

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

NASM Webinar; 21 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

jv.colostate.edu@Smogdr

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



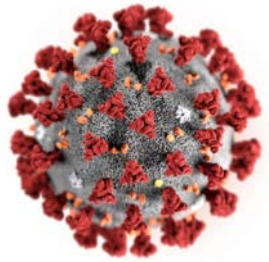
Smoke

Smoke

Pollen

Clap Dust

Musical and Vocal Arts?



0.1

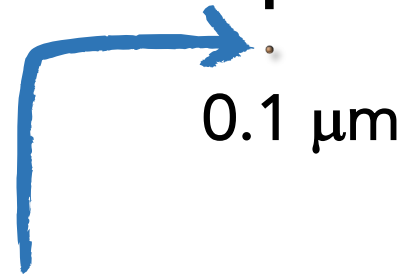
1

10

100

Particle Size, μm

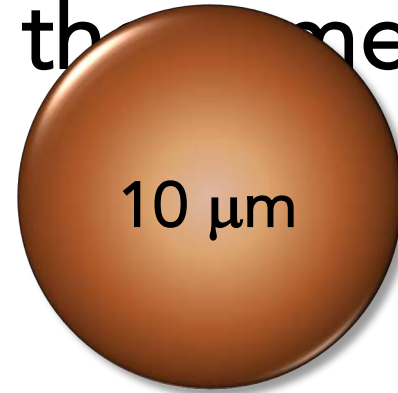
Human bioaerosol spans a huge size range (and not all particles behave the same)



