LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Computing and Networks in High Energy Physics

Advanced and Distributed Computing Group

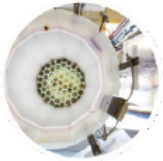
WHAT

LIP IS

The reference institution for experimental particle physics in Portugal and the Portuguese reference partner of CERN as well as other international scientific infrastructures

Has centres in:
Lisbon, Coimbra, Braga

Experimental particle and **astroparticle physics**

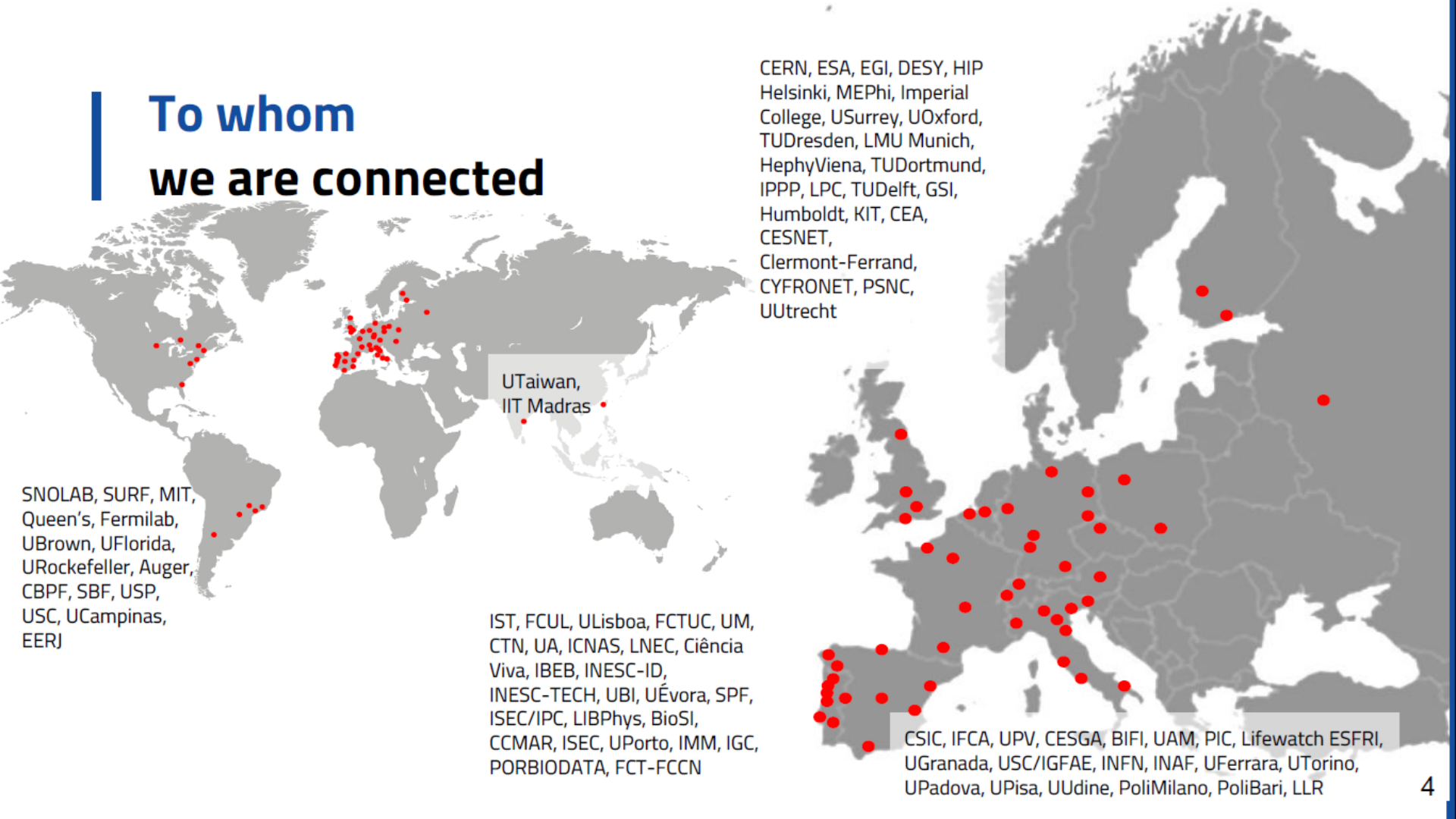


Development of **new instruments** and **methods**

Scientific computing

Knowledge transfer, education and **outreach**

To whom we are connected



CERN, ESA, EGI, DESY, HIP Helsinki, MEPhi, Imperial College, USurrey, UOxford, TUDresden, LMU Munich, HephyViena, TUDortmund, IPPP, LPC, TUDelft, GSI, Humboldt, KIT, CEA, CESNET, Clermont-Ferrand, CYFRONET, PSNC, UUtrecht

UTaiwan, IIT Madras

SNOLAB, SURF, MIT, Queen's, Fermilab, UBrown, UFlorida, URockefeller, Auger, CBPF, SBF, USP, USC, UCampinas, EERJ

IST, FCUL, ULisboa, FCTUC, UM, CTN, UA, ICNAS, LNEC, Ciência Viva, IBEB, INESC-ID, INESC-TECH, UBI, UÉvora, SPF, ISEC/IPC, LIBPhys, BioSI, CCMAR, ISEC, UPorto, IMM, IGC, PORBIODATA, FCT-FCCN

CSIC, IFCA, UPV, CESGA, BIFI, UAM, PIC, Lifewatch ESFRI, UGranada, USC/IGFAE, INFN, INAF, UFerrara, UTorino, UPadova, UPisa, UUdine, PoliMilano, PoliBari, LLR

LIP activities

High Energy Physics and related areas

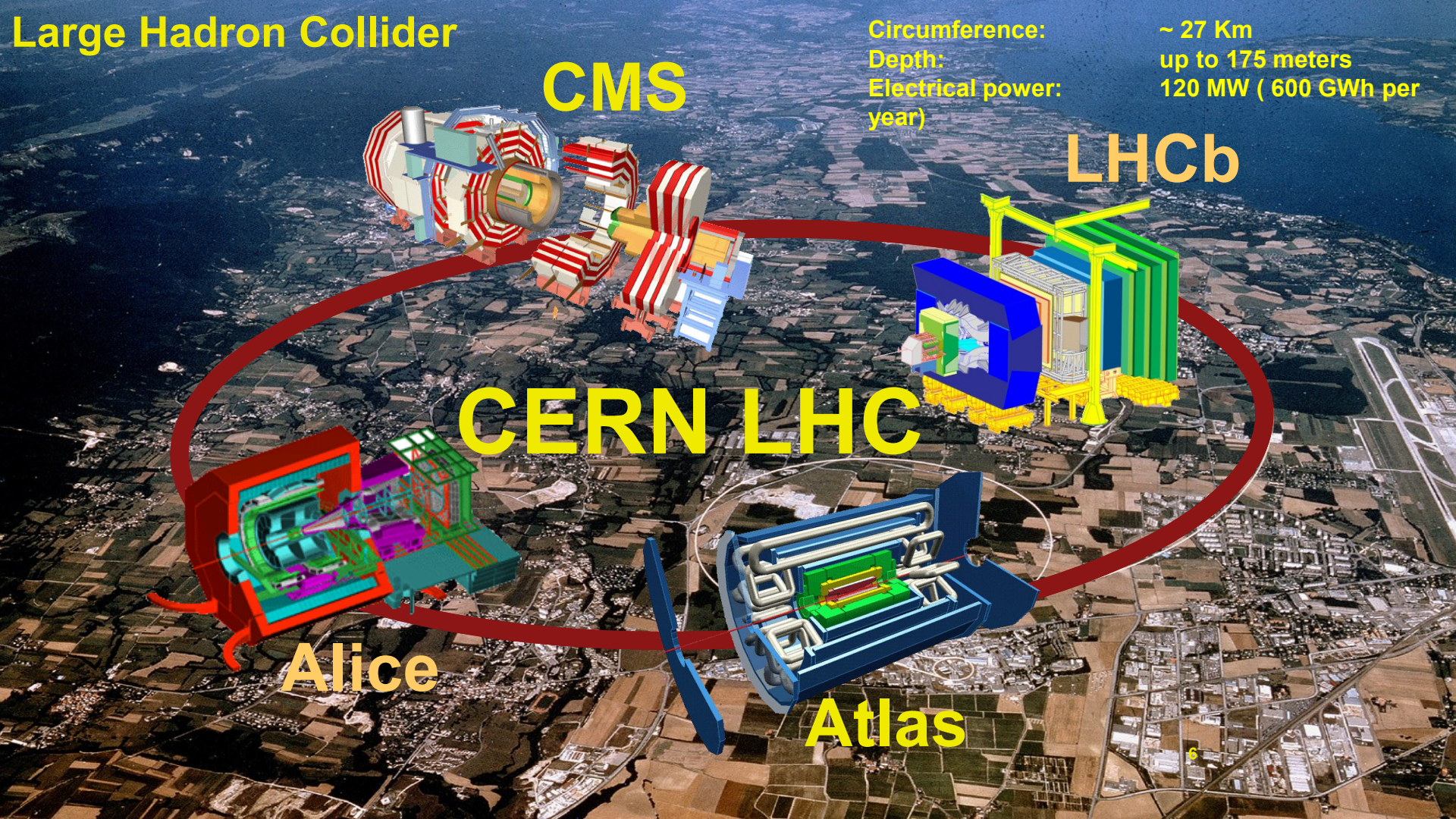
High Energy Physics
Trying to answer many open questions about our universe

