INL/CON-23-74239-Revision-0

Extended Reality Visualization at INL

August 2023

Nathan Woods, Rajiv Khadka

Changing the World's Energy Future

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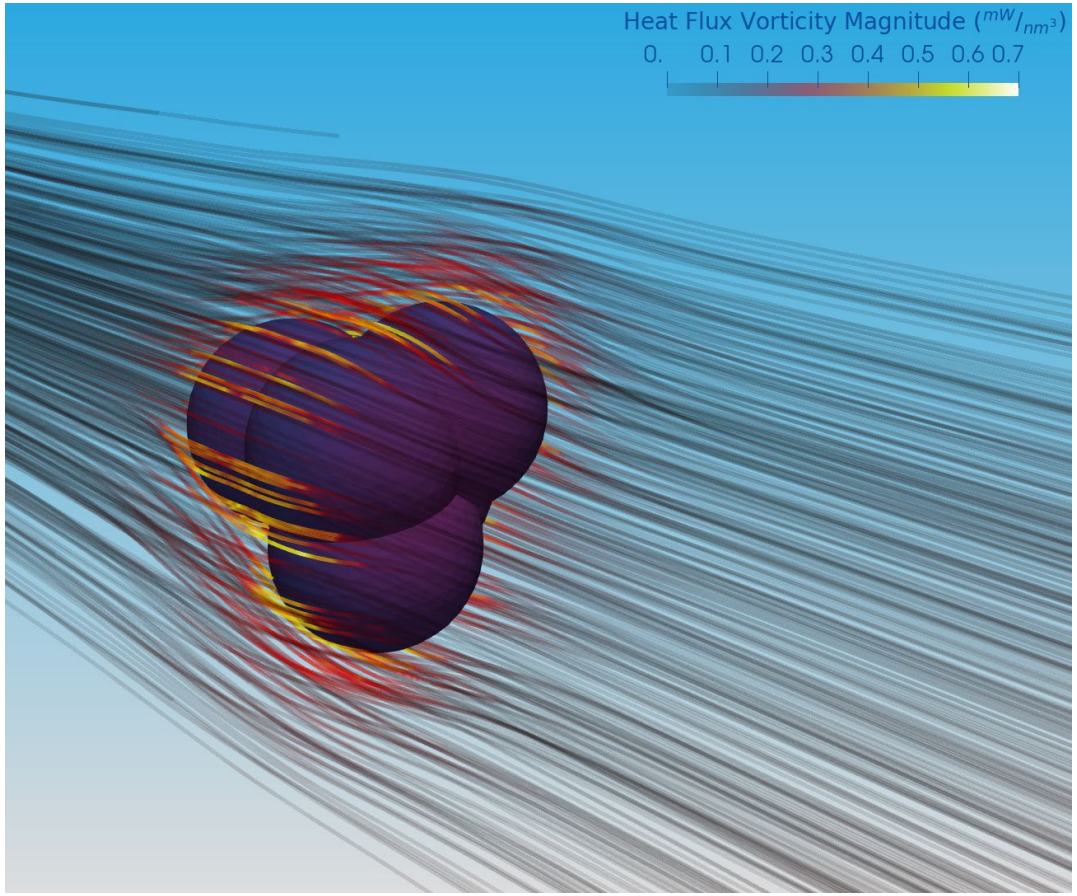
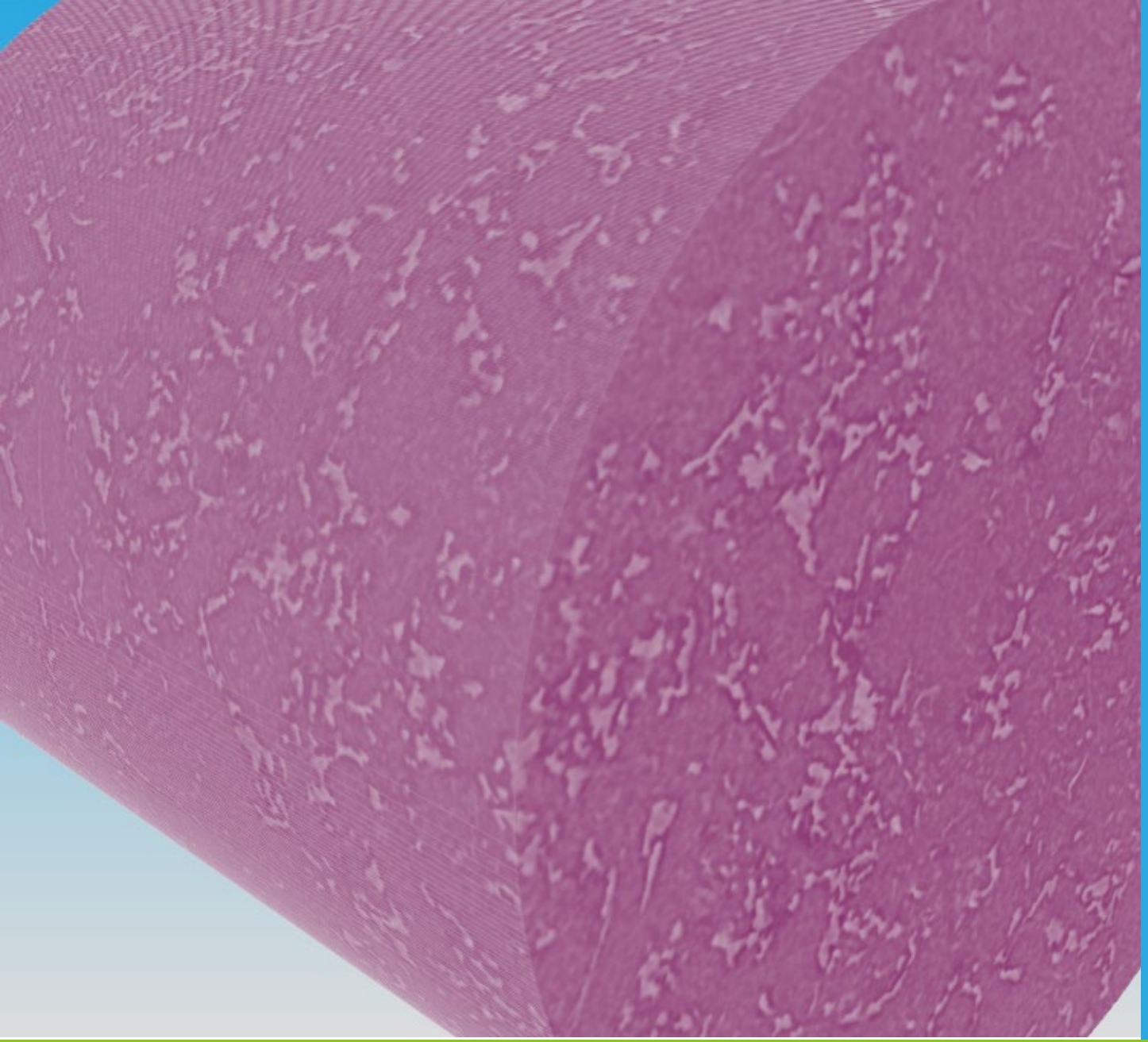
Idaho National Laboratory

