FOR HEALTH

HEALTHY BUILDINGS

Our goal is to improve the lives of all people, in all buildings, everywhere, every day.

A Program at the

HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH

COVID-19

HEALTHY SCHOOLS

9 FOUNDATIONS OF HEALTHY BUILDINGS

COGFX STUDY

CLIMATE CO-BENEFITS

NEXT

The 'Why'

The Risks of School Closure

Keeping Schools Closed

The Long-Term Individual and Societal Costs

Discussion of risk needs to consider risks of closures

- Virtual dropouts
- Food security
- Physical activity
- Socialization
- Abuse, neglect, exploitation, violence

The 'Who'

Kids *and* Adults

What do we know about kids spreading covid-19?

Less likely to get infected than adults
Less likely to suffer most severe consequences
Less likely to transmit

Plans are designed to reduce risk for adults and kids

The 'When' to Open

Open Based on Community Spread Metrics

HARVARD GLOBAL HEALTH INSTITUTE

EDMOND J. SAFRA Center for Ethics

The Path to Zero and Schools: Achieving Pandemic Resilient Teaching and Learning Spaces

The single best policy to suppo
is suppression of COVID to near
rigorous social distancing, redu
and Supported Isolation (TTSI)

Covid Risk Level	Case Incidence	
Red	>25	daily new cases per 100,000 people
Orange	10<25	daily new cases per 100,000 people
Yellow	1<10	daily new cases per 100,000 people
Green	<1	daily new case per 100,000 people

The 'What' to Do

Risk Reduction Strategies for Reopening Schools

SCHOOLS FOR HEALTH

Risk Reduction Strategies for Reopening School

COVID-19

June, 2020

HARVARD T.H. CHAN
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What strategies should schools consider to reduce risk of COVID-19 transmission?

HEALTHY ACTIVITIES

HEALTHY CLASSROOMS

HEALTHY BUILDINGS

HEALTHY POLICIES

HEALTHY SCHEDULES

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The 'How To' of Ventilation

Measuring and Estimating Outdoor Air Ventilation Rates in Classrooms

Disclaimer

The Harvard Healthy Buildings team was not retained as a formal consultant to the town of Brookline and is not an engineering firm or HVAC contractor.

The goal of the site visit on Saturday, August 15, 2020, was to demonstrate techniques used in our field for measuring and estimating outdoor air ventilation rates.

The testing followed standard procedures and techniques that our team and others have used for years to measure and estimate ventilation rate in buildings.

However, this was not a formal engineering assessment or HVAC survey.

Note the limitations at the end of this slide deck that are inherent in measuring and estimating ventilation rates.

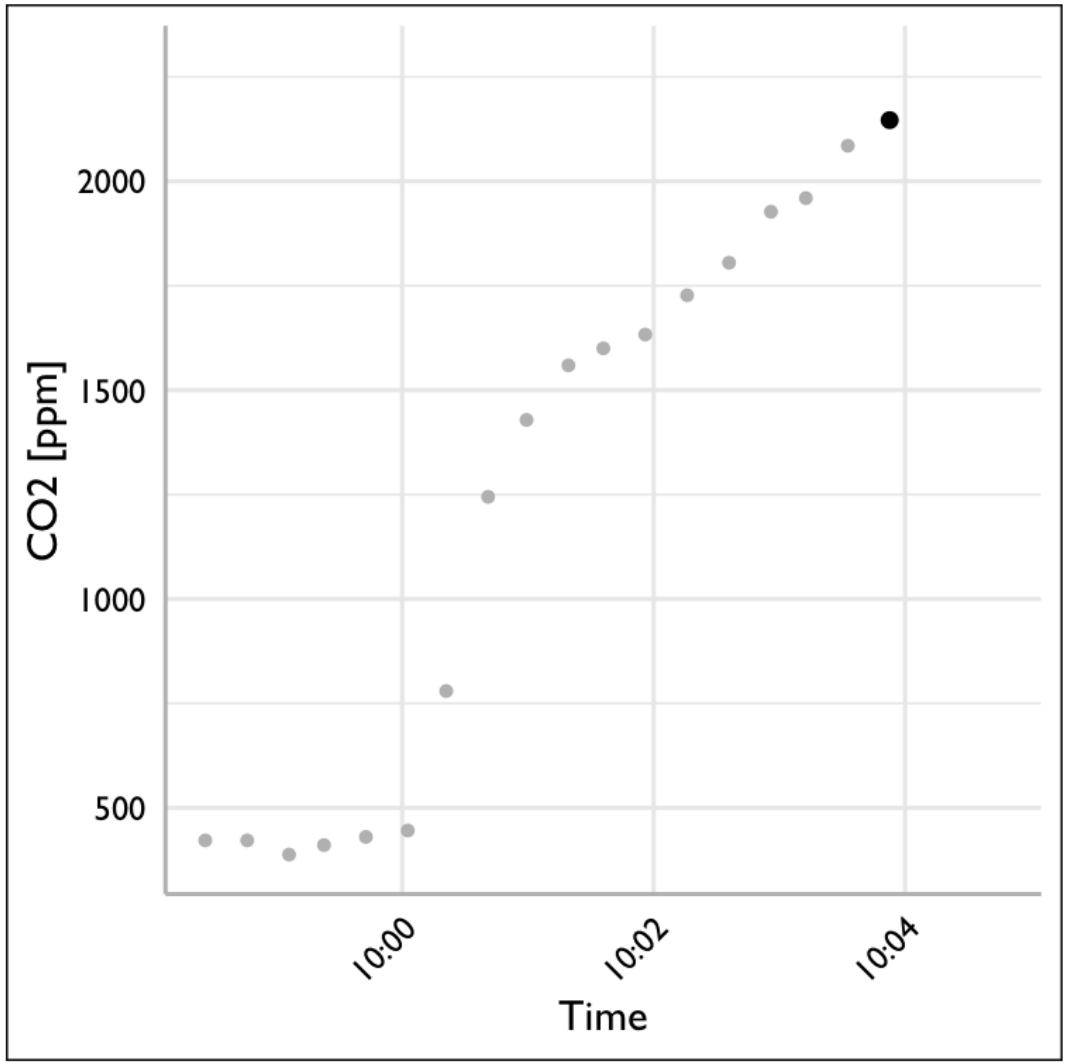
Measuring outdoor air ventilation rates using a balometer (air flow capture hood)

