DMM linearity and distribution

The test was carried out in the basement corridor of the Oulu university. The basement corridor is used only for service purposes and thus very few people visit there. The measurement distance between laser and DMM was 10 m. A hot air blower (power 2000 W) was directed towards the laser exit window. (Fig. 1). The laser used was Leica Rugby 830. The hot air blower was used for achieving real (Gaussian) distribution for the results and as can be seen from the distribution of the results, it works pretty well (Fig. 2). The measurement was done by measuring 100 and 1000 pulses (samples) in each measurement and repeating those measurements several times. As the laser rotates at 600 rpm, the measurement frequency is 10 Hz and the time duration of 100 and 1000 pulse measurements are 10 and 100 seconds, respectively. The deviation (sigma value) is approximately +/-0.5 mm in this measurement. Without the hot air blower and at short distance like this the practically all results would be in one channel (60 mm in this case). In real world wind causes air turbulence, which affects the same way as the hot air blower in this measurement.

Fig. 1. Creating artificial air tubulence using a hot air blower.

Averaged values:

[mm]	Average	Samples
All results	59,95	6084
Sample 1	59,96	100
Sample 2	59,91	100
Sample 3	59,97	100
Sample 4	59,93	100
Sample 5	59,91	1000
Sample 6	59,95	1000
Sample 7	59,95	1000
Sample 8	59,96	1000

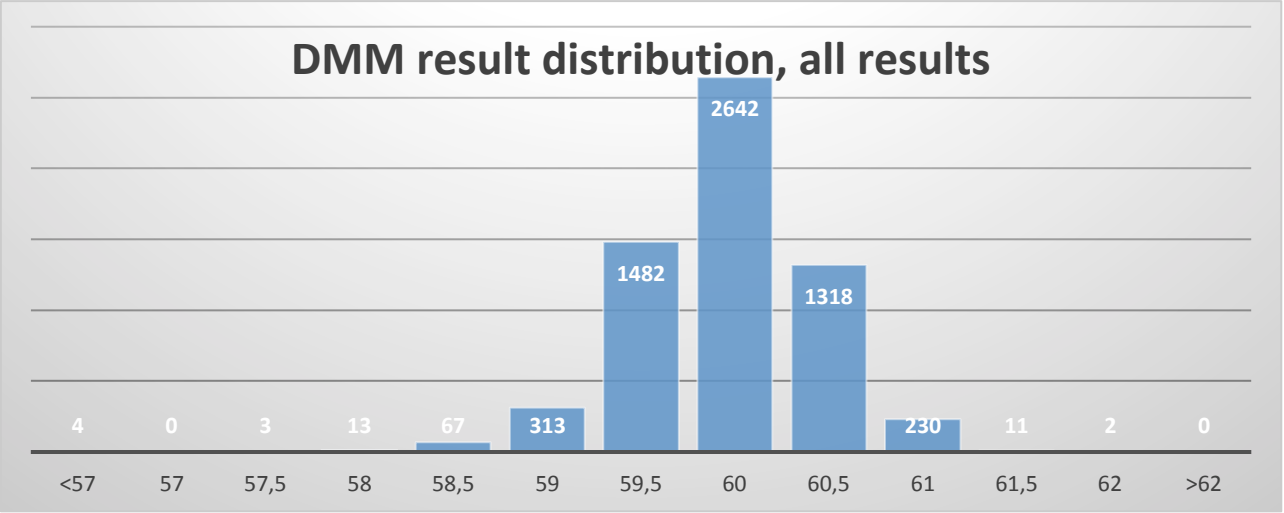

Fig. 2. The distribution of all results in the hot air blower test.

The linearity of the DMM sensor was measured utilizing the same kind of measurement setup like in the distribution measurement, except that the measurement distance was 15 m. The laser was installed on a tripod, on a stable position, and the vertical position of the DMM was changed with a ballsrew / step motor combination in 0.1 mm steps. The result can be seen on Fig.3. Differential nonlinearity of +/-0.25 mm can be seen on the results. This is due to the positioning inaccuracy of the 1 x 1 mm photodiodes on the printed circuit board. This has happened in the manufacturing process and thus the nonlinearity can be repeated and in theory could be eliminated in the results using a calibration curve. However, in practice the +/-0.25 mm nonilinearity is so small, especially compared to the variation due to air turbulence at long distances, that the nonlinearity error is hidden behind the sample to sample variation in the results.
In the linearity measurement the finite laser spot size can also be seen as the nonlinearity increases, when part of the laser spot hits outside the photosensor array of the DMM.

