CMS Overview

From Current Constraints to the HL-LHC

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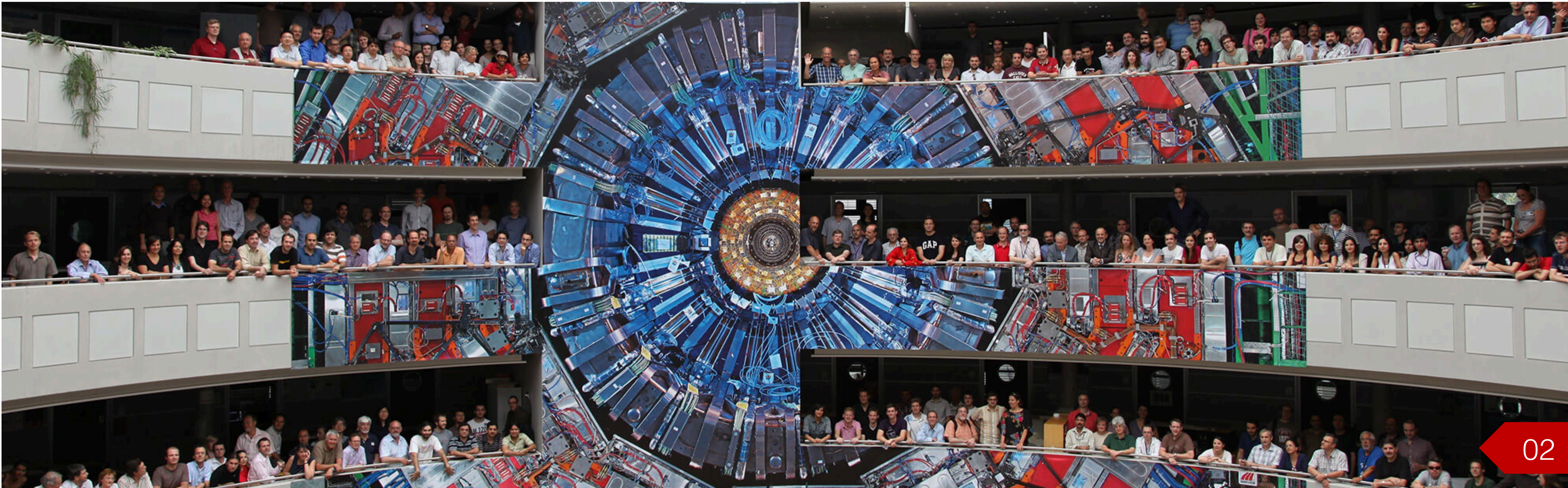
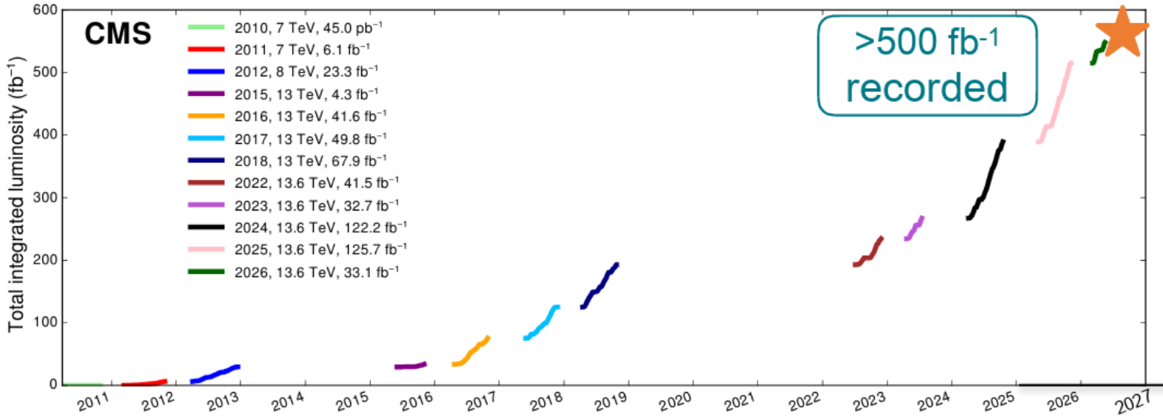
Universidad Iberoamericana Ciudad de México

Outline

1. Where we are
2. CMS Highlights
3. CMS Mexico Highlights
4. Where we are going



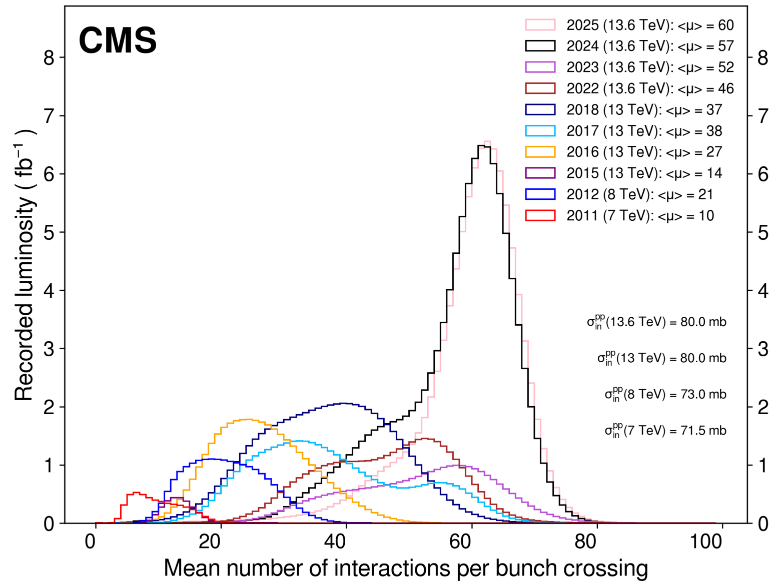
Fifteen years in…



2028 2029 2030

Run 1 2009–2012 « **Run 2** 2015–2018 « **Run 3** 2022–2026 « HL-LHC 2030-2041

HL-LHC:
- 6× more luminosity
- better detector
- better trigger
- better methods
- better tools



