CERN

Workshop

Welcome to CERN!

20-21 May 2019
Geneva, Switzerland

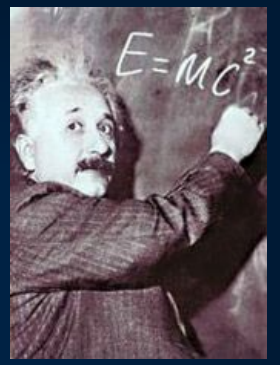
Frédéric Hemmer
CERN - IT Department

Document Classification: Restricted

The Mission of CERN

- **Push back** the frontiers of knowledge

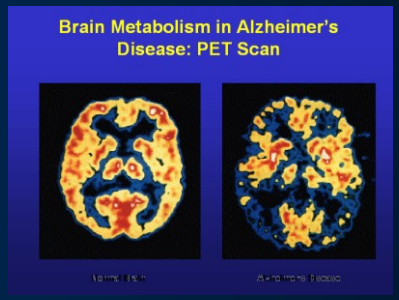
  E.g. the secrets of the Big Bang …what was the matter like within the first moments of the Universe's existence?



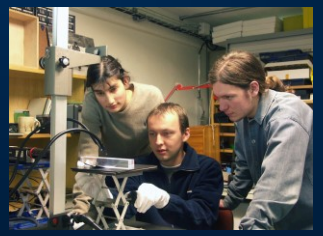
- **Develop** new technologies for accelerators and detectors

  Information technology - the Web and the GRID

  Medicine - diagnosis and therapy



- **Train** scientists and engineers of tomorrow



- **Unite** people from different countries and cultures

CERN: founded in 1954: 12 European States

"Science for Peace"

Today: 21 Member States

~ 2300 staff
~ 1400 other paid personnel
~ 12500 scientific users

Budget (2016) ~1000 MCHF

Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom

Associate Member States: Pakistan, Turkey

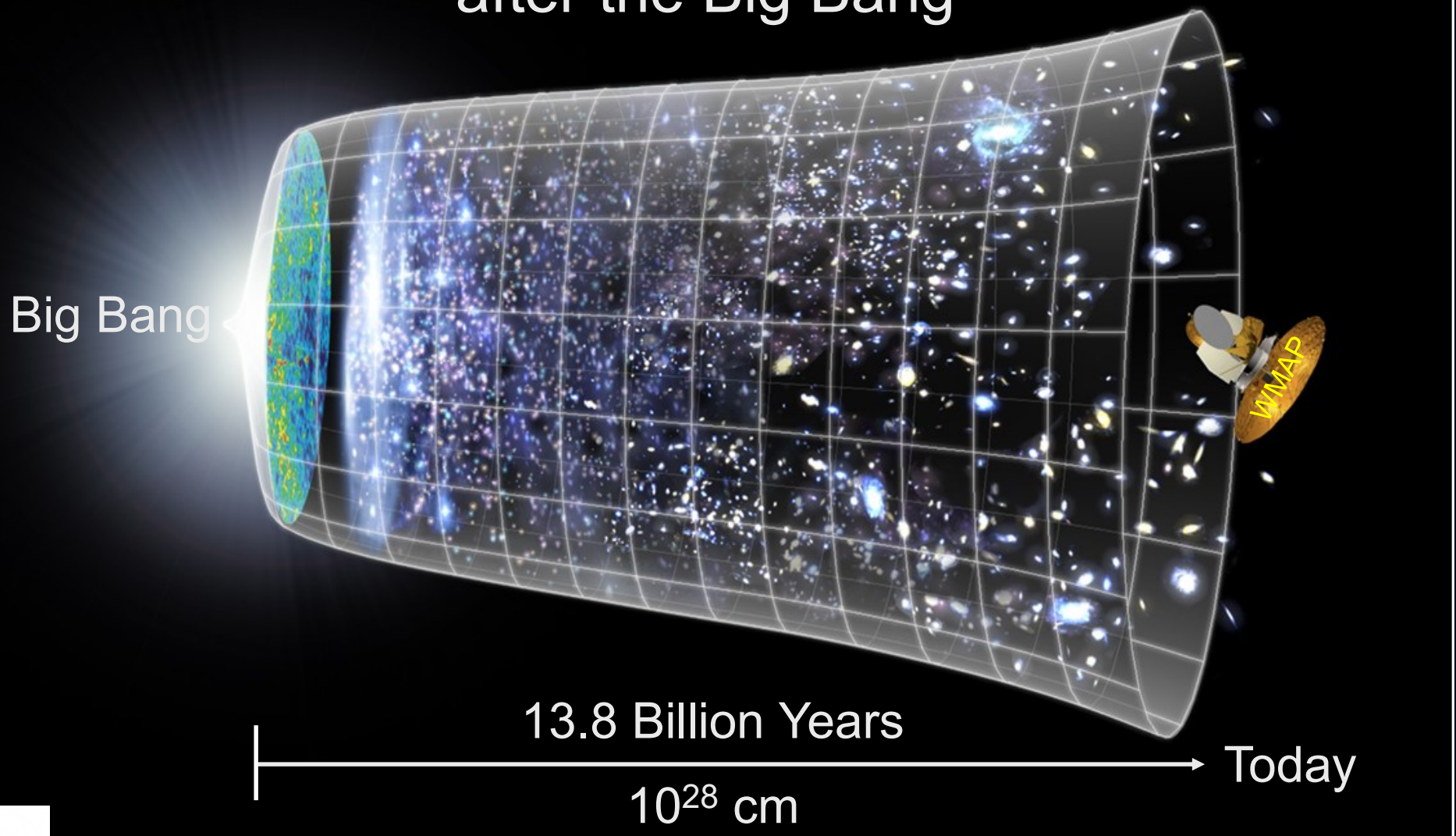
States in accession to Membership: Cyprus, Romania, Serbia

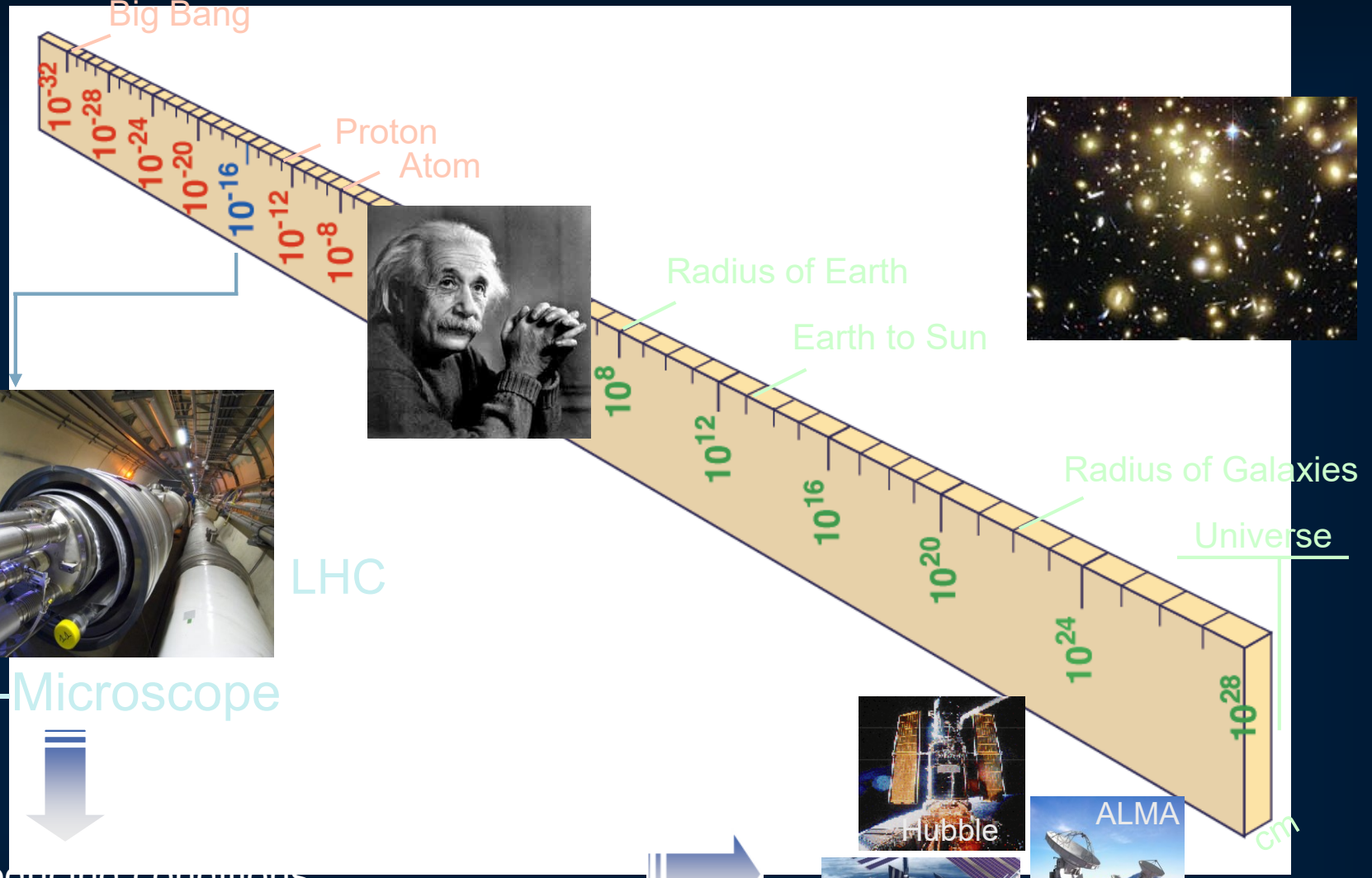
Applications for Membership or Associate Membership: Brazil, Croatia, India, Lithuania, Russia, Slovenia, Ukraine

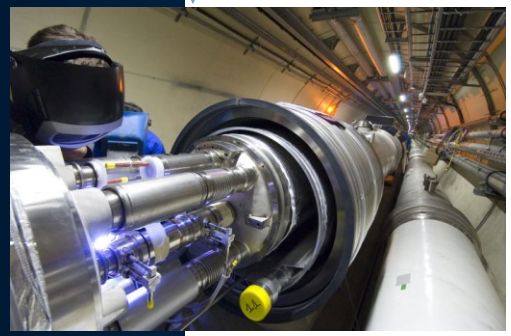
Observers to Council: India, Japan, Russia, United States of America; European Union, JINR and UNESCO

Next Scientific Challenge:

to understand the very first moments of our Universe after the Big Bang







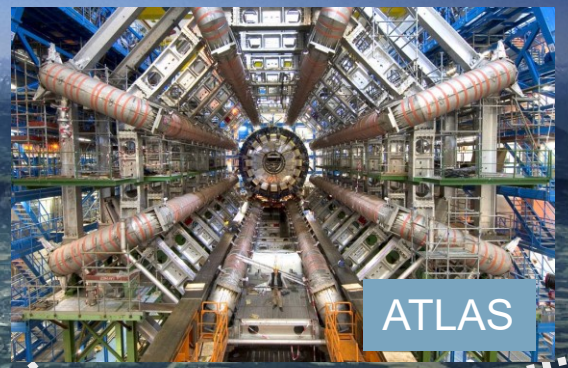
LHC

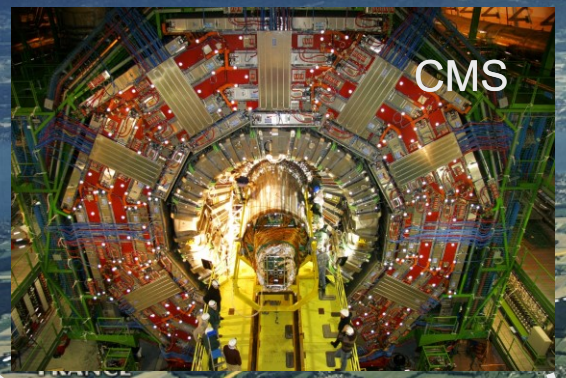
Super-Microscope

Reproducing conditions

Looking back

2010: a New Era in Fundamental Science





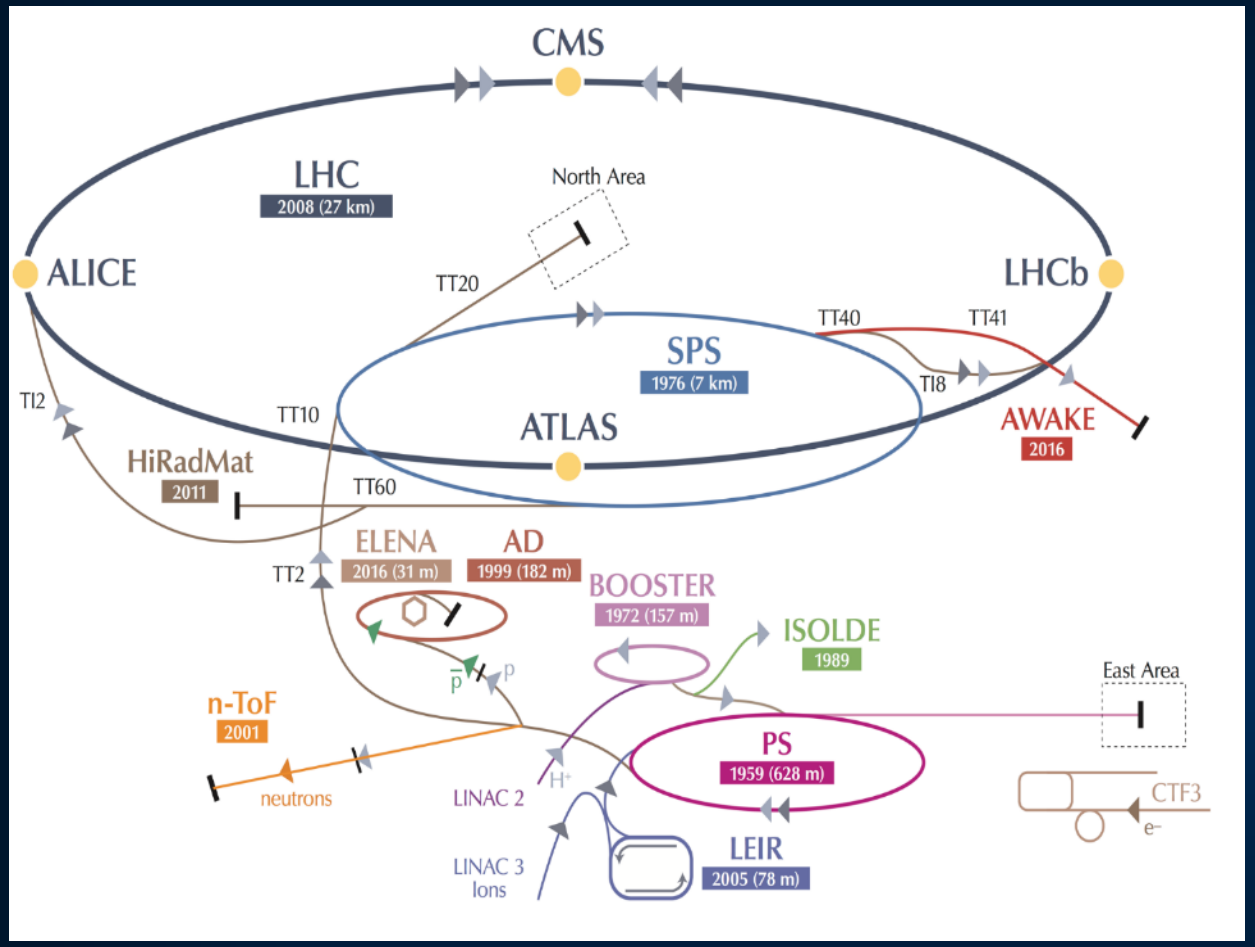
LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
CMS
ALICE

Exploration of a new energy frontier
in p-p and Pb-Pb collisions

Discovery 2012, Nobel Prize in Physics 2013

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".*

CERN's scientific diversity programme



~20 experiments, > 1200 physicists

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AWAKE: proton-induced plasma wakefield acceleration

CAST, OSQAR: axions

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Neutrino Platform: ν detectors R&D for experiments in US, Japan

n-TOF: n-induced cross-sections

UA9: crystal collimation

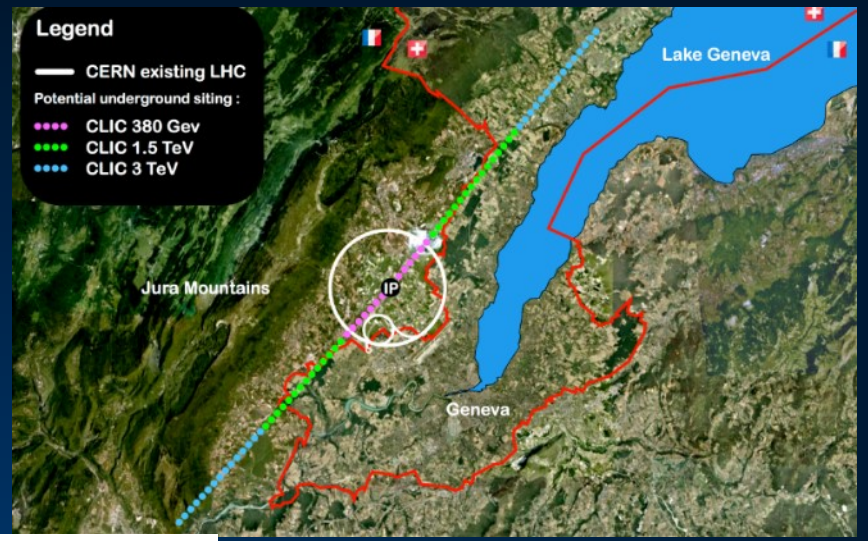
Future of particle physics

High Luminosity LHC until 2035

- Ten times more collisions than the original design

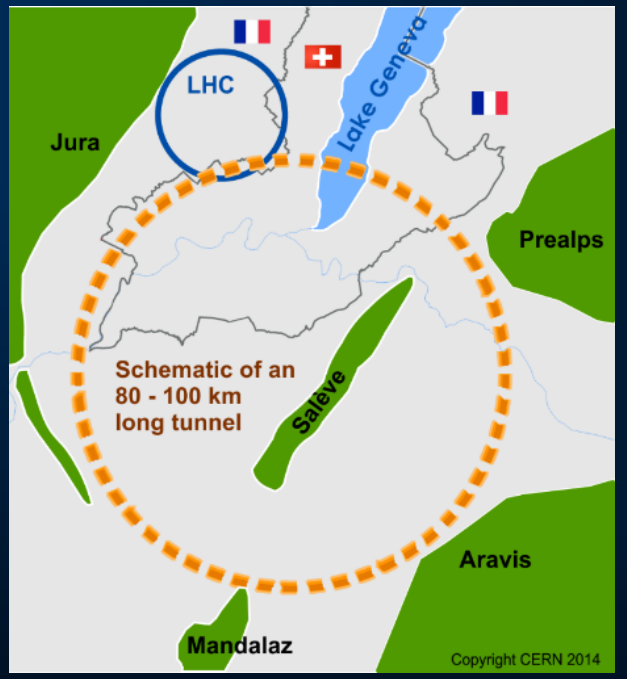
Studies in progress:
Compact Linear Collider (CLIC)

- Linear e^+e^- collider $\sqrt{s}$ up to 3 TeV



Future Circular Collider (FCC)

- New technology magnets → 100 TeV pp collisions in 100km ring
- e^+e^- collider (FCC-ee) as 1st step?
- HE-LHC in the present LHC tunnel with FCC-hh technology?



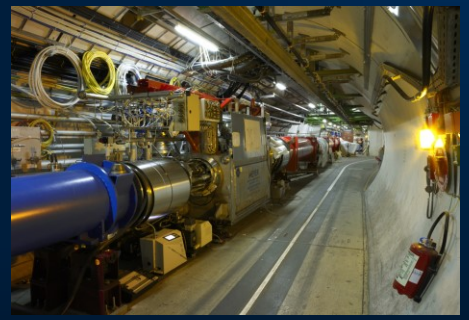
European Strategy for Particle Physics

- Preparing next update in 2020

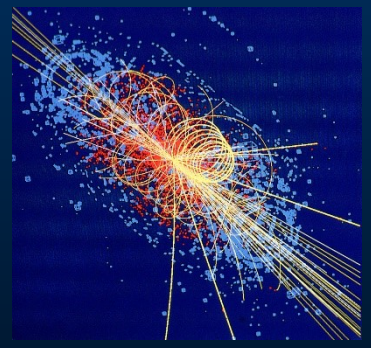
CERN: Particle Physics and Innovation

- Interfacing between fundamental science and key technological developments

- CERN Technologies and Innovation



Accelerating particle beams

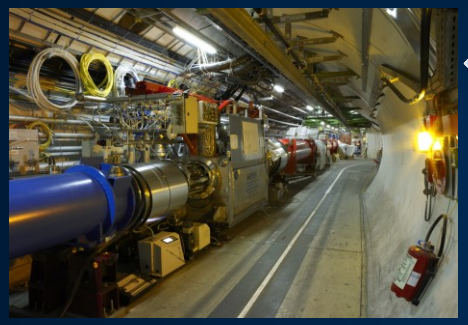


Detecting particles

Large-scale computing (Grid)

Medical Application as an Example of Particle Physics Spin-off

Combining Physics, ICT, Biology and Medicine to fight cancer

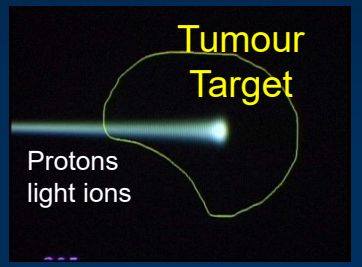


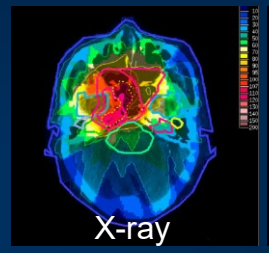
Accelerating particle beams

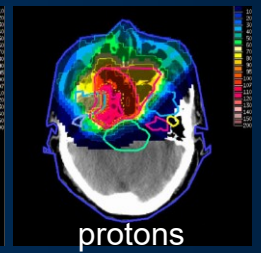
~30’000 accelerators worldwide

~17’000 used for medicine

Hadron Therapy



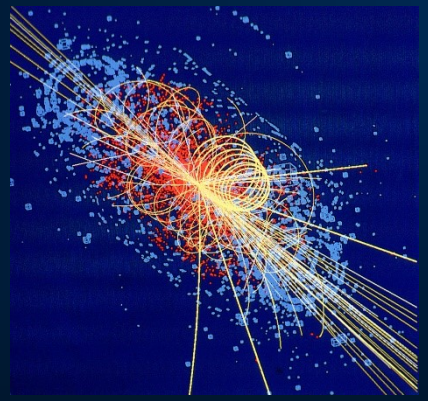




Leadership in Ion Beam Therapy now in Europe and Japan

>100’000 patients treated worldwide (45 facilities)

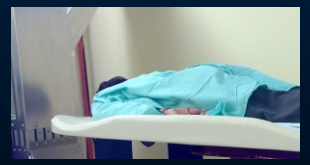
>50’000 patients treated in Europe (14 facilities)



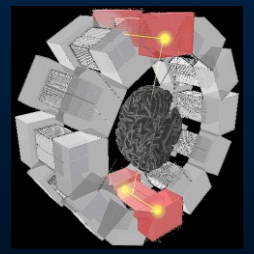
Detecting particles

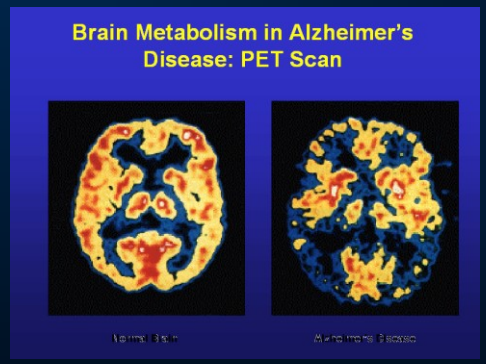
Imaging

Clinical trial in Portugal, France and Italy for new breast imaging system (ClearPEM)



