# Key Global Application Drivers in Asia and Korea

September 17, 2019

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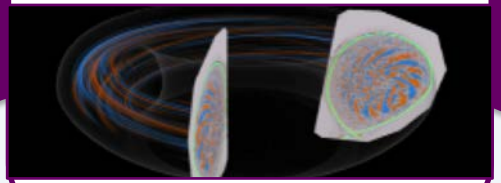
Enabling Science Discovery

- New particle, “Higgs” in CERN LHC
- Gravitational Wave in LIGO
- Blackhole Event Horizon in Astronomy

Supermassive black hole
in the heart of galaxy M87

**High Energy Physics & Fusion Energy Science**



**Astronomy & Climate Changes**

**Education & e-Culture**

**Future Internet & Construction**

**Advanced Scientific Computing Research**

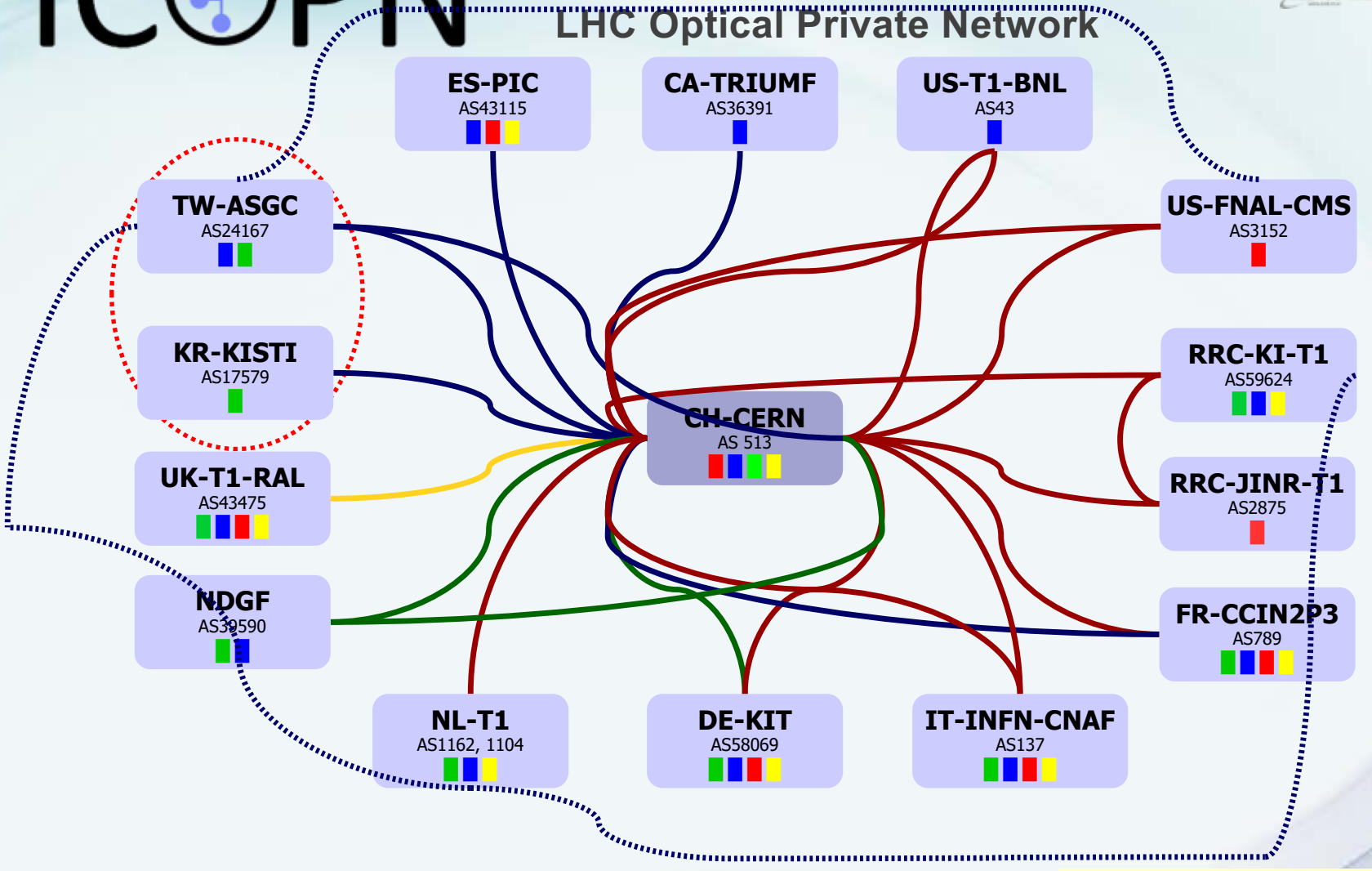
**Bio/Genome Research & Medical Science**