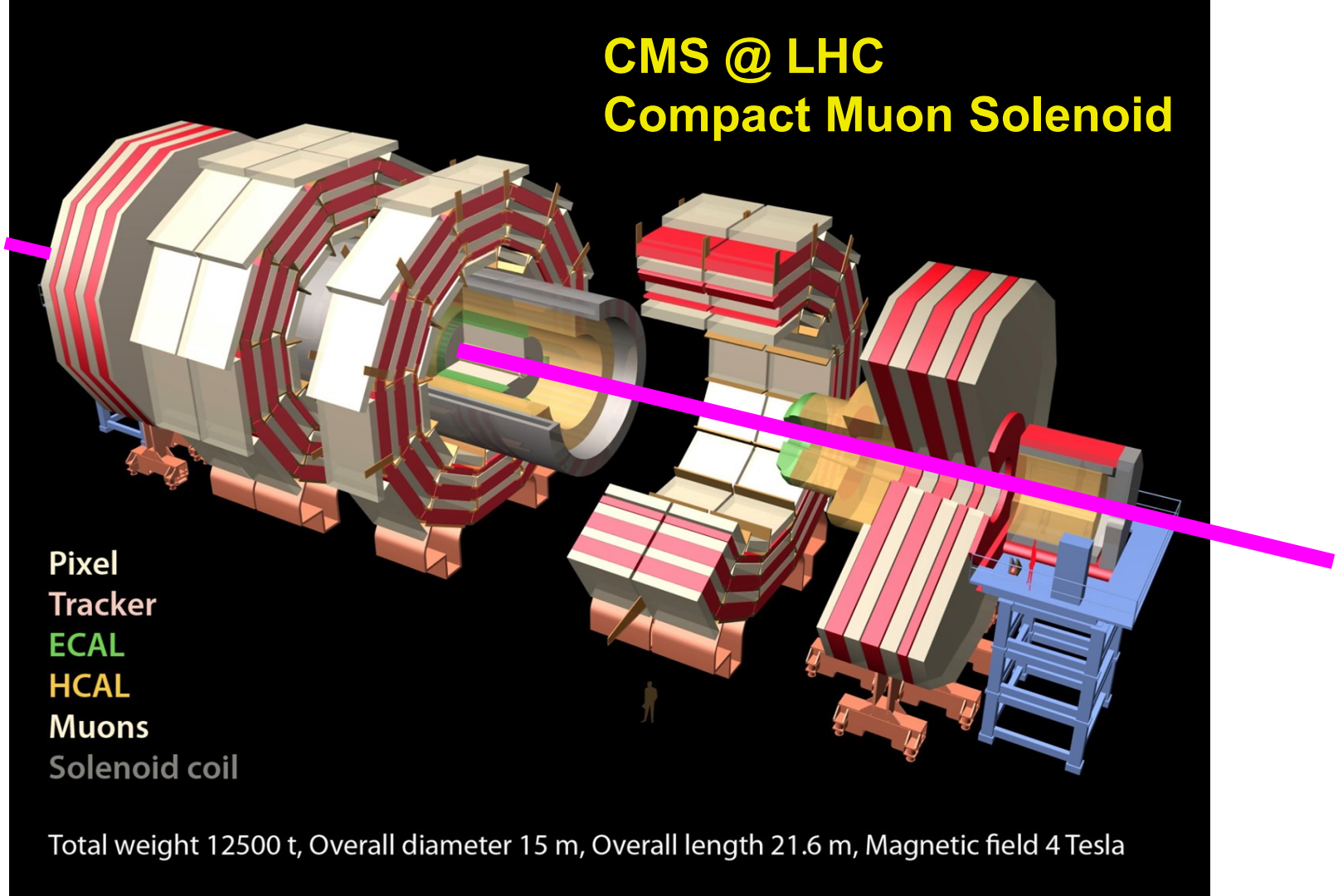
Many open questions …

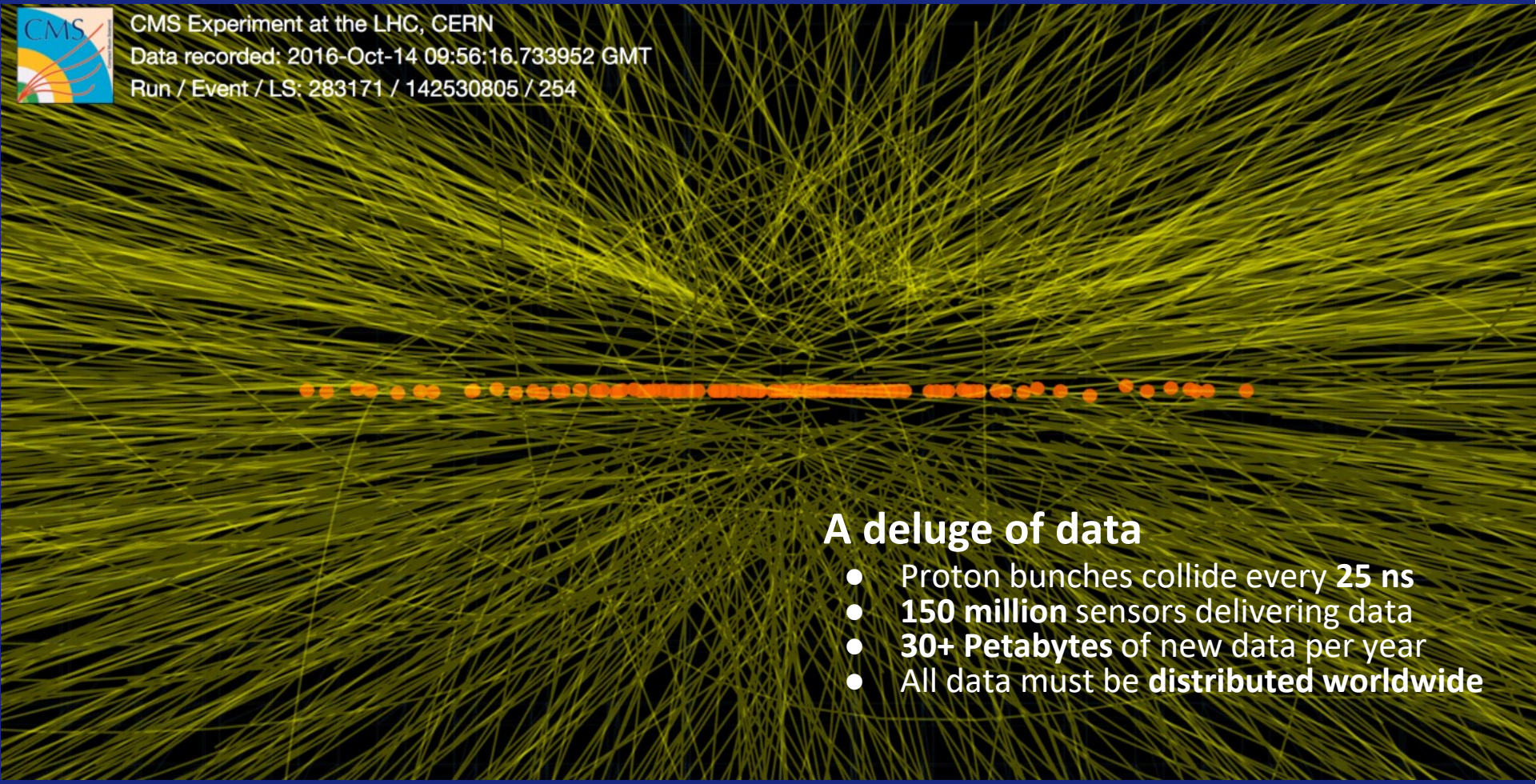
- What is the origin of mass? why some particles are very heavy while others have no mass at all ?
- Is the 125 GeV Higgs boson the fundamental scalar predicted by SM, or is it explained by an extend theory (why 125 GeV) ?
- What are dark Matter and dark energy?
- Why is there far more matter than antimatter in the universe?
- How does the quark-gluon plasma give rise to the particles that constitute the matter of our Universe?
- and many more …

Search for new phenomena …

- Gravity and extra dimensions ?
- Supersymmetric particles ?
- New fundamental interactions ?
- New generations of quarks/leptons ?
- Leptoquarks ?
- Something else completely new ?


Large Hadron Collider
Circumference: ~ 27 Km
Depth: up to 175 meters
Electrical power: 120 MW (600 GWh per year)
CMS
LHCb
CERN LHC
Alice
Atlas


CMS @ LHC
Compact Muon Solenoid
Pixel
Tracker
ECAL
HCAL
Muons
Solenoid coil
Total weight 12500 t, Overall diameter 15 m, Overall length 21.6 m, Magnetic field 4 Tesla



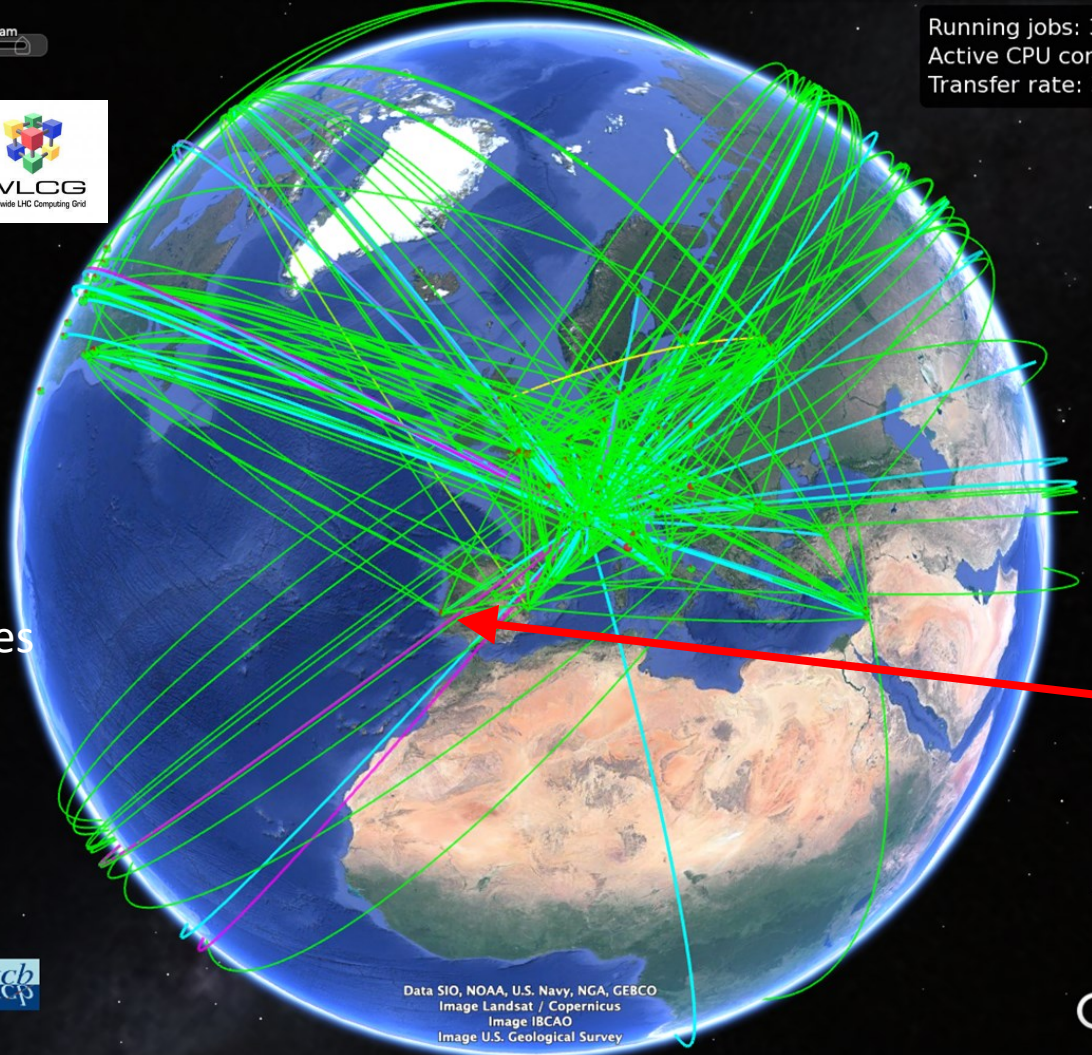
A deluge of data

- Proton bunches collide every **25 ns**
- **150 million** sensors delivering data
- **30+ Petabytes** of new data per year
- All data must be **distributed worldwide**

Worldwide LHC Computing Grid

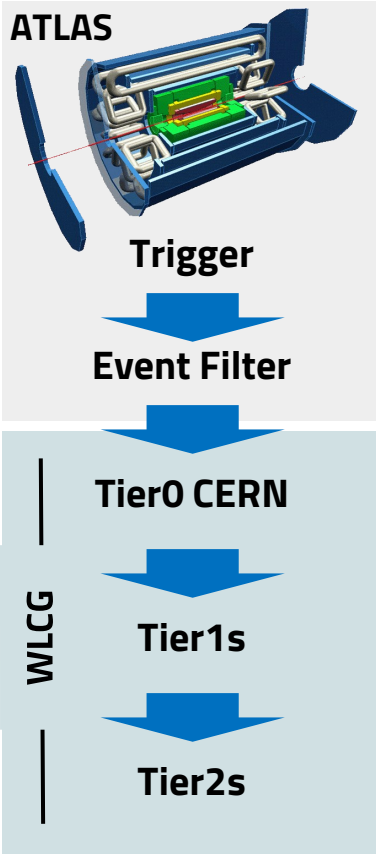
Computing and data infrastructure for the LHC experiments

- 170+ sites
- 42 countries
- 2 million tasks/day
- 1.4 million CPU cores
- 1.5 Exabytes
- 12 000 users

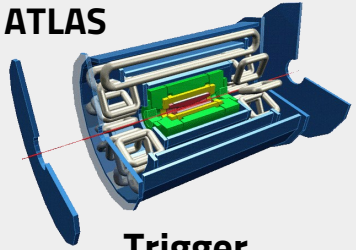


Portugal has a Tier-2 site operated by **LIP** + INCD

Overview of the data processing in the ATLAS experiment



Overview of the data processing in the ATLAS experiment



Trigger

Event Filter

WLCG

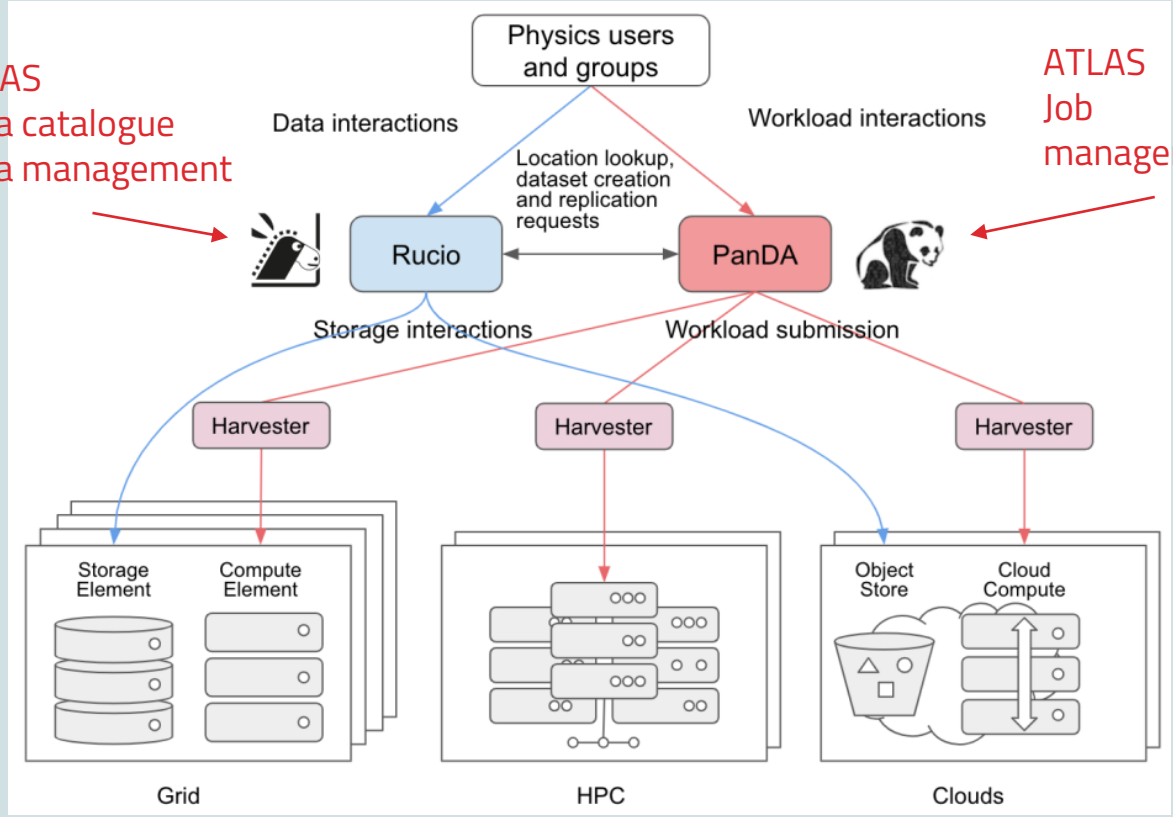
Tier0 CERN

Tier1s

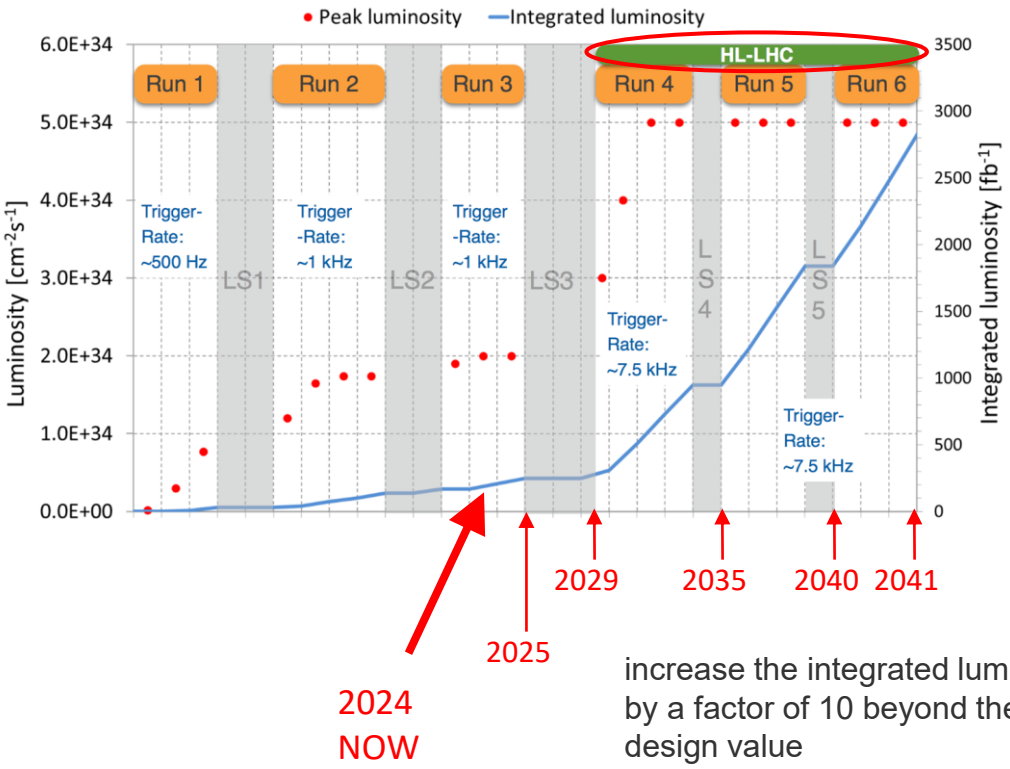
Tier2s

ATLAS
Data catalogue
Data management

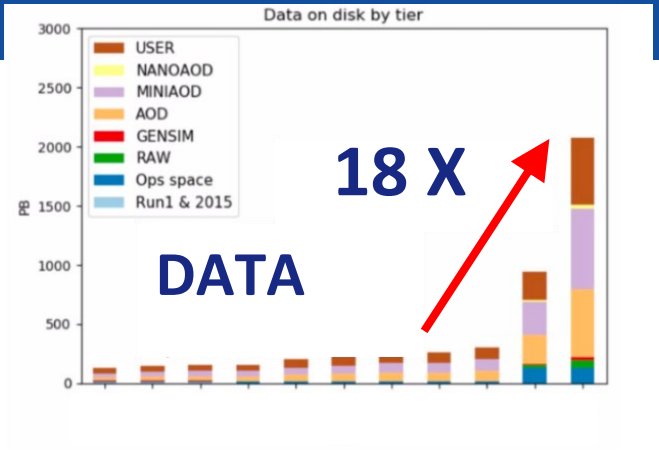
ATLAS
Job
management

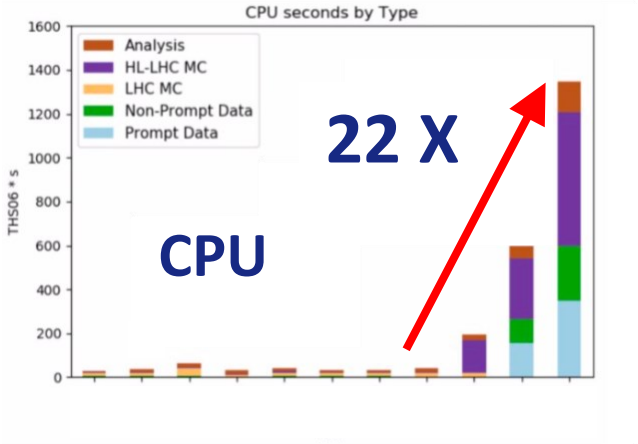


A growing challenge ⇒ High Luminosity LHC (HL-LHC)



increase the integrated luminosity by a factor of 10 beyond the LHC's design value





