



## Integrated & Real-time PM<sub>2.5</sub> Concentrations in Kitchens, Bedrooms, and Outdoors in Highland Guatemala Using both Gravimetric and UCB Particle Monitor

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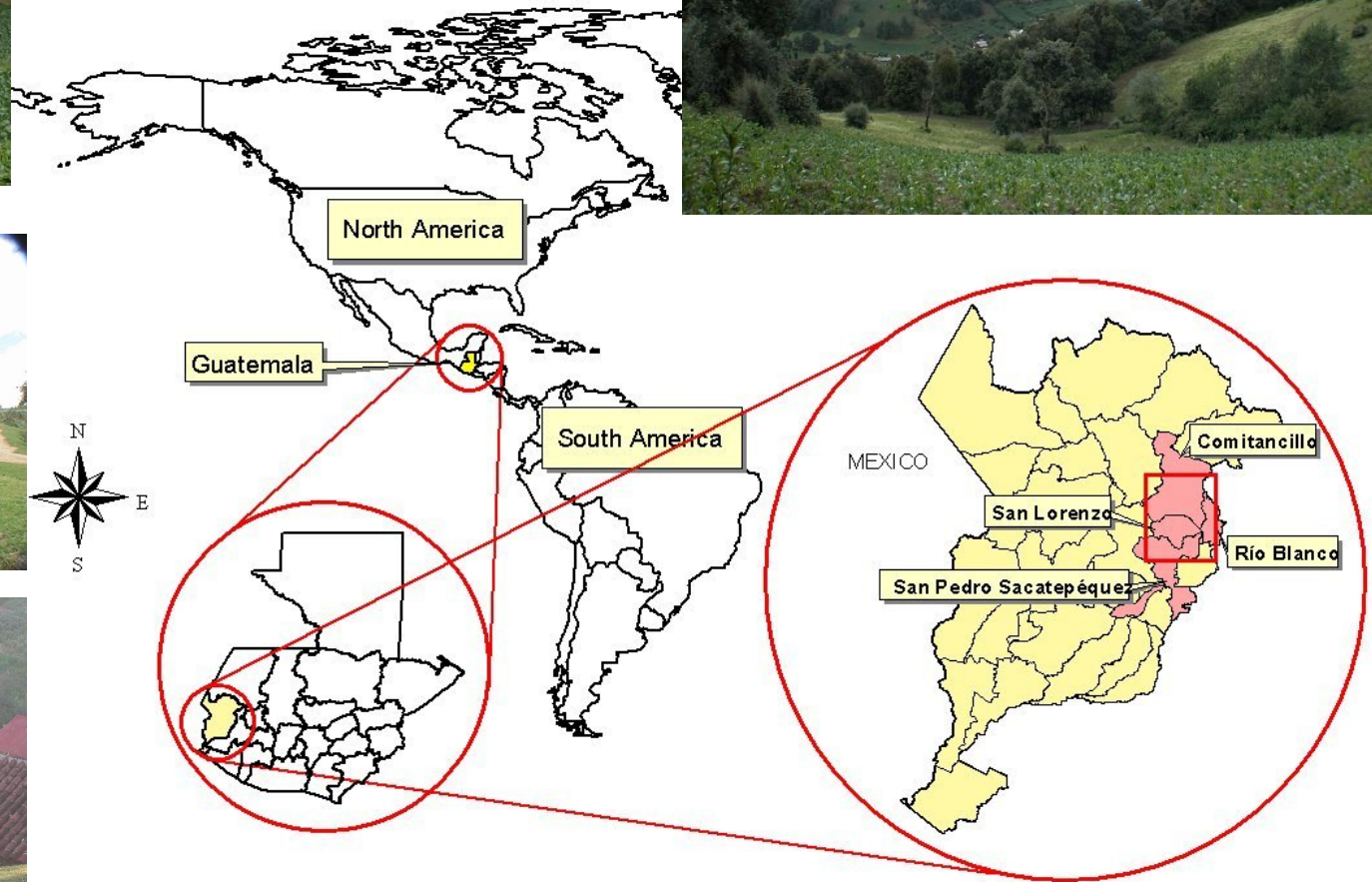
\*5 School of Medicine, University of California at Irvine



# Objectives of Study

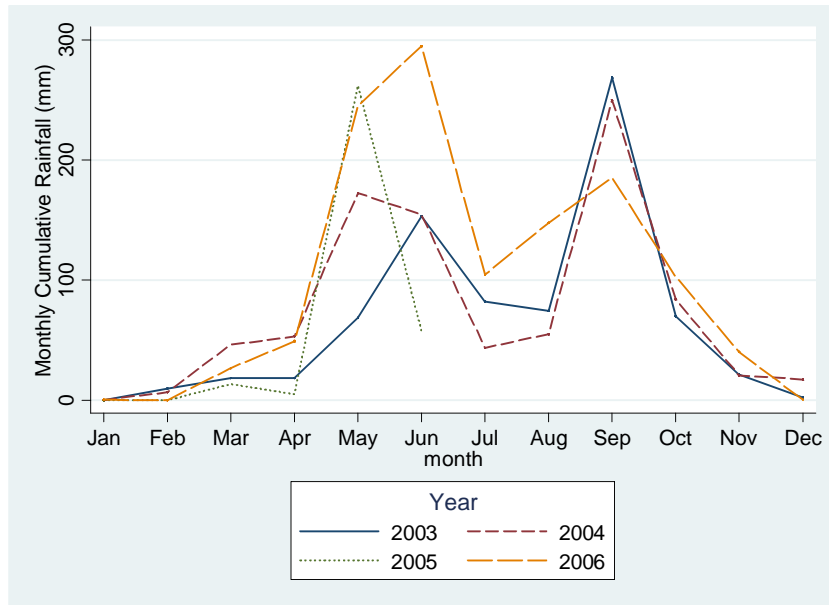
- First Randomized Stove Intervention Trial on Air Pollution and respiratory health
  
- Purpose of Main Study:
  - Establish a causal relationship between exposure to particulate matter and pneumonia
    - Introduction of chimney woodstove into households using open fire
    - Measure exposure to air pollution and its health effects to sensitive groups (children and women)
  
