Field Evaluation
Speck Sensor

Background

- From 04/23/2015 to 06/19/2015, three **Speck Sensors** were deployed in Rubidoux and ran side-by-side with two Federal Equivalent Method (FEM) instruments measuring the same pollutant

- <u>Speck Sensor (*3 units tested*)</u>:
  - ➤ Particle sensors (optical; non-FEM)
  - ➤ Each unit measures: $PM_{2.5}$ ($\mu g/m^3$)
    Unit cost: ~$150
  - ➤ Time resolution: 1-min
  - ➤ Units IDs: BA686, BB106, EBE1F

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

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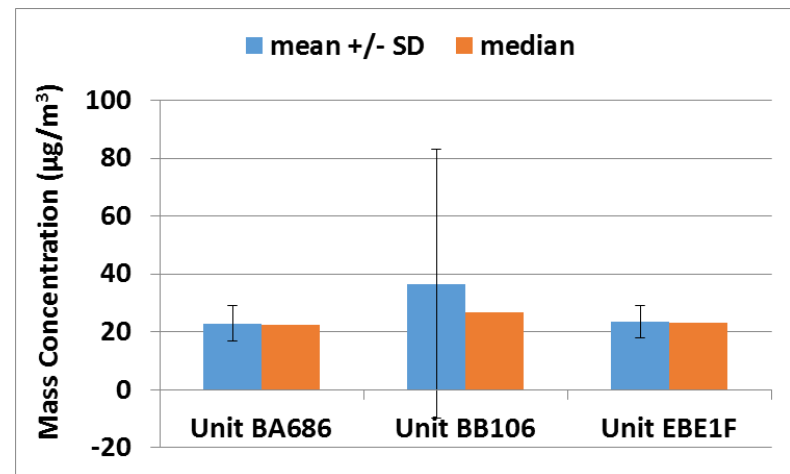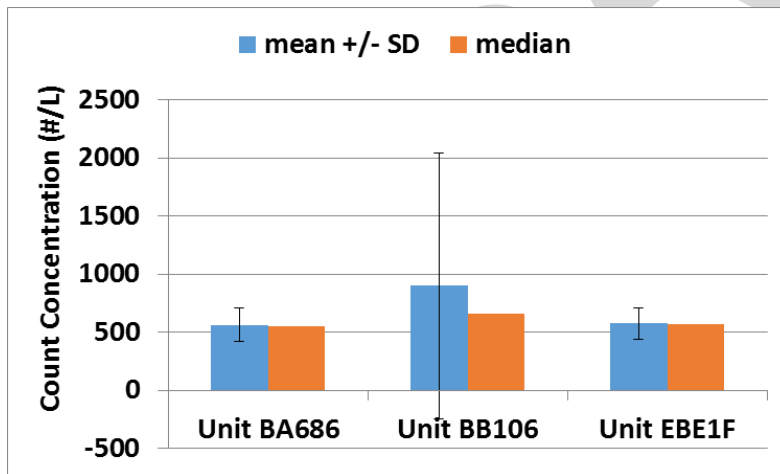 - ➤ Cost: ~$25,000 and up
  - ➤ Time resolution: 1-min

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 $PM_{2.5}$ was ~ 95% from all three sensors

Speck Sensors; intra-model variability

- Low measurement variations between BA686 and EBE1F were observed; BB106 showed large variability compared to the other two sensors

