



Status of the Experiments

Plenary RRB 56th Meeting

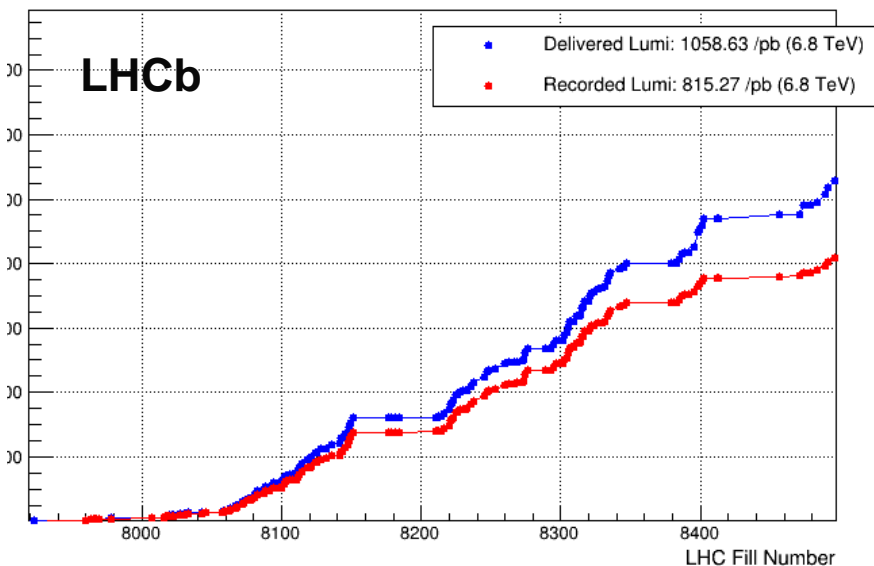
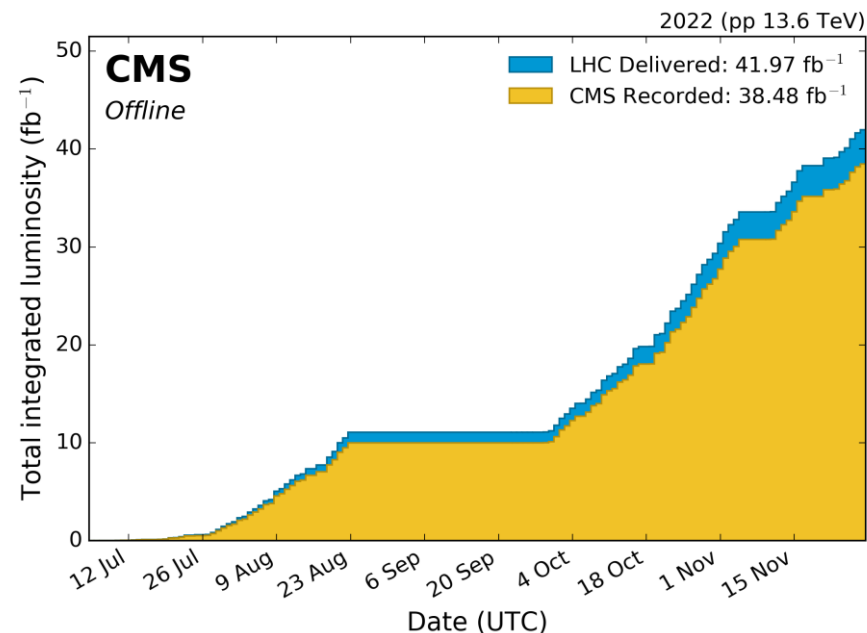
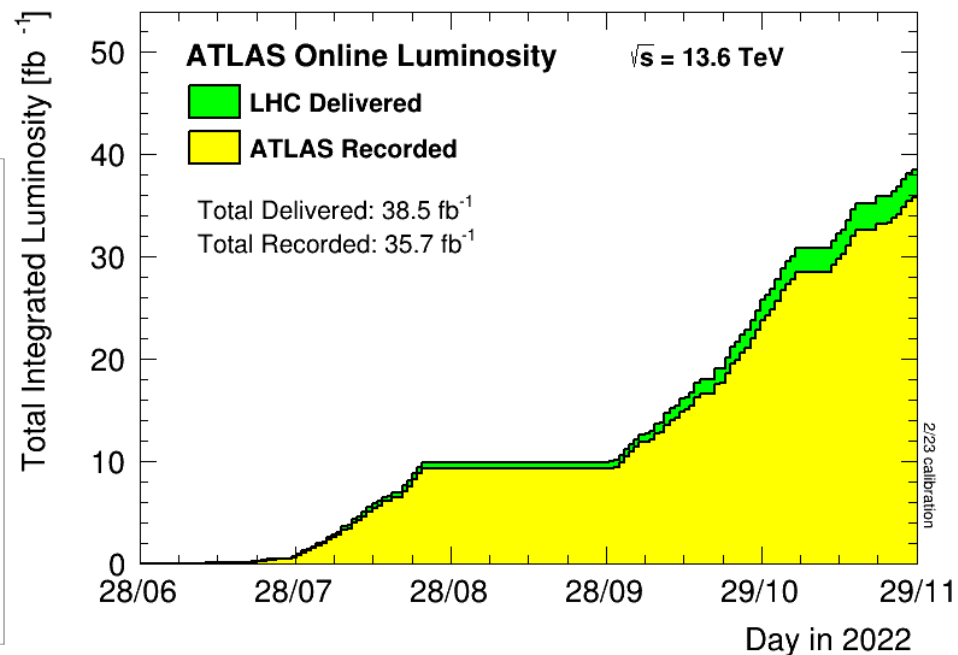
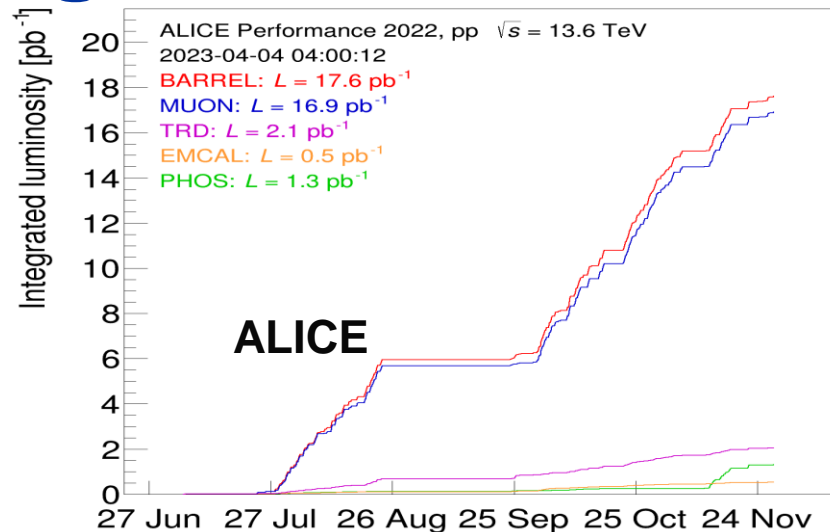
Joachim Mnich

April 24th, 2023

- ❑ 2022 run
- ❑ A few physics results
- ❑ YETS and preparation 2023 run
- ❑ Progress Phase II upgrades
- ❑ WLCG & Computing

2022 Data Taking

- Approx. 40 fb⁻¹ pp delivered to ATLAS & CMS
- Run was shortened by 2 weeks to help mitigating energy crisis
- Only pp, no significant HI run will be compensated in 2023

