

New Reference Listening Room for Two-Channel and Multi-Channel Stereophony

(Design - Measurement - Modelling)

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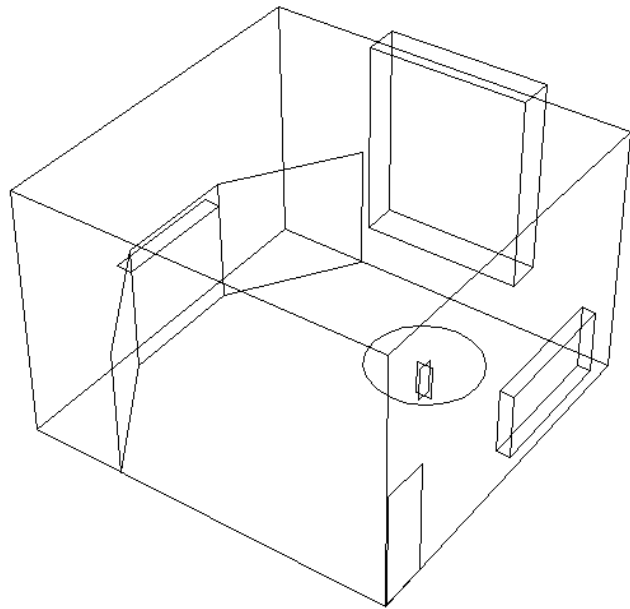


Hungarian Section of AES

104th AES Convention, May 1998

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1. Introduction

- The need...
 - to test different techniques by listening tests all over the world needs to improve the listening conditions
- The demand...
 - to achieve a special environment for listening conditions



- The design
 - of a new reference listening room **in the Hungarian Radio**
- The aim
 - to achieve the requirements given by recommendations.
 - 2-channel
 - 5-channel

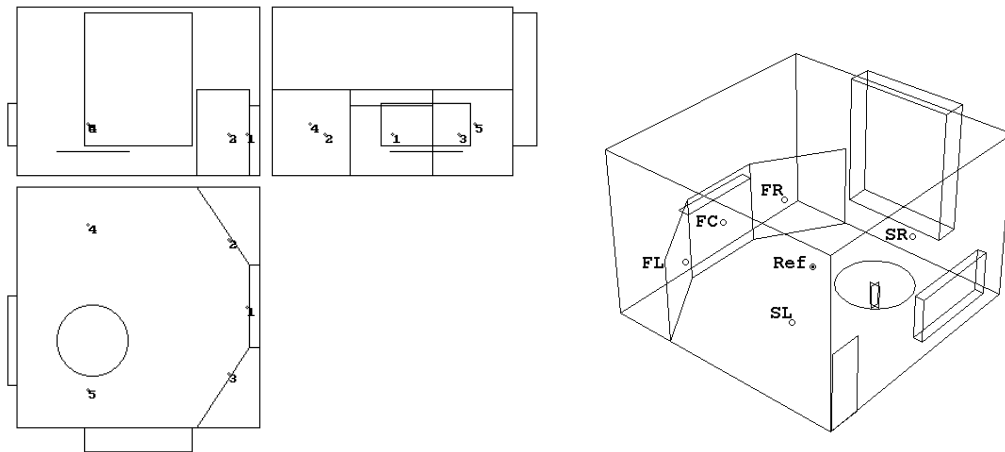
2. Design Considerations

- Basis of the design considerations

EBU recommendation: the last version EBU Tech 3276 "Listening conditions for the assessment of sound programme material: monophonic and **two-channel stereophonic**"

- The room geometry

the listening room was designed into an existing room



Floor plan and the 3- dimensional view

3. The Measured Sound Field Parameters

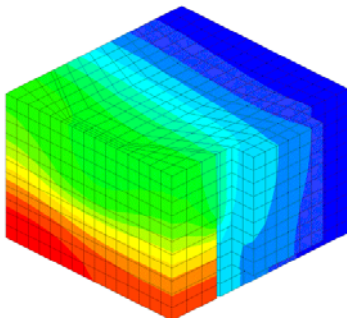
For practical reasons the room is used for talk studio too
compromises