Data validation & recovery

- Basic QA/QC procedures were used to validate the collected data from the FEM (i.e. obvious outliers, negative values and invalid data-points were eliminated from data-set)
- Data recovery for 1-hr averages of $PM_{2.5}$ was 99% from the FEM BAM and 73% from the FEM GRIMM (due to power outage) instruments.
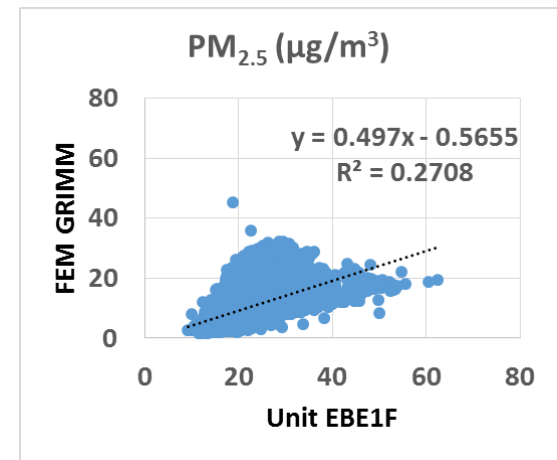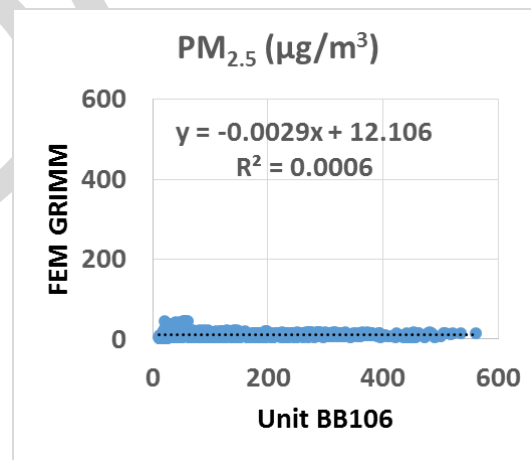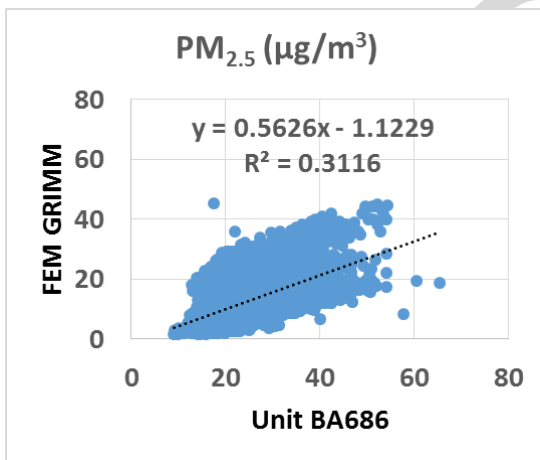
Equivalent Methods: BAM vs GRIMM

- Very good correlation between the two equivalent methods
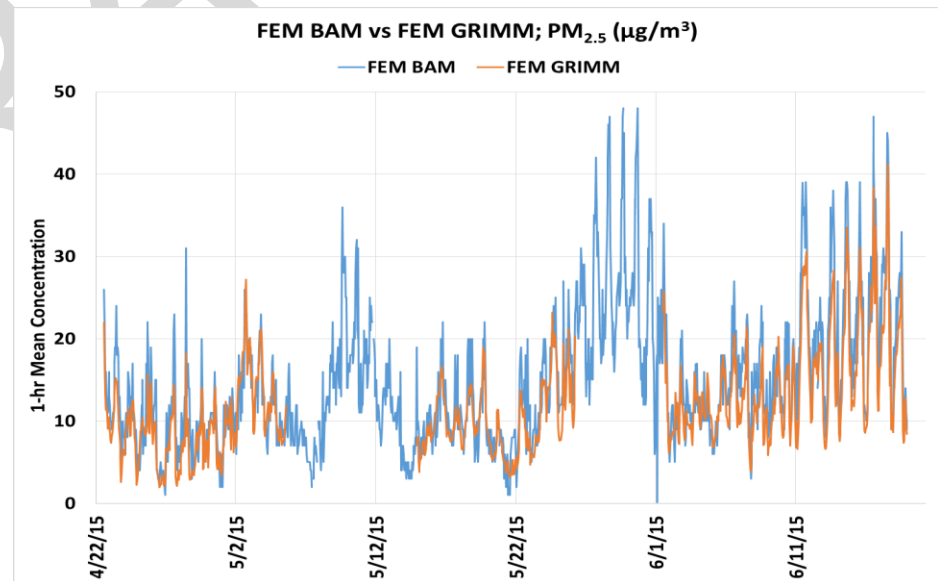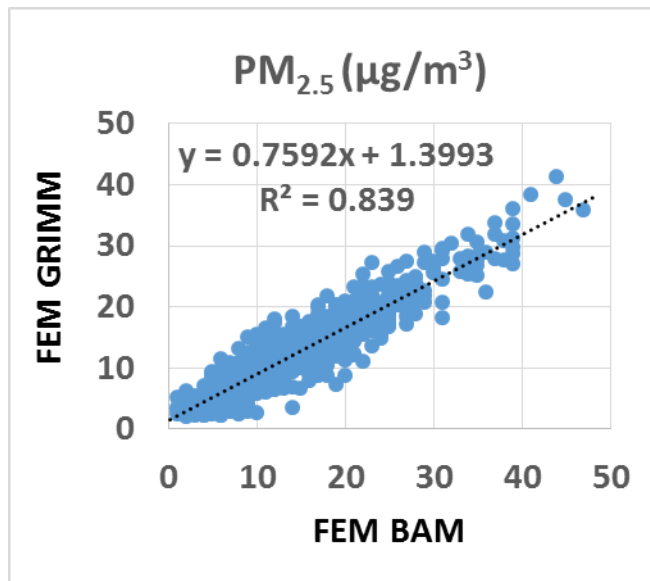
Speck Particle Mass vs FEM GRIMM PM$_{2.5}$ Mass (5-min mean)