Twiki

Run 3 more than twice as large as Run 2

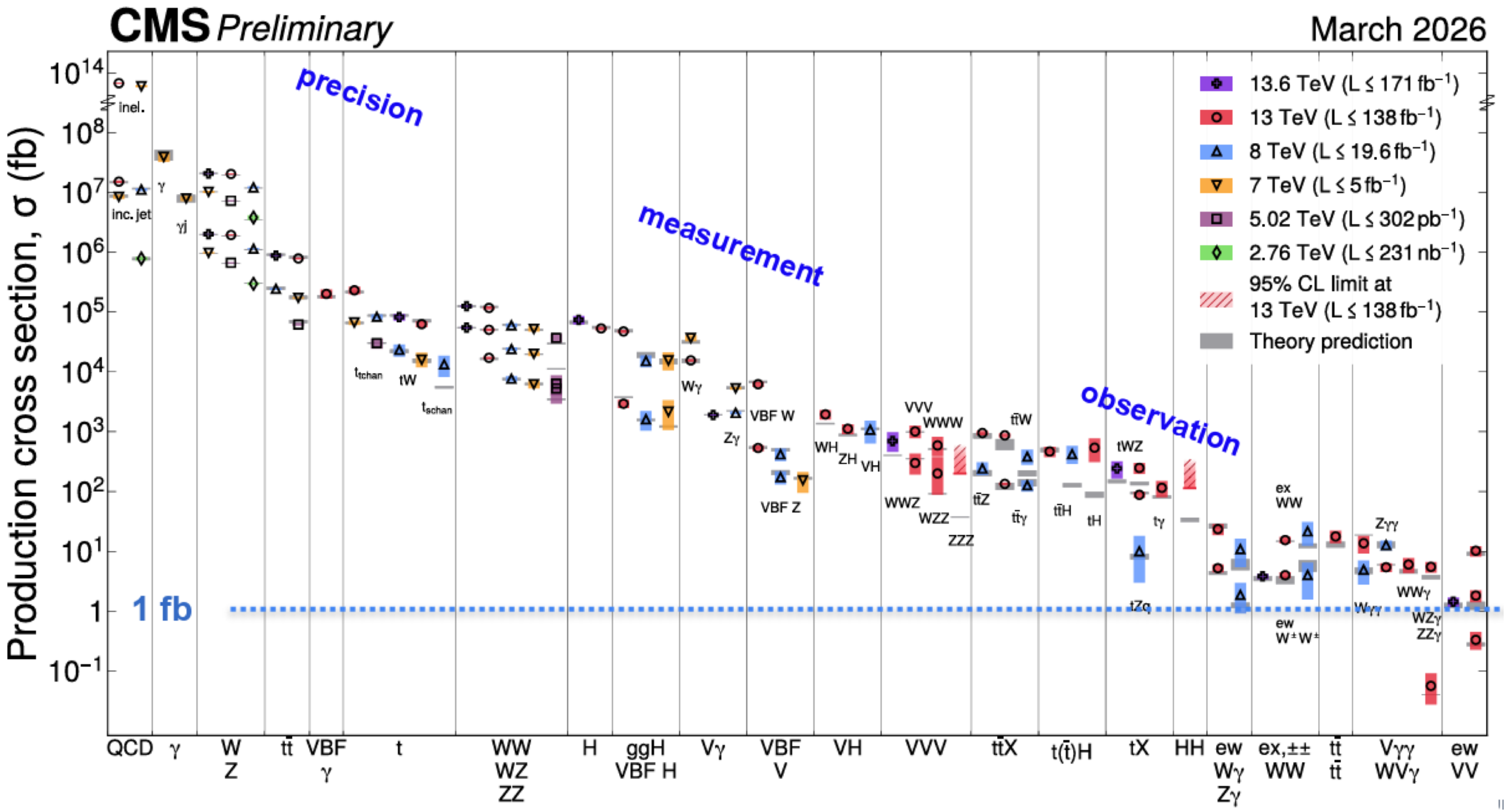
2024+2025/6 alone: 250 fb^{-1} for physics => larger than all other years together

From Andreas Meyer

Excellent detector performance and innovative approaches to technical challenges.

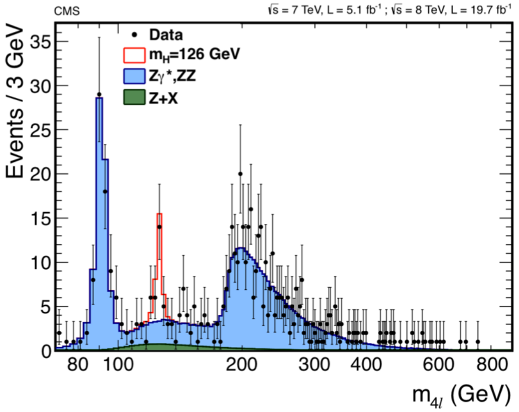
Rich and diverse physics program:
- Measurement of Higgs boson properties (couplings, signal strengths, cross sections).
- Study of the QGP.
- Precision SM measurements.
- Heavy flavor physics and ultra-rare decay modes.
- New physics searches.

Legacy from Runs 1-3 (1/3)

