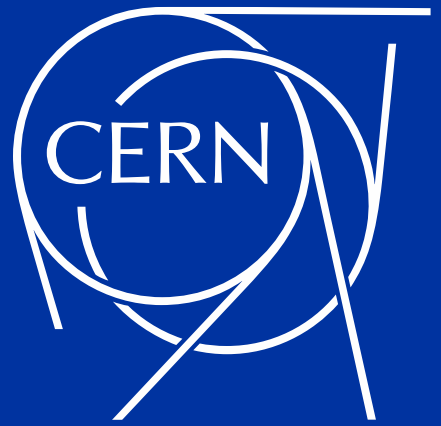


Status of the Experiments

- 2023 run
- A few physics results
- Progress Phase II upgrades
- NextGen trigger proposal
- WLCG & Computing

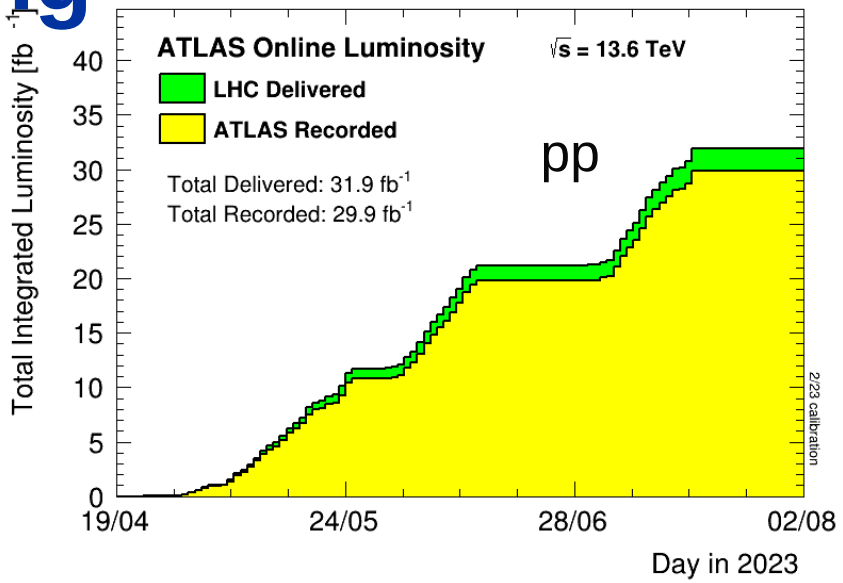
Plenary RRB 57th Meeting

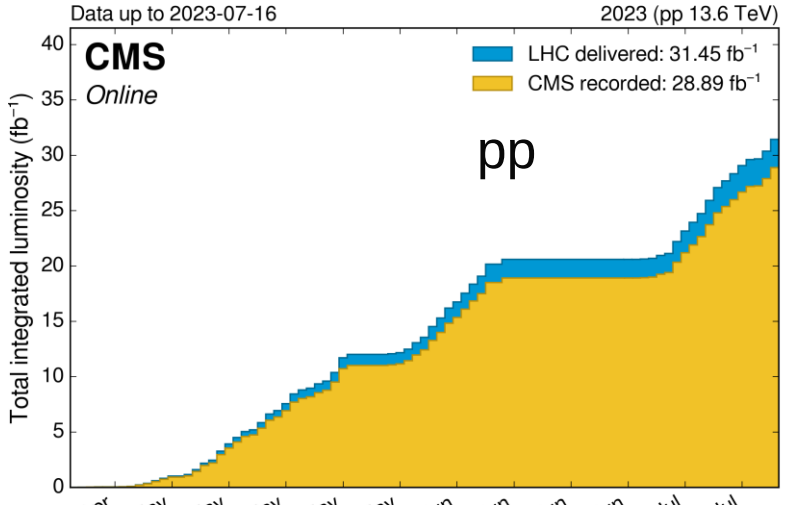
Joachim Mnich

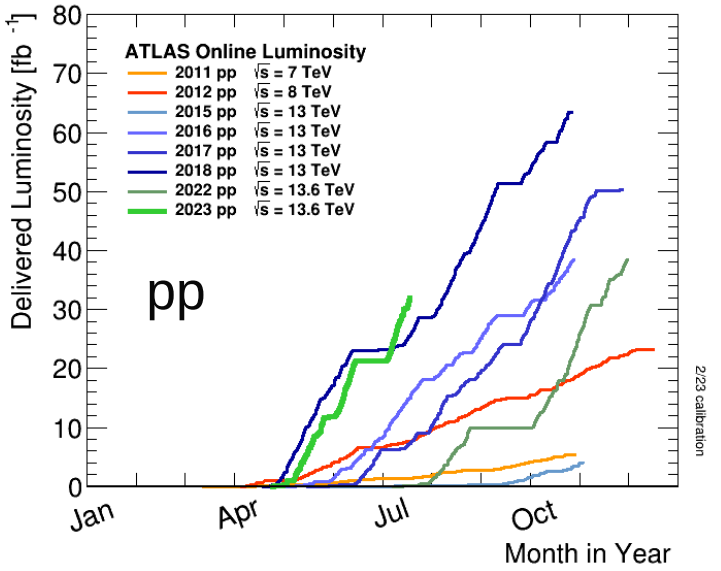
October 24rd, 2023

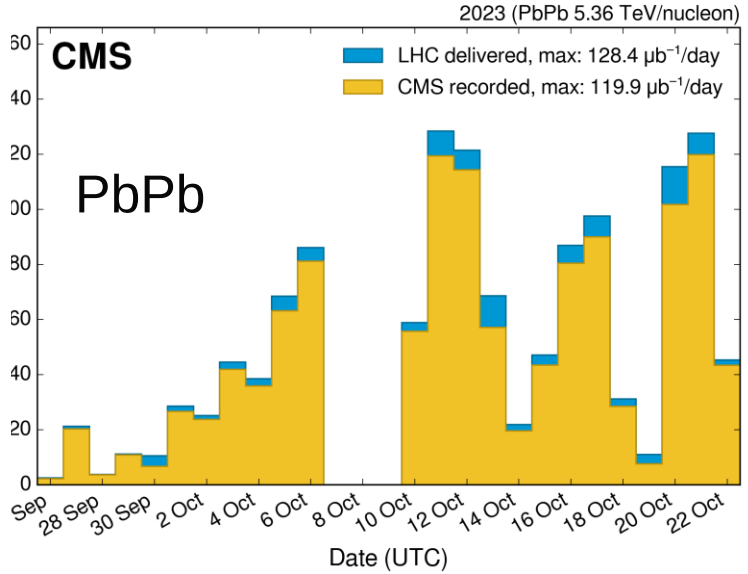
2023 Data Taking

- Approx. 32 fb^{-1} pp luminosity delivered to ATLAS & CMS
- Until mid July best year ever!
- Due to several issues the goal of 75 fb^{-1} was not reached
- Heavy Ion run still ongoing until October 30th









ATLAS: Search for Magnetic Monopoles

Contrary to electric charge magnetic monopoles have never been observed

- Offer an explanation for the quantization of electric charge
- Predicted by extension of the Standard Model, e.g. Grand Unification Theories
- Masses could be at the TeV scale

Dirac's quantization conditions for the fundamental magnetic charge

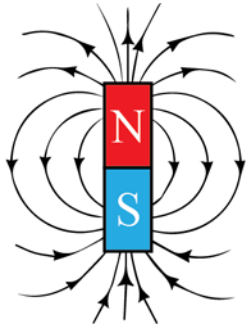
$$g_D = \frac{e}{2\alpha} \approx 68.5e$$

Magnetic charge should be a multiple of this fundamental charge $g_D, 2g_D, 3g_D, \ldots$

Would give rise to spectacular signals in the detectors!

