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

NASM - 2 Dec 20

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

Kristen Fedak, Dan Goble, Nick Good, Amy Kiesling, Christian L'Orange, Emily Morton, Rebecca Phillips, & 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…*

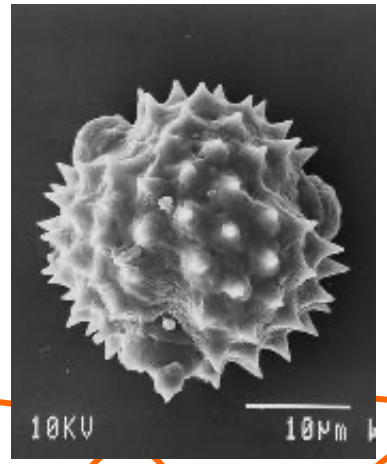
Questions we hope to answer

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

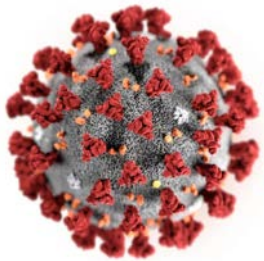


Smoke

Spray

Pollen

Flour Dust



0.1

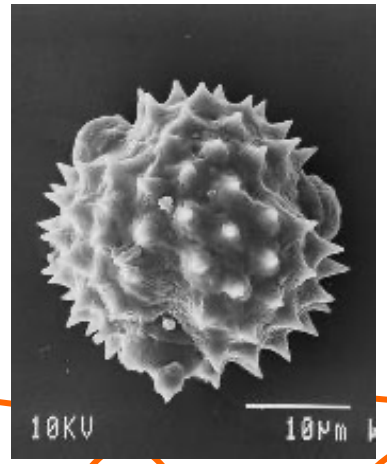
1

10

100

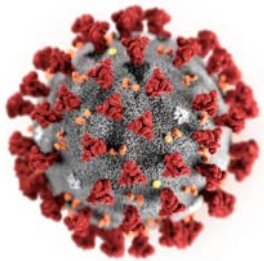
Particle Size, µm

Some Sizes and Sources of Airborne Particles



Smoke … ur Dust

Musical and Vocal Arts?



Sneezing & Coughing

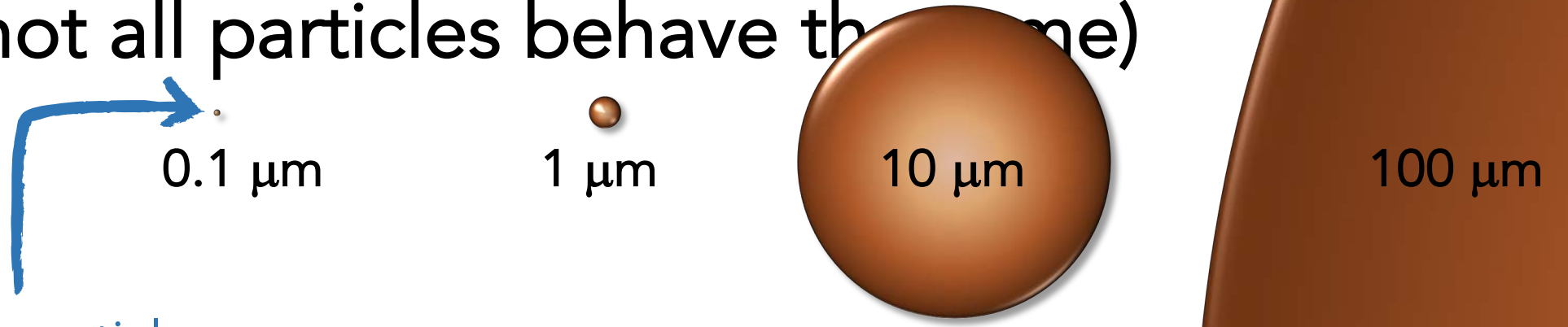
Talking

Breathing

0.1 1 10 100

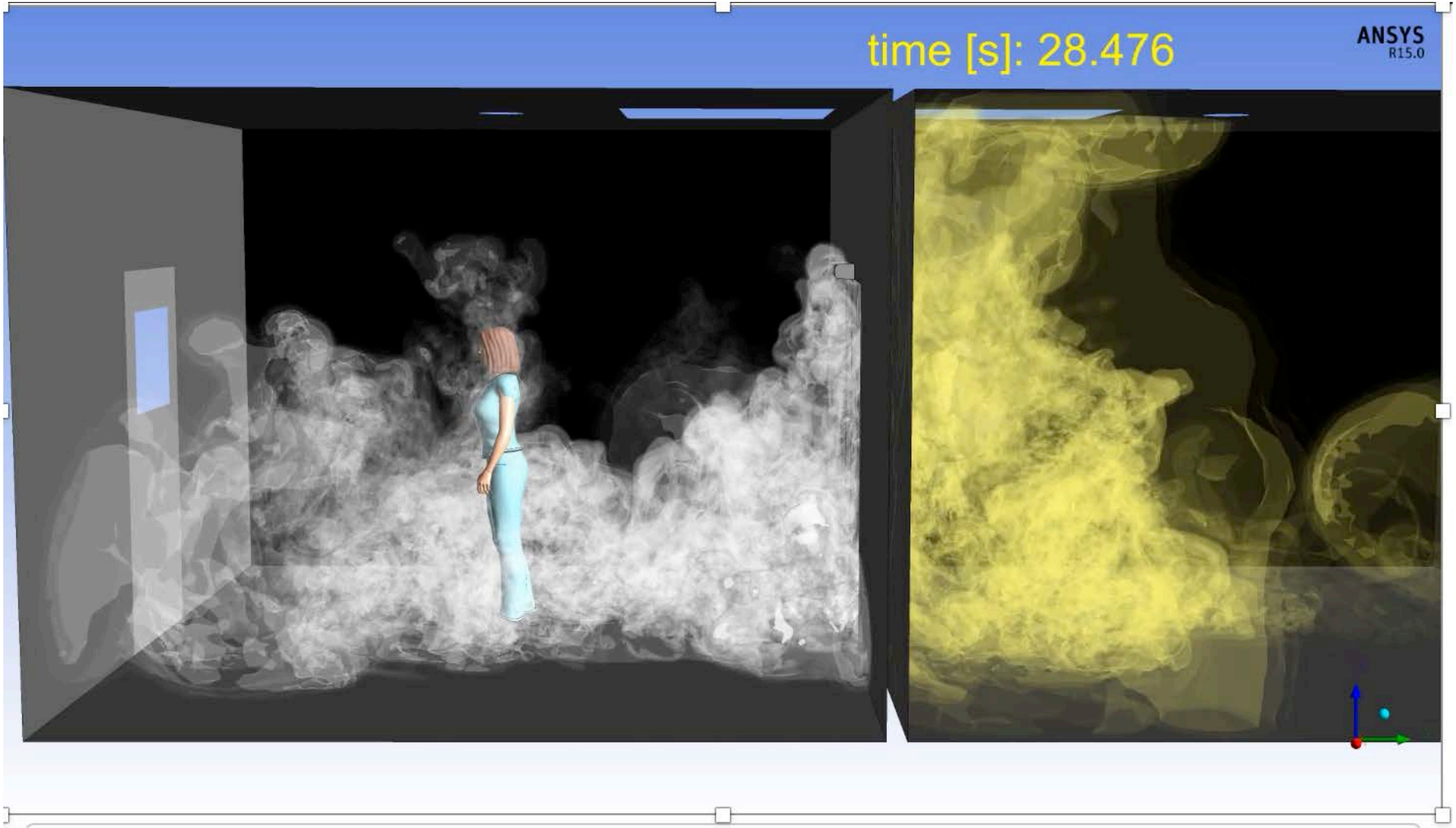
Particle Size, µm

Human bioaerosol spans a huge size range
(and not all particles behave th me)



