Remote Telepresence for Exploring Virtual Worlds

Foundational Talk

Virtual World and Immersive Environments

January 26, 2008

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

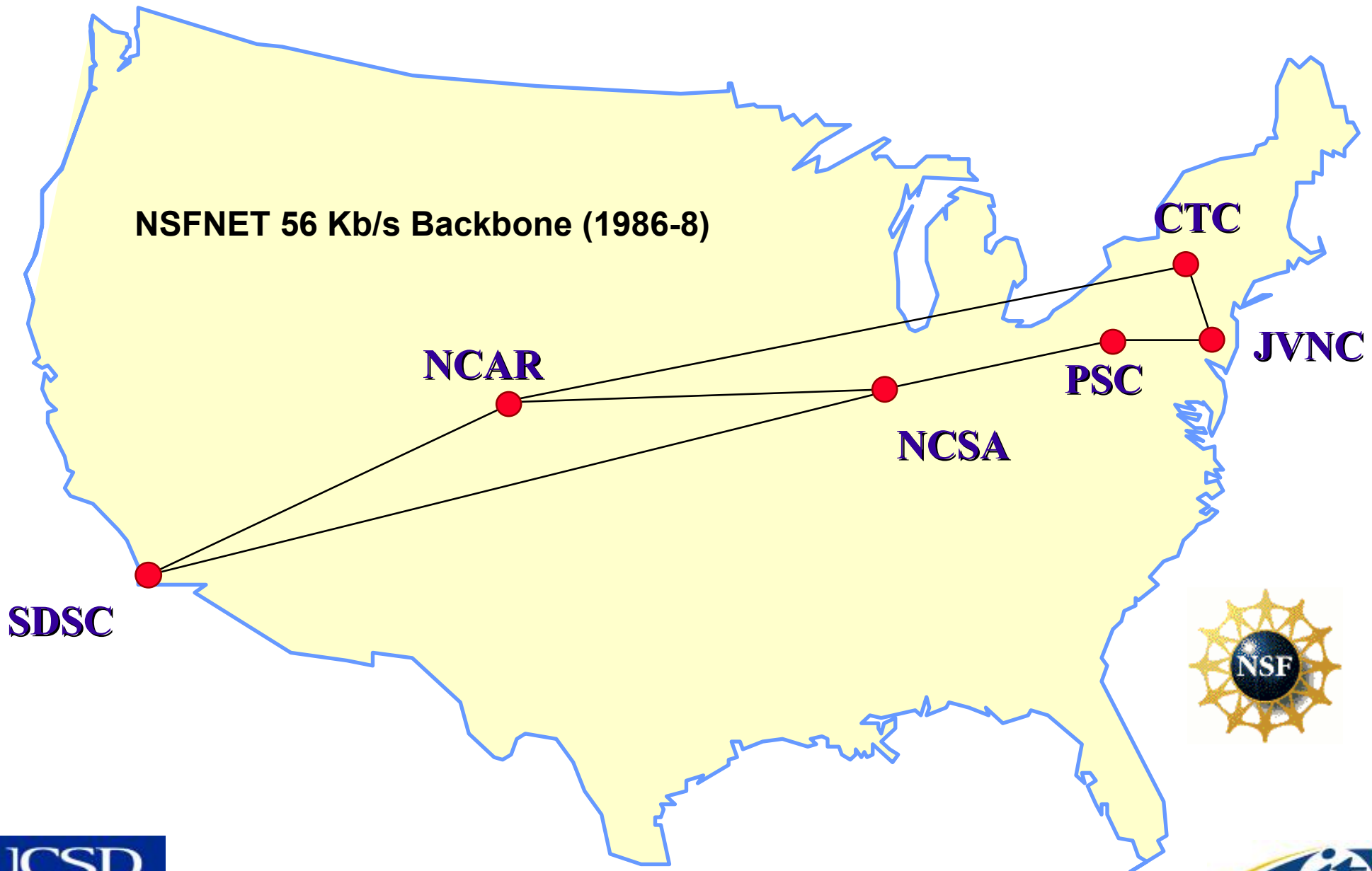
Jacobs School of Engineering, UCSD

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it²

The NSFnet (Later Expands to Form Today's Internet) Connected the Six NSF Supercomputers at 56kbps!



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A Simulation of Telepresence for Exploring Virtual Worlds: Using Analog Communications to Prototype the Digital Future

"What we really have to do is eliminate distance between individuals who want to interact with other people and with other computers."
— Larry Smarr, Director, NCSA

- **Televisualization:**
  - **Telepresence**
  - **Remote Interactive Visual Supercomputing**
  - **Multi-disciplinary Scientific Visualization**







"We're using satellite technology…to demo what It might be like to have high-speed fiber-optic links between advanced computers in two different geographic locations."

— Al Gore, Senator
Chair, US Senate Subcommittee on Science, Technology and Space

ATT & Sun

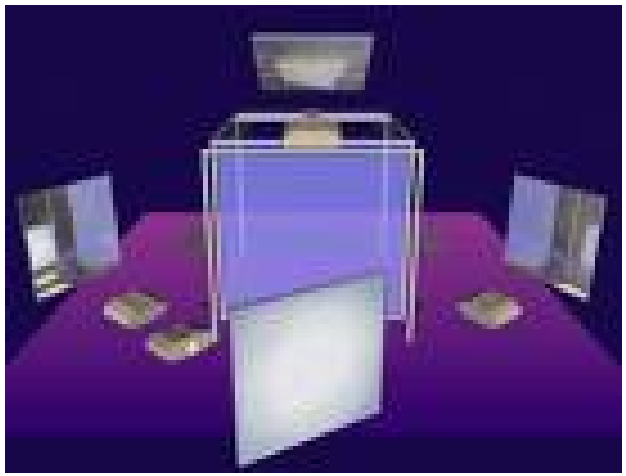
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SIGGRAPH 1989

NCSA™

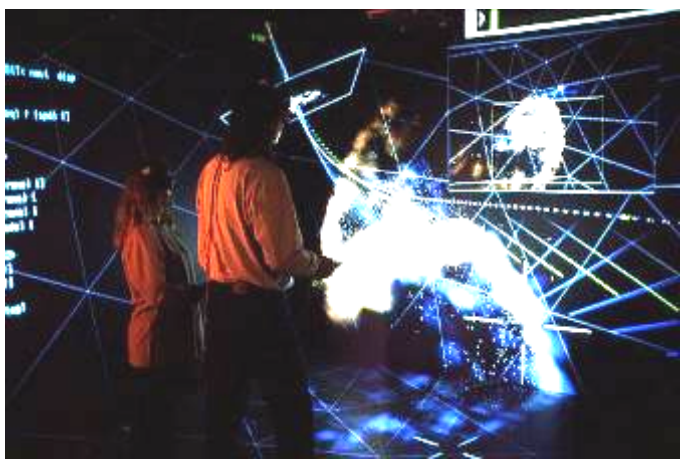
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The CAVE Virtual Reality System: Fully Immersive Science and Fantasy Worlds



The CAVE

- EVL Invents ‘91
- Debuts SIGGRAPH ’92
- National Access NCSA ‘93



Colliding Galaxies



Crayoland



QUAKE II

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CAVE conceived in 1991 by Tom DeFanti and Dan Sandin (EVL co-directors) and implemented by Carolina Cruz-Neira (Ph.D. student)

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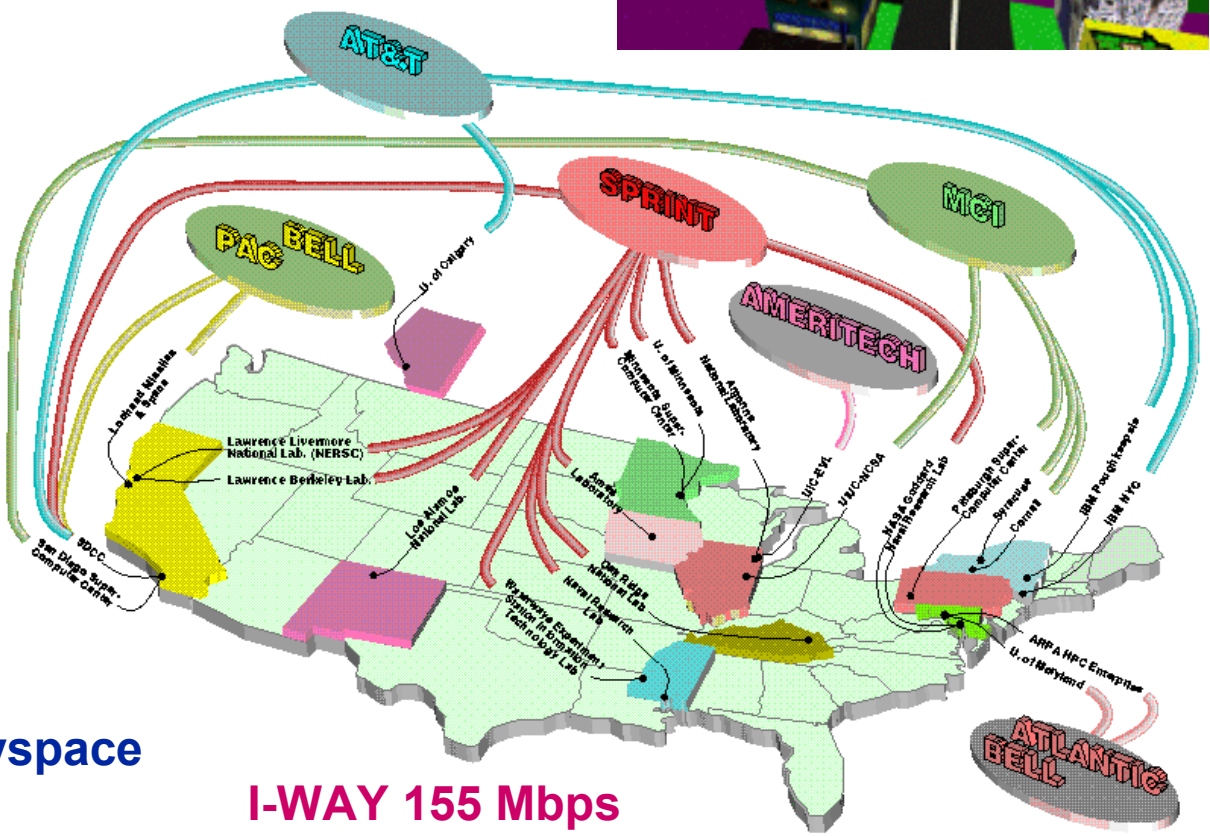
Kids Building Virtual Cities
Supercomputing '95 San Diego

