

Обзор новых результатов экспериментов ATLAS и CMS

А. Масленников

По материалам конференции ICHEP 2026,
Natal, Brazil, 30/07-05/08/2026

<https://indico.cern.ch/event/1522800/contributions/7071365/attachments/3323292/5950547/2026-08-03-ATLASHighlights.pdf> Kerstin Tackmann, DESY

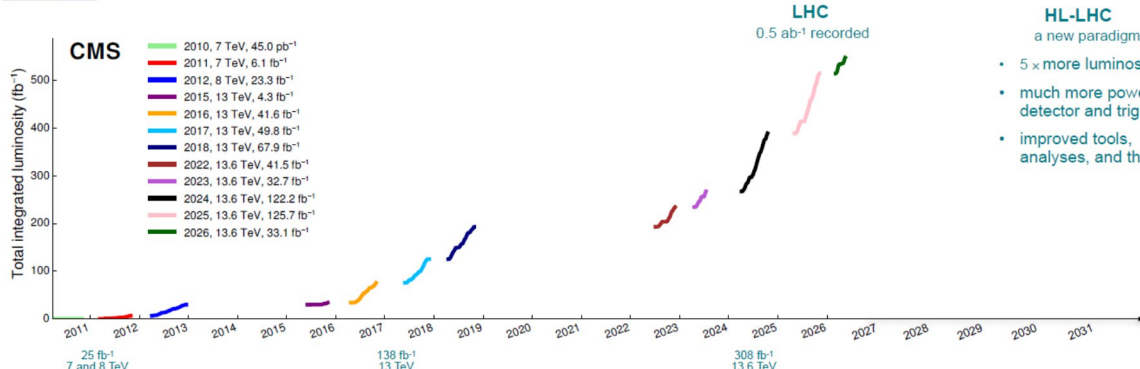
https://indico.cern.ch/event/1522800/contributions/7071366/attachments/3323341/5950641/CMS_Highlights_ICHEP26_ameyer.pdf Andreas B. Meyer, DESY

2-ое выездное собрание Дискуссионного клуба ИЯФ, б/о Разлив, 24/08/2026



CMS data

Run 3 is a game changer



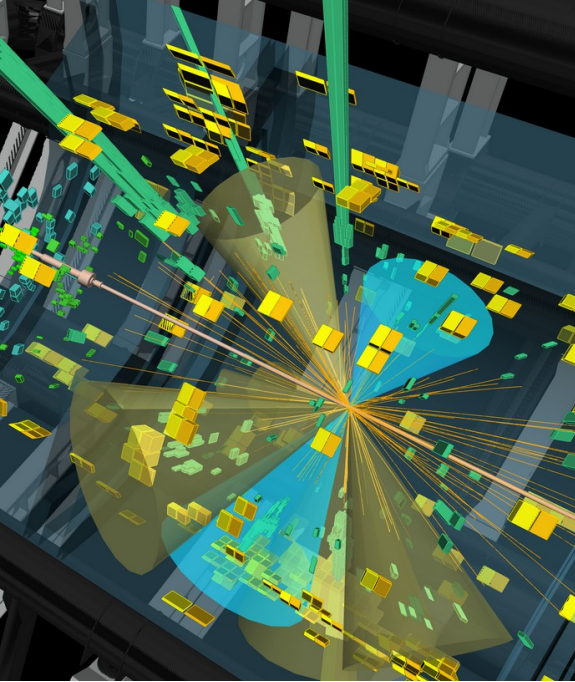
Run 1
2009–2012

Run 2
2015–2018

Run 3
2022–2026

HL-LHC
2030–2041

Run 3: data unprecedented in size, energy, quality, and physics reach



ATLAS highlights

ICHEP 2026

August 3, 2026



ICHEP 2026

NATAL | BRAZIL

Kerstin Tackmann
(DESY and Universität Hamburg)

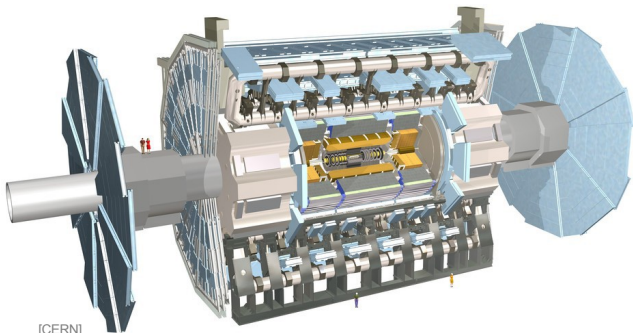
on behalf of the ATLAS collaboration



Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

The ATLAS experiment.



New for Run 3 (2022-2026):

- Muon New Small Wheel (reduce trigger fakes)
- LAr calorimeter electronics with higher granularity for trigger
- L1 endcap muon and calorimeter triggers

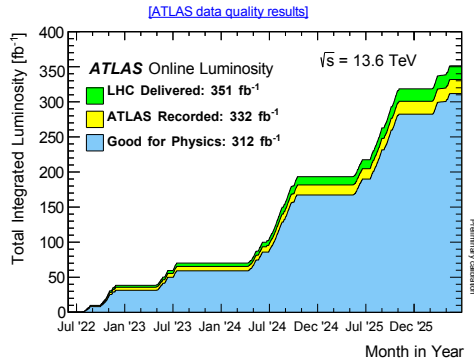
General-purpose detector with excellent reconstruction, identification and energy/momentum resolution for electrons, photons, muons, taus, and jets, as well as excellent flavor-tagging capabilities

- γ energy calibration to 0.2% at 60 GeV, $e^\pm$ energy calibration to 0.05% at 45 GeV
- $\mu^\pm$ momentum calibration to 0.1-0.05%
- jet energy calibration to 1% above 60 GeV
- τ energy calibration to $\sim 1\%$

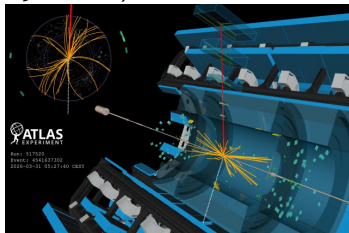
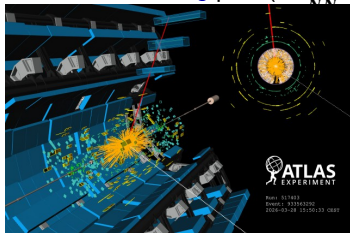
Run 3 harvest.

Recorded data in Run 3

- 332 fb⁻¹ of pp collision data at 13.6 TeV ($\mu_{MPV} = 64$)
 - ★ High recording (94.6%) and good-for-physics (94%) efficiency
 - ★ Run 2: 147 fb⁻¹ pp collision data at 13 TeV
- A diverse set of ion collision data ($\sqrt{s_{NN}} = 5.36$ TeV)
 - ★ 9 nb⁻¹ Pb+Pb (~ 4x Run 2)
 - ★ 465 pb⁻¹ p+p
 - ★ 8 nb⁻¹ O+O
 - ★ 1 nb⁻¹ Ne+Ne
 - ★ 11 nb⁻¹ p+O ($\sqrt{s_{NN}} = 9.62$ TeV)



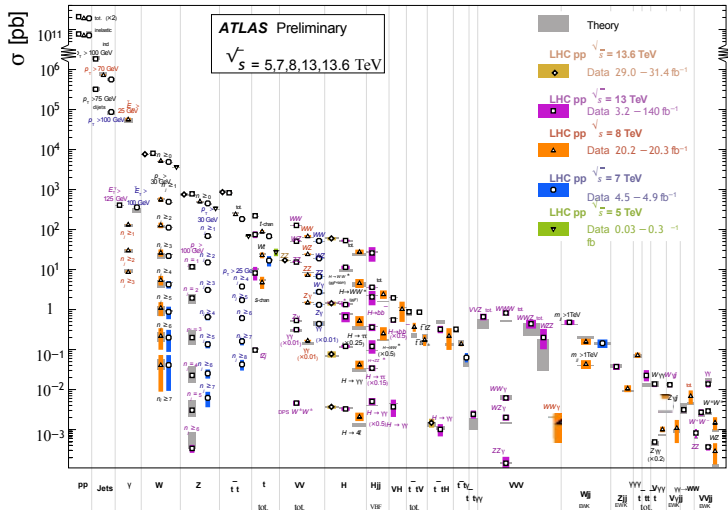
pp collision data includes
1.26 fb⁻¹ of low- μ data,
levelled at $\langle \mu \rangle = 3$ for
precision measurements



Probing the Standard Model of particle physics.

Status: July 2026

Standard Model Production Cross Section Measurements



Extremely successful in describing
collider-based measurements
over many orders of magnitude

Probing the SM broadly and deeply across all its sectors

[\[SM summary plots\]](#)

There is a lot we do not yet understand.

ATLAS Heavy Particle Searches* - 95% CL Upper Exclusion Limits

Status: Spring 2026

ATLAS Preliminary

$\int \mathcal{L} dt = (3.6 - 195) \text{ fb}^{-1}$ $\sqrt{s} = 13, 13.6 \text{ TeV}$

What is dark matter?

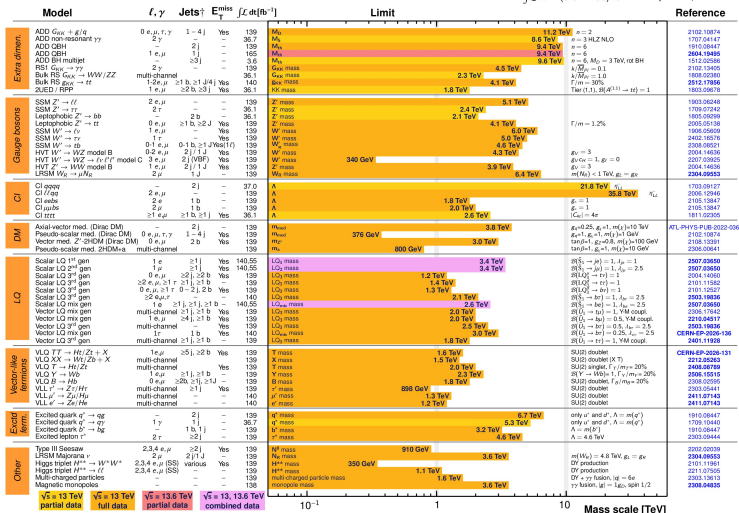
Origin of the matter/antimatter asymmetry?

Why 3 fermion generations?

Hierarchy problem?

Nature of EW phase transition?

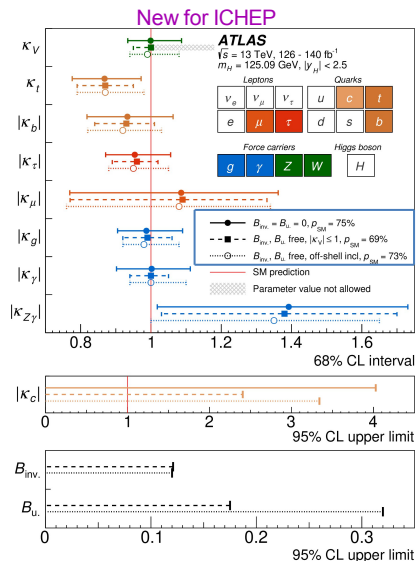
Searching for BSM particles and phenomena



Characterization of the Higgs boson.

Most detailed and precise measurements of Higgs production, decays, and couplings from combination of 26 Run 2 single and di-Higgs analyses from ATLAS

- Couplings to W, Z, t, b, τ measured to 5-12%
- Charm coupling constrained to $|\kappa_c| < 4.1$ at 95% CL
- $B(H \rightarrow \text{inv}) < 12\%$ at 95% CL
- Higgs boson width $\Gamma_H = 3.6^{+2.1}_{-1.6}$ MeV
- Self-coupling constrained to $-1.5 < \kappa_\lambda < 6.5$ at 95% CL based on single and di-Higgs analyses
- Includes also differential measurements for the main production processes

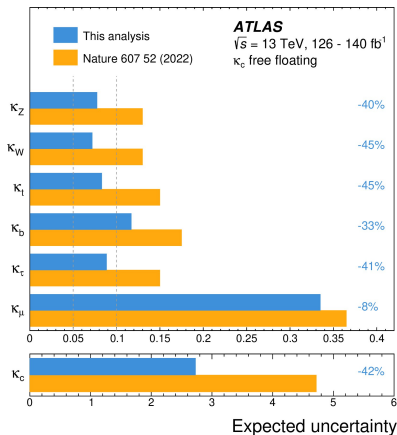


Characterization of the Higgs boson.

New for ICHEP

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Search for di-Higgs: $HH \rightarrow b\bar{b}\tau\tau$. New for ICHEP

Probe of Higgs self-coupling: crucial to understand the nature of the EW phase transition and the stability of the EW vacuum

Joint analysis of Run 2 + 2022+2023:

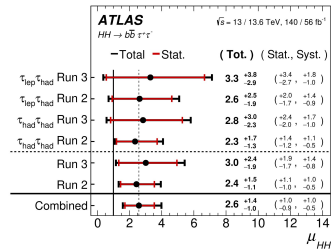
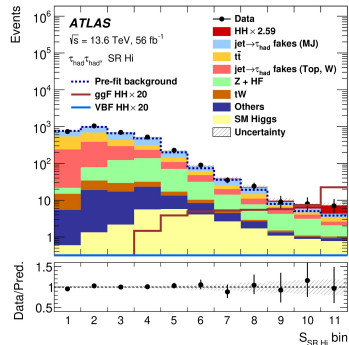
- Signal strength $\mu_{HH} = 2.6_{+1.40}$
- Significance 2.6σ obs. (1.2σ exp.)
- Sensitivity close to Run 2 ATLAS+CMS combined result (1.3σ exp.)

