“Genomic Research: The Jump to Light Speed"

Invited Talk
Genomes, Medicine, and the Environment Conference 2005
Hilton Head, SC
October 19, 2005

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

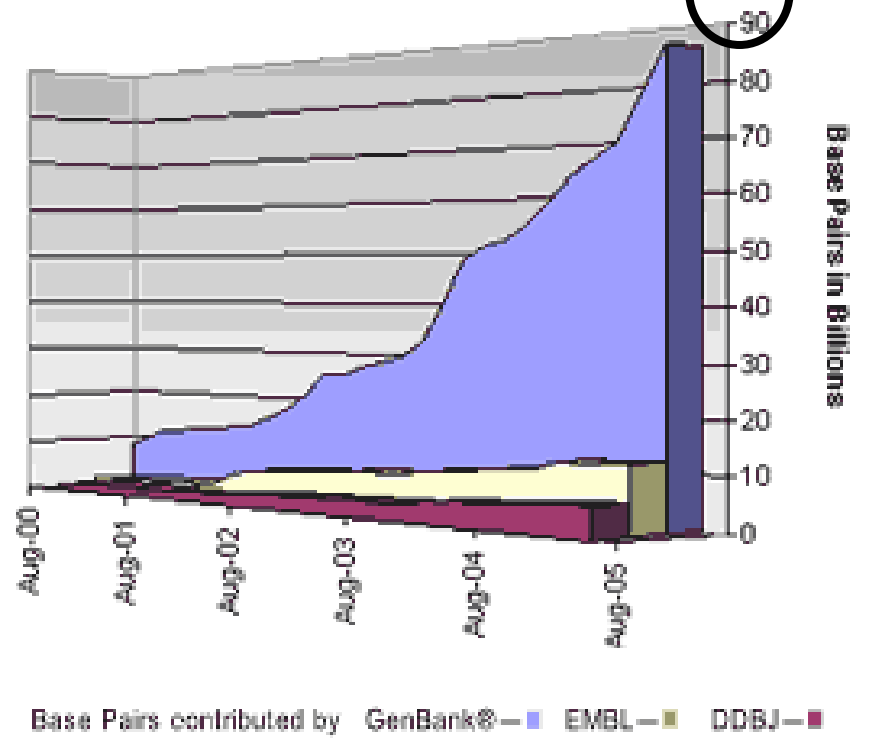
OptIPuter

it²

Genomic Data Is Growing Rapidly, But Metagenomics Will Vastly Increase The Scale…

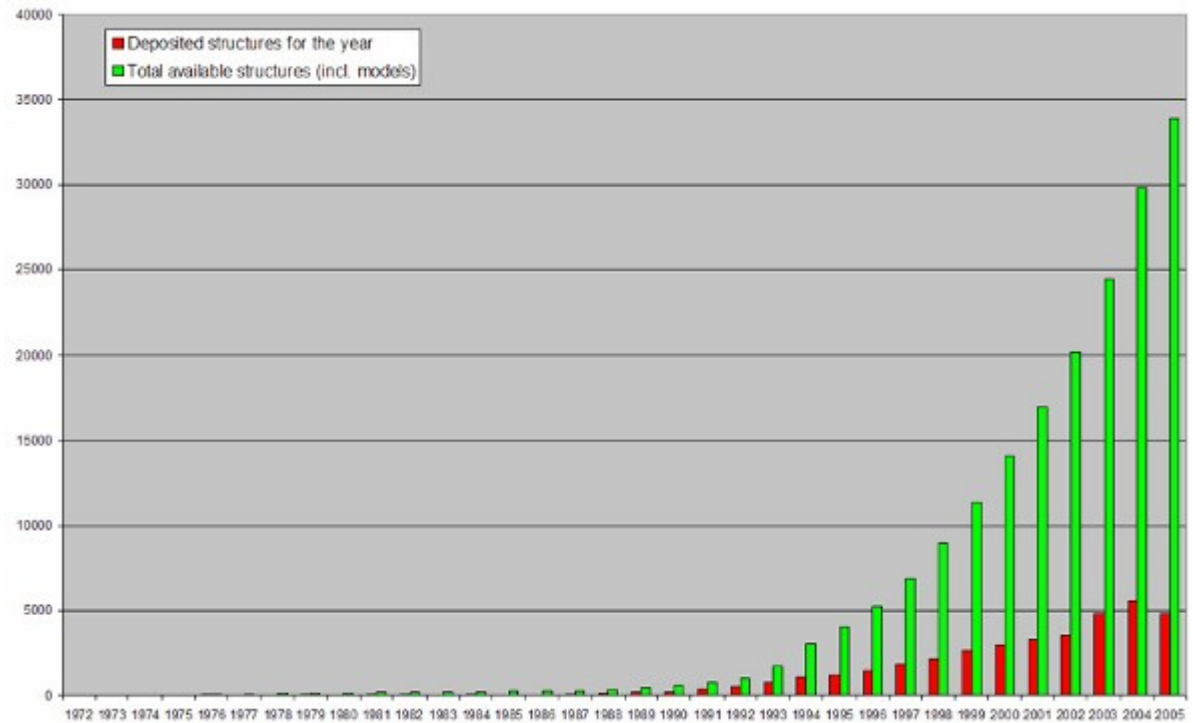
100 Billion Bases!

GenBank



www.ncbi.nlm.nih.gov/Genbank

Protein Data Bank



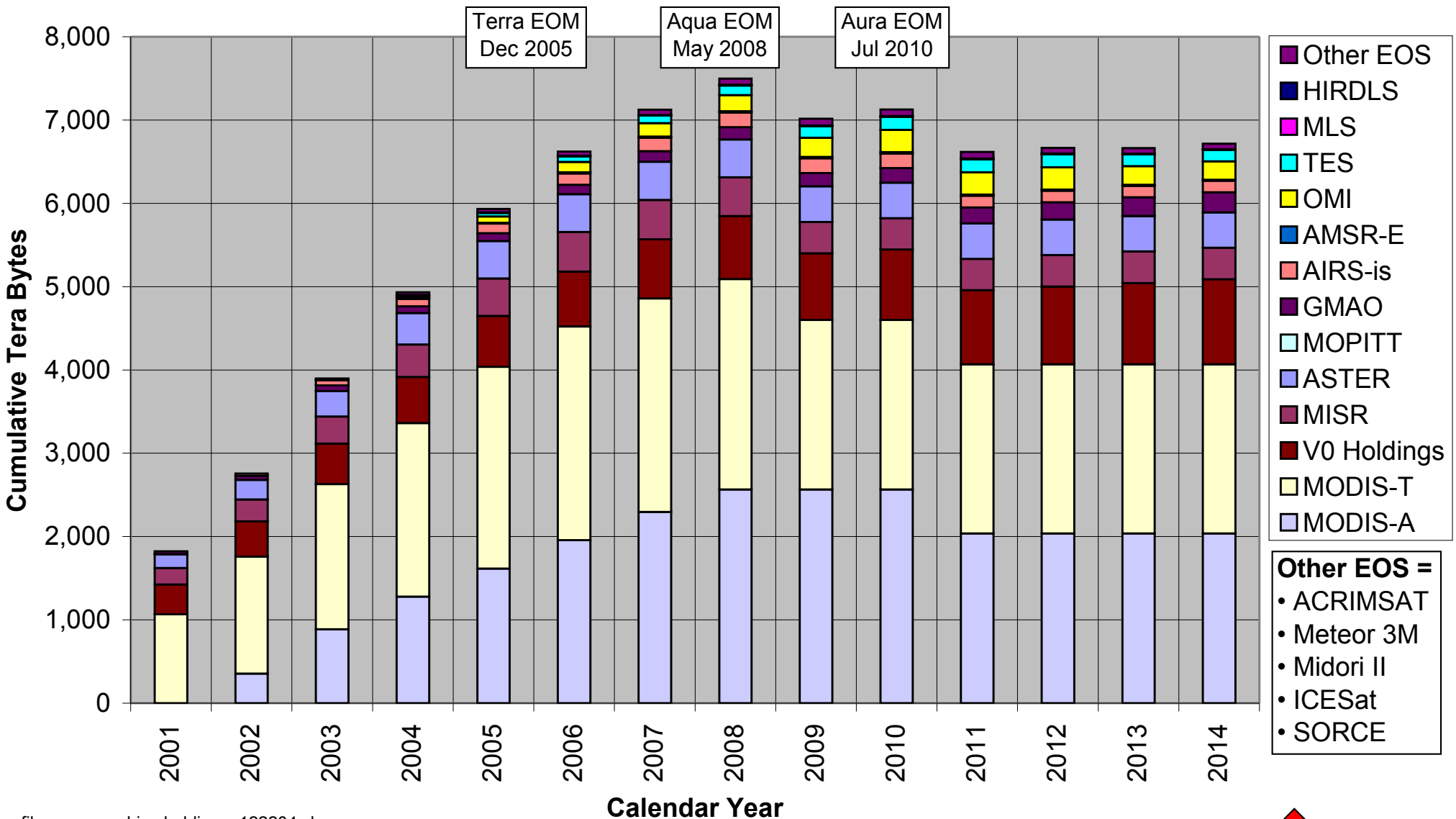
www.rcsb.org/pdb/holdings.html

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Total Data < 1TB

it2

Metagenomics Will Couple to Earth Observations Which Add Several TBs/Day



file name: archive holdings_122204.xls
tab: all instr bar

NOTE: Data remains in the archive pending transition to LTA

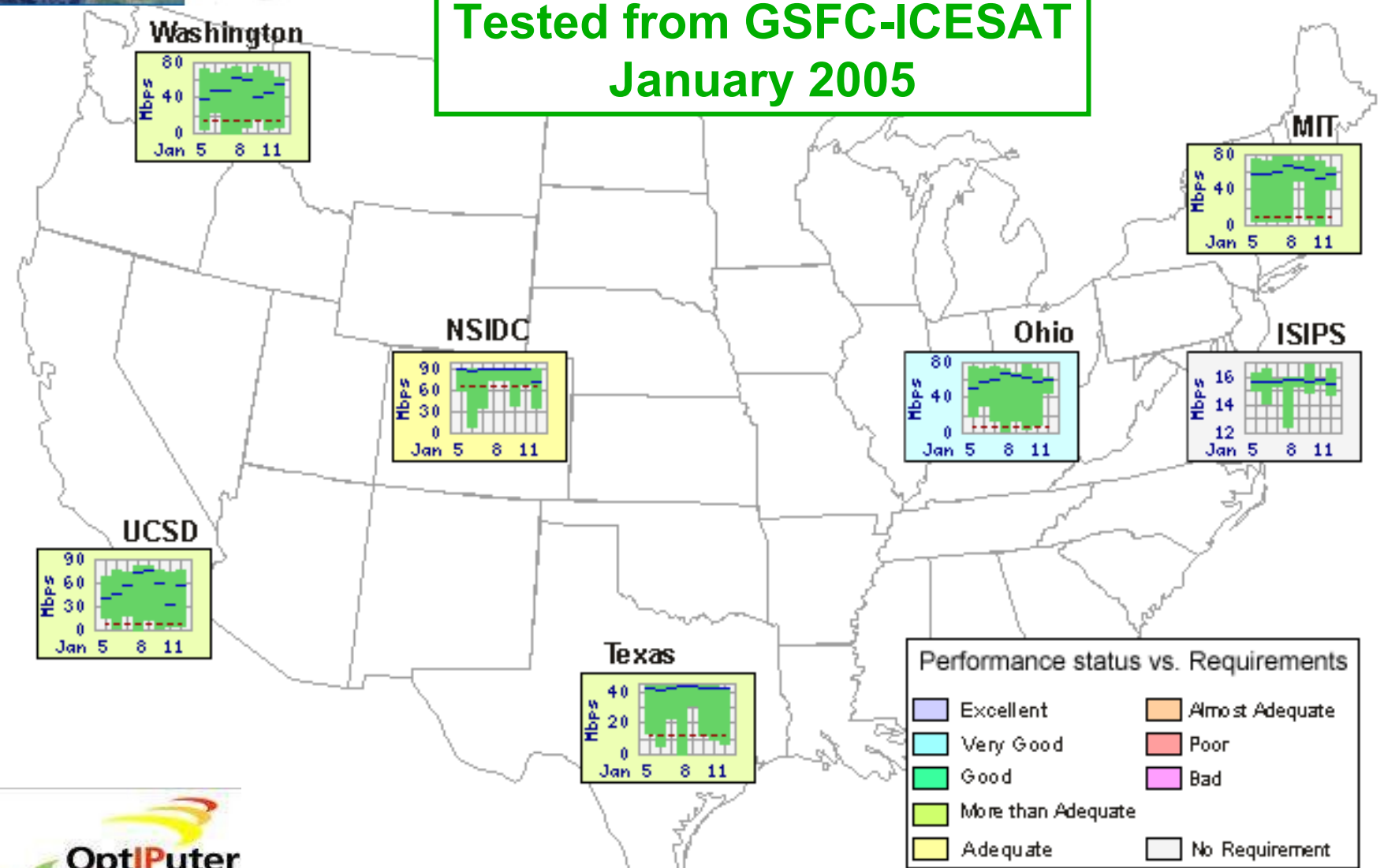
Source: Glenn Iona, EOSDIS Element Evolution Technical Working Group January 6-7, 2005

