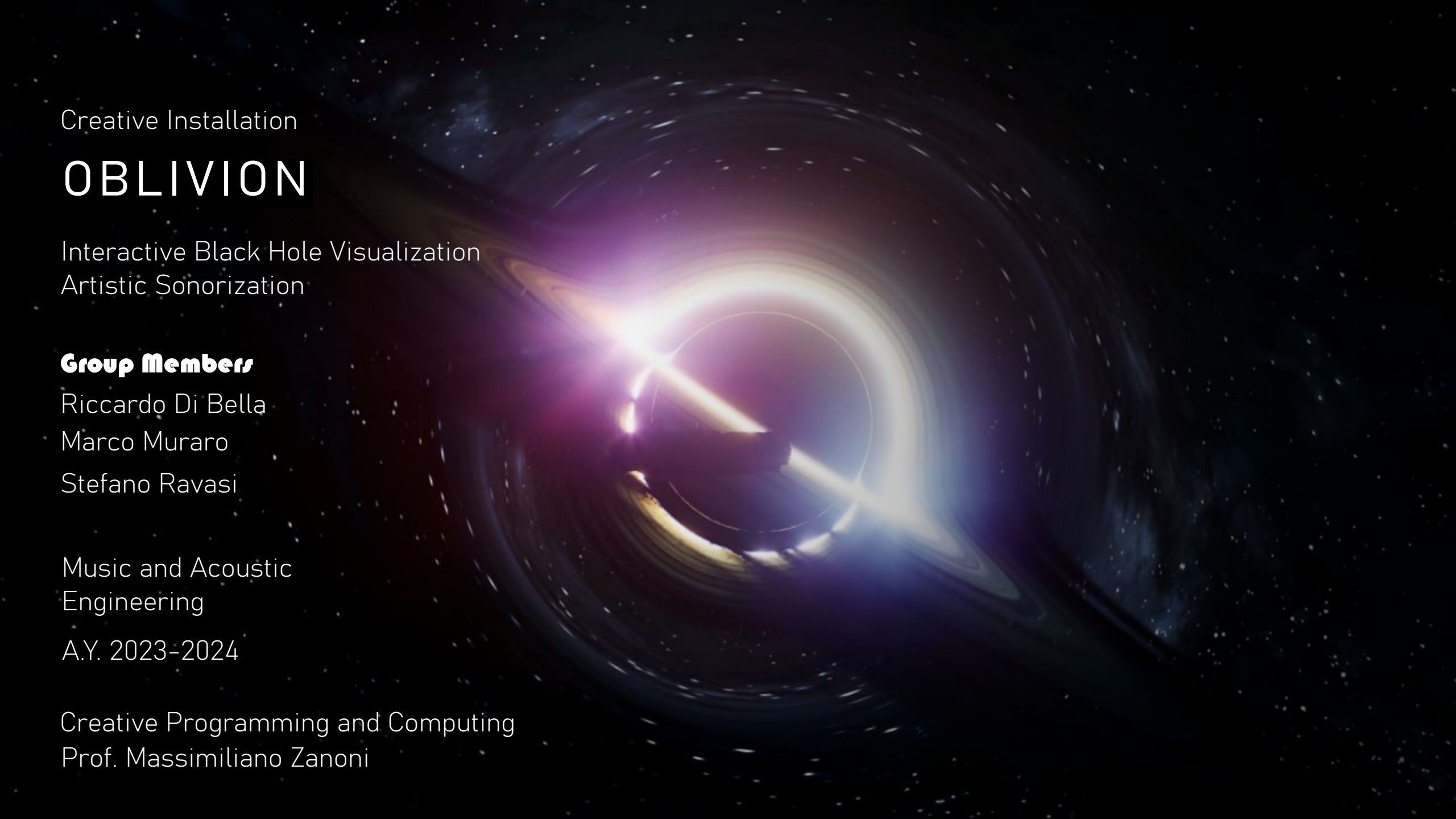


Creative Installation

OBLIVION

Interactive Black Hole Visualization
Artistic Sonorization

Group Members

Riccardo Di Bella

Marco Muraro

Stefano Ravasi

Music and Acoustic Engineering

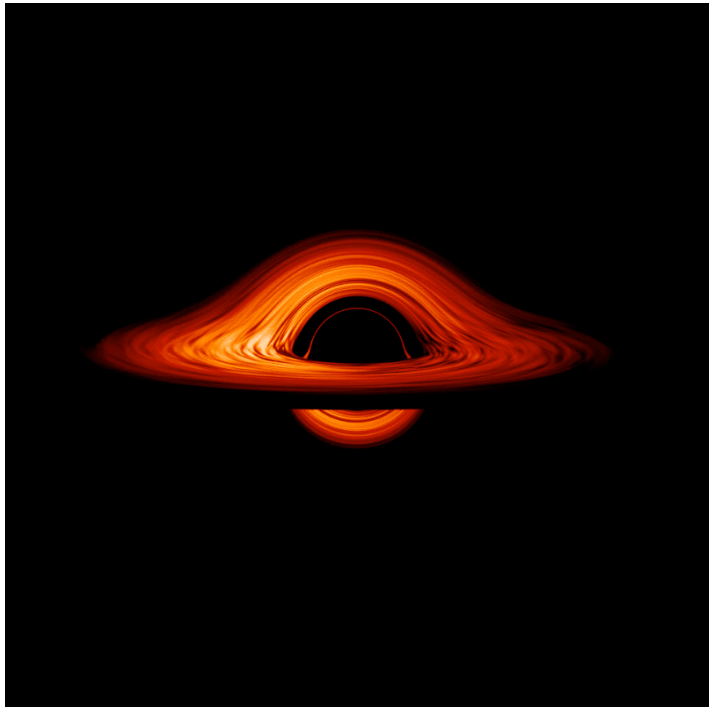
A.Y. 2023-2024

Creative Programming and Computing
Prof. Massimiliano Zanoni

What is a black hole?

