Science Drivers For Next Generation Advanced Open Communication Exchange Facilities:

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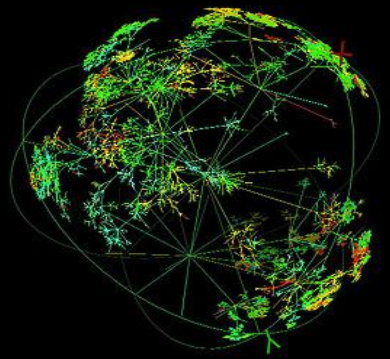
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Co-Director, StarLight, PI-iGENI, PI-OMNINet (www.startap.net/starlight)

Hong Kong Workshop on Next Generation Open Communication Exchanges for Science Research
University of Hong Kong

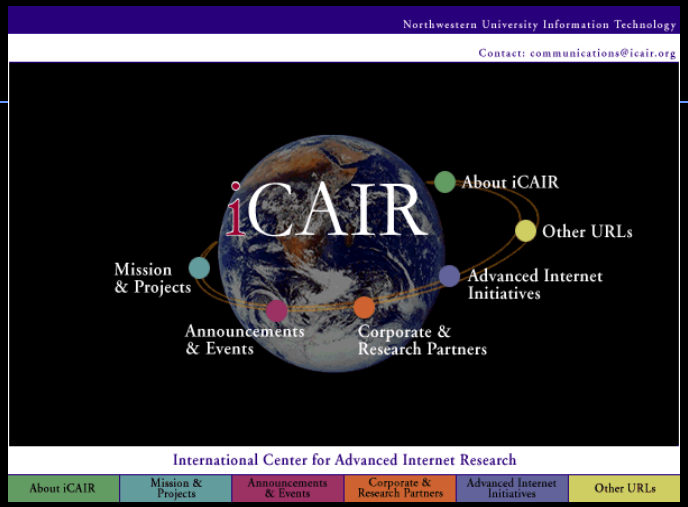
January 18, 2011



iCAIR

STARLIGHT SM

Introduction to iCAIR:



Accelerating Leading Edge Innovation and Enhanced Global Communications through Advanced Internet Technologies, in Partnership with the Global Community

- **Creation and Early Implementation of Advanced Networking Technologies - The Next Generation Internet All Optical Networks, Terascale Networks, Networks for Petascale Science**
- **Advanced Applications, Middleware, Large-Scale Infrastructure, NG Optical Networks and Testbeds, Public Policy Studies and Forums Related to NG Networks**
- **Three Major Areas of Activity: a) Basic Research b) Design and Implementation of Prototypes c) Operations of Specialized Communication Facilities (e.g., StarLight)**

Wider Context: Advanced Communications Research Topics

- **Many Current Topics Could Be Considered "Grand Challenges" In Communications**
  - **Scaling the Internet from A Service For 1-2 Billion Individuals (Current) to 4-6 Billion (Future) and Beyond**
  - **Improving the Current Internet (Creating a "Better Internet," Removing Limitations, Adding Capabilities, Increasing Security, Reliability, etc.)**
  - **Migrating Services from Layer 3 Only to Multi-Layer Services, Including L2.5, L2, L1, e.g., Lightpaths**
  - **Creating the "Internet of Things" (Currently 5 Billion Devices Are Connected – Soon 20 Billion)**
  - **Migration the Internet From Data and Image Services To Rich Multi-Media**
  - **Empowering *Edge* Processes, Applications, and Users**
- ***Creating a Fundamentally New Architecture That Allows for Accomplishing All of These Goals***

Macro Network Science Themes

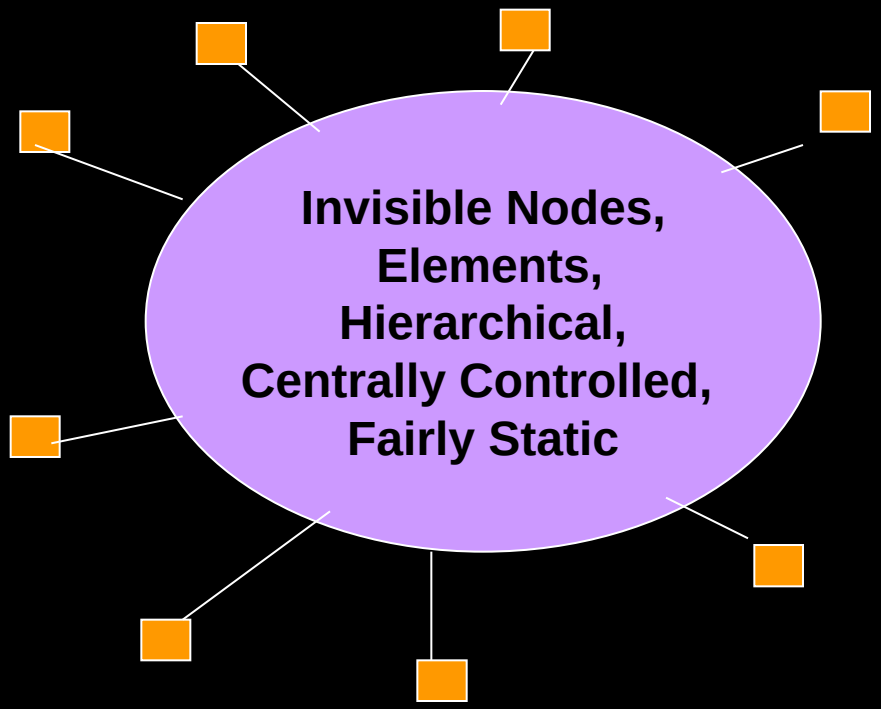
- Transition From Legacy Networks To Networks That Take Full Advantage of IT Architecture and Technology
- Extremely Large Capacity (Multi-Tbps Streams)
- High Degrees of Communication Services Customization
- Highly Programmable Networks
- Network Facilities As Enabling Platforms for Any Type of Service
- Network Virtualization
- Highly Distributed Processes
- The Network Science Community Is Now Designing and Implementing Their Own Distributed Research Facilities

Motivation for New Communications Architecture

- Traditional Networking Architecture and Technology Are Oriented to Supporting A Relatively Few Communications Modalities e.g., Voice, Video, Common Data, for a Very Long Time (Many Years...).
- Traditional Networking Infrastructure Is Too Rigid To Accommodate Changes Quickly
- Traditional Services Are Essentially Based on 19th Century Utility Models of Service and Infrastructure, Which --
  - *Severely Restrict the Inherent Potential of Digital Technology*
  - *Cannot Meet Many Emerging Requirements for 21st Century Services*
- A Fundamentally New Architectural Model is Required
- A New Architecture Replaces The Traditional Network With a New Communication Services Foundation – a Highly Distributed Facility That Can Support Multiple Networks With Different Characteristics Each Supporting Multiple Highly Differentiated Services

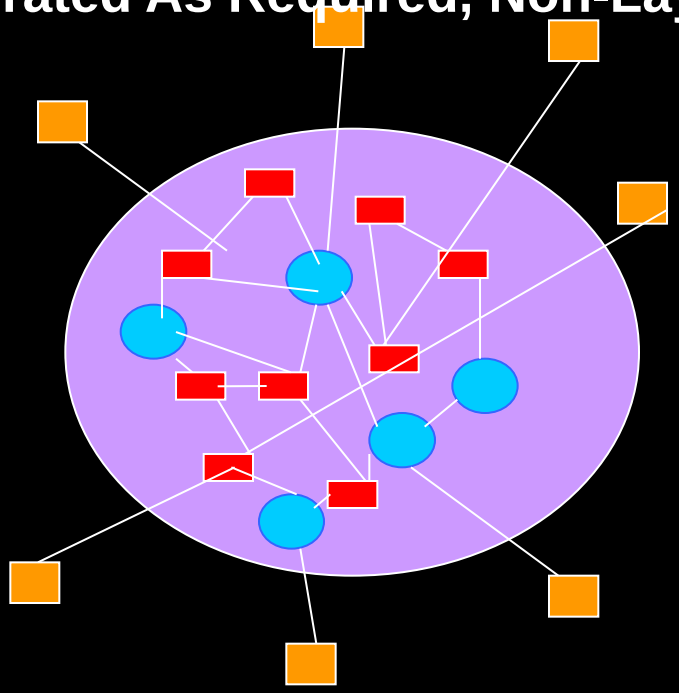
Paradigm Shift – Ubiquitous Services Based on Large Scale Distributed Facility vs Isolated Services Based on Separate Component Resources

Traditional Provider Services:
Invisible, Static Resources,
Centralized Management,
Highly Layered



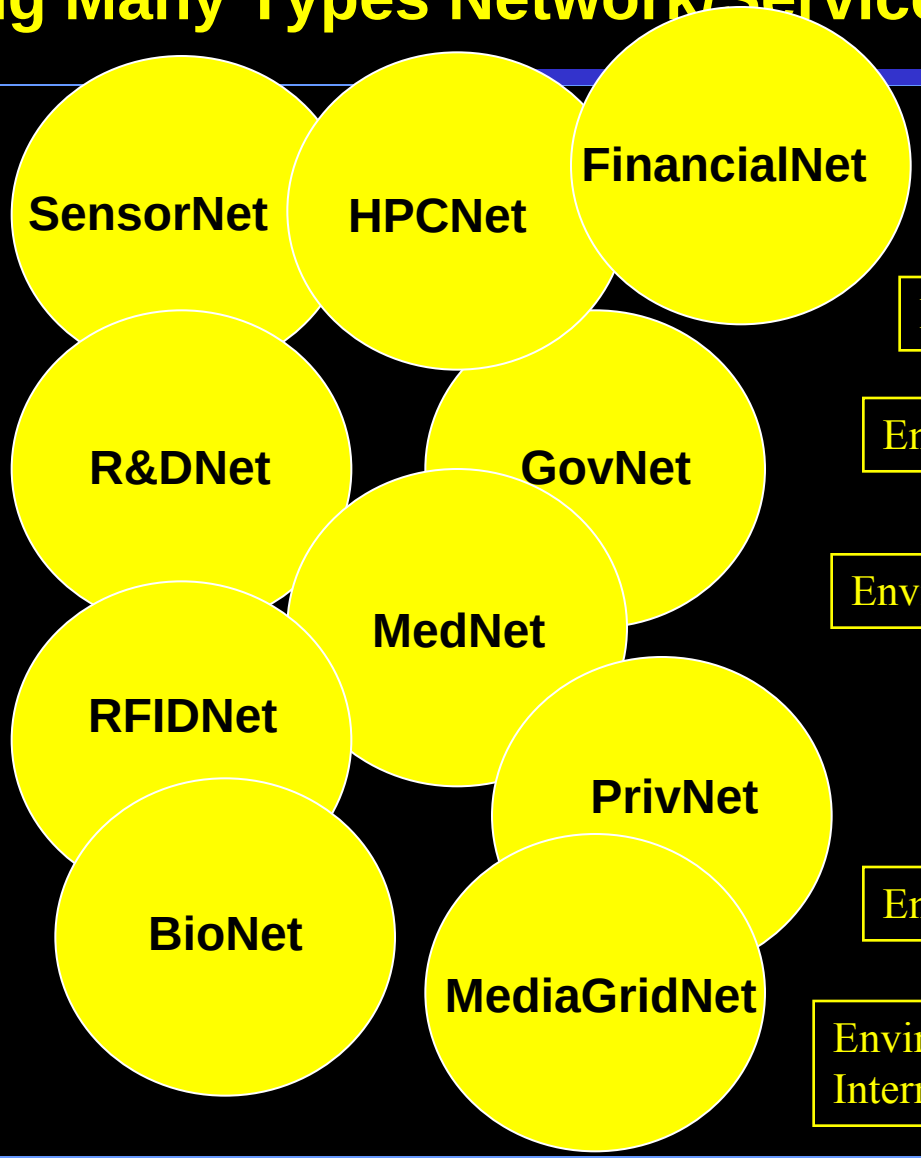
Limited Services, Functionality,
Flexibility, Expandability

Distributed Programmable Resources,
Dynamic Services,
Visible & Accessible Resources,
Integrated As Required, Non-Layered



Unlimited Services, Functionality,
Flexibility, Expandability

A Next Generation Architecture: *Distributed Facility*
Enabling Many Types Network/Services



Environment: VO

Environment: Real Org1

Environment: Intelligent Power Grid Control

Environment: RFIDNet

Environment: Bio Org

Environment: Large Scale System Control

Environment: Global App

Environment: Financial Org

Environment: Sensors

Environment: Real Org

Environment: Real Org2

Environment: Gov Agency

Environment: Control Plane

Environment: Lab

Environment: International Gaming Fabric

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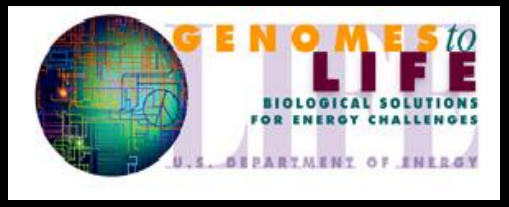
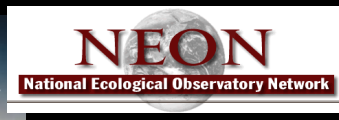
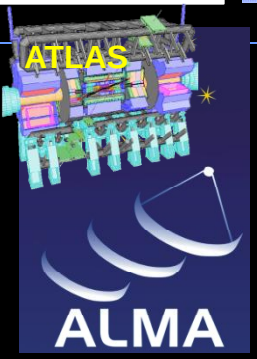
Large Scale Data Intensive Science Motivates the Creation of Next Generation Communications

- Large Scale, Data (and Compute) Intensive Sciences Encounter Technology Challenges Many Years Before Other Domains
- Resolving These Issues Creates Solutions That Later Migrate To Other Domains
- 30+ Year History of Communication Innovations Has Been Driven Primarily By Data and Compute Intensive Sciences
- Best Window To the Future = Examining Requirements of Data and Compute Intensive Science Research
- Science Is Transitioning From Using Only Two Classic Building Blocks, Theory and Experimentation To Also Utilizing a Third – Modeling and Simulation – With Massive Amounts of Data
- Petabytes, Exabytes, Zettabytes
- For Communications, Data Volume Capacity Not Only Issue, But a Major Issue



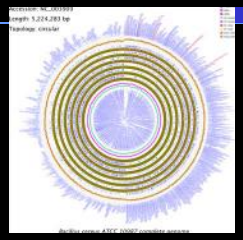




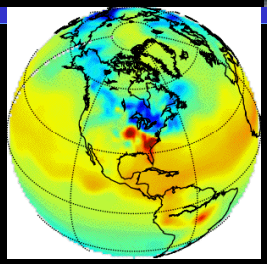
ALMA: Atacama Large Millimeter Array

ANDRILL: Antarctic Geological Drilling
www.andrill.org

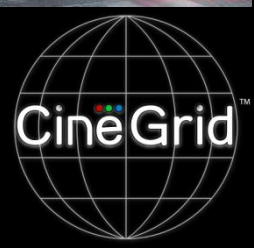
BIRN: Biomedical Informatics Research Network
www.nbirn.net



CAMERA metagenomics
camera.calit2.net

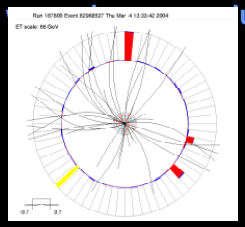


Carbon Tracker
www.esrl.noaa.gov/gmd/ccgg/carbontracker



CineGrid
www.cinegrid.org

LHCONE
www.lhcone.net



DØ (DZero)
www-d0.fnal.gov

GEON: Geosciences Network
www.geongrid.org

GLEON: Global Lake Ecological Observatory Network

OOI-CI
ci.oceanobservatories.org

ISS: International Space Station
www.nasa.gov/station

Comprehensive Large-Array Stewardship System
www.class.noaa.gov

LIGO
www.ligo.org

WLCG
lcg.web.cern.ch/LCG/public/

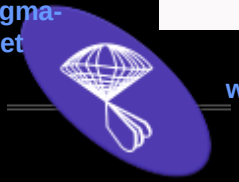
Pacific Rim Applications and Grid Middleware Assembly
www.pragma-grid.net

IVOA: International Virtual Observatory
www.ivoa.net

OSG
www.opensciencegrid.org

Globus Alliance
www.globus.org

SKA
www.skatelescope.org



Sloan Digital Sky Survey
www.sdss.org

TeraGrid
www.teragrid.org

XSEDE
www.xsede.org

Compilation By Maxine Brown

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Petascale Computational Science

For Decades, Computational Science Has Driven Network Innovation
Today –
Petascale Computational Science

BLUE WATERS
SUSTAINED PETASCALE COMPUTING

National Center for Supercomputing Applications, UIUC

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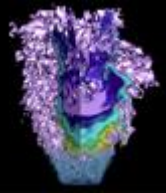
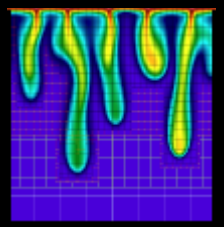
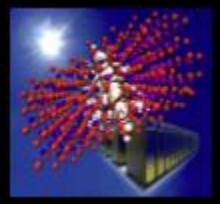
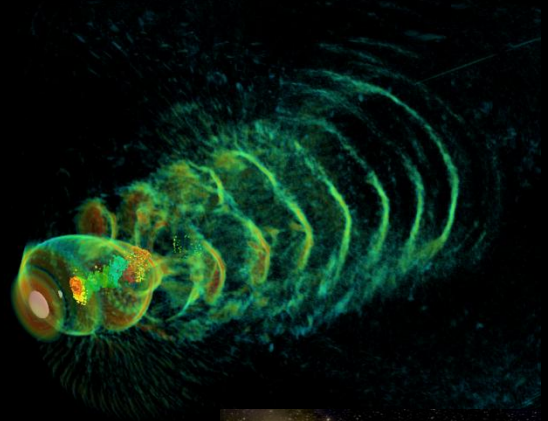
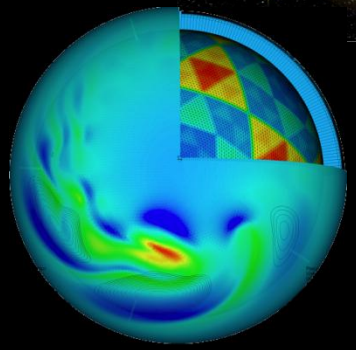
HPC Cloud Computing











DOE Magellan Initiative: Testbed To Explore Cloud Computing For Science

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Multiple HPC Cloud Computing Testbeds Specifically Designed for Science Research

At Scale Experimentation
Integerated With High Performance Networks

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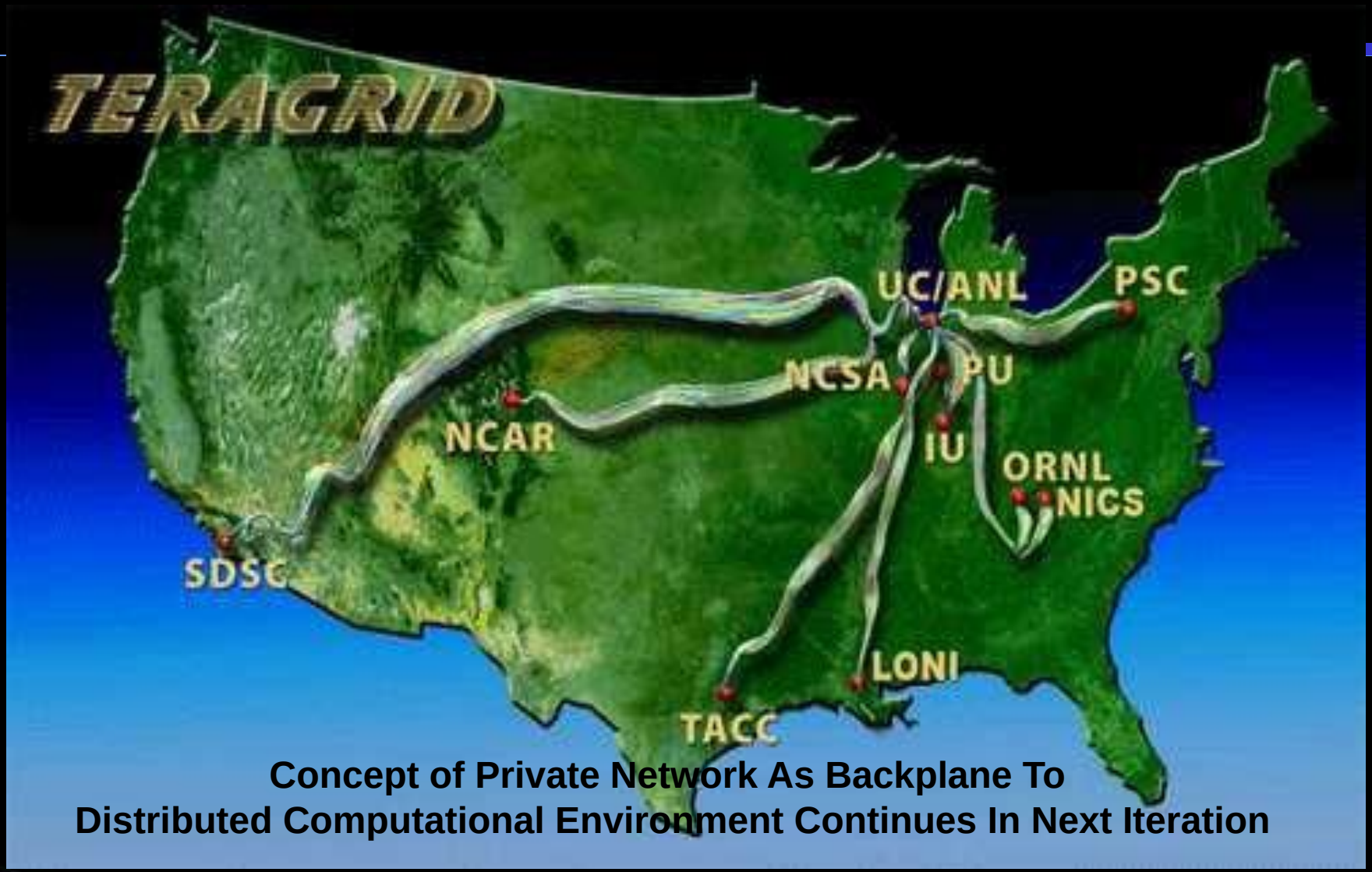
XSEDE

- Extreme Science and Engineering Discovery Environment (XSEDE)
- Goal: Create a Distributed Computational Science Infrastructure to Enable Distributed Data Sharing and High-Speed Computing for Data Analysis and Numerical Simulations
- Builds on Prior Distributed TeraGrid

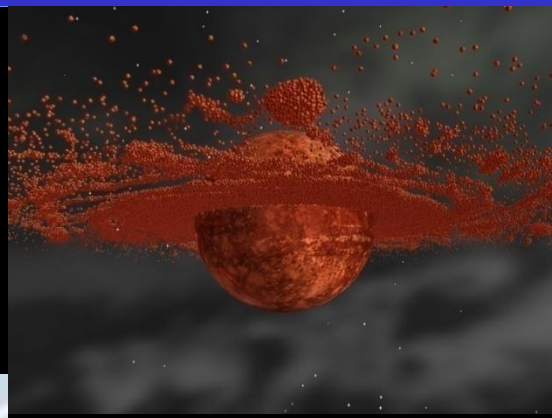
TeraGrid=> XSEDE



Concept of Private Network As Backplane To Distributed Computational Environment Continues In Next Iteration

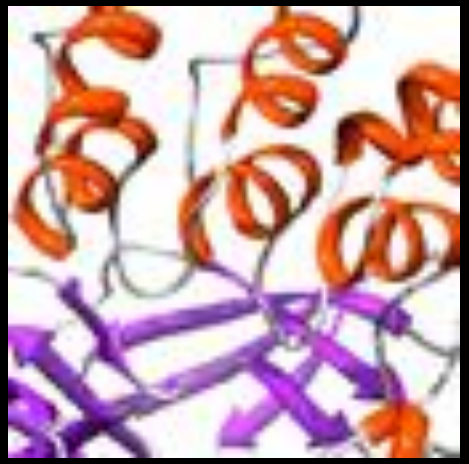
Other Distributed Computational Environments: e.g., Data Reservoir Project

- Goal: Create a Global Grid Infrastructure to Enable Distributed Data Sharing and High-Speed Computing for Data Analysis and Numerical Simulations
- Online 2-PFLOPS System, Became Fully Operational in 2008

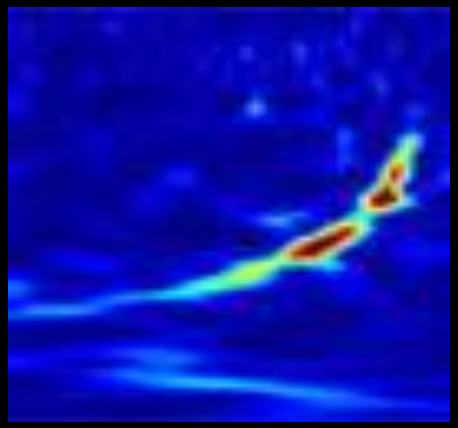


- University of Tokyo, WIDE Project, JGN2 network, APAN, Fujitsu Computer Technologies, NTT Communications, Japan
- Chelsio Communications
- StarLight, PNWGP, IEEAF, USA
- CANARIE, Canada
- SURFnet, SARA and University of Amsterdam, The Netherlands

Open Science Grid: Selected Investigations

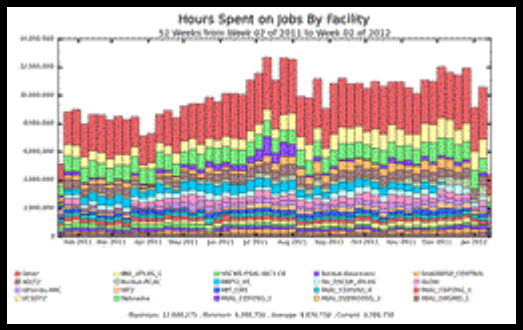


DNA Modeling



Gravity Wave Modeling

Nutrino Studies



Usage

Open Science Grid

This Distributed Facility
Supports Many Sciences

HEP = Staggering Amounts of Data

BaBar 0.3 PetaByte/year (2001)