The nonlinearity measurement was repeated in ”real world” measurements using 2 DMMs on top of each other and at a measurement distance of 75 m (Fig. 4.). Using 2 DMMs the measurement range of one DMM (160 mm) can be duplicated to 320 mm (in practice a little bit smaller due to the finite spot size). In this measurement the vertical position of 2 DMM combination was moved by 200 mm, which was the maximum range of the ballscrew / step motor combination. First the DMM was moved in 5 mm steps (the beam in the area of the lower DMM) and then in 1 mm steps in the range, when the measurement beam hits is close to the edge of the 2 DMMs and when the beam is totally in the measurement area of the upper DMM. It can be also seen that the DMMs can be used with no additional error when the vertical measurement range needed is more than 160 mm.

Fig. 3. The linearity measurement at 15 m distance, with hot air blower.

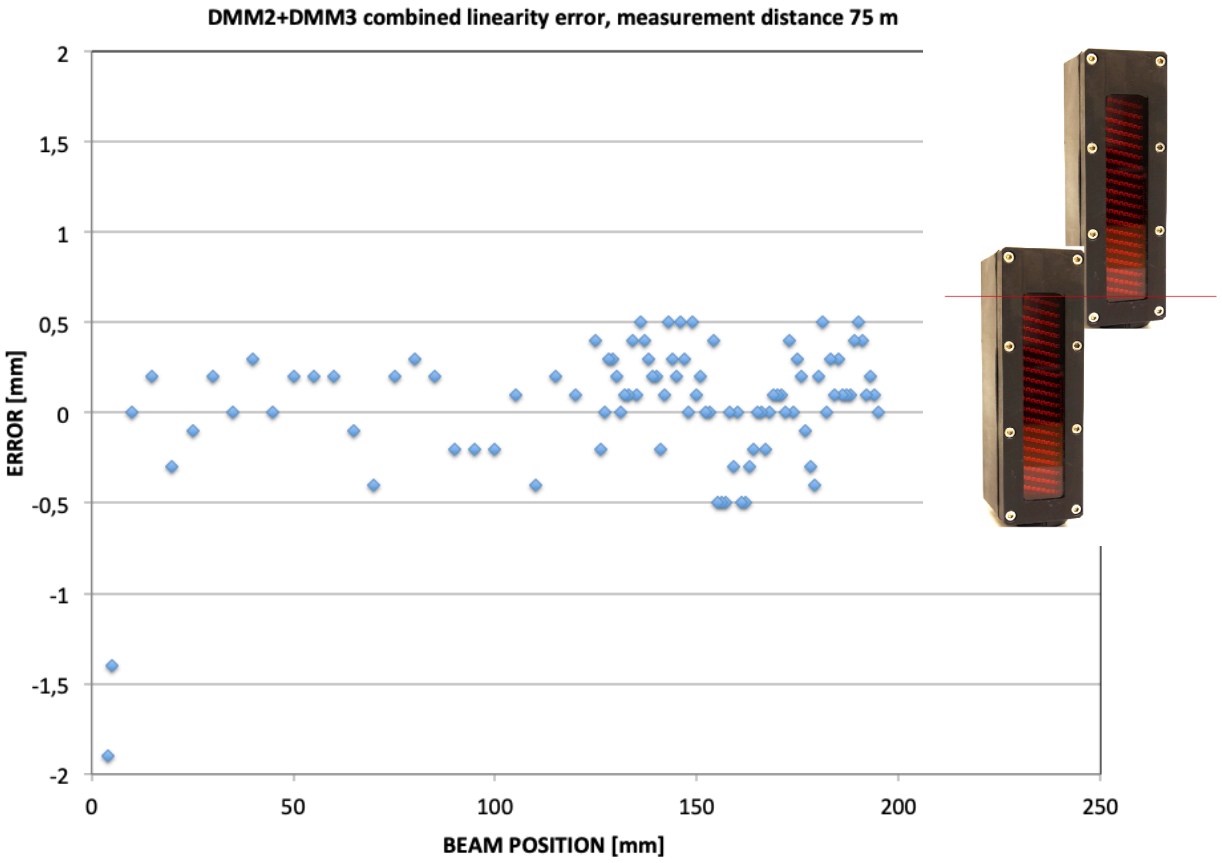

Fig. 4. The linearity measurement at 75 m distance, with 2 DMMs.