INCD and the Portuguese Tier-2

Infraestrutura Nacional de Computação Distribuída
Portuguese Worldwide LHC Computing Grid Tier-2

INCD centers in 2023

Cloud Computing
cloud computing

HTC Computing
high throughput computing (GRID)

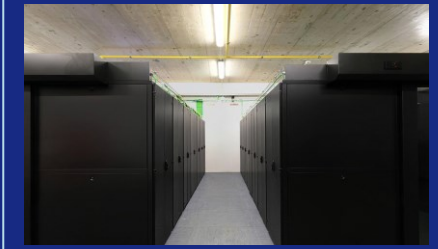
HPC Computing
high performance computing

RNCA

INCD-A @ LNEC in Lisbon
HPC / HTC / Cloud / Federation
6000 CPU cores
5 Petabytes online raw
100 Gbps + 100 Gbps LHCONE
Includes the WLCG Tier-2

INCD-B @ REN in Riba-de-Ave (partially moved to Lisbon)
HPC / HTC
2600 CPU cores (640 cores)
384 Terabytes raw
1 Gbps

INCD-L @ LIP in Lisbon
Tape storage
1 Petabyte backups
10 Gbps



INCD-D @ UTAD in Vila Real
HPC / HTC / Cloud / Federation
5000 CPU cores + IB HDR200
4 Petabytes online raw
10 Gbps

INCD-C @ UC in Coimbra (BEING IMPROVED)
Tape storage expansion
20 Petabytes
10 Gbps

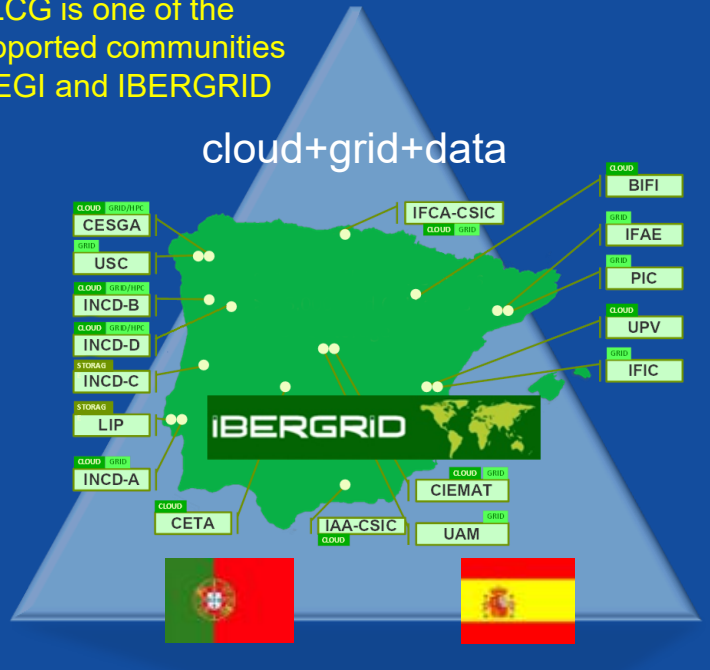
LIP in **IBERGRID and EGI**

Federating compute and storage from hundreds of data centres for research.
WLCG is one of the supported communities In EGI and IBERGRID

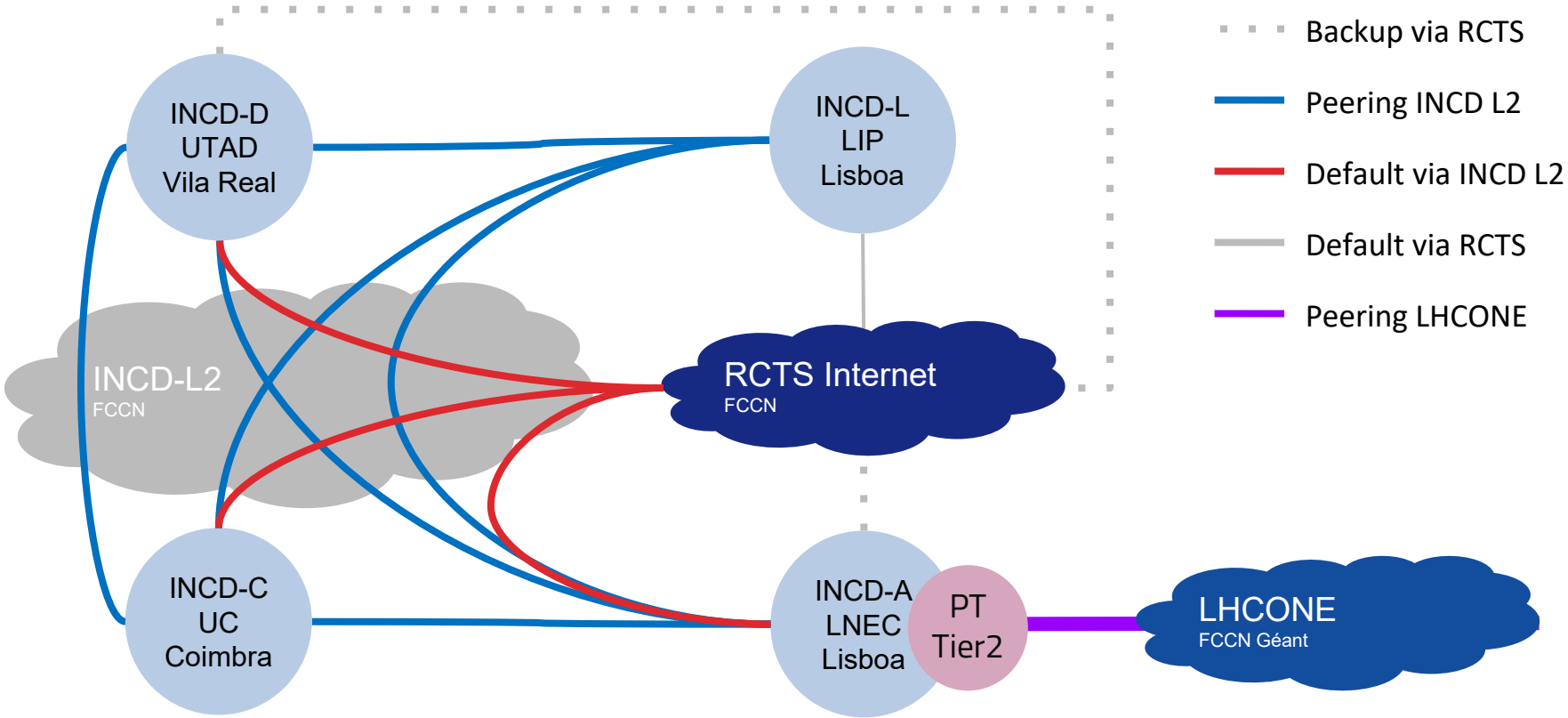
36 EU funded projects
1790 Enabled articles
7.1B HTC CPU hours consumed
29 EGI Council participants
84.000 Users
407M Computational jobs
70M Cloud CPU hours consumed

LIP responsibilities and activities:

- IBERGRID and EGI provide the backbone for WLCG
- Infrastructure operations coordination at Iberian level and interface with EGI operations
- Software management for the EGI and IBERGRID federations
- National technical contact point
- Security contact for Portugal
- Support to user communities
- Developing and operating core services e.g. software repositories for the EGI federation
- Integration of thematic and/or user services



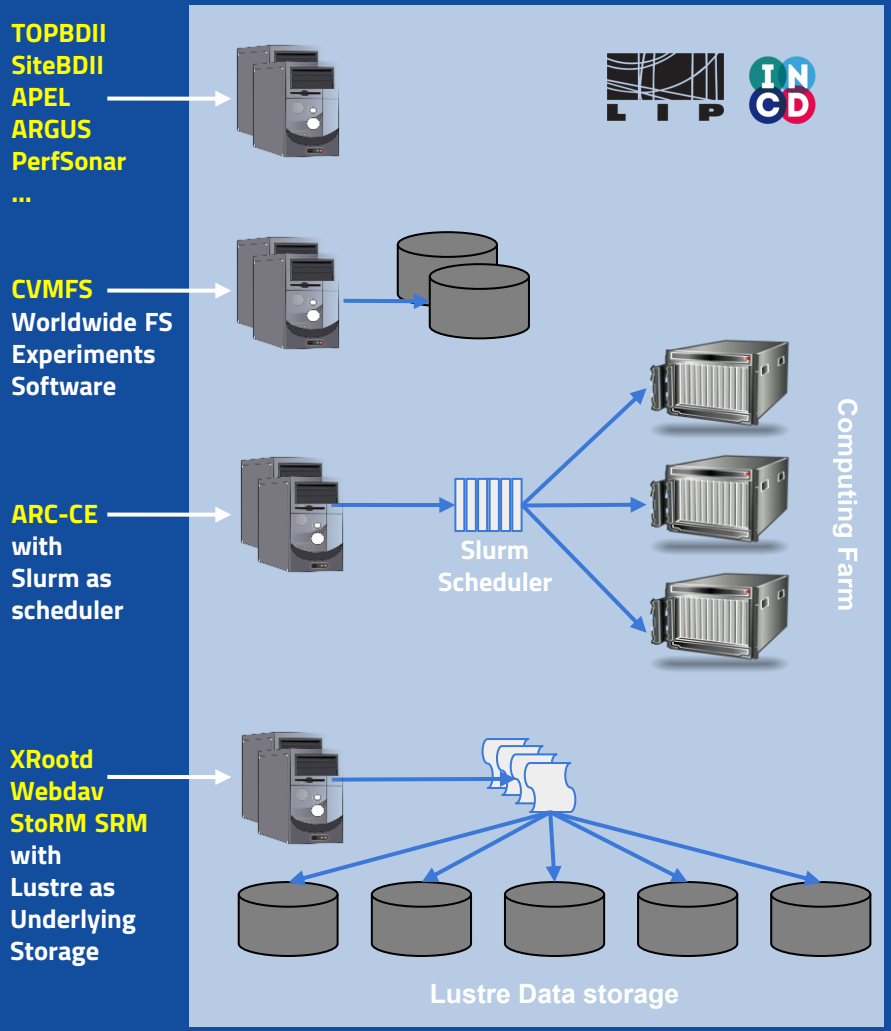
Peerings


Backup via RCTS
Peering INCD L2
Default via INCD L2
Default via RCTS
Peering LHCONE
INCD-D
UTAD
Vila Real
INCD-L
LIP
Lisboa
INCD-L2
FCCN
RCTS Internet
FCCN
INCD-C
UC
Coimbra
INCD-A
LNEC
Lisboa
PT
Tier2
LHCONE
FCCN Géant

Portuguese WLCG Tier-2
ATLAS and CMS

The **Tier-2 / Tier-3** uses the INCD infrastructure and is **operated by the LIP** computing team.

- High Throughput Computing facility
- Based at INCD using the Lisbon site
- Shares the INCD Slurm batch system
- Shares the INCD Lustre storage system
- Intensive data processing and analysis
- Montecarlo simulations
- Continuous data WAN data transfers



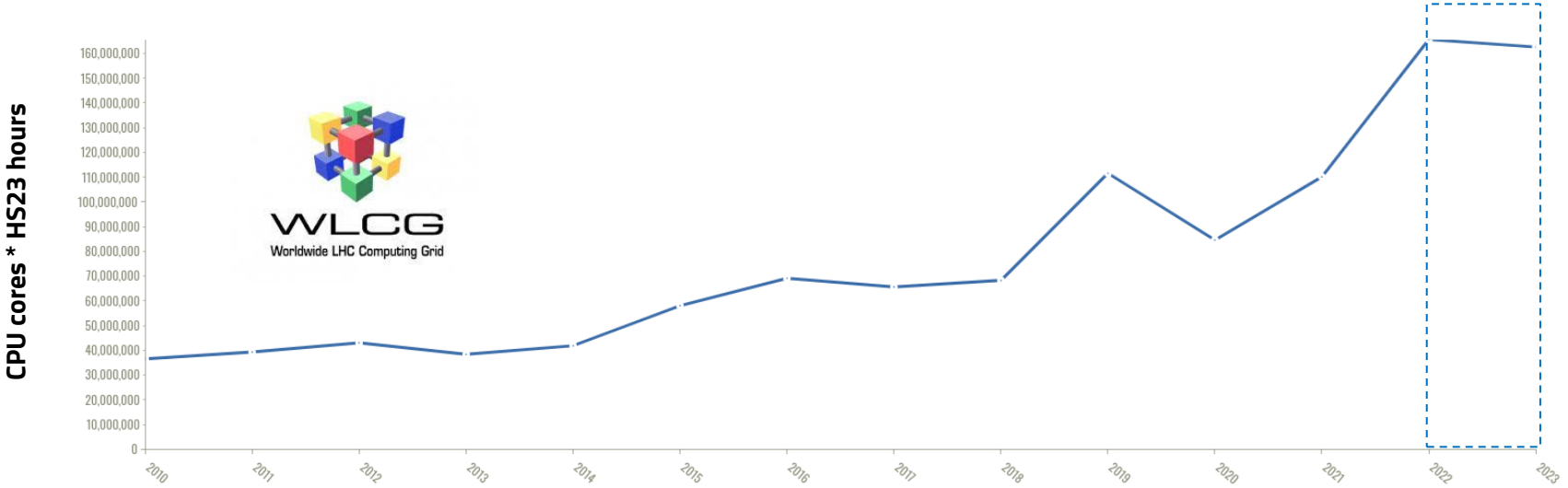
Portuguese WLCG Tier-2
ATLAS and CMS

Operating 24x365 since 2010:

- 22,471,371 jobs
- 1,131,173,940 HS23 hours

Supported experiments:

- ATLAS (50%)
- CMS (50%)

