



BERKELEY LAB

LAWRENCE BERKELEY NATIONAL LABORATORY



U.S. DEPARTMENT OF
ENERGY

Cooking, Health and Decarbonization

Iain Walker



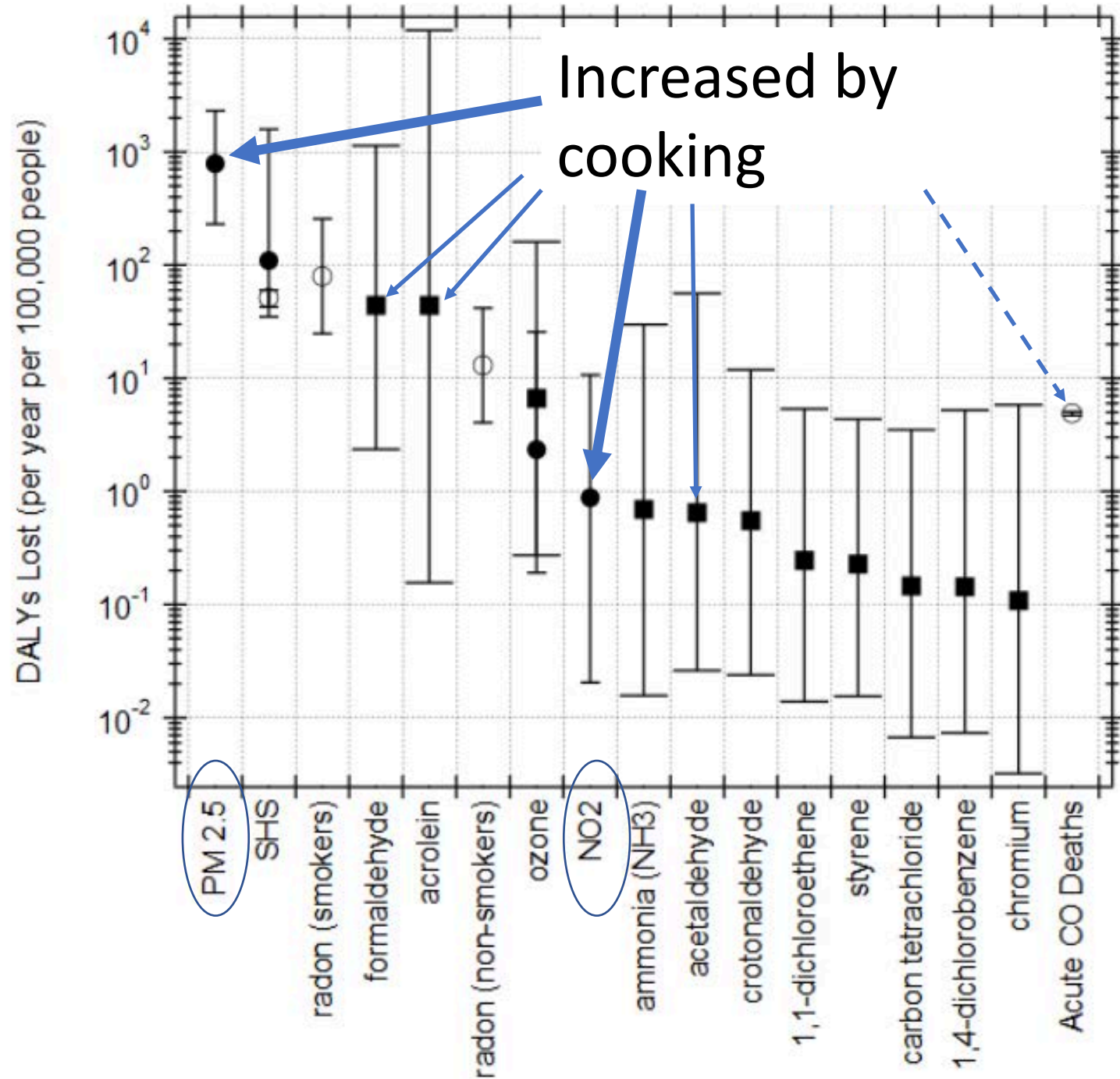
BUILDING TECHNOLOGY & URBAN SYSTEMS DIVISION

