

# Sound power characterization of Corsi-Rosenthal boxes using DIY comparison method

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GRADUATE PROGRAM  
IN ACOUSTICS



# What is a Corsi-Rosenthal (CR) box?



- Cost effective ~\$100 DIY environmental air purifier
  - Four MERV 1900 20"x20"x2" air filters
  - Box fan / packaging
  - Duct tape
- Commonly used during the COVID-19 pandemic in educational and private settings
- Can limit exposure to pathogens and viruses like COVID-19 in small settings
- Emit broadband noise that can be an issue in educational settings

# Consumers struggle to compare noise from air filters

- No consumer industry standard exists for noise metrics
- Example of where it DOES exist is in bathroom vent fans
- It was desired to develop a method for **consumers to measure various noise sources *in situ***
- Common for consumers to measure sound pressure level, which varies based on product orientation and room effects
- **Sound power level is a better source metric for product-product comparisons**



# Overview of comparison method

1. Temporal and spatial averaged sound pressure level of a reference (known) sound power source is measured in one-third-octave bands
  - Room needs to be moderately reverberant
2. Temporal and spatial averaged sound pressure level of unknown source is measured in one-third-octave bands
3. One-third octave band sound power levels can then be found

$$L_w = L_{w_r} + \overline{L_p} - \overline{L_{p_r}}$$

Unknown sound power

Reference sound power (previously known)

Unknown source sound pressure level

Reference source sound pressure level



# A DIY Sound power measurement is proposed

- ANSI S12.57-2011 provides a standard sound power comparison technique using a **calibrated sound power source**
- Reference sources are expensive
- Want a cheap repeatable source that can be used as a DIY reference source

