Global Research Platform Workshop: An Overview

Joe Mambretti, Director, (j-mambretti@northwestern.edu)
International Center for Advanced Internet Research (www.icair.org)
Northwestern University
Director, Metropolitan Research and Education Network (www.mren.org)
Director, StarLight International/National Communications Exchange Facility (www.startap.net/starlight),
PI StarLight SDX, Co-PI Chameleon, PI-iGENI, PI-OMNINet

Global Research Platform Workshop
Co-Located With IEEE International Conference On eScience
Chicago, Illinois
September 15-16, 2025

iCAIR

STARLIGHT SDX

Global Research Platform Workshop – Co-Located With IEEE International Conference On eScience Sept 15-16, 2025

STARLIGHT℠

GRP: Next Generation Platform For Global Science

A Global Community Creating Next Generation Ecosystems for New Knowledge Discovery

STARLIGHT℠

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

- Large Scale, Powerful, and Sophisticated Instrumentation Integrated With New Computational Science Methods (Especially Now) Are Revolutionizing Science Research.
- This Revolution Is Transforming Research, Practice, And Education In Science
- Such A Large Scale Transformation Is Made Possible By International Collaboration – ***Science Is Global!***
- Global Partners Are Creating World-Wide Comprehensive Distributed Environments Interlinking Global Science Communities And Integrating Instruments, High Performance Computing, Networking, Storage, Analytics, And Specialized Facilities.
- This Environment Enables Novel Integration Of Theoretical, Experimental, and Observational Methods For New Knowledge Discovery

Large Scale Science Ecosystems

- **Planning Processes Are Defining Future, Specialized Requirements.**
- **In Response To These Requirements Cyberinfrastructure *Blueprints* Are Being Created: Architecture, Services, Techniques, Technologies, Processes, Methods et al**
- **Current Processes Are Examining Opportunities For Improving Relationships Among Science Workflows And Foundation Resource Services and Resources, Particularly With AI/ML/DL**
- **Dedicated vs Shared**
- ***Key Issues Focus On Policies Determining What Resources Are A) Devoted To Domains B) Shared Among Domains And C) Combining Dedicated And Shared Resources***

Global Collaborative Research Communities

- 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: Concepts, Experiments, Instruments, Methods, Techniques, Data, Architecture, Implementation, Technologies, Operations, and Results
- The GRP Also Provides Opportunities For eScience Environment Infratstructure Sharing Among Collaborative Science Communities
- The GRP Facilitates High Performance World-Wide Data Gathering, Analytics, High Capacity, High Performance Transport, Computing, Storage, And Analytics
- www.theglobalresearchplatform.net

Foundation For Global Research Platform: Major R&E Networks

Visualization courtesy of Bob Patterson, NCSA; data compilation by Maxine Brown, UIC.

GRP Foundation: Open R&E Exchanges

STARLIGHT℠

Selected Applications/Instruments

Open Storage Network
www.openstorage network.org

OSG
www.openscience grid.org

Polar Geospatial Center
www.pgc.umn.edu

LSST
www.lsst.org

ISS
www.nasa.gov/ station

Virgo
www.virgo-gw.eu

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

GRP
theglobalresearch platform.net/

IceCube
icecube.wisc.edu

Pierre Auger Observatory
www.auger.org

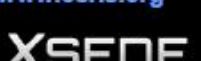
LIGO
www.ligo.caltech. edu

GLEON
www.gleon.org

OSiRIS
www.osris.org

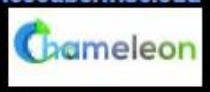
SKA
www.skatelescope. org

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



XSEDE
www.xsede.org

PRP
pacificresearch platform.org



Chameleon
www.chameleon cloud.org

USGS EROS
www.usgs.gov/ centers/eros

Blue Waters
bluewaters.ncsa. illinois.edu

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

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

NEON
www.neonscience. org

Genomic Science Program
genomicscience. energy.gov

LBNF/DUNE/ ProtoDUNE
lbnf.fnal.gov

NOvA
novaexperiment. fnal.gov

ALMA
www.alma observatory.org

CENTRA
www.global centra.org

SAGE2
sage2.sagecommons. org

IVOA
www.ivoa.net

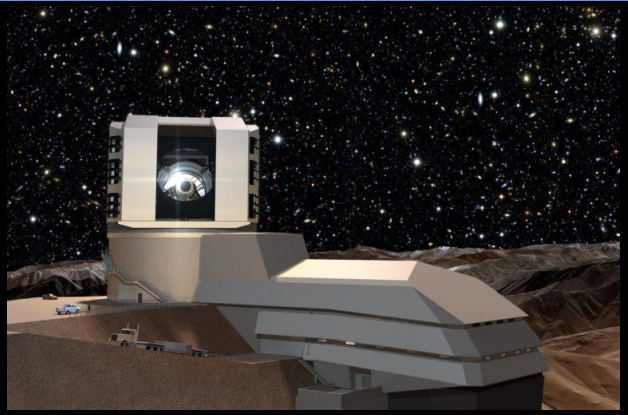
Compilation by Maxine Brown and Joe Mambretti

STARLIGHT℠

Large Scalee Instruments: Exebytes Of Data

High Luminosity LHC

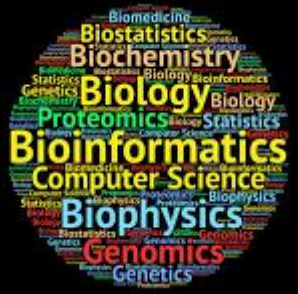
SKA Australia Telescope Facility



Vera Rubin Observatory

KSTAR Korea Superconducting Tokamak

Next Gen Advanced Photon Source

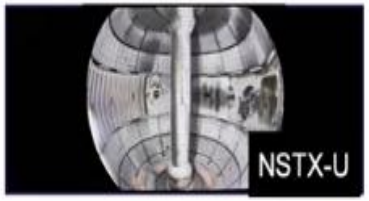


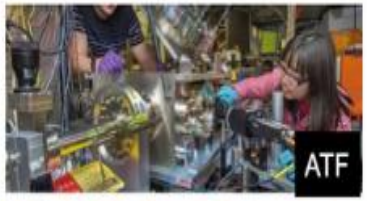
Bioinformatics/Genomics


The international journal of science / 13 February 2025
nature
COSMIC CATCHER
Deep-sea telescope detects neutrino with highest energy ever recorded

