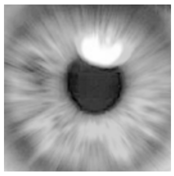

Luminance measurements at very low levels

Definition

<u>LOD – limit of detection</u>.

From the ICAM technical note "I101 Definitions", it is known that a precision of $\pm 2\times\sigma$ (σ is the standard deviation) gives a level of confidence of approximately 95 %. With a precision of $\pm 3\times\sigma$ the level of confidence is approximately 99.7 % meaning that if 1000 measurements of a property are made, only 3 of the measured values are expected to fall outside the range $[\ \mu - 3\times\sigma\ ;\ \mu + 3\times\sigma\ ]$.

If a value falls outside this range it is most probably not due to lack of precision in the measurement, but because the property has changed.

Therefore we define the 'LOD – Limit Of Detection' as plus/minus three times the standard deviation.

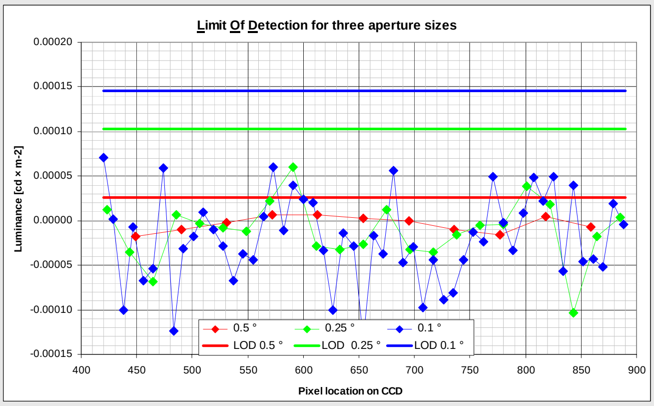

Figure 1 Luminance measurements

Example: Luminance measurements of absolute black are performed with three different apertures. See figure 1. If a value greater than LOD is measured we assume, and with very good reason, that the luminance has changed to a level greater than absolute black.

Apertur size [°]	σ	LOD
	[10^{-6} · cd × m^{-2}]	
0.50	8.79	26.4
0.25	34.2	103
0.10	48.6	146

Table 1. LOD for three aperture sizes.

LOD for ICAM

In DELTA's accredited photometric laboratory it is possible to realize luminance with high accuracy. The inside of an Ulbrecht sphere is indirectly illuminated and at the luminous port a variety of neutral density filters can be applied. In this fashion the luminance can be varied in the range app. 1500 cd×m^{-2} and at least down to app. 0.15 cd×m^{-2}. Lower luminances are realized by using neutral density filters. This introduces some uncertainty of the absolute value, but not on the magnitude which is the topic of this investigation.

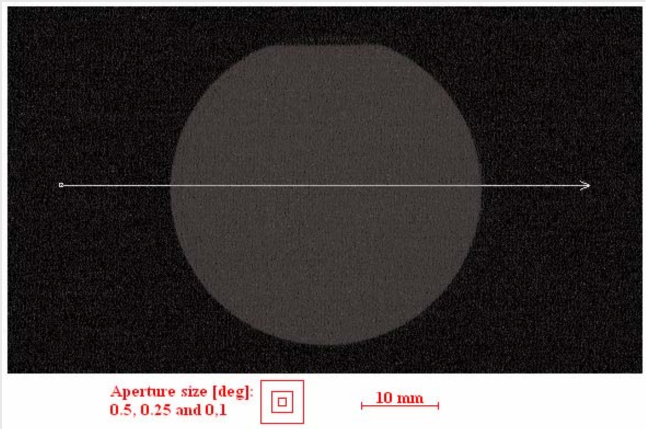

Figure 2 Luminous port of an Ulbrecht sphere

In figure 2 is shown the luminous port measured by ICAM and on the figure are indicated the aperture sizes and scaling. The exposure time used was 2 sec. and the ICAM measurement was averaged over 32 frames.

