Field Evaluation
AirBeam PM Sensor


South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

- From 04/30/2015 to 06/19/2015, three **AirBeam PM Sensors** were deployed at one of our monitoring stations in Rubidoux, CA and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant

- <u>AirBeam Sensor</u> (*3 units tested*):
  - ➤ Particle sensors (optical; non-FEM)
  - ➤ Each unit measures: $PM_{2.5}$ mass (μg/m^3) and $PM_{2.5}$ count (hundred particles/ft^3)
  - ➤ Unit cost: ~$200
  - ➤ Time resolution: 1-min
  - ➤ Firmware: March 2015 AirBeam
  - ➤ Units IDs: CC7, CA9, D42

- <u>MetOne BAM</u> (*reference method*):
  - ➤ Beta-attenuation monitor (FEM)
  - ➤ Measures $PM_{2.5}$ mass (μg/m^3)
  - ➤ Unit cost: ~$20,000
  - ➤ Time resolution: 1-hr

- <u>GRIMM</u> (*reference method*):
  - ➤ Optical particle counter (FEM)
  - ➤ Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 mass from particle number measurements
  - ➤ Unit Cost: ~$25,000 and up
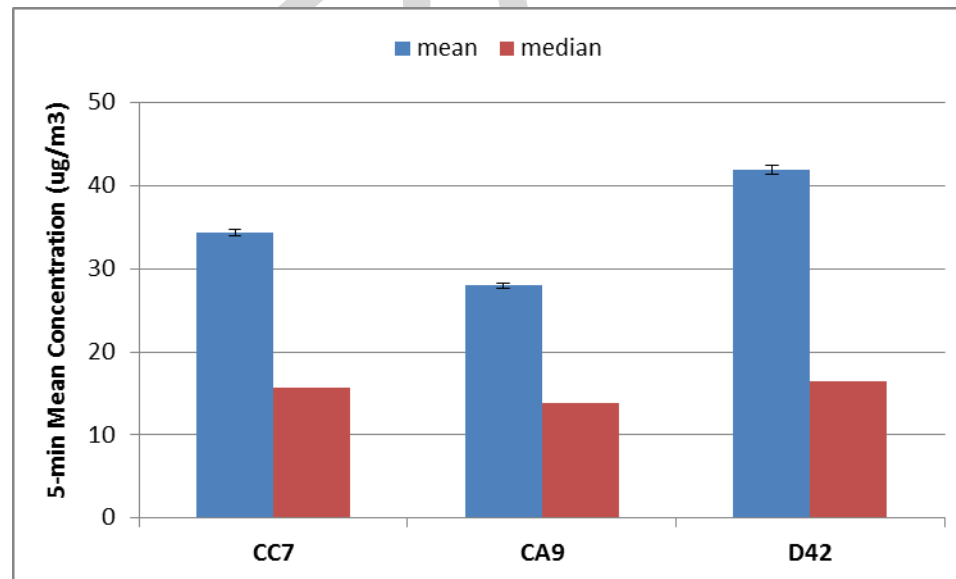 - ➤ Time resolution: 1-min
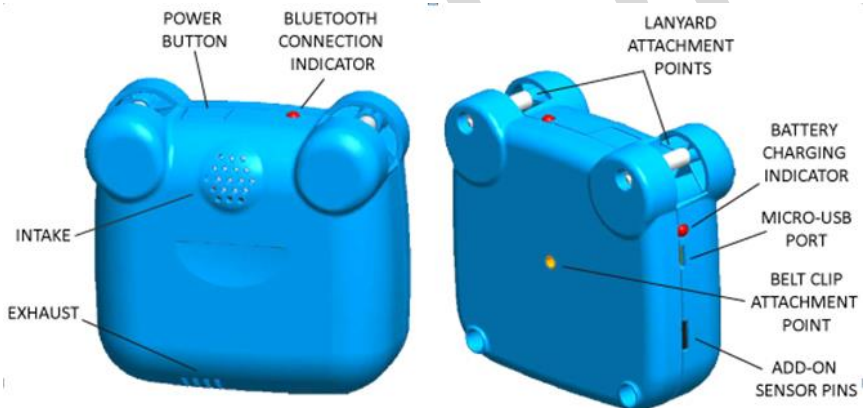
Data validation & recovery

- 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 $PM_{2.5}$ from all three AirBeam Sensors was >99%