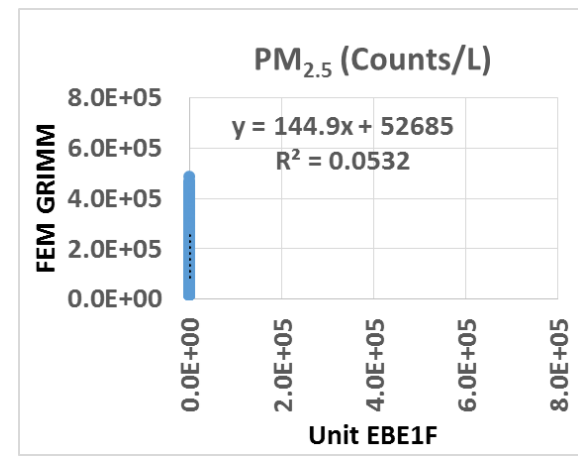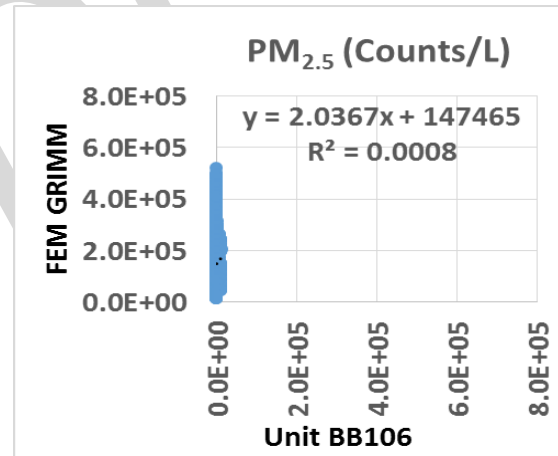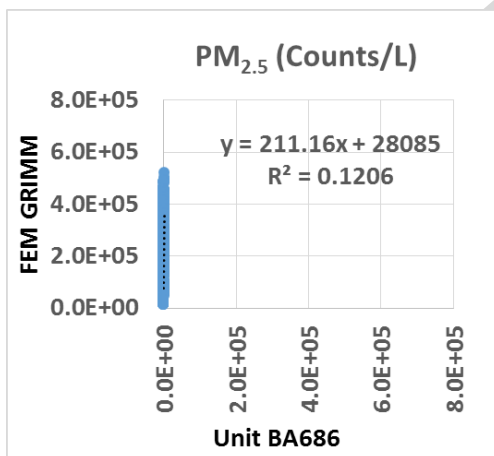Speck Particle Mass vs FEM GRIMM PM$_{2.5}$ Mass (µg/m³)
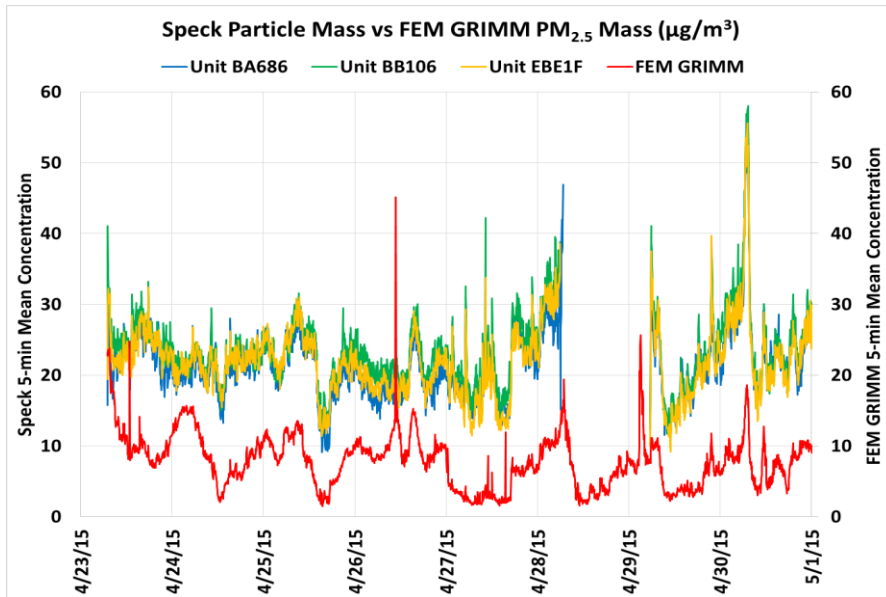
- Particle mass measurements from units BA686 and EBE1F do not correlate well ($R^2 < 0.32$) and overestimate the corresponding FEM GRIMM PM$_{2.5}$ data.
- However, sensors' PM mass measurements seem to track the diurnal variations of the FEM GRIMM PM$_{2.5}$ mass data.
- Measurements from unit BB106 may not all be valid as some of its values are too high compared to the other two sensors and the FEM method used


