



Latin American Participation in the CERN experimental HEP programme

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Why am I here?

- [LASFRI](#) Preparatory Group member for CERN / Europe
- [LAA-HECAP](#) Board member
 - Education committee
- Director of CERN Schools of High-Energy Physics
 - CERN HEP schools in [Latin America](#), Europe, Asia
- CERN Research Physicist -- CMS collaboration (previously: DELPHI, D0)
Selection of physics topics:
 - Higgs, W boson and top quark precision measurements
 - Diffractive physics with proton tagging
 - Muon detection and reconstruction (atmospheric and collider muons)



Latin American involvement in experimental HEP (a selection of milestones in particle physics)

High-energy particle colliders allow exploration of matter at the smallest scales (= highest energies) under controlled conditions inside the laboratory - requiring large infrastructures and international collaboration.

Over the years LA institutes have joined these international efforts:

- **1983** CERN SPS **0.45 TeV ppbar**: discovery W and Z bosons (UA1, UA2)
 - No LA institutes* listed on discovery papers
- **1995** Fermilab TEVATRON **1.8 TeV ppbar**: top quark discovery (CDF, D0)
 - 3 LA institutes* listed on discovery papers (Bogota,CBPF,CINVESTAV: all in D0)
- **2005** CERN LEP, SLD **up to 209 GeV e+e-**: precise measurements of Z boson (ALEPH, DELPHI, L3, OPAL, SLD)
 - 4 LA institutes* listed on the final LEP+SLD publication (all in DELPHI and from Rio de Janeiro)
- **2013** CERN Large Hadron Collider **7-8 TeV pp**: Higgs boson discovery (ATLAS, CMS)
 - 17 institutes* from 5 LA countries listed on ATLAS (4 Brazil, 2 Argentina, 2 Chile, 1 Colombia) and CMS (3 Brazil, 1 Colombia, 4 Mexico) discovery publications
 - Today: 40 institutes* in 9 LA countries connected to CERN experiments (ALICE, ATLAS, CMS, LHCb, .. more)

(*) only counting institutes, not the individuals with LA nationality who contributed



Discovery of the charged pion

- **1947** Cosmic rays, photographic emulsions -- C.M.G. Lattes, H. Muirhead, G.P.S. Occhialini, C. F. Powell



CERN: A laboratory for people around the world

Number of CERN Users by the country of their home institutes as of 31 December 2023

Students, Researchers & Technologists visiting for >5% of their working time over a 5-year window.

Local communities are ~3-5 times larger e.g. (under-)graduate students, engineers participating remotely or locally



Geographical & cultural diversity
Users of 110 nationalities
22.5% women

Member States 7438

Austria 86 – Belgium 129 – Bulgaria 46 – Czech Republic 252
Denmark 47 – Finland 88 – France 842 – Germany 1296
Greece 112 – Hungary 80 – Israel 74 – Italy 1609 – Netherlands 167
Norway 77 – Poland 322 – Portugal 105 – Romania 113
Serbia 38 – Slovakia 67 – Spain 413 – Sweden 106
Switzerland 419 – United Kingdom 950