CDF or D0 Run II

0.5 PetaByte/year (2003)

LHC Mock Data Challenge
1 PetaByte/year (~2005)

CMS or ATLAS

2 PetaBytes/year (~2008)

KTeV 50 TeraBytes /year (1999)

SLD 3 TB /year (1998)

Run I (CDF or D0) 20 TB /year (1995)

L3 5 TB /year (1993)

E791 50 TB /year (1991)

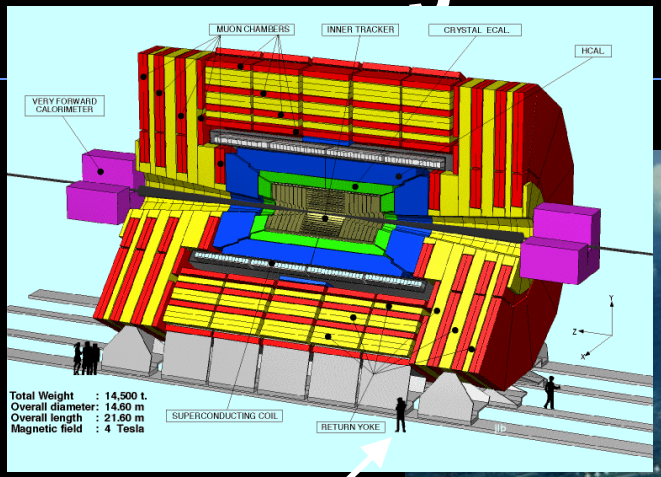
EMC 400GB /year (1981)

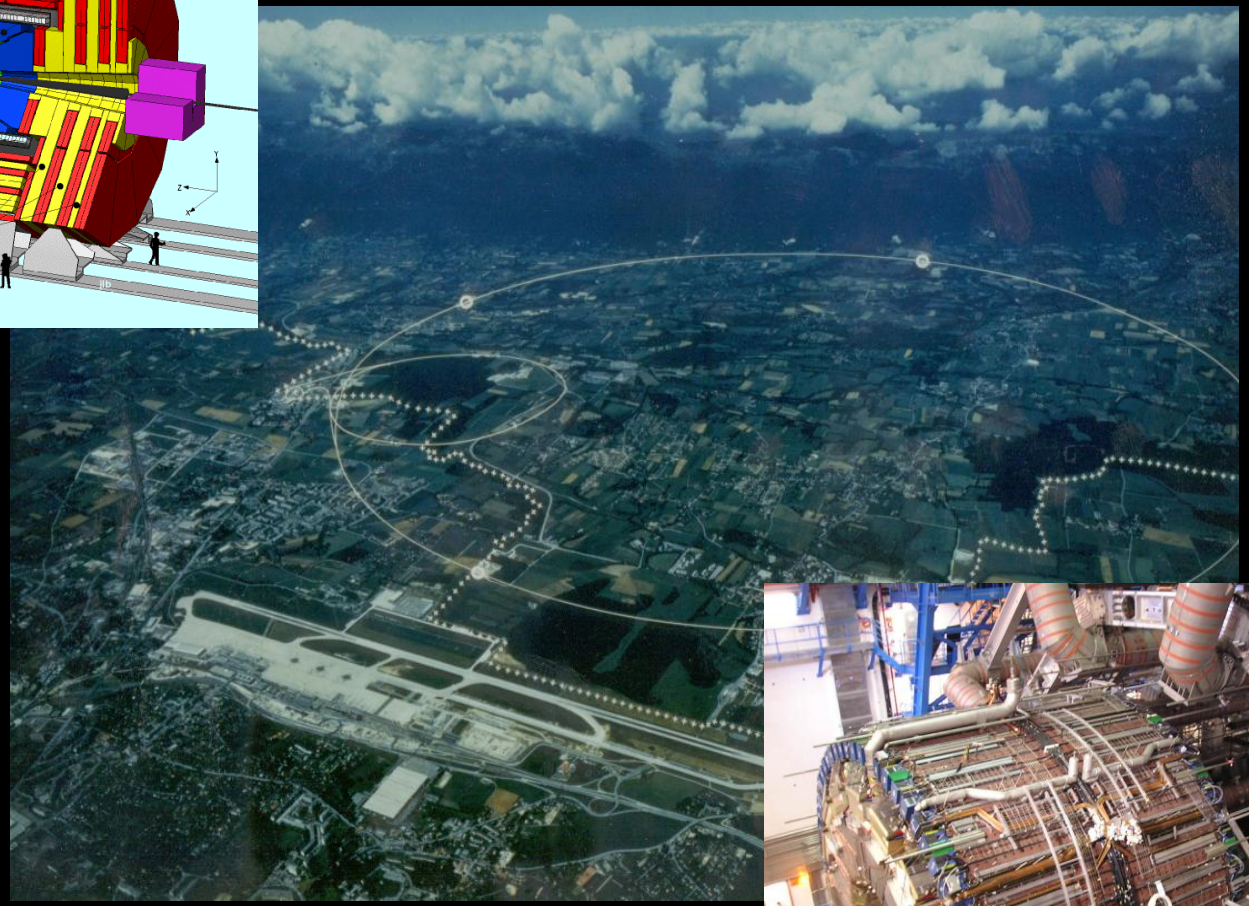
In 1977 the Upsilon (bottom quark) was discovered at Fermilab by experiment E288 led by now Nobel laureate Leon Lederman

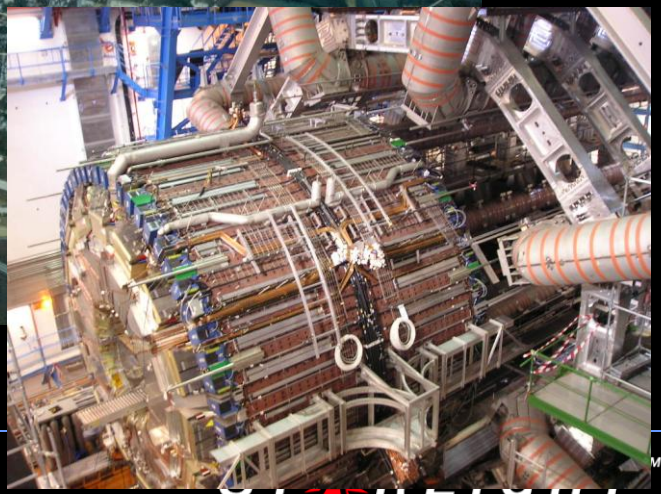
The experiment took about 1 million events and recorded the raw data on ~ 300 magnetic tapes for about 6 GB of raw data

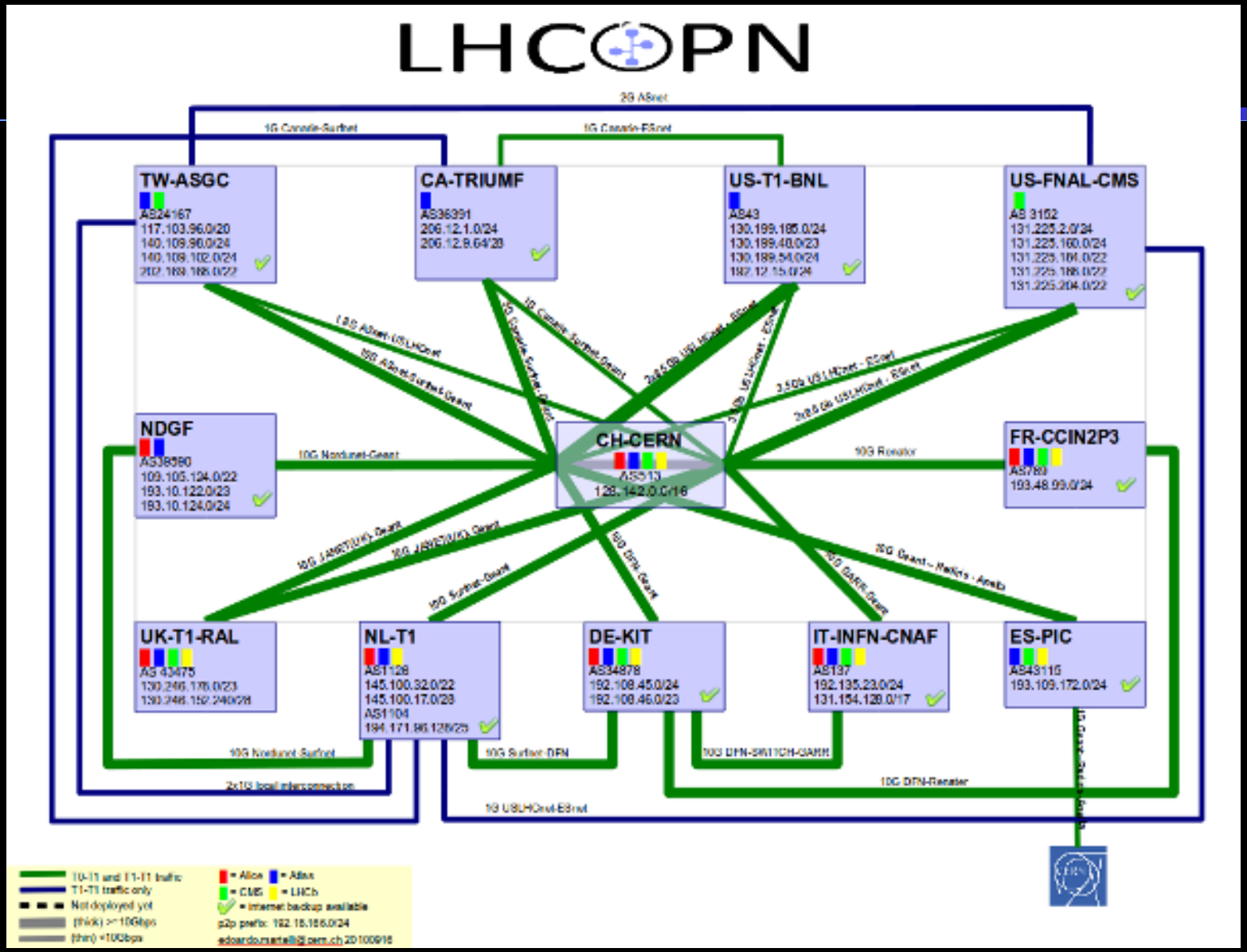
Source: Fermi Lab

Large Hadron Collider at CERN








LHCOPN
2G ASnet
1G Canada-Surfnet
1G Canada-ESnet
TW-ASGC
AS24167
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10G Renater
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IT-INFN-CNAF
AS137
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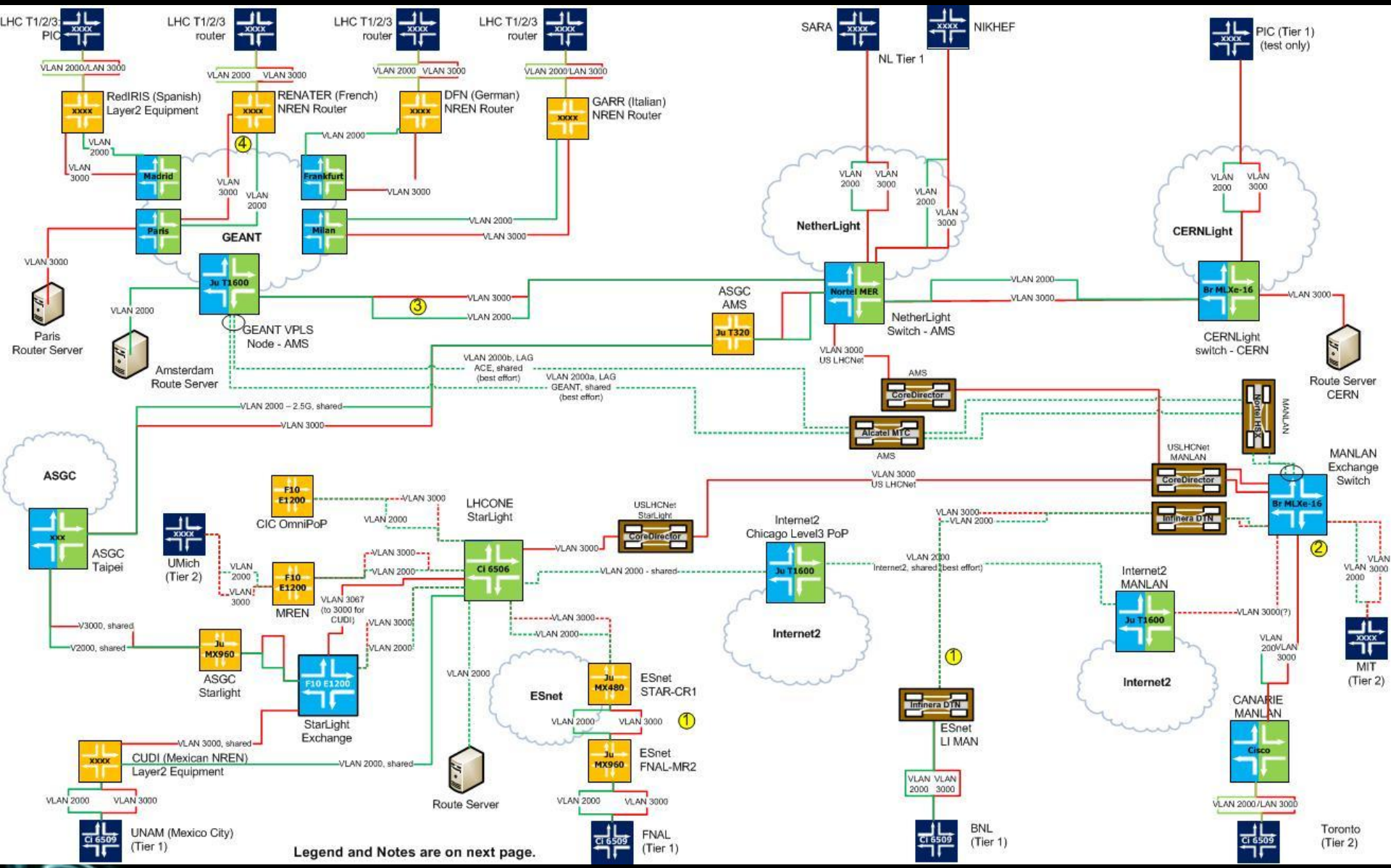
131.154.128.0/17
ES-PIC
AS43115
193.109.172.0/24
10G Nordunet-Surfnet
10G Surfnet-DFN
10G DFN-SWITCH-GARR
10G DFN-Renater
2x10 local interconnection
10 USLHCnet-ESnet
T0-T1 and T1-T1 traffic
T1-T1 traffic only
Not deployed yet
(thick) >= 10Gbps
(thin) <10Gbps
= Alice
= Atlas
= CMS
= LHCb
= Internet backup available
p2p prefix: 192.16.166.0/24
edoardo.martelli@cern.ch 20100916



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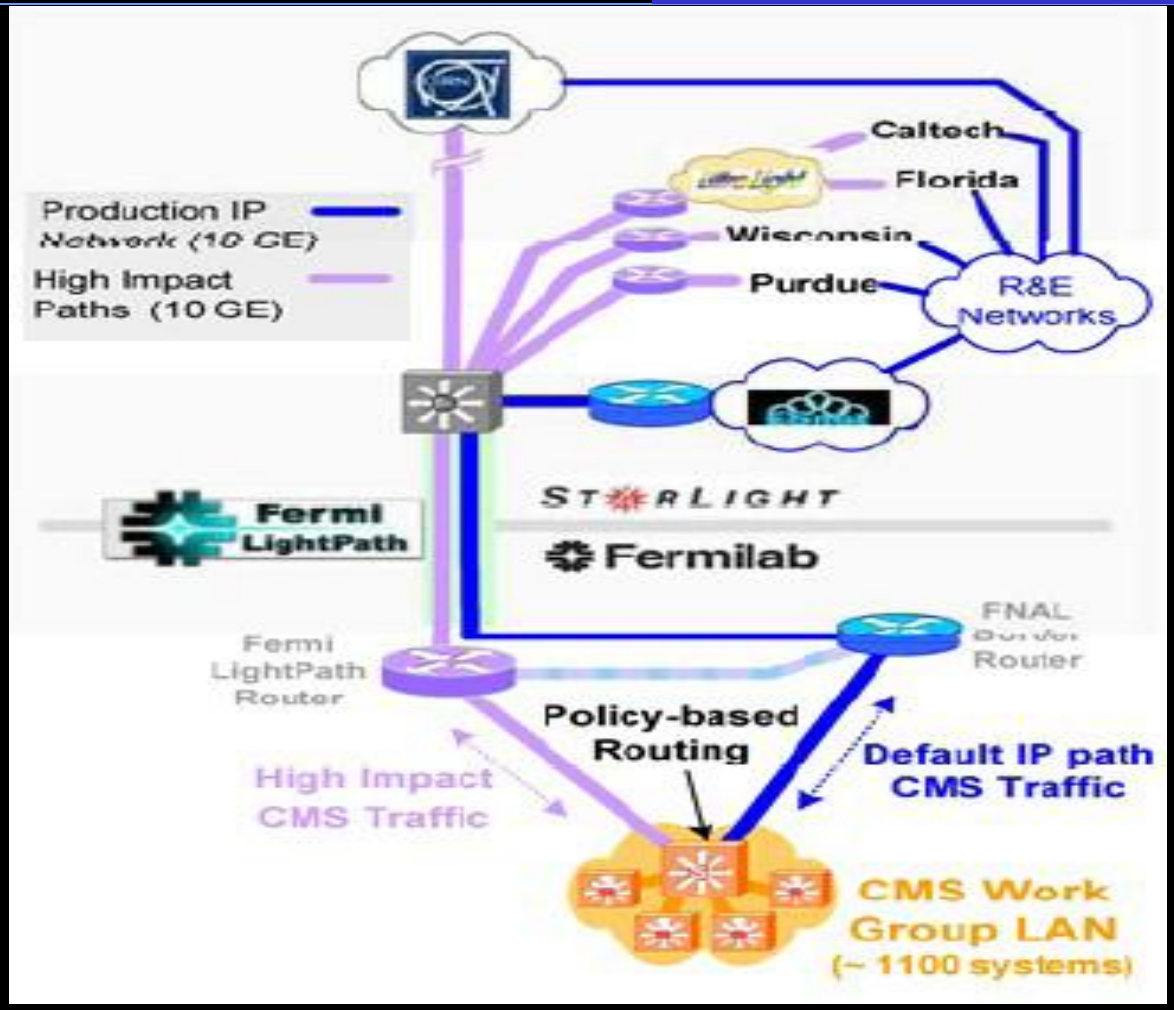
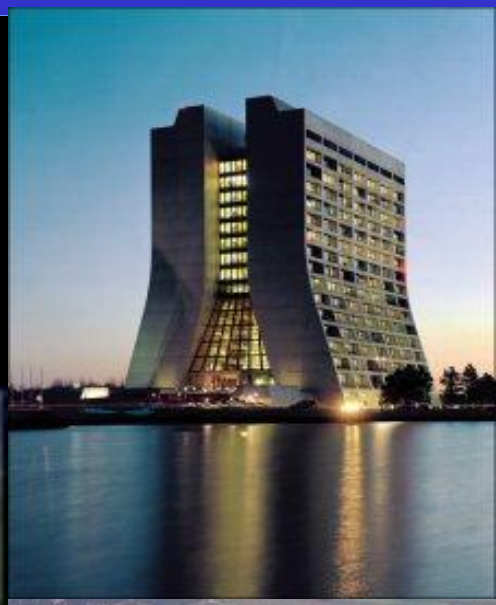
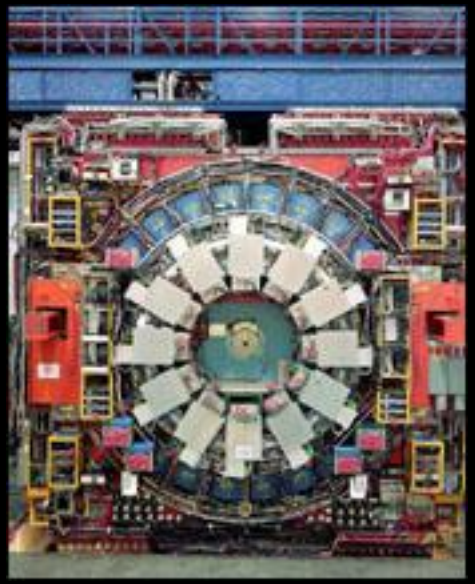

Caltech
Florida
Wisconsin
Purdue
R&E Networks
Production IP
Network (10 GE)
High Impact
Paths (10 GE)
Fermi LightPath
STARLIGHT
Fermilab
FNAL
Router
Fermi
LightPath
Router
Policy-based
Routing
Default IP path
CMS Traffic
High Impact
CMS Traffic
CMS Work
Group LAN
(~ 1100 systems)

