IEEE Signal Processing Society

Supported by the IEEE Signal Processing Society Challenge Program

Listener Acoustic Personalisation Challenge 2024

Task 2: Results and Analysis

UKAN SIG-SAIA Annual Meeting - KEF 2025

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Queen Mary University of London

VIABAL Virtual, Immersive, Augmented & Binaural Audio Lab

centre for digital music

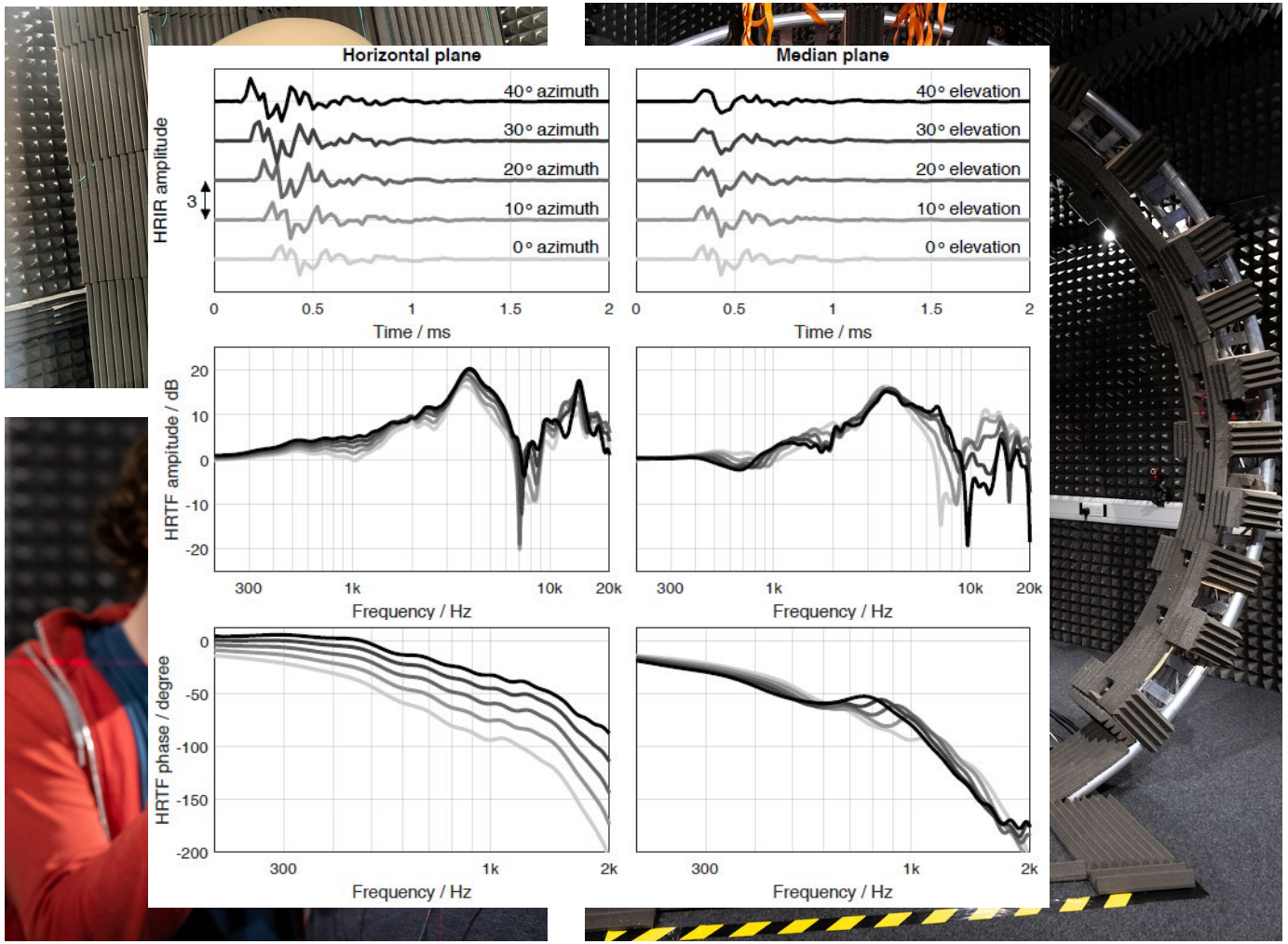
SONICOM

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101017743

Listener Acoustics

Head-Related Transfer Functions

- **Generic HRTFs** (dummy-head)
  - “one fits all”
- **Individual HRTFs**
  - Time-/resource-consuming measurements
  - Special equipment
- **Personalised HRTF**
  - Individual HRTFs for everyone are still prohibited.
  - Many psychological / neurophysiological / neurological studies relied on generic HRTFs. Are they valid?
  - If personalization is involved, no proper knowledge of the impact of that specific personalization is usually provided
  - Discussion / limitation point on the impact of personalization.



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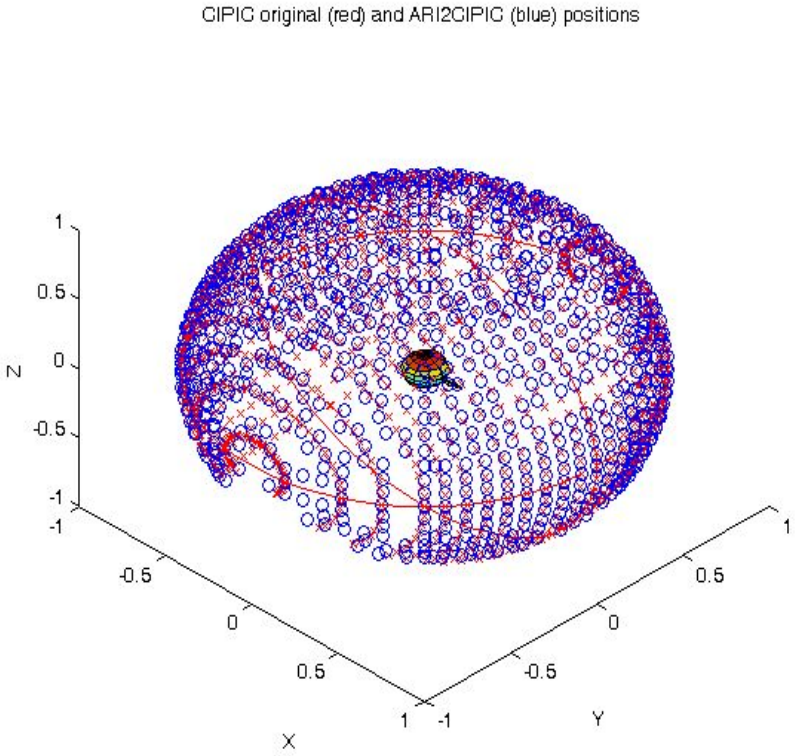
Task 2