Challenge: Average Throughput of NASA Data Products to End User is Only < 50 Megabits/s



ENSIGHT Active Testing ICESat Destinations

Tested from GSFC-ICESAT January 2005

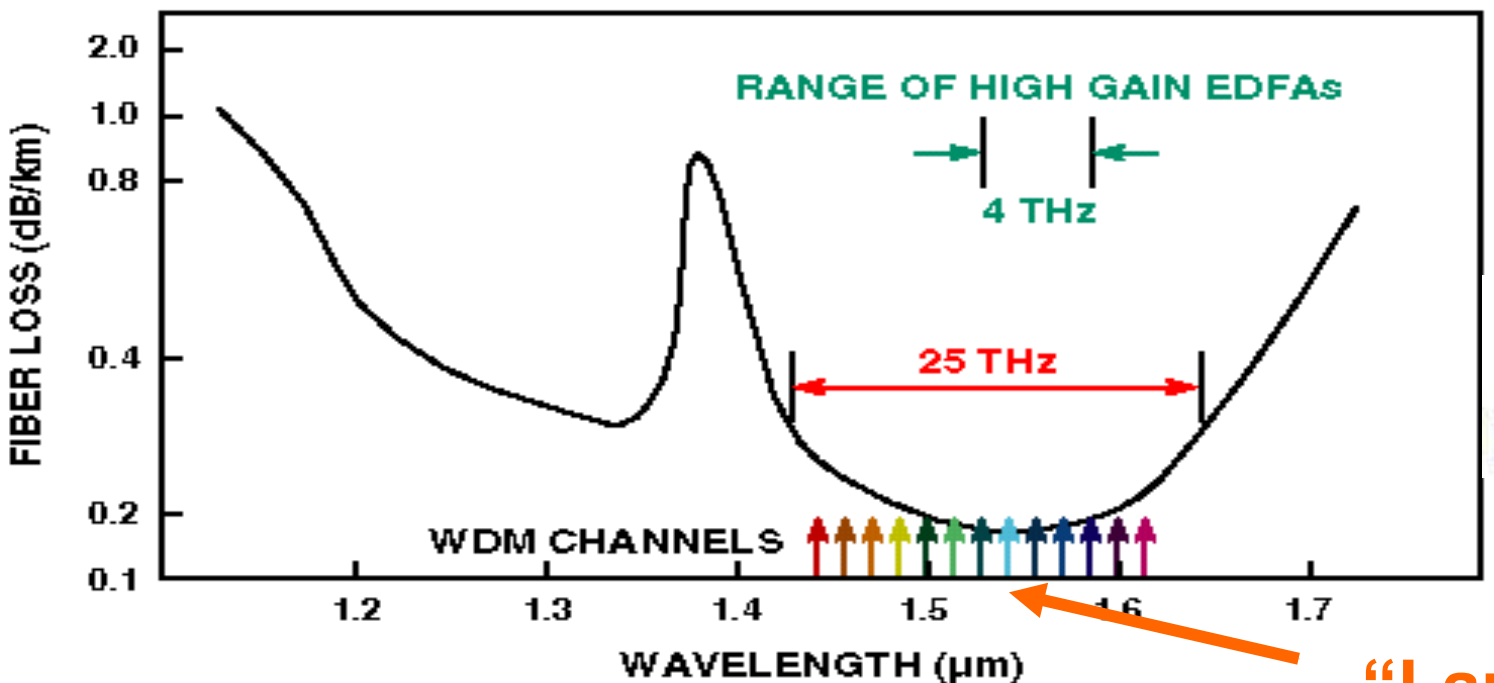


http://ensight.eos.nasa.gov/Missions/icesat/index.shtml

Solution: Individual 1 or 10Gbps Lightpaths -- "Lambdas on Demand"

WAVELENGTH DIVISION MULTIPLEXING (WDM)

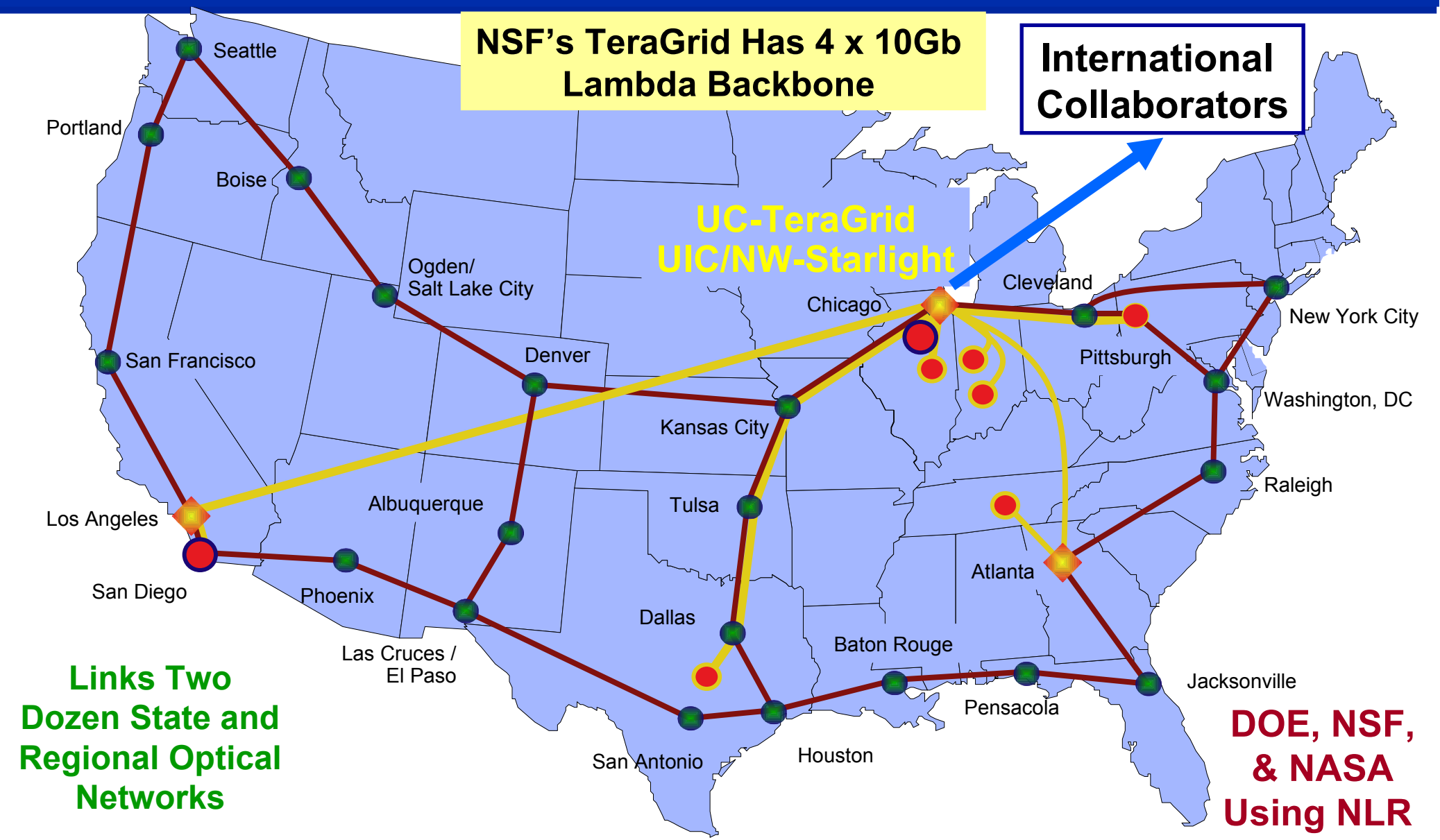
- EXPLOITS
  - ENORMOUS BANDWIDTH OF SILICA FIBER
  - HIGH-GAIN WIDEBAND OPTICAL AMPLIFIERS



"Lambdas"

Source: Steve Wallach, Chiaro Networks

National Lambda Rail (NLR) and TeraGrid Provides Cyberinfrastructure Backbone for U.S. Researchers



