Particle Distribution Dependent Inaccuracy of the Plantower PMS5003 low-cost PM-sensor

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Particle Distribution Dependent Inaccuracy of the Plantower PMS5003 low-cost PM-sensor

Bernd Laquai, 22.10.2017

During a single measurement run, the Plantower PMS5003 and the Grimm were exposed to a strong change in particle mass distribution versus size. In the first phase the particle spectrum only contained particles sizes < 3um in the second phase the particle spectrum contained only particle sizes > 3um.

During the measurement, the Grimm 1.108 reference instrument reported the expected PM values: For the first phase PM10 = PM2.5, for the second phase PM10 >> PM2.5.

The Plantower PMS5003 reported PM10>PM2.5 for the first phase and PM10=0 for the second phase. For large PM2.5 mass concentrations (> 400ug/m^3) the PMS5003 reported slightly less (factor 0.5) than the Grimm, for smaller PM2.5 mass concentration it reported slightly more (factor 1.5).

From these measurements, we conclude that the Plantower PMS5003 is able to measure PM2.5 more or less correct. With a suitable calibration, it may be calibrated to a reference instrument such as the Grimm. The PMS5003 however is not able at all to directly measure large particles > 3um. When it outputs PM10 values, these are pure estimates based on particle sizes it can measure (d < 3um) and under the assumption of a broadly distributed particle spectrum. When the particle spectrum is not containing PM mass contributions at sizes < 3um, the PMS5003 erroneously outputs PM10 values close to zero. It therefore behaves similar to the SDS011 low-cost PM-sensor from Nova Fitness.

These findings intensify the strong suspicion that low-cost PM-sensors, mainly produced by Chinese manufacturers and designated as PM2.5 sensors but also reporting PM10 values, aren't able to measure particles larger than 3um and therefore solely extrapolate on PM10 values assuming a certain particle distribution.

See also: Bernd Laquai, Impact of Particle Mass Distribution on the Measurement Accuracy of Low-Cost PM-Sensors, 20.10.2017

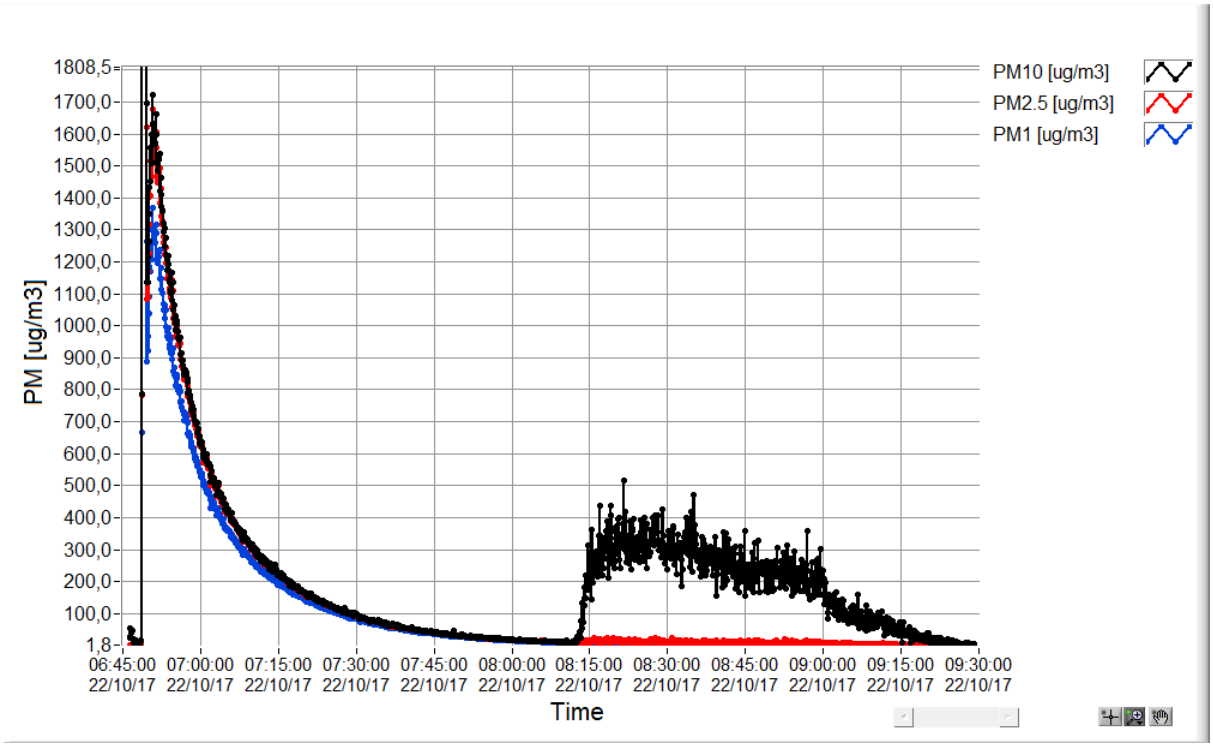

Fig. 1a: The applied particle distribution over time as seen by the Grimm (lin. scale)