Fermi National Accelerator Laboratory

Fermi LightPath

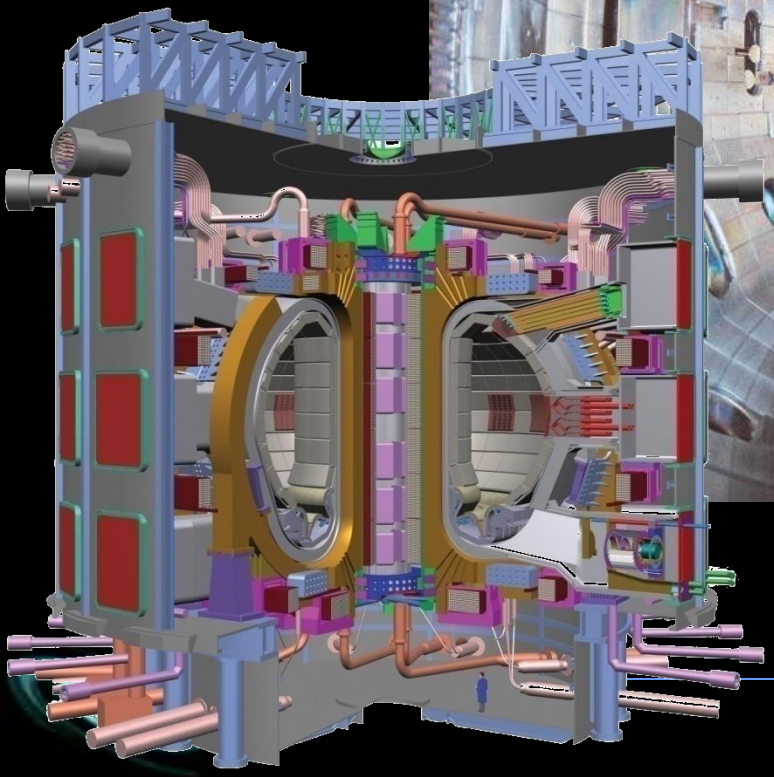
35 Mile LAN PHY to StarLight





Magnetic Fusion Energy

New Sources
Of Power



Source: DOE

Source: DOE

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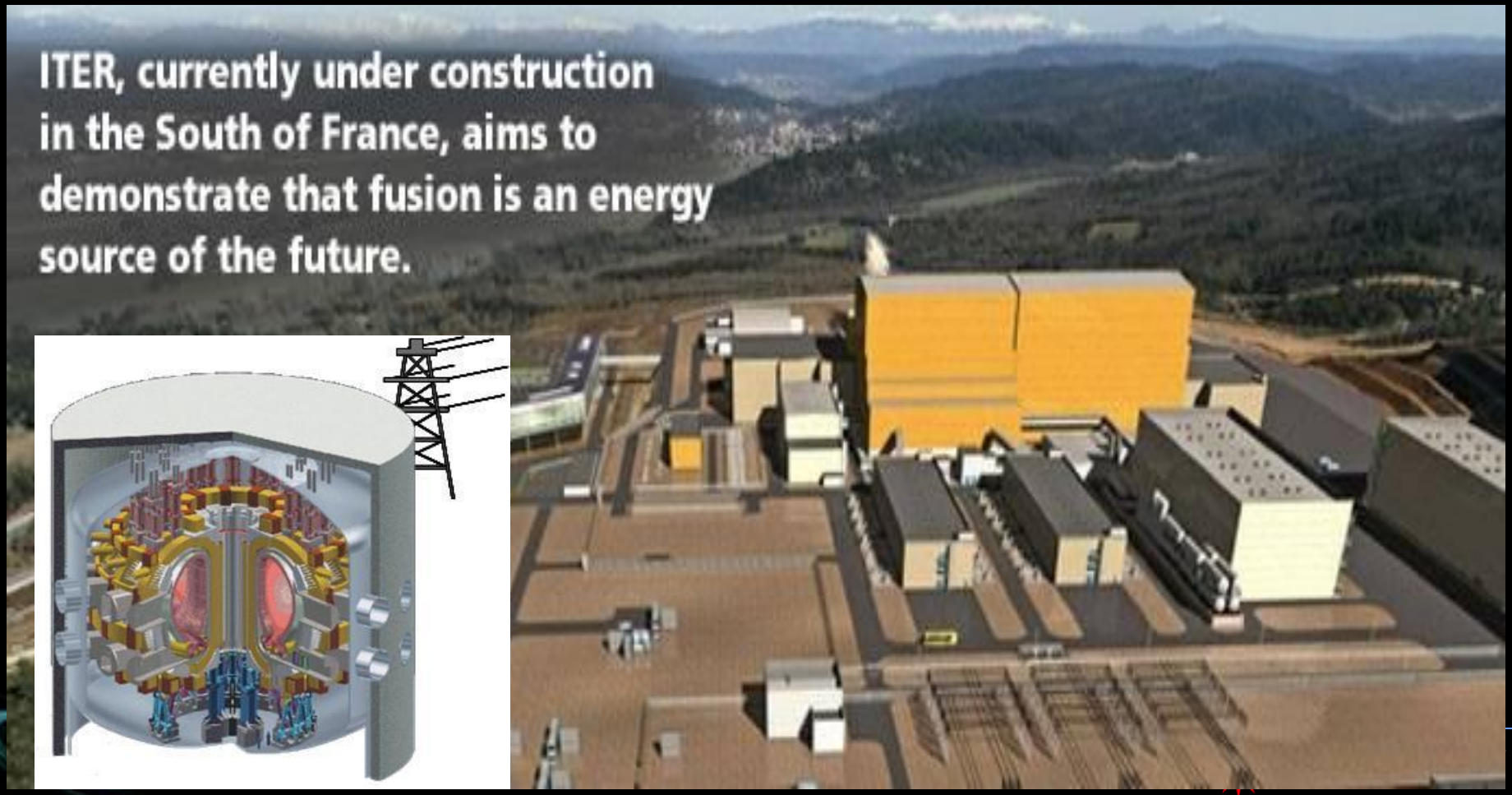
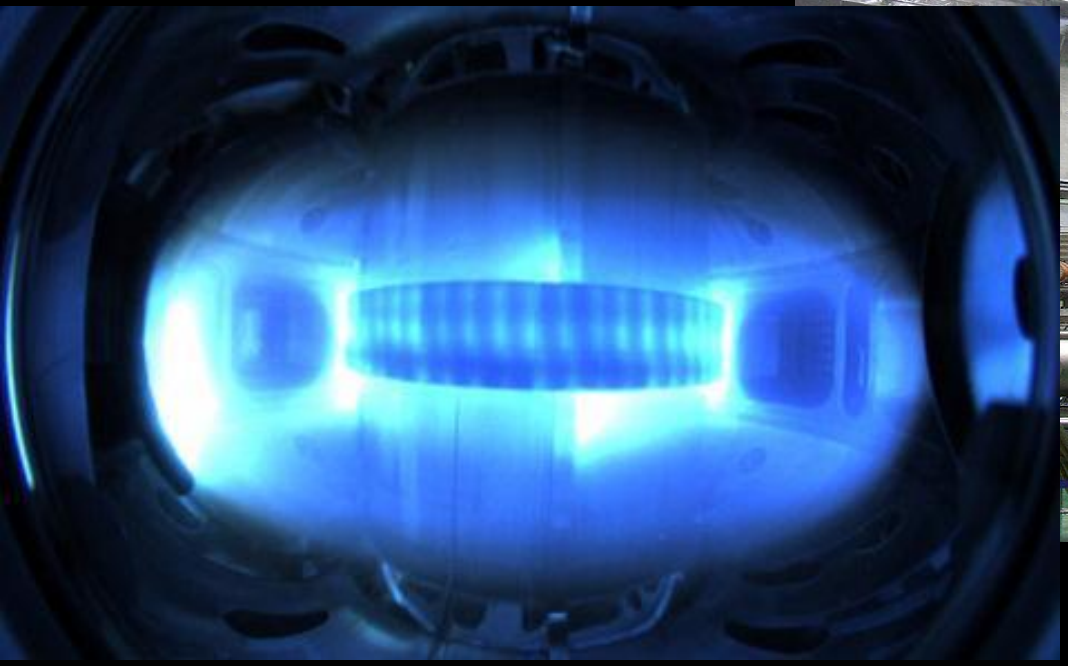
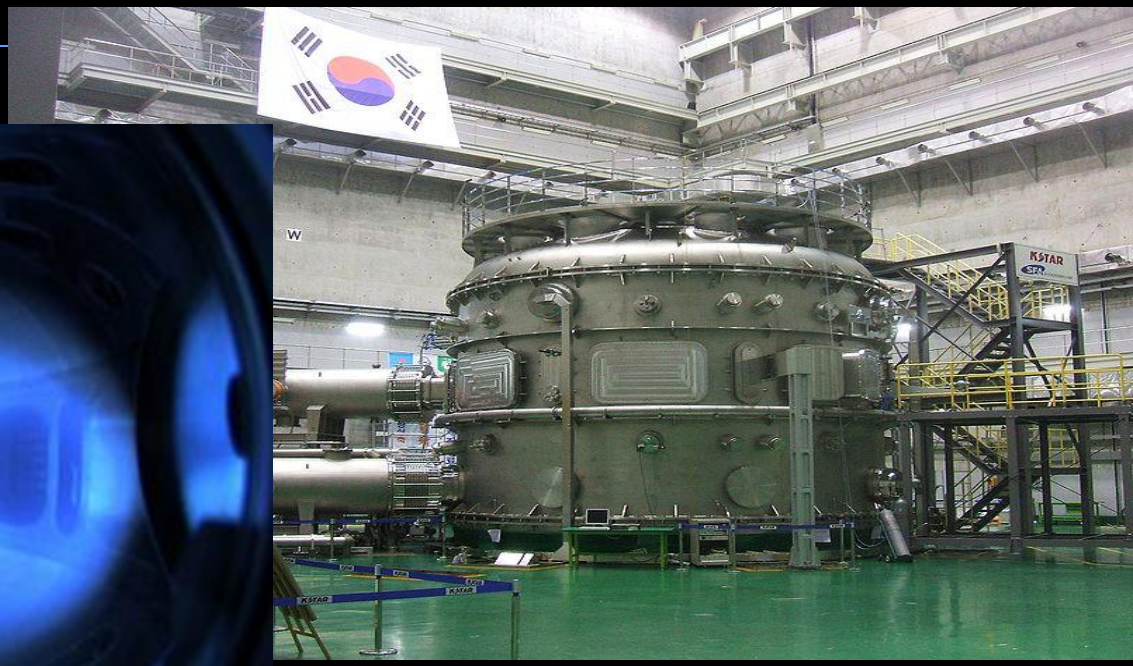
ITER (Formally- International Thermonuclear Experimental Reactor)

- **ITER Is One of the World's Largest and Most Ambitious International Science Project Extremely Data Intensive**



Fusion Energy Research





KSTAR, or Korea Superconducting Tokamak Advanced Research: Magnetic Fusion Device At the National Fusion Research Institute in Daejon, South Korea. KSTAR Is Providing Major Contributions To ITER.

Investigations Based On Synchrotronic Light Sources

- BIOXHIT Will Set Standards for Macromolecular Crystallography Beamlines For All Synchrotron Sources in Europe
- Diamond (New UK synchrotron Under construction)
- Third Generation Advanced Photon Source at Argonne National Laboratory, Near Chicago

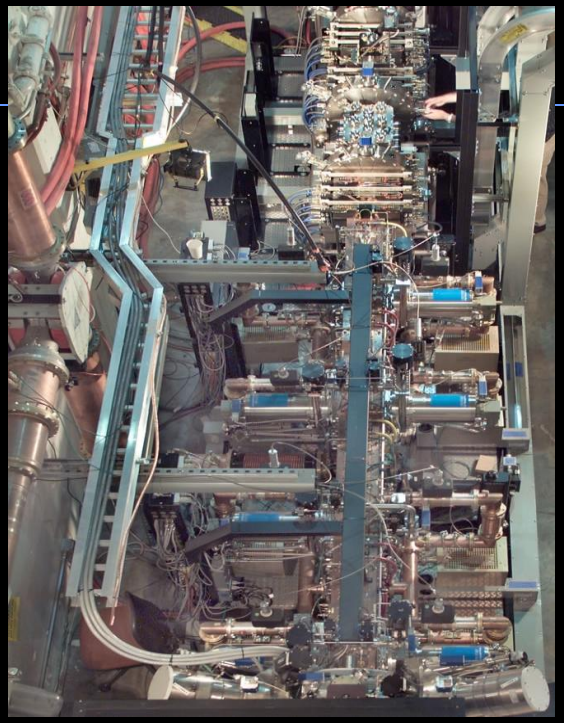
BIOXHIT

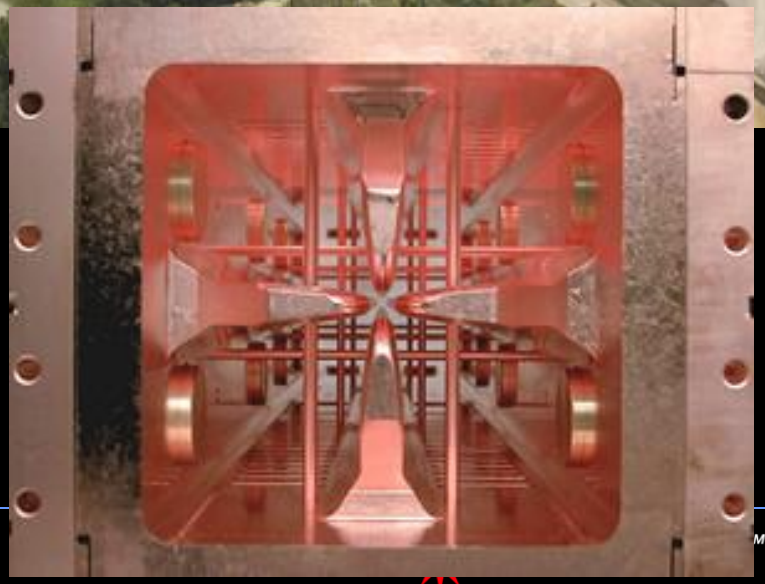
Diamond

ANL APS

Many Others Have Been Built and Are Planned

Spallation Neutron Source (SNS) at ORNL





Neutron Beams Are Directed At Different Types of Materials To Investigate Their Atomic Properties, Including Structures

iCAIR

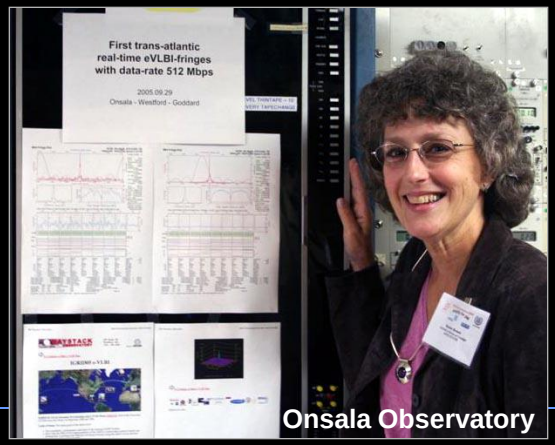
Source: DOE

Real-Time Global e-Very Long Baseline Interferometry

DRAGON (Dynamic Resource Allocation via GMPLS Optical Networks)

- Mid Atlantic Crossroads (MAX) GigaPoP, USA
- Information Sciences Institute, USA
- Westford Observatory, MIT Haystack, USA
- Goddard Geophysical and Atmospheric Observatory, NASA, USA
- Kashima, NiCT, Japan
- Onsala, Sweden
- Jodrell Bank, UK
- JIVE, The Netherlands
- Westerbork, Observatory/ ASTRON, The Netherlands

Real-time e-VLBI data correlation from telescopes in USA, Sweden, the Netherlands, UK and Japan



Onsala Observatory

http://dragon.maxgigapop.net

STARLIGHT SM

The Australia to Netherlands Lightpath Route

Credit: EXPReS

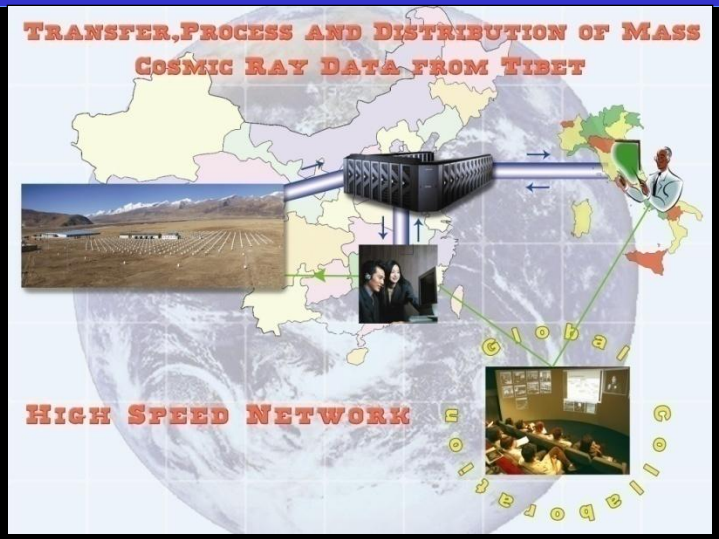
iCAIR

STARLIGHT SM

eVLBI JIVE-Arecibo Project

Yangbajing (YBJ) International Cosmic Ray Observatory
Chinese/Italian Collaboration

- ARGO-YBJ Project: a Sino-Italian Cooperation In the Tibetan Highland, Became Fully Operational in 2007
- Researching Origin of High-Energy Cosmic Rays
- Generates More Than 200 Terabytes of Raw Data Per Year, Being Transferred from Tibet to the Beijing Institute of High Energy Physics, Processed and Made Available to Physicists Worldwide



- Chinese Academy of Sciences (CAS), China
- Istituto Nazionale di Fisica Nucleare, Italy

http://argo.ihep.ac.cn

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STARLIGHT℠

Square Kilometer Array

Square Kilometer Array

Computational Astrophysics

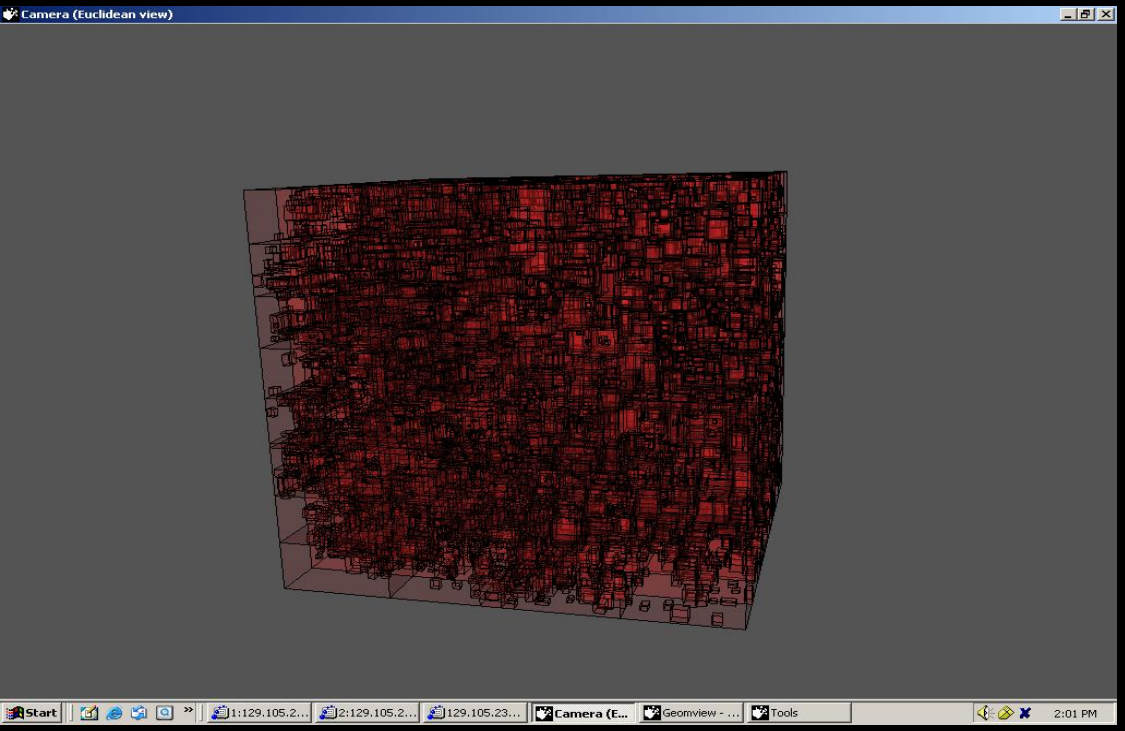
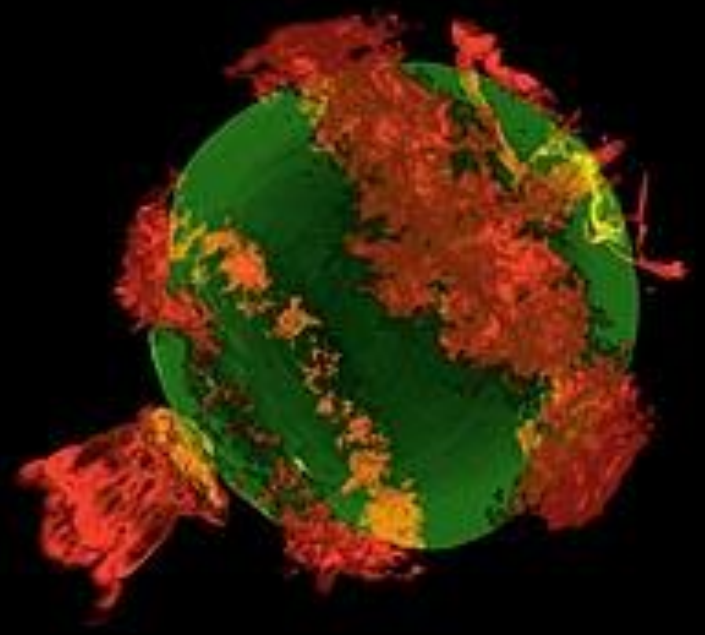


Image Source Code: Mike Norman, UCSD



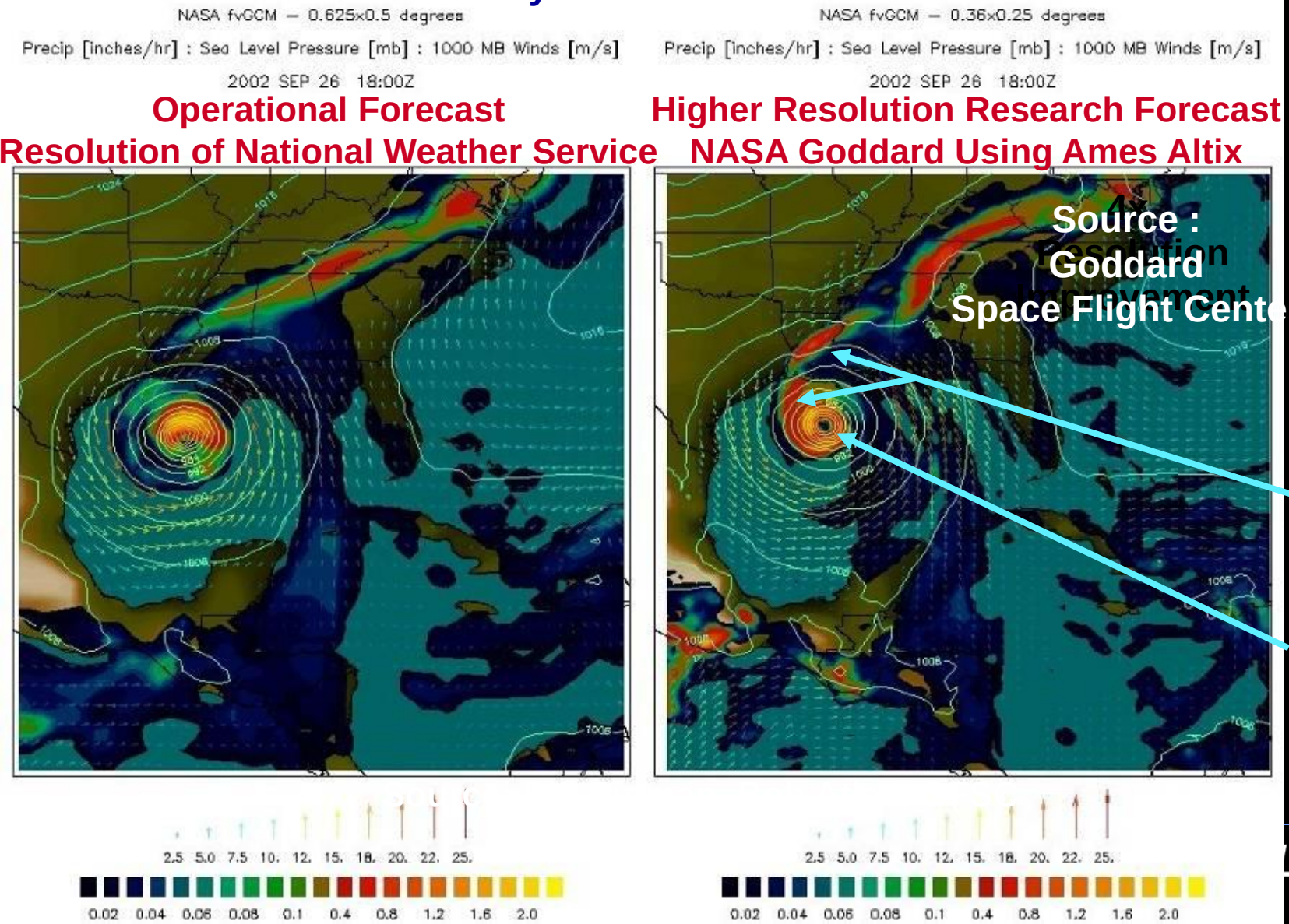
Super Nova NASA

iCAIR

STARLIGHT SM

Increasing Accuracy in Hurricane Forecasts
Ensemble Runs With Increased Resolution

