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CAN SPATIAL LISTENING ASPECTS OF A HALL BE MEASURED DURING A CONCERT?

ISMRA, La Plata, Sunday 11th September 2016

Spatial aspects and metrics.

Source Broadening	ASW
Listener Envelopment	LEV
Inter-Aural Cross-Correlation	IACC
Binaural Room Impulse Response	BRIR
IACC of BRIR Early part (0-80ms)	IACCE
IACC of BRIR Late part (80-1000ms)	IACCL

This we know about IACC and BRIR

Whenever G and C80 is adequate, then

IACCE = 0.3-0.4 => very good ASW

IACCL = 0.1- 0.2 => very good LEV

Higher IACCE => lower ASW => less source broadening

Higher IACCL => lower LEV => less listener envelopment

Applies to BRIR

However, listneners rarely hear such impulses

Pursuing the ASW-LEV-Meter

Ultimate goal: Measure all listener aspects «live»

Milestone: Measure ASW and LEV live

Milestone: Measure ASW and LEV from recordings

Milestone: Decode IACCE and IACCL from IACC(t)

Milestone: Proof of consistent hall-to-hall differences in IACC(t), despite large temporal fluctuations in music

Start: Investigating IACC(t) behaviour from recordings

IACC and the Median Plane

Equal sound at both ears => IACC=1.0

Sounds arriving in the Median Plane contributes to higher IACC:

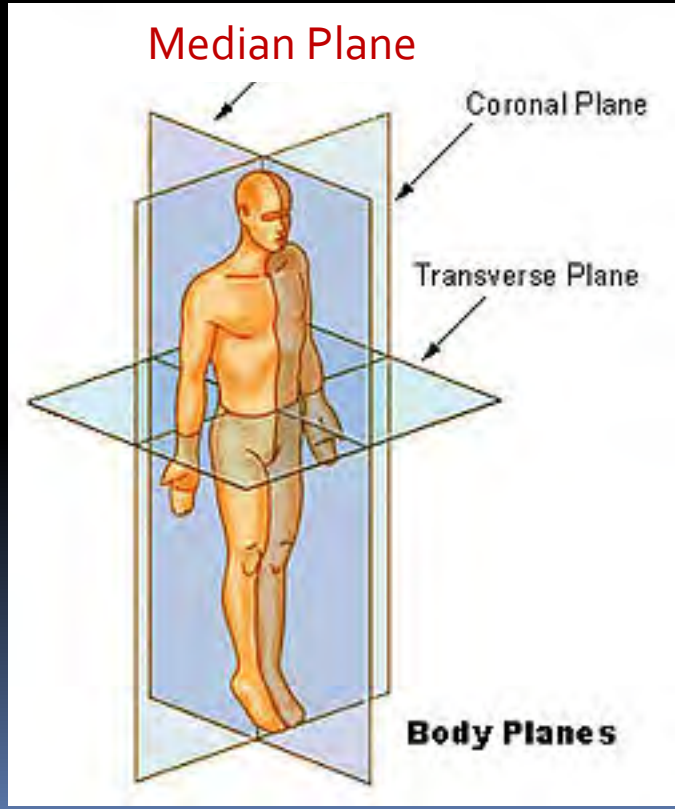
Direct sound in the Median Plane

Early reflected sound in the Median Plane

Late reflected sound in the Median Plane

Sound arriving from outside the Median Plane contributes to lower IACC

Lateral sound in particular



Sampling IACC(t) in 100ms bins

Definition used in this report:

Discrete IACC(t) , where $t_i = i \cdot 100ms$, $i=0,1,2,\ldots n$

Discussion: 100ms, a trade-off between

80ms traditional early energy limit, and

125ms traditional loudness build-up limit (time constant «Fast»)

Maximum temporal resolution 30-50ms considered, but assumed less relevant than loudness build-up

Measurement equipment?