Associate Member States

in the pre-stage to membership 69

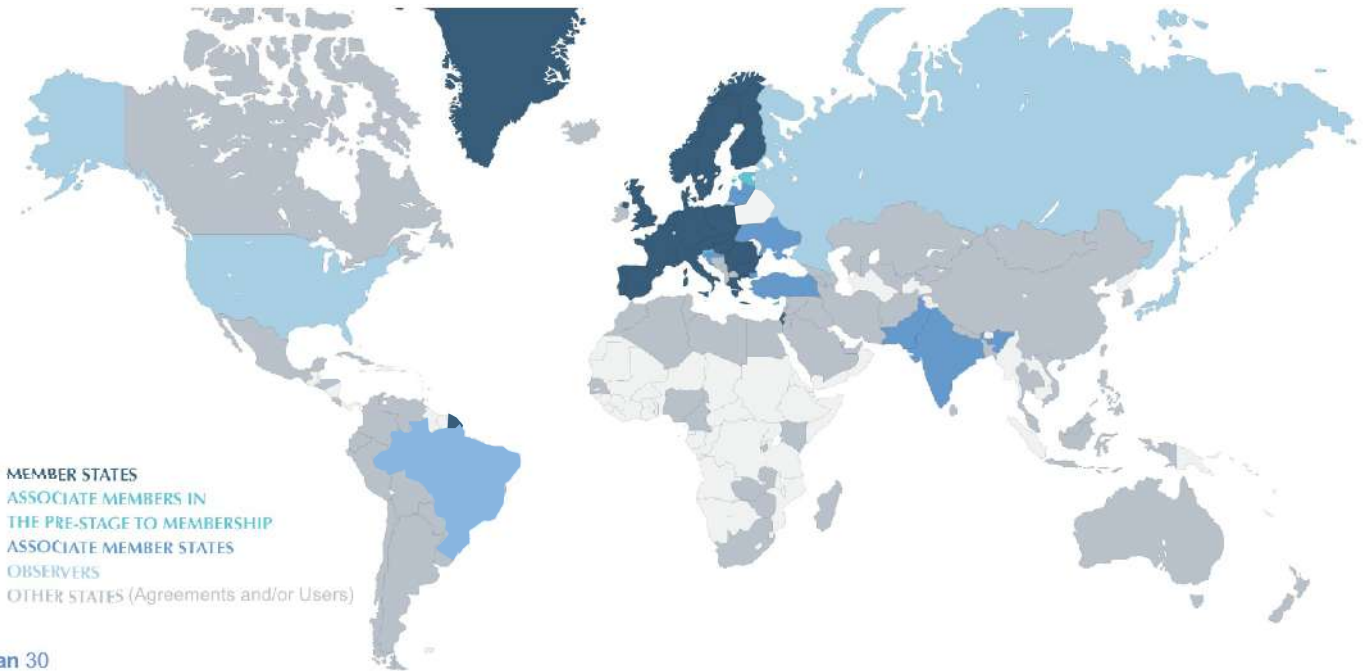
Cyprus 14 – Estonia 29 – Slovenia 26

Associate Member States 541

Brazil 135 – Croatia 37 – India 145 – Latvia 21 – Lithuania 17 – Pakistan 30
Türkiye 129 – Ukraine 27