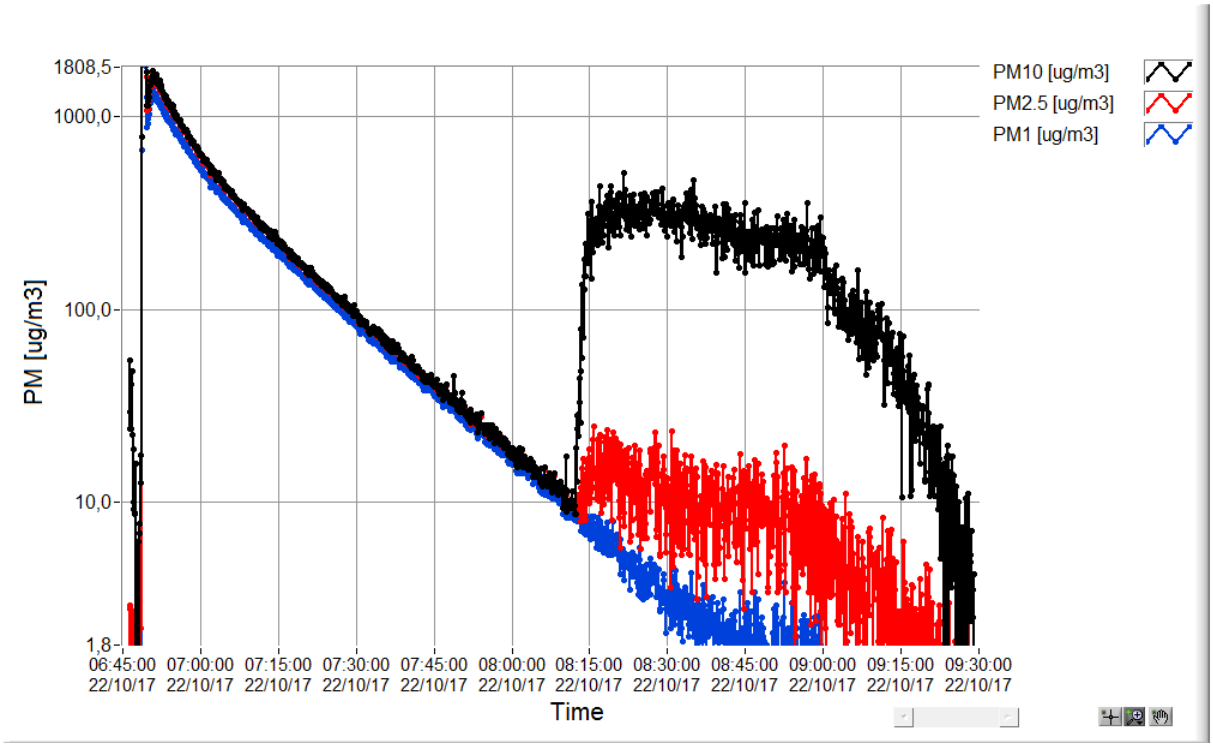

Fig. 1b: The applied particle distribution over time as seen by the Grimm (log. scale)

