Determination of directional echograms and application in room acoustics

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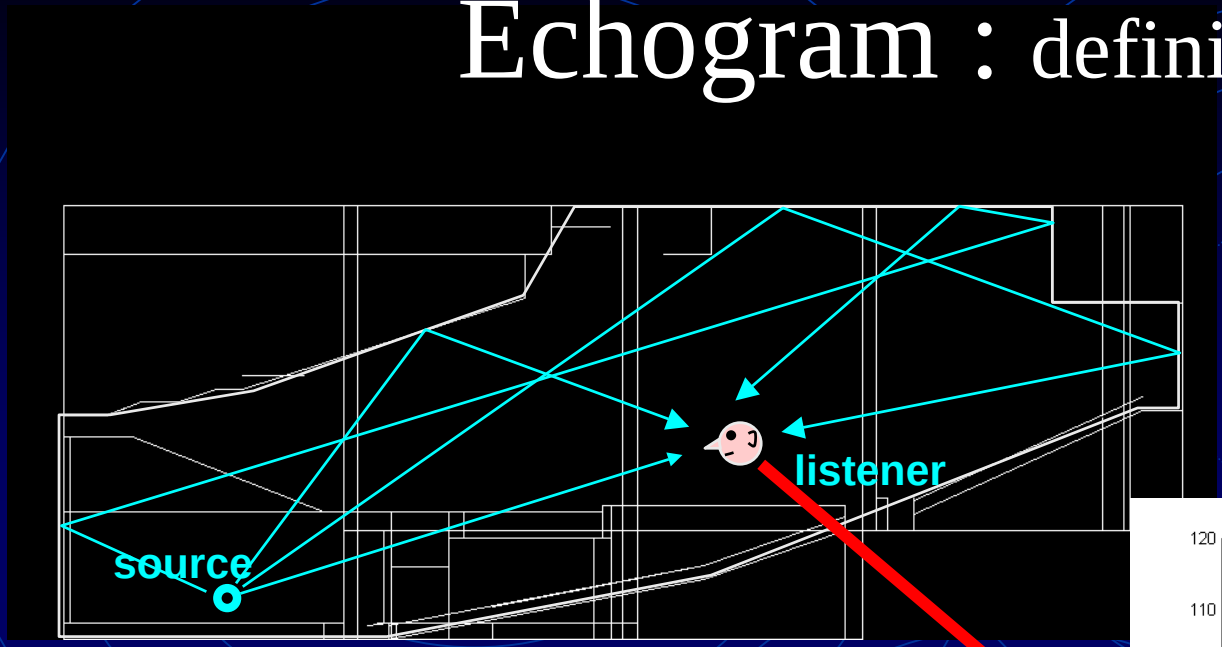
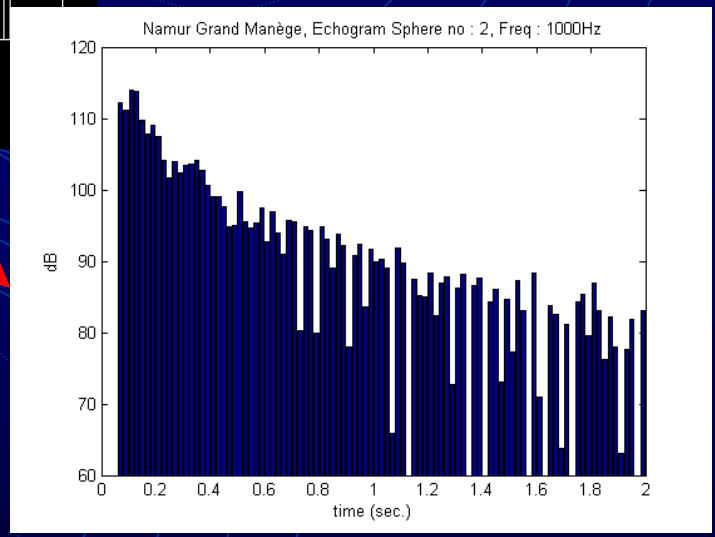
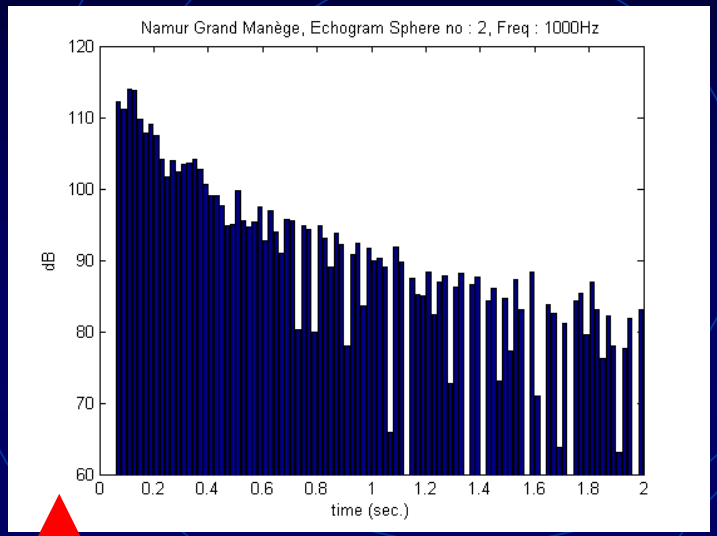
Echogram : definition





A diagram showing the distribution of the acoustical energy at the receiver, as a function of time arrival. (whatever the direction of incidence)

Echogram : applications in room acoustics



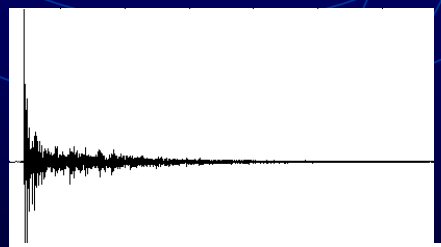
Room acoustics parameters :

-T30, EDT

- SPL

- C80, D50

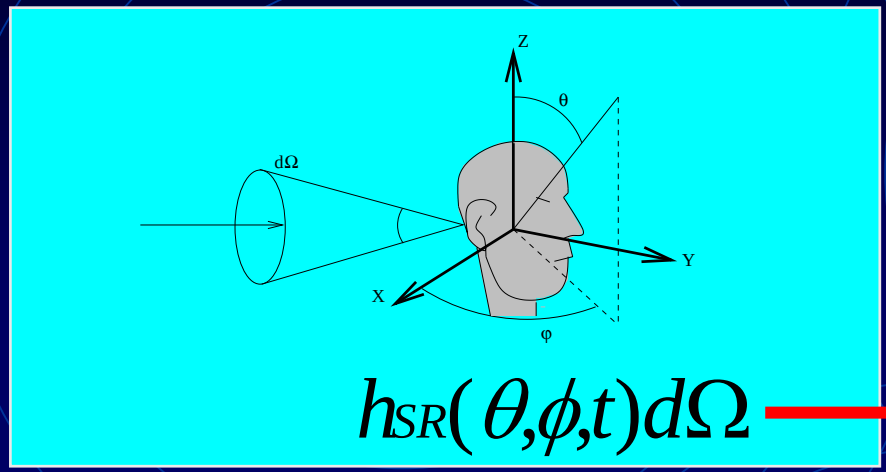
- …

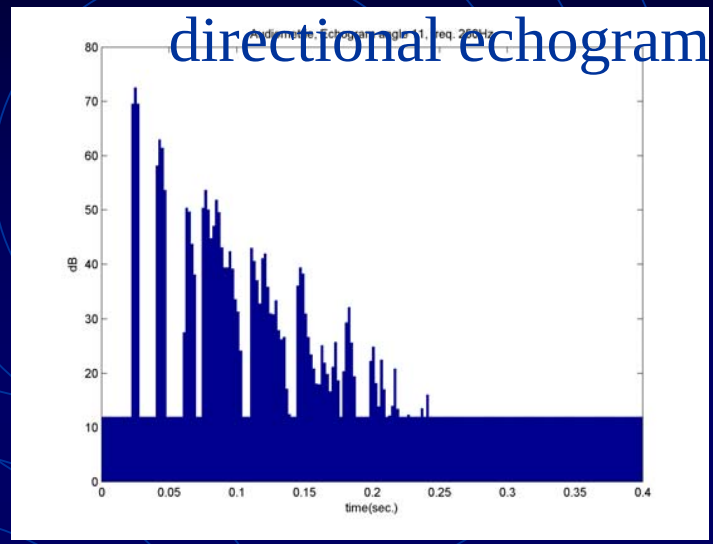


Room impulse response

auralization

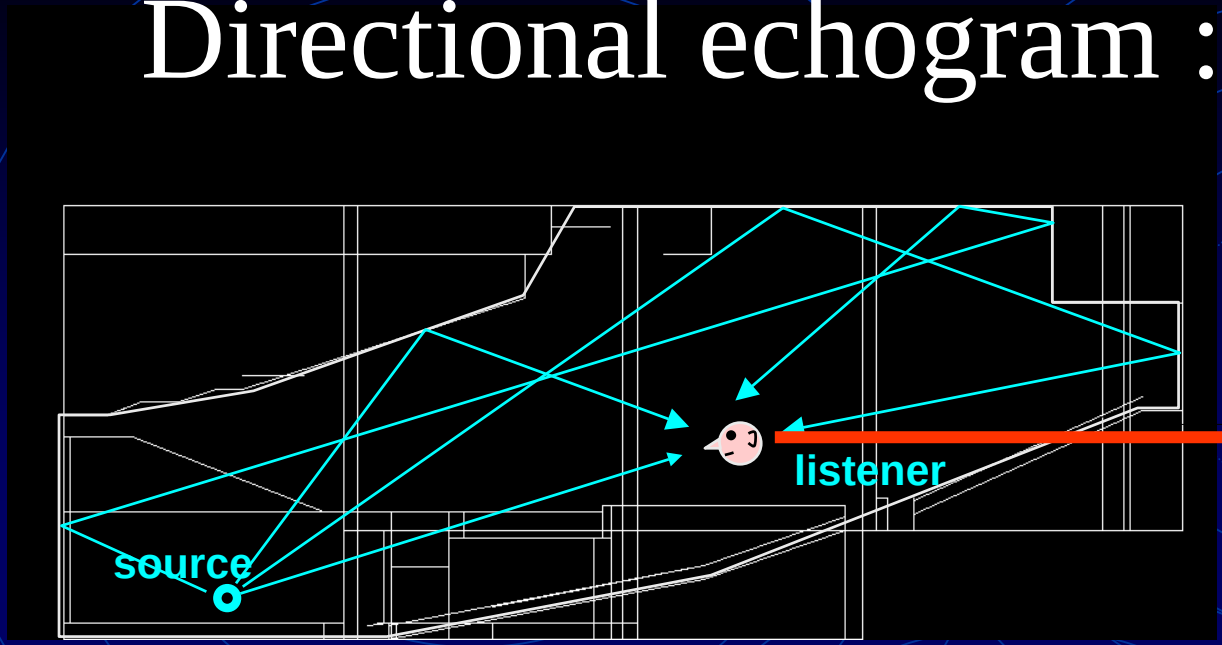
Directional Echogram : definition

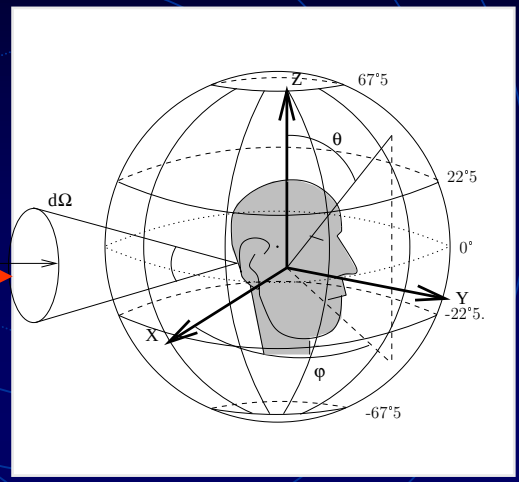




A diagram showing the distribution of the acoustical energy at the receiver, as a function of time arrival, in a particular direction of incidence.

Directional echogram : computation

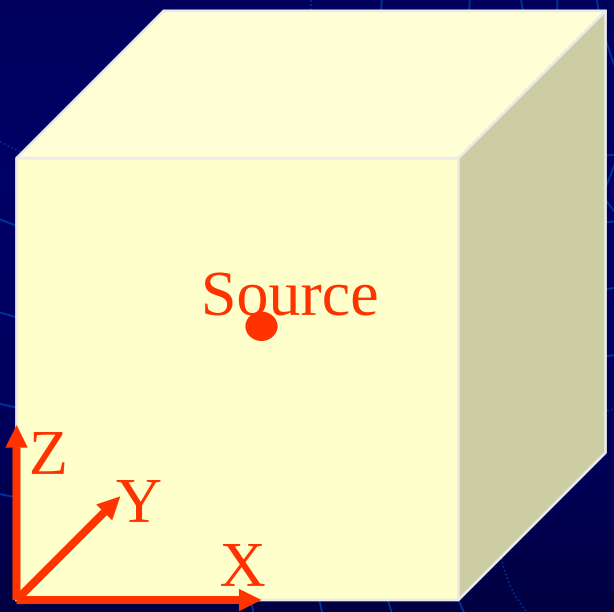




The directional echograms are evaluated by ray-tracing, at each listener's position.
The 3D space around the listener's head is divided into 26 solid angles, simulating 26 directional microphones.