Validation with ZZ and ZH :

$$\mu_{ZZ} = 0.64^{+0.39}_{-0.36} \quad \mu_{ZH} = 1.52^{+0.52}_{-0.48}$$

Most sensitive HH search thanks to several improvements

- Addition of Run 3 data (2022+2023) (15%)
- Improved flavor tagging (10%)
- Improved classification strategy based on transformers (15-20%)

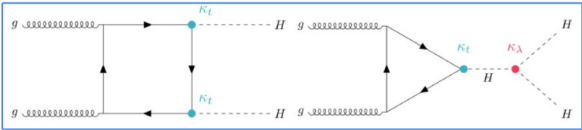


Double-Higgs production is a direct probe of Higgs boson self-coupling λ

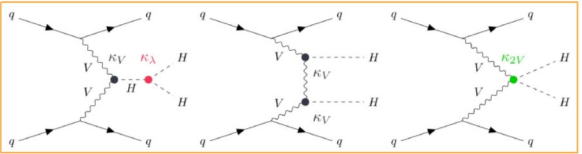
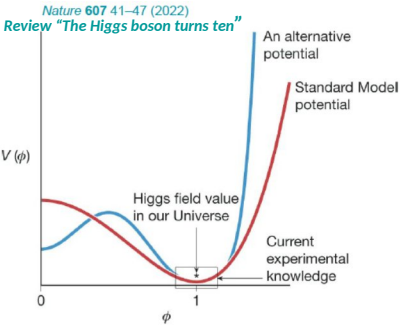
- directly related to the shape of Higgs boson potential after the electroweak symmetry breaking

$$V(H) = V_0 + \frac{m_H^2}{2}H^2 + \lambda v H^3 + \frac{\lambda}{4}H^4$$

- important consequences on our comprehension of early cosmological eras
- in the SM, two main contributions:

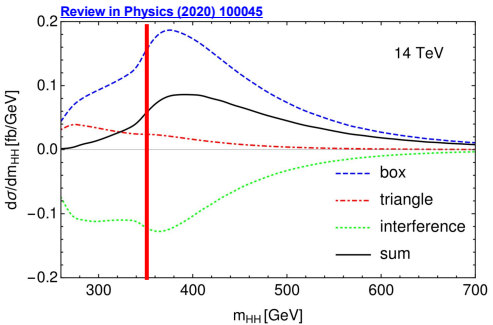
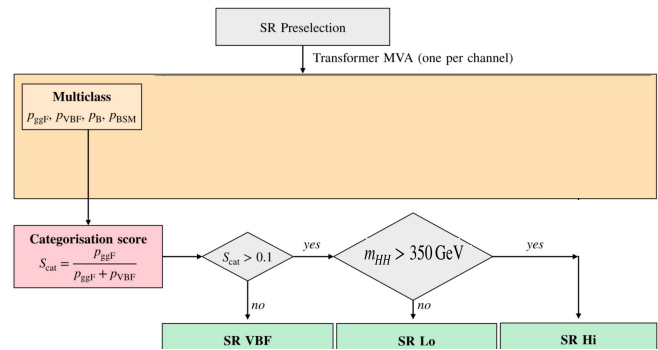


GGF: $\sigma_{\text{GGF}} \approx 31 \text{ (34) fb @ 13 (13.6) TeV}$

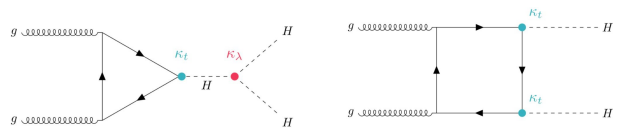


VBF: $\sigma_{\text{VBF}} \approx 1.7 \text{ (1.9) fb @ 13 (13.6) TeV}$

Multivariate strategy



2. Split GGF events at $m_{HH}= 350 \text{ GeV}$ to isolate “triangle” from “box”



Boson polarization: inclusive ZZ and VBS WZ.

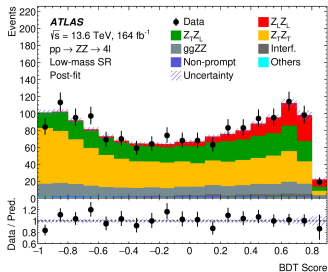
New for ICHEP

[arXiv:2607.12879]

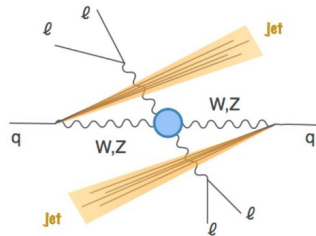
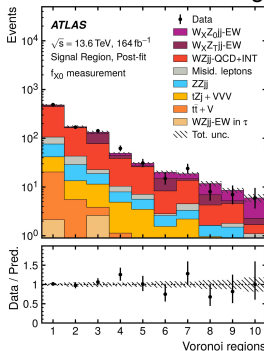
[arXiv:2607.20246]

Gauge boson longitudinal polarization closely related to EW symmetry breaking

Goldstone equivalence theorem: at high energy scale
Goldstone bosons $\leftrightarrow$ longitudinal polarization



Vector-boson scattering unitarized by Higgs couplings



Joint analysis of Run 2 + 2022-2024:

4.0 σ (2.9 σ exp.) for $W Z_L$
jj

first evidence

Inclusive polarization fraction

$$f_{LL} = 0.080 \pm 0.017$$

★ Also measured in two regions of $m_{4\ell}$

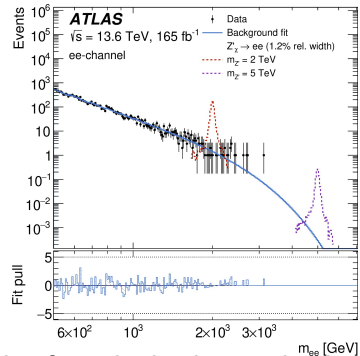
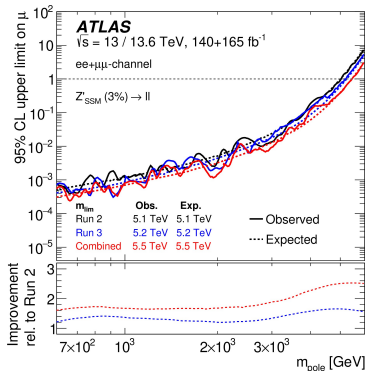
Combination with Run 2 data: 6.5 σ (5.6 σ exp.)

for $Z_L Z_L$ production first observation

Search for dilepton resonances.

New for ICHEP

- High-mass vector bosons appear in many BSM models
- Search benefits from higher $\sqrt{s}$ in Run 3



- No globally significant deviation from the background-only hypothesis
- Limits on sequential SM and E6-motivated grand unification model
- Combination with Run 2 improves
 - Run 2 Z'_{SSM} cross section limits by >60%
 - Run 2 Z'_{SSM} mass limit by 0.4 TeV to 5.5 TeV (5.5 TeV exp.)

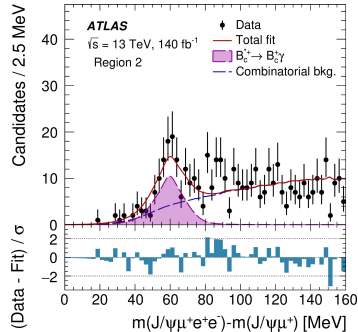
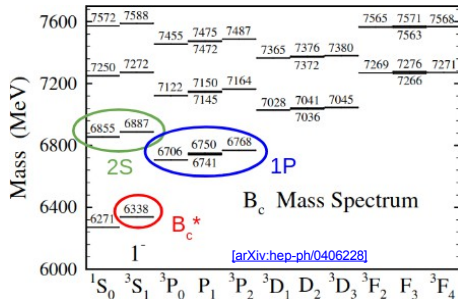
Observation of B_c^* .

New May 2026

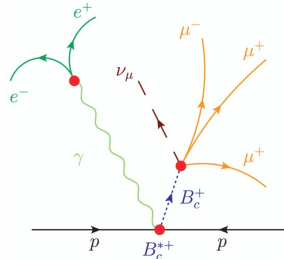
B_c 1P and 2S states observed at LHC

B_c^* challenging

- small mass splitting ($\sim 50\text{-}70$ MeV)
- $B_c^* \rightarrow B_c \gamma$ with very soft γ



- B_c^+ reconstructed as $B_c^+ \rightarrow J/\psi(-\mu\mu)\mu\nu X$
 - Converted γ reconstructed from e^+e^- with tracking down to 100 MeV
 - Observed with $>8\sigma$
 - $\Delta m(B_c^*, B_c) = 65.5 \pm 1.4(\text{stat})_{-1.4}^{+1.0}(\text{syst}) \text{ MeV}$
- First observation of B_c^*



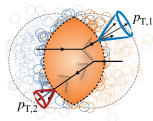
Quark-gluon-plasma in light ion collisions?

New June 2026

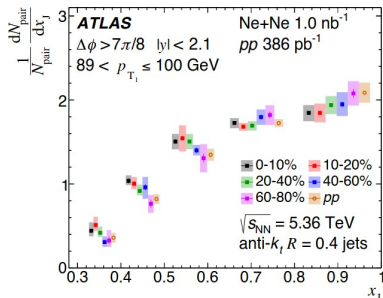
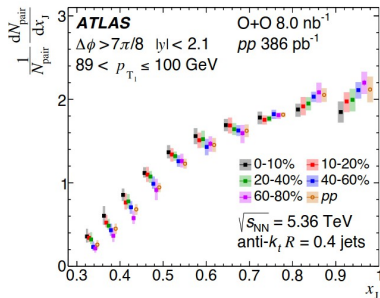
Formation of quark-gluon-plasma established in heavy ion collisions

Direct probe: parton energy loss $\rightarrow$ in dijets: different path length in medium leads to momentum imbalance (first seen in Pb+Pb in 2010)

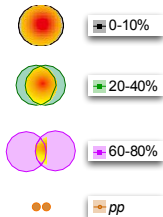
How about lighter ions?



$$X_J = \frac{p_{T,2}}{p_{T,1}}$$



centrality



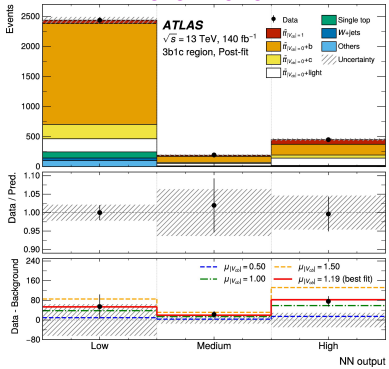
- Systematically increasing modification with increasing centrality
- Significant modification ($>5\sigma$) out to 20-40% for O+O and 10-20% for Ne+Ne

Clear observation of parton energy loss in O+O and Ne+Ne collisions

A few selected other new results.

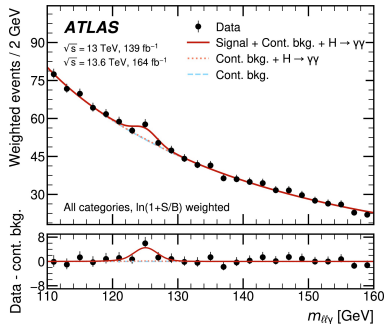
[JHEP 07 (2026) 078]
 [CERN-EP-2026-223]
 [arXiv:2606.14362]

March 2026



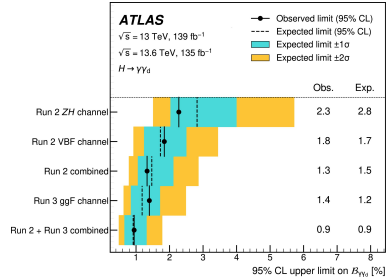
First $|V_{cb}|$ measurement
 in $t\bar{t}$ decays
 $|V_{cb}| = (50^{+11}_{-14}) \times 10^{-3}$

New for ICHEP



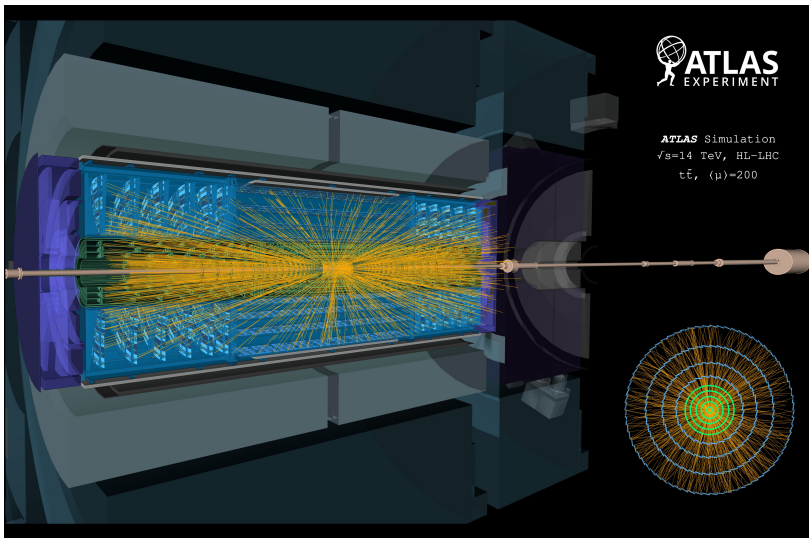
$H \rightarrow \ell\ell\gamma$ ($m_{\ell\ell} < 30 \text{ GeV}$)
 with 2022-2024 data:
 3.4σ (3.3σ exp.)
 combined with Run 2

New May 2026



Search for $H \rightarrow \gamma\gamma_d$
 with 2023+2024 data:
 new trigger to target
 gluon fusion production
 $B(H \rightarrow \gamma\gamma_d) < 0.9\%$
 at 95% CL
 combined with Run 2

Towards the future: Upgrades for HL-LHC.



