

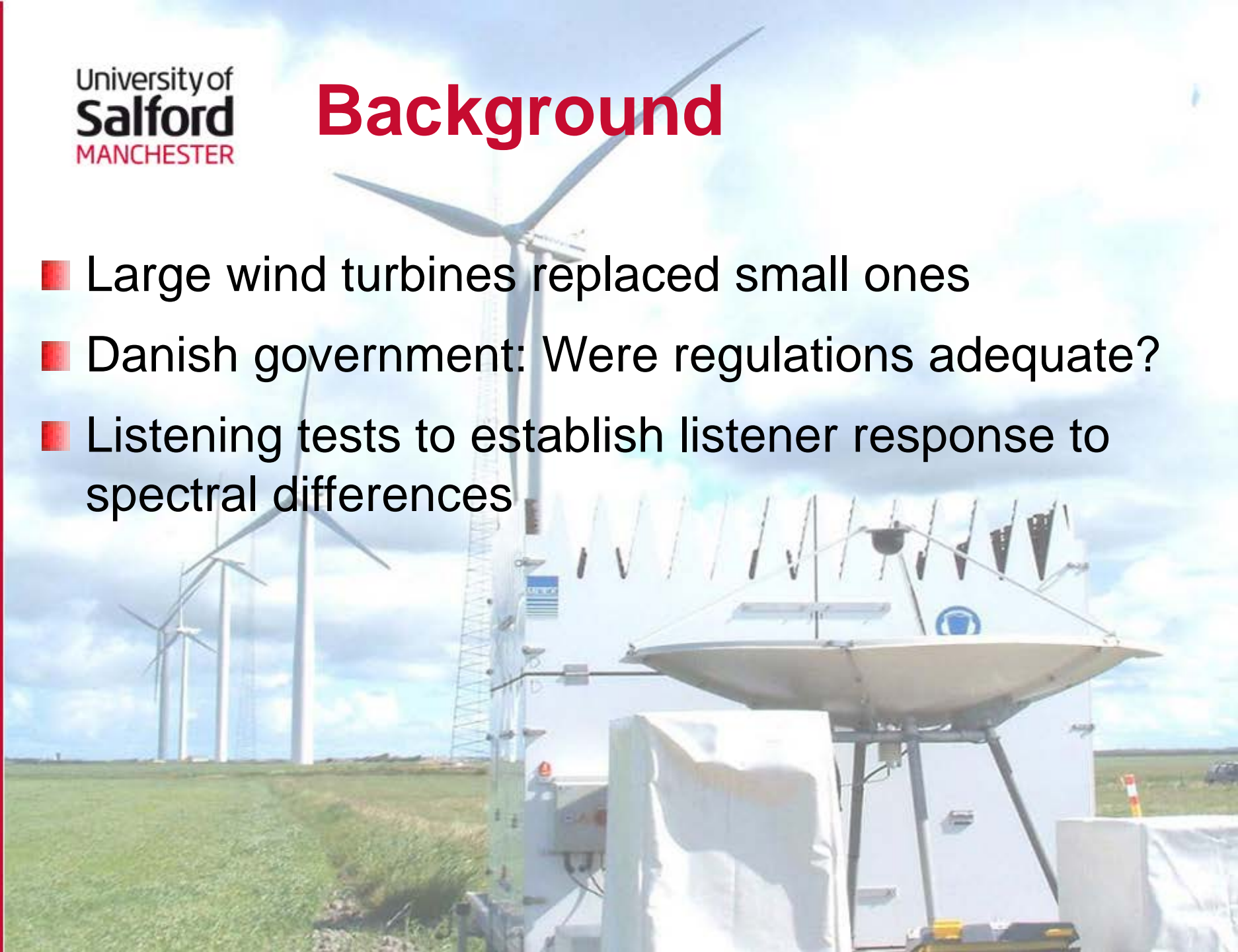
Affective response to noise from wind turbines

Sabine von Hünenbein

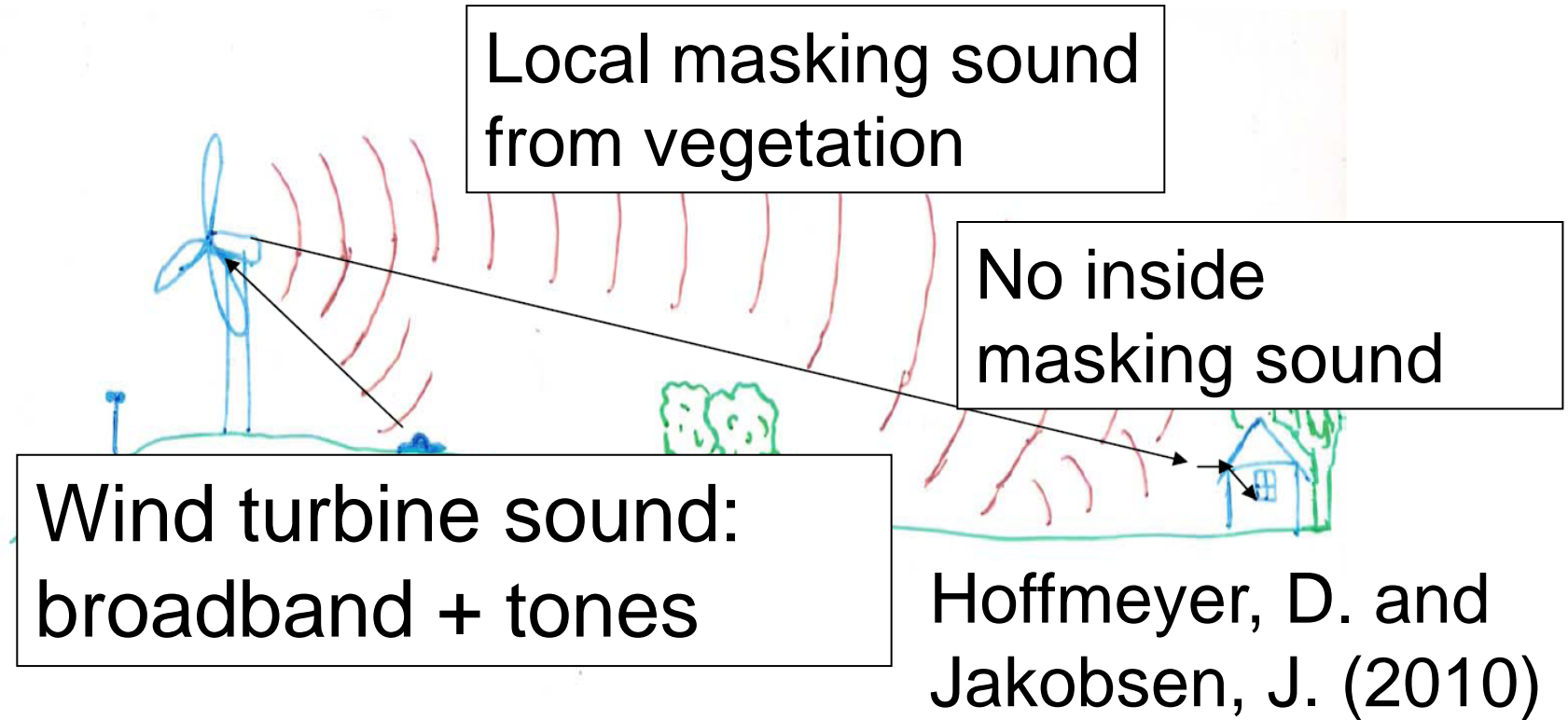


Background

- Large wind turbines replaced small ones
- Danish government: Were regulations adequate?
- Listening tests to establish listener response to spectral differences