Energy Technologies Area



Critical
contaminants
related to health
are emitted by
cooking

DALY = Disability Adjusted Life Year



Both food and heat sources generate pollutants

Gas



CO₂ & H₂O

Particles, NO₂ (and NO), CO, Formaldehyde,

Food



Particles, Formaldehyde, Acetaldehyde, Acrolein, H₂O, Odors

Electric



Ultrafine particles



Measurements in homes

Cooking and range hood monitoring

Monitor cooktop and oven use with iButton temperature sensors

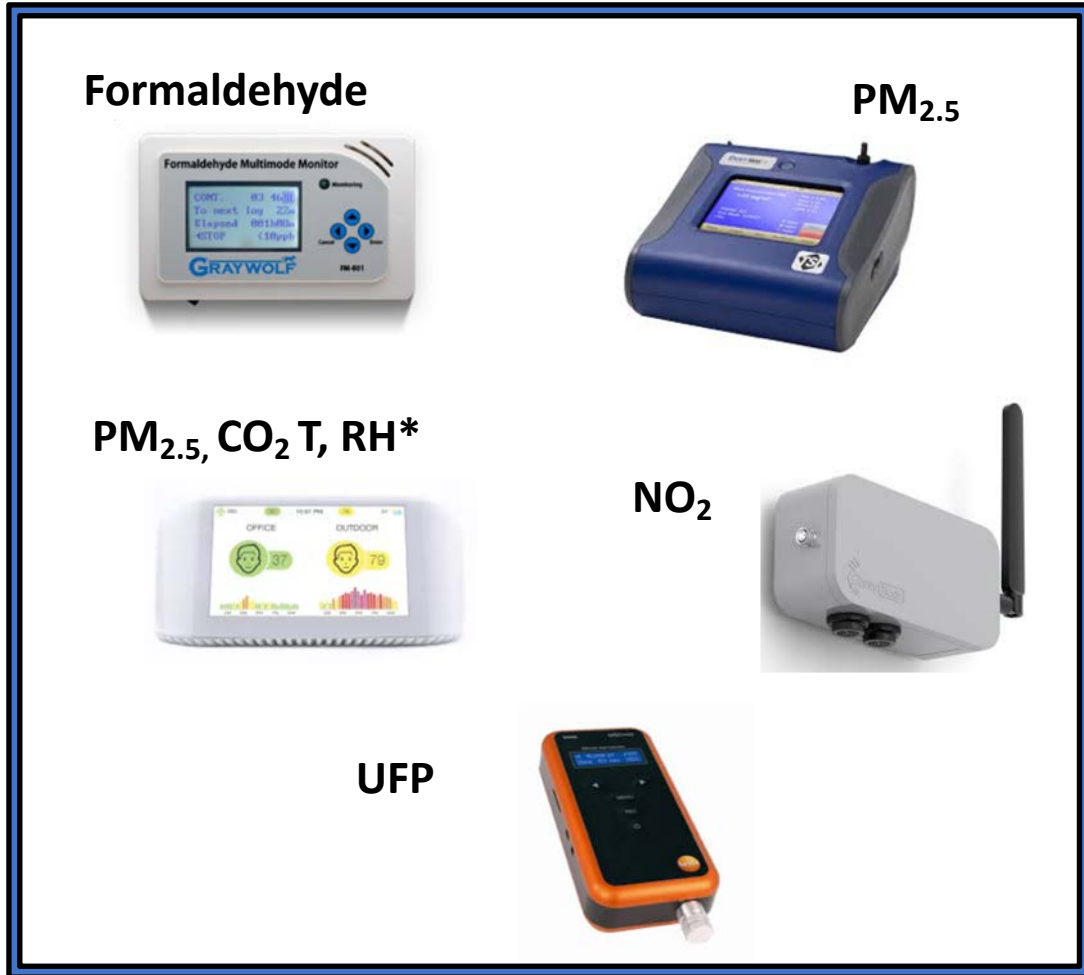


Monitor range hood (RH) use with anemometer



IAQ Monitoring

Time-resolved IAQ



Time-integrated



Concurrent Outdoor Monitoring

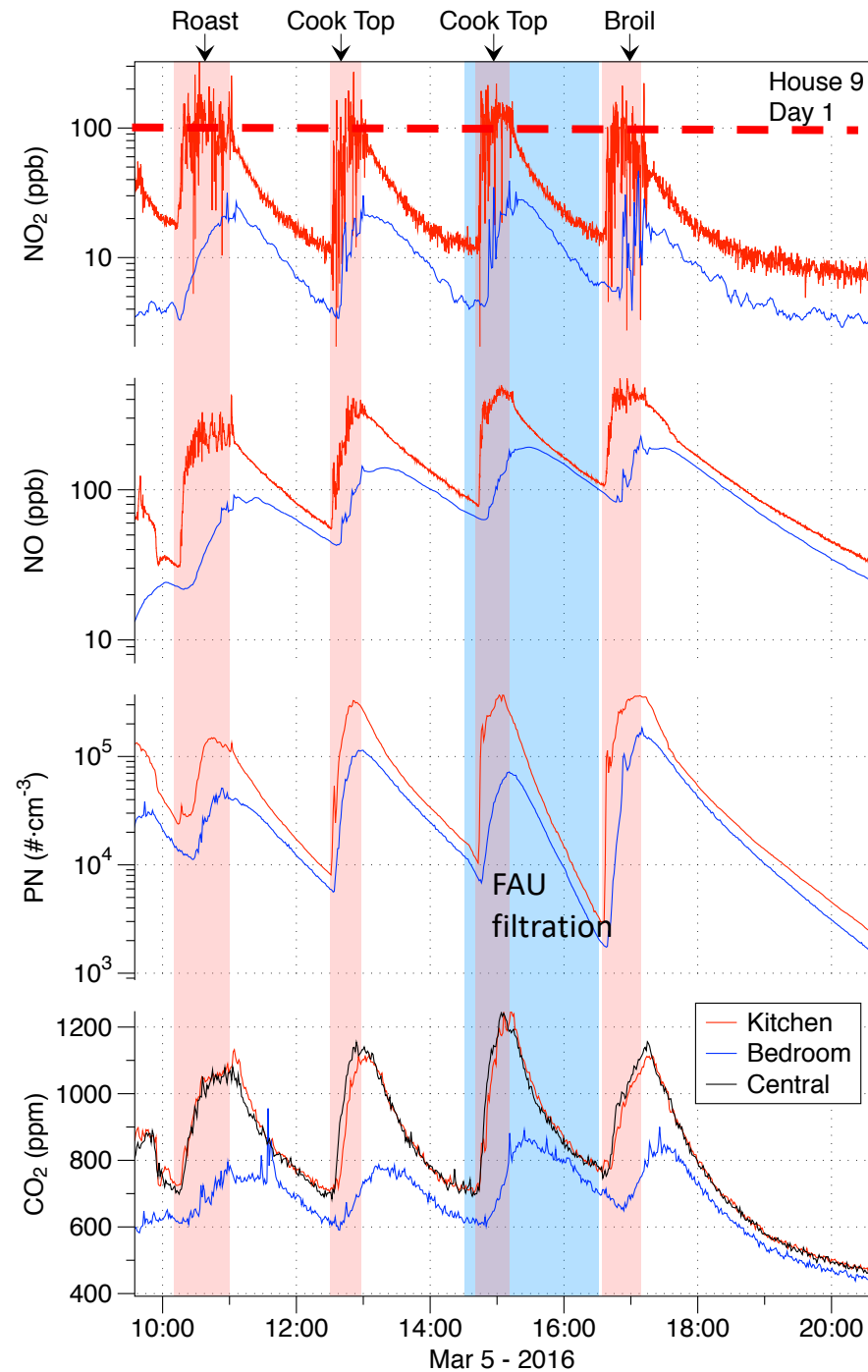


* Monitored at two locations: central area, bedroom

Scripted cooking with gas

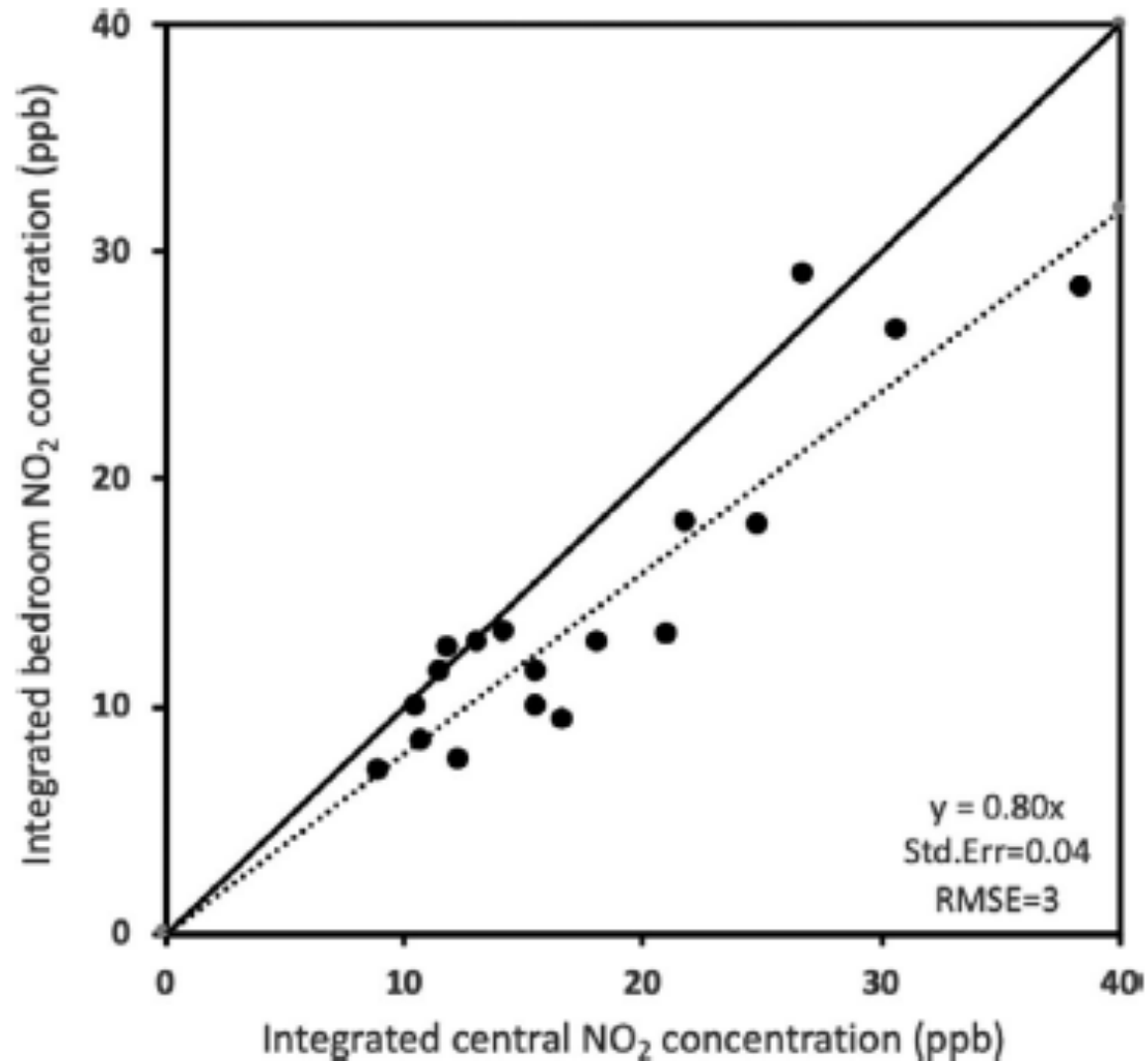
NO_2 in kitchen exceeds ambient Air Quality threshold value

4 of 9 homes had kitchen NO_2 exceed 100 ppb over 1h



$\text{NO}_2 > 100$ ppb in kitchen

Does NO₂ just stay in the kitchen?



