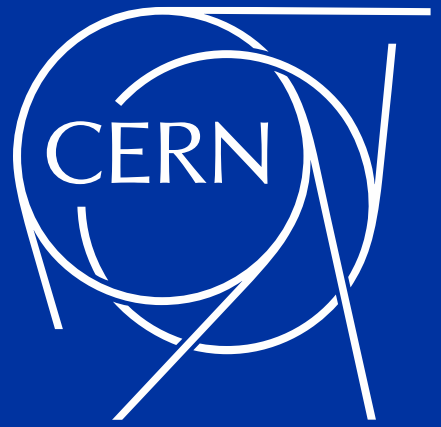


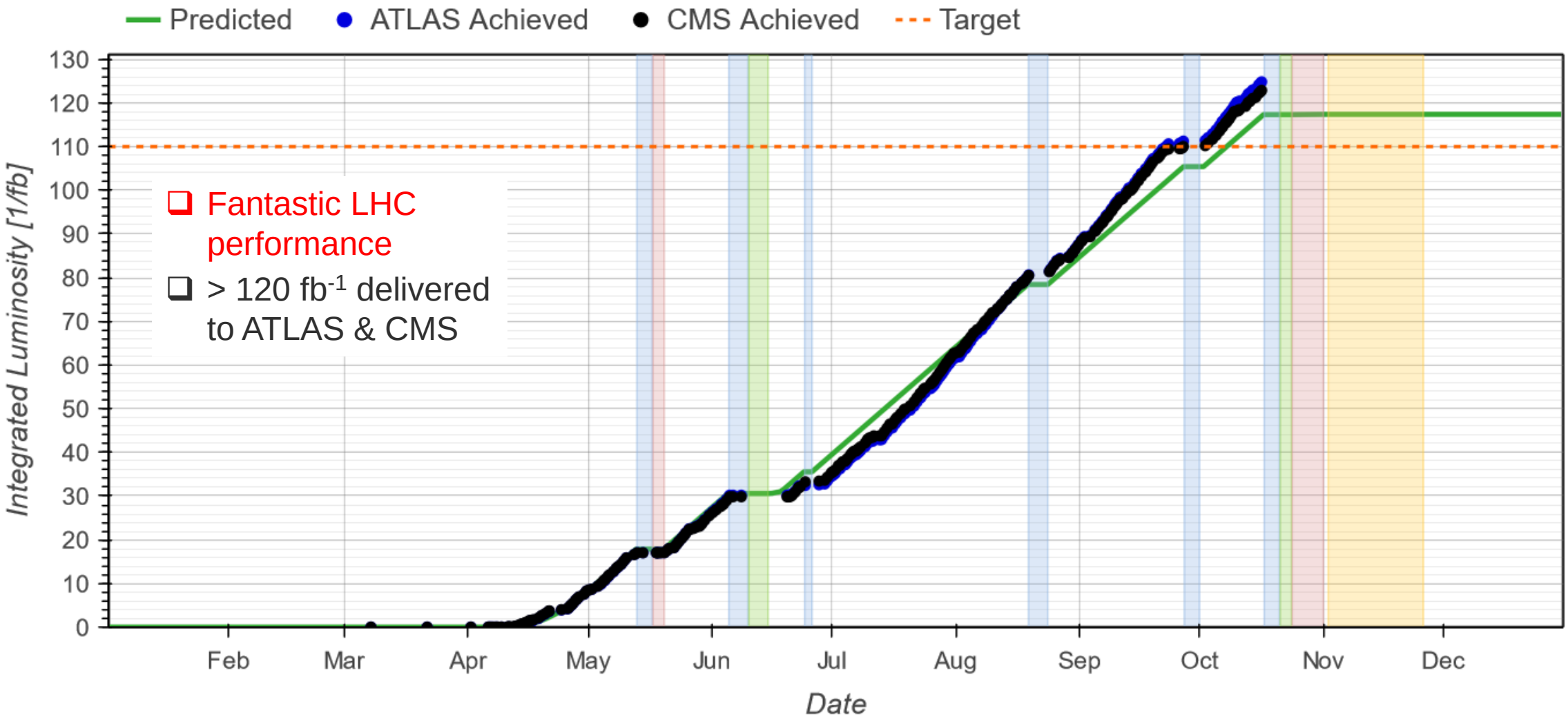

# Report from CERN

115th Plenary ECFA Meeting

Joachim Mnich

November 14th, 2023

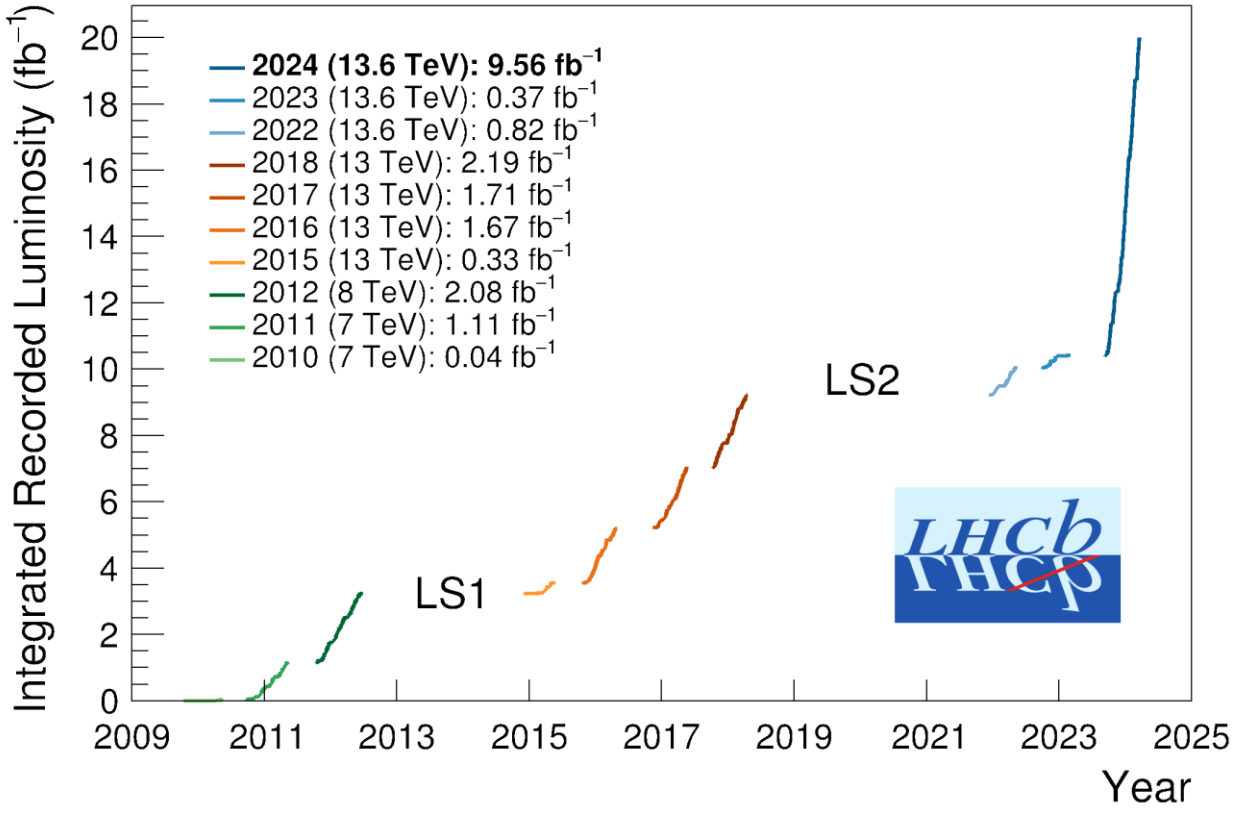
# 2024 LHC pp Run

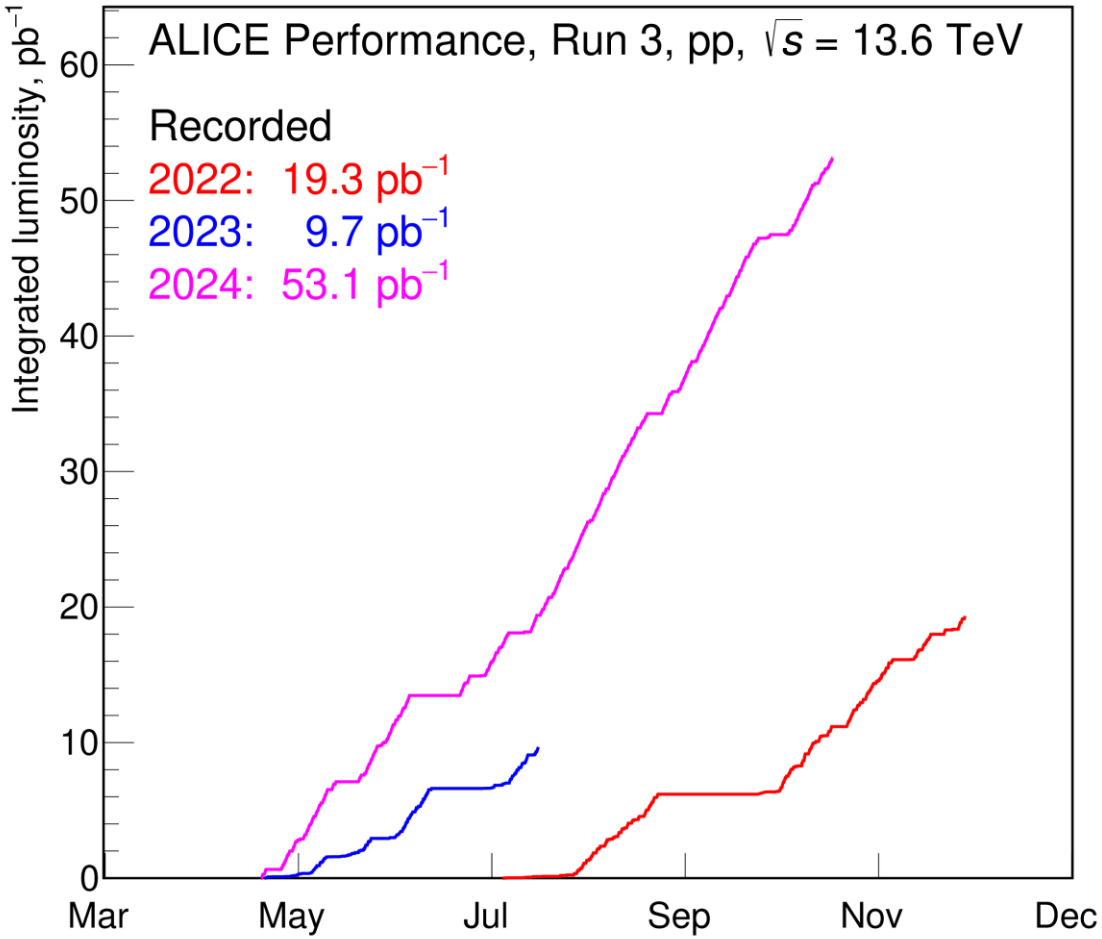



- Fantastic LHC performance
