Global Research Platform: An Overview

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PI IRNC: RXP: StarLight SDX, Co-PI Chameleon, PI-iGENI, PI-OMNINet

Next Gen Networks
TNC
Brighton, UK
June 9-13, 2025

iCAIR

STARLIGHT SDX

Next Generation Distributed Environment For Global Science

A Next Generation Ecosystems for New Knowledge Discovery

STARLIGHT℠

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
- Some Resources Are Dedicate/Restricted, Some Minimally Shared, Some Widely Shared

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**

Annual Global Research Platform Workshop – Co-Located With IEEE International Conference On eScience Sept 16-17, 2024
Also, GRP Workshop Co-Located With Supercomputing Asia, Singapore, March 2025

Next GRP Workshop Co-Located With IEEE International Conference On eScience September 15-18, 2025, Chicago Illinois

Selected Applications/Instruments

GENI
www.geni.net

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

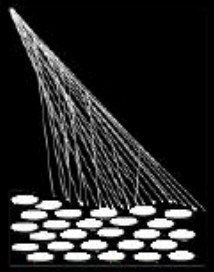
Virgo
www.virgo-gw.eu

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

GLEON
www.gleon.org

GRP
theglobalresearch platform.net/

IceCube
icecube.wisc.edu



Pierre Auger Observatory
www.auger.org

LIGO
www.ligo.caltech. edu

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

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

NEON
www.neonscience. org

CENTRA
www.global centra.org

SAGE2
sage2.sagecommons. org

Genomic Science Program
genomicscience. energy.gov

LBNF/DUNE/ ProtoDUNE
lbnf.fnal.gov

NOvA
novaexperiment. fnal.gov

ALMA
www.alma observatory.org

IVOA
www.ivoa.net

Compilation by Maxine Brown and Joe Mambretti

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Instruments: Exebytes Of Data