PM$_{2.5}$ (µg/m³)

$y = 0.5626x - 1.1229$
$R^2 = 0.3116$

Unit BA686

PM$_{2.5}$ (µg/m³)

$y = -0.0029x + 12.106$
$R^2 = 0.0006$

Unit BB106

PM$_{2.5}$ (µg/m³)

$y = 0.497x - 0.5655$
$R^2 = 0.2708$

Unit EBE1F

Speck Particle Count vs GRIMM PM$_{2.5}$ Count (5-min mean)

Speck Particle Count vs FEM GRIMM PM2.5 Count; #/L
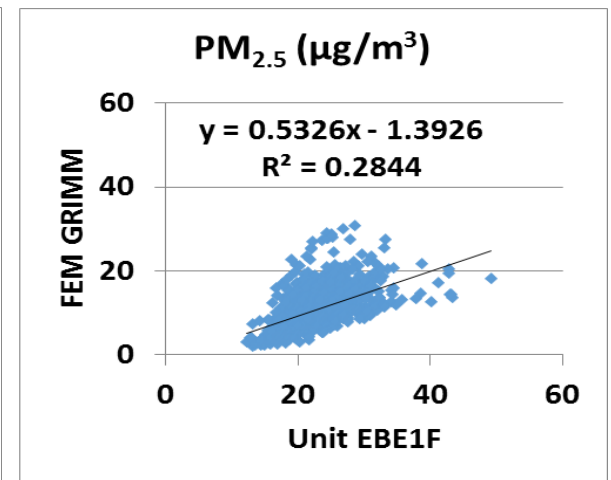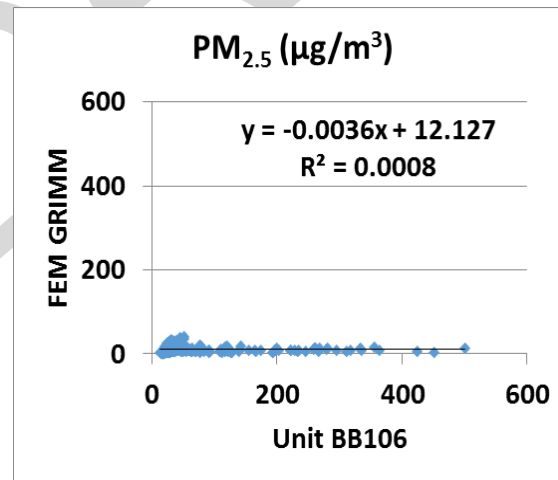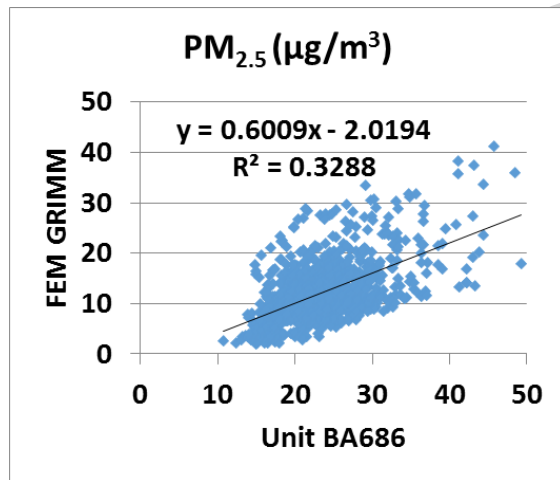— Unit BA686   — Unit BB106   — Unit EBE1F   — FEM GRIMM
