“The Increasing Use of the National Research Platform by the CSU Campuses”

CIO Council

Cal Poly Humboldt

September 22, 2023

Dr. Larry Smarr

Founding Director Emeritus, California Institute for Telecommunications and Information Technology;

Distinguished Professor Emeritus, Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

http://lsmarr.calit2.net

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

2015-2022: The Pacific Research Platform NSF Grants Were Built on CENIC

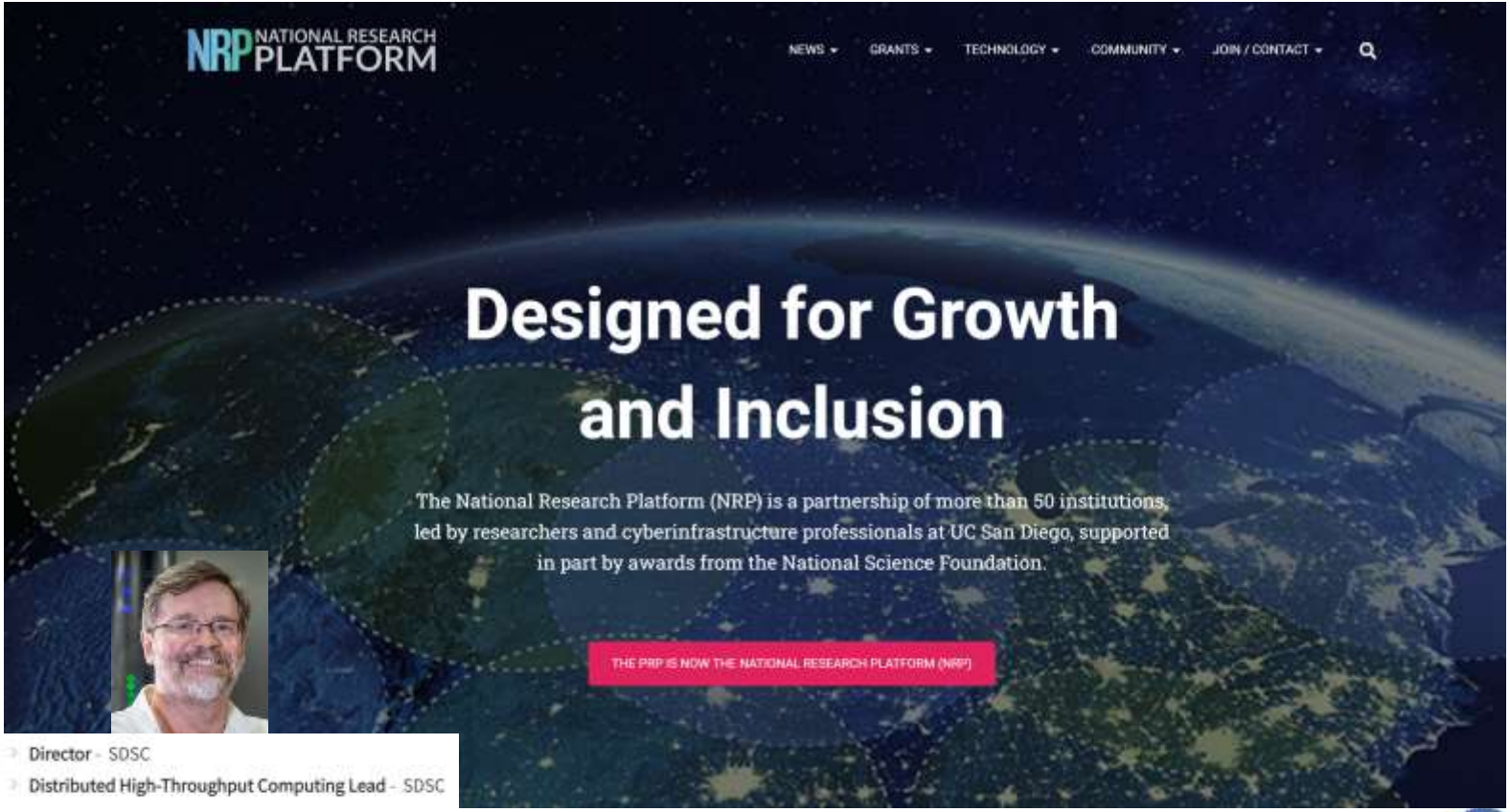


NSF CC*DNI Grant
$7.3M 10/2015-10/2020
Extended 2 Years – Ended 10/2022



Source: John Hess, CENIC

2023 - The National Research Platform Unifies The Previous 8 Years of NSF Grants



2023: NRP's *Nautilus* is a Multi-Institution Hypercluster Which Creates a "Cyberinfrastructure Commons"

Sept. 14, 2023

~200 FIONAs on 30 Partner Campuses
Networked Together at 10-100Gbps

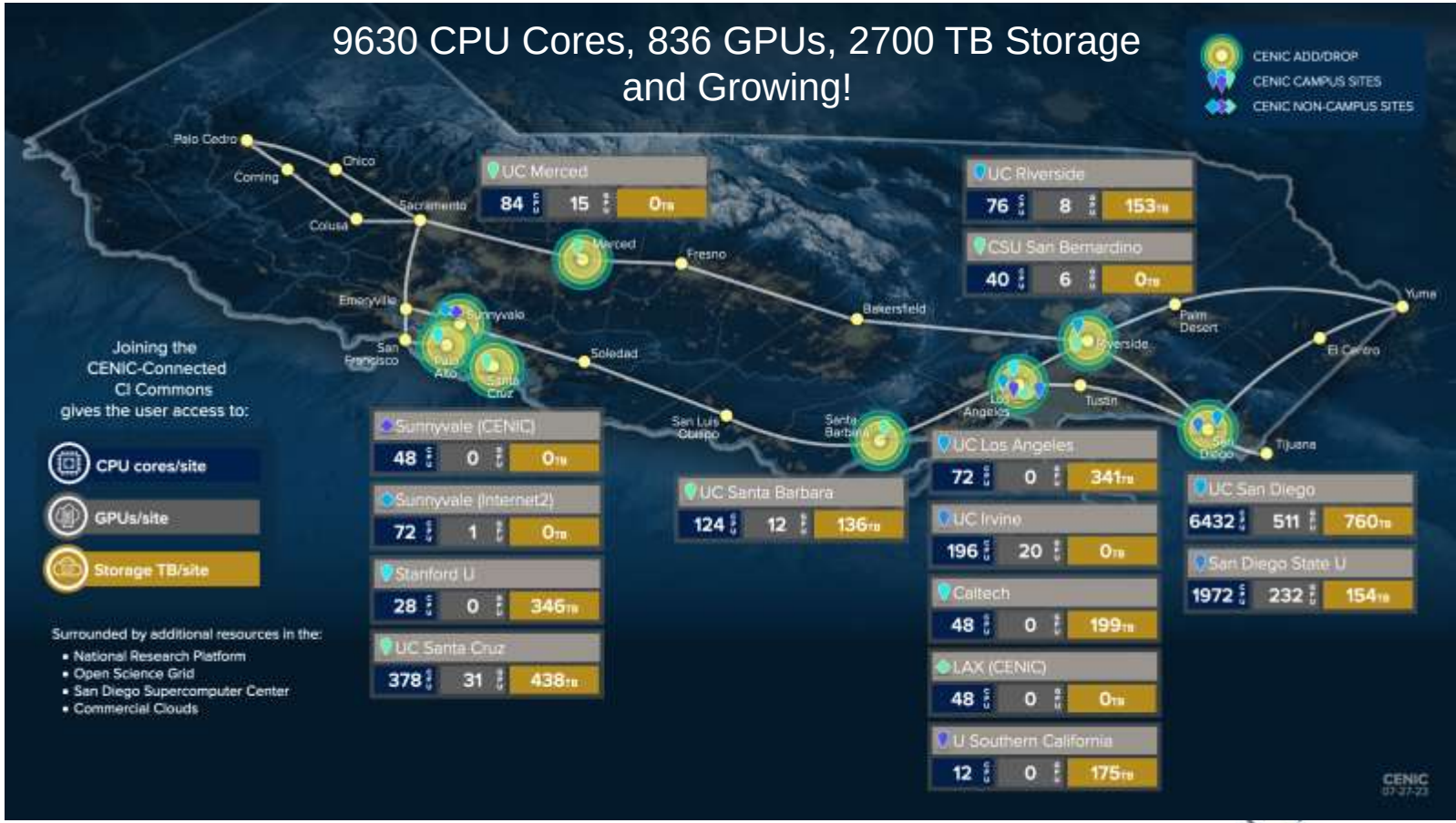
Installed CPU Cores	Installed GPUs	Rotating Storage
19857	1281	10,000 TB