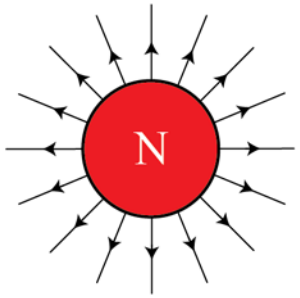
Magnetic

Dipole



exist, e.g muon anomalous muon dipole moment

Monopole

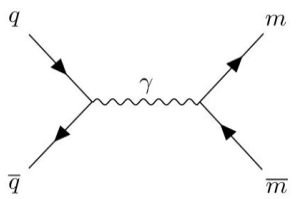


not yet observed

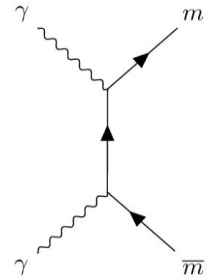
ATLAS using full Run 2 data

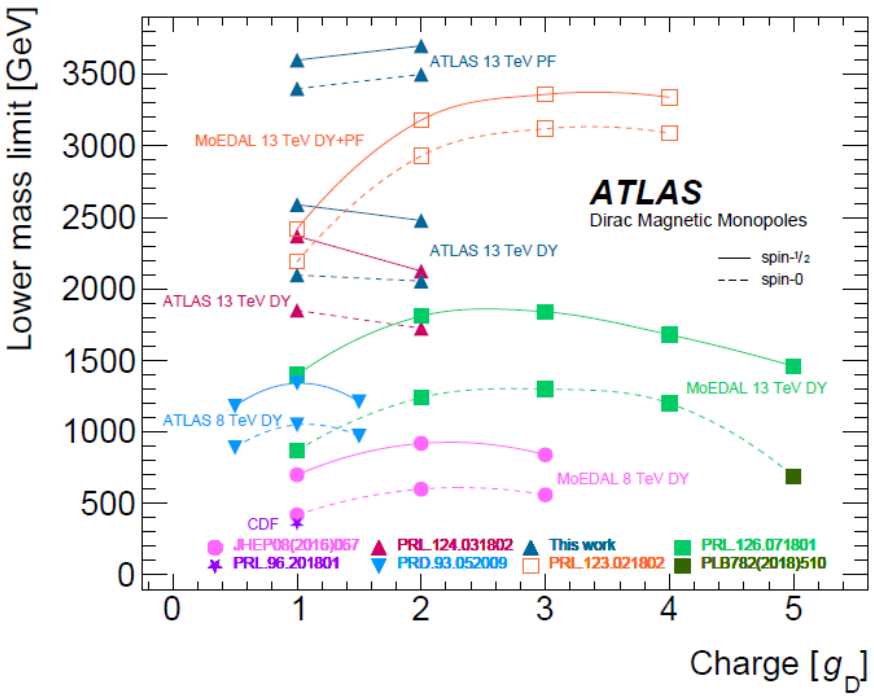
- New improved limits on monopole mass from searches in Drell-Yan and photon fusion processes

Drell-Yan

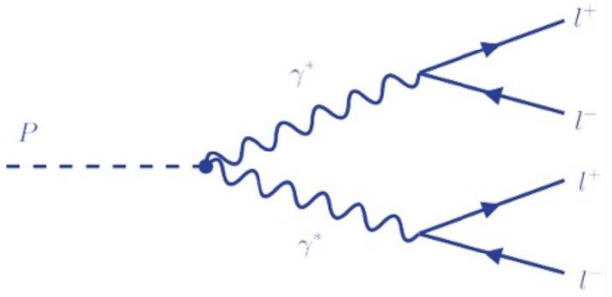


Photon fusion





Observation of η → 4μ



A rare double Dalitz decay (BR O(10^{-9})) that has eluded discovery so far

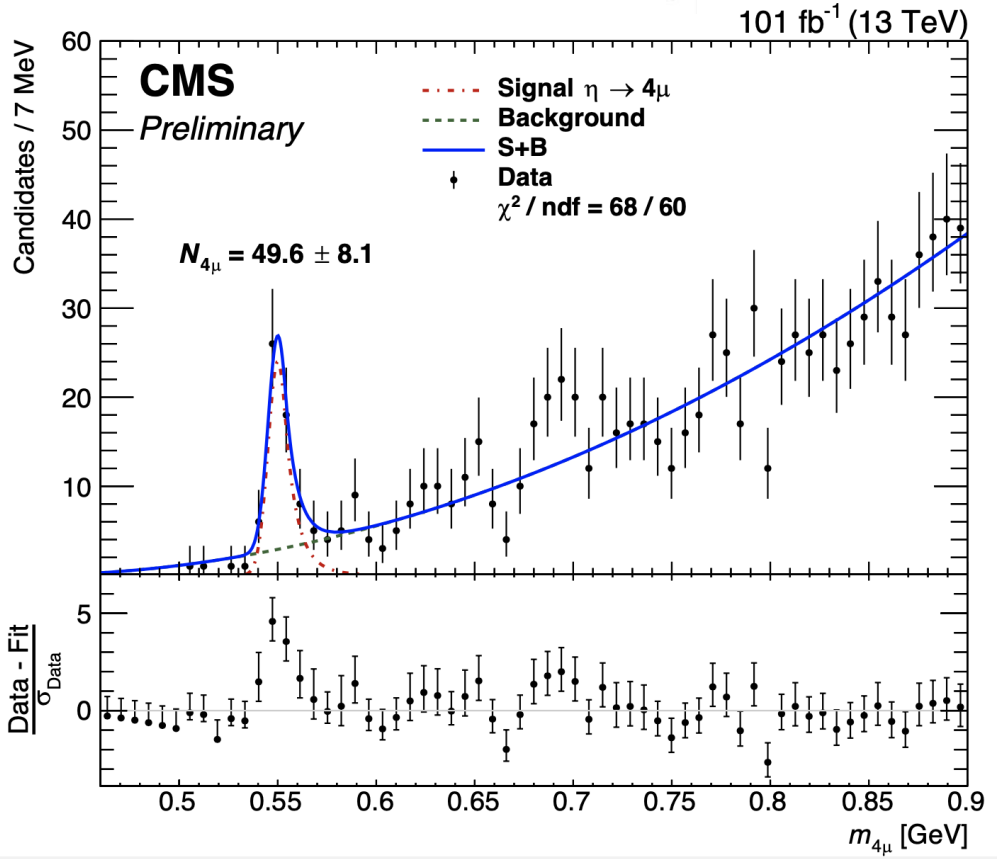
Search performed on data scouting

- ❑ Loose L1 triggers, no HLT selection
- ❑ Stored HLT muons for offline analysis
- ❑ High-rate trigger that extends the CMS sensitivity to low mass di-muon and four-muon resonances