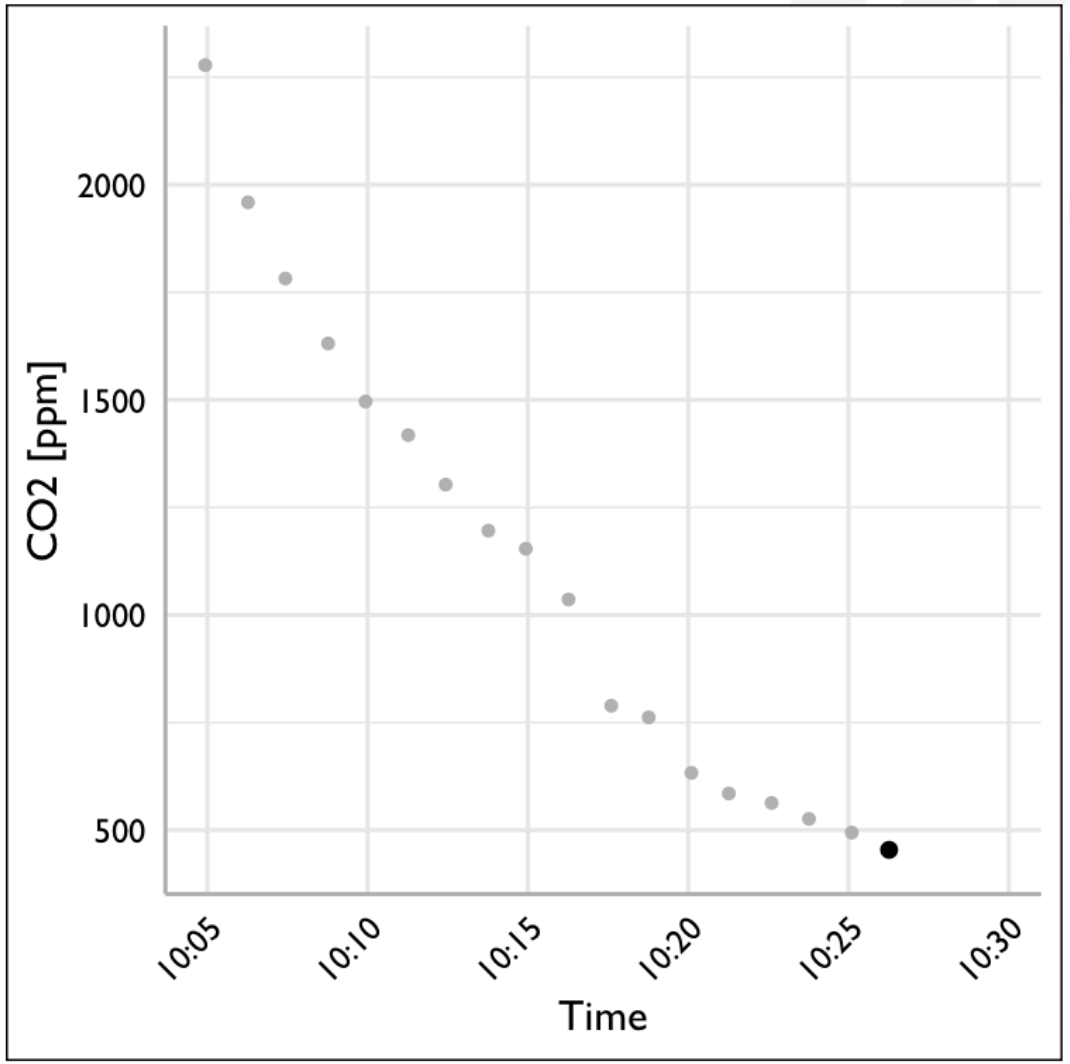
Estimating outdoor air ventilation rates using carbon dioxide as a tracer

