

3D SOUND LABS

**3D Audio
&
Personal Acoustics**

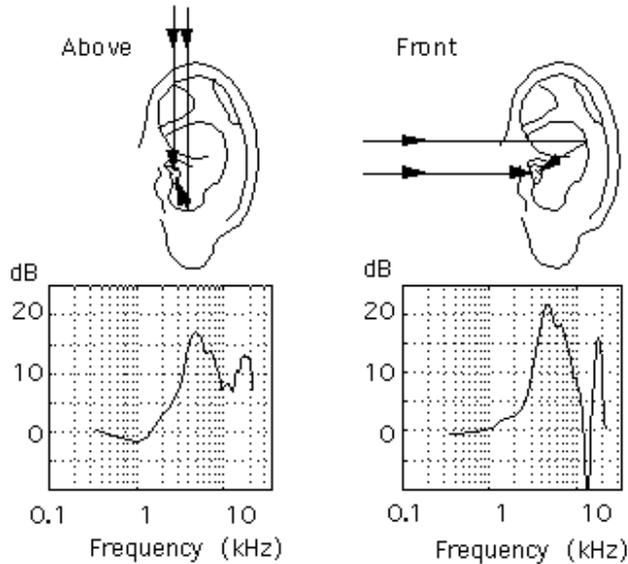
April 2018

Xavier BONJOUR
x.bonjour@3dsoundlabs.com
Tel: +33 6 84 77 66 92

Dimitri SINGER
d.singer@3dsoundlabs.com
Tel: +33 6 18 39 79 12

Ear morphology: Did you know that ...

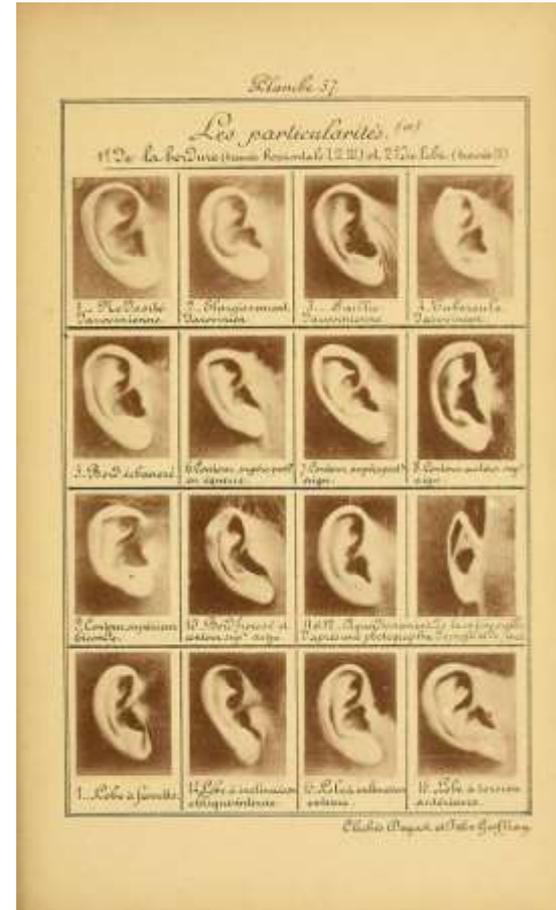
... Natural evolution has designed the human ear **to perceive sound direction**?



HRTF (Head Related Transfer Function) are directional acoustic filters created by the reflection of sound waves on the ear.

Our brain has “memorized” these directional filters and recognizes sound direction with “pattern matching”.

... everybody has different ears?

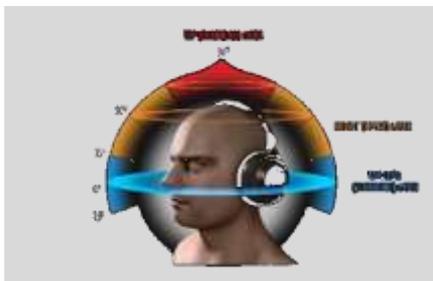


Like fingerprints, **ears are a biometric sign!**

DIGITAL EAR Applications

The DIGITAL EAR, set of specific parameters related to the 3D shape of the ear of individuals can be leveraged in several use cases.

3D Audio



Spatial Audio perception depends on the shape of the ear (HRTF). All 3D Audio engine are based on the concept of HRTF. Personalized HRTF are used to provide improved spatial audio experience to the end user.

Key feature in VR, AR and next generation of Digital TV.

Custom Fit Ear Piece



Custom made ear piece for better performance, comfort and insulation in several applications:

- Earphones
- Hearing aids
- Hearables (sensors)
- Hearing Protections
- Water protections

“In The Ear” Microphone Directivity



Leverage the shape of the ear to improve directivity of microphones located in the hearing instrument.

- “In The Ear” (ITE) Hearing Aids
- Hearables

Augmented Reality Audio



Improve the frequency response of the “Near the Ear” drivers with near field HRTF in one single direction.

Main application is in Augmented Reality (AR) headsets or glasses which use an “open ear” solution to superimpose existing and simulated 3D audio.