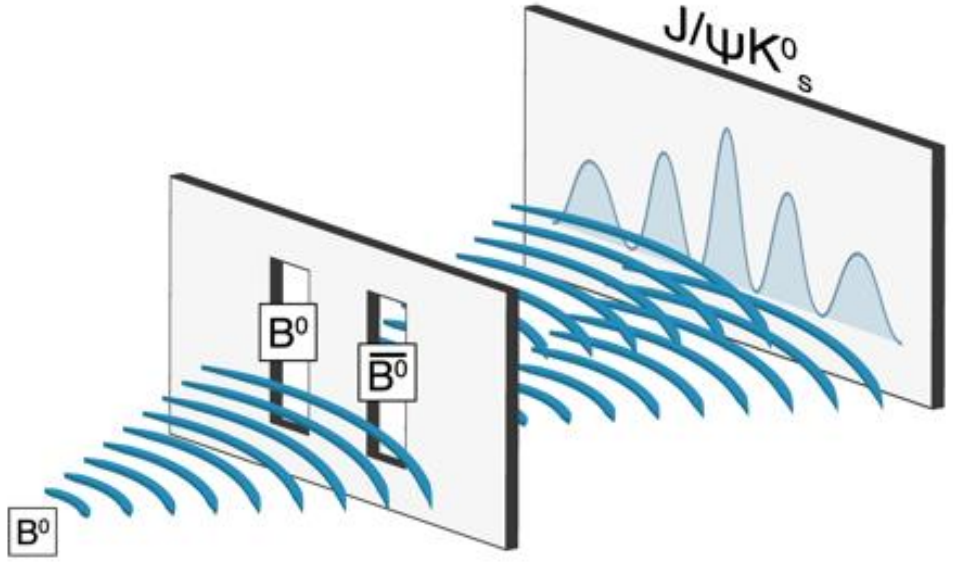
Exploit $\eta \to \mu^+\mu^-$ decay as normalisation

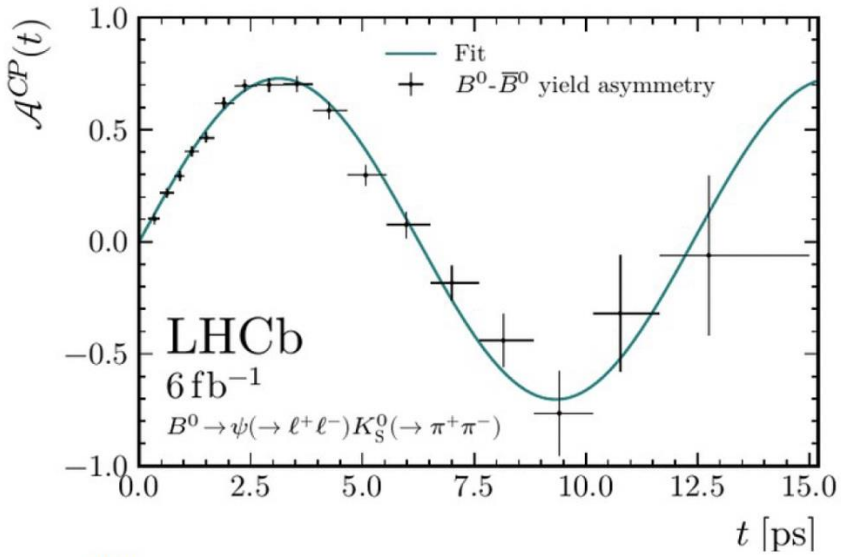
$BR(\eta \to \mu^+\mu^- \mu^+\mu^-) = (5.0 \pm 0.8_{stat} \pm 0.7_{sys} \pm 0.7_{bkgd}) \times 10^{-9}$

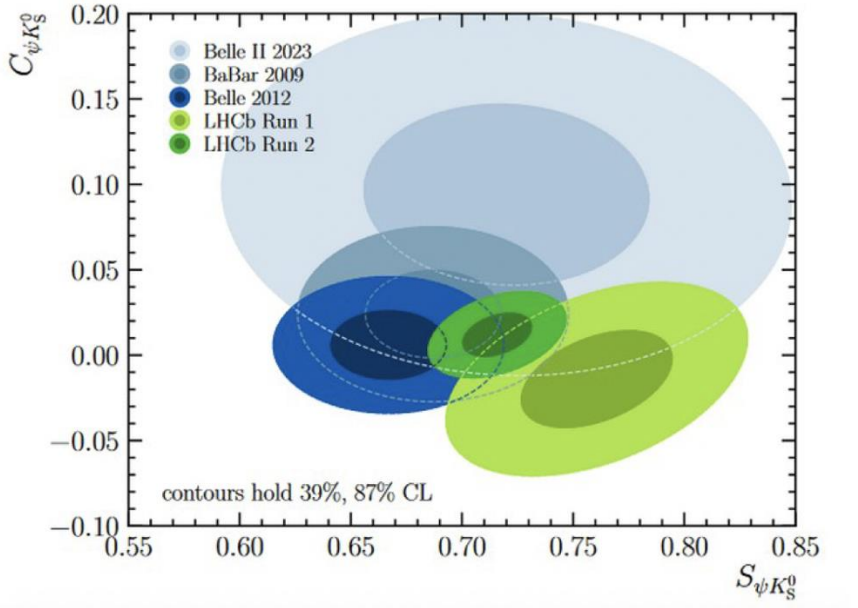
- ❑ In agreement with theoretical estimates
- ❑ Significance > 5σ



LHCb: Most Precise Measurement of sin(2β)







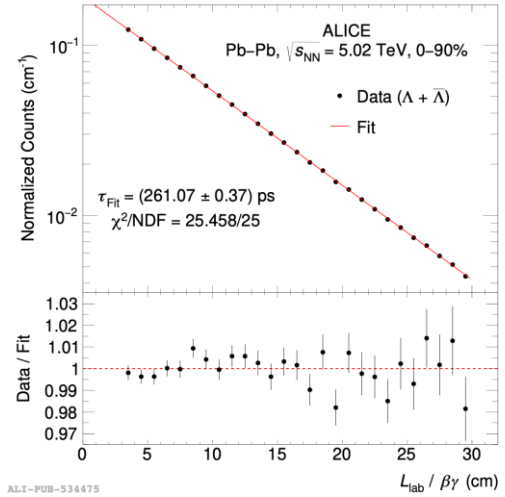
- World's best measurement of sin(2β) from $B_0 \to J/\psi\, K_S$
- This was the golden measurements of B factories
- With the addition of Run-2 data LHCb has greatly improved the precision

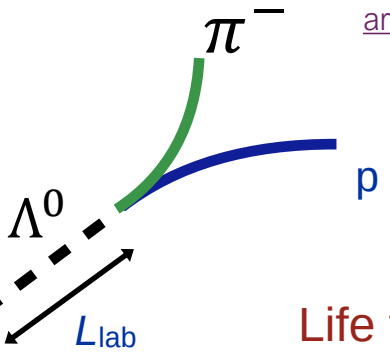
$$S^{\text{Run 1+2}}_{J/\psi\, K^0_S} = 0.724 \pm 0.014\,(\text{stat+syst})$$