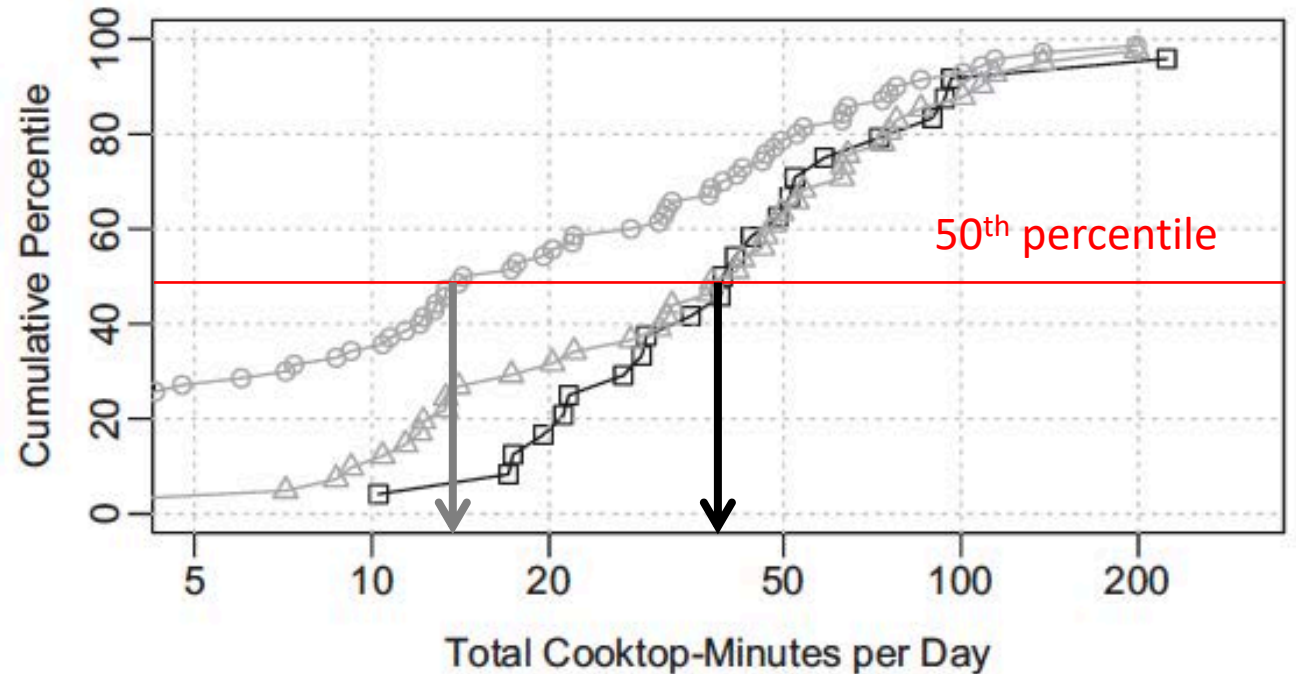
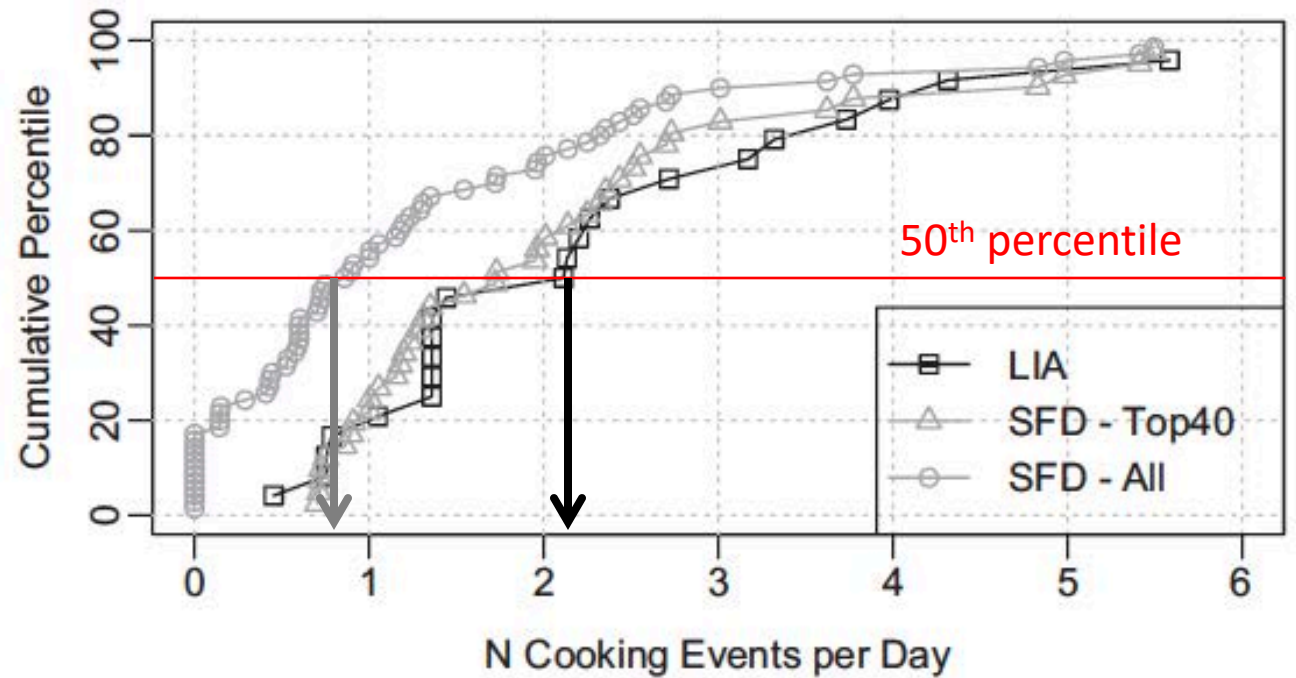
No it does not.....

In this example:
bedrooms about
20% lower than
central location

Apartments & smaller homes more critical

LIA = Low Income Apartments
SFD = Single Family Detached

Low Income:
About twice as much cooking
More cooking for longer = Bigger Health Risk