PROBLEM: Capturing a DIGITAL EAR is complicated

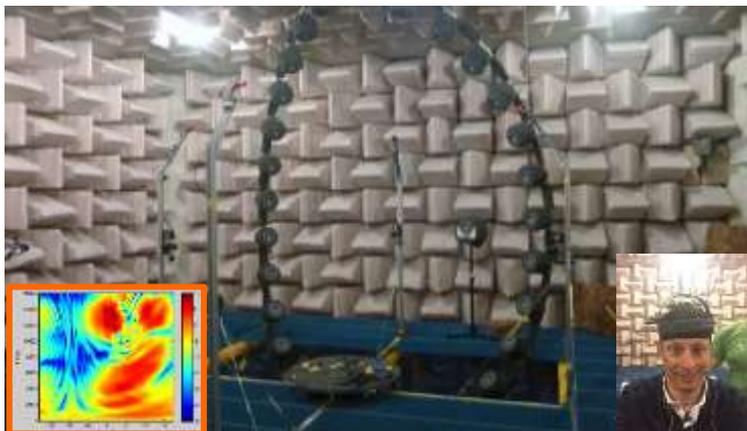
Until now, it has been **complex and expensive!**



3D scanning (Not Applicable!)



High Resolution Ear Scanner for audiologists (>10k€)



Acoustic HRTF capture in anechoic room (> 100k€)



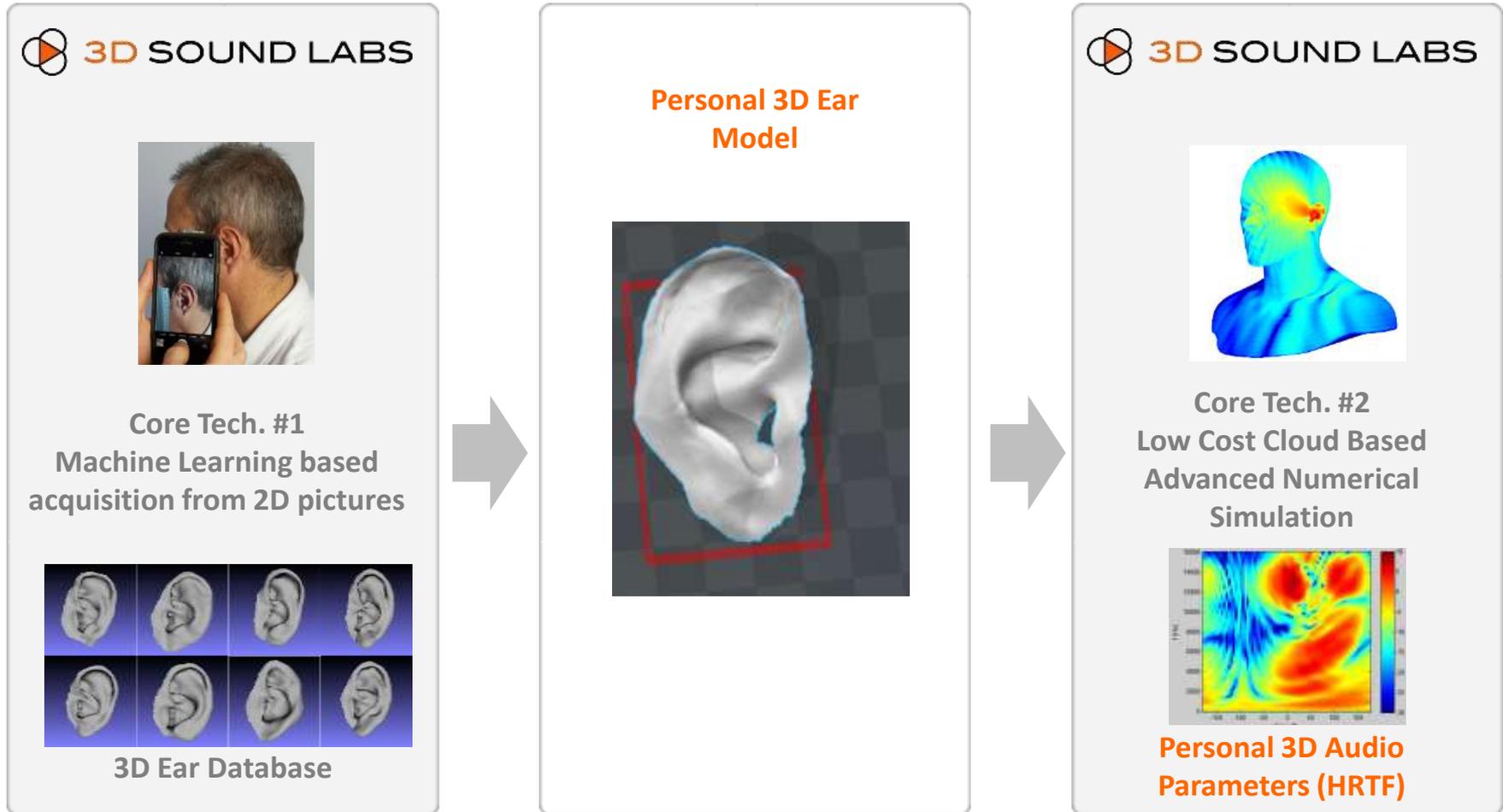
Traditional Silicon Ear Impression (<100€)