# High Energy Physics

- LHCOPN & LHCONE
- WLCG Data Lake

# LHCOPN

## LHC Optical Private Network



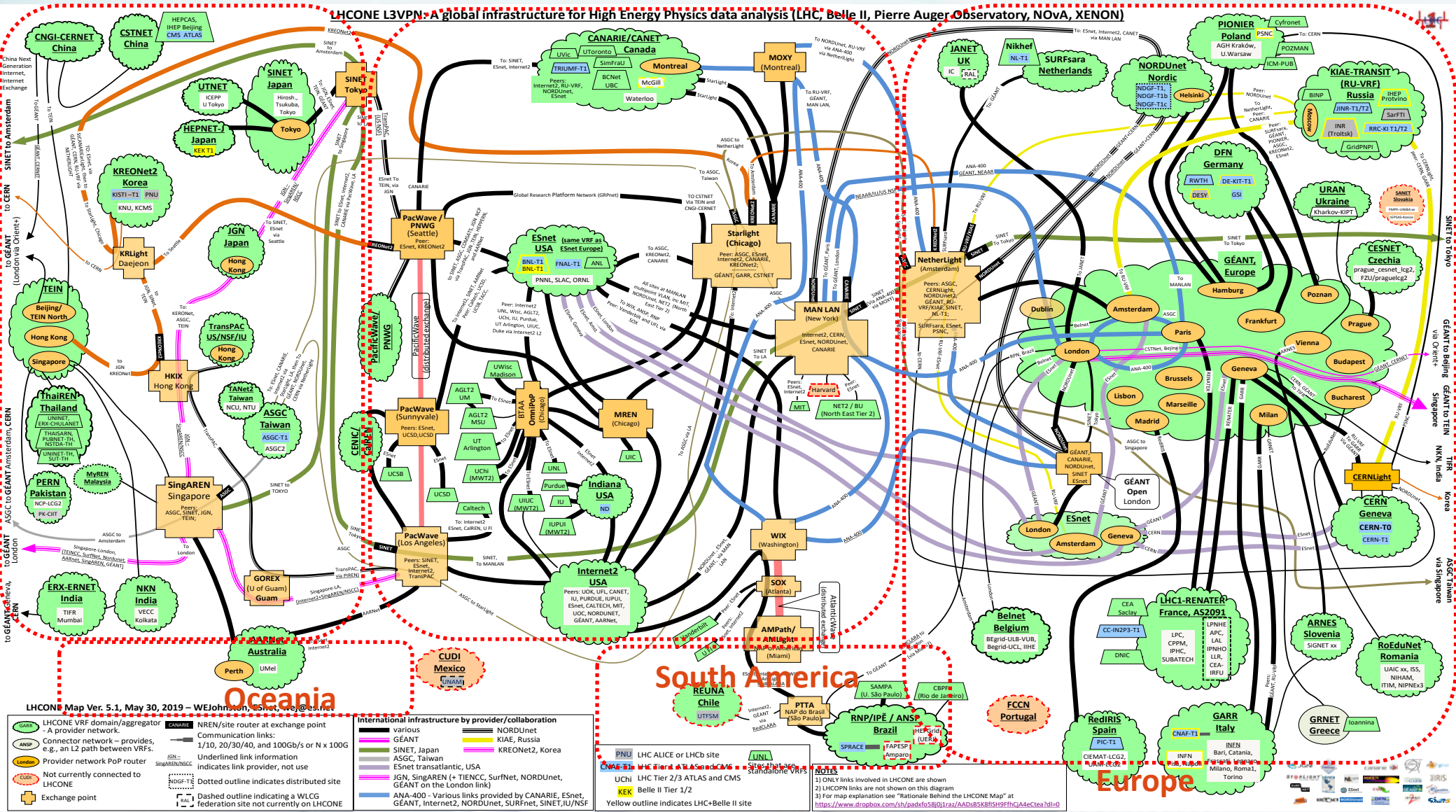

Ref: https://twiki.cern.ch/twiki/bin/view/LHCOPN/OverallNetworkMaps

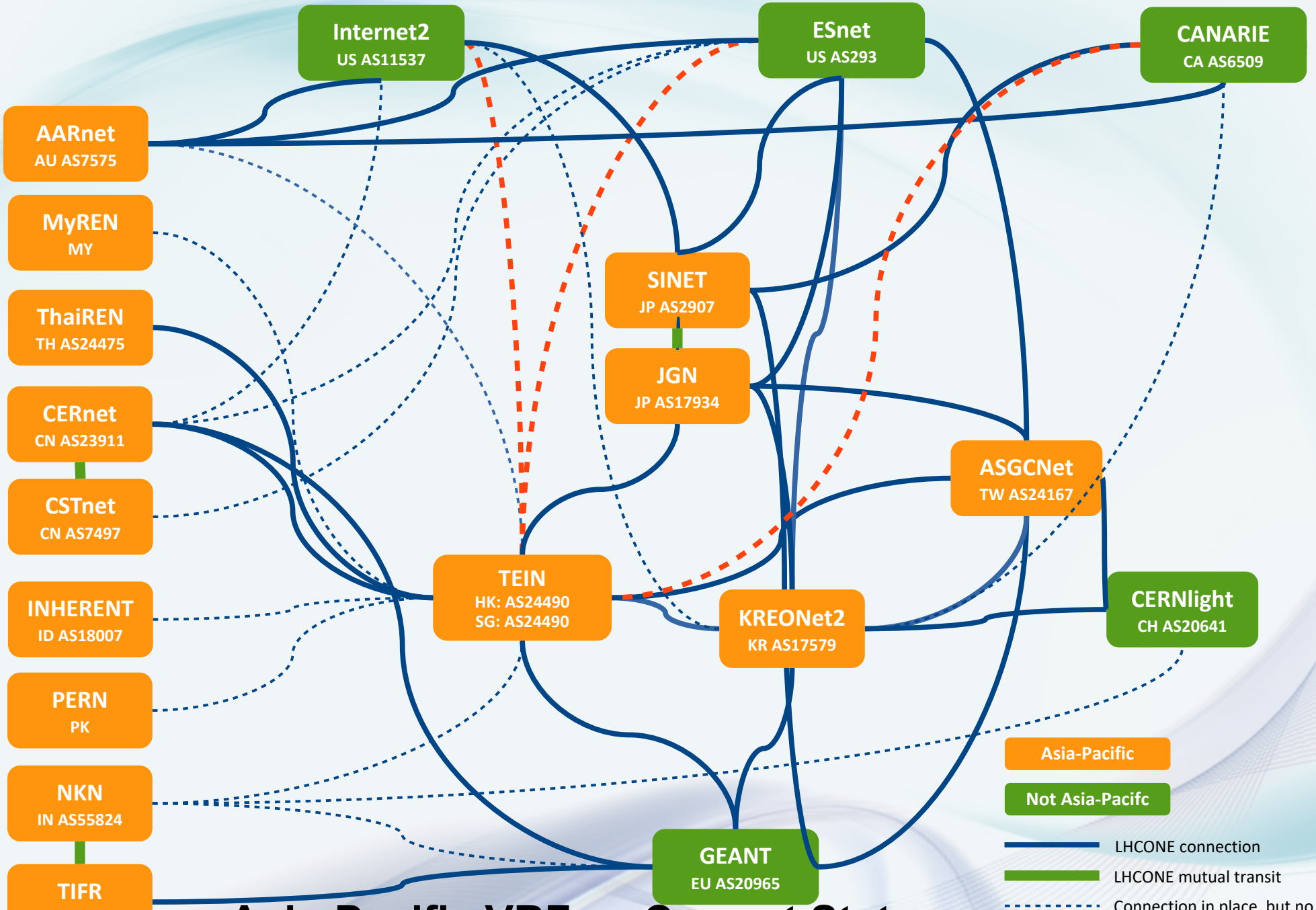
**Private network connecting Tier0 and Tier1s**

# Layer3 (routed) Virtual Private Network

LHCONE

- 20 R&E networks
- 14 Tier1s and ~70 Tier2s in 5 continents
- ~250 perfSONAR instances
- Collaboration with Bell II experiment, DUNE experiment