HL-LHC data taking
scheduled to start in 2030

Aim to increase dataset to
 3000 fb^{-1}

Pileup 140-200

Detector upgrades to cope
with high occupancies and
harsh radiation

Towards the future: Upgrades for HL-LHC.

Improved muon coverage

Inner barrel: new RPC and SMDT detectors
→ Better trigger efficiency and reduced fakes
Improved forward (TGC) coverage

New trigger and readout

First-level trigger at 1 MHz (10x LHC): complete event with full-granularity calo data at hardware trigger level (in addition to high-resolution muon trigger) → allows global trigger with higher-level features

Luminosity detectors and beam conditions monitors

New LUCID for %-level lumi
New diamond-based BCM
New Pixel luminosity ring

New electronics

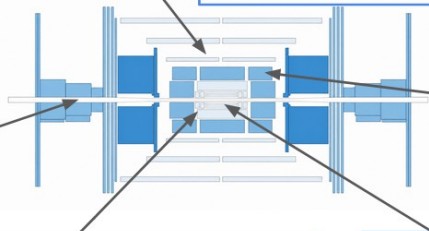
For LAr, Tile, and muon spectrometer

New high-granularity timing detector (HGTD)

30-50 ps time resolution per track for pileup rejection
 $2.4 < |\eta| < 4$

New silicon tracker (ITk)

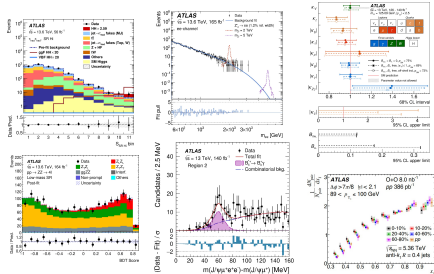
Pixels and strips (50x more channels)
Coverage up to $|\eta| < 4$
10x higher radiation tolerance



Conclusions.

New ATLAS results probe the electroweak and strong sectors of the SM, and search directly for BSM physics

- Detailed characterization of the Higgs boson
- First observation of $Z_L Z_L$ and first evidence for VBS $W Z_L$
- Most sensitive $H H$ search in $H H \rightarrow b\bar{b}t\bar{t}$
- Much improved limits on $Z' \rightarrow \ell\ell$
- First observation of B_c
- Observation of parton energy loss in light ion collisions
- And more...



More results and details in the talks by Meng Xiao, Reina Camacho Toro, Marco Vanadia, Michael Pitt, Yurii Maravin, Carla Gobel Burlamaqui De Mello, Fabrizio Groza, and in the parallel sessions



Good progress on detector upgrade
– we are building a much better detector for HL-LHC



CMS Highlights

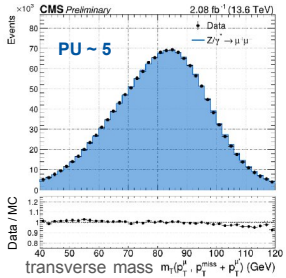
Andreas B. Meyer
on behalf of CMS
ICHEP 2026, Natal

CMS data

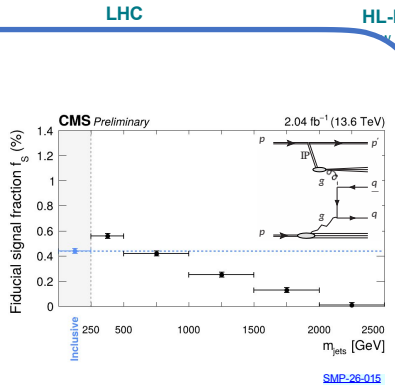
Run 3 is a game changer

CMS

- pp 2022 13.6 TeV, 41.5 fb⁻¹
- PbPb
- pp low-pileup 2026
- pp very high pileup
- pp (2.4 TeV)
- pp (5.36 TeV)
- p0
- 00



Excellent description of the new data by MC



Fraction of jet events with an intact forward proton

First results from the large low-pileup run recorded in April this year



CMS Physics

A multi-frontier program

>1500 Physics papers by CMS

Standard model:

- Precision
- QCD, electroweak, top
- Higgs boson properties

Flavour factory:

- Spectroscopy
- Fragmentation
- CP violation
- Rare decays

Heavy- and light-ion physics:

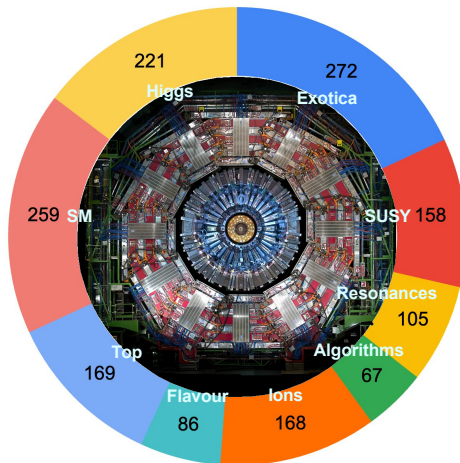
- Medium response, quark-gluon plasma
- Ultra-peripheral collisions

Search frontiers:

- Energy
- Luminosity
- Long lifetime
- Low mass
- Anomaly detection
- Trigger-less data taking

Detectors, technology, and algorithms:

- Physics performance
- Machine learning
- Statistical techniques



In Run 3, several frontiers significantly strengthened

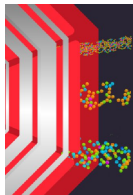


HLT Scouting

Trigger-level analysis: do more with less

- Higher-level trigger (HLT):
hybrid CPU + GPU system to reconstruct and select events
- HLT input/output rates: $\sim 110/40$ kHz
- Scouting: high-level trigger objects only (15 kB/event)

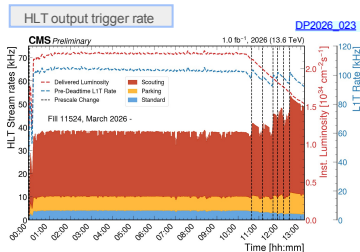
[PR 1115 \(2025\) 678](#)



Scouting: ~ 30 kHz
15 kB/event

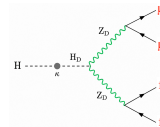
Parking: ~ 6 kHz
1 MB/event

Standard: ~ 4 kHz
1 MB/event

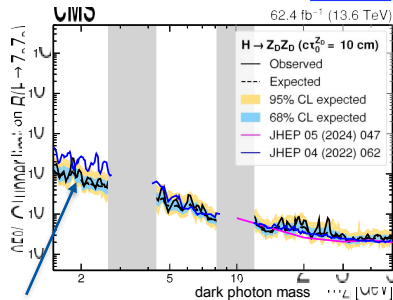


[DP2026_097](#)

- 600 B Scouting events recorded in Run 3



[arXiv:2606.25840](#)



Run 3
Scouting

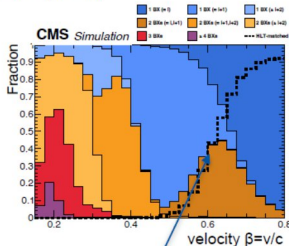
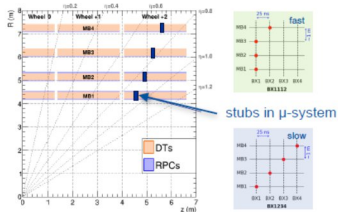
Reach lower mass and longer lifetimes



L1 Scouting

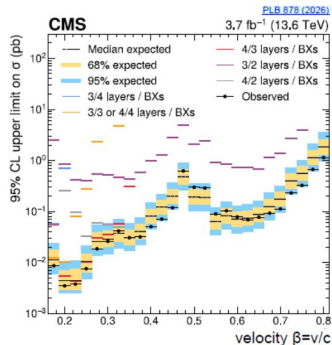
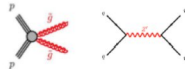
Trigger-less recording at 40 MHz

- Record the full L1 trigger information for full LHC orbits
- HL-LHC demonstrator system in operation since 2024
- First physics result:**
Search for heavy stable charged particles (HSCP)



Standard HLT: $\beta \approx 0.6$

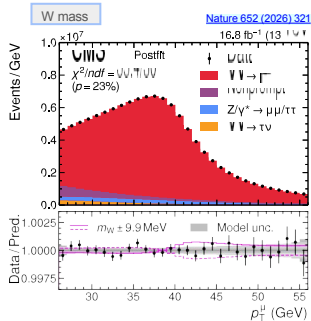
Limits as low as few fb at $\beta=0.2$



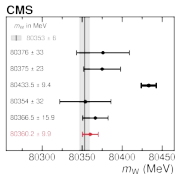


W boson measurements

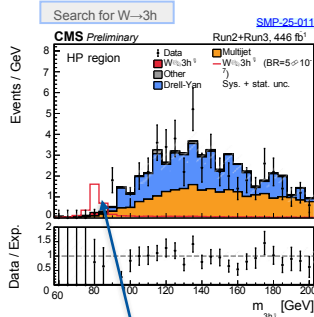
Highest precision to highest luminosity



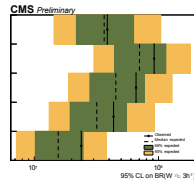
Electroweak fit
PDG 110 (2024) 030001
LEP combination
Phys. Rep. 532 (2013) 119
D0
PRL 108 (2012) 151804
CDF
Science 375 (2022) 6889
LHCb
JHEP 01 (2022) 036
ATLAS
EPJ C 84 (2024) 1309
CMS
This work



$$m_W = 80360.2 \pm 9.9 \text{ MeV}$$



Expected signal for
 $B(W \rightarrow 3h) = 5 \times 10^{-7}$



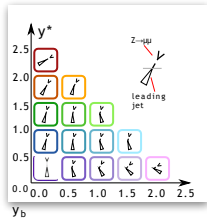
$$B(W \rightarrow 3h) < 2.4 \times 10^{-7} \text{ @95\%CL}$$

cf. Yuri Maravin's talk on Wednesday

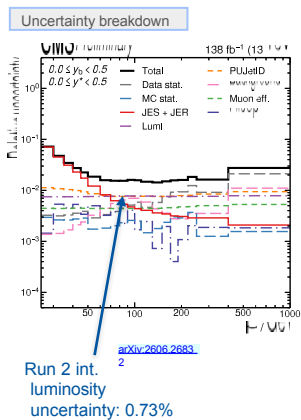
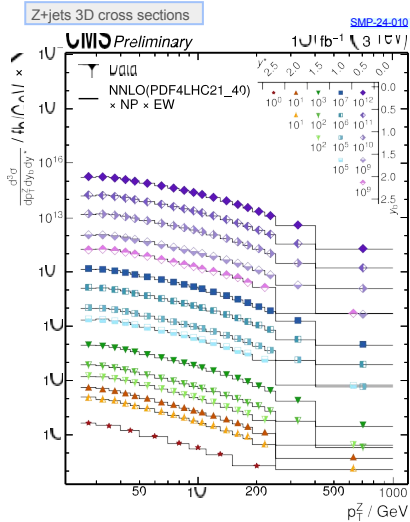
Triple differential Z+jets cross section

Test and improve QCD calculations

- Unfolded in $p_T(Z)$, y_b , y^*
- Key input to constraining parton density distributions
- Complementary to dijet cross sections



cf. Michael Pitt's talk on Wednesday



Bulk uncertainty: 1.5%

Vector boson and lepton-lepton scattering

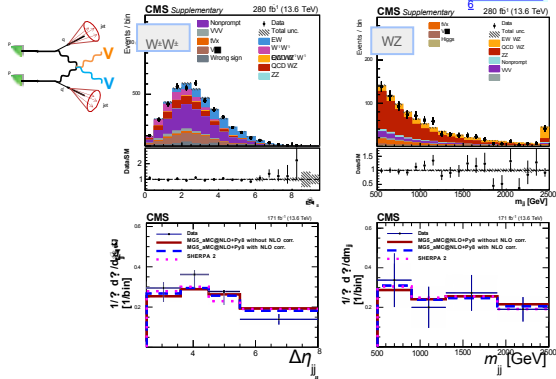
The LHC is also a boson, a photon, and a lepton collider

- Run 2: evidence for VBS in all massive-V channels, also in $\gamma\gamma$ -collisions

[SMP-24-013](#)

- Run 3: first differential VBS cross sections

[JHEP 06 \(2026\) 187](#)

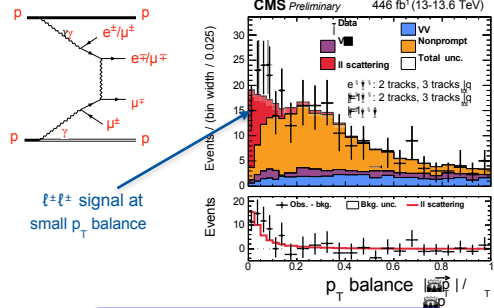


- $\ell^+\ell^-$ scattering:

Events with 4 or less tracks

3 categories ($\mu^+\mu^+$, $e^+\mu^+$, $\mu^+\mu^+\mu^-$)

[SMP-26-008](#)



$\ell^+\ell^-$ signal at small p_T balance

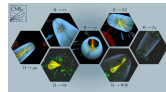
Observation:

$\ell^+\ell^-$ scattering: 5.4σ (6.0σ exp.)