The luminances measured were 0.00160 cd×m^{-2}, 0.00016 cd×m^{-2}, 0.00008 cd×m^{-2} and 0.00000 cd×m^{-2} and each

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level were sample with apertures of 0.50°, 0.25° and 0.10°. The results are shown in figure 3 to 5.

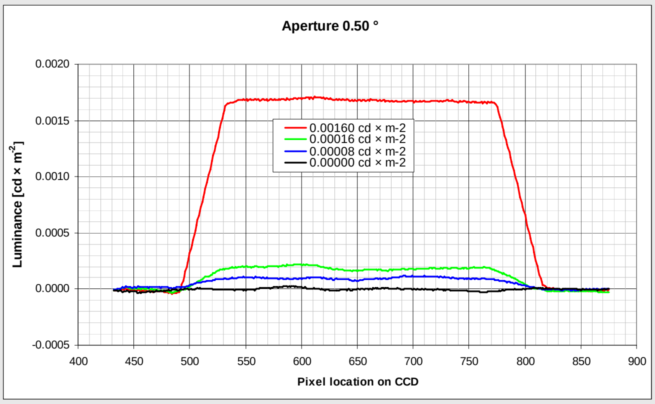

Figure 3 Sampling at 0.50° aperture

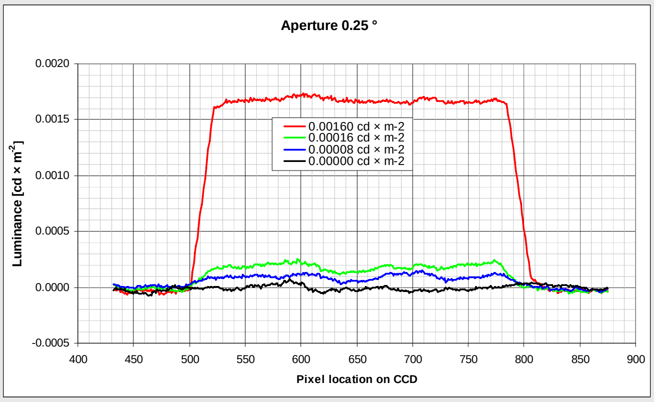

Figure 4 Sampling at 0.25° aperture

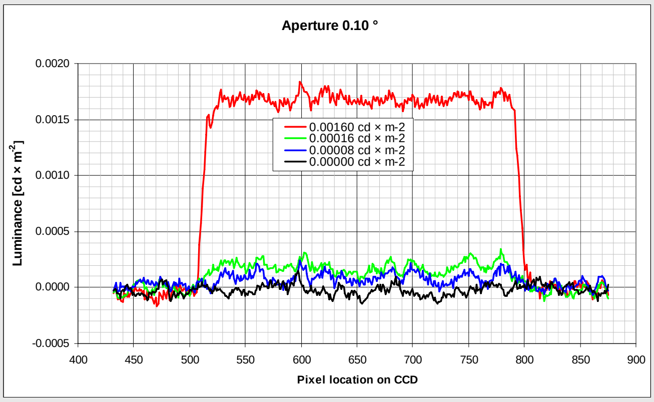

Figure 5 Sampling at 0.10° aperture

From the result it is seen that luminance levels at 0.00005 cd×m^{-2} are easily detected and separated from the background noise when using a 0.5° aperture.

Trueness

During the realisation of the low luminances, the levels were measured with an LMT luminance meter with an accuracy of app. 2.5 %.

Conclusions

With ICAM is possible to detect luminance's at levels down to at least 0.00005 cd×m^{-2}, 0.0001 cd×m^{-2} and 0.0005 cd×m^{-2} using aperture sizes of 0.50°, 0.25° and 0.10°.

The ability to measure very low luminance with very small aperture size makes it possible to measure not only luminance but also luminance variations on low luminous surfaces like a display showing "black".