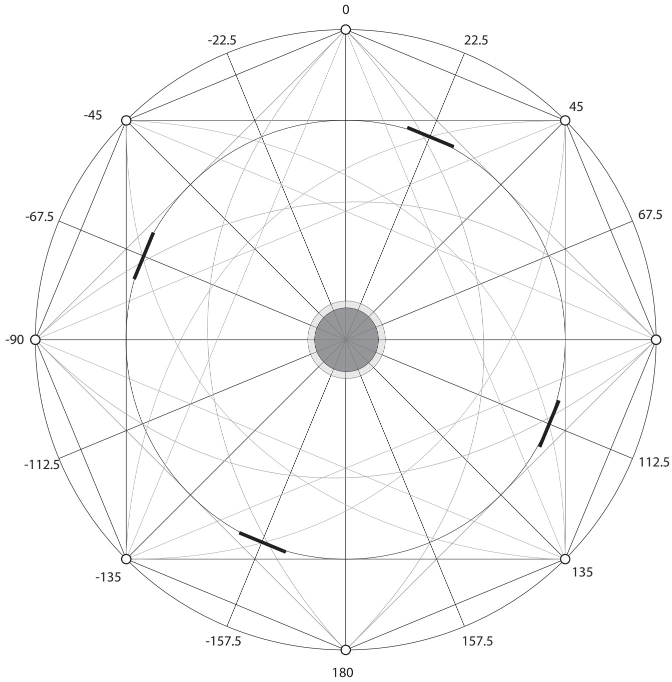
Geophonies~

What sounds do noises make?



]Millennium Art-Science Project 2025[

Nicolas Germain | *Jean-Marc Routoure*

v. 5.0 - jan 2025

Summary

« Capturing, amplifying and transforming vibrations emitted by matter. Just as today we listen to the song of the forest and the sea, tomorrow we will be enchanted by the vibrations of a diamond or a flower.»

Filippo Tommaso Marinetti et Pino Masnata, 1933

Noise is a sound that is considered undesirable.

Sounds that cannot be understood as speech or music are often equated with noise, even if their perception is not unpleasant (ambient noise).
From an environmental point of view, unwanted sounds are a nuisance. Those who complain about them equate them with pollution. The level of this noise pollution is measured in decibels. For musicians in the European classical tradition, noise is a sound of indeterminate pitch.

Technically speaking, noise refers to unwanted elements added to a signal, even if it is not acoustic. The signal must be separated from the background noise.

Noise as a signal
Noise is the part of the electrical signal that cannot be decoded into information. Signals with the same characteristics as noise can be created to test systems.

Integration of noise into music
In the 19th century, symphony orchestras began to include non-melodic percussion instruments. (Thunder, waves, birdsong, etc.) In the 20th century, Edgar Varèse made extensive use of noises such as sirens, clashes and the rustling of metal.

In '**The Art of Noises**,' written in 1913, Luigi Russolo argues that the human ear has become accustomed to the speed, energy, and noise of the urban and industrial sound environment, and that this new sound palette requires a renewed approach to instruments and musical composition.
He sets out a number of conclusions in which he describes how electronics and other technologies will enable futurist musicians to 'replace the limited number of sounds that the orchestra has today with the infinite variety of sounds contained in noises, reproduced using appropriate mechanisms.'

In 1917, Erik Satie presented his music for the ballet ***Parade***, which featured various 'noisy instruments' such as a typewriter, a revolver, a lottery wheel and an alarm siren: the music of Parade was 'unacceptable noise' to many critics when the work was first performed.

Hyperprism is a short work by Edgar Varèse written in 1922–1923 for sixteen percussion instruments and nine wind instruments. It was Varèse's first attempt to ***spatialise*** music, turning it into a prismatic reality in its dimension of decomposition, diffraction and fragmentation. It also references crystals, which he uses to compare the interactions between groups of instrumentalists in this score with the attractions and repulsions that occur in the constituents of a crystal in formation.

The work was premiered on 4 March 1923 in New York, conducted by the composer. The reception was stormy, but conductor Leopold Stokowski defended it and performed the piece several times that same year.
Varèse declared on that occasion: 'I don't give a damn if people don't like my music.'

«When a noise bothers you, listen to it.»

John Cage

«Within a thin atmospheric layer, our planet expresses itself and resonates through an infinite variety of acoustic manifestations and phenomena. What if the Anthropocene could be described and experienced through sound?»

Quentin Arnoux, Écouter l’anthropocène 2021

Geophonies, quels sons font les bruits ?

As a subject of theoretical and scientific study, as well as a source of musical and visual creation, noise and the movement of sound through space will be at the heart of experiments and creations resulting from a collaboration between an artist and a scientist.

The Geophonies project focuses on the reactions of imaginary jellyfish to the sounds that populate their marine environment. At the crossroads of underwater bioacoustics, cellular physiology and marine ethology, it explores how these creatures, which have no central nervous system, perceive and react to acoustic vibrations, whether they come from natural phenomena (waves, sounds from other organisms) or human activities (boat engines, sonar). This research offers a sensitive reflection on the sound perception of cnidarians and questions the effects of noise pollution on marine life.

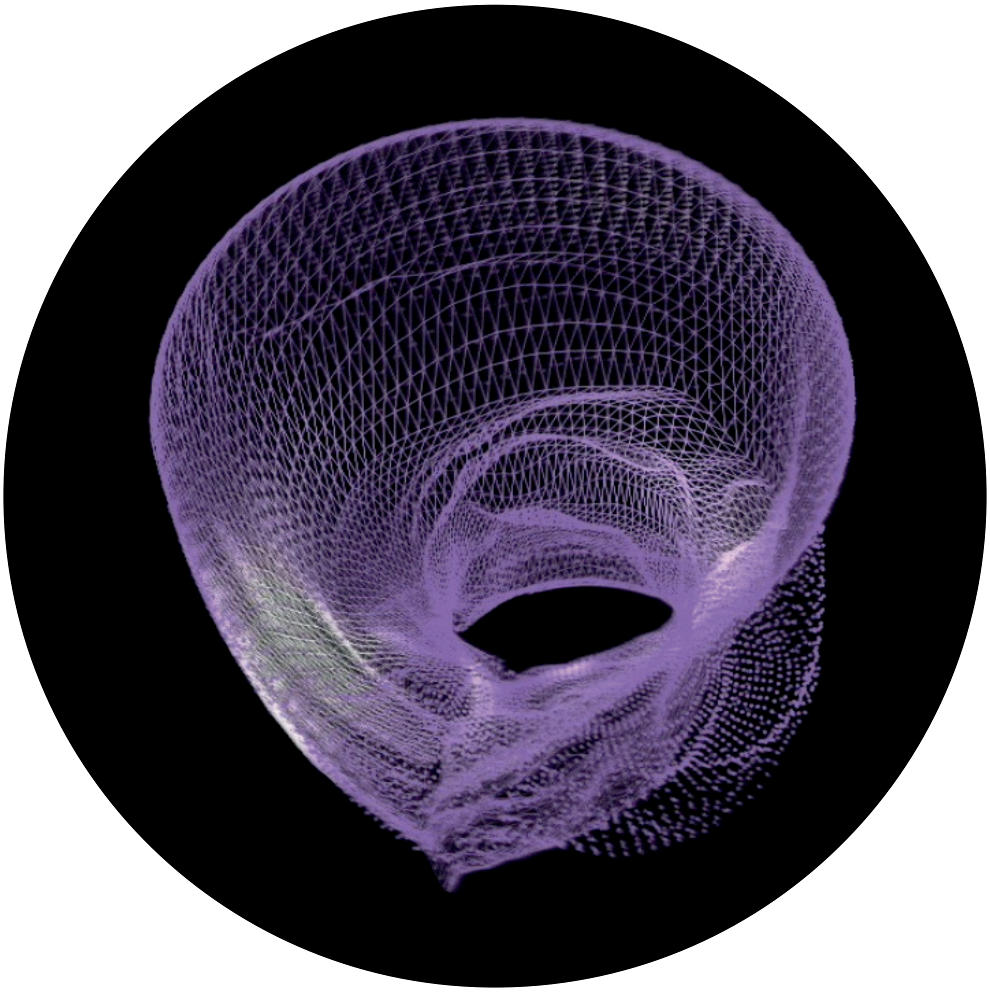
Several stages of work have already been defined: creation of a database of component noises, recording and processing of sounds, experiments in spatialisation of non-synthetic noises from components analysed in the laboratory, and the design of a tool for generating and controlling specific noises in real time. By establishing links between the sounds of electronic components and those observed in nature, this research paves the way for a broader understanding of sound phenomena.

The sounds produced by electronic components, which bear potential similarities to natural sounds such as wind, water or animal life, could thus provide new insights into the transport mechanisms at play and suggest analogies between technological systems and natural ecosystems.

Areas of research also include the use of new signal analysis methods (such as wavelet decomposition) to enrich the visualisation of sounds, experiments to translate noises imperceptible to the human ear into sounds and images, and linking Fourier spectral analysis in the scientific and musical fields. Inspired by the soundscapes of nature, these analyses could also give rise to compositions that resonate with natural environments, thus establishing a poetic link between technology and nature.

A sound and visual scenography of microscopic interactions, in a cubic structure reminiscent of semiconductor components, will spatialise noise and its microscopic origins on a human scale. This immersive device, by providing a space where one can explore the effects of displacement on sound, will also allow us to reimagine the place of humans and technology in a larger natural world, where each sound tells an interconnected story.

This device will provide an inspiring setting for developing new hypotheses about the microscopic origins of low-frequency fluctuations, while immersively exploring the relationship between technology, art and nature.



Nicolas Germain is a sound artist, teacher, and member of the Modular Laboratory at ésam in Caen-Cherbourg, France.

He conducts research on the concept of immersive sound spaces and the perception of moving sounds. The spatialised fragmentation of a continuous sound, for example, gives rise to an auditory experience in which each frequency segment is perceived as coming from different directions, enriching the spatial dimension of listening. He works with a modular synthesiser that allows him to create unique sound material that can be modulated in real time. The choreographies used in octophony are inspired by nature (celestial or geological movements, fluids or the living world, mechanical movements, etc.) to confront them poetically through changes of scale.

He also works on forms of sound visualisation, created by spectral analysis (sonograms), creating three-dimensional landscapes modulated in real time, particularly from sounds inaccessible to the human ear. He distributes his music under the name el TiGeR CoMiCs GRoUP.

Last albums :
After - (Gestation Production / Station Mir)
After~Live - (Gestation Production / Laboratoire Modulaire ésam-C2)

Jean-Marc Routoure is a professor at the University of Caen-Normandy, France

He conducts his research in the electronics team at GREYC, a joint research unit of the University of Caen, ENSICAEN and CNRS. He is interested in the fluctuations and fundamental mechanisms that cause different types of noise in electronic components. Measurements based on temperature or electrical current intensity enable the mechanisms behind the transport of electrical charges and their associated fluctuations to be identified in detail: several types of noise (white noise, 1/f (or excess) noise, Lorentzian noise, and popcorn noise) appear during mechanisms of drift, diffusion, or carrier recombination generation.

Noise, observed since the 1930s, remains an open research topic because theoretical models are still incomplete regarding 1/f noise and its existence at very low frequencies. Its location in components is also a subject of debate: is it an effect that appears at interfaces or a volume effect (Hooge 1969)? In this case, the Brownian motion of charge carriers and the collisions of these carriers with the atoms of the crystal lattices may help to interpret the measurements.

Goals

Make the 1/f noise generated by the electronic component audible and visible
(amplification - audification - sonification - real-time 3D animation).

Highlight noise fluctuations
(subtractive synthesis - focus on low frequencies).

Use noise/sound material as a basis for composition and as spatialisation data
(Synthesis - Sonification)

Highlight links with the sounds of nature
(Geophonic sound creation - Subtractive synthesis - Composition)

Create a soundscape
(Fragmentation - Spatialisation - Choreography)

Create aquatic species that are sensitive to the environment
(Generation of 3D images based on sonograms)

Animals react in different ways to surrounding sound
(Behaviour, colour, material, transparency, defence system, etc.)

Perform all manipulations ***in real time***.

Work steps

Montage circuit d’amplification du bruit (résistance) V.2	2024 ok
Mesures et analyses du bruit par enregistrement	2024 ok
Optimisation du circuit d’amplification + isolation	V3 en cours
Ajout d’un module de variation du courant vers la résistance	nov 2024 ok
Création outils de mesure (densité spectrale)	2024 ok
Création d’outils de filtrage (synthèse soustractive)	dec 2024 ok
Tests traitement de l’audio en temps réel	jan 2025 ok
Création de différents sons dans le domaine de la géophonie	juin dec 2024
Création du dispositif de monstration du circuit électronique (caillou magique) - Réalisation d’un prototype	mars 2025
Création du système de visualisation (génération vidéo et analyse FFT temps réel)	2023-2025
Conception moniteurs-aquariums Réalisation d’un prototype et tests	fevrier 2025
Conception scénographie globale de l’audio et sa spatialisation	juin déc 2024
Test de la mise en relation des modules à l’échelle 1 et en temps réel	dec 2024 > mars 2025
Optimisation du circuit et de la chaine audio	mai 2025
Assemblage des différents traitements (audio - filtrage - composition - spatialisation - animation vidéo	jan > mai 2025
Réalisation des moniteurs-aquariums et de leur support (système de rotation ?)	juillet 2025
Scénarisation audio - écriture des tableaux	jan > aout 2025
Conception et réalisation des supports et modules de transport	aout 2025

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Credits

Production : *Station Mir ▪ festival]interstice[*

STATIONMIR • festival]interstice[

Project Development and Networking: *Oblique/s*

OBLIQUE|S
ARTS & CULTURES
NUMÉRIQUES
NORMANDIE

Technical coordination delegated to: *Manœuvre*

Scientific partners :

GREYC, GREYC is the Caen Research Group on Computing, Imaging and Instrumentation, a digital science research laboratory located in Caen, France

GREYC

Université de Caen Normandie

UNICAEN UNIVERSITÉ CAEN NORMANDIE

Credits

Electronic circuit

Conception : Jean-Marc Routoure
Réalisation : Jean-Marc Routoure, Sylvain Lebargy, Julien Gasnier, Lucas Bessin

Magic Stone LED Headband

Conception et réalisation : Brice Feli, Marion Lacavalerie, Dorianne Vildey, Adrien Perrin (étudiant.e.s en M1 Information Médiation Scientifique et Technique Université de Caen)

Resistor cover

Conception et réalisation : Lila Hays, Maika Grenier-Journe, Gabriel Ploquin, Fanny Le Baccon (étudiant.e.s en M1 Information Médiation Scientifique et Technique Université de Caen)