**3D Audio & Personal Acoustics
Solutions**

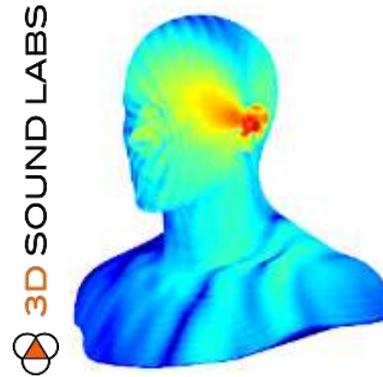
SOLUTION: 3D Sound Labs DIGITAL EAR

2D Picture provides personal 3D Ear Model and HRTF (Head Related Transfer Function)



DIGITAL EAR for 3D Audio HRTF

2D Picture provides **personalized HRTF** for VR/AR, Video Games and 3D Audio Music



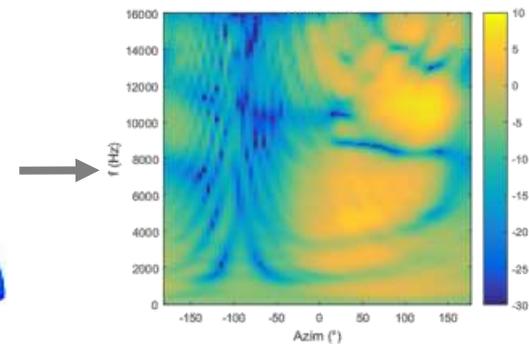
Personalized HRTF Files

Extension .sofa  Audio Engineering Society

AES69-2015 - AES standard for file exchange - Spatial acoustic data file format used for object based HRTF for far field description.

Extension .hrtf  3D SOUND LABS

3D Sound Labs file format for its VR Audio SDK including object based HRTF for far field and **near field** as well as HRTF **designed for High Order Ambisonics (HOA) to Binaural rendering**

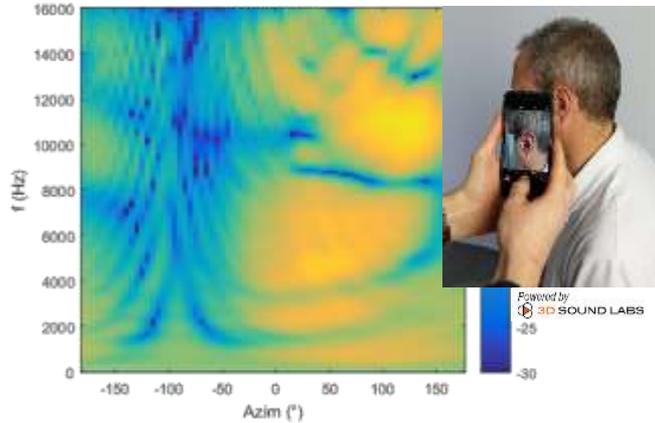


HRTF

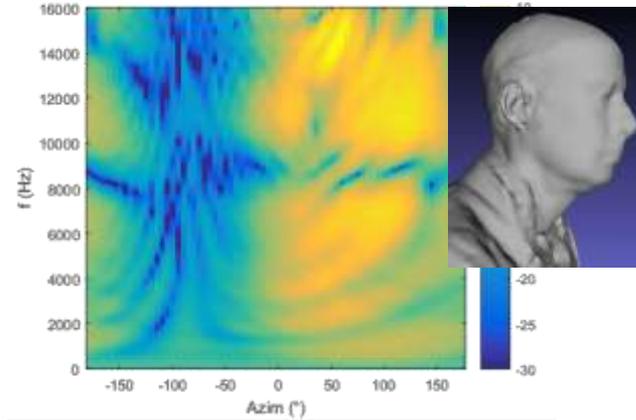
DIGITAL EAR for 3D Audio HRTF

3D Sound Labs HRTF Individualization solution based on 2D pictures provides **performances similar to HiRes Scanning and to Acoustic Capture.**

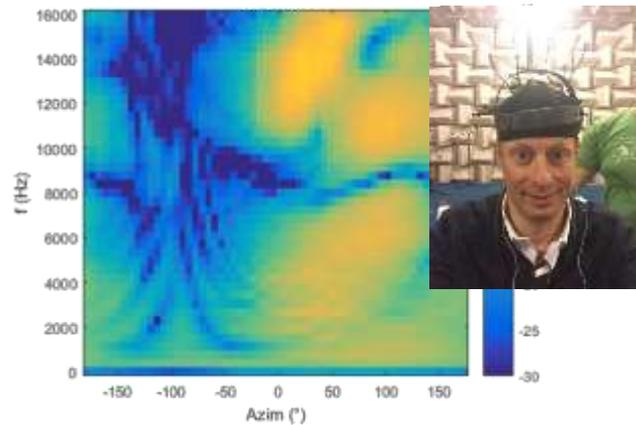
One 2D Picture + 3DSL Numerical Simulation



