“Shrinking the Planet: A New Global Research Platform – Dedicated 10Gbps Lightpaths”

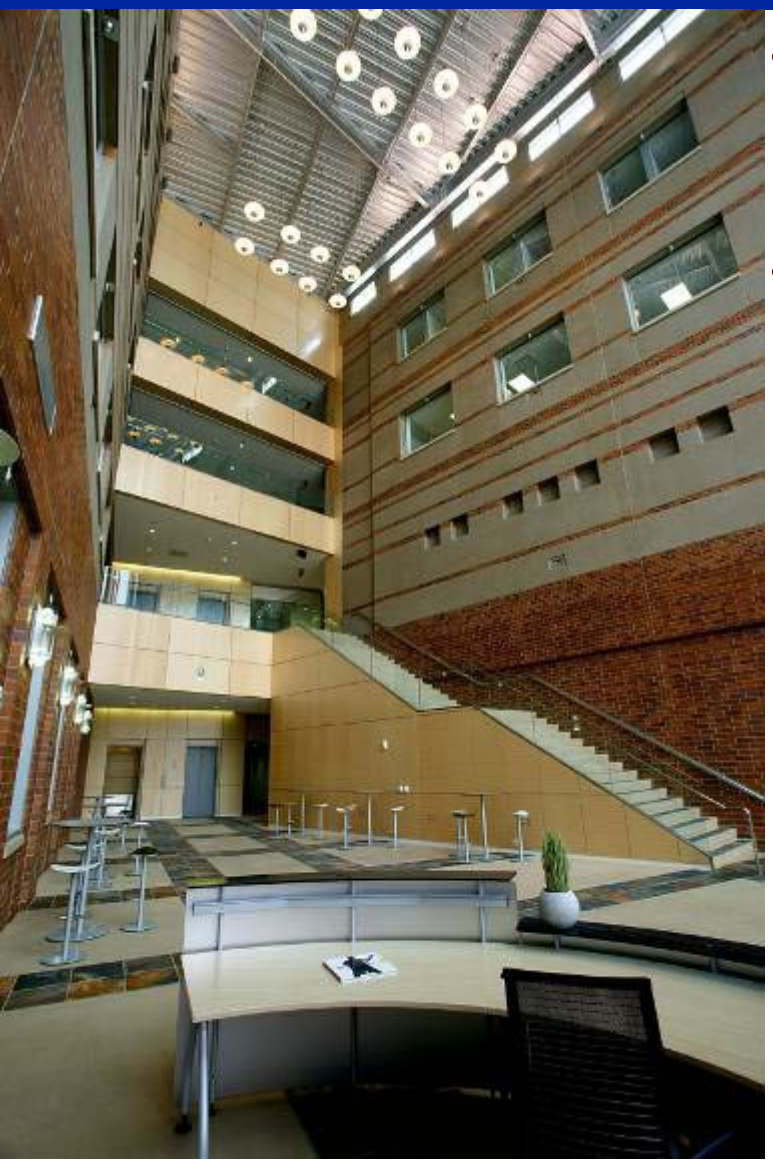
Presentation at the
TTI/Vanguard "NextGens Technologies" Conference
Phoenix, AZ
December 9, 2008

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

OptIPuter

it²

Two New Calit2 Buildings Provide 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



TTI Vanguard Tour Feb. 19, 2009

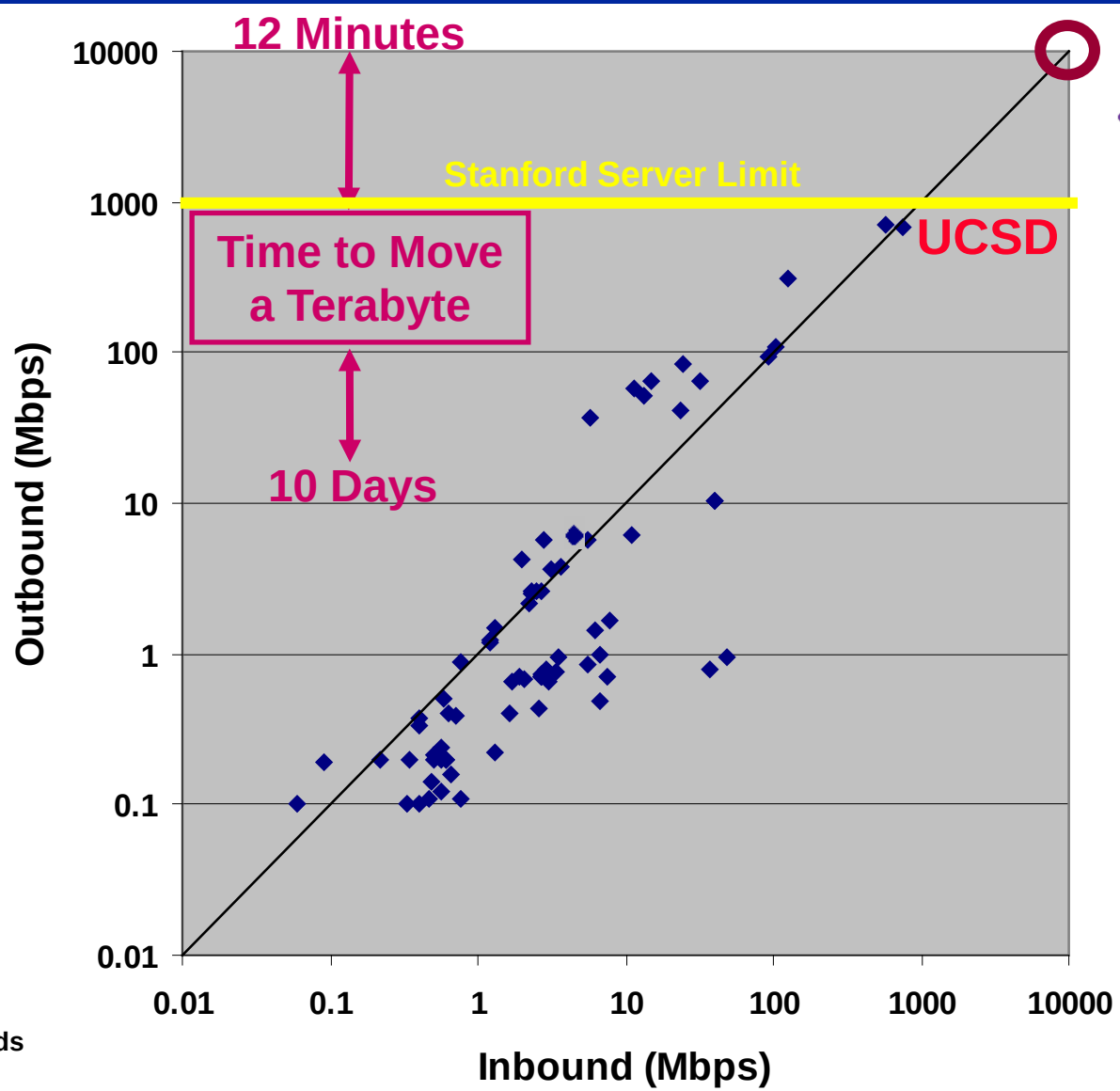
www.calit2.net

Preparing for a World in Which Distance is Eliminated…

Shared Internet Bandwidth: Unpredictable, Widely Varying, Jitter, Asymmetric

Computers In:

Australia
Canada
Czech Rep.
India
Japan
Korea
Mexico
Moorea
Netherlands
Poland
Taiwan
United States



OptIPuter

100-1000x Normal Internet!

Data Intensive Sciences Require Fast Predictable Bandwidth

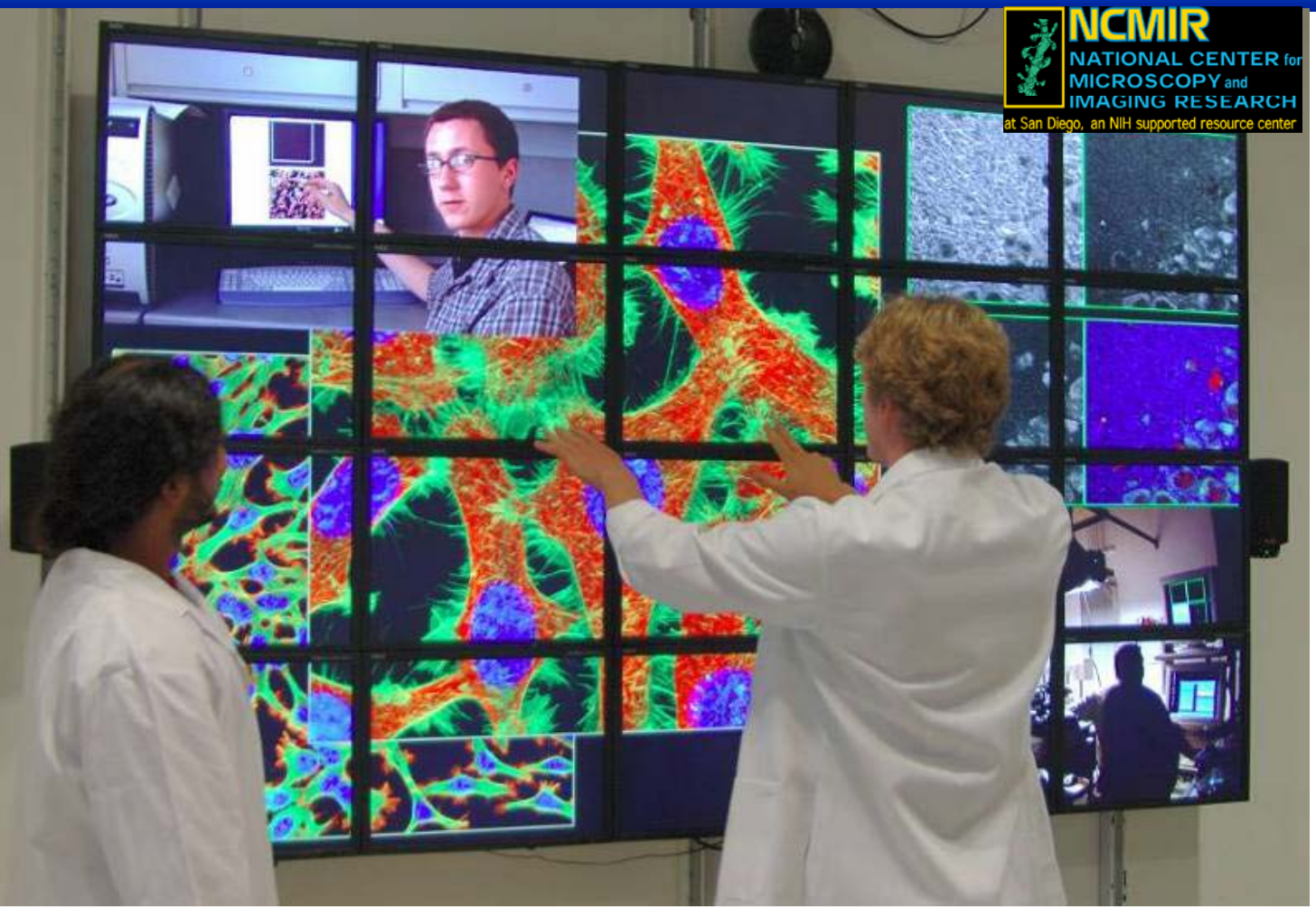
Source: Larry Smarr and Friends

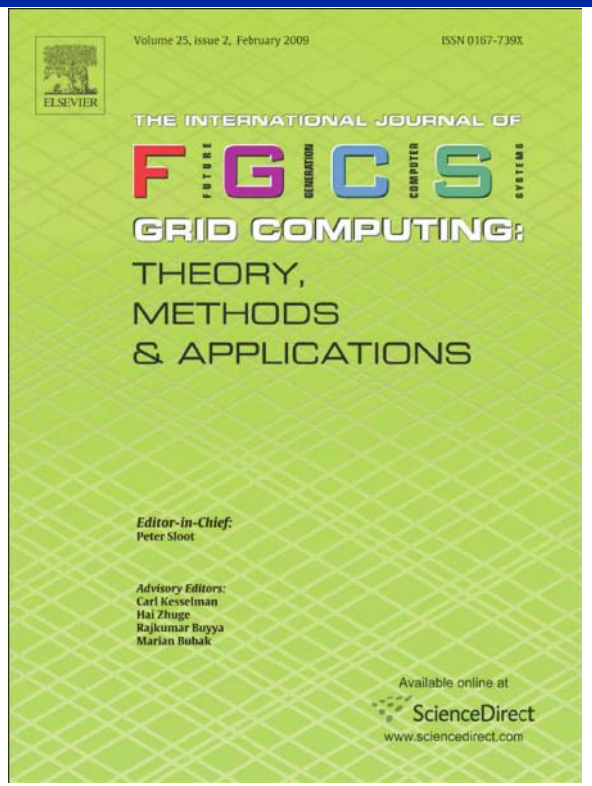
Measured Bandwidth from User Computer to Stanford Gigabit Server in Megabits/sec
http://netspeed.stanford.edu/

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





"OptIPlanet: The OptIPuter Global Collaboratory" –
Special Section of Future Generations Computer Systems, Volume 25, Issue 2, February 2009

Picture Source: Mark Ellisman, David Lee, Jason Leigh

ROCKS
www.rocksclusters.org

evl electronic visualization laboratory

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

OptIPuter

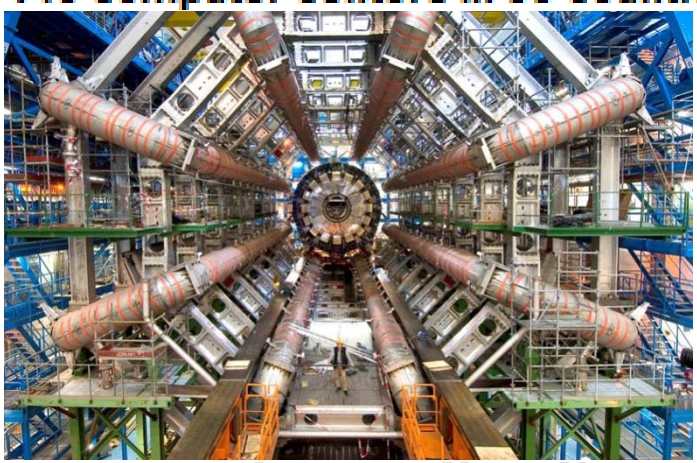
it²

The Large Hadron Collider Uses a Global Fiber Infrastructure To Connect Its Users

CERN Unveils Global Grid For Particle Physics Research

The network can pull in the IT power of more than 140 computer centers in 33 countries to crunch an expected 15 million GB of data every year.