0.1 μm

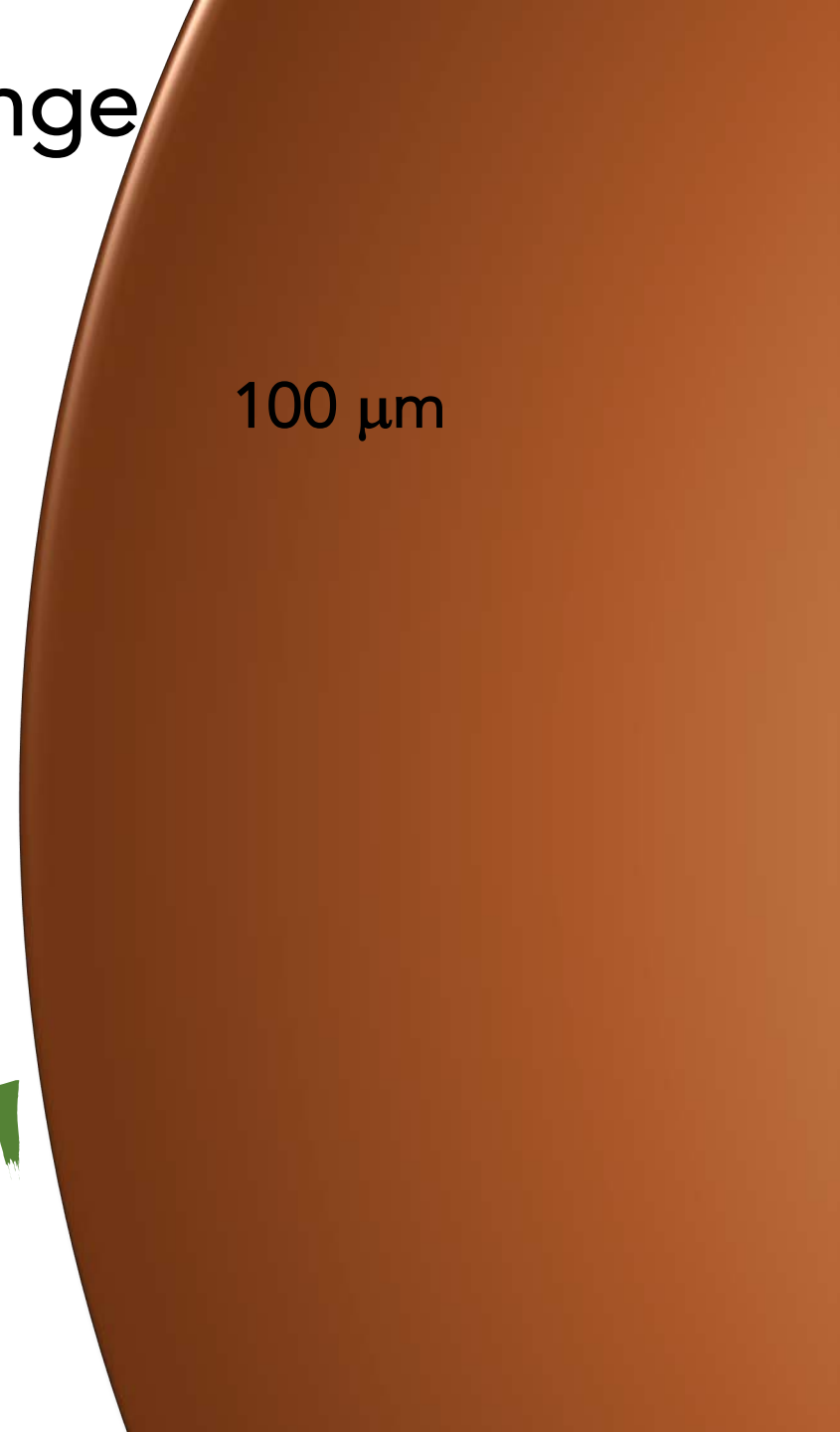


1 μm



10 μm

100 μm



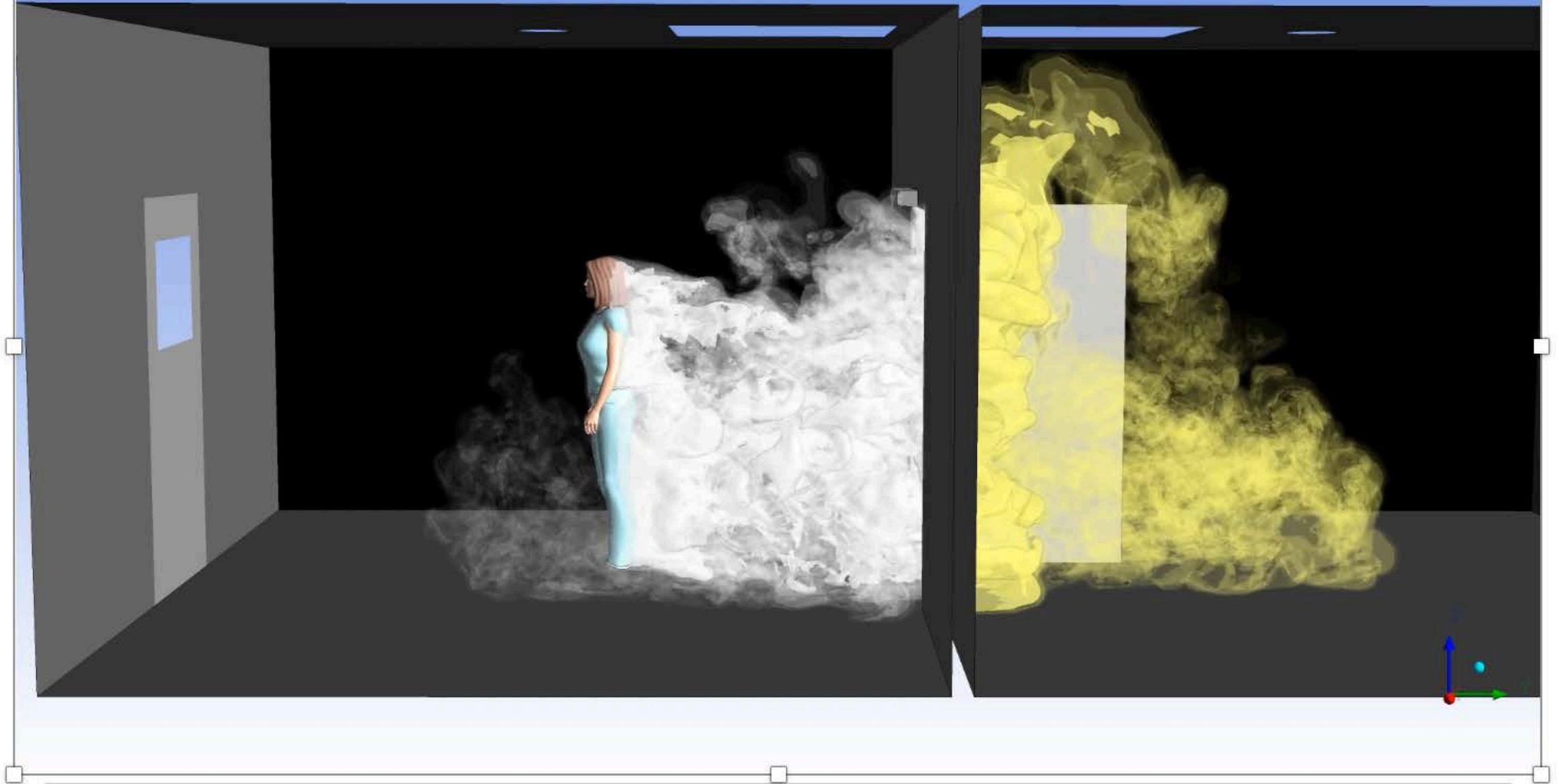
If this particle were
the size of a baseball