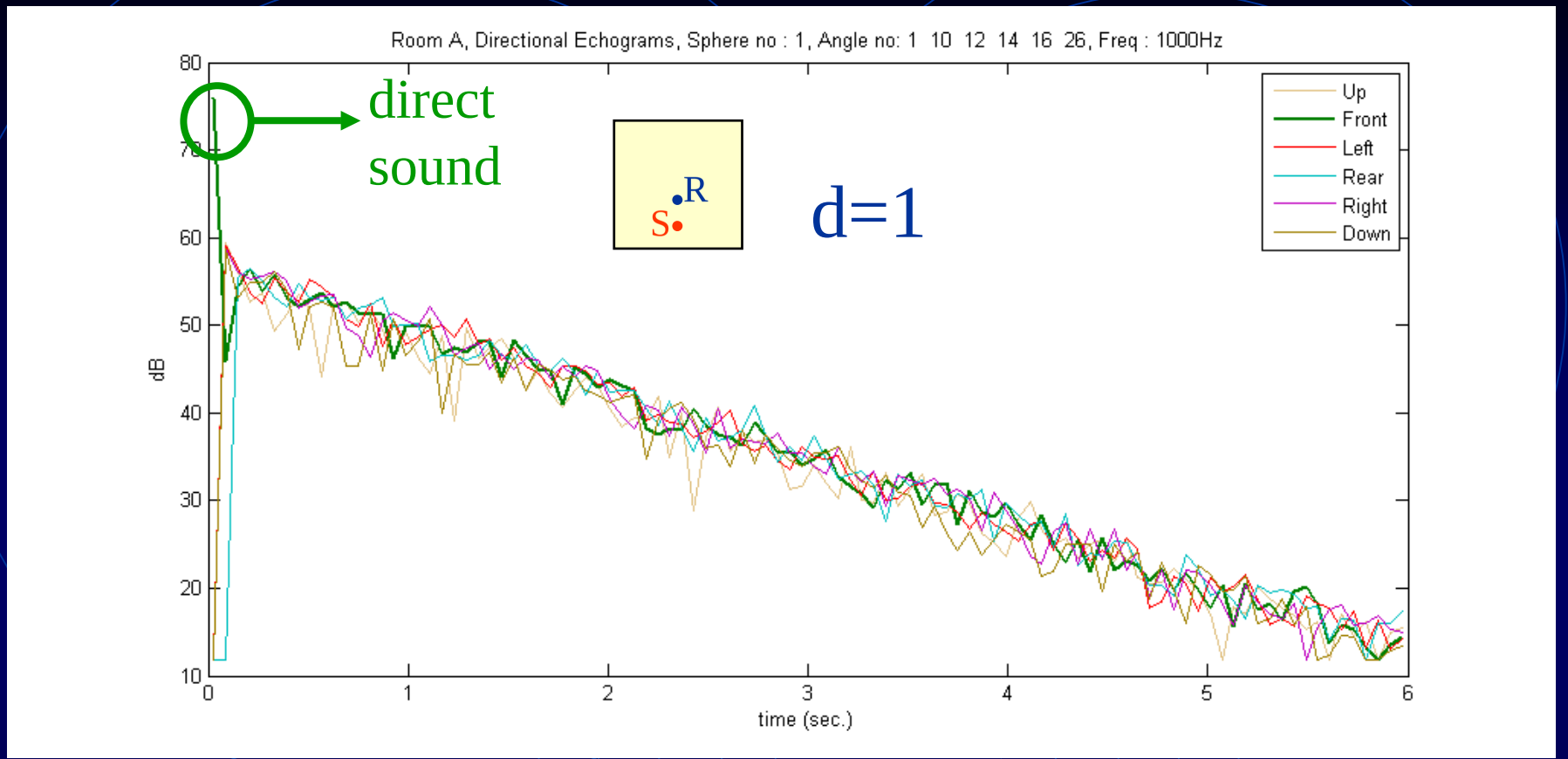
Directional echograms : computation in two « academic » room acoustics problems

Example 1 : Room A (ref. Hodgson, JASA, 89(2), 1991)

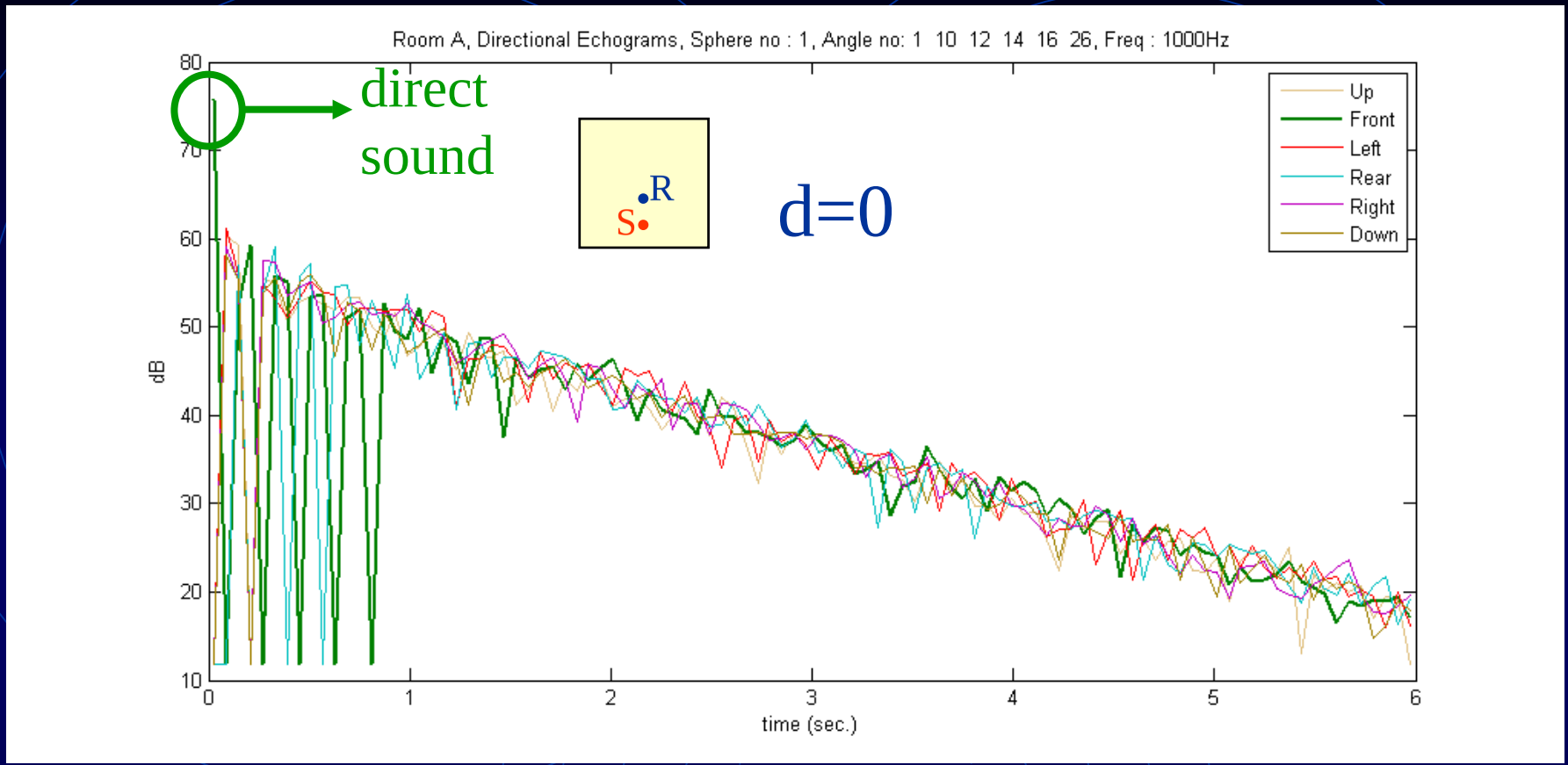


Cubic room

-side length : 27.5m
-absorption coefficient of all faces : 0.068
-scattering coefficient of all faces : d=0 or d=1

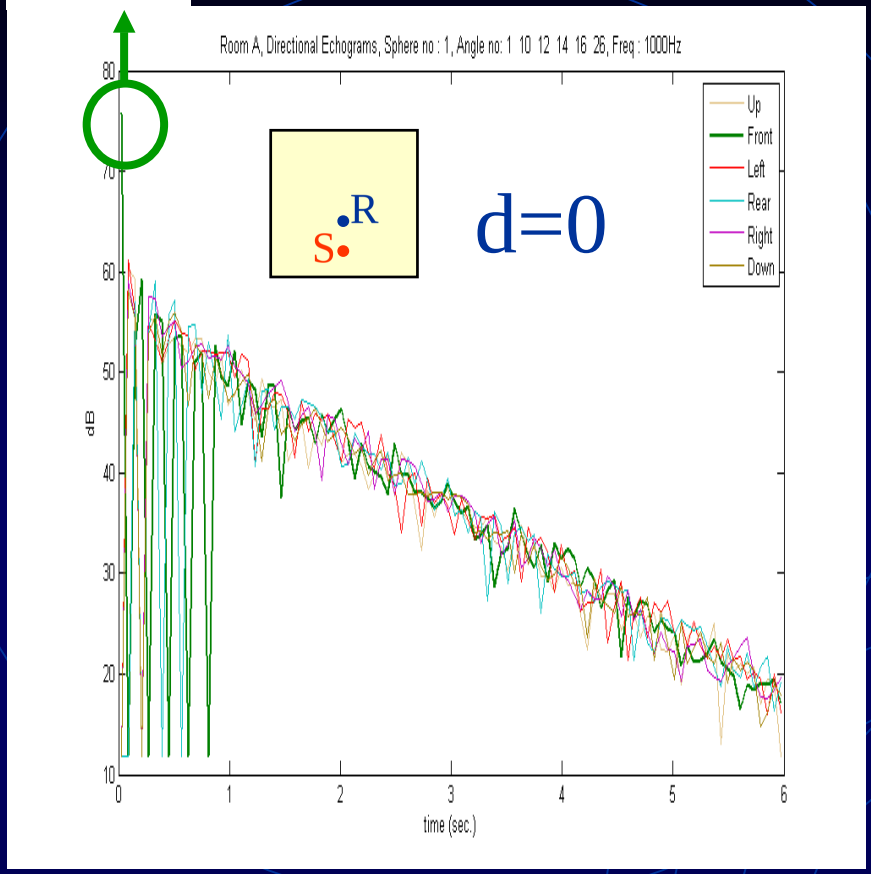


Room A : Directional echograms at one receiver position, 5m away from the source, diffusing surfaces.

