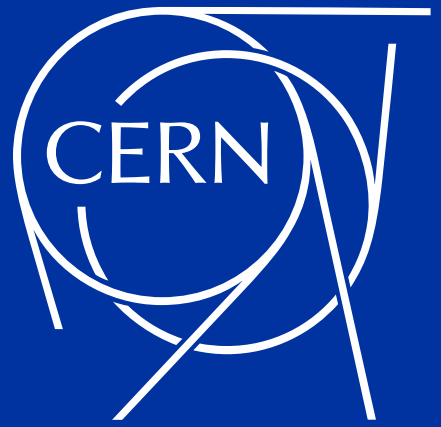


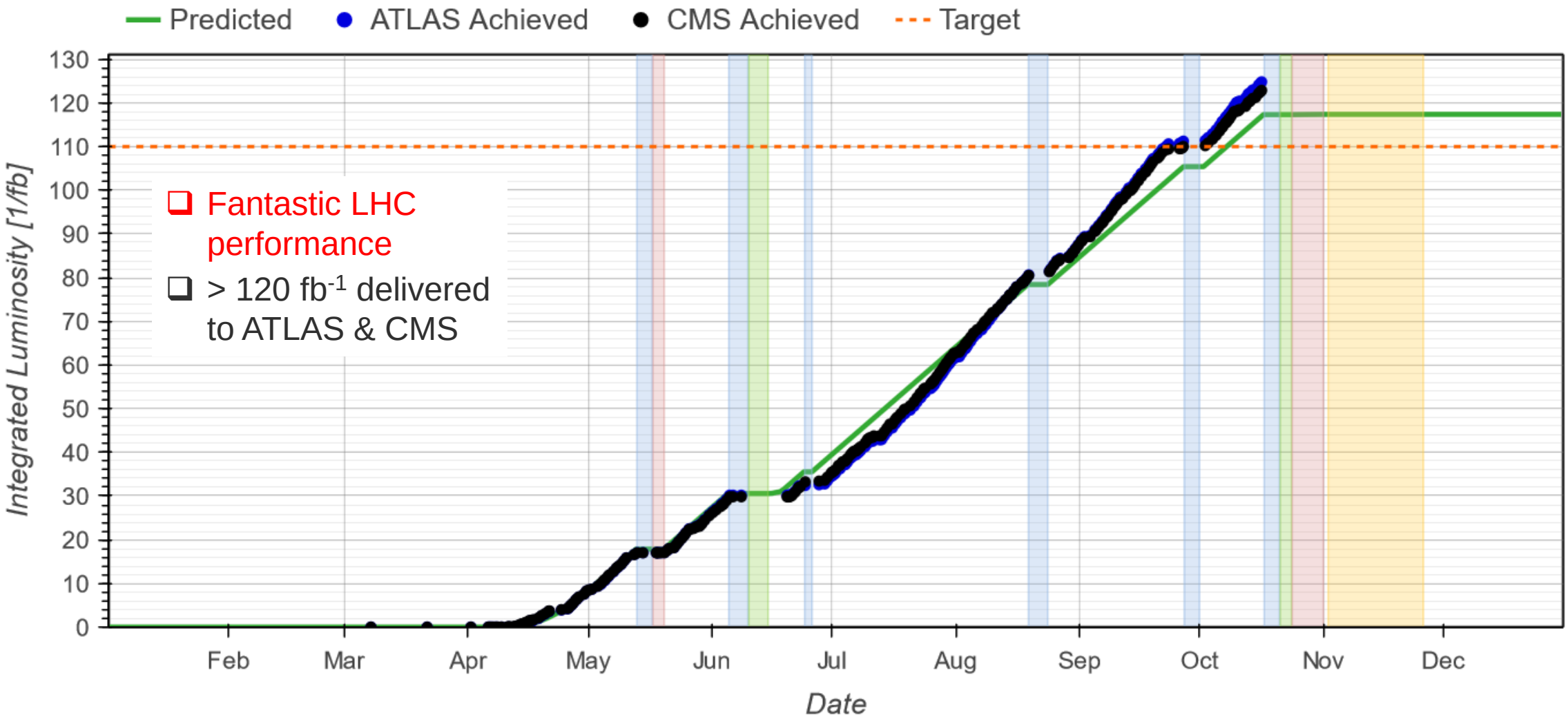
Status of the Experiments

Plenary RRB 59th Meeting

Joachim Mnich

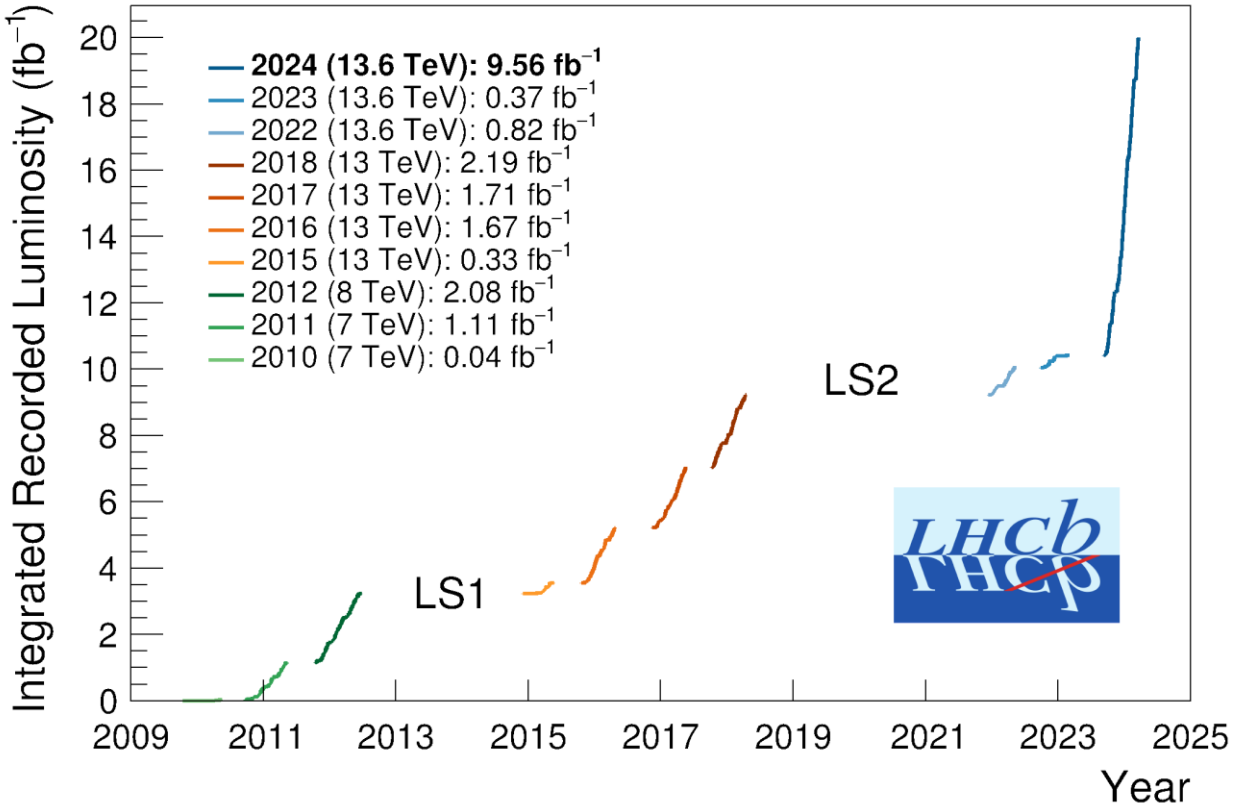
October 28th, 2024

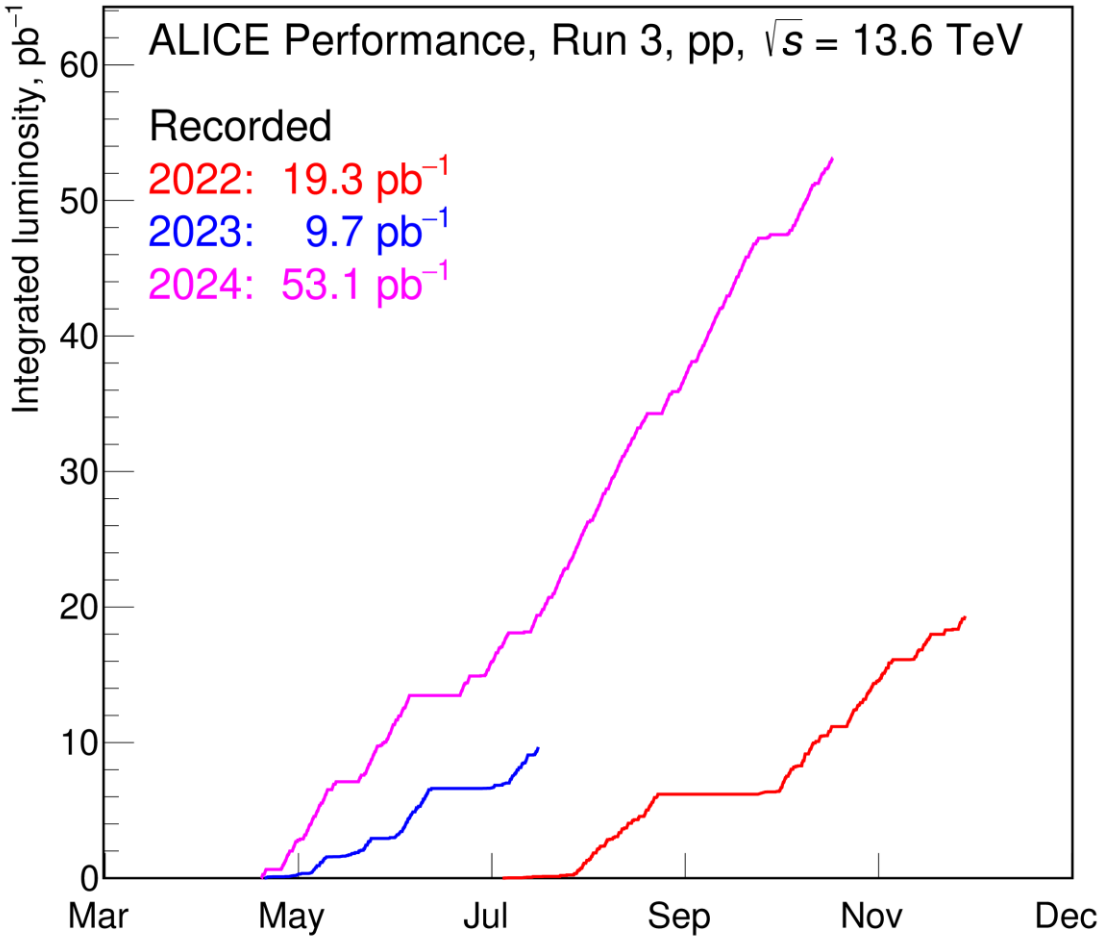
2024 LHC Run


Predicted
ATLAS Achieved
CMS Achieved
Target
Integrated Luminosity [1/fb]
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
❑ Fantastic LHC performance
❑ > 120 fb-1 delivered to ATLAS & CMS
[Generated at: 2024-10-21 09:25:59]