Then this particle would be
the size of a baseball stadium



time [s]: 10.4

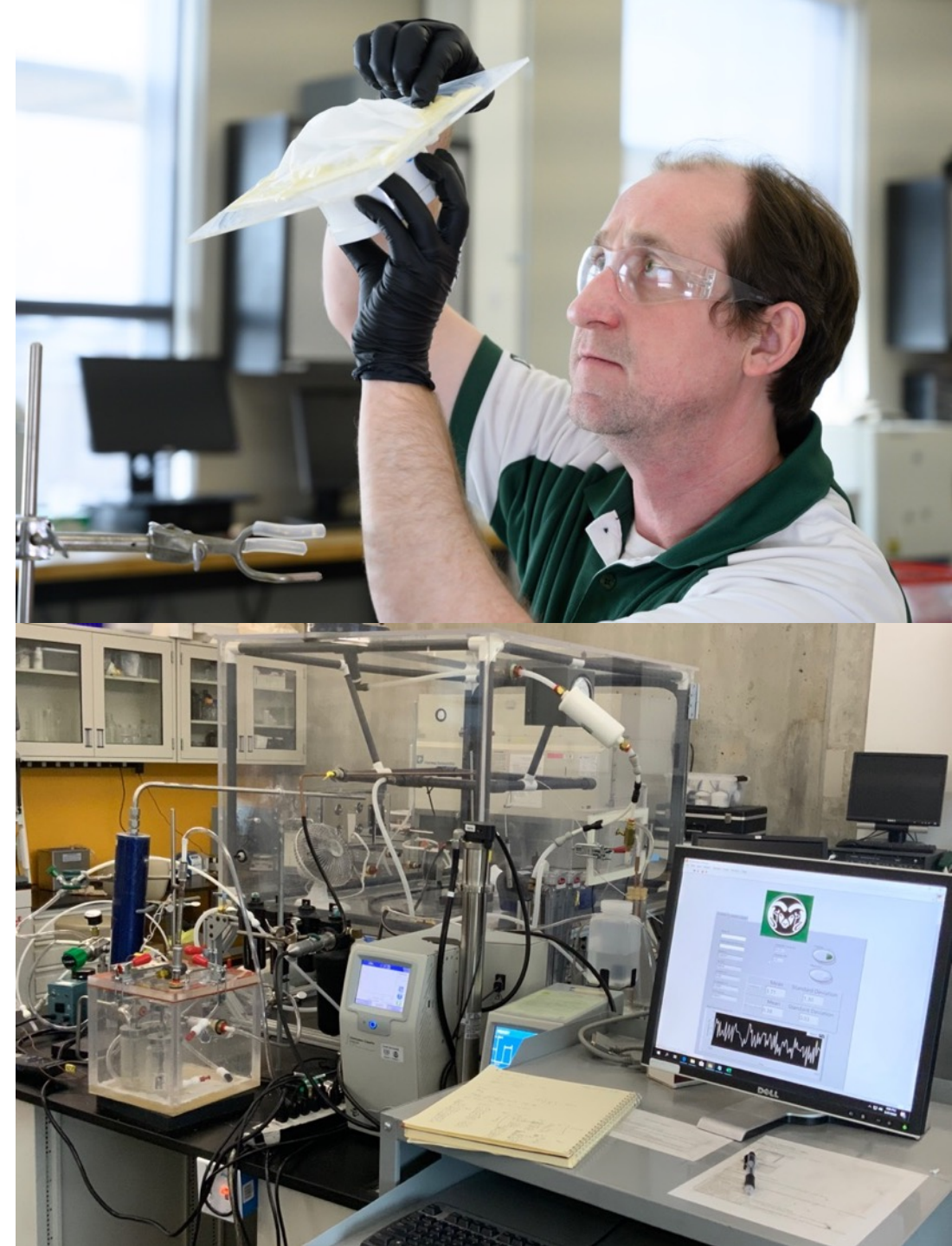
ANSYS
R15.0



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

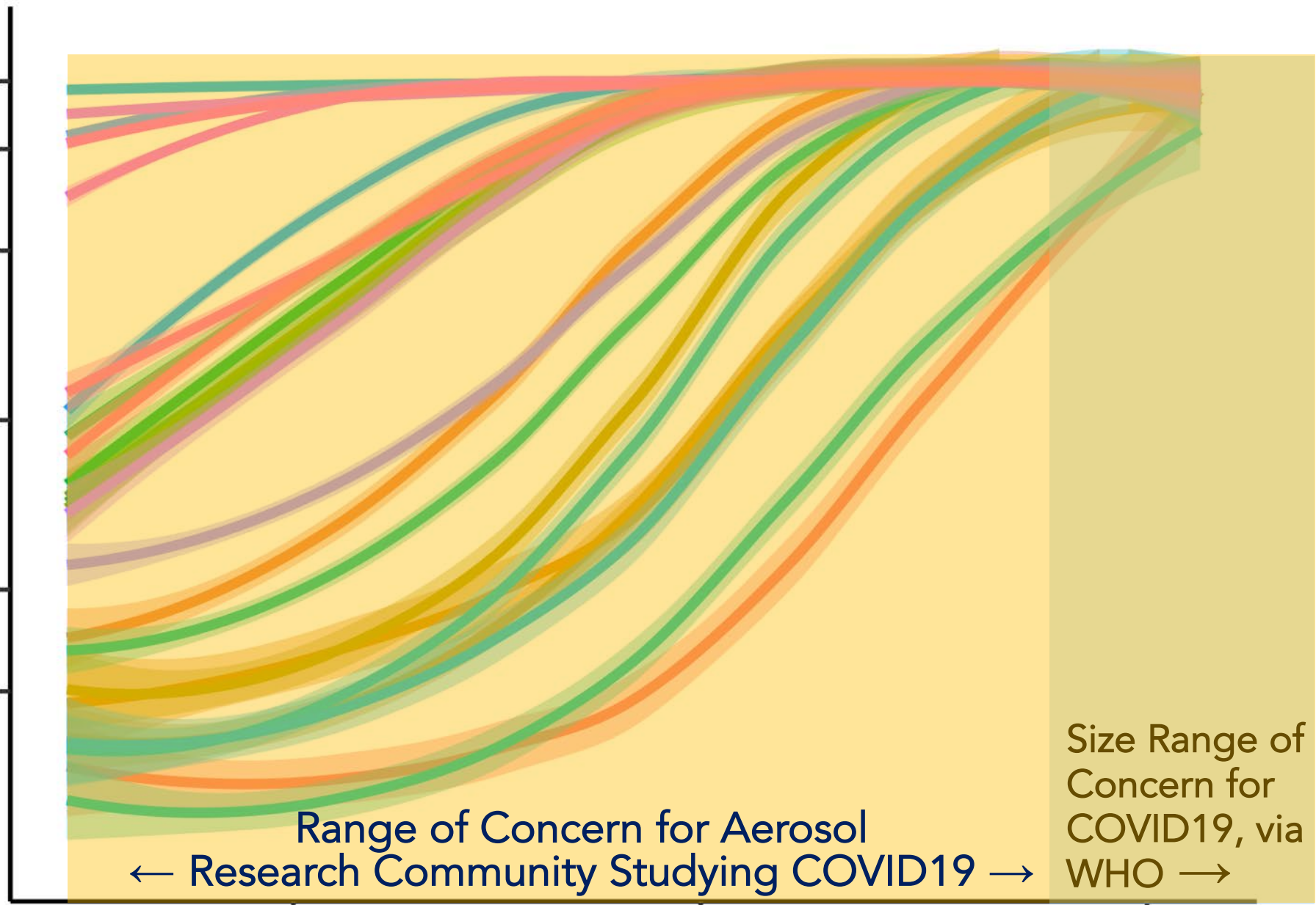
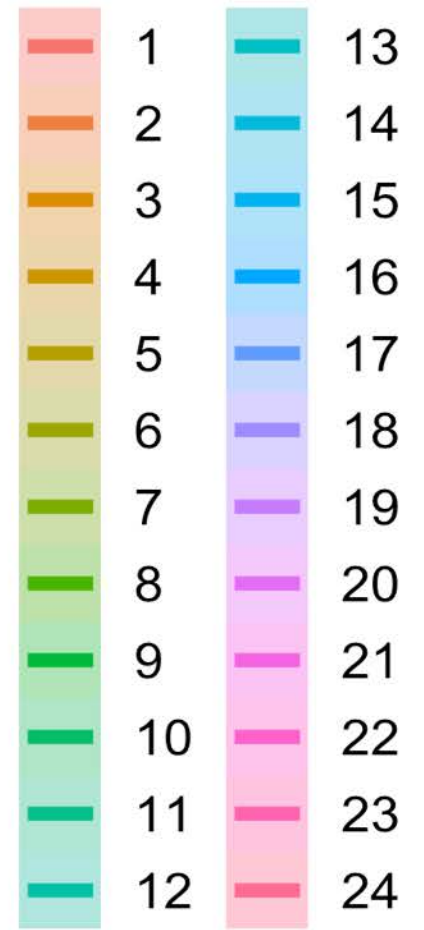
1.00
0.90
0.75
0.50
0.25
0.10

