Building The Lens

Visualization Instrument Research at EVL

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Electronic Visualization Lab

- Est. 1973, Oldest CS/Art collaboration in the US
- Main Research
  - Virtual Reality
  - High-Speed Networking
  - Scientific Visualization
  - HCI
  - Human Augmentics

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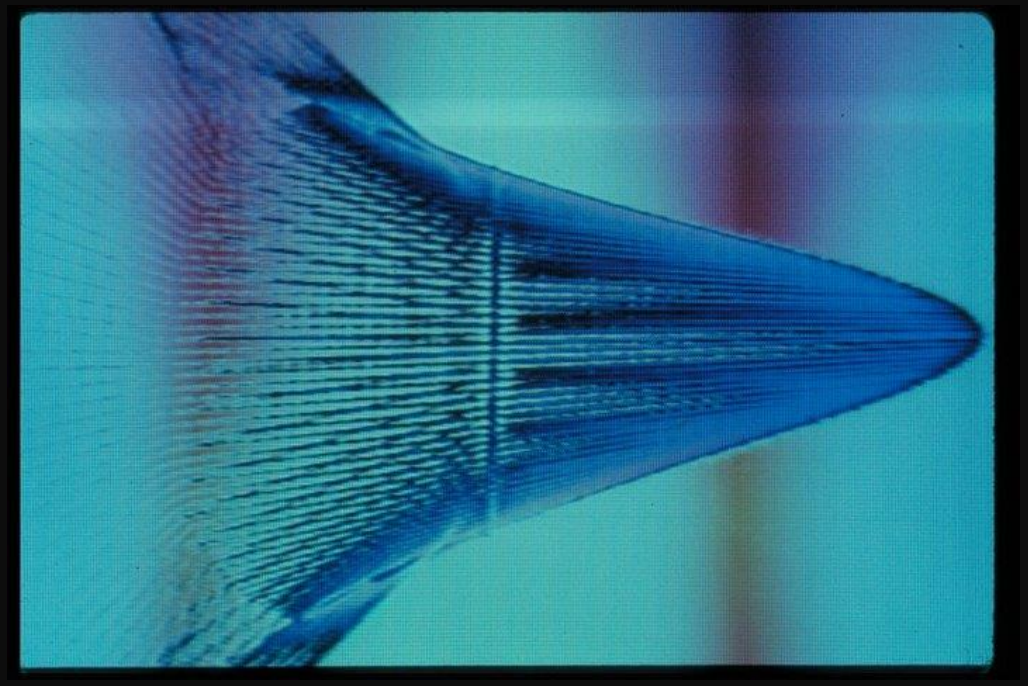
EVL History

- Founded by Dan Sandin & Tom DeFanti
  - Sandin Image Processor
  - GRASS Language



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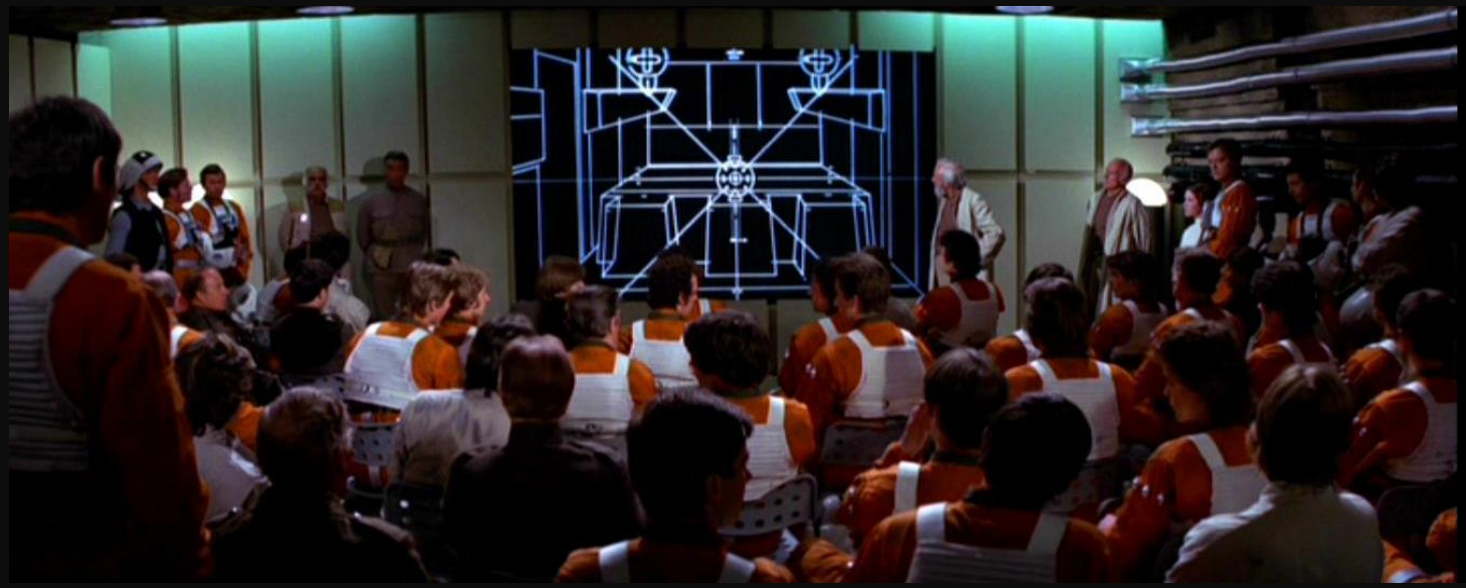
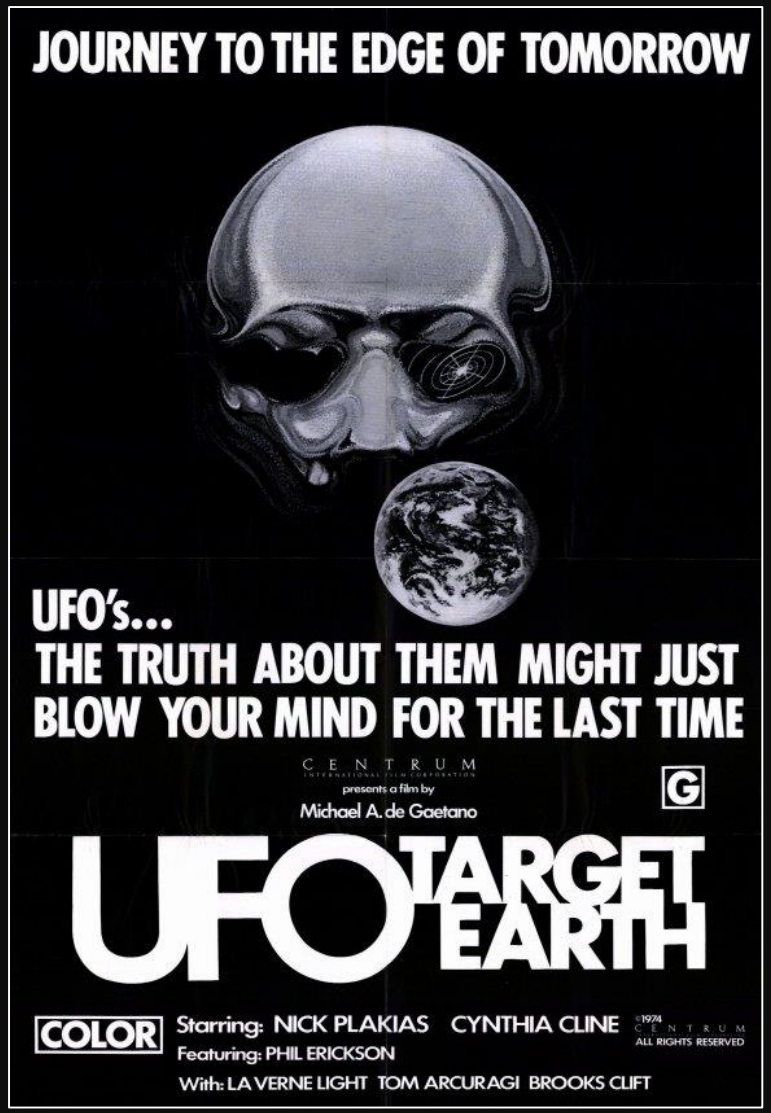
The Good Movie!

EVL Worked on Graphics for rebel briefing scene in Star Wars



And The Bad One ☺



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1990s

- Main Research: Virtual Reality

Original CAVE

ImmersaDesk

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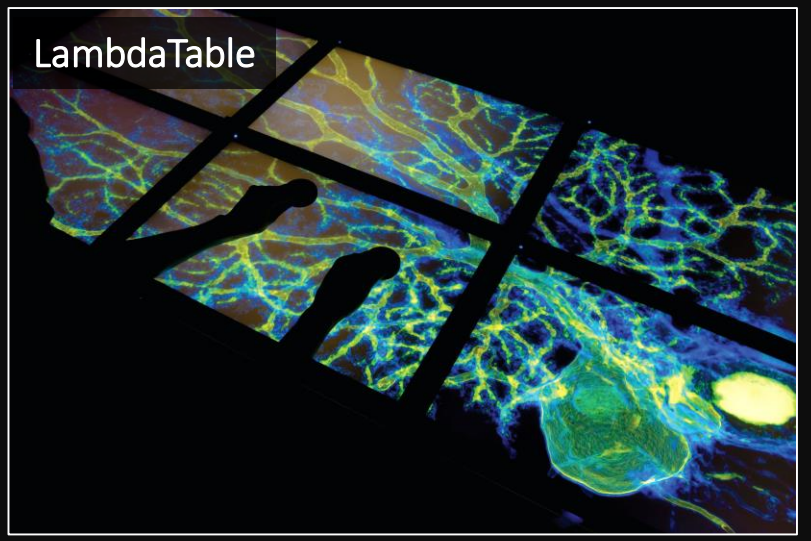
2000s

- Director: Jason Leigh
- Main Research: Display Walls
  - Devices
  - Applications
  - Interaction



Now

- Main Research:
  - Human Augmentics
  - SciVis/InfoVis
  - Hybrid Environments
- New Directors:
  - Maxine Brown
  - Andy Johnson

What I Work(ed) On

- Hybrid Environments
  - OmegaDesk
  - CAVE2
- Scientific Visualization
  - Environmental & Planetary Science
  - Brain Connectome / Vasculature
- HCI
  - Medical Informatics
  - Co-Located collaboration