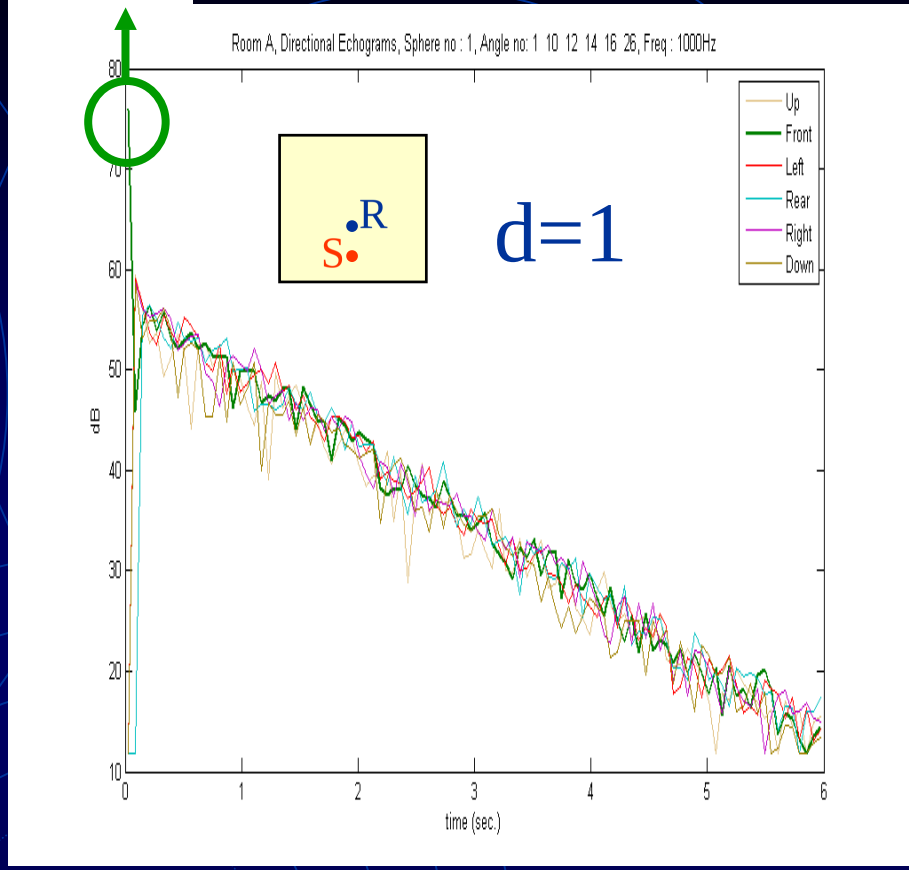


Room A : Directional echograms at one receiver position, 5m away from the source, specular surfaces.

direct

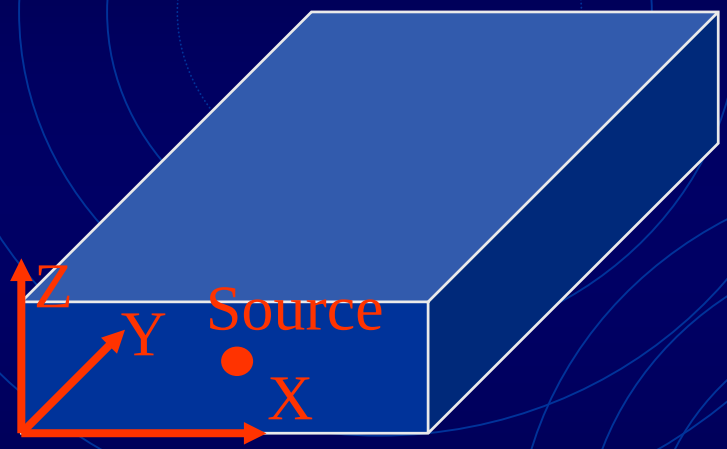


direct



Room A : Directional echograms at one receiver position, 5m away from the source.

Example 2 : Room B (ref. Hodgson, JASA, 89(2), 1991)