Scientific Visualization

Animations and Video

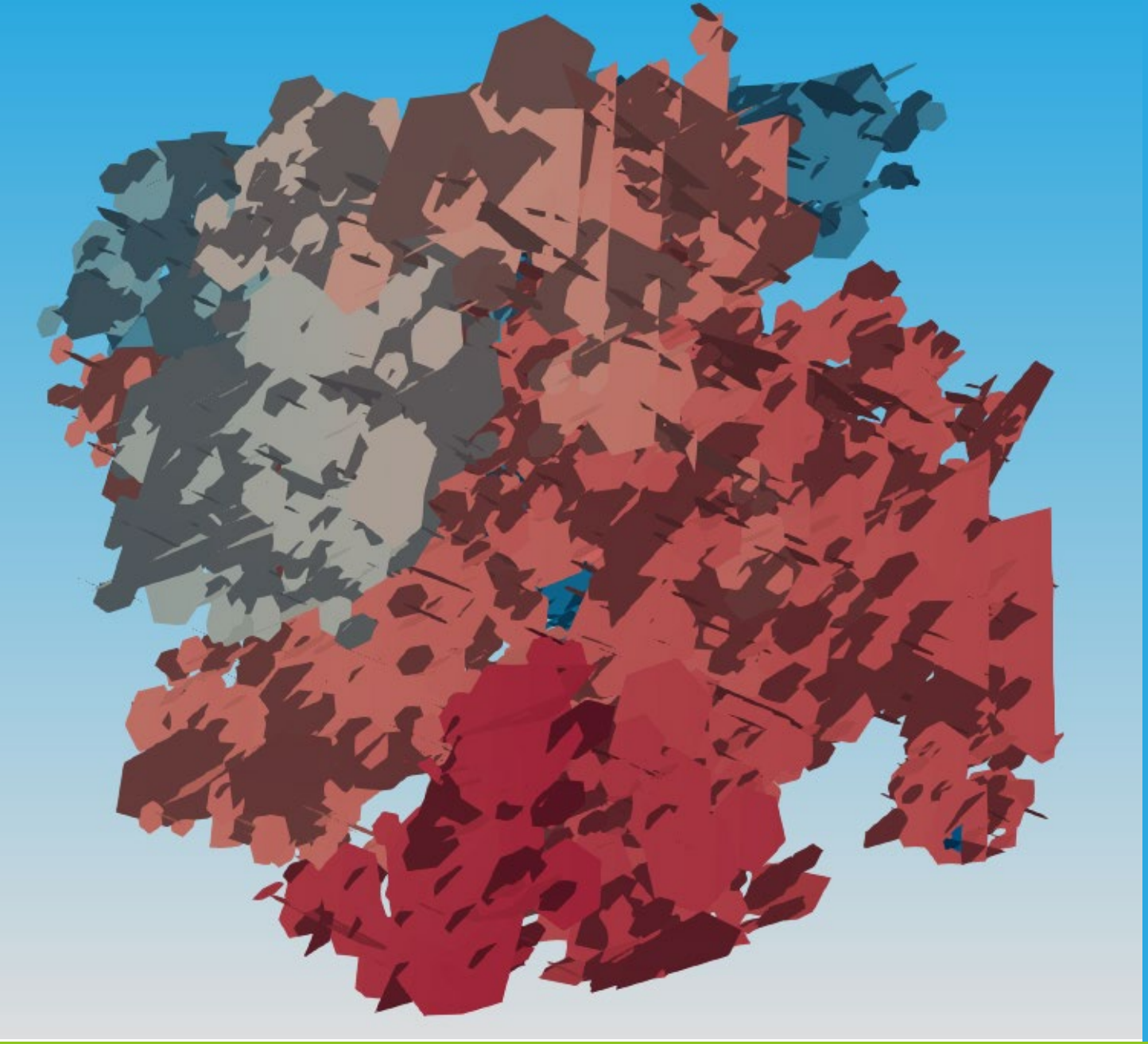
- Animated visual aids can convey the meaning of scientific results better than words and pictures alone
- The process of making even mildly complex video requires tools outside the normal scientific toolbox
- This is the most publicly impactful aspect of scientific visualization





Visualizing “Large” Data

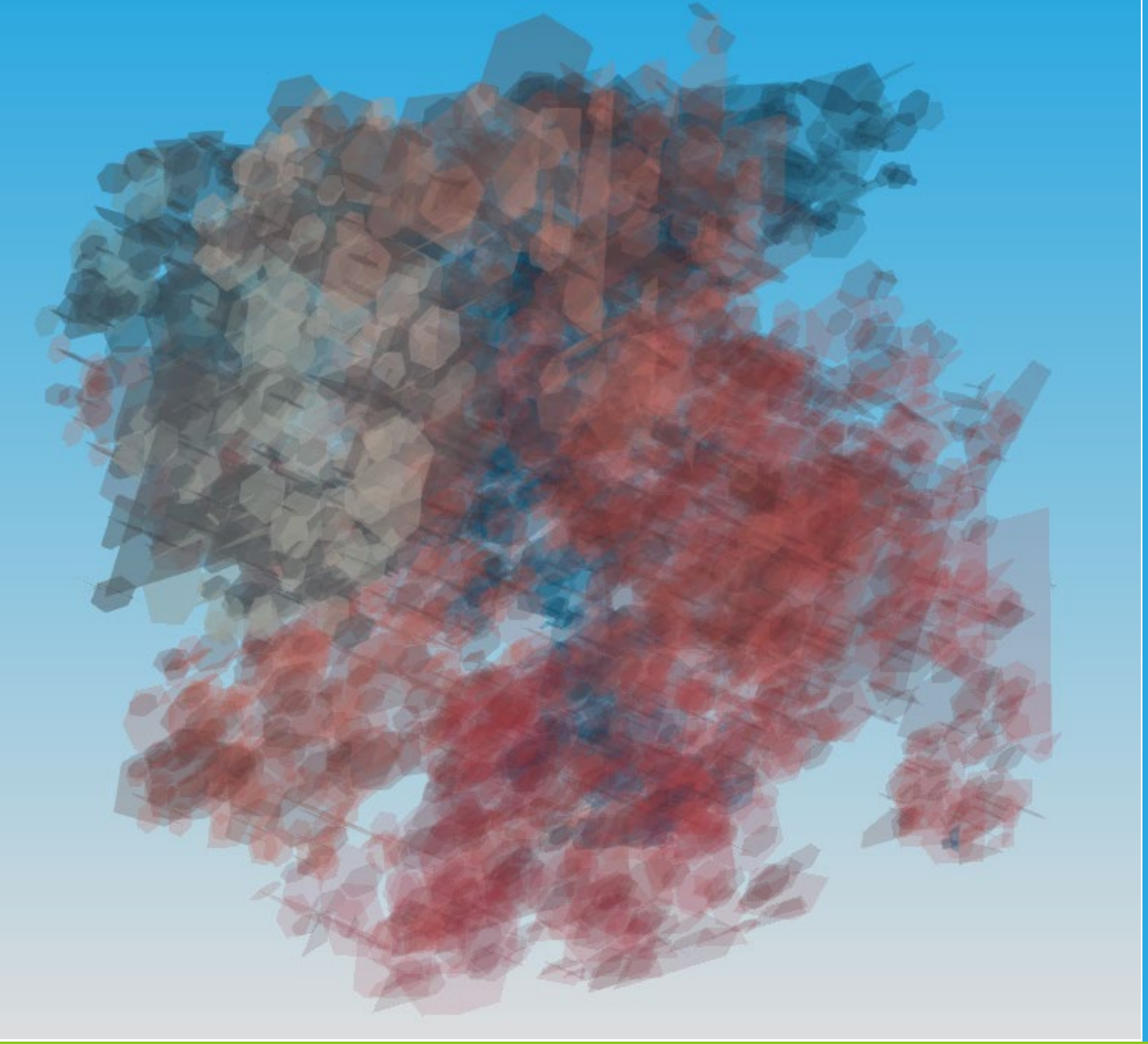
- Datasets larger than a few GB become unwieldy on individual workstations
- Individual expertise can mitigate this problem
- Must take care to work in the most efficient representations
- Distributed rendering is used uncommonly by most people



“Difficult” data

- Datasets can be difficult to visualize for many reasons

- Discrete Fracture Networks:
  - Entirely 2-dimensional
    - No volume rendering
    - No streamlines
  - Lots of boundaries
    - Transparency is ineffective