- The room dimensions:

length	7.8 m
width	7.05 m
height	4.85 m
area:	55 m ²
volume:	267 m ³

- All dimensions suit the recommendation:
 - proportions of the room
 - floor area
 - volume

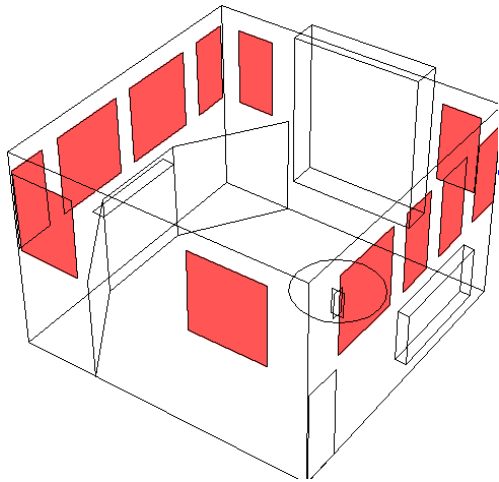
Since these calculations assume perfectly rigid walls
and rectangular shape...



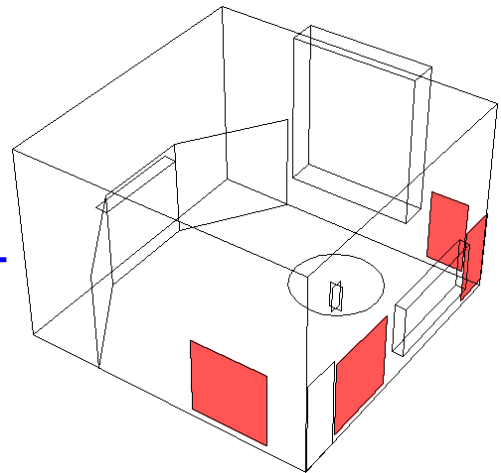
...a finite element model was created to
investigate the low frequency behaviour
of the room (SYSNOISE).

3. The Measured Sound Field Parameters

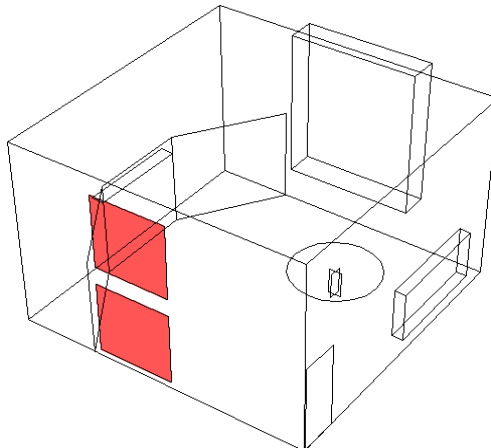
- The choice of the acoustical elements on the basis of the calculations placements of the elements



- Low-frequency absorbers



- Diffusers



- Wide-band absorbers

3. The Measured Sound Field Parameters

The properties of the sound field produced by the loudspeakers in the listening area determines the quality of the listening environment.

- The sound field parameters specified by the EBU:
 - A Direct sound
 - B Early reflections
 - C Reverberant field
 - D Operational room response curve
 - E Background noise

- The measurements...
 - with the MLSSA analyser of DRA Lab.