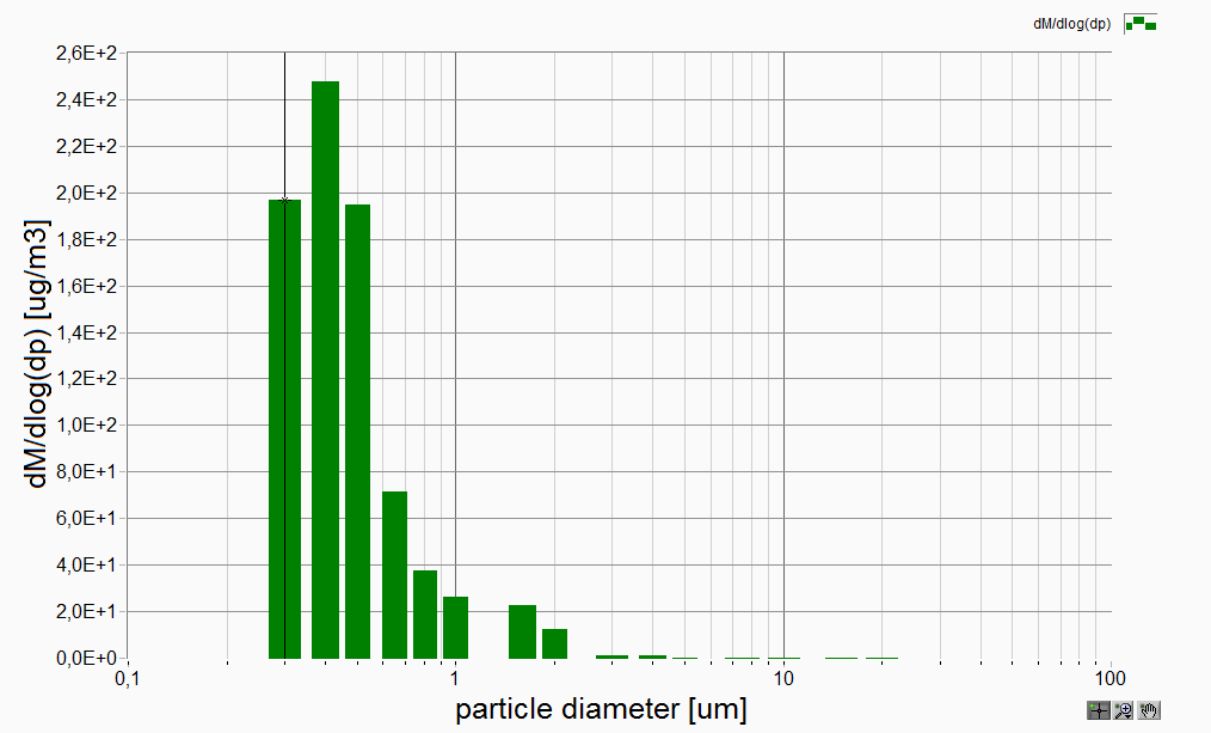

Fig 2a: A typical mass distribution plot of the Grimm SW during the first phase of the measurement (dM_dlog(dp)-2017-10-22-07h23.png)

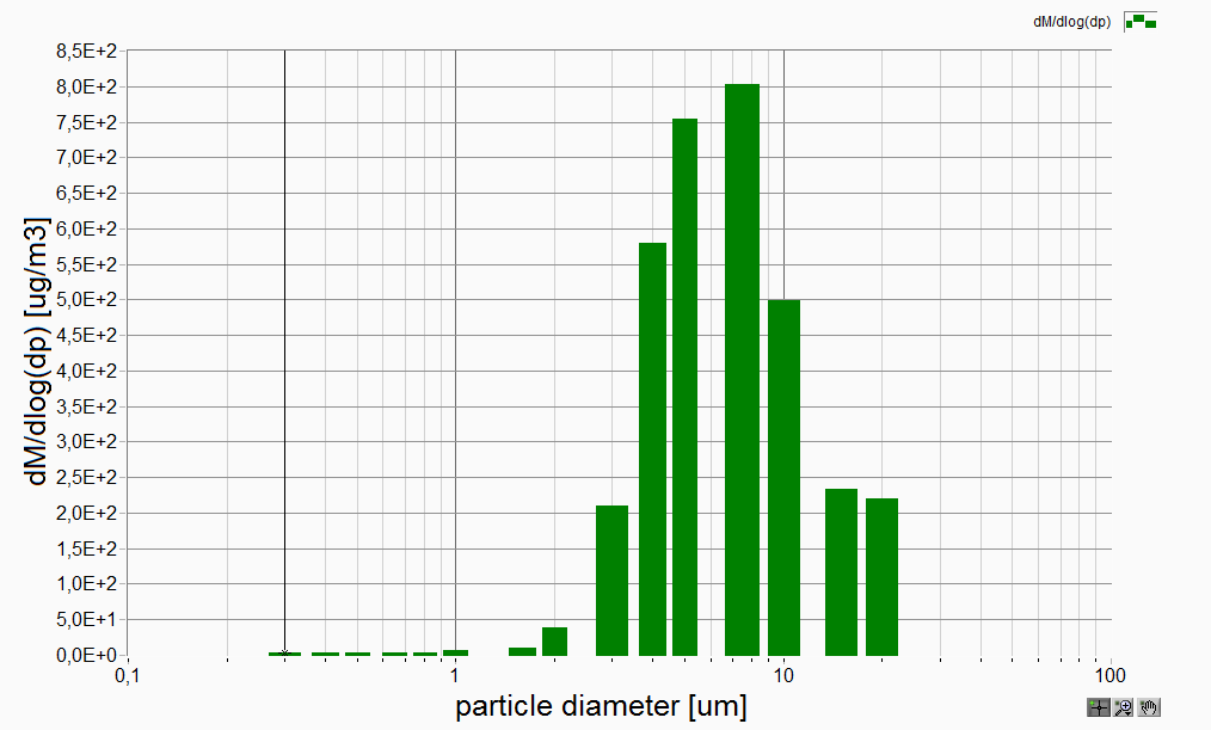

Fig 2b: A typical mass distribution plot of the Grimm SW during the second phase of the measurement (dM_dlog(dp)-2017-10-22-08h32.png)