- > 120 $fb^{-1}$ delivered to ATLAS & CMS

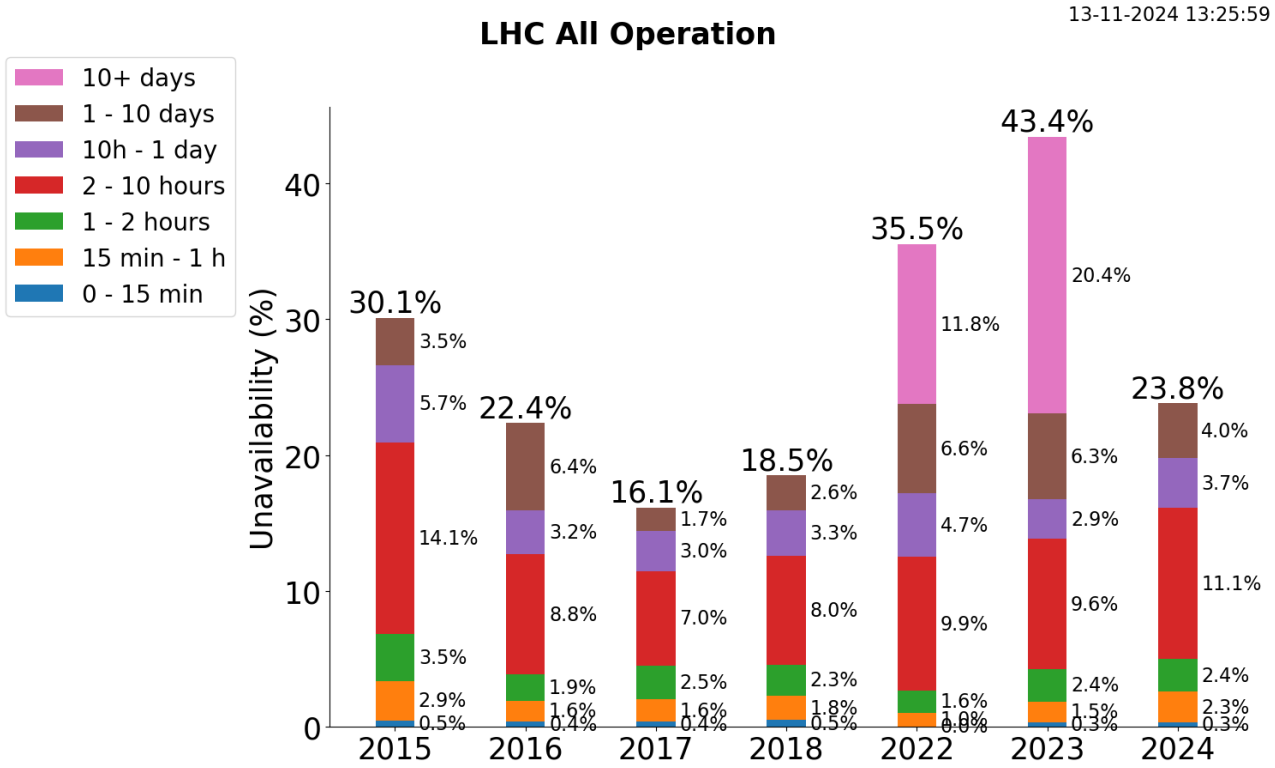
# 2024 LHC pp Run

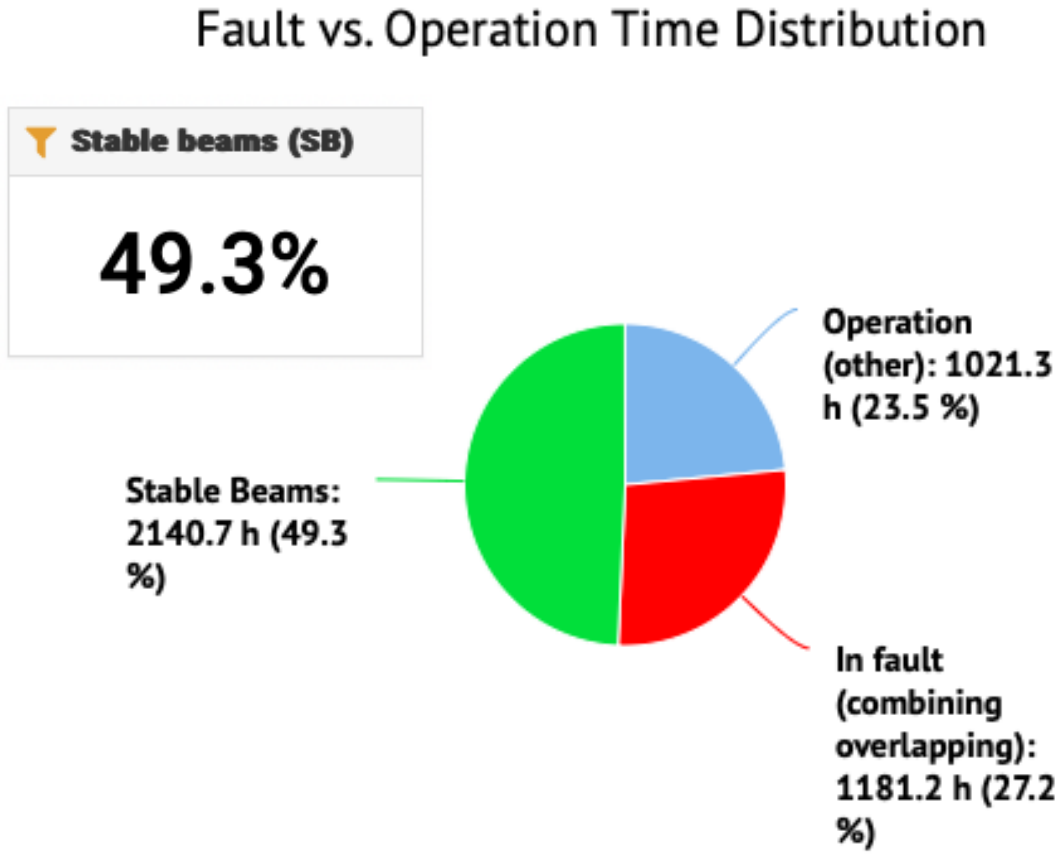
- LHCb and ALICE doubled their pp luminosity in 2024
- With all Phase I upgrades fully commissioned
  e.g. ALICE 1000 times more minimum bias events in central barrel because of continuous readout