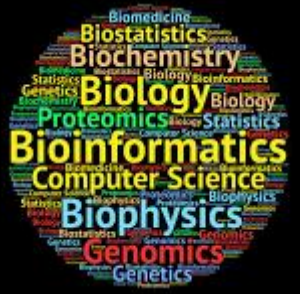
High Luminosity LHC

SKA Australia Telescope Facility

Vera Rubin Observatory

KSTAR Korea Superconducting Tokamak

Next Gen Advanced Photon Source



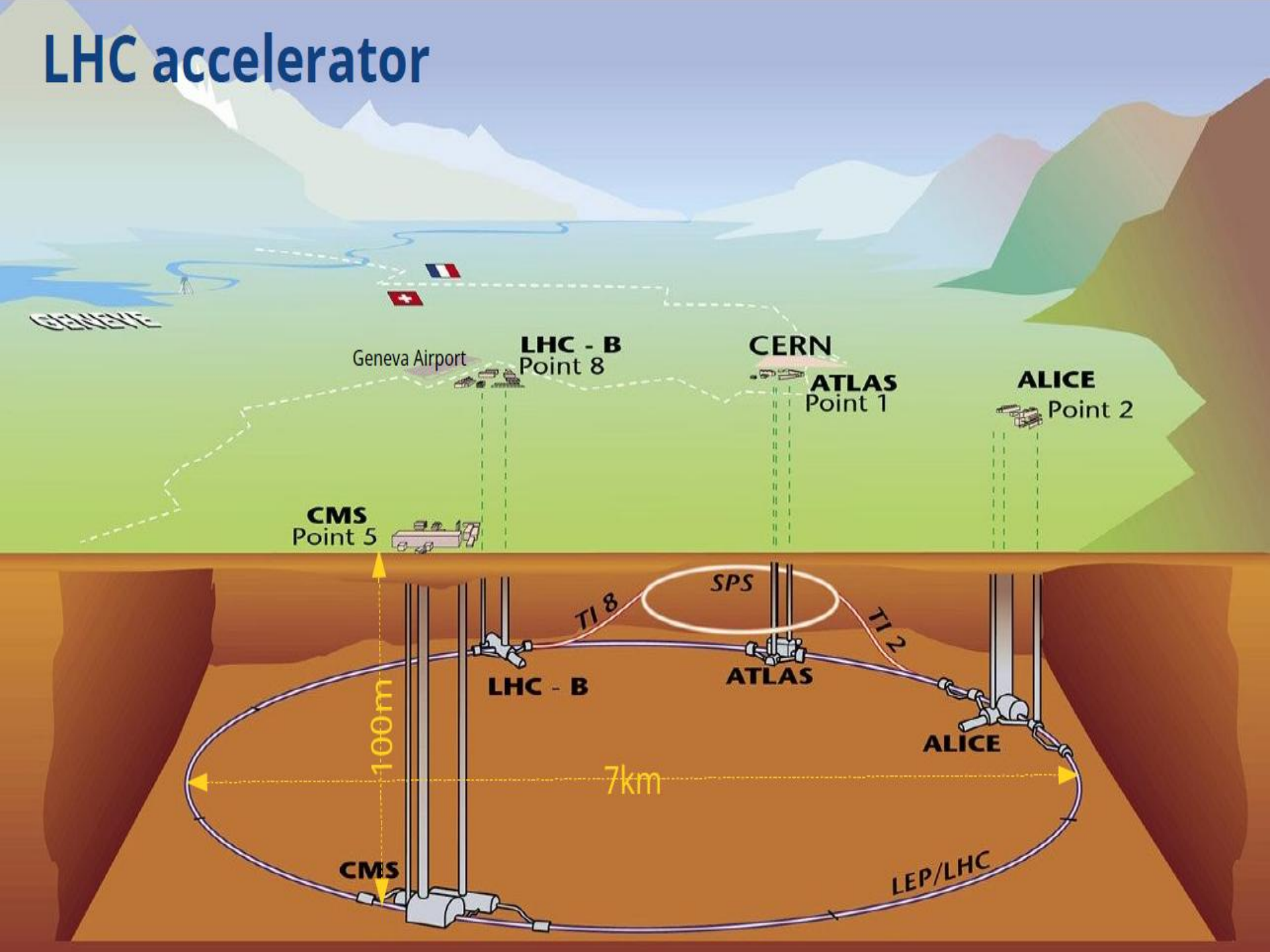
Bioinformatics/Genomics


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

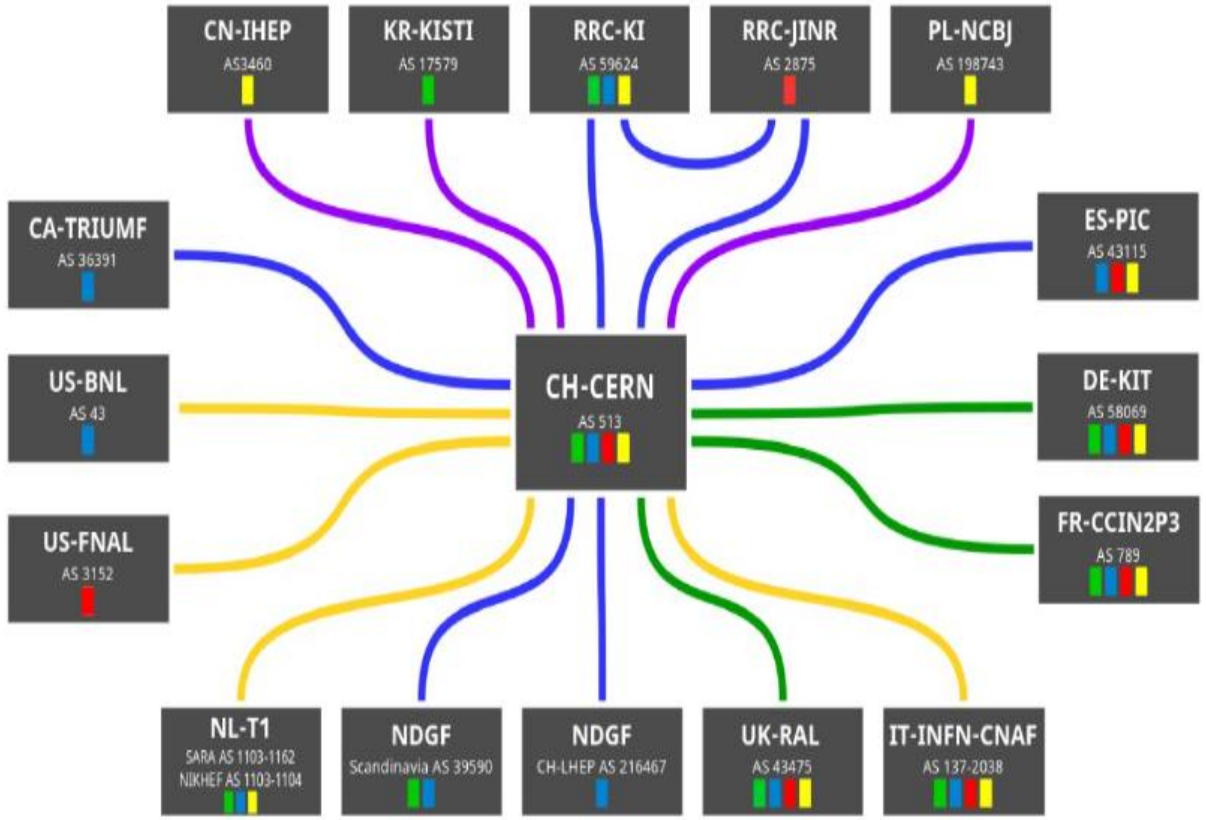
Next Generation Research Platforms

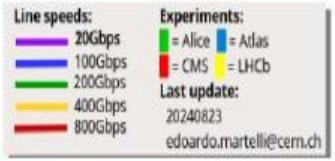
- US National Research Platform
- Asia Pacific Research Platform
- Korean Research Platform
- EU SLICES
- Worldwide LHC Computing Grid (WLCG)
- DOE Integrated Research Infrastructure (IRI)
- Open Science Grid
- Open Science Data Grid
- Et Al

