

Advanced Visualization Instrumentation

A person wearing a VR headset and a light-colored shirt is standing in a dark room, looking at a large, curved screen. The screen displays a 3D visualization of a planetary surface, likely Mars, with a bright light source on the horizon. The person is looking at the screen from the side, and their hand is near the screen. The background is dark with some stars visible.

Jason Leigh

Professor of Computer Science

Director

Electronic Visualization Laboratory,
University of Illinois at Chicago

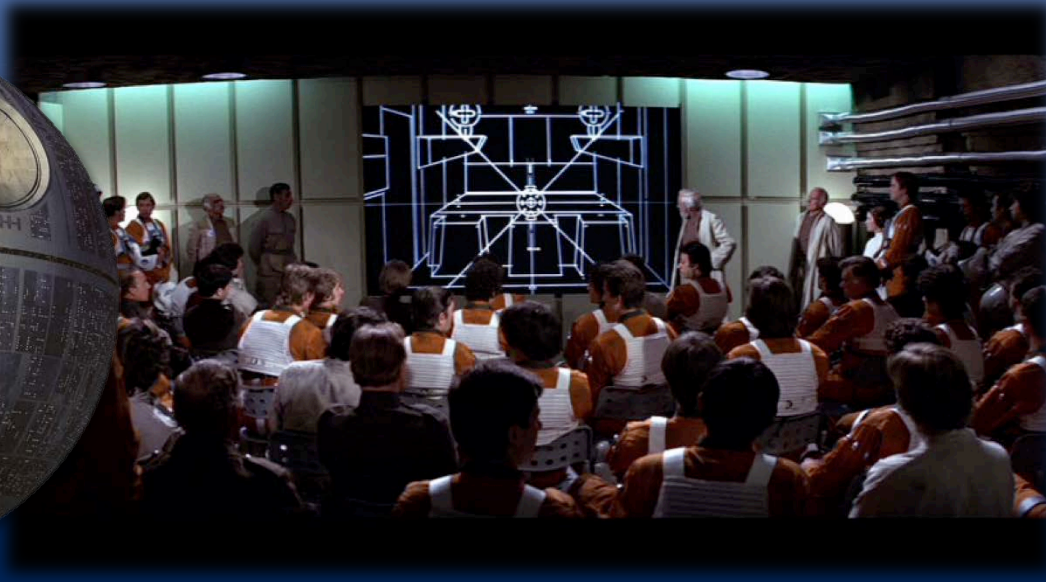
Laboratory for Advanced Visualization & Applications
University of Hawai'i at Mānoa

Electronic Visualization Laboratory

- Established in 1973
- Director: Jason Leigh
- 10 full-time staff
- Currently 15 funded grad students, 4 undergrads
- Interdisciplinary CS, Art, Biomedical, Communications Depts working in partnership with universities, research labs, non-profit orgs and industry.



Star Wars (1976)



Scientific Visualization (1987)



Advanced Displays as Instruments for Bringing Big Data into Focus

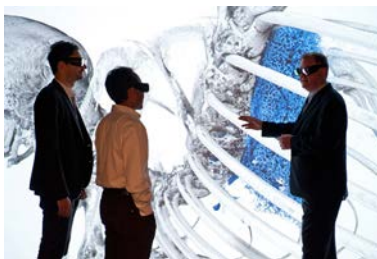
General Motors

CAVE (1992)



eScience Components

**Advanced
Visualization**



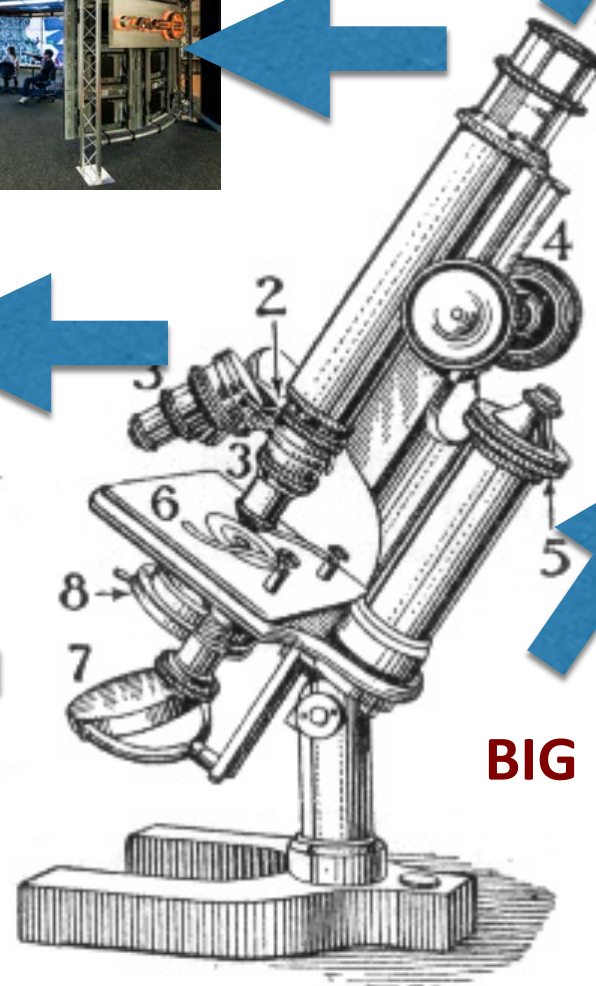
**Data Processing and
Analytics, HPC, Tools**



**Data Capture
Instrumentation**



**Dissemination and Data
Services**



BIG DATA

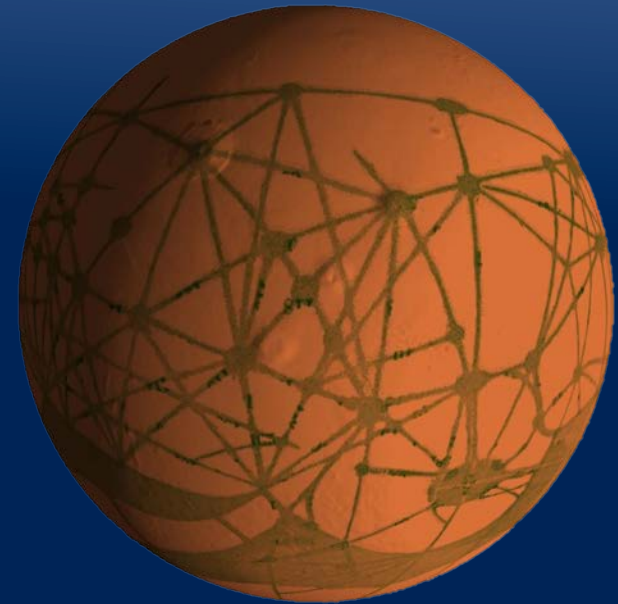
The Quality of the Instrument Can Determine The Quality of the Insight



Percival Lowell

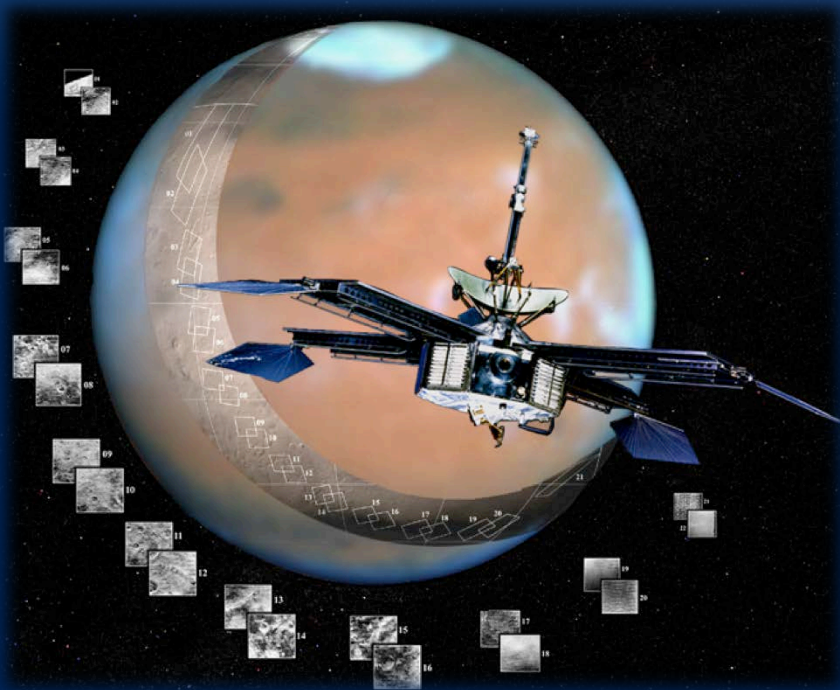


Lowell Observatory
Flagstaff Arizona



Mars – 1895

Took Us 70 Years To Resolve That Controversy



NASA Mariner Missions
1970s

How Do Mortals Deal With Complexity & Scale in Data?

Will Self, English novelist known for crafting complex narratives with weaving story lines



www.will-self.com/writing-room



Merging Northwest & Delta Airlines

IN THE BEGINNING: BRIDGING

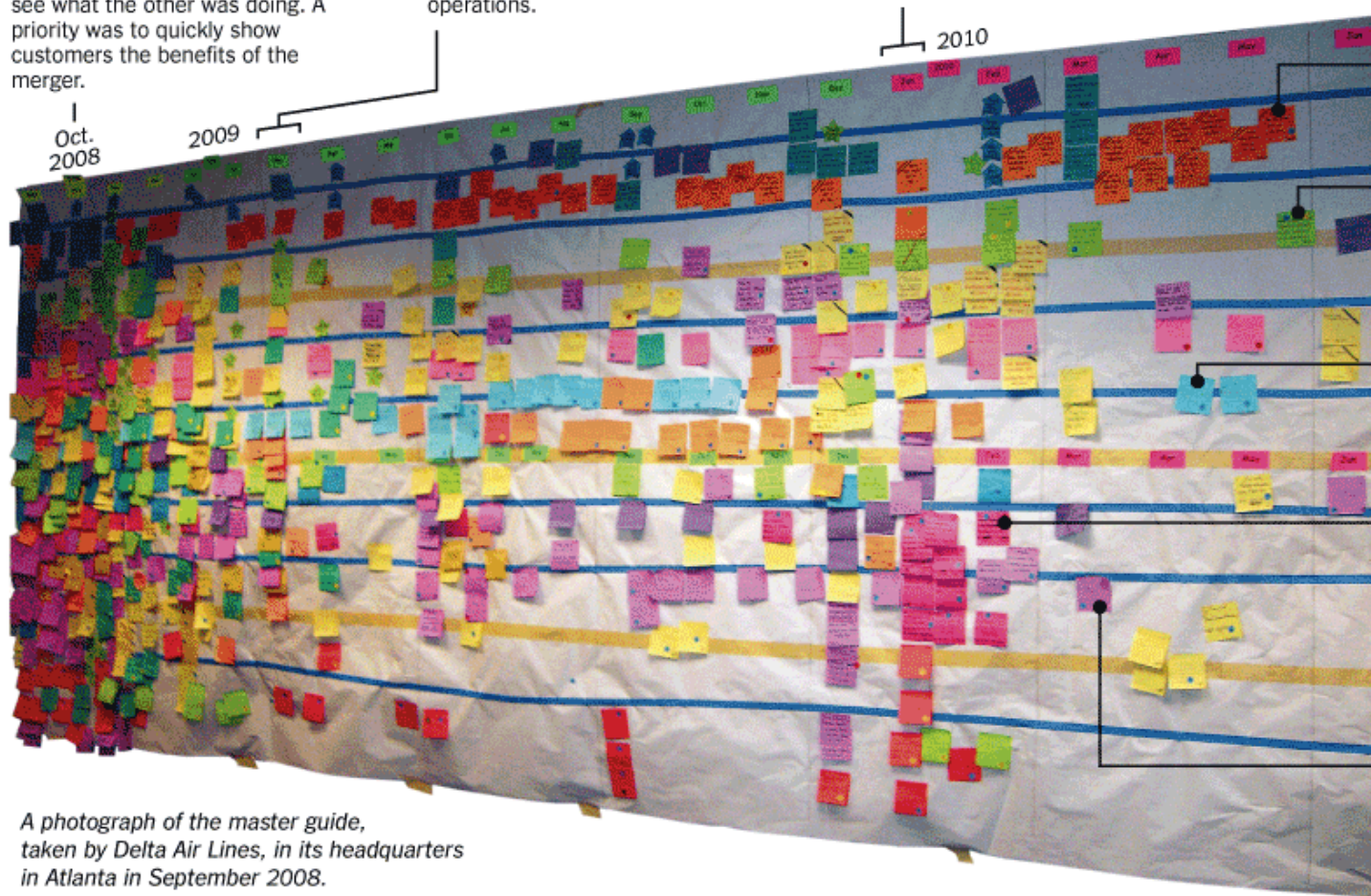
In the months around October 2008, when the merger was closed, there was a flurry of "bridging" projects: opening up access between the airlines' computer systems so each could see what the other was doing. A priority was to quickly show customers the benefits of the merger.

