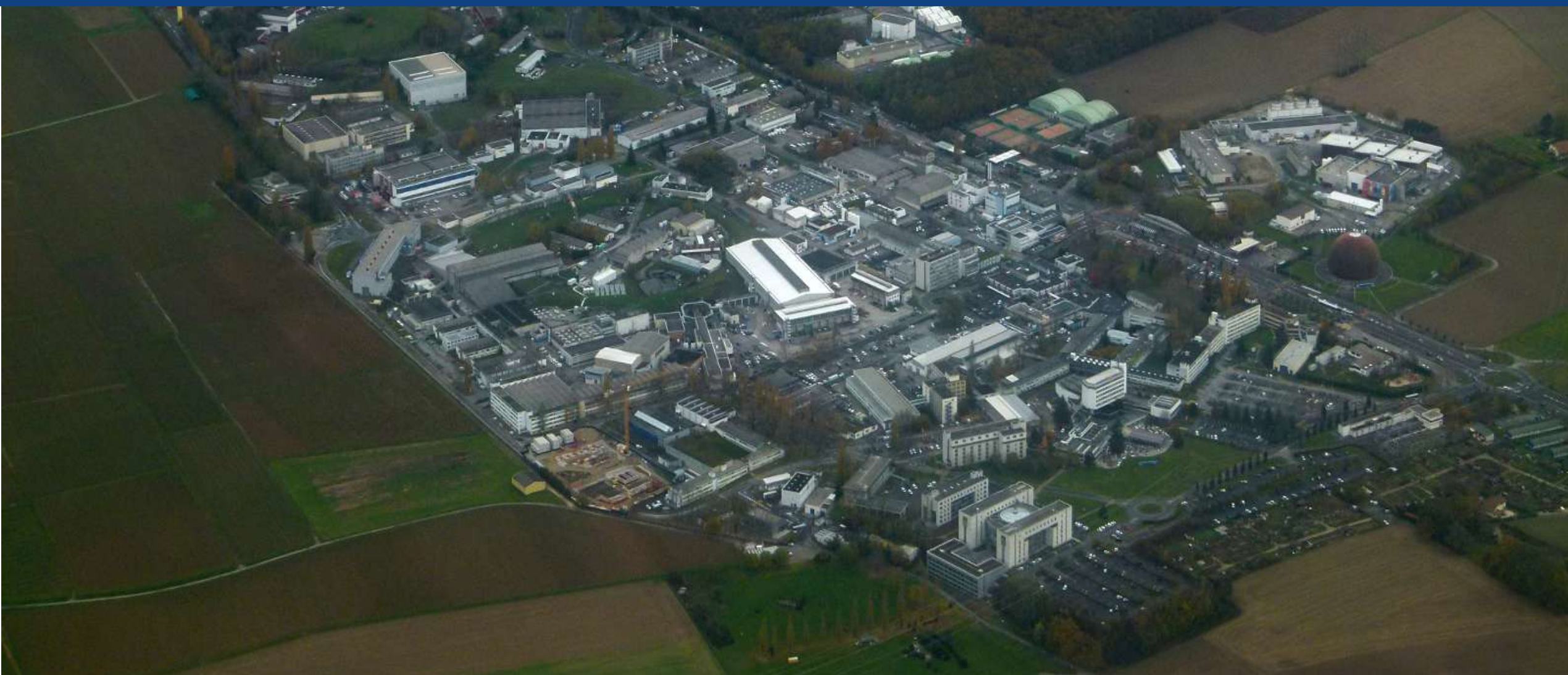# CERN, LHC and challenges ahead

4th SIG-NGN meeting
CERN, Geneva CH
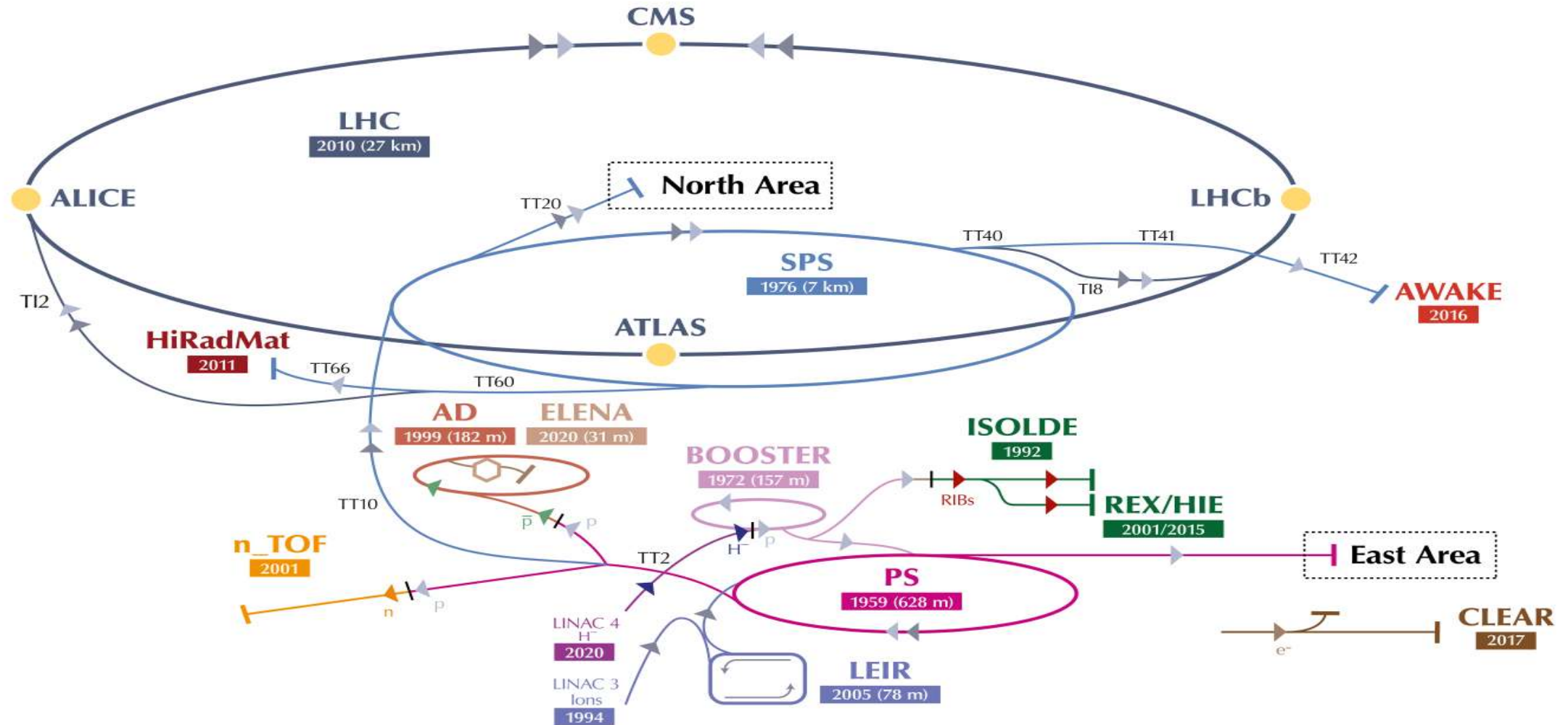
15th January 2020
edoardo.martelli@cern.ch

About CERN and the LHC

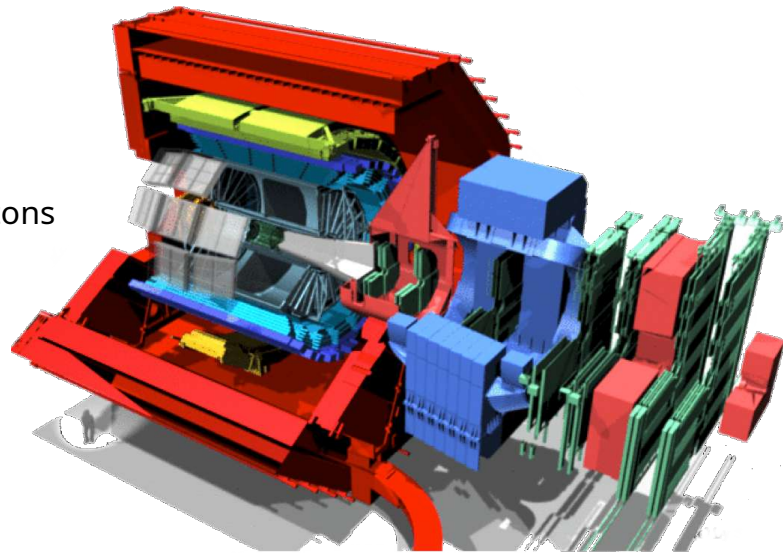# CERN accelerator complex

LHC major experiments

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

Detector characteristics
Width: 44m
Diameter: 22m
Weight: 7000t
CERN AC - ATLAS V1997

Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding

ATLAS
Weight: 7,000 tons
Length: 44 m
Diameter 22 m
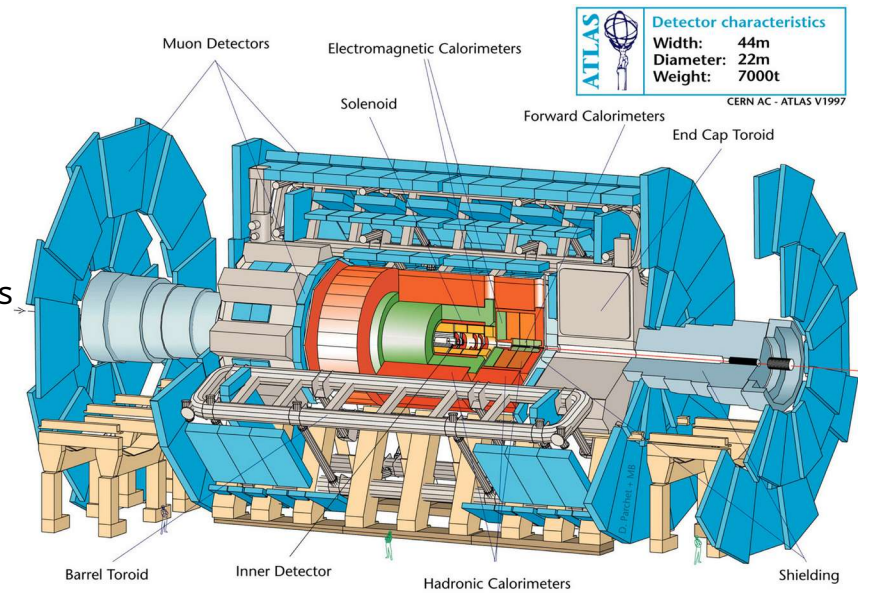
CMS
Weight: 14,000 tons
Length: 28 m
Diameter 15 m
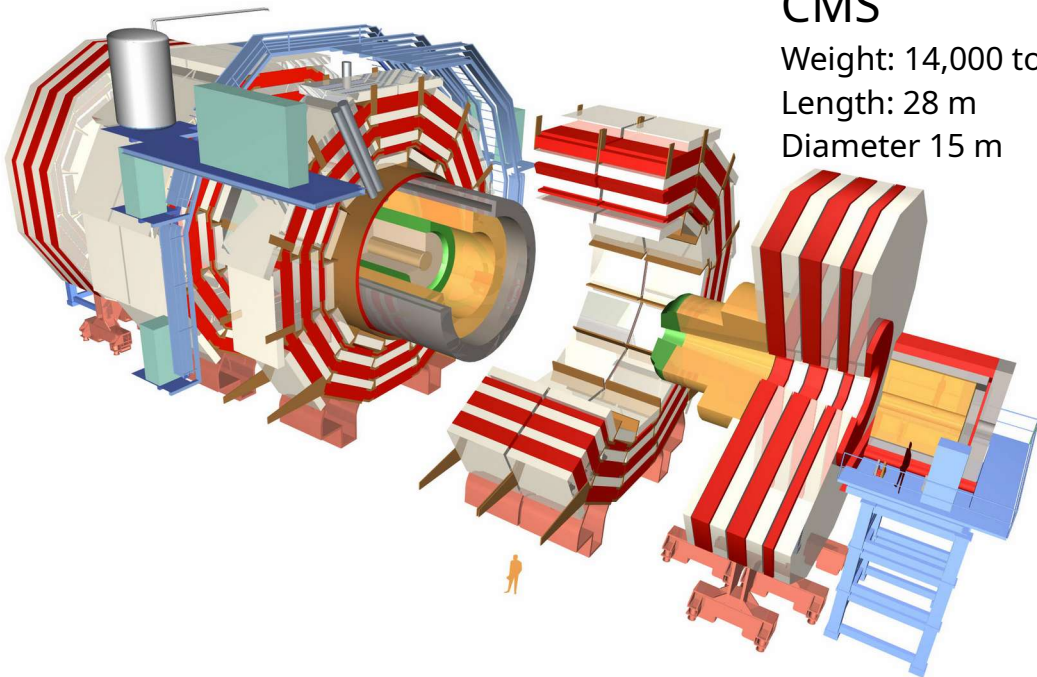
LHCb
Weight: 5,600 tons
Length: 21 m
Diameter 12 m

