# Laboratory Evaluation
# Dylos - DC1700 PM Sensor

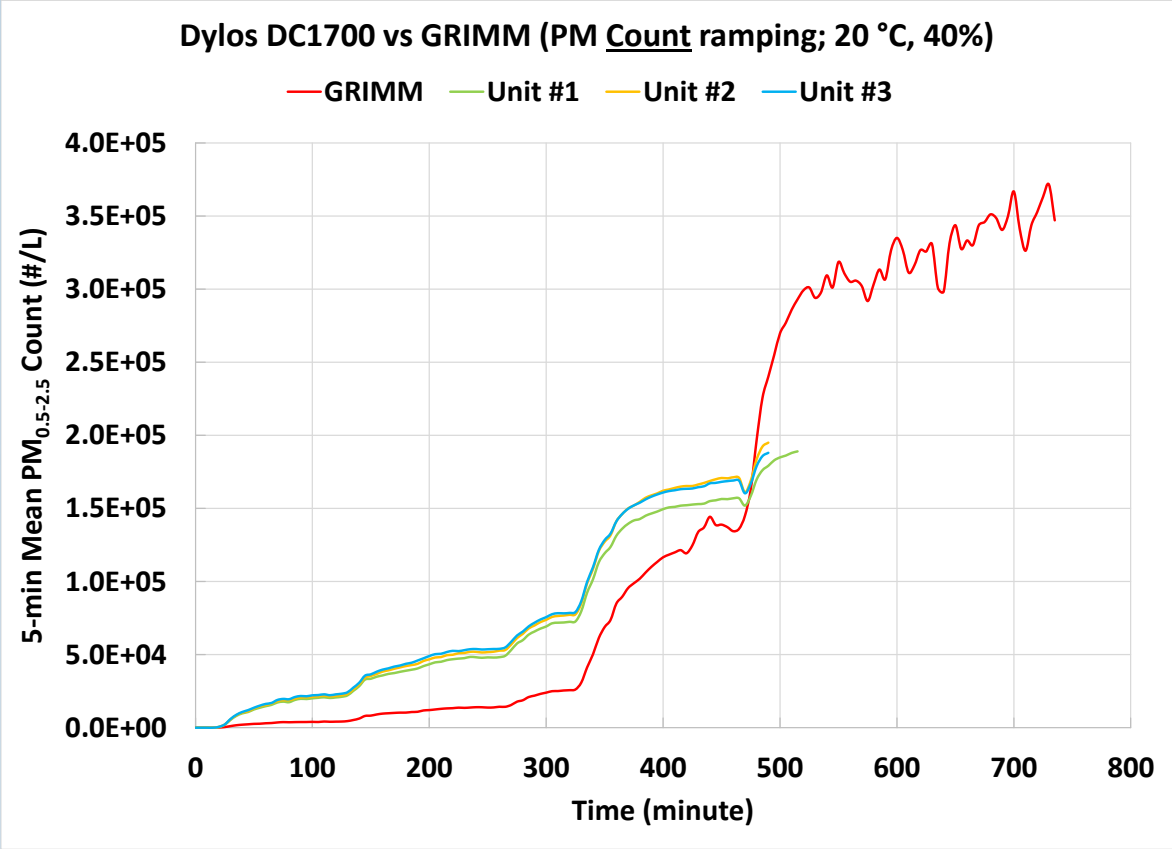

# Background

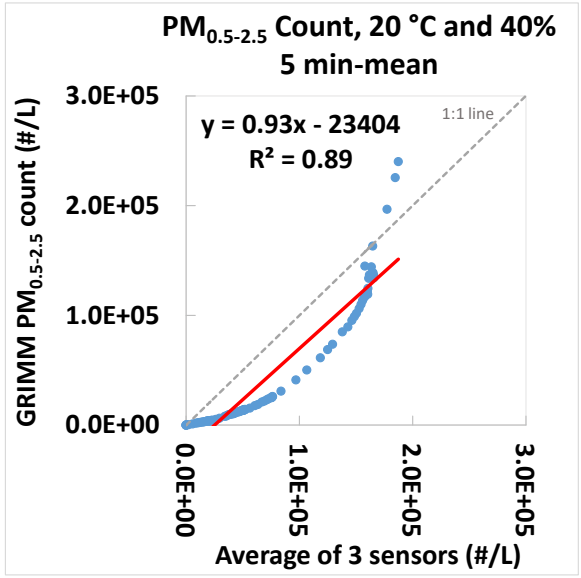
- Three Dylos DC1700 PM sensors were evaluated in the South Coast AQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity conditions. Previously, three Dylos DC1100 PRO PM sensors were tested in the field under ambient conditions. The main difference between the two models was the power supply: DC1100 PRO is powered by battery, whereas DC1700 runs both on battery and power cable.

- Dylos (*3 units tested*):
  - Optical particle counter (non-FEM)
  - Measures count of particles larger than 2.5 µm in diameter and particles larger than 0.5 µm in diameter
  - Particle count of $PM_{0.5\text{-}2.5}$ = particle count ($D_p$ > 2.5 µm) – particle count ($D_p$ > 0.5 µm)
  - Cost: ~$500
  - Time resolution: 1-min

- GRIMM (*reference method*):
  - Optical particle counter
  - Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and $PM_1$ from particle number measurements
  - Cost: ~$25,000
  - Time resolution: 1 min

# Dylos DC1700 vs GRIMM ($PM_{0.5-2.5}$ count; 5-min mean)




- Dylos sensors showed strong correlations with GRIMM $PM_{0.5-2.5}$ measurement data ($R^2$ = 0.89) when GRIMM $PM_{0.5-2.5}$ was lower than $2.0*10^5$ #/L. Dylos sensors overestimated the low $PM_{0.5-2.5}$ concentration as measured by the GRIMM.