>\$2k

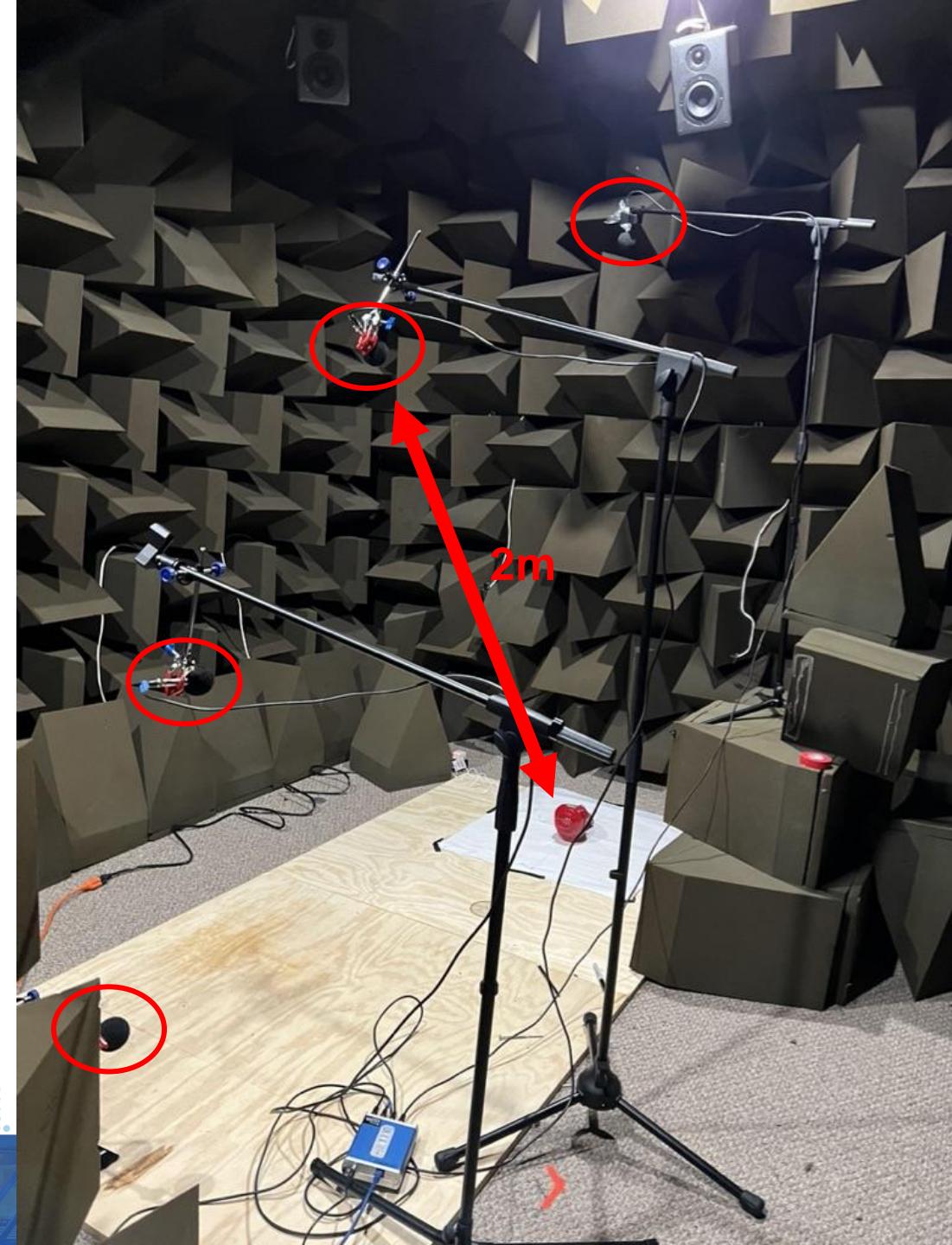


\$20

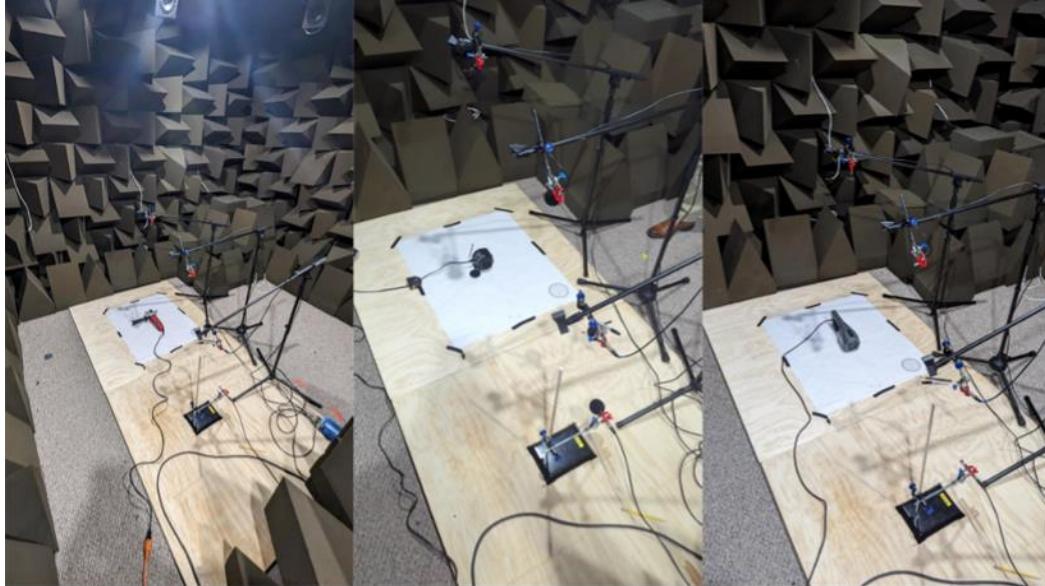


# DIY ref. sound sources needed to be measured

- ANSI S12.54-2011 was used to measure several potential DIY reference sound sources.
- Random incidence microphones were placed in a 2m radius around the object under test above a reflecting plane in an anechoic chamber
- Sound pressure levels were then measured at 60 degree increments
- Several potential sound power sources were measured
  - Angle grinder
  - Small blower fan
  - Hand vacuum
  - Sleep white noise generator