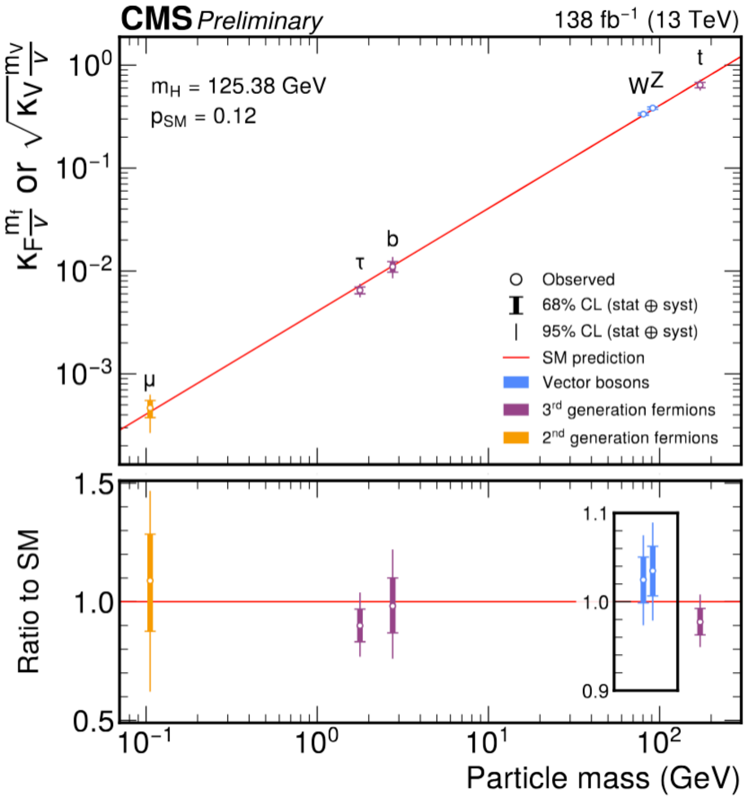


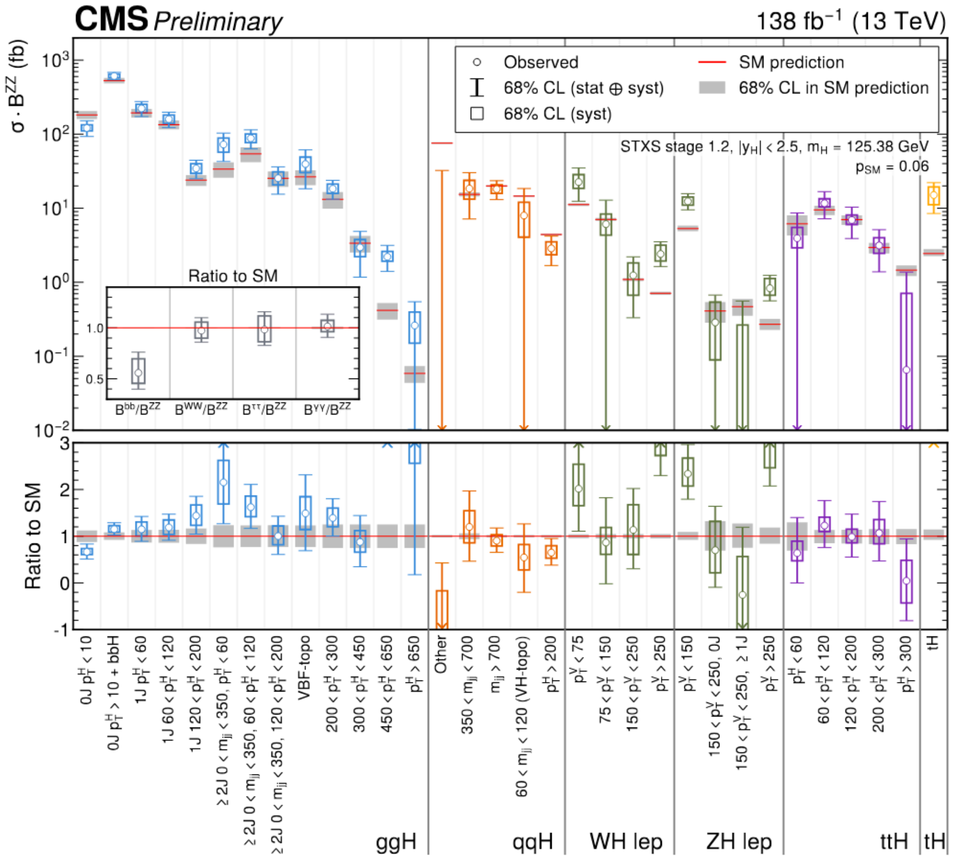
Legacy from Runs 1-3 (2/3)

From:



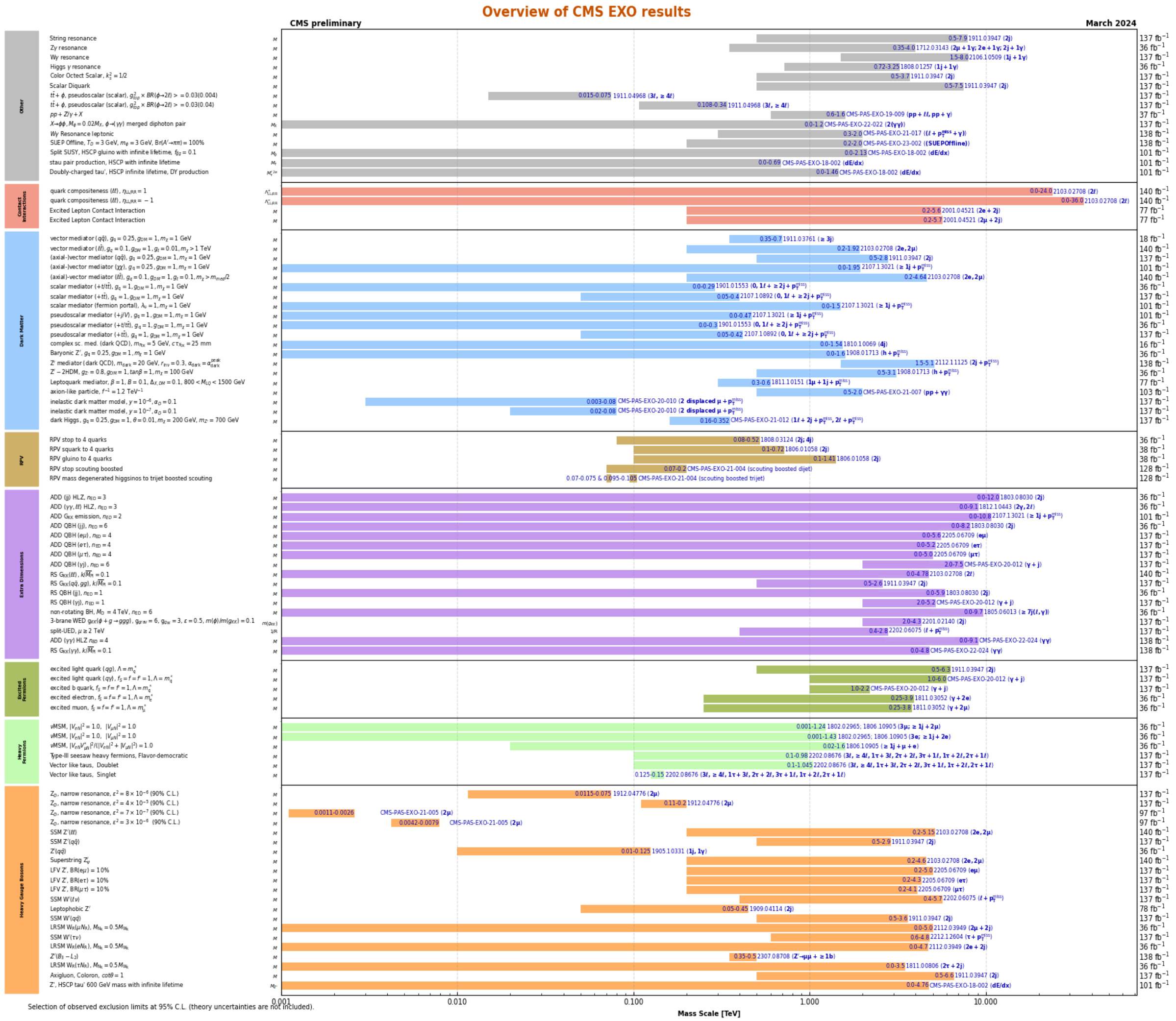
To:

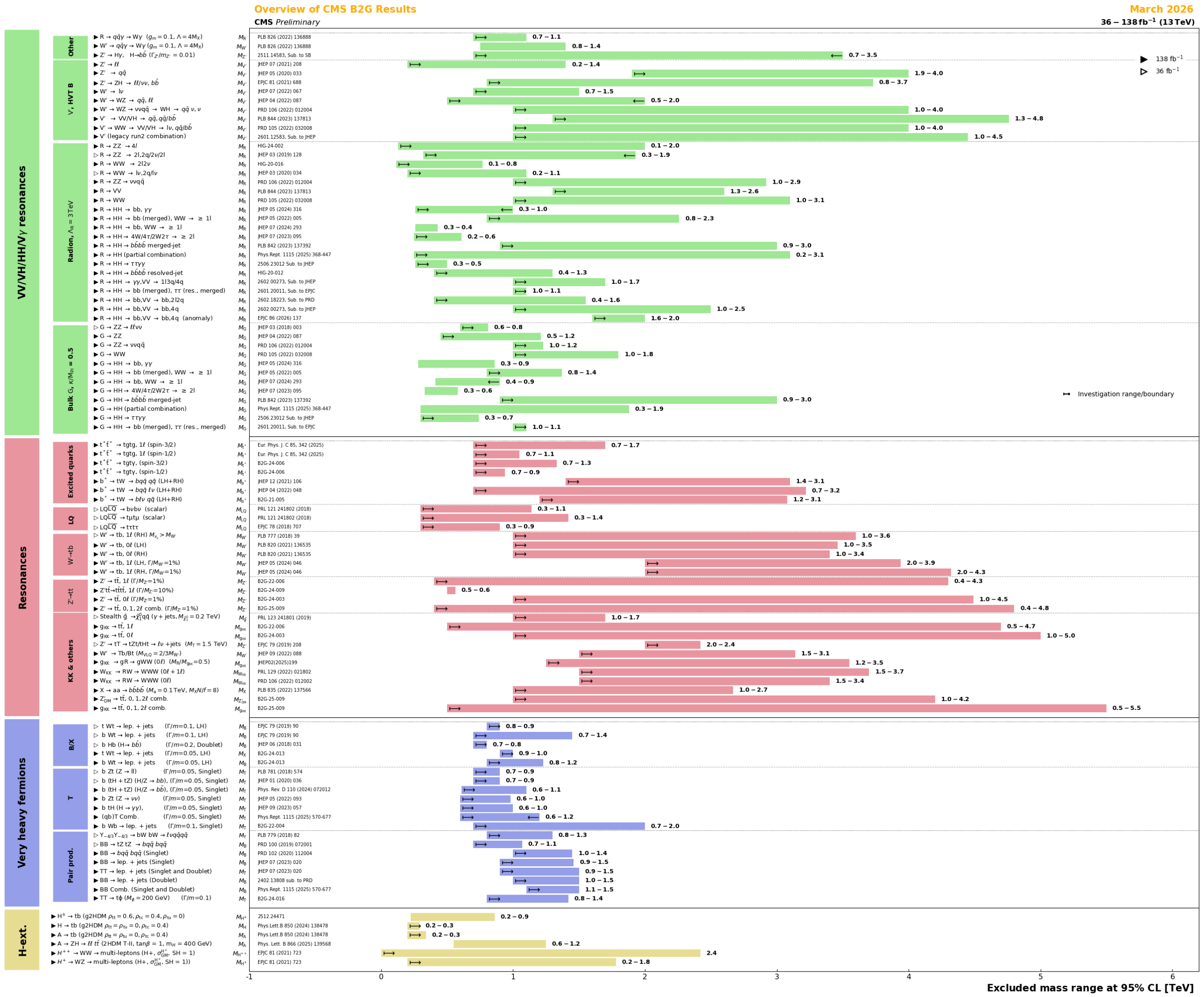




CMS-PAS-HIG-21-018

Legacy from Runs 1-3 (3/3)





Recent highlights

OPEN ACCESS
IOP Publishing

Reports on Progress in Physics
Rep. Prog. Phys. 88 (2025) 087801 (25pp)
https://doi.org/10.1088/1361-6633/adf7d3

Observation of a pseudoscalar excess at the top quark pair production threshold

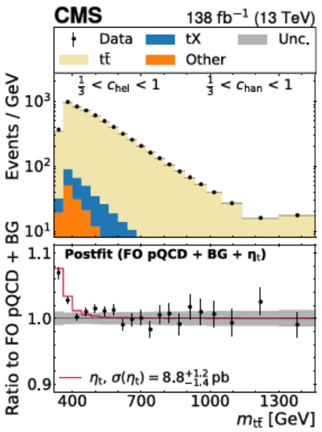
The CMS Collaboration

CERN, Geneva, Switzerland

E-mail: cms-publication-committee-chair@cern.ch

Received 28 March 2025, revised 23 July 2025
Accepted for publication 5 August 2025
Published 22 August 2025

Corresponding editor: Dr Lorna Brigham



10.1088/1361-6633/adf7d3

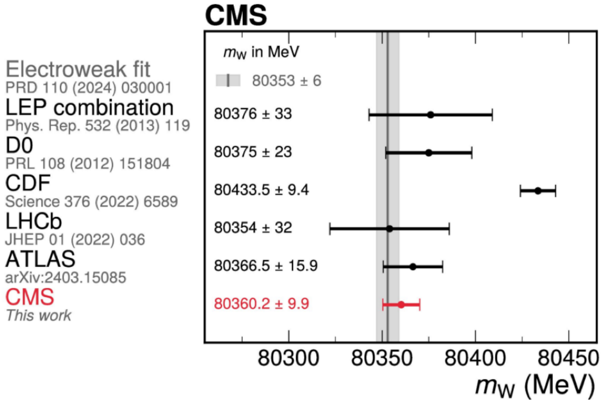
Article

High-precision measurement of the W boson mass with the CMS experiment

https://doi.org/10.1038/s41586-026-10168-5
Received: 18 December 2024
Accepted: 21 January 2026
Published online: 8 April 2026
Open access
Check for updates

The CMS Collaboration*✉

In the standard model of particle physics, the masses of the W and Z bosons, the carriers of the weak interaction, are uniquely related. A precise determination of their masses is important because quantum loops of heavy, undiscovered particles could modify this relationship. Although the Z mass is known to the remarkable precision of 22 parts per million (2.0 MeV), the W mass is known much less precisely. A global fit to measured electroweak observables predicts the W mass with 6 MeV uncertainty[1–3]. Reaching a comparable experimental precision would be a sensitive and fundamental test of the standard model, made even more urgent by a recent challenge to the global fit prediction by a measurement from the CDF Collaboration at the Fermilab Tevatron collider[4]. Here we report the measurement of the W mass by the CMS Collaboration at the CERN Large Hadron Collider, based on a large data sample of $W \rightarrow \mu\nu$ events collected in 2016 at the proton–proton collision energy of 13 TeV. The measurement exploits a high-granularity maximum likelihood fit to the kinematic properties of muons produced in W decays. By combining an accurate determination of experimental effects with marked in situ constraints of theoretical inputs, we reach a precise measurement of the W mass, of 80,360.2 ± 9.9 MeV, in agreement with the standard model prediction.