THE NEXT STEP

About five months after the merger, the two airlines began "cross-fleeting," when critical systems like reservations had to start talking to each other. But they remain separate operations.

ONE AIRLINE, ONE BRAND

Delta received final government approval to operate as a single airline in January 2010. At that point, all the computer systems could be switched to unified platforms. Many, like reservations and seat availability and pricing, had to be switched over at the same time.



AIRPORTS AND GATES

Orange notes indicate changes in customer service at airport counters and kiosks.

ALLIANCE PARTNERS

Bright green notes were for updates in coordinating with the airlines' partners, like Air France-KLM.

LOYALTY PROGRAMS

Light blue notes show steps in integrating customer loyalty programs.

AIRPORT OPERATIONS

Pink notes represent airlines' interaction with the airports — coordinating gates, flights and communications with the control tower.

AIRCRAFT CONTROL

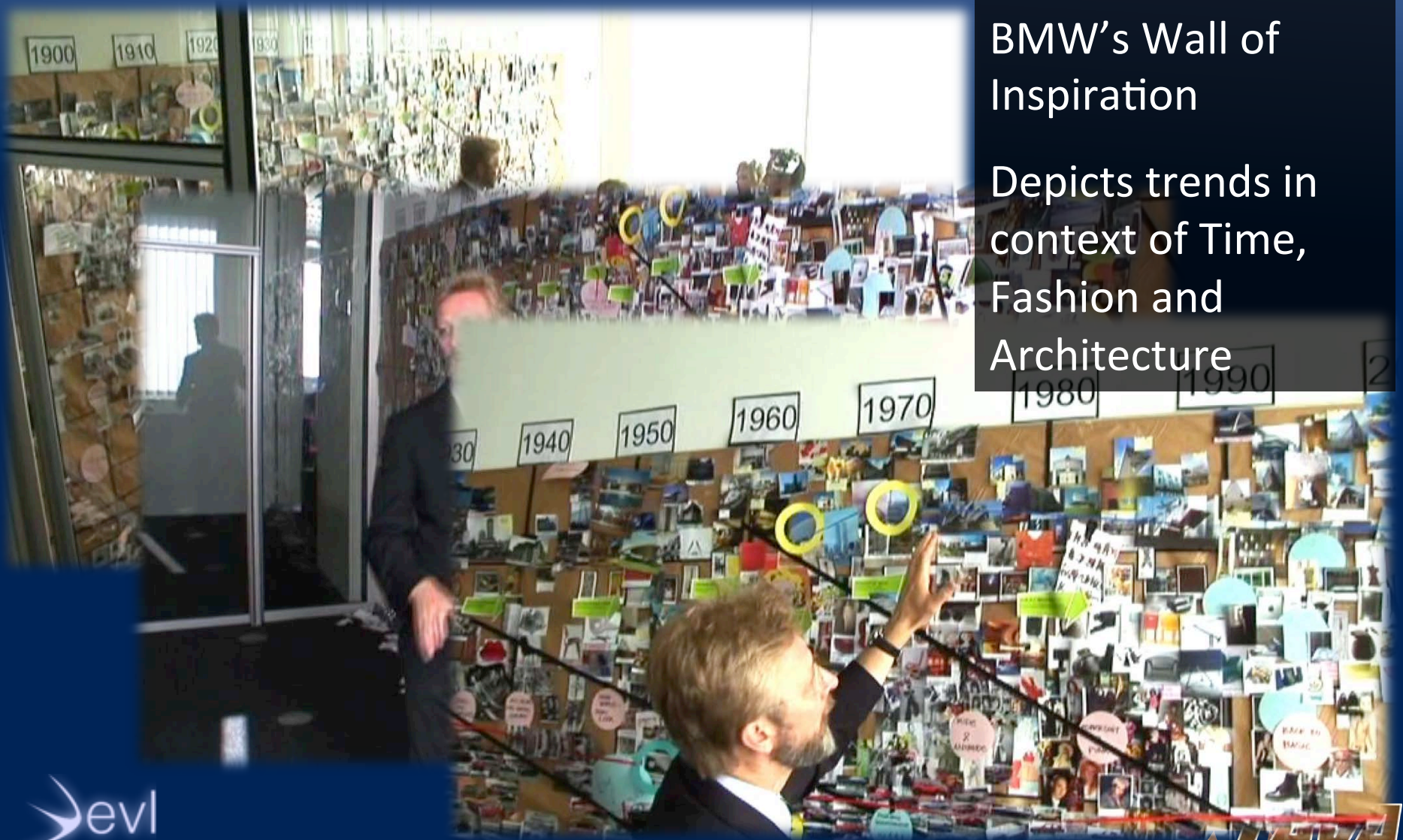
Light purple notes were for changes in the systems that keep track of where flights are, rerouting and cancellations.

A photograph of the master guide, taken by Delta Air Lines, in its headquarters in Atlanta in September 2008.

How Do Mortals Deal With Complexity & Scale in Data?

BMW's Wall of Inspiration

Depicts trends in context of Time, Fashion and Architecture



How Do Mortals Deal With Complexity & Scale in Data?

Antarctic Drilling Program

Documenting features is done by hand, on paper



Managing Scale & Complexity in Teams



“War” Rooms / Project Rooms help us come together to solve problems that are too complex for us to individually manage.

Common Behavior Patterns

- Spread information out
- Organize information in a variety of ways- e.g. spatially
- Link between information
- Teams are needed to solve big problems & with big data
- Make the result persistent for later referral



The Continuum (2000)

Technology Research Education and Commercialization Center



- People can work in parallel in these spaces & therefore faster
- They never want to go back to the old way of doing things

Leigh, J., Johnson, A., Park, K., Nayak, A., Singh, R., Chowdhry, V., DeFanti, T.

[Amplified Collaboration Environments](#)

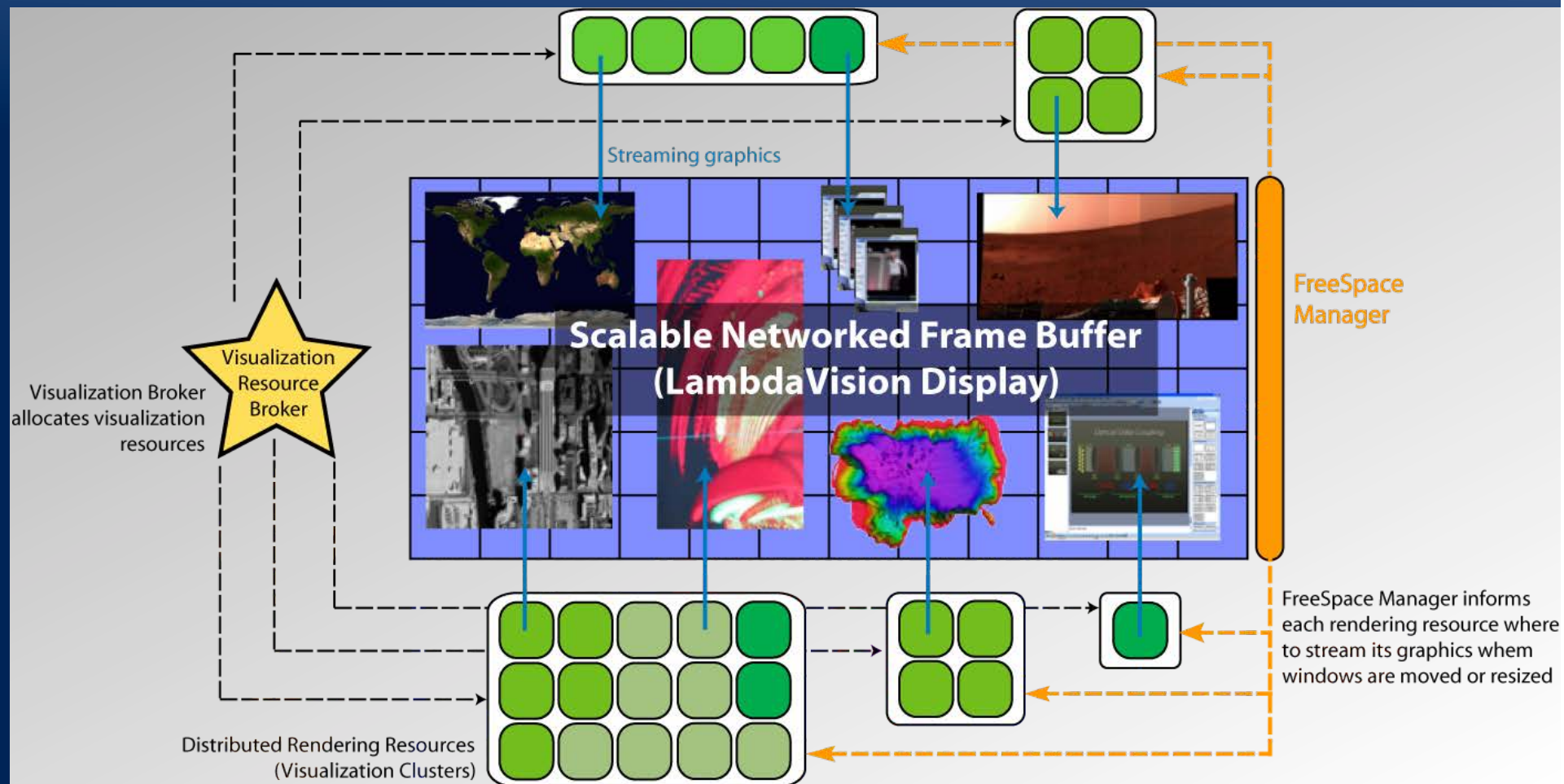
VizGrid Symposium, Tokyo, Japan, 11/01/2002 - 11/01/2002



