Plasma Diagnostics

Evaluating expected signal loss due to SiPM saturation for short, low flux light pulses in tapered light pipe systems

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In many applications, silicon photomultiplier (SiMP) detectors have come to replace photomultiplier tubes (PMTs) due to numerous advantages in scale and operation. There is, however, a concern with SiPMs, which did not affect PMTs, that an illumination from a short light pulse, heavily localised on a detector surface, can lead to the signal response to incoming photons becoming non-linear. This is caused by each detector microcell having a finite recovery time between responses. Raytracing techniques were used to investigate whether tapered light pipe systems produce this type of illumination from input light pulses that are Lambertian and special uniform. Signal losses due to this effect were found to be negligible, making this an unimportant effect to consider when designing light pipe systems. Limited tests were also carried out with Lambertian light sources originating from a single point, which produced similar results; however, non-Lambertian sources may produce different results.

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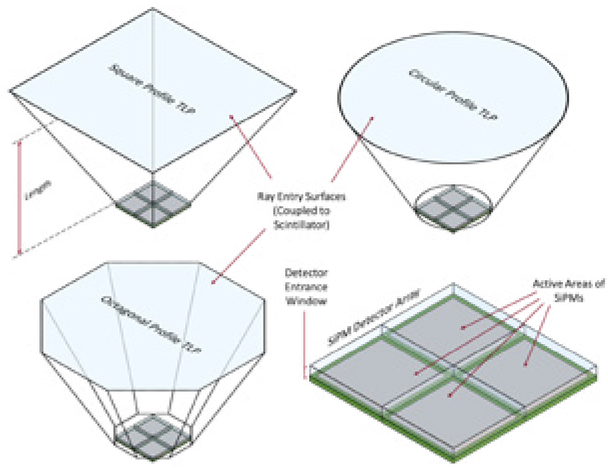

Schematics of the detector and tapered light pipes that were investigated; the detector was modelled as a 2 × 2 array of KETEK PM3325-WB-D0 SiPMs.

Investigating Contrast, Resolution and Field-of-View of the Questar QM-1 SZ Tele-Microscope

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Current imaging diagnostics used in high power laser facilities, such as Vulcan, can be limited by space, resolution, field-of-view or all three. An alternative imaging solution is the tele-microscope, which is able to image at high magnification while being located outside of the target chamber, thereby allowing more space in the chamber for other diagnostics. This paper presents the characterisation of the Questar QM-1 SZ tele-microscope (Figure 1), recently purchased by the CLF.

The resolution of the tele-microscope was tested using a USAF resolution test grid, where the Modulated Transfer Function would then be calculated. The field-of-view was then measured using a ruler. These tests were done at two working distances, with the results for 65 cm distance being shown in Table 1.

These tele-microscopes are now ready to be used in real experiments, however two will be re-modified in order to work at a distance over 3 m.

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Figure 1: Image of the QM-1 SZ Tele-microscope.

Focal Length	Resolution	Field of View
1	39.3 um	13.5 mm
2	19.6 um	4 mm
3	13.9 um	2 mm
4	11.05 um	1.5 mm
5	6.96 um	1 mm

Table 1: Table of the results for MTF and field-of-view for a working distance of 65 cm

Performance of a Kromek multi-channel analyser for a silicon photomultiplier – scintillator gamma ray detector

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To resolve 511 keV X-rays for a photonuclear activation based gamma ray detector, a multi-channel analyser can be used to easily digitise signals. The lower range of the linear response of a Kromek multi-channel analyser is shown to be improved by using a charge amplifier, which increases pulse widths to 1.2 μs. Two charge sensitive amplifiers allow a multi-channel analyser to resolve signals from silicon photomultiplier (SiPM) – scintillator detectors of small and large crystal volumes. A 26.5X gain charge amplifier, CR-112, is ideal for operation with a large scintillator crystal with a 36 mm^2 SiPM, for the resolution of 50 keV – 2 MeV X-rays.

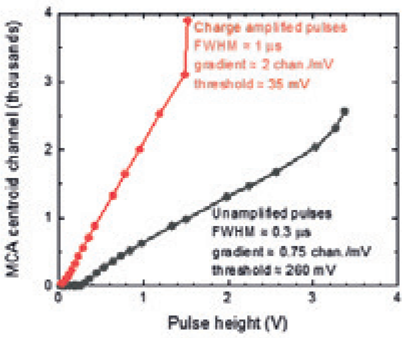

Figure 1: Linearity of multi-channel amplifier response with input pulse heights, for 0.35 μs FWHM unamplified pulses, and 1.2 μs charge amplified pulses