Task 2:

Spatial upsampling for obtaining a high-spatial-resolution HRTF from a very low number of directions



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Task 2

Spatial Up-sampling of HRTF Sets

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Task 2 - Recap

NUMBER OF SUBMISSIONS: 8

TASK: Upsampled HRTFs of **12 subjects** to full resolution

DATA PROVIDED:
SONICOM publicly available dataset ***(****200 subjects)*

SONICOM not publicly available dataset *(12 subjects)*

- 4 sparsity levels (**100**, **19, 5**, and **3** measurement points)
- 3 subjects per sparsity level

EVALUATION:
Full resolution measured HRTFs of the **12 subjects** (**793** positions) not publicly available)

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Task 2 – Validation (stage 1)

Verify that the 10 out of the 12 submitted HRTFs are within ITD/ILD/LSD thresholds.

The submissions that fail to meet the criteria will be disqualified from further evaluation.

IOA3D	✓	
SYT_FSP-AE	✓	
SUpDEQ_MCA	✓	
GEP-GAN	✓	
Kalimotxo	✓	
UDiPD	✗	ITD issue
MERLI	✓	
MERL 2	✓	
Baseline 1 – Barycentric	✗	levels 3 and 5 – ILD and LSD
Baseline 2 - SH	✗	

Table 1

Feature	Threshold
ITD	100 µs
ILD	4.4 dB
LSD	7.4 dB

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Task 2 – Evaluation (stage 2)

The resulting 12 metrics (three metrics at stage 1 for each of the four sparsity levels) are normalised using a standard score (z-score) based on the distributions for the baseline methods.

The three z-scores at each difficulty level are then summed, and the initial rankings of each submission will be released per difficulty level (from the smallest z-score corresponding to the best performance in the difficulty level).

Finally, the four z-scores will be summed again, and the submission with the lowest total z-score will be declared the final winner of the challenge.

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Task 2 - Submissions

Solution	Brief description
IOA3D	Convolutional neural network
SYT_FSP-AE	Autoencoder-based neural network
SUpDEQ_MCA	Magnitude-Corrected and Time-Aligned Interpolation
GEP-GAN	Convolutional super-resolution generative adversarial network
Kalimotxo	Autoencoder-based neural network
UDiPD	Psychoacoustically-motivated IIR neural field
MERLI	Retrieval-augmented neural field
MERL 2	Retrieval-augmented neural field (2nd ver)

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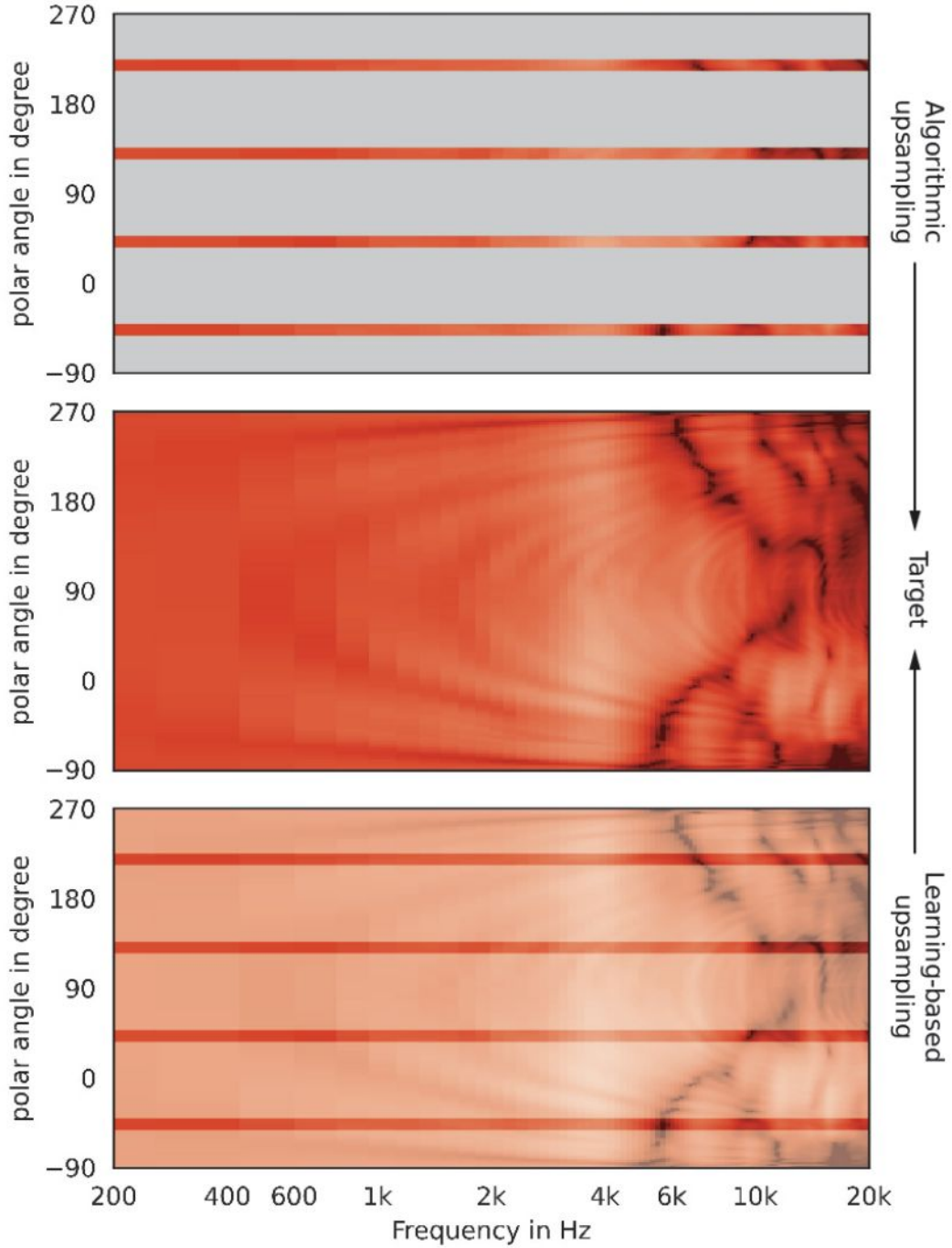
Learning-Based vs Algorithmic Upsampling



