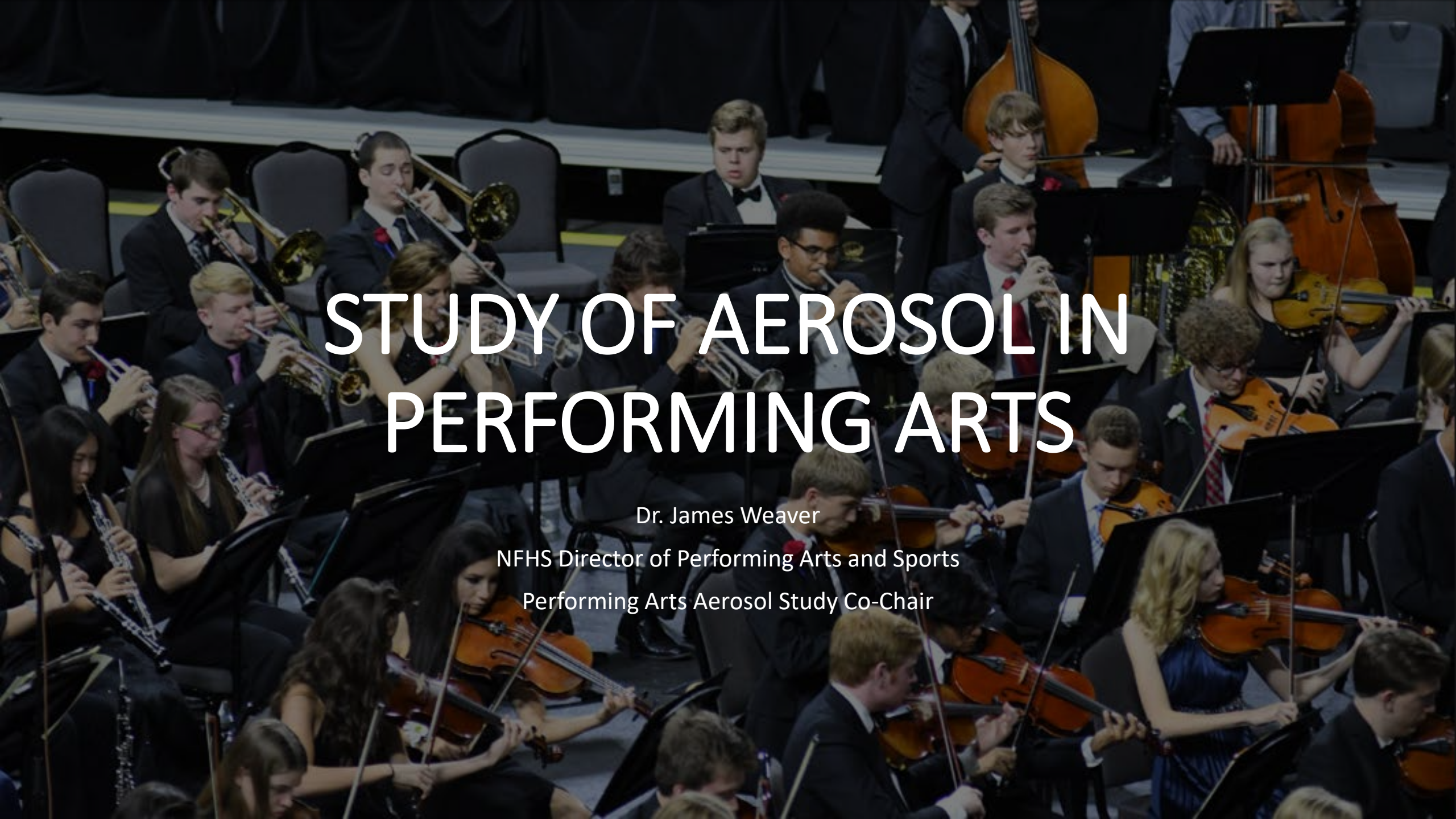


STUDY OF AEROSOL IN PERFORMING ARTS

Dr. James Weaver

NFHS Director of Performing Arts and Sports

Performing Arts Aerosol Study Co-Chair

STUDY CHAIRS

Dr. James Weaver - NFHS Director of Performing Arts and Sports

Dr. Mark Spede – CBDNA President, Director of Bands, Clemson University

LEAD FUNDERS

NAMM Foundation®

NFHS NATIONAL FEDERATION OF STATE HIGH SCHOOL ASSOCIATIONS

CBDNA College Band Directors National Association

D'Addario Foundation

CONTRIBUTING ORGANIZATIONS

CALIFORNIA YOUTH SYMPHONY

Indiana State School Music Association

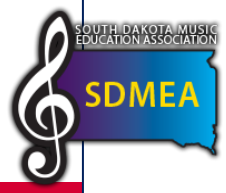
International Double Reed Society

National Association for Music Education

NEW YORK STATE BAND DIRECTORS ASSOCIATION

Church Music Publishers Association

CONTRIBUTING ORGANIZATIONS



CONTRIBUTING COLLEGIATE CONFERENCE BAND ASSOCIATIONS AND UNIVERSITIES

Collegiate Conference Band Associations:
ACC Band Directors Association
Big 12 Band Directors Association
Big 10 Band Directors Association
PAC 12 Band Directors Association
SEC Band Directors Association

Individual School Band Programs:
Clemson University Bands
Linn-Benton Community College Bands
University of California Los Angeles (UCLA) Bands
University of Utah Bands

SUPPORTING ORGANIZATIONS

American School Band Directors Association (ASBDA)
American String Teachers Association (ASTA)
Arts Education in Maryland Schools (AEMS)
Association Européenne des Conservatoires/Académies de Musique et Musikhochschulen (AEC)
Buffet et Crampon
Bundesverband der deutschen Musikinstrumentenhersteller e.V
Chicago Children's Choir
Children's Chorus of Washington
Chorus America
Confederation of European Music Industries (CAFIM)
Drum Corps International (DCI)
Educational Theatre Association (EdTA)
European Choral Association - Europa Cantat
HBCU National Band Directors' Consortium
High School Directors National Association (HSBDNA)
International Conductors Guild
International Society for Music Education
League of American Orchestras
Louisiana Music Educators Association (LMEA)
MidWest Clinic
Minority Band Directors National Association
Music Industries Association
Musical America Worldwide
National Dance Education Organization (NDEO)
National Flute Association (NFA)
National Guild for Community Arts Education
Percussive Arts Society (PAS)
Save the Music Foundation
United Sound
WGI Sport of the Arts