Huge concentration of matter packed into a very tiny space, called **singularity**.

A black hole is so dense that the gravitation pull just beneath its surface, the **event horizon**, is so strong that nothing, not even light, can escape.

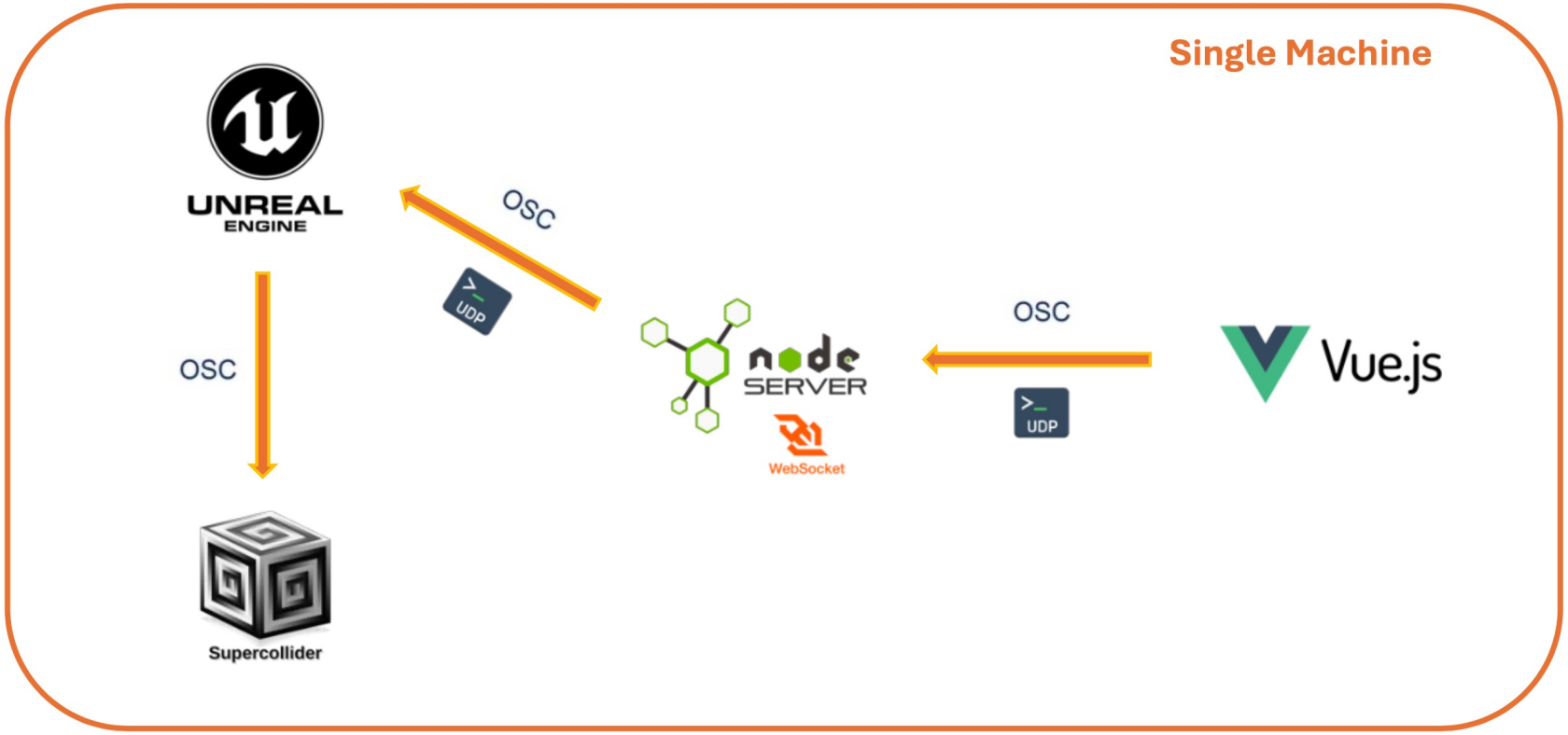


Accretion Disk

Some black holes are surrounded by **hot, swirling matter progressively falling inward towards the event horizon**.

