

Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safer Return from COVID19

ACB Connects; 30 Aug 20

John Volckens

Department of Mechanical Engineering
School of Biomedical Engineering
Colorado School of Public Health

Nick Good, Kristen Fedak, Jacob Fontenot, Christian L'Orange & Ky Tanner



Colorado State University

[@Smogdr](http://jv.colostate.edu)

Why don't
we have
more
answers
here?

- For every 1,000 doctors that graduate from US medical schools, we see ~1 new PhD granted in aerosol science
- There are probably fewer than 5,000 *aerosol* PhDs actively working in the U.S.
- 80% of those PhDs work outside of academia
- Probably less than 5% study *bioaerosols* and *public health*
- *Not everything you read on the internet is true...*

Questions we hope to answer

1. What is the rate (and size) of bioaerosol emitted by performers of varying age and gender when engaging in music, voice, and dance?
2. How effective are active and passive control measures at reducing bioaerosol emissions and exposures?
 - isolation and distancing
 - room ventilation and filtration
 - use of homemade masks, respirators, shields or other barriers
3. Can the risks of co-exposure be reduced to “acceptable levels” using these active and passive controls?

Some Sizes and Sources of Airborne Particles

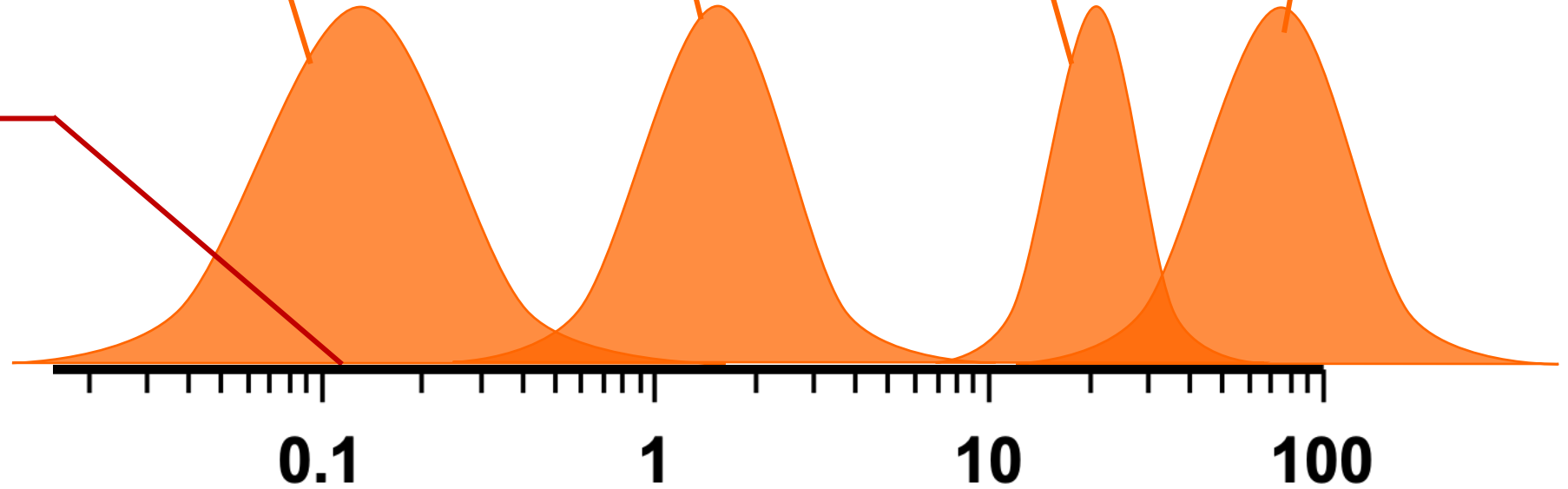
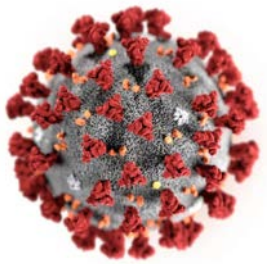


Smoke

Spray

Pollen

Flour Dust



Particle Size, μm

Some Sizes and Sources of Airborne Particles



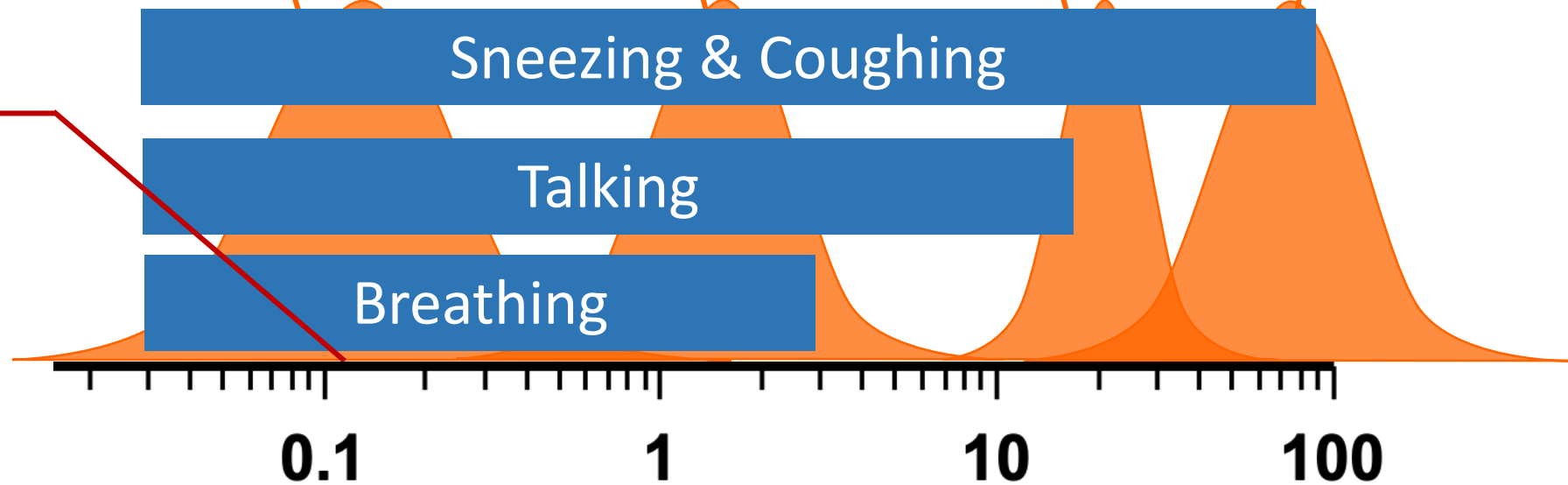
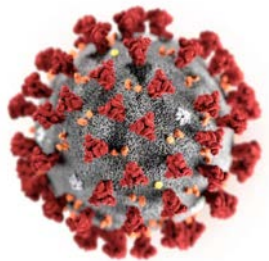
Smoke

