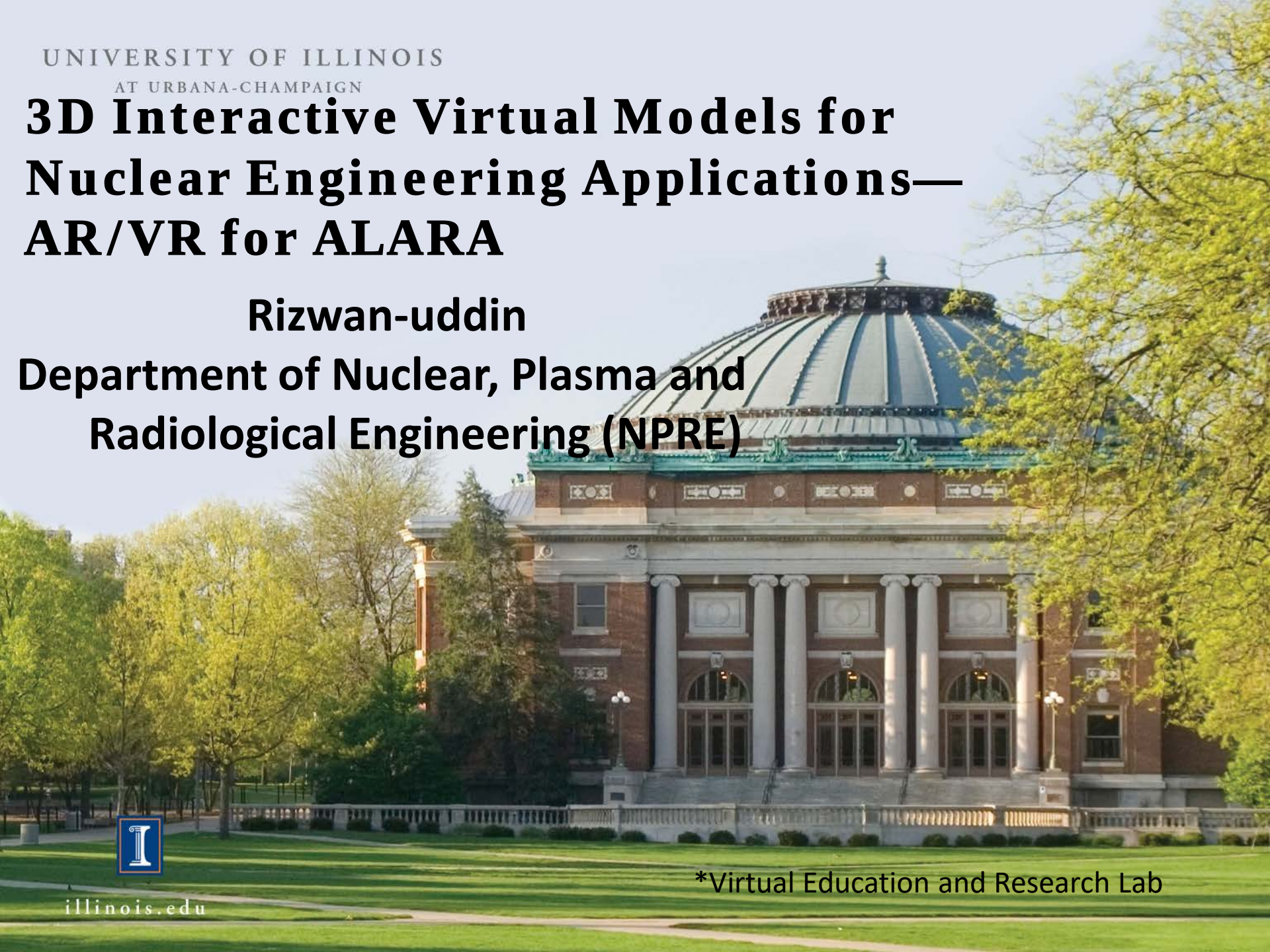


UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

3D Interactive Virtual Models for Nuclear Engineering Applications—AR/VR for ALARA

Rizwan-uddin

Department of Nuclear, Plasma and Radiological Engineering (NPRE)

*Virtual Education and Research Lab

illinois.edu

A talk given at
ISOE NATC PEP
(Professional Enrichment Program)
January 7, 2018

Theme

Doing More with Less: Embracing New Technology to Achieve ALARA Excellence in Outage Work Management & Efficiency/Cost Savings

(Drones; Driverless cars; IoT; and … VR/AR)

Virtual Education & Research Lab at NPRE at the University of Illinois

- Goals span research, teaching, service and outreach.
- Tools used are innovative and mostly computer based.
- Applications are in nuclear as well as other energy systems
- *Modeling and Simulation* is the common theme in (almost) all of our projects.
  - Fundamental advances in numerical methods;
  - Advanced modeling and simulation of different aspects of scientific and engineering problems;
    - Turbulence models for porous media
    - Lattice Boltzmann Method for two phase flow
    - Coupled neutronics/thermal-hydraulics modeling of nuclear systems
    - Coupled CFD/system-code analysis of nuclear systems
    - Fuel cycle analysis
    - Modeling of nuclear fuel
- **Virtual, 3D models for training, education and outreach**

Students and colleagues who have worked on various aspects of VERL projects

Allen Toreja*	Daniel Rock	Fei Wang
Yuxiang Gu	Quan Zhou*	Prashant K. Jain*
Suneet Singh	Federico Teruel	Jianwei Hu
Jeff Cardoni	Imran Haddish	Xi Chen
Hsingtzu Wu	Huang Kai	Yizhou Yan
Nick Karancevic	J'Tia Taylor	Stefano Markidis
Ye Li (Gary)	Gavin Mattingly	Eric Riewski
Justin Joseph	Quansheng Tan	Daniel Chun
Zahra Hanifah	Arnav Das	

* Winner of the American Nuclear Society's Mark Mills Award for Best Research of the Year by a graduate student

Funding has been largely from the DOE and NRC.

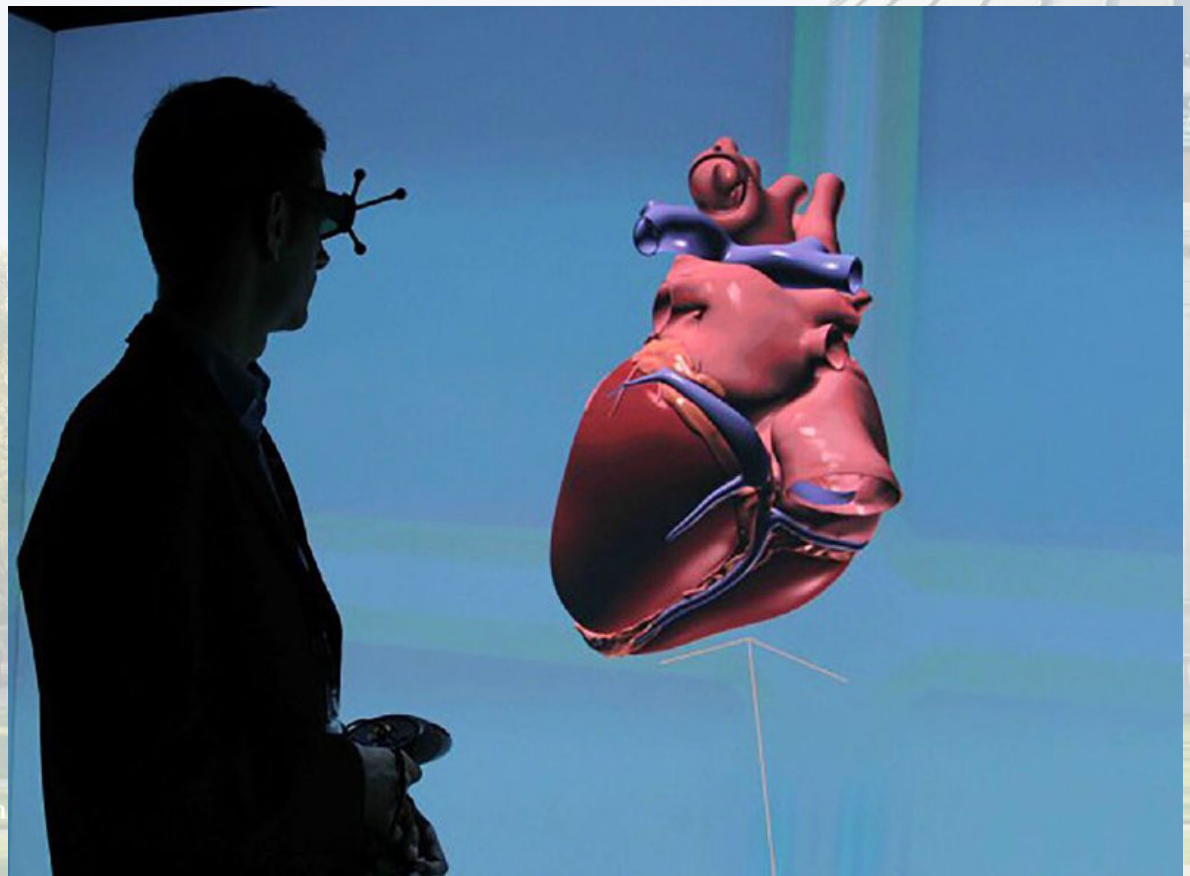
The Future Of Cardiology Will Be Shown In 3-D

MAY 22, 2015 3:41 PM ET

CHRISTINA FARR

http://www.npr.org/sections/health-shots/2015/05/22/408810461/the-future-of-cardiology-will-be-shown-in-3-d

A 3-D simulation of a human heart created by The Living Heart project.



Contents

1. Motivation
2. History
3. Software and Hardware
4. Capabilities and Features of Virtual Models (Labs, workspace, ...)
5. Process of 3D Modeling
6. Demonstration of Virtual Education, Training and Testing
7. Conclusions

Innovative Training Tools for Improved Human Performance (1 of 2)

- Training in and around nuclear facilities is often a challenging task.
- Factors such as radiation levels as well as likelihood of hindering ongoing operations make it difficult to carry out training at actual sites.
- Traditional methods of repeating a task over and over again also cannot be realistically employed in many operating facilities.
- However, a good 3D view of, and some form of interactivity with, the actual system can help in effective and efficient training.

Innovative Training Tools for Improved Human Performance (2 of 2)

- Training of contract workers
- Training of regular work force; for a new environment
- Optimization of a procedure in a hazardous environment for ALARA
- Optimization to minimize time
-

Driving Force:

A convergence of need and several recent technological breakthroughs
have led to the rapid development in the games-for-training and
games-for-education fields

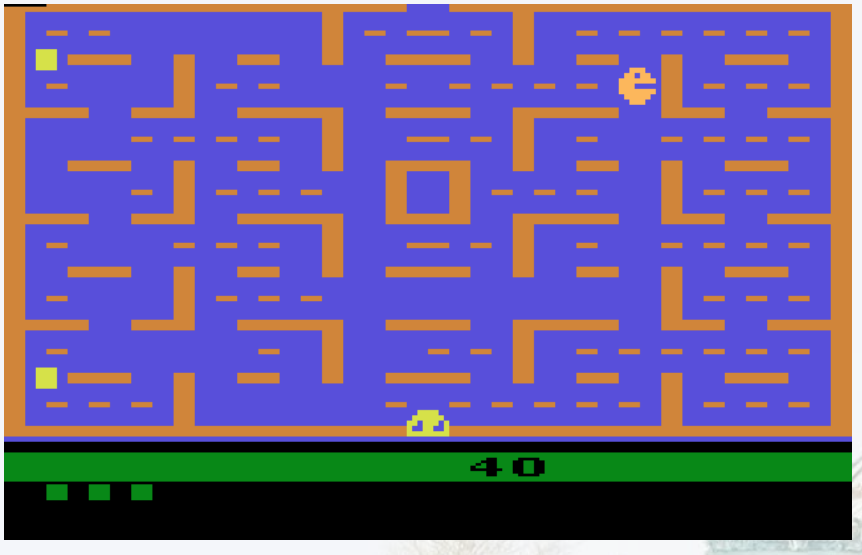
History

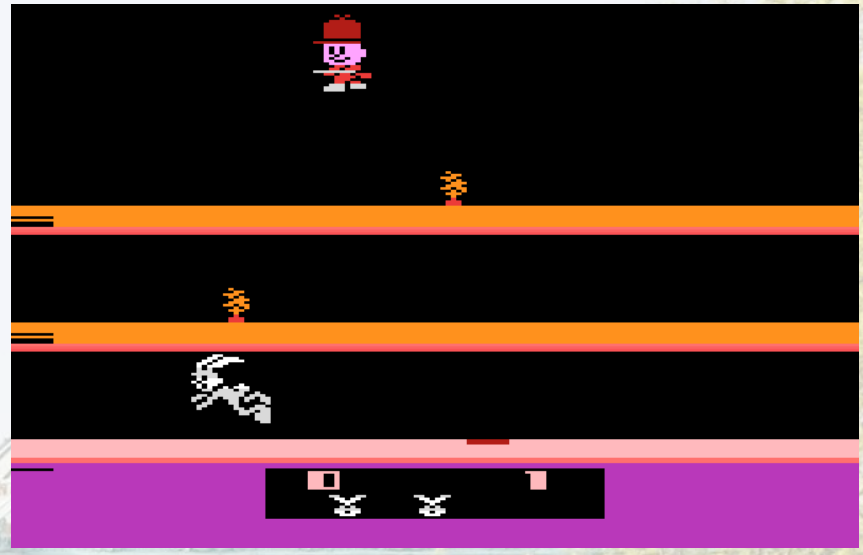

SCHOOL.FAILBLOG.ORG


Who is that?
BACH!