Building up CO_2 concentrations with dry ice

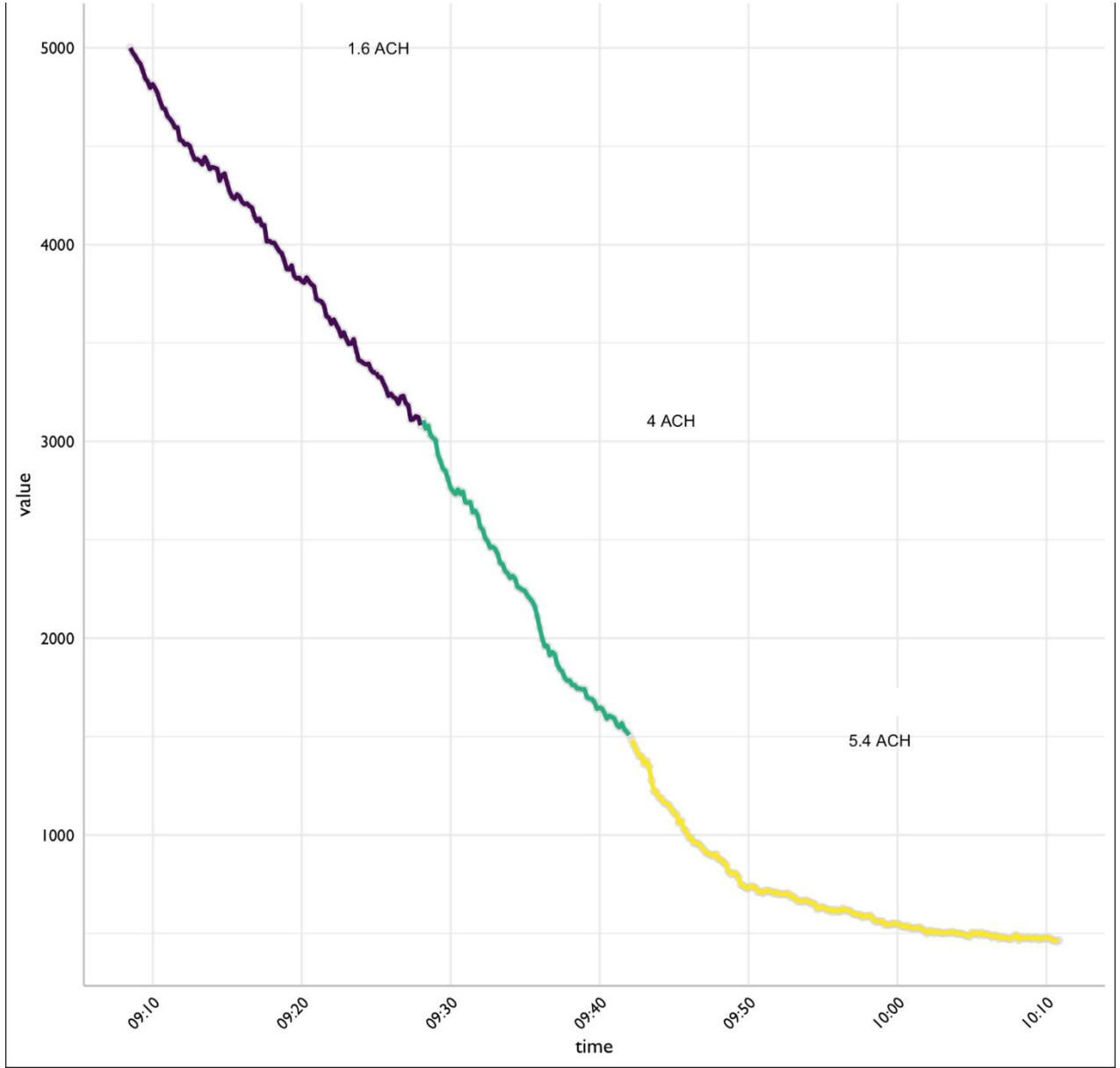
Testing the impact of opening windows approx. 6 inches

Plots showing the buildup, and decay, of CO_2, used to estimate ventilation rates





Example CO_2 decay curve used to assess ventilation rates across three conditions



Mechanical ventilation
(ie, unit ventilator on)

+ windows open

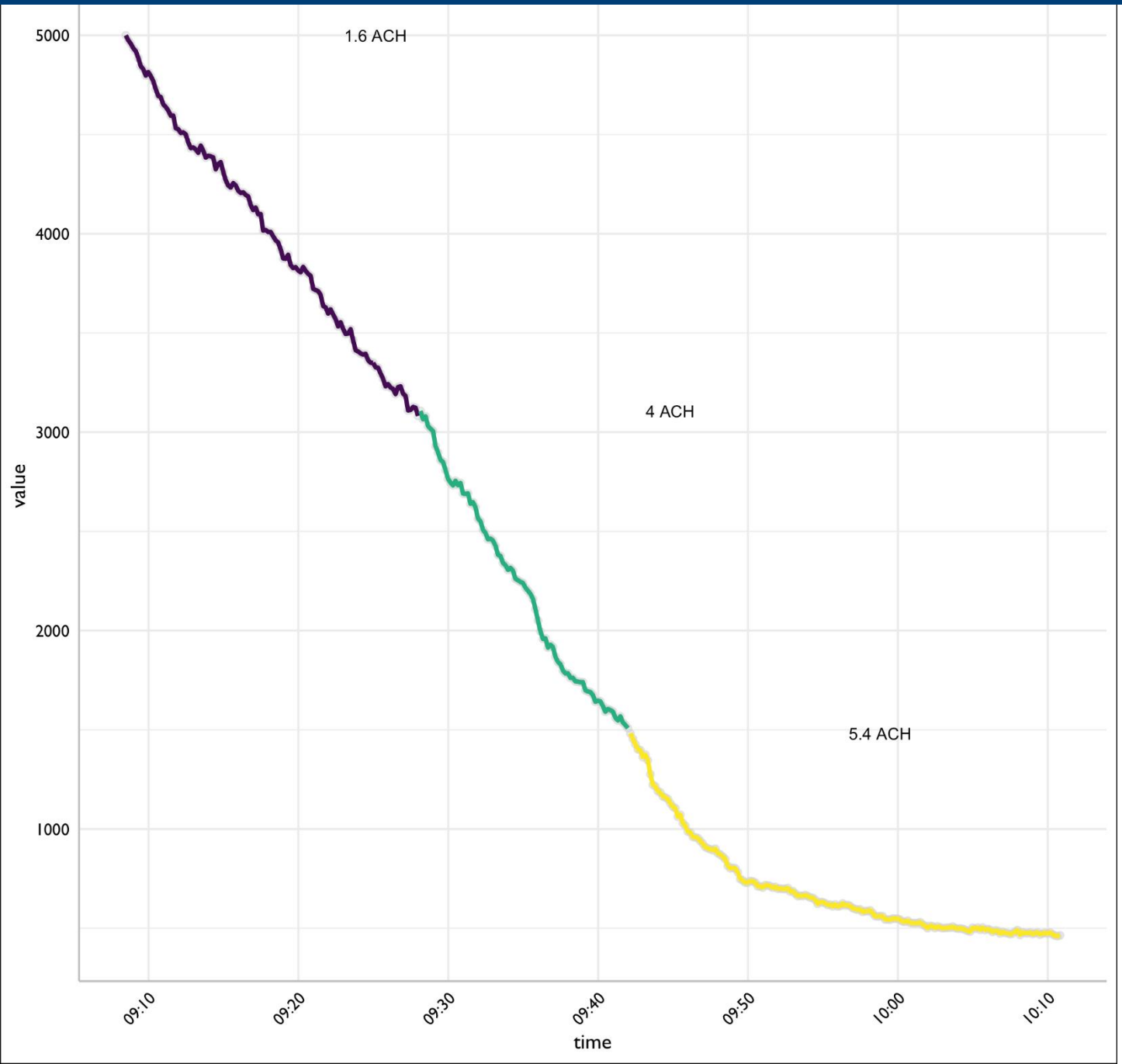
+ doors open

Target air changes per hour (ACH) (for basis, see: https://tinyurl.com/portableaircleanertool)