3. The Measured Sound Field Parameters

A Direct sound

Loudspeakers:

- FL,FC, FR - Genelec 1038A
- SL,SR - Genelec 1032A

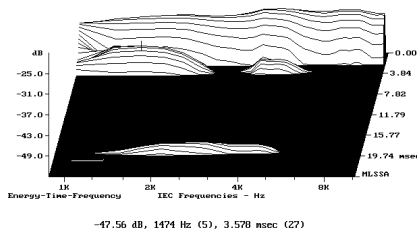
...suit the specifications

B Early reflections

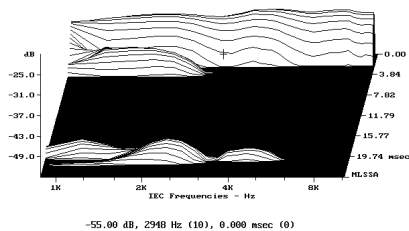
For the two - channel stereophonic:

Acceptable level of the early reflections: **-10dB** after the direct sound up to **15-20msec**.

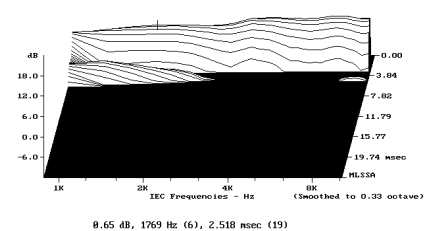
Front - left



Front - center



Front - right



ETF (Waterfall)

Energy - Time - Frequency response at the reference listening point.

3. The Measured Sound Field Parameters

The results of the subjective tests show...

...the influence of the early reflections around the surround loudspeakers can be disturbing.

Acceptable level of the reflections?...

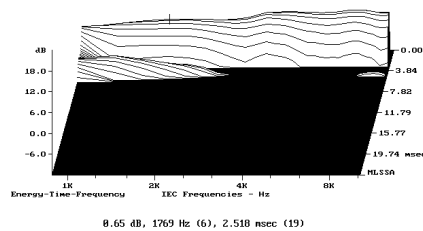
...need for further investigations.



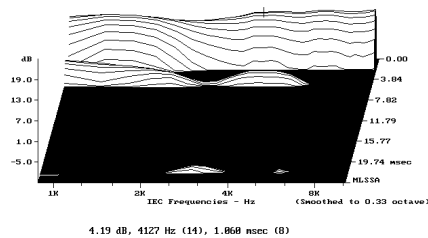
The design objective:

to avoid the strong early reflections for every channel.

Surround - left



Surround - right



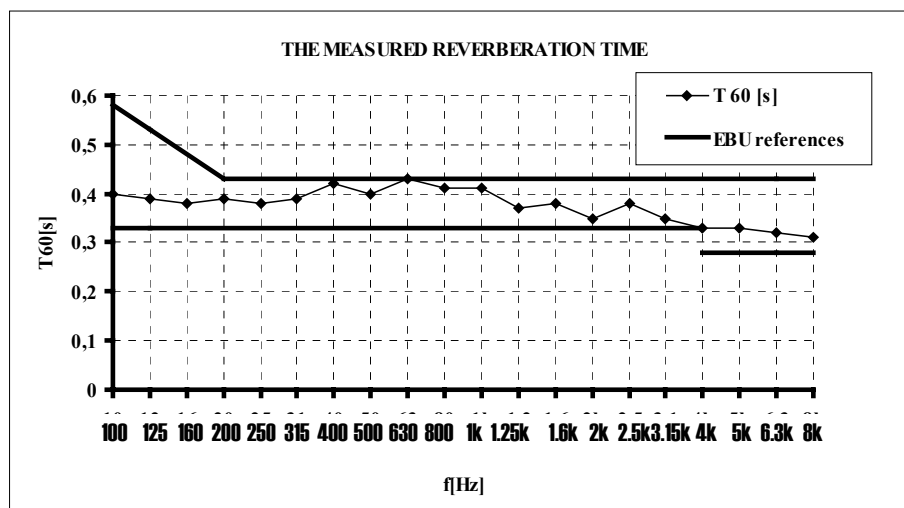
ETF response at the reference listening point - from surround speakers.

