“The Pacific Research Platform- a High-Bandwidth Global-Scale Private ‘Cloud’ Connected to Commercial Clouds”

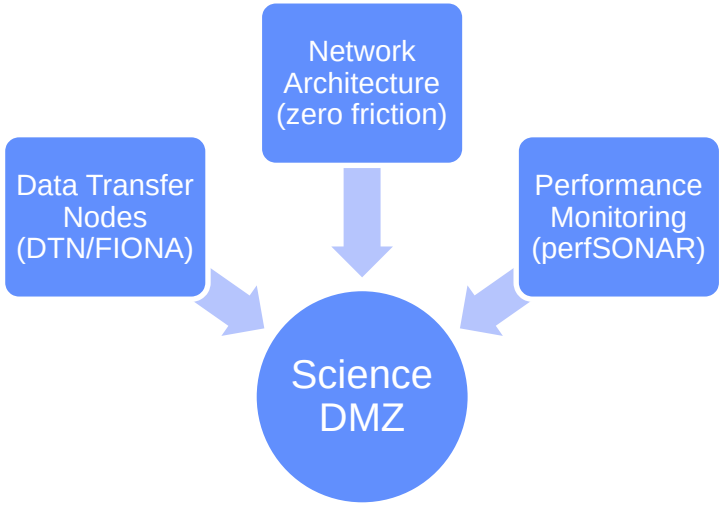
Presentation to the UC Berkeley Cloud Computing MeetUp
May 26, 2020

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
http://lsmarr.calit2.net

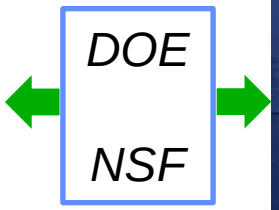
PACIFIC RESEARCH PLATFORM

Before the PRP: ESnet's ScienceDMZ Accelerates Science Research: DOE & NSF Partnering on Science Engagement and Technology Adoption

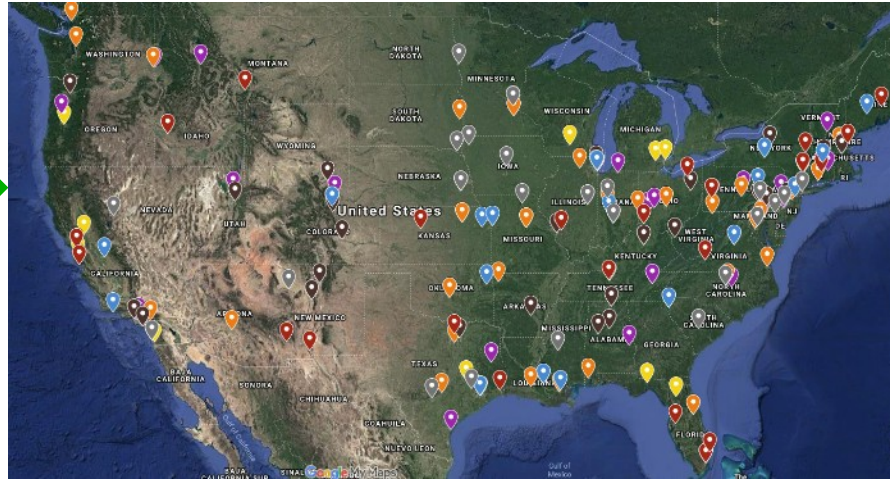
ScienceDMZ Coined in 2010 by ESnet
Basis of PRP Architecture and Design