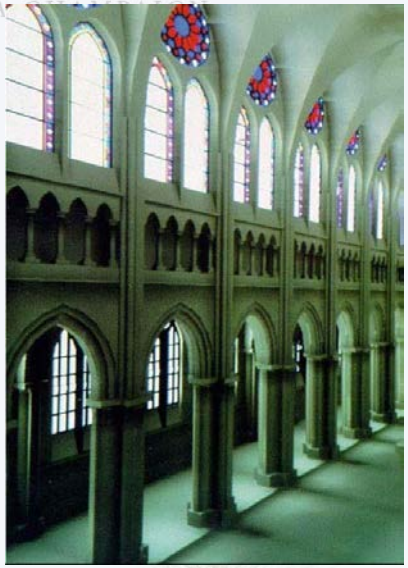

COURSE TECHNOLOGY
CENGAGE Learning
Professional • Technical • Reference
THE
MULTIPLAYER
CLASSROOM
Designing Coursework as a Game
Lee Sheldon

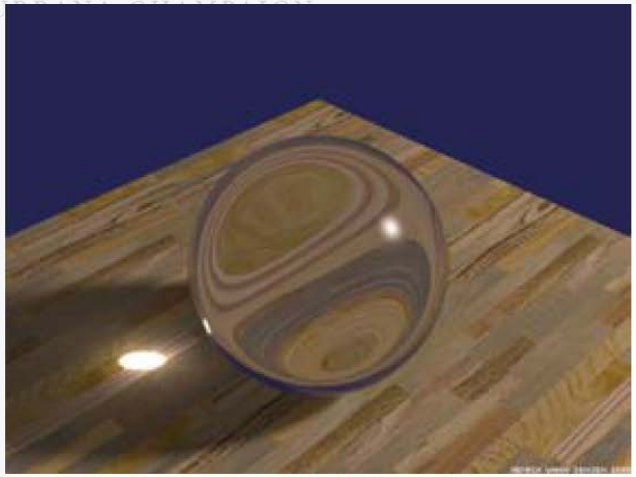
Memory Lane .....

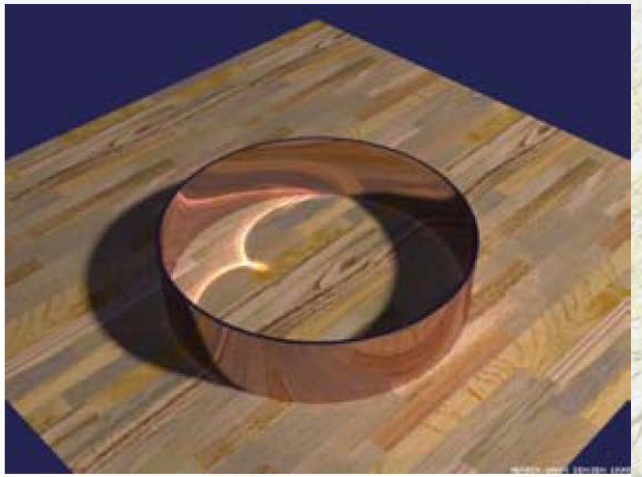




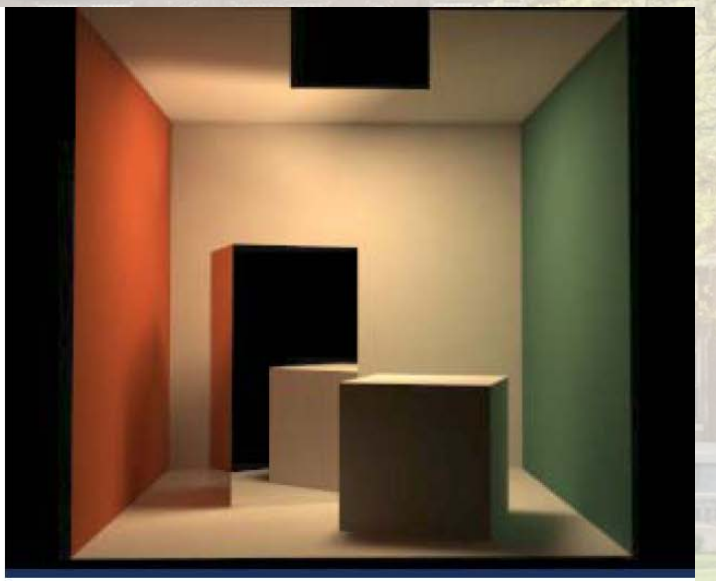

DOOM 3
doom3.com
ACTIVISION.
id







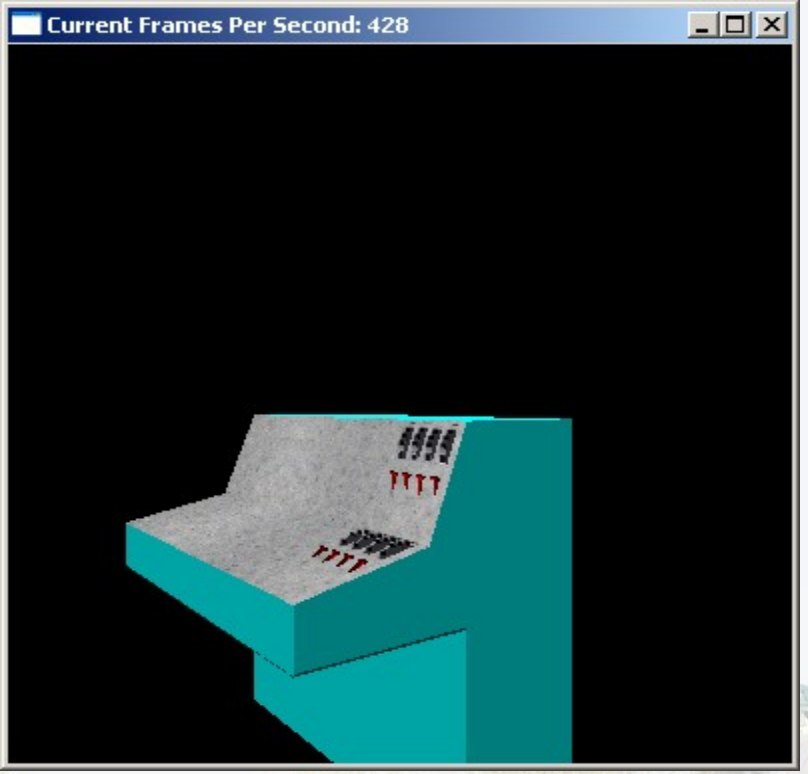
images by Henrik Wann Jensen http://graphics.stanford.edu/~henrik/images/caustics.html

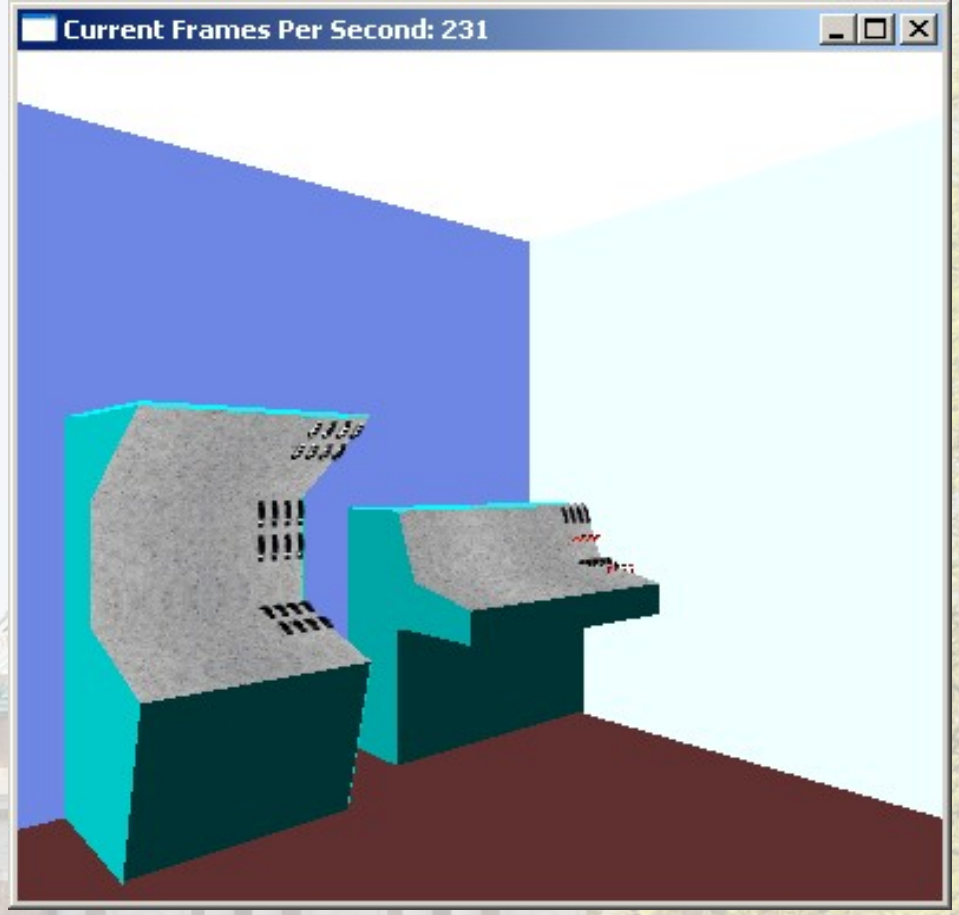


Which image is the photograph and which is the simulation?

Software

- OpenGL
- 3D modeling software
- ....
- ....
- 3D, interactive game development platforms





- Develop and design one component at a time
- Component integration, design of a tree structure

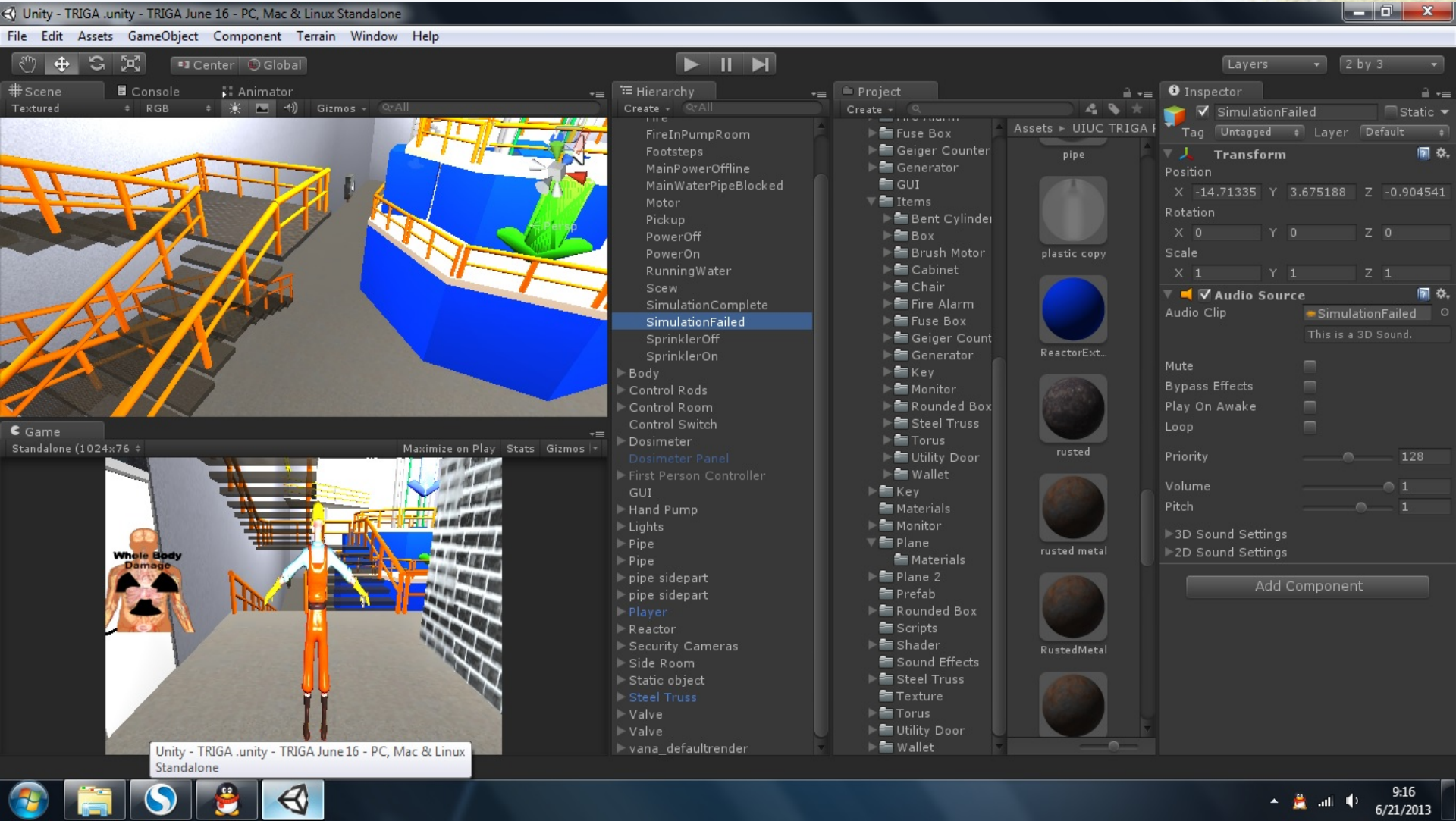
- Each component consists of data (eg. Needle position), procedures to modify it (eg. Exponential decay curve), and functions to draw it (eg. Draw a Geiger counter)