- Purpose of this Presentation
  - Determine the change of Particulate Matter in the kitchen, bedroom and outdoor by the intervention

# Study Location

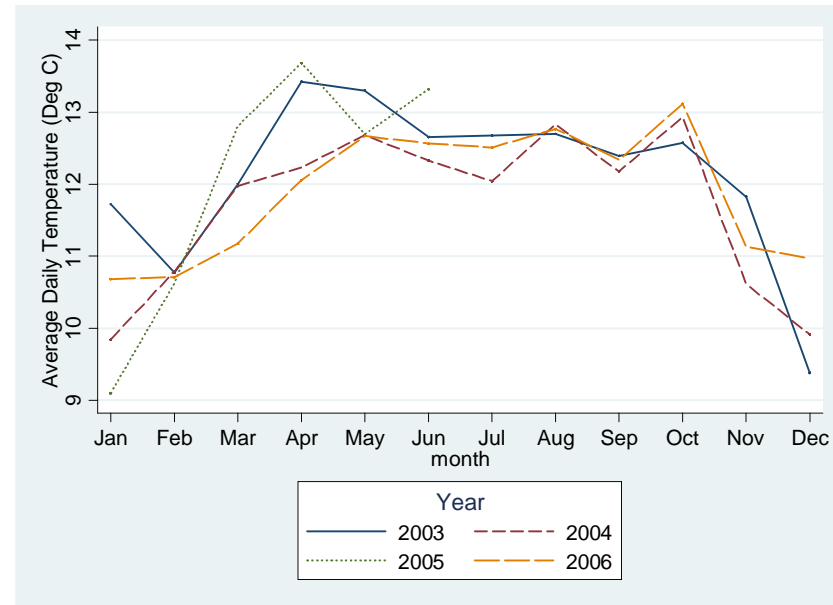


# Meteorology of Study Area

## Monthly Total Rainfall



## Average Daily Temperature



- Rainfall: May-June and Sept-Oct Peaks
- Temperature: 10-14 degrees C year-round

# Overall Study Framework

Rapid Assessment  
~5500 households

Eligibility Criteria: House with Open Fire & woman  
third trimester pregnant or child less than 4 months  
~540 Households