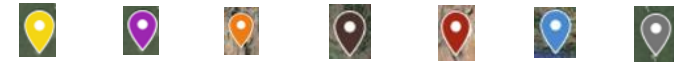


http://fasterdata.es.net/science-dmz/



NSF Campus Cyberinfrastructure Program
Has Made Over 250 Awards





Slide Adapted From Inder Monga, ESnet

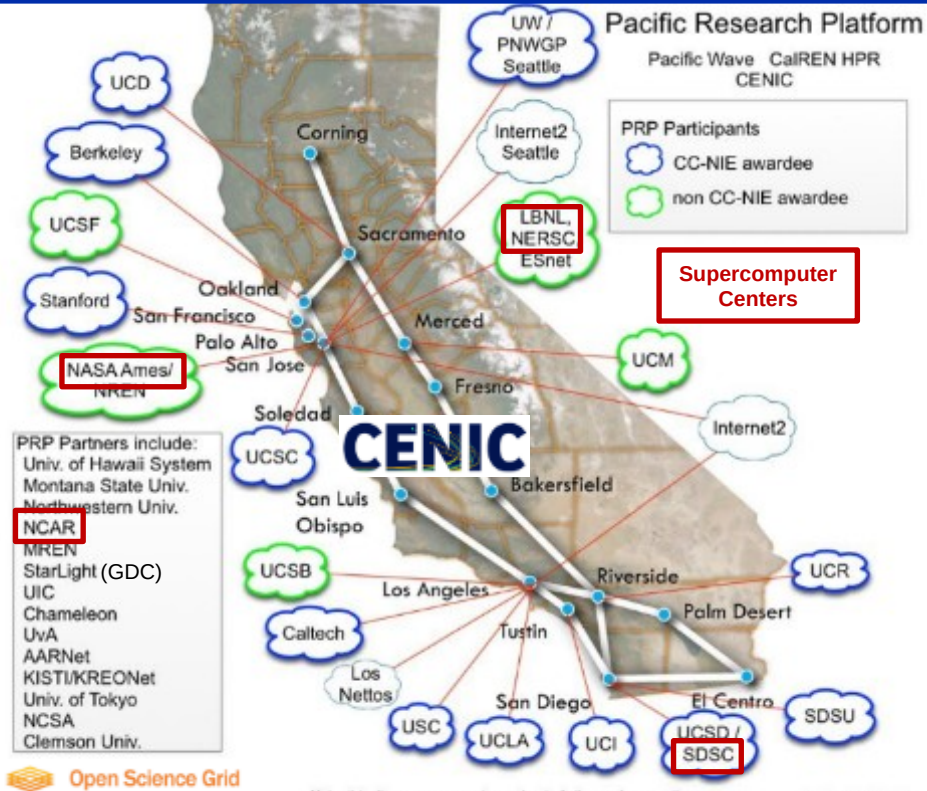
PRP PACIFIC RESEARCH PLATFORM

ESnet FASTERDATA KNOWLEDGEBASE

NSF

it²

2015 Vision: The Pacific Research Platform Will Connect Science DMZs Creating a Regional End-to-End Science-Driven Community Cyberinfrastructure



Source: John Hess, CENIC

NSF CC*DNI Grant
$6.3M 10/2015-10/2020
In Year 5 Now

PI: Larry Smarr, UC San Diego Calit2

Co-PIs:

- **Camille Crittenden, UC Berkeley CITRIS,**
- **Philip Papadopoulos, UCI**
- **Tom DeFanti, UC San Diego Calit2/QI,**
- **Frank Wuerthwein, UCSD Physics and SDSC**



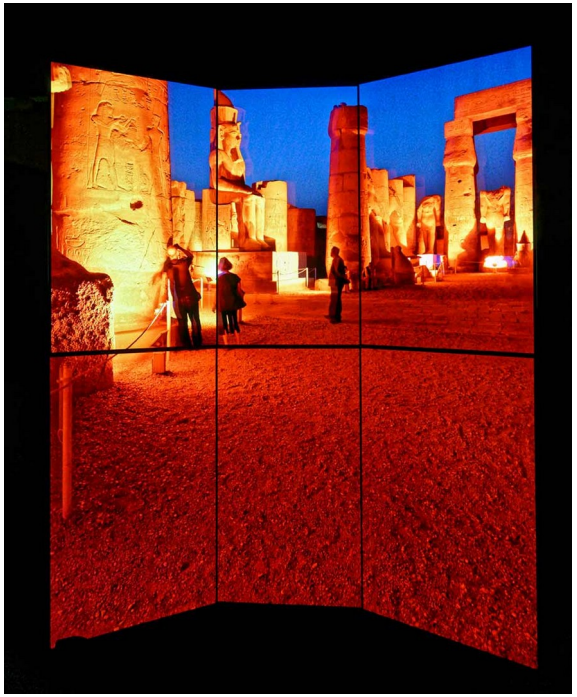
Letters of Commitment from:

- ***50 Researchers from 15 Campuses***
- ***32 IT/Network Organization Leaders***

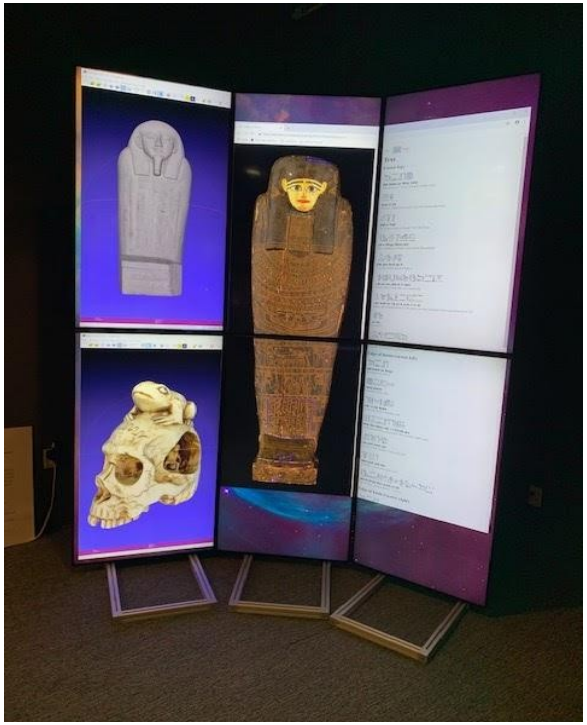
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SDSC CITRIS BANATAO INSTITUTE it²

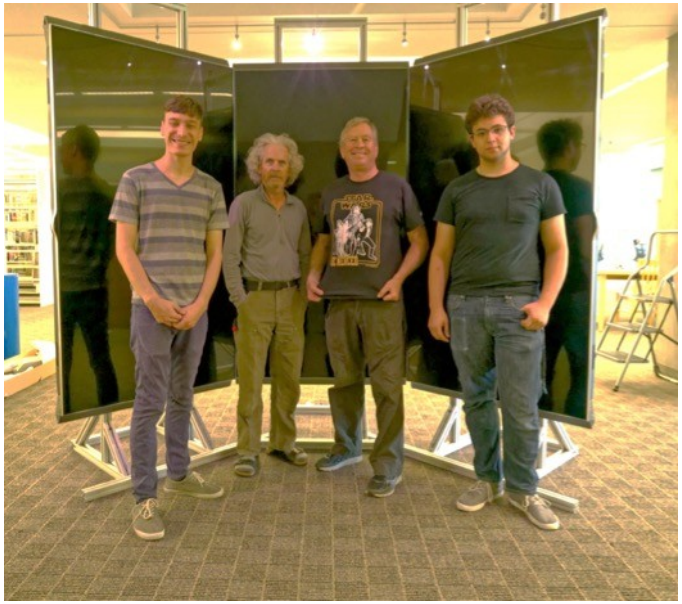
PRP Links At-Risk Cultural Heritage and Archaeology Datasets at UCB, UCLA, UCM and UCSD with CAVEkiosks



