

UPDATE:

Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safer Return from COVID-19

Dec. 2, 2020

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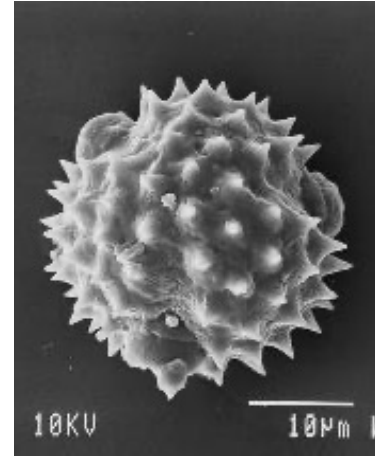
Why don't
we have
more
answers
here?

- 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?

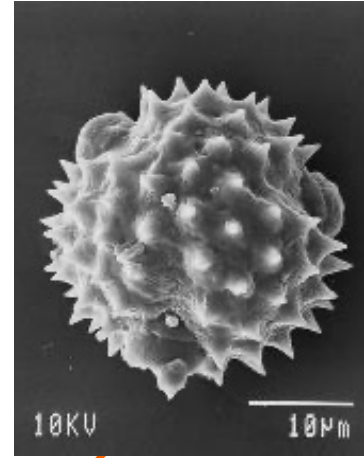
Some Sizes and Sources of Airborne Particles



Flour Dust



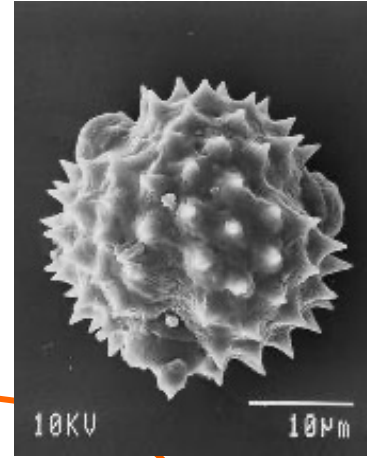
Some Sizes and Sources of Airborne Particles



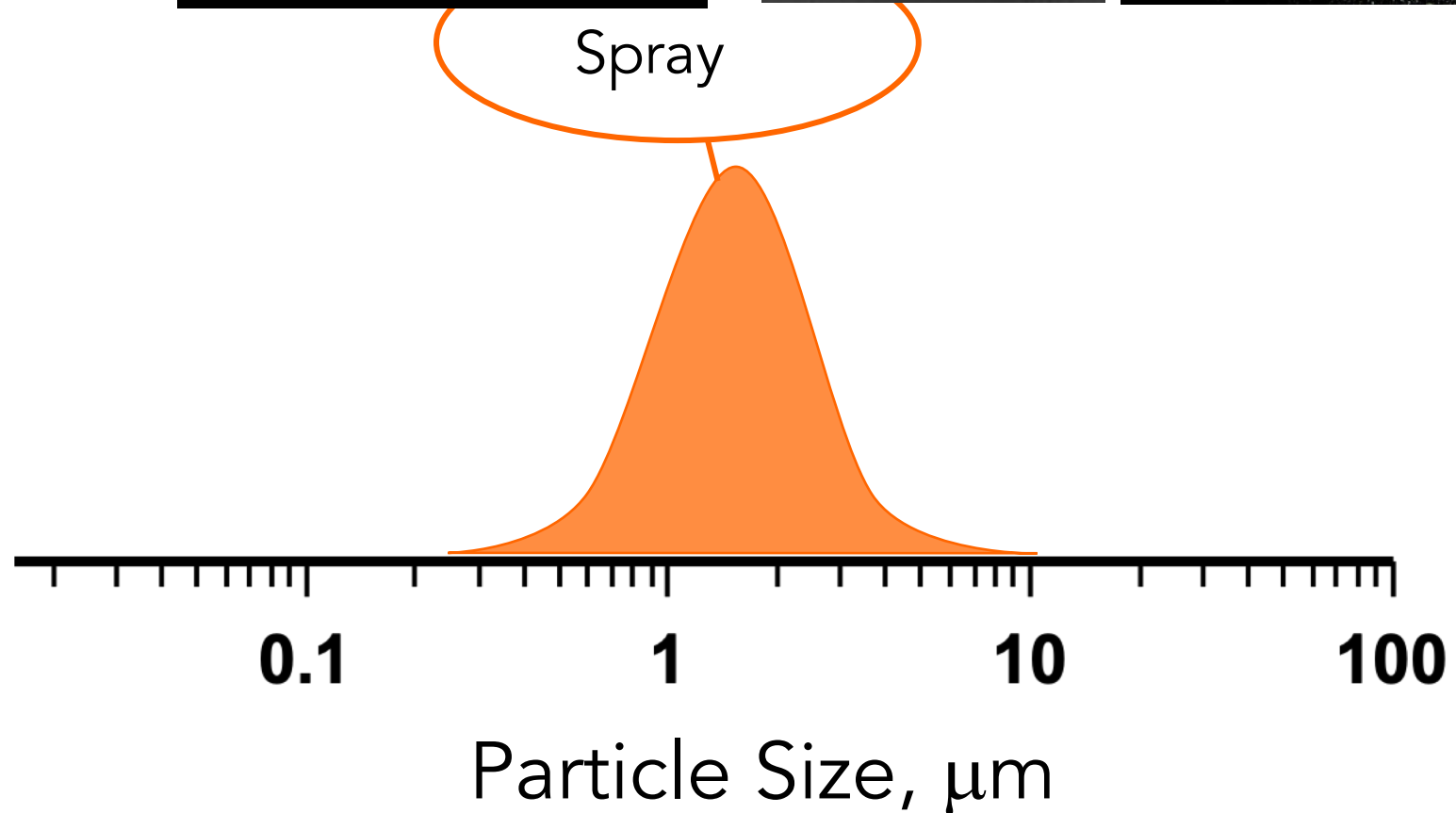
Pollen



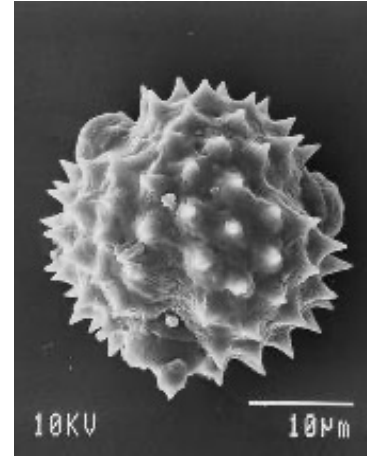
Some Sizes and Sources of Airborne Particles



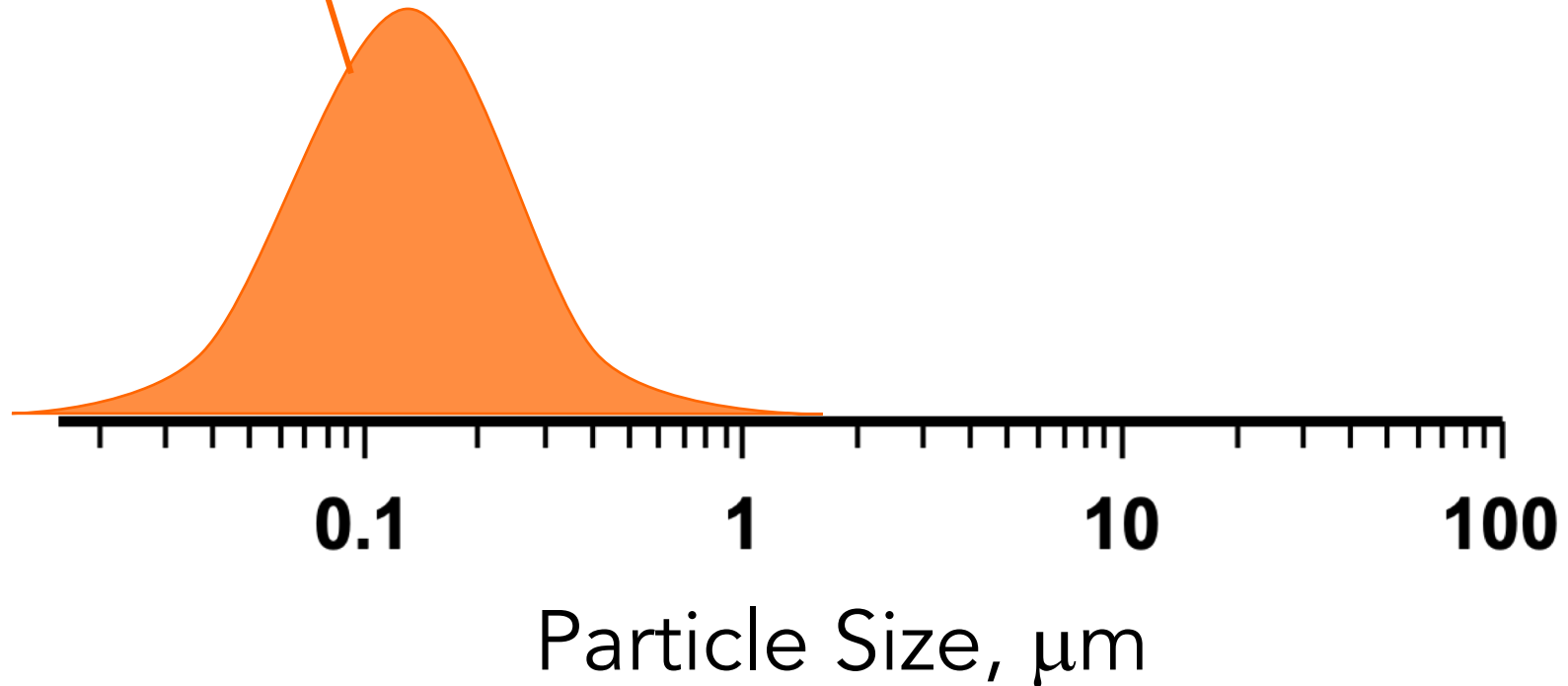
Spray



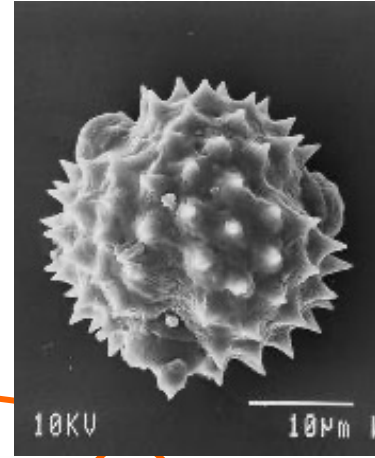
Some Sizes and Sources of Airborne Particles