I don’t think so

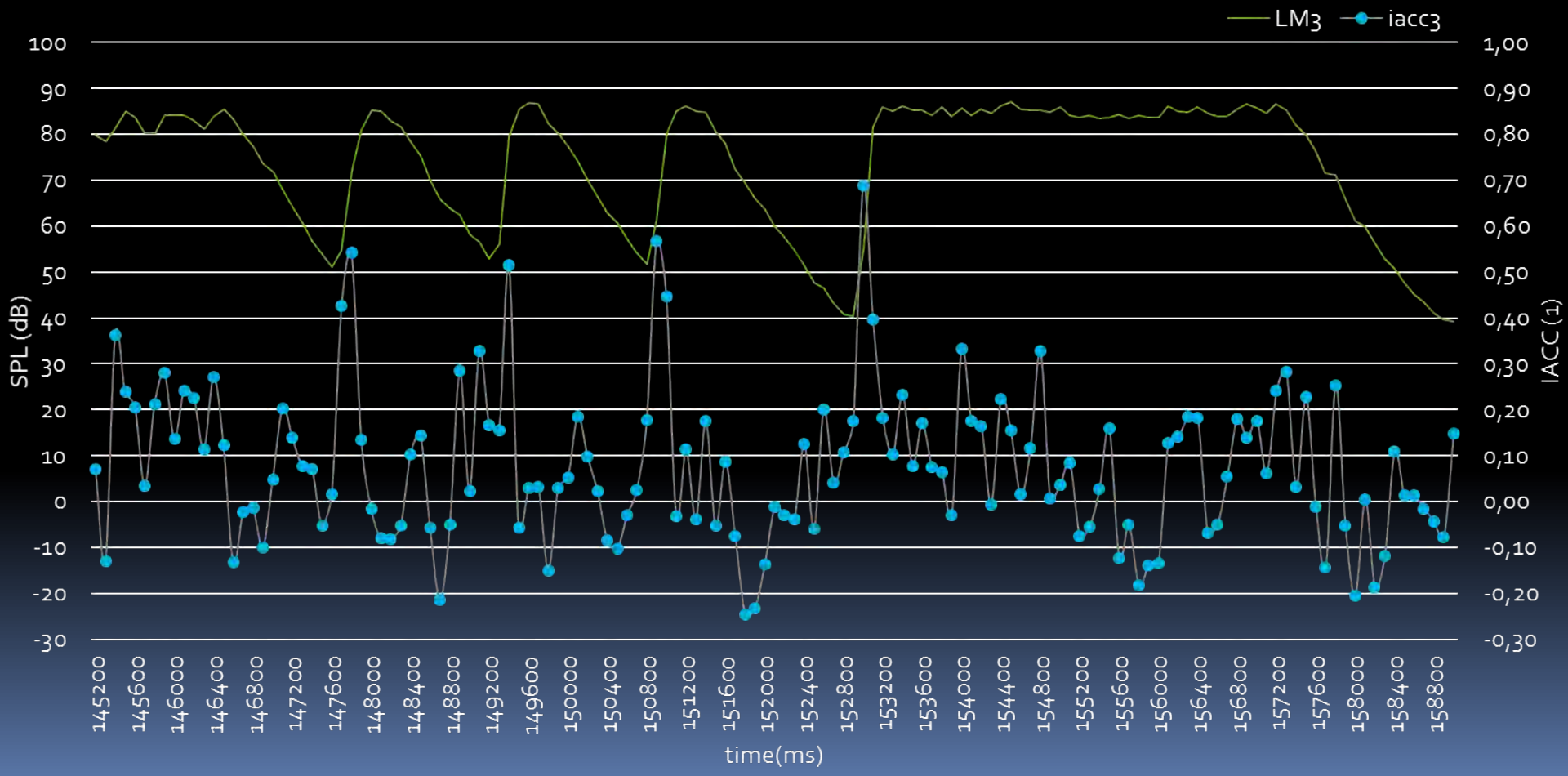
Measurement equipment

Post-processing soft-ware:

- Audacity
- winMLS 2004

Example: Boston, Brahms 1st Symphony

Boston, Level and IACC-samples 10/s



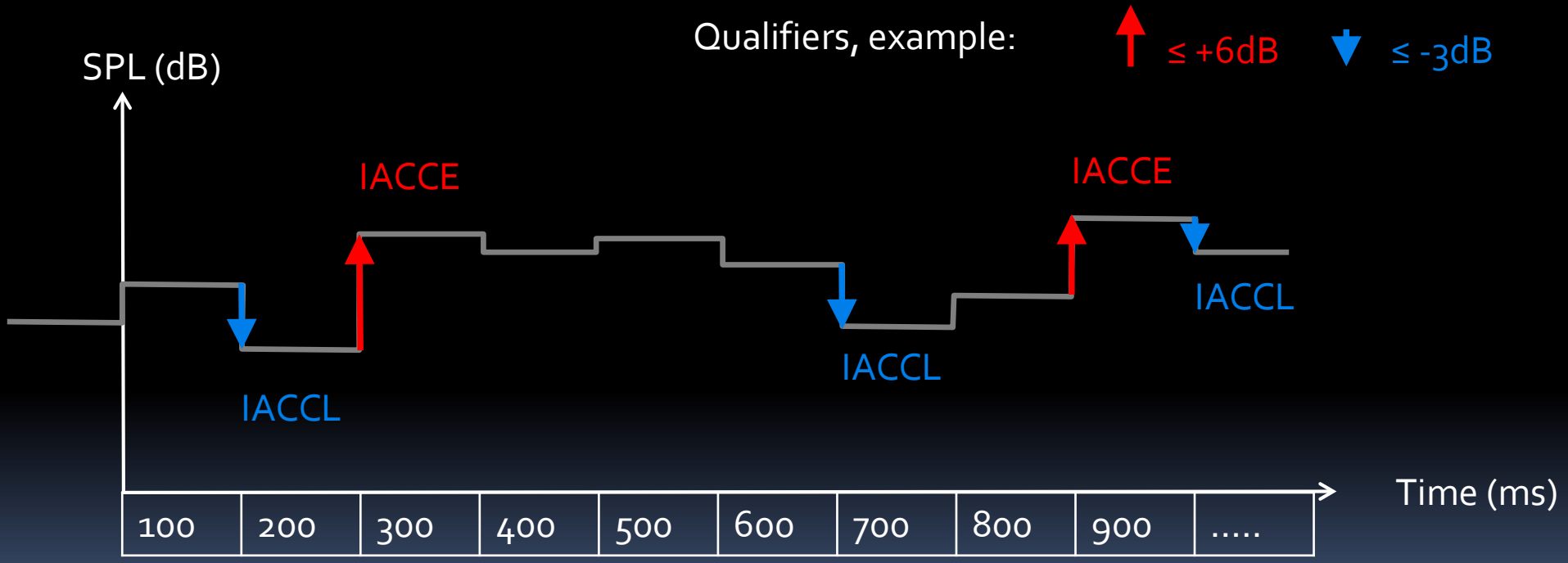
Stochastic behaviour of IACC(t)