10.1038/s41586-026-10168-5

Available on the CERN CDS information server
CMS PAS EXO-25-021

CMS Physics Analysis Summary

Contact: cms-pag-conveners-exotica@cern.ch

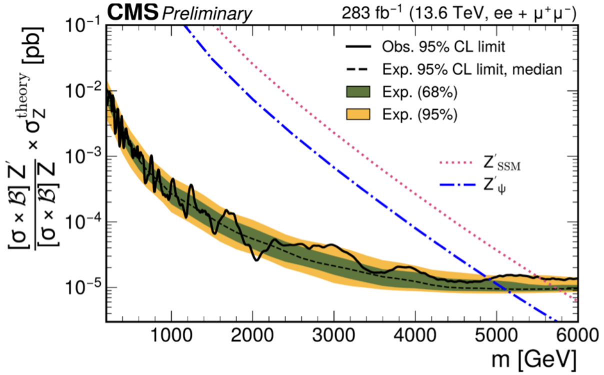
2026/05/16

Search for resonant new phenomena in high-mass dilepton final states at $\sqrt{s} = 13.6$ TeV

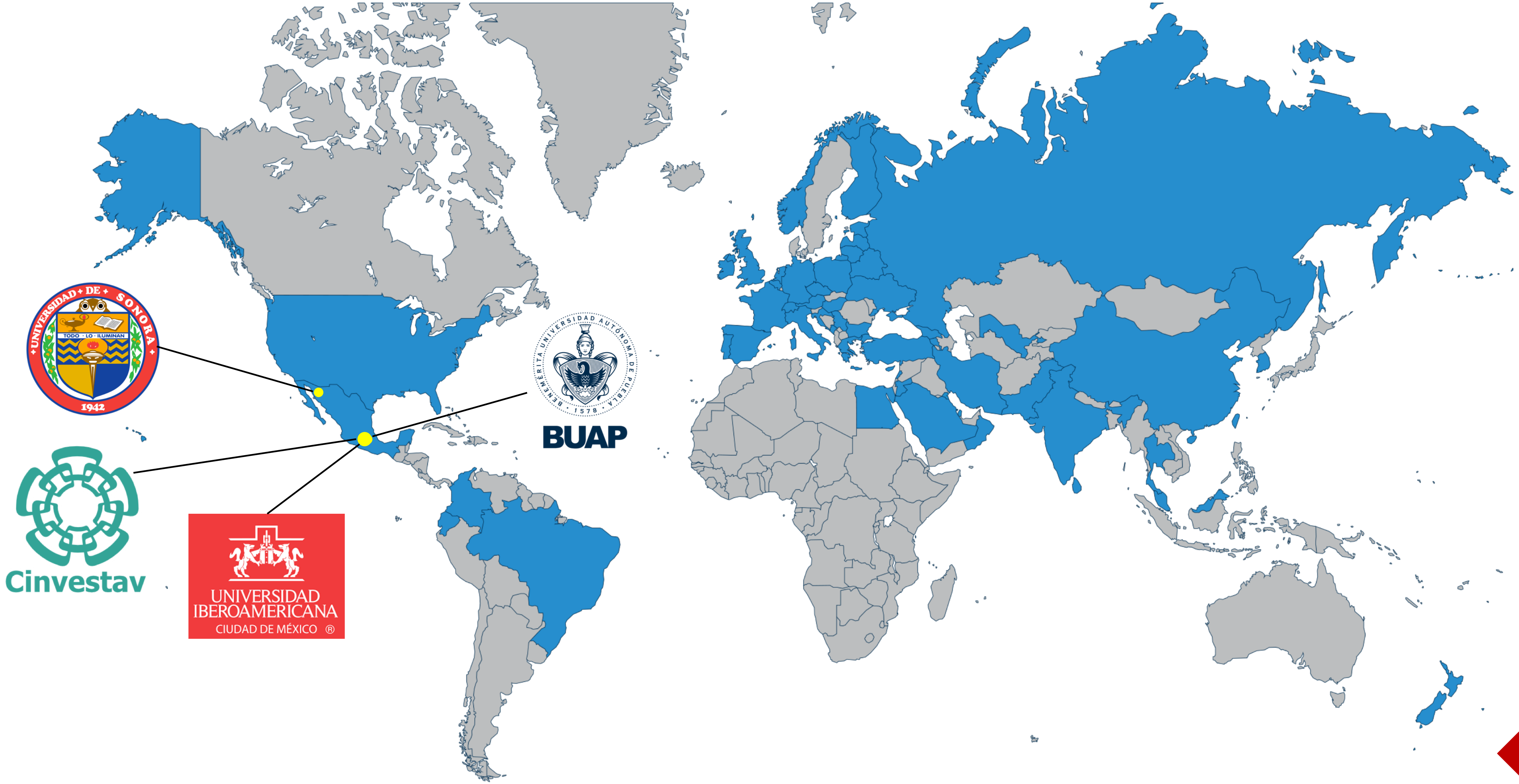
The CMS Collaboration

Abstract

A search for heavy new resonances decaying into pairs of electrons or muons is presented. The search uses proton-proton collision data at a centre-of-mass energy of $\sqrt{s}$ = 13.6 TeV, collected by the CMS experiment at the LHC during 2022-2025 and corresponding to an integrated luminosity of 283 fb^{-1}. A model-independent search for heavy resonances is conducted covering a wide mass range spanning from 200 GeV to 6 TeV. No significant deviation is observed with respect to the Standard Model expectation. Upper limits are presented on the ratio of the product of the production cross section and the branching fraction to dileptons of a new narrow resonance to that of the Z boson. These provide the most stringent lower limits to date on the mass for various spin-1 particles and spin-2 gravitons in the Randall-Sundrum model. In particular, lower mass limits of 5.55 (4.95) TeV are set on Z'_{SSM} (Z'_ψ) bosons at 95% confidence level.