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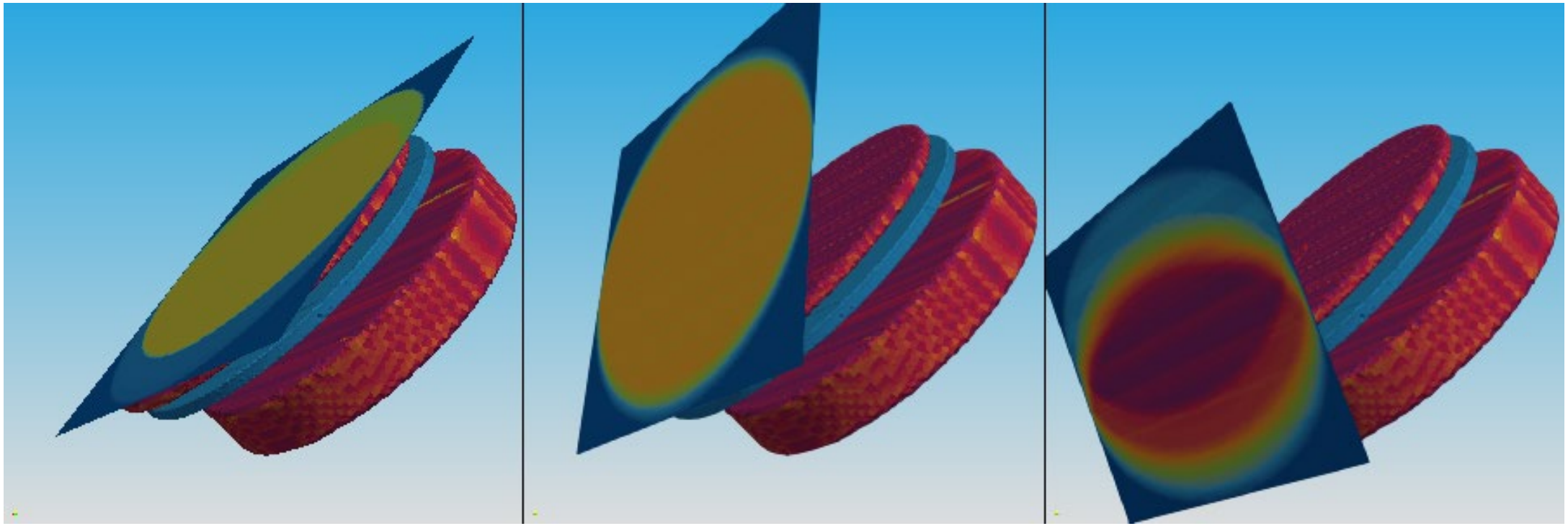
“Difficult” Data

Analysis
Computing areal density for a given angle



Extended Reality

Who am I ..

- Rajiv Khadka
  - Visualization Researcher, Applied Visualization Laboratory
  - Ph.D. from University of Wyoming

- Conducting research in:
  - Collaborative VR/AR, 3D User Interfaces, HCI
  - Immersive Data Visualization
  - Immersive Analytics, Digital Twins

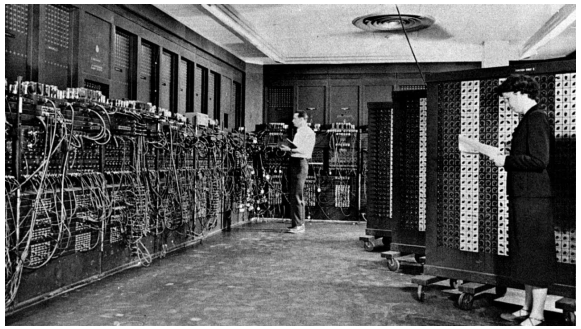
AR?
AUGMENTED REALITY

VR?
VIRTUAL REALITY

MR?
MIXED REALITY

Extended Reality (XR)?

Evolution of Computer



1960-70’s

Room

1970-80’s

Desk

1980-90’s

Lap

1990-2000’s

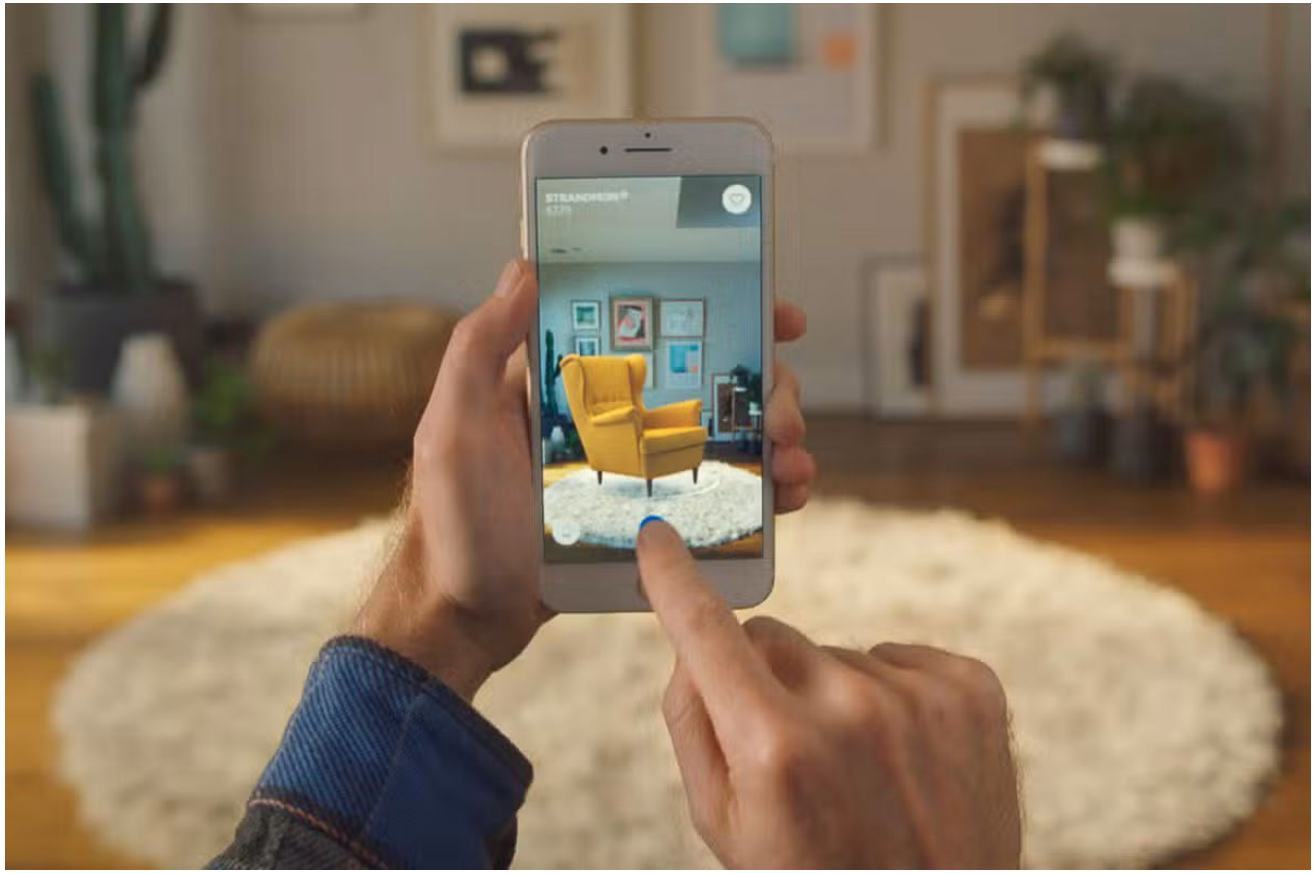
Hand

2010-

Head

Virtual Reality

Augmented Reality



Mixed Reality

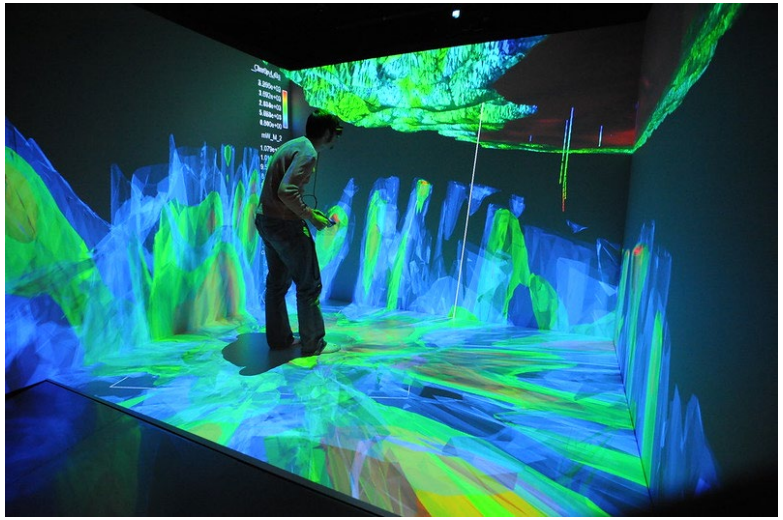
Extended Reality (XR)