Smoke



Some Sizes and Sources of Airborne Particles

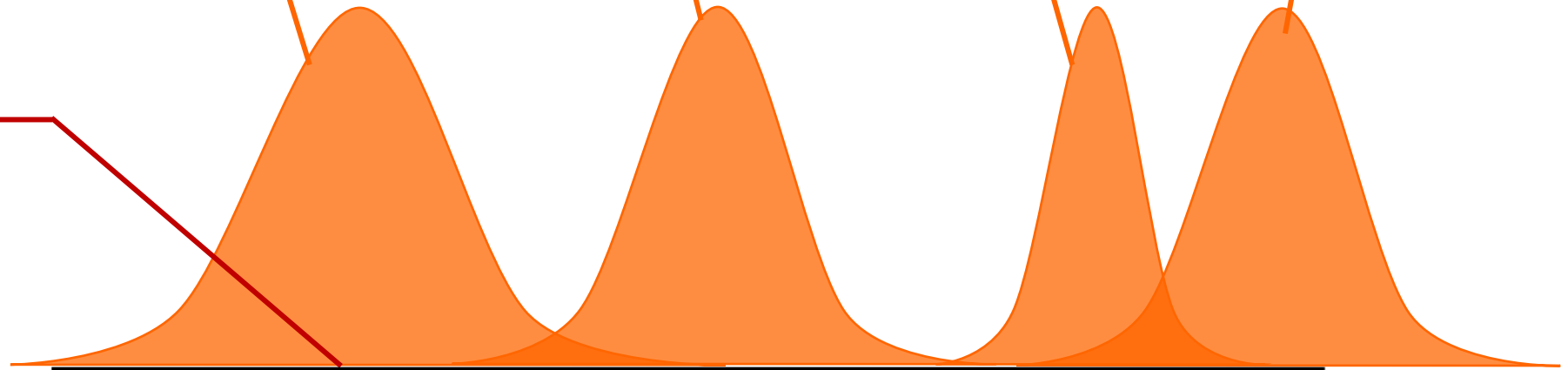
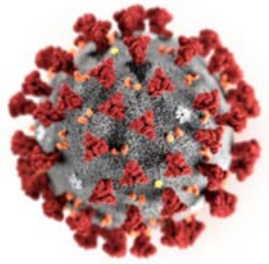


Smoke

Spray

Pollen

Flour Dust



0.1

1

10

100

Particle Size, μm

Some Sizes and Sources of Airborne Particles

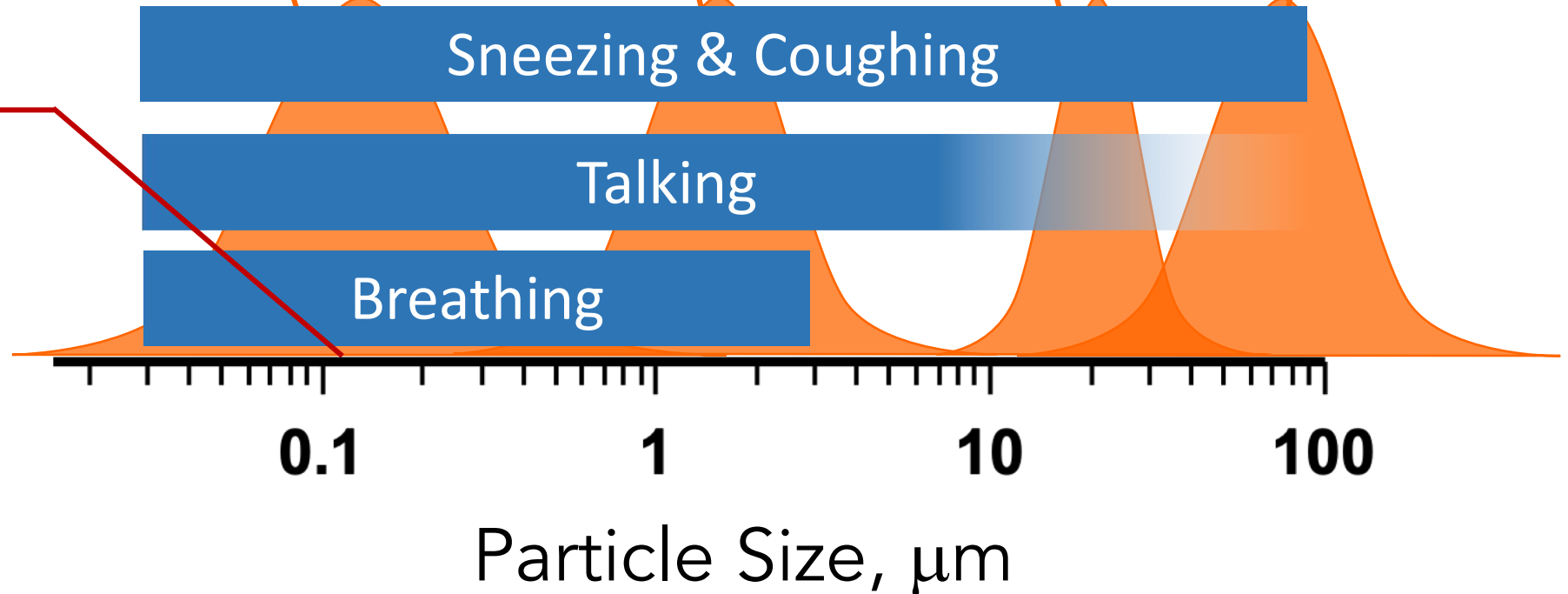
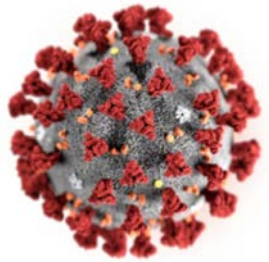


Smoke

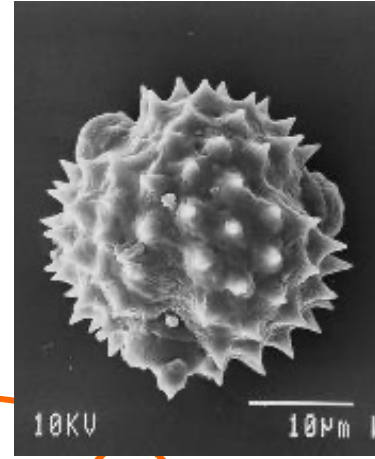
Spray

Pollen

Flour Dust



Some Sizes and Sources of Airborne Particles



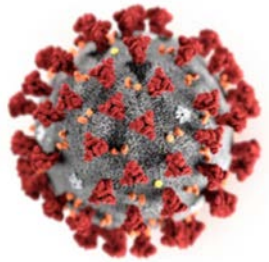
Smoke

6

Pollen

Hand Dust

Musical and Vocal Arts?



