Field Evaluation
Laser Egg PM Sensor

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 08/01/2016 to 09/26/2016, three **Origins Laser Egg PM Sensors** were deployed at our (SCAQMD) Rubidoux station and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant

- *Laser Egg Sensor (3 units tested):*
  - Particle sensors (optical; non-FEM)
  - Each unit reports: $PM_{2.5}$ and PM_{10} mass concentration ($\mu g/m^3$)
  - PM sensor: Plantower PMS3003
  - Unit cost: ~$200
  - Time resolution: 30-sec
  - Units IDs: 9d45, 9146, CCAE

- MetOne BAM (*reference method*):
  - Beta-attenuation monitors (FEM)
  - Measures $PM_{2.5}$ & PM_{10} mass ($\mu g/m^3$)
  - Unit cost: ~$20,000
  - Time resolution: 1-hr

Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data (i.e. obvious outliers, negative values and invalid data-points were eliminated from the data-set)
- Data recovery for $PM_{2.5}$ and PM_{10} from Laser Egg units 9146 and CCAE was 99.9%, while from unit 9d45 was 75 %.

Laser Egg sensors; intra-model variability

- Very low measurement variations were observed between the three Laser Egg devices for $PM_{2.5}$ and PM_{10} mass concentrations ($\mu g/m^3$)
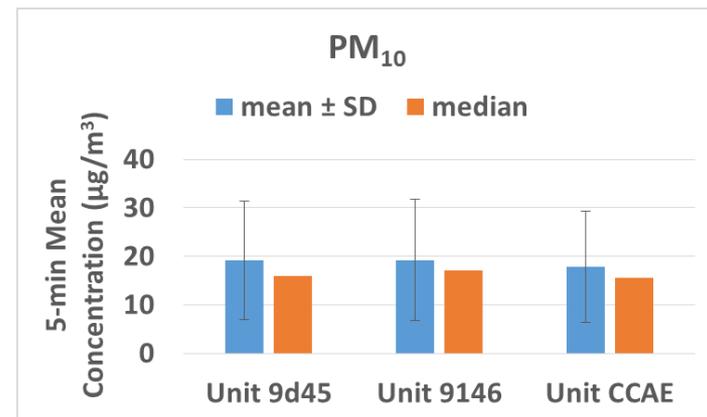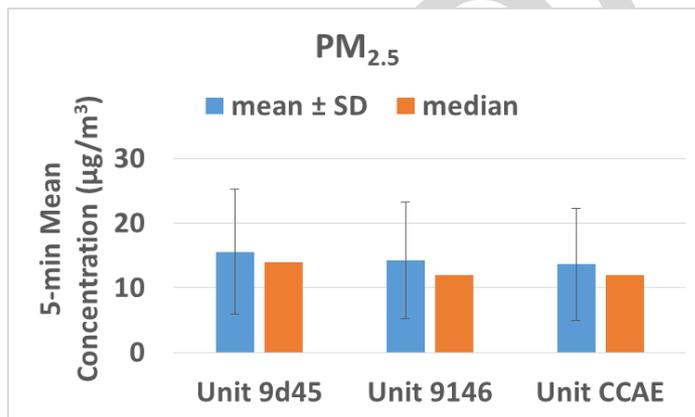
Laser Egg Sensor vs FEM BAM (PM$_{2.5}$; 1-hr mean)

Laser Egg vs FEM BAM (PM$_{2.5}$)