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

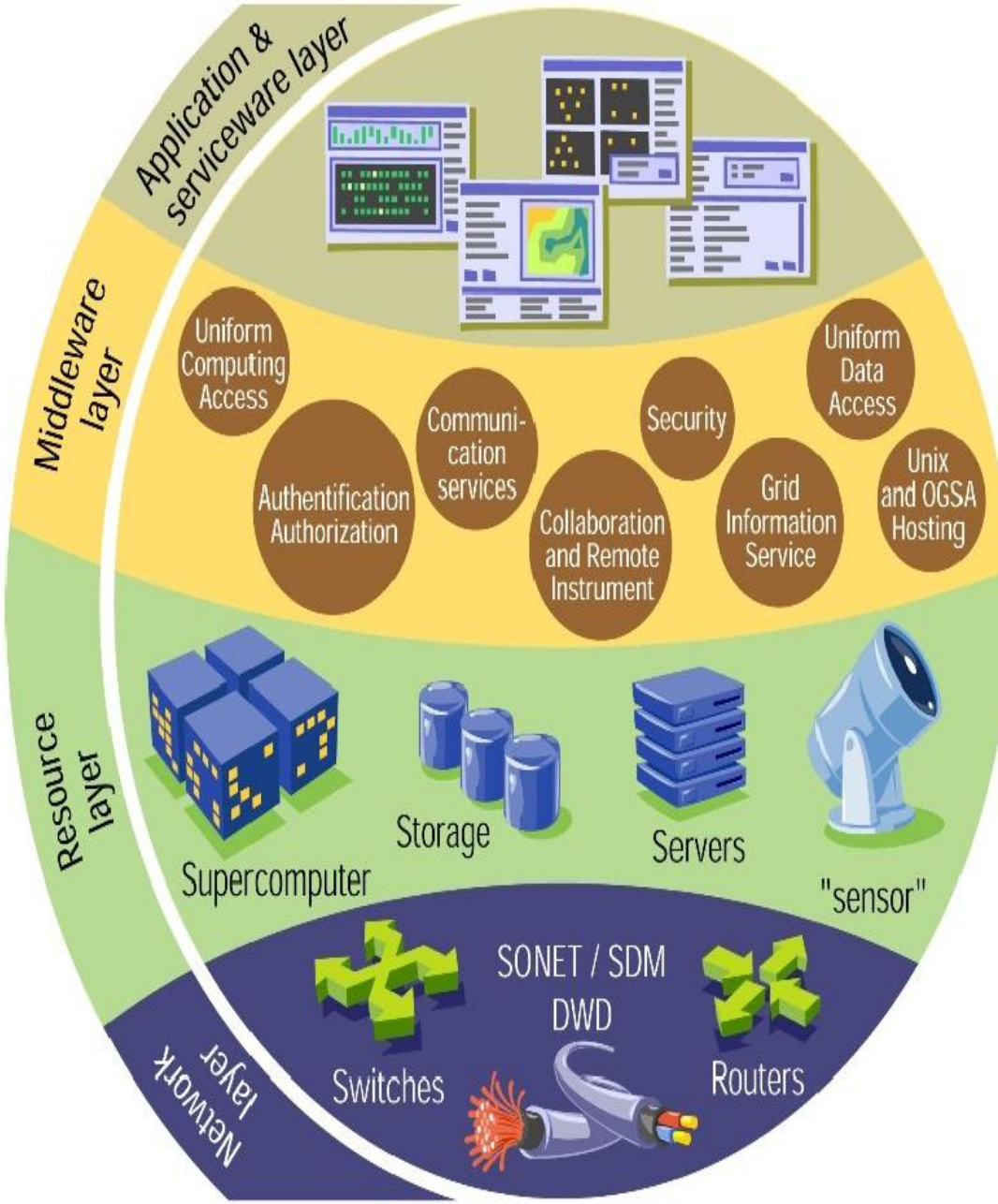
- US National Research Platform
- Asia Pacific Research Platform
- Korean Research Platform
- EU SLICES
- Worldwide LHC Computing Grid (WLCG)
- DOE Integrated Research Infrastructure (IRI)
- Open Science Grid
- Open Science Data Grid
- And Many Others Around the World

Worldwide LHC Computing Grid

- **The Worldwide LHC (Large Hadron Collider) Computing Grid (WLCG): Global Collaboration Of ~ 170 Computing Centers In More Than 40 Countries, Integrating National and International Grid Infrastructures.**
- **WLCG Provides Global Resources To Gather, Store, Distribute and Analyze ~200 Petabytes of LHC Data Each Year, *Planned To Significantly Increase When the High Luminosity LHC Is Implemented (~10*X)***
- **WLCG – Partnership of EGI (European Grid Infrastructure), OSG (Open Science Grid), and NeIC (Nordic e-Infrastructure Collaboration).**

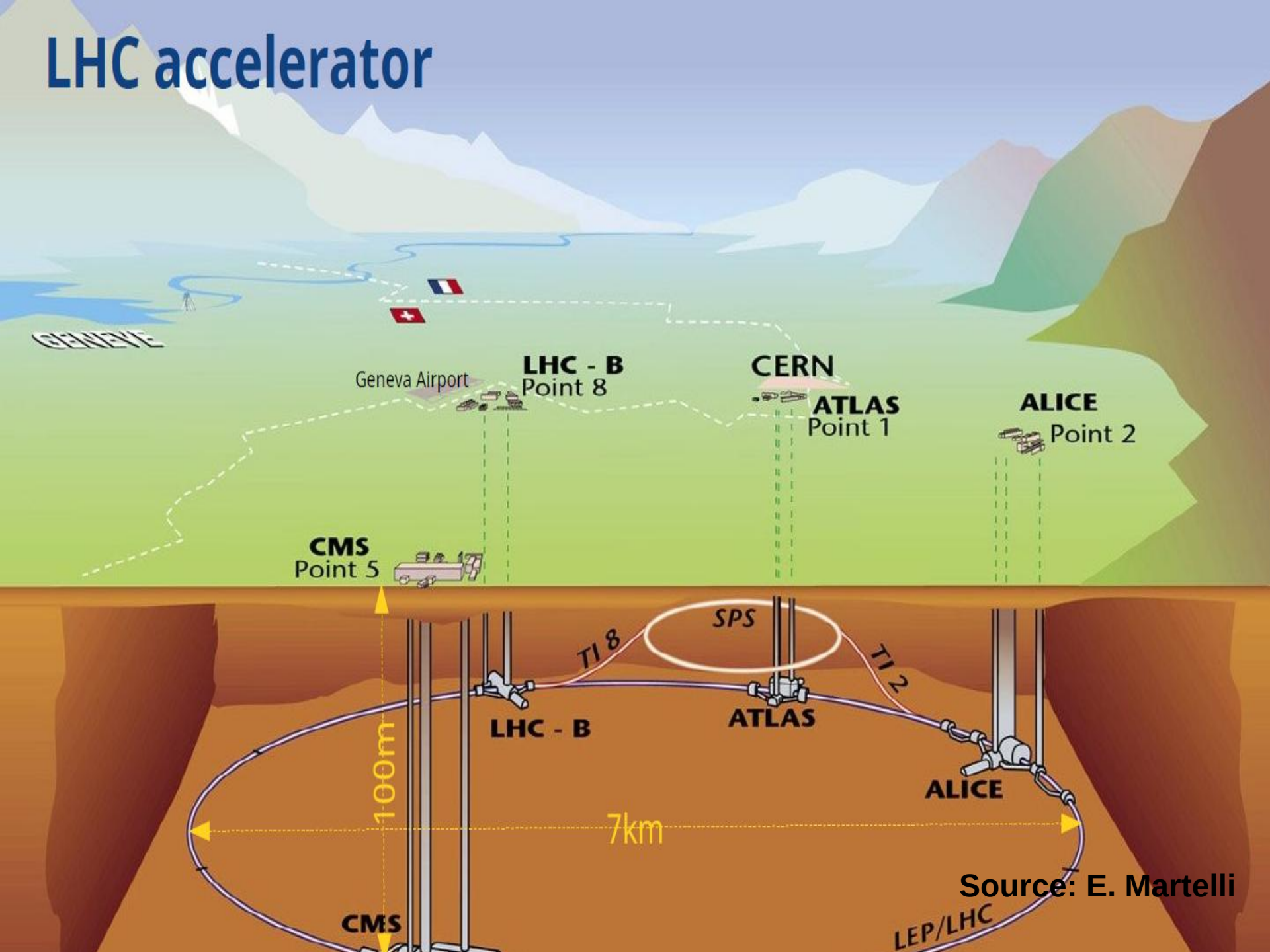
WLCG

The Worldwide LHC Computing Grid (WLCG) is **a large, distributed computing and storage infrastructure and the software framework to exploit it**