Mexico in CMS



Our highlights (1/2)

Physics Reports
Volume 1115, 17 April 2025, Pages 448-569

Dark sector searches with the CMS experiment

CMS Collaboration

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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-EP-2026-087
2026/04/24

CMS-SUS-23-013

Search for dark matter produced in association with a dark Higgs boson decaying into a bottom quark-antiquark pair in proton-proton collisions at $\sqrt{s} = 13$ TeV

The CMS Collaboration*

Abstract

A search for dark matter produced in association with a dark Higgs boson decaying into a bottom quark-antiquark pair has been performed using proton-proton collision data at a center-of-mass energy of 13 TeV. The search uses data collected with the CMS detector at the CERN LHC during the 2016–2018 data-taking period, corresponding to an integrated luminosity of 138 fb^{-1}. The results are interpreted in terms of a theoretical model of dark matter production that, together with a spin-1 gauge boson mediator, predicts the existence of a Higgs-boson-like particle in the dark sector (i.e., a dark Higgs boson). This search focuses on an experimental signature with large missing transverse momentum from dark matter production and a resonant structure in the invariant mass of the bottom quark-antiquark pair from the dark Higgs boson decay. Upper limits at 95% confidence level on the signal strength for dark Higgs boson mass hypotheses below 160 GeV are set. Values of the mediator mass up to 4.5 (2.5) TeV are excluded at 95% confidence level for a dark Higgs boson mass of 50 (150) GeV. This represents the most stringent limits set to date for the dark Higgs boson masses considered in this study.

Submitted to the European Physical Journal C

arXiv:2604.20999v1 [hep-ex] 22 Apr 2026

Dark matter

BUAP

Physics Reports
Volume 1115, 17 April 2025, Pages 570-677

Review of searches for vector-like quarks, vector-like leptons, and heavy neutral leptons in proton–proton collisions at √s=13 TeV at the CMS experiment

CMS Collaboration

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Vector-like quarks

UNIVERSIDAD IBEROAMERICANA CIUDAD DE MÉXICO

Physics Reports
Volume 1115, 17 April 2025, Pages 678-772

Enriching the physics program of the CMS experiment via data scouting and data parking

CMS Collaboration

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B physics

Cinvestav

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-EP-2025-290
2026/06/02

CMS-HIN-22-004

Dependence of two-particle azimuthal correlations on the forward rapidity gap width in pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

The CMS Collaboration*

Abstract

One of the most striking features of relativistic heavy ion collisions is the presence of collective flow of thousands of produced particles. This flow can be characterized by the Fourier coefficients ($V_{n\Delta}$) of the azimuthal angular distributions of charged particles, and its existence can be explained by the formation of a quark gluon plasma, which behaves as a fluid. Surprisingly, the angular distributions of particles from very small systems such as proton-lead (pPb), proton-proton (pp), electron-positron, and photon-proton (γp) collisions also exhibit non-zero Fourier coefficients, raising the question of whether collective flow is present. This paper presents measurements of $V_{n\Delta}$ from a sample of pPb events at $\sqrt{s_{NN}} = 8.16$ TeV that are enriched in photon-lead (γPb) and pomeron-lead ($\mathbb{P}$Pb) interactions by requiring no particles in the proton-going region. Measurements are made as a function of the forward rapidity gap width (the rapidity range in which no particles are found), the transverse momentum of the particles, and the multiplicity of particles in the event. The results are compared to previous measurements of pp, pPb, and $\gamma p + \mathbb{P}p$ events as well as modern event generators.

Submitted to Physical Review C

arXiv:2606.00171v1 [nucl-ex] 29 May 2026

Physics Letters B
Volume 844, 10 September 2023, 137905

Two-particle azimuthal correlations in γp interactions using pPb collisions at $\sqrt{s_{NN}} = 8.16$ TeV

The CMS Collaboration*

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PHYSICAL REVIEW LETTERS **134,** 111903 (2025)

Search for Nuclear Modifications of B^+ Meson Production in p-Pb Collisions at $\sqrt{s_{NN}} = 8.16$ TeV

A. Hayrapetyan *et al.**
(CMS Collaboration)

(Received 7 July 2024; revised 17 October 2024; accepted 31 January 2025; published 19 March 2025)

Nuclear medium effects on B^+ meson production are studied using the binary-collision scaled cross section ratio between events of different charged-particle multiplicities from proton-lead collisions. Data, collected by the CMS experiment in 2016 at a nucleon-nucleon center-of-mass energy of $\sqrt{s_{NN}} = 8.16$ TeV, corresponding to an integrated luminosity of 175 nb^{-1}, were used. The scaling factors in the ratio are determined using a novel approach based on the $Z \to \mu^-\mu^+$ cross sections measured in the same events. The scaled ratio for B^+ is consistent with unity for all event multiplicities, putting stringent constraints on nuclear modification for heavy flavor.

DOI: 10.1103/PhysRevLett.134.111903

Heavy ions

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Our highlights (2/2)

Nuclear Instruments and Methods in Physics Research A 1077 (2025) 170484

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Gas gaps and chambers quality control of improved Resistive Plate Chambers

M.A. Ali [34,*], B. El-Mahdy [12,*,a], F.E. Neri Huerta [30,*], M. Tytgat [1,b], K. Mota Amarilo [2,c], A. Samalan [2,d], K. Skovpen [2], G.A. Alves [3], E. Alves Coelho [3], F. Marujo da Silva [3], M. Barroso Ferreira Filho [4], E.M. Da Costa [4], D. De Jesus Damiao [4], B.C. Ferreira [4], S. Fonseca De Souza [4], L. Mundim [4], H. Nogima [4], J.P. Pinheiro [4], A. Santoro [4], M. Thiel [4], R. Gomes De Souza [4], T. De Andrade rangel Monteiro [4], A. Aleksandrov [5], R. Hadjiiska [5], P. Iaydjiev [5], M. Shopova [5], G. Sultanov [5], A. Dimitrov [6], L. Litov [6], B. Pavlov [6], P. Petkov [6], A. Petrov [6], E. Shumka [6], P. Cao [7], W. Diao [7], W. Gong [7], Q. Hou [7], H. Kou [7], Z.-A. Liu [7], J. Song [7], N. Wang [7], J. Zhao [7], S.J. Qian [8], C. Avila [9], D.A. Barbosa Trujillo [9], A. Cabrera [9], C.A. Florez [9], J.A. Reyes Vega [9], R. Aly [10,12,e], A. Radi [11,f], Y. Assran [12,g], I. Crotty [13], M.A. Mahmoud [13], L. Balleyguier [14], X. Chen [14], C. Combaret [14], G. Galbit [14], M. Gouzevitch [14], G. Grenier [14], I.B. Laktineh [14], A. Luciol [14], L. Mirabito [14], W. Tromeur [14], I. Bagaturia [15], O. Kemularia [15], I. Lomidze [15], Z. Tsamalaidze [15,h], V. Amoozegar [16], B. Boghrati [16], M. Ebrahimi [16], F. Esfandi [16], Y. Hosseini [16], M. Mohammadi Najafabadi [16], E. Zareian [16], M. Abbrescia [17,18], N. De Filippis [17,19], G. Iaselli [17,19], F. Loddo [17], G. Pugliese [17,19], D. Ramos [17], L. Benussi [20], S. Bianco [20], S. Meola [20,i], D. Piccolo [20], S. Buontempo [21], F. Carnevali [21,22], L. Lista [21,22,j], P. Paolucci [21,k], F. Fienga [23], A. Braghieri [24], P. Montagna [24,25], C. Riccardi [24,25], P. Salvini [24], P. Vitulo [24,25], T.J. Kim [26], E. Asilar [26], Y. Ryou [26], S. Choi [27], B. Hong [27], K.S. Lee [27], J. Goh [28], J. Shin [28], Y. Lee [29], I. Pedraza [30], C. Uribe Estrada [30], H. Castilla-Valdez [31], R. Lopez-Fernandez [31], A. Sánchez Hernández [31], M. Ramírez García [32], D.L. Ramirez Guadarrama [32], M.A. Shah [32], E. Vazquez [32], N. Zaganidis [32], A. Ahmad [33], M.I. Asghar [33], H.R. Hoorani [33], S. Muhammad [33], J. Eysermans [35], on behalf of the CMS Collaboration