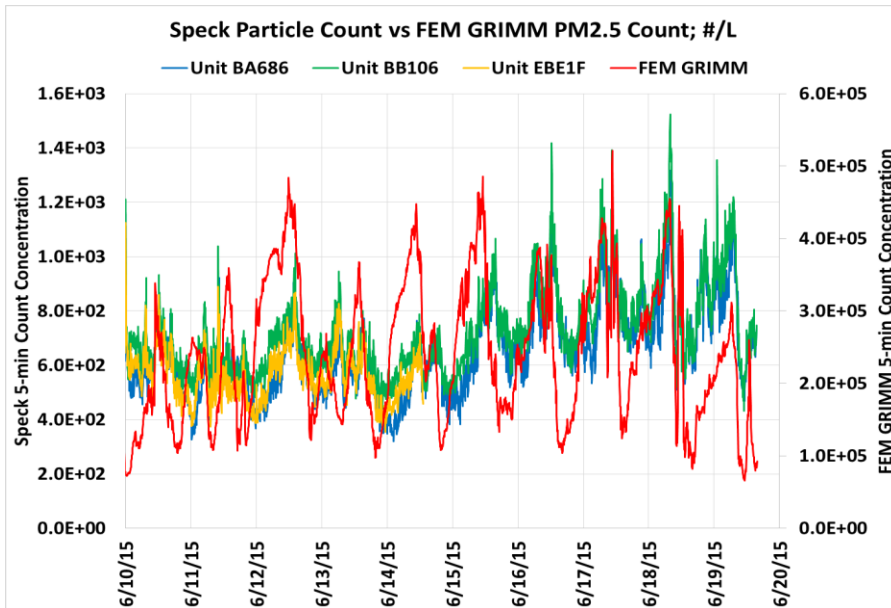
- Particle count measurements from all three speck sensors do not correlate (R^2~0.0) and underestimate the corresponding GRIMM PM$_{2.5}$ count data.
- However, sensors' PM count measurements seem to track the diurnal variations of the GRIMM PM$_{2.5}$ count data.
- Measurements from BB106 may not all be valid as some of its values are too high compared to the other two sensors and the method used
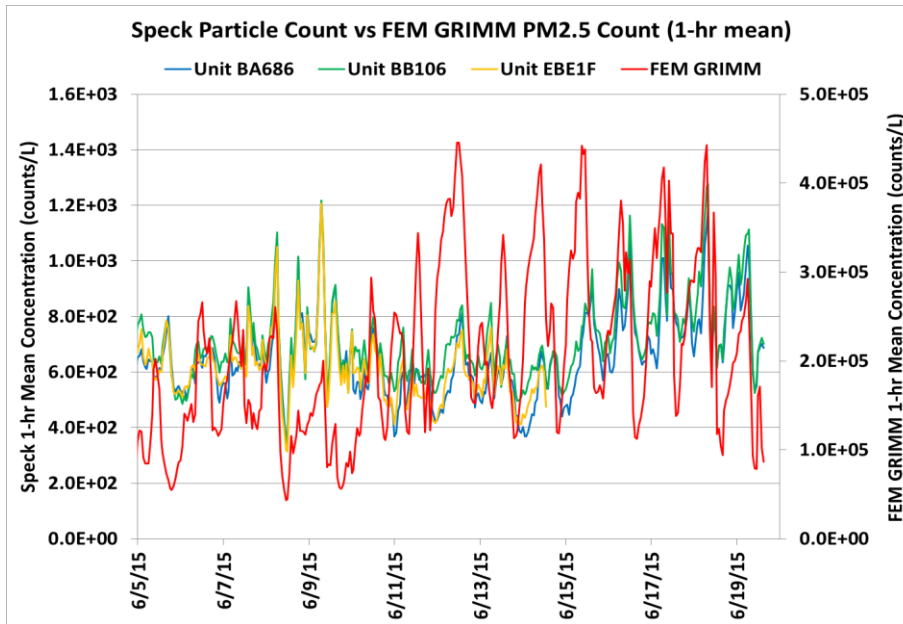