3. The Measured Sound Field Parameters

C Reverberant field

The recommended nominal value

$$0.2 \text{ sec} < T_m < 0.4 \text{ sec}$$



The measured reverberation time

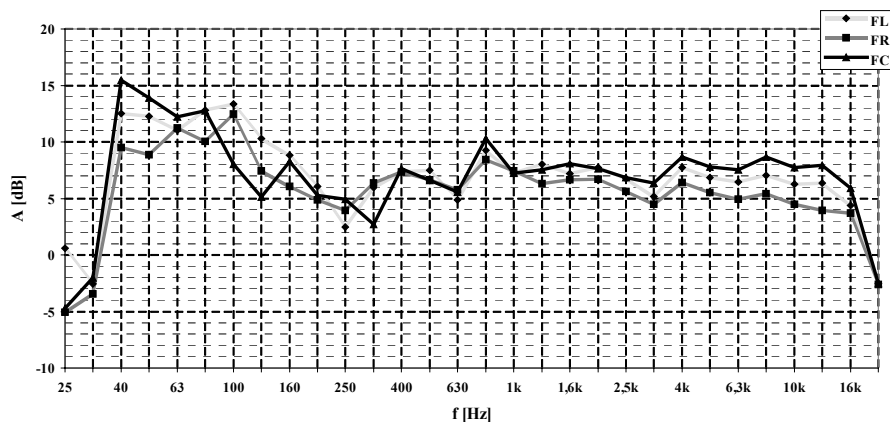
3. The Measured Sound Field Parameters

D Operational room response curve

Definition: the sound pressure level produced by the loudspeakers at the reference point.

