

The Astroparticle Immersive Synthesizer AIS³

DPG Frühjahrstagung Karlsruhe
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The **Epilepsy Warning** rsive

**Videos with flashing
lights and irregular
sounds**

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Rifaie, Tim Otto ... sch, Simon Zierke

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The Astroparticle Immersive Synthesizer (AIS³)

Project:

- Initiated by artist who saw an event display of IceCube at a conference (early 2010s)
- Idea: Create an installation using light moving through space
- Collaboration between artists and scientists

Concept:

- **Astroparticle:** Use data from astroparticle detectors as score for composition
- **Immersive:** Let visitors experience the exhibition by traversing the installation
- **Synthesizer:** Create Sound and light at discrete points in space and time

People involved:

- Imagination Projects ([website](#)):
 - Artist Tim Otto Roth
 - Assistant Miriam Seidler
- Science Partners:
 - Christian Spiering (DESY)
 - Christopher Wiebusch (RWTH)
 - Elisa Resconi (TUM)
 - Paschal Coyle (CPPM)
 - ...
- Technical Support:
 - Simon Zierke
 - Martin Rongen
 - Lasse Halve
 - A lot of other students...

Sponsors



Scientist vs. Artists Perspective

(Naive) Scientist perspective:

- Build a giant event viewer you can walk through
- Make our data look as pretty as possible
- Use the most interesting physics events
- This is an outreach project

Artists perspective:

- Use data from physics detectors as a natural score for composing
 - Manipulate timescales, sound waveforms and pitches, and color representation
- Combine space and sound to form a psychoacoustic experiment
 - Clear connection between origin of sound and light
- Interactive experience for visitors:
 - Walk/Stand/Lie through/in the installation
 - Impression changes modes/data every few minutes



Data for AIS³

Preparation of Detector Data for AIS³

Pick data from event selections:

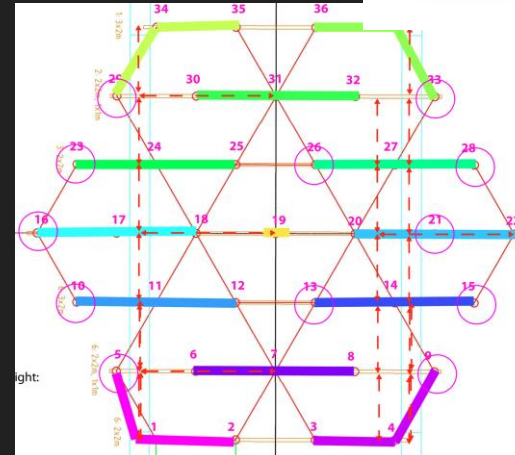
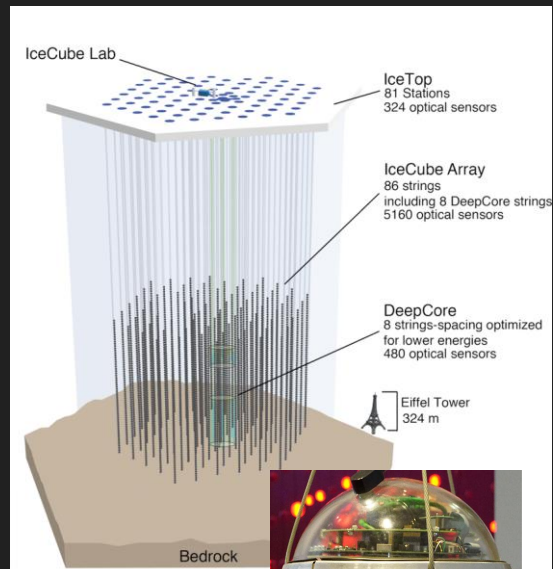
- High-Energy Muon Tracks
- High-Energy Cascades
- Fixed-Rate Trigger (Detector Noise)