48 Megapixel CAVEkiosk
UCSD Library



48 Megapixel CAVEkiosk
UCB CITRIS Tech Museum



24 Megapixel CAVEkiosk
UCM Library

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UC President Napolitano's Research Catalyst Award to
UC San Diego (Tom Levy), UC Berkeley (Benjamin Porter), UC Merced (Nicola Lercari) and UCLA (Willeke Wendrich)

it²

Terminating the Fiber Optics - Data Transfer Nodes (DTNs): Flash I/O Network Appliances (FIONAs)

UCSD-Designed FIONAs Solved the Disk-to-Disk Data Transfer Problem *at Near Full Speed* on Best-Effort 10G, 40G and 100G Networks



Two FIONA DTNs at UC Santa Cruz: 40G & 100G
Up to 192 TB Rotating Storage

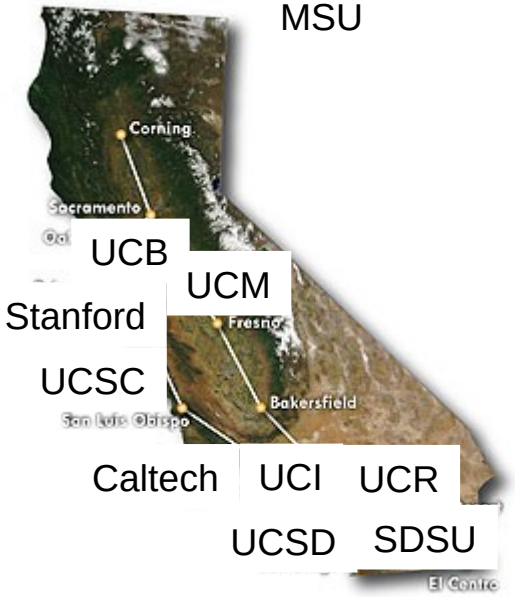




Add Up to 8 Nvidia GPUs Per 2U FIONA
To Add Machine Learning Capability

FIONAs Designed by UCSD's Phil Papadopoulos, John Graham, Joe Keefe, and Tom DeFanti

2017-2020: NSF CHASE-CI Grant Adds a Machine Learning Layer Built on Top of the Pacific Research Platform



CI-New: Cognitive Hardware and Software Ecosystem Community Infrastructure (CHASE-CI)

For the Period September 1, 2017 – August 31, 2020

SUBMITTED – January 18, 2017

PI: Larry Smarr, Professor of Computer Science and Engineering, Director Calit2, UCSD
Co-PI: Tajana Rosing, Professor of Computer Science and Engineering, UCSD
Co-PI: Ken Kreutz-Delgado, Professor of Electrical and Computer Engineering, UCSD
Co-PI: Ilkay Altintas, Chief Data Science Officer, San Diego Supercomputer Center, UCSD
Co-PI: Tom DeFanti, Research Scientist, Calit2, UCSD

NSF Grant for High Speed "Cloud" of 256 GPUs
For 30 ML Faculty & Their Students at 10 Campuses
for Training AI Algorithms on Big Data

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JACOBS SCHOOL OF ENGINEERING

SDSC UC San Diego

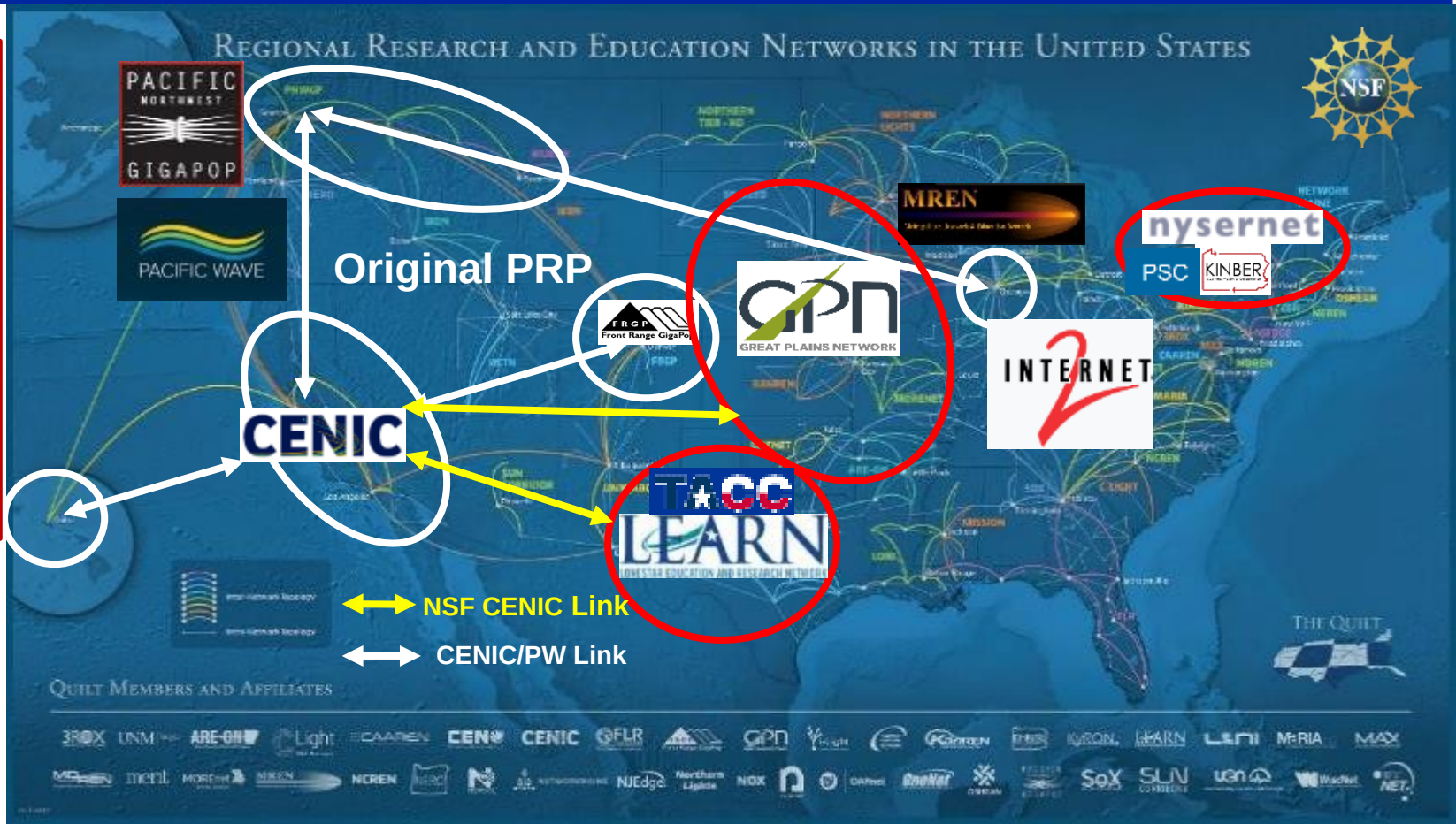
2018-2021: Toward the National Research Platform (NRP) - Using CENIC & Internet2 to Connect Quilt Regional R&E Networks