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Task 2 – The Winner

Spatial Up-sampling of HRTF Sets

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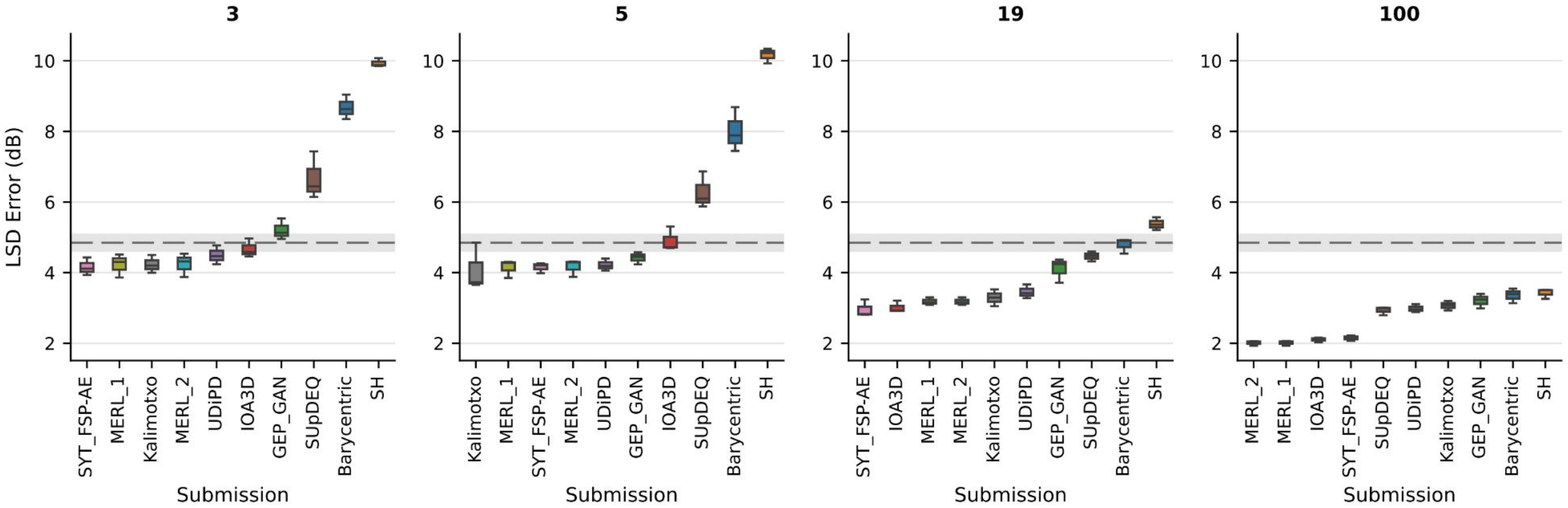
Task 2 – Evaluation (stage 2) - LSD



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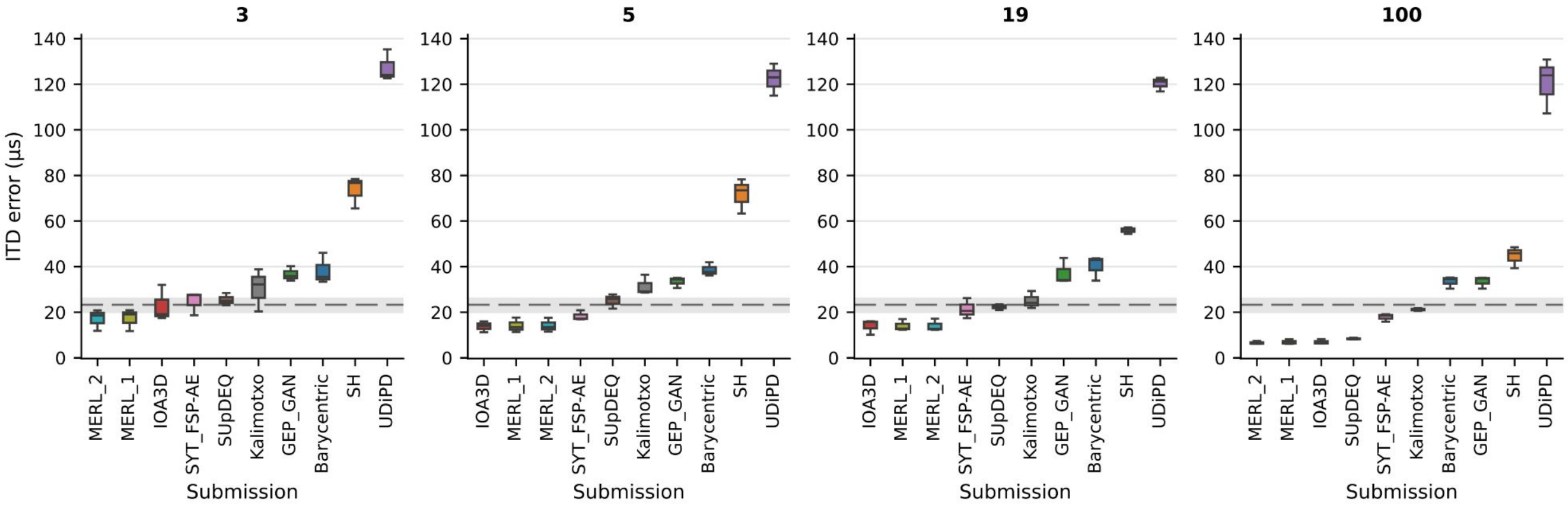
Task 2 – Evaluation (stage 2) - ITD