Glass globe Magic Stone

Réalisation : Veramy

Magic stone stand and monitor feet

Réalisation : Collectif *Manœuvre*

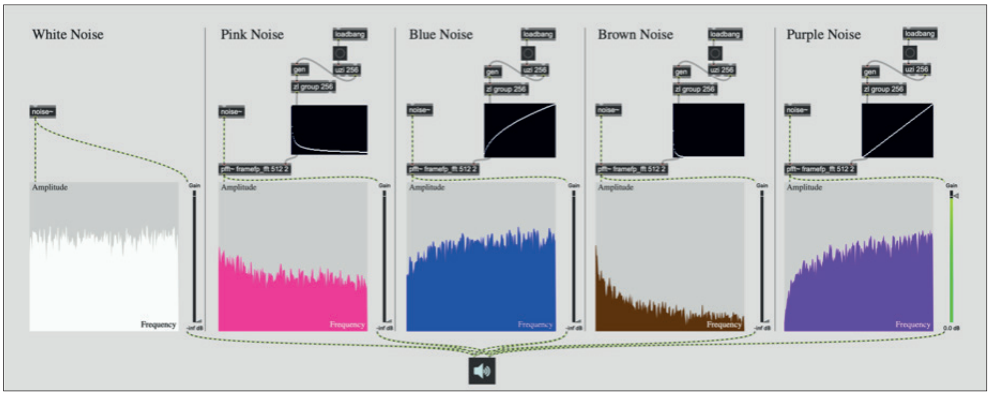
Audio processing, composition, spatialisation, video creation

Nicolas Germain

Glossary

White noise
White noise is the realisation of a random process in which the spectral power density is the same for all frequencies in the bandwidth. (Wikipedia)

Pink noise
While white noise has constant spectral energy across the entire frequency range, i.e. per hertz, pink noise has constant energy per octave band. For example, with pink noise, the octave band ranging from 500 to 1000 hertz contains the same energy as the band ranging from 4000 to 8000 hertz. Thus, the spectrum of pink noise decreases with frequency, unlike white noise, which remains constant.
One of the natural sounds that most closely resembles pink noise is that of a torrent or waterfall, produced by the random frequencies added together from the impact of varying amounts of water on rocks. (Wikipédia)



Coloured noise spectra: White, Pink, Blue, Brown, Purple

Flicker noise
Flicker noise is electronic noise that is always present in active components and in certain passive components.
It is also known as flicker noise, flickering noise, low-frequency noise or excess noise.
It is a type of pink noise with a power curve of 1/f. (Wikipedia)

Thermal noise
Thermal noise, generated by the passage of current through a resistor, is also known as resistance noise, Johnson noise or Johnson-Nyquist

noise. It is the noise produced by the thermal agitation of electrons in an electrical resistor in thermal equilibrium. Thermal noise is white noise whose spectral power density depends solely on the value of the resistor. Thermal noise can be modelled by a voltage source in series with the resistor that produces the noise. It depends on the technology used to manufacture the resistor (carbon, ceramic, metal layer).
(Wikipedia)

Amplification
The act of increasing or expanding the range or volume.An increase in voltage, current intensity or electrical power, achieved using an amplifier.

Audification
The amplitude and frequency of the measured data are transcribed in the form of a sound wave. This involves amplifying the original signal, often from infrasonic or ultrasonic frequencies, to transpose it into the audible range.
(From Field Recording to the Art of Sonification, Andrea Giomi 2022)

Sonification
Sonification is the representation and transmission of data in the form of non-verbal acoustic signals for the purpose of transmitting or perceiving information. (e.g. the Geiger counter in 1913)
*'To concretely introduce **real-world phenomena** into the semantics of sound art, to **assign data** the responsibility of **generative composition**, to use sounds as a medium to make phenomena audible **that would otherwise be imperceptible**.'*
(From Field Recording to the Art of Sonification, Andrea Giomi, 2022)

«Regardless of the object being studied, sonification ***by mapping*** consists of associating salient data parameters with sound qualities that make it possible to create temporal objects *that reveal meaningful forms* that can be interpreted by the research community. The sound produced here creates auditory images.»
(Lorella Abenavoli 2017)

Examples of the use of sonification in the field of art :

Alvin Lucier (ondes Alpha)
Greg Niemeyer (dioxyde de carbonne)
Christina Kubisch (ondes électromagnétiques)
Andrea Polli (géosonification)
Hildegard Westerkamp (géosonification)
Gérard Grisey (Pulsar)
Ryoji Ikeda (mathématiques)
Pauline Oliveiros (signaux électriques)
Gordon Mumma (électronique)
Robert Barry (gaz inertes, ultrasons)
Joyce Hinterding (forces énergétiques)
Herman Kolgen (sismographie)
Lorella Abenavoli (sismographie)
Leah Barclay (GPS)
Andrea Polli (données environnementales)...

Subtractive synthesis
Subtractive sound synthesis is a sound synthesis process that involves generating a signal rich in harmonics and then softening it using frequency filters.
This signal is either a periodic signal characterised by a perceptible pitch and timbre, or an aperiodic signal resulting from random oscillation, the latter being referred to as noise. (Wikipedia)

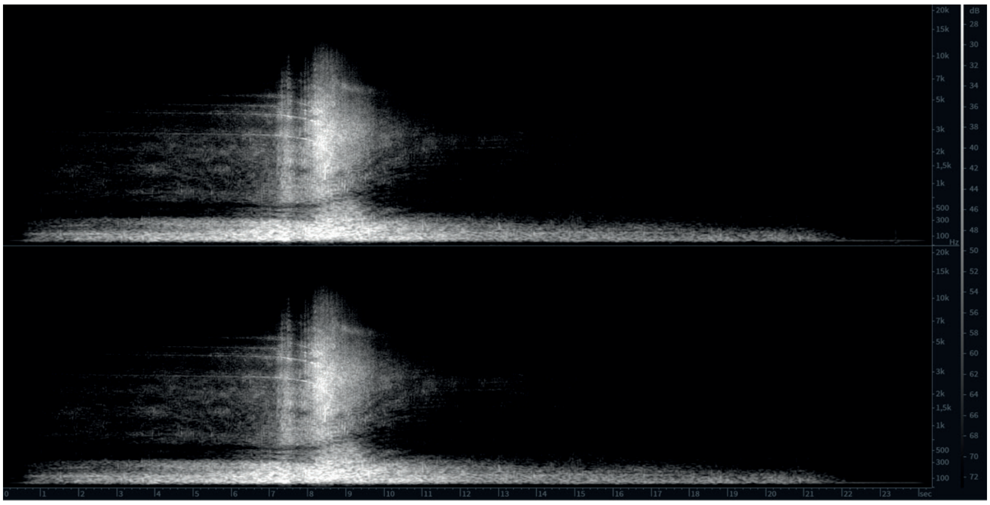
Spatialisation
In music mixing, spatialisation is used to distribute the different instruments in space in order to improve their intelligibility. In the field of virtual reality or cinema, spatialisation contributes to the feeling of immersion.
Human hearing is capable of determining the position of sound sources in space, mainly by comparing the sound signals received by both ears, but also by comparing direct sound and reverberation, or by analysing the timbre of the spectrum. (Wikipedia)

Sonogram
A sonogram, or sound graph, is a representation used for spectral analysis of variable sounds, acoustic pressure or associated tension, using a colour scale based on frequency and time, plotted on the y-axis and x-axis respectively.

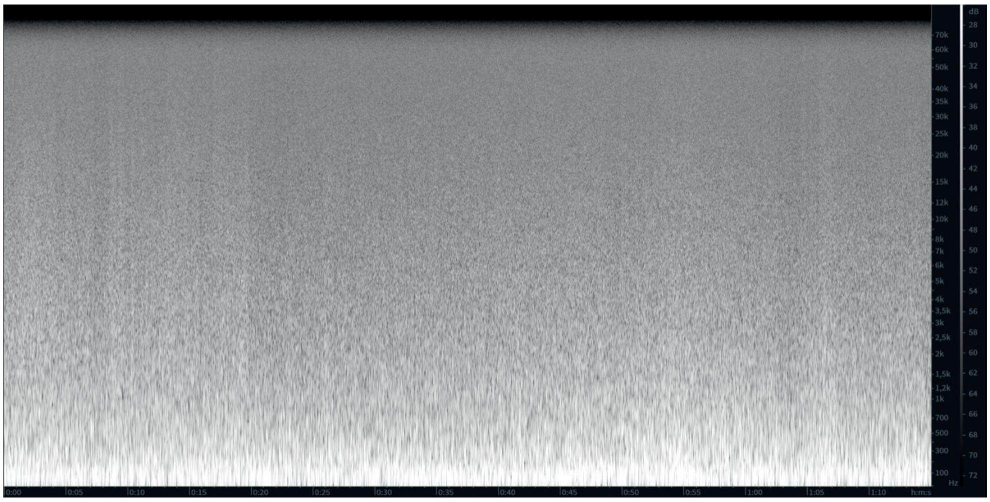
The sonogram represents three parameters in a single two-dimensio-

nal diagram:
- time
- frequency
- sound amplitude

The accuracy with which the frequency can be identified depends on the analysis time, according to the uncertainty principle. The frequency ranges that can be distinguished all have the same absolute width f2-f1, whereas perception, particularly musical pitch, is based on geometric growth, with f2/f1 remaining roughly constant. A long window makes the dynamics indistinct, while a short window makes the frequency imprecise.



Sonogramme d’un avion (x = temps | y = fréquence | intensité = amplitude)



Sonogramme d’un bruit blanc

Soundscape
The term 'soundscape' is a neologism coined in 1977 by Canadian composer and ecologist R. Murray Schafer in his book The Tuning of the World (The Soundscape), translated into French in 1979 under the title *Le Paysage sonore.* The entire history of our sound environment through the ages.
According to this author, a soundscape is composed of three main elements:
- Key or tonic sounds
In music, the term 'key' refers to the fundamental tone, which is not always perceptible to the listener. It is the sound from which other sounds will be perceived. Tonic sounds are not always consciously perceived, but they 'mark the temperaments of the people who experience them' (Schafer).
Examples of tonic sounds in nature are the sound of wind, water, forests, plains, birds, insects and, in urban areas, traffic noise.
- Sounds with a signalling value or sound signals
These sounds are at the forefront of a soundscape. We hear them consciously.
Examples include warning signals such as the sound of bells, whistles, horns, sirens, etc.
- Sound markers
This term refers to a sound that is characteristic of a place.

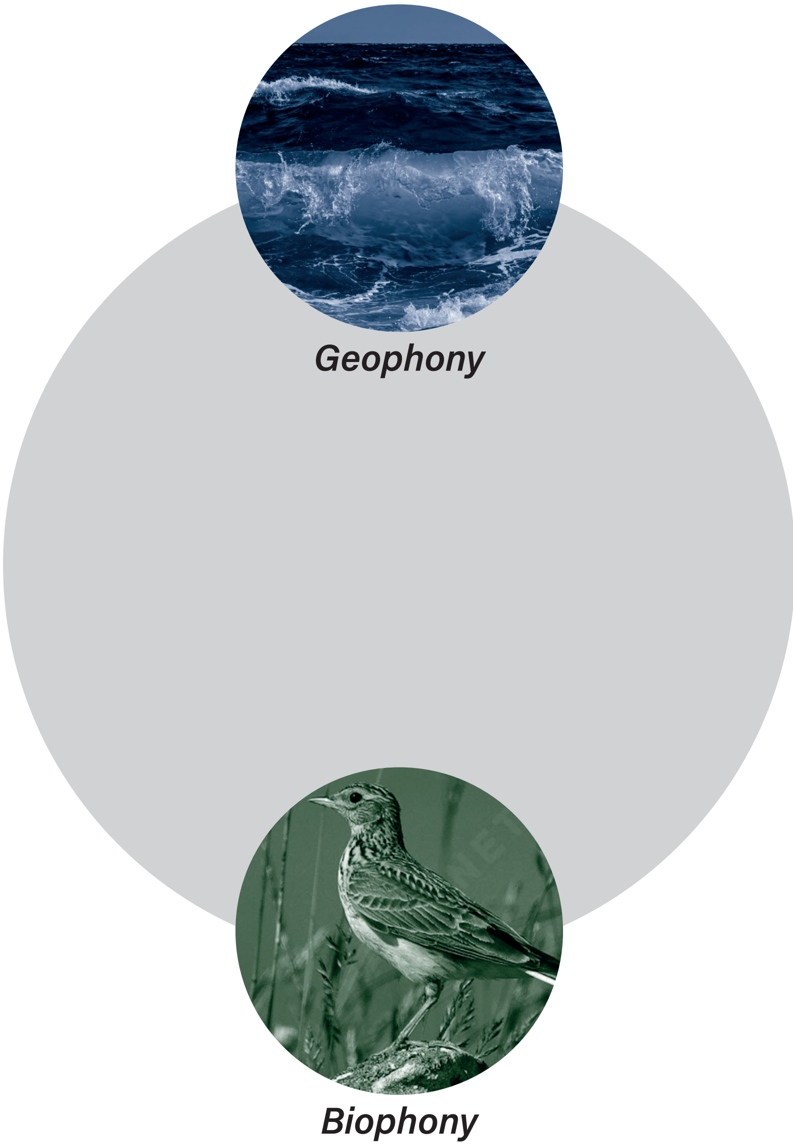
Bernie Krause divides the soundscape into three parts: ***Geophony,*** which includes all sounds that are not of biological origin (wind, grass, water, trees). ***Biophony*** (sounds produced by living organisms). And ***anthropophony***, sounds produced by humans.

Some scientific articles suggest the existence of a new acoustic layer, ***technophony (***Farina 2019).