# LHC availability 2024

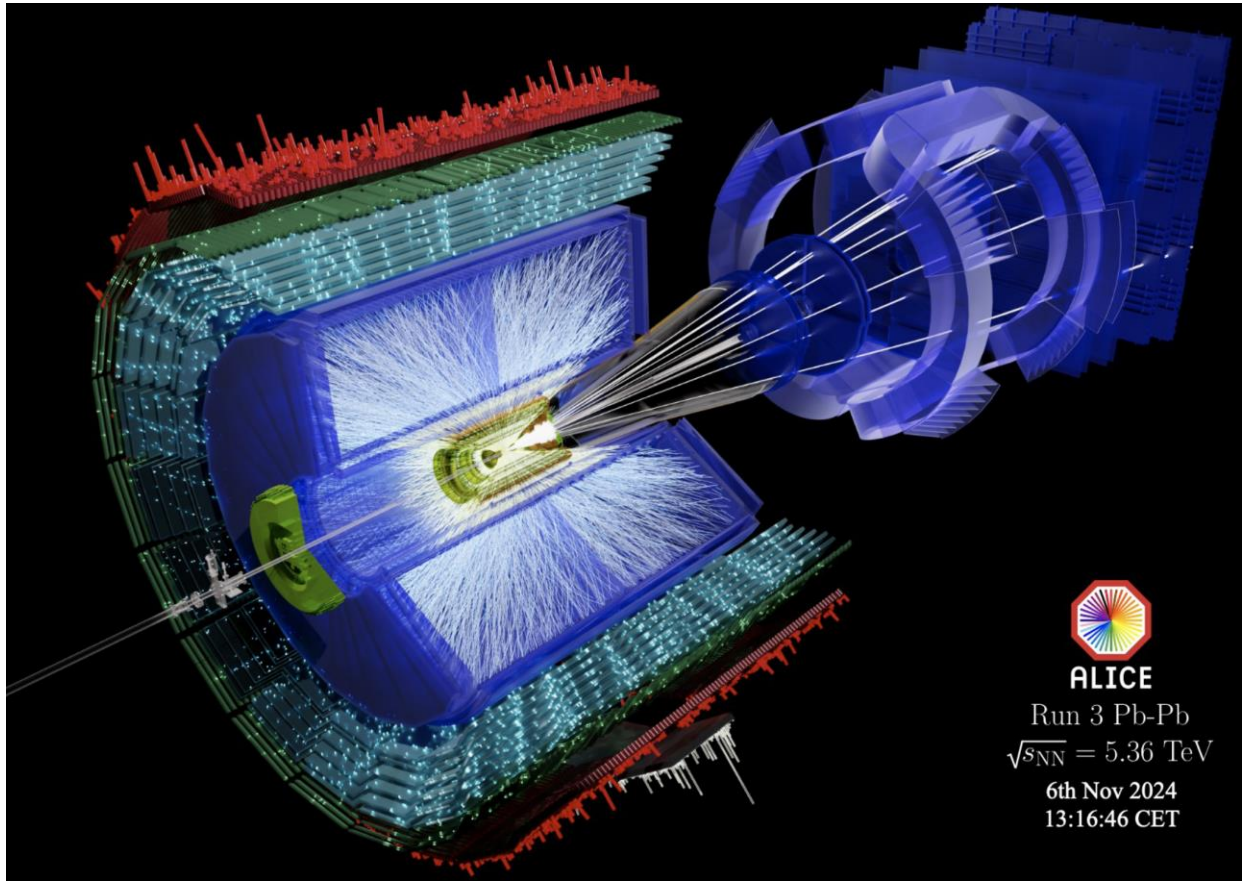


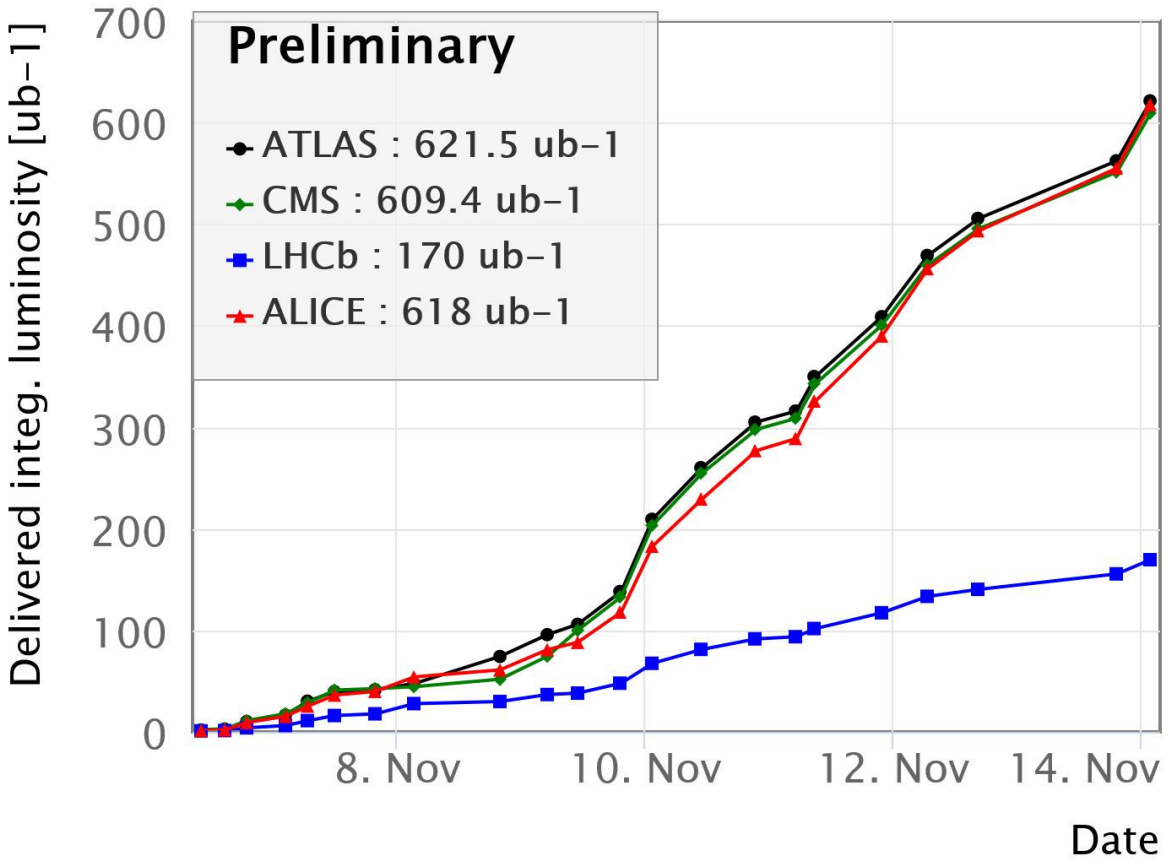
# Availability Overview LHC Injector Chain
## proton period

| Facility | Destination | '21/'22/'23 Overall [%] | 2023 | Achieved 2024 | | Period |
|---|---|---|---|---|---|---|
| | | | Per destination [%] | Overall [%] | Per destination [%] | |
| **LINAC4** | PSB | 97.3 / 96.8 / 98 | 98 | 97.1 | 97.1 | 15.02.2024 – 20.09.2024 |
| **PSB** | PS | 94.5 / 94.8 / 96.1 | 96.4 | 95.7 | 96.1 | 21.02.2024 – 20.09.2024 |
| | ISOLDE | | 96.6 | | 97.2 | 28.03.2024 – 20.09.2024 |
| **PS** | SPS | 88.1 / 89.6 / 92 | 92.8 | 93.0 | 93.7 | 01.03.2024 – 20.09.2024 |
| | East Area | | 93.5 | | 94.6 | 22.03.2024 – 20.09.2024 |
| | nTOF | | 92.8 | | 94.6 | 25.03.2024 – 20.09.2024 |
| | AD | | 92.6* | | 94.3 | 14.03.2024 – 20.09.2024 |
| **SPS** | LHC | 73.4 / 74.1 / 86 | 94.3 | 84.1 | 93.9 | 08.04.2024 – 20.09.2024 |
| | North Area | | 86.6 | | 85.3 | 25.03.2024 – 20.09.2024 |
| | AWAKE | | 98.4 | | 96.4 | 15.04.2024 – 20.09.2024 |
| | HiRadMat | | 99.1 | | 98.7 | 29.04.2024 – 20.09.2024 |

# Status 2024 Heavy Ion Run




Delivered Luminosity 2024




On track to deliver:

- ❑ 1.9 $nb^{-1}$ to ATLAS/ALICE/CMS and 0.5 $nb^{-1}$ to LHCb
- ❑ End of 2024 run: November 25th

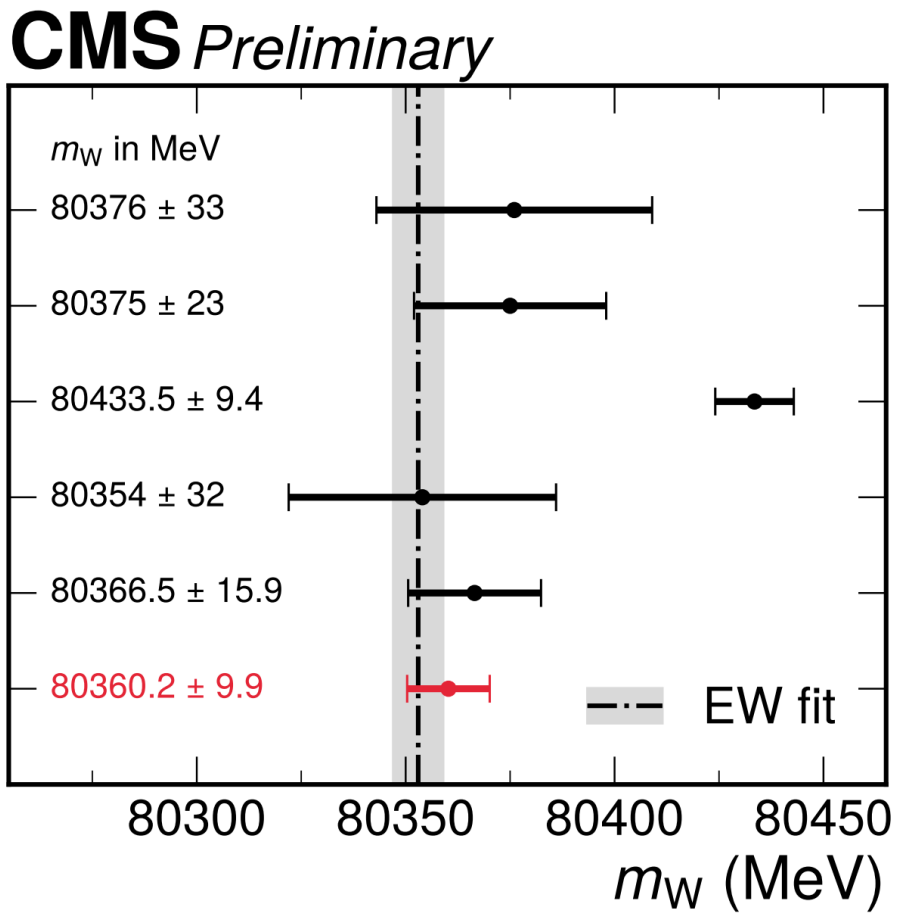
# CMS: Measurement of the W Mass

- Use well-understood subset of 13 TeV data: 16.8 $fb^{-1}$ from later part of 2016 run (~ 30 mean interactions per crossing)
- Focus on muon channel
- Larger experimental systematics for electrons and hadronic recoil, especially with higher pileup
- Result:

$$m_W = 80\,360.2 \pm 9.9\ \text{MeV}$$

- This is compatible with the Standard Model expectation and with other measurements
- Clear tension with CDF measurement

LEP combination
Phys. Rep. 532 (2013) 119
D0
PRL 108 (2012) 151804
CDF
Science 376 (2022) 6589
LHCb
JHEP 01 (2022) 036
ATLAS
arxiv:2403.15085, subm. to EPJC
CMS
*This Work*



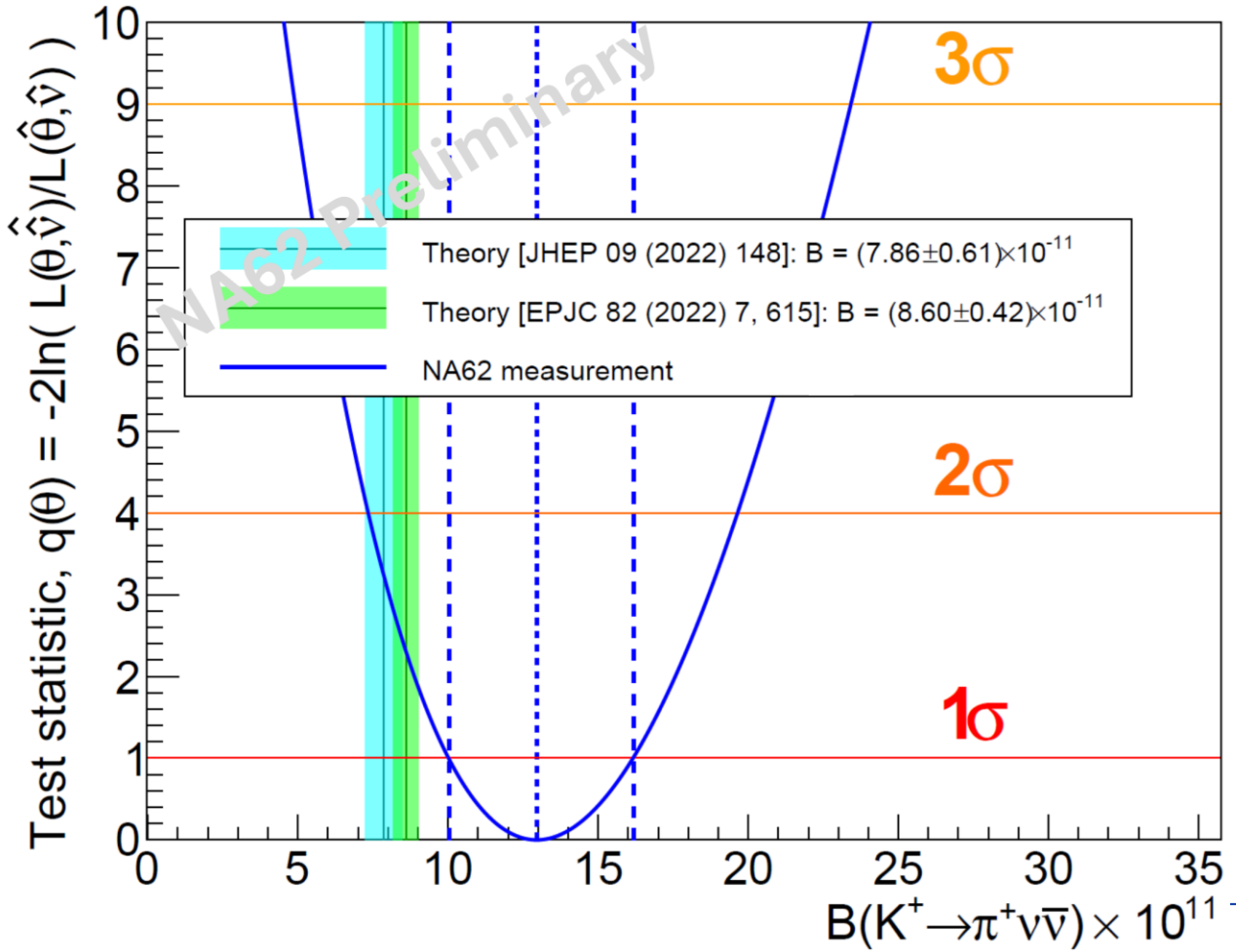
# $K^+ \to \pi^+ \nu\bar{\nu}$ : NA62 Combined Result 2016-22 Data

