
CERN

How WLCG secures network capacity

Tony Cass, 9th April 2024

It doesn’t!

How WLCG ~~secures~~ network capacity

Tony Cass, 9th April 2024

“Why” is easier to answer than “How”

- LHC and the experiments were approved in the ’90s without any provision for the necessary computing.
- Work in the late ’90s and early ’00s led to the Worldwide LHC Computing Grid Collaboration.
  - Costs for computing (and networking) are shared between participants.

WLCG MoU

Memorandum of Understanding

for Collaboration in the Deployment and Exploitation of the Worldwide LHC Computing Grid

WLCG MoU

4.2.1 Resources. These shall be pledged separately (as applicable) for Tier 1 services and Tier 2 services (defined in Annex 3)

- Processing capacity (expressed in commonly agreed units).
- Networking. Due to the distributed nature of the WLCG, it is particularly important that each Institution provides appropriate network capacity with which to exchange data with the others. The associated Computing Resource Levels shall include I/O throughput and average availability[1].
- Access to data (capacity and access performance parameters of the various kinds of storage, making clear which figures refer to archival storage).

WLCG MoU

Annex 3. Minimal Computing Resource and Service Levels to qualify for membership of the WLCG Collaboration

Annex 3.1. Host Laboratory Services

i. Operation of the Tier0 facility providing:
   1. high bandwidth network connectivity from the experimental area to the offline computing facility (the networking within the experimental area shall be the responsibility of each Experiment);

iii. Support of the termination of high speed network connections by all Tier1 and Tier2 Centres as requested.

iv. Coordination of the overall design of the network between the Host Laboratory, Tier1 and Tier2 Centres, in collaboration with national research networks and international research networking organisations.

Annex 3.2. Tier-1 Services

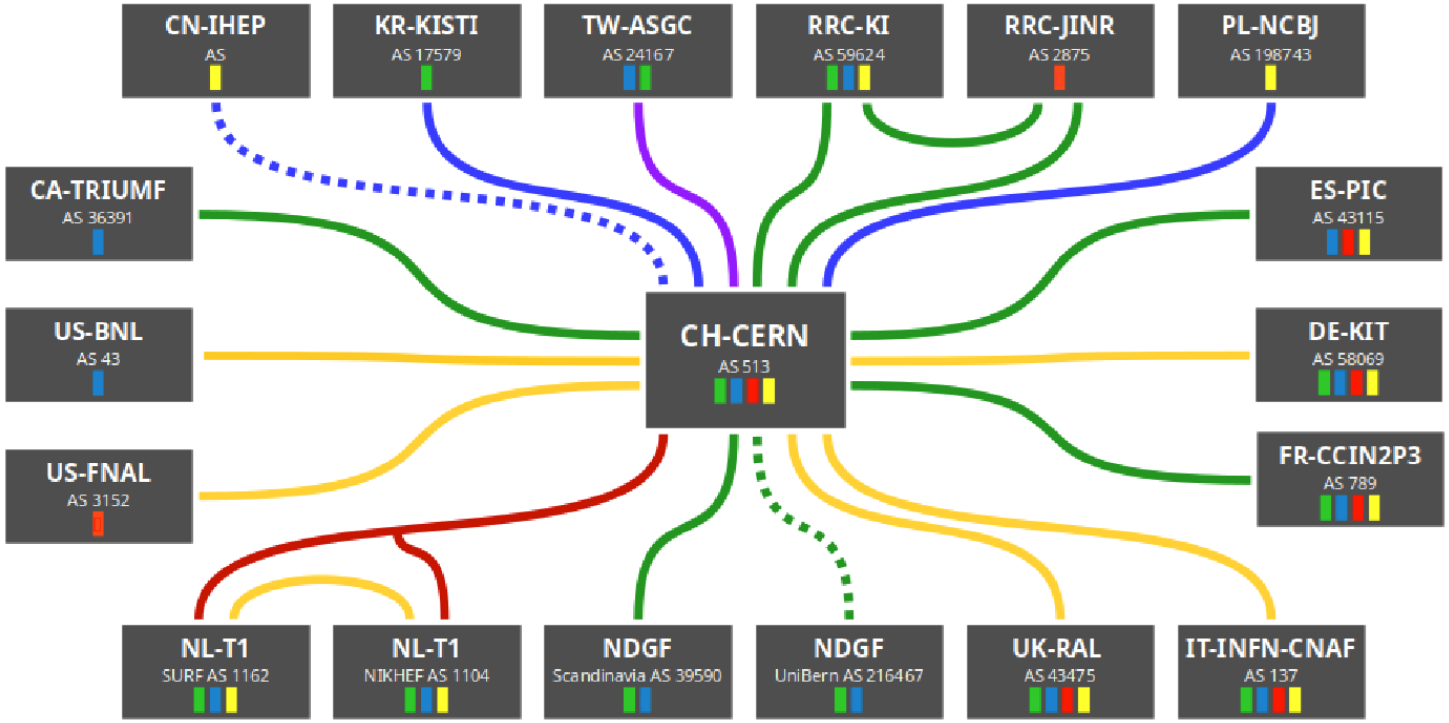
x. ensure high-capacity network bandwidth and services for data exchange with the Tier0 Centre, as part of an overall plan agreed amongst the Experiments, Tier1 and Tier0 Centres;

