Documentation of the SiPM characterization environment setup

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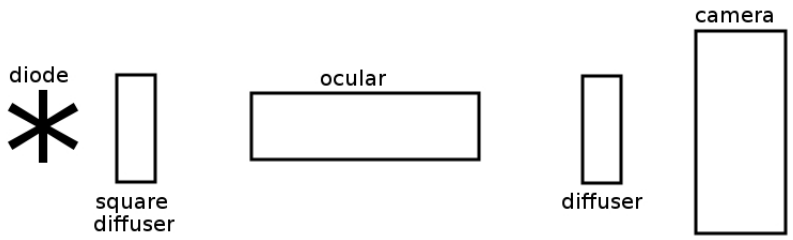
The testing environment for the SiPMs requires a largely *homogeneous light spot* within the SiPM tile's area as well as sufficient *light intensity*. While the homogeneity calibration was conducted with a blue diode, we applied a 408 nm laser for the intensity configuration and examination of the SiPMs response signal, which will also be used in the actual SiPM characterization.

1 Producing a homogeneous light spot

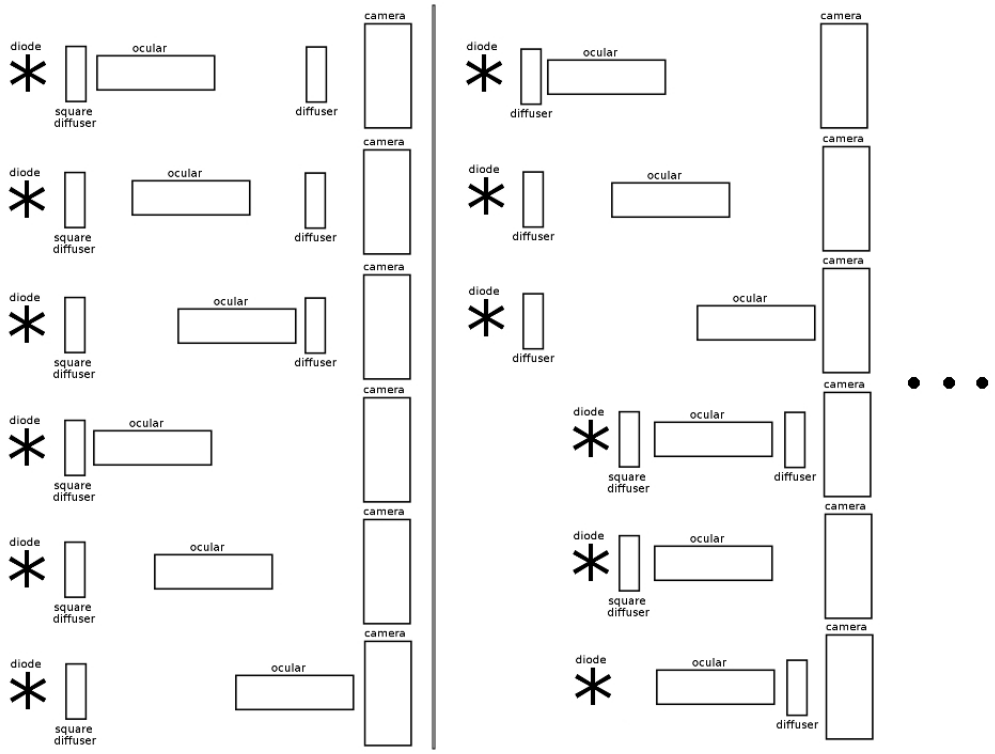
For the homogeneity calibration we used:

- blue diode
- CCD camera: SXVR-H18
- diffuser: DG10-120-MD ⌀1.0" 120 GRIT
- square diffuser: ED1-S20-MD ⌀1.0" 20° SQUARE TOP-HAT DIFFUSER
- ocular: Plan N 10x/0.25 ∞ / - / FN22
- beam splitter: CM1-BS013 400-700nm 05:05