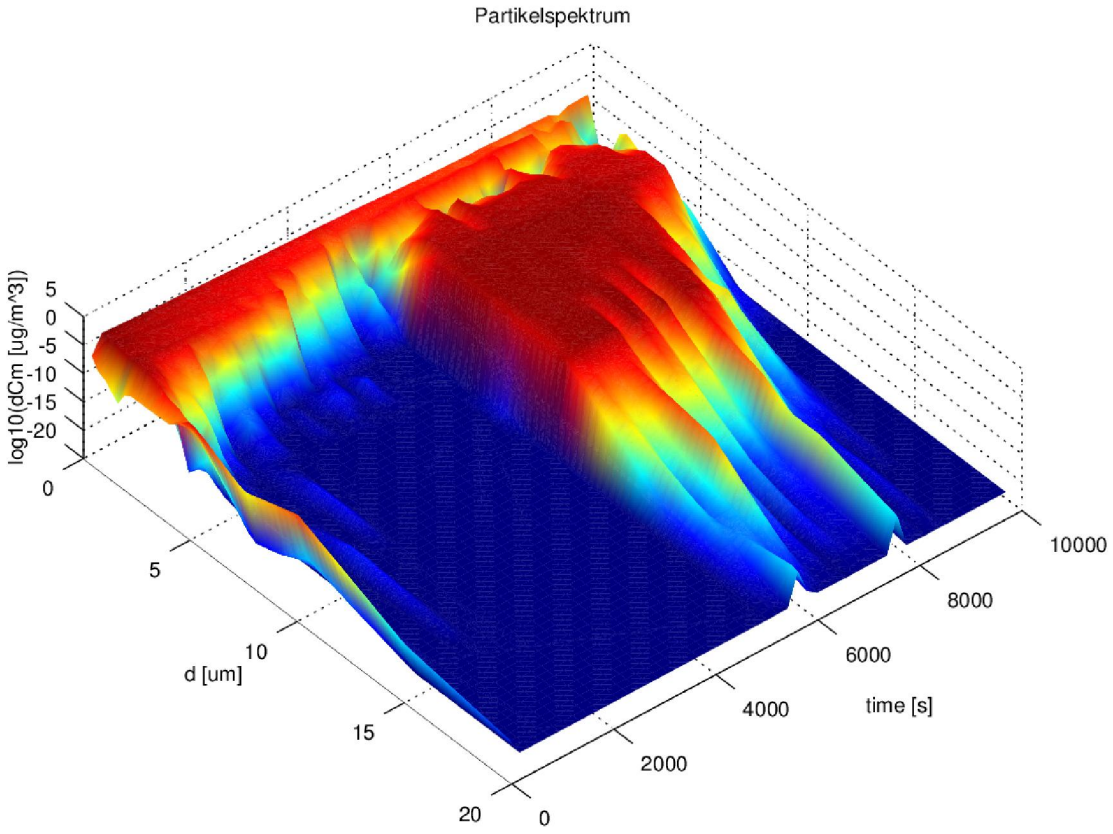

Fig. 3: Contour plot (log. scale) of the change between two different particle distributions during the measurement versus size and time