Source: E. Martelli

LHC accelerator

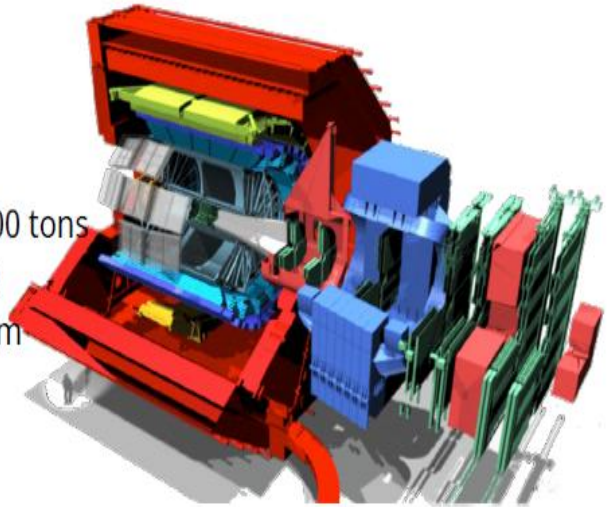


Source: E. Martelli

LHC major experiments

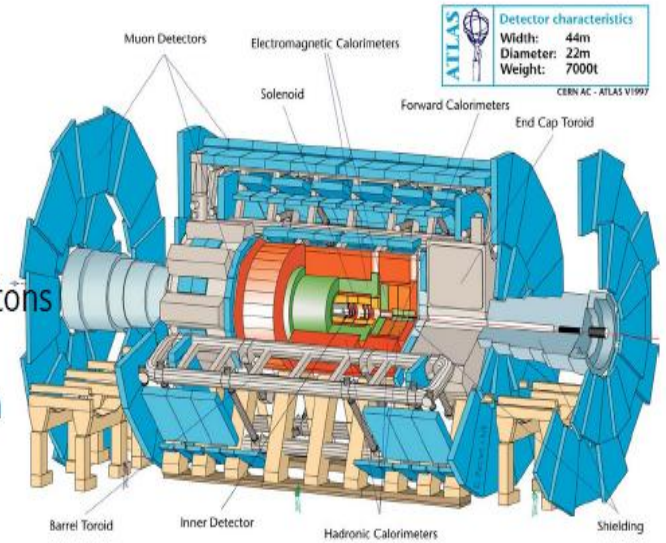
ALICE

Weight: 10,000 tons
Length: 26 m
Diameter 16 m



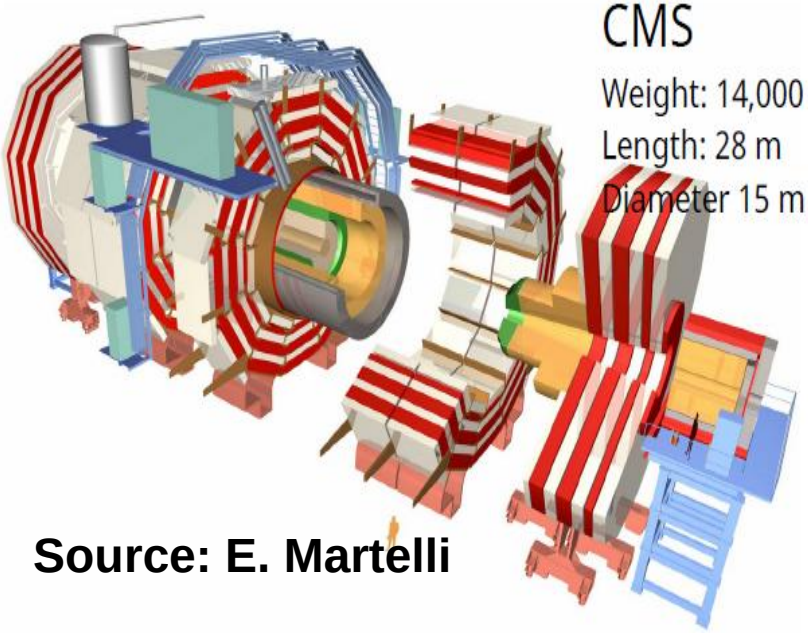
ATLAS

Weight: 7,000 tons
Length: 44 m
Diameter 22 m



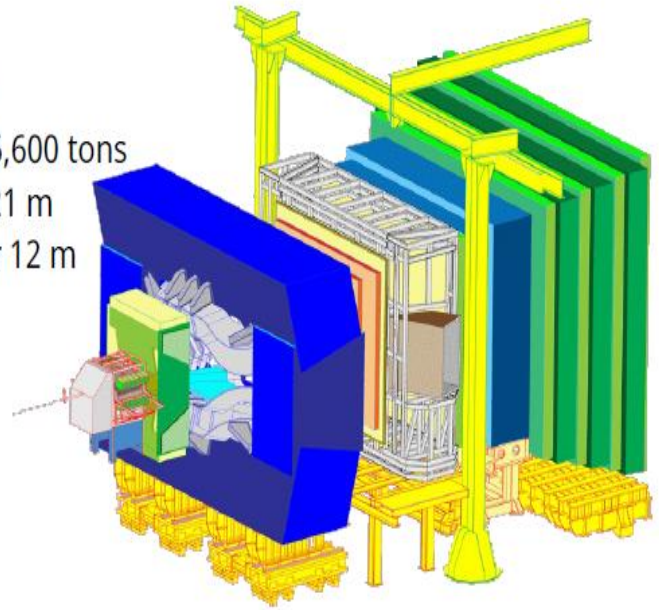
CMS

Weight: 14,000 tons
Length: 28 m
Diameter 15 m



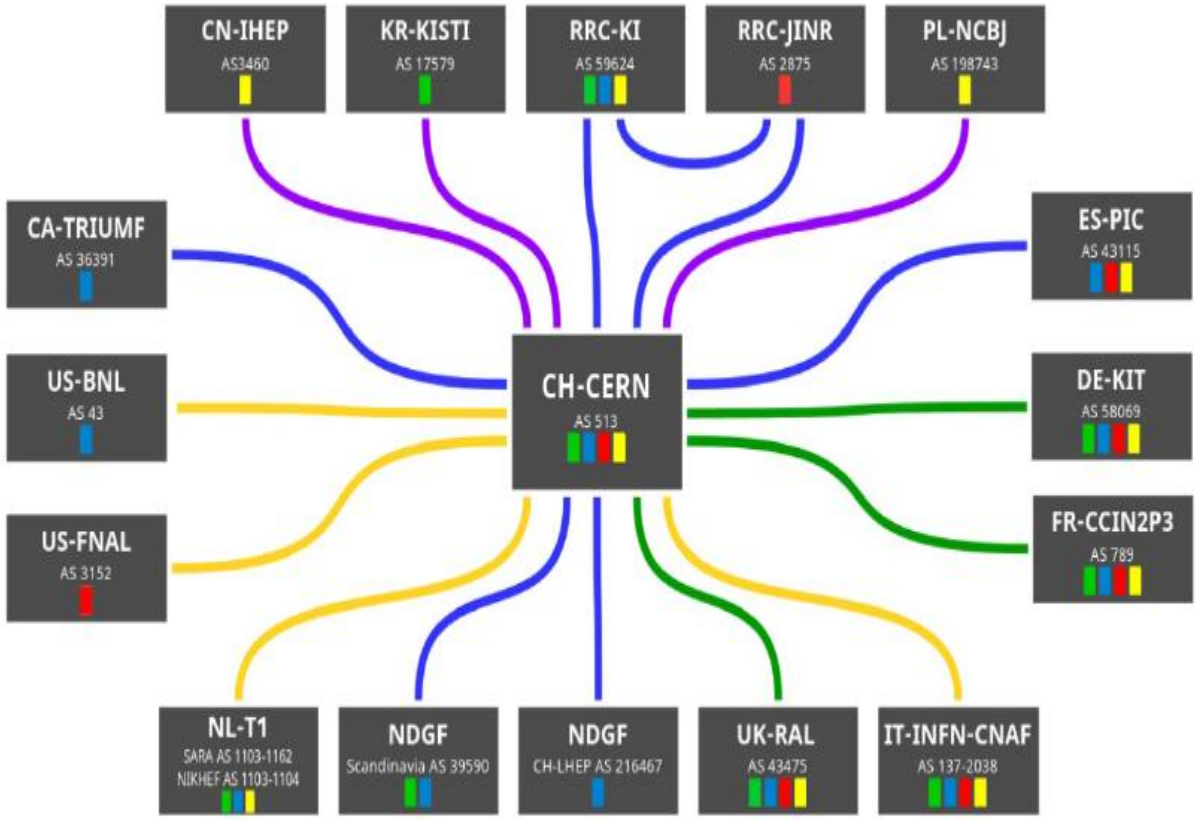
LHCb

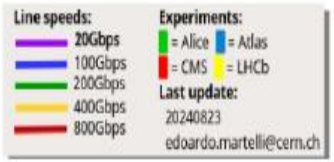
Weight: 5,600 tons
Length: 21 m
Diameter 12 m