CERN locations

GENÈVE

Geneva Airport

LHC - B
Point 8

CERN

ATLAS
Point 1

ALICE
Point 2

CMS
Point 5

SPS

TI 8

TI 2

LHC - B

ATLAS

ALICE

100m

7km

CMS

LEP/LHC
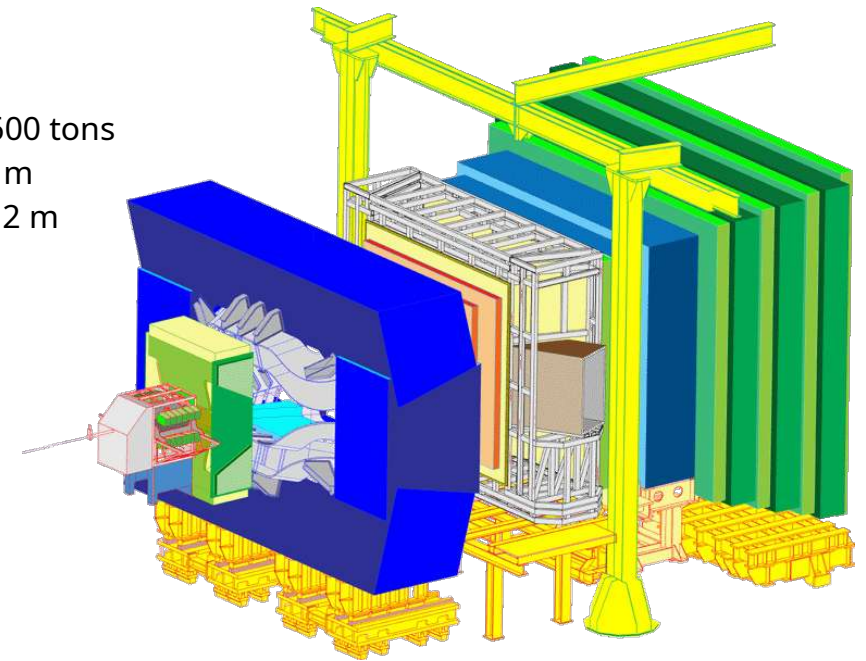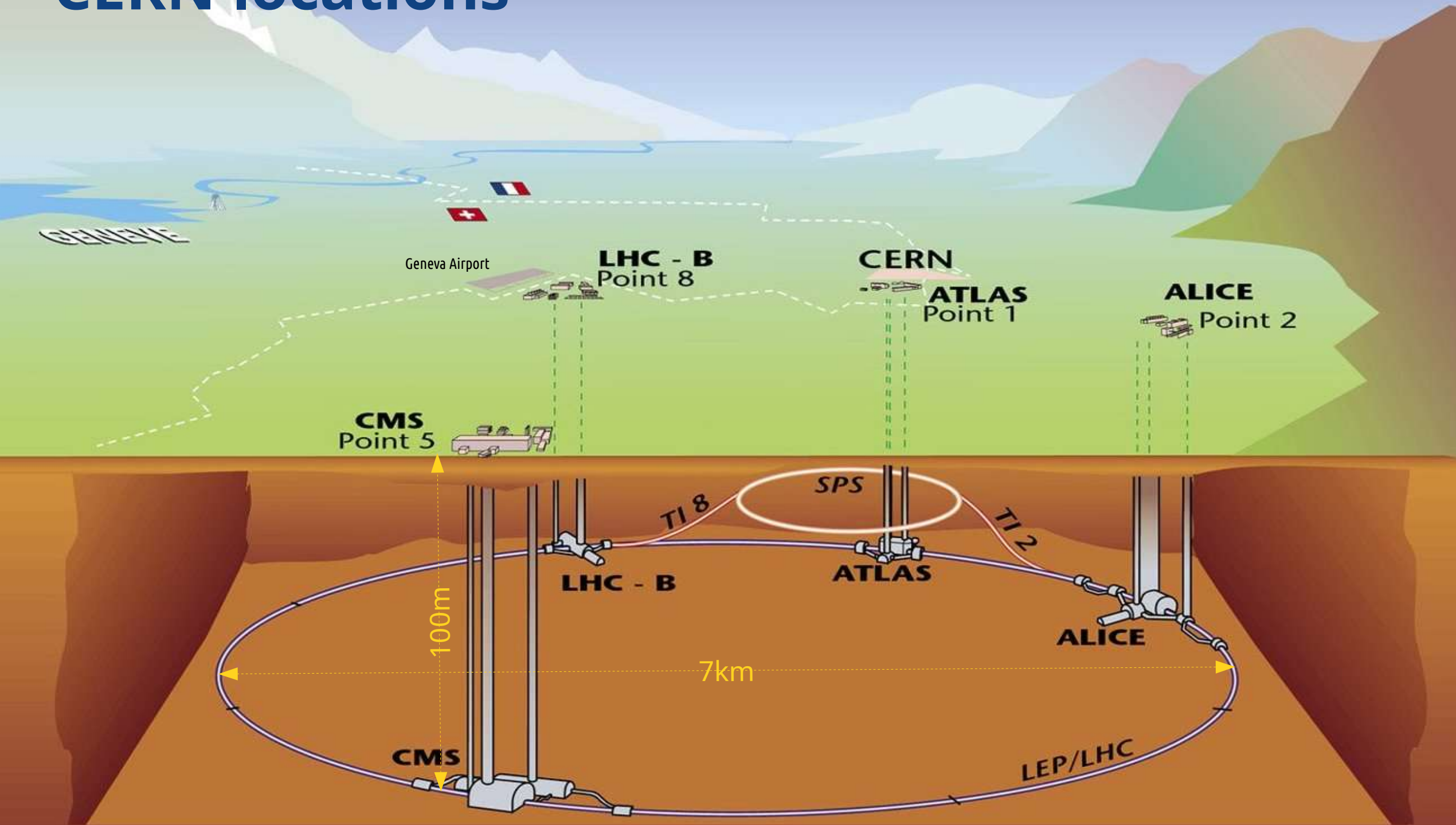
Comparing theory...
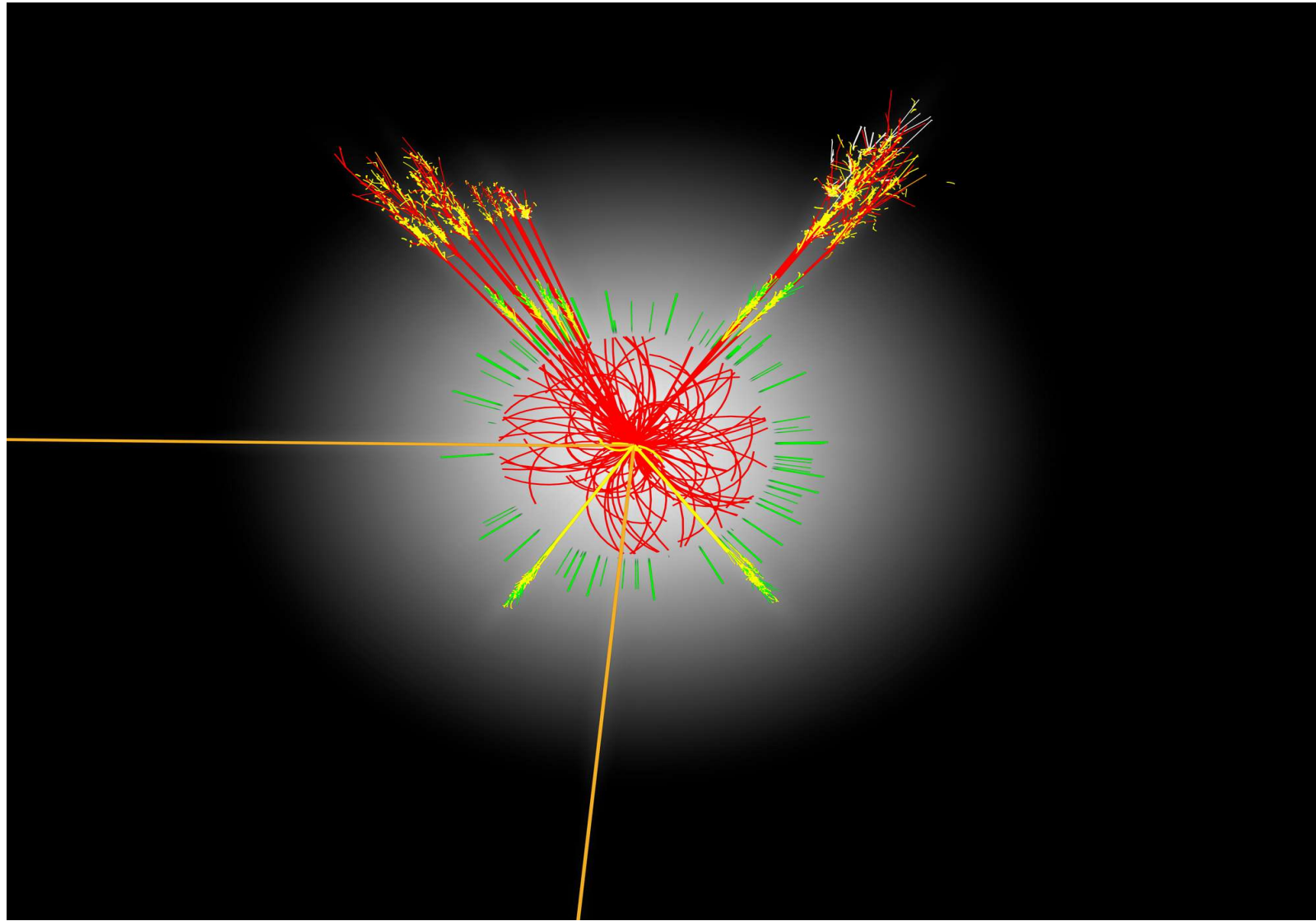
Simulated production of a Higgs event in ATLAS