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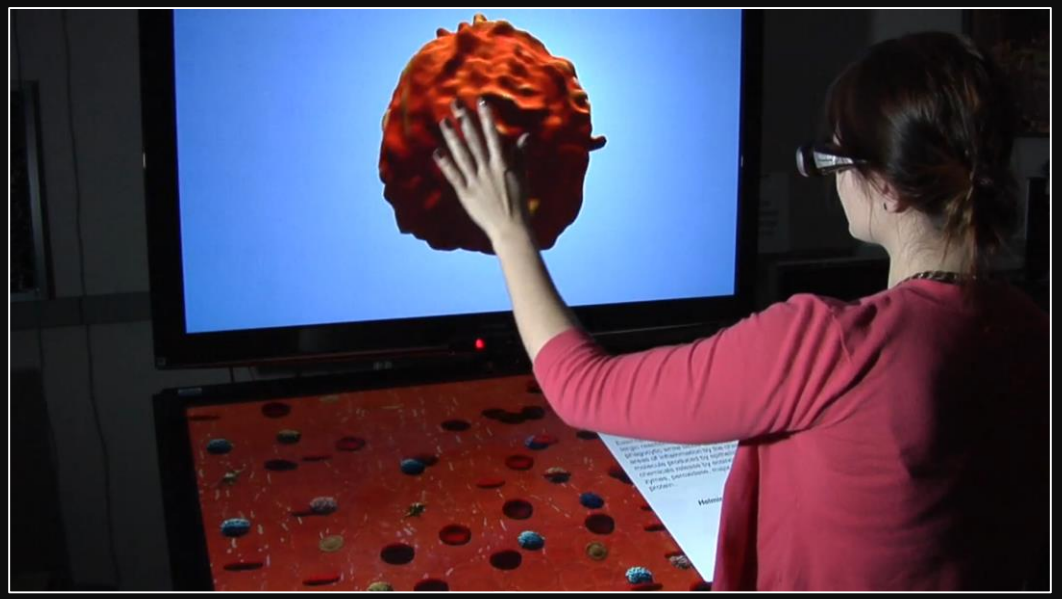
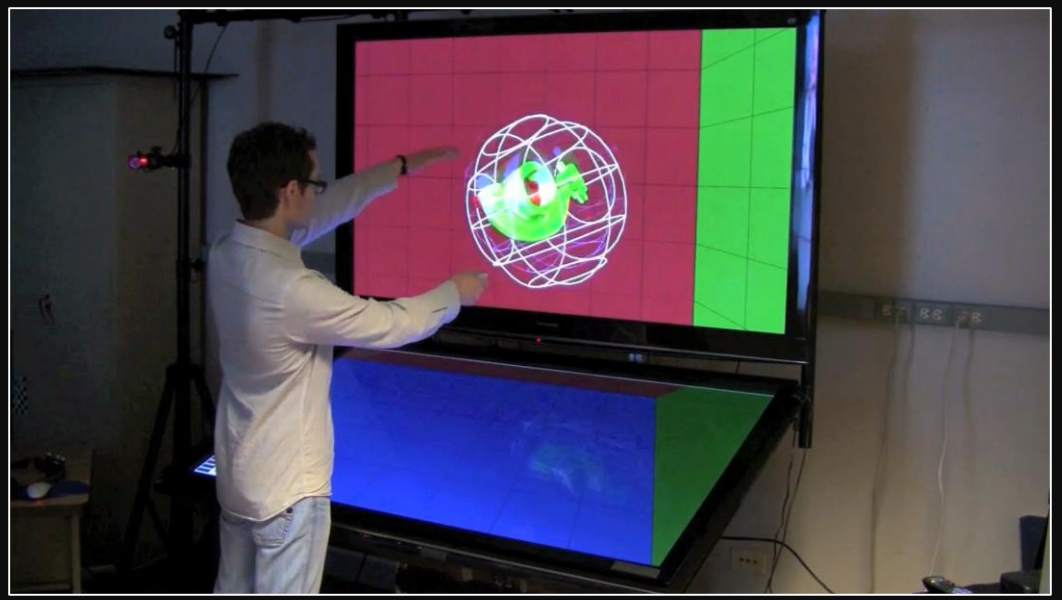
The OmegaDesk[1]

- Hybrid Work Desk
- Mixed 2D + 3D Modes
- Touch + Tracked Interaction



1. **Febretti, A.**, Mateevitsi, V.A., Chau, D., Nishimoto, A., McGinnis, B., Misterka, J., Johnson, A., Leigh, J. "The OmegaDesk: Towards A Hybrid 2D & 3D Work Desk" *7th International Symposium on Visual Computing (ISVC11), Las Vegas, Nevada, 09/26/2011*



Hybrid Reality Environments

Immersive Environments

User-Centered Stereo
3D Spatial Data
Single User

Display Walls

High Resolution
Multiple Views
Multiple Users

HREs

High Resolution 3D + 2D
Natural Interaction
Collaborative Space

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The CAVE2 HRE[2,3]

2. Febretti, A., Nishimoto, A., Thigpen, T., Talandis, J., Long, L., Pirtle, J., Peterka, T., Verlo, A., Brown, M., Plepys, D., Sandin, D., Renambot, L., Johnson, A., Leigh, J. "CAVE2: A Hybrid Reality Environment for Immersive Simulation and Information Analysis"*IS&T/SPIE Electronic Imaging. International Society for Optics and Photonics, 2013*

3. Reda, K., **Febretti, A.,** Knoll, A., Aurisano, J., Leigh J., Johnson, A., Papka, M., Hereld, M. "Visualizing Large, Heterogeneous Data in Hybrid Reality Display Environments". IEEE Computer Graphics and Applications, Vol. 33.4 (July-August 2013), pp. 38-48

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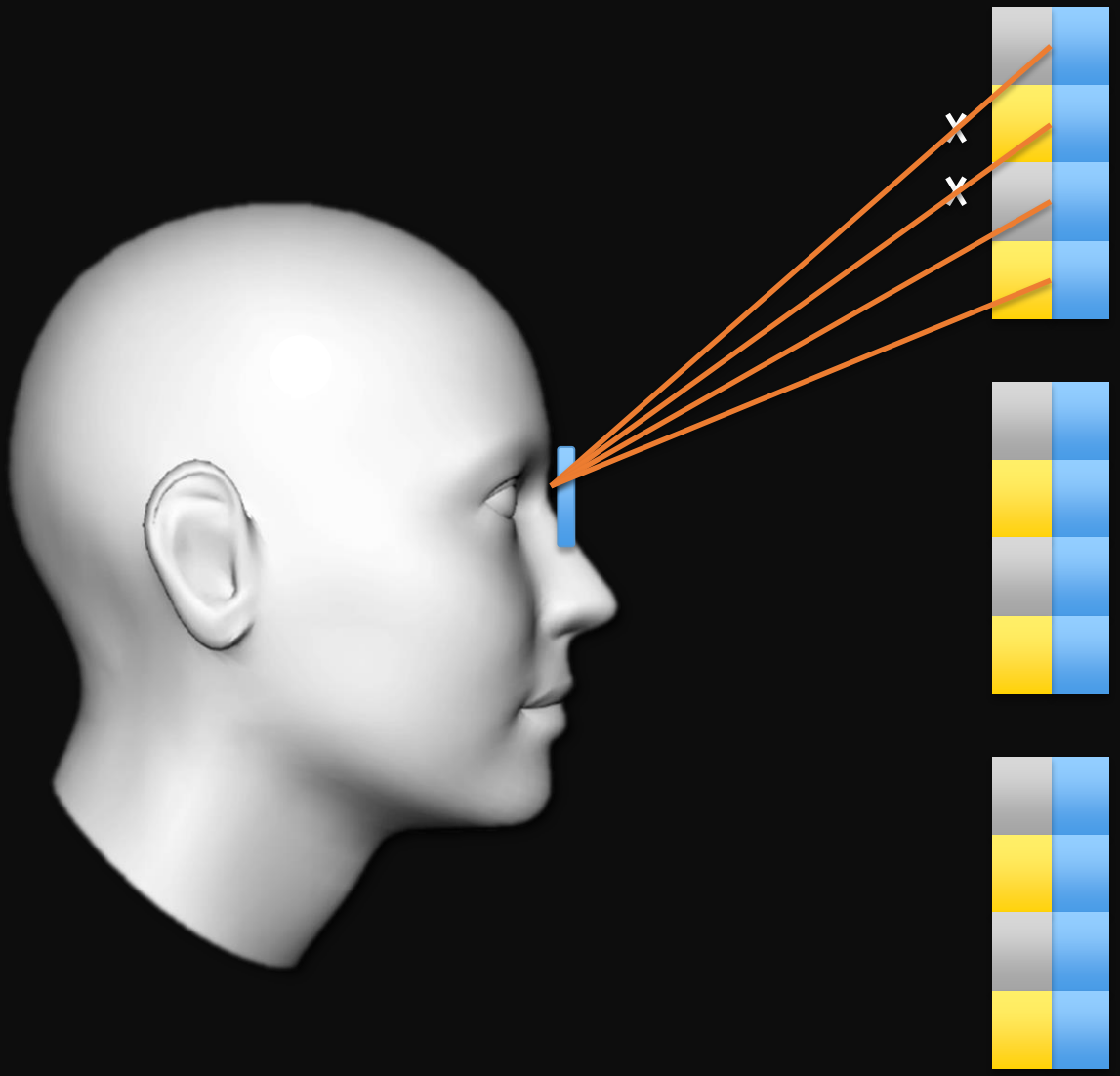
Optimizing off-axis Stereo