LEAD RESEARCHERS

Dr. Shelly Miller
University of Colorado Boulder

Dr. Jelena Srebric
University of Maryland

RESEARCH TEAM

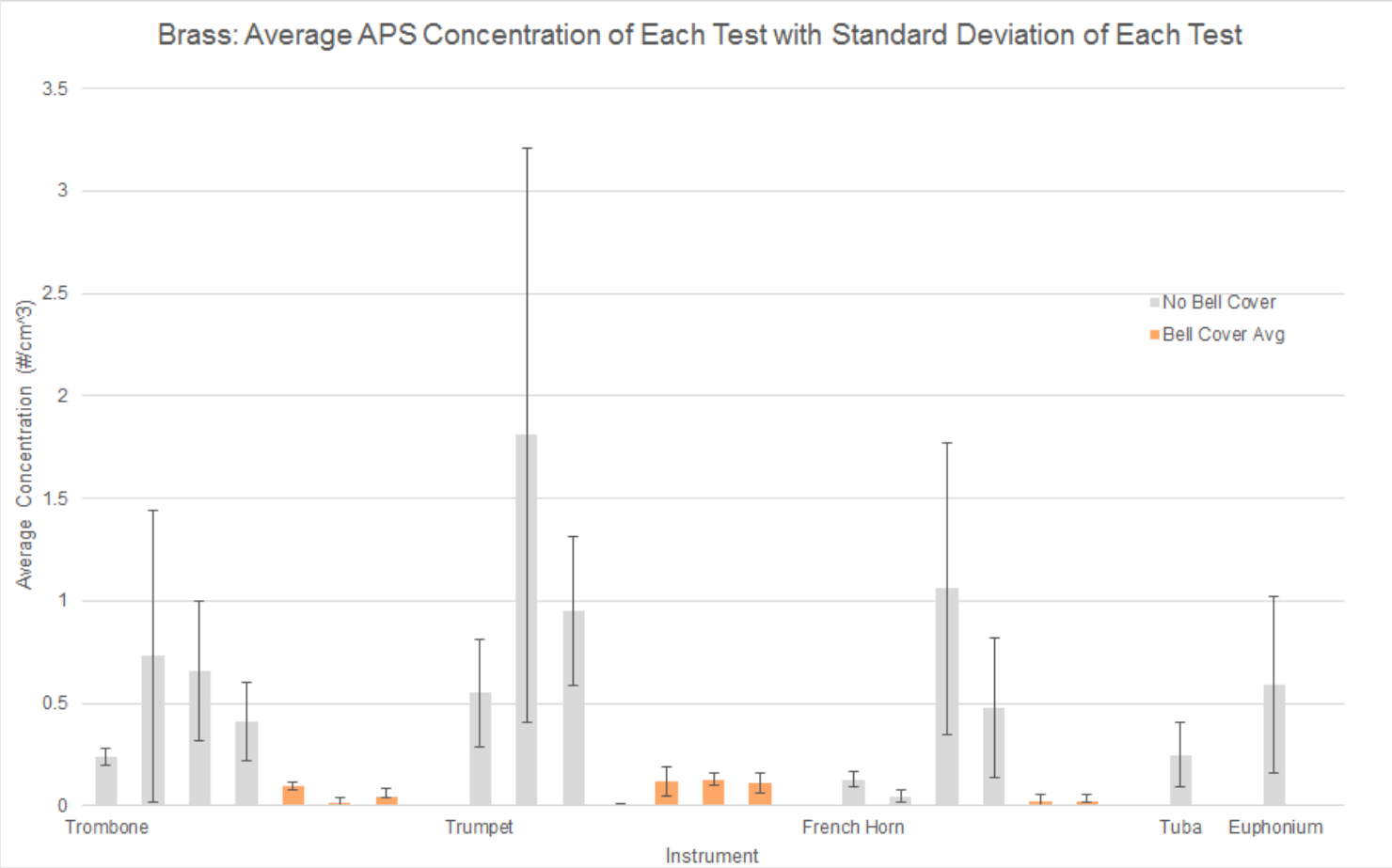
University of Colorado Boulder

- Professor Jean Hertzberg
- Abhishek Kumar
- Dr. Sameer Patel
- Tehya Stockman
- Professor Darin Toohey
- Professor Marina Vance

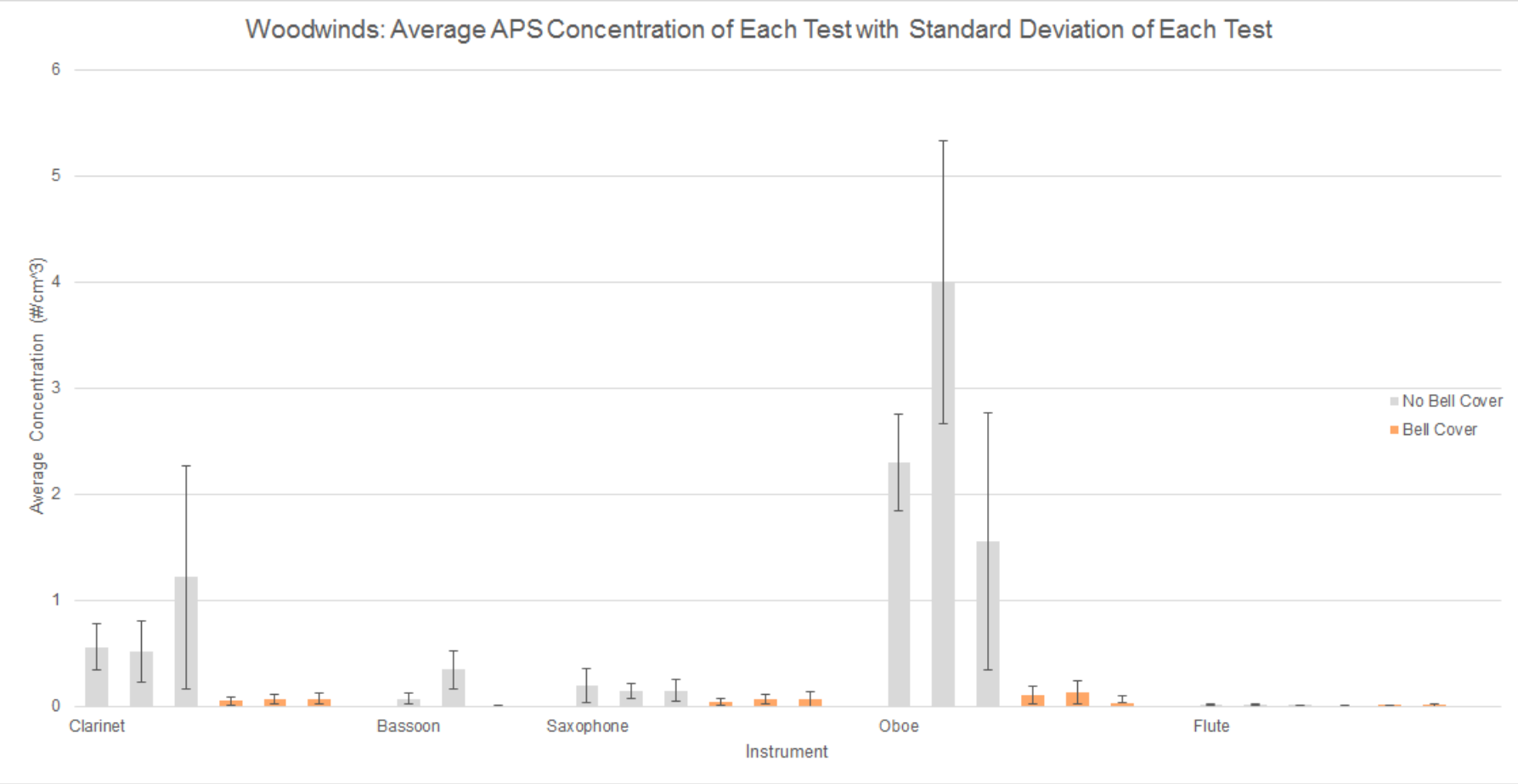
University of Maryland, Center for Sustainability in the Built Environment