.. to real events
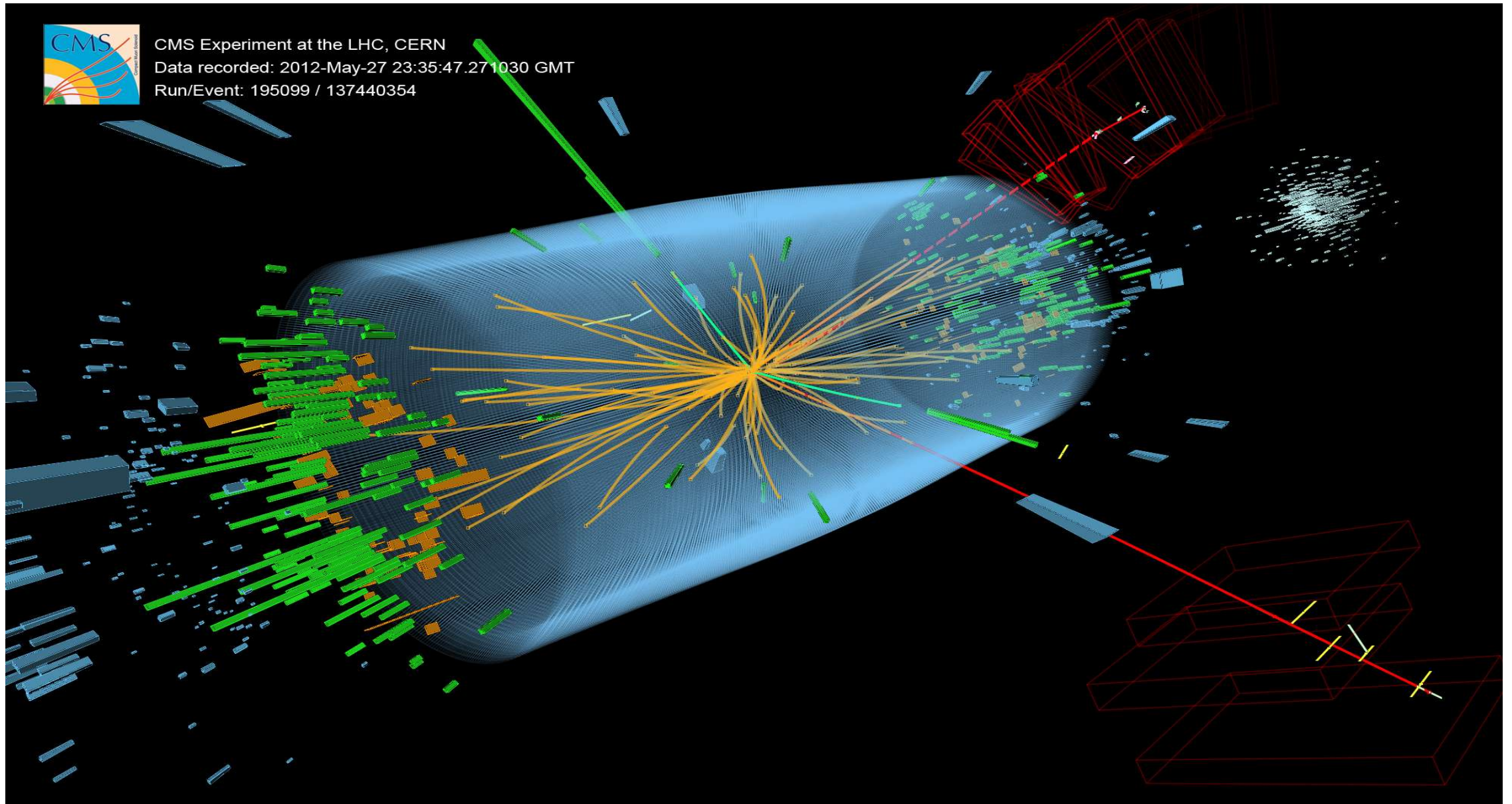
Higgs event in CMS

Data flow

24 Pbit/s

Filter and first selection

200 Gbit/s
to the CERN computer center

Create sub-samples

World-Wide Analysis

10 Tbit/s
Distributed + local

Physics
Explanation of nature

100 Gbit/s

40 Gbit/s

Store on disk and tape

Export copies

4 Experiments

PS

SPS
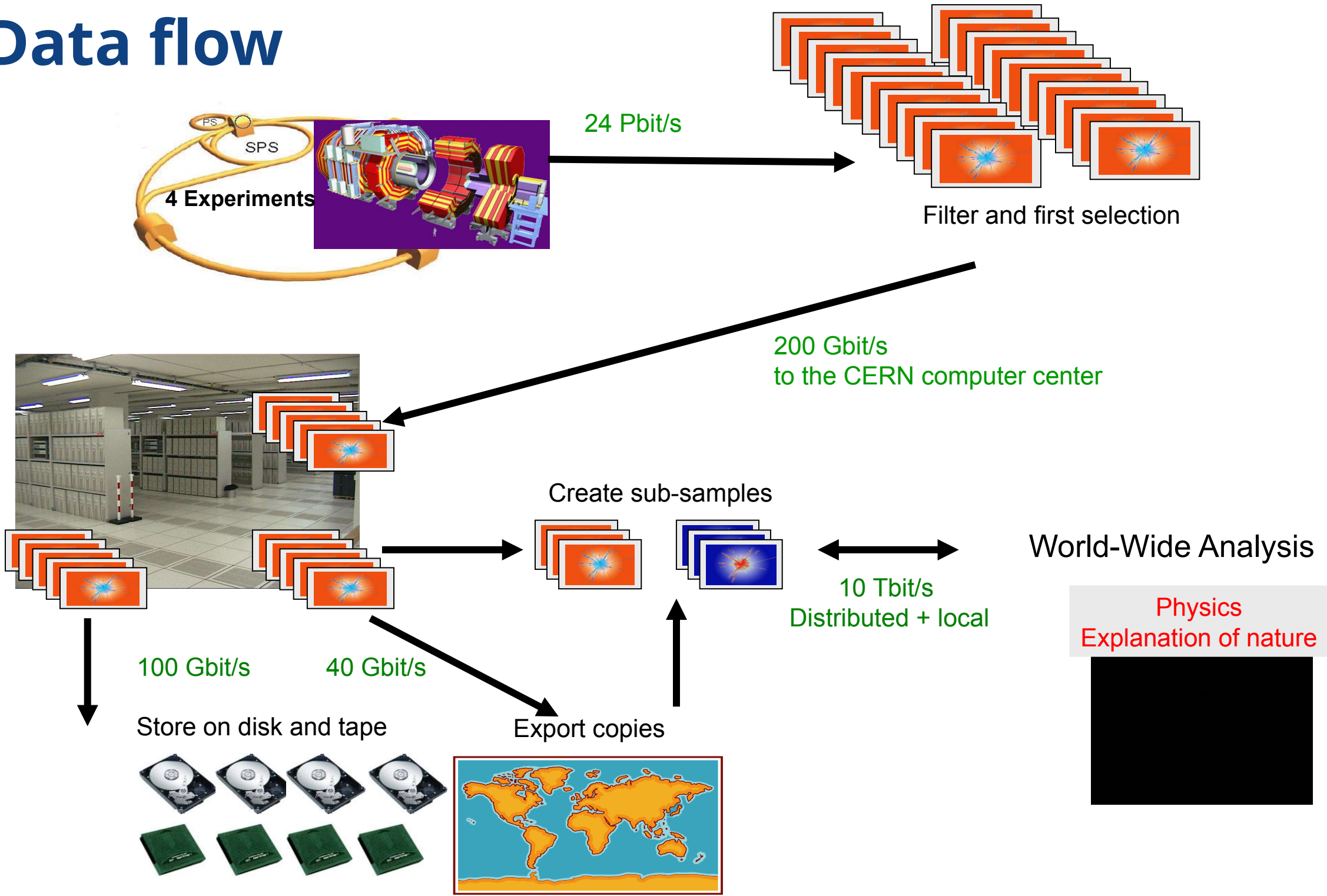
Data Challenge

- 40 million collisions per second

- After filtering, 1000 collisions of interest per

    second

- 10^{10} collisions recorded each year
    > 20 Petabytes/year of data

Muon tracks

Energy deposits

Muon Spectrometer

Muon

Neutrino

Hadronic Calorimeter

Proton

Neutron

The dashed tracks are invisible to the detector

Electromagnetic Calorimeter

Electron

Solenoid magnet

Transition Radiation Tracker

Photon

Tracking

Pixel/SCT detector
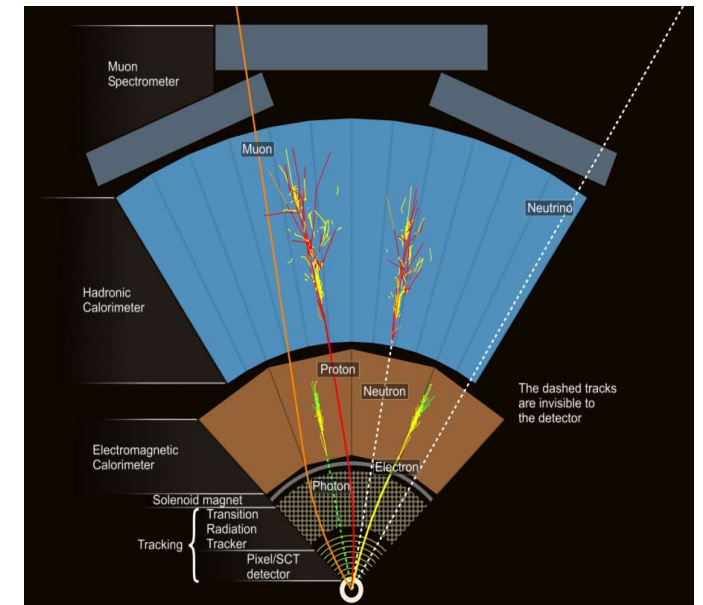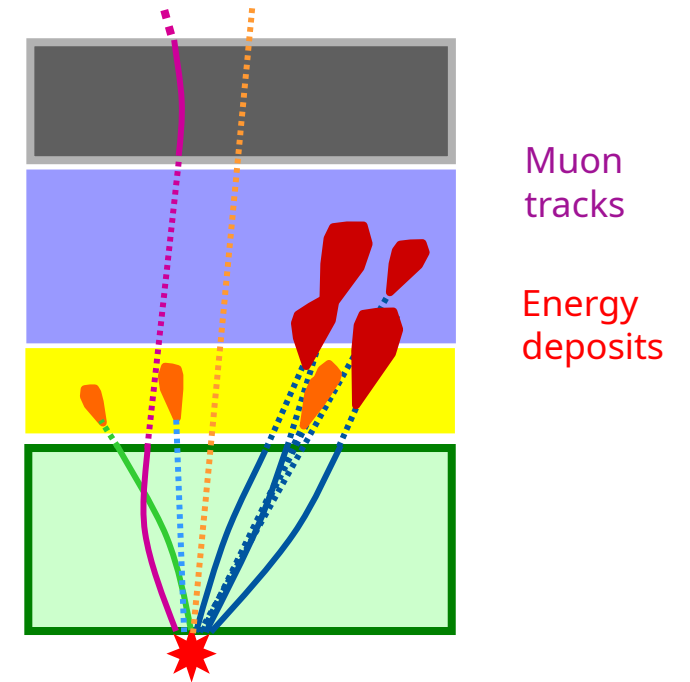
The High Luminosity LHC

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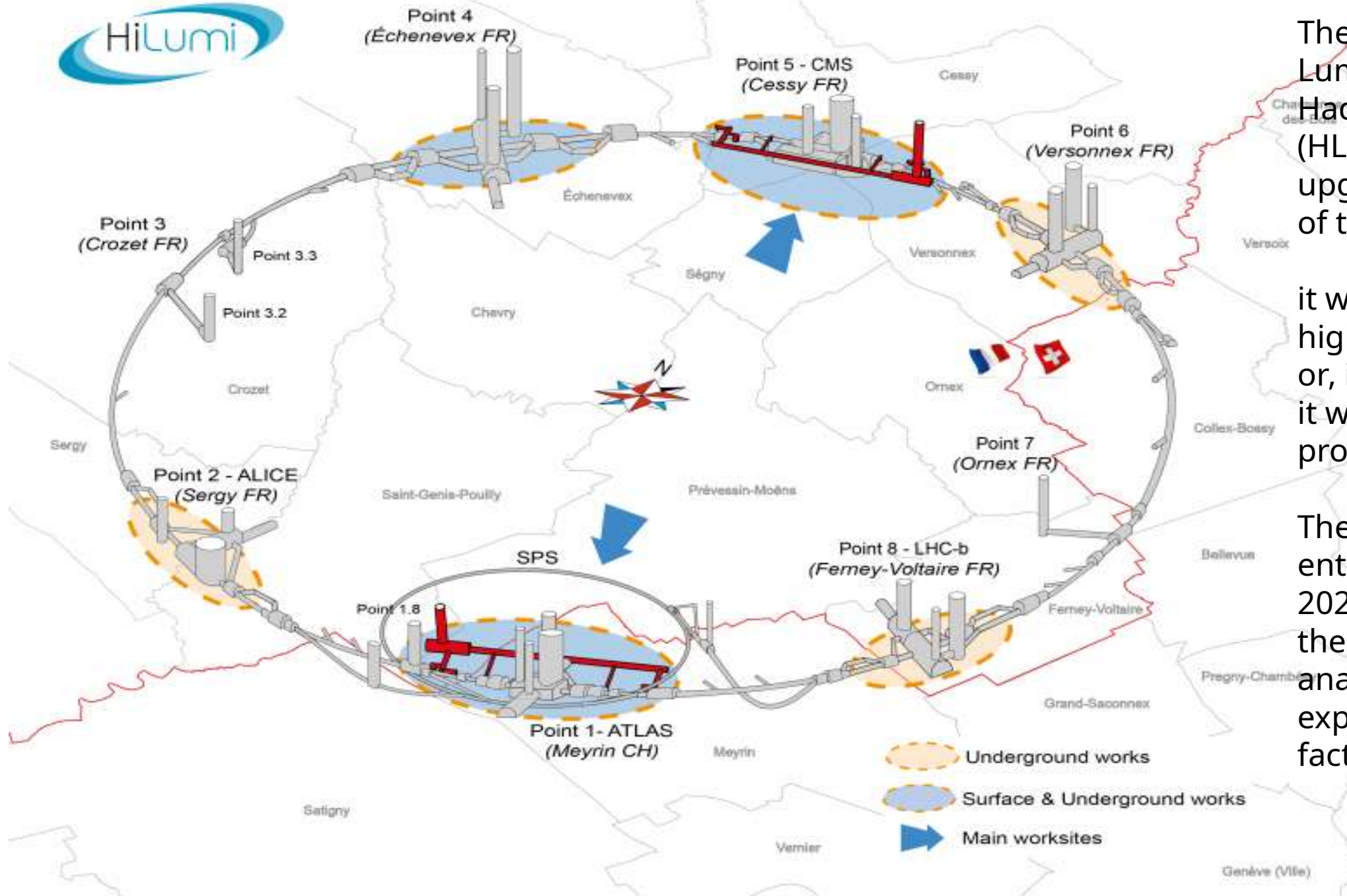
The High-Luminosity Large Hadron Collider (HL-LHC) is an upgraded version of the LHC.

it will operate at a higher luminosity or, in other words, it will be able to produce more data.