- When GRIMM $PM_{0.5-2.5}$ count was less than $2.0*10^5$ #/L, the Dylos sensors tracked well the conc. variations (concentration ramping) as recorded by the GRIMM.
- At GRIMM $PM_{0.5-2.5}$ count higher than $2.0*10^5$ #/L, the Dylos sensors did not respond properly, reporting invalid count concentrations (not shown in the above figure, only in the raw data files).

# Dylos DC1700 vs GRIMM Accuracy

- Accuracy* (20 °C and 40% RH)

| Steady State (#) | Sensor mean (#/L) | GRIMM (#/L) | Accuracy (%) |
|---|---|---|---|
| 1 | 22223 | 4235 | -325 |
| 2 | 52460 | 14314 | -166 |
| 3 | 76464 | 26176 | -92 |
| 4 | 165596 | 136104 | 78 |

- Overall, the three Dylos sensors showed accuracy in the range of -325% to 78% as compared to GRIMM at 20 °C and 40% RH. The accuracy improved as $PM_{0.5\text{-}2.5}$ count concentration increased.
- Dylos stopped recording valid count numbers when the $PM_{0.5\text{-}2.5}$ surpassed $2*10^5$ #/L as recorded by the GRIMM.

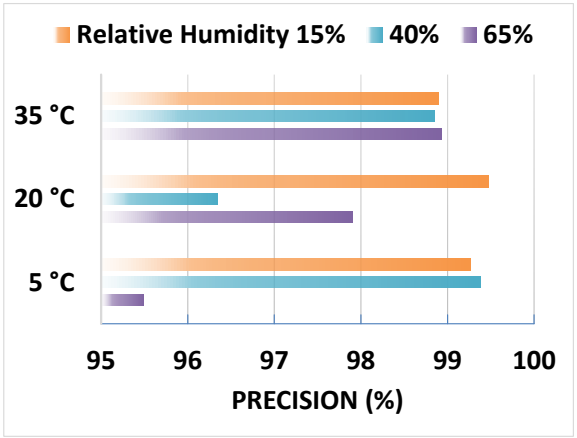
# Dylos DC1700 data recovery & intra-model variability

- Data recovery for $PM_{0.5\text{-}2.5}$ count from Unit #1, Unit #2, and Unit #3 was 100%, 97%, and 100% respectively.
- Low $PM_{2.5}$ measurement variations were observed between the three units.