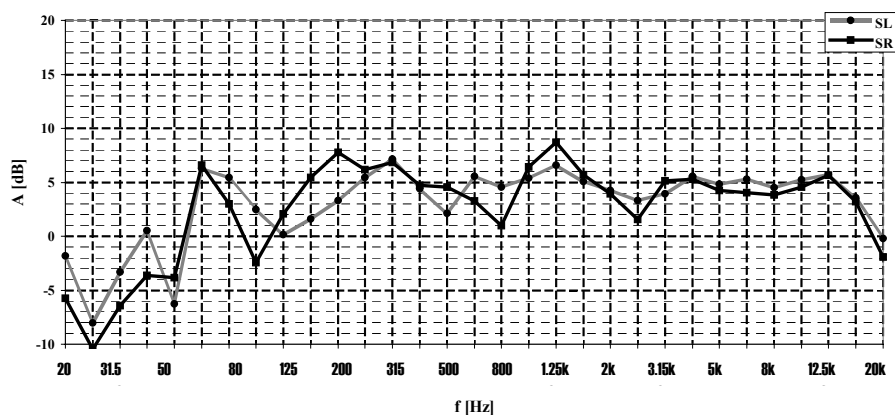
Front -

- *Left (FL)*
- *Center (FC)*
- *Right (FR)*



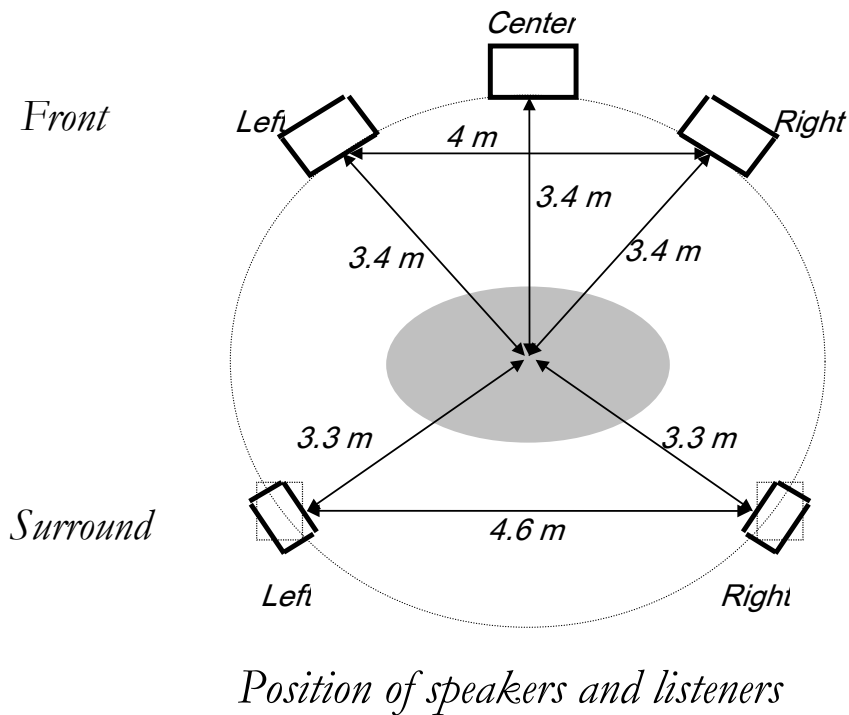
Surround -

- *Left (SL)*
- *Right (SR)*



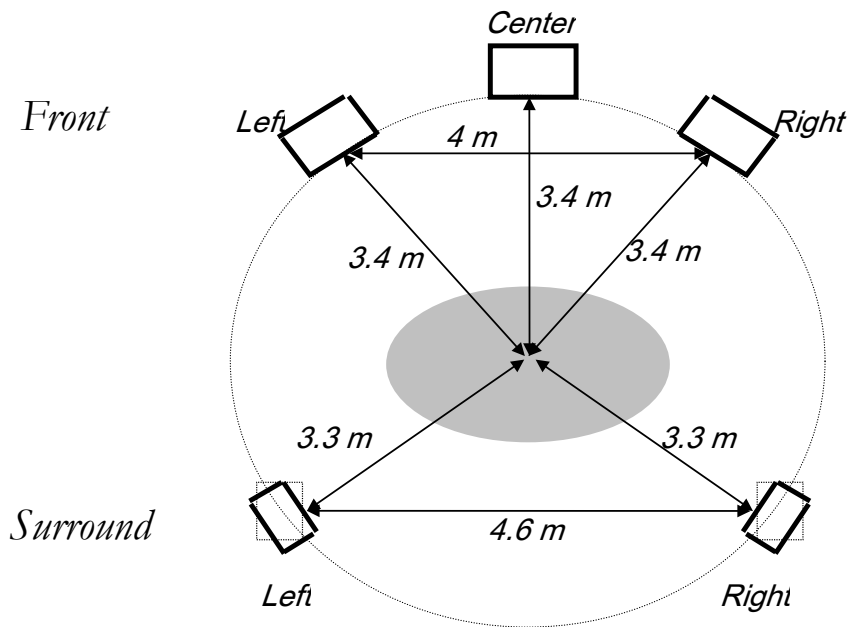
Measured operational room response curves

4. Listening Tests (5-channel)



- Test procedures and equipment
 - Yamaha DSP-E492 commercial Dolby Pro Logic decoder with Dolby Surround encoded music/effects
 - Tascam DA88 8-channel digital recorder with discrete 5-channel recordings