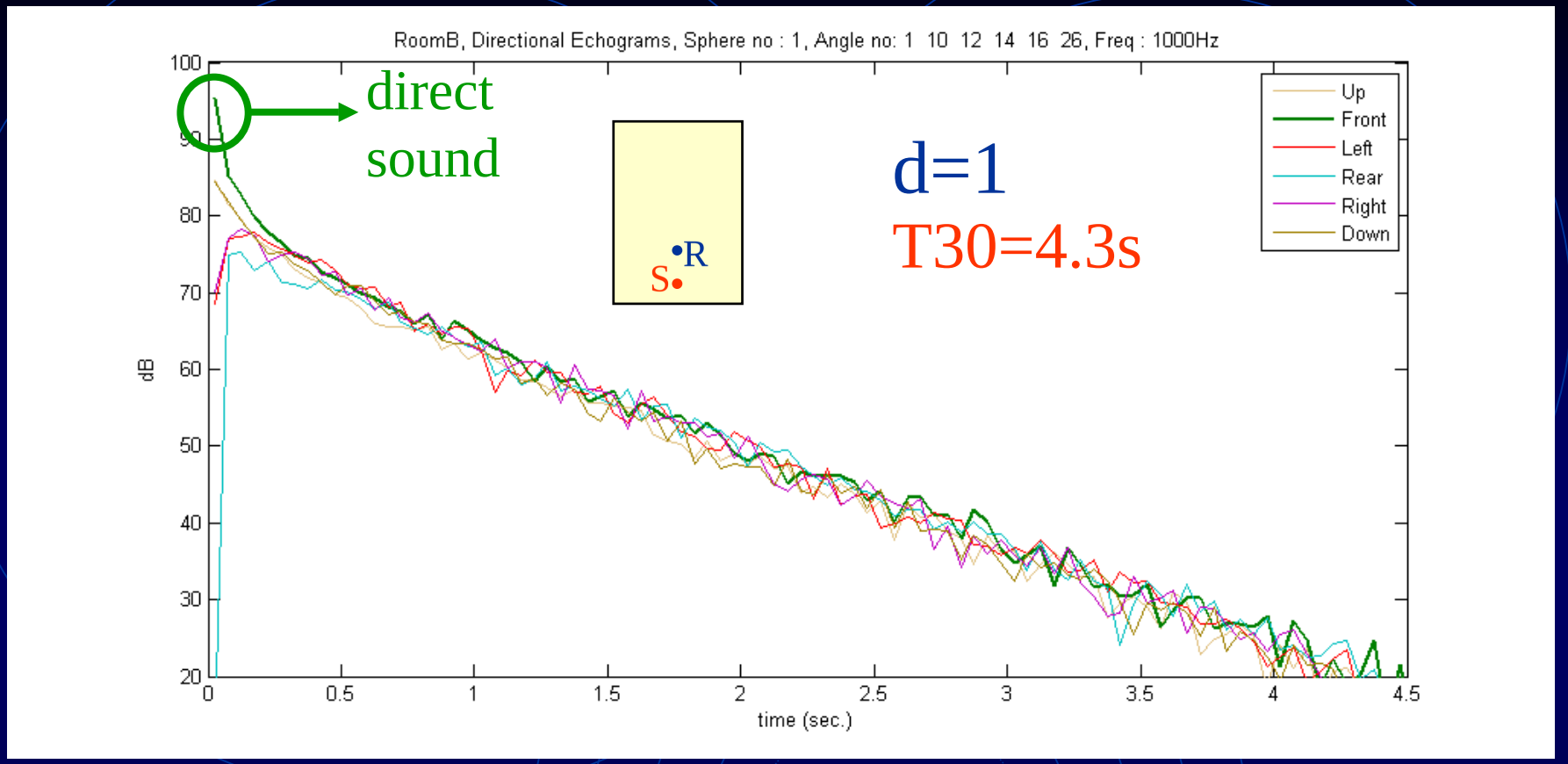


Long disproportionate room

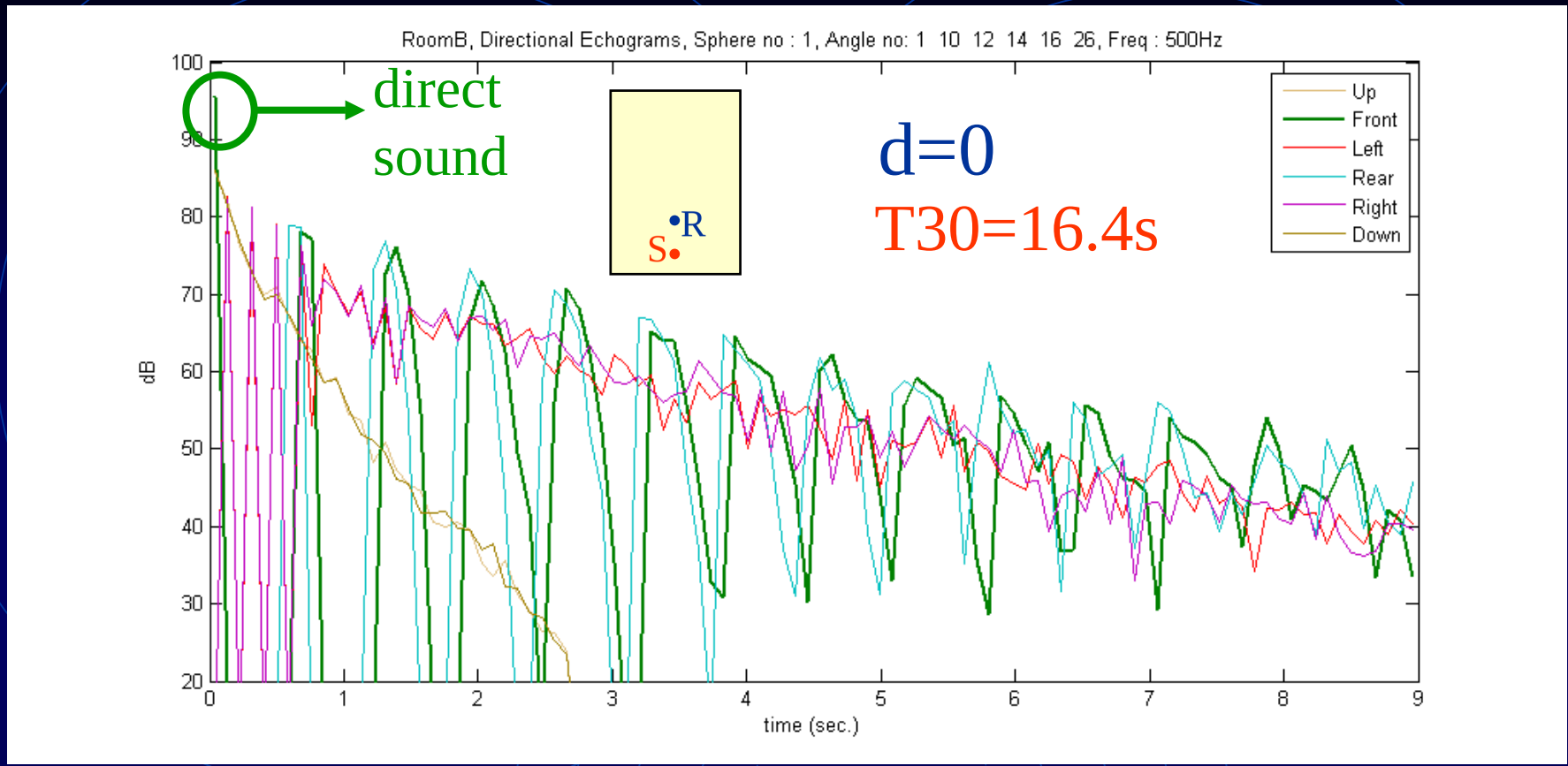
-55m x 110m x 5.5m

-absorption coefficient of all faces : 0.068

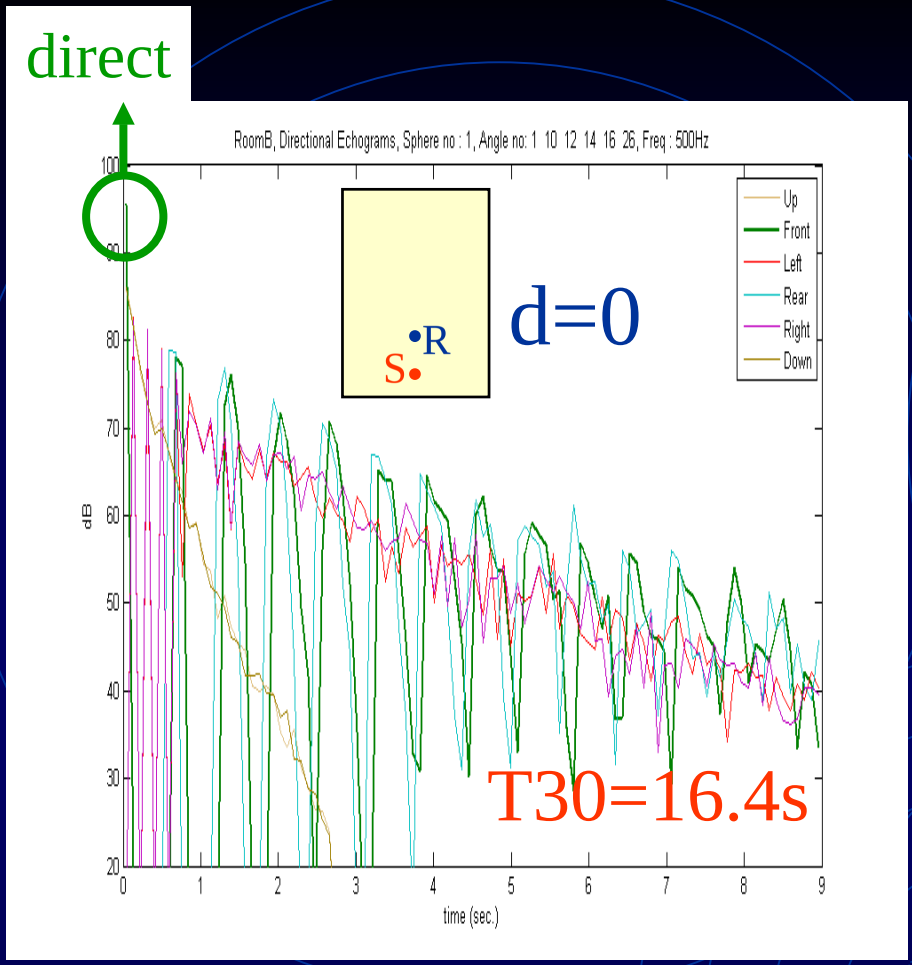
-scattering coefficient : d=0 or d=1

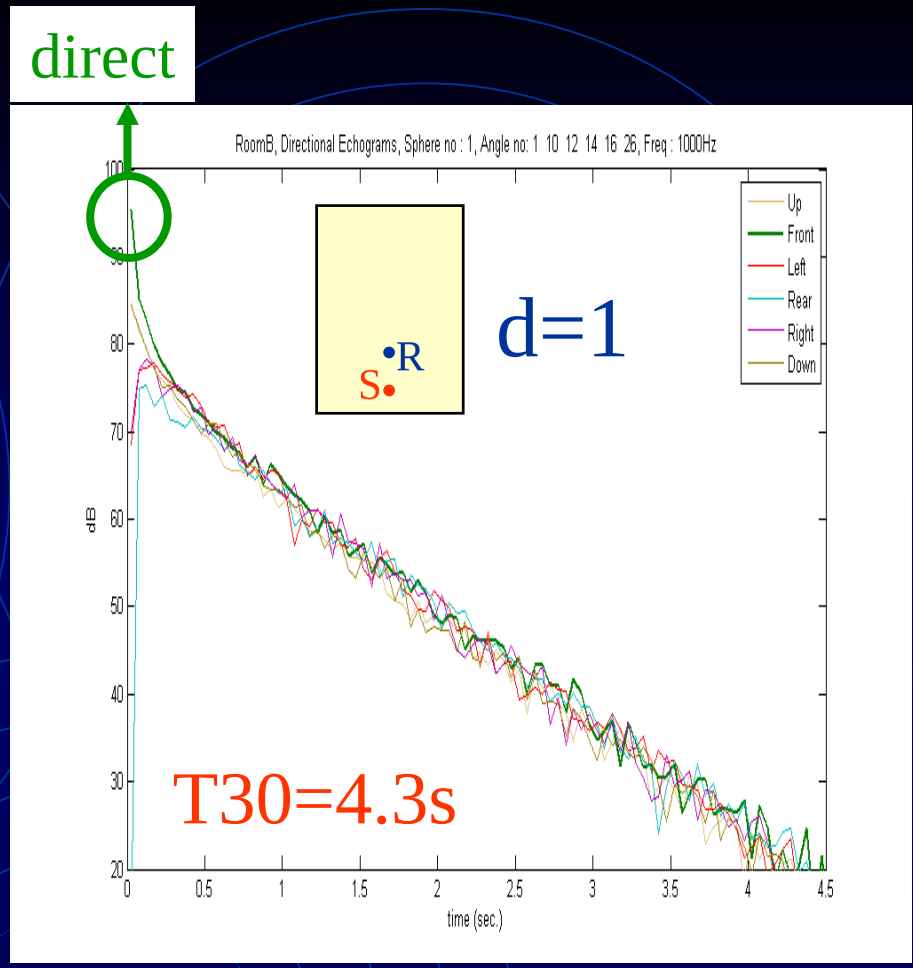


Room B : Directional echograms at one receiver position, 5m away from the source, diffusing surfaces.

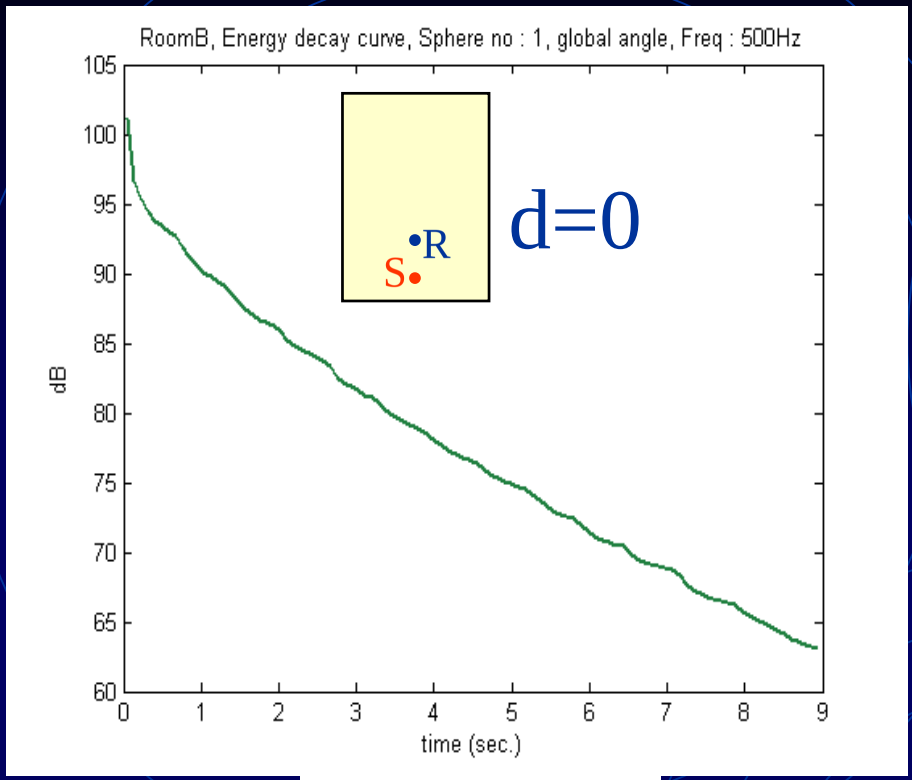


Room B : Directional echograms at one receiver position, 5m away from the source, specular surfaces.

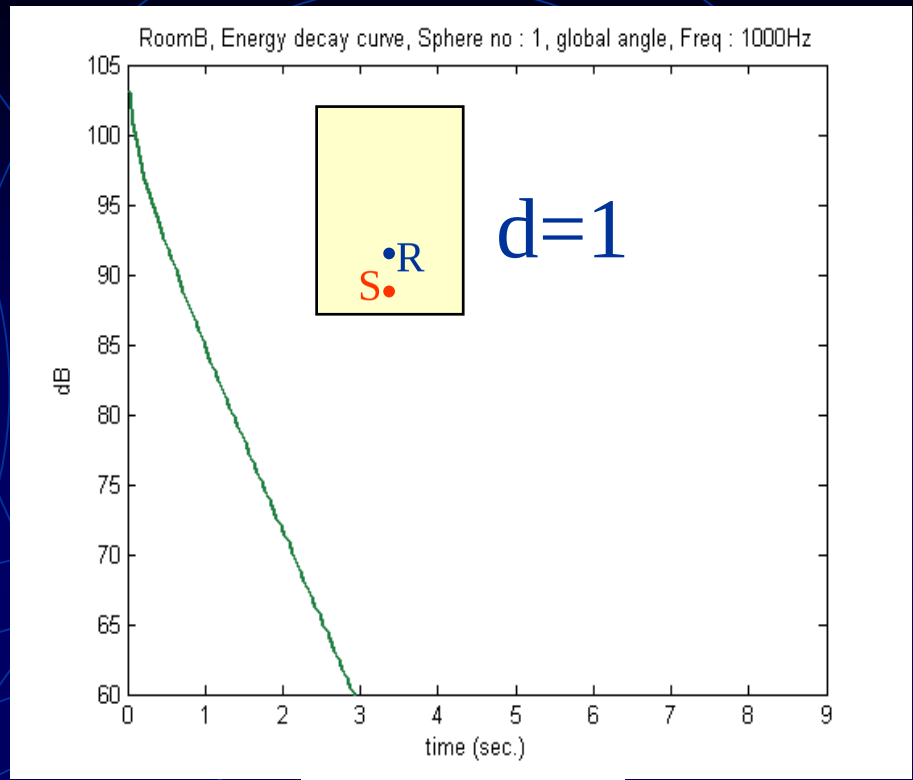




Room B : Directional echograms at one receiver position, 5m away from the source.

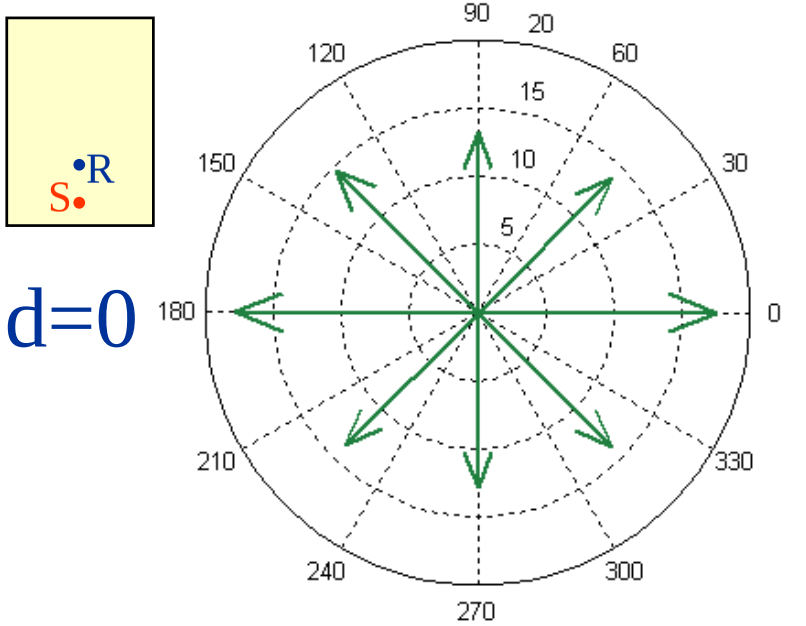


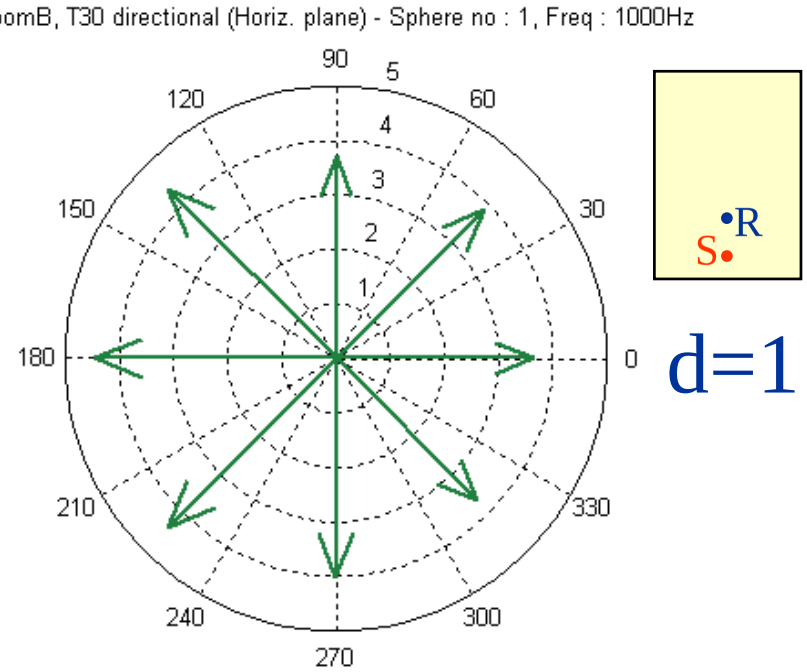
T30=16.4s



T30=4.3s

Room B : Energy decay curve at one receiver position, 5m away from the source.





Room B : T30 directional at one receiver position, 5m away from the source.