Source: E. Martelli

LHCOPN

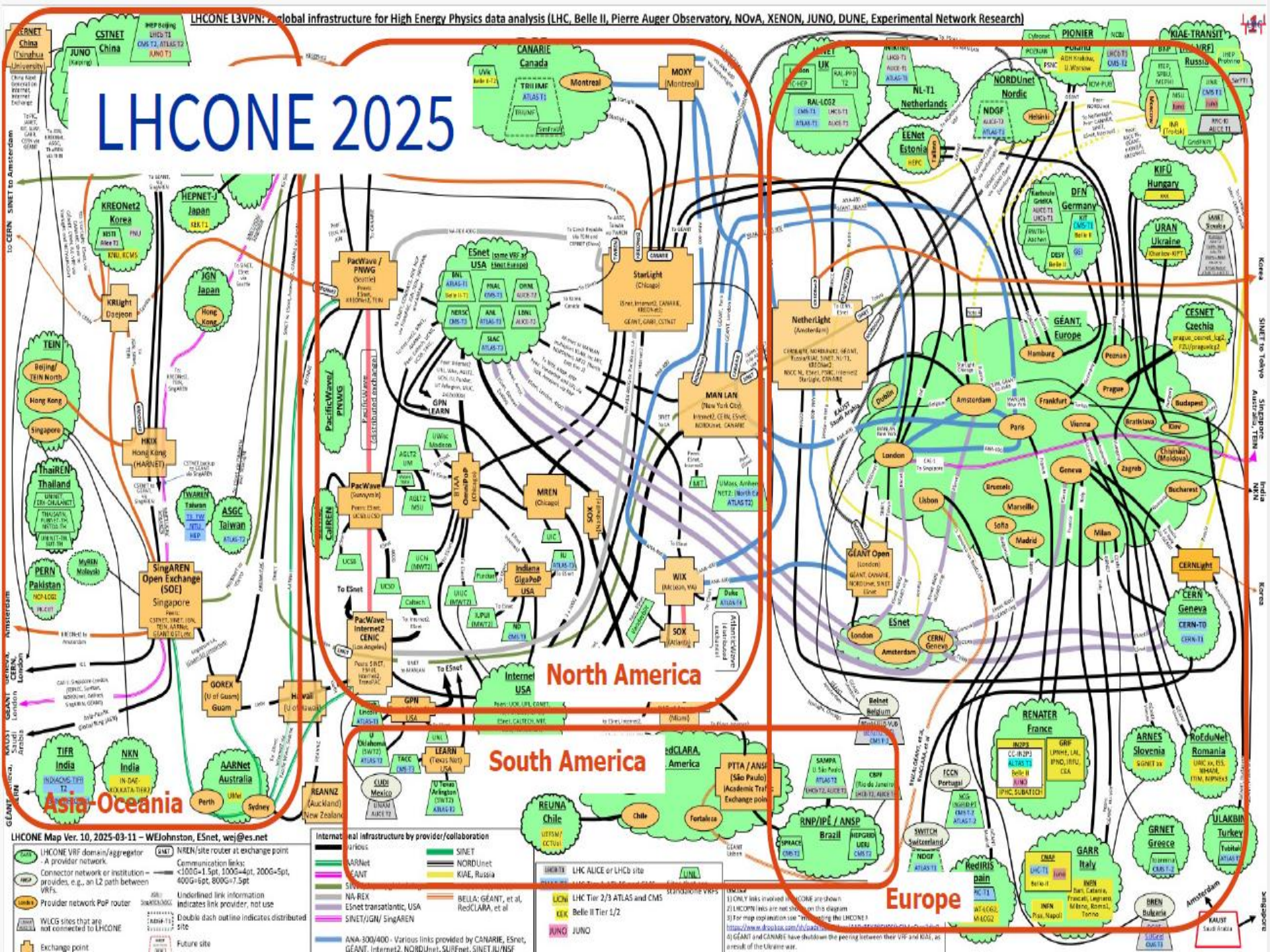




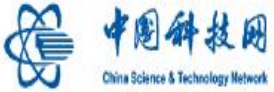
https://twiki.cern.ch/twiki/bin/view/LHCOPN/OverallNetworkMaps

Numbers

- 17 sites for 15 Tier1s + 1 Tier0
- 14 countries in 3 continents
- 2.88 Tbps to the Tier0


LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOvA, XENON, JUNO, DUNE, Experimental Network Research)
LHCONE 2025
North America
South America
Europe
Asia-Oceania
LHCONE Map Ver. 10, 2025-03-11 – WEJohnston, ESnet, wej@es.net
International infrastructure by provider/collaboration
LHCONE VRF domain/aggregator - A provider network.
Connector network or institution – provides, e.g., an L2 path between VRFs.
Provider network PoP router
WLCG sites that are not connected to LHCONE
Exchange point
NREN/site router at exchange point
Communication links: <100G=1.5pt, 100G=4pt, 200G=5pt, 400G=6pt, 800G=7.5pt
Underlined link information indicates link provider, not use
Double dash outline indicates distributed site
Future site
Various
GÉANT
NA-REX
ESnet transatlantic, USA
SINET/IGN/ SingAREN
SINET
NORDUnet
KIAE, Russia
BELLA: GÉANT, et al, RedCLARA, et al
ANA-300/400 - Various links provided by CANARIE, ESnet, GÉANT, Internet2, NORDUnet, SURFnet, SINET,JU/NSF
LHC Tier 2/3 ATLAS and CMS
Belle II Tier 1/2
JUNO
standalone VRFs
1) ONLY links involved in LHCONE are shown
2) LHCOPN links are not shown on this diagram
3) For map explanation see "What's in the LHCONE?"
4) GÉANT and CANARIE have shutdown the peering between their VRF and KIAE, as a result of the Ukraine war.

NRENs supporting HEP



Open to other HEP collaborations

Non-LHC Scientific Communities Using LHCONE

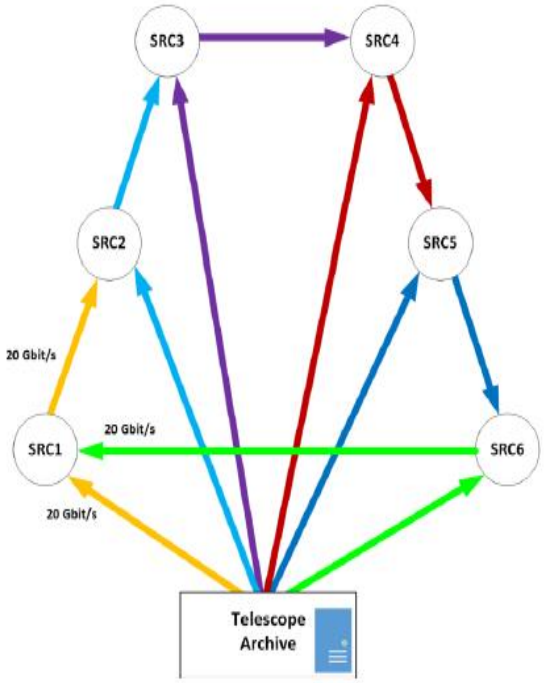
- Belle II Experiment, Particle Physics Experiment Designed To Study Properties od B Mesons (Heavy Particles Containing a Bottom Quark)
- Pierre Auger Observatory, Studying Ultra-High Energy Cosmic Rays, the Most energetic and Rarest Particles in The Universe
- LIGO and Virgo (In August 2024 This Collaboration Measured a Gravatation 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
- Futures – High Luminosity LHC, MultiONE, Future Circular Collider