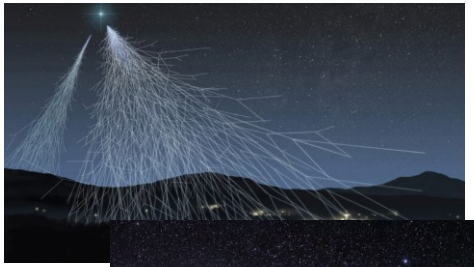


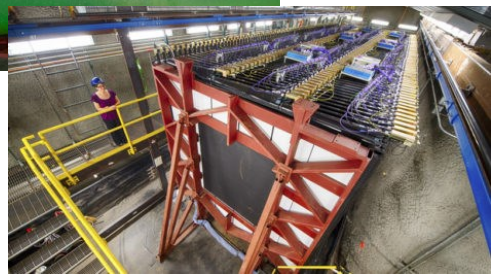
BELLA

High Energy Physics data across the atlantic

LIP common projects with Latin America

- Common CERN LHC experiments **CMS** and **ATLAS**
- **AUGER @ Pierre Auger Laboratory** cosmic rays observatory in Argentina
- **MARTA** muon detector Argentina
- **DUNE** at LBNF - Fermilab US
- **SWGO** Southern Wide-Field Gamma Ray Observatory





BELLA-S

cedia

RedCLARA

RedUNA
Ciencia y Educación en Red

RNP
REDE NACIONAL DE ENSINO E PESQUISA

GÉANT

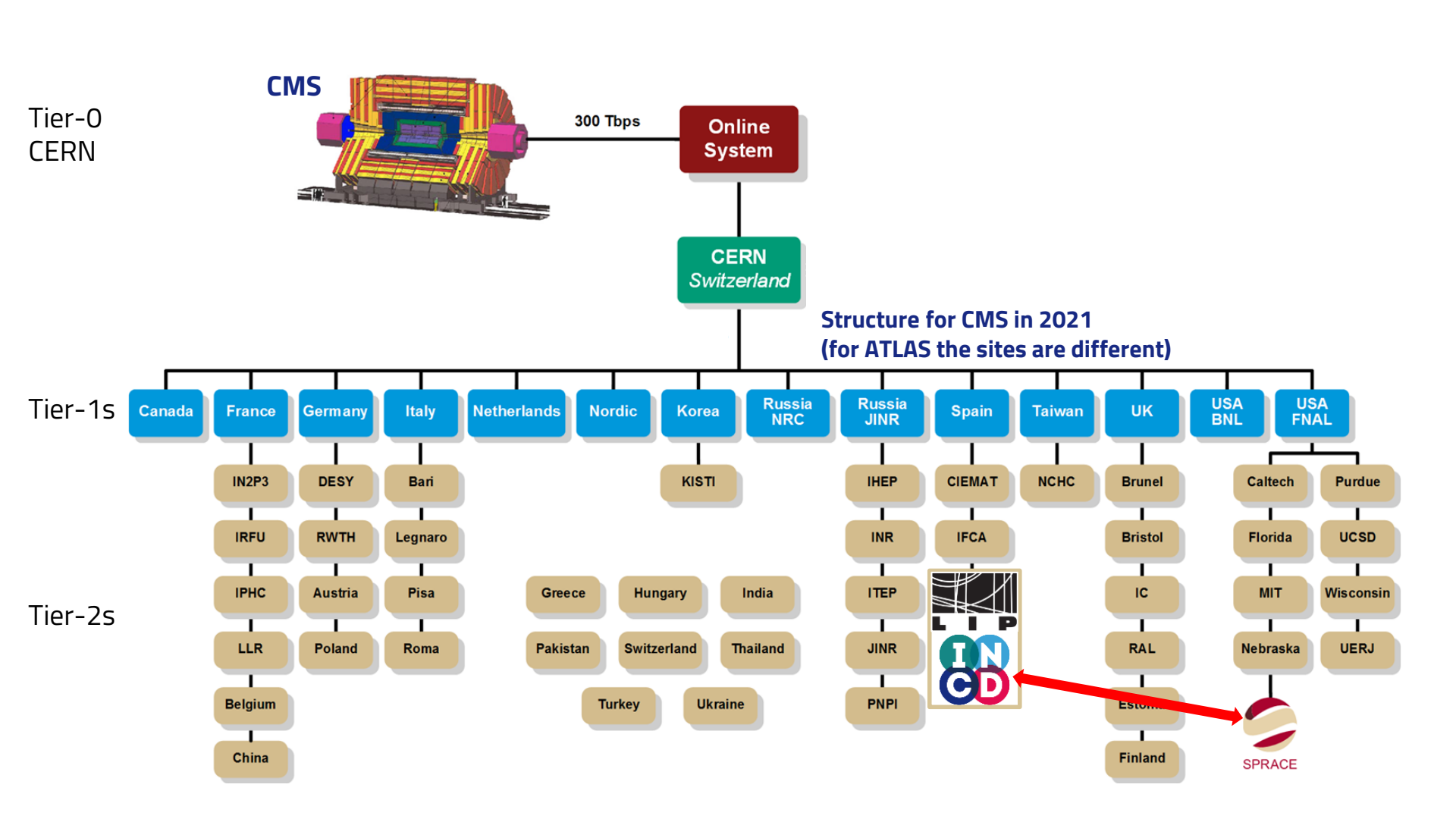
DFN
DEUTSCHES FORSCHUNGSNETZ

FCT Fundação para a Ciência e a Tecnologia
Computação Científica Nacional
FCCN

Consortium GARR

Red IRIS

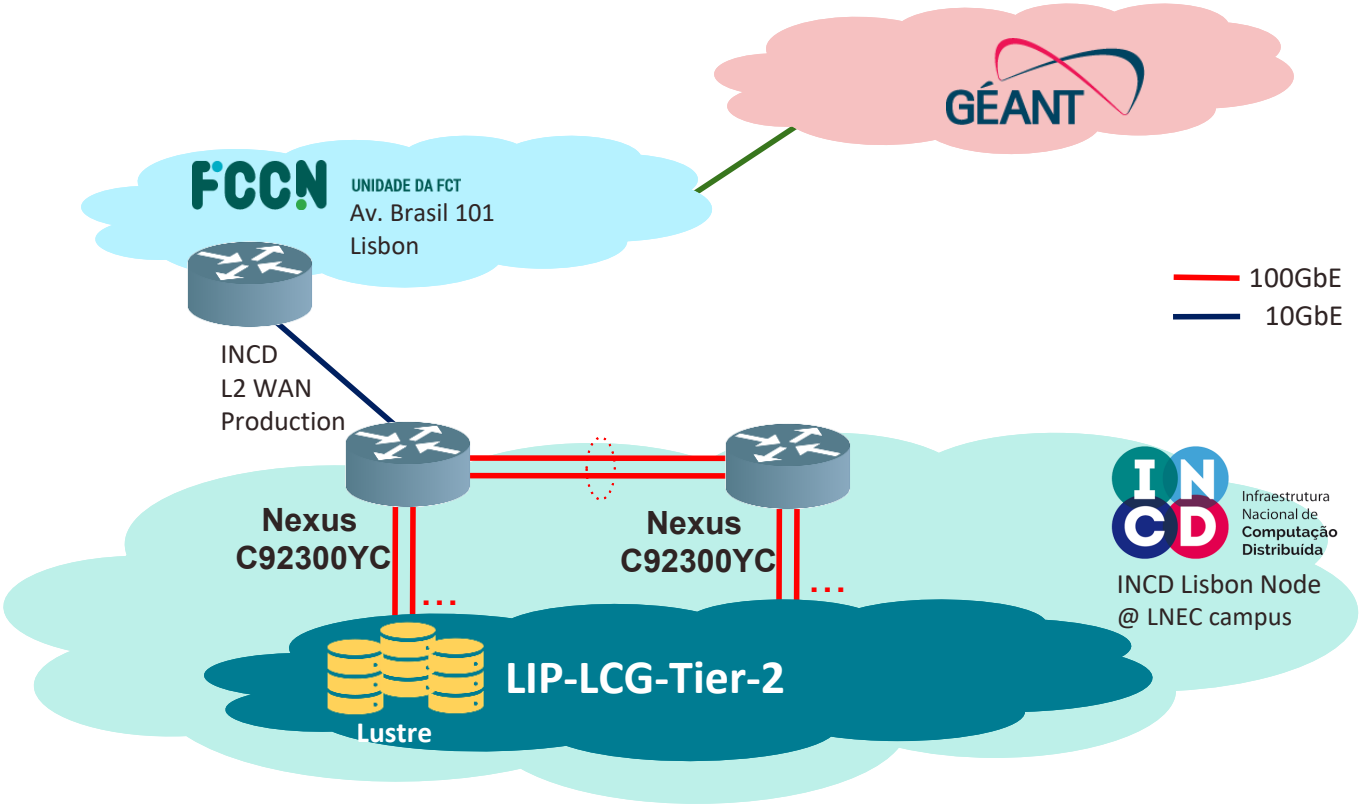
RENATER
CONNECTEUR DE SAVOIRS


Tier-0
CERN
CMS
300 Tbps
Online System
CERN
Switzerland
Structure for CMS in 2021
(for ATLAS the sites are different)
Tier-1s
Canada
France
Germany
Italy
Netherlands
Nordic
Korea
Russia NRC
Russia JINR
Spain
Taiwan
UK
USA BNL
USA FNAL
Tier-2s
IN2P3
IRFU
IPHC
LLR
Belgium
China
DESY
RWTH
Austria
Poland
Bari
Legnaro
Pisa
Roma
Greece
Hungary
India
Pakistan
Switzerland
Thailand
Turkey
Ukraine
KISTI
IHEP
INR
ITEP
JINR
PNPI
CIEMAT
IFCA
LIP
INCD
NCHC
Brunel
Bristol
IC
RAL
Finland
Caltech
Florida
MIT
Nebraska
Purdue
UCSD
Wisconsin
UERJ
SPRACE

LIP-Tier2 connectivity for Bella 2021

LIP-Tier-2

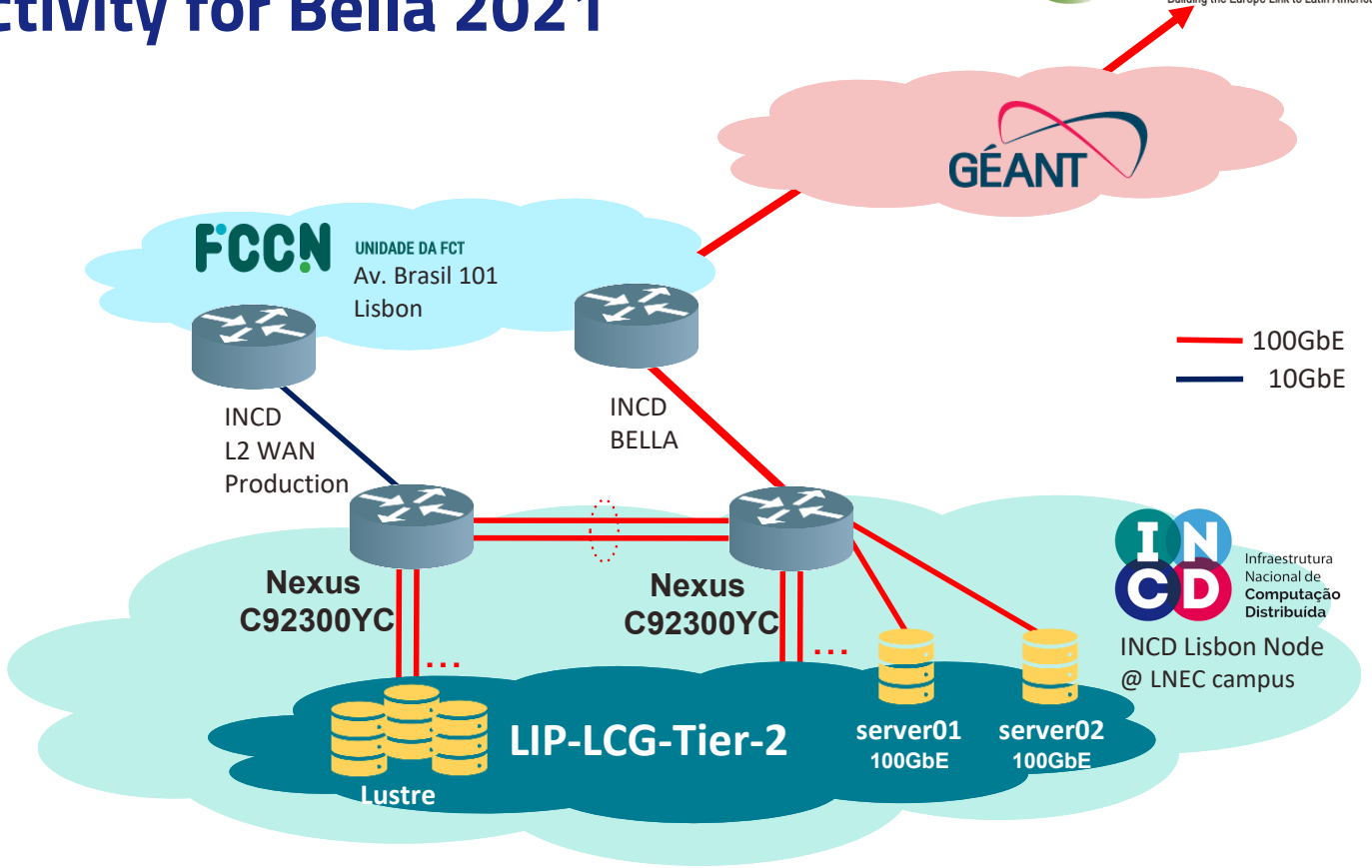
- Supports CMS and ATLAS experiments
- The Tier-2 is part of the INCD infrastructure



LIP-Tier2 connectivity for Bella 2021

LIP-Tier-2

- Supports CMS and ATLAS experiments
- The Tier-2 is part of the INCD infrastructure



server01 Xeon Silver 4110 2.1GHz 16C 160GB RAM + Mellanox NIC + NVME
server02 Epyc 7501 2.0GHz 64C 512GB RAM + Mellanox NIC + NVME

