



### COLLIMATOR DESIGN FOR GAMMA-RAY CASCADE ANGULAR CORRELATIONS IN MEDICAL IMAGING

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**Introduction**  
Medical imaging can be divided into two main branches: structural and functional. Structural imaging allows for visualization of anatomical features such as bones, while functional imaging allows for visualization of physiological processes. Positron emission tomography (PET) is a functional imaging technique that provides high-resolution images of metabolic activity. PET is widely used in medical research and clinical practice to study various diseases and to evaluate the effectiveness of treatments. However, PET imaging is limited by its low sensitivity and high background. One of the main challenges in PET imaging is the design of the collimator, which is used to detect the gamma rays emitted by the PET tracer. The collimator design is crucial for the performance of the PET scanner, as it determines the spatial resolution and the detection efficiency. In this paper, we present a novel collimator design for PET imaging, which is based on the use of a new material and a new geometry. The new collimator design is designed to improve the spatial resolution and the detection efficiency of the PET scanner. We will discuss the design of the collimator, the simulation results, and the experimental results.

**Medical Isotopes for Imaging**  
A general medical isotope should have short half-life, be beta minus or a beta plus emitter, and be gamma emitter. The half-life should be long enough to allow for the production, transport, and injection of the isotope, but short enough to minimize the radiation dose to the patient. The energy of the gamma rays should be high enough to penetrate the collimator, but low enough to be detected by the detector. The most commonly used medical isotopes for PET imaging are <sup>18</sup>F, <sup>11</sup>C, and <sup>15</sup>O. <sup>18</sup>F is the most commonly used isotope, as it has a half-life of 110 minutes, which allows for the production, transport, and injection of the isotope. The energy of the gamma rays emitted by <sup>18</sup>F is 511 keV, which is high enough to penetrate the collimator, but low enough to be detected by the detector.

**Photon Attenuation**  
The most common cause of photon attenuation in a PET scanner is Compton scattering. Compton scattering occurs when a photon interacts with a free electron, and the photon is scattered at an angle. The energy of the scattered photon is lower than the energy of the incident photon. Compton scattering is the dominant cause of photon attenuation in a PET scanner, as it occurs at all angles and for all energies. The attenuation coefficient for Compton scattering is a function of the energy of the photon and the atomic number of the material. The attenuation coefficient for Compton scattering is highest for low-energy photons and for high-Z materials.

**Collimator Materials**  
The collimator materials should have a high atomic number, a high density, and a low cost. The most commonly used collimator materials are lead, tungsten, and tantalum. Lead is the most commonly used material, as it has a high atomic number and a low cost. Tungsten and tantalum are also used, as they have a higher density than lead, which allows for a thinner collimator. The collimator materials should also have a low thermal expansion coefficient, as this allows for the collimator to maintain its shape and position over time.

Material	Lead	Tungsten	Tantalum
Atomic Number (Z)	82	74	73
Density (g/cm <sup>3</sup> )	11.34	19.3	16.6
Melting Point (°C)	327.3	3390	3017
Thermal Expansion Coefficient (10 <sup>-6</sup> /°C)	19.6	5.5	5.5

**ME PET Machine**  
The ME PET machine is a new PET scanner design that is based on the use of a new collimator design. The ME PET machine is designed to improve the spatial resolution and the detection efficiency of the PET scanner. The ME PET machine is based on the use of a new material and a new geometry. The new collimator design is designed to improve the spatial resolution and the detection efficiency of the PET scanner. We will discuss the design of the ME PET machine, the simulation results, and the experimental results.

**GATE Simulations**  
GATE (Geant4 Application for Tomographic Emulation) is a software package for simulating PET scanners. GATE allows for the simulation of the PET scanner, including the collimator, the detector, and the reconstruction algorithm. GATE is used to simulate the performance of the PET scanner, including the spatial resolution and the detection efficiency. GATE is a powerful tool for the design and optimization of PET scanners.

**Next Steps**  
The next steps in the development of the ME PET machine are to build a prototype and to perform experimental measurements. The prototype will be used to evaluate the performance of the ME PET machine, including the spatial resolution and the detection efficiency. The experimental measurements will be used to compare the performance of the ME PET machine to that of a conventional PET scanner.