Randomization

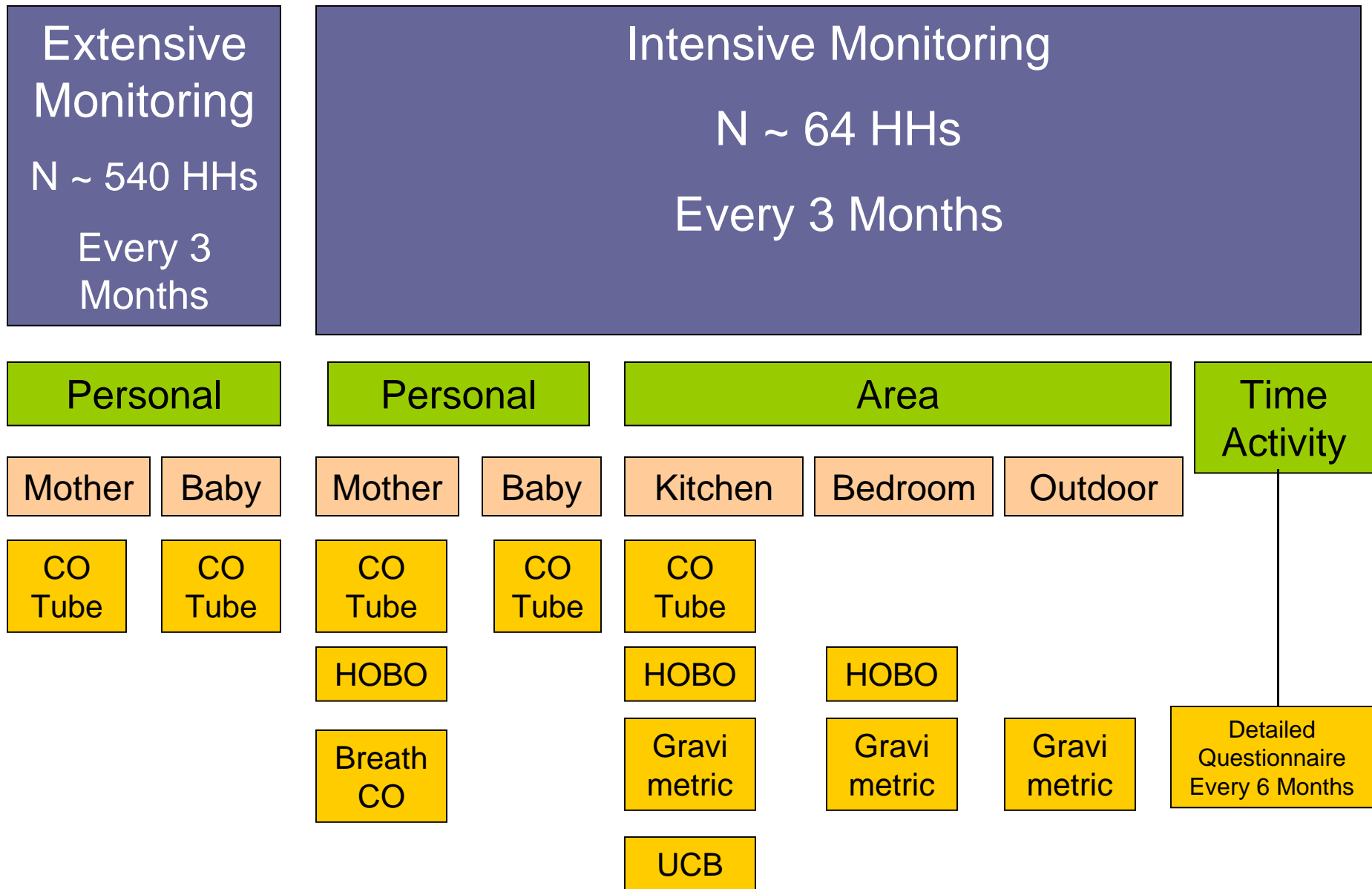
50% Open Fire    50% Plancha

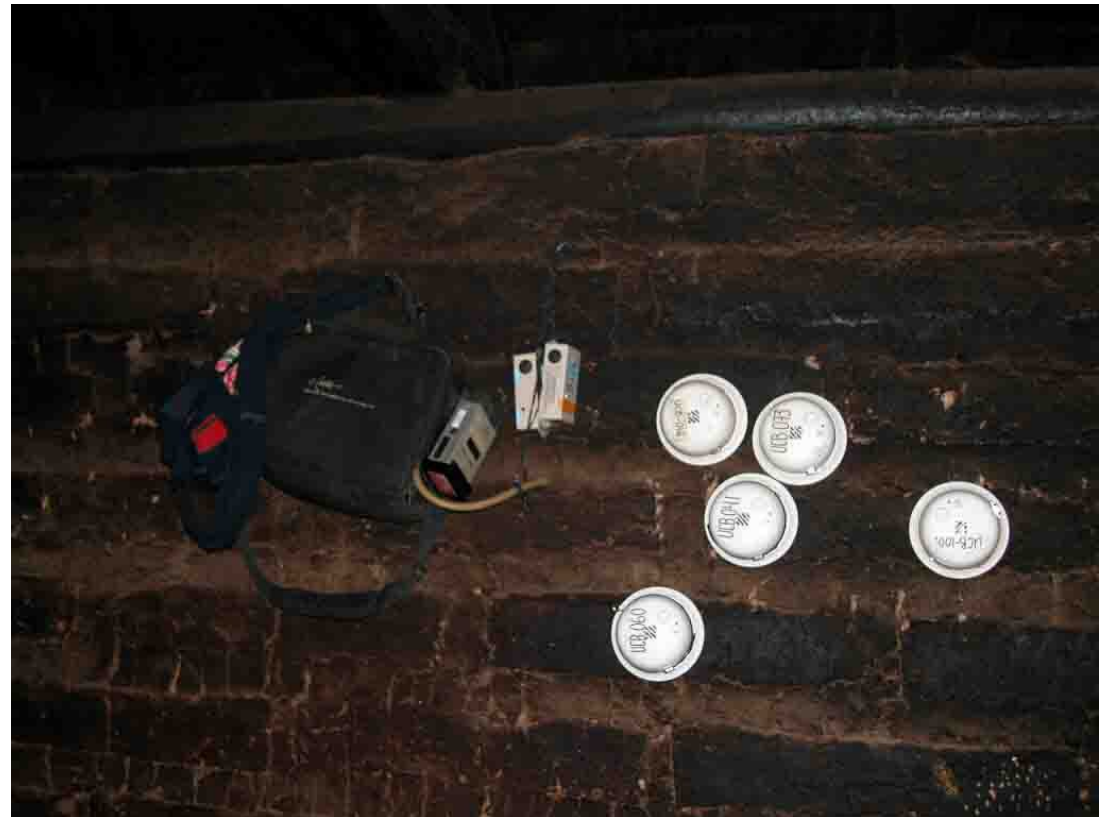
Follow households until child 18 months

5 Years



# Overall IAP Monitoring Framework





# Household Characteristics (SES)

Variable	Means and percentages		Statistical Test
	Intensive	Extensive	
Mother's Age	26.8 yrs	26.7 yrs	t-tests (ind.) p = .92 p = .64
Father's Age	29.7 yrs	29.2 yrs	
Cooking area in separate structure (C1 = 3 or 4)	90.9	83.2	Chi-sq p = .08
Use a latrine	80.5	80.5	Chi-sq p = .99
Throw away garbage	62.3	57.5	Chi-sq p = .43
Boil water (always/not)	88.3	91.2	Chi-sq p = .41
Reported leakages in roof or walls	20.8	30.2	Chi-sq p = .09
Owns house	93.5	93.4	Chi-sq p = .98
Owns radio	83.1	80.7	Chi-sq p = .62
Owns television	19.5	19.3	p = .96
Owns bicycle	24.7	21.4	p = .53
Smoker inside the house	20.8	24.1	P = .53
Migrates during the year	18.2	17.3	P = .85
Number of rooms in HH	1.17	1.15	t-test p=.51
Number providing economic support	1.39	3.65*	t-test p=.47
Space between walls and roof partially or completely open	84.4	80.5	P = .42



# Overview of Field Monitoring: PM

- ~64 HHs monitored every 3 months
- PM Gravimetric Data collected
  - Use of a size selective cyclone at 3.5 and 1.5 LPM. Flow checked before and after every use with rotameter
  - Rotameter calibrated by Gilibrator every 3 months
  - Gravimetric in kitchen
    - PM<sub>1.0</sub>: 24-hr and 48-hr Integrated Gravimetric PM<sub>1.0</sub>
    - PM<sub>2.5</sub>: 24-hr and 48-hr Integrated Gravimetric PM<sub>2.5</sub>
  - Duplicate measurements and blanks
- UCB Particle Monitor in kitchen
  - min-by-min continuous 48-hr: can easily identify cooking periods
  - Zero-ed before every use in particle free bags
  - Measurements taken every second with data logged every minute