Hexagonal Layout of AIS³ is similar to that of IceCube, Antares, KM3NeT

Automated Data Extraction:

- Read in data files
- Extract arrival times and accumulated charges for each PMT
- Define subset of detector to represent AIS³ layout
- Shift subset in x,y,z and pick the region of the detector with the largest total charge
- Write AIS³ data file with structure:
 - String ID
 - Sphere ID
 - Timestamp
 - Total Charge

IceCube layout



IceCube DOM

AIS³ layout

Interpretation and Composition

- Data is loaded
 - Detector data from AIS³ files
 - Geometric figures from blender renders
- Timestamps and Charges are normalized
- Data is converted to events for loudspeaker spheres with conversion parameters:
 - Absolute Volume
 - Color Space
 - Frequency Space
 - Sound Waveform
 - Sine
 - Sawtooth
 - White Noise
 - Timescale
- Conversion parameters and sequence of data is generated by a PureData (pd) interface
 - Artist has full control of interpretation of data
 - Artist can compose with data from many sources



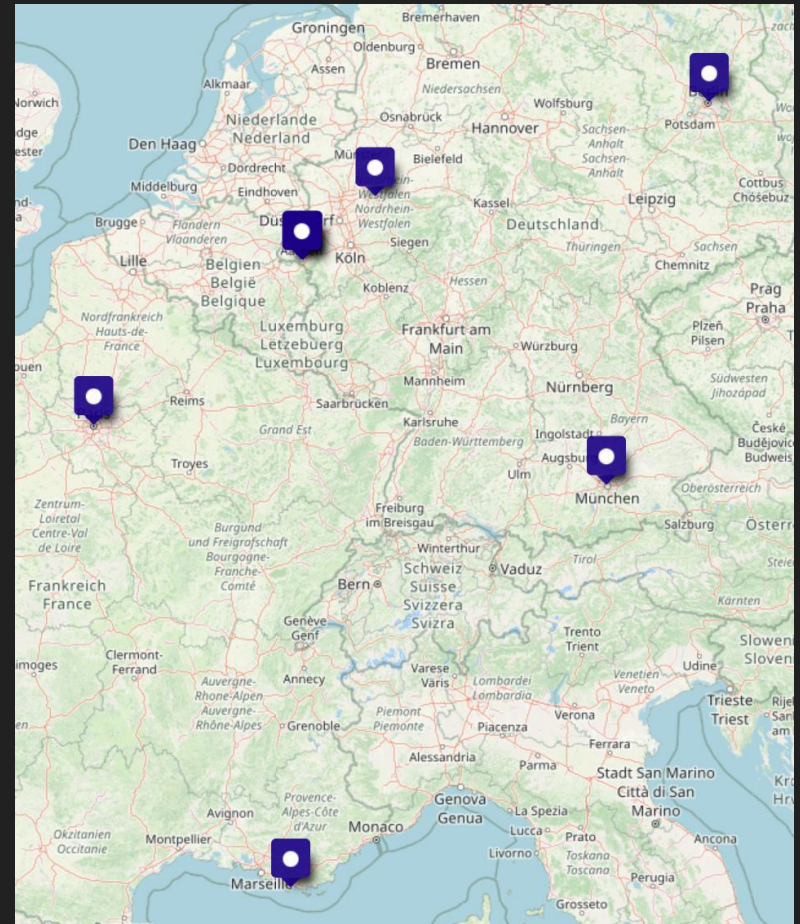
Exhibitions

Exhibitions

- St. Elisabeth Kirche Berlin (August 2018)
 - First large-scale exhibition
 - Welcome evening for TeVPA 2018
 - Art and Science Symposium
- Reaktorhalle München (January 2019)
 - Accompanied by dance company
- Ludwigforum Aachen (Sep. - Nov. 2019)
 - Talks and Discussions with:
 - Dr. Sibylle Anderl
 - Prof. Dr. Wolfgang Ullrich
 - Robert Bary
 - Tandem guided tours (Art History and Science)
- Musée de Arts et Métiers Paris (Dez. 2023 - Feb. 2024)
 - Part of exhibition 'De Abysses au Cosmos'
 - Additional data from Antares and KM3NeT