0.1

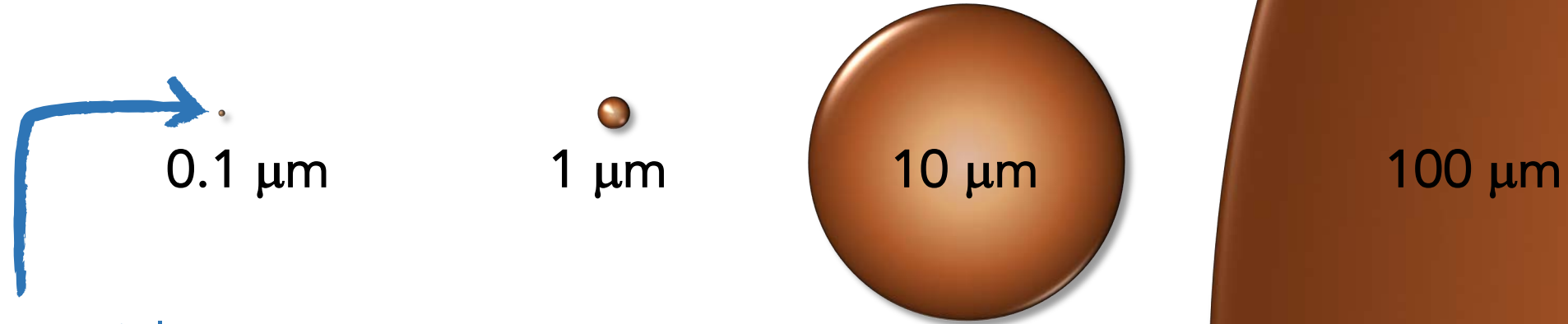
1

10

100

Particle Size, μm

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

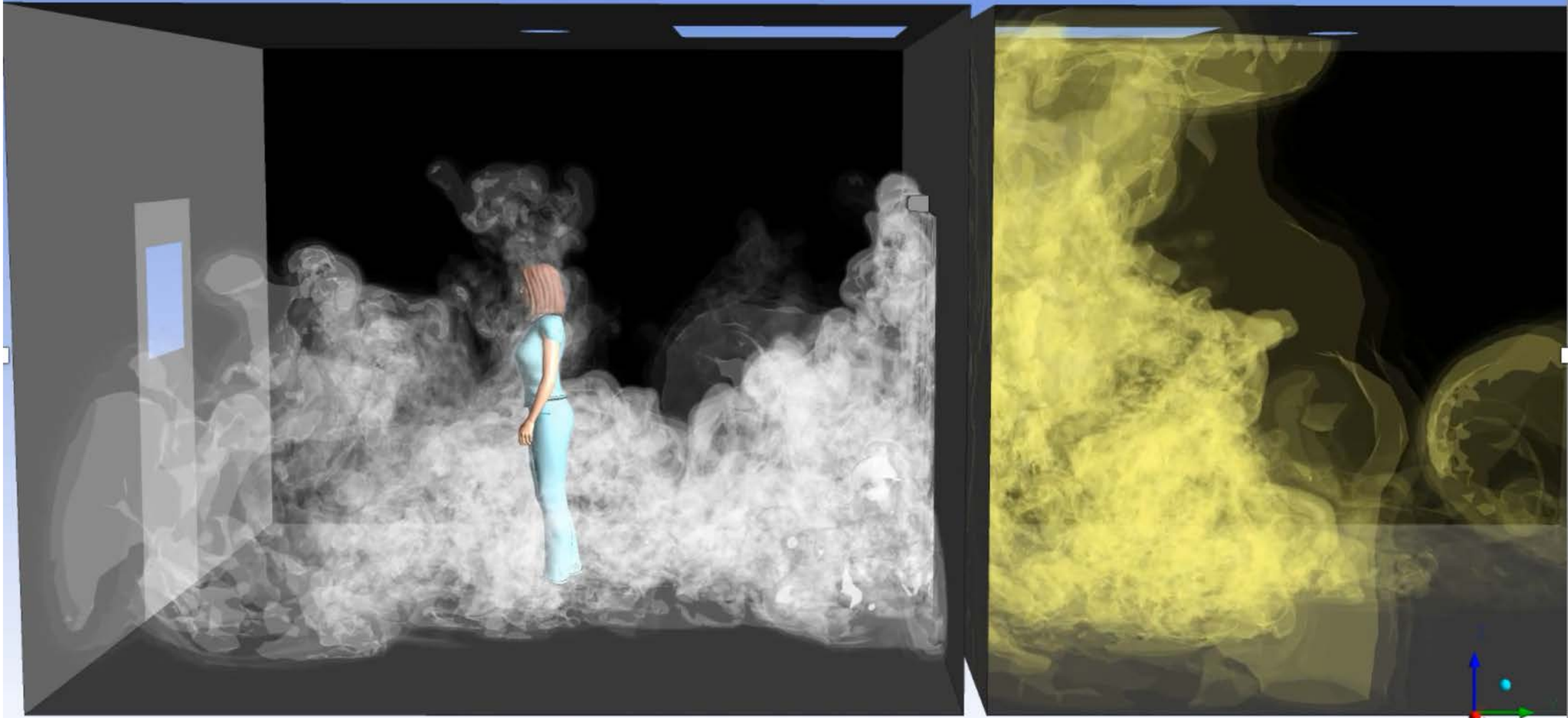


If this particle were
the size of a baseball

Then this particle would be
the size of a baseball stadium

time [s]: 28.476

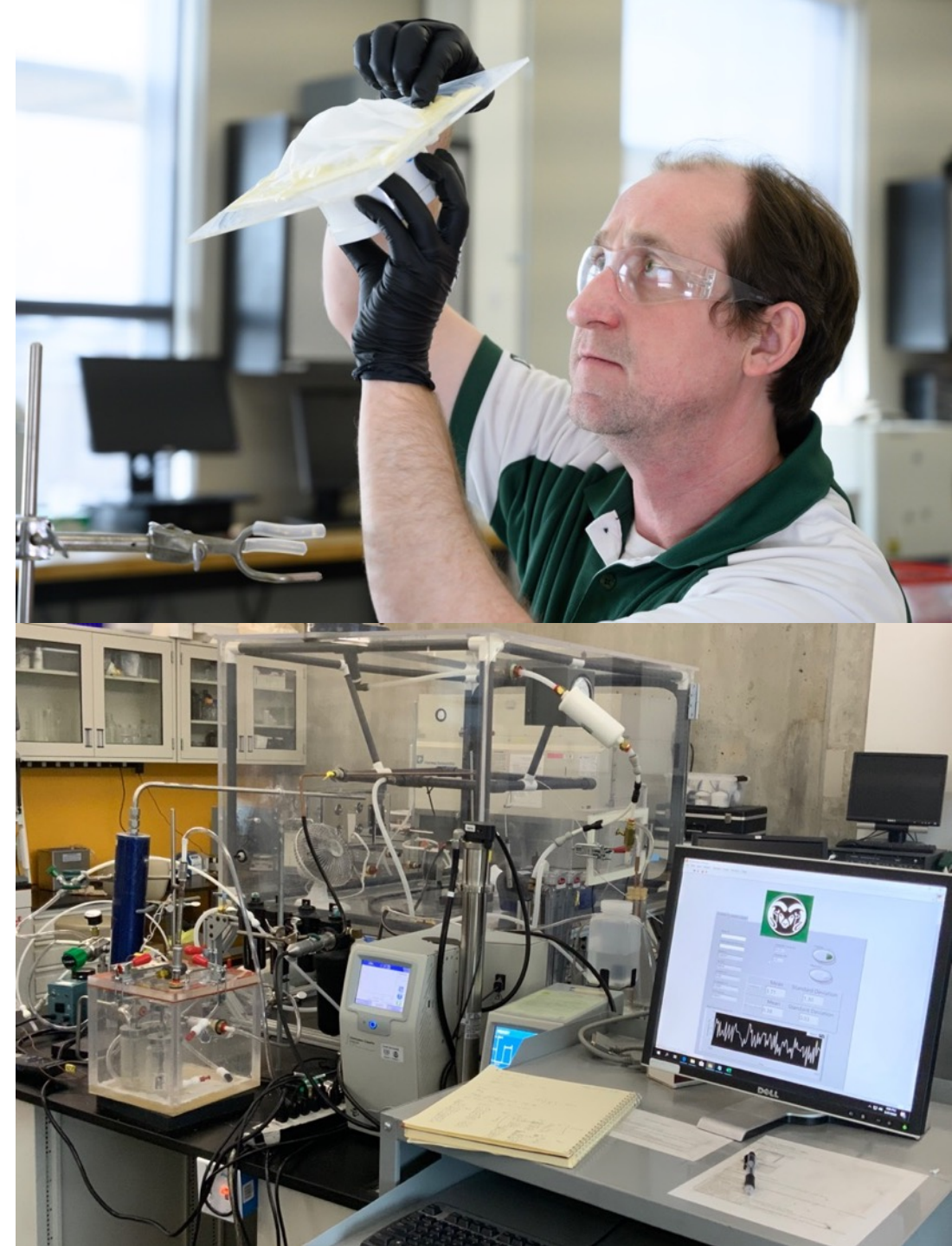
ANSYS
R15.0



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 25, Colorado Governor Jared Polis asked our lab to provide respirator testing and performance verification for State of Colorado COVID-19 Task Force

Over 300 different mask designs tested as of Dec. 1, 2020



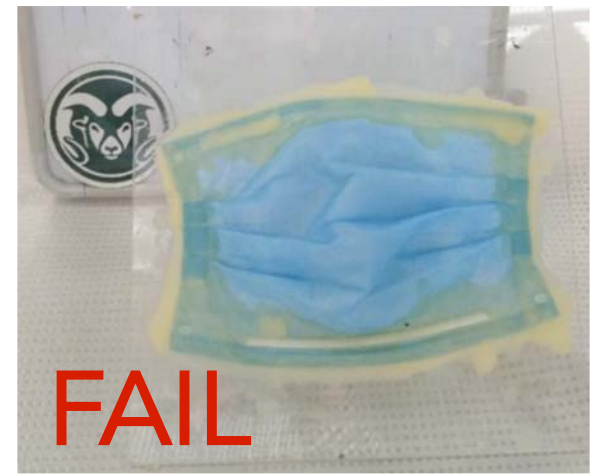
N95 means >95% removal efficiency for particles that flow into the mask

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>

N95s are great if you can get them
(but you can't)
so what about cloth masks?