The HL-LHC will enter service after 2025, increasing the volume of data analysed by the experiments by a factor of 10.

HL-LHC plan

HL-LHC: luminosity forecast
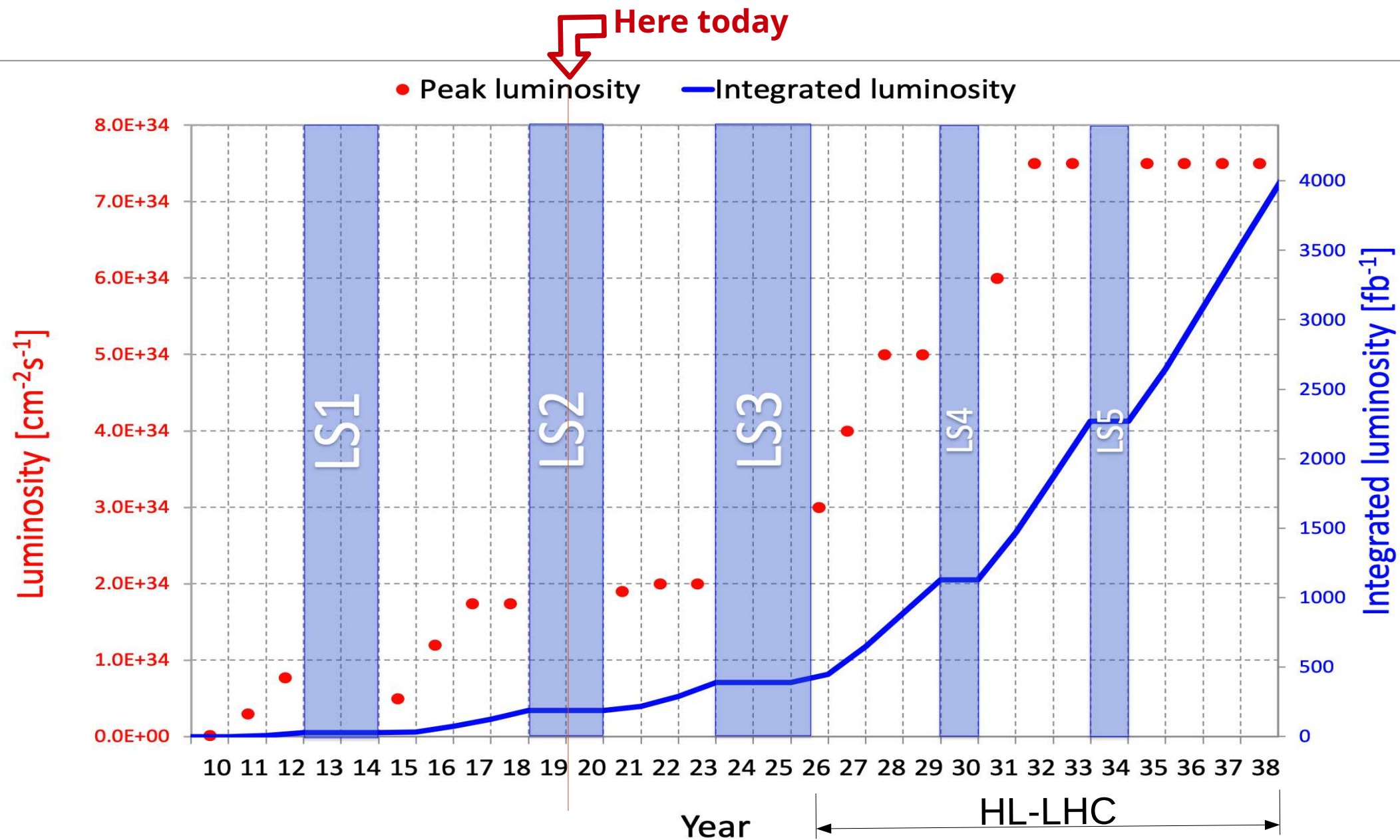
Computing challenges

Computing resources needs for HL-LHC

CPU projections for HL-LHC

Fast vs Full simulation:
Run 3: 50% of simulation with fast sim
Run 4: 75% of simulation with fast sim

ATLAS Preliminary
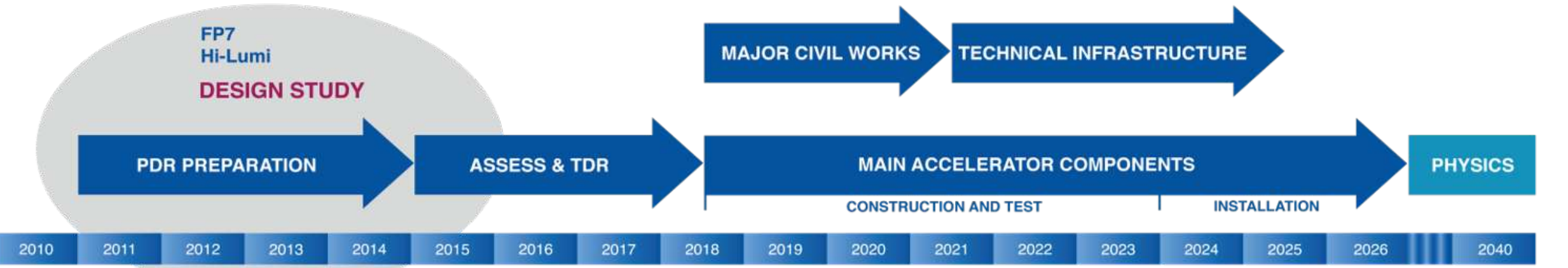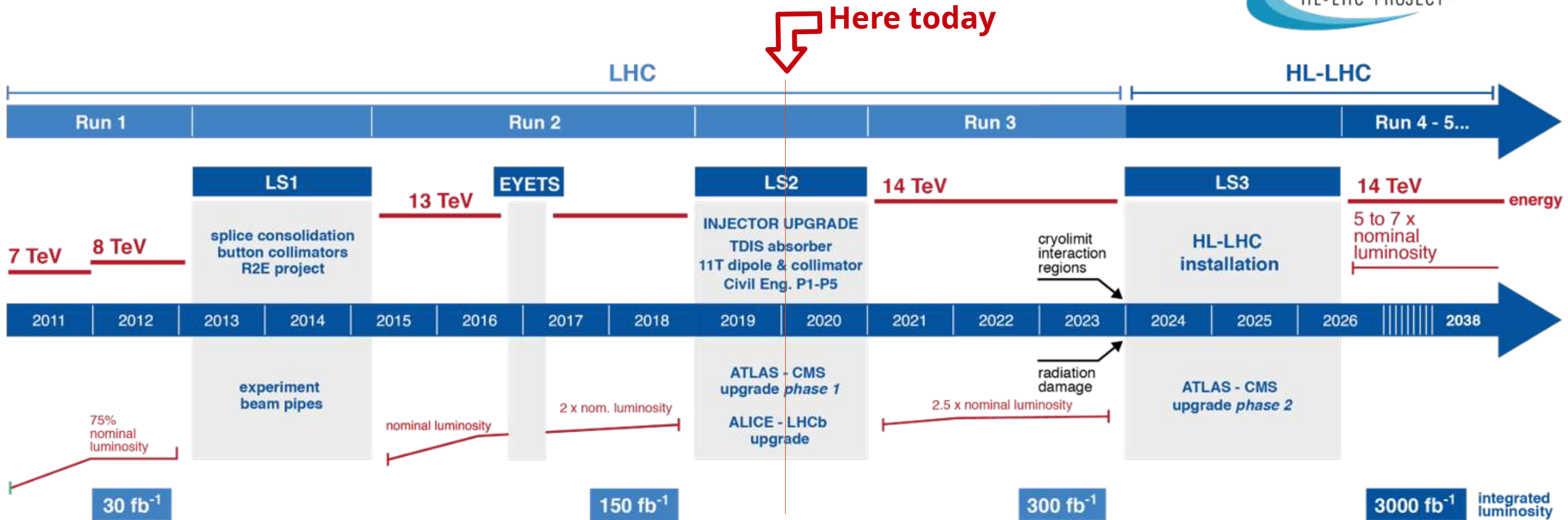CPU resource needs
- 2017 Computing model
- 2018 estimates:
  - MC fast calo sim + standard reco
  - MC fast calo sim + fast reco
  - Generators speed up x2
  - Flat budget model (+20%/year)

Annual CPU Consumption [MHS06]

Run 2   Run 3   Run 4   Run 5
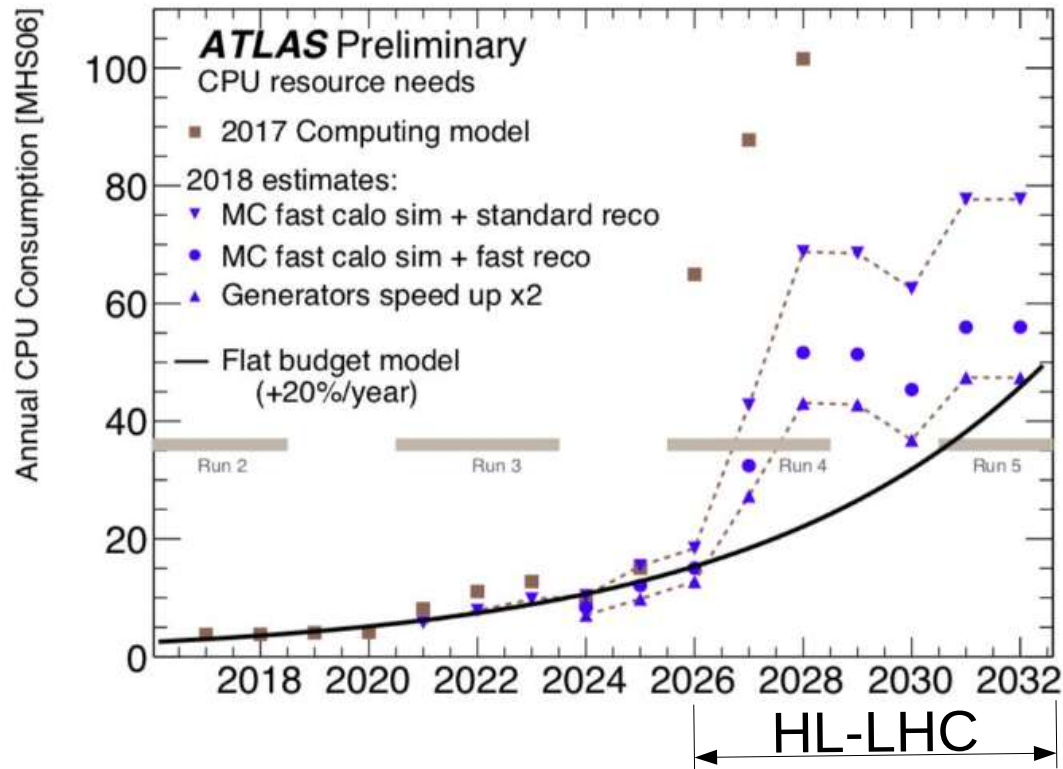
HL-LHC

Disk storage projections for HL-LHC

ATLAS Preliminary
Disk resource needs
- 2017 Computing model
- 2018 estimates:
  - Baseline model
  - Reduced storage model
  - Flat budget model (+15%/year)

Disk Storage [PBytes]