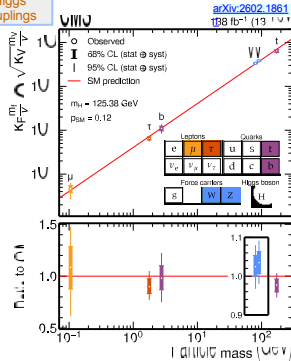
$\mu^+\mu^+$ scattering: 4.0σ (5.1σ exp.)

Higgs: from pieces to precision

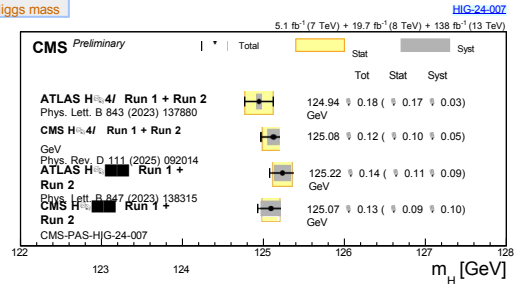
<https://cms.cern/news/building-the-higgs-bosons-truest-portrait-to-date>



Higgs couplings



Higgs mass



Run 2 STXS

$$\sigma/\sigma_{SM} = 1.014 \pm 0.028_{stat} \pm 0.025_{exp} \pm 0.040_{theo}$$

CMS combination (Run 1+2):

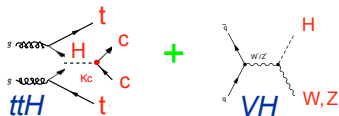
$$m_{Higgs} = 125.07 \pm 0.09(stat) \pm 0.10(syst) \text{ GeV}$$

Run 2 Legacy: Higgs physics entering precision regime

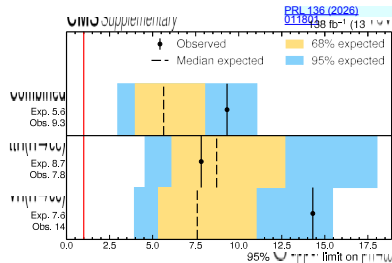
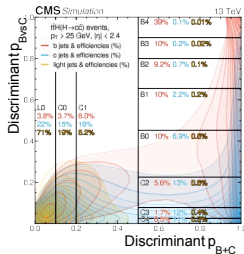
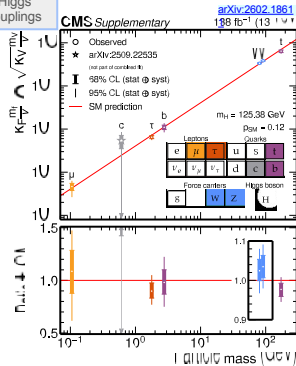
cf. Meng Xiao's talk later today

Higgs to charm

<https://cms.cern/news/topping-charming-higgs>



Higgs
couplings

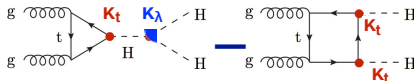


Run 2 combination of VH and ttH
 $\mu(H \rightarrow cc) < 9.3$ (5.6 exp.) $|K_c| < 3.5$ (2.7 exp.)

Charm had been considered impossible at the LHC

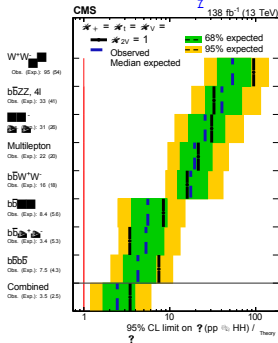
HH production

Determine the Higgs self-coupling

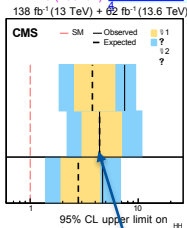


CMS Run 2

arXiv:2510.0752



HH→4b

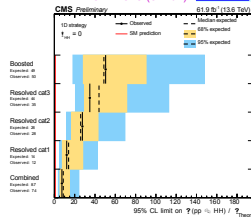
Run 2 + 22/23 (200 fb⁻¹) arXiv:2604.2704

Run 2
Obs. 7.5
Exp. 3.8

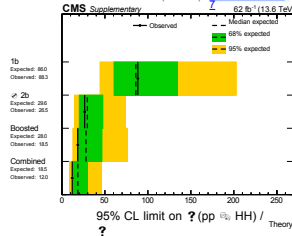
Run 3
Obs. 4.4
Exp. 4.4

Combination
Obs. 4.7
Exp. 2.8

HH→bbγγ

2022/2023 (62 fb⁻¹) HIG-25-007

HH→bbWW→bbττν

2022/2023 (62 fb⁻¹) arXiv:2604.0212

ATLAS + CMS Run 2

arXiv:2602.2399

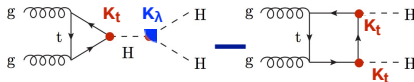
$$\mu_{\text{HH}} = 0.8 \pm 0.9$$

Run 3: same
sensitivity with half the
luminosity

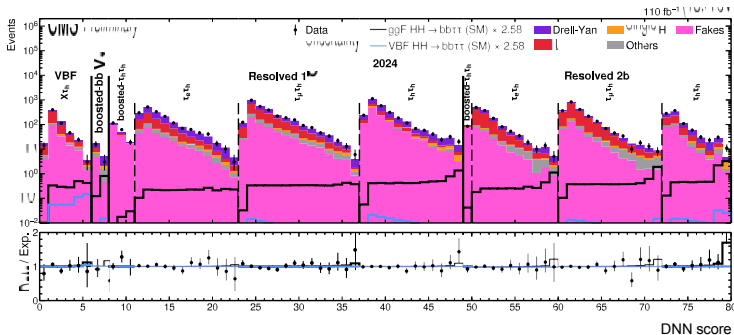
Run 3: significant improvements in
triggering, flavour tagging, and analysis methods

HH production

Determine the Higgs self-coupling



HH $\rightarrow$ bb $\tau\tau$

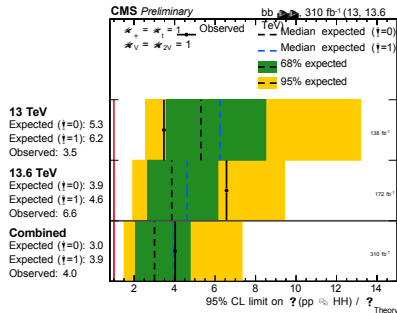


2016–2024 (310 fb $^{-1}$)

$$\mu(\text{HH} \rightarrow \text{bb}\tau\tau) < 4.0 \text{ (3.0 exp) } \times \text{SM at 95\% CL}$$

Results with partial Run 3 available in all significant HH channels

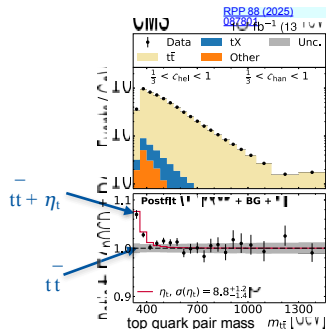
HIG-25-008
(to appear)



Excess at the $t\bar{t}$ threshold

Consistent with pseudoscalar toponium

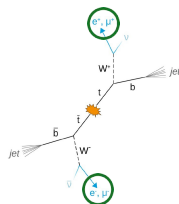
- 2024: first observed by CMS in the dilepton channel



Dileptons: CMS: $8.8^{+1.2}_{-1.4}$ pb

ATLAS: $13.1^{+1.9}_{-1.7}$ pb

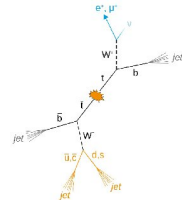
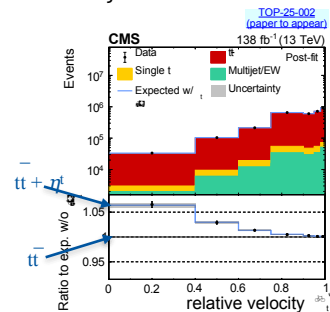
NRQCD prediction: 6.4 pb



Fit in $m_{t\bar{t}}$ in bins of c_{hel} and c_{han}

$c_{hel} = \cos(\theta_t)$ in t rest frame

- 2026: independent analysis in the ℓ +jets channel



Fit in β_t^* , c_{hel} , c_{han} , S_{NN} and b tag

β_t^* : velocity of t in $t\bar{t}$ rest frame,
 S_{NN} : $t\bar{t}$ reco significance

$$\sigma(\eta_t) = 5.3^{+0.9}_{-0.9} \text{ pb}$$

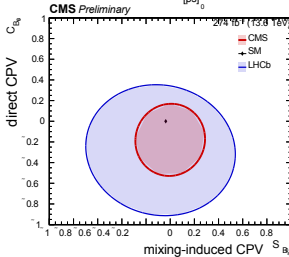
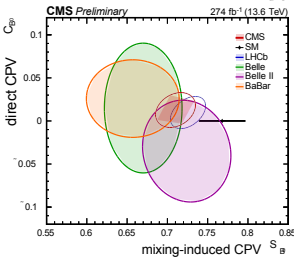
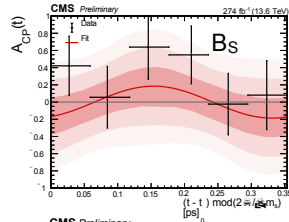
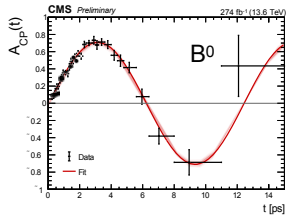
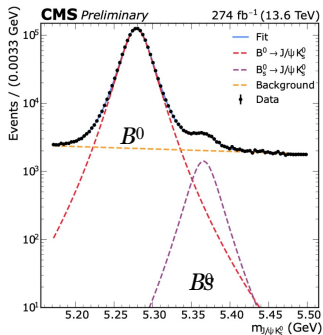
CMS confirming excess in complementary final state

Time-dependent CP violation in $B^0_{(s)} \rightarrow J/\psi K_S$

Made possible by the Run 3 dimuon trigger strategy

Run 3 2022–2025 (274 fb⁻¹)

- 1.4M B^0 and 16k B_s candidates
- State-of-the-art flavour tagging



CMS competitive precision

1 Introduction

In the standard model (SM), CP violation (CPV) arises from a single irreducible complex phase in the Cabibbo–Kobayashi–Maskawa (CKM) matrix, which governs charged-current weak interactions among quarks. Precision measurements of CP -violating observables in $B_{(s)}^0$ -meson decays provide stringent tests of the SM description of flavour physics, and offer sensitivity to contributions from physics beyond the SM (BSM) at energy scales beyond the direct reach of collider searches [1]. In neutral B-meson systems, CPV manifests through the interference between direct decay and decay following flavour oscillation, and can be quantified through the time-dependent asymmetry $a_{CP}(t)$ between initially produced $B_{(s)}^0$ and $\bar{B}_{(s)}^0$ mesons decaying to a common CP eigenstate f :

$$a_{CP}(t) = \frac{S_f \sin(\Delta m t) - C_f \cos(\Delta m t)}{\cosh(\Delta \Gamma t/2) - D_f \sinh(\Delta \Gamma t/2)}, \quad (1)$$

where Δm and $\Delta \Gamma$ are the mass and decay-width differences between the heavy and light neutral $B_{(s)}^0$ mass eigenstates, respectively, and S_f , C_f , and D_f describe mixing-induced and direct CP violation effects. S_f and C_f are the primary observables of this measurement.

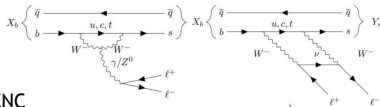
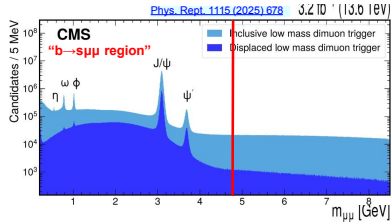
Among the many B-meson decay modes accessible at hadron colliders, decays to final states containing a charmonium resonance are particularly well suited for this programme. The decay $B^0 \rightarrow J/\psi K_S^0$ proceeds predominantly through the $b \rightarrow c\bar{c}s$ transition, whose amplitude is dominated by a single weak phase, which results in small and well-controlled theoretical uncertainties. In the SM, neglecting higher-order contributions from penguin diagrams, the parameters satisfy $S_f = \sin 2\beta$ and $C_f = 0$, where $\beta = \arg[-(V_{cd}V_{cb}^*)/(V_{td}V_{tb}^*)]$ is one of the angles of the CKM unitarity triangle. The parameter $\sin 2\beta$ has been measured with high precision at $B_{(s)}^0$ factories and LHCb [2–8], and it remains a cornerstone of global CKM fits. The best measurement of these parameters in the $J/\psi K_S^0$ final state is $S = 0.726 \pm 0.014$ and $C = 0.010 \pm 0.012$ from the LHCb Collaboration, combining data collected in the LHC Run 1 and Run 2 [8]. However, the theoretical cleanliness of this mode rests on the hypothesis that penguin contributions are negligible, and controlling this assumption requires input from topologically related decay modes [9, 10].

The $SU(3)$ -partner decay $B_s^0 \rightarrow J/\psi K_S^0$ provides precisely such a handle. This decay proceeds through a CKM-suppressed but topologically similar transition, offering direct sensitivity to the weak phase $\beta_s \equiv \arg[-(V_{tb}^*V_{ts})/(V_{cb}^*V_{cs})]$. Moreover, the comparison of CPV parameters between the two modes allows penguin-induced shifts in the interpretation of $\sin 2\beta$ to be constrained [11, 12]. Subleading hadronic contributions of this kind represent one of the dominant sources of uncertainty in BSM interpretations of CPV measurements, and their control is therefore of broad importance to the field. CP violation in $B_s^0 \rightarrow J/\psi K_S^0$ has previously been studied by the LHCb Collaboration [13]; a simultaneous measurement of both modes within a single experiment provides a coherent and self-consistent probe of the SM flavour structure.