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

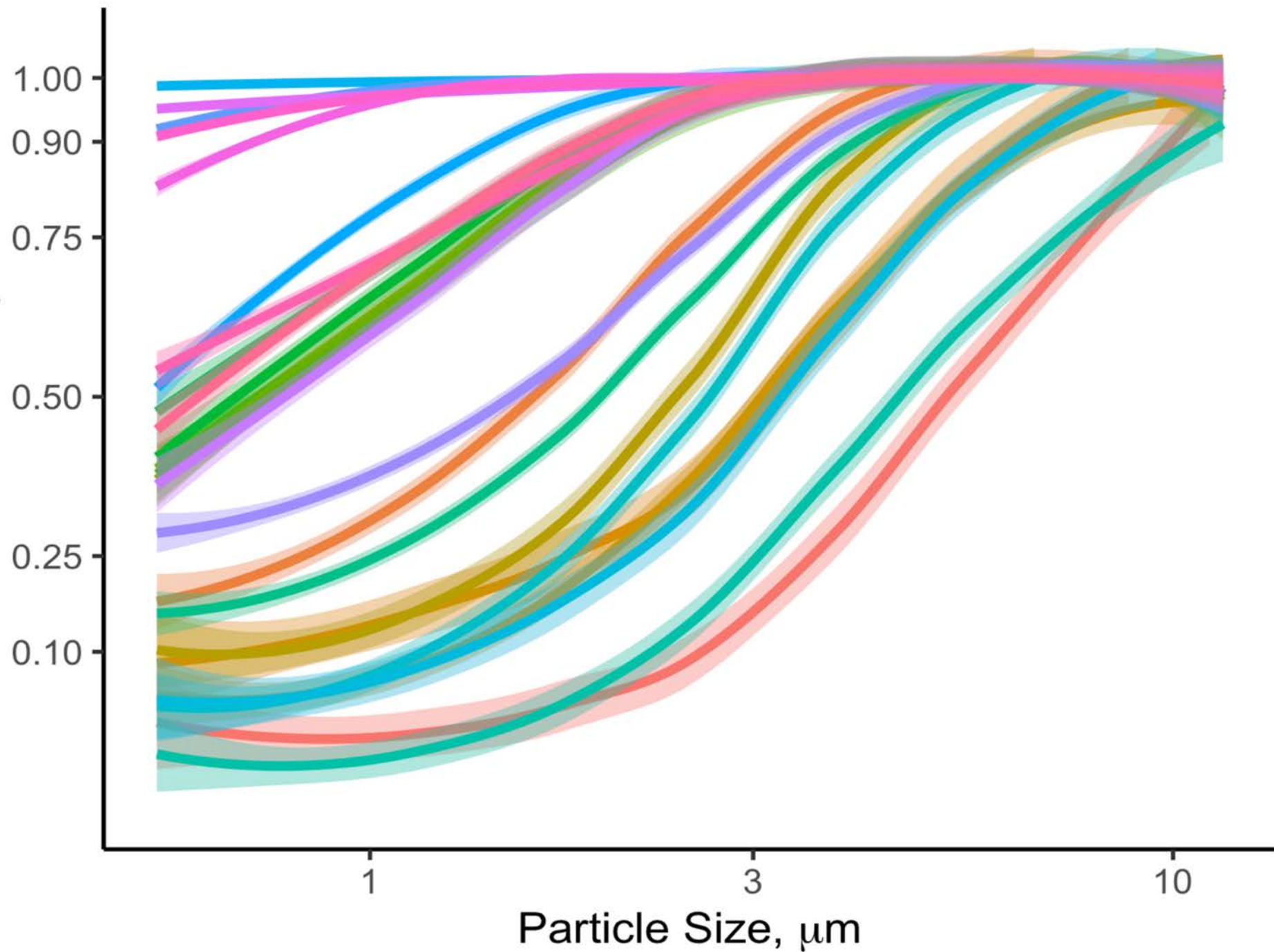
Particle Size, μm

mask

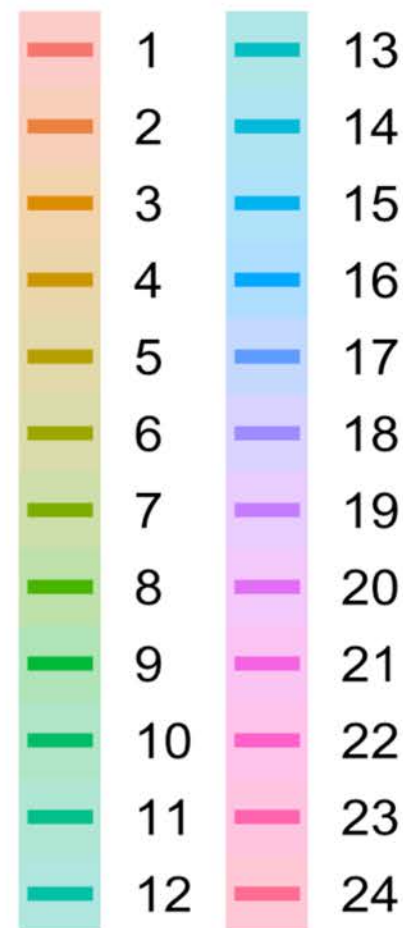


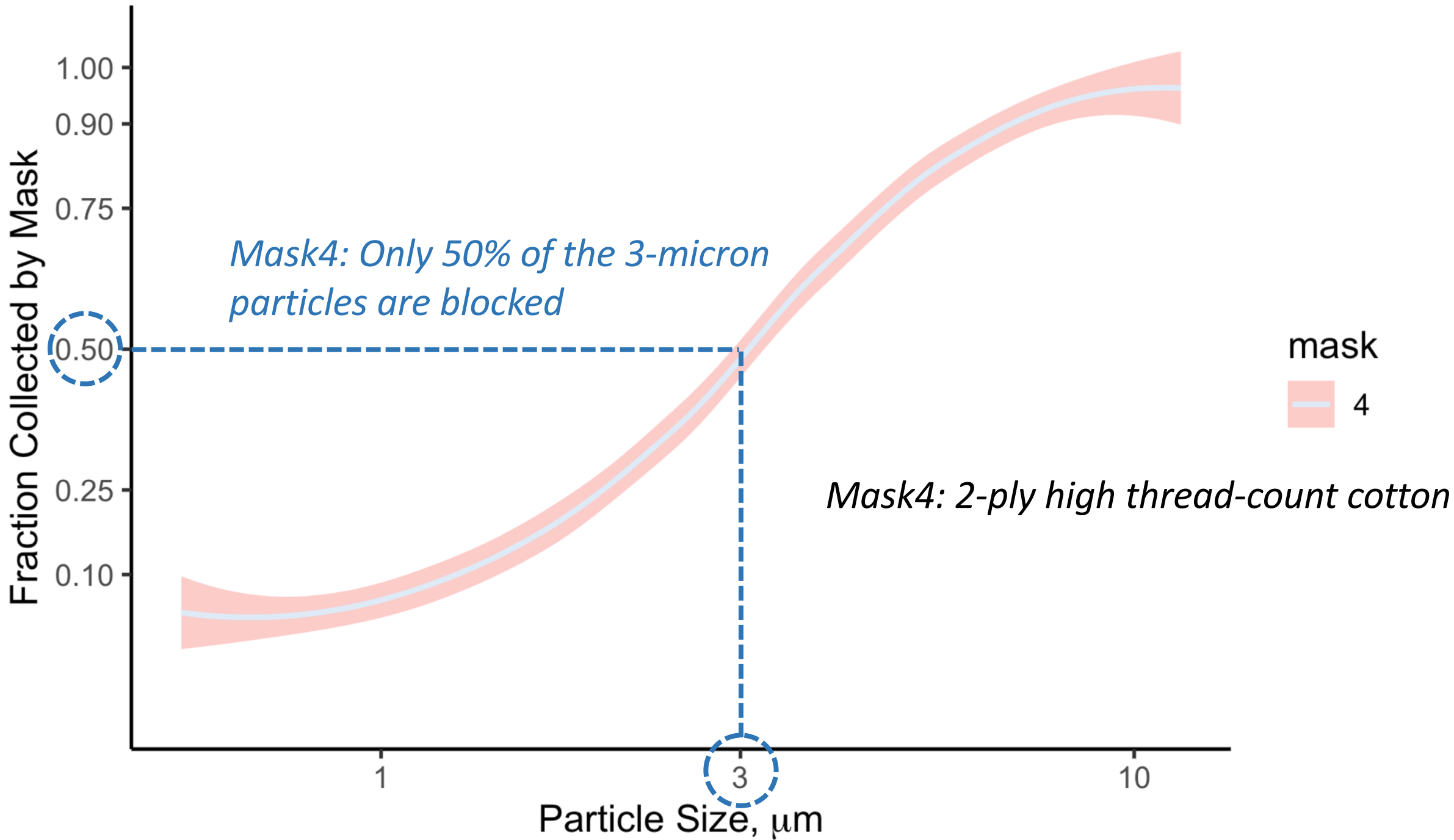
N95

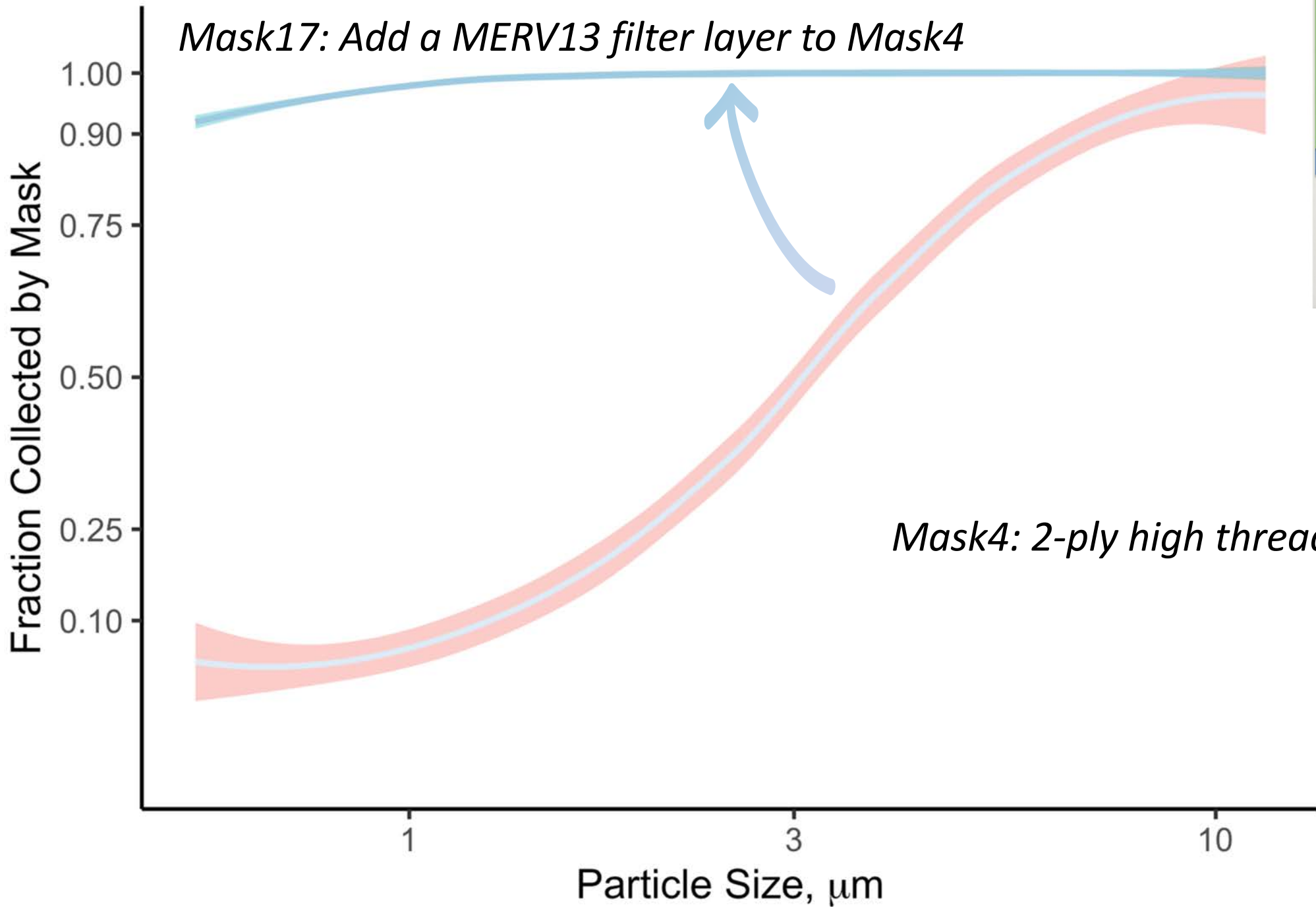
Fraction Collected by Mask



mask



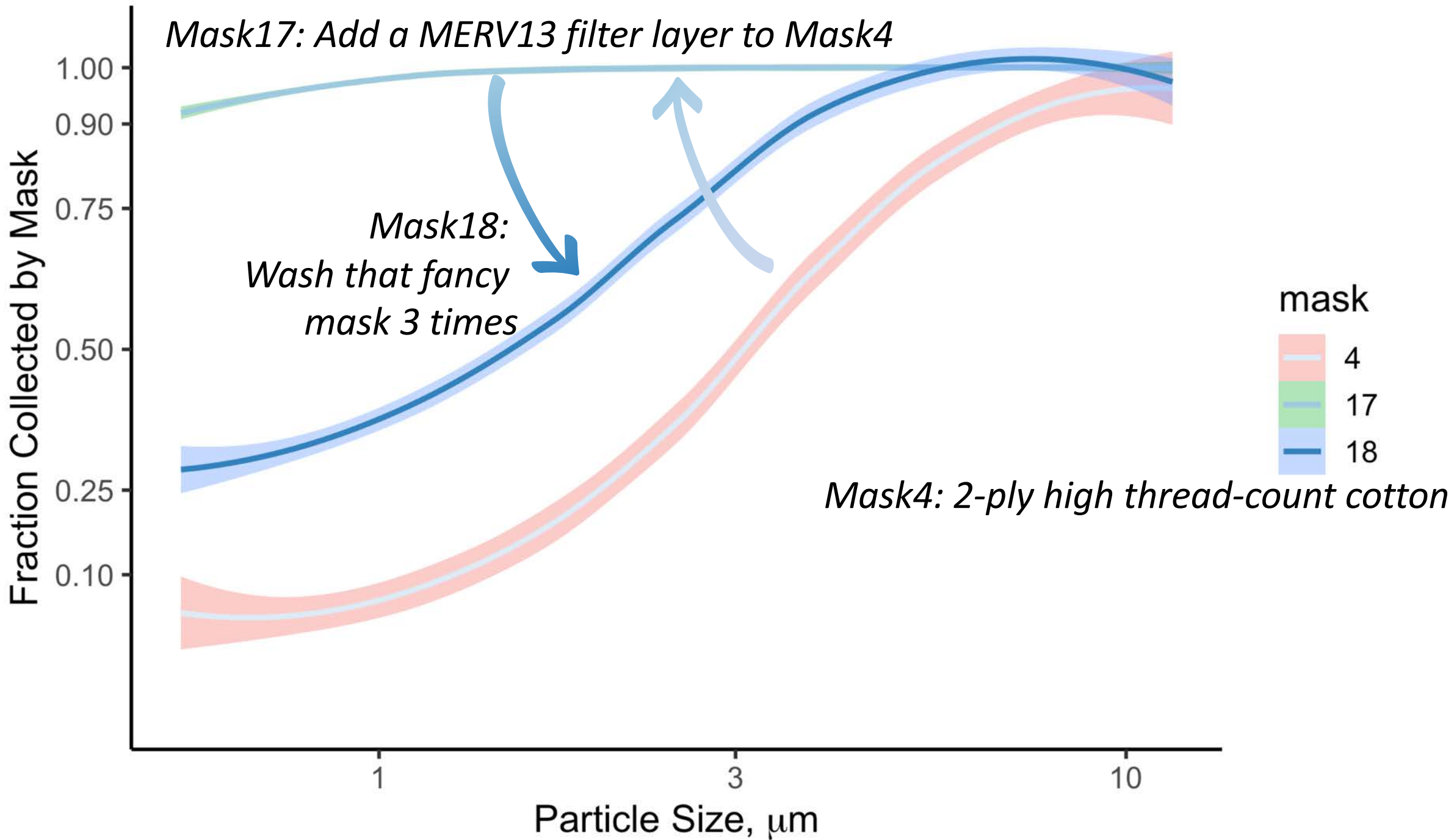




mask

- 4
- 17

Mask4: 2-ply high thread-count cotton



What about “Singer’s Masks”?