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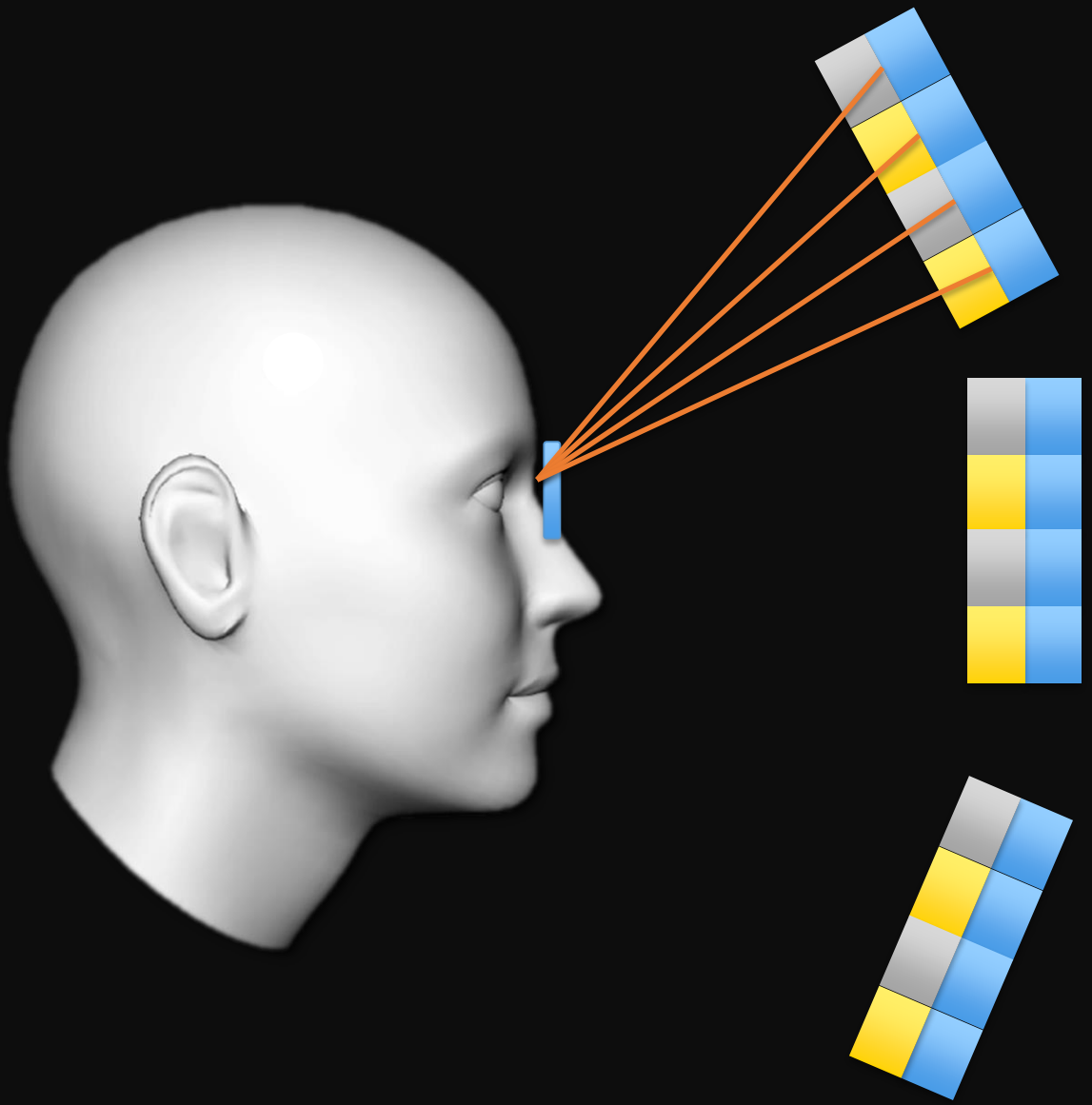
Optimizing off-axis Stereo: curve display



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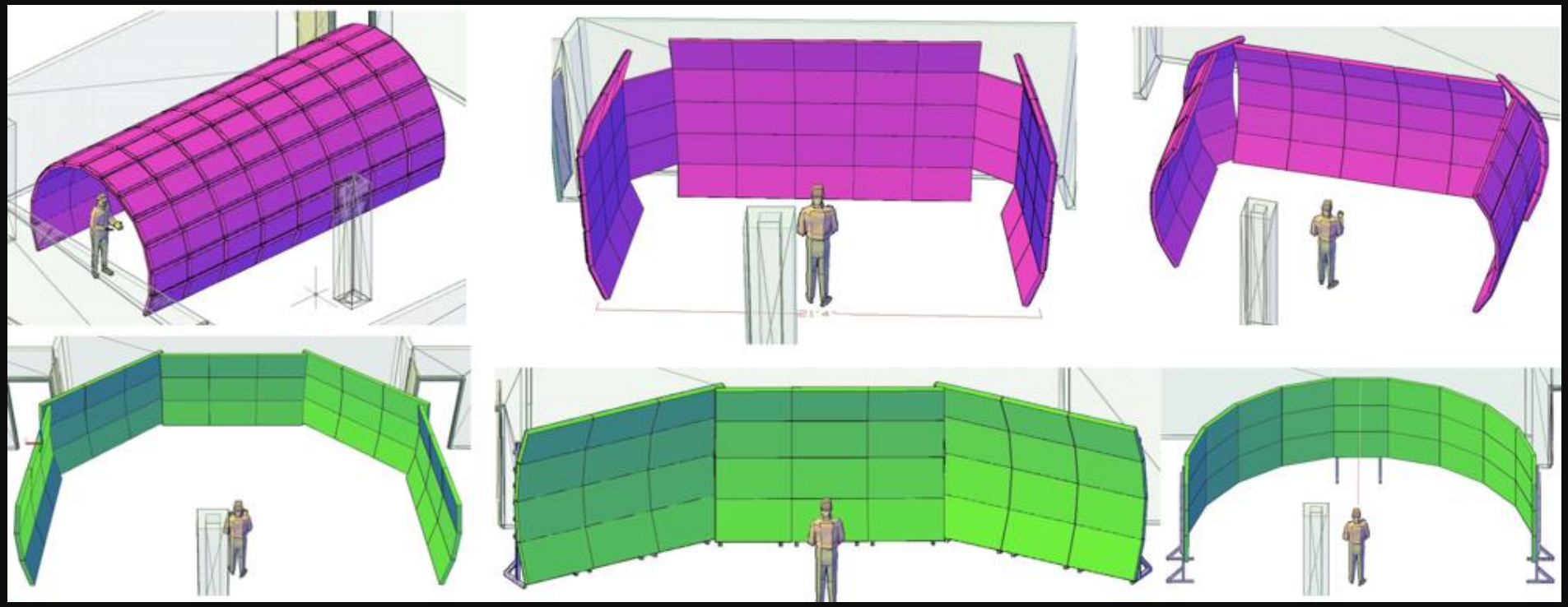
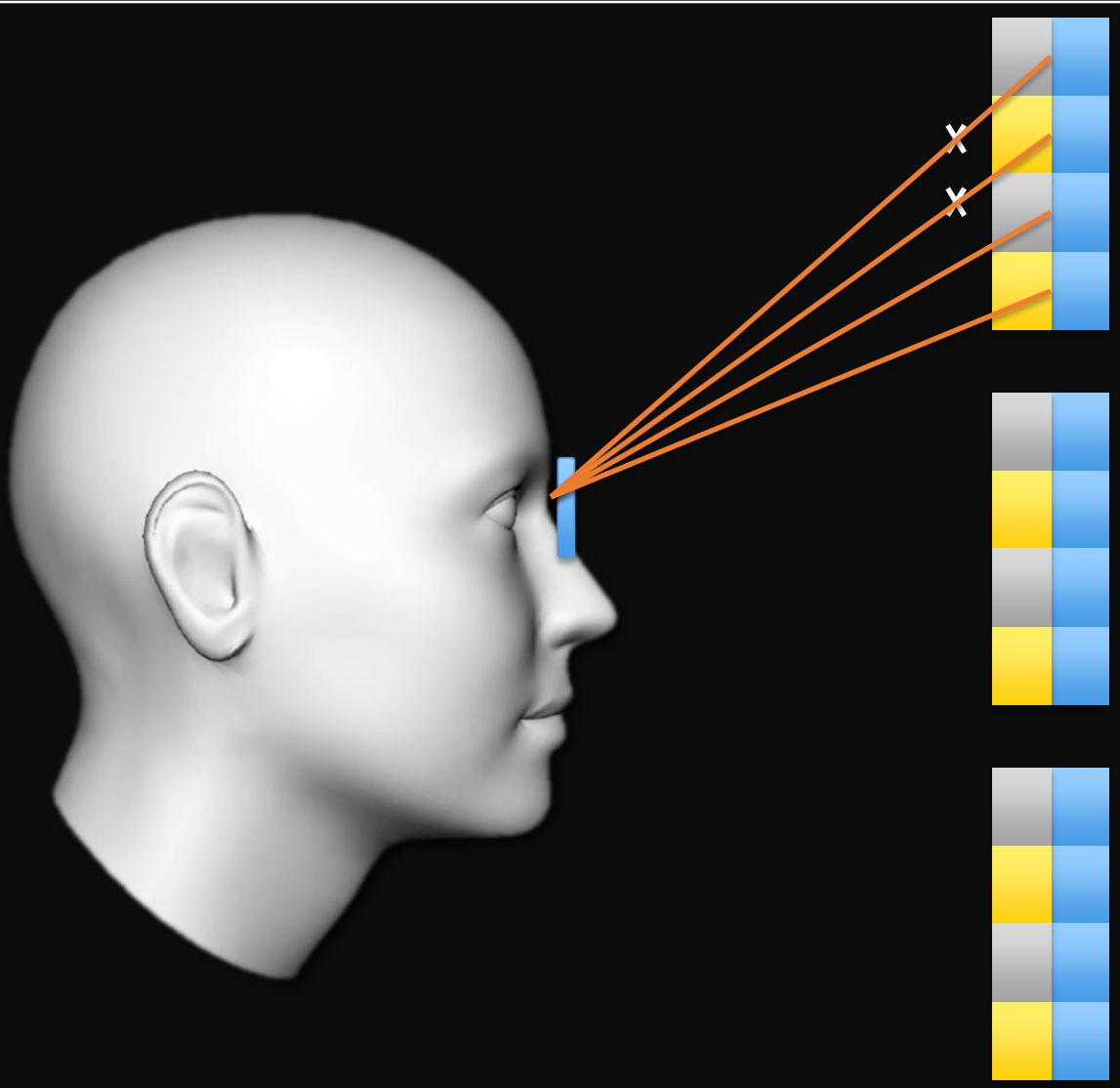
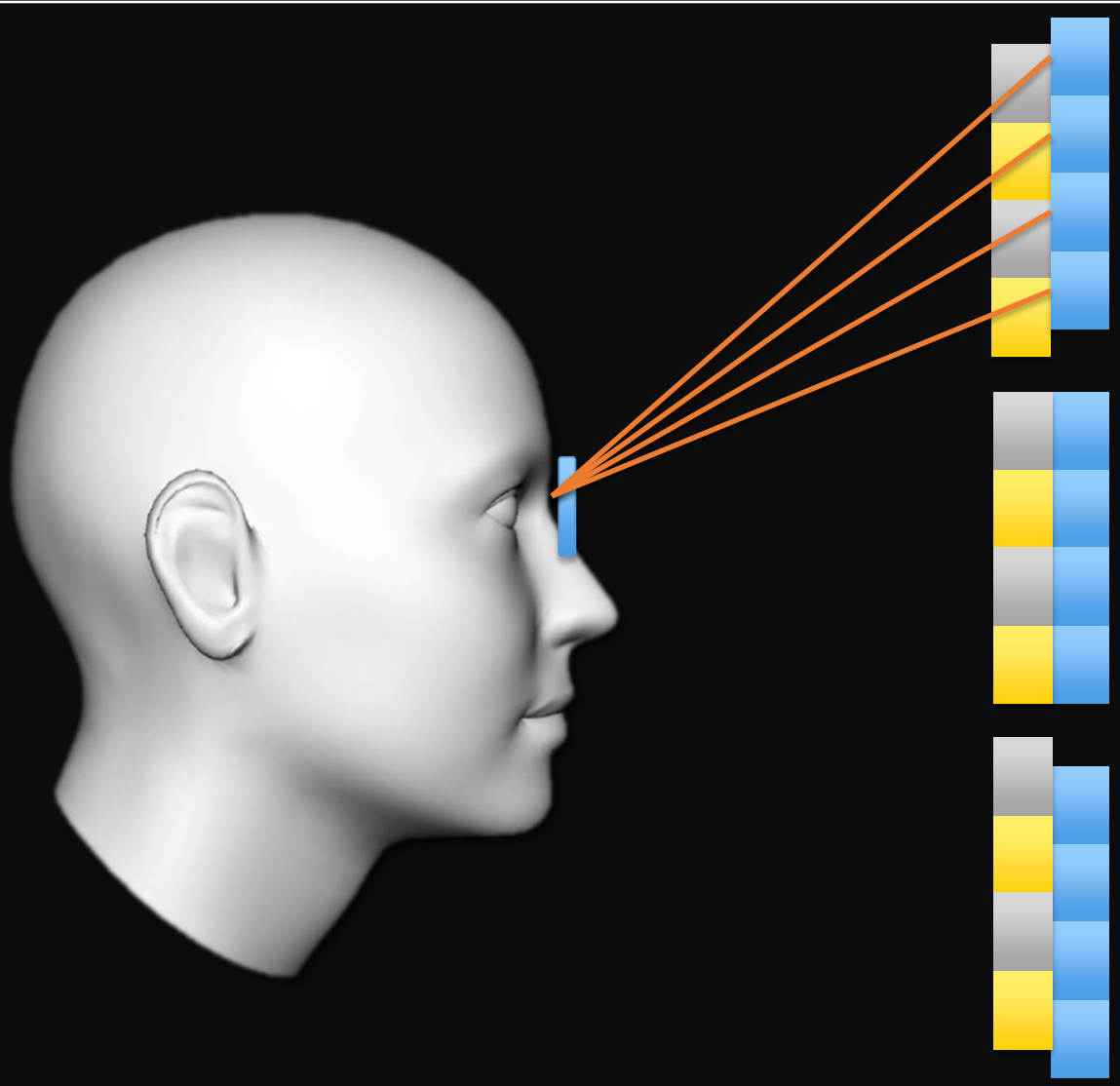
Off-axis Optimized Designs