PM$_{2.5}$ (Counts/L)

$y = 211.16x + 28085$
$R^2 = 0.1206$

Unit BA686

PM$_{2.5}$ (Counts/L)

$y = 2.0367x + 147465$
$R^2 = 0.0008$

Unit BB106

PM$_{2.5}$ (Counts/L)

$y = 144.9x + 52685$
$R^2 = 0.0532$

Unit EBE1F

Speck Particle Mass vs FEM GRIMM PM$_{2.5}$ Mass (1-hr mean)

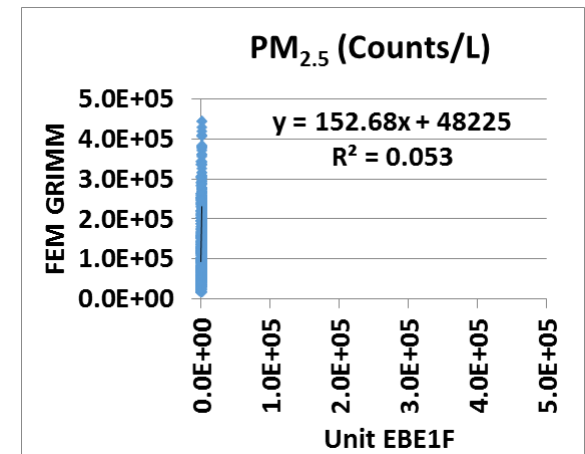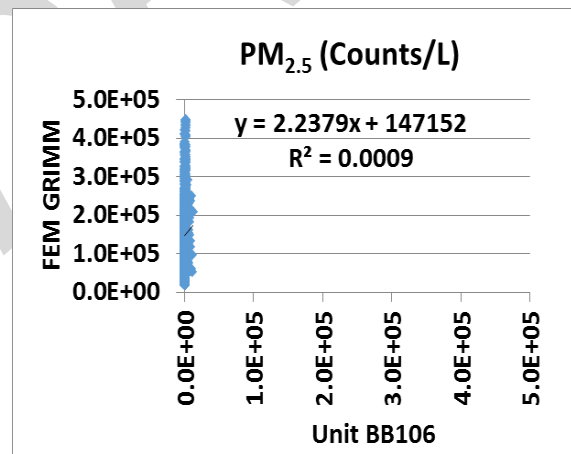Speck Particle Mass vs FEM GRIMM PM$_{2.5}$ Mass (1-hr mean)
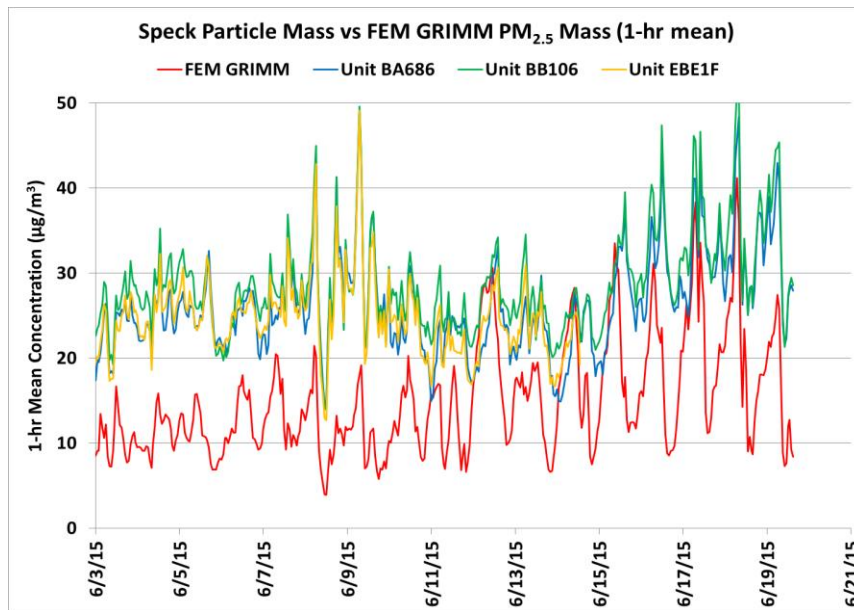
- Particle mass measurements from units BA686 and EBE1F do not correlate well ($R^2 < 0.33$) and usually overestimate the corresponding FEM GRIMM PM$_{2.5}$ data.
- However, sensors' PM mass measurements seem to track the diurnal variations of the FEM GRIMM PM$_{2.5}$ mass data.
- Measurements from BB106 may not all be valid as some of its values are too high compared to the other two sensors and the FEM method used