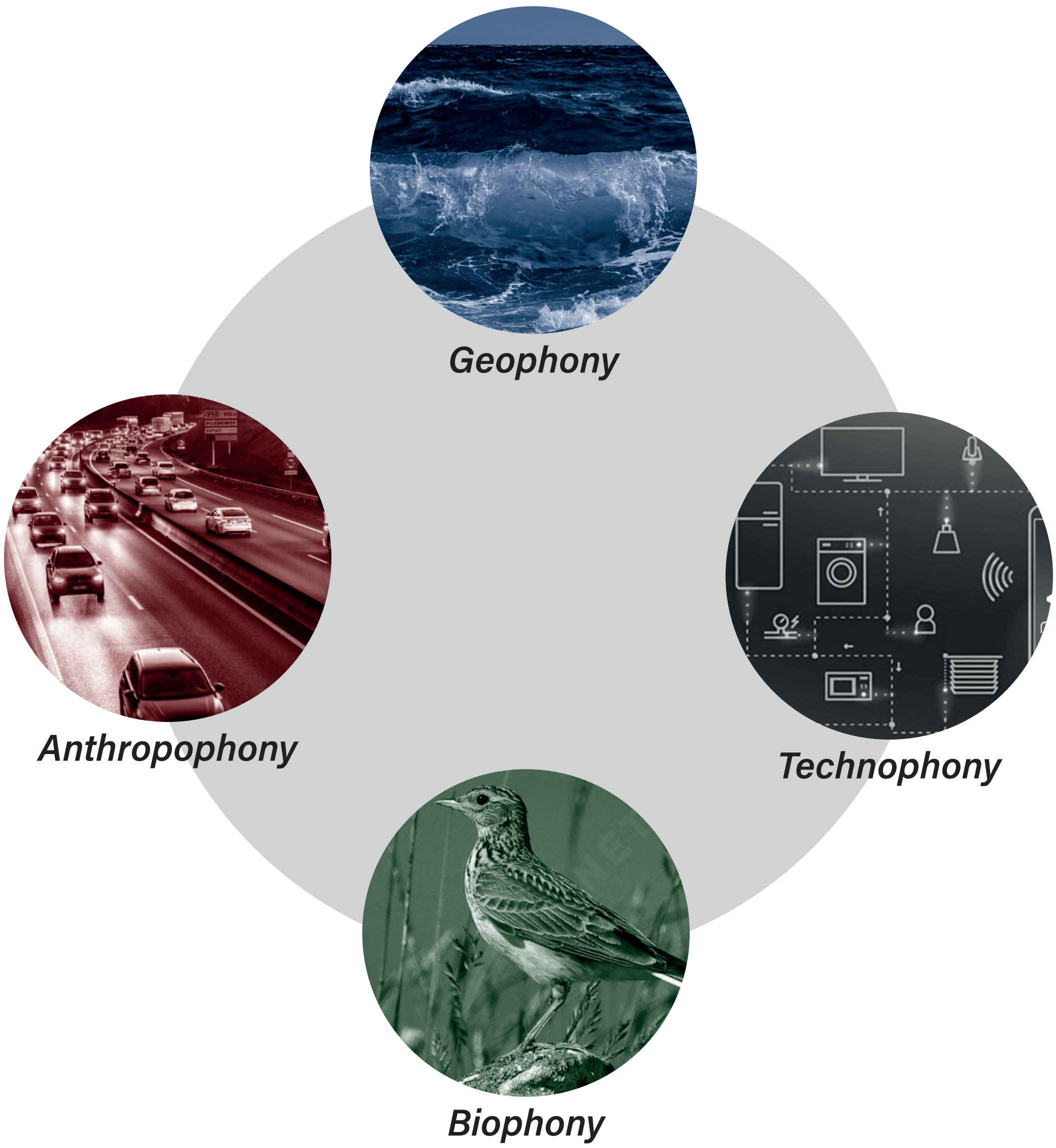
Pauline Oliveros, a post-war electronic music composer, defines the soundscape as «all the waves that the mechanisms of the ear transmit to our auditory cortex

Anthropocene
The Anthropocene is a proposed geological epoch that began when human influence on geology and ecosystems became significant on the scale of Earth's history.
The term Anthropocene, meaning 'the age of humans,' was popularised in the late 20th century by meteorologist and atmospheric chemist Paul Josef Crutzen, winner of the Nobel Prize in Chemistry in 1995, and biologist Eugene Stoermer to designate a new geological epoch, which they believed began at the end of the 18th century with the Industrial Revolution, thus succeeding the Holocene.

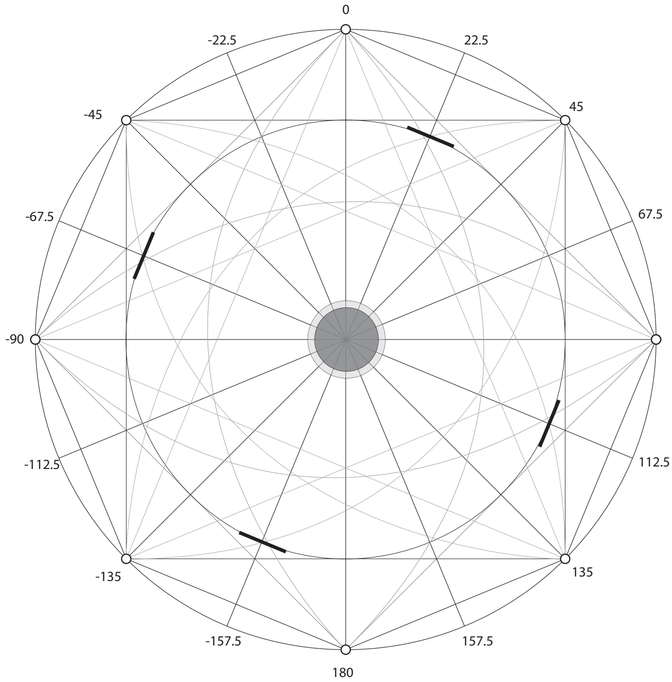
Sounscape
in the Holocene period



Soundscape in the anthropocène period



Technical Data Sheets



TDS : Amplification

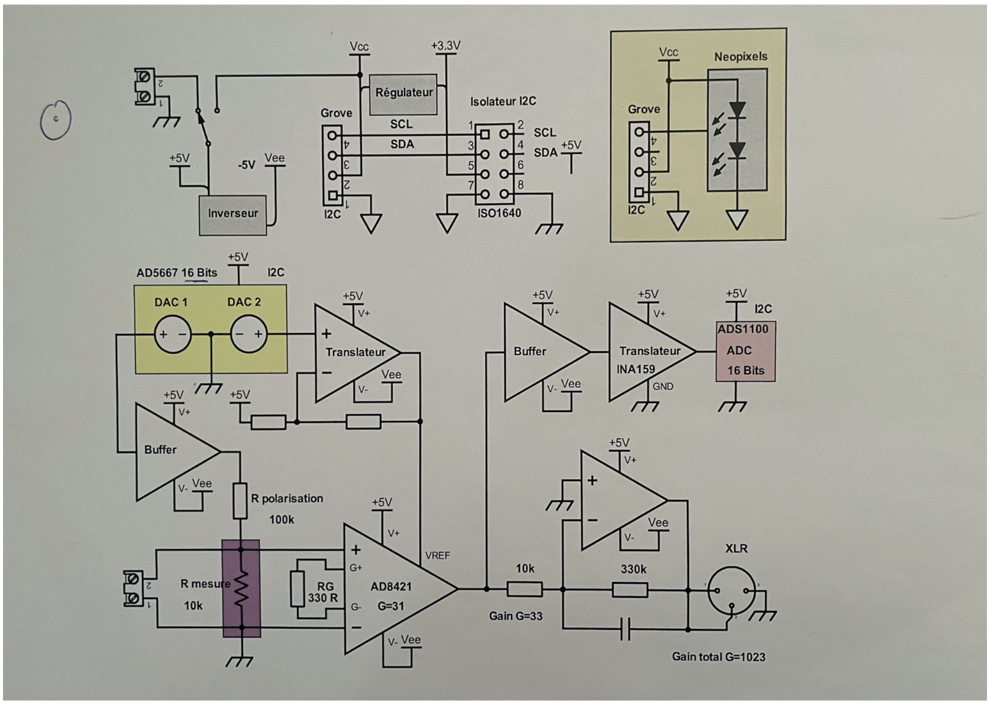
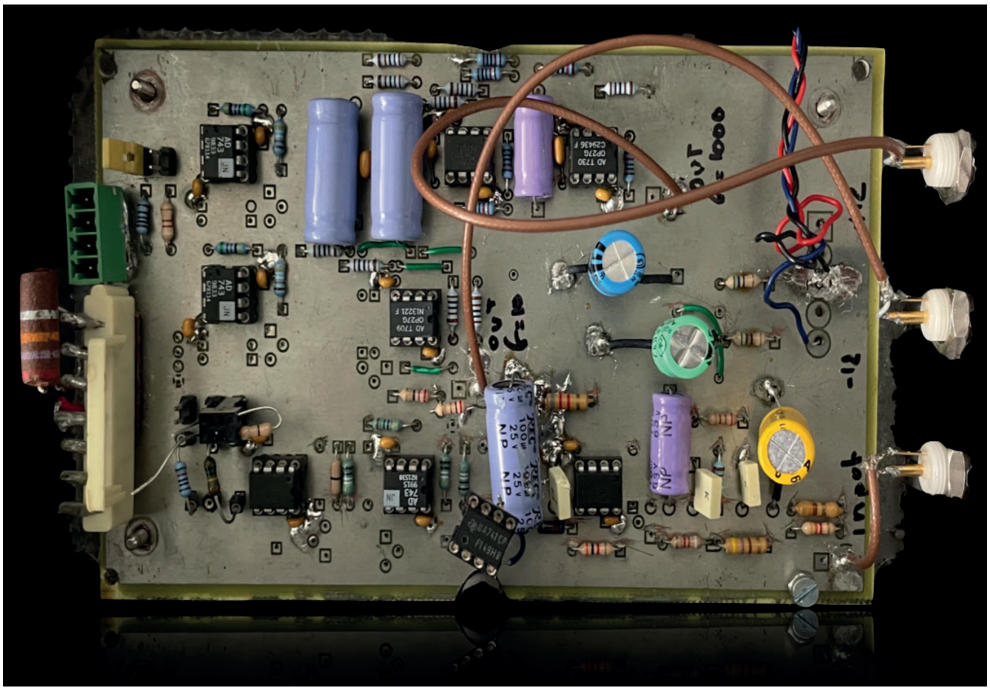
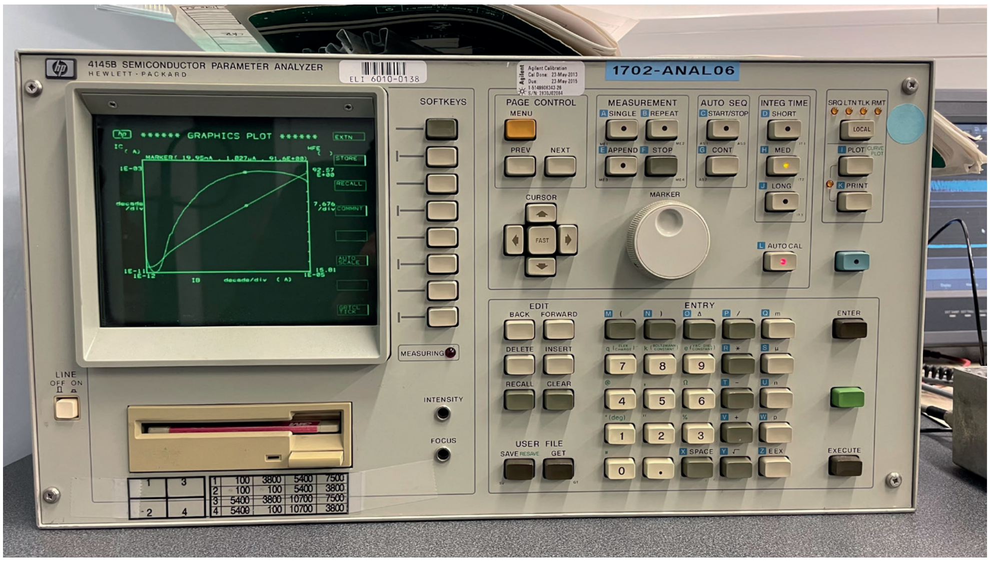


Schéma du circuit d'amplification (J-M. Routoure)

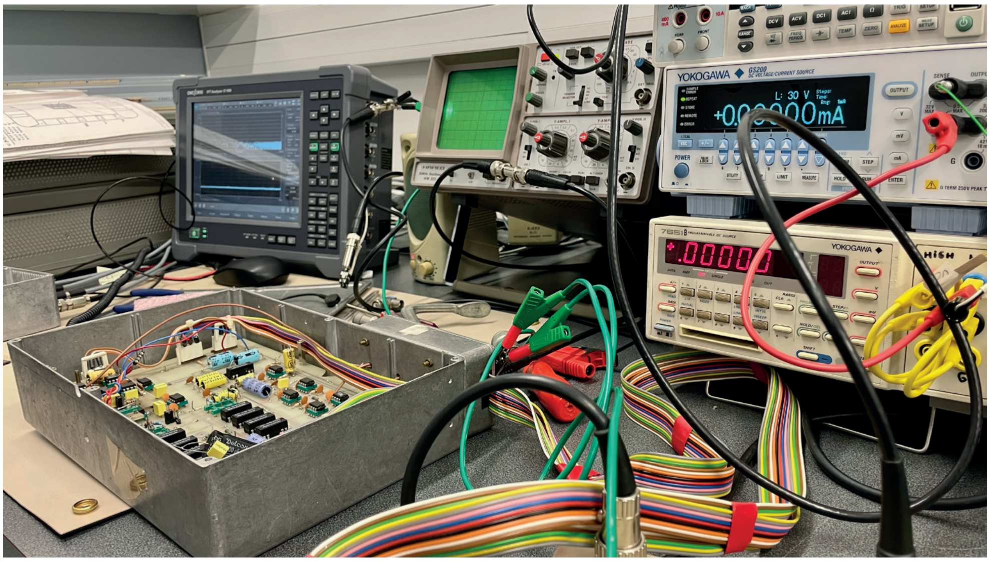


Circuit d'amplification version 1.0 (J-M. Routoure)