- **First User-Generated Virtual World**
  - Coco Conn (producer), Zane Vella (director), Chris Cederwall (programmer), et al.
  - Ported to CAVE SIGGRAPH '94
  - Networked Over I-Way '95

evl electronic visualization laboratory







I-WAY 155 Mbps

http://en.wikipedia.org/wiki/Cityspace

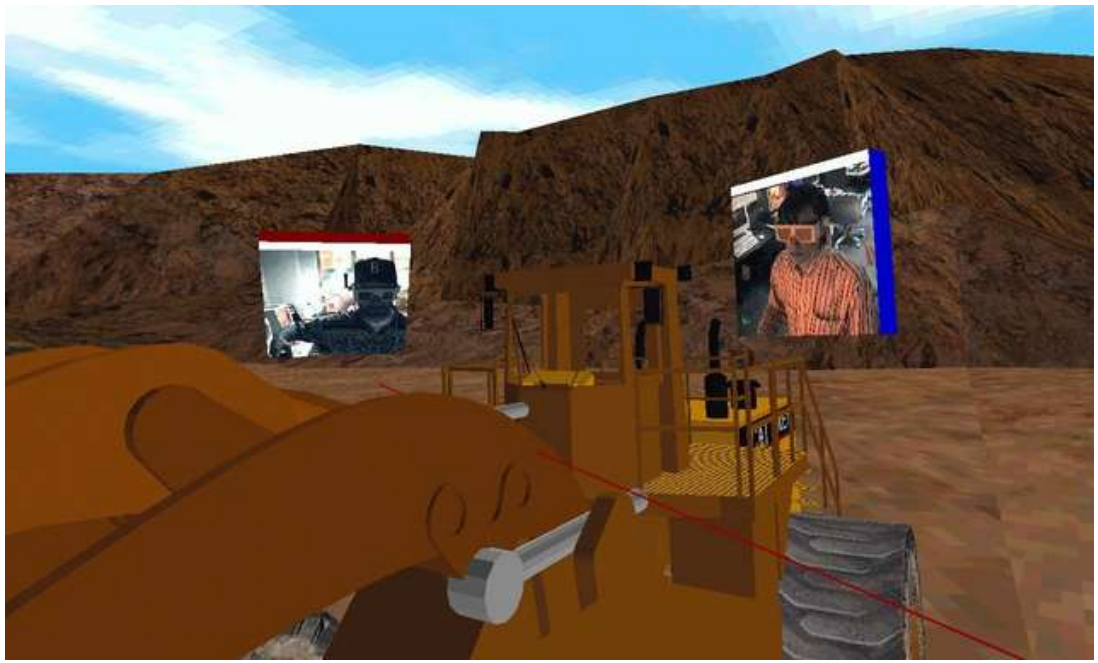
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UIC mcs NCSA

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Caterpillar / NCSA: Distributed Virtual Reality for Global-Scale Collaborative Prototyping

Floating Rendered Video





NCSA™

Real Time Linked Virtual Reality and Audio-Video Between NCSA, Peoria, Houston, and Germany

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1996

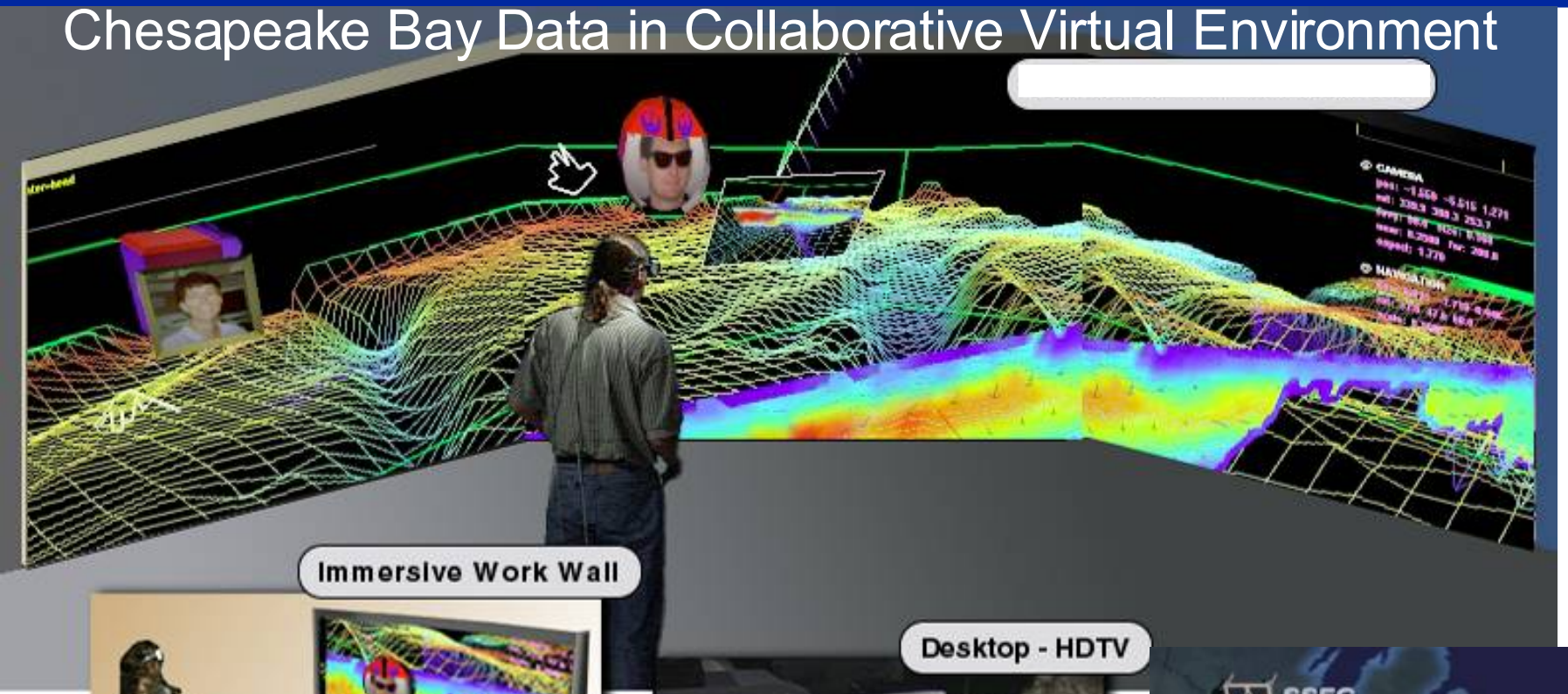
www.sv.vt.edu/future/vt-cave/apps/CatDistVR/DVR.html

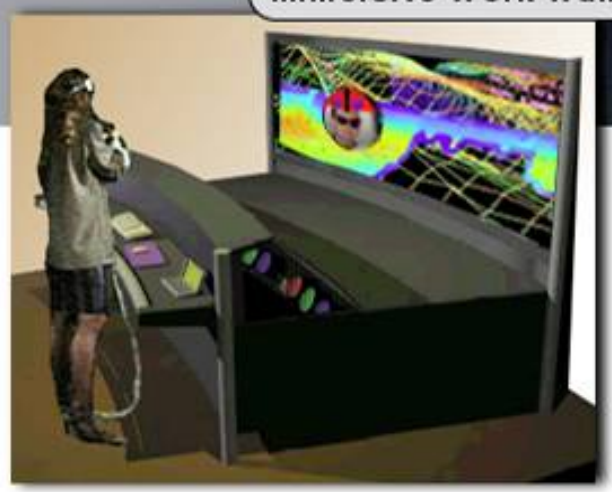
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Grid-Enabled Collaborative Analysis of Ecosystem Dynamics Datasets

Chesapeake Bay Data in Collaborative Virtual Environment

1997







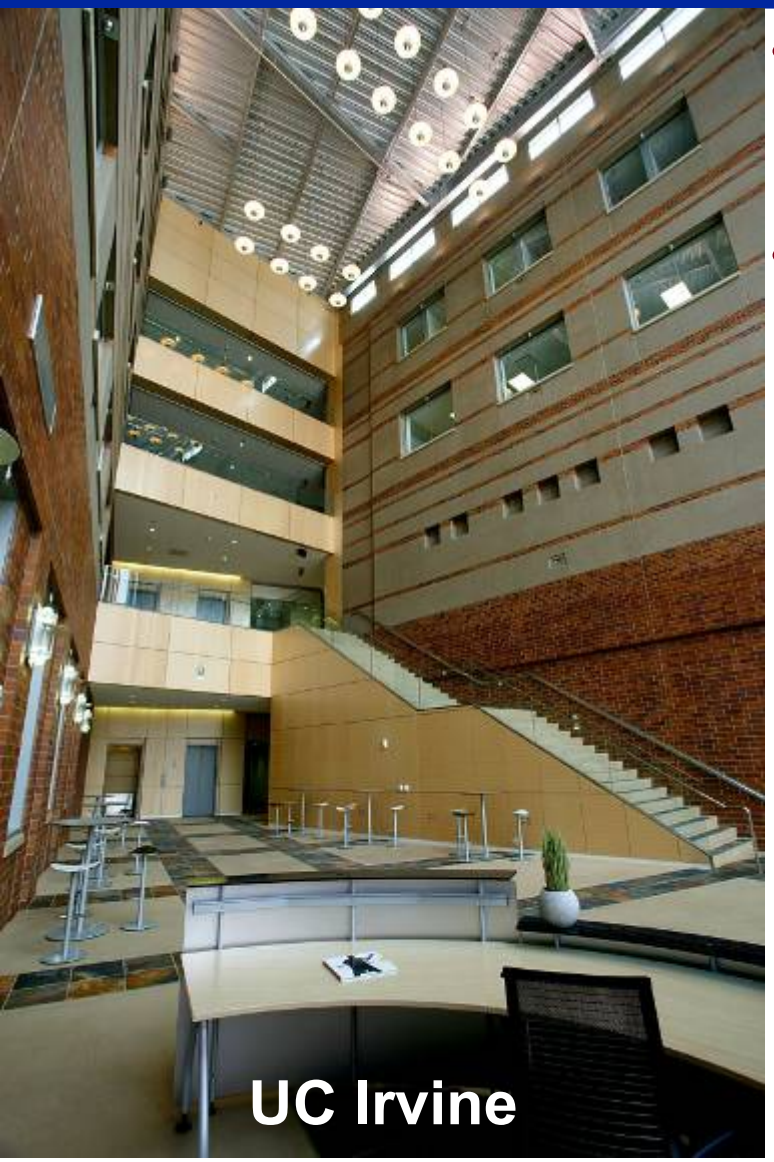


Donna Cox, Robert Patterson, Stuart Levy, NCSA Virtual Director Team
Glenn Wheless, Old Dominion Univ.