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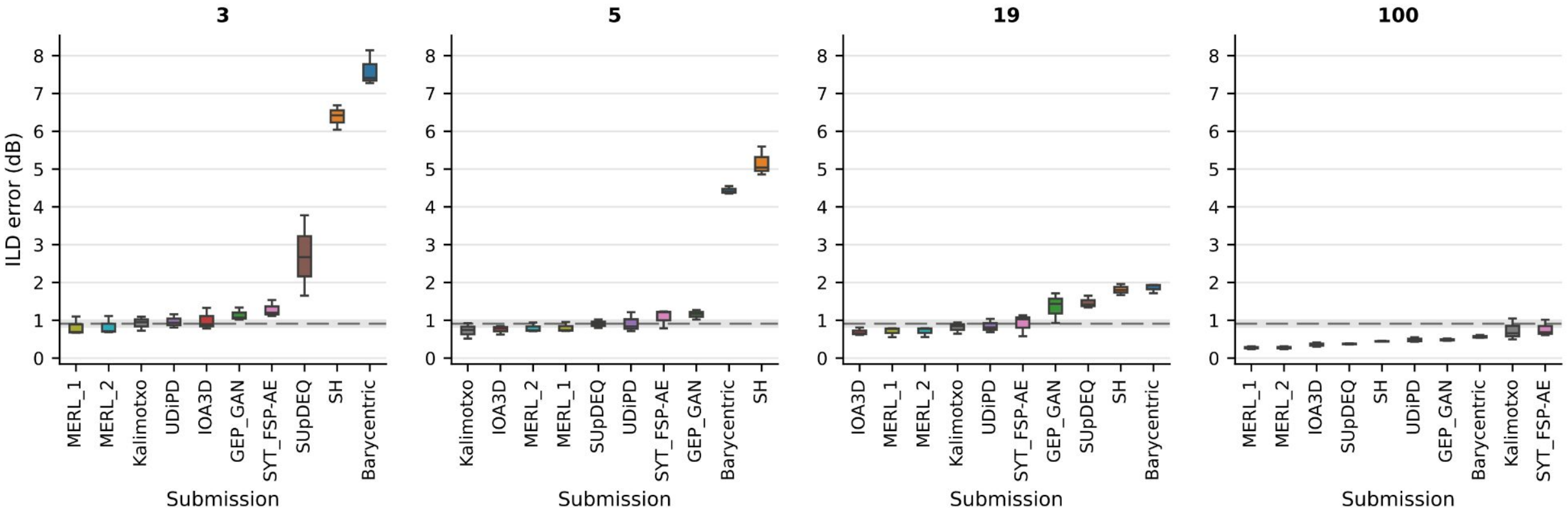
Task 2 – Evaluation (stage 2) - ILD



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Task 2 – Ranking Summary

Sparsity level 3		Sparsity level 5		Sparsity level 19		Sparsity level 100	
model	score	model	score	model	score	model	score
MERL_1	-12.688	MERL_1	-13.329	IOA3D	-14.732	MERL_2	-17.600
MERL_2	-12.674	MERL_2	-13.312	MERL_1	-14.514	MERL_1	-17.543
IOA3D	-11.002	IOA3D	-12.612	MERL_2	-14.510	IOA3D	-17.341
SYT_FSP-AE	-10.922	SYT_FSP-AE	-12.270	SYT_FSP-AE	-13.241	SUpDEQ	-16.165
Kalimotxo	-10.249	Kalimotxo	-10.488	Kalimotxo	-12.353	SYT_FSP-AE	-14.920
GEP_GAN	-7.848	GEP_GAN	-9.264	SUpDEQ	-10.773	Kalimotxo	-13.366
SUpDEQ	-6.360	SUpDEQ	-8.956	GEP_GAN	-8.696	GEP_GAN	-11.372

Ranking Summary for Task 2 submissions

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Task 2 - Winner - MERL 2

Overall	
model	score
MERL_2	-58.098
MERL_1	-58.075
IOA3D	-55.688
SYT_FSP-AE	-51.355
Kalimotxo	-46.457
SUpDEQ	-42.256
GEP_GAN	-37.182