AR
AUGMENTED REALITY

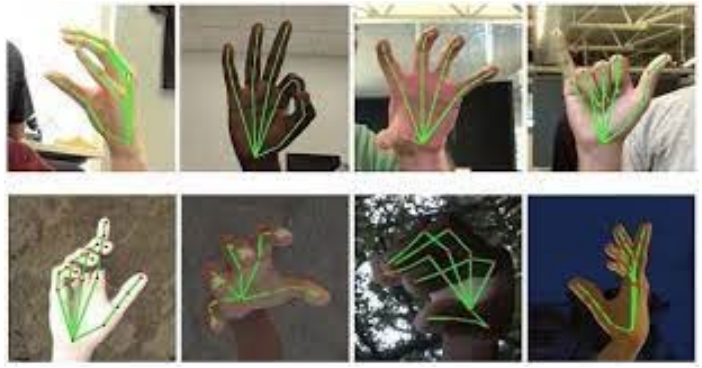
VR
VIRTUAL REALITY

MR
MIXED REALITY

Display Devices

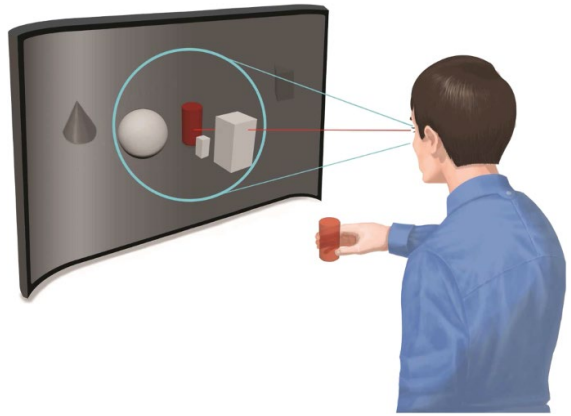


Interaction

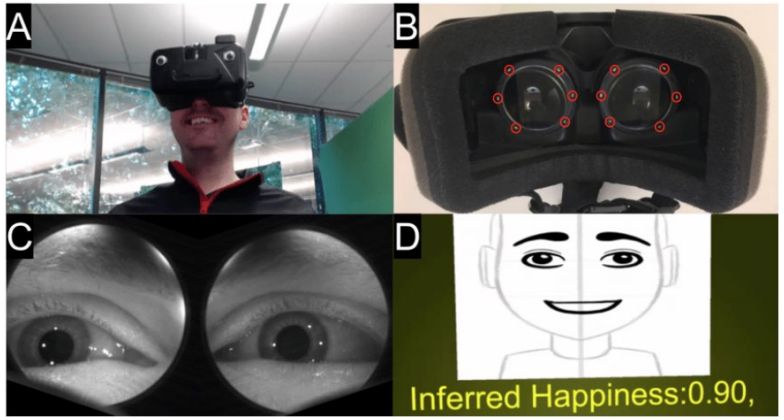


https://how2electronics.com/gesture-recognition-application-machine-learning/

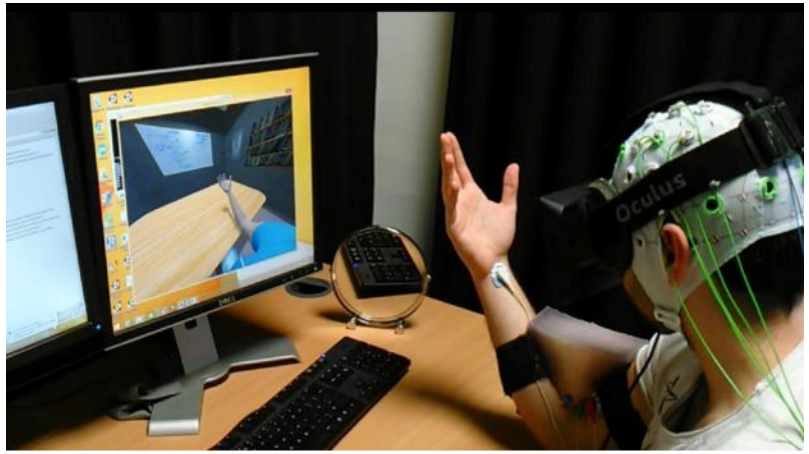
https://hcis-journal.springeropen.com/articles/10.1186/s13673-018-0154-5



https://link.springer.com/article/10.1007/s12193-019-00305-y



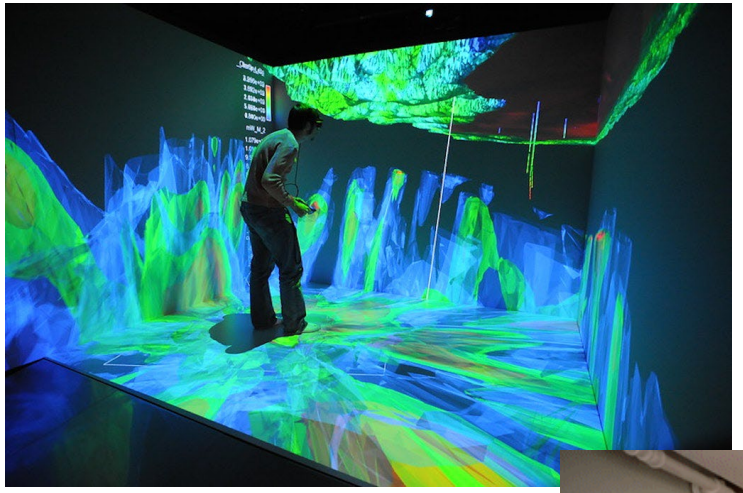
https://www.researchgate.net/figure/Eyemotion-visual-schematic-A-A-user-wearing-the-VR-HMD-used-for-expression-tracking_fig1_331606987



https://www.semanticscholar.org/paper/Movement-intention-..based-Brain-Computer-Interface-Wairagkar-Zoulias/046422e95aee75912b030de34ec2371803247d22

Why XR Matters?

- Enhanced Perception
- Expanding Boundaries
- Increased Engagement
- Empowering Decision-Making



https://gifer.com/de/s/mixed-reality
https://makeagif.com/gif/microsoft-hololens-mixed-reality-in-the-modern-workplace-Vle_HX

Effectiveness of VR/AR

	Classroom	E-learn	VR
How many times were you multitasking or distracted during this experience?	0.78	1.93	0.48
How many minutes do you estimate it took to get back on task?	1	2.63	0.48

VR-trained learners were up to 4 times more focused during training than their e-learning peers and 1.5 times more focused than their classroom peers.