AirBeam sensors; intra-model variability

- A substantial measurement variation was observed between the three AirBeam devices tested
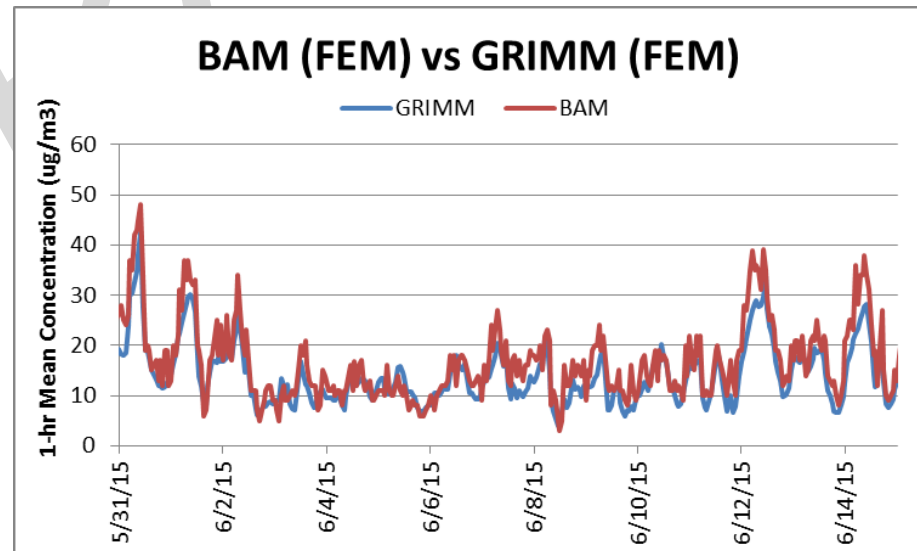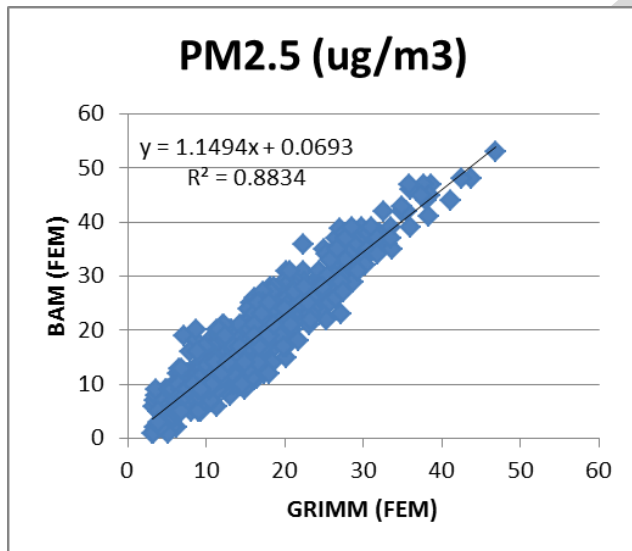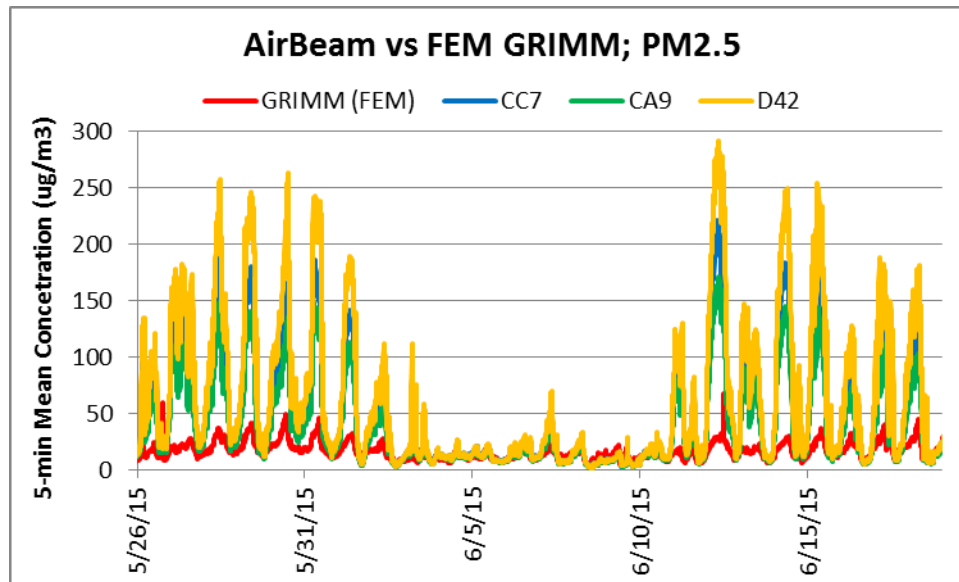
Data validation & recovery

- Basic QA/QC procedures were used to validate the collected FEM data (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- $PM_{2.5}$ data recovery was 80% for the GRIMM and >99% for the BAM
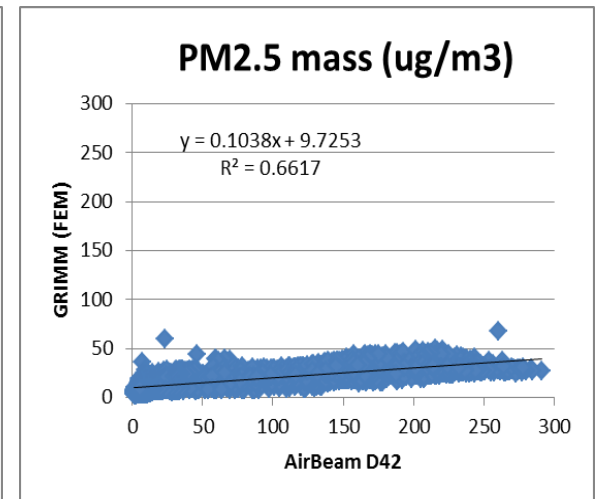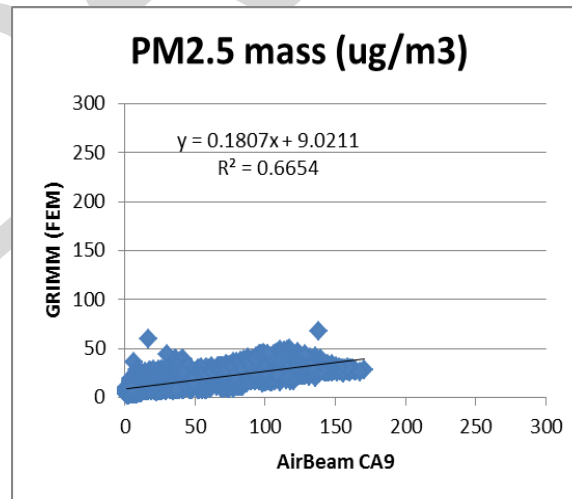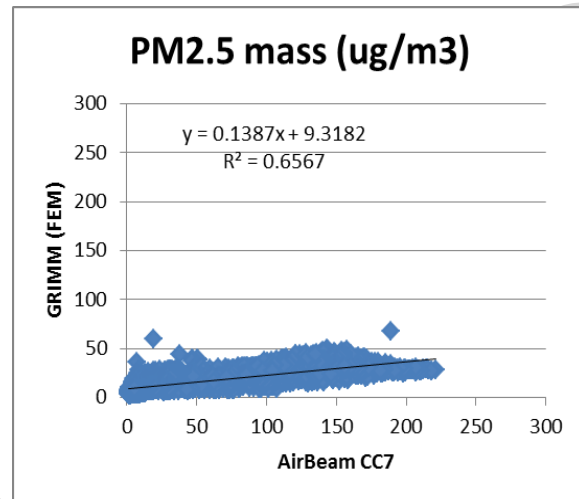
Equivalent methods: BAM vs GRIMM
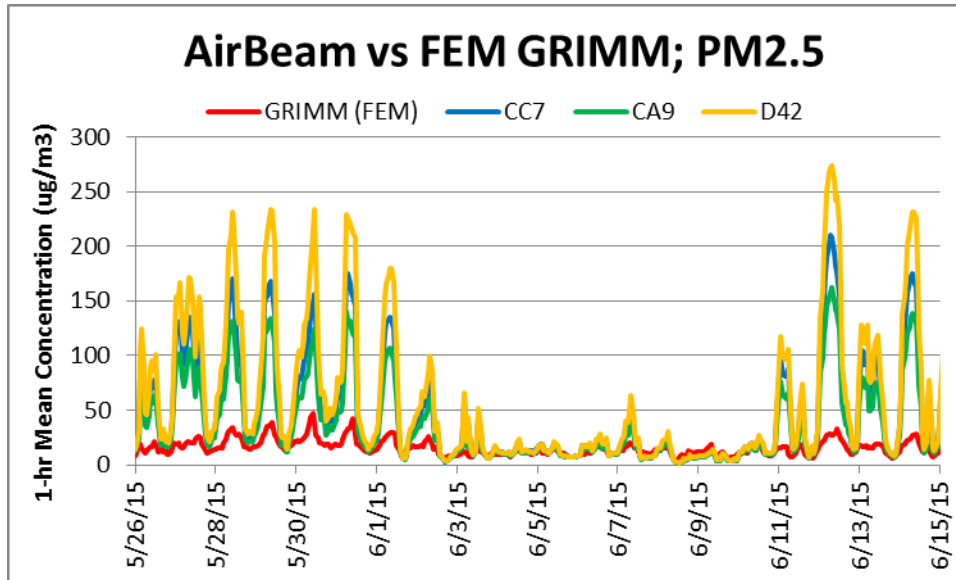
Very good correlation between the two equivalent methods

AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 5-min mean)

AirBeam vs FEM GRIMM; PM2.5
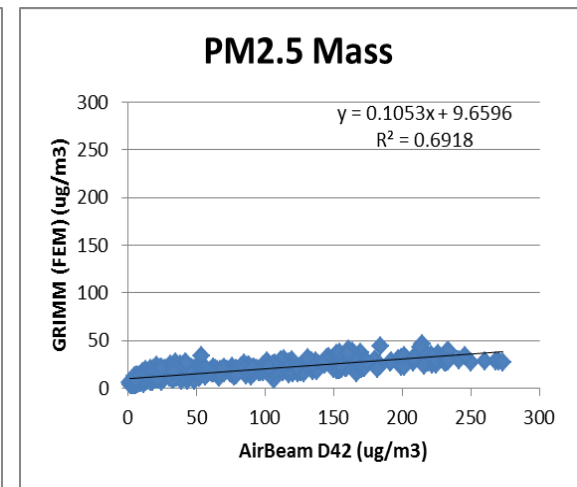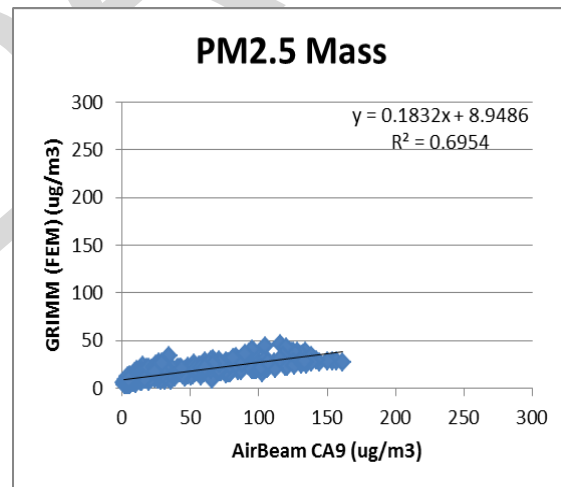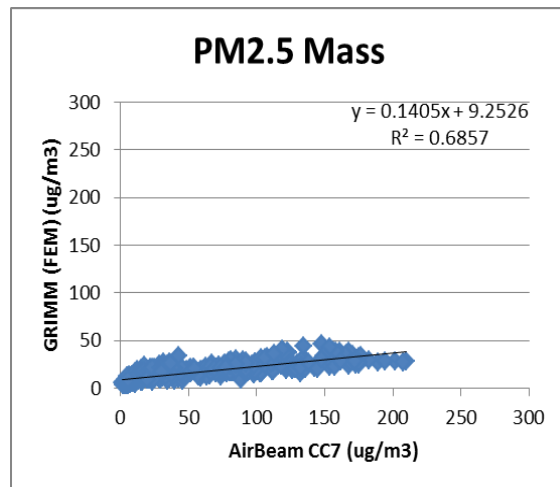
GRIMM (FEM) — CC7 — CA9 — D42

- PM$_{2.5}$ measurements correlate fairly well with the corresponding FEM GRIMM data (R^2>0.65), but the three AirBeam sensors largely overestimate measured PM$_{2.5}$ concentrations
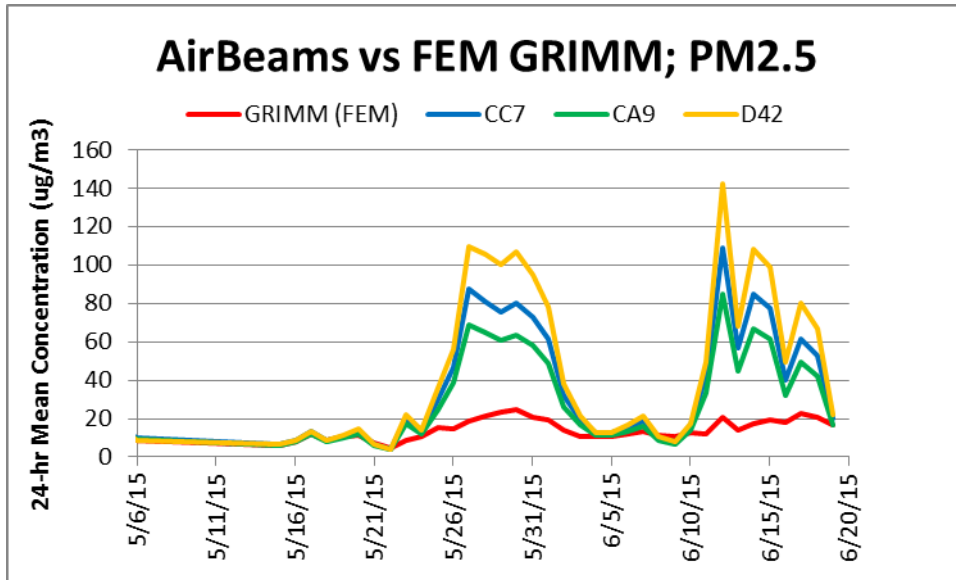
PM2.5 mass (ug/m3)