Optimizing off-axis Stereo



Optimizing off-axis Stereo: shift polarizer



Final CAVE2 Design

Shifted polarizer allowed for CAVE2 cylindrical design

- Good immersion
- active enclosed space
- Seamless design
- Ease of assembly

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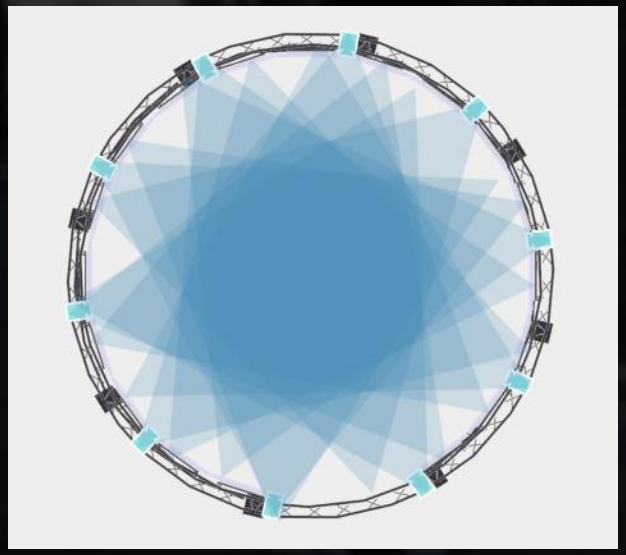
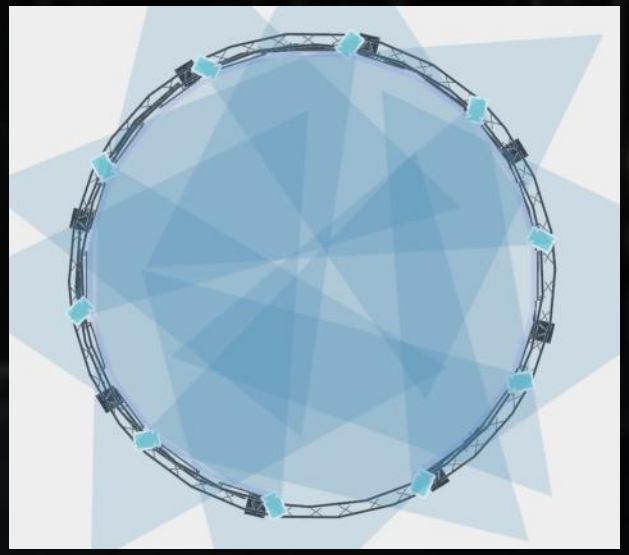
CAVE2

- Display: 4 x 18 thin bezel Planar displays
  - 36MP stereo resolution (13X original CAVE)
- Cluster system: 36 16-core Xeon nodes + head
  - Nvidia GTX 680 2GB
- Network: 2x 10Gb/s links (100Gb/s planned)
- Storage: 36 2TB local storage + 2TB shared
  - ~22,000X original CAVE
- Audio: 22 total channels (20 speakers + 2 sub)
- Size: 20+ feet radius

- Tracking System
  - 10 Vicon Bonita cameras
  - Asymmetric orientation maximizes coverage
  - Separate machine handles tracking & input preprocessing





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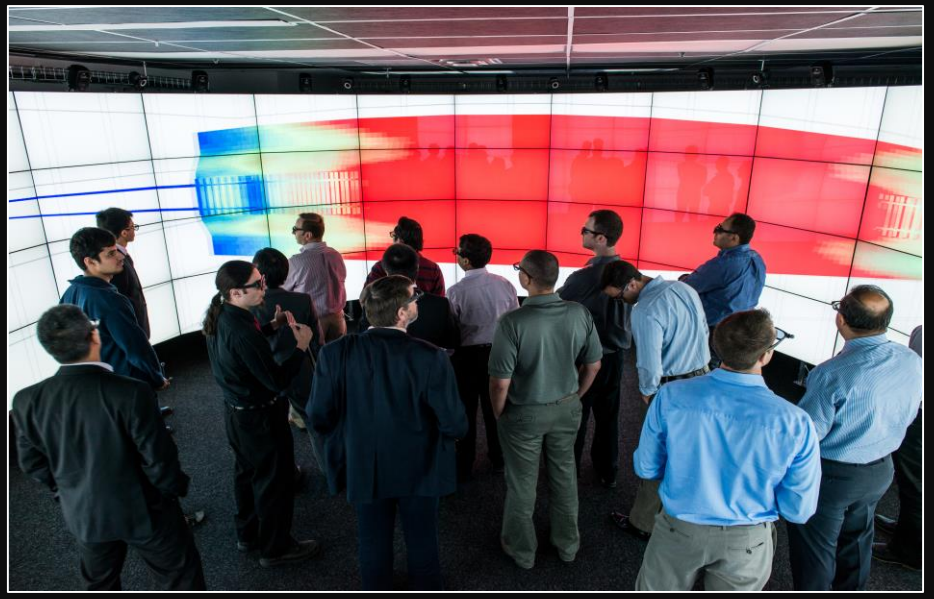
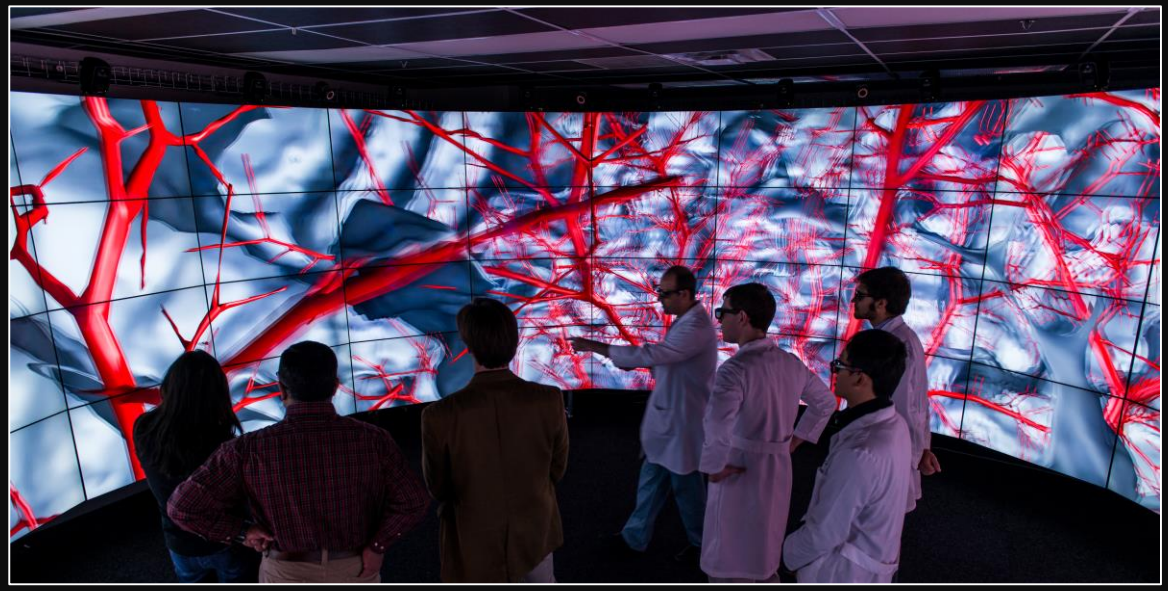
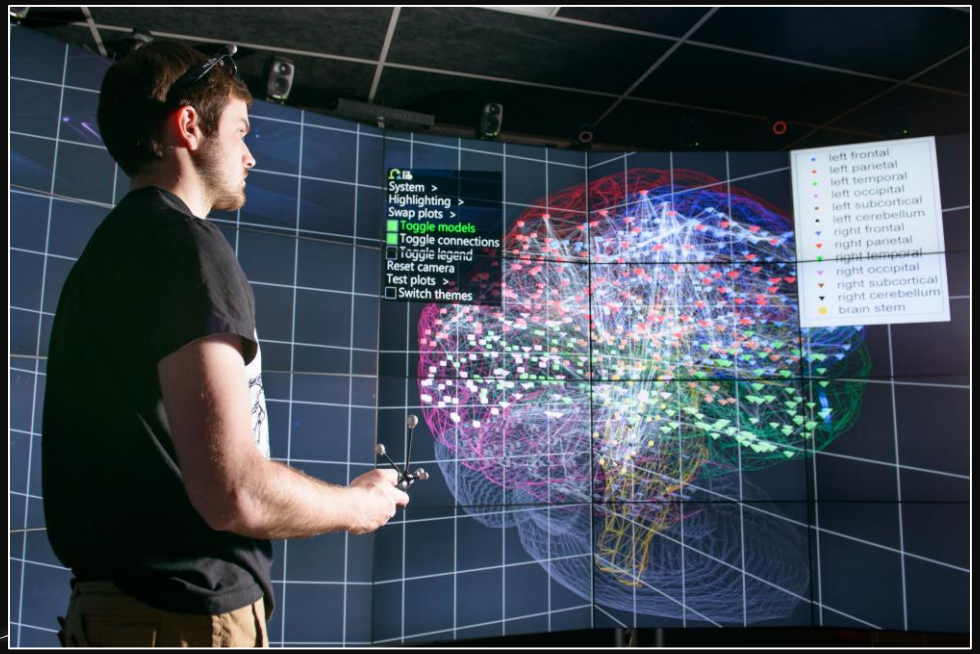
CAVE2 Applications