— FEM — Unit 9d45 — Unit 9146 — Unit CCAE
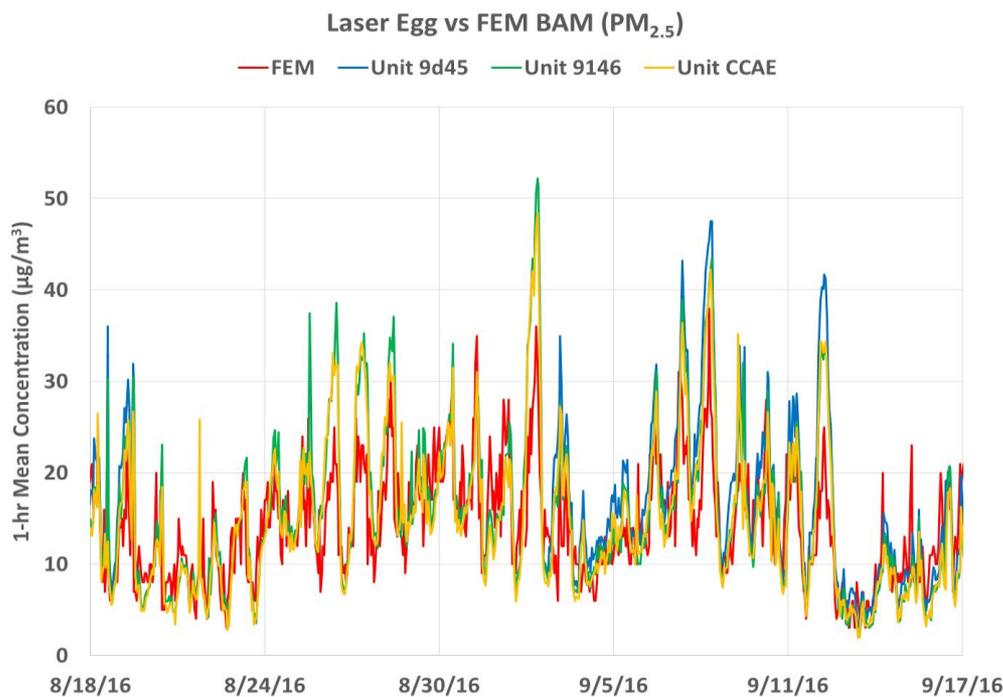
- Laser Egg PM$_{2.5}$ mass measurements correlate well with the corresponding FEM BAM data (R^2 > 0.57)
- The three sensor units tracked the diurnal PM variations recorded by the FEM BAM instrument well
- Measurements from all three Laser Egg devices are moderately accurate when compared to the corresponding FEM BAM data
- Data recovery for FEM BAM PM$_{2.5}$ was 95.6% and for PM$_{10}$ 100%

PM$_{2.5}$ (µg/m³; 1-hr mean)

$y = 0.4958x + 5.883$
$R^2 = 0.5711$

Unit 9d45

PM$_{2.5}$ (µg/m³; 1-hr mean)

$y = 0.5414x + 6.2754$
$R^2 = 0.5724$

Unit 9146

PM$_{2.5}$ (µg/m³; 1-hr mean)