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Speck Particle Count vs GRIMM PM$_{2.5}$ Count (1-hr mean)

Speck Particle Count vs FEM GRIMM PM2.5 Count (1-hr mean)

- Particle count measurements from all three speck sensors do not correlate well ($R^2 < 0.13$) and underestimate the corresponding GRIMM PM$_{2.5}$ count data.
- However, sensors' PM count measurements seem to track the diurnal variations of the GRIMM PM$_{2.5}$ count data.
- Measurements from BB106 may not all be valid as some of its values are too high compared to the other two sensors and the method used

PM$_{2.5}$ (Counts/L)

$y = 226.47x + 19465$
$R^2 = 0.1264$

Unit BA686

PM$_{2.5}$ (Counts/L)

$y = 2.2379x + 147152$
$R^2 = 0.0009$

Unit BB106

PM$_{2.5}$ (Counts/L)

$y = 152.68x + 48225$
$R^2 = 0.053$

Unit EBE1F

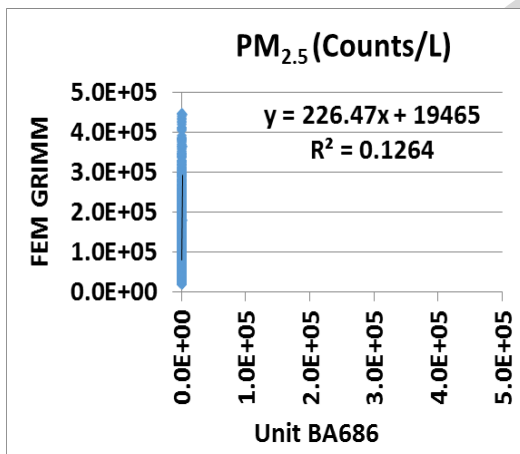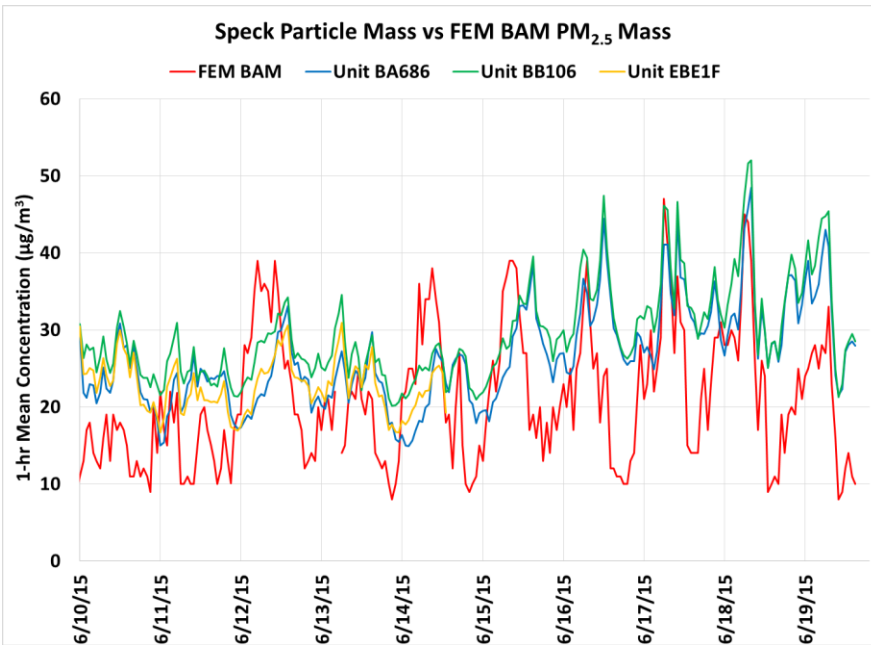# Speck Particle Mass vs FEM BAM PM$_{2.5}$ Mass (1-hr mean)

