# Plasma Diagnostics

## Assessment of cameras for low intensity acquisitions

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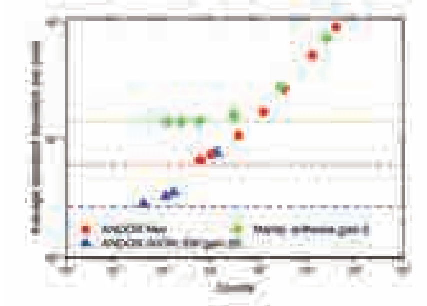
Three high bit depth cameras were tested to benchmark their performance in low intensity acquisitions: the iXon and the Neo by Andor, and the Manta by Allied Vision. These cameras are regularly used in the Central Laser Facility to probe laser plasma interactions where very low intensity signals are common.

The cameras were subjected to progressively lower intensities of light, to assess their read noise floors and dynamic ranges. It was concluded that the Neo and iXon were the least noisy cameras. For single photon situations, the iXon performed best, with a dynamic range of near 15 bits, and a read noise of only 2 counts. For low but above 10 photons per pixel acquisitions, the Neo performed well, with a dynamic range of 13 bits and a read noise of 6 counts. The Manta was found to perform very well, given its size and lack of cooling. If used for small (sub 1s) exposure times and as a single shot device, it had a dynamic range of 12 bits and a read noise floor of 14 counts (at 16 bit scaling).



*Plot of counts to the average standard deviation per pixel. The noise falls linearly until the noise floor (indicated by the dashed lines) is hit, where it begins to flatten out. The data for the Manta camera is the raw counts produced from saved files (12 bit scaled up to 16 bit).*

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## Specular Transmittance of 3D printed plastic at different thickness

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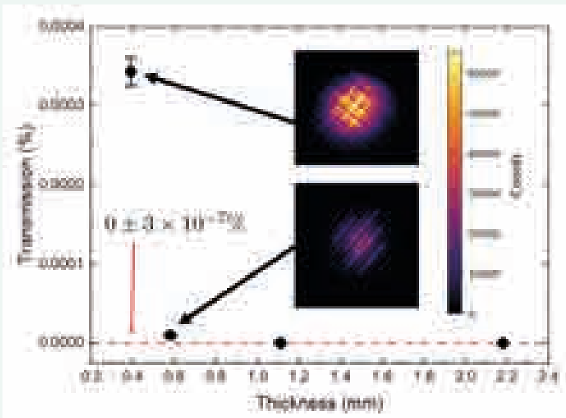
The optical transmittance of 3D-printed acrylonitrile styrene acrylate (ASA) sheets was tested, to determine the light tightness of enclosures made from this material. At greater than 1.1 mm thickness, it was found that the material is opaque to the limit of 3 x10$^{-7}$% transmission.




*Graph showing transmission of laser light through the printed plastic sheets of different thicknesses. An image captured for the two non-zero transmissions is also shown. At greater than 1.1 mm, the transmittance is below the detectable background (measured with an Andor Neo which, with the lens used, had a noise floor of 3 x 10$^{-7}$%). The top colour map was taken with a 0.3 s exposure, the lower one with 6 s.*

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# Simulating short pulse scintillation light with a pulsed LED

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Light emitting diodes (LEDs) were tested as a short pulsed light source, simulating the output for fast scintillators. These Scintillators usually have a pulse duration between the nanosecond and microsecond range. Commercial LEDs of wavelengths of 400-800nm are readily available, and offer a cheap solution for matching the wavelength and pulse duration of these scintillators. It was found that a pulse as short as 4ns could be obtained at 405nm.

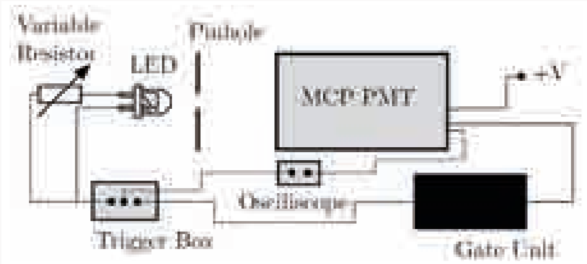


*Fig 1: Setup for the LED characterisation test. The LED was pulsed with a driving pulse from a trigger box. This also triggered the PMT, and sent a driving pulse to the oscilloscope to be recorded. The LED light was funnelled through a pinhole to avoid scattered light from falling onto the PMT.*

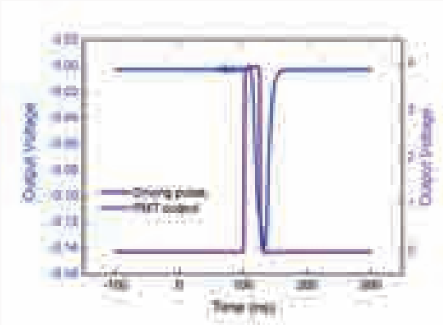

*Fig 2: Trace of a 25ns pulse detection from a 405nm LED. Pulse matches typical LYSO emission in wavelength and pulse duration.*

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# Application of silicon photomultipliers in scintillation based radiation detectors