- Nicholas Mattise
- Sebastian Romo
- Lingzhe Wang
- Dr. Shengwei Zhu

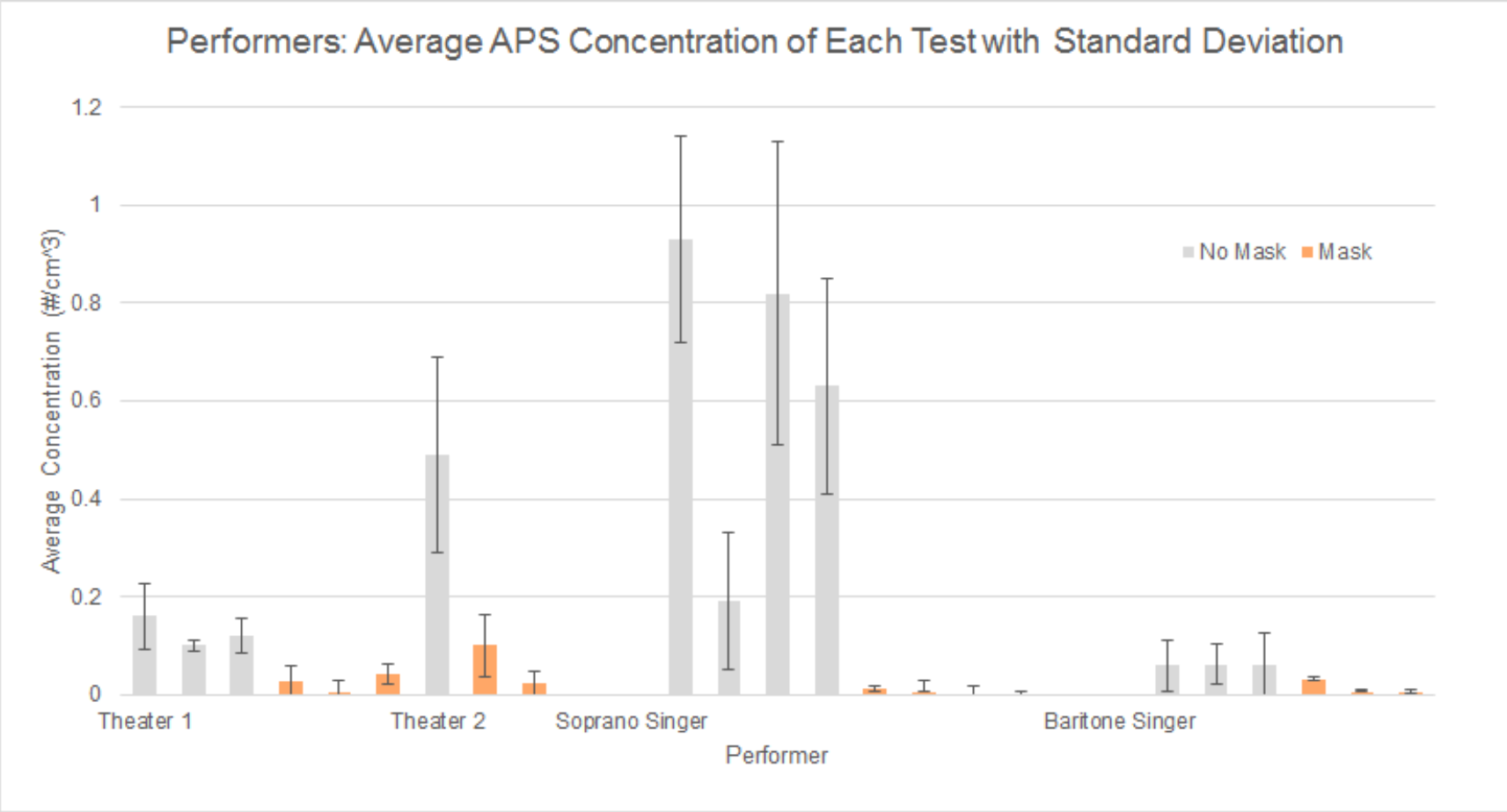
AEROSOL CONCENTRATIONS OVER TIME



AEROSOL CONCENTRATIONS OVER TIME



AEROSOL CONCENTRATIONS OVER TIME



MITIGATION EFFECTIVENESS

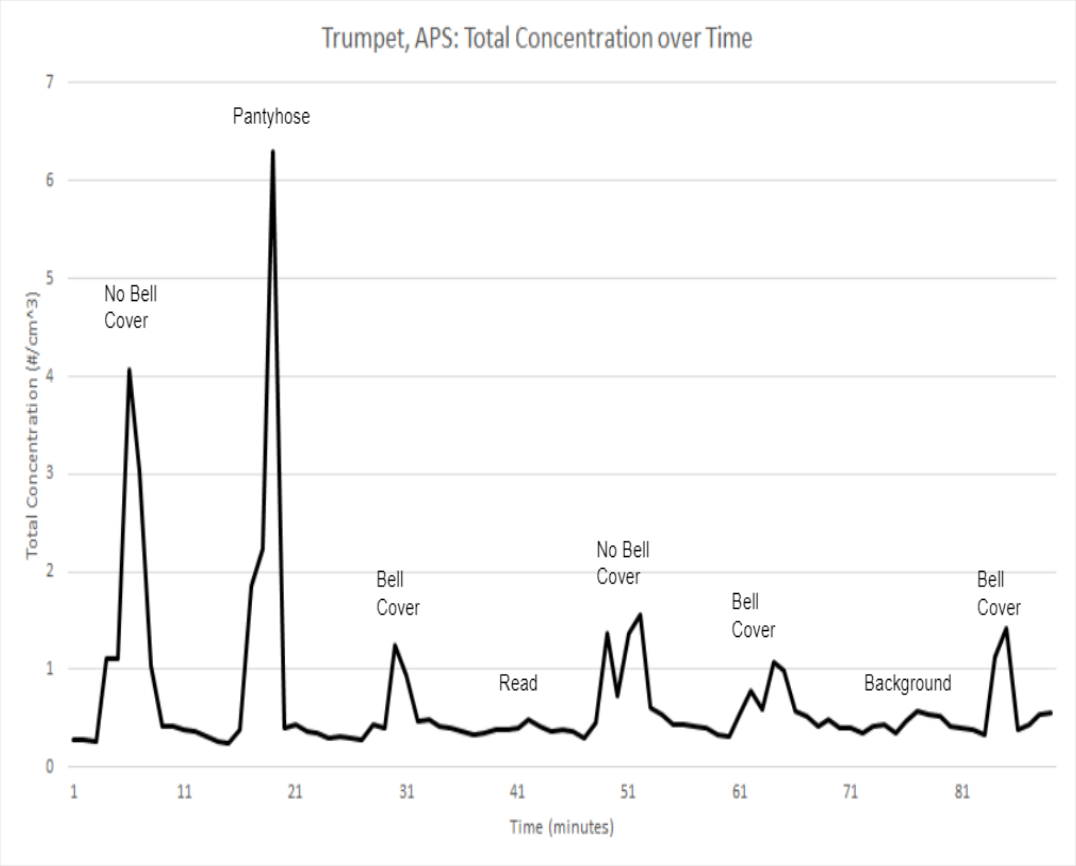
- Sampling performed at the bell does not take into account what is expelled at the keyholes. Bell covers diffuse the air coming out of an instrument bell, causing the plume to not be as concentrated. The samples are also not as concentrated as when playing without a bell cover. The efficiency percentages below are related to the aerosol produced in Appendix A. It is important to identify the reference to the background aerosol levels between Appendix C, to fully understand the depth of the mitigated aerosol release.