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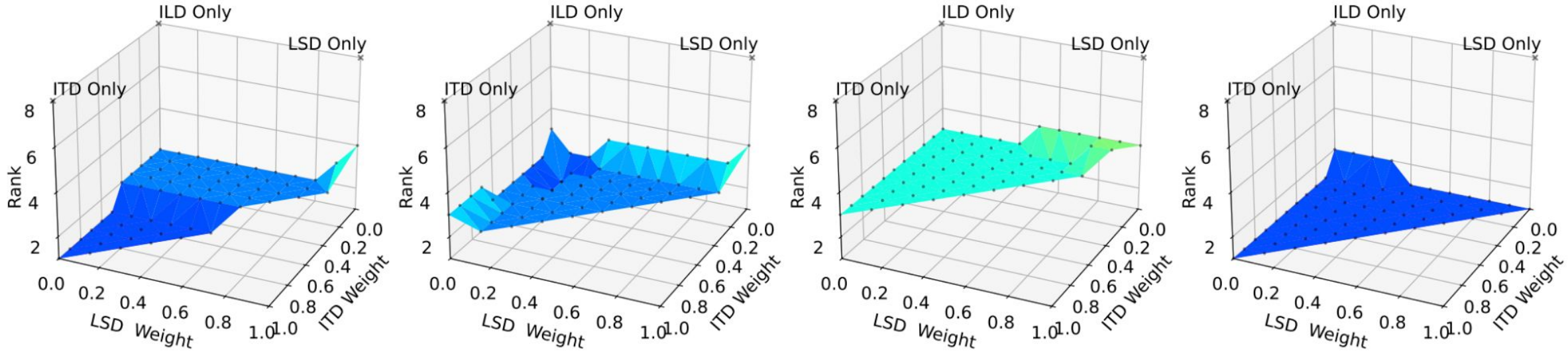
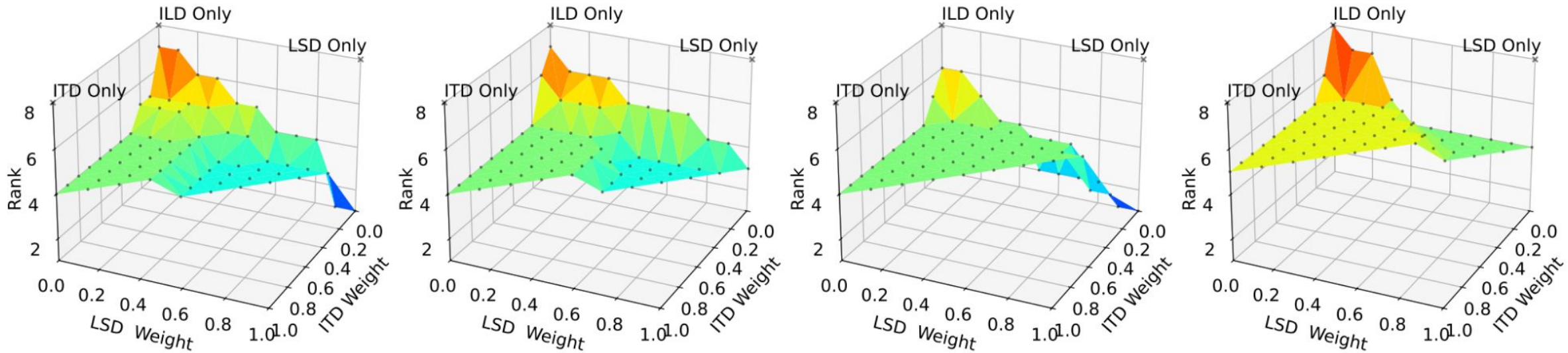


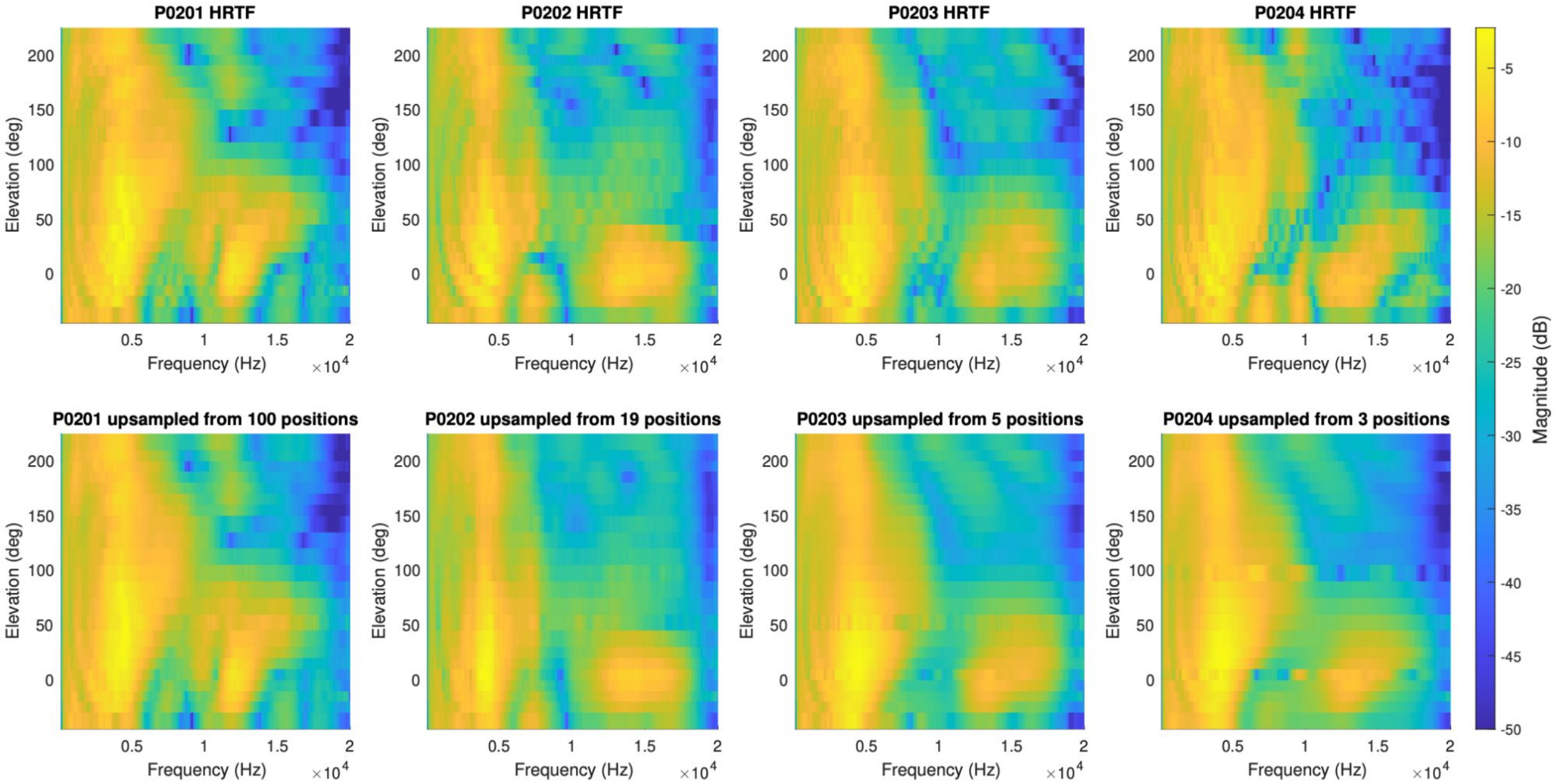
(a) Sparsity level 3 (b) Sparsity level 5 (c) Sparsity level 19 (d) Sparsity level 100