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

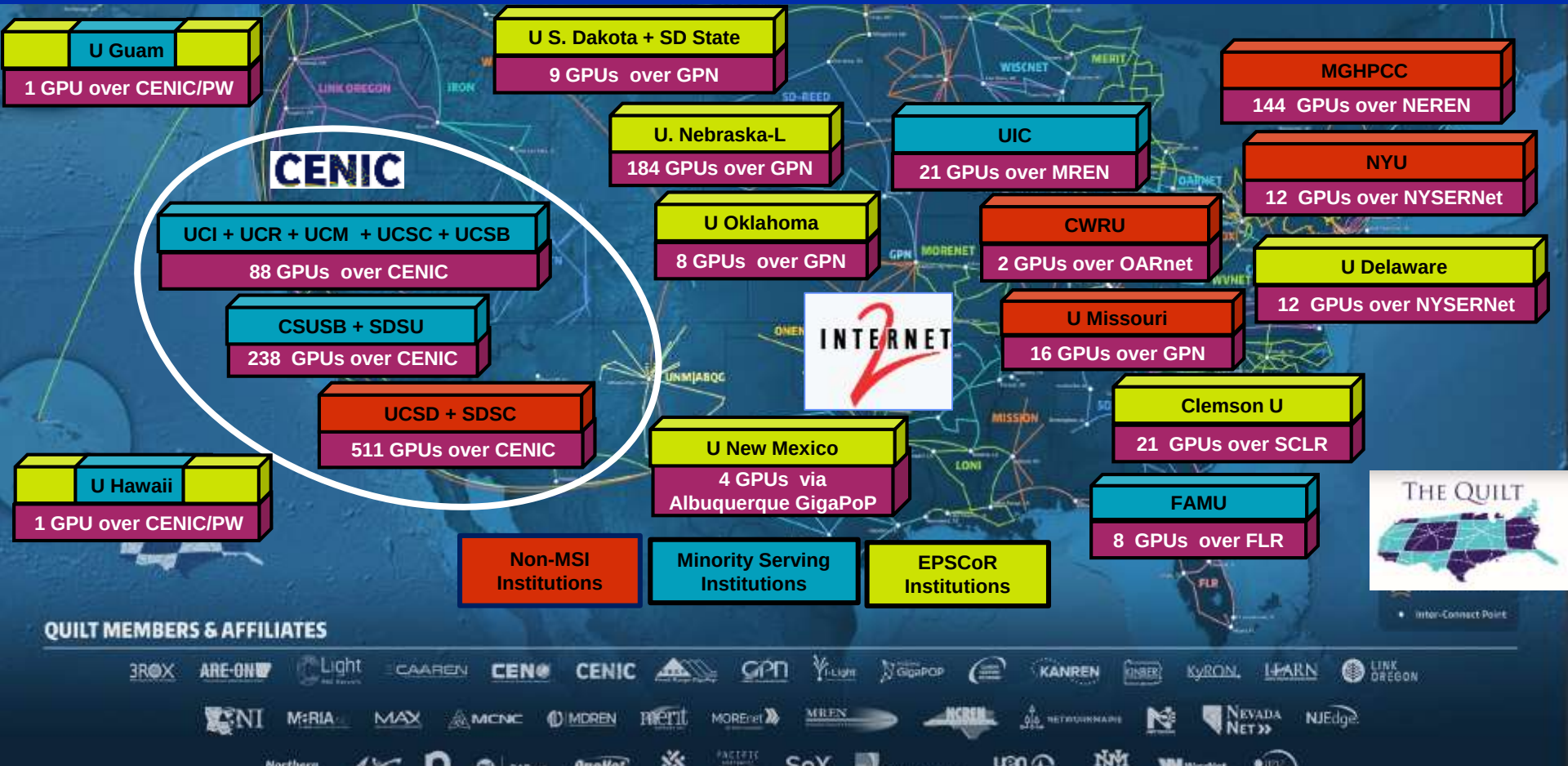
The CENIC-Connected Cyberinfrastructure Commons: Hosted by and Available to CENIC Members-Including the CSU Campuses

The CENIC-Connected Subset of the NRP's Nautilus



Graphics by Hunter Hadaway, CENIC; Data by Tom DeFanti, UCSD

The Users of the CENIC-Connected CI Commons Can Burst into NRP's Nautilus Hypercluster Outside of California



The Users of the CENIC-Connected CI Commons Can Burst into The Open Science Grid (OSG), Which Has Been Integrated With the NRP

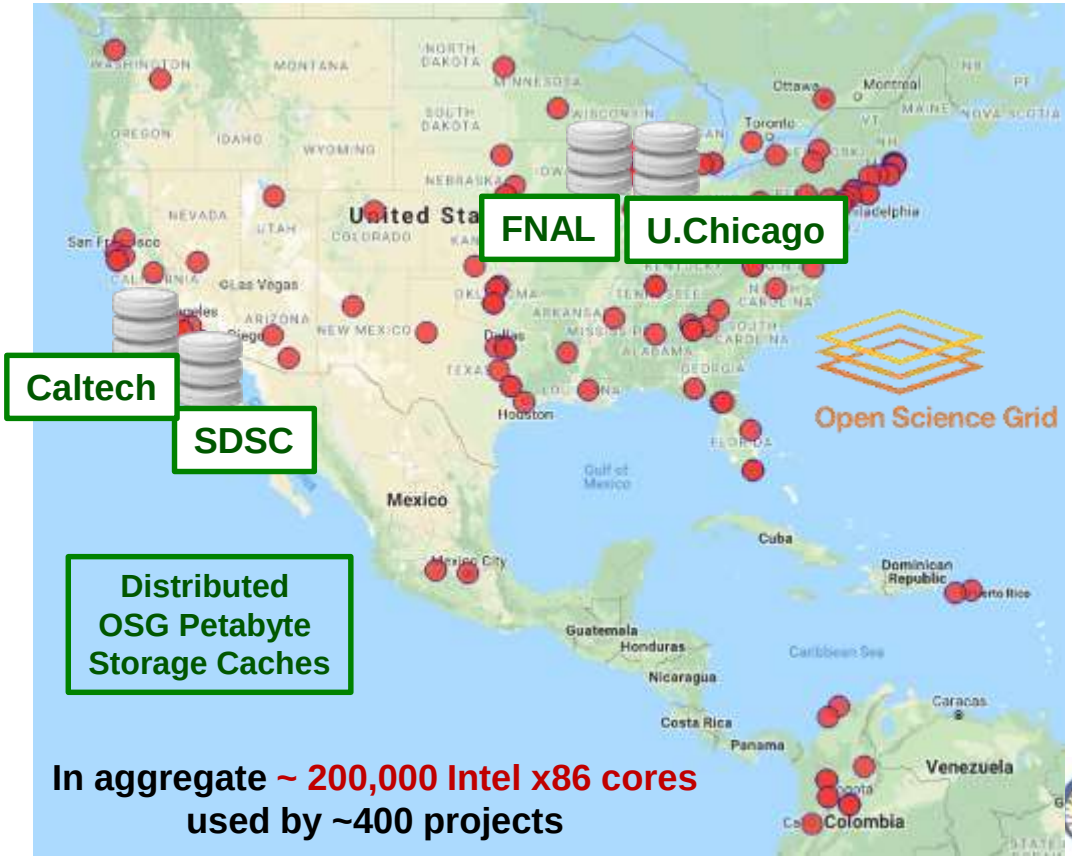
Source: Frank Würthwein,
OSG Exec Director; PRP co-PI; UCSD/SDSC