PET Scanner



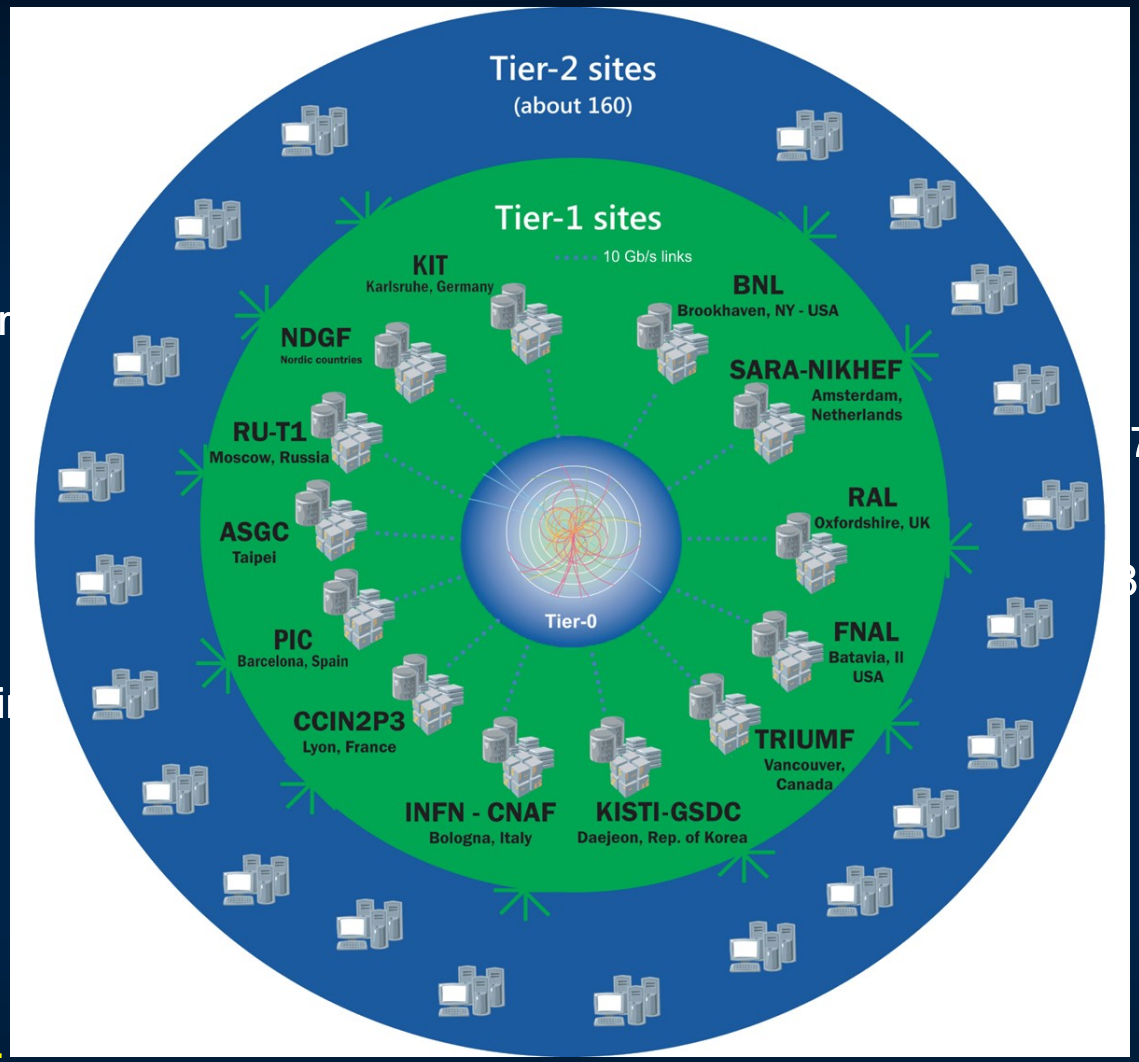


The Worldwide LHC Computing Grid

Tier-0
(CERN and Hungar
data recording,
reconstruction and
distribution

Tier-1: permanent
storage, reprocessi
analysis

Tier-2: simulation,
end-user analysis



>170 sites in,
42 countries

750k CPU cores

300 PB of storage

2 million jobs/day

35 GB/s global
transfers

WLCG:
An International collaboration to distribute and analyse LHC data

Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists

CERN Education Activities

Scientists at CERN
Academic Training Programme

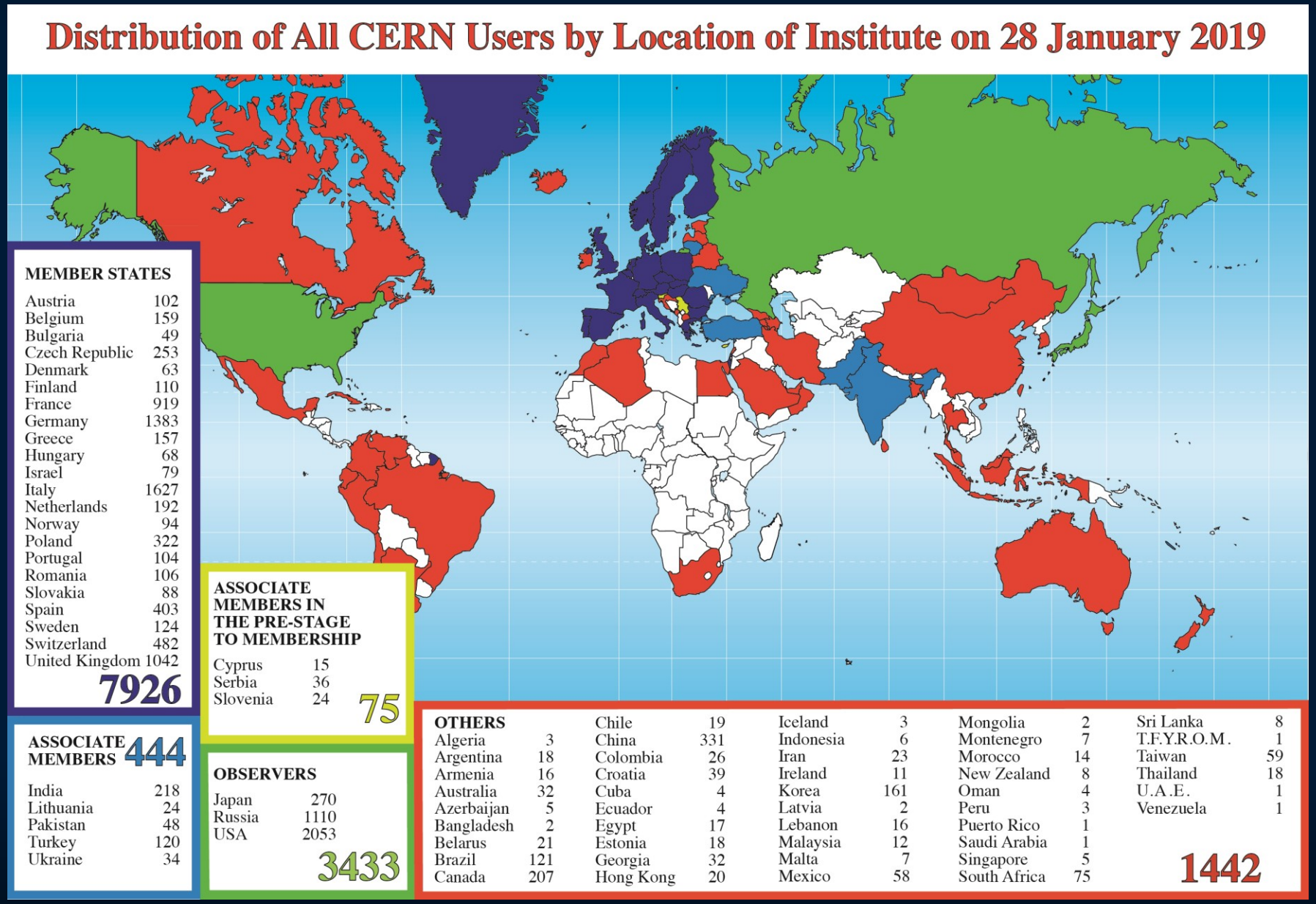
Young Researchers
CERN School of High Energy Physics
CERN School of Computing
CERN Accelerator School

Undergraduates
Summer Students Programme

CERN Teacher Schools
International and National Programmes

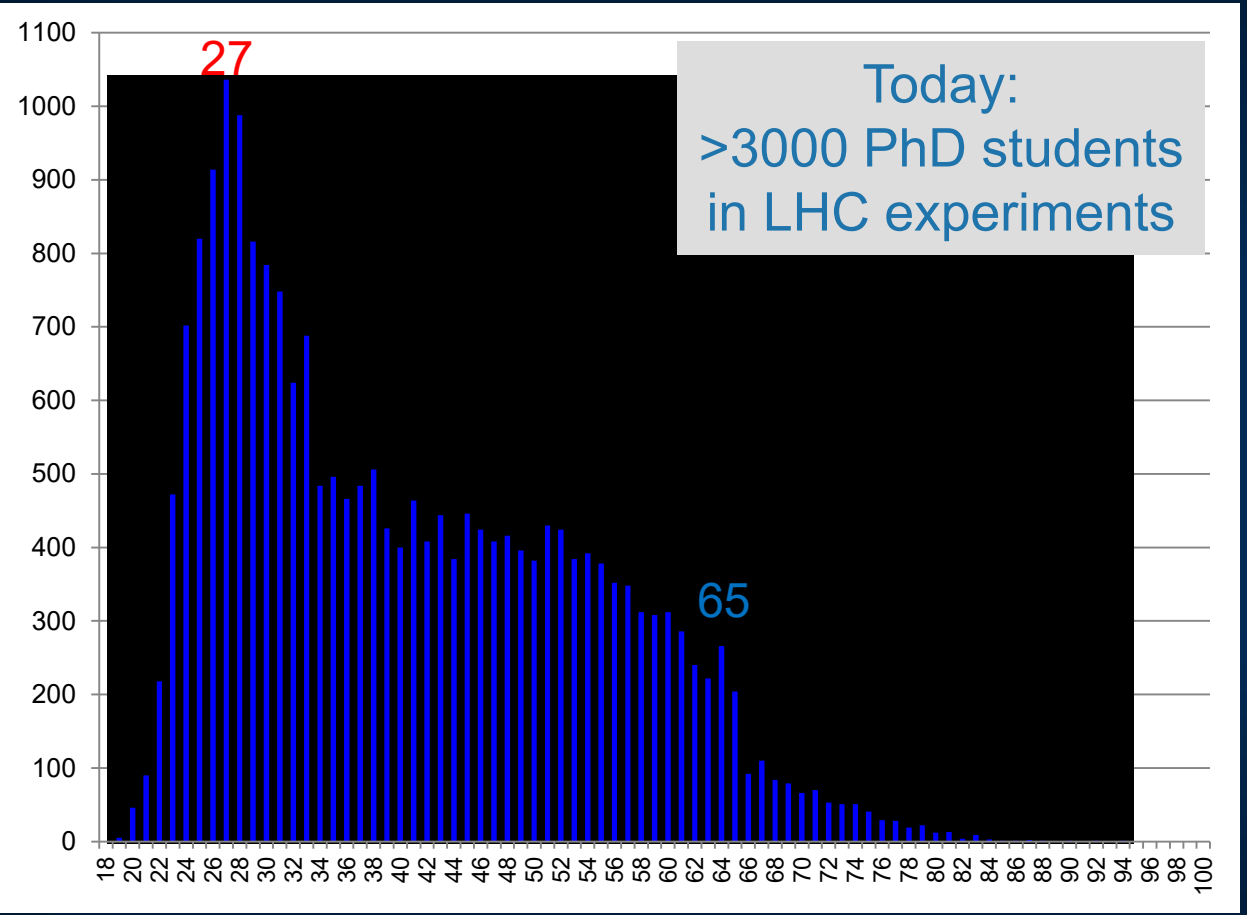
Public visitors
135 thousand per year

Science is getting more and more global



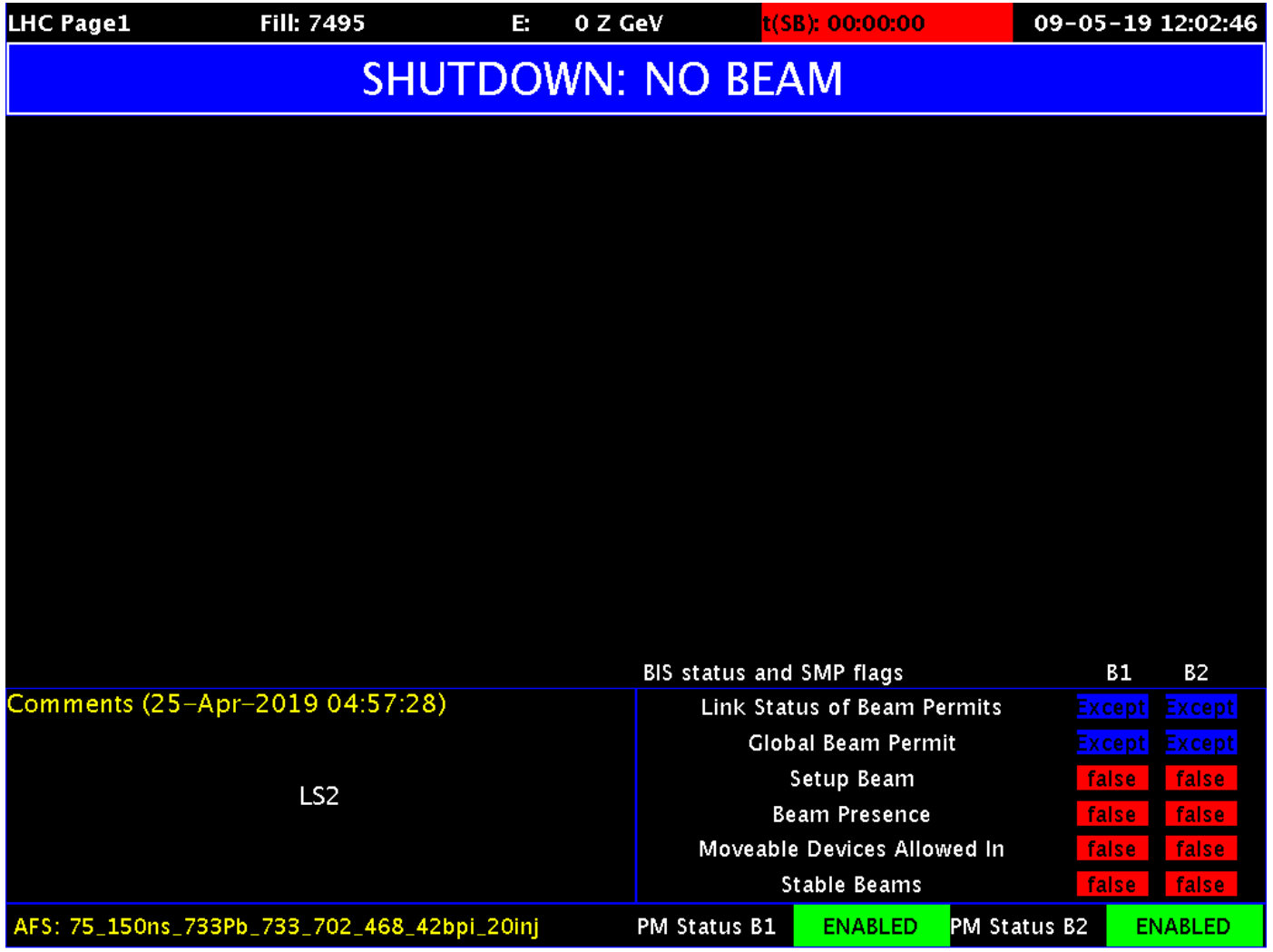
Age Distribution of Scientists

- and where they go afterwards



They do not all stay: where do they go?