OpenGL

3D, first person shooter games, and game engines

- Unreal
- Doom
- Quake
- *Halflife*
- *Halo*
- *Call of Duty*
- *Unity-3d*

Unity-3D


Unity - TRIGA .unity - TRIGA June 16 - PC, Mac & Linux Standalone
File Edit Assets GameObject Component Terrain Window Help
Scene
Console
Animator
Hierarchy
Project
Inspector
Game
Whole Body Damage
Unity - TRIGA .unity - TRIGA June 16 - PC, Mac & Linux Standalone

on Play | Stats | Gizmos

- Pickup
- PowerOff
- PowerOn
- RunningWater
- Scew
- SimulationComplete
- SimulationFailed
- SprinklerOff
- SprinklerOn
- Body
- Control Rods
- Control Room
- Control Switch
- Dosimeter
- Dosimeter Panel
- First Person Controller
- GUI
- Hand Pump
- Lights
- Pipe
- Pipe
- pipe sidepart
- pipe sidepart
- Player
- Reactor
- Security Cameras
- Side Room
- Static object
- Steel Truss
- Valve
- Valve
- vana_defaultrender

- Bent Cylinder
- Box
- Brush Motor
- Cabinet
- Chair
- Fire Alarm
- Fuse Box
- Geiger Count
- Generator
- Key
- Monitor
- Rounded Box
- Steel Truss
- Torus
- Utility Door
- Wallet
- Key
- Materials
- Monitor
- Plane
  - Materials
- Plane 2
- Prefab
- Rounded Box
- Scripts
- Shader
- Sound Effects
- Steel Truss
- Texture
- Torus
- Utility Door
- Wallet


plastic copy


ReactorExt...


rusted

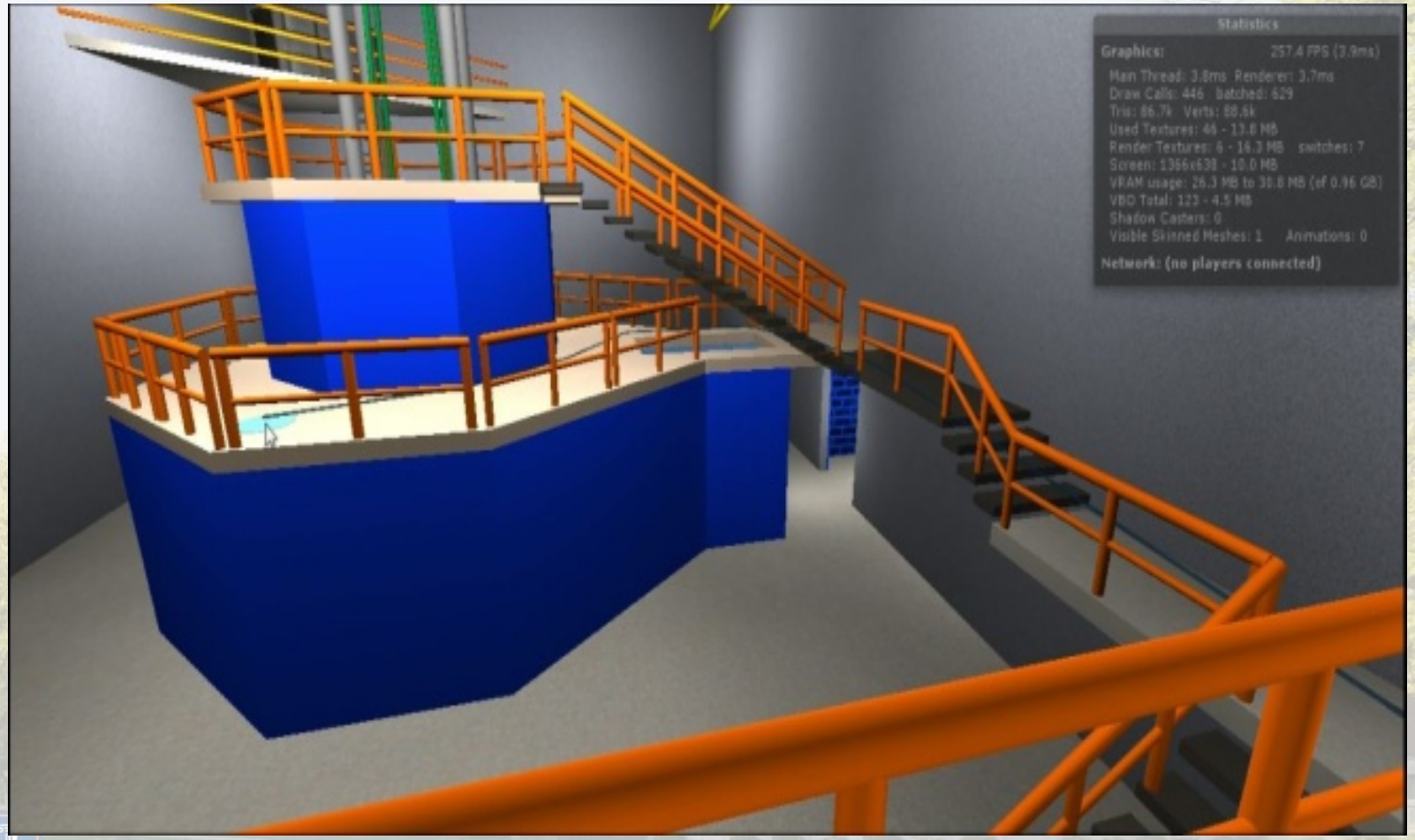

rusted metal


RustedMetal

X
Scale
X
Audi
Mute
Bypa
Play
Loop
Prior
Volu
Pitch
3D
2D


DOOM 3
doom3.com
ACTIVISION.
id

Models- UIUC TRIGA Reactor



Model of a Lab

A picture of the real lab

A picture of the Virtual Lab

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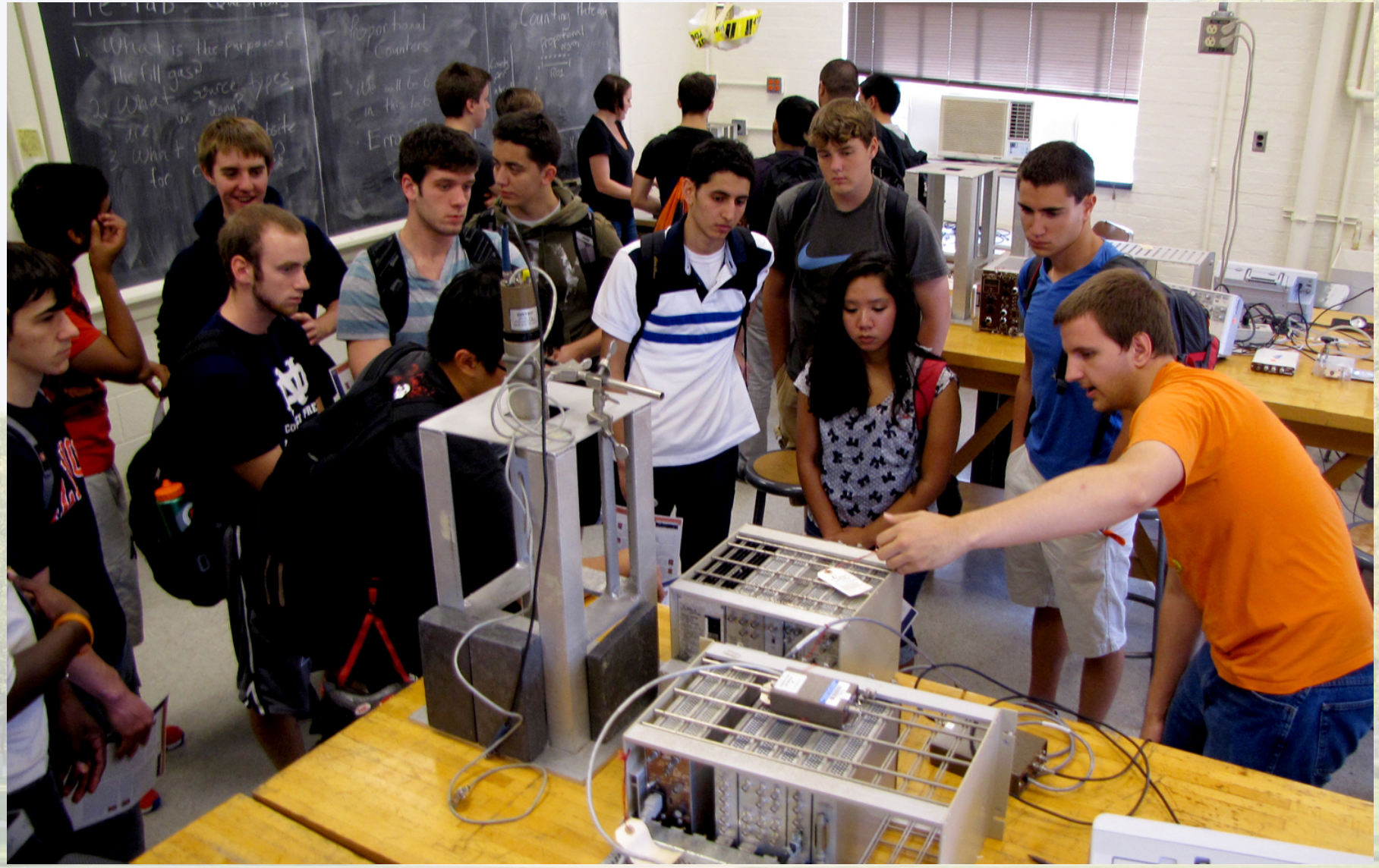
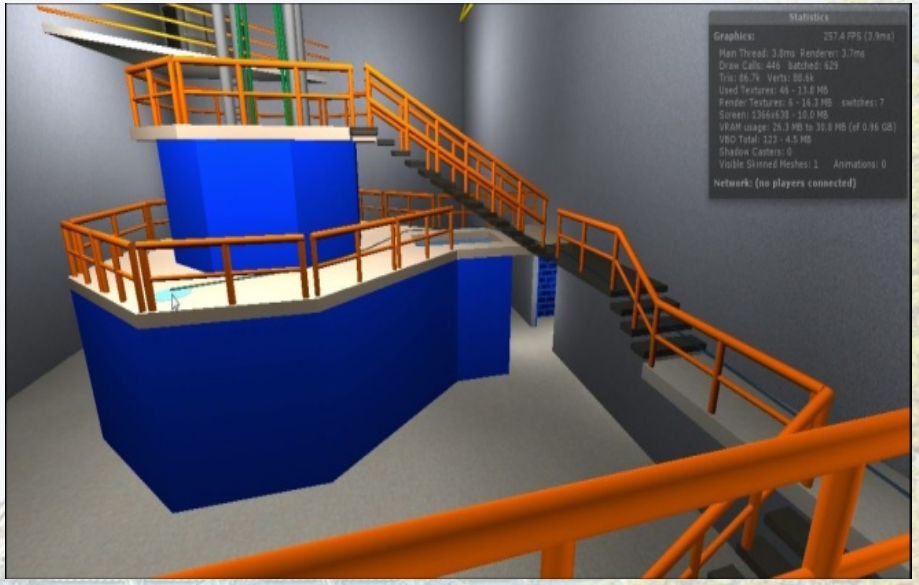
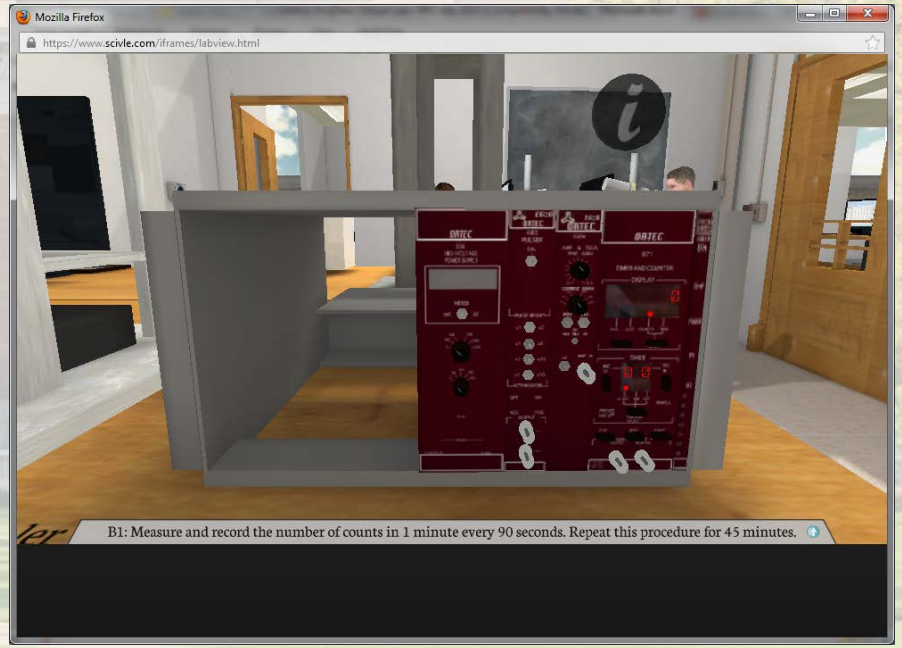
Radiation Lab