37 mm Teflon Filter

Gilibrator



SKC Pump

Battery

Cyclone



## Gravimetric QA/QC

### ■ Blanks:

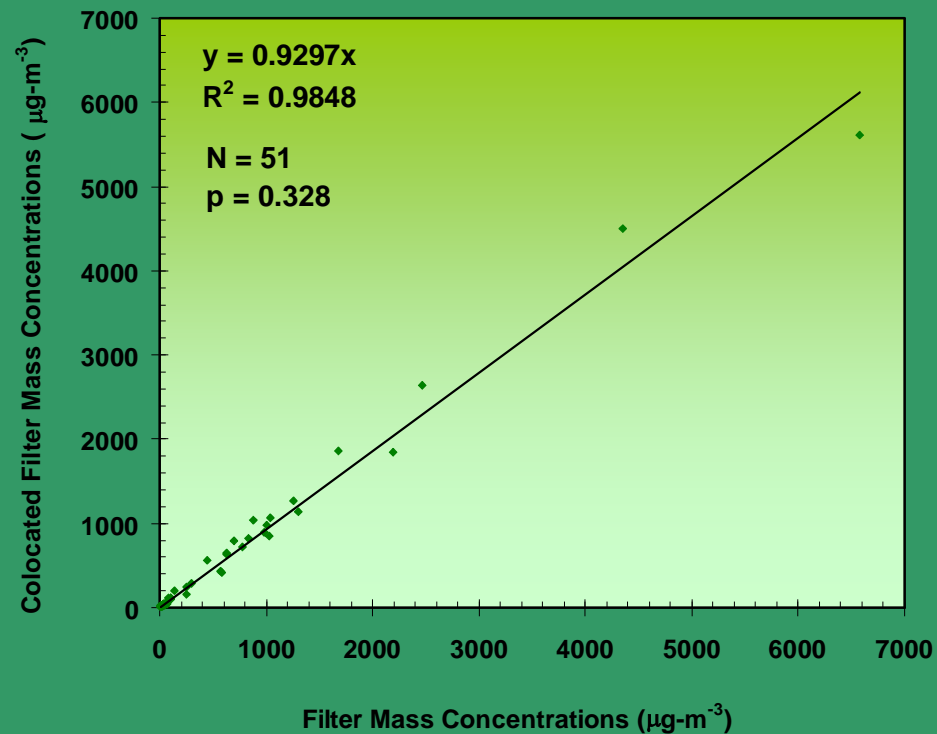
- N = 46
- Mean =  $-1.7 \mu\text{g}$
- Range ( $-8.5 \mu\text{g}$  to  $+7.0 \mu\text{g}$ )

### ■ Flow

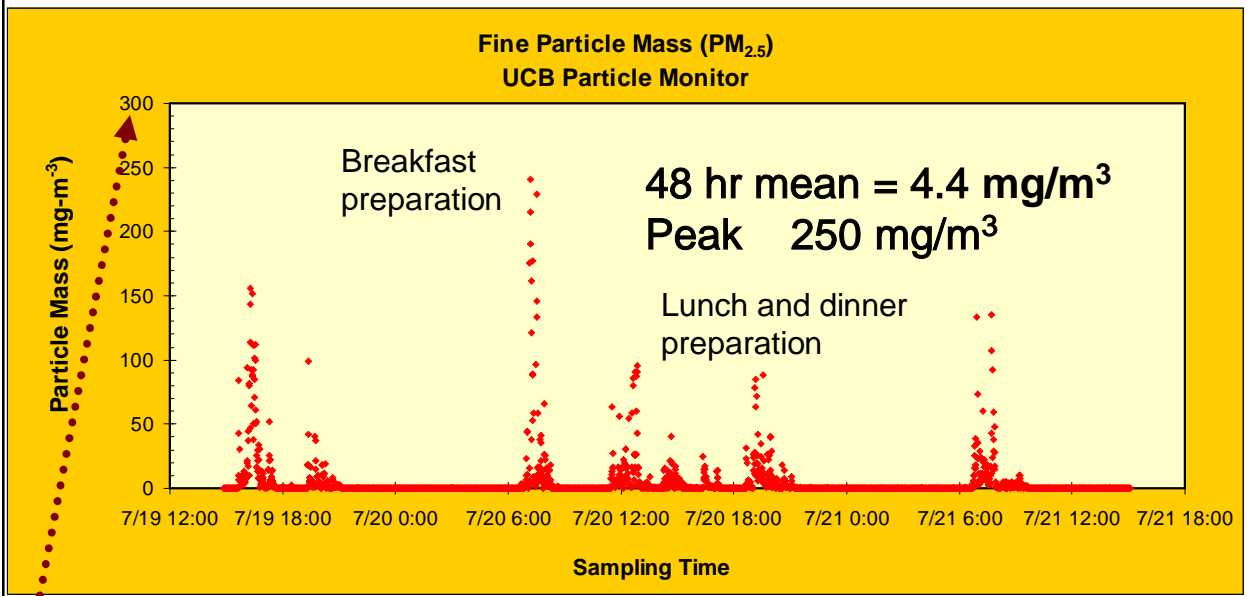
- $1.52 \text{ lpm} \pm 0.02$  (N = 471)