NLR 4 x 10Gb Lambdas Initially Capable of 40 x 10Gb wavelengths at Buildout

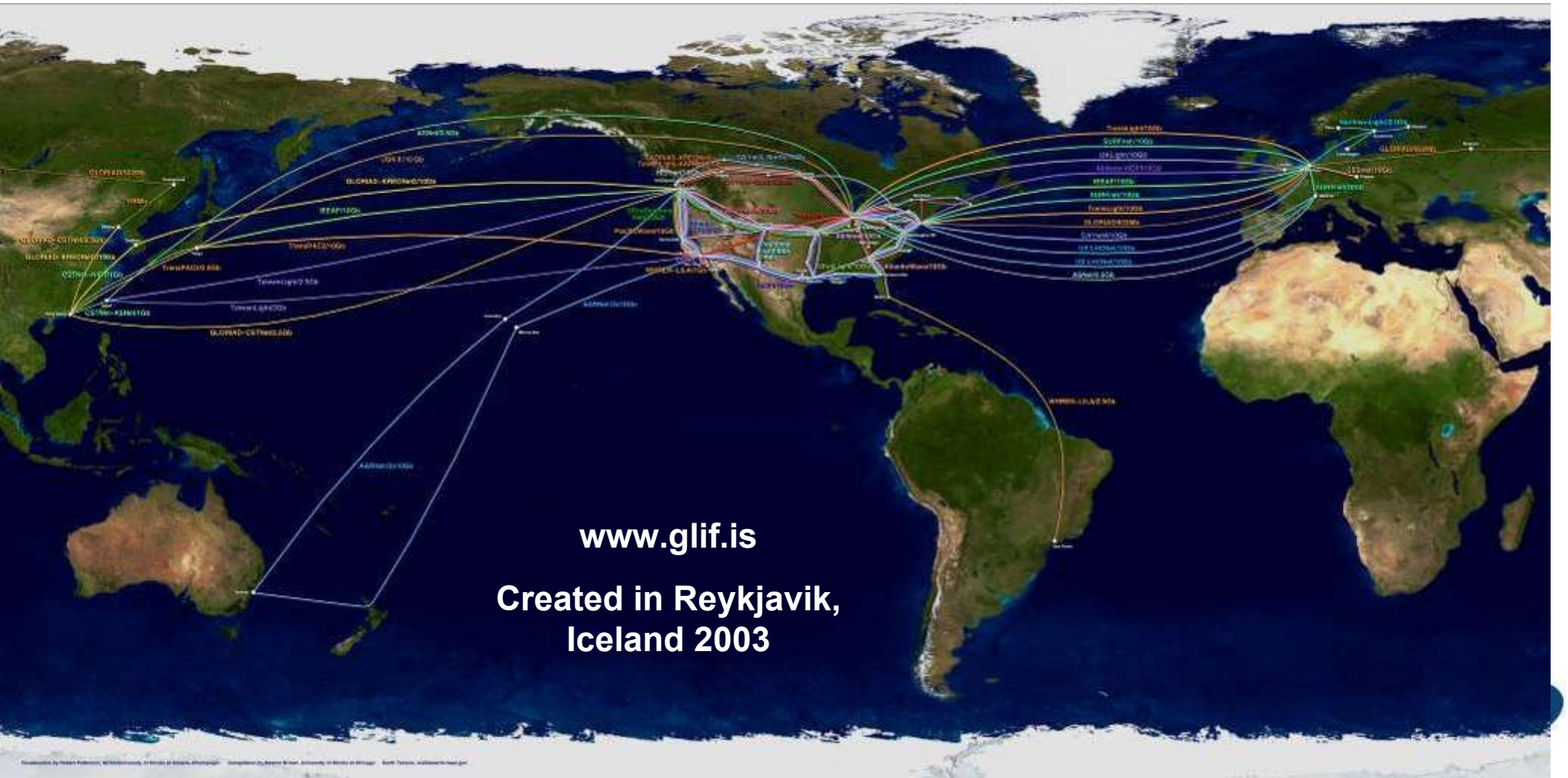
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The Global Lambda Integrated Facility (GLIF) Creates MetaComputers on the Scale of Planet Earth

Many Countries are Interconnecting Optical Research Networks

to form a Global SuperNetwork



Two New Calit2 Buildings Will Provide a Persistent Collaboration "Living Laboratory"



- **Over 1000 Researchers in Two Buildings**
  - Linked via Dedicated Optical Networks
  - International Conferences and Testbeds
- **New Laboratory Facilities**
  - Virtual Reality, Digital Cinema, HDTV
  - Nanotech, BioMEMS, Chips, Radio, Photonics, Grid, Data, Applications



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Learning to Live on Lambdas

it²

The Networking Double Header of the Century Is Driven by LambdaGrid Applications

the UC Discovery Grant

Maxine Brown, Tom DeFanti, Co-Organizers

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY



www.startap.net/igrid2005/

September 26-30, 2005

Calit2 @ University of California, San Diego

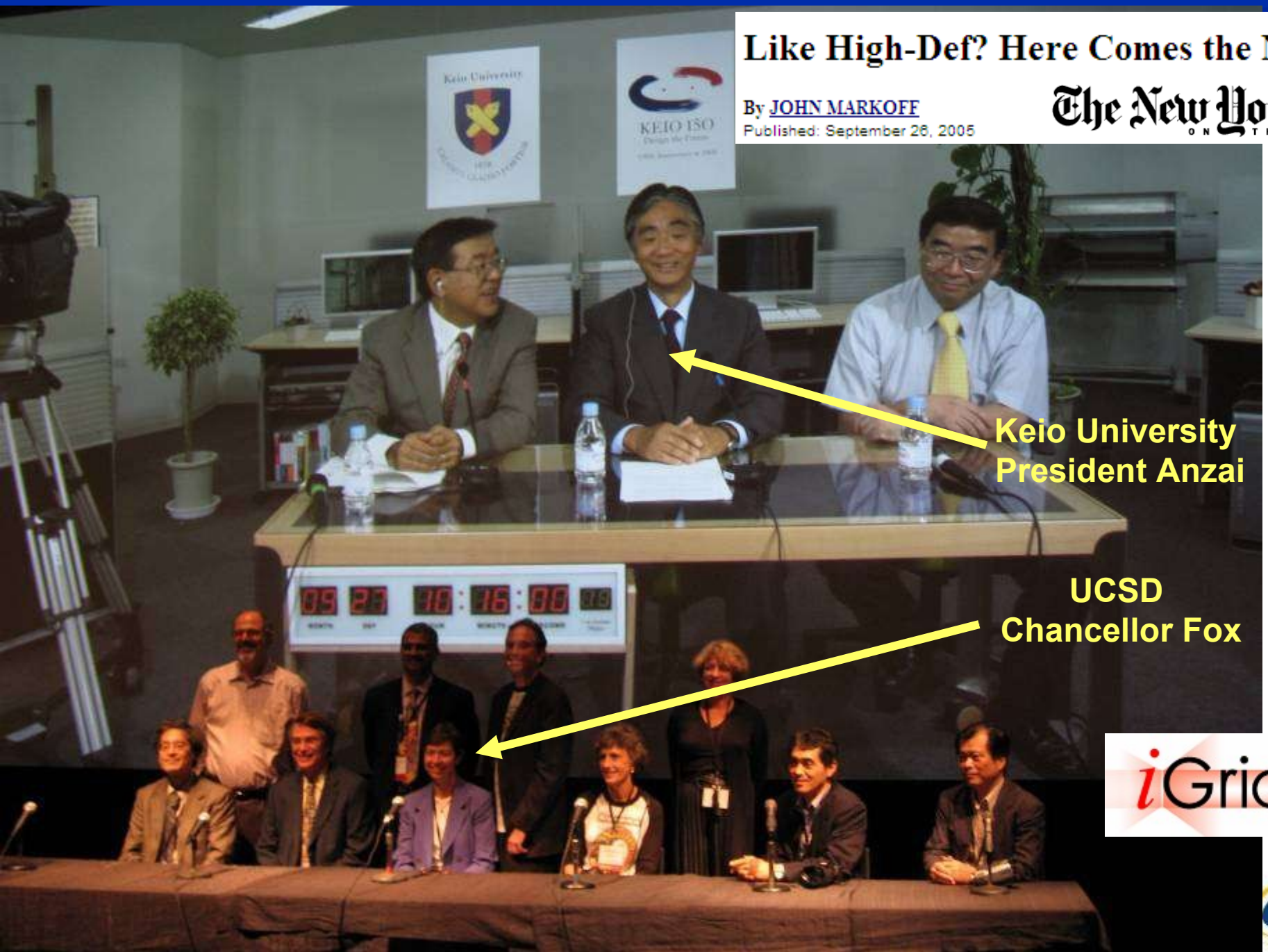
California Institute for Telecommunications and Information Technology

SC|05 Gateway to Discovery

Washington State Convention and Trade Center Seattle, WA
November 12-18 2005

http://sc05.supercomp.org

First Trans-Pacific Super High Definition Telepresence Meeting Over 1 Gbps Lambda



Like High-Def? Here Comes the Next Level

By JOHN MARKOFF
Published: September 26, 2005

The New York Times ON THE WEB

SHD=
4x HD

Sony
NTT
SGI

iGrid 2005

it²

Lambdas Enable First Remote Interactive High Definition Video Exploration of Deep Sea Vents



Ginger Armbrust (Talk on Monday) was on VISIONS '05 Voyage

Source John Delaney & Deborah Kelley, UWash

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A Near Future Metagenomics Lambda-Enabled Data Generator

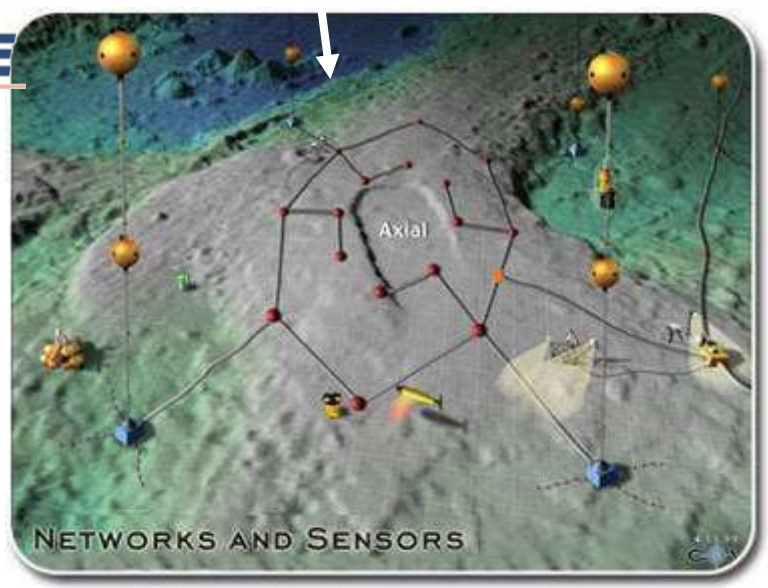


Source John Delaney, UWash

NSF's Ocean Observatories Initiative (OOI) Envisions Global, Regional, and Coastal Scales



NEPTUNE



LEO15 Inset Courtesy of Rutgers University, Institute of Marine and Coastal Sciences

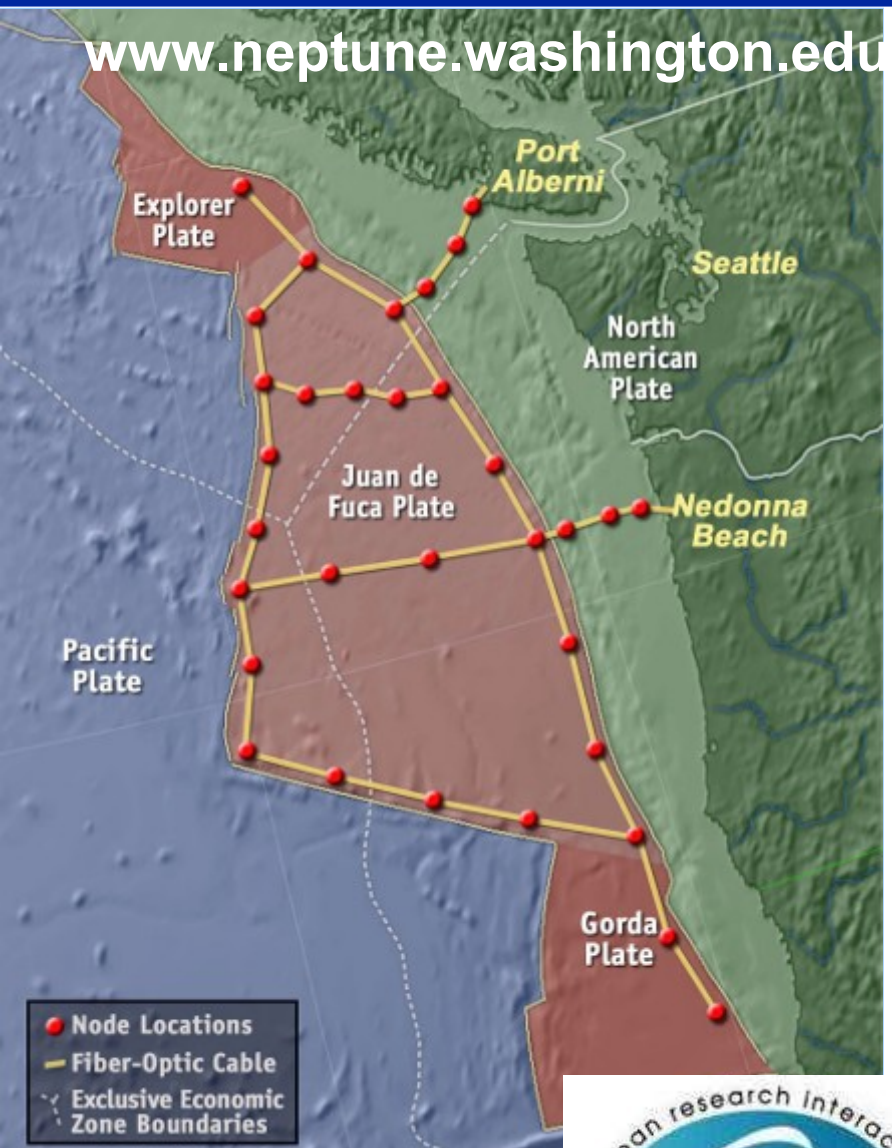
NSF

ocean research interactive ORION observatory networks

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Adding Web and Grid Services to Lambdas to Provide Real Time Control of Ocean Observatories