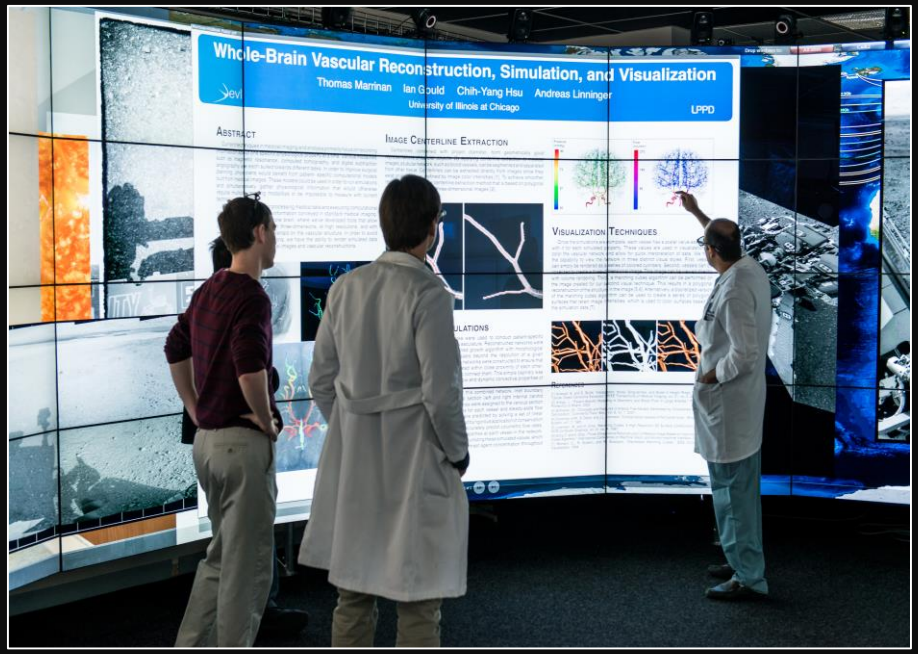


Neuroscience and Neurosurgery

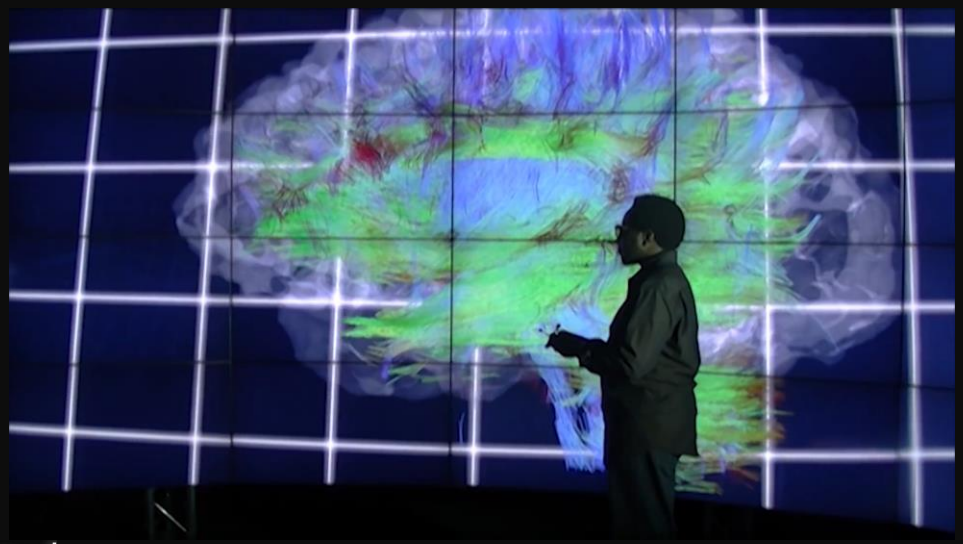
- Brain Vasculature Vis
- Functional Mapping
- Outreach

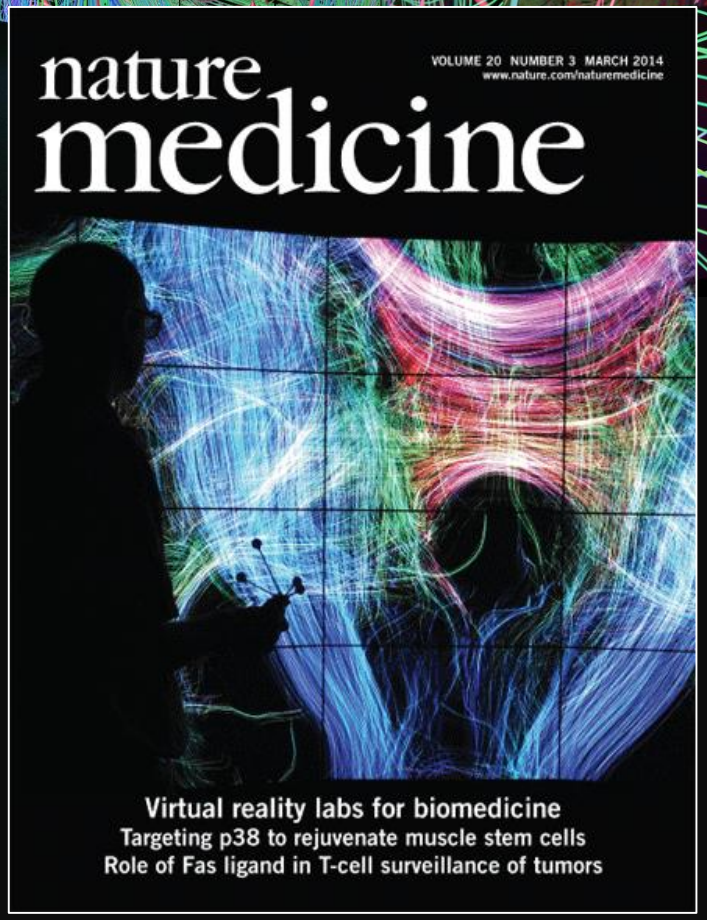






Neuroscience and Neurosurgery





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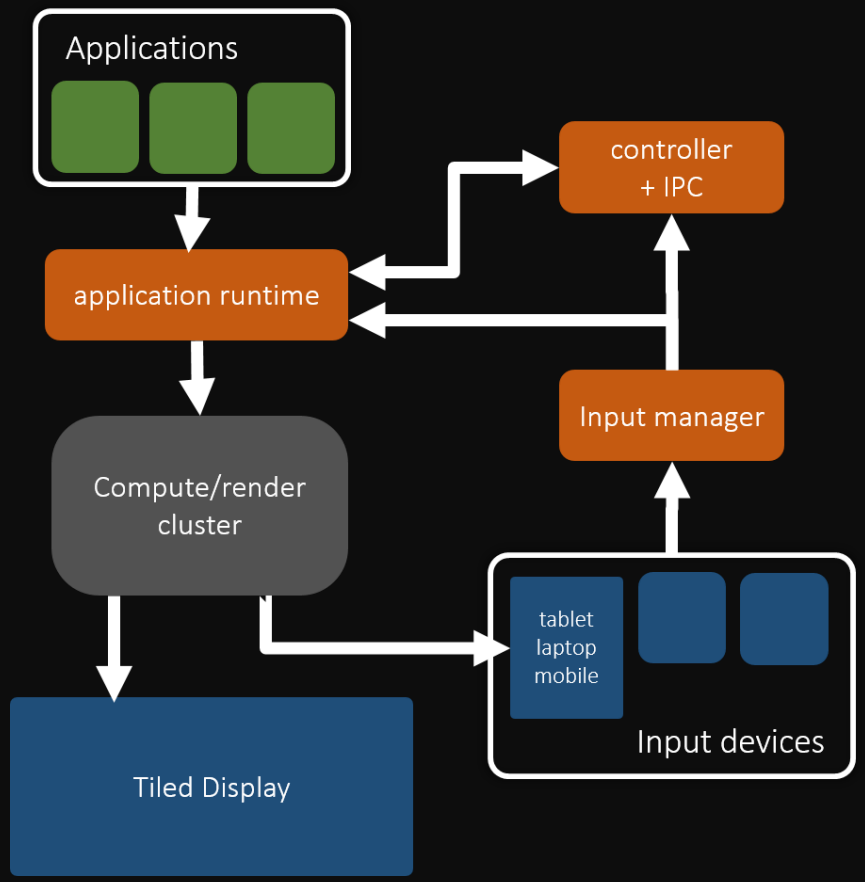
HRE OS Model



To make optimal use of HRE Hardware we need to merge capabilities of **Wall Display Software** with capabilities of **Immersive Environment Software** into an

HRE Operating System

- Runtime + Controller + Input Manager
- All components are distributed
- Our implementation: Omegalib