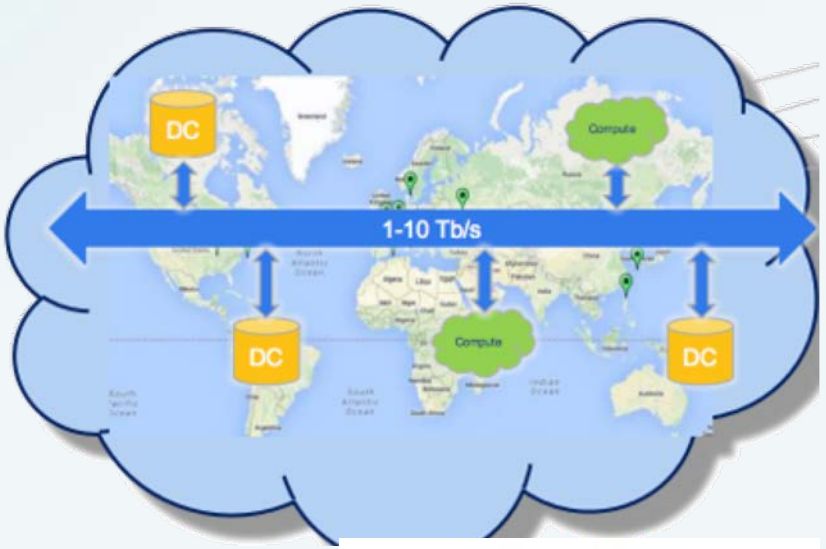


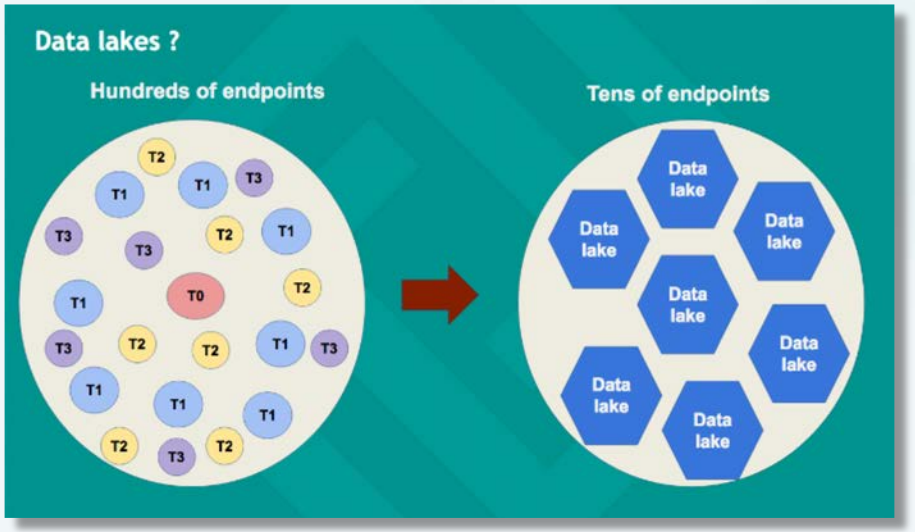


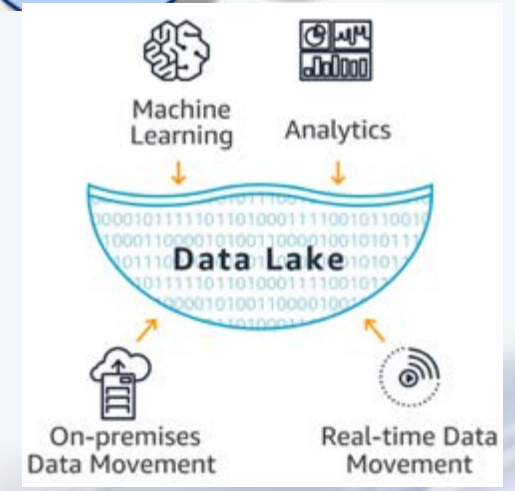

# Asia-Pacific VRFs – Current Status

# WLCG Data Lake, Distributed Regional Storage

Localize bulk data in Cloud Service

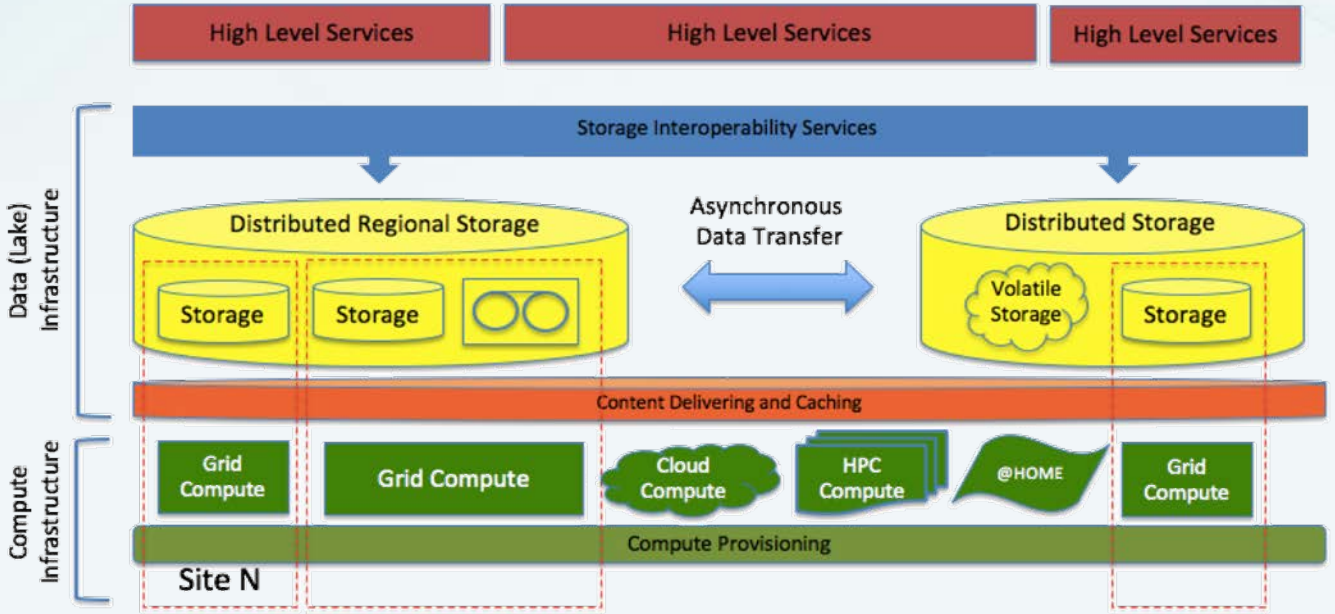


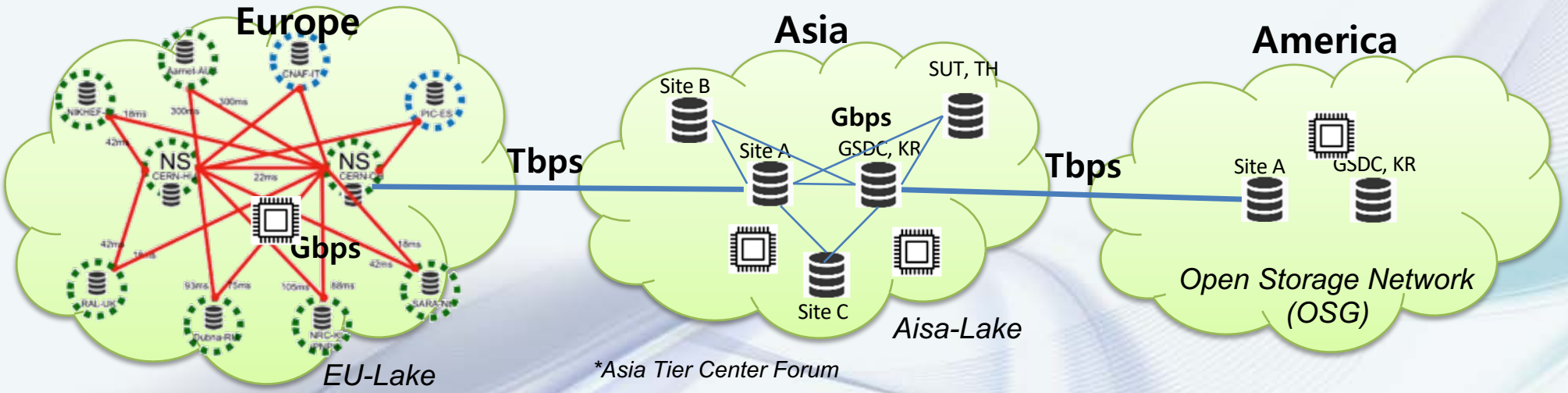




Daniele Cesini , Patrick Fuhrmann, “The Data Lake model for the scientific computing of the next decade“, 2018

# WLCG Data Lake, Distributed Regional Storage




- Data Organization, Management, Access (DOMA)
- Storage consolidation
- Cashing and data access
- Data Transfer among Storage in distributed Regional Storage (DRS) or among DRSs
- QoS



# Fusion Energy : KSTAR & ITER

- KSTAR : Dr. Yoon’s presentation
- ITER

# ITER Broader Approach Activities

1) Engineering Validation and Engineering Design Activities for the International Fusion Materials Irradiation Facility (IFMIF/EVEDA:2007-2017)

2) International Fusion Energy Research Centre (IFERC: 2007-2017), project leader is N.Nakajima

a) DEMO Design and R&D coordination Centre

b) Computational Simulation Centre

c) **ITER Remote Experimentation Centre**

- Estimation for the ITER data amount in 2016

| ITER Phase | Total DAN* archive rate | Plasma duration Time | Data Volume per Shot |
|---|---|---|---|
| Initial | 2 GB/s (16Gbps) | 400 – 500 sec (6.7 – 8.3 min) | 800 GB – 1 TB |
| Final | 50 GB/s (400Gbps) | 1000 s (16.7 min) | 50 TB |

H. Nakanishi et al, "High-Performance Data Transfer for Full Data Replication between ITER and the Remote Experimentation Centre", 26th IAEA Fusion Energy Conference, 2016

-Total archive capacity: 90 - 220 TB/day

3) Satellite Tokamak Programme (2007-2019) Participation to upgrade of JT-60 Tokamak to JT-60SA and its exploitation.

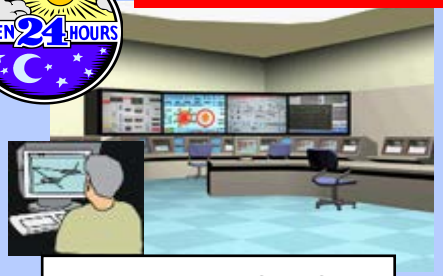
Korean Participation Center

Russian Participation Center

# ITER Remote Experimentation Centre

**The ITER remote experimentation centre will be made to participate the experim ent remotely, where the experimental proposal and data collection and analyses will be done through the broadband network.**

ITER Organization (Saint-Paul-les-Durance)



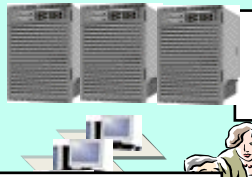
Validation of safety of the facility and Operation

**Broad band internet**

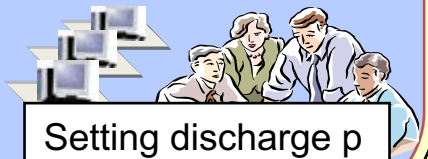
ITER Remote Experimentation Centre (Rokkasho, Japan)