$y = 0.1387x + 9.3182$
$R^2 = 0.6567$

AirBeam CC7

PM2.5 mass (ug/m3)

$y = 0.1807x + 9.0211$
$R^2 = 0.6654$

AirBeam CA9

PM2.5 mass (ug/m3)

$y = 0.1038x + 9.7253$
$R^2 = 0.6617$

AirBeam D42

AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 1-hr mean)

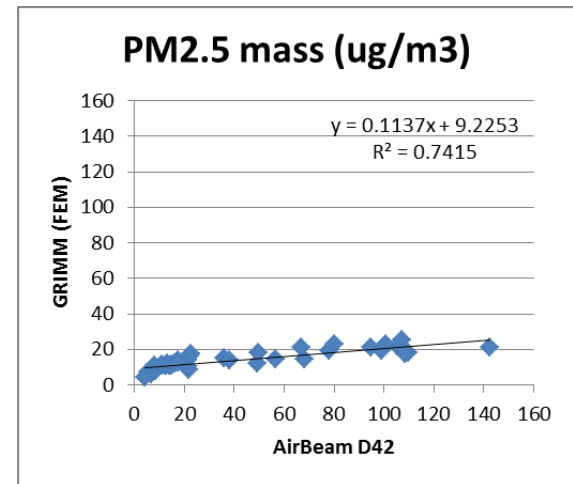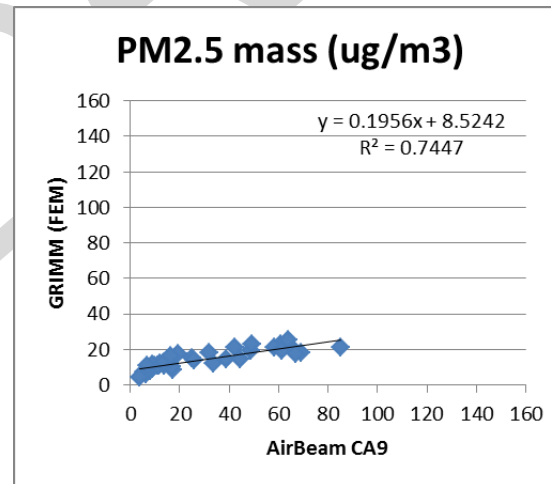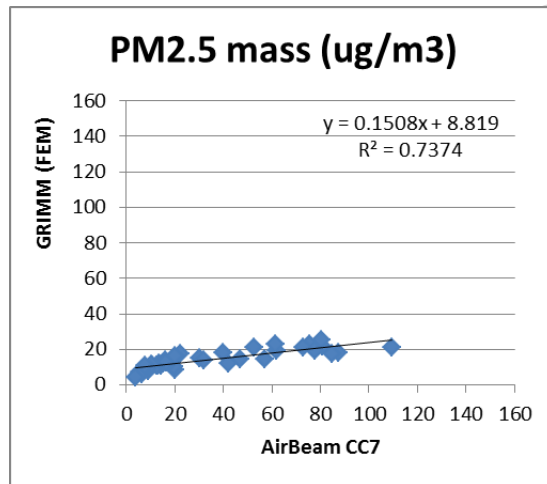**AirBeam vs FEM GRIMM; PM2.5**

Legend: GRIMM (FEM), CC7, CA9, D42

- All PM measurements correlate fairly well with the corresponding FEM GRIMM data (R^2>0.68), but the three AirBeam sensors largely overestimate measured PM$_{2.5}$ concentrations
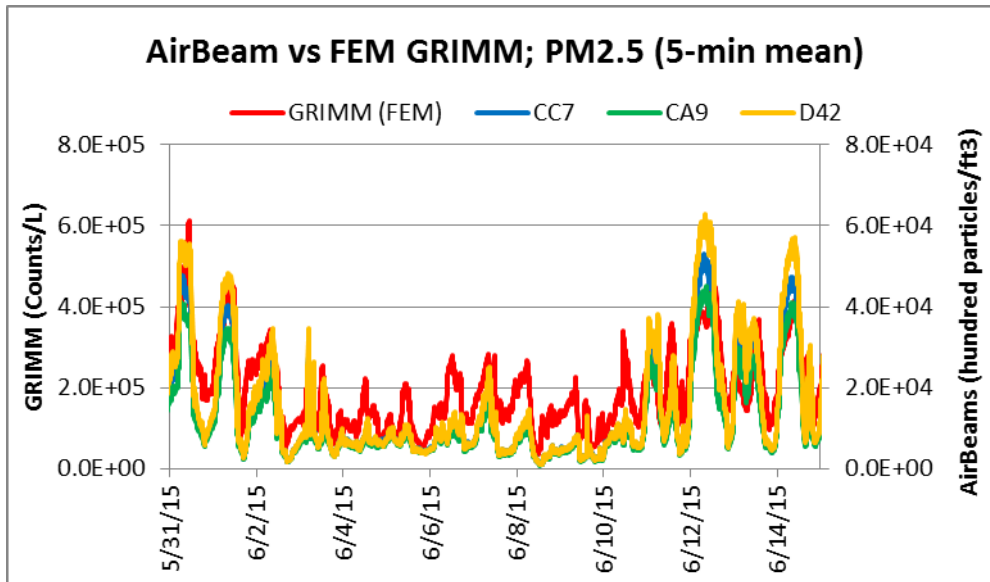