5.75 Day Forecast of Hurricane Isidore



Operational Forecast Resolution of National Weather Service

Higher Resolution Research Forecast NASA Goddard Using Ames Altix

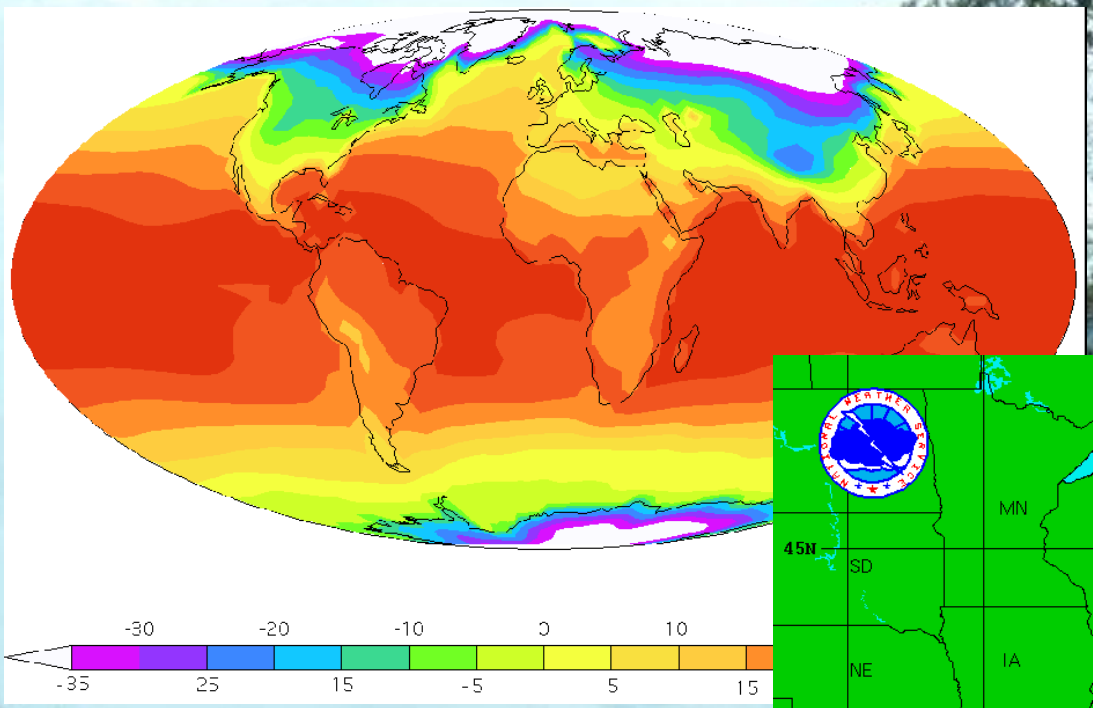
Source : Goddard Space Flight Center

Intense Rain-Bands

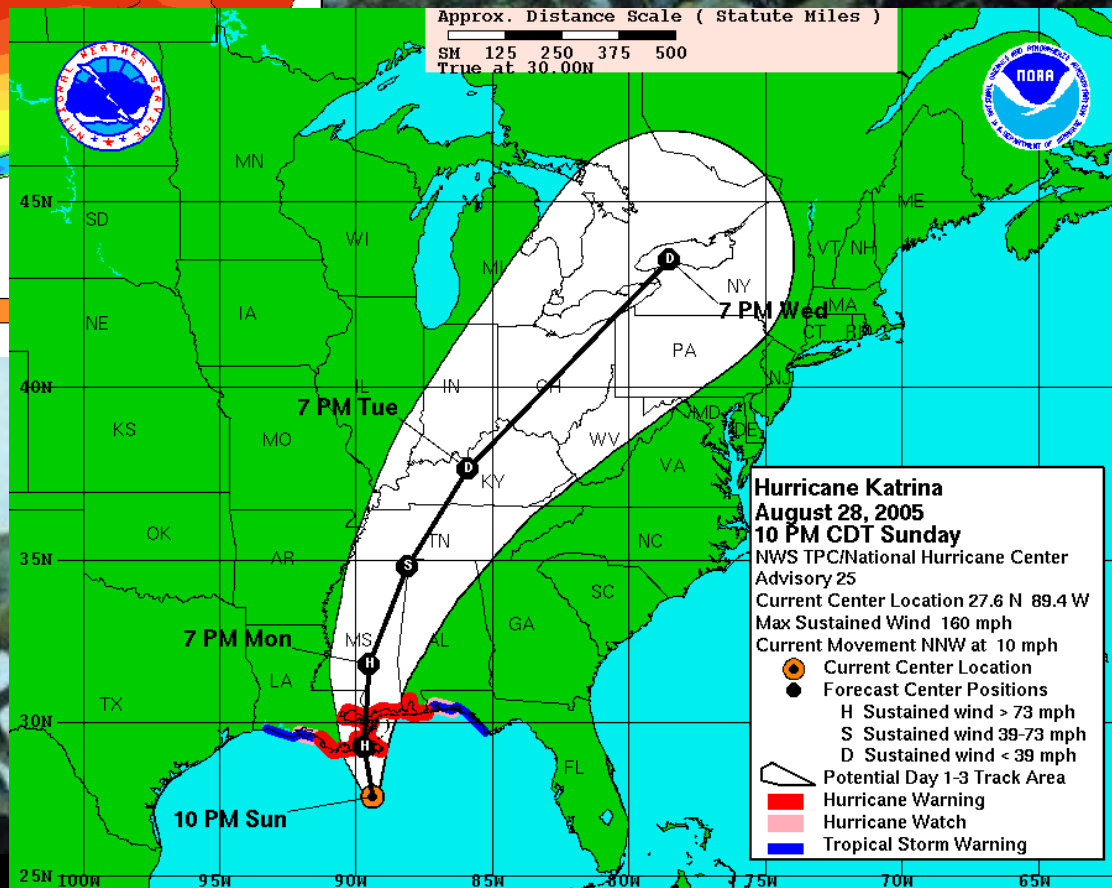
Resolved Eye Wall

LIGHT℠

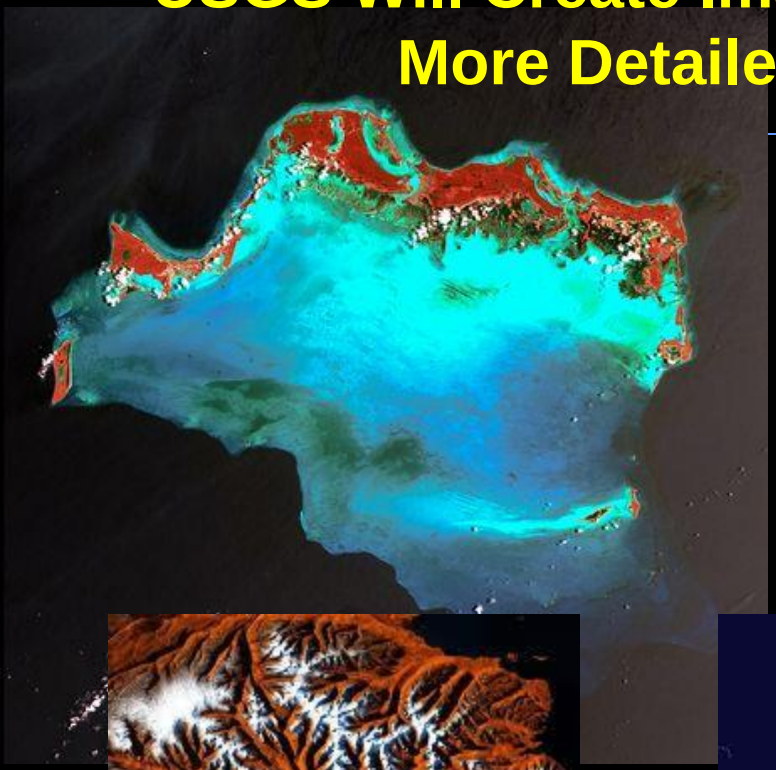
Climate Modeling

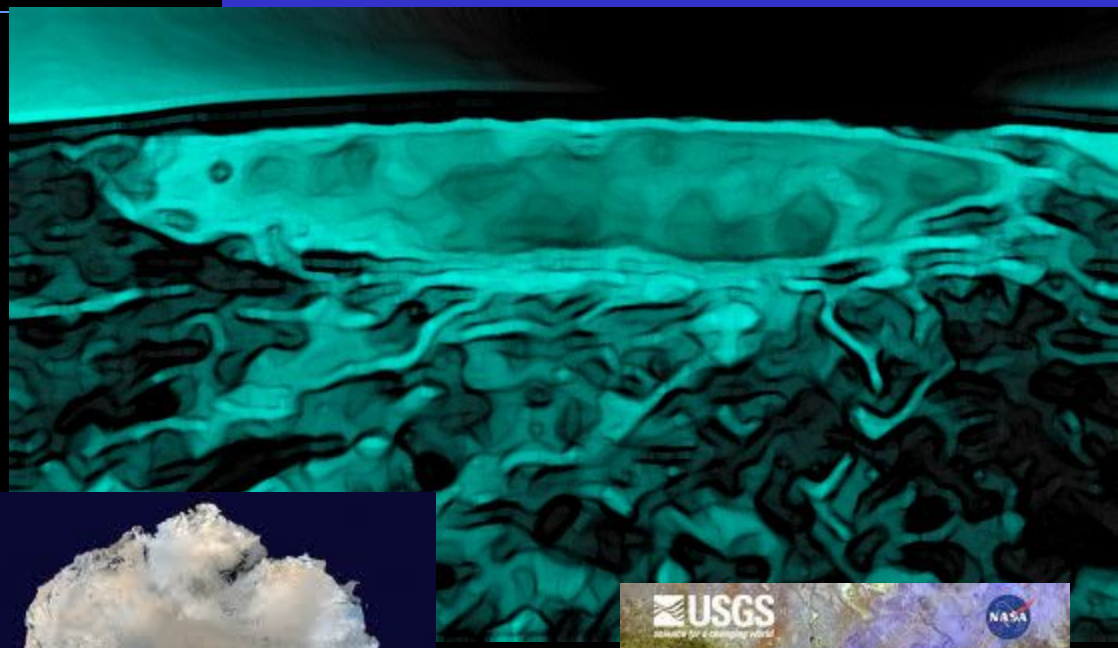


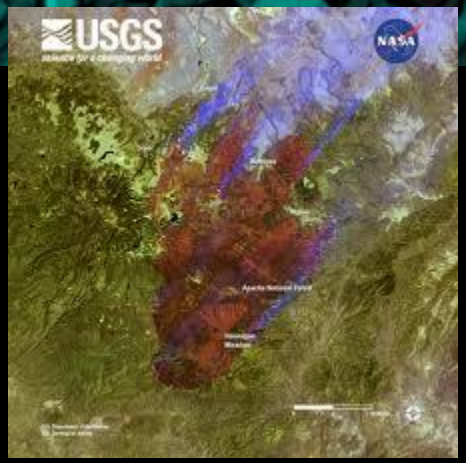
Source: DOE



USGS Will Create Images Many Thousands Of Times More Detailed With Landsat 8 In 2013





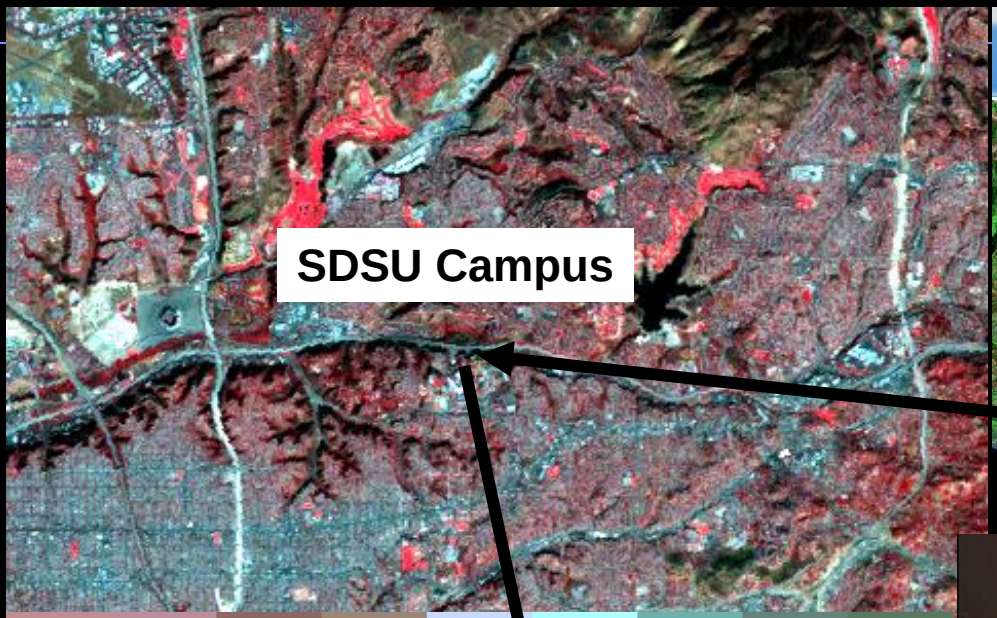


Resolution Can Be Less Than 6 inches

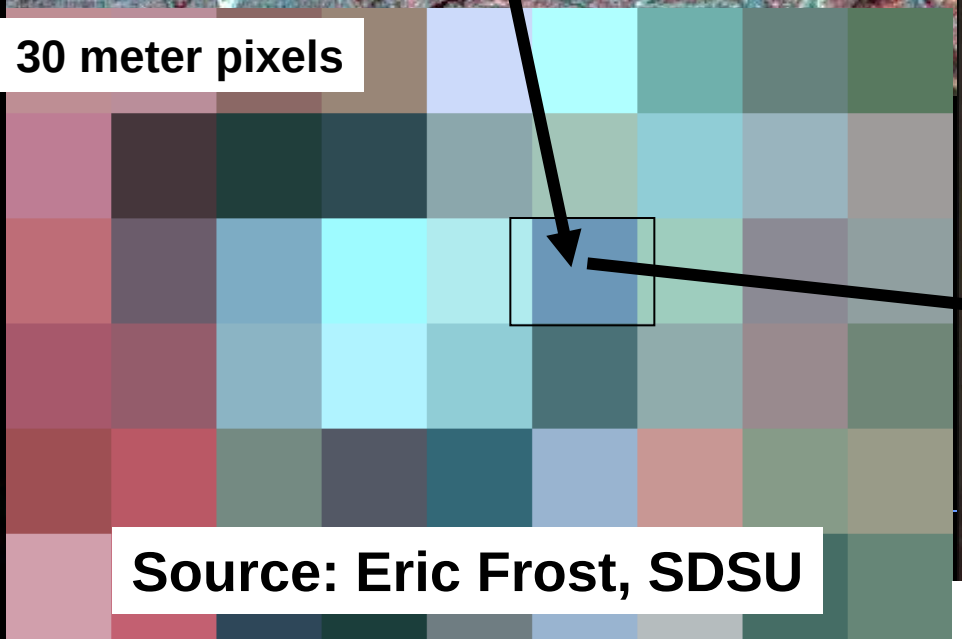
Source: EVL, UIC

STARLIGHT℠

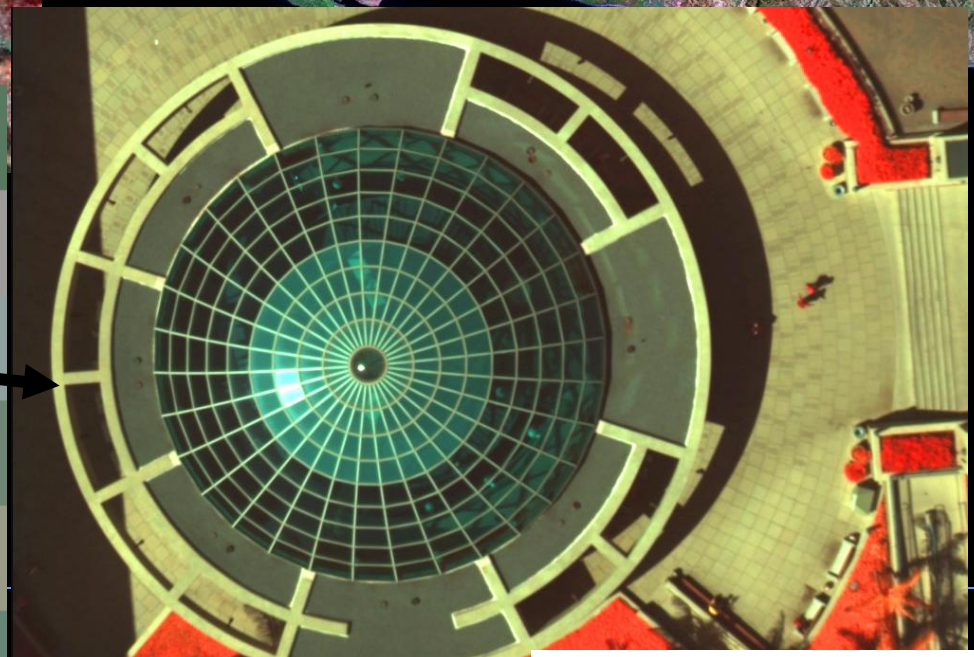
Aerial Imaging is >500,000 Times More Detailed than Landsat7



30 meter pixels



Source: Eric Frost, SDSU

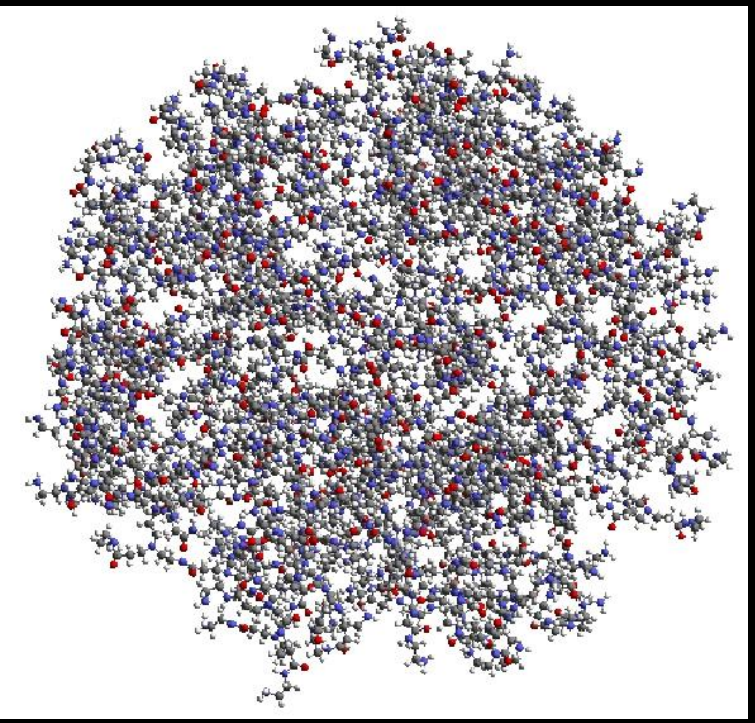


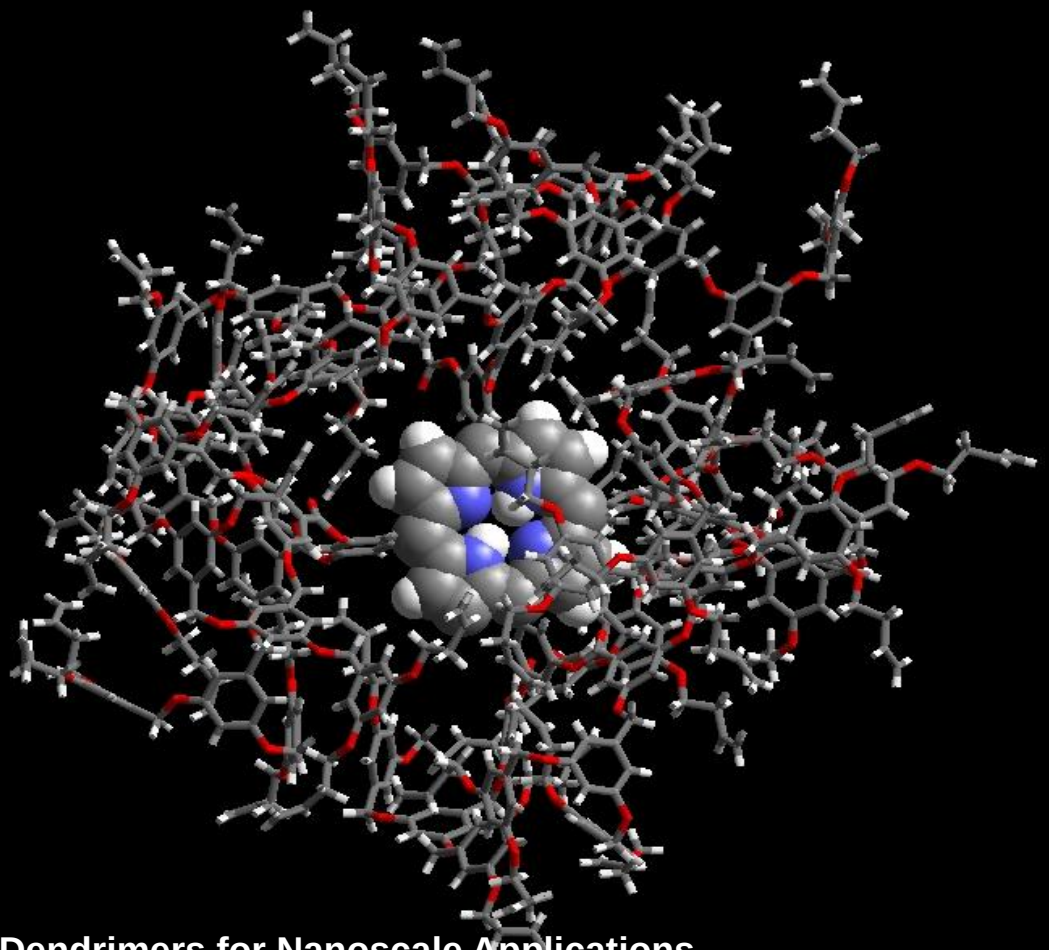
Laurie Cooper, SDSU

4 centimeter pixels

Large Scale Multi-National Molecular Modeling

Interactive
Molecular Dynamics
Simulations At Scale





Molecular Modeling of Dendrimers for Nanoscale Applications
By Tahir Cagin*, Guofeng Wang, Ryan Martin, and William A. Goddard III California Institute of Technology, Materials and Process Simulation Center and Division of Chemistry and Chemical Engineering

Source: UCL

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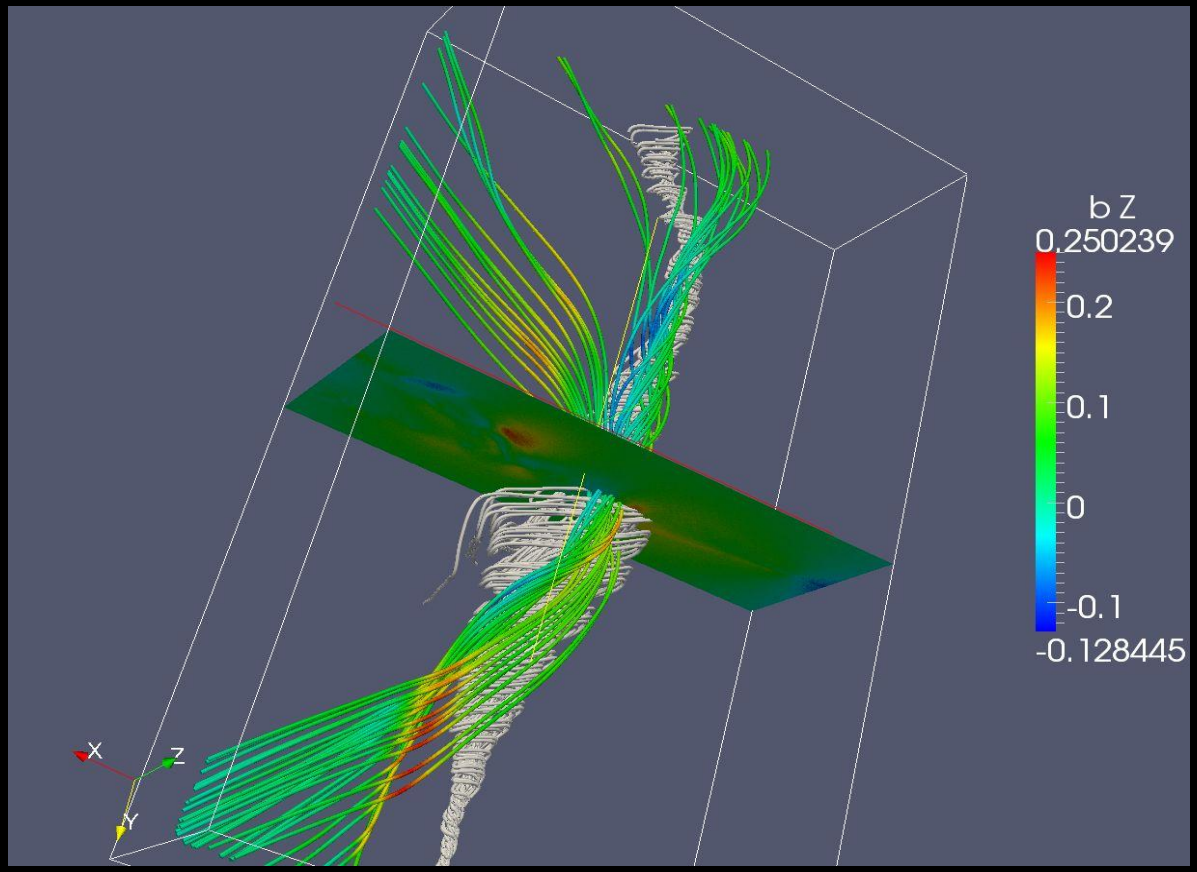
Modeling Fundamental Properties



Characterizing how turbulence within sheets of electrons generates structures
"Flux ropes" from simulations by Homa Karimabadi and Collaborators UCSD

The Crisis Response Room of the Future

SHD Streaming TV -- Immersive Virtual Reality – 100 Megapixel Displays

Source: EVL, UIC

STARLIGHT SM

Brain Imaging Collaboration -- UCSD & Osaka Univ. Using Real-Time Instrument Steering and HDTV

Most Powerful Electron Microscope in the World - - Osaka, Japan

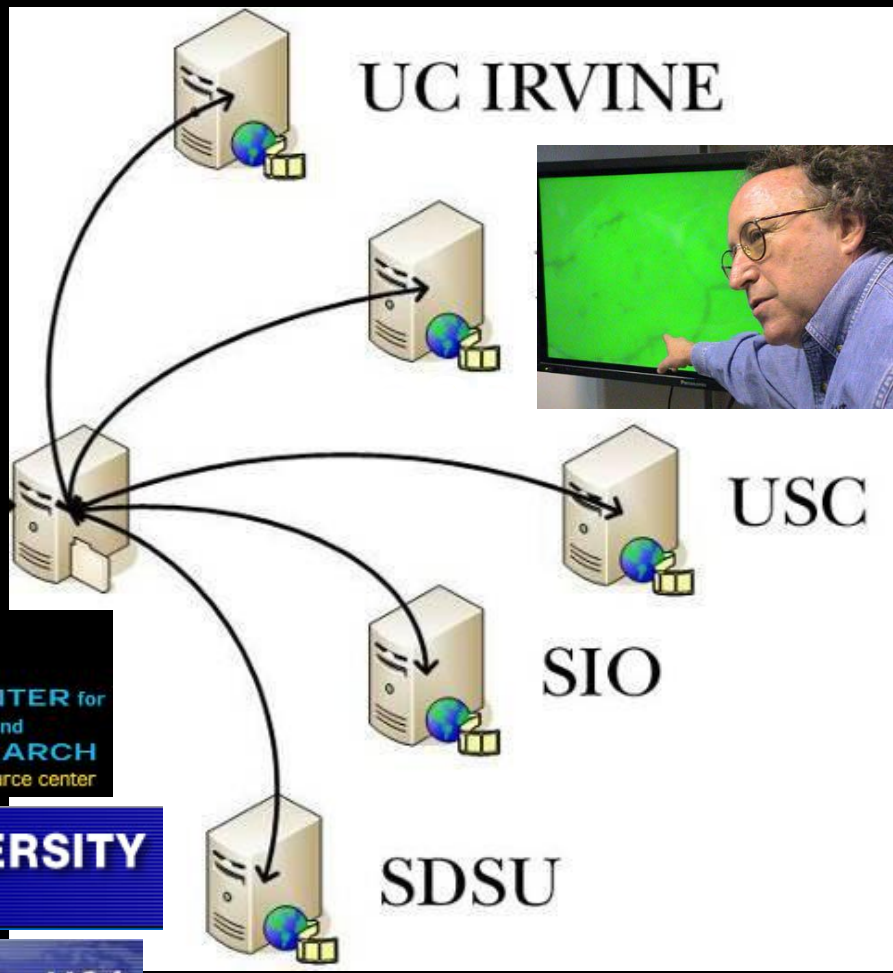
HDTV

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

OSAKA UNIVERSITY

KDDI Labs USA

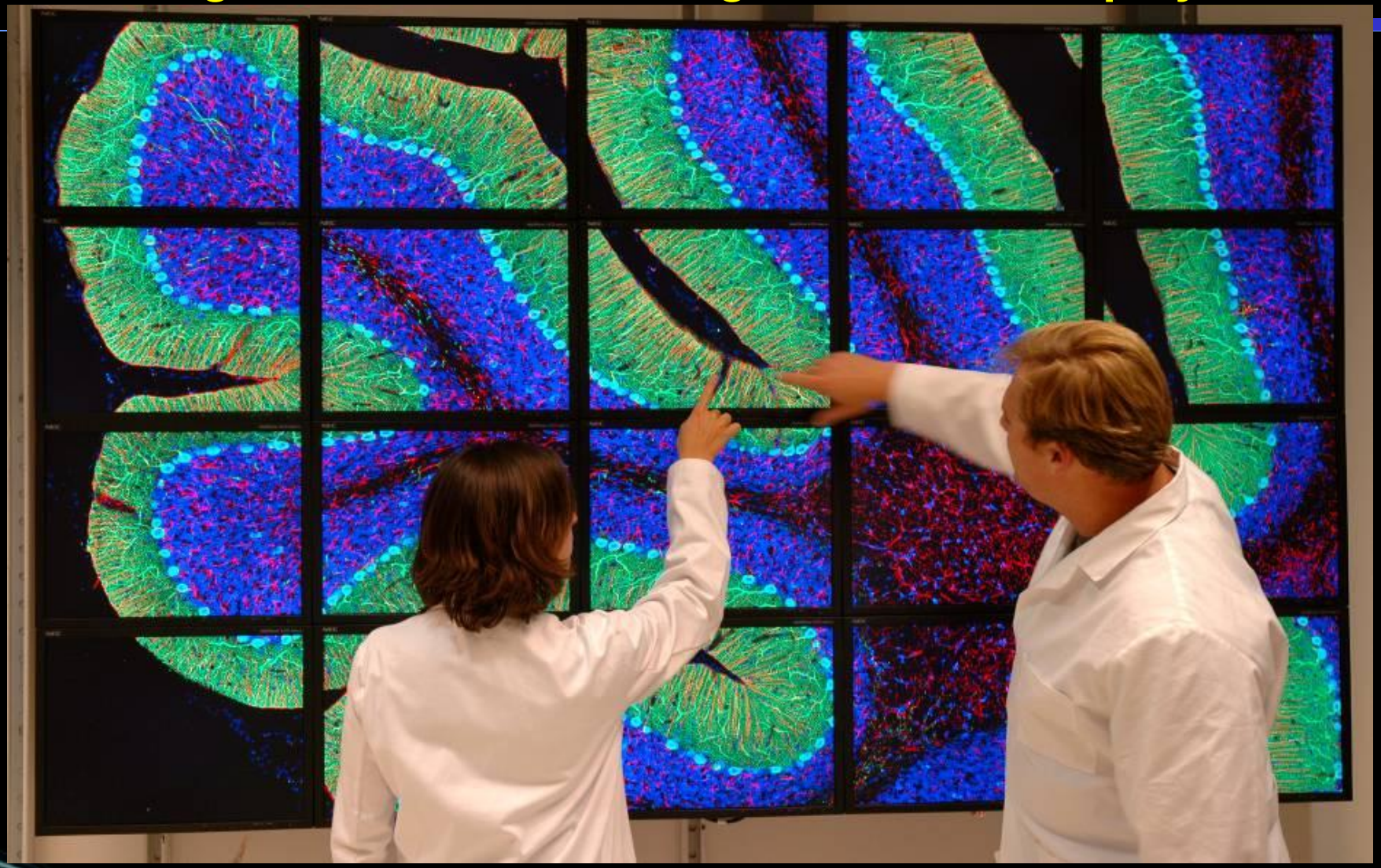
Southern California OptIPuter



STARLIGHT SM

Source: Mark Ellisman, UCSD

OptIPuter JuxtaView Software for Viewing High Resolution BioImages on Tiled Displays



