TOTAL EFFECTIVE SOUND PRESSURE LEVEL OF ACOUSTIC CAMERA (RING 32-4211) COMPARED WITH FOUR FREE-FIELD ½”-MICROPHONES

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ABSTRACT

As a result of the higher sampling rates used with the GfaI acoustic camera it has been assumed that the effective sound pressure levels to be higher than those measured with a standard microphone system at the same focal distance.

GfaI have stated that the overall effective sound pressure level of a acoustic camera ring with 32 microphones is systematically about 1.0 to 1.5dB higher than sound pressure level measurements with standard microphones. To validate this statement an investigation in a hemi anechoic test cell has been carried out.

Using a reference sound source a comparison has been made between the acoustic camera and a standard microphone measurement system. Measurements were made with variations in focal distances and sampling rates to validate the conclusions.

In this comparison the effective sound pressure level of the acoustic camera is 2.0 to 2.3dB higher than the averaged SPL from the free-field microphones

The differences in effective sound pressure levels can be traced back not to the higher sampling rates but to the difference in the spectral content measured by the two separate systems. Further work needs to be done to investigate these differences more closely.

1 INTRODUCTION

The investigations with a 'modified' Ring Array 32-4211 [1] has been conducted in a hemi-anechoic test cell.
As a 'independent' sound source a B&K 4204 reference sound source [2] was used, placed on a post in the center of the anechoic cell.

Four B&K 4190 1/2"-free-field microphones [3] have been arranged on the ring equally spaced with their membranes adjusted almost to same level as the ring-microphones. The signals of the four microphones were sampled with Harmonie™ [4], a portable four-channel system and analysed with dBFA32 [5] signal processing software package.

2 SETUP AND CONDITIONS OF MEASUREMENTS

The time period recorded was 2 seconds. The integration time to calculate an acoustic Photo with a x-Pixel-resolution of 150 was always done with the full signal by 'Select all'. The equivalent continuous sound level L_{Aeq} calculated in dBFA32 was also integrated over 2 seconds. The highest sampling rate of 51.2kHz for the Harmonie was always selected, to get the maximum real-time bandwidth of 20kHz, with resolution per channel of 20bit.

The measurements have been conducted with a focal distance 1m, 1.5m and 2m from the sound source. To verify the influence of higher sampling rates to overall effective sound pressure level , each focal distance was additionally sampled with 96kHz and 192kHz .

For the major comparison however the sample rate of the acoustic camera was reduced to 48kHz to get similar acquisition parameters

2.1 Adapting and Positioning of B&K 4190 Microphones

Fig.1. Positions 4 B&K 4190 Mic's on Ring

Fig.2. Detail Adapter of B&K Mic Nr.4

3 RESULTS

3.1 Influence of higher sample rate to overall effective sound pressure level

Doubling the sample rate reduces the effective sound pressure level about 0.1dB, so at 192kHz we will get 0.2dB less effective sound pressure at each focus distance.

Fs [kHz]	Fs/2 [kHz]	A.C. Soundlevel (all) [dBA]		
		1.0 [m]	1.5 [m]	2.0 [m]
48	24	83.9	80.7	78.5
96	48	83.8	80.6	78.4
192	96	83.7	80.5	78.3

Table1.Results of three different sample rates & focus distances

This can be explained by the effect of the digital filter properties of the used weighting filter curves. There is a range of inaccurate approximation at 48kS/sec.[6] The higher the fs/2, the higher is the precision of the weighting curve or let's say the 'damping behaviour'.

3.2 Major comparison at three different focus distances

It can be seen, that the acoustic camera shows higher effective overall sound pressure levels, starting with 2dB at 1m and ends with 2.3dB at 2m focal distance. The overall level decreases in this case by 5.3dB per doubling of distance (spherical spreading due to inverse square law). The decrease should be 6dB as long the environment is effectively free field.