What's happening now at CERN?



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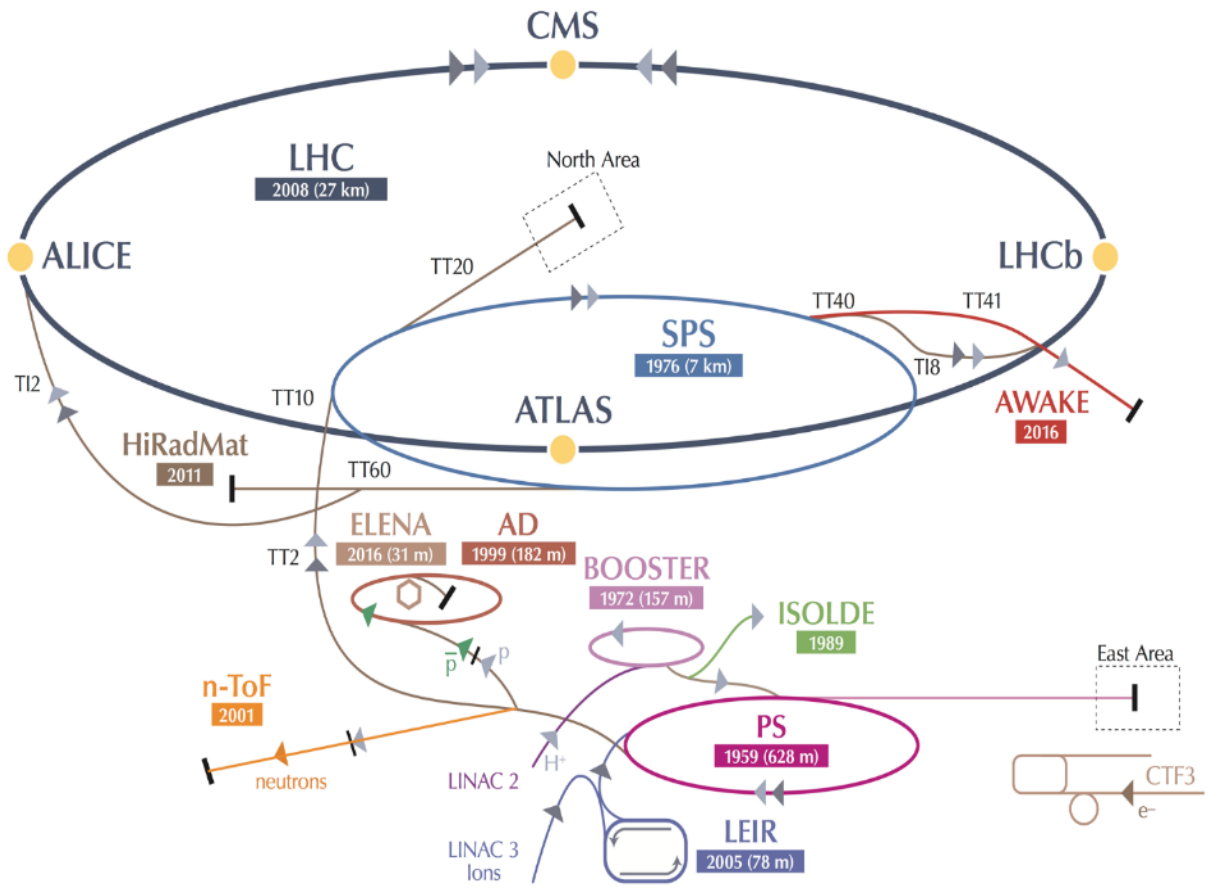
CERN's scientific diversity programme

CERN accelerators



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Neutrino Platform: ν detectors R&D for experiments in US, Japan

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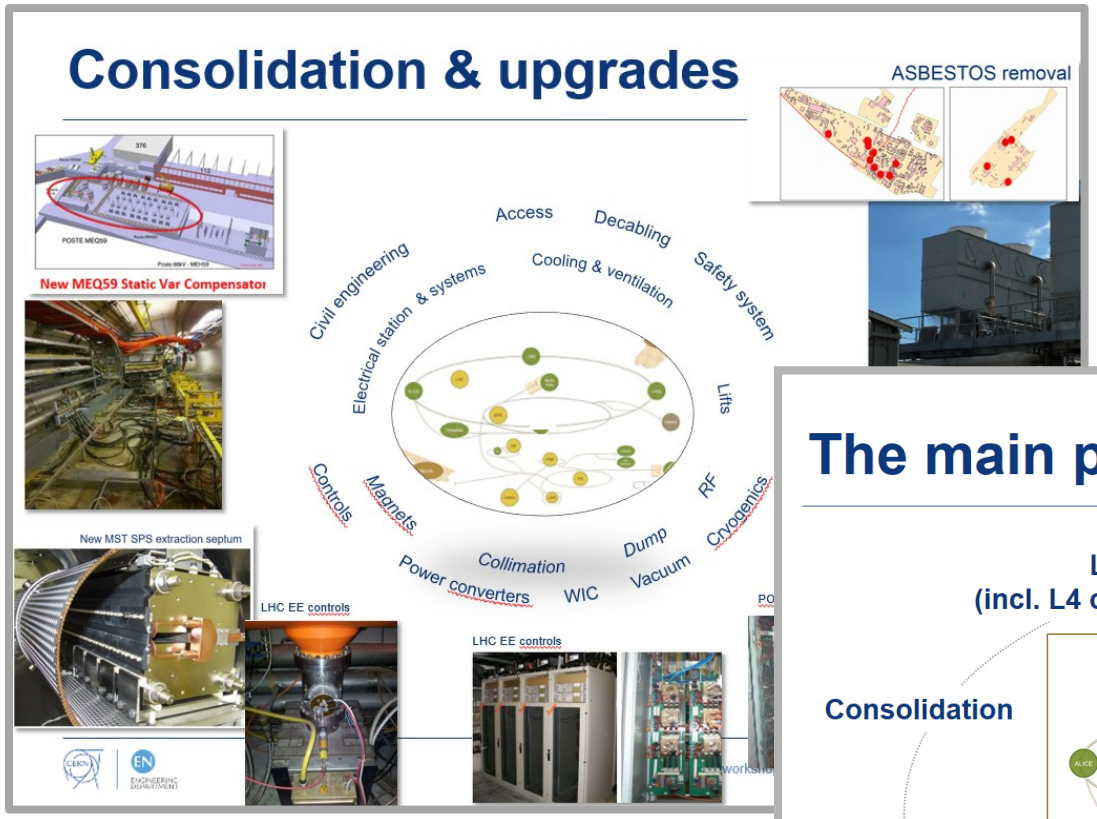
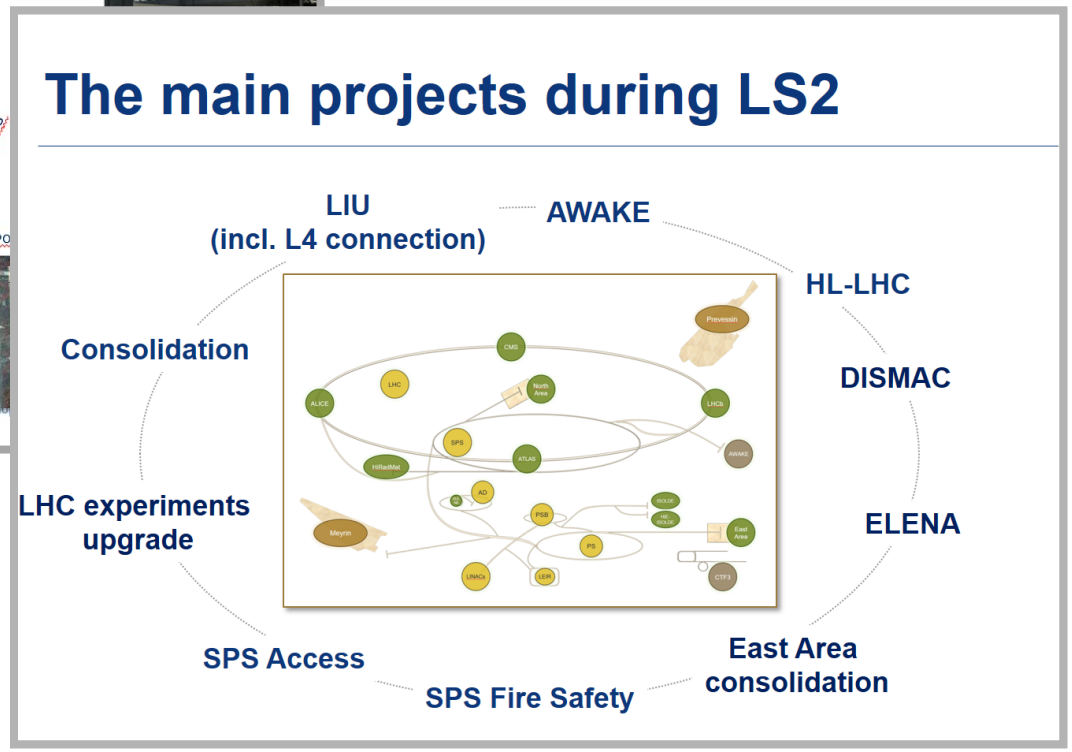
LS2 (2019-2020 period): coordination of multi projects





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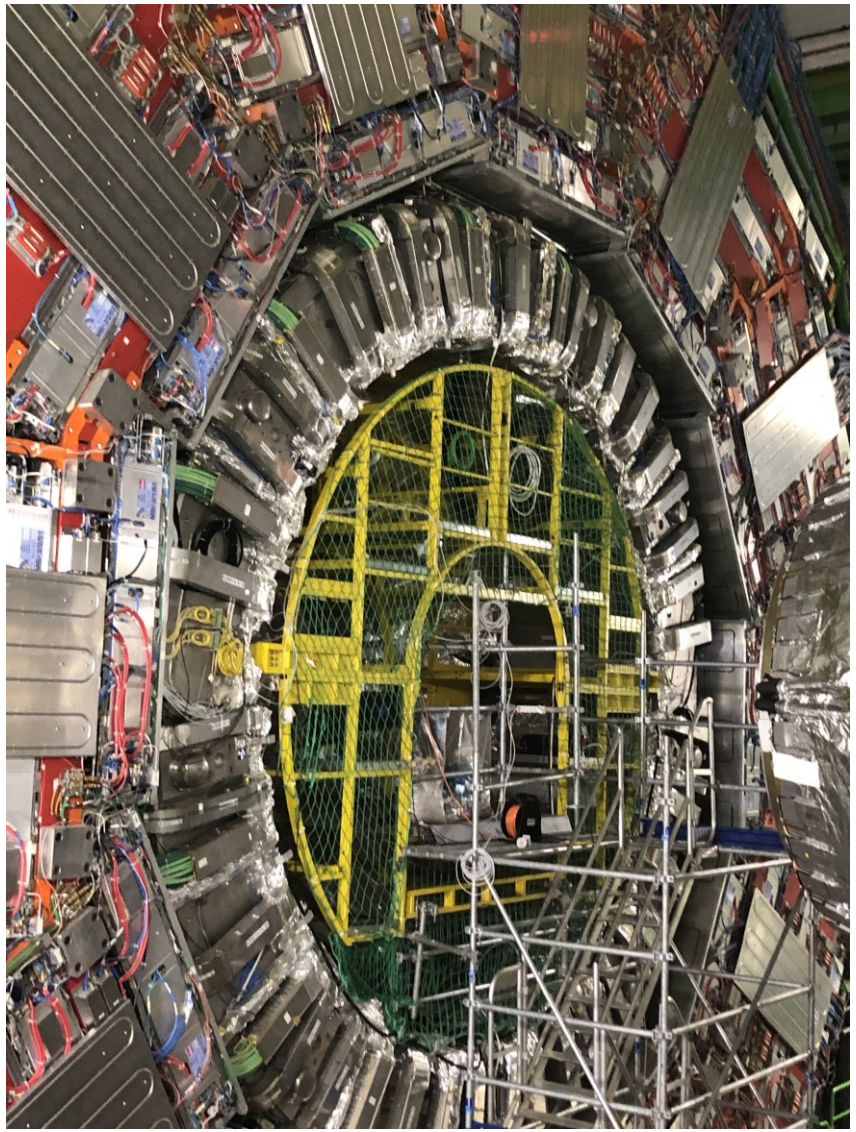