Observers 3005

Japan 219 – Russia (Through November 2024) 779 – United States of America 2007

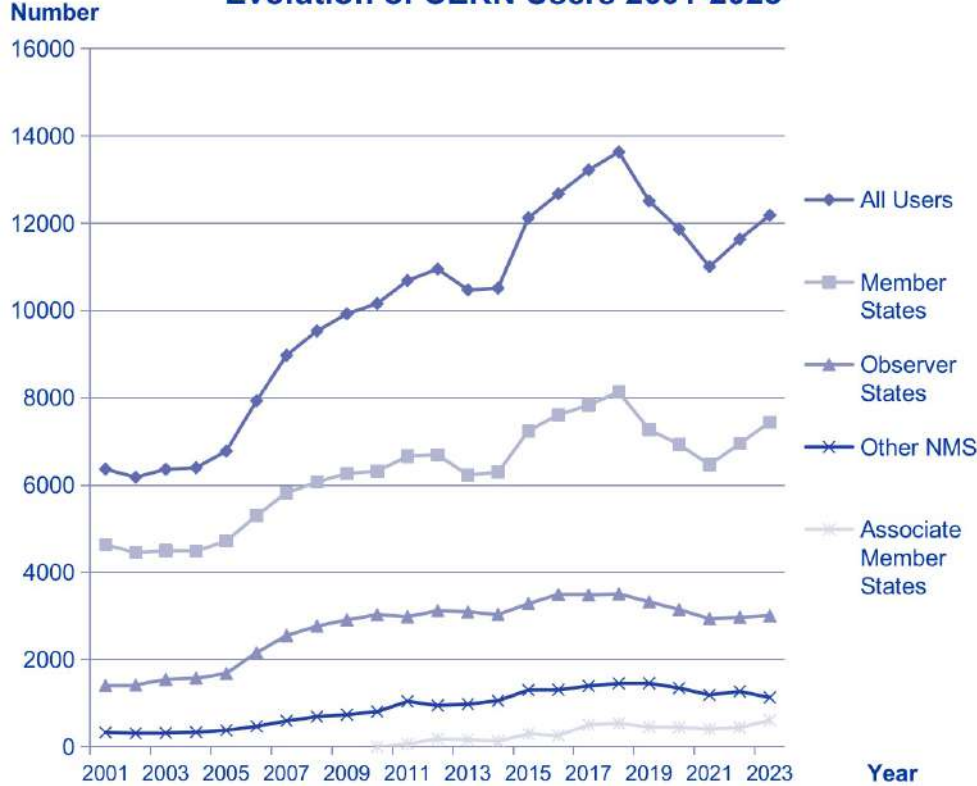


Non-Member States and Territories 1132

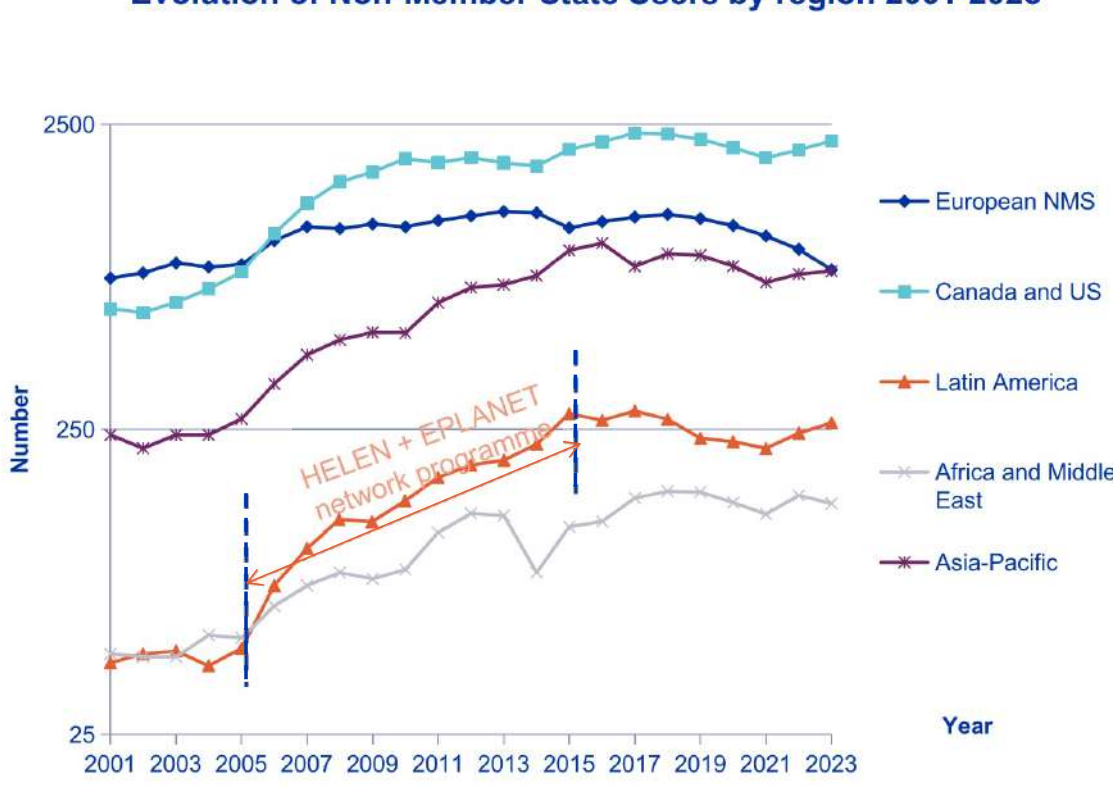
Algeria 2 – Argentina 13 – Armenia 8 – Australia 21 – Azerbaijan 2 – Bahrain 4 – Canada 199
Chile 34 – Colombia 21 – Costa Rica 2 – Cuba 3 – Ecuador 4 – Egypt 20 – Georgia 32
Hong Kong 15 – Iceland 3 – Indonesia 5 – Iran 11 – Ireland 5 – Jordan 5 – Kuwait 4 – Lebanon 13 – Madagascar 1
Malaysia 4 – Malta 1 – Mexico 49 – Montenegro 4 – Morocco 19 – New Zealand 5 – Nigeria 1 – Oman 1
Palestine 1 – People's Republic of China 333 – Peru 2 – Philippines 1 – Republic of Korea 147 – Singapore 2
South Africa 52 – Sri Lanka 10 – Taiwan 45 – Thailand 17 – Tunisia 2 – United Arab Emirates 7 – Viet Nam 1

Evolution of CERN users 2001 - 2022

Evolution of CERN Users 2001-2023



Evolution of Non-Member State Users by region 2001-2023



Current participation of LA institutes in the CERN experimental programme

- Brazil became an Associate Member State in March 2024. Chile is well advanced in this process.
- Since the 90's CERN has had International Cooperation Agreements with 11 countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Paraguay, Peru). Guatemala, Uruguay under discussion
- About 300 'users' from 40 institutes in 9 countries participating in the CERN experimental programme (2.5% of total. Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Honduras (indirectly), Mexico, Peru).
- About 120 additional Latin American nationals as 'users' with institutes outside the region.
- 5 more institutes collaborate in the accelerator sector (Argentina, Brazil, Colombia, Mexico)



N.B. 'Users' are Researchers & technologists visiting CERN for >5% of their working time over a 5-year window. Local communities are ~3-5 times larger (e.g. graduate students, engineers) participating remotely

Different forms of CERN engagement:

Institutional participation at national level	Capacity building (individual)	Scientific collaboration (e.g. LHC experiments)
<p>MS: member state -</p> <ul style="list-style-type: none"> • contribute to CERN budget (e.g. LHC operations/upgrade) according to size of economy • access to industrial contracts, CERN staff and student positions <p>AMS: associate member state - as MS, with 90% discount and ceiling on returns</p> <ul style="list-style-type: none"> • Brazil AMS since March'24 • Chile: application in progress <p>ICA: international collaboration agreement - 11 LA countries</p>	<p>Summer Student programme @CERN - includes NMS students</p> <p>CERN Schools in LA region: CLASHEP & possibly accelerator, computing schools - NMS students accepted and supported</p> <p>Technical and doctoral students @CERN - typically only (A)MS, but NMS accepted with external funding (government or philanthropic)</p> <p>Teacher programme sessions dedicated to (A)MS countries + open sessions in English and Spanish</p>	<p>University/Lab or consortium joins an experimental collaboration - access to infrastructure and ecosystem with (up to) 1000s of scientists</p> <p>Technical membership: (initial) focus on technical contributions</p> <p>Collaboration member: full partner in scientific research (build hardware, write software, service task, do analysis, publish papers)</p> <p>MoU - stipulates contribution to hardware and software, pay fair share of maintenance and operation (M&O) costs according to # of post-doctoral authors (students are 'free')</p>



Example of capacity building: CERN -- Latin-American Schools of HEP (CLASHEP)

CLASHEP2015, Ecuador

- Hosted every 2 years in a different LA country
- Since 2001: Brazil x2, Mexico x2, Argentina x2, Chile x2, Colombia, Peru, Ecuador... **next: Costa Rica in 2025!**
- Two weeks residential, intense PhD-level courses in HEP, by world-renowned lecturers, for 60-80 students
- Students from any country are welcome - competitive merit-based selection - travel and/or accommodation support is available for students from LA region
- In addition to academic training, cultural exchange and networking are important aspects!



Public engagement -- Open Science

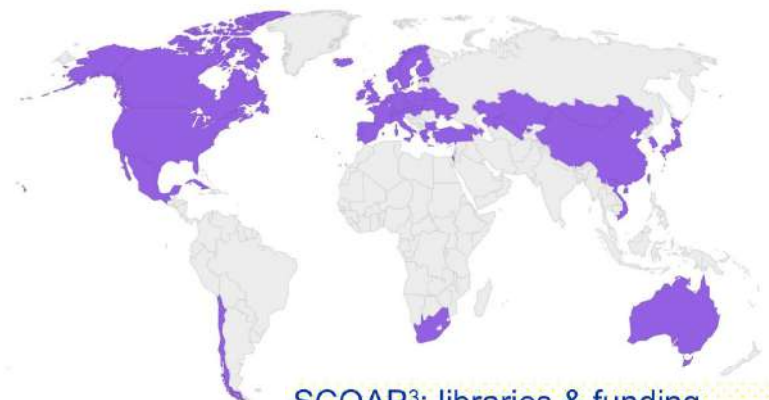
>> see white papers

CERN is also helping the community to integrate by hosting and supporting the following services / infrastructure:

- **Open Access:** [SCOAP³](#) partnership supports open access publishing in leading particle physics journals, at no cost to the authors (and obviously readers!)
- **InspireHep:** share and find accurate scholarly information (authors, articles, jobs, conferences, etc)
- **Open data:** CERN [Open Data Policy](#) encourages the LHC experiments to ensure openness and preservation of experimental data. LHC experiment data (and simulation samples and analysis software) are made publicly available in accessible format via the [Open Data](#) portal for educational and/or scientific (re-interpretation, training) purposes
>> to what extent can this benefit education / outreach / capacity building in the LA region?



Chile, Estonia and Lithuania Join SCOAP³ Consortium, Expanding Global Reach



SCOAP³: libraries & funding agencies in 44 partner countries, including Chile, Cuba, Mexico..



Common Challenges to unlock full potential of participation >> see white papers; to be discussed later this week

You are all familiar with these issues..!