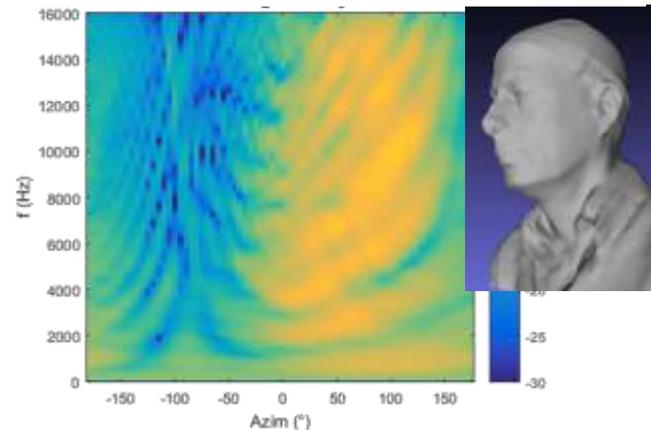
HiRes Scan + Standard Numerical Simulation



Acoustic Capture

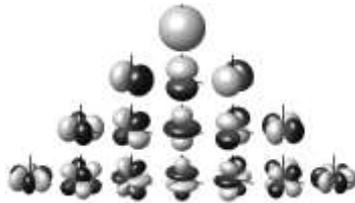


LowRes Scan + Standard Numerical Simulation



Solution: VR Audio SDK

High Order Ambisonics



VR Audio Engine core processing made in High Order Ambisonics domain yields key benefits:

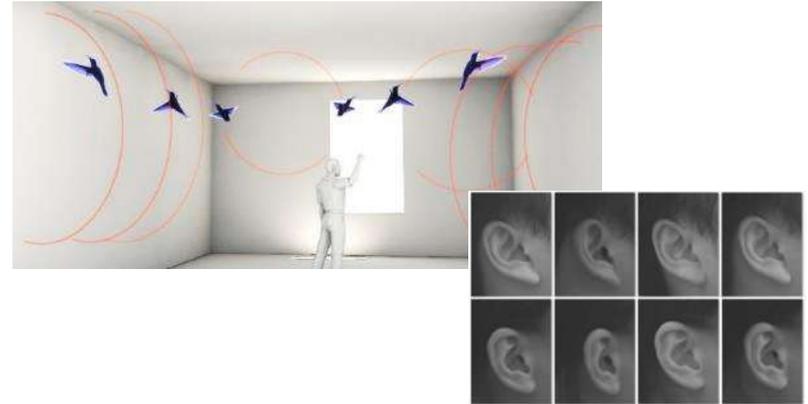
Low CPU Usage for:

- Low Latency Head Tracking
- High number of sources
- Ambisonics: B-Format (FOA) & HOA

Scalability:

- CPU Load management
- One content for both High End (PC based) and Low End (Mobile)

Realism & Immersion



3D Sound Labs has introduced two features that dramatically improve the spatial audio rendering.

HRTF Individualization

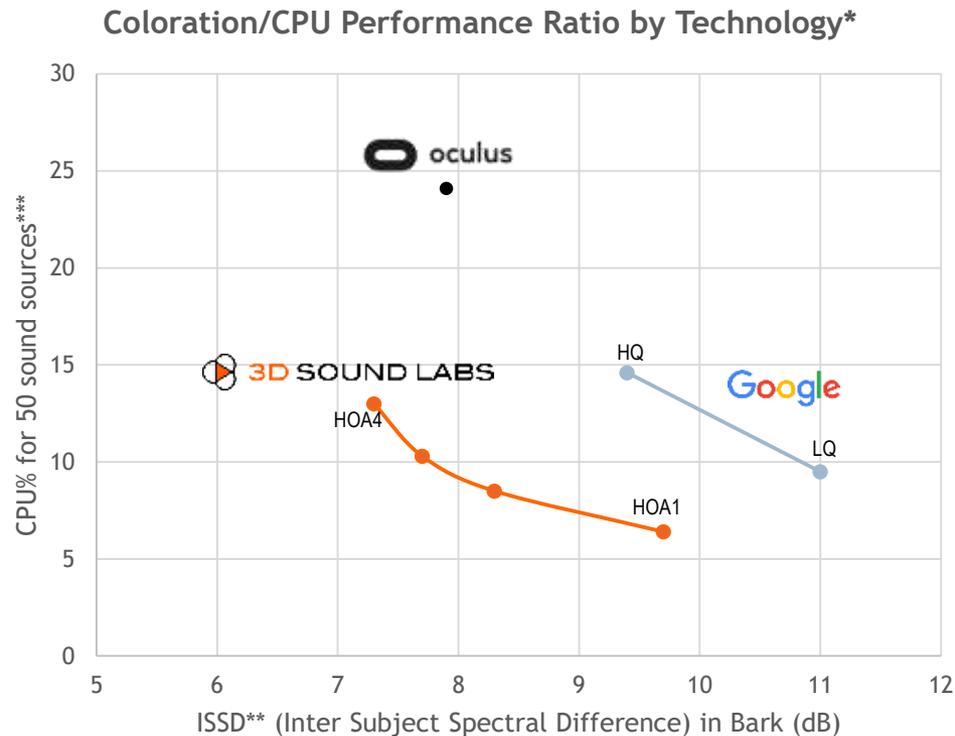
Head related transfer function personalization provide a dramatic improvement to spatial sound perception.

Low Sound Coloration in HOA Domain

Specific and proprietary processing in HOA domain brings a more realistic and natural sound quality.