Smaller Exhibitions:

- IceCube Collaboration Meeting Aachen
- IceCube Press Conference Dortmund
- La Seyne-sur-Mer (KM3Net Exhibition)



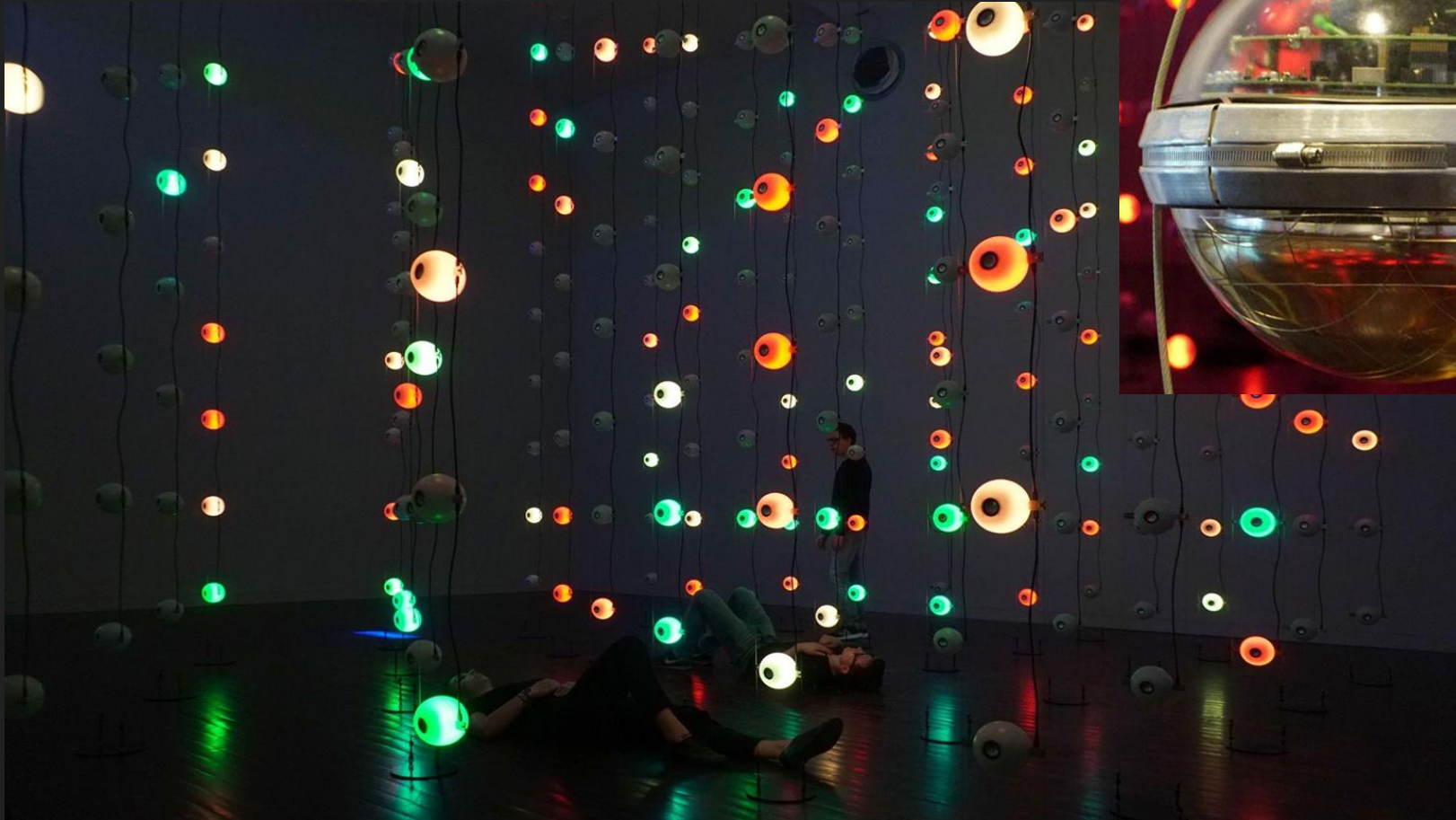
St. Elisabeth in Berlin



Reaktorhalle München



Ludwigforum Aachen



La Seyne-sur-Mer



Musée de Arts et Métiers Paris



Reception in the press

Radio interviews/reports:

- RBB Inforadio
- Deutschlandfunk

Newspaper Articles:

- Berliner Zeitung
- Badische Zeitung
- Frankfurter Allgemeine
- Neue Zeitschrift für Musik
- Süddeutsche
- Aachener Nachrichten

TV appearances:

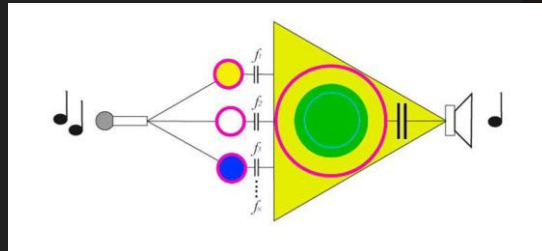
- Deutsche Welle
- WDR Lokalzeit Aachen
- ARD Alpha: Space Night Science



Sonapticon – Theatre of Memory

- Spin-Off project from AIS³
- Smaller Layout
 - 14 Strings
 - 5 Spheres per String
- Additional microphones in the spheres
- Speakers are activated/inhibited by frequency bands
- Resembles neural network
- Interaction with audience through voices/noises

Exhibition in 'Tieranatomisches Theater Berlin'
until 23.03.2024



Summary

- The Astroparticle Immersive Synthesizer (AIS³) is an art installation using data from neutrino telescopes as a score for composition.
- The project was initiated by artist Tim Otto Roth and was supported by many scientific collaborators, especially the Institute 3B from RWTH Aachen
- There have been numerous exhibitions in large cities, the last presentation closed last month in Paris
- The reception by the art community was very positive, and spin-off projects are active



BACKUP

Who is Tim Otto Roth?

- Conceptual artist, composer, and art historian
- Born and lives in the black forest
- Studied philosophy and politics in Tübingen
- Study in free art at Kunsthochschule Kassel
- Ph. D. in Art and Science History at Kunsthochschule für Medien Köln
- Leads Imagination Projects ([website](#))
- Focus on:
 - Space & the Physics of Art
 - Light and Shadow
 - Affinity between Art & Science