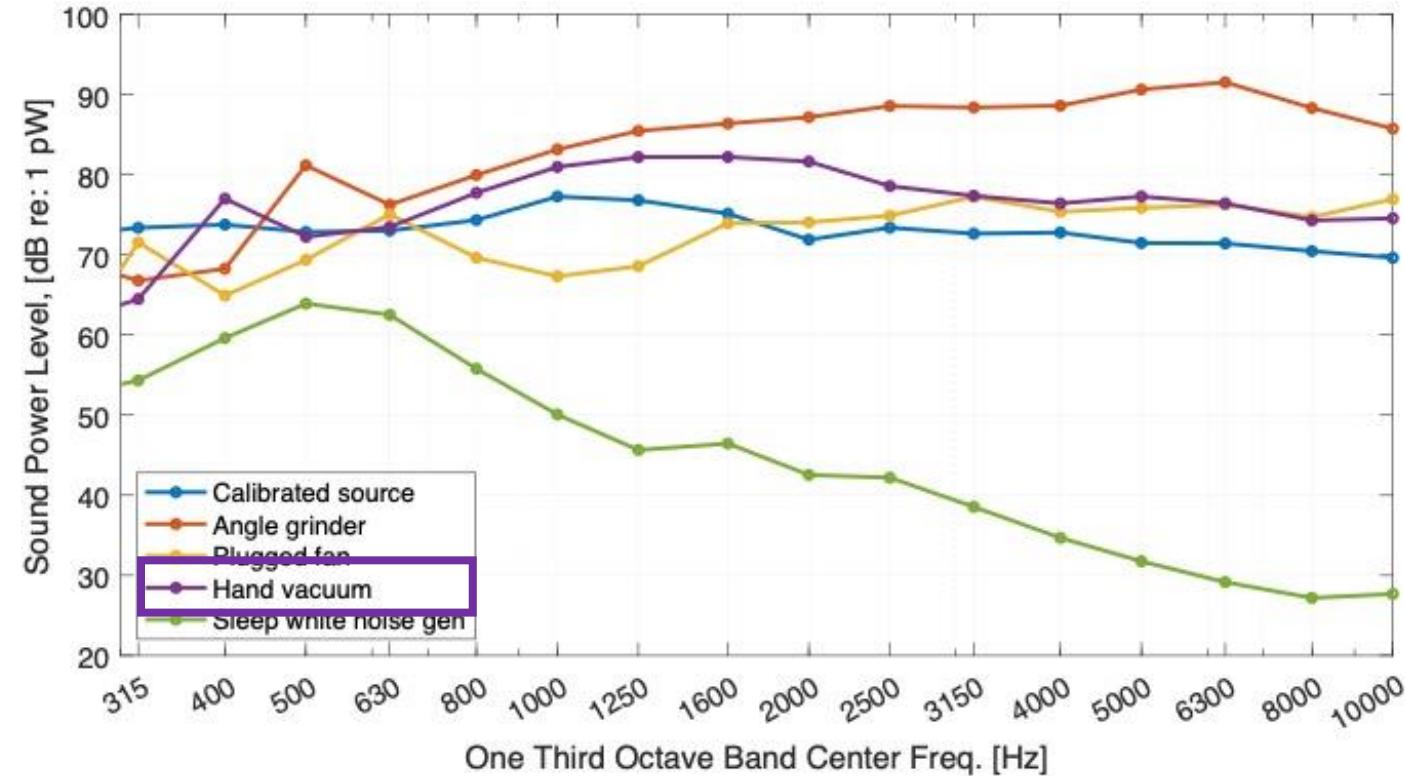
# Potential DIY ref. sound source sound power levels