30 Million Pixel Display
NCMIR Lab UCSD

Source: David Lee, Jason Leigh, EVL, UIC

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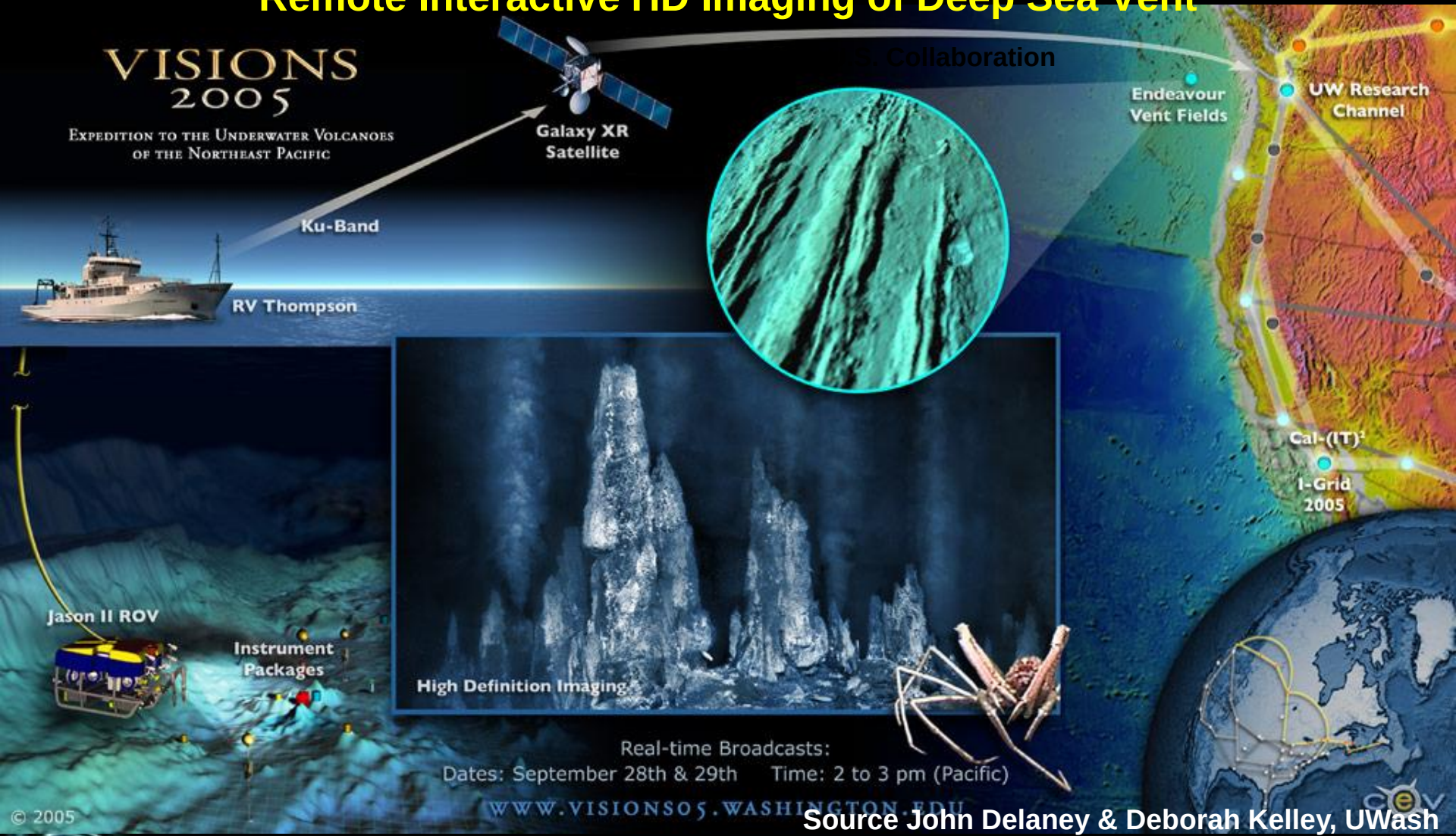
Laboratory for the Ocean Observatory Knowledge Integration Grid (LOOKING)

Remote Interactive HD Imaging of Deep Sea Vent



Source John Delaney & Deborah Kelley, UWash

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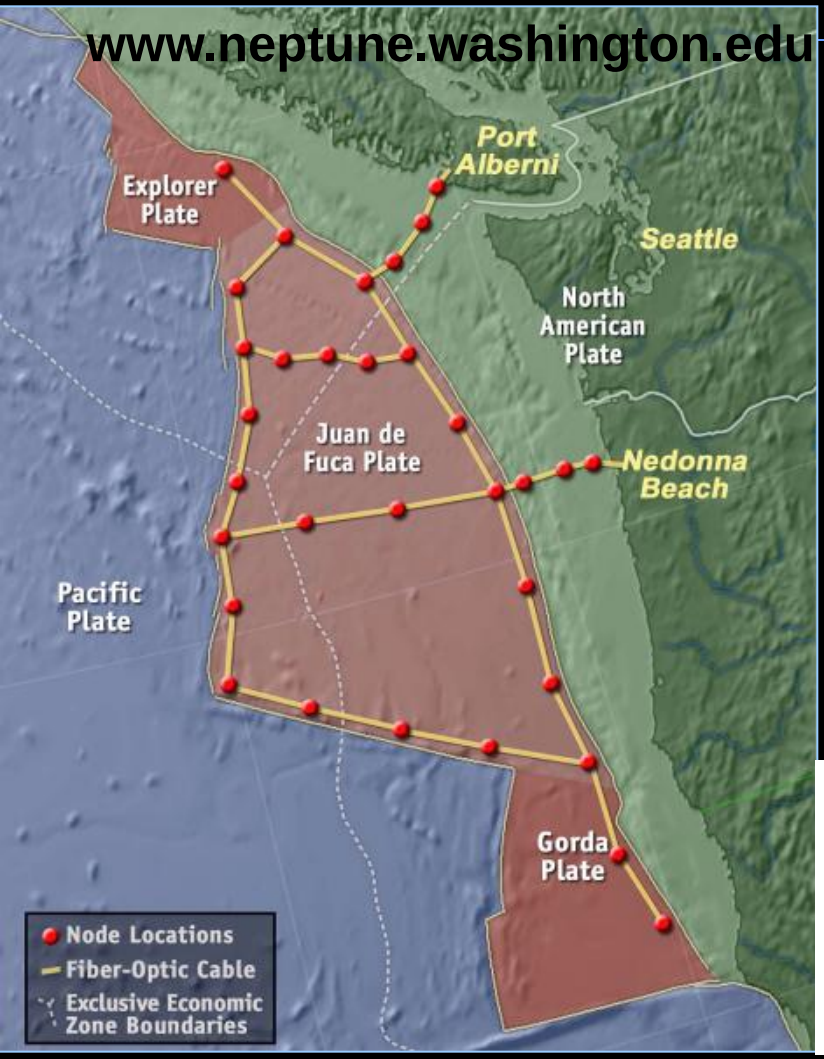
New OptIPuter Driver: Gigabit Fibers on the Ocean Floor
A Working Prototype Cyberinfrastructure for NSF's ORION



- NSF ITR with Principal Investigators
  - John Orcutt & Larry Smarr - UCSD
  - John Delaney & Ed Lazowska –UW
  - Mark Abbott – OSU
- Collaborators at:
  - MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, N[illegible]E

LOOKING (Laboratory for the Ocean Observatory Knowledge Integration Grid) –
Adding Web Services to LambdaGrids

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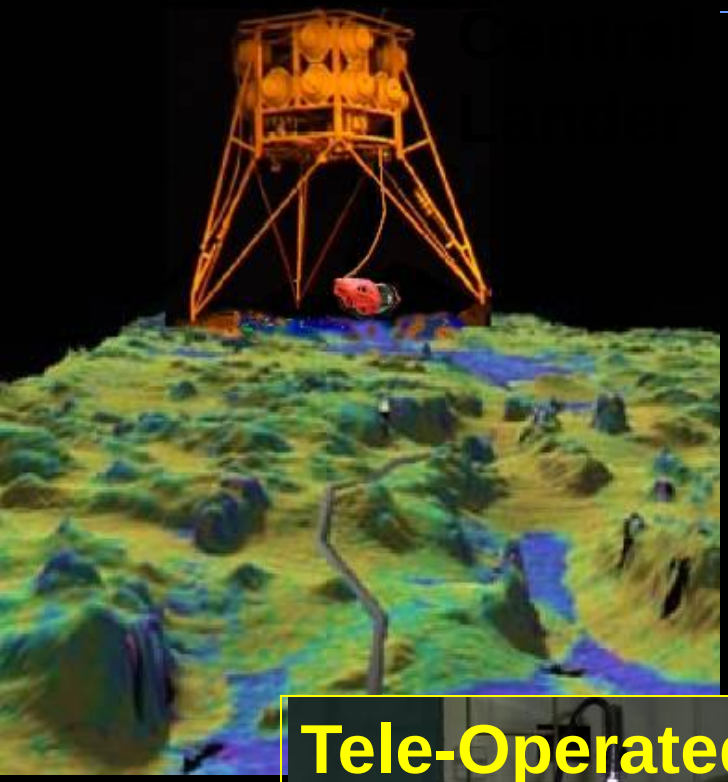
Goal – From Expedition to Cable Observatories with Streaming Stereo HDTV Robotic Cameras

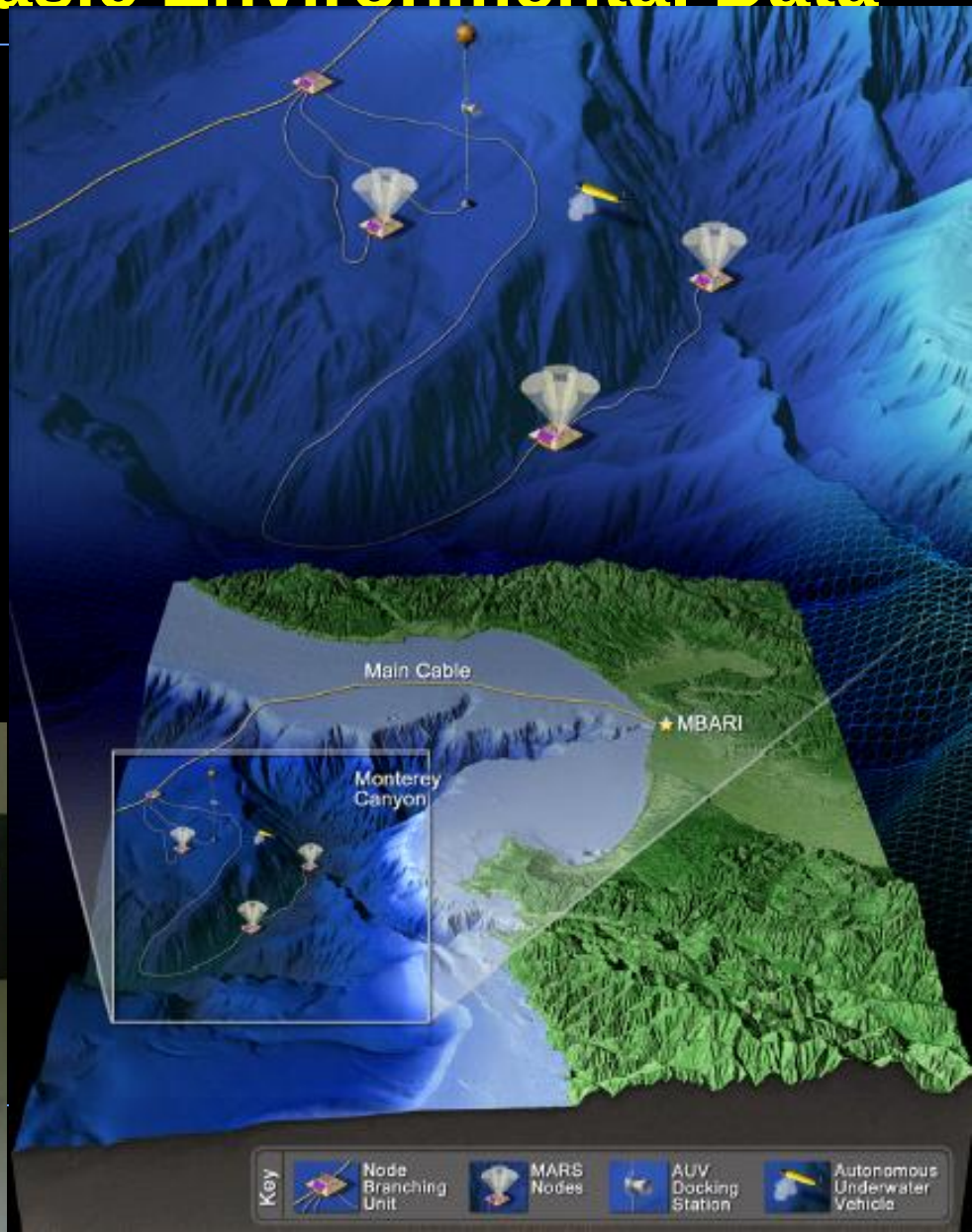
http://disney.go.com/disneypictures/aliensofthedeep/alienseduguide.pdf

Scenes from The Aliens of the Deep, Directed by James Cameron & Steven Quale

Source: Smarr, Cameron

MARS New Gen Cable Observatory Testbed - Capturing Real-Time Basic Environmental Data





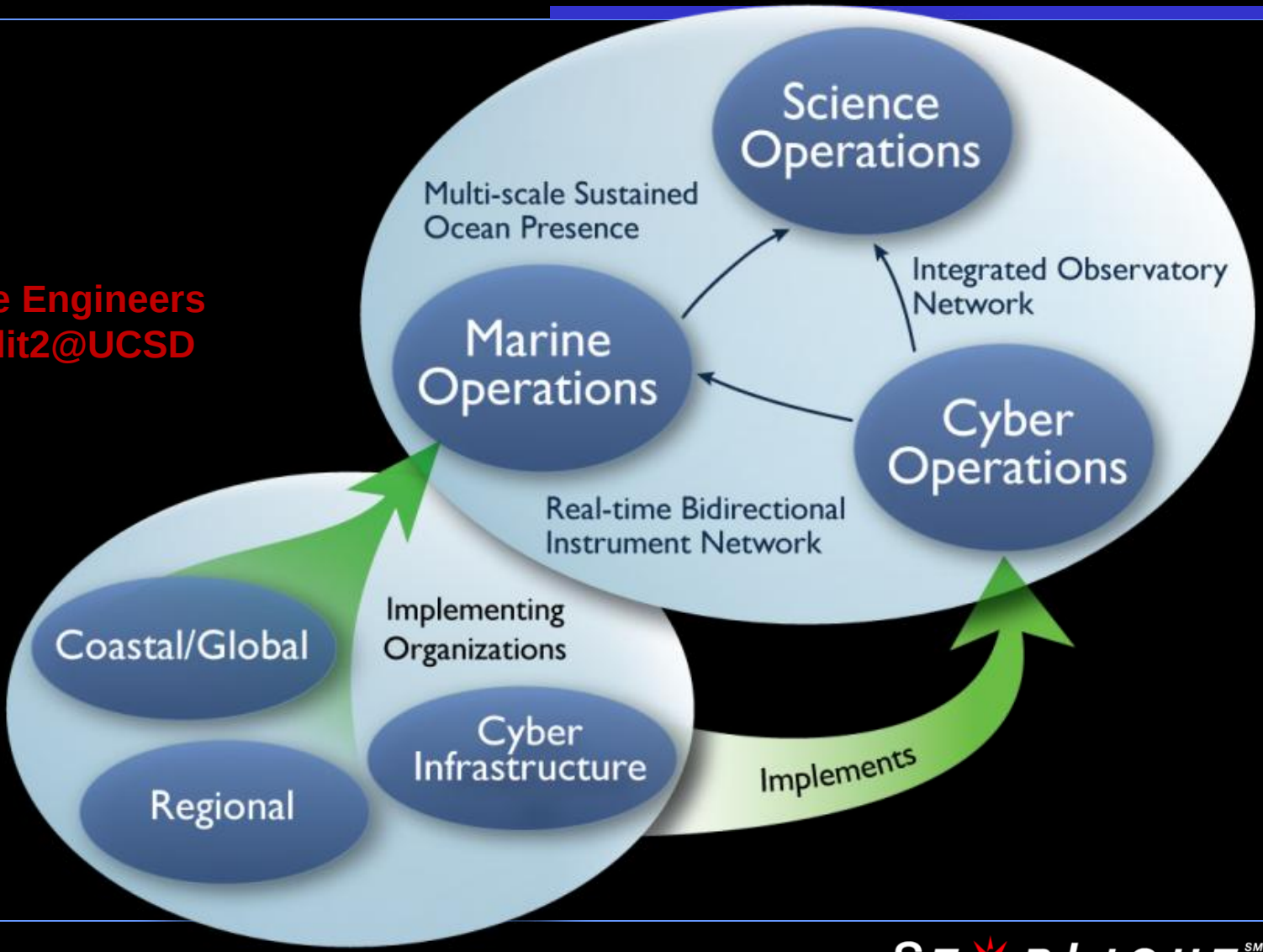
Tele-Operated Crawlers

Source: Jim Bellingham, MBARI

NSF OOI

OCEAN OBSERVATORIES INITIATIVE

30-40 Software Engineers Housed at Calit2@UCSD



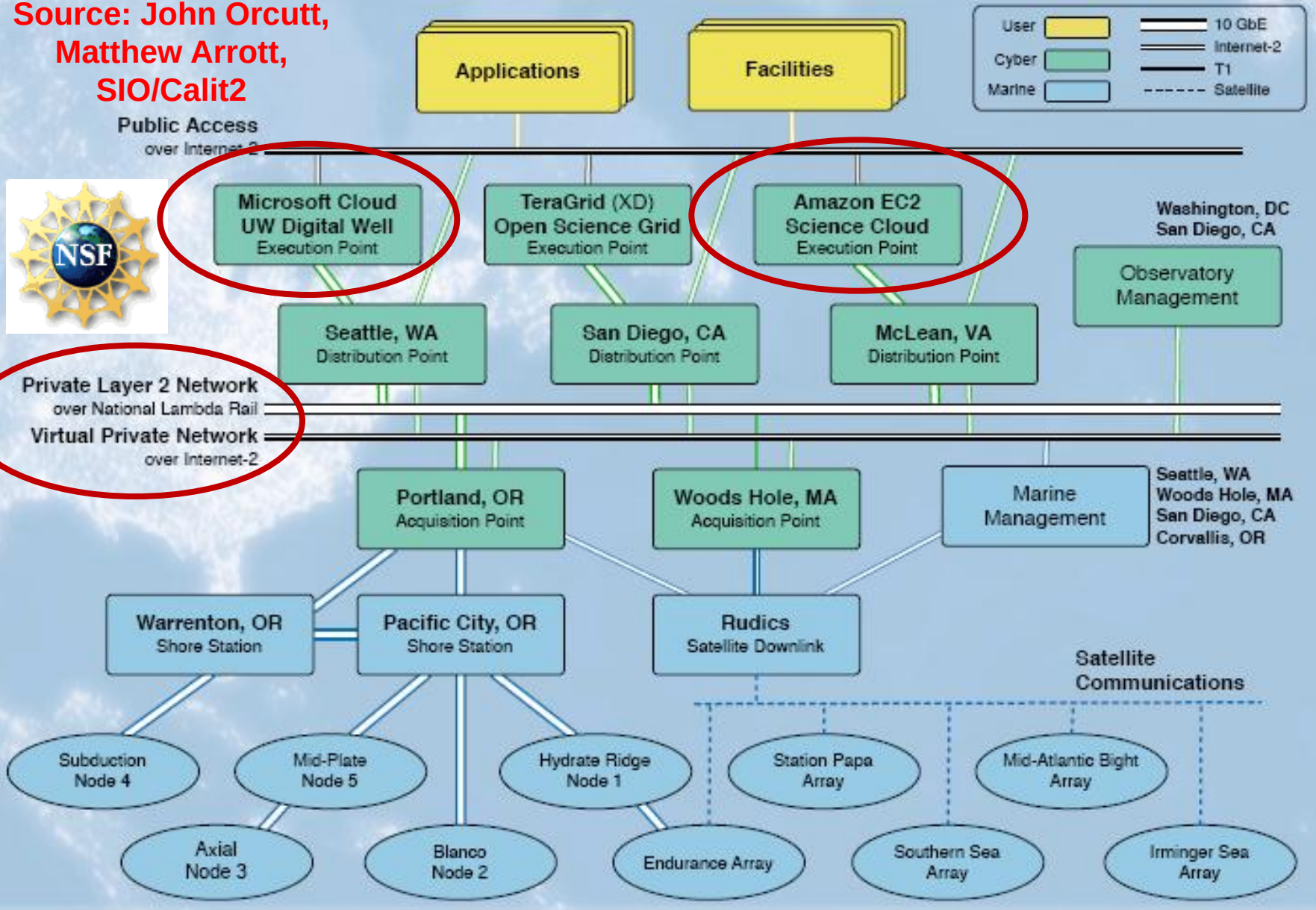
STARLIGHT SM

Source: Matthew Arrott, Calit2 Program Manager for OOI CI

OOI CI
is Built on National R&E Optical Infrastructure

OCEAN OBSERVATORIES INITIATIVE

Source: John Orcutt, Matthew Arrott, SIO/Calit2



CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis

National LambdaRail
Direct Connect
Computation and Storage Complex

Funded by: Gordon and Betty Moore Foundation

Joint Partnership of:

PI Larry Smarr

STARLIGHT℠

Marine Genome Sequencing Project
Measuring the Genetic Diversity of Ocean Microbes

MARINE MICROBIOLOGY INITIATIVE

Gordon and Betty MOORE FOUNDATION

CAMERA Includes All Sorcerer II Metagenomic Data

J. Craig Venter INSTITUTE

Source: Larry Smarr, C. Venter

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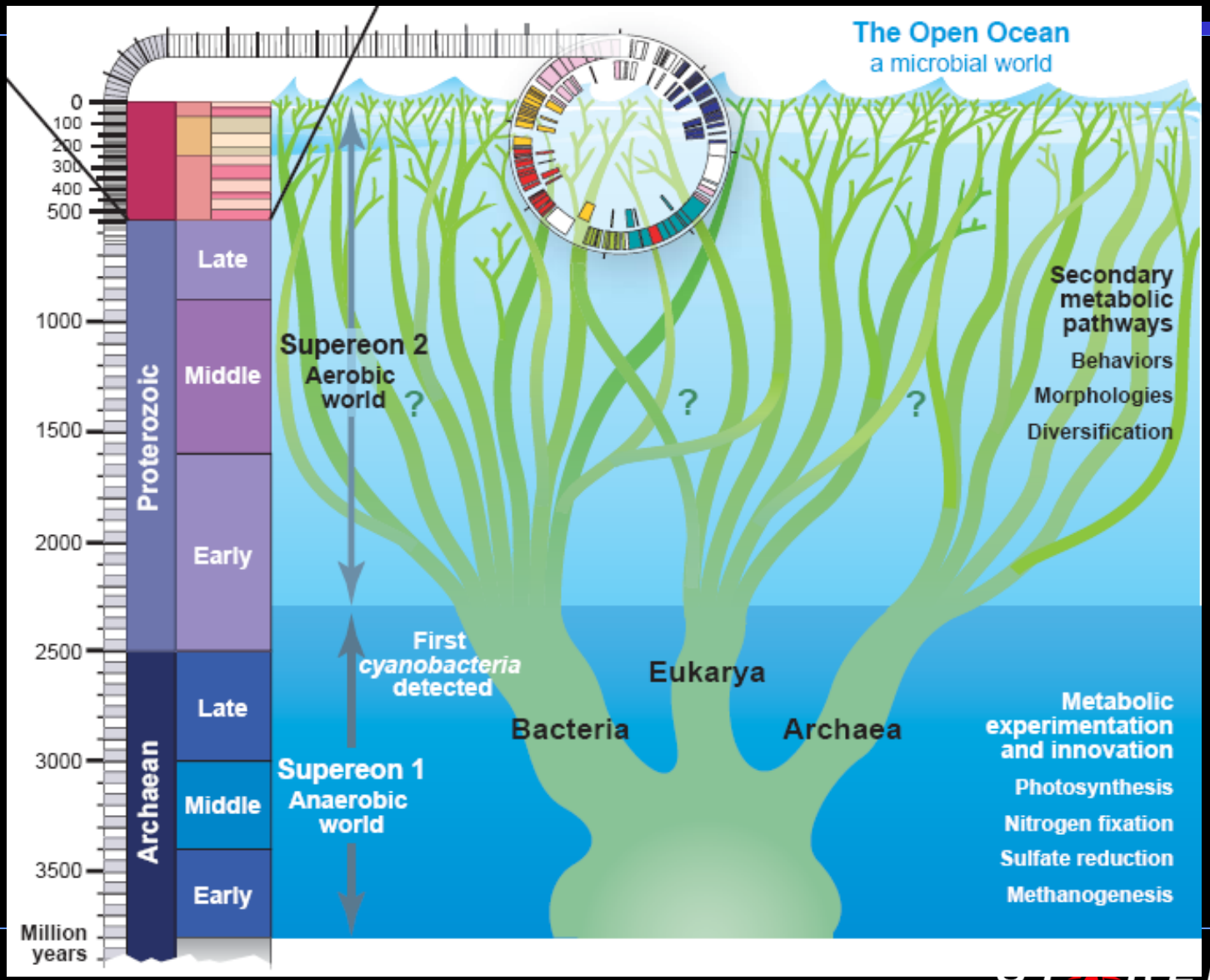
Looking Back Nearly 4 Billion Years In the Evolution of Microbe Genomics