Inhaler

Pollen

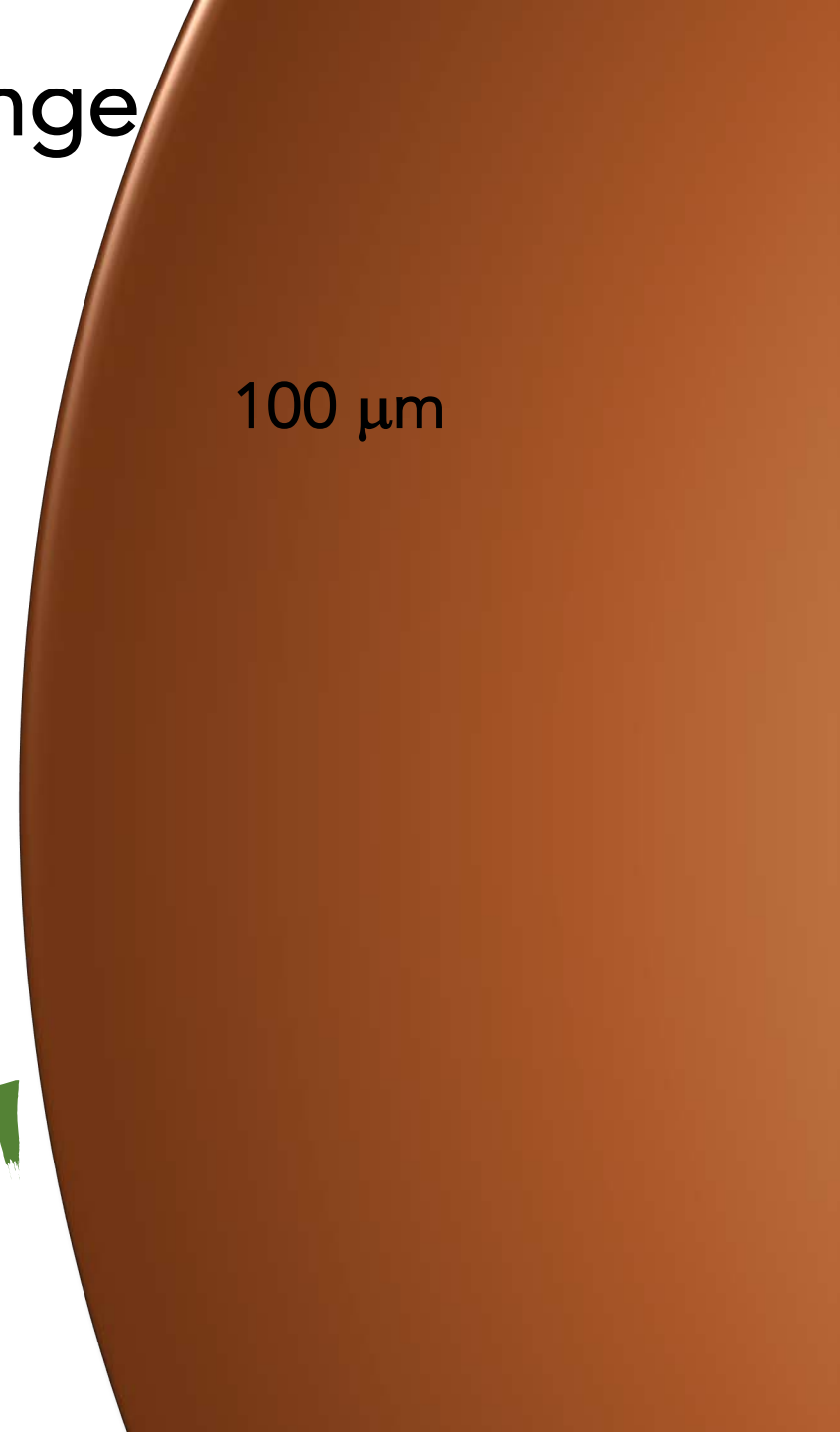
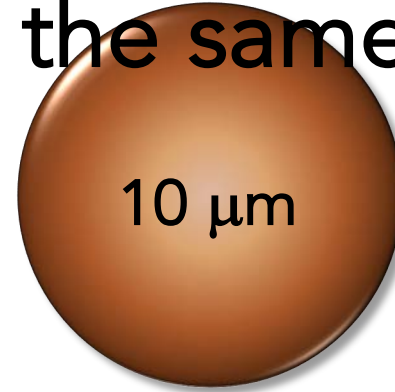
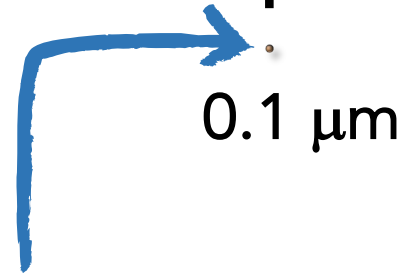
Clapping Dust

Musical and Vocal Arts?



Particle Size, μm

Human bioaerosol spans a huge size range (and not all particles behave the same)