Some models



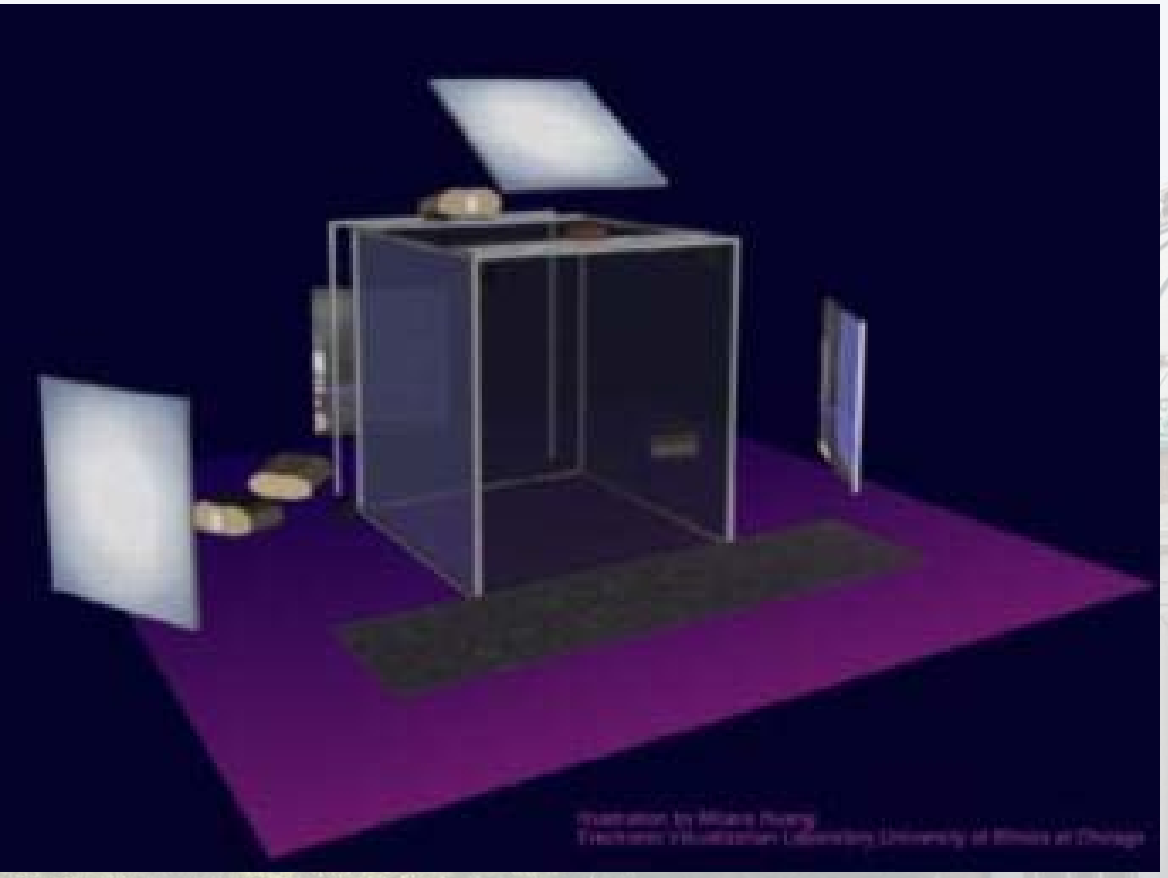

Mozilla Firefox
https://www.scivle.com/iframes/labview.html
B1: Measure and record the number of counts in 1 minute every 90 seconds. Repeat this procedure for 45 minutes.


Mozilla Firefox
https://www.scivle.com/iframes/labview.html
B1: Measure and record the number of counts in 1 minute every 90 seconds. Repeat this procedure for 45 minutes.

Hardware

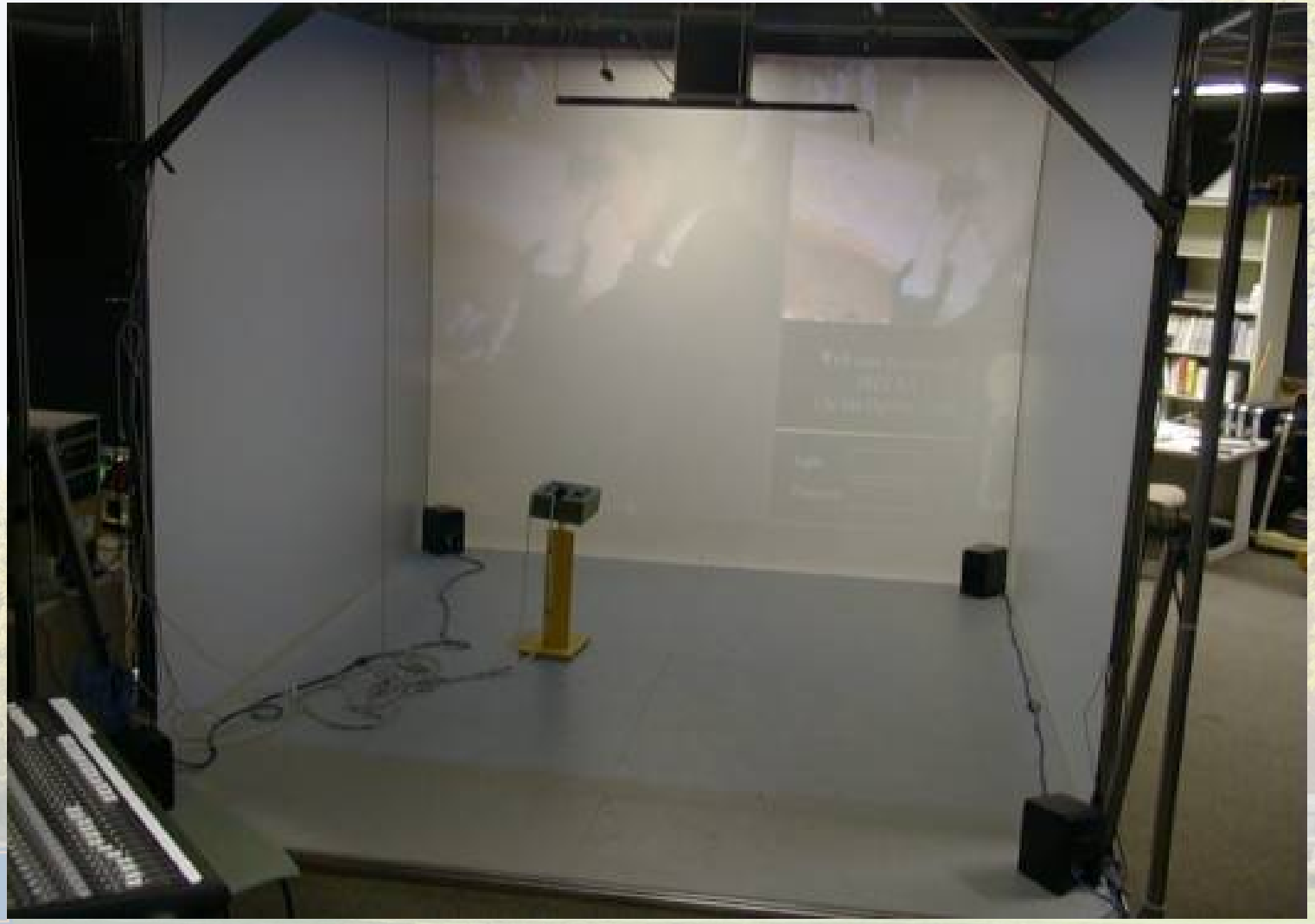
- CAVE (4 surfaces; 3D, immersive)
- CUBE (6 surfaces, 3D, immersive)
- Visbox (single surface, 3D, partial immersion)
- Wearable 3D tools (Oculus-Rift; HTC-VIVE)
- PCs/laptops with 3D monitors
- Regular PCs

CAVE Lab

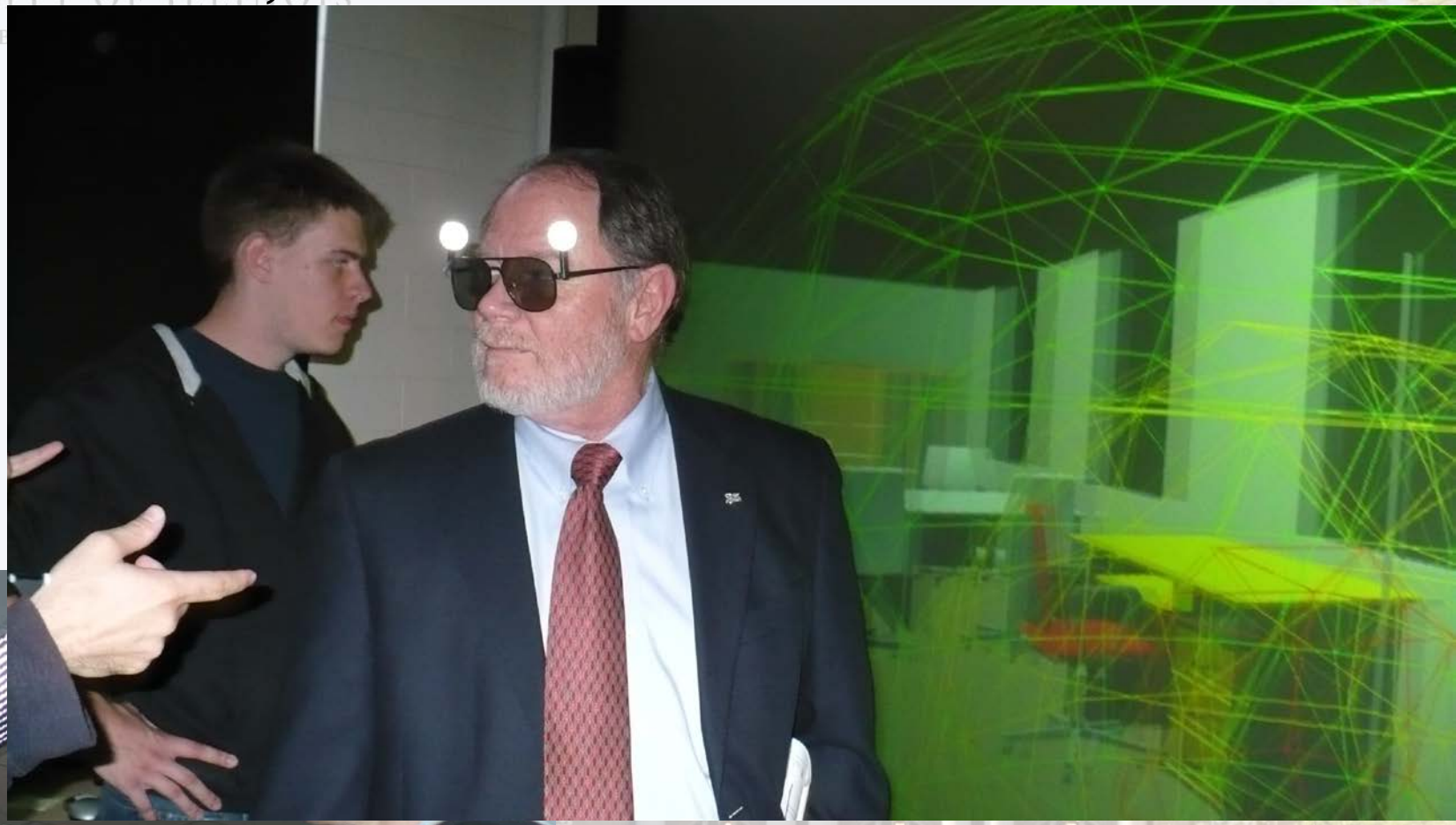


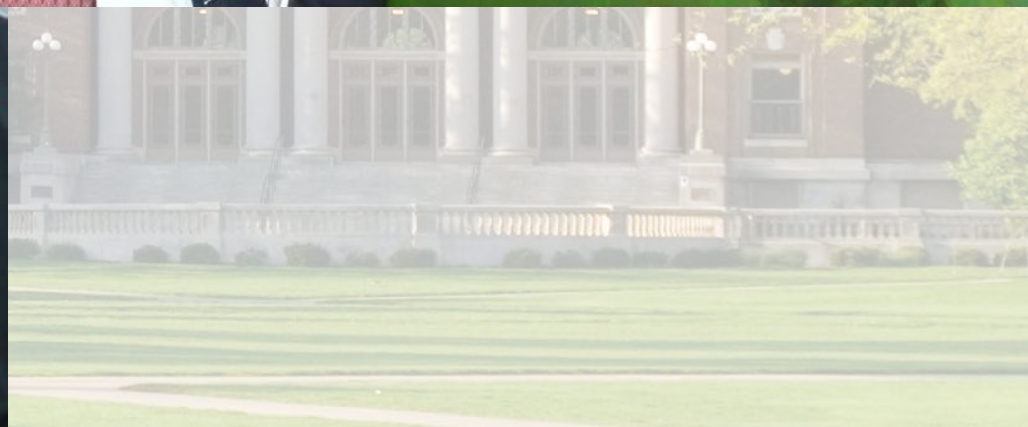
- The CAVE (CAVE Automatic Virtual Environment) is a surround-screen, surround-sound, projection based virtual reality system at Beckman Institute at UIUC.