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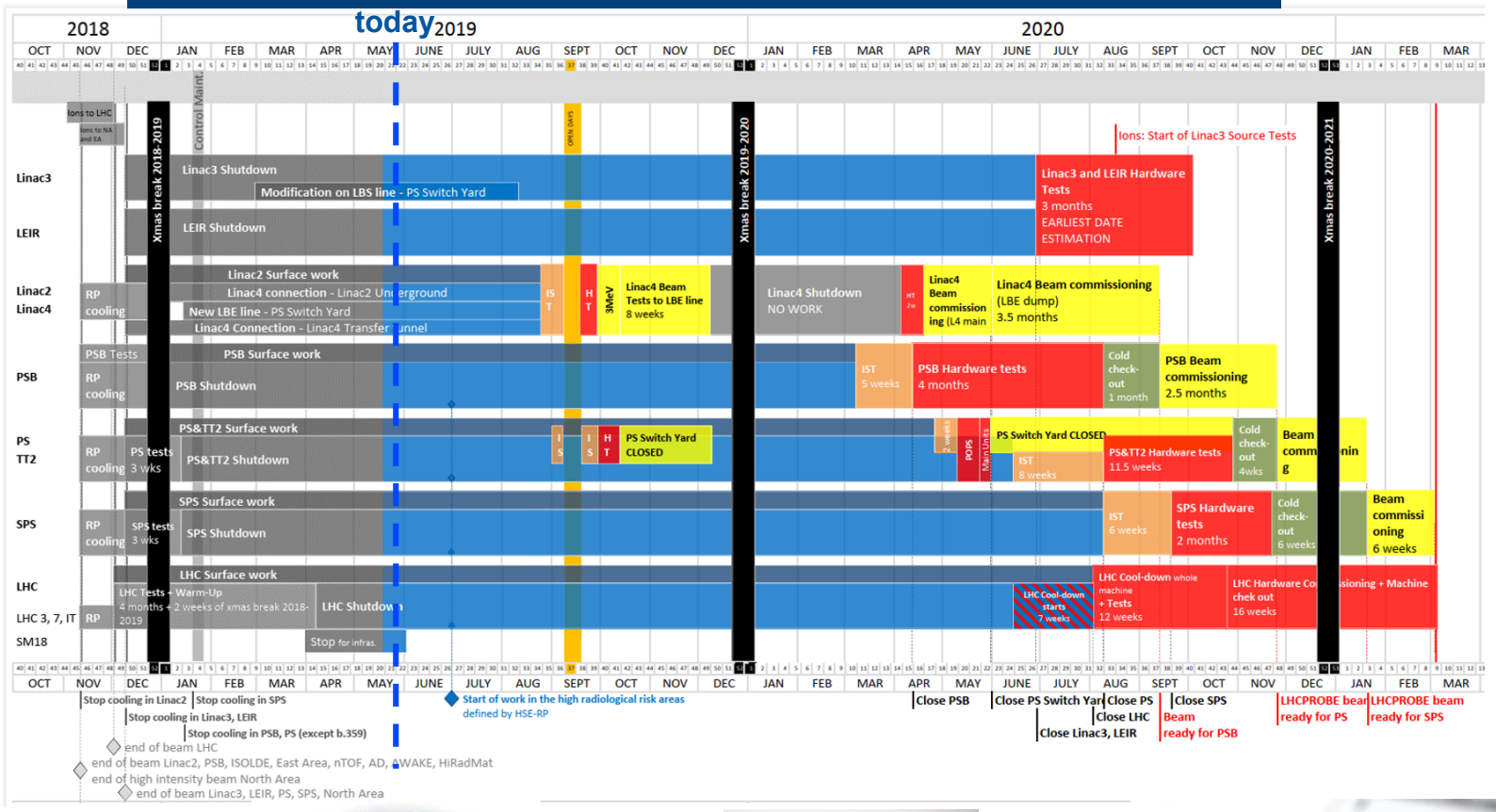
Master Schedule of the Long Shutdown 2



Safety First

Quality second

Schedule third

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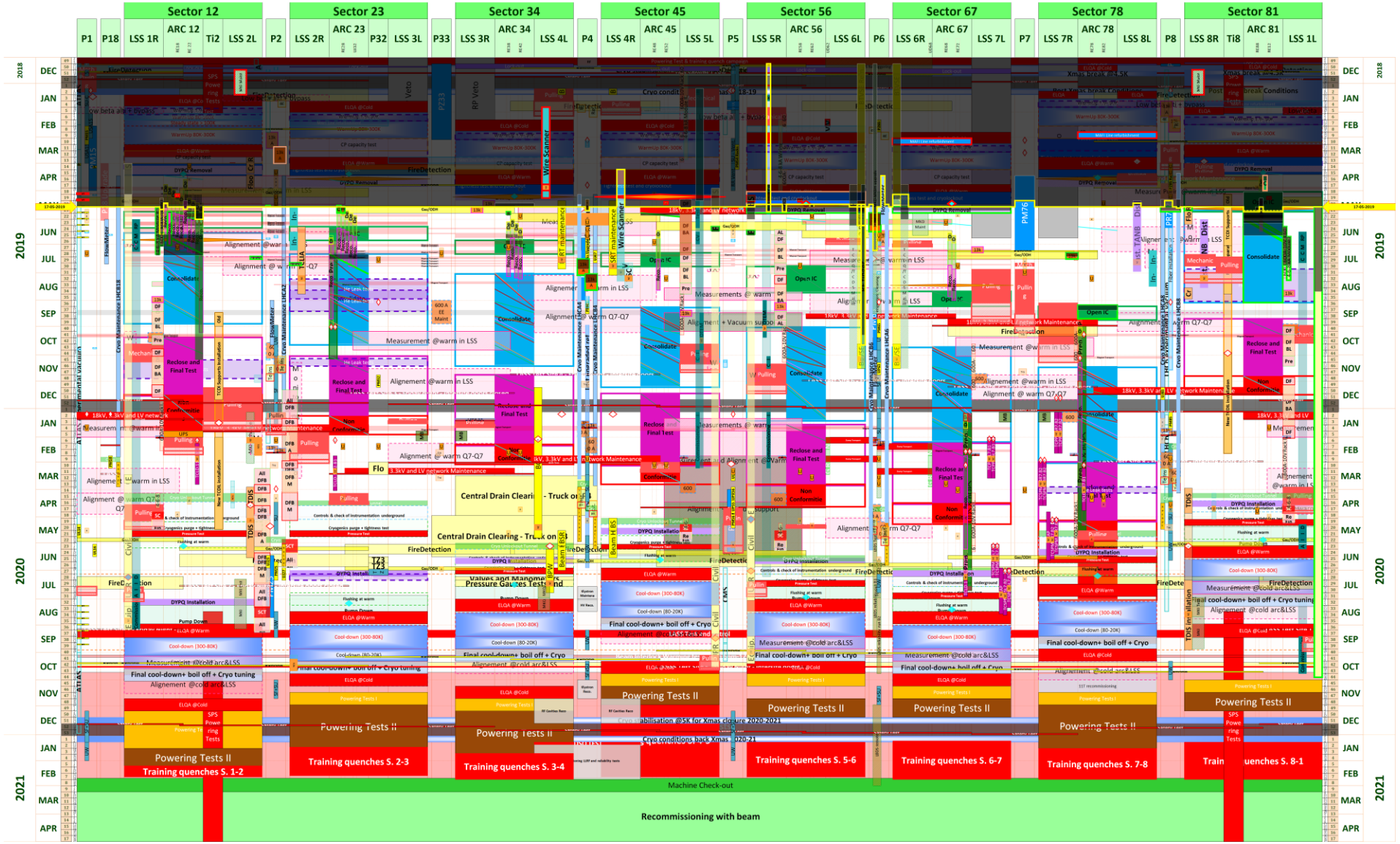
LHC: LS2 planning (version 1.4)

https://cern.ch/lhcdashboard/ls2



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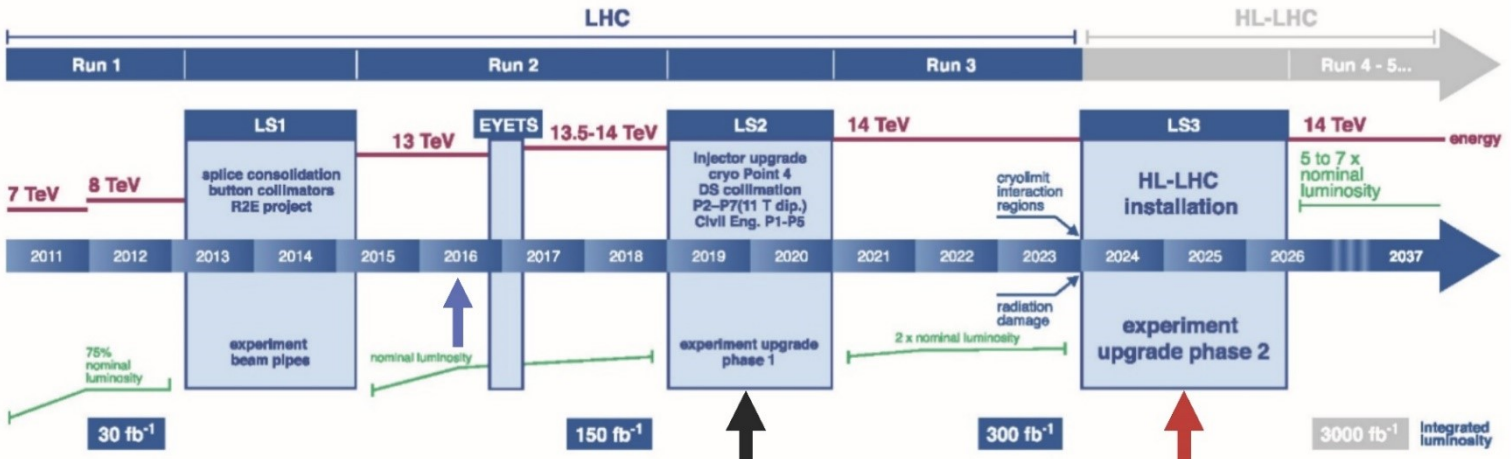
Nominal LHC: $\sqrt{s}$ = 14 TeV, L= 1x10^{34} cm^{-2} s^{-1}
Integrated luminosity to ATLAS and CMS: 300 fb^{-1} by 2023 (end of Run-3)

HL-LHC: $\sqrt{s}$ = 14 TeV, L= 5x10^{34} cm^{-2} s^{-1} (levelled)
Integrated luminosity to ATLAS and CMS: 3000 fb^{-1} by ~ 2035



LS2 (2019-2020):
- ❑ LHC Injectors Upgrade (LIU)
- ❑ Civil engineering for HL-LHC equipment P1,P5
- ❑ First 11T dipoles P7; cryogenics in P4
- ❑ Phase-1 upgrade of LHC experiments

LS3 (2024-2026):
- ❑ **HL-LHC installation**
- ❑ Phase-2 upgrade of ATLAS and CMS

Project timeline driven by radiation damage to some machine components: end of lifetime ~2023

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(W) LHC Computing

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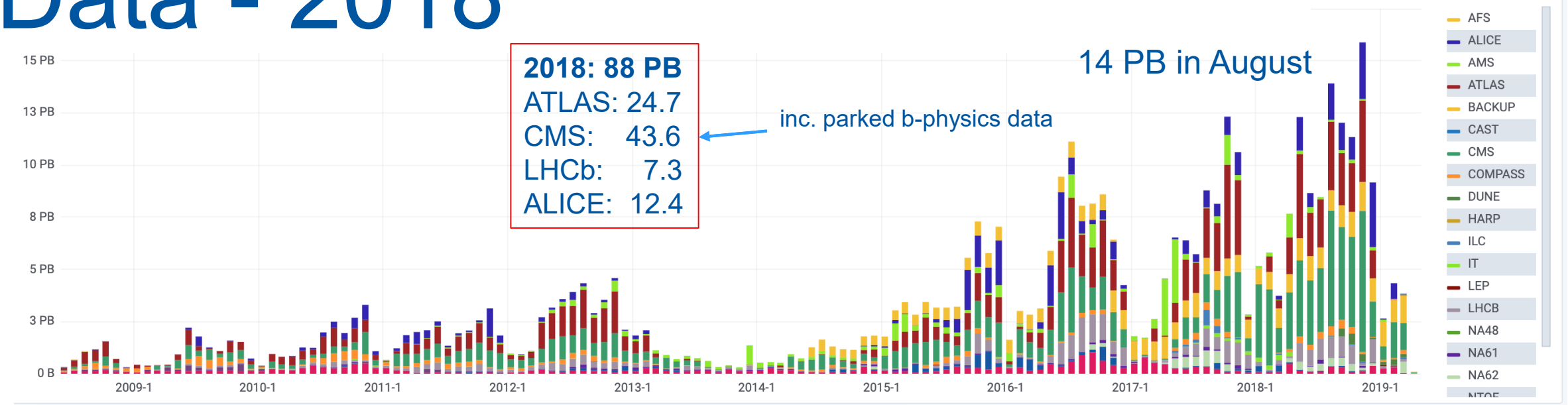
Data - 2018