Alliance Application Technologies
Environmental Hydrology Team

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Two New Calit2 Buildings Provide New Laboratories for "Living in the Future"



- "Convergence" Laboratory Facilities
  - Nanotech, BioMEMS, Chips, Radio, Photonics
  - Virtual Reality, Digital Cinema, HDTV, Gaming
- Over 1000 Researchers in Two Buildings
  - Linked via Dedicated Optical Networks



www.calit2.net

Preparing for a World in Which Distance is Eliminated…

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Borderless Collaboration Between Global University Research Centers at 10Gbps

Maxine Brown, Tom DeFanti, Co-Chairs

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.igrid2005.org

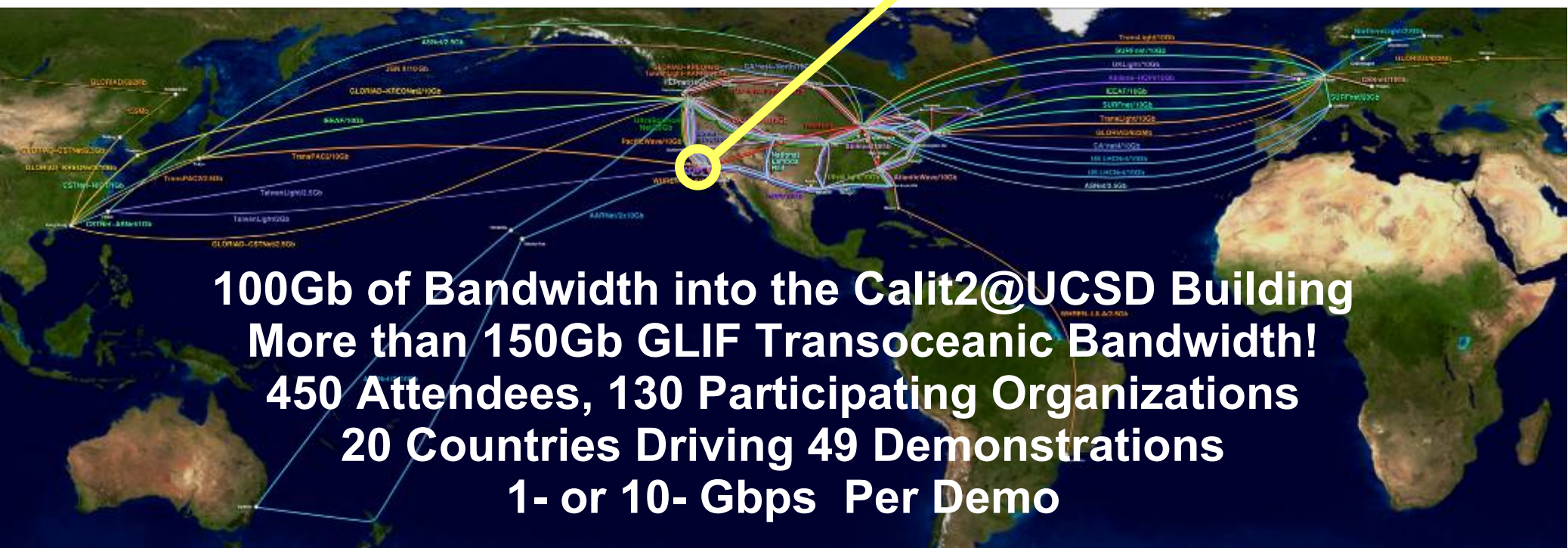


the UC Discovery Grant

September 26-30, 2005

Calit2 @ University of California, San Diego

California Institute for Telecommunications and Information Technology



100Gb of Bandwidth into the Calit2@UCSD Building

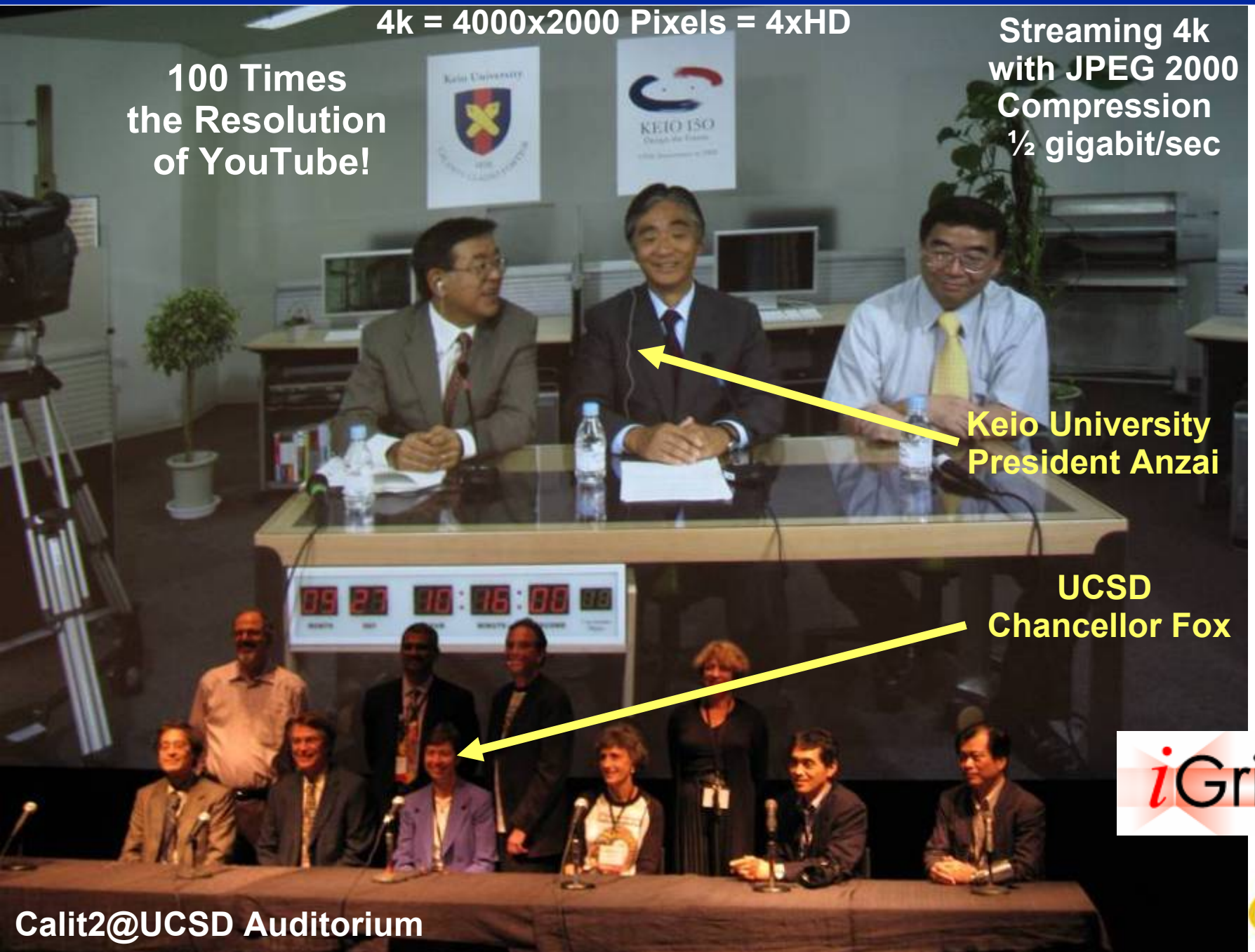
More than 150Gb GLIF Transoceanic Bandwidth!

450 Attendees, 130 Participating Organizations

20 Countries Driving 49 Demonstrations

1- or 10- Gbps Per Demo

First Trans-Pacific Super High Definition Telepresence Meeting Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

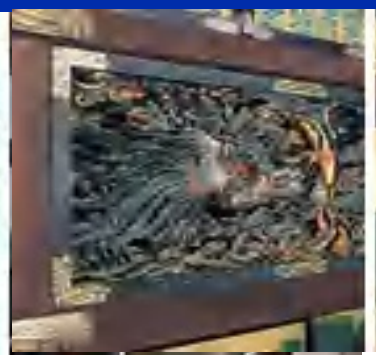
Sony
NTT
SGI

iGrid 2005

it²

Interactive VR Streamed Live from Tokyo to Calit2 Over Dedicated GigE and Projected at 4k Resolution









Source: Toppan Printing

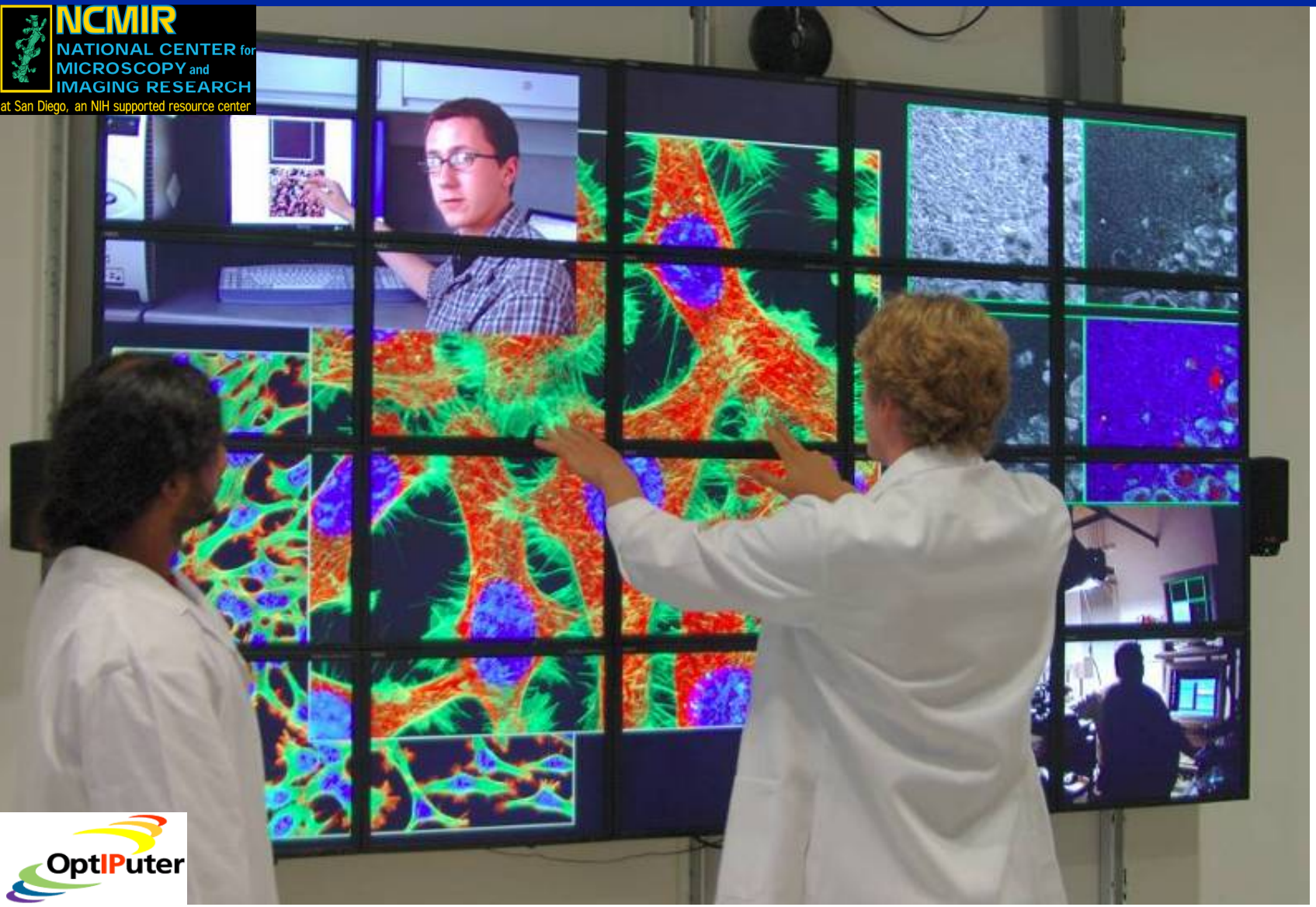
iGrid 2005 Kyoto Nijo Castle

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The OptIPuter Project: Creating High Resolution Portals Over Dedicated Optical Channels to Global Science Data

NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center



Scalable Adaptive Graphics Environment (SAGE)

evl electronic visualization laboratory

NSF

$13.5M Over Five Years

Picture Source: Mark Ellisman, David Lee, Jason Leigh

OptIPuter

UCSD
UCIrvine

Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
Univ. Partners: SDSC, USC, SDSU, NW, TA&M, UvA, SARA, KISTI, AIST
Industry: IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent

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My OptIPortal™ – Affordable Termination Device for the OptIPuter Global Backplane

- 20 Dual CPU Nodes, 20 24” Monitors, ~$50,000
- 1/4 Teraflop, 5 Terabyte Storage, 45 Mega Pixels--Nice PC!
- Scalable Adaptive Graphics Environment (SAGE) Jason Leigh, EVL-UIC

evl electronic visualization laboratory





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Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

it²

Tiled Displays Allow for Both Global Context and High Levels of Detail—150 MPixel Rover Image on 40 MPixel OptIPuter Visualization Node Display

"Source: Spirit Rover Landing Site Panorama, Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Interactively Zooming In Using UIC's Electronic Visualization Lab's JuxtaView Software

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"

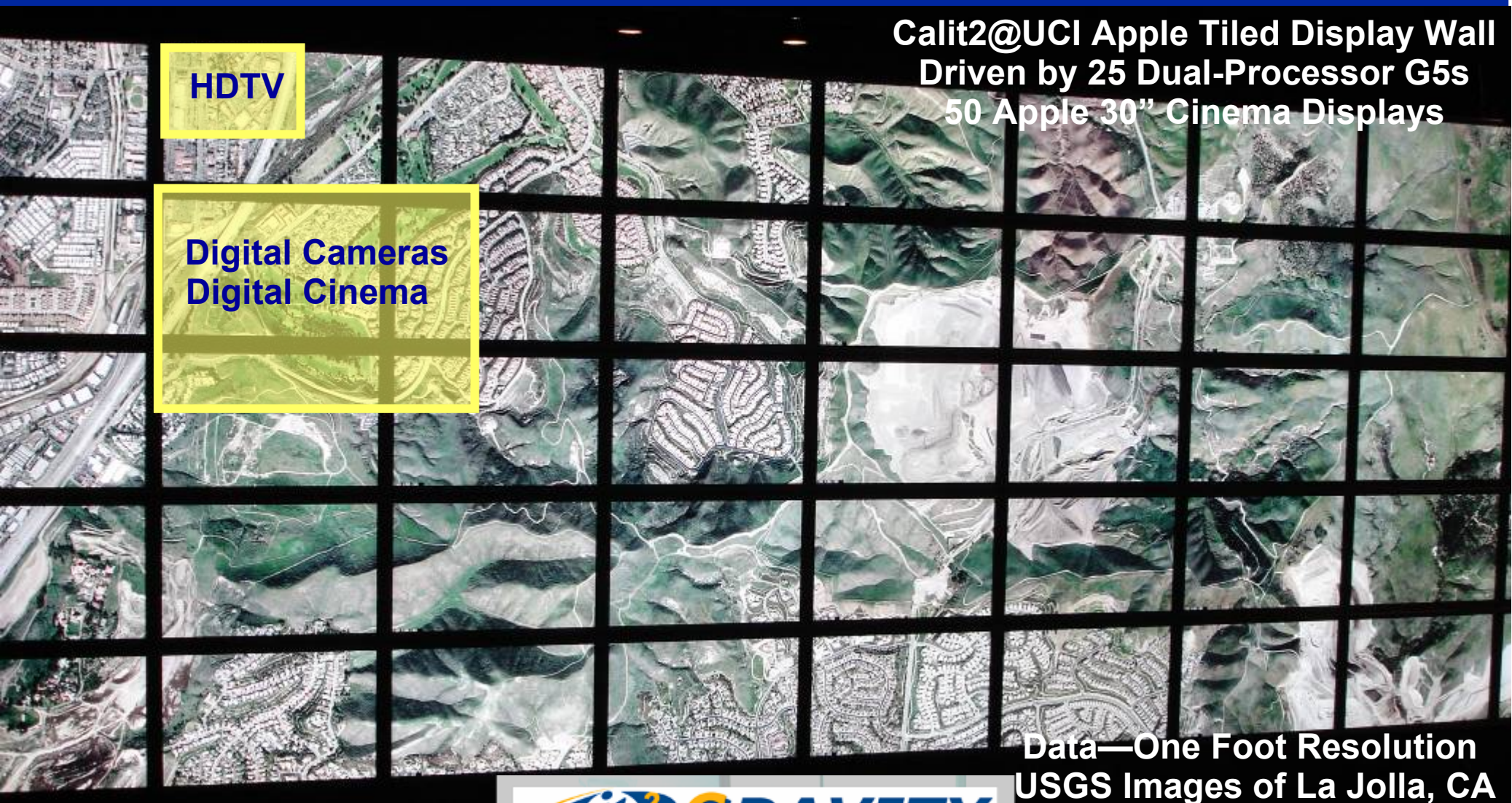


Highest Resolution Zoom

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Beyond 4k –
From 8 Megapixels Towards a Billion Pixels



it² Center of GRAVITY
Center of Graphics, Visualization and Imaging Technology

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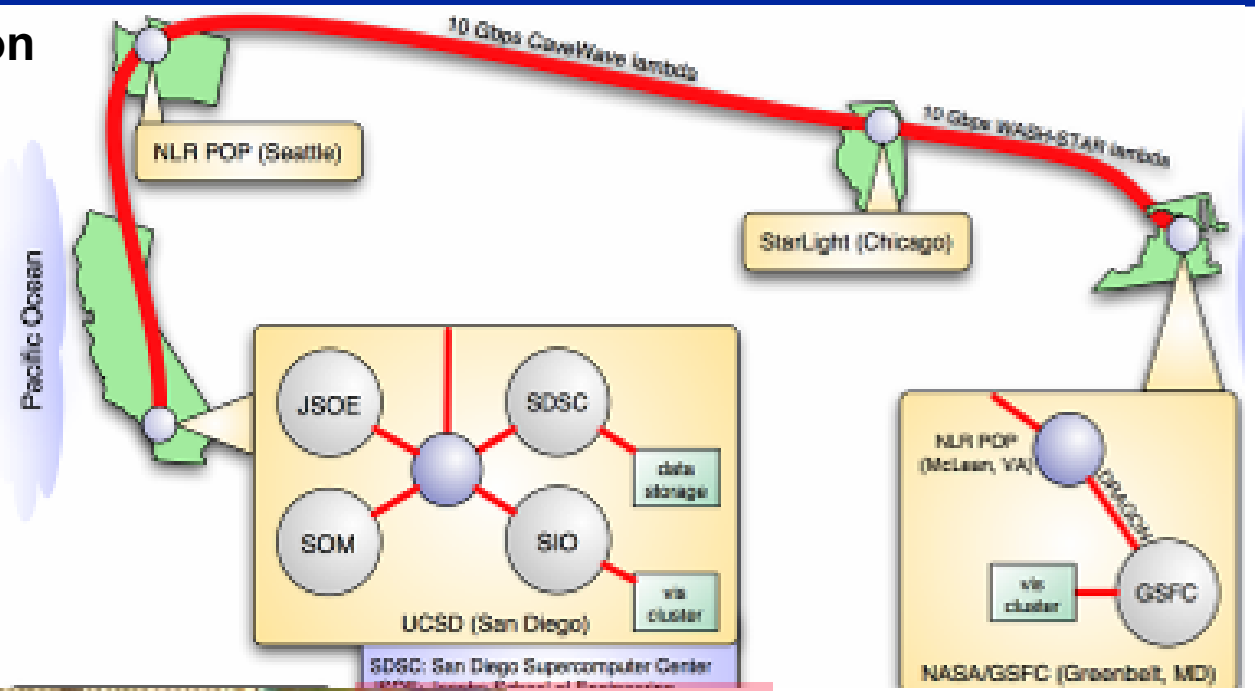
Source: Falko Kuester, Calit2@UCI
NSF Infrastructure Grant

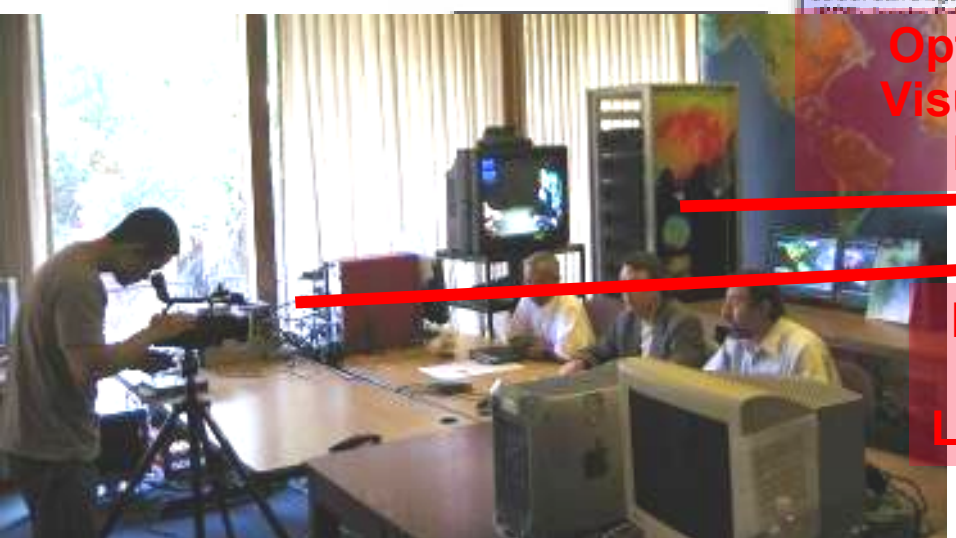
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OptIPuter Enables Telepresence Combined with Remote Interactive Analysis

Live Demonstration

of 21st Century National-Scale Team Science





OptIPuter Visualized Data

HDTV Over Lambda



SIO/UCSD

NASA Goddard

August 12, 2005

UCSD
UCIrvine

The OptIPuter Enabled Collaboratory: Remote Researchers Jointly Exploring Complex Data