Run 2   Run 3   Run 4   Run 5

HL-LHC
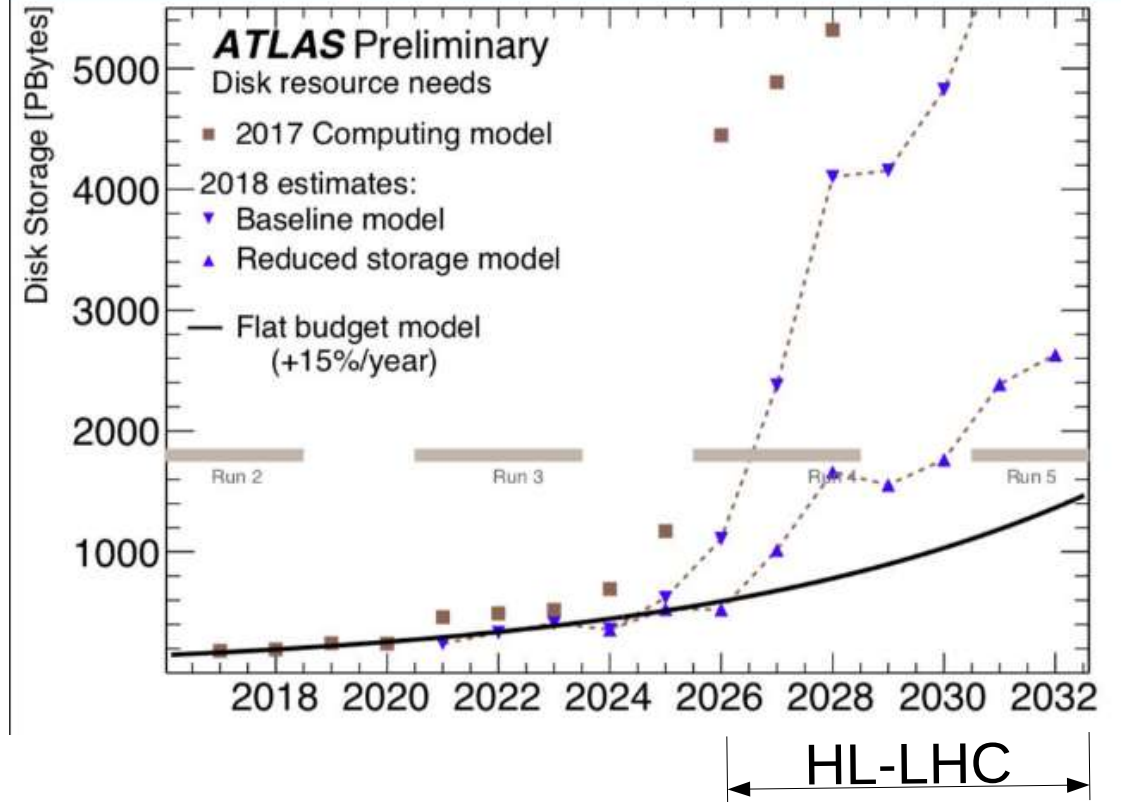
Evaluating new computing models

DOMA project
(Data Organization, Management, Access)

A set of R&D activities evaluating components and techniques to build a common HEP data cloud

Three main Working Groups:
- **ACCESS** for Content Delivery and Caching
- **TPC** for Third Party Copy
- **QoS** for storage Quality of Service

And other activities (like networking, AAI), reporting regularly

Storage Orchestration Services

Data (Lake) Infrastructure

Distributed Storage

Asynchronous Data Transfer Services

Storage

Storage

Storage

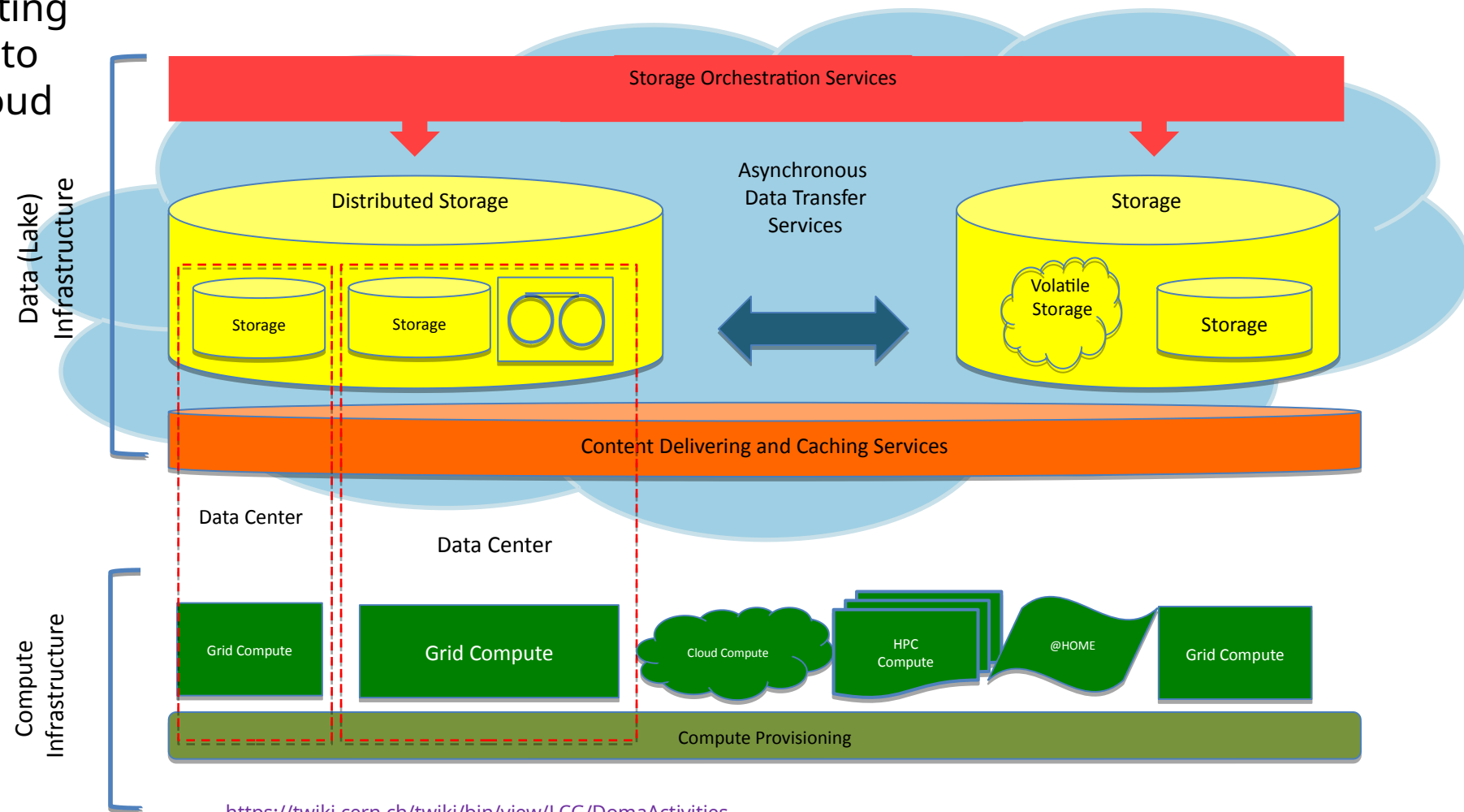Volatile Storage

Storage

Content Delivering and Caching Services

Data Center

Data Center

Compute Infrastructure

Grid Compute

Grid Compute

Cloud Compute

HPC Compute

@HOME

Grid Compute

Compute Provisioning

https://twiki.cern.ch/twiki/bin/view/LCG/DomaActivities

Datalake draft model: components

	AC — Archive Centers	DCC — Data and Compute Centers	CC — Compute Centers	AF — Analysis Facility	EF — Ephemeral facilities (HPC, IaaS)
Archive	☆☆☆	☆			
Disk Storage	☆	☆☆☆	☆	☆	
Staging Area	☆☆☆	☆☆	☆	☆	
Cache			☆☆☆	☆	☆☆
CPU	☆	☆☆☆	☆☆☆	☆☆	☆☆

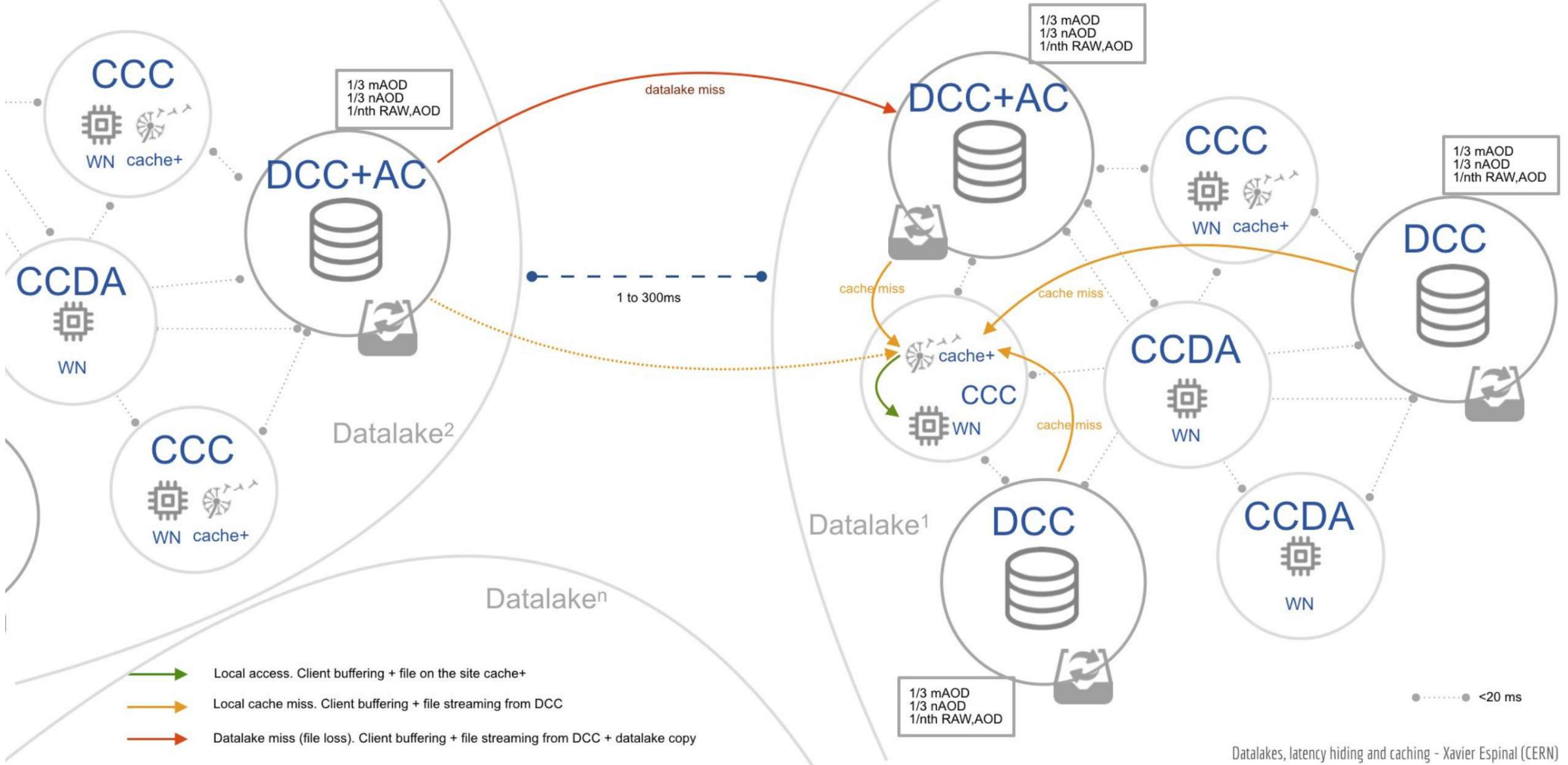☆ Optional ☆☆ Available ☆☆☆ Large

Datalakes, latency hiding and caching - Xavier Espinal (CERN)
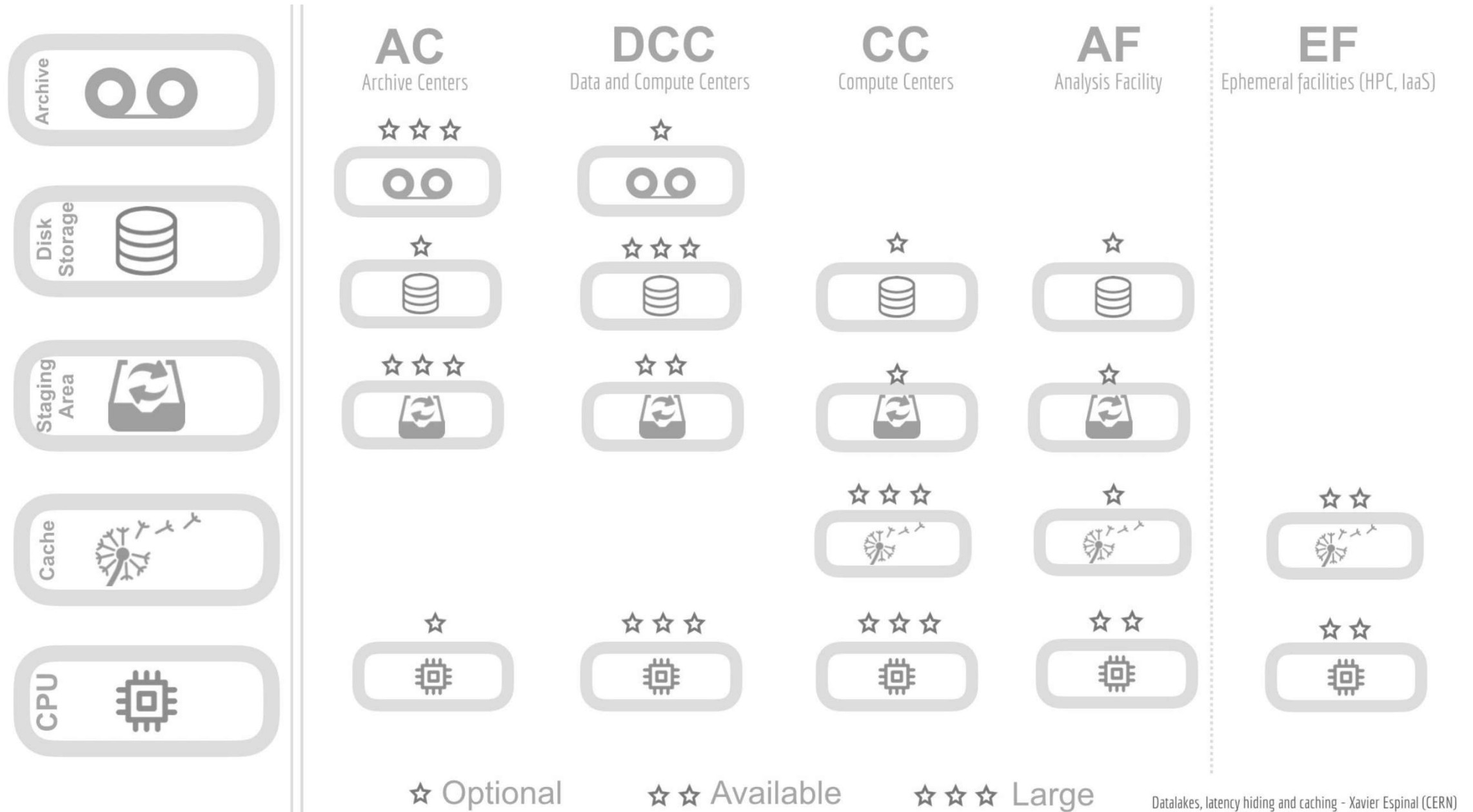
Datalake draft model