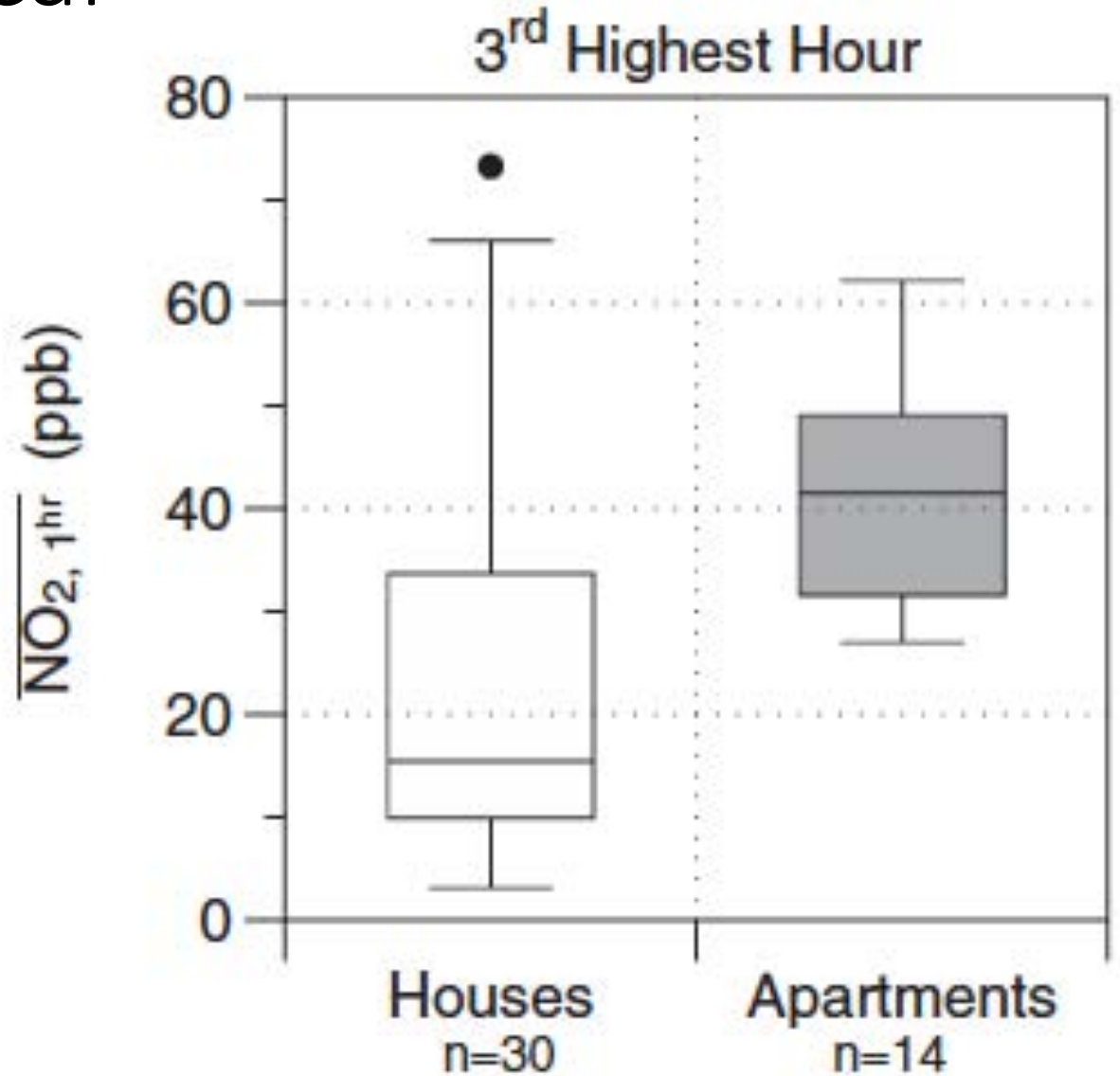
Apartments are more critical

Apartments more likely to be:

- Low Income
- Disadvantaged communities



Improvements in kitchen venting and switching to electric cooking are helping those that need it most



Kitchen Venting

Range hood effectiveness



Capture efficiency (CE):

The fraction of pollutants emitted at the cooktop or in the oven that are removed before mixing into the air of the home

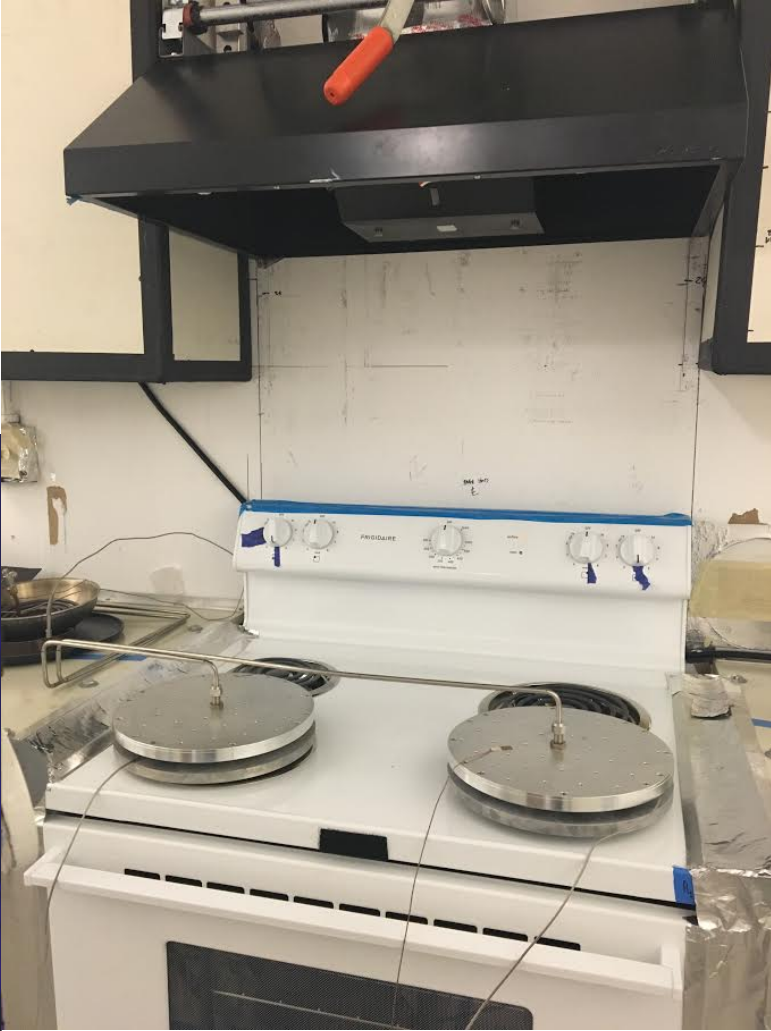
Standardized test method for rating about to become international = ratings coming soon