Science Falkowski and Vargas 304 (5667): 58

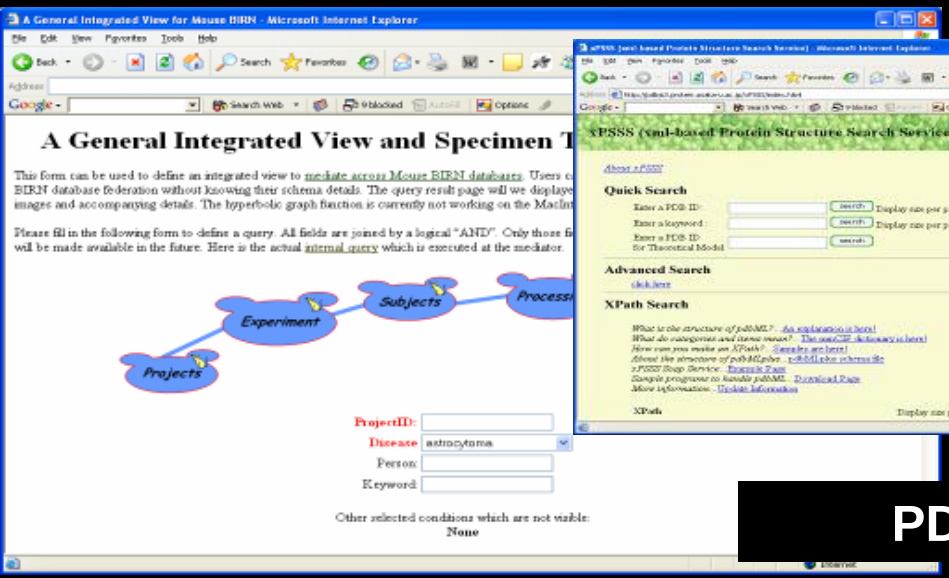
Beyond Traditional Web-Accessible Databases

Data Backend (DB, Files)

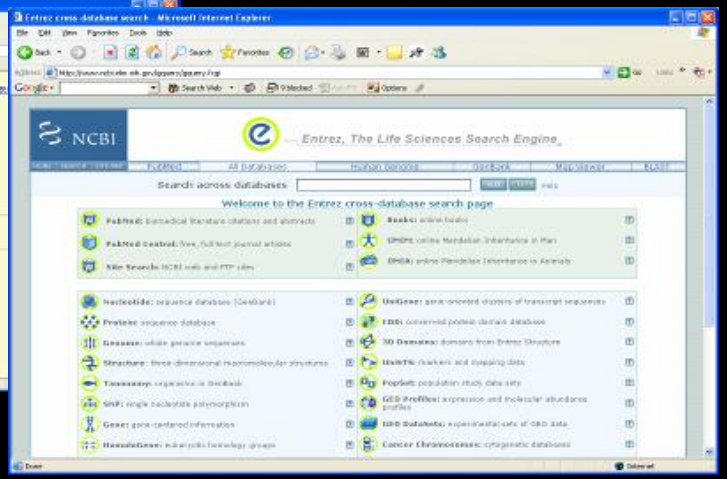
W E B PORTAL (pre-filtered, queries metadata)

Request

Response



PDB



BIRN

Source: CalIT2

+ many others

NCBI Genbank

STARLIGHT SM

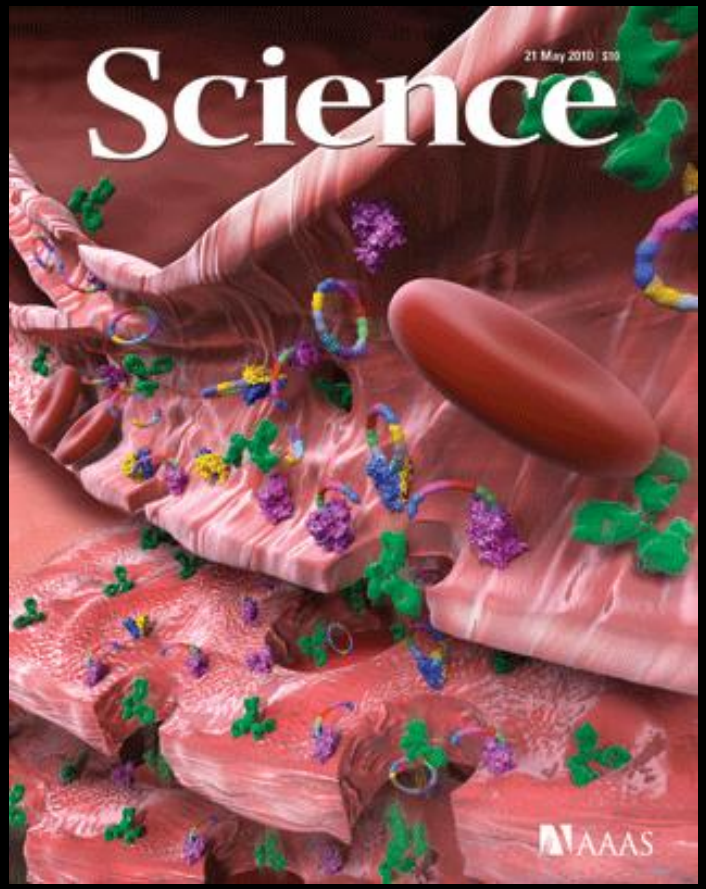
Source: Phil Papadopoulos, SDSC, Calit2

Community Cyberinfrastructure for Advanced Microbial Ecology Research and Analysis

Gordon and Betty MOORE FOUNDATION

RLIGHT SM

Craig Venter Announces Creation of the First Synthetic Life Form

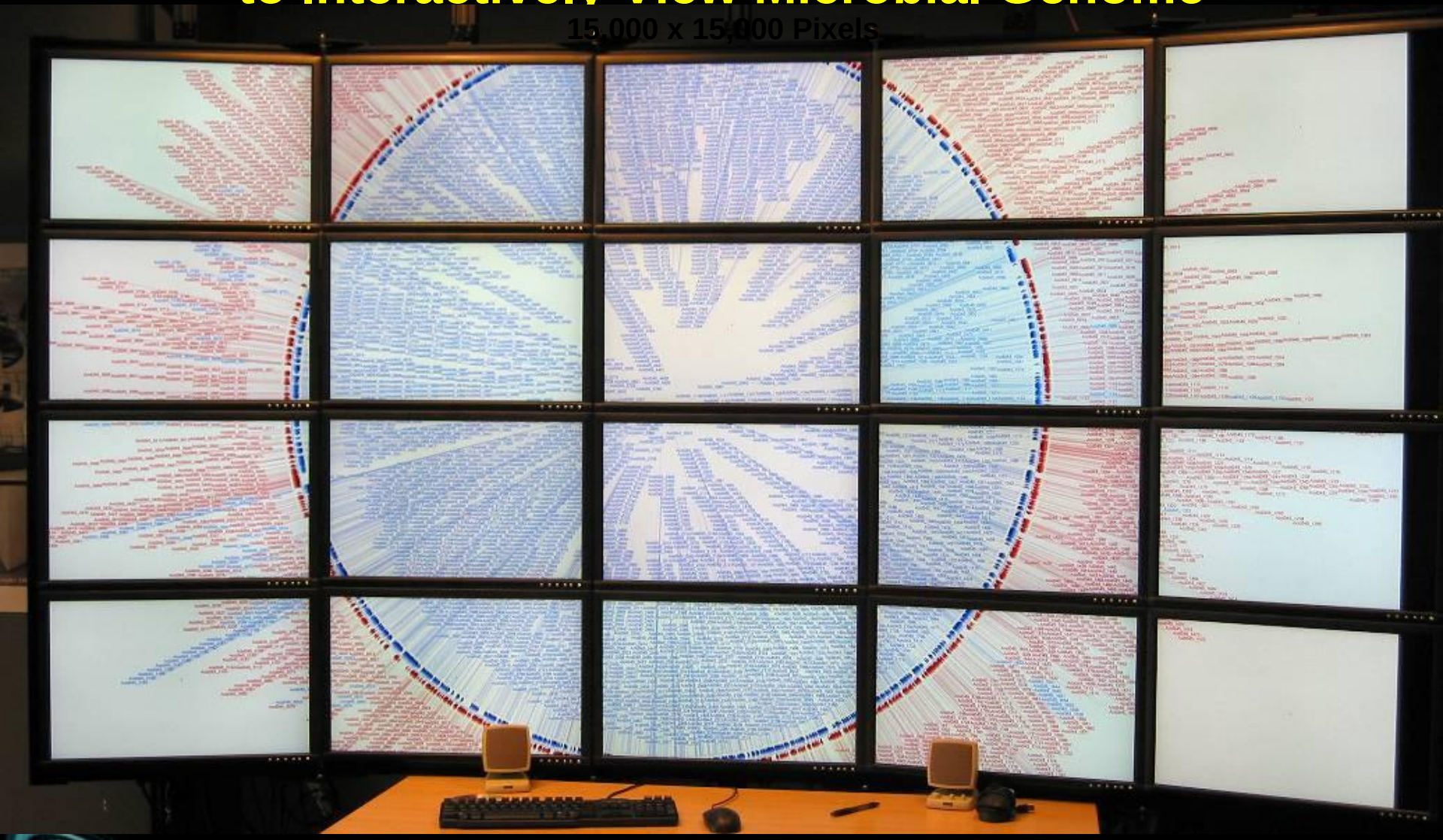


Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome

Daniel G. Gibson,1 John I. Glass,1 Carole Lartigue,1 Vladimir N. Noskov,1 Ray-Yuan Chuang,1 Mikkel A. Algire,1 Gwynedd A. Benders,2 Michael G. Montague,1 Li Ma,1 Monzia M. Moodie,1 Chuck Merryman,1 Sanjay Vashee,1 Radha Krishnakumar,1 Nacyra Assad-Garcia,1 Cynthia Andrews-Pfannkoch,1 Evgeniya A. Denisova,1 Lei Young,1 Zhi-Qing Qi,1 Thomas H. Segall-Shapiro,1 Christopher H. Calvey,1 Prashanth P. Parmar,1 Clyde A. Hutchison, III,2 Hamilton O. Smith,2 J. Craig Venter1,2,*

Published in Science, May 20, 2010
***Science* DOI: 10.1126/science.1190719**

Use of OptIPortal to Interactively View Microbial Genome



Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (NCBI)
Soil Bacterium 5.6 Mb

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Use of OptIPortal to Interactively View Microbial Genome

Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (RESBT)
Soil Bacterium 5.6 Mb

STARLIGHT SM

Use of OptIPortal to Interactively View Microbial Genome

Source: Raj Singh, UCSD

Acidobacteria bacterium Ellin345 (RICBT)
Soil Bacterium 5.6 Mb

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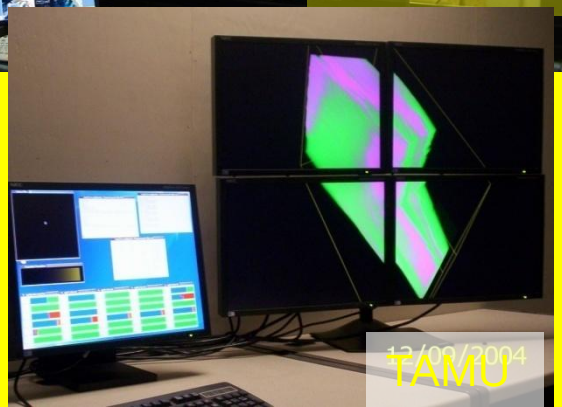
OptIPortal Scalable Display Systems
(Source: Smarr, DeFanti OptIPuter)



Advanced Visualization Enabled By Optical Lightpaths

The 200-million-pixel HIPerWall at Calit2 on the UC Irvine campus is now part of the OptIPortal Collaboratory.

Source: UCSD

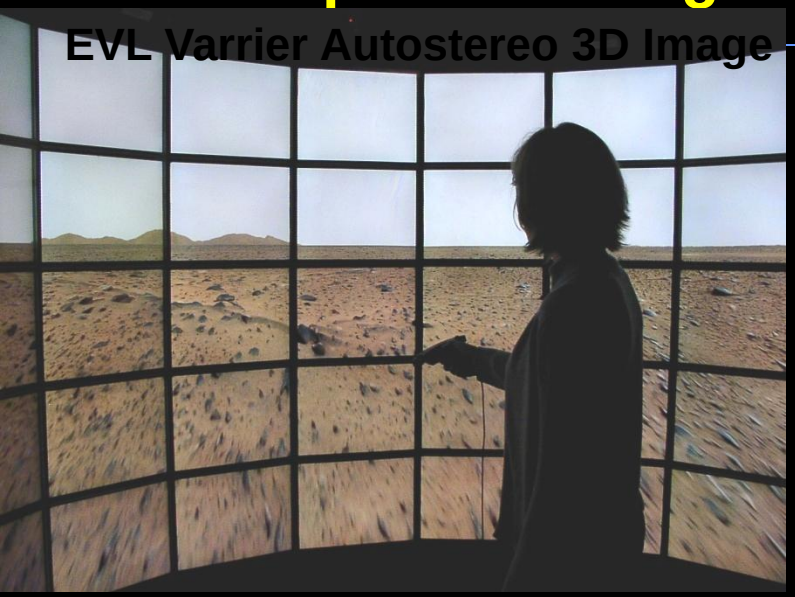
STARLIGHT℠

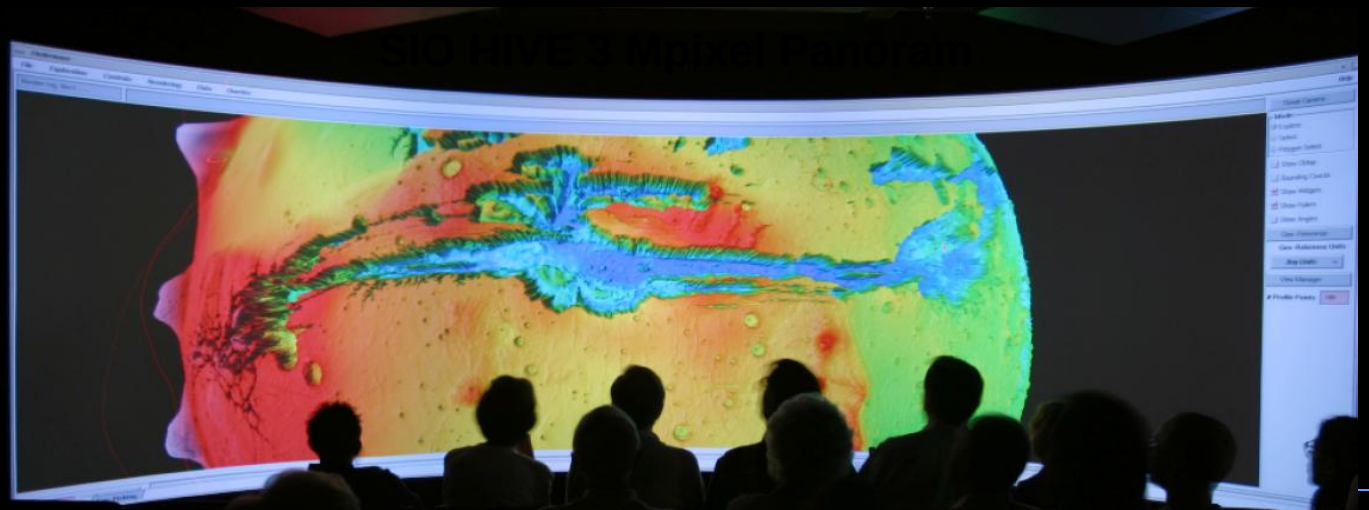
STARLIGHT℠


iCAIR
STARLIGHT

Tornado Visualization: NCSA

Earth and Planetary Sciences are an OptIPuter Large Data Object Visualization Driver





Source: Smarr, Defanti: OptIPuter

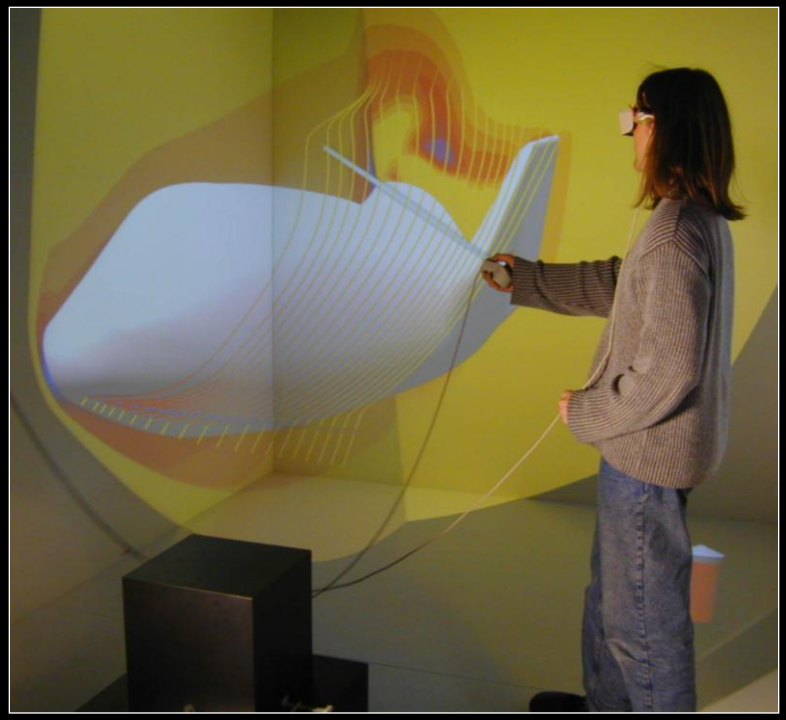
LIGHT SM

3D Modeling and Simulation

Distributed Simulation Analysis

- Sandia National Laboratories, USA
- High Performance Computing Center Stuttgart
- (HLRS), Germany

Thanks to the Computer Services for Academic Research Centre (Manchester, UK), the Centre of Virtual Environments at University of Salford (UK), Tsukuba Advanced Computing Center (Japan) and Pittsburgh Supercomputing Center (USA) for additional supercomputing resources.



This application emphasizes distributed parallel supercomputing and a collaborative virtual-reality computation steering environment applied to Grand Challenge problems.

Source: Tom Defanti Dan Sandia, EVL

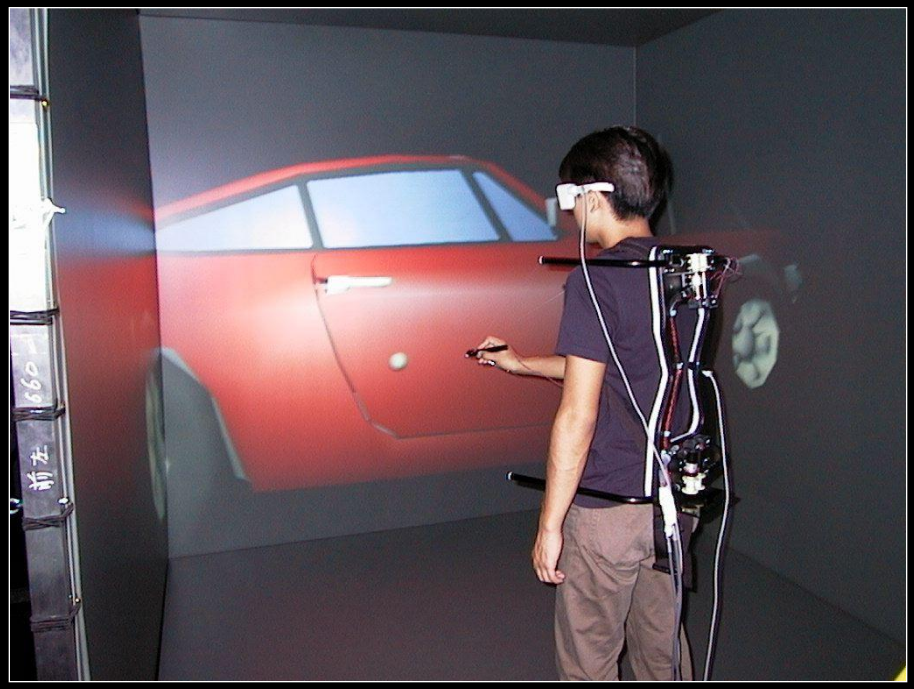
VR

Tele-Immersive

Haptics

Haptic Collaboration in a Networked Virtual Environment

- Gifu MVL Research Center, Telecommunications Advancement Organization (TAO), Japan
- University of Tokyo, Japan

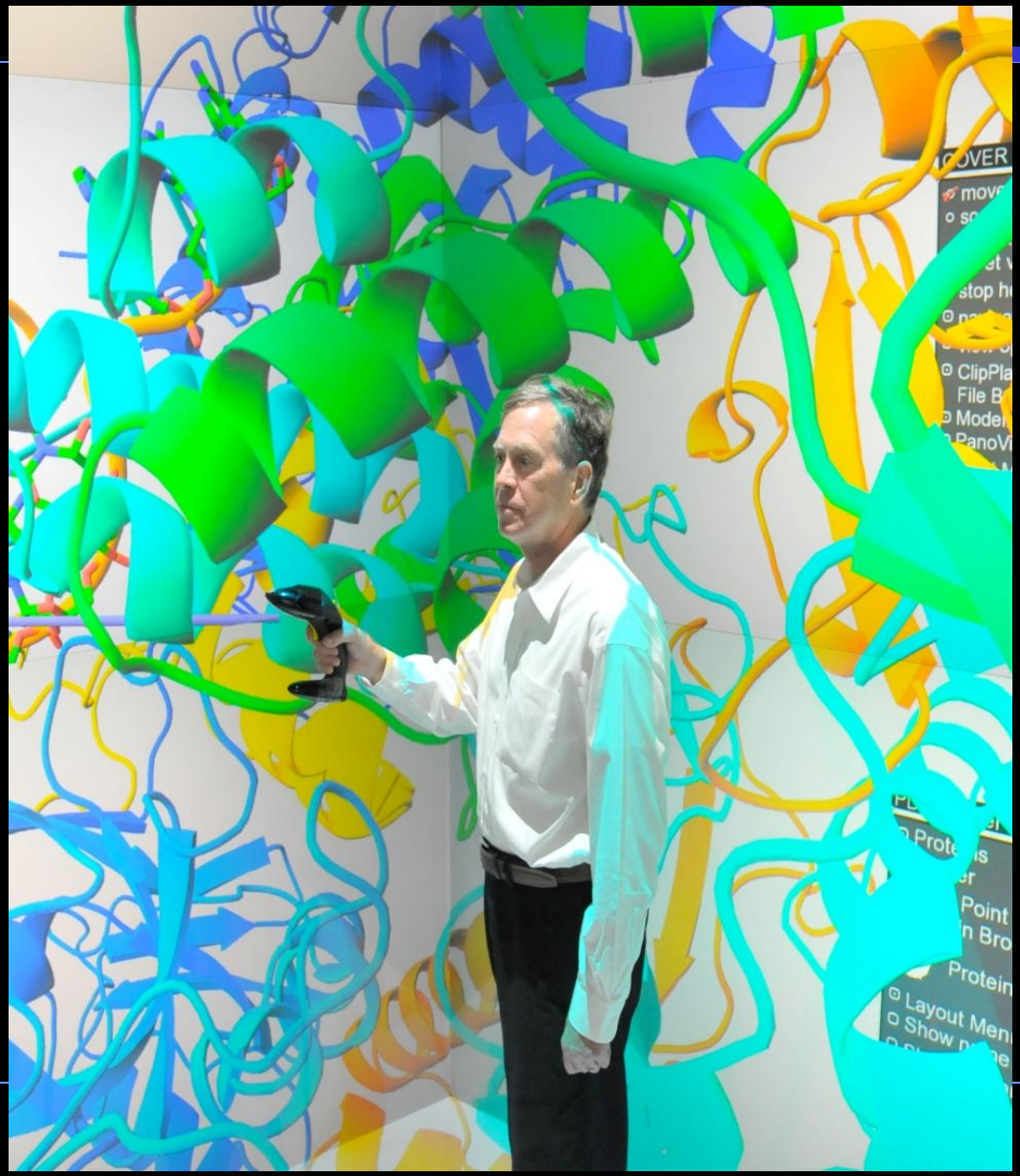


A demonstration of wearable haptic gear (touch and force) communication, as well as visual communication, first public demonstration between the CAVE at iGrid 2000 and CABIN at the University of Tokyo.