2024 LHC 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





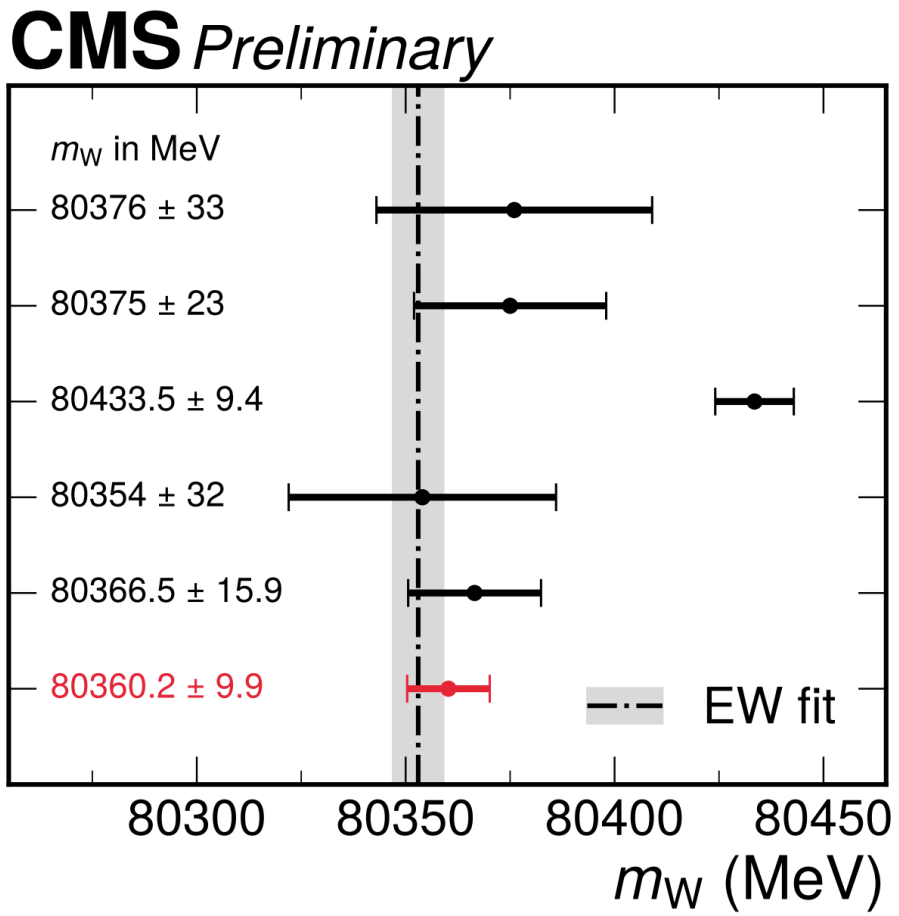
CMS: Measurement of the W Mass

- 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



ATLAS: Search for Magnetic Monopoles

- Maxwell's equations governing electro-magnetism

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$ electric charge

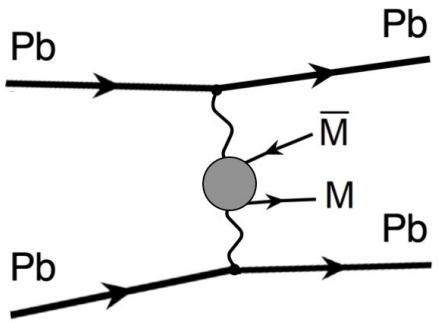
$$\nabla \cdot \mathbf{B} = 0$$ but no magnetic „monopoles"!