Distance [m]	A.C.Ring	Avg.4 Mics	Difference
1	83.8 dB	81.5 dB	2.0
1.5	80.5 dB	78.4 dB	2.1
2	78.5 dB	76.2 dB	2.3

Table 2. Results of the three different focus distances

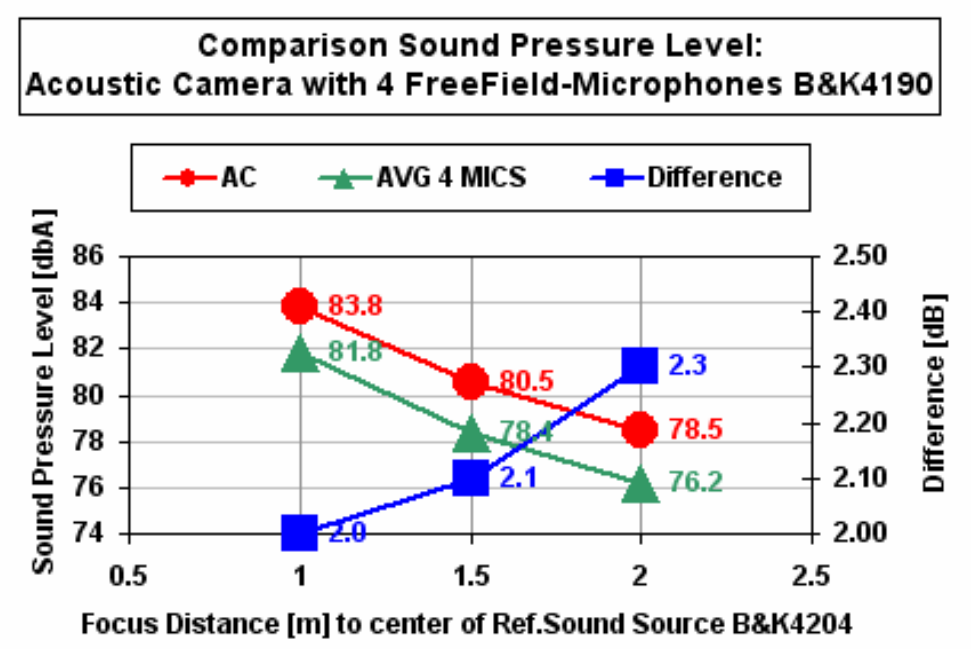

Fig. 3. Diagram Absolute SPL and Difference between A.C. & Avg.4 Mics

3.3 Spectral Investigation with sets of microphone signals

To get more information about the cause of this difference in overall sound pressure level, the signals of the four B&K microphones (B&K Microphones #1…#4) and the signals of two A.C. microphone sets AC microphones #06,#14,#21,#30 (closest to the B&K microphones) and AC microphones #02,#10,#18,#25 (away from the influence of the B&K microphones) have been analysed in the frequency domain with 1/3-octave representation.