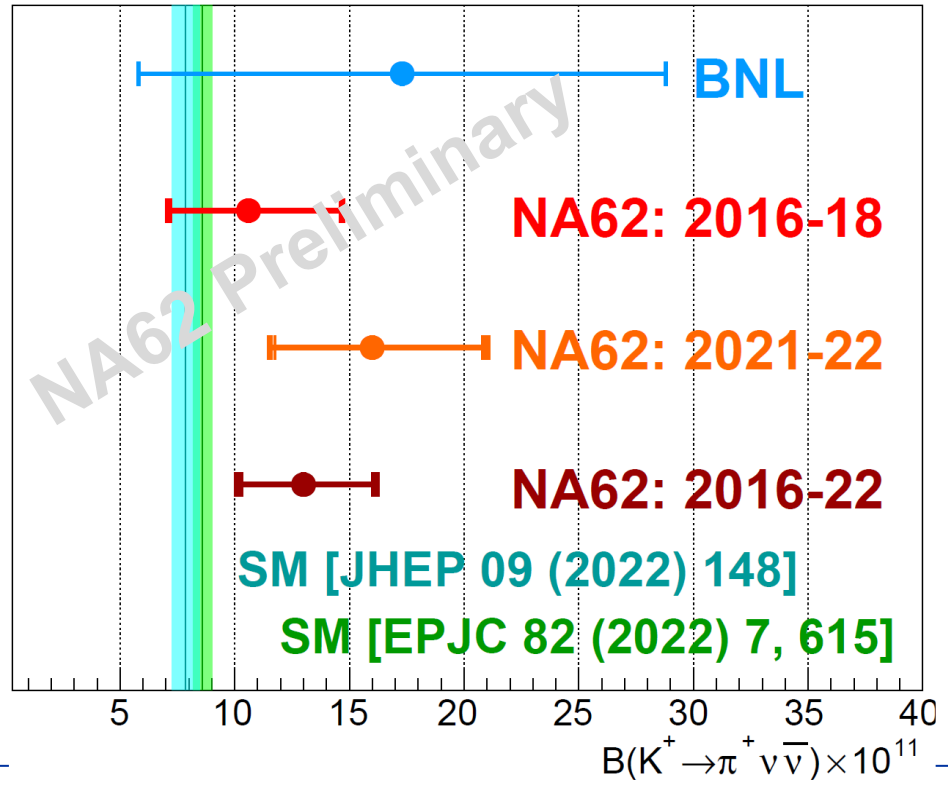
| | |
|---|---|
| Single Event Sensitivity | $(0.42 \pm 0.02) \times 10^{-11}$ |
| Expected background | $18^{+3}_{-2}$ |
| **Observed** | **51** |

**b-only hyp. rejection significance: $Z = 5\sigma$**

$$\mathcal{B}_{\pi\nu\nu} = \left[13.0\left(^{+3.0}_{-2.7}\right)_{stat}\left(^{+1.3}_{-1.2}\right)_{syst}\right] \times 10^{-11}$$

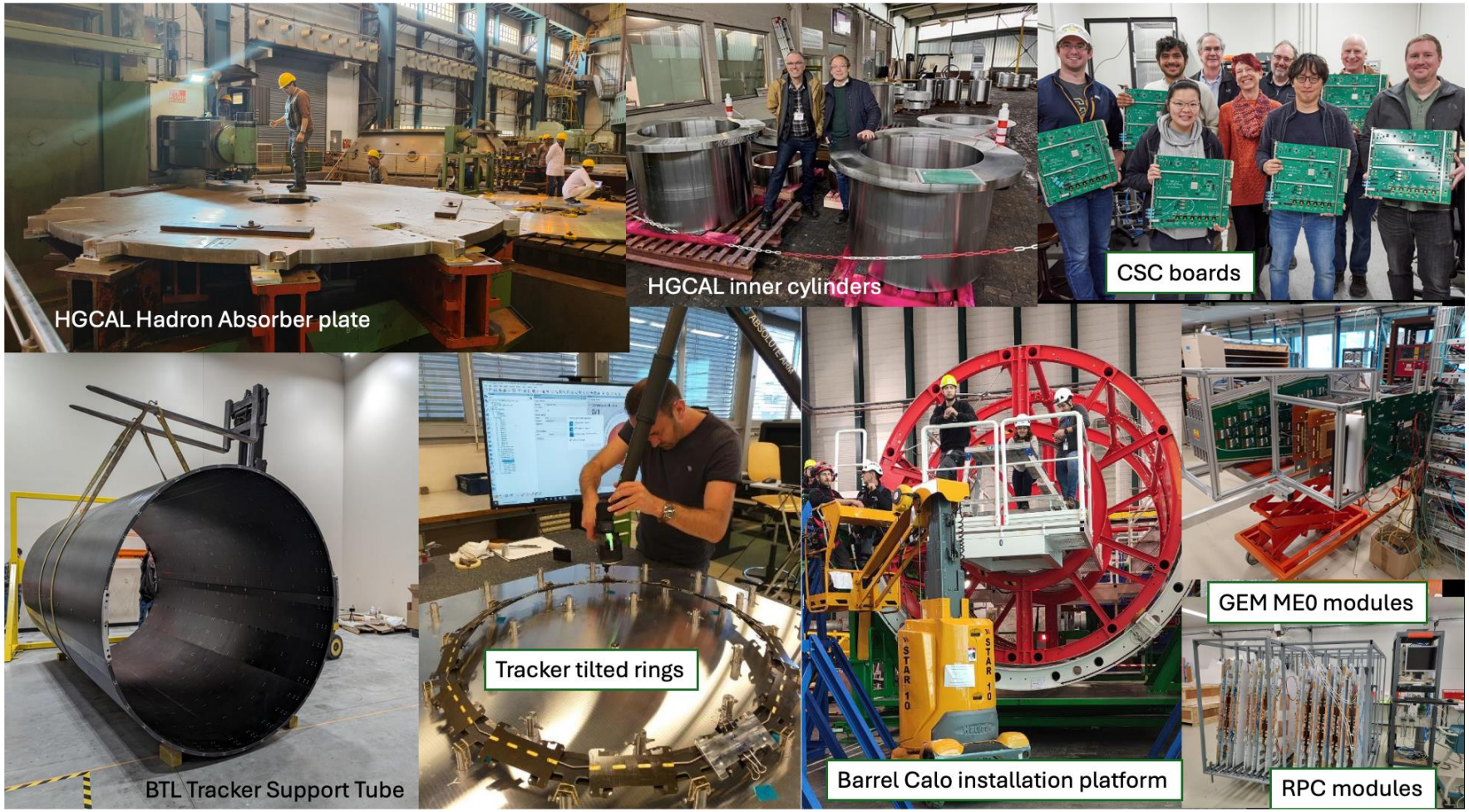
$$\mathcal{B}_{\pi\nu\nu} = \left(13.0^{+3.3}_{-2.9}\right) \times 10^{-11}$$



# Status of HL-LHC and Phase II Projects

## A lot of progress in CMS…




See talk
Katja Klein

# Status of HL-LHC and Phase II Projects

**And a lot of progress in ATLAS…**



See talk
Craig Sawyer

# Status of HL-LHC and New Schedule

**BUT:**

**Significant delays in the Phase II projects of ATLAS and CMS**

- in particular ATLAS ITk and CMS HGCAL
- no or even negative time contingency left
- in addition, significant schedule risks remaining

**P2UG/LHCC/SPC conclusion: schedule is not tenable**
(conclusion in September 2024)

**LS3 Cost and Schedule Review in September 2024**

- Remaining civil engineering work for HL-LHC requires an extension of LS3 by 4 months

**Decision of CERN directorate:**

- Delay start of HL-LHC by 1 year, composed roughly by 1/2 year extension of Run 3 in 2026 and 1/2 year extension of LS3 as required by the LHC and by CMS

**Key dates of new LHC schedule:**

**Operation in 2026:**

- short YETS 2025/26
- run LHC until end of June with possibly HI run taking place in June
- run injectors until end August

**Restart in 2030:**

- start hardware commissioning in January 2030
- closure of experimental caverns mid-May
- beam in the machine as of June
- restart of injectors to be defined

**Post-LS3:**

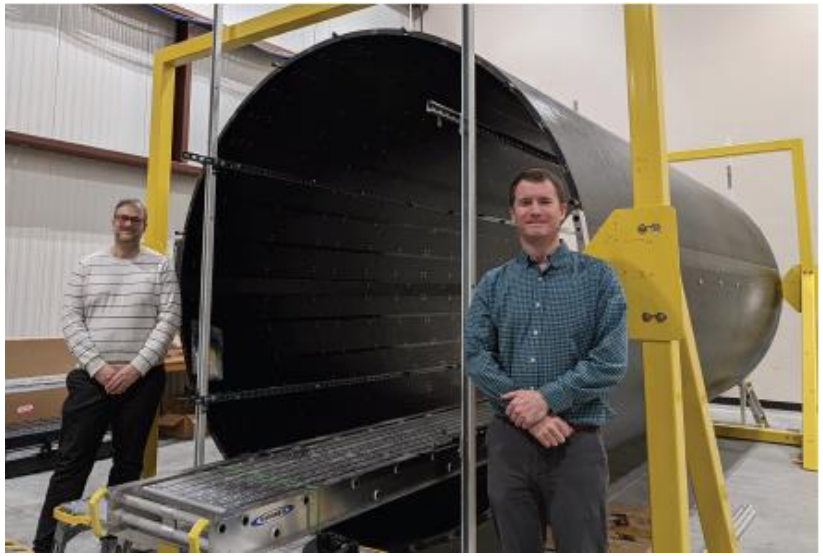
- LS4 moved by one year: from 2033/34 to 2034/35
- LS5 will become an EYETS

**Details still to be worked out, optimization to be performed**

# Schedule Risks

Risks remain also on the new schedule:

- Established risk registers with impact and mitigation measures with the experiments
- Examples (which were not even thought of before!)
- CMS outer shell accident
  - incident on the road
  - fortunately no major damage
  - looks like we were lucky…
- lpGBT chip
  - by testing large number of components recently a problem with the low power GigaBit Transceiver (lpGBT) chip has been discovered
  - in about 1% of the cases the chip does not restart, impact on detectors is being evaluated
  - new production will take 6-12 months



To avoid any further, very detrimental delays

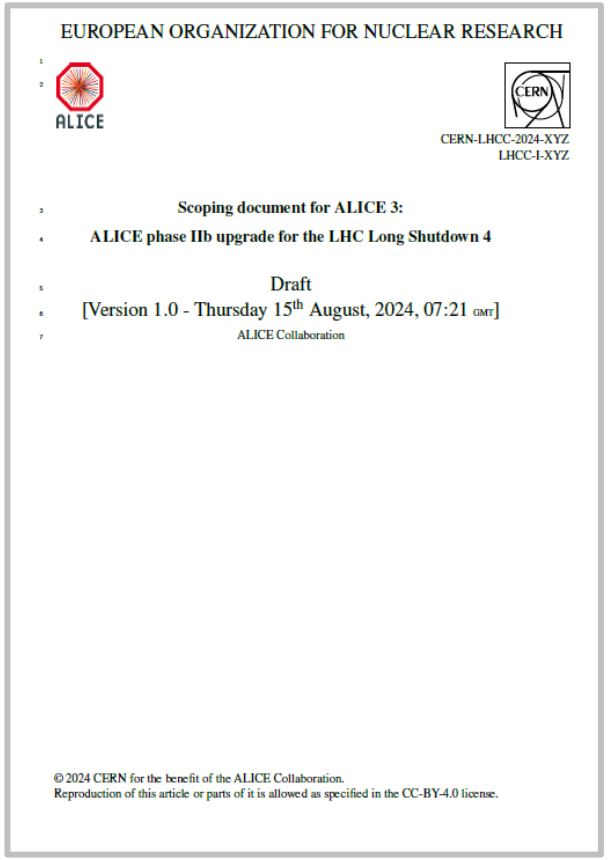
- Highest priority must be given to the upgrade projects
- Increased efforts by all institutes and collaborators will be necessary!

# Phase IIb: ALICE and LHC

See talks
Felix Reidt &
Vava Gligorov

## Scoping documents submitted

- ❑ For both experiments scenarios of core costs between ≈ 125 MCHF and 180 MCHF are presented
- ❑ Under scientific and technical review by the LHCC
- ❑ Results expected by March 2025
- ❑ In parallel discussions with Funding Agencies to define realistic funding envelopes
- ❑ Aim to define upgrade scope, based on LHCC and FA input, in spring 2025
- ❑ Then start to work on TDRs



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALICE

CERN-LHCC-2024-XYZ
LHCC-I-XYZ

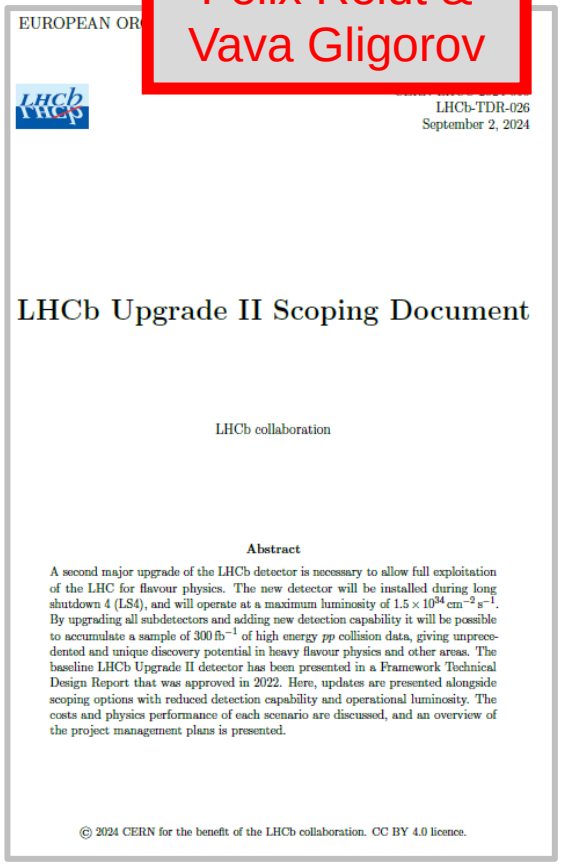
**Scoping document for ALICE 3:**

**ALICE phase IIb upgrade for the LHC Long Shutdown 4**

Draft
[Version 1.0 - Thursday 15th August, 2024, 07:21 GMT]

ALICE Collaboration





EUROPEAN OR

LHCb-TDR-026
September 2, 2024

LHCb Upgrade II Scoping Document

LHCb collaboration

**Abstract**

A second major upgrade of the LHCb detector is necessary to allow full exploitation of the LHC for flavour physics. The new detector will be installed during long shutdown 4 (LS4), and will operate at a maximum luminosity of $1.5 \times 10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. By upgrading all subdetectors and adding new detection capability it will be possible to accumulate a sample of $300\,\mathrm{fb}^{-1}$ of high energy $pp$ collision data, giving unprecedented and unique discovery potential in heavy flavour physics and other areas. The baseline LHCb Upgrade II detector has been presented in a Framework Technical Design Report that was approved in 2022. Here, updates are presented alongside scoping options with reduced detection capability and operational luminosity. The costs and physics performance of each scenario are discussed, and an overview of the project management plans is presented.



## Detector improvements during LS3:

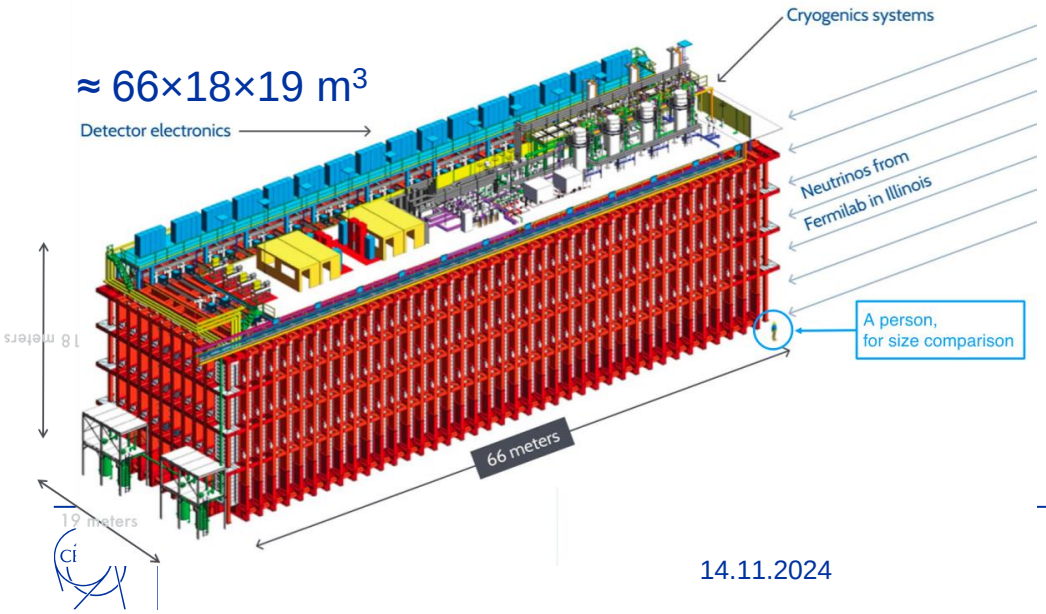
- ❑ ALICE: ITS3 and FoCal: TDRs are completed and endorsed by Research Board
- ❑ LHCb: ECAL, RICH; endorsed by RB; DAQ Enhancement TDR; LHCC recommended for approval

# Neutrino Platform and LBNF/DUNE

At CERN two main activities for the LBNF/DUNE project in the US:

1) **Construction of two large cryostats for the DUNE far detectors**

- ❑ Production of warm steel structure completed for both cryostats
- ❑ Transport of 1st cryostat to the US failed: Infestation of packaging wood, required re-exporting from US for treatment
- ❑ Both warm steel structures are now ready for transport to the US