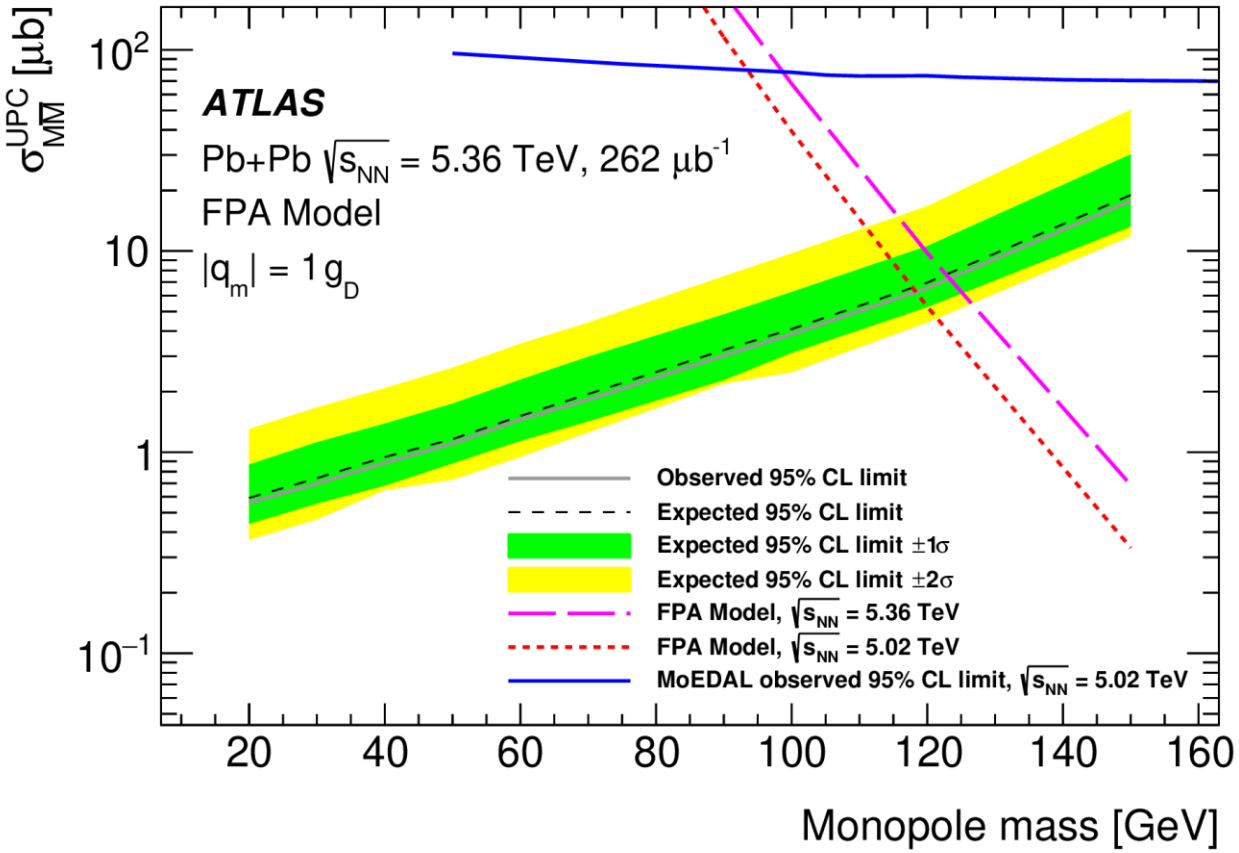
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

- No fundamental reason why there are no single magnetic charges (monopoles)

- ATLAS searched for magnetic monopoles in ultra-peripheral lead-lead collisions:





- Excluding magnetic monopoles with mass < 120 GeV
- Improves on previous cross section limits set by MoEDAL

LHCb: Determination of the CKM Angle γ

- New measurement of the angle γ of the unitarity triangle
- Using new and improved methods, more channels

$B^0 \to DK^{*0}, D \to h^+h'^+(\pi^+\pi^-)$ with 3 simultaneous D final states

$B^0 \to DK^{*0}, D \to K^0_S h^+h^+$, binned D decay Dalitz plane analysis.

$B^\pm \to DK^{*\pm}$, 4 simultaneous D decays, and first time $D \to K^0_S h^+h^+$ decay.

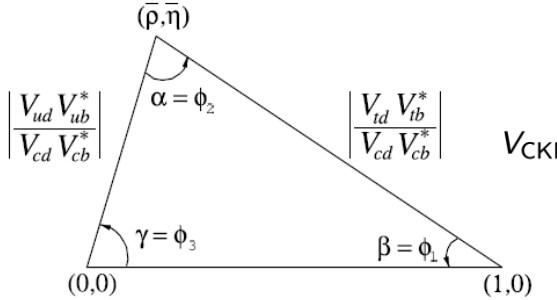
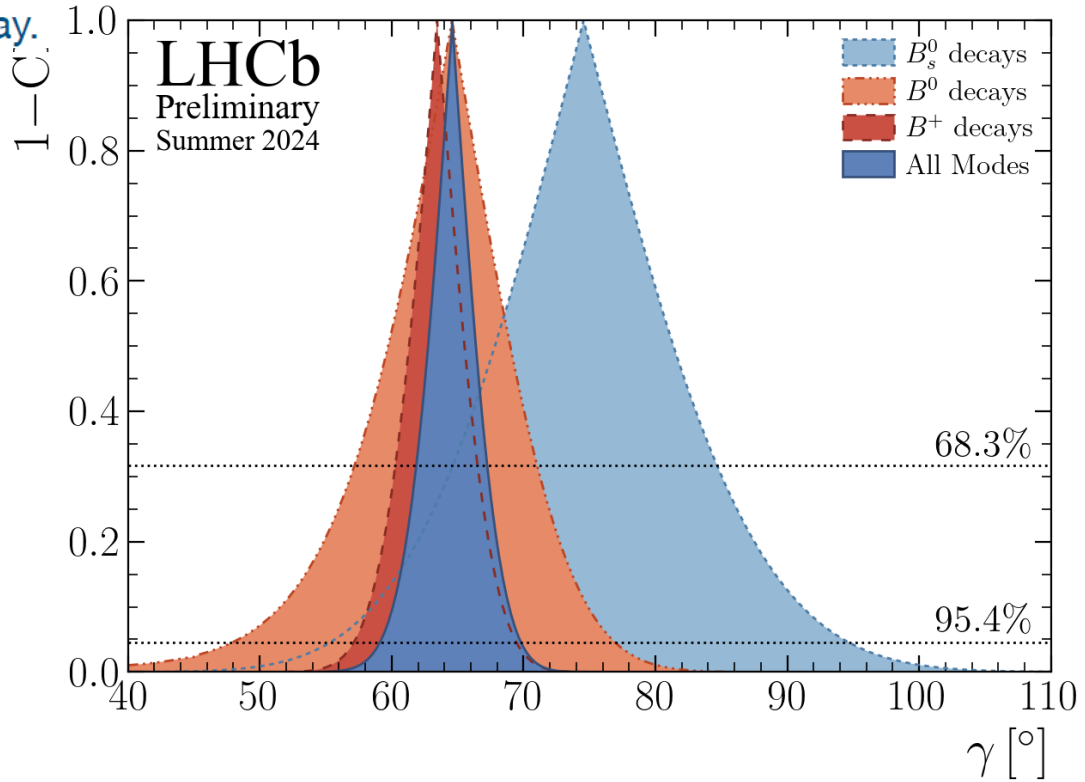


Figure 12.1: Sketch of the unitarity triangle.

$$V_{CKM} \sim \begin{pmatrix} |V_{ud}| & |V_{us}| & |V_{ub}|e^{-i\gamma} \\ -|V_{cd}| & |V_{cs}| & |V_{cb}| \\ |V_{td}|e^{-i\beta} & -|V_{ts}|e^{i\beta_s} & |V_{tb}| \end{pmatrix}$$

