Virtual Beamline - VR, WebVR, and AR Applications for Laser Research

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1. Introduction

Since the expansion of virtual and augmented reality, it is recognized that these immersive technologies can play important role in industrial and research environments. Therefore ELI Beamlines, European laser research centre, has been developing tool called Virtual Beamline (VBL) that represents set of interactive 3D web and virtual reality applications for complete contextual virtual simulation of its facility and research.

2. Development of Virtual Beamline

Development of the VBL is an ongoing long term project. This demo paper introduces three significant parts of its current stage and results. The implementation is undertaken in parallel on two real-time 3D platforms: Unity 3D and WebGL.

2.1 Virtualization of Research Infrastructure

Key component of the VBL is detailed virtual model of our research infrastructure - five large experimental halls located in the basement of the facility. Each hall is dedicated to different area of physics research and contains unique instruments and systems for conducting experiments (see **Figure 1** and **Figure 2**). In order to provide fully-detailed virtual model for use in real-time 3D applications a complex workflow for transferring, processing, and optimization of extremely large CAD datasets had to be implemented. A combination of automated and semi-automated steps with manual processing in 3Ds Max gives us resulting highly-optimized virtual model without losing any details. Currently, it consists of 6 600 objects, of which around 1 200 are unique. Even though this results in total of 60M triangles, our current Unity 3D application runs at 60 fps on PCs with VR-ready GPUs.

For integration of this model into WebGL application, we have implemented MeshLab server solution for generating up to five Level of Detail (LOD) models for each entity. Combined with custom-developed backend and frontend solutions our current prototype can display the entire model at high frame rates.

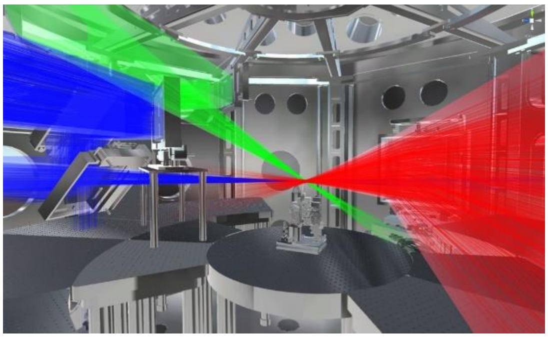

Figure 1. (Left) Experimental Hall 5, Unity VR scene
Figure 2. (Right) Setup of experiment with three laser beams, Unity VR scene

2.2 Visualization of scientific simulations

We have developed 3D interactive web application for real-time animated scientific visualization based on WebGL 2.0. This application runs in a regular web browser and it utilizes VR mode to offer scientists completely new point of view of their simulations.

Our data come from large scale simulations of interactions of ultra-intense lasers with plasma, computed on a several thousand CPU core cluster. Such a simulation traces the behaviour of billions of charged elementary particles over thousands of time steps, generating up to terabytes of data. To display it in real-time on the web, we reduce the data to several GB, by pre-processing them in a node.js script without reducing the number of particles, then we pass them in a binary format to a custom-built WebGL 2.0 solution which renders them on the GPU. Thanks to this optimization process the application maintains 60 fps performance. The **Figure 3** shows visualization of one of the largest datasets. Its original size was reduced from 1TB to approximately 4 GB. Among other layers it contains 100 million points in 400 animation frames.

The application includes display of orthogonal views, textual and numeric information, graphical user interface containing timeline animation controls, as well as additional graphical elements based on D3.js for plotting of graphs and legends.

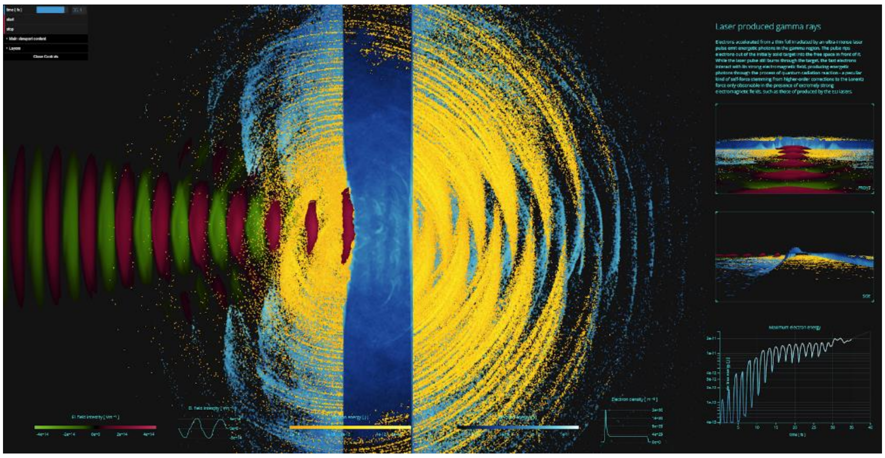

Figure 3. Visualization of dataset containing simulation of laser produced gamma rays

2.3 Augmented reality

Setups of laser-matter experiments can also be visualized in our prototype smartphone augmented reality application. It features our largest interaction chamber - Plasma Physics Platform with a diameter of 4.5 meters. Users can place detailed model of the chamber on surfaces detected by the ARCore platform and switch between several different setups of experiments. Using touch input users can scale the chamber down for placement on tables, reposition it on the surface, and disable the display of the chamber shell to have open view of the layout of the experiment.

3. Future work

Our vision is to optimize and combine all current and future VBL parts into a single 3D web application. This application should help users to design, configure, simulate, and interactively visualize experiments before arriving to the facility. Next, it should serve for analysis and education when allowing access to layouts and results of already conducted campaigns.