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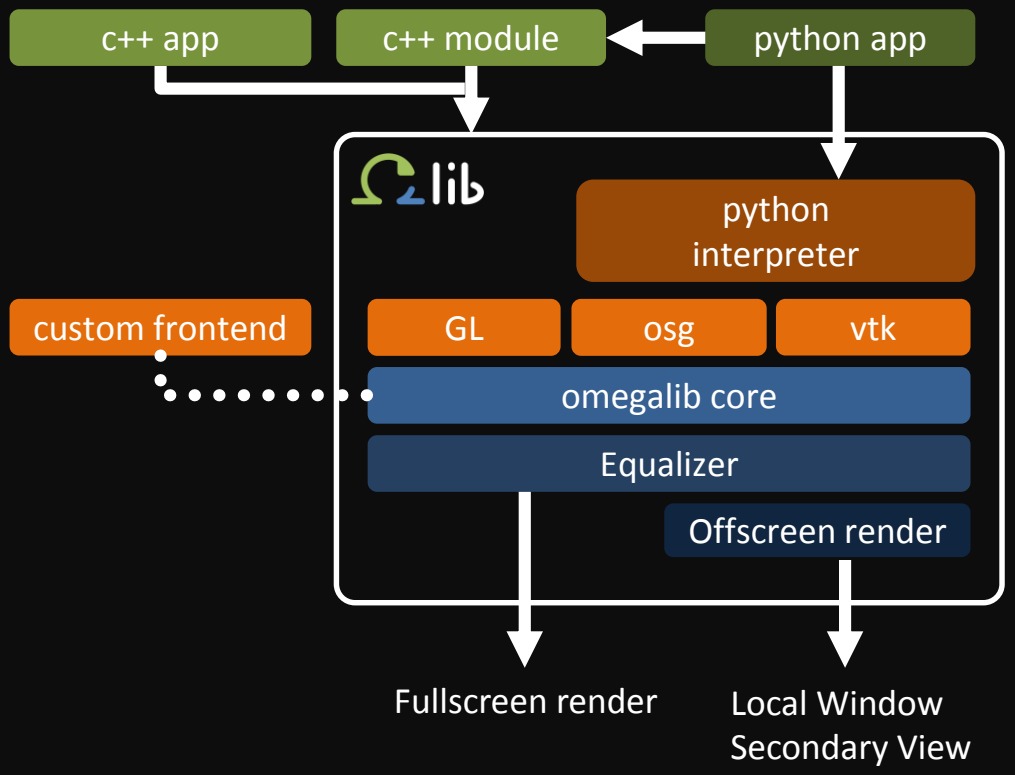
Omegalib[4]



- Runtime
  - Back-end: Equalizer
  - Pluggable front-ends
  - Embedded python interpreter
- Input Manager
  - Run embedded or as server
  - 3D & 2D input semantics
  - Ray-based event filtering
- Application controller
  - customizable message exchange protocol
  - Python-based RPC
  - Can be used by external apps (command line, C++, python)

4. Febretti, A., Nishimoto, A., Mateevitsi, V., Renambot, L., Johnson, A., Leigh, J., "Omegalib: a Multi- View Application Framework for Hybrid Reality Environments". *to appear in the proceedings of IEEE Virtual Reality (IEEE VR 2014), Minneapolis, MN, March 29 - April 2, 2014*

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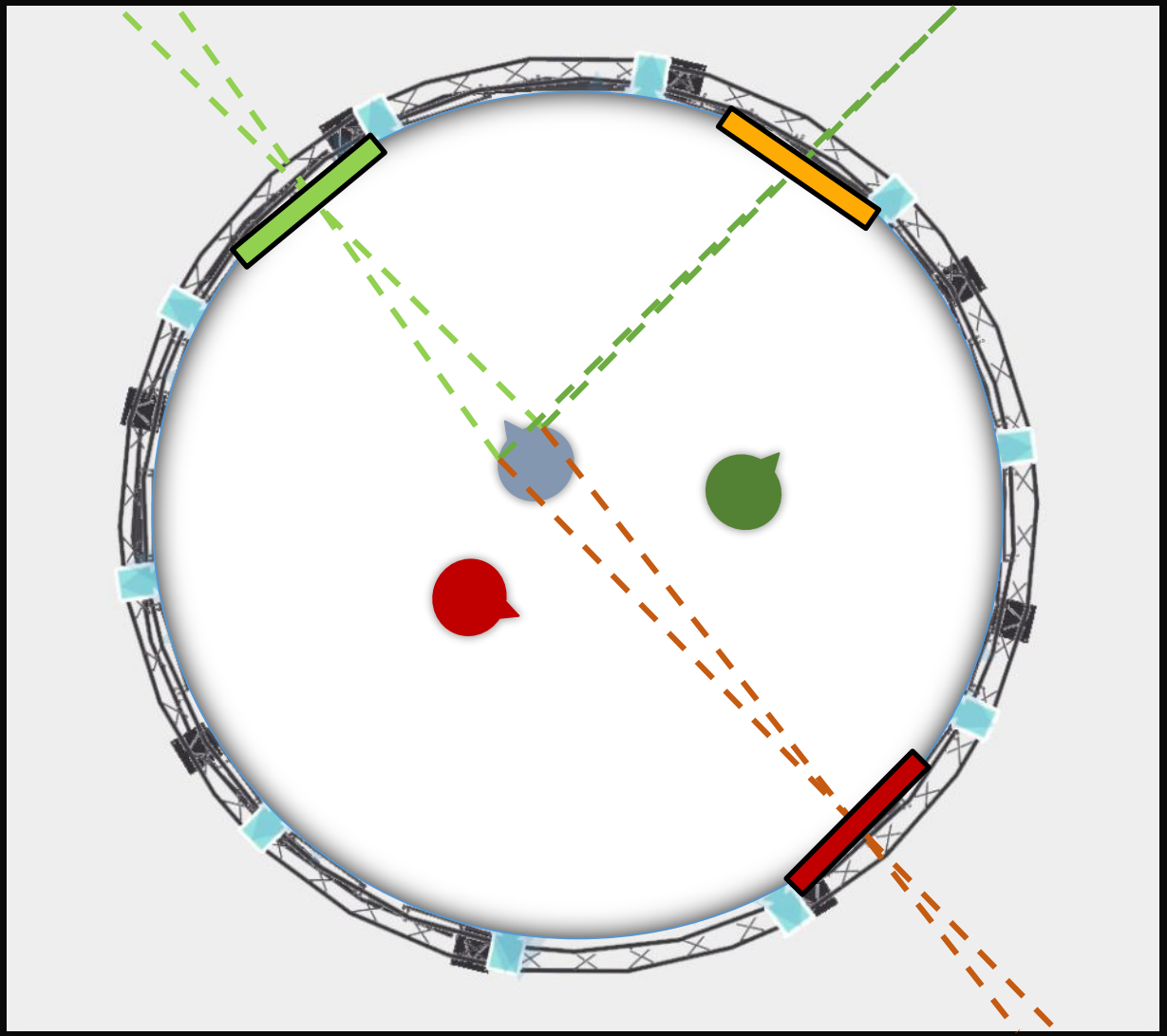
User-Centered Stereo

- 100% correct for tracked user
- Broken for other users
- Head rotation ‘blur’
  - Tracker latency
  - Framerate



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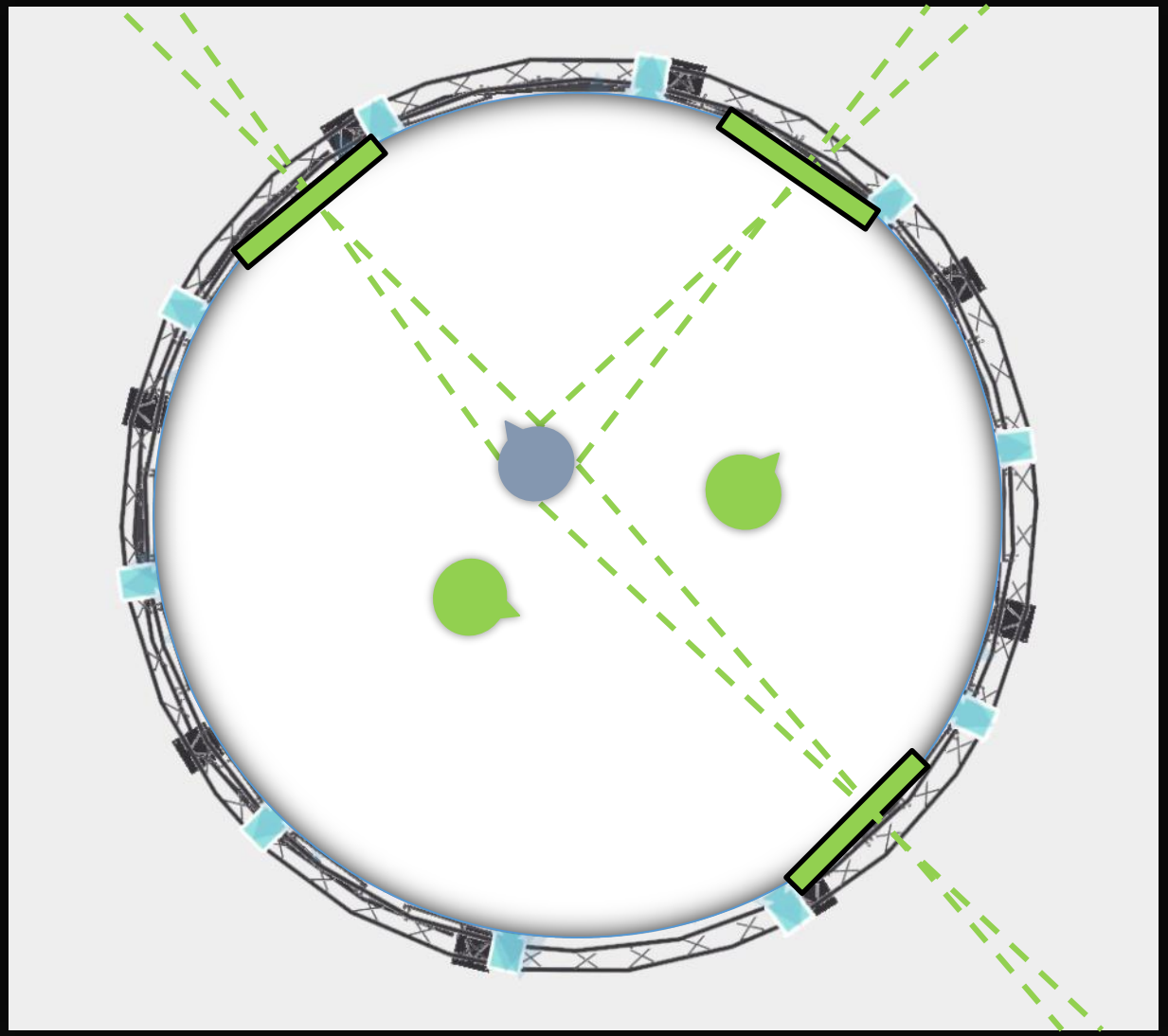
Panoptic Stereo

- Comfortable viewing for tracked and nontracked users
  - Cost: no head roll
- No rotation ‘blur’
- Runtime option



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Dynamic Configuration

Omegalib allows display configuration changes…

- When application starts (static workspace)
  - 2D display region as startup argument
  - Generator creates Equalizer configuration for tile subset
  - Automatic network port assignment
  - Multiple applications can run simultaneously
- At runtime (dynamic workspace)
  - Visible application area can be adjusted (within static workspace bounds)
  - GPU resources deallocated for disabled tiles, but application keeps running on the cluster node

Examples: Display Reconfiguration

5. Richmond, K., **Febretti, A.**, Gulati, S., Flesher, C., Hogan, B.P., Murarka, A., Kuhlman, G., Sridharan, M, Johnson, A., Stone, W.C., Priscu, J., Doran, P. "Sub-Ice Exploration of an Antarctic Lake: Results from the ENDURANCE Project" 17th International Symposium on Unmanned Untethered Submersible Technology , Portsmouth, NH, US, 08/21/2011
6. Febretti, A., Richmond, K., Gulati, S., Flesher, C., Hogan, B.P., Johnson, A., Stone, W.C., Priscu, J., Doran, P. "Poisson reconstruction of extreme submersed environments: The ENDURANCE exploration of an under-ice Antarctic Lake" *8th International Symposium on Visual Computing (ISVC12), Crete, Greece, Lecture Notes in Computer Science, 2012*

Examples: Display Reconfiguration

Examples: View Streaming

Bay bridge model provided by Falko Kuester, UCDS

Availability

- Omegalib available on github
  - https://github.com/uic-evl/omegalib/
  - Wiki & support forum
- Builds out-of-the-box on Windows, OSX, Linux (several distros tested)
- Cherry pick additional modules during build
  - ~25 available now https://github.com/omega-hub
    - Rift, SAGE, osg, vtk, html5, point clouds, osgEarth, …

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Future Work

Vision: Desktop-like environment for HRE[7,8]

● Cluster-aware ● Multi-user aware ● Supporting Hybrid Views

- Challenges:
  - How do we do user-centered stereo for dynamic viewports?
  - How do we optimize cluster resource usage?
  - How do we consistently handle 2D/3D interaction?