$y = 0.566x + 6.2765$
$R^2 = 0.5862$

Unit CCAE
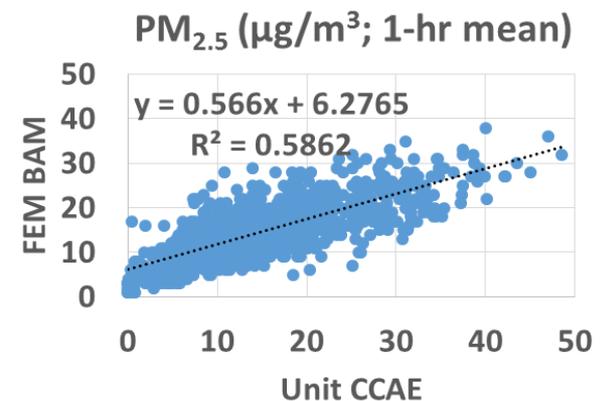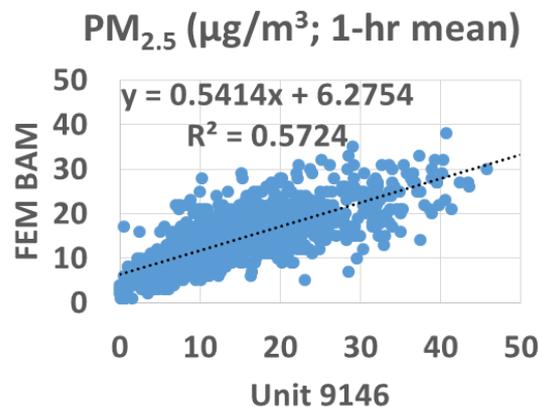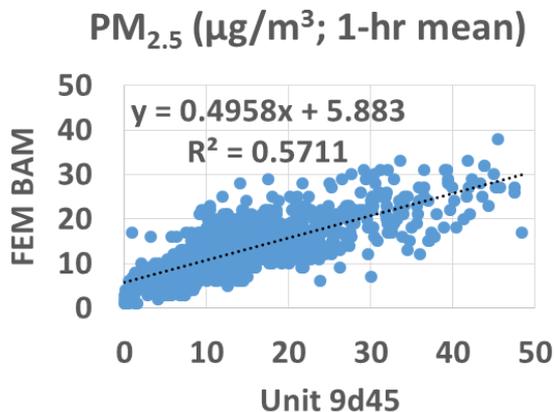
Laser Egg Sensor vs FEM BAM (PM_{10}; 1-hr mean)
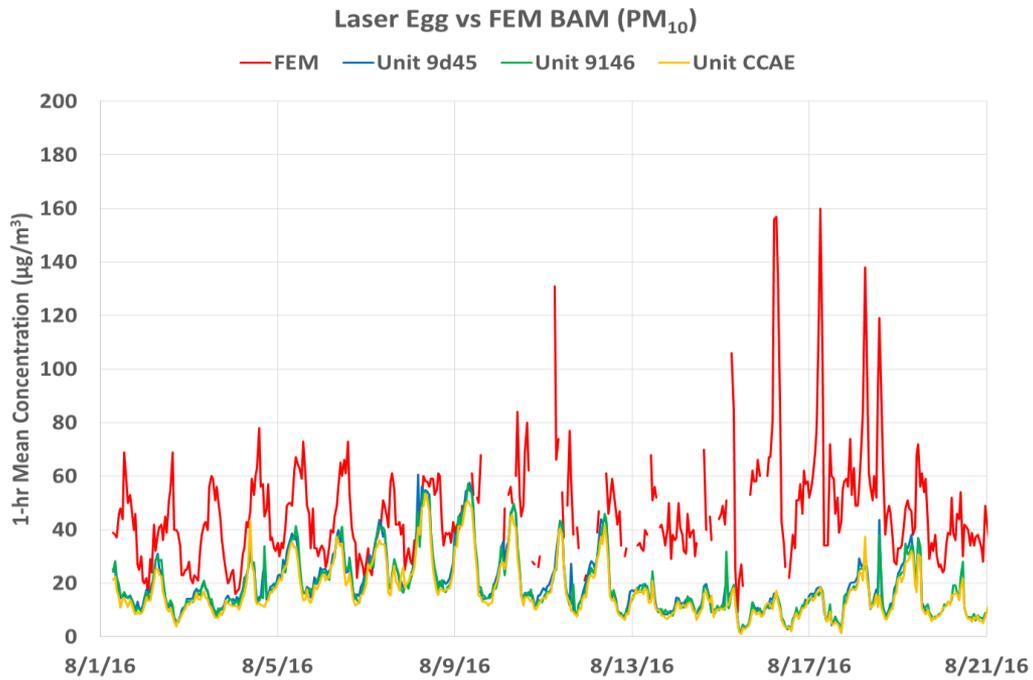
Laser Egg vs FEM BAM (PM_{10})

- Laser Egg PM_{10} mass measurements do not correlate with the corresponding FEM BAM data ($R^2 \sim 0.0$)
- The three sensor units do not always track the diurnal variations recorded by the FEM BAM instrument
- Laser egg PM_{10} measurements are underestimated with respect to the corresponding FEM BAM data

PM_{10} ($\mu g/m^3$; 1-hr mean)

$y = 0.332x + 40.083$
$R^2 = 0.0285$

PM_{10} ($\mu g/m^3$; 1-hr mean)

$y = 0.4111x + 38.737$
$R^2 = 0.0509$

PM_{10} ($\mu g/m^3$; 1-hr mean)