If this particle were
the size of a baseball

Then this particle would be
the size of a baseball stadium

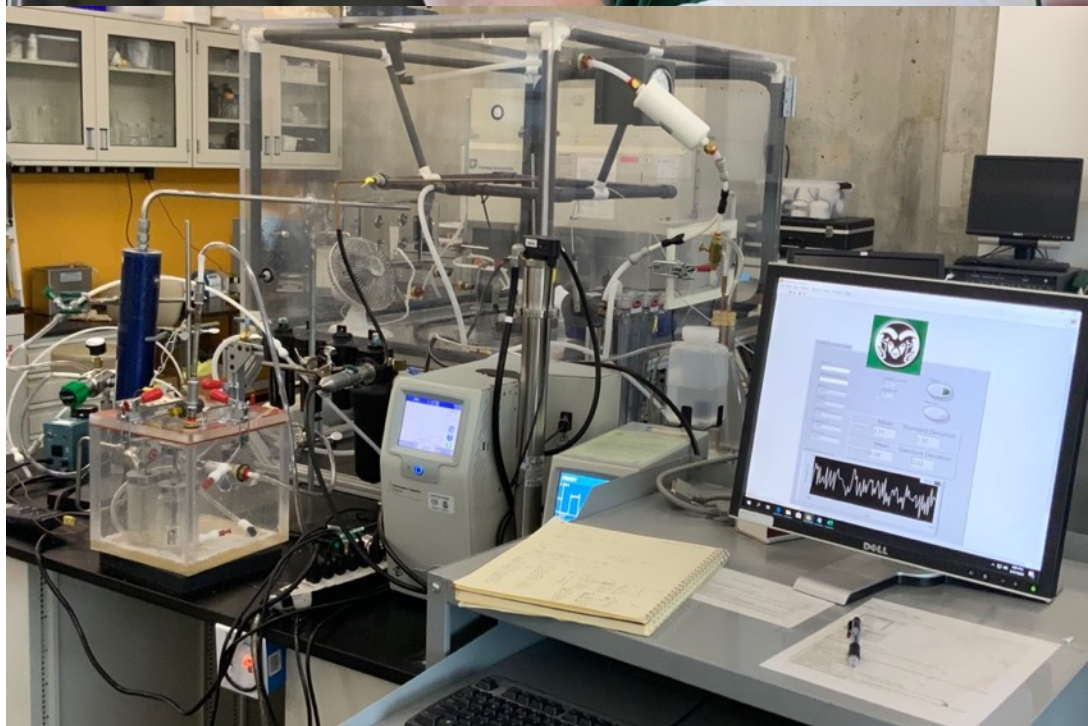


Saarinen et al. (2016) PLOS ONE.
https://doi.org/10.1371/journal.pone.0130667

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 300 different mask designs tested as of 1 Dec 20



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

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

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

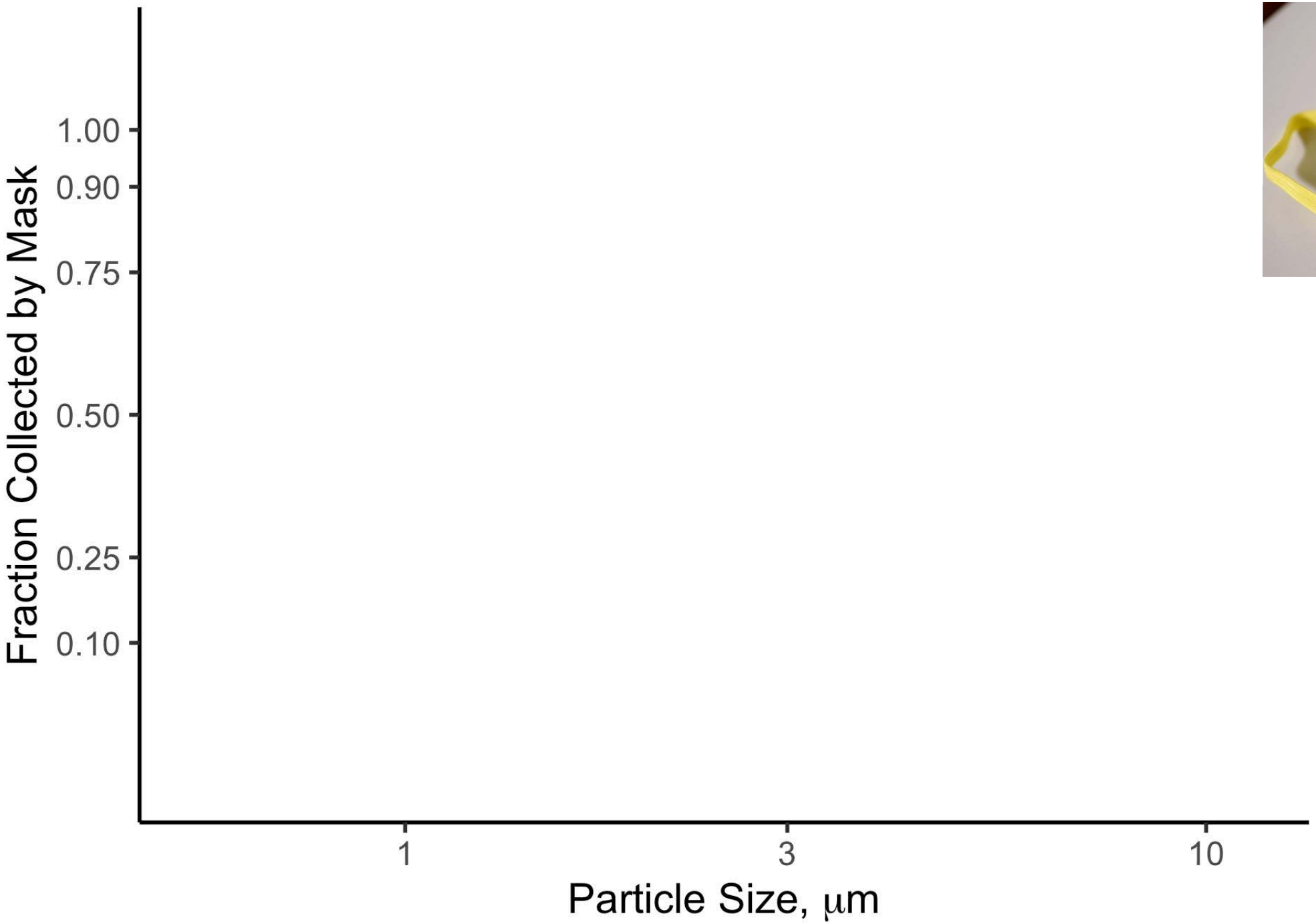
"Looks" can be deceiving!