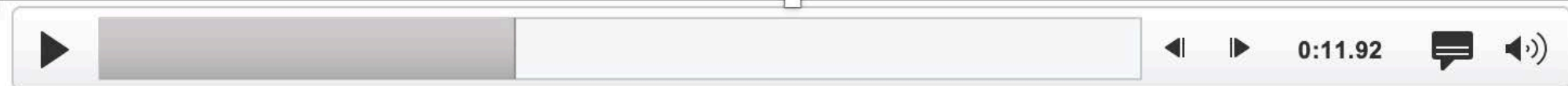
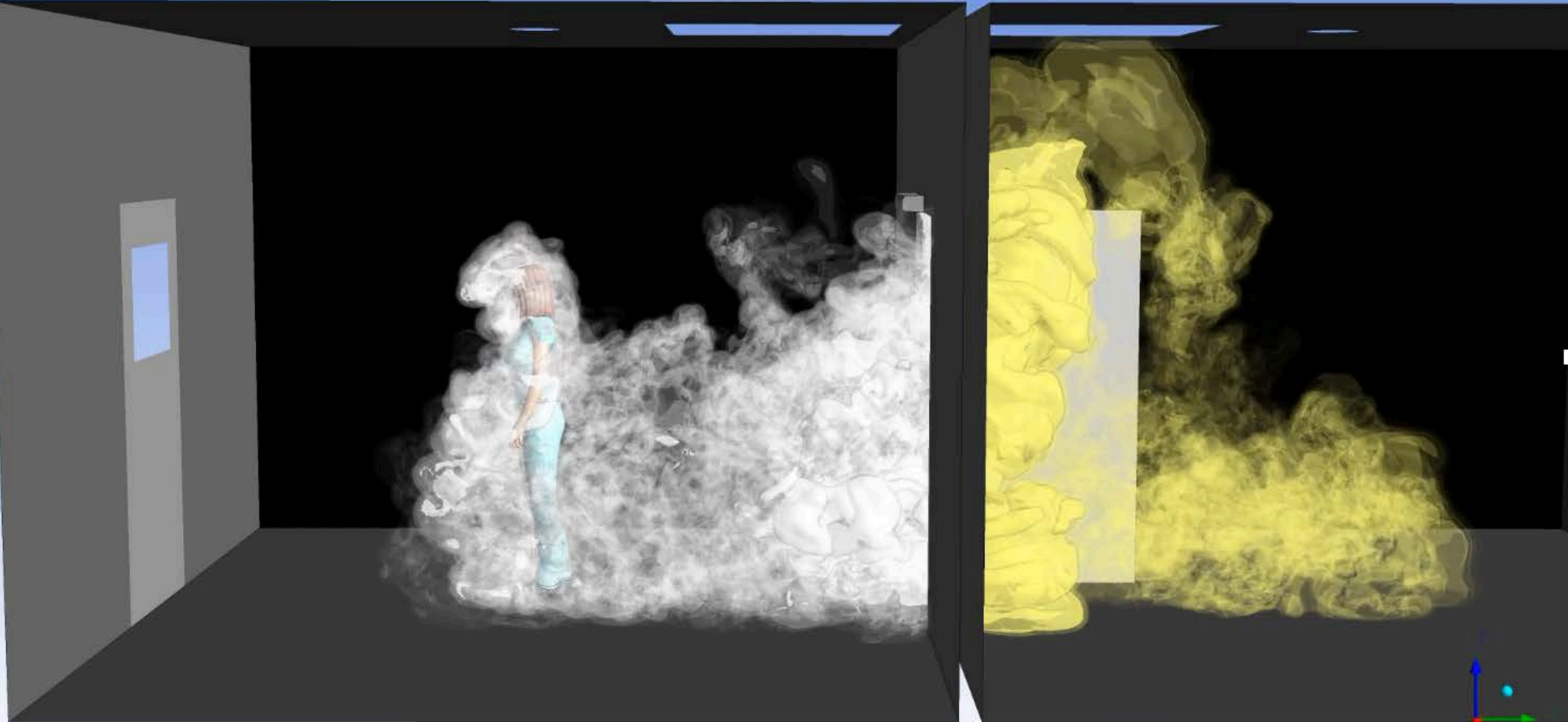
If this particle were
the size of a baseball

Then this particle would be
the size of a baseball stadium



time [s]: 11.92

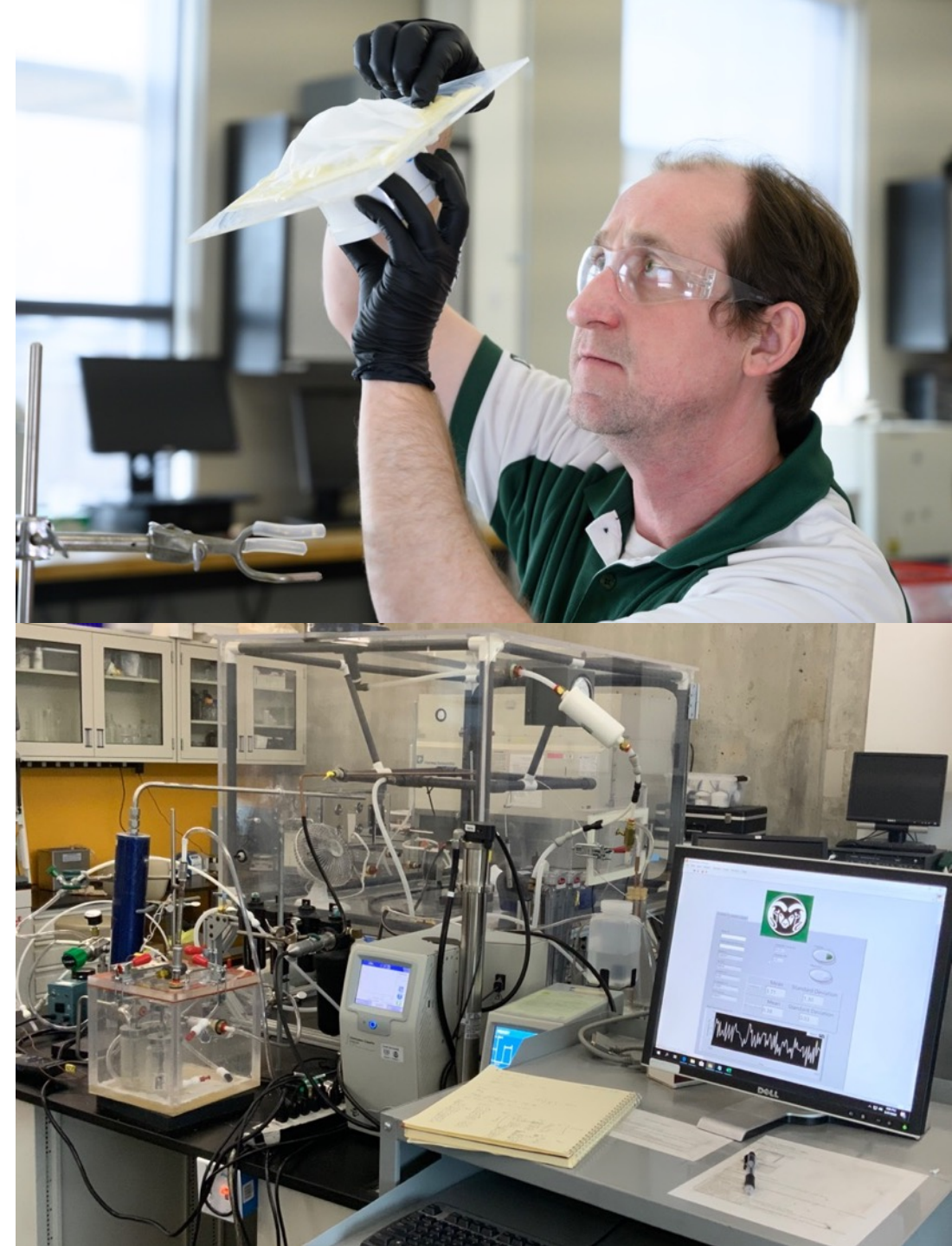
ANSYS
R15.0



CSU Mask and Respirator Testing Program

- Shortage of N95 respirators for healthcare workers across Colorado
- Supply of domestic and international respirators of unknown quality / performance
- On March 25th, Colorado Governor Jared Polis asked our lab to provide respirator testing & performance verification for State of Colorado COVID-19 Task Force

Over 200 different mask designs tested as of 20 Aug 20



N95 means 95% removal efficiency for particles that flow into the mask

CSU testing program follows modified* NIOSH protocol for particle collection and "breathability"

"Looks" can be deceiving!