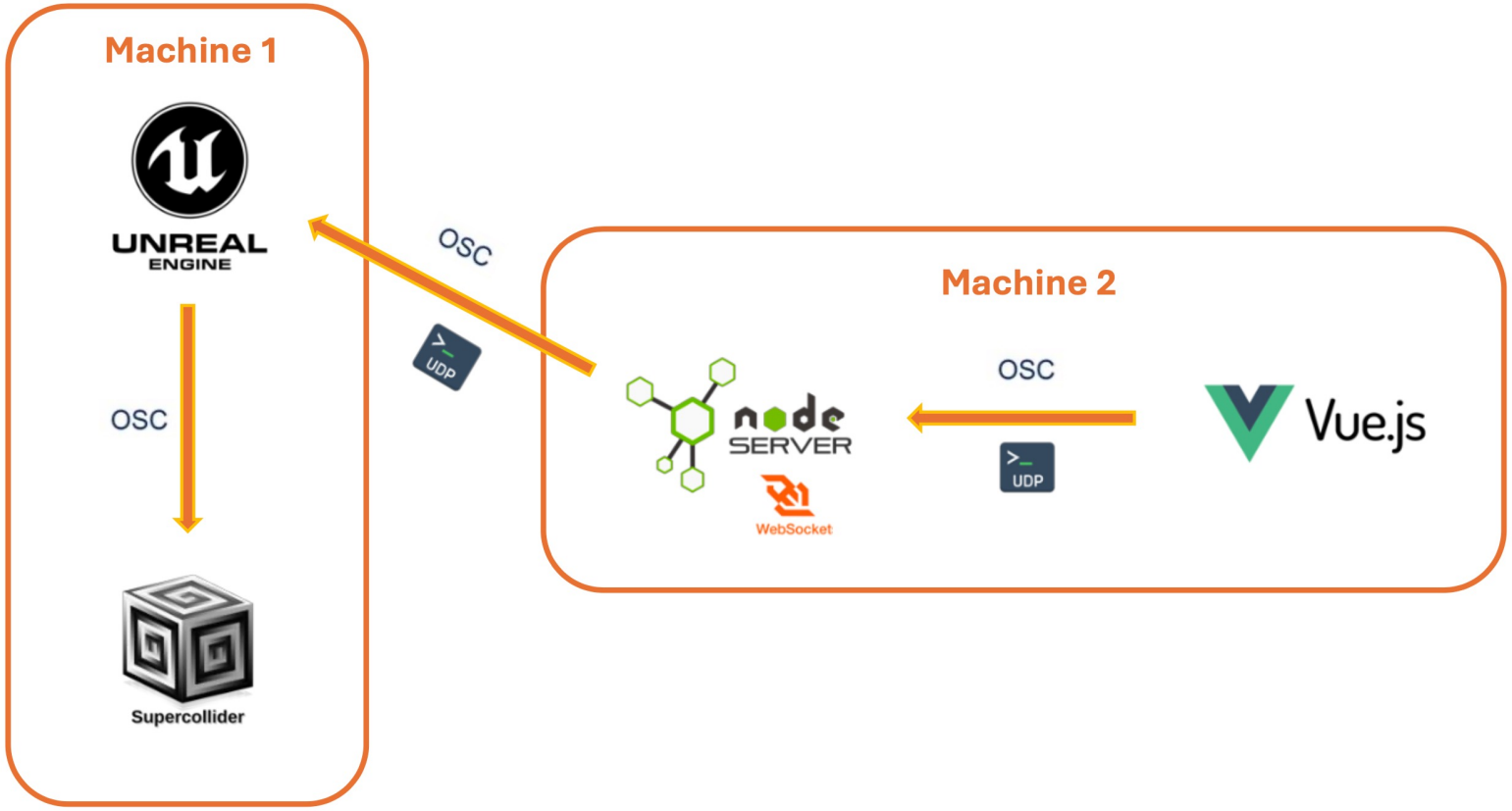
Architecture

Single Machine



Architecture

Separate Machines



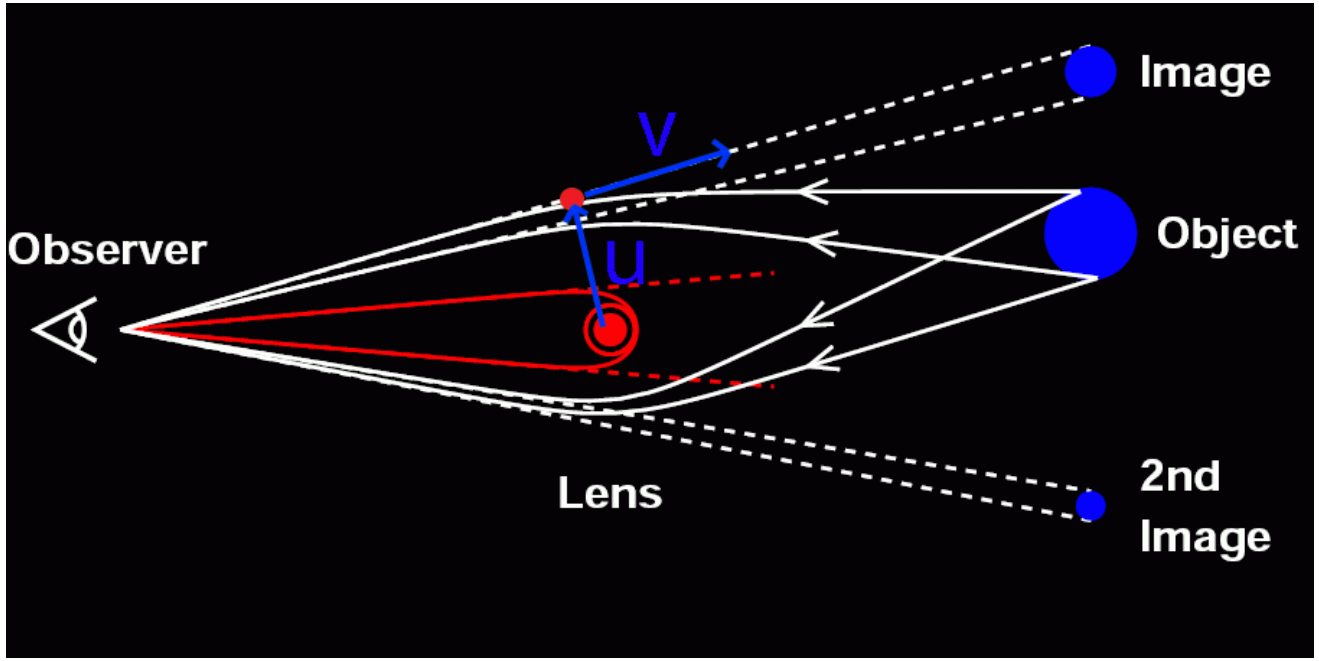
Black Hole Rendering

Implemented as a custom **shader** inside Unreal Engine

- **Ray Marching** technique
- Scene inside a sphere covered by sky space texture

Gravitational Lensing – simplified model

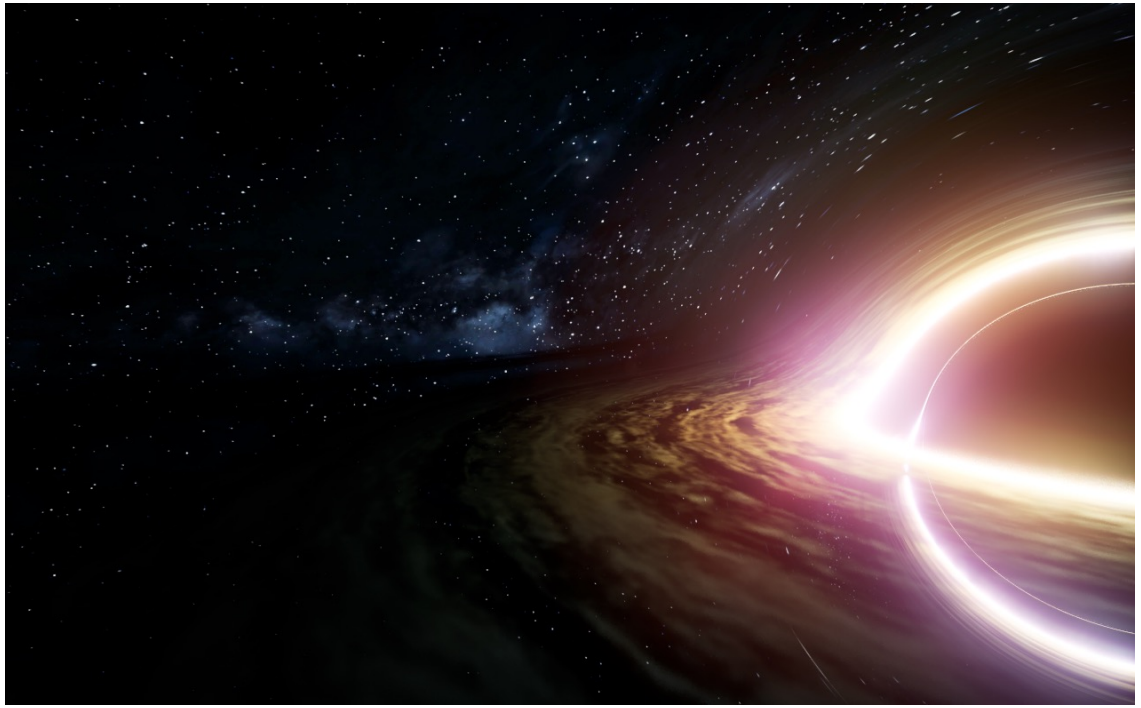