Designation: E3087 - 17

Standard Test Method for
Measuring Capture Efficiency of Domestic Range Hoods¹

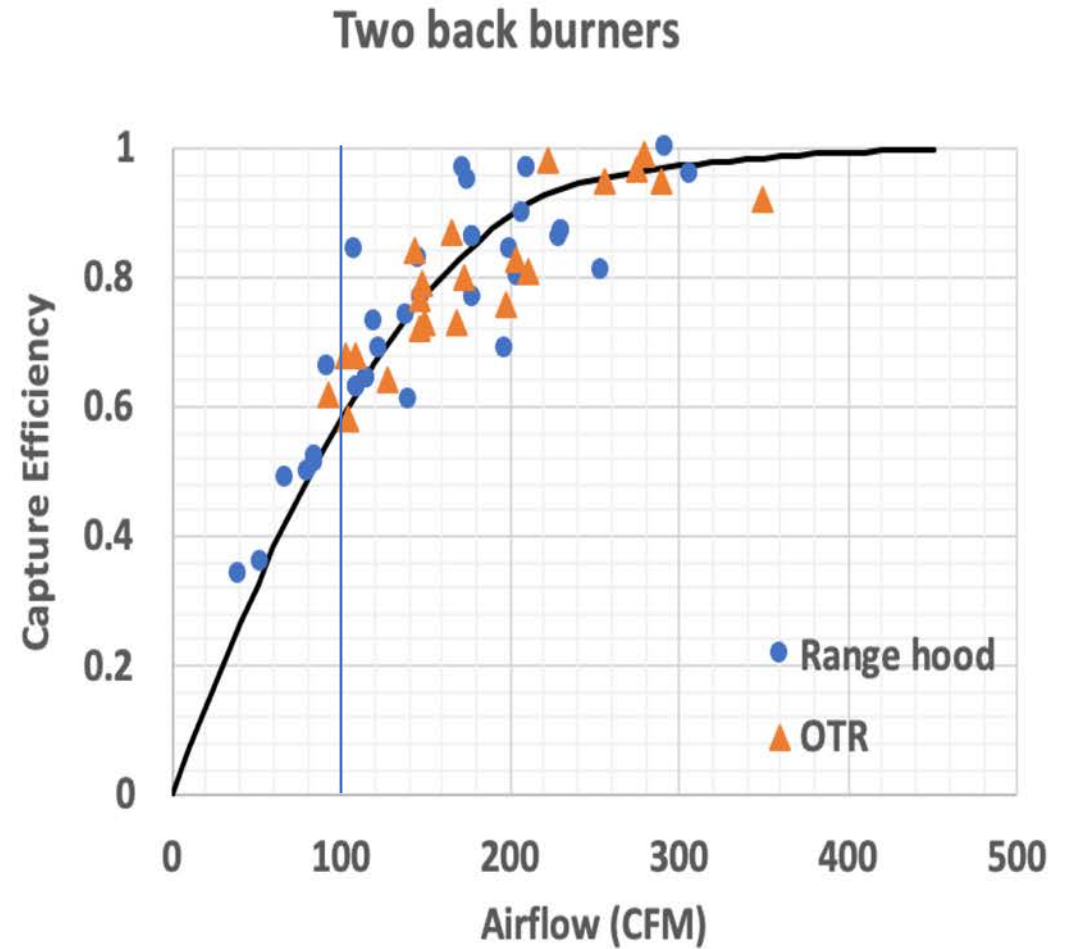
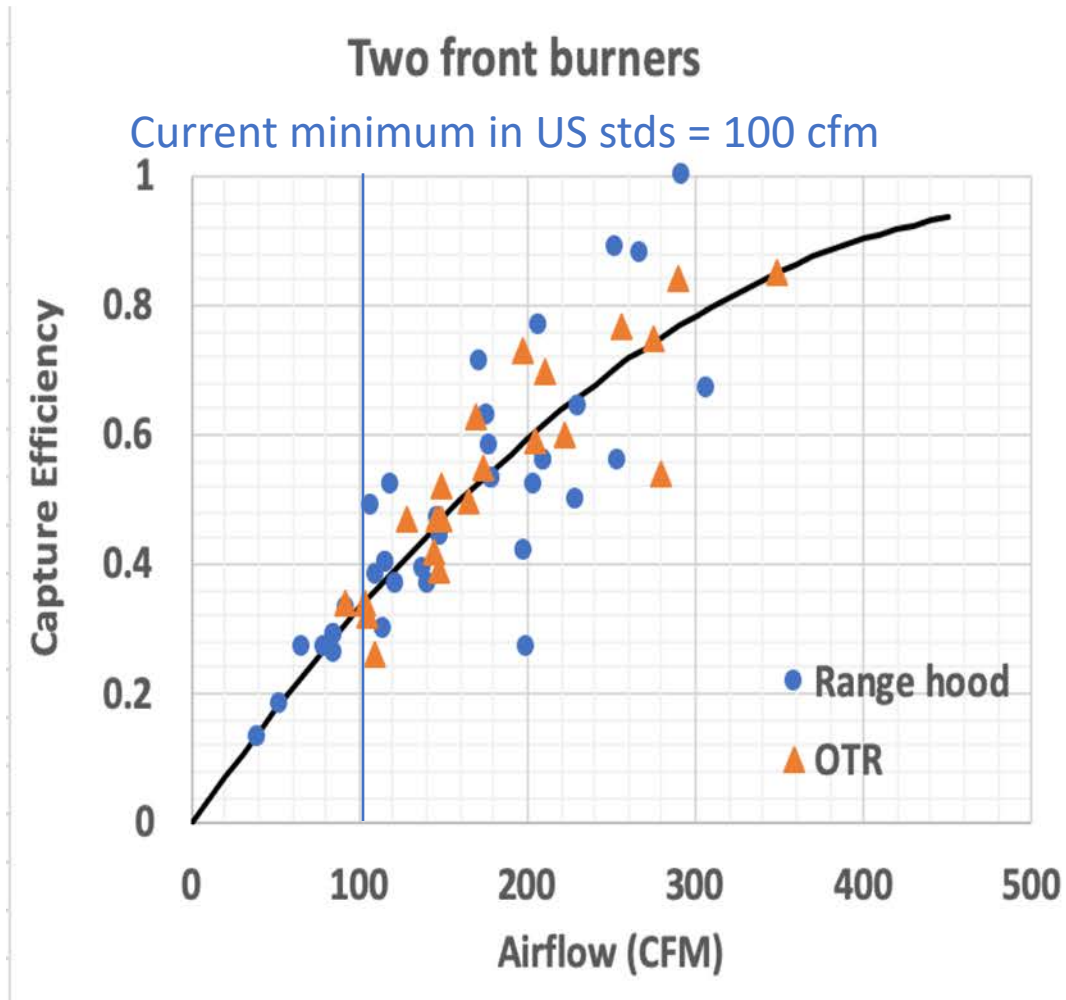
Lab Testing