By Antone Gonsalves
InformationWeek
October 3, 2008 04:57 PM



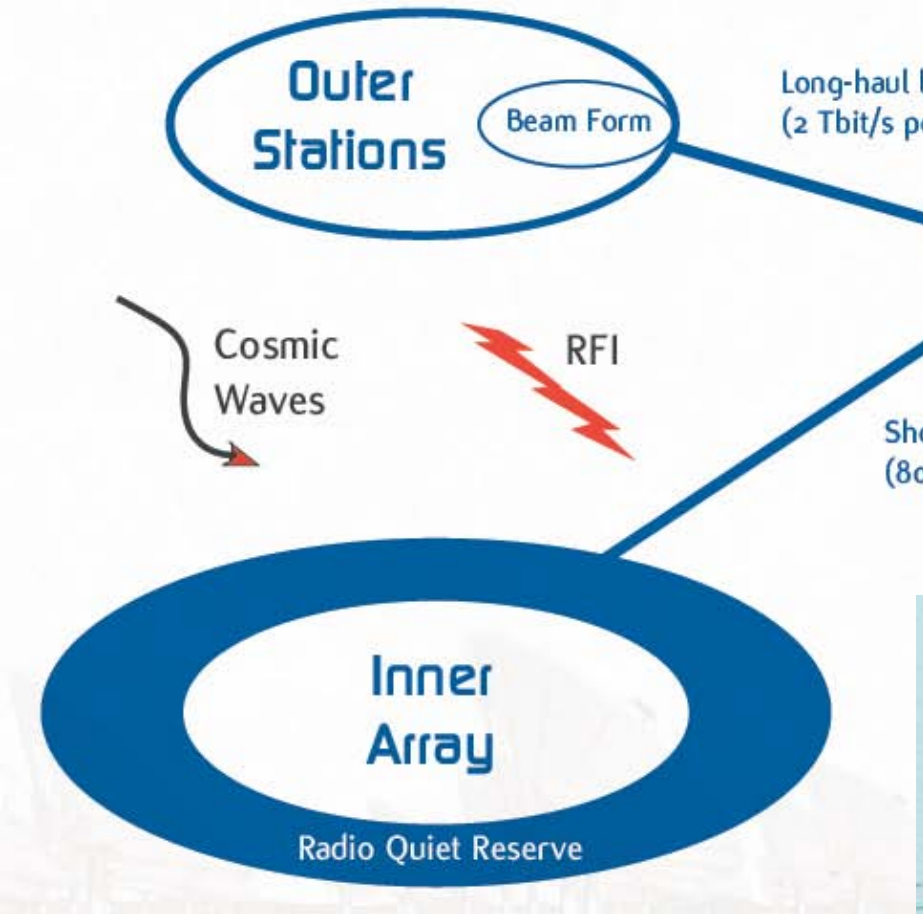
- The grid relies on optical fiber networks to distribute data from CERN to 11 major computer centers in Europe, North America, and Asia
- The grid is capable of routinely processing 250,000 jobs a day
- The data flow will be ~6 Gigabits/sec or 15 million gigabytes a year for 10 to 15 years

OptIPuter

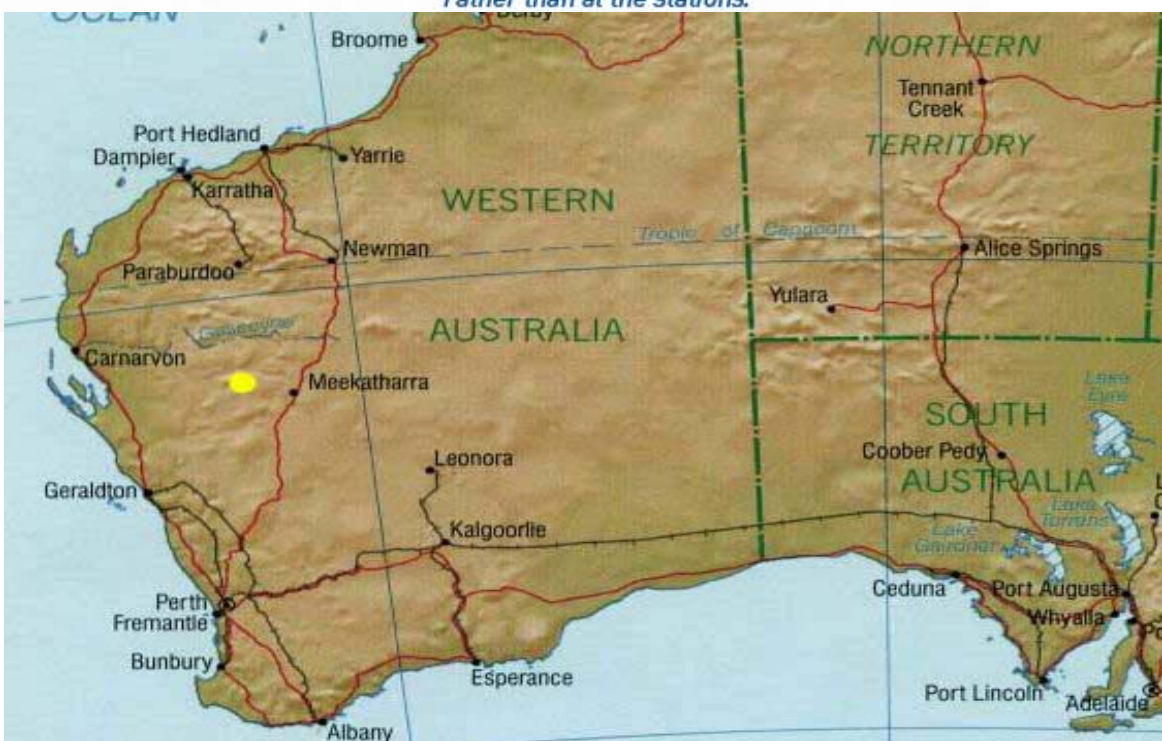
it²

Next Great Planetary Instrument: The Square Kilometer Array Requires Dedicated Fiber

www.skatelescope.org



Schematic of SKA signal flow. Advances in signal transport technology may later allow more signals to be processed at the core, rather than at the stations.



Transfers Of 1 TByte Images World-wide Will Be Needed Every Minute!

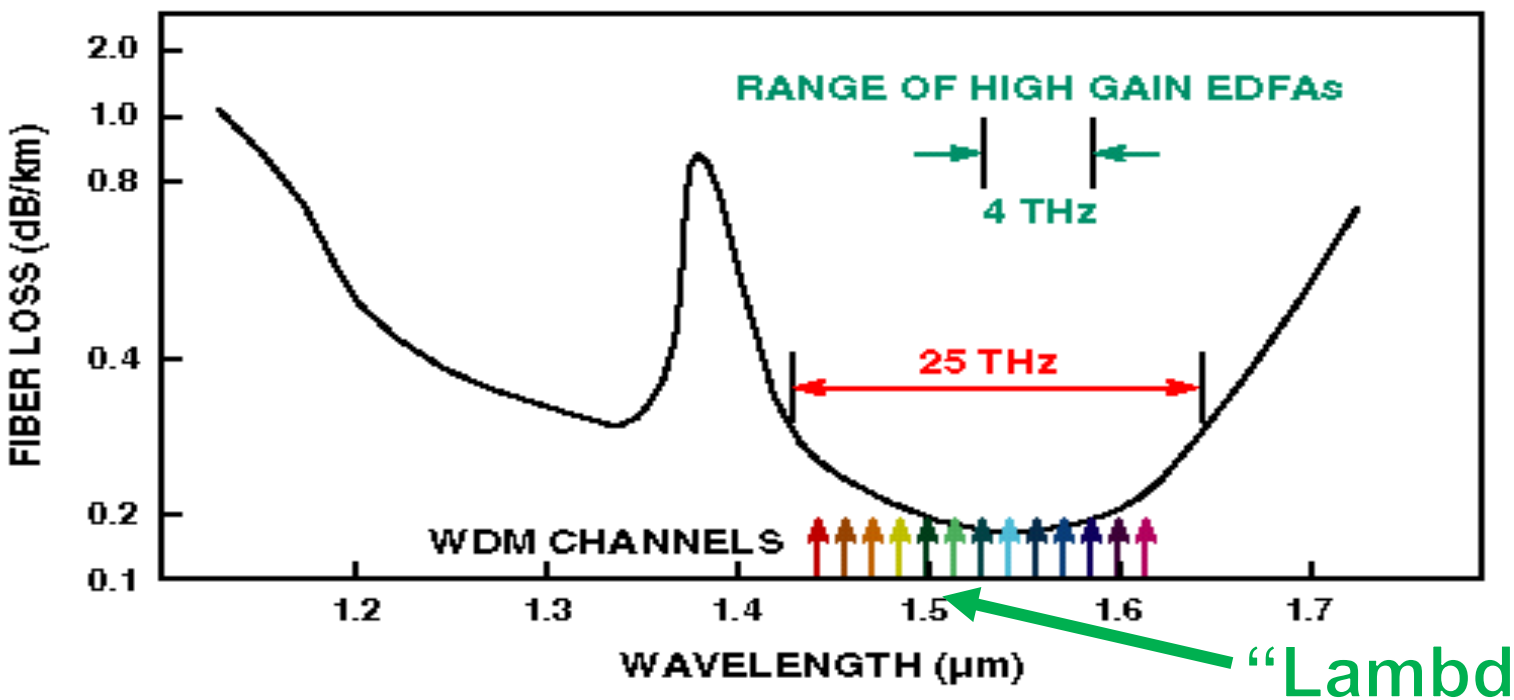
OptIPuter

OptIPuter Step I:
From Shared Internet to Dedicated Lightpaths

Dedicated Optical Fiber Channels Makes High Performance Cyberinfrastructure Possible

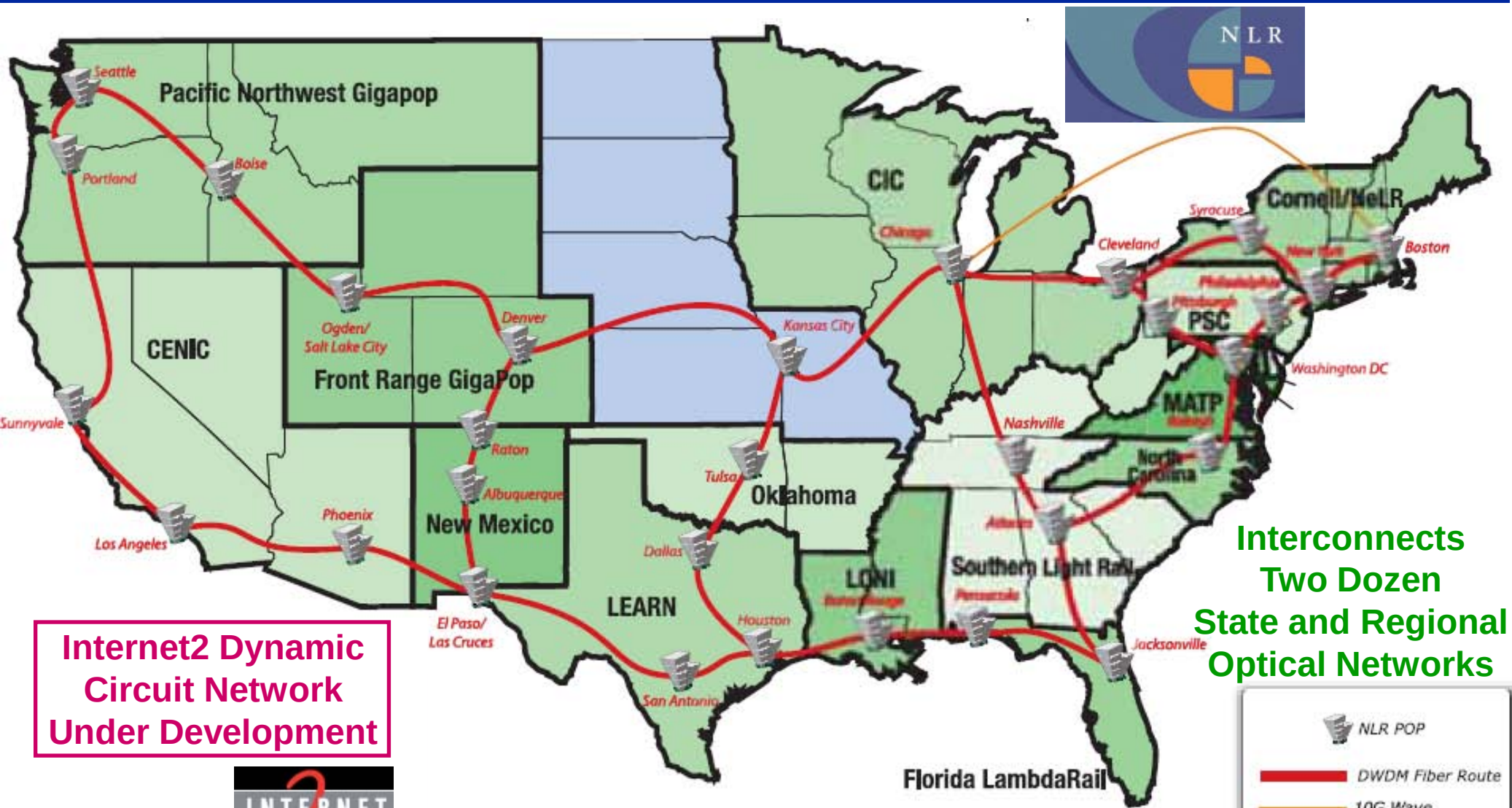
WAVELENGTH DIVISION MULTIPLEXING (WDM)

- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS

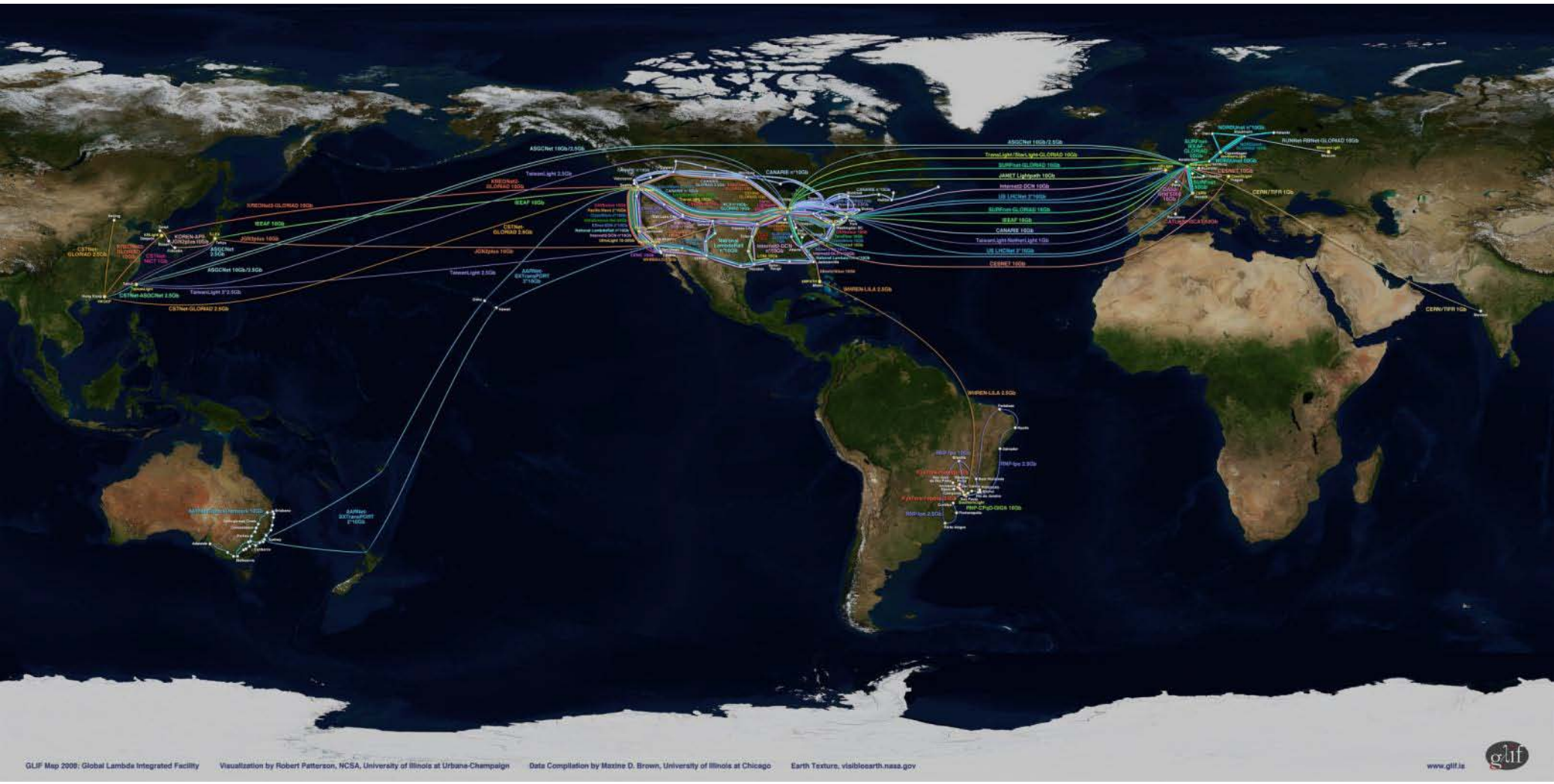


WDM Enables 10Gbps Shared Internet on One Lambda and a Personal 10Gbps Lambda on the Same Fiber!

Dedicated 10Gbps Lightpaths Tie Together State and Regional Fiber Infrastructure



Global Lambda Integrated Facility
1 to 10G Dedicated Lambda Infrastructure



Interconnects Global
Public Research Innovation Centers

Source: Maxine Brown, UIC and Robert Patterson, NCSA

OptIPuter Step II:
From User Analysis on PCs to OptIPortals

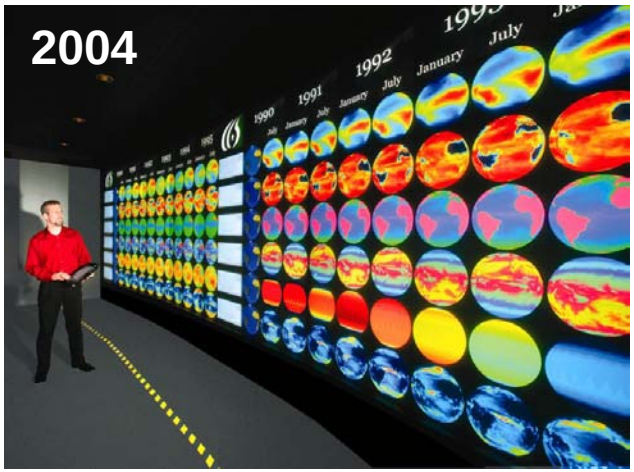
Challenge—How to Bring Scalable Visualization Capability to the Data Intensive End User?



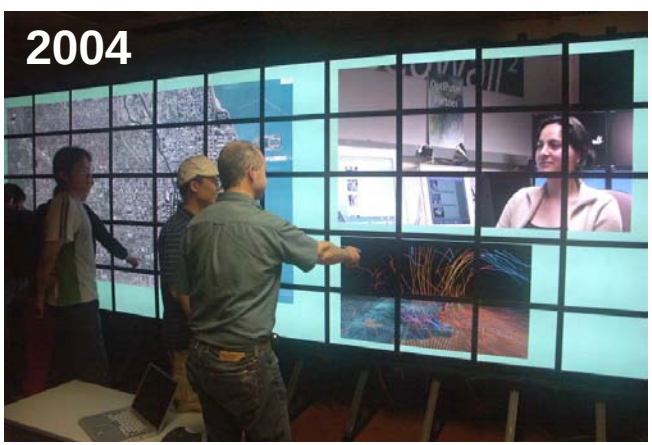
NCSA 4 MPixel
NSF Alliance PowerWall



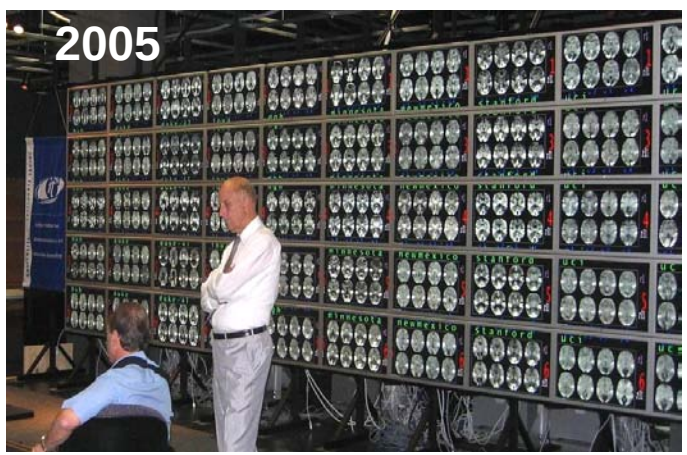
LLNL 20 Mpixel Wall



ORNL 35Mpixel EVEREST



EVL 100 Mpixel LambdaVision
NSF MRI



Calit2@UCI 200 Mpixel HiPerWall
NSF MRI



TACC 307 Mpixel Stallion
NSF TeraGrid

OptIPuter

A Decade of NSF Investment
Two Orders of Magnitude Growth!