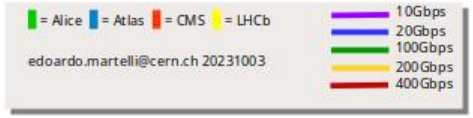
xi. ensure network bandwidth and services for data exchange with Tier1 and Tier2 Centres, as part of an overall plan agreed amongst the Experiments, Tier1 and Tier2 Centres;

Annex 3.3. Tier-2 Services

v. ensure network bandwidth and services for data exchange with Tier1 Centres, as part of an overall plan agreed between the Experiments and the Tier1 Centres concerned.

LHCOPN





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

Numbers

- 18 sites for 15 Tier1s + 1 Tier0
- PL-NCBJ just joined, CN-IHEP and NDFG-LHEP in the process to connect
- 15 countries in 3 continents
- 2.1 Tbps to the Tier0

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10

July 2007

27 Jul LHC OPN in A

April 2007

20 Apr LHC OPN Mee

January 2007

12 Jan LHC OPN Mee

September 2006

21 Sept LHC OPN Me

June 2006

16 Jun LHC OPN mee

April 2006

04 Apr LHC OPN Mee

January 2006

31 Jan T0/T1 Network

November 2005

14 Nov T0/T1 Network

July 2005

19 Jul T0/T1 Network

07 Jul ESNet Network

April 2005

08 Apr T0/T1 network

January 2005

20 Jan - 21 Jan T0/1 Ne

October 2010

07 Oct - 08 Oct LHCOPN Mee

June 2010

28 Jun - 29 Jun LHCOPN mee

March 2010

08 Mar - 09 Mar LHCOPN mee

December 2009

10 Dec - 11 Dec LHCOPN mee

August 2009

31 Aug - 01 Sept LHCOPN me

April 2009

21 Apr - 22 Apr LHCOPN mee

January 2009

15 Jan - 16 Jan LHCOPN mee

October 2008

16 Oct - 17 Oct LHC OPN Me

June 2008

16 Jun - 17 Jun LHC OPN Mee

March 2008

10 Mar - 11 Mar LHC OPN Me

December 2007

07 Dec LHCOPN Operations

November 2007

05 Nov - 06 Nov LHCOPN Ope

June 2013

17 Jun - 18 Jun LHCOPN and L

May 2013