File access orchestration: WN to Cache to Staging Area to Datalake

- Disk failures estimation: **only 1%** of data will be fetched outside the local datalake   - **Efficiently hide** latencies with **buffering** at the client side and **access through cache+**
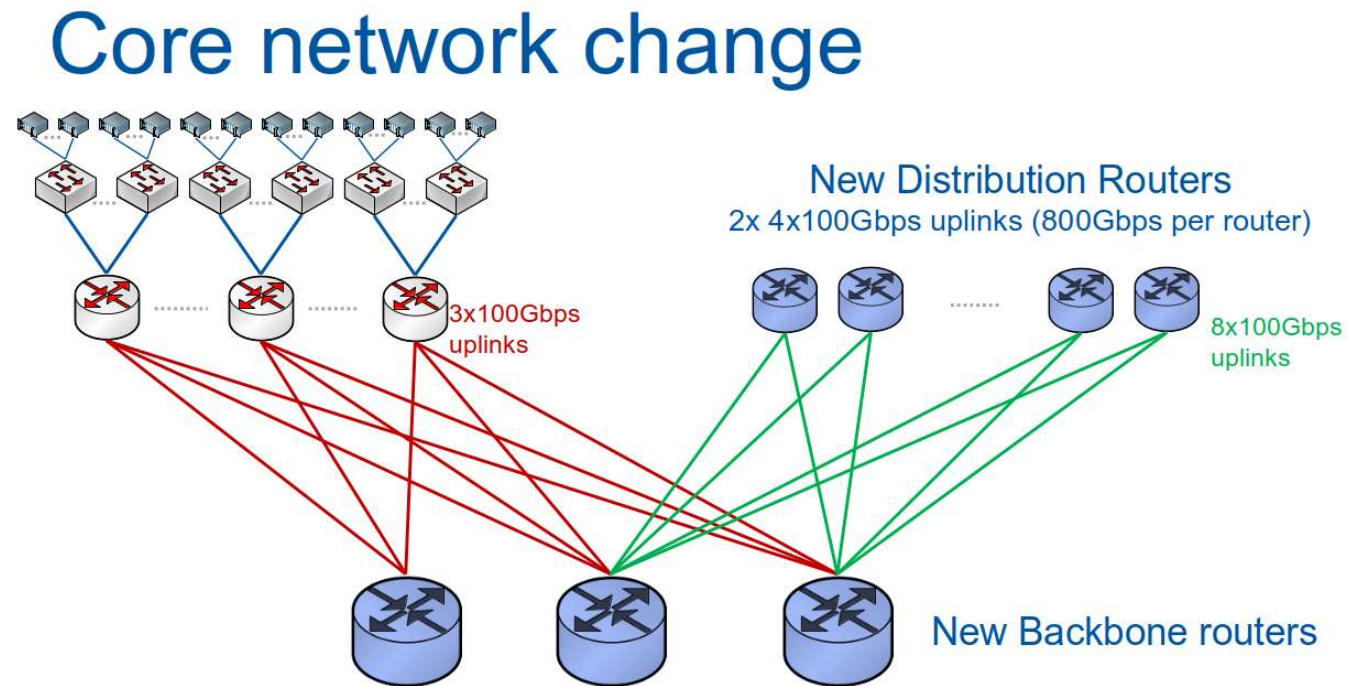
Local access. Client buffering + file on the site cache+

Local cache miss. Client buffering + file streaming from DCC

Datalake miss (file loss). Client buffering + file streaming from DCC + datalake copy

Datalakes, latency hiding and caching - Xavier Espinal (CERN)

CERN IT plans

CERN data-centre B513

- New datacentre network based on Juniper QFX10008

- Increasing new routers' interconnections to 800 Gbps with possibility to grow to 1.6Tbps

- Deploying new architecture with router redundancy using VXLAN ESI-LAGs

- Testing Openstack integration for IP mobility (Tungsten Fabric)

Core network change

New Distrution Routers
2x 4x100Gbps uplinks (800Gbps per router)

3x100Gbps uplinks

8x100Gbps uplinks

New Backbone routers

Point8 (LHCb) Data-centre extension

- Two LHCb containers (out of six) will be used by CERN IT to host servers during Run3
- 24 racks per container
- Being filled with refurbished servers coming from Wigner
- 800Gbps connection to Meyrin Data-centre with DWDM PAM4 system
- To be returned to LHCb at the end of Run3
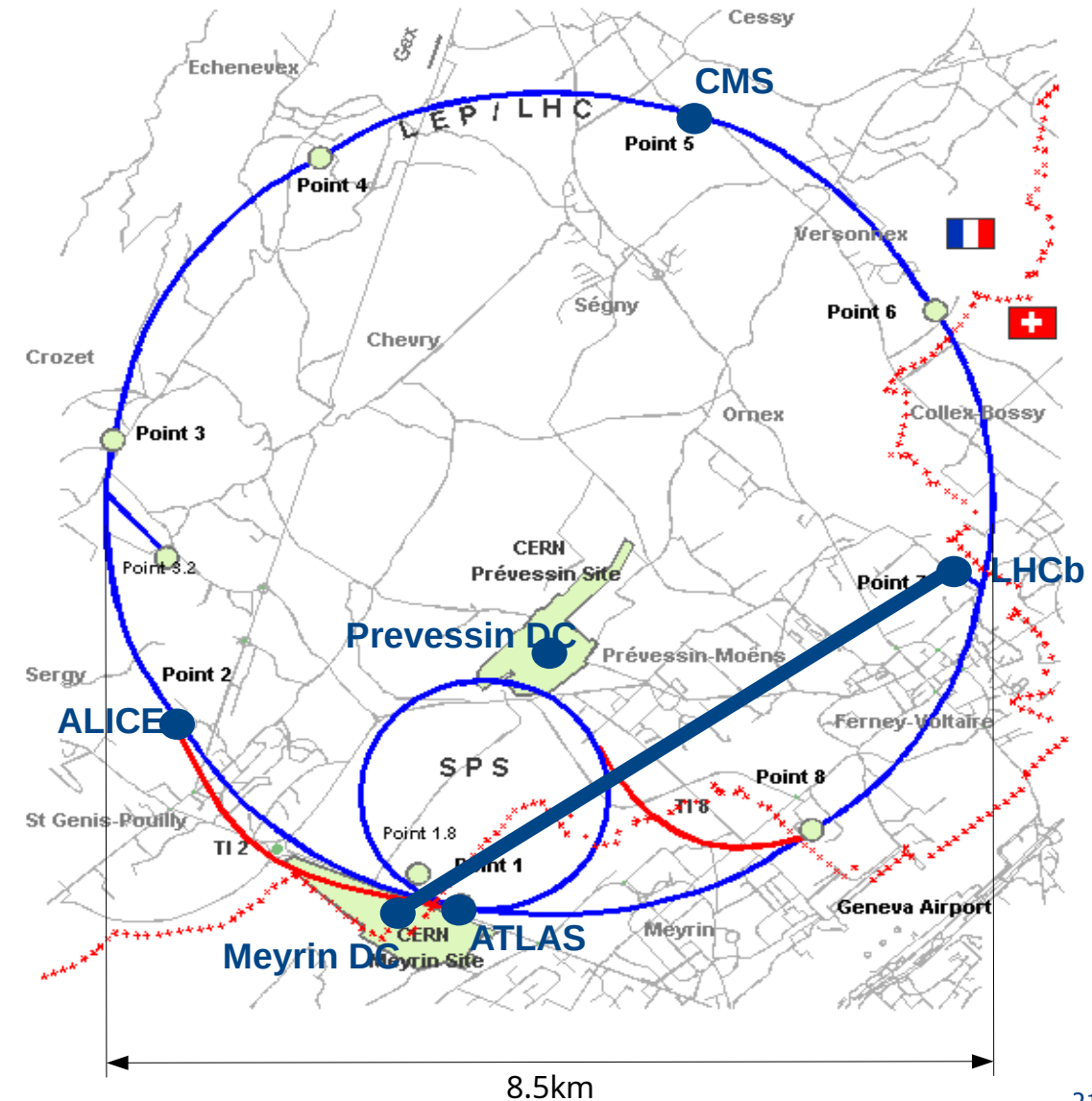
PCC: Prevessin Computer Centre

Plan for the Construction of new Computer Centre in the CERN French site of Prevessin:

- Project fully approved by CERN management

- To be built during Run3 (2021-24), to be ready for Run4

- Machines only building, inspired to GSI Green Cube

GSI Green Cube
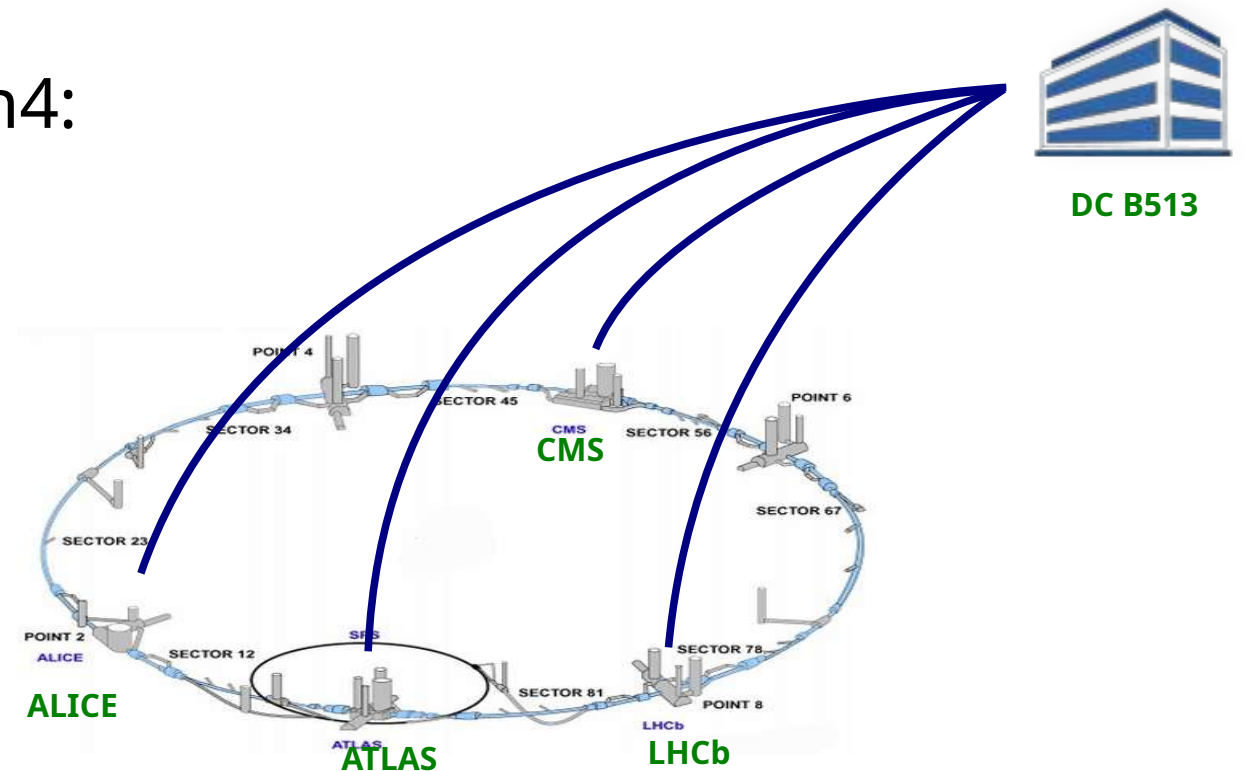
Information Technology Department
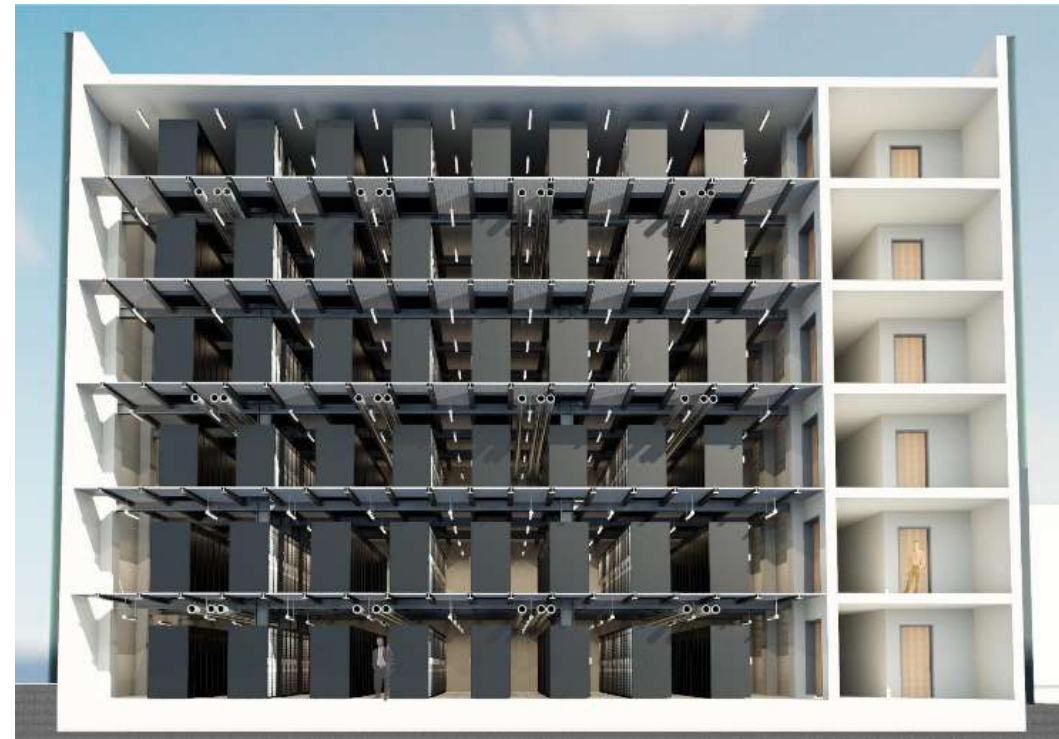
Experiments' DAQ lines to data-centre