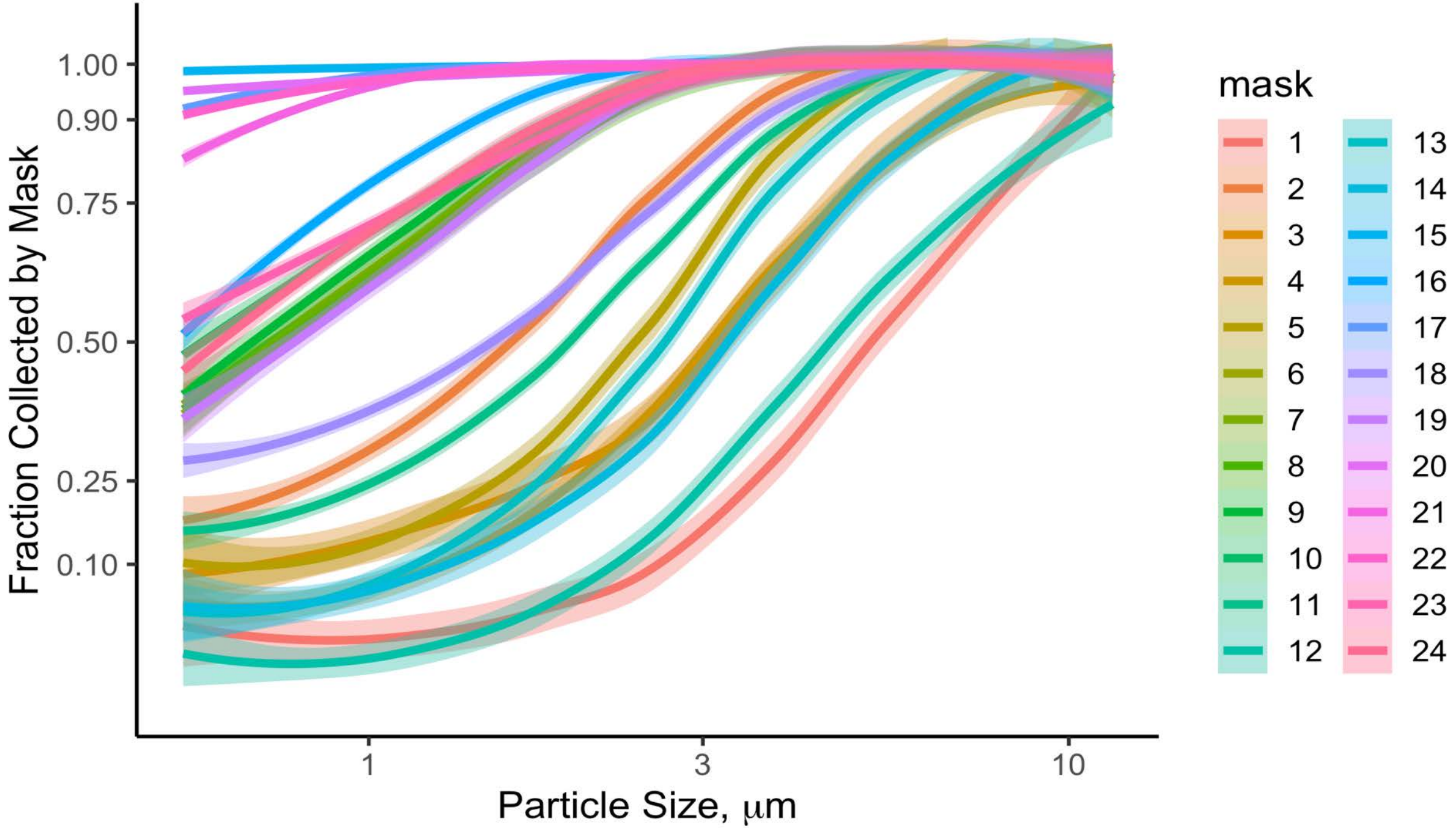
* https://www.cdc.gov/niosh/npptl/respirators/testing/default.html

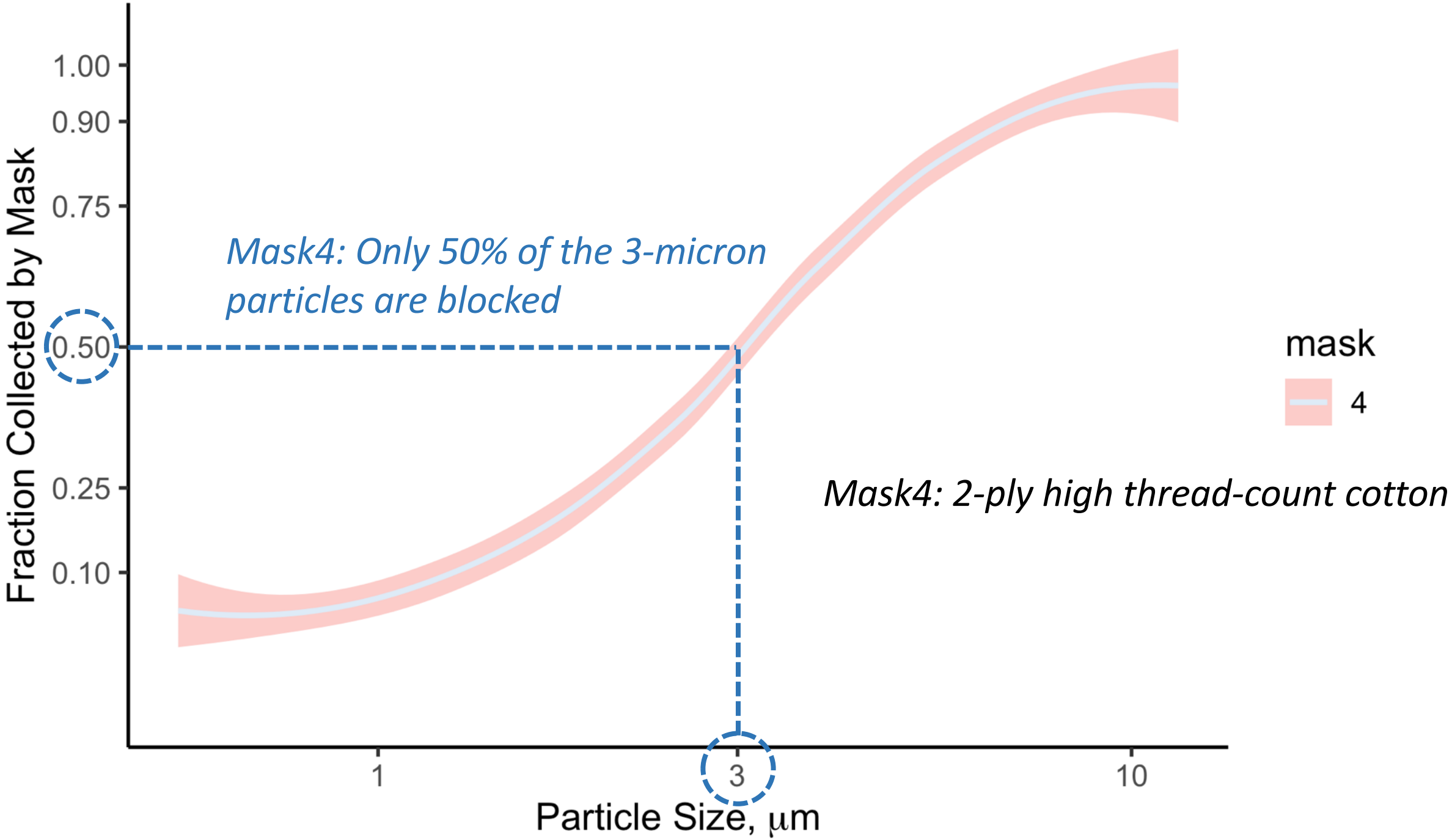
N95s are great if you can get them *(but you can't)* so what about cloth masks?