- The measurement is still dominated by statistical uncertainties

ALICE: Lifetime of Strange Baryons and Nuclei

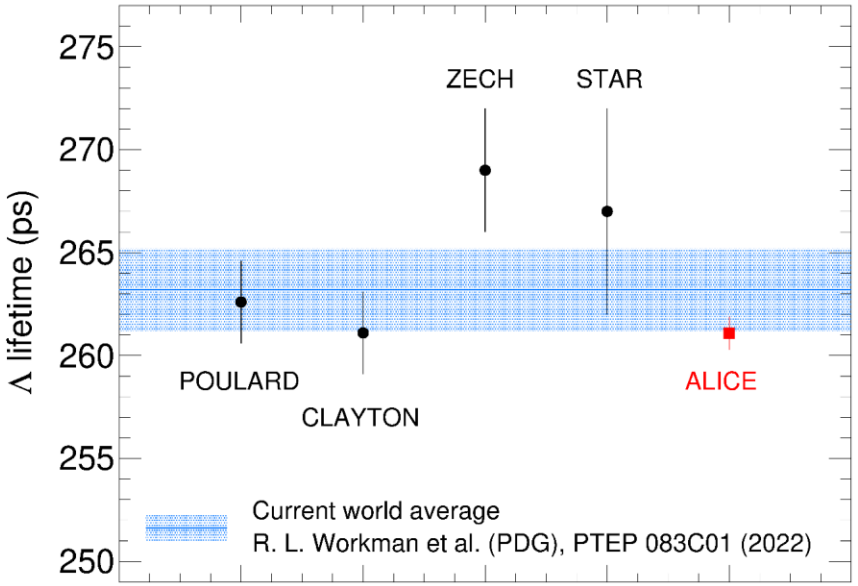
Proper decay length distribution





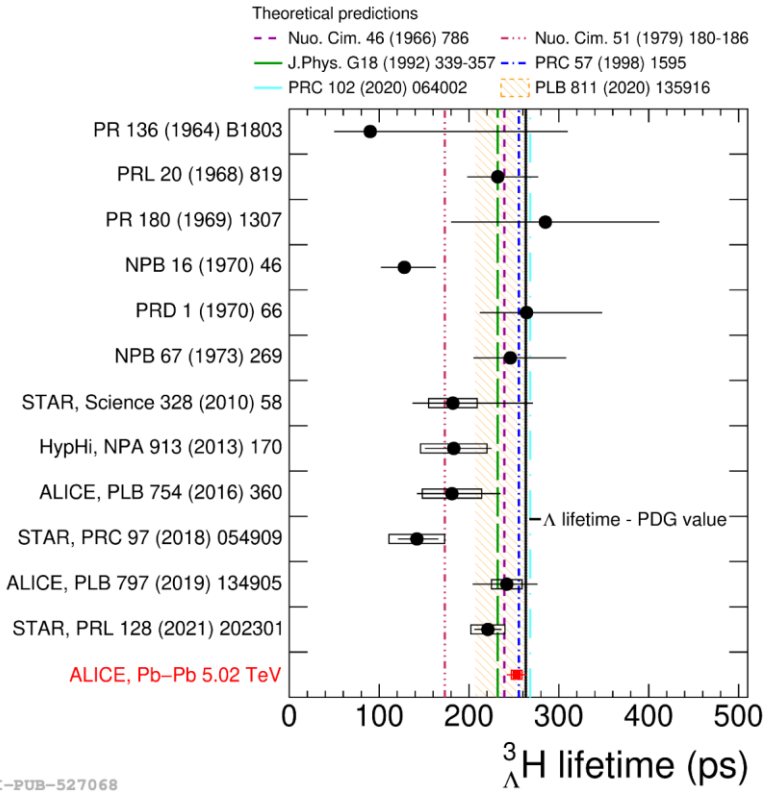
arXiv:2303.00606

Life time: comparison to existing results

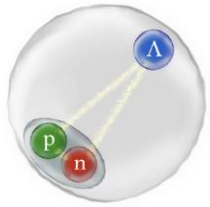


$$\tau_{\Lambda+\bar{\Lambda}} = [261.07 \pm 0.37(\text{stat.}) \pm 0.72(\text{syst.})]\ \text{ps}.$$

Hypernuclei life time



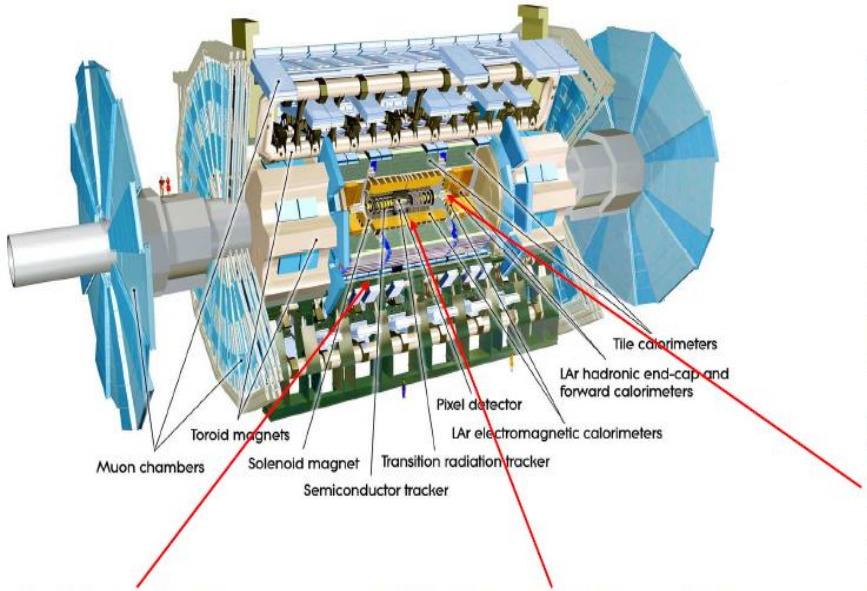
arXiv:2209.07360



Life time measurements of hyperons and hypernuclei competitive with world data

Phase II Upgrade ATLAS & CMS

ATLAS



New Muon Chambers

Inner barrel region with new RPC and sMDT detectors

New Inner Tracking Detector (ITk)

All silicon, up to $|\eta| = 4$

Upgraded Trigger and Data Acquisition system

Level-0 Trigger at 1 MHz

Improved High-Level Trigger (150 kHz full-scan tracking)

Electronics Upgrades

LAr Calorimeter

Tile Calorimeter

Muon system

High Granularity Timing Detector (HGTD)

Forward region ($2.4 < |\eta| < 4.0$)

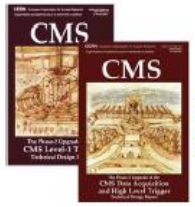
Low-Gain Avalanche Detectors (LGAD) with 30 ps track resolution

Additional small upgrades

Luminosity detectors (1% precision goal)

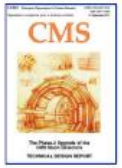
HL-ZDC

CMS

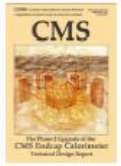


L1-Trigger HLT/DAQ
https://cds.cern.ch/record/2714892
https://cds.cern.ch/record/2759072
- Tracks in L1-Trigger at 40 MHz
- PFlow selection 750 kHz L1 output
- HLT output 7.5 kHz
- 40 MHz data scouting

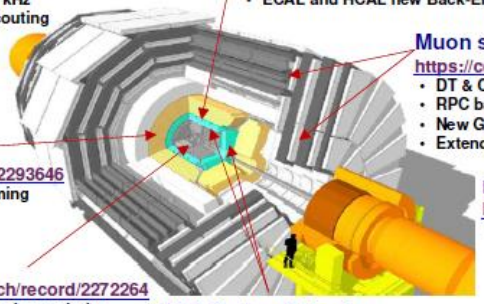
Barrel Calorimeters
https://cds.cern.ch/record/2283187
- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards



Muon systems
https://cds.cern.ch/record/2283189
- DT & CSC new FE/BE readout
- RPC back-end electronics
- New GEM/RPC $1.6 < \eta < 2.4$
- Extended coverage to $\eta \simeq 3$