"Towards The NRP"
3-Year Grant Funded by NSF
$2.5M
October 2018

PI Smarr
Co-PIs Altintas Papadopoulos Wuerthwein Rosing DeFanti

SDSC

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2018/2019: PRP Game Changer!
Using Kubernetes to Orchestrate Containers Across the PRP

CADE METZ BUSINESS 06.10.14 01:15 PM

GOOGLE OPEN SOURCES ITS SECRET WEAPON IN CLOUD COMPUTING

WIRED

"Kubernetes is a way of stitching together a collection of machines into, basically, a big computer,"
--Craig Mcluckie, Google
and now CEO and Founder of Heptio

"Everything at Google runs in a container."
--Joe Beda,Google

News

How Kubernetes Conquered 2017 (and is Positioned for 2018)



Dan Meyer | Editor-in-Chief
December 25, 2017 4:00 AM

sdxcentral



Kubernetes, an open-source software project that started at Google, has exploded in popularity and is now used by at least 54% of the Fortune 500. BUSINESS INSIDER **Rosalie Chan** Jan. 27, 2019,

PRP PACIFIC RESEARCH PLATFORM

CLOUD NATIVE COMPUTING FOUNDATION

it²

PRP's *Nautilus Hypercluster* Adopted Kubernetes to Orchestrate Software Containers and Rook, Which Runs Inside of Kubernetes, to Manage Distributed Storage



Battle-tested, production storage

Rook is based on an embedded version of Ceph, which has 10+ years of production deployments and runs some of the worlds largest clusters.