Conclusion of the analysis of two « academic » problems

The directional echograms can afford interesting additional information, especially for :

-disproportionate rooms,

-weak diffusing surfaces,

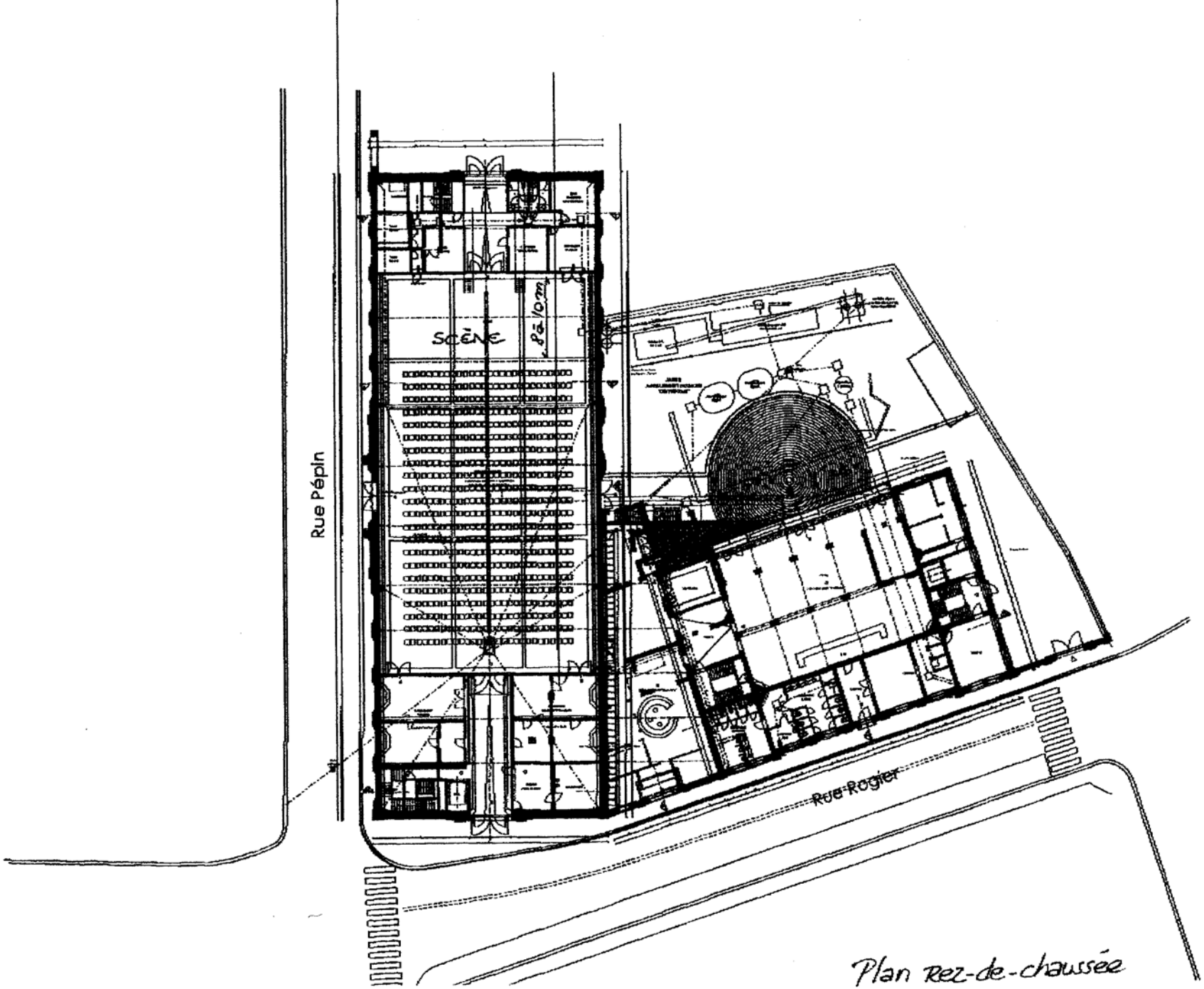
-asymmetrical distribution of acoustical absorption.

Directional echograms : application in a room acoustics project

Project :

Renovation of an ancient horse-riding school into a cultural polyvalent hall.

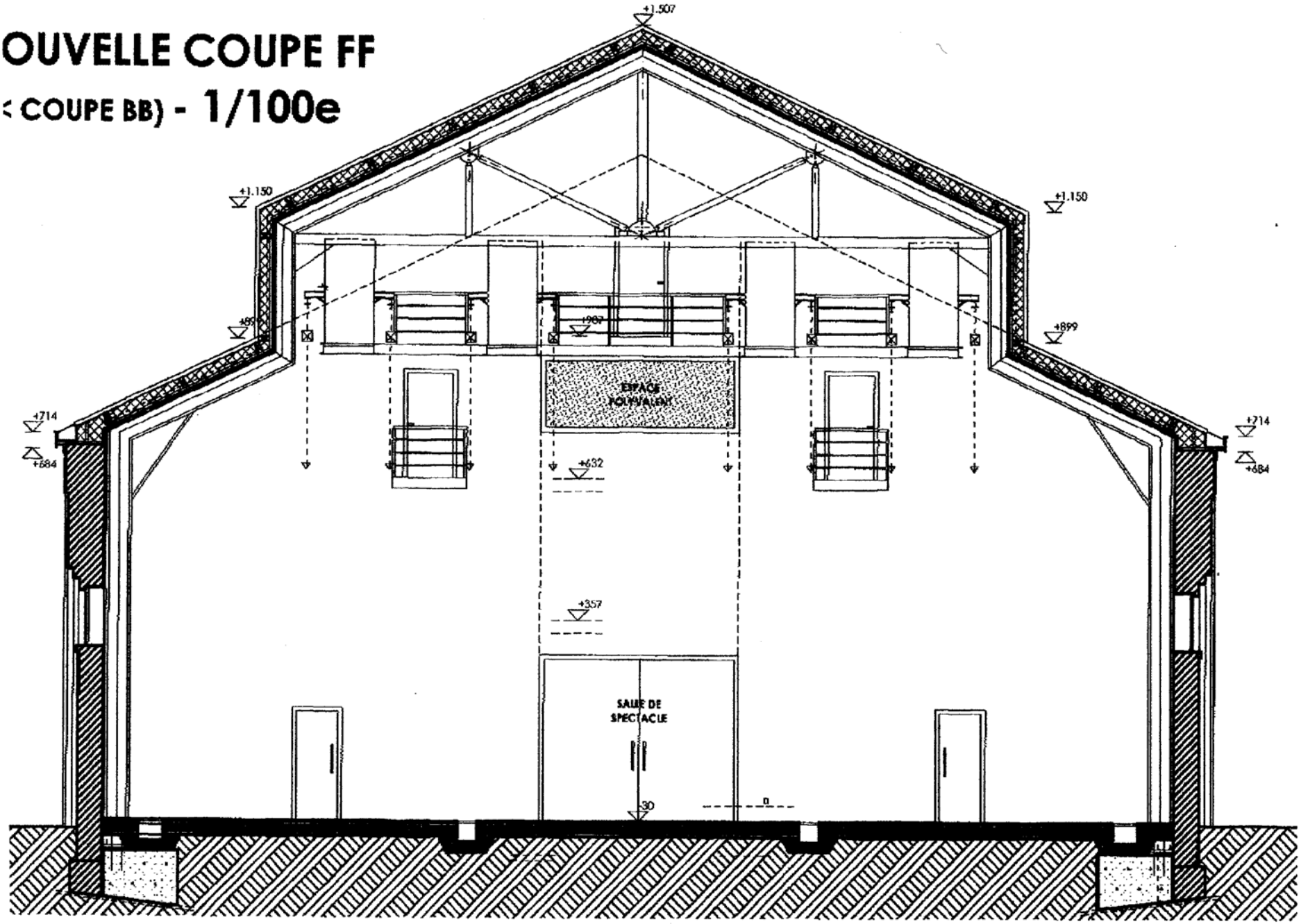
Théâtre du Grand Manège (Namur)