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

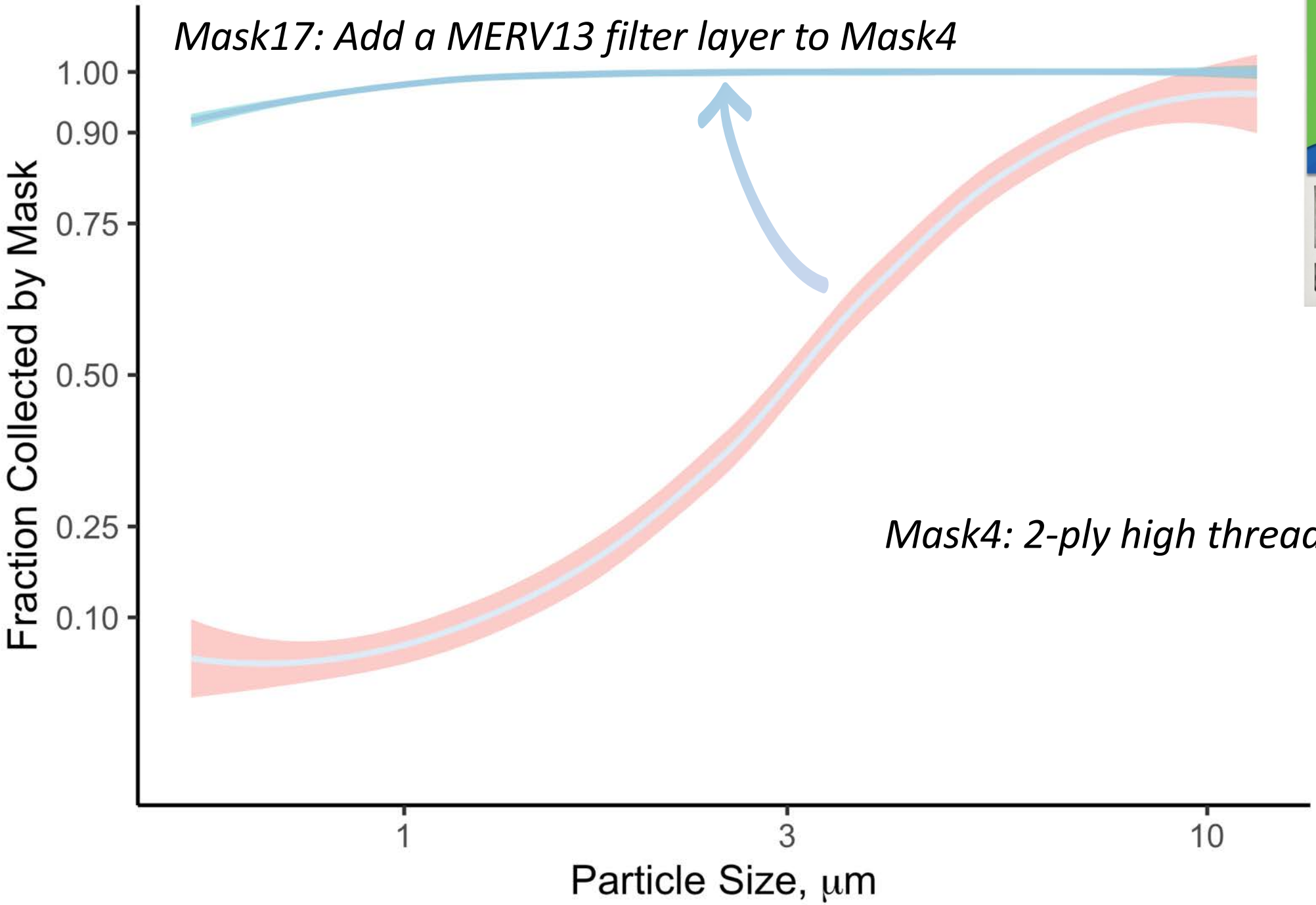

WARNING
N95
3M 8210Plus


Fraction Collected by Mask
1.00
0.90
0.75
0.50
0.25
0.10
1
3
10
Particle Size, μm
mask
N95

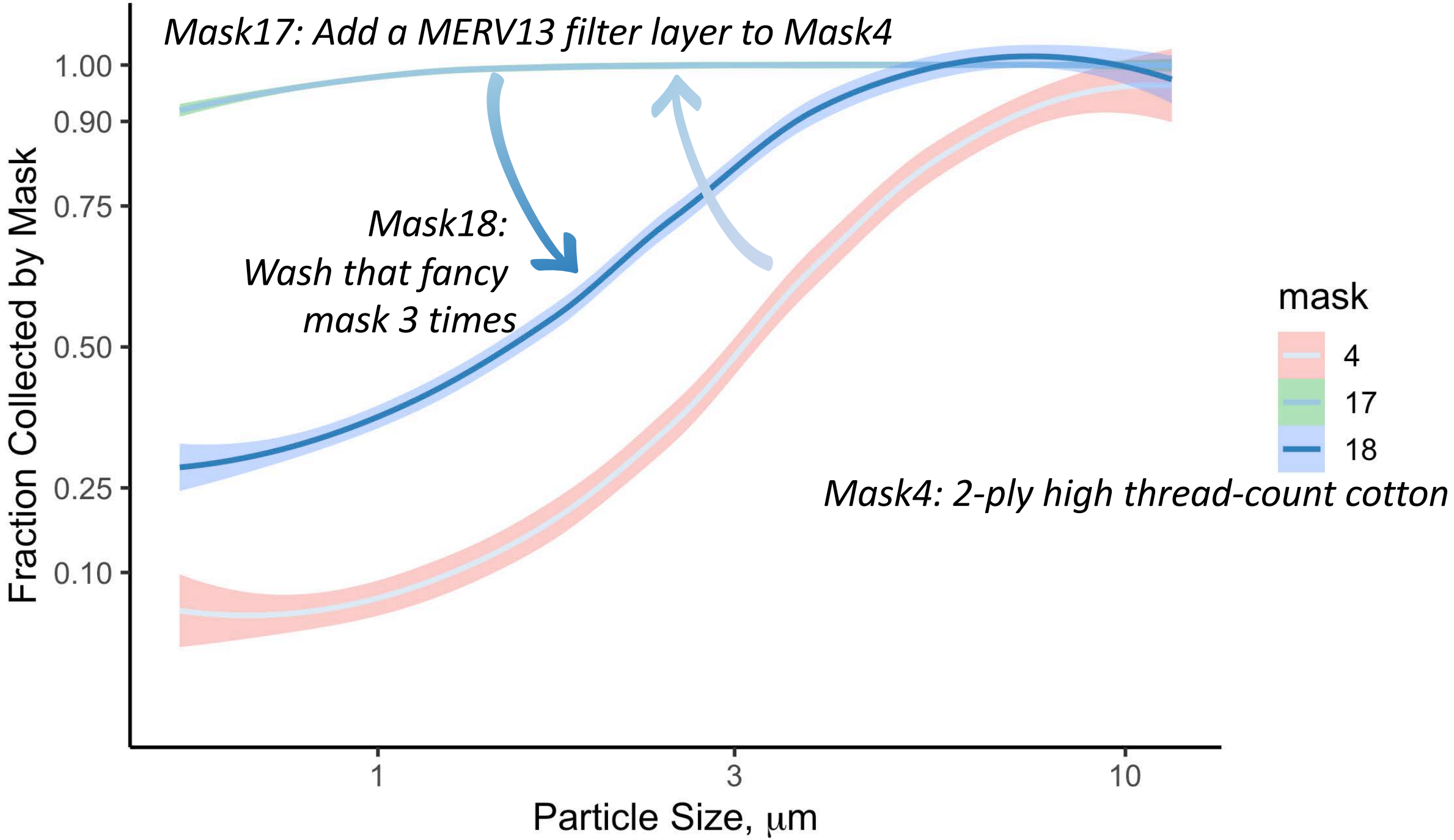

Fraction Collected by Mask
1.00
0.90
0.75
0.50
0.25
0.10
1
3
10
Particle Size, μm
mask
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24


1.00
0.90
0.75
0.50
0.25
0.10
Fraction Collected by Mask
Mask4: Only 50% of the 3-micron particles are blocked
mask
4
Mask4: 2-ply high thread-count cotton
1
3
10
Particle Size, µm

Mask17: Add a MERV13 filter layer to Mask4



Mask4: 2-ply high thread-count cotton


Mask17: Add a MERV13 filter layer to Mask4
Mask18:
Wash that fancy
mask 3 times
Mask4: 2-ply high thread-count cotton
Fraction Collected by Mask
1.00
0.90
0.75
0.50
0.25
0.10
1
3
10
Particle Size, μm
mask
4
17
18