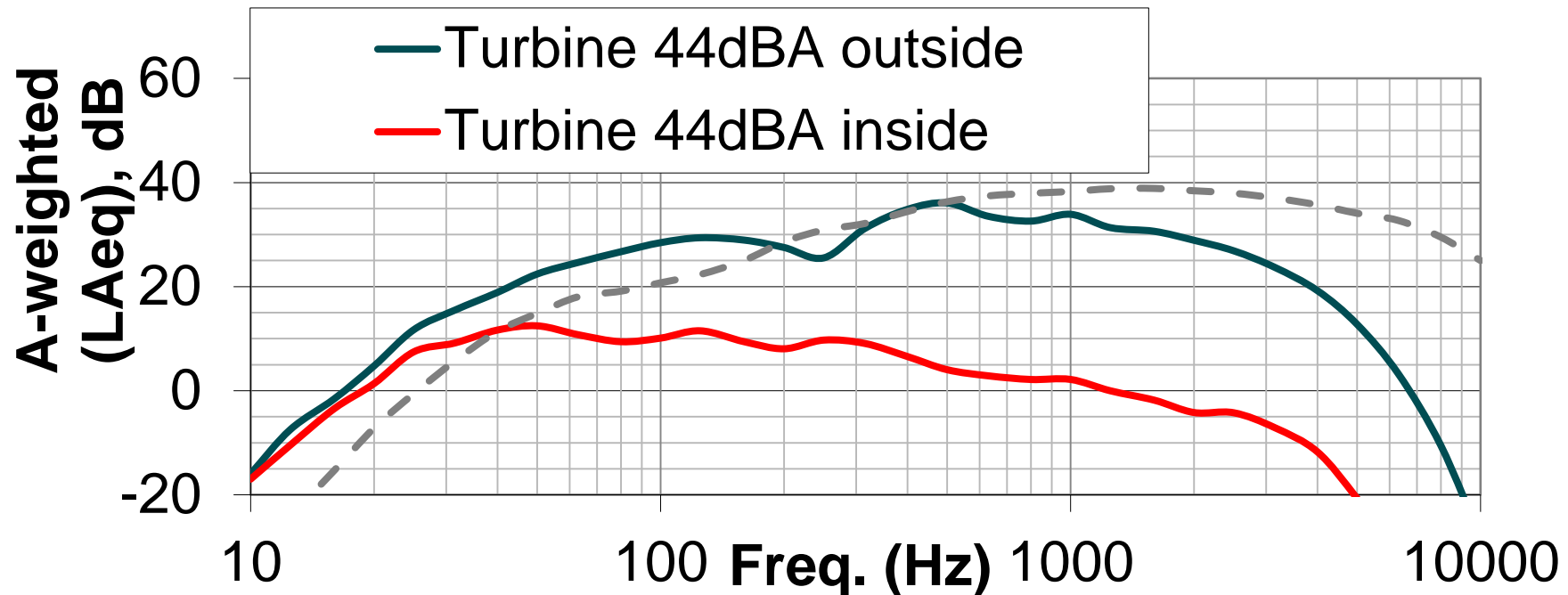


Stimuli design

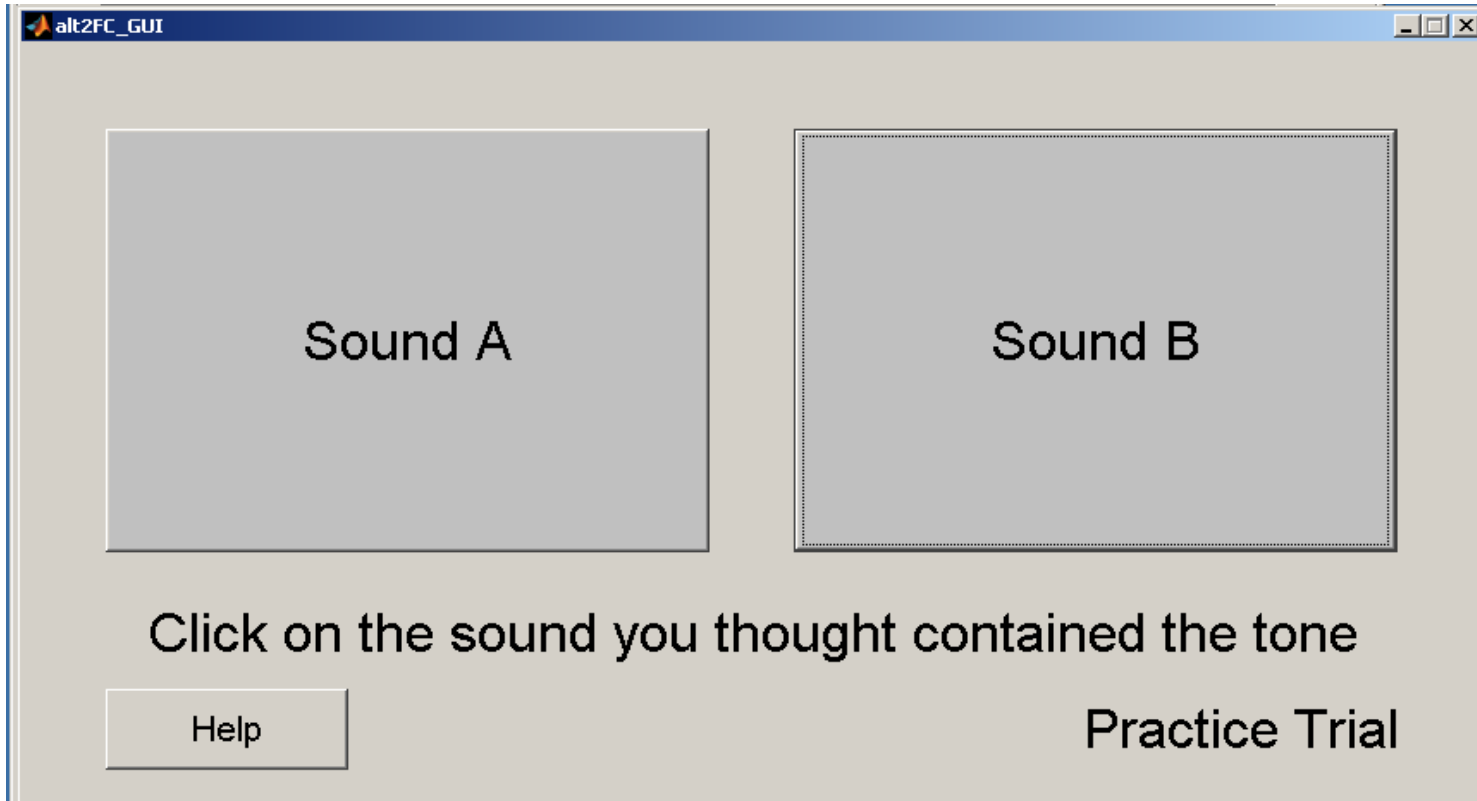


Study in three parts

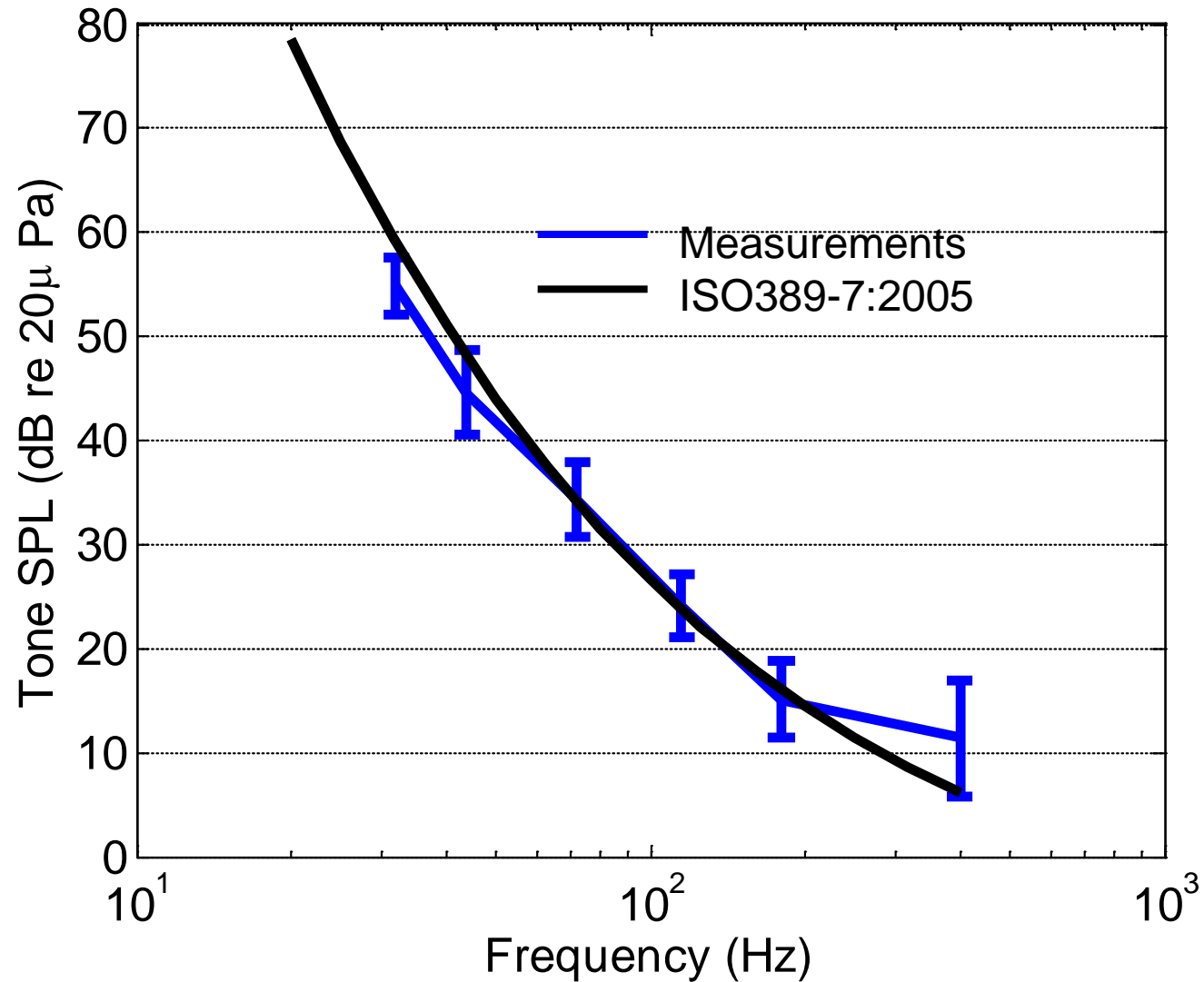
- Determination of audibility and masking thresholds
- Equal annoyance contours from idealised stimuli
- Comparison with recorded stimuli