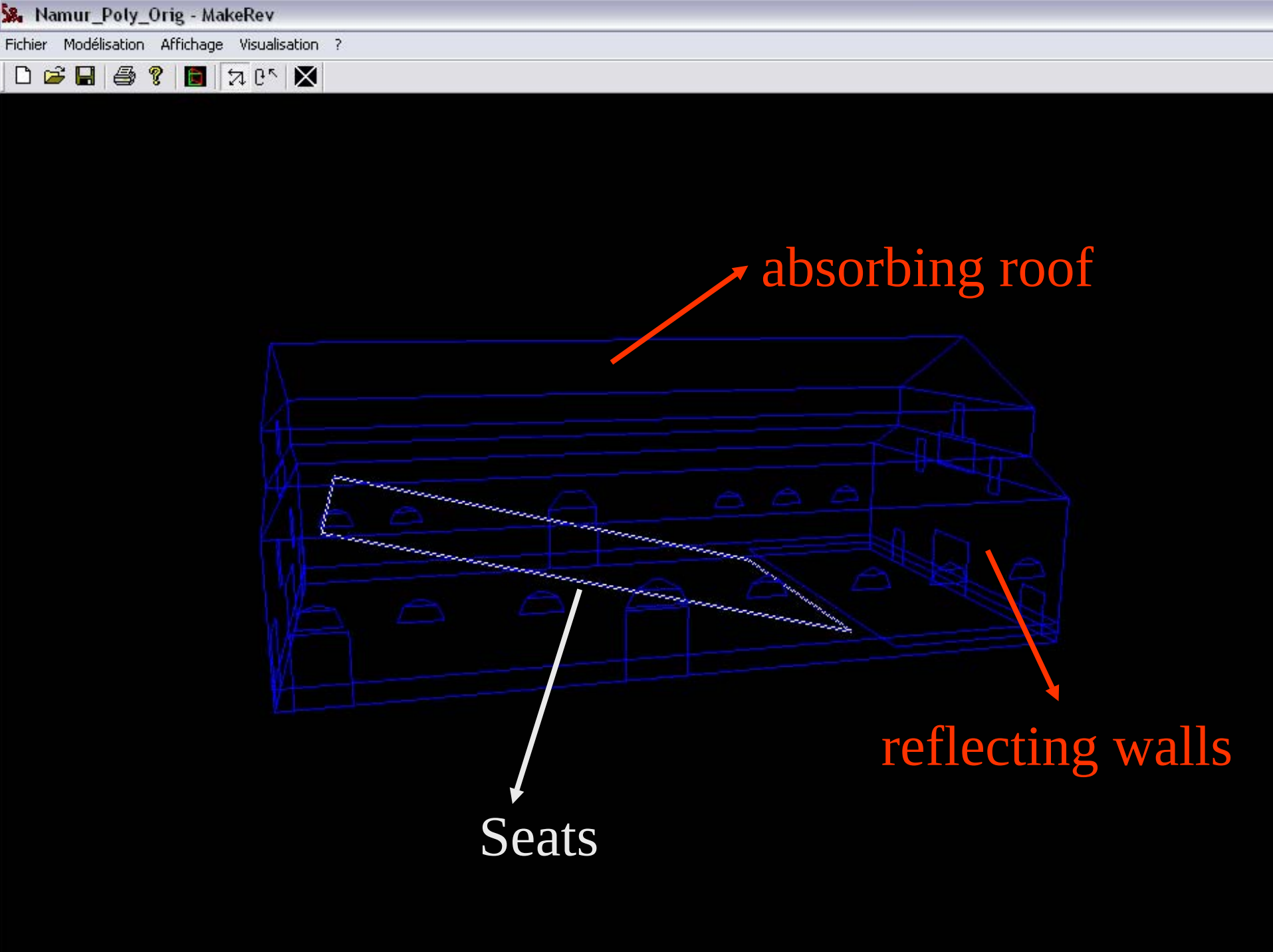


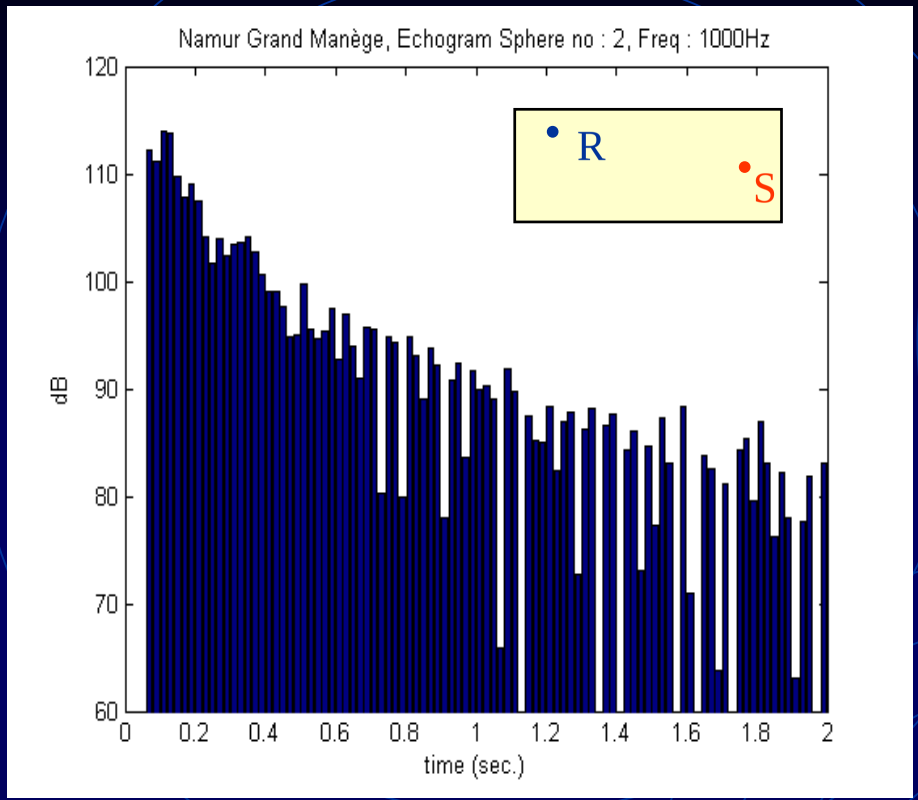
Plan Rez-de-chaussée
1/500e

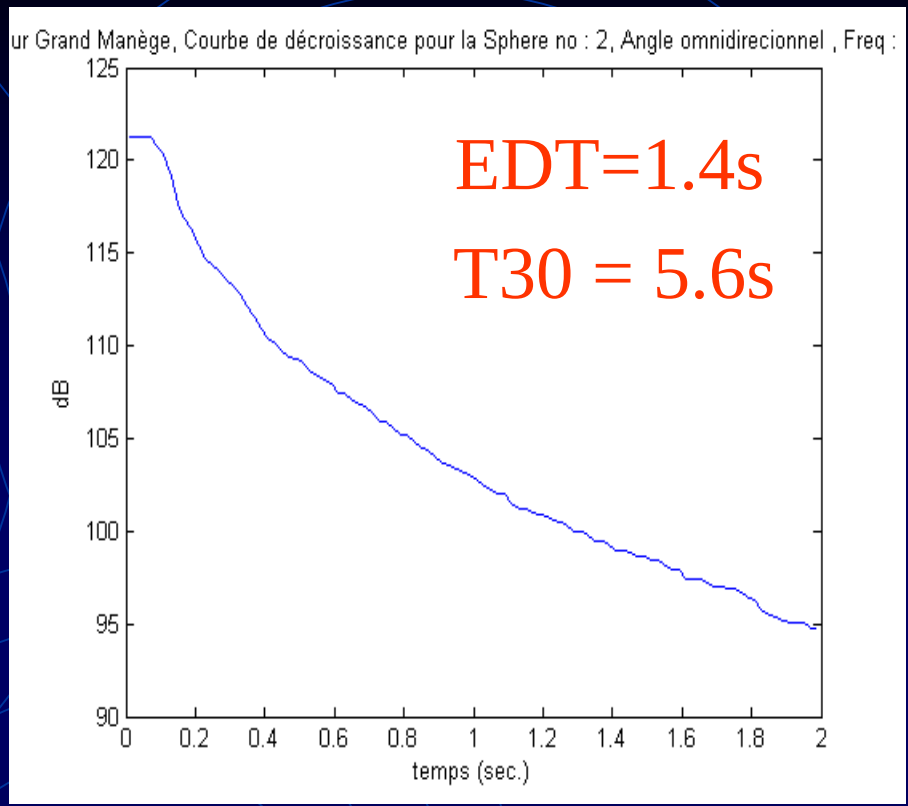
OUVELLE COUPE FF

< COUPE BB) - 1/100e

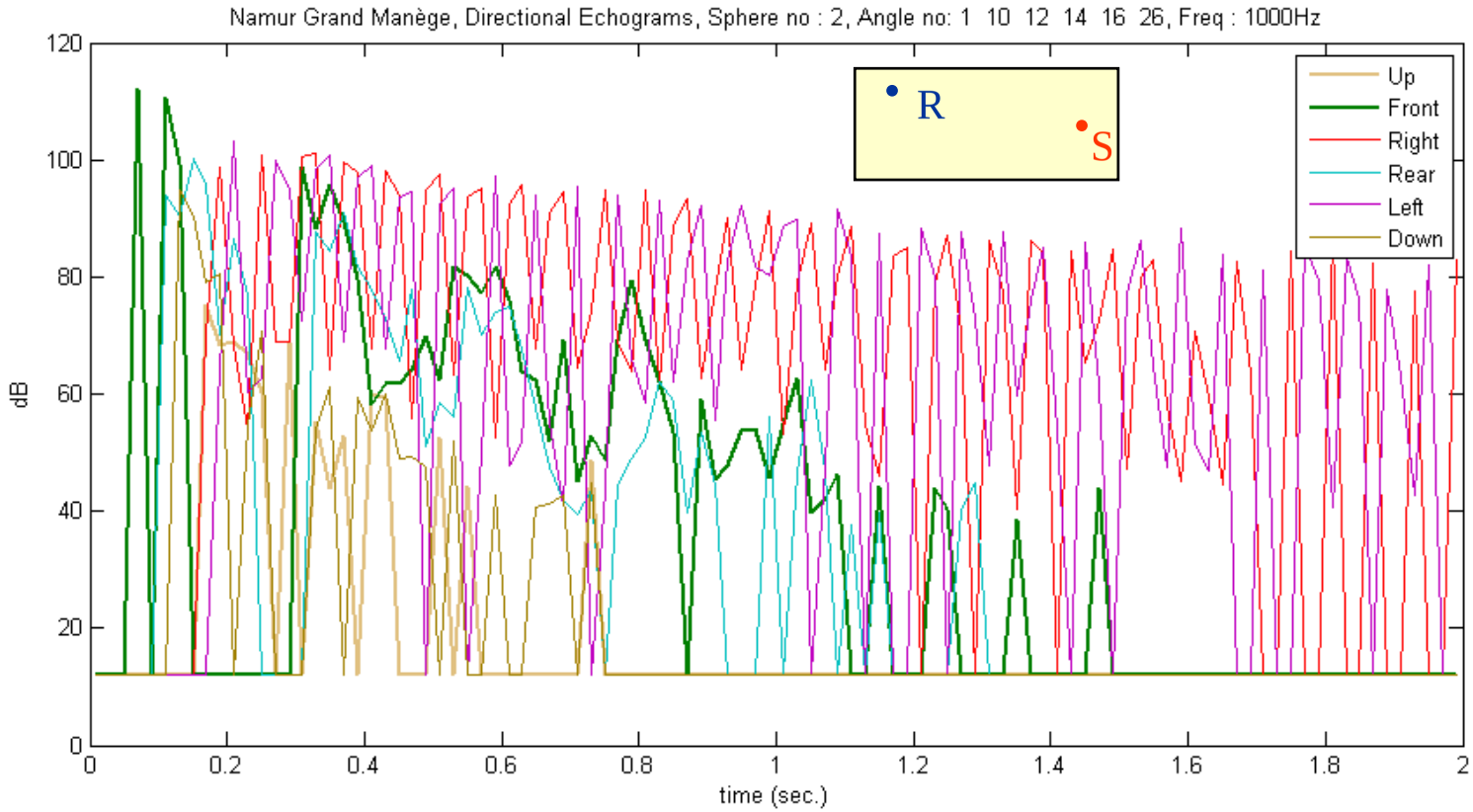



Namur_Poly_Orig - MakeRev
Fichier Modélisation Affichage Visualisation ?
absorbing roof
reflecting walls
Seats

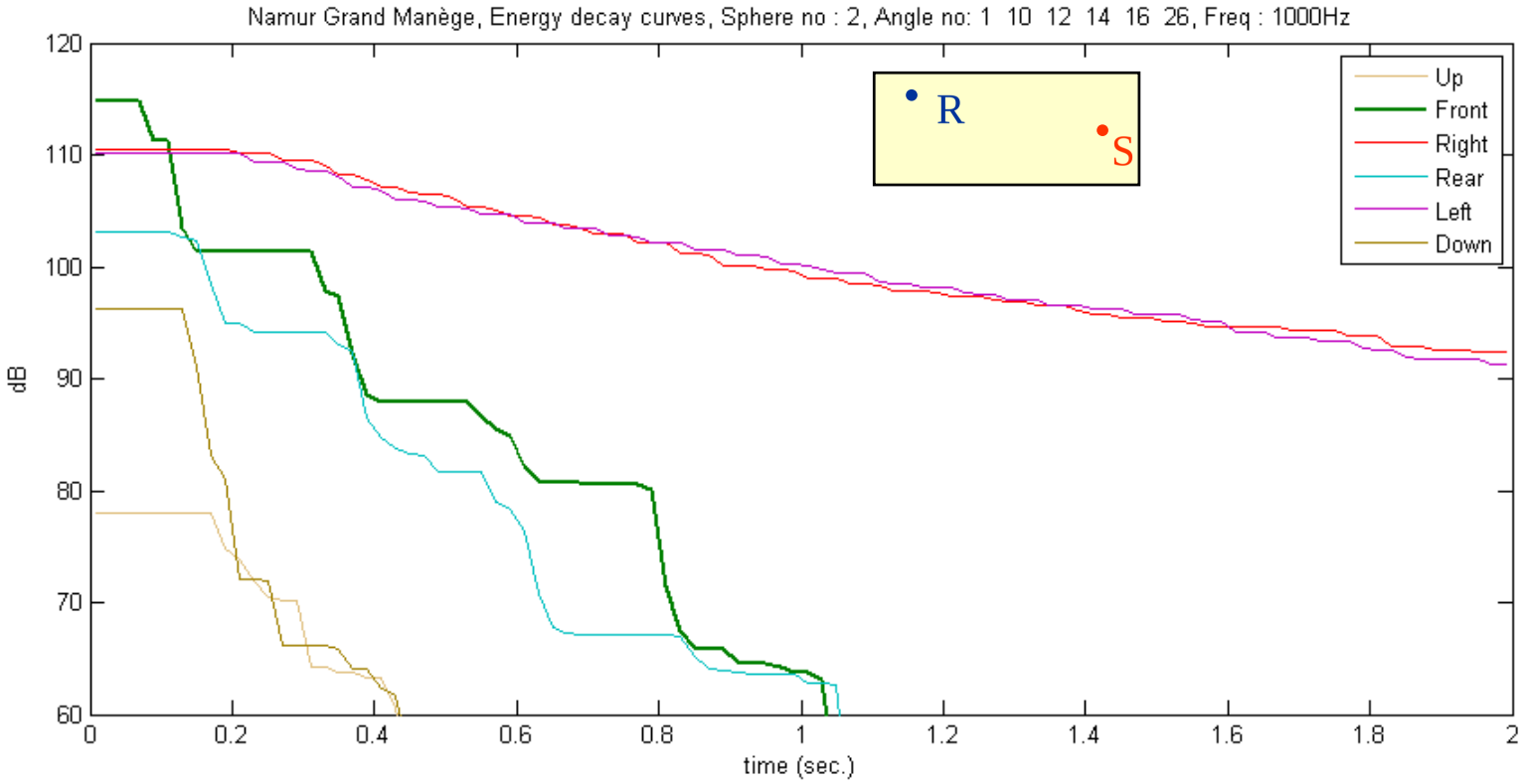




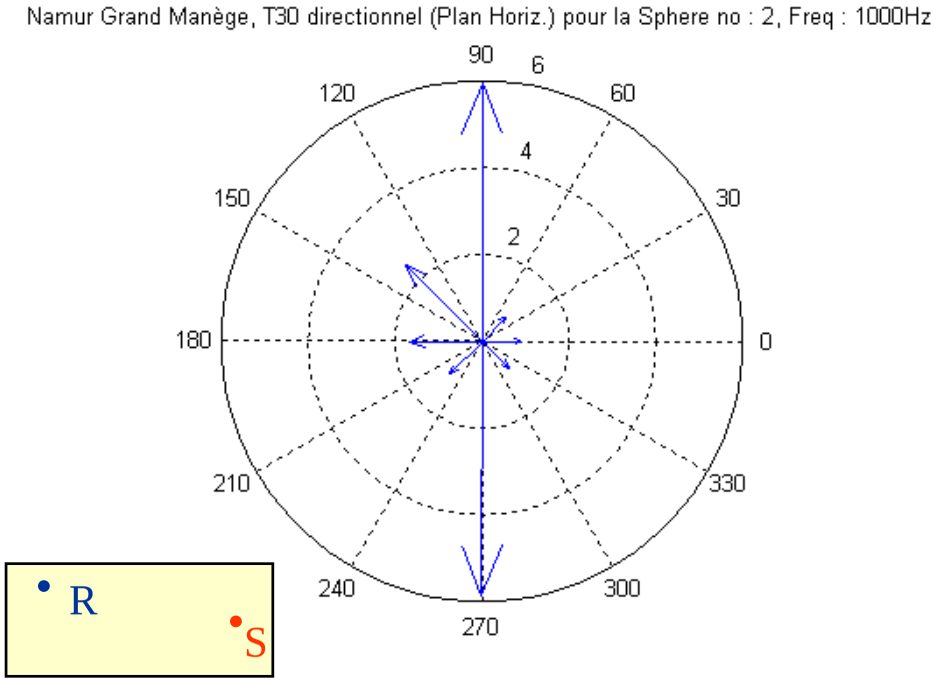
Polyvalent hall, original situation :
Echogram and energy decay curve at one receiver position.

