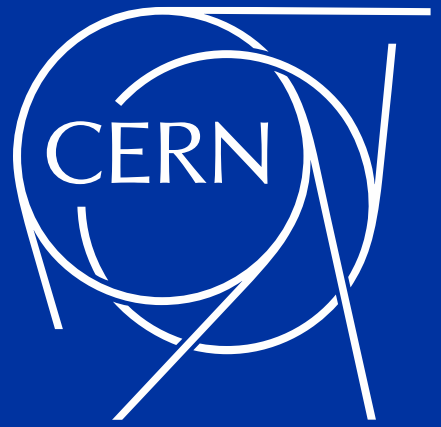


Status of the Experiments

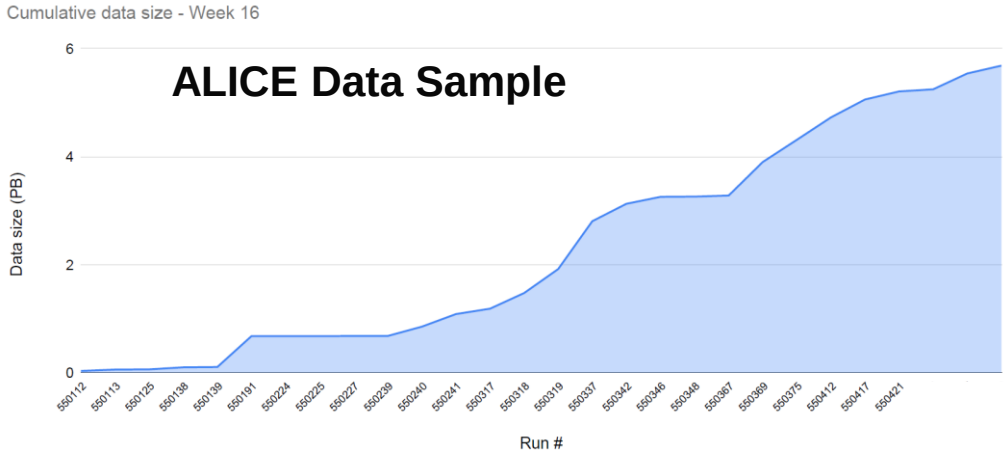
Plenary RRB 58th Meeting

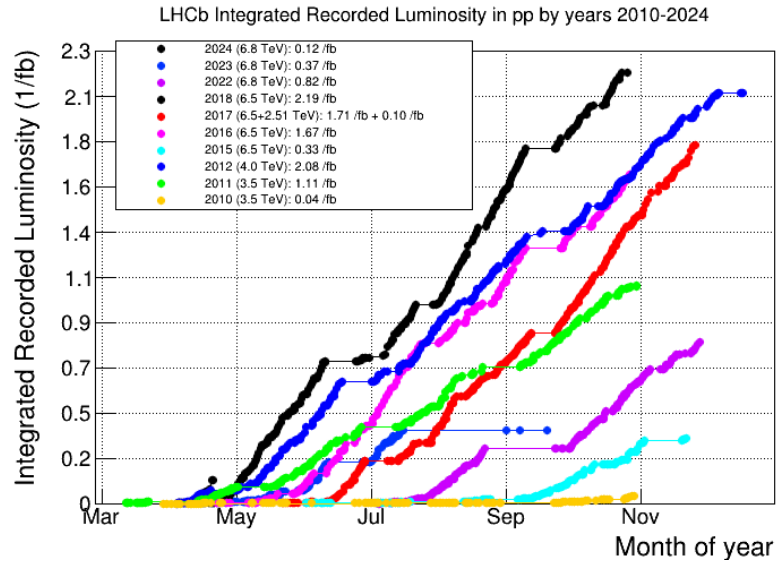
Joachim Mnich

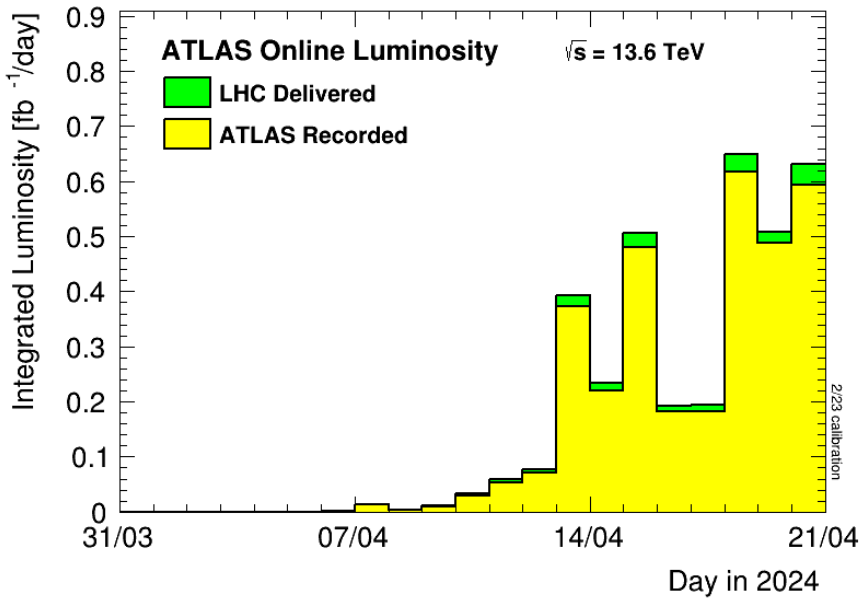
April 22nd, 2024

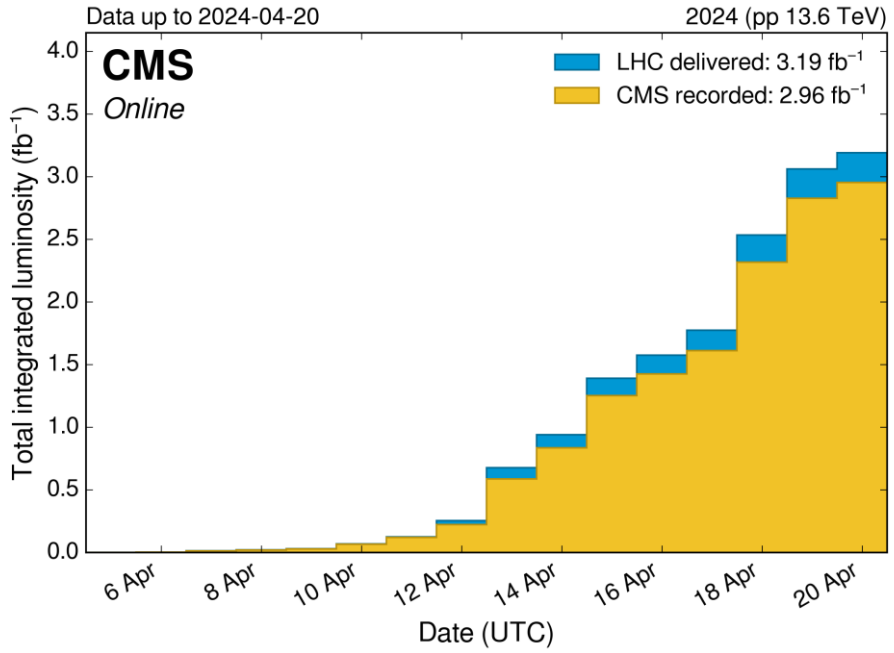
Start of 2024 Run

- All 4 experiments up and running
- Good data taking efficiency
- > 3 fb^{-1} pp luminosity recorded so far in 2024 by ATLAS & CMS