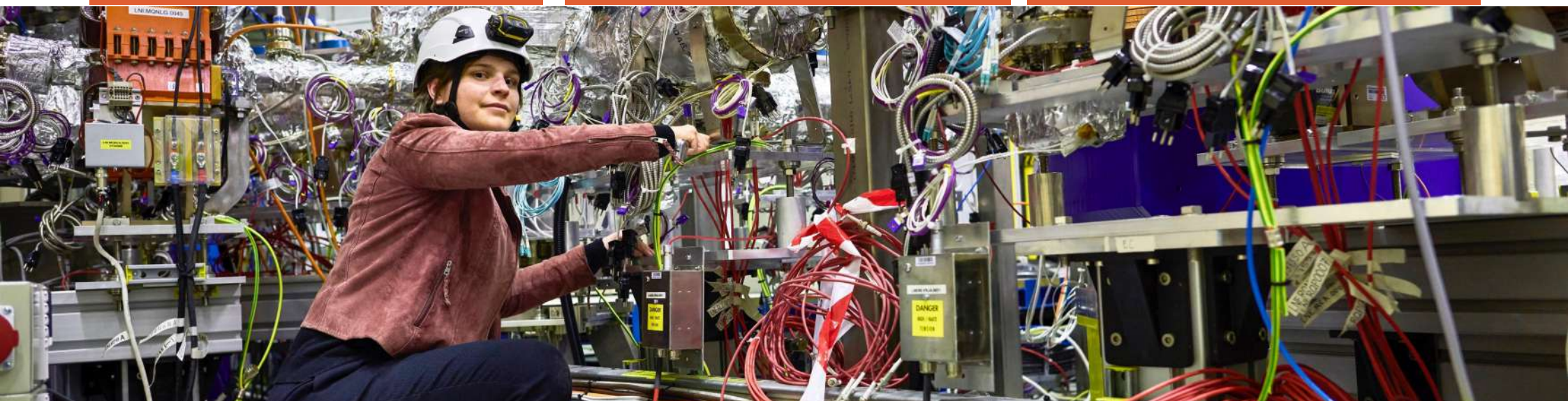
- building and maintaining full talent pipeline (under-graduate, graduate, post-doctoral), and offering availability of positions for researchers
- brain drain (within the field, to other countries) for highly-skilled Early-Career Researchers post-training (e.g. 40% of CERN users with LA nationality are affiliated to institutes outside the region)
- initial funding, followed by sustainable long-term funding for commitments to international collaboration vs funding/organizational/political volatility
- access for Early-Career Researchers or doctoral students to Europe-based research infrastructures (travel, subsistence, stipend, scholarship) -- European support from HELEN and EPLANET programmes alleviated this issue 2005-2015, but this funding is no longer available

CERN: broad and diverse scientific research programme

Nuclear Physics
(ISOLDE, n-TOF)

Antimatter Research
(Antiproton Decelerator)

Cosmic rays and cloud formation
(CLOUD)



Fixed-target experiments,
which include searches for rare phenomena

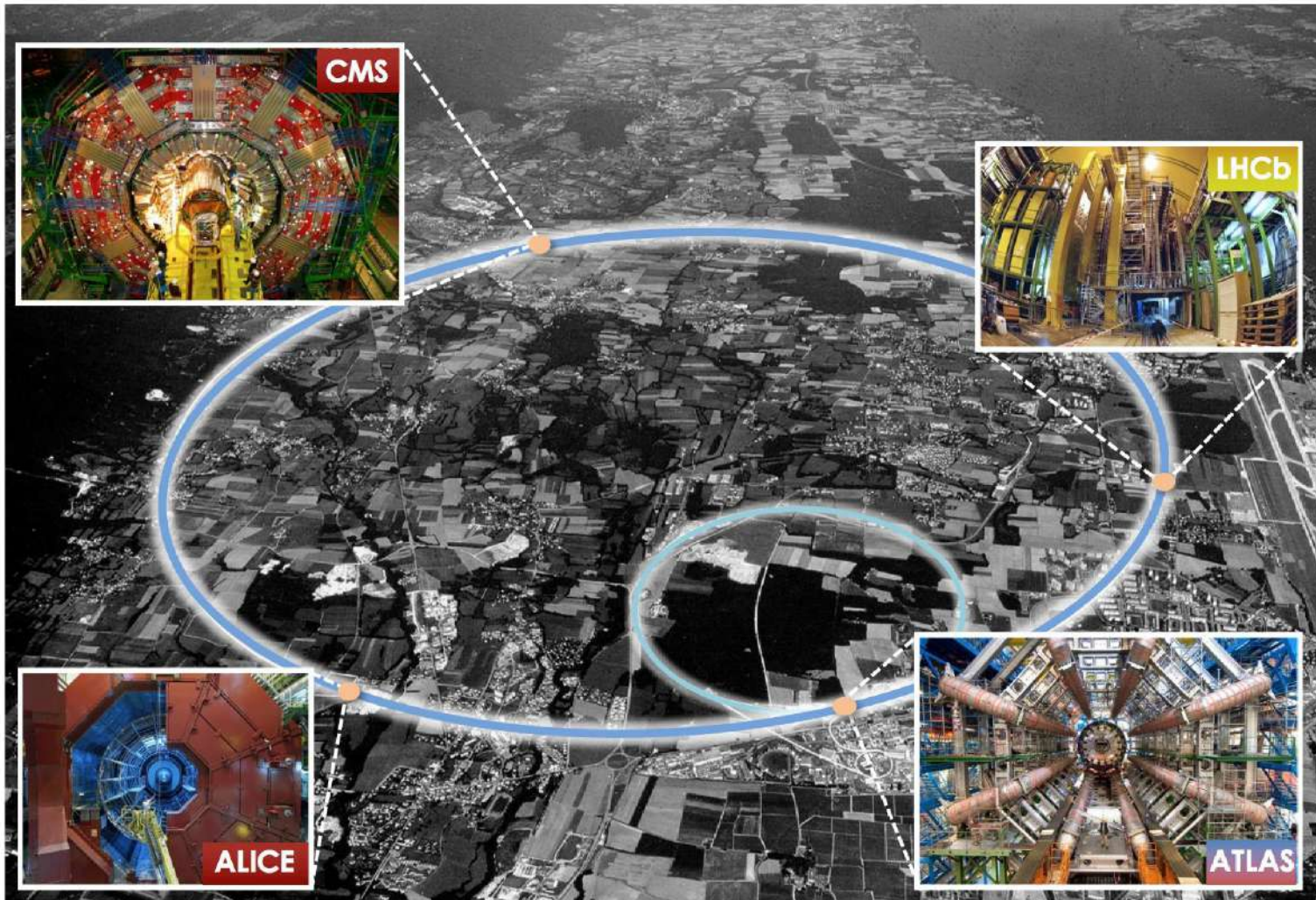
Contribution to the Long Baseline
Neutrino Facility in the USA (LBNF)