This note presents a measurement of time-dependent CP violation in $B_{(s)}^0 \rightarrow J/\psi K_S^0$ decays, reconstructed through the $J/\psi \rightarrow \mu^+\mu^-$ and $K_S^0 \rightarrow \pi^+\pi^-$ final states, using proton–proton (pp) collision data at $\sqrt{s} = 13.6$ TeV collected with the CMS detector at the CERN LHC during 2022–2025, corresponding to an integrated luminosity of approximately 274 fb^{-1} . The CP -violating parameters S and C for both decay modes are extracted from fits to the time-dependent CP asymmetry. The initial B-meson flavour at production is inferred using dedicated flavour-tagging algorithms, and experimental effects that dilute the observed asymmetry are carefully accounted for. Throughout this note, charge-conjugate states are implied, and the symbol $B_{(s)}^0$ denotes either a B^0 or $\bar{B}_s^0$ meson unless stated otherwise.

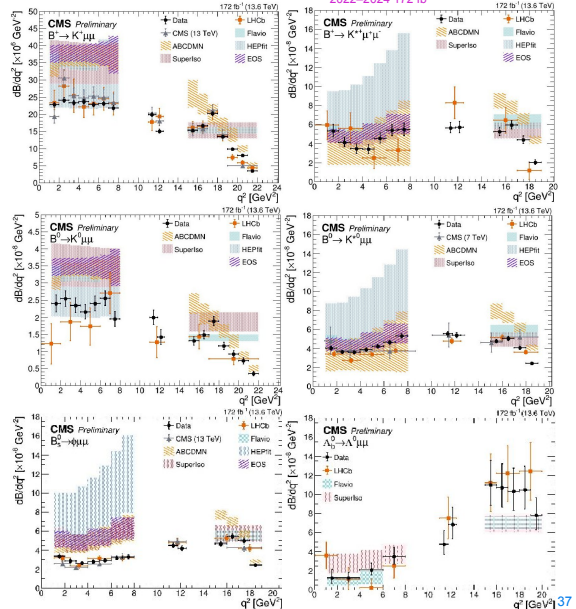
$b \rightarrow s \mu \mu$ differential branching ratios

CMS is a 4π flavour factory for final states with muons



- $b \rightarrow s$: FCNC
BR $\sim 10^{-7} \Rightarrow$ sensitivity to new physics
- Also measured: isospin asymmetry, $R(\psi(2S))$

Six different channels measured simultaneously
— most precise measurements to date



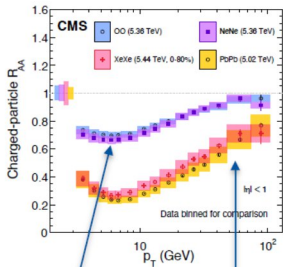
Quark-gluon plasma in light ions

pO, OO and NeNe collision data recorded in July 2025

- System-size dependence of charged-particle R_{AA}

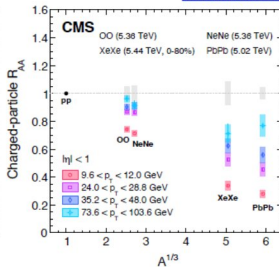
$$R_{AA} = \frac{1}{A^2} \left[\left(\frac{d\sigma^{AA}}{dp_T} \right) / \left(\frac{d\sigma^{PP}}{dp_T} \right) \right]$$

PLB 880 (2026) 140679



suppression observed in OO and NeNe

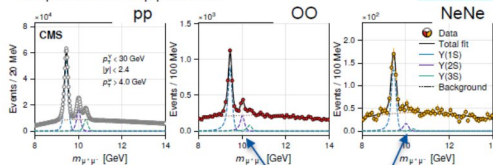
R_{AA} measured up to 100 GeV



Linear dependence on nucleon radius

- Sequential Y suppression

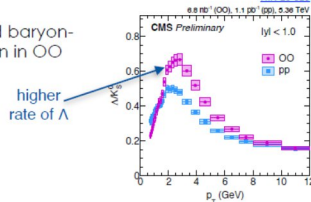
arXiv:2607.13758



Y(2S) and Y(3S) suppression in OO and NeNe

- Enhanced baryon-production in OO

HIN-25-020



Almost all signatures of QGP formation also measured in light ions — within just one year since the data taking

CMS public results

July 2026



July 2026

 $\sqrt{s} = 13, 13.6 \text{ TeV}, \quad \mathcal{L} = 36\text{--}283 \text{ fb}^{-1}$

<http://www.summarysearches.com/chloro-01.html>

[improvements-counting.com/searches.do](http://www.improvements-counting.com/searches.do)

Leptoquarks

Overview of CMS long-lived particle searches

July 20

[https://cms-summary-](https://cms-summary-searches.docs.cern.ch/1/b-bar/)
[searches.docs.cern.ch/1/b-bar/](https://cms-summary-searches.docs.cern.ch/1/b-bar/)

SUSY RPV

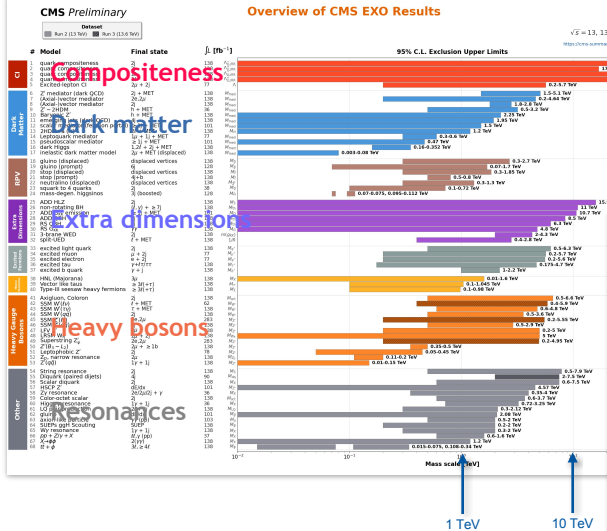
SUSY RPC

Extended Higgs

Selection of observed exclusion limits at 95% C.L. (theory uncertainties are not included). The y-axis tick labels indicate the studied long-

ICHP Nata 2026

39



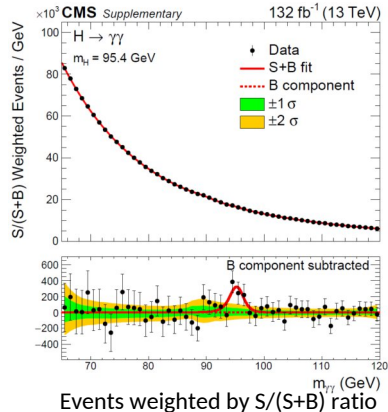
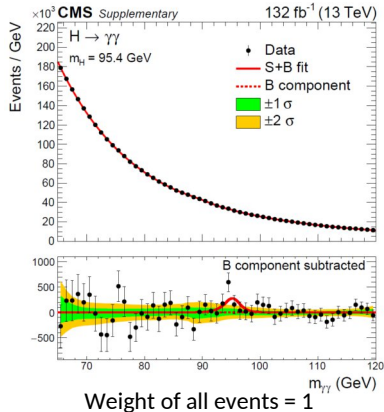
“Search for a standard model-like Higgs boson in the mass range between 70 and 110 GeV in the diphoton final state in proton-proton collisions at $\sqrt{s} = 13$ TeV”

<https://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-20-002/index.html>

Phys. Lett. B 860 (2024) 139067

<https://arxiv.org/pdf/2405.18149> v1 24/05/2024, v2 06/01/2025

Full Run 2, 132.2 fb (2016-18) 🐼 2.9 sigma local, 1.3 sigma global (i.e. corrected for LEE)



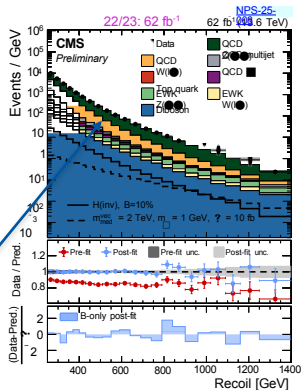
Searches for invisible or long-lived particles

Benefit from higher Run 3 energy and triggers

Monojets

- Jet(s) + invisible
- Generic p_T^{miss} “precision search”
 - Dark matter
 - $H \rightarrow \text{invisible}$
 - Extra-dimensions
 - ...

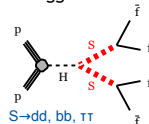
$Z \rightarrow \nu\nu$ background from fit to $Z \rightarrow \ell\ell$, $W \rightarrow \ell\nu$, $\gamma + \text{jets}$



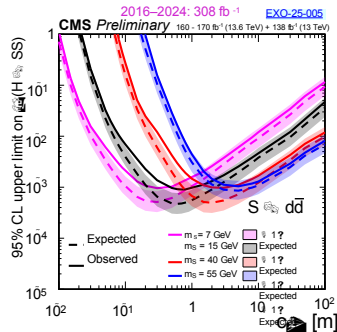
For $m_{\text{DM}} \sim 1 \text{ GeV}$, $m_{\text{med}} < 1.9 \text{ TeV}$
 $B(H \rightarrow \text{inv.}) < 42\%$ (39% exp.) at 95% CL

Muon detector showers

- Long-lived particles showering in the μ system
- High-multiplicity μ -trigger since Run 3
- Twin-Higgs scenario



Limits on $B(S \rightarrow dd, bb, \tau\tau)$ for τ between 1 cm and 100 m



Most stringent limits to date

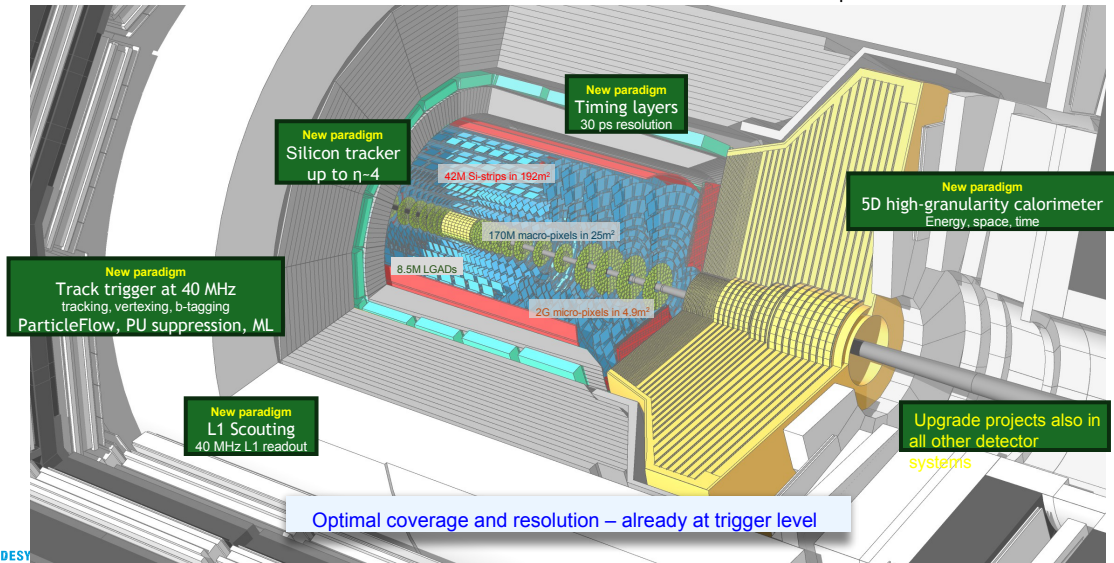


CMS upgrade

Build the best possible detector for HL-LHC

HL-LHC
2030–2041

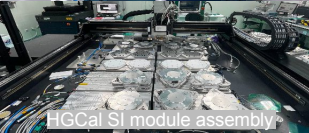
3 ab^{-1} at up to $7.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$



CMS Upgrade status



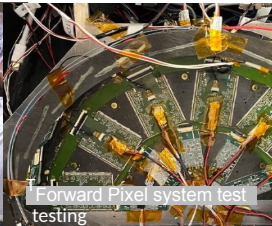
HGCal Cassette assembly



HGCal SI module assembly



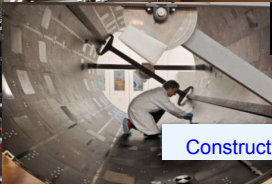
HGCal absorber



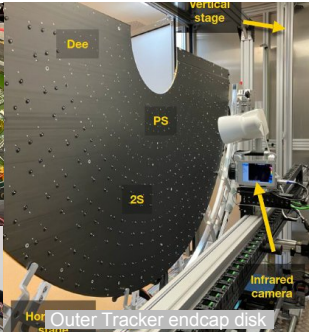
Forward Pixel system test testing



Barrel timing layer trays



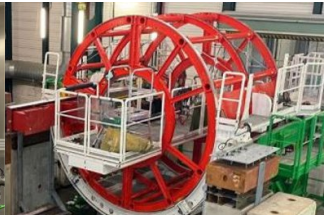
Barrel timing support tube



Outer Tracker endcap disk



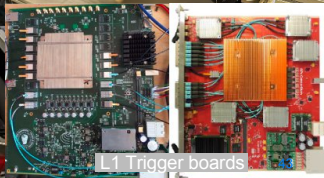
Inner Tracker modules



ECAL "Enfourneurs" mounting device



Drift Tubes muon detector



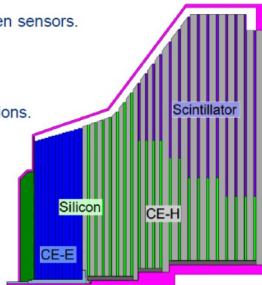
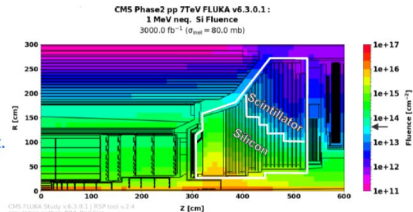
L1 Trigger boards

Construction in full swing

Proposed Detector – HGCAL

- HGCAL needs to fit in the envelope of the previous calorimeters (EE and HE) and provide **high granularity, radiation-tolerance (2 MGy), and efficient readout.**
- Each HGCAL is **5.4 m in diameter** and weighs about **230 tonnes.**
- The **electromagnetic part (CE-E)** is designed with fine longitudinal resolution, and thin absorber layers of lead and CuW/copper between the active layers.
- The **hadronic part (CE-H)** has thick stainless-steel absorbers between sensors.
- Active sensors cover **$\approx 1000 \text{ m}^2$ total over both endcaps.**
 - Silicon sensors** as active material in the front sections.
 - Plastic **scintillator tiles**, read out by SiPMs, in lower radiation regions.
- Challenges:**
 - Engineering (electronics, mechanical, and thermal).**
 - Data transmission,** and level-1 (L1) trigger formation.