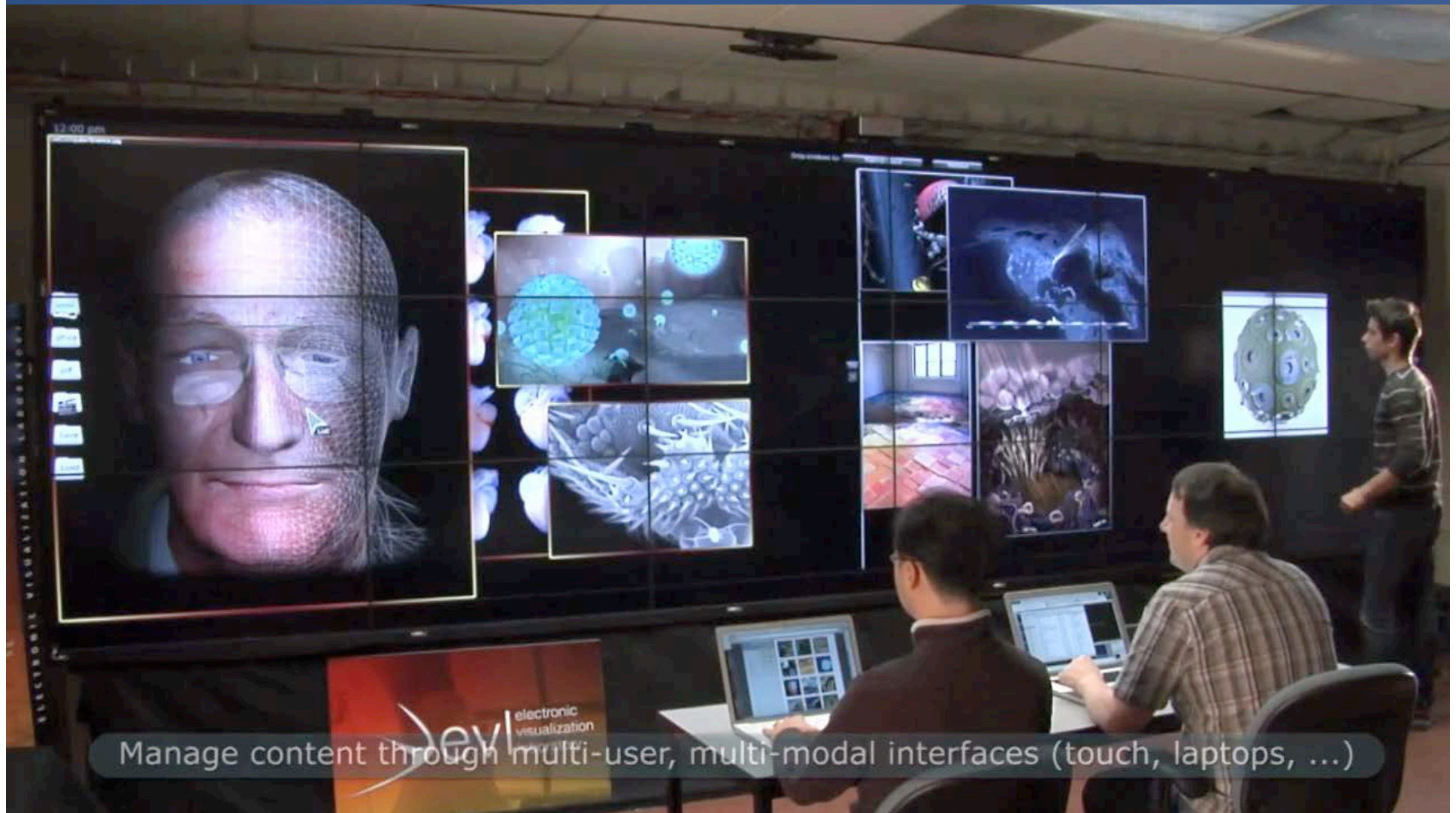
To Experiment With These Ideas...



100 Megapixel LambdaVision Display Wall



Working with SAGE



Manage content through multi-user, multi-modal interfaces (touch, laptops, ...)

SAGE User Community

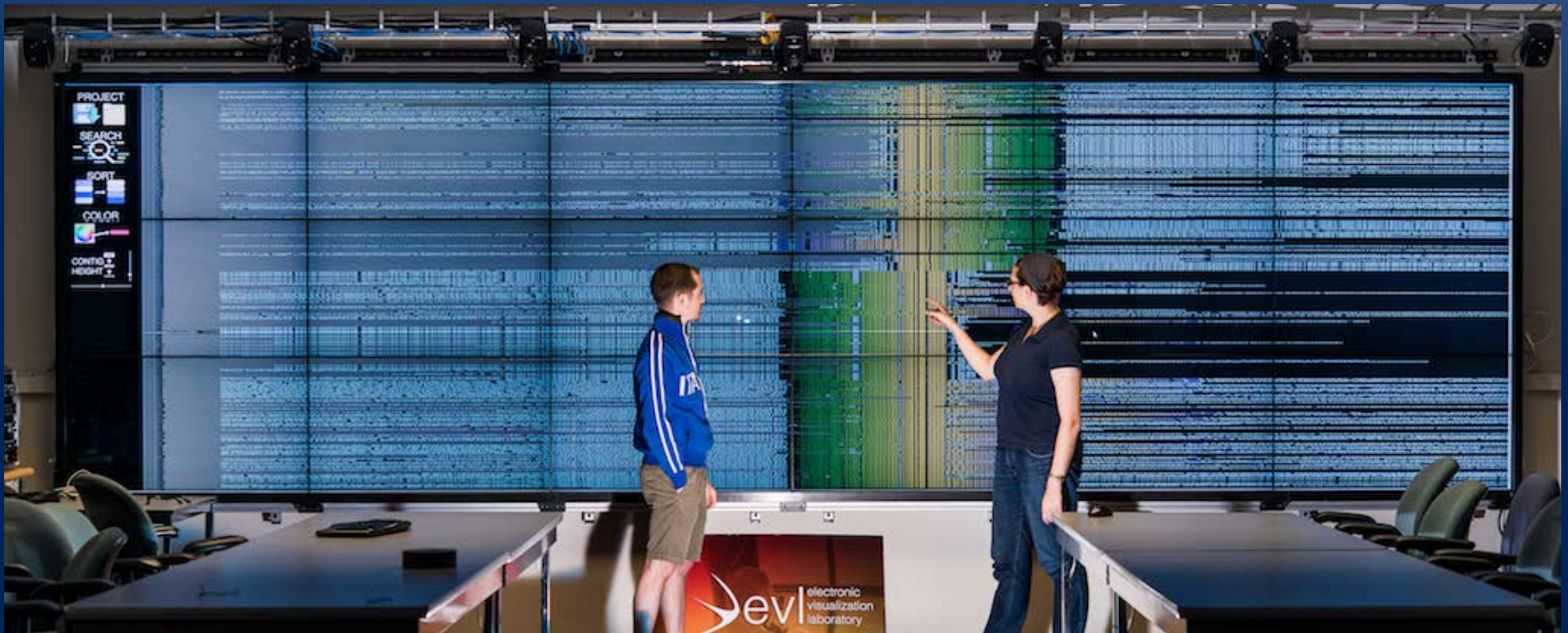
Over 107 Sites (58 U.S. and 49 Global)

SAGE User Sites 2013			
Australia <ul style="list-style-type: none"> AARNet Australian National University CSIRO Discovery Center CSIRO Information and Communication Technologies, Marsfield Monash University – Caulfield Monash University – Clayton Monash University – Clayton, eResearch Centre, CAVE2 University of Melbourne University of Queensland Belgium <ul style="list-style-type: none"> Katholieke Universiteit Leuven, IBBT Brazil <ul style="list-style-type: none"> RNP (Brazilian R&E Network) University of Sao Paulo, Laboratory of Computer Architecture and Networks Canada <ul style="list-style-type: none"> CANARIE Ciena Networks (2) Communications Research Centre Simon Fraser University China <ul style="list-style-type: none"> Beihang University, State Key Lab of Software Environment Dev. Chinese Academy of Sciences, Computer Network Information Center Czech Republic <ul style="list-style-type: none"> Czech Technical Univ in Prague Masaryk Univ, Lab of Advanced Networking Technologies (2) Germany <ul style="list-style-type: none"> Braunschweig University of Technology, Institute of Computer and Network Engineering India <ul style="list-style-type: none"> Monsanto Research Centre 	Japan <ul style="list-style-type: none"> Cybernet Systems Co., Inc. Knowledge Capital, VisLab Osaka Kyoto University National Institute of Adv. Industrial Science and Technology (AIST) National Institute of Information and Communications Technology (NICT), Koganei, Japan (3) NICT, Keihanna Research Center NTT Advanced Technologies Corp NTT Network Innovation Laboratories, Yokosuka Osaka University, CyberMedia Center Korea <ul style="list-style-type: none"> Gwangju Institute of Science and Technology (GIST) Korea Institute of Science and Technology Information (KISTI) Mexico <ul style="list-style-type: none"> Ensenada Center for Scientific Research and Higher Education (CICESE) Netherlands <ul style="list-style-type: none"> SURFsara SURFsara Collaboratorium University of Amsterdam, e-BioScience Laboratory University of Amsterdam, System and Network Engineering Research Group New Zealand <ul style="list-style-type: none"> Victoria University of Wellington Poland <ul style="list-style-type: none"> Poznan Supercomputing and Networking Center Russia <ul style="list-style-type: none"> Russian Academy of Sciences, Science and Innovation Center Russian Academy of Sciences, Space Research Institute 	Saudi Arabia <ul style="list-style-type: none"> King Abdullah University for Science and Technology (KAUST) Taiwan <ul style="list-style-type: none"> National Center for High-performance Computing (NCHC) National Central University, GeoComputing Laboratory United States <ul style="list-style-type: none"> Adler Planetarium & Astronomy Museum Argonne National Laboratory, Center for Nanoscale Materials (2) Argonne National Laboratory, Math and Computer Science Argonne National Laboratory, Transportation Research and Analysis Computing Center Calit2/U California, Irvine Calit2-QI/U California, San Diego (7) Casa Familiar Case Western Reserve University, Kelvin Smith Library Extreme Networks Florida International University, Center for Internet Augmented Research & Assessment (CIARA) Lakota Technical Solutions Inc Louisiana State University, Center for Computation and Technology Lucasfilm, Information Technology Michigan Technological Univ., Computer Science Monsanto (3) NASA Ames Research Center, Lunar Science Institute NASA Goddard Space Flight Center, Space Visualization Studio Naval Postgraduate School (7) Northwestern University, Int'l Center for Advanced Internet Research (ICAIR) 	<ul style="list-style-type: none"> Purdue University, Envision Center for Data Perceptualization Rincon Research Corporation Sharp Laboratories of America South Metro Career Center Texas A&M University, Computer Science Earth Resources Obs and Science United States Geological Survey Univ California, Davis, Institute for Ultra-Scale Visualization Univ California, San Diego Nat'l Ctr for Microscopy and Imaging Rsrh Univ California, San Diego, Scripps Institution of Oceanography University of Hawaii, Center for Microbial Oceanography: Research and Education (2) University of Illinois at Chicago (UIC), ACM Student Chapter UIC, Electronic Visualization Lab (EVL), CAVE2 UIC, EVL, Cyber-Commons 3D UIC Graham Clinical Performance Center UIC Innovation Center UIC Pathology Department UIUC National Center for Supercomputing Applications University of Michigan, Dept. of Atmospheric, Oceanic & Space Sciences University of Michigan, Digital Media Commons University of Michigan, School of Information University of Texas at Austin, Texas Advanced Computing Center (TACC) University of Washington Zoom Digital Signage