Data collection and analyses

**Monitor of the operation, Transfer results of experiment**



Data storage and Analyses



Setting discharge p arameter

**Send discharge parameter**

Proposal and settin g discharge param eter by remote user

JW Farthing, “Progress on ITER remote experimentation Center”, 2017

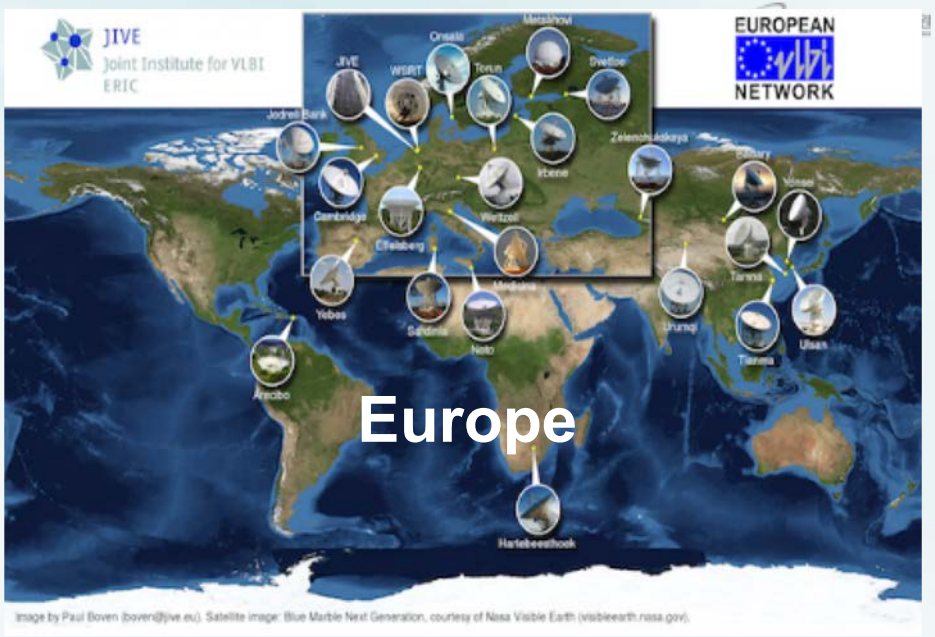
# Astronomy

Written by colaboration with Dr. Taehyun Jung, Korea Astronomy & Space Science Institute