### ■ Duplicate

- $R^2 = 0.985$
- N = 51
- p-value = 0.328

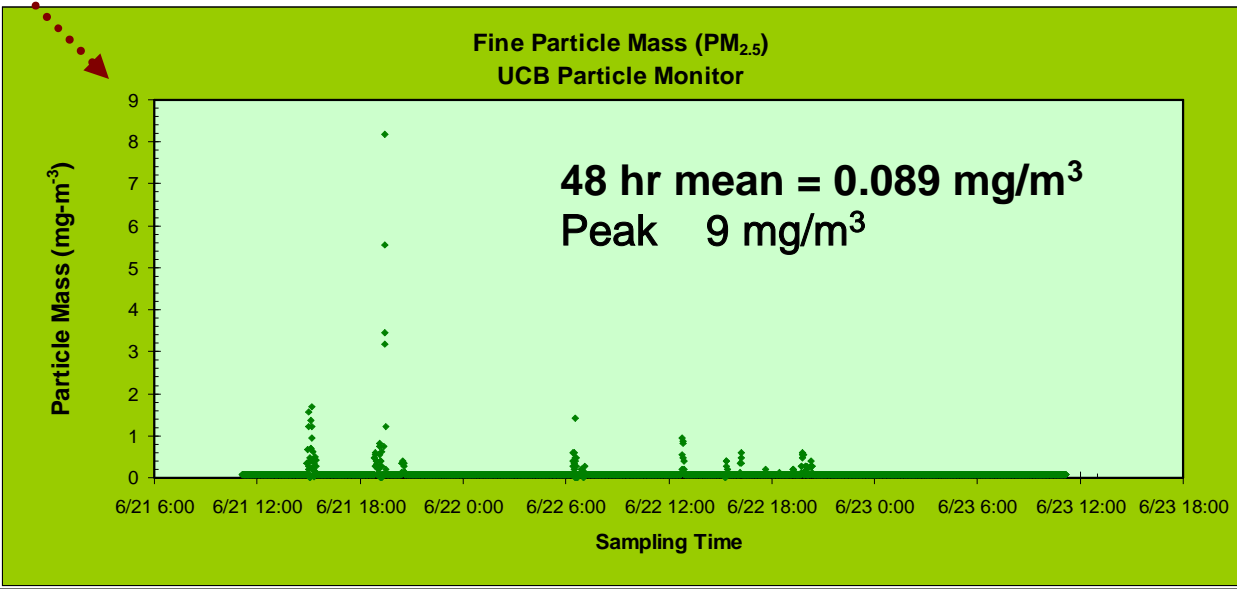


# Real-time PM<sub>2.5</sub> Concentrations with UCB Particle Monitor



Open Fire

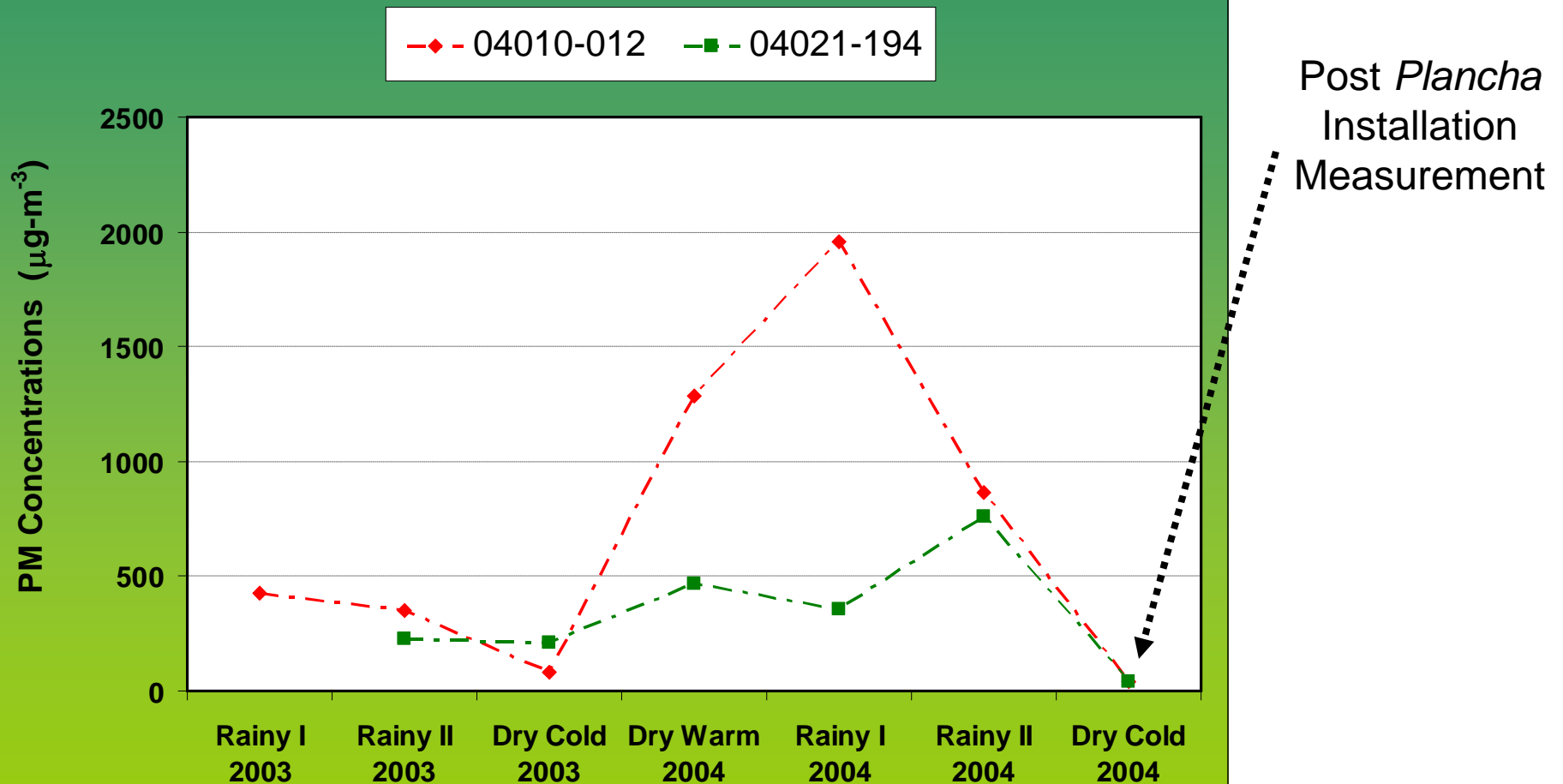
Note: Y-Axis Scales are different