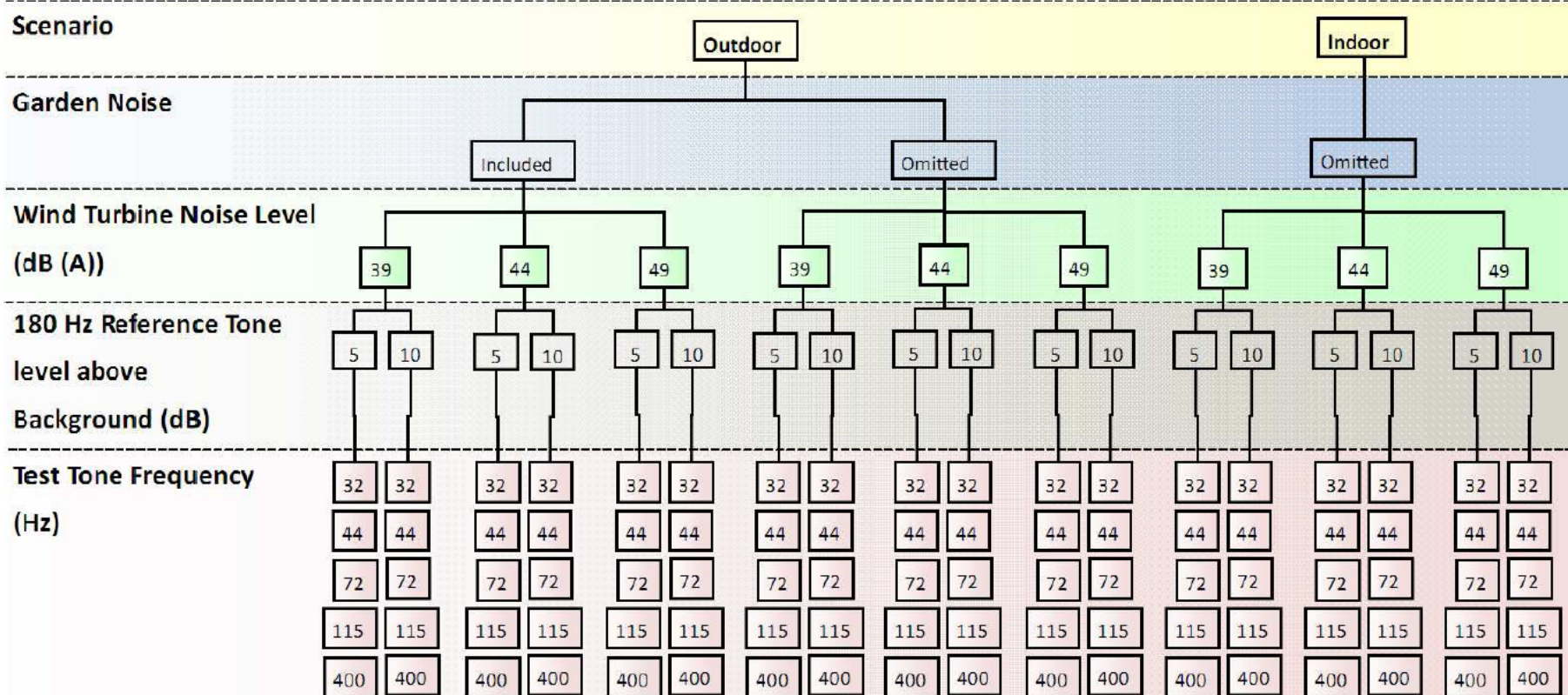


Audibility thresholds: GUI

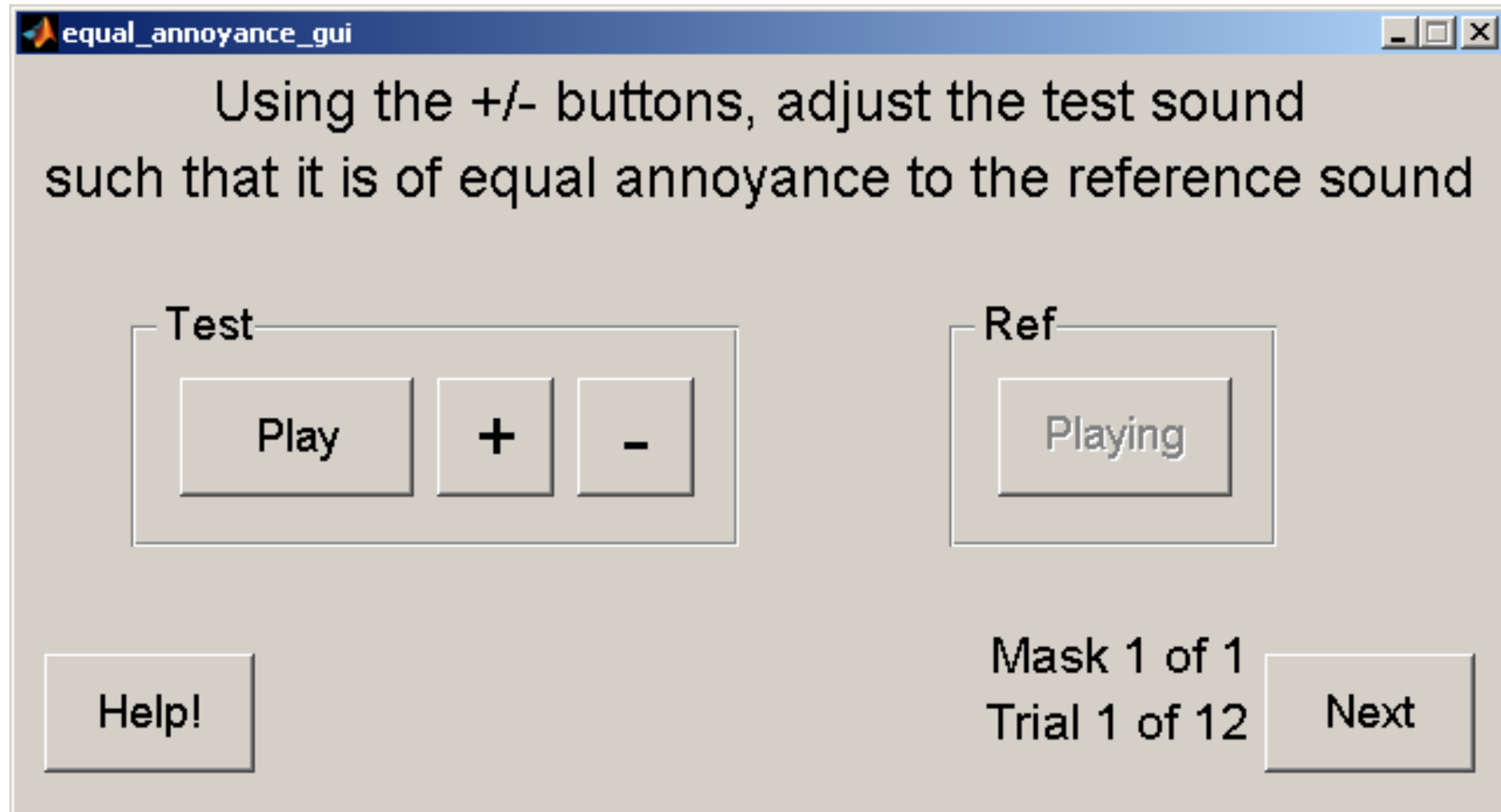


Audibility thresholds

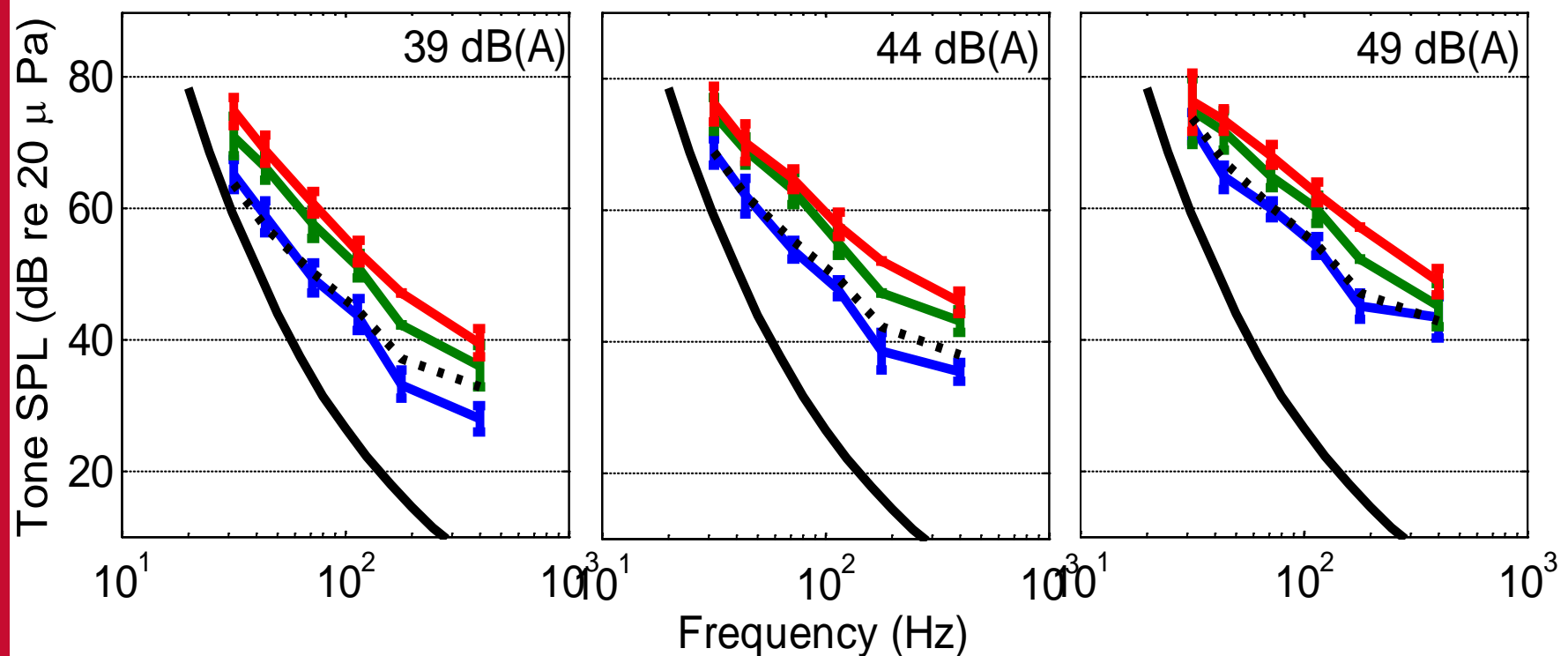




How equal annoyance works

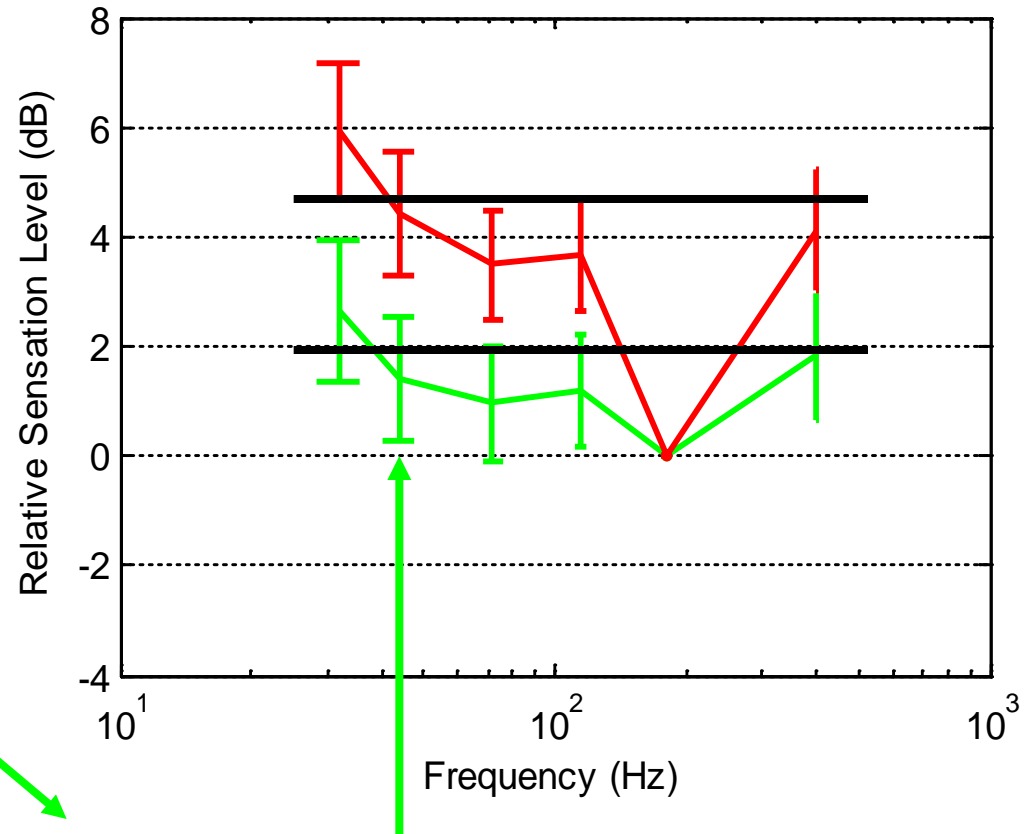
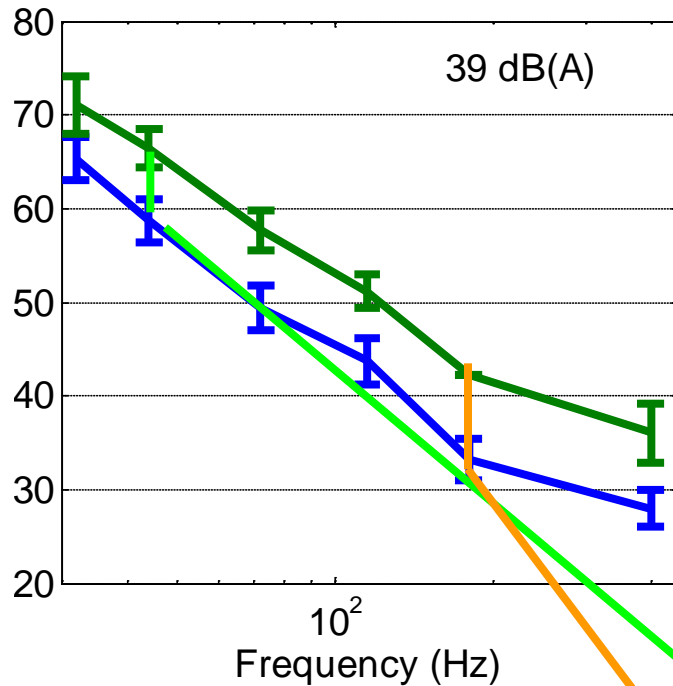