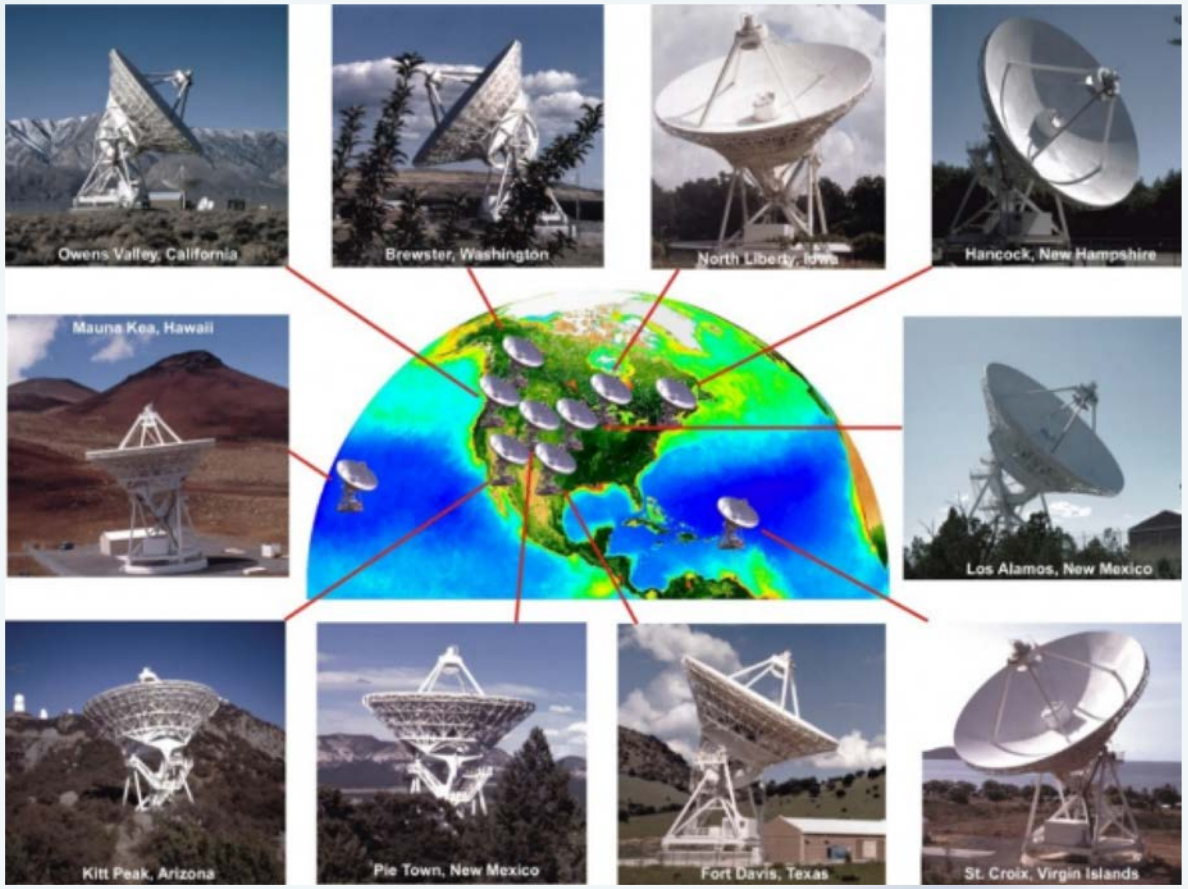
**- Global VLBI alliance initiative**

**- eKVN & World wide Geodetic VLBI**

# Global VLBI Communities

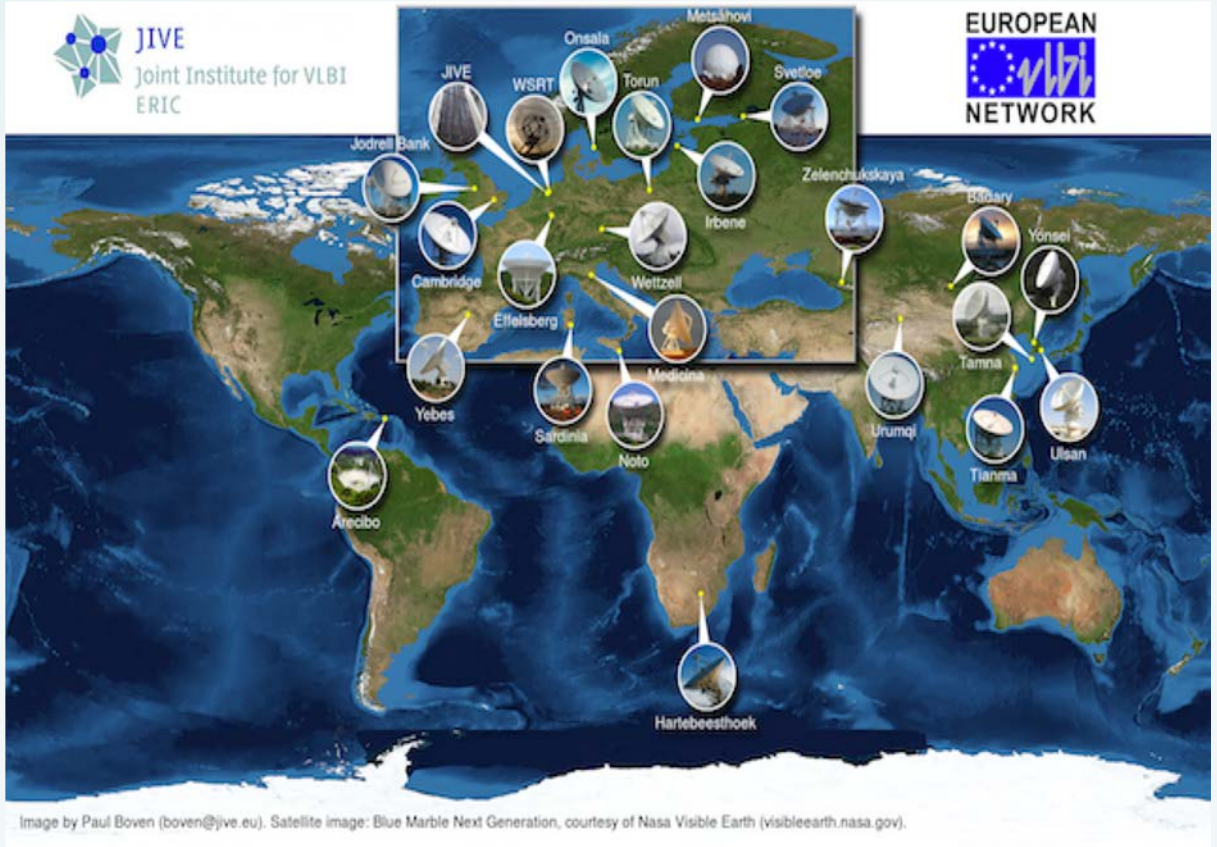


# Very Long Baseline Array (VLBA)



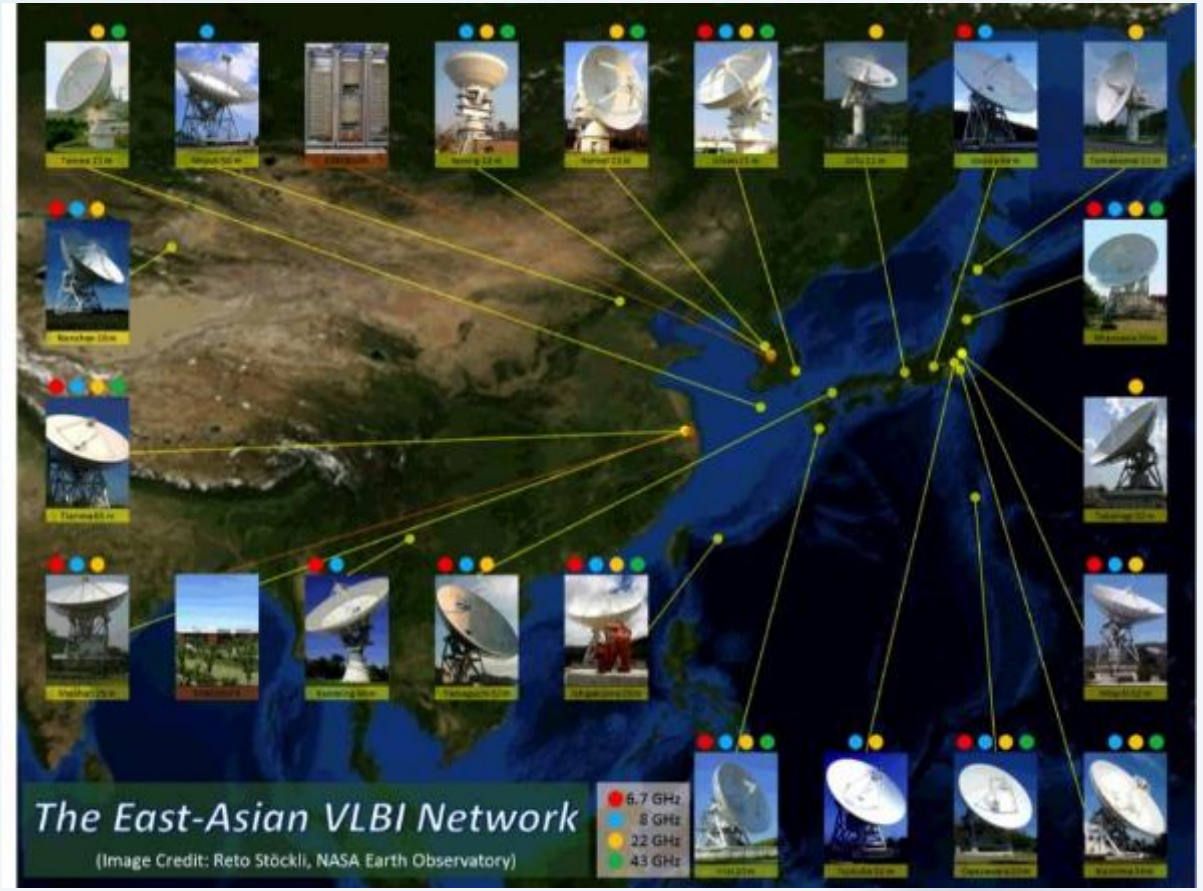

- 25m x 10 radio telescopes operated by NRAO (National Radio Astronomical Observatory), US
- Observing wavelength: 90cm – 3mm
- Correlator: NRAO in Socorro, USA

# European VLBI Network (EVN)

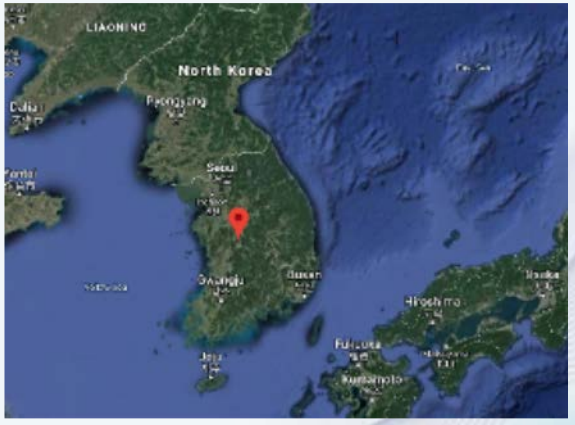



- ~ 24 radio telescopes in Europe, Asia, South Africa and 10 radio telescopes in Puerto Rico
- Observing wavelength: 90cm – 7mm
- Correlator: The joint Institute for VLBI ERIC (JIVE) in Dwingeloo, Netherland

# East Asian VLBI Network (EAVN)




- ~ 20 radio telescopes in China, Japan and S. Korea
- Observing wavelength: 5cm – 7mm
- Correlator: KASI in Daejeon, South Korea



# Long Baseline Array (LBA)

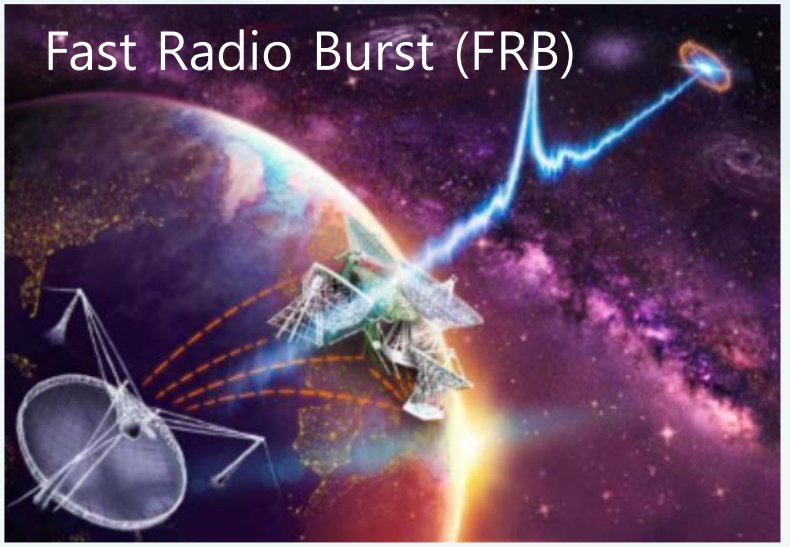
- ~ 11 radio telescopes in Australia operated by CSIRO
- Observing wavelength: 20cm – 3mm
- Correlator: Pawsey Supercomputing Centre in Perth, Australia

# Global VLBI Communities

## Global VLBI Alliance Initiative

- “Earth VLBI alliance” : VLBA + EVN + EAVN + LBA + …
- Provide simpler the global VLBI access for astronomers in order to pursue the breakthrough science by maximizing the power of VLBI in worldwide

# VLBI : Time Domain Astronomy and Rapid Response Science




- VLBI imaging can help
  - to clarify the astrophysics
  - precise localizations of the origin
  - to Identify potential persistent radio counterparts
  - e.g. Transients, Neutron star mergers, Gravitational Wave, Fast Radio Burst etc.
- e-VLBI is greatly important for rapid response sciences and multi-messenger astronomy