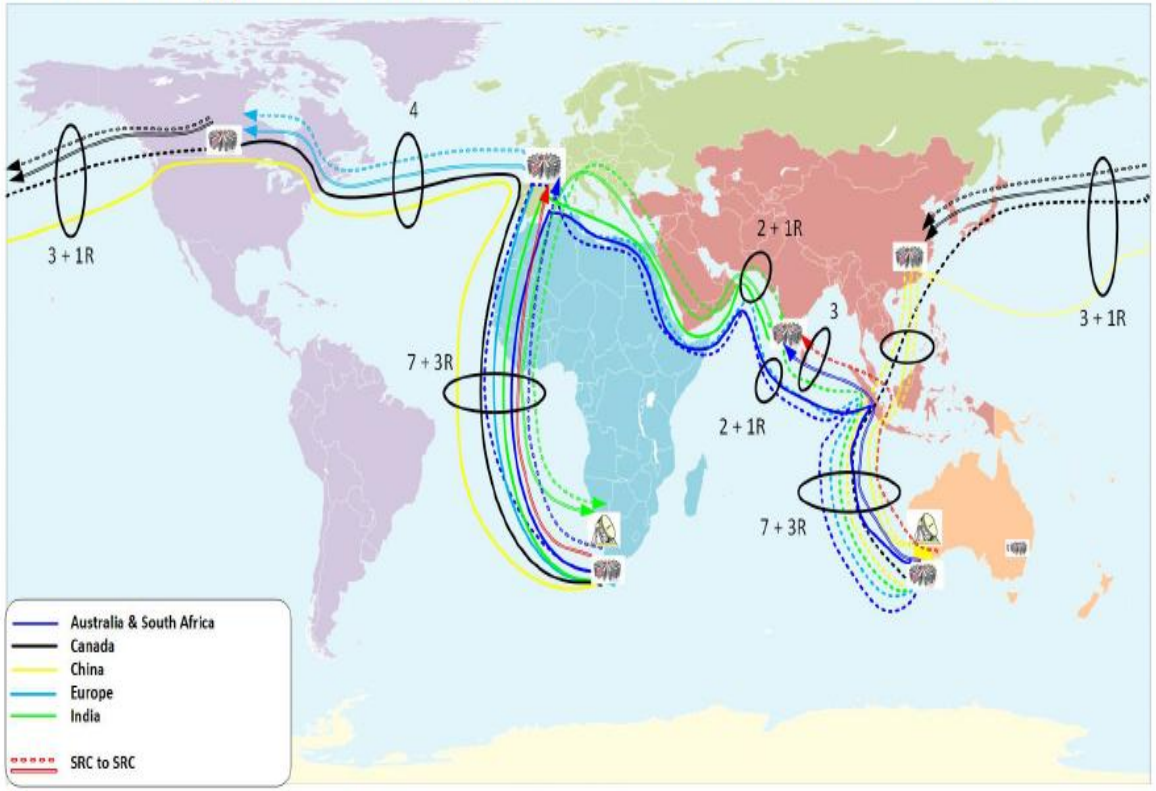
WLCG Network Requirements For HL-LHC

- Each Major Tier1 Will Require:
- 1 Tbps Path To the Tier0 At CERN (LHCOPN)
- 1 Tbps Path to the Tier2s (Aggregated, LHCONE)
- Each Major Tier2 Will Require:
- More Than 400 Gbps (LHCONE)
- WLCG, The NREN Communities, And The Open Exchange Communities Support Projects Addressing These Requirements

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**



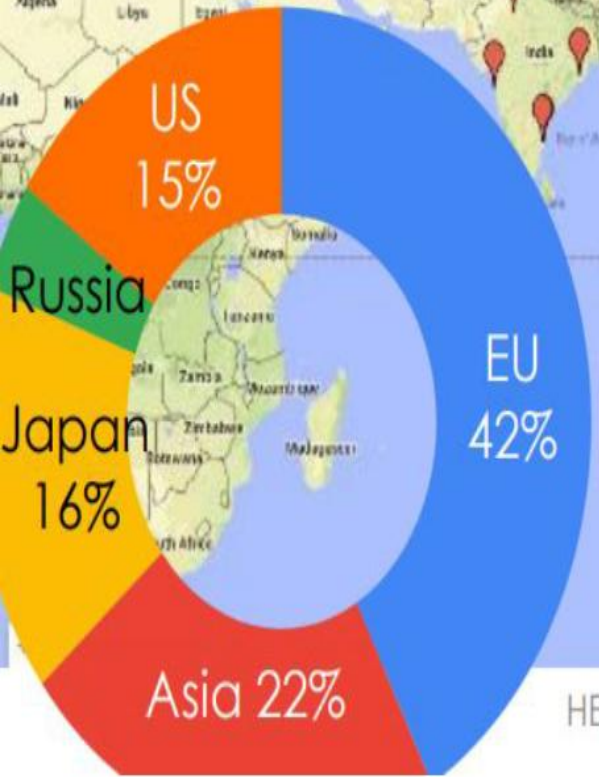


LHCOPN+LHCONE community meetings

- A forum for site mangers, NRENs, experiments to discuss requirements and policies, plan upgrades, design new features
- Meeting two times per year
- Just held meeting #54, hosted by SKAO in UK

Belle II Collaboration

A Global Collaboration
as wide as an LHC experiment



26 countries/regions
123 institutes
1,075 researchers

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

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

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, Becoming Critically Important Tools In The Near Term (e.g., Networking for AI, AI for Networking)

International Testbeds for Data-Intensive Science

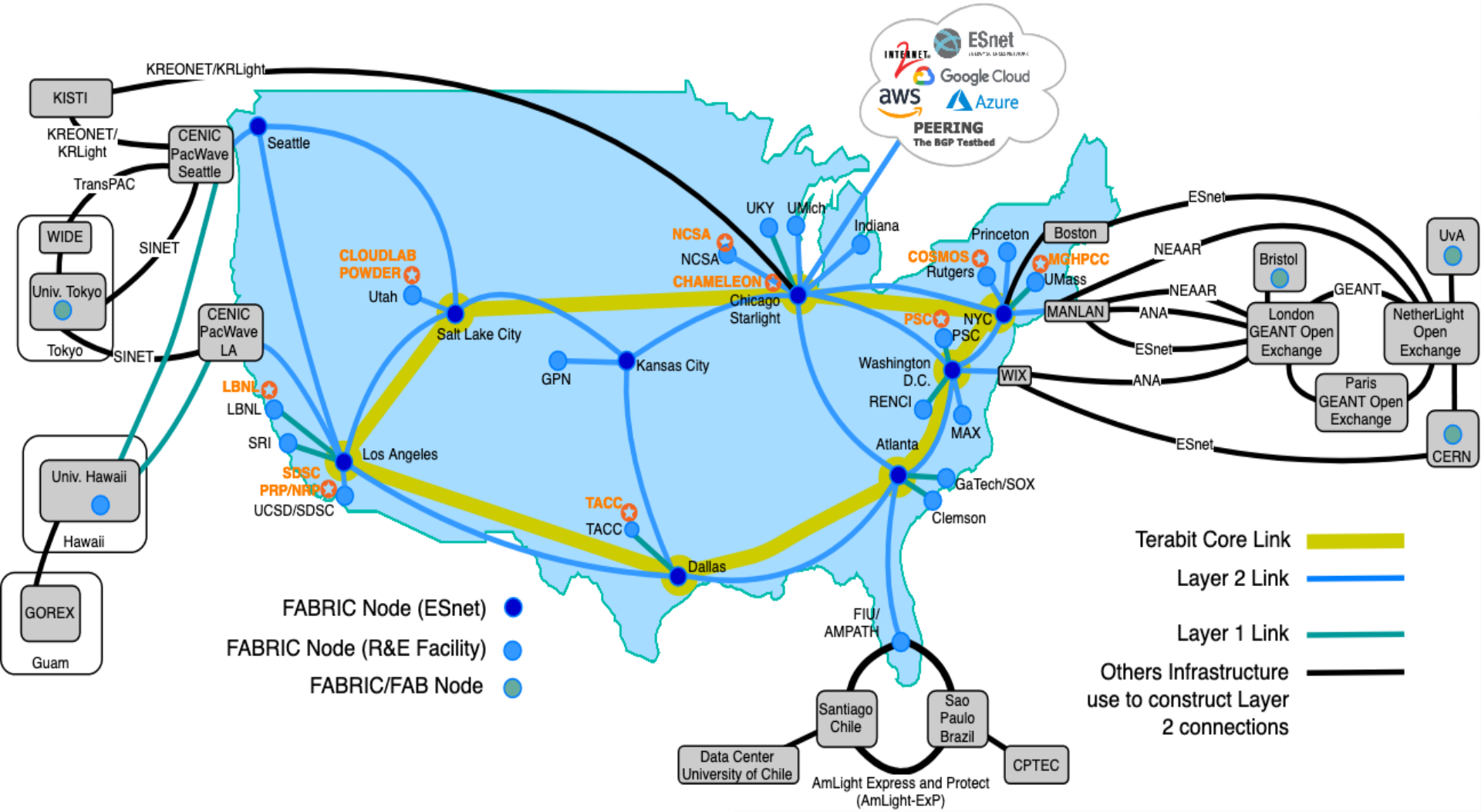
- Challenging Requirements Of Anticipated Large Scale Science Projects Along With Accelerated Rates Of Innovation Require International Testbeds For Pre-Production Investigations And Prototyping Of New Technologies And Techniques Specifically Related To Data Intensive Science, e.g., Tbps E2E WAN Services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