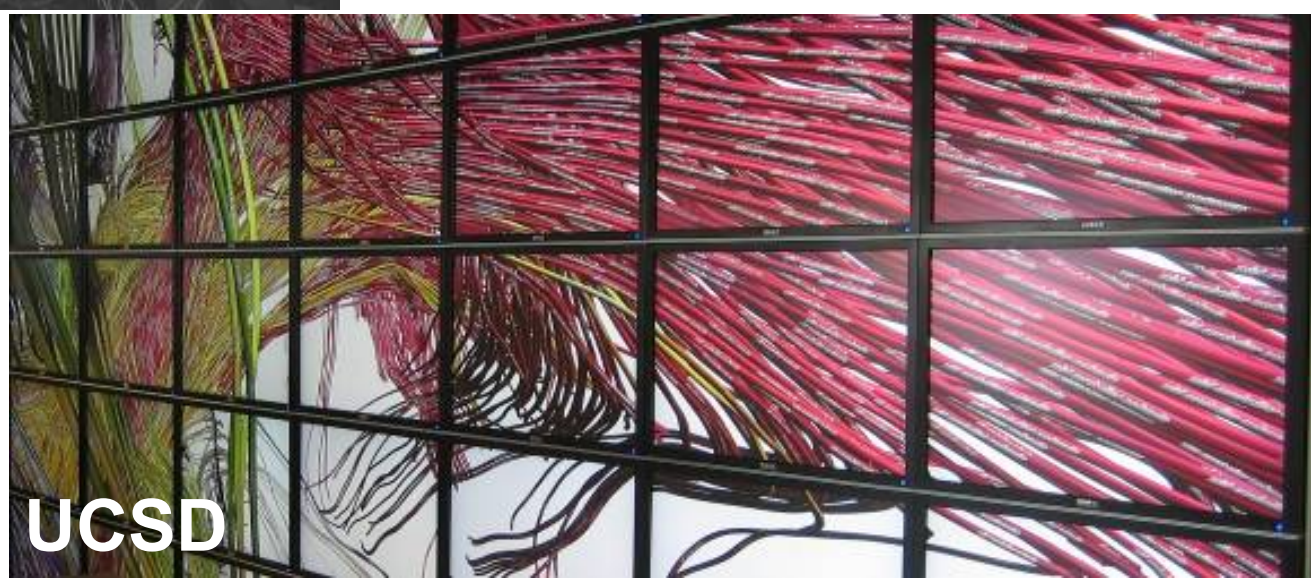
Falko Kuester, UCSD;
Steven Jenks, UCI

OptIPuter

2,000 Mbps

80 NVIDIA Quadro FX 5600 GPUs

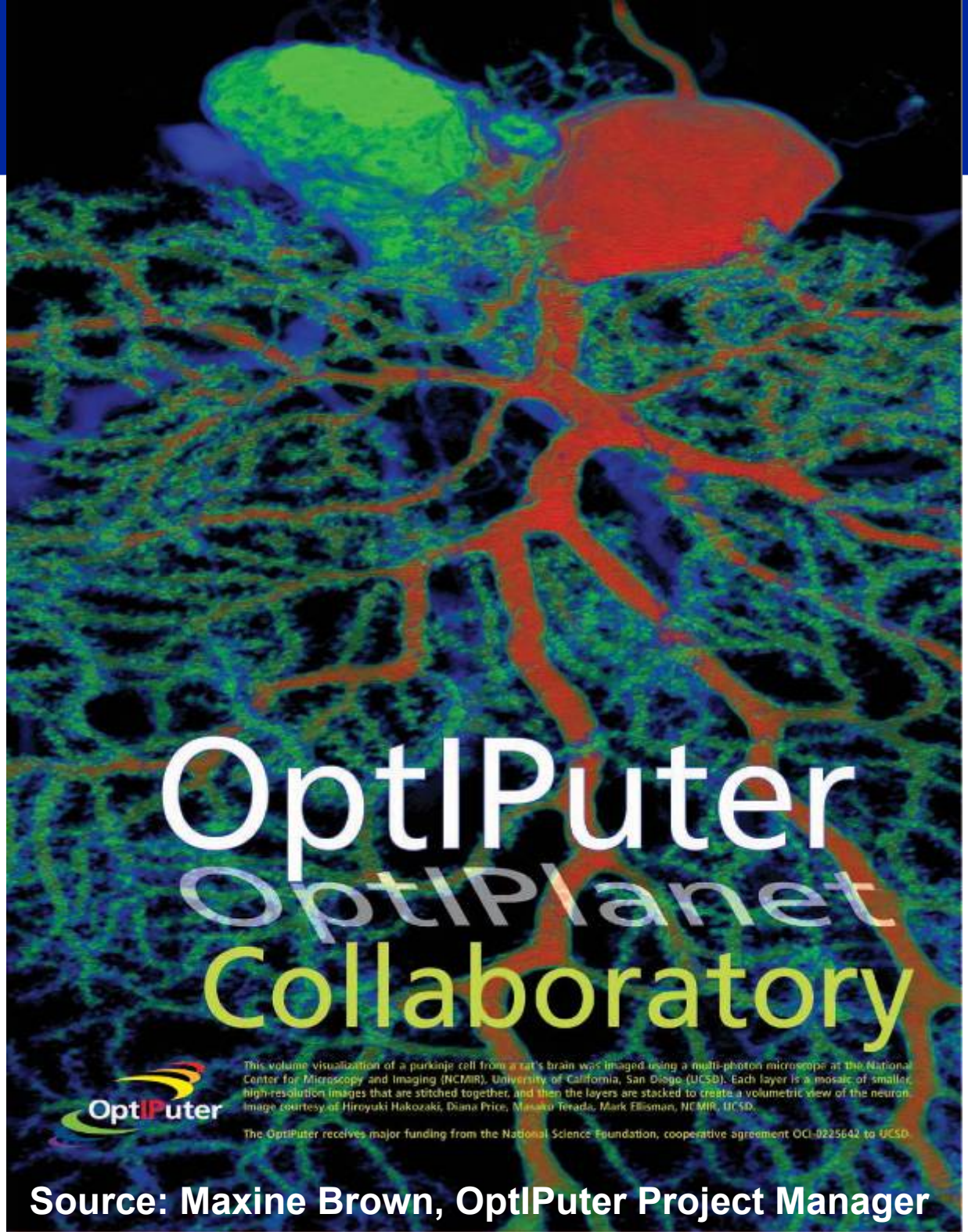
OptIPuter Connects the Calit2@UCI 200M-Pixel Wall to the 220M-Pixel Display at Calit2@UCSD With Shared Fast Deep Storage and High Definition Video



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Brain Circuitry Modeling and Visualization
In Collaboration with the
Transdisciplinary Imaging Genetics Center (TIGC) at UCI

it²



Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

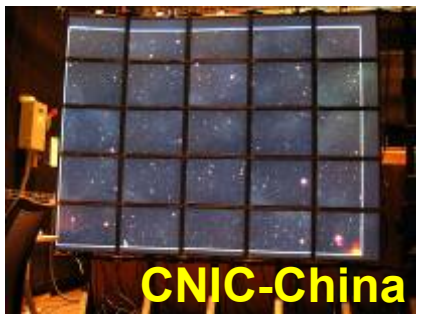
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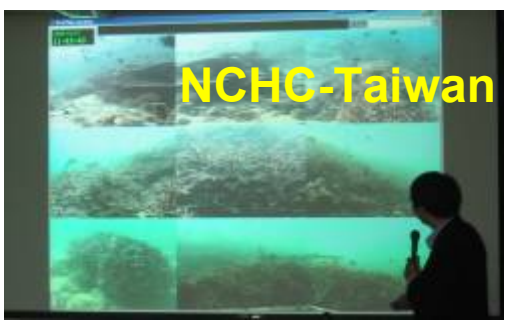
OptIPortals
Are Being Adopted Globally


AIST-Japan


Osaka U-Japan


KISTI-Korea


CNIC-China


NCHC-Taiwan


UZurich


SARA- Netherlands


Brno-Czech Republic


EVL@UIC


Calit2@UCSD


Calit2@UCI


NCMIR@UCSD

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Powered by Rocks ROCKS

evl electronic visualization laboratory

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Launch of the 100 Megapixel OzIPortal Over Qvidium Compressed HD on 1 Gbps CENIC/PW/AARNet Fiber



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www.calit2.net/newsroom/release.php?id=1219

it²

“Using the Link to Build the Link”
Calit2 and Univ. Melbourne Technology Teams

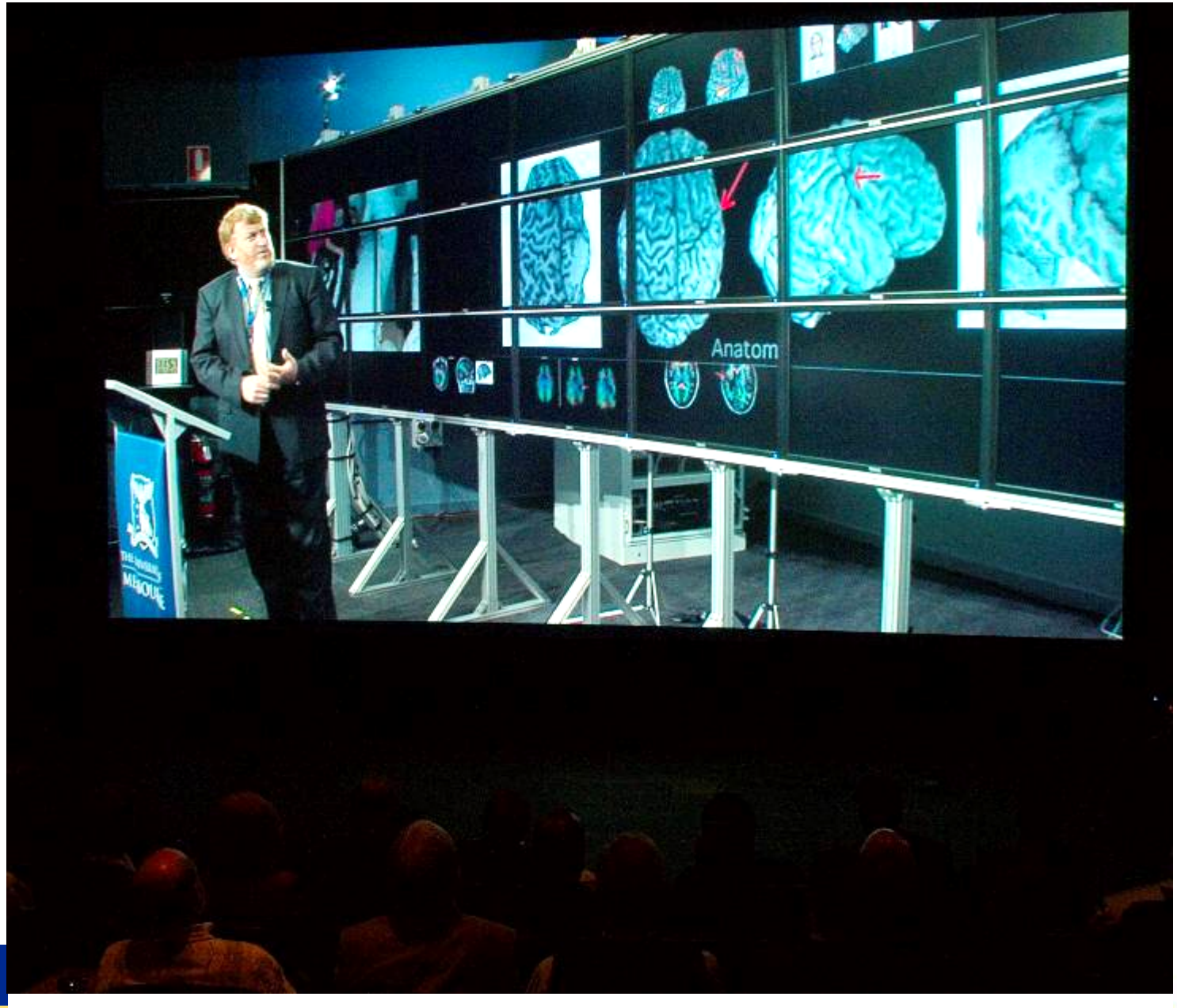


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No Calit2 Person Physically Flew to Australia to Bring This Up!