02 May - 03 May LHCONE Poir

January 2013

31 Jan - 01 Feb LHCOPN and L

December 2012

13 Dec - 14 Dec LHCONE Poin

September 2012

20 Sept - 21 Sept LHCOPN and

May 2012

03 May - 04 May LHCOPN and

January 2012

30 Jan - 01 Feb LHCOPN and L

December 2011

01 Dec - 02 Dec LHCONE Arch

September 2011

26 Sept - 27 Sept LHCOPN and

June 2011

13 Jun - 14 Jun LHCOPN and L

February 2011

10 Feb - 11 Feb LHCOPN Meet

10 Feb LHCT2S Technical me

January 2011

13 Jan LHCT2S Technical Me

October 2017

16 Oct - 17 Oct LHCOPN-

April 2017

04 Apr - 05 Apr LHCOPN-

September 2016

19 Sept - 20 Sept LHCOPN

March 2016

13 Mar - 14 Mar LHCOPN-

October 2015

28 Oct - 29 Oct LHCOPN-

June 2015

01 Jun - 02 Jun LHCOPN-

February 2015

09 Feb - 10 Feb LHCOPN-

September 2014

15 Sept - 17 Sept LHCOPN

August 2014

13 Aug LHCONE Asia-P

April 2014

28 Apr - 29 Apr LHCOPN-

February 2014

10 Feb - 11 Feb LHCONE

December 2013

03 Dec - 05 Dec LHCOPN

March 2022

29 Mar - 30 Mar LHCOPN-LHCONE meeting #48 - Virtual meeting

October 2021

11 Oct - 12 Oct LHCOPN-LI

March 2021

23 Mar - 24 Mar LHCOPN-L

September 2020

16 Sept - 17 Sept LHCOPN/

May 2020

13 May LHCOPN/LHCON

March 2020

08 Mar - 09 Mar CANCELLE

January 2020

14 Jan LHCONE ESnet side meeting

13 Jan - 14 Jan LHCOPN/LHCONE workshop - CERN Geneva, CH

June 2019

04 Jun - 05 Jun LHCOPN-LHCONE meeting #42 - Umeå (SE)

October 2018

30 Oct - 31 Oct LHCOPN-LHCONE meeting - Fermilab, Batavia (US)

March 2018

06 Mar - 07 Mar LHCOPN-LHCONE meeting - RAL Abingdon (UK)

January 2018

25 Jan TIFR-LHCONE meeting

April 2024

09 Apr - 11 Apr LHCOPN-LH

October 2023

18 Oct - 20 Oct LHCOPN-LI

