Global Research Platform Workshop: An Overview

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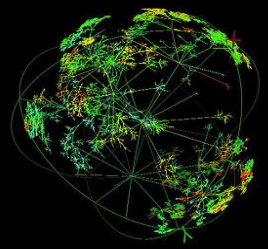
Global Research Platform Workshop
Co-Located With IEEE International Conference On eScience
Osaka, Japan
September 16-17, 2024



Annual Global Research Platform Workshop – Co-Located With IEEE International Conference On eScience Sept 16-17, 2024

Introduction

- "***New Tools Reveal New Truths***"
  Rosalyn Yalow, Nobel Laureate

Next Generation Distributed Environment For Global Science

A Next Generation Ecosystems for New Knowledge Discovery

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NSF's Cyberinfrastructure Framework for the 21st Century (CIF21)

- **Large Scale, Powerful and Sophisticated Instrumentation Integrated With New Computational Science Methods Are Revolutionizing New Knowledge Discovery In all Major Science Disciplines.**
- **According to the US National Science Foundation: *"This Revolution Will Transform Research, Practice, And Education In Science and Engineering As Well As Advance Innovation In Society"***
- **NB: Policy Statements Published By Related Agencies In Multiple Countries**
- **This Transformation Is Made Possible By *"A Comprehensive, Scalable, Cyberinfrastructure That Bridges Diverse Scientific Communities and Integrates High---Performance Computing, Data, Software, and Facilities …Bringing Theoretical, Computational, Experimental, and Observational Approaches Together To Advance the Frontier."***

Large Scale Science Ecosystems

- Science Domains Are Creating Cyberinfrastructure Ecosystems, Including Those That Are Large Scale And Distributed World Wide, Both Devoted To Domains and Shared Among Domains
- Planning Projections Define Future, Specialized Requirements.
- In Response Cyberinfrastructure ***Blueprints*** Are Created: Architecture, Services, Techniques, Technologies, Processes, et al
- Many Current Studies Are Examining Relationships Between Science Workflows Are Foundation Resource Services and Resources, Particularly With AI/ML/DL Overlays
- Results Define Next Generation Ecosystems

Global Collaborative Research Communities

- ***Science Is Global***
- **The Global Research Platform (GRP) Is An International Collaborative Partnership Creating A Distributed Environment (Ecosystem) for International Data Intensive Science**
- **Open Information Sharing, A Cornerstone of The Science Process, Motivates This Forum**
- **The GRP Provides Opportunities For eScience Environment Information Sharing To Among Collaborative Science Communities World-Wide -- Concepts, Experiments, Instruments, Methods, Techniques, Data, Architecture, Implementation, Technologies, Operations, and Results**
- **The GRP Facilitates High Performance World-Wide Data Gathering, Analytics, Transport (100 Gbps-Tbps E2E), Computing, And Storage**
- **www.theglobalresearchplatform.net**

A Few Questions

- The GRP Focuses On Investigating Topics Related To Large Scale Global Data Intensive Science – In Part, Examining
  - What Services, Architecture, Technologies, and Techniques Be Replicated Across Large Scale Science Ecosystems?
  - To What Degree Can Large Scale Science Ecosystems Be Generalized To Support Multiple Science Domains?
  - What Designs, Techniques, and Technologies Can Be Shared Among Domains?
  - Given A Context Of A Cambrian Explosion Of Requirements and Innovations, What Should Be Key Focal Areas?

Selected Applications/Instruments

GENI
www.geni.net

Open Storage Network
www.openstoragenetwork.org

OSG
www.opensciencegrid.org

Polar Geospatial Center
www.pgc.umn.edu

LSST
www.lsst.org

Virgo
www.virgo-gw.eu

LHC
home.cern/science/accelerators/large-hadron-collider

GLEON
www.gleon.org

OSiRIS
www.osris.org

GRP
theglobalresearchplatform.net/

IceCube
icecube.wisc.edu

Pierre Auger Observatory
www.auger.org

ISS
www.nasa.gov/station

LIGO
www.ligo.caltech.edu

XSEDE
www.xsede.org

PRP
pacificresearchplatform.org

Chameleon
www.chameleoncloud.org

SKA
www.skatelescope.org

LHCONE
twiki.cern.ch/twiki/bin/view/LHCONE/WebHome

USGS EROS
www.usgs.gov/centers/eros

Blue Waters
bluewaters.ncsa.illinois.edu

Jetstream
www.jetstream-cloud.org

Belle II
www.belle2.org

XENON
xenon.astro.columbia.edu

SDSS
www.sdss.org

LHCOPN
twiki.cern.ch/twiki/bin/view/LHCOPN/WebHome

PRAGMA
www.pragma-grid.net

CHASE-CI
www.calit2.net/newsroom/article.php?id=2910

NEON
www.neonscience.org

CENTRA
www.globalcentra.org

SAGE2
sage2.sagecommons.org

Genomic Science Program
genomicscience.energy.gov

LBNF/DUNE/ProtoDUNE
lbnf.fnal.gov

NOvA
novaexperiment.fnal.gov

ALMA
www.almaobservatory.org

IVOA
www.ivoa.net

Compilation by Maxine Brown and Joe Mambretti

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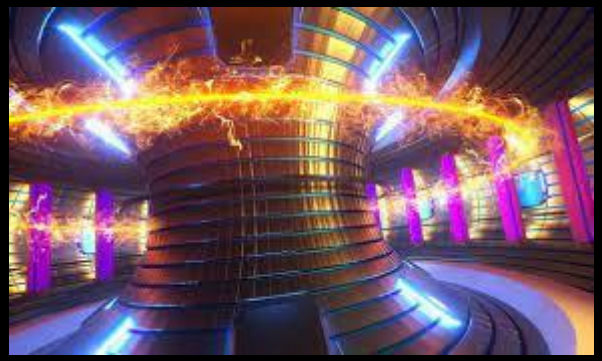
Instruments: Exebytes Of Data