Setup example (the beam splitter is positioned between diffuser and camera, not included in the scheme):

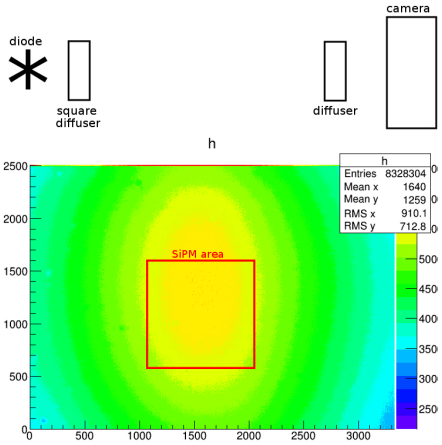


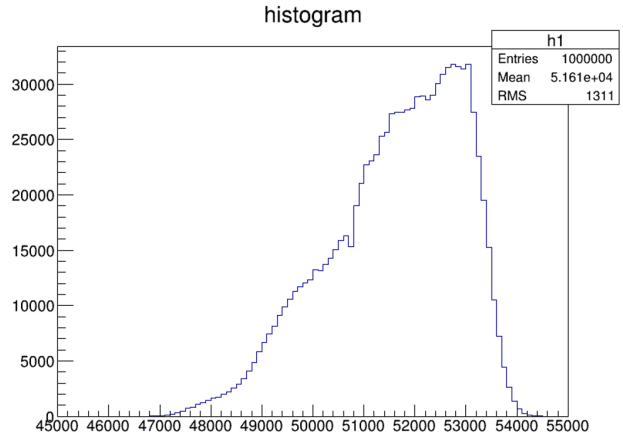
By altering the component's positions and leaving out certain parts we examined over 30 different configurations:



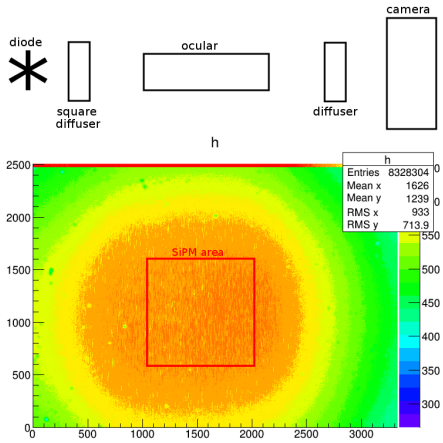
The light spot's form and intensity were recorded to binary files with the CCD camera, with exposure times of 1s, 2s, and then plotted with ROOT, which was also used to create the corresponding *intensity distribution histograms* within the tile's area (1000px x 1000px in the plot). We also measured the corresponding background intensities and substracted them from the results. The eight most interesting ones were further tested:

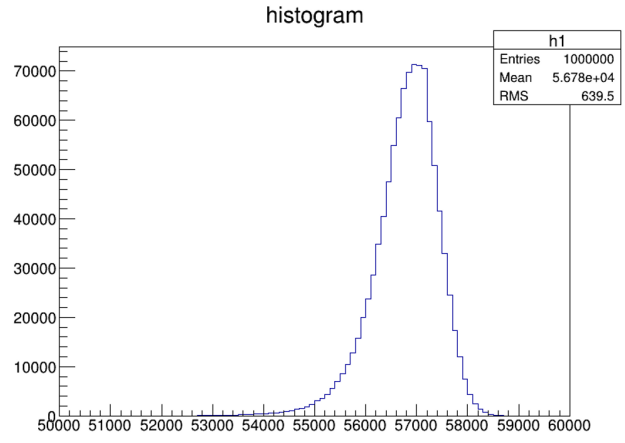
setup 1 - exposure: 2s, RMS: $\sim 2.54\%$