7. **Febretti, A.** "Supporting Multi-View Immersion on Hybrid Reality Environments". to appear in the proceedings of IEEE Virtual Reality (IEEE VR 2014) Doctoral Consortium, Minneapolis, MN, March 29 - April 2, 2014
8. Reda, K., Aurisano, J., **Febretti, A.**, Leigh, J. Johnson, A., "Visualization Design Patterns for Ultra-Resolution Display Environments". *VISTech Workshop: Visualization Infrastructure and Systems Technology (VISTech 2013), 2013*

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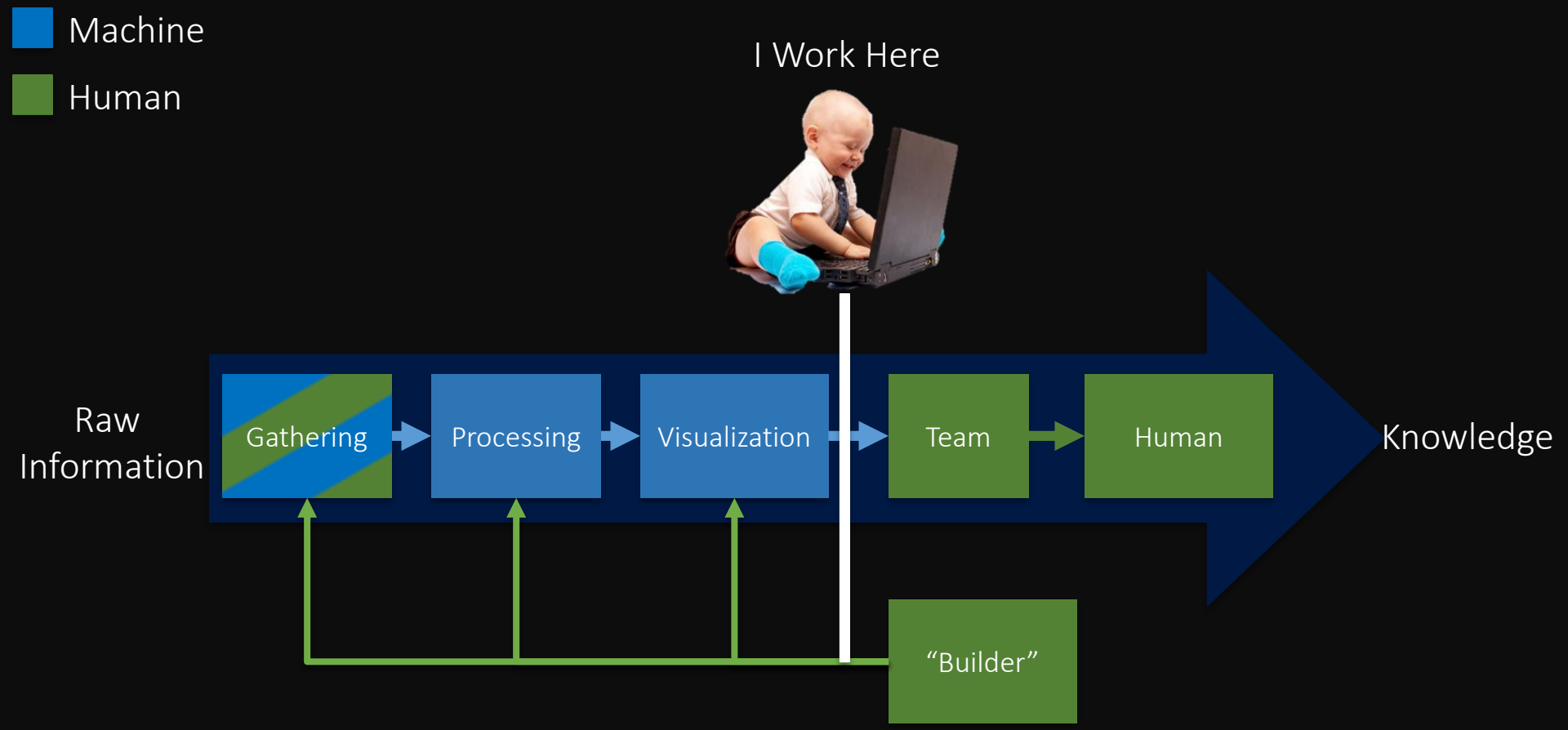
Wrap Up


Machine
Human
I Work Here
Raw Information
Gathering
Processing
Visualization
Team
Human
Knowledge
“Builder”

Thank You!

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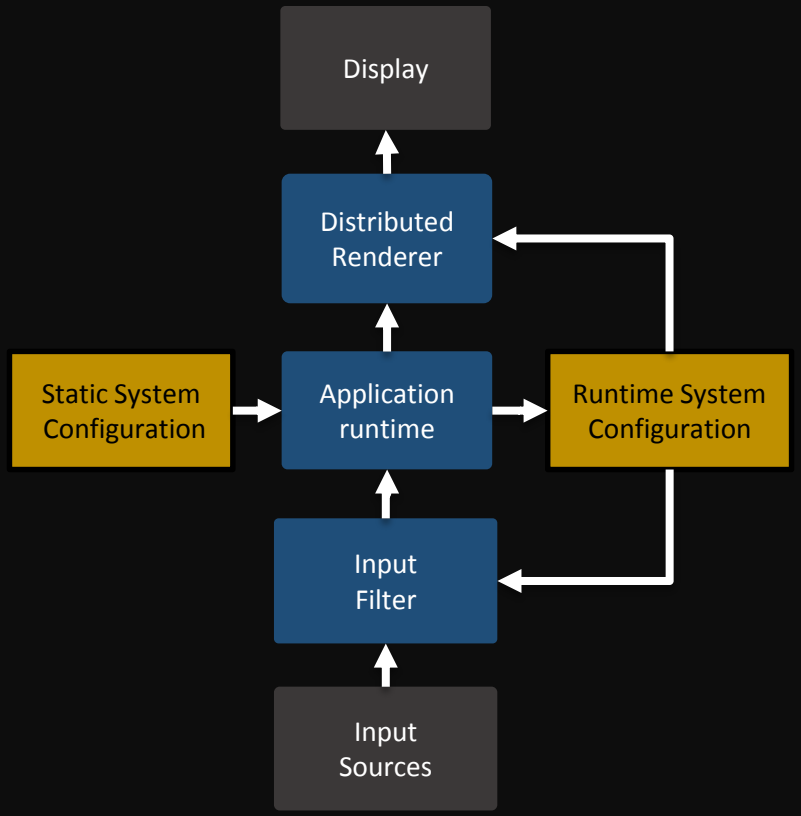
Input Management

All input sources processed by separate HRE OS component (Omicron)

Each application receives input stream from manager

Runtime can filter events based on workspace configuration

- With tracked devices, only application ‘pointed at’ handles input
- Wand-based or gaze-based



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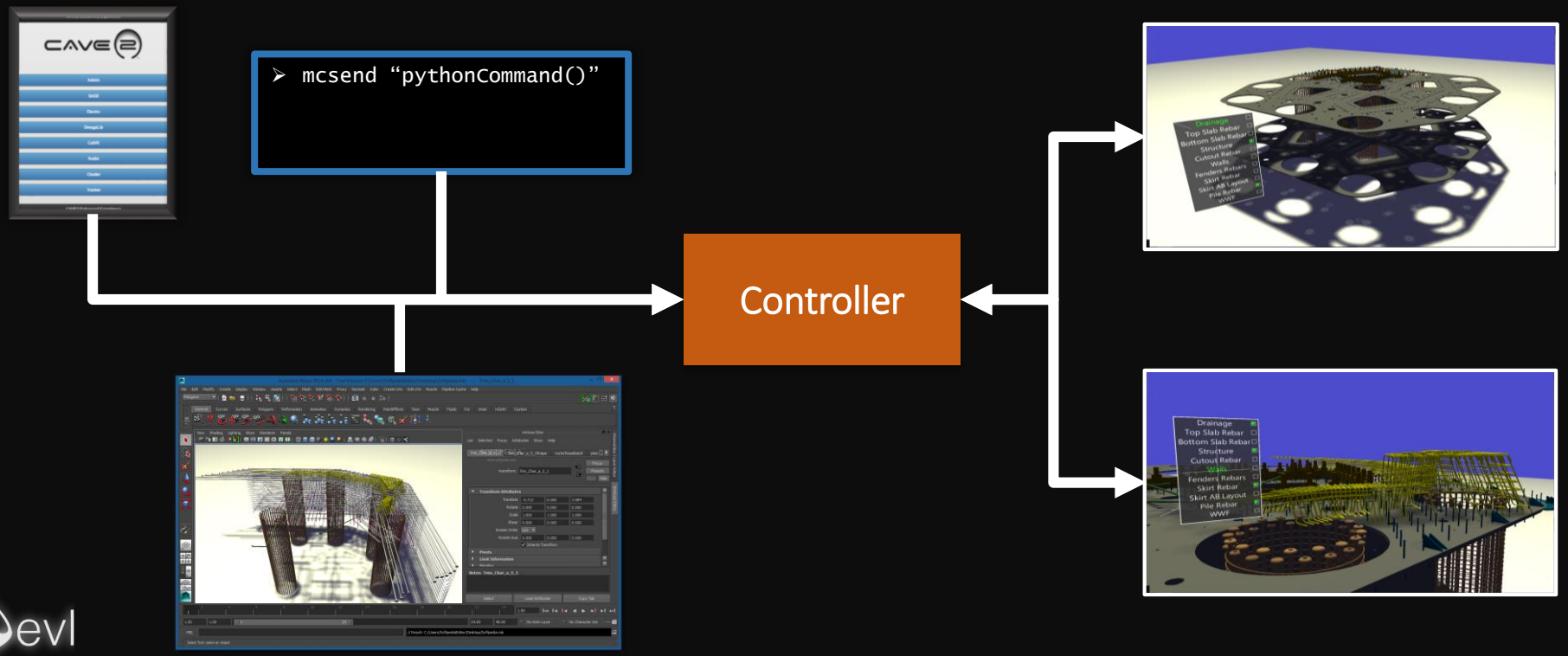
Application Controller

