

# Exploring Large-Scale Scientific Data in Virtual Reality

Investigating methods for data transfer, interaction, and manipulation in virtual reality.

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## ABSTRACT

The conventional method of data exploration primarily relies on 2D and 3D visualization tools. However, with the advent of lower-cost virtual reality (VR) hardware, a transformation is underway. This study presents a novel data pipeline developed from ParaView to Unity Game Engine to investigate this transition. Specifically, we apply Virtual Reality technology to the exploration of particle-based scientific datasets, focusing on data generated by a Hardware/Hybrid Accelerated Cosmology Code (HACC) simulation.

This project applies VR to the identification of patterns and clusters within HACC particle-based datasets. We enable effective user interaction by integrating VR into the broader field of large data exploration, which includes features like data interaction, manipulation, and in-depth analysis. We implement custom interactions to enable interrogation of underlying data streams to provide deeper insight.

## MOTIVATION

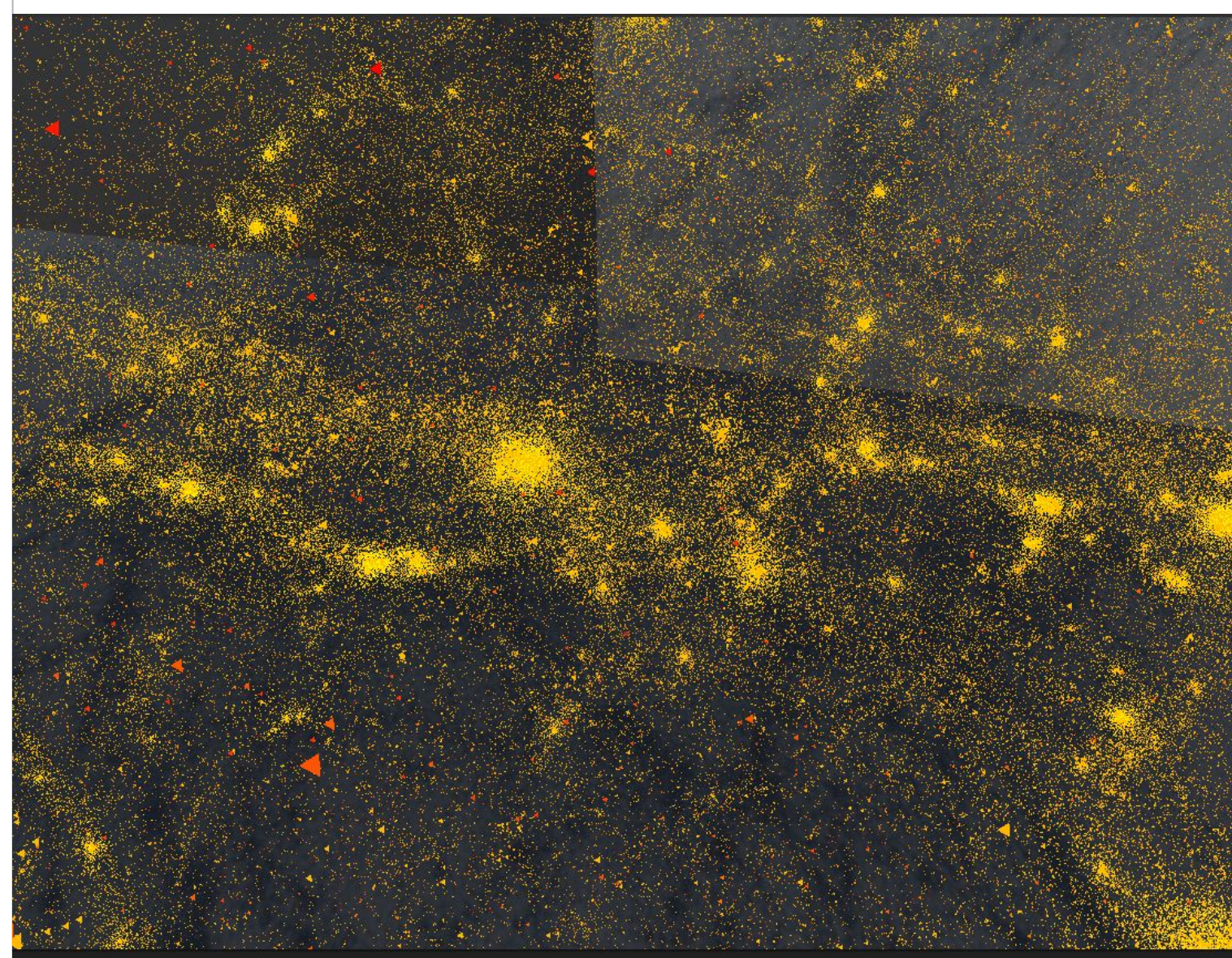
- This project aimed to develop a seamless pipeline for loading large scale scientific data into virtual reality.
- ParaView to Unity Gaming Engine
- Data interaction for in-depth analysis
- Goal: To create a virtual environment that imports scientific data of any format, represents it accurately, and allows immersive interaction to aid in identifying patterns and clusters.