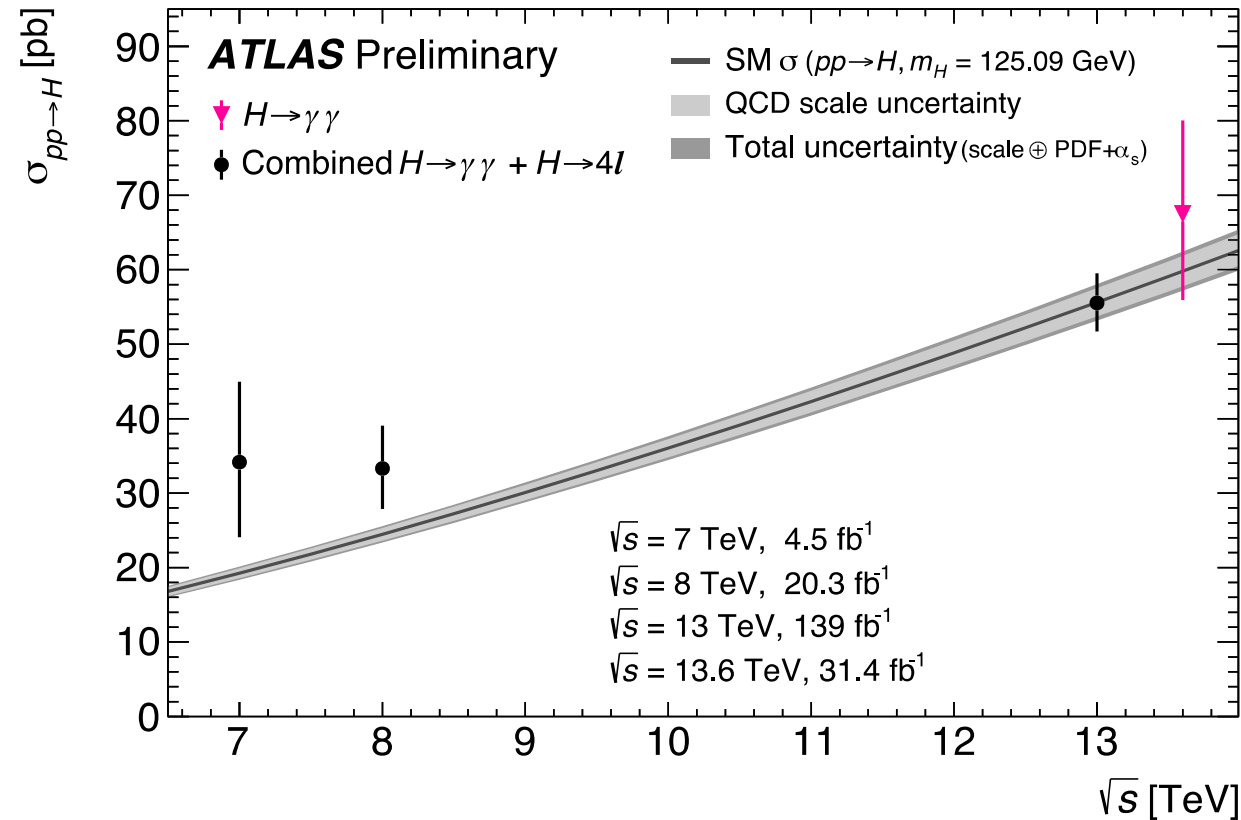
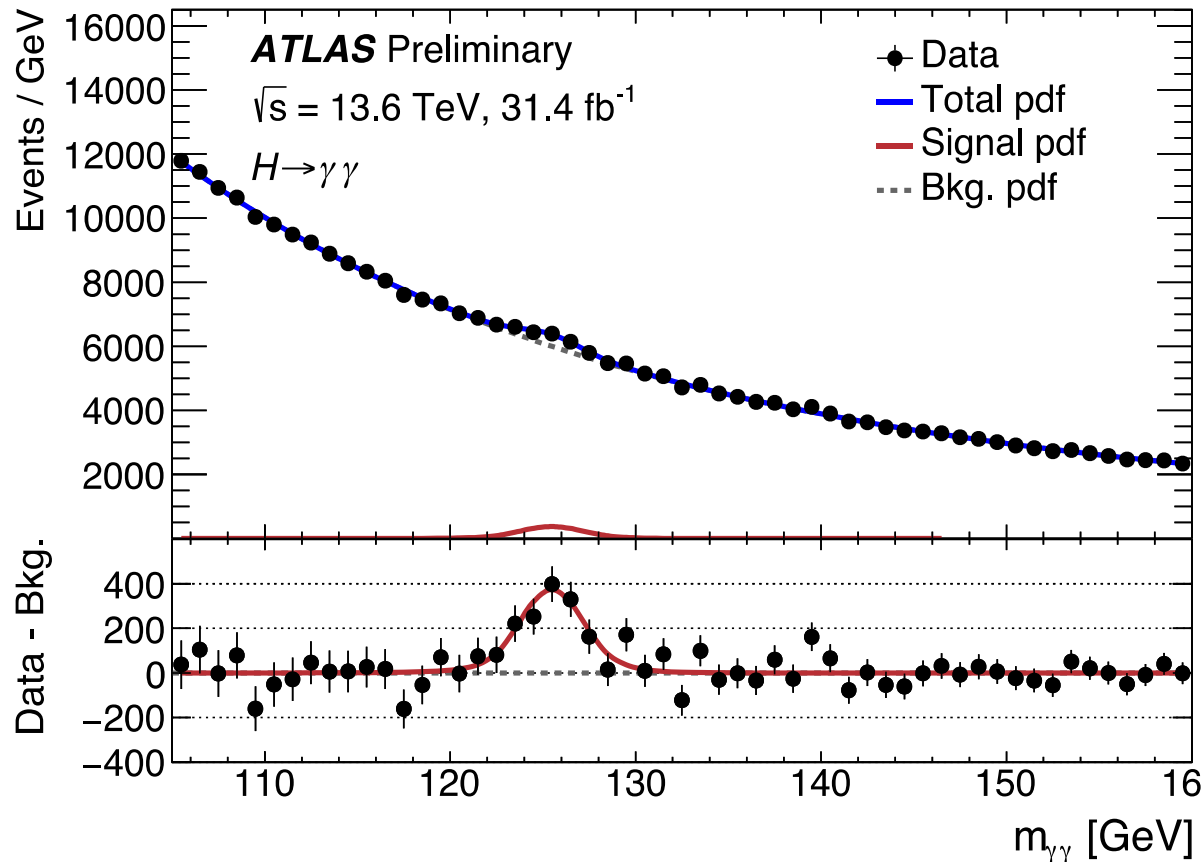


ATLAS: 2022 Higgs Analysis

H → γγ re-observation at 13.6 TeV (2022 data, 31.4 ± 0.7 fb⁻¹)

Measured fiducial cross section: $\sigma_{\text{fid}}(pp \rightarrow H \rightarrow \gamma\gamma) = 76_{-13}^{+14} \text{ fb} = 76 \pm 11(\text{stat})_{-7}^{+9}(\text{syst}) \text{ fb}$ (SM: 67.5 ± 3.4 fb)

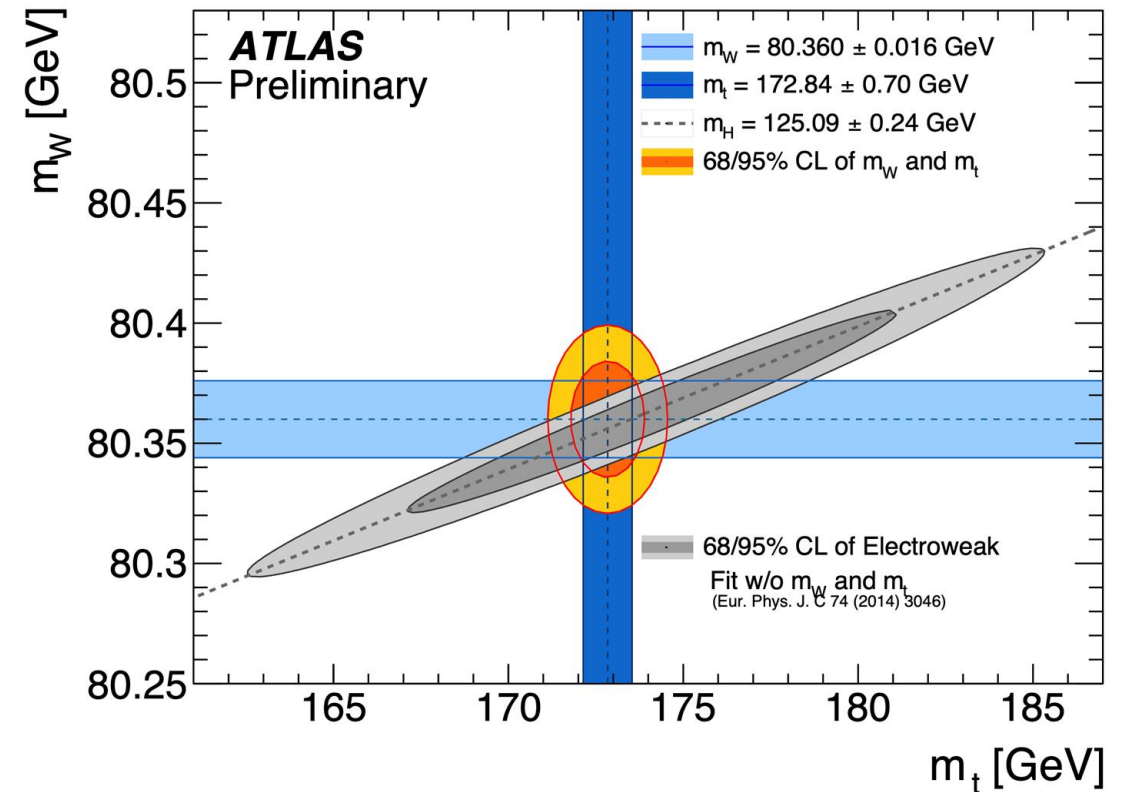
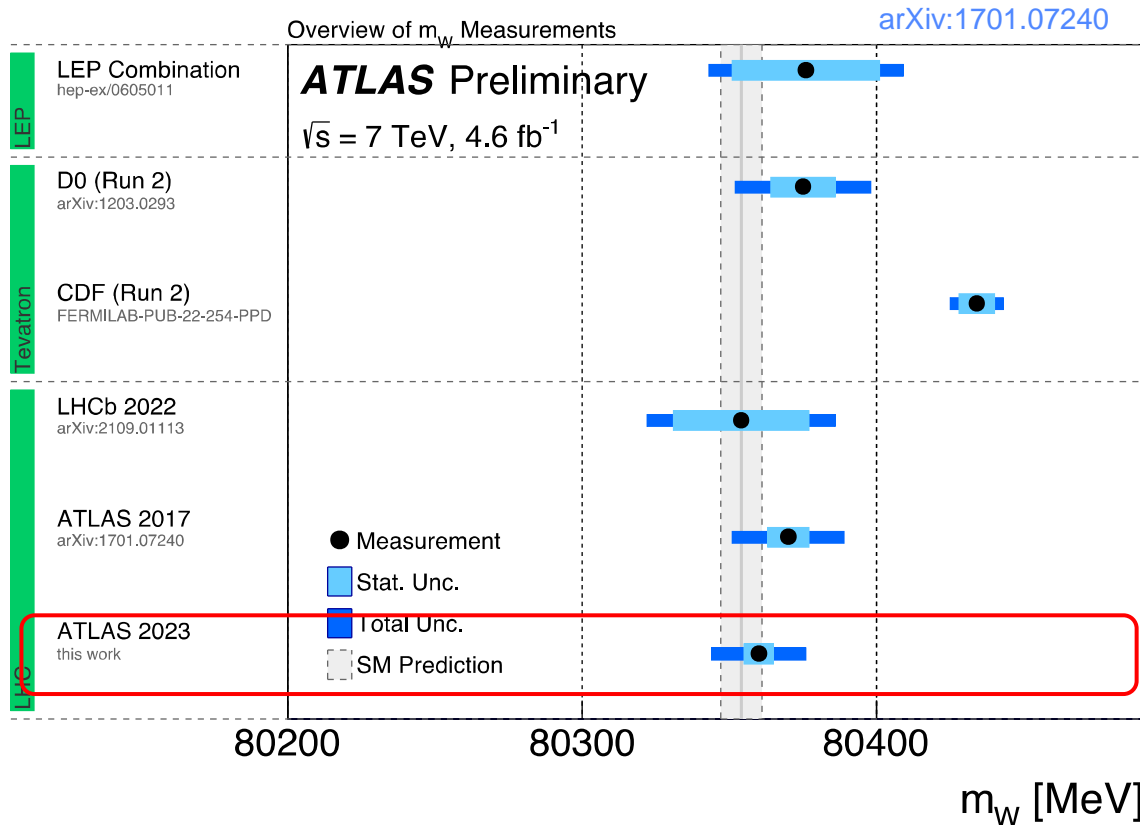
ATLAS-CONF-2023-004



ATLAS: Improved Measurement of the W Mass

Re-analysis of 7 TeV data with improved precision: $m_W = 80360 \pm 16 \text{ MeV}$ (previous ATLAS results: $80370 \pm 19 \text{ MeV}$)

- Based on sample of 5.9 million $W \rightarrow e\nu$ and 7.8 million $W \rightarrow \mu\nu$ events
- More recent PDF, constrained profile likelihood fit, verification of $p_{T,W}$ modelling with dedicated Run 2 low-pileup data
- Agreement with SM



CMS: Measurement of Tau Polarisation

- ❑ Tau polarization determined from the angular distributions of the visible τ decay products in $Z \rightarrow \tau\tau$ (leptonic or hadronic)
- ❑ Average polarization is extracted from a template fit in an invariant mass interval of the $\tau\tau$ pairs of 75-120 GeV
- ❑ Major uncertainties come from reconstruction of the hadronic decay mode of tau leptons