See presentations by Aidan Grummer (front-end electronics and readout) and Stavros Mallios (back-end electronics).
Andre Stahl will be presenting reconstruction and performance.



Both Endcaps	Silicon	Scintillator
Area	$\sim 620 \text{ m}^2$	$\sim 370 \text{ m}^2$
Channel Size	$0.5 - 1.2 \text{ cm}^2$	$4 - 30 \text{ cm}^2$
# Channels	$\sim 6\text{M}$	$\sim 280\text{k}$
# Modules	$\sim 26\text{k}$	$\sim 4\text{k}$
Op. Temp.	-35°C	-35°C

Per Endcap	CE-E	CE-H
	Si	Si+Scint.
Absorber	Pb, CuW, Cu	SS, Cu
Depth	$27.7 X_0$	10λ
Layers	26	7 14
Weight	23 t	205 t

HGCAL cross-section (~axisymmetric)



T. French / CALOR2024 /
Tsukuba / 24th May 2024

<https://indico.cern.ch/event/1339557/contributions/5919422/attachments/2863068/5009668/Overview%20of%20CMS%20HGAL%20CALOR24.pdf>

Testing entanglement and Bell inequalities in $H \rightarrow ZZ$ J. A. Aguilar-Saavedra^{*,} A. Bernal[†], J. A. Casas[‡], and J. M. Moreno[§]*Instituto de Física Teórica, IFT-UAM/CSIC, Universidad Autónoma de Madrid,
Cantoblanco, 28049 Madrid, Spain*

(Received 4 October 2022; accepted 3 January 2023; published 20 January 2023)

We discuss quantum entanglement and violation of Bell inequalities in the $H \rightarrow ZZ$ decay, in particular when the two Z -bosons decay into light leptons. Although such process implies an important suppression of the statistics, this is traded by clean signals from a “quasi maximally entangled” system, which makes it very promising to check these crucial phenomena at high energy. In this paper we devise a novel framework to extract from $H \rightarrow ZZ$ data all significant information related to this goal, in particular spin correlation observables. In this context we derive sufficient and necessary conditions for entanglement in terms of only two parameters. Likewise, we obtain a sufficient and improved condition for the violation of Bell-type inequalities. The numerical analysis shows that with a luminosity of $L = 300 \text{ fb}^{-1}$ entanglement can be probed at $> 3\sigma$ level. For $L = 3 \text{ ab}^{-1}$ (HL-LHC) entanglement can be probed beyond the 5σ level, while the sensitivity to a violation of the Bell inequalities is at the 4.5σ level.

<https://arxiv.org/pdf/2603.26463>

Measurements of Z -boson pair entanglement in decays of Higgs bosons at the ATLAS experiment

<https://atlas.cern/Updates/Briefing/Run3-Higgs-4/>

ATLAS explores quantum entanglement using Higgs boson decays, while charting its properties

<https://cds.cern.ch/record/2949823/files/HIG-25-011-pas.pdf>

“Study of spin correlations in Higgs boson decays to four leptons at CMS”

(Abstract) ... Implications regarding quantum entanglement and the violation of a Bell-type inequality are discussed.

But, some **strong arguments** doubting (or just convincingly excluding) the feasibility of tests of local realism via Bell's inequalities at colliders are stated and published since (at least) LEP times :

1) Phys. Lett. B, vol. 280, pp. 304–312, 1992

https://www.academia.edu/92495433/Testing_locality_at_colliders_via_Bells_inequality

2) Bell's inequality and tau-physics at LEP, H. Dreiner (TAU92 W-shop, Columbus, OH, 09/1992)

<https://arxiv.org/abs/hep-ph/9211203>

3) «A critical appraisal of tests of locality and of entanglement versus non-entanglement at colliders»

<http://www.arxiv.org/abs/2507.15947>

4) «Colliders are testing neither Locality via Bell's Inequality nor Entanglement versus Non-Entanglement»

<http://www.arxiv.org/abs/2507.15949>

5) “Addressing Local Realism through Bell Tests at Colliders”, M. Low, U. of Pittsburgh

<https://arxiv.org/pdf/2508.10979> v2, 30/10/2025

Quantum Observables for Collider Physics 2026 w/shop (20-24/04/2026, CERN)

“Measurements of Z-boson pair entanglement in $H \rightarrow Z Z^*$ at ATLAS”, Tairan Xu, UofMichigan
https://indico.cern.ch/event/1603106/contributions/7003930/attachments/3259565/5819424/ATLAS_QEHZZ_042126.pdf

“Mapping the quantum state of the $H \rightarrow Z Z$ at CMS”, Jeffrey Davis, John Hopkins U
https://indico.cern.ch/event/1603106/contributions/7003925/attachments/3259507/5819303/Quantum_Observables_2026.pdf

“Opportunities, assumptions and limitations for QI measurements at the LHC”, F. Cerutti
<https://indico.cern.ch/event/1603106/contributions/7004113/attachments/3260255/5820808/QI-CERN-ws-April22.pdf>

(Some of) the items of the talk:

Assumptions, Limitations, (Answers to – added by A.M.) Criticisms

No talks from criticsers (of feasibility of local realism tests via Bell's inequalities at colliders) !

More or less balanced formulation in

<https://cds.cern.ch/record/2949823/files/HIG-25-011-pas.pdf>

“Study of spin correlations in Higgs boson decays to four leptons at CMS”

2.4 Quantum entanglement

The polarization density matrix in $H \rightarrow ZZ$ decays has recently attracted significant attention, owing to its relevance to the quantum entanglement between the spin states of the two particles, as discussed in Refs. [36–40] and references therein. It has even been suggested that a test of locality via Bell-type inequalities or a test of entanglement versus non-entanglement could be performed in such a system.

However, Relativistic Quantum Mechanics (QM) was assumed in deriving the polarization density matrix, evident following the reasoning behind Eq. (18). The spin polarization states are not measured directly but are inferred from the momenta of the final-state particles, which determine the angular distributions in Eq. (18). As a result, it is not possible to definitively rule out non-entanglement or test locality through a Bell-type inequality [51–53]. (= ref. 1,3,4 on page 46)

Nonetheless, it remains possible to test the consistency of the observed states with quantum entanglement and potential violation of the Bell-type inequality, providing a means to scrutinize the predictions of the SM. Entanglement is a phenomenon in which the state of one particle cannot be described independently of the state of another. It is a fundamental feature of QM.

while assuming the validity of QM to test its own validity may not yield fundamentally new information, unless violation is observed, entanglement remains a phenomenon that can be experimentally investigated.



ICHEP 2026

JULY 30 - AUGUST 5 | 2026 | NATAL, BRAZIL

43rd INTERNATIONAL CONFERENCE
ON HIGH ENERGY PHYSICS

Thank you!



ICHEP 2026
NATAL | BRAZIL

CMS Backup



New CMS results for ICHEP

<https://cms.cern/news/cms-ichep-2026>



at



CMS

ICHEP 2026

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CMS Physics Analysis
Summaries

Title	CDS Link	De
Search for a heavy resonance decaying into a Higgs boson and a new scalar boson using the bb $\gamma\gamma$ final state	B2G-24-019	138 fb $^{-1}$
Search for new resonances decaying into a pair of Higgs bosons in the bb $\tau\tau$ final state	B2G-24-011	138 fb $^{-1}$
Search for a new resonance decaying to a Higgs boson and a scalar boson in events with two b jets and two Z bosons	B2G-24-002	138 fb $^{-1}$
Search for rare leptonic decays of neutral K mesons	BPH-25-005	287 fb $^{-1}$ 2022-2025
Simultaneous dBF/dq 2 measurement of b $\rightarrow$ s $\mu\mu$ decays with Run 3 data	BPH-24-005	170 fb $^{-1}$ 2022-2024
Observation of $\eta\rightarrow 2\mu 2\pi$ and improved measurement of the branching fraction for η to 4 μ	BPH-26-004	62.6 -1 22/23
Measurement of the differential cross section for inclusive isolated photon production in proton-proton collisions	SMP-25-004	27 fb $^{-1}$ 2022
Search for W boson decays to 3 charged hadrons	SMP-25-011	446 fb $^{-1}$ (2016–2026)
Constraints on Effective Field Theory operators from multiboson production measurements	SMP-25-002	138 fb $^{-1}$
Measurement of 4 point energy correlator projections in Z+jet events	SMP-25-009	60 fb $^{-1}$ (2018)
Study of lepton scattering	SMP-26-008	446 fb $^{-1}$ (2016–2026)
Measurement of double-differential groomed and ungroomed jet mass cross sections in Z+jet events with the CMS experiment	SMP-26-010	138 fb $^{-1}$
Observation of the production of high- p_T jets or electroweak bosons with an intact forward proton	SMP-26-015	2 fb $^{-1}$ (2026)
Study of WW production in the channel with a light lepton and an hadronic tau	SMP-24-011	62 fb $^{-1}$ (22/23)
Measurement of the Vcb element of the CKM matrix from top quark pair events in proton-proton collisions at 13 TeV	TOP-26-001	138 fb $^{-1}$
HH $\rightarrow$ bb τ (non-resonant), resolved+semi-boosted	HIG-25-008	310 fb $^{-1}$
t $\bar{t}$ HH(4b)	HIG-24-016	138 fb $^{-1}$
Search for exotic decays of the Higgs boson into a pair of light bosons with two b jets and two photons in the final state	SUS-24-008	138 fb $^{-1}$
Search for new phenomena in events with energetic jets and large missing transverse momentum	NPS-25-008	62 fb $^{-1}$ (22/23)
Boosted H(125) $\rightarrow$ aa $\rightarrow$ bbbb	NPS-25-005	138 fb $^{-1}$
Search for inelastic dark matter with low-momentum displaced electrons	EXO-24-036	138 fb $^{-1}$
Search for LLPs with Muon Detector Showers in Run 3	EXO-25-005	310 fb $^{-1}$ (2016–2024)
Search for Higgs compositeness effects in high-mass dilepton final states	EXO-25-001	207 fb $^{-1}$ (2016–2023)
Search for long-lived particles decaying to photons in decays of the Higgs boson	EXO-23-012	138 fb $^{-1}$
Search for nonresonant production of strongly coupled dark matter	EXO-24-010	138 fb $^{-1}$
Search for a right-handed W boson decaying into a tau-flavored heavy neutral lepton	EXO-24-024	138 fb $^{-1}$
Measurement of the jet quenching effect with Z + jet events in pp and PbPb collisions	HIN-25-017	1.64 nb $^{-1}$ and 479 pb $^{-1}$
AXOL1TL+CICADA	MLG-25-001	2024

New CMS results for ICHEP

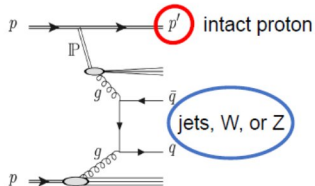
<https://cms.cern/news/cms-ichep-2026>



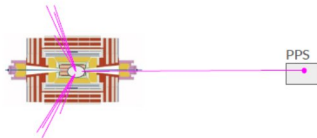
CMS Detector Performance
Notes

Title	CDS Link
Output rates and bandwidths of the High-Level Trigger during 2025 & 2026 PbPb runs	DP-26-094
Identifying quenched jets in CMS using machine learning	DP-26-095
Pixel detector performance in 2025	DP-26-096
Evolution of the HLT Scouting of the CMS experiment in 2022 -- 2026 during LHC Run 3: statistics	DP-26-097
Retrained ParticleNet for AK8 bb-tagging at HLT	DP-26-099
Alpaka-based pixel digi morphing for radiation damage mitigation at the CMS HLT	DP-26-100
Primary vertex and track impact parameter resolutions in the 2022, 2023, 2024 datasets with the CMS Phase-1 pixel detector	DP-26-101
CMS silicon strip tracker performance results with 2025 data	DP-26-102
Performance of boosted top quark identification based on jet substructure using data collected in 2022, 2023 and 2024	DP-26-103
The global particle transformer for boosted-jet tagging and mass regression: development and performance from v1 to v3	DP-26-104
Global particle transformer for HLT Scouting at CMS	DP-26-105
Generative-modeling based calibration of flavour tagging algorithms at the CMS experiment	DP-26-106
RPC 2025 performance	DP-26-107
Performance summary of AK4 jet b tagging with data from 2024 proton-proton collisions at $\sqrt{s} = 13.6$ TeV with the CMS detector	DP-26-108
Jet energy scale and resolution measurements using Run 3 data collected by CMS in 2025 and 2026 at 13.6 TeV	DP-26-109
Wide-cone jet substructure tagging in the CMS Phase-2 Level-1 Correlator Trigger	DP-26-110
Performance of jet, missing transverse momentum, and (machine-learned) particle flow reconstruction in pp collision data with more than 100 pileup interactions at the CMS experiment	DP-26-111
Speeding up the electron pixel seeding using GPUs	DP-26-113
Accelerated tracking for a high-throughput Phase-2 NGT HLT Scouting stream: Computing and Physics performance	DP-26-114