VR Audio SDK Performance

3D Sound Labs HOA to Binaural rendering method provides **less sound coloration** than virtual speaker methods and object base, **with lower CPU %**



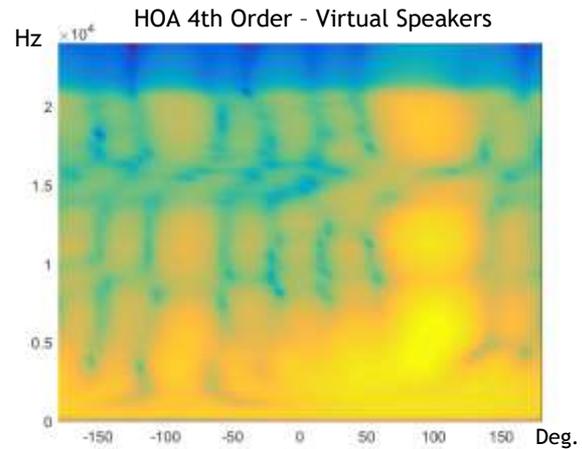
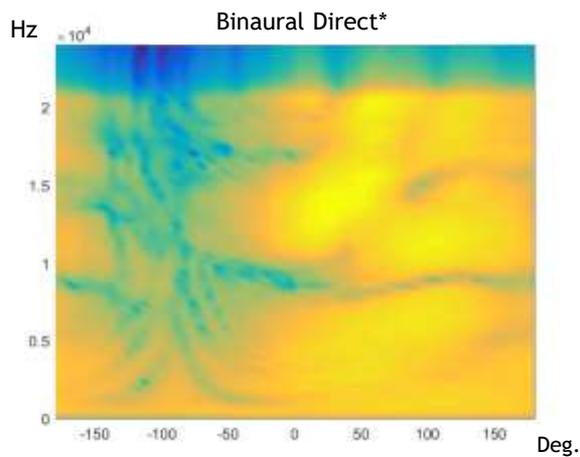
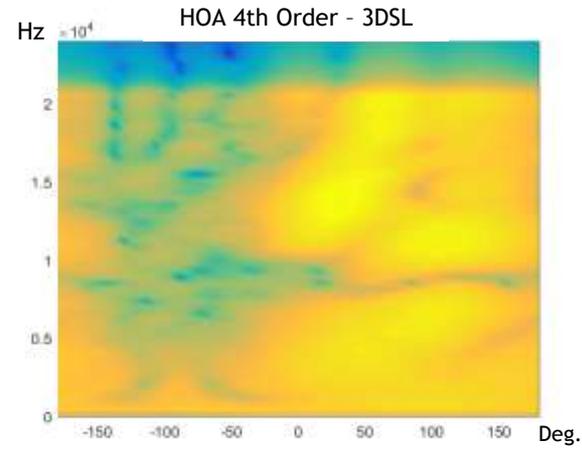
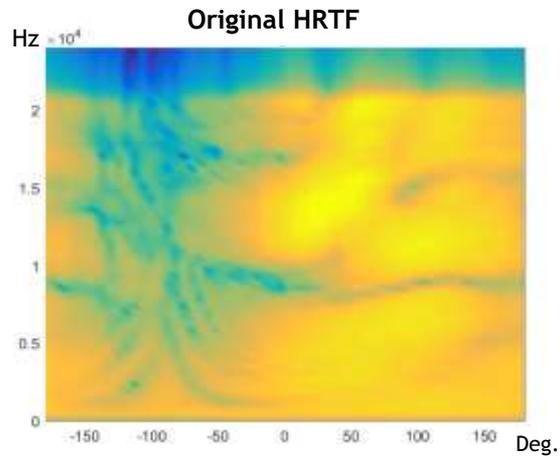
* SDK Versions: 3D Sound Labs (v 0.3.0) HOA 1st to 4th order, Google (1.0.1) LQ & HQ modes, Oculus (1.1.0)

** Average ISSD (Inter Subject Spectral Difference) in Bark applied between the frequency response and the HRTF of the 84 subjects of the ARI database. The ISSD is a metric that is based on the variance in the difference between frequency spectrum that illustrates well the difference of coloration between two HRTF.

*** Laptop Lenovo ideapad - CPU Intel i5-4210U @2,40 GHz, Windows 8.1 64bits, Single-core mode

VR Audio SDK Quality

3DSL Solution provides **less coloration artifacts and better spatialization** than Virtual Speakers Method