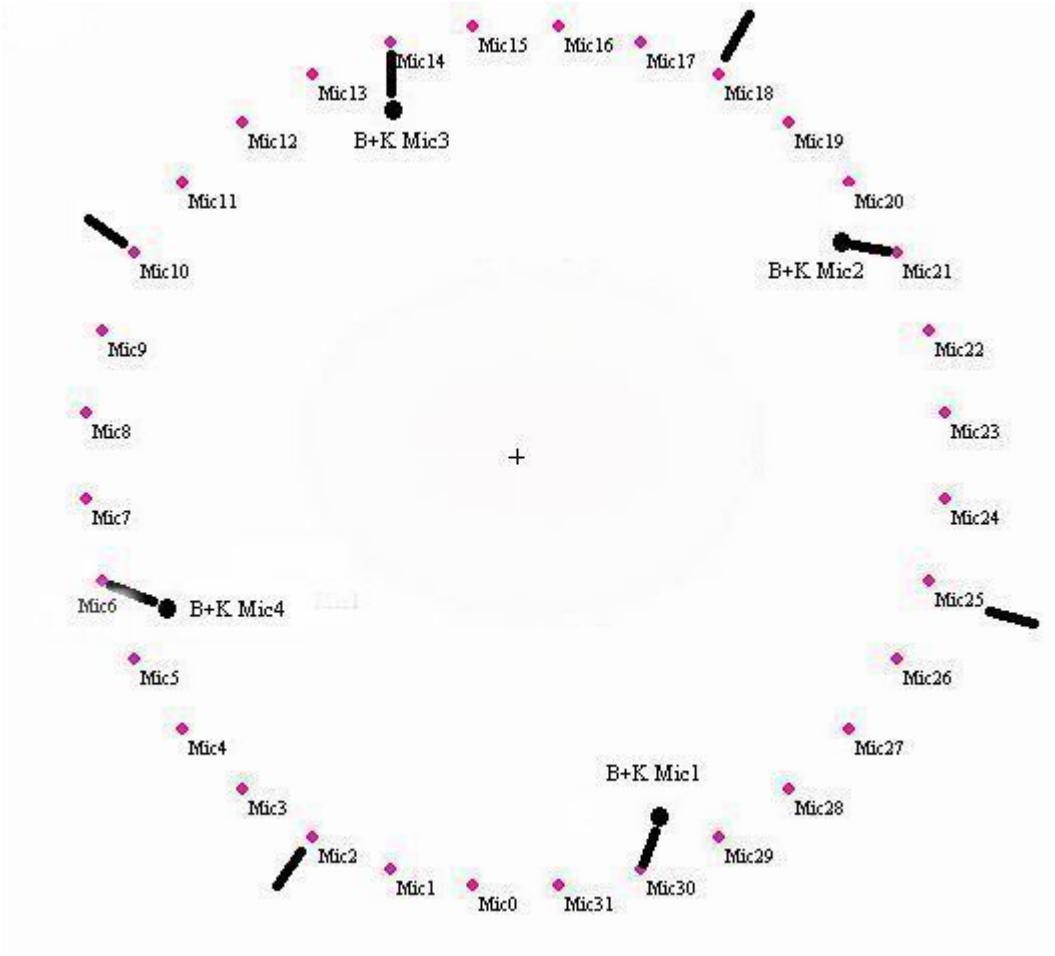

Fig. 4.Definition and Position of compared microphones on ring array

First a comparison of the overall sound pressure level of the selected A.C. microphone sets has been done.

Acoustic photos were calculated by selecting ALL (Mic0..Mic31), then Set 1 (Mic6,14,21,30) and then Set 2 (Mic2,10,18,25). The maximum absolute difference between the sets is 0.3dB at 1.0m und 1.5 m distance.

Distance [m]	Sound level (all) [dBA] Photo A.C.mic's		
	ALL	6,14,21,30	2-10-18-25
1	83.8	84.1	83.8
1.5	80.5	80.8	80.5
2	78.5	78.6	78.4