All OSG User Communities Use HTCondor for Resource Orchestration

HTCondor
High Throughput Computing

NSF

OSG Federates ~100 Clusters Worldwide



In aggregate ~ 200,000 Intel x86 cores used by ~400 projects

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

The Users of the CENIC-Connected CI Commons Can Burst into SDSC's Supercomputing and Data Storage Resources

SDSC SAN DIEGO SUPERCOMPUTER CENTER
at the UNIVERSITY OF CALIFORNIA SAN DIEGO
COMPUTING WITHOUT BOUNDARIES



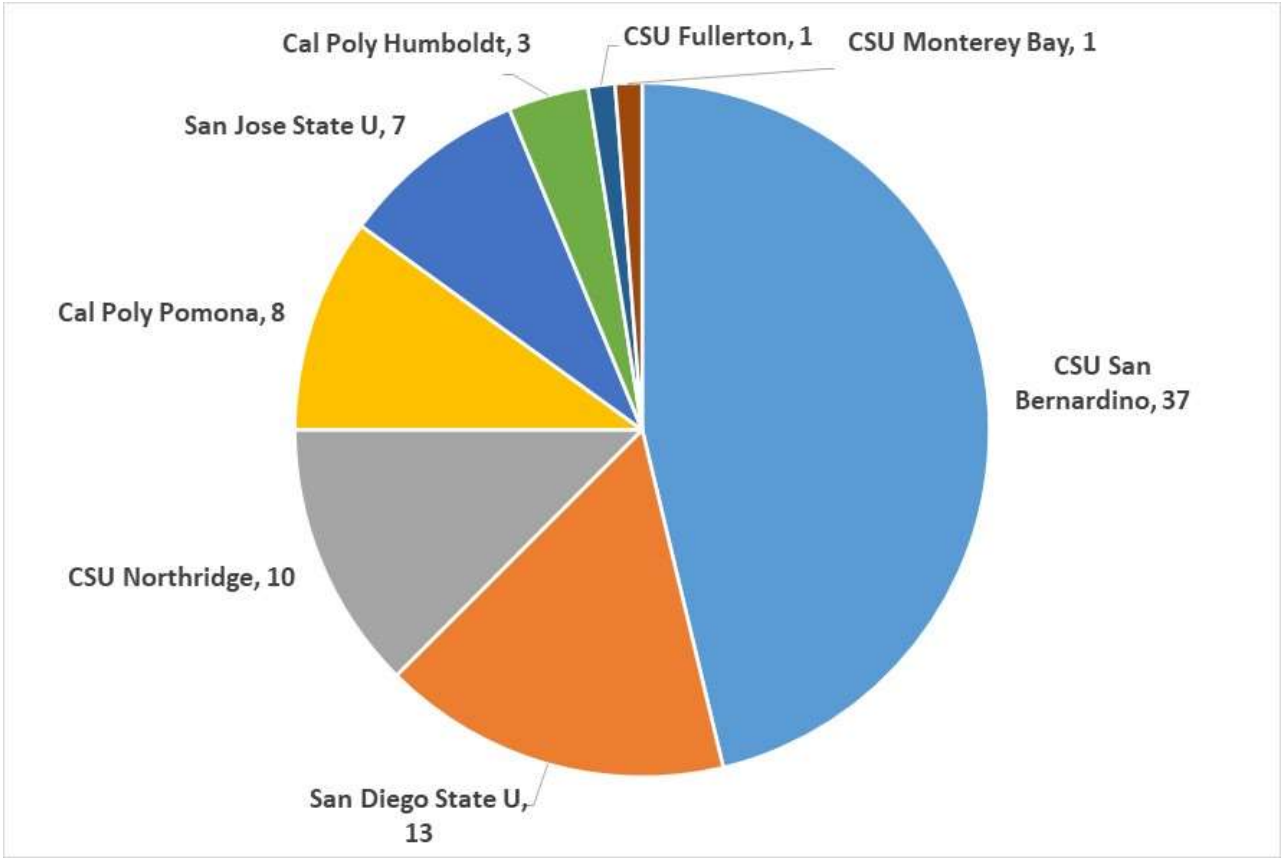
EXPANSE

Data Oasis

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

8 of 23 CSU Campuses
Have 1 or More Users Who Have Logged Onto Nautilus

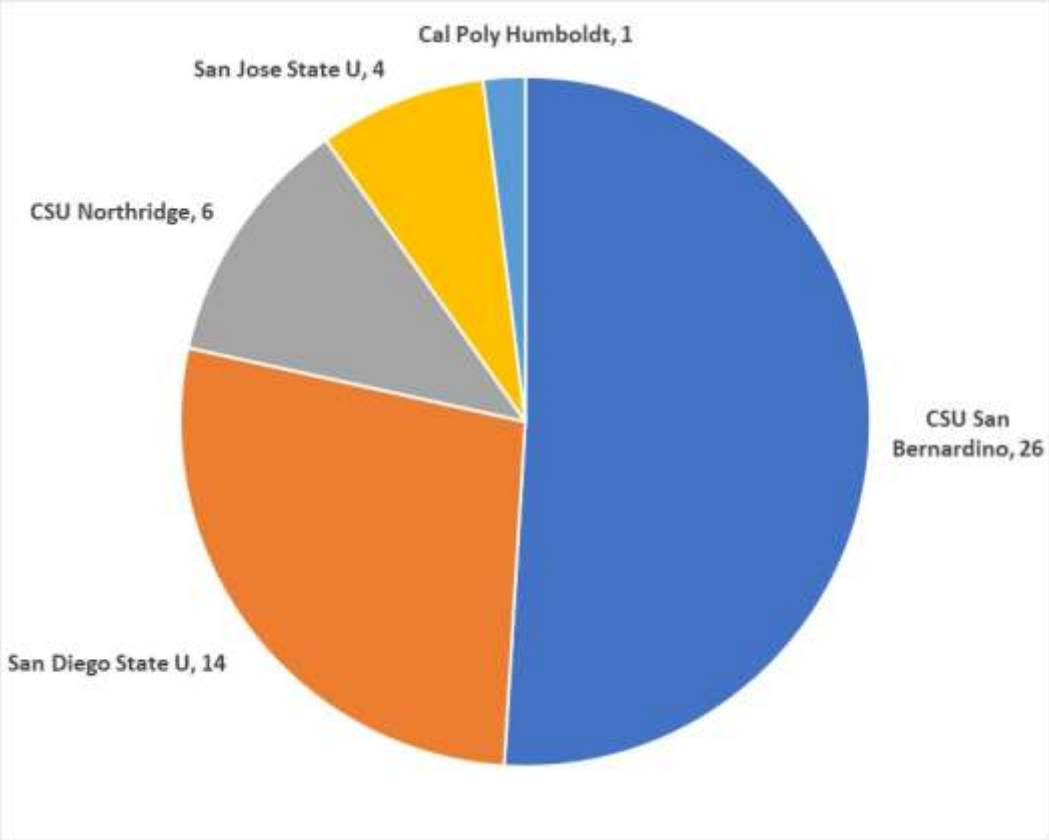