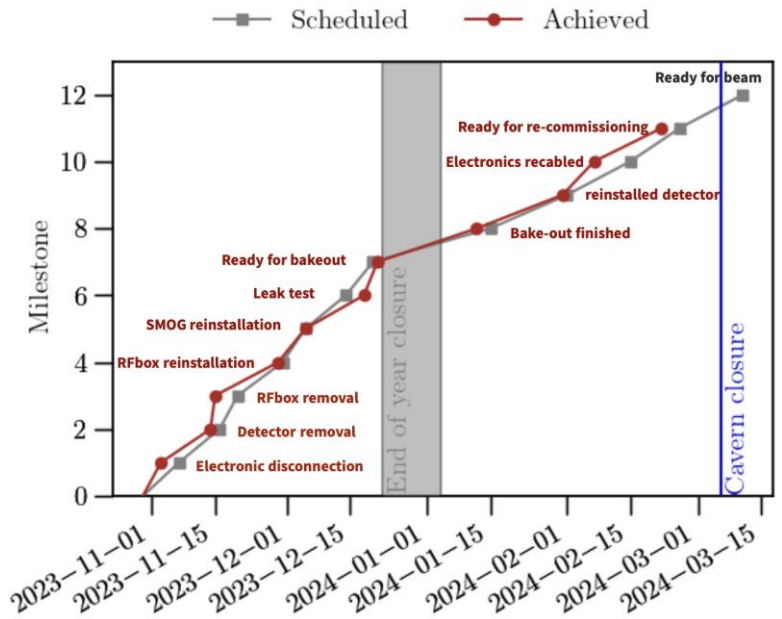


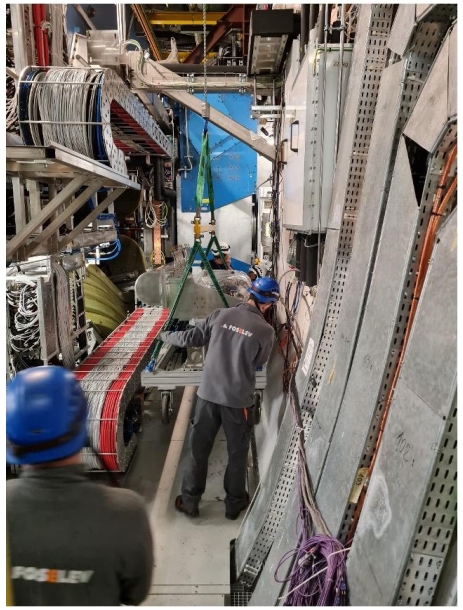




LHCb VELO Repair

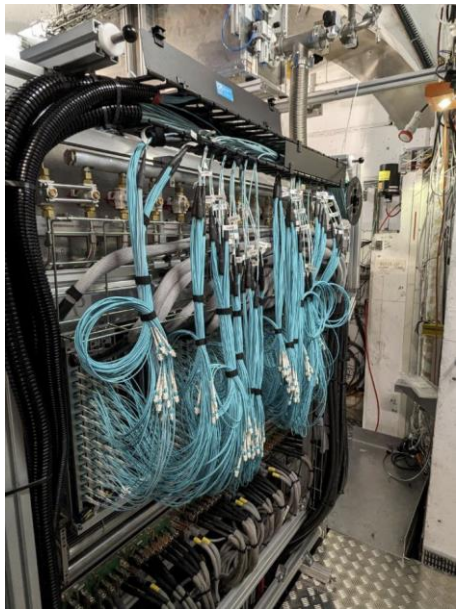
- VErtex LOcator (VELO): in January 2023 plastic deformation after an incident with the vacuum system
- RF-foil replacement and detector re-installation went smoothly
  - 0.5 mm shims are installed on each side,
    to be removed during TS1





VELO A-side transportation

VELO installation



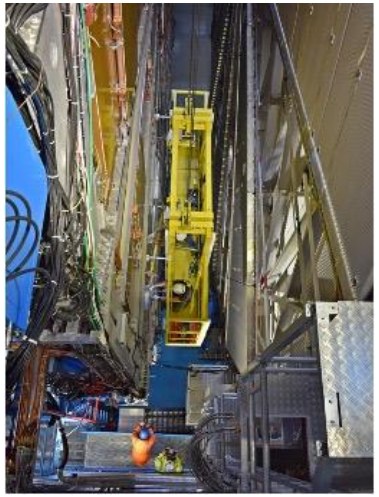
VELO re-cabling

ATLAS EYETS Activities

- Clogging issues of the Helium Shield Refrigerator during 2023 data-taking
  - Water found to be the contaminant
- Addition of a second larger-capacity dryer which is now fully installed in parallel to allow regeneration of current dryer

- Muon system:
- RPC gas leak repairs and gas inlet consolidation focusing on cases affecting trigger (~ 200 repairs)
- 19 TGC Chamber replacements to recover individual layers with HV issues
- NSW sTGC VTRx replacements on both wheels around the rim

New dryer installation



TGC chamber replacement

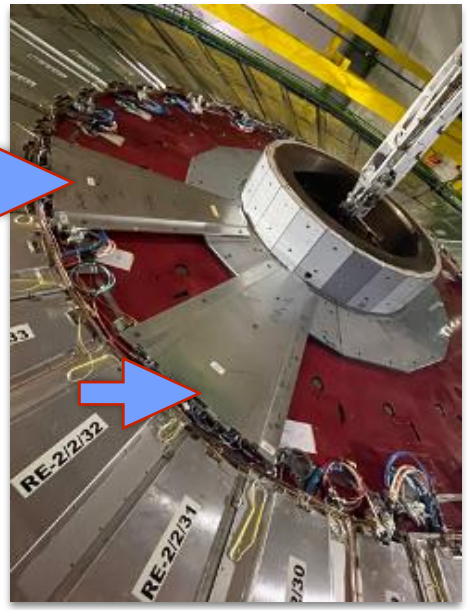
VTRx replacements on NSW rim

CMS EYETS Activities

- Installation of some Phase II forward µ-chambers (-z end)
- New forward shielding