Angle  
grinder

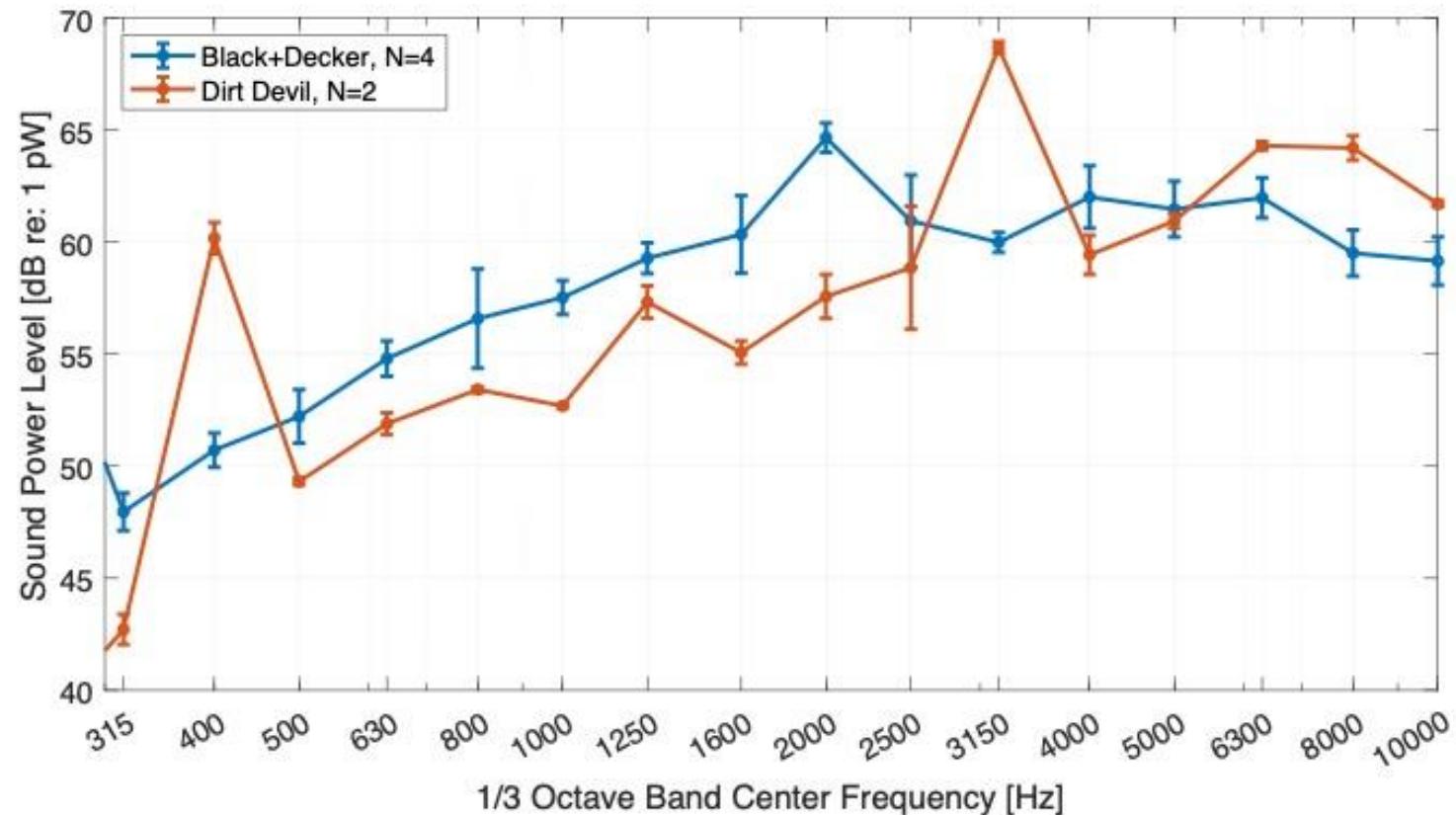
Small  
blower

Hand  
vacuum

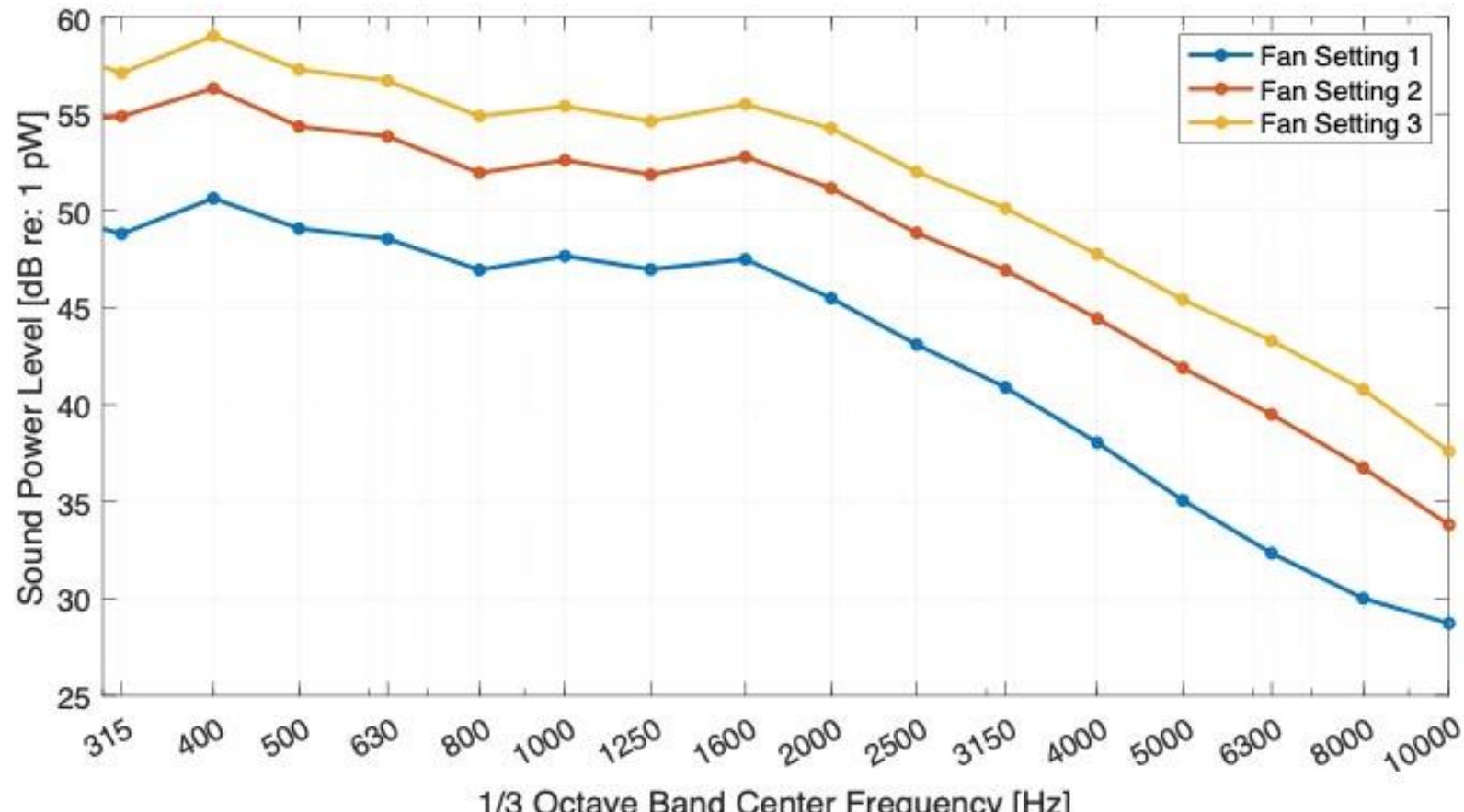


# Two types of hand vacuum were tested

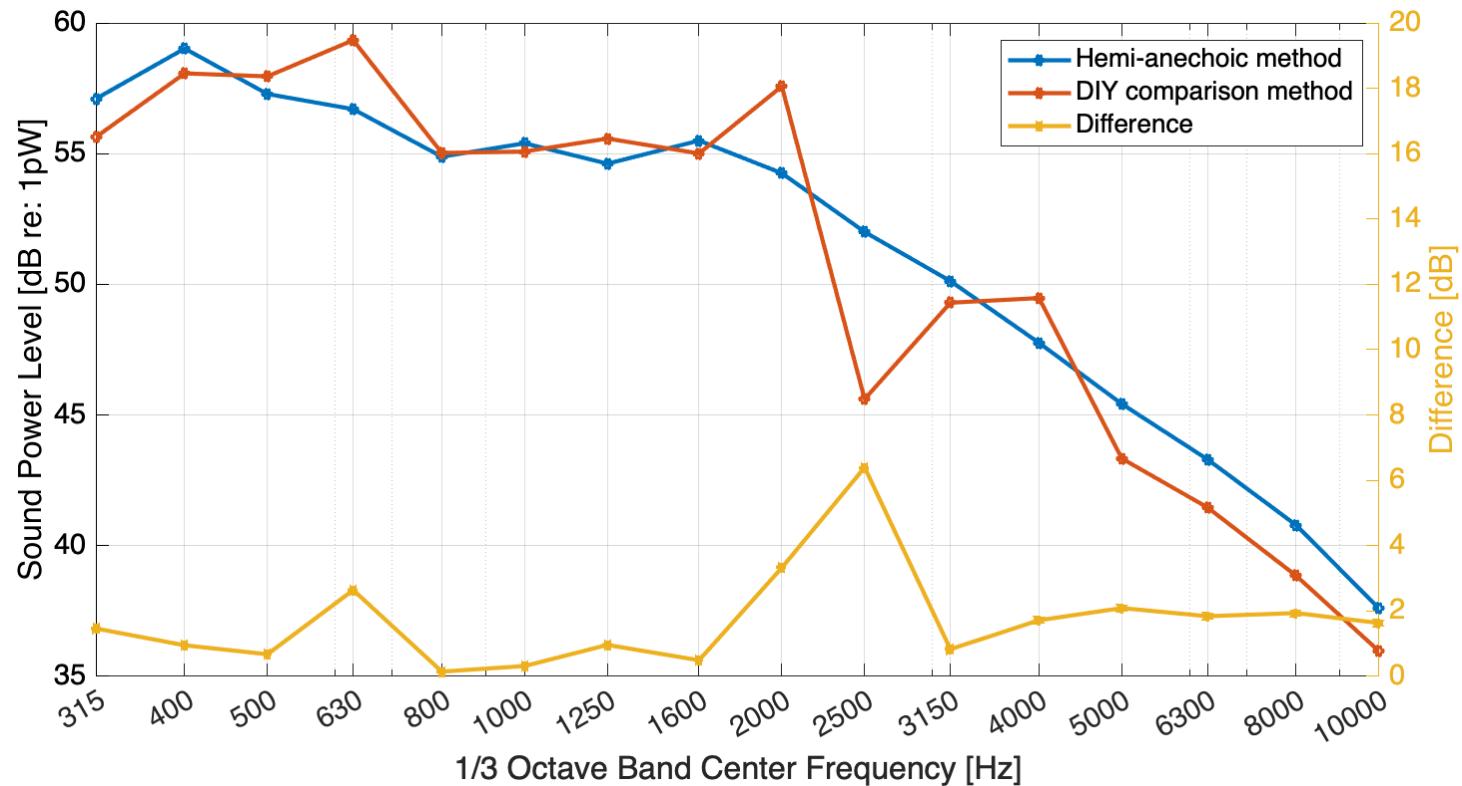
- Black & Decker HNVC115J
- Dirt Devil BB30008
- Averaged sound power levels as measured in the hemi-anechoic method are shown
- We chose the Black & Decker vacuum
- Flatter frequency response and higher overall sound power levels



# Corsi-Rosenthal Lw measured with hemi-anechoic method as “ground truth”



# Corsi-Rosenthal box Lw was measured in lab using DIY reference source



The DIY method was at most 1.7 dB from the “ground truth” at a 95% confidence interval across all frequency bands.

# Future work and study limitations

- Facility used in hemi-anechoic method was not large enough to fulfill space requirements of standard