Cryostat #1 in La Coruña harbour after repacking


Cryostat #2 transported to the harbour

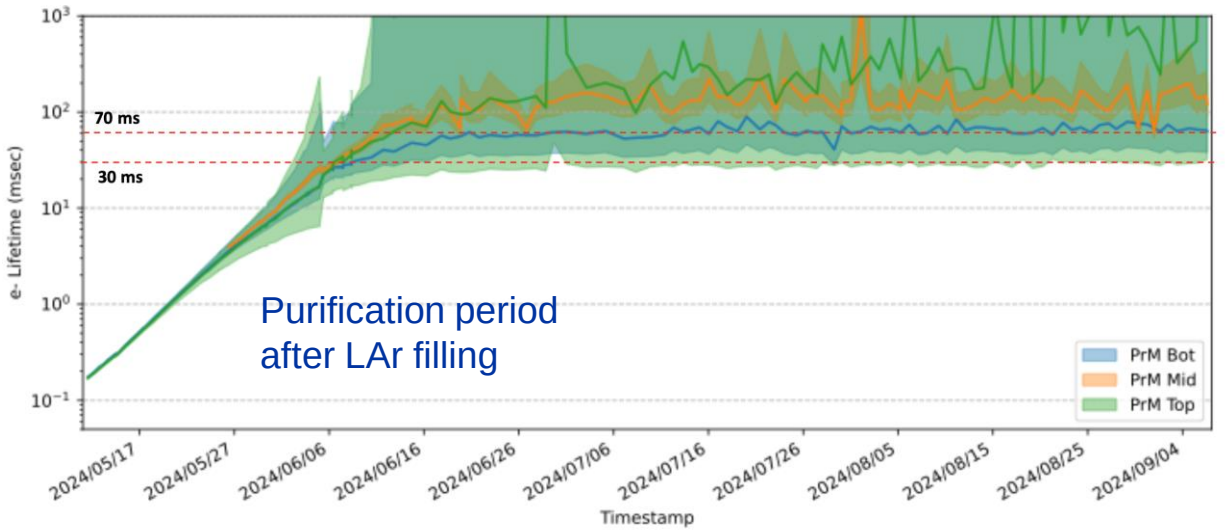
# Neutrino Platform Activities

**2) ProtoDUNE: Validation of the final prototypes of the DUNE far detectors (Horizontal and Vertical Drift concepts)**

- ❑ NP04 in operation since beginning of May
- ❑ Extremely pure: drifting electron lifetime exceeding 50 ms (Note: requirement is 3 ms)
- ❑ Very low electronic noise and only ~1 ‰ channels loss or problematic
- ❑ Stable HV >99.9% uptime at nominal field
- ❑ DAQ throughput exceeding DUNE requirements

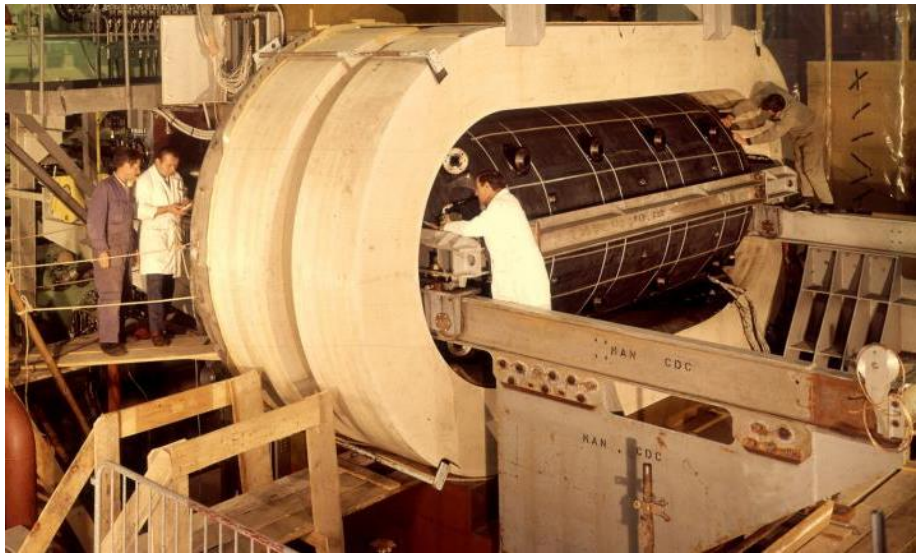

About 30 million triggers from 10 weeks testbeam campaign:

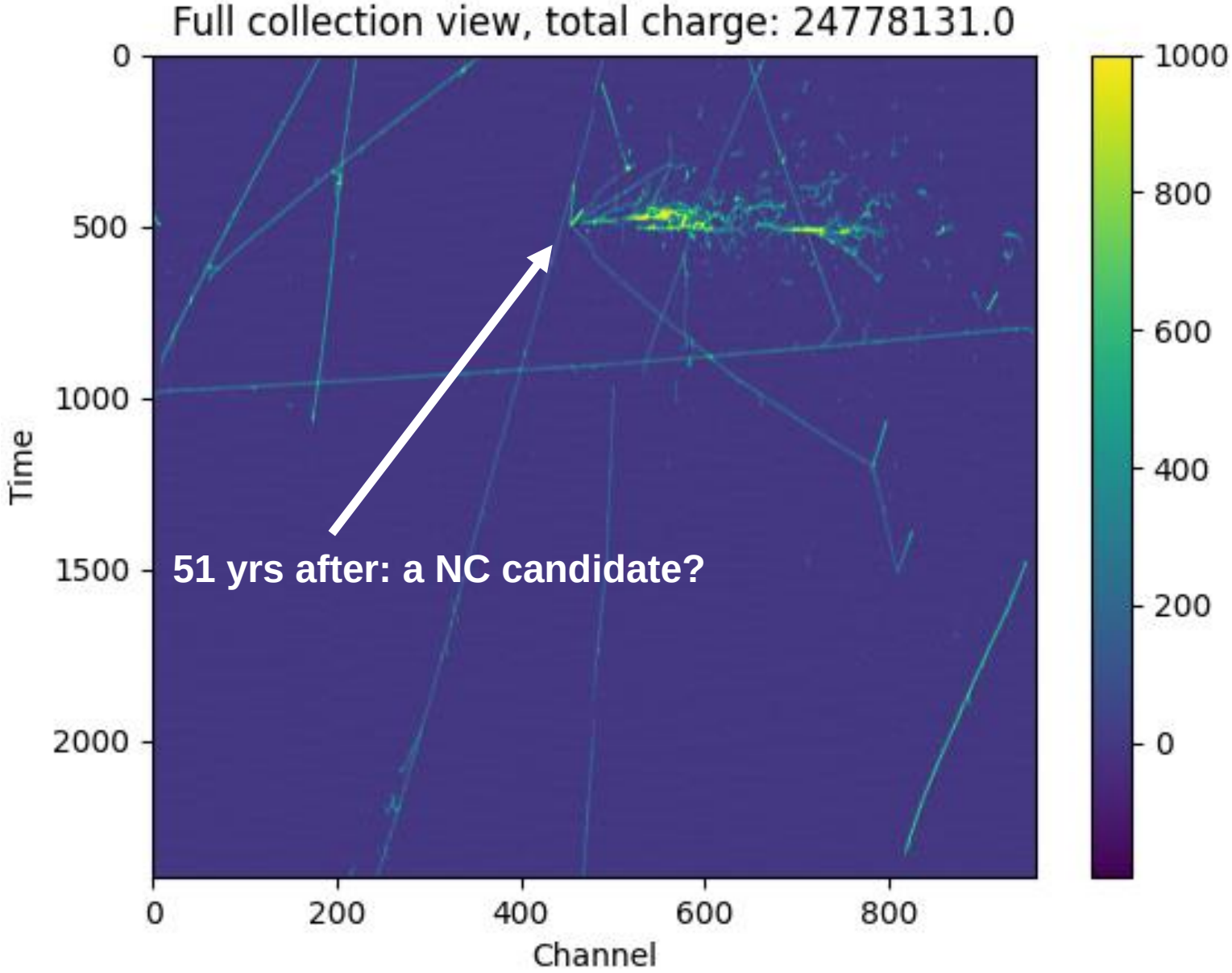
- ❑ Beam scans: 1-7 GeV/c with both polarities
- ❑ Most data at 1 GeV/c for pion cross-section measurement
- ❑ 2 million beam trigger with 5 GeV/c K and p (+/- )
- ❑ Unique sample for physics
- ❑ 4.2 PB of beam data, 0.8 PB of cosmics



# ProtoDUNE: NP04

*In a seminar at CERN on 19 July 1973, Paul Musset (Gargamelle) presented the first direct evidence of weak neutral currents*





# Status DRD Collaborations

- **DRD1** **Gaseous detectors**
- **DRD2** **Liquid Detectors**
- **DRD4** **Photodetectors & PID**
- **DRD6** **Calorimetry**

**Fully approved by RB in Dec 2023 on recommendation of the DRDC for 3 years**

- **DRD3** **Semiconductor Detectors**
- **DRD5** **Quantum Sensors**
- **DRD7** **Electronics**