LHC accelerator



LHCOPN

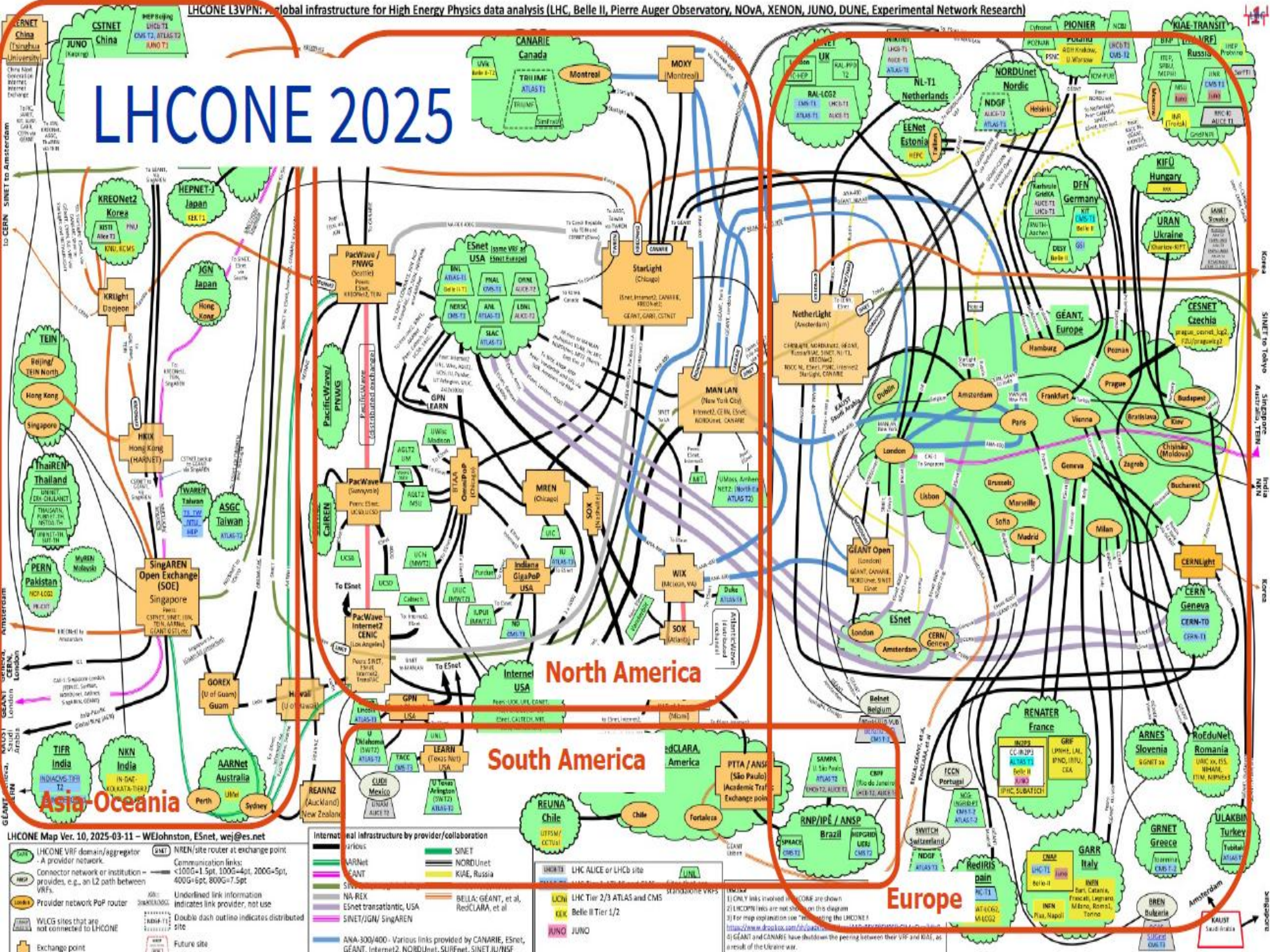




https://twiki.cern.ch/twiki/bin/view/LHCOPN/OverallNetworkMaps

Numbers

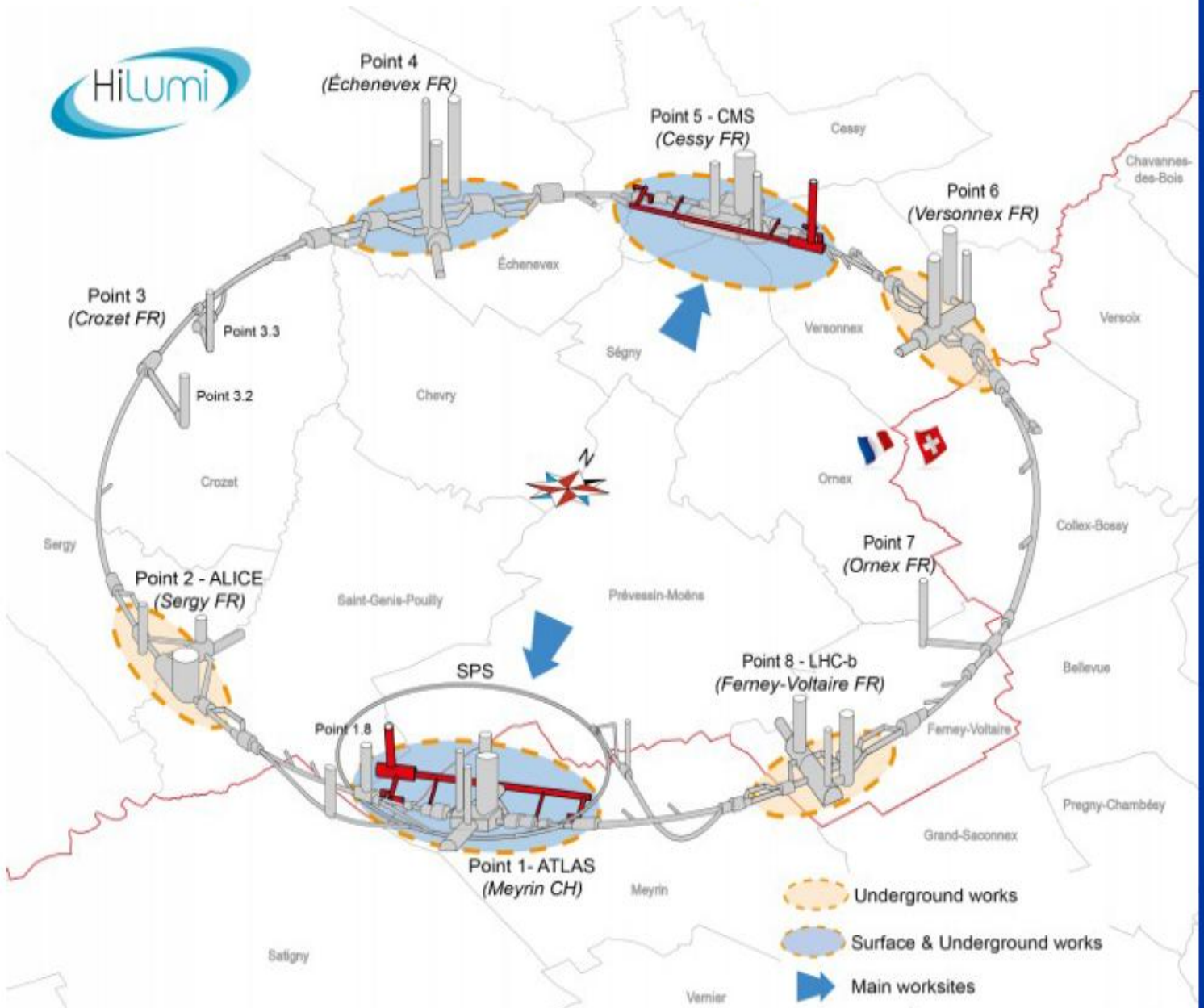
- 17 sites for 15 Tier1s + 1 Tier0
- 14 countries in 3 continents
- 2.88 Tbps to the Tier0


LHCONE 2025
LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOvA, XENON, JUNO, DUNE, Experimental Network Research)
Asia-Oceania
North America
South America
Europe
CANARIE Canada
Montreal
MOXY (Montreal)
StarLight (Chicago)
ESnet USA
PacWave / PNWG (Seattle)
MAN LAN (New York City)
NetherLight (Amsterdam)
GÉANT, Europe
WIX (McLean, VA)
SOX (Atlanta)
MREN (Chicago)
Indiana GigaPoP USA
PacWave (Sunnyvale)
PacWave Internet2 CENIC (Los Angeles)
Internet2 USA
GPN USA
LEARN (Texas Net) USA
CUDI Mexico
RedCLARA, Latin America
PTTA / ANSP (São Paulo) (Academic Traffic Exchange point)
RNP/IPÊ / ANSP Brazil
REUNA Chile
Chile
Fortaleza
SingAREN Open Exchange (SOE) Singapore
HKIX Hong Kong (HARNET)
KRLight Daejeon
KREONet2 Korea
HEPNET-J Japan
JGN Japan
TEIN
ThaiREN Thailand
ASGC Taiwan
TWAREN Taiwan
MyREN Malaysia
PERN Pakistan
TIFR India
NKN India
AARNet Australia
Perth
Sydney
REANNZ (Auckland) New Zealand
GOREX (U of Guam) Guam
Hawaii (U of Hawaii)
CSTNET China
CERNET China (Tsinghua University)
IHEP Beijing
JUNO (Kaiping)
UK
NL-T1 Netherlands
NORDUnet Nordic
PIONIER Poland
KIAE-TRANSIT (NRF) Russia
EENet Estonia
DFN Germany
KIFÜ Hungary
URAN Ukraine
CESNET Czechia
CERN Geneva
CERNLight
GÉANT Open (London)
RENATER France
GARR Italy
RedIRIS Spain
FCCN Portugal
SWITCH Switzerland
Belnet Belgium
ARNES Slovenia
RoEduNet Romania
GRNET Greece
ULAKBIM Turkey
BREN Bulgaria
KAUST Saudi Arabia
Amsterdam
London
Paris
Frankfurt
Geneva
Hamburg
Poznan
Prague
Vienna
Budapest
Bratislava
Kiev
Zagreb
Milan
Madrid
Lisbon
Marseille
Sofia
Bucharest
Brussels
Dublin
Chisinau (Moldova)
SINET to Tokyo
Singapore Australia, TEIN
India
Korea
LHCONE Map Ver. 10, 2025-03-11 – WEJohnston, ESnet, wej@es.net
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
International infrastructure by provider/collaboration
Various
AARNet
GÉANT
SINET
NORDUnet
KIAE, Russia
NA-REX
ESnet transatlantic, USA
SINET/JGN/ SingAREN
BELLA: GÉANT, et al, RedCLARA, et al
ANA-300/400 - Various links provided by CANARIE, ESnet, GÉANT, Internet2, NORDUnet, SURFnet, SINET,IU/NSF
LHC ALICE or LHCb site
LHC Tier 2/3 ATLAS and CMS
Belle II Tier 1/2
JUNO
1) ONLY links involved in LHCONE are shown
2) LHCOPN links are not shown on this diagram
4) GÉANT and CANARIE have shutdown the peering between their VRF and KIAE, as a result of the Ukraine war.

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
- JUNO - JiaJiangmen Underground Neutrino Observatory DUNE/ProtoDUNE – Deep Underground Nutrino Experiment

Next: the HL-LHC project



The **High-Luminosity Large Hadron Collider** (HL-LHC) is an **upgraded version of the LHC**

It will operate at a higher luminosity, i.e. it will produce more collisions and data

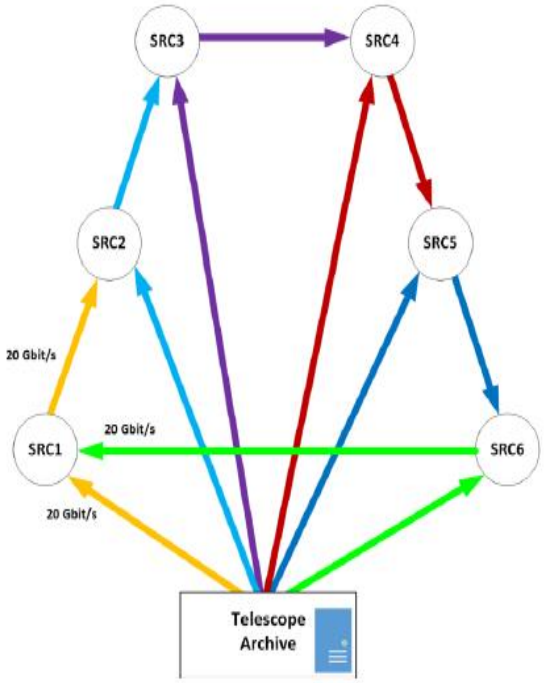
The HL-LHC will enter service in 2030, **increasing the volume of data** produced by the experiments **by a factor of 10**