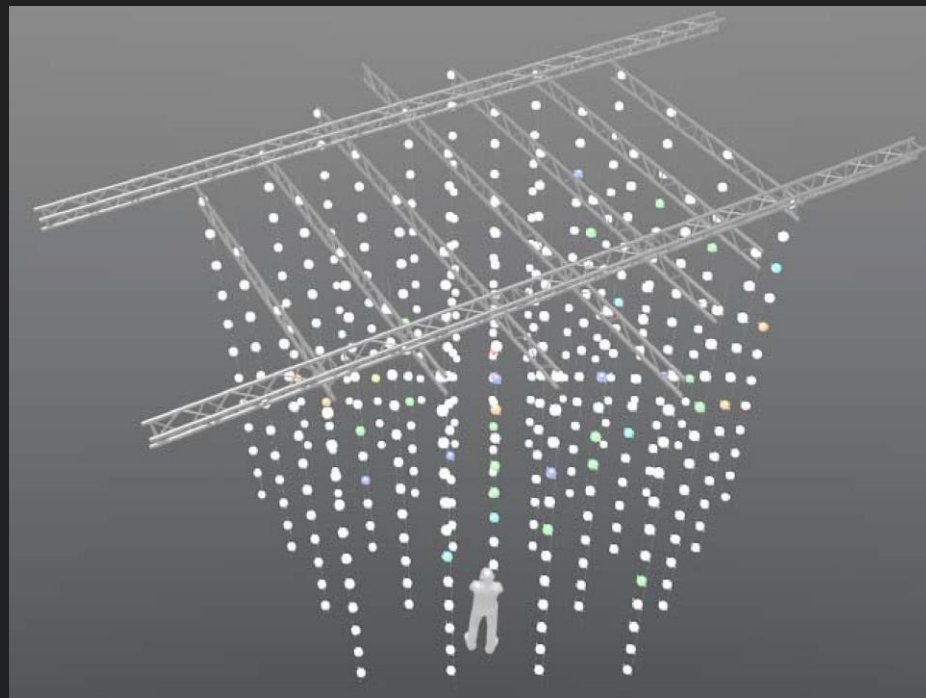


Guts of the installation

Layout of the installation

- Rigg constructed from steel trusses
 - Standard event tech materials
 - Can self-hoist with motors to fixpoints
- Hexagonal Footprint
 - 37 vertical strings
 - Distance between strings $\sim 1.5\text{m}$
 - Anchored to floor with weight stacks
- Loudspeakers mounted to strings
 - 12 spheres per string
 - Vertical distance of $\sim 52\text{cm}$
 - Total height: 6m to 7.5m
- Total size:
8m x 8m x 6m

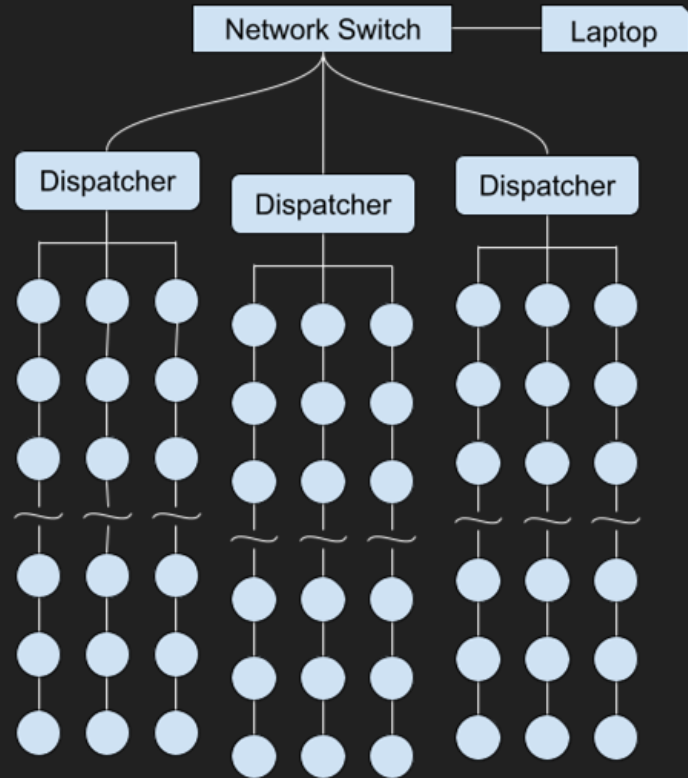
Resembles the detector design of neutrino telescopes (IceCube, KM3NeT, Antares)



Data distribution

- PureData (pd) frontend generates a sequence of data and display settings (composed by the artist)
- Python interface generates UDP packages for the installation
- Laptop sends UDP packages via network to dispatchers at top of the installation
- Dispatchers distribute the data to connected strings
- Loudspeaker spheres receive and decode data
 - > Illumination
 - > Sound Output