- Relocation of CMS control room into new building

Two iRPC (RE-3/1) chambers



Two GEM (GE-2/1) chambers

New forward shielding

Other activities:

- Consolidation of the magnet system to ensure operational stability
- Preparation of Phase II infrastructure: CO2 cooling, electricity, cranes, laser labs

ALICE: Matter-Anti-Matter Asymmetry

- Baryon chemical potential μ_B characterizes baryon-anti-baryon asymmetry

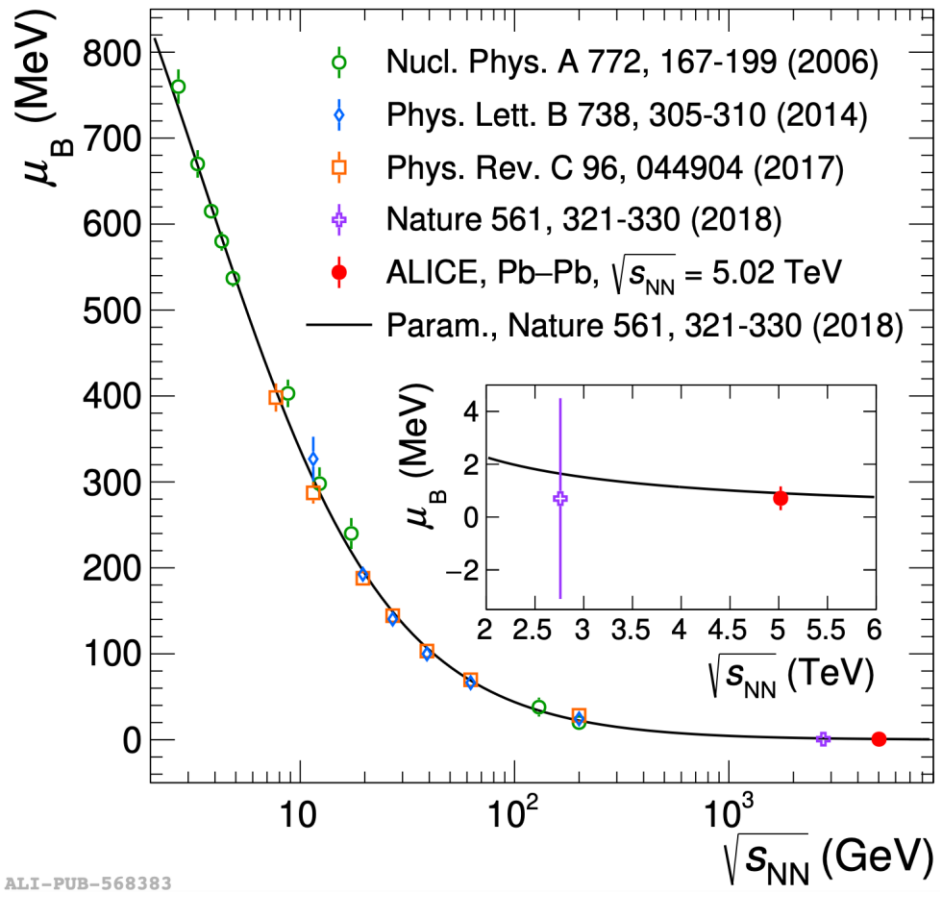
$$\frac{\overline{h}}{h} \propto exp - 2\left(B + \frac{S}{3}\right)\frac{\mu_B}{T}$$

- ALICE measurement with unprecedented precision:

$$\mu_B = 0.71 \pm 0.45\text{MeV}$$

- At LHC same number of baryons and anti-baryons
  Production of baryon-anti-baryon pairs dominates over initial baryon number from lead ions (A = 208)