NA-REX North America Research & Education Exchange Collaboration

November 2023

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

Paul Ruth PI, RENCI: FABRIC



Core = 1.2 Tbps

STARLIGHT℠

Chameleon

www.chameleoncloud.org

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

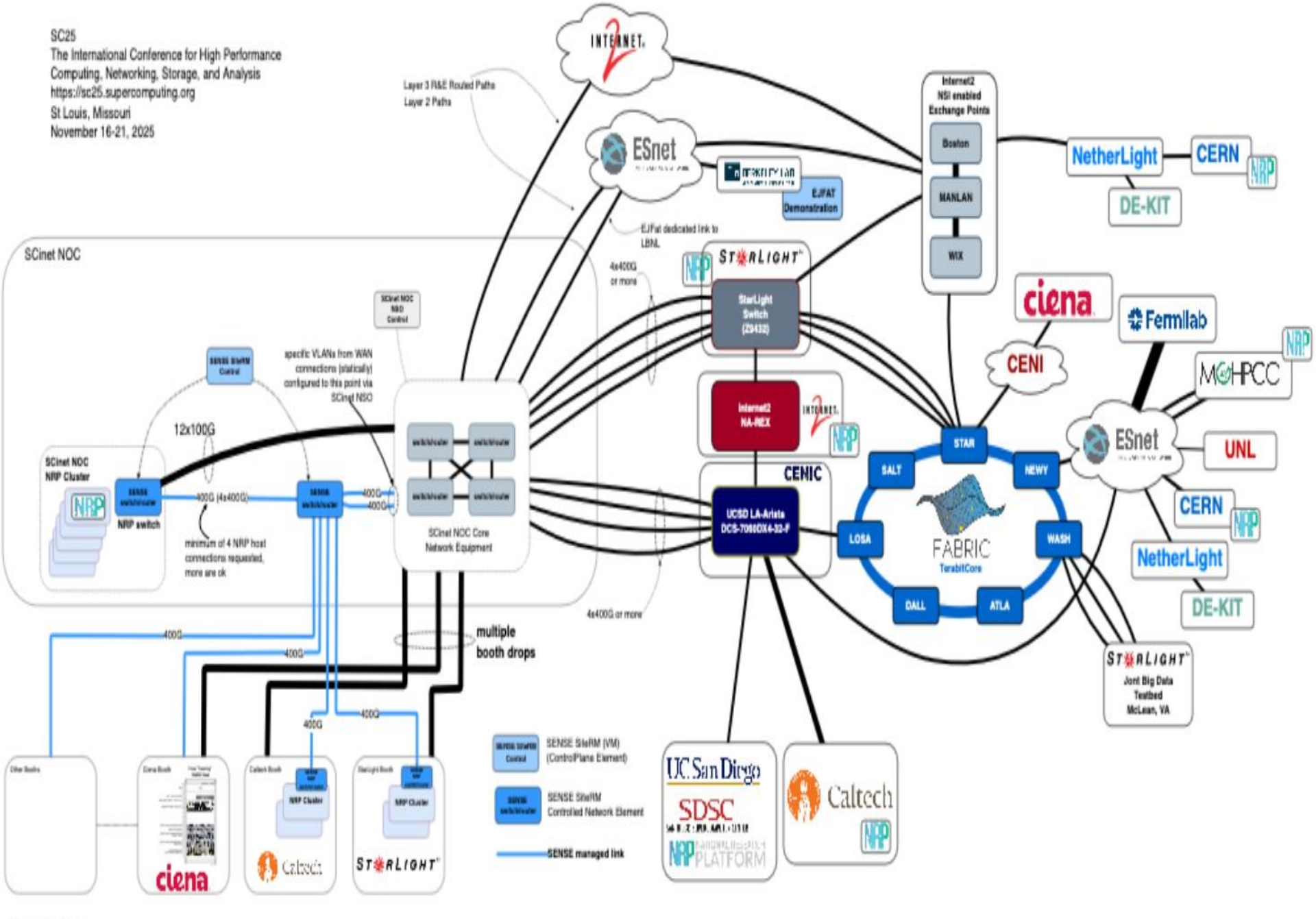
Kate Keahey

Joe Mambretti, Pierre Riteau, Paul Ruth, Dan Stanzione

THE UNIVERSITY OF CHICAGO TACC renci NORTHWESTERN UNIVERSITY NSF

SC25 NREs, SCinet, SENSE, AutoGOLE, FABRIC, NRP Multi-Resources Services Automation

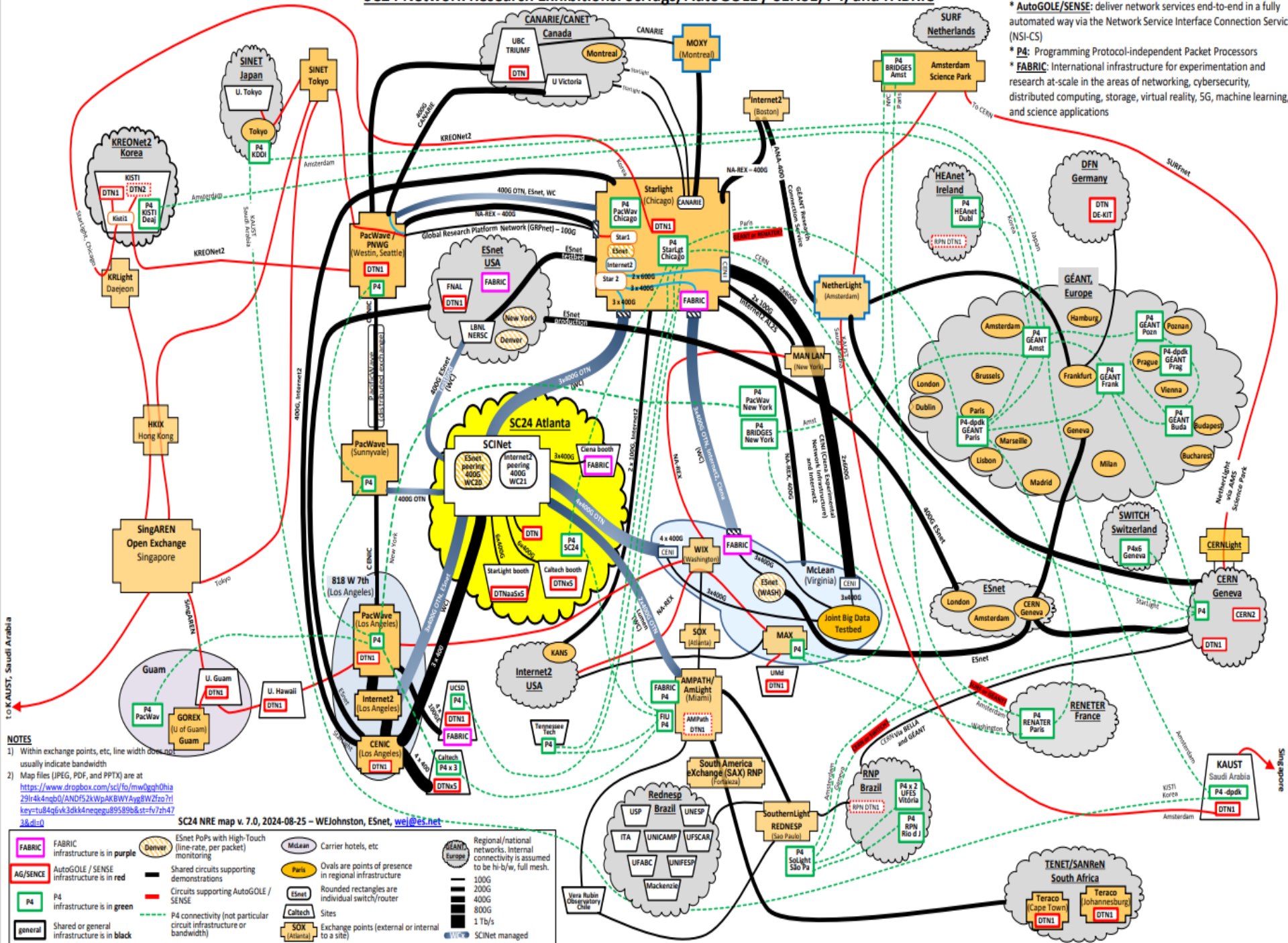
SC25
The International Conference for High Performance Computing, Networking, Storage, and Analysis
https://sc25.supercomputing.org
St Louis, Missouri
November 16-21, 2025