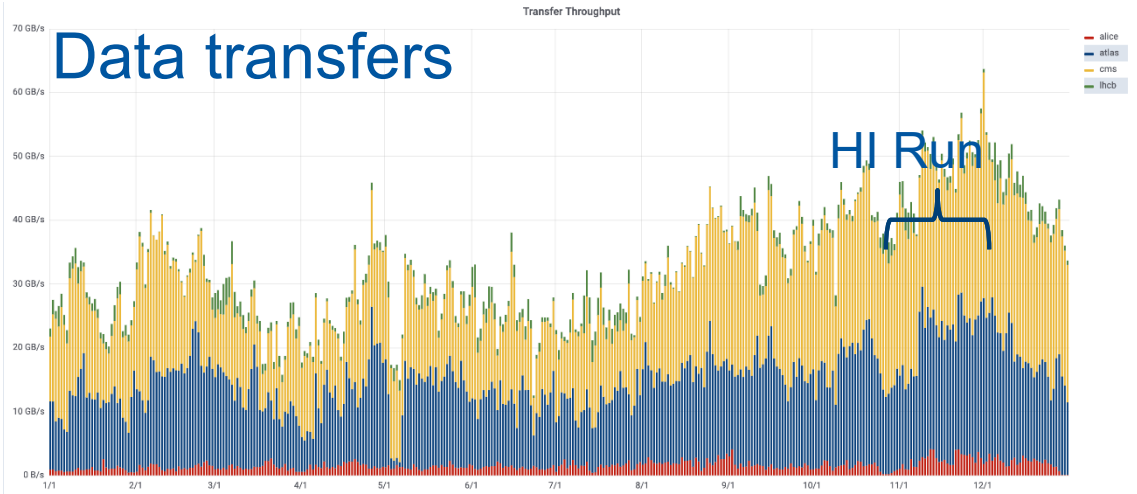
2018: 88 PB
ATLAS: 24.7
CMS: 43.6
LHCb: 7.3
ALICE: 12.4

inc. parked b-physics data

14 PB in August



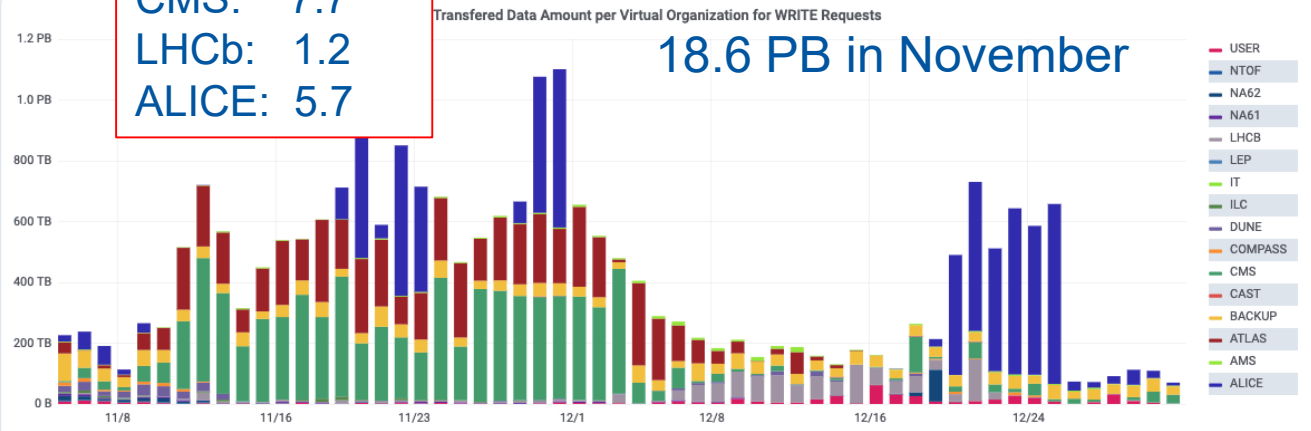
Data transfers



2018: 19.8 PB
ATLAS: 5.2
CMS: 7.7
LHCb: 1.2
ALICE: 5.7

HI Run

18.6 PB in November



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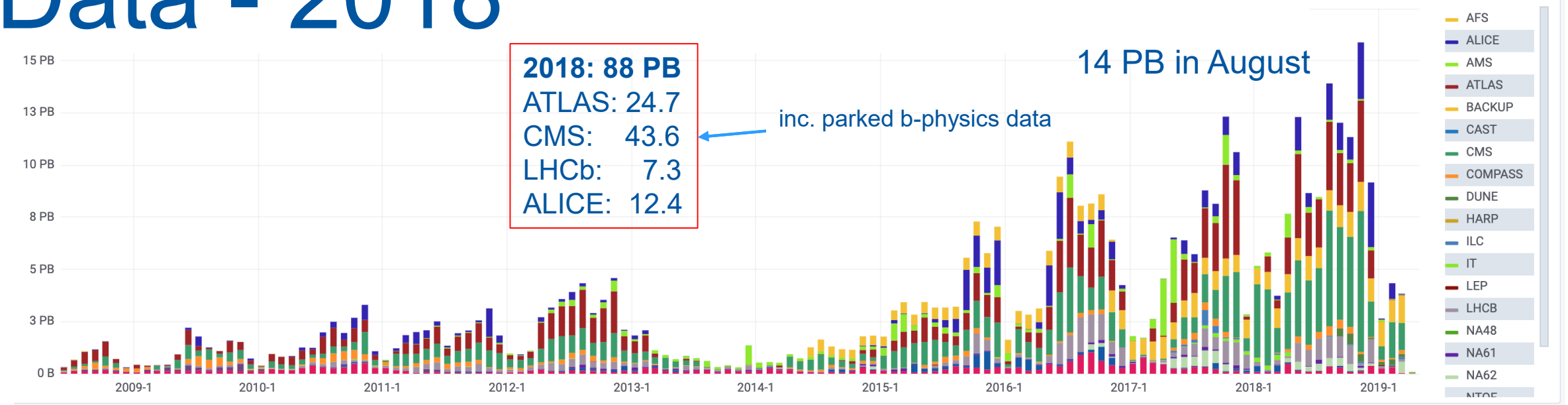
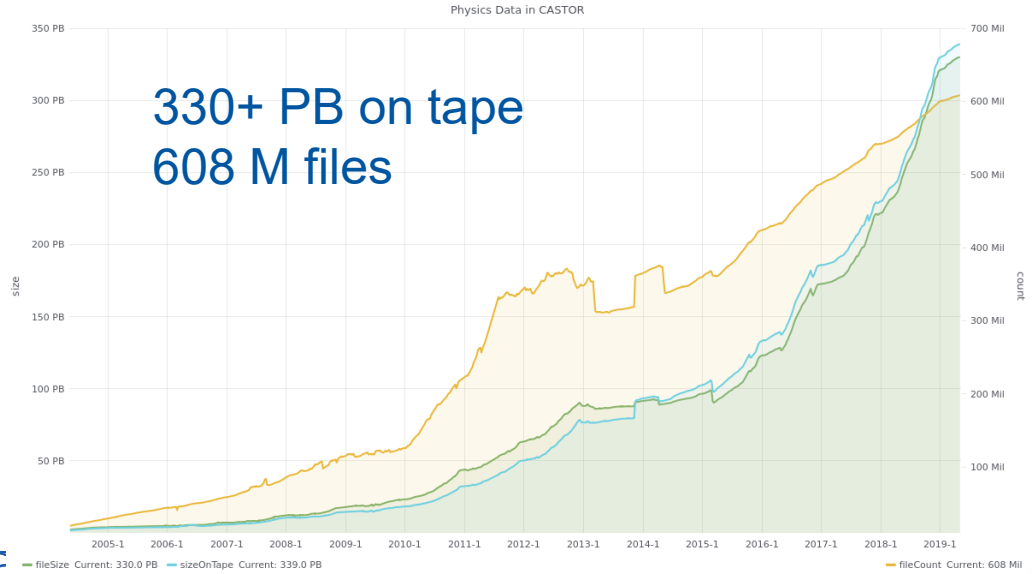


330+ PB on tape
608 M files



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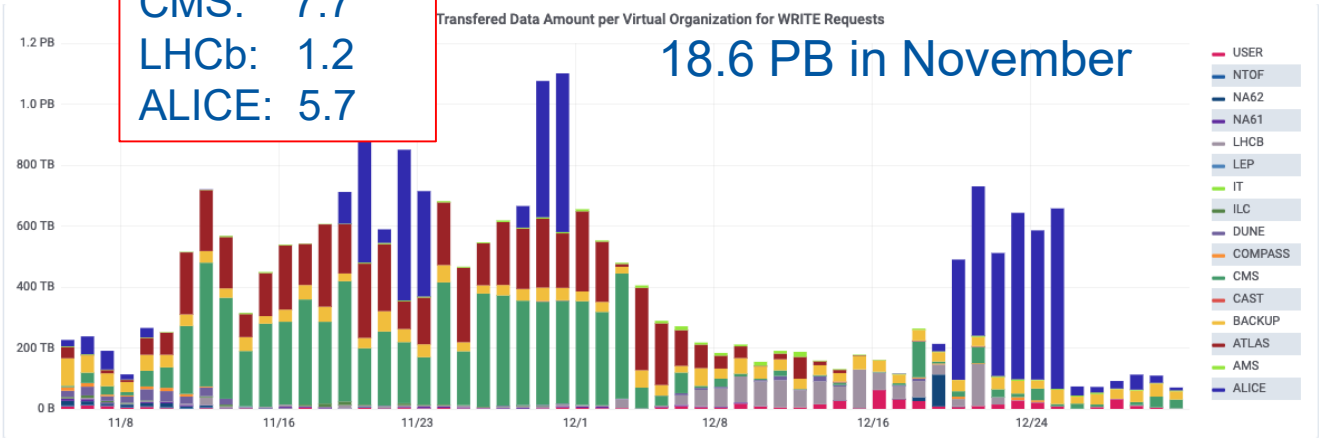

