The recently developed Silicon PhotoMultiplier (SiPM) is a solid state photon detector operating in the Geiger mode. Due to avalanche nature of its signal, it has a fast response time; this makes it an ideal candidate for use in fast Time-Of-Flight (TOF) applications. This work is aimed at the application of TOF to medical imaging. In this study we characterised SiPMs from three manufacturers: breakdown voltages, dark count rates, rise times of dark noise signals and signal in response to light sources were measured. Two-channel demonstrators were built coupling SiPMs to LaBr_3(Ce) and LYSO crystals and their time performances were studied. The best timing resolution was measured to be 298ps (σ).

1. The system

2. 1-V curves and breakdown voltages

Breakdown voltages were calculated for all SiPMs. These breakdown voltages were found to be in the range 1.0-2.0V below the operating point (V_{break}) recommended by the manufacturers.

3. The dark noise

4. Rise time studies

Timing resolution studies of two-channel demonstrators: $^{22}$Na source.

5. Timing resolution studies for two-channel demonstrators

Output signals of three different two-channel demonstrators, clearly showing the 511 keV peaks from $^{22}$Na.

6. Conclusions and future work

A preliminary characterisation of SiPMs was carried out using a simple data acquisition system based on a fast oscilloscope. Breakdown voltages, dark count rates and signal rise times were measured for all SiPMs. The timing resolutions of two-channel demonstrators were measured and the best one was found to be 298ps (σ). This preliminary result is comparable to other ones reported in literature. Based on our results we identified our system limitation in the read-out electronics, which we are in the process of upgrading. We are expecting further improvements in the timing performances with properly engineered two-channel demonstrator systems and set-ups.

Plan for future work:

- Acquire faster pre-amplifiers for the Hamamatsu 1x1mm$^2$ 50µm and Hamamatsu 3x3mm$^2$ 50µm SiPMs that are better matched to their capacitance and repeat measurements with these devices.
- Investigate the effects on the timing resolution of the crystal size and of the Ce concentration in the case of LaBr_3(Ce).