# Characteristics of eVLBI experiment of global VLBI alliance

- Data Intensive Science
  - High performance networking and computing, Big data
  - Large-scale instruments : telescope
  - Data Center and HPC involved
- **Event-driven (or scheduled) Rapid Response Science**
  - Fast response to request for observation
  - Real-time, more robust against failure
  - Immediate feedback on the state of variable and transient phenomena
  - Noticed immediately and addressed instantaneously
  - Dynamically addressable to telescope, network and correlator
  - Real-time correlation (saving the storage cost)
- Collaborative Science
  - Globally Multi-partners and multi-sites of telescopes
  - Sometime a telescope is located at an out-of-the-way place
  - large-scale global collaboration

# The Network for eVLBI experiment

## Data-Intensive Science

- **End-to-end high performance network**
  - Large bandwidth network with 100Gbps
  - Science DMZ + DTN + PerfSONAR + Science Engagement
  - (Static) allocation of lightpaths
  - Virtual Private Network

## Rapid Response Science  Collaborative Science

- **Dynamically provisioning and optimizing network**
  - Locally and internationally (inter-continent) connected
  - Dynamic allocation of lightpaths
  - Bandwidth on demand
  - Automated GOLE
  - Programmable capability
- **Automated operation** enabled by networkers and operated by astronomer

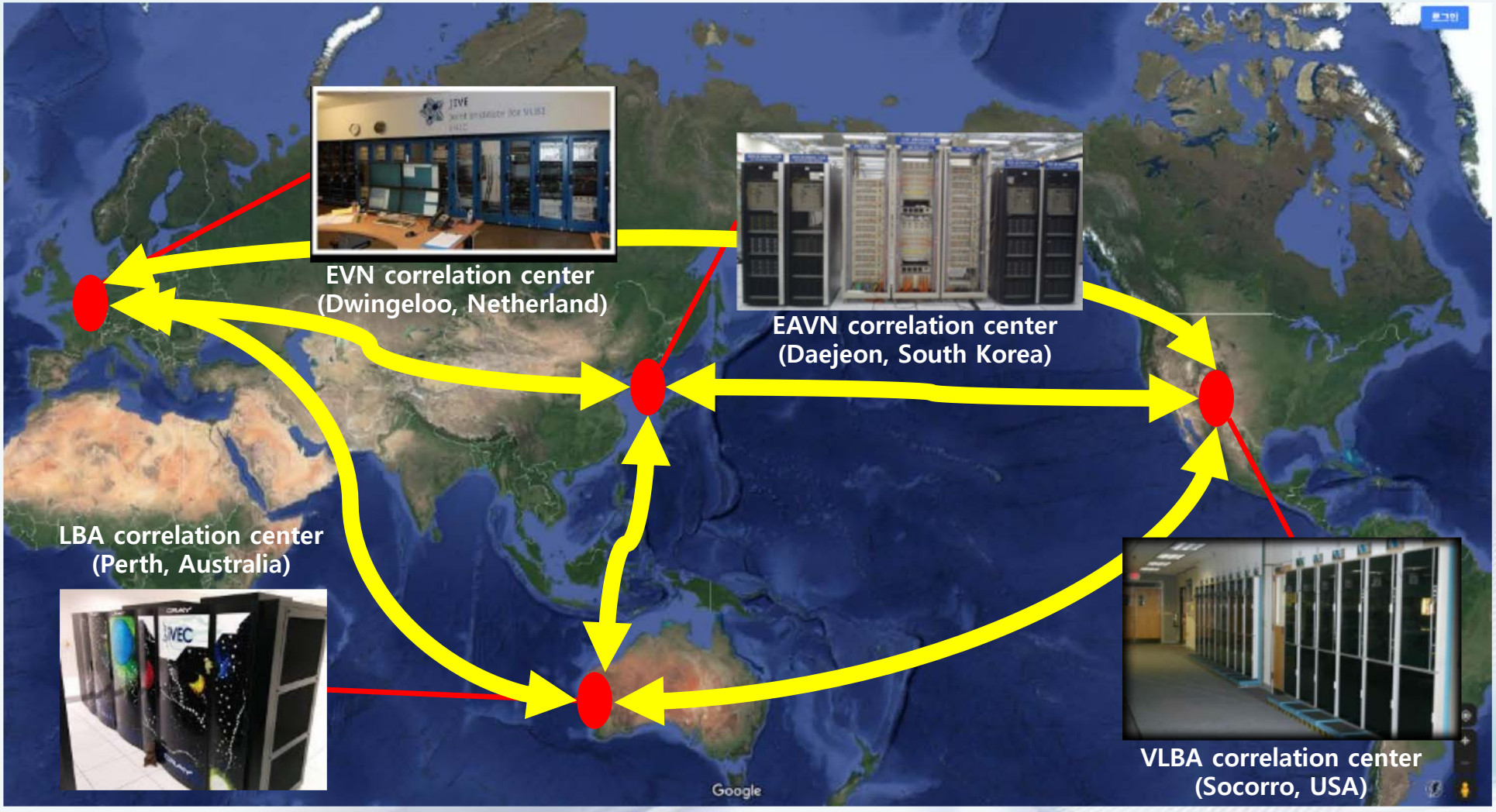
**Why not? Automated Dynamic Virtual Private Network**

# Global VLBI Alliance (GVA) Initiative

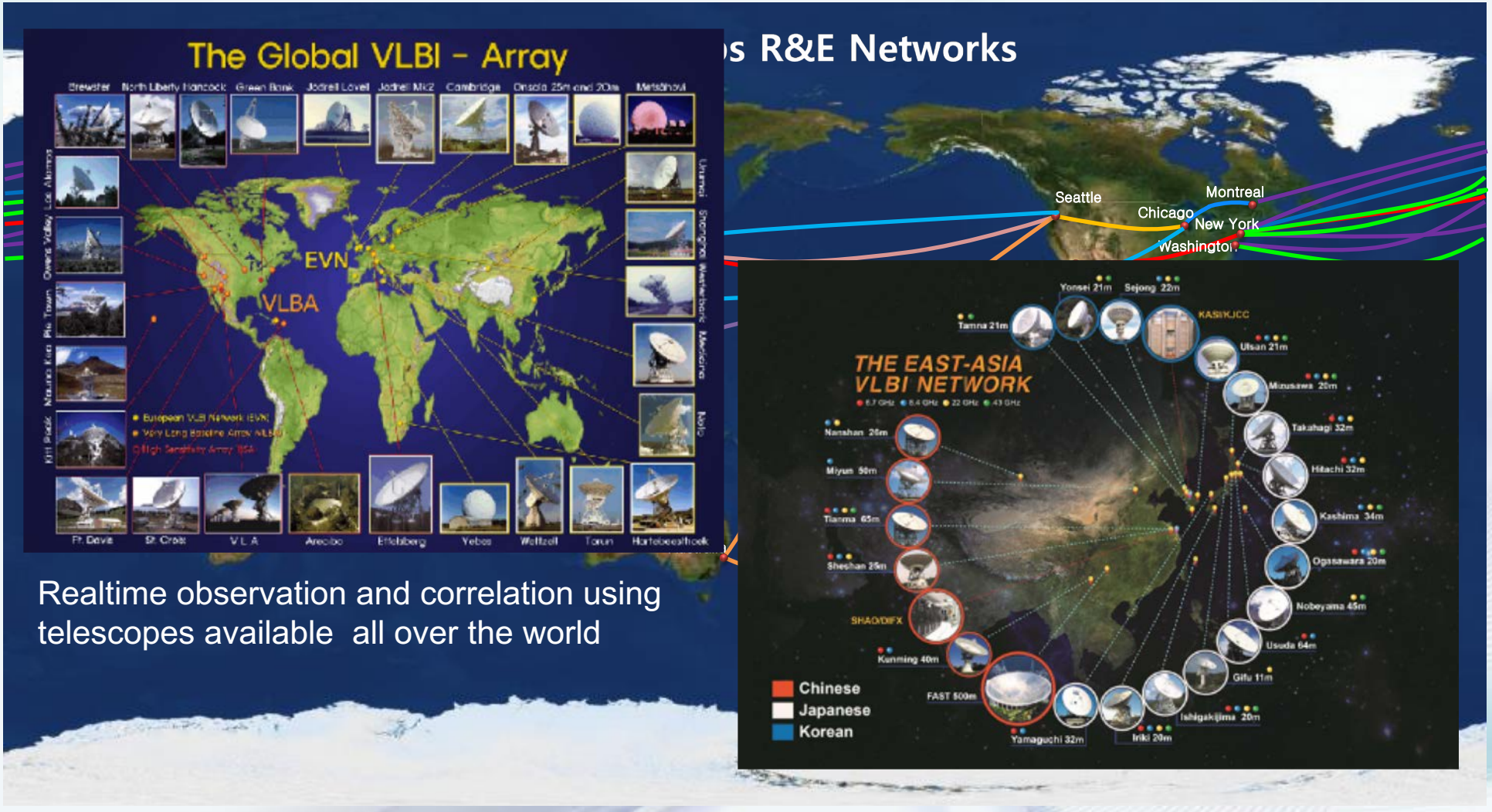
- Global VLBI Alliance (GVA) demonstration with the most common frequency (22GHz/13mm)
  - Number of telescopes
    - VLBA (10), EVN (14), EAVN (15), LBA (5)
    - Total 44 radio telescopes (RT)
  - Data rate
    - 1Gbps / 2Gbps / 4Gbps / 8Gbps (Currently)
    - 16Gbps / 32Gbps / 64Gbps … (Future)
  - Realtime e-VLBI capabilities
    - EVN/LBA: real-time e-VLBI correlation
    - VLBA/EAVN: not supported yet