Field Testing

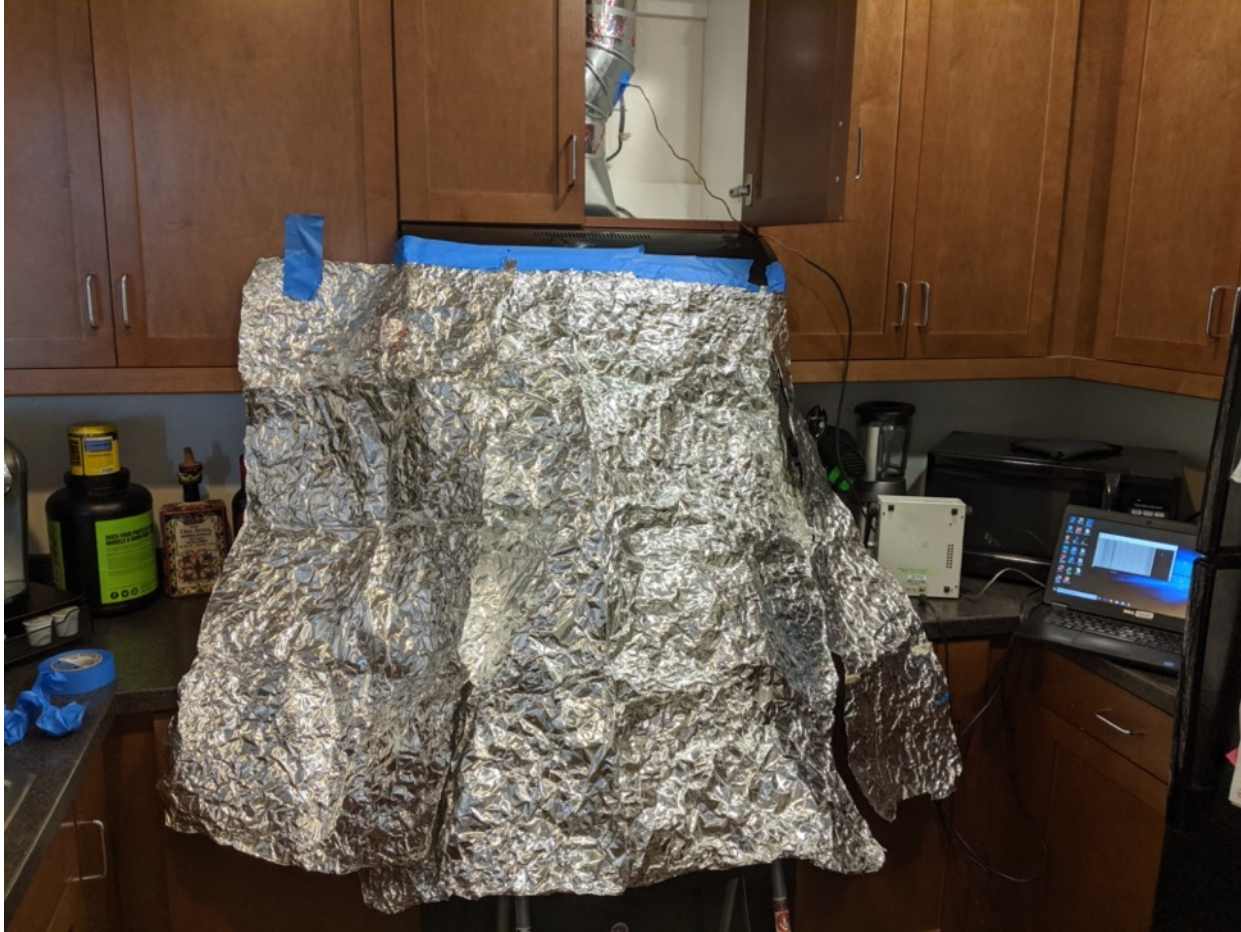


Capture Efficiency



OTR = Microwave with Exhaust

Some Impractical Solutions

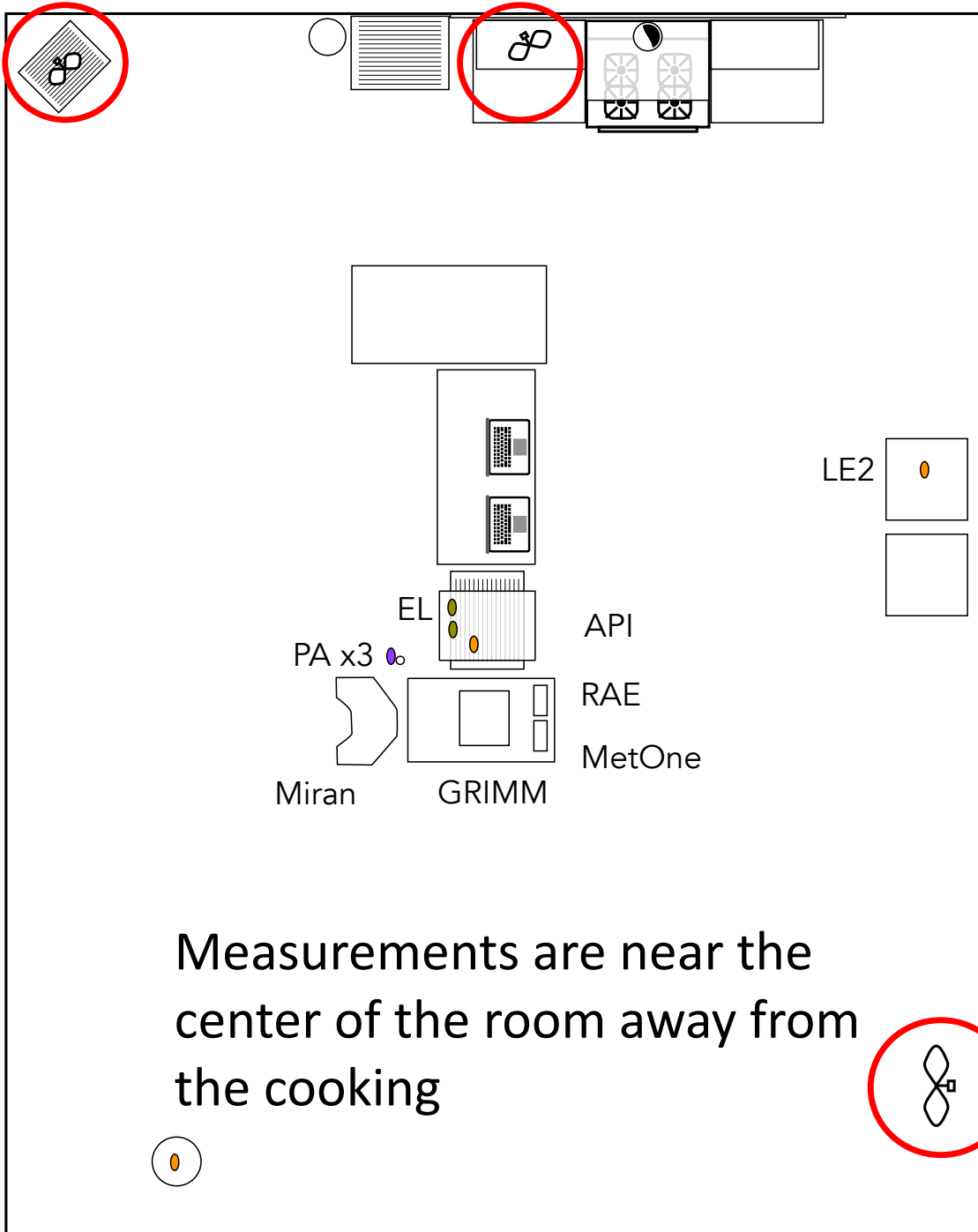


Laboratory Testing for Contaminants

Gas Range in a unit of
FlexLab at LBNL



Hood exhaust balanced
with MERV13 filtered
supply



Reference Instruments

GRIMM Particle Spectrometer - PM, PN, distributions

MetOne - PM

API Gas analyzer - NO, NO₂, NO_x

RAE VOC analyzer - tVOC

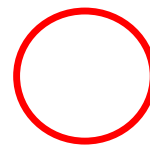
Miran IR gas analyzer - R124 tracer for ventilation rate