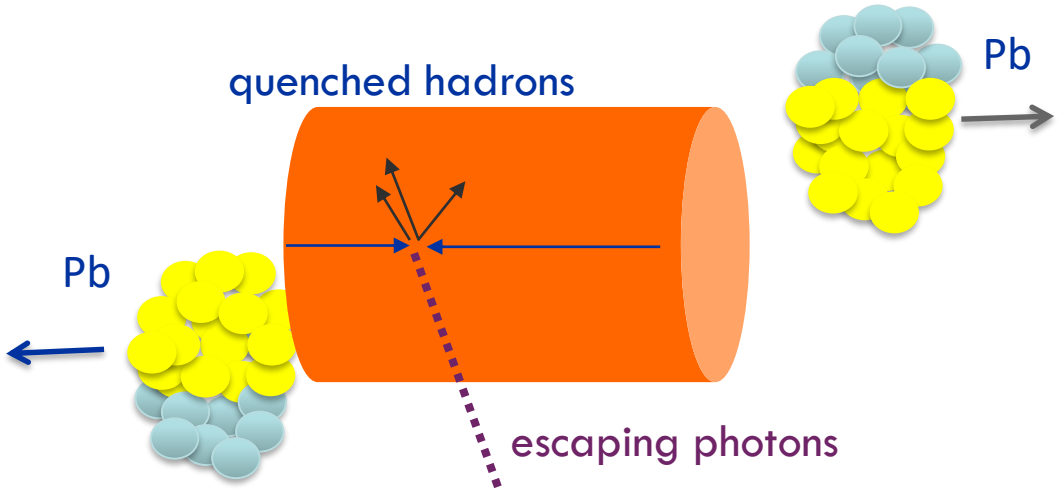
$$\gamma = (64.6 \pm 2.8)^o$$

Decreased uncertainty by 0.7^o since 2022



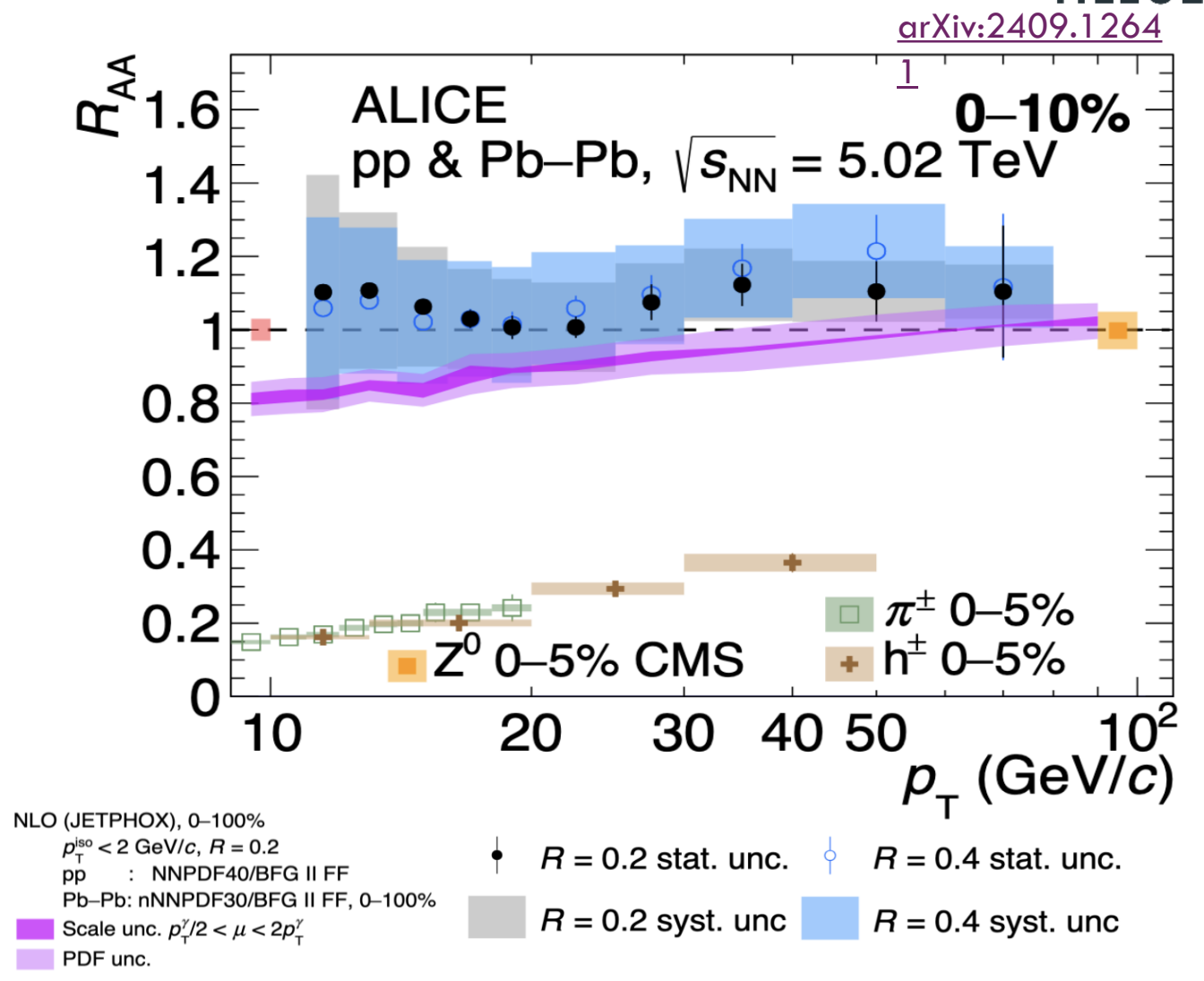
- This measurement is statistically limited
- Improvements expected from Run 3 data

ALICE: Isolated photon production in Pb-Pb collisions



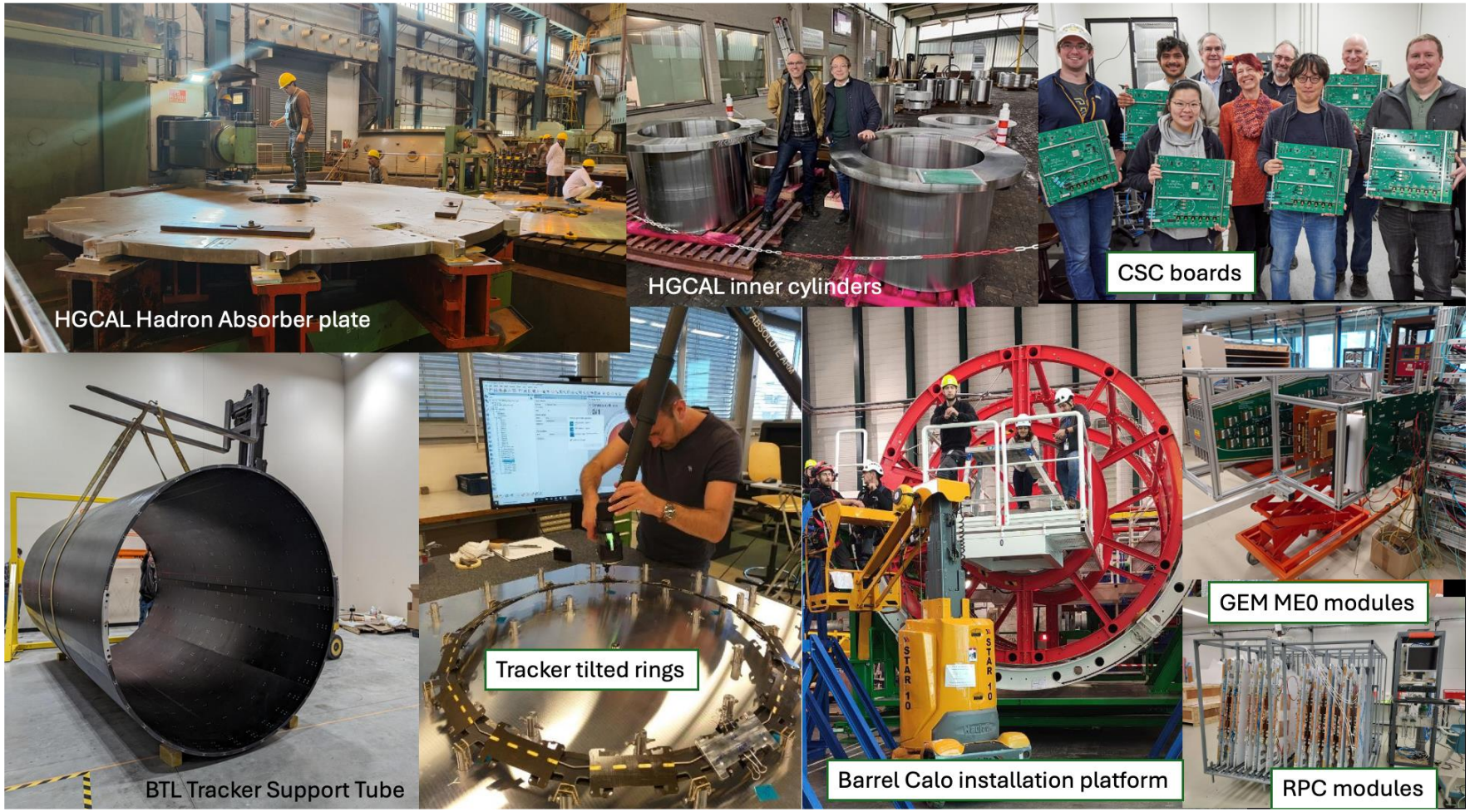
- Select photons without any other particle in a surrounding cone (R) to suppress decay and fragmentation photons
- Divide by the production in pp collisions scaled by the number of binary nucleon-nucleon collisions (RAA)