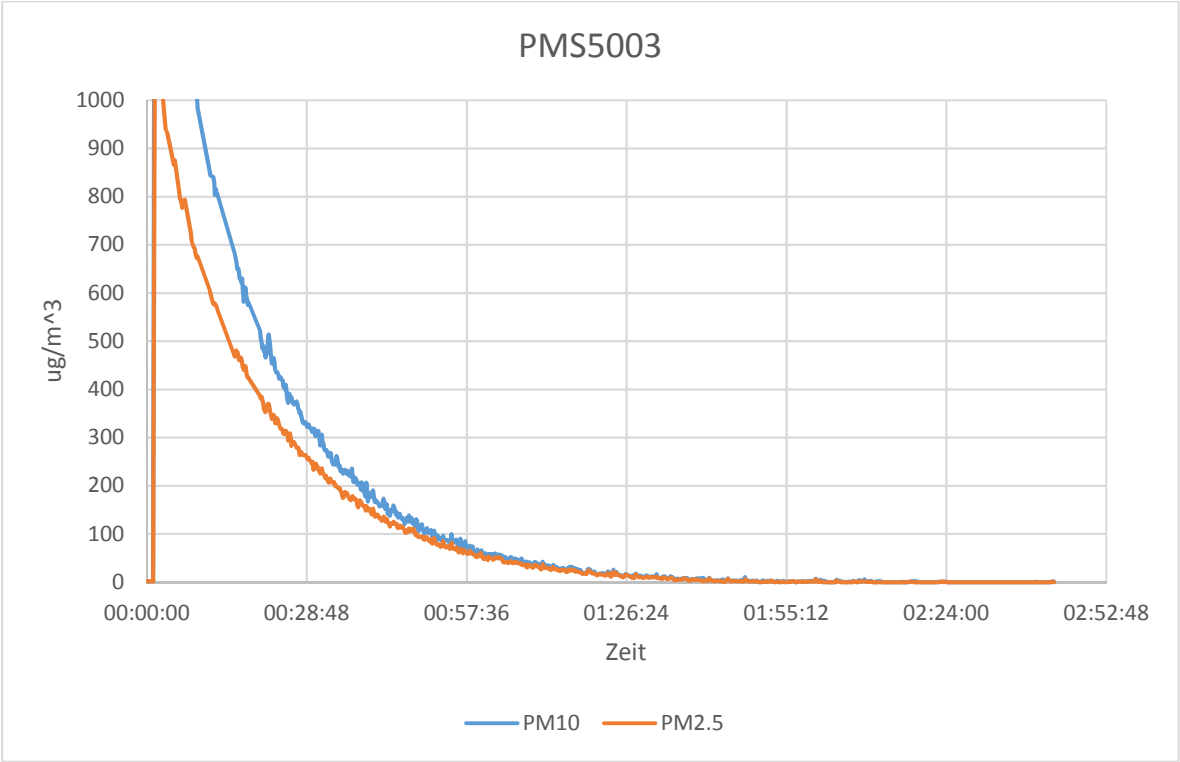

Fig.4: PM10 and PM2.5 readings of the PMS5003, no indication for the large particles in phase 2