TARGET IS AT LEAST 5 TOTAL AIR CHANGES PER HOUR	
	Ideal (6 ACH)
	Excellent (5-6 ACH)
	Good (4-5 ACH)
	Bare minimum (3-4)
	Low (<3 ACH)

Minimum outdoor air ventilation for schools based on ASHRAE 62.1 (2019)

						Calcs based on ASHRAE					
ASHRAE						500 sq ft room*			1000 sqft room*		
		cfm/person	cfm/sq ft	Default occupancy (per 1000 sq ft)		cfm	cfm/person	ACH	cfm	cfm/person	ACH
Classrooms	5-8 year olds	10	0.12	25		185.0	14.8	**2.8**	370.0	14.8	**2.8**
	9+ years old	10	0.12	35		235.0	13.4	**3.5**	470.0	13.4	**3.5**
						*assumes 8 foot ceiling			*assumes 8 foot ceiling		



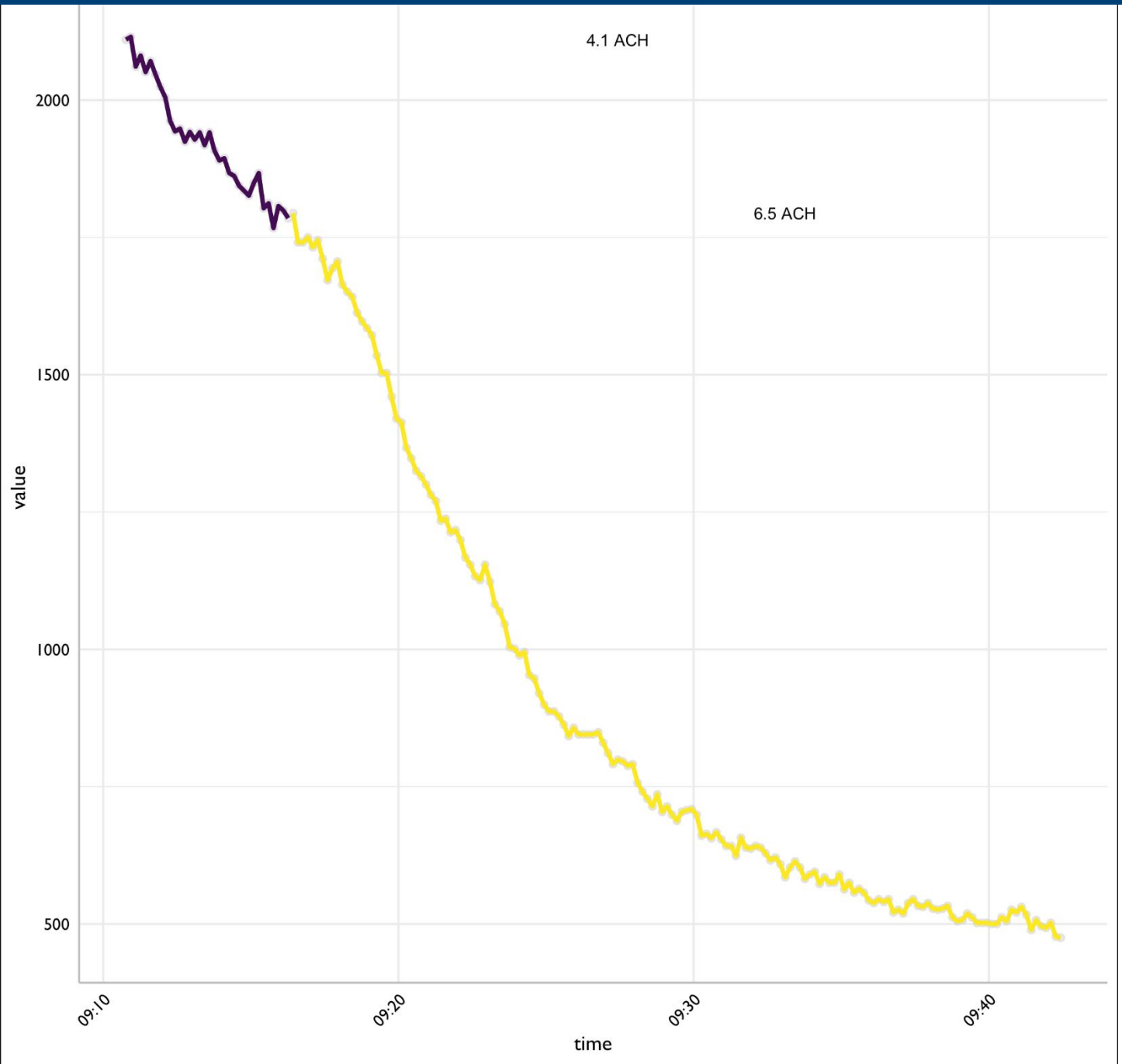
Condition	ACH
mechanical vent	1.6 - 2.1
+ windows	3.3 – 4.0
+ doors	5.4 – 6.5

Measured:

OA supply	231 cfm
Indoor supply	800 cfm
% OA	29%
ACH	1.4 ACH

Note: We report a range of ACH values for the rooms in which multiple CO_2 monitors were used. However, only one CO_2 plot is shown.