High Luminosity LHC

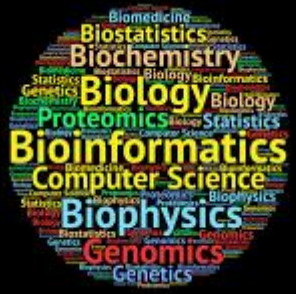
SKA Australia Telescope Facility

Vera Rubin Observatory



KSTAR Korea Superconducting Tokamak

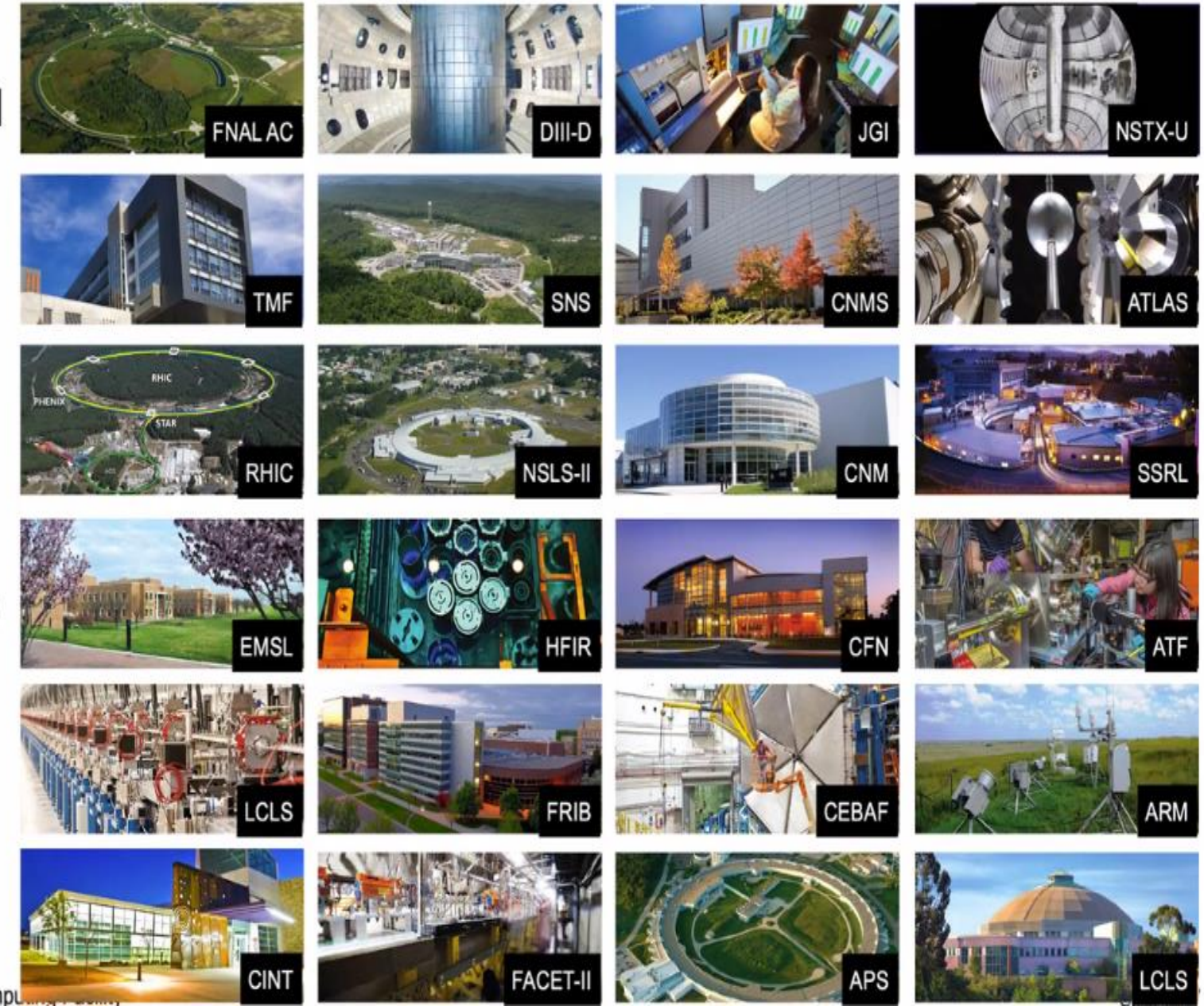
Next Gen Advanced Photon Source



Bioinformatics/Genomics

DOE EXPERIMENTAL USER FACILITIES

- DOE operates 24 experimental user facilities
- Similar to the computing facilities, some of them are undergoing upgrades
- Their data rates and their computing needs will increase accordingly



Next Generation Research Platforms

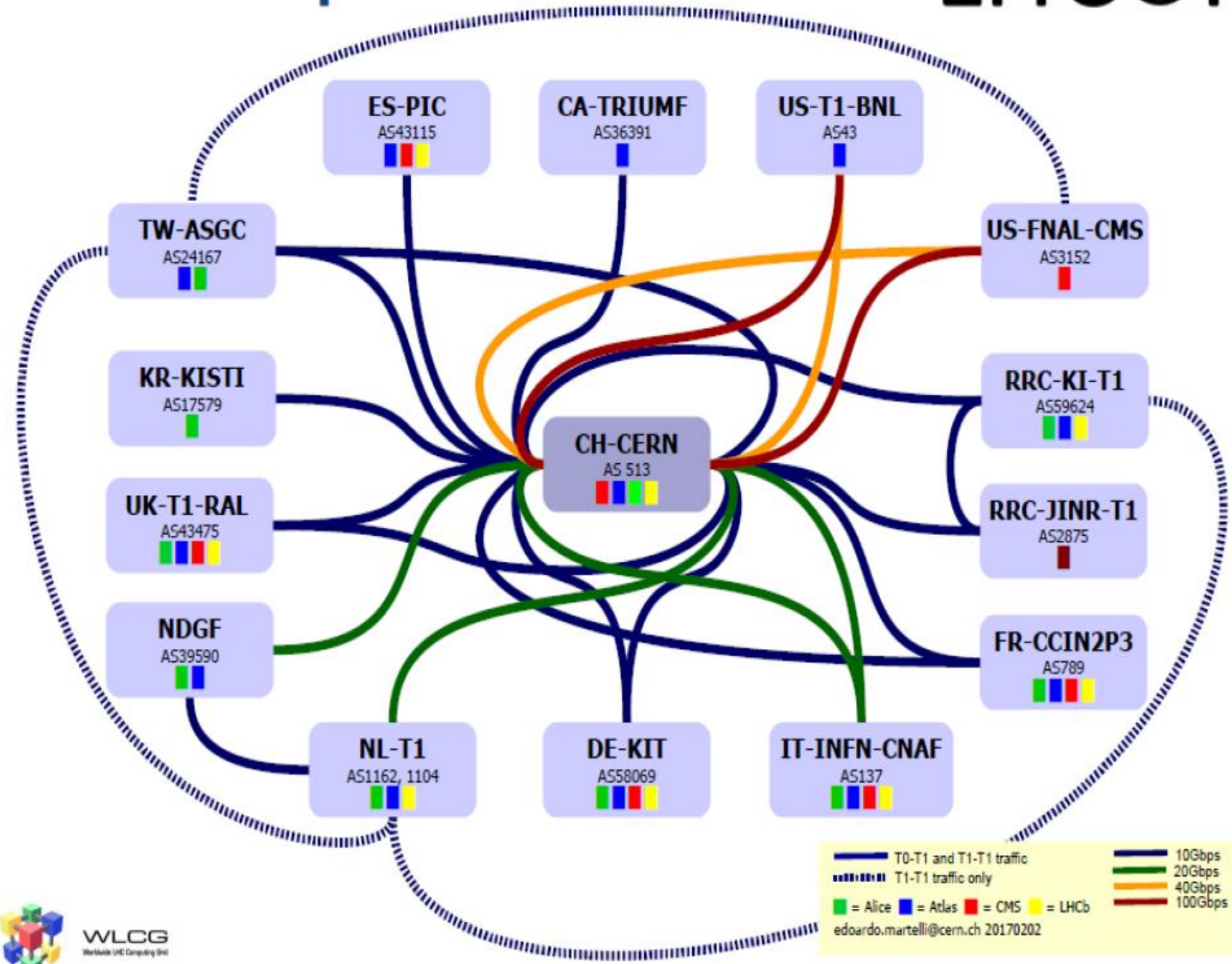
- US National Research Platform
- Asia Pacific Research Platform
- Korean Research Platform
- EU SLICES
- Worldwide LHC Computing Grid (WLCG)
- DOE Integrated Research Infrastructure (IRI)
- Open Science Grid
- Open Science Data Grid
- Et Al

Worldwide LHC Computing Grid

- The Worldwide LHC Computing Grid (WLCG): Global Collaboration Of ~ 170 Computing Centres In More Than 40 Countries, Integrating National and International Grid Infrastructures.
- WLCG Provides Global Resources To Gather, Store, Distribute and Analyse ~200 Petabytes of LHC Data Each Year
- WLCG – Partnership of EGI (European Grid Infrastructure), OSG (Open Science Grid), and NeIC (Nordic e-Infrastructure Collaboration).