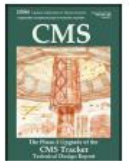


Calorimeter Endcap
https://cds.cern.ch/record/2293646
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

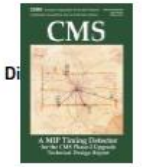


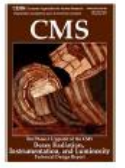
Beam Radiation Instr. and Luminosity
http://cds.cern.ch/record/2759074
- Bunch-by-bunch luminosity measurement: 1% offline, 2% online

Tracker https://cds.cern.ch/record/2272264
- Si-Strip and Pixels increased granularity
- Design for tracking in L1-Trigger
- Extended coverage to $\eta \simeq 3.8$



MIP Timing Detector
https://cds.cern.ch/record/2667167
Precision timing with:
- Barrel layer: Crystals + SiPMs
- Endcap layer: Low Gain Avalanche Di





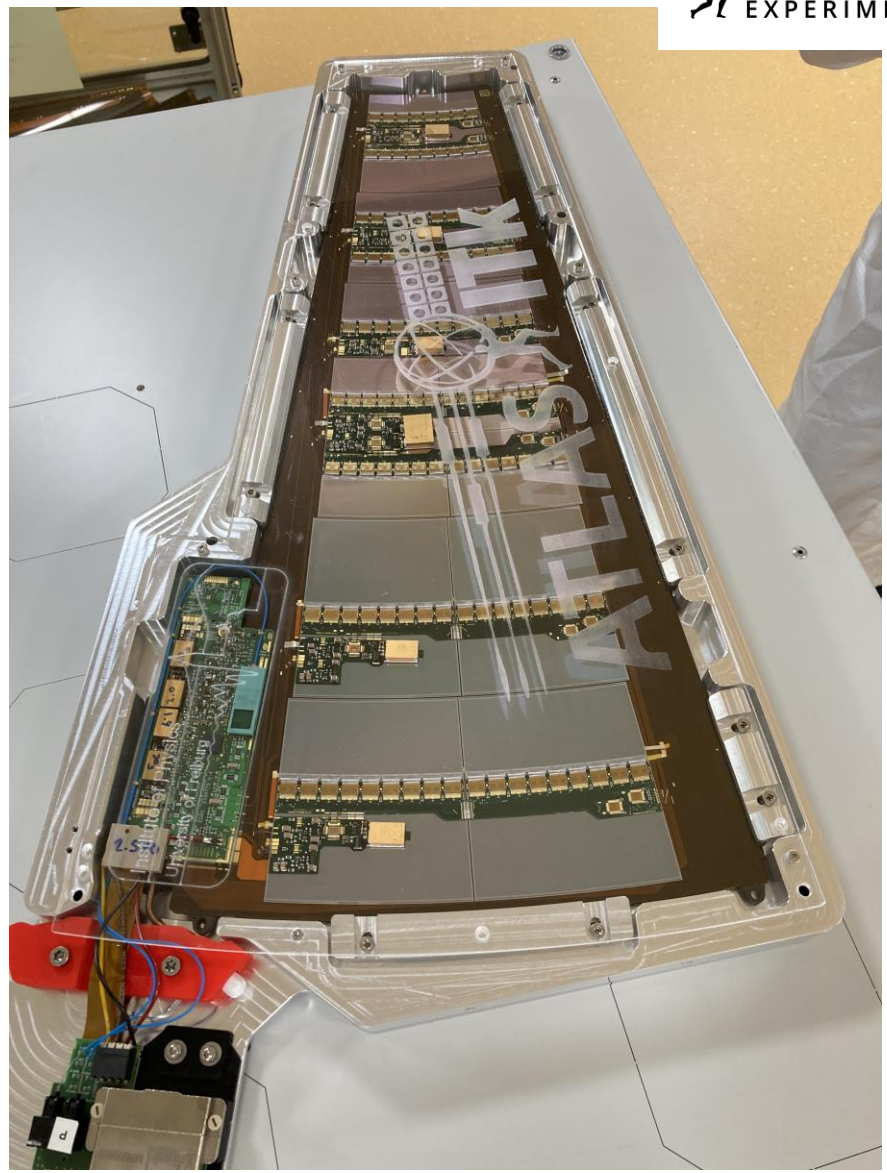
- Projects are making very good progress
  - Now in transition to (pre-)production
- However, schedule for both experiments remains extremely tight with no significant contingency

Status ATLAS Phase II Upgrade

Projects are making very good progress

Overall status:

- Huge progress in all projects transiting towards production, critical final design reviews passed, but still a few technical challenges to overcome
- ITk Pixel and Strip define critical path of schedule and have continued to use up contingency due to technical & procurement challenges, urgent actions taken to improve services situation
- Muon upgrade (RPC) also entering critical schedule
- Increasing resources mobilised for Phase-II upgrade



First fully functioning petal of the ITk endcap

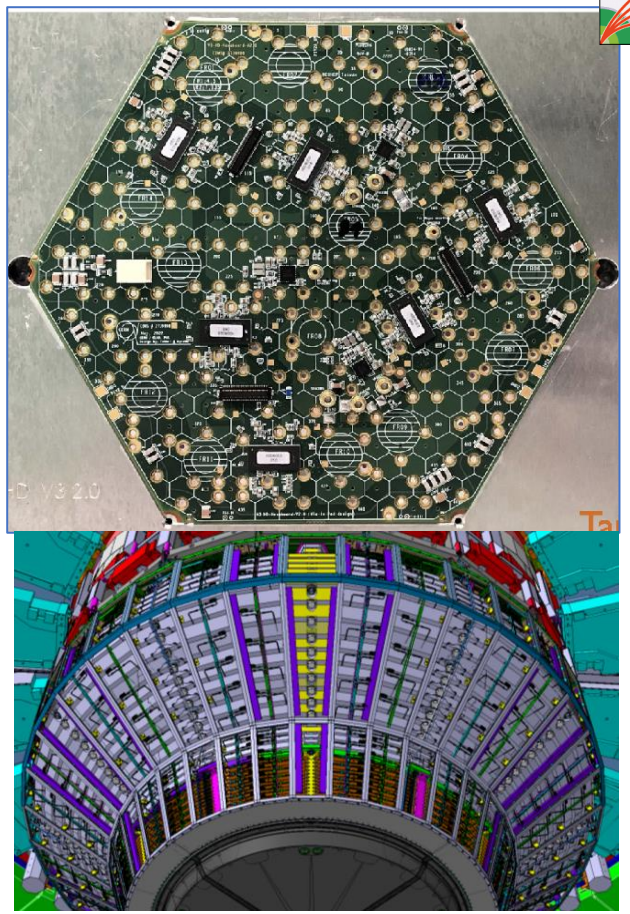
Status CMS Phase II Upgrade

Detector upgrade projects are making good technical progress

- ❑ L1 Trigger decision shown to fit into 9.5 μs with 12.5 μs available
- ❑ ASIC designs are proceeding well and nearly complete
- ❑ Many more items are moving into pre-production or production
- ❑ Global float for the upgrade is now ~3-4 months

Focus on understanding the resources needed to complete the upgrades

- ❑ Collaboration building - “Upgrade Days” with broad participation across the projects
- ❑ There has been progress in securing mitigations for CMS Upgrade deliverables that are at risk on account of the war in Ukraine



First ladder fully equipped with 12 functional 2S modules

ATLAS & CMS Phase II Upgrades

Workshop with Fraunhofer IPA

Factory Planning and Production Management

- Two workshops on CMS HGCAL
  26.06. - 28.06.2023
  30.08. - 01.09.2023
- One workshop on ATLAS ITk project
  11.10 – 13.10.2023
  Follow-up in February 2024
- Complementary to LHCC, P2UG reviews
- ATLAS and CMS spent a lot of effort in the preparation of the review
  Perhaps this is the largest benefit of the review!
- Fraunhofer impressed by the quality and depth of the planning, tools developed to plan, simulate production and estimate schedule
- No obvious mistake, no important items overlooked
  - Potential for production identified and under study (for CMS, ATLAS to be discussed in Feb 2024)
  - Larger engagement of collaboration, more personnel required

Future is our product
Sustainable. Personalized. Smart.