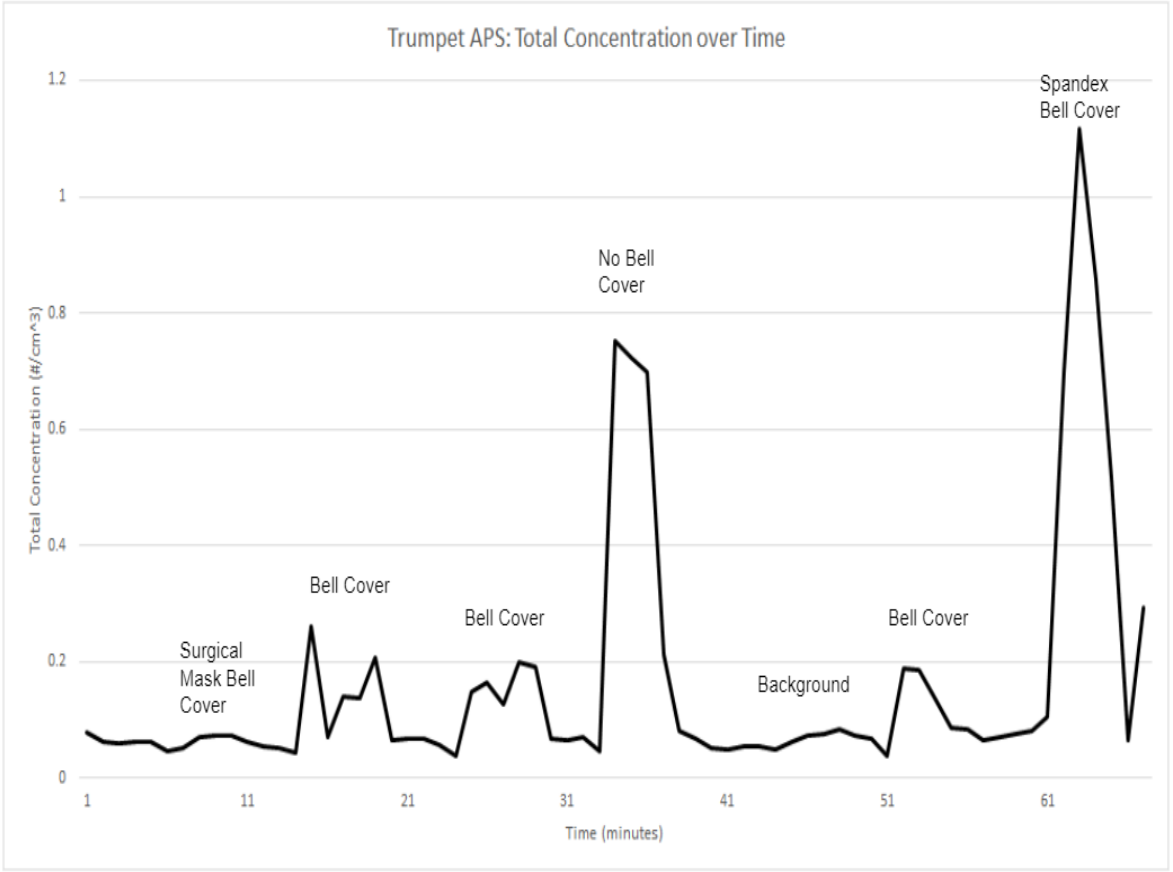
Example A: Saxophone has an overall aerosol release of 0.7 pp cm3 unmitigated and an aerosol release of 0.32 pp cm3 (64% reduction) with a bell cover, placing mitigated saxophone just above background levels of aerosol.

Example B: Oboe has an overall aerosol release of 4.00 pp cm3 unmitigated and an aerosol release of 0.5 pp cm3 (96% reduction) with a bell cover, placing mitigated oboe in line with other mitigated instruments and singers.

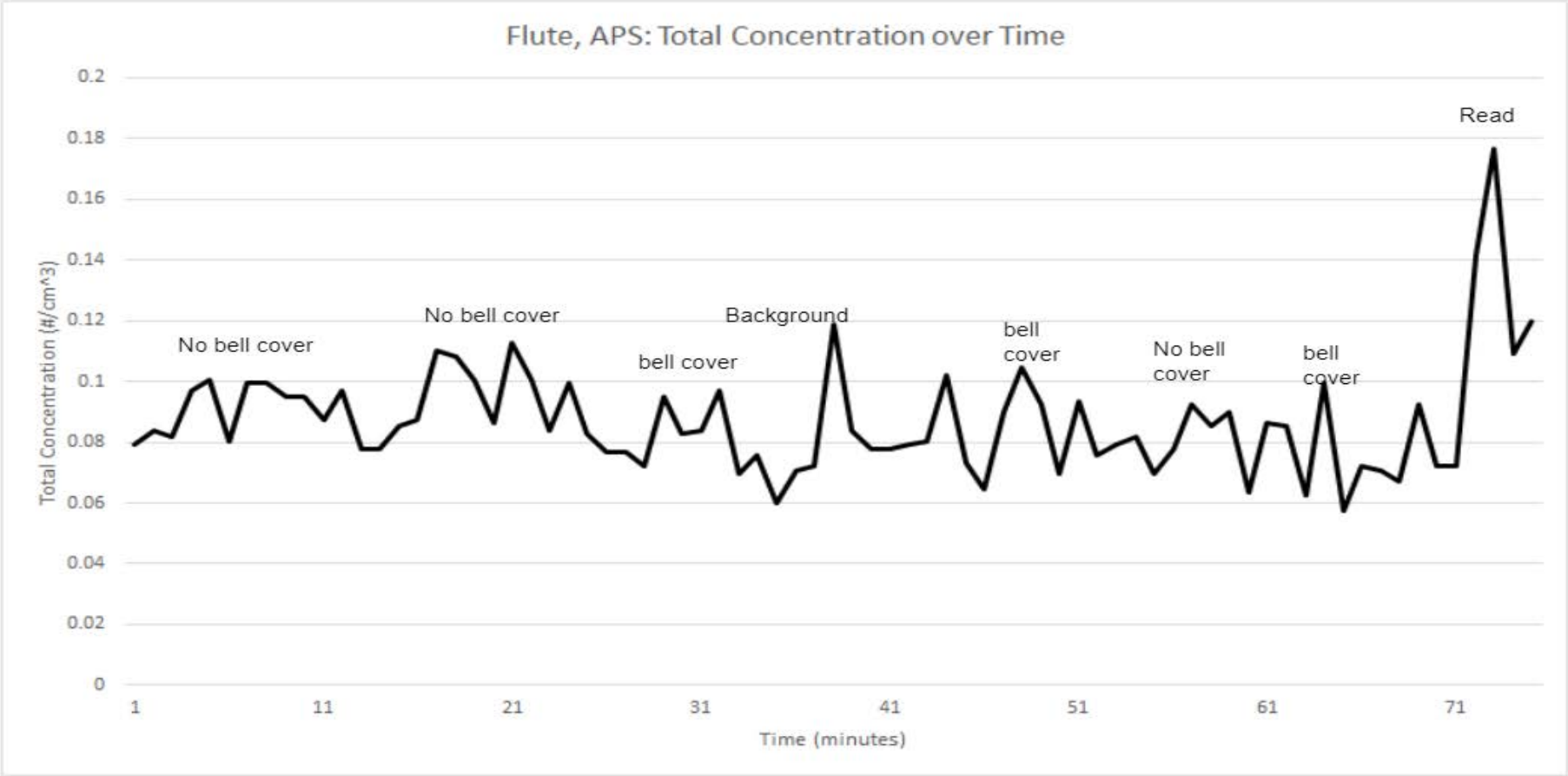
INSTRUMENT	EFFICIENCY CALCULATED, SAMPLED AT BELL / MOUTH
Saxophone	64%
Flute	67%
Baritone Singer*	79%
Theater 1*	80%
Clarinet	87%
Theater 2*	88%
Bassoon	89%
Trombone	89%
Trumpet	92%
French Horn	95%
Oboe	96%
Soprano Singer*	98%