Equal Annoyance Contours: Outdoors, no garden noise



- Measurements
- ISO389-7:2005
- ISO1996-2:2007
- Equal Annoyance +5dB reference tone level
- Equal Annoyance +10dB reference tone level

Are low frequency tones more annoying?



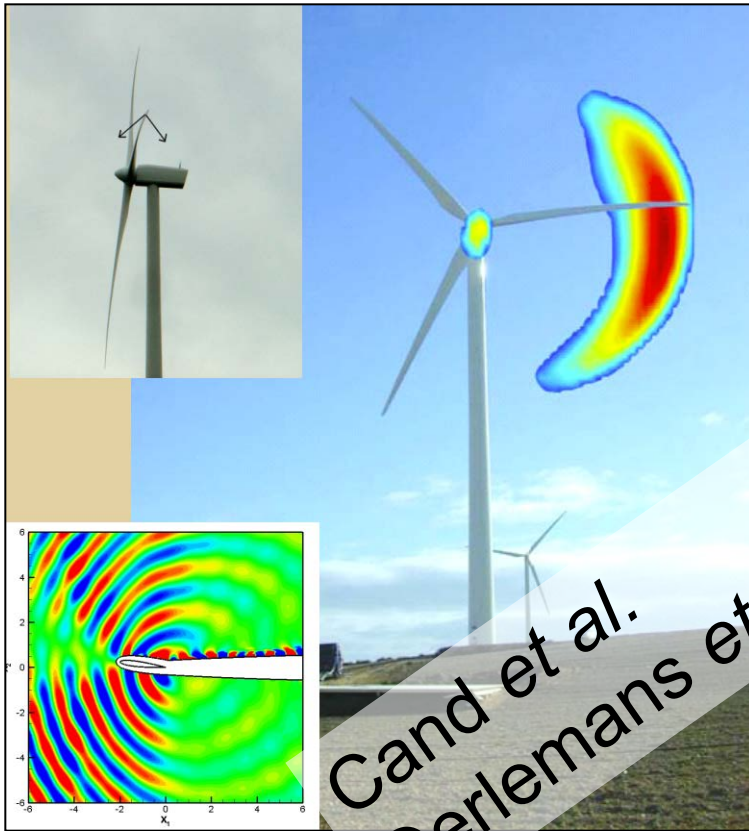
Difference between gaps: | - | = Relative Sensation Level

Conclusions

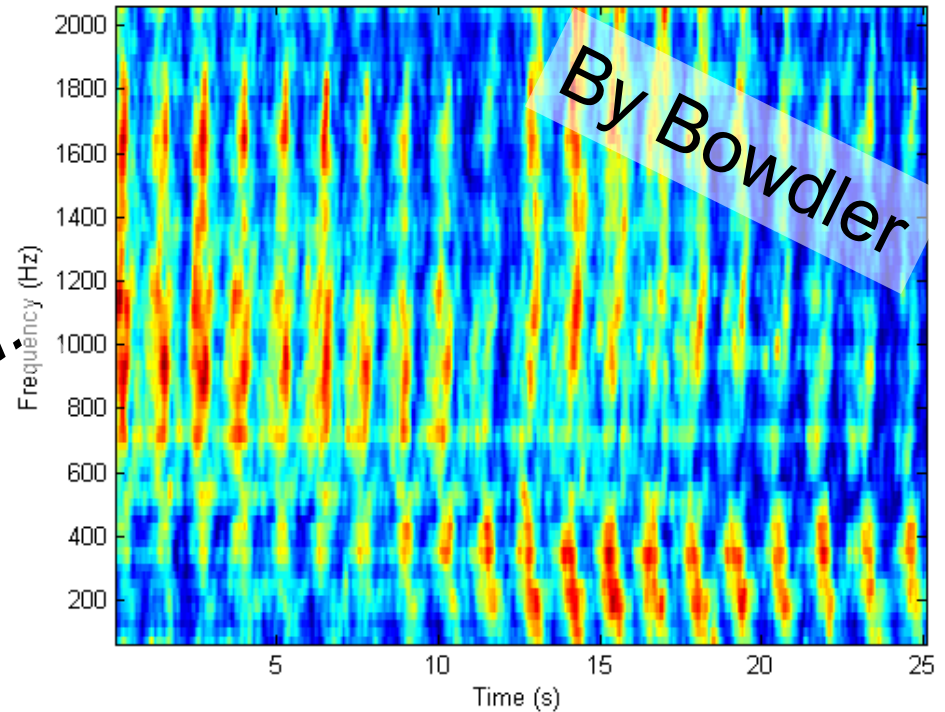
- Tones in WTN quite common
- Consistent results on wind turbine noise perception
- Large and small WT not significantly different
- Annoyance frequency dependent and
- strongly related to hearing and masking thresholds



Remaining challenges: periodicity, random occurrence long term exposure



Cand et al.
Oerlemans et al.



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More details:

<http://www.madebydelta.com/>

Search term: EFP06

On listening tests:

<http://www.madebydelta.com/imported/images/EFP-06-project-Perception-of-Noise-from-Large-Wind-Turbines.pdf>

On full project:

<http://www.madebydelta.com/imported/images/A401929-Danish-Energy-Authority-EFP-06-project-Final-report-for-LF-noise-from-large-wind-turbines-av127210.pdf>



Additional slides for detailed information

Composition of stimuli

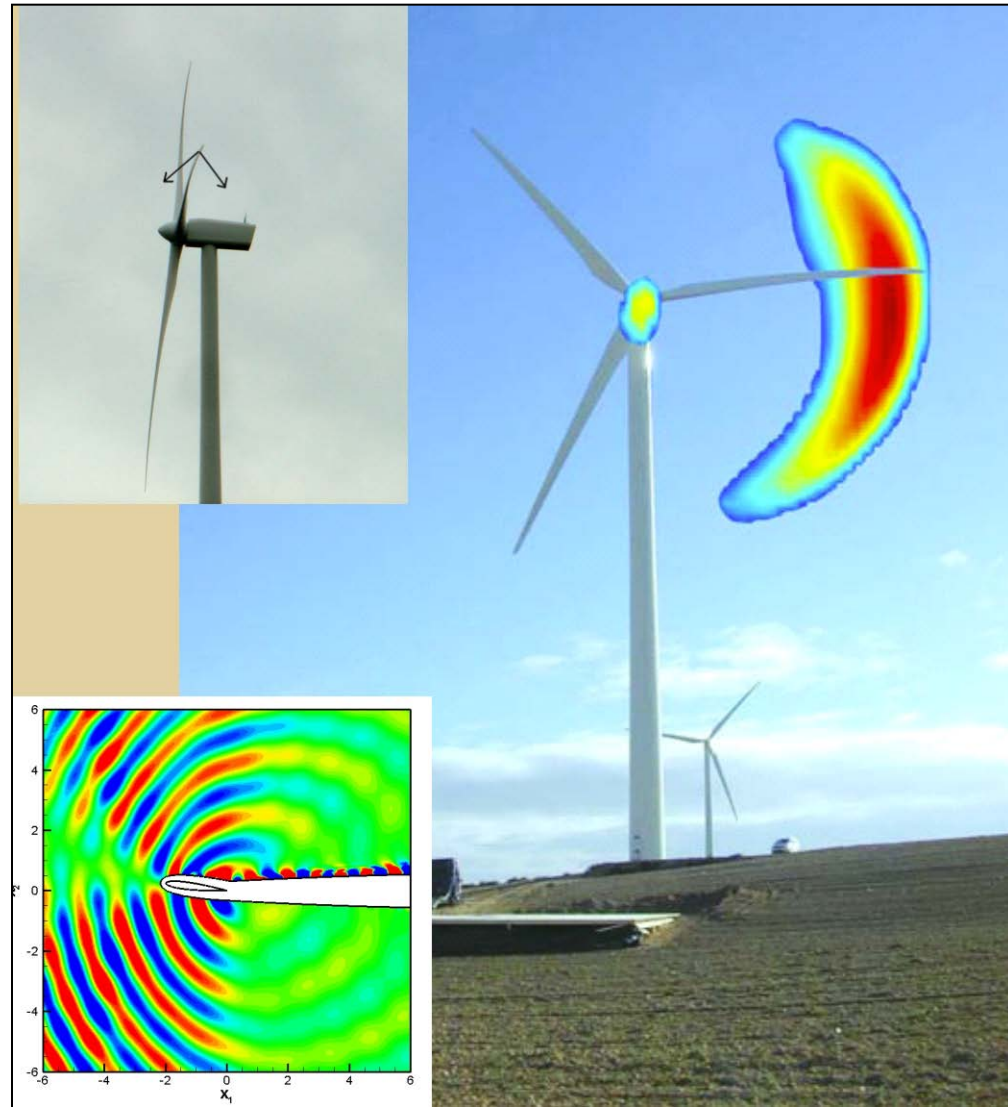
Noise spectrum at recipient consists of

- windturbine created tones
 - broadband windturbine noise
 - local (vegetation) noise
- } Masking noise