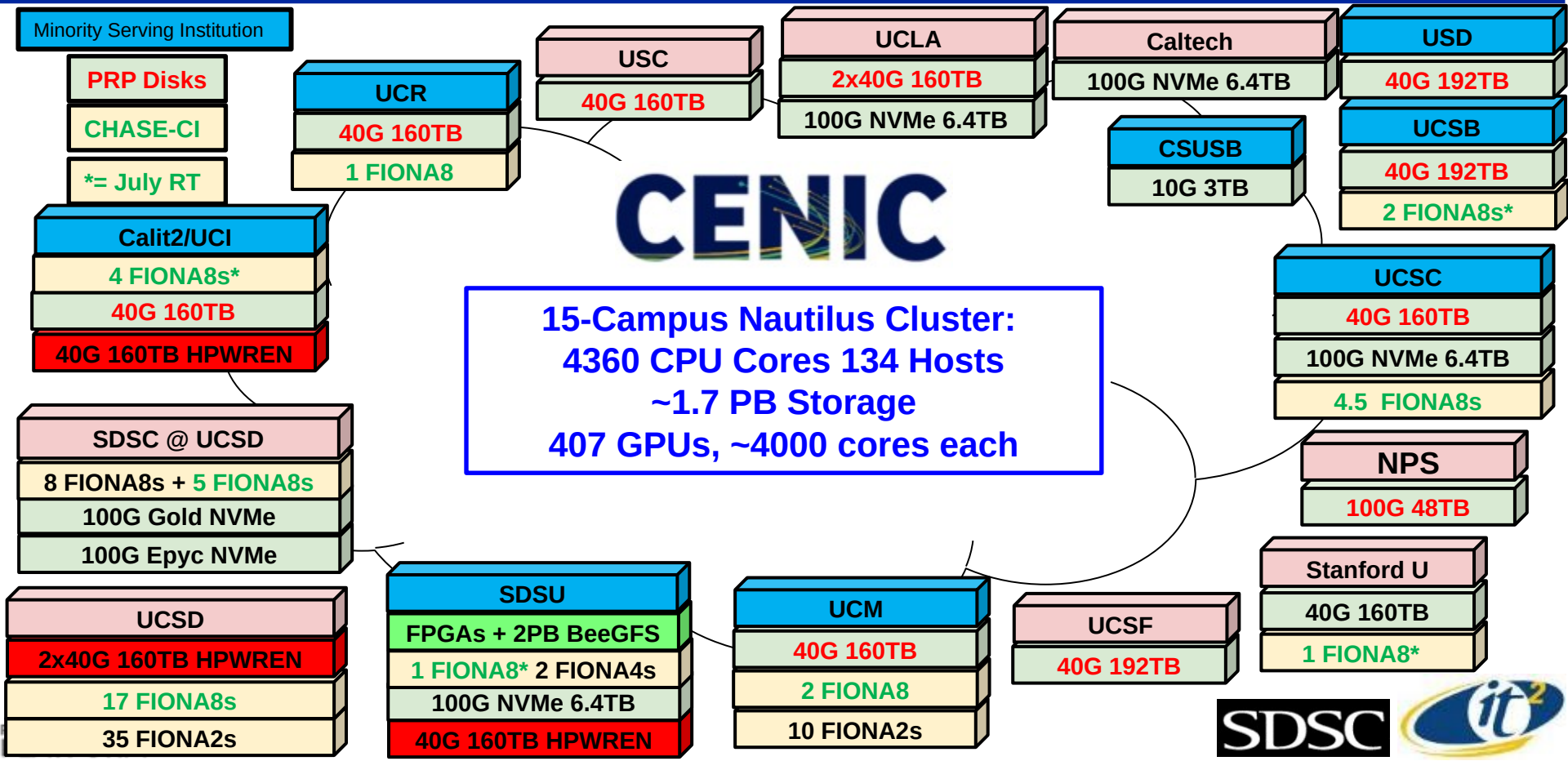
Cloud-native environment integration

Rook runs as a cloud-native service for optimal integration with applications in need of block, object, or file storage.

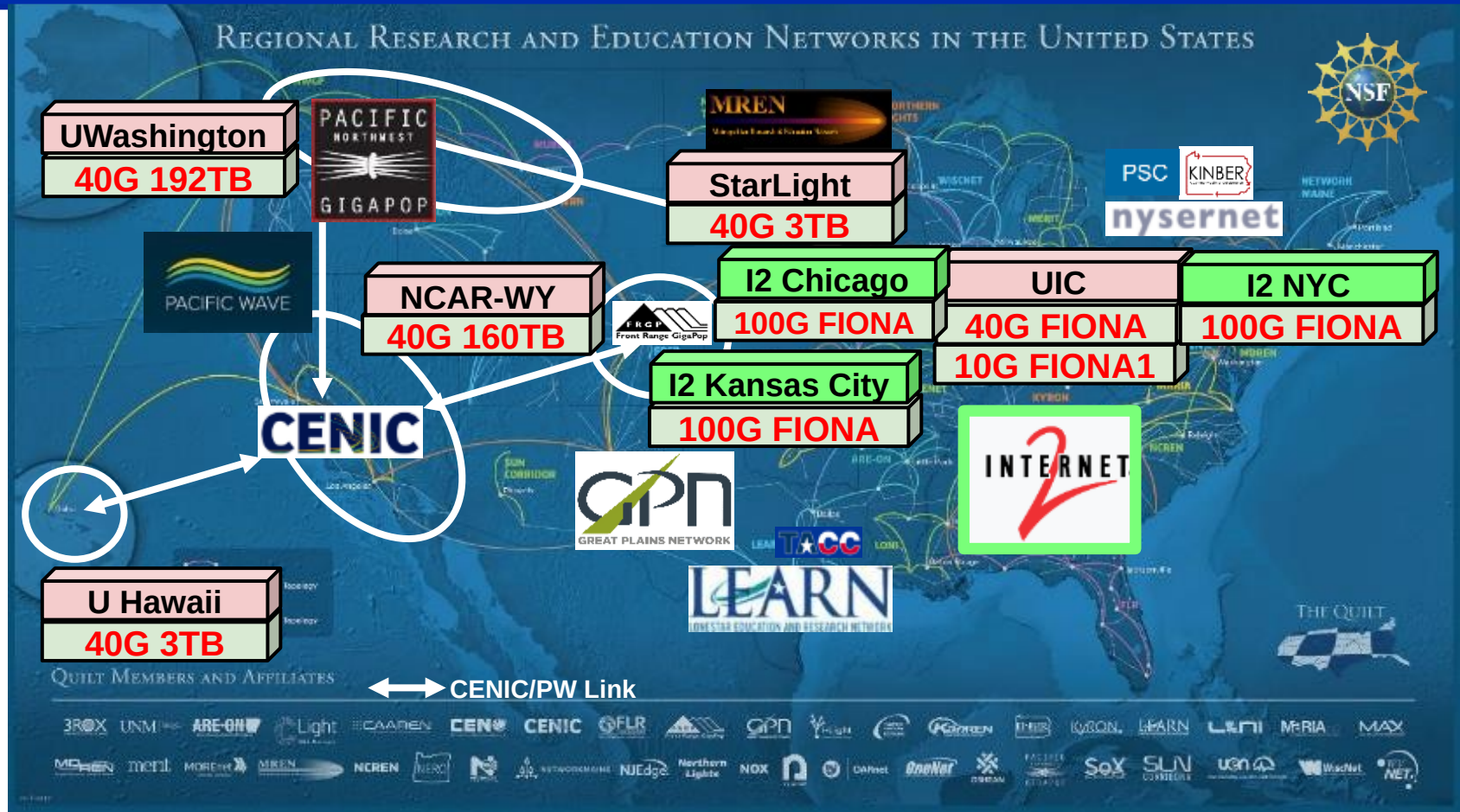
"Kubernetes with Rook/Ceph Allows Us to Manage Petabytes of Distributed Storage and GPUs for Data Science,
While We Measure and Monitor Network Use."
--John Graham, Calit2/QI UC San Diego

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PRP's California Nautilus Hypercluster Connected by Use of CENIC 100G Network