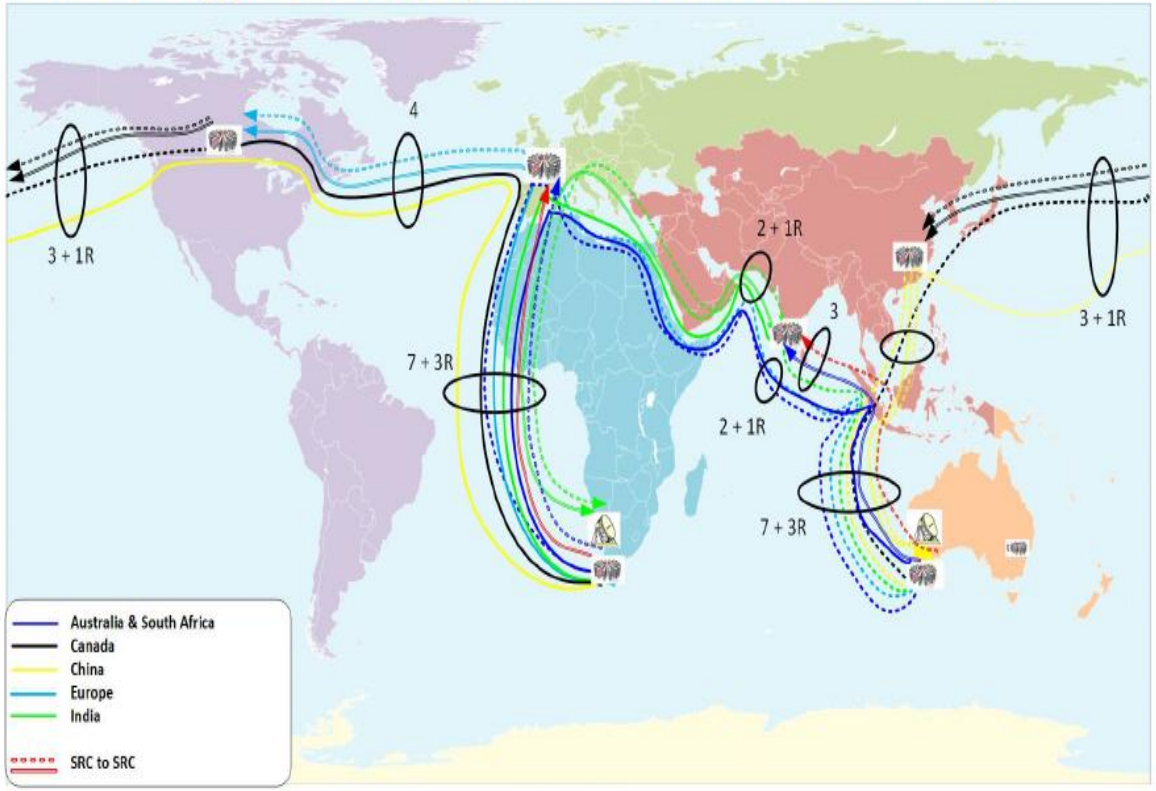
LHCOPN+LHCONE community meetings

- 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

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

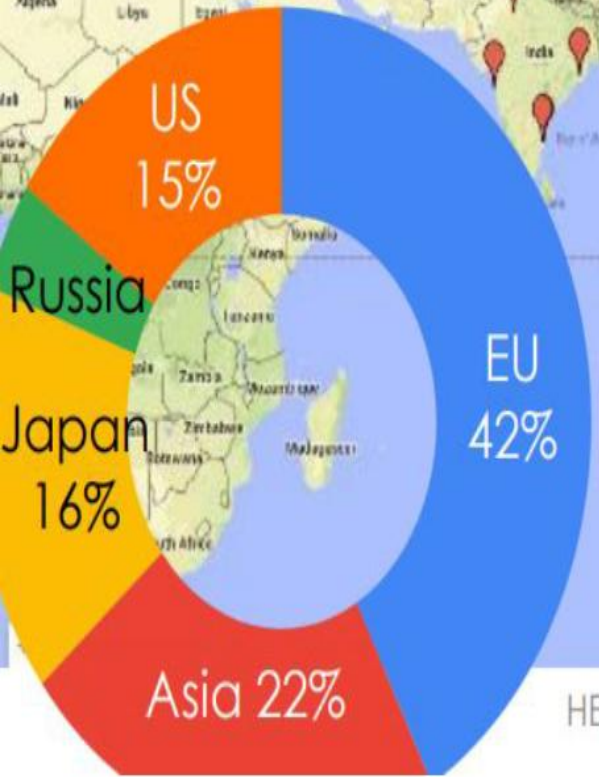
- Each SRC accepts its fraction of the Observatory Data Products and re-distributes to another SRC.
- SRC has 20 Gbit/s flow from the telescope & a second continuous 20 Gbit/s flow from another SRC.
- Each SRC sends out a 20 Gbit/s flow.
- Makes substantial use of the shared academic network which would 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**





Belle II Collaboration

A Global Collaboration as wide as an LHC experiment



26 countries/regions
123 institutes
1,075 researchers

DUNE Collaboration

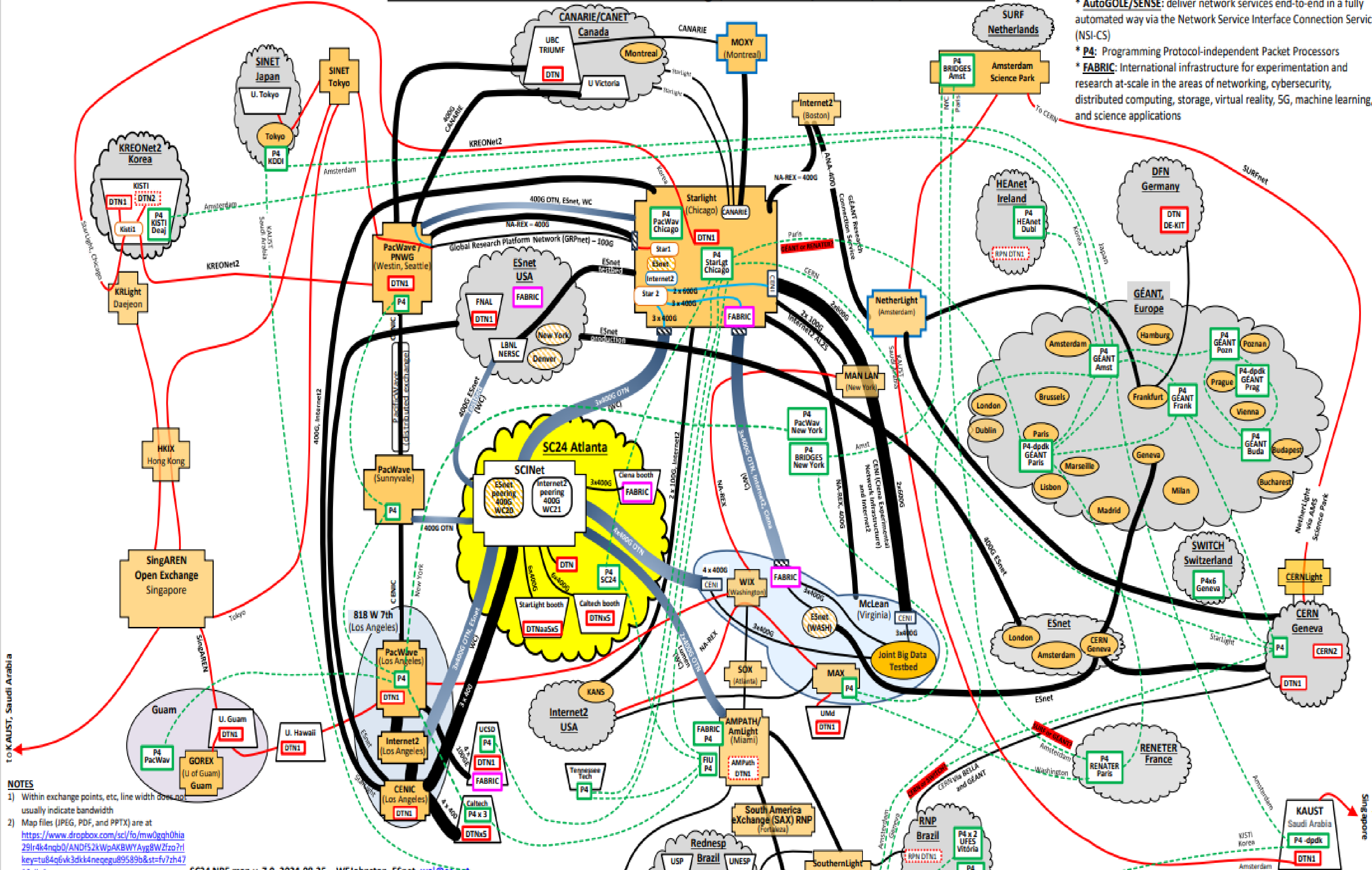
An international effort

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

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 Service (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/ANDf52kWpAKBWYAyg8WZfzo?rlkey=tu84q6vk3dkk4neqegu89589b&st=fv7zh473&dl=0