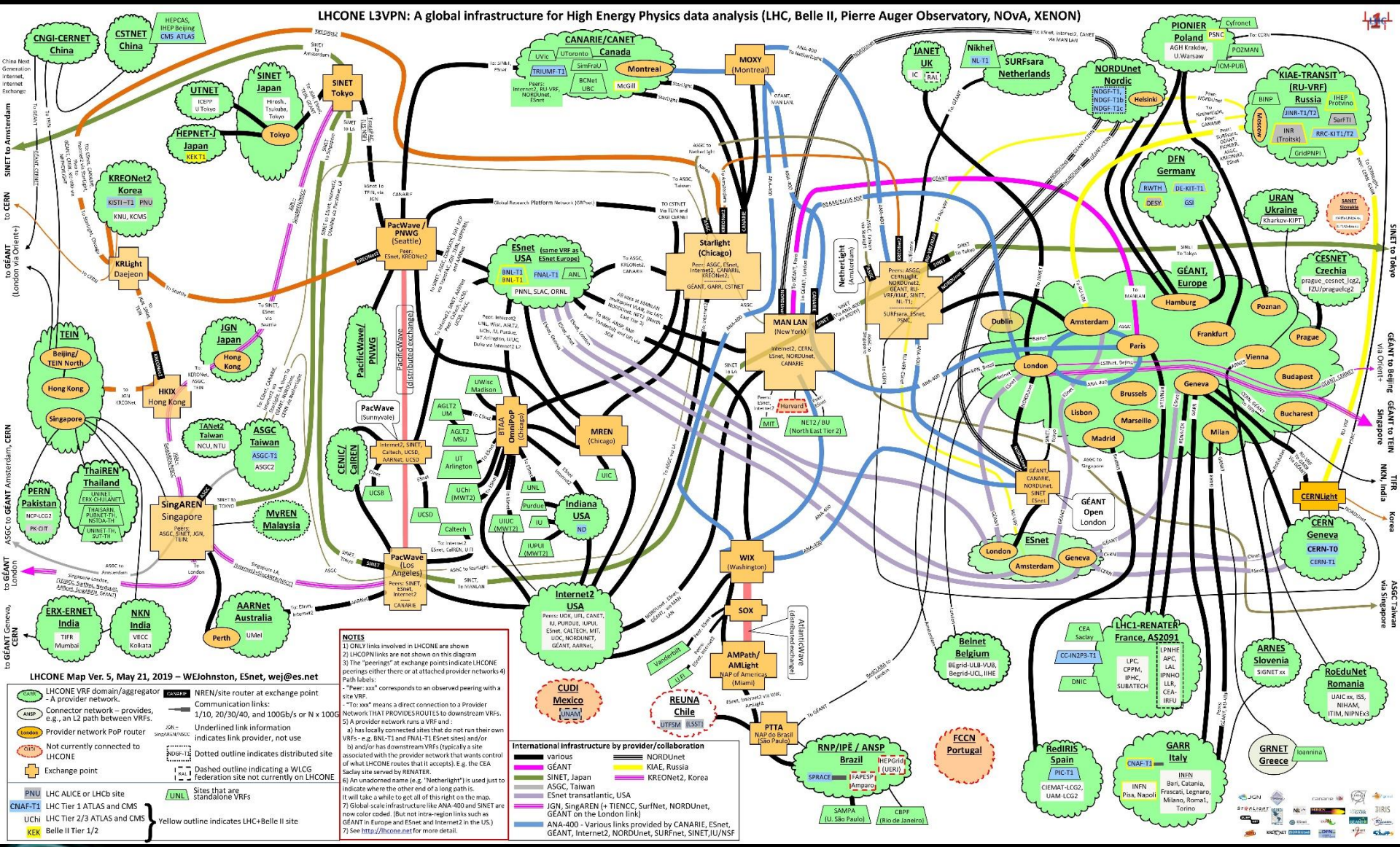
LHCOPN map

LHCOPN



WLCG

LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOvA, XENON)



LHCONE Map Ver. 5, May 21, 2019 – WEJohnston, ESnet, wej@es.net

- LHCONE VRF domain/aggregator - A provider network.
- Connector network – provides, e.g., an L2 path between VRFs.
- Provider network PoP router
- Not currently connected to LHCONE
- Exchange point
- NREN/site router at exchange point
- Communication links: 1/10, 20/30/40, and 100Gb/s or N x 100G
- Underlined link information indicates link provider, not use
- Dotted outline indicates distributed site
- Dashed outline indicating a WLCG federation site not currently on LHCONE
- PNU LHC ALICE or LHCb site
- CNAF-T1 LHC Tier 1 ATLAS and CMS
- UChi LHC Tier 2/3 ATLAS and CMS
- KEK Belle II Tier 1/2
- Yellow outline indicates LHC+Belle II site
- UNL Sites that are standalone VRFs

NOTES

1) ONLY links involved in LHCONE are shown
2) LHCOPN links are not shown on this diagram
3) The "peerings" at exchange points indicate LHCONE peerings either there or at attached provider networks 4) Path labels:
- "Peer: xxx" corresponds to an observed peering with a site VRF.
- "To: xxx" means a direct connection to a Provider Network THAT PROVIDES ROUTES to downstream VRFs.
5) A provider network runs a VRF and :
a) has locally connected sites that do not run their own VRFs - e.g. BNL-T1 and FNAL-T1 ESnet sites) and/or
b) and/or has downstream VRFs (typically a site associated with the provider network that wants control of what LHCONE routes that it accepts). E.g. the CEA Saclay site served by RENATER.
6) An unadorned name (e.g. "Netherlight") is used just to indicate where the other end of a long path is.
It will take a while to get all of this right on the map.
7) Global-scale infrastructure like ANA-400 and SINET are now color coded. (But not intra-region links such as GÉANT in Europe and ESnet and Internet2 in the US.)
7) See http://lhcone.net for more detail.

International infrastructure by provider/collaboration

- various
- GÉANT
- SINET, Japan
- ASGC, Taiwan
- ESnet transatlantic, USA
- JGN, SingAREN (+ TIENCC, SurfNet, NORDUnet, GÉANT on the London link)
- ANA-400 - Various links provided by CANARIE, ESnet, GÉANT, Internet2, NORDUnet, SURFnet, SINET,JU/NSF
- NORDUnet
- KIAE, Russia
- KREONet2, Korea

