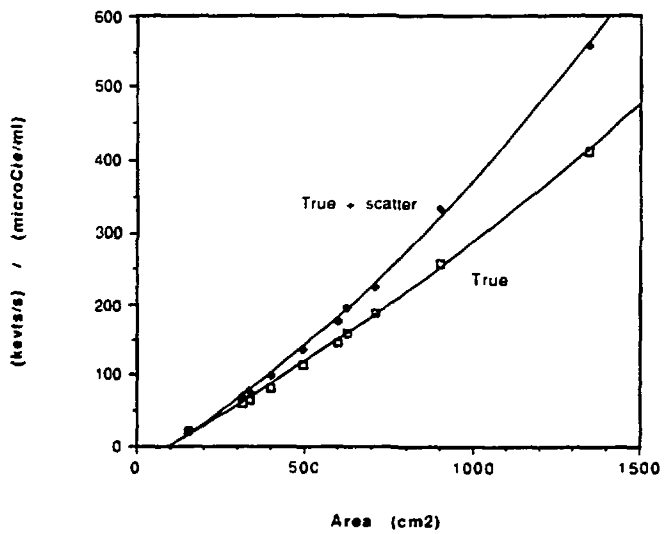

Figure 2: Coincidence counts.
Threshold = 350 keV. Distance = 90 cm.