PM2.5 Mass

$y = 0.1405x + 9.2526$
$R^2 = 0.6857$

AirBeam CC7 (ug/m3)

PM2.5 Mass

$y = 0.1832x + 8.9486$
$R^2 = 0.6954$

AirBeam CA9 (ug/m3)

PM2.5 Mass

$y = 0.1053x + 9.6596$
$R^2 = 0.6918$

AirBeam D42 (ug/m3)

AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Mass; 24-hr mean)
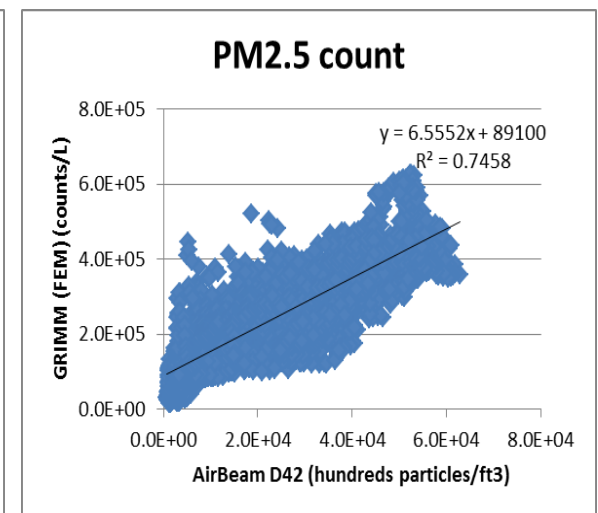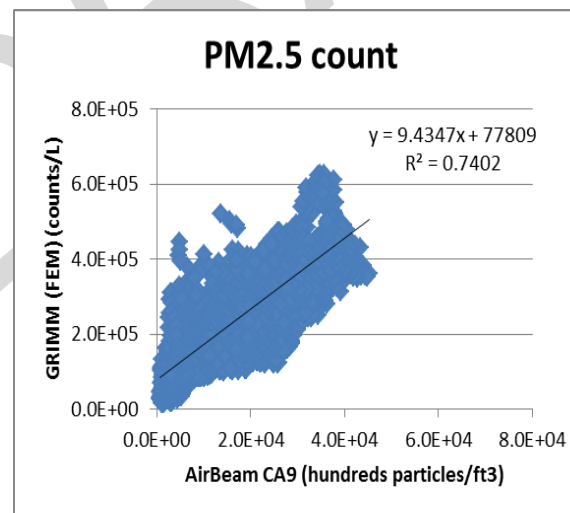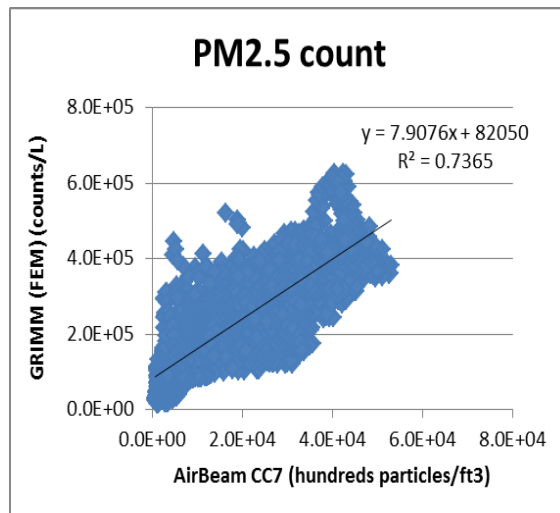

AirBeams vs FEM GRIMM; PM2.5

- All PM measurements correlate fairly well with the corresponding FEM GRIMM data ($R^2 > 0.73$), but the three AirBeam sensors largely overestimate measured PM$_{2.5}$ concentrations

PM2.5 mass (ug/m3)

$y = 0.1508x + 8.819$
$R^2 = 0.7374$

AirBeam CC7

PM2.5 mass (ug/m3)

$y = 0.1956x + 8.5242$
$R^2 = 0.7447$

AirBeam CA9

PM2.5 mass (ug/m3)

$y = 0.1137x + 9.2253$
$R^2 = 0.7415$

AirBeam D42

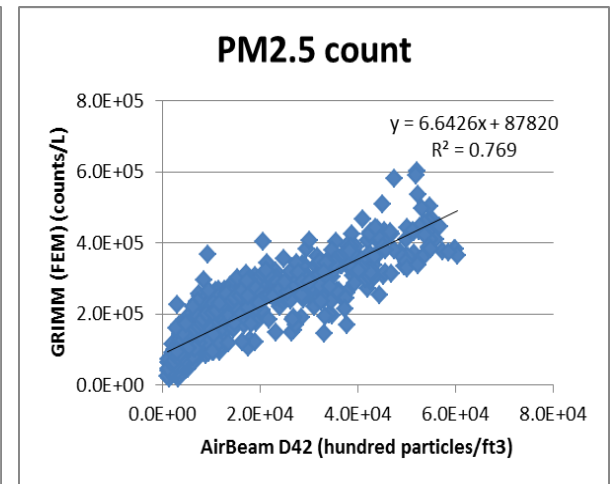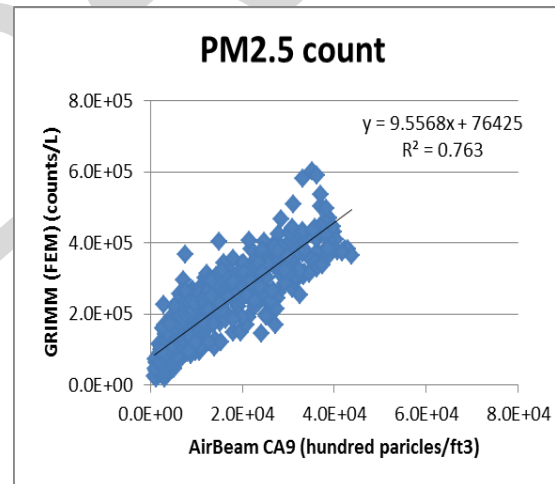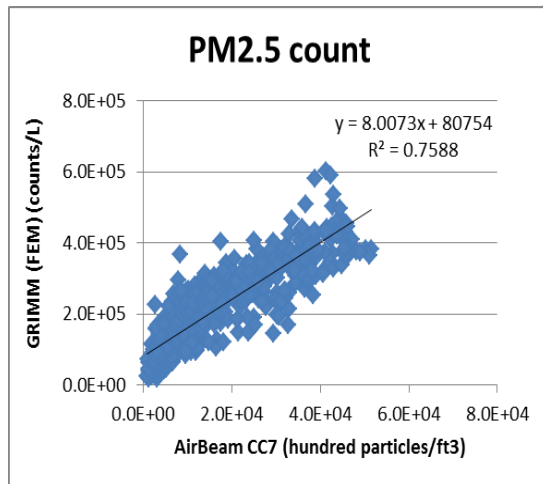# AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Count; 5-min mean)