www.calit2.net/newsroom/release.php?id=1219

UM Professor Graeme Jackson Planning Brain Surgery for Severe Epilepsy



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www.calit2.net/newsroom/release.php?id=1219

Victoria Premier and Australian Deputy Prime Minister Asking Questions



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www.calit2.net/newsroom/release.php?id=1219

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University of Melbourne Vice Chancellor Glyn Davis in Calit2 Replies to Question from Australia



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Remote Interactive High Definition Video of Deep Sea Hydrothermal Vents



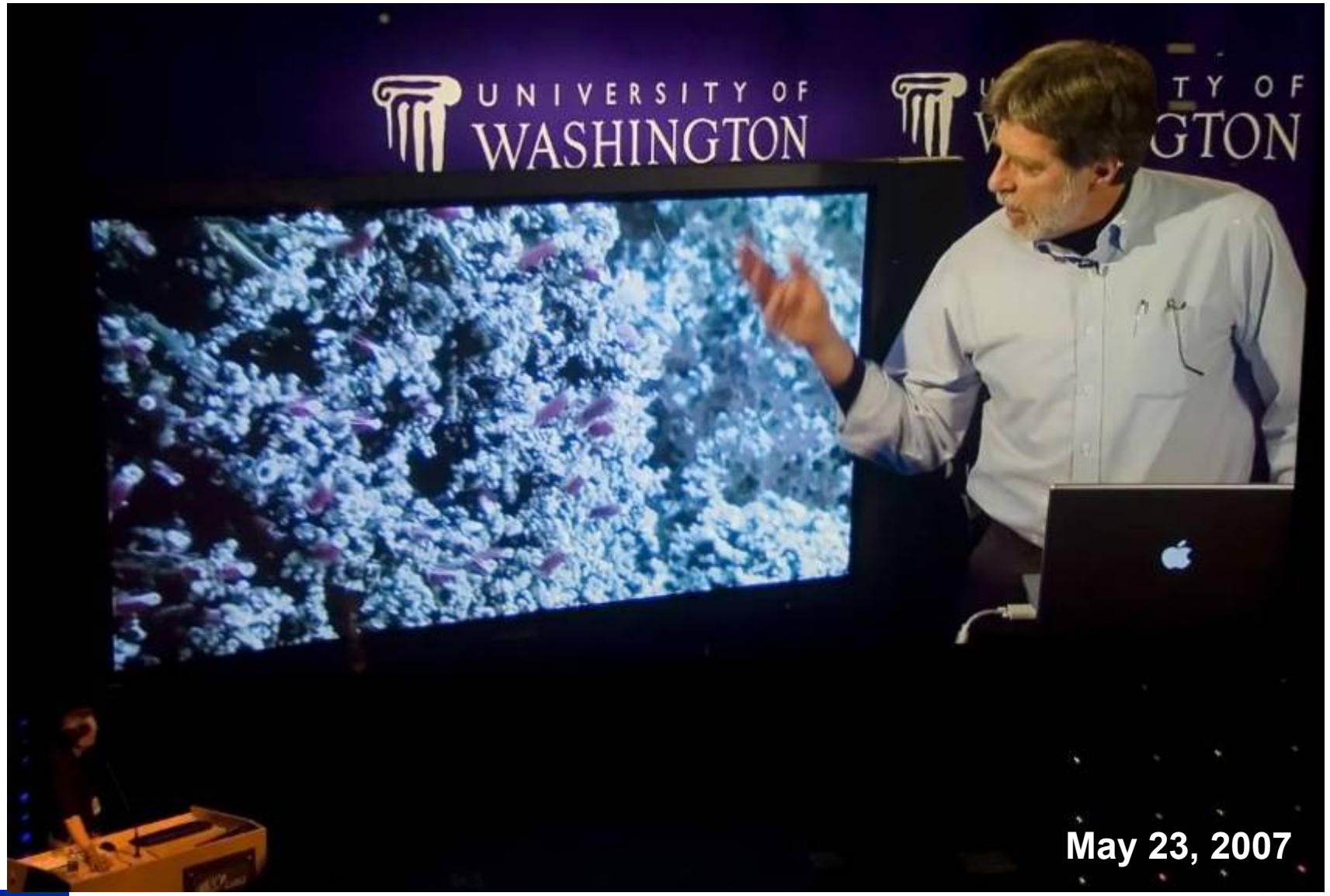
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Source John Delaney & Deborah Kelley, UWash

it²

e-Science Collaboratory Without Walls Enabled by iHDTV Uncompressed HD Telepresence

1500 Mbits/sec Calit2 to UW Research Channel Over NLR

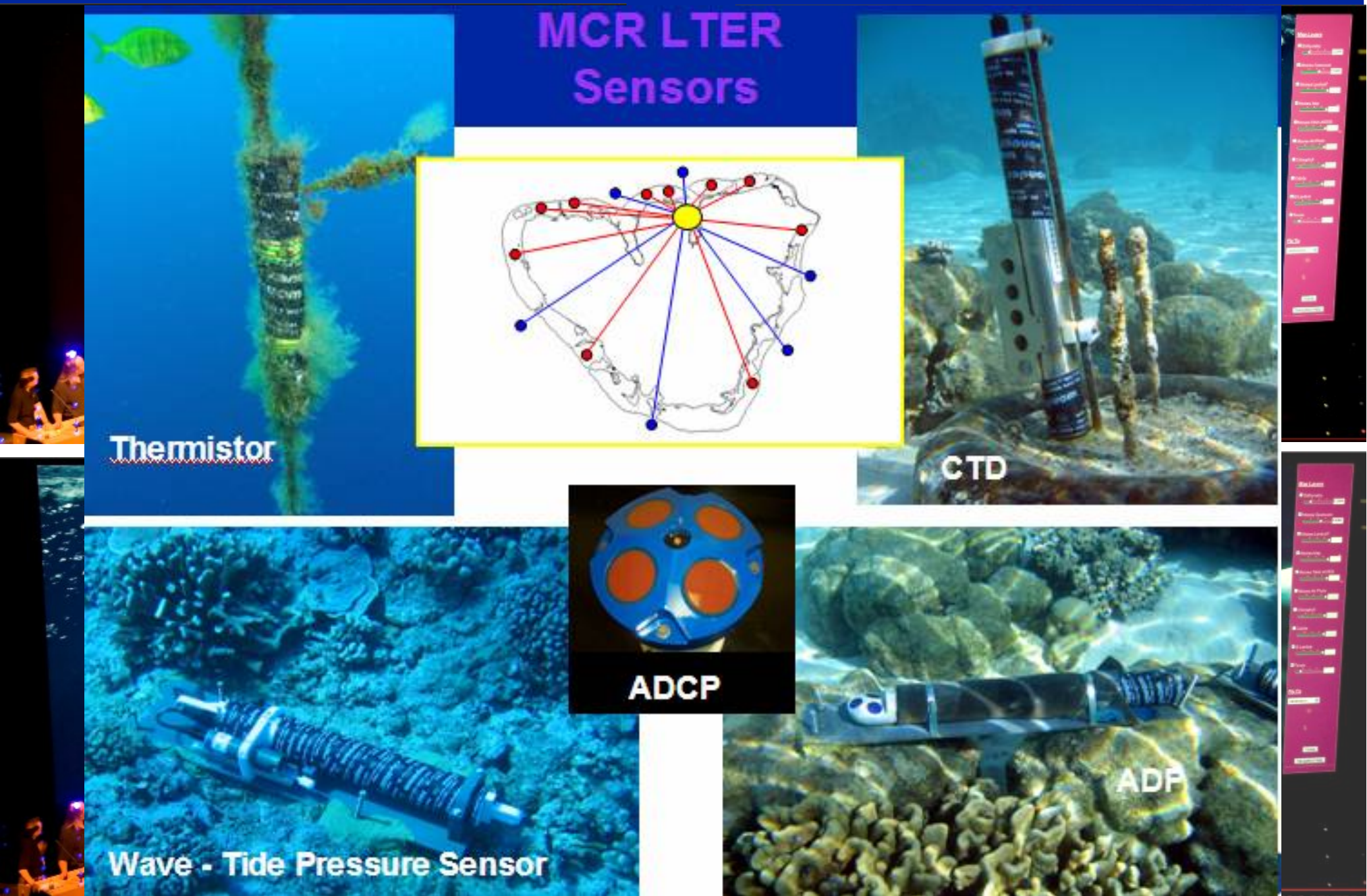


John Delaney, PI LOOKING, Neptune

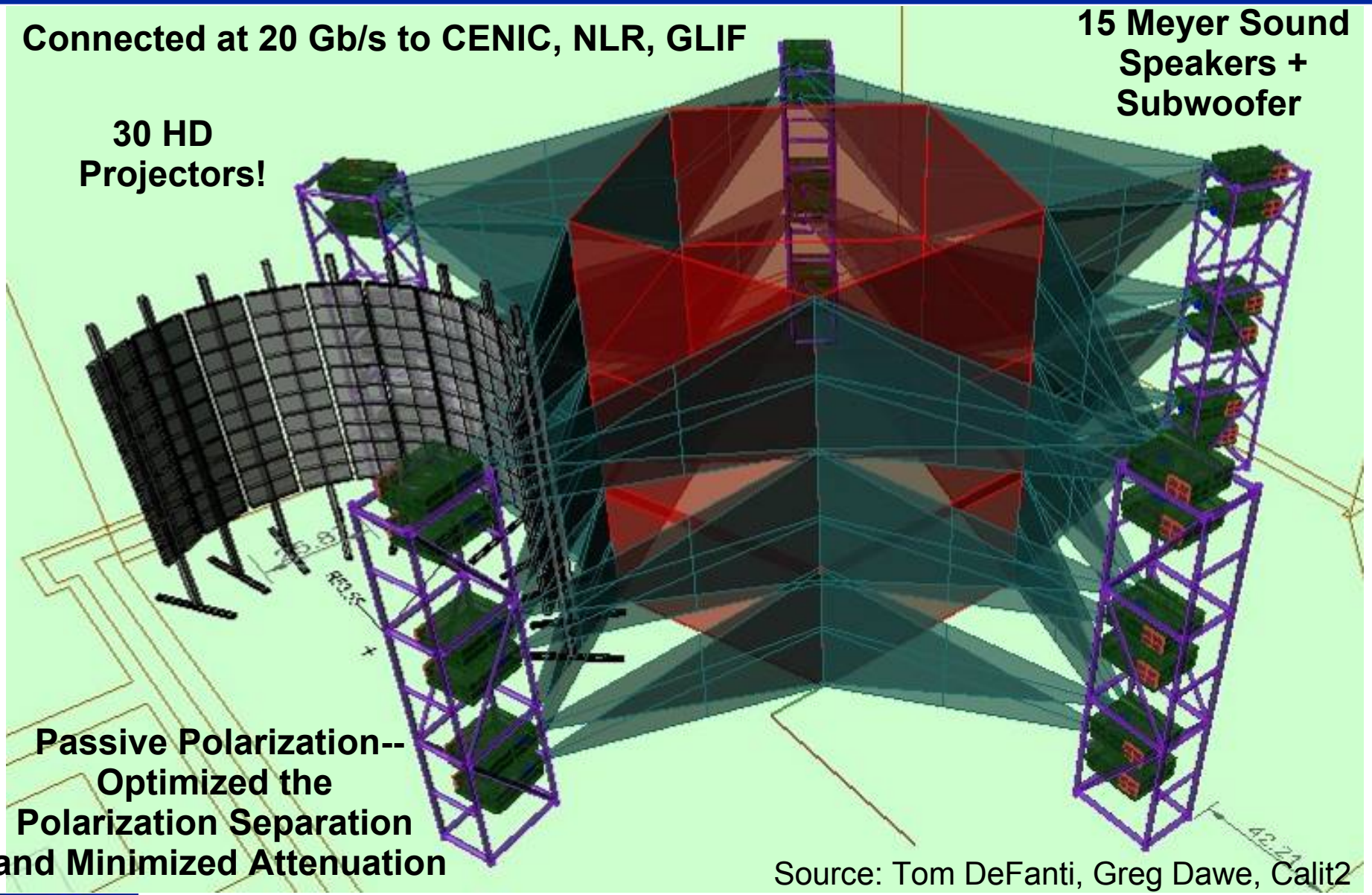
Photo: Harry Ammons, SDSC

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Creating a Digital Moorea
Calit2 Collaboration with UC Gump Station (UCB, UCSB)