➔ Color insensitive probes do not show any nuclear modification (RAA ~ 1) in contrast to coloured probes (hadrons)



Status of HL-LHC and Phase II Projects

A lot of progress in CMS…



Status of HL-LHC and Phase II Projects

And a lot of progress in ATLAS…

Status of HL-LHC and Phase II Projects

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

See also special online RRB on July 15th

P2UG/LHCC/SPC: schedule is not tenable

Example: From the P2UG/CMS chair M. Demarteau:

- There has been a persistent 50% slip for key elements of the project, though the delay is leveling off for some subprojects.
- Based on the information presented and the evolution of the project over the years, the P2UG believes the projects will not be able to deliver the project on the current proposed timeline

Further comments from the P2UG report:

- Delivery of the HL-LHC has to be a resounding success and should be viewed as the highest priority of the whole community. Any distraction, in whatever form, may seriously affect particle physics
- Success breeds success and future projects will depend on the successful completion of the HL-LHC with the experiments meeting their physics goals
- The whole community needs to come together, collaborating institutions, funding agencies, host lab, etc. to deliver this for a healthy future of the field

Key Dates of New HL-LHC Schedule

As decided by the 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

Operation in 2026:

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

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

Note: this delay of HL-LHC start will incur additional costs to CERN and the Funding Agencies

There are Additional Risks to the New Schedule

ATLAS

	Risk	Probability (%)	Impact (months)	Cost - Material (kCHF)	Cost - Personnel (FTE*Year)
S1	Technical issues with custom connectors/cables being procured from industrial partners leading to delay of harnessing contracts	10	6	TBD	N/A
S2	Failure of sensor cracking mitigations	5	12	TBD	TBD
S3	Stave core production rate issues	20	2	25	3
S4	Module production rate issues	25	4	100	15+
P1	Additional iteration of FE chip	5	16.5	900	TBD
P2	Module pre-production issue leading to delay of the PRR or production time for module assembly longer than estimated	20	7.5	400	15+
P3	Triplet Module PCB design is delayed	10	3.5	N/A	1
P4	Commercial items not ready for surface integration	10	4.5	400	1
P5	Delay in development of BCM', leading to delay of Inner System integration	20	3.5	N/A	0.5
P6	Hybridization vendor(s) drop out or production rates slower than foreseen	35	4.5	TBD	N/A
P7	In-house production rates (other than module assembly) lower than foreseen	30	4.5	100	30+

CMS

(extracts of long complete versions of the risk registers)

	Risk	Probability	Impact vs. LS3 end	Mitigation
HGCAL1	HGCROC, need an ASIC additional iteration	20%	12m	*delay incompressible*
HGCAL2	ECON ASIC, need of another iteration	5%	up to 9m	*delay incompressible (mitigation done early to decrease risk)*
HGCAL3	Missing commitments from FAs for components, e.g. sensors	80%	strongly degraded HGCAL	identify funds, allow a loan
HGCAL4	Late finalisation of designs/qualification: e.g. HD wagons, HD engines, power distribution, cassette integration, prepare labs	30%	up to 10m	add experienced personnel to finish designs, (consolidation) plus additional personnel comes *too late for full mitigation*
HGCAL5	Reduced production throughput of module, tiles, tileboards and cassettes, plus speedup during detector integration at P5	20%	up to 6m	shifts at module, tile assembly, speedup integration at P5. Schedule highly optimized thus *no full mitigation possible*
Tracker1	Late hybrid delivery	50%	up to 4m	pay premium to increase production speed at company plus increase testing & module production (see later line)
Tracker2	Persistent MaPSA or pixel hybridization quality and prod. volume issues	30%	2m	shift production to higher cost vendors
Tracker3	Reduced module or ladder assembly throughput	30 - 50%	up to 4m	build distributed production overcapacity
BRIL	Late delivery of day-1 instrumentation for CMS & LHC acc. commissioning	50%	up to 10m	2 electronics system engineers
ME0	Delay in PCB, frame or foil production	10% or 50%	up to 4m	increase parallel module production
General1	Late system wide fault, e.g. high noise, poor cooling	10%	up to 10m	more effort now/soon on system test and verification. risk and potential resulting impact *cannot be fully mitigated*
General2	Loss of key personnel	30%		extend short/fixed terms contracts. Hire new staff ahead of time to guarantee overlap and handover
General3	Infrastructure (upgrade of infrastructure) not fully operational on time for detector check-out	50%		Additional time for preparation and commissioning of infrastructure ahead of detector installation
General4	Significant time windows with no main services available (maintenance and consolidation)	60%	interruption of install. & commis.	Longer LS3 or increased personpower from support groups to execute disruptive interventions in parallel

Example:

- Recently problems with the low power GigaBit Transceiver (lpGBT) chip observed
  - 1% of the ASICs do not start at power-up, randomly?
  - Equalizer attenuation
- Production of corrected chip launched, investigations of impact ongoing
- Note: this was not even included in the above lists of risks!

Risk Mitigation

Are there ways to mitigate these known (and also unknown) risks on the schedule?

Any further slippage would require even more resources and reputationally be very detrimental

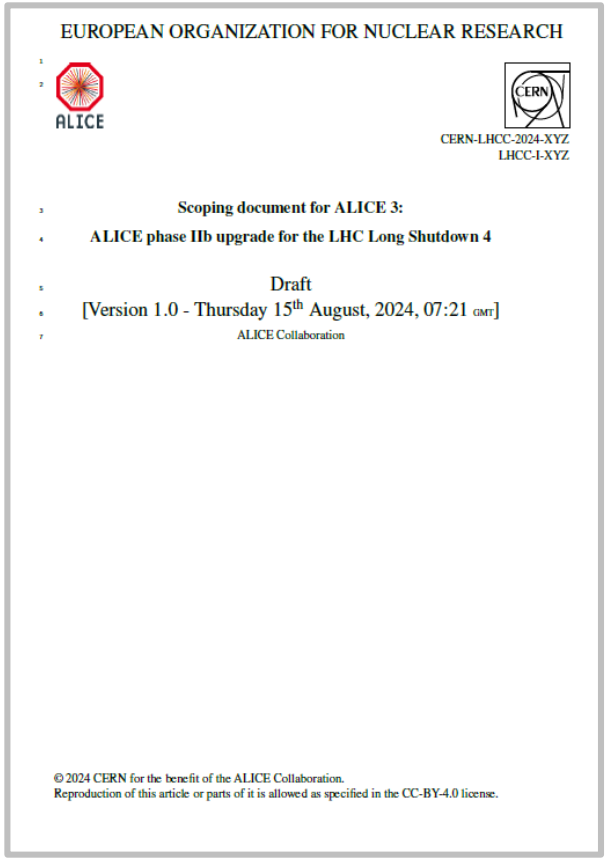
Measures where Funding Agencies could help:

- ❑ More flexibility sub-projects which are rigidly defined in the MoUs
  flexibility in money and person power
- ❑ More flexibility in common resources
- ❑ Mechanism to socialize cost overruns in big items with savings in others (compensation mechanism)
- ❑ Prioritise Phase II wrt. other LHC related request
  Help to spread and raise the awareness among the collaboration members that Phase II is the highest priority project and must be completed on schedule
- ❑ Help to avoid cash flow problems in the collaborations
  e.g. 50% of the CMS Detector Upgrade Fund (DUF) is still missing
- ❑ Strong support (physicists, engineers, technicians) will be required also during the detector installation in LS3 and after that for commissioning

Phase IIb: ALICE and LHC

Scoping documents submitted

- ❑ For both experiments scenarios of core costs between ≈ 125 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

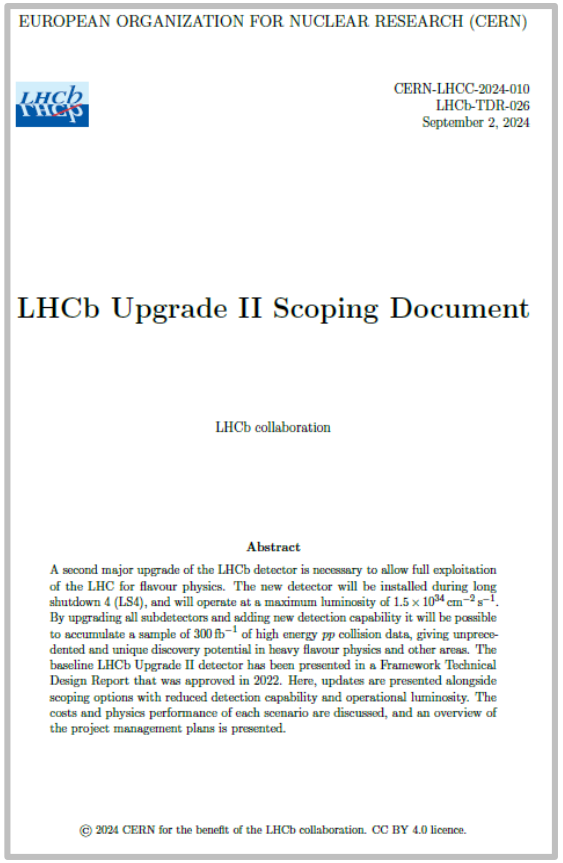
CERN-LHCC-2024-XYZ
LHCC-I-XYZ

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 ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-LHCC-2024-010
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:

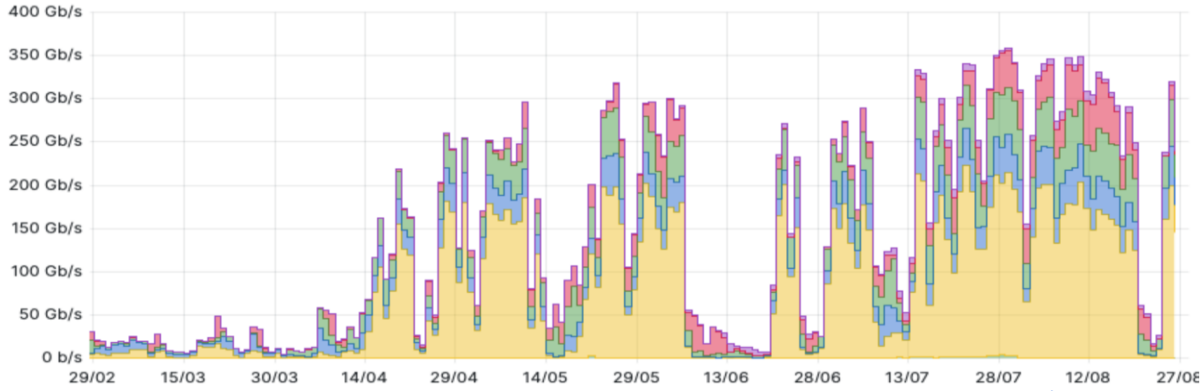
- ❑ ALICE: ITS3 and FoCal: TDRs are completed and endorsed by Research Board
- ❑ LHCb: ECAL, RICH; endorsed by RB; DAQ Enhancement TDR; LHCC recommended for approval

Computing

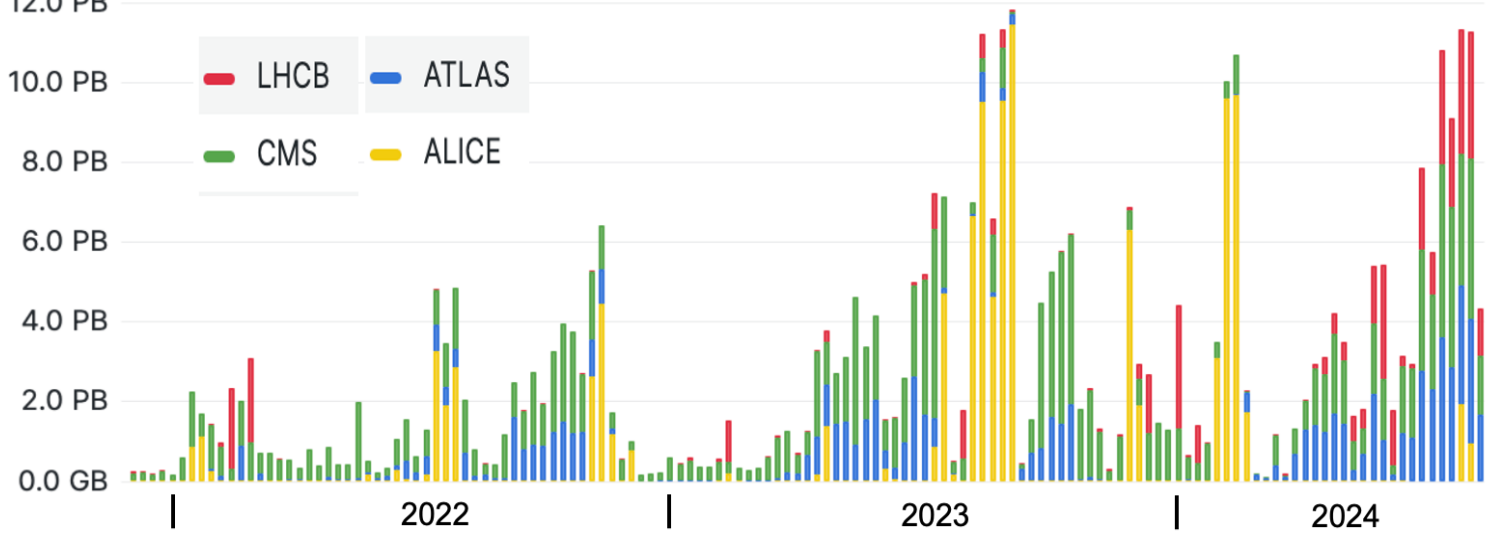
- CERN Data Centres:
  - Prévessin Data Centre (PDC): fully operational.
  - Meyrin Data Centre (MDC): record storage rate of 11 PB/week in July 2024, from experiments to MDC (guaranteed bandwidth in Run3: 25 PB/week)
- Data promptly archived at CERN and at the Tier-1 centres

Data promptly delivered from the experiments to the Tier-0 with no delay nor sign of network saturation

Daily data rate from experiments to Tier 0 (Gb/s)