Giving you a competitive edge
Sustainable. Flexible. Economical.

Fraunhofer IPA
Factory Planning and Production Management
Nobelstraße 12 | 70569 Stuttgart

Conception of a “Next Generation Triggers” Proposal

Sep 2022 A group of private donors interested in supporting CERN scientific mission visits CERN to share ideas with CERN management and physics/computing experts

Oct 2022 Eric Schmidt contacts CERN impressed by its vision and contributions to the advancement of science and proposes that his foundation could **fund work on advanced Artificial Intelligence (AI) and Quantum Computing techniques to improve the LHC experiments data acquisition, analysis, and simulation workflows**.

Nov 2022 – **Dec 2023** A task force composed of experts from EP, IT, TH, ATLAS, CMS and external experts works on a concept proposal. A 5-page concept is submitted to the **Eric and Wendy Schmidt Fund for Strategic Innovation** for a **project with a value of 48M USD over 5 years**

Feb 2023 The Foundation informs CERN that they have **positively evaluated the proposal** and are ready to enter into a more detailed discussion of technical milestones, budget and legal/admin procedures

Jun 2023 The task force prepares a detailed proposal **which is validated from the administrative, legal, financial points of view, as well as international relations and reputation aspects, by the respective CERN competent bodies**

Aug 2023 – **Sep 2023** The proposal **NextGen** is **positively considered by CERN management**, legal negotiations with the Foundation lead to a draft agreement. A proposal for approval submitted to CERN Council

Oct 2023 **NextGen approved by CERN Council,** grant agreement being finalised to start project in January 2024

NextGen Objectives

Enhance the trigger and analysis capabilities, and thus the scientific potential, of ATLAS and CMS in the HL-LHC phase beyond the currently projected scope

- Accelerate the evaluation and introduction of **novel computing, engineering and scientific ideas** already for Run 3, but with main focus on HL-LHC
- Provide a major push to the work already ongoing in the experiments, by enabling **lines of research currently not feasible within existing financial, human and technological resources limits**
- Provide **critical insight to develop future detectors and data flows** for the even more ambitious objectives of a future collider, such as the Future Circular Collider (FCC) currently in its Feasibility Study phase

The EP, IT and TH departments are also involved to ensure that other current & future CERN experiments benefit from the results in terms of computing frameworks and physics theory models.

All project results will be released under a valid open science policy and IP generated will be released under appropriate open licenses **in compliance with the CERN Open Science Policy.**

NextGen Activities

WP0: “Project management and communications” to ensure overall project coordination, management of the relations between CERN and the E&W Foundation, the LHC experiments collaborations, the external partners, and the internal CERN services

WP1: “Infrastructure, Algorithms and Theory” to improve ML-assisted simulation and data collection, develop common frameworks and tools, and better leverage available and new computing infrastructures and platforms

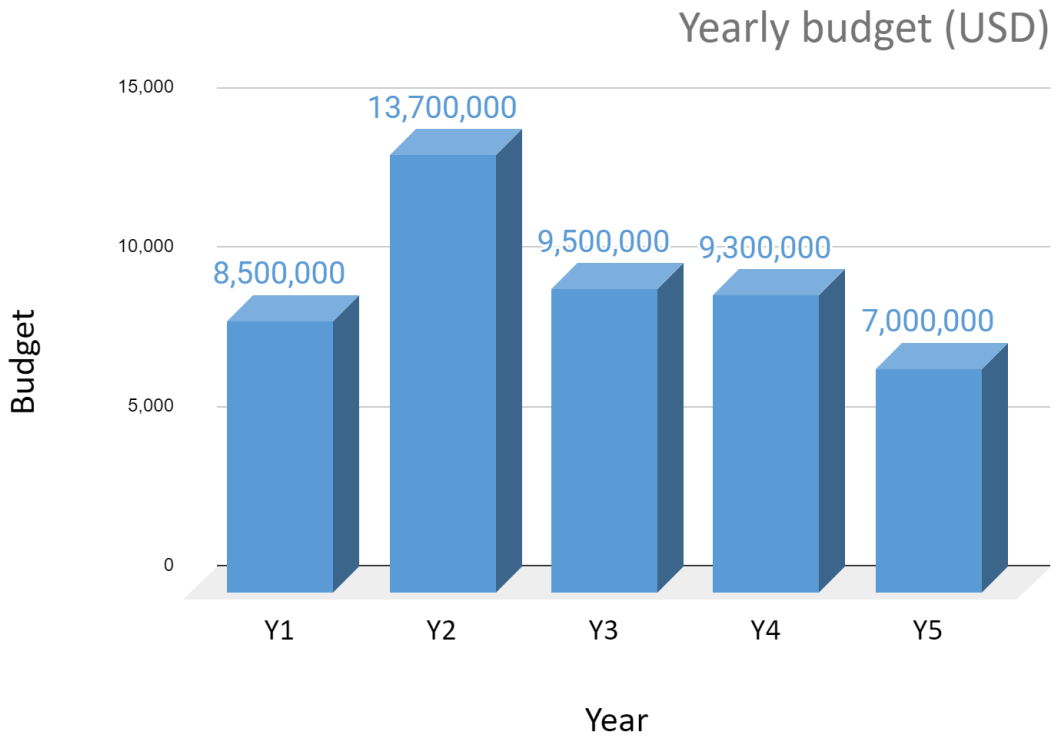
WP2: “Enhancing the ATLAS Trigger and Data Acquisition” to focus on improved and accelerated filtering and exotic signature detection

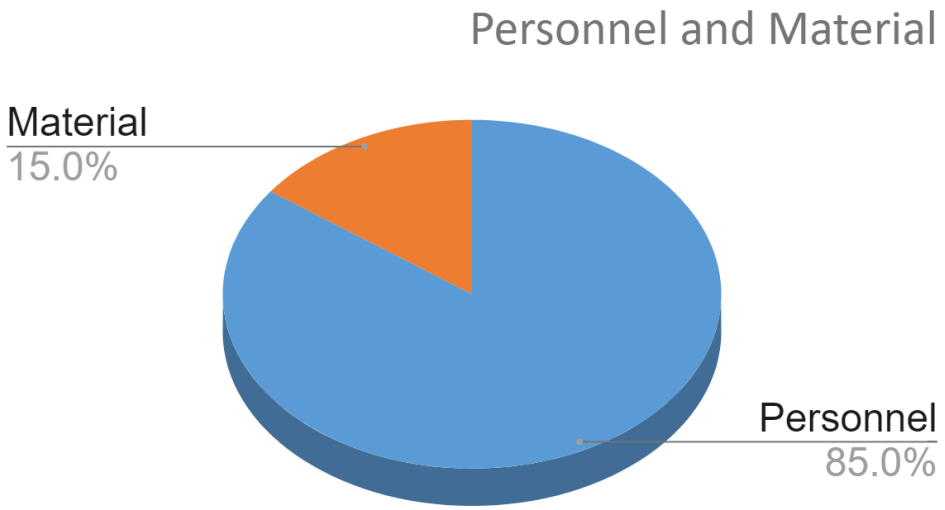
WP3: “Rethinking the CMS Real Time Data Processing” to design a novel AI-powered real-time processing workflow to analyze every single collision produced in the LHC