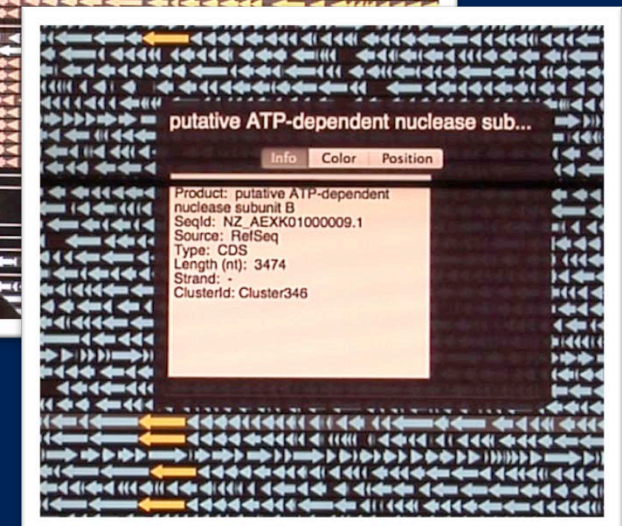
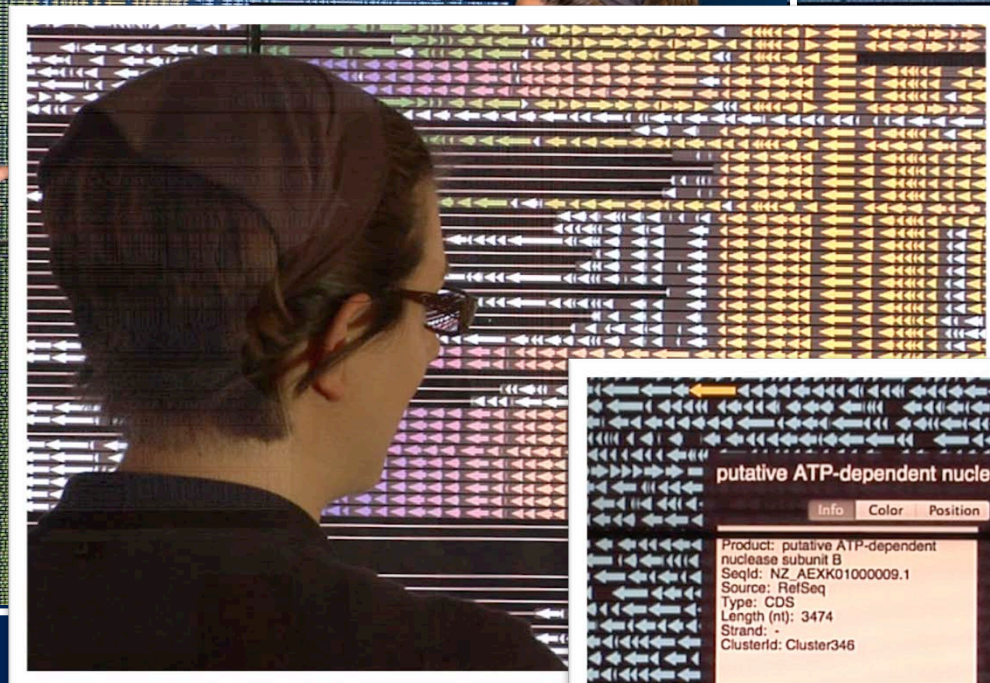
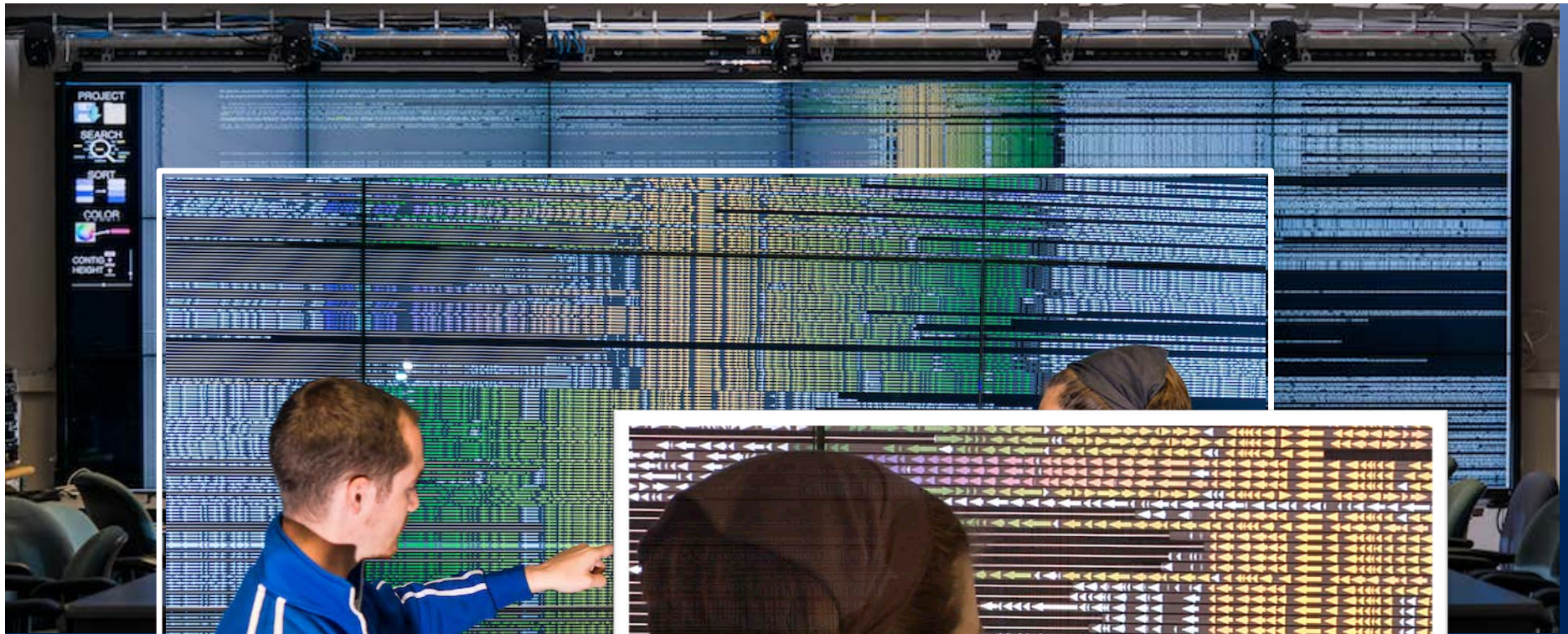
SAGE Walls Are Great For...

Showing Context & Detail in Data at the Same Time



GenoSAGE: High Density Genomic Data Visualization
Visualizing hundreds of *Lactobacillus* genes.





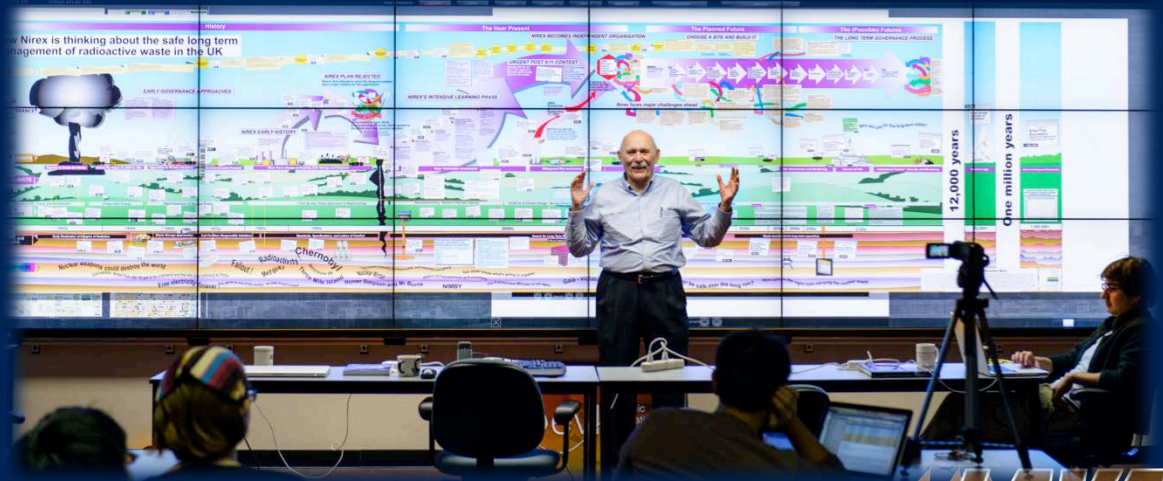
SAGE Walls Are Great For...

Supporting Data Rich
Collaboration

Integrating Disparate
Pieces of Evidence



Comparing
Stories About
The Data



Benefits of Large High Resolution Display Environments

- Reduced window switching, see detail & context simultaneously [Czerwinski03, Ball05]
- Helps externalize the working memory of teams [Andrews10]
- Increases parallel processing amongst team members [Park03]
- Improves location memory of information [Tan01]
- Reduces gender performance gap in navigation tasks in VR [Tan03]
- Perceptual scalability: helps user performance keep pace with increasing data size [Yost07]
- Results in greater confidence in conclusions drawn when able to see all info at once [Ball05]
- Users begin to look for higher level patterns & relationships (i.e. they start to look for the bigger picture) [Reda12]



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- [Ball 05] Ball, R., & North, C. (2005). Analysis of user behavior on high-resolution tiled displays. In Human-Computer Interaction-INTERACT 2005 (pp. 350-363). Springer Berlin Heidelberg.
- [Ball 07] Ball, R., North, C., & Bowman, D. A. (2007, April). Move to improve: promoting physical navigation to increase user performance with large displays. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 191-200). ACM.
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- [Endert 13] A. Endert, L. Bradel, C. North (2013). Beyond Control Panels: Direct Manipulation for Visual Analytics. Computer Graphics and Applications 33(4)
- [Fisher 12] K. Fisher, S. Counts, A. Kittur. Distributed sensemaking: improving sensemaking by leveraging the efforts of previous users. CHI '12
- [Park03] Park, K., Renambot, L., Leigh, J. and Johnson, A., The Impact of Display-rich Environments for Enhancing Task Parallelism and Group Awareness in Advanced Collaborative Environments , In Workshop on Advanced Collaboration Environments, June 22-24, 2003, Seattle, WA.
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- [Tan 03] Tan, D. S., Czerwinski, M., & Robertson, G. (2003, April). Women go with the (optical) flow. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 209-215). ACM.
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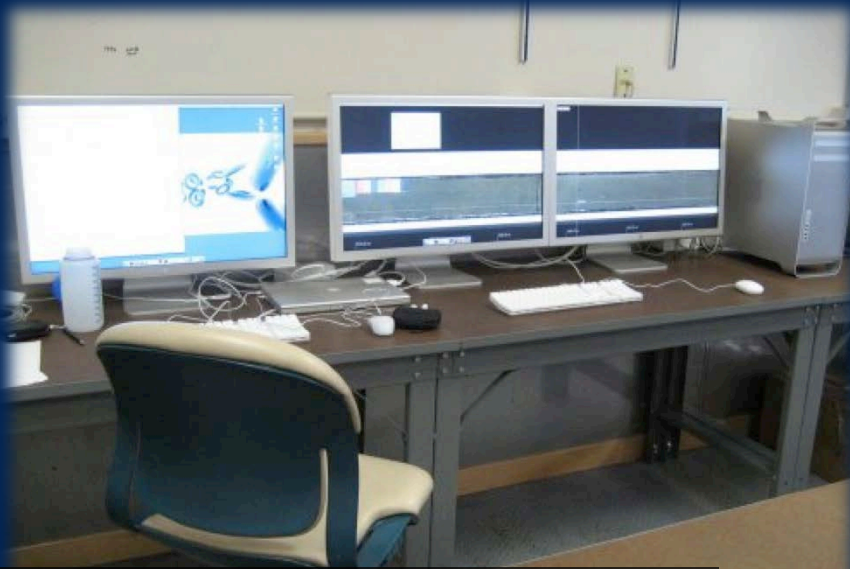


CoreWall

www.corewall.org



JOIDES Resolution Drill Ship



ANDRILL. McMurdo stations, Antarctica



LDEO, Columbia University, NY



Emi Ito – Lacustrine Core Repository – U of Minnesota

At LacCore, all visiting users and in-house users take CoreWall for granted in the sense that **they cannot imagine conducting initial core description or deciding on sediment sampling scheme without its use**. They see features they cannot see with naked eye. For most lake cores, CoreWall is indispensable for visual correlation of cores from different areas within one lake.

I once spent **2 weeks of 8+ hour** days, with actual 1.5 meter long cores out on a table trying to correlate 5 cores (each 6 to 9m long) all collected from within 20m of each other. The task can now be accomplished **in 2 to 3 days** with high resolution images and geophysical parameters such as magnetic susceptibility displayed on CoreWall.

Also **at 11 of 13 EarthCube end-user and disciplinary workshops**, on-demand 3-D or 4-D visualization of different types of geologic data was at the very top or close to the top of the wishlist.

Sean Higgins – Lamont-Doherty Earth Observatory – Columbia University

The Clast Utility plugin to Corelyzer that Julian devised allowed all the clast counting/characterization of a km of core to be done on screen instead of laid out down the floor of a lab. **Makes experiment repeatable and quality controlled.**

Obviously, things like CoreWall were devised to be scaleable so they work on small screens as well if needed in the field or some ones laptop but you lack the **context and ability of putting multiple cores next to each other**, other data, etc..