And one 'flagship' project: the LHC / HL-LHC

with involvement of Latin American institutes in the experiments by country (LASFRI 2020, *now*)

Brazil
Colombia
Ecuador
Mexico
Chile
(Peru)



Brazil
Colombia
Costa Rica
(Honduras)

Brazil
Cuba
Mexico
Peru

Argentina
Brazil
Chile
Colombia

At the middle of the (HL)LHC journey

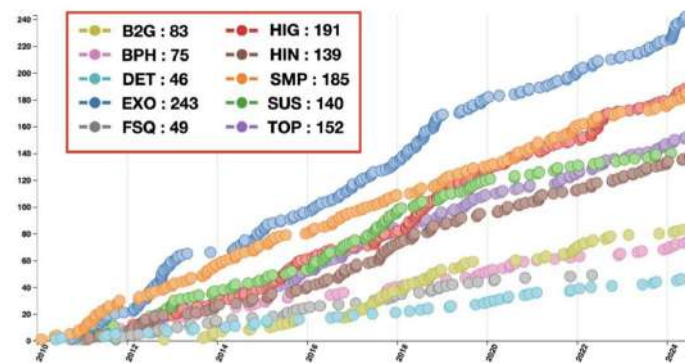


LHC and experiments are performing extremely well

- First phase of LHC program to be completed soon
 - On track to deliver $>300 \text{ fb}^{-1}$ (Run2+Run3) per experiment by end of 2025
- Preparing for the High-Luminosity phase
 - The target is 3000 fb^{-1} by 2041
- Already now, experiments are pushing detectors beyond (original) design limits
 - e.g. CMS/ATLAS recording $O(60)$ simultaneous collisions/event ($>2x$ design, 45% of HL-LHC).
- Experiments are employing innovative strategies to maximize data collection capabilities: e.g., use of GPUs in trigger / offline, max use of AI, alternative workflows, data streams and storage, data formats, ...

e.g. CMS @ICHEP2024:

1305 papers submitted with Run1, Run2 and Run3 data



>3800 LHC publications submitted to date

Detector upgrades for the High-Luminosity LHC

In LS3 (2026-2028)

