1. Main microphone

In "Multichannel natural music recording based on psychoacoustic principles" Theile presents a three channel main microphone system, called "optimized cardioid triangle" (OCT). This microphone system consists of one cardioid microphone for the center channel and two super-cardioid microphones for the channels L and R. The super-cardioid microphones are turned by 90° off center to the sides (see fig.1). In this way the interchannel crosstalk problem is minimized.

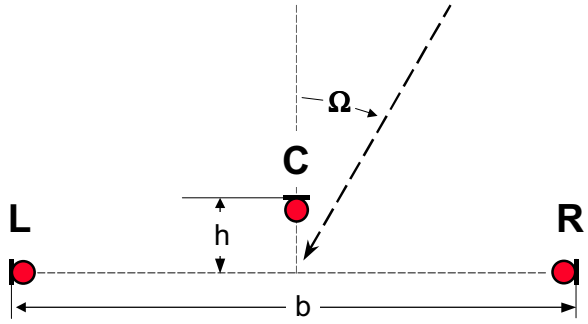

Fig. 1: OCT

The distance b between the microphones L and R depends on the intended recording angle. The distance h = 8cm.

2. 4-channel square room microphones

In 3/2-stereo recordings the OCT is used to pick up the prime sound of a source. It is responsible for the frontal directional imaging by means of the three loudspeakers L, C and R. For the spatial imaging an additional microphone system, placed in the diffuse sound field, is needed.

Theile suggests among other possible solutions e.g. square arrangements to enable the appropriate imaging of side reflections. They have proven to be important for the perception of apparent source width (ASW), the distance of the source and spatial depth.

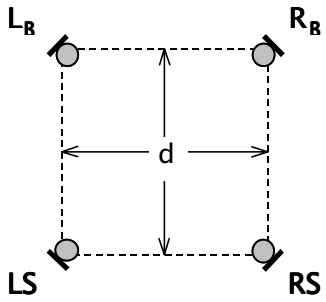

Fig. 2: 4-channel square room microphone

The microphones L_R and R_R are discretely routed to the channels L and R, the microphones LS and RS to the channels LS and RS. So each pair of microphones L_R-R_R, R_R-RS, RS-LS and LS-L_R provides a stereophonic representation of early reflections and reverberation.

The degree of coherence of these pairs of microphones is connected directly to the perception of the reproduced sound field. It influences the perception of spatial depth, ASW, spatial impression and envelopment. The following recordings were made to investigate the effect of the interchannel coherence on the spatial impression.

2.1 Test Setup

The OCT system was placed close to the musicians. In a distance of 8,50 m to the OCT a total of six room microphone square arrangements with different side lengths were set up. Three of them were built up with cardioid microphones and the other three with omnidirectional microphones. The side lengths of the squares were:

- cardioid microphones:
  d_1 = 15 cm; d_2 = 25 cm; d_3 = 300 cm

- omnidirectional microphones:
  d_1 = 40 cm; d_2 = 215 cm; d_3 = 500 cm (see fig. 3)