$y = 0.4191x + 39.159$
$R^2 = 0.045$
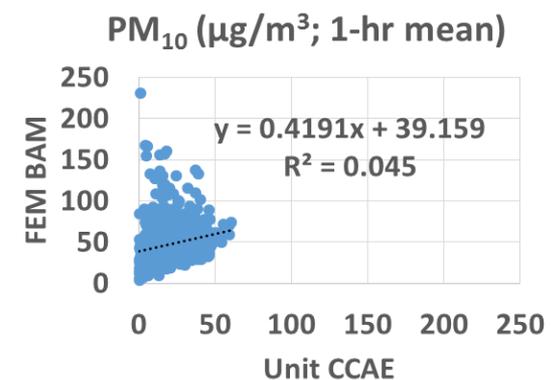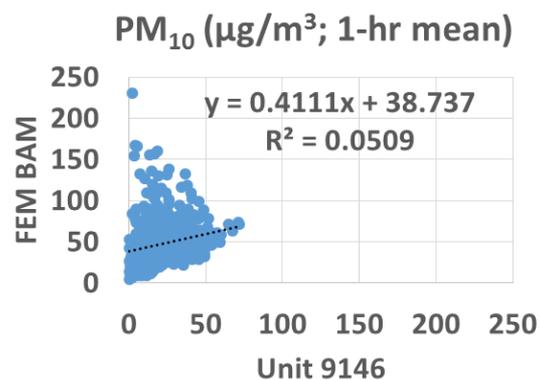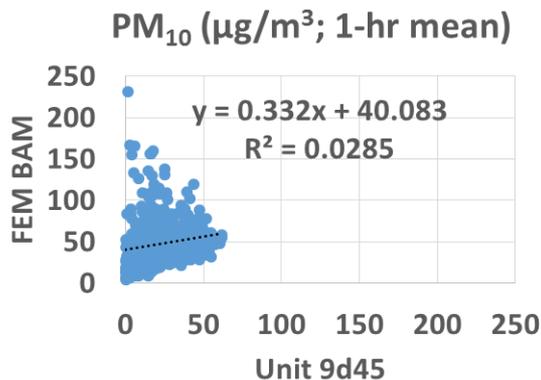
Laser Egg Sensor vs FEM BAM (PM$_{2.5}$; 24-hr mean)

Laser Egg vs FEM BAM (PM$_{2.5}$)

— FEM — Unit 9d45 — Unit 9146 — Unit CCAE
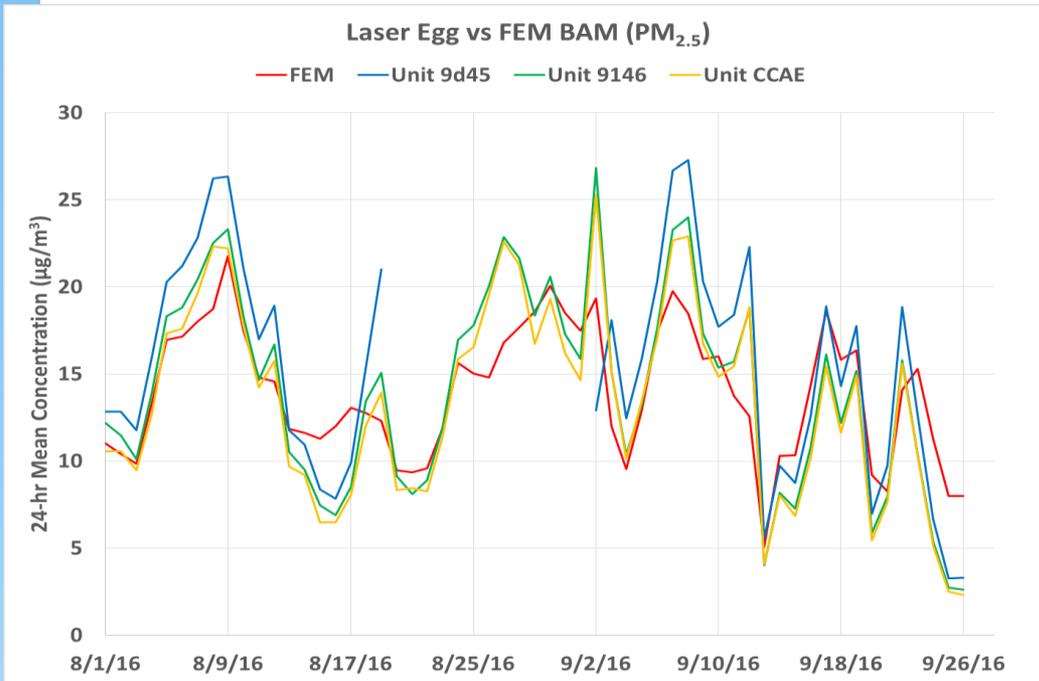
- Laser Egg PM$_{2.5}$ mass measurements correlate well with the corresponding FEM BAM data (R^2 > 0.66)
- The three sensor units tracked the diurnal PM variations recorded by the FEM BAM instrument well

PM$_{2.5}$ (μg/m³; 24-hr mean)

$y = 0.4788x + 6.3369$
$R^2 = 0.6636$

PM$_{2.5}$ (μg/m³; 24-hr mean)

$y = 0.5643x + 6.0143$
$R^2 = 0.7664$

PM$_{2.5}$ (μg/m³; 24-hr mean)