All halls,
All orchestras
All music pieces
All parts, all bars
Standard deviation of IACC(100ms) is $\sigma \approx 0.25$

What if we separate IACC-samples in relevant categories?

Energy increment	-> «Early energy»	-> IACCE
Energy decrement	-> «Reverberant sound»	-> IACCL

Detecting «Early» and «Late» parts



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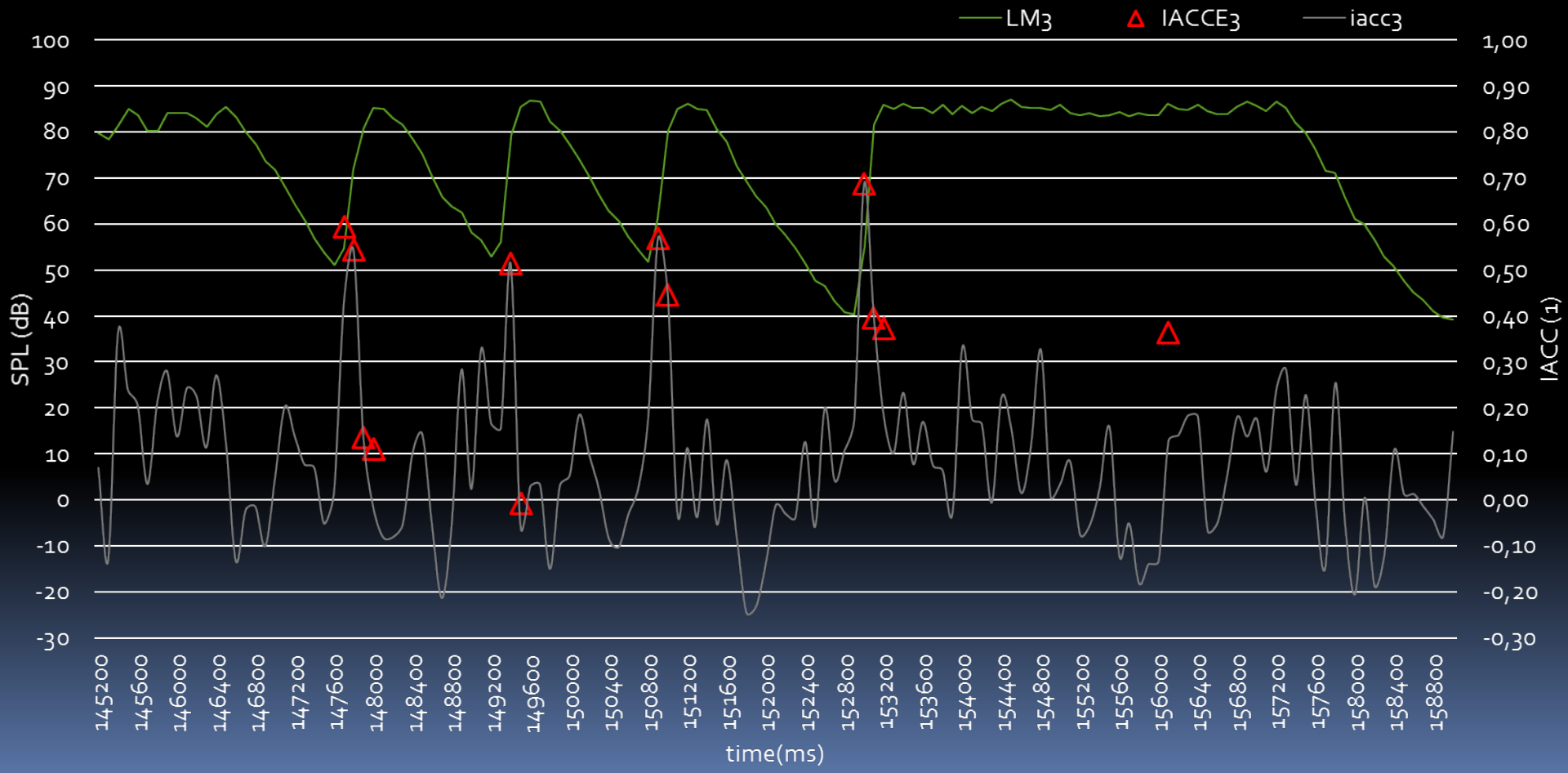
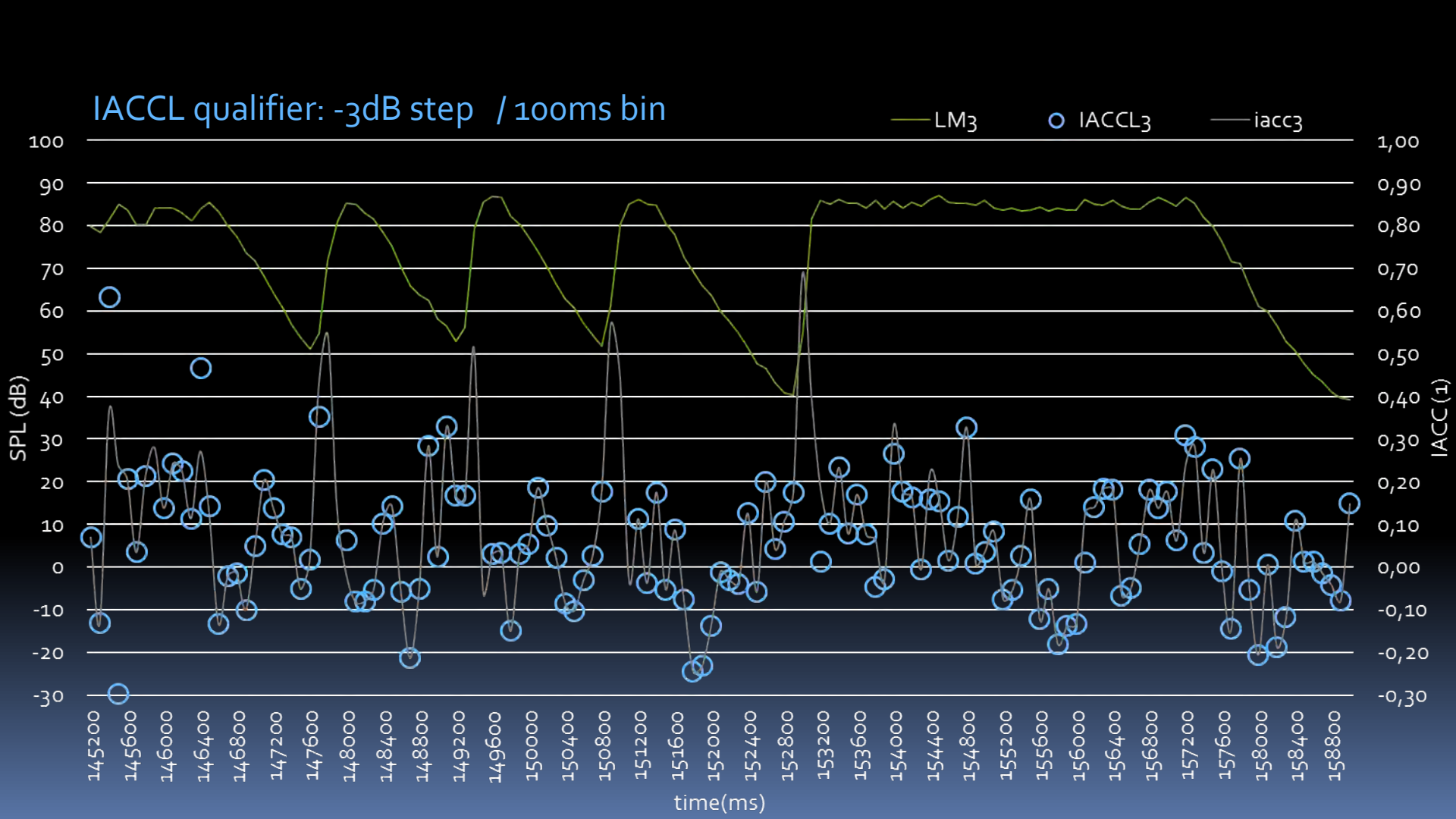
IACCE qualifier: +6dB step / 100ms bin