Total: 80 CSU Nautilus Users

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

5 of 23 CSU Campuses Have Created 1 or More Nautilus Namespaces



Last 12 Months
9/13/2022 to
9/13/2023

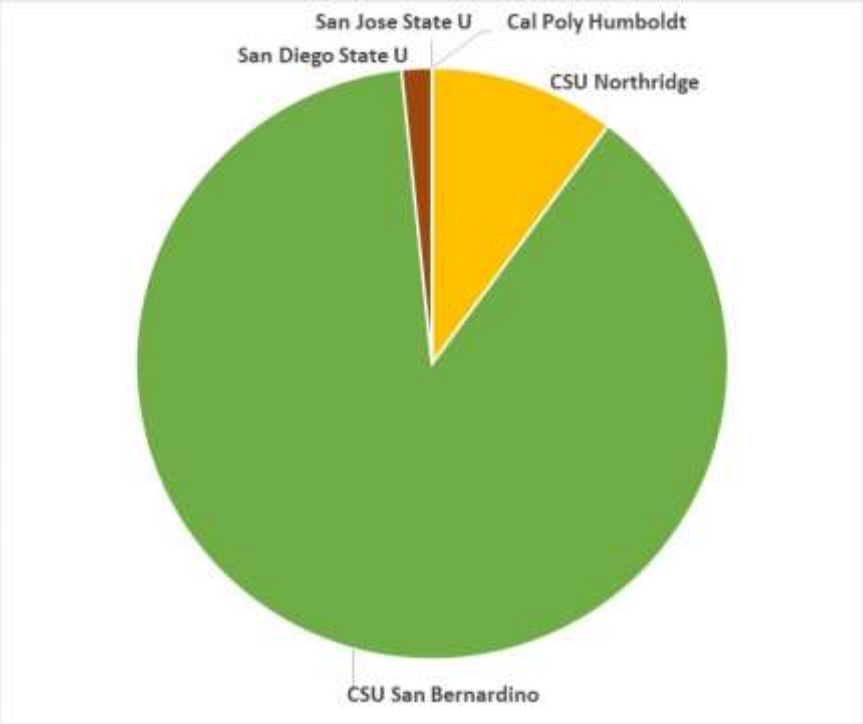
Total: 51 CSU Nautilus Namespaces

NRP NATIONAL RESEARCH PLATFORM

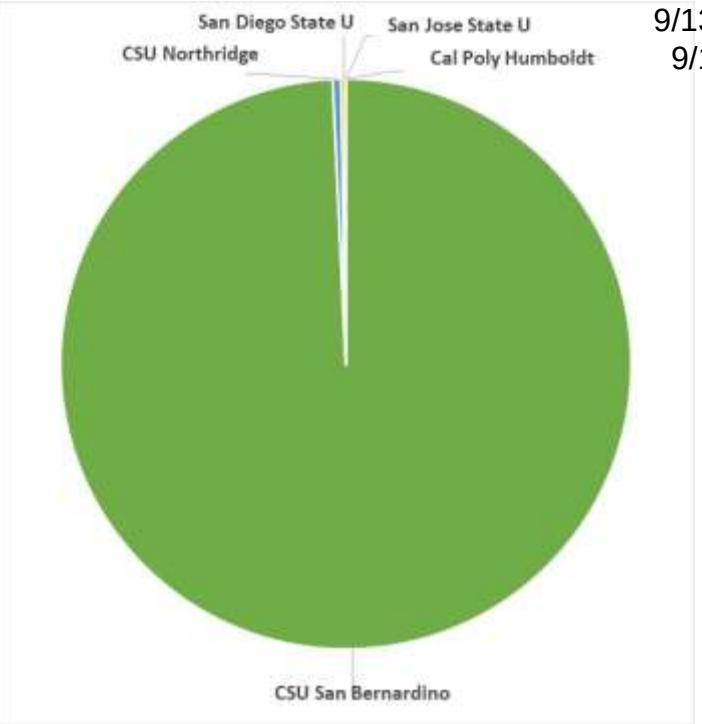
NRP Nautilus

5 of 23 CSU Campuses Have Used Nautilus GPU and/or CPUs

Last 12 Months
9/13/2022 to
9/13/2023



90,800 GPU-Hours

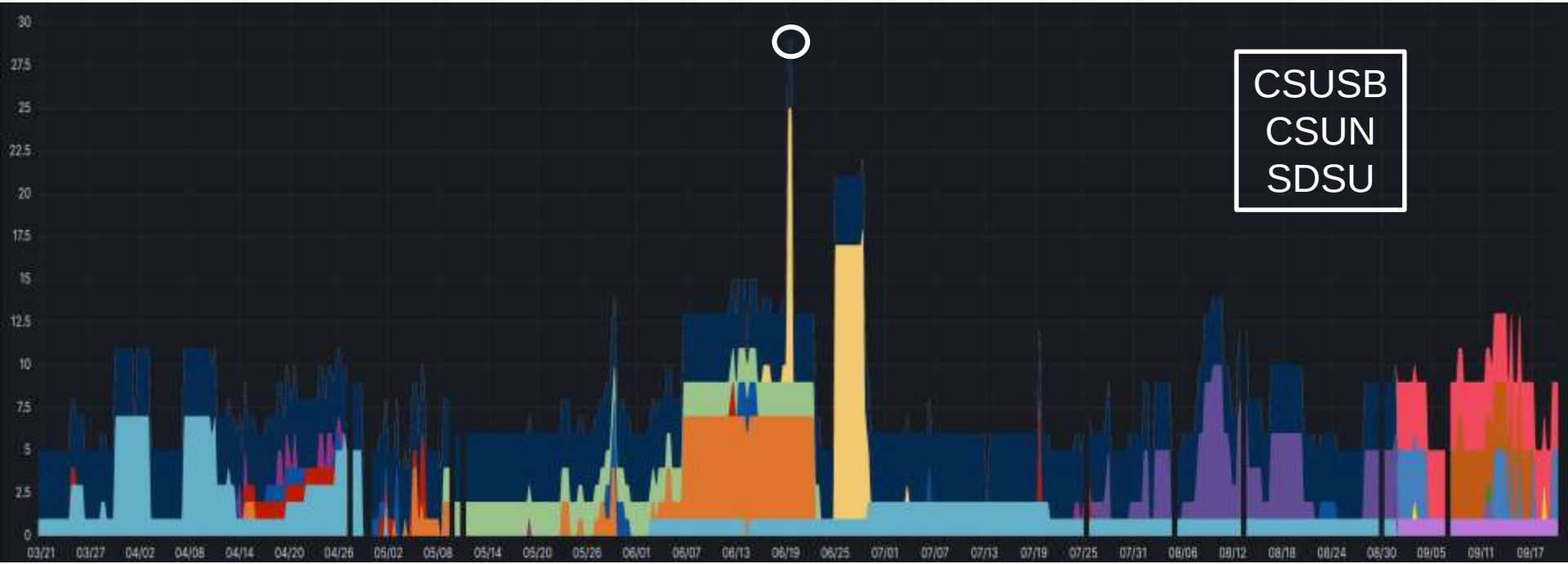


160,850 CPU Core-Hours

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

CSU Campuses Have Used Up to 30 Nautilus GPUs Simultaneously Over The Last 6 Months