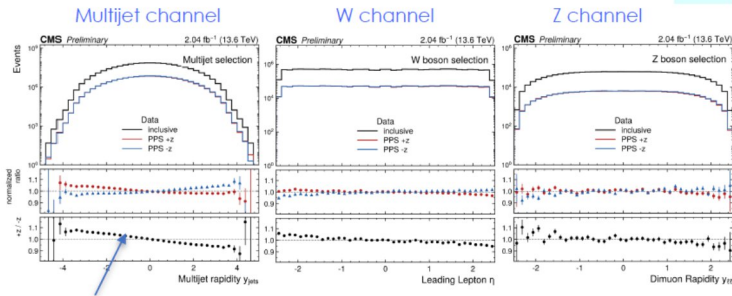
Observation of W, Z, and TeV-scale jets with intact forward proton



- Measure longitudinal boost of central system, correlate with proton side (+z or -z)
- Extract fractions of diffractive jets, W, Z: 0.5%, 1%, 1%



[SMP-26-015](#)



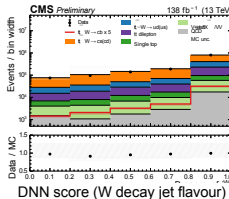
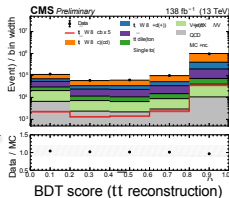
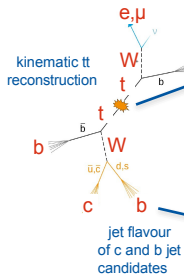
Ratio of events with a proton in PPS on +z side over PPS on -z side

[cf Martijn Mulders' talk on Thursday](#)

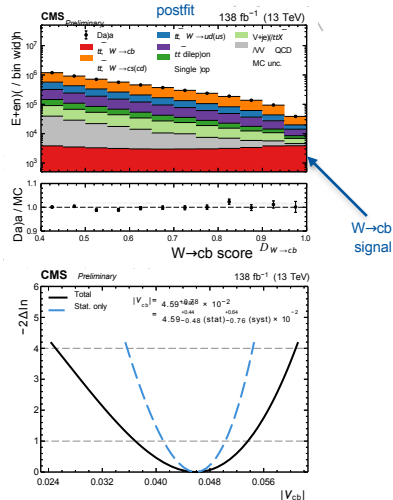
Measurement of V_{cb} from $t\bar{t}$ events

Use $t\bar{t}$ as source of real W bosons

- Complementary to B decays
- Measure $W \rightarrow cb$ decays in processes of large energy



inputs to final $W \rightarrow cb$ score



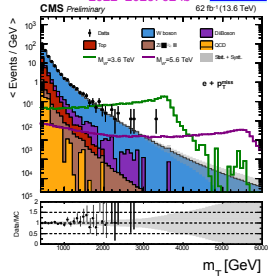
Most precise result from W boson decays at a hadron collider

Searches for high-mass particles

Benefit from higher Run 3 energy

$W' \rightarrow \ell \nu$

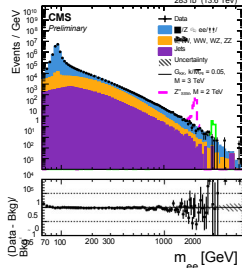
2022–2023: 62 fb⁻¹ EXO-24-021



$m(W'_{SSM}) > 5.9 \text{ TeV}$
at 95% CL (6.2 TeV exp.)

$Z' \rightarrow \ell \ell$

2022–2025: 283 fb⁻¹ EXO-25-021



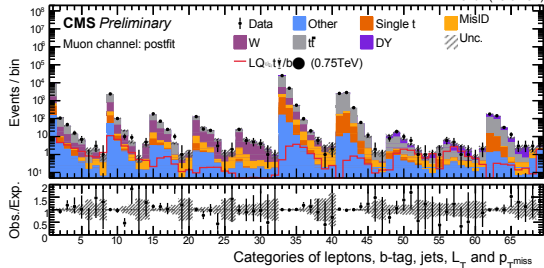
$m(Z'_{SSM}) > 5.6 \text{ TeV}$
at 95% CL (5.8 TeV exp.)

$LQ \rightarrow \text{top} + \ell$

2024–2025: 220 fb⁻¹

B2G-25-011

220 fb⁻¹ (13.6 TeV)

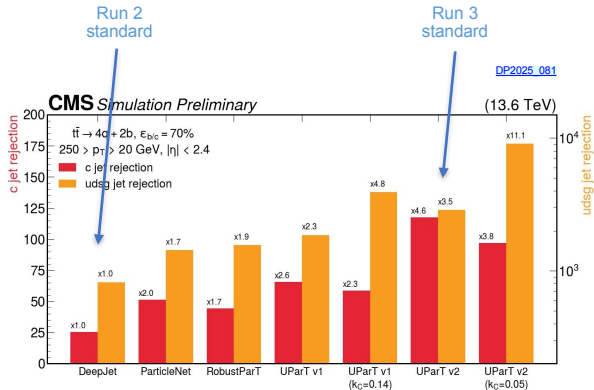
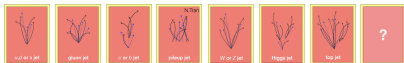
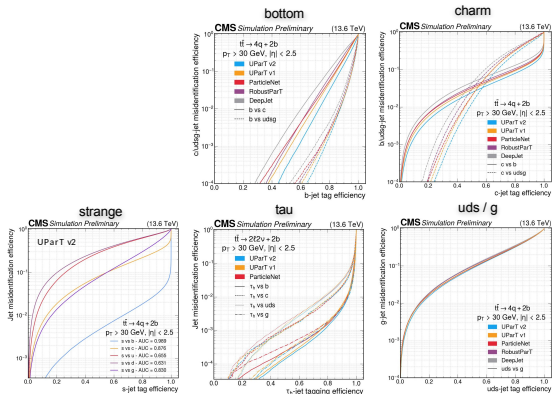


$m(LQ_{\text{scalar}}) > 1.72 \text{ TeV}$
at 95% CL (1.76 TeV exp.)

Most stringent limits to date

ML for jet flavour tagging

Unified tagging across all flavours



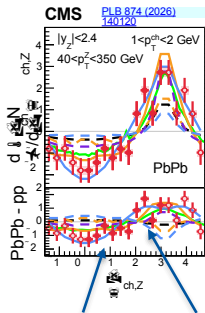
Truly unexpected improvements in recent years
Up to factor 10 better purity than DeepJet during Run 2

Physics with heavy ions

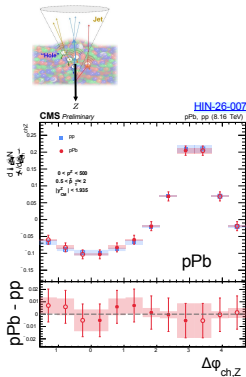
CMS is a heavy-ion physics experiment

- Hard probes:

Example: Z boson-hadron correlations



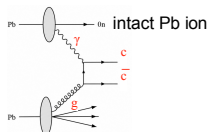
Diffusion wake, momentum broadening at low p_T in PbPb, but not in pPb



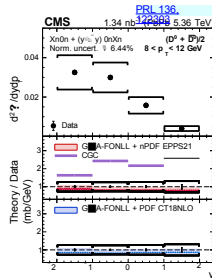
Explore ion-collision properties from all sides

- Ultraperipheral collisions

Example: D^0 production

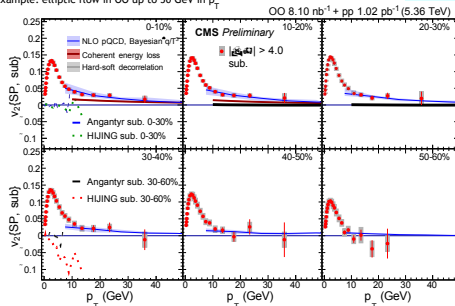


UPC probing nuclear PDF



- Azimuthal anisotropy

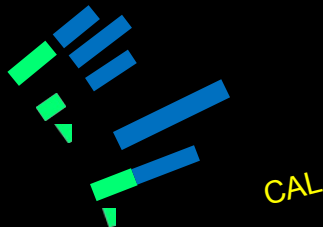
Example: elliptic flow in OO up to 50 GeV in p_T



understand medium properties in small systems



The Level-1 trigger today



MUONS

With this trigger, we already produced > 1500 papers

CMS

Compact Muon Solenoid

The Level-1 trigger at the HL-LHC

TRACKER

MUONS

HGCAL

zoom

Full event reconstruction already at trigger level

ATLAS Backup

New results since LHCP.

[Observation of electroweak production of \$\gamma\gamma jj\$](#)

[Measurements of VBF \$W\$ production at 13 TeV](#)

[Polarisation in VBS \$WZ\$ production at \$\sqrt{s}\$ of 13 and 13.6 TeV](#)

[Observation of pair production of longitudinally polarised \$Z\$ bosons in four-lepton final states](#)

[Charged-particle phase-space measurement of \$Z\$ +jets production at 13 TeV \(to come\)](#)

[\$tH\(\rightarrow \tau\tau\)\$ and combination Run 2 \$tH\$ searches and \$H \rightarrow \gamma\gamma\$ partial Run 3](#)

[Non-resonant \$HH \rightarrow b\bar{b}\tau\tau\$ Run2 + partial Run 3](#)

[\$t\bar{t}H\$ and \$tH H \rightarrow \tau\tau\$ at 13 and 13.6 TeV](#)

[Resonant search for \$SH \rightarrow b \bar{b} b\$](#)

[Search for \$H \rightarrow \gamma^* \gamma\$ at 13.6 TeV \(to come\)](#)

[Run 2 Higgs combination \(to come\)](#)

[Search low-mass di- \$\tau\$ resonances in association with top quark pairs](#)

[Search for high mass dilepton resonances at 13.6 TeV](#)

[Search for exotic pair-produced VLQ \$T \rightarrow St\$ decays](#)

[Search for HNL t-channel in final states with \$\tau\$ leptons](#)

[\$\gamma\$ +jet resonance search \(to come\)](#)

[\$J/\psi\$ suppression and \$J/\psi\$ jet correlations in Pb+Pb collisions](#)

[Charged-particle production in O+O and Ne+Ne collisions](#)

[Dijet asymmetry in O+O and Ne+Ne collisions](#)

[Isolated photon plus multi-jet correlations in Pb+Pb and pp collisions](#)

[Photon-hadron correlations in OO and pp](#)

[Forward Jet RAA in Pb+Pb collisions at 5.02 TeV](#)

[Jet \$v_n\$ in O+O and Ne+Ne collisions at 5.36 TeV](#)

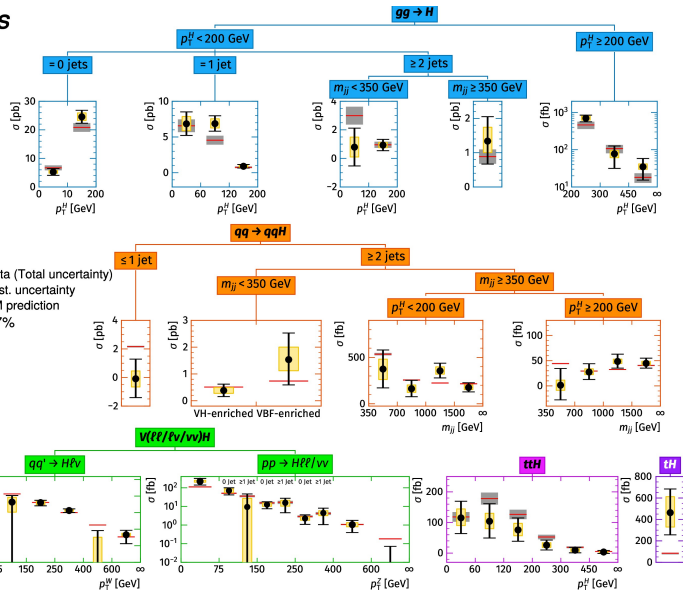
[Large-R Jet Calibration in Run2](#) —

[GN2 \$c\$ -jet and \$b\$ -jets calibration using \$t\bar{t}\$ semi-leptonic events](#)

[GN2 \$b\$ -jet calibration using \$t\bar{t}\$ dileptonic events](#)

Characterization of the Higgs boson: differential.

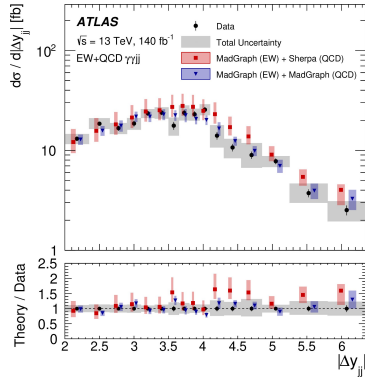
ATLAS



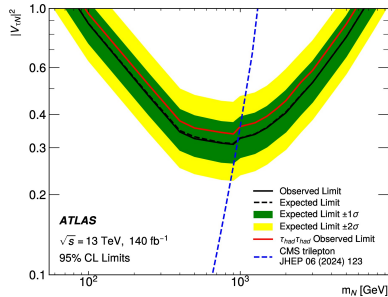
Measurements in 44 kinematic regions of 5 production processes (assuming SM branching fractions)

Agreement with SM: $p = 47\%$

A few selected other new results.