275%
more confident to act on what they learned after training

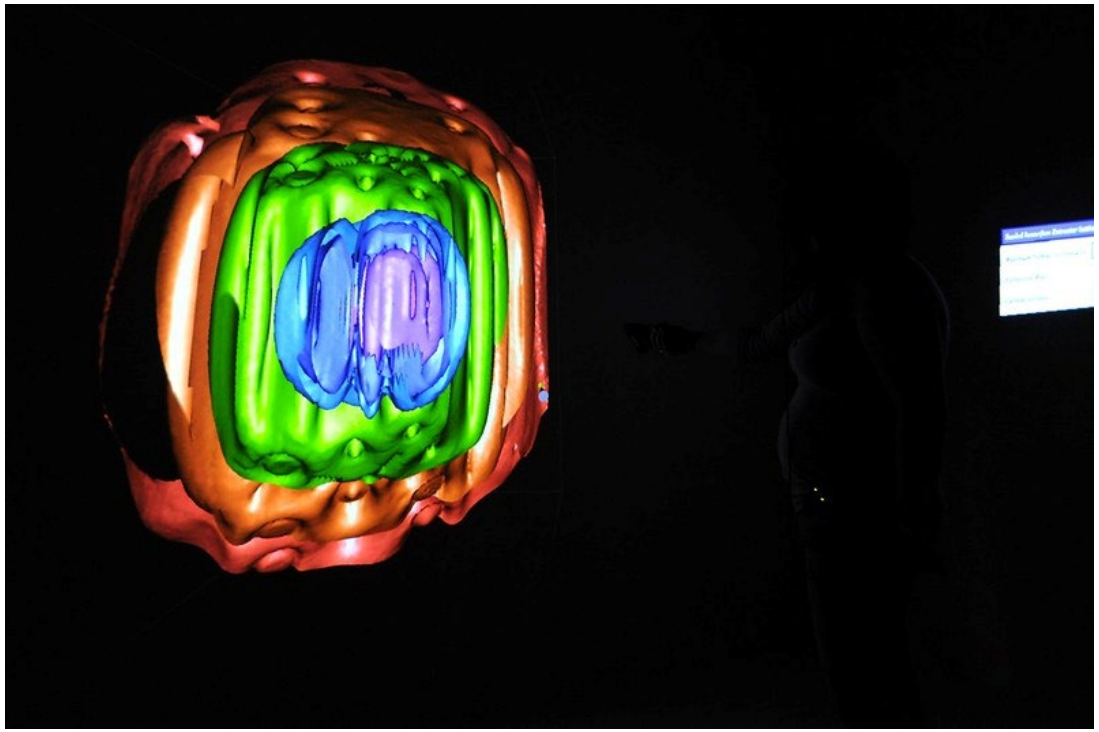
4x
faster than classroom training on average

4x
more focused than e-learners

3.75x
more emotionally connectedto the content than classroom learners

https://www.futurevisual.com/blog/pwc-study-virtual-reality-training-enterprises/

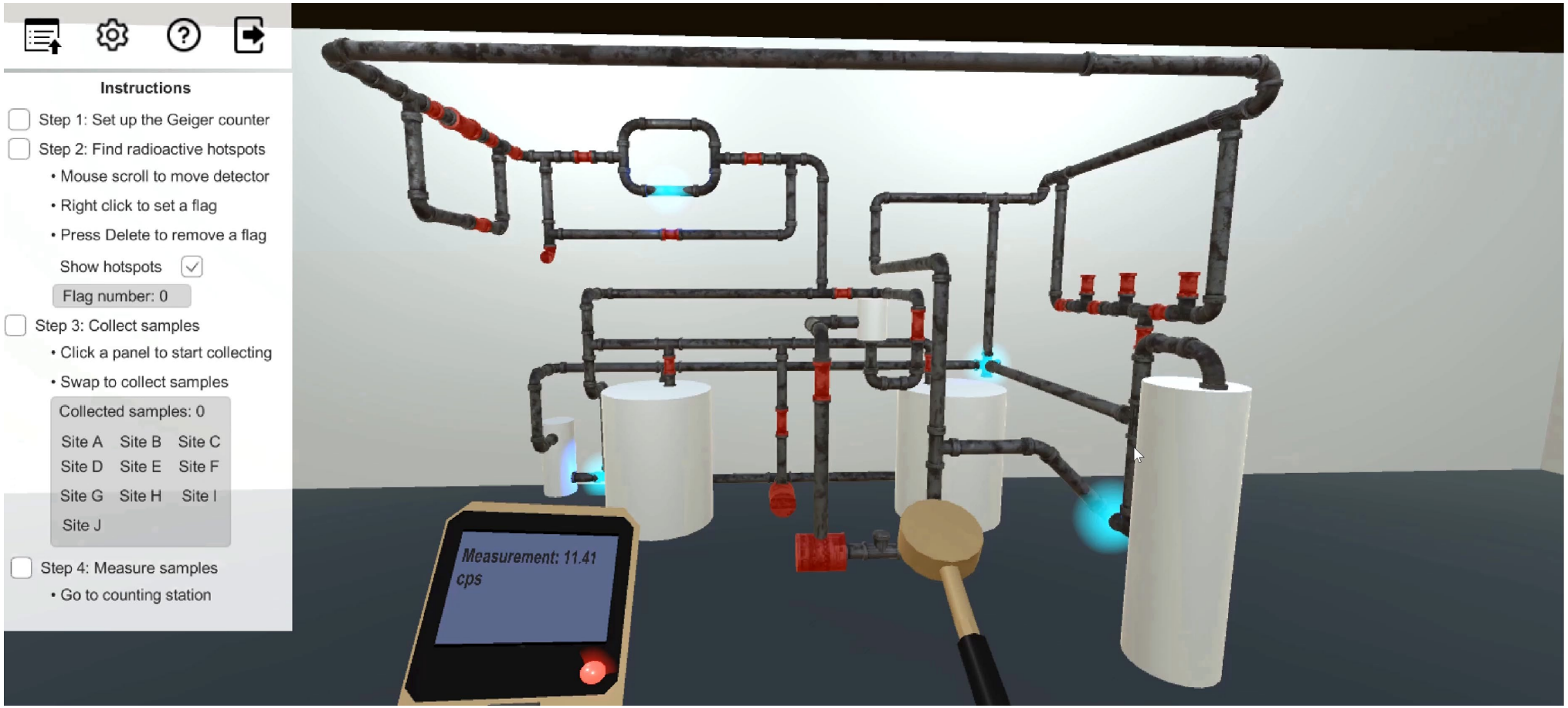
XR for Scientific Discovery



Neutron flux levels generated in the core of INL's Advanced Test Reactor during operation. Neutron levels are highest in the blue and purple areas, and lower in the orange and red areas.