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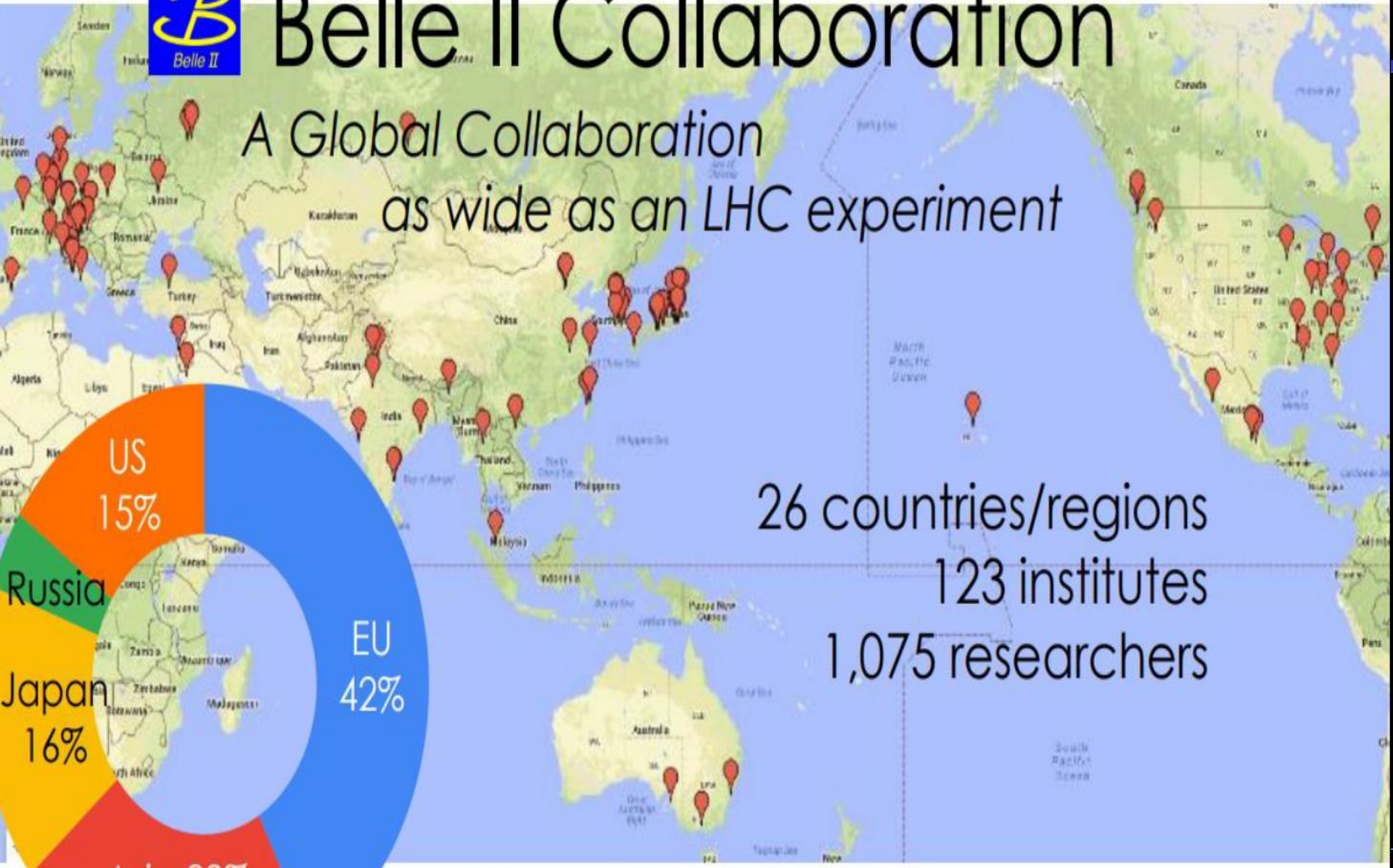
Non-LHC Scientific Communities Using LHCONE

- Belle II Experiment, Particle Physics Experiment Designed To Study Properties od B Mesons (Heavy Particles Containing a Bottom Quark)
- Pierre Auger Observatory, Studying Ultra-High Energy Cosmic Rays, the Most energetic and Rarest Particles in The Universe
- LIGO and Virgo (In August 2027 This Collaboration Measured a Gravitational Wave Originating From a Binary Neutron Star Merger.
- NOvA Experiment: Designed To Answer Fundamental Questions In Neutrino Physics
- XEON Dark Matter Project: Global Collaboration Investigating Fundamental Properties of Dark Matter, Largest Component of the Universe
- DUNE/ProtoDUNE – Deep Underground Nutrino Experiment

Belle II Collaboration

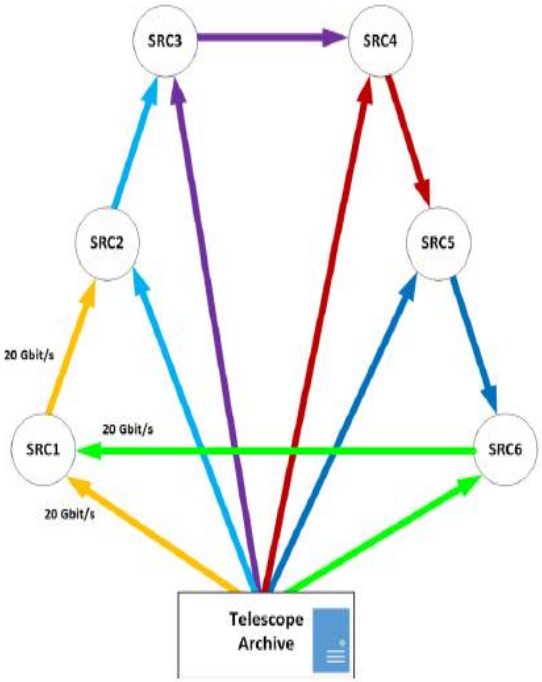
A Global Collaboration
as wide as an LHC experiment

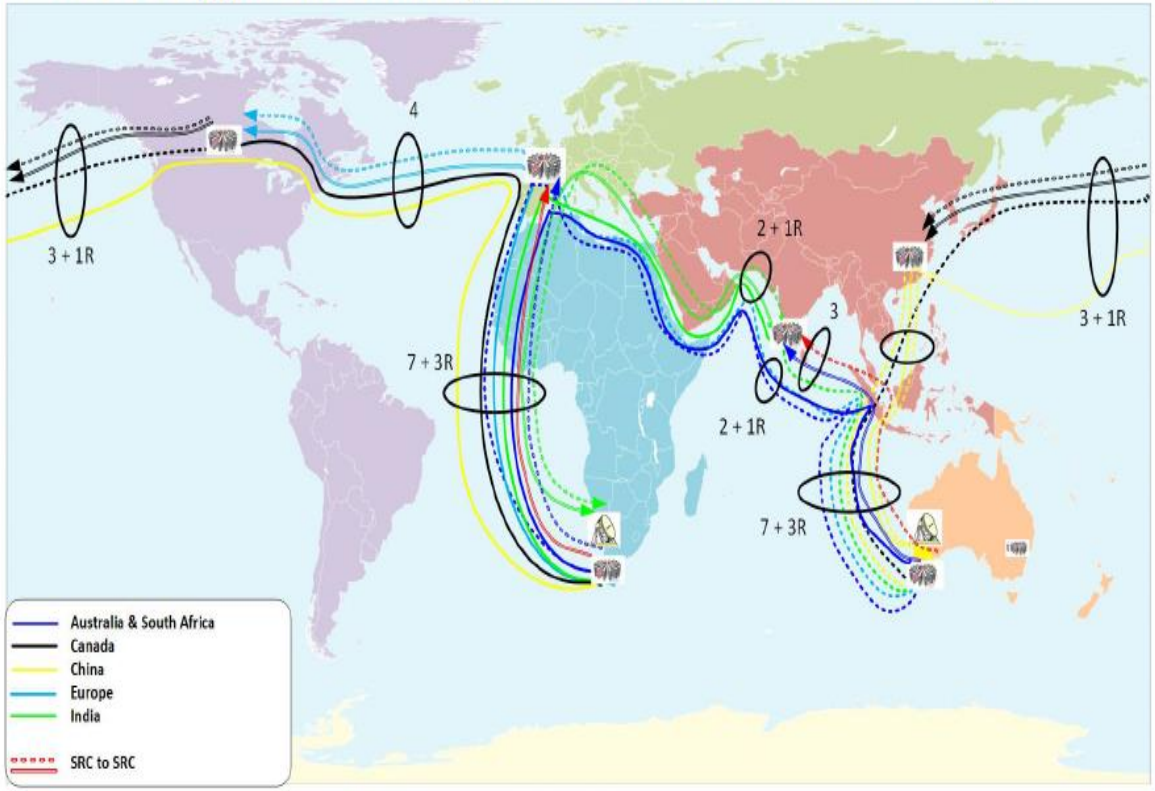


26 countries/regions
123 institutes
1,075 researchers

Global Data Flows if the SRC Re-distribute data – 2 Replicas

- Each SRC accepts its fraction of the Observatory Data Products and re-distributes to another SRC.
- SRC has 20 Gbit/s flow from the telescope & a second continuous 20 Gbit/s flow from another SRC.
- Each SRC sends out a 20 Gbit/s flow.
- Makes substantial use of the shared academic network which would imply charges to the SKA community.
- **Probable cost to SKA community Very approx. ~ 0.8 M USD/year not allowing for the extra BW from the telescopes**





DUNE Collaboration

An international effort

The Deep Underground Neutrino Experiment brings together over 1,000 scientists from more than 30 countries around the world.