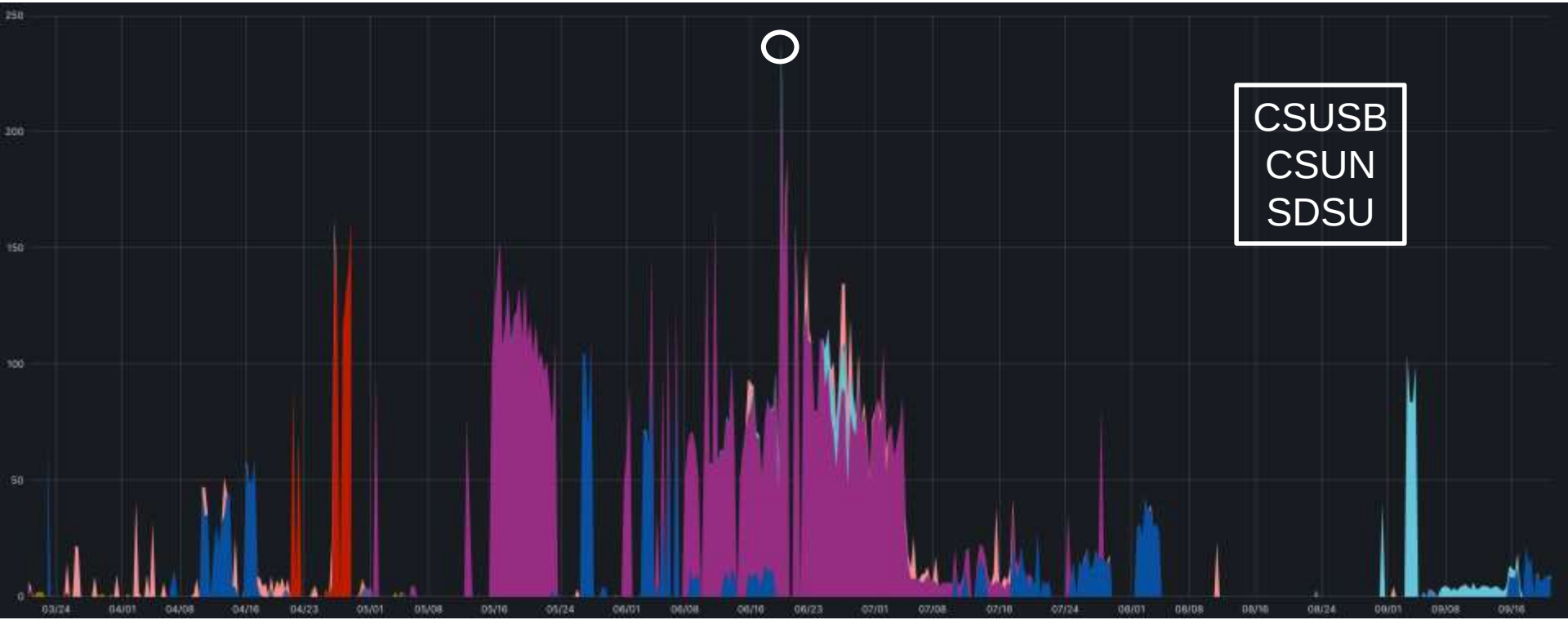


Colors Represent Different Namespaces

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

CSU Campuses Have Used Up to 230 Nautilus CPU Cores Simultaneously Over The Last 6 Months



Colors Represent Different Namespaces

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

California State University San Bernardino is an Excellent Example of How to Help Your CSU Faculty and Students To Use NRP



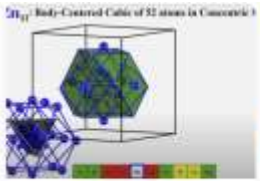
Their Campus HPC Program
Enabled CSUSB Faculty & Students
to Use More NRP GPU-Hours
In the Last 12 Months
Than 8 of the 10 UC Campuses!

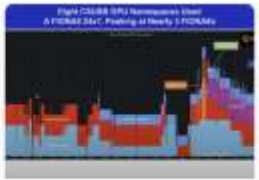


JupyterHub, NRP



ACCESS


Projects


2023 Faculty Showcase

www.csusb.edu/academic-technologies-innovation/xreal-lab-and-high-performance-computing/high-performance-computing

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

The CSUSB HPC Team Is the Major Reason For CSUSB Having the Largest NRP Utilization of 23 CSUs

- **Dr. Sam Sudhakar**
  - Chief Financial Officer and Vice President, Finance, Technology, & Operations
- **Gerard Au**
  - Chief Information Officer
- **Dr. Bradford Owen**
  - AVP for Faculty Development, Chief Academic Technologies Officer
- **Dr. Dung Vu**
  - HPC Consultant, Analyst/Programmer
- **James MacDonell**
  - HPC Consultant, Information Security Analyst
- **Prof. Youngsu Kim**
  - HPC Faculty Fellow, Asst. Prof. of Mathematics

A Key Reason CSUSB Has The Largest CSU Nautilus Usage: They Installed and Publicized the JupyterHub "Easy Button"



https://csusb-jupyter.nrp-nautilus.io/hub/login

Over 150 Total Users!

Slide Adapted from Prof. Youngsu Kim



CSUSB Provides Human and On-Line Support For Faculty, Students, and Staff to Easily Use JupyterHub to Access NRP

www.csusb.edu/faculty-center-for-excellence/idat/high-performance-computing/jupyterhub-nrp

CSUSB JupyterHub

- Accessible to anyone with a CoyoteID
- Each user is provided with 50 GB of dedicated storage, expandable upon request
- Resources include large RAM and storage and multiple CPUs and GPUs
- Pre-installed software includes Linux desktop, Python, Matlab, R, Scipy, Pyspark, Tensorflow, a data science package, and SageMath
- Other software can be installed upon request
- Can be used for research and classes

CSUSB JupyterHub for faculty research

- Dedicated to faculty research
- Contact Youngsu Kim or Dung Vu to access this server

National Research Platform

- National Research Platform (NRP) Nautilus Cluster
- Petabyte of distributed Ceph storage
- CPU and GPU computing distributed across 150+ nodes
- Our JupyterHubs are hosted on the PRP server





NRP NATIONAL RESEARCH PLATFORM

CSUSB WE DEFINE THE Future

NRP Nautilus

The Rapid Rise of Machine Learning, Artificial Intelligence, and Data Science Research Applications & Student Training on the NRP

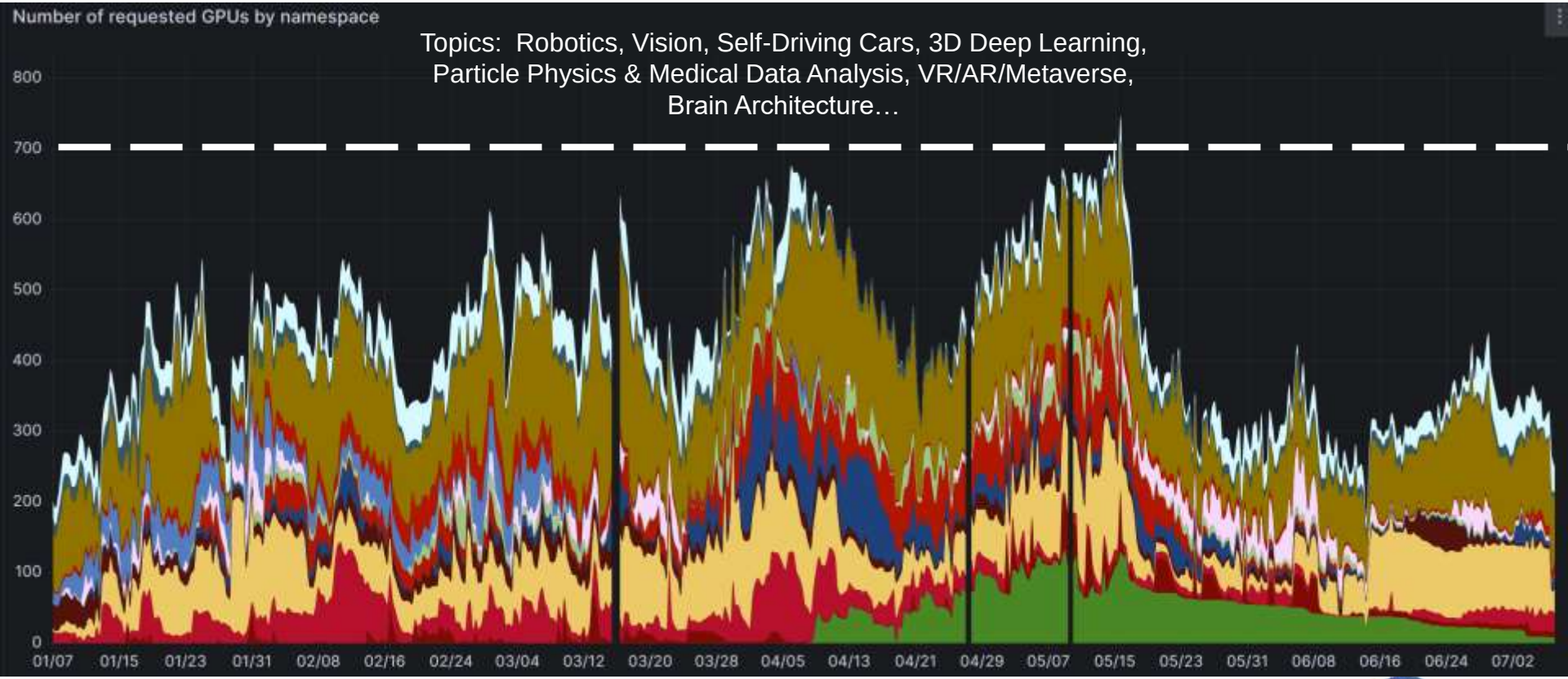
"Graphics processing units (GPUs), originally developed for accelerating graphics processing, can dramatically speed up computational processes for deep learning. They are an *essential* part of a modern artificial intelligence infrastructure, and new GPUs have been developed and optimized specifically for deep learning."