LOOKING:
(Laboratory for the Ocean Observatory Knowledge Integration Grid)

http://lookingtosea.ucsd.edu/

- **Goal:**
  - **Prototype Cyberinfrastructure for NSF's Ocean Research Interactive Observatory Networks (ORION) Building on OptIPuter**
- **LOOKING NSF ITR with PIs:**
  - **John Orcutt & Larry Smarr - UCSD**
  - **John Delaney & Ed Lazowska –UW**
  - **Mark Abbott – OSU**
- **Collaborators at:**
  - **MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie**

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ocean research interactive ORION observatory networks

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Use SCCOOS As Prototype for Coastal Zone Data Assimilation Testbed

Goal:

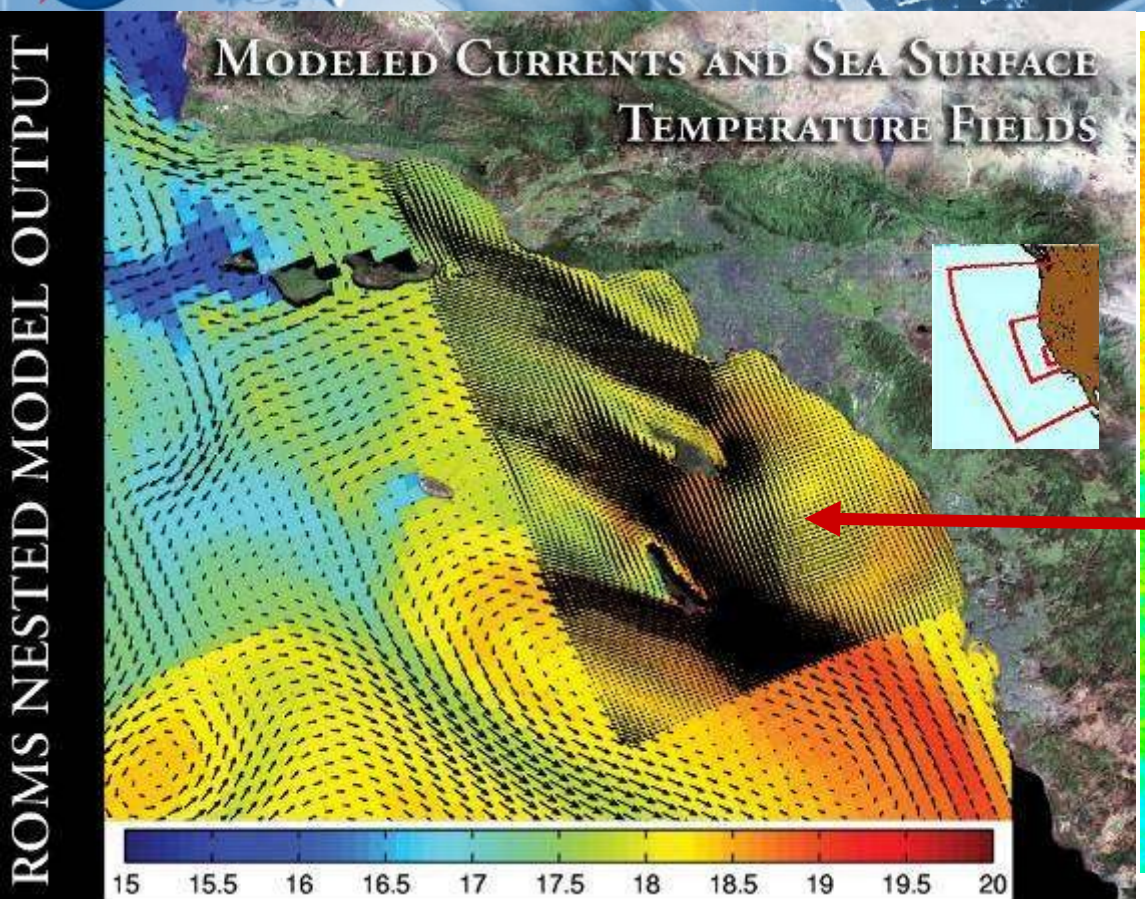
Link SCCOOS Sites with LambdaGrid to Prototype Future Ocean and Earth Sciences Observing System

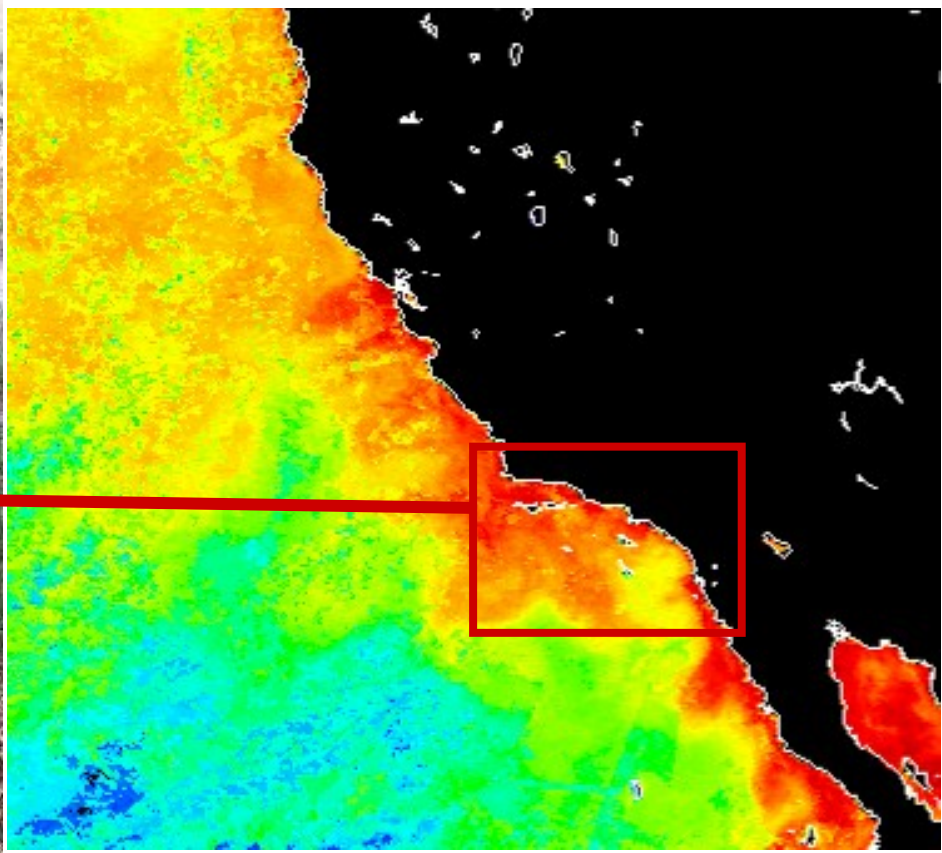


OptIPuter

Use OptIPuter to Couple Data Assimilation Models to Remote Data Sources Including Biology







NASA MODIS Mean Primary Productivity for April 2001 in California Current System

JPL ONR MBARI

Regional Ocean Modeling System (ROMS)

http://ourocean.jpl.nasa.gov/

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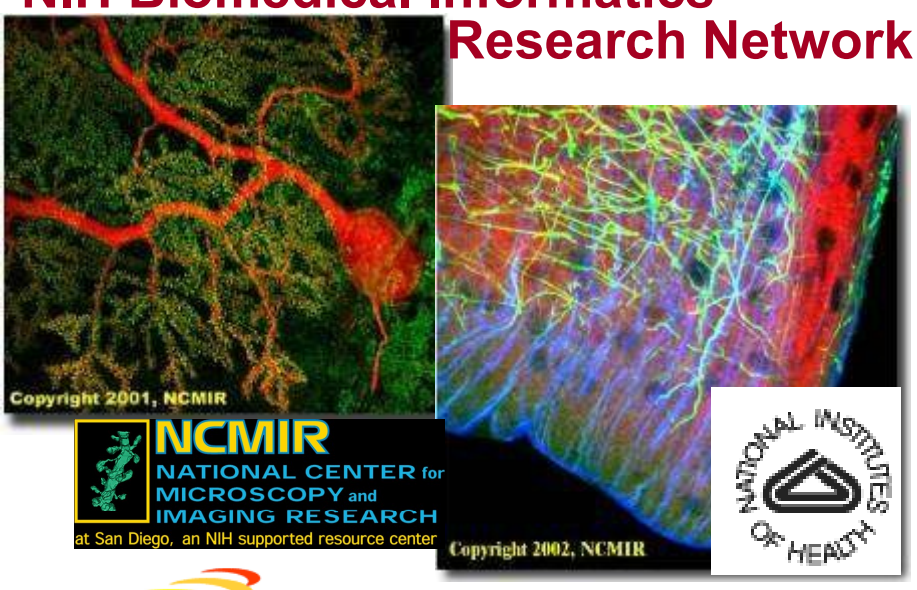
The OptIPuter Project –

Creating a LambdaGrid "Web" for Gigabyte Data Objects

- **NSF Large Information Technology Research Proposal**
  - Calit2 (UCSD, UCI) and UIC Lead Campuses—Larry Smarr PI
  - Partnering Campuses: USC, SDSU, NW, TA&M, UvA, SARA, NASA
- **Industrial Partners**
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- **$13.5 Million Over Five Years**
- **Linking Global Scale Science Projects to User's Linux Clusters**