Armenia	Finland	Mexico	Spain
Brazil	France	Netherlands	Sweden
Bulgaria	Greece	Paraguay	Switzerland
Canada	India	Peru	Turkey
Chile	Iran	Poland	Ukraine
China	Italy	Romania	United Kingdom
Colombia	Japan	Russia	United States
Czech Republic	Madagascar	South Korea	

Orchestration Among Multiple Domains

- Instrumentation and Analytic, Storage Resources Are Highly Distributed Among Multiple Domains Interconnected With High Performance Networks
- A Key Issues Is Discovering Resources, Claiming Them, Integrating Them, Utilizing Them and Releasing Them
- Increasingly, New Software Defined Infrastructure Architecture, Services, Techniques And Technologies Are Addressing These Issues

Large-Scale High Capacity Data WAN Transport

- Large-Scale High Capacity Data WAN Transport Has Always Been And Remains A Major Challenge, Especially Over Global Paths
- This Issue Is Emphasized By A Next Generation Of Instrumentation That Will Generate Exponentially Large Volumes Of Data That Has To Be Distributed Across the Globe
- More Than Network Capacity - An E2E Issue, Especially Given Advances In Core Optical Networking Technologies

High-Fidelity Data Flow Monitoring, Visualization, Analytics, Diagnostic Algorithms, Event Correlation AI/ML/DL

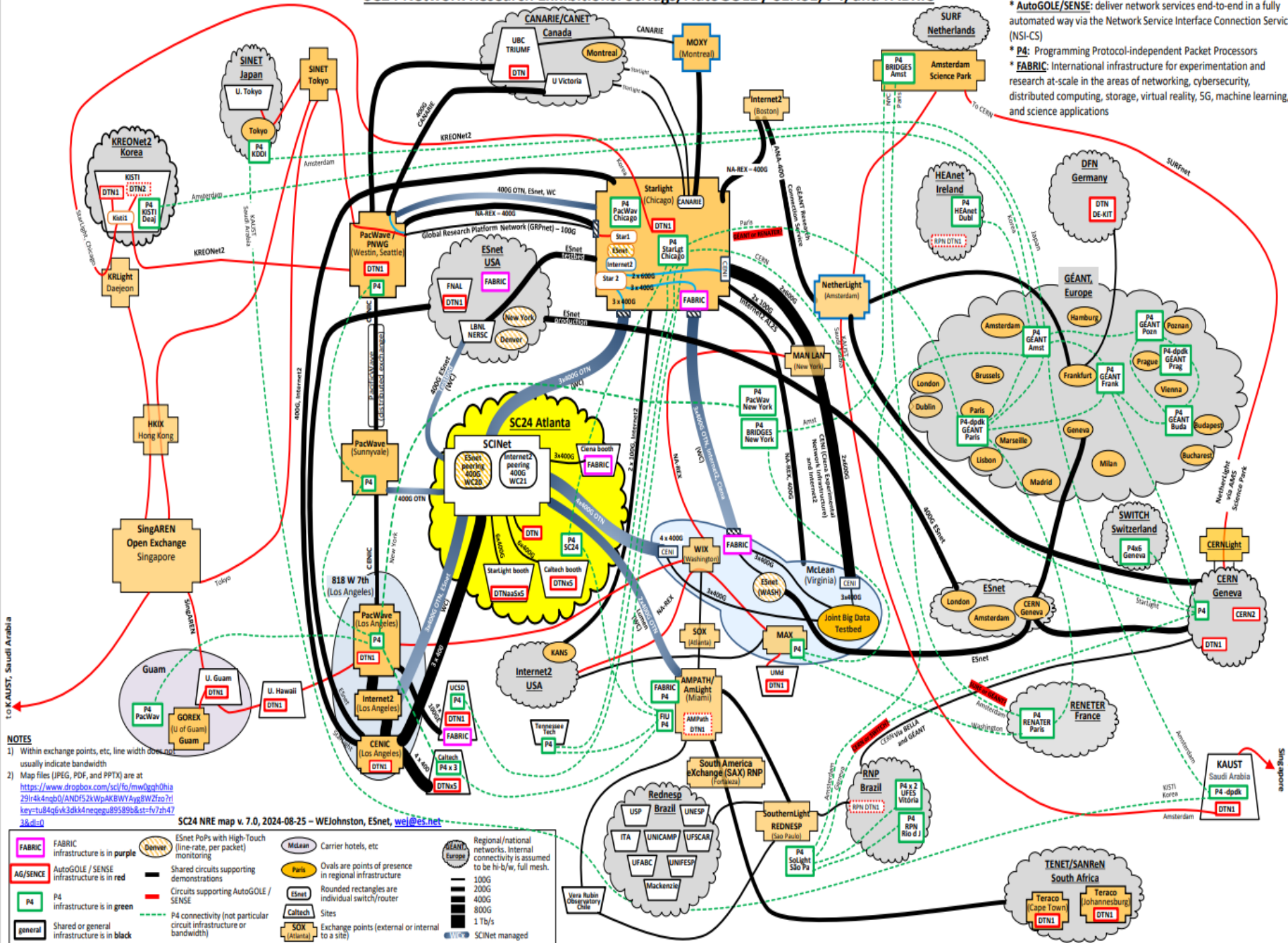
- A Major Opportunity For Data Transport Optimization Is Being Provided By New Methods For Directly Detecting And Analyzing All Data Flows And Their Characteristics
- Because These Techniques Enable High-Fidelity Views Of All Flows, Real Time, Dynamic Traffic Engineering Is Possible With Much More Sophistication Than Traditional Approaches
- These Techniques Can Be Significant Enhanced Using AI/ML/DL, Which (Although Still Emerging) Are Becoming Critically Important Tools In The Near Term

International Testbeds for Data-Intensive Science

- Challenging Requirements Of Anticipated Large Scale Science Projects Along With Accelerated Rates Of Innovation Require International Testbeds For Pre-Production Investigations And Prototyping Of New Technologies And Techniques Specifically Related To Data Intensive Science, e.g., Tbps E2E WAN Services Among Sites
- Global Experimental Research Testbeds Are Being Developed With Enhanced Capacities, Additional Sites, And Innovative Capabilities

SC24 Network Research Exhibitions: SciTags, AutoGOLE / SENSE, P4, and FABRIC

* **SciTags**: packet marking and flow labelling
* **AutoGOLE/SENSE**: deliver network services end-to-end in a fully automated way via the Network Service Interface Connection Servic (NSI-CS)
* **P4**: Programming Protocol-independent Packet Processors
* **FABRIC**: International infrastructure for experimentation and research at-scale in the areas of networking, cybersecurity, distributed computing, storage, virtual reality, 5G, machine learning, and science applications