## METHODS

- The process involves using a Python module to read HACC's Generic I/O files (.gio), perform extraction and filtering, then export as a format to be imported in Unity.
- Develop a technique for analyzing time varying HACC data.
- Implement a Dynamically loaded library (DLL) in C for a more efficient import process
- Represent Halo data with a sphere prefab

## Results

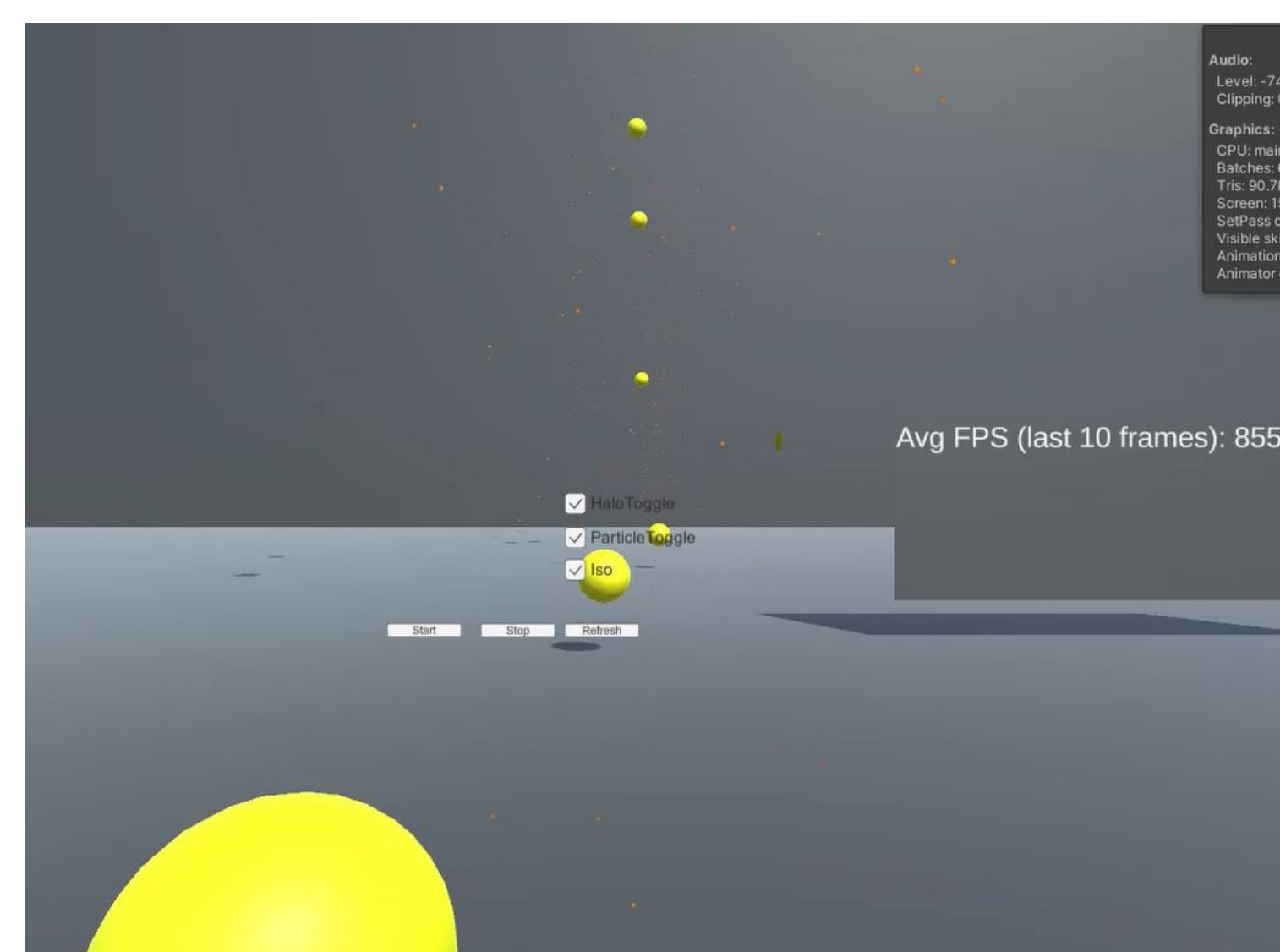
This project used three different data representations: Particle data, Halo data and Isosurface data. Due to the uniqueness of each data type, they had to follow different import methodology to ensure VR compatibility, proper data representation and preservation. The images shown below are the results of successful implementations.