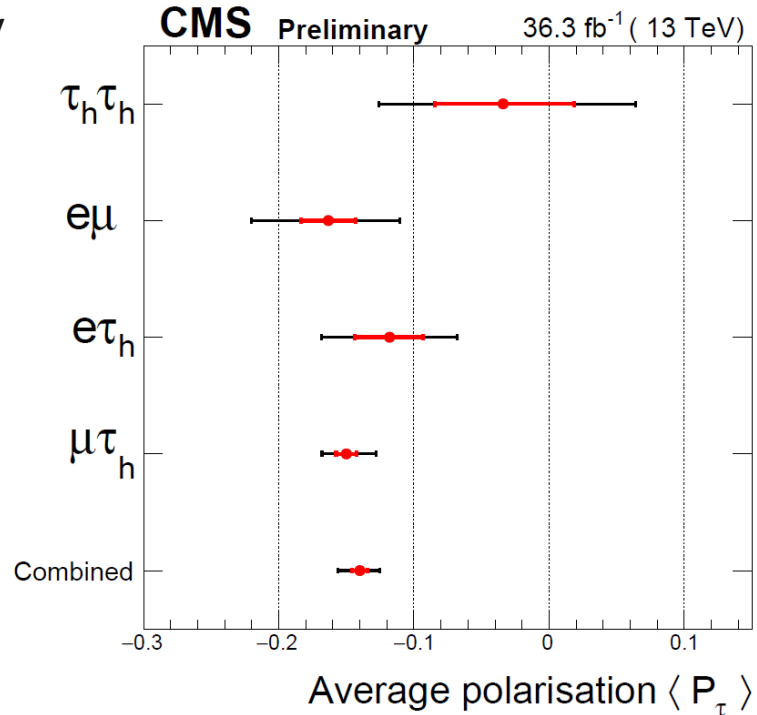
$$P_{\tau}(Z) = -0.144 \pm 0.006(\text{stat}) \pm 0.014(\text{syst})$$

$$(\text{SM } A_1 = 0.1468 \pm 0.0003)$$

And the effective weak mixing angle is measured

$$\sin^2 \theta_w^{\text{eff}} = 0.2319 \pm 0.0008(\text{stat}) \pm 0.0018(\text{syst})$$

<https://cds.cern.ch/record/2848665?ln=en>



CMS (13 TeV)
36.3 fb⁻¹

ATLAS (8 TeV)
arXiv:1709.03490

LEP-SLD
Phys. Rept. D 98
030001 (2018)

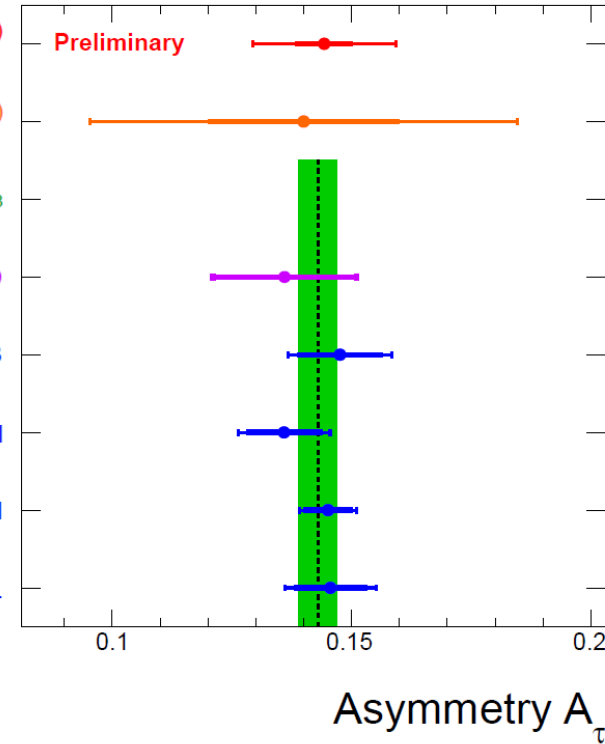
SLD

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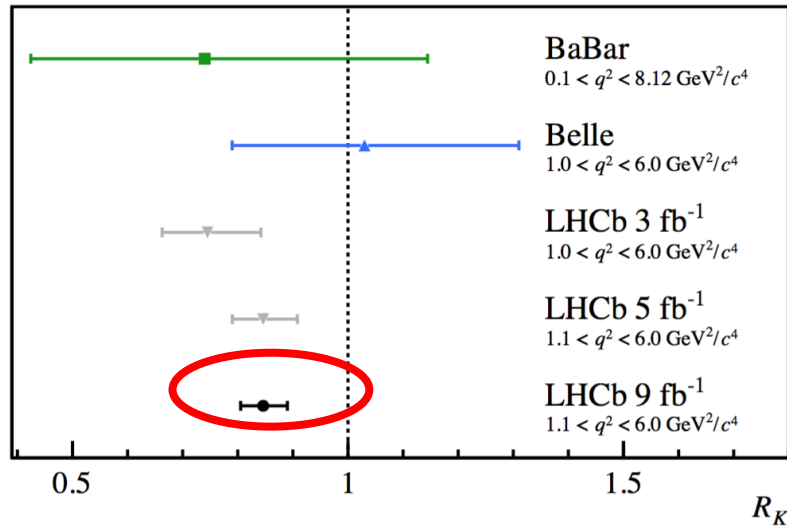
OPAL



LHCb: B Anomalies $R(K)$ & $R(K^*)$

Test of lepton flavour universality ratios in rare $b \rightarrow sll$ processes

- 2021 LHCb paper reported 3.1σ deviation from SM prediction ($R_K = 1$):

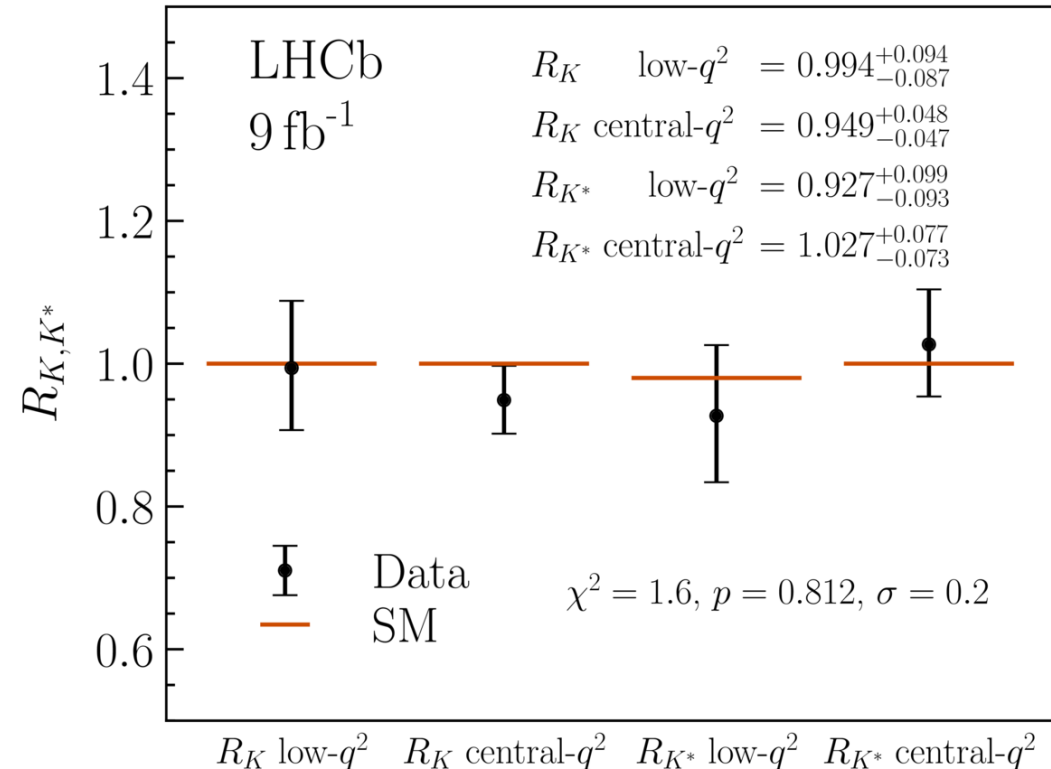


$$R_K = N(B \rightarrow K\mu^+\mu^-)/N(B \rightarrow Ke^+e^-)$$

New analysis:

- New treatment of hadronic misidentified background to electrons

- All results in good agreement with SM

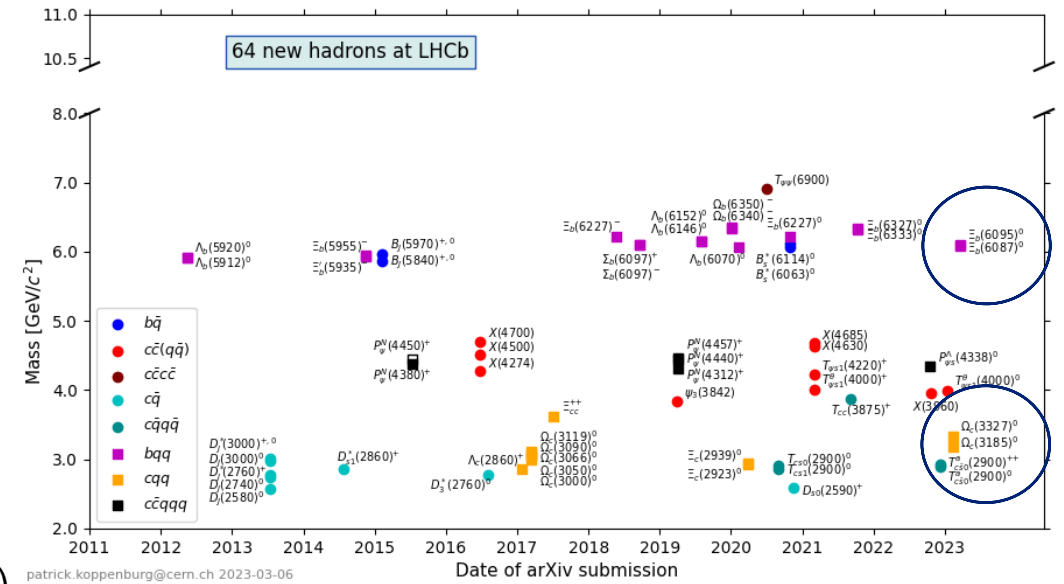
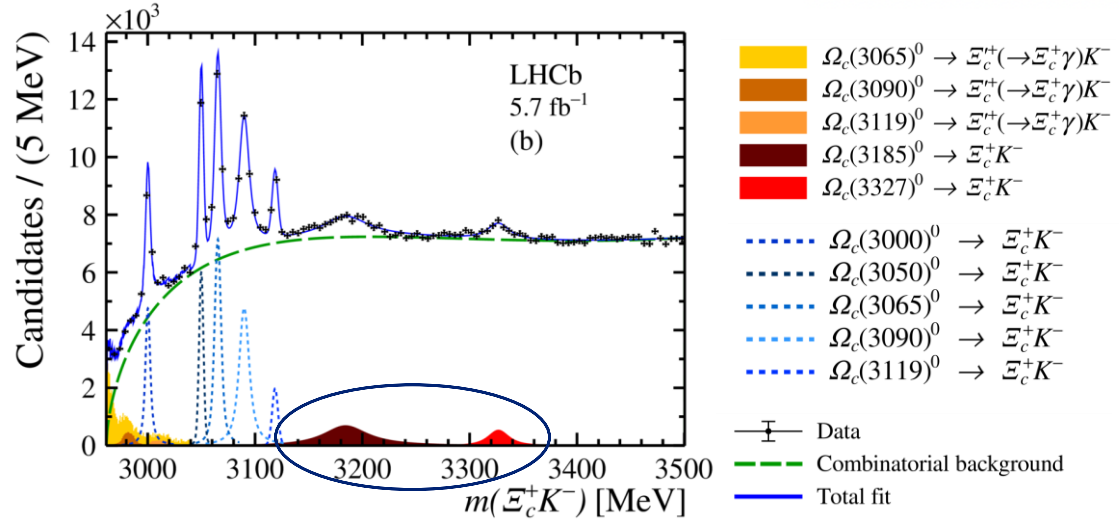