APS DATA OF AEROSOL EMISSIONS - TRUMPET

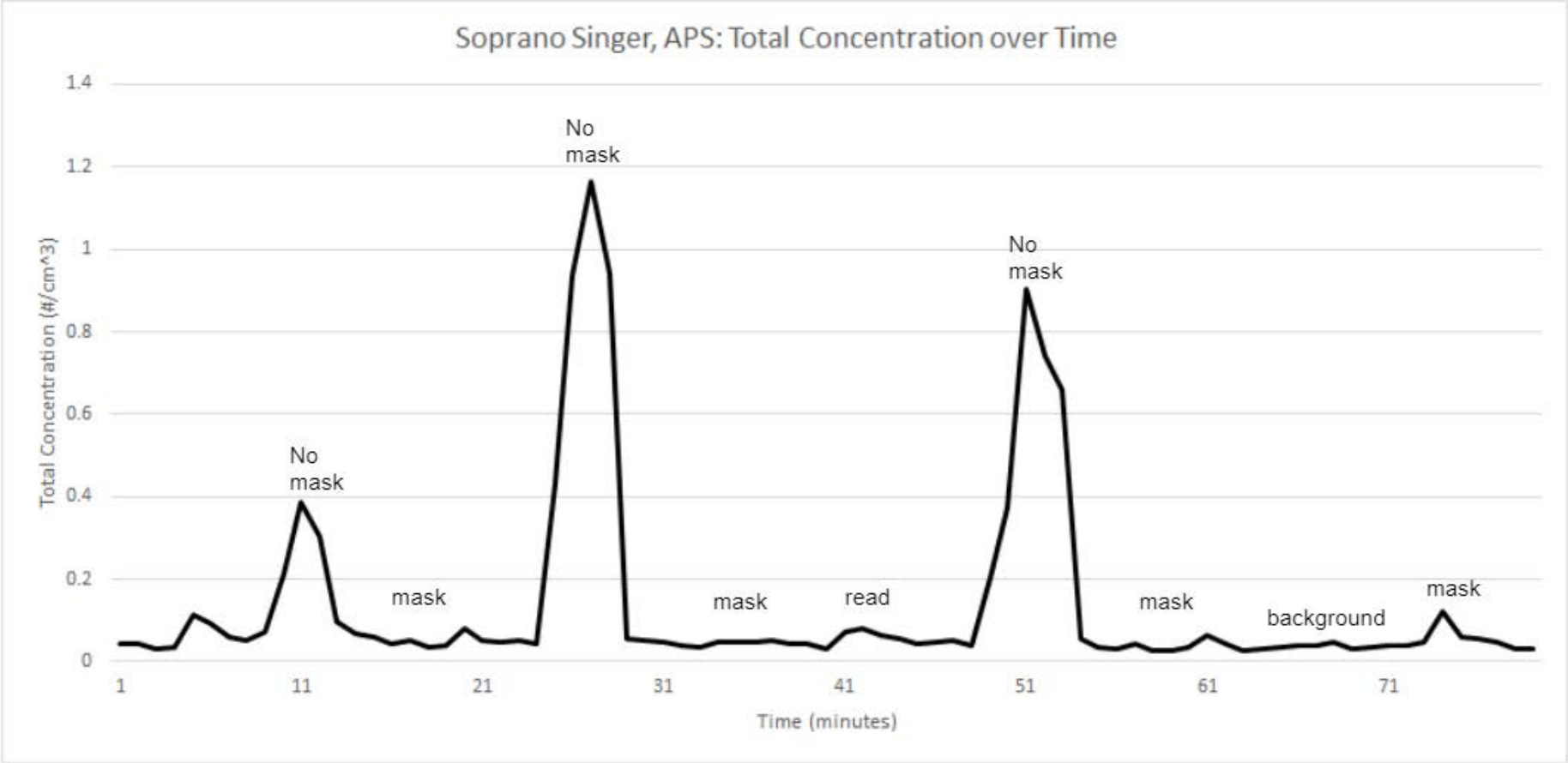




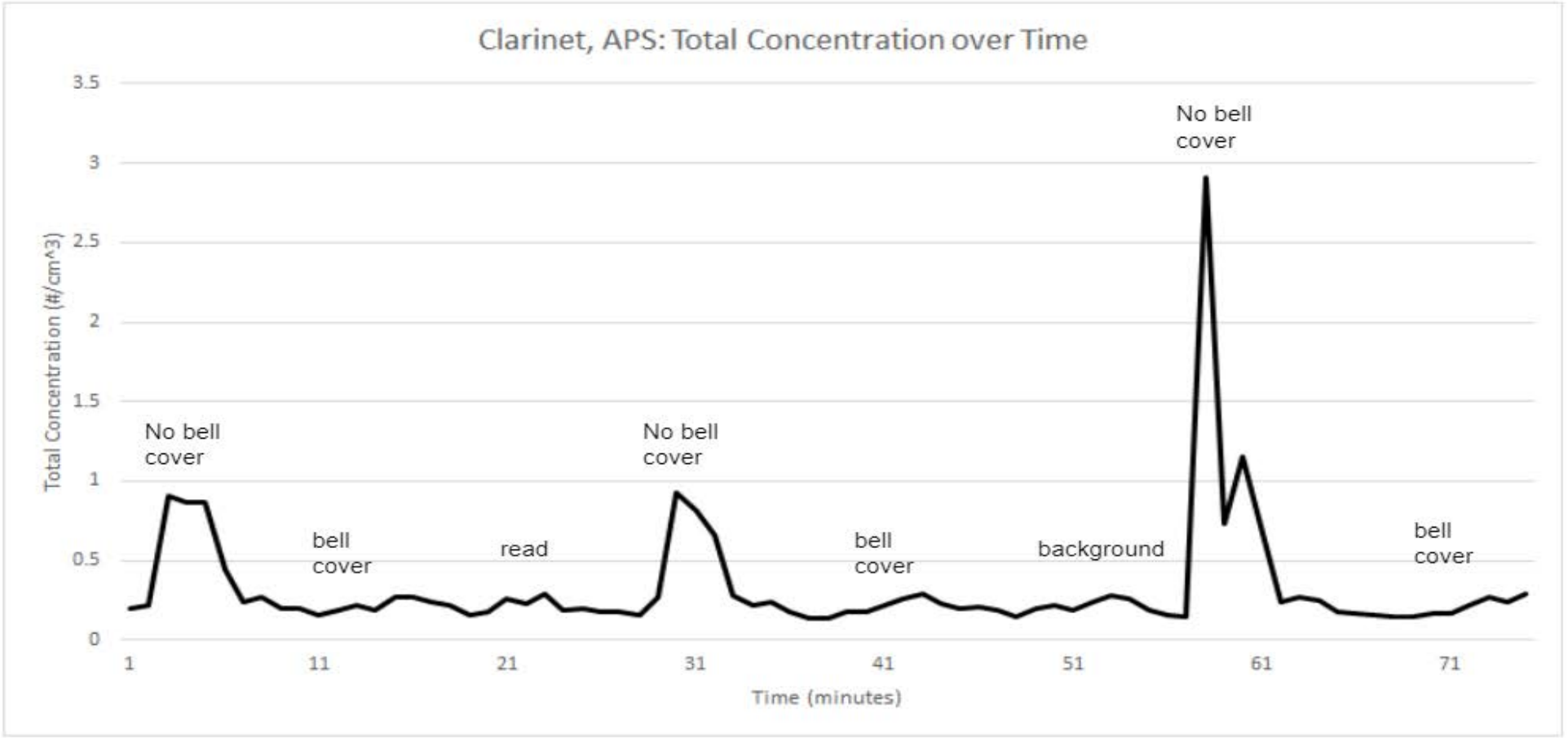
APS DATA OF AEROSOL EMISSIONS - FLUTE



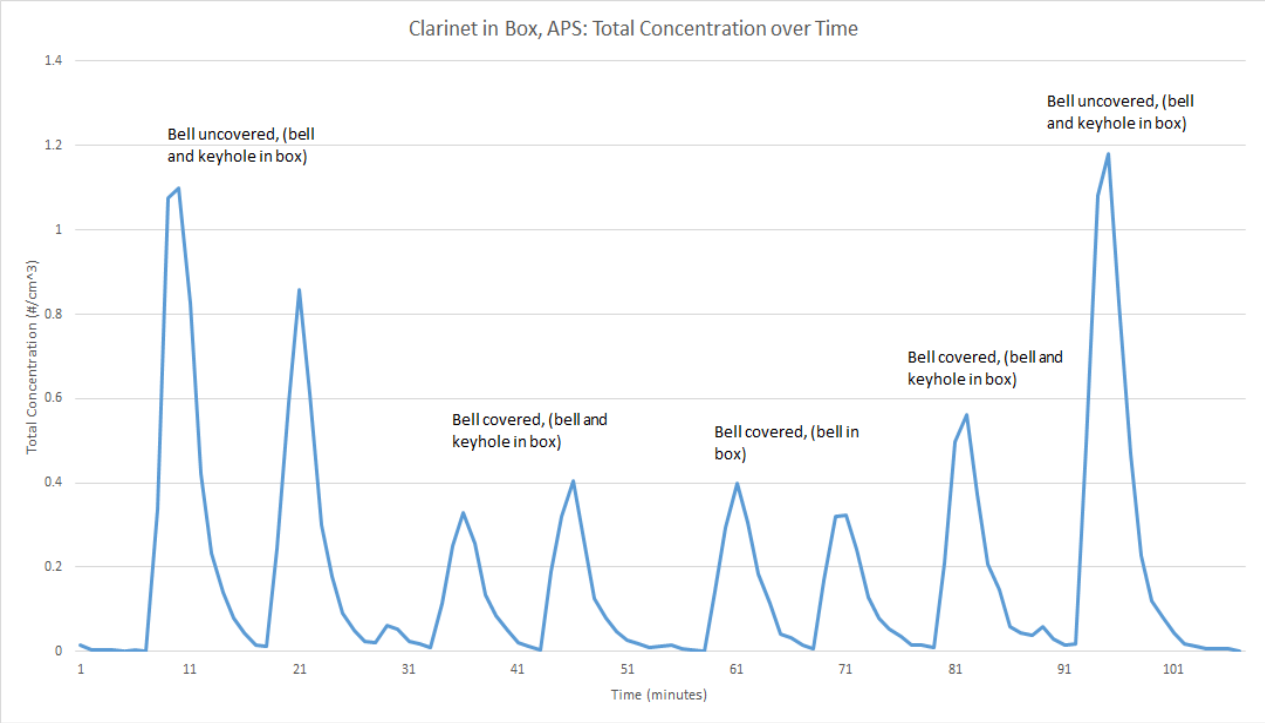
APS DATA OF AEROSOL EMISSIONS - SINGING