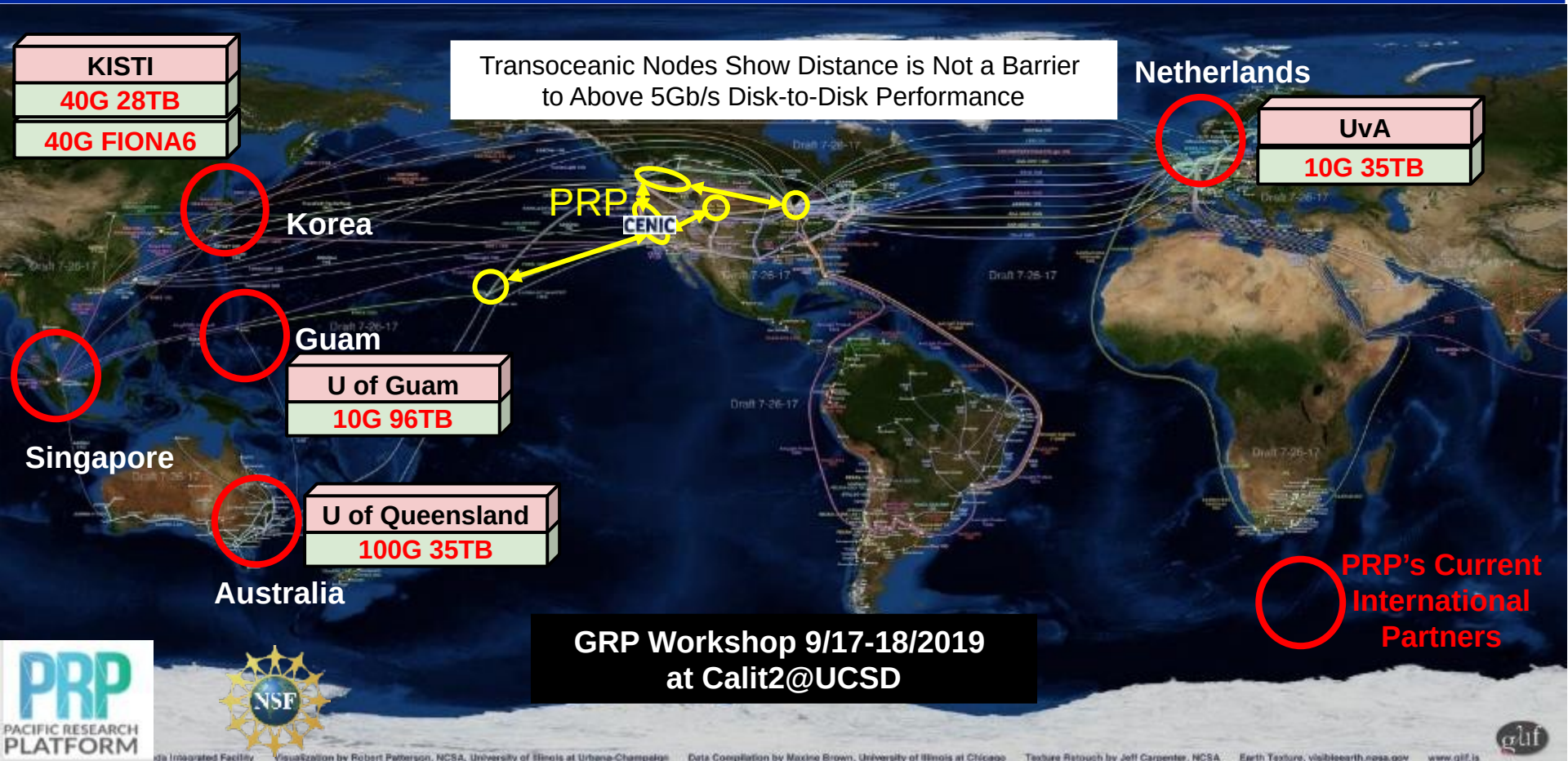


PRP/TNRP's United States Nautilus Hypercluster FIONAs Now Connects 4 More Regionals and 3 Internet2 Storage Sites

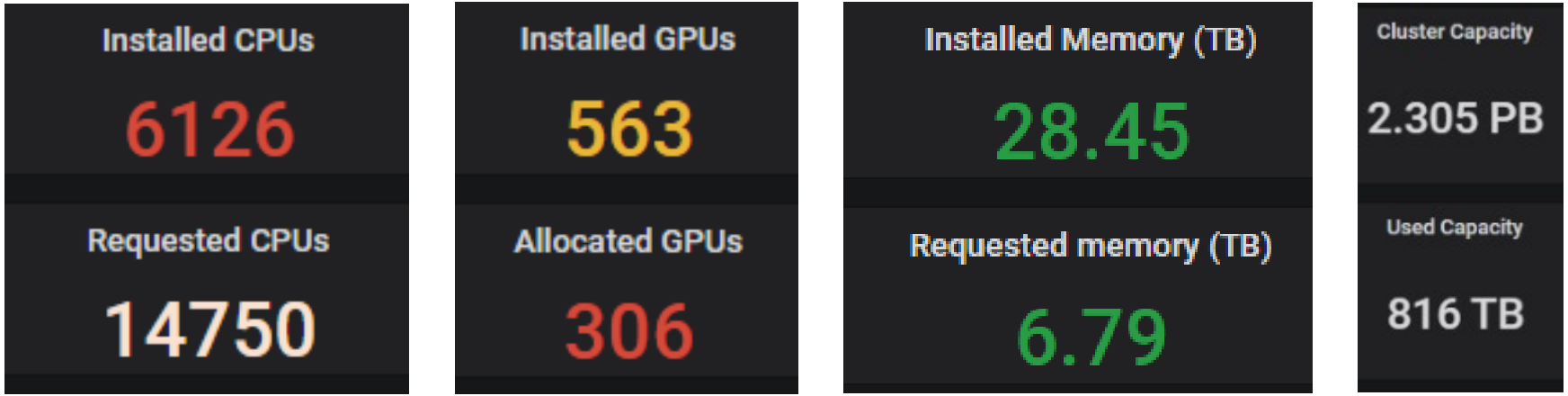


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PRP Global Nautilus Hypercluster Is Rapidly Adding International Partners Beyond Our Original Partner in Amsterdam