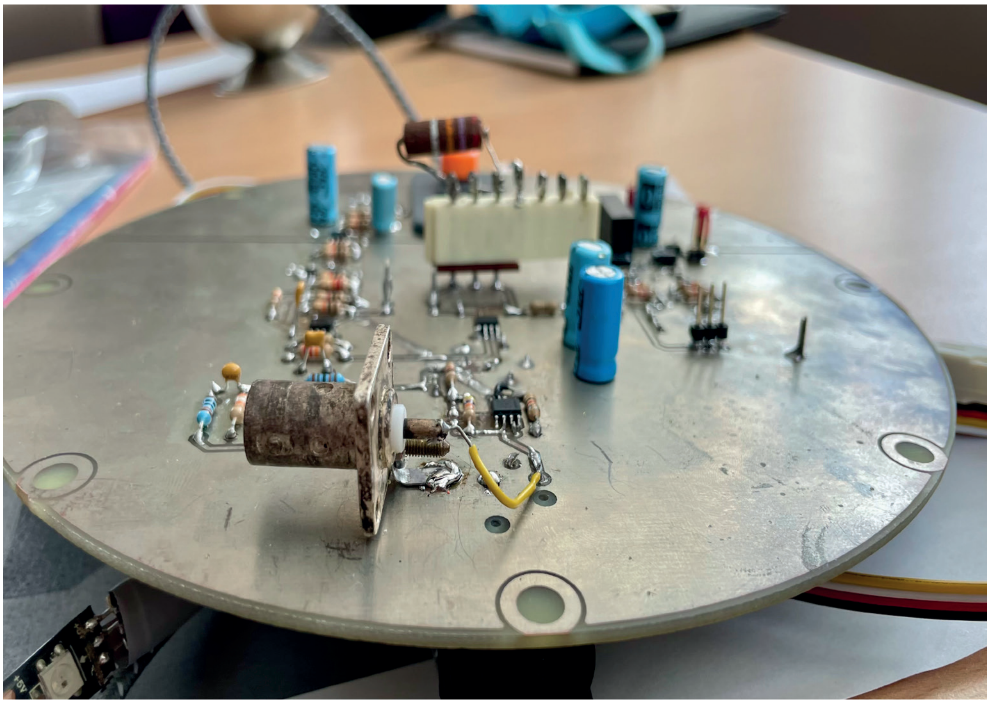
TDS : Analysis



Tests en laboratoire



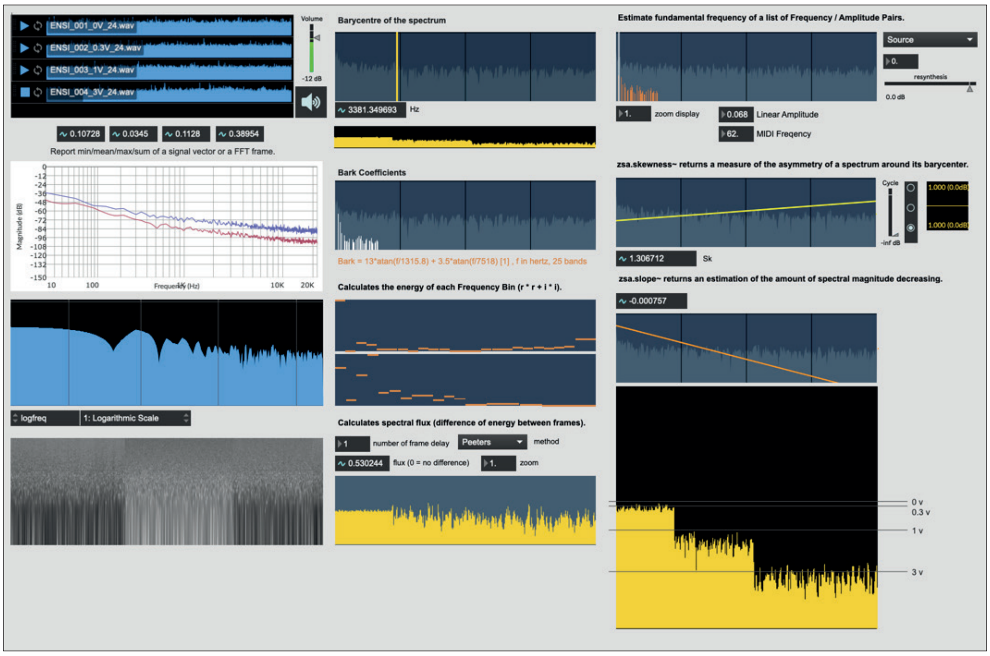
TDS : Amplification



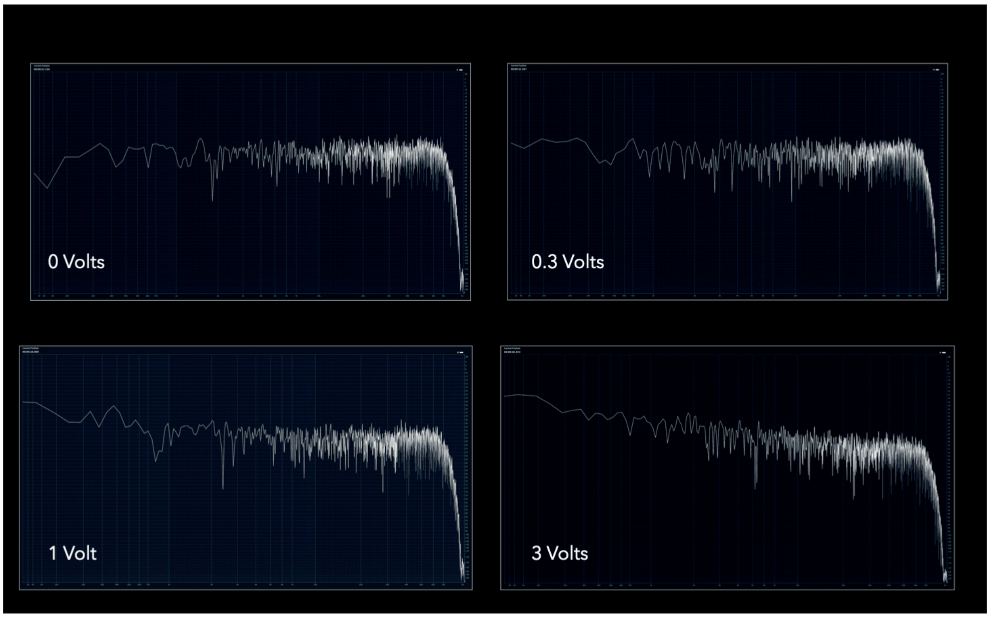
Circuit d'amplification version 2.0 (Jean-Marc Routoure, Sylvain Lebargy, Julien Gasnier, Lucas Bessin)

Circuit d'amplification version 3.0 (Jean-Marc Routoure, Sylvain Lebargy, Julien Gasnier, Lucas Bessin)

TDS : Analysis

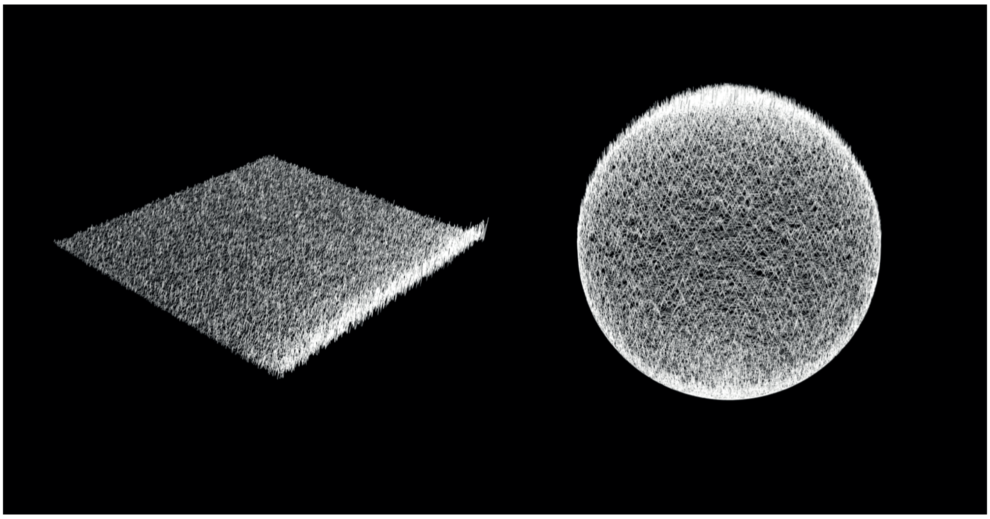


Analyses fluctuations (centre de gravité, énergie, différences, asymétrie, flux, etc.)

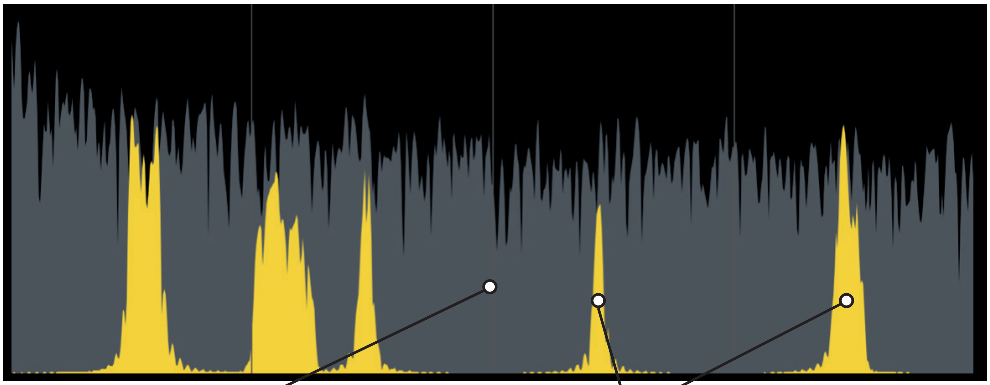


Analyses spectrales (intensité courant électrique)

TDS : Filtering

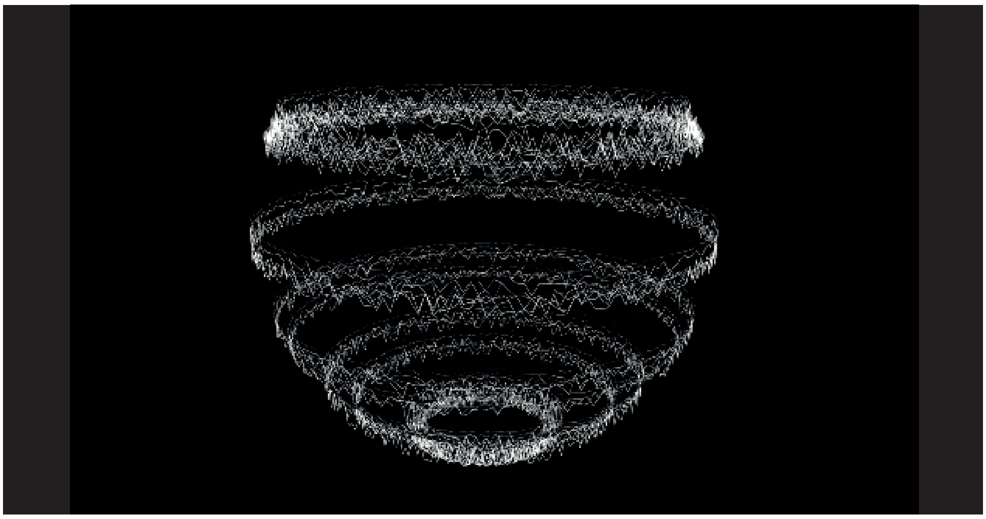


Visualisation bruit - sonogramme 3D



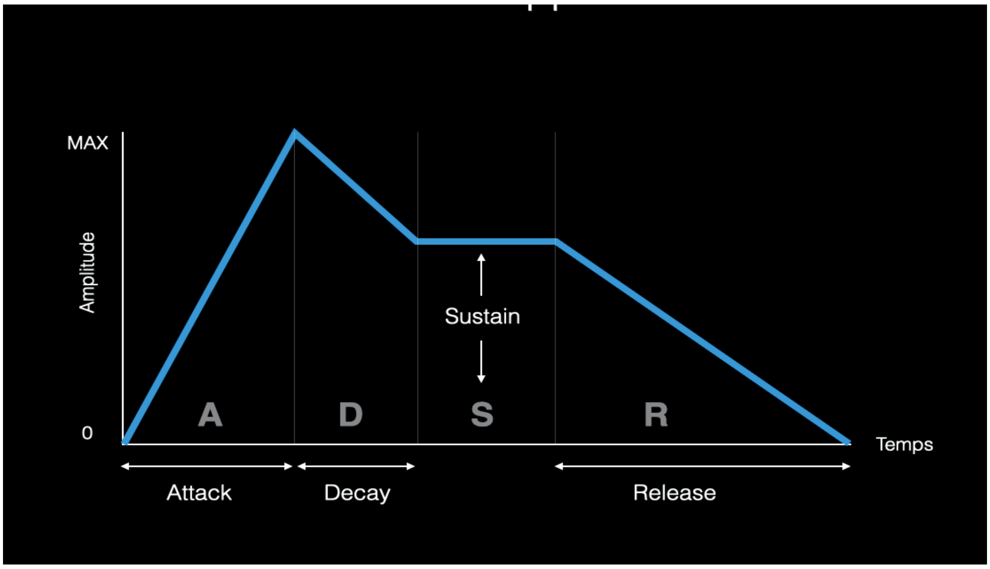
Son original (bruit)