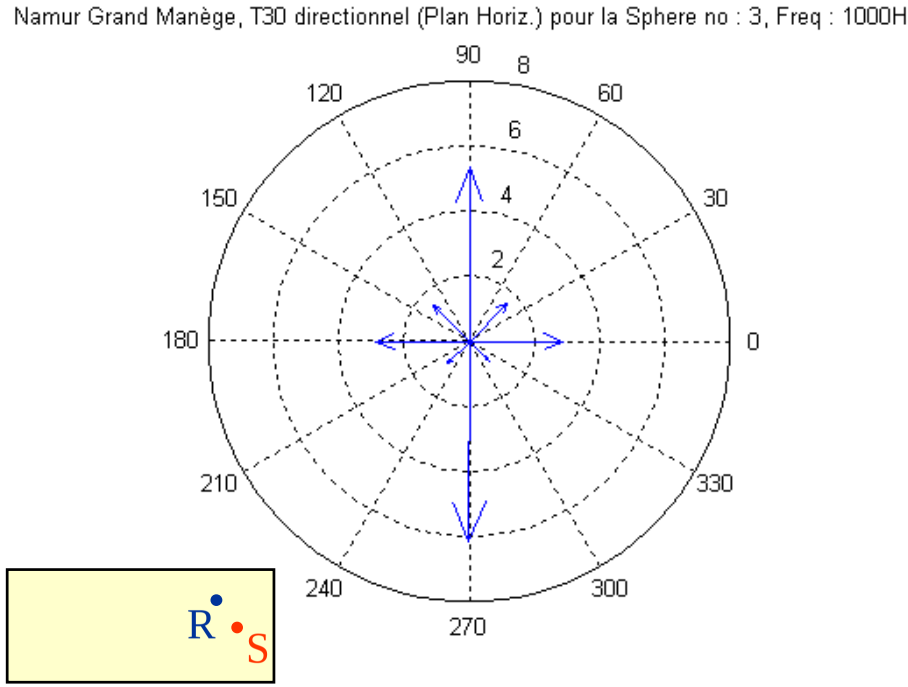


Polyvalent hall, original situation :
Directional echograms at one receiver position, 1 kHz.



Polyvalent hall, original situation :
Directional energy decays at one receiver position, 1 kHz.

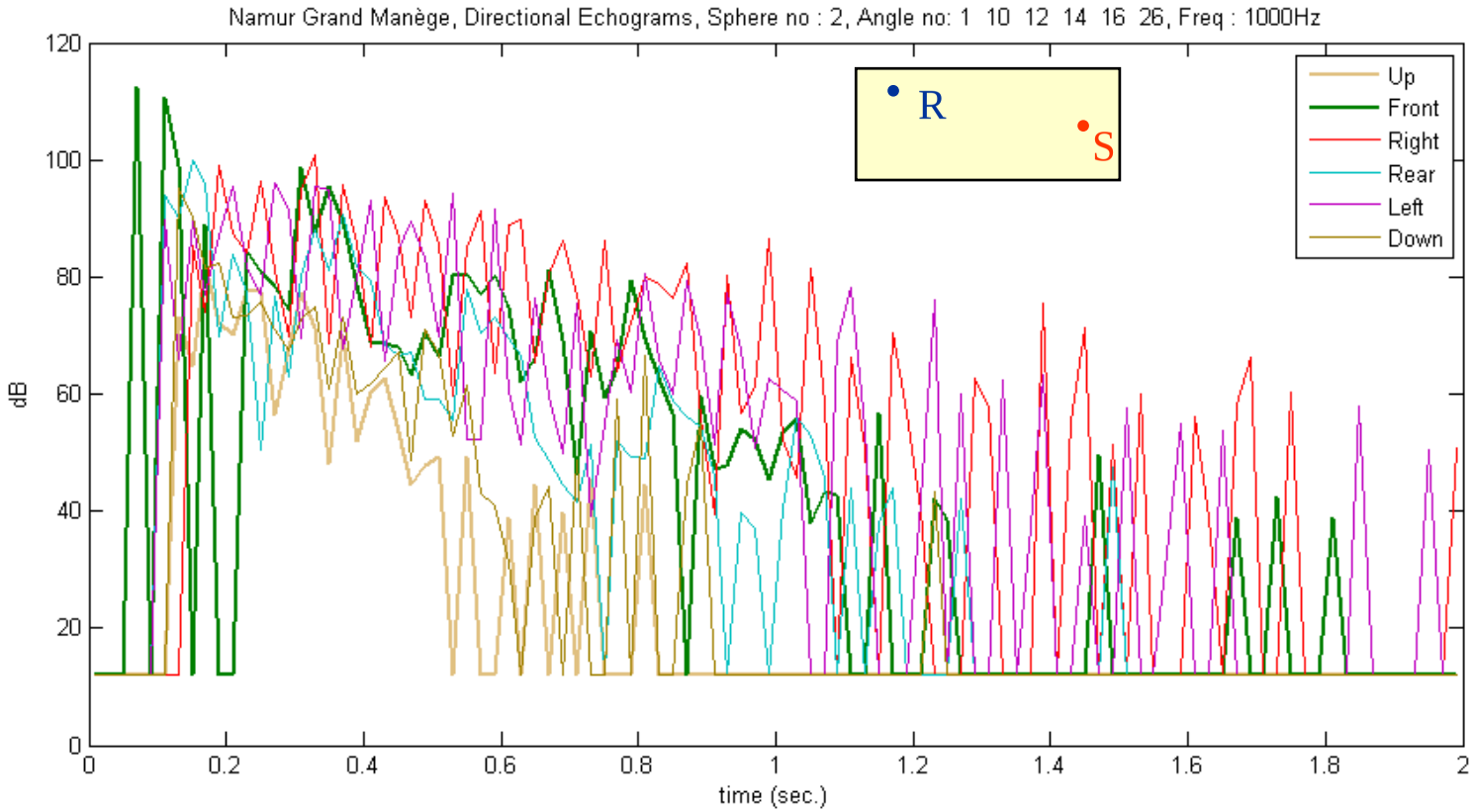




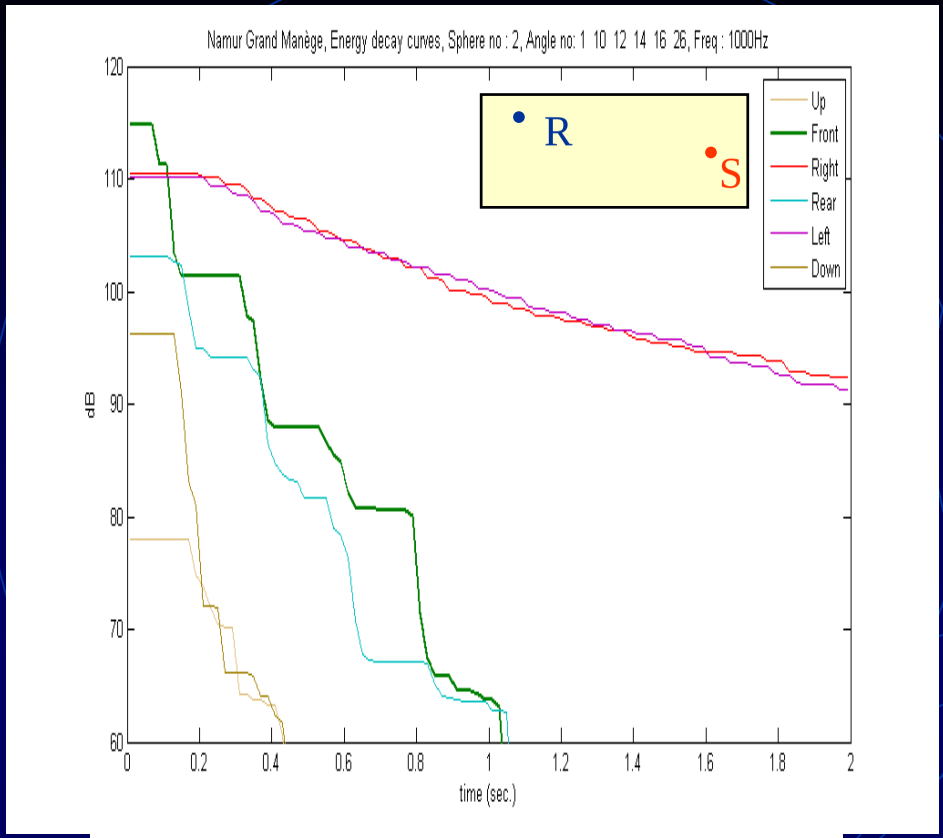
Polyvalent hall, original situation :
Directional T30 at two receiver positions, 1 kHz.

Théâtre du Grand Manège
(Namur)

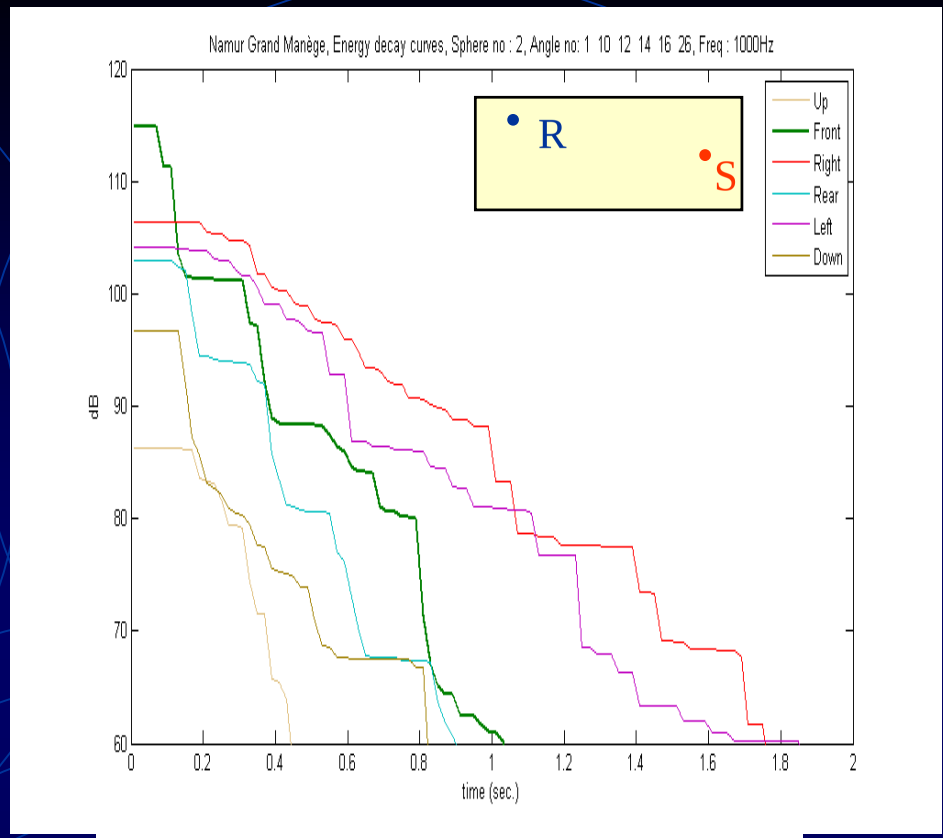
First acoustical treatment :
Absorbent and diffusing surfaces on the left wall
(when looking from the scene)



Polyvalent hall, first acoustical treatment :
Directional echograms at one receiver position, 1 kHz.



before treatment : T30=5.6s



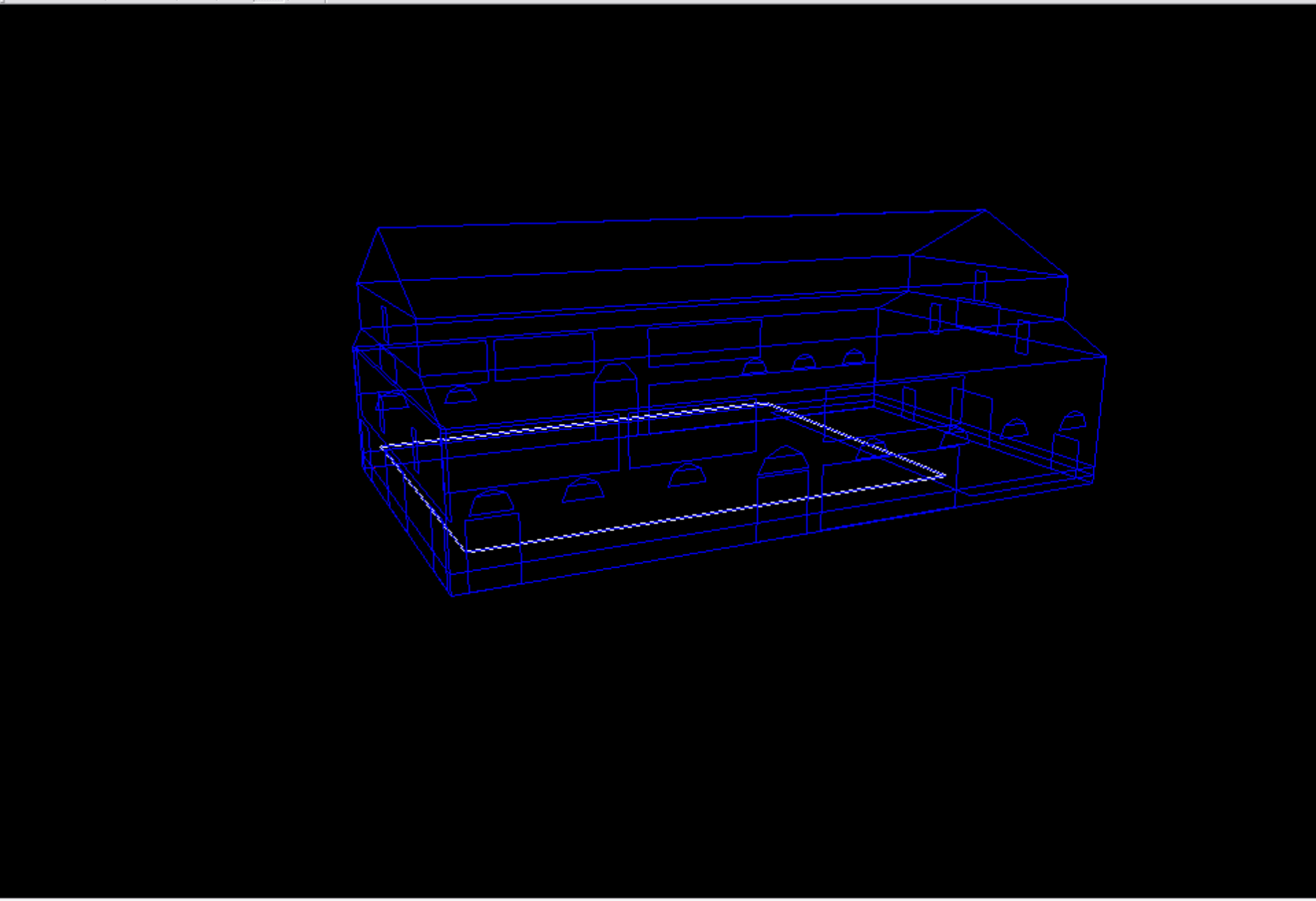
after treatment : T30=1.9s

Polyvalent hall:
Directional energy decays at one receiver position, 1 kHz.