- All PM measurements correlate fairly well with the corresponding FEM GRIMM data (R^2>0.73)
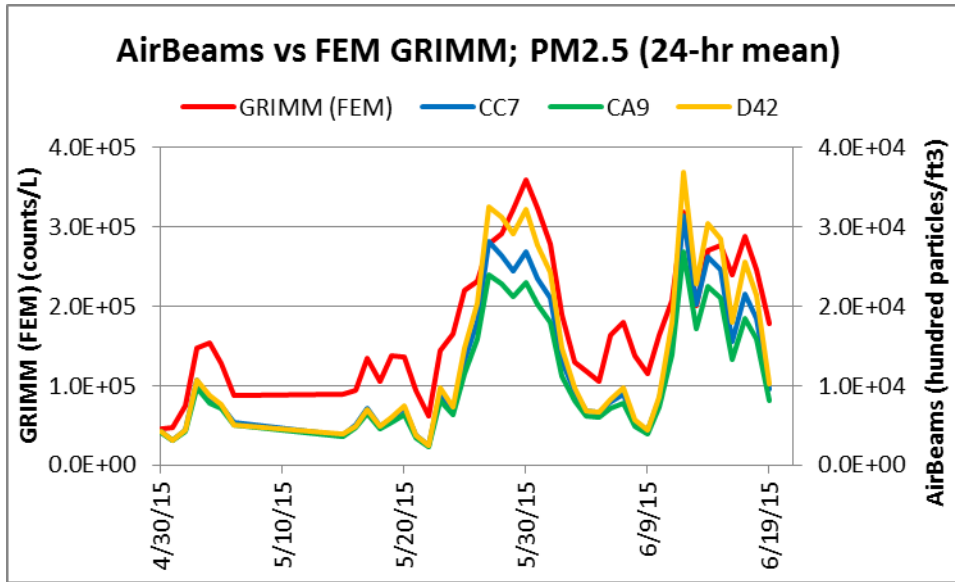- GRIMM and AirBeam particle count measurements show a much better agreement than the corresponding particle mass data

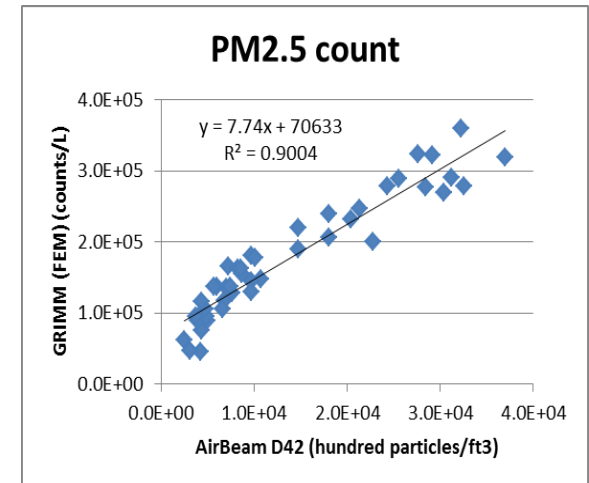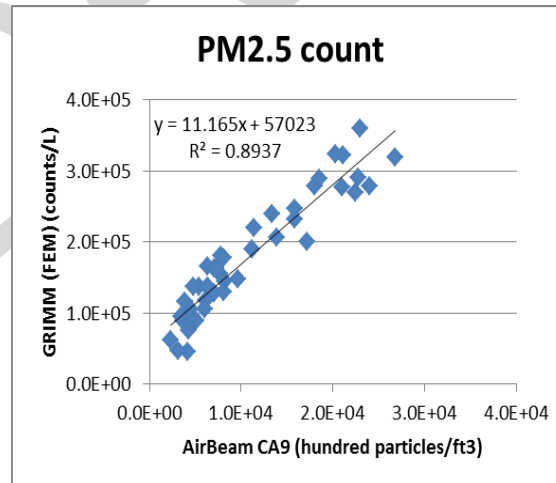# AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Count; 1-hr mean)
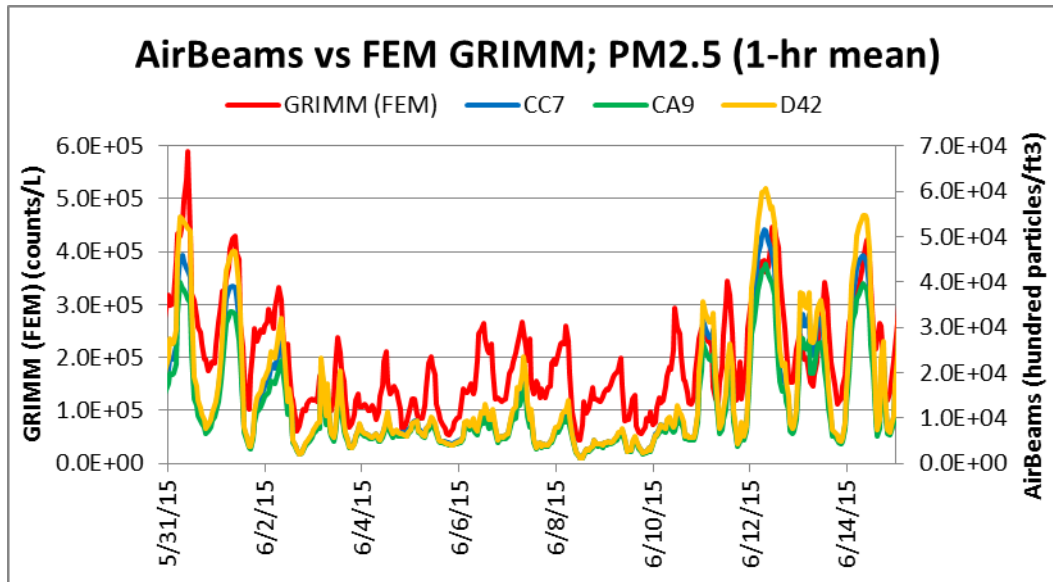
- All PM measurements correlate very well with the corresponding FEM GRIMM data (R^2>0.75)
- GRIMM and AirBeam particle count measurements show a much better agreement than the corresponding particle mass data