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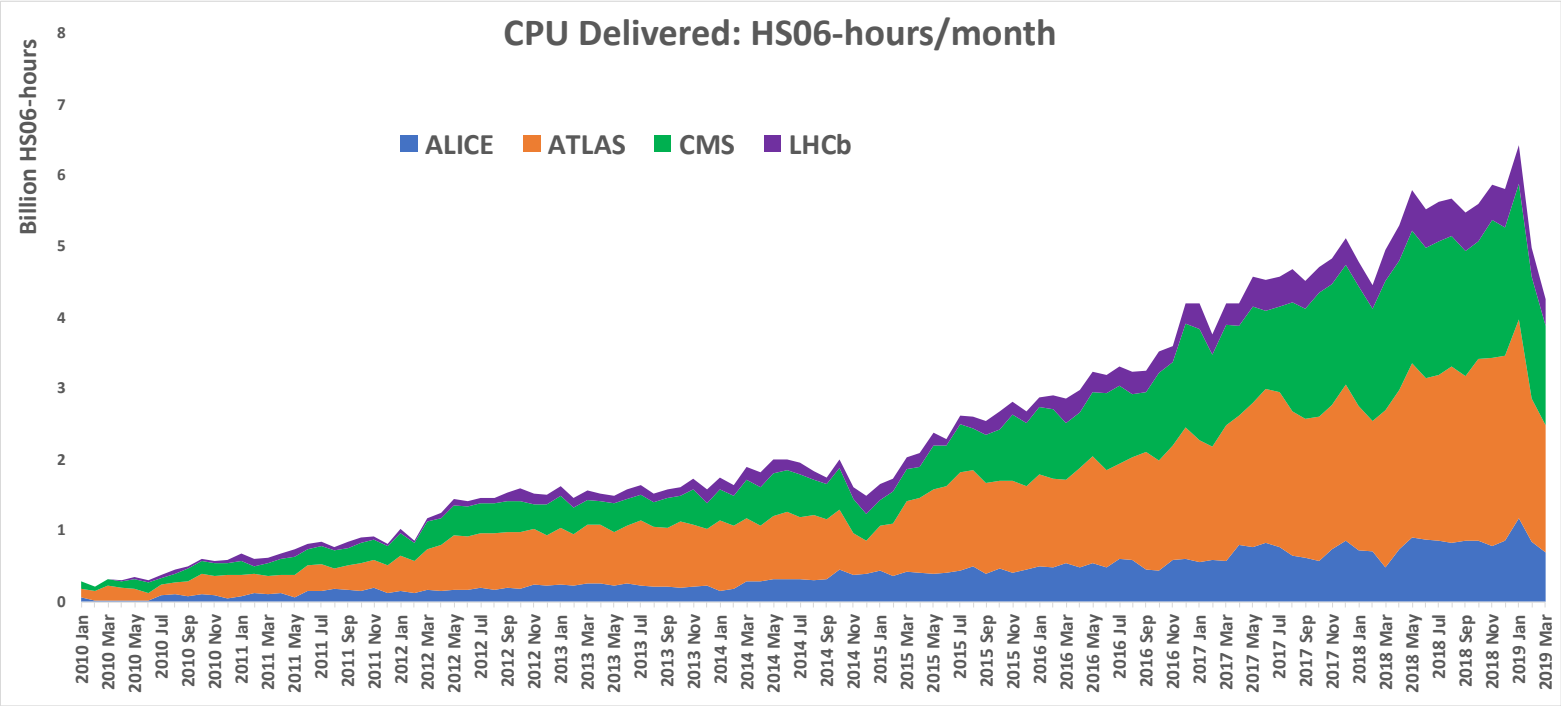
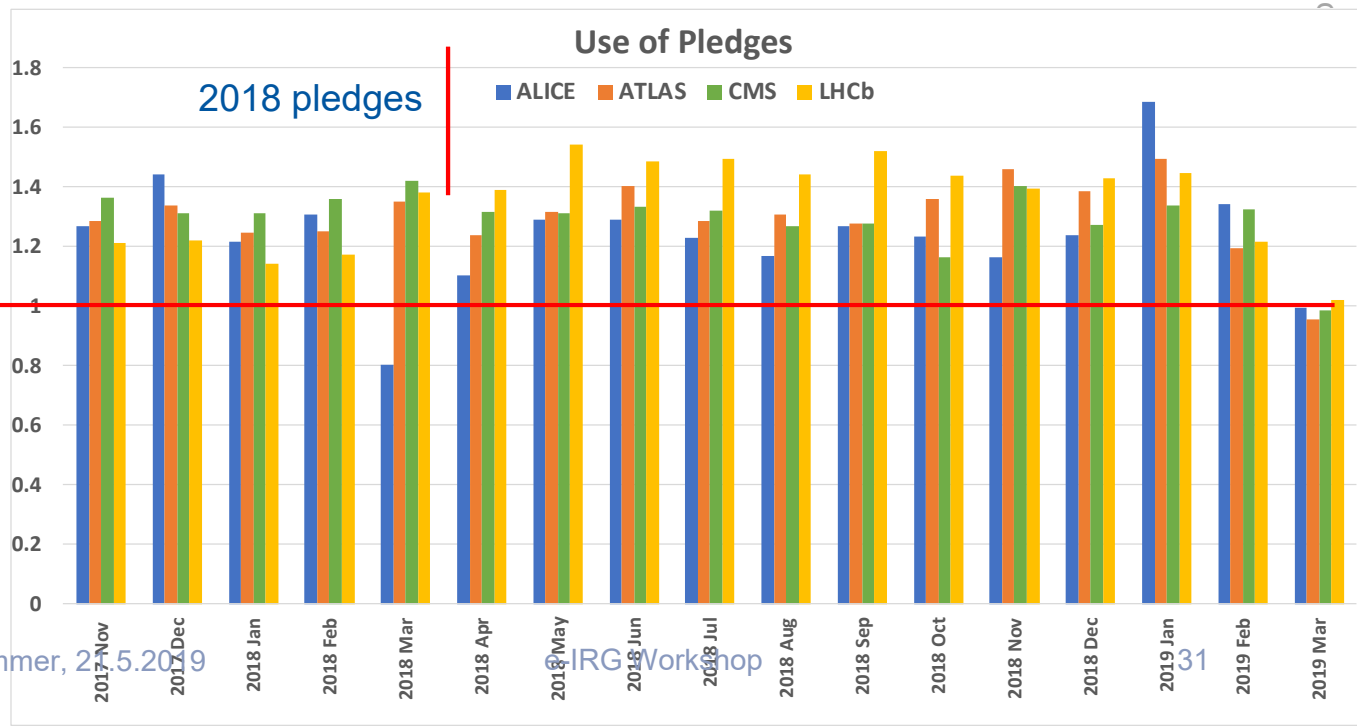
CPU Delivered



New peak: ~270 M HS06-days/month

~ 860 k cores continuous



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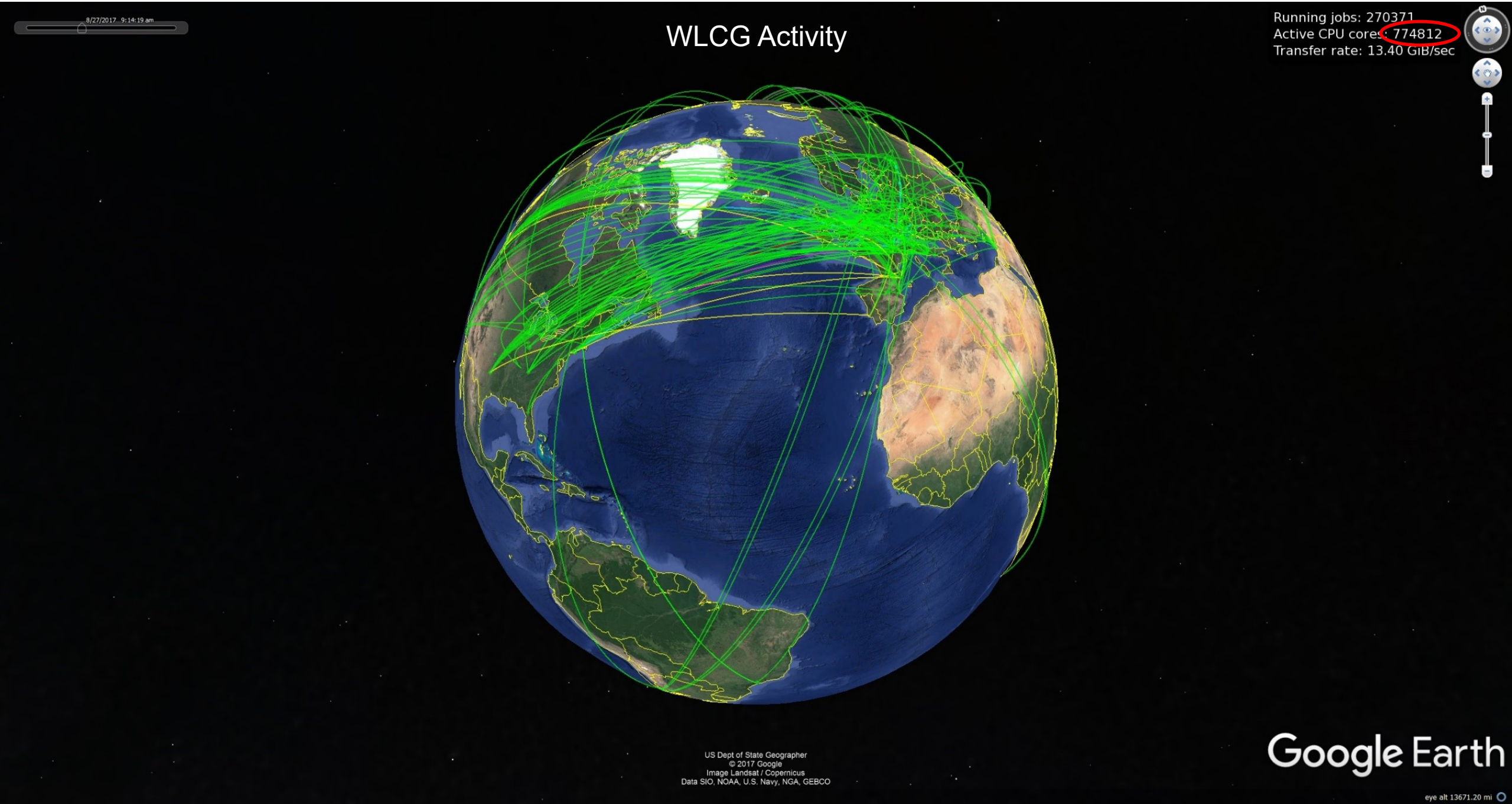
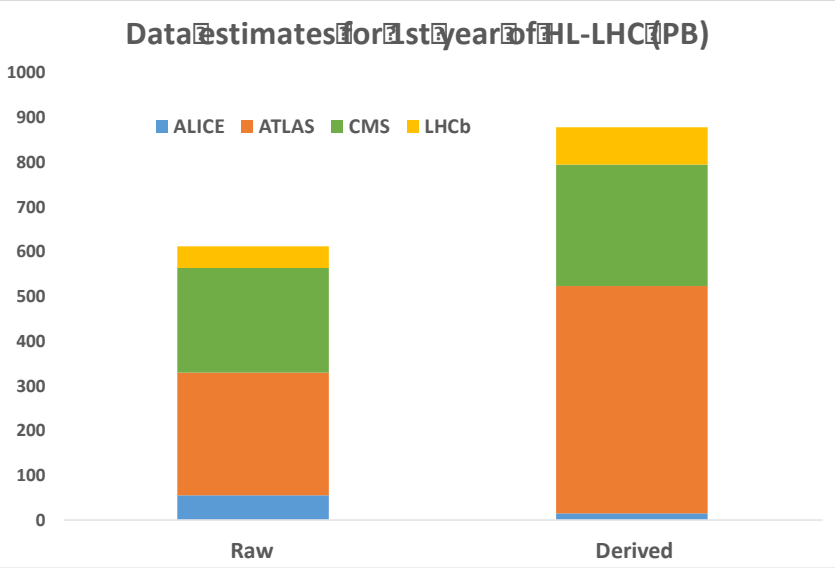
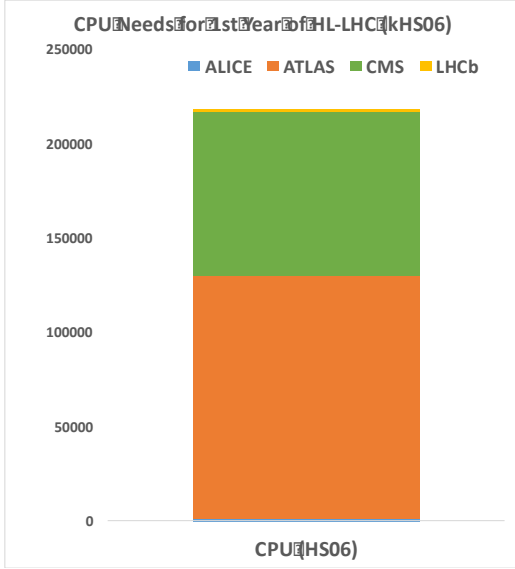

8/27/2017 9:14:19 am
WLCG Activity
Running jobs: 270371
Active CPU cores: 774812
Transfer rate: 13.40 GiB/sec
US Dept of State Geographer
© 2017 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth
eye alt 13671.20 mi

Estimates of resource needs for HL-LHC





Data:
- Raw 2016: 50 PB → 2027: 600 PB
- Derived (1 copy): 2016: 80 PB → 2027: 900 PB

CPU:
- x60 from 2016

Technology at ~20%/year will bring x6-10 in 10-11 years

- Simple model based on today's computing models, but with expected HL-LHC operating parameters (pile-up, trigger rates, etc.)
- At least x10 above what is realistic to expect from technology with reasonably constant cost

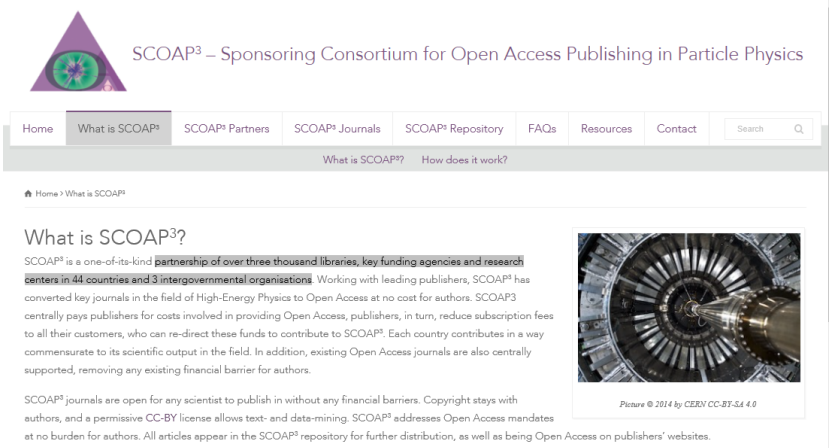
Document Classification: Restricted

CERN, IT & EOSC

Document Classification: Restricted

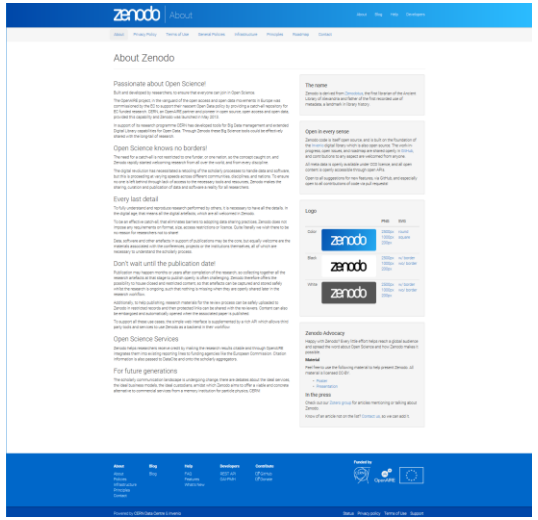
CERN Services for the Global Community

- SCOAP^3: Open Access Publishing for Particle Physics
  - Journals at no cost for the Authors



- CERN Open Data Portal
  - Explore more than **1 petabyte** of open data from particle physics!