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 ★

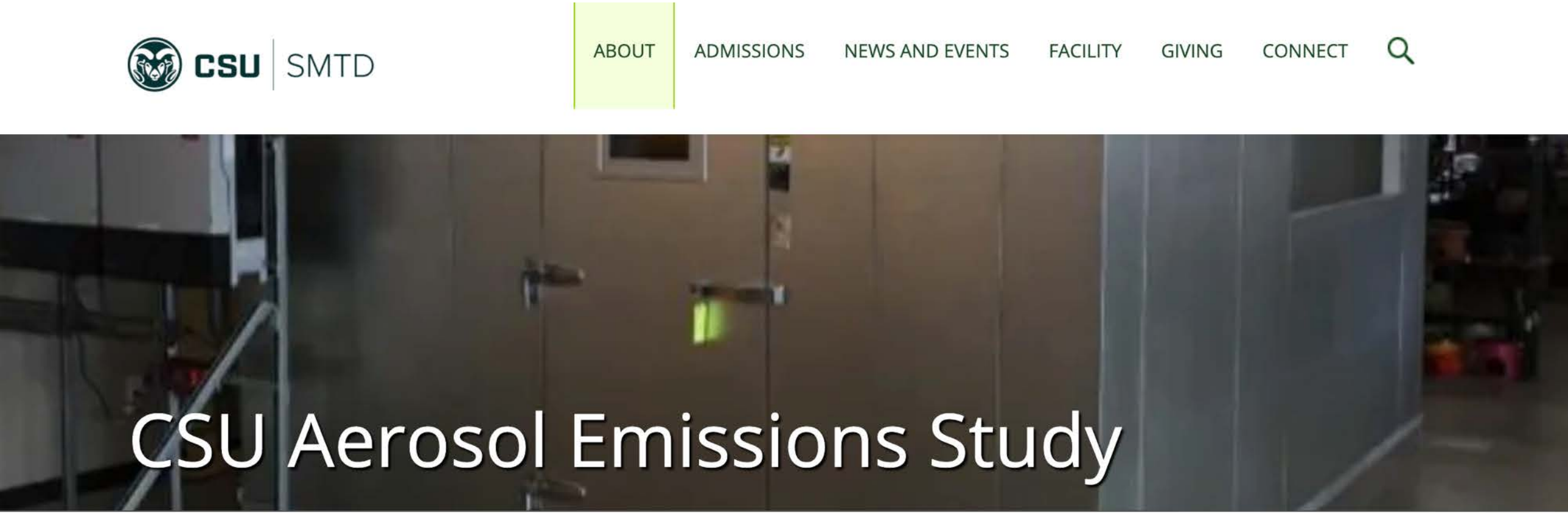
Beware the half-mast-maskers. Photo by Marcel Strauß on Unsplash. Cropped by author.

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 though it?
3. **Breathability**
   - How easy is it to draw air through the mask?
4. **Compliance**
   - Are you doing what was asked of you?

https://smtd.colostate.edu/



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

Experimental Design

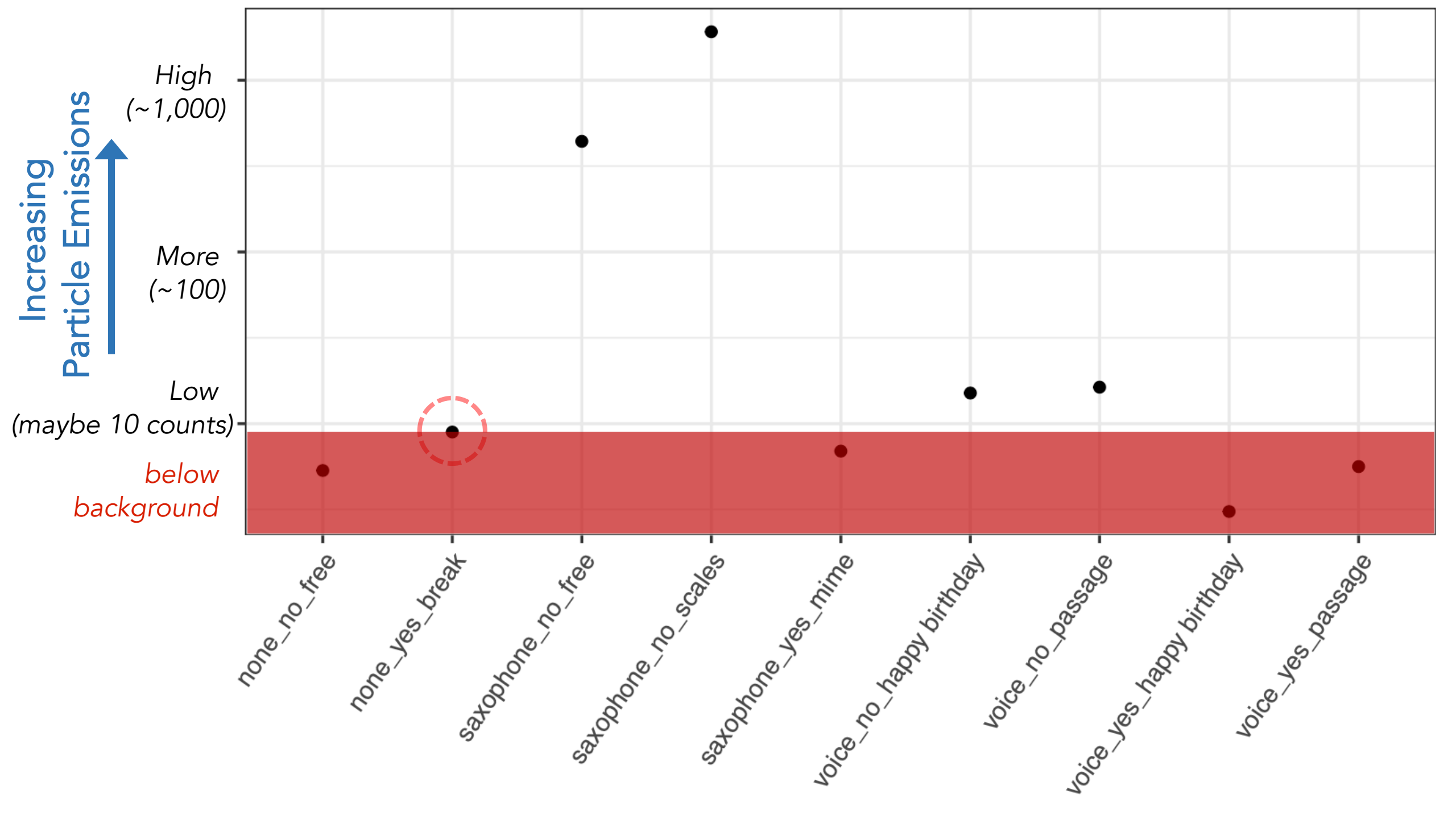
- 100 volunteers over ~~3~~ 6 months (~2/day)
  - Open to ages 12 and up; all genders
  - ~28 singers, actors, dancers
  - ~72 instrumentalists: bassoon, clarinet, euphonium, flute, French horn, trumpet, trombone, saxophone, and possibly others
- Everybody speaks, sings and "does their thing"
  - With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

Photo credits: CSU SOURCE, Erik Hardy

SET Facility: A Musical Class 100 Cleanroom

SET Facility: A Musical Class 100 Cleanroom


Increasing
Particle Emissions
High
(~1,000)
More
(~100)
Low
(maybe 10 counts)
below
background
none_no_free
none_yes_break
saxophone_no_free
saxophone_no_scales
saxophone_yes_mime
voice_no_happy birthday
voice_no_passage
voice_yes_happy birthday
voice_yes_passage

Ongoing Instrument Results (particles > 0.3 μm)