v-September 6, 2025

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

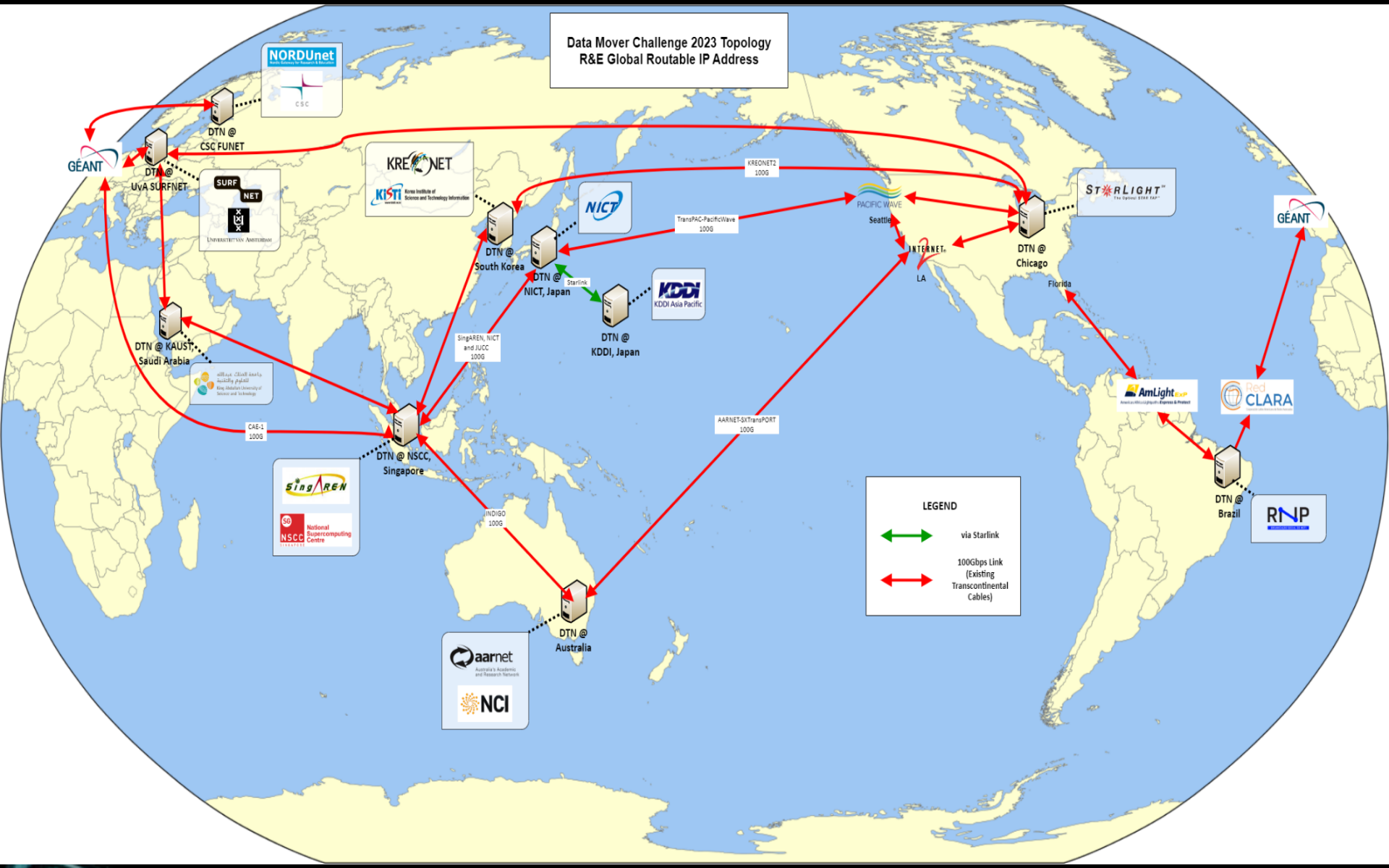


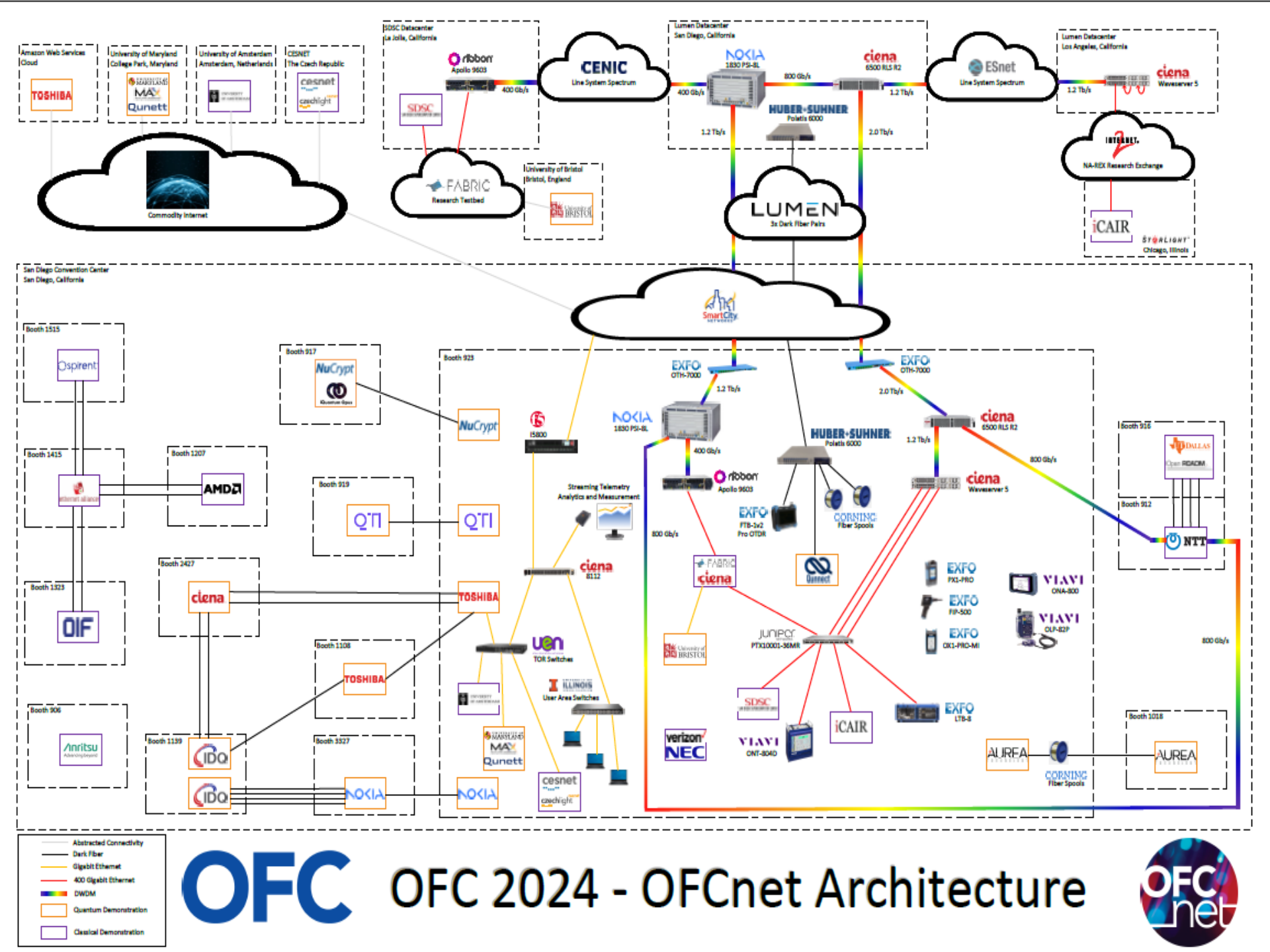
NOTES

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

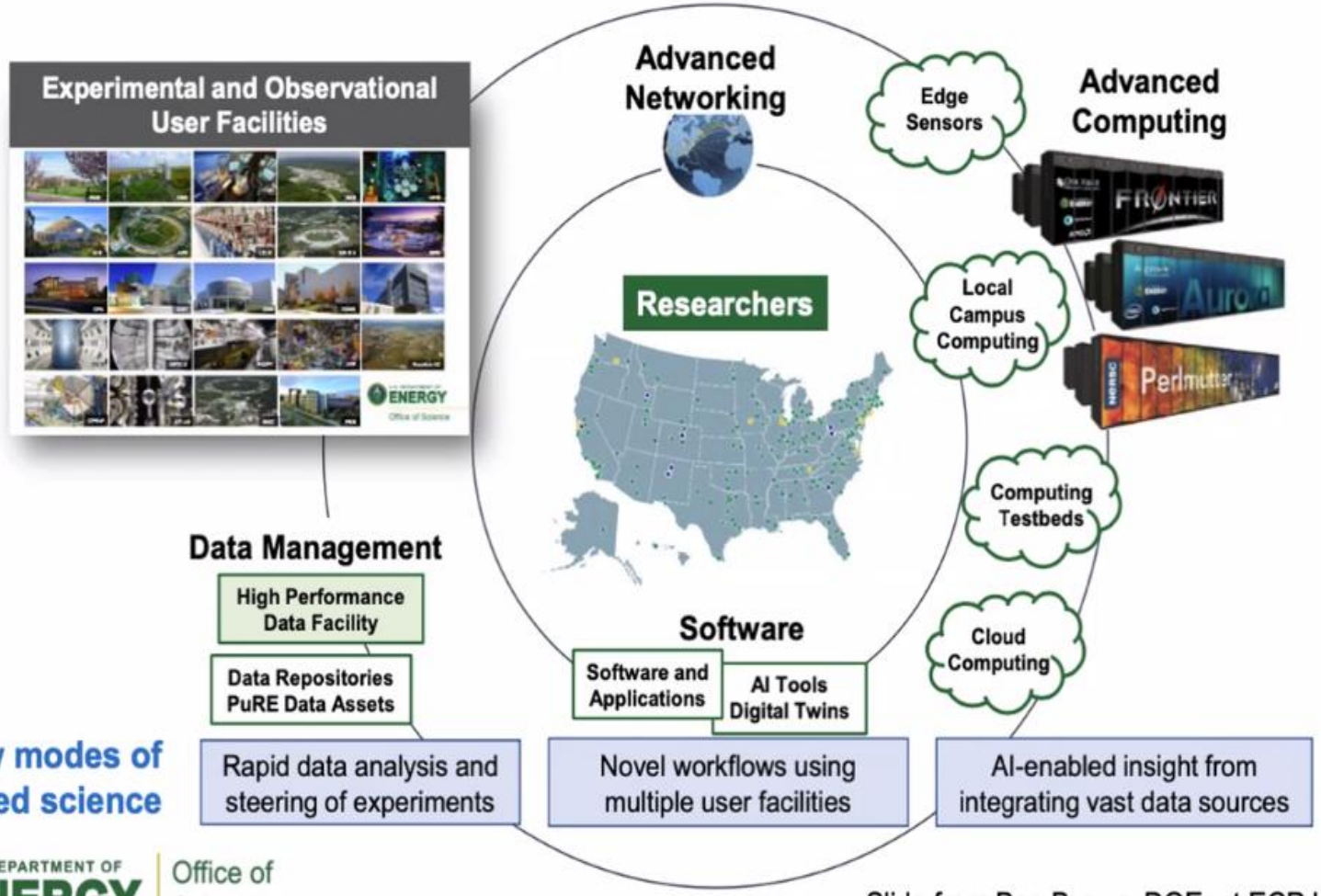
FABRIC	FABRIC infrastructure is in **purple**	Denver	ESnet PoPs with High-Touch (line-rate, per packet) monitoring	McLean	Carrier hotels, etc
AG/SENCE	AutoGOLE / SENSE infrastructure is in **red**		Shared circuits supporting demonstrations	Paris	Ovals are points of presence in regional infrastructure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


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


Amazon Web Services Cloud
TOSHIBA
University of Maryland College Park, Maryland
MAX
Qunett
University of Amsterdam Amsterdam, Netherlands
CESNET The Czech Republic
cesnet
czechlight
Commodity Internet
SDSC Datacenter La Jolla, California
ribbon Apollo 9603
400 Gb/s
SDSC
FABRIC Research Testbed
University of Bristol Bristol, England
CENIC Line System Spectrum
Lumen Datacenter San Diego, California
NOKIA 1830 PSI-8L
ciena 6500 RLS R2
800 Gb/s
400 Gb/s
1.2 Tb/s
HUBER+SUHNER Polatis 6000
2.0 Tb/s
LUMEN 3x Dark fiber Pairs