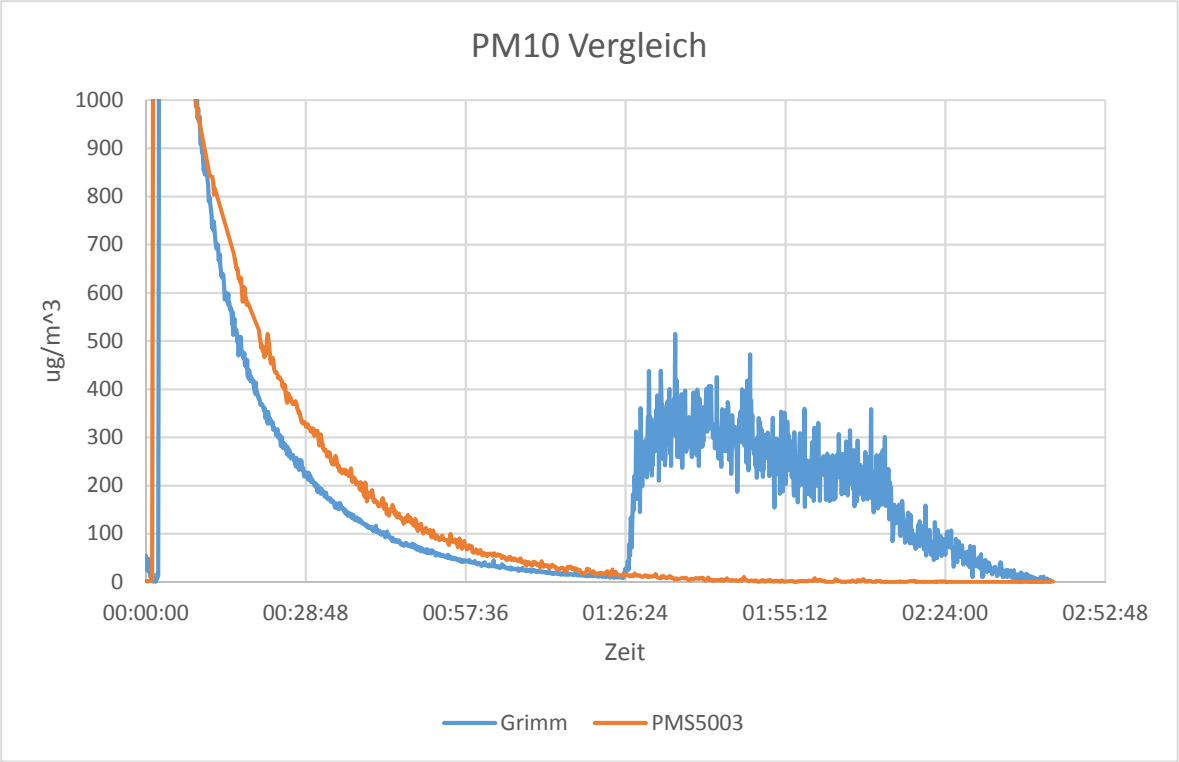

Fig 5a: Comparison for PM10 values reported by the Grimm and the PMS5003

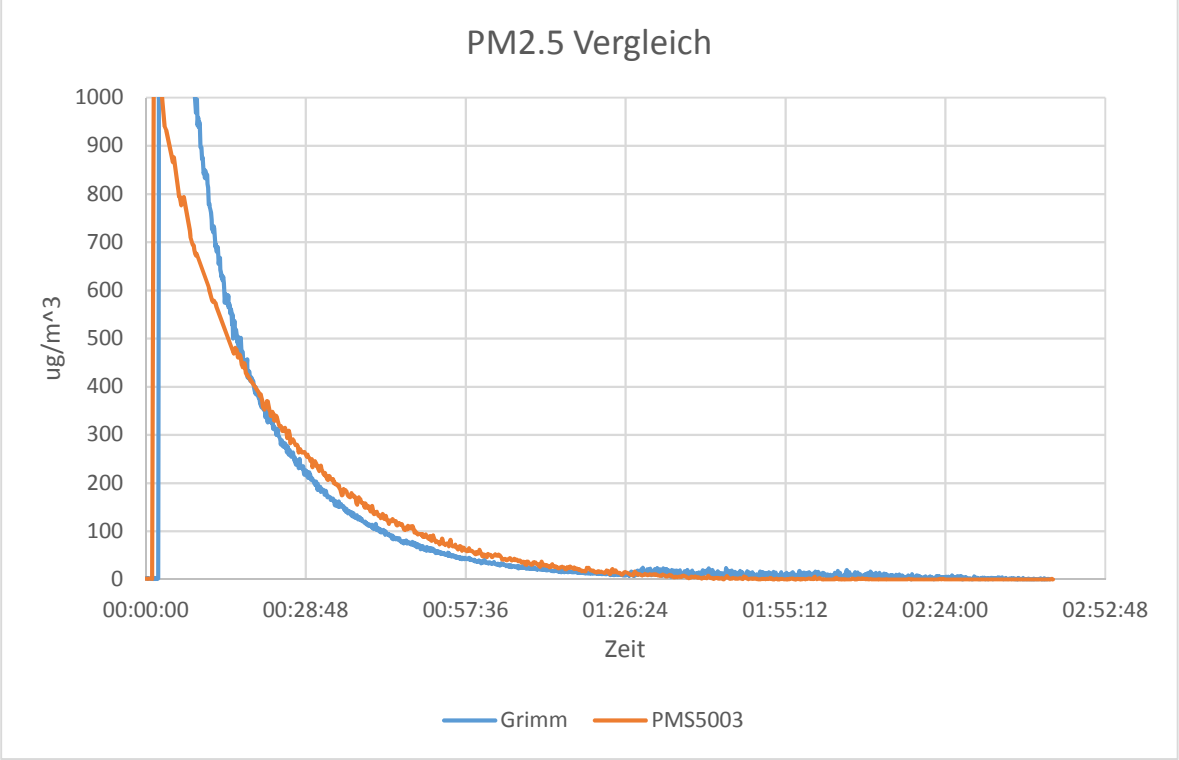

Fig 5b: Comparison for PM2.5 values reported by the Grimm and the PMS5003