[arXiv:2212.09153](https://arxiv.org/abs/2212.09153)
[arXiv:2212.09152](https://arxiv.org/abs/2212.09152)

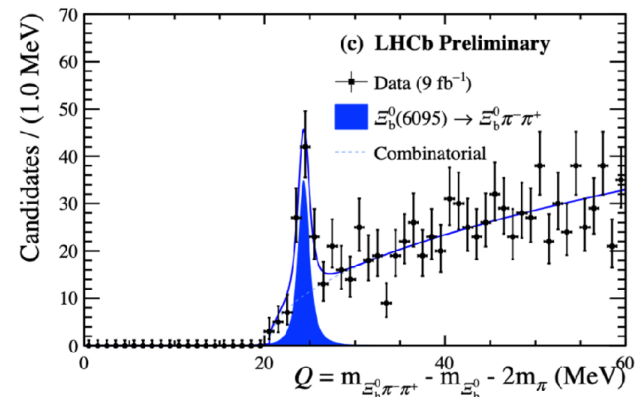
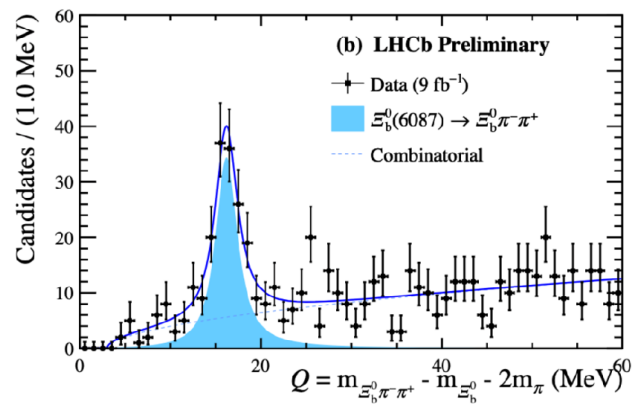
LHCb: New Heavy Baryons Observed



Observation of two new states: $\Omega_c(3185)^0$ and $\Omega_c(3327)^0$



Observation of two new states: $\Xi_b^0(6087)$ and $\Xi_b^0(6095)$



New observations brings total to **64 particles** discovered at LHCb

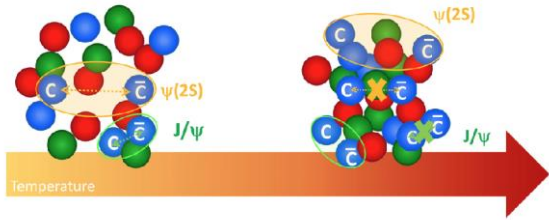




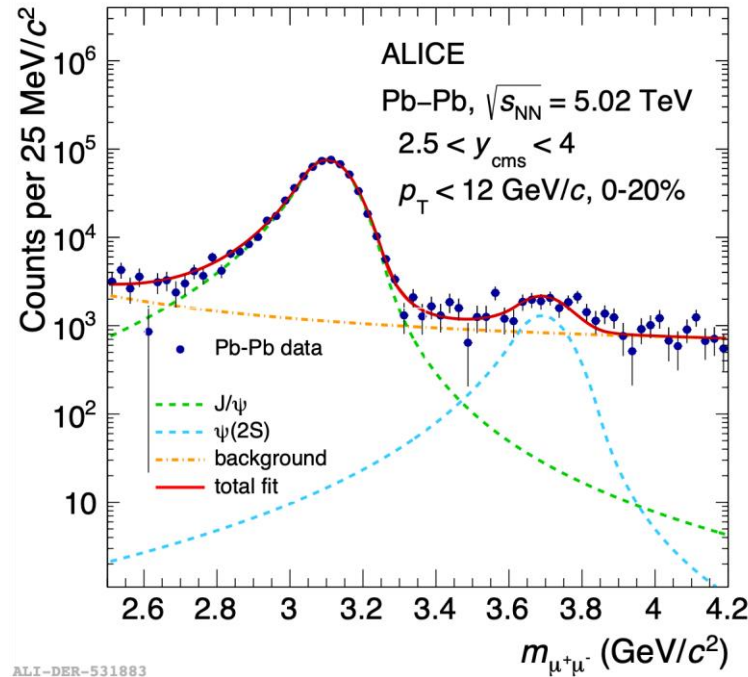
ALICE

ALICE: Melting and Regeneration of Charmonia

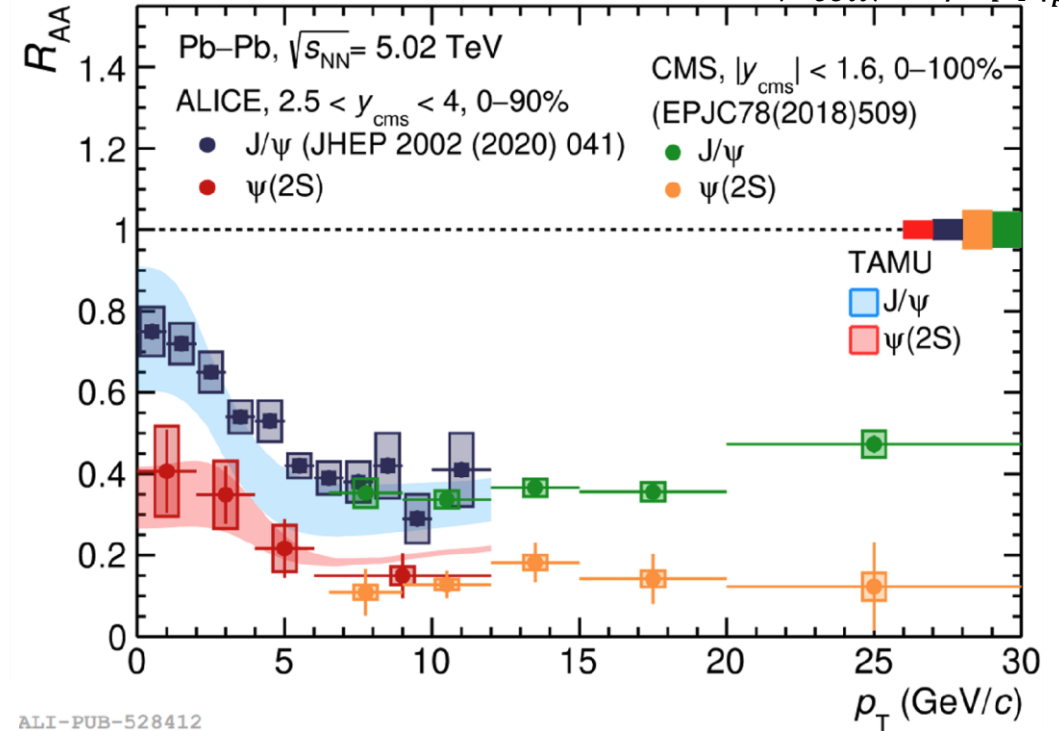
$\psi(2S)$ vs J/ψ



Different $c\bar{c}$ bound states:
 $\psi(2S)$ and J/ψ
different binding energies, sizes