Son prélevé par bandes de fréquences

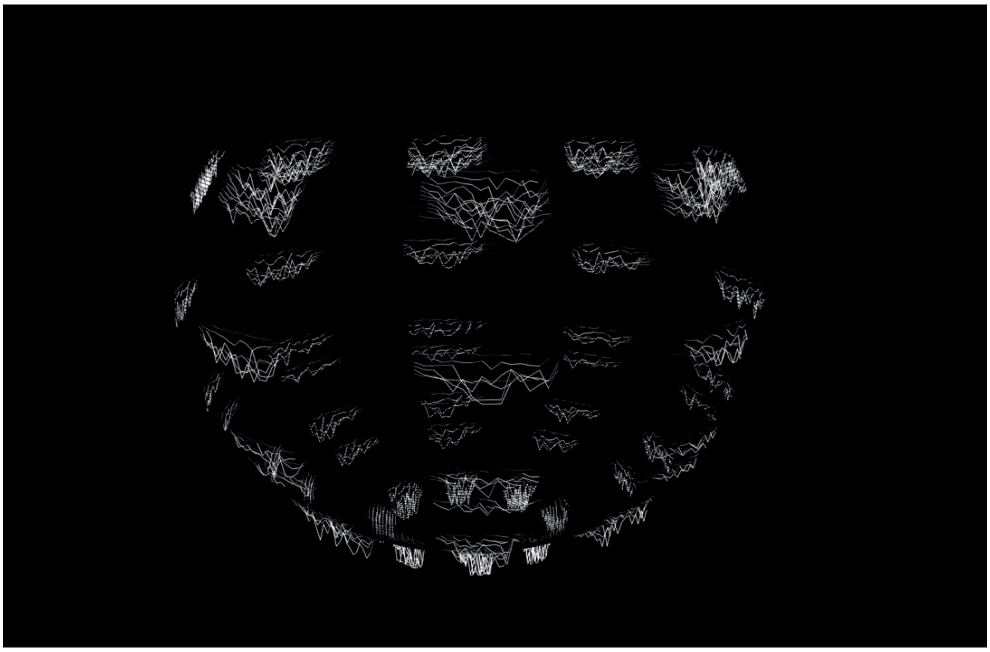


Visualisation bruit filtré - sonogramme 3D

TDS : Envelopes

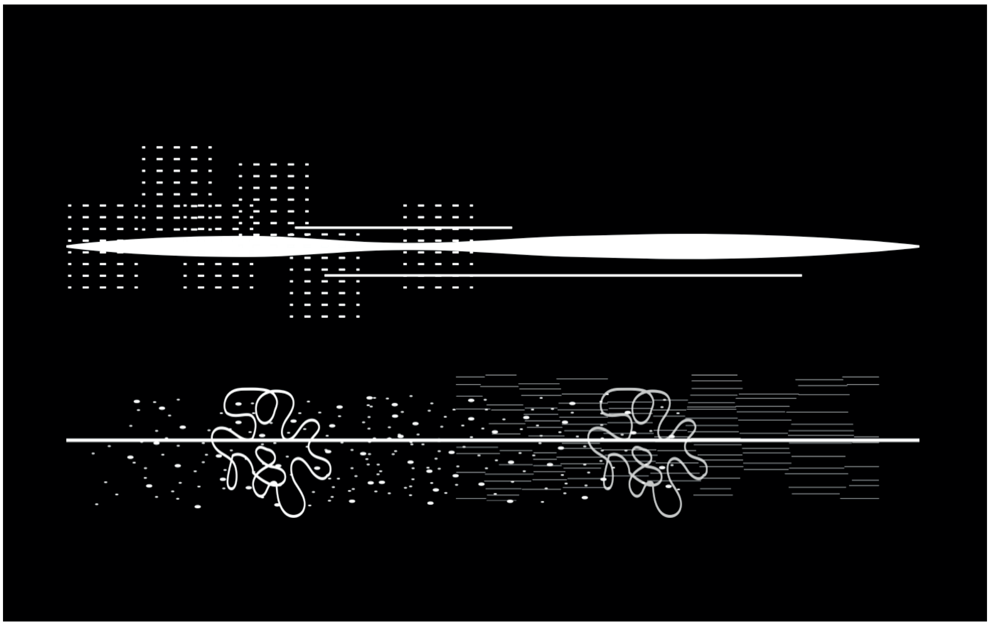


Enveloppe ADSR

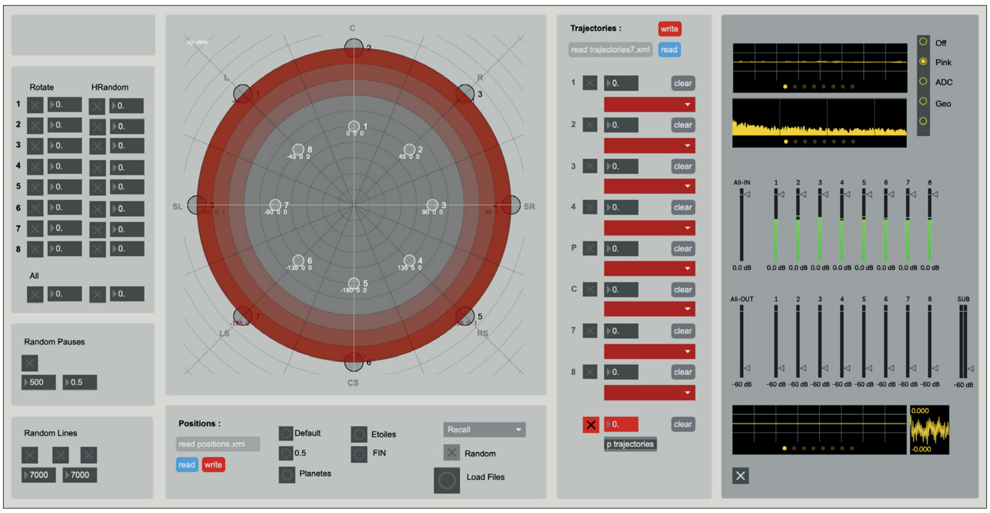


Visualisation bruit découpé et déclenché par enveloppe - sonogramme 3D

TDS : Composition

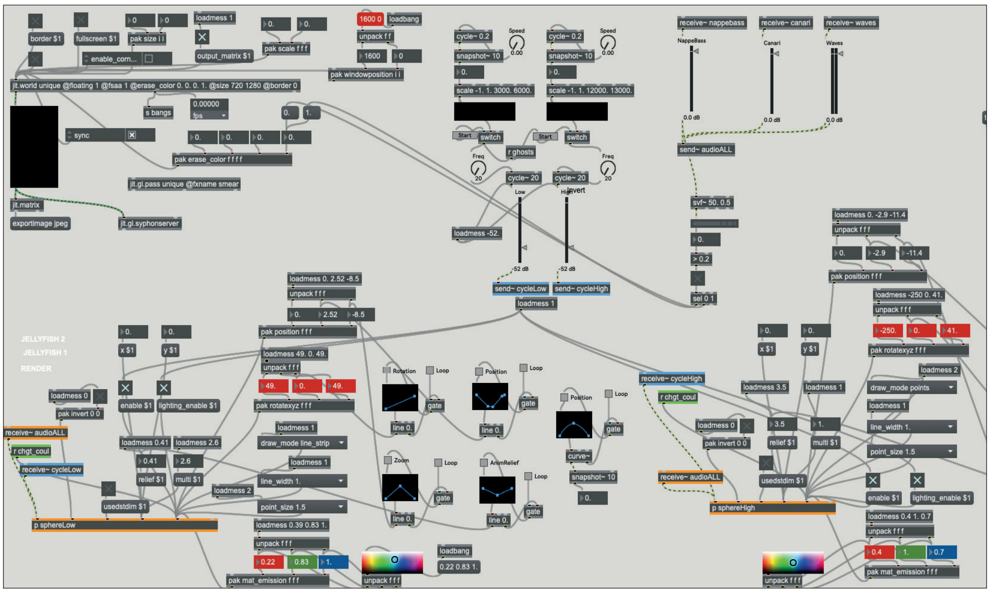


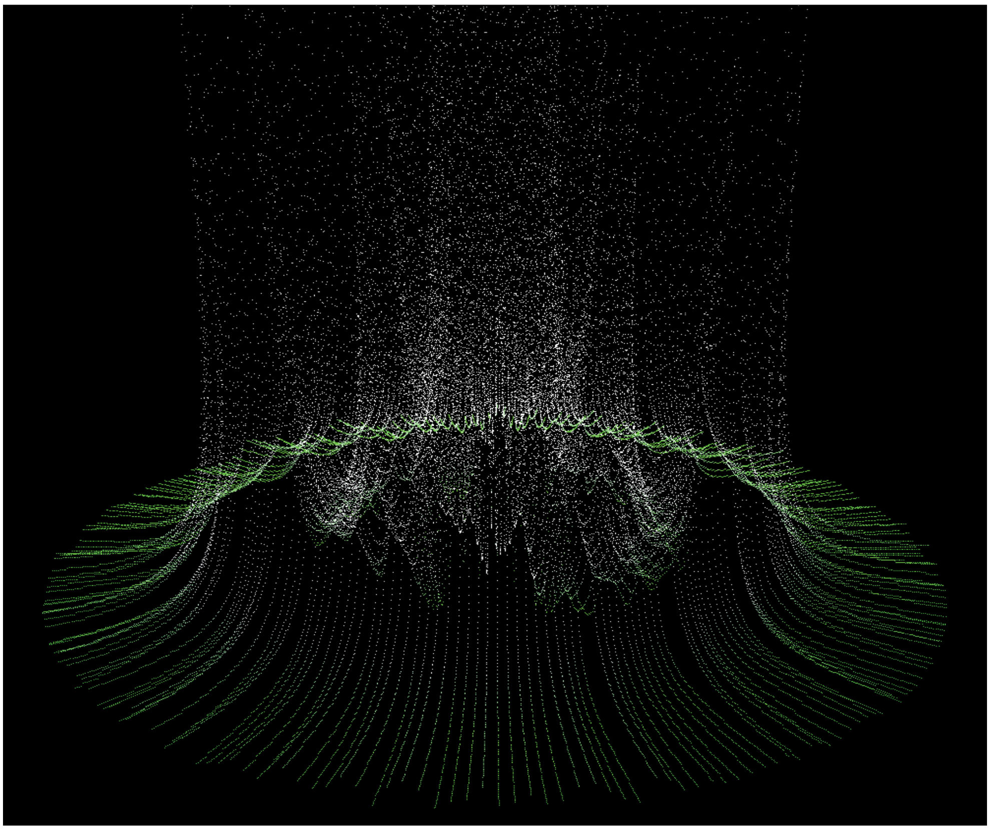
TDS : Spatialisation



Outil de spatialisation sonore réalisé avec Max et les Ambisonic Tools - ICST Zurich University of the Arts