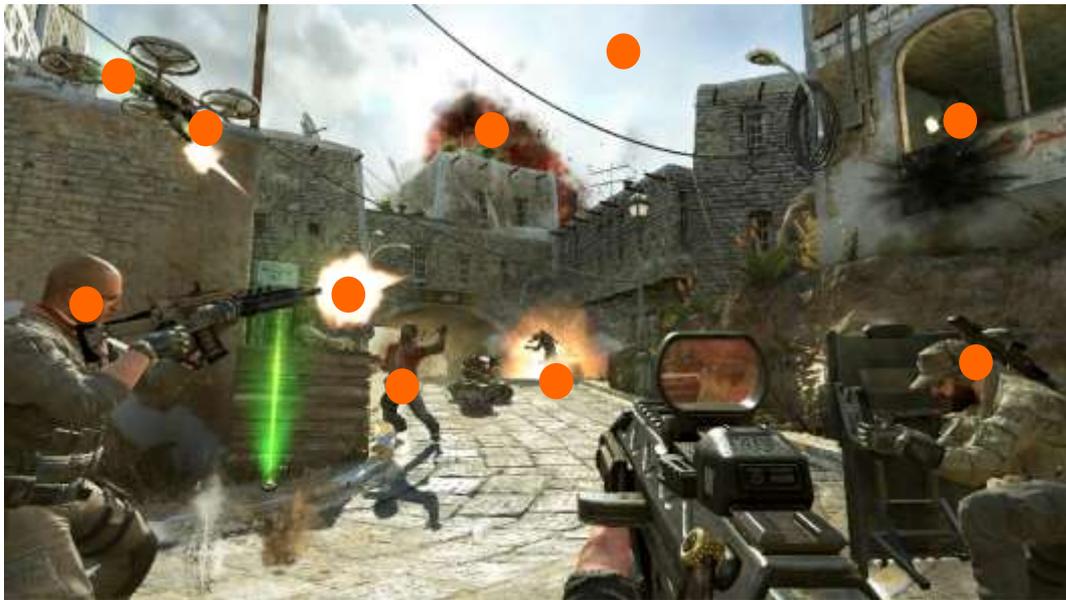


Binaural Direct result matches the original HRTF used (by definition). 3DSL HOA Filters give very comparable results, contrarily to Virtual Speaker method which introduces artifacts

VR Audio SDK: Hybrid Mode (Objects + HOA)

Unique 3D Sound Labs Hybrid mode provides different level of spatial precision to:

- Optimize CPU usage
- Manage End user attention in VR Story telling



Precise Sounds:

One enemy gun shot
Two team mates' talking

Normal Sounds:

Two explosions
Two Friendly gunshots
Drone engine

Ambiance Sounds:

Street atmosphere

Precise and Normal sounds all rendered with 6 early reflections to provide realistic audio sound scene.

Object Based Rendering

- 8 sounds with each 6 early reflections: 56 objects
- 1 ambience sound in stereo (poor realism)
- Difficult for the "player" to make a difference between important sound (enemy shot) and other sounds.