Table3.Results SPL(all) Photo of selected A.C. microphones

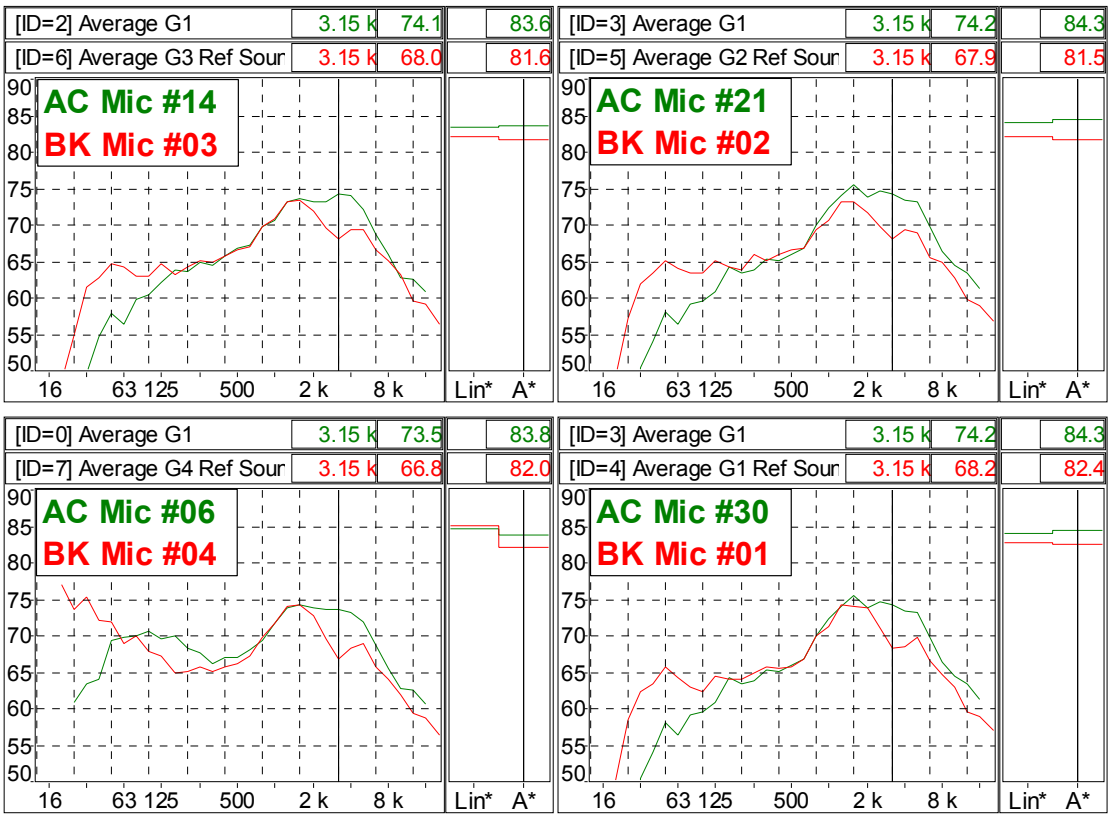

Fig.5 1/3-octave-spectra A.C. Mic-set 1: Focus 1m fs=48kHz; Cursor at fc=3.15kHz

Mic's compared	Difference SPL [dB] for..	
	Fc=3.15kHz	Overall
BKMic#01-ACMic#30	-6.0	-1.9
BKMic#02-ACMic#21	-6.3	-2.8
BKMic#03-ACMic#14	-6.1	-2.0
BKMic#04-ACMic#06	-6.7	-1.8

Table4.Results 1/3-octave-spectra: Focus 1m fs=48kHz; Cursor at fc=3.15kHz

At 3.15kHz the four B&K-microphones show systematically about 6.3 dB lower pressure levels and this yields about 2.1 dB lower overall sound pressure level than the microphones of the acoustic camera. To check a influence of the adapters with B&K-microphones to the ring microphones a different set of ring microphones was analysed spectrally. (see Fig.9: Mic2,Mic10,Mic18,Mic25)