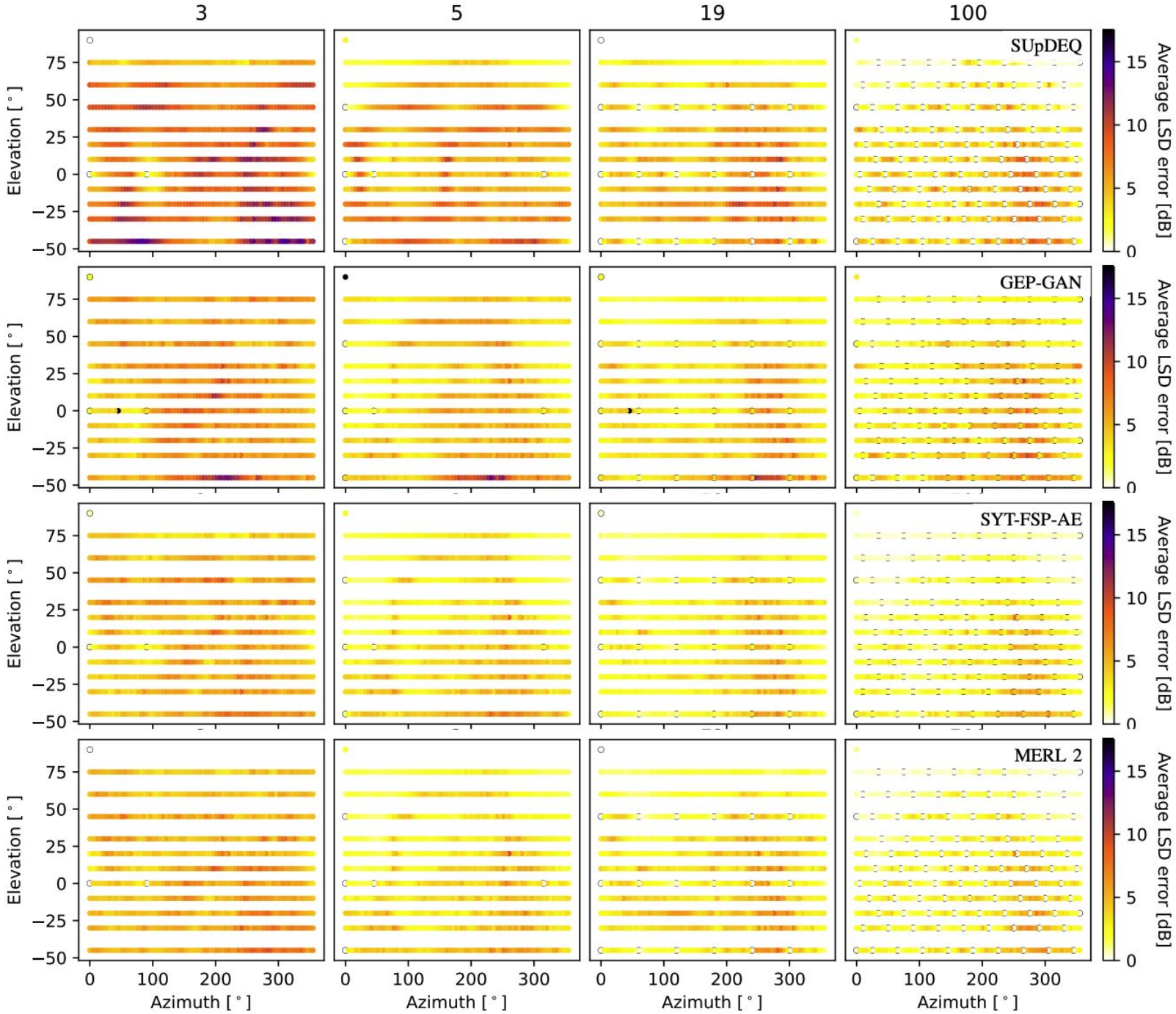
FIGURE 6. MERL 2 (winner) Ranking. This winning solution is very resilient to changes in metric weighting.