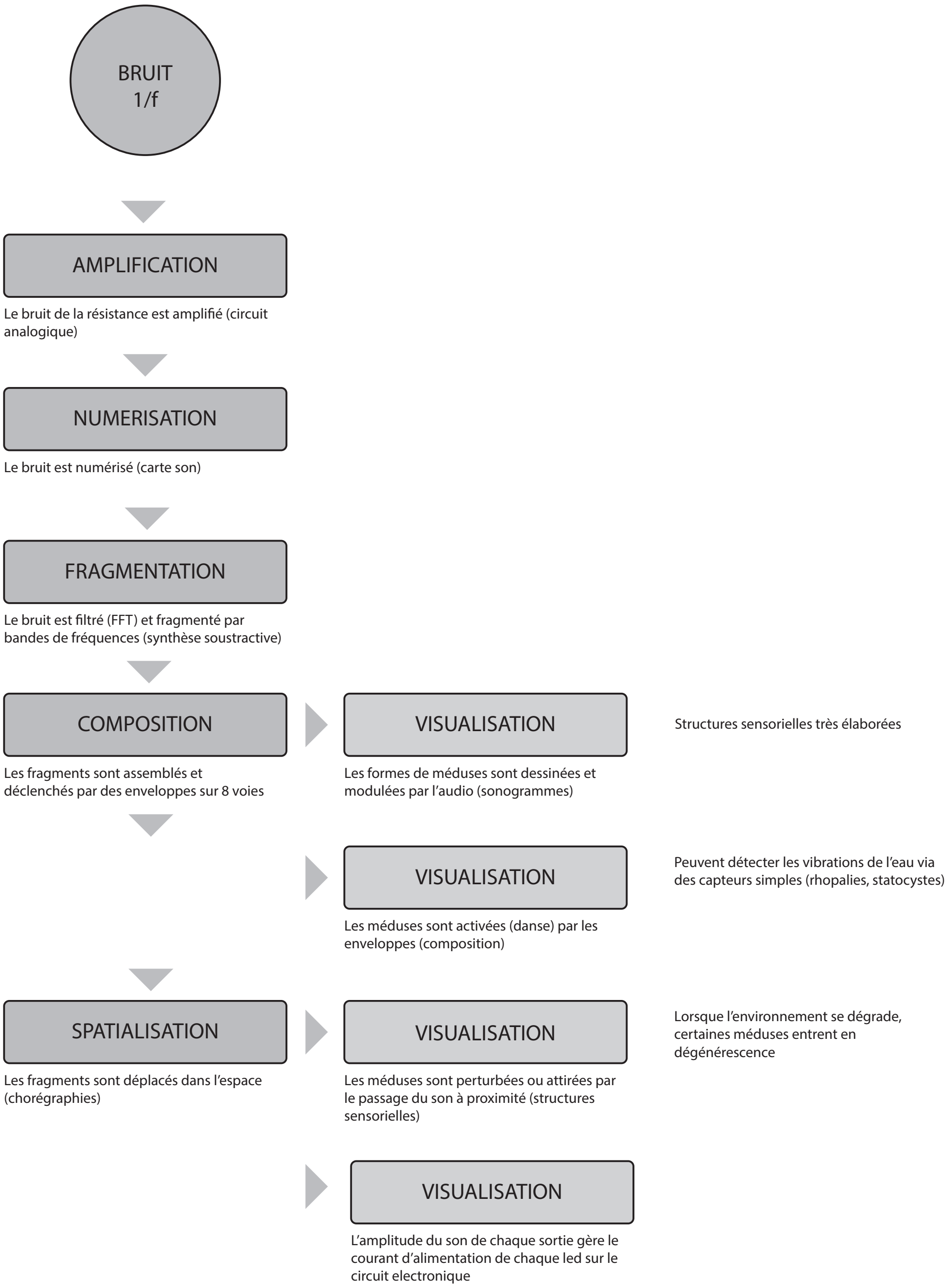
TDS: 3D Animation



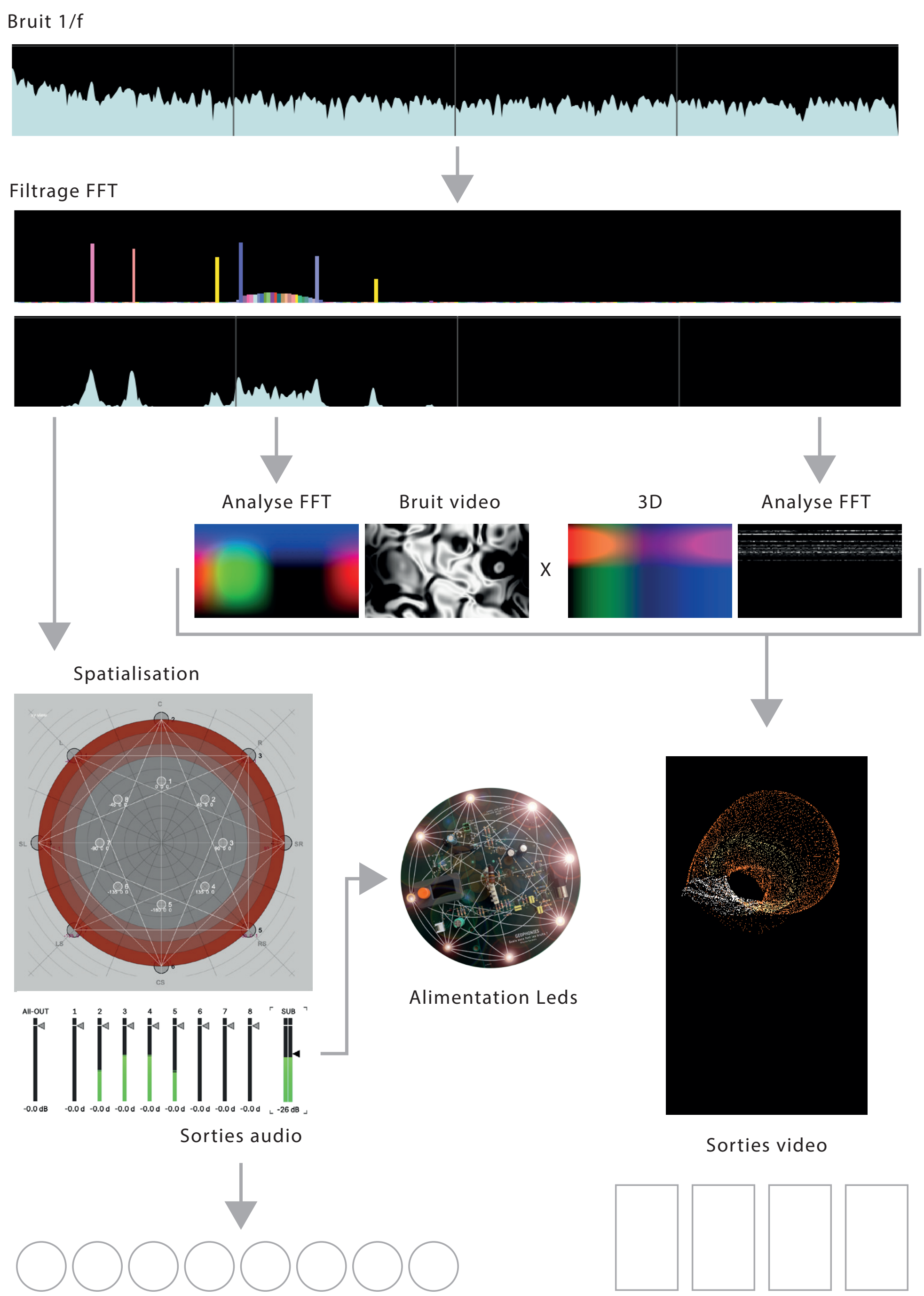


Exemple d’image animée dessinée par le sonogramme

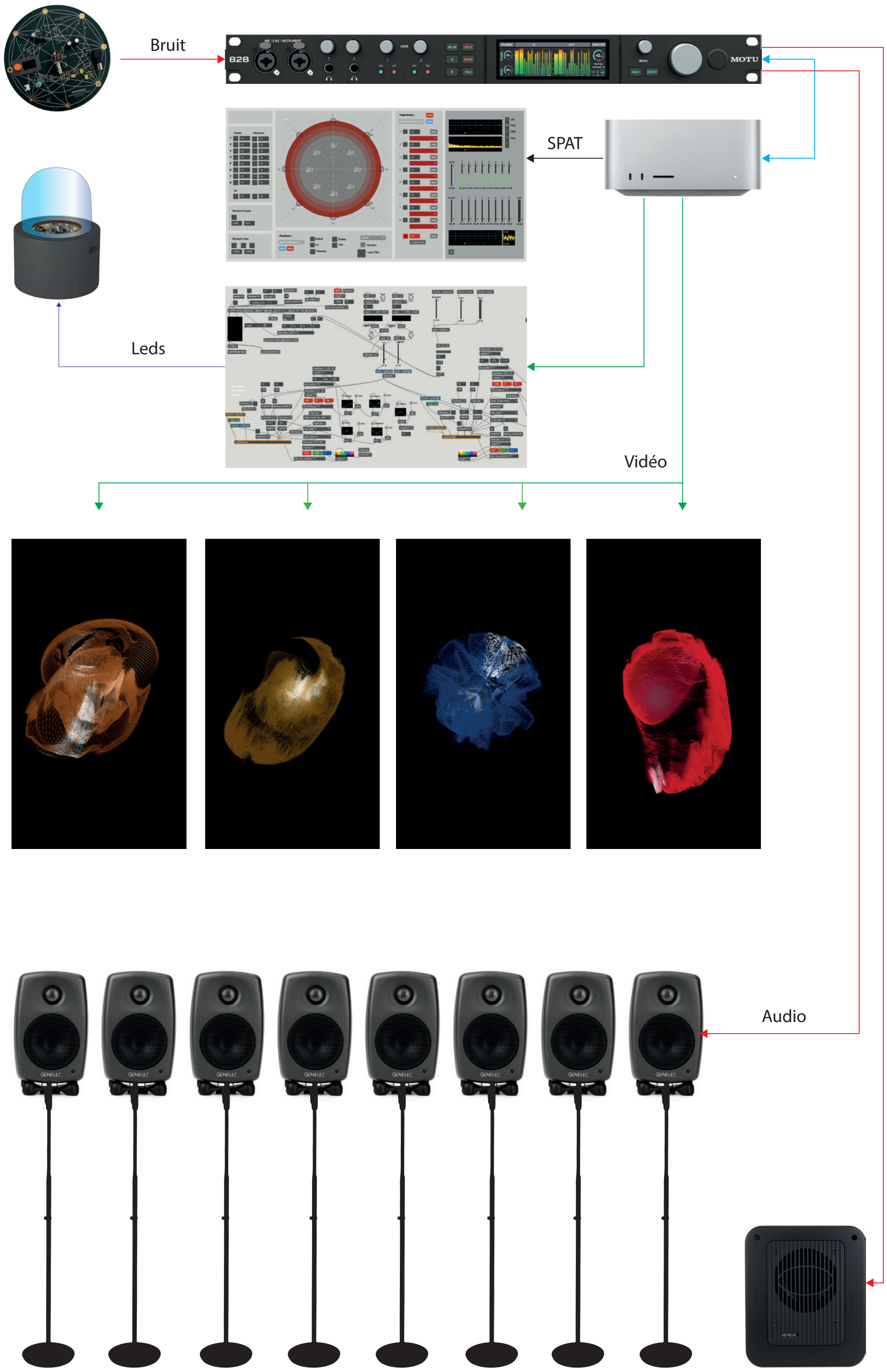
TDS : The Path of Noise



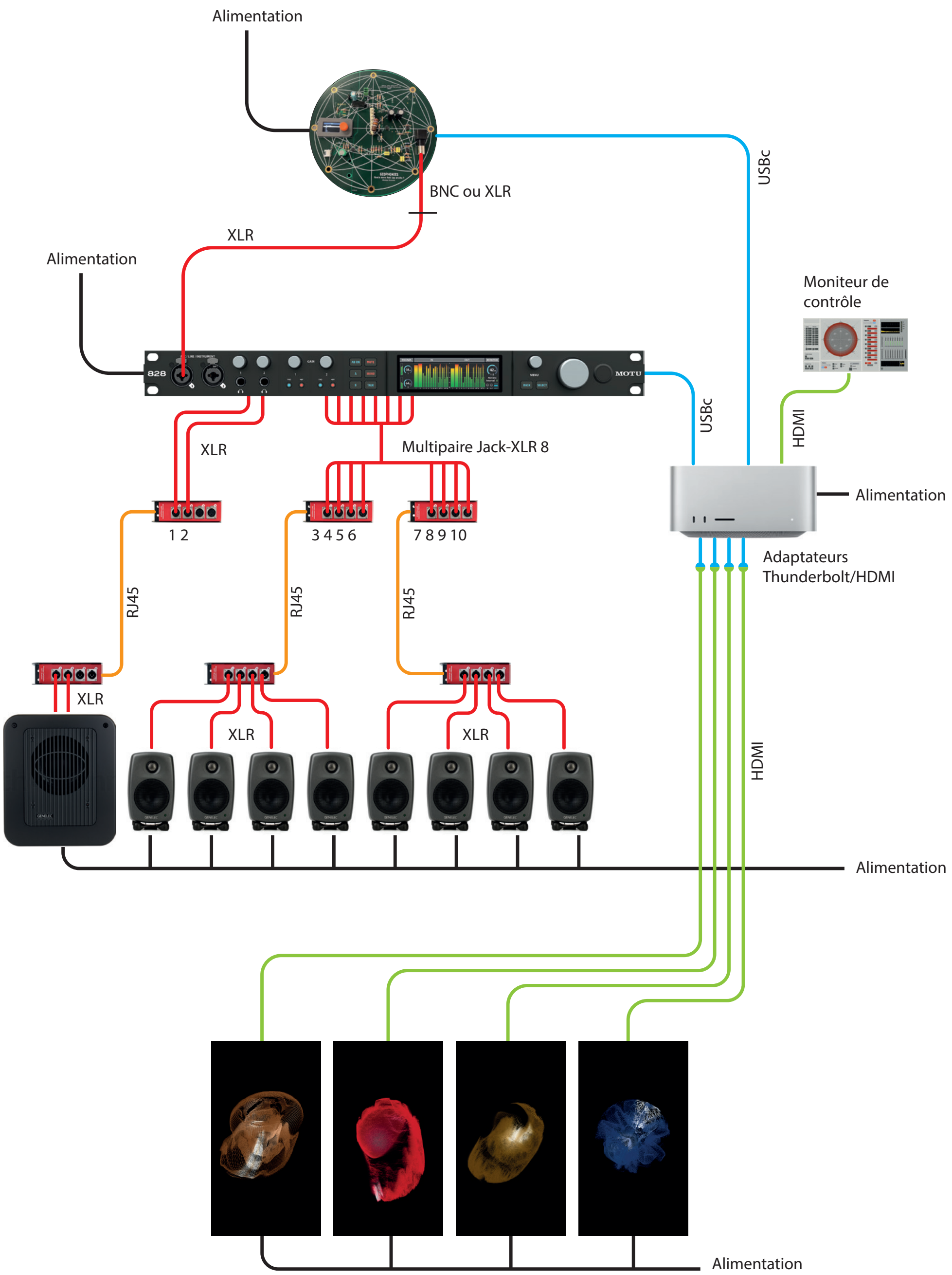
TDS : The Path of Noise



TDS : Connections



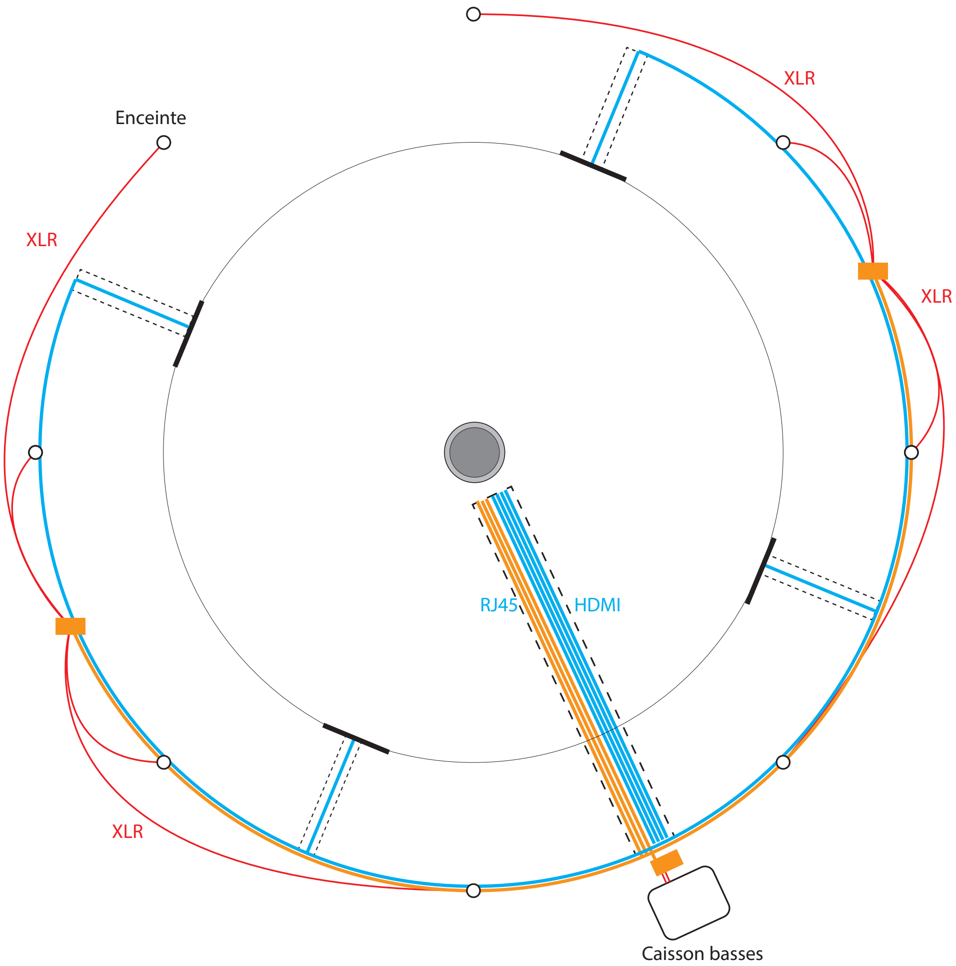
TDS : Connections



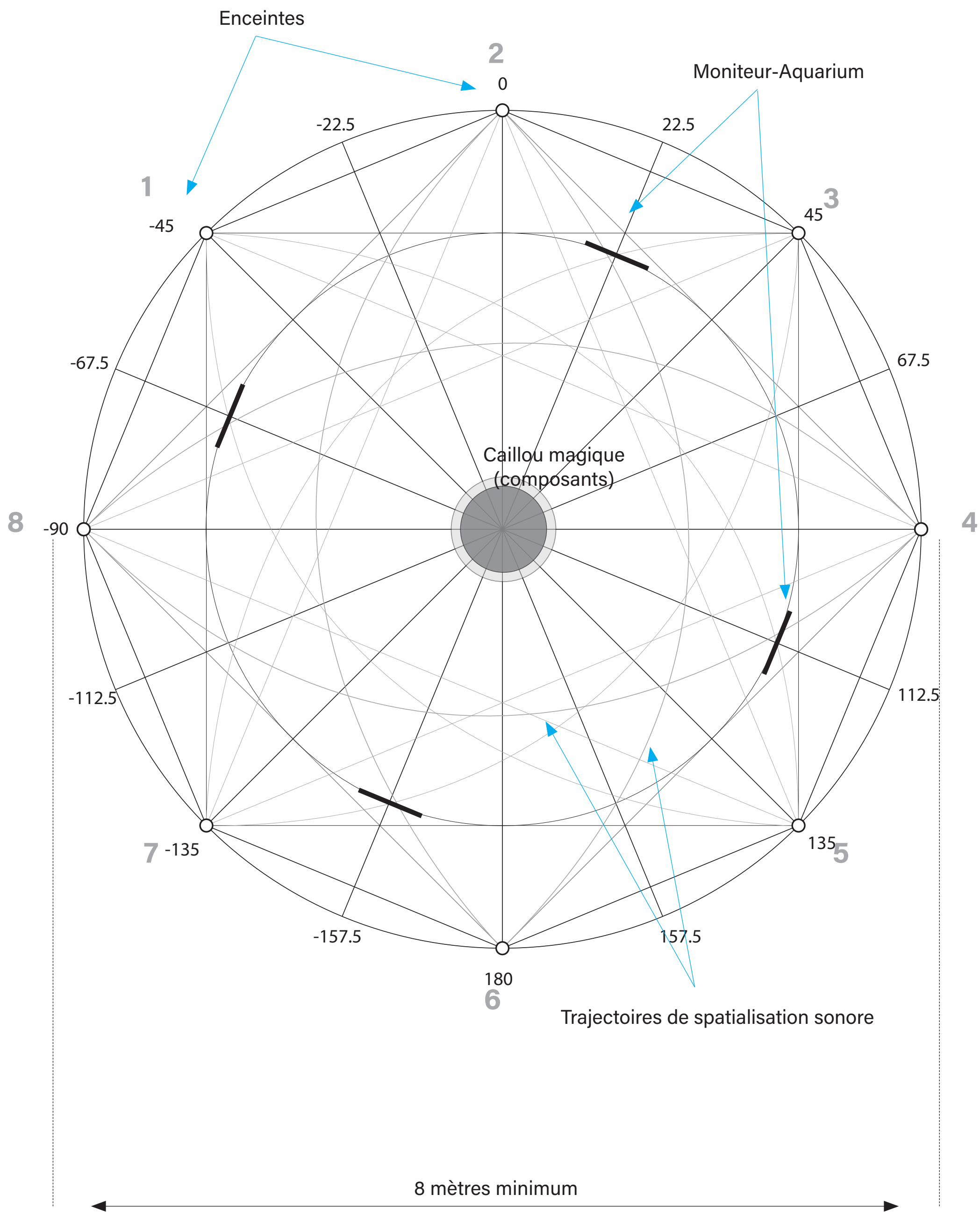
TDS : Wiring diagram

Vidéo
Audio
Passe-Câbles

HDMI : 4 X 25m
XLR : 4 X 10m + 6 X 5m
RJ45 : 2 X 20m

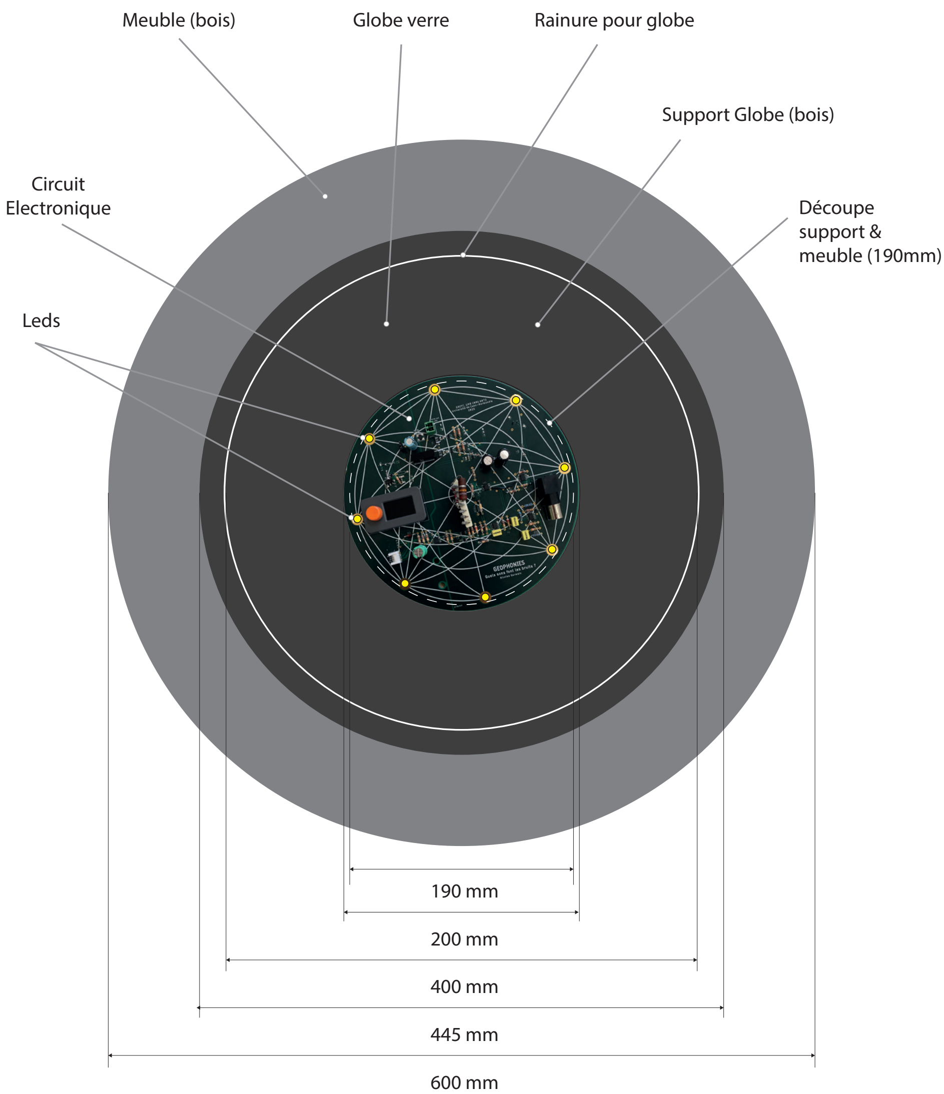


TDS : Scenography Spatialisation plan

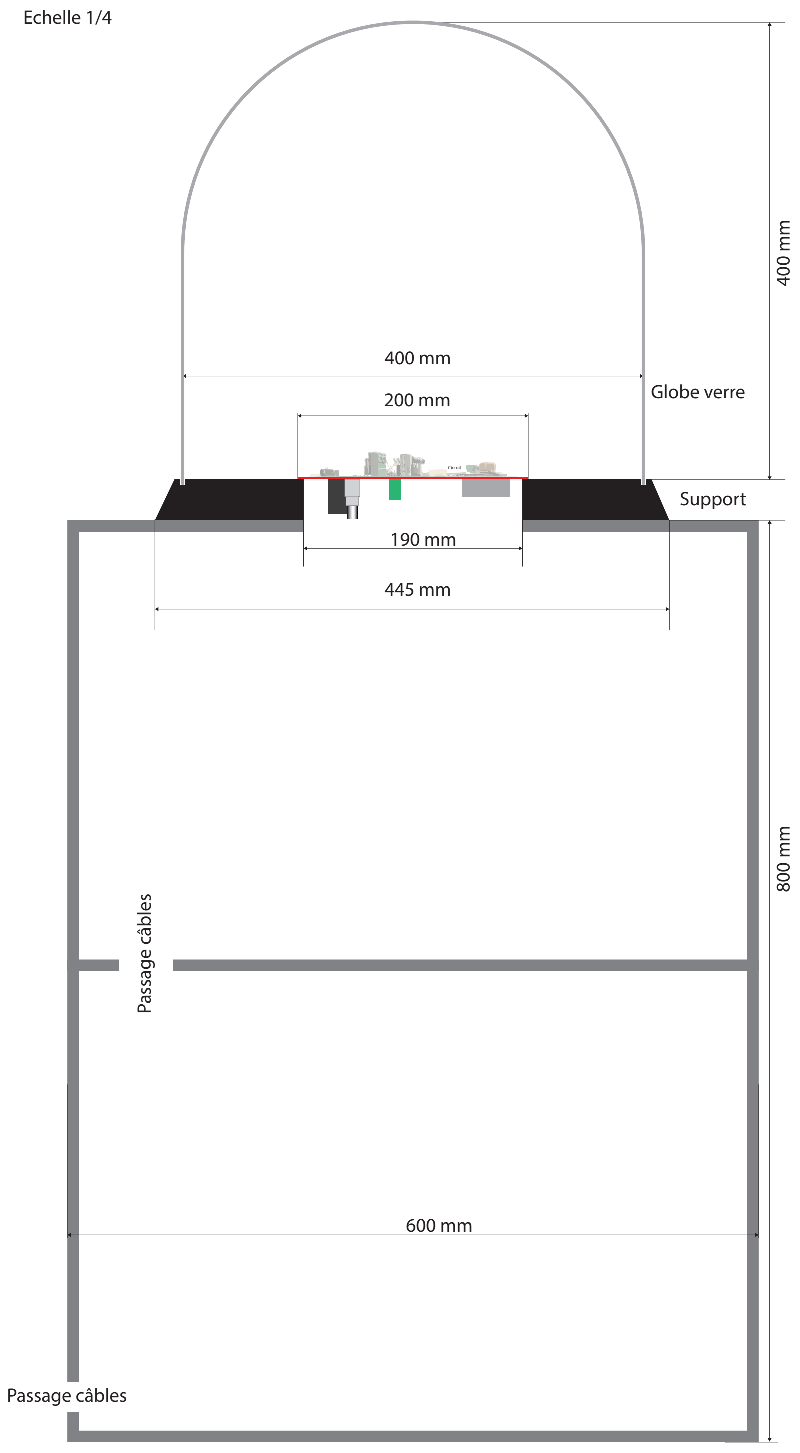


TDS: Circuit *Magic Stone (simulation)*

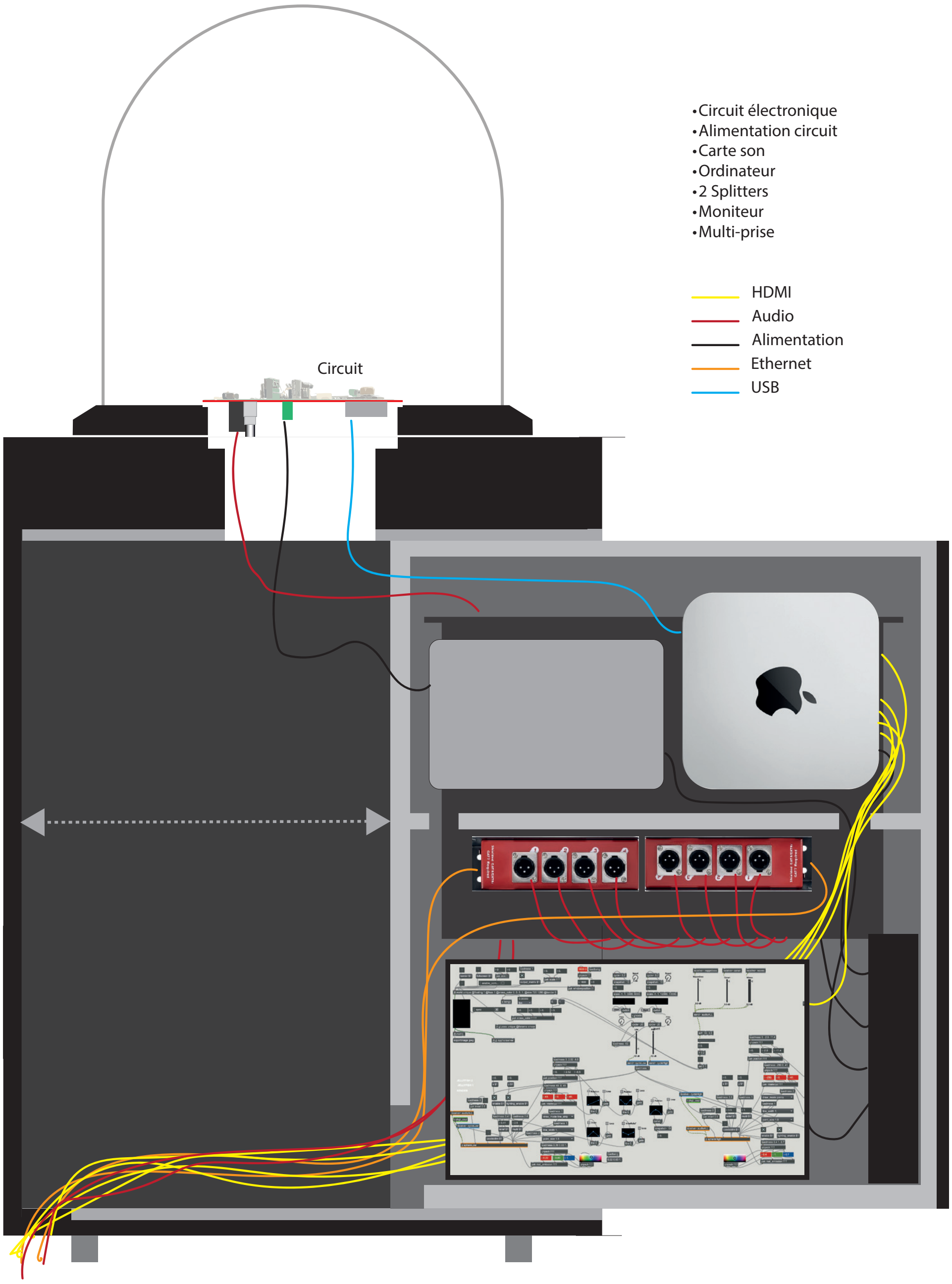