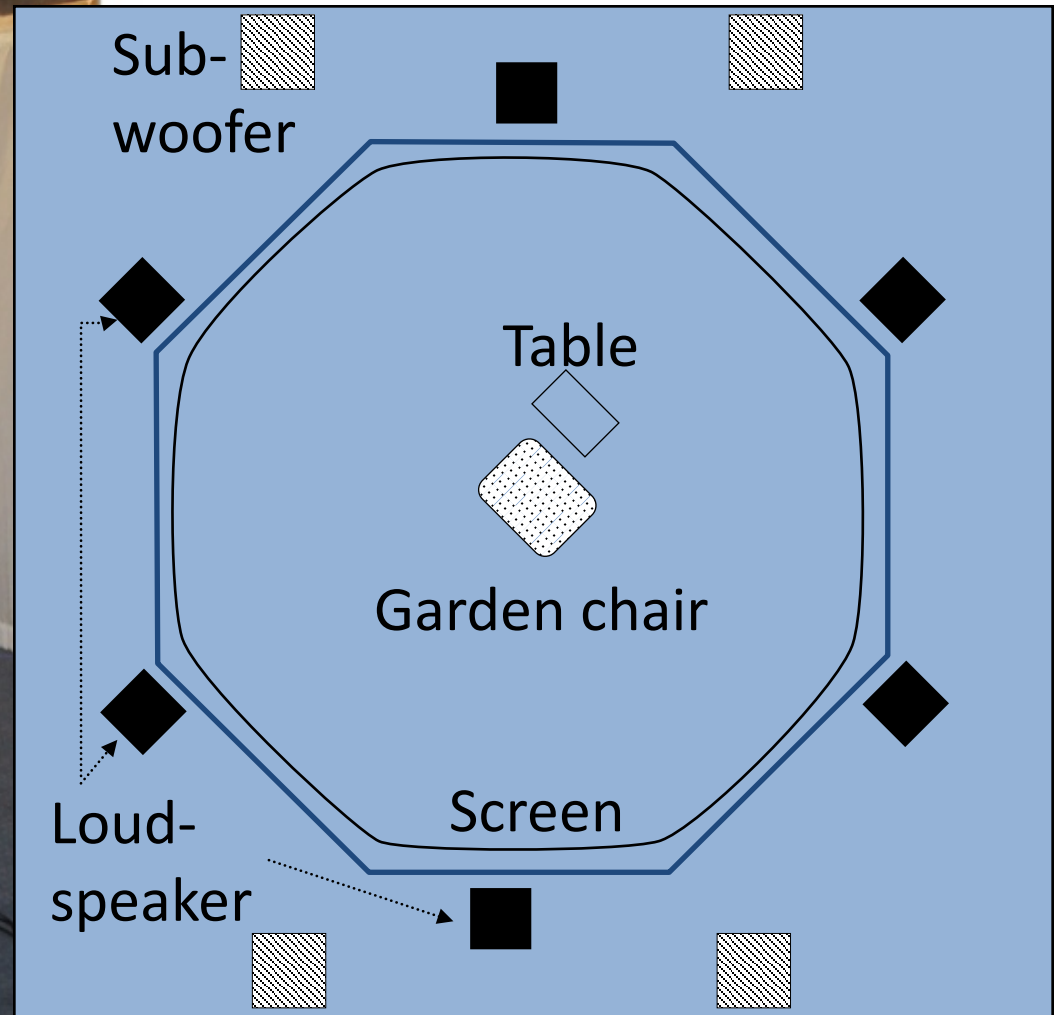
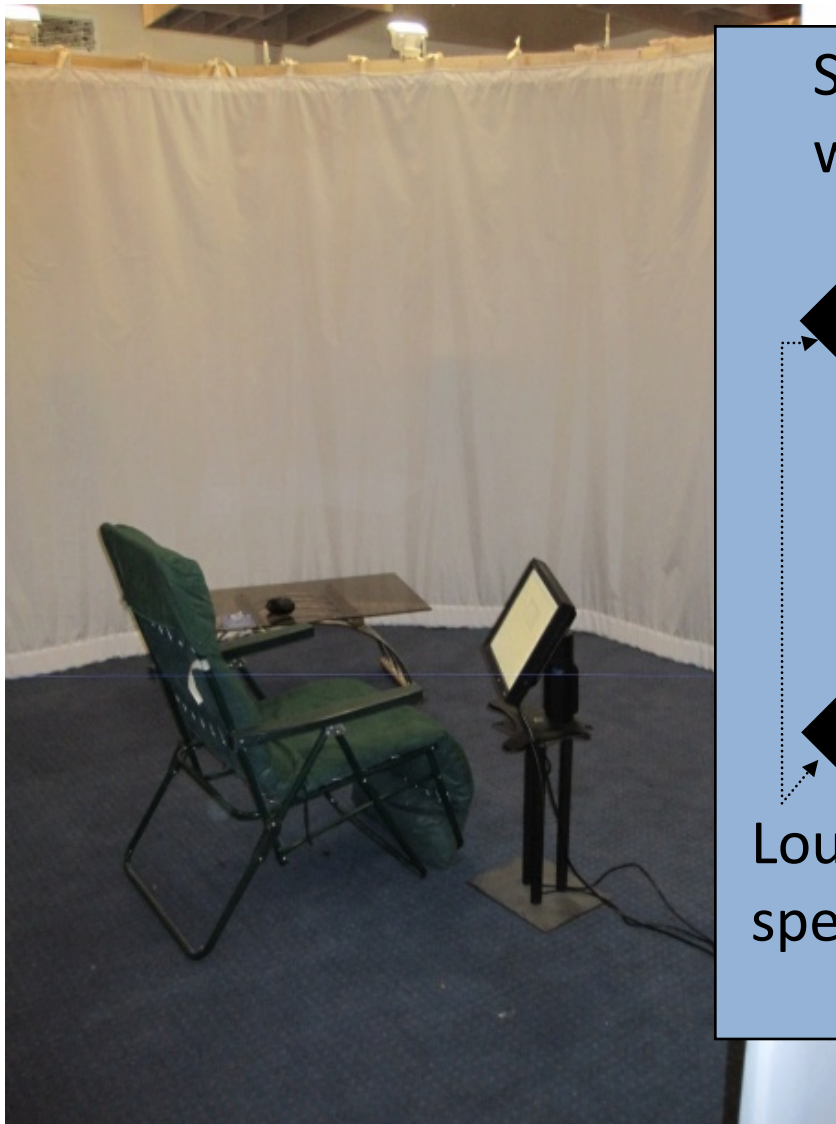
Source highly
directive

Cand *et al.* WTN 2011
after Oerlemans *et al.*:
WTN 2009

⇒ WTN audibility
changeable in
situations of varying
wind direction



Listening room setup



Listening room design



Room specifications:

- Acoustically neutral
- Efficient sound insulation
- Resembles living room

Study control centre



- Monitors playback with loudspeaker
- Camera to observe participant behaviour
- Available to assist participants

The listening environment



To avoid distraction and intimidation:

- Hide acoustic room treatment (diffusers and absorbers)
- Hide loudspeakers and microphones