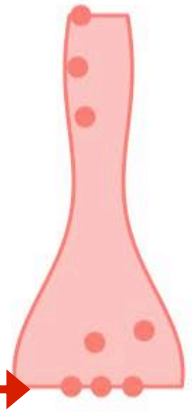
Relative Particle Emissions

highest

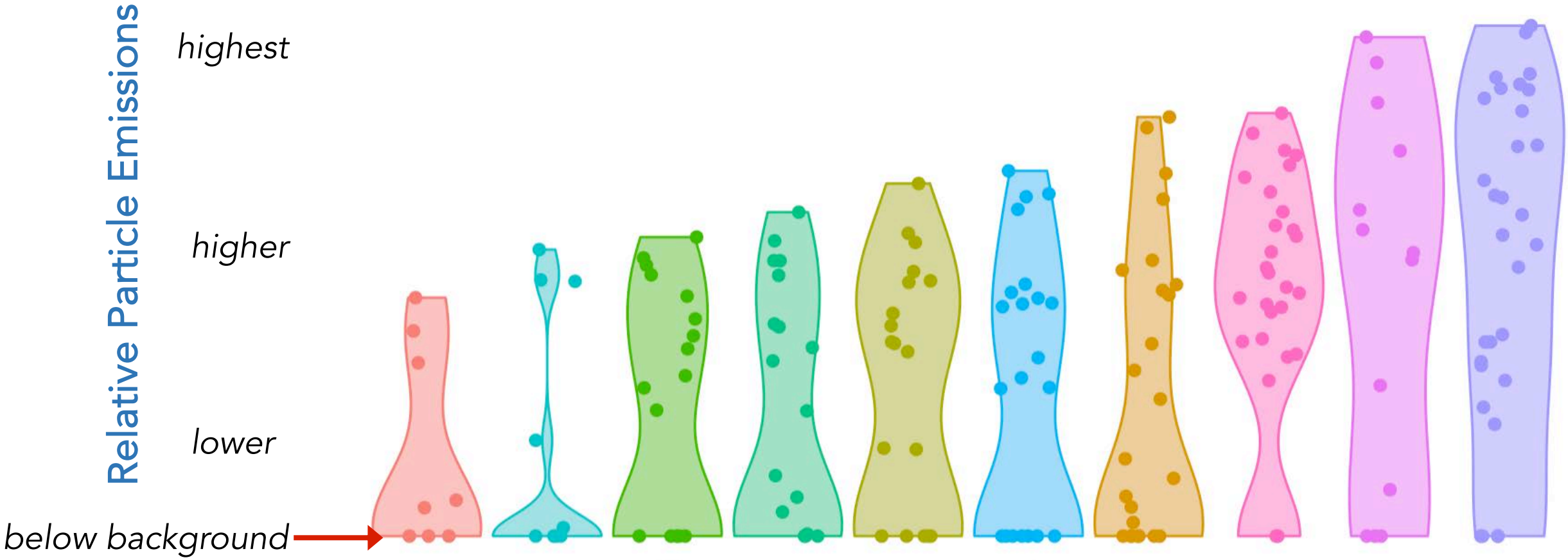
higher

lower

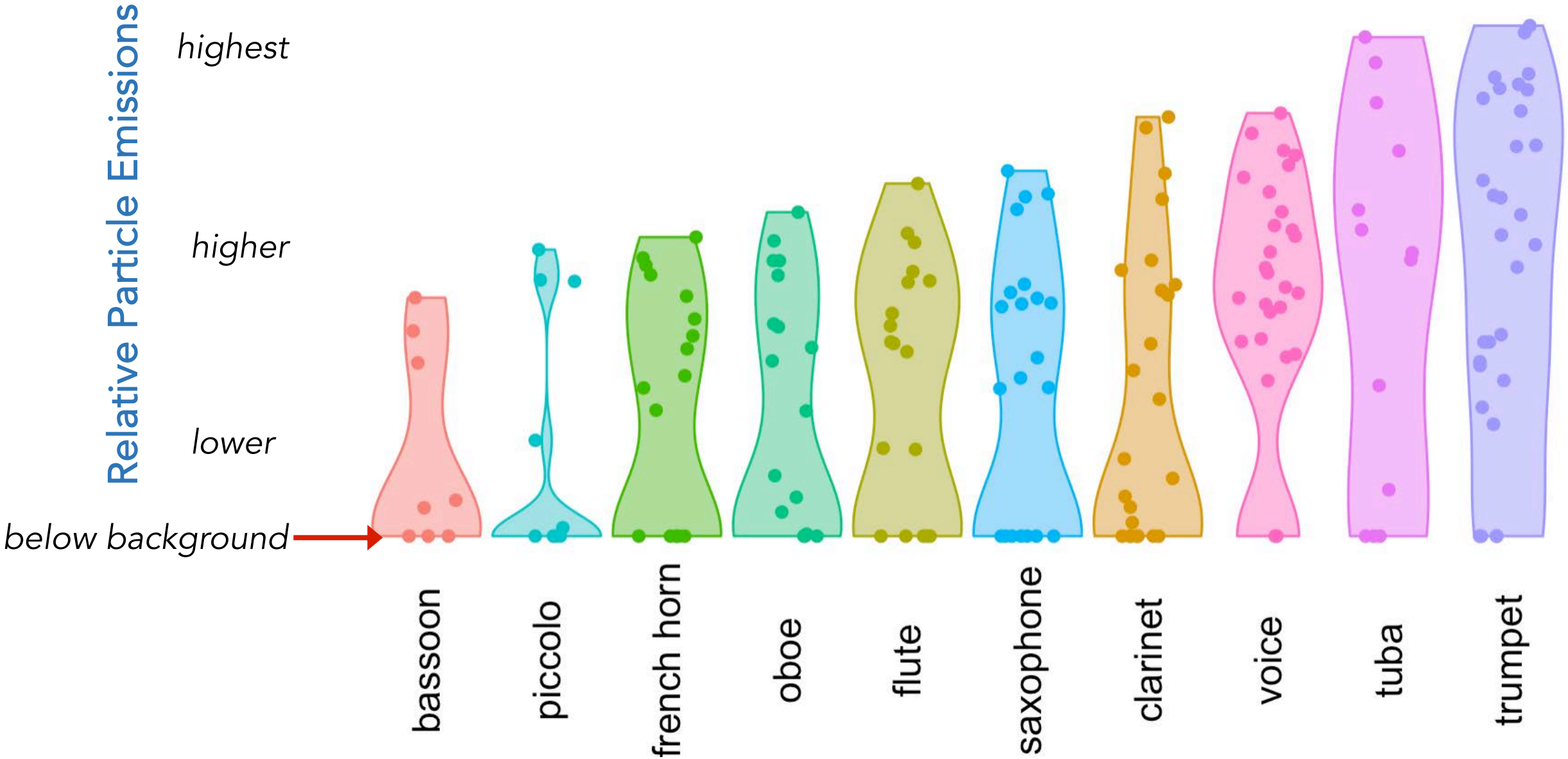
below background



Ongoing Instrument Results (particles > 0.3 μm)

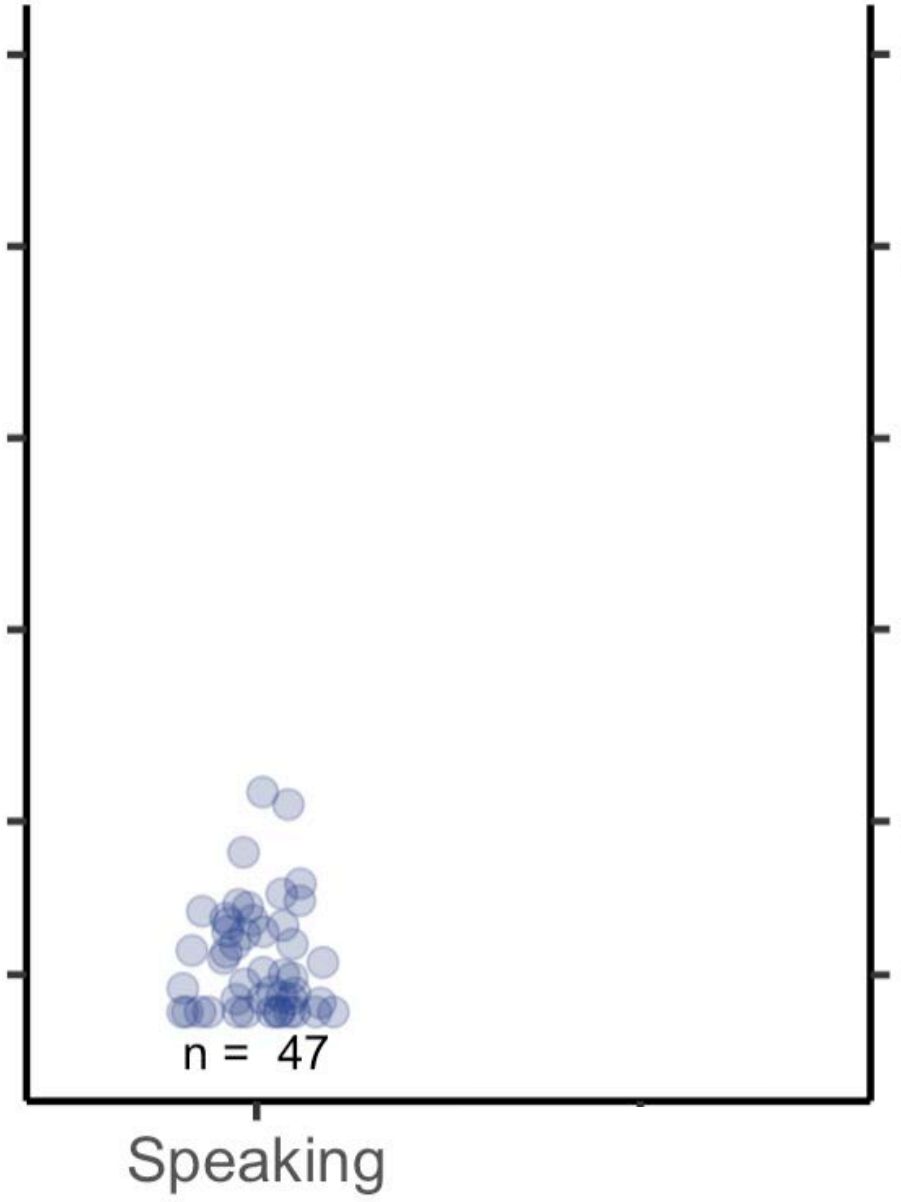


Ongoing Instrument Results (particles > 0.3 μm)