Consumer Instruments

eLichens - PM, CO₂, tVOC, NO₂, T, RH

LaserEgg2 - PM, T, RH

PurpleAir - PM, T, RH



Mixing fans

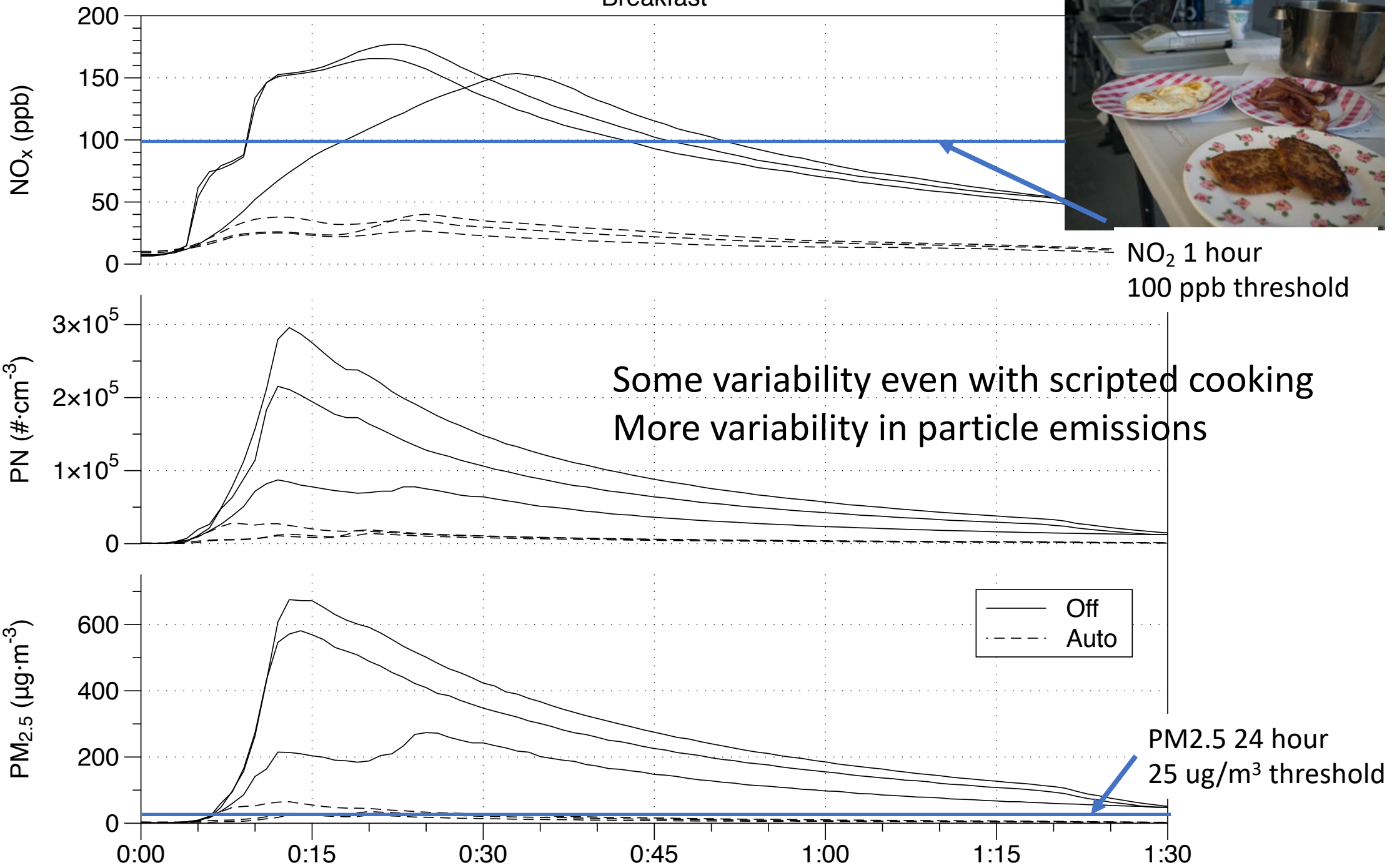
Scripted Breakfast Meal

Breakfast Cooking Details - PARALLEL

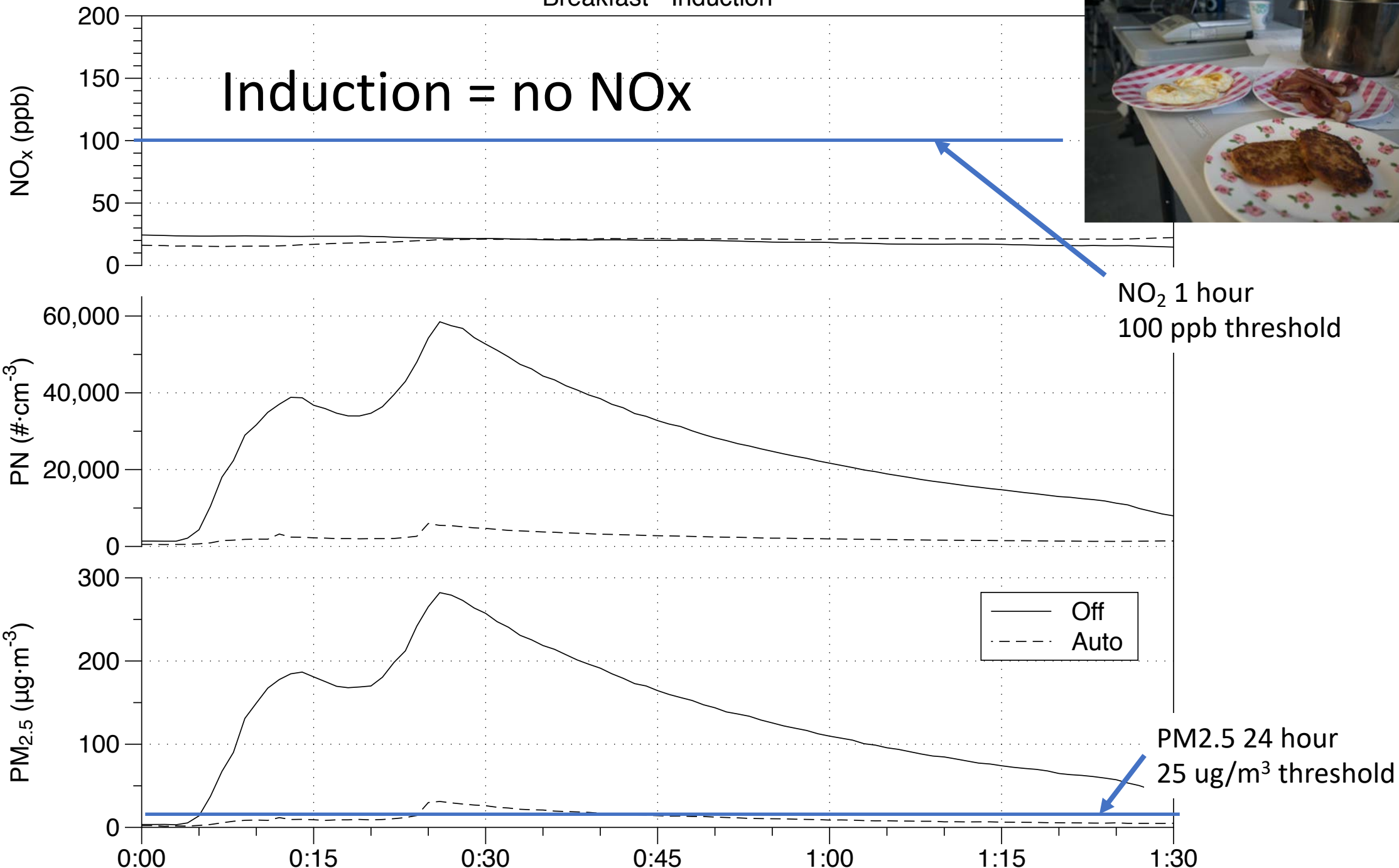
Time (min)	Activity	Gas (lpm)
0	Start front left burner on medium (2 lpm) for hash browns	->
0:15	Start front right burner on medium (+2 lpm; Total 4 lpm) - bacon in pan (cook 12 min); remain to watch oil	->4.04
1.5	Add 2 hash browns to small skillet (cook 9 min); remain	
2	flip bacon and adjust in pan; remain	
3.5	Press hash browns 5s each; remain	
4	Flip bacon and adjust in pan; remain	
5.5	Flip hash browns; press 5s each; remain	3.99
6	Flip bacon and adjust in pan; remain	
7	Flip bacon and adjust in pan; remain	3.97
8	Press hash browns 5s each; remain	3.96
8-12	Flip bacon every 30s	
10	Return; flip hash browns; press	3.94
10:30	Stop front left burner; remove hash browns to plate with paper towel; place skillet on back left burner.	->2.02
12	Stop front right burner; remove bacon to plate; move pan to rear burner; leave uncovered	0
12.5	Place non-stick pan with butter on front left burner, start and adjust to medium (2 lpm)	->2.04
14	Add eggs to non-stick pan (cook 4 min); remain	2.05
17	Flip eggs	2.05
18	Stop front left burner; remove eggs to plate; place pan on front right burner	->0
48	Remove skillets and fry pan from cooktop	



Breakfast



Breakfast - Induction



Induction = no NOx

NO₂ 1 hour
100 ppb threshold

— Off
- - - Auto

PM_{2.5} 24 hour
25 ug/m³ threshold



What next?

Different code requirements: proposed CA T24

- Key health contaminants are PM_{2.5} (gas and electric cooking) and NO₂ (only from gas)
- To meet health guidelines more/better kitchen ventilation is required for NO₂, i.e., gas cooking

Cooking Fuel	Floor Area (ft ²)	Capture Efficiency	Airflow as installed (cfm)
Electricity	>1500 ft ²	0.50	110
	1000 - 1500 ft ²	0.50	110
	750 - 1000 ft ²	0.55	130
	<750 ft ²	0.65	160
Gas	>1500 ft ²	0.70	180
	1000 - 1500 ft ²	0.80	250
	750 - 1000 ft ²	0.85	280
	<750 ft ²	0.85	280

New studies

- Health studies, e.g., California Energy Commission & Asthmatic Children intervention study
- More focus on ultrafine particles
- Specifically investigate induction c/w electric resistance
- Is non-stick better?
- Work internationally – much more induction cooking in other countries
- Assessing safety advantages
- Assessing energy use: preliminary studies for commercial cooking show savings from efficiency (heat the pot not the cooktop/element/room) and shorter heat up time

Thanks to my colleagues:

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Haoran Zhao

Brennan Less

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Question/Comments?