UNIDADE DA FCT

Red CLARA

Cooperación Latino Americana de Redes Avanzadas

SPRACE

SÃO PAULO RESEARCH AND ANALYSIS CENTER

Infraestrutura
Nacional de
Computação
Distribuída

Latency between the PT CMS Tier-2 and BR CMS tier-2

Before Bella

- Latency to SPRACE ~ 254 ms

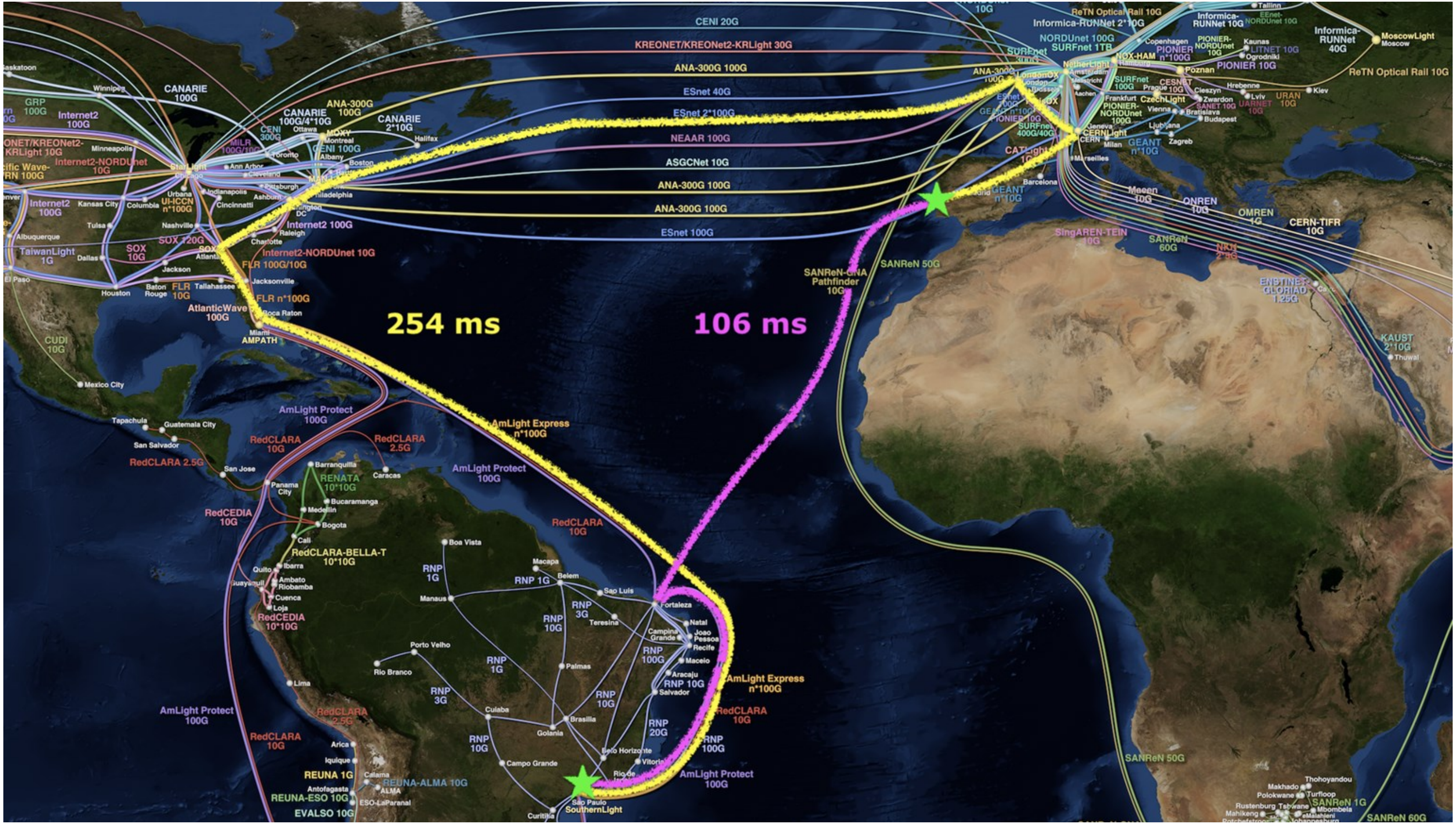
1 172.16.203.254 (172.16.203.254) 0.437 ms
2 172.16.100.1 (172.16.100.1) 0.346 ms
3 Router63.Lisboa.fccn.pt (193.137.1.233) 0.698 ms
4 Router30.Lisboa.fccn.pt (194.210.6.112) 0.617 ms
5 Router1.Lisboa.fccn.pt (194.210.6.103) 0.752 ms
6 fccn.mx2.lis.pt.geant.net (62.40.124.97) 0.407 ms
7 ae4.mx1.mad.es.geant.net (62.40.98.97) 9.513 ms
8 ae7.mx1.gen.ch.geant.net (62.40.98.67) 44.189 ms
9 ae6.mx1.par.fr.geant.net (62.40.98.183) 36.771 ms
10 ae5.mx1.lon2.uk.geant.net (62.40.98.178) 43.299 ms
11 ae6.mx1.lon.uk.geant.net (62.40.98.36) 44.102 ms
12 internet2-gw.mx1.lon.uk.geant.net (62.40.124.45) 118.094 ms
13 ae-1.4079.rtsw.atla.net.internet2.edu (198.71.45.6) 131.068 ms
14 et-3-0-0.4079.rtsw.jack.net.internet2.edu (162.252.70.43) 136.614 ms
15 198.71.45.189 (198.71.45.189) 148.902 ms
16 ae0-2005.rt04.ce.ampath.net (190.103.185.11) 257.684 ms
17 143-108-254-242.ansp.br (143.108.254.242) 253.750 ms
18 200.136.80.225 (200.136.80.225) **253.616 ms** !X

With Bella

- Latency to SPRACE ~ 106 ms

1 172.16.203.254 (172.16.203.254) 0.382 ms
2 194.210.4.169 (194.210.4.169) 1.162 ms
3 Router30.Lisboa.fccn.pt (194.210.6.108) 0.562 ms
4 Router1.Lisboa.fccn.pt (194.210.6.103) 0.646 ms
5 fccn.mx2.lis.pt.geant.net (62.40.124.97) 0.495 ms
6 redclara-gw.lis.pt.geant.net (62.40.127.151) 62.728 ms
7 for-sao.redclara.net (200.0.204.7) 106.989 ms
8 sprace01.redclara.net (200.0.207.116) **106.452 ms** !X

Traceroutes from the LIP Tier-2 to SPRACE


254 ms
106 ms
CENI 20G
KREONET/KREONet2-KRLight 30G
ANA-300G 100G
ESnet 40G
ESnet 2*100G
NEAAR 100G
ASGCNet 10G
ANA-300G 100G
ANA-300G 100G
ESnet 100G
CANARIE 100G
Internet2 100G
Internet2-NORDUnet 10G
Internet2 100G
Internet2-NORDUnet 10G
FLR 100G/10G
FLR n*100G
AtlanticWave 100G
AMPATH
AmLight Express n*100G
AmLight Protect 100G
AmLight Protect 100G
AmLight Protect 100G
AmLight Protect 100G
AmLight Express n*100G
RedCLARA 10G
RedCLARA 2.5G
RedCLARA 2.5G
RedCLARA 10G
RedCLARA 10G
RedCLARA 10G
RedCLARA 10G
RedCEDIA 10G
RedCEDIA 10*10G
RedCLARA-BELLA-T 10*10G
RENATA 10*10G
RNP 1G
RNP 3G
RNP 10G
RNP 100G
RNP 10G
RNP 20G
RNP 100G
REUNA 1G
REUNA-ALMA 10G
REUNA-ESO 10G
EVALSO 10G
SouthernLight
Sao Paulo
Fortaleza
SANReN-GNA Pathfinder 10G
SANReN 50G
SANReN 50G
SANReN 60G
SANReN 1G
SANReN 60G
GEANT n*10G
GEANT n*10G
NetherLight
CERNLight
CERN
NORDUnet 100G
SURFnet 1TB
NOX-HAM
PIONIER 10G
ReTN Optical Rail 10G
Informica-RUNNet 2*10G
Informica-RUNNet 40G
MoscowLight
CERN-TIFR 10G
OMREN 1G
ONREN 10G
SingAREN-TEIN 10G
KAUST 2*10G
Mexico City
CUDI 10G
TaiwanLight 1G
SOX 10G
SOX 120G
Miami
Chicago
StarLight
MAN LAN
Barcelona
Marseilles

Latency between the PT CMS Tier-2 and BR CMS tier-2

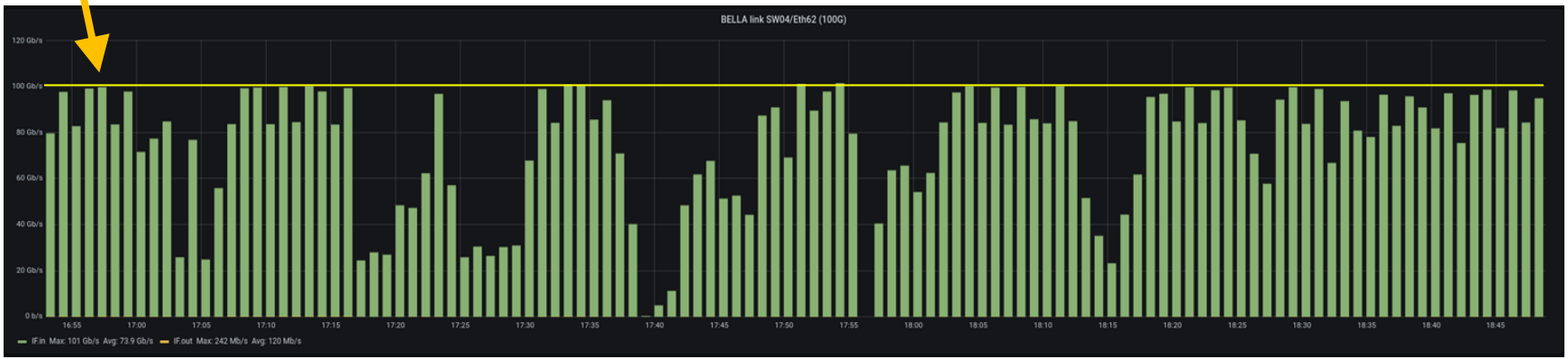
Production 10GbE

- Peak to SPRACE ~ 6 Gbps
- Using ~ 800 iperf streams

Using Bella 100GbE

- Peak to SPRACE ~ 100 Gbps
- Using ~ 480 iperf streams

100Gb/s



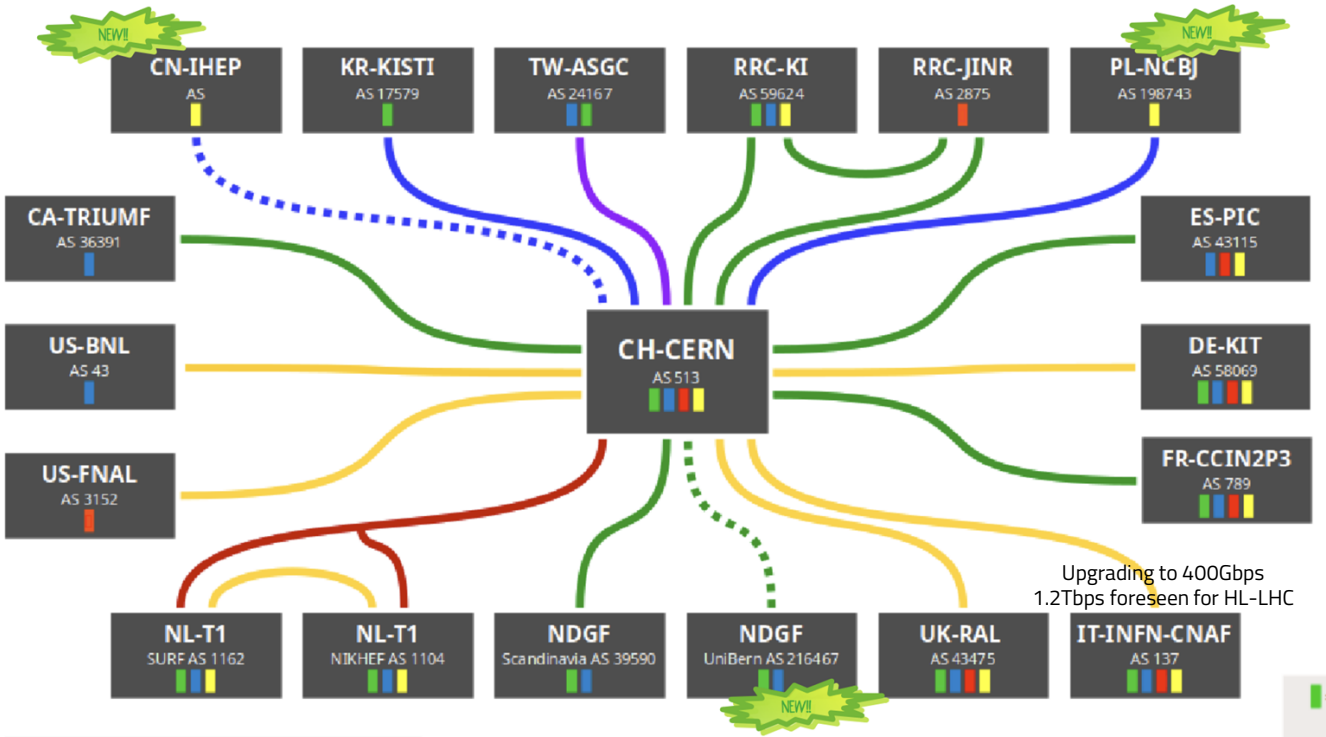
Using 2x INCD servers and 2x SPRACE servers (with 100GbE interfaces)

LHCOPN

LHC Optical private Network

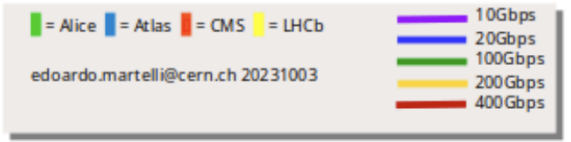
LHCOPN

LHC Optical Private Network (LHCONE)
Interconnects the WLCG Tier-1 centres worldwide