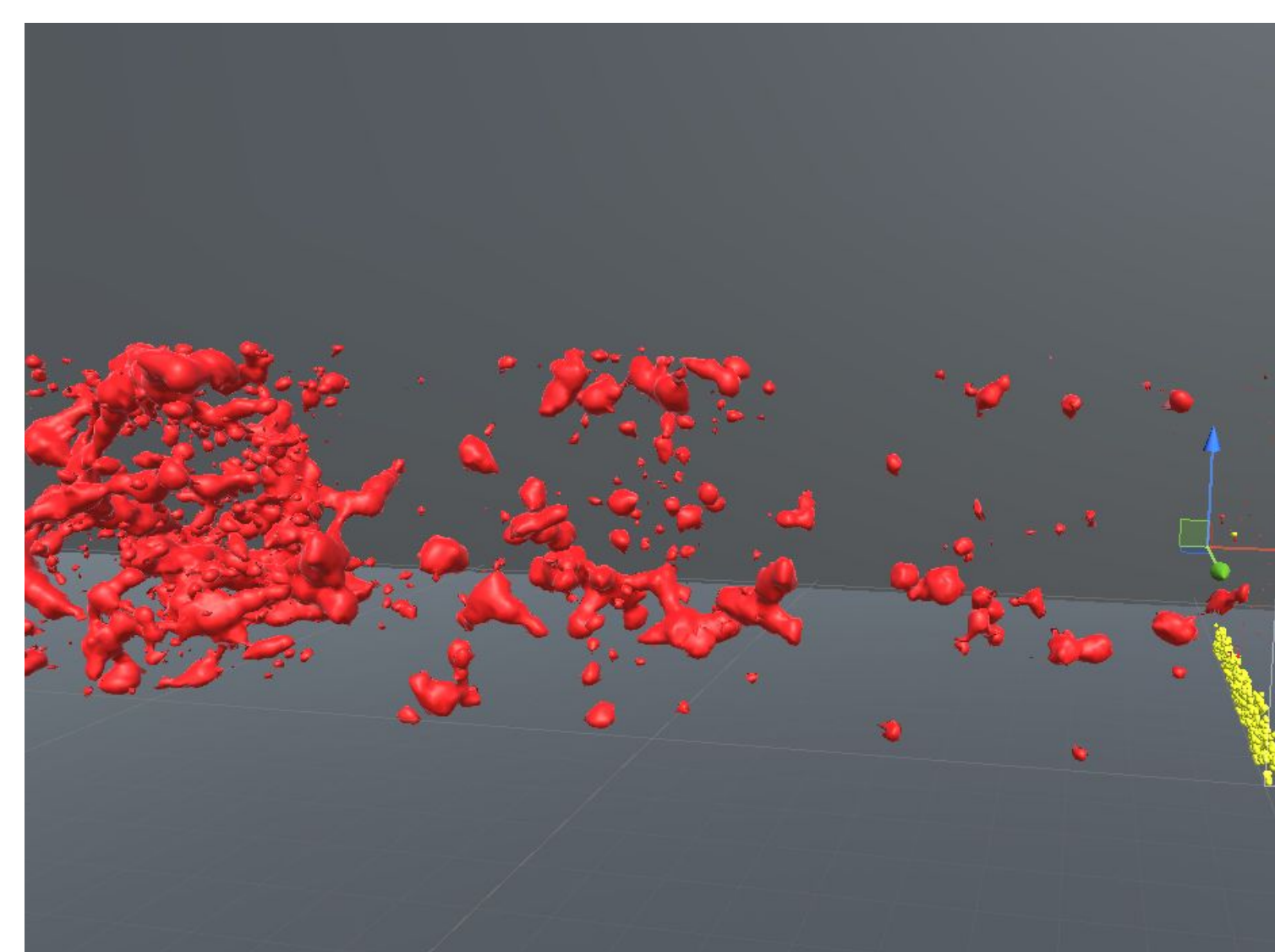
Particle Data - Headset view



Particle Data - Desktop view



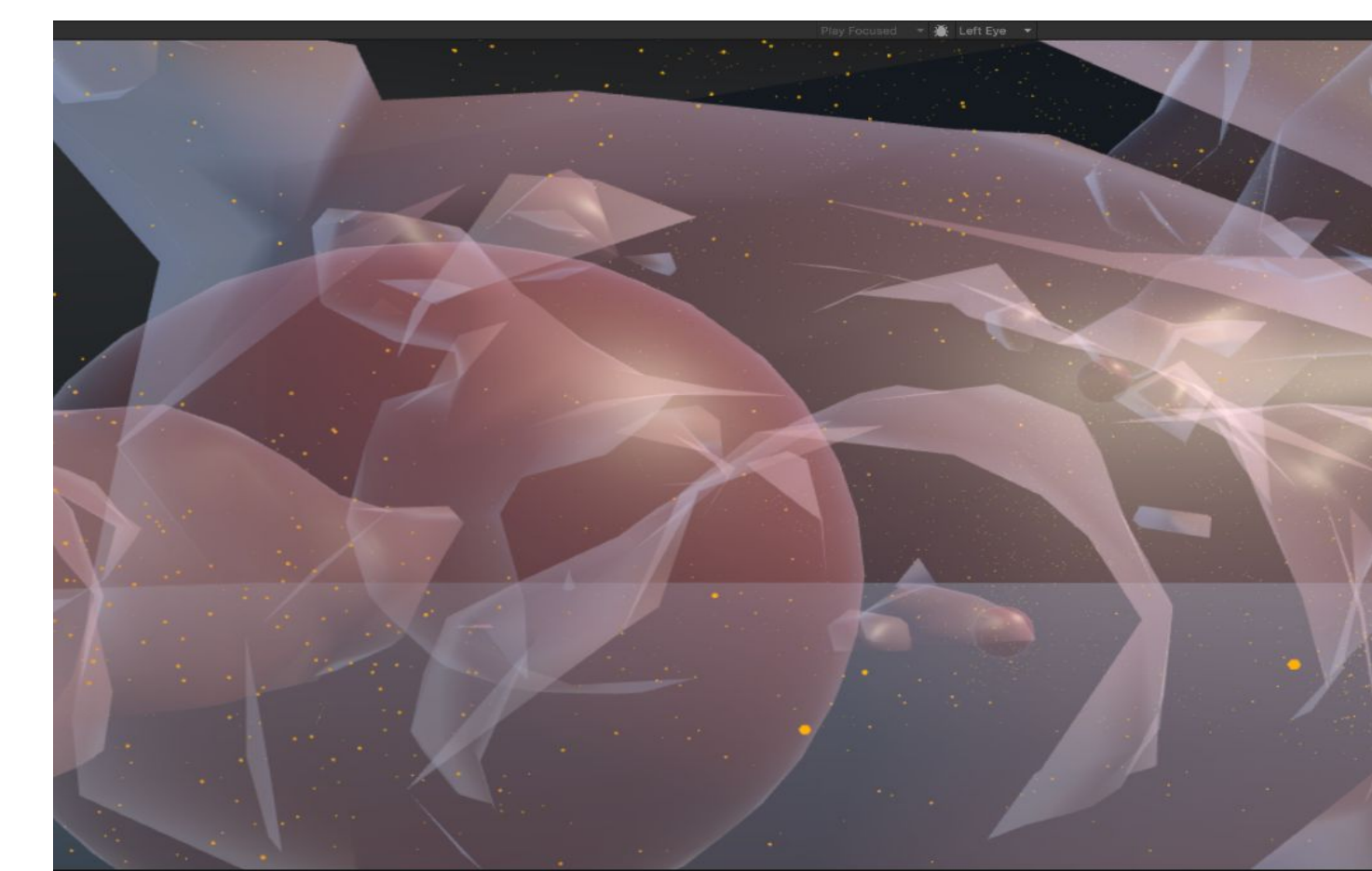
Halo Data - Desktop view



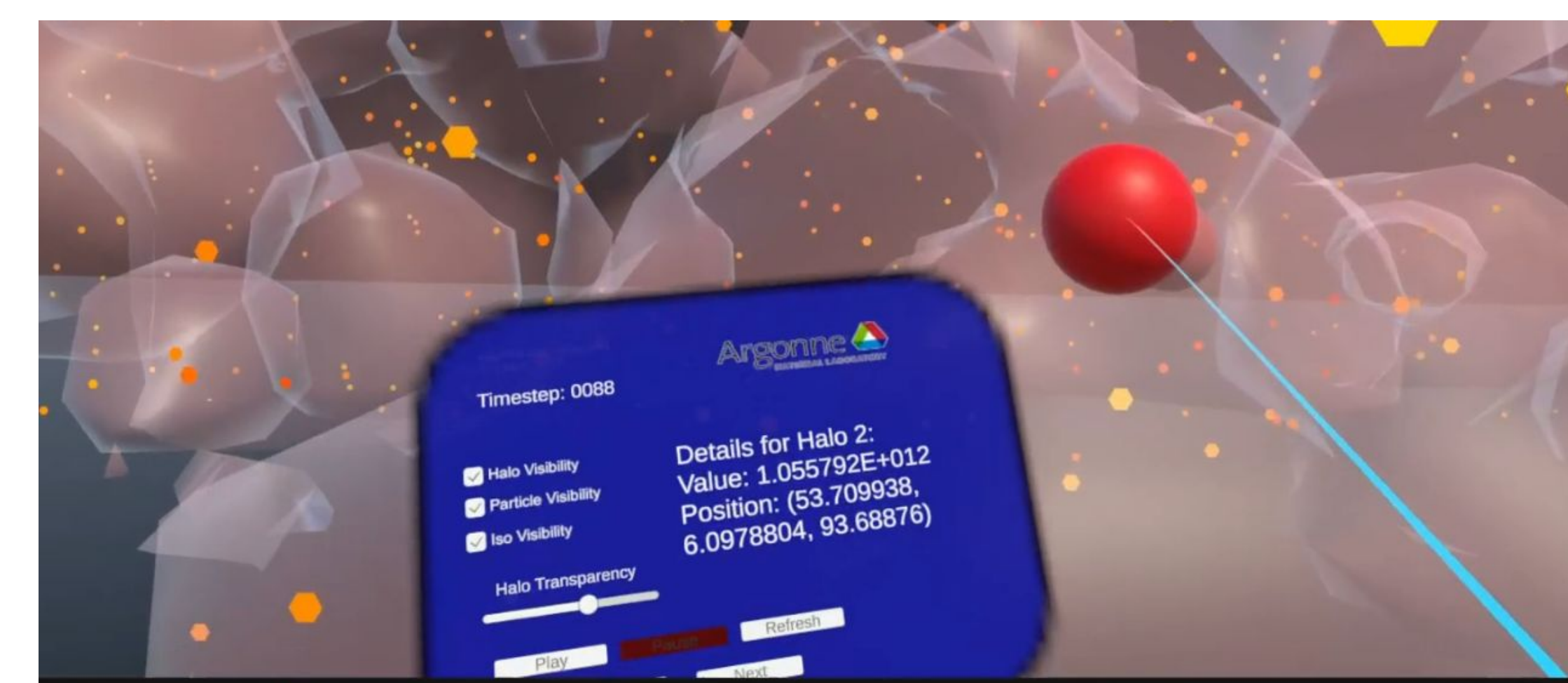
Isosurface Data - Desktop view

## Results

This project was further developed to add Halo interactions where each individual sphere that represents a Halo can be queried to get details on that particular Halo. There is an inclusion of toggles that handles the visibility of each data type to provide an avenue to focus on one data type at a time. To further aid visibility, a transparency slider is included to adjust the opacity of the sphere prefab to enable users to view the inside of each Halo representation. Overall, this project provides improved VR interactions that enables an efficient and immersive way to interact with data in virtual reality.



All Data representations in a Scene



Halo interaction

## Discussion

- The process of getting the three data types together in a scene was successful.
- The project continues to evolve, aiming for more formats, framework enhancements, and integration with other headsets.

## Future work

- Direct import for .gio files into Unity
- Additional format testing
- Web version of the project
- Additional Halo interactions such as Halo mergers and tracking
- Meta Headset build

## REFERENCES

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