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

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

SCINet managed

SciTags

scitags.org

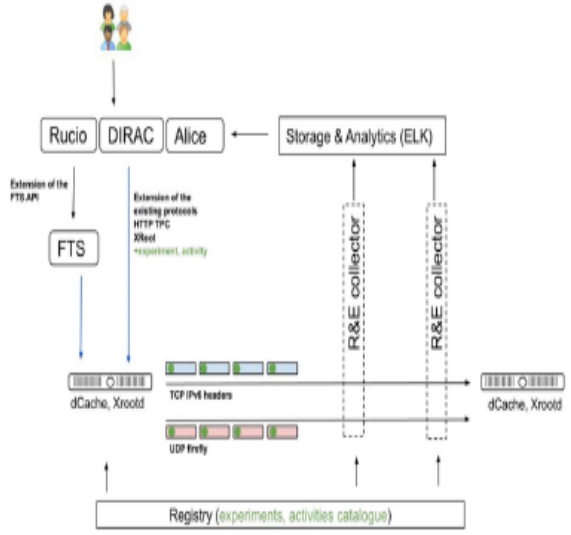
Network Flow and Packet Marking for Global Scientific Computing

NB: Demonstrations At IEEE/ACM International Supercomputing Conferences

Science Tags: marking of data packets and flows with Experiment and Application IDs for better network accounting

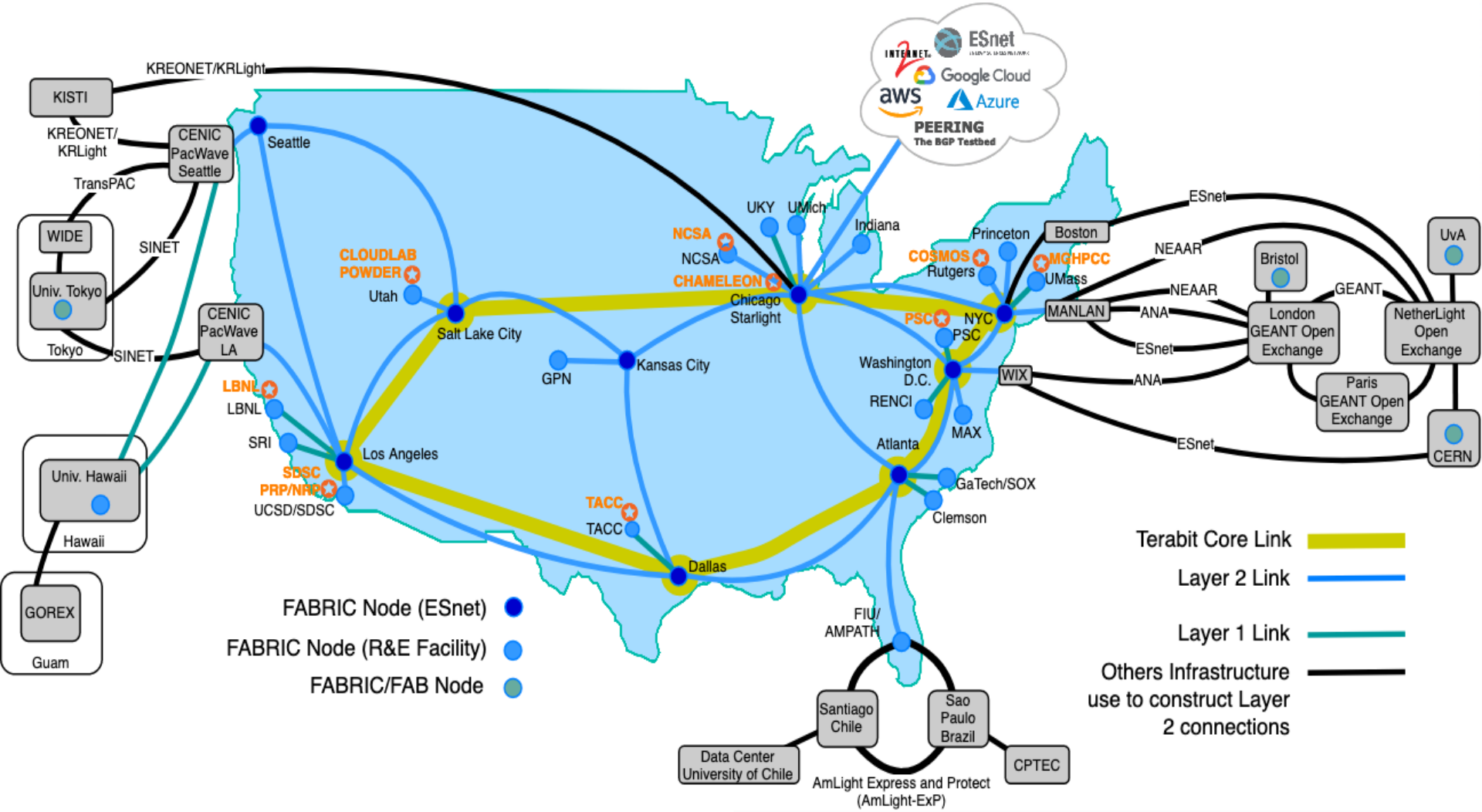
Two options being implemented:

- Tag in the IPv6 flowlabel field (proposed IETF draft: draft-cc-v6ops-wlcg-flow-label-marking)
- Tags (and more info) in UDP fireflies (UDP packets sent in parallel to each flow)