Baker School // Room 115 // August 15, 2020

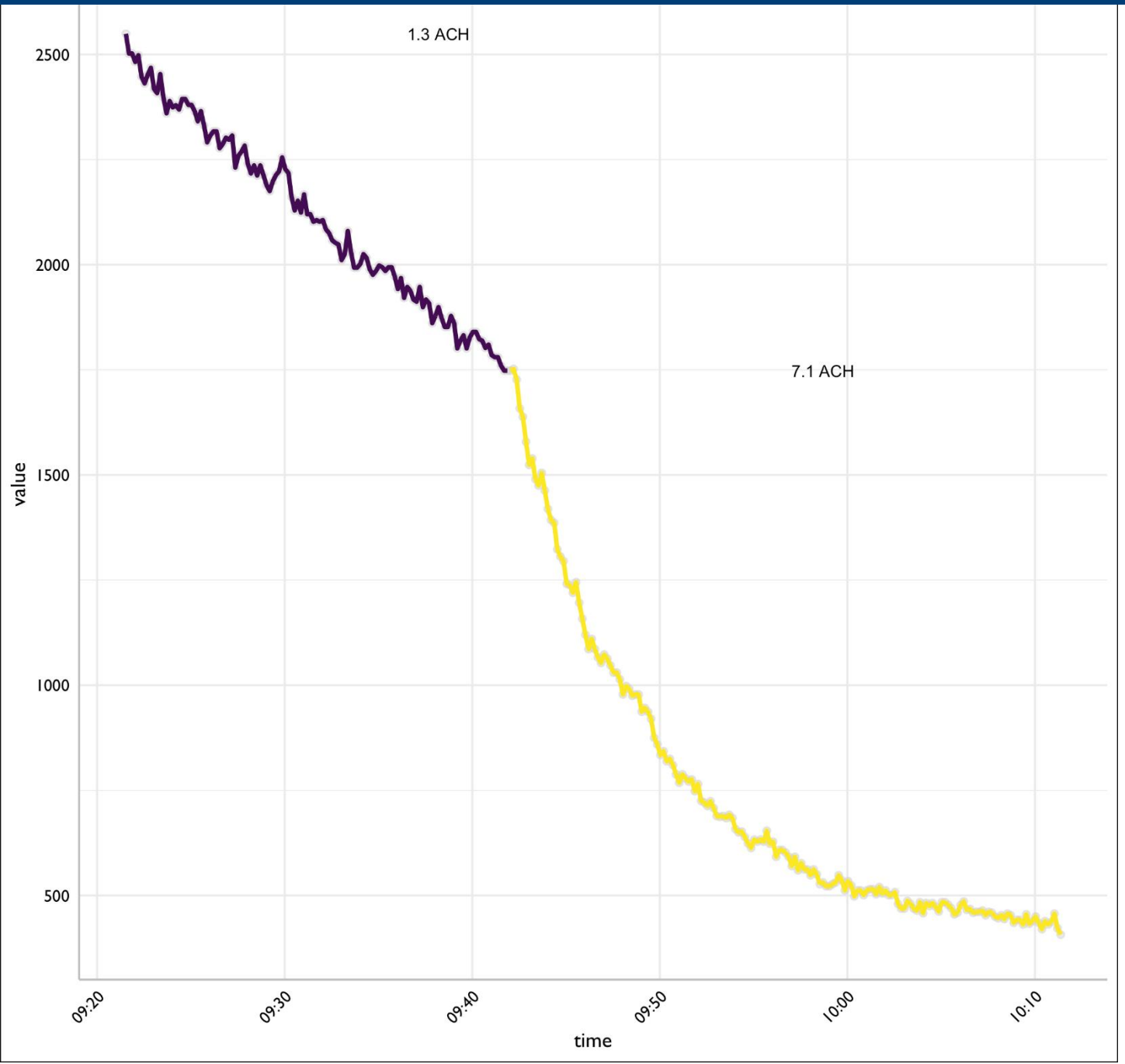


Condition	ACH
mechanical vent	4.1
+ windows	6.5
+ doors	N/A*

Measured:	
OA supply	434 cfm
Indoor supply	732 cfm
% OA	59%
ACH	3.2 ACH

*rapid decay during window test resulted in not enough CO_2 to measure impact of doors open