$$\vec{F} = \frac{-3M\left|\left|\hat{u} \times \hat{v}\right|\right|^2}{\left|\left|\vec{u}\right|\right|^2}\hat{u}$$



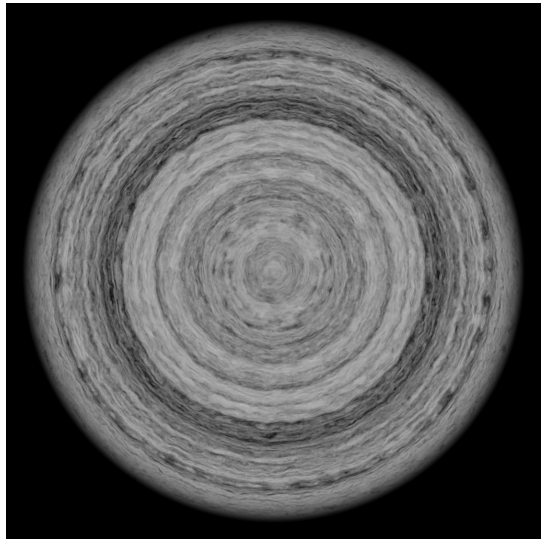
Black Hole Rendering

Accretion Disk – Rendering Process

- Check intersection with disk region
- Compute **density** using pre-defined texture
- Compute light intensity using **square roll-off**
- Compute shadow (light absorption) using **volumetric ray-marching**
- Sum contribution of **disk** and **fog layer**