www.cyber.rcast.u-tokyo.ac.jp/mvl2/

STARLIGHT SM

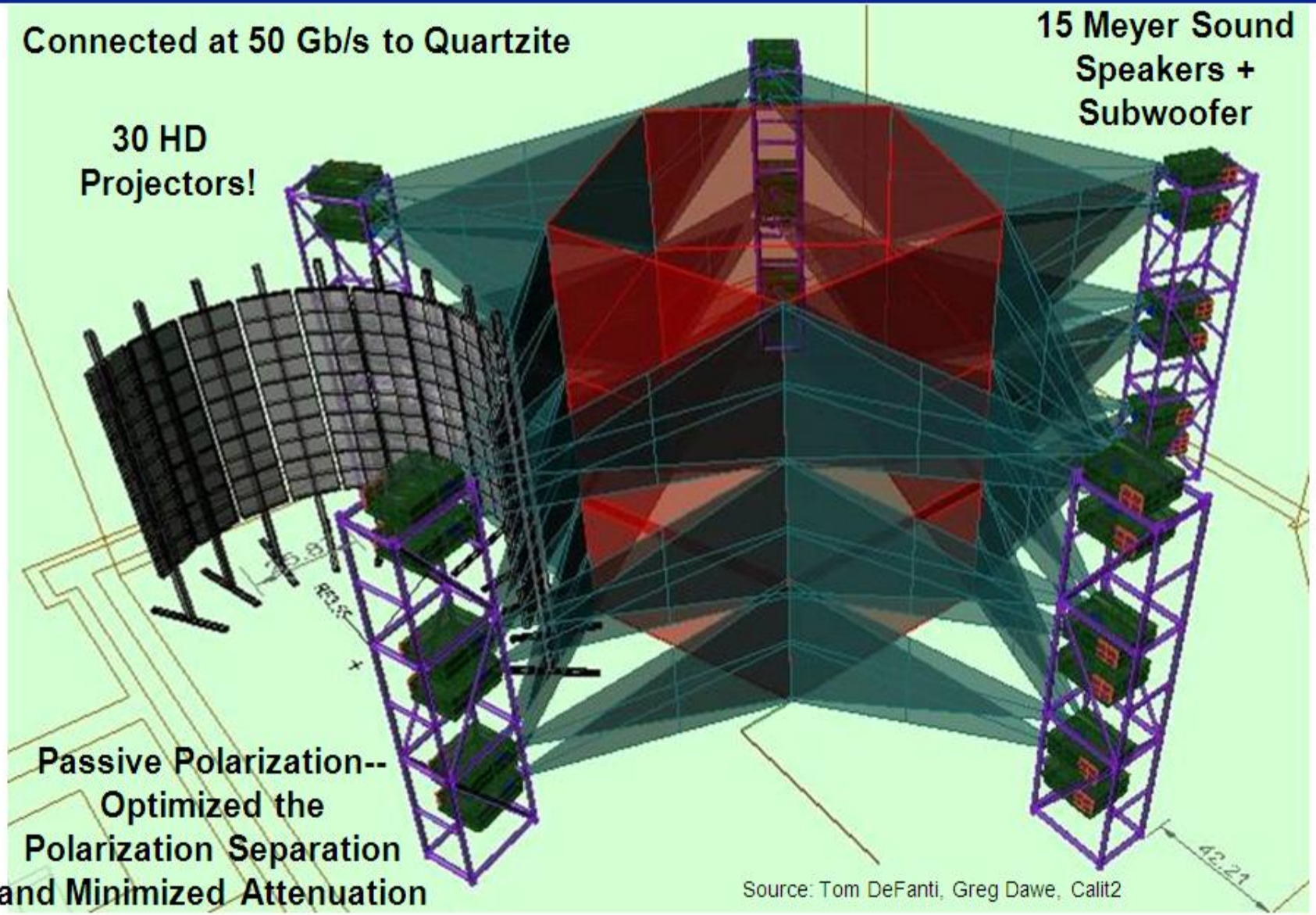
The StarCAVE as a 25kW or 50kW Browser: Tom DeFanti, CalIt2 UCSD



STARLIGHT SM

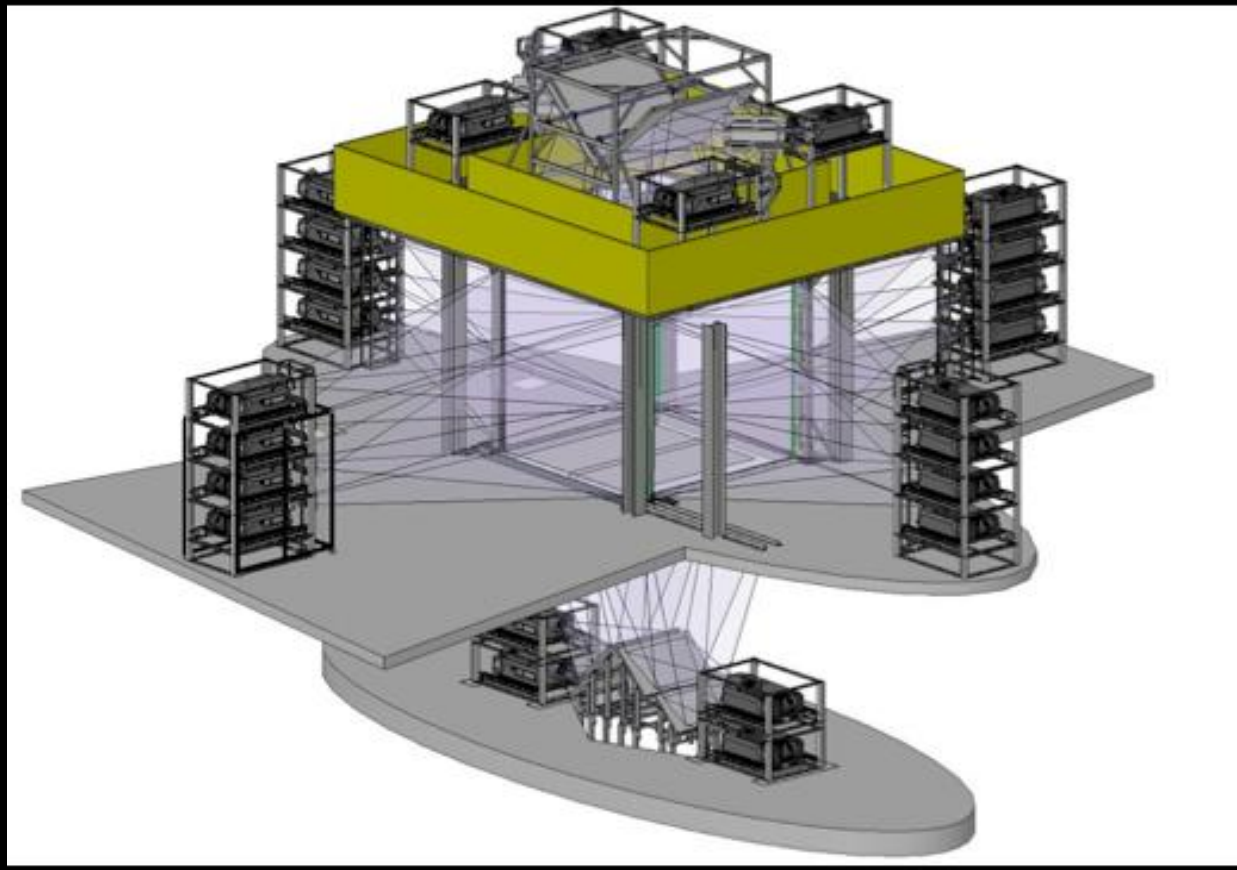
Calit2 3D Immersive StarCAVE OptIPortal

Calit2 3D Immersive StarCAVE OptIPortal



CORNEA

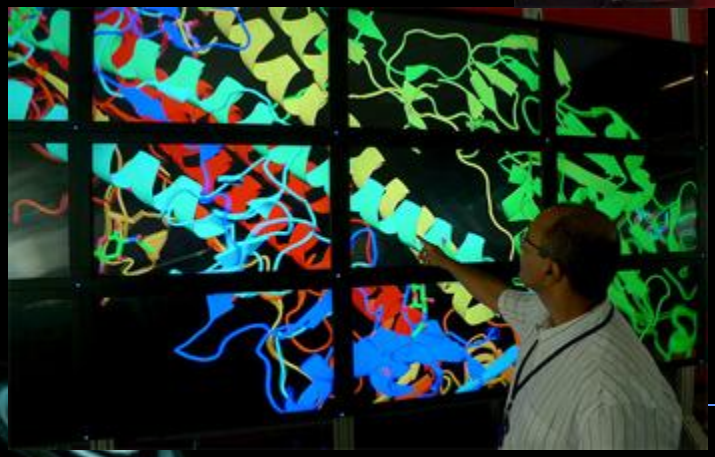
- Next step up in res/power: KAUST-Saudi Arabia
- 24 Sony 4K projectors 100 Million Pixels/eye
- 240,000 lumens!
- Mechdyne/Iowa State Design based on original 1991 EVL CAVE

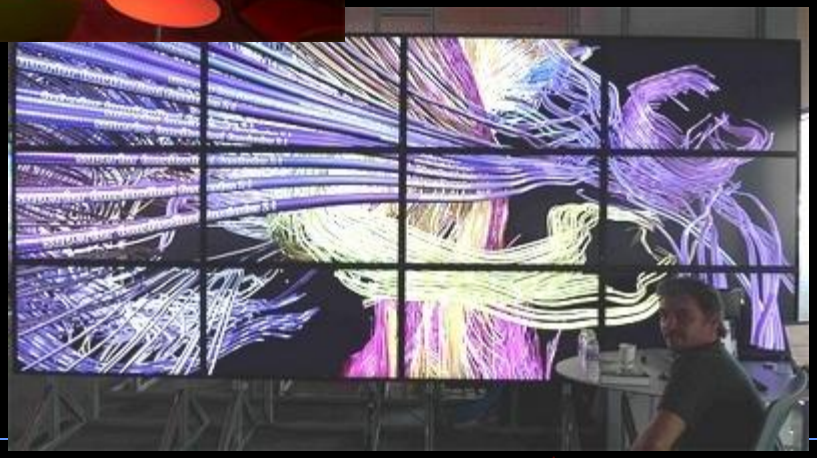


Source: Tom DeFanti, UCSD, KAUST

STARLIGHT℠

KAUST
CORNEA





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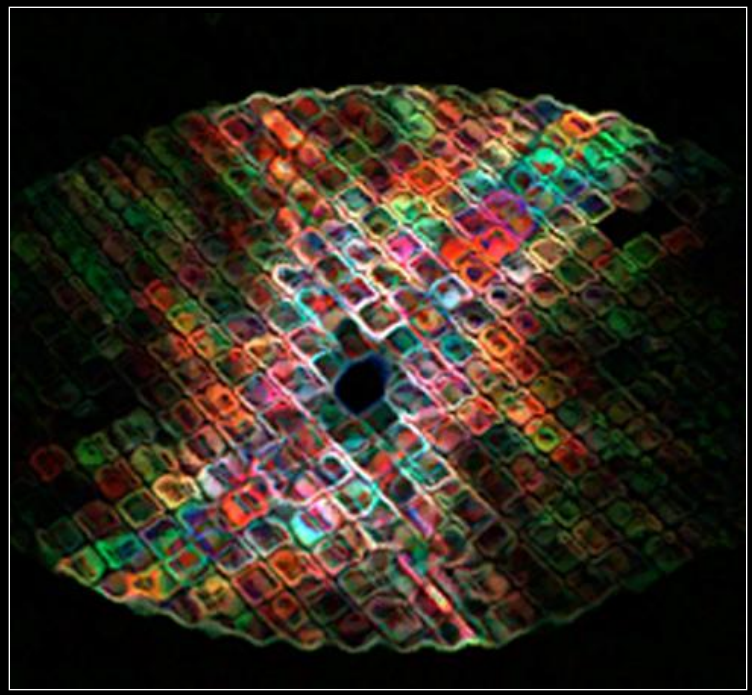
Digital Media (iGrid 2000, Yokohama Japan

USA, Canada, Japan, Singapore, Netherlands, Sweden, CERN, Spain, Mexico, Korea)

GiDVN: Global Internet Digital Video Network

- Digital Video Working Group, Coordinating Committee for International Research Networks
- CERN, Switzerland
- APAN, Japan; KDD, Japan
- APAN-KR, Korea; Seoul National University, Korea
- SURFnet, The Netherlands
- DFSCA-UNAM, Mexico
- SingAREN, Singapore
- Universitat Politecnica de Catalunya, Spain
- Royal Institute of Technology, Sweden
- Int'l Center for Advanced Internet Research (iCAIR), Northwestern, USA

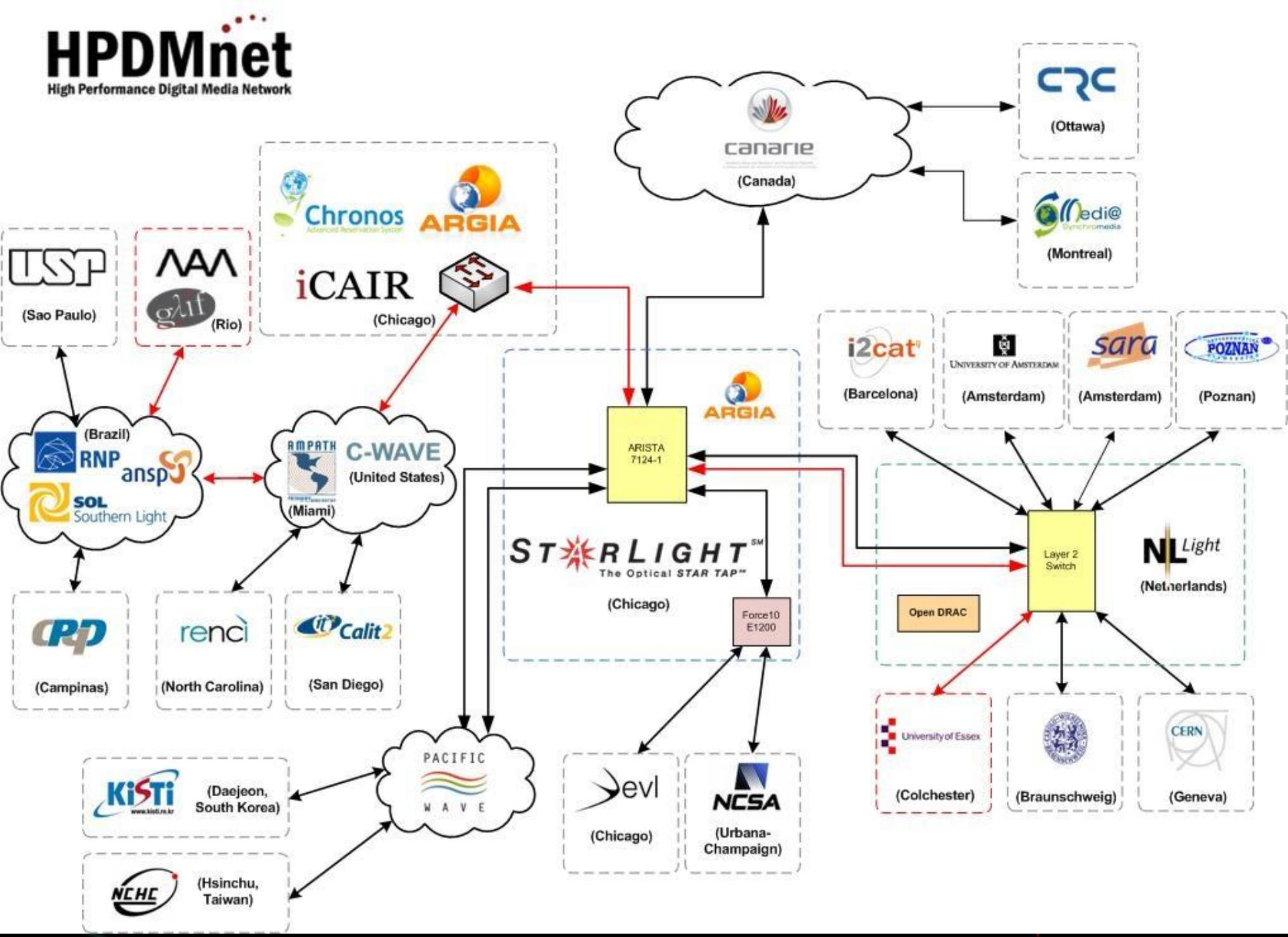


GiDVN projects have enhanced media capabilities for the next-generation Internet, enabling new applications to interoperate throughout the world.

www.icair.org/inet2000

iCAIR

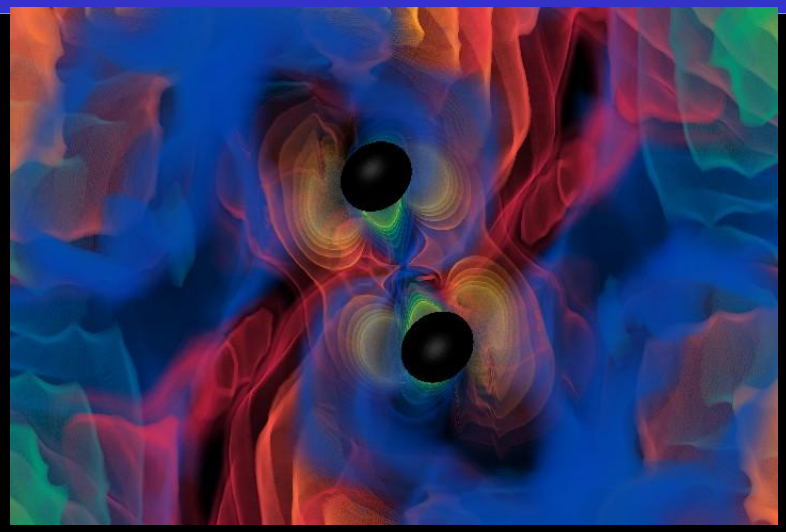
STARLIGHT℠


HPDMnet
High Performance Digital Media Network
canarie
(Canada)
CRC
(Ottawa)
Medi@
(Montreal)
Chronos
ARGIA
iCAIR
(Chicago)
USP
(Sao Paulo)
AAA
GIIF
(Rio)
(Brazil)
RNP
ansp
SOL
Southern Light
AMPATH
C-WAVE
(United States)
(Miami)
ARISTA
7124-1
ARGIA
STARLIGHT
The Optical STAR TAP
(Chicago)
Force10
E1200
i2cat
(Barcelona)
University of Amsterdam
(Amsterdam)
sara
(Amsterdam)
POZNAN
(Poznan)
Layer 2
Switch
Open DRAC
NL Light
(Netherlands)
CPqD
(Campinas)
renci
(North Carolina)
Calit2
(San Diego)
University of Essex
(Colchester)
(Braunschweig)
CERN
(Geneva)
PACIFIC
WAVE
KiSTi
(Daejeon,
South Korea)
NCHC
(Hsinchu,
Taiwan)
evl
(Chicago)
NCSA
(Urbana-
Champaign)

High-Performance Digital Media

For Interactive Remote Visualization (2006)

- Interactive visualization coupled with computing resources and data storage archives over optical networks enhance the study of complex problems, such as the modeling of black holes and other sources of gravitational waves.
- HD video teleconferencing is used to stream the generated images in real time from Baton Rouge to Brno and other locations



- Center for Computation and Technology, Louisiana State University (LSU), USA
- Northwestern University
- MCNC, USA
- NCSA, USA
- Lawrence Berkeley National Laboratory, USA
- Masaryk University/CESNET, Czech Republic
- Zuse Institute Berlin, Germany
- Vrije Universiteit, NL

iCAIR

www.cct.lsu.edu/Visualization/iGrid2005
http://sitola.fi.muni.cz/sitola/igrid/

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4K Media

4K Digital Media
Ultra High Definition
Digital
Communications

Digital communications using SHD transmits extra-high-quality, digital, full-color, full motion images.

4k pixels horizontal, 2k vertical

4 * HDTV – 24 * DVD

4K Video is approximately 4X standard HD

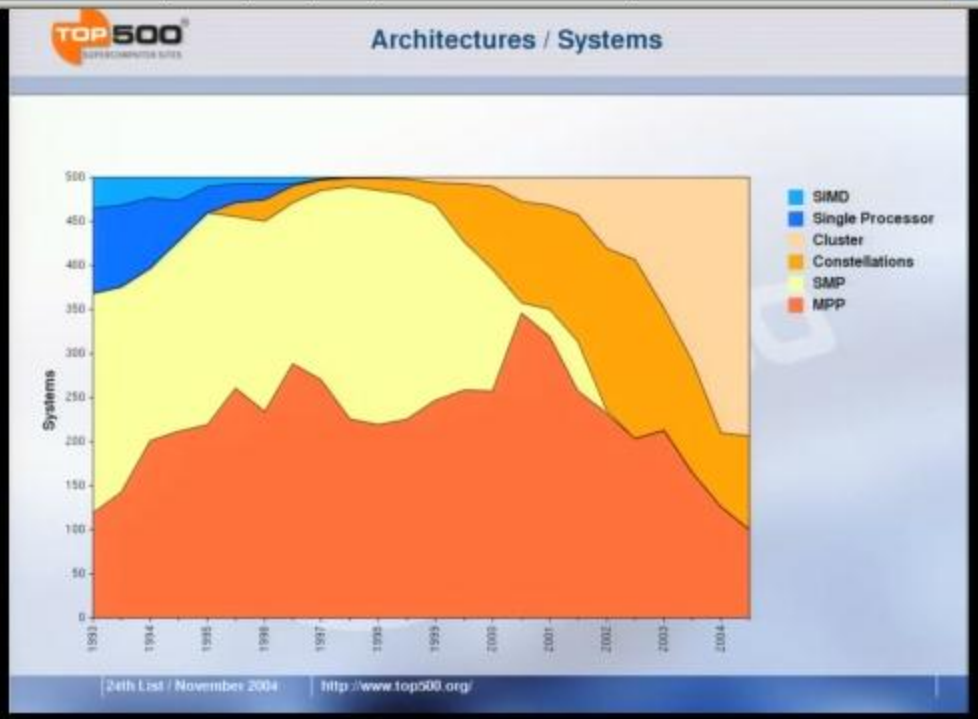
HD = 720x1280 or 1080x1920 pixels

4K = 3840x2160 pixels

www.onlab.ntt.co.jp/en/mn/shd

8k Media Experiments At the Univ of Essex

Edit View Favorites Tools Help
Back Search Favorites
https://www.cct.lsu.edu/csc7600/media/ncast/20070116-163021-001.mp4
Go Links Google Setting



Introduction to High Performance Computing

Dr. Thomas Sterling
January 16, 2007

Week One: Class One Introduction

LSU Center for Computation & Technology
http://www.cct.lsu.edu/

one
Internet

The First Public Demonstration Of HPDMnet GDOM Was Staged At GLIF 2007 in Prague, Czech Republic Sept 17-18, 2007

iCAIR

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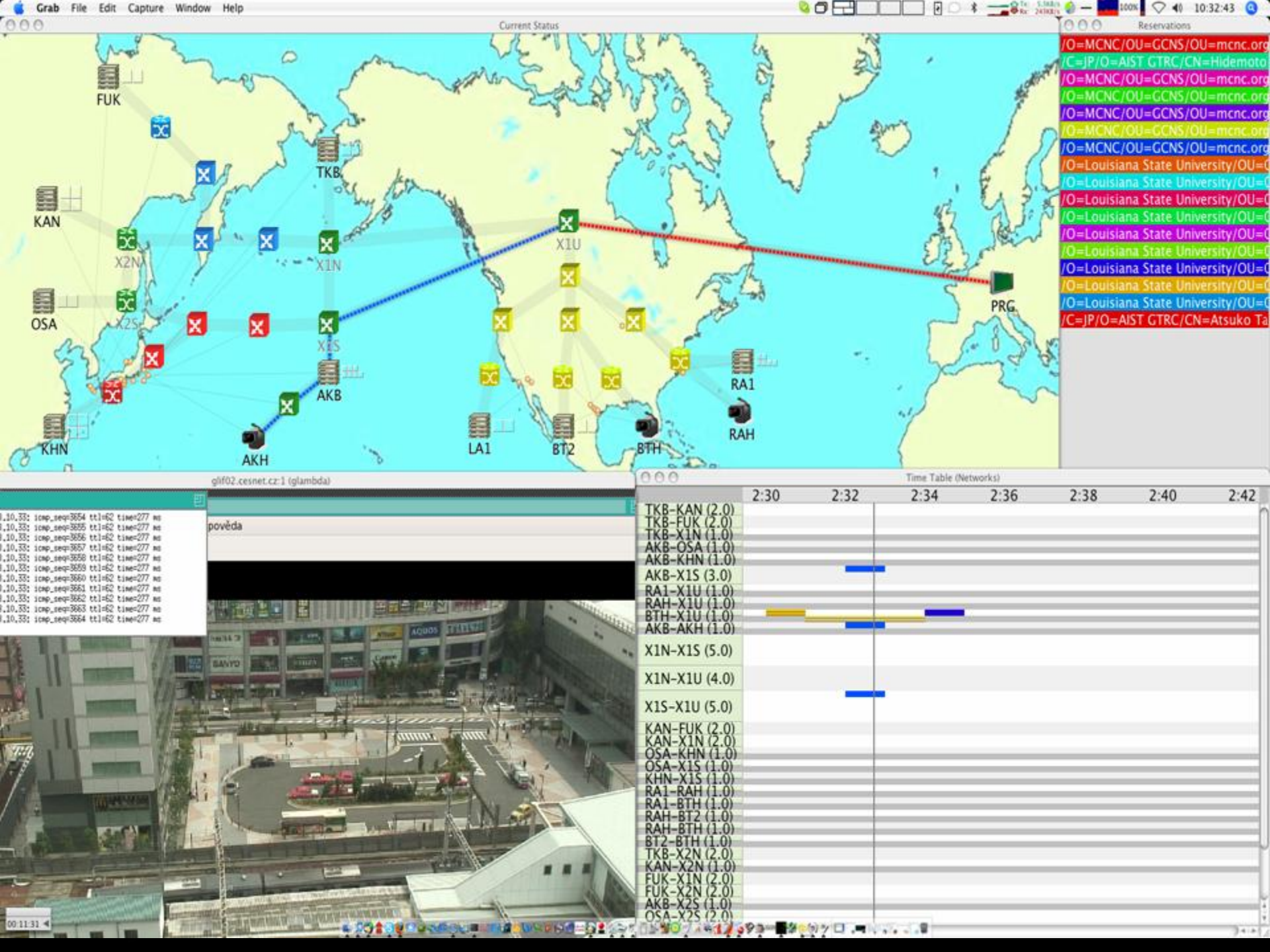
High Performance Digital Media GLIF