- Frequencies below 300 Hz could not be measured accurately due to room dimensions and construction
- Small sample size of objects tested did not fully canvas what was available on market
- Only one environment was tested in the DIY comparison method. Multiple environments of varying size and reverberation time would be beneficial.
- More than 4 hand vacuums from different manufacturing dates/locations/stocks would be desired as well

# Summary and conclusions

- A simple method was desired for consumers to compare air purifiers (or other household objects)
- A sound power level comparison method was used
  - Easy for consumers to take a temporal and spatial average of sound pressure level with smartphone
  - Does not generally depend on room acoustics
  - Involves an easy calculation, as long as the consumer is given the measured sound power for their DIY source
- A small battery-operated hand vacuum was chosen as the reference source
  - Runs on DC power– can be used in any country regardless of AC voltage/frequency with proper DC power supply
  - Can be purchased anywhere (amazon, Alibaba...)
  - <\$20

# Summary and conclusions

- Sound power level of this source was then measured using the hemi-anechoic method. (Results from 4 vacuums were averaged)
- The "calibrated" DIY source was then used to measure the sound power level of a Corsi-Rosenthal box using the comparison method. Results were compared with a "ground truth" sound power measured using the hemi-anechoic method.
- The resulting sound power level from DIR comparison method was within 1.7 dB at a 95% confidence interval from the hemi-anechoic method.

# Contact Information

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# Questions?