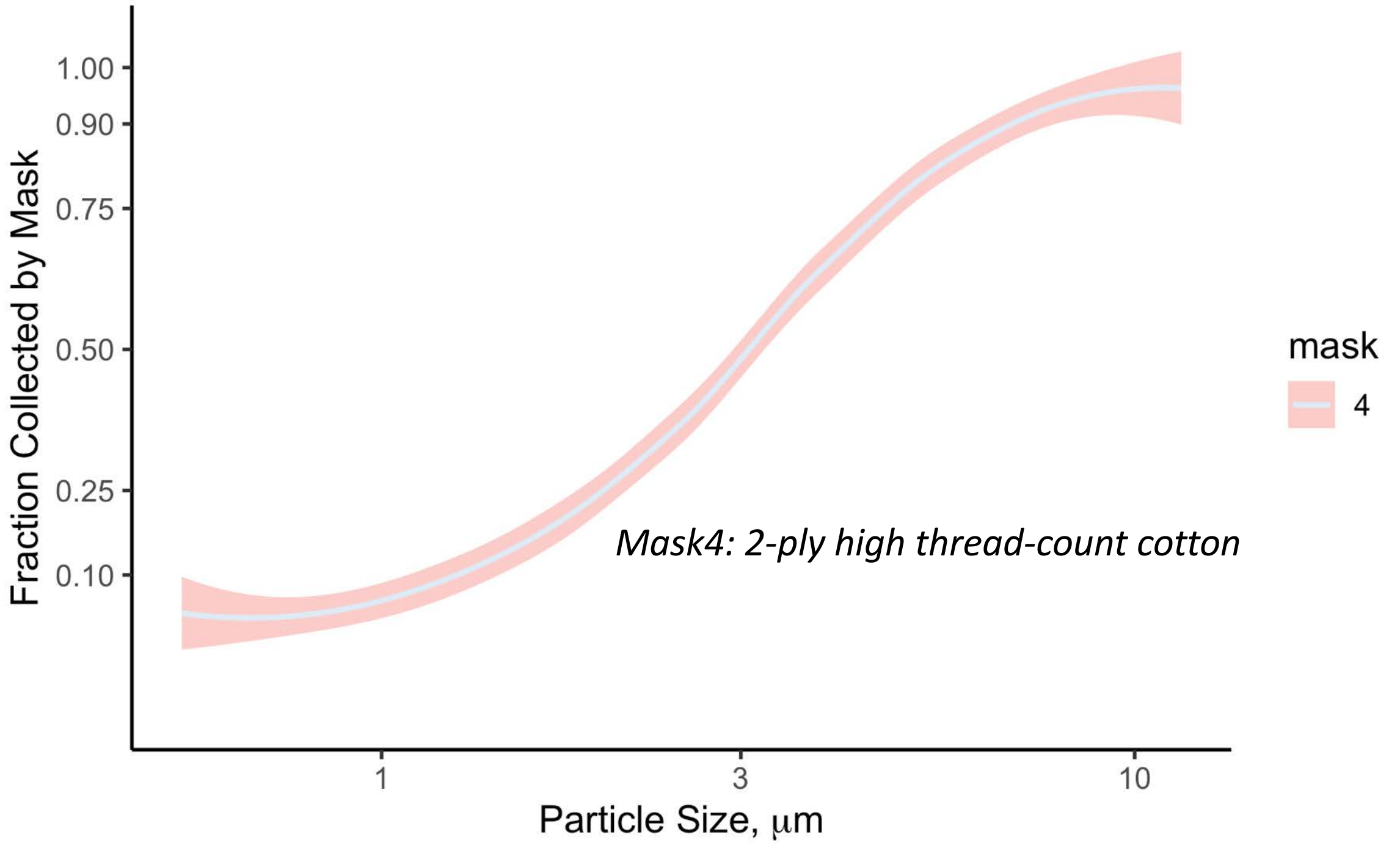
← Range of Concern for Aerosol
Research Community Studying COVID19 →