| Obs. Mode | GVA (44 RTs) | Total Data Rate | Total amount of Data (Obs 8hr) |
|---|---|---|---|
| 1 Gbps | 1 Gbps x 44 | 44 Gbps | ~ 160 TB |
| 2 Gbps | 2 Gbps x 44 | 88 Gbps | ~ 320 TB |
| 4 Gbps | 4 Gbps x 44 | 176 Gbps | ~ 640 TB |
| 8 Gbps | 8 Gbps x 44 | 352 Gbps | ~ 1.267 PB |

# 1st Step Collaboration among correlation centers for GVA

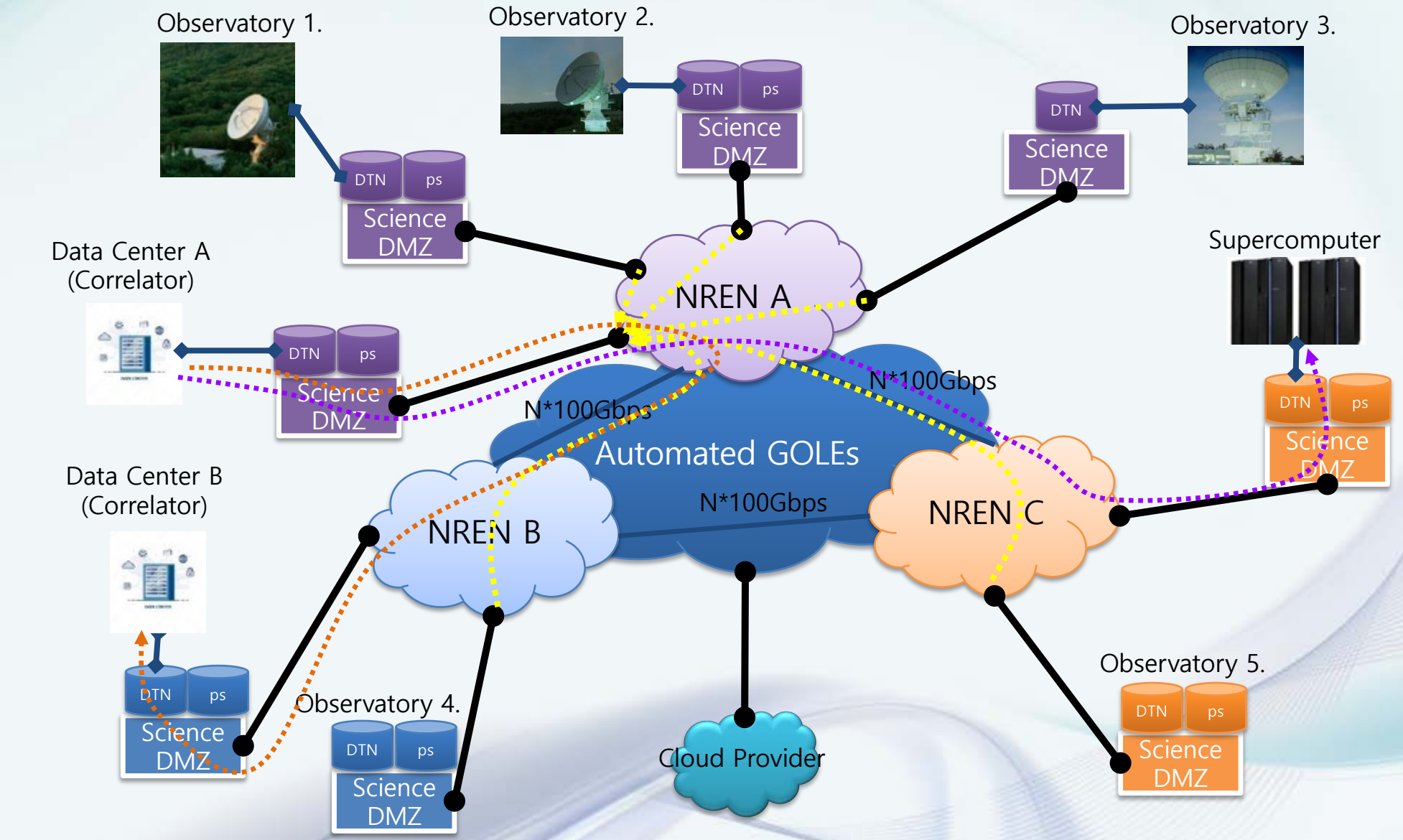


# 2nd Step Collaboration for real-time correlation of GVA

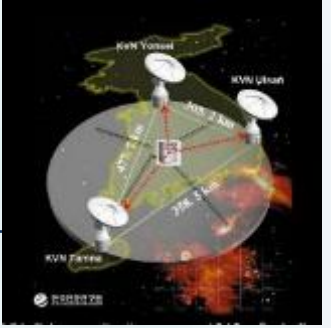



KREONet2, KOREN, Internet2/SingAREN, TransPAC, SXTransport, SINET, AMLight Exp, AGGCnet, APR(SingAREN/JGN), NEAAR, ANA(Internet2, NORDUnet, SURFnet, CANARIE, GEANT), Esnet, CAE-1, GRP

# Optimized Network (Research) Platform for GVA



# e-KVN (e-VLBI Network in Korea)



- e-KVN: Korean e-VLBI(electronic Very Long Baseline Interferometry) Network

**=> Toward Real-time e-VLBI observation with real-time correlation among observatories**

@East Asia

@Europe

Korea-Japan Correlation Center (KJCC) @Daejeon

Yonsei Astronomy Observatory @Seoul

40G (+1G)

100G

Daejeon

100G

KRLight

KREONet2

Seoul

KREONET

Jeju

Sejong

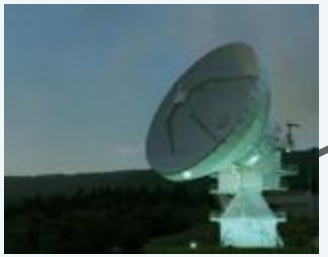
Ulsan

10G(+1G)

10G

10G(+1G)