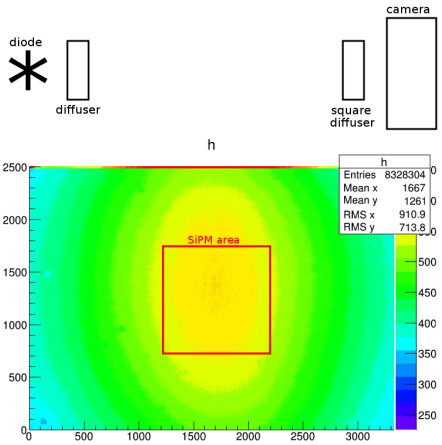


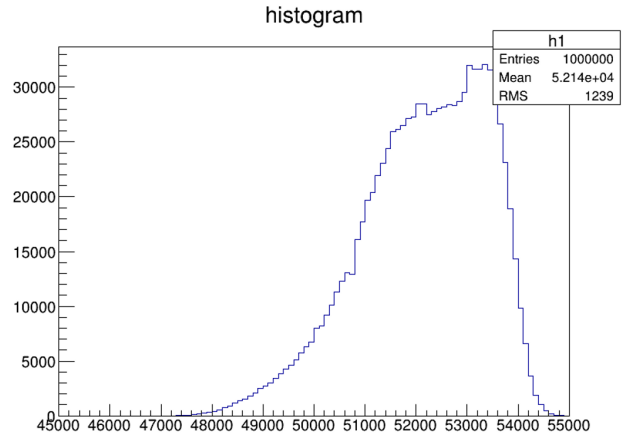
setup 2 - exposure: 2s, RMS: $\sim 1.13\%$



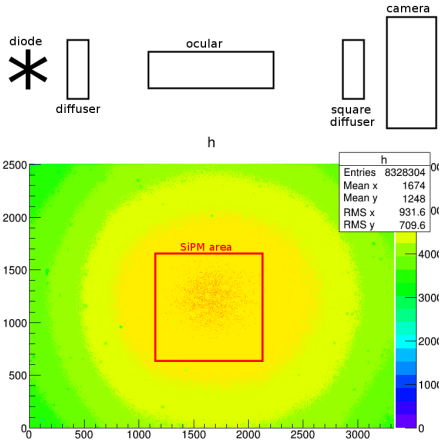


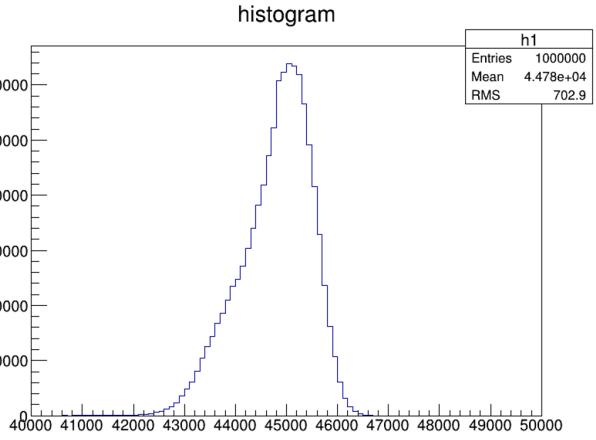
setup 3 - exposure: 2s, RMS: $\sim 2.38\%$