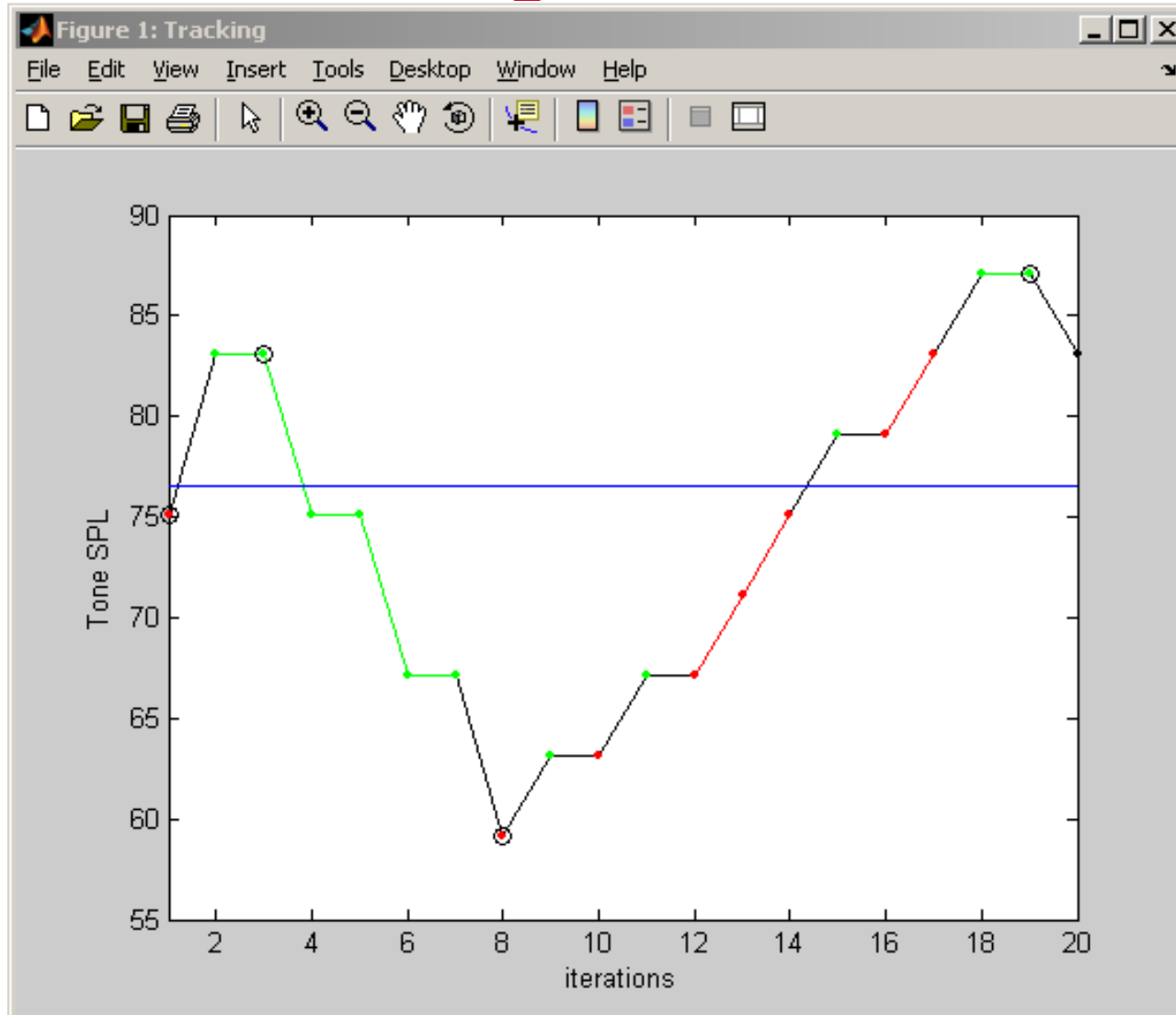
Stimulus quality evaluation

Recordings using a dummy head allow to

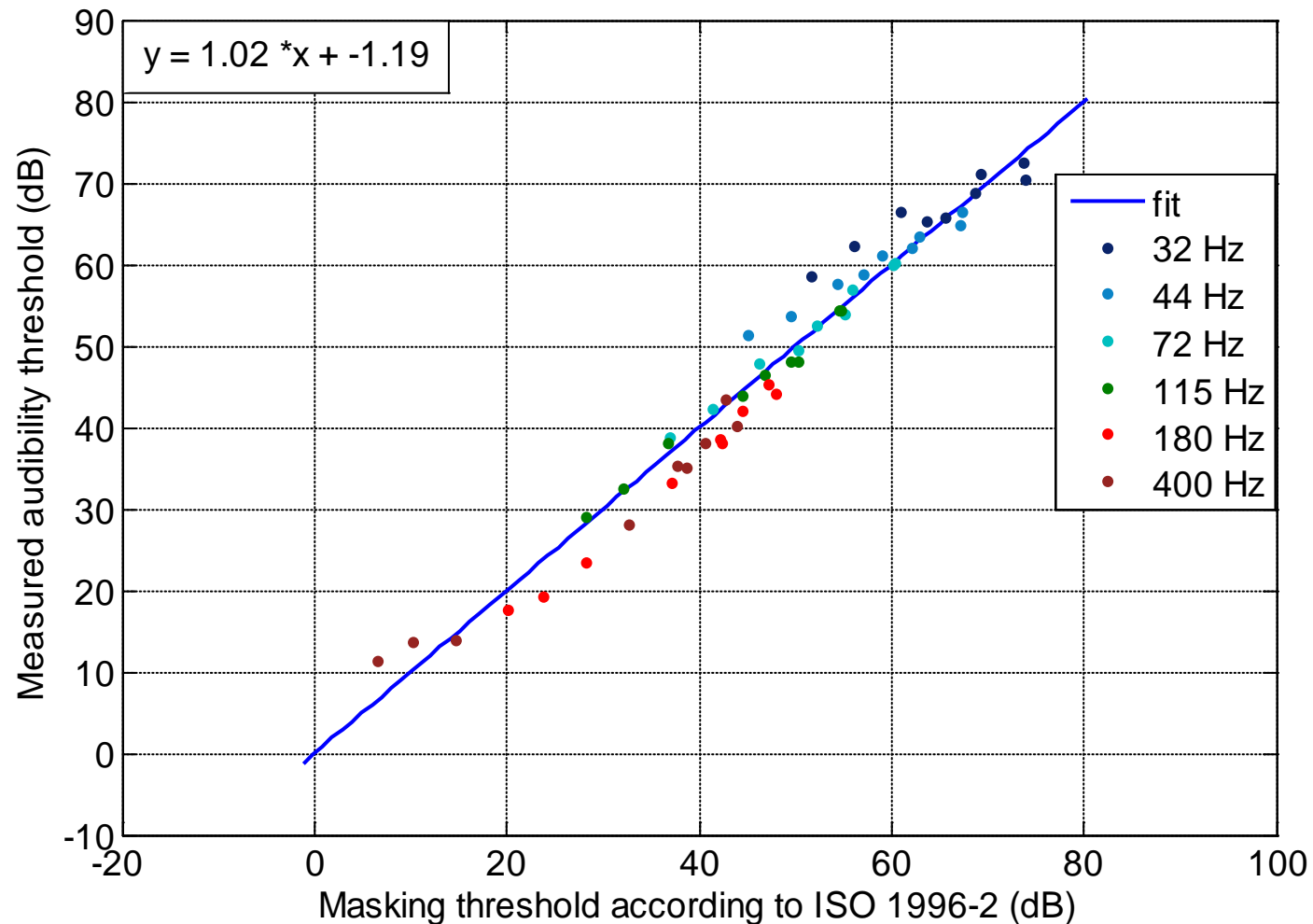
- check room calibration
- check directionality of ambisonic reproduction
- document stimuli for the interested public



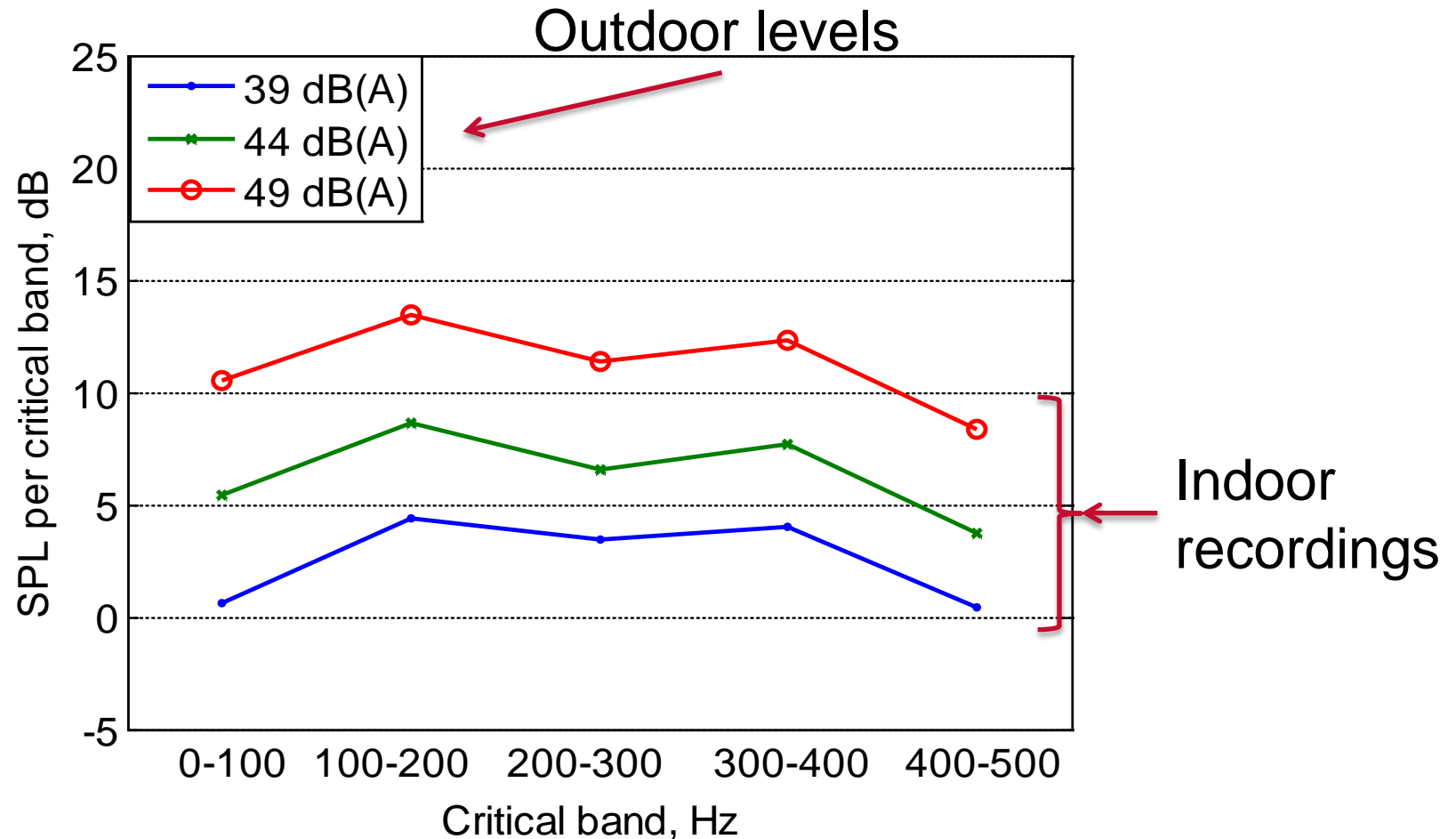
Audibility thresholds (AT): Tracking



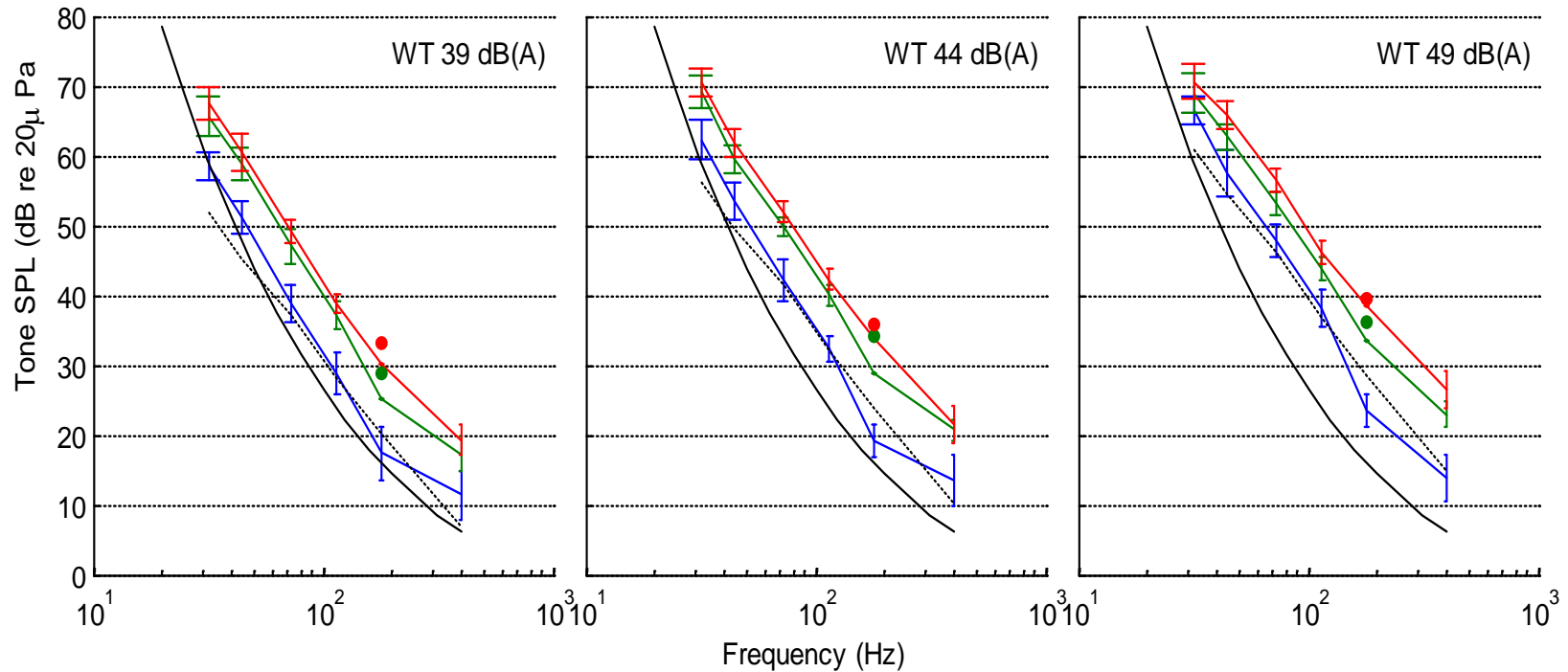
How well do masking thresholds relate to ISO1996-2?