Can reach update frequencies for the whole installation of $O(100\text{Hz})$



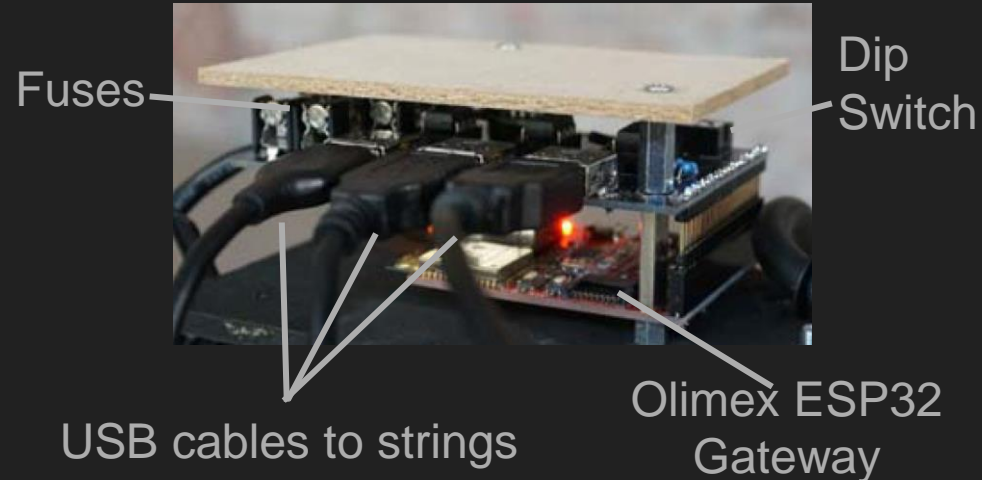
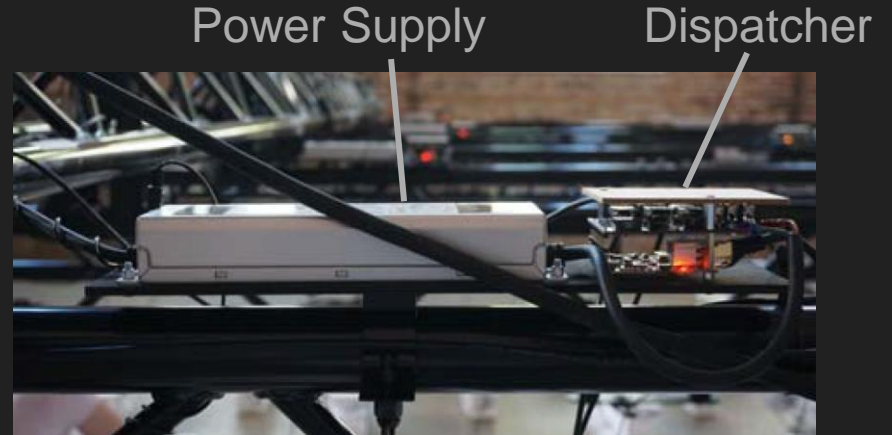
The AIS³ Dispatcher

Responsible for:

- Power supply
- Data distribution to strings

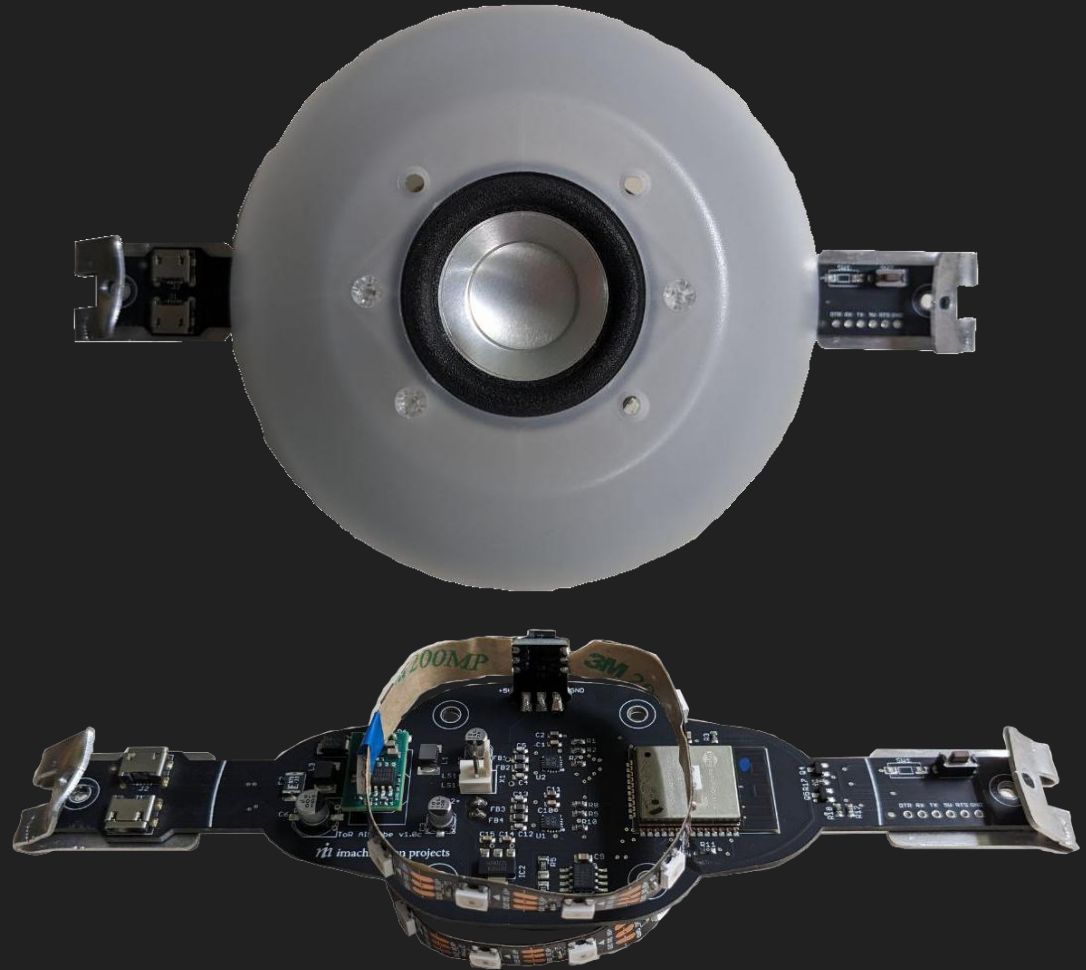
Realization:

- 24V Power supply (Meanwell ELG-240-24A)
- Olimex ESP32 Gateway Board
 - IP configured by dip-switch
 - Receives data via Ethernet
 - Decodes data for each connected string (up to 3)
 - Forwards data to strings
- Adapter Board on top of Gateway:
 - USB connectors for each string
 - 24V spliced into USB cable
 - Fuses for each string



The AIS³ Module

- Diffusing Hull
- Two LED Strips
 - RGB LEDs, non-addressable
 - Illuminate diffusing sphere
- ESP 32 microcontroller
 - Synthesizer + Filters
 - Sine waves
 - Sawtooth waves
 - White noise
 - Communication en-/decoding
- Two Loudspeakers (Visaton BF-45)
 - High power output
 - Hand bandwidth
- USB connectors
 - Power supply (24V)
 - Serial bus daisy chain
- Extensions outside the sphere
 - Cable clips connect to hanging wire
 - USB connectors
 - Power supply (24V)
 - Serial bus daisy chain
 - Reset & test mode buttons
 - Programming pins



Construction and Testing

- All loudspeaker spheres and dispatchers assembled at RWTH
- Development and tests of firm- and software for spheres, dispatchers, data conversion, and slow control by students
- Full-scale tests of installation at RWTH



Exhibitions

Musée de Arts et Métiers Paris