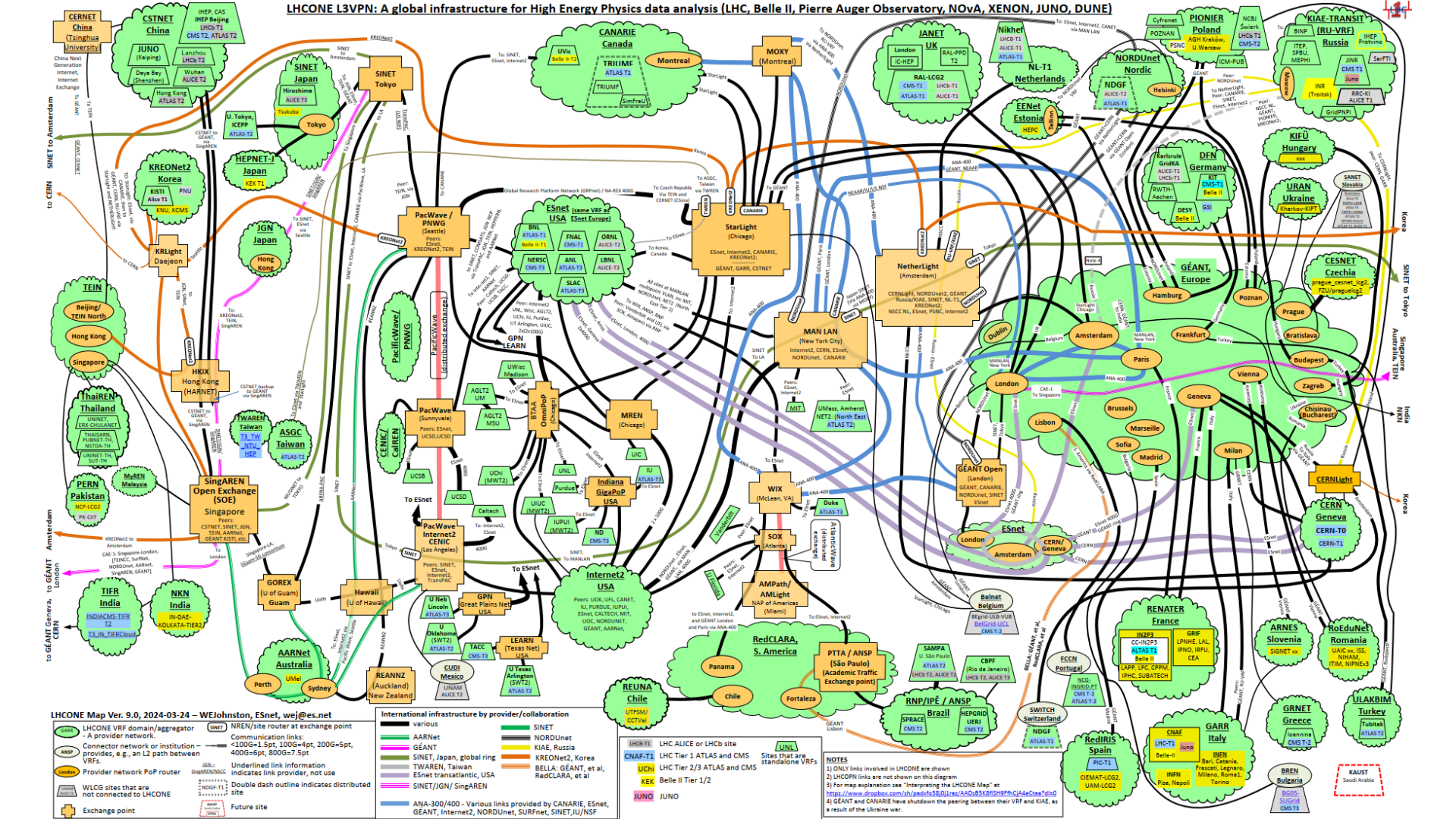
April 2023

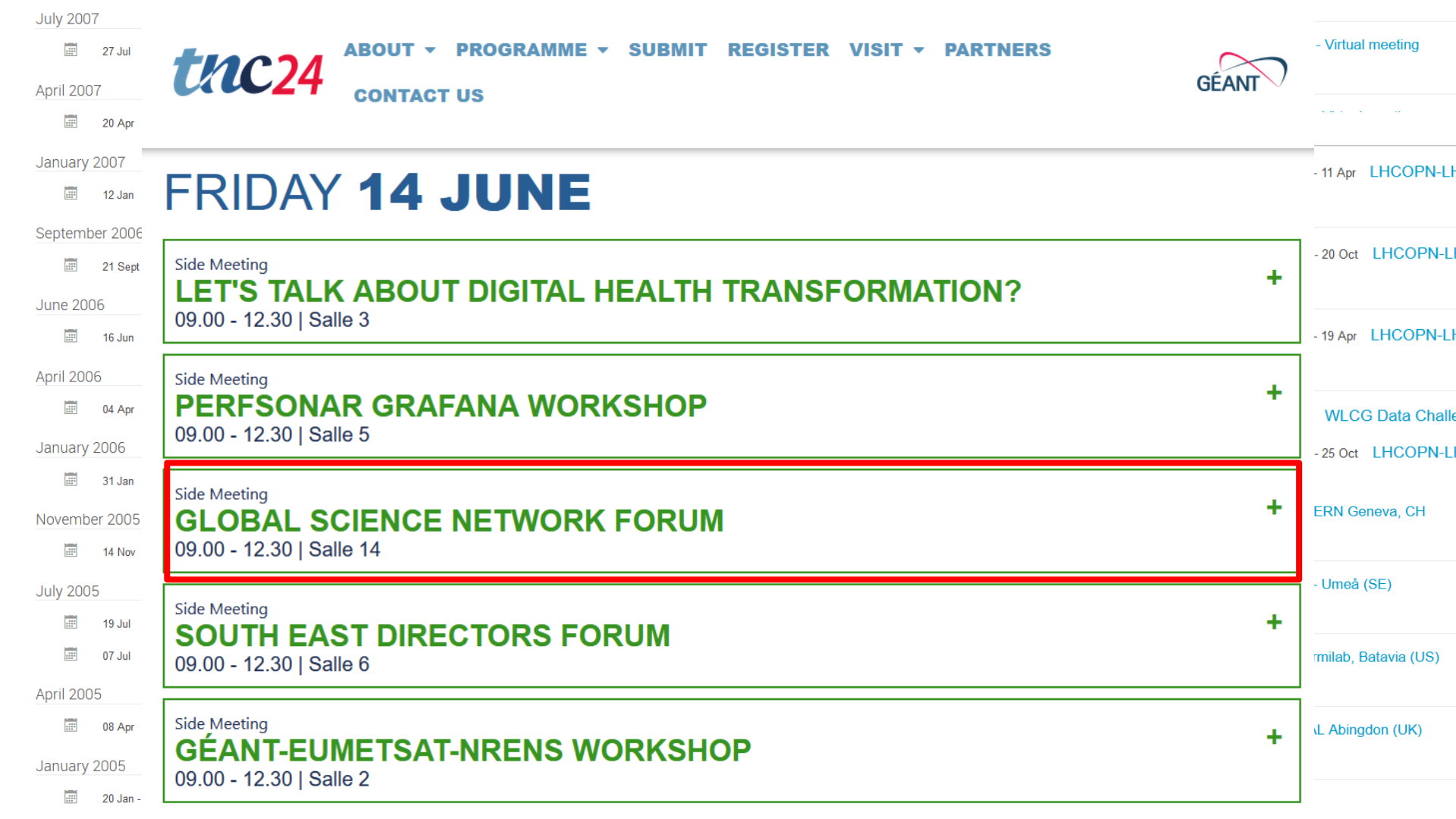
18 Apr - 19 Apr LHCOPN-LH

October 2022

26 Oct WLCG Data Challe

24 Oct - 25 Oct LHCOPN-LI


LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOvA, XENON, JUNO, DUNE)
CERNET China (Tsinghua University)
CSTNET China
IHEP, CAS
IHEP Beijing
LHCb T1
CMS T2, ATLAS T2
JUNO (Kaiping)
Lanzhou LHCb T2
Daya Bay (Shenzhen)
Wuhan ALICE T2
Hong Kong ATLAS T2
SINET Japan
Hiroshima ALICE T3
Tsukuba
Tokyo
U. Tokyo, ICEPP
ATLAS-T2
HEPNET-J Japan
KEK T1
SINET Tokyo
KREONet2 Korea
KISTI Alice T1
PNU
KNU, KCMS
KRLight Daejeon
JGN Japan
Hong Kong
TEIN
Beijing/ TEIN North
Hong Kong
Singapore
HKIX Hong Kong (HARNET)
ThaiREN Thailand
UNINET, ERX-CHULANET
THAISARN, PUBNET-TH, NSTDA-TH
UNINET-TH, SUT-TH
MyREN Malaysia
PERN Pakistan
NCP-LCG2
PK-CIIT
SingAREN Open Exchange (SOE) Singapore
Peers: CSTNET, SINET, JGN, TEIN, AARNet, GÉANT KISTI, etc.
TWAREN Taiwan
T3_TW_NTU_HEP
ASGC Taiwan
ATLAS-T2
GOREX (U of Guam) Guam
Hawaii (U of Hawaii)
TIFR India
INDIACMS-TIFR T2
T3_IN_TIFRCloud
NKN India
IN-DAE-KOLKATA-TIER2
AARNet Australia
UMel
Perth
Sydney
REANNZ (Auckland) New Zealand
CANARIE Canada
UVic
Belle II-T2
TRIUMF
ATLAS T1
TRIUMF
SimFraU
Montreal
MOXY (Montreal)
PacWave / PNWG (Seattle)
Peers: ESnet, KREONet2, TEIN
PacificWave/ PNWG
PacificWave distributed exchange node
ESnet USA (same VRF as ESnet Europe)
BNL ATLAS-T3
Belle II-T1
FNAL CMS-T1
ORNL ALICE-T2
NERSC CMS-T3
ANL ATLAS-T3
LBNL ALICE-T2
SLAC ATLAS-T3
StarLight (Chicago)
ESnet, Internet2, CANARIE, KREONet2; GÉANT, GARR, CSTNET
NetherLight (Amsterdam)