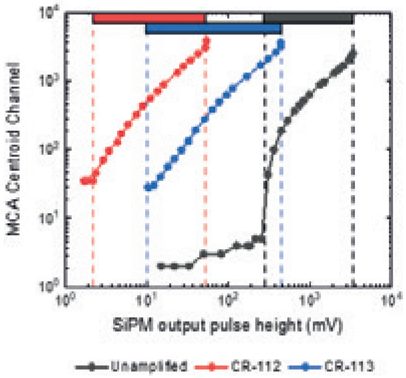

Figure 2: MCA spectrum centroid channels vs. SiPM pulse heights when pulses are unamplified, and amplified with two charge amplifiers with order of magnitude different gain. Coloured rectangles and dashed lines indicate effective dynamic range of detector system with each amplifier. CR-112 amplifier allows resolution of 2-45 mV pulse signals

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Gain characterisation of RF amplifiers for silicon photo multiplier – scintillation detector

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This report details and compares the gain character of several different amplifiers, for use with a 36 mm² silicon photomultiplier (SiPM) coupled to a gamma ray counting diagnostic that examines the signals produced from scintillation events. Resolving 511 keV X-rays is essential for counting the 15 MeV – 30 MeV gamma-induced photonuclear reactions in $^{27}_{13}Al$. However, such events typically produce silicon photomultiplier pulses with amplitudes below the 260 mV threshold of a multi-channel analyser. A charge sensitive pre-amplifier is shown to be linear for the required energy range, and its pulse lengthening behaviour lowers the effective detection threshold so that scintillation signals from 0.1 – 2 MeV photons can be resolved by a digitiser.

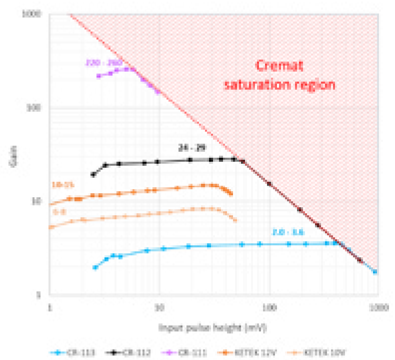

Figure 1: Gain vs. input pulse heights for three charge sensitive amplifiers driven at 13.6 V, and a KETEK SiPM preamplifier driven at 10 V and 12 V. Black dotted lines indicate the dynamic range of the silicon photomultiplier, and the gain of each amplifier is labelled.

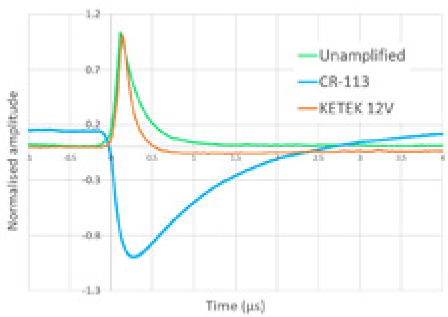

Figure 2: Normalised typical SiPM output traces: unamplified; amplified with a Cremat charge sensitive preamplifier; and amplified with the KETEK SiPM preamplifier. The increase in pulse width with the charge sensitive amplifier is clearly visible.

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Design of a Compton Spectrometer with a detection range of 15 keV – 3 MeV for Laser Plasma Experiments

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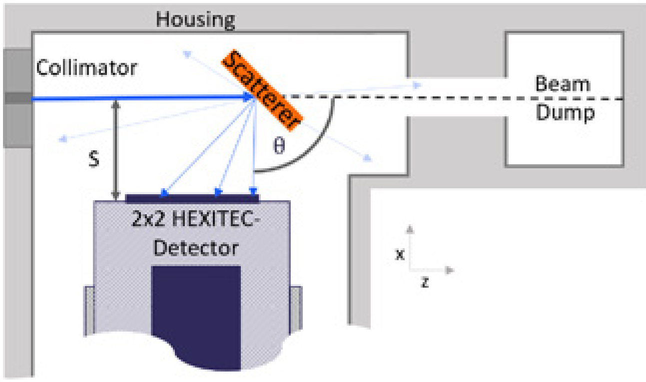
Measuring the X- and γ-ray emission spectra from laser-produced plasmas is essential to enable the physical processes at play to be quantified and understood. Operating sensitive detectors capable of energy resolving the incident photons in the primary beam is difficult, due to pulse pile up and possibly γ-ray energies of several MeV. Hence, the energy and flux of the incident radiation have to be adjusted to the specifications of the detector. Using Compton Scattering and placing the detector at an angle can potentially achieve this.

In this report, a design is presented that places a pixelated CdTe detector in a 90° angle towards a 1 mm thin Carbon scattering target. Monte Carlo simulations have been used to evaluate the geometry's performance and it has been computed that the detectors energy range of 10 – 600 keV was extended to 15 keV – 3 MeV with an energy resolution at 511 keV of 5 %.



Geometry of the Compton Spectrometer

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