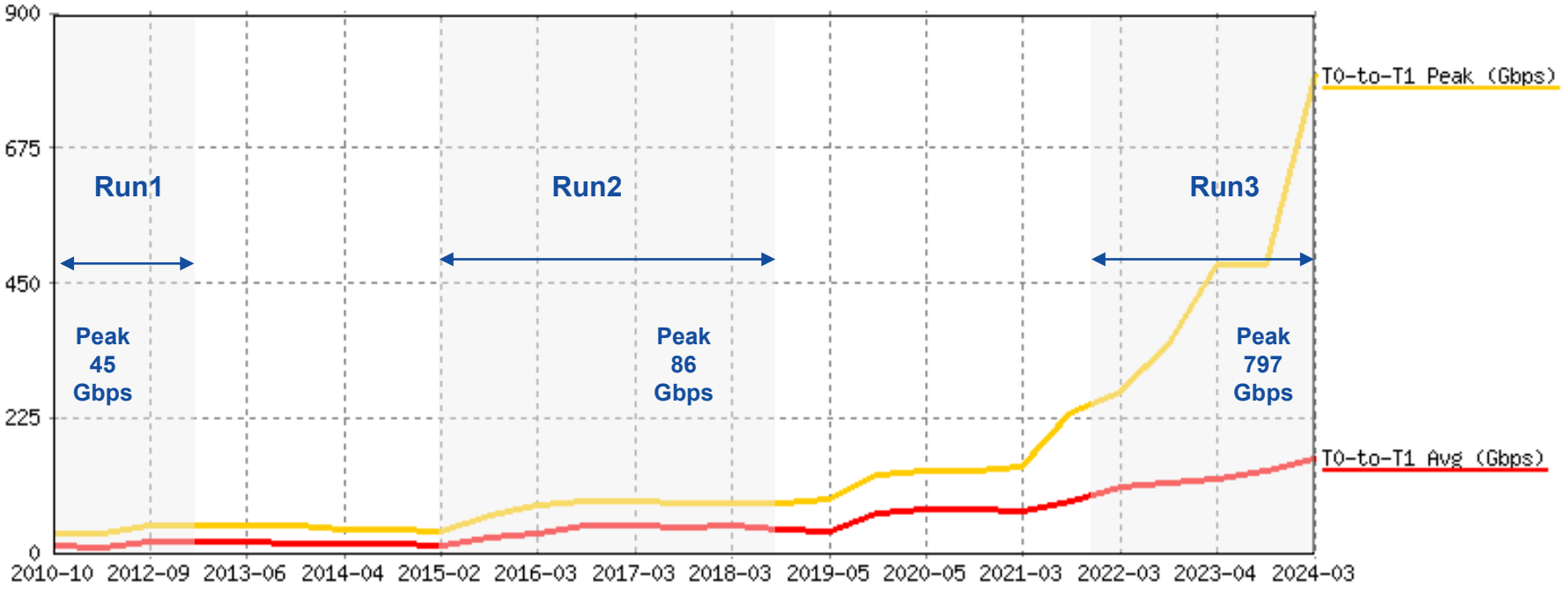
Star topology

- 1x Tier-0
- 15x Tier-1s
- 18x Sites
- 15x countries
- 3x continents



Requirement for 2029: 1 Tbps per site

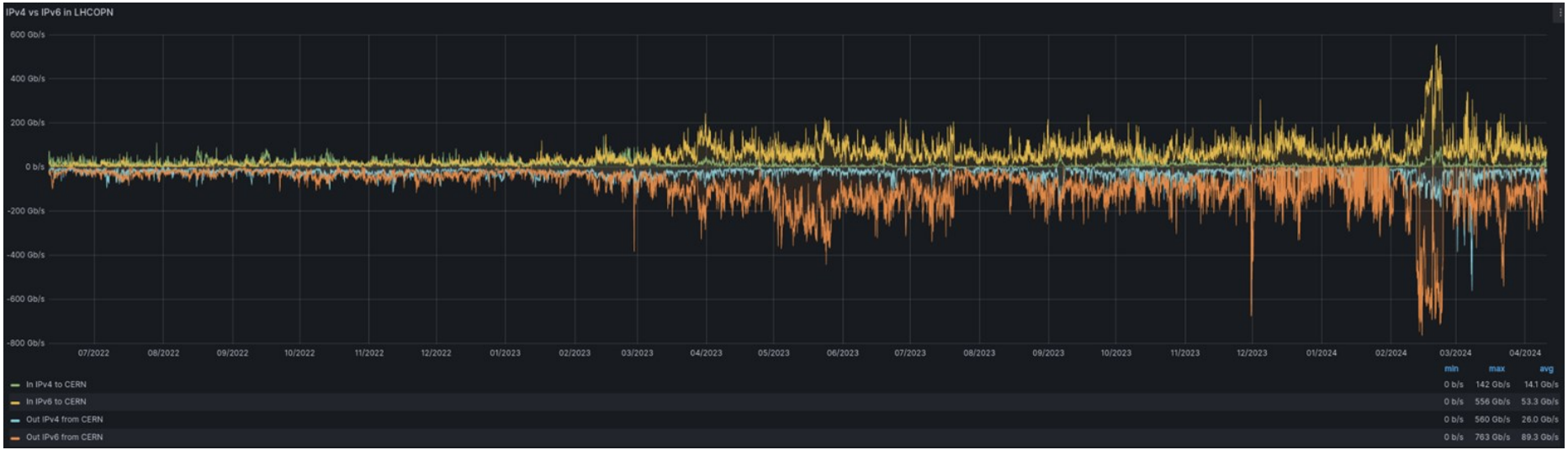
LHCOPN network traffic



LHCOPN network traffic from CERN Tier0 to all the aggregated Tier1s

CERN Tier0 outgoing → WLCG Tier1 centres (flow of data from the experiments at CERN to T1s)

LHCOPN traffic IPv4 / IPv6



CERN Light - LHCOPN IPv6 and IPv4 (IN+OUT)
Last 22 months

LHCONE

LHC Open Network Environment

LHCONE
LHC Open Network Environment (L3VPN service)

Private Network connecting WLCG sites (Tier-1s + Tier-2s)

- Dedicated network for LHC
  - **ATLAS**, **CMS**, ALICE LHCb
- A collaborative effort among Research & Education Network Providers
- Multi domain **L3 VPN**
- Routed Virtual Private Network connecting Science-DMZs
- BGP communities for traffic engineering
- Only for declared IP prefixes

The LHCONE is open to other HEP scientific collaborations

- Belle II
- Xenon
- Juno
- Nova
- **Pierre Auger Observatory**
- **DUNE**

The

- > 33 countries
- > 144 sites

LHCONE
News

LHCONE recent upgrades

- CERN upgrade to 400G with ESnet
- CERN upgrade to 2x 400G with GEANT

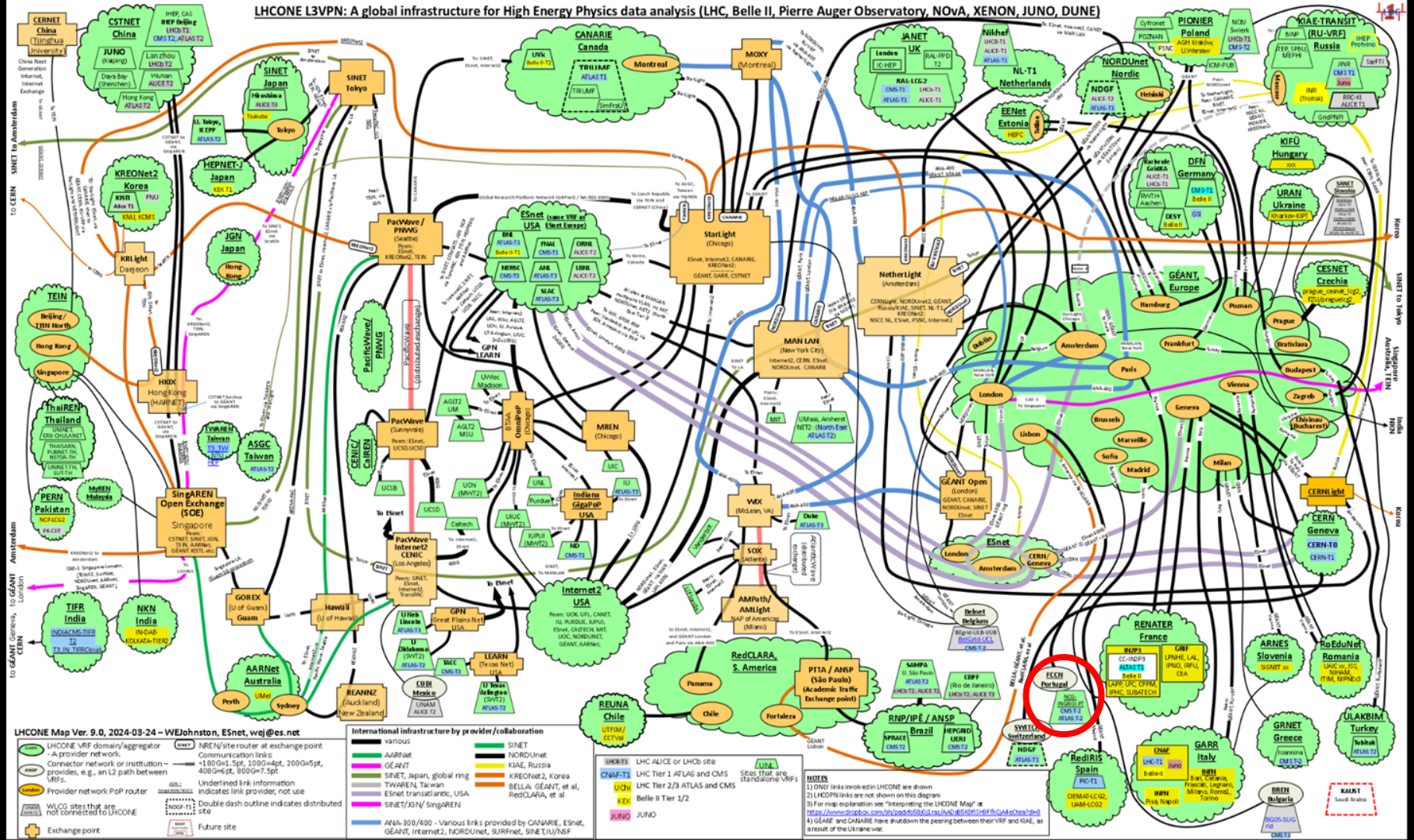
New sites in LHCONE:

- Lawrence Berkeley National Laboratory (US)
- University of Massachusetts (US)
- **LIP (Portugal) ⇐**

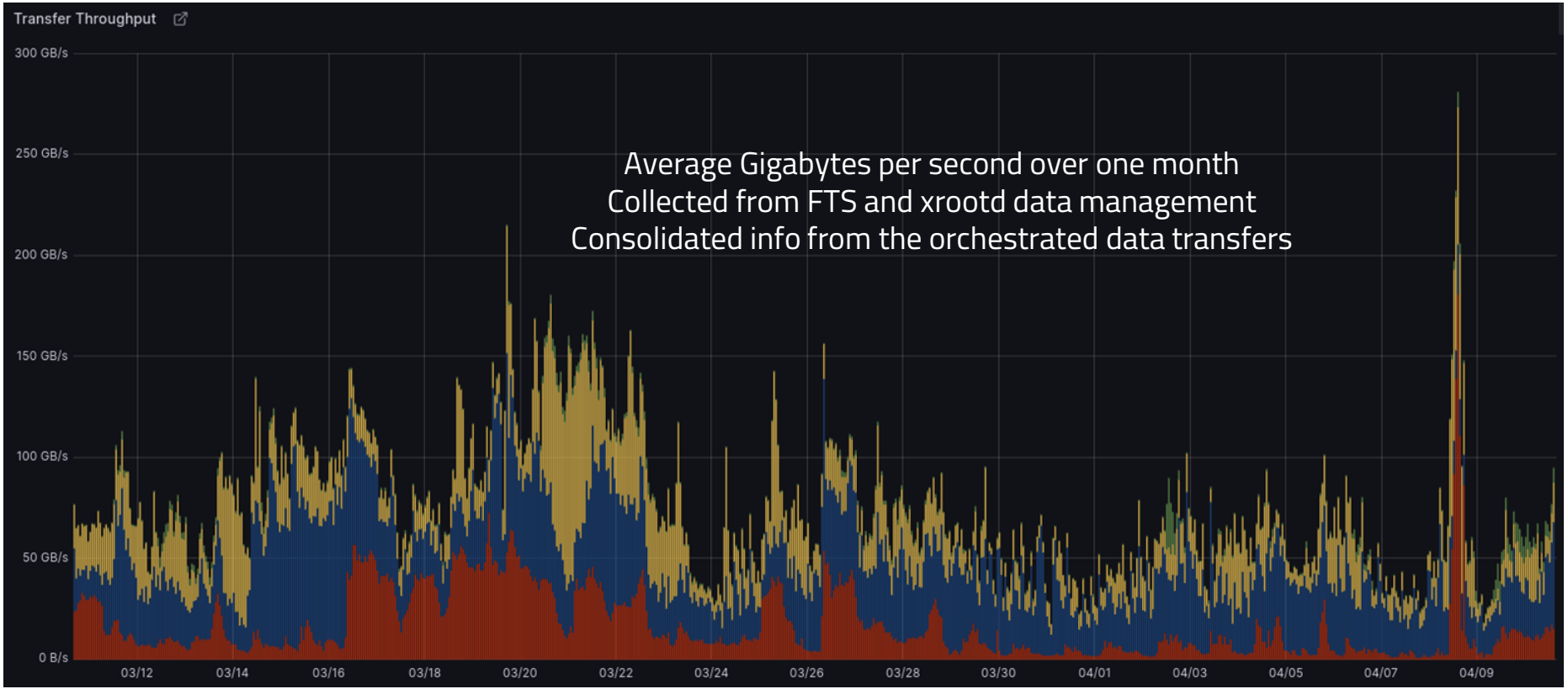
Traffic:

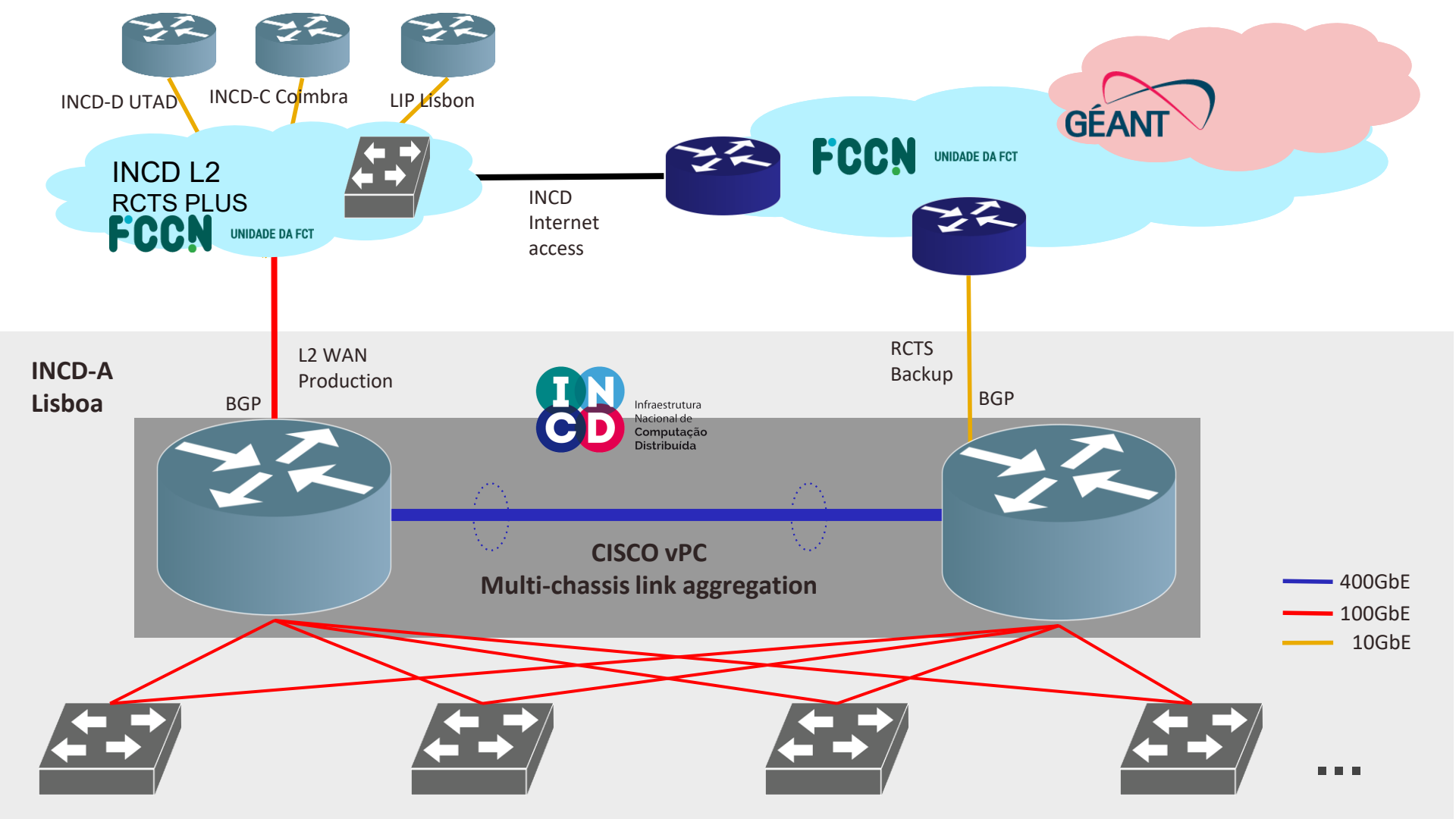
- Seen first LHCONE peak above 1 Tbps in GEANT

