h

sonification of a cloud chamber

'h' is the sonification of a physical phenomenon that is observed (and listened to) by visitors through a cloud chamber[1].
The installation is named after the conventional symbol for Planck's constant.

We realized a sonification based on a series of sound synthesis processes that use, as data, traces left by particles in the cloud chamber which are captured by a camera: a computer recognizes the traces and interprets the images they create, generating realtime sound, as defined by settings and choices specified by the composer and by stimuli from the recognition module.

'h' was first premiered during the 'Notte dei ricercatori 2011' event in Trieste.

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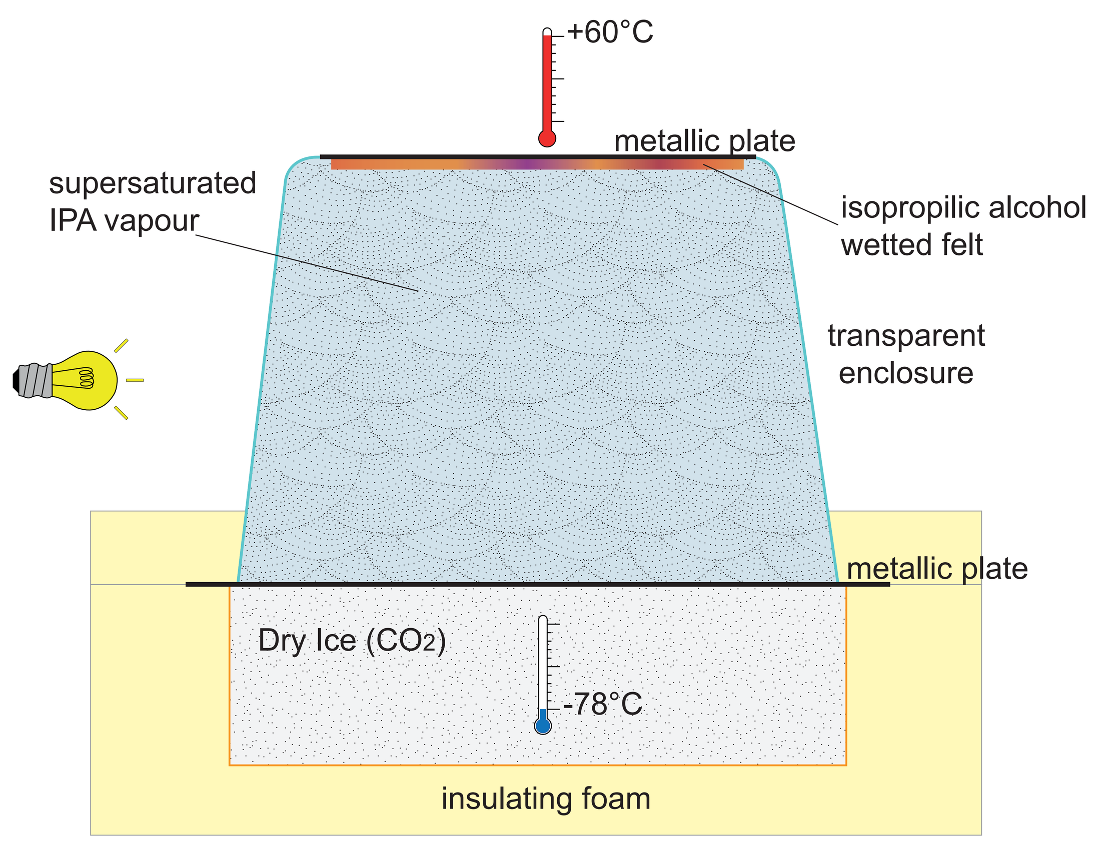
A diffusion cloud chamber is a device used by nuclear physicists to detect and study elementary particles. These particles are emitted by unstable (radioactive) atomic nuclei and produced during nuclear collisions. Some of them reach the earth as cosmic rays.