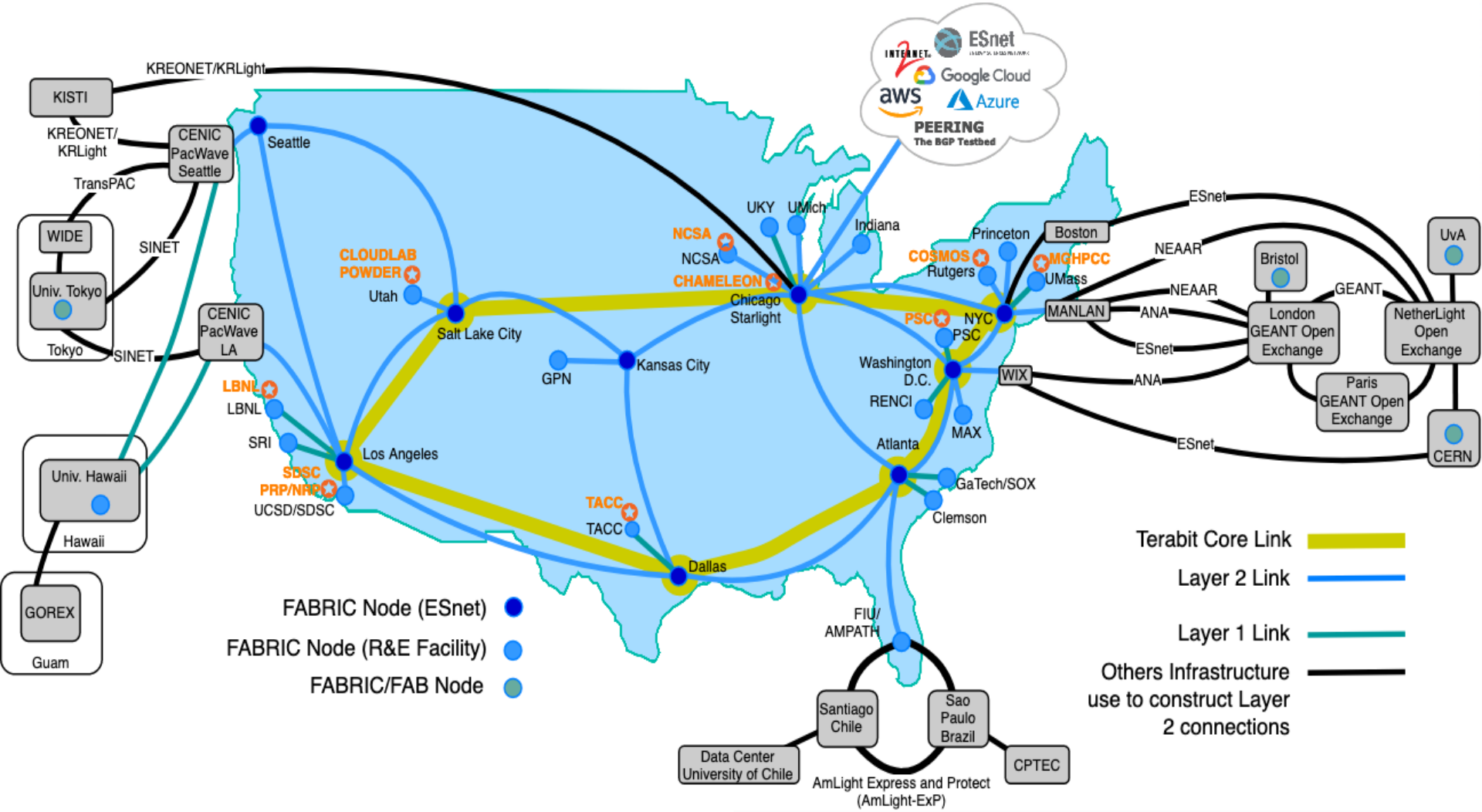
NOTES

1) Within exchange points, etc, line width does not usually indicate bandwidth
2) Map files (JPEG, PDF, and PPTX) are at https://www.dropbox.com/scl/fo/mw0gqh0hia29lr4k4nqb0/ANDf52kWpAKBWYAyg8W2fzo?rlkey=tu84q6vk3dkk4neqegu89589b&st=fv7zh473&dl=0

SC24 NRE map v. 7.0, 2024-08-25 – WEJohnston, ESnet, wej@es.net

FABRIC	FABRIC infrastructure is in **purple**	Denver	ESnet PoPs with High-Touch (line-rate, per packet) monitoring	McLean	Carrier hotels, etc	GÉANT Europe	Regional/national networks. Internal connectivity is assumed to be hi-b/w, full mesh.
AG/SENCE	AutoGOLE / SENSE infrastructure is in **red**		Shared circuits supporting demonstrations	Paris	Ovals are points of presence in regional infrastructure		100G
P4	P4 infrastructure is in **green**		Circuits supporting AutoGOLE / SENSE	ESnet	Rounded rectangles are individual switch/router		200G
general	Shared or general infrastructure is in **black**		P4 connectivity (not particular circuit infrastructure or bandwidth)	Caltech	Sites		400G
				SOX (Atlanta)	Exchange points (external or internal to a site)		800G
							1 Tb/s
							SCINet managed