www.run.ai/guides/gpu-deep-learning

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

Top 15 GPU-Consuming ML/AI Academic Research Nautilus Namespaces: Last Six Months-Peaking at Over 700 GPUs



NRP NATIONAL RESEARCH PLATFORM

For More Details on Nautilus Applications, Including ML/AI Namespaces Like the Ones Above See my 4NRP Talk:
www.youtube.com/watch?v=1yUz0BwObGs&list=PLbbCsk7MUIGdHZzgZqNbZkV7KGVZ7gn1g&index=19

NRP Nautilus

CSUN Prof. Bingbing Li
Machine Learning Research Projects Utilizing Nautilus

Source: Bingbing Li



CSUN Prof. Bingbing Li

- **Energy Disaggregation for Manufacturing Plant**
  - Faculty Lead: Dr. Bingbing Li (CSUN), Dr. Richard Donovan (UCI)
  - **DNNs: Long Short-Term Memory (LSTM) RNN, PyTorch**
- **Graph Representation Learning for Material Prediction and Recommendation in CAD Automation**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Daniele Grandi @ Autodesk and Dr. Thomas Lu @JPL
  - **DNNs: UV-Net Graph Neural Networks (GNN), PyTorch**
- **Knowledge Graph Construction Through the Potential of Large Language Models within Manufacturing**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Jerry Fuh & Senthil Kumar @ National University of Singapore
  - **DNNs: LLMs (ChatGPT & LLaMa), Tensorflow**
- **Multi-Domain AI for Future Manufacturing**
  - Faculty Lead: Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Edward Chow & Dr. Thomas Lu @JPL
  - **DNNs: LLMs (ChatGPT & LLaMa), Tensorflow**
- **Medical Image Restoration through Optical & CT Scanning**
  - Faculty Lead: Dr. Xiyi Hang & Dr. Bingbing Li (CSUN)
  - Collaborator: Dr. Ye Pu and Prof. Demetri Psaltis @ Swiss Federal Institute of Technology Lausanne
  - **DNNs: Large-Kernel CNN, Tensorflow**

TensorFlow PyTorch

LLM LARGE LANGUAGE MODEL ChatGPT Meta

NRP NATIONAL RESEARCH PLATFORM

CSUN ARCS Autonomy Research Center for STEAHM

NRP Nautilus

CSUN Prof. Bingbing Li's Publications Powered by NRP: Demonstrates the Research Leverage of Nautilus

Source: Bingbing Li

UCI Prof. GP Li's Nautilus Namespace *cesmii-scw* (mainly used by Bingbing's research team) used nearly 12,000 GPU-Hours in the Last Year

Namespace: cesmii-scw

- Li C., Bian S.J., Wu T.Z., Donovan R.P., and Li B.B.*, "Affordable Artificial Intelligence-Assisted Machine Supervision System for Small and Medium-Sized Manufacturers", Sensors, 2022, Vol. 22 (16): 6246.
- Kim Y., Donovan R.P., Ren Y.T., Bian S.J., Wu T.Z., Purawat S., Manzo A.J., Altintas I., Li B.B. , and Li G.P.*, "Smart Connected Worker Edge Platform for Smart Manufacturing: Part 1: Architecture and Platform Design", Journal of Advanced Manufacturing and Processing, 2022, Vol. 4 (4): e10129.
- Donovan R.P., Kim Y., Manzo A.J., Ren Y.T., Bian S.J., Wu T.Z., Purawat S., Helvajian H., Wheaton M., Li B.B., and Li G.P.*, "Smart Connected Worker Edge Platform for Smart Manufacturing: Part 2: Implementation and On-site Deployment Case Study", Journal of Advanced Manufacturing and Processing, 2022, Vol. 4 (4): e10130.
- Bian S.J., Li C., Fu Y.W., Ren Y.T., Wu T.Z., Li G.P., Li B.B.*, "Machine Learning-based Real-time Monitoring System for Smart Connected Worker to Improve Energy Efficiency", Journal of Manufacturing Systems, 2021, Vol. 61, pp. 66-76.
- Bian S.J., Lin T.C., Li C., Fu Y.W., Jiang M.R., Wu T.Z., Hang X.Y., Li B.B.*, "Real-time Object Detection for Smart Connected Worker in 3D printing", 2021 International Conference on Computational Science (ICCS 2021), Krakow, Poland, June 16-18, 2021.

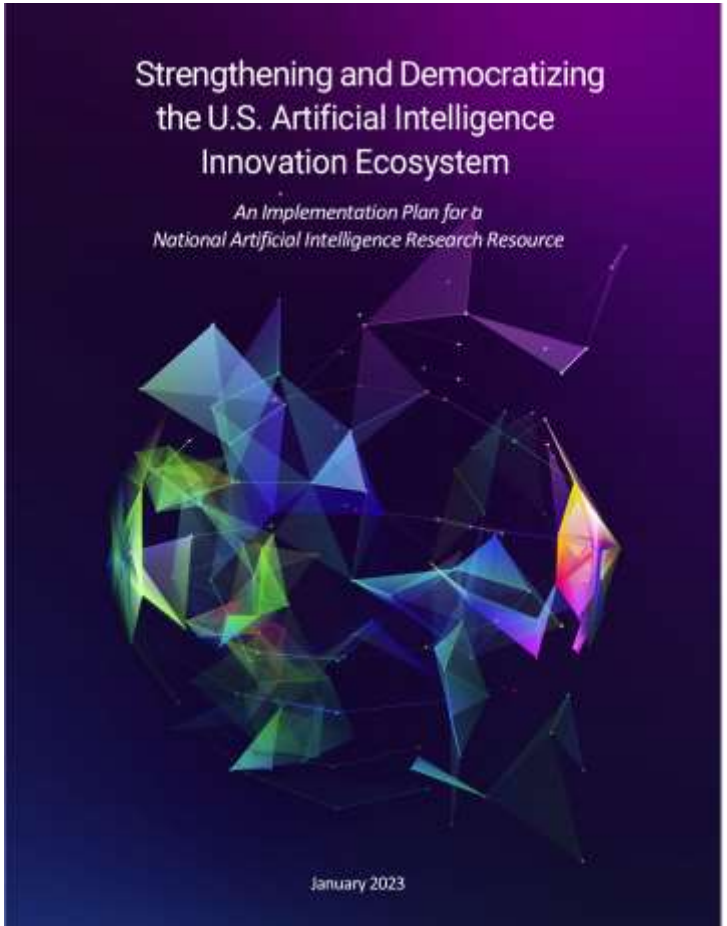
CSUN Prof. Bingbing Li's Nautilus Namespace *nsf-maica* used over 9,000 GPU-Hours in the Last Year