CAVE Lab

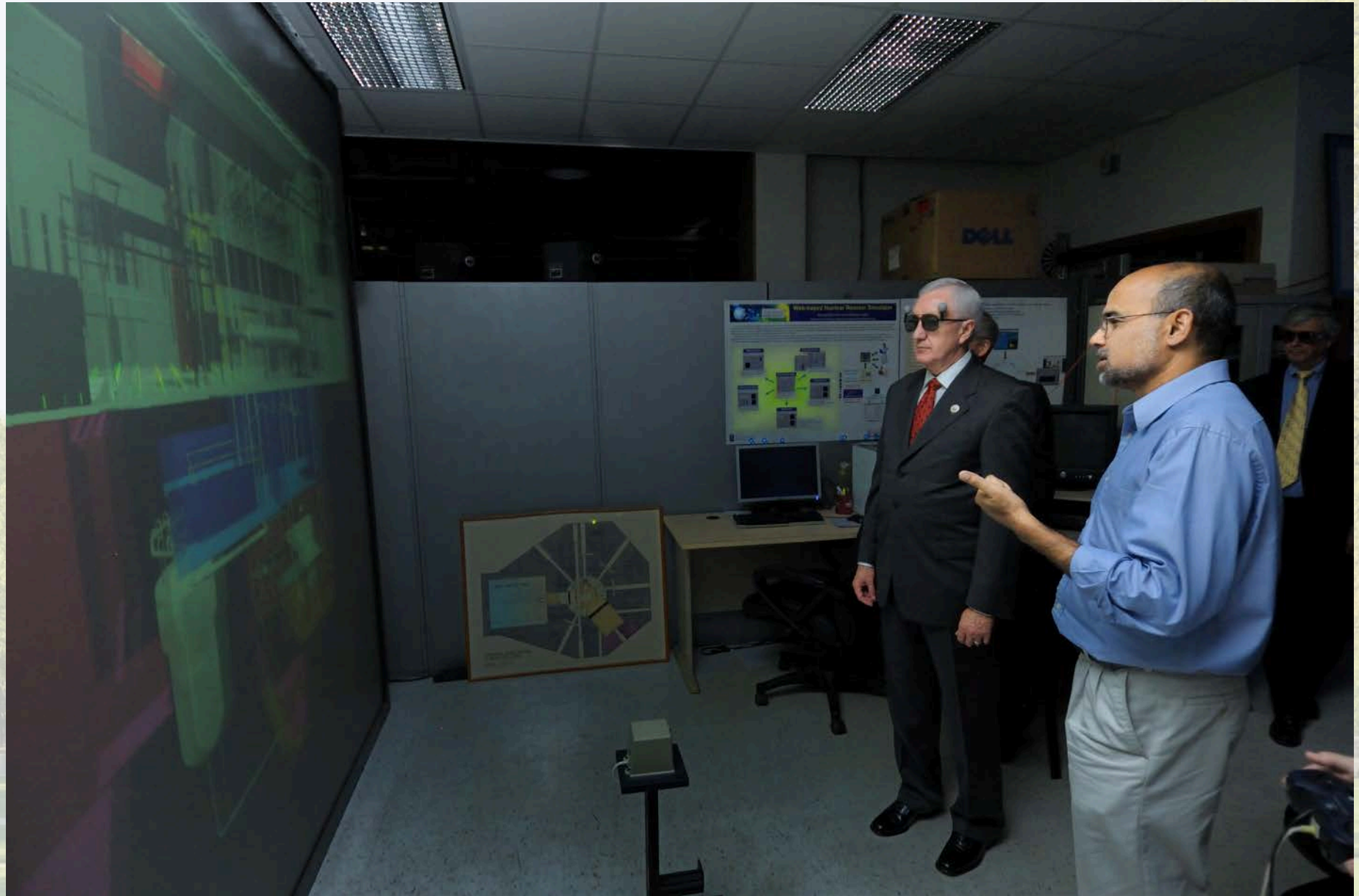


Visbox; ANS President Tom Sanders





NRC Commissioner, Dale Kline



But, the future is not in million $ facilities; its in PCs

(PCs will inherit the capabilities of million $ facilities)

Headware:

Oculus-Rift
Samsung-VR
HTC-VIVE

Work with PCs, laptops and even smart phones

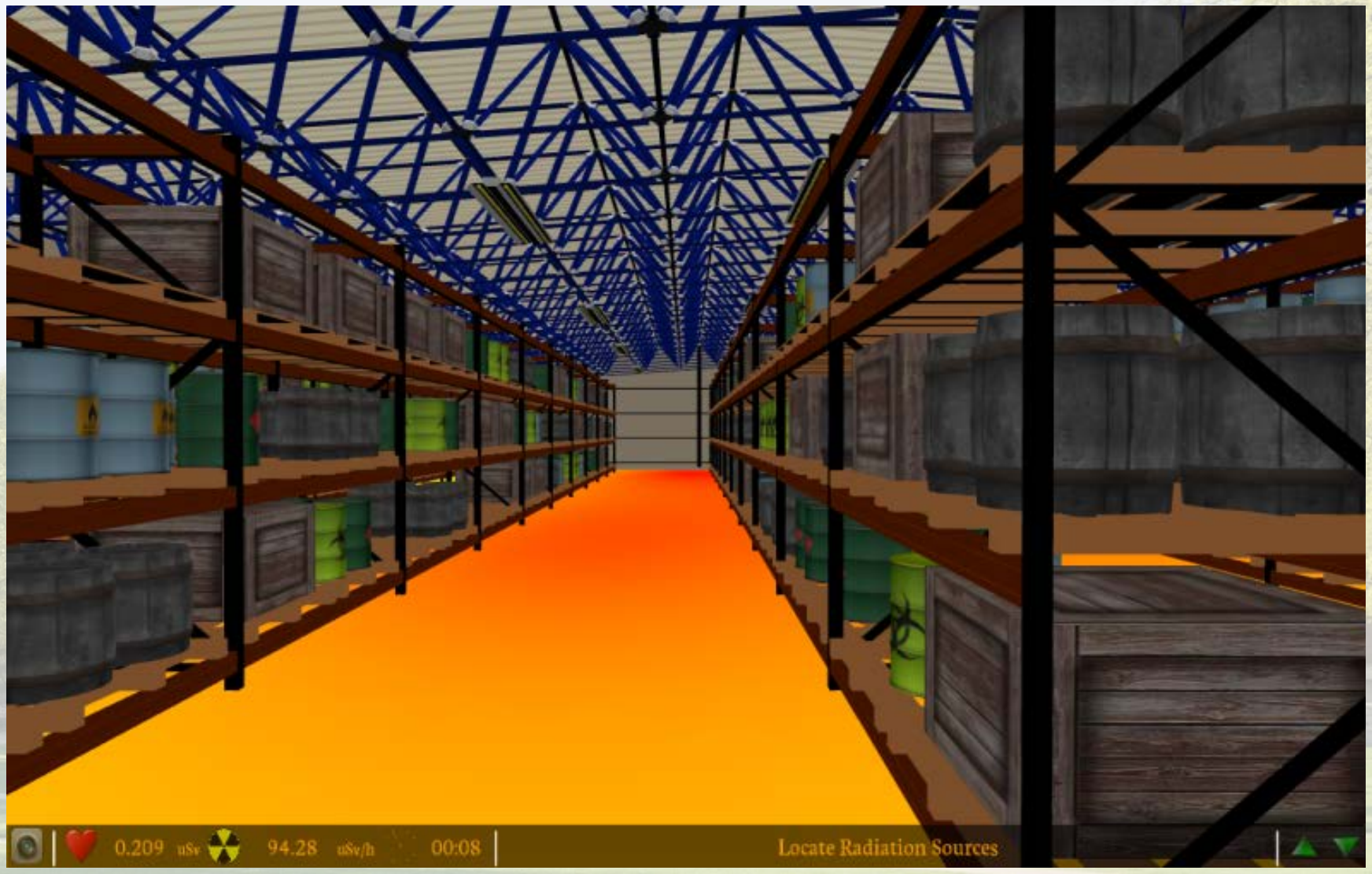
(Has yet to overcome the dizziness problem)

Features

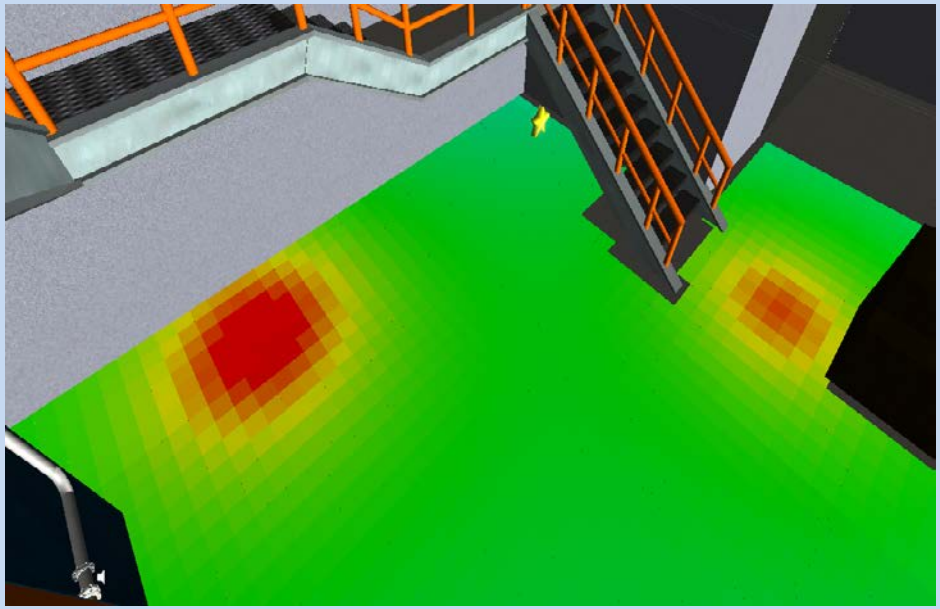
- Triggers
- Color coded radiation map
- Dosimeter (Health meter, modified)
- Non player controlled avatars
- Virtual security cameras
- First person or third person view
- Multi-players (trainee and supervisor)
- Internet ready