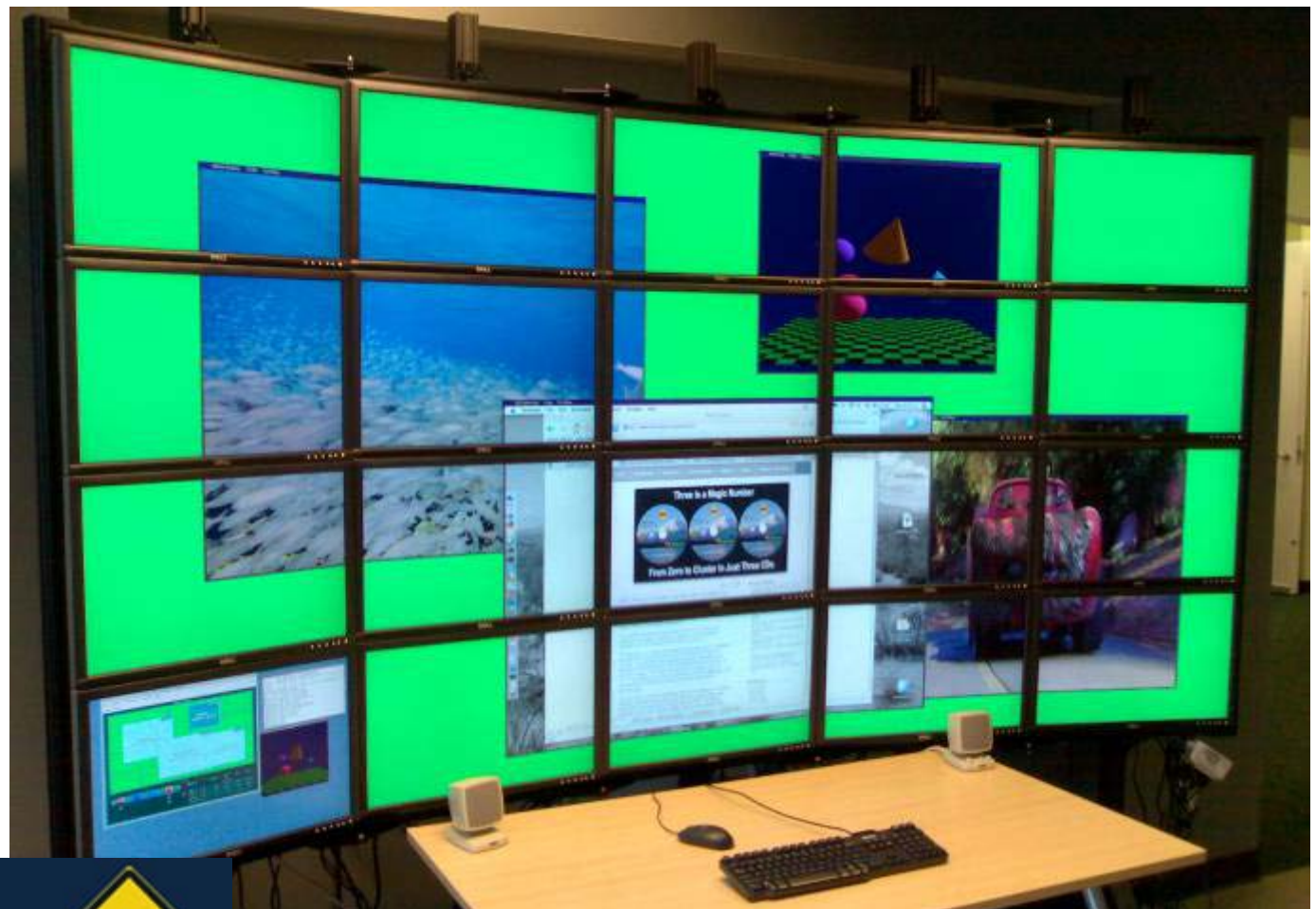
it²

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





OptIPuter

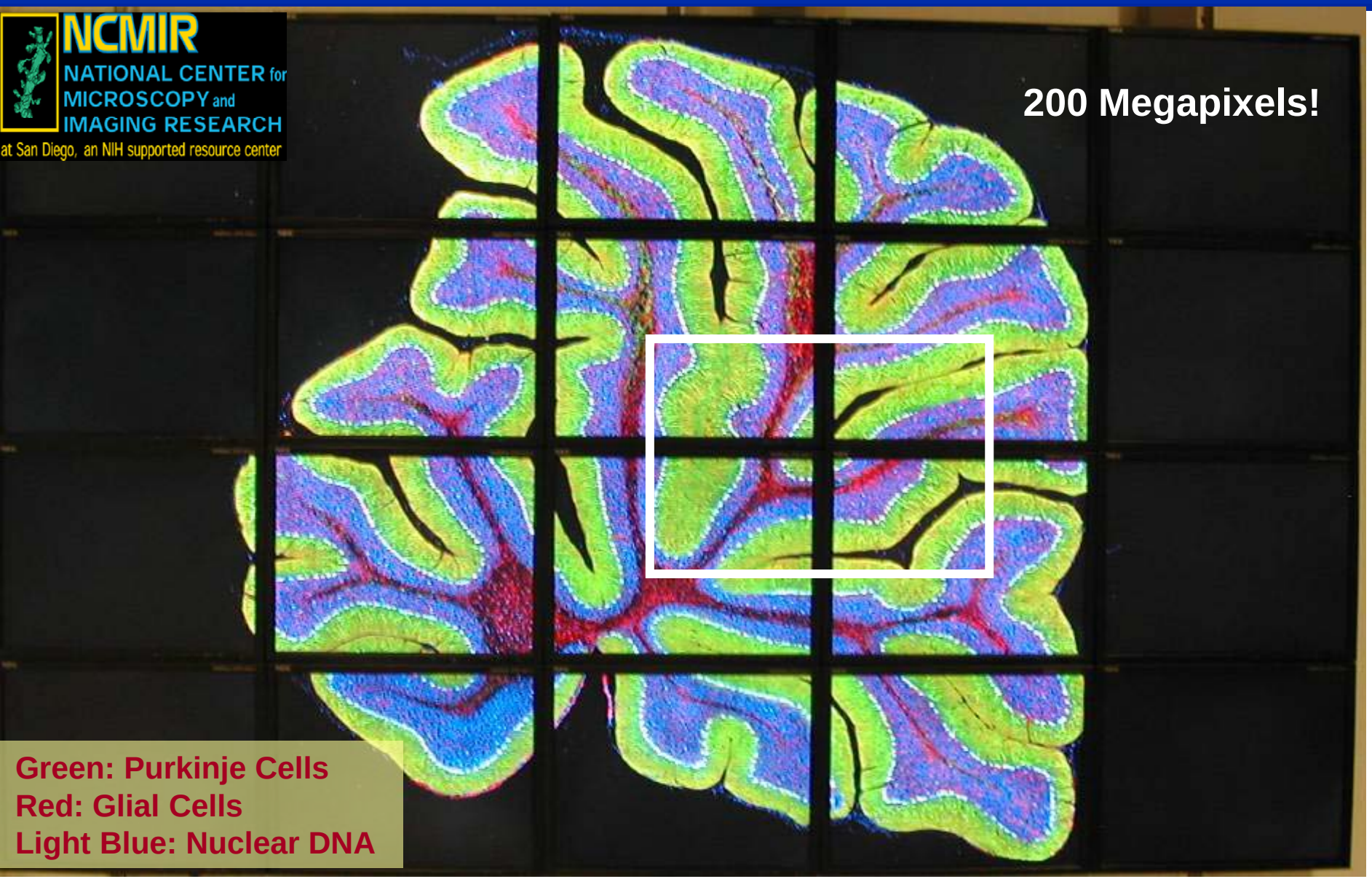
Powered by Rocks ROCKS

Source: Phil Papadopoulos SDSC, Calit2

it²

OptIPuter Scalable Displays Are Used for Multi-Scale Biomedical Imaging

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



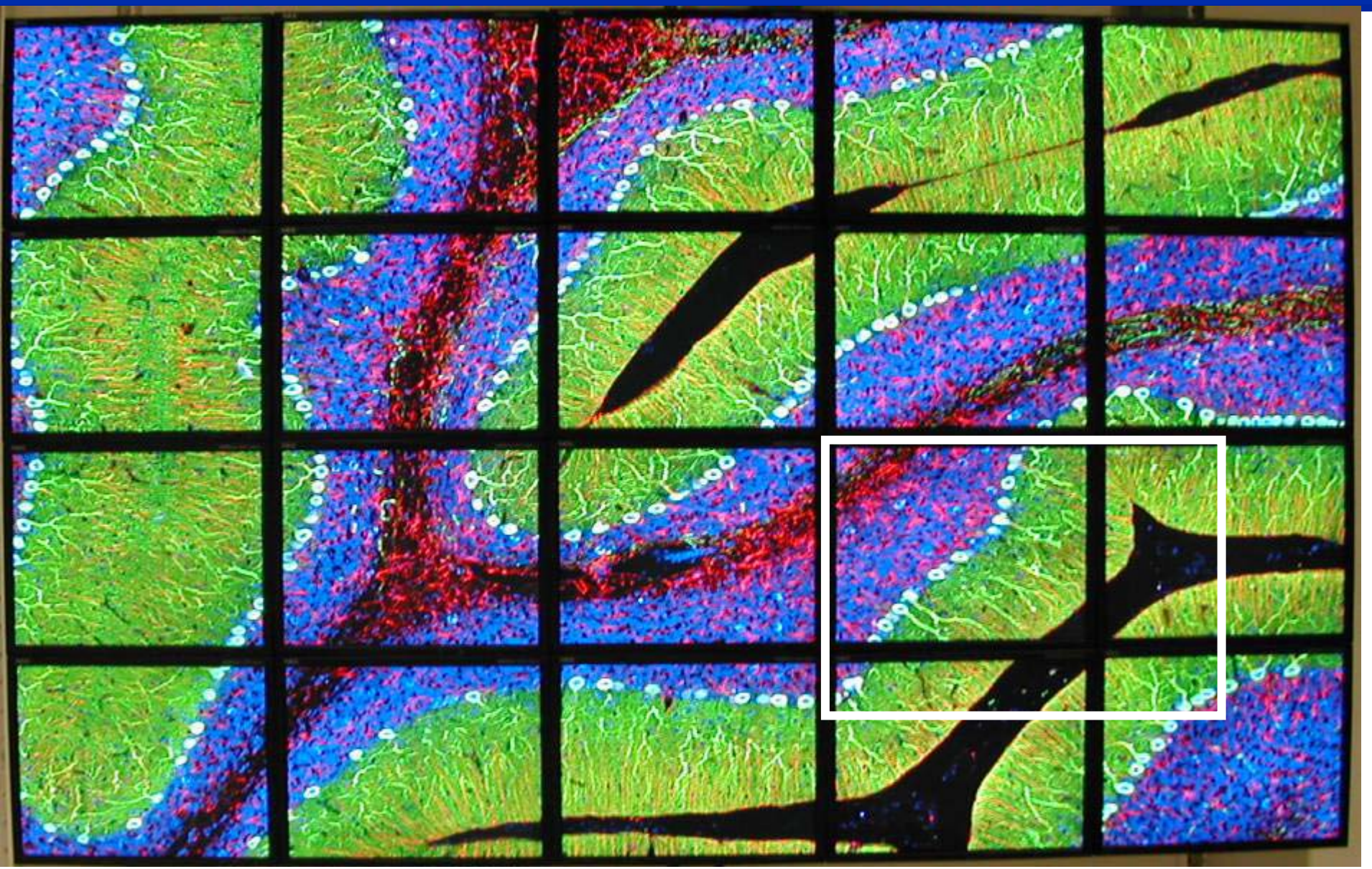
Source: Mark Ellisman, David Lee, Jason Leigh

Two-Photon Laser Confocal Microscope Montage of 40x36=1440 Images in 3 Channels of a Mid-Sagittal Section of Rat Cerebellum Acquired Over an 8-hour Period

OptIPuter

it²

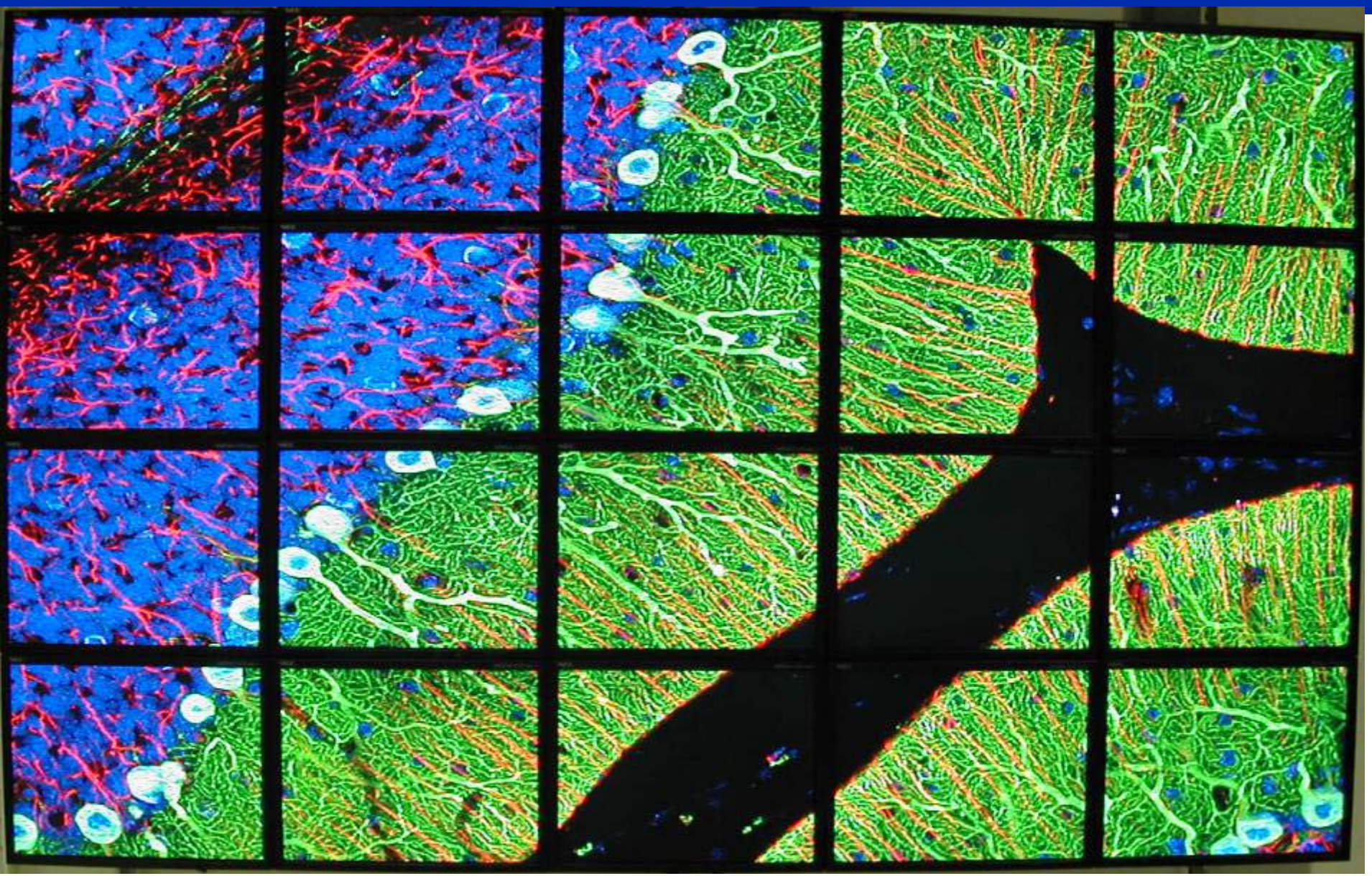
Scalable Displays Allow Both Global Content and Fine Detail



OptIPuter

it²

Allows for Interactive Zooming from Cerebellum to Individual Neurons



OptIPuter

it²

1/3 Billion Pixels Enables Viewing of Very Large Images or Many Simultaneous Images



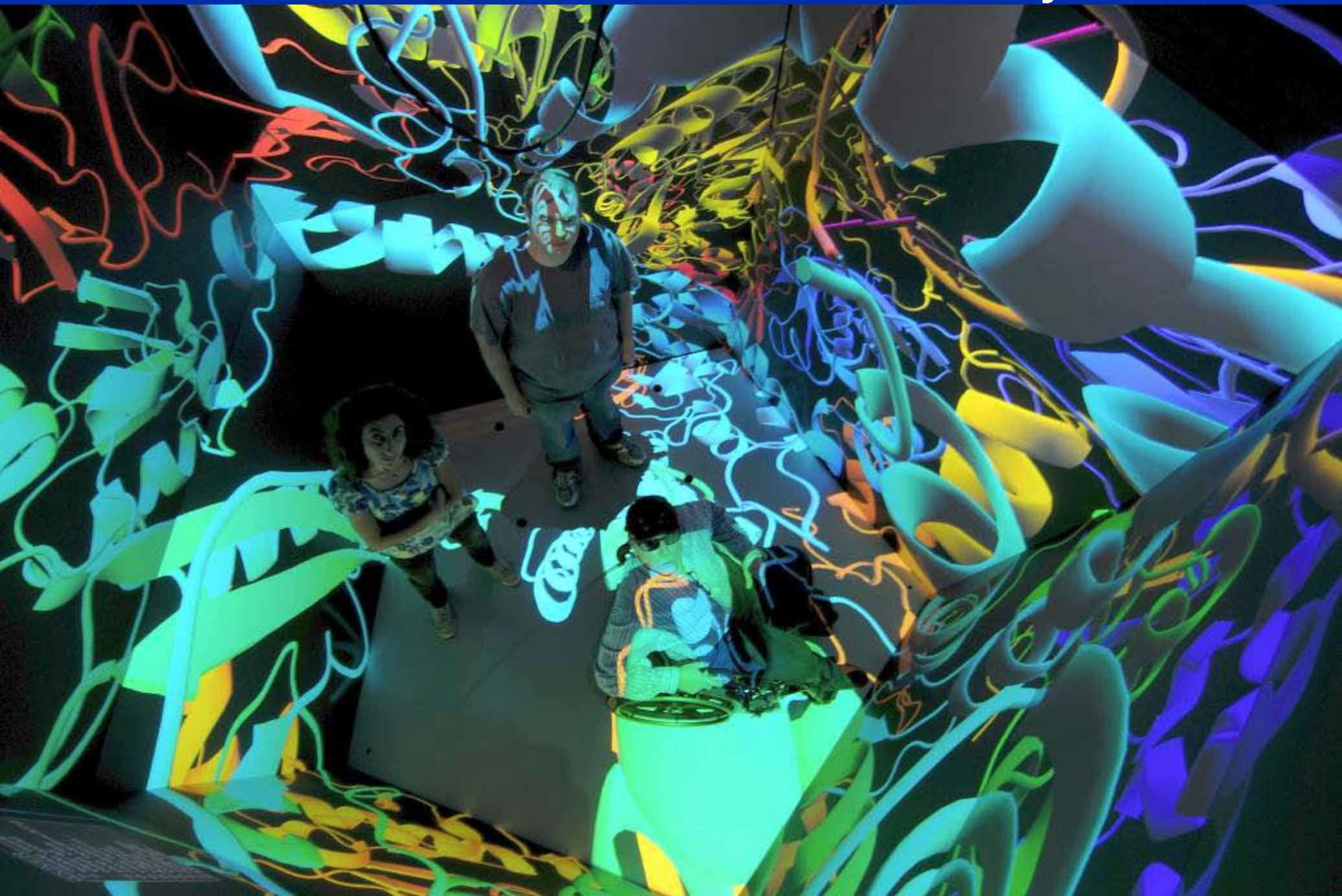
Spitzer Space Telescope (Infrared)