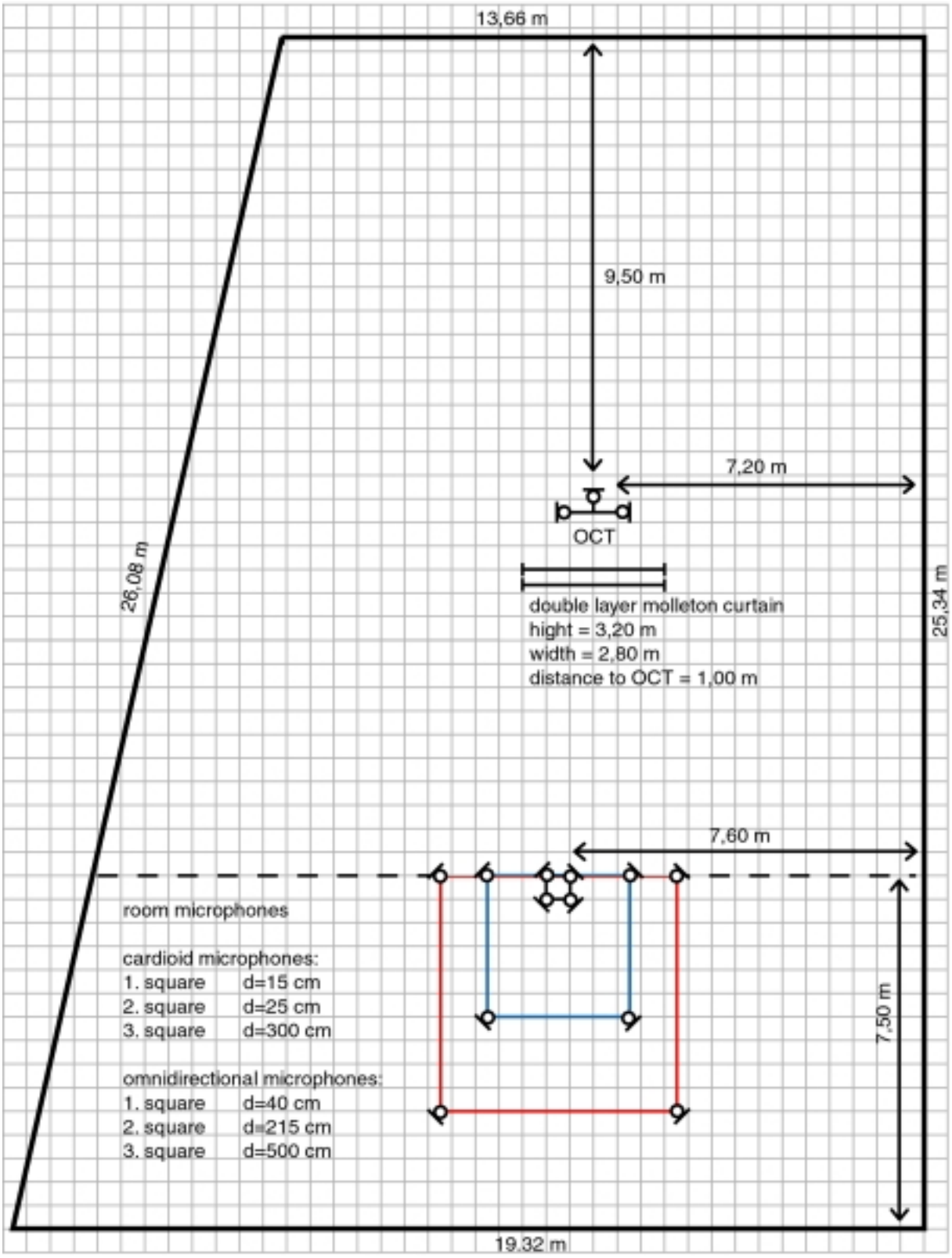

Fig. 3: microphone setup

The gain of all room microphones was set equal to the gain of the microphones of the OCT. At a distance of 1 m behind the OCT a double layered molleton curtain was set up to prevent indirect sound from hitting the OCT.

2.2 Recording room

The room where the recording took place was the orchestral rehearsal room of the Württembergische Philharmonie Reutlingen.

Attributes of the room:

area: 420 m^2
volume: 3250 m^3
reverberation radius (omnidirectional sound source): 2,75 m

Reverberation time see fig. 4:

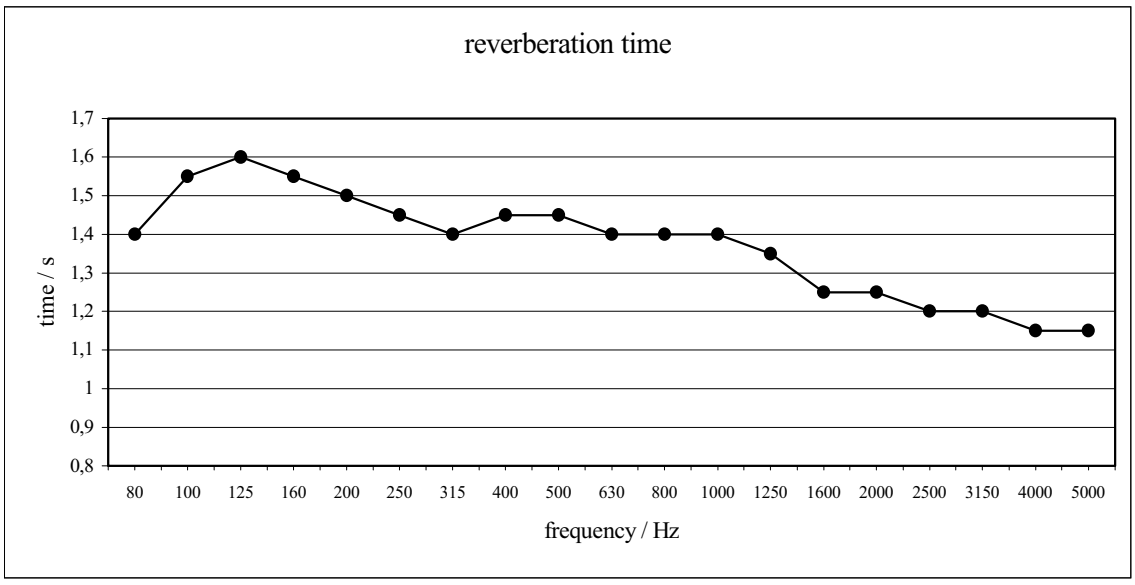

Fig. 4: reverberation time of the recording room

2.3 Mixdown

The five signals of the OCT and the four signals of each room microphone square arrangement had to be mixed down to the channels L, C, R, LS, RS. The following table shows the mixing parameters:

	OCT	room microphones percussion	room microphones strings
delay	10 ms	-	-
routing	L, R, C	L, R, LS, RS	L, R, LS, RS
levels	cardioids 0 dB omnis -5 dB	cardioids 0 dB omnis -4 dB	cardioids +1 dB omnis -3 dB
equalizing	omnis lowpass at 100 Hz center highpass at 120 Hz	60 Hz; -3 dB 120 Hz; -3 dB	60 Hz; -3 dB 120 Hz; -3 dB

Tab. 1: mixing parameters

It was found that in superior concert halls the first reflections followed the direct sound by about 20 ms. It is important that this arrival time gap doesn't get too long for the avoidance of echo effects. In this recording the onset of the indirect sound was about 24 ms after the direct sound because the room microphones had a distance of 8,50 m to the OCT. With very percussive music there might have appeared echo effects. That is why the OCT was delayed by 10 ms. So the arrival time gap was 14 ms (see fig. 5)

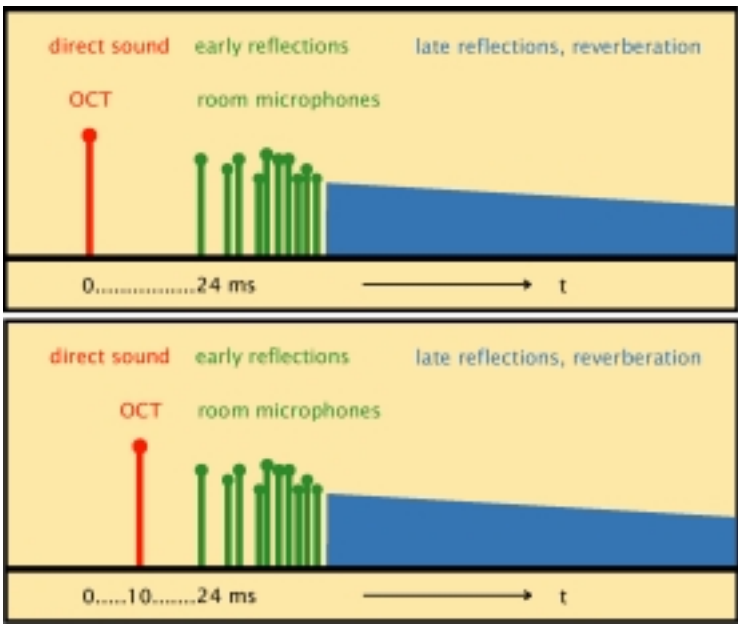

Fig. 5: delay OCT in the mix

The levels of the room microphones were determined by listening so that the rear loudspeakers could not be localized. Because of their directivity cardioid microphones give less level in the diffuse sound field than omnidirectional microphones. That is why they had to be mixed with 4 dB more level.

2.4 Listening test results

Two different music examples were used for the tests:

- a slow excerpt of a string quintet
- a percussion trio

These results were found:
Though the omnidirectional microphones had a stronger low frequency response than the cardioid microphones the spatial impression created by the different microphones was quite similar.

However, these special observations were made listening to the wide square arrangements (215 cm, 300 cm, 500 cm):

- string quintet: Auditory "clouds" appeared in the regions of the loudspeakers. The spatial impression wasn't homogeneous. No ASW was observed.

- percussion trio: The ensemble sounded very close. The spatial impression was weak.

These observations were made listening to the small square arrangements (15 cm, 25 cm, 40 cm):

- string quintet: The spatial impression was very homogeneous and "natural" and resistant against movements of the listener. A strong ASW appeared.

- percussion trio: The ensemble sounded further away from the listener than with the wide arrangement. A real impression of space, distance and depth could be observed which was also very stable.

An explanation for these observations could be that the small square arrangements produce a natural reflection pattern. ASW and perception of depth are closely related to the presence of early lateral reflections. Since these perceptions only occurred with the small square arrangements one may conclude that the wide arrangements didn't produce a natural reflection pattern. Only by an adequate coherence of the signals the lateral stereophonic areas are exploited for reproduction of reflection patterns. If the signals are incoherent reflections will only be perceived from the directions of the loudspeakers.