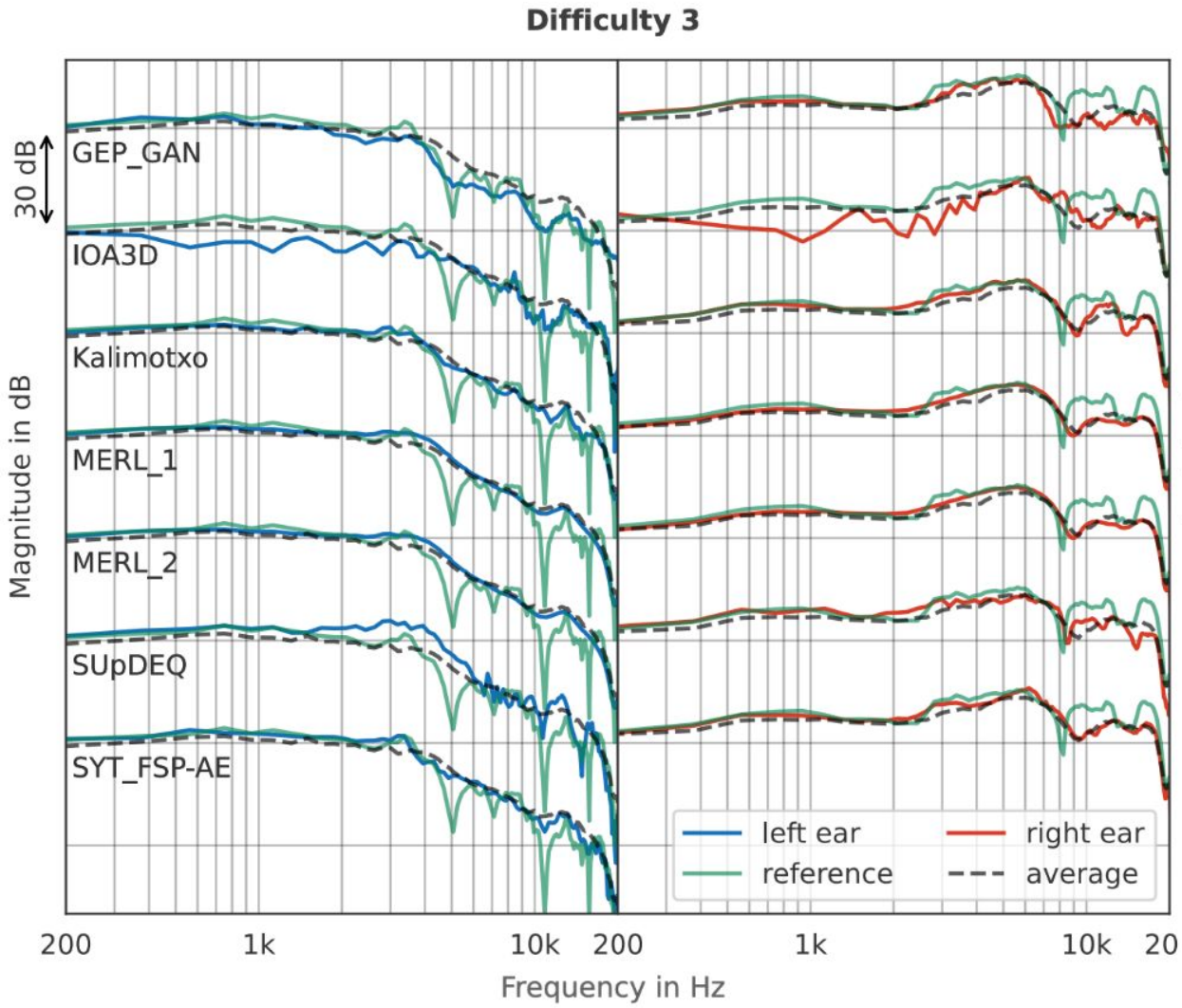


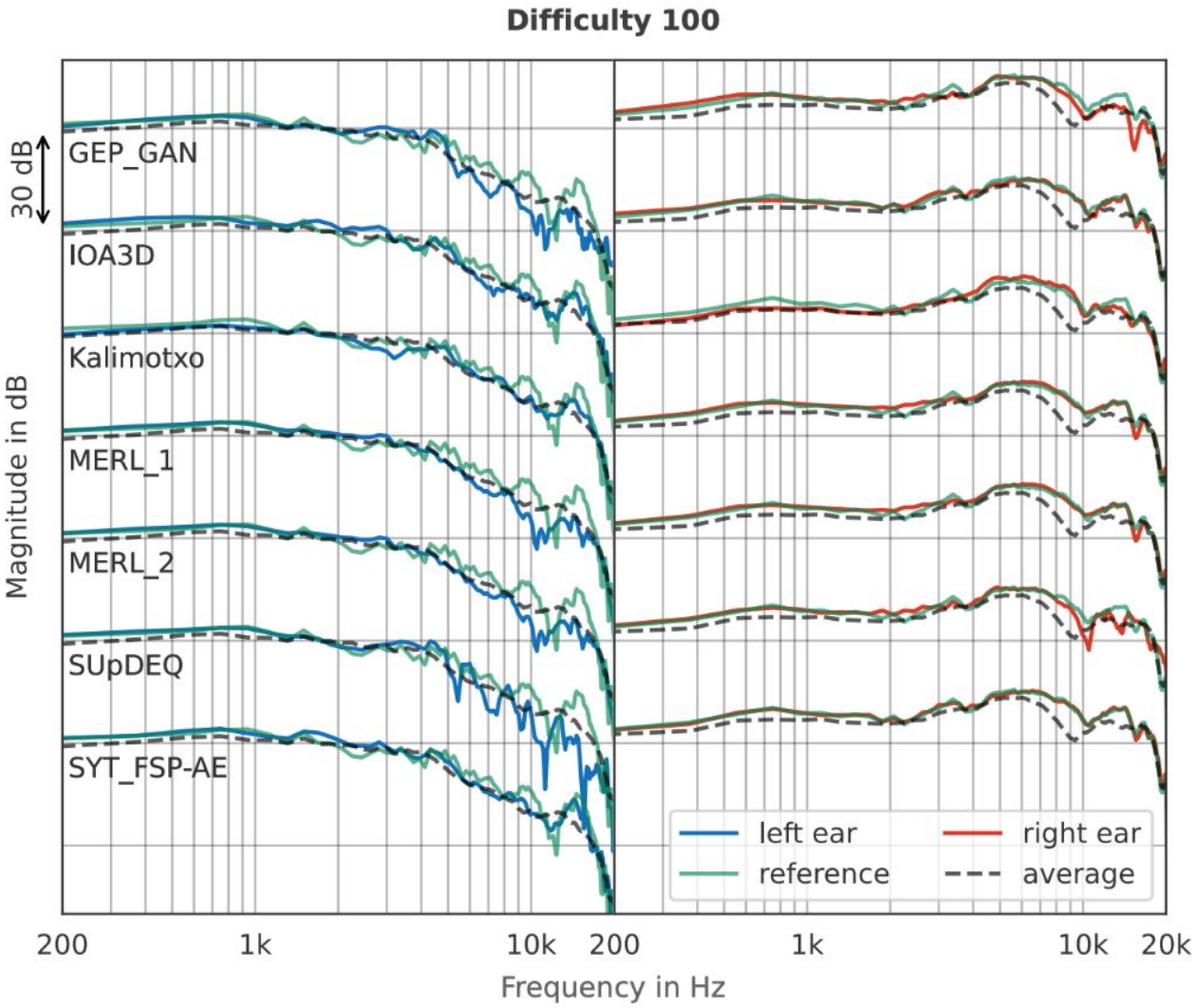
(a) Sparsity level 3 (b) Sparsity level 5 (c) Sparsity level 19 (d) Sparsity level 100