Disk texture



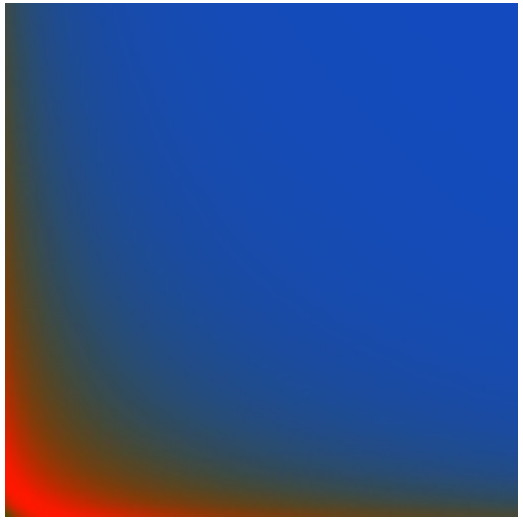
Black Hole Rendering

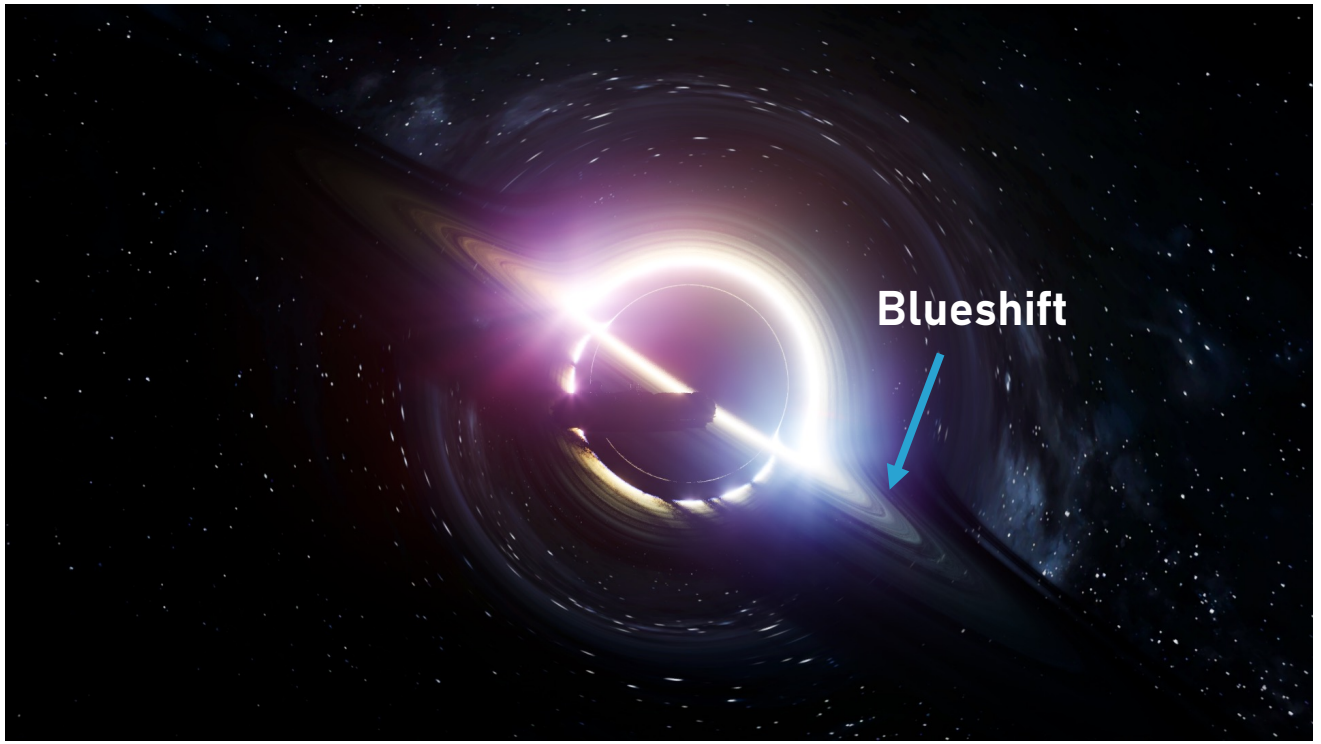
Accretion Disk – Color

Color is determined using a **black body radiation** map

- Sample according to temperature and frequency shift
- Temperature decreases with distance
- Frequency shift due to motion (**doppler effect**)

Blackbody radiation map





Generative Music

Everything implemented using **SuperCollider**. The **OSC** communication protocol makes it communicating with Unreal Engine.

The main goal is to **emulate sci-fi music in a generative fashion** while maintaining a certain grade of control on the algorithm.