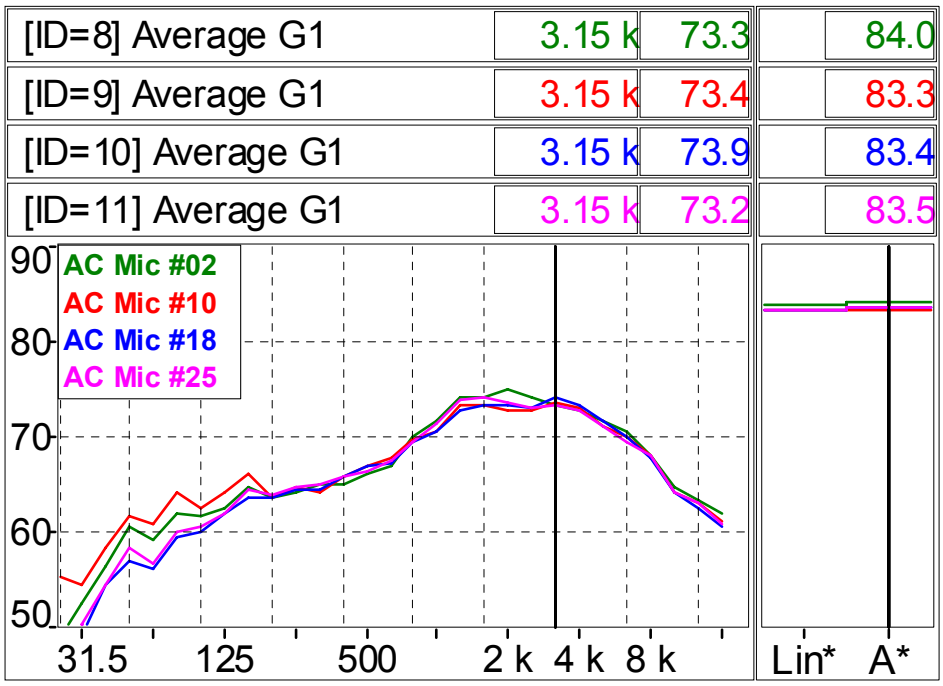

Fig.6 1/3-octave-spectra A.C. Mic-set 2: Focus 1m fs=48kHz; Cursor at fc=3.15kHz

Also this A.C. Mic-set2 (without influence of B&K mics) shows ~5.7dB higher 3.15kHz-octaves than the 4 B&K microphones.

Distance [m]	Max.sound level at hot-spot AC mic's			Avg. B&K mic's #1,#2,#3,#4
	ALL	#6,#14,#21,#30	#2,#10,#18,#25	
1	80.9	81.3	81.0	81.5
1.5	78.3	78.6	78.3	78.3
2	76.4	76.8	76.5	76.5

Table5.Results max.SPL 'Hot-spots' of selected A.C. microphones

From Table 5. it can bee seen, that the maximum sound pressure level of the detected 'hot-spot' correlates well with the respective averaged sound pressure level of the four B&K-microphones.

The maximum absolute difference reaches here 0.6dB

4 CONCLUSIONS

It has been shown, that the assumption of using higher sample rates of the acoustic camera would yield higher effective overall sound pressure level, is incorrect. Doubling the sample rate will decrease the effective overall sound pressure level by 0.1dB.

Comparing 1/3-octave spectra between 4 B&K4190 free field microphones and 2 sets of A.C. microphones (first set is nearest to B&K microphones, second set is shifted ~45°) show about 6dB higher pressure level at fc=3.15kHz of the A.C. microphones.

In the effective overall sound pressure level the Acoustic Camera shows ~2dB higher results.

An explanation for this high spectral difference cannot be given as yet. As the difference lies in a most important frequency range, further investigation should be carried out. For example, frequency response measurements of built-in standard microphone capsule and repetition of these measurements with different acoustic arrays and reference microphones.

REFERENCES

[1] GfaI, Acoustic Camera User Manual, English,8-7,2004

[2] Datasheet Brüel&Kjaer B&K Type 4204 Reference Sound Source; Calibration Table Reference Sound Source 4204 SN820159 (15.Feb.1985).

[3] Datasheet Brüel&Kjaer B&K Type 4190 ½”-Free-Field Microphone

[4] Harmonie™ , 01dB-Stell , MVI technologies group, Technical Specifications, Rev.:01-2002

[5] dBFA32; Stell 01dB Metravib,User Manual Version 4.611

[6] GfaI, Acoustic Camera User Manual, English, 10-26, 2004