NRENs run fireflies collectors, supports deployment and testing

Paul Ruth PI, RENCI: FABRIC



Core = 1.2 Tbps

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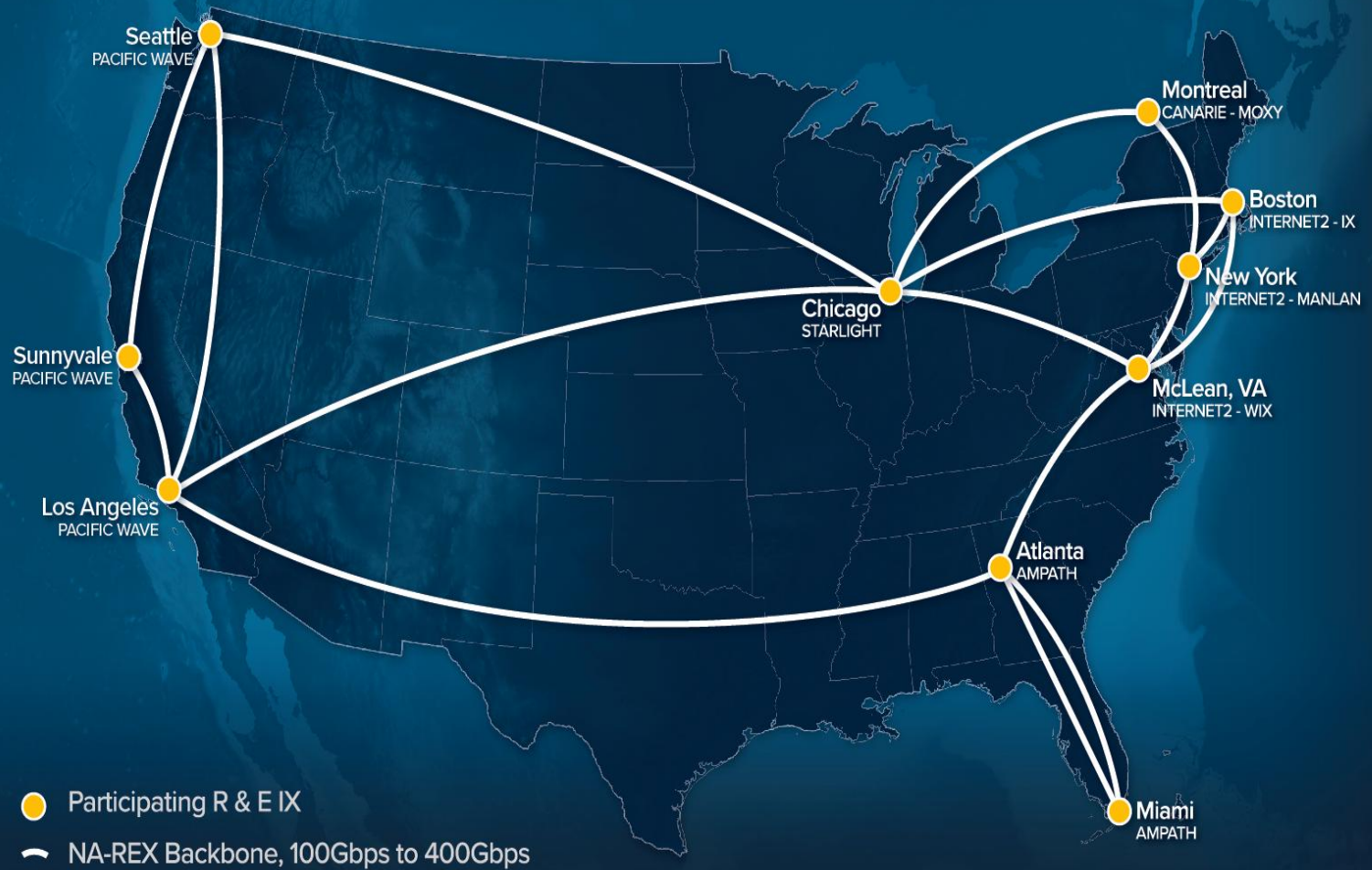
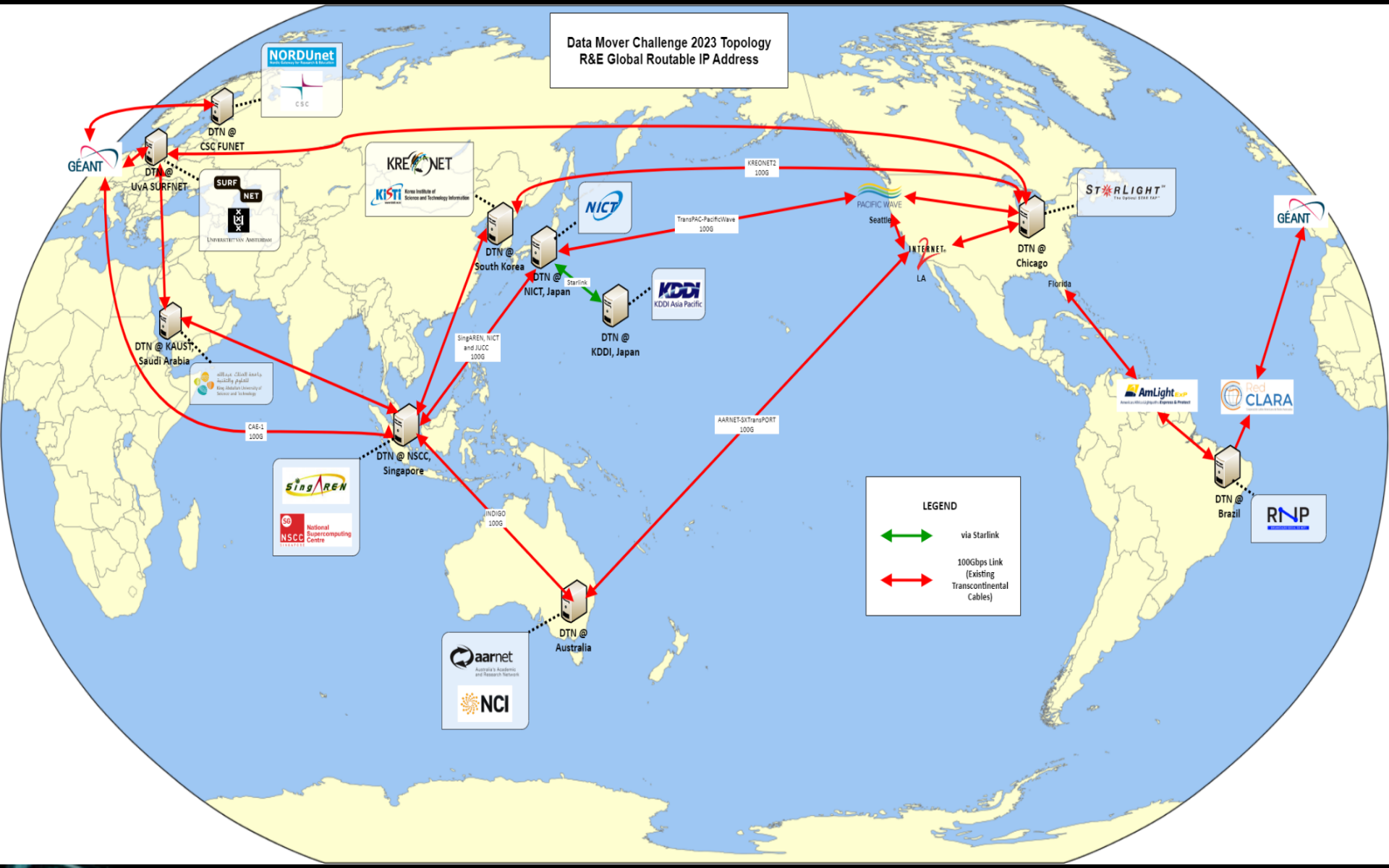
NA-REX North America Research & Education Exchange Collaboration