WP4: “Education Programmes and Outreach” to foster and train computing skills in the next generation of high energy physicists

NextGen Budget

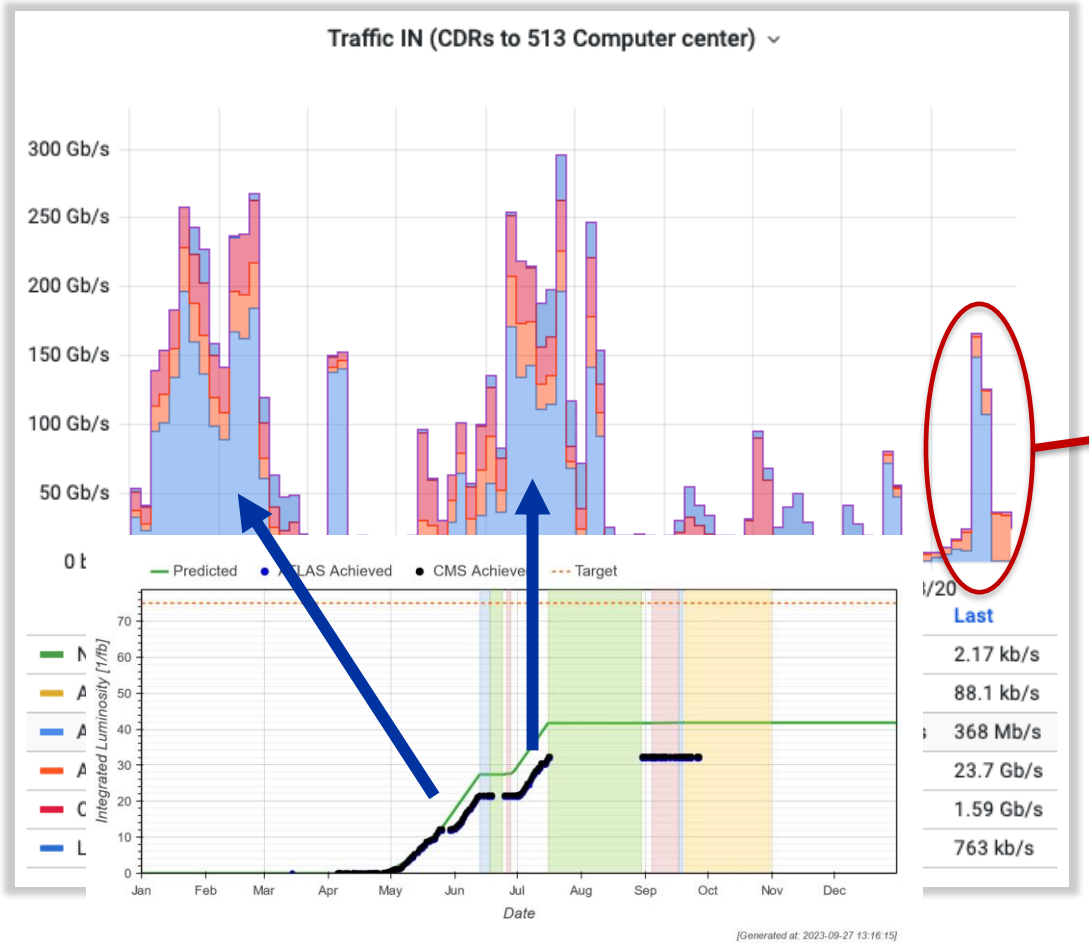
WP	Personnel costs (USD)	Material costs (USD)	Total Cost (USD)
Management	1.8M	0.0M	1.8M
WP1	11.2M	6.0M	17.2M
WP2	12.4M	0.6M	13.0M
WP3	12.4M	0.6M	13.0M
WP4	3.0M	0.0M	3.0M
Total	**40.8M**	**7.2M**	**48.0M**
Percentage	**85%**	**15%**	**100%**