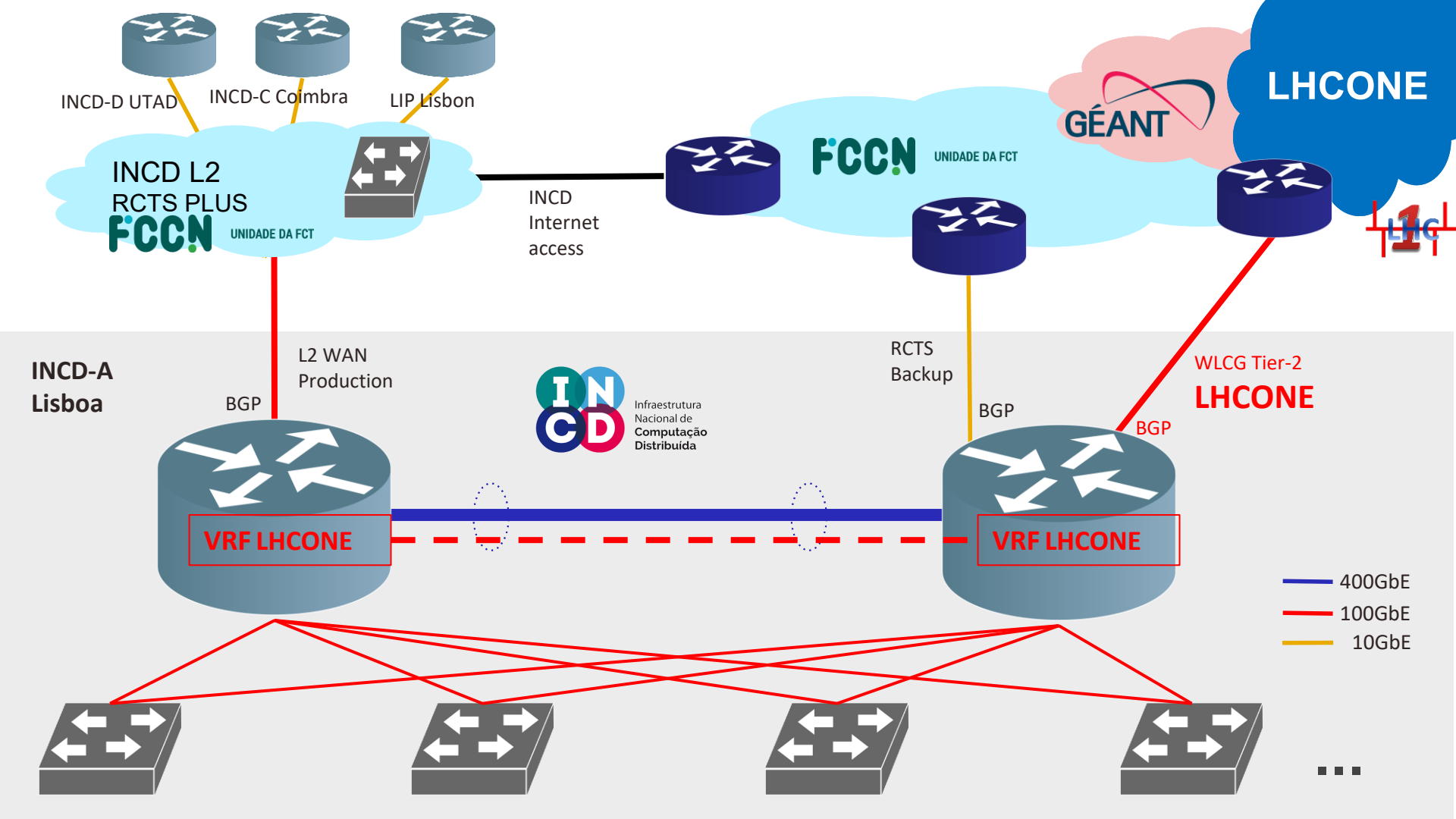
LHCONE L3VPN: A global infrastructure for High Energy Physics data analysis (LHC, Belle II, Pierre Auger Observatory, NOvA, XENON, JUNO, DUNE)

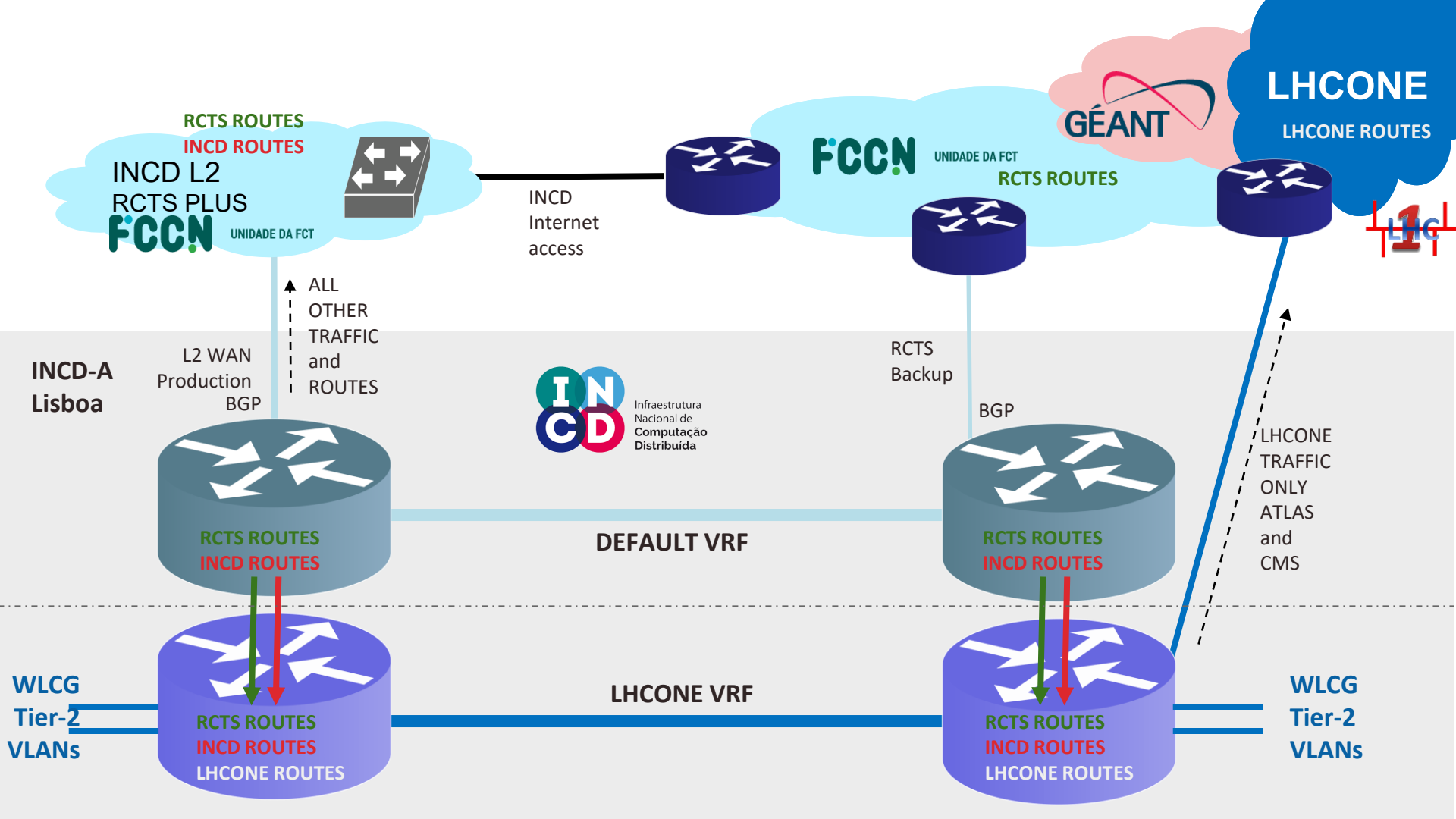


WLCG data transfers




INCD-D UTAD
INCD-C Coimbra
LIP Lisbon
INCD L2
RCTS PLUS
FCCN UNIDADE DA FCT
INCD
Internet
access
FCCN UNIDADE DA FCT
GÉANT
INCD-A
Lisboa
L2 WAN
Production
BGP
RCTS
Backup
BGP
Infraestrutura
Nacional de
Computação
Distribuída
CISCO vPC
Multi-chassis link aggregation
400GbE
100GbE
10GbE
...


INCD-D UTAD
INCD-C Coimbra
LIP Lisbon
INCD L2
RCTS PLUS
FCCN UNIDADE DA FCT
INCD
Internet
access
FCCN UNIDADE DA FCT
GÉANT
LHCONE
INCD-A
Lisboa
L2 WAN
Production
BGP
RCTS
Backup
BGP
BGP
WLCG Tier-2
LHCONE
Infraestrutura
Nacional de
Computação
Distribuída
VRF LHCONE
VRF LHCONE
400GbE
100GbE
10GbE
...


RCTS ROUTES
INCD ROUTES
INCD L2
RCTS PLUS
FCCN
UNIDADE DA FCT
INCD
Internet
access
FCCN
UNIDADE DA FCT
RCTS ROUTES
GÉANT
LHCONE
LHCONE ROUTES
ALL
OTHER
TRAFFIC
and
ROUTES
INCD-A
Lisboa
L2 WAN
Production
BGP
RCTS
Backup
BGP
Infraestrutura
Nacional de
Computação
Distribuída
LHCONE
TRAFFIC
ONLY
ATLAS
and
CMS
RCTS ROUTES
INCD ROUTES
DEFAULT VRF
RCTS ROUTES
INCD ROUTES
WLCG
Tier-2
VLANs
RCTS ROUTES
INCD ROUTES
LHCONE ROUTES
LHCONE VRF
RCTS ROUTES
INCD ROUTES
LHCONE ROUTES
WLCG
Tier-2
VLANs

LHCONE vs Internet

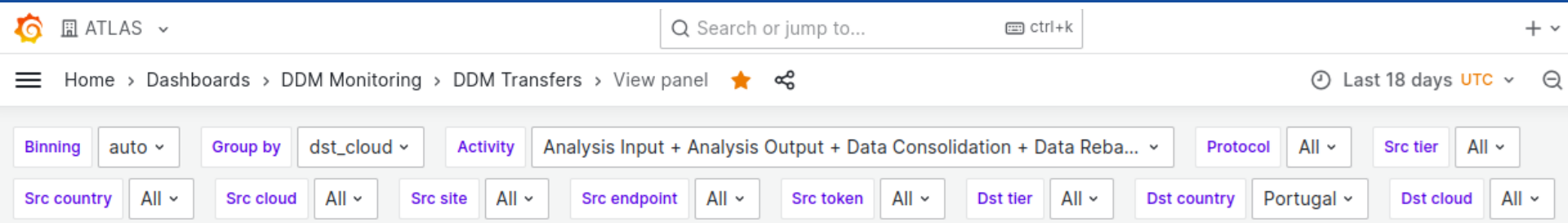
- Conventional Internet connectivity
- Personar latency node @Brookhaven (US)
- mtr -6 lhcperfmon.bnl.gov

```
                                My traceroute  [v0.85]
wn302.a.incd.pt (::)                                    Wed Apr 10 19:00:23
2024

                                                 Packets               Pings
 Host                                         Loss%   Snt   Last   Avg  Best  Wrst
StDev
 1. 2001:690:2150:aa:28:ffff:ffff:3            0.0%    61    0.7   0.8   0.6   1.1
0.0
 2. Router61.Lisboa.fccn.pt                   15.0%    61    0.9   1.0   0.8   1.9
0.0
 3. Router60.Lisboa.fccn.pt                    0.0%    61    6.5   6.5   6.4   7.4
0.0
 4. Router40.Porto.fccn.pt                     0.0%    61    6.7   6.6   6.4   6.8
0.0
 5. Router2.Porto.fccn.pt                     56.7%    61    6.7   7.0   6.6  10.9
0.8
 6. fccn-bckp-gw.rt1.por.pt.geant.net          0.0%    61    6.3   7.3   6.2  26.5
3.8
 7. ae2.rt1.bil.es.geant.net                   0.0%    61   36.2  35.6  35.1  36.9
0.2
 8. ae4.mx1.par.fr.geant.net                   0.0%    61   35.3  35.7  35.1  50.9
2.0
 9. ae8.mx1.lon2.uk.geant.net                  0.0%    61   31.8  32.3  31.8  32.5
0.0
10. ae2.mx1.lon.uk.geant.net                   0.0%    61   32.5  32.7  32.2  32.9
0.0
11. esnet-eex.lon.uk.geant.net                 0.0%    61  102.6 103.0 102.5 103.5
0.0
```

- LHCONE connectivity
- Personar latency node @Brookhaven (US)
- mtr -6 lhcperfmon.bnl.gov

```
                                My traceroute  [v0.85]
gftp01.ncg.ingrid.pt (::)                               Wed Apr 10 18:58:45 2024

                                                 Packets               Pings
 Host                                         Loss%   Snt   Last   Avg  Best  Wrst StDev
 1. 2001:690:2150:aa:35:ffff:ffff:4            0.0%    61    1.0   0.7   0.6   1.2   0.0
 2. 2001:690:810:154::1                       37.7%    61    1.2   1.2   0.7   6.9   0.9
 3. Router30.Lisboa.fccn.pt                    0.0%    61    0.9   0.7   0.5   0.9   0.0
 4. ???
 5. fccn-ap1-lhcone.mx2.lis.pt.geant.net       0.0%    61    0.4   1.4   0.3  27.4   3.9
 6. ae3.rt1.por.pt.geant.net                   0.0%    60   26.3  26.5  26.1  36.0   1.3
 7. ae2.rt1.bil.es.geant.net                   0.0%    60   28.6  28.5  28.2  36.9   1.1
 8. 2001:798:111:1::75                         0.0%    60   28.7  28.9  28.1  41.0   2.1
 9. newy32aoa-cr6--geant--se366-v6.lhcone.es   0.0%    60  101.2 101.2 101.1 101.7   0.0
10. bnl515b-cr6--bnl-se-101.lhcone.es.net      0.0%    60  100.6 100.5 100.4 101.0   0.0
11. bnl--bnl-se-101.lhcone.es.net              0.0%    60  102.6 102.6 102.5 103.1   0.0
12. ???
13. lhcperfmon.bnl.gov                         0.0%    60  102.5 102.5 102.5 102.8   0.0
```