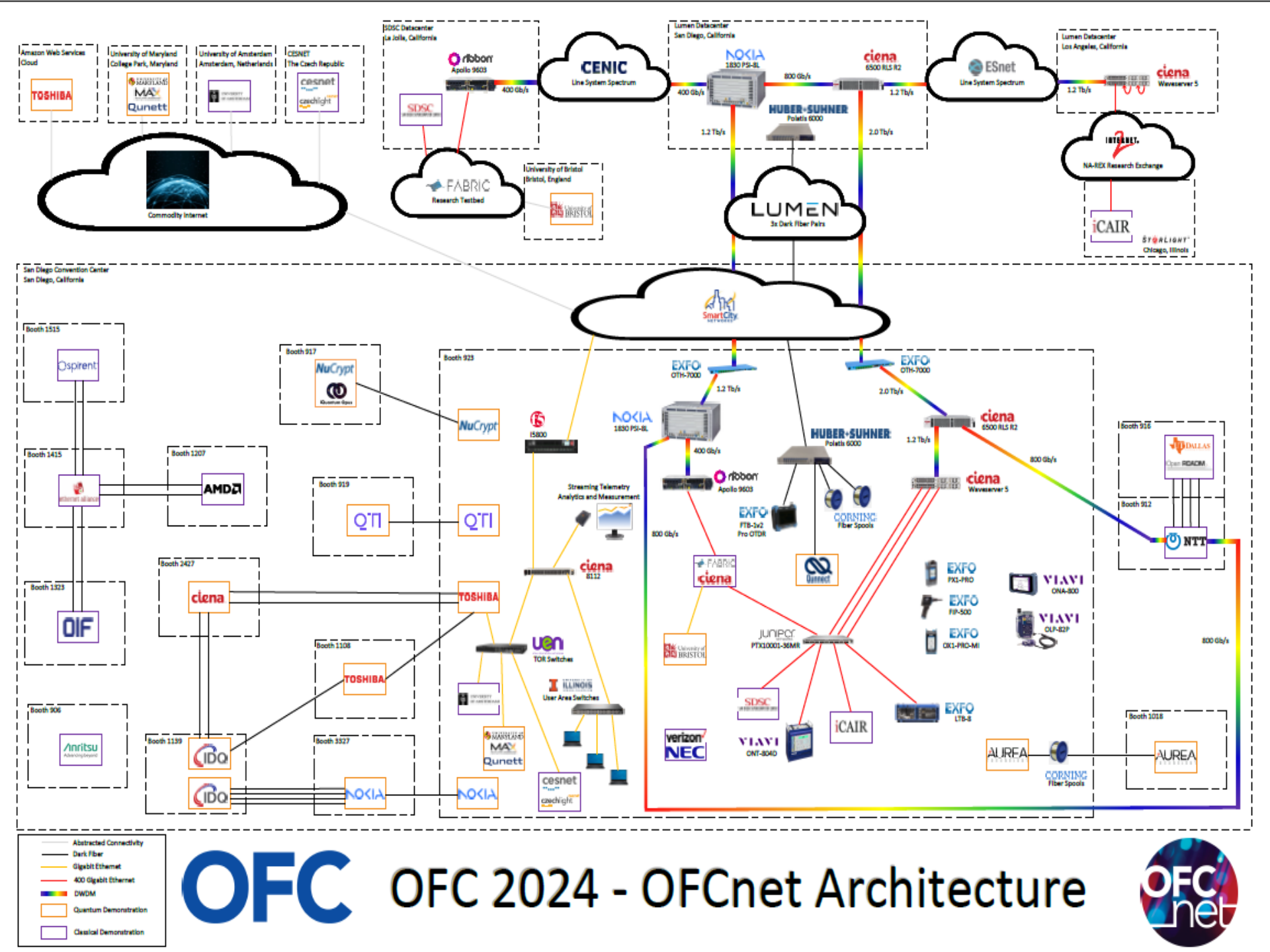


AMPATH PATHWAY TO THE AMERICAS
canarie
ESnet ENERGY SCIENCES NETWORK
INTERNET2
International Networks at Indiana University
STARLIGHT The Optical STAR TAP
CENIC
PACIFIC NORTHWEST GIGAPOP
PACIFIC WAVE

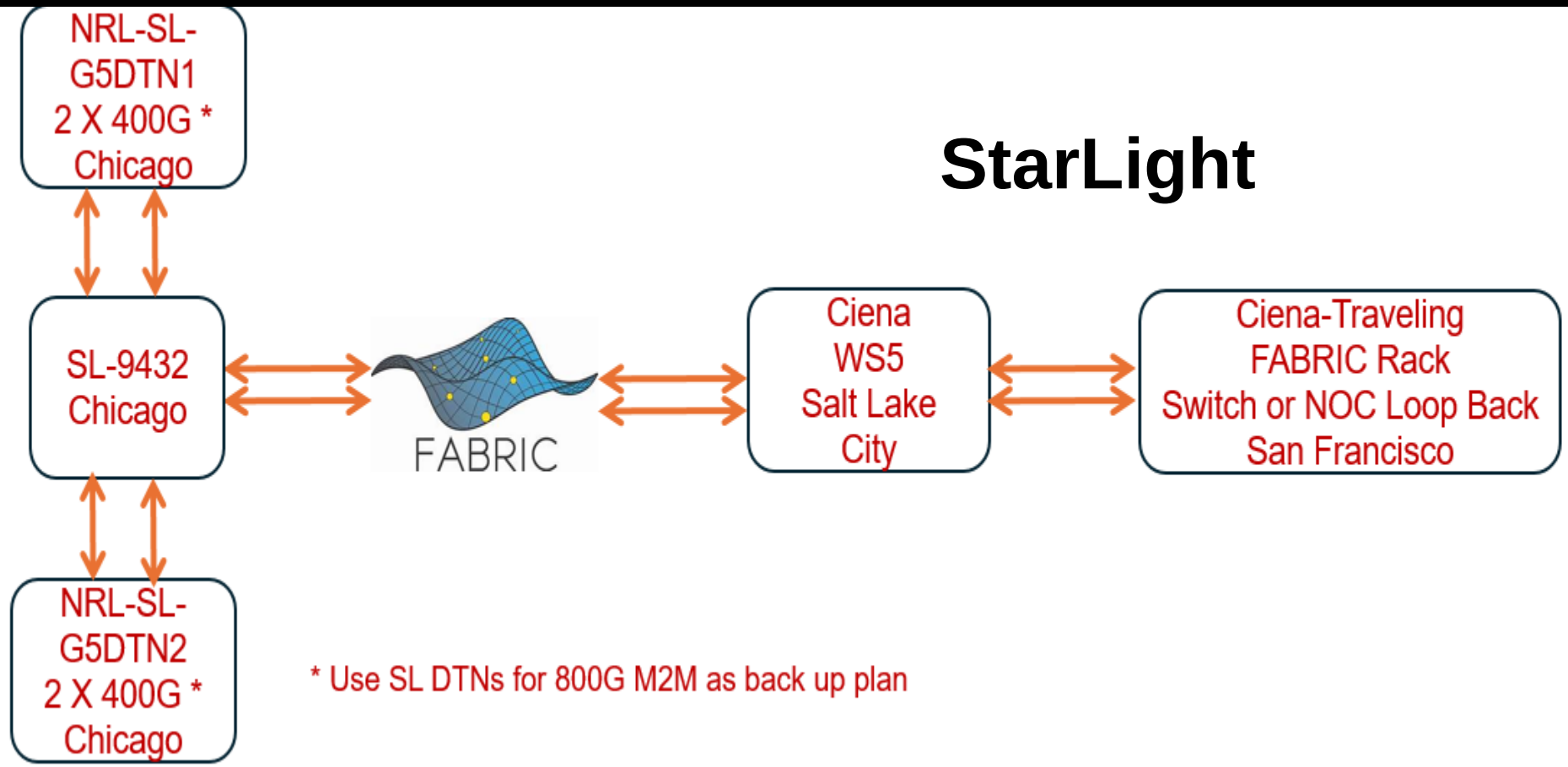
November 2023


Data Mover Challenge 2023 Topology
R&E Global Routable IP Address
NORDUnet
DTN @ CSC FUNET
GÉANT
DTN @ UvA SURFNET
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
Florida
GÉANT
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)

STARLIGHT℠


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
juniper PTX10001-36MR
EXFO FXI-PRO
EXFO FIP-500
EXFO OX1-PRO-MI
VIAVI ONA-800
VIAVI OLP-82P
EXFO LTB-8
VIAVI ONT-804D
verizon NEC
AUREA
Booth 918
DALLAS Open ROADM
Booth 912
NTT
Booth 1018
Abstracted Connectivity
Dark Fiber
Gigabit Ethernet
400 Gigabit Ethernet
DWDM
Quantum Demonstration
Classical Demonstration
OFC
OFC 2024 - OFCnet Architecture
OFCnet