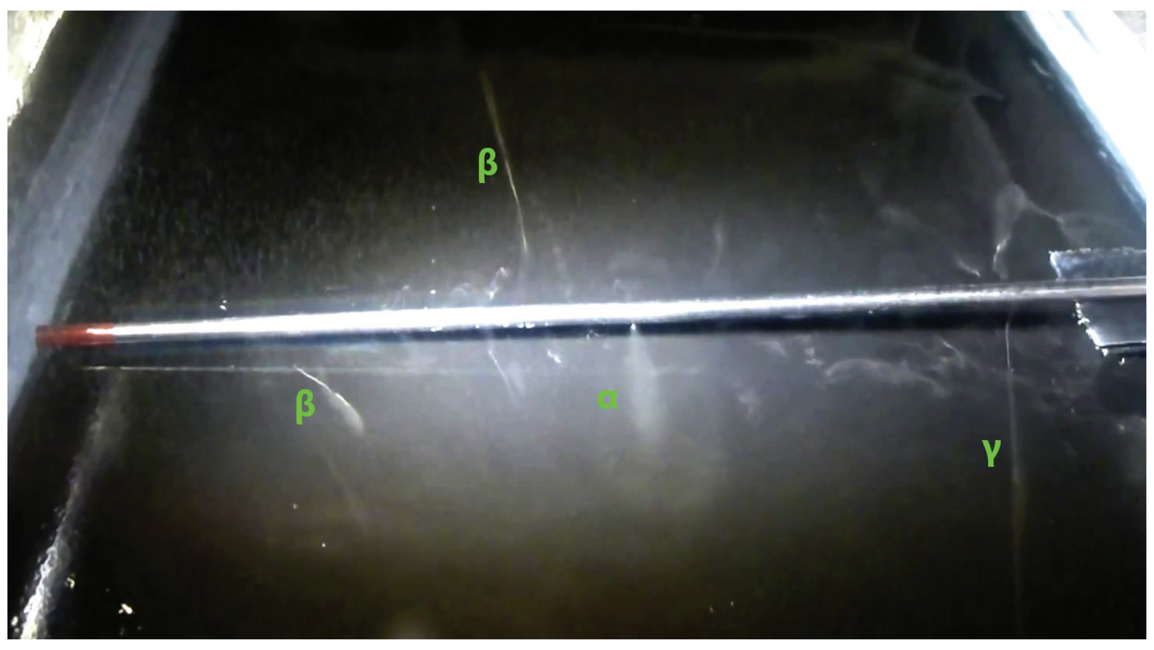


Cloud Chamber (section)

The chamber is full of supersaturated vapours of isopropyl alcohol; this mist is generated thanks to a high temperature gradient (> 100°C) between the base of the instrument (-76°C) and its upper part (>60°C). This vapour condenses around ion trails left by ionizing particles in a way similar to contrails made by airplanes.

The path, which appears as a track of mist, is called a cloud track. By directly studying the trajectory, or a photograph of it, a physicist can determine the energy and electric charge of the particle that produced it. Every kind of particle has a characteristic cloud track, which varies in shape, length, and width:

- α particles (alpha) have a short and thick trace. α particles are helium nuclei (2 protons + 2 neutrons) and their typical energy is very low – a simple sheet of paper is enough to stop them.
- β particles (beta) have much longer and better defined trails than α. They are high energy electrons but their flight can be stopped by a few millimeters of aluminium. They are sensible to magnetic fields and a nearby magnet will bend their trajectory.
- γ rays (gamma) are high energy photons and the trace left by their passage is longer than β. Their visibility is "indirect" because γ rays ionize the neighbour atoms. Several centimeters of lead are needed to stop γ rays.
- Protons and Mesons (from the interaction of cosmic rays) – protons leave short and thick traces; due to their high energy mesons have very long trails with thickness between α and β