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Nuclear Instruments and Methods in Physics Research A 1066 (2024) 169510

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Studies of eco-friendly gas mixtures for RPC detectors

D.L. Ramirez Guadarrama [a,*], D. Ramos [b], on behalf of the RPC ECOgas@GIF++ and CMS Collaborations

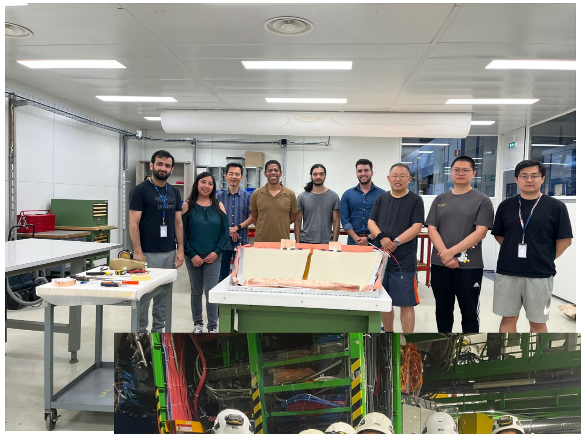
[a] *Universidad Iberoamericana, Mexico*
[b] *Politecnico di Bari, INFN, Italy*

ARTICLE INFO

Keywords:
RPC
Green-House Gases (GHG)
HFO
Detectors

ABSTRACT

In the context of climate change, one of the main contributors to global warming is the greenhouse effect. Regulations have been implemented in different areas of society to reduce or ban the use of Greenhouse Gases (GHG), such as Tetrafluoroethane (TFE). Despite the fact that large-scale experiments (such as the ones held at CERN) have been excluded from these restrictions, it is necessary to look for alternatives more eco-friendly to the environment. In this work we present performance studies for RPC detectors using eco-friendly gas mixtures tested at the Gamma Irradiation Facility (GIF++) at CERN in the context of the Phase II upgrade of the CMS detector.



iRPC detectors

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CMS PAS LUM-20-001

CMS Physics Analysis Summary

Contact: cms-pog-conveners-lum@cern.ch

2025/08/23

Precision luminosity measurement in proton-proton collisions at $\sqrt{s} = 13$ TeV with the CMS detector

The CMS Collaboration

Luminosity

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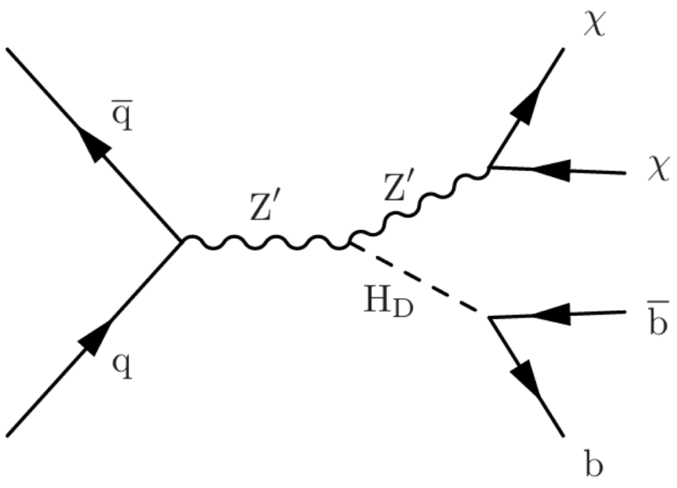
Dark matter searches (1/2)

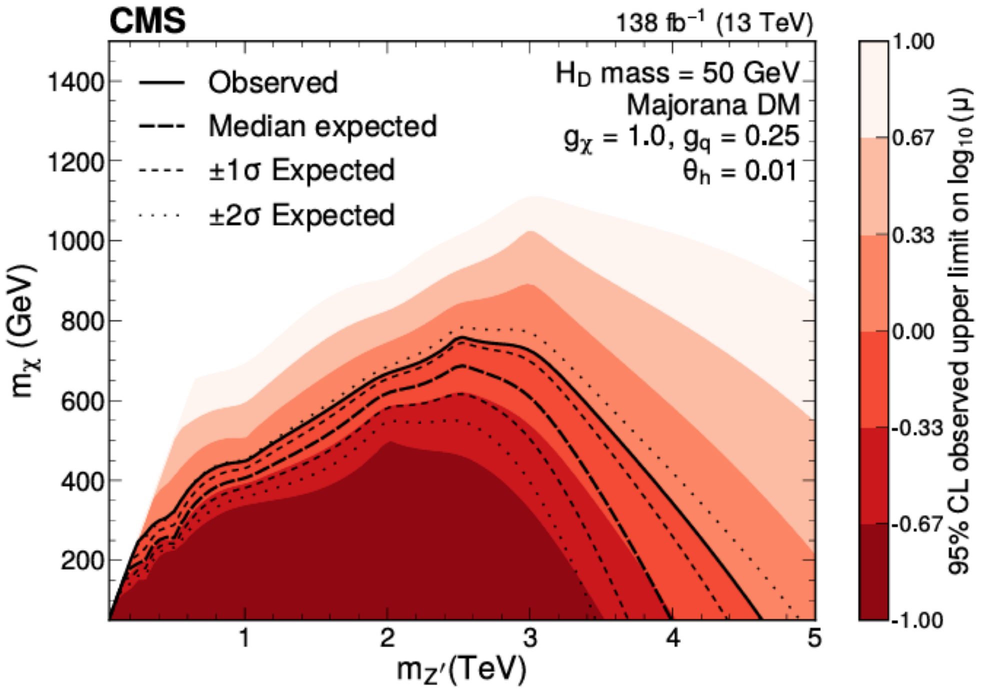
Submitted to Eur. Phys. J. C

Diana León Silverio | Néstor Raúl Mancilla Xinto (BUAP)

Production of DM (χ) via a Z′ mediator emitting a dark Higgs boson (H_D) to explain the observed relic abundance of DM



Using 138 fb^{-1} of 13 TeV pp data, the search targets events with large missing transverse momentum (p_{Tmiss}) from DM and a resonant structure in the invariant mass of a bb pair from the H_D decay.