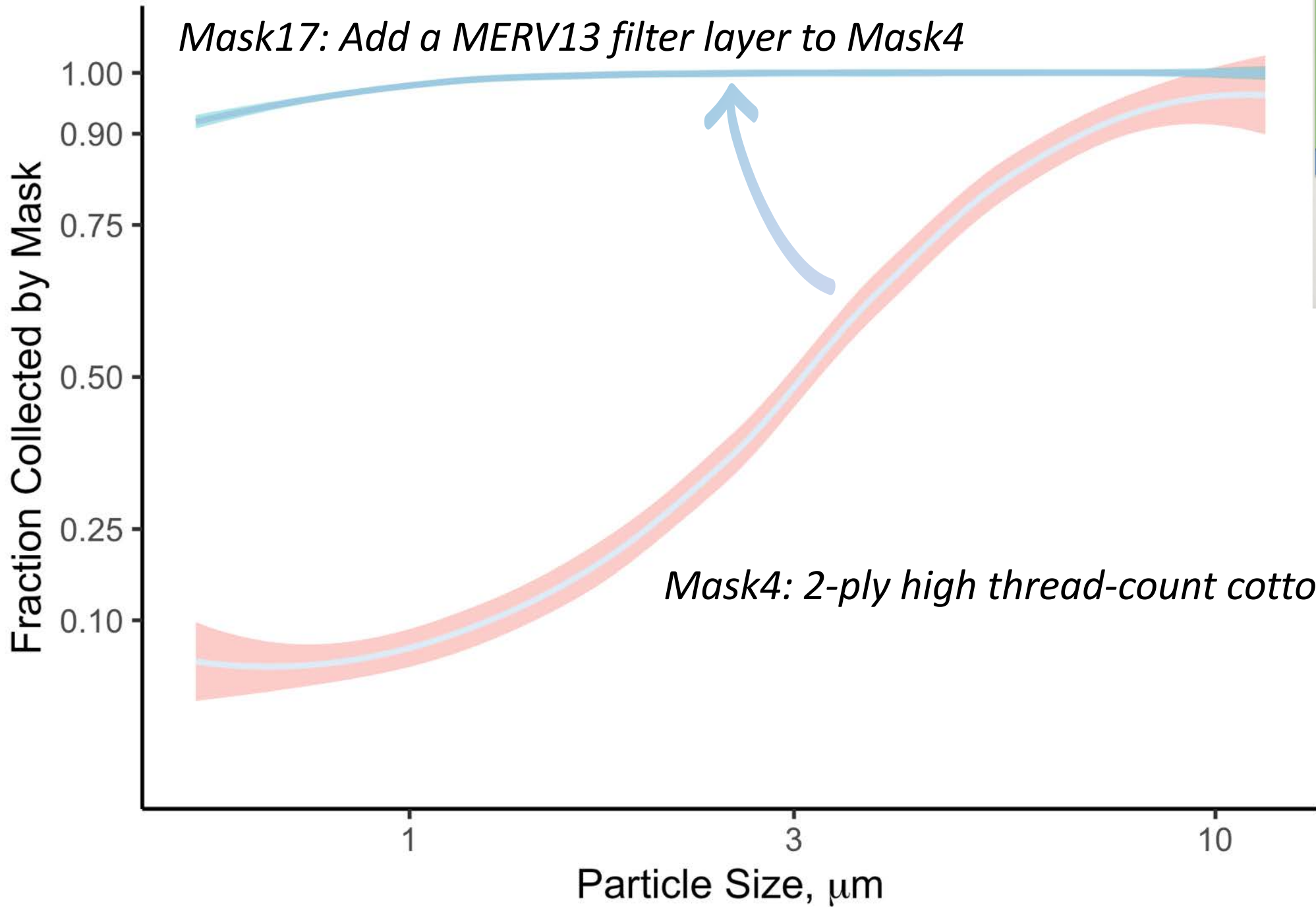
Size Range of
Concern for
COVID19, via
WHO →