<http://jv.colostate.edu/masktesting/>



Want to learn more? Watch our free webinar on mask design: <https://col.st/Wq2Bu>

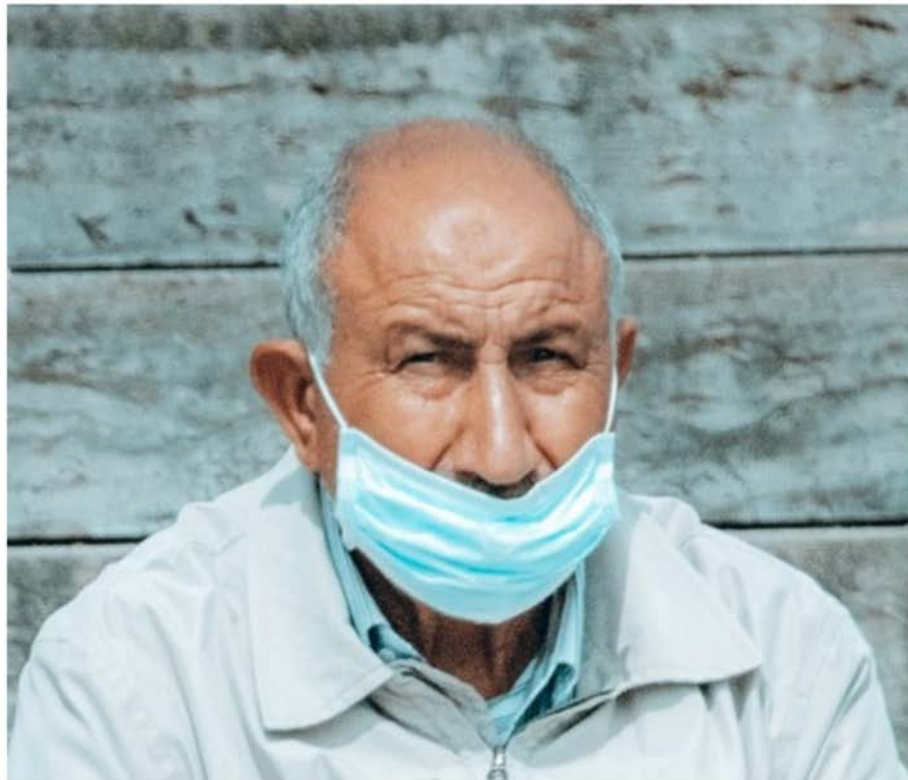
Study Confirms Nose Holes Connect to Lungs

Below-the-nose mask wearers shocked by science



Rachael Ann Sand [Follow](#)

Aug 26 · 2 min read ★



Beware the half-mast-maskers. Photo by [Marcel Strauß](#) on [Unsplash](#). Cropped by author.