Only CDC/NIOSH can certify masks to bear the "N95" label



* <https://www.cdc.gov/niosh/npptl/respirators/testing/default.html>

Anonymous Donor:

"Please test these 24 different masks, each made with popular mask material, and make the data publicly available"



Most N95 masks remove ~99% of all particle sizes

Fraction Collected by Mask

1.00
0.90
0.75
0.50
0.25
0.10

1

3

10

Particle Size, μm

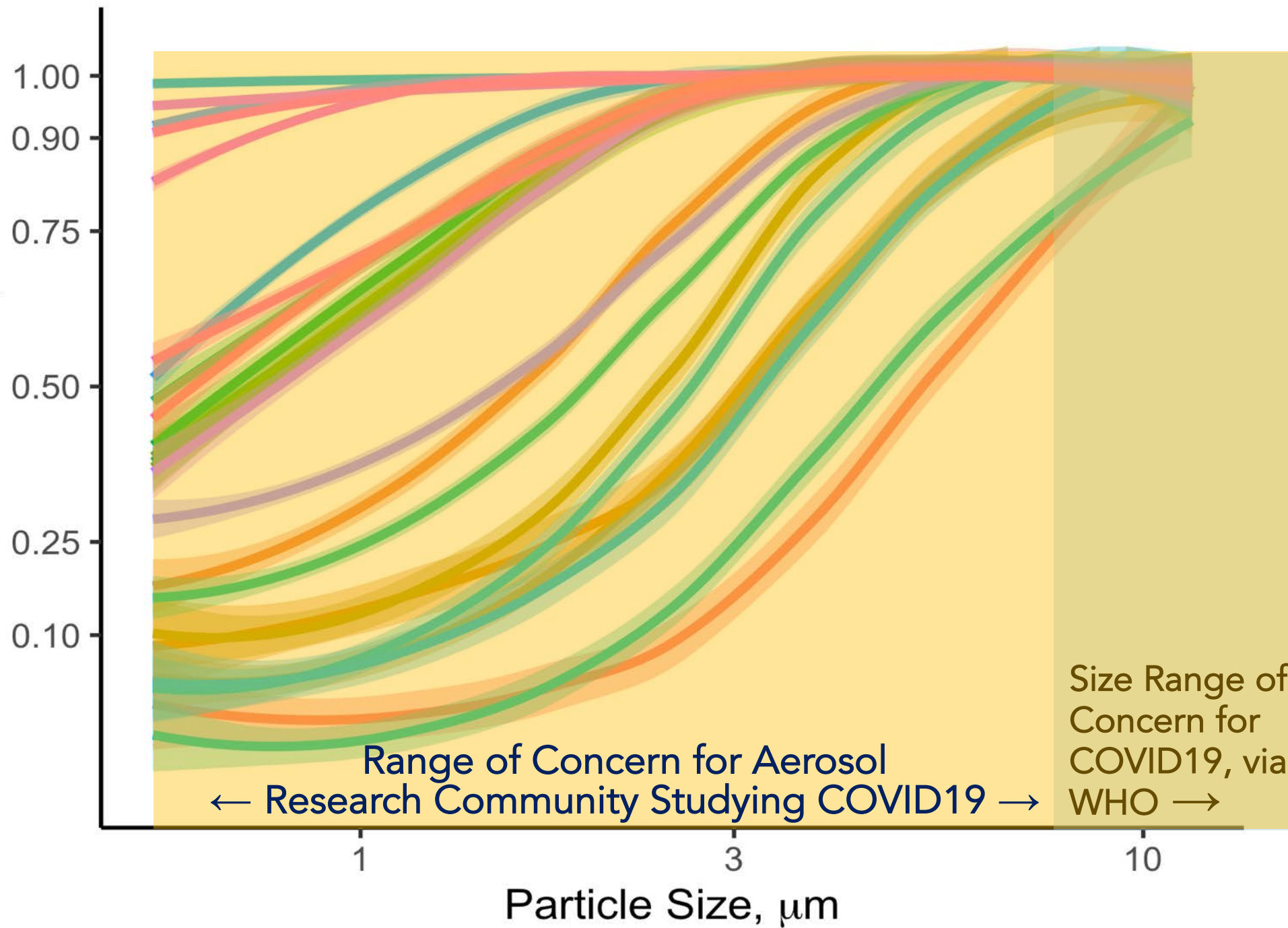


mask

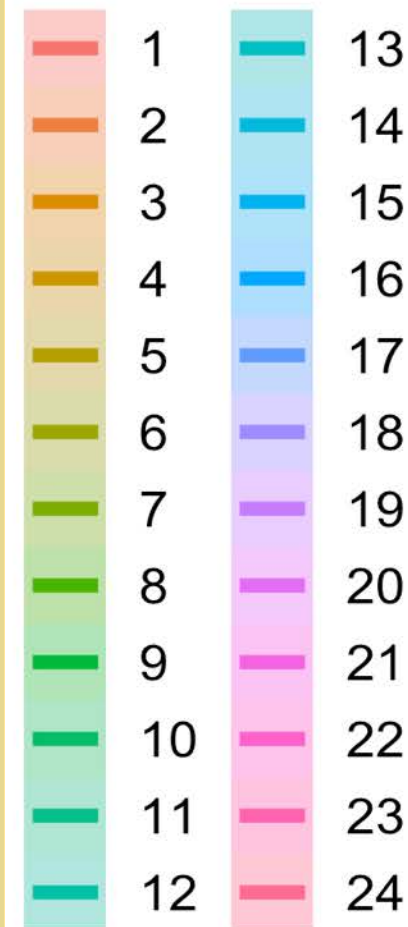


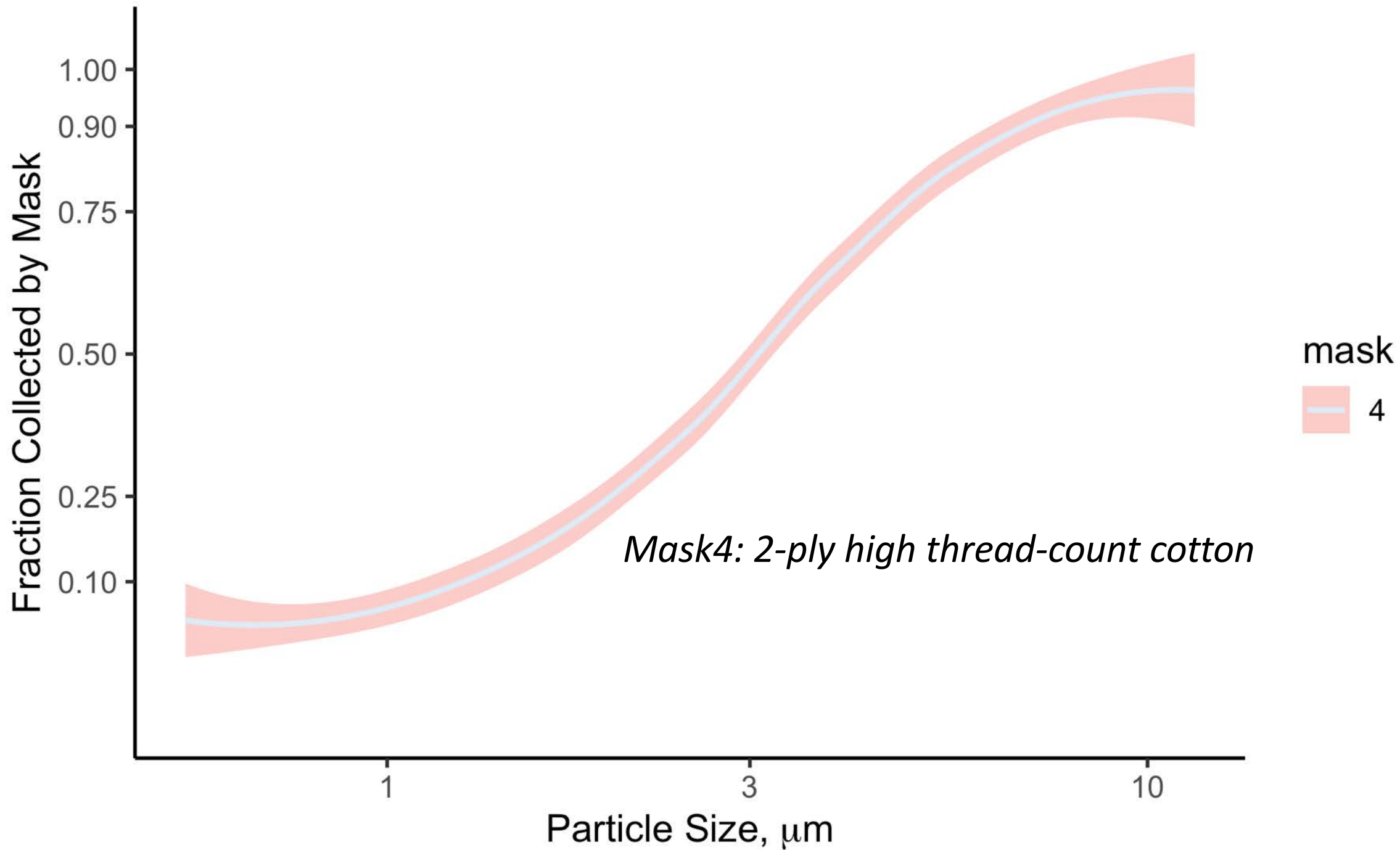
N95

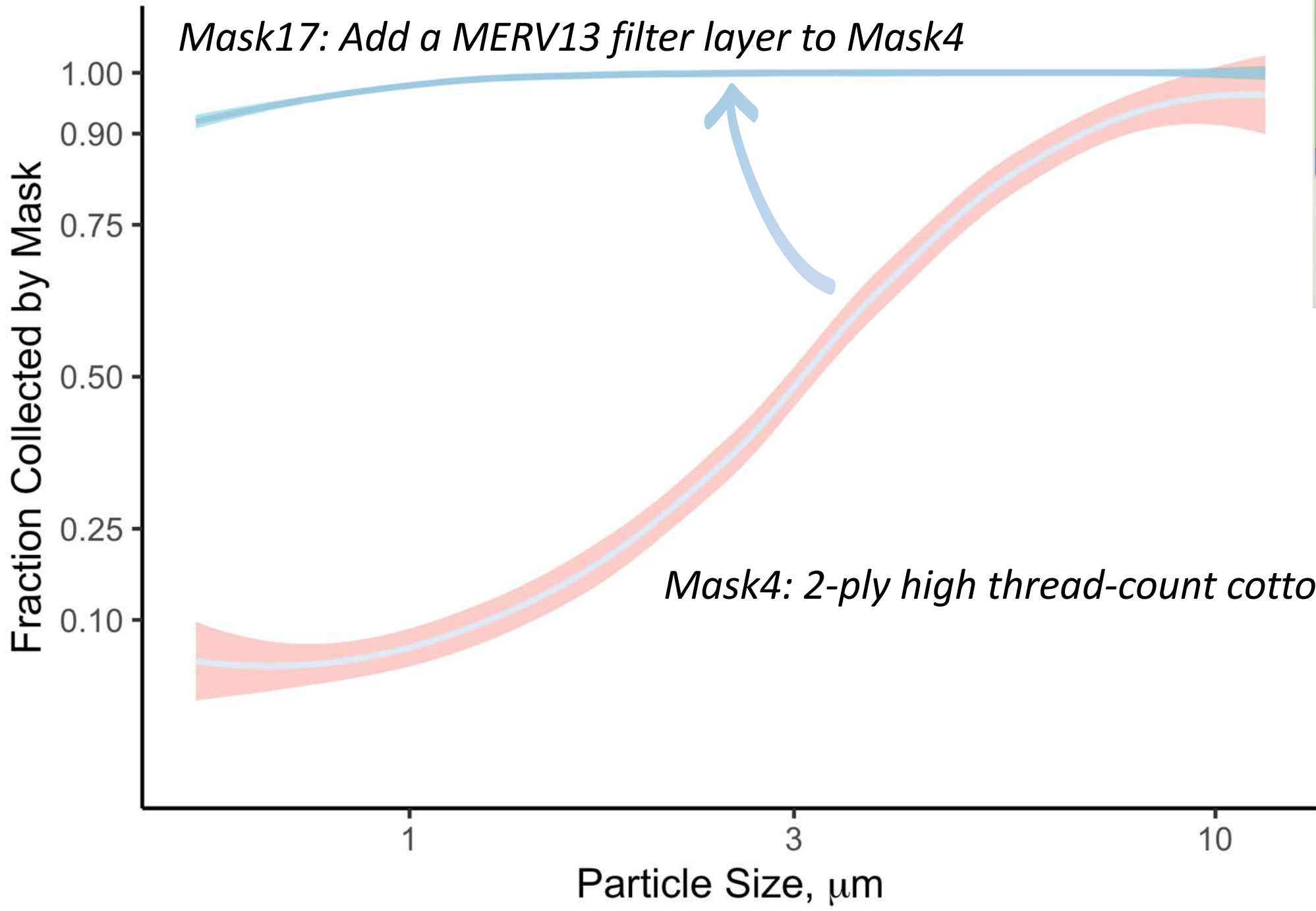
Fraction Collected by Mask



mask



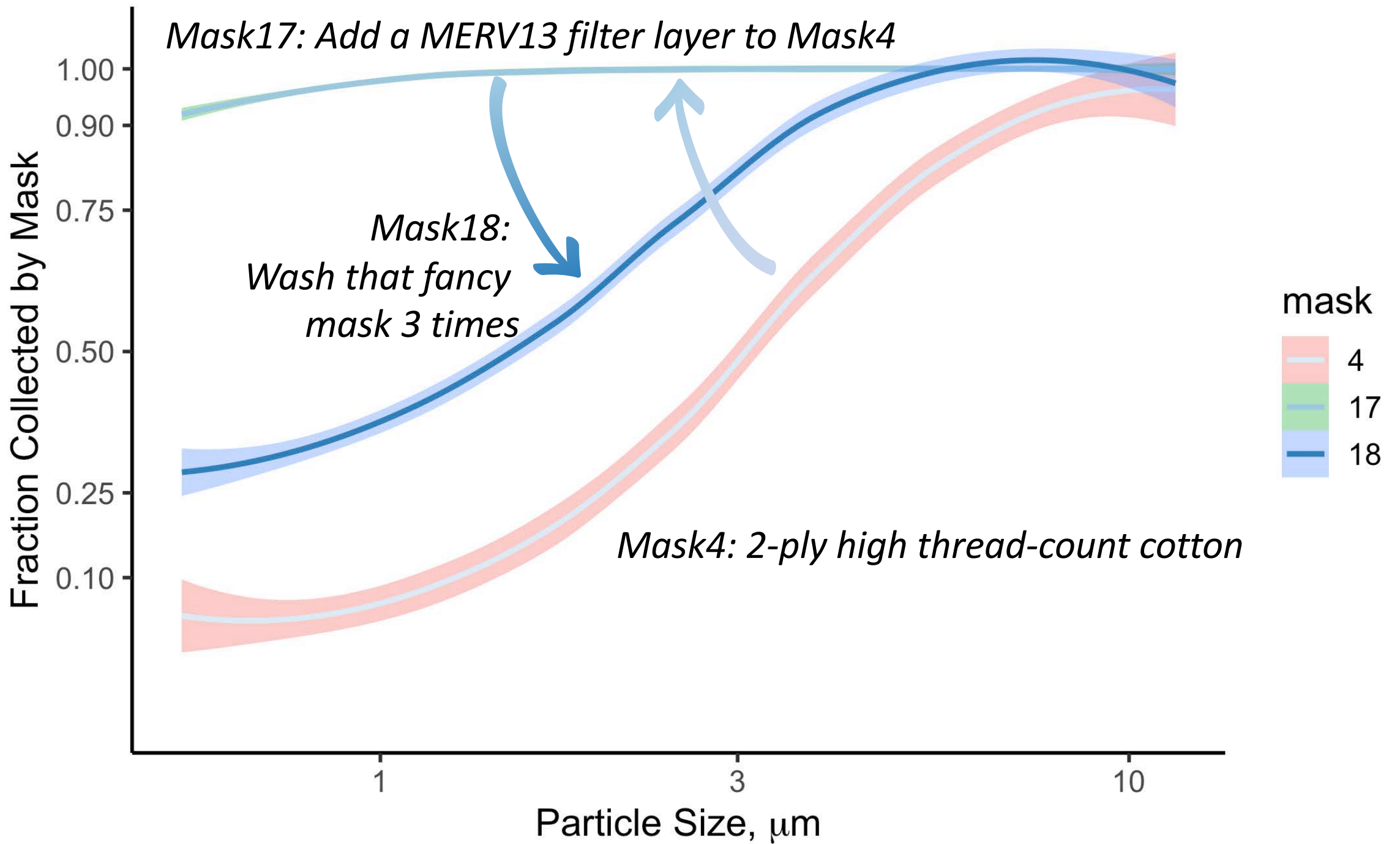




mask

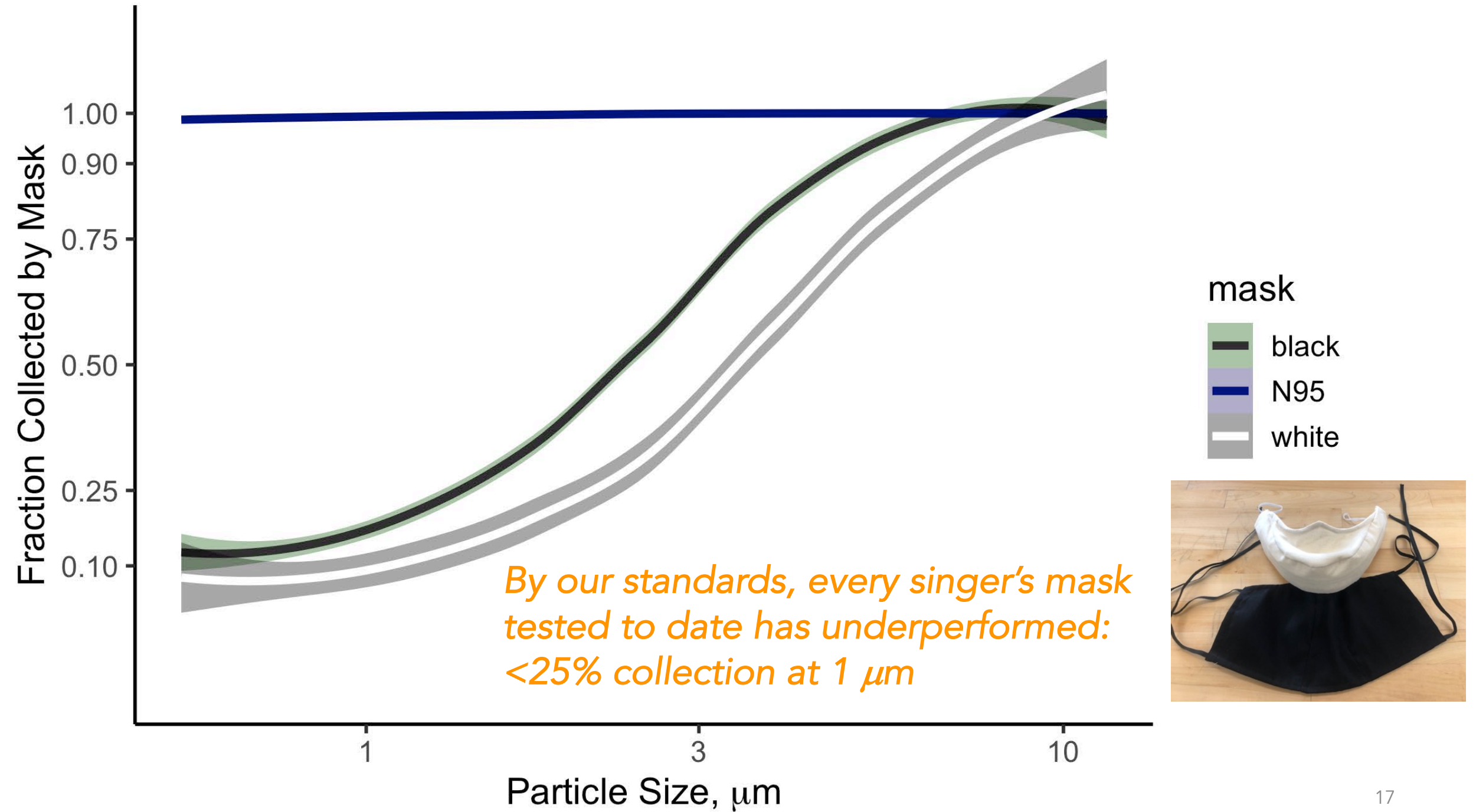
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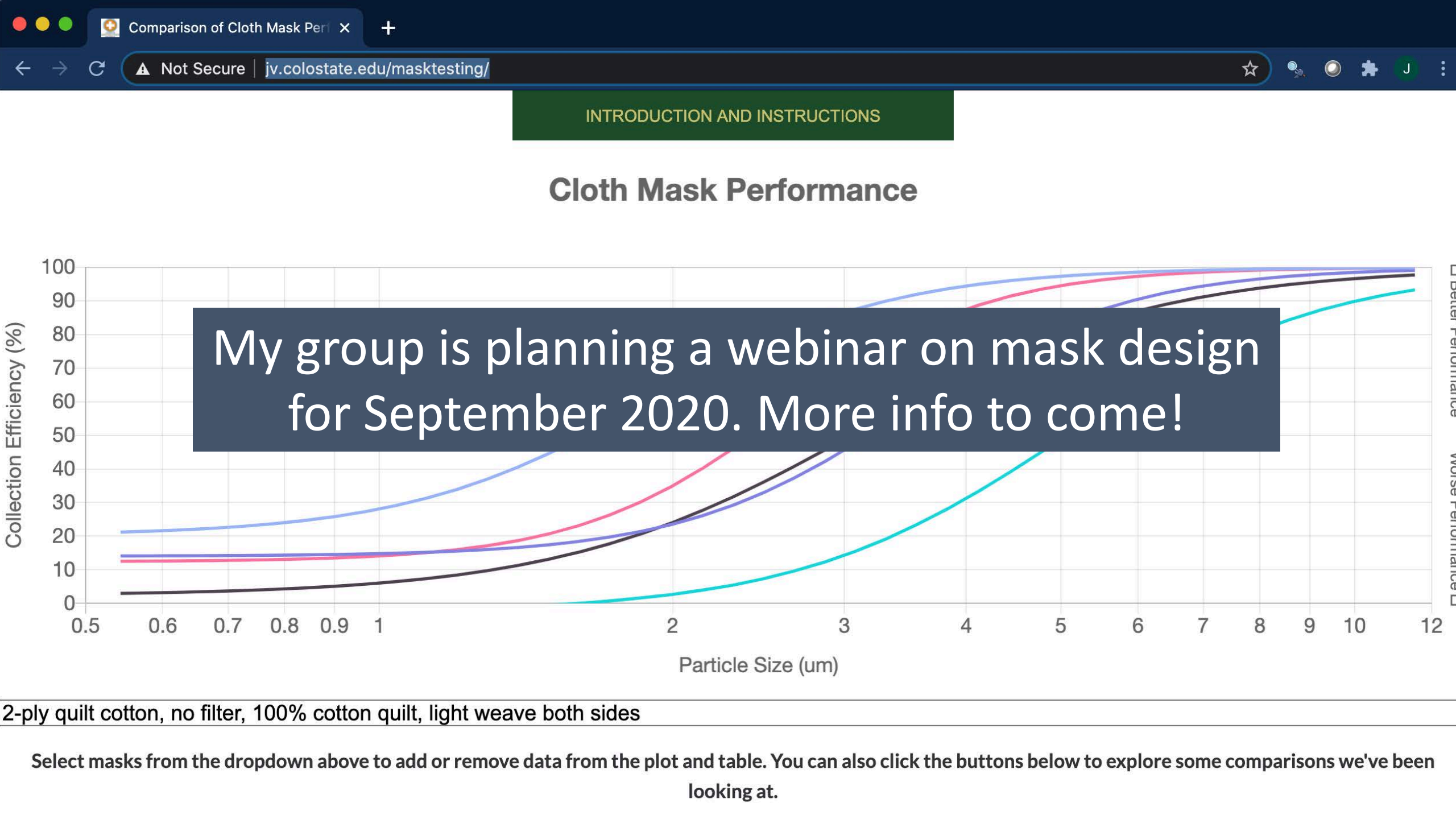
17



What about "Singer's Masks"?







<https://smt.d.colostate.edu/>



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SMTD

ABOUT

ADMISSIONS

NEWS AND EVENTS

FACILITY

GIVING

CONNECT



CSU Aerosol Emissions Study

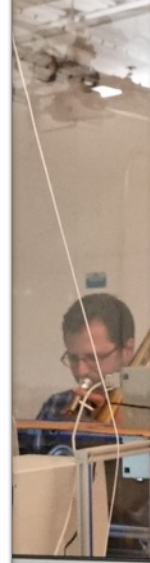
Reducing Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safer Return from COVID19

Experimental Design

- 100 volunteers over 3 months (~2/day)
 - Open to ages 12 and up; all genders
 - ~28 singers, actors, dancers
 - ~72 instrumentalists: bassoon, clarinet, euphonium, flute, French horn, trumpet, trombone, saxophone, and possibly others
- Everybody speaks, sings and “does their thing”
 - With and without control technologies in place
 - Masks, bell covers, and screens to be tested
 - “BYOM” approach to testing
- Particle sizes from 0.01 to 100 micrometers