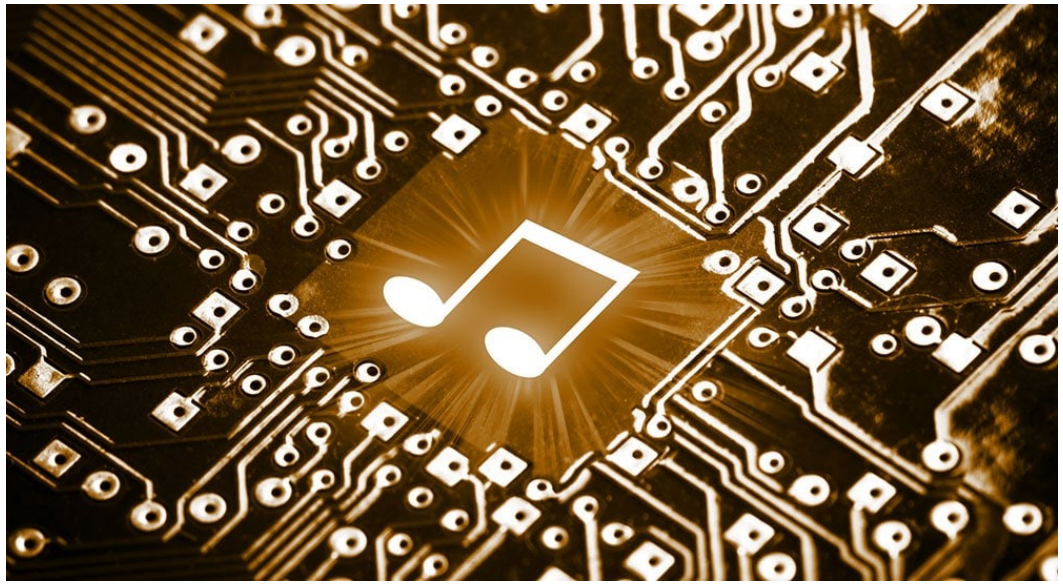
The aim of this algorithm is to **enlighten the vastity of the universe and the immense power of a black hole**.

Generative Music

Different kind of synthesis:

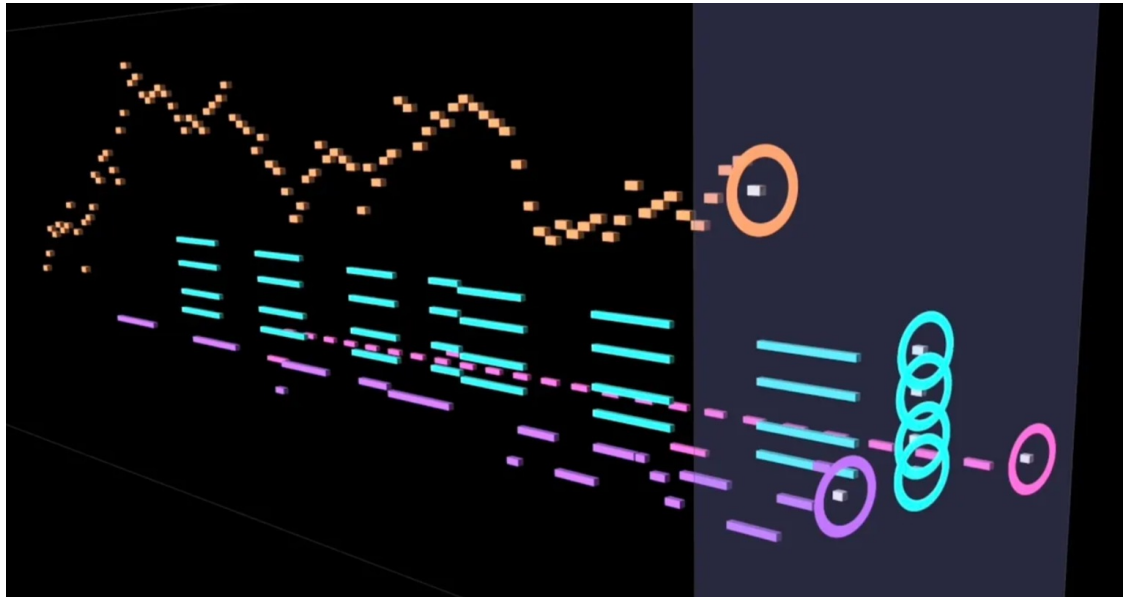
- **Subtractive** (main background)
- **FM** (modulated FX and "particle noise")
- **Wavetable** (Ringing sounds)
- **Digital Waveguide** ("gusts of wind")

All the synths are processed by a **reverb** effect which also provides **companding** and **limiting functionalities**.



Generative Music

Fundamental frequencies are picked up from a more restricted set of values while all the other parameters are randomly generated within a pre-established range. All the sounds are generated regularly in time with a minimum grade of randomness.