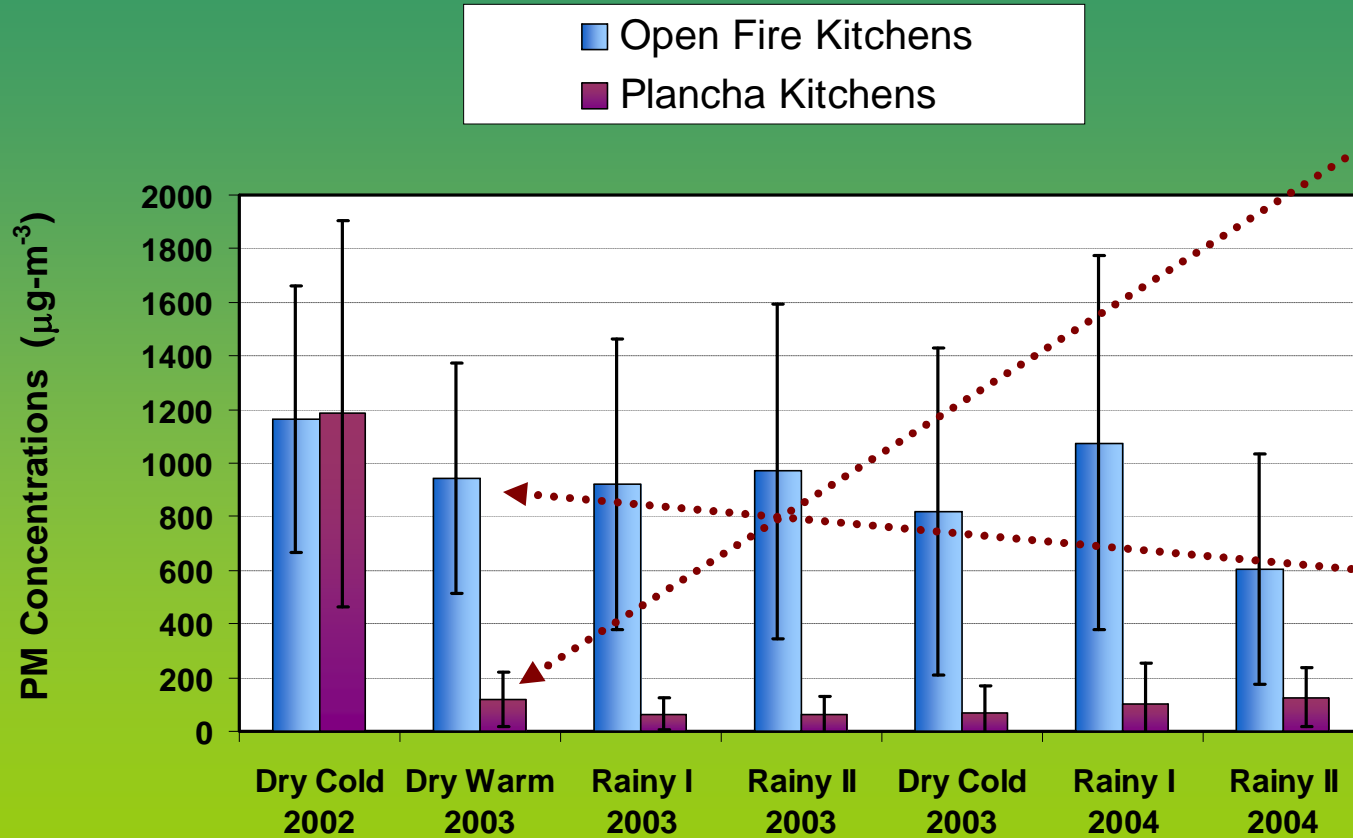
Plancha

# Intra-household Variability

## Household PM<sub>2.5</sub>



# PM<sub>1.0</sub>: Control Vs Intervention



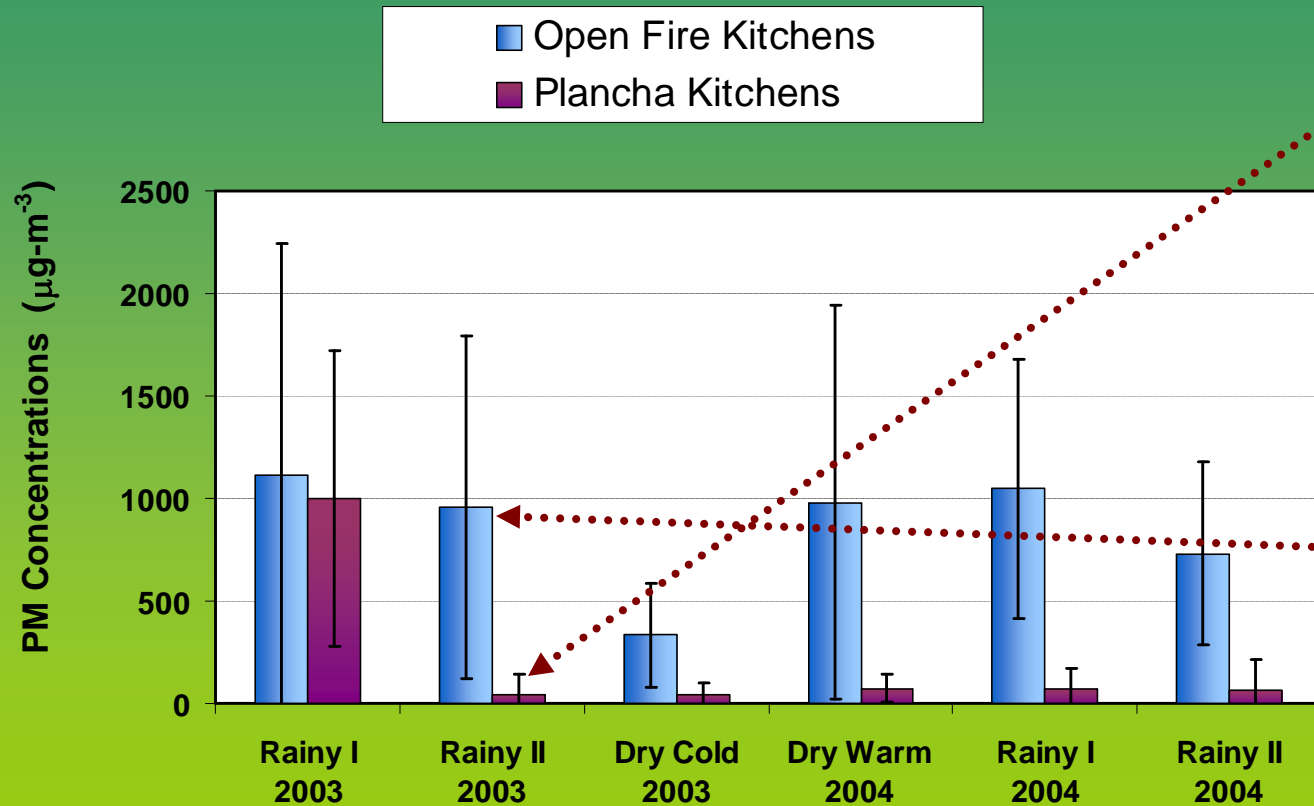
Across Seasons (2002-2004) and Households