Baryon chemical potential vs energy



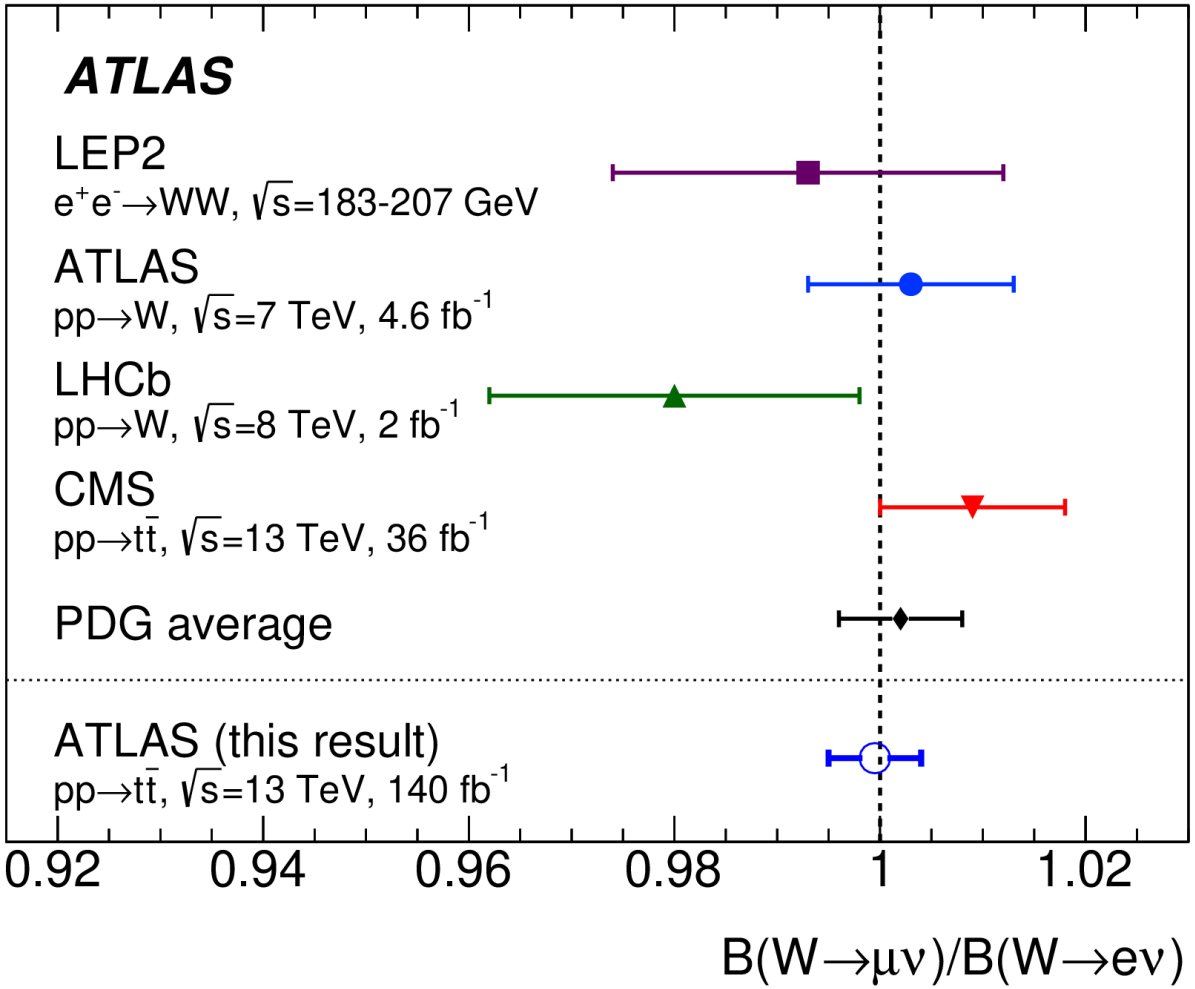
arXiv:2311.13332

ATLAS: Probing Lepton Universality in W Decays

New ATLAS result on lepton universality in W decays

- Improves single-experiment precision by factor of two and is more precise than current world average
- Measurement exploits clean W bosons from top-pair decays

$$R_W^{\mu/e} = 0.9995 \pm 0.0045$$



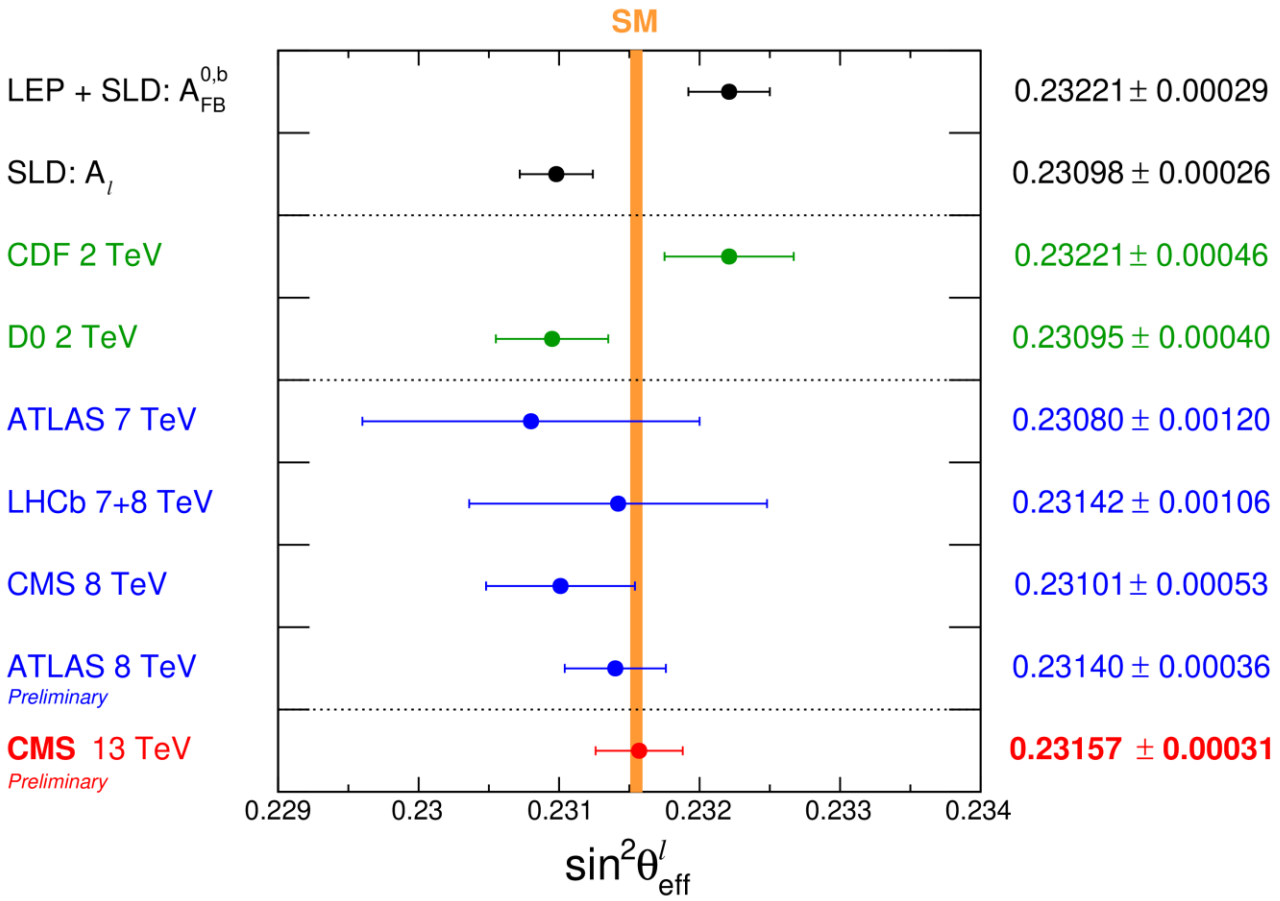
CMS: Measurement of the Weak Mixing Angle

CMS performed a precise measurement of the effective leptonic electroweak mixing angle

- 137 fb-1 used (Run 2)
- based on the study of Drell–Yan dimuon and dielectron events (forward-backward asymmetry)

$$\sin^2\theta^{\ell}_{\text{eff}} = 0.23157 \pm 0.00031$$

- Precision comparable to LEP & SLD results

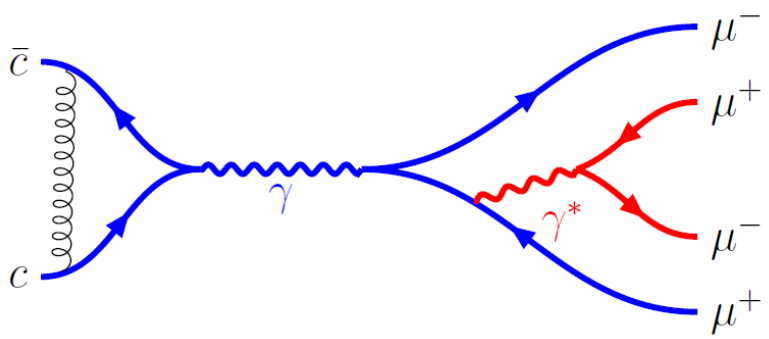


Error break down:

$$\sin^2\theta^{\ell}_{\text{eff}} = 0.23157 \pm 0.00010(\text{stat}) \pm 0.00015(\text{syst}) \pm 0.00009(\text{theo}) \pm 0.00027(\text{PDF})$$