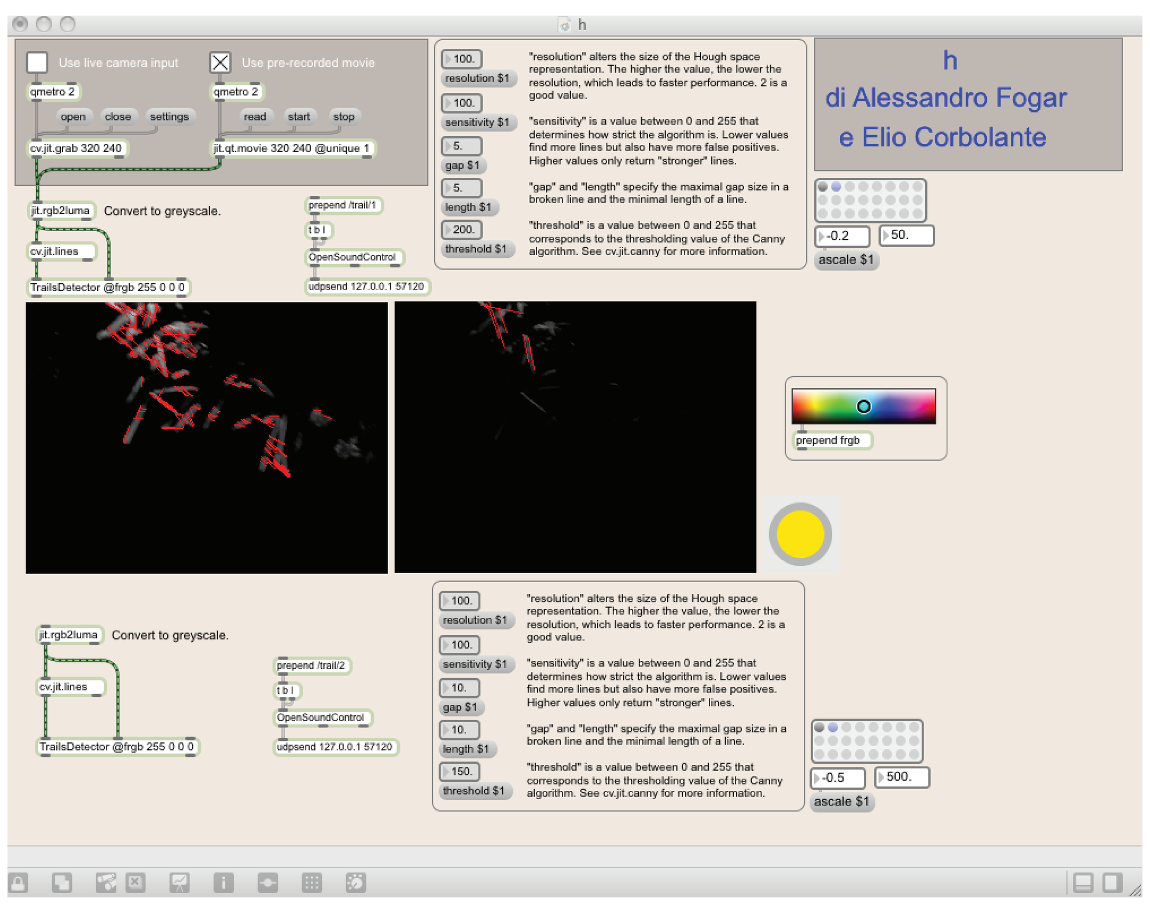


The detection of the traces left by the elementary particles in the cloud chamber is implemented using the *cv.jit* library by Jean Marc Pelletier[2], a collection of objects and tools for computer vision based on Max/Msp/Jitter. The main *external* used for the detection is *cv.jit.lines*. The images are captured by a camera with a resolution of 320 x 240 pixels and converted to grayscale.

Initially, the Canny algorithm[3] is used to find image edges. The edge image is then transformed into a Hough representation[4], from which line candidate features are extracted. The output of *cv.jit.lines* is a 4-plane matrix of long type. The number of cells in the matrix corresponds to the number of lines found in the image. The four planes describe the position of the line segments.

Data are then extracted from the matrix and sent to the sonification module.

The approach chosen aims at detecting the lines that best approximate the traces. There are two different tracking processes that operate on the same image capture. The second algorithm is set so that only the most obvious tracks are recognized.The trace recognition algorithm is set so as to discard tracks whose length is lower than a defined threshold and higher than another specified limit.



Communication between the computer vision module and the sonification module is via the OSC Protocol[5]. This allows easy distribution of the processing load between two computers, one dealing with trace detection and the other with sonification. The two track recognition algorithms send their data separately and are processed by two different sonification modules.

'h' is the physical constant (Planck's constant) whose value is the quantum of action in quantum mechanics. It determines the distance between the values of the number of physical quantities such as energy, the main theme of "Notte dei ricercatori 2011" for which the installation was conceived. Tracked lines are "quantized" into four levels according to their length, i.e. their energy.

The sonification module was developed using the Supercollider programming language, with *JITLib* for Just In Time programming techniques[6]. We chose this approach not because of the need to change sonification algorithms in realtime but for the ease of the development and the tuning of the module itself.

The Warp1 SC3 unit has been used for the sonification: it is a granular time stretcher and pitchshifter based on a sound buffer allowing us to sonificate tracks and detected lines, and obtaining from these the parameters for granulating a number of soundfiles. The particles leave a sonic trace of their passage as if they were scrubbing on a virtual audio files. Starting and ending reading positions in the soundfile derive from coordinates taken on the x-axis, the pitch from the y-axis coordinates, duration and choice of soundfile by the length of the line i.e. its "quantum" of energy (4 levels). The amount of reverb and multitap delay derive inversely from the event density. The soundfiles were "composed" previously by the author using Supercollider with characteristics that make them suitable to that "level" of line/energy.

References:

[1] http://en.wikipedia.org/wiki/Cloud_chamber

[2] Pelletier, J.: "A shape-based approach to computer vision musical performance systems" Proceedings of the 2004 Conference on New interfaces For Musical Expression.

[3] Canny, J.: "A Computational Approach To Edge Detection" IEEE Trans. Pattern Analysis and Machine Intelligence, 8(6):679–698, 1986.

[4] Duda, R. O. and P. E. Hart: "Use of the Hough Transformation to Detect Lines and Curves in Pictures" Comm. ACM, Vol. 15, pp. 11–15 (January, 1972)

[5] Wright, M. and Freed, A.: " Open Sound Control: A New Protocol for Communicating with Sound Synthesizers" in International Computer Music Conference Proceedings, (Thessaloniki, Hellas, 1997).

[6] Rohrhuber, J. and de Campo, A.: "Just in time programming" The SuperCollider Book. MIT Press, Cambridge, Massachusetts, 2011.

[7] de Campo, A., Rohrhuber, J., and Bovermann, T. and Frauenberger, C.: "Sonification and Auditory Display in SuperCollider" The SuperCollider Book. MIT Press, Cambridge, Massachusetts, 2011.