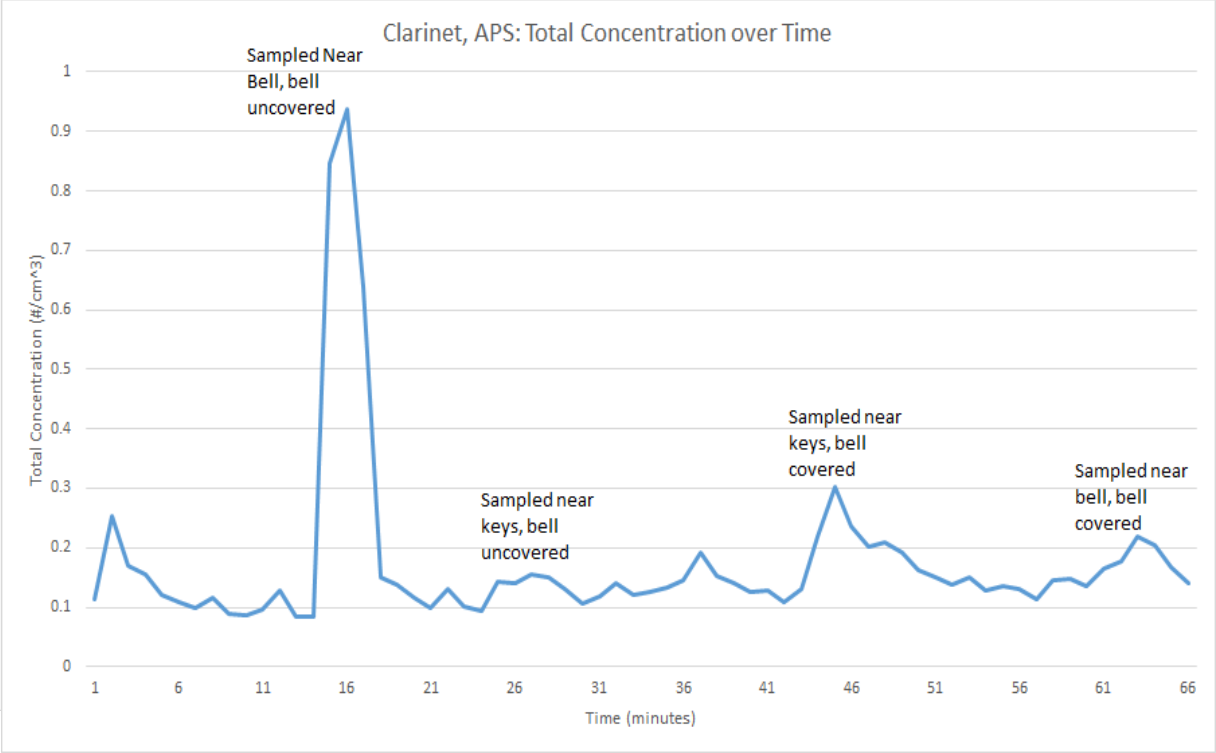


APS DATA OF AEROSOL EMISSIONS - CLARINET

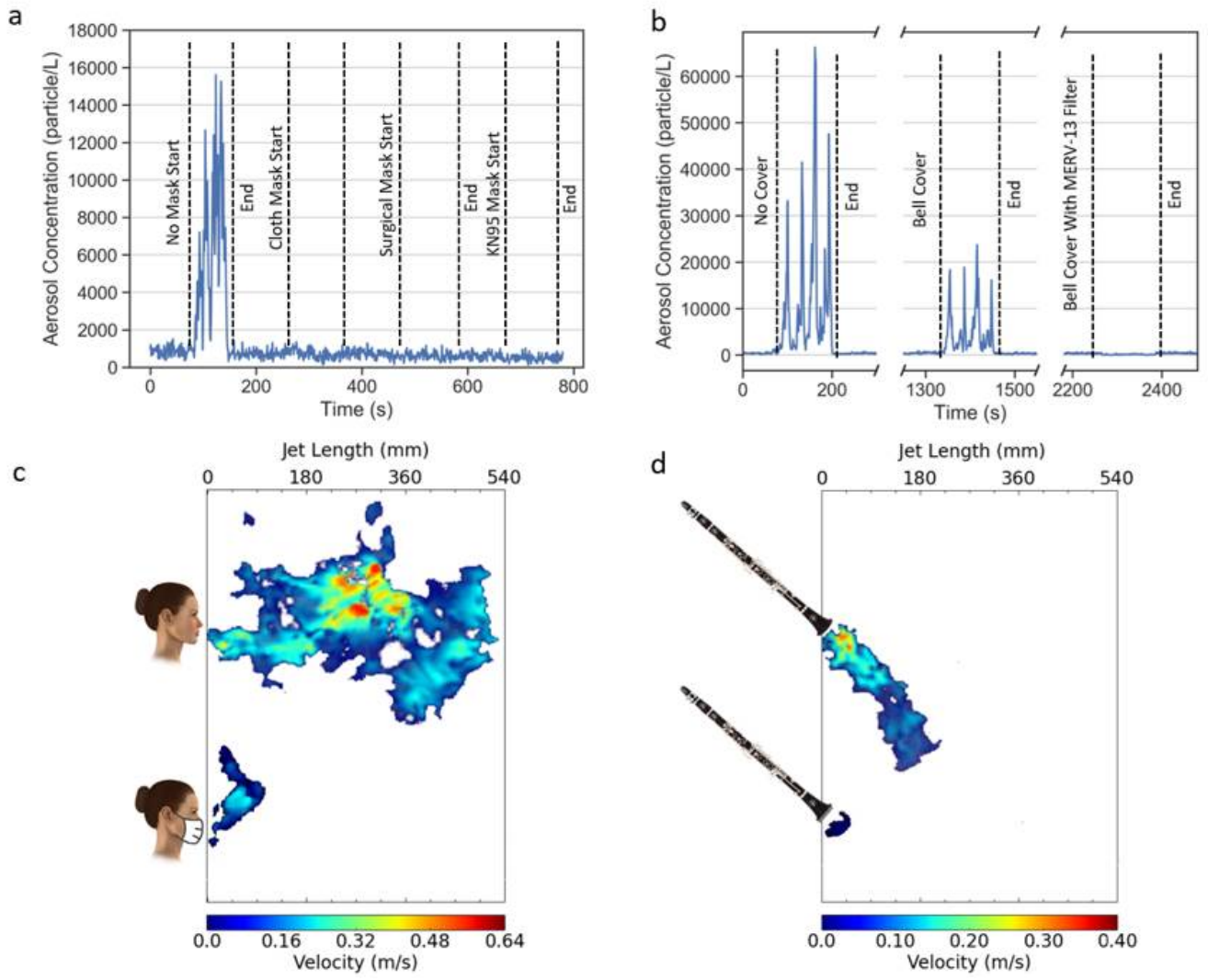


CLARINET KEYHOLE EMISSIONS



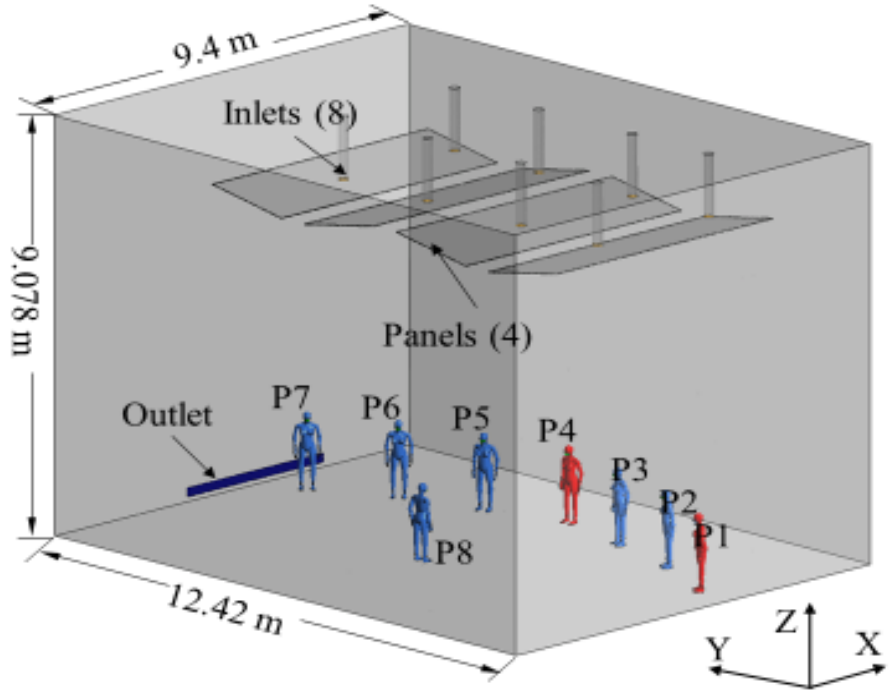


WHAT THE STUDY MEANS VISUALLY



CFD MODELING