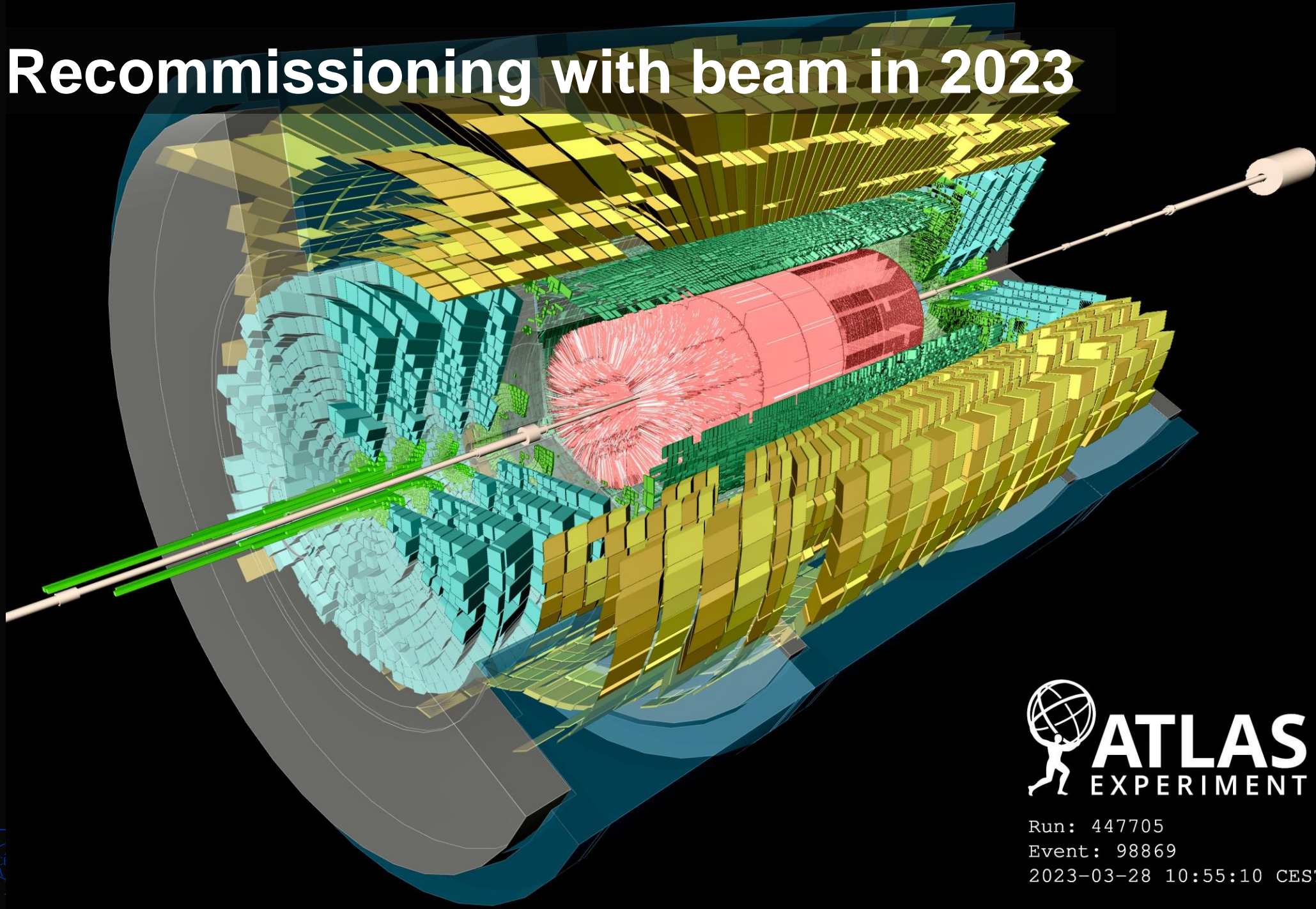
Nuclear modification factor vs p_T $R_{AA} = \frac{dN/dp_T|_{AA}}{\langle N_{coll} \rangle dN/dp_T|_{pp}}$



[arXiv:2210.08893](https://arxiv.org/abs/2210.08893)

- ❑ High p_T : stronger suppression of $\psi(2S)$ — lower melting temperature
- ❑ Low p_T : R_{AA} increases — regeneration similar to J/ψ

Recommissioning with beam in 2023



Run: 447705
Event: 98869
2023-03-28 10:55:10 CEST

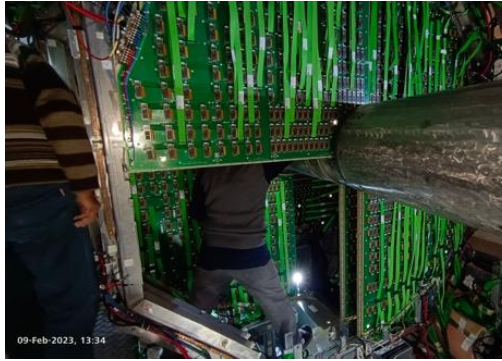
ALICE YETS and 2023 Startup



ALICE

Year-end technical stop (YETS) activities:

- ❑ Several routine maintenance items
- ❑ Cleaning of a few muon chambers
- ❑ Work on TOF cooling (unclogging)



Replacement MCH ST2 quadrant



Replacement MID RPCs



Maintenance on the 66kV transformer (EN-EL)

Smooth restart of operations for 2023

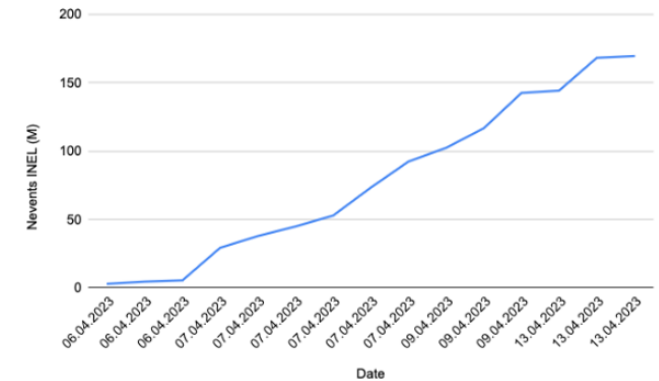
- ❑ Commissioning shifts started March 6th
- ❑ First 900 GeV collisions on April 6th

Goals for 2023:

- ❑ 30 pb⁻¹ pp at full energy
- ❑ 3.25 nb⁻¹ of Pb-Pb collisions
- ❑ 3 pb⁻¹ pp collisions at Pb-Pb energy (reference run)



Easter morning: stable beam at injection energy



First runs at injection energy: 170M events recorded

ALICE is ready for data taking!

CMS YETS Activities

The YETS was successful

- ☐ CMS is closed

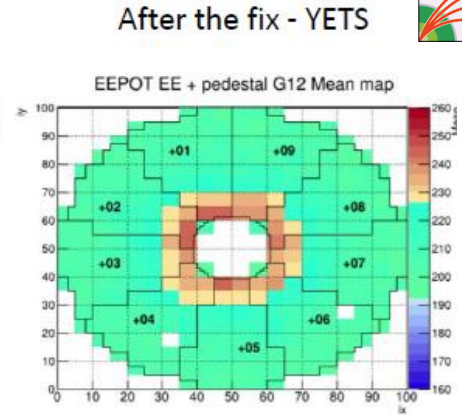
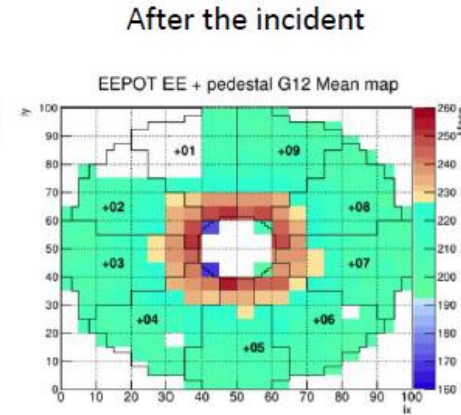
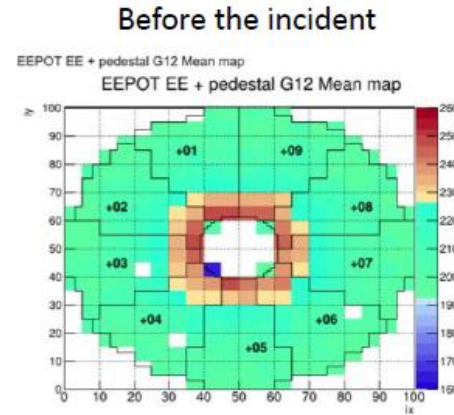
ECAL water leak repaired

- ☐ Flexible pipe replaced
- ☐ Further analysis on the damaged pipe did not reveal any issue

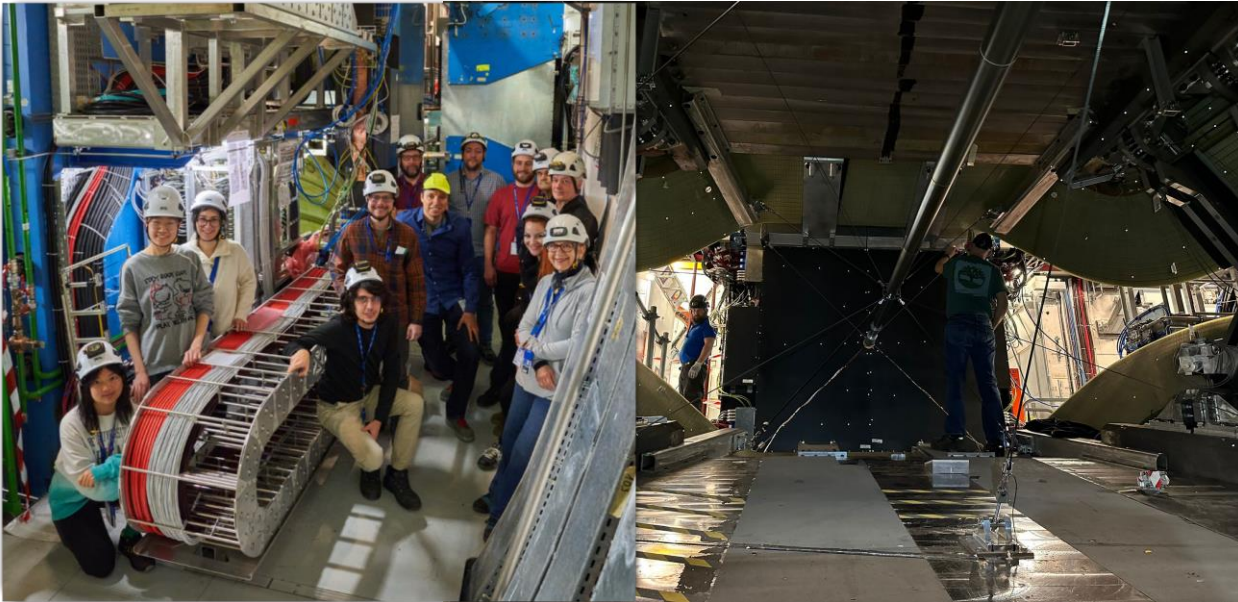
HCAL completed replacement of faulty frontend components

- ☐ Significant update in automatization of detector calibration
- ☐ Further improvements on the detector timing

CMS ready for 2023 data taking



LHCb Commissioning & Upstream Tracker Installation

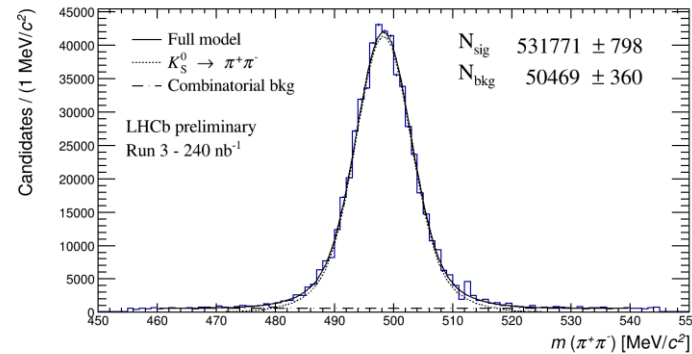


Silicon strip tracker successfully installed on tight schedule during shutdown

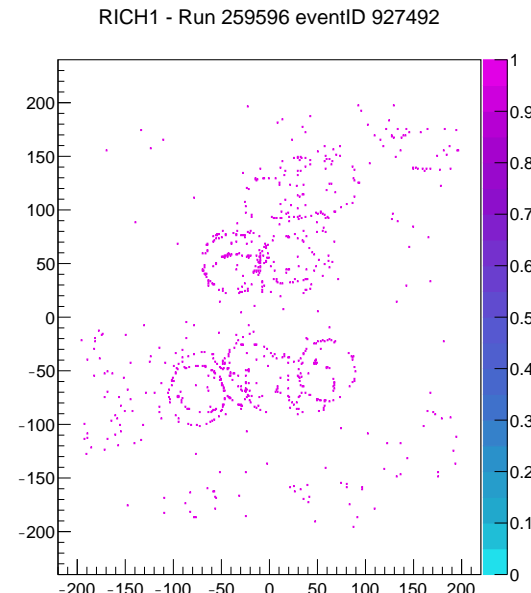
- ❑ Final system of the Upgrade I for Run 3 & 4
- ❑ Upgrade I completed inside original budget