CERNLight, NORDUnet2, GÉANT, Russia/KIAE, SINET, NL-T1, KREONet2, NSCC NL, ESnet, PSNC, Internet2
MAN LAN (New York City)
Internet2, CERN, ESnet, NORDUnet, CANARIE
GPN LEARN
PacWave (Sunnyvale)
Peers: ESnet, UCSD,UCSD
PacWave Internet2 CENIC (Los Angeles)
Peers: SINET, ESnet, Internet2, TransPAC
BTAA OmniPoP (Chicago)
MREN (Chicago)
Indiana GigaPoP USA
WIX (McLean, VA)
SOX (Atlanta)
AtlanticWave distributed exchange node
AMPath/ AMLight NAP of Americas (Miami)
Internet2 USA
Peers: UDK, UFL, CANET, IU, PURDUE, IUPUI, ESnet, CALTECH, MIT, UOC, NORDUNET, GÉANT, AARNet,
GPN Great Plains Net USA
LEARN (Texas) Net) USA
U Texas Arlington (SWT2)
ATLAS-T2
TACC CMS-T3
CUDI Mexico
UNAM ALICE T2
RedCLARA, S. America
Panama
Chile
PTTA / ANSP (São Paulo) (Academic Traffic Exchange point)
Fortaleza
REUNA Chile
UTFSM/ CCTVal
SAMPA U. São Paulo
ATLAS T2
LHCb T2, ALICE T2
CBPF (Rio de Janeiro)
LHCb T2, ALICE T2
RNP/IPÊ / ANSP Brazil
SPRACE
CMS T2
HEPGRID UERJ
CMS T2
JANET UK
London
IC-HEP
RAL-PPD T2
RAL-LCG2
CMS-T1
ATLAS-T1
LHCb-T1
ALICE-T2
Nikhef
LHCb-T1
ALICE-T1
ATLAS-T1
NL-T1 Netherlands
EENet Estonia
HEPC
NORDUnet Nordic
NDGF
ALICE-T2
ATLAS-T1
Helsinki
PIONIER Poland
Cyfronet
POZNAN
PSNC
AGH Kraków, U.Warsaw
NCBJ Świerk
LHCb T1
CMS-T2
ICM-PUB
KIAE-TRANSIT (RU-VRF) Russia
BINP
ITEP, SPbU, MEPhI
IHEP Protvino
JINR
CMS T1
Juno
INR (Troitsk)
SerFT1
RRC-KI
ALICE T1
GridPNPI
Moscow
KIFÜ Hungary
xxx
URAN Ukraine
Kharkov-KIPT
SANET Slovakia
DFN Germany
Karlsruhe GridKA
ALICE-T1
LHCb-T1
RWTH-Aachen
KIT
CMS-T1
Belle II
DESY
Belle II
GSI
GÉANT, Europe
Hamburg
Poznan
Prague
Bratislava
Budapest
Zagreb
Chisinau (Bucharest)
Frankfurt
Amsterdam
Dublin
Paris
London
Vienna
Geneva
Brussels