Received requirements for Run3:

- ALICE: 2Tbps

- LHCb: 1Tbps

- CMS: 400Gbps

- ATLAS: 200Gbps

Estimated requirements for Run4:

- ATLAS: 4Tbps

- CMS: 4Tbps

DC B513

POINT 4
SECTOR 45
CMS
SECTOR 34
SECTOR 56
CMS
POINT 6
SECTOR 23
SECTOR 67
POINT 2
ALICE
SECTOR 12
SPS
SECTOR 78
SECTOR 81
POINT 8
LHCb
ALICE
ATLAS
LHCb

Experiments' DAQ lines to data-centres

- Acquired PAM4 DWDM system from Smartoptics
- To be used for LHCb and ALICE connections
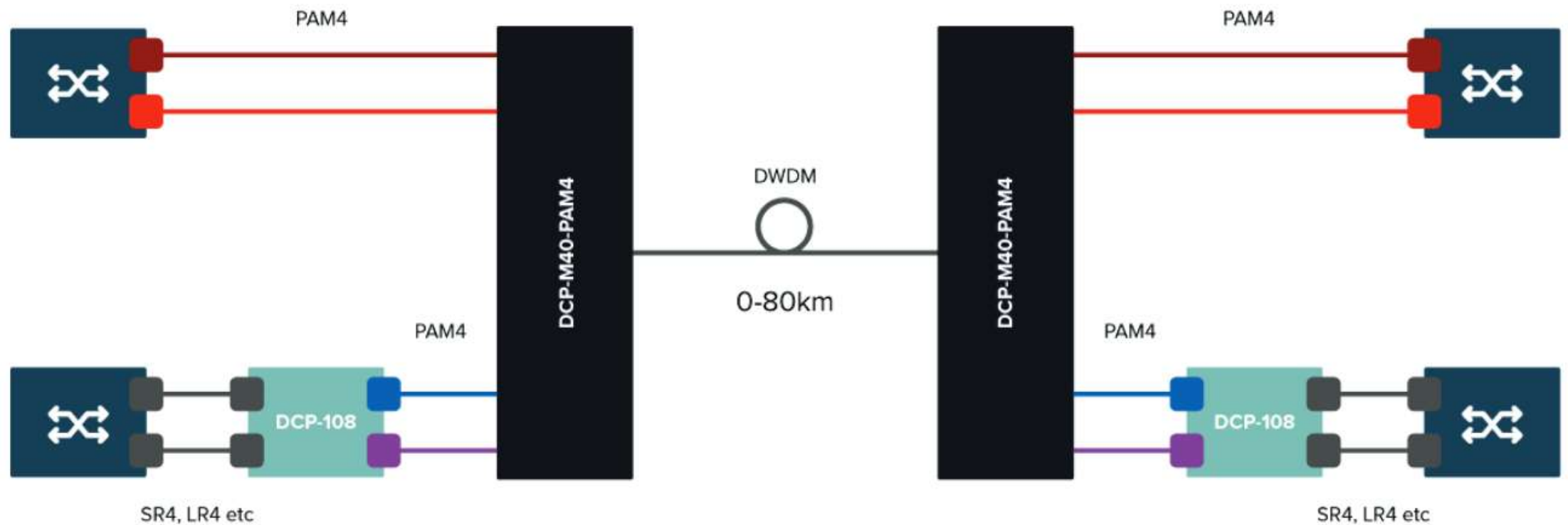
NOTED

Network activity in the WLCG DOMA contest

Implement a **Transfer broker:**

- Identify upcoming and on-going substantial data transfers
- get information from transfer services (FTS, Rucio ...)
- map transfers to network endpoints
- make transfers info available to network providers

Demonstrate a **Network Controller:**

- takes input from Transfer Broker
- modify network behavior to increase transfer efficiency
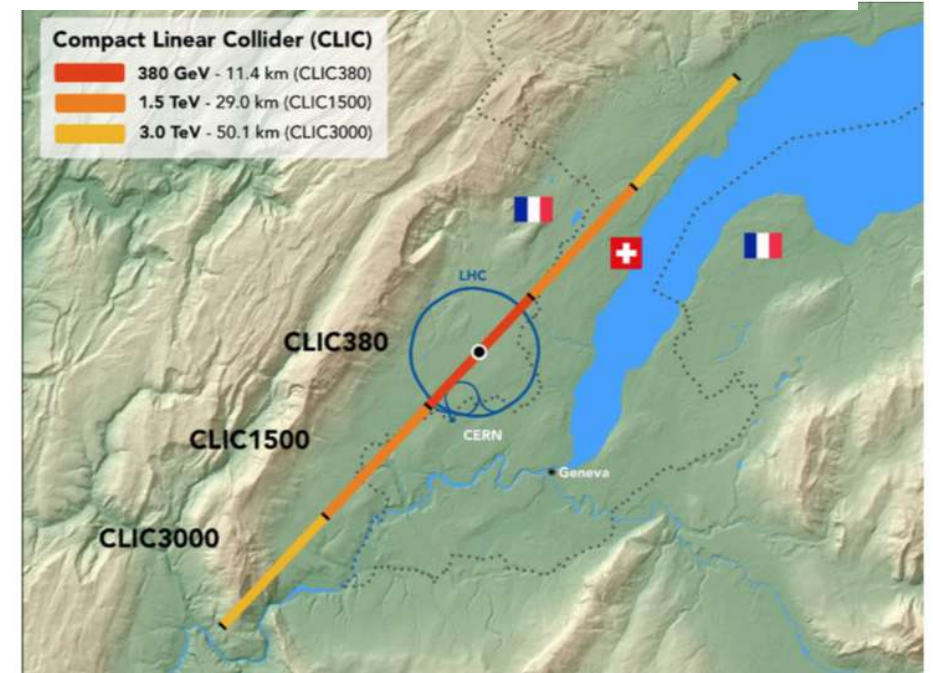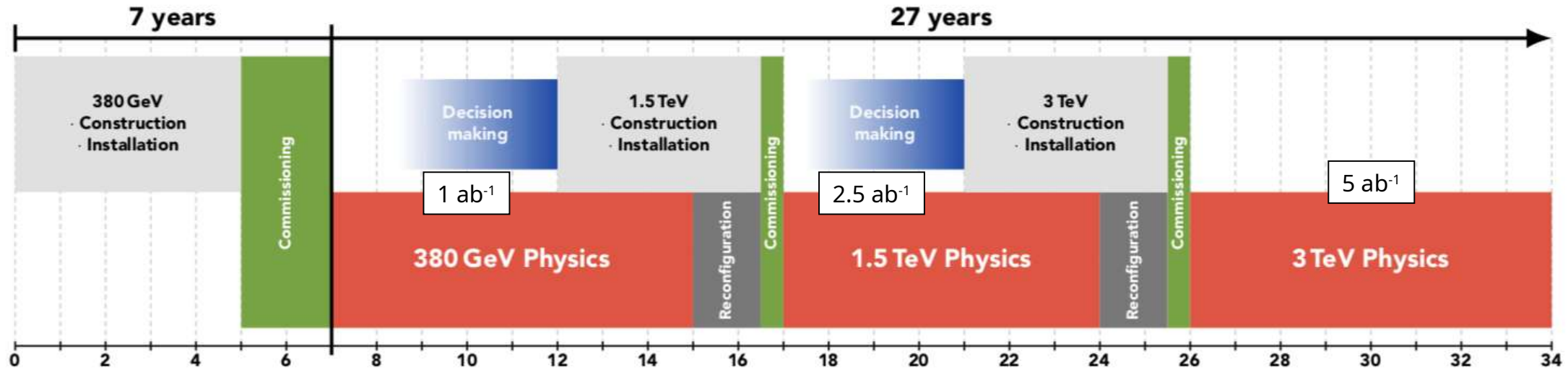- take into account real-time network status information
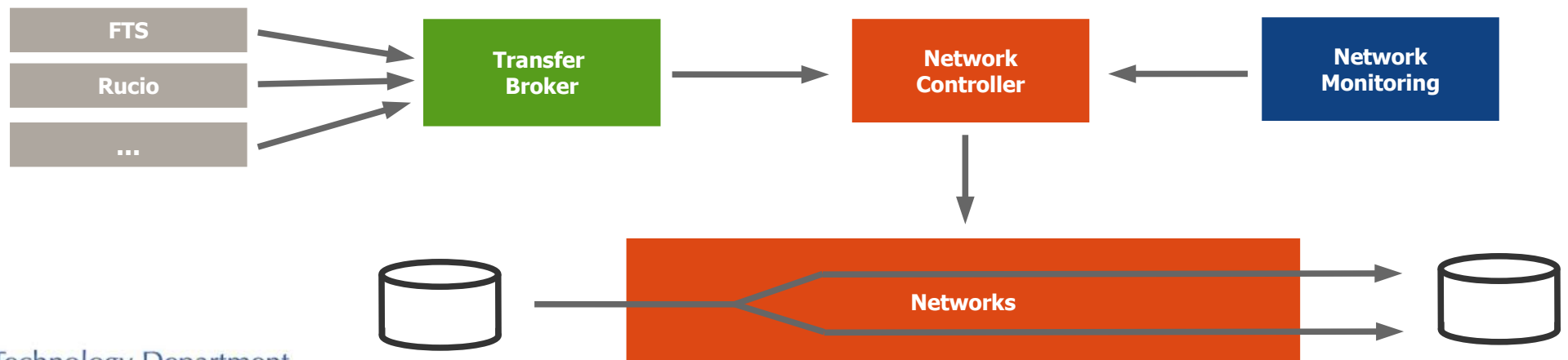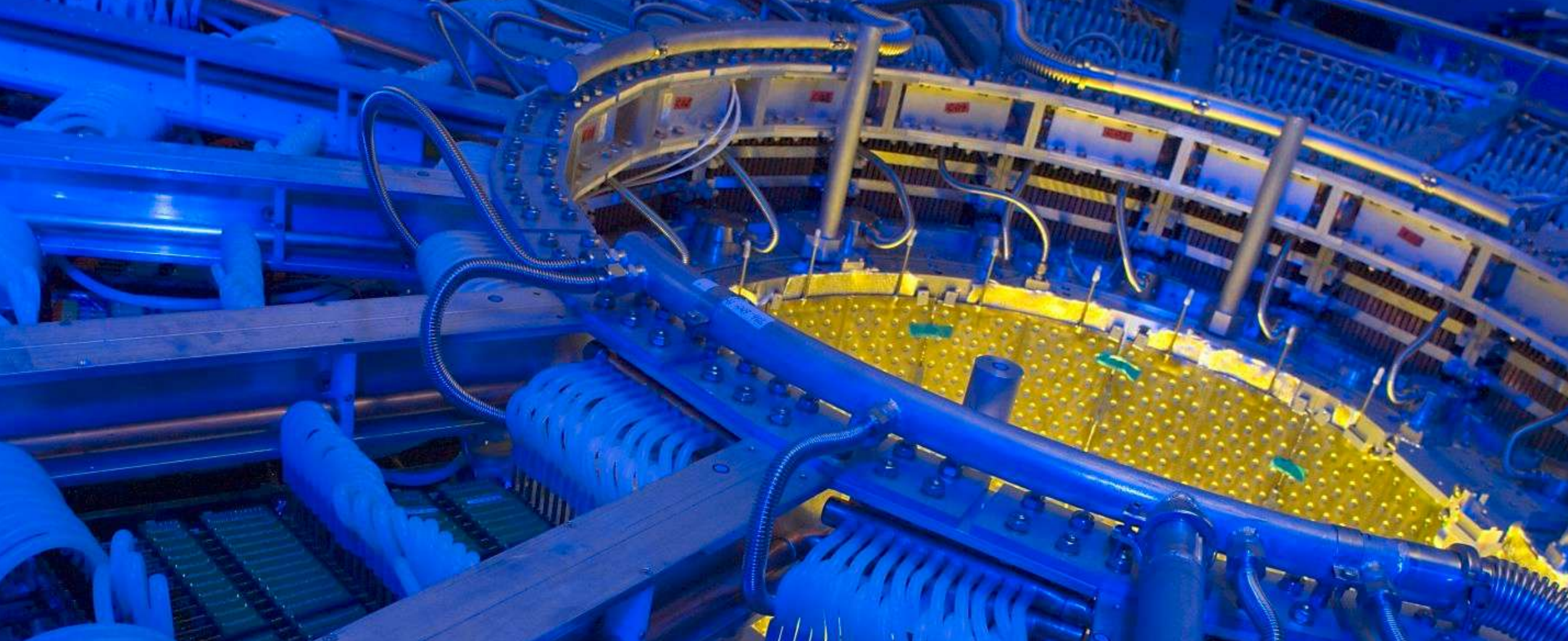
Beyond the LHC