LHCb Upgrade implements innovative fully software trigger, with first level reconstruction in GPUs

- ❑ Additional GPUs installed following successful proof in 2022 run
- ❑ Good start made to detector commissioning in 2023



K_S^0 reconstructed in real-time GPU based trigger in 2022



RICH1 rings in first fill of 2023

VELO Vacuum Volume Incident

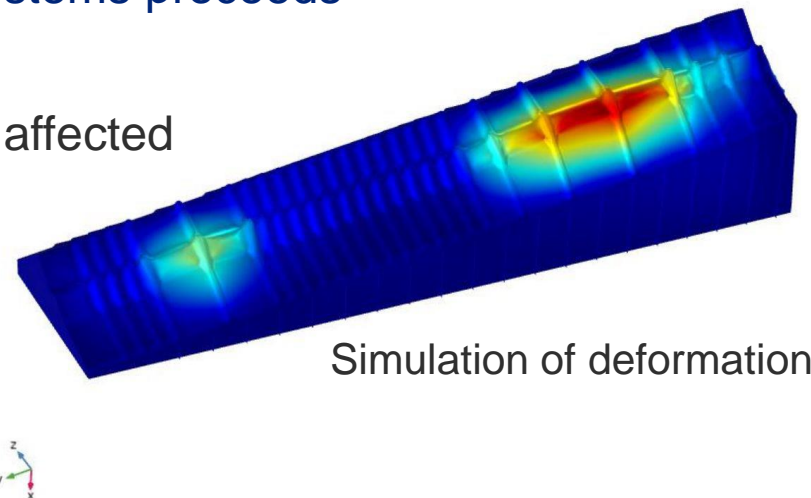
On January 10th, 2023 an incident occurred due to a failure of the vacuum system of the VELO

- ❑ Detector modules & cooling are not damaged
- ❑ The system has been returned to a safe situation

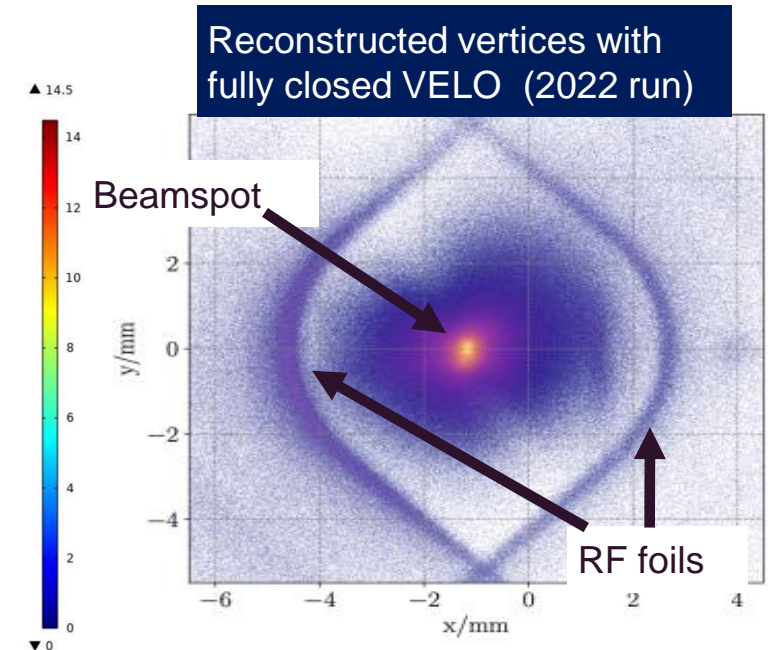
RF foil has undergone plastic deformation

- ❑ Replace in the shutdown at the end of 2023
schedule: 13 weeks + contingency 3 weeks
- ❑ Commissioning of Upgrade I systems proceeds

LHCb physics programme in 2023 affected
as VELO cannot be fully closed
but opportunities remain



RF Foil: 150-250 μm thick, separates primary and secondary vacuum volumes



Phase II Progress

Production of large structures has started

Example:

ATLAS ITk Strip Barrel Layer 3 shell

- ❑ Carbon fibre structure, 2.8 m long
- ❑ Produced by a company in California under supervision of Berkeley
- ❑ Now at Oxford: installation of locking points to mount the staves of layer 3



Status ATLAS ITk Pixel

Contingency is reduced to few months, driving the tracker readiness

Several areas close to the CP or critical:

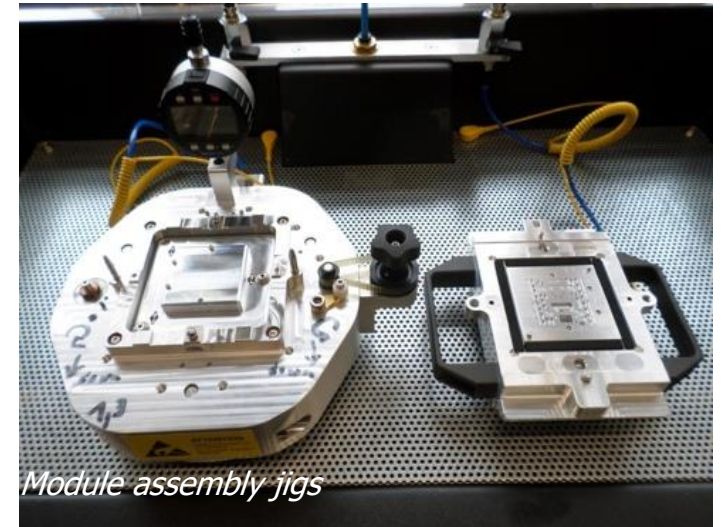
- ❑ FE ASIC: SEU vulnerability prevented the submission in November, unusable also for CMS
- ❑ Few non-conformities remain but considered manageable in operation

Submitted in March!

- ❑ Module preproduction is now starting with site qualification

Excellent progress in other areas:

- ❑ Sensor production started
- ❑ Hybridization contracts signed and preproduction started. More than 200 modules already in hand
- ❑ Data transmission: first full chain tests completed



Status CMS HGCAL

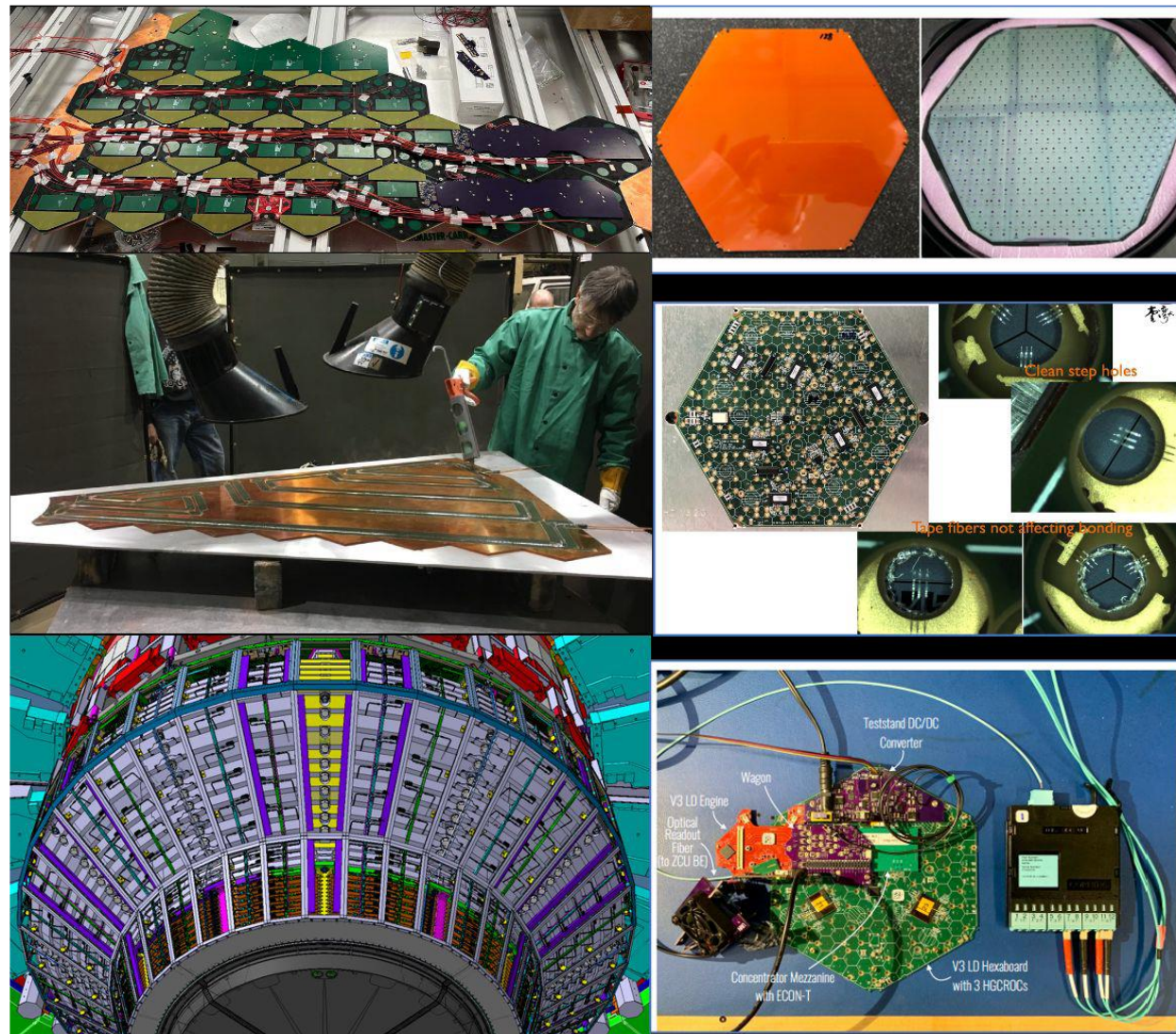
High Granularity Calorimeter (HGCAL):