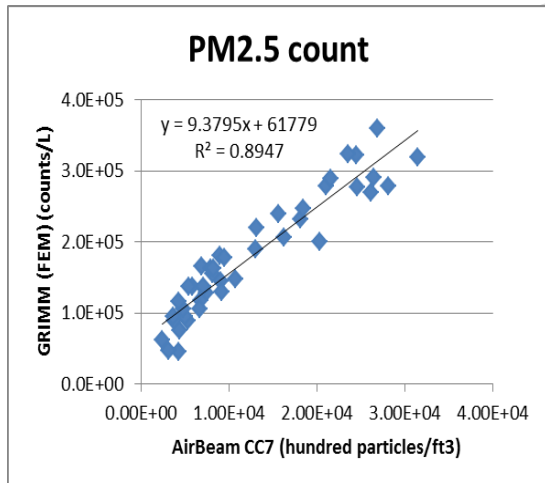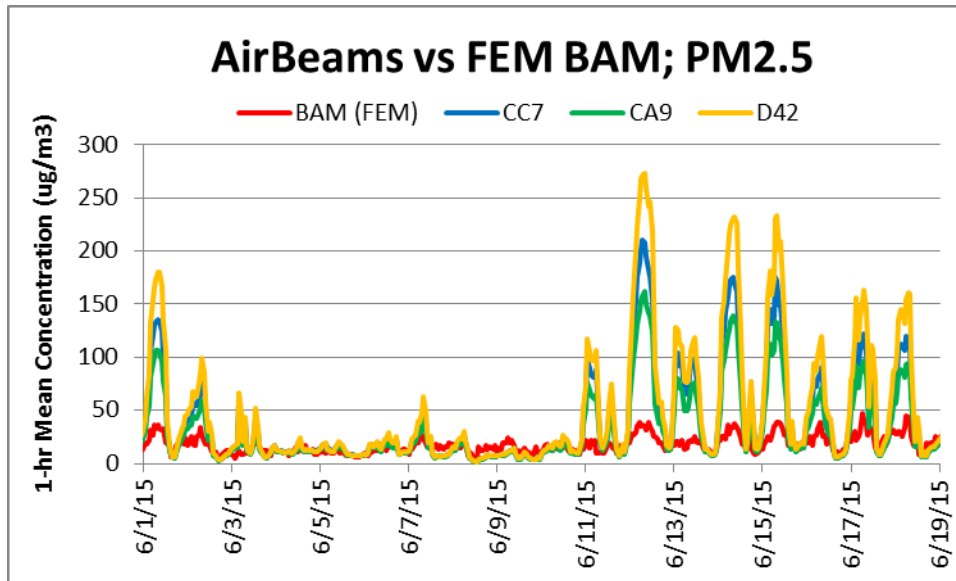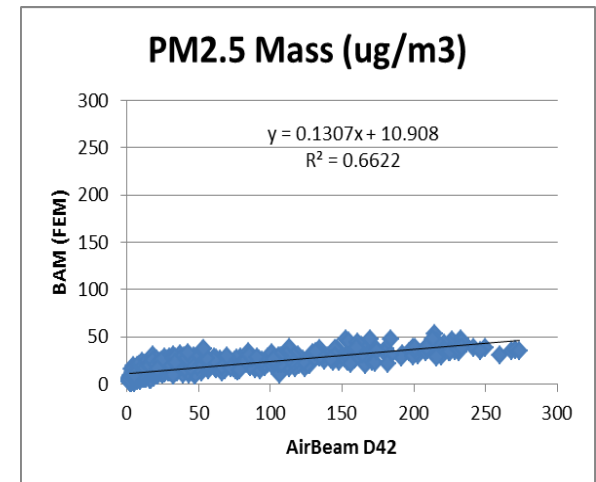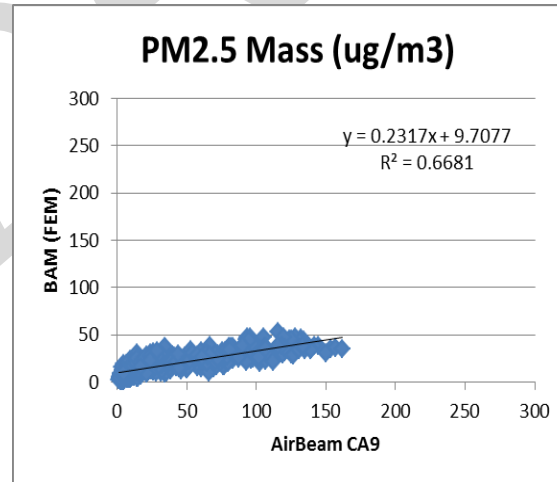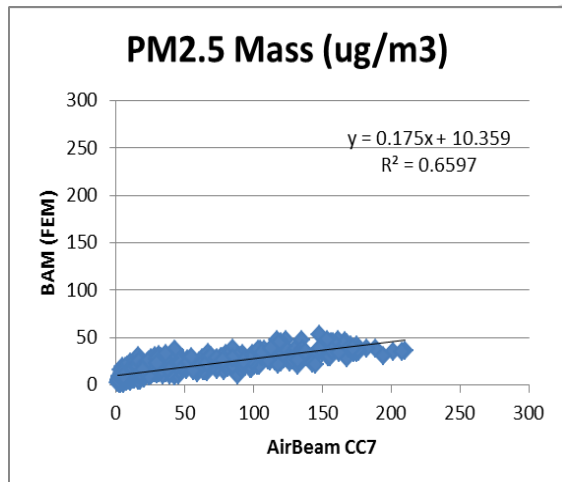# AirBeam Sensor vs FEM GRIMM (PM$_{2.5}$ Count; 24-hr mean)