TDS : Circuit *Magic Stone (top view)*



TDS : Circuit *Magic Stone (front view)*

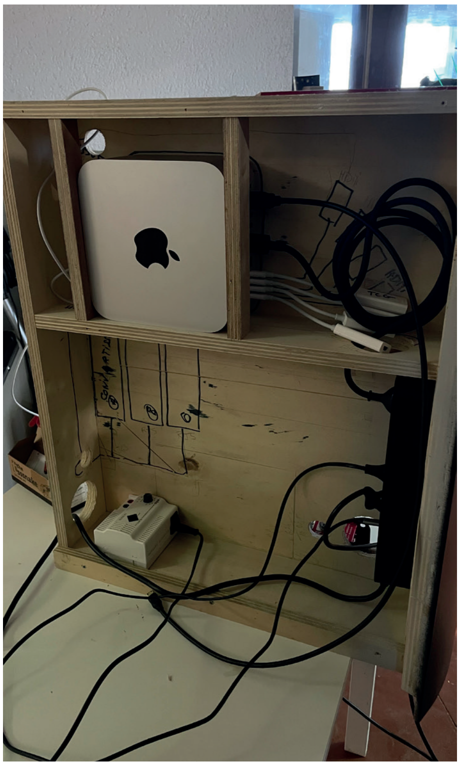


TDS : Circuit *Magic Stone (with drawer and hadware)*

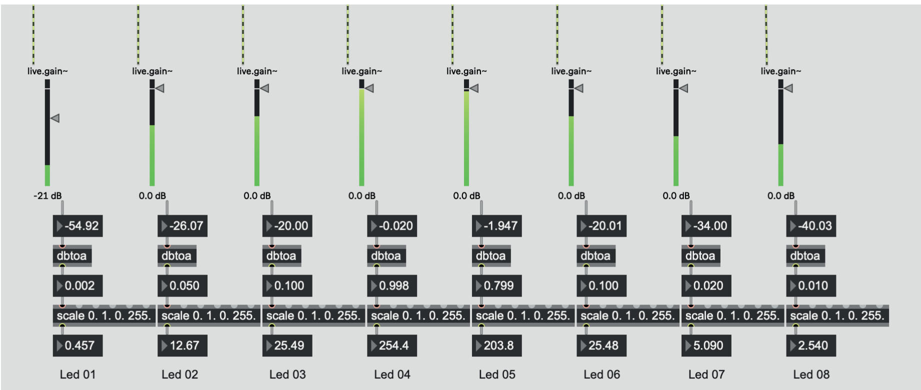


TDS : Circuit *Magic Stone (construction)*

TDS: Circuit *Magic Stone (construction)*



*TDS : **Circuit** Leds power supply*

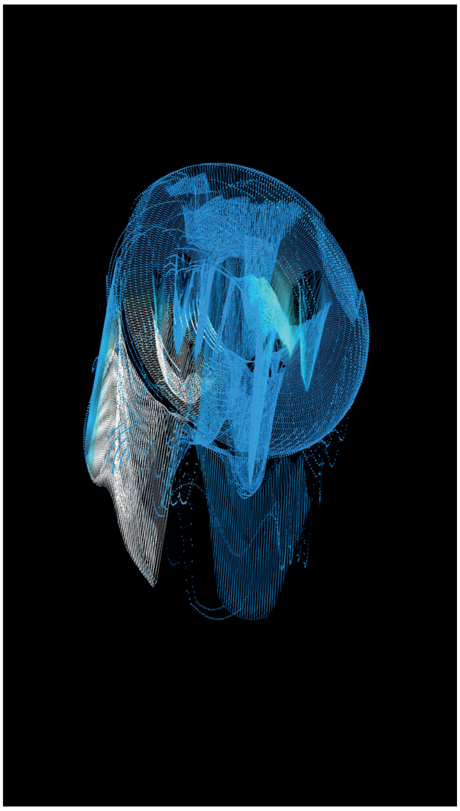
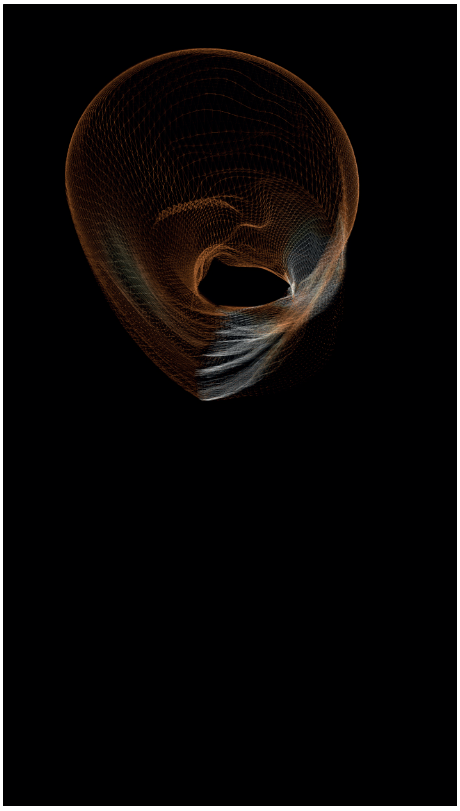
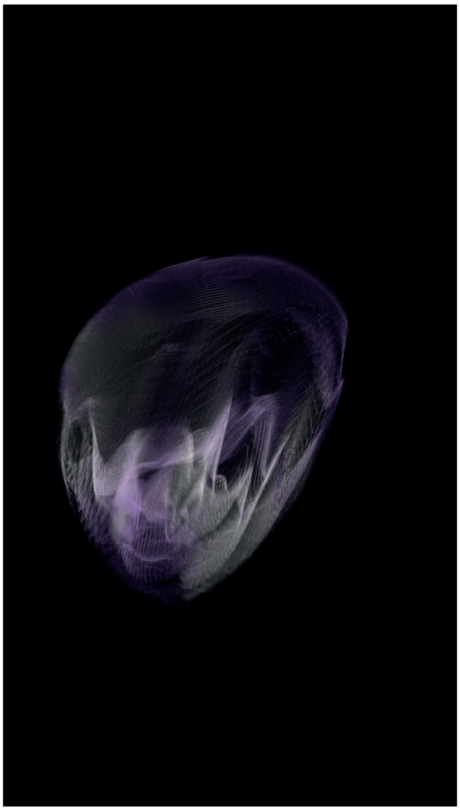
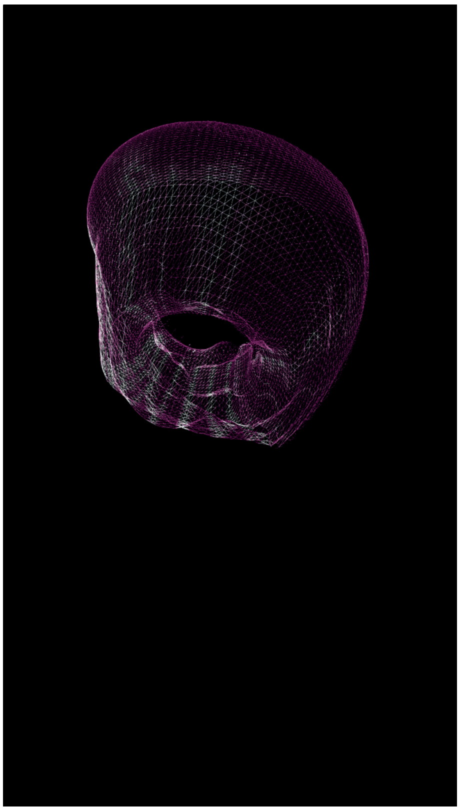


Amplitudes audio (-70 > +6 dB) = intensité Leds (0 > 255)

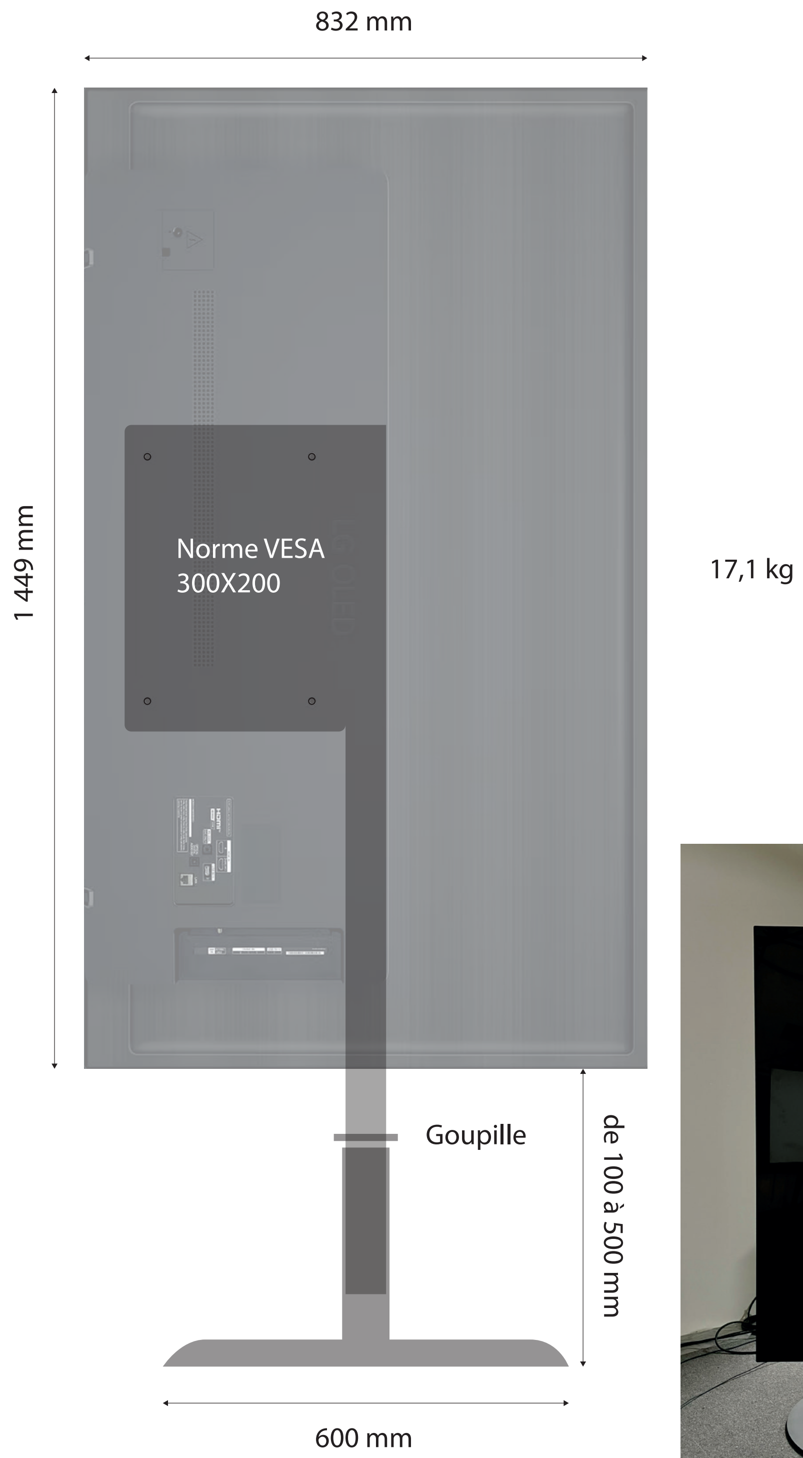
PRESETS > Random 4 (Couleurs méduses)

Exemple
couleur
toutes leds : 23 56 130
intensité