IACCL qualifier: -3dB step / 100ms bin
LM3
IACCL3
iacc3
SPL (dB)
IACC (1)
time(ms)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
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-0,10
-0,20
-0,30
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146000
146400
146800
147200
147600
148000
148400
148800
149200
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150400
150800
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152000
152400
152800
153200
153600
154000
154400
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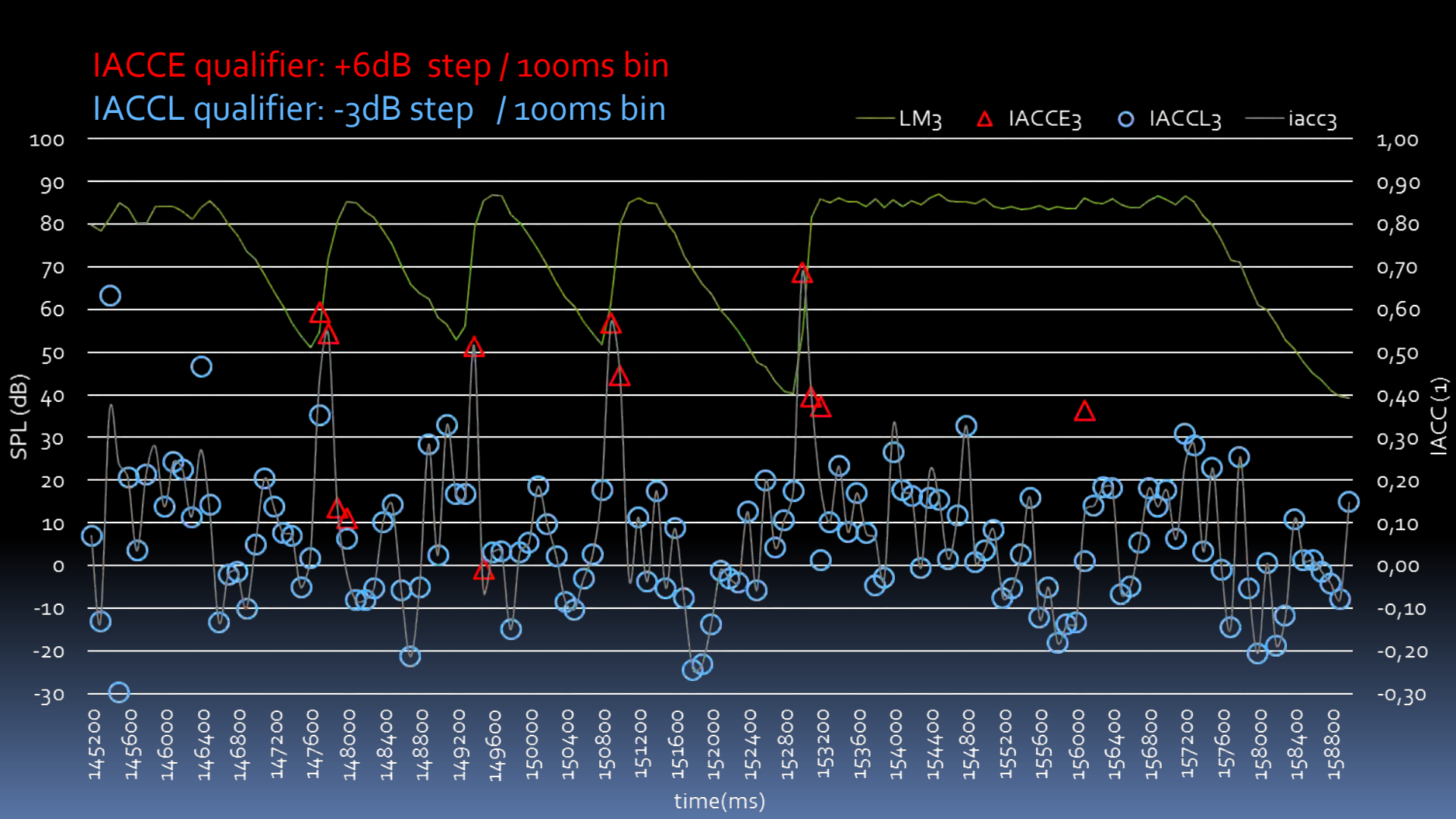
158400
158800


IACCE qualifier: +6dB step / 100ms bin
IACCL qualifier: -3dB step / 100ms bin
LM3
IACCE3
IACCL3
iacc3
SPL (dB)
IACC (1)
time(ms)
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158000
158400
158800

Stochastic behaviour of IACC(t)