Particle Size, μm

mask



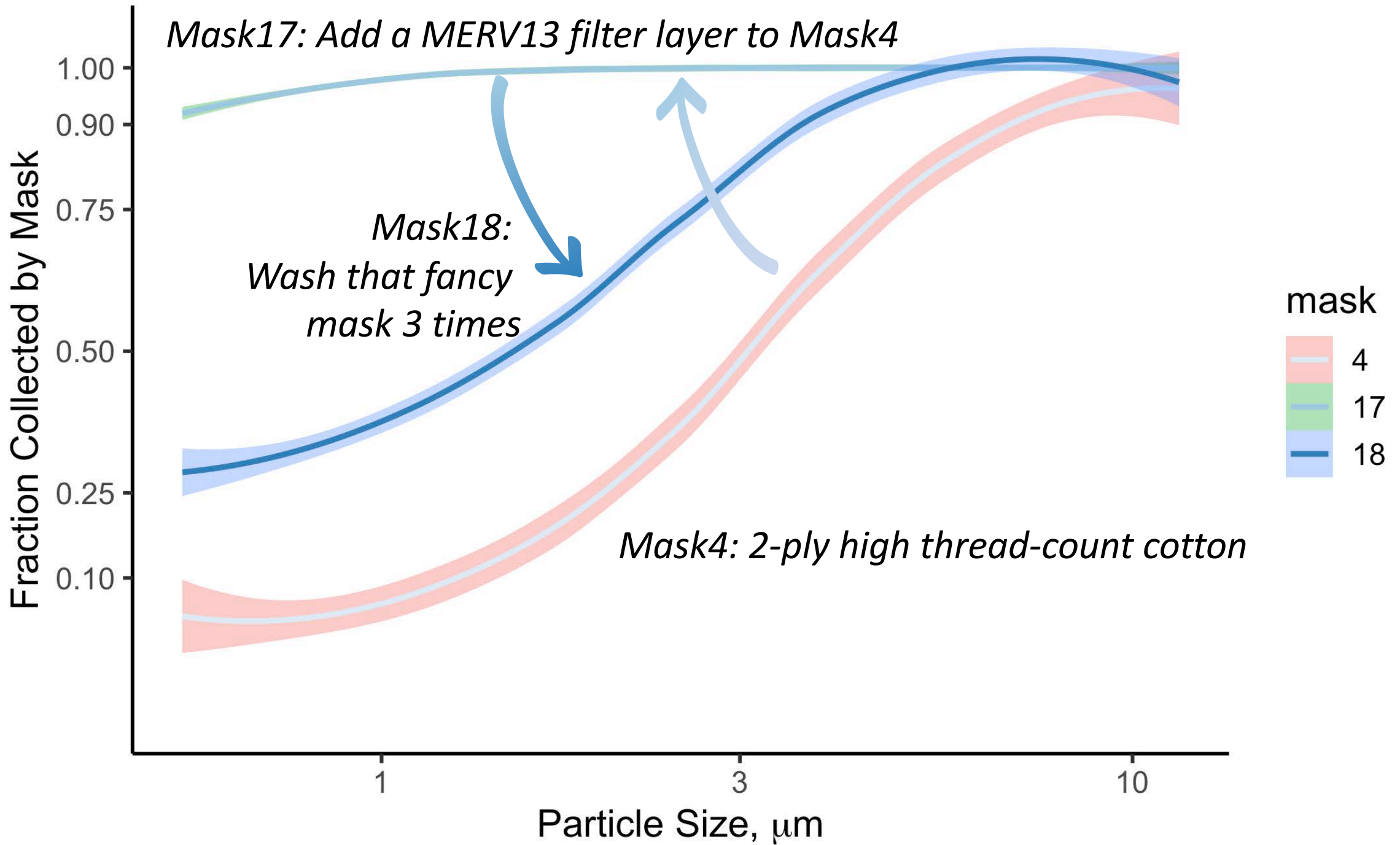




mask

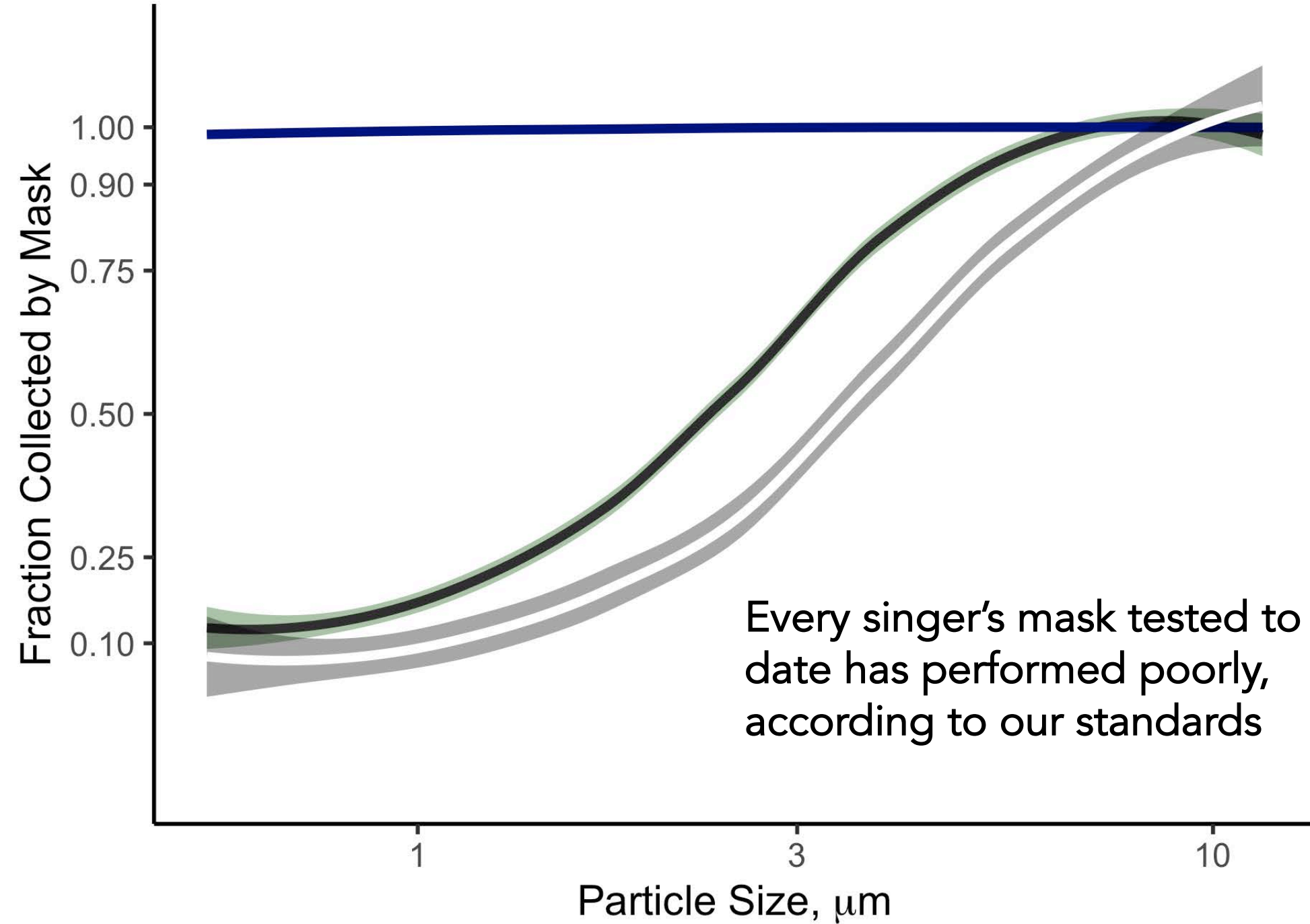
- 4
- 17

Mask4: 2-ply high thread-count cotton



What about "Singer's Masks"?