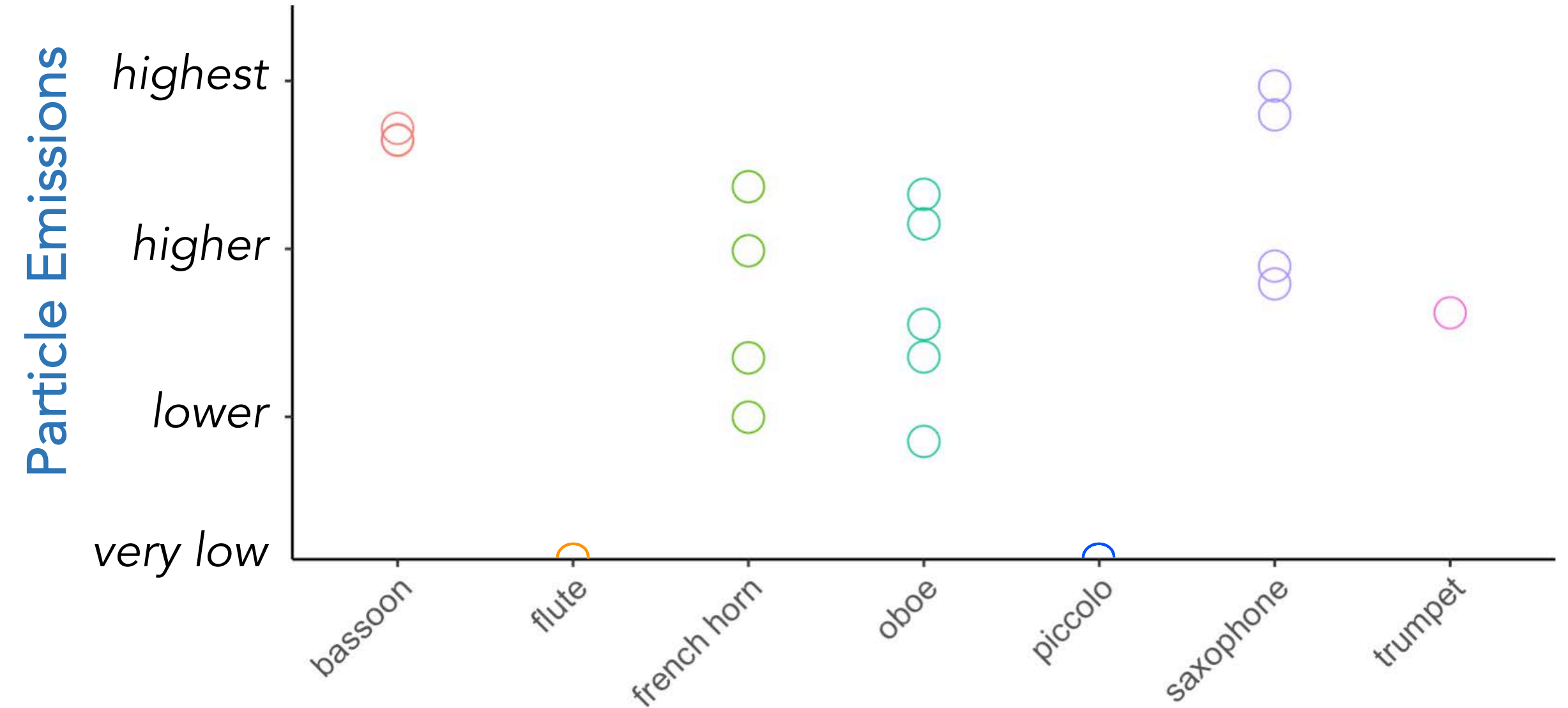


SET Facility: A Musical Class 100 Cleanroom



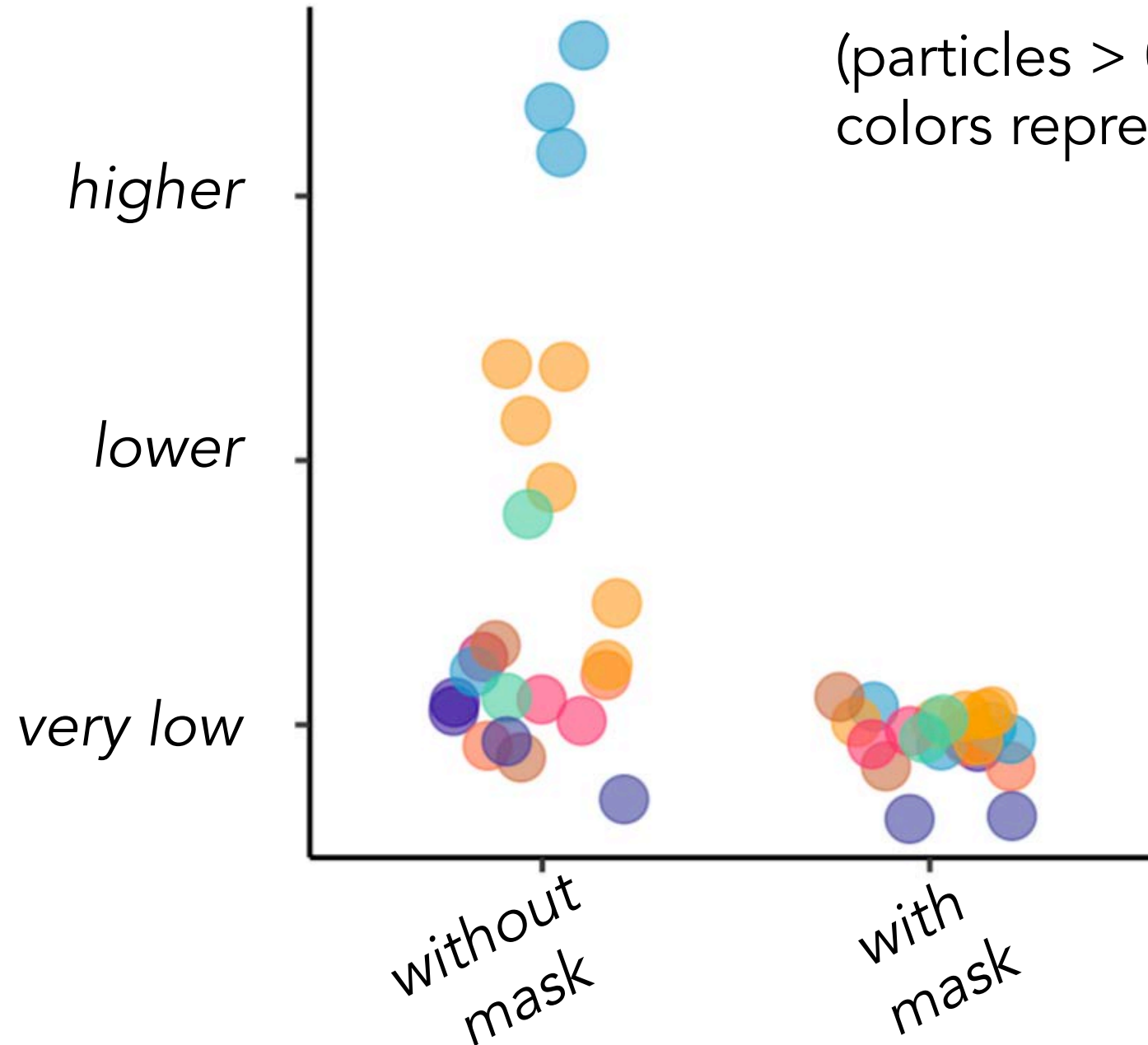
SET Facility: A Musical Class 100 Cleanroom

Preliminary Instrument Results (particles > 0.3 μm)





Preliminary Vocal Results

(particles $> 0.3 \mu\text{m}$; $n = 9$ participants;
colors represent different individuals)



Preliminary Findings (less than 1/5th of the way there)

1. Wind instruments produce aerosol of varied concentration and size

higher levels  *intermediate*  *very low*
Trumpet, saxophone, bassoon > French horn, oboe, voice > flute, piccolo

2. Masks reduce vocal emissions by 90% or more

3. Variability from one person to the next is IMPORTANT.



Airborne Transmission of SARS-CoV-2

A Virtual Workshop from the
Environmental Health Matters Initiative
Aug 26 - 27, 2020

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Check soon for recording to be posted:
<https://www.nationalacademies.org/>

Thank you to those who made this work possible!

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