Baker School // Room 117 // August 15, 2020

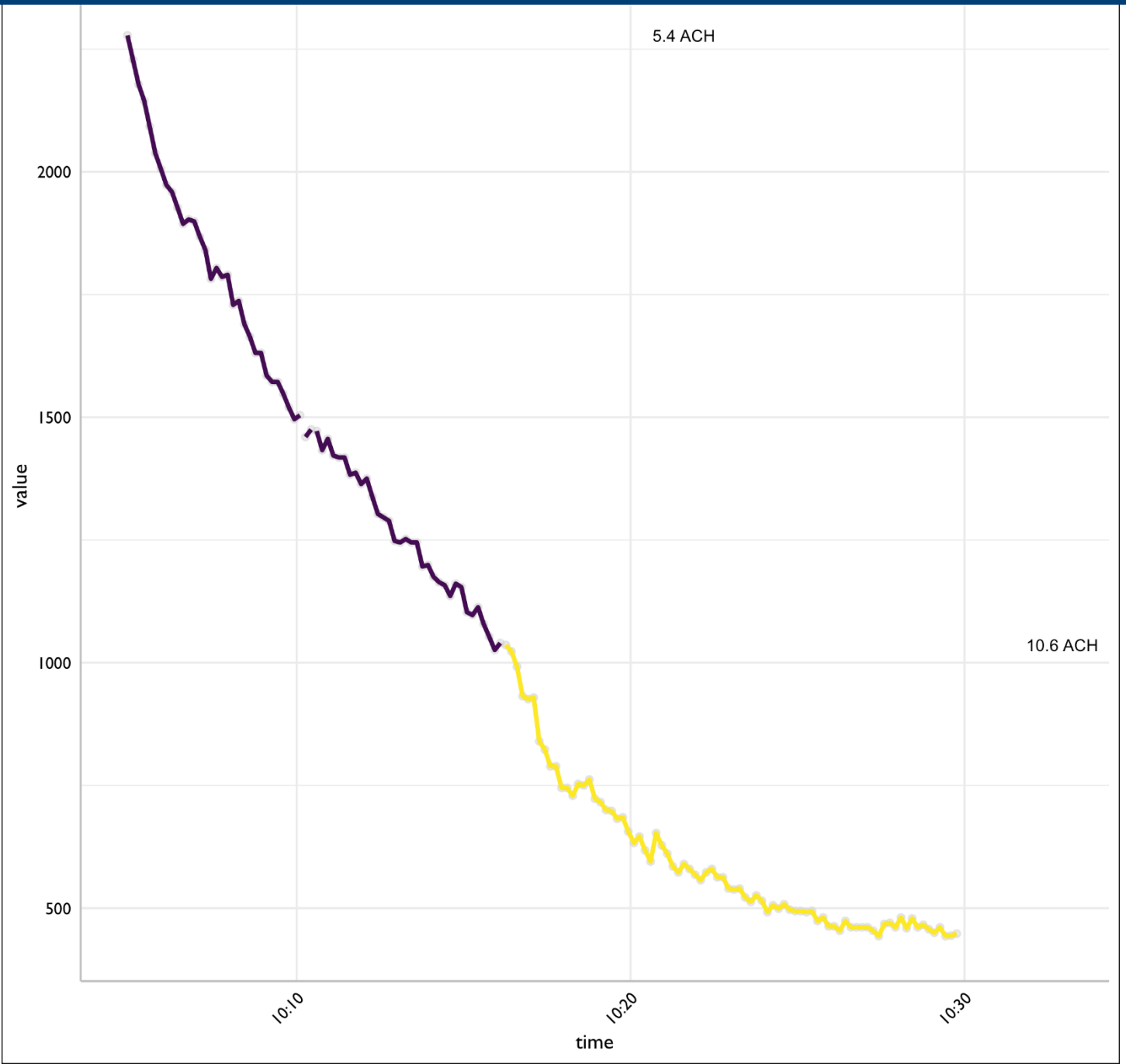


Condition	ACH
mechanical vent	1.3
+ windows	7.1
+ doors	N/A*

Measured:	
OA supply	101 cfm
Indoor supply	770 cfm
% OA	13%
ACH	0.75 ACH

*rapid decay during window test resulted in not enough CO_2 to measure impact of doors open

Baker School // Room 126 // August 15, 2020



Condition	ACH
mechanical vent	5.4

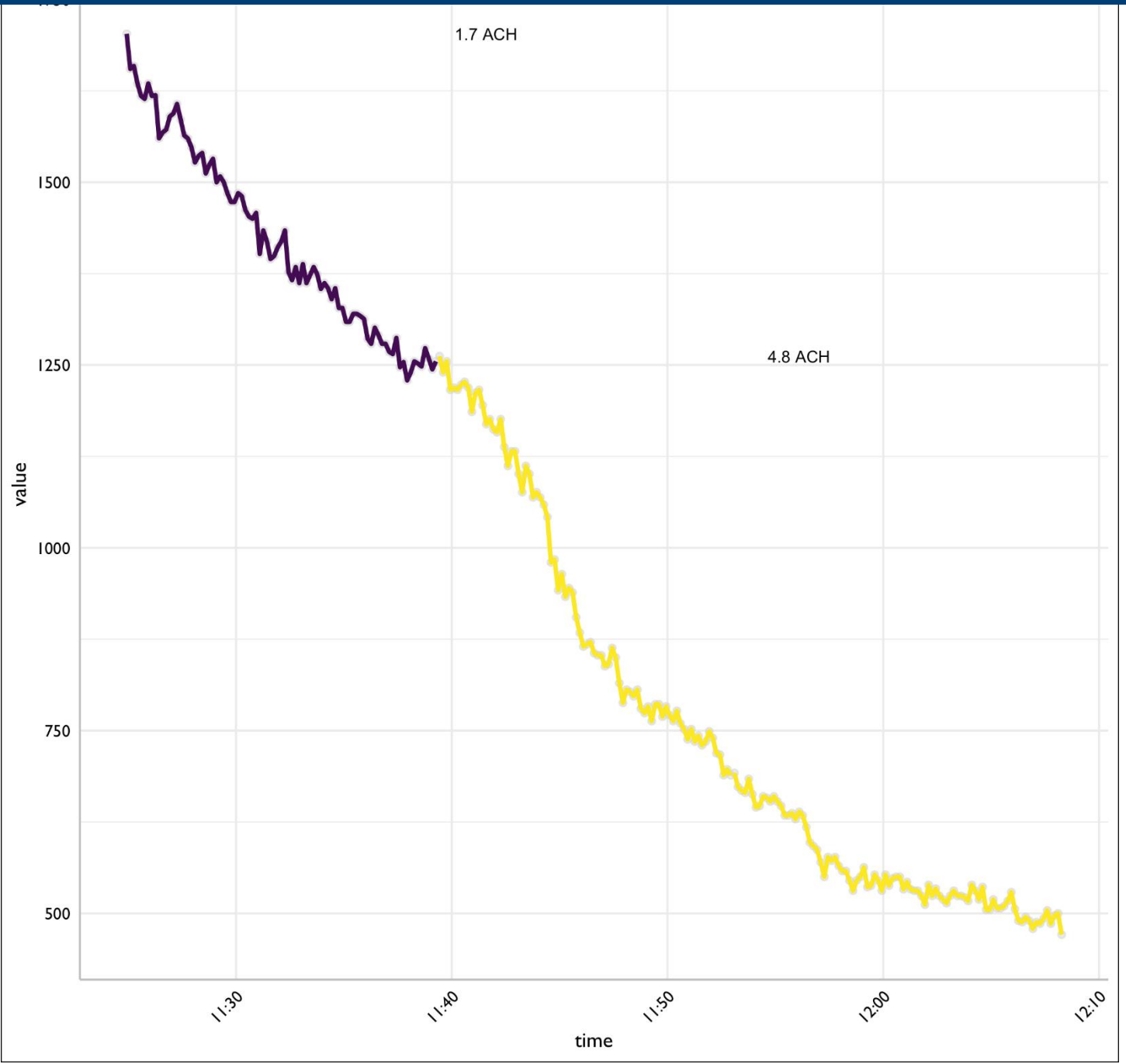
Measured:	
OA supply 1	320 cfm
OA supply 2	271 cfm
TOTAL OA supply	591 cfm
ACH	5.86 ACH