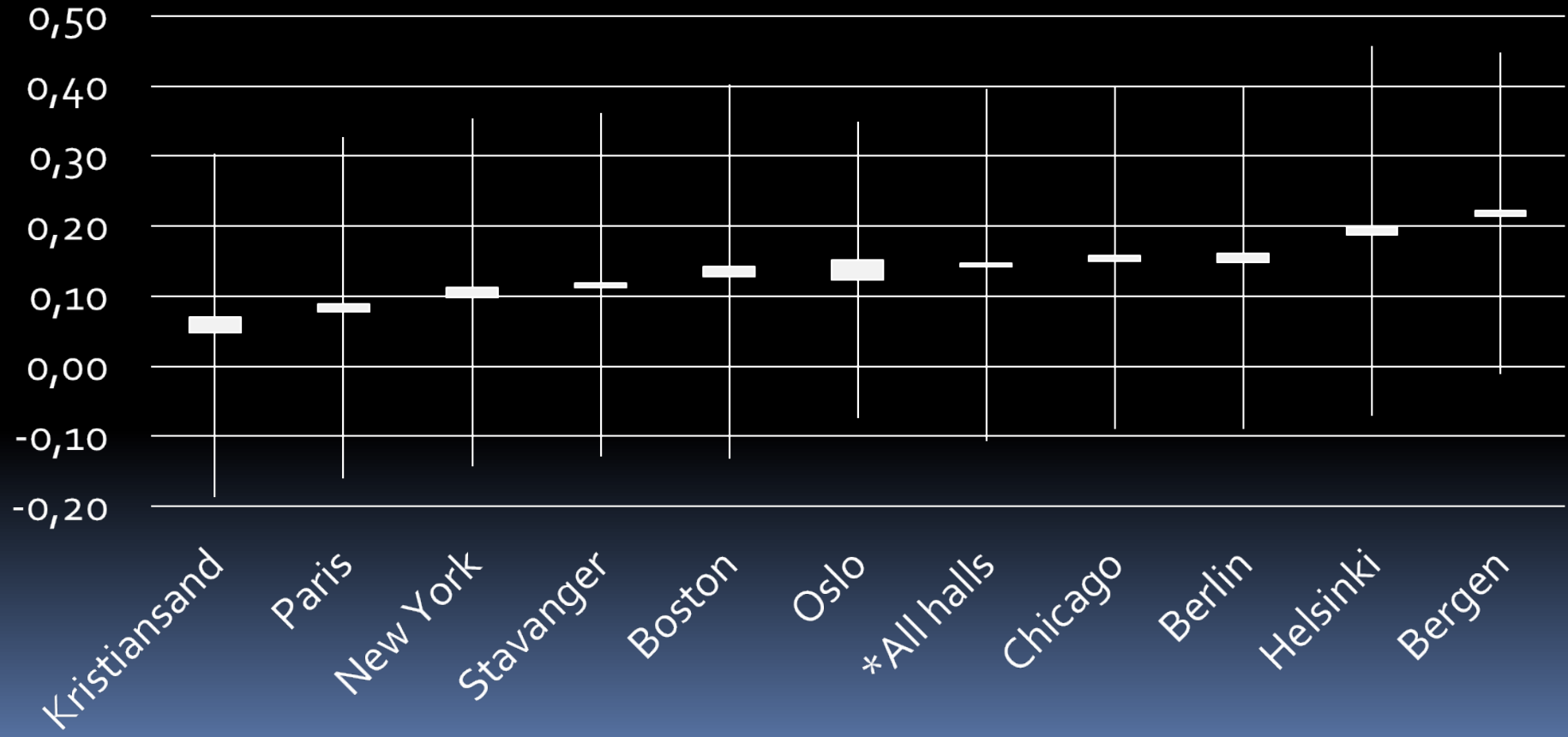
In the population: All samples from all halls, the 3 categories of IACC-samples fluctuate with $\sigma = 0.24$

However, with different means:

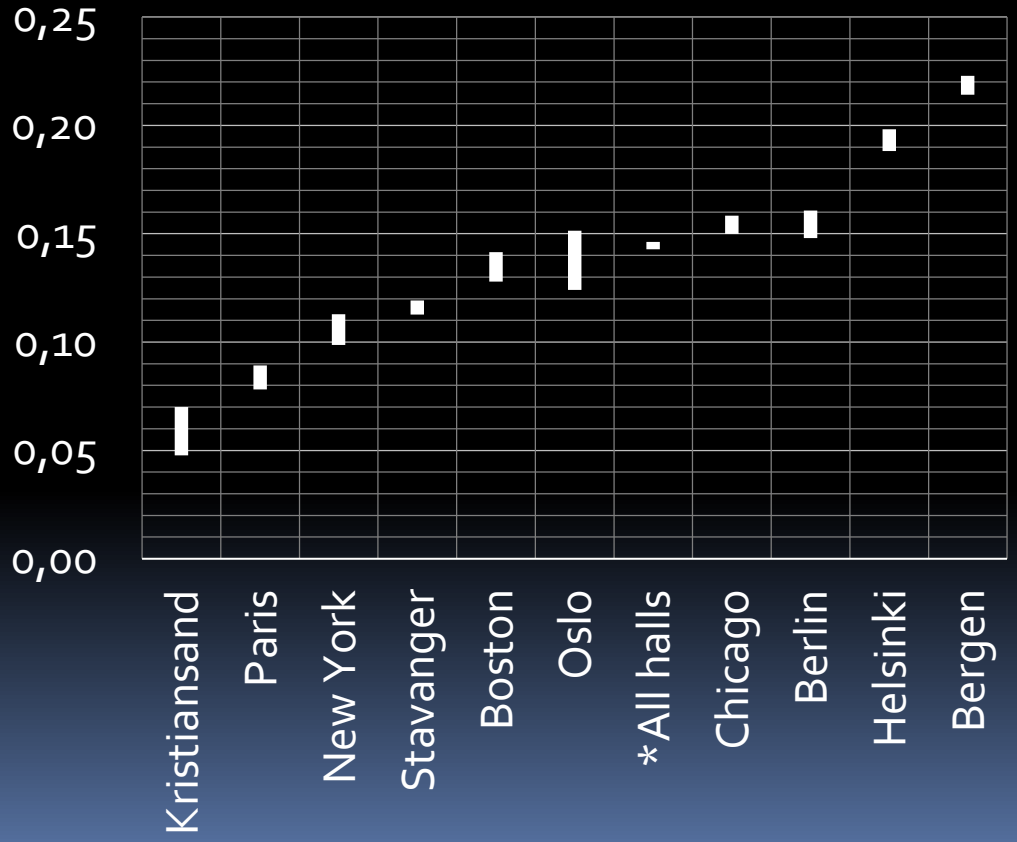
	$IACCL_3$	$IACC_3$	$IACCE_3$
μ	-0,02	0,14	0,37
σ	0,24	0,24	0,24

Confidence intervals around μ, are they narrow enough to reveal significant differences between halls?

IACC, 95% confidence, and σ bars



IACC3, 95% confidence around means



Apparently small range 0.06-0.22

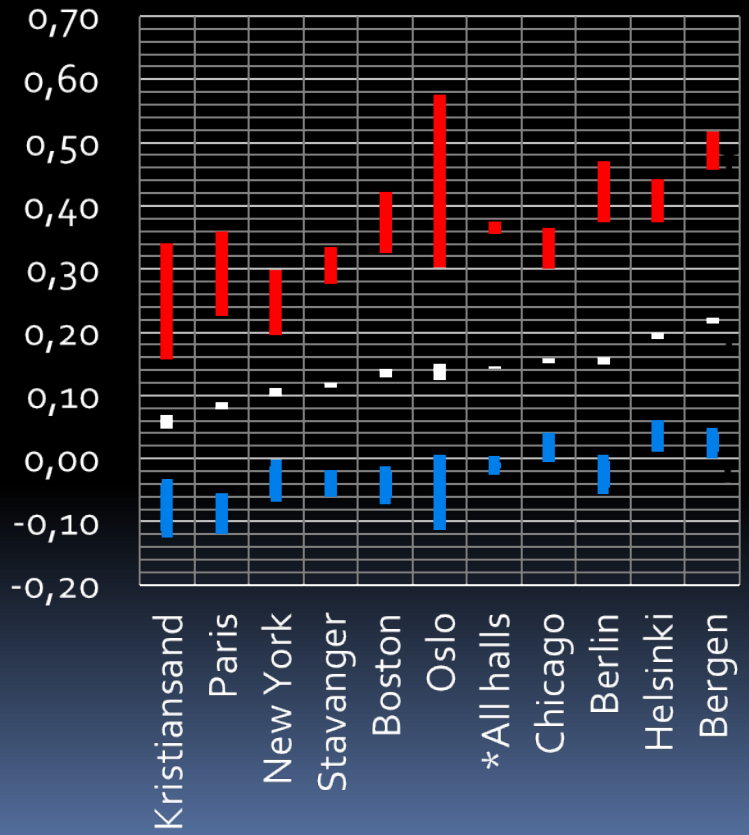
However,

Significant differences between halls

All halls except Oslo differ from the population of all halls.