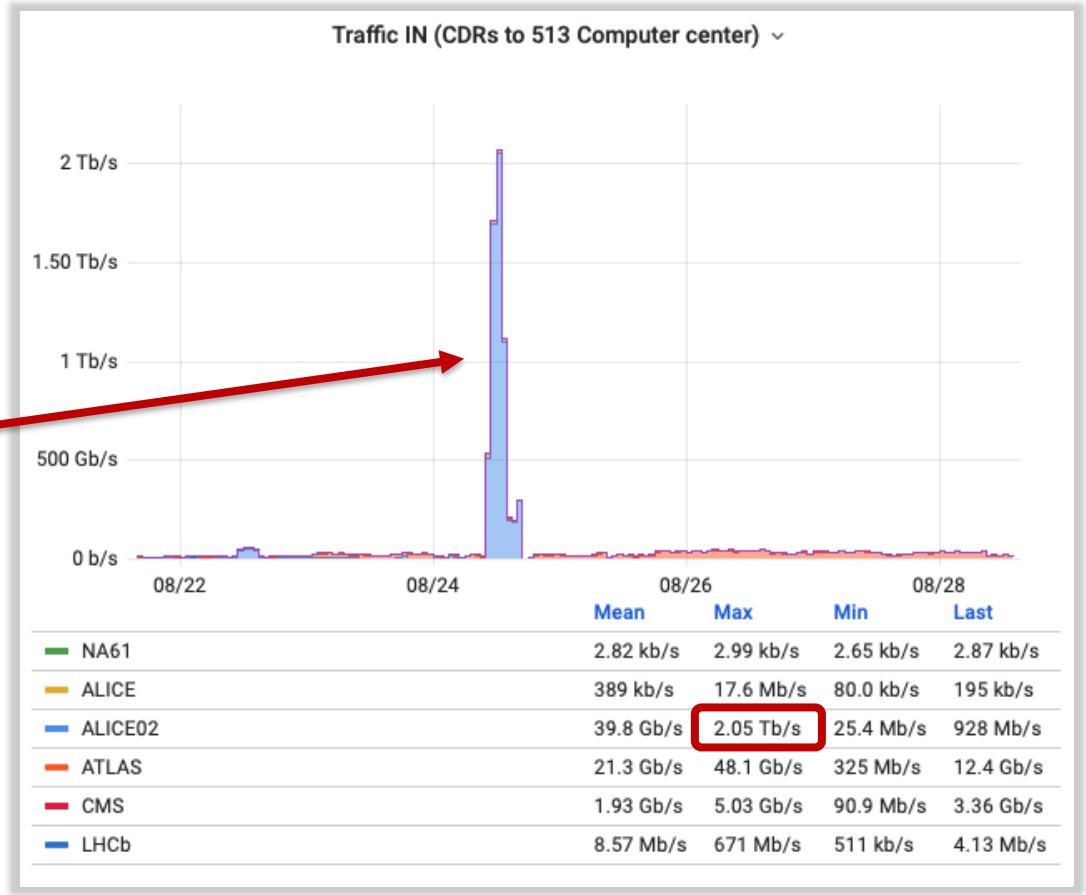


Computing: 2023 LHC data taking

Traffic experiments → T0 in the last 6 months



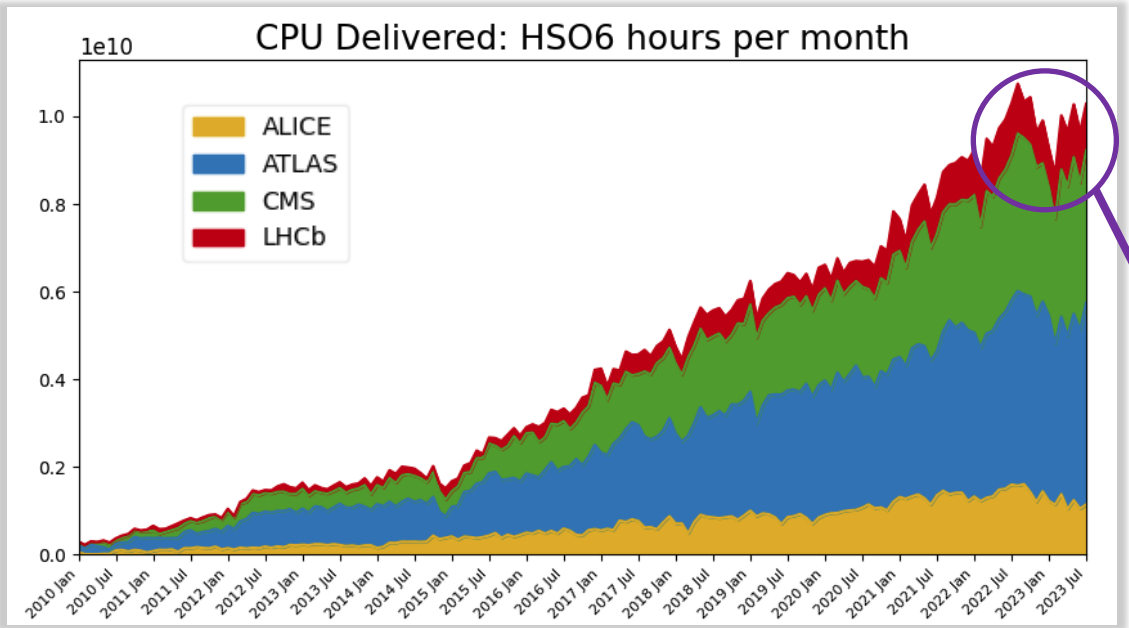
P2 (ALICE) → T0 throughput test



	Mean	Max	Min	Last
NA61	2.82 kb/s	2.99 kb/s	2.65 kb/s	2.87 kb/s
ALICE	389 kb/s	17.6 Mb/s	80.0 kb/s	195 kb/s
ALICE02	39.8 Gb/s	2.05 Tb/s	25.4 Mb/s	928 Mb/s
ATLAS	21.3 Gb/s	48.1 Gb/s	325 Mb/s	12.4 Gb/s
CMS	1.93 Gb/s	5.03 Gb/s	90.9 Mb/s	3.36 Gb/s
LHCb	8.57 Mb/s	671 Mb/s	511 kb/s	4.13 Mb/s

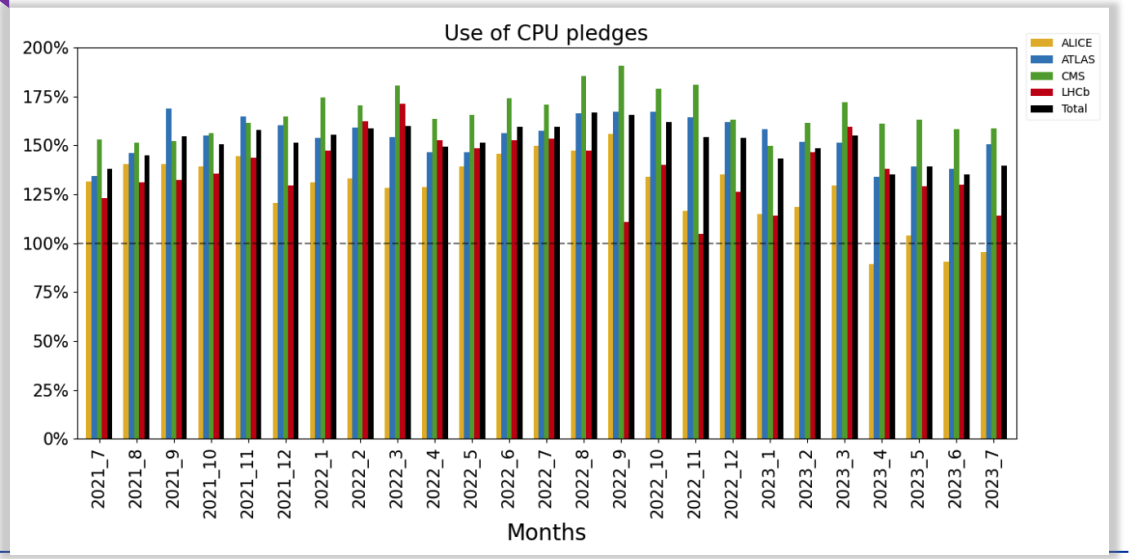
Before and after proton runs, time was dedicated to expanding peak capabilities for heavy ion run

WLCG Computing Resources



Reduction of processing activity at WLCG sites in winter 2023 due to ~ energy crisis

Mostly recovered now, still not reaching the peak of summer 2022



Experiments globally can leverage ~40% beyond pledge capacity at WLCG sites

Prévessin Data Centre

to end October 2023

- Commissioning (incl. building and services such as electrical, cooling, ventilation)

to end December 2023

- IT trial installation and tests (incl. one POD)
  POD = 2 rows of racks with hot aisle containment

during January 2024

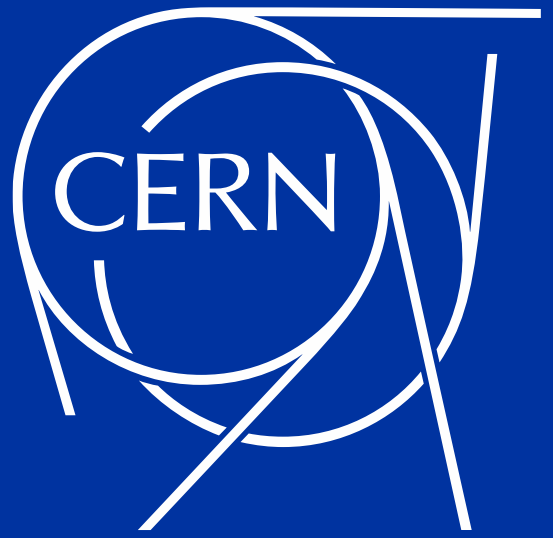
- Installation of the rest of the first batch of equipment

Summary

- Detectors took successfully data in 2023
  - however, luminosity goal could not be reached
- Experiments continue to produce excellent physics results
- Good progress in Phase II upgrades
  - but challenges remain on the schedule and due to worldwide economic and political situation
  - work with Fraunhofer experts to optimize production and to identify opportunities to accelerate production schedule
- WLCG is running smoothly
  - progress in addressing HL-LHC and energy challenges
  - Prévessin Data Centre nearing completion

Big thank you to the Funding Agencies for their continuous support!

Thank you for your attention!



Backup