NASA Earth Satellite Images Bushfires October 2007 San Diego

Source: Falko Kuester, Calit2@UCSD

Ultra Resolution Virtual Reality: Toward a 3D Global Collaboratory



OptIPuter Step III:
From YouTube to Digital Cinema Streaming Video

HD Talk to Australia's Monash University from Calit2: Reducing International Travel



Qvidium Compressed HD ~140 mbps

Source: David Abramson, Monash Univ

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

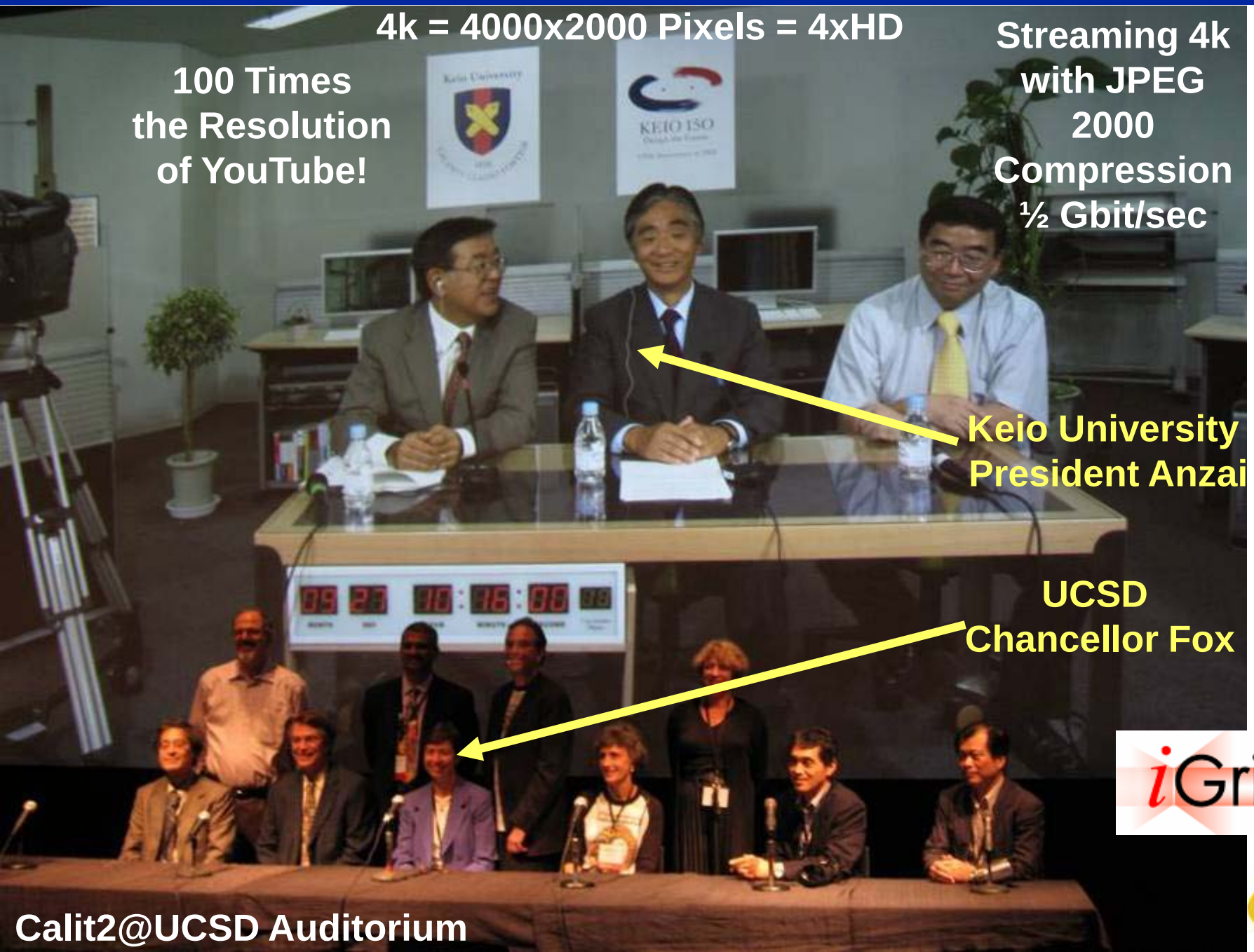
1500 Mbits/sec Calit2 to UW Research Channel Over NLR



John Delaney, PI LOOKING, Neptune

Photo: Harry Ammons, SDSC

Telepresence Meeting
Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

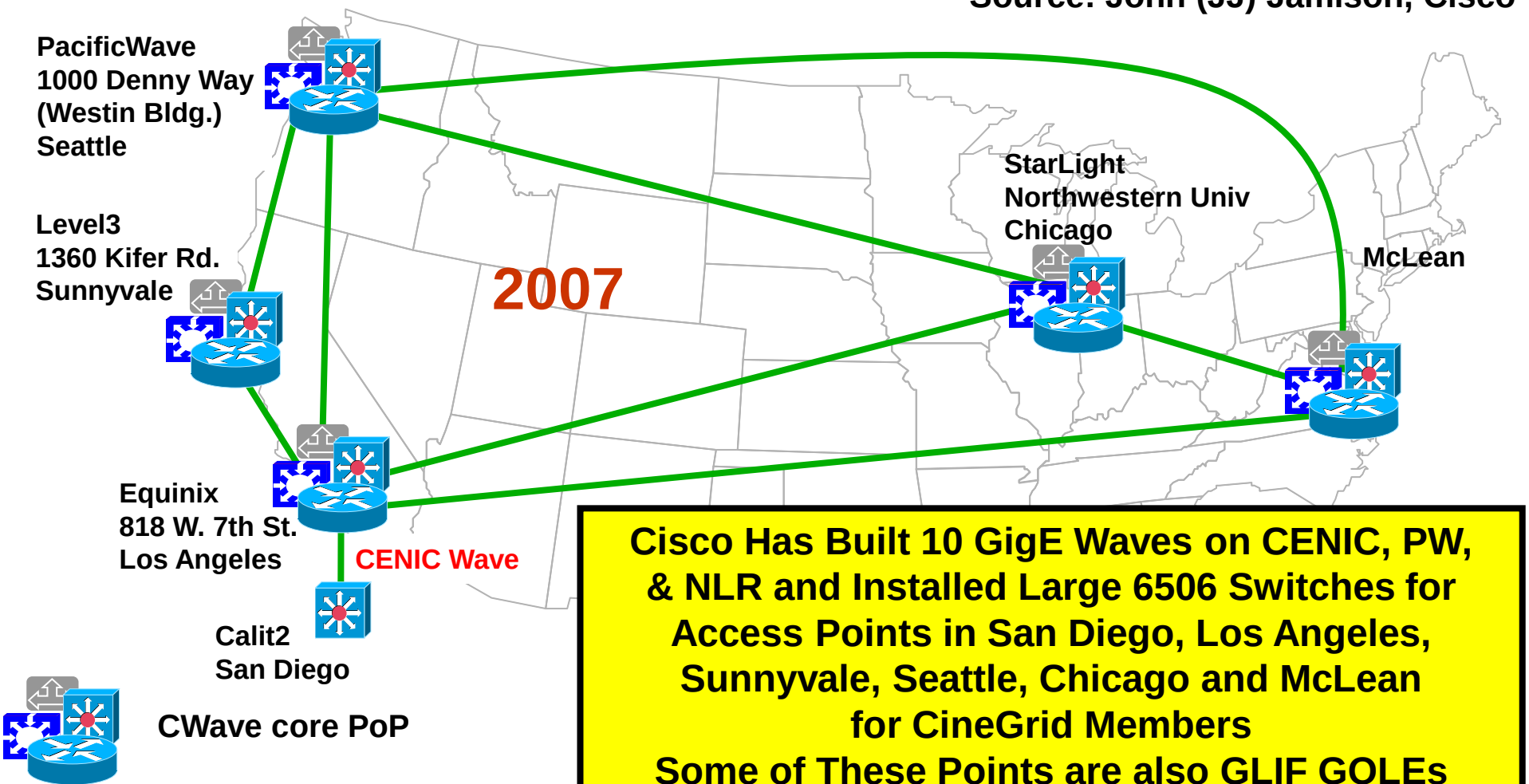
Sony
NTT
SGI

iGrid 2005

it²

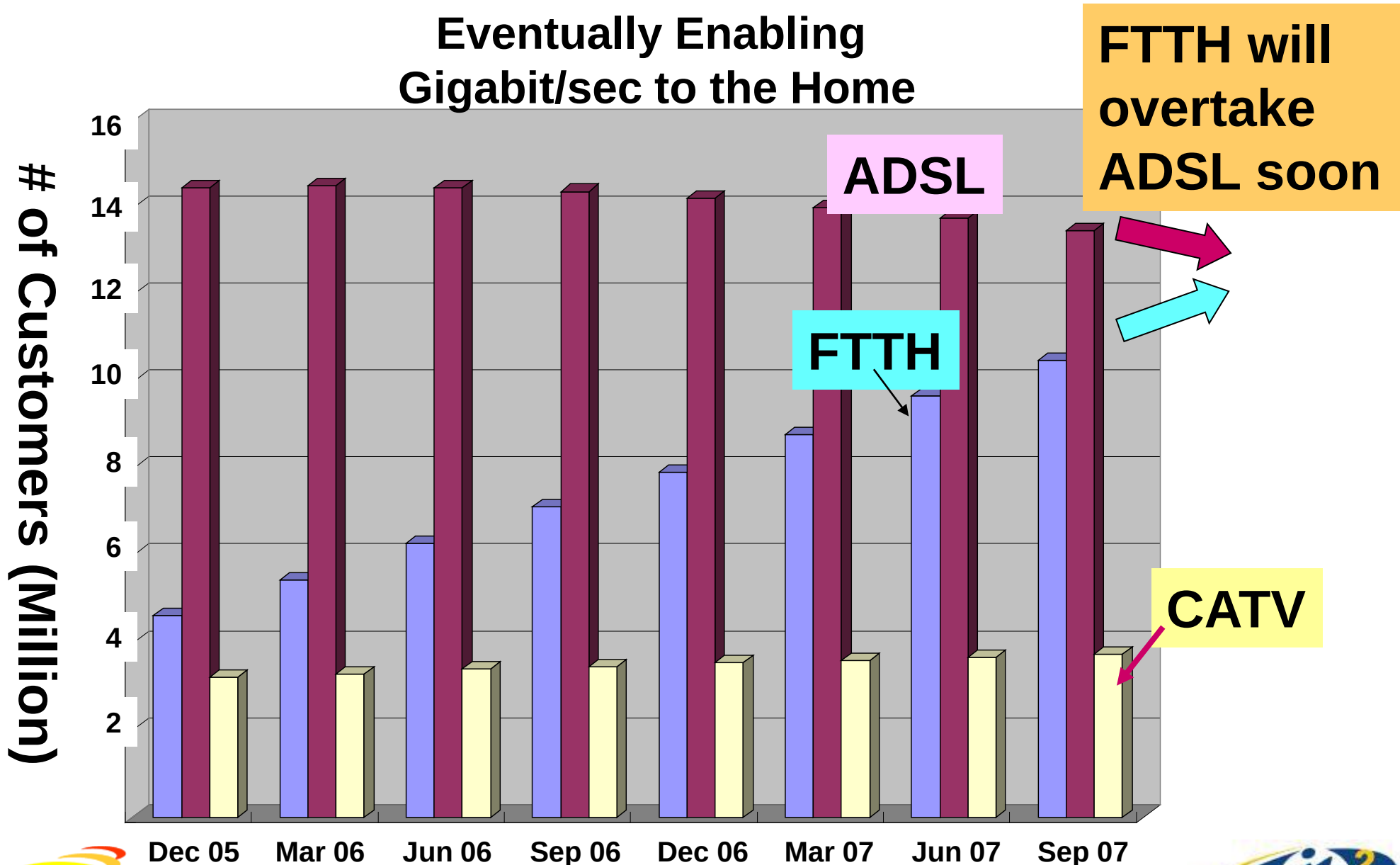
Cisco CWave for CineGrid: A New Cyberinfrastructure for High Resolution Media Streaming*