- Particle mass measurements from units BA686 and EBE1F do not correlate well ($R^2 < 0.25$) and usually overestimate the corresponding FEM BAM PM$_{2.5}$ mass data.
- However, sensors' PM mass measurements seem to track the diurnal variations of the FEM BAM PM$_{2.5}$ mass data.
- Measurements from BB106 may not all be valid as some of its values are too high compared to the other two sensors and the FEM method used
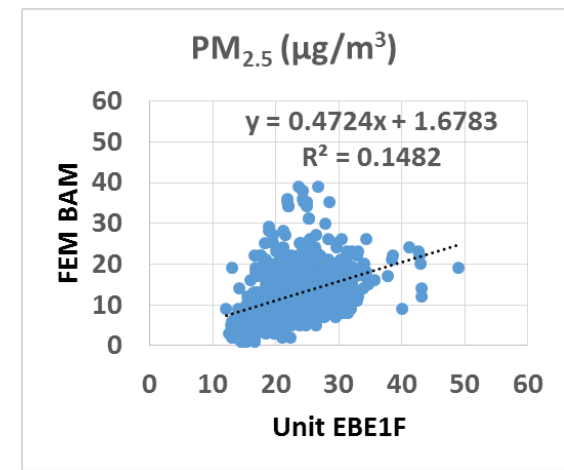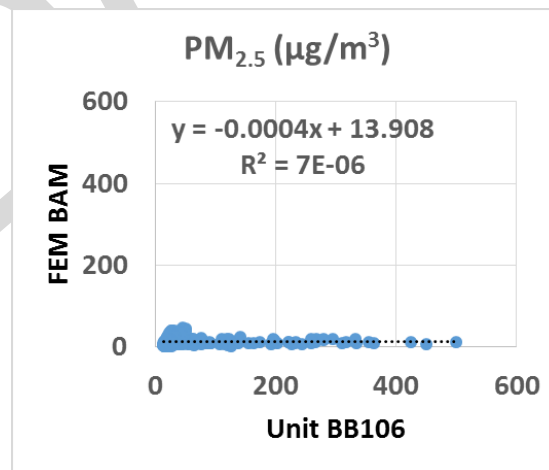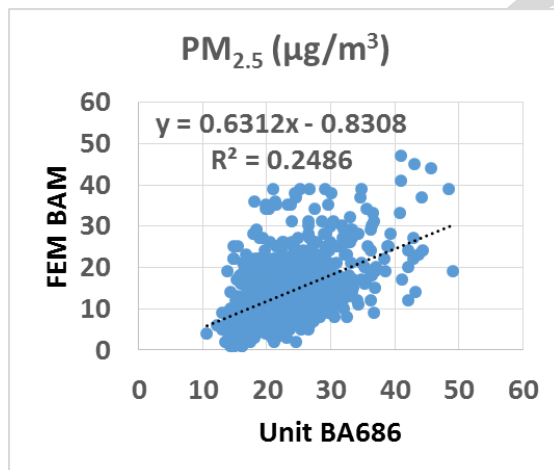
Discussion

- Overall, the three Speck Sensors did not perform well and showed:
    - Unit EBE1F: significant down time over a period of about two months (23% data loss)
    - Units BA686 and EBE1F: good intra-model agreement
    - Unit BB106: significant amount of off-scale values

- The three sensors did not correlate well ($R^2 < 0.33$) with the two FEM instruments (BAM and GRIMM)

- Speck mass data was usually overestimated with respect to FEM GRIMM and BAM $PM_{2.5}$ mass data

- Speck count data was usually underestimated with respect to GRIMM $PM_{2.5}$ count data, although no sensor calibration was performed prior to the beginning of this field testing

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

- All results are preliminary