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Scripted Pasta Meal

Time (min)	Activity	Gas (lpm)
0	Start front right burner on high (6 lpm) for pasta. Pasta lid is on; walk away	-> 6.03
1:30	Return; start front left burner; adjust to medium (+2 lpm, 8 lpm total) ; remain	-> 8.06
3	Spread oil with wood spoon; add onions (cook 6 min) ; stir 15s; walk away	7.99
5	Return; stir onions 5s; Walk away	7.87
6	Adjust flow of FRONT LEFT burner to 8 lpm total ; stay as far as possible from range hood	7.9
7	Return; stir onions 5s; remain	7.91
8	Stir onions 5s; remain	7.87
9	Add beef (cook 8 min) ; stir and break chunks for 30s	
9:30	Walk away	7.81
11	Return; stir beef for 30s;	
11:30	Walk away	7.75
14	Return; stir beef for 15s; lift pot lid to check water, replace lid; remain	7.70
15	Stir beef 15s; remain	7.68
16	Remove pot lid to confirm rolling boil; add pasta (cook 13 min) ; stir 5s; remain	7.66
17	Add jar of sauce to saute pan ; stir 15s; place lid on saute; remain	->7.65
18	Stir pasta 5s; adjust front right burner to medium (+2.5 lpm, 4.5 lpm total) ; remain	
18:30	Stir sauce 5s; remain	4.46
19	Stir sauce; Adjust front left burner to medium-low (+1.0 lpm, 3.5 lpm total) ; place lid on saute	->
19:30	Walk away	3.5
21	Return; stir pasta 5s; stir sauce 5s and replace lid; walk away	3.49
24	Return; stir pasta 5s; stir sauce 5s and replace lid; walk away	3.46
27	Return; remove one piece of pasta from pot, dip in water and taste; remain	->3.46
29	Taste another piece of pasta; turn off front right burner; drain pasta ; put pasta back into pot and place on stove	->1.52
30	Turn off front left burner (sauce); pour meat sauce into pasta pot or another bowl on cooktop; cover saute pan; remove pasta and meat sauce; leave pots on back burners.	0
60	Remove pots from chamber	
90	Start venting chamber	

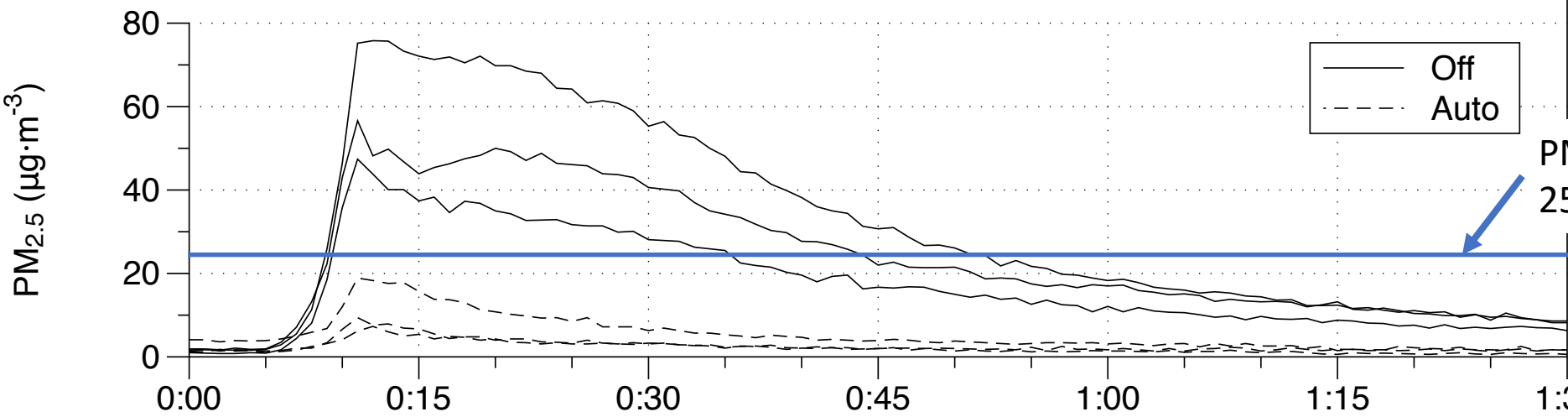
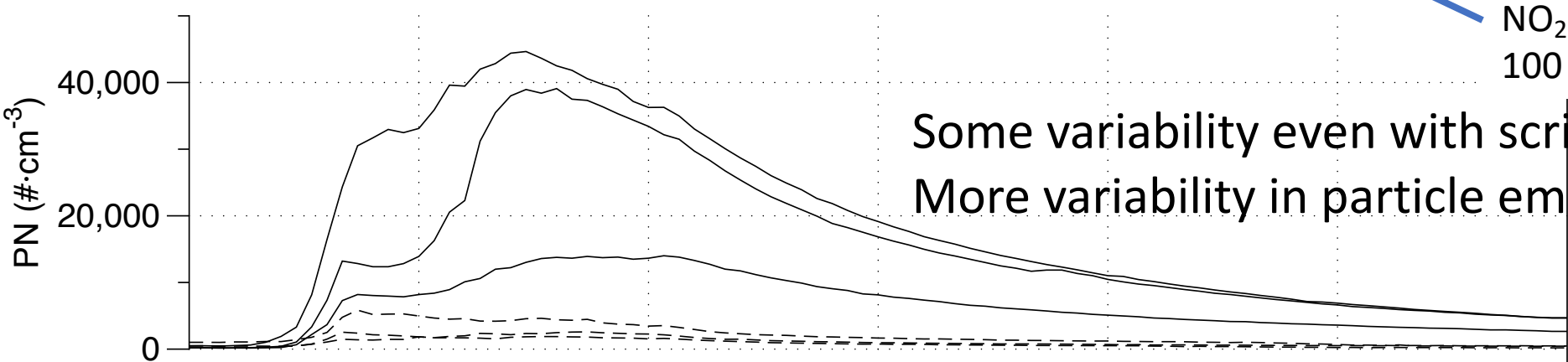
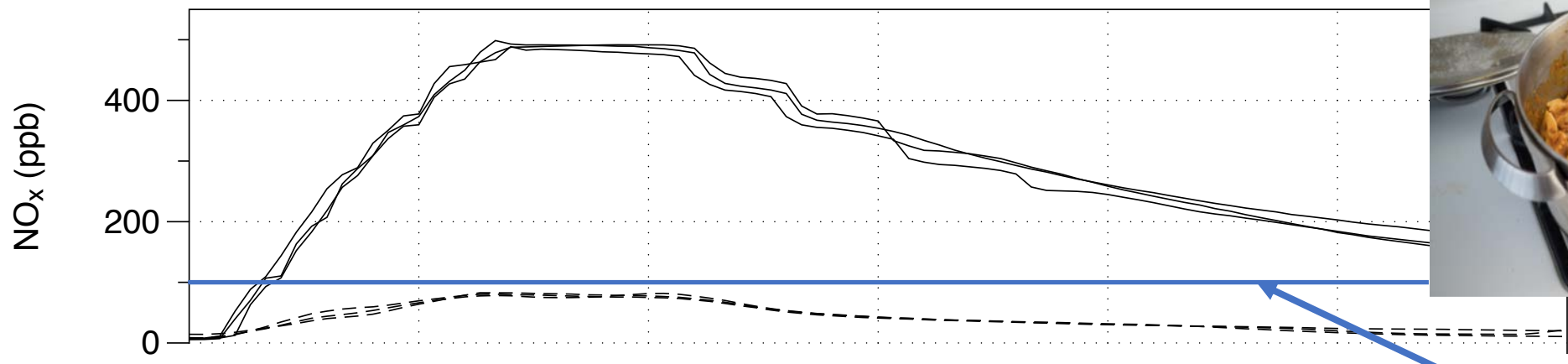


Scripted Oven Meal (Orange Chicken)

Time (min)	Activity	Gas (lpm)
0	Preheat oven to 400 dF for 10 minutes (start timer when gas valve opens)	> 9.05
10:00	Place chicken nuggets on cookie sheet and insert in oven	> 8.55
29:00	Turn oven off. Remove cookie sheet from oven, place cookie sheet on cooktop, transfer nuggets to a pot, cover, and move to separate table	
	Start purge	



Pasta



Orange Chicken