The Controller Handles application lifetime

- Start/Stop applications
- Send control messages (typically scripts)

Applications can exchange messages through the controller



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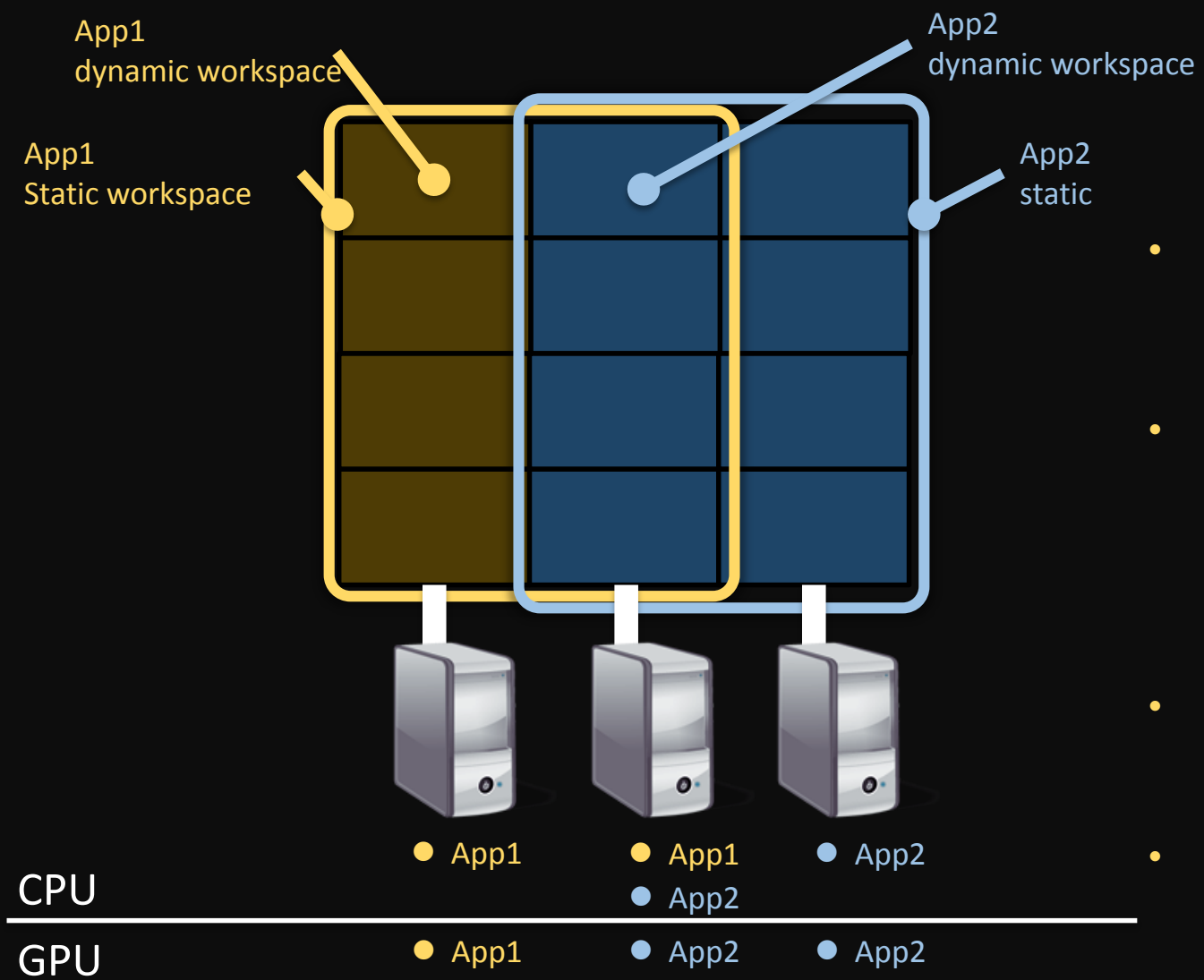
Dynamic Configuration



- Static workspace set at startup
  - CPU Usage
- Dynamic workspace set at runtime (within static bounds)
  - GPU Usage
- Static Workspaces can overlap
- Tradeoff between flexibility and cluster resource usage

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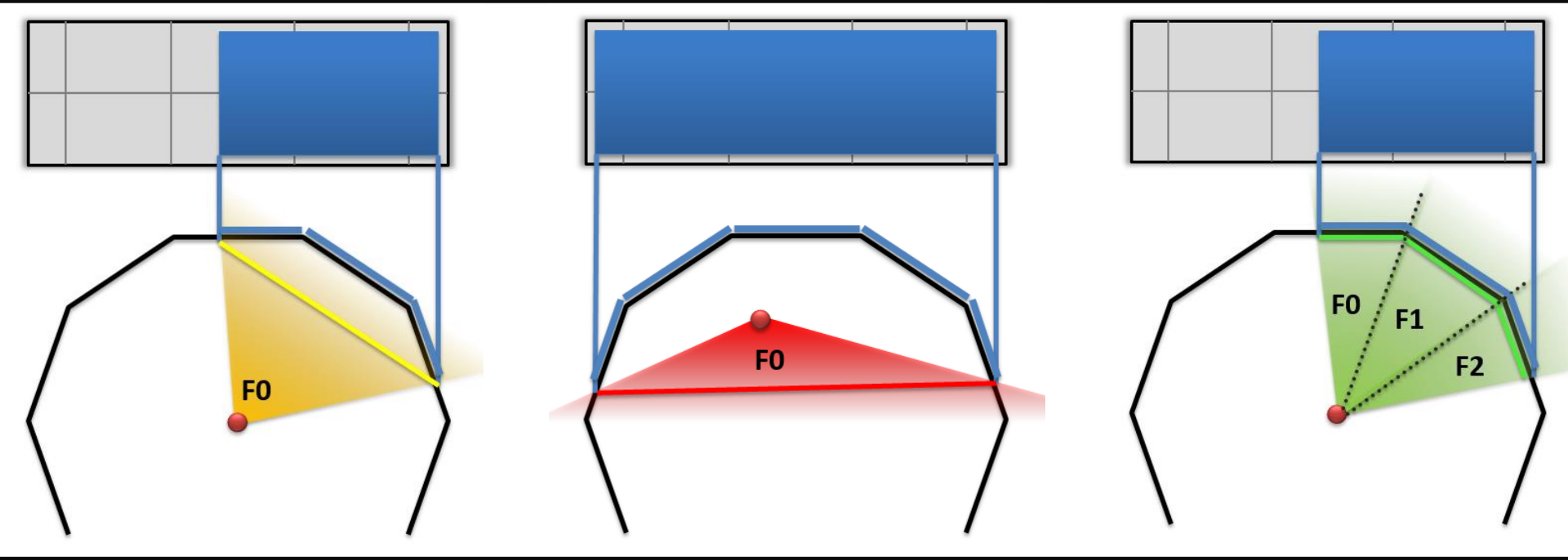
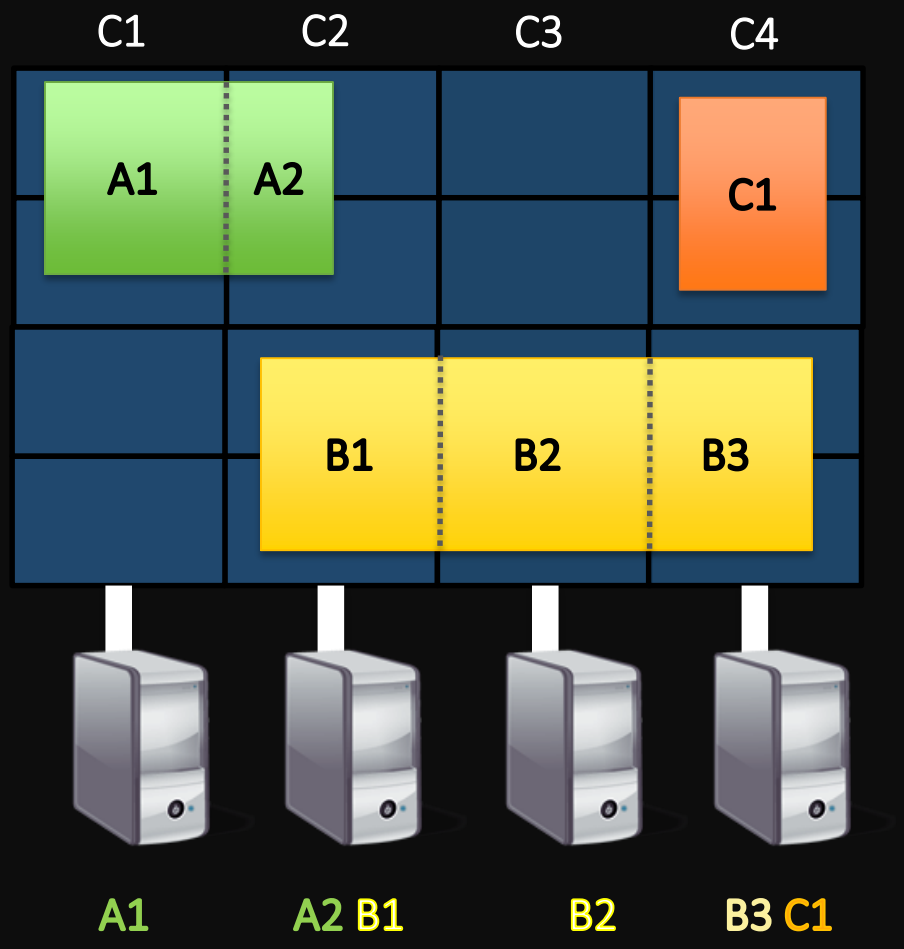
Immersion in Dynamic Viewports



- As viewport moves, projection, view and navigation transforms need to be adjusted
  - Projection needs to be computed per-tile
  - View adjusted to keep objects in viewport.
  - Navigation

Distributed Rendering Allocation



Static Workspace:

Applications run on full cluster

Dynamic Workspace:

As windows move/resize, reallocate rendering resources

- Intersect window / tile
- Each intersection renders on node driving the tile
- Reconfigure pixel streams

✓ Node render load ≤ fullscreen render load

✓ Node affinity: reduces bandwidth / latency

✓ Could be extended to consider global system load (balancing / network usage tradeoff)

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