In-Game Instructions

Features: Color coded radiation map


0.209 uSv
94.28 uSv/h
00:08
Locate Radiation Sources

Radiation Field and Virtual Dosimeter



Radiation field

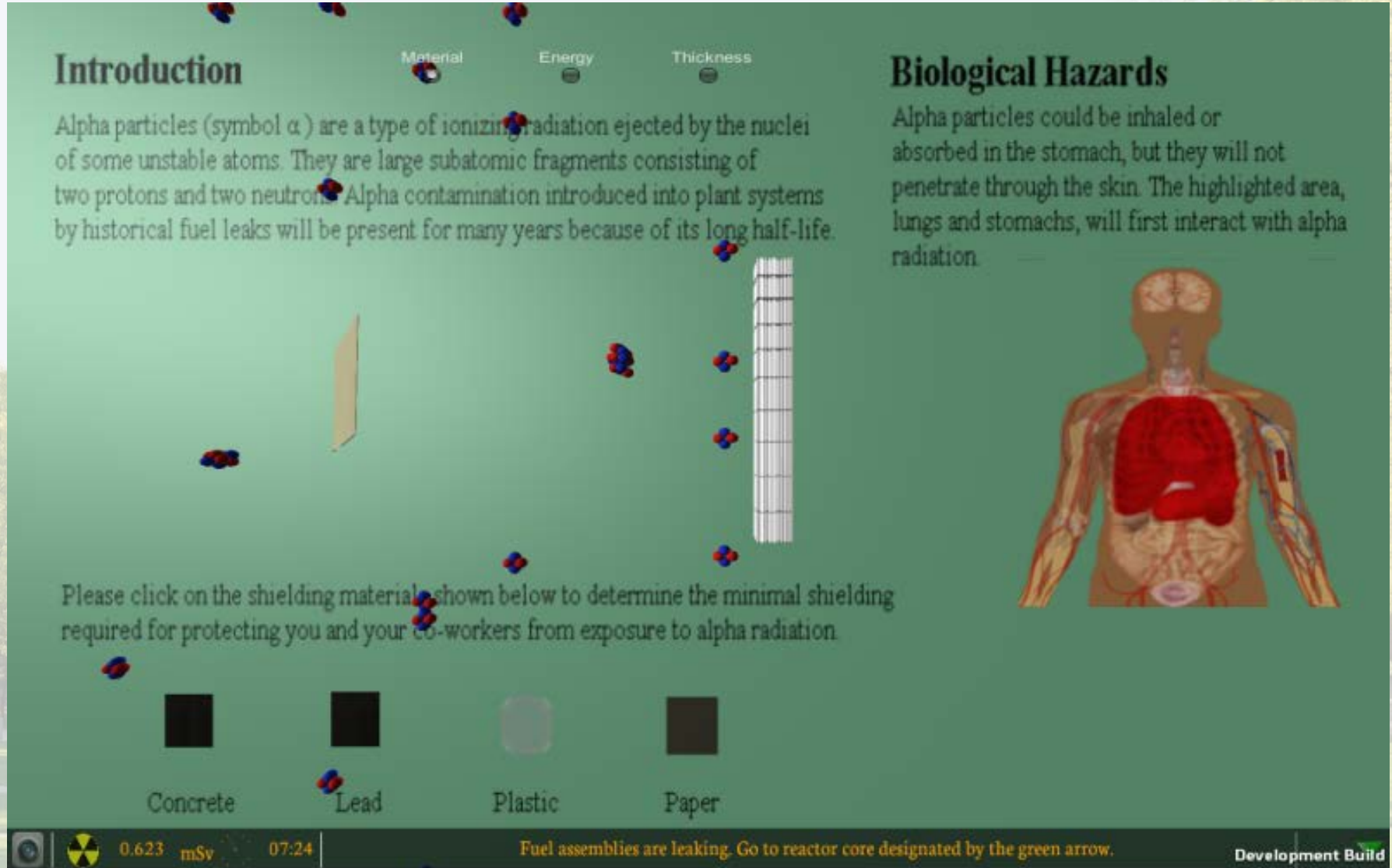
Virtual dosimeter

Features: Non Player controlled avatar

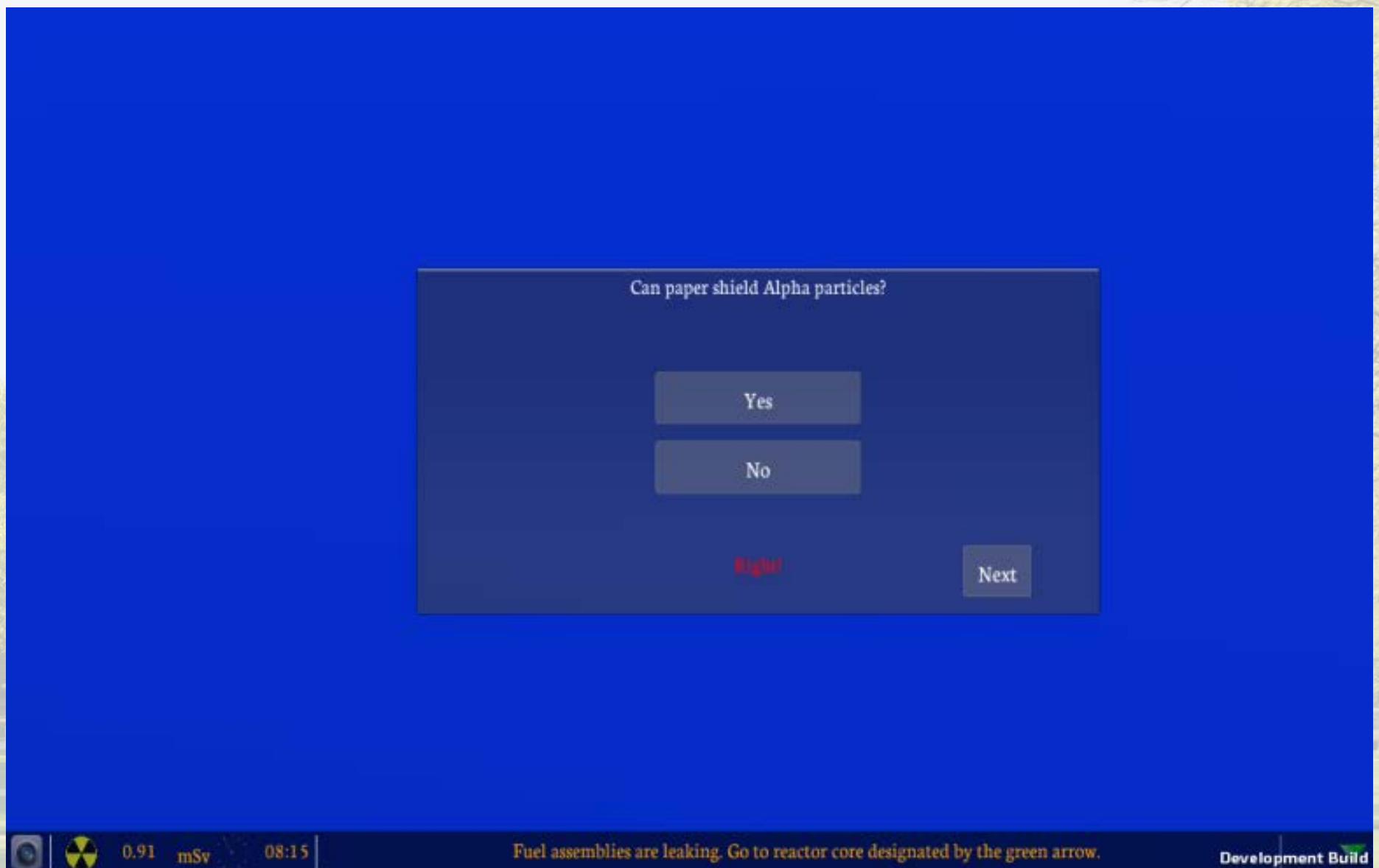
Dosimeter: Concept of Shielding--1

Dosimeter: Concept of Shielding--2

In-Game, Interactive Tutorials



In-Game Quizes

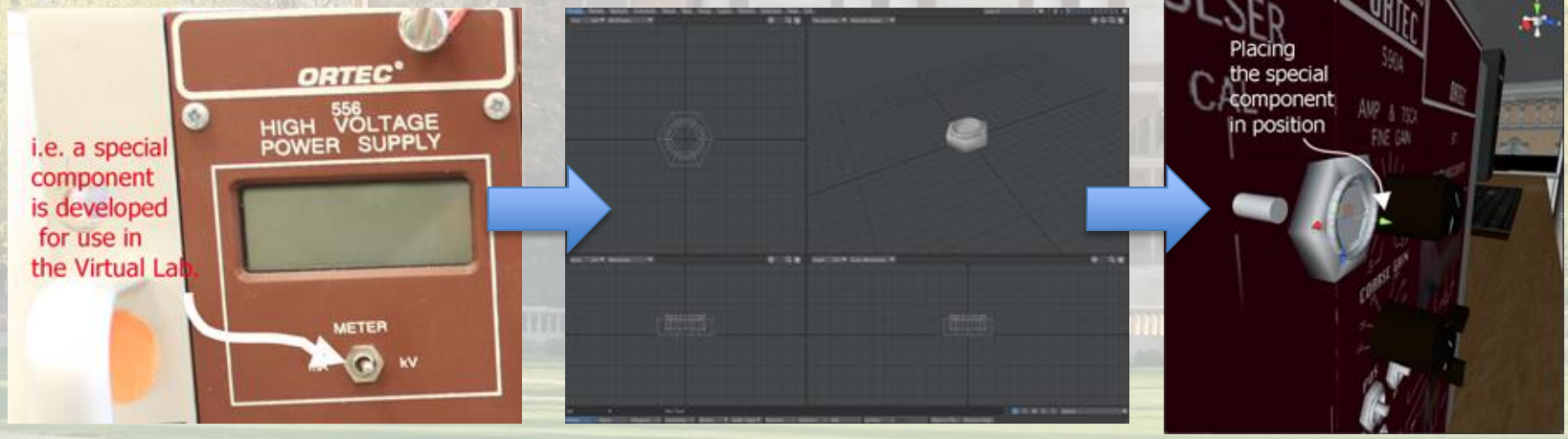


Additional Features

- Built using a game engine development platform
- Interactive
- On-line
- Multi-player
- Real physics

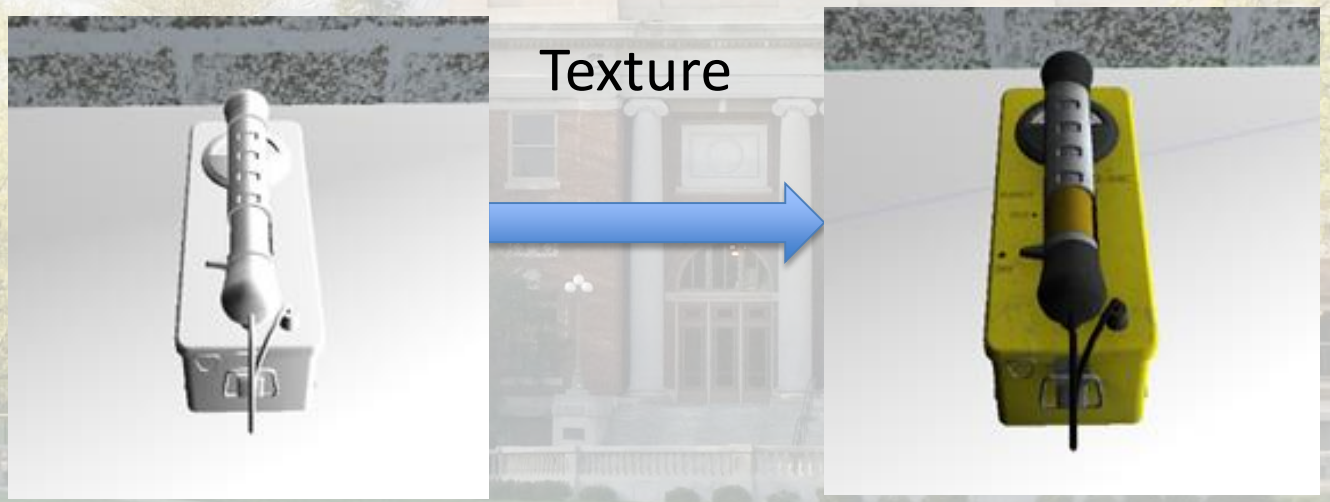
Process of 3D Modeling

1. Measure dimensions of the lab (e.g. height, area) to ensure everything virtual is made to scale.
2. Setup the basic skeleton of the lab in 3D modeling software such as Maya 3D or 3ds Max
3. Special purpose objects (such as a Geiger counter) can be developed using 3D modeling software and exported to Unity3D



Process of 3D Modeling

1. Make textures by taking pictures of the object surfaces and by using image-editing software; or using laser scanner
2. Write Codes (develop all kinds of functionalities, capabilities and GUIs)



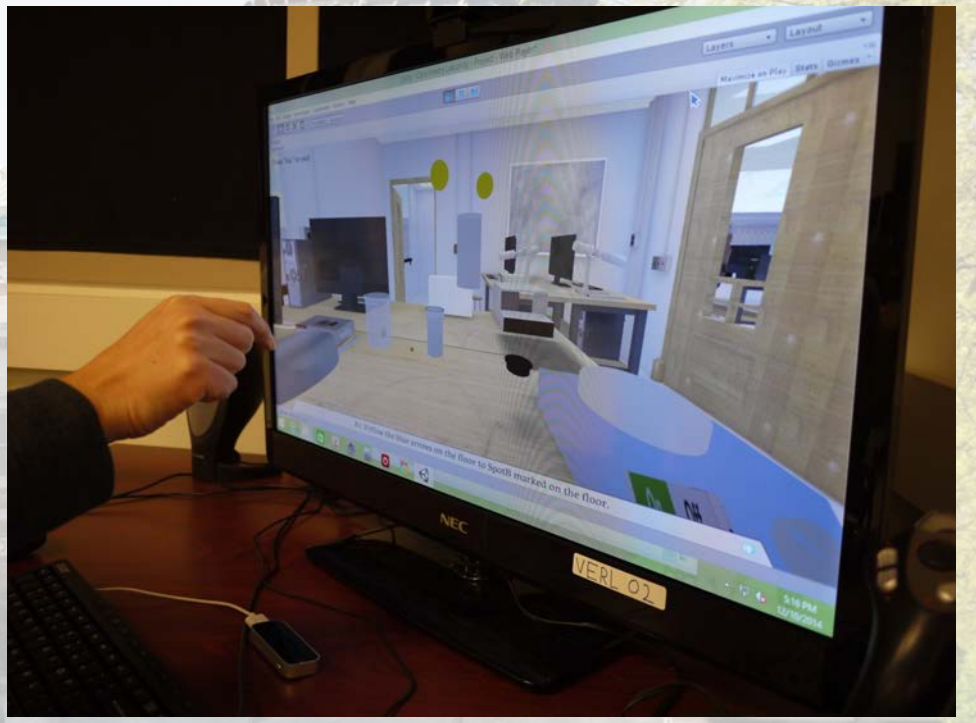
Process of 3D Modeling

A picture of the real lab

A picture of the Virtual Lab

New Capabilities (HMI)

User interface (LEAP)



3D motion sensor
"Leap Motion"

Mouseless Control

Demos

1. Model of a chemistry lab
    1. Embedded videos
    2. Interactivity
    3. Training
2. Shielding (and half-life) labs
    1. Physics models
    2. Data display and acquisition
    3. Interactivity
3. Specific heat measurement using a calorimeter
    1. Same as 2
4. TRIGA model
    1. Dose minimization training (dosimeter)
    2. Reactor operations
    3. Reactor physics