4. Listening Tests (5-channel)

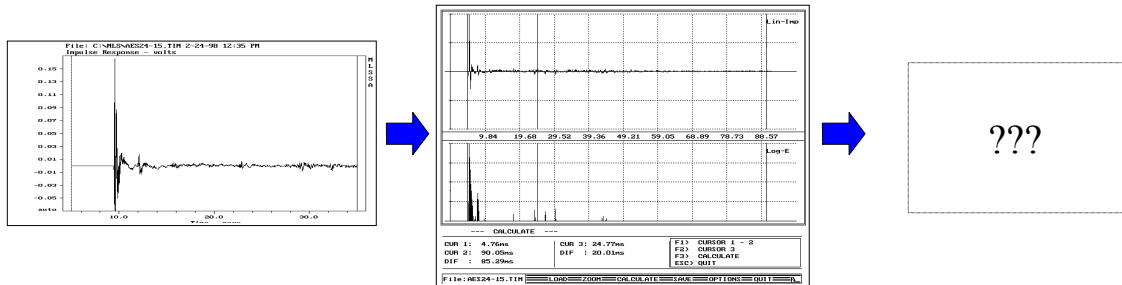


Position of speakers and listeners

- Subjective results
 - Dolby Surround: better if surround speakers are turned to face each other
 - Discrete 5-channel: better if surround speakers are turned to listeners
 - Surround speakers shall sound as diffuse as possible
 - Spatial impression is less position dependent

4. Listening Tests (5-channel)

- Subjective and objective parameters



Impulse Response

Processing

Objective parameters

- modified M-factor:

$$M = 10 \log_{10} k_2(t_1) - 10 \log_{10} k_2(t_2)$$

$$k_2(t) = \frac{\int_0^t p^2(t) dt}{\int_t^\infty p^2(t) dt}$$

- Centre time:

$$t_s = \int_0^\infty \frac{t \cdot p^2(t) dt}{p_{\max}^2}$$

5. Modelling

- Why computer aided modelling?
 - prediction in design phase,
 - shorter design period,
 - low costs;
 - modelling posteriorly helps improvement of modelling procedure;
 - experiments with “virtual” set-ups.

- Modelling with computers - review
 - numerical solutions (FDM, FEM, BEM)
 - geometrical room acoustics (Image-source models, Ray-tracing, Cone-tracing, Beam-tracing)

5. Modelling

- Modelling technical rooms - problems
 - relatively small sizes (architecture and furniture together, near-field modelling of sources and reflections, limits of geometrical acoustics)
 - special surfaces and materials (diffuser, absorber, etc.)
 - special requirements (what parameters, measuring surface material and sound source properties - no high resolution data available)

- Low Frequency Modelling (SYSNOISE)
 - acoustic modes
 - positioning of low-frequency sources
 - effect of the “rigid” wall

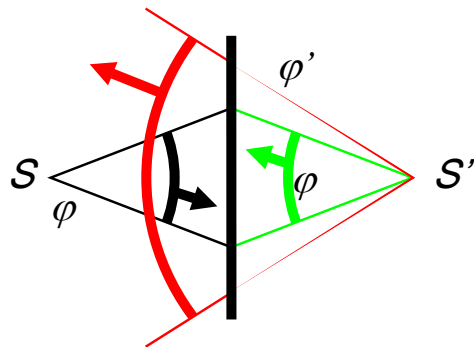
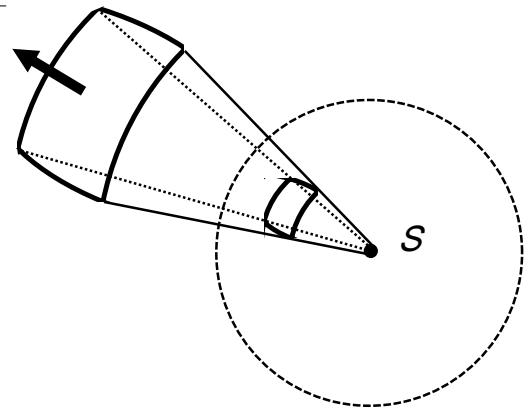
5. Modelling

■ High Frequency Model

- why developing a new software...