The earth sciences in particular spend a good amount of effort examining lots of physical specimens and spatial relationships and ability to put them together in a visual environment is a tremendous advantage. Actual real estate, graphical tools, etc. make a big difference in how well and quickly you can evaluate this material or situation.



Emi Ito – Lacustrine Core Repository – U of Minnesota

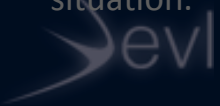
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U of Michigan Atmospheric Sciences Department



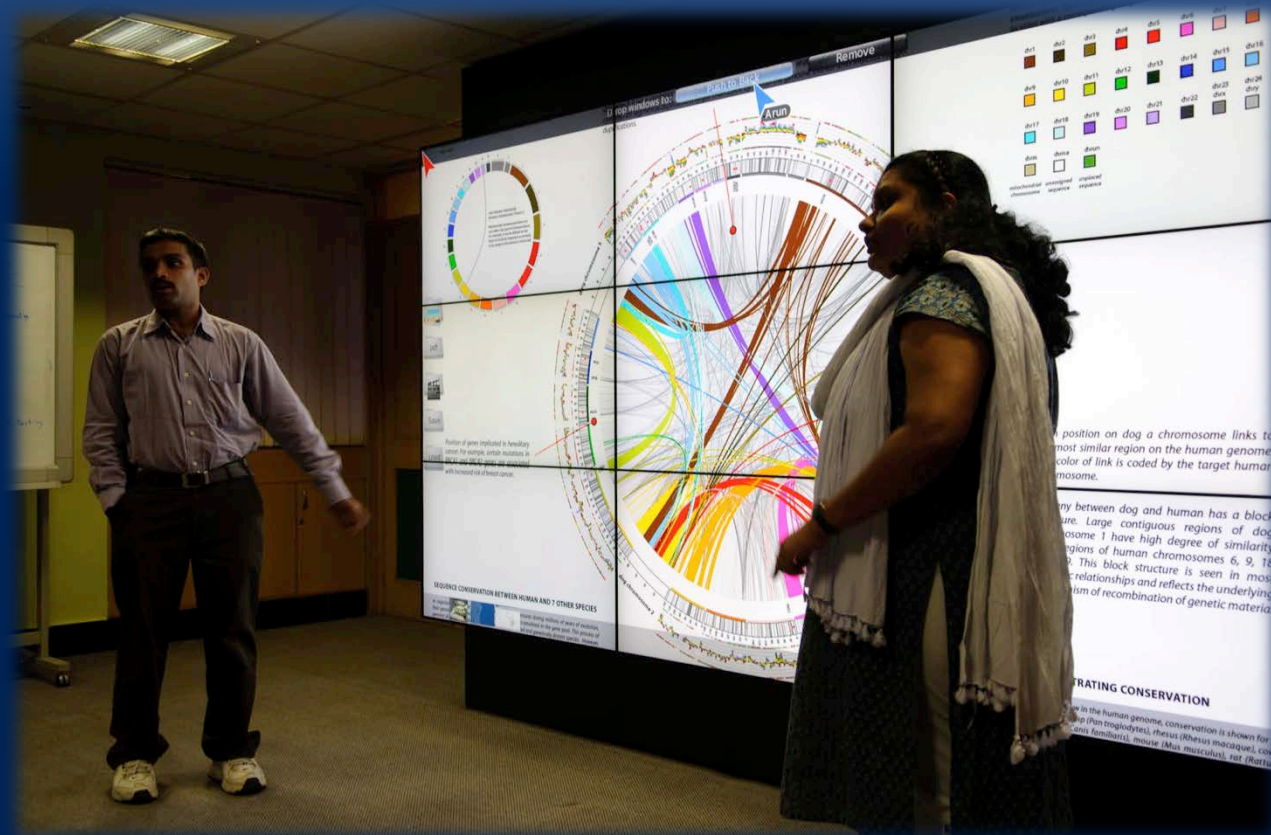
300 Megapixel Wall at Texas Advanced Supercomputer Center (2009)



UC San Diego Calit2, Vroom (2010)



... for agricultural bioengineering

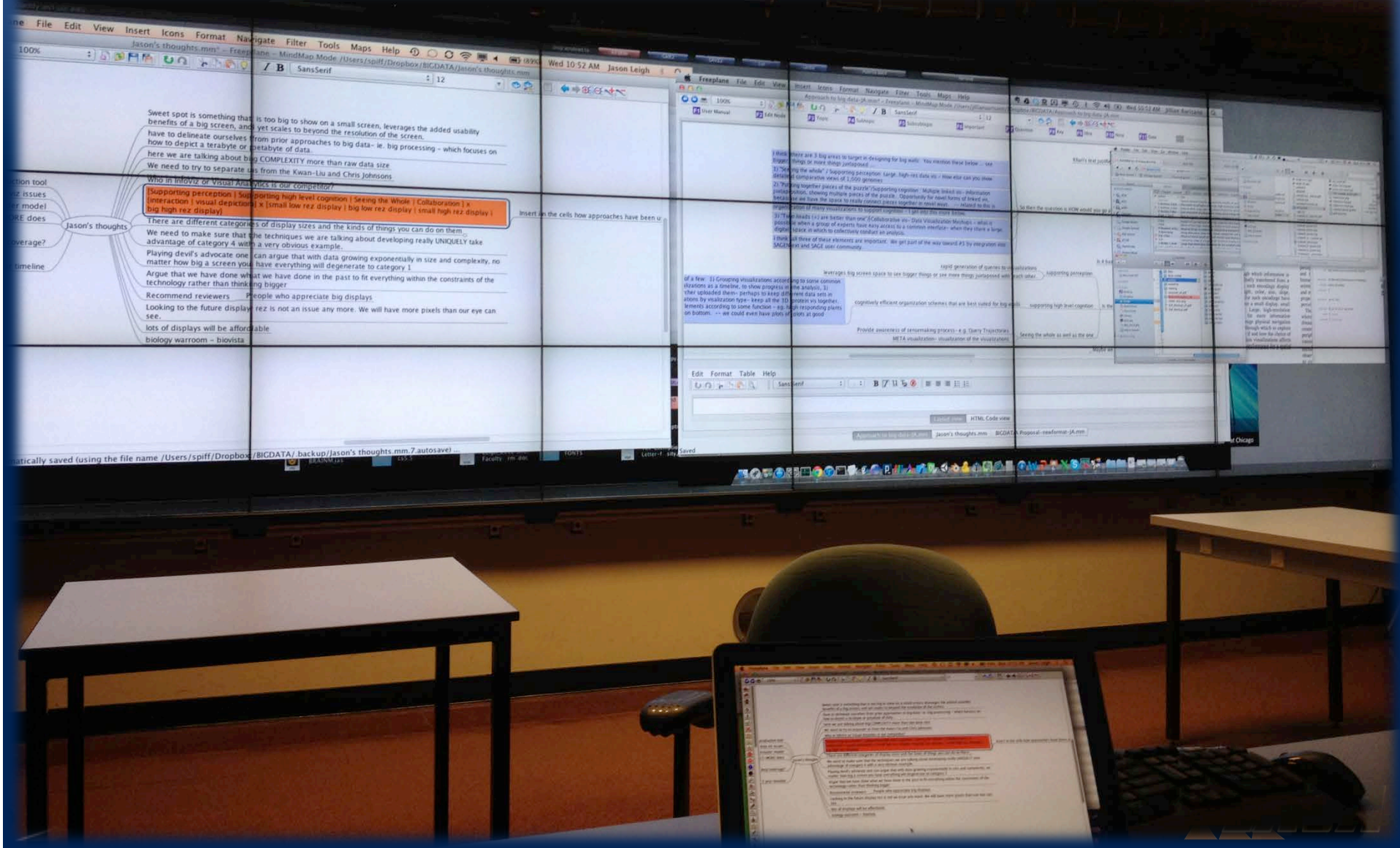


Monsanto Research Centre Bangalore (2011)

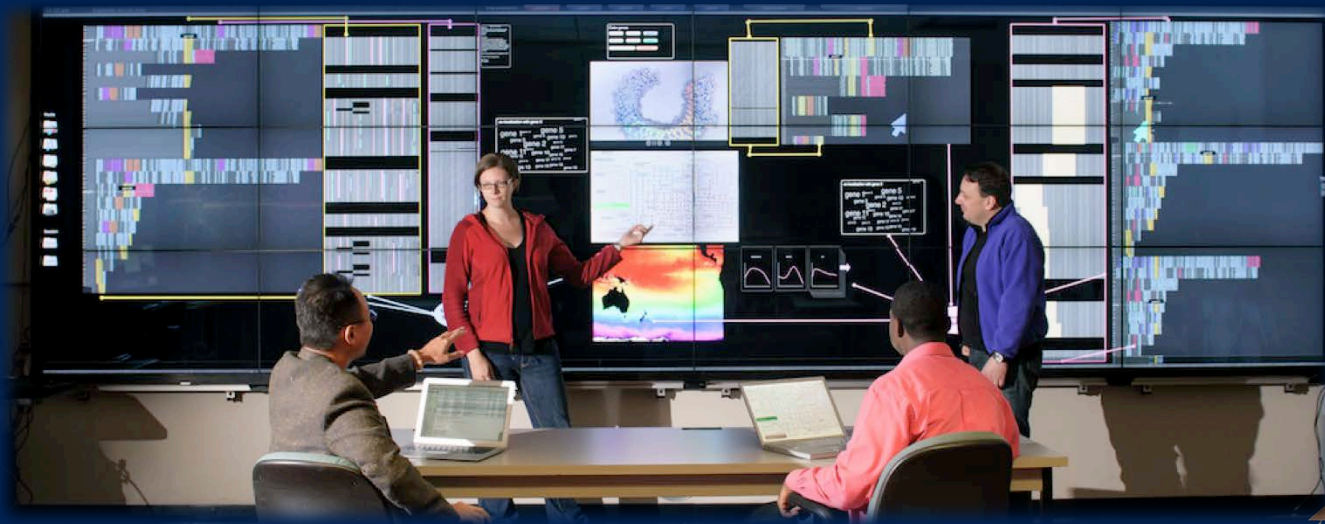
www.monsantoindia.com/monsanto/layout/researchcentre



Writing Better Grant Proposals ☺



Merge Benefits of Immersive Virtual Reality with Ultra High Resolution Tiled Display



Passive Stereo LCD Panels



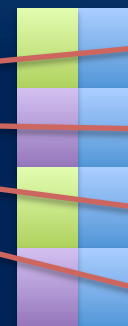
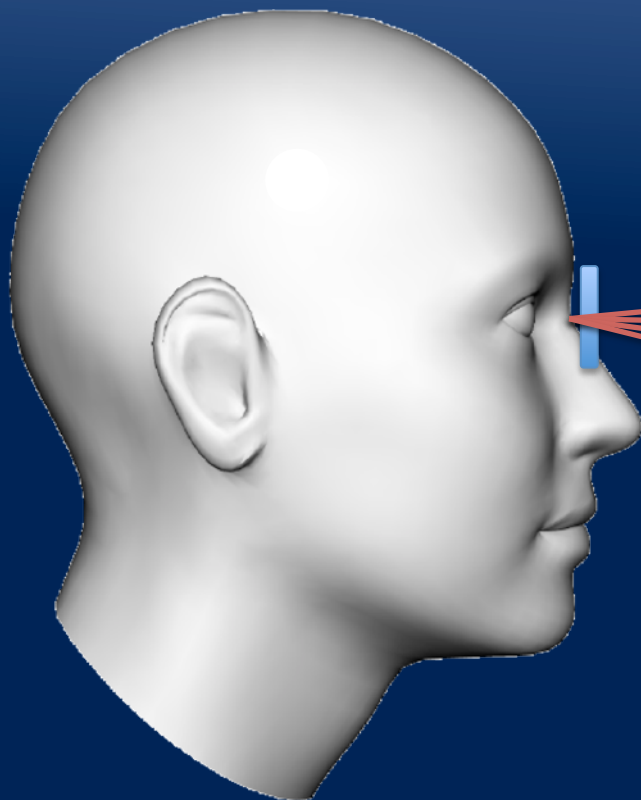
Interleaved
Polarizers