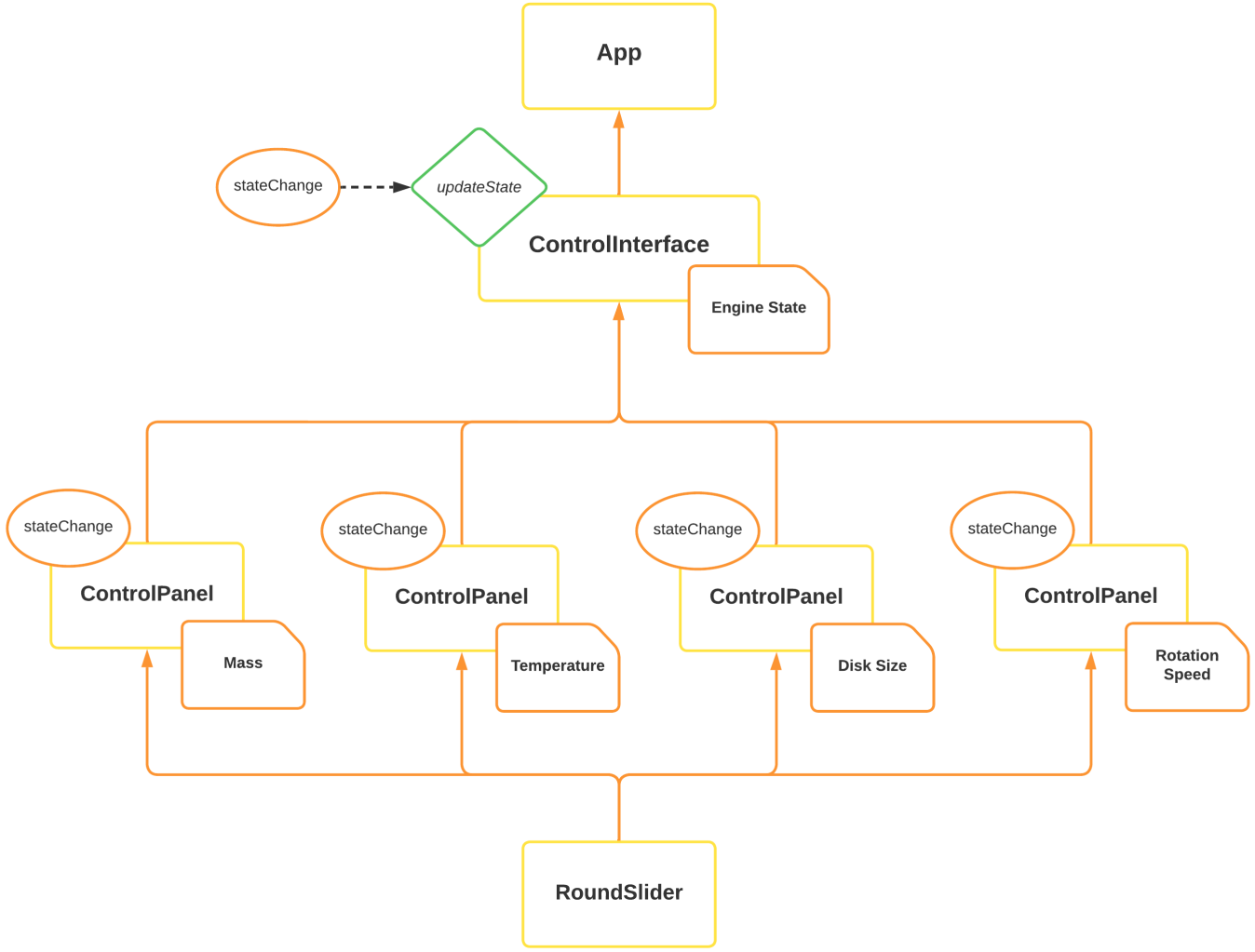
Parameters from the physical simulation influence the soundscape:

- **Mass**: low frequencies amplitude
- **Temperature**: "particle noise" amplitude
- **Disk Size**: mid frequencies amplitude
- **Rotation Speed**: high frequencies amplitude
- **Distance**: FXs amplitude and rate of occurrence

Web Application

Vue App

Web App Architecture



Engine State

```
14  export default {
15      name: 'ControlInterface',
16      components: {
17          ControlPanel
18      },
19      data() :{engineState:  {
20          return {
21              title: 'OBLIVION',
22              engineState: {
23                  mass: {
24                      name: 'Mass',
25                      label: 'mass',
26                      unrealLabel: 'Mass',
27                      value: 5,
28                      min: 1,
29                      max: 20,
30                      step: 1,
31                      display: 'up'
32                  },
33  >               temperature: {name: 'Temperature'...},
43  >               diskSize: {name: 'Disk Size'...},
53  >               rotationSpeed: {name: 'Rotation Speed'...}
63              }
64          }
65      },
```

The global state of available parameters is defined as an object, named **engineState**, in the **ControlInterface** component within its data function.

This object holds on its turn multiple objects, one for each parameter control displayed within the GUI.

Each one of these objects is passed as a property to the corresponding ControlPanel instance (child component) for initialization of its round slider.

POLITECNICO MILANO 1863

Engine State Update

v-model directive automatically updates the **internal state** of the single **ControlPanel** component.

A **Vue Watcher** is employed for each instance to emit **stateChange** custom event that is dispatched to the parent whenever the user modifies the single parameter value.