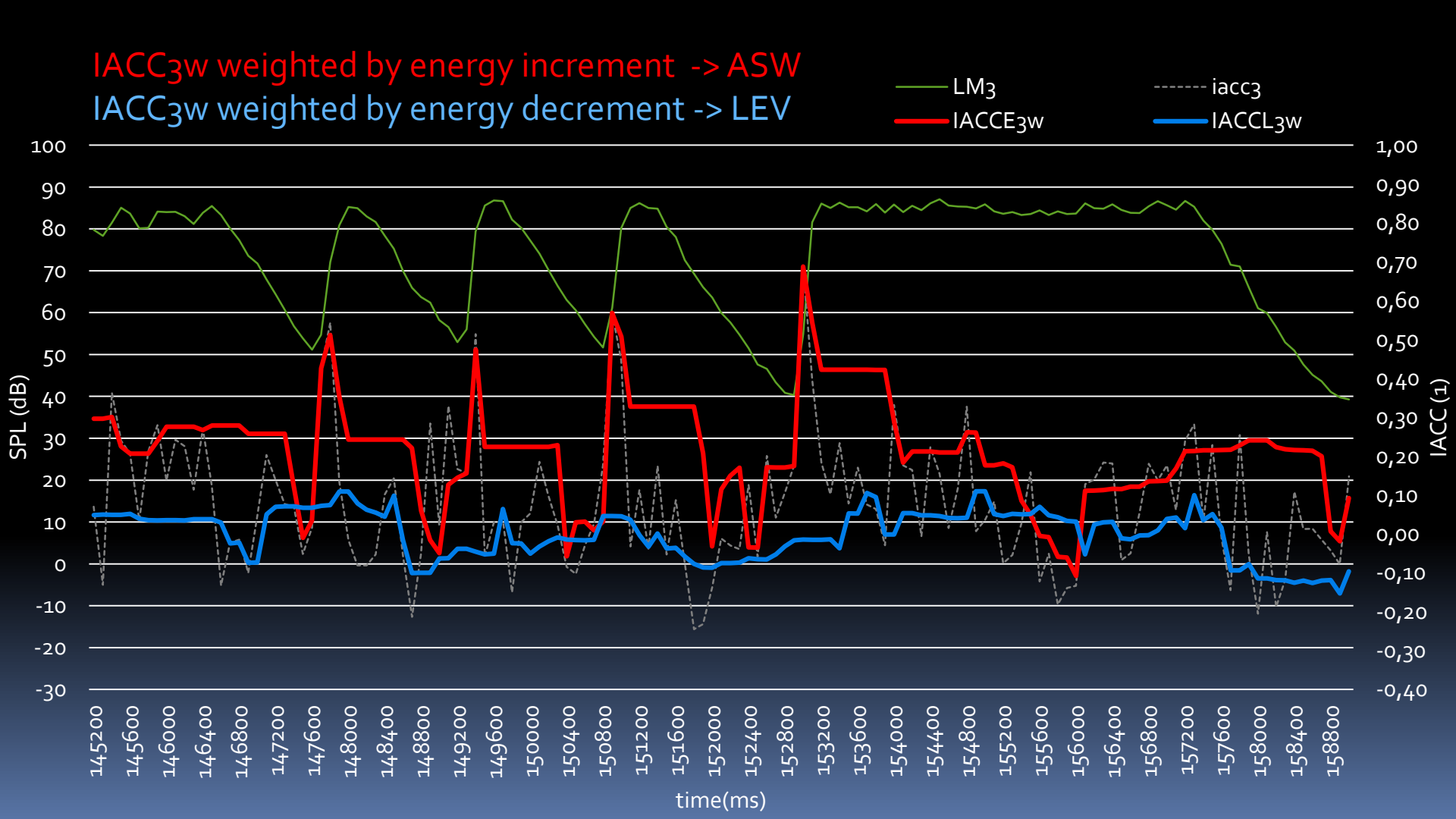
But are the differences noticeable?

IACCE3, IACC3 and IACCL3



Strict criteria in IACCE and IACCL detection
⇒ Small population of IACCE and IACCL
⇒ Wide confidence intervals

Try continuous weighting instead of «Qualified» or «Not Qualified»


IACC3w weighted by energy increment -> ASW
IACC3w weighted by energy decrement -> LEV
LM3
iacc3
IACCE3w
IACCL3w
SPL (dB)
IACC (1)
time(ms)
100
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80
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Summary

- Measurements from 10 halls, total 360.000 IACC-samples
- Stochastic, Gaussian features found in data set, large temporal variance, σ=0.24
- Small, but statistically significant hall-to-hall differences
- Further work
  - Try acquire IACCE and IACCL from continuous weighting
  - Compare results with those from BRIR
  - Investigate within-hall differences
  - Investigate recorded cases of equal music played in different halls
  - Compare results with available subjective assessment
  - Include HF-cues, from ILD
  - Is ASW and LEV created continuously, or memories of peak moments?

BREKKE STRAND

Thank you

More info?

The www center for search, research and open sources in acoustics

www.akutek.info

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