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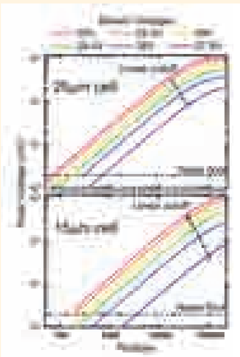
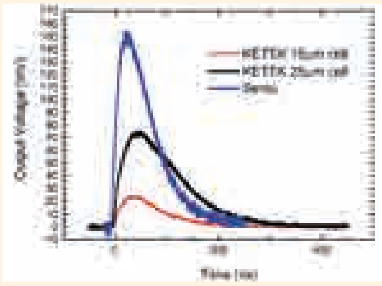
An application for silicon photomultipliers as sensitive time resolved radiation detectors was investigated. Absolute light response, with and without amplification, was investigated for different models of SiPM. Radiation spectra with LYSO were also obtained. It was found that, in terms of sensitivity, the SiPMs with the set-up used were able to produce readouts in the order of 10s of photons, but require amplification to approach this level.





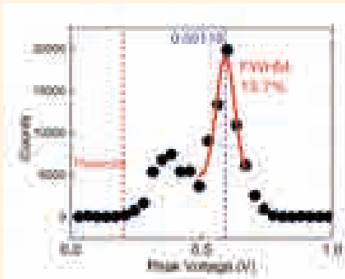


*Fig 1: (left) Fitting of the response curves of different biased voltages as indicated and plot of the number of photons below which the response is linear. Linearity is defined as where the non-linear component of the fit contributes less than 10%. These 'cut-off' values are also indicated by vertical dashed lines on the left of the plot.*
*Fig 2: (middle) Typical trace from the KETEK SiPMs, cell sizes indicated. Peak heights of traces illustrated are representative of a 511 keV LYSO detection. A similar output from the SensL chip is also shown. As can be seen, the SensL chip is much faster both in rise time and recovery than the KETEK ones. Biased voltage of 30V used, scope coupling at 50Ω*
*Fig 3: (right) Spectra of activated Tc decay (emitting 141 keV x-ray) at 9.75 MBq, detected by a KETEK SiPM with a Cremat amplifier. The count rate is much higher, as seen by the peak height compared to the background.*

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# A novel in-situ dual channel alignment system for precision alignment of complex targetry

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As targetry for High Energy Density Physics (HEDP) experiments has become more complex, methods to position the laser focal spot more accurately on the desired region of the target prior to the shot are needed. When the target feature sizes are similar in scale to the spatial jitter of the laser, a second requirement for on-shot laser positional information becomes important.

We have successfully designed and deployed a novel in-situ front surface imaging diagnostic for both pre-shot target alignment and on-shot focal spot position determination. The dual channel system is designed to align targets with feature sizes of 20-50 µm. An IR channel (1053 nm) was used to align the target prior to the shot, and then a second-harmonic channel (527nm) was used to image the self-emission indicating on-shot position of the focal spot. This alignment system was deployed during a recent experiment using the VULCAN Petawatt system and proved invaluable for categorising successful shots.

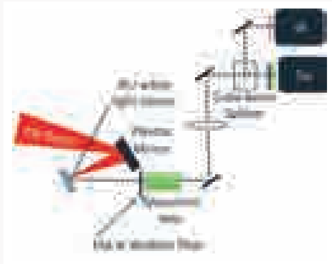

*Fig 1: In-situ layout of the alignment system*


*Fig 2: a) image of self-emission directly on cone tip, b) clipping the cone tip, and c) completely displaced from the cone tip.*

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# 3D ray tracing of a high intensity laser beam through plasma guiding structures

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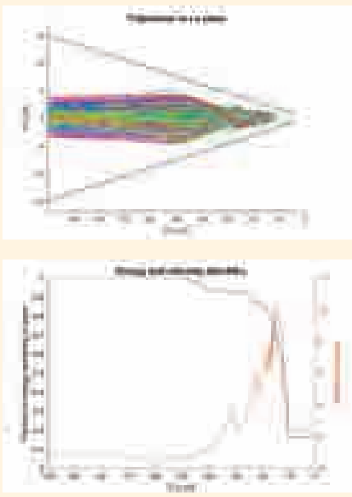
High power lasers are challenging to focus down to useful intensities using normal optical components. This project seeks to use the optical properties of plasma to do this.

A 3D ray tracing program has been developed using MATLAB to study how a high power, short pulse laser beam may travel through a plasma guiding structure. The guiding structures predominantly used in this study were hollow tapered cones on the micron scale. The motivation for this was the prospect of confining the beam sufficiently to increase the intensity, potentially by a factor of up to 10.

Significant increases in intensity were observed in the simulations, despite modelling the effects of the beam losing energy to the plasma. The effect of varying a number of parameters of the beam-cone configuration have been investigated. Wave optics effects were not treated here, but it is hoped that this geometrical study will provide some insight into laser confinement by short-lived plasmas.



*Trajectories (top) and intensity (bottom) for f3 beam entering double edge plasma modelled cone with scale length 0.5µm. Note the light stops at boundary with over-dense region.*

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