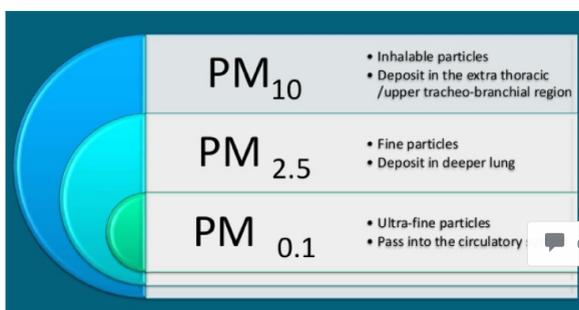


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## A test of inexpensive LLS fine particle sensors



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### 1. Intro

Fine particle measurements are hip, and unbelievable articles about the death-toll they cause abound. Usually traffic (and especially Diesel cars, the new villain of the block) are given as the main culprit. This is completely nonsense, as only about 25% of fine particles come from car engines; a big chunk has a natural origin, and a real big part comes from wood burning. Nevertheless, measuring these very small particles is important, but not easy. Here we speak about sizes less than 2.5um or less than 10 um (1 um = 1 micrometer = one thousands part of a millimeter). "Official" measurement devices are costly, typically in the **20000 Euro** range and measure directly the mass per cubic-meter of dry air (in ug/m<sup>3</sup>). They are based either on the attenuation of radioactive beta radiation (BAM) or on a direct mass measurement: either by weighing a filter exposed to the dust (for integral measurements over longer periods) or by detecting the changes of the oscillation frequency of an oscillator on which the particles attach themselves. A real problem is humidity: many type of particles (e.g. salt dust) absorb water vapor and increase in size and mass, and so give faulty results. So professional sensors first dry the incoming air flow, which must be kept rigorously constant and be influenced by changes in atmospheric pressure or wind conditions.

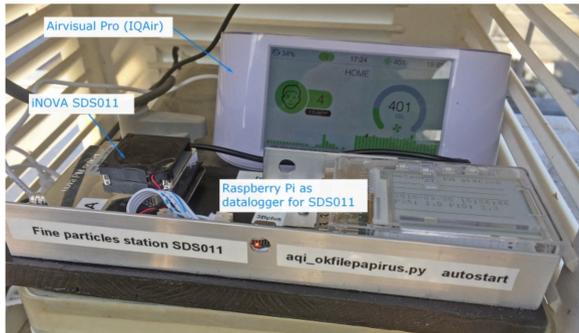
Laser light scattering (LLS) sensors are completely different. A laser beam from a solid-state sensor is more or less diffracted by the number of particles in a black chamber, and the diffracted light is measured by a photosensor and analyzed by a micro-controller. Actually what is measured is the count of particles per volume, and from this count, by many assumptions and proprietary algorithms, a mass per volume is calculated. In the inexpensive sensors like the Nova SDS011 or the Plantower series the air is pushed into the measurement chamber by a small fan; so there is no drying, and the airflow is under the influence of changes of atmospheric pressure and wind. Clearly, this type of sensor cannot rival the professional ones, but they are far from useless. Many grass-root movements of "citizen science" use these sensors which often are in a price range between **15 and 50 Euros**; nearly all are made in China or in Japan.

### 2. The meteoLCD test setup

I started working on these sensors in June by buying several SDS011 and a Airmaster AM7, which combines PM2.5 and PM10 with T (temperature), RH (relative humidity) and CO2 measurements. All these sensors do not store their measurements, but either give a binary stream (SDS011) or a stream of ASCII lines. So I added a Raspberry Pi nano-computer running a Python script to make a standalone device, which logged its data on the SD card. A third type of sensor acquired was the [Airvisual Pro](#) from the Swiss company IQAir. This is a real stylish device costing 259 Euro which has its own storage and WiFi communication facility. The picture below shows the Airmaster AM7 with the Rapsberry Pi mounted in a Stevenson hut on the meteoLCD terrace in a previous test:



The next test (which gave the data for the paper) had a SDS011 and an Airvisual Pro in the hut:

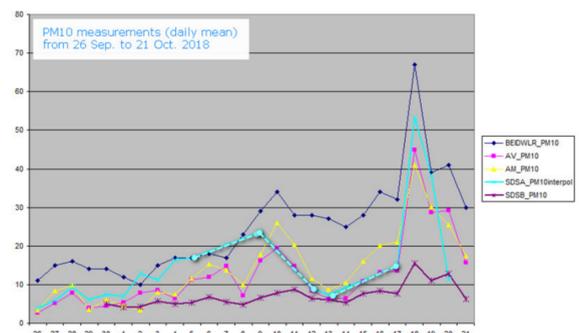


The black box on the SDS011 is the fan, and the shining case with the letter A is the measuring chamber. The serial output is read by the Raspberry Pi through a serial-to-USB converter.

### 3. Test results

The test ran from 25th Sep. to 22 Oct. 2018, and the full days 26/09 to 21/10 were used to compare the results to the of the nearest official station (Beidweiler). The full text of the report is [here](#).

Let me just give the figure which shows that the inexpensive sensors were able to reproduce the variations of the average daily PM10 concentrations, and also the peak event on the 18th October:



BEIDWLR = Beidweiler station, AV = Airvisual Pro, AM = Airmaster. Left scale in ug/m<sup>3</sup>.

The test period was rather dry, with RH not exceeding 75%, a number which is given by some authors as the threshold above which measurement become strongly impacted by humidity. So a test during wet and foggy days will be repeated in the near future.

### 4. Conclusion

The test shows that these inexpensive LLS sensors are more than a useless gimmick. Sure, they lack the bell and whistles of the professional sensors costing 400 times more, and certainly should not be used as a basis for legal action. But they are able to give a nice picture of the ambient fine particle concentration, and its variation. If you want to impress, strike a match (or light a candle) and blow out the flame in front of a sensor. You will be surprised by spectacular peak values!

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