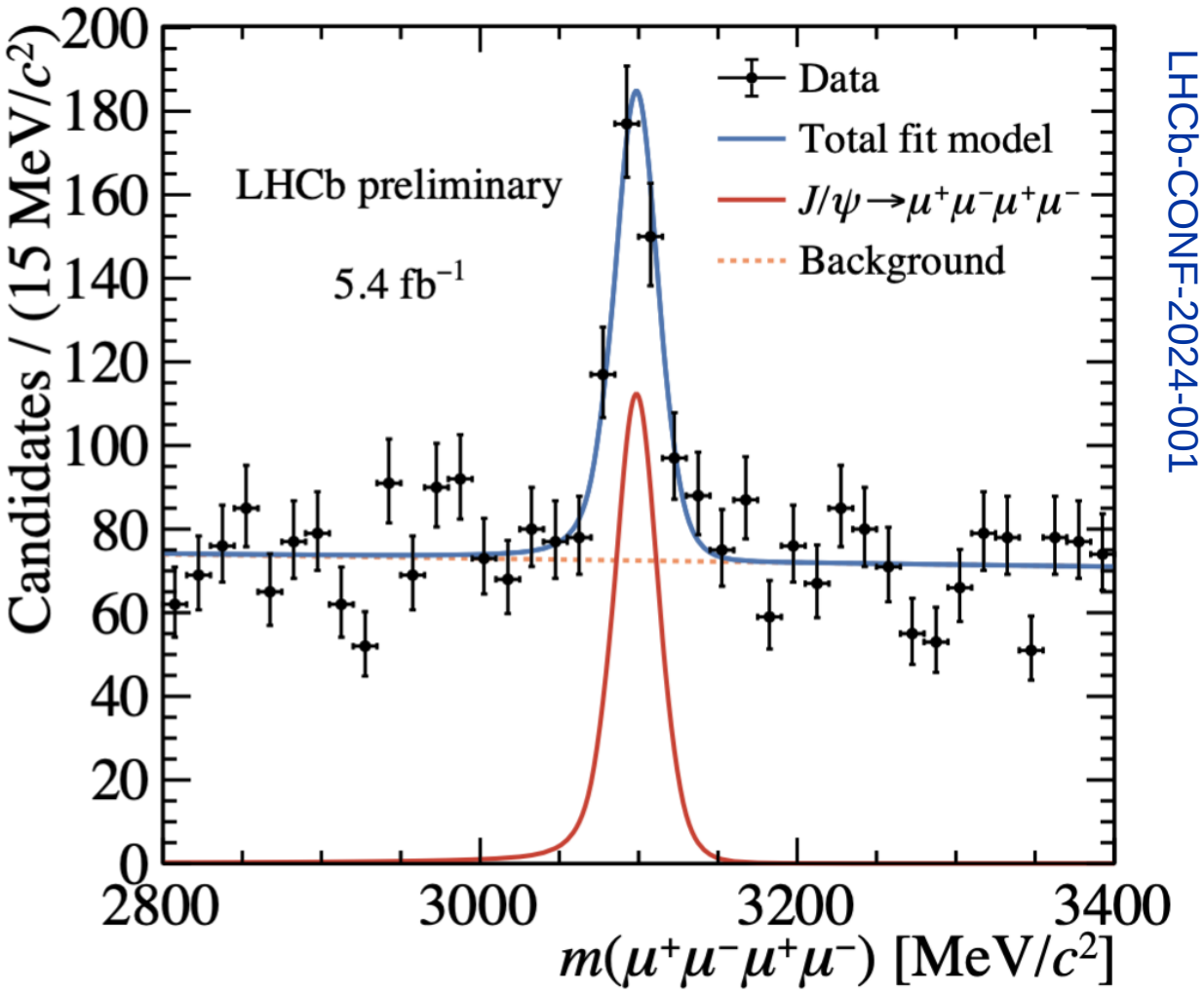
LHCb: Observation of the rare decay $J/\psi \to 4\mu$

LHCb measured the rare decay J/$\psi \to \mu^+\mu^-\mu^+\mu^-$:



$BR(J/\psi \to \mu^+\mu^-\mu^+\mu^-) = (1.13 \pm 0.10 \pm 0.05 \pm 0.01) \times 10^{-6}$

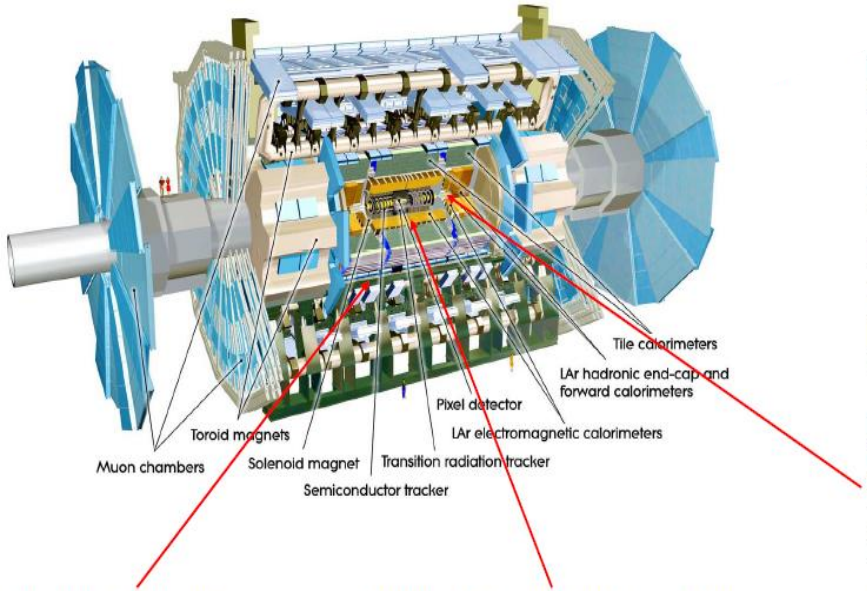
- Most precise measurement to date of this branching fraction