First observation of
 EW $\gamma\gamma jj$ process
 with 6.2σ (6.5σ exp.)



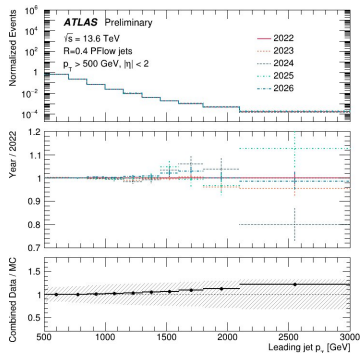
Search for heavy Majorana
 neutrinos in VBS
 in τ final states:
 strongest constraints
 for $m_N > 1 \text{ TeV}$ and
 first constraints
 for $m_N \gtrsim 1.5 \text{ TeV}$

Both new for ICHEP

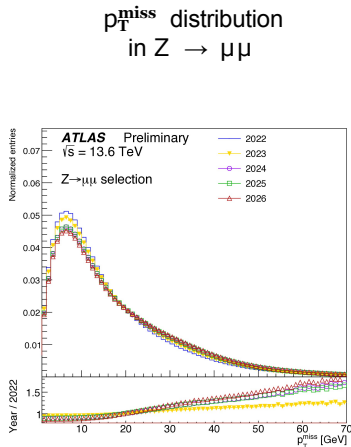
Run 3 data holds many promises.

[\[Public plots\]](#)

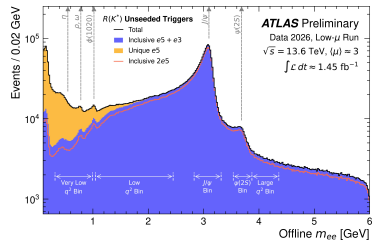
[\[Public plots\]](#)



Jet p_T distributions
in 2022-2026 data

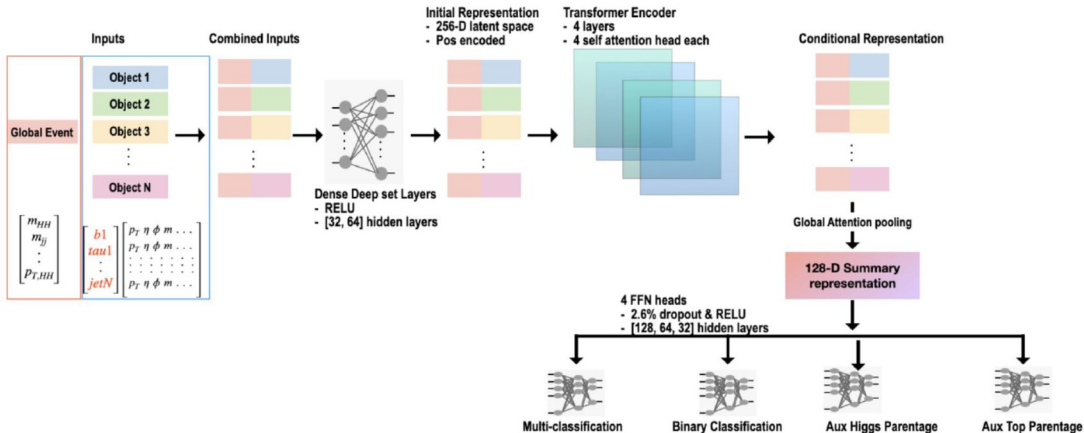


p_T^{miss} distribution
in $Z \rightarrow \mu\mu$



Almost unseeded (di)electron
trigger in Run 3 opens
new phase space for ATLAS

Transformer model



ATLAS approach to bPOL problems.

- bPOL: DC-DC voltage regulator used in many upgrade projects in ATLAS and CMS
- Combination of radiation, cold temperatures, and stress time (bPOL powered but disabled) leads to failures
- New problem discovered recently: overshooting output voltage at power down (after irradiation)
- New bPOL in development in CERN electronics group



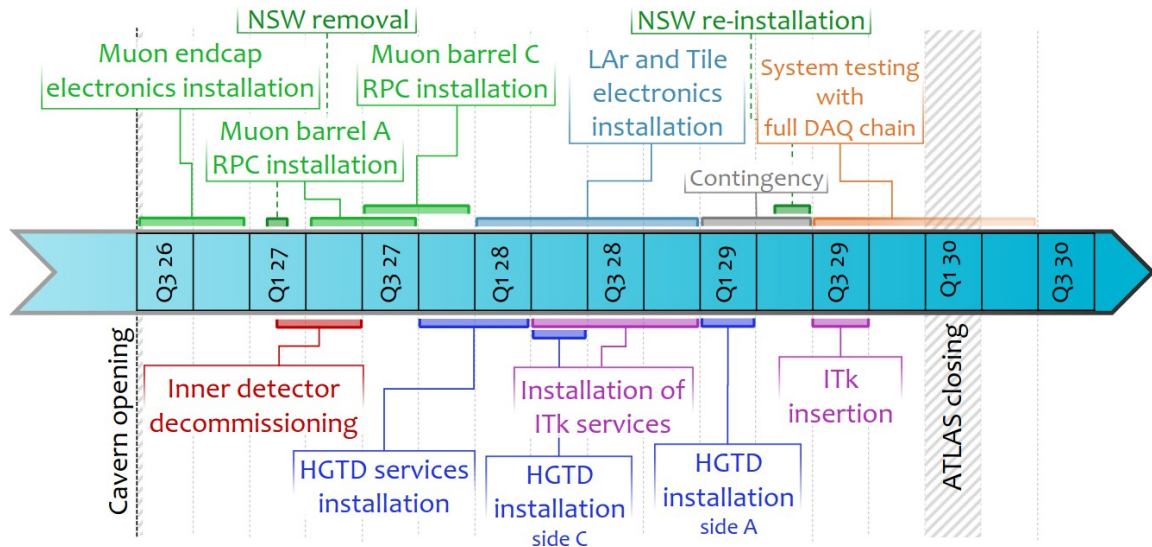
bPOLs

ITk Strip Petal

Mitigation strategies

- ITk Pixels: Wait for new bPOL (schedule allows for it)
- ITk strips: Proceed with current bPOL:
 - ★ redefined wire-bonding scheme to minimize stress time
 - ★ change power supply to slow input voltage ramp down and add additional resistor on End Of Substructure cards for faster reduction of output voltage
- LAr: Proceed with current bPOL, redesigned front-end boards to minimize stress time
- HGTD: Wait for new bPOL, redesigning peripheral electronics boards as fall-back option (difficult)

Schedule for long shutdown 3.



«Combination of Higgs boson measurements at $\sqrt{s} = 13$ TeV
and their interpretations by the ATLAS experiment»

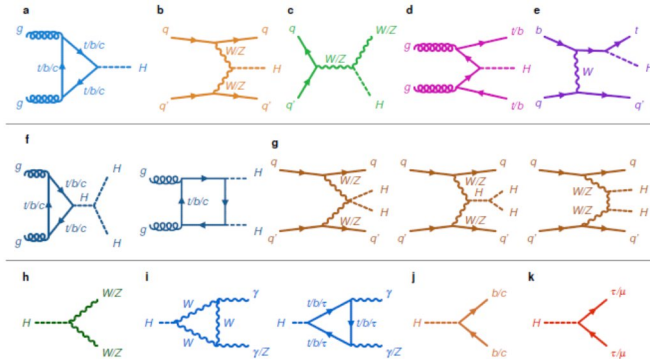


Figure 1: Examples of Feynman diagrams for single (top row) and double (middle row) Higgs boson production, and Higgs boson decay (bottom row): Higgs boson production via gluon–gluon fusion (ggF; a), W or Z vector-boson fusion (VBF; b), and associated production with W or Z bosons (VH; c), top- or b-quark pairs (ttH, bbH; d), or a single top quark (tH; e); Higgs boson pair production via gluon–gluon fusion (f), and Higgs boson pair production via vector-boson fusion (g). Higgs boson decays into a pair of W or Z bosons (h), a pair of photons, or a Z boson and a photon (i), a pair of quarks (j), and a pair of charged leptons (k).

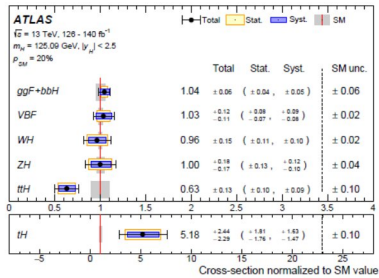


Figure 3: Observed cross-section values for the main Higgs boson production modes, relative to their SM predictions. The bbH mode is considered together with ggF . Higgs boson decay branching ratios are assumed to be equal to their SM expectations within theory uncertainties. Total uncertainties in the measurements and their statistical and systematic components are shown. The vertical line and the shaded regions represent the SM predictions and their uncertainties.

Table 2: Measured values of Higgs boson production cross-sections, assuming branching ratios match their expectations in the SM within theory uncertainties. Observed and expected uncertainties are shown along with their contributions from data statistics (stat.) and systematic uncertainties (syst.). The last column indicates the corresponding SM predictions together with their theory uncertainties.

Production mode	Observed value [pb]	Observed uncertainty [pb]			Expected uncertainty [pb]			SM prediction [pb]	
		Total	Stat.	Syst.	Total	Stat.	Syst.		
$ggF + bbH$	46.7	$+2.9$ -2.8	± 1.8	± 2.2	± 2.8	± 1.8	$+2.2$ -2.1	44.8	± 2.6
VBF	3.6	± 0.4	± 0.3	± 0.3	± 0.4	± 0.3	± 0.3	3.50	± 0.07
WH	1.17	$+0.19$ -0.18	± 0.14	$+0.13$ -0.12	$+0.19$ -0.18	± 0.14	$+0.13$ -0.12	1.216	± 0.024
ZH	0.79	$+0.14$ -0.13	$+0.11$ -0.10	$+0.10$ -0.08	$+0.14$ -0.13	$+0.11$ -0.10	$+0.09$ -0.08	0.796	± 0.029
ttH	0.32	± 0.07	± 0.05	$+0.05$ -0.04	± 0.07	± 0.05	± 0.05	0.50	± 0.05
tH	0.44	$+0.21$ -0.19	± 0.15	$+0.14$ -0.12	$+0.17$ -0.15	$+0.14$ -0.13	$+0.11$ -0.09	0.085	$+0.005$ -0.011

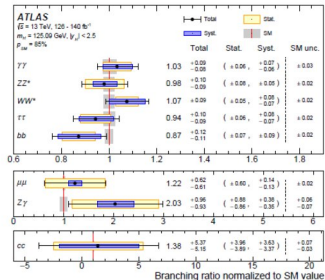


Figure 4: Observed branching ratio values in the $H \rightarrow \gamma\gamma$, $H \rightarrow ZZ^*$, $H \rightarrow WW^*$, $H \rightarrow \tau\tau$, $H \rightarrow bb$, $H \rightarrow \mu\mu$, $H \rightarrow Z\gamma$ and $H \rightarrow cc$ decay modes, relative to their SM predictions. Higgs boson production cross-sections are assumed to be equal to their SM expectations within theory uncertainties. Total uncertainties in the measurements and their statistical and systematic components are shown. The vertical line and the shaded regions represent the SM predictions and their uncertainties.

Table 3: Measured values of Higgs boson decay branching ratios, assuming production cross-sections to match their expectations in the SM within theory uncertainties. Observed and expected uncertainties are shown along with their contributions from data statistics (stat.) and systematic uncertainties (syst.). The last column indicates the corresponding SM predictions together with their theory uncertainties.

Decay mode	Observed value [%]	Observed uncertainty [%]			Expected uncertainty [%]			SM prediction [%]
		Total	Stat.	Syst.	Total	Stat.	Syst.	
$H \rightarrow bb$	51	$+7$ -6	$+4$	$+6$ -5	$+7$	$+4$	$+6$ -5	58.1 ± 0.7
$H \rightarrow WW^*$	23	$+2$	$+1$	$+2$	$+2$	$+1$	$+2$	21.5 ± 0.3
$H \rightarrow \tau\tau$	5.9	± 0.6	± 0.4	$+0.5$ -0.4	± 0.6	± 0.4	$+0.5$ -0.4	6.26 ± 0.08
$H \rightarrow cc$	4	± 15	± 11	± 10	$+15$ -14	± 11	$+10$ -9	2.9 ± 0.2
$H \rightarrow ZZ^*$	2.6	$+0.3$ -0.2	± 0.2	± 0.1	$+0.3$ -0.2	± 0.2	± 0.1	2.64 ± 0.03
$H \rightarrow \gamma\gamma$	0.23	± 0.02	± 0.01	$+0.02$ -0.01	± 0.02	± 0.01	± 0.01	0.227 ± 0.004
$H \rightarrow Z\gamma$	0.31	$+0.15$ -0.14	$+0.14$ -0.13	$+0.06$ -0.05	$+0.14$ -0.13	± 0.13	$+0.05$ -0.04	0.154 ± 0.008
$H \rightarrow \mu\mu$	0.027	± 0.013	± 0.013	± 0.003	± 0.013	± 0.013	$+0.003$ -0.002	0.0217 ± 0.0003