Source: John (JJ) Jamison, Cisco



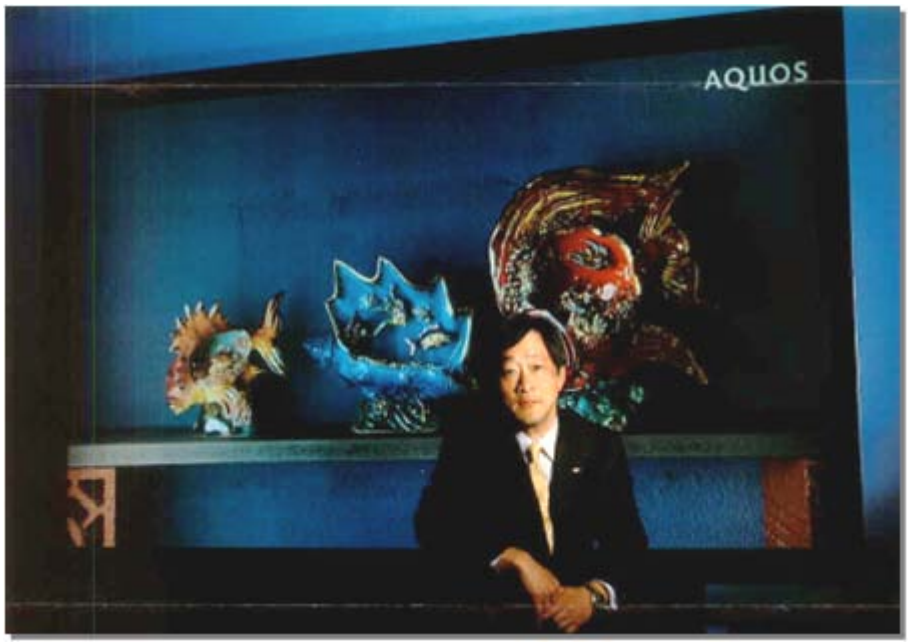
Cisco Has Built 10 GigE Waves on CENIC, PW, & NLR and Installed Large 6506 Switches for Access Points in San Diego, Los Angeles, Sunnyvale, Seattle, Chicago and McLean for CineGrid Members
Some of These Points are also GLIF GOLEs

Broadband Users in Japan: Over 10 Million Homes Have Fiber Connection



Source: Takashi Shimizu, NTT Network Innovation Laboratories

In the Near Future, Walls of Homes and Offices will be Electroactive



Chairman of Sharp

"In Ten Years' Time Entire Walls Could Be Screens"

Forbes, June 4, 2007

Sharp Labs of America / EVL Public-Private Partnership



Studying User-Interaction Issues and Moving Image Synchronization Issues in Future Ultra High Resolution Environments

electronic visualization laboratory, university of illinois at chicago

OptIPuter Step IV:
Integration of Lightpaths, OptIPortals, and Streaming Media

The Calit2 OptIPortals at UCSD and UCI Are Now a Gbit/s HD Collaboratory

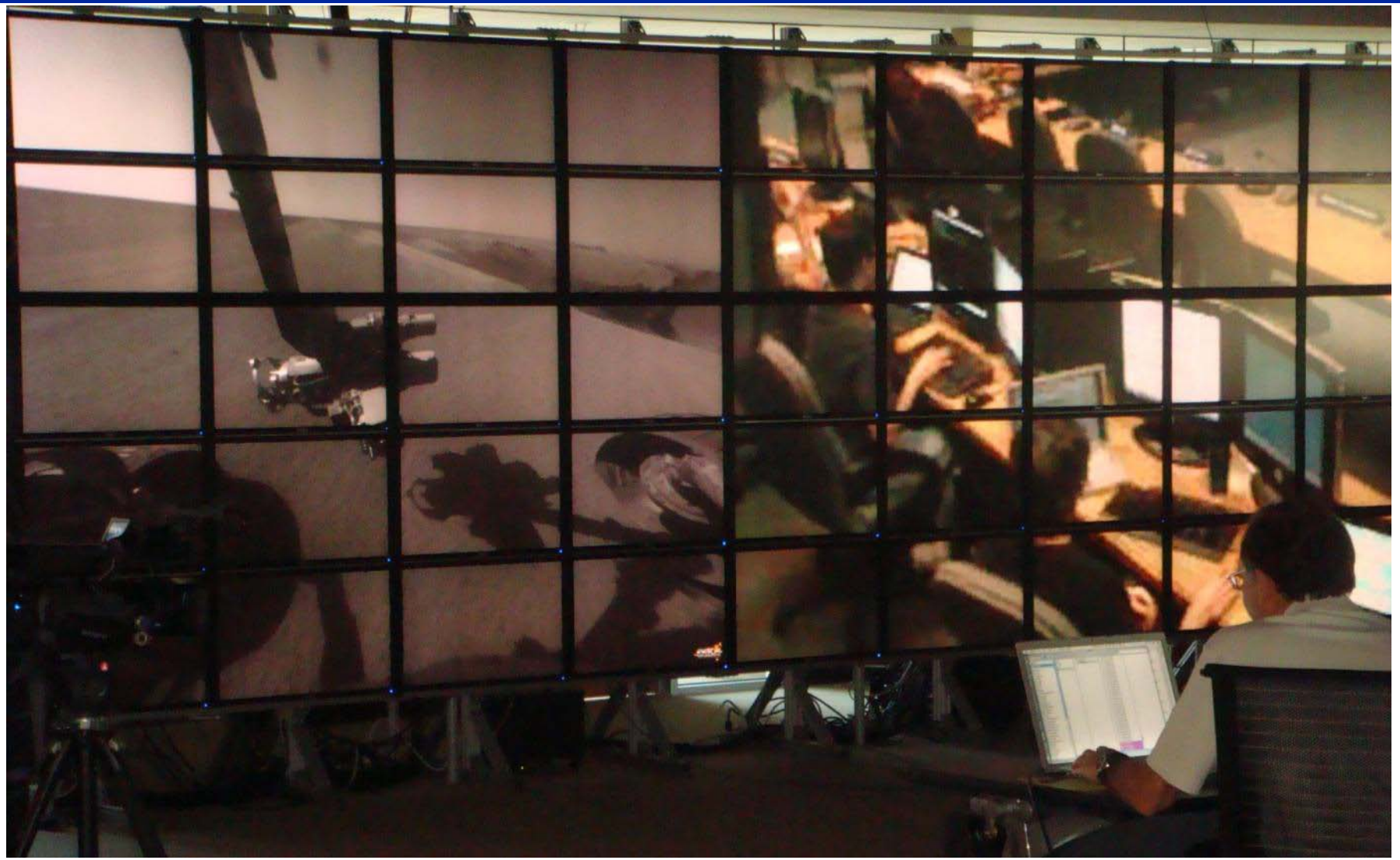


OptIPuter

UCSD cluster: 15 x Quad core Dell XPS with Dual nVIDIA 5600s
UCI cluster: 25 x Dual Core Apple G5

it²

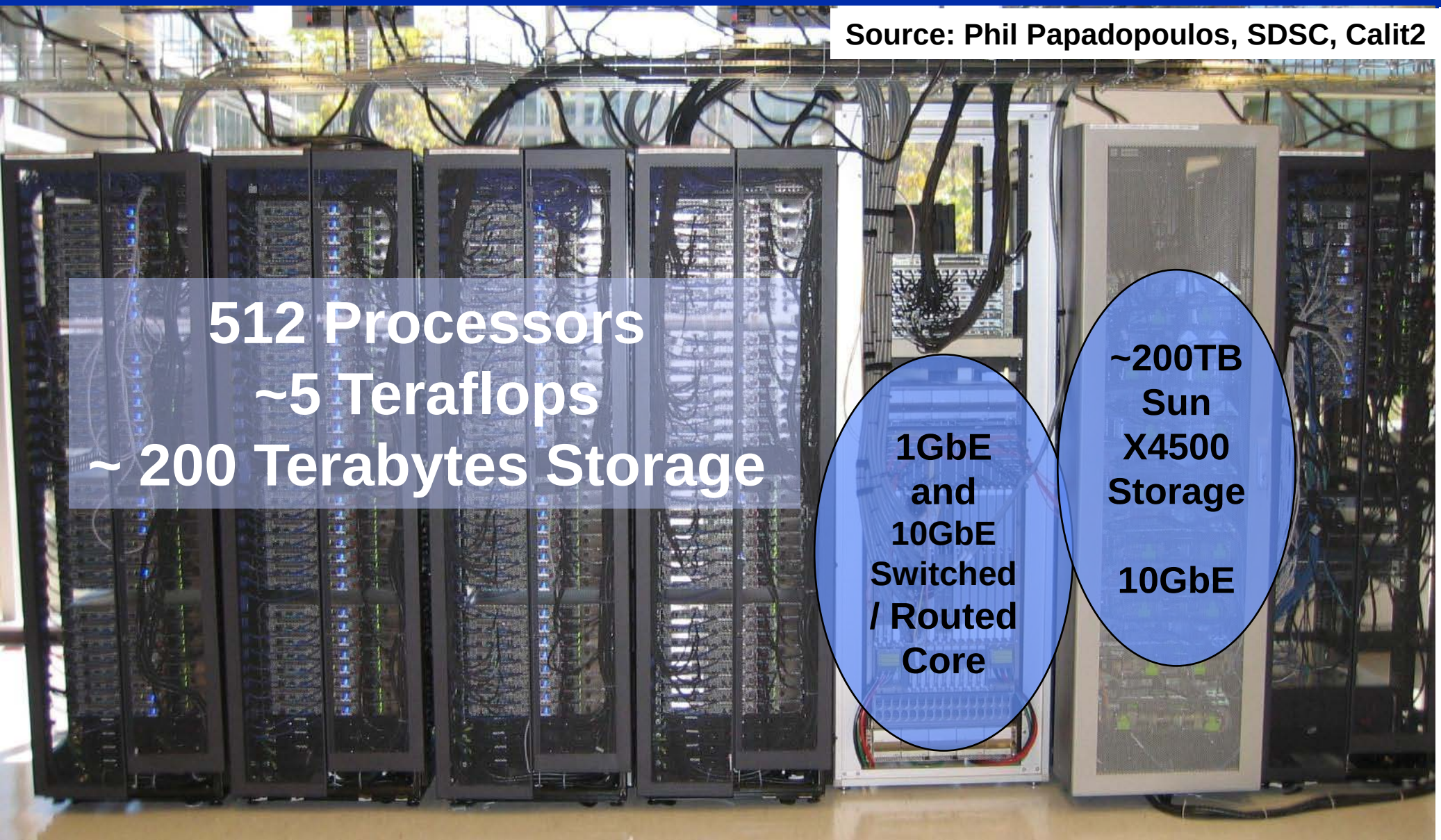
Remote Control of Scientific Instruments: Live Session with JPL and Mars Rover from Calit2



Source: Falko Kuester, Calit2; Michael Sims, NASA

Calit2 Microbial Metagenomics Cluster- Next Generation Optically Linked Science Data Server

Source: Phil Papadopoulos, SDSC, Calit2



OptIPuter SDSC ROCKS camera Marine Microbial Ecology J. Craig Venter INSTITUTE it2

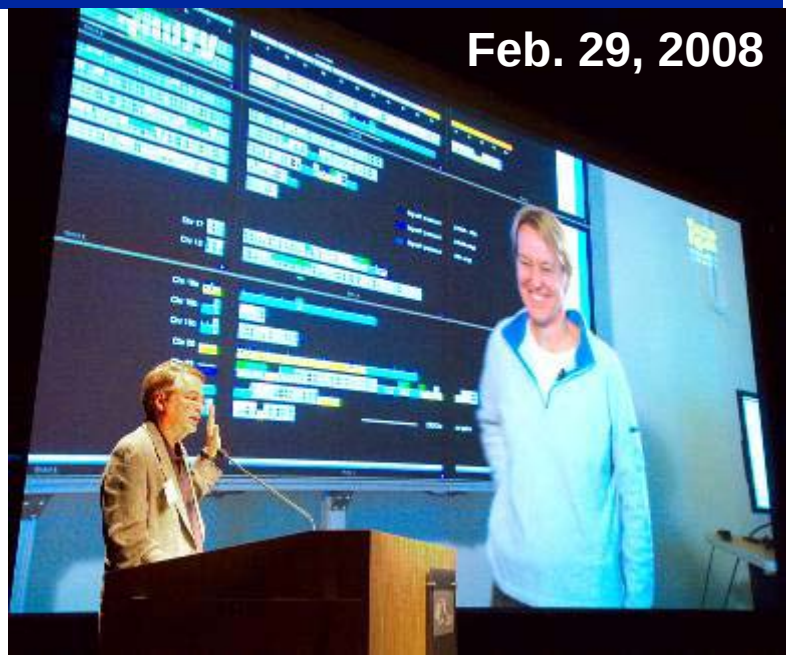
OptIPuter Persistent Infrastructure Enables Calit2 and U Washington Collaboratory