- Zenodo Digital Repository
  - Support for Open Science



Document Classification: Restricted

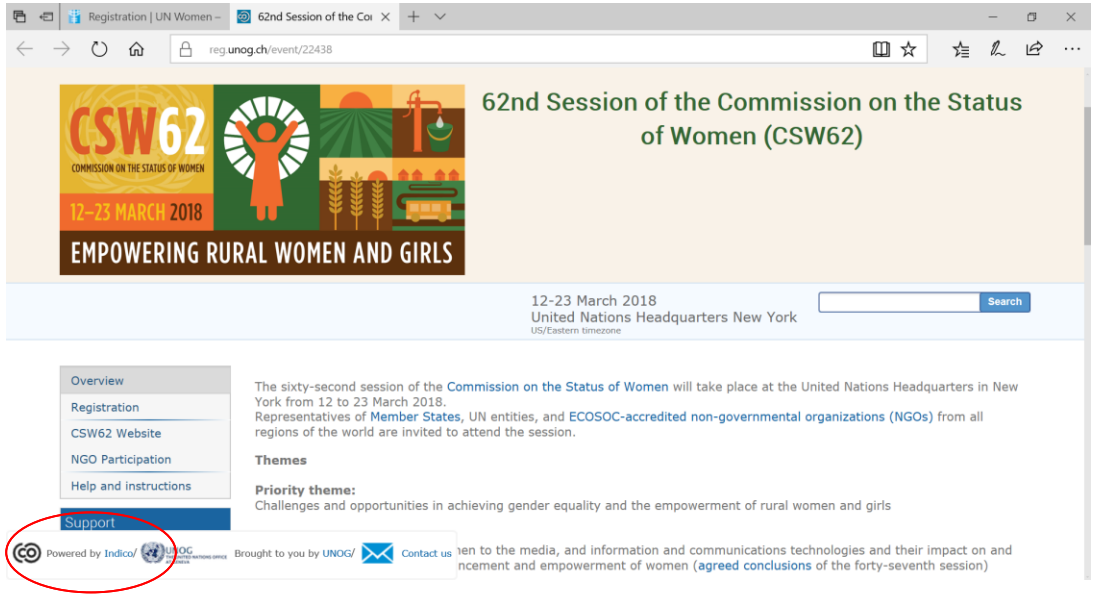
An example of CERN Technology Transfer through Open Source Software

CERN's Indico Conference & Meetings Management Software

Document Classification: Restricted

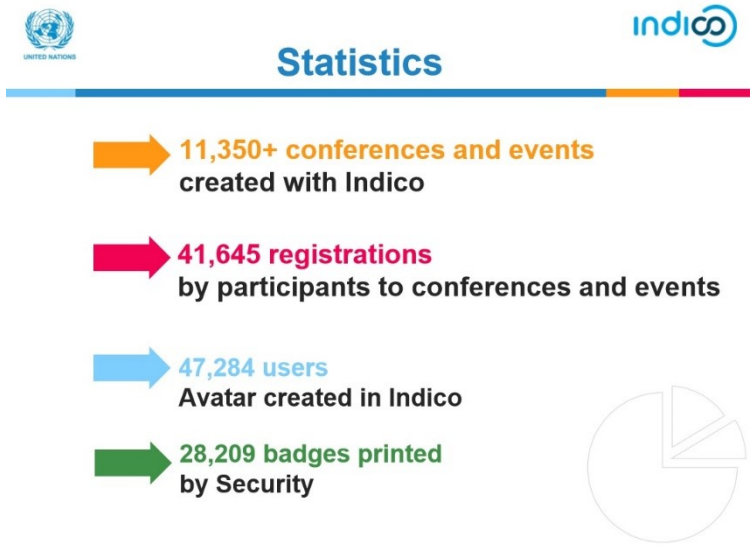
United Nations

- Mandated by UNOG
- Implemented during 2015-2017



Benefits as seen by UN

- Shorter and faster queues at the Pregny Gate
- Increased efficiency by Security
- Expanded services to conference participants
- Modernised business processes
- Improved UN image
- Support for remote venues



> 220 (known) Indico instances worldwide

https://getindico.io/

Document Classification: Restricted

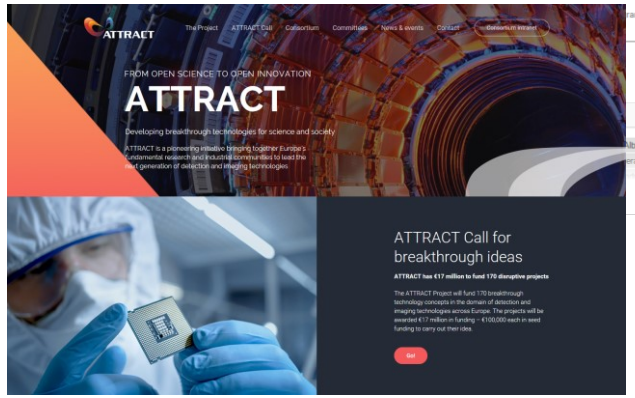
CERN Contributions to EOSC

- OpenAIRE: Zenodo service
- EOSC-Hub: operational security, biz model development
- GEANT 4-3: Collaborate with SWITCH on ‘Trust and Identity Services’ & ‘Enabling Communities (FIM4R)’
- HNSciCloud and OCRE: practical models for the procurement of commercial cloud services
- ESCAPE: interfacing FAIR data services from the Astronomy & Particle physics ESFRI research infrastructures to EOSC
- eXtreme DataCloud (XDC): developing scalable technologies for federating storage resources and managing data in highly distributed computing environment
- EOSCsecretariat: helping plan EOSC with contributions to business models and relations to industry
- Up to University (Up2U): developing tools and services for educational environment
- ARCHIVER: procurement of innovative services to support the long term data preservation needs of research communities

Document Classification: Restricted

EOSC, ESFRI's & EIROForum

- ESFRI's & EIROForum organisations are big data factories production high quality data
  - Attracting end-users and bringing credibility
- HPC & new architectures are becoming essential for data intensive research
  - CERN participates in DEEP-EST
- Innovation is key in this context
  - ATTRACT kickoff 170 projects will be awarded 17 M€
  - CERN IT is contributing two projects
  - through the CERN openlab
    - FPGA & Quantum Computing



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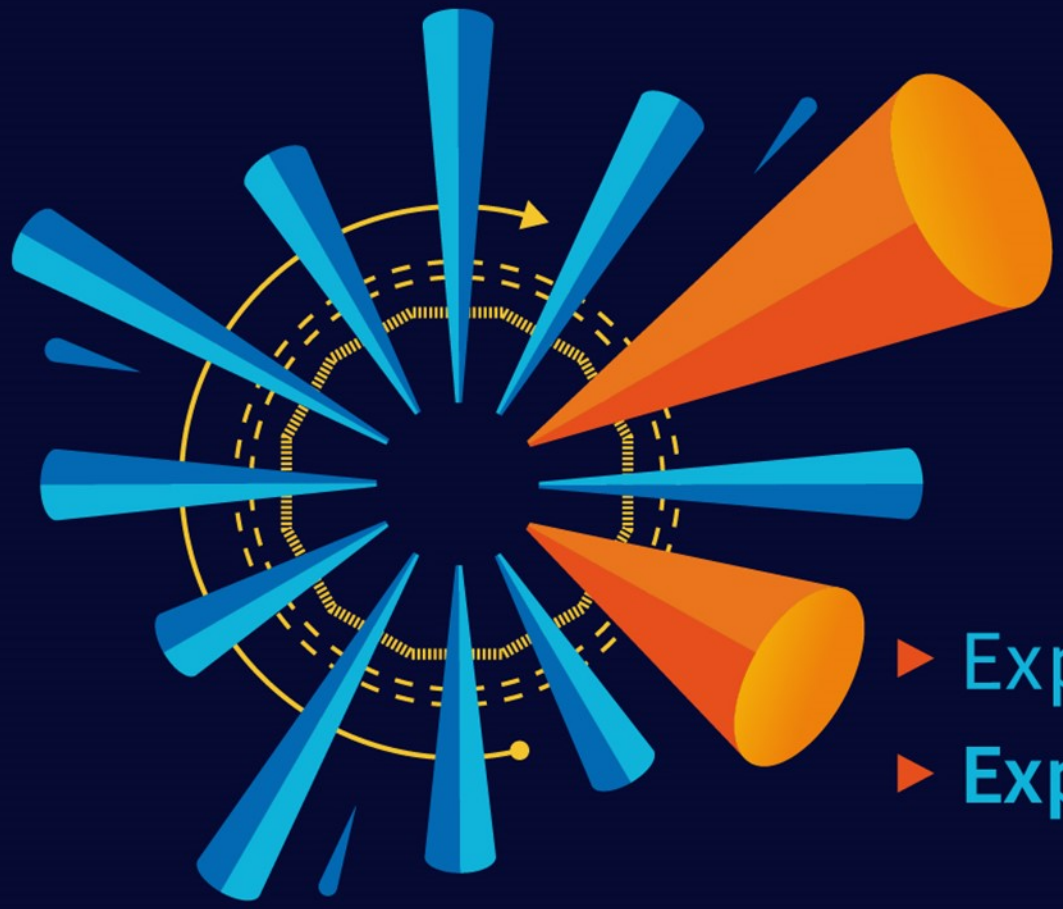
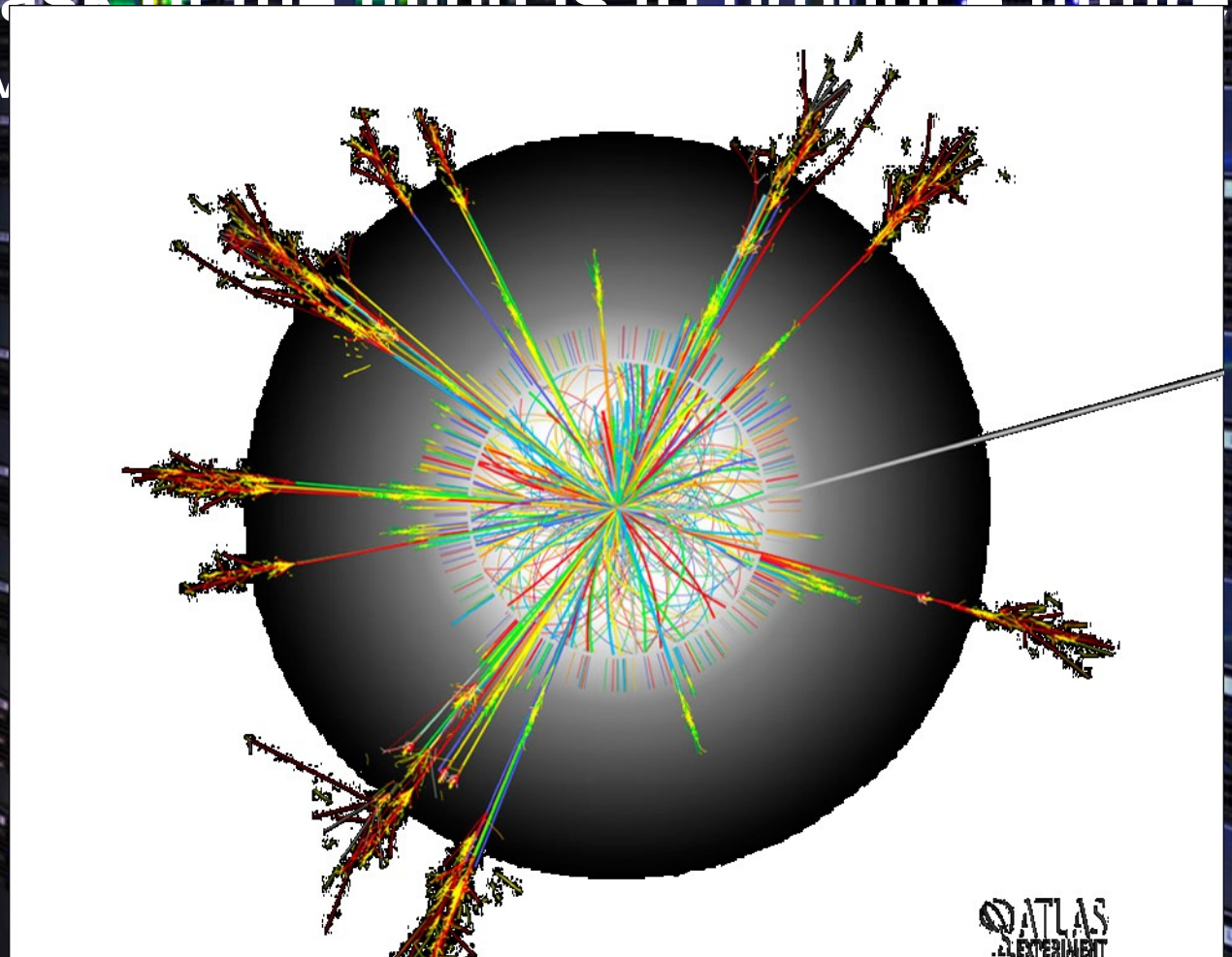


CERN OPENDAYS

- Explore the future with us
- **Explorez le futur avec nous**

14 - 15 septembre / September 2019

Thank you for your attention

"The task of the mind is to produce future"

Paul V