- ❑ Production silicon sensors arriving
- ❑ ASICs: HGCAL ECON-D (on critical path) – **submitted**

❑ Latest prototype modules perform well

Mechanics are going very well:

- ❑ Engineering Design Review (EDR) in February
- ❑ Pre-production steel plates arrived in Pakistan



Phase II Schedule

Despite good progress areas of concern remain:

Projects with insufficient contingency:

- ❑ ATLAS Pixel and Strip Tracker
- ❑ CMS Tracker and HGICAL

Deliverables from institutes in Russia (and Belarus)

- ❑ Redistribute contributions in the collaborations
- ❑ CMS HGICAL most exposed project

To regain contingency on the most critical projects during production phase workshops with external experts will be organised



**Fraunhofer Institute for
Manufacturing Engineering
and Automation**

**Factory Planning and
Production Optimization
Stuttgart, Germany**

CMS: 26. – 28. June 2023

ATLAS: in Q3 of 2023

WLCG Run-3 Processing

Reduction of processing activities at WLCG sites in the last few months of 2022

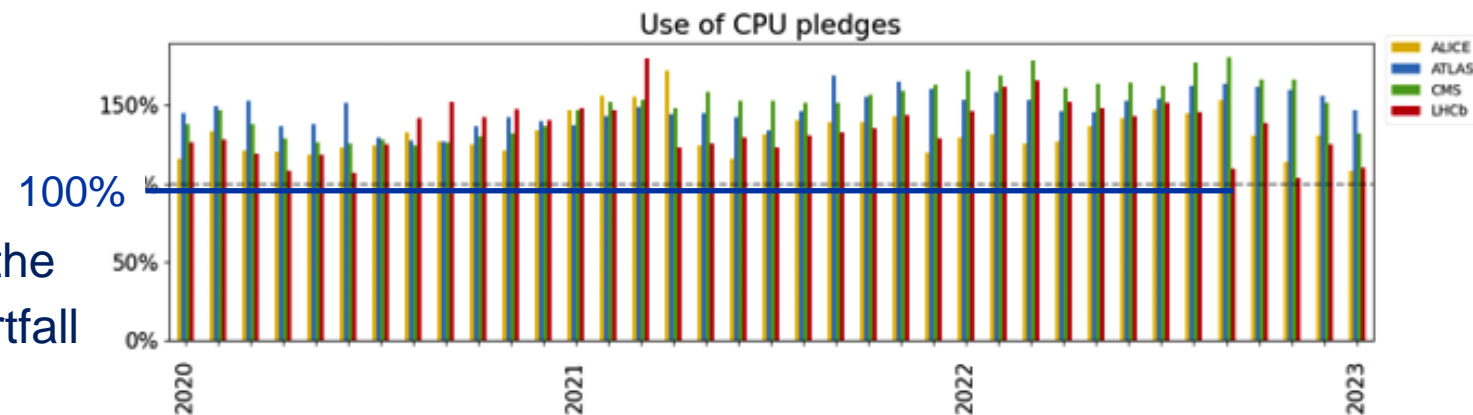
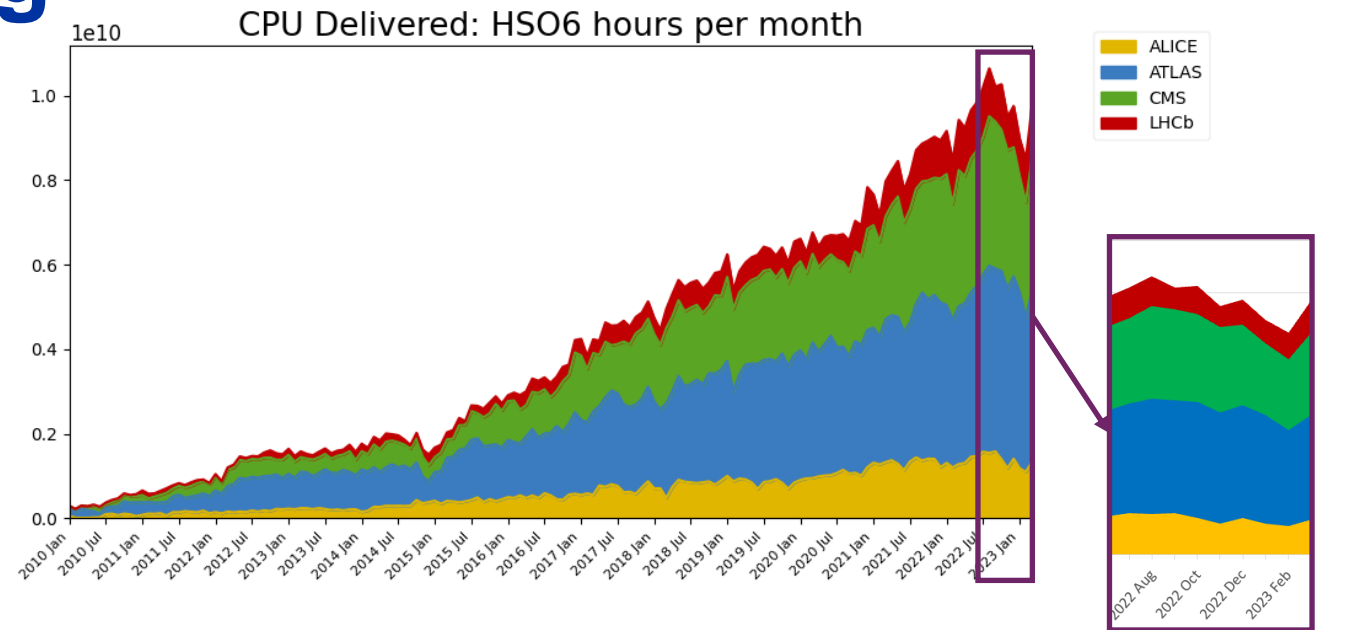
- ❑ Partially due to the external factors, e.g. to save energy
- ❑ Partially to a lower experiments' activity

All experiments still benefit from more resources than pledged at WLCG sites

- ❑ From HPCs, HLTs

WLCG is ready for the 2023 run

- ❑ Many thanks to the **Funding Agencies** for the excellent support, also to mitigate the shortfall of resources from Russia



Reducing IT's Energy Footprint: 3 lines of action

The Hardware

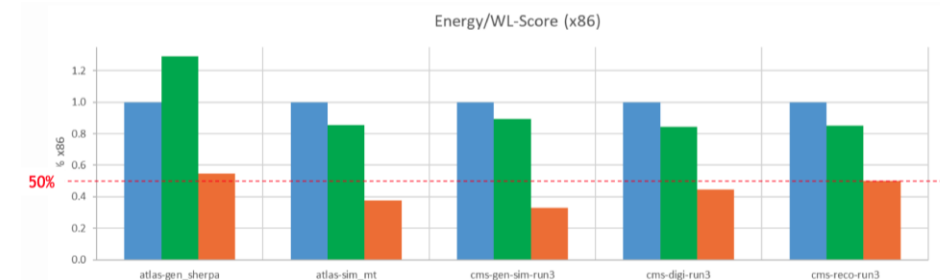
- ❑ Procuring power efficient hardware
- ❑ Extending hardware lifetime
- ❑ CPU virtualisation, Disk Server densification, Tape evolution

The Software

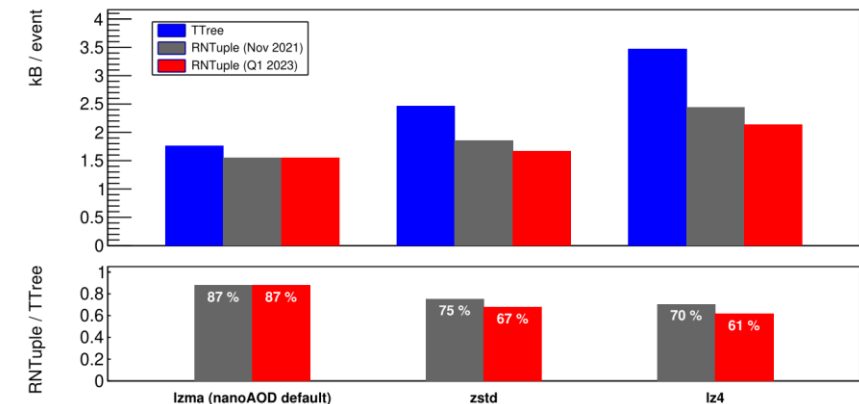
- ❑ Improving software efficiency; focused C++ training courses
- ❑ Innovating computing models
- ❑ Using accelerators to improve efficiency of Generation & Simulation

The Data Centre

- ❑ New data centre with efficient cooling and heat recovery
- ❑ An optimized hardware life-cycle



ATLAS and CMS workloads: on ARM cf x86



ROOT foundation layer: less CPU, less disk hungry

Prévessin Data Centre

to end October

- ❑ 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



Exterior Finishings (Thu 20th April)