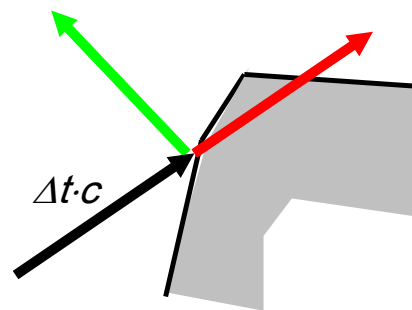
Basic Assumptions

- beam-tracing
- beam surfaces are exact pieces of the wave front
- boundaries may be curved - beam distortion



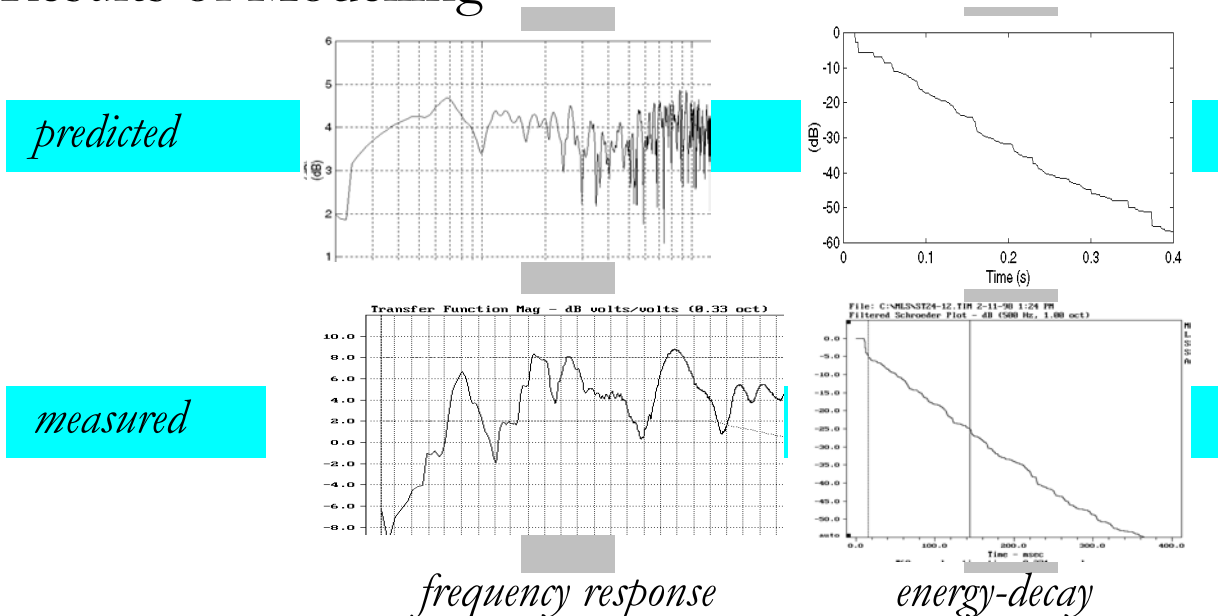
- diffuse reflection means the change of solid angle of the beam

- “sampling” in detection of reflections



5. Modelling

■ Results of Modelling

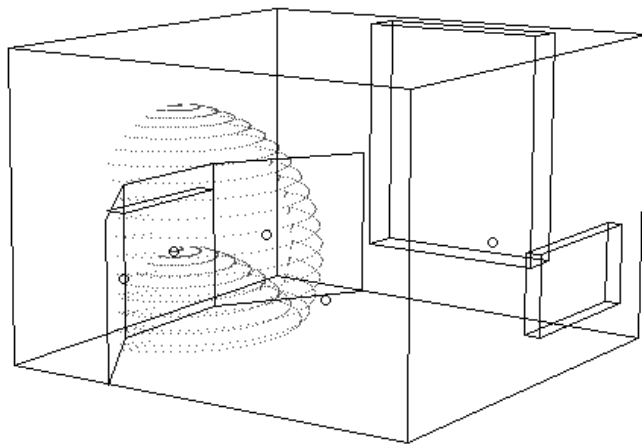


■ Improvements

- correct diffuse reflection model
- correct diffraction model - sampling a very coarse approach
- introduction of phase
- near-field model of sources and reflections
- precise data about sources and materials

6. Conclusion

- Requirements
- Measurements
- Subjective Test
- Modelling
- Next...