Paul Ruth PI, RENCI: FABRIC



Core = 1.2 Tbps

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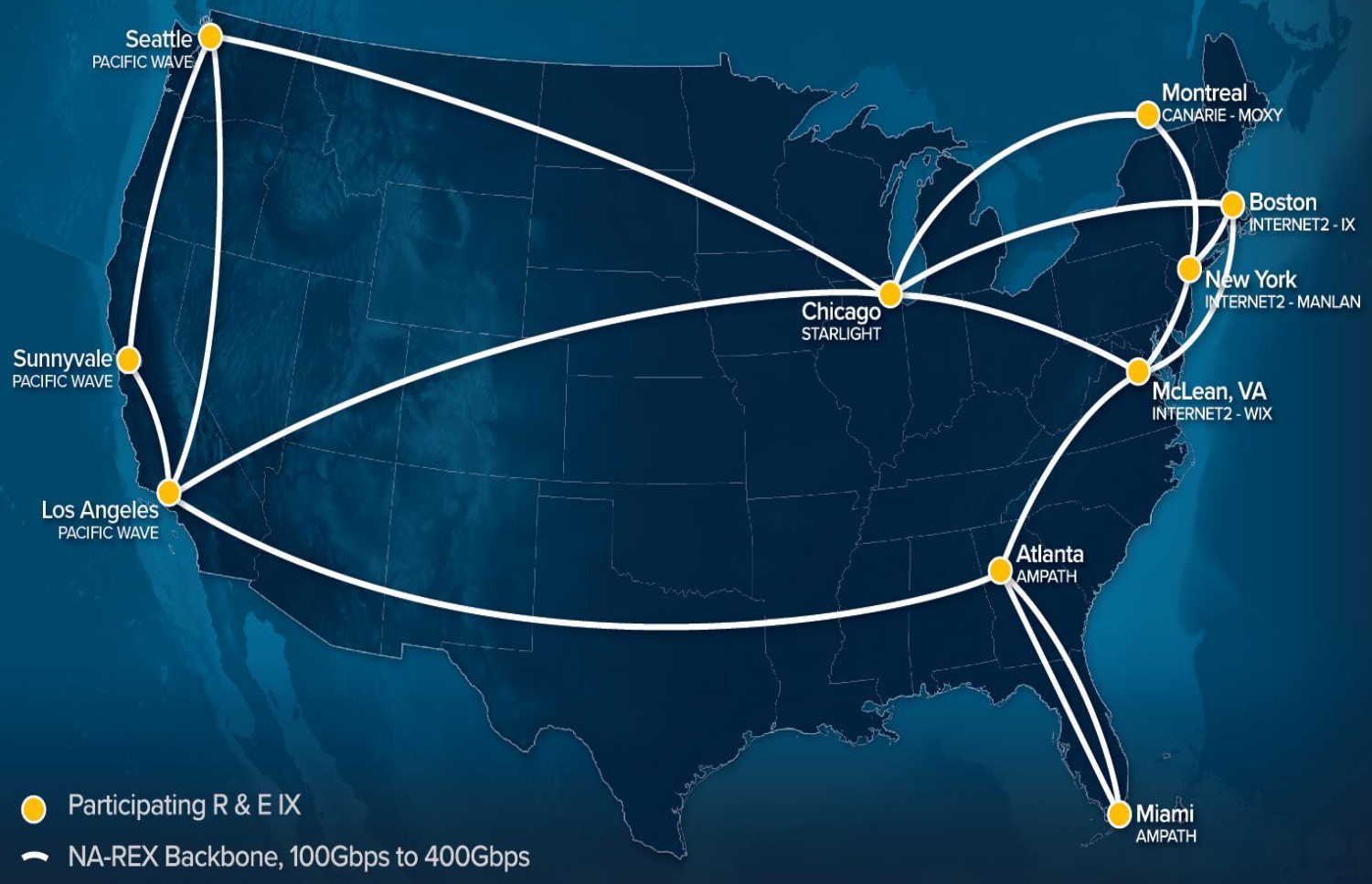
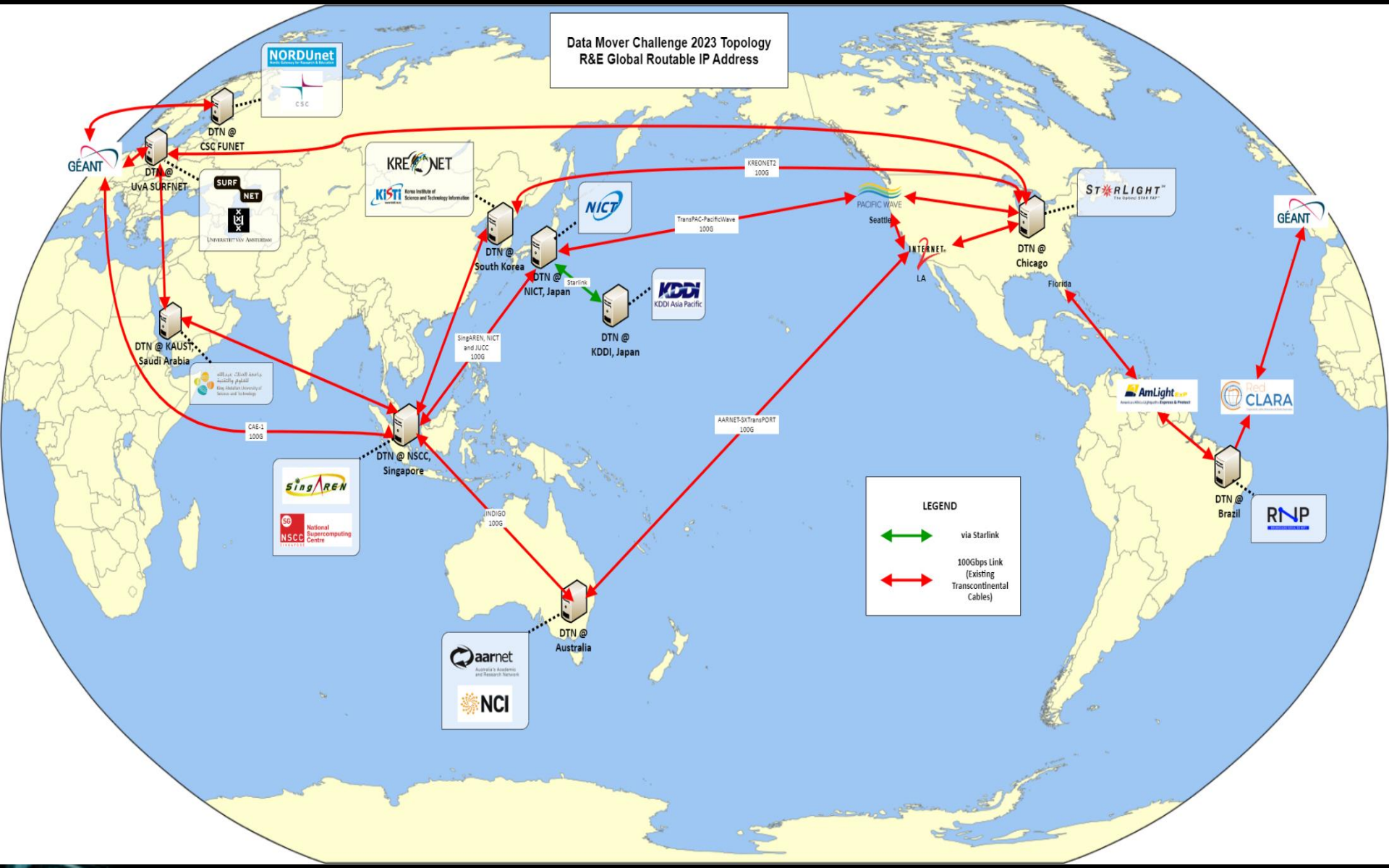
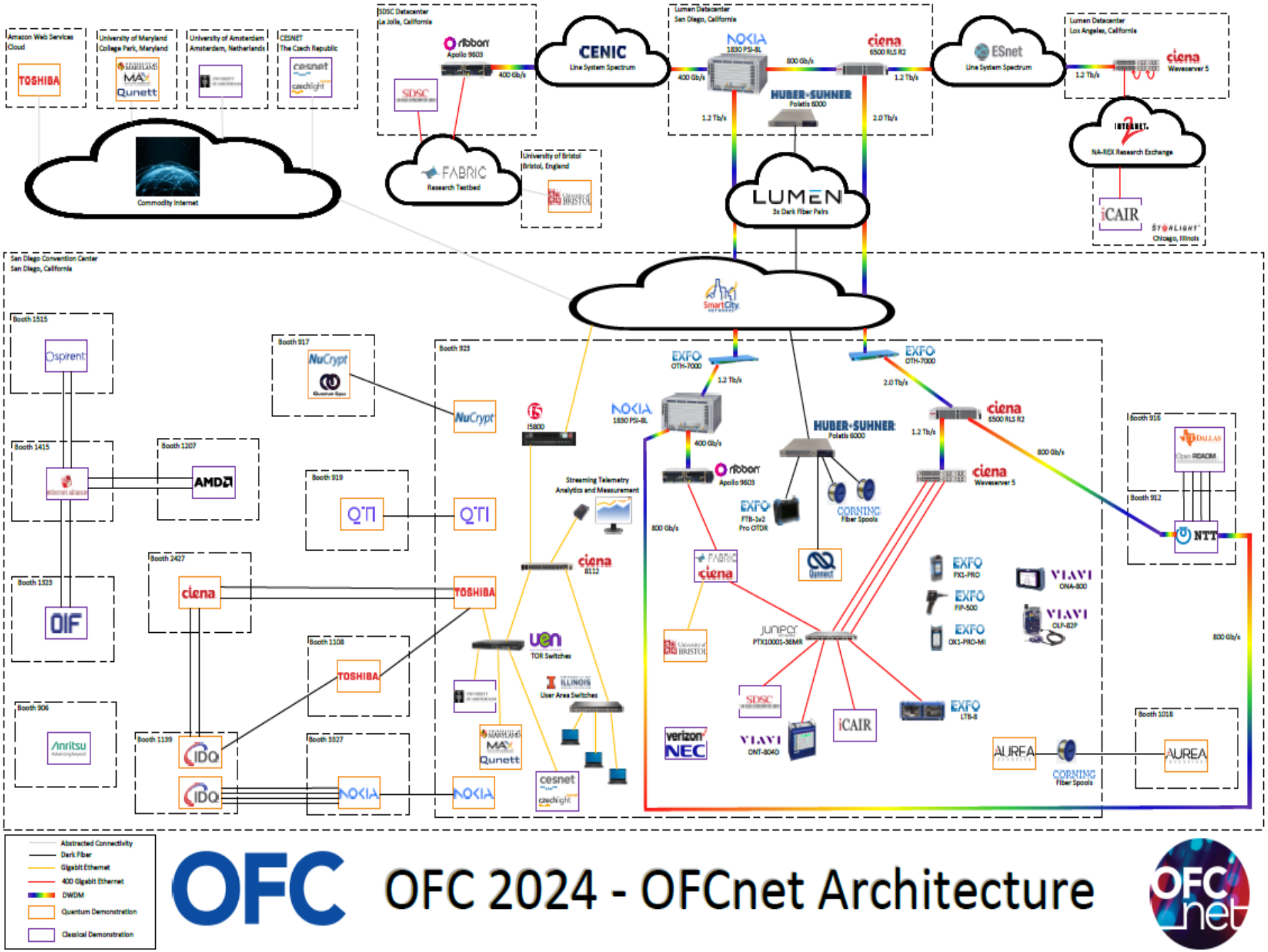
NA-REX North America Research & Education Exchange Collaboration