Namespace: nsf-maica

- Fan H.L., Fuh J.Y., Lu W.F., Kumar A.S., and Li B.B.*, "Unleashing the Potential of Large Language Models for Knowledge Graph Construction: A Practical Experiment on Incremental Sheet Forming", Proceedings of International Conference on Industry 4.0 and Smart Manufacturing (ISM 2023), Lisbon, Portugal, November 22-24, 2023.
- Zhang H.J., Jiao Y.C., Yuan Y.Z., Li Y.C., Wang Y.Q., Lu W.F., Fuh J.Y., and Li B.B.*, "Object Detection and Text Recognition for Immersive Augmented Reality Training in Laser Powder Bed Fusion", International Conference on Industry 4.0 and Smart Manufacturing (ISM 2023), Lisbon, Portugal, November 22-24, 2023.
- Rose A., Nisce I., Gonzalez A., Davis M., Uribe B., Carranza J., Flores J., Jia X.D., Li B.B., Jiang X.F.*, "A Cloud-based Real-Time Traffic Monitoring System with Lidar-based Vehicle Detection", 2023 IEEE Green Energy and Smart Systems Conference (IGESSC 2023), Long Beach, CA, November 13-14, 2023.
- Bian S.J., Grandi D., Liu T.Y., Jayaraman P.K., Willis K., Sadler E.T., Borijin B., Lu T., Otis R., Ho N., and Li B.B.*, "HG-CAD: Hierarchical Graph Learning for Material Prediction and Recommendation in CAD", Journal of Computing and Information Science in Engineering, 2023, pp. 1-28.
- Li B.B., Wu T.Z., Bian S.J., Sutherland J.W.*, "Predictive Model for Real-time Energy Disaggregation Using Long Short-term Memory", CIRP Annals, 2023, Vol. 72 (1): 25-28.
- Morales-Badajoz A., Elieh N., Diederich A., Sadler E., Glover J., Nizampatnam M., Israel T., Wang A., Zhang L., Besnilian A., George A., Miller J., Jiang X.F., Li B.B.*, "Astro Cultivators: Autonomous Growth System for Space Farming based on Machine Vision and Multi-Sensor Fusion", ACM Cyber-Physical Systems and Internet of Things Week, San Antonio, TX, May 9-12, 2023.
- Bian S.J., Grandi D., Hassani K., Sadler E., Borijin B., Fernandes A., Wang A., Lu T., Otis R., Ho N.T., Li B.B.*, "Material Prediction for Design Automation Using Graph Representation Learning", ASME 2022 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (IDETC/CIE 2022), St. Louis, MO, August 14-17, 2022.

The Congress Has Asked NSF to Develop a National AI Research Resource

A widely accessible
AI research cyberinfrastructure
that brings together
computational resources, data,
testbeds, algorithms, software,
services, networks,
and expertise,
as described in this report,
would help to democratize
the AI R&D landscape
in the United States
for the benefit of all.



In order to achieve
its vision and goals,
the Task Force estimates
the budget for the NAIRR
as $2.6 billion
over an initial
six-year period.

The NAIRR must provide
a platform that can be used
for educational activities
in order to lower the barriers
to participation in the AI
research ecosystem.

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

UCSD's Information Technology Services Has Adapted PRP FIONA8s To Support Students in Data Science (DS) & Machine Learning (ML) Courses



SDSC Racked FIONAs:

- 139 32-bit GPUs (10% NRP)
- 2048 CPU-cores
- 10/25/40G Networking
- *Not* Federated With NRP

Software Used By Students

TensorFlow, PyTorch, Caffe, jupyter, NumPy, ANACONDA, NVIDIA CUDA, docker, kubernetes

- **Student-Focused Platform For:**
  - **Undergraduate & Graduate Coursework**
  - **For-Credit Independent Study**
  - **Thesis/Dissertation Research**
  - **Capstones & Projects**
- **Research-Driven Architecture**
- **Managed by UCSD IT Services**

Source: Adam Tilghman, UCSD ITS

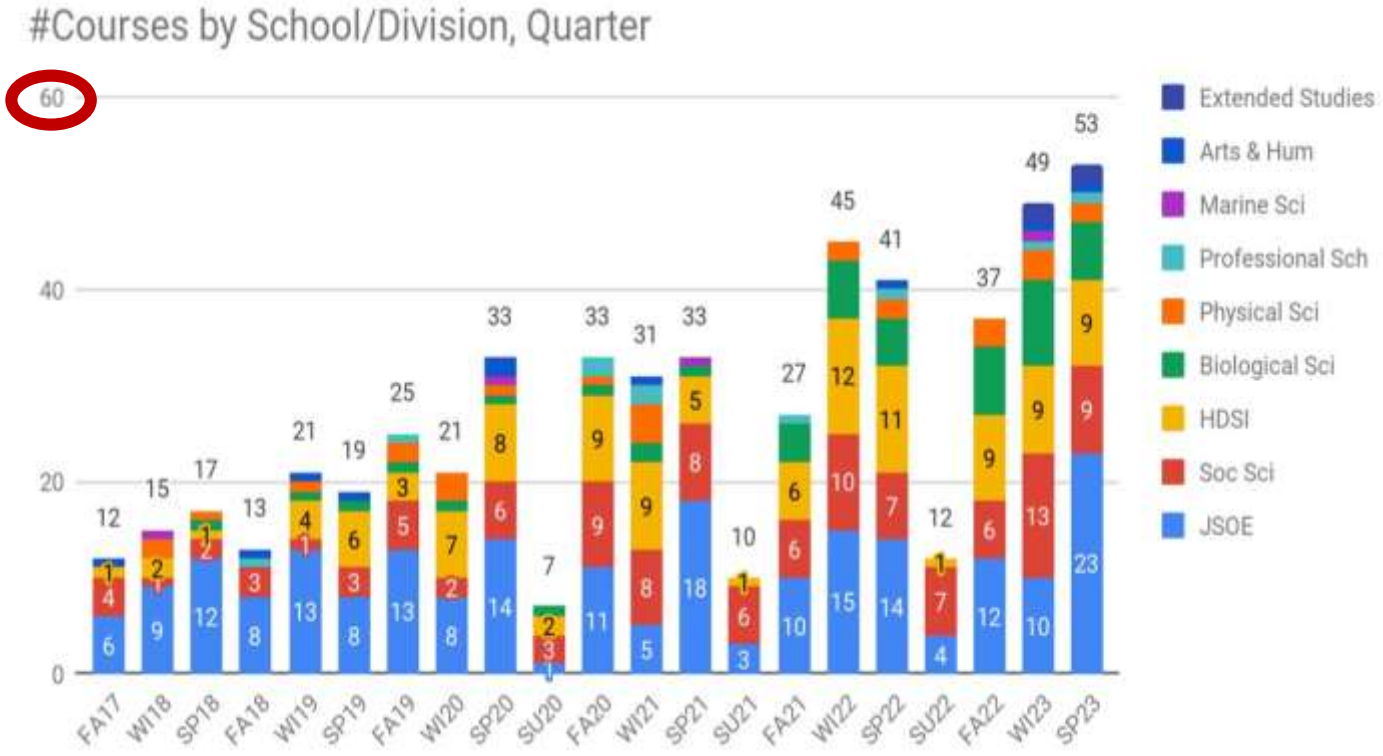
Data Science/ML Platform - 5/2023 Update