Pixels

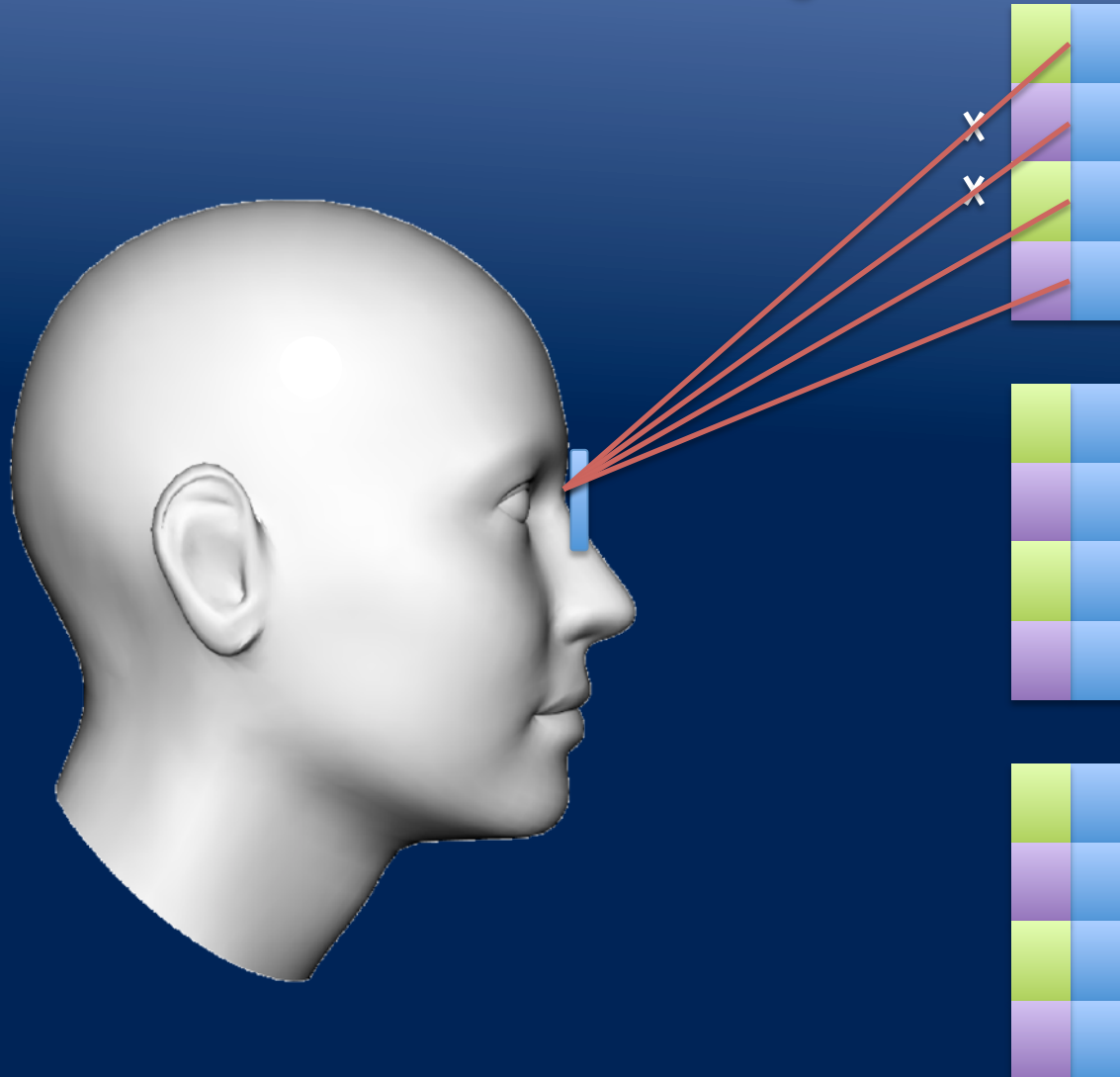


Interleaved
Polarizers

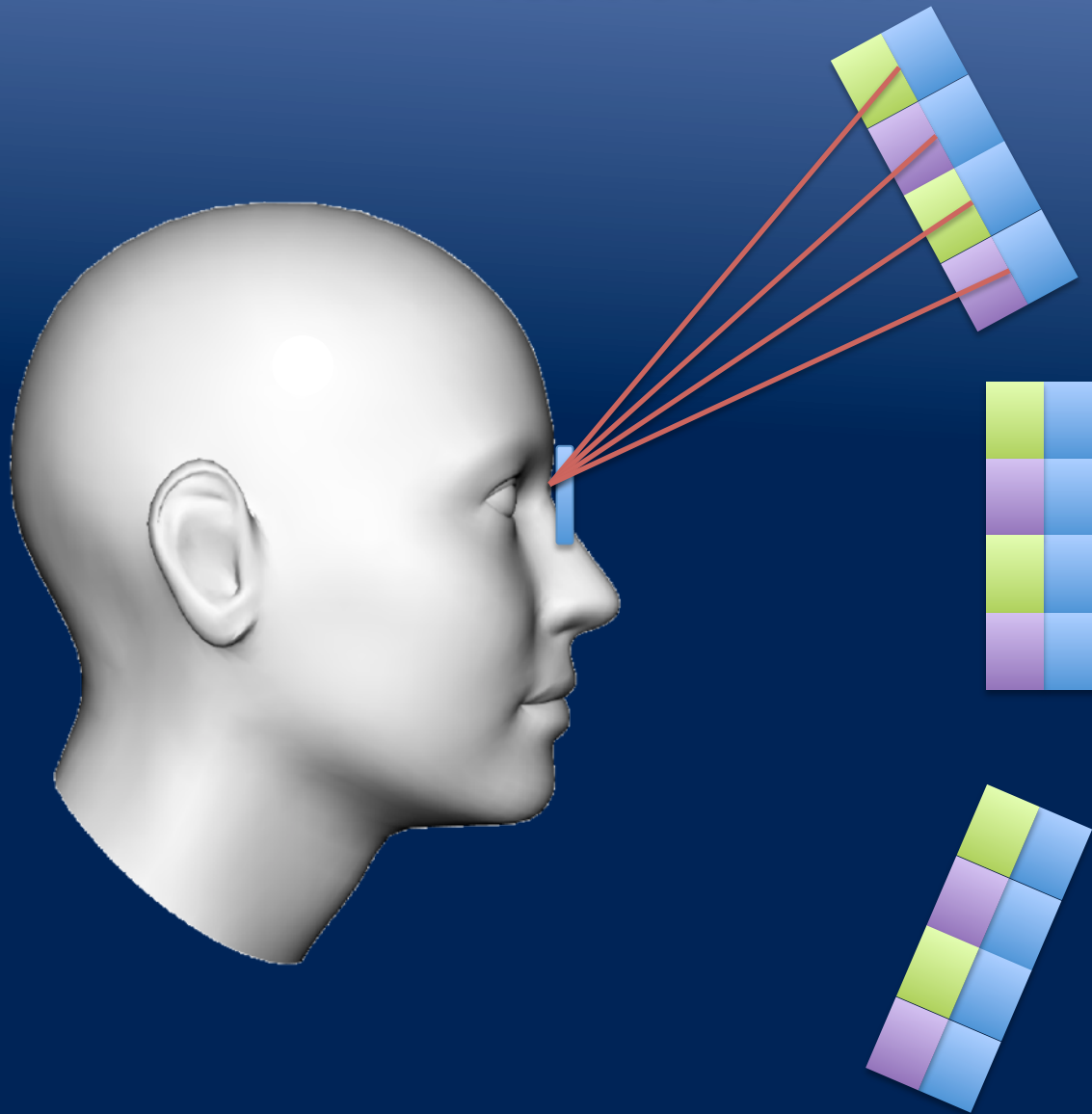
Pixels



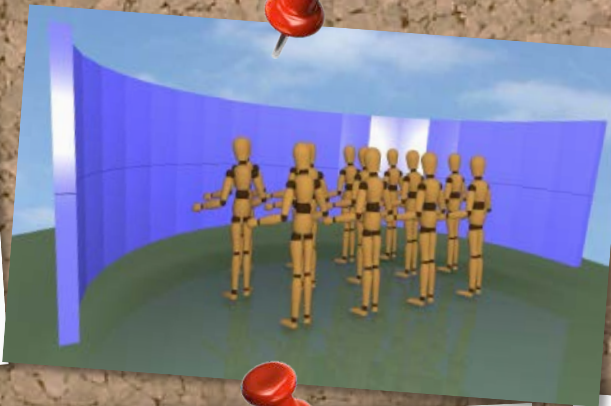
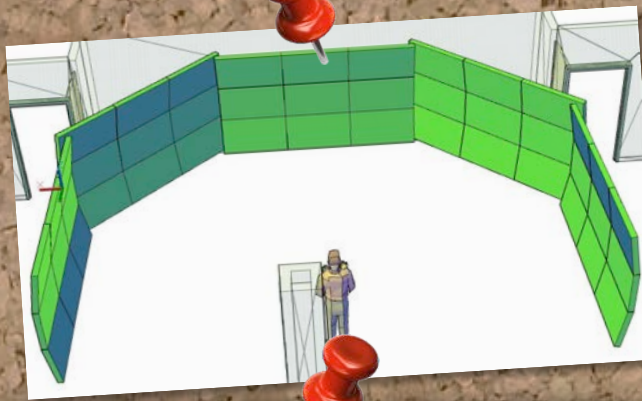
Polarizer aligned to wrong pixel



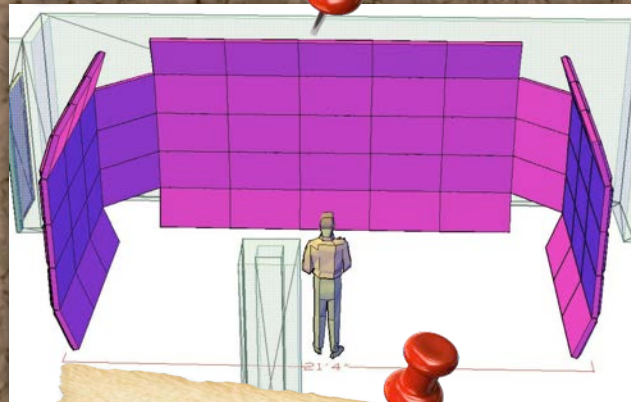
Possible Solution



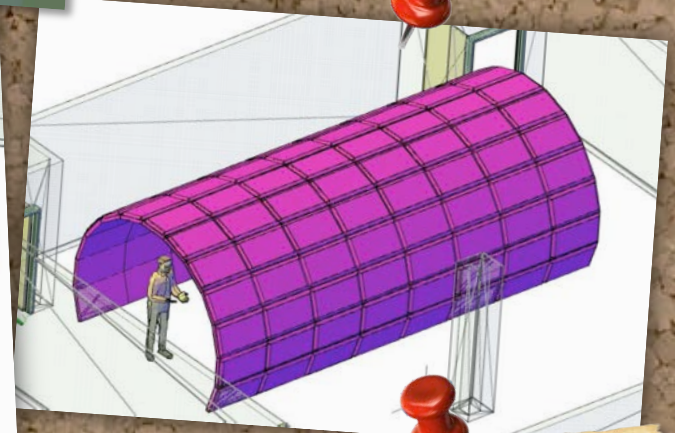
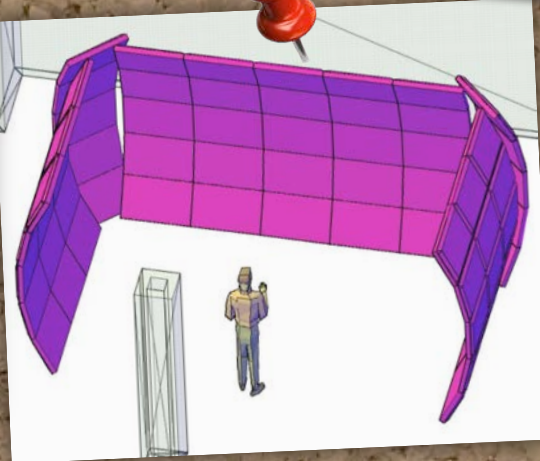
Early Concepts