LHCb-CONF-2024-001

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

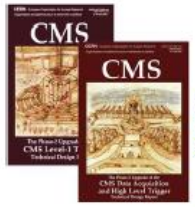
Low-Gain Avalanche Detectors (LGAD) with 30 ps track resolution

Additional small upgrades

Luminosity detectors (1% precision goal)

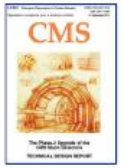
HL-ZDC

CMS

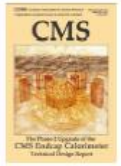


L1-Trigger HLT/DAQ
https://cds.cern.ch/record/2714892
https://cds.cern.ch/record/2759072
- Tracks in L1-Trigger at 40 MHz
- PFlow selection 750 kHz L1 output
- HLT output 7.5 kHz
- 40 MHz data scouting

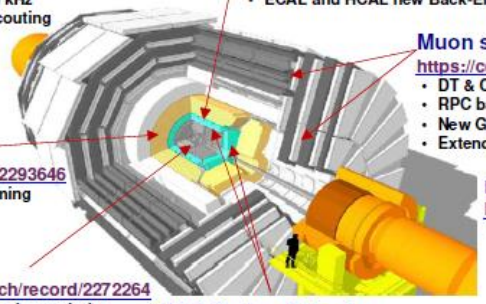
Barrel Calorimeters
https://cds.cern.ch/record/2283187
- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards



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 $\eta \simeq 3$

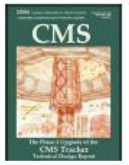


Calorimeter Endcap
https://cds.cern.ch/record/2293646
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

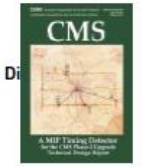


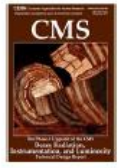
Beam Radiation Instr. and Luminosity
http://cds.cern.ch/record/2759074
- Bunch-by-bunch luminosity measurement: 1% offline, 2% online

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

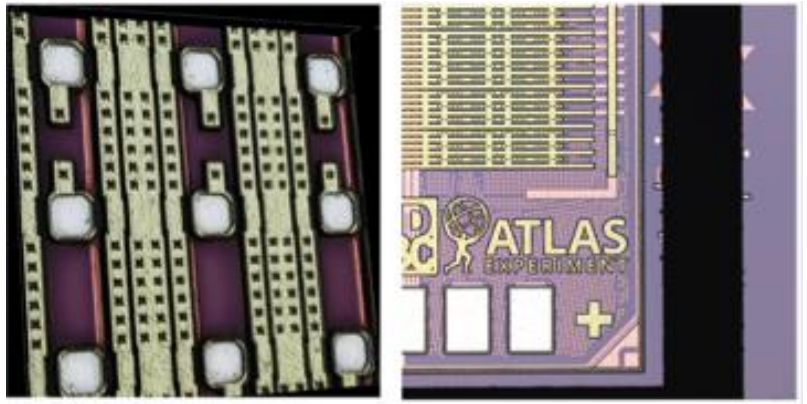
ATLAS Phase II

- ATLAS upgrade projects are largely in the production phase
- Work to identify tasks close to the critical path and ways to gain contingency (→ Fraunhofer workshops)

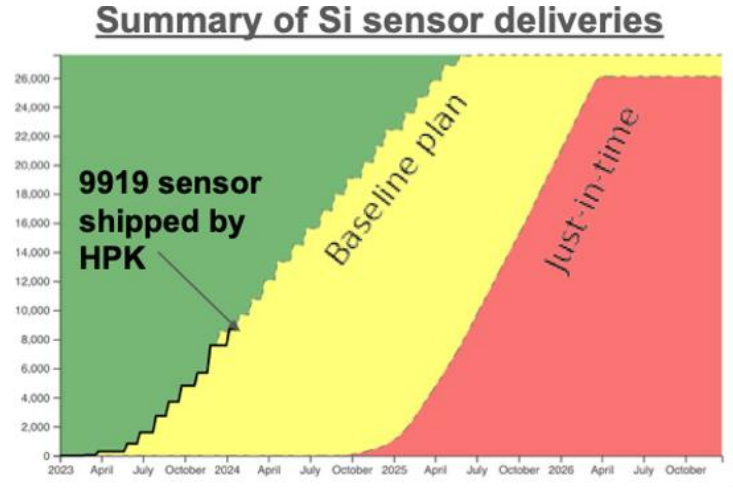
- ITk Pixel:
  - ITkPixV2 ASIC now fully verified and in production
  - Progress being made on hybridisation
- ITk Strips:
  - Sensor cracking: First staves loaded with new epoxy glue
  - ASIC probing almost complete
  - Sensor production proceeding as planed
- Good progress in all other detectors

Shortfall of contributions of institutes in Russia:

- As discussed in previous RRBs MoU annexes have been prepared and sent to the FAs



CMS Phase II



High Granularity Calorimeter (HGCAL)

- Silicon sensor: production going according to plan, excellent quality
- ASIC: First HGCROC V3b arrived in early February
  - Issues with previous version have been fixed
  - But new bug found, investigations are ongoing, not holding up system test
  - Final Endcap Concentrator ASIC pre-production engineering run ongoing with vendor

Status of mitigation of the Russian funding shortfall:

- In-kind contributions are fully covered technically:
  - US took up: HGCAL Cu cooling plates, Scintillators, most Muons items
  - Good progress on the Neutron Monitors in BRIL (INFN)

RRB endorsed the Detector Upgrade Fund DUF to compensate for the funding shortfall on fair share principle

- CMS needs DUF funds now to pay for the Common Fund, CuW-baseplates and silicon sensors
- 1/5 of funding agencies paid (incl.in-kind from above) and another 1/5 signalled to pay, but 3/5 commitments missing

Risk to impact the schedule!