Demonstration

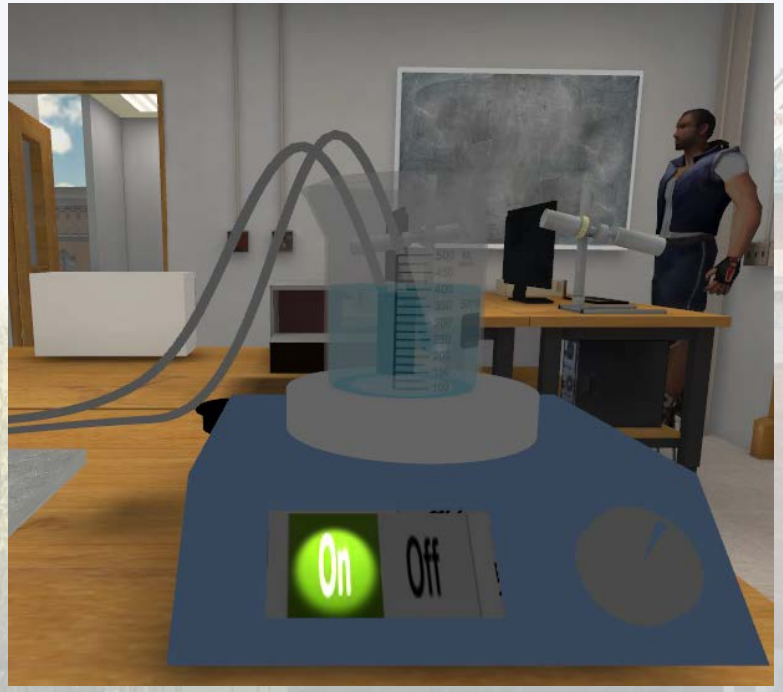
Safety Training Before Chemistry Labs

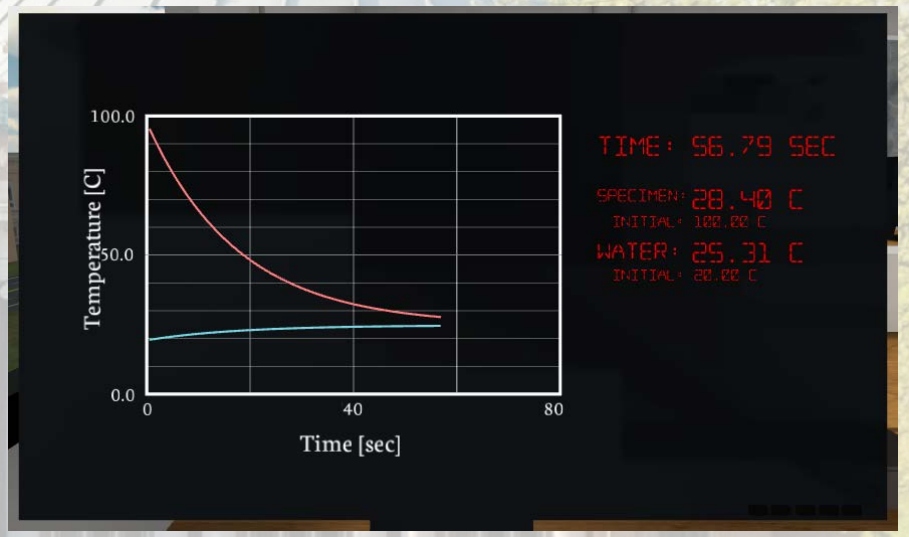
Demonstration

Overview of Virtual Calorimetry Lab (video 1)

Demonstration

Scenario to conduct the calorimetry lab (video 2)



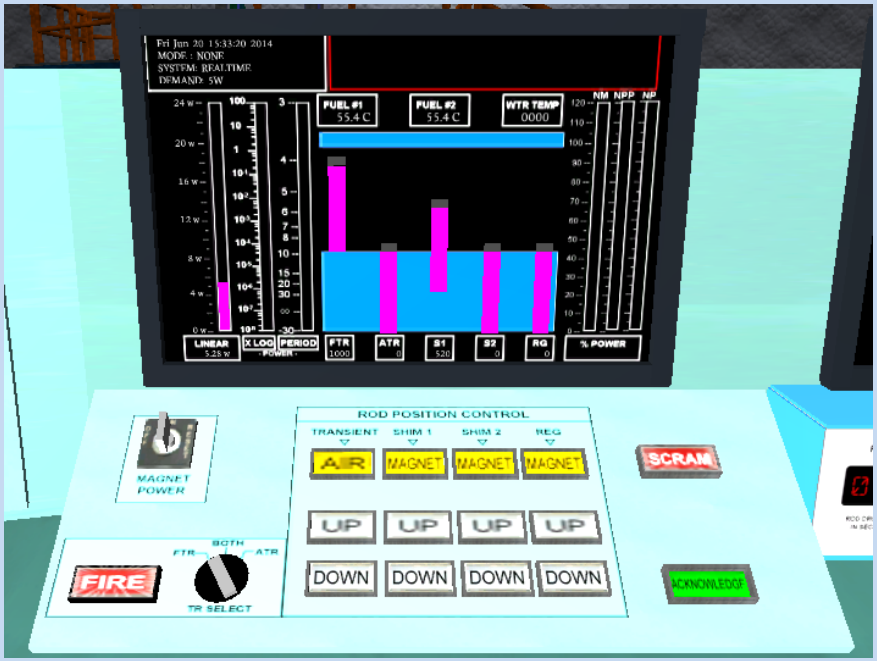


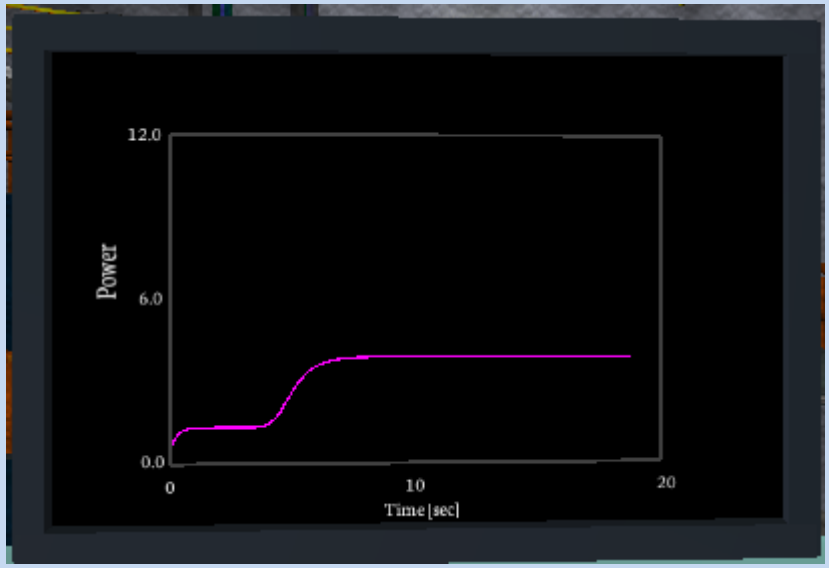
Demonstration

Overview of UIUC TRIGA reactor lab (video 3)

Demonstration

Scenario to learn the reactor operation (rod calibration) (video 2)

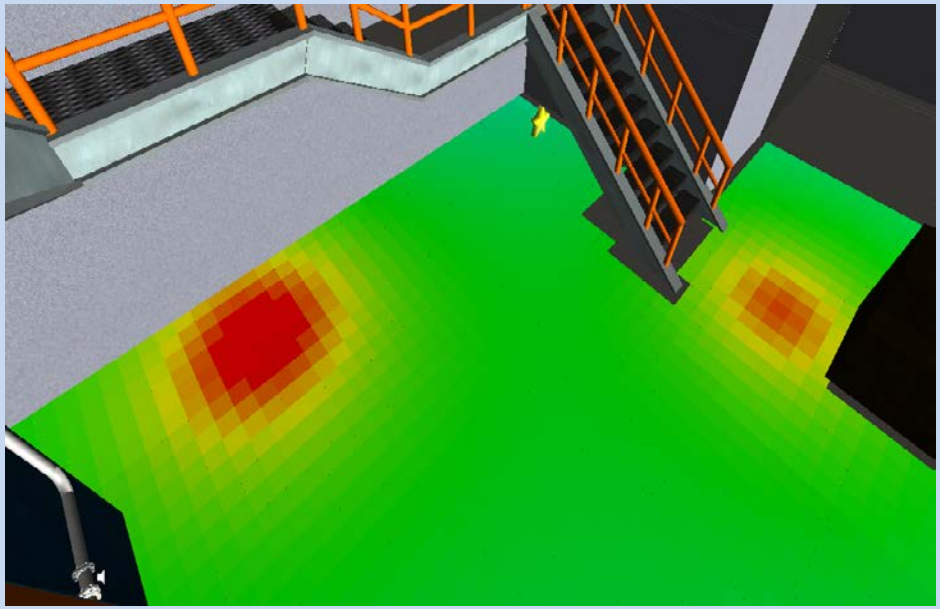




To determine the real time reactor response to operator actions,
Point reactor kinetics with simplified thermal feedback model is implemented

Demonstration (Tools)

Additional tools in TRIAGA model (video 3)



Radiation field

Virtual dosimeter

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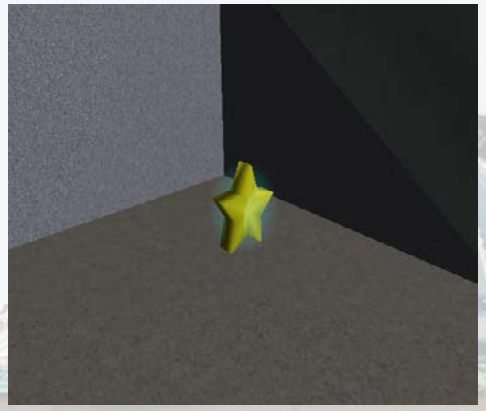
Dose Minimization Game

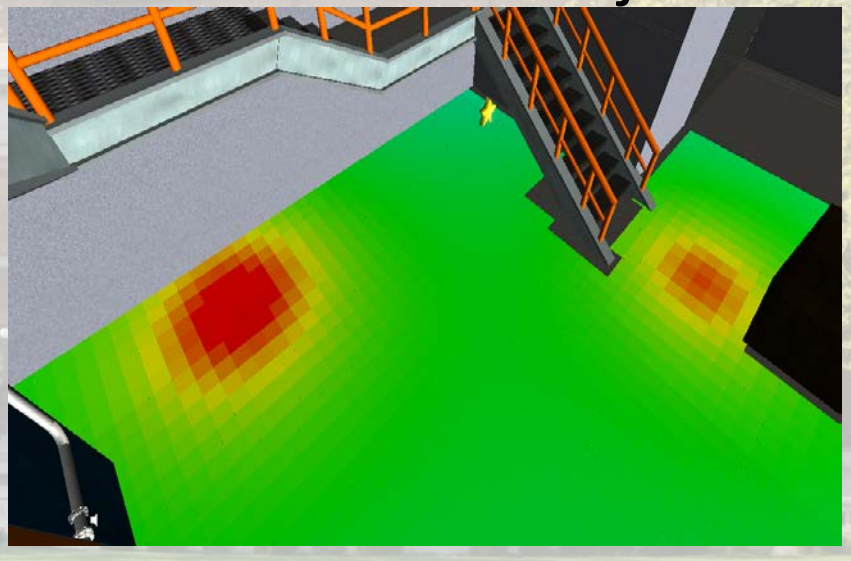
illinois.edu

Objective

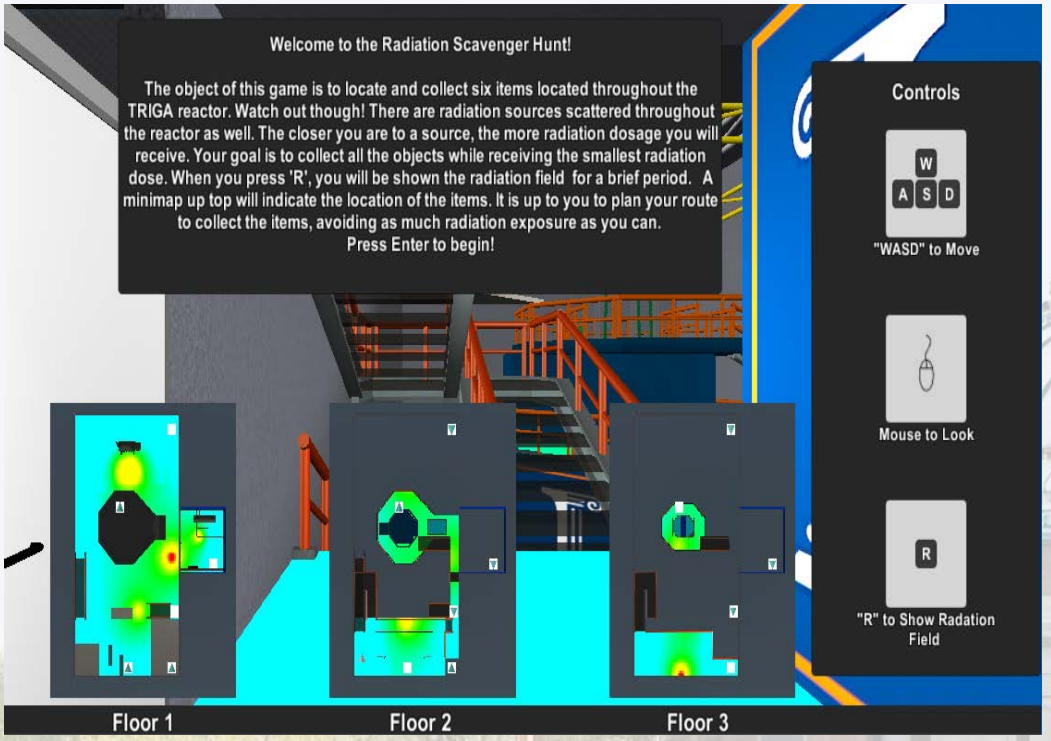
- What is radiation?
- Collect objects while trying to receive the lowest dosage.
- To receive a minimal dose, players must plan their route around radiation sources of varying strengths.