Lisbon
Marseille
Sofia
Madrid
Milan
CESNET Czechia
prague_cesnet_lcg2, FZU/praguelcg2
GÉANT Open (London)
GÉANT, CANARIE, NORDUnet, SINET ESnet
ESnet
London
Amsterdam
CERN/ Geneva
CERNLight
CERN Geneva
CERN-T0
CERN-T1
Belnet Belgium
BEgrid-UGB-VUB
BelGrid-UCL
CMS T-2
RENATER France
IN2P3
CC-IN2P3
ATLAS T1
Belle II
LAPP, LPC, CPPM
IPHC, SUBATECH
GRIF
LPNHE, LAL, IPNO, IRFU, CEA
FCCN Portugal
NCG-INGRID-PT
CMS T-2
ATLAS T-2
SWITCH Switzerland
NDGF
ATLAS-T1
RediRIS Spain
PIC-T1
CIEMAT-LCG2, UAM-LCG2
ARNES Slovenia
SIGNET xx
RoEduNet Romania
UAIC xx, ISS, NIHAM, ITIM, NIPNEx3
GRNET Greece
Ioannina CMS T-2
ULAKBIM Turkey
Tubitak
ATLAS T2
GARR Italy
CNAE
LHC-T1
Juno
Belle-II
INFN Bari, Catania, Frascati, Legnaro, Milano, Roma1, Torino
INFN Pisa, Napoli
BREN Bulgaria
BG05-SUGrid
CMS T3
KAUST Saudi Arabia
SINET to Amsterdam
to CERN
to GÉANT Amsterdam
to GÉANT London
to GÉANT Geneva, to CERN
Korea
SINET to Tokyo
Singapore Australia, TEIN
India NKN
LHCONE Map Ver. 9.0, 2024-03-24 – 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, Japan, global ring
TWAREN, Taiwan
ESnet transatlantic, USA
SINET/JGN/ SingAREN
SINET
NORDUnet
KIAE, Russia
KREONet2, Korea
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 1 ATLAS and CMS
LHC Tier 2/3 ATLAS and CMS
Belle II Tier 1/2
JUNO
Sites that are standalone VRFs
NOTES
1) ONLY links involved in LHCONE are shown
2) LHCOPN links are not shown on this diagram
3) For map explanation see "Interpreting the LHCONE Map" at https://www.dropbox.com/sh/padxfo58j0jtrez/AADs85K8fSH9PfhCjA4eCtea?dl=0
4) GÉANT and CANARIE have shutdown the peering between their VRF and KIAE, as a result of the Ukraine war.