Heat flow around bubbles

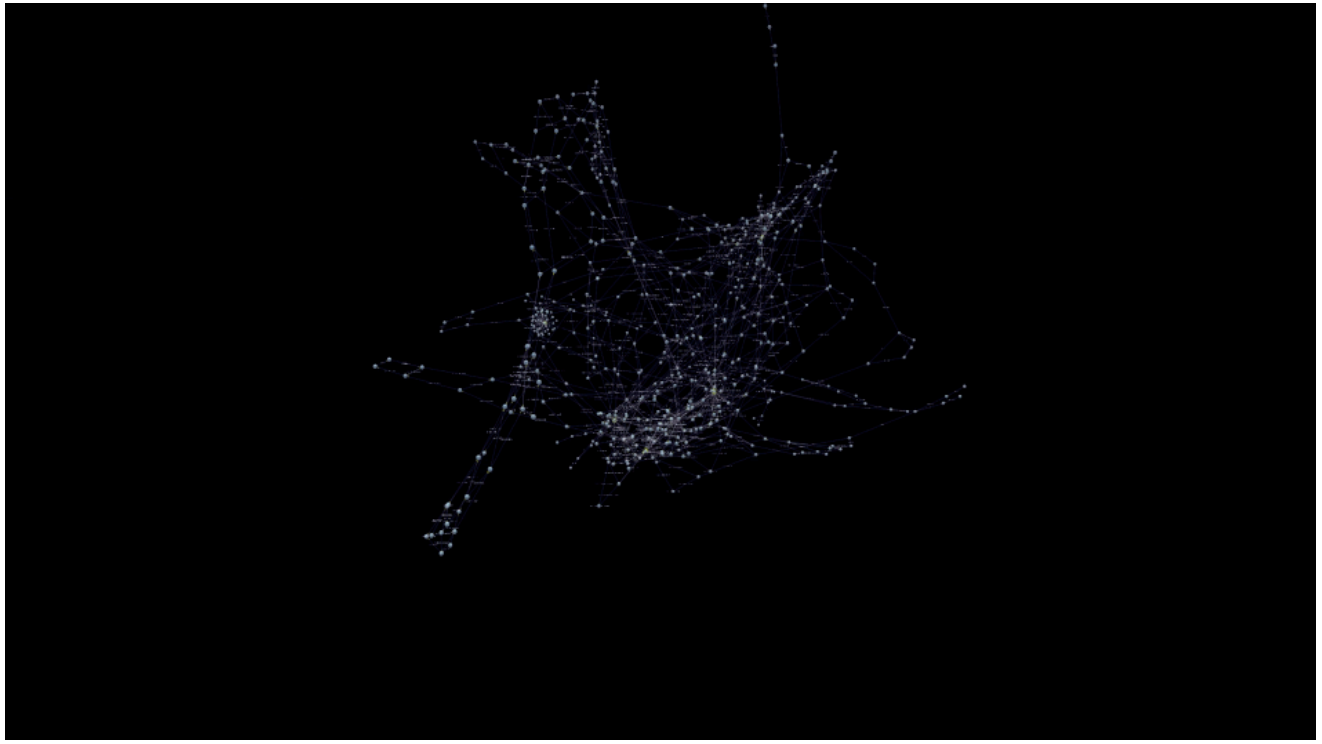
Revolutionizing Education

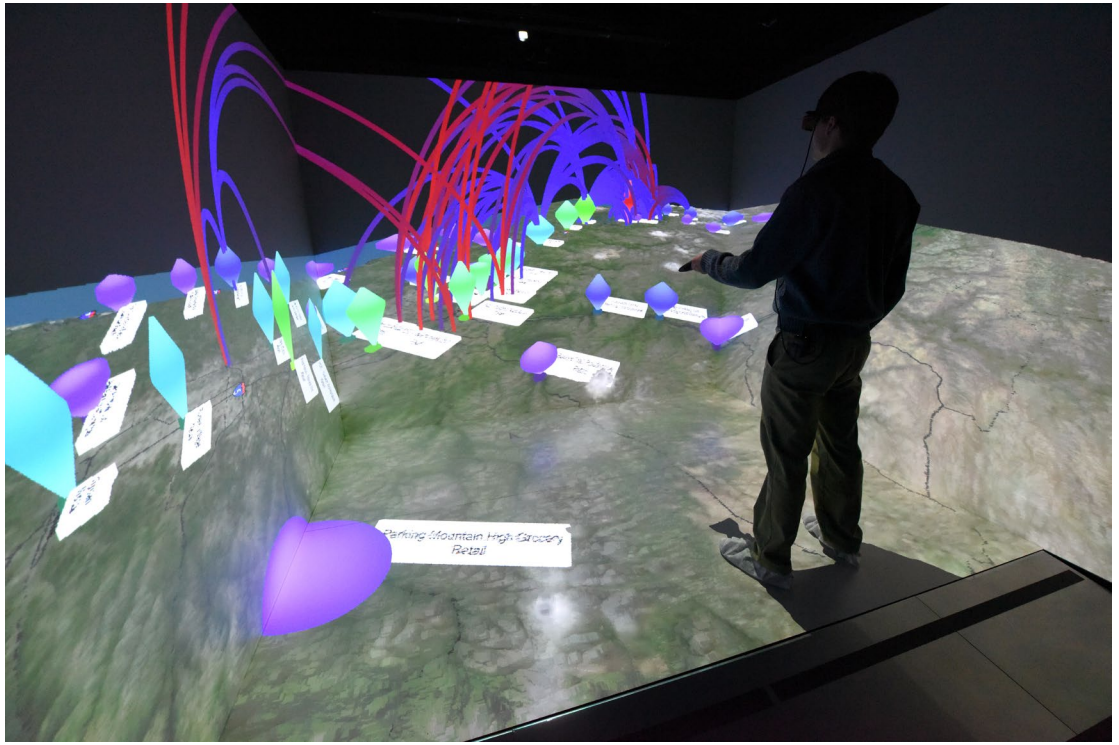


Innovations in Engineering Prototype & Designs

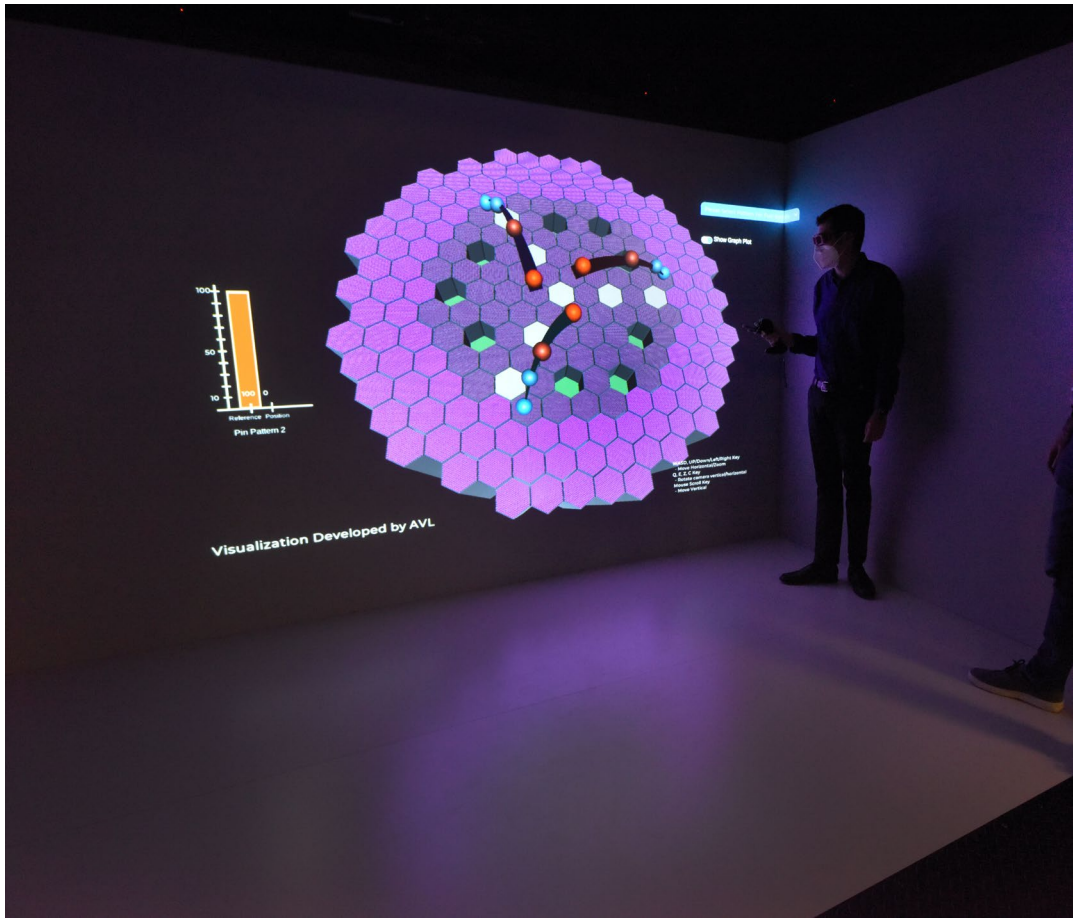
Virtual Prototype of Mobile Hot Cell (left), radiation modeling of the environment (middle) and inner components (right)