PRP's Nautilus Forms a Multi-Application Powerful Distributed "Big Data" Storage and Machine-Learning Computer



Source: grafana.nautilus.optiputer.net on 1/27/2020

Collaboration on Distributed Machine Learning for Atmospheric Water in the West Between UC San Diego and UC Irvine

Pacific Research Platform (10-100 Gb/s)

Complete workflow time:
19.2 days 52 Minutes!
532 Times Faster!

UC, Irvine

CENTER FOR HYDROMETEOROLOGY & REMOTE SENSING
CHRS
UCIrvine

GPUs



Calit2's FIONA

SDSC's COMET



Source: Scott Sellers, CW3E

UC, San Diego

GPUs



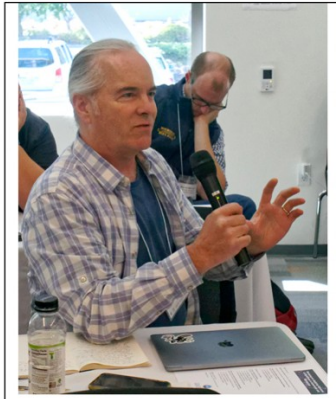
Calit2's FIONA

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UCB Science Engagement Workshop:
Applying Advanced Astronomy AI to Microscopy Workflows

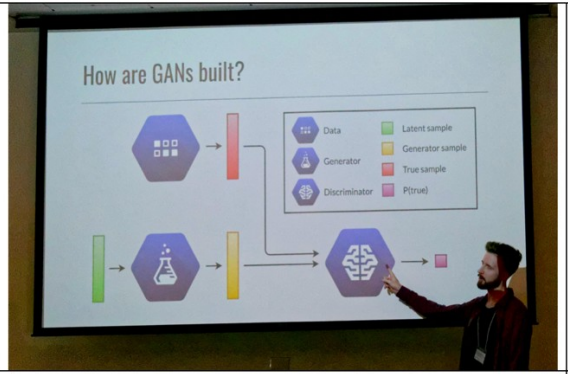
Organized and Coordinated by UCB's PRP Science Engagement Team