Source: [medium.com](#)

Mask efficacy is determined by four primary factors:

1. Fit

- Does the air flow through the mask or around the mask?

2. Filtration

- How efficient is the mask at removing particles that flow through it?

3. Breathability

- How easy is it to draw air through the mask?

4. Compliance

- Are you doing what was asked of you?

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



CSU | SMTD

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CSU Aerosol Emissions Study

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

Experimental Design

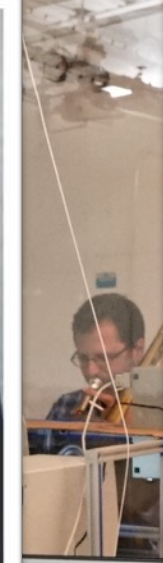
- 100 volunteers over ~~3~~ 6 months (~2/day)
 - Open to ages 12 and up; all genders
 - ~28 singers, actors, dancers
 - ~72 instrumentalists: bassoon, clarinet, euphonium, flute, French horn, trumpet, trombone, saxophone, and possibly others
- Everybody speaks, sings and “does their thing”
 - With and 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

Cameron Peak Fire: August 13 – December 1, 2020

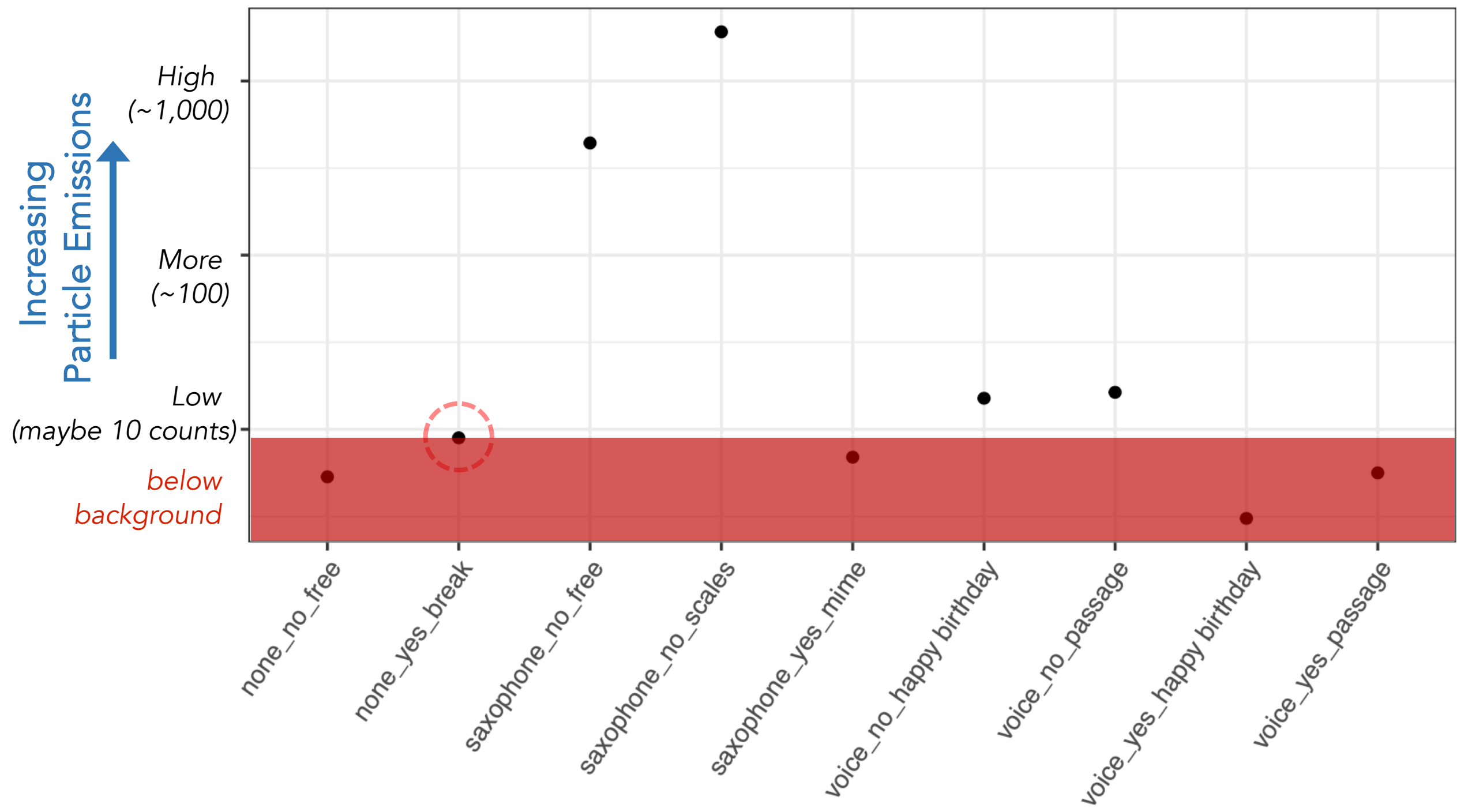




SET Facility: A Musical Class 100 Cleanroom



SET Facility: A Musical Class 100 Cleanroom



Ongoing Instrument Results (particles > 0.3 μm)

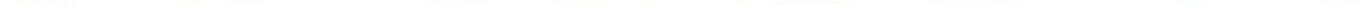
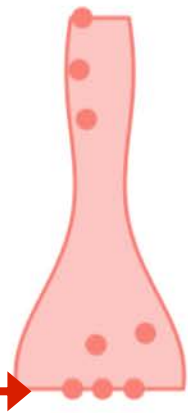
Relative Particle Emissions