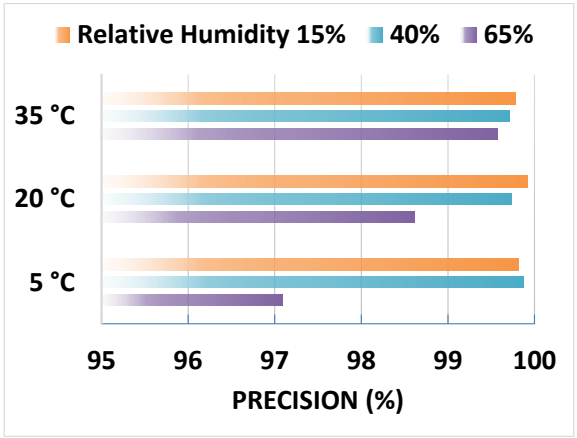
# Dylos DC1700 vs GRIMM Precision

- Precision (Effect of $PM_{0.5-2.5}$ conc.,Temperature and Relative Humidity)

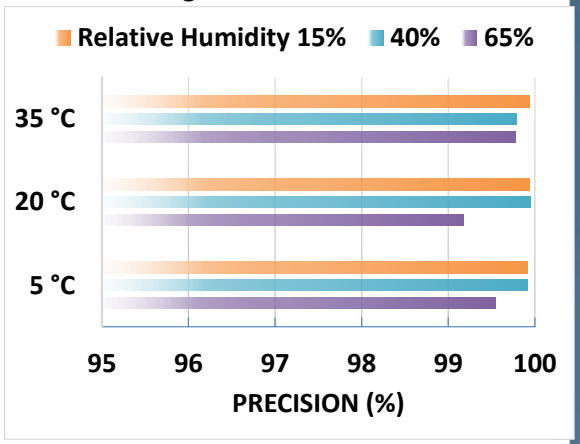
Low PM count




Medium PM count

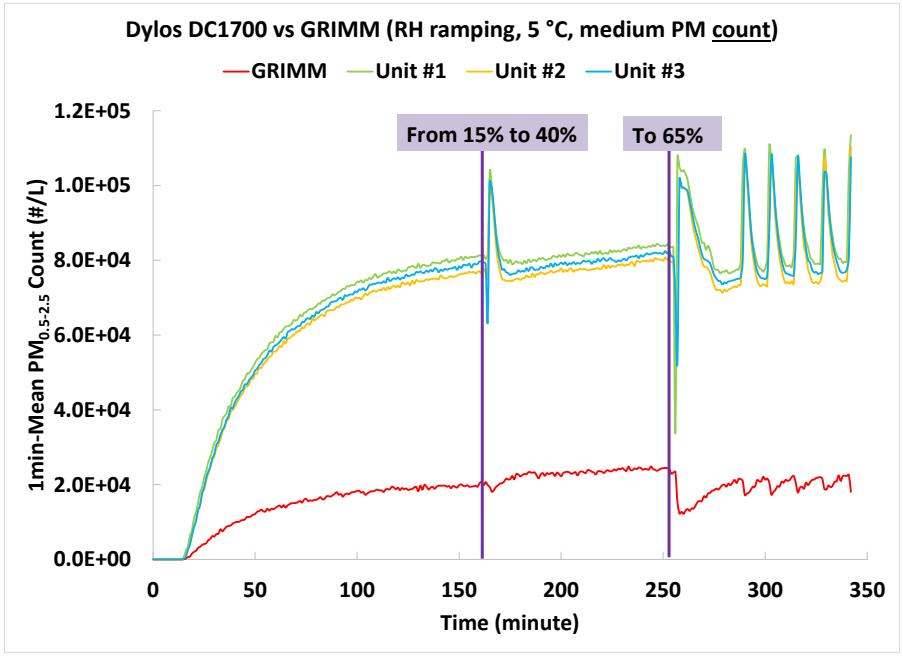



High PM count

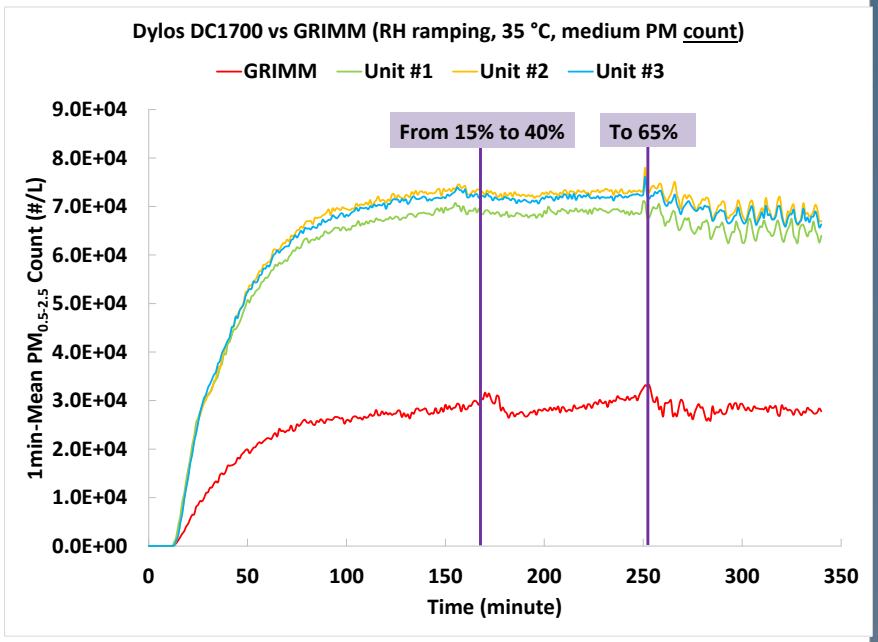



- Dylos sensors have good precision for most of the test combinations ($PM_{0.5-2.5}$, T and RH), except at low temperature and high humidity, where the precision was affected by the out-of-scale spikes.

# Dylos DC1700 Climate Susceptibility




Low Temp – RH ramping
(medium conc.)




High Temp – RH ramping
(medium conc.)

# Discussion

The three Dylos DC1700 (battery and power cable capabilities) sensors were only tested in the laboratory chamber. The previous version Dylos DC1100 PRO (battery only) was only tested in the field.

- **Accuracy**: Overall, Dylos DC1700 units have low accuracy at low PM concentrations and high accuracy (78%) around $1.5*10^5$ #/L , as compared to the GRIMM for $PM_{0.5-2.5}$ ranging 0 to $2*10^5$ #/L (refer to slide 4).