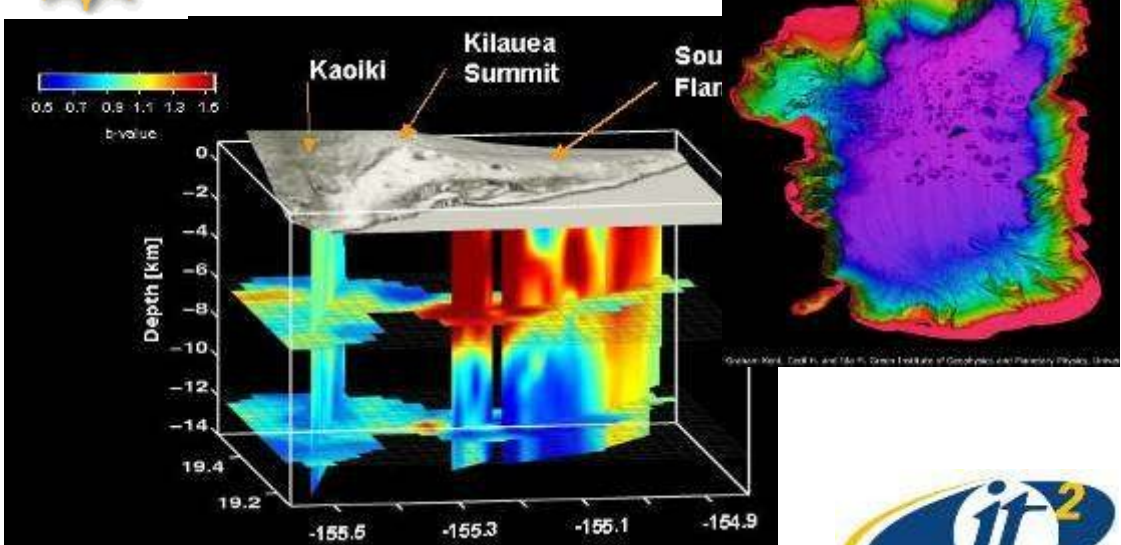
OptIPuter

NIH Biomedical Informatics Research Network



NSF

NSF EarthScope and ORION

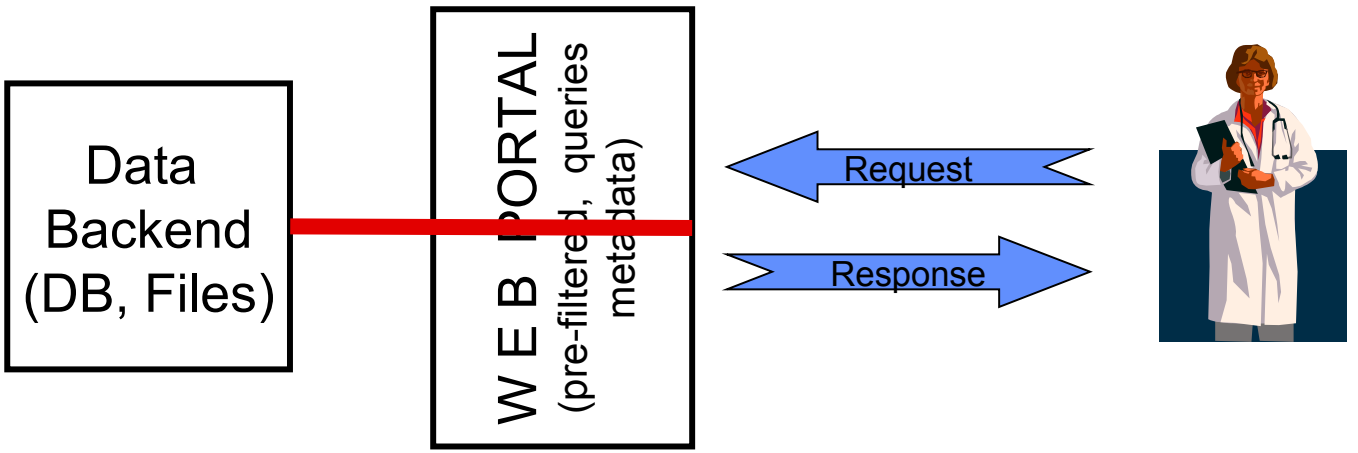


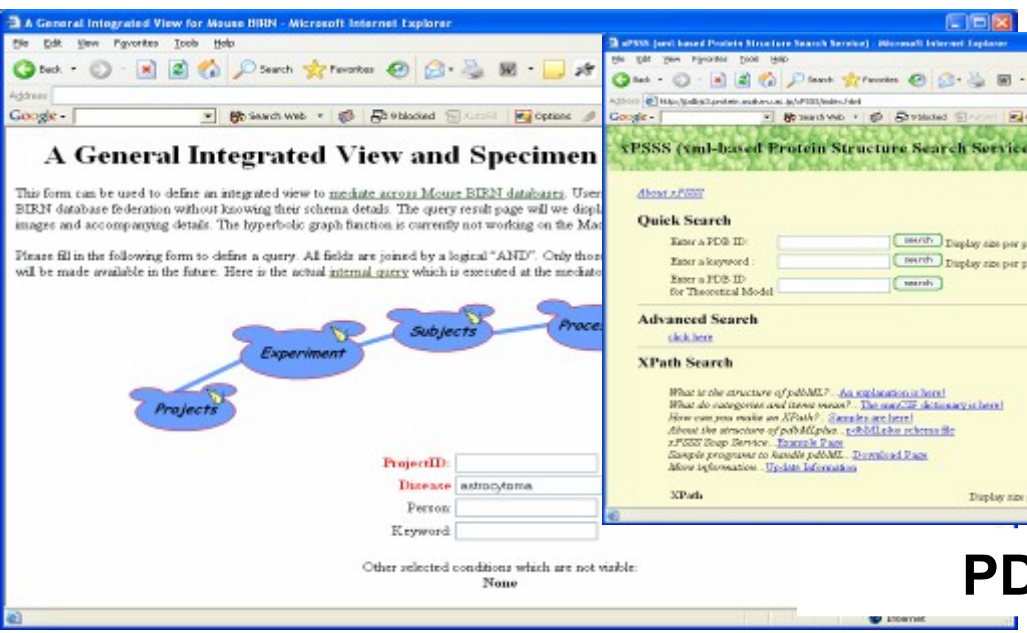
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SDSC
SAN DIEGO SUPERCOMPUTER CENTER

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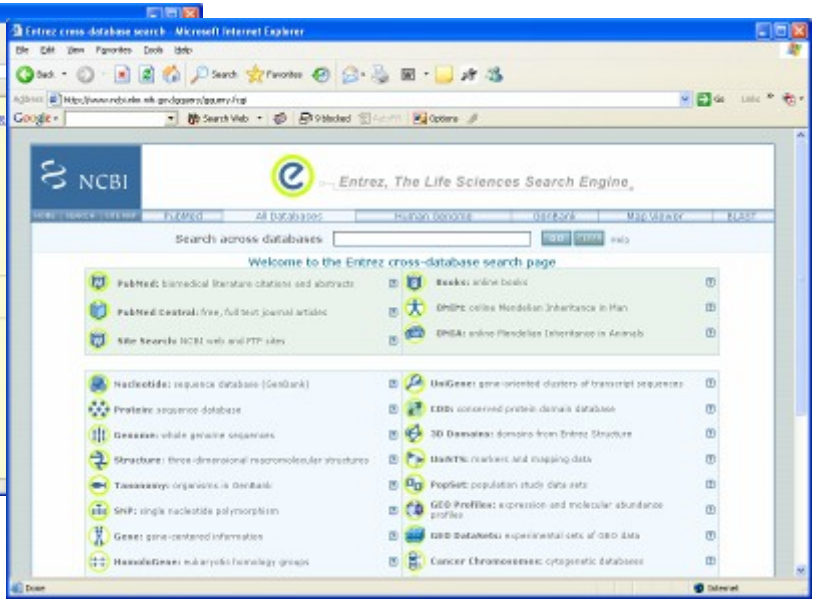
Calit2 Intends to Jump Beyond Traditional Web-Accessible Databases





BIRN

PDB



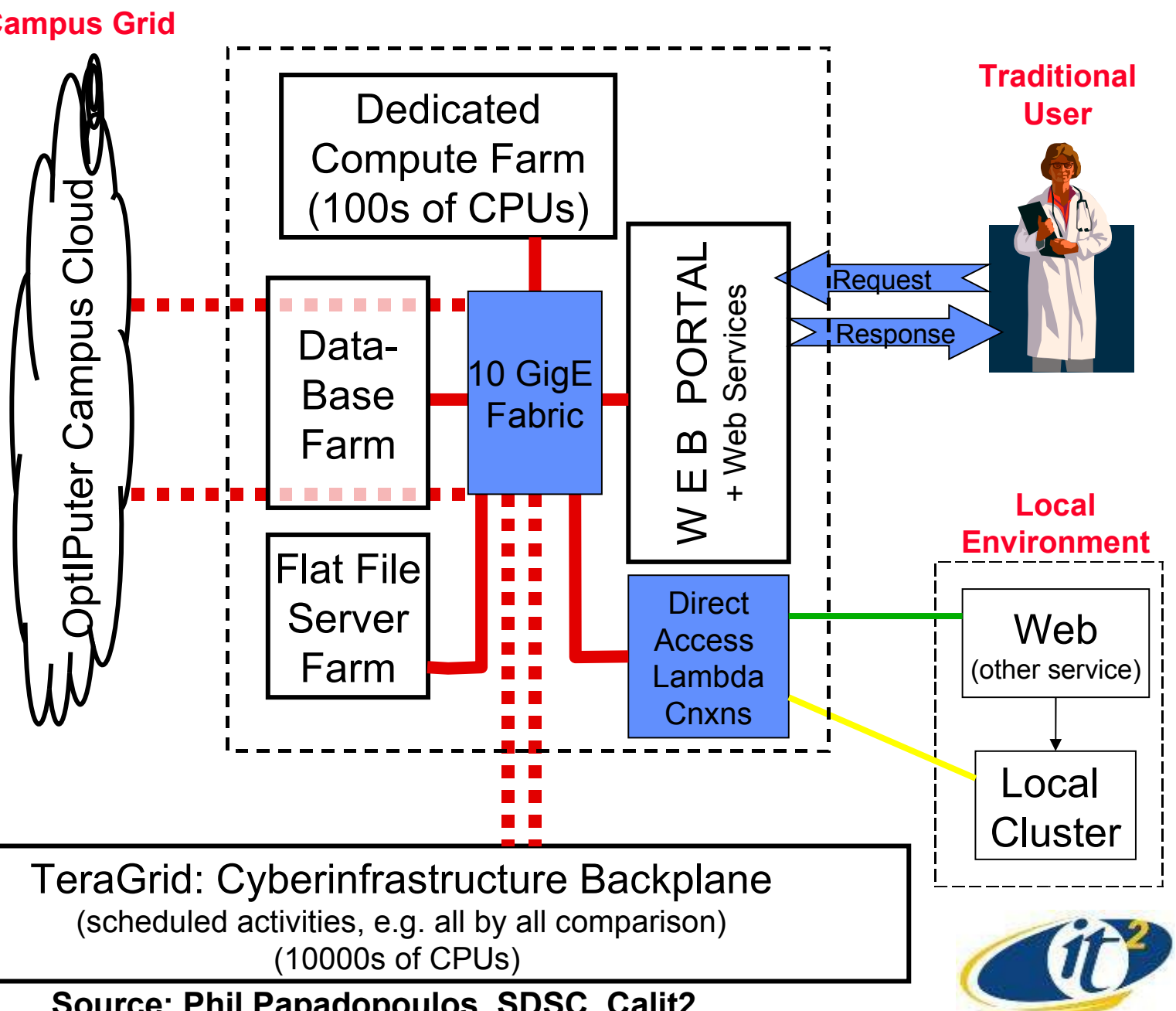
NCBI Genbank

+ many others

Source: Phil Papadopoulos, SDSC, Calit2

Calit2's Direct Access Core Architecture Creates Next Generation Metagenomics Server