ControlInterface.vue | ControlInterface.js | ControlInterface.css | ControlPanel.js

```
32      watch: {
33          value() : void  {
34              //console.log(this.name + ' changed:', this.value);
35              this.$emit( event: "stateChange",  args: {label: this.label, value: this.
36          }
37      }
```

ControlInterface.vue | ControlInterface.js | ControlInterface.css | ControlPanel.js

```
66      methods: {
67          sendOSCMessage(update) : void  {
68              osc.open();
69              const message : Message  = new OSC.Message( address: '/' + update.unrealLabel, update.value);
70              osc.on( eventName: 'open',  callback: () : void  => {
71                  osc.send(message);
72                  //console.log('Message Sent!');
73              });
74          },
75          updateState(update) : void  {
76              this.engineState[update.label].value = update.value;
77              update.unrealLabel = this.engineState[update.label].unrealLabel;
78              //console.log(this.engineState[update.label].name + " updated: ", update.value);
79              this.sendOSCMessage(update);
80          }
81      }
```

ControlInterface.vue | ControlInterface.js | ControlInterface.css | ControlPanel.js

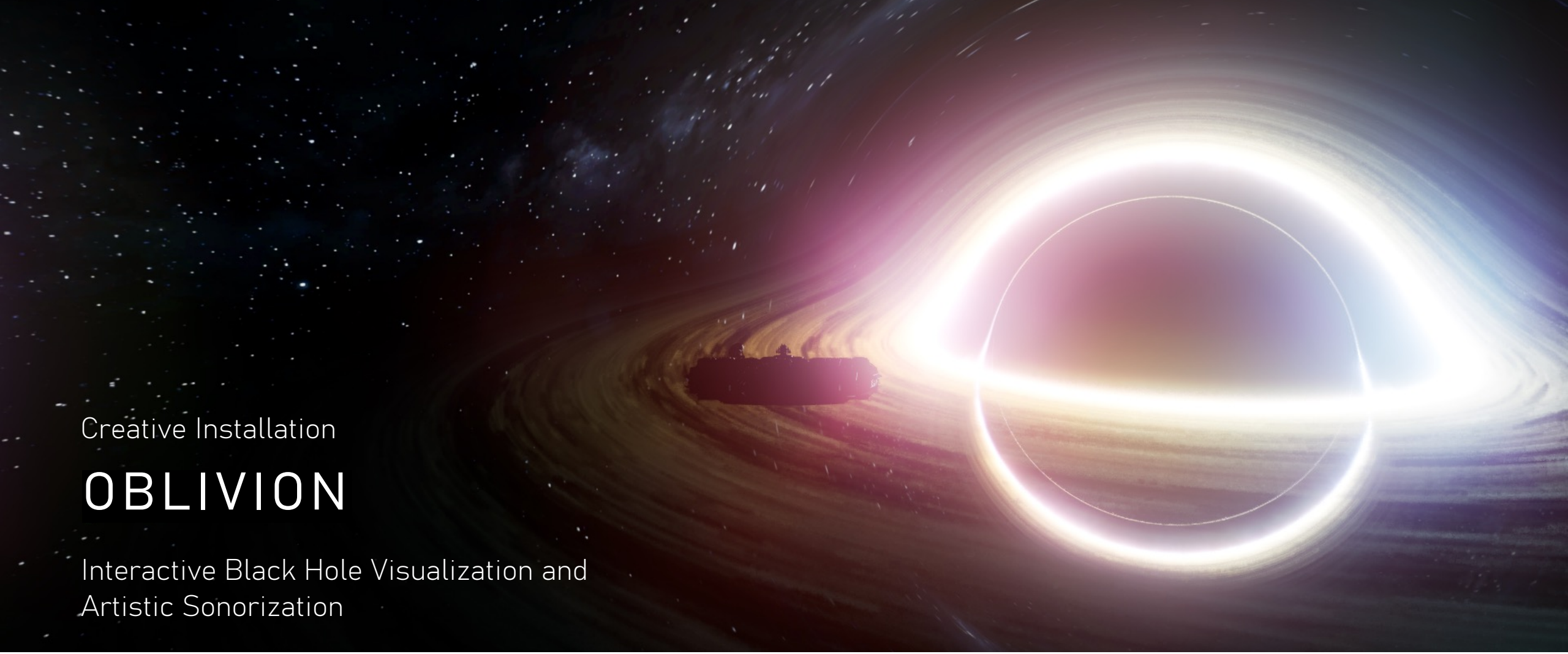
```
4       <div id="control-panel" class="flex-container-column">
5         <div class="controls-wrapper flex-container-row">
6           <div class="control-box">
7             <ControlPanel
8                 :controlParam="engineState.mass"
9                 @stateChange="updateState"
10            />
11          </div>
12          <div class="control-box">
13            <ControlPanel
14                :controlParam="engineState.temperature"
15                @stateChange="updateState"
16            />
17          </div>
18        </div>
```

OSC Communication over UDP

The **OSC Communication** between the **Web App** and **Unreal Engine** was implemented through a **Node WebSocket Server** listening to OSC Messages coming from an **OSC WebSocket Client** running within the Vue App.

OSC Messages are then **broadcasted over UDP** to the receiver, which could run on the same machine or on a remote one.


let's jump into Space!



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THANK YOU!

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ENGINEERING

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