OptIPuter

Ginger Armbrust's Diatoms: Micrographs, Chromosomes, Genetic Assembly

ROCKS





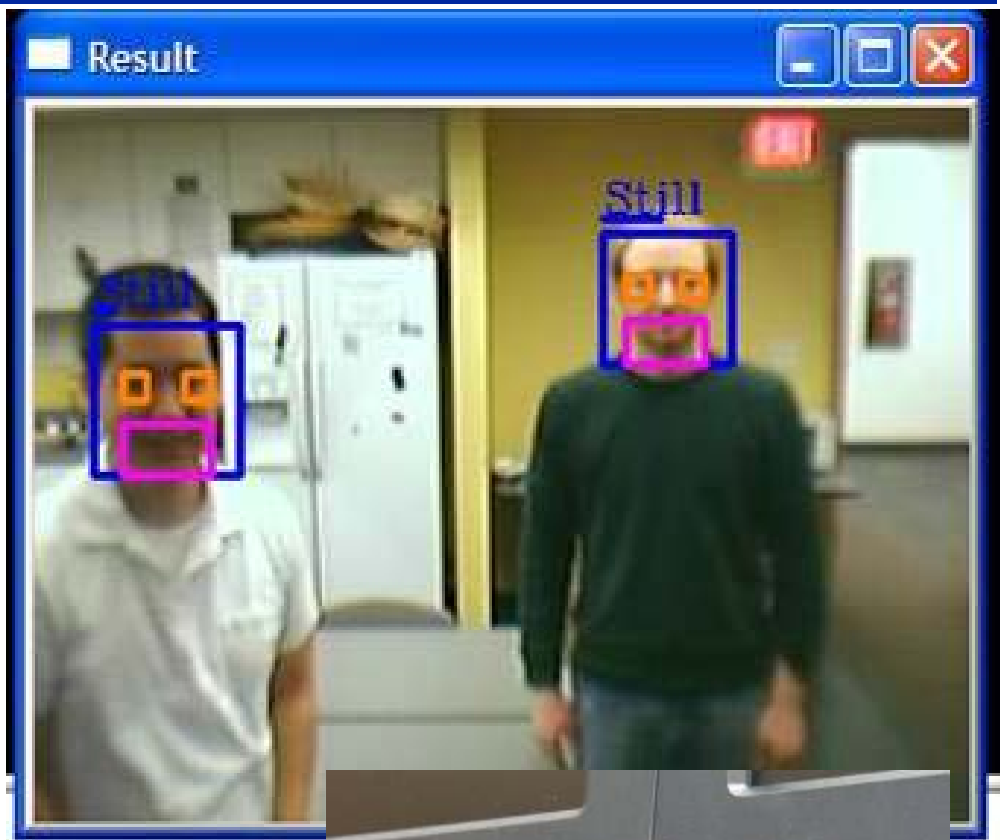


UW's Research Channel
Michael Wellings

it²

U Michigan Virtual Space Interaction Testbed (VISIT) Instrumenting OptIPortals for Social Science Research

- **Using Cameras Embedded in the Seams of Tiled Displays and Computer Vision Techniques, we can Understand how People Interact with OptIPortals**
  - **Classify Attention, Expression, Gaze**
  - **Initial Implementation Based on Attention Interaction Design Toolkit (J. Lee, MIT)**
- **Close to Producing Usable Eye/Nose Tracking Data using OpenCV**





Leading U.S. Researchers on the Social Aspects of Collaboration

OptIPuter

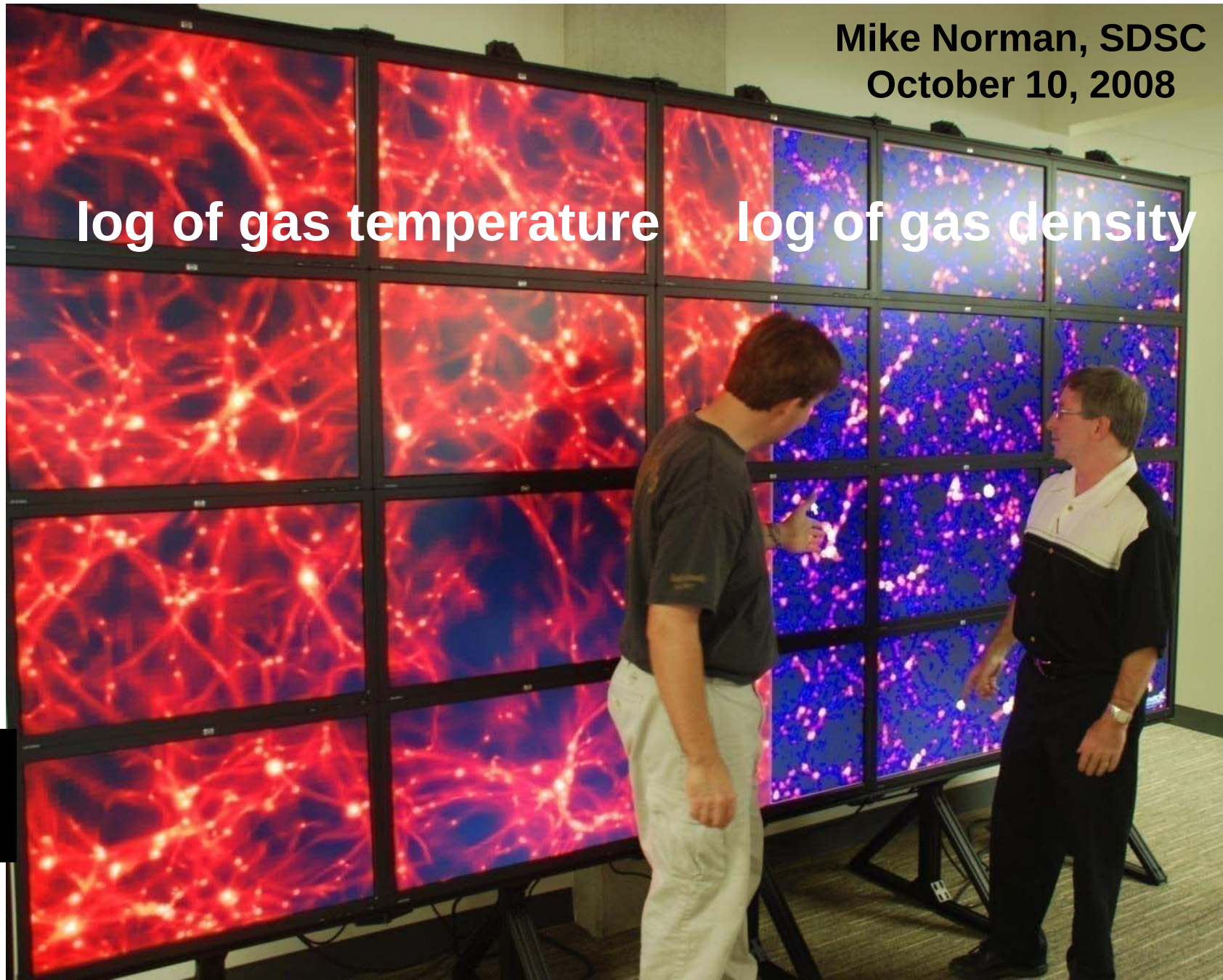
Source: Erik Hofer, UMich, School of Information

it²

Using OptIPortals to Analyze Supercomputer Simulations

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

Two 64K Images From a Cosmological Simulation of Galaxy Cluster Formation



CGLX

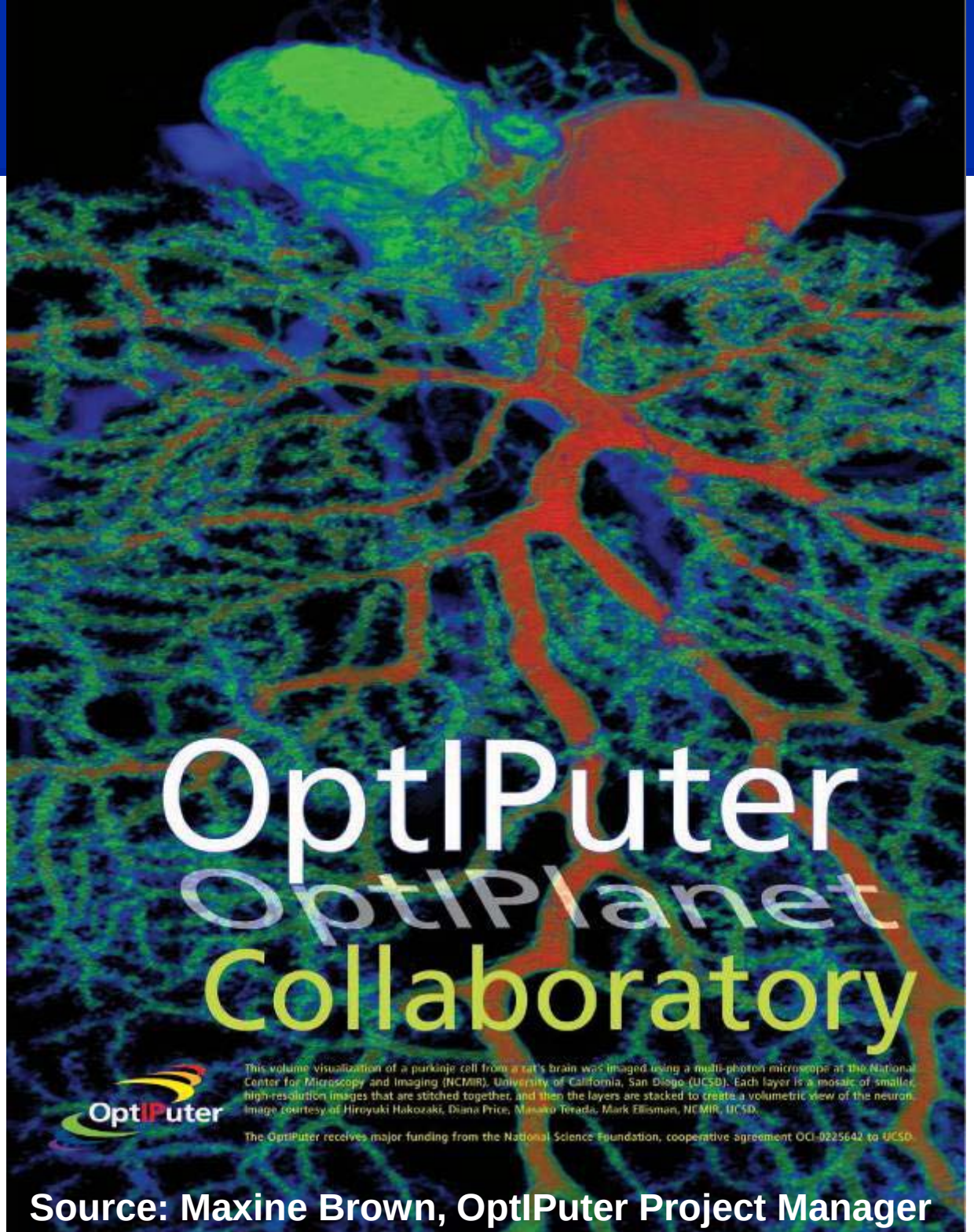
OptIPuter

Streaming Underwater Video From Taiwan's Kenting Reef to Calit2's OptIPortal



Empowering the Scientific Community with Streaming Data Middleware

UCSD: Rajvikram Singh, Sameer Tilak, Jurgen Schulze, Tony Fountain, Peter Arzberger
NCHC : Ebbe Strandell, Sun-In Lin, Yao-Tsung Wang, Fang-Pang Lin

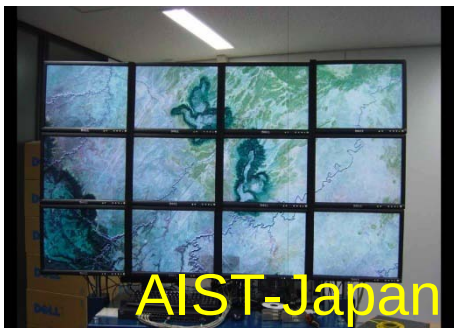


Source: Maxine Brown, OptIPuter Project Manager

Green Initiative:

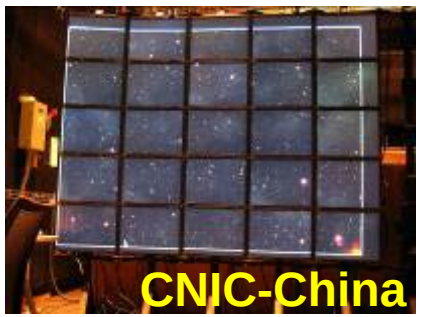
Can Optical Fiber Replace Airline Travel for Continuing Collaborations ?