July 2007
27 Jul
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12 Jan
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21 Sept
June 2006
16 Jun
April 2006
04 Apr
January 2006
31 Jan
November 2005
14 Nov
July 2005
19 Jul
07 Jul
April 2005
08 Apr
January 2005
20 Jan -
tnc24
ABOUT
PROGRAMME
SUBMIT
REGISTER
VISIT
PARTNERS
CONTACT US
GÉANT
- Virtual meeting
- 11 Apr LHCOPN-LH
- 20 Oct LHCOPN-LH
- 19 Apr LHCOPN-LH
WLCG Data Challe
- 25 Oct LHCOPN-LH
ERN Geneva, CH
- Umeå (SE)
rmilab, Batavia (US)
L Abingdon (UK)
FRIDAY 14 JUNE
Side Meeting
LET'S TALK ABOUT DIGITAL HEALTH TRANSFORMATION?
09.00 - 12.30 | Salle 3
Side Meeting
PERFSONAR GRAFANA WORKSHOP
09.00 - 12.30 | Salle 5
Side Meeting
GLOBAL SCIENCE NETWORK FORUM
09.00 - 12.30 | Salle 14
Side Meeting
SOUTH EAST DIRECTORS FORUM
09.00 - 12.30 | Salle 6
Side Meeting
GÉANT-EUMETSAT-NRENS WORKSHOP
09.00 - 12.30 | Salle 2

WLCG MoU

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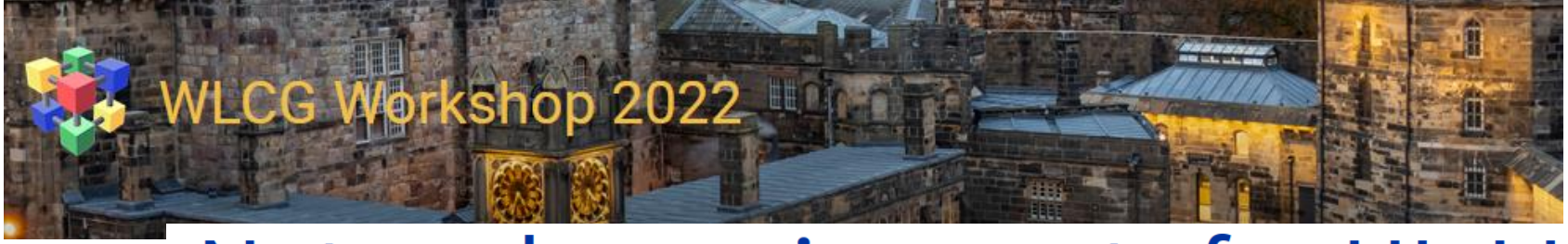

Network requirements for HL-LHC

T1
CA-TRIUMF
DE-KIT
ES-PIC
FR-CCIN2P3
IT-INFN-CNAF
KR-KISTI-GSDC
NDGF
NL-T1
NRC-KI-T1
UK-T1-RAL
RU-JINR-T1
US-T1-BNL
US-FNAL-CMS
(atlantic link)
Sum

Table 1: netv

Tier1s:

- 1Tbps to the Tier0 (LHCOPN)
- 1 Tbps to the Tier2s (aggregated, LHCONE)

Tier2s

- 400 Gbps and more


CERN