+ windows
+ doors

10.6*

*we had opportunity to test one condition in this classroom and decided to test windows + doors

Runkle School // Room 118 // August 15, 2020

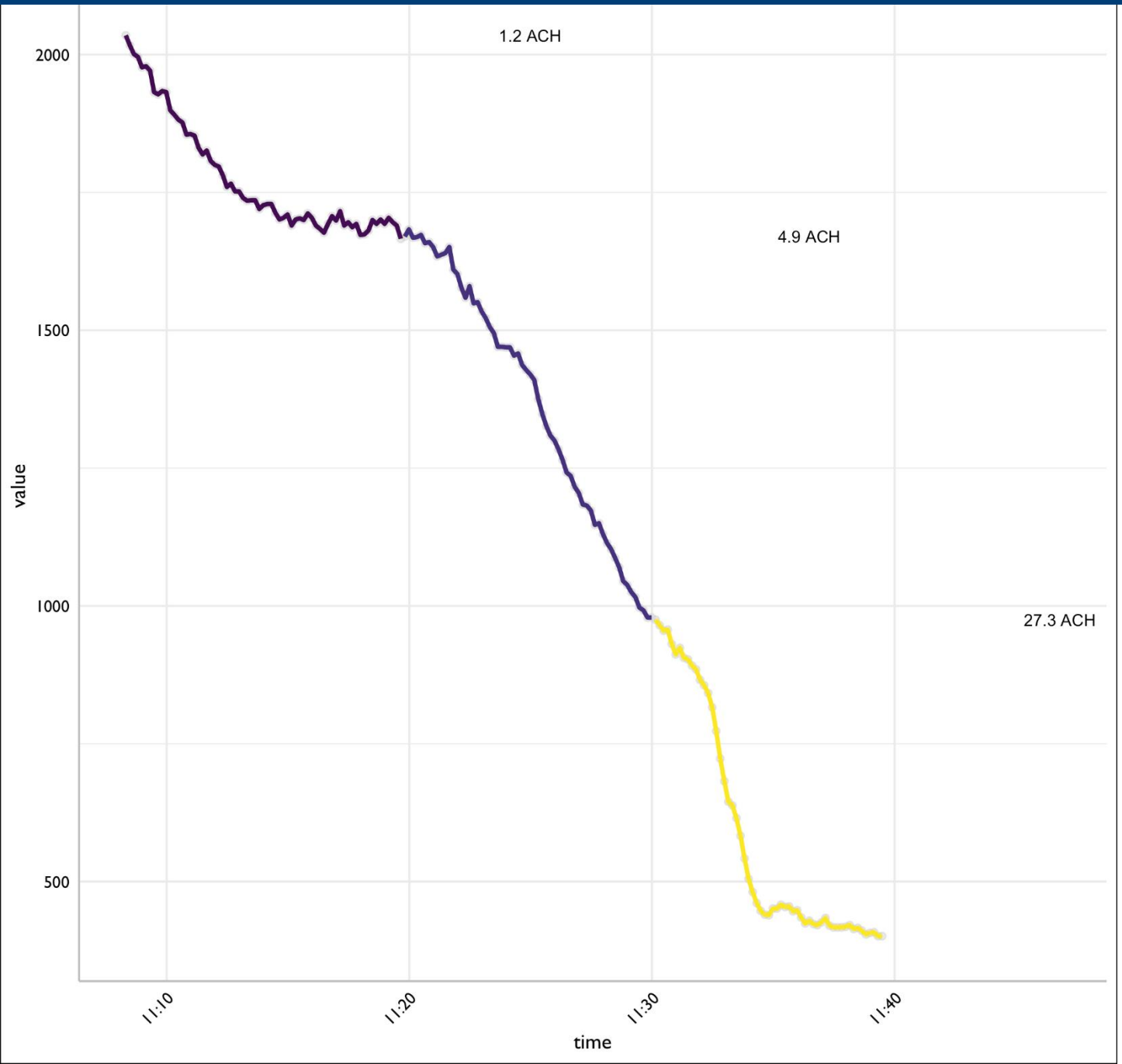


Condition	ACH
Baseline/AC only*	1.7 – 3.0
+ window + doors	4.8-5.4

**Unit ventilator.* Unit ventilator was turned on to 100% OA by town system but measurements confirmed no OA. When facilities team opened unit ventilator cabinet they found motor was not installed correctly, confirming no OA through mechanical ventilation.

**AC unit.* System had ventilation option. Relatively small area but we could not measure at outdoor diffuser. Turned on at 11:50am. Not enough CO_2 left at that point to measure decay associated with this unit running with ventilation.

Runkle School // Room 123 // August 15, 2020



Condition	ACH
Baseline/AC only	1.2 – 1.3
+ mechanical vent	4.9
+ window + doors	17 - 27

Measured:

OA supply	550 cfm*
Indoor supply	770 cfm
% OA	70%
ACH	4.3 ACH

*town central system said 100% OA. Difficult to measure at supply side outdoors so 550 cfm may not be accurate. However, the measured value of 4.3 matches the estimated 4.9 ACH, indicating the system was only operating at 70% OA. (If actually was 100% OA and supplying 770 cfm, ACH would have been closer to 6 ACH but this was not observed with the CO_2 decay method.)