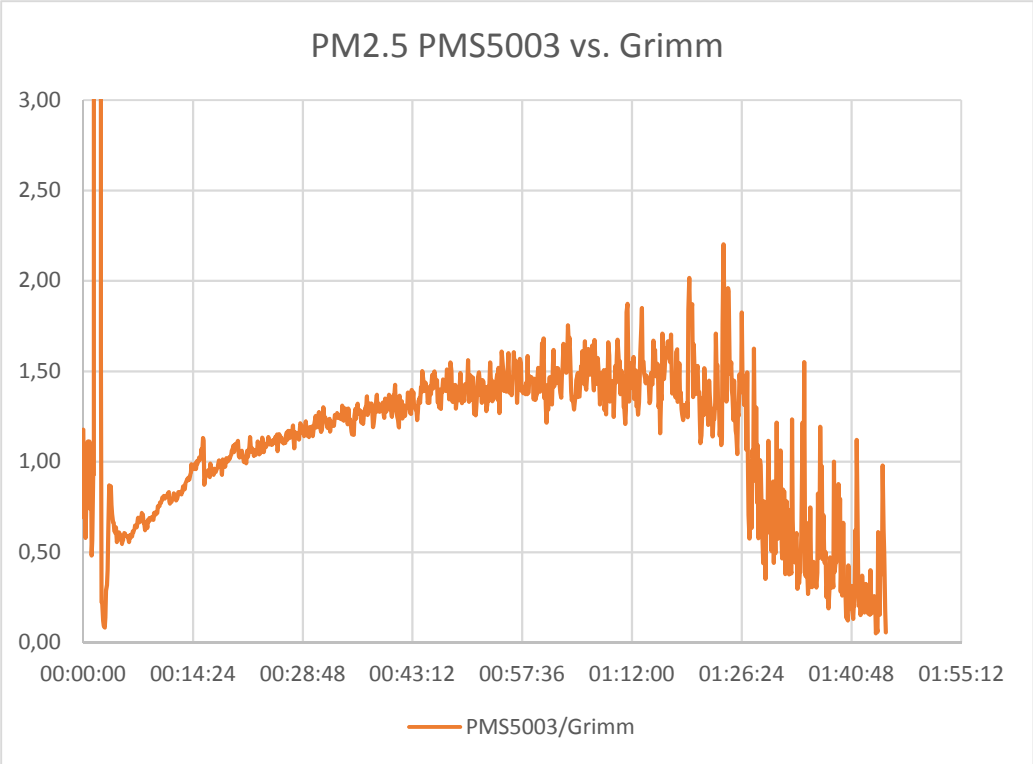

Fig. 6: The ratio PMS5003/Grimm for PM2.5 during the measurement Fig 5a: Comparison for PM10 values reported by the Grimm and the PMS5003