**Fully approved by RB in Mar 2024 on recommendation of the DRDC for 3 years**

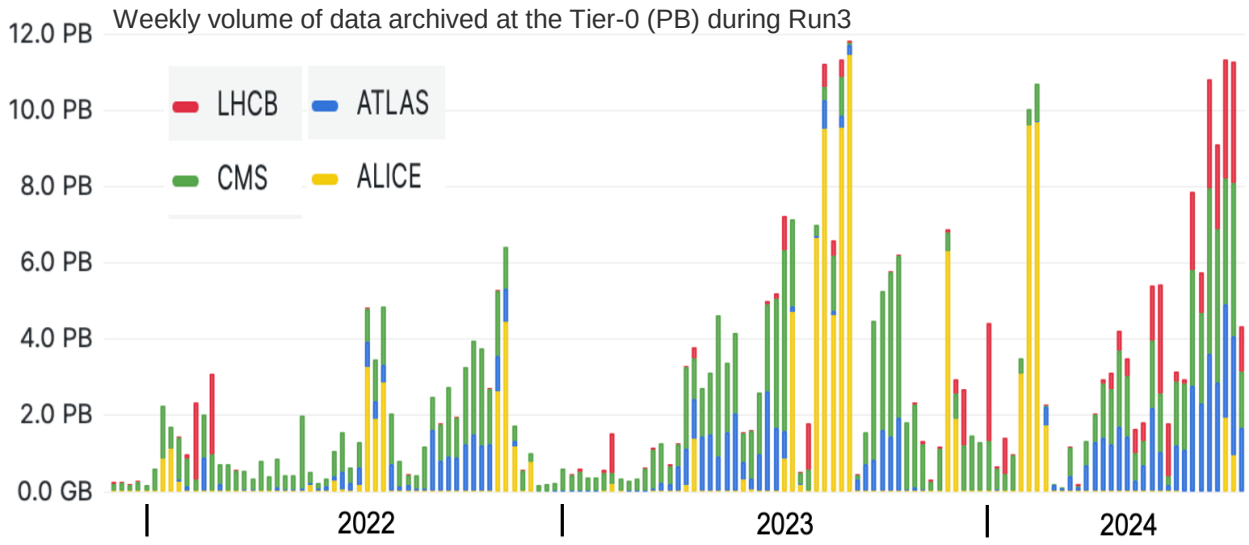
- **DRD8** **Integration**

**Full proposal received Oct 2024**

MoUs in preparation and being discussed with the DRD collaborations

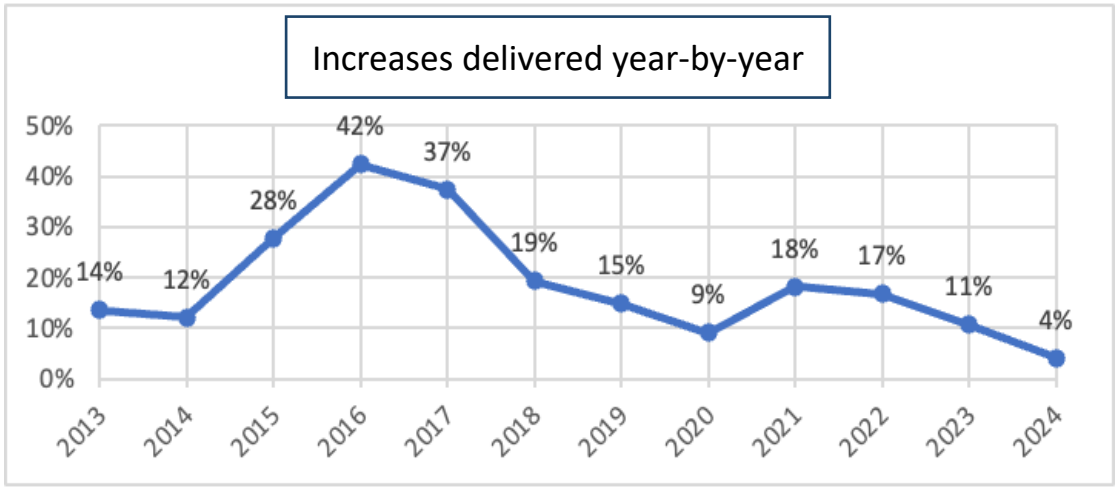
# Computing

- **CERN Data Centres:**
  - Prévessin Data Centre (PDC): fully operational.
  - Meyrin Data Centre (MDC): record storage rate of 11 PB/week in July 2024, from experiments to MDC (guaranteed bandwidth in Run3: 25 PB/week)
- Data promptly archived at CERN and at the Tier-1 centres
- IT infrastructure handles the data flow from the extraordinary performance of the LHC with headroom




- **WLCG:**
  reached 1.4 million computing cores and over 4 EB of storage, thanks to about 170 sites worldwide

Growing number of compute resources provided to the experiments, but less growth recently



# FCC

Recent good news

- ❑ FCC week in San Francisco
- ❑ Signature of a joint statement between USA and CERN
- ❑ Draghi report: includes a chapter „The CERN success story“
- ❑ Speeches at CERN 70 celebration, e.g. President of the European Commission

- ❑ Aim to present Feasibility Study to Council in spring 2025, in time for European Strategy Update

Joint statement USA and CERN

signed in the White House, April 2024

Should the CERN Member States determine the FCC-ee is likely to be CERN’s next world-leading research facility following the high-luminosity LHC, the US intends to collaborate on its construction and physics exploitation, subject to appropriate domestic approvals.

Ursula von der Leyen

*President of the European Commission*


Speech at CERN70 on October 1st, 2024

# CERN70

- Community event on September 17th
- Party with 8000 people (CERN access card and their families)
- Also > 100 events in Member States and beyond

- High level event on October 1st
- 8 heads of state/government, 13 ministers and other (V)VIPs

# Symposium to honour Carlo Rubbia

- Nobel Prize winner
- Former CERN DG
- Turned 90 years earlier this year

- Symposium with excellent speakers describing his truly outstanding achievements in science: Fabiola Gianotti, Chris Llewellyn Smith, Gerardus 't Hooft, Sam Ting, Luciano Maiani and others
- See https://indico.cern.ch/event/1450340/ for slides and recordings

# Estonia 24th CERN Member State

As of August 30th, Estonia is 24th CERN Member State

❑ CERN family October 2024:

**24** Member States

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

**1** Associate Member State in the pre-stage to membership

Slovenia

**9** Associate Member States

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

**6** Observers

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

Flag-raising ceremony Estonia October 17th

Chile and Ireland have applied for Associate Membership

# News from CERN Council

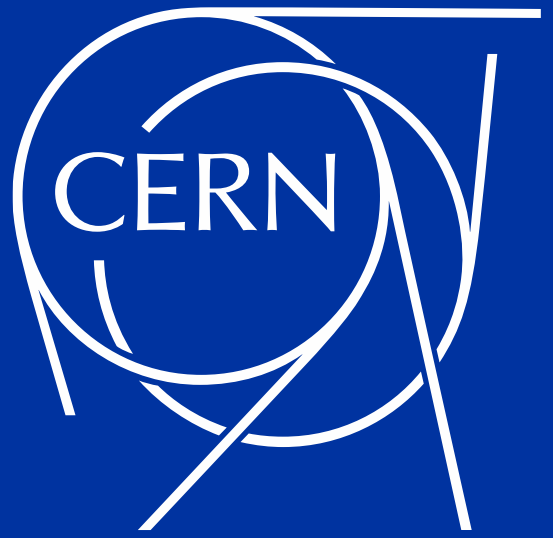
- Costas Fountas elected as next President of the CERN Council starting January 1st, 2025

- Mark Thomson elected as next Director General of CERN starting January 1st, 2026

# Summary

- Very successful proton-proton run in 2024
  - More than 120 $fb^{-1}$ pp luminosity delivered to ATLAS & CMS
  - ALICE and LHCb doubled their total pp data sets
  - PbPb run is going on
- Experiments continue to produce excellent physics results
- Despite good progress in Phase II upgrades HL-LHC start had to be delayed by 1 year
  - As further significant risks to the schedule remain, additional efforts are required to meet the new schedule
- Good progress at Neutrino Platform and for LBNF/DUNE cryostats
- WLCG is running smoothly
  - Pay attention to development of hardware costs
- Successful events at CERN and in Member States celebrating CERN 70$^{th}$ anniversary

# Thank you for your attention!



# Backup

# Science Gateway

- To date > 400 000 visitors since 8 October 2023 (day of opening to the public) from 159 countries as compared to ≈ 150 000/year before
- ≈ 60% individuals and families, ≈ 26% groups

- >4800 trainings given to >1400 individual guides (mostly users and staff)

→ **many thanks to all colleagues who volunteered!**

# Remaining LHC Schedule for 2024