Proposed System Joint with Venter Institute, SIO, and Moore Foundation



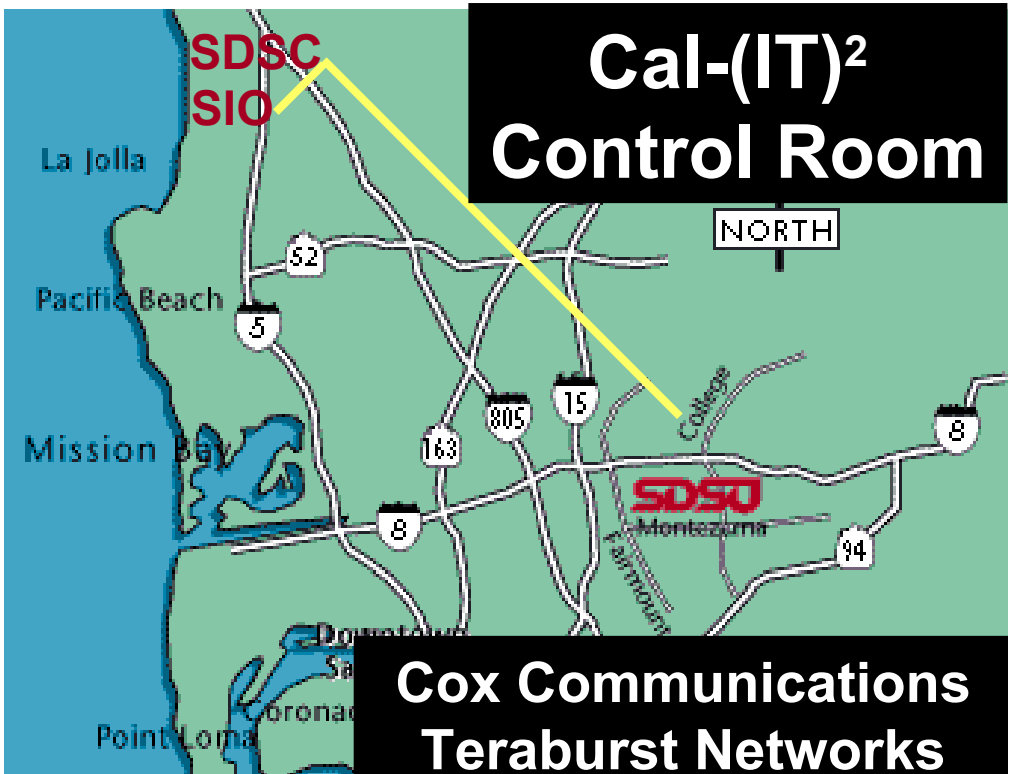
Source: Phil Papadopoulos, SDSC, Calit2

Vast Data Sets Will Require High Resolution Data Analysis Facilities

Celera Control Room



Newsday Photo
Ira Schwarz



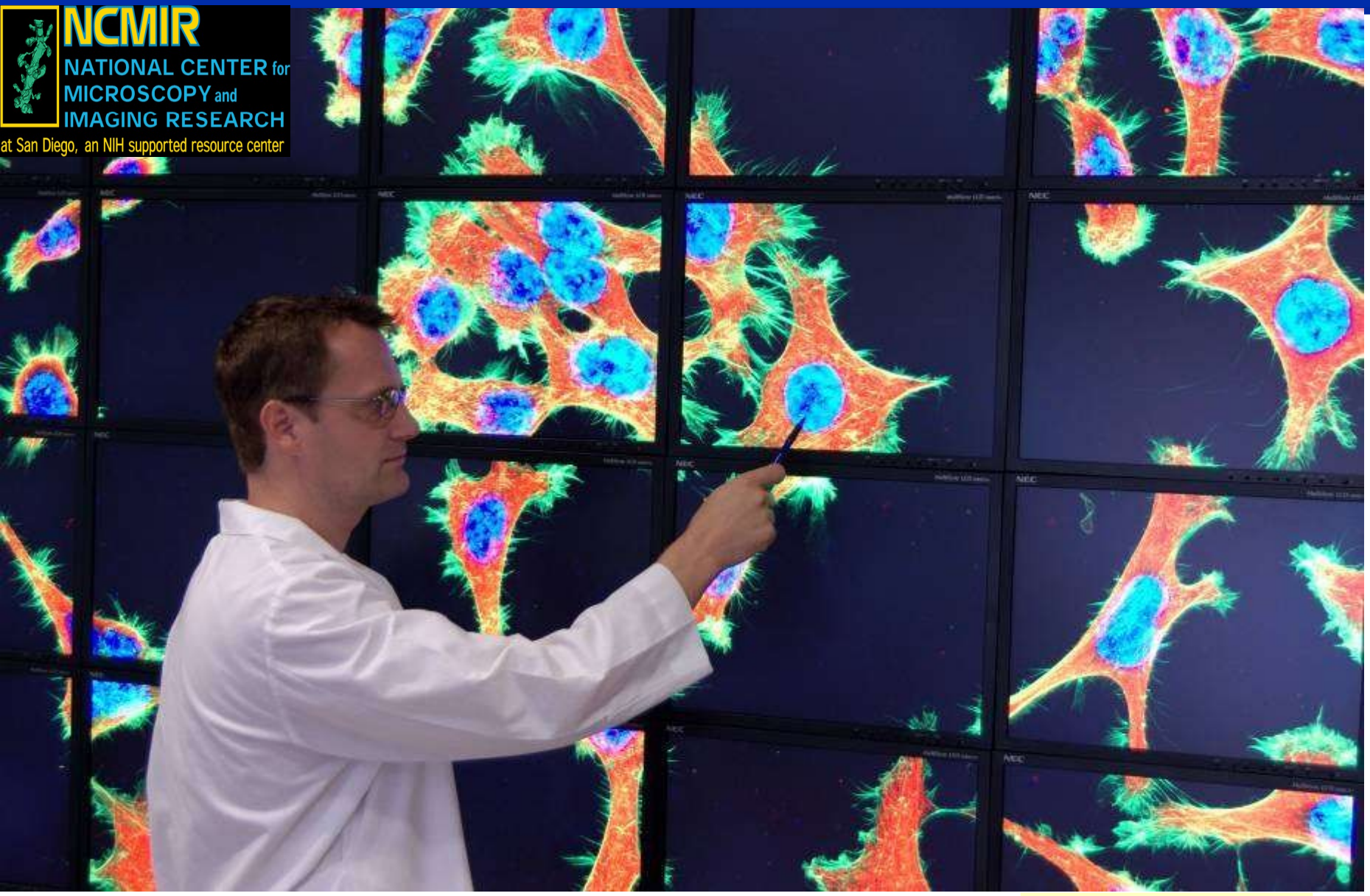
Cal-(IT)² Control Room

Cox Communications
Teraburst Networks
Panoram Technologies



From Smarr Talk 2000

Realizing the Dream:
High Resolution Portals to Global Science Data



Source: Mark Ellisman, David Lee, Jason Leigh, Tom Deerinck

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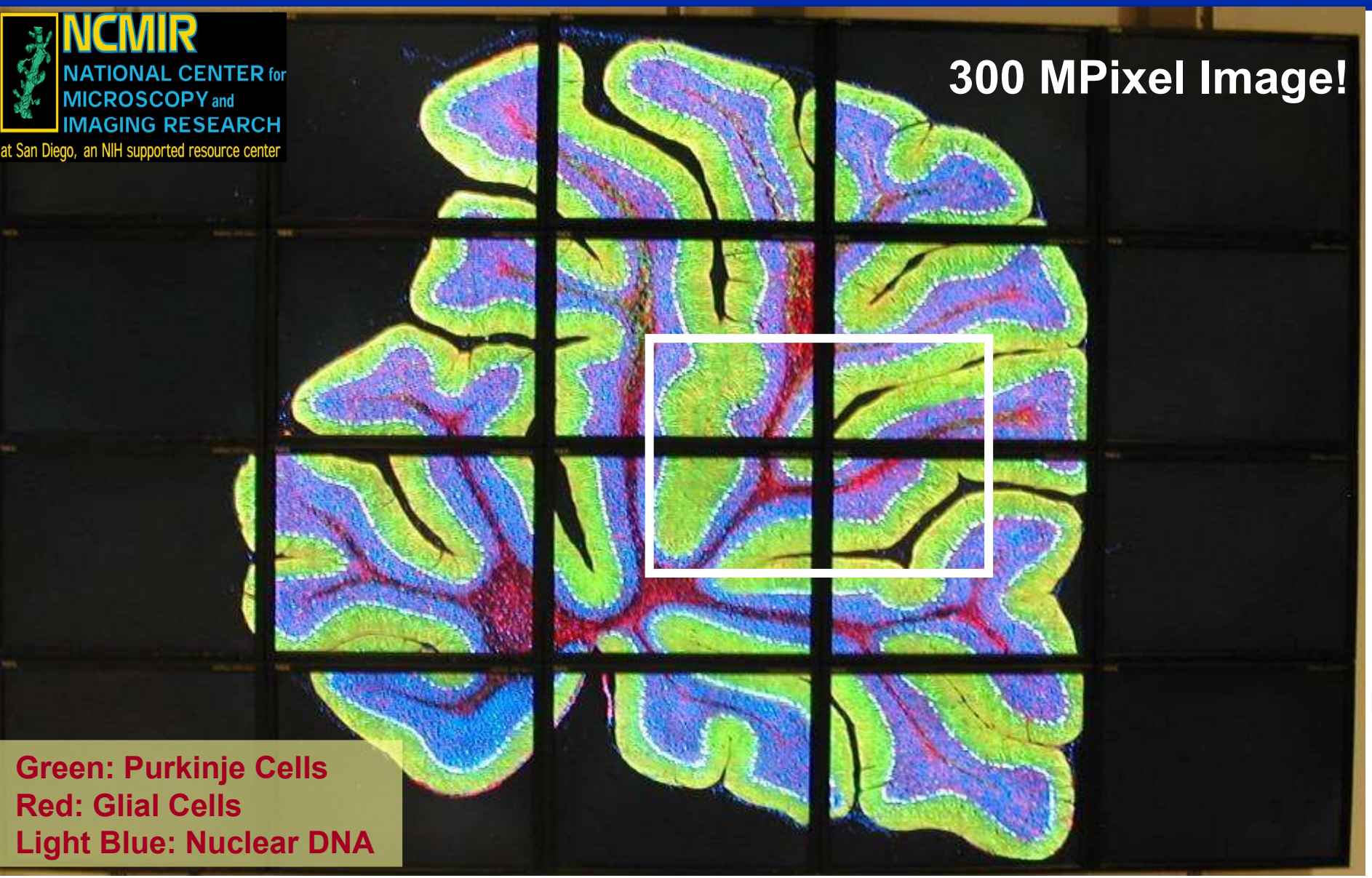
650 Mpixel 2-Photon Microscopy
Montage of HeLa Cultured Cancer Cells

Green: Actin
Red: Microtubles
Light Blue: DNA

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Scalable Displays Being Developed for Multi-Scale Biomedical Imaging