$y = 0.5746x + 6.2295$
$R^2 = 0.7498$
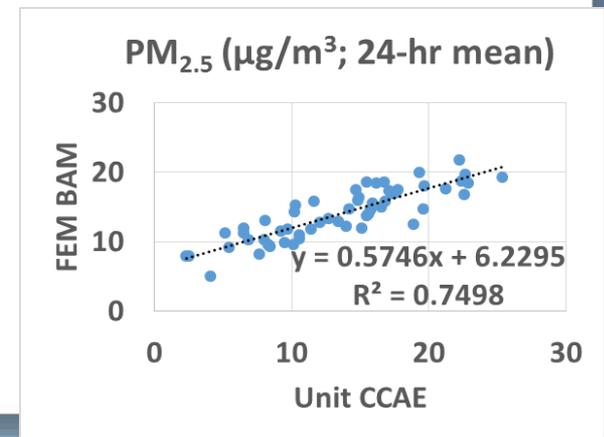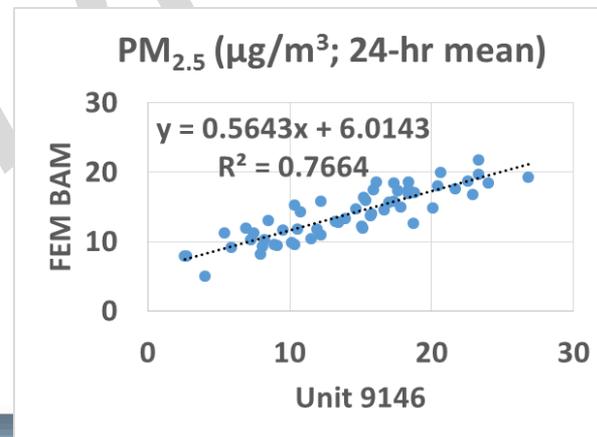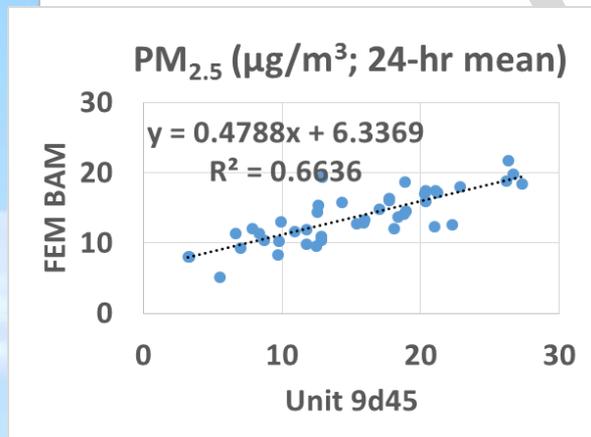
Laser Egg Sensor vs FEM BAM (PM$_{10}$; 24-hr mean)
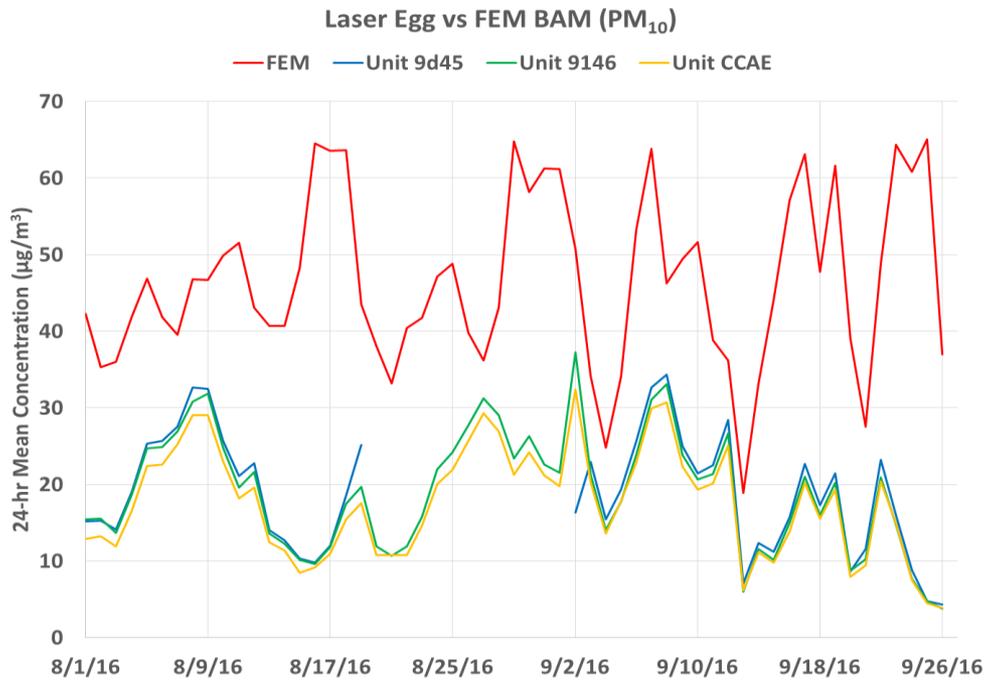
Laser Egg vs FEM BAM (PM$_{10}$)