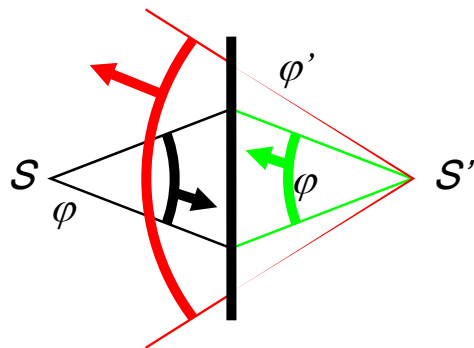
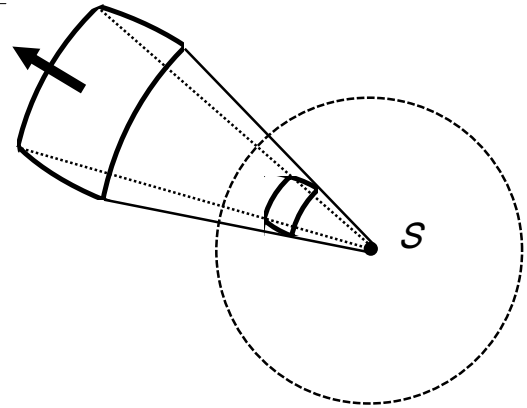
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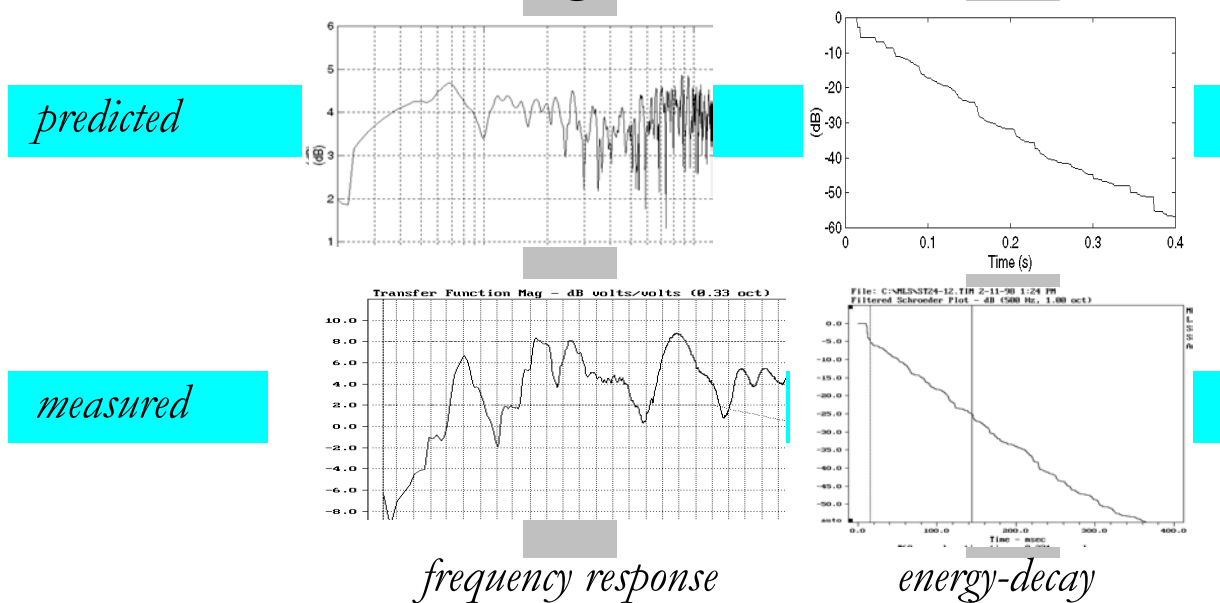
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- diffuse reflection means the change of solid angle of the beam

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- introduction of phase
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- precise data about sources and materials