ATLAS DDM (data transfers) monitoring



Before LHCONE

Efficiency

	CA	CERN	DE	ES	FR	IT	ND	NL	RU	UK	US
NCG-INGRID-PT_DATADISK	66%	43%	76%	11%	67%	88%	11%	77%	94%	85%	87%

With LHCONE

Efficiency

	CA	CERN	DE	ES	FR	IT	ND	NL	RU	UK	US
NCG-INGRID-PT_DATADISK	98%	100%	100%	91%	82%	90%	96%	100%	100%	95%	99%

Evolution and final remarks

Ongoing

IPv6 in WLCG

- WLCG now supports IPv6-only clients
- Tier-1s: complete; Tier-2s: 97% storage is IPv6 capable
- Most data transfers use IPv6
- We have concentrated on ensuring use of IPv6
  - LHCOPN/LHCONE can be 90-95% IPv6 - **but not always**!
- We continue to address more obstacles to IPv6 in WLCG
  - All WLCG CPU services and CPU clients to dual-stack is priority now
  - Approved by WLCG MB on 17 Oct 2023
- **End point is still IPv6-only services (IPv4 is "legacy" networking)**
- ***Message to new research communities - build on IPv6 from start***

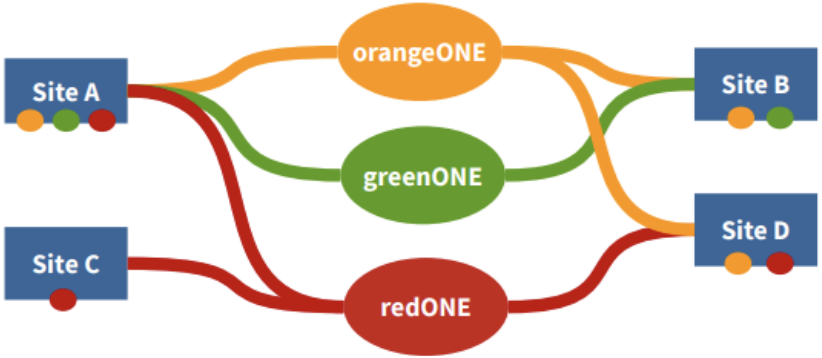
multiONE

LHCONE already very large, it could become risky to include other large science projects

Better to implement multiple VPNs, one for each collaboration:

- Each site joins only the VPNs it is collaborating with, to reduce the exposure of their data-centre

But it's difficult to separate the traffic for sites member of multiple collaborations. Work in Progress. A new proposal will be made tomorrow at the LHCONE meeting



Networking for the LIP Tier-2
Developments ongoing

- Monitoring
  - perfSONAR 5 instances (bandwidth, latency)
  - Improve monitoring
- Jumbo frames
  - For data transfers within LHCONE
  - First for storage gateways then for compute nodes
- Storage
  - Increase the number of storage gateways significantly
- Compute nodes
  - Separate traffic and route to LHCONE destinations
  - IPv6 as preferred protocol and bypass firewall for file transfers
- Enlarge usage to other projects
  - DUNE and AUGER

LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Thanks!

Discovery through science

Innovation through technology

Sharing with People

Use of the IPv6 Flow Label for WLCG Packet Marking
draft-cc-v6ops-wlcg-flow-label-marking-02

Workgroup: Internet Engineering Task Force
Internet-Draft: draft-cc-v6ops-wlcg-flow-label-marking-02
Published: 10 July 2023
Intended Status: Informational

Network Flow and Packet Marking for Global Scientific Computing (scitags.org)

- **IPv6 flowlabel tagging**

or another option

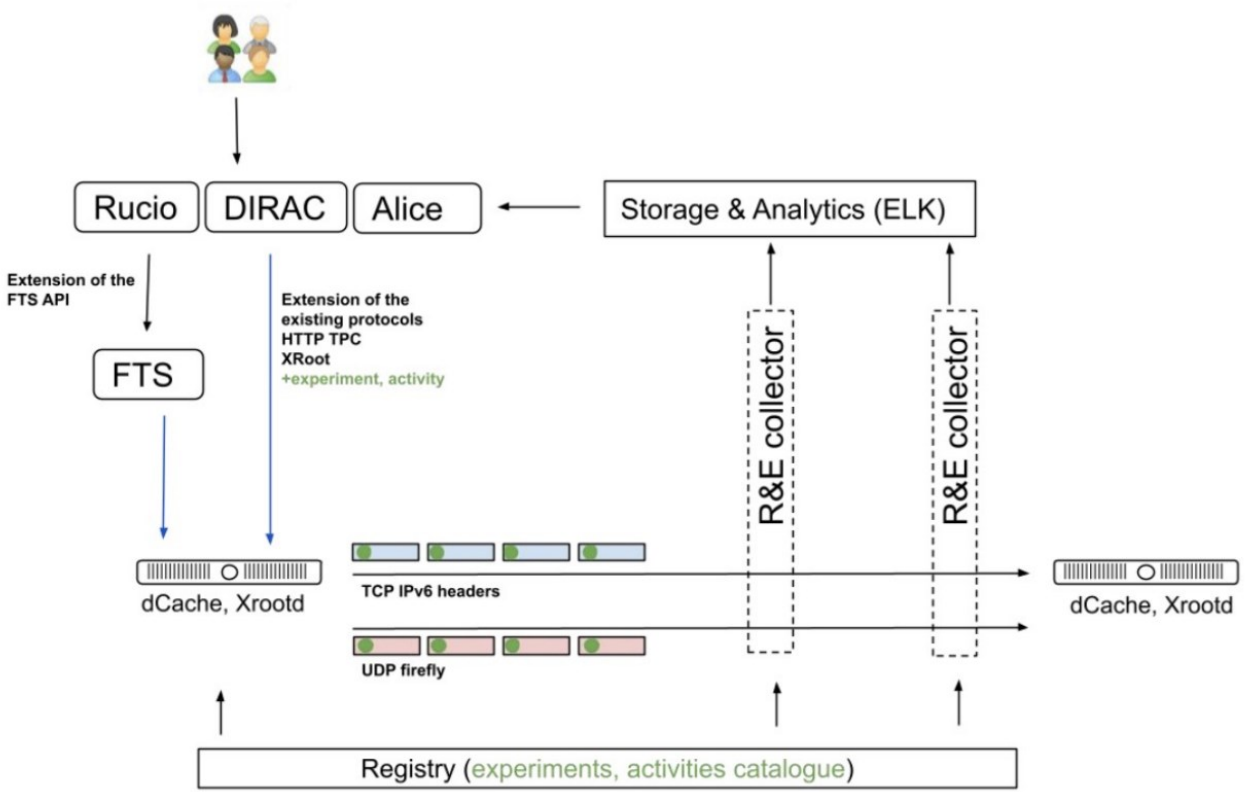
- **Firefly flow marking**

Use of the IPv6 Flow Label for WLCG Packet Marking

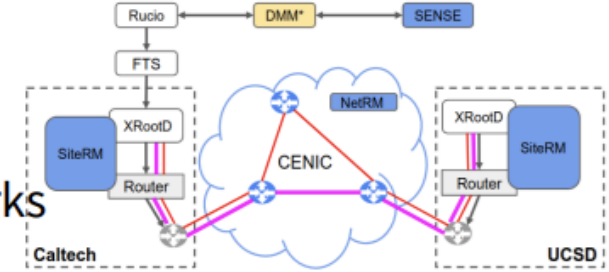
Abstract
This document describes an experimentally deployed approach currently used within the Worldwide Large Hadron Collider Computing Grid (WLCG) to mark packets with their project (experiment) and application. The marking uses the 20-bit IPv6 Flow Label in each packet, with 15 bits used for semantics (community and activity) and 5 bits for entropy. Alternatives, in particular use of IPv6 Extension Headers (EH), were considered but found to not be practical. The WLCG is one of the largest worldwide research communities and has adopted IPv6 heavily for movement of many hundreds of PB of data annually, with the ultimate goal of running

Use of the IPv6 Flow Label for WLCG Packet Marking

scitags.org



SENSE to move data



Project led by UCSD and Caltech

The increased requirements of the HL-LHC requires to use any resource in the most efficient way, including networks

Objectives of the project:

#1 Make Rucio capable to schedule transfers on the network and prioritize them

#2 Predetermined transfer speed and quality of service (time to completion)

Demonstrated:

- SENSE can build VPNs between pairs of XrootD servers in charge of FTS transfers requested by Rucio
- QoS can be provisioned in the network to prioritize the traffic in the VPN

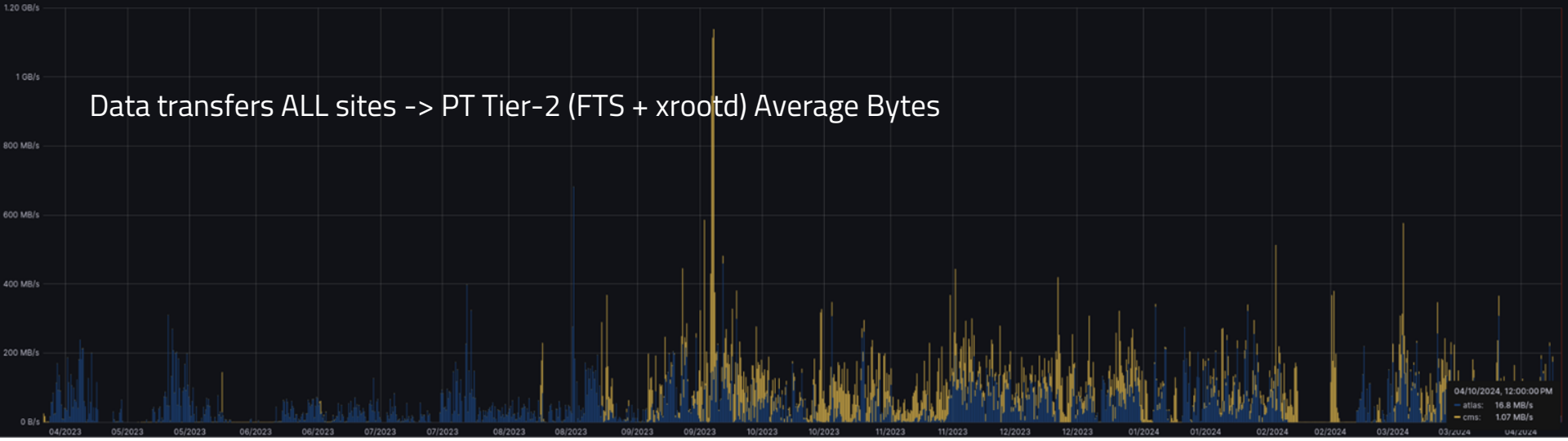
CERN connectivity

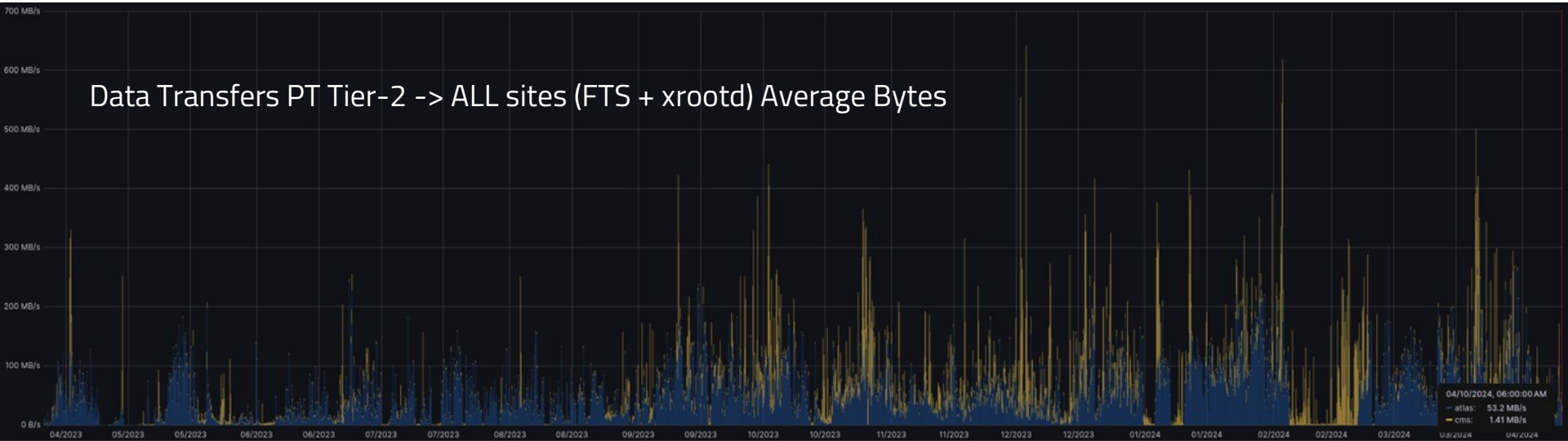
Experiments' DAQ lines to CERN IT data-centre, Capacity in place for LHC Run3:

- ALICE: 3.2 Tbps
- LHCb: 400 Gbps
- CMS: 400 Gbps
- ATLAS: 200 Gbps

CERN External Network: some numbers:

- LHCOPN capacity: 2.1 Tbps
- LHCONE capacity: 1.2 Tbps
- Internet capacity: 1 Tbps
- Stateful Firewall capacity: 0.6 Tbps
- HTAR (firewall bypass) capacity: 0.6 Tbps


Data transfers ALL sites -> PT Tier-2 (FTS + xrootd) Average Bytes
1.20 GB/s
1 GB/s
800 MB/s
600 MB/s
400 MB/s
200 MB/s
0 B/s
04/2023
05/2023
05/2023
06/2023
06/2023
07/2023
07/2023
08/2023
08/2023
09/2023
09/2023
10/2023
10/2023
11/2023
11/2023
12/2023
12/2023
01/2024
01/2024
02/2024
02/2024
03/2024
04/10/2024, 12:00:00 PM
atlas: 16.8 MB/s
cms: 1.07 MB/s


Data Transfers PT Tier-2 -> ALL sites (FTS + xrootd) Average Bytes
700 MB/s
600 MB/s
500 MB/s
400 MB/s
300 MB/s
200 MB/s
100 MB/s
0 B/s
04/2023
05/2023
05/2023
06/2023
06/2023
07/2023
07/2023
08/2023
08/2023
09/2023
09/2023
10/2023
10/2023
11/2023
11/2023
12/2023
12/2023
01/2024
01/2024
02/2024
02/2024
03/2024
04/10/2024, 06:00:00 AM
atlas: 53.2 MB/s
cms: 1.41 MB/s