%-reduction = 93%

p-value =  $8.5 \times 10^{-23}$

N = 121 Open Fire + 121 Plancha

## PM<sub>2.5</sub>: Control Vs Intervention



Across Seasons (2003-2004) and Households

%-reduction = 91%

p-value =  $9.5 \times 10^{-7}$

N = 87 open fire + 57 Plancha

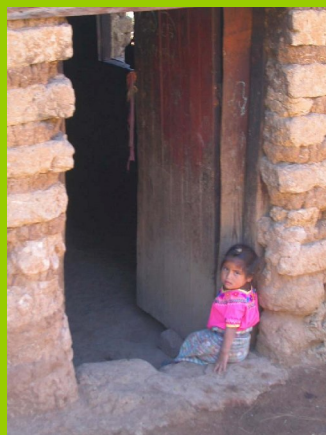
# PM<sub>1.0</sub> in Bedrooms

% reduction = 64%

P-value = 0.296

N = 63 open fire + 57 Plancha

Not Significant



# PM<sub>1.0</sub> in Outdoor

% reduction = 27%

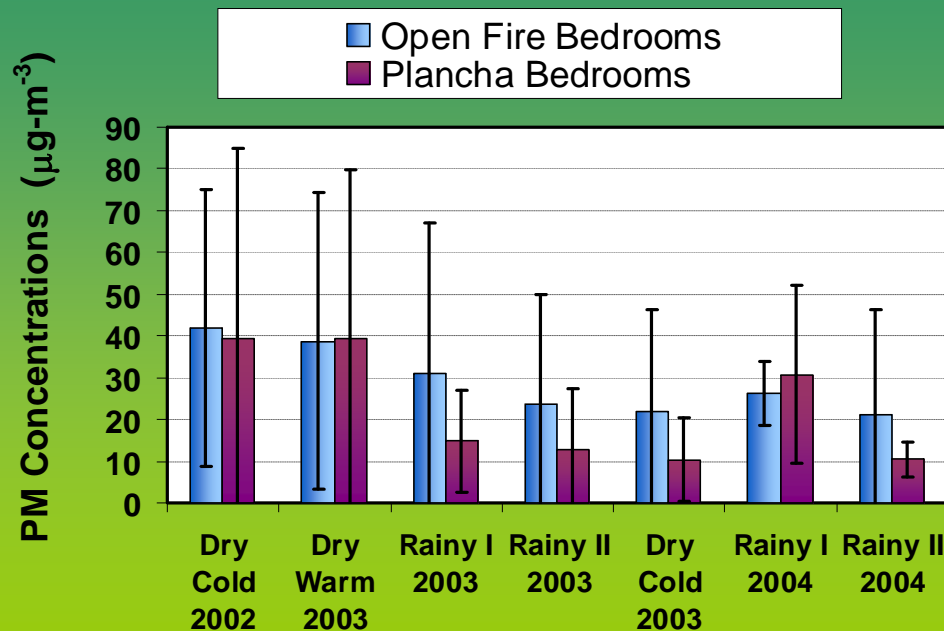
p-value = 0.176

N = 56 open fire + 49 plancha

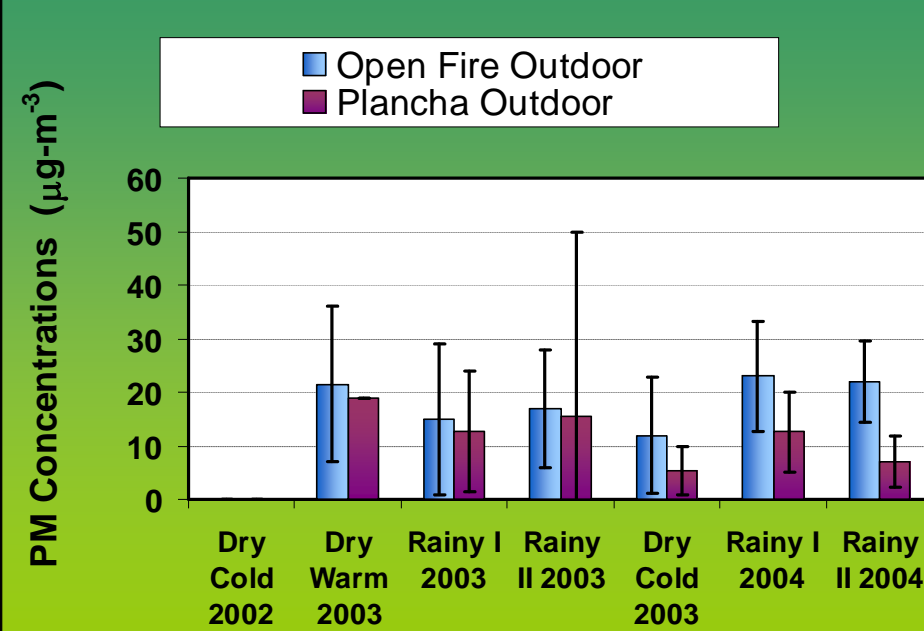
Not Significant



## PM<sub>1.0</sub>: Control Vs Intervention



## PM<sub>1.0</sub>: Control Vs Intervention





# Conclusions

- Significant reduction (93%) of PM in Intervention **kitchens**
  - Control homes also reduced their PM exposure
- Reduction of PM observed (but change not statistically significant) in **bedrooms** and **outdoors**
- These results demonstrate the potential reduction of particles by installing improved stoves in rural areas where solid fuel is being used for cooking

# Acknowledgement

## ■ Funding:

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- World Health Organization, Geneva
- AC Griffin Family Trust

## ■ Collaborators:

- University of California, Berkeley
  - Harvard School of Public Health
  - University of Liverpool
  - University of California, Irvine
- 
- Fieldworkers and participants
  - Guatemala Ministry of Health



Thank You!