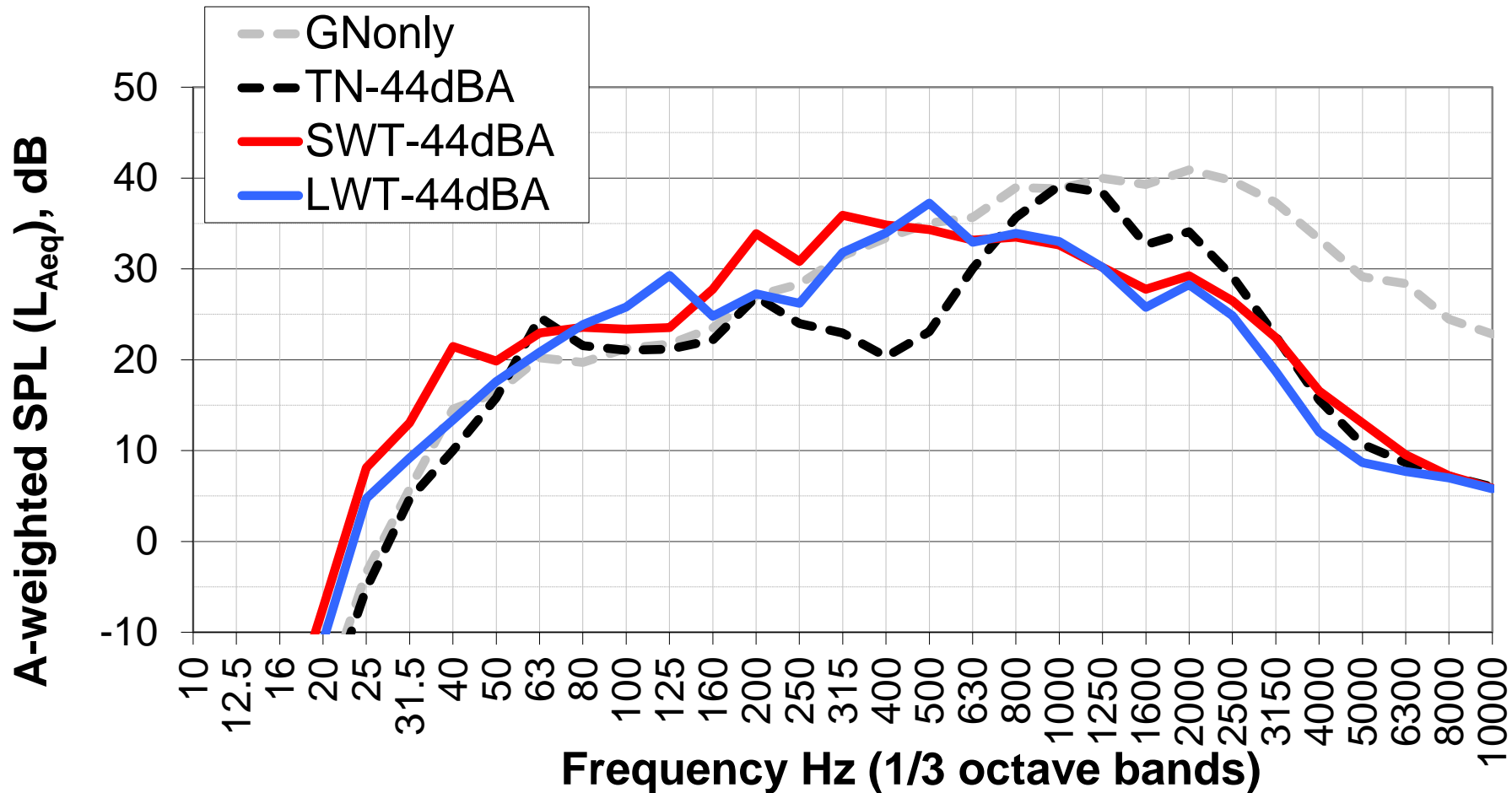
Audibility of indoors masking sounds



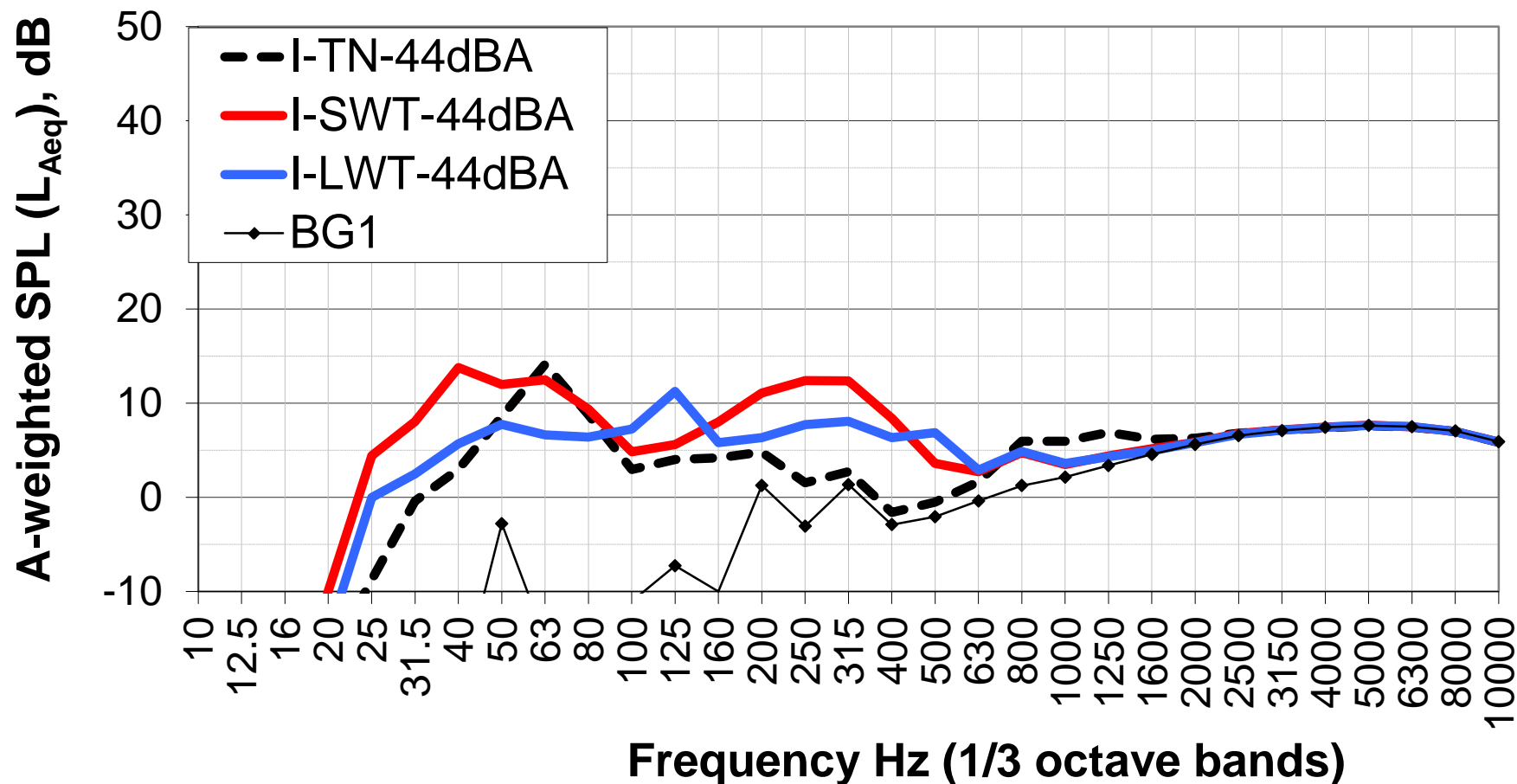
Indoors results



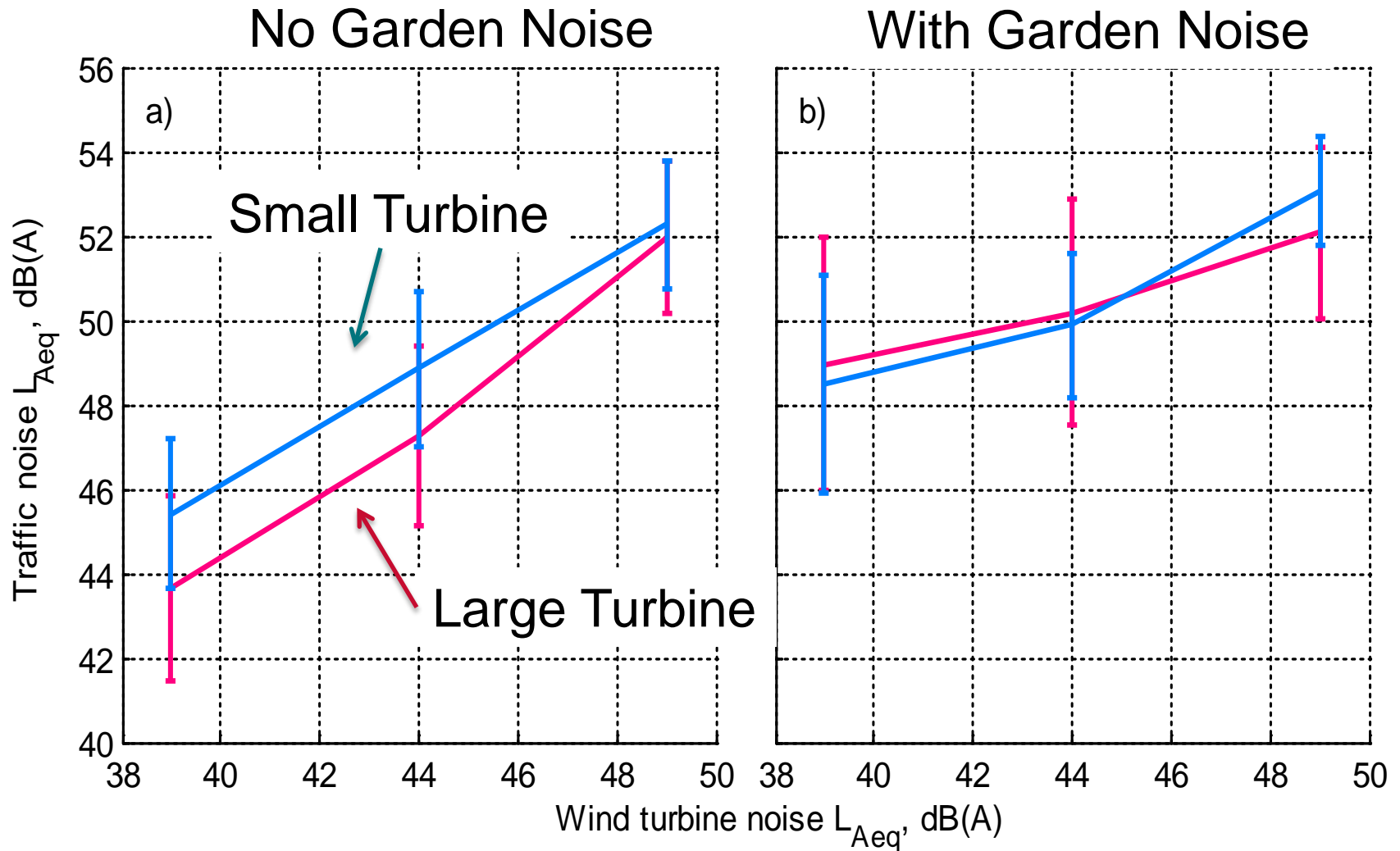
Part B: Comparison with recordings



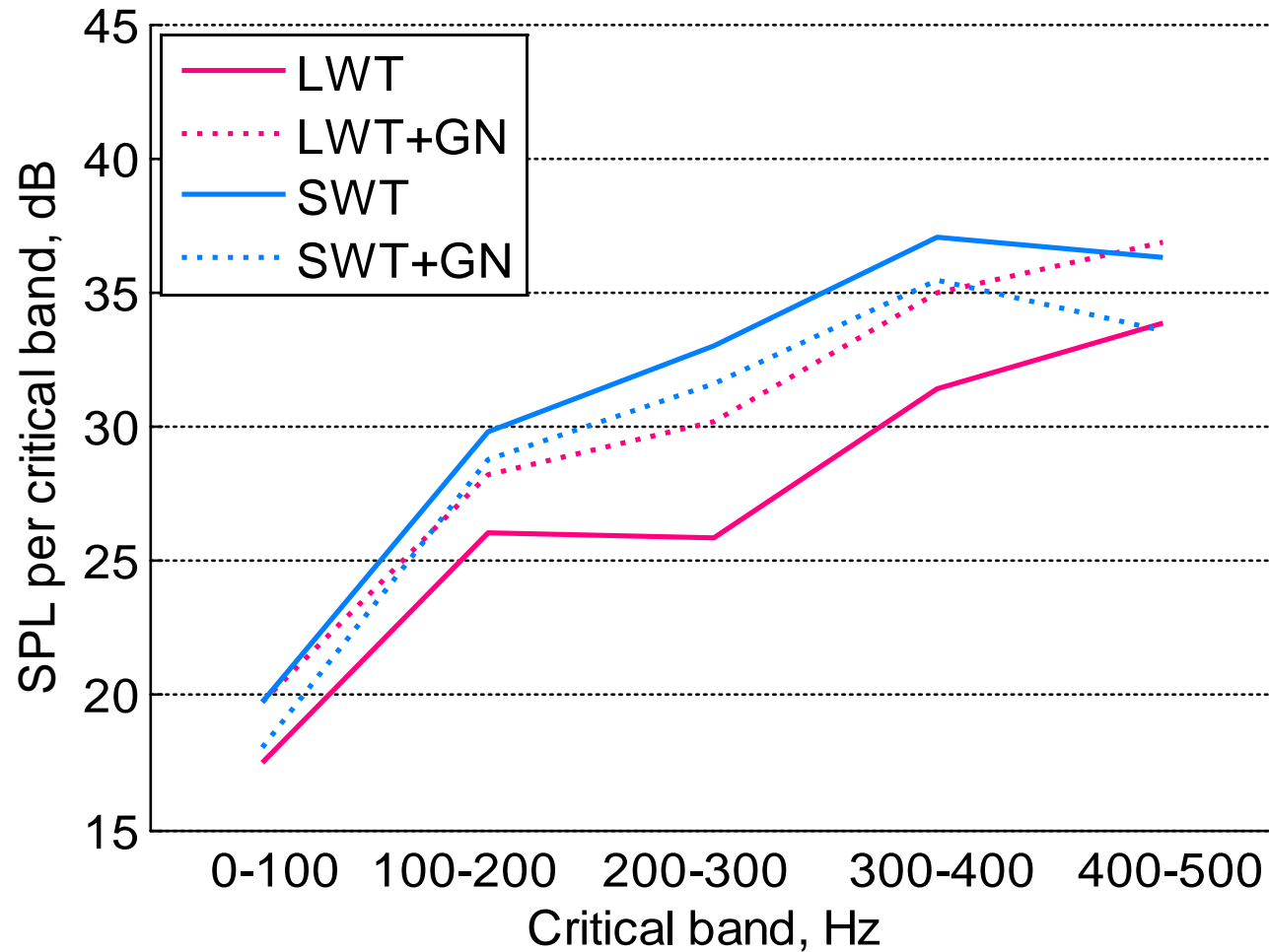
Part B: Comparison with recordings



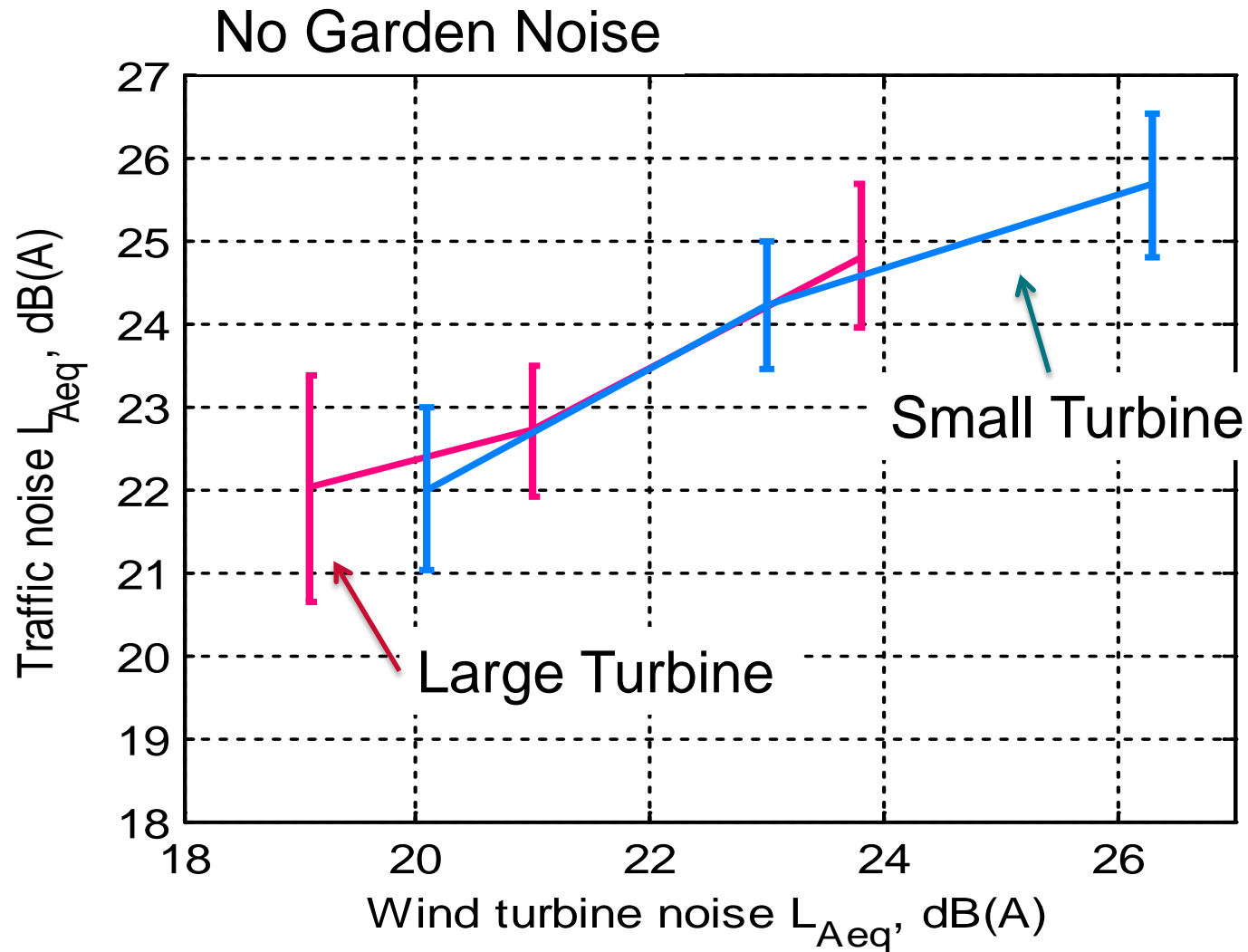
Part B: outdoors EA results



Part B: Audibility of outdoors stimuli



Part B: indoors EA results



Conclusions

- Listening test results from synthesised tones in broadband wind turbine noise
- Listening tests produced consistent results on wind turbine noise perception
- No significant difference in annoyance between large and small wind turbines found
- Annoyance levels frequency dependent and strongly related to hearing and masking thresholds
- Good agreement between Parts A & B of the study