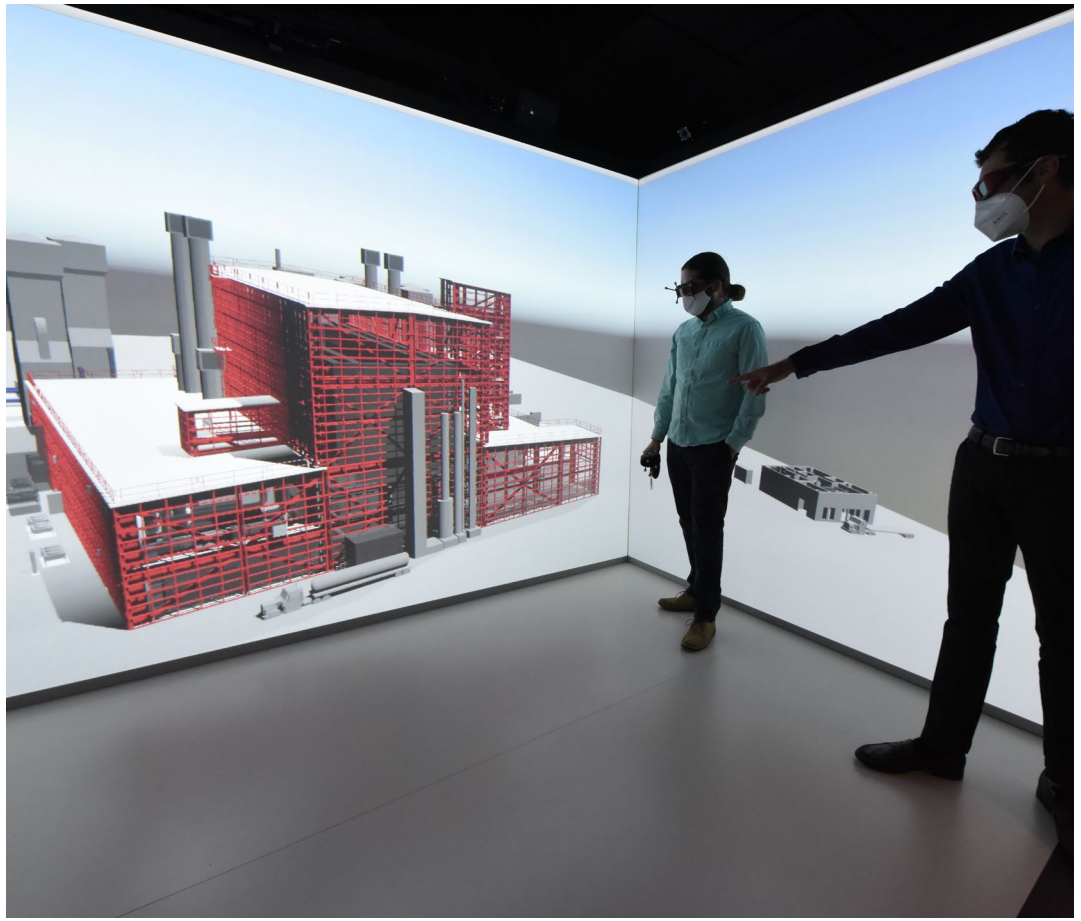
Advancing Data Analysis



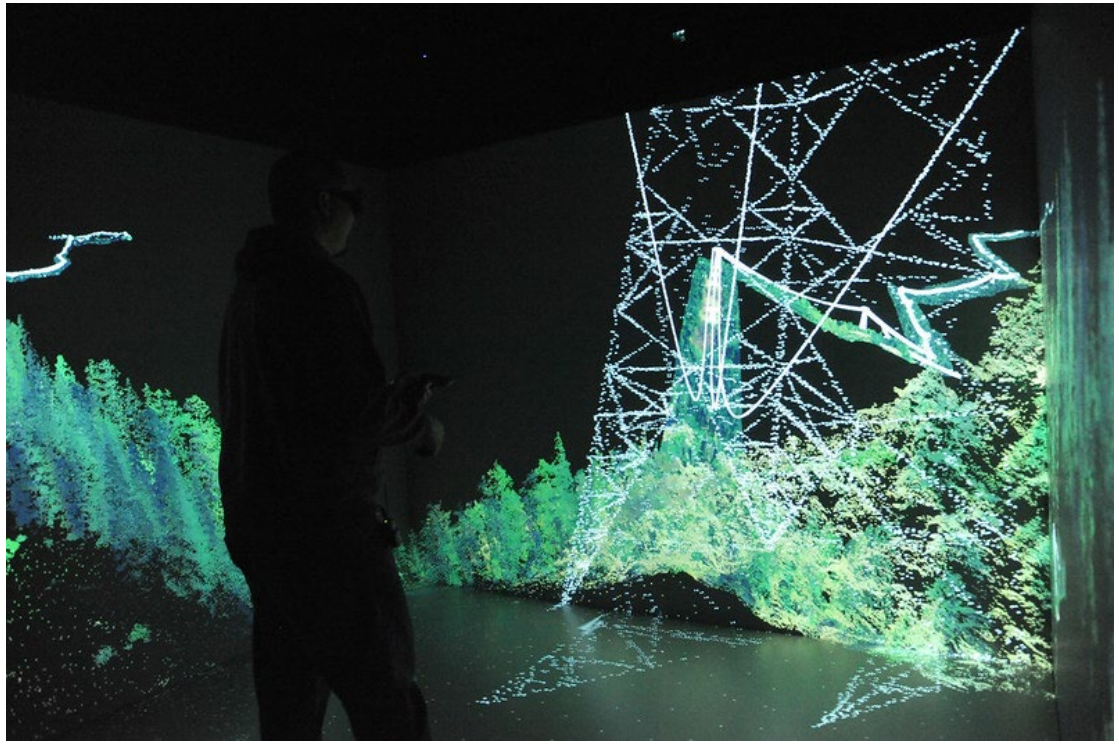


Immersive Visualization for Digital Twins





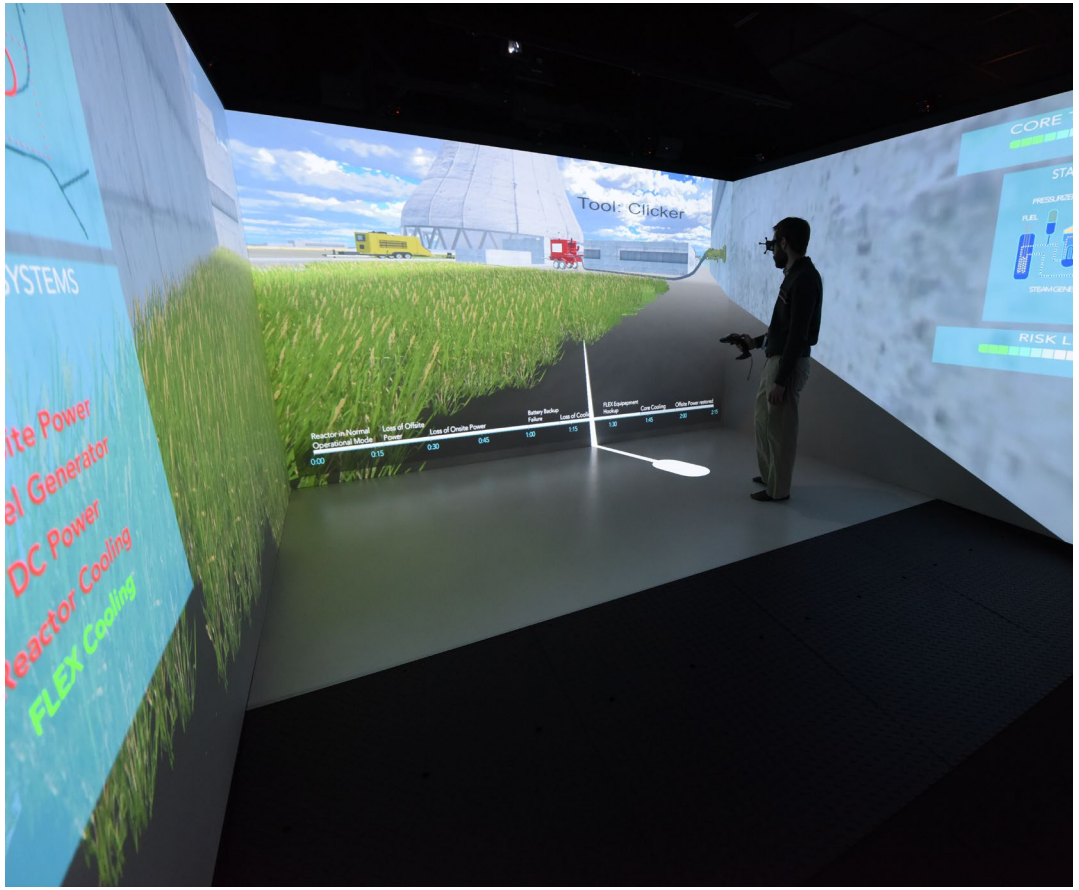
Lidar Visualization

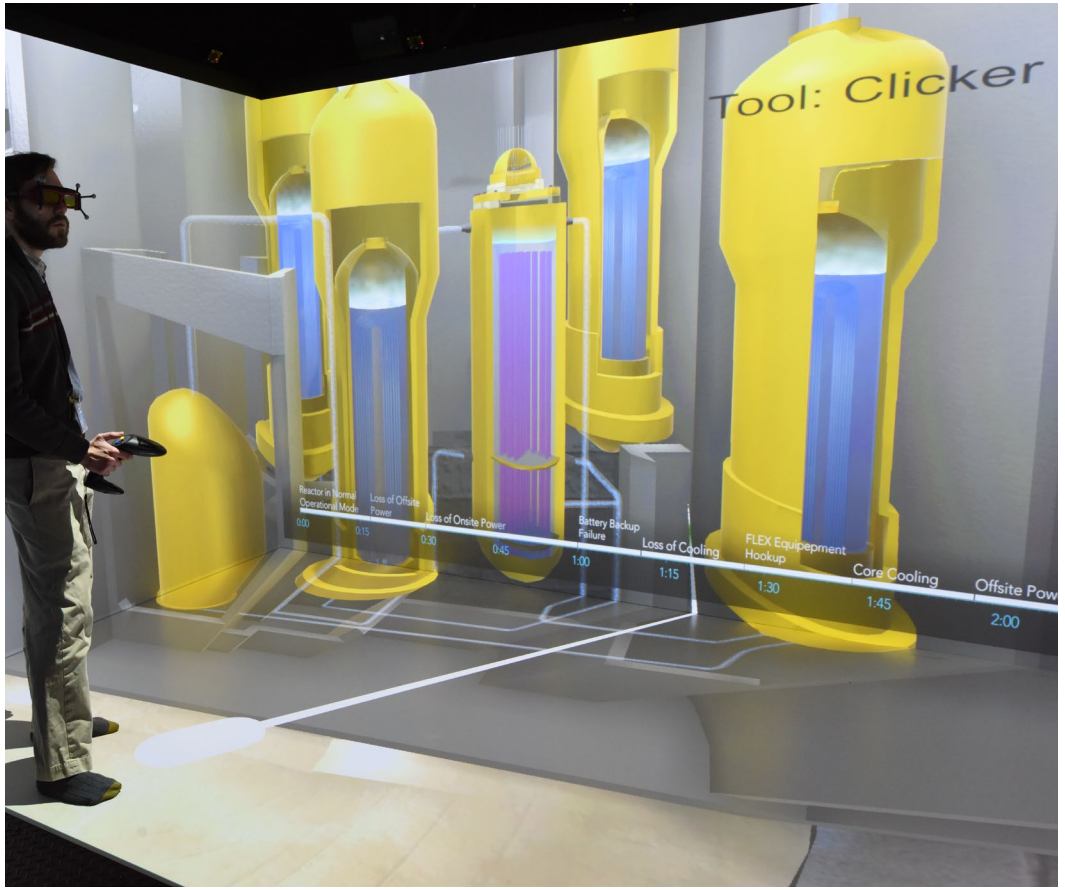


Utility companies can upload LiDAR data to the CAVE to analyze real or planned power line corridors.

Human Factors and Ergonomics

Maintenance and Inspections





Education & Outreach

A group of users using large-immersive system for visualization.

Challenges

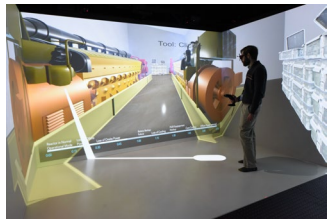
- Cost
- Motion sickness
- Privacy concerns
- Content creation complexities
- Interoperability
- Accessibility

Key Takeaways

Immersive Engineering

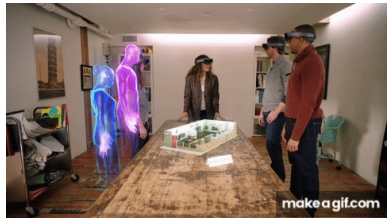
VR/AR Practical Application In Engineering Industries Will Keep Growing

Safety and Risk



Enhance safety and reduce risks in the nuclear industry

Reduce cost & Accelerate Progress



Detect project issues earlier
Remote Maintenance
Easily design iterations

Workforce Preparation

Preparing for new generation of workforce

Applied Visualization Laboratory

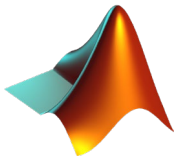