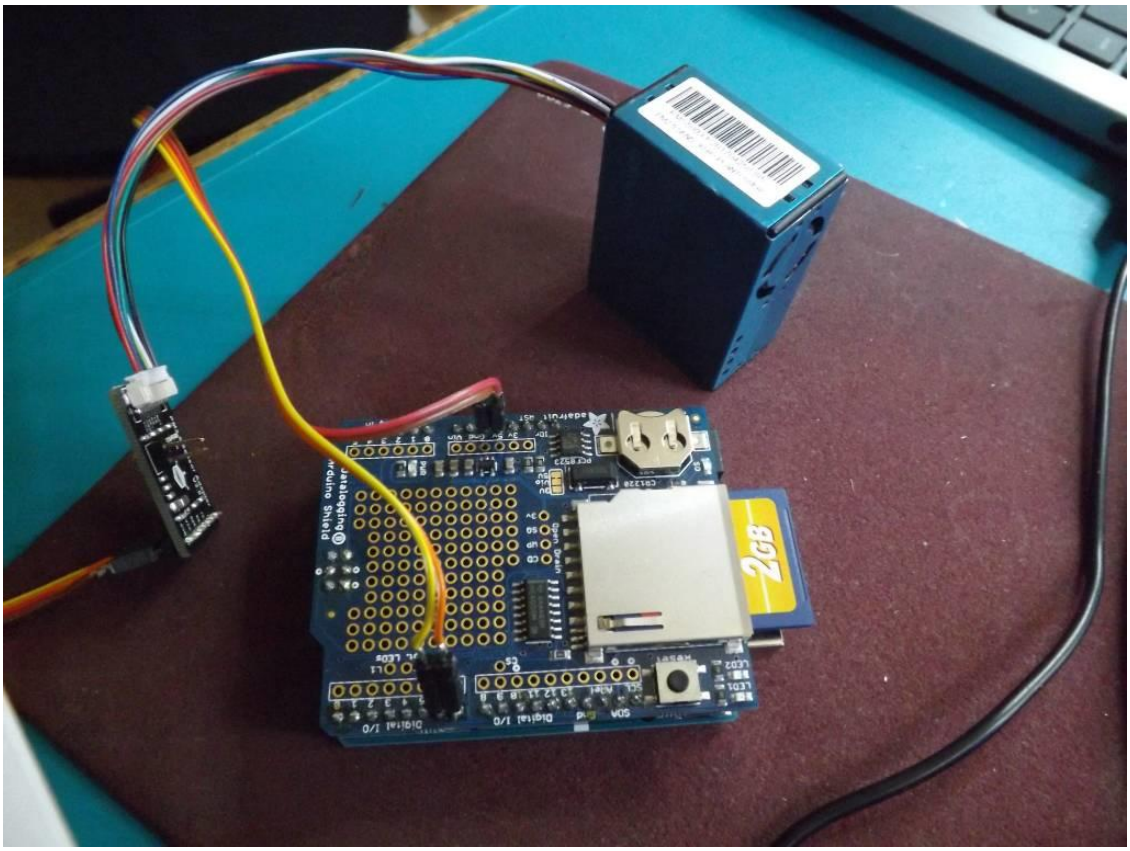

Fig. 7: Plantower PMS5003 device connected to an Arduino based datalogger

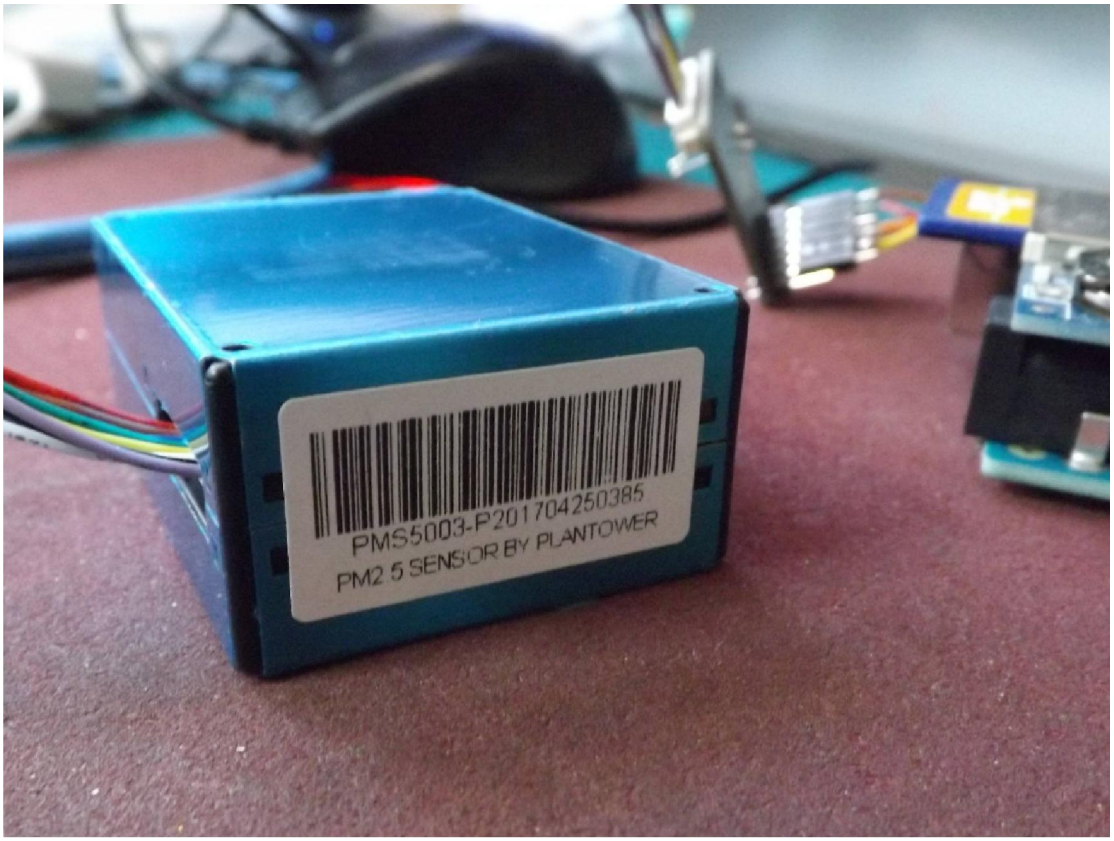

Fig. 8: The PMS5003 with attached product sticker designating it as PM2.5 sensor

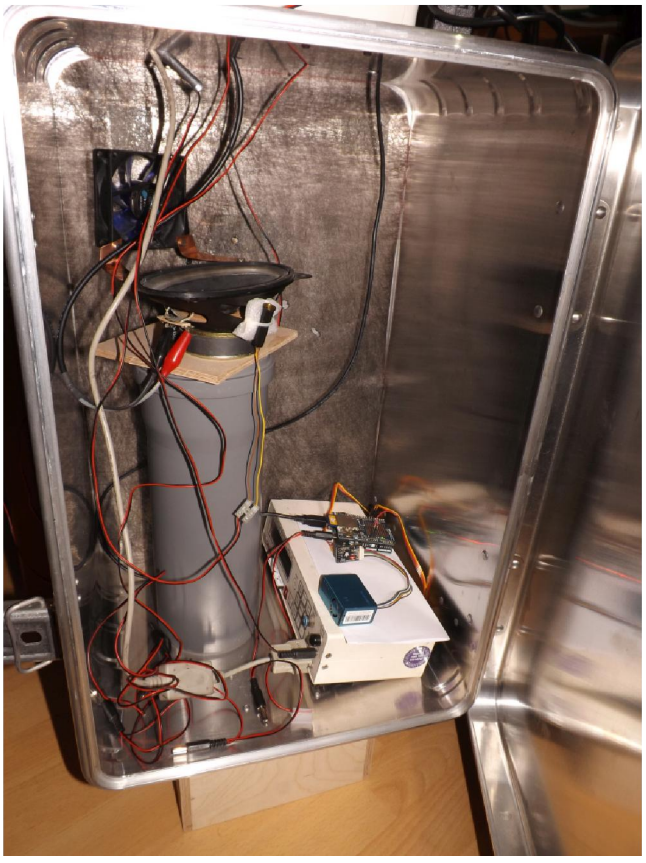

Fig. 9: The measurement chamber of the particle generator with Grimm and PMS5003