Modeling of UC Rehearsal Hall with Singers



Rehearsal Hall Room:

- Inlet:
  $d = 0.2$ m, $v = 3.774$ m/s (3.2 ACH), $T = 22$°C (71.6°F)
- Outlet:
  3.6 m (X) × 0.2 m (Z)
- Walls & other solid surfaces:
  adiabatic

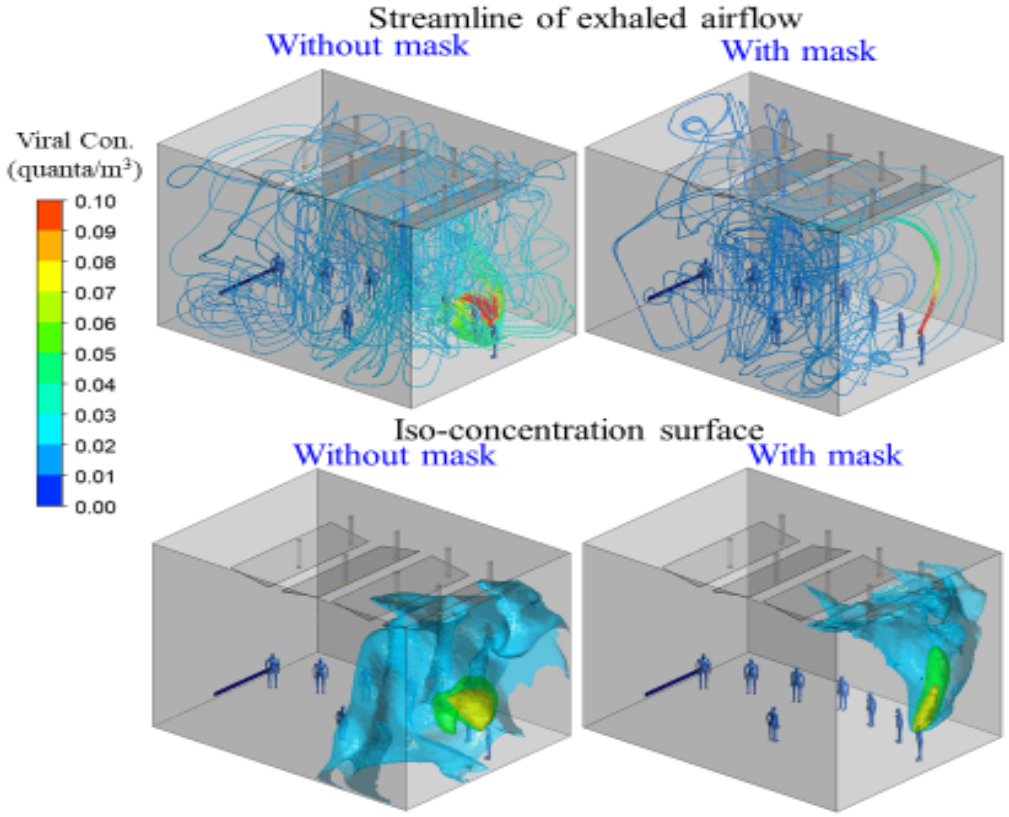
Human body:

- All body surface:
  convective heat flux = 23 W/m²
- Mouth of the infected singer (P1):
  $A = 3.8$ cm², $v = 0.56$ m/s, $T = 33$°C (91.4°F),
  $S = 48$ quanta/hr for COVID-19 virus
- Nostril of the susceptible singers & director:
  $A = 3.3$ cm², $v = 1.679$ m/s (14 L/min, 1.8 met)

❖ In the simulation, P1 was assumed to do constant exhalation with the susceptibles were assumed to do constant inhalation.

CFD MODELING

Spread of Viral Aerosols from P1



Infection risk for susceptible singers & director after 60 minutes (%).

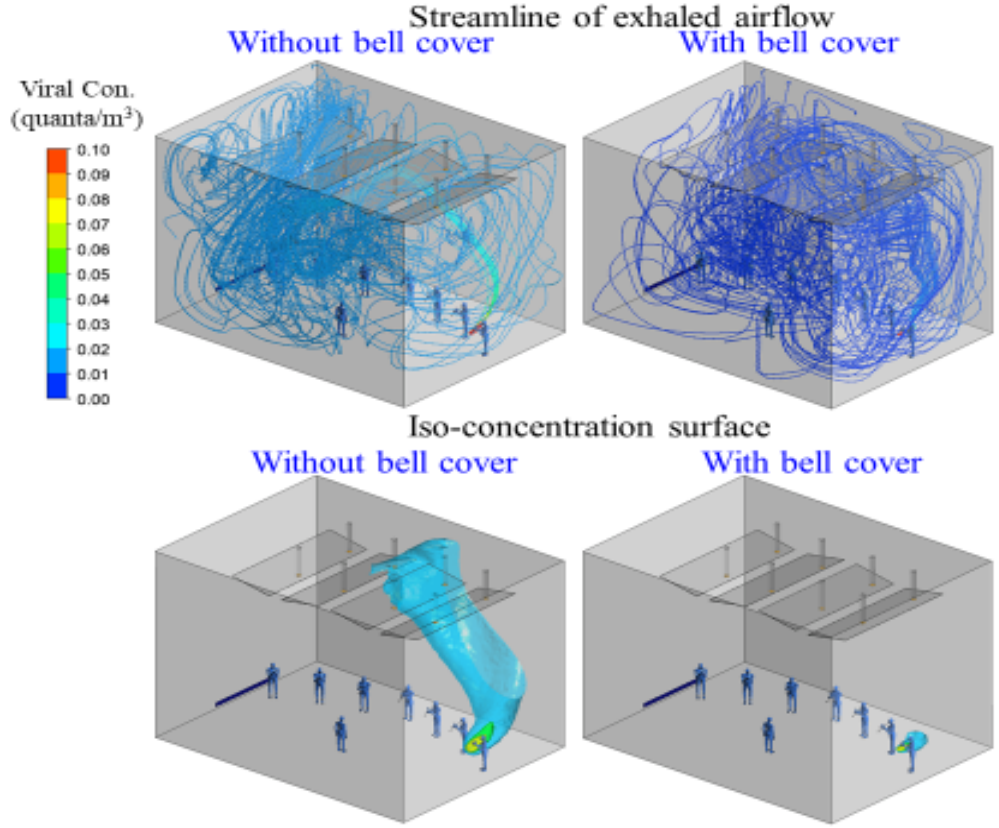
	P2	P3	P5	P6	P7	P8	Well-mixed
No mask	11	4	2	3	3	3	2.85e-04
With mask	2	1	1	1	1	1	5.25e-05
Reduction in risk	85%	61%	57%	60%	62%	58%	82%

- It is assumed that wearing a mask can filter 48.83% of aerosols for susceptible people.[1)]
- "Well-mixed" show the risk under the perfectly mixed ventilation conditions resulting in an underestimate of risk.

- **P2 has a high risk to be infected by P1 if not wearing a mask.**
- **Wearing a mask reduced the infection risk by over 57% for each susceptible person.**
- **However, indoor airflow rates could be increased to improve mixing and reduce the risk.**

CFD MODELING

Spread of Viral Aerosols from P1



Infection risk for susceptible clarinet players & director after 60 minutes (%).

Source	P2	P3	P5	P6	P7	P8	Well-mixing
No cover	3	3	3	3	3	3	2.85e-04
With cover	1	1	1	1	1	1	1.03e-04
Reduction in risk	56%	60%	59%	62%	64%	64%	64%

- The bell cover is assumed to have the same particle removal efficiency as a surgical mask: 64%.
- The susceptible people do not wear a mask.
- "Well-mixed" show the risk for the perfectly mixed ventilation resulting in an underestimate of risk.
- **Due to good air mixing in lower layers of room, with the same source strength, viral aerosols from playing clarinet resulted in a similar concentration distribution at the height of mouth as a whole, as well as the risk for the susceptible people except for P2.**
- **Using a bell cover greatly reduced the viral aerosol concentration at the height of month, resulting a reduction in infection risk by over 56%.**

EFFECTIVE RECOMMENDATIONS FOR INDOOR MUSIC

Masks. Masking with appropriate material* remains the best way of reducing potential infected aerosol from circulating in an indoor space. Masks are recommended be worn while singing and speaking.

Bell Covers. Bell covers made from appropriate material* remain the best way of reducing potential infected aerosol from circulating in an indoor space. Slitted performance masks are optional.

Rehearsal Times. In spaces with good ventilation rates and HEPA filtration, increased indoor rehearsal times of 50 minutes may be considered. A minimum of 3 air exchanges per hour should be used, if there are spaces with higher air change rates, you may consider longer rehearsal times.

Physical Distancing. Distancing may be decreased to 3 feet, adjusting farther or closer depending on local conditions.

Hygiene. Continue good hygiene practice moving forward, including appropriate elimination of brass fluid.

HEPA Air cleaners appropriately sized for the space being used.

RISK ASSESSMENT

- Alpha Variant
  - 3,000 music programs surveyed
  - 1,641 had COVID-19 positive cases
  - 8 self-identified additional spread
  - 1 beyond 1-to-1 transmission
  - Risk level = (1) in 2,192,287
    (1) in 273,124

- Delta Variant
  - 5,000 music programs surveyed
  - CDC analyzing
  - Results due last week of April.

THANK YOU!

Dr. James Weaver
Jweaver@nfhs.org