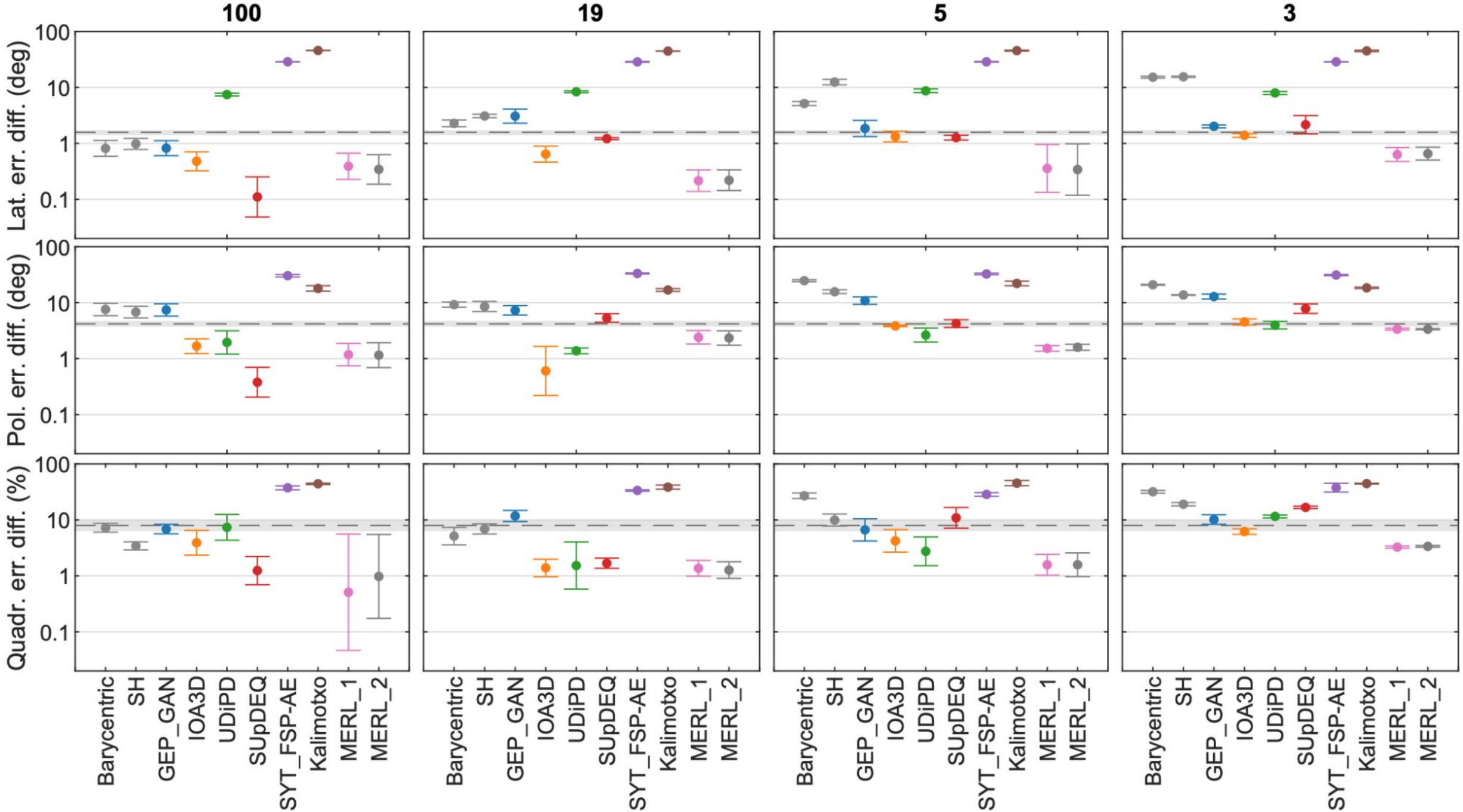
FIGURE 7. SYT-FSP-AE Ranking. This is an example where a solution is not very resilient to changes in metric weighting.


P0201 HRTF
P0202 HRTF
P0203 HRTF
P0204 HRTF
P0201 upsampled from 100 positions
P0202 upsampled from 19 positions
P0203 upsampled from 5 positions
P0204 upsampled from 3 positions
Elevation (deg)
Frequency (Hz)
×10^4
Magnitude (dB)


3
5
19
100
SUpDEQ
GEP-GAN
SYT-FSP-AE
MERL 2
Elevation [°]
Azimuth [°]
Average LSD error [dB]
75
50
25
0
−25
−50
0
100
200
300
15
10
5


Difficulty 3
30 dB
GEP_GAN
IOA3D
Kalimotxo
MERL_1
MERL_2
SUpDEQ
SYT_FSP-AE
Magnitude in dB
left ear
right ear
reference
average
200
1k
10k
200
1k
10k
20
Frequency in Hz


Difficulty 100
30 dB
GEP_GAN
IOA3D
Kalimotxo
MERL_1
MERL_2
SUpDEQ
SYT_FSP-AE
Magnitude in dB
left ear
right ear
reference
average
200
1k
10k
200
1k
10k
20k
Frequency in Hz


100
19
5
3
Lat. err. diff. (deg)
Pol. err. diff. (deg)
Quadr. err. diff. (%)
100
10
1
0.1
Barycentric
SH
GEP_GAN
IOA3D
UDiPD
SUpDEQ
SYT_FSP-AE
Kalimotxo
MERL_1
MERL_2

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Special Thanks!
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Relevant URLs, Documents and Resources

LAP Challenge 2024

https://www.sonicom.eu/lap-challenge/

Evaluation Code

https://github.com/Audio-Experience-Design/LAPChallenge

Spatial Audio Metrics library (Python)

https://spatial-audio-metrics.readthedocs.io/en/latest/

Technical Report

https://imperialcollegelondon.app.box.com/s/okuvkjiizrlv761na73ico2ocpqkfn7d

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Dreamwaves

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Thank You

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