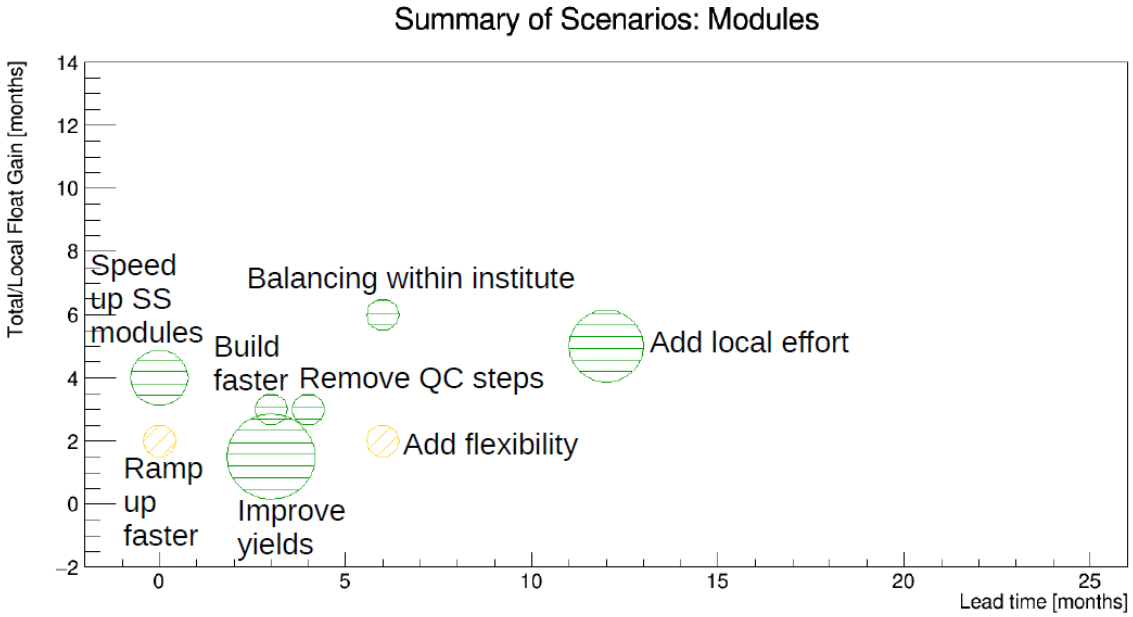
- Inner Tracker final ASIC (CROCv2): First 16 wafers received & tested 25 more ordered

Fraunhofer Workshops

- Completed for CMS HGCAL (workshops in June and August 2023)
- ATLAS ITk analysis workshop in October 2023
  Concept workshop February 2024 had to be cancelled and is being rescheduled
- Positive experience and very much appreciated by the experiments
  - CMS organised an internal “Fraunhofer-style” workshop for the tracker
- Many recommendations from the experts taken on board
- Options for possible production accelerations, contingencies identified, make schedules more resilient
  → example ATLAS strip module production

Scenarios to speed up production,
e.g. ATLAS ITk strip modules:

- Expected float gain vs implementation lead time
- Size of circles indicate additional effort required



Bottom line Phase II:

- A lot of progress but schedules remain extremely tight
- Efforts must be sustained and even increased in some areas

Status DRD Collaborations

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

Fully approved by RB Dec 2023 on recommendation of the DRDC

- **DRD3** **Semiconductor Detectors**

Conditionally approved

- **DRD5** **Quantum Sensors**
- **DRD7** **Electronics**

DRDC received full proposal in March 2024

- **DRD8** **Integration**

Full proposal expected end 2024

MoU templates in preparation and being discussed with the DRD collaborations

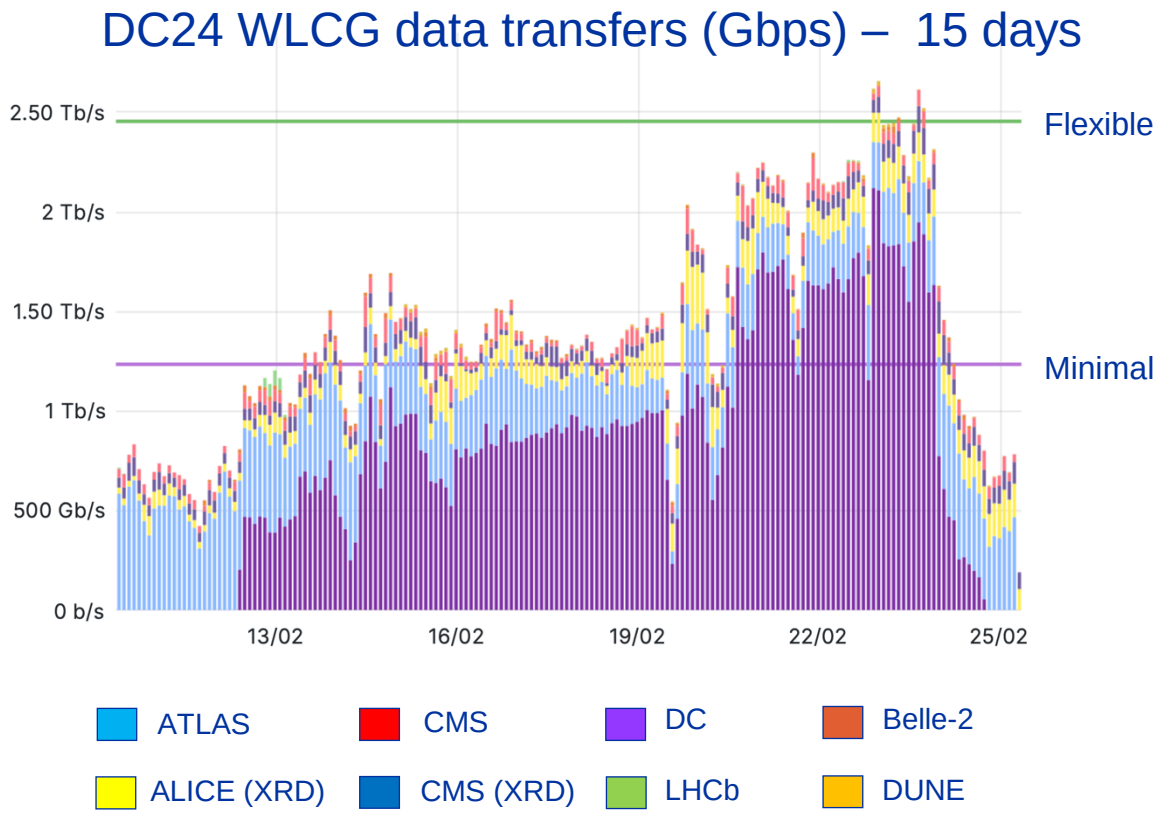
Computing: Preparation 2024 LHC Run

Preparation 2024 LHC Run:

- WLCG pledges for 2024 look ok, deadline is April 1st

HL-LHC:

- Data Challenge 24 was next phase of the computing infrastructure commissioning for HL-LHC
- Goals:
  - Measure the end-to-end data transfer capabilities at WLCG sites (target is 25% of HL-LHC needs)
  - Assess the progress integrating new technologies (e.g. tokens and monitoring)
  - Assess the status of different R&D initiatives
- Targets:
  - 1200 Gbps minimal scenario
  - 2400 Gbps flexible scenario