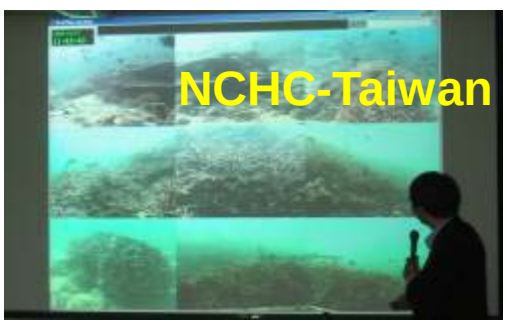
OptIPortals
Are Being Adopted Globally Connected by GLIF

























OptIPuter

Powered by Rocks ROCKS

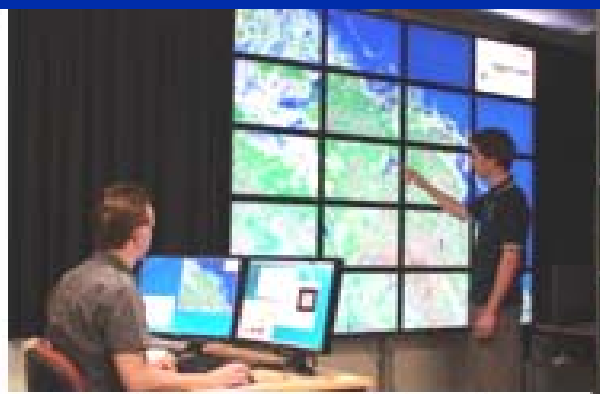
evl electronic visualization laboratory

it2

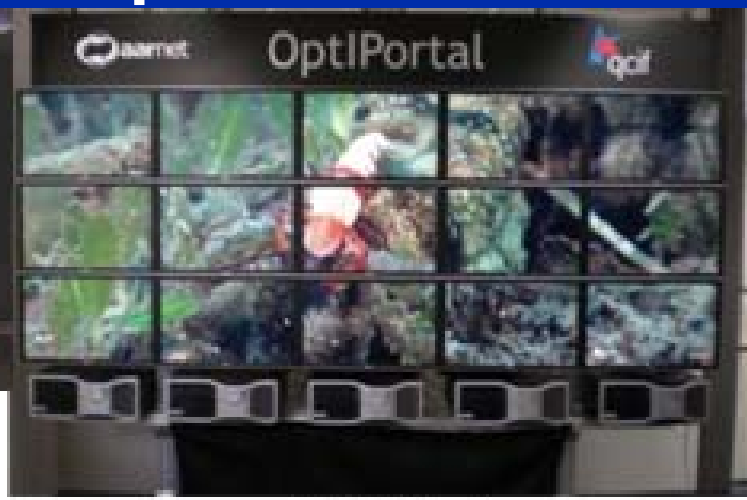
Launch of the 100 Megapixel OzIPortal Kicked Off a Rapid Build Out of Australian OptIPortals



ANU



U Queensland



AARNet



Monash U



CSIRO

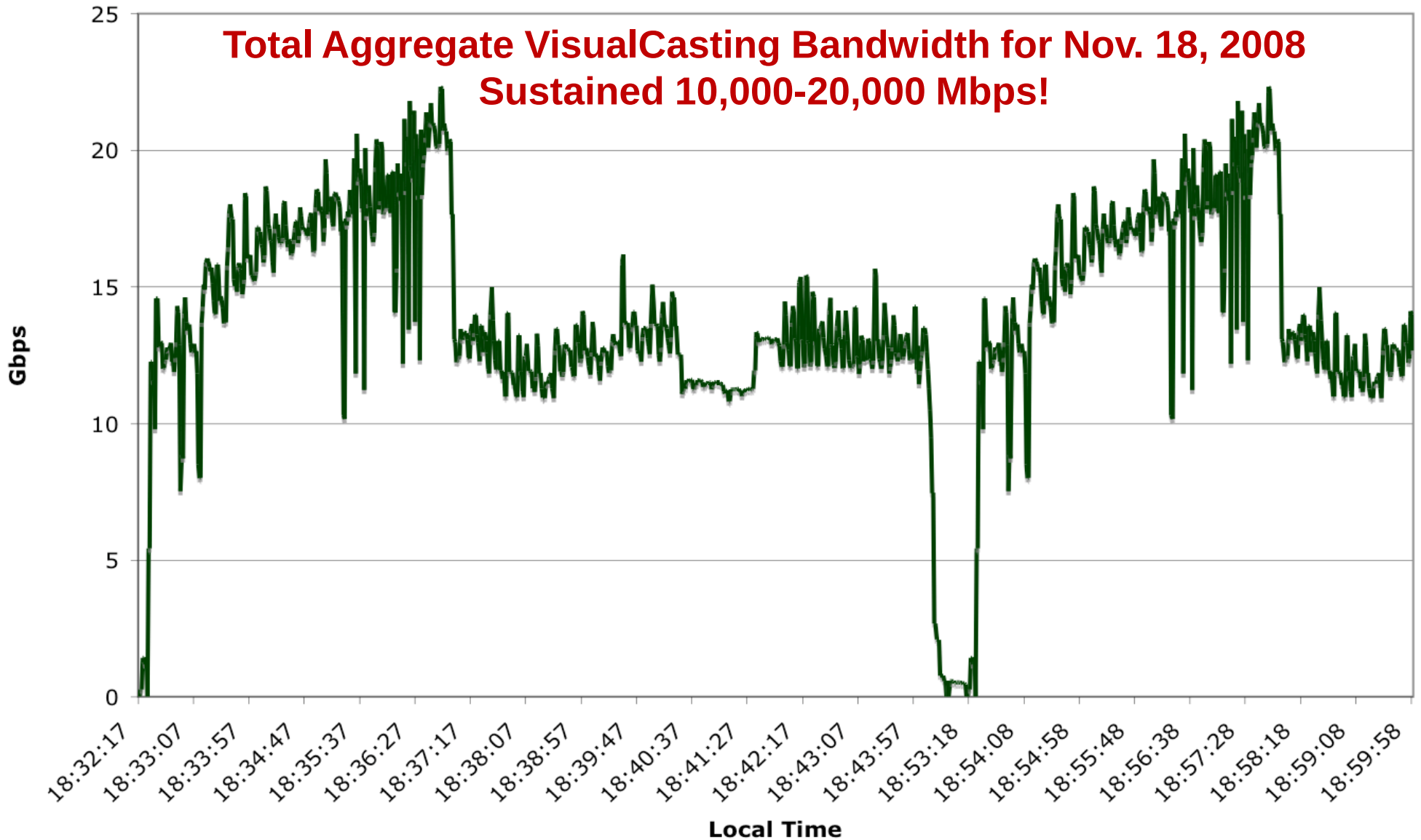


U Wellington, NZ

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

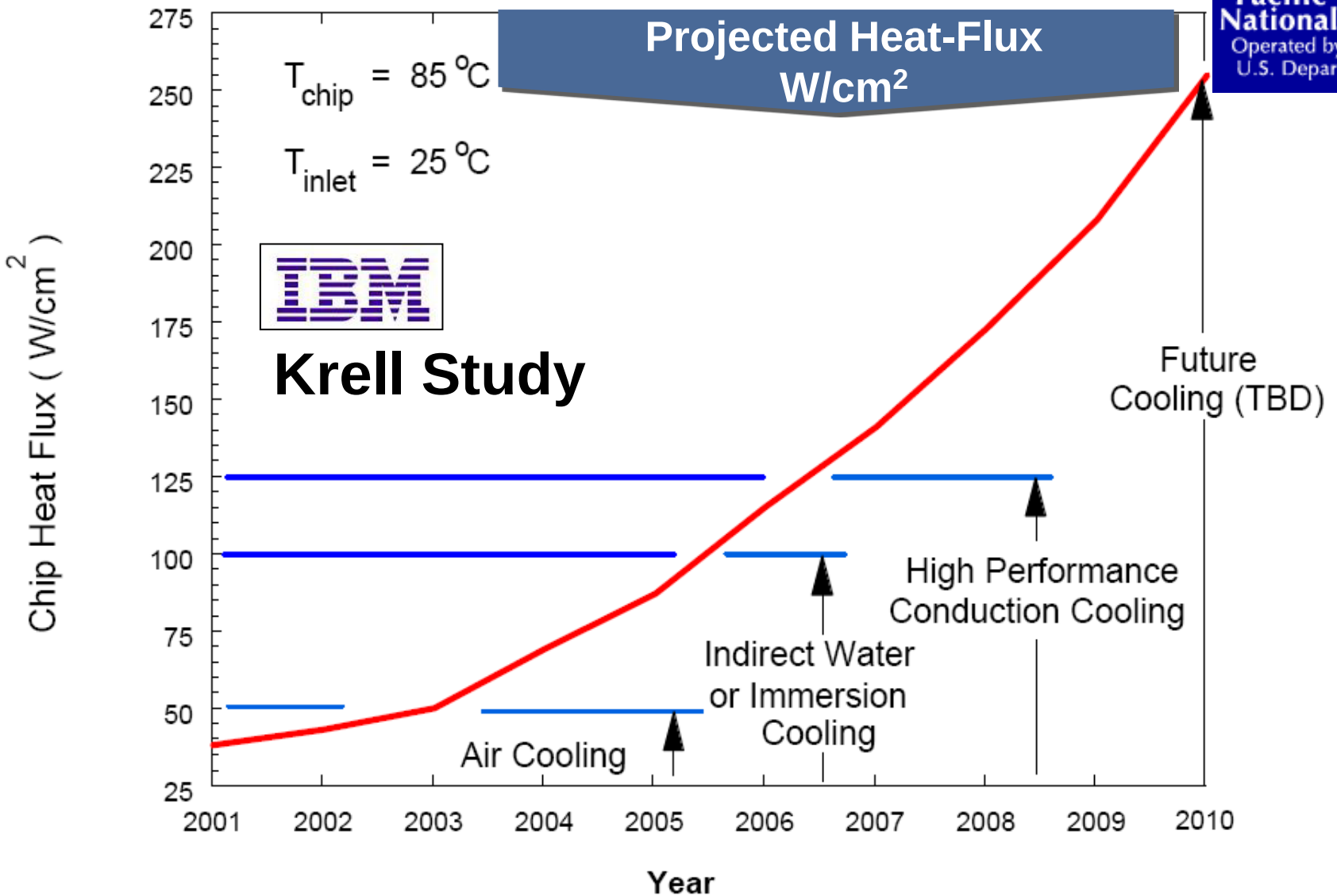
Covise, Phil Weber, Jurgen Schulze, Calit2
CGLX, Kai-Uwe Doerr , Calit2
http://www.calit2.net/newsroom/release.php?id=1421

EVL's SAGE OptIPortal VisualCasting Multi-Site OptIPuter Collaboratory



Source: Jason Leigh, Luc Renambot, EVL, UI Chicago

Threat to CI Deployment—Research Needed on How to Deploy a Green CI



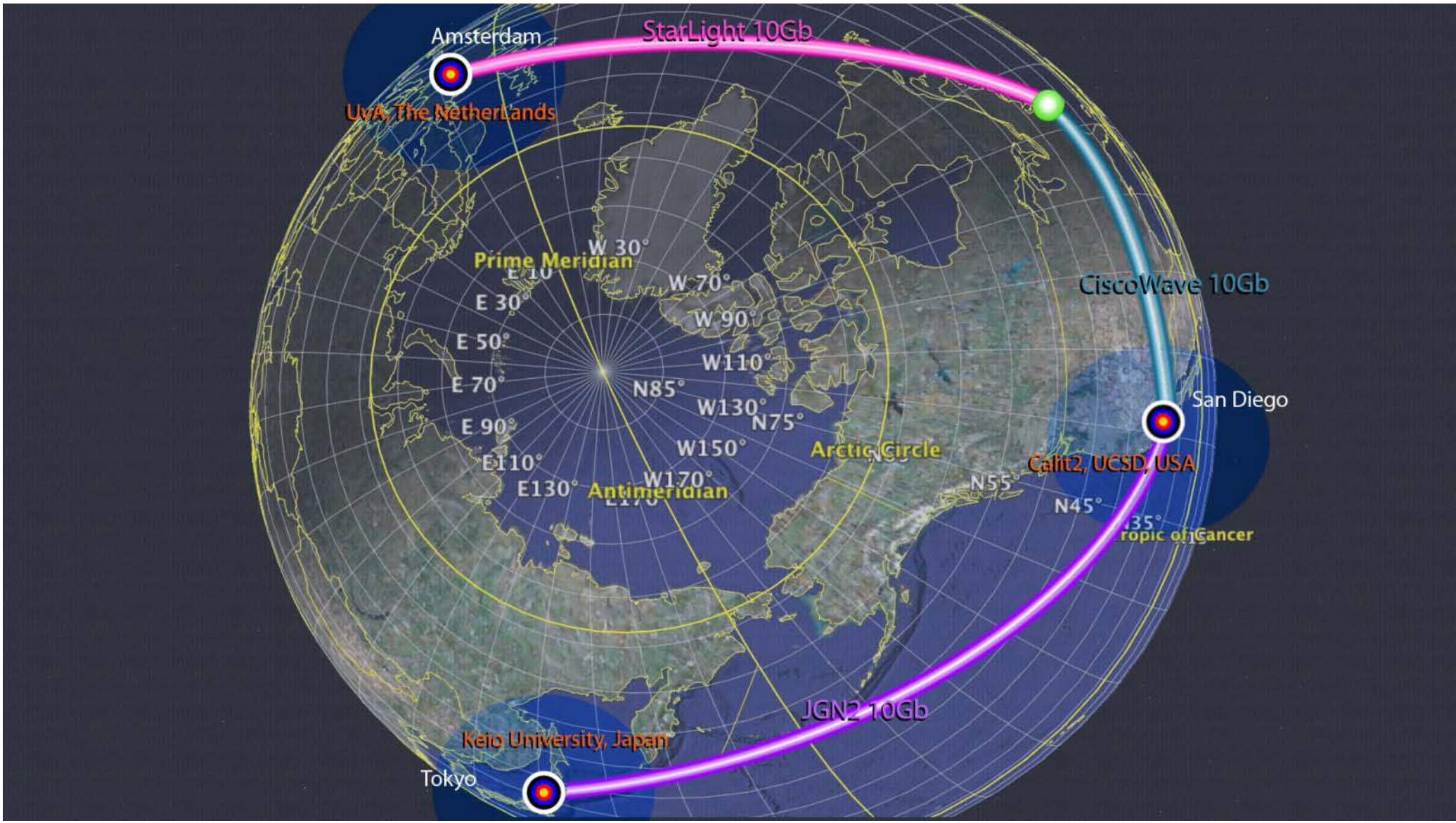
The ICT Industry Carbon Footprint is Roughly that of the Aviation Industry!

Calit2 NSF GreenLight Project Enables Green IT Computer Science Research



- **Computer Architecture**
  - Rajesh Gupta/CSE
- **Software Architecture**
  - Amin Vahdat & Ingolf Kruger/ CSE
- **CineGrid Exchange**
  - Tom DeFanti/Calit2
- **Visualization**
  - Falko Kuster/Structural Engineering
- **Power and Thermal Management**
  - Tajana Rosing/CSE
- **Analyzing Power Consumption Data**
  - Jim Hollan/Cog Sci

CineGrid Exchange:
Using Optical Fibers to Create Remote Storage



Global Warming will Drive Cloud Computing!