Example of radiation field and object



Tools



Example of the minimap

Start screen of the game which shows the controls, gives a map of the reactor, and gives a basic introduction to the game.

End of Game

- Last Screen that shows
  - Dose received
  - The time the radiation field was viewed
  - A score based on these two values
  - Some typical doses for comparison

6. Conclusions

- Virtual labs and workspaces offer a cost effective & flexible means for education and training.
- Any environment & scenario can be modeled & simulated.
- Models developed in Unity3D run inside web browsers.
- Even cell phone apps can be easily developed.

THANK YOU

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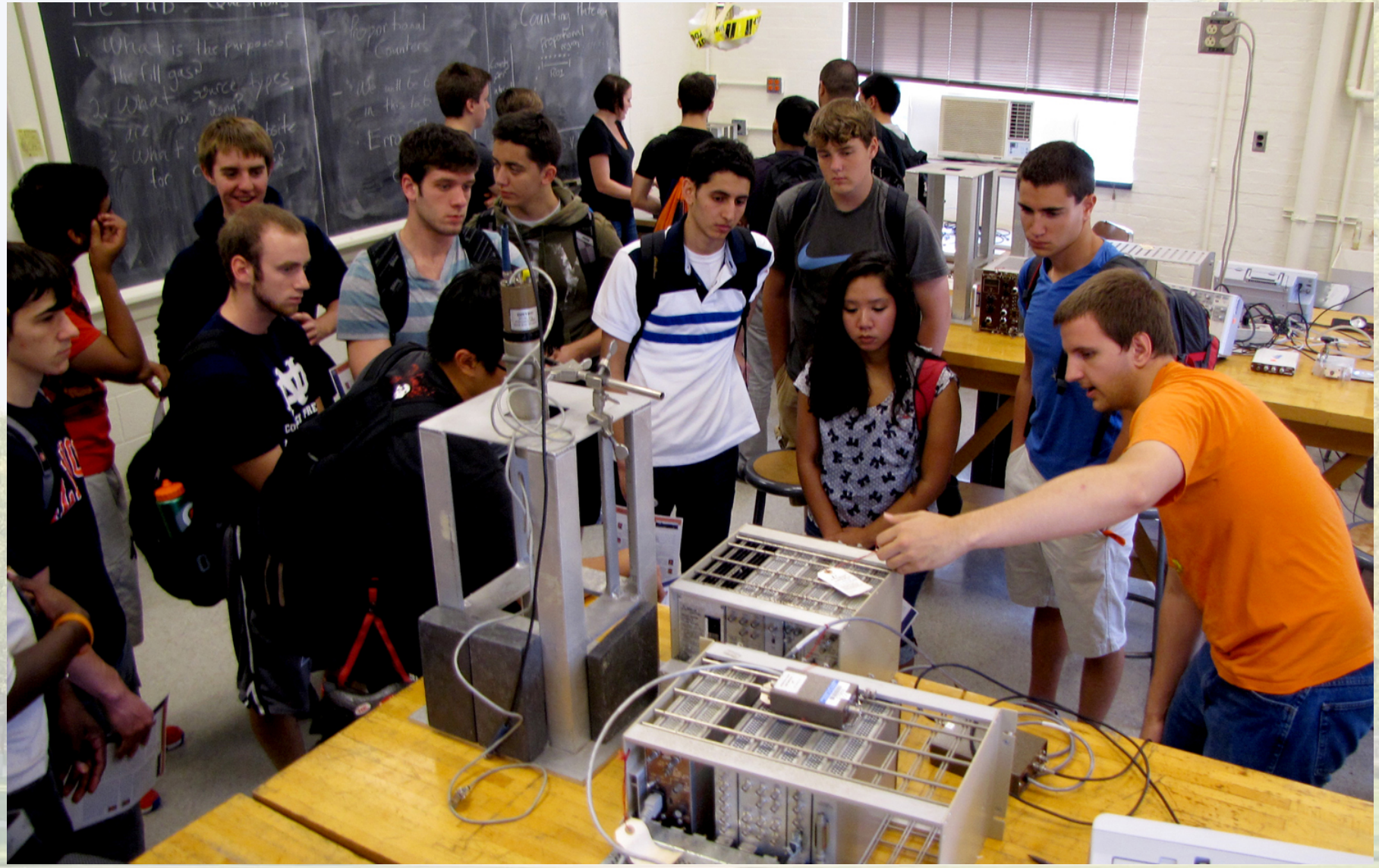
Radiation Lab



How to use Google Cardboard for the iPhone6

- Go to the App Store.
- Search “Roller Coaster VR.”; and download it (It’s free).
- Run the app.
- Insert your iPhone into the google cardboard visors with the app running.
- Put on the goggles and enjoy your virtual roller coaster ride
- Note: Make sure to look around (turn your neck) in all directions (including behind you) to see that you are completed immersed in VR.
- Note: If you start to feel nauseated, remove the visors immediately.
- The Google cardboard goggles are not compatible with the iPhone 5 because the iPhone 5 is too small in size.

How to use Google Cardboard for Android phones

- Go to the Google Play store
- Search “Crazy Swing VR” by Fibrum. Note that this app will normally take 90 MB of data to download, so make sure you are connected to Wi-Fi to prevent using data.
- If you would like to download a smaller (but far less exciting) virtual model, search “Singapore NDP Fireworks VR” by Tiny Quests.
- Download and then run the app of your choice.
- When you run the app, there may be ads. Close the ads, and then place your smartphone (with the app running) inside of the Google cardboard visor.
- Put on the visor and enjoy. [If you are using the “Crazy Swing VR,” the ride may take around 30 seconds to start.]
- Note: Make sure to look around (turn your neck) in all directions (including behind you) to see that you are completed immersed in VR.
- Note: If you start to feel nauseated, remove the visors immediately.

Distance and virtual labs for education

Distance Lab is a real physical lab, which is web-casted for live "participation" by those who are not present in the lab.

Virtual Lab is a "model" of a lab that resides inside a computer, which may be 3D, interactive, immersive, with real physics, etc. This lab can be available at any time and anywhere for single- or multi-student (multi-player) use.

Interactive virtual models of facilities can be used for training and education.

7. Future Work

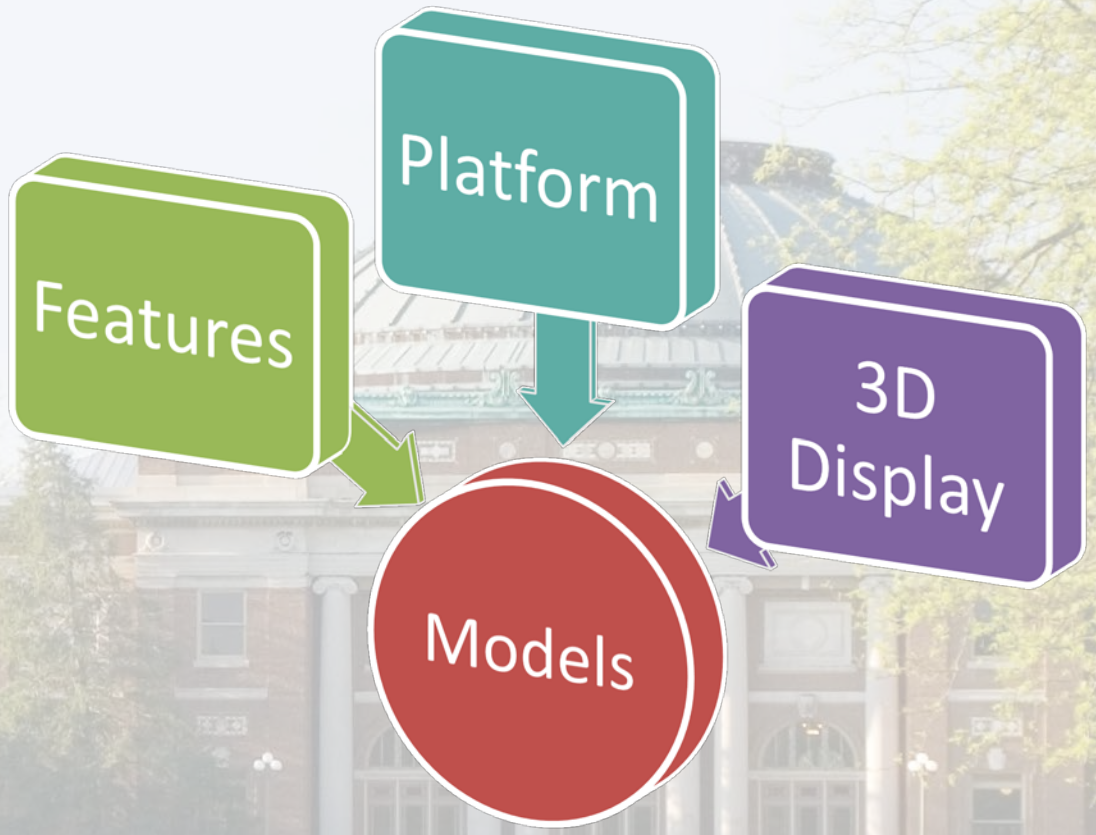
- Making other scenarios in this TRIGA model for students to learn other reactor operations
- Assessment and improvement of the usability
- Developing other virtual labs for engineering education

You can try our contributions. Please access our web page.

http://verl.npre.illinois.edu/default.html

Outline

- Models
- Platform
- Features
- 3D display
- Scenarios



Model of subcritical graphite assembly

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Virtual Radiation Lab

NPRE 100 backup video

01:25

8:04 PM
10/23/2012

1. Objectives

- Develop virtual models of laboratories to carry out virtual experiments with real physics
- Develop virtual models of workspace for efficient and effective training

- Motivation:
  - Increasing number of students
  - Complements and supplements real labs
  - Space- and time constraints are removed
  - Training for dose reduction
  - Outage and refueling
  - Others

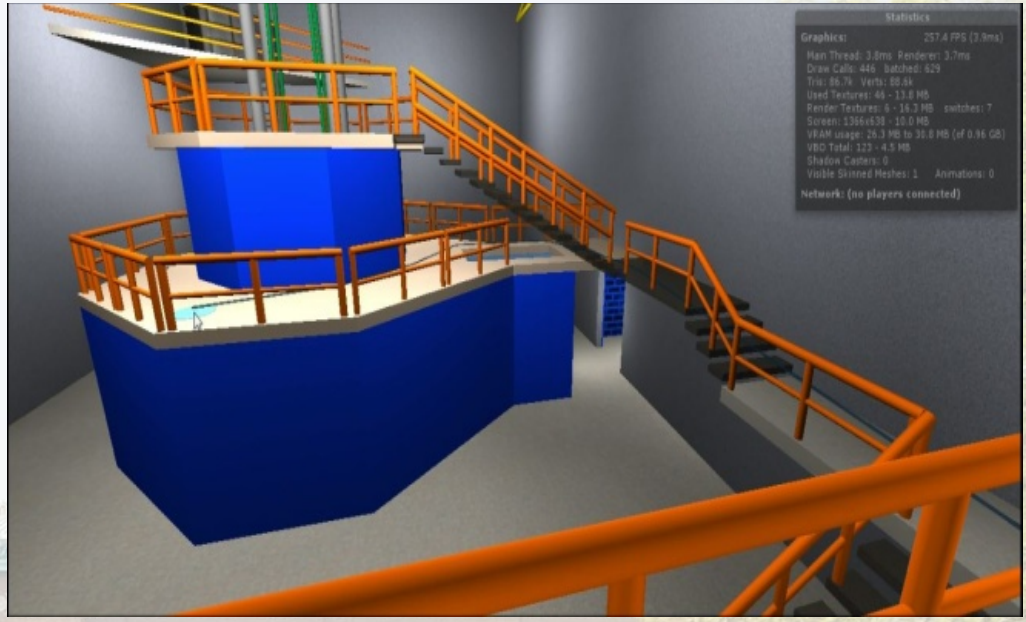
2. Capabilities of Virtual Lab

- Realistic rendering with fine level of detail
- Internet ready
  - Multiplayer play & instructor/supervisor/TA oversight
- Analytics
  - Determine where students/workers struggle and excel
- Freedom to explore
  - No dose; and opportunity to practice over and over
- Real physics
  - Virtual equipment can be modeled to act in the same manner as its real life counterpart

Features

1. Web based
2. Single- or multi-player (worker)
3. Remote cameras
4. Radiation field display
5. Health meter as dosimeter
6. Real physics
7. Motion sensor integration
8. Interactive
    1. User operation
    2. Data display
    3. Data analytics

Some models


Statistics
Graphics:
Network: (no players connected)


Mozilla Firefox
https://www.scivle.com/iframes/labview.html
A
B
C
D
B1: Measure and record the number of counts in 1 minute every 90 seconds. Repeat this procedure for 45 minutes.


Mozilla Firefox
https://www.scivle.com/iframes/labview.html
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