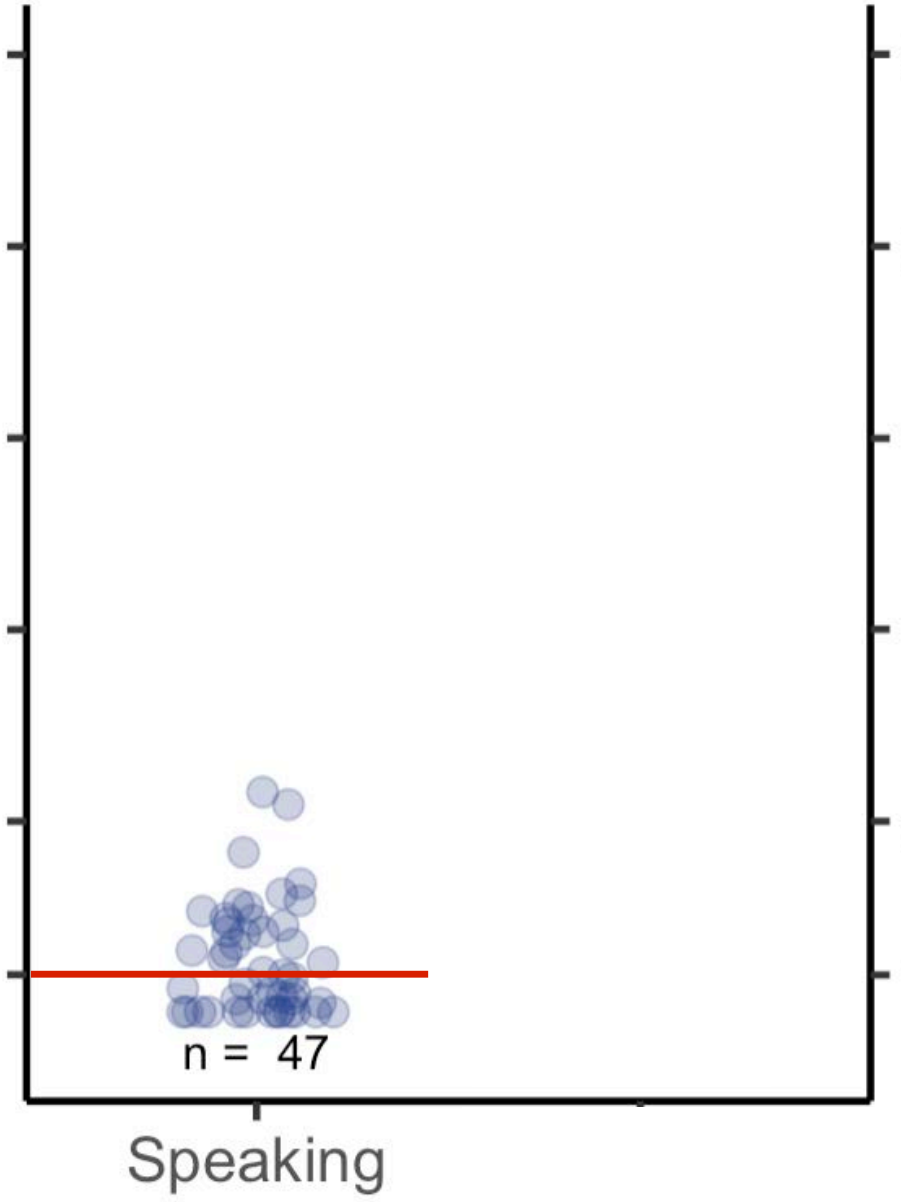


Ongoing Vocal Results (particles > 0.3 μm)

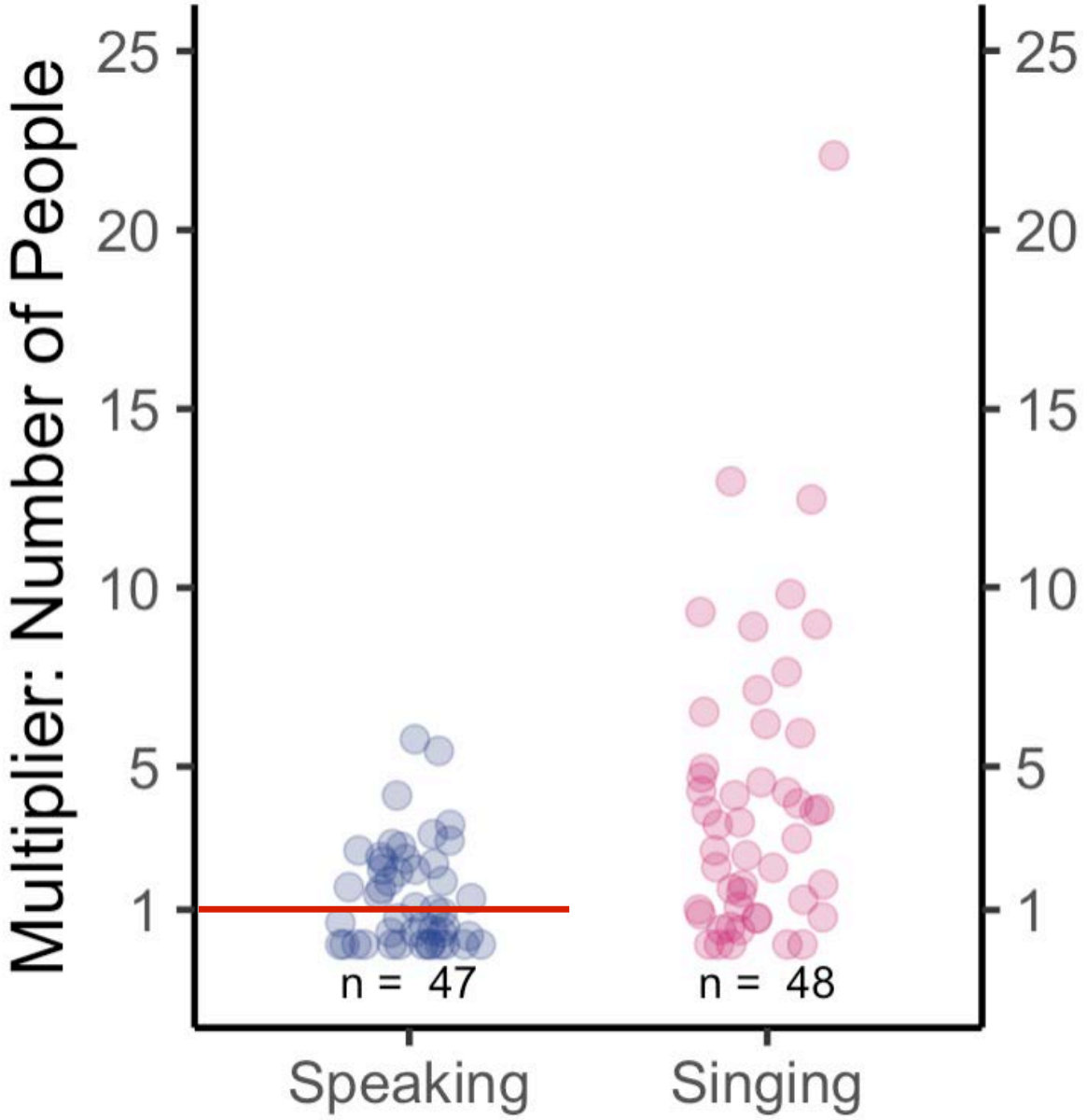
Ongoing Vocal Results (particles > 0.3 μm)