CALIT2 NexCAVE

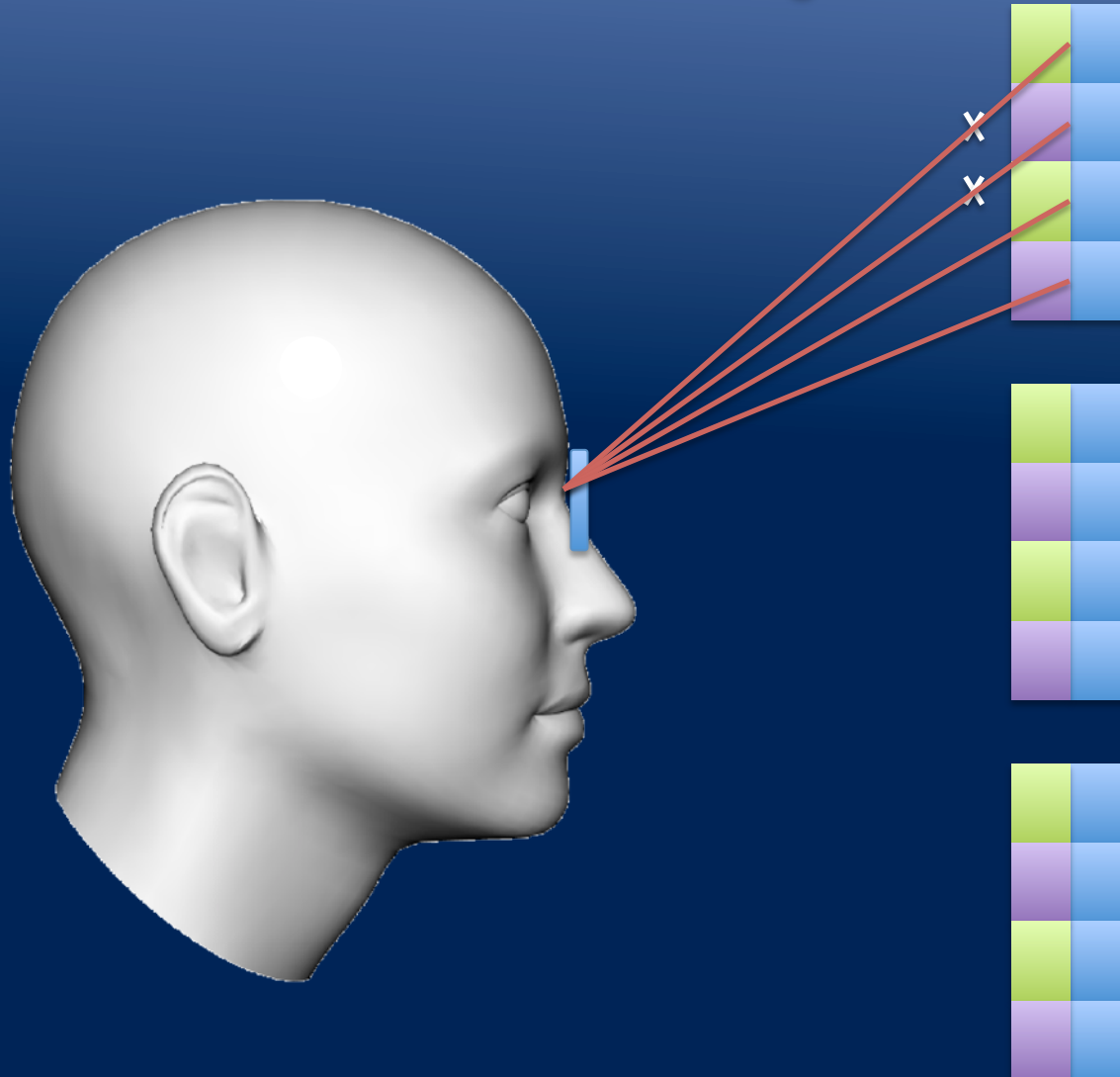


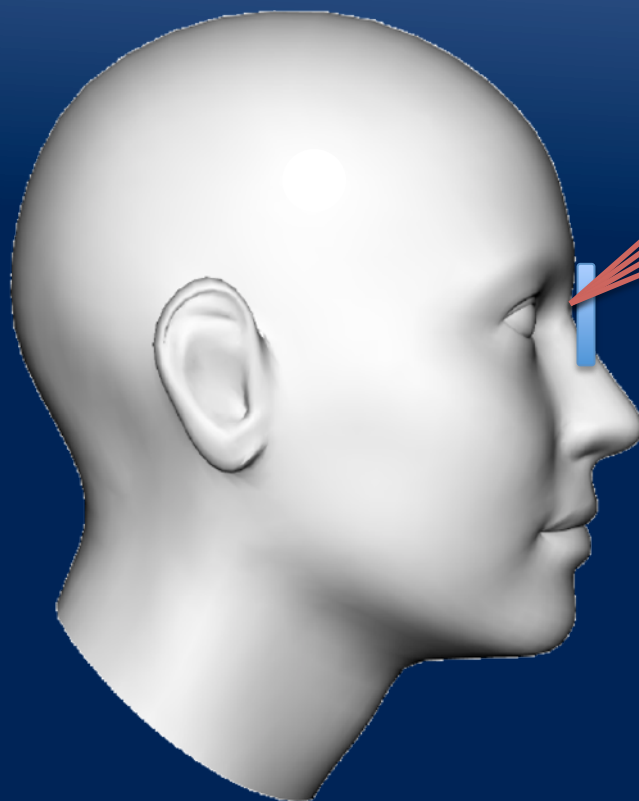
The Tie Fighter



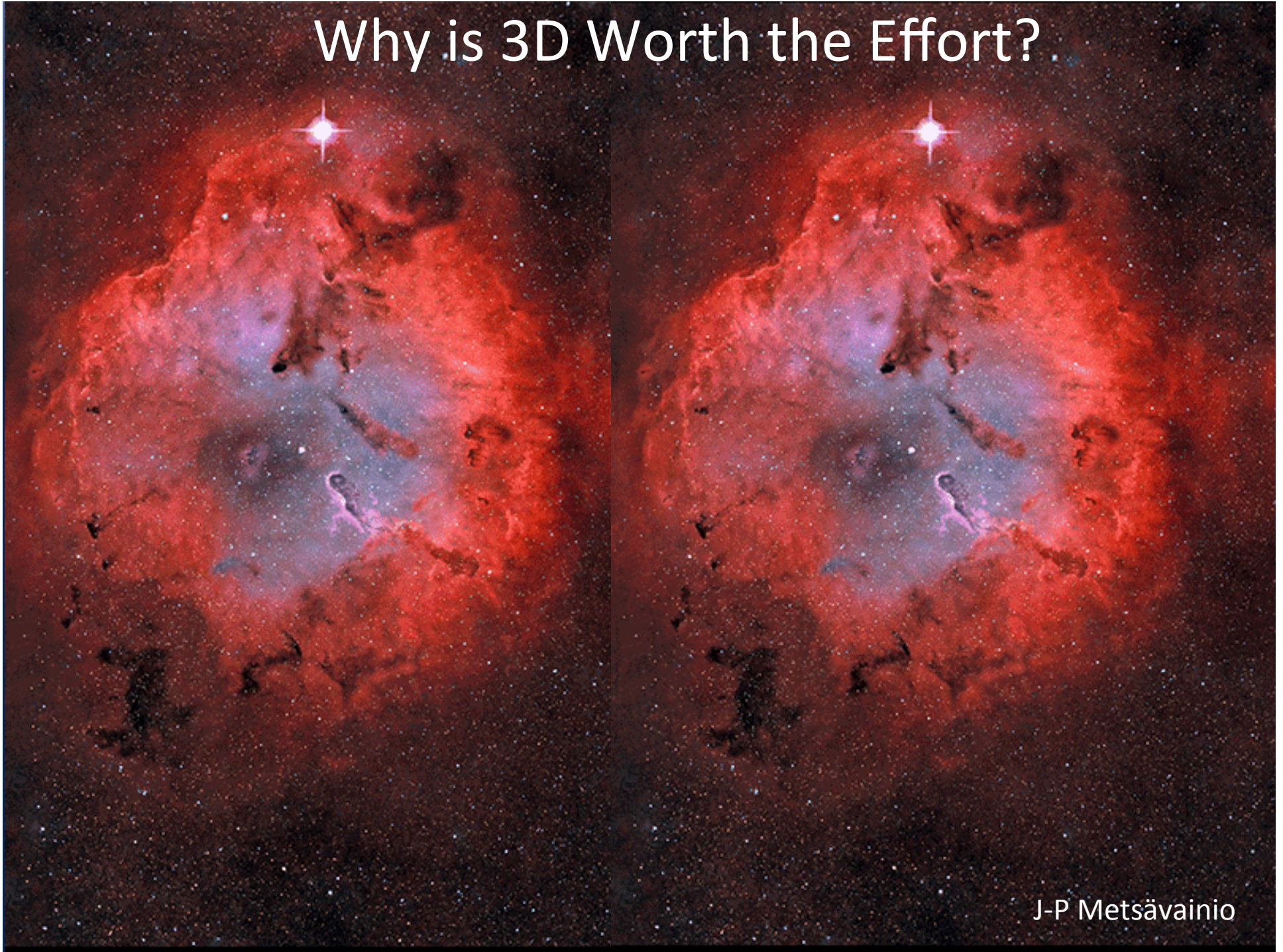
The Tootsie Roll

Polarizer aligned to wrong pixel





Why is 3D Worth the Effort?