Weekly volume of data archived at the Tier-0 (PB) during Run3

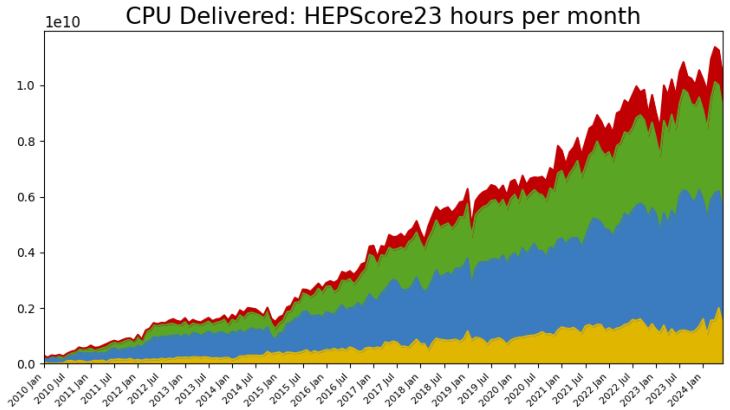


IT infrastructure handles the data flow from the extraordinary performance of the LHC with headroom

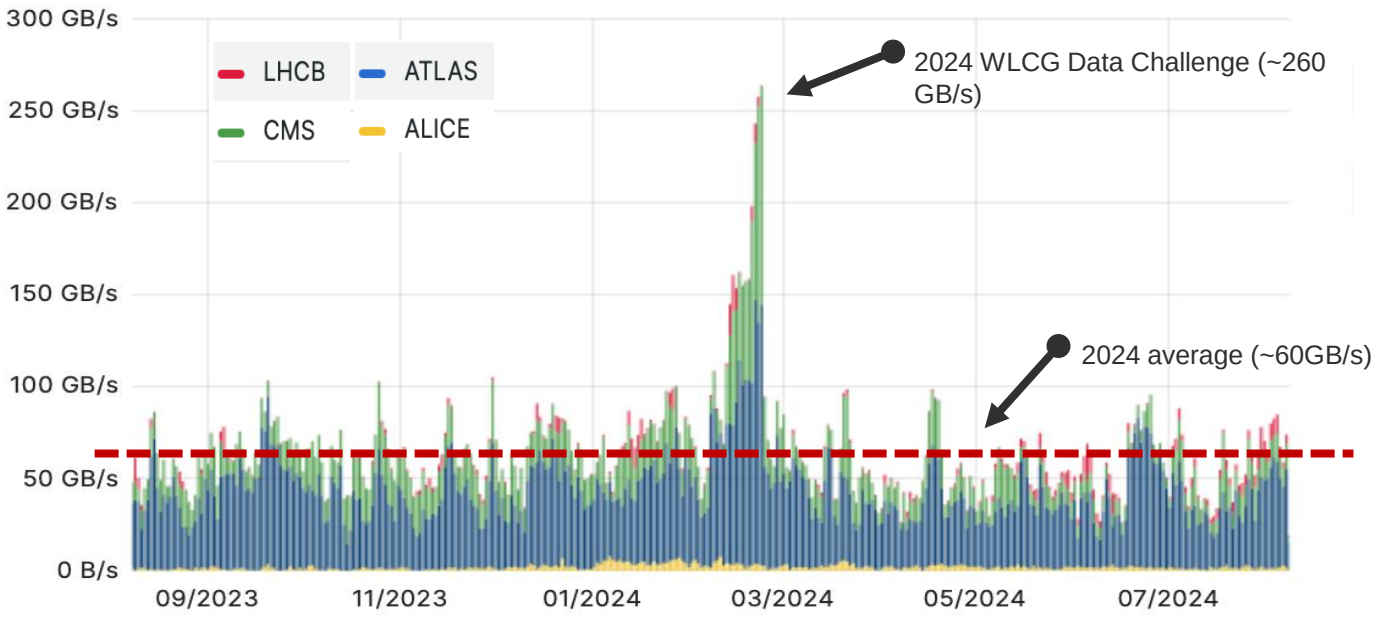
WLCG

- WLCG reached 1.4 million computing cores and over 4 EB of storage, thanks to about 170 sites worldwide
- IHEP (China) becomes Tier-1

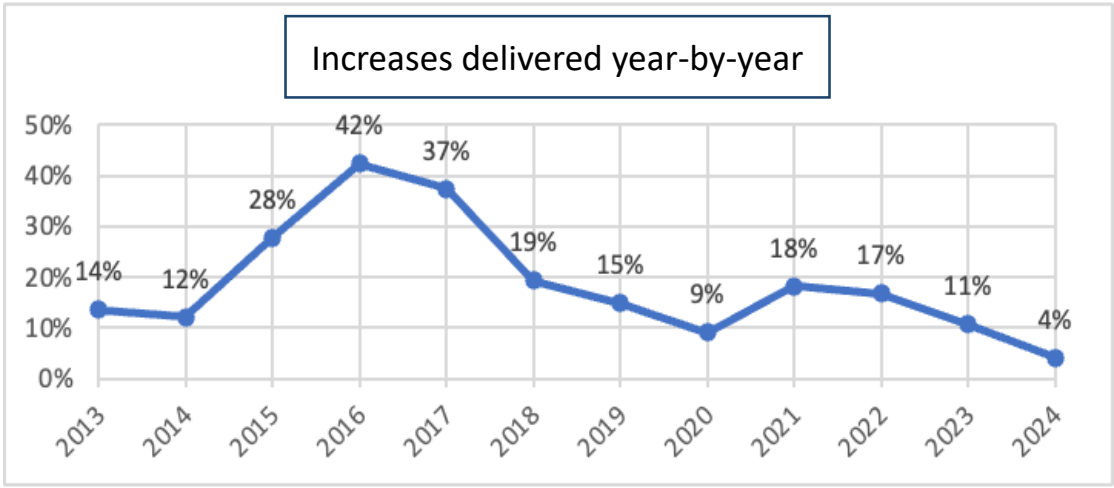
WLCG sites are providing experiments with up to ~45% additional capacity beyond their formal commitments



WLCG traffic (GB/s) in the last 12 months



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

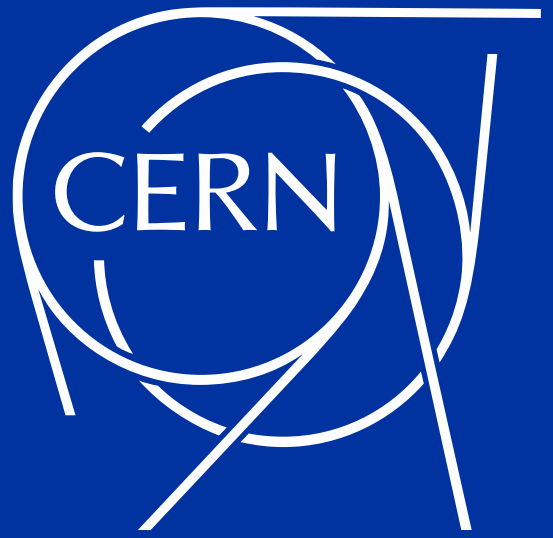


Summary

- Very successful proton-proton run in 2024
  - More than 120 fb^{-1} delivered to ATLAS & CMS
  - ALICE and LHCb doubled their total pp data sets
  - PbPb run is being prepared
- 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 CERN, experiments and Funding Agencies should discuss mitigation measures
  - Cash flow issues are potentially an additional hazard to the schedule
- WLCG is running smoothly
  - Prévessin Data Centre in operation
  - To be watched: development of performance over costs