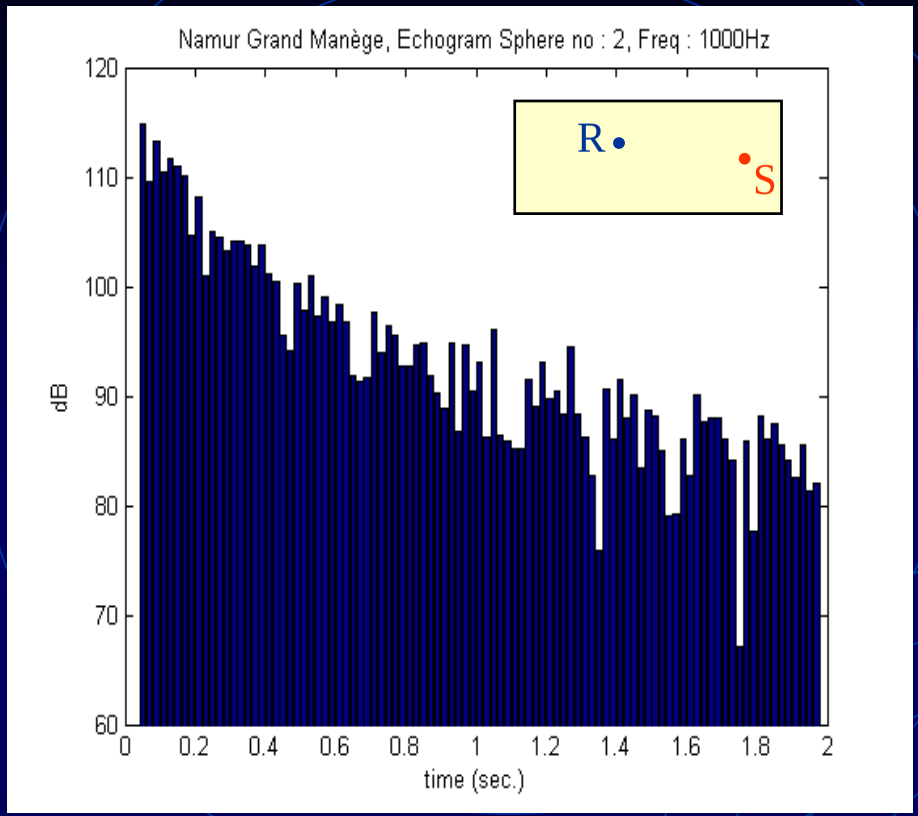
Théâtre du Grand Manège
(Namur)

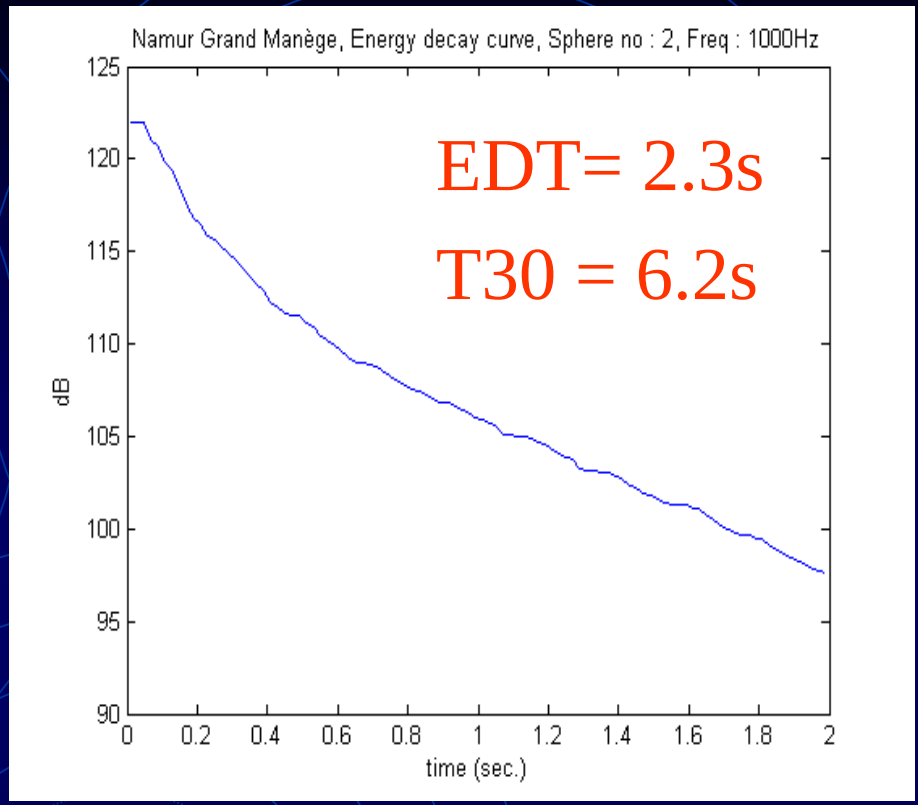
Horizontal audience surface

Fichier Modélisation Affichage Visualisation ?

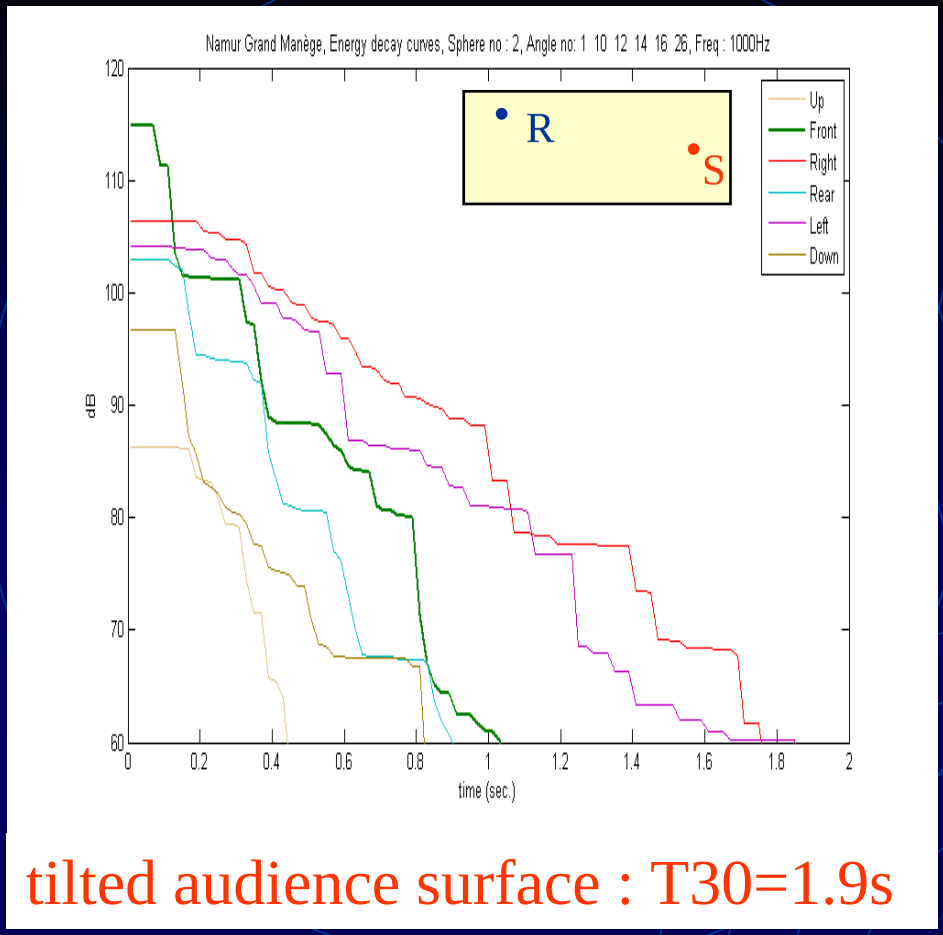


Prêt

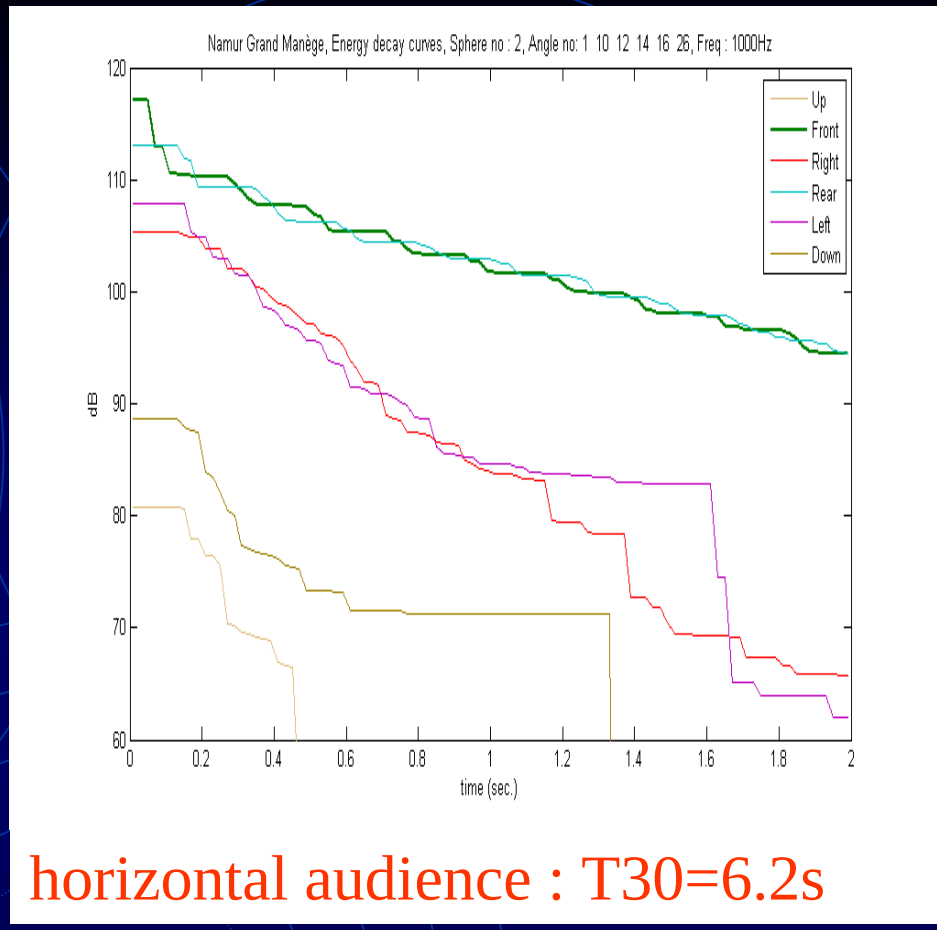




Polyvalent hall, horizontal audience surface :
Echogram and energy decay curve at one receiver position.



tilted audience surface : T30=1.9s



horizontal audience : T30=6.2s

Polyvalent hall, horizontal audience surface :
Directional energy decays at one receiver position, 1 kHz.

Conclusions

-Directional echograms can give original information in non-diffuse acoustical fields.

-They are particularly useful in the detection of potential flutter echos, lack of diffusivity and asymmetrical distribution of absorption.

- They can explain significant differences between T30 and EDT, as a result of nonlinear energy decays.

- They can suggest optimal placement of absorbent and/or diffusing material to attenuate reverberation.