J-P Metsävainio



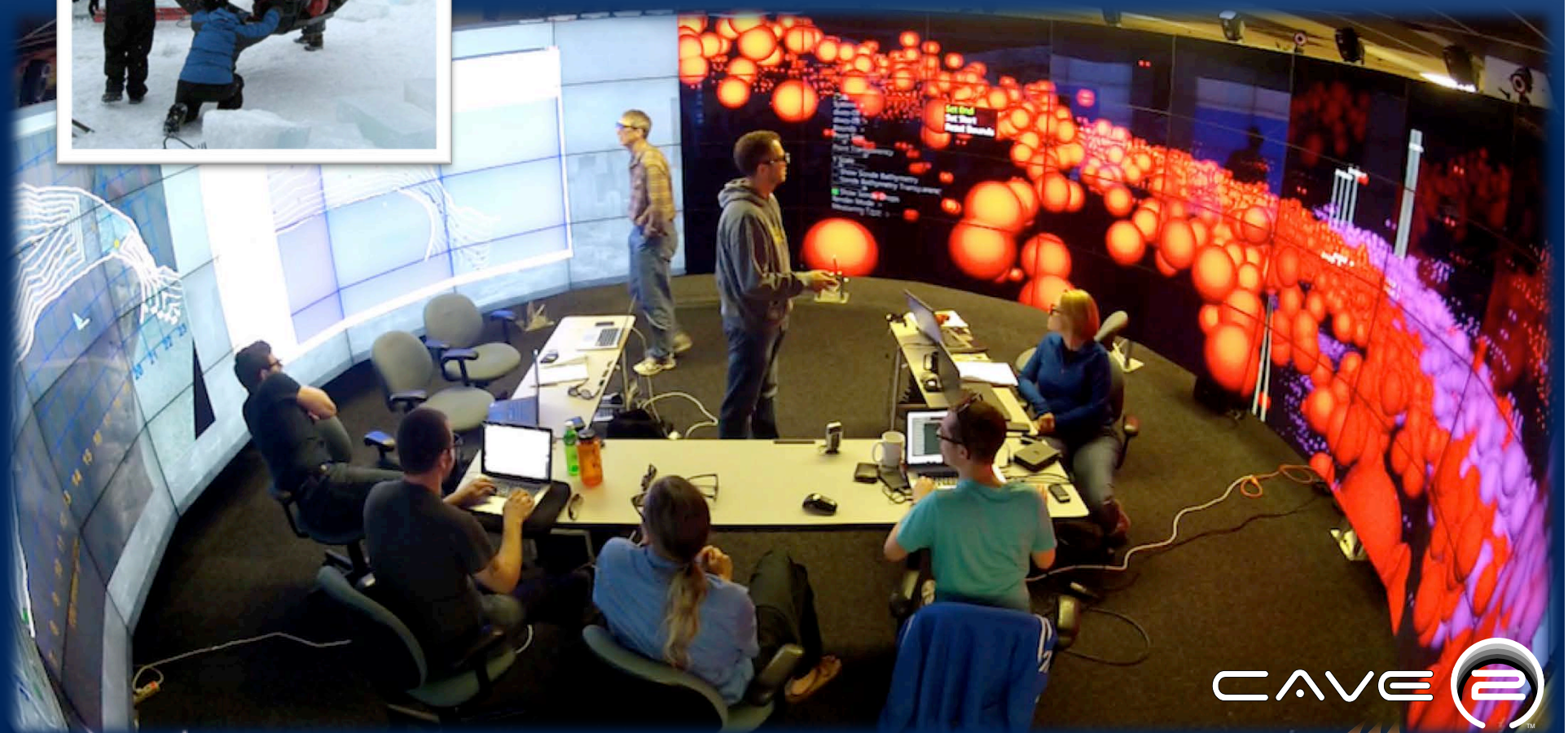
CAVE2

HYBRID REALITY ENVIRONMENT



NASA ENDURANCE

Environmentally **Non-Disturbing** Under-ice Robotic
ANtarctic Explorer





Visualization of Crime Data



5-Million Atom Simulation from Argonne National Laboratory's Advanced Leadership Computing Facility



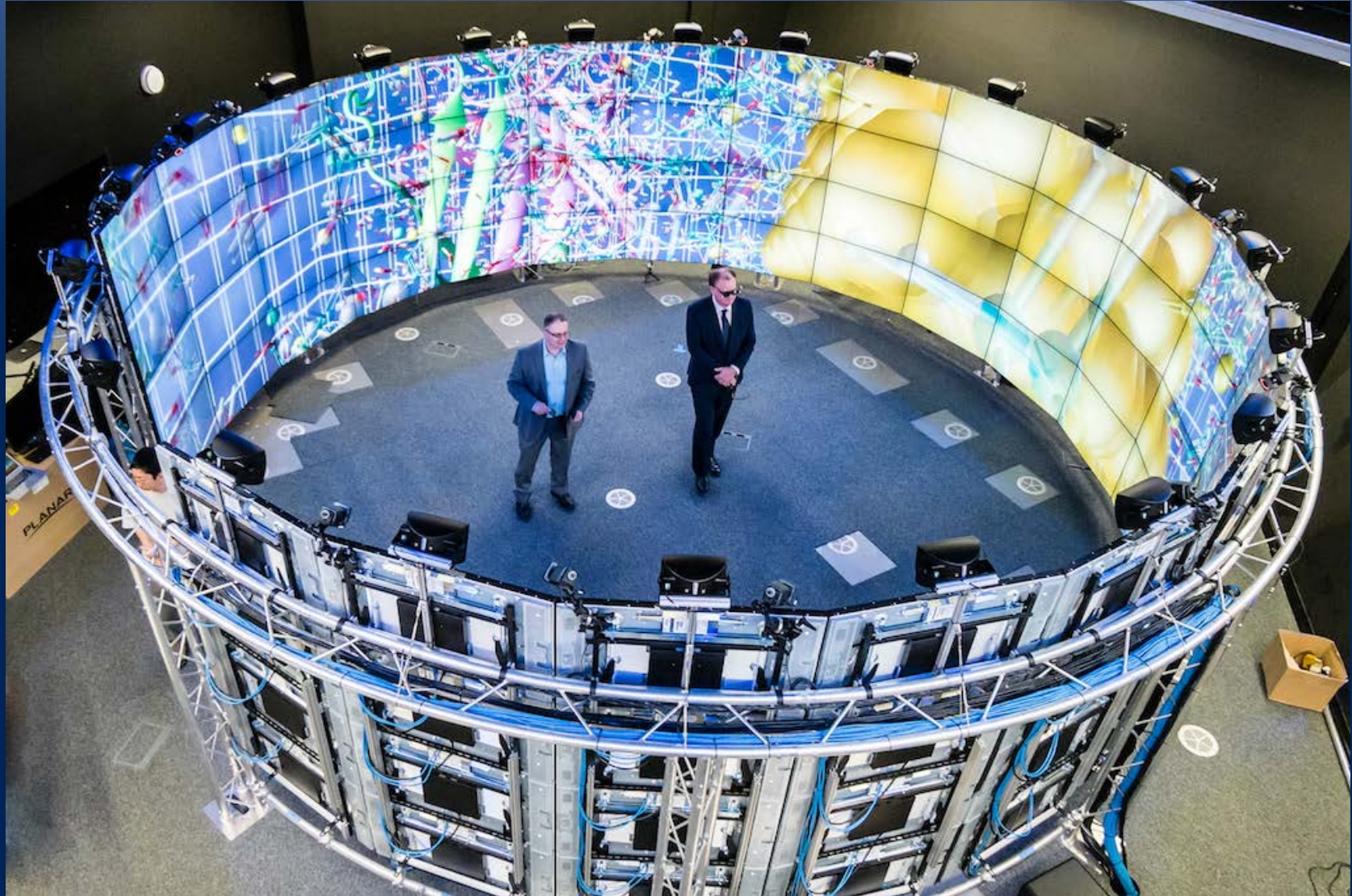
CAVE 


Argonne
NATIONAL
LABORATORY

Visualization Class Surrounded by Visualizations



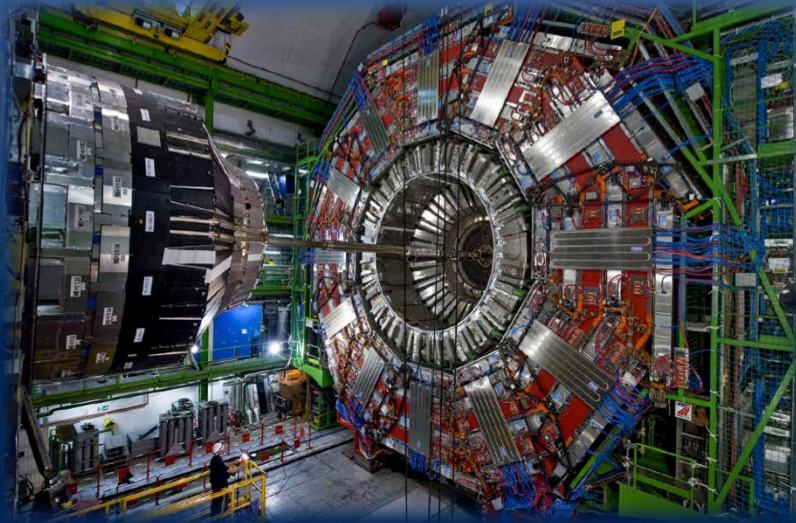
CAVE2 at Monash University, Australia



80 Displays – 80 Megapixels



Other lenses...



- Large Hadron Collider
- \$9 Billion



- 30 Meter Telescope
- Starts construction 2014
- Can observe planets around stars other than our Sun
- See 13 Billion light years away
- \$1 Billion

Science & Engineering at the Extreme



Audi

24 hour test of technology



Why does Audi spend \$125M per year to whiz 3 cars around a track?



Same Reason We Participate in Conference Challenges



Supercomputing / iGrid Challenges

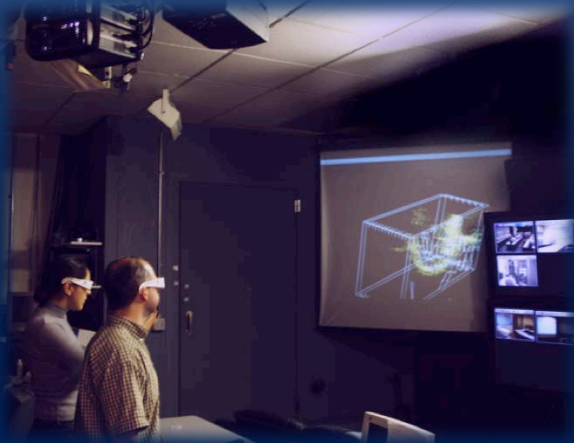
- Push the limits of our technology to:
- Attempt new applications of the technology
- Discover what breaks under stress.
- E.g. 1G, 10G, 100G Networking Infrastructure



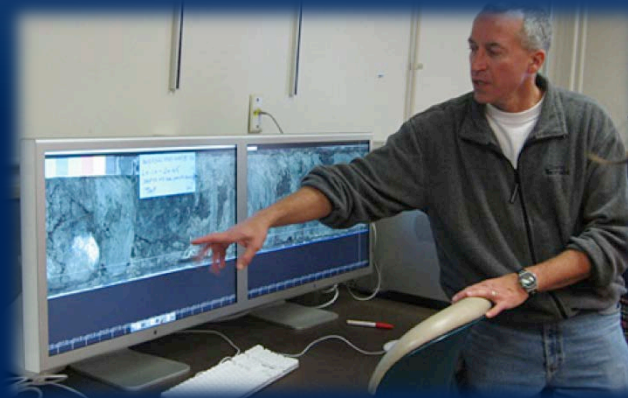
The research trickles down to the product line



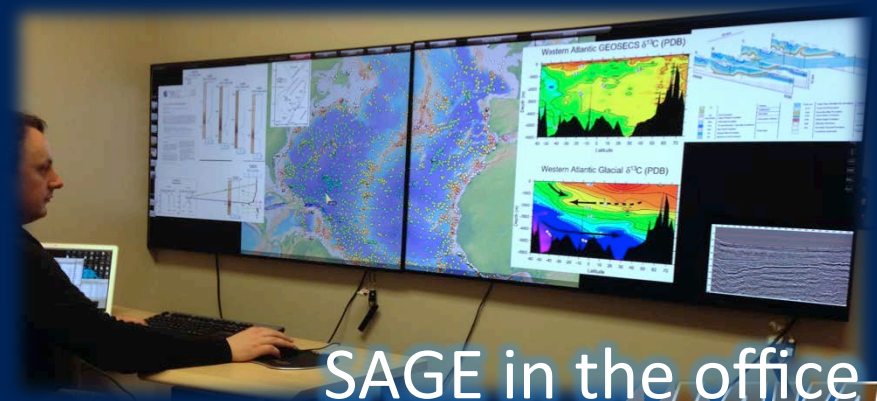
The research enables the realization of affordable systems for end-users



GeoWall



CoreWall - ANDRILL. McMurdo stations, Antarctica



SAGE in the office



Inspire Next Generation Big Dreams

“If you want to build a ship, don’t drum up the men to gather wood, divide the work, and give orders. Instead, teach them to yearn for the vast and endless sea.”

- Antoine de Saint-Exupéry

(Pioneering Aviator & Author of The Little Prince)



For More Info!

- **SAGE BOF at SC : Tues 12:15 in 501**
- **VisTech Workshop at SC: Fri 8:30 in 205**
- www.evl.uic.edu
- www.youtube.com/evltube
- jasonleigh.me



Major support for this research comes from NSF and DOE: award OCI-0943559, ACI-1339772, CNS-0959053 and DOE DE-SC005067