Extra Slides

# Theory Behind Smoke Detector Technology

(Litton et al. 2002, 2004)

Operates on principles of ion depletion and optical scattering by smoke particles

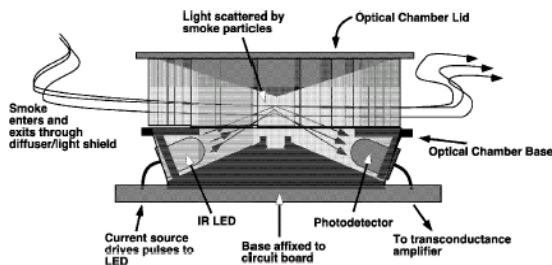
FA302 unit combines both ionization chamber and optical scattering sensing



## Photoelectric Chamber

Responds to larger particles produced from smoldering.

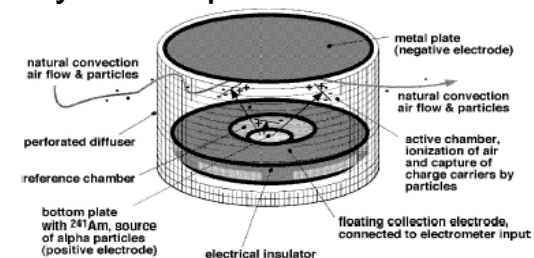
Uses LED with an output wavelength of 880 nm and a photodiode that measures the intensity of scattered light at a 45° angle from forward direction.



## Ionization Chamber

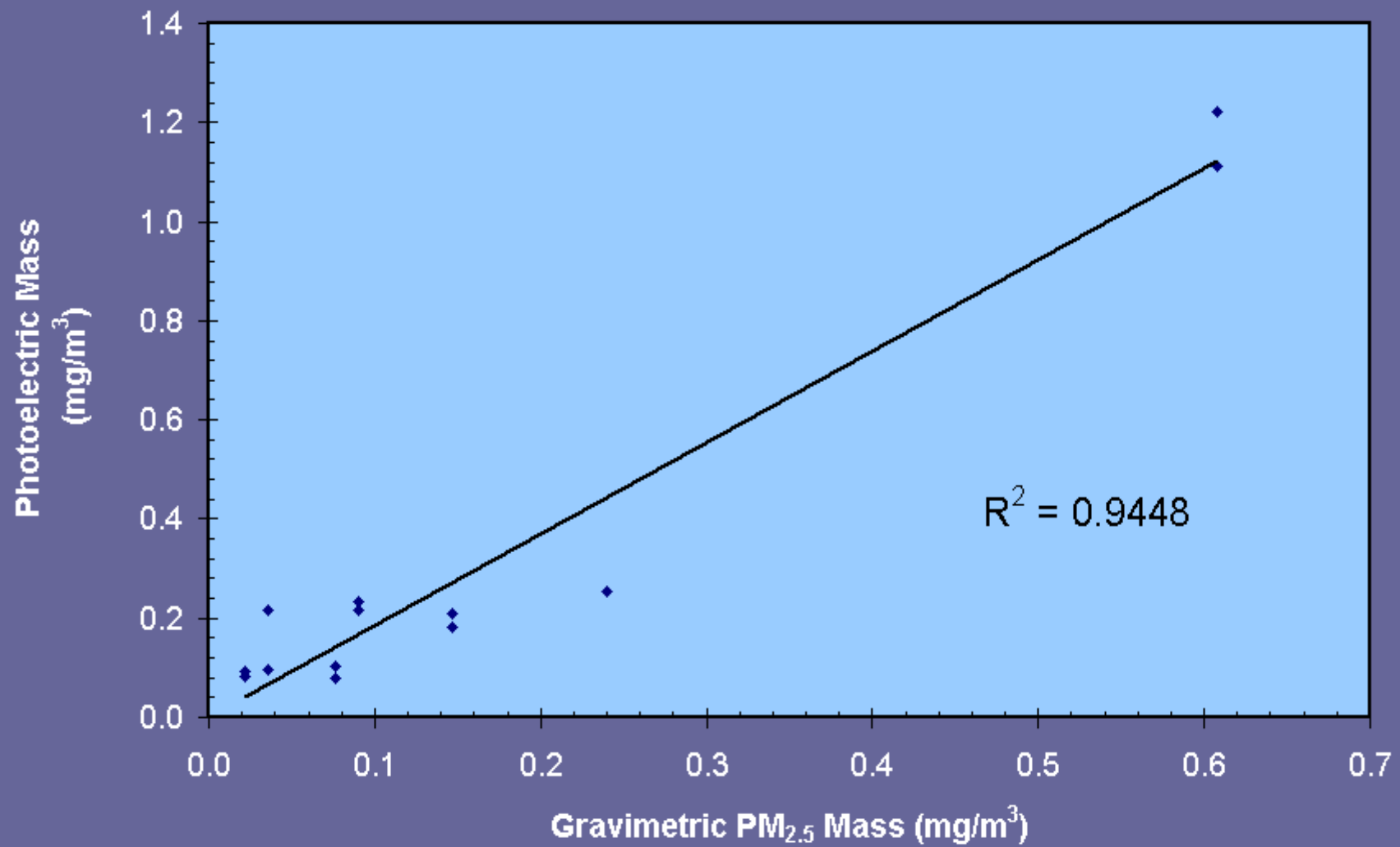
Responds to small particles produced during flaming.

Ions are produced from alpha particles using a 0.9  $\mu\text{Ci}$  source of  $^{241}\text{Am}$ . As particles enter, current is disrupted proportionally to the particle levels.





## Comparison Gravimetric PM<sub>2.5</sub> to Photoelectric Mass



# Measuring Household T and RH

HH ID 04043-237 & UCB007

	Temperature (°C)	Relative Humidity (%)
Arithmetic Mean	13.75	64.09
Arithmetic Std Dev	4.19	9.57
Geometric Mean	13.04	63.36
Geometric Std Dev	1.41	1.17
Median	14.12	64.60
Min	5.66	37.00
Max	21.17	91.90
5th %-ile	6.98	49.70
25th %-ile	10.08	56.90
75th %-ile	17.60	70.50
95th %-ile	19.60	79.70
15-min Avg Highest	21.02	89.75
15-min Avg Lowest	5.68	39.35
15-min Mean	13.73	64.18
15-min Std Dev	4.18	9.44