Experience and Expertise in Visualization & AR/VR/XR at INL

https://www.pwc.com.au/digitalpulse/report-seeing-believing-ar-vr.html

Incorporating XR into Scientific Visualization Workflows

Principal Tools for Scientific Visualization at INL (in descending order of popularity)

- Microsoft Excel



- Matlab

- Matplotlib

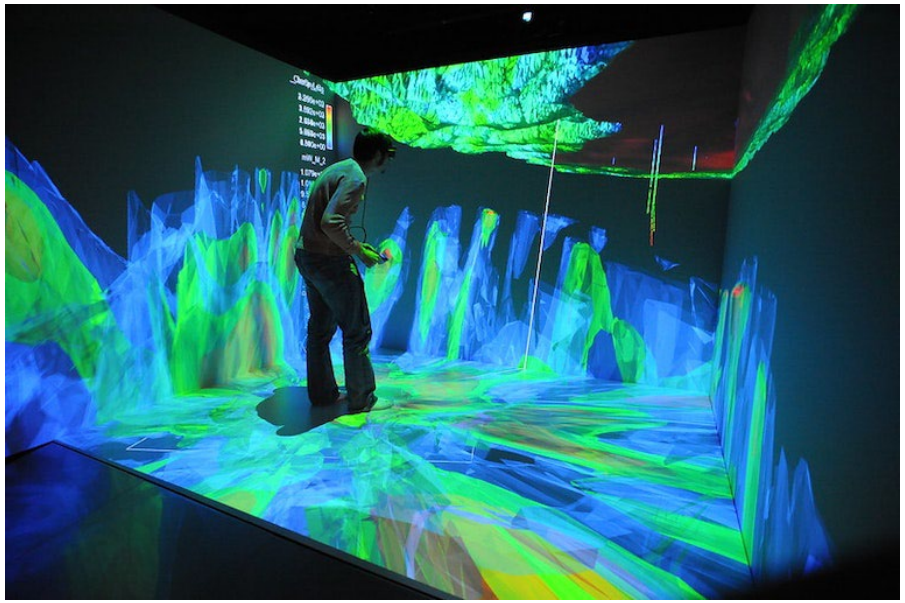
- Paraview

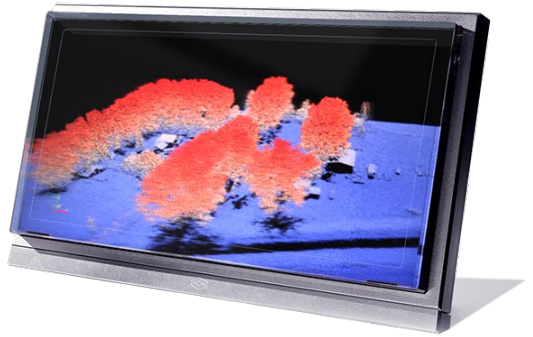
- Everything else

- Notably, this doesn't include proprietary tools built into e.g. instrument control software
- XR technologies must be integrated into the scientific analysis workflow in order to be useful
- Anything that requires interaction with specialized visualization personnel is a tough sell

Current Development of Scientific Visualization at INL

- Fully incorporate ParaView into the CAVE environment at AVL
- Continue to explore ParaView XR capabilities and develop new scientific workflows in headsets
- Explore applications of new visualization hardware, such as the Looking Glass holographic displays





Idaho National Laboratory

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