3D OptIPortals: Calit2 StarCAVE and Varrier Alpha Tests of Telepresence "Holodecks"



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Cluster with 30 Nvidia 5600 cards-60 GB Texture Memory

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The StarCAVE as a “ Browser” for the NASA’s “Blue Marble” Earth Dataset



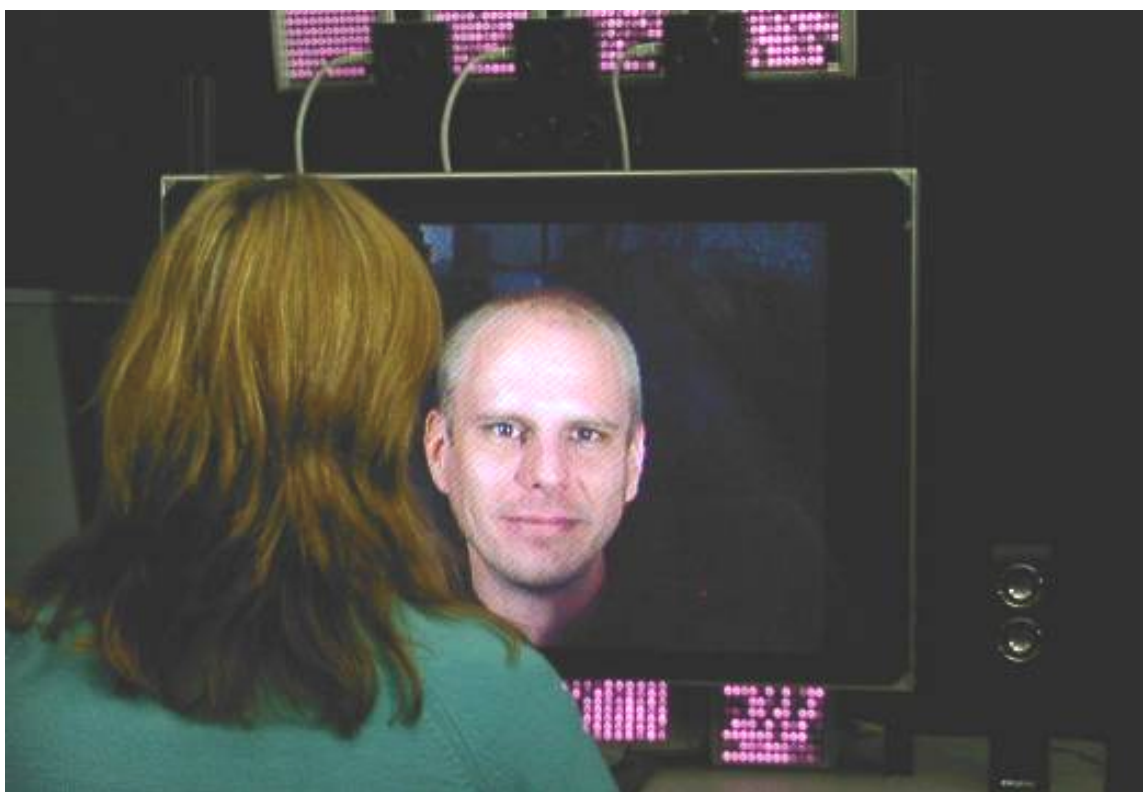
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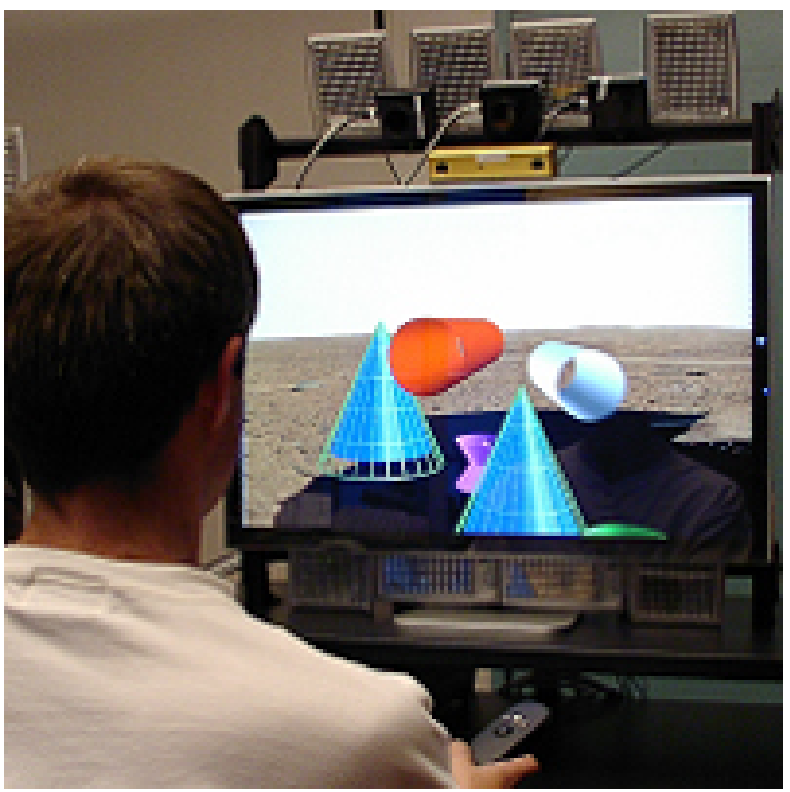
Source: Tom DeFanti, Jurgen Schulze, Bob Kooima, Calit2/EVL

it²

3D Videophones Are Here!
The Personal Varrier Autostereo Display

- **Varrier is a Head-Tracked Autostereo Virtual Reality Display**
  - **30” LCD Widescreen Display with 2560x1600 Native Resolution**
  - **A Photographic Film Barrier Screen Affixed to a Glass Panel**
- **Cameras Track Face with Head Tracker to Locate Eyes**
- **The Display Eliminates the Need to Wear Special Glasses**





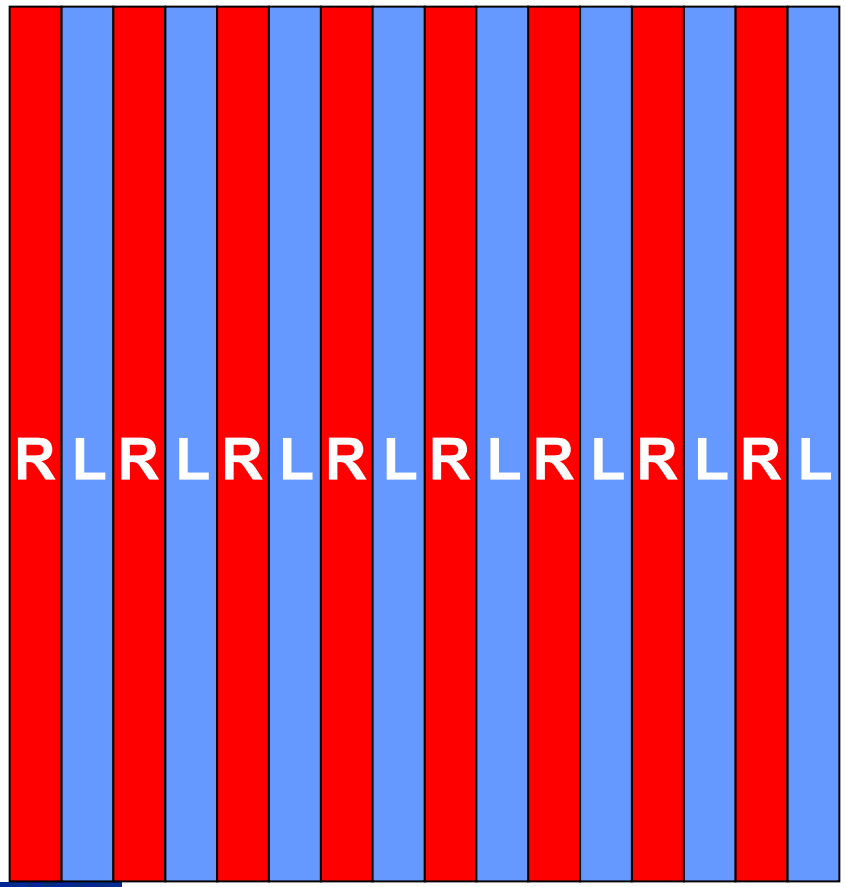
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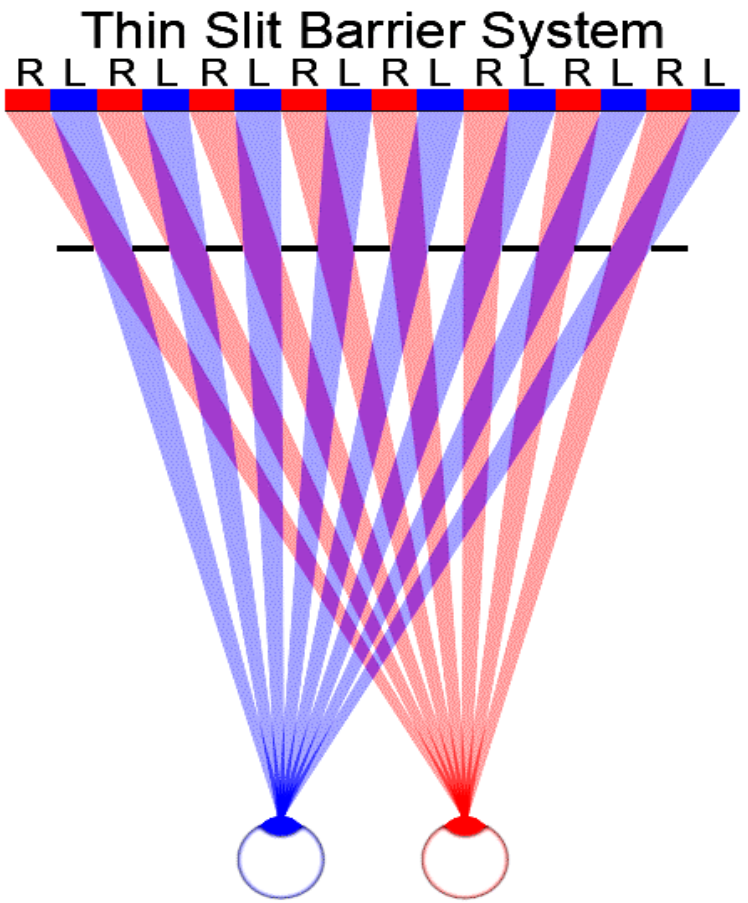
Source: Daniel Sandin, Thomas DeFanti, Jinghua Ge, Javier Girado, Robert Kooima, Tom Peterka—EVL, UIC