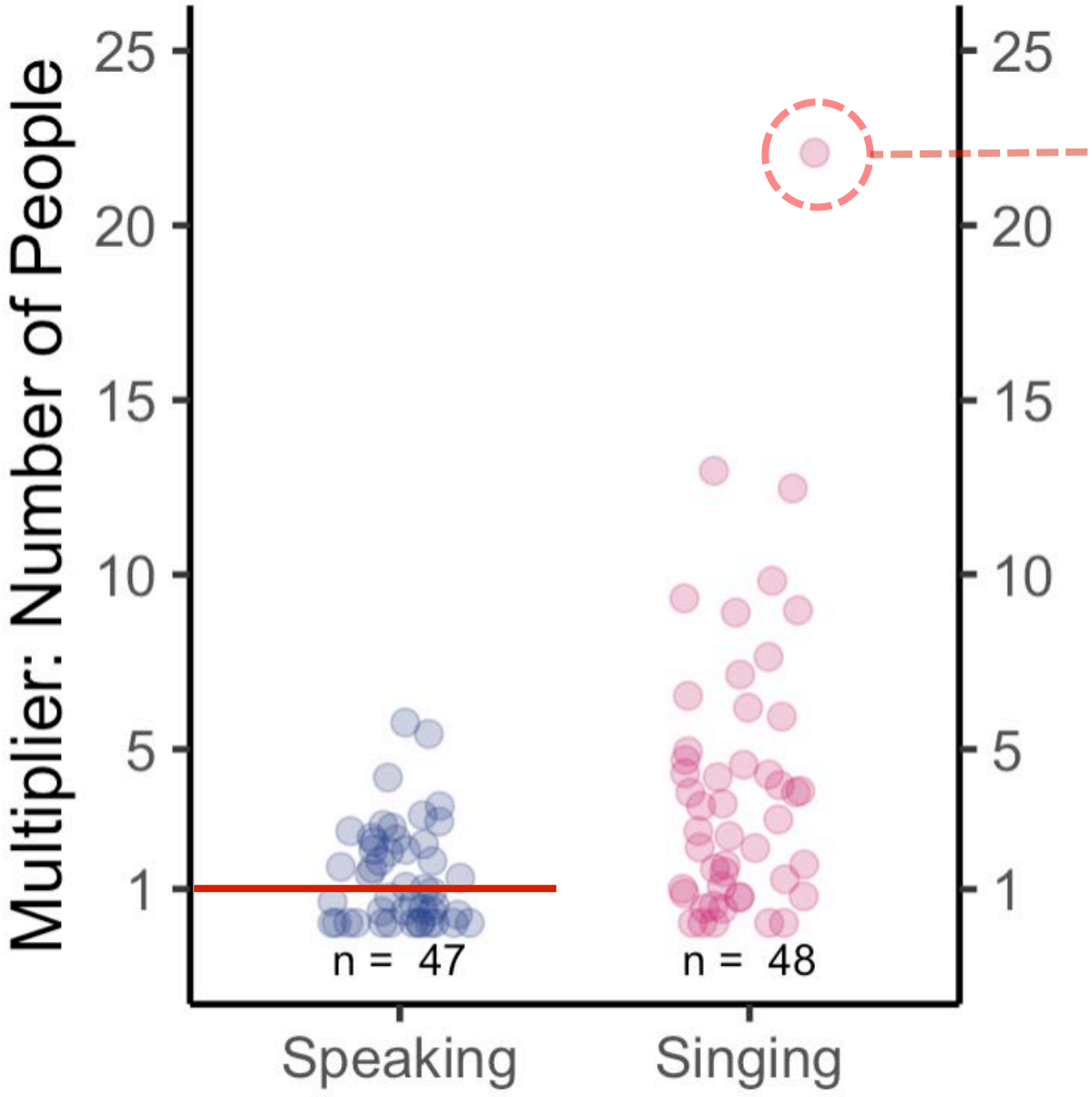
Ongoing Vocal Results (particles > 0.3 μm)



Ongoing Vocal Results (particles > 0.3 μm)

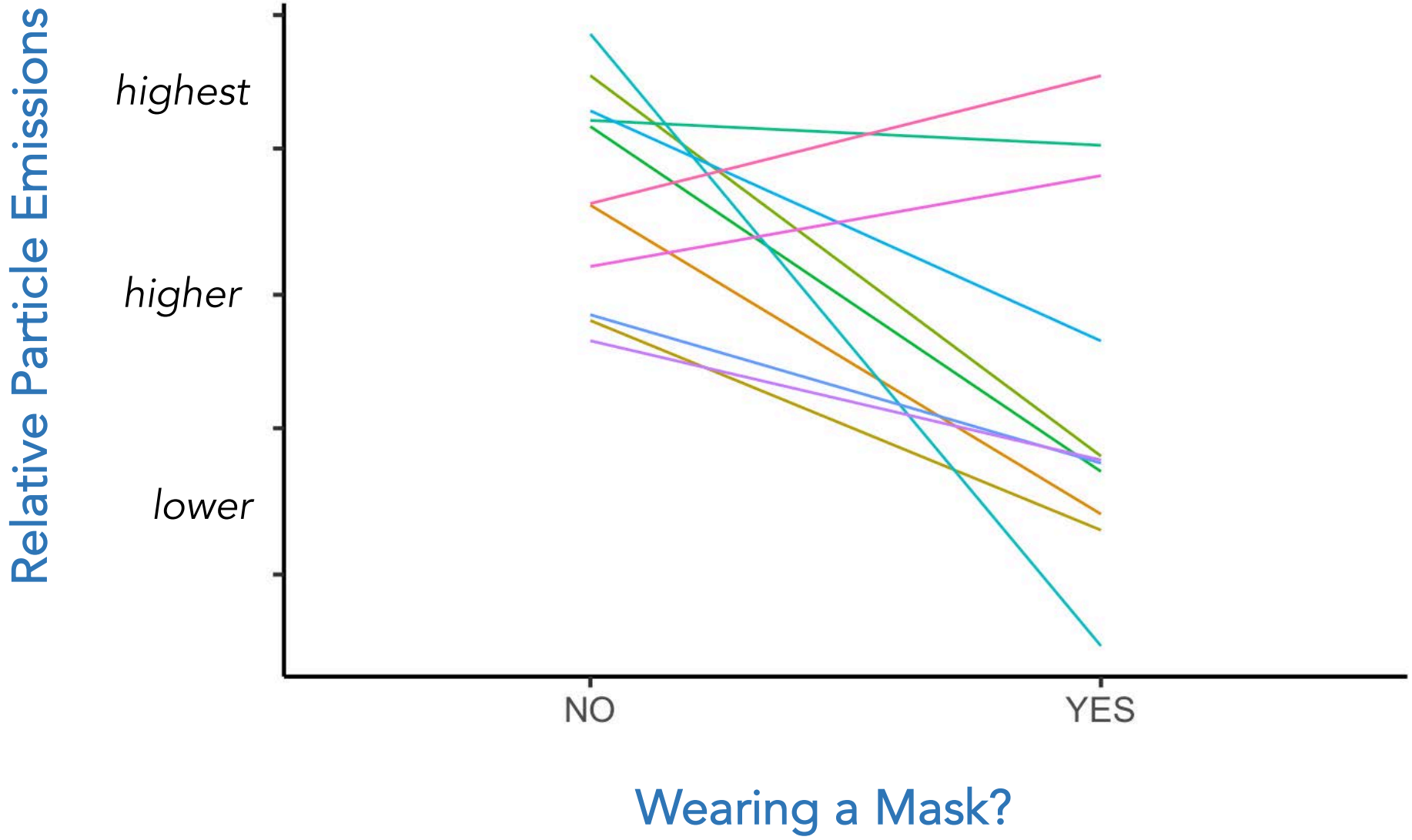


Ongoing Vocal Results (particles > 0.3 μm)



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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