highest

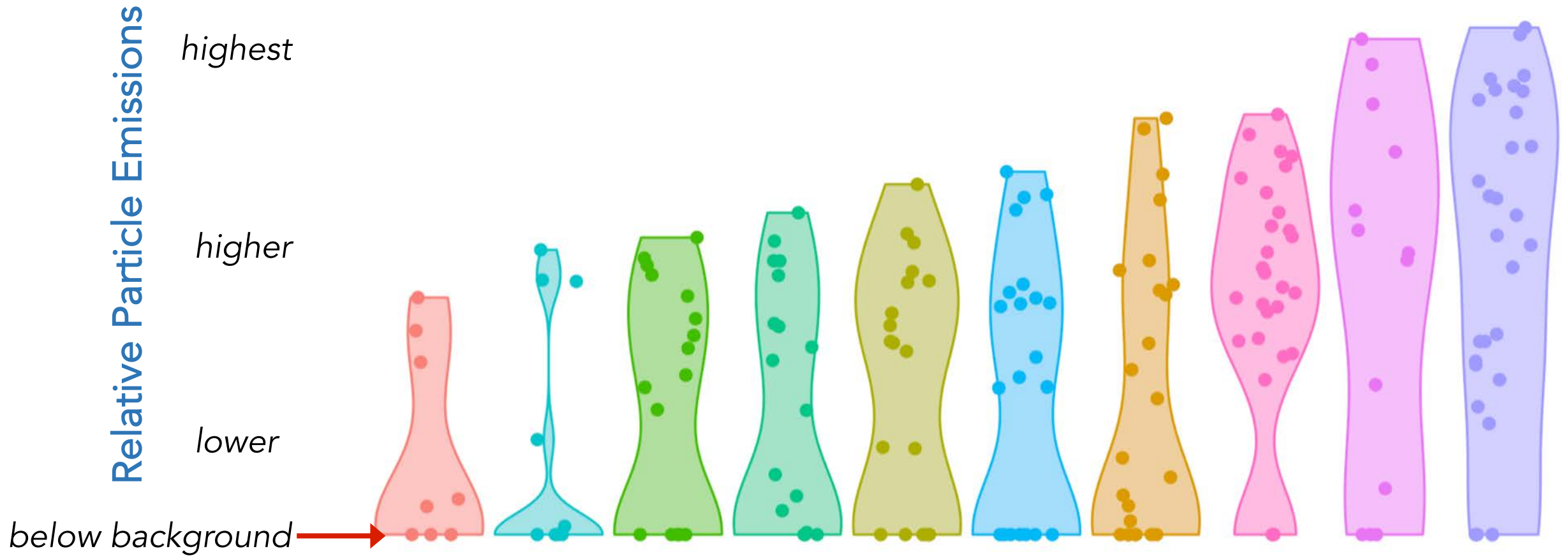
higher

lower

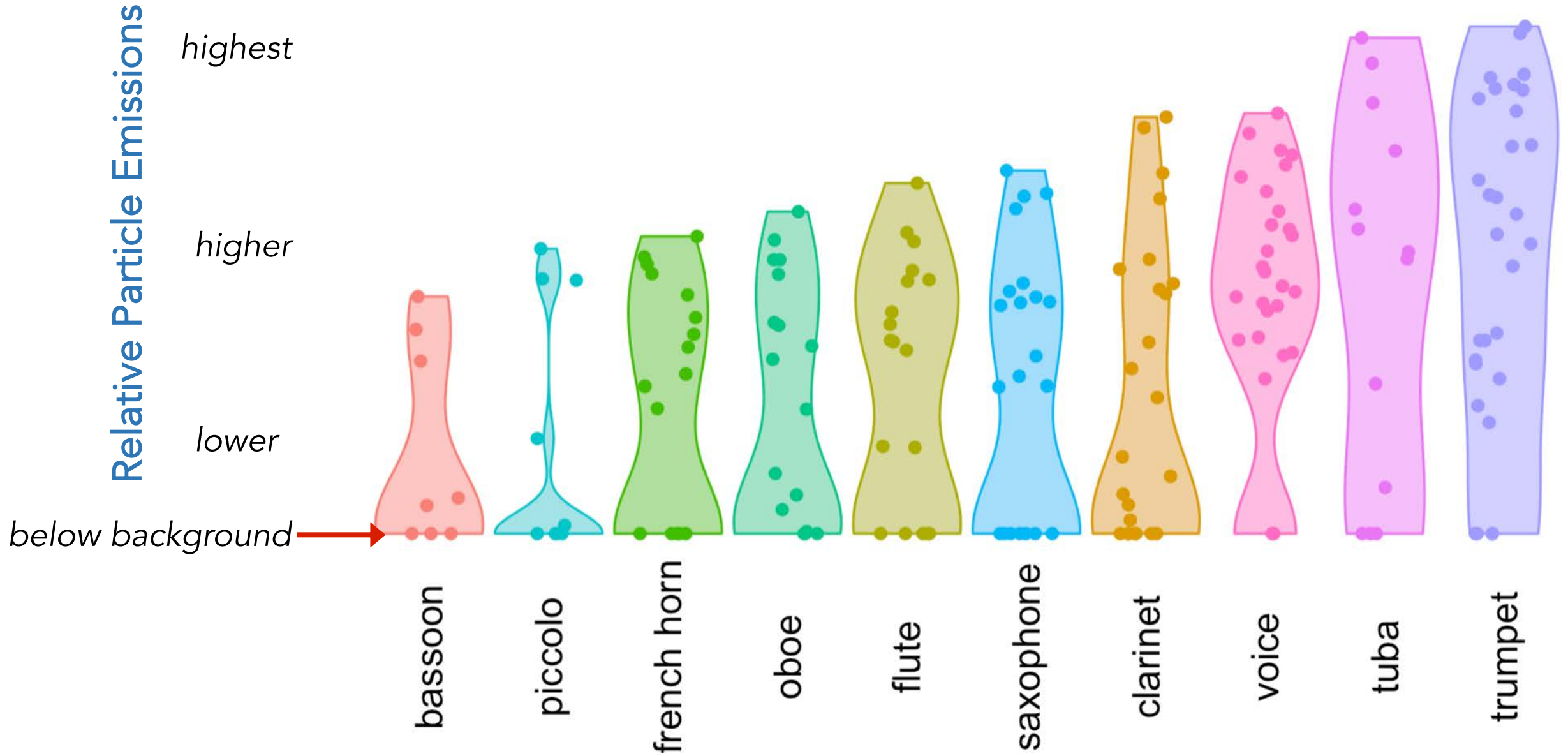
below background



Ongoing Instrument Results (particles > 0.3 μm)

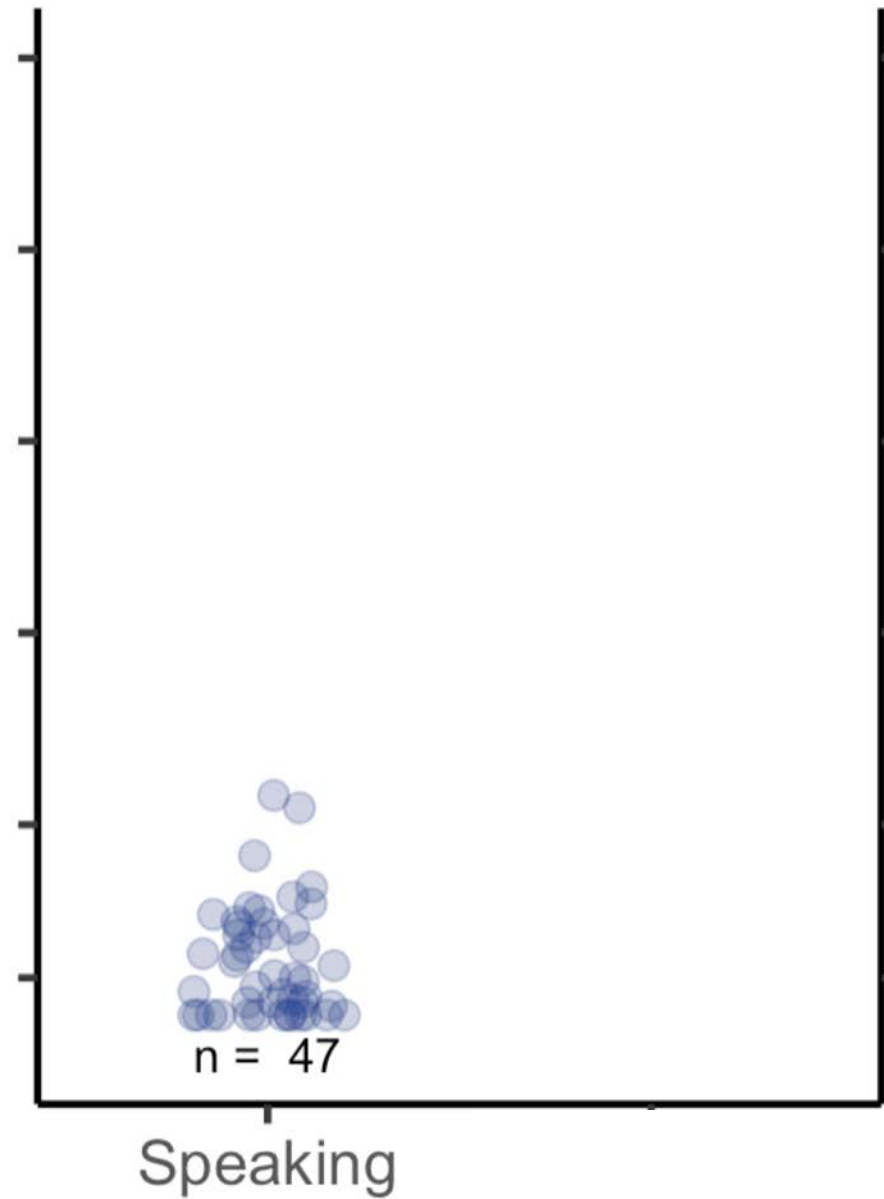


Ongoing Instrument Results (particles > 0.3 μm)

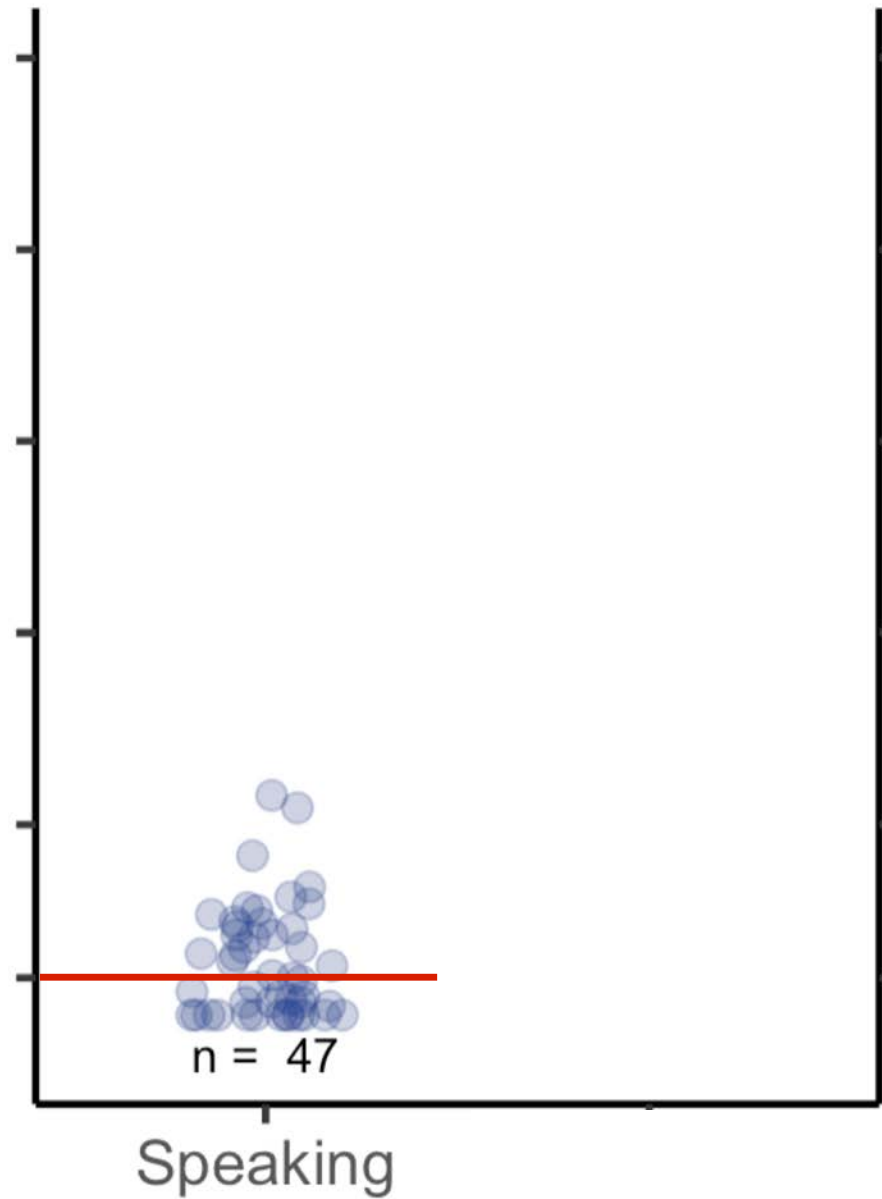


Ongoing Vocal Results (particles $> 0.3 \mu\text{m}$)

