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Design of a charge sensitive spectroscopy amplifier for Compton camera

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Synopsis A charge sensitive spectroscopy amplifier has been designed to couple with the silicon strip detector of a Compton camera. The amplifier was optimized by using a wave form generator and the output gain of 10^{12}V/C was achieved when the shaping time is 1μs.

Compton camera is widely used in the radiology and radiation therapy for online dose control and high resolved 3D image reconstruction [1]. A typical Compton imaging system is composed of two detectors where a double-sided silicon strip detector closest to the source of radiation is denoted as the scatterer and a scintillator is absorber. In this system, the incident γ-ray with energy of $h\upsilon$ will ideally Compton scatter from an orbital electron in the scatterer, transferring a fraction of its kinetic energy E, and then the scatted γ-ray interact via photoelectric absorption in the absorber, depositing its remaining energy. The scattering angle θ of the incident ray depends on E and $h\upsilon$, and

$$\cos\theta = 1 - \frac{E m_e c^2}{h\upsilon(h\upsilon - E)}$$

where $m_e c^2$ is the rest mass energy of the electron, $h\upsilon$ is assumed to be known and E is measured value [1].

Usually, the performance of a Compton camera is evaluated based on spatial, energy and time resolution of the SSD and a previous work showed that integrating the electronics into a detector is an optimal method for noise reduction and resolution improvement [2]. In this abstract, we present a low noise spectroscopy amplifier which could be integrated into the SSD.

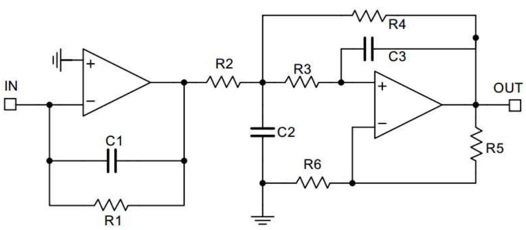

Figure 1. Logic diagram of the spectroscopy.

As shown in figure 1, the amplifier includes a charge sensitive pre-amplifier followed by a two stage Bessel low pass active filter in a multi-feedback topology as the pulse shaper.

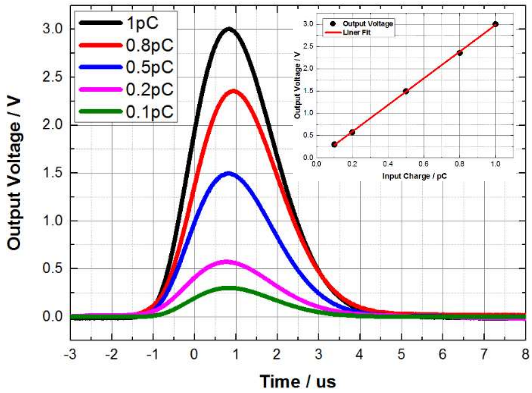

Figure 2. Output signal of the amplifier stimulated by an Agilent 81150A waveform generator.

A wave form generator is employed to simulate the signal from the SSD which enables us to optimize the amplifier. As can be seen from figure 2, the output amplitude is about 3 V when the input charge is 1 pC, which means the gain of the amplifier is about 3×10^{12} V/C. The shaping time is about 1 μs and the full width of the output is about 5 μs, which allows a count rate as high as 25 kHz with a tolerance of 10% pile up. As shown in the inset in figure 2, the output integral nonlinearity of the amplifier is evaluated within 0.3% when the range of input charge is from 0.1 pC to 1 pC, respectively.

The present design will be utilized in a Compton camera which is under construction in Institute of Modern Physics, Chinese Academy of Sciences.

References

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