@Australia



Tamna Astronomy Observatory @ Jeju

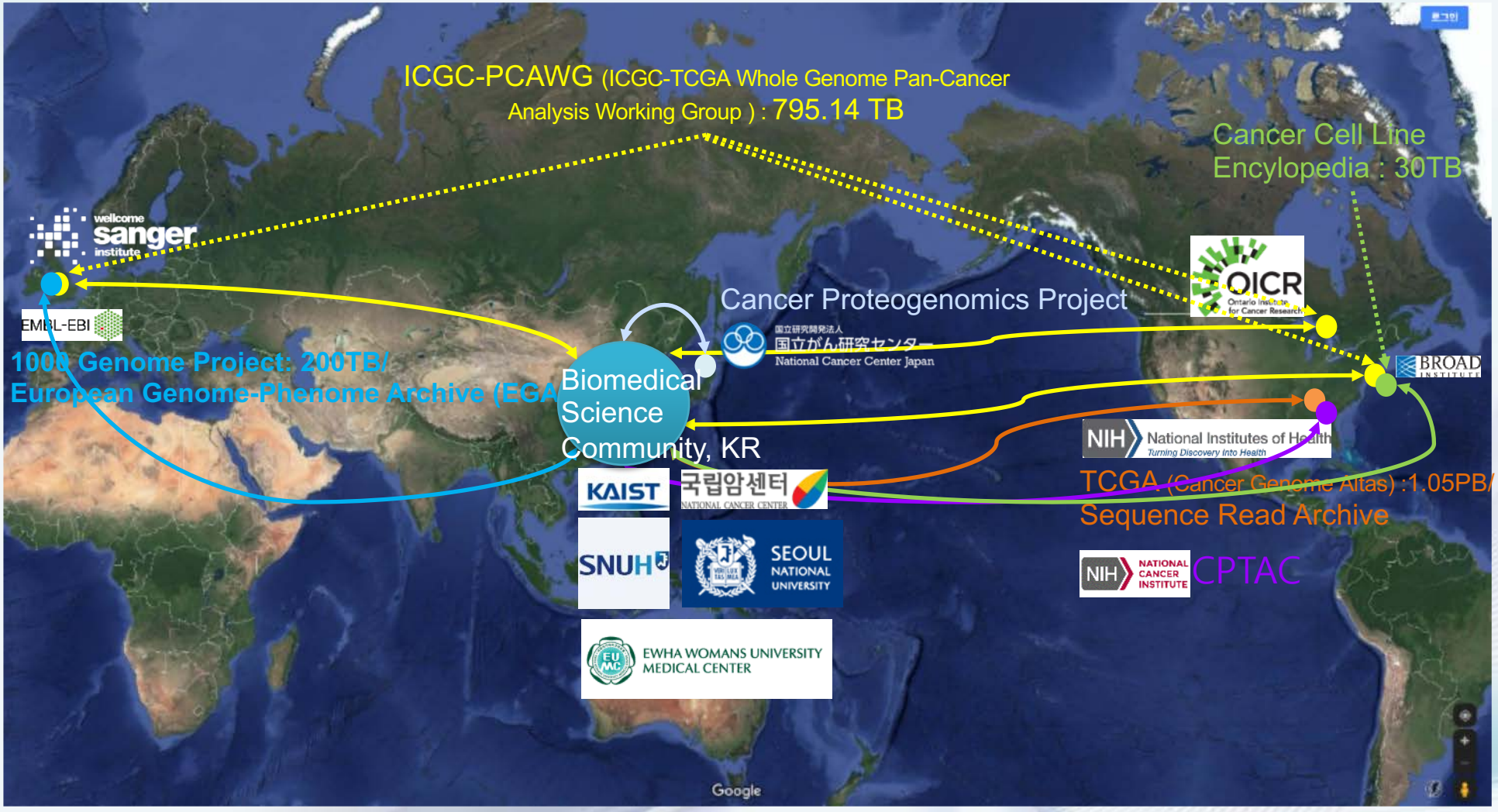
VLBI antenna @ Sejong Space Geodetic Observation Center

Ulsan Astronomy Observatory @Ulsan

# World wide Geodetic VLBI (16countries)

# Biomedical Science and Genomics

# Global Collaboration of the Biomedical Science community

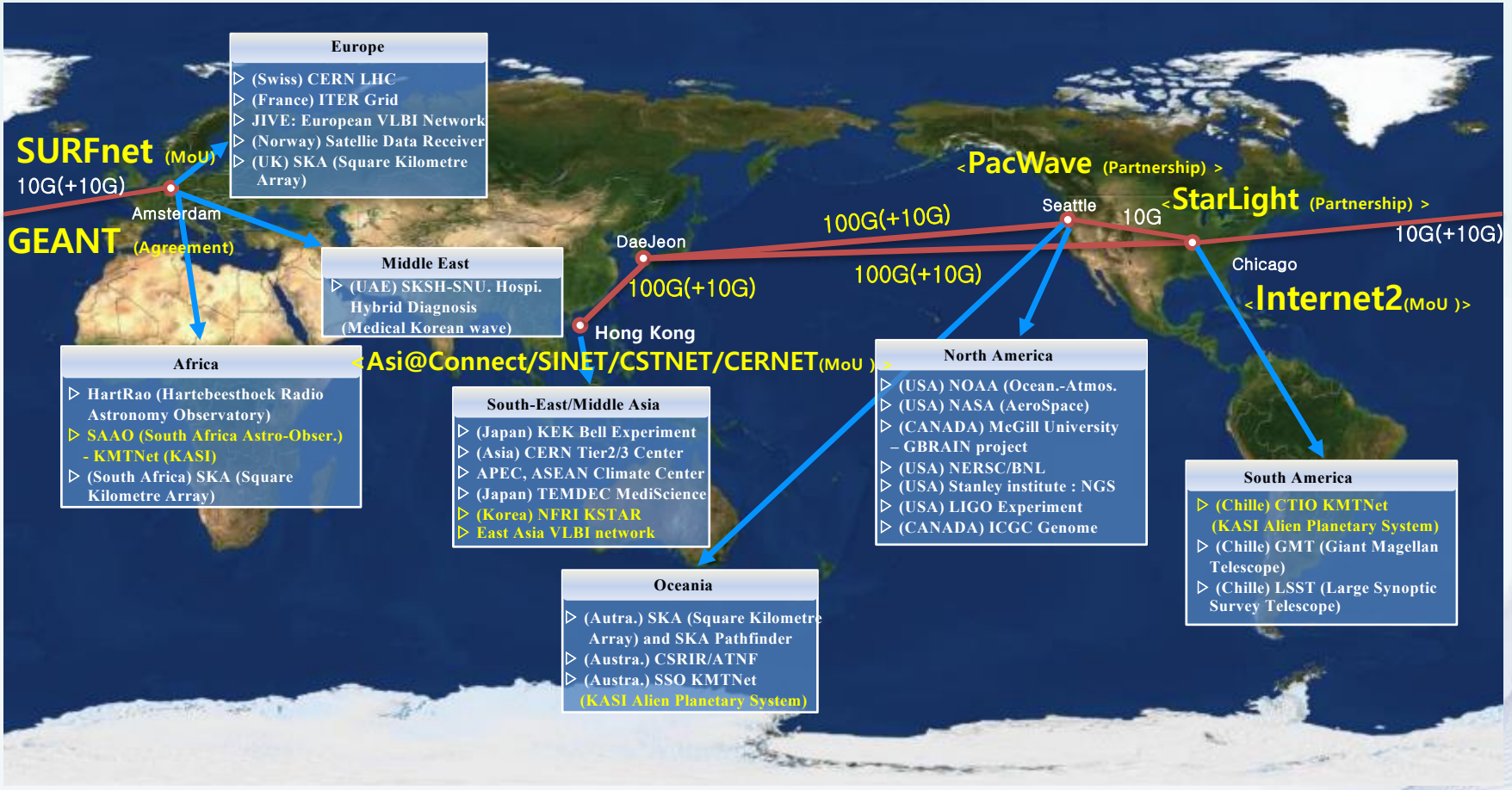


# KREONET/KREONet2

KOREA RESEARCH ENVIRONMENT OPEN NETWORK

- National-wide 100Gbps National Research Network
- 17 Domestic GigaPoPs, 4 International GigaPoPs
- 100G upgrade for international network: Seattle, Hong Kong
- New GigaPoP in Korea: Chuncheon
- User: about 200 national research institutes, universities etc. (500,000 users)

# KREONet2's Global Research Networking & Collaboration



# Conclusion

- *Key Global Application Drivers in Korea and Asia*
- **High Energy Physics & Fusion Energy**
- **Astronomy**
  - **Global VLBI Alliance Initiative**
    - Accessible to astronomers for all available world-wide telescope
    - Enabling real-time correlation as a global VLBI array
  - Rapid Response Science
    - Automated Dynamic Virtual Private Network
  - SKA, GMT, LSST, …
- **Biomedical Science and Genomics**
  - ICGC, TCGA, ICGC-TCGA PCAWG, ..
- **AI enabled (HPC) Datacenter**

# Thank you

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