led 1 : 23 led 2 : 35 led 4 : 60 led 5 : 56 led 6 : 3 led 7 : 124 led 8 : 100

TDS : *«Aquariums»* ***Monitors***

TDS : «Aquariums» Monitors



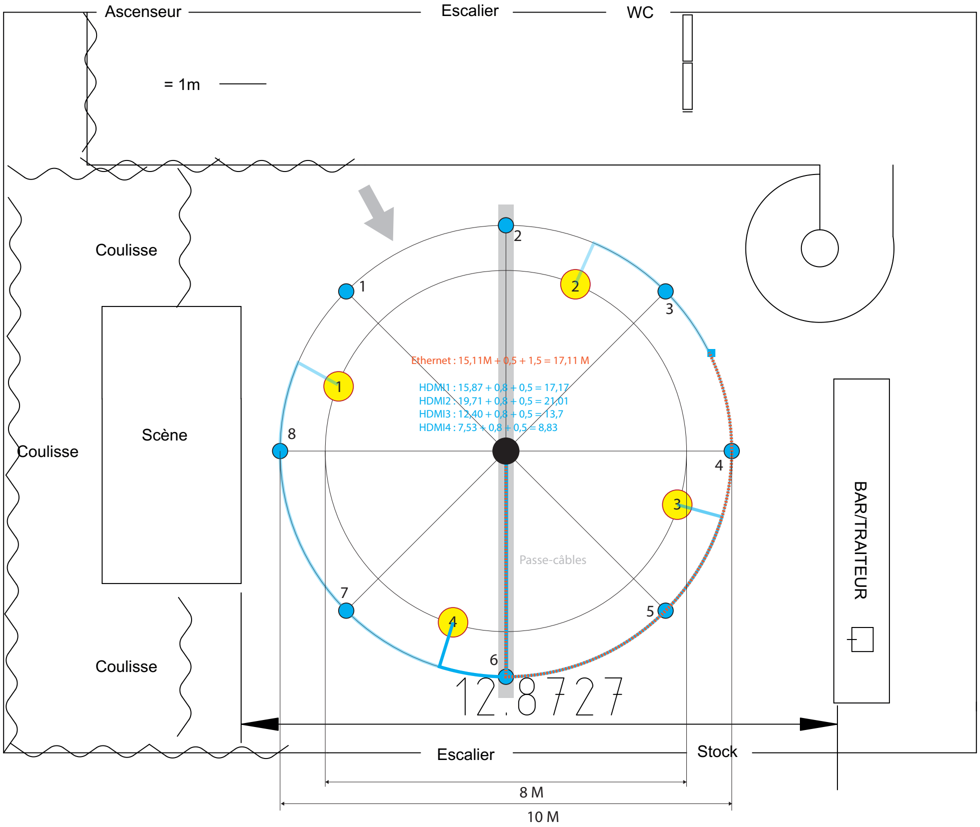
TDS : Scales

TDS : Simulation

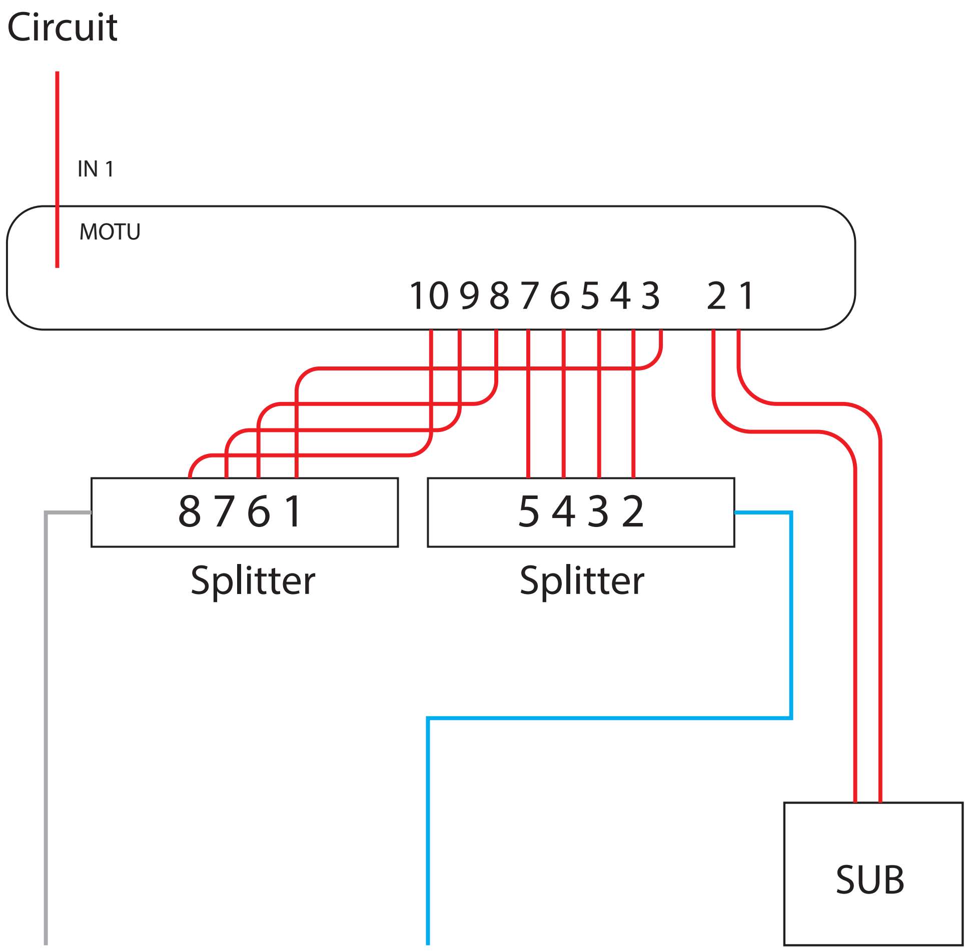
On-site equipment

- 1 Circuit électronique sous cloche en verre avec support et éclairage intégré (80cm au sol)
- 4 moniteurs vidéo-aquariums sur pieds (hauteur 190cm)
- 8 enceintes amplifiés sur pieds (hauteur 130cm)
- 1 caisson de basse au sol
- 1 ordinateur de contrôle (dans support cloche)
- 1 carte son 24 bits/96 kHz 10 sorties
- Câblages audio et alimentations

TDS : Scenography Le Dôme



TDS: Scenography Le Dôme (splitters audio)



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