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

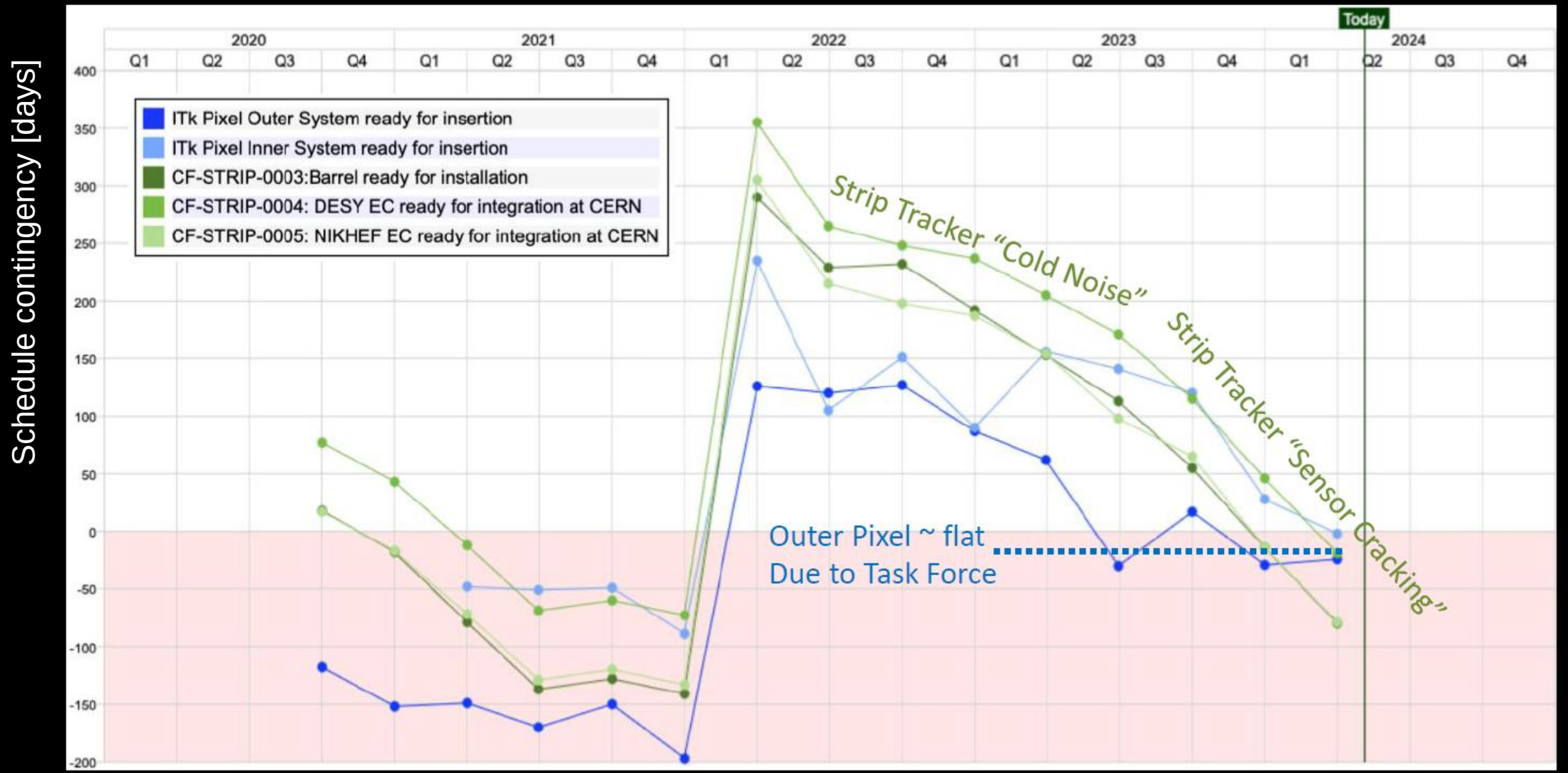
Thank you for your attention!



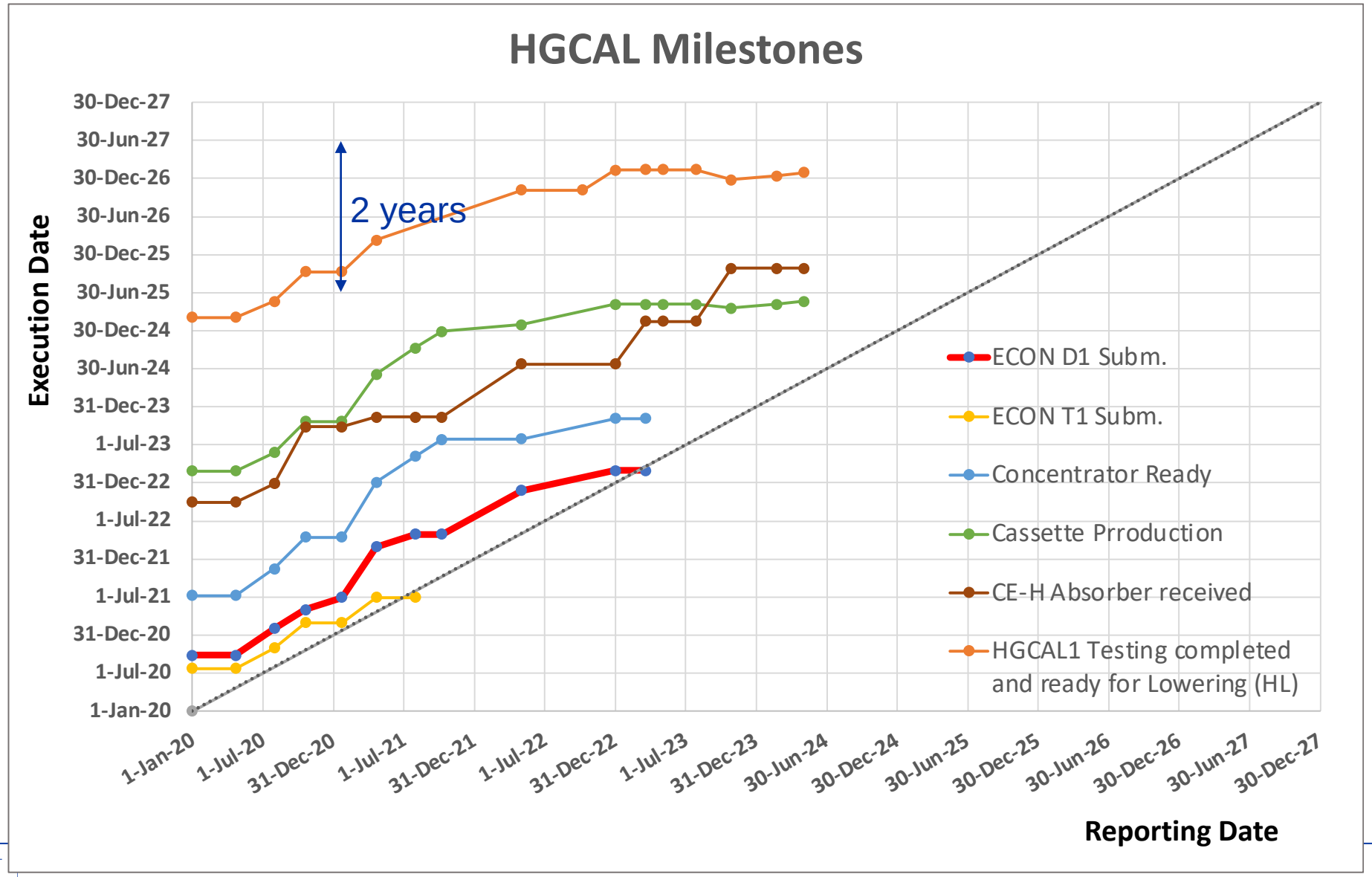
Backup

Schedule - ITk

From P2UG/ATLAS



Schedule Reporting



Marcel Demarteau
P2UG Chair CMS
May 2024