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



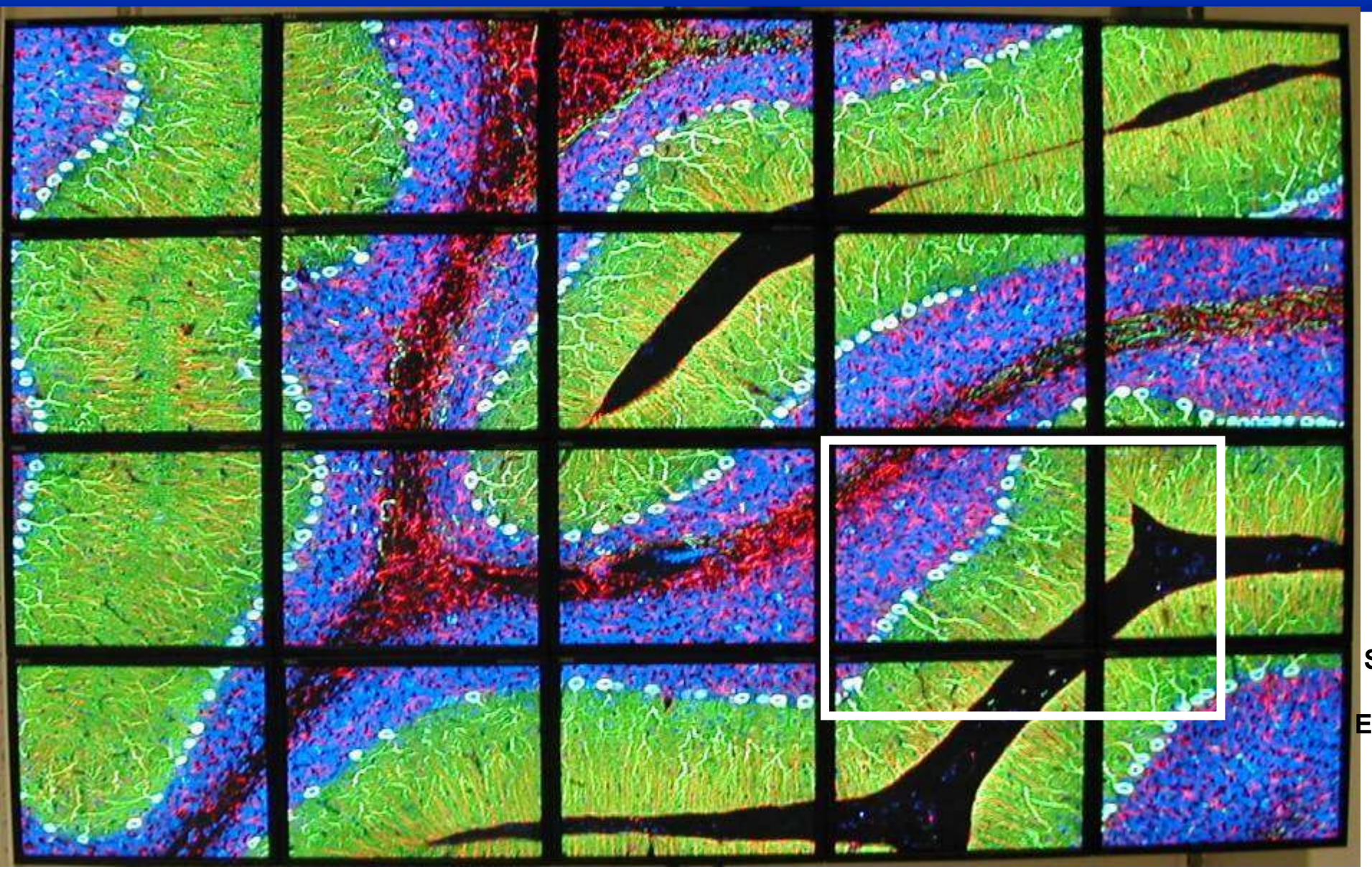
Source: Mark Ellisman, David Lee, Jason Leigh

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

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Scalable Displays Allow Both Global Content and Fine Detail



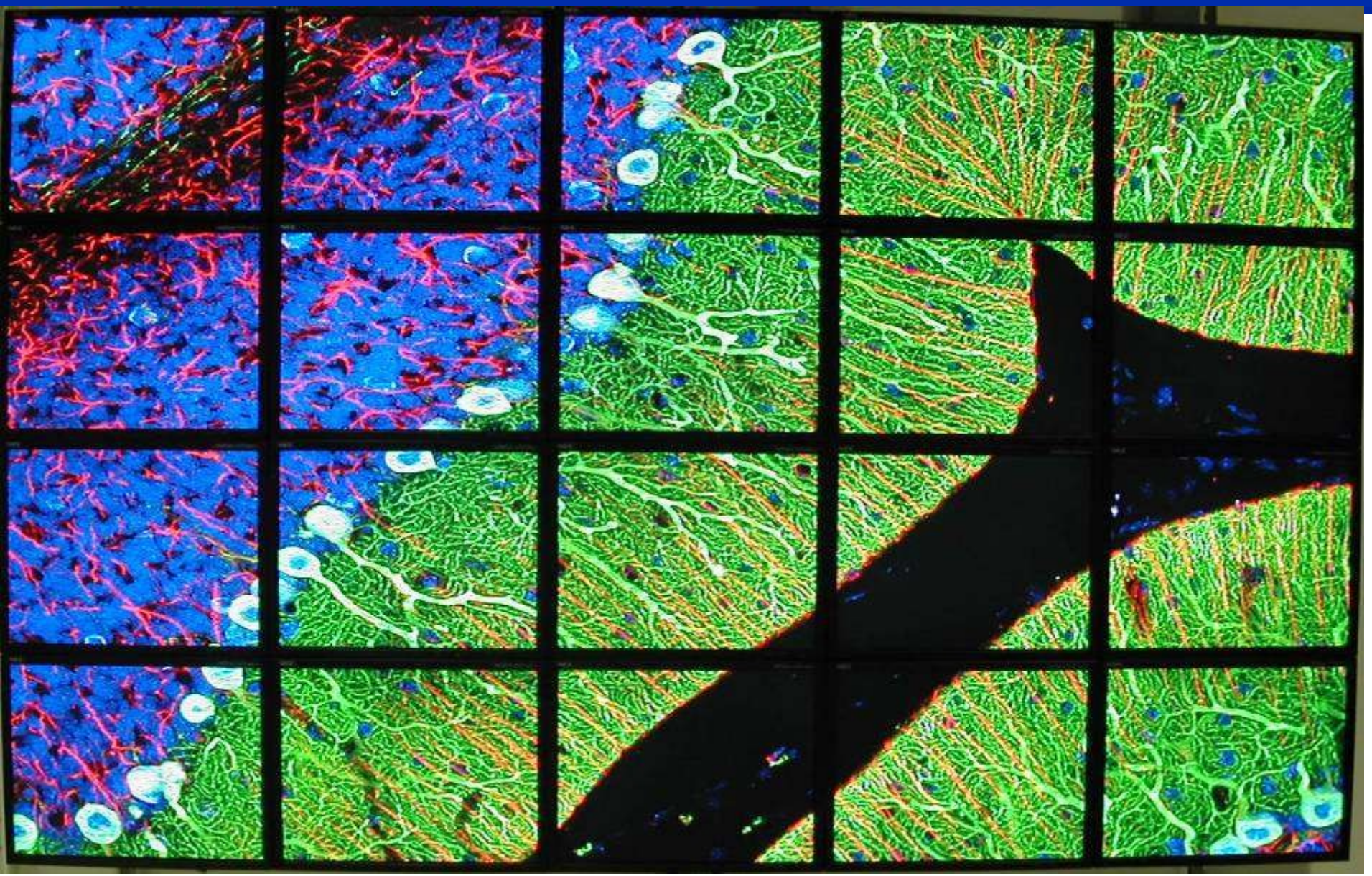
Source: Mark Ellisman, David Lee, Jason Leigh

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30 MPixel SunScreen Display Driven by a 20-node Sun Opteron Visualization Cluster

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Allows for Interactive Zooming from Cerebellum to Individual Neurons

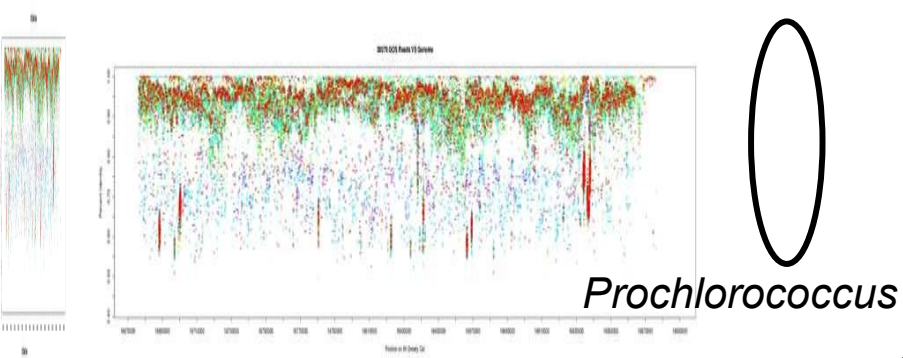


OptIPuter

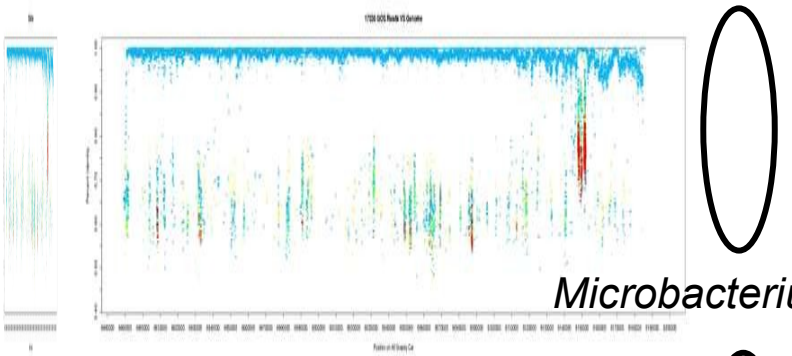
Source: Mark Ellisman, David Lee, Jason Leigh

it²

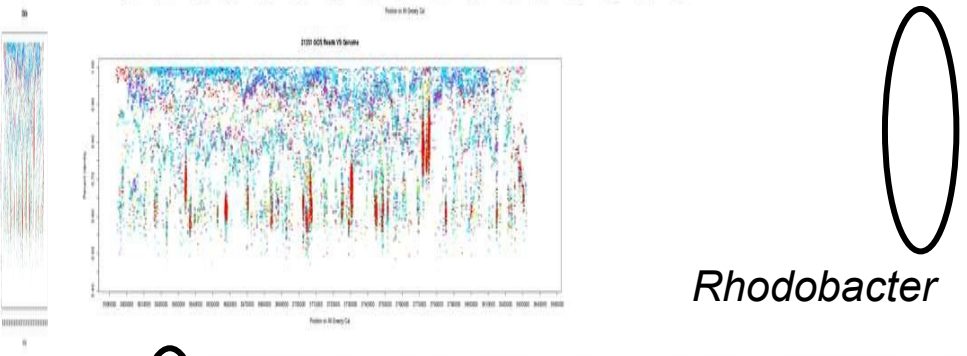
Metagenomics "Extreme Assembly" Requires Large Amount of Pixel Real Estate