it²

Varrier Barrier Strip Auto-Stereo Quick Review

- Columns of right and left eye images viewed through slits

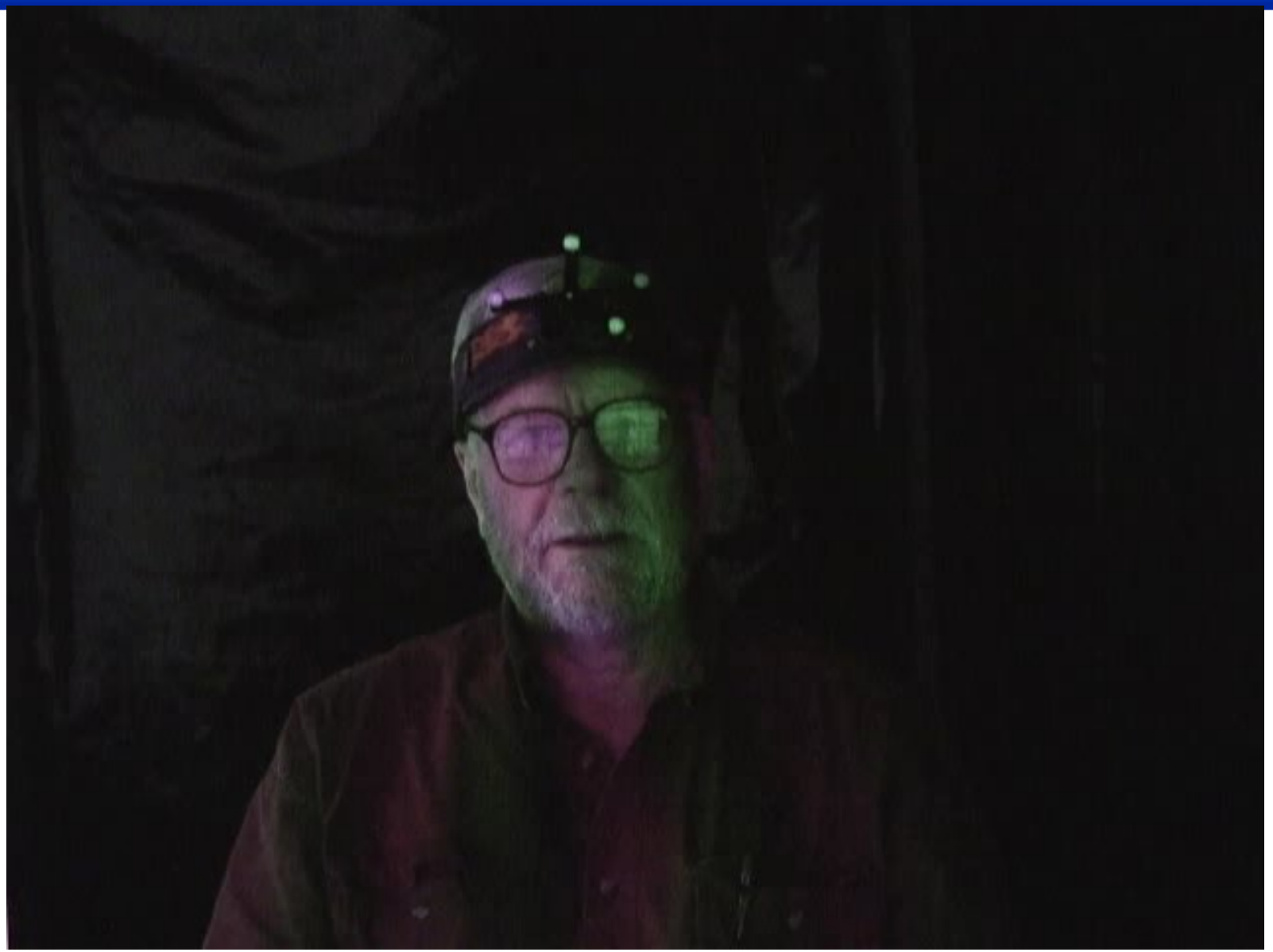




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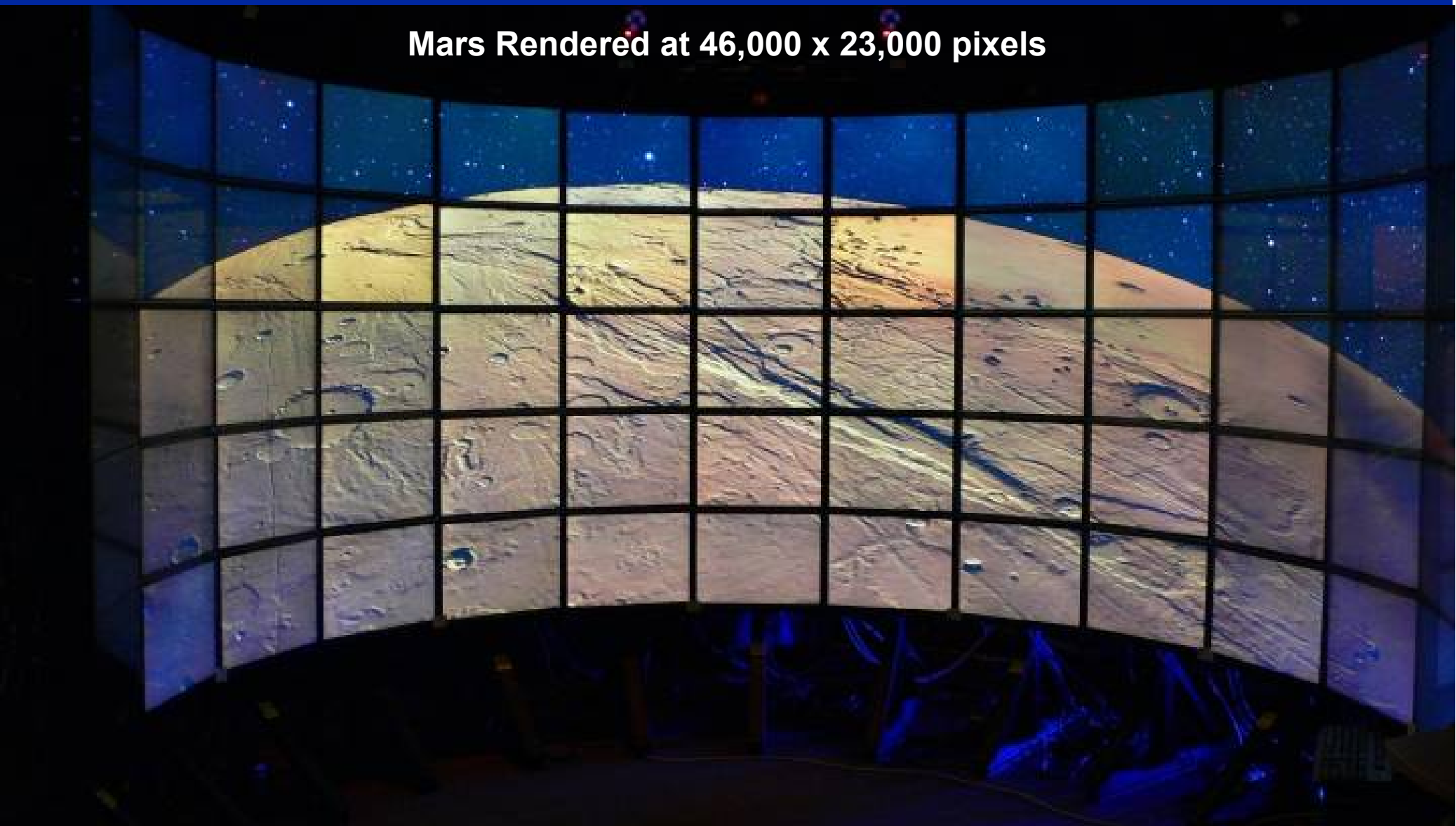
Source: Dan Sandin, EVL/ Calit2

EVL/Calit2's Varrier Developer Dan Sandin Explains How it Works



Source: Dan Sandin, EVL/ Calit2

Calit2/EVL Varrier -- 60 Screen Stereo OptIPortal, no Glasses Needed



evl electronic visualization laboratory
UCIrvine

Dan Sandin, Greg Dawe, Tom Peterka, Tom DeFanti, Jason Leigh, Jinghua Ge, Javier Girado, Bob Kooima, Todd Margolis, Lance Long, Alan Verlo, Maxine Brown, Jurgen Schulze, Qian Liu, Ian Kaufman, Bryan Glogowski

it2

Exploring Virtual Mars with the Varrier



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Source: Dan Sandin, EVL/ Calit2

it²

The Mars demo integrates data from 3 sources. The primary data set is a topographical map collected by Mars Global Surveyor (MGS), a sun-synchronous polar orbiting Mars probe launched by NASA/JPL in 1996. The data was collected between 1996 and 2001, though the probe remains functional as a communications relay in Mars orbit to this day. Topographic measurement was performed by the Mars Orbiter Laser Altimeter (MOLA), giving planetary radius with 1 meter precision at a resolution of 128 pixels per degree, or approximately half a kilometer at the equator.

Topographical data is textured using color imagery composited and color-matched from NASA's Viking Orbiter data collected during the late 70s. The color data has a resolution of approximately 64 pixels per degree. The background starfield is the Hipparcos catalog, a database of 120,000 nearby stars collected by the ESA's HIPPARCOS satellite between 1989 and 1993, rendered as correctly scaled and colored points.

The total size of the topographical data set is 46080 by 22528 pixels. At 16-bit precision it consumes 2GB of storage. When rendered using OpenGL, a position, normal, and texture coordinate must be computed per pixel. This expands the data set out to over 30GB, much too large to be rendered efficiently.

A topo data caching mechanism was designed to enable real-time display on the Varrier. To begin, the raw topo data set is mipmapped using a linear filter, giving a pyramid of data sets of decreasing resolutions. For each rendered frame, a level-of-detail algorithm recursively subdivides the surface of Mars into square areas, determines which of these areas are visible, and computes the minimum resolution for the optimal display of each. For each visible area, a 45-by-45 vertex geometry page is generated from the raw mipmap level that most-closely matches the optimal resolution of that area. These 45-by-45 vertex pages are streamed directly to the video RAM of the graphics board, and stored there under a least-recently-used caching policy. The smooth motion of the viewpoint provides a locality of reference that ensures efficient use of this VRAM geometry cache. This mechanism cycles approximately 40 times per second, with each of the 33 nodes of the 65-panel Varrier maintaining a separate parallel cache representing its own subset of the total view.