Every singer's mask tested to date has performed poorly, according to our standards

mask

- black
- N95
- white



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



CSU | SMTD

ABOUT

ADMISSIONS

NEWS AND EVENTS

FACILITY

GIVING

CONNECT



CSU Aerosol Emissions Study

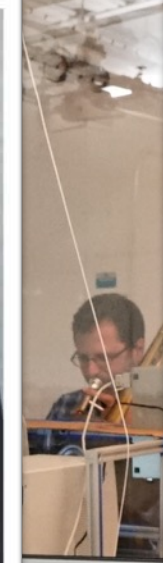
Reducing Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safer Return from COVID19

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

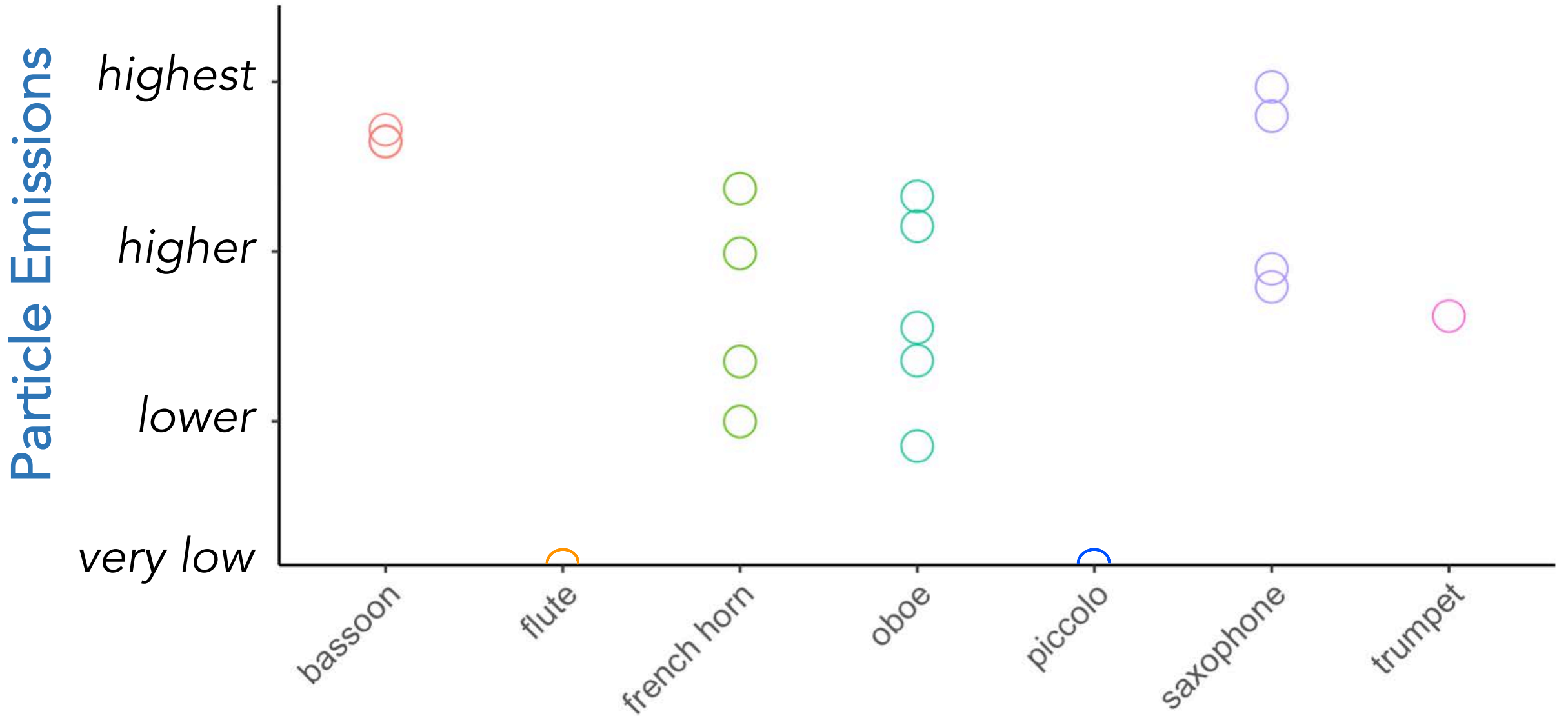


SET Facility: A Musical Class 100 Cleanroom



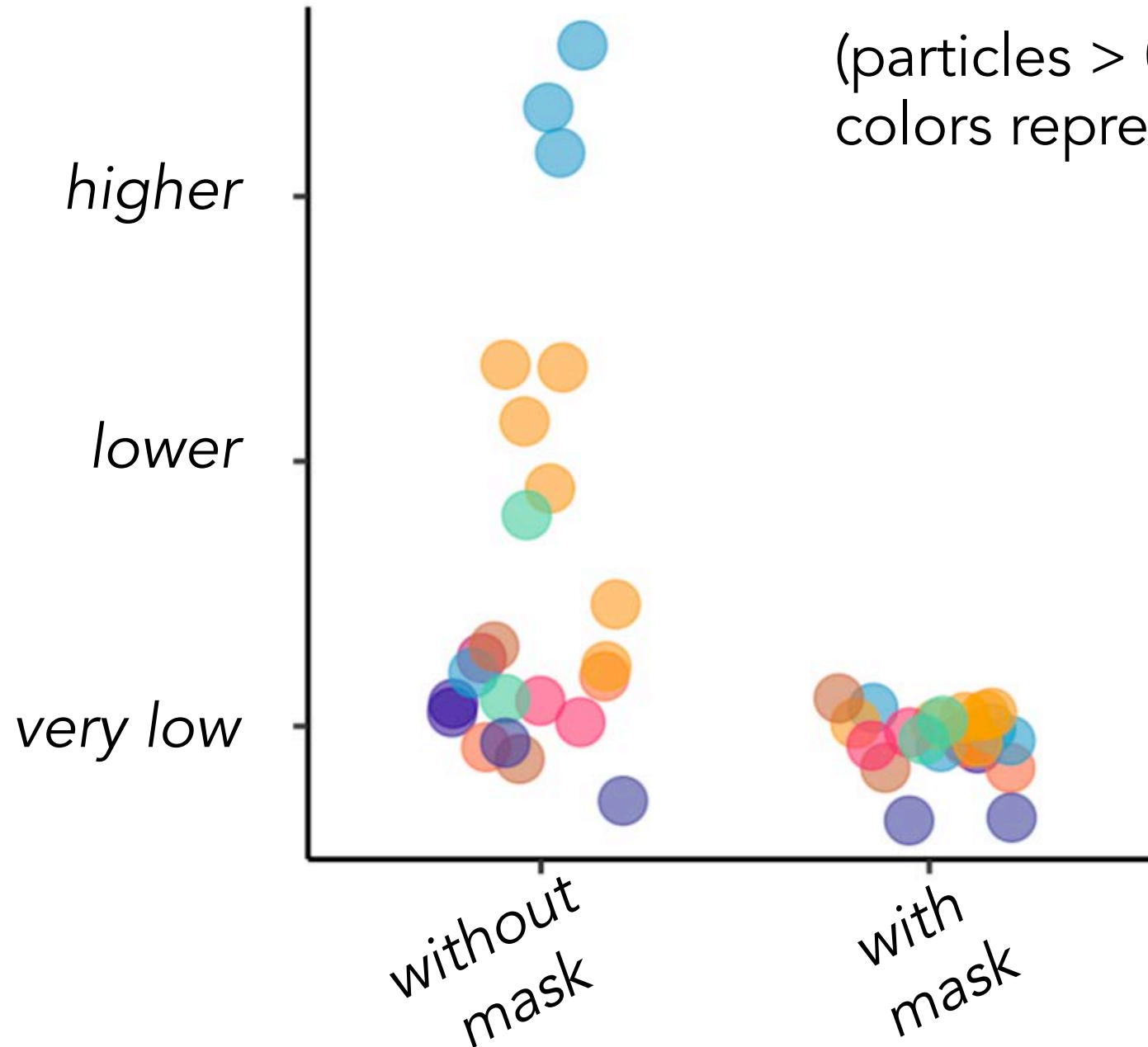
SET Facility: A Musical Class 100 Cleanroom

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.

Thank you to those who made this work possible!

Major Supporters:

Yamaha Corporation

United States Institute for Theatre Technology (USITT)

Lead Supporters:

American Bandmasters Association Foundation

American Choral Directors Association

American Guild of Musical Artists (AGMA)

Auburn University

Big Ten Band Directors Foundation

CSU School of Music, Theatre, and Dance

Mill City Church

National Band Association

University of Kentucky

Wenger Corporation

Valued Donors:

Toni Atkinson, Susan Baker, Lisa Baldwin, Diane Barrett, Stephanie Barth, David Betz, Douglas Boyer, Aubree Brasser, Myra Brown, Jo Anne Busch, Beatrice Chetard, Jennifer Clary Jacobs, Jennifer Clippert, College Orchestra Directors, Association, Colorado Flute Association, Wendi Davis, Ann Donoghue, Cynthia Dotson, Mark Douglass, Nick Drabik, Catherine Flannery, Flute Plus, Julie Gatesman, Elena Georgieva, David Hahn, Utah Hamrick, Cindy Haraway, Leslie Harrington, Karen Howat, Ryan Hyde, Nancy Jianakoplos, George Jones, Richard Kellogg, Evan Key, Bob Kreutz, Ira Kroll, Sheri Linnell, Manchester Choral Society, National Catholic Band Association, Megan Miller, Randy Moench, Karen Olsen, Jan Opalach, Kathy Payne, Georgia Peeples, Laura Piechota, Flute Plus, Janet Puckett, Louann Reid, Randy Rosette, Jane Sandstrom, Molly Sayles, Belinda Shreckengost, Craig Shuler, Linda Sommer, Erin Spencer, Kellie Sponberg, Cary Stewart, Leslie Stewart, Susquehanna Chorale, Steven Szalaj, Adam Torres,, Malia Van Rooy, Kirsten Wells, Rosemary Whitaker, Nina Zheng

Advisory Board:

Dan Goble, CSU

Allen Henderson, Ga Southern

Emily Morgan, CSU

Rebecca Phillips, CSU

Heather Pidcoke, CSU

Timothy Rhea, TAMU

Supporters:

Association of Concert Bands

Community Foundation of Northern Colorado

Conn-Selmer Corporation

Diana Anderson

Gayle Treber

O'ahu Band Directors Association

Texas A&M University Bands

Women Band Directors International Foundation