ATLAS

ITK, HGTD, New Muon Chambers, Trigger, DAQ, Electronics Upgrade

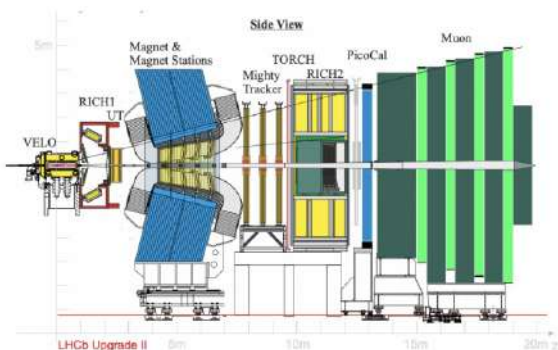
CMS

Tracker, HGCAL, MTD, BRIL, Muon Upgrade, L1 Trigger, DAQ, HLT

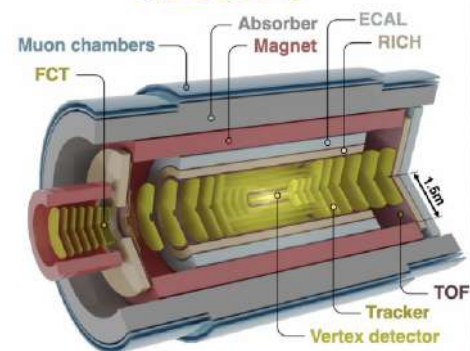
Moving into production of detector components

In LS4 (2033/34)

LHCb Upgrade II



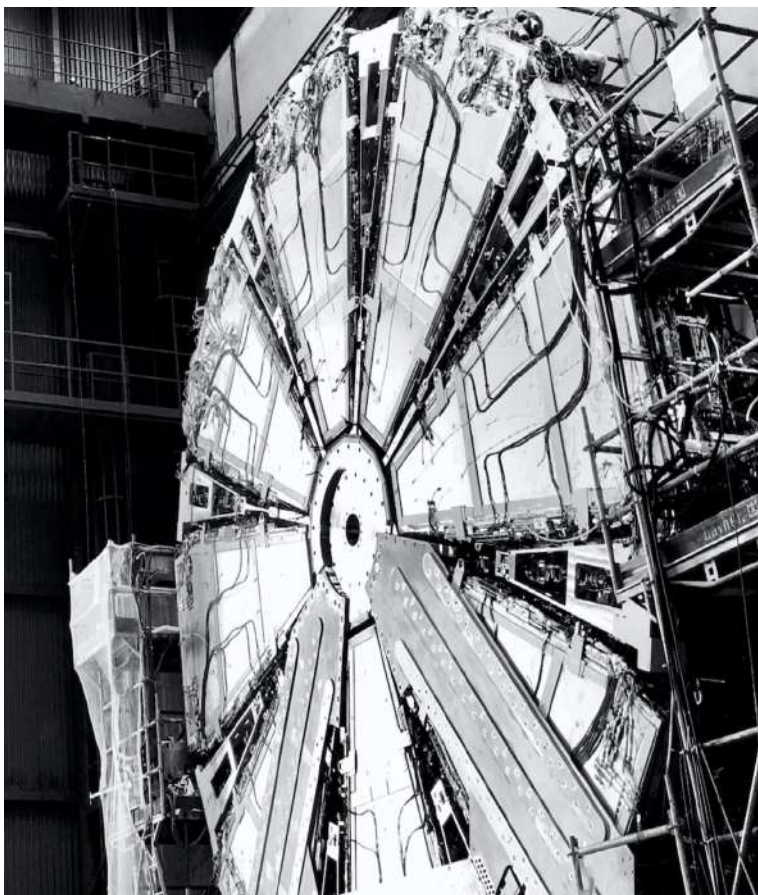
ALICE 3



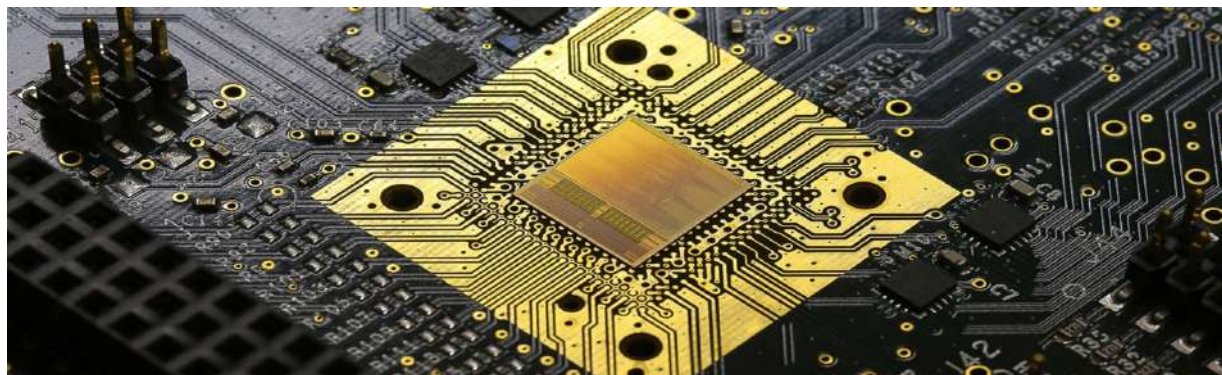
Scoping documents under preparation to be reviewed by LHCC

Examples of upgrade contributions..