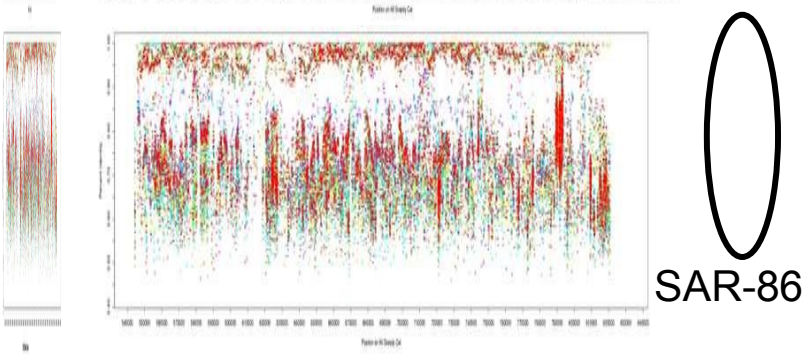
Prochlorococcus



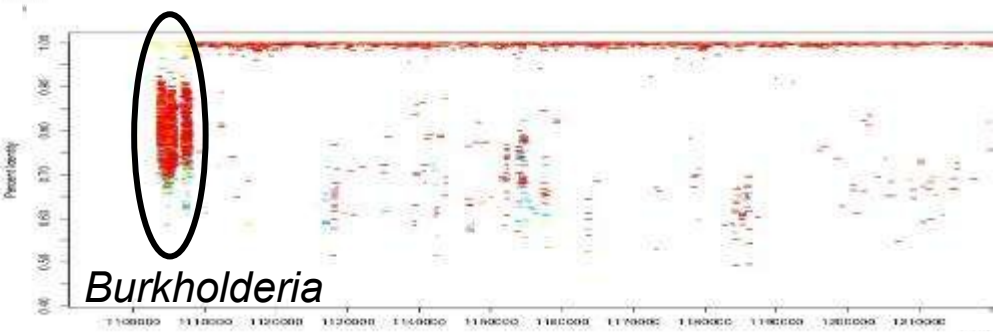
Microbacterium



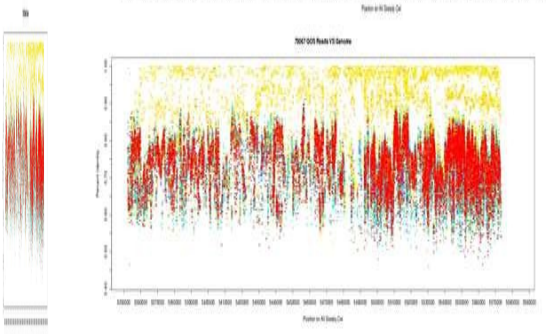
Rhodobacter



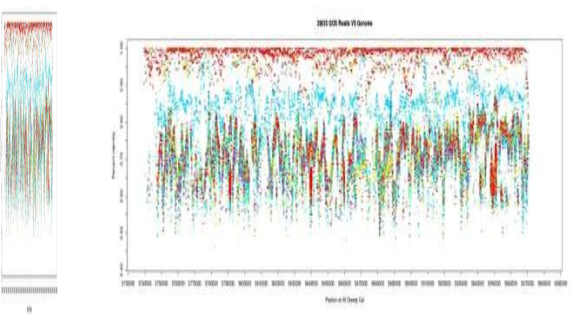
SAR-86



Burkholderia



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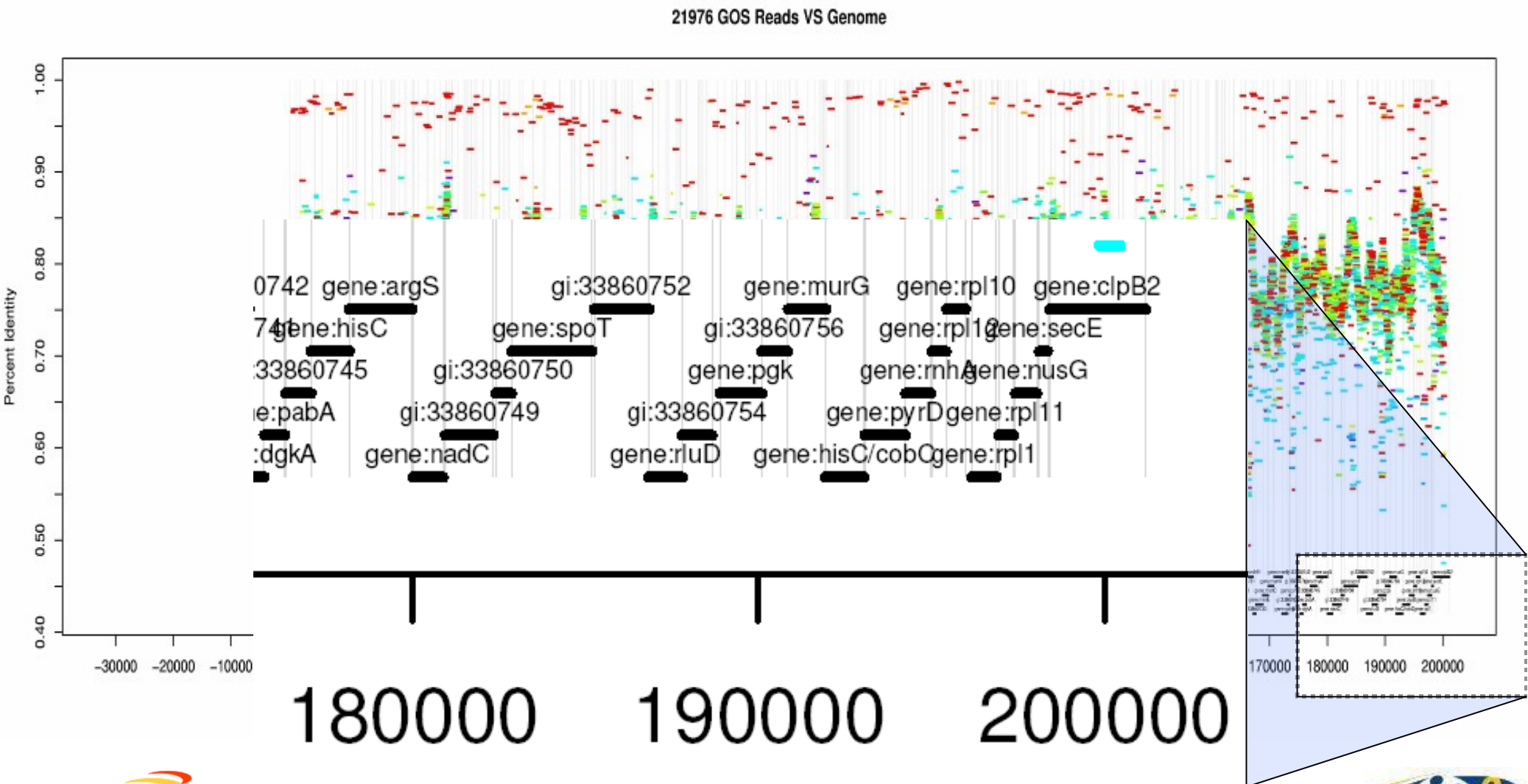


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Source: Karin Remington
J. Craig Venter Institute

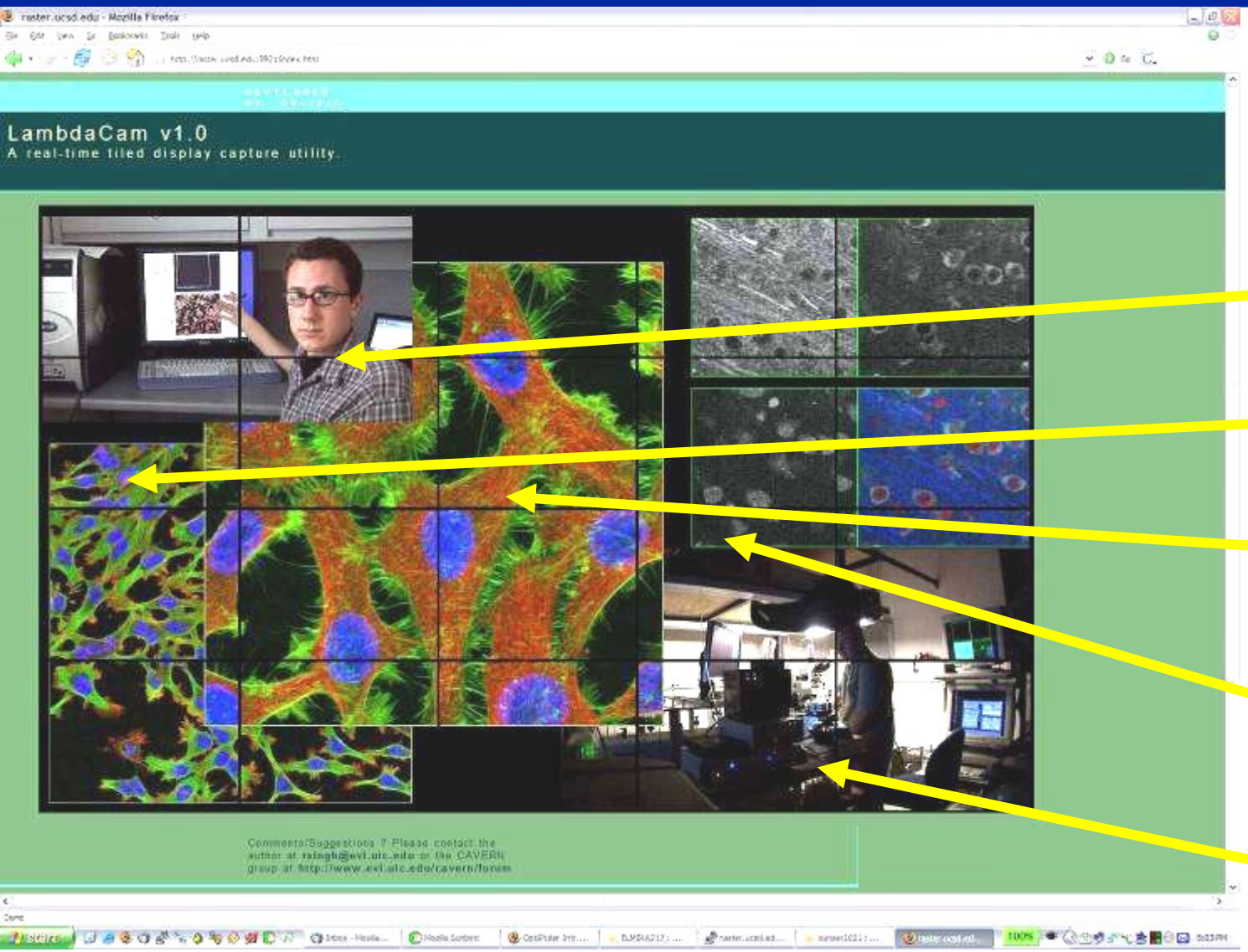
Metagenomics Requires a Global View of Data and the Ability to Zoom Into Detail Interactively

Overlay of Metagenomics Data onto Sequenced Reference Genomes (This Image: Prochloroccocus marinus MED4)



Source: Karin Remington
J. Craig Venter Institute

OptIPuter Scalable Adaptive Graphics Environment (SAGE) Allows Integration of HD Streams



SAGE Developed Under Jason Leigh, EVL

- HD Video from BIRN Trailer
- Macro View of Montage Data
- Micro View of Montage Data
- Live Streaming Video of the RTS-2000 Microscope
- HD Video from the RTS Microscope Room

LambdaCam Used to Capture the Tiled Display on a Web Browser

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evl electronic visualization laboratory

Source: David Lee, NCMIR, UCSD

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

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Extending Telepresence with Remote Interactive Analysis of Data Over NLR

www.calit2.net/articles/article.php?id=660