- A Consortium of Research Centers From Around the World Has Formed a Cooperative Partnership To Explore the Key Issues Related to the Challenges and Opportunities Related to Using Lightpaths for High Performance Digital Media (HPDM)
- At the Annual Global LambdaGrid Workshop in Prague, Demonstrations Have Been Designed to Show the Current Project Status
- Multiple Sites Require High Performance/High Volume/High Definition Digital Media Streaming Simultaneously Among All Locations (Multi-Point to Multi-Point)

Music Grid Canada - Prague


Grab File Edit Capture Window Help
10:32:43
Current Status
Reservations
/O=MCNC/OU=GCNS/OU=mcnc.org
/C=JP/O=AIST GTRC/CN=Hidemoto
/O=MCNC/OU=GCNS/OU=mcnc.org
/O=MCNC/OU=GCNS/OU=mcnc.org
/O=MCNC/OU=GCNS/OU=mcnc.org
/O=MCNC/OU=GCNS/OU=mcnc.org
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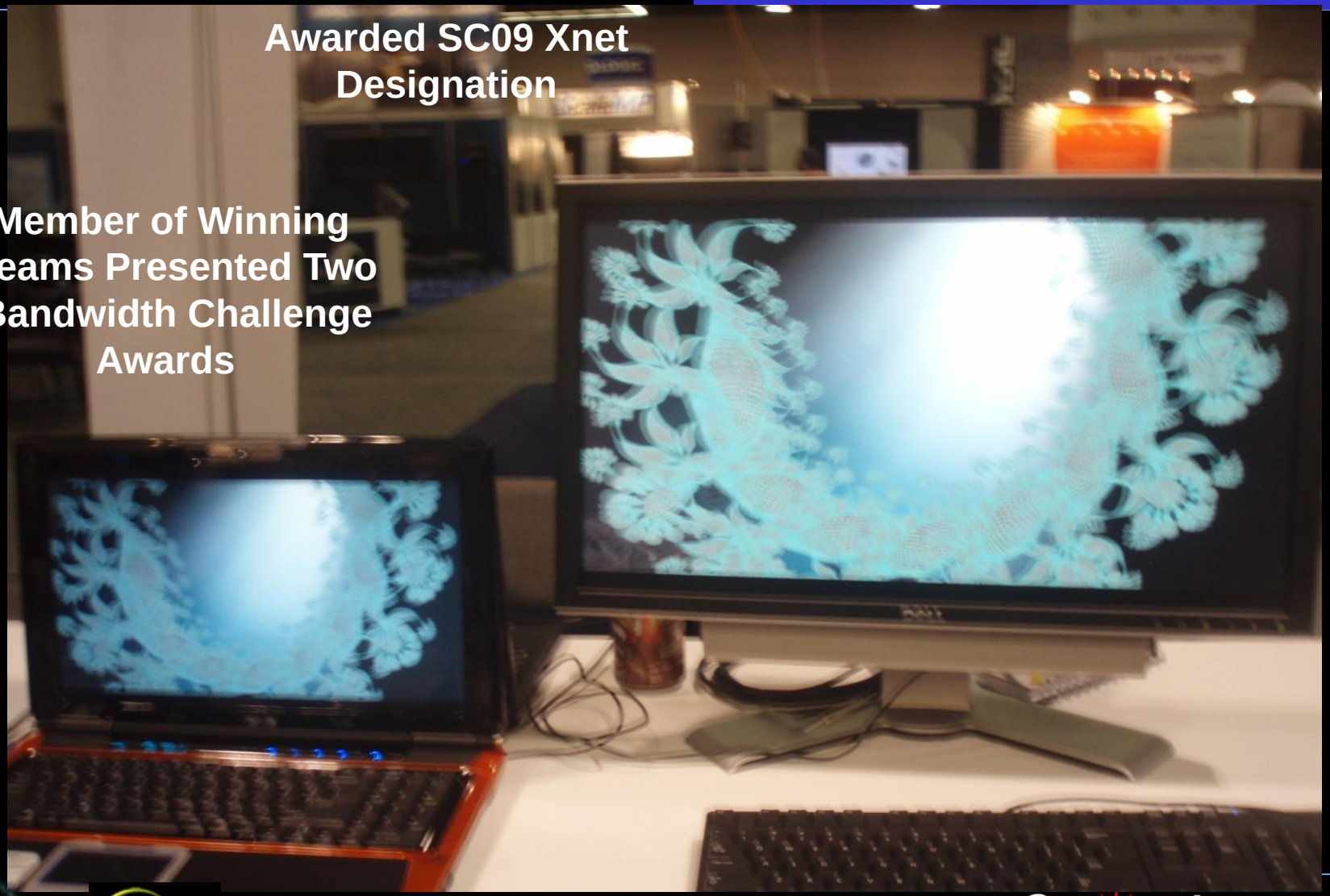
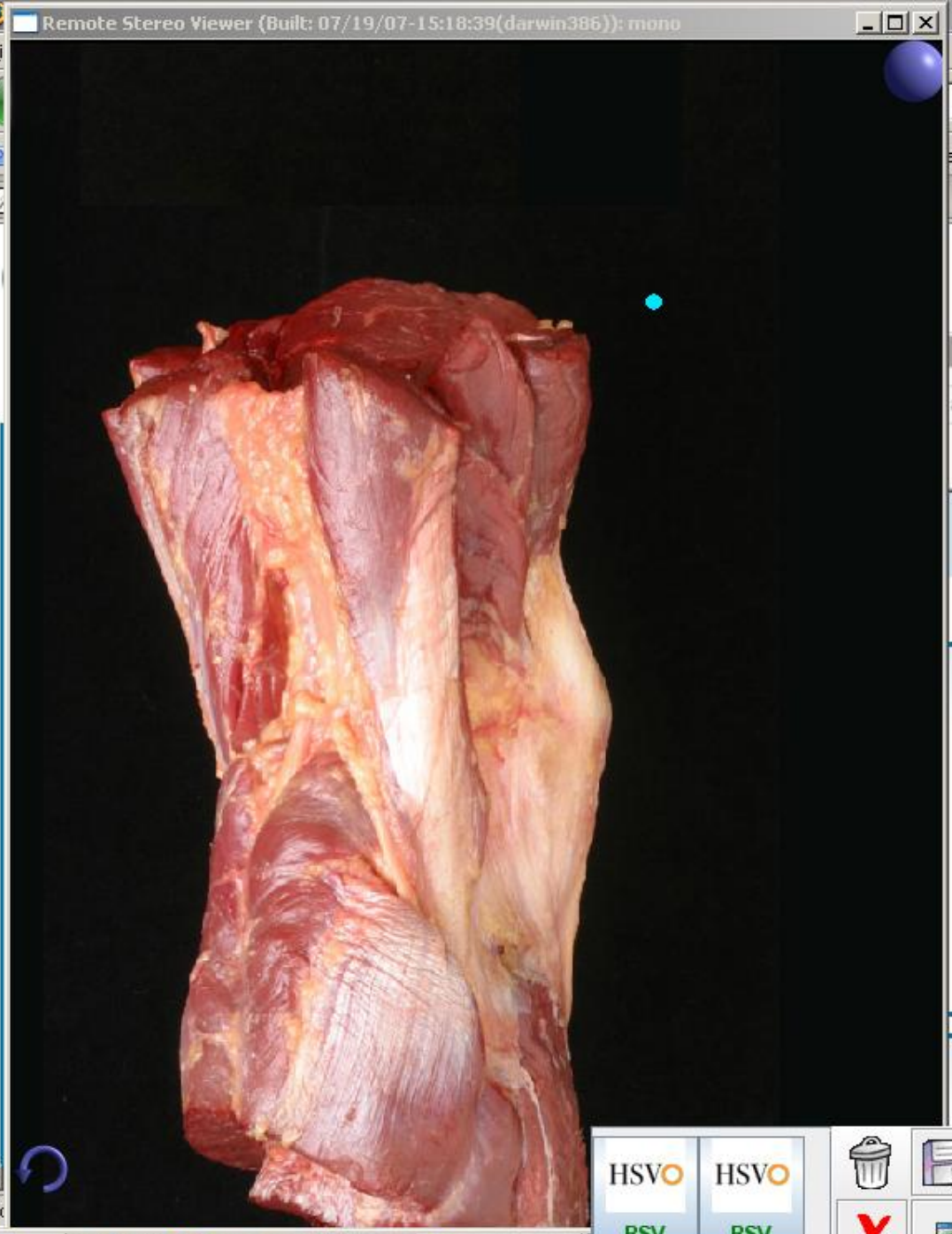
/O=Louisiana State University/OU=
/C=JP/O=AIST GTRC/CN=Atsuko Ta
FUK
TKB
KAN
X2N
X1N
X1U
PRG
OSA
X2S
X1S
AKB
RA1
RAH
KHN
AKH
LA1
BT2
BTH
glif02.cesnet.cz:1 (glambda)
pověda
Time Table (Networks)
2:30
2:32
2:34
2:36
2:38
2:40
2:42
TKB-KAN (2.0)
TKB-FUK (2.0)
TKB-X1N (1.0)
AKB-OSA (1.0)
AKB-KHN (1.0)
AKB-X1S (3.0)
RA1-X1U (1.0)
RAH-X1U (1.0)
BTH-X1U (1.0)
AKB-AKH (1.0)
X1N-X1S (5.0)
X1N-X1U (4.0)
X1S-X1U (5.0)
KAN-FUK (2.0)
KAN-X1N (2.0)
OSA-KHN (1.0)
OSA-X1S (1.0)
KHN-X1S (1.0)
RA1-RAH (1.0)
RA1-BTH (1.0)
RAH-BT2 (1.0)
RAH-BTH (1.0)
BT2-BTH (1.0)
TKB-X2N (2.0)
KAN-X2N (1.0)
FUK-X1N (2.0)
FUK-X2N (2.0)
AKB-X2S (1.0)
OSA-X2S (2.0)

iCAIR HPDMnet Demonstration at SC09 Portland Oregon




RSV
Server: RSV2_CENIC, Service Name: Bassett-Hand
Get Channels
Start RSV
nternet Explorer
http://198.164.40.210:8080/savoir/
이동
연결
HSVO
SAVOIR - HSVO Project
Web Services Development Team
Release Web Page
For the latest dem
Click Here
Not Knowing How To Use The
Download User Guide
SAVOIR GALLERY
Remote Stereo Viewer (Built: 07/19/07-15:18:39(darwin386)): mono
iCAIR 3D HD HPDMnet
Demonstration
At GLIF Deajong,
South Korea
Oct 2009
iCAIR
HSVO
RSV



Command Prompt - ping -t 10.20.200.91

```
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
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Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
Reply from 10.20.200.91: bytes=32 time=78ms TTL=64
```
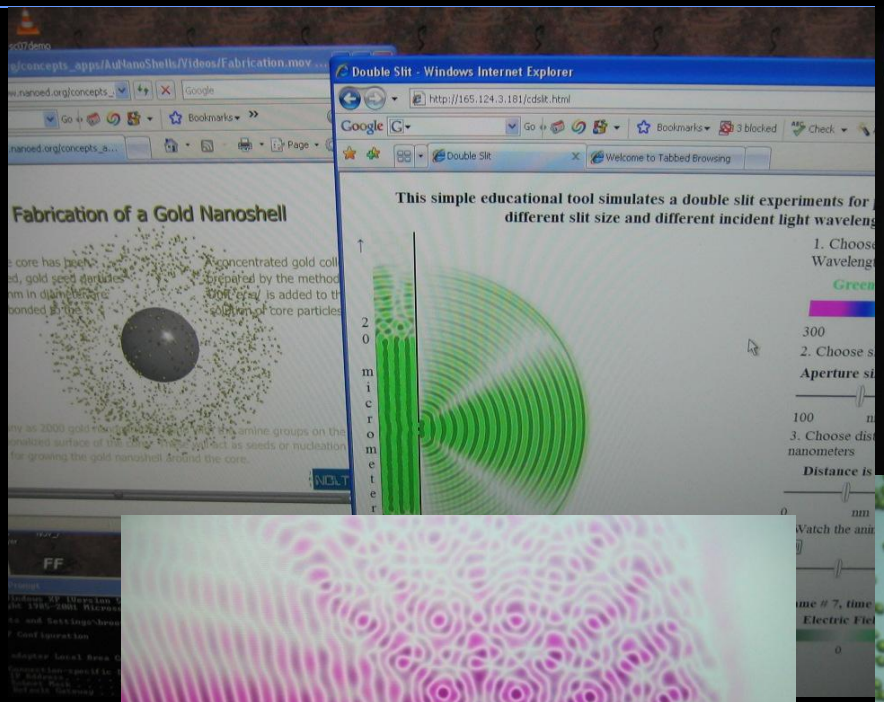
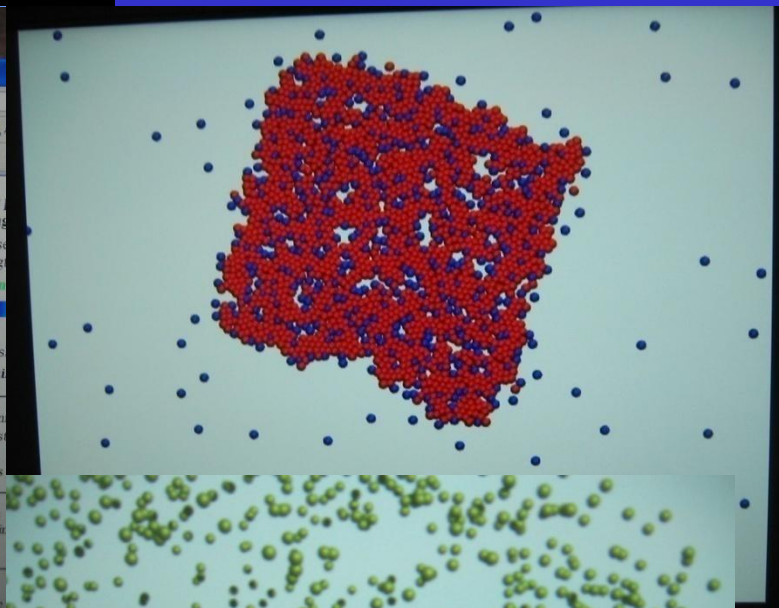
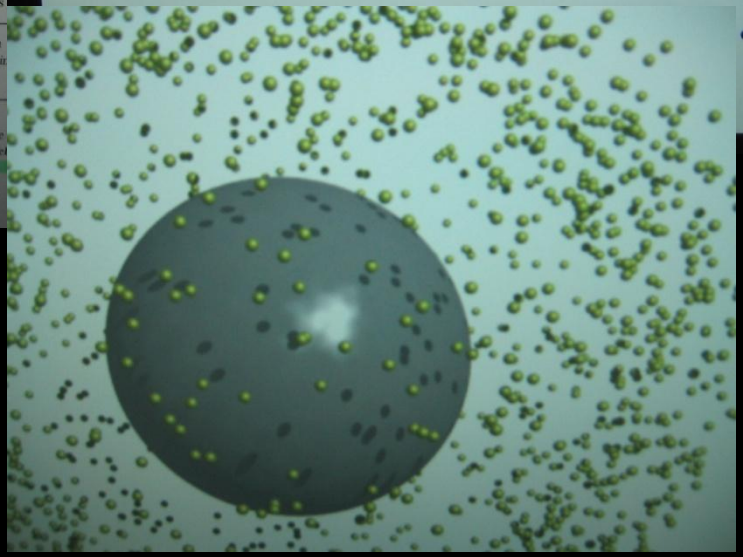

Virtual Instruments for Science

Cooperative Project iCAIR, NCLT

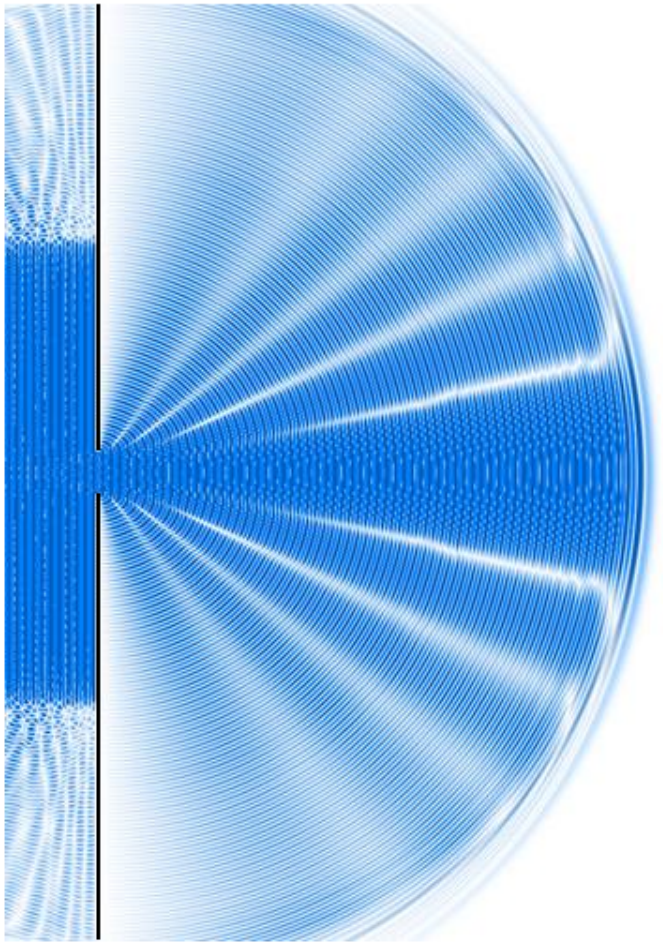






Single Slit Experiments (test 3a) - Microsoft Internet Explorer
File Edit View Favorites Tools Help
NCLT National Center for Learning and Teaching in Nanoscale Science and Engineering

This simple educational tool simulates a single slit experiments for parameters such as different slit size and different incident light wavelength.



Click the picture to zoom in (picture will appear in a new window)

1. Choose the color of light source. Wavelength appears in nanometers

Indigo(465 nm)

380 nm 680

2. Choose slit size in multiples of incident wavelength

Aperture size is 5 λ

0.5λ 10λ

3. Run test and watch the animation

Run Test | Animate | Stop

1 15

Frame # 5, time is 115fs

Legend

-2550 0 2550

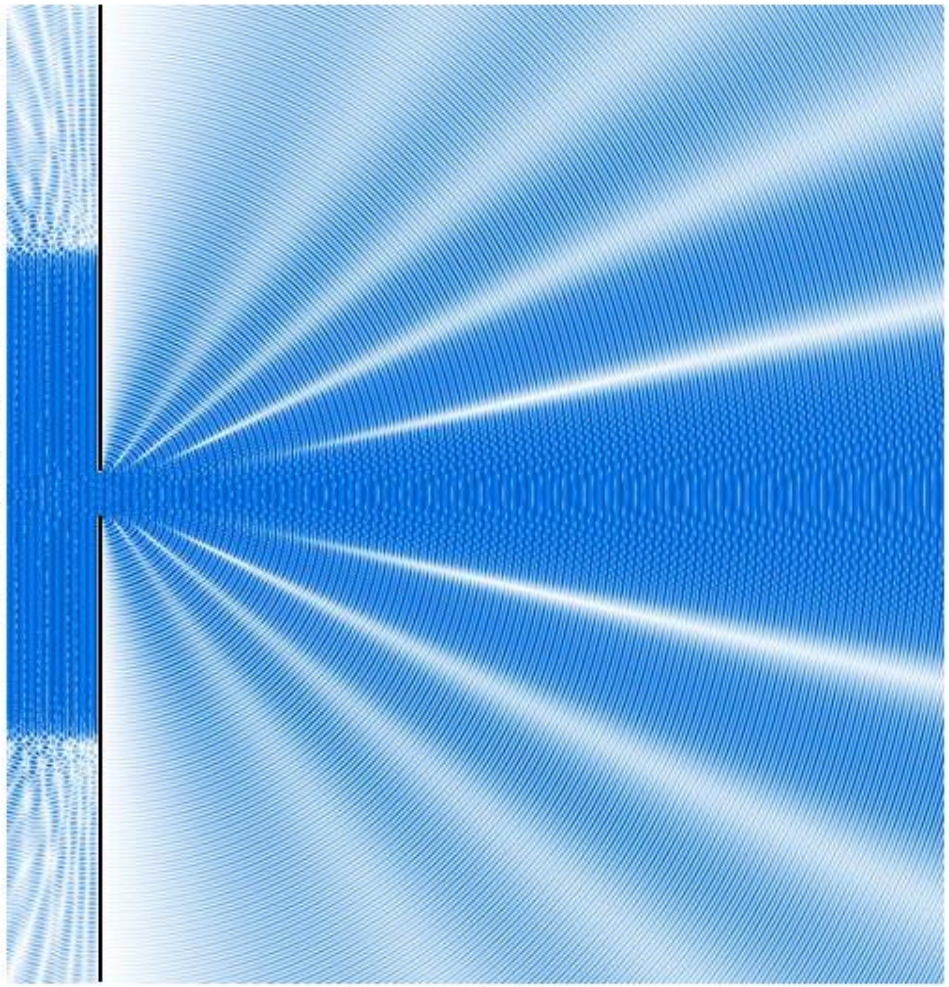
Done Internet
start Eudora Meeting Maker ... https://www.cc... Single Slit Exper... Microsoft Powe... 99% 12:01 PM

File Edit View Favorites Tools Help

National Center for Learning and Teaching in Nanoscale Science and Engineering

Settings

This simple educational tool simulates a single slit experiments for parameters such as different slit size and different incident light wavelength.



Click the picture to zoom in (picture will appear in a new window)

1. Choose the color of light source. Wavelength appears in nanometers

Indigo(465 nm)

380 nm 680

2. Choose slit size in multiples of incident wavelength

Aperture size is 5 λ

0.5λ 10λ

3. Run test and watch the animation

Run Test | Animate | Stop

1 15

Frame # 11, time is 253fs

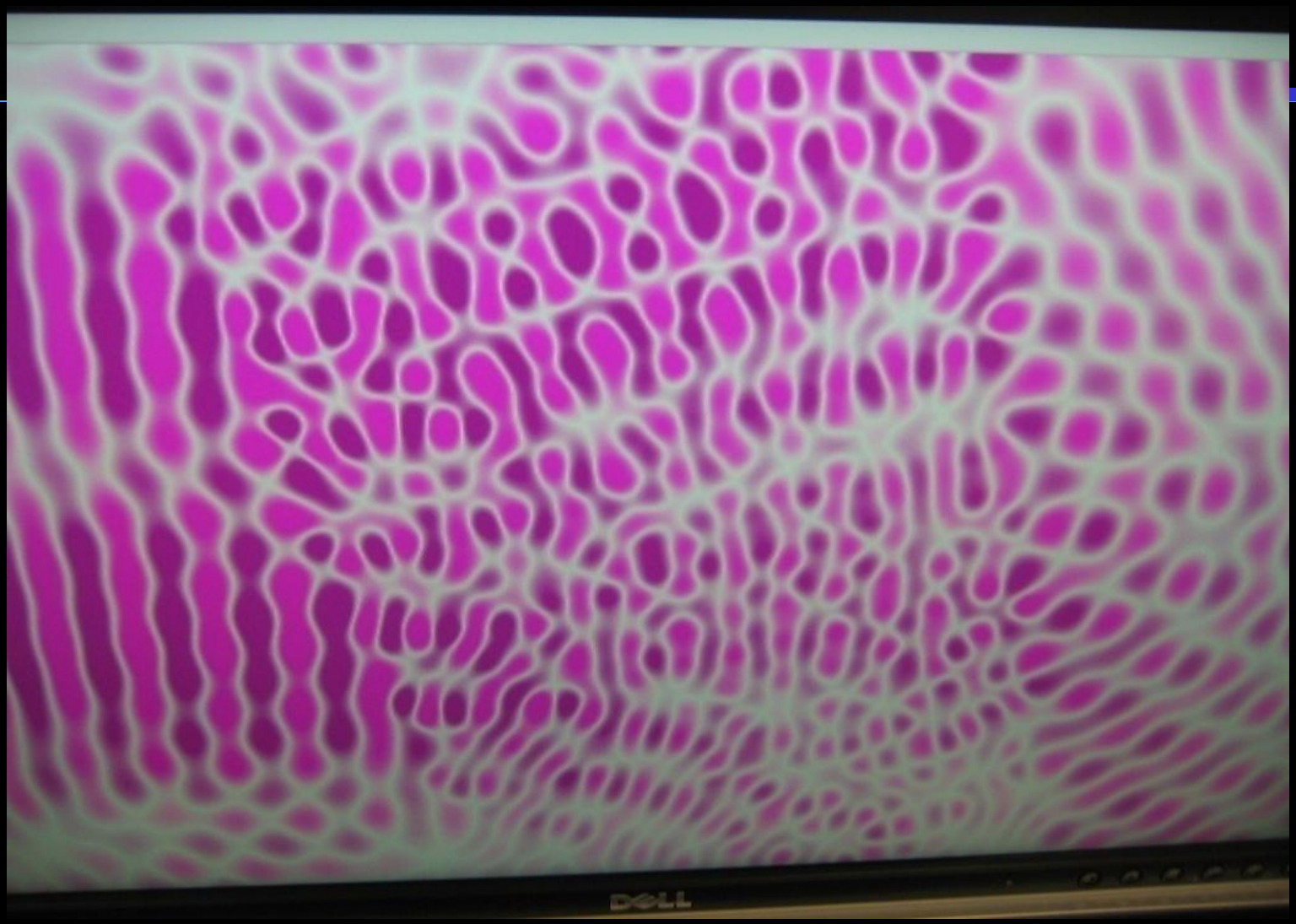
Legend

-2550 0 2550

Done

Internet

start Eudora Meeting Maker ... https://www.cc... Single Slit Exper... Microsoft Powe... 99% 12:02 PM


DELL

Summary

- Large Scale, Data (and Compute) Intensive Sciences Encounter Technology Challenges Many Years Before Other Domains
- Resolving These Issues Creates Solutions That Later Migrate To Other Domains
- Generally Implemented Networks, Including Common R&E Networks Are Not Suffcient To Meet The Needs of 21st Century Science
- Many Private Customized Networks Are Being Created for Specific Sciences
- New Advanced Communication Exchanges Are Being Designed and Implemented To Meet These Emerging and Anticipated Requirements