The Virtual Environment for Neutrinos

Marco Del Tutto
24th July 2022
Snowmass 2022 - Seattle
VENu is an event display for the MicroBooNE experiment. It was developed mainly between 2015 and 2018 (I will talk about this). Today, it is being upgraded and ported to other experiments.

- MicroBooNE is a neutrino experiment at Fermilab.
- The neutrino detector is a Liquid Argon Time Projection Chamber.
- VENu allows users to virtually go inside the detector.
Goals of **MicroBooNE**:  
- low-energy excess observed by MiniBooNE  
- SBN search for sterile neutrinos with 5σ sensitivity  
- ν-Ar cross section measurements  
- R&D for future LArTPC experiments
MicroBooNE

Cathode Plane

Liquid Argon TPC

Charged Particles

Incoming Neutrino

$E_{\text{drift}}$

8192 wires (3 mm pitch)

170 ton LArTPC (total mass)

32 8” Cryogenic PMTs

MicroBooNE

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Fermilab
What is it?

VENu... ...is built and rendered in a 3D environment
VENu...  ...displays actual neutrino interactions from the MicroBooNE detector
What is it?

VENu runs on smartphones
VENu... ...is a multi-platform event display

Desksops  Smartphones  Web
What is it?

VENu... is a mobile app

iOS

Android
VENu... is designed to exhibit both augmented and virtual reality features.
Google Cardboard
**Google Cardboard**
Uses smartphone for display, rotating tracking and processing

**Oculus Rift**
Tracks lateral motion of the head
Tracks the position of motion controller
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Oculus Rift
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- We have an Oculus Rift version of VENu
- Needs a powerful computer to run
- Currently used in outreach events
- But not portable
VR

**Google Cardboard**
Uses smartphone for display, rotating tracking and processing

**Oculus Rift**
Tracks lateral motion of the head
Tracks the position of motion controller

- Can be paired with many of the smartphones available on the market
- Portable
- Not expensive (can be used as gadget)
- Limited by smartphone performances
Why?

50% Characterize scientists as secretive

55% Believe science is too specialized for them to understand

From “Public Attitudes to Science” 2014, UK Government
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From “Public Attitudes to Science” 2014, UK Government
• Connections with the general public;

• The educational game included in the application will allow young people to hunt neutrinos and to learn more about them in a fun environment;

• To offer a tool for neutrino physicists to interact with the public while describing their research.
Development

How did we do it?
We used Blender to render the detector geometry.

Blender is an open-source 3D modeling software, that imports easily into Unity.
Development

We built VENu using the Unity game engine
Development

The data from the MicroBooNE detector are processed in a simplified json format.

They are then transformed into Unity prefabs.

defines in Unity are assets that allow to store a game object (like a particle trajectory)
Development

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prefabs in Unity are assets that allow to store a game object (like a particle trajectory).

All code available on GitHub!

https://github.com/VENuProject
History

- **December 2015** first idea to develop VENu for smartphones
- Development...
- **October 2016** testing among MicroBooNE collaborators
- **November 2016** testing with students at Arnold Matthew School (Oxford)
- **December 2016** website construction
- **January 2017** launch!
- **Up to now** outreach events
The Menu

Main Menu

- Display
- Game
- Vuforia
- Learn
- Feedback
- Credits
The Menu

Main Menu

Display Menu

Display

Game

Vuforia

Learn

Feedback

Credits

Simulation

Display

Cardboard

Real Events

Display

Cardboard

Back
The Display
The VR Mode
The Learning Sections

Learn Menu

What are neutrinos?
Where do neutrinos come from?
How to make a neutrino beam
Neutrino interactions
What is a cross-section?
Cosmic rays

Learn Section

Where do neutrinos come from?

Neutrinos were first produced in the universe some 14 billion years ago, 10 to the -43 seconds after the Big Bang. A mere second later, they were already rapidly moving away from the rest of the hot and dense primary particle soup; scientists are still seeking to detect these neutrinos that survive from the Big Bang. So far, only two sources of extraterrestrial neutrinos have been observed: the sun and supernovae.
All starts with a neutrino beam produced at Fermilab...
The Game

Clicking on the neutrino-induced track

Congratulations! You found the neutrino event!
Who was engaged?

Downloads mainly from UK, USA, Canada, Italy, France, Germany, Australia, Switzerland, China, and India.
Who was engaged?

More than 5000 downloads!

> 1k Android downloads (score 4.9/5)
> 4k iOS downloads, 273k impressions (score 5/5)
What now?

VENu has been used for outreach events at Fermilab and in many other institutions (Oxford, Bern, Columbia, …)

We are working on upgrading the app and making it available also for other experiments
Custom Cardboards

We designed custom Google Cardboards
Stargazing, Oxford University, 28 January 2017
Chicago Science Festival, 20 May 2017
Conclusions

Website: venu.physics.ox.ac.uk

The app is currently undergoing maintenance and has been temporarily removed from the stores.
It will be available soon!
MOBILE APP, CARDBOARD VERSION AND GAME
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