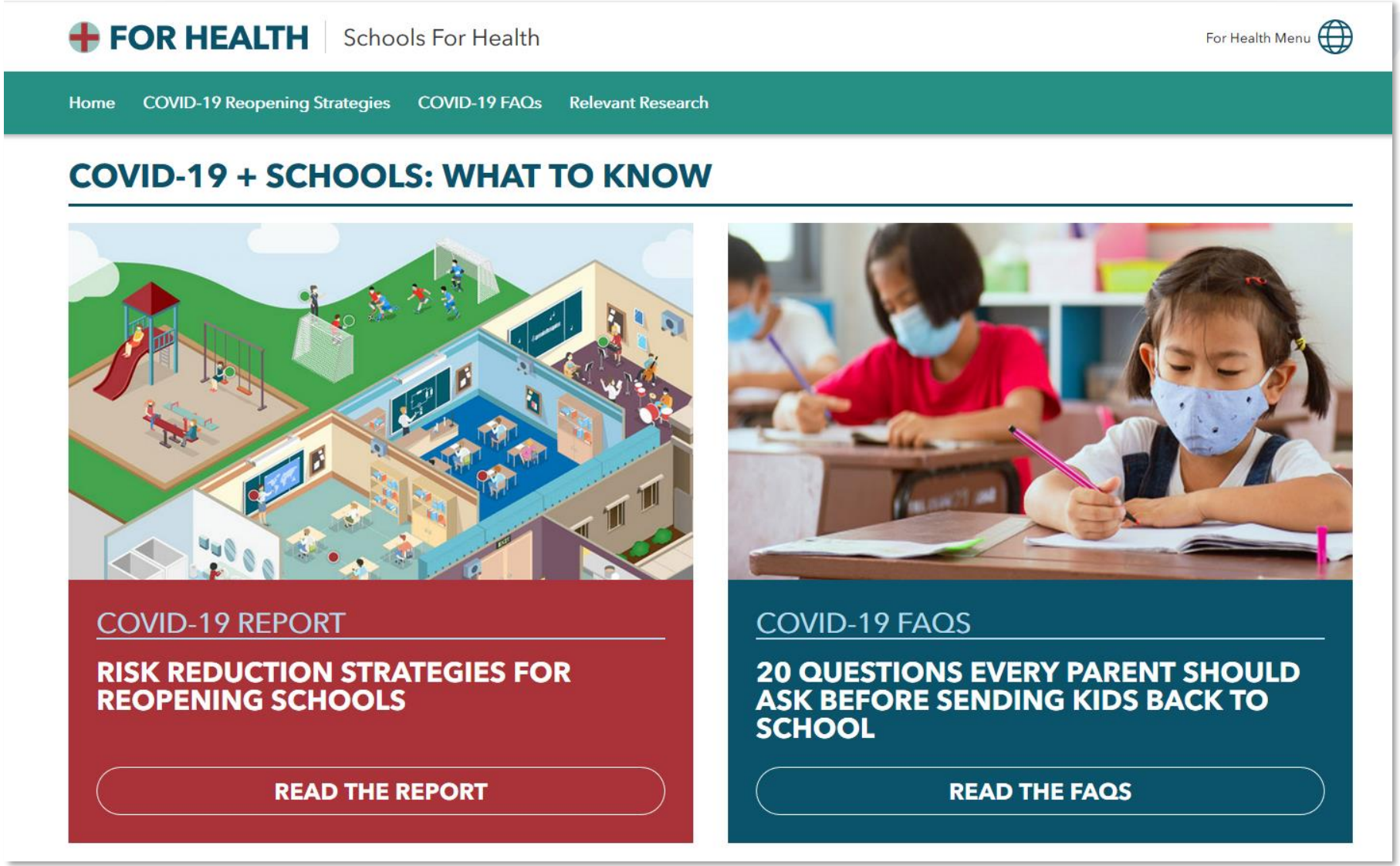
Limitations of this methodology

- Values measured on one day will reflect only the conditions experienced that day, both within and outside the building. Infiltration and flow through windows is highly dependent on outdoor weather conditions, whether the classroom and hallway doors are open, and whether the exhaust system (gravity or mechanical) is working as intended.
- Opening windows and doors is not a permanent solution and should not replace efforts to ensure ventilation systems are working properly.
- Not all areas of the room can be considered well mixed. Ideally the mechanical system was originally designed to more thoroughly mix the central area of a classroom but corners or other peripheral areas might actually experience less ACHs
- Our target ACH values are based on classroom default densities as expressed in ASHRAE standard 62 (25 students/1000 sq ft). These densities should not be exceeded not only because of an effective reduction of the equivalent ventilation rate per person considered in our calculations (~30 cfm/p), but also because of the risk of droplet transmission if not preserving the recommended physical distancing.
- Limitations of using CO_2 to estimate ventilation:
  - For the purpose of infectious disease control, filtering recirculated air with high efficiency filters (MERV 13 or higher) provides additional air flow capable of diluting bioaerosols. Estimating air exchange rates with CO_2 is only capable of approximating the rate of outdoor air supply. For more details on how to combine the flow from adequately filtered air, please use our portable air cleaner calculator (tinyurl.com/portableaircleanertool)
  - The results are sensitive to errors due to poorly calibrated CO_2 sensors, proper selection of the start and end points of the decay, flows from other spaces within the building, as well as changes in ventilation rate during the measurement due to changes in pressure differentials within the building and in the building envelope.

Definitions

ACH	Air changes per hour (1/h)
CFM	cubic feet per minute
CO_2	carbon dioxide
OA	Outdoor air

For more information and additional resources, visit: Schools.ForHealth.org



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