CLIC – Compact LInear Collider

Technically, construction could start in ~2026 (TDR in 2025) → first collisions at √s=380 GeV in ~2035 → 25-30 years of physics exploitation

FCC – Future Circular Collider

Purely technical schedule, assuming green light to preparation work in 2020.
A 70 years programme

| 8 years preparation	10 years tunnel and FCC-ee construction	15 years FCC-ee operation	11 years FCC-hh preparation and installation	25 years FCC-hh operation pp/PbPb/eh
2020-2028		2038-2053		2064-2090

Copyright CERN 2014
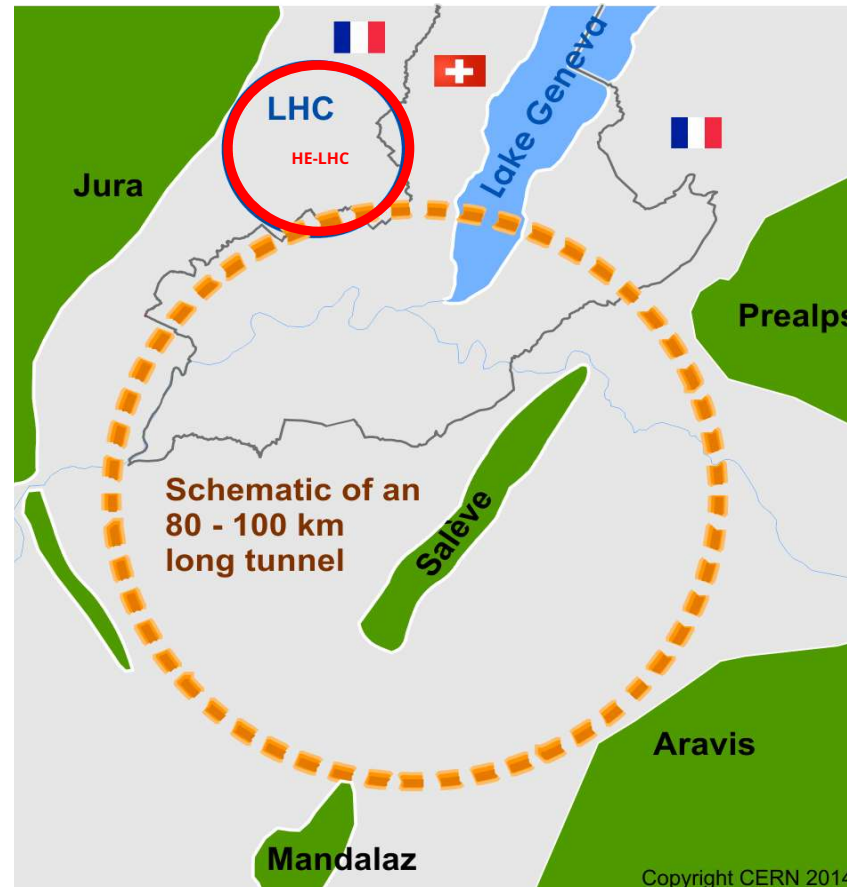
Granada meeting

- Update on European Strategy for Particle Physics
  https://cafpe.ugr.es/eppsu2019/

- CLIC and FCC presented

- future strategy depends on whether Japan will build an ILC and what will happen with the Chinese plans for a large collider

Science Gateway

- The Science Gateway will be an emblematic education and outreach facility next to the Globe of Science and Innovation
- Construction will start in 2020
- To be completed in 2022
- 79M CHF funded through donations
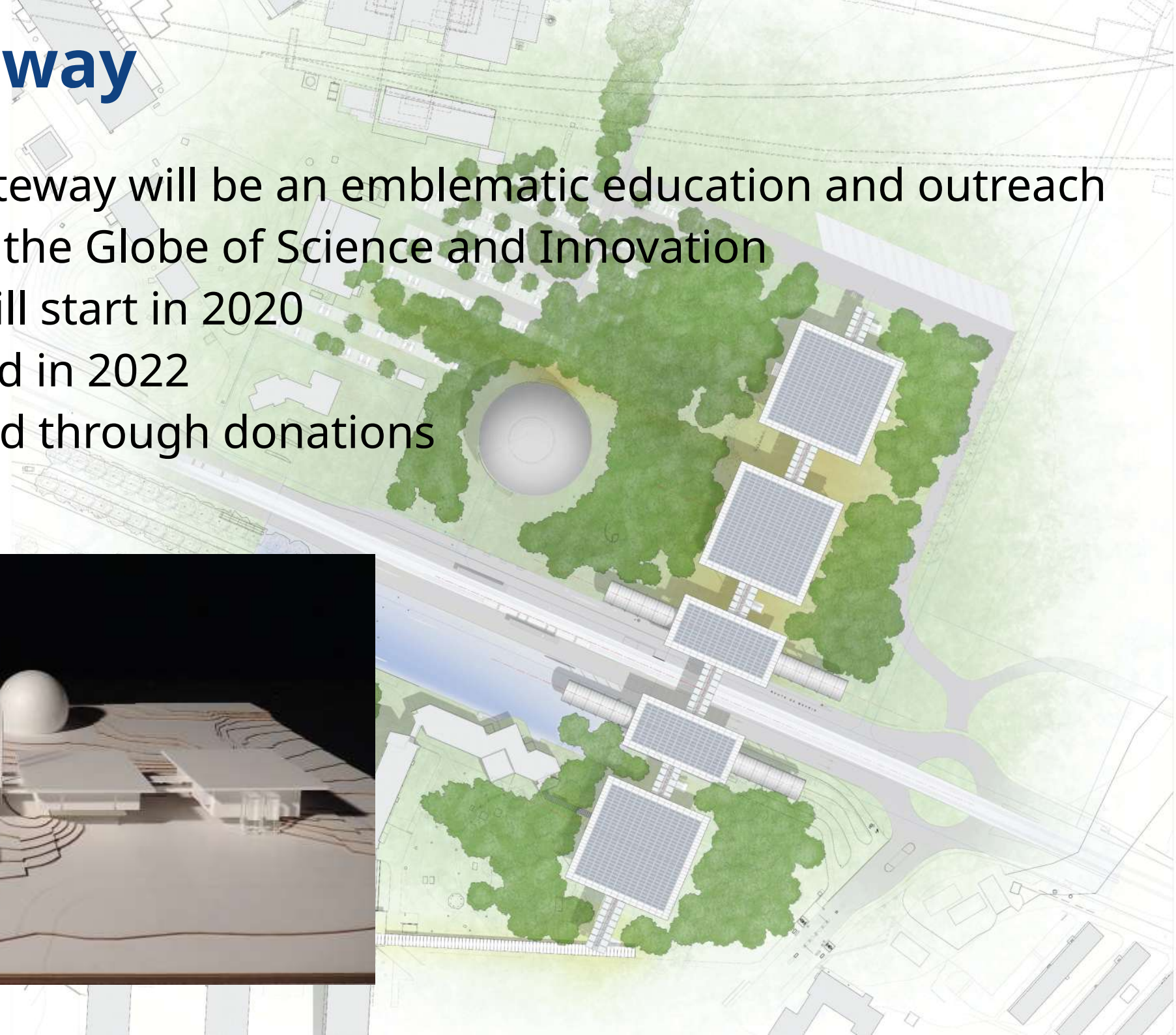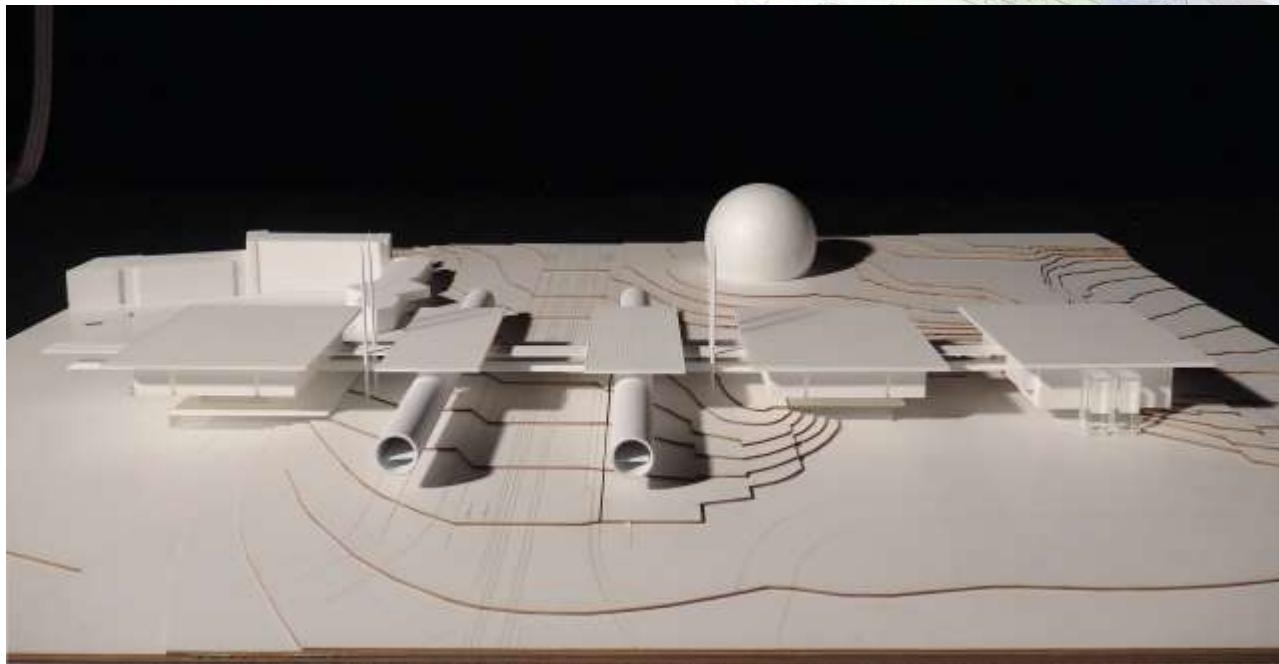
Questions?

edoardo.martelli@cern.ch