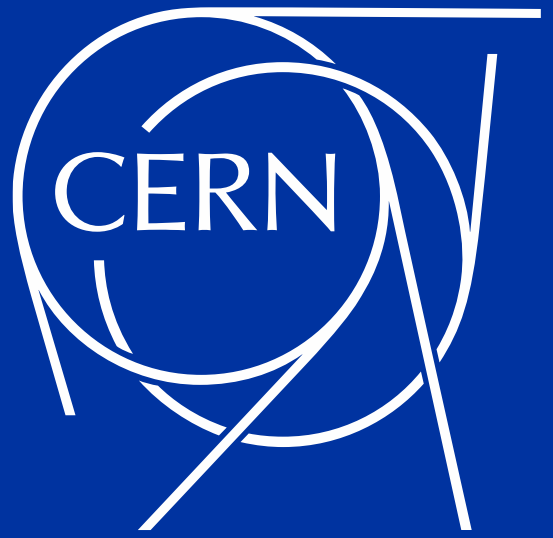


Summary

- Detectors successfully started data taking in 2024
  - Extensive maintenance & repair activities during YETS
- 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
  - Cash flow issues are potentially an additional hazard to the schedule
  - 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 Phase I completed

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

Thank you for your attention!



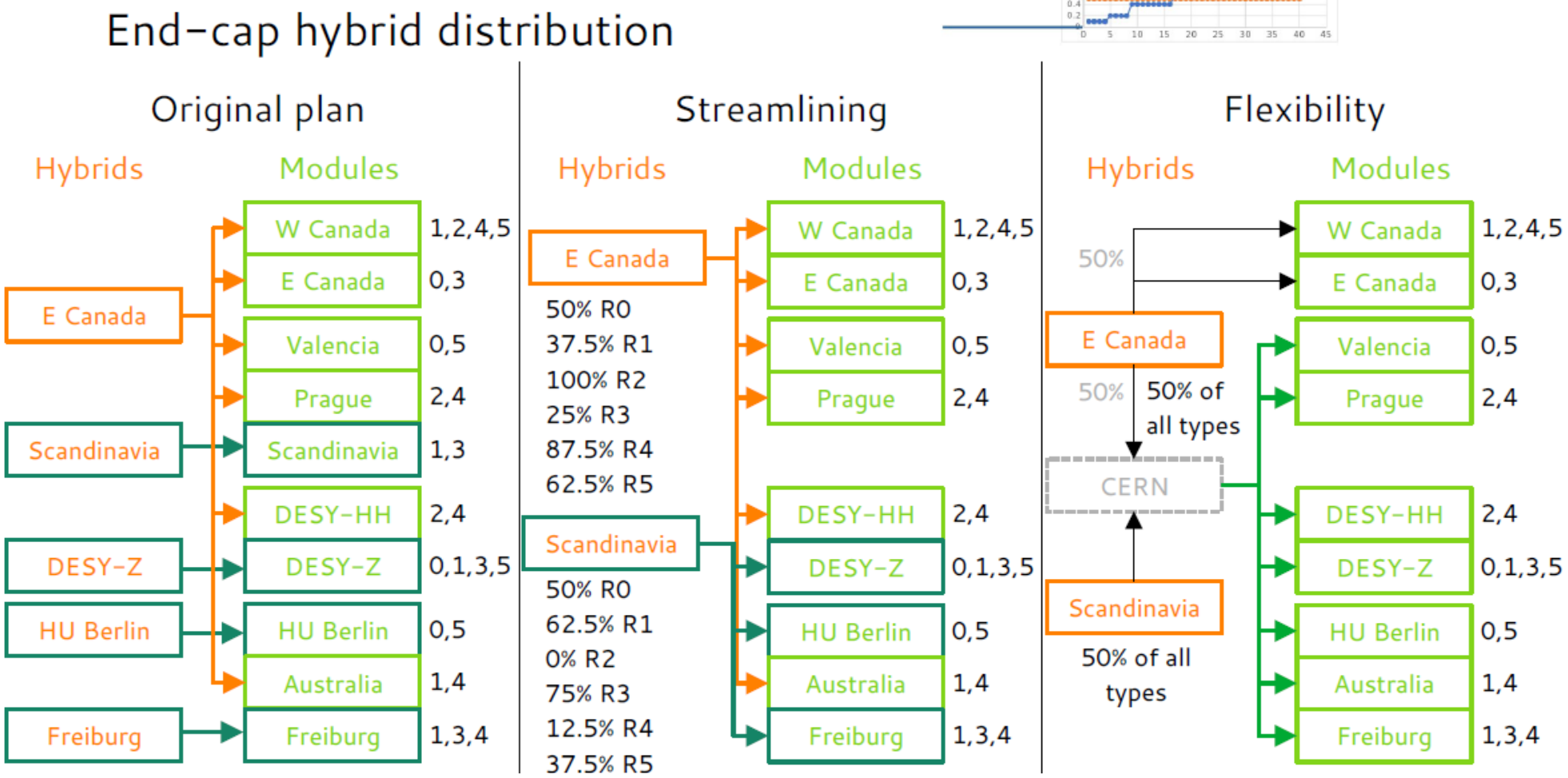
Backup

ATLAS Module Production

L. Poley

ITk strip detector:

- ❑ Optimisation of hybrid & module production plan
- ❑ Increased flexibility and resilience
- ❑ Thanks to FAs for being flexible on the funding



Quantum Technology Initiative

Starting of the activities for Phase 2 since January 2024

- ❑ Set up the governance (Program Committee is in place, Technical Expert Group and Advisory Board memberships are being discussed)
- ❑ Started procurement process for quantum hardware resource access (diversified set of technologies from both EU and US providers)
- ❑ Define detailed research plan
  - ❑ Personnel plans are approved across all departments involved
  - ❑ Detailed timeline for the prioritised objectives is being finalized
  - ❑ Plan for procuring additional funds to complement approved budget (two EC proposals submitted in March 2024)
  - ❑ Organisation of the QT4HEP conference in November 2024 has started (logistics, scientific committee, ..)

A full report on the results of the QTI 1 available in June 2024

Open Quantum Institute

Pilot Phase OQI hosted at CERN for 3 years

- Official start March 1st, 2024
- Operational Launch Event on March 5th
  - ~200 people attended 4 workshops
  - +100 remote participants at public session
- Opened applications for membership
  - Friend / Member / Partner
- Setting up Governance
  - Advisory Board: MS were invited to nominate a member if interested Scientific and Impact Committees:
    terms-of-referencee and composition being finalised
- Next Actions
  - Preparing partnership agreement template
  - Preparing personel recruitment
  - Preparing call for use cases in April