- **Precision**: Dylos sensors have good precision for most of the test combinations ($PM_{0.5-2.5}$, T, and RH), except at low temperature and high RH (refer to slide 5).
- **Data Recovery:** Data recovery for $PM_{0.5-2.5}$ count from Unit #1, Unit #2, and Unit #3 was 100%, 97%, and 100% respectively.
- **Coefficient of Determination**: Dylos sensors showed strong correlation/linear response with the corresponding GRIMM $PM_{0.5-2.5}$ measurement data ($R^2 = 0.89$) for count # below $2*10^5$ #/L (refer to slides 3)
- **Concentration range**: 0 to $2*10^5$ #/L $PM_{0.5-2.5}$ as measured by GRIMM. Dylos sensors largely overestimated the $PM_{0.5-2.5}$ count. When GRIMM $PM_{0.5-2.5}$ count was higher than $2*10^5$ #/L, Dylos sensors started to record invalid count numbers.
- **Climate susceptibility**: During the laboratory studies, temperature and relative humidity had some effect on the precision of the sensors. At low temperature-high RH, Dylos sensors' precision was affected. In addition, in order to maintain 40% and 65% RH at 5 °C, the chamber has a fast heating and cooling mechanism, causing a variation around the target RH. Consequently, it also resulted into spiked and invalid values as recorded by the Dylos sensors.