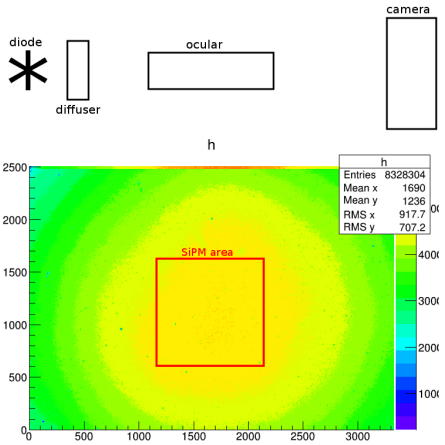


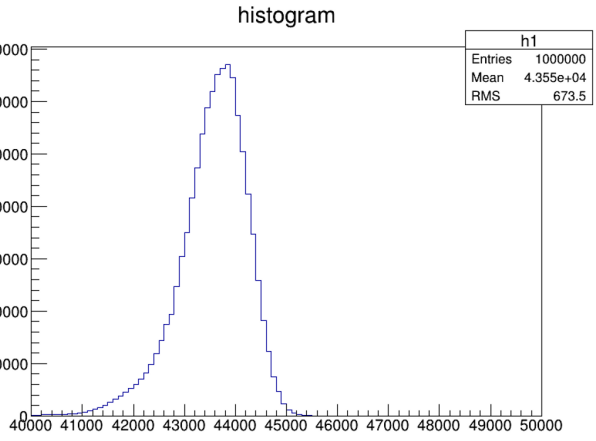
setup 4 - exposure: 2s, RMS: $\sim 1.57\%$



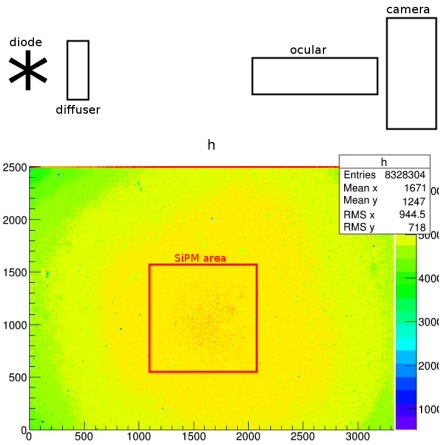


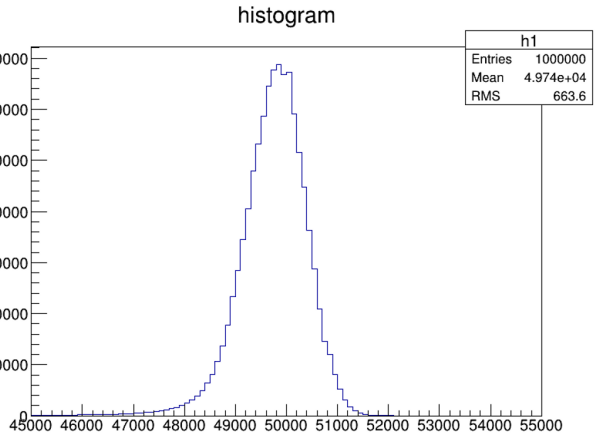
setup 5 - exposure: 1s, RMS: $\sim 1.55\%$



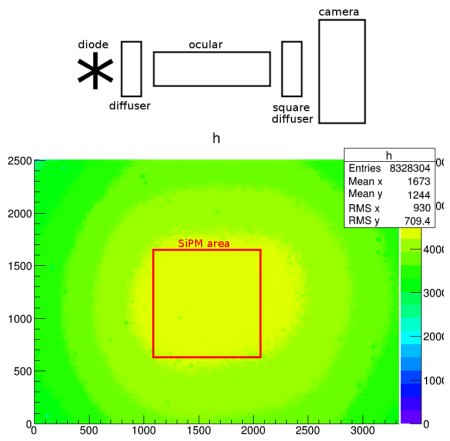


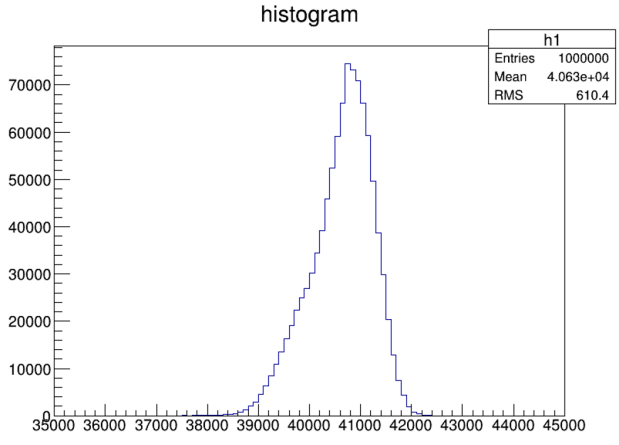
setup 6 - exposure: 2s, RMS: $\sim 1.33\%$