ESnet Line System Spectrum
Lumen Datacenter Los Angeles, California
ciena Waveserver 5
INTERNET2 NA-REX Research Exchange
iCAIR
STARLIGHT Chicago, Illinois
San Diego Convention Center San Diego, California
SmartCity NETWORKS
Booth 1515
Ospirent
Booth 1415
ethernet alliance
Booth 1207
AMD
Booth 1323
OIF
Booth 906
Anritsu
Booth 917
NuCrypt
Booth 919
QTI
Booth 2427
ciena
Booth 1108
TOSHIBA
Booth 1139
IDQ
Booth 3327
NOKIA
Booth 923
EXFO OTH-7000
1.2 Tb/s
2.0 Tb/s
i5800
Streaming Telemetry Analytics and Measurement
ciena 8112
TOR Switches
User Area Switches
EXFO FTB-1v2 Pro OTDR
CORNING Fiber Spools
FABRIC ciena
Qunect
EXFO FXI-PRO
EXFO FIP-500
EXFO OX1-PRO-MI
VIAVI ONA-800
VIAVI OLP-82P
JUNIPER PTX10001-36MR
EXFO LTB-8
VIAVI ONT-804D
verizon NEC
AUREA
CORNING Fiber Spools
Booth 918
DALLAS Open RDACM
Booth 912
NTT
Booth 1018
AUREA
Abstracted Connectivity
Dark Fiber
Gigabit Ethernet
400 Gigabit Ethernet
DWDM
Quantum Demonstration
Classical Demonstration
OFC
OFC 2024 - OFCnet Architecture
OFCnet

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

**Thanks to the NSF, DOE, NASA, NIH, DARPA
Universities, National Labs, International & Industrial Partners,
and Other Supporters**

STARLIGHT℠