CPU
25%

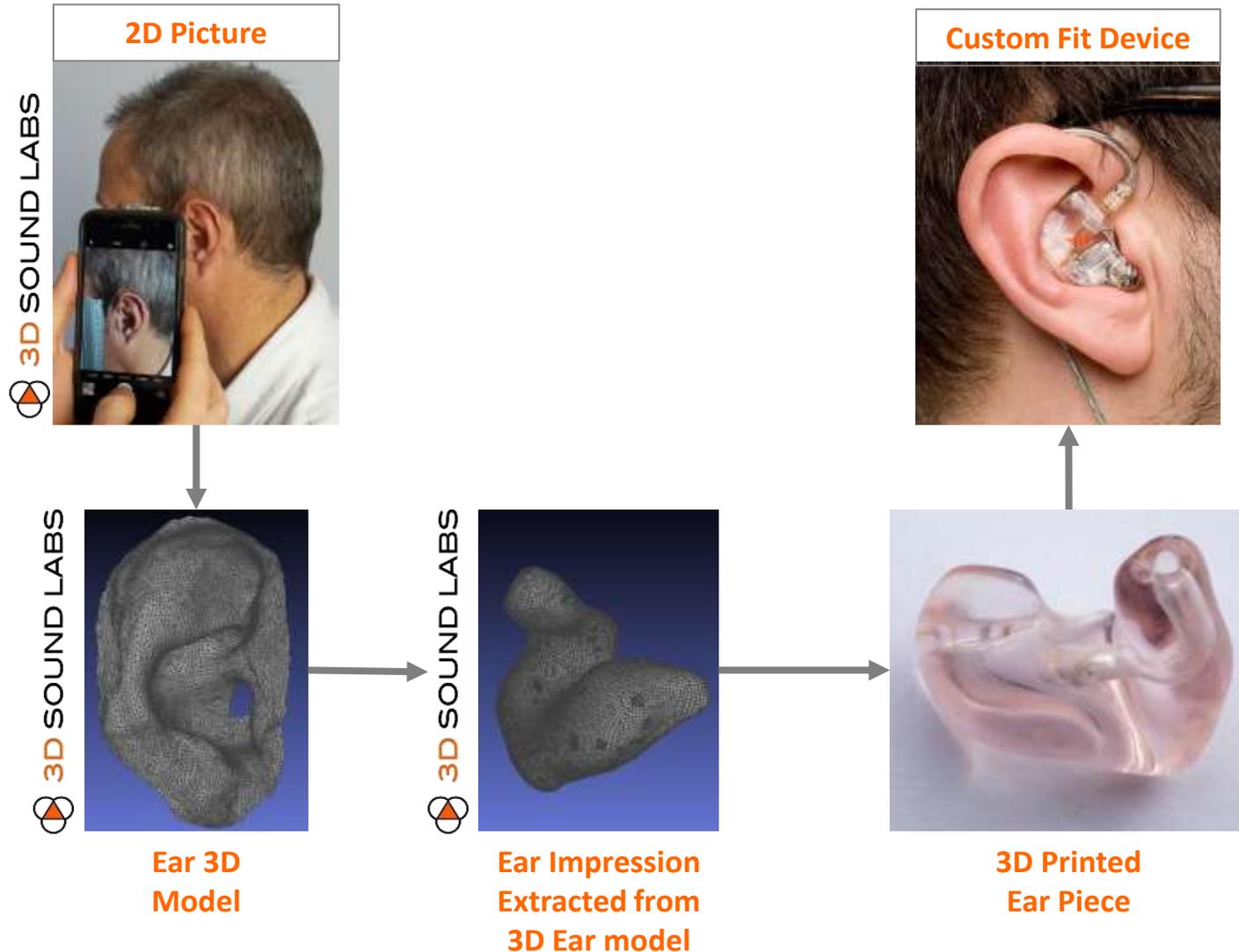
Hybrid Based Rendering

- 3 precise sounds with the first 2 early reflections object based and 4 next early reflection in HOA order 2
- 5 normal sounds with early reflections in HOA order 2
- 1 realistic ambience sound in HOA order 2

CPU
10%

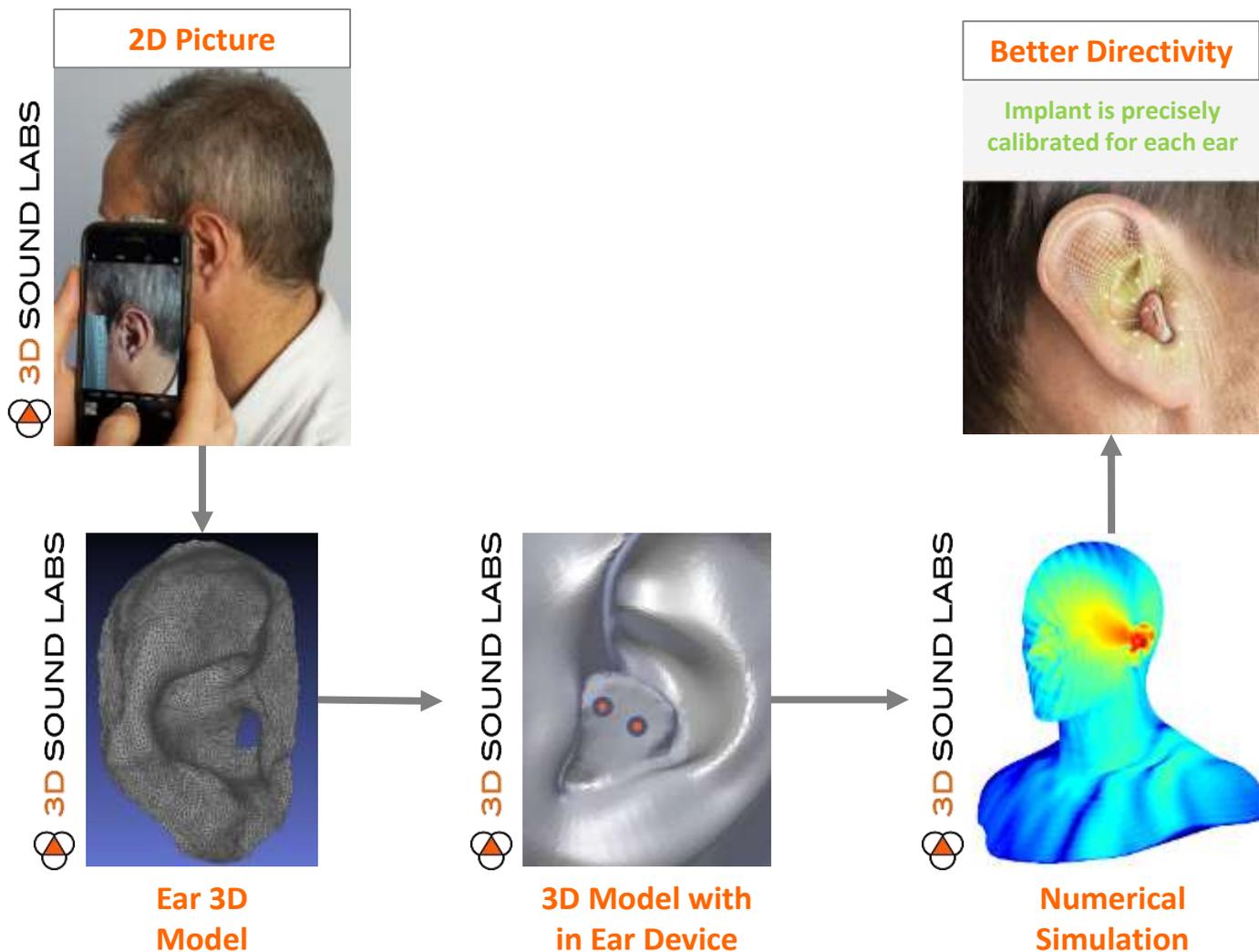
DIGITAL EAR for Custom Ear Piece

2D Picture provides personal 3D Ear Model for 3D Printing



DIGITAL EAR for Hearable Microphone Directivity

2D Picture provides personal 3D Ear Model enabling the biometric calibration microphone beamforming enabling improved frontal directivity for better speech intelligibility in noise.



3D Sound Labs, a Technology Company

Founders



Xavier Bonjour (Chairman)

- Technicolor, LG and Philips
- Startup board member: Movea
- Heriot-Watt University, ESIEE, ESCP.