AMPATH PATHWAY TO THE AMERICAS
canarie
ESnet ENERGY SCIENCES NETWORK
INTERNET2
International Networks at Indiana University
STARLIGHT The Optical STAR TAP
CENIC
PACIFIC NORTHWEST GIGAPOP
PACIFIC WAVE

November 2023


Data Mover Challenge 2023 Topology
R&E Global Routable IP Address
NORDUnet
DTN @ CSC FUNET
GÉANT
DTN @ UvA SURFNET
SURFNET
KREONET
KISTI
DTN @ South Korea
NICT
DTN @ NICT, Japan
Starlink
DTN @ KDDI, Japan
KDDI Asia Pacific
KREONET2 100G
TransPAC-PacificWave 100G
PACIFIC WAVE
Seattle
INTERNET2
LA
DTN @ Chicago
Florida
STARLIGHT
GÉANT
DTN @ KAUST, Saudi Arabia
SingAREN, NICT and JUCC 100G
CAE-1 100G
DTN @ NSCC, Singapore
SingAREN
NSCC National Supercomputing Centre
INDIGO 100G
AARNET-SXTransPORT 100G
DTN @ Australia
aarnet
NCI
AmLight
Red CLARA
DTN @ Brazil
RNP
LEGEND
via Starlink
100Gbps Link (Existing Transcontinental Cables)



OFC 2024 - OFCnet Architecture

Chameleon

www.chameleoncloud.org

CHAMELEON: A LARGE SCALE, RECONFIGURABLE EXPERIMENTAL INSTRUMENT FOR COMPUTER SCIENCE

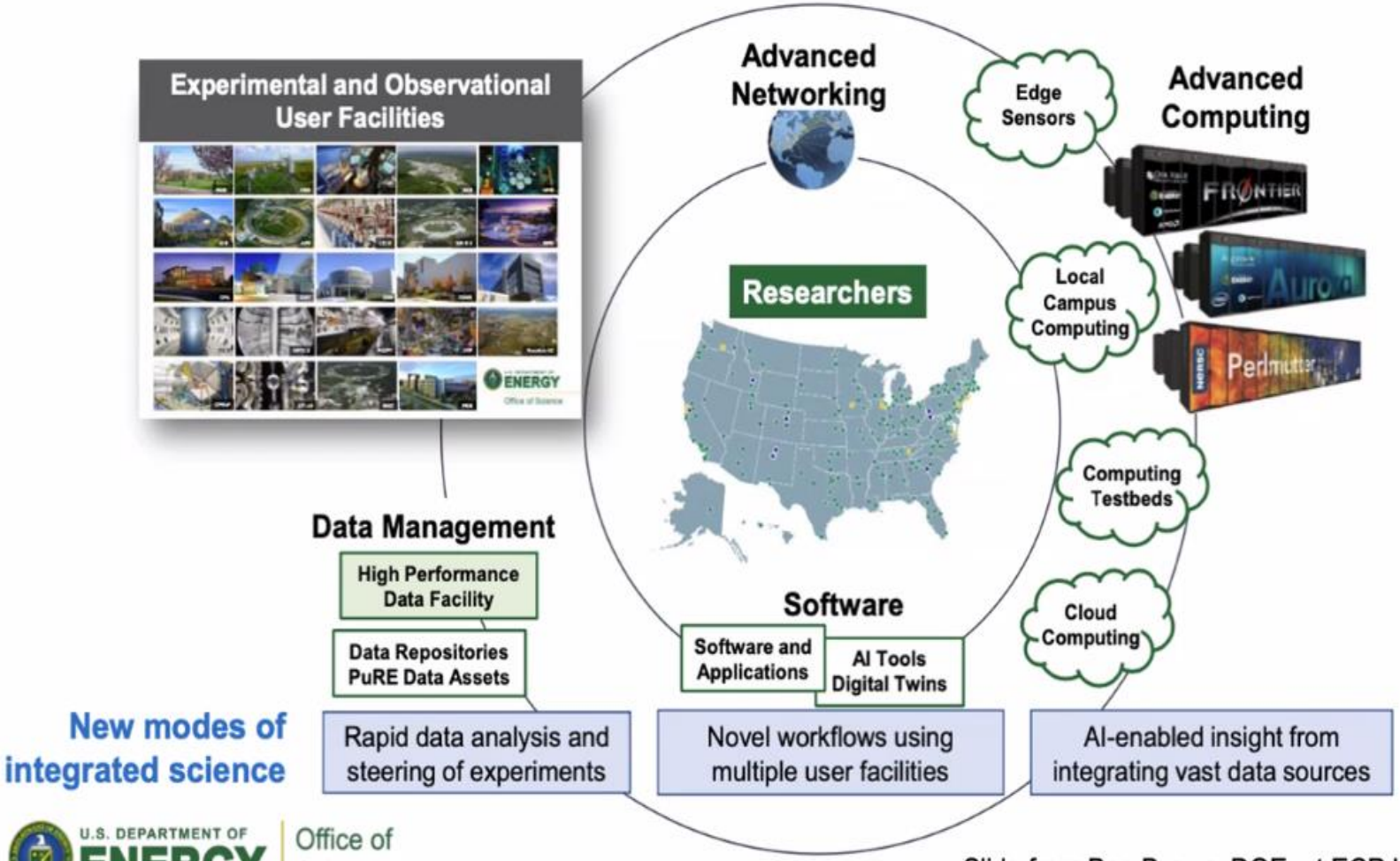
Kate Keahey

Joe Mambretti, Pierre Riteau, Paul Ruth, Dan Stanzione

THE UNIVERSITY OF CHICAGO TACC renci NORTHWESTERN UNIVERSITY NSF

DOE's Integrated Research Infrastructure (IRI) Vision:

To empower researchers to meld DOE's world-class research tools, infrastructure, and user facilities seamlessly and securely in novel ways to radically accelerate discovery and innovation



U.S. DEPARTMENT OF ENERGY | Office of Science

Slide from Ben Brown, DOE, at ECP IAC – Jan 2024

www.startap.net/starlight

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