800 Gbps Disk To Disk Over WANs



Chameleon

www.chameleoncloud.org

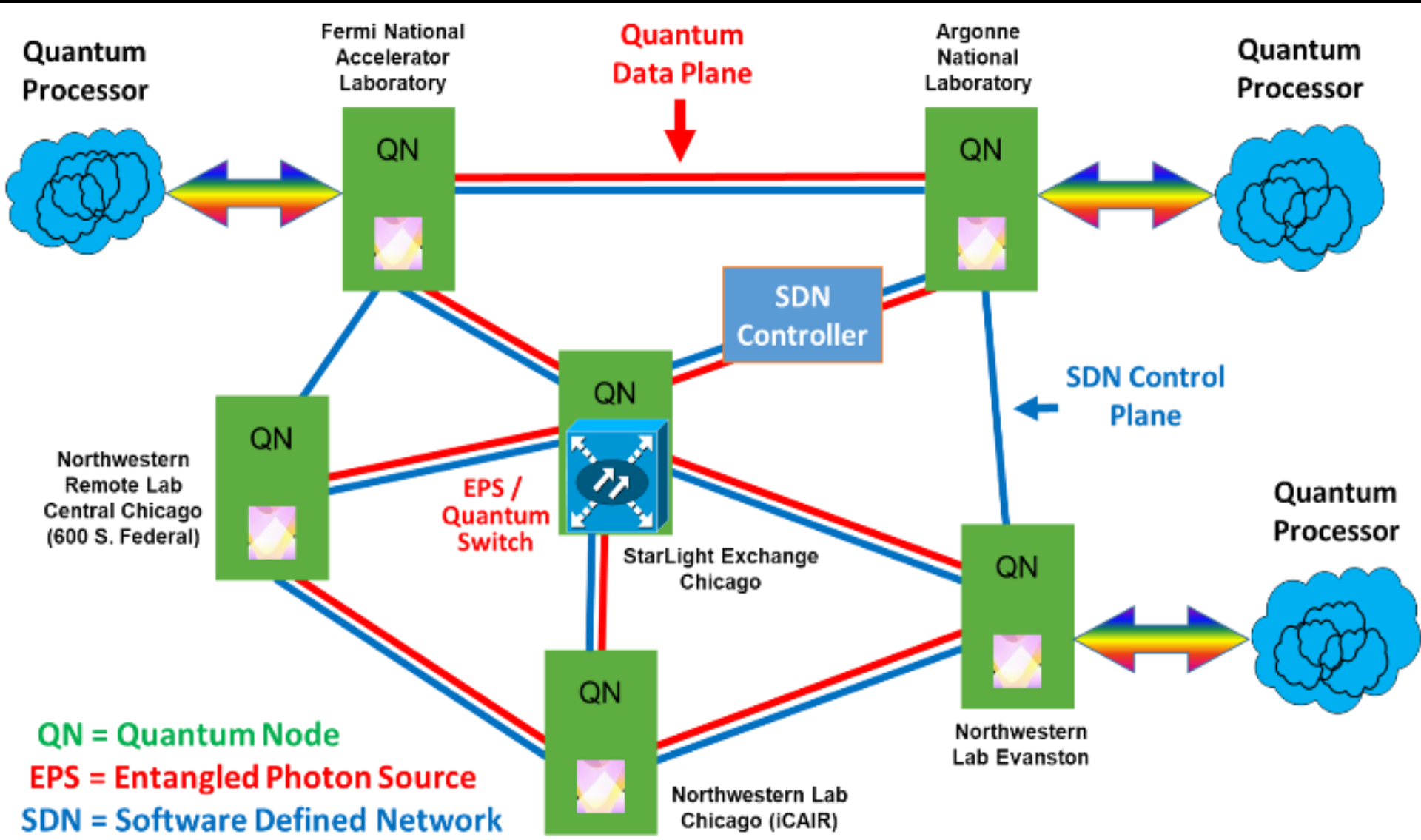
CHAMELEON: A LARGE SCALE, RECONFIGURABLE EXPERIMENTAL INSTRUMENT FOR COMPUTER SCIENCE

Kate Keahey

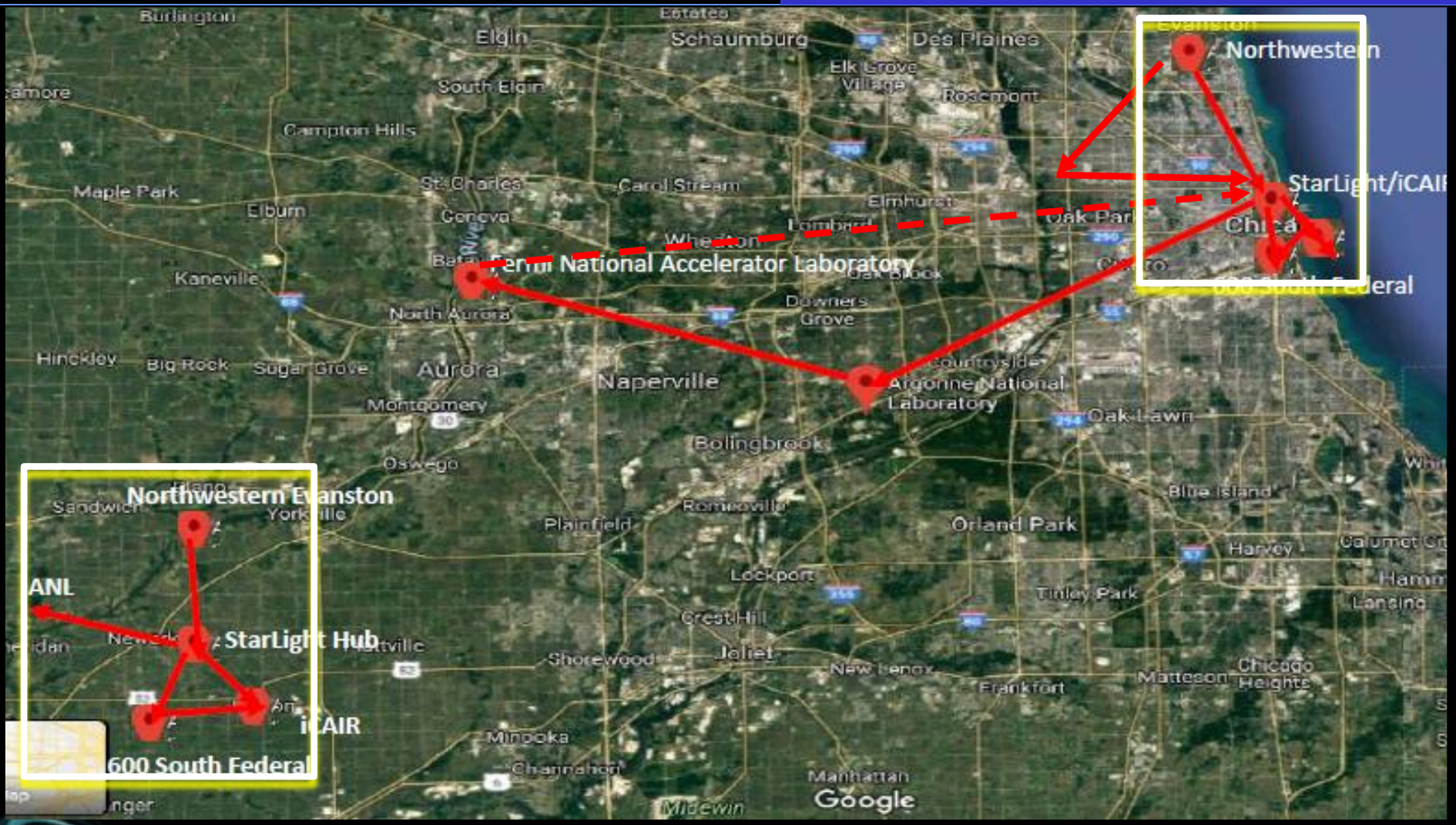
Joe Mambretti, Pierre Riteau, Paul Ruth, Dan Stanzione

THE UNIVERSITY OF CHICAGO TACC renci NORTHWESTERN UNIVERSITY NSF

IEQnet Quantum Networking Testbed



IEQnet Testbed Topology



Optica Paper

- “Quantum Teleportation Coexisting With Classical Communications In Optical Fiber” Optica 11(12), 1700-1707 (Dec 2024) , Jordan M. Thomas, Fei I. Yeh, Jim Hao Chen, Joe J. Mambretti, Scott J. Kohlert, Gregory S. Kanter, and Prem Kumar

www.startap.net/starlight

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Universities, National Labs, International & Industrial Partners,
and Other Supporters**

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