Legend: FEM — Unit 9d45 — Unit 9146 — Unit CCAE

- Laser Egg PM$_{10}$ mass measurements do not correlate with the corresponding FEM BAM data (R^2 ~ 0.0)
- The three sensor units do not always track the diurnal variations recorded by the FEM BAM instrument
- Laser Egg PM$_{10}$ measurements are underestimated with respect to the corresponding FEM BAM data

PM$_{10}$ (µg/m^3; 24-hr mean)

$y = 0.1482x + 43.548$
$R^2 = 0.01$

Unit 9d45

PM$_{10}$ (µg/m^3; 24-hr mean)

$y = 0.2293x + 42.181$
$R^2 = 0.0252$

Unit 9146

PM$_{10}$ (µg/m^3; 24-hr mean)

$y = 0.2525x + 42.083$
$R^2 = 0.0258$

Unit CCAE
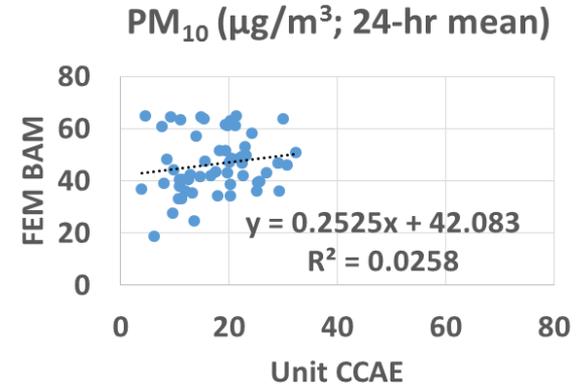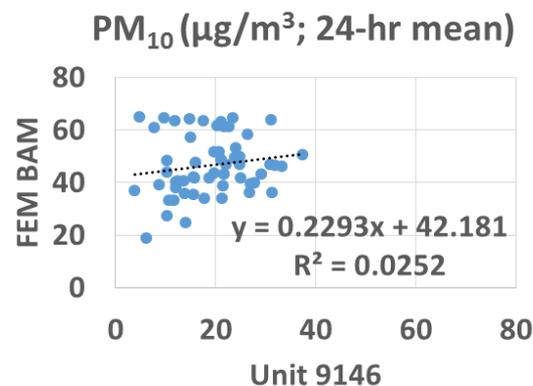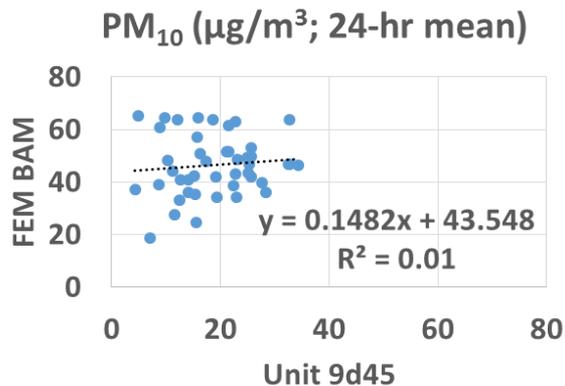
Discussion

- Overall, the three **Laser Egg PM Sensors** were reliable (data recovery was between 75 and 99.99 % for all units tested) and were characterized by very low intra-model variability

- Laser Egg $PM_{2.5}$ sensors showed a modest correlation ($R^2 \sim 0.58$) with the corresponding measurements collected using an FEM BAM. The sensors did not correlate with the BAM for PM_{10} ($R^2 \sim 0.0$)

- No sensor calibration was performed by SCAQMD staff prior to the beginning of this test

- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions

- <u>All results are still preliminary</u>