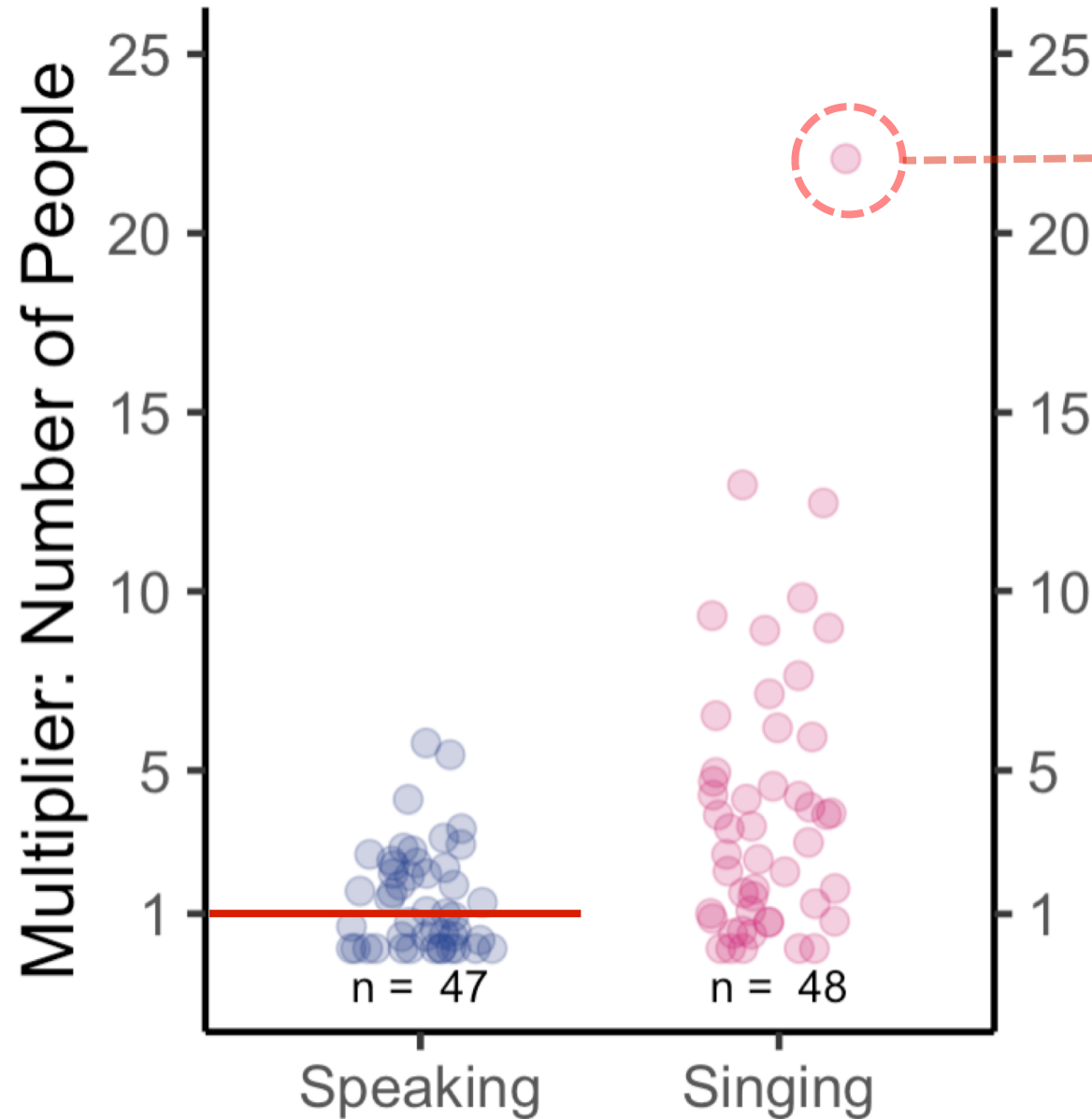
Ongoing Vocal Results (particles > 0.3 μm)



Ongoing Vocal Results (particles > 0.3 μm)

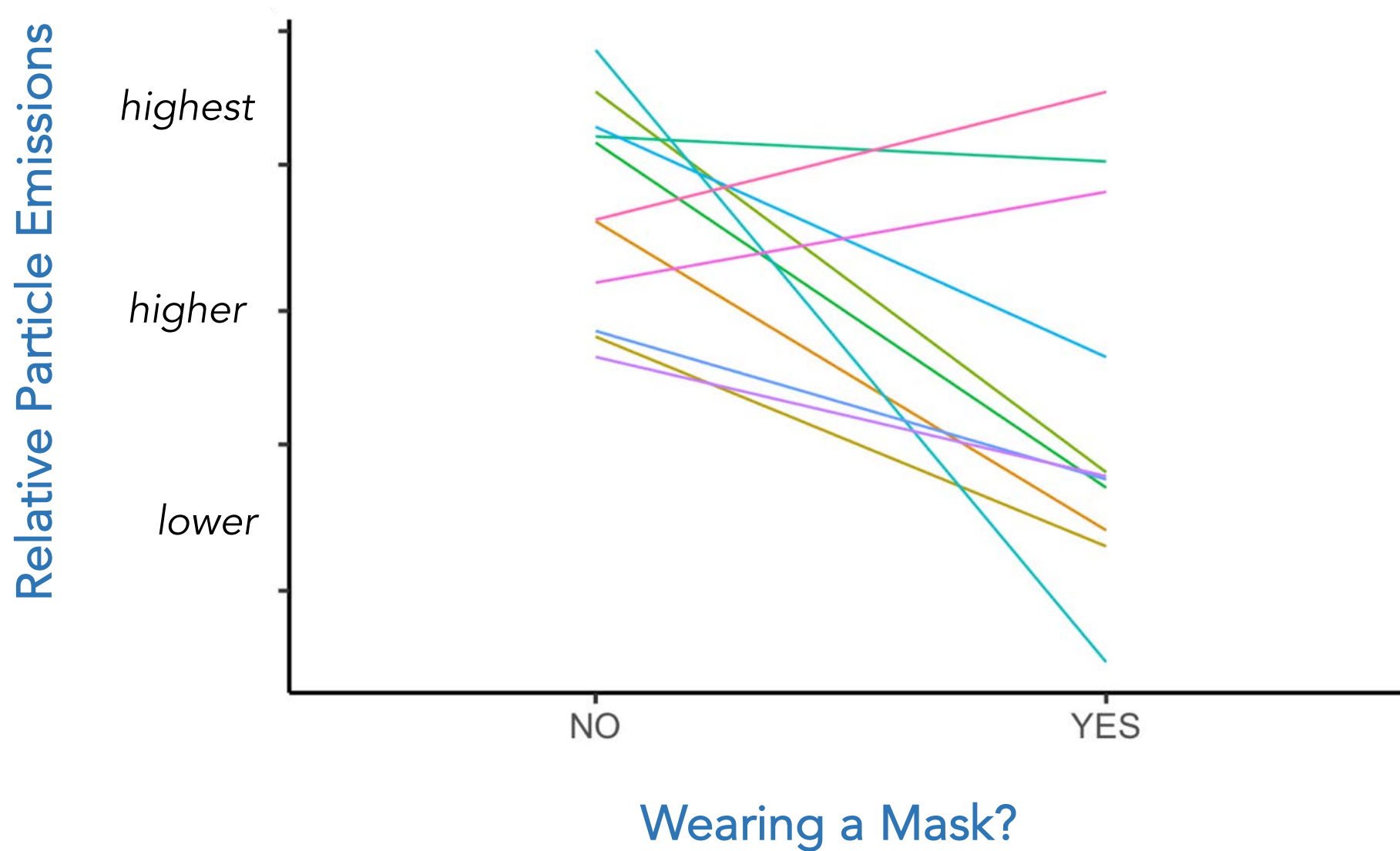


Ongoing Vocal Results (particles > 0.3 μm)



This person singing happy birthday emitted aerosol equivalent to 22 people all talking at once

Mask Efficacy for Singing (particles > 0.3 μm)



Updated Findings as of 2 Dec 20 (1/2 of the way there)

1. Yes, some instruments produce more aerosol than others.

For example: Trumpet, tuba > bassoon, piccolo.

But the performer is a major determinant of instrument emissions.

Soon we will examine effects like age, sex, and volume level.

2. Bioaerosol emissions can vary massively from one person to the next.

"Super-spreaders" are maybe 2-5% of the population.

3. Masks and bell covers appear to be effective.

Masks/covers will stop particles larger than 10 microns (bigger droplets)

But what about aerosol between 0.3 and 10 um? Masks and bell covers certainly help but we can't (yet) say by how much with confidence.

We'll know more in 1-2 months.

Thank you to those who made this work possible!

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