- All PM measurements correlate very well with the corresponding FEM GRIMM data (R^2>0.89)
- GRIMM and AirBeam particle count measurements show a much better agreement than the corresponding particle mass data
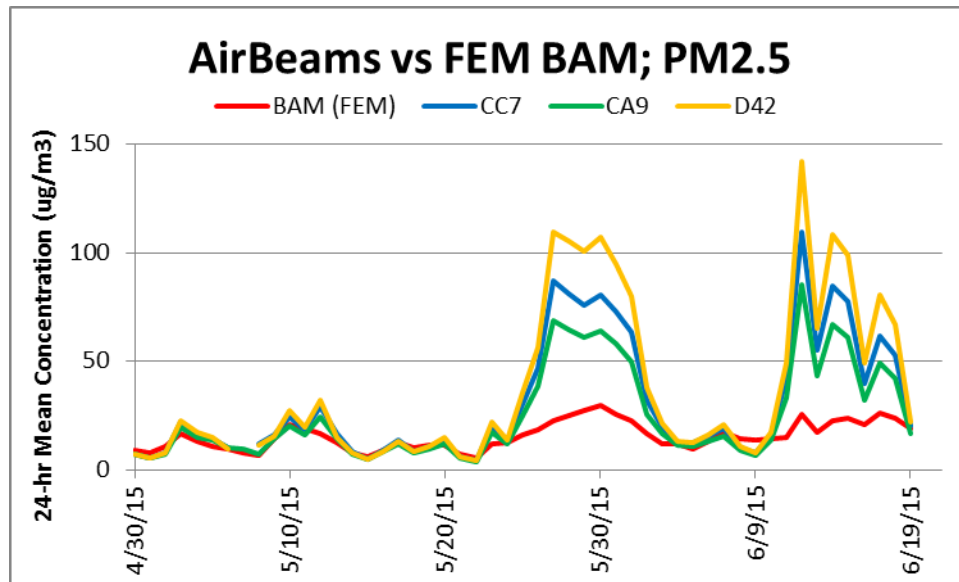
AirBeam Sensor vs FEM BAM (PM$_{2.5}$ Mass; 1-hr mean)

- All PM measurements correlate well with the corresponding FEM BAM data (R^2>0.65), but the three AirBeam sensors largely overestimate measured PM$_{2.5}$ concentrations
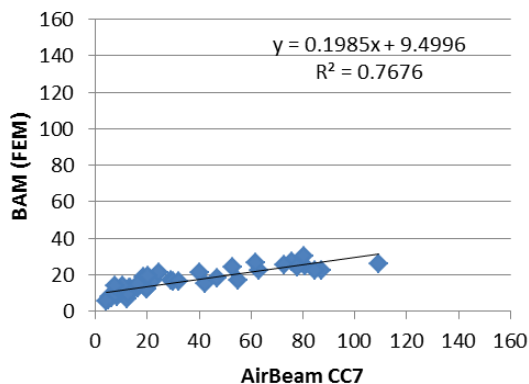
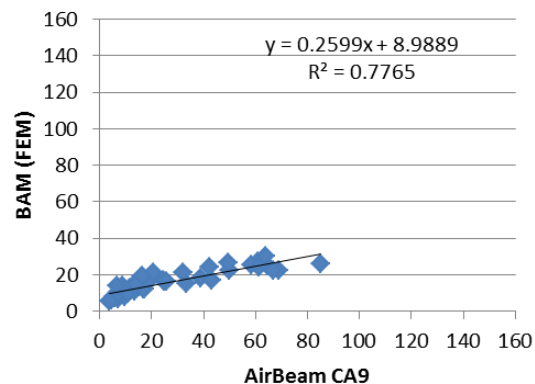# AirBeam Sensor vs FEM BAM (PM$_{2.5}$; 24-hr mean)

- All PM measurements correlate very well with the corresponding FEM BAM data ($R^2 > 0.76$), but the three AirBeam sensors largely overestimate measured PM$_{2.5}$ concentrations
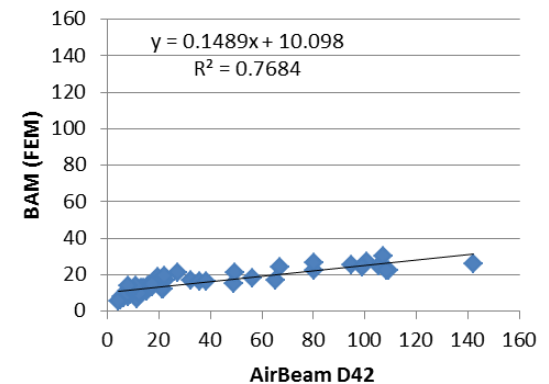
Discussion

- Overall, the three AirBeam Sensors were reliable (i.e. no down time over a period of about two months), but were characterized by substantial intra-model variability
- Despite the good correlation (R^2) with substantially more expensive FEM instruments (i.e. BAM and GRIMM), the AirBeam mass data was largely overestimated. It should be noted that no sensor calibration had been performed by SCAQMD Staff prior to the beginning of this field testing
- FEM and AirBeam particle count measurements showed a much better agreement than the corresponding particle mass data. This may indicate that the algorithms used to convert particle count to particle mass may have to be revised and/or that different conversion equations may be necessary at different locations or under different environmental conditions
- Updated firmware for converting particle count concentration to particle mass concentration will be available soon [*last updated on 10/21/2015*]
- Laboratory chamber testing is necessary to fully evaluate the performance of these sensors over different / more extreme environmental conditions

- All results are still preliminary