Dimitri Singer (CEO)

- General/growth management: Coolsand, Wipulse, TikiLabs
- Coach, mentor, advisor for multiple startups
- Telecom Paris, INSEAD



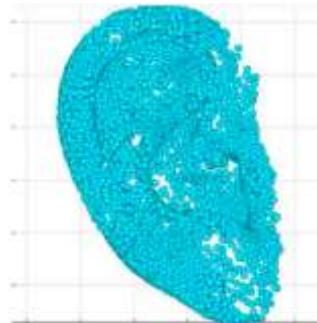
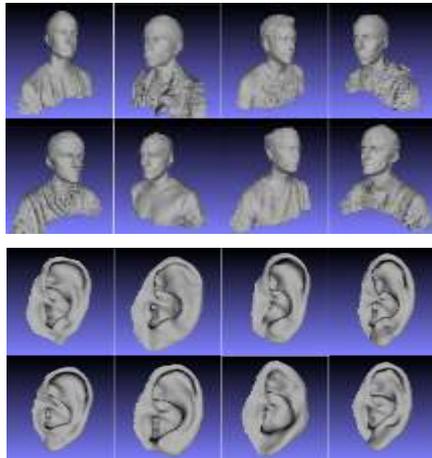
Renaud Séguier (Scientific Advisor)

- Professor at CentraleSupélec
- Co-founder of DYNAMYXZ, successful start-up company.
- PhD in Signal Processing,

Team based in France



Software, Databases and Models



4 Filed Patents



BREVET D'INVENTION CERTIFICAT D'UTILITE

Réception électronique de la soumission

Il est certifié par la présente qu'une demande de brevet (ou d'un certificat d'utilité) a été reçue par le biais du dépôt électronique sécurisé de l'INPI. Après réception, un numéro d'enregistrement et une date de réception ont été automatiquement attribués.

Número de demande	1558279
Número de soumission	1000309795
Date de réception	07 septembre 2015
Vos références	69927 BRU
Demandeur	3D SOUND LABS
Pays	FR
Titre de l'invention	Procédé et système d'élaboration d'une fonction de transfert relative à la tête adaptée à un individu



3D Audio & Personal Acoustics

HRTF Individualization – Benefits for 3D Audio

Localization

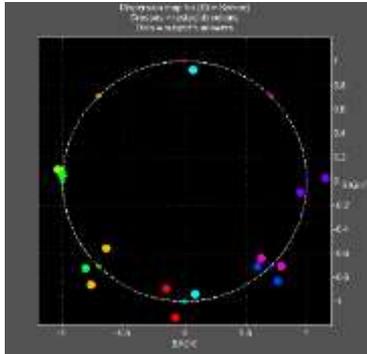
Spatial Resolution

(Image analogy)

Spectral “Coloration”

(Image analogy)

Standard
HRTF



Localization errors

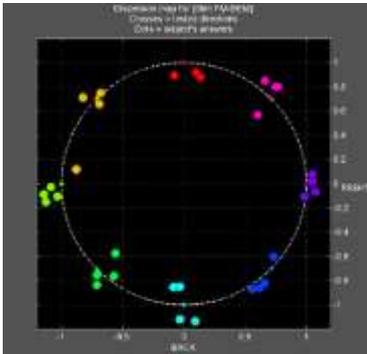


Fuzzy perception of the soundscape



Unnatural Timbral Coloration

Personal
HRTF



Good Localization



Crisp and Clear perception of the soundscape



Natural Timbral “Coloration”

3D Sound Labs – Binci Project

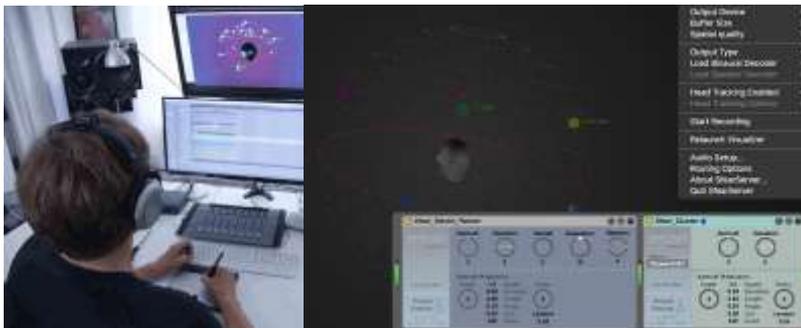


The **BINCI** project “Binaural Tools for Creative Industries” has the objective to allow the creation of immersive binaural 3D music and other binaural contents for applications in the virtual reality, augmented reality or videogames sector.



3D Audio Content Creation Tools

Advanced 3D Audio content creation plug-in allowing for **head-tracking and HRTF individualization**, including 3D Sound Labs rendering for **consistent experience between creation and play out**.



3D Audio Multiple Speakers System

Rental or purchase of inflatable domes with integrated loudspeakers for innovative experiences based on 3D sound at music festivals, promotional events, ...



3D Audio Player on Mobile Platforms (VR/AR/Headphones with Headtracking)



Use Case: Recorded content Distribution Exemple

3D Sound Labs and Viaccess-Orca are **first** to present VR video with **compressed 3rd Order Ambisonics 3D Audio** on a **mobile** platform