Summary

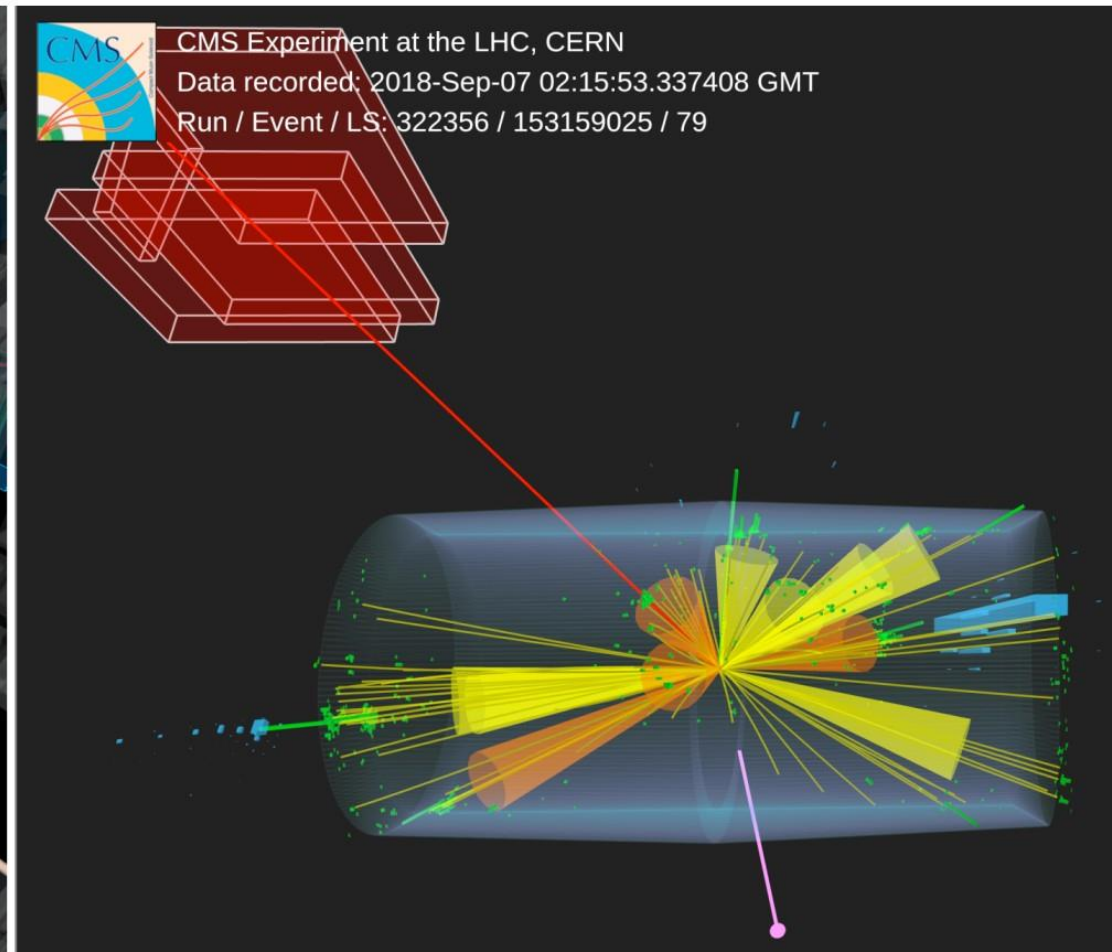
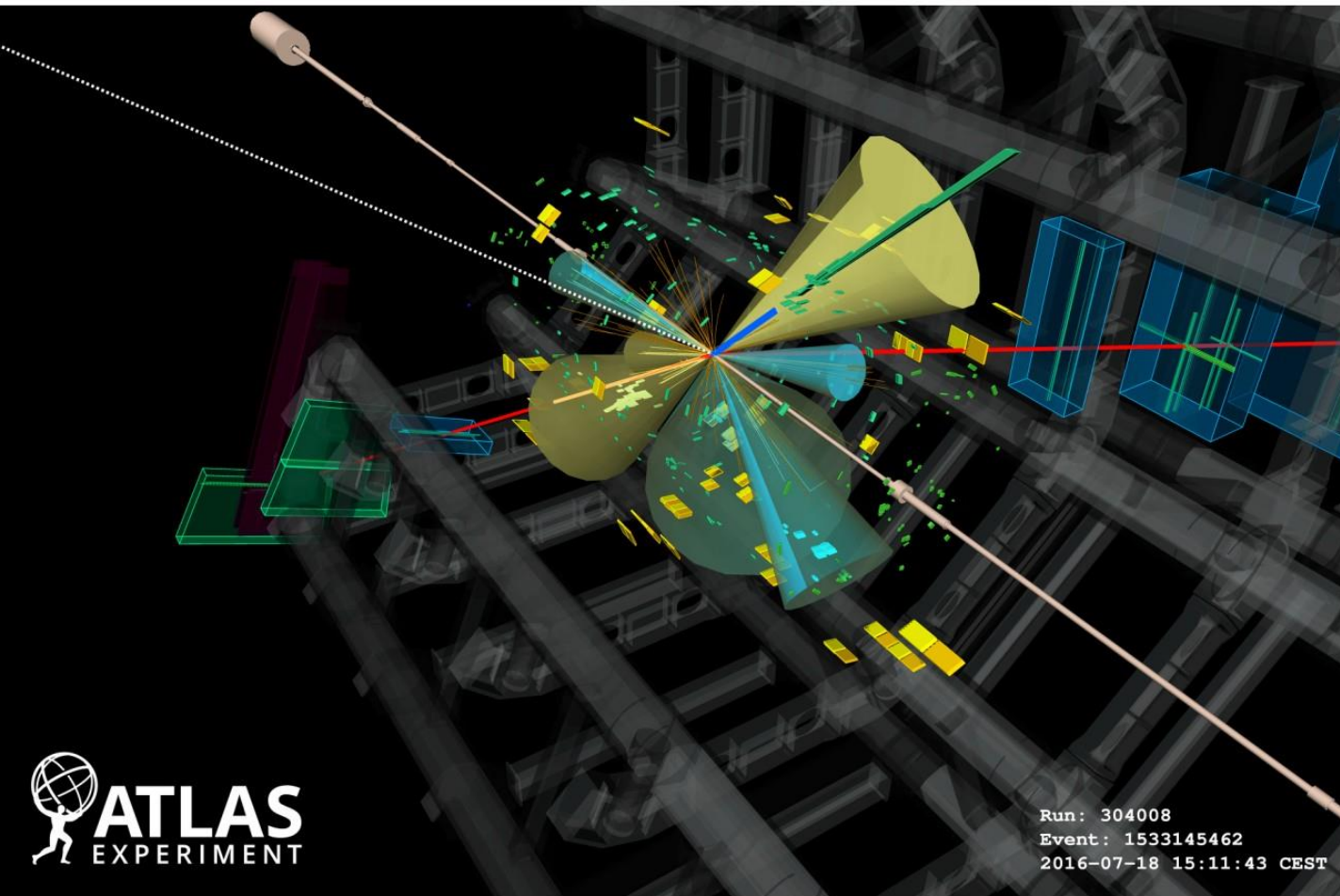
- ❑ Experiments are ready for 2023 run
 - ❑ only major issue is the VELO
- ❑ Experiments continue to produce excellent physics results
- ❑ Agreement on author/institution list found and being applied
- ❑ Good progress in Phase II upgrades
 - ❑ but challenges remain on the schedule and due to worldwide economic and political situation
- ❑ WLCG is ready for 2023 run
 - ❑ progress in addressing HL-LHC and energy challenges

Big thank you to

- ❑ All people who contributed to the successful start of 2023 Run
- ❑ All Funding Agencies for their continuous support

Simultaneous Production of Four Top Quarks

ATLAS and CMS presented the observation $pp \rightarrow 4 \text{ top} + X$ at the winter conferences

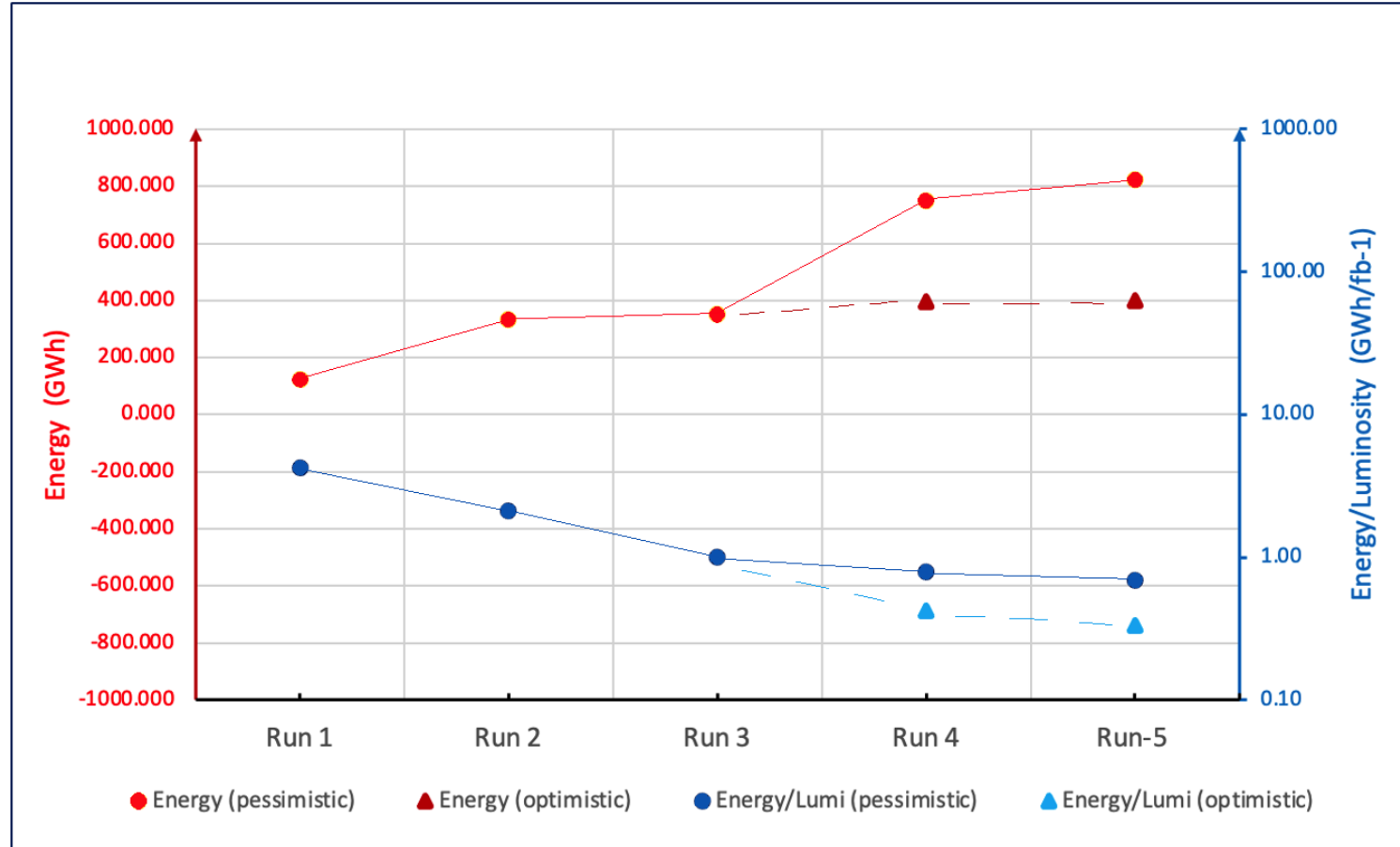


Backup

WLCG: Energy Efficiency

RED scale shows the **energy** needed to analyse the data of each run

- i.e. consumption of all WLCG sites (T0+T1+T2) in a Run plus the following LS
- pledged CPU only



BLUE scale shows the **energy per unit of luminosity** recorded needed to analyse the data in each run (nb log scale)

Based on the ATLAS and CMS resource projections made in 2022. More details [here](#)
 Pessimistic scenario: Run-4/5 +100% compared to Run-2
 Optimistic scenario: Run-4/5 +10% compared to Run-2