ATLAS New Small Wheel (Chile)



Sampa ASICs Chip ALICE TPC (Brazil)



What is next for CERN?

Current CERN priorities, based on 2020 European Strategy, include:

- Exploitation of the [High-Luminosity phase of the LHC](#)
- A broad [diverse scientific](#) programme, complementary to the collider and carried out mainly at the injectors and in dedicated facilities.
- Towards the next major project: feasibility study for a [Future Circular Collider \(FCC\)](#) --> **see talk by Christophe Grojean**
R&D and design studies for [alternatives options](#) (linear colliders, muon colliders) also being pursued.
- [Accelerator](#) and [Detector R&D](#) programmes to develop technologies and instruments for future projects
- [Computing](#) developments to support increasing challenges of the field; and inspiring and motivating [theory](#) effort
- Participation in neutrino efforts US and Japan through [Neutrino Platform](#) (including proto-Dune exp setup and in-kind contributions to Dune detector)

The next update of the European Strategy is starting now, with the following timeline:

--> **see talk by Paris Sphicas**

- [2024](#): preparatory year where all committees are established and venues of meetings chosen
- [2025](#): March submission of scientific input by community, June community Open Symposium, December drafting of Strategy document
- [March and June 2026](#): Council discussion and update of the Strategy



Summary

CERN has an exciting, unique scientific programme now and in the future, with numerous challenges and great prospects, supported by a remarkable accelerator complex and other world-leading infrastructure and services, backed by profound technology base and outstanding personnel expertise.

The contributions of countries from all over the world to CERN's scientific programme are and will continue to be crucial to accomplish CERN's mission.

The participation of Latin American groups in experiment collaborations at CERN, as well as in some technology projects, has continued to grow in recent years.

CERN welcomes new countries and institutes join the effort, and participating ones ramping up responsibilities, and to see increased local collaboration and dialogue, enhanced by the LASFRI strategy process.



Thank you



CERN was founded in 1954 with 12 European Member States as a treaty-based intergovernmental organisation

23 Member States

Austria – Belgium – Bulgaria – Czech Republic
Denmark – Finland – France – Germany – Greece
Hungary – Israel – Italy – Netherlands – Norway
Poland – Portugal – Romania – Serbia – Slovakia
Spain – Sweden – Switzerland – United Kingdom

3 Associate Member States
in the pre-stage to membership
Cyprus – Estonia – Slovenia

8 Associate Member States

Brazil – Croatia – India – Latvia – Lithuania – Pakistan
Türkiye – Ukraine

6 Observers

Japan – Russia (suspended) – USA
European Union – IINR (suspended) – UNESCO

Brazil joined in March 2024 as the first Associate Member state from Latin America

**Estonia will soon join as 24th full Member State
Ratification process completed**

Around 50 Cooperation Agreements with non-Member States and Territories

Albania – Algeria – Argentina – Armenia – Australia – Azerbaijan – Bangladesh – Belarus – Bolivia
Bosnia and Herzegovina – Canada – Chile – Colombia – Costa Rica – Ecuador – Egypt – Georgia – Honduras
Iceland – Iran – Jordan – Kazakhstan – Lebanon – Malta – Mexico – Mongolia – Montenegro – Morocco – Nepal
New Zealand – North Macedonia – Palestine – Paraguay – People's Republic of China – Peru – Philippines – Qatar
Republic of Korea – Saudi Arabia – Sri Lanka – South Africa – Thailand – Tunisia – United Arab Emirates – Vietnam

CERN in a few numbers

> 70 running experiments/facilities
Publications (2023): > 760 papers (experiments + theory, ~ 300 from LHC)

Annual Budget: ~ 1.3 BCHF
(shared by Member States based on their net national income)

CERN's community: > 17500 people (> 110 nationalities),
increasing!

- 2666 staff
- 1002 graduates (technical students, post-docs, etc.)
- 12370 users, 1513 other associates
- > 3700 PhD students from all over the world
- ~ 4500 young people trained at CERN at any time
- US population: 2007 users (+100 since last year) from 142 Institutes

2 main sites in CH and France, 15 smaller satellite sites
630 hectares, 700 buildings
70 km underground tunnels, > 30 caverns
1000 km technical galleries/trenches
500 hotel rooms
3000 meals served daily
4000 contractors' personnel
9000 people on site every day

Every year:
150000 visitors until now → 340000 expected now with Science Gateway
170000 press cuttings
5 million visitors to CERN website
130 million CERN social media views