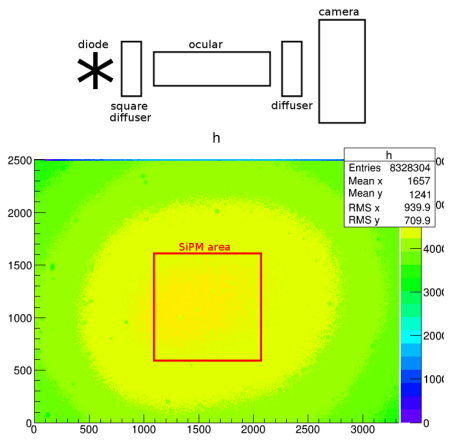


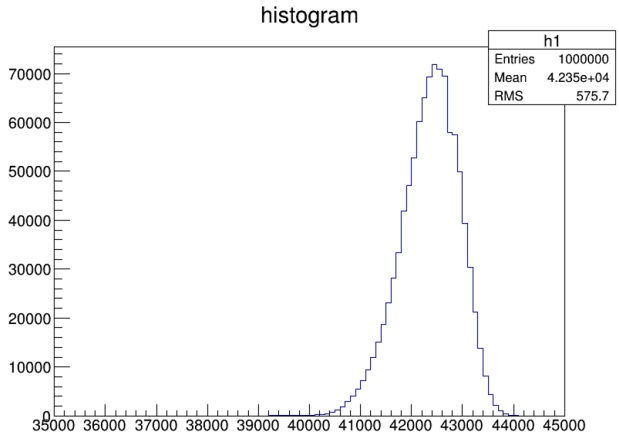
setup 7 - exposure: 1s, RMS: $\sim 1.50\%$