NRP NATIONAL RESEARCH PLATFORM

IT SERVICES

UC San Diego

UCSD's DS/ML Platform Supported Nearly 60 Courses Spring Quarter 2023



Source: Adam Tilghman, UCSD ITS

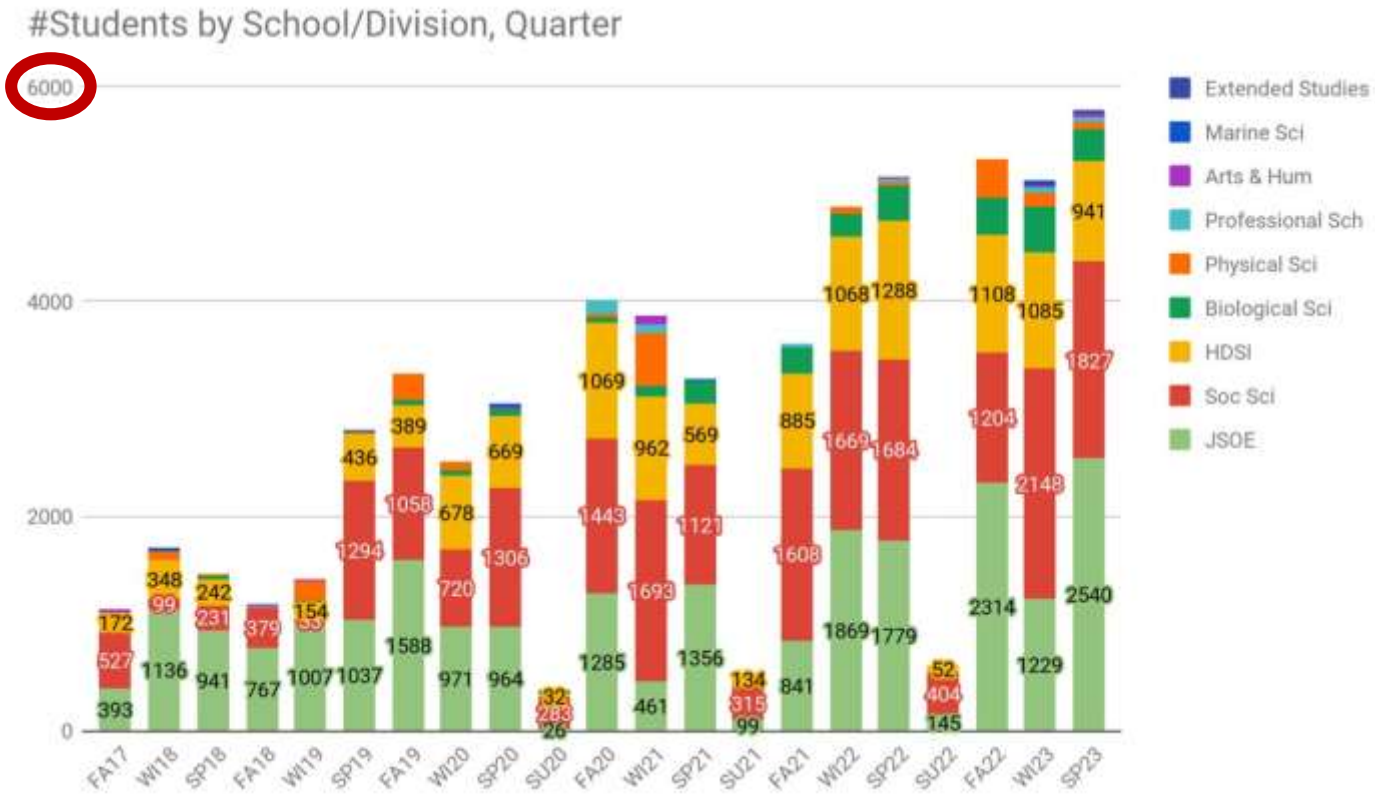
Data Science/ML Platform - 5/2023 Update

NRP NATIONAL RESEARCH PLATFORM

IT SERVICES

UC San Diego

UCSD's DS/ML Platform Supported Over 6,000 Students Spring Quarter 2023



Source: Adam Tilghman, UCSD ITS

Data Science/ML Platform - 5/2023 Update

NRP NATIONAL RESEARCH PLATFORM

IT SERVICES

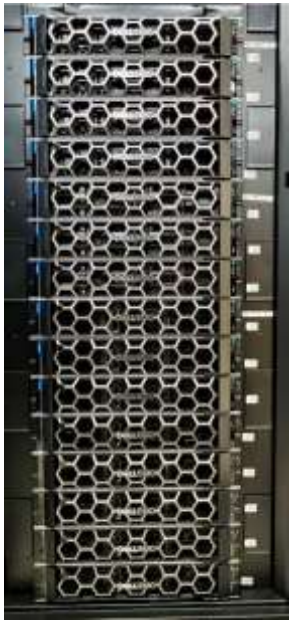
UC San Diego

Selected Courses, Spring 2023

- Advanced Computer Vision
- Bioinformatics for Immunologists
- Computational Physics: Probabilistic Models/Sim.
- Data Analysis/Design for Biologists
- Data Science/Spatial Analysis
- Deep Learning and Applications
- Intro to Causal Inference
- Neural Networks/Pattern Recognition
- Numerical Analysis for Multiscale Biology
- Robot Manipulation and Control

SDSU's VERNE Expands the UCSD Instructional Model by Federating with NRP: Visionary, Education, Research, Network, Ecosystem

SDSU Information Technology Division



CENIC

jupyter TensorFlow PyTorch kubernetes NVIDIA docker

- Dell PowerEdge Cluster for Instructional Use, with 15 Nodes with 32 A100 GPUs (managed as 232 independent GPUs), 768 CPU cores, and 960 TB Storage.
- A Learning Resource that *Surges* for Research and Instruction
- System Administration as a Service from the NRP
- Friendly User mode this Spring with
  - ~90 Users in Computational Engineering 361 & Astronomical Techniques ASTR 350
  - Research in Developing Synthetic Medical Data for Machine Learning Training

NRP NATIONAL RESEARCH PLATFORM

Slide courtesy of Jerry Sheehan, SDSU CIO

NRP Nautilus

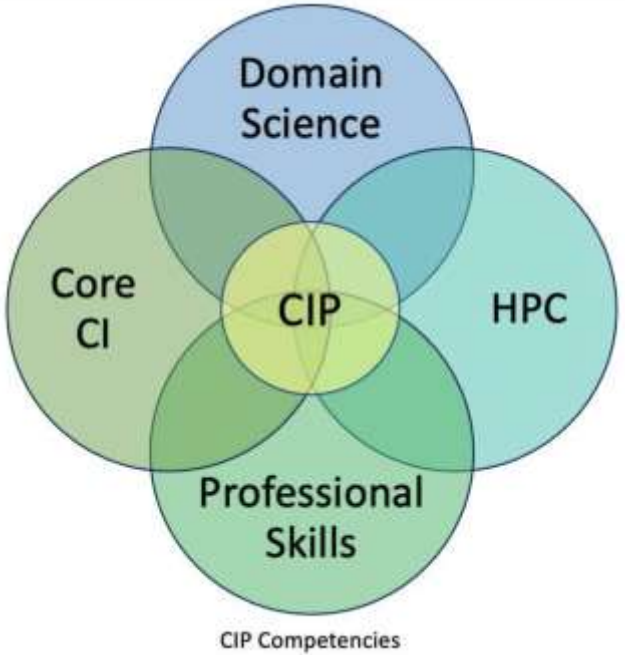
But Who Will Train the Trainers?
NSF is Providing CyberTraining Funding

October 20, 2022

Three California Universities Commit to Growing a Community of Cyberinfrastructure Professionals

SDSC at UCSD, SDSU & CSUSB have been awarded $6.7 million for training and mentoring a cohort of CI professionals.

Our training program cohort will be drawn from populations including domain scientists, interdisciplinary research professionals, faculty, students and other NSF workforce individuals and underrepresented STEM communities."
--PI Mary Thomas, SDSC



CIP Competencies

NSF award #2230127

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

Two Recently Submitted NSF Proposals With CSUs as NRP Drivers

CC* Regional Computing:

The California State University

Technology Infrastructure for Data Exploration (TIDE)

PI Jerry Sheehan, SDSU

CIRC: Grand: The National Research Platform's Community Infrastructure for Research in Computer and Information Science and Engineering (NRP-CIRC)

For the Period 04/01/2024 - 03/31/2029

PI Tom DeFanti, UCSD

NRP NATIONAL RESEARCH PLATFORM

NRP Nautilus

NRP Support and Community:

- US National Science Foundation (NSF) awards and subawards to UCSD
  --CNS-1456638, CNS-1730158, CNS-2100237, CNS-2120019
  --ACI-1540112, ACI-1541349, OAC-1826967, OAC-2029306, OAC-2112167
- DOD DURIP awards to UCSD
- UC Office of the President, Calit2 and Calit2's UCSD Qualcomm Institute
- San Diego Supercomputer Center and UCSD's Research IT and Instructional IT
- CENIC, Pacific Wave/PNWGP, StarLight/MREN, The Quilt, Great Plains Network, NYSERNet, Open Science Grid, Internet2, DOE ESnet, NCAR/UCAR & Wyoming Supercomputing Center, AWS, Google, Microsoft, Cisco, Juniper, Arista