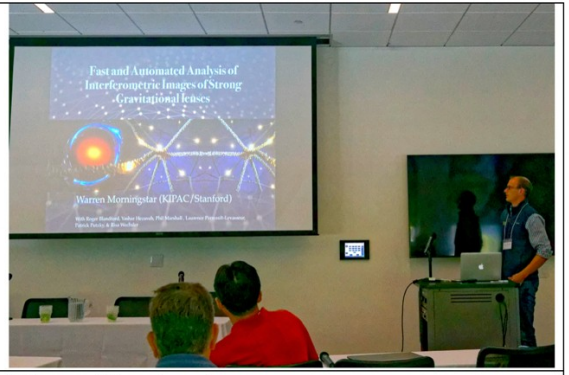
Chris Hoffman



Afternoon Panel: Yee Ting Li, Shawfeng Dong, Debbie Bard, Jeffrey Weekley



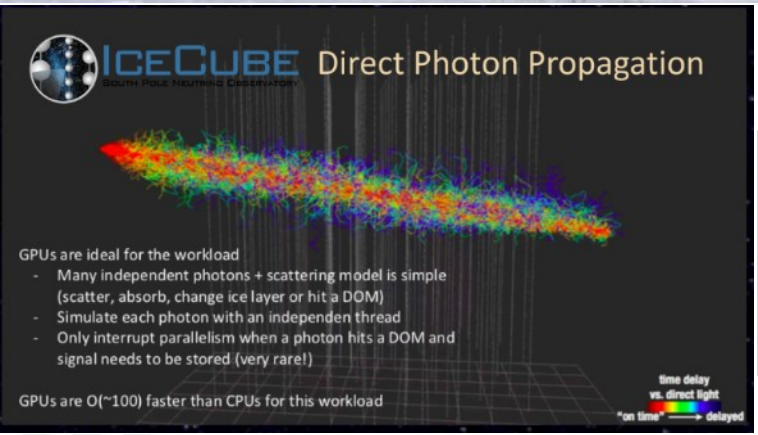
David Reiman



Warren Morningstar

NSF Large-Scale Observatories
Asked to Utilize PRP Compute Resources



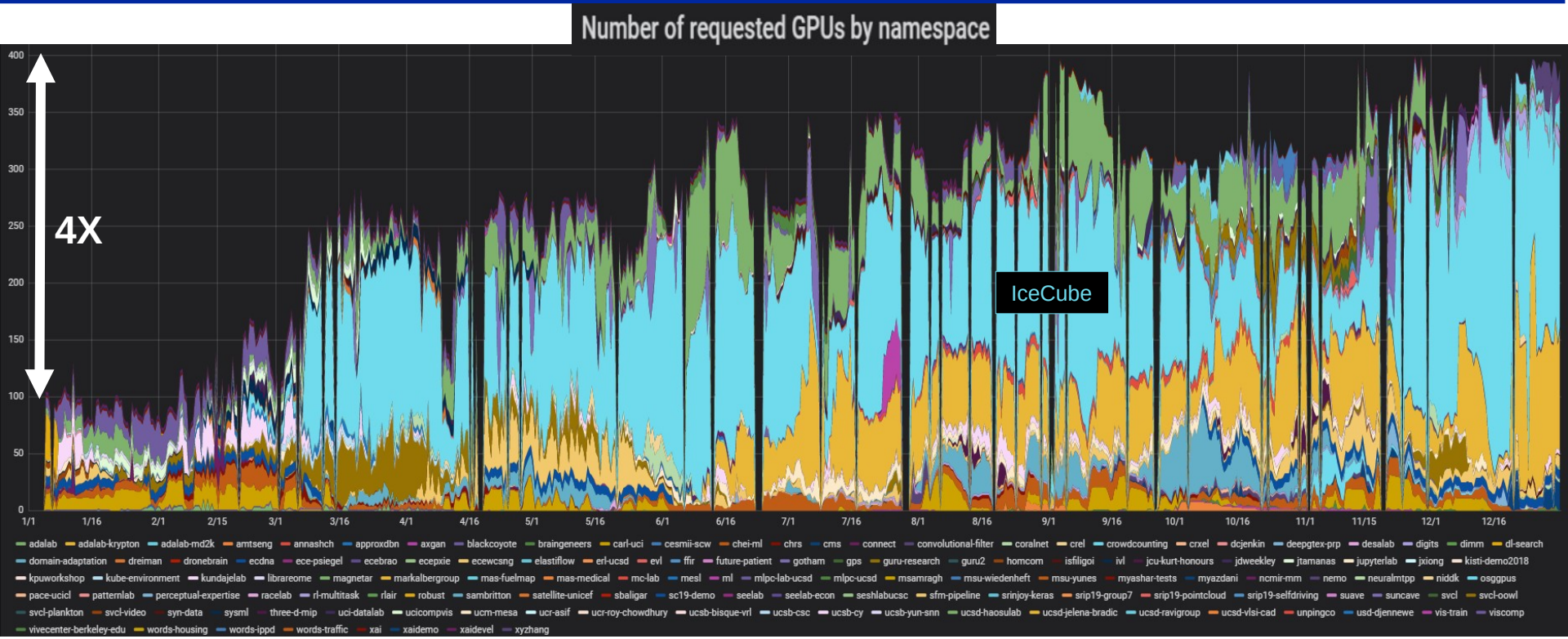


GPU Simulations Needed *to Improve Ice Model*.
⇒ Results in *Significant Improvement*
in Pointing Resolution for Multi-Messenger Astrophysics
⇒ But IceCube Did Not Have Access to GPUs

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Number of Requested PRP Nautilus GPUs For All Projects Has Gone Up 4X in 2019 Largely Driven By the Unplanned Access by NSF's IceCube



https://grafana.nautilus.optiputer.net/d/fHSeM5Lmk/k8s-compute-resources-cluster-gpus?orgId=1&fullscreen&panelId=2&from=1546329600000&to=1577865599000

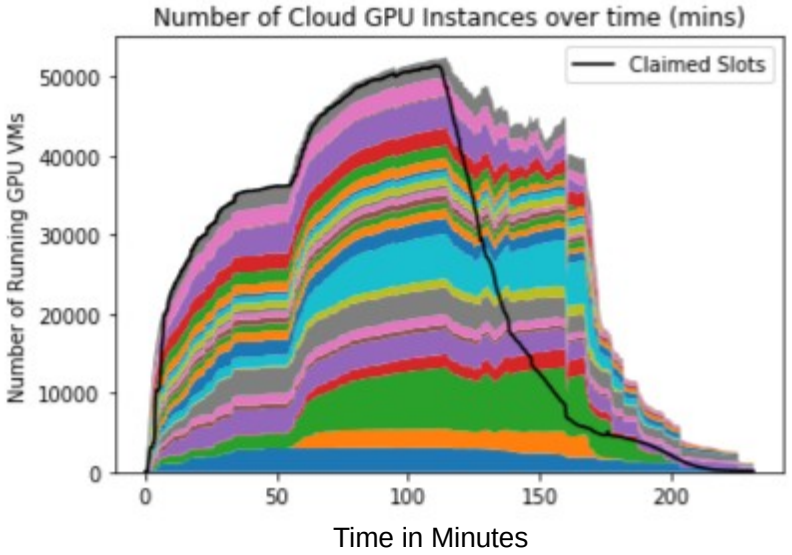
Multi-Messenger Astrophysics with IceCube Across All Available GPUs in the Cloud

- **Integrate All GPUs Available for Sale Worldwide into a Single HTCondor Pool**
  - Use 28 Regions Across AWS, Azure, and Google Cloud for a Burst of a Couple Hours, or so
  - Launch From PRP FIONAs
- **IceCube Submits Their Photon Propagation Workflow to this HTCondor Pool.**
  - The Input, Jobs on the GPUs, and Output are All Part of a Single Globally Distributed System
  - This Demo Used Just the Standard HTCondor Tools

Run a GPU Burst Relevant in-Scale for Future Exascale HPC Systems

PACIFIC RESEARCH PLATFORM

Science with 51,000 GPUs Achieved as Peak Performance



Each Color is a Different Cloud Region in US, EU, or Asia.

Total of 28 Regions in Use

Peaked at 51,500 GPUs

~380 Petaflops of FP32

Summary of Stats at Peak - 8 Generations of NVIDIA GPUs Used

	V100	P100	P40	P4	T4	M60	K80	K520
Num GPUS	9.2k	7.2k	2.1k	0.5k	4.6k	10.1k	12.5k	5.4k
PFLOP32s	132.2	68.1	25.2	2.5	38.6	48.8	51.6	12.4

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Engaging More Scientists: PRP Website
http://ucsd-prp.gitlab.io/