setup 8 - exposure: 1s, RMS: $\sim 1.35\%$

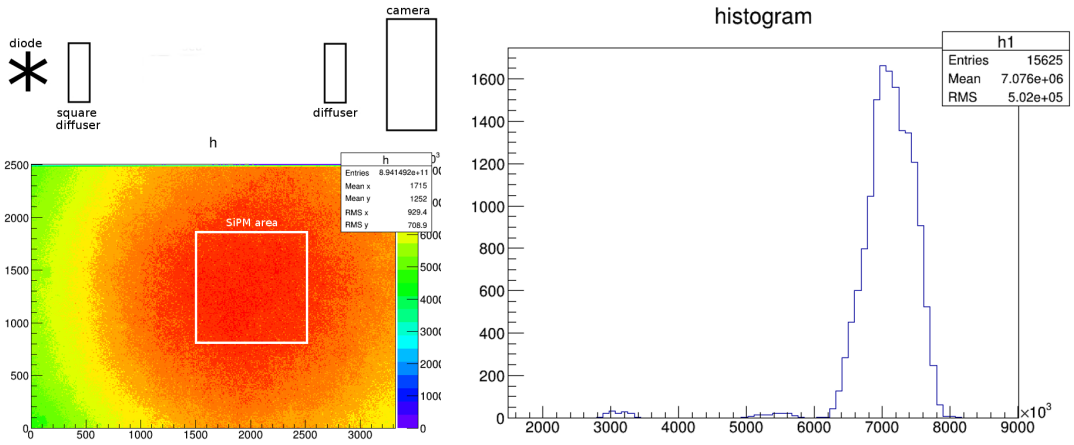




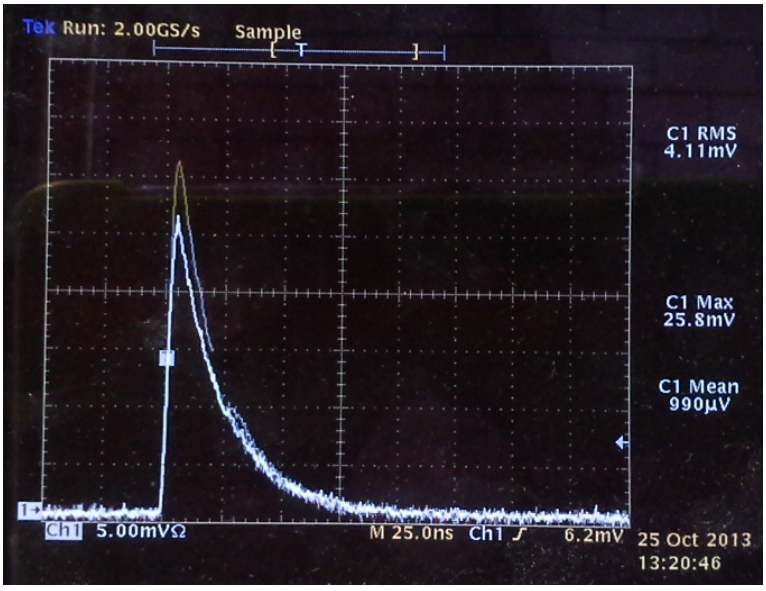
Configuration (2) with the lowest relative RMS and a satisfying intensity (also considering the exposure time) was chosen as the most promising result.

2 Laser intensity calibration

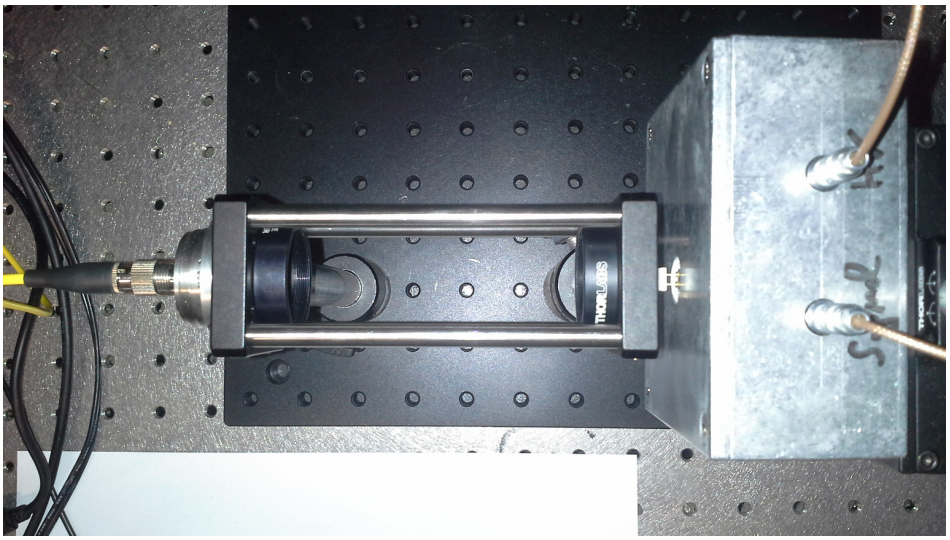
The diode was then replaced with the 408 nm laser ($P_p = 1W$, $P_e = 0.1mW$, $f = 1Mhz$). Usage of the ocular showed little to no effect, hence it was removed. The intensity distribution was measured ten times (substracting the background) and added into a single plot. The bin size was changed to 8px x 8px, which corresponds with the SiPM tile's resolution. The relative RMS is about $\sim 7.09\%$.



The tile was supplied with an input voltage of 72V from an Agilent 6614C DC Power Supply, the beam splitter was removed. By further calibrating the laser beam's form we maximized the output signal's amplitude, which fluctuates between about 20mV and 30mV. The average intensity is very sensitive to mechanical influence on the apparatus.



The final setup:



Summary

A homogeneous light spot was produced from a diode by testing different combinations of diffusers and an ocular with a CCD camera and plotting the results using ROOT. The best result was then optimized and the diode was replaced with a 408 nm laser. The output signal of a SiPM tile was maximized by calibrating the laser beam.