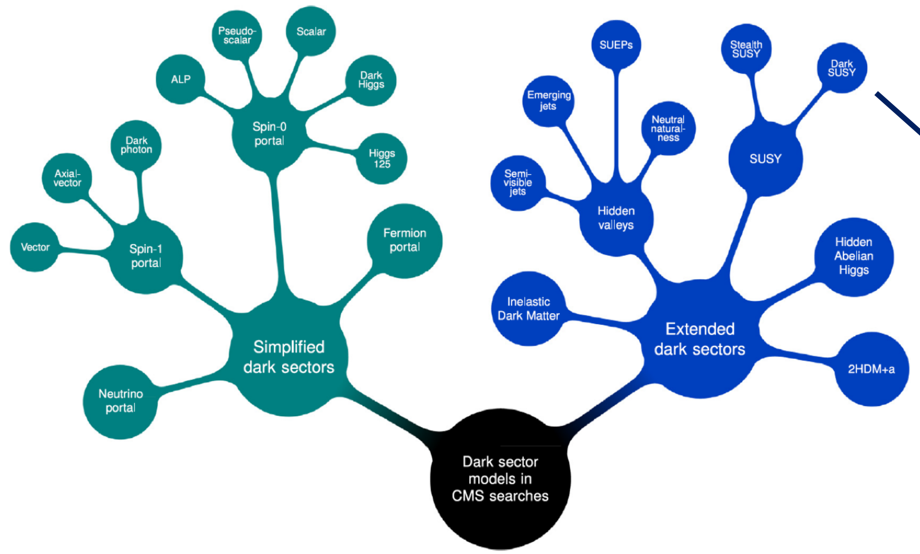


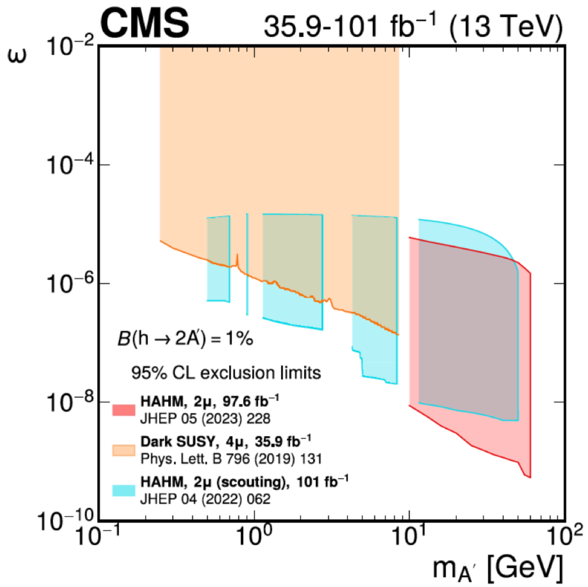
No significant excess was observed over the SM background.

The study sets 95% CL upper limits on the signal strength for H_D masses between 50–150 GeV, excluding for example mediator masses up to 4.5 TeV for a 50 GeV dark Higgs.

These results represent the **most stringent limits** set to date for dark Higgs boson masses in this specific production channel, significantly outperforming previous searches by CMS and ATLAS for similar hypotheses.

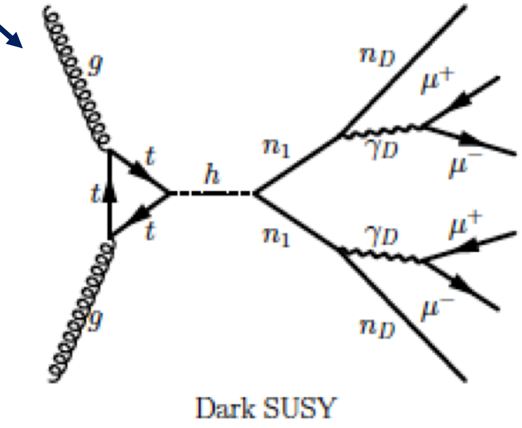
Dark matter searches (2/2)

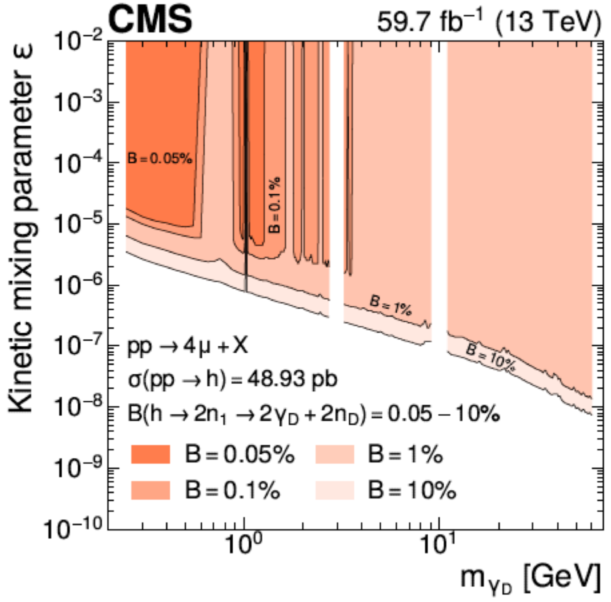




Model-independent search for the pair production of a new boson that decays into a pair of oppositely charged muons.

Model-independent limits and interpretation in terms of several models including: axion-like particle, dark photons signatures.





10.1007/JHEP12(2024)172

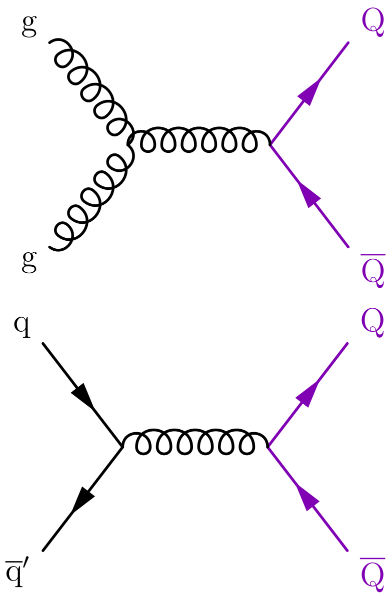
Interpretation results for extended dark sector in models including long living particles in the phase space defined by the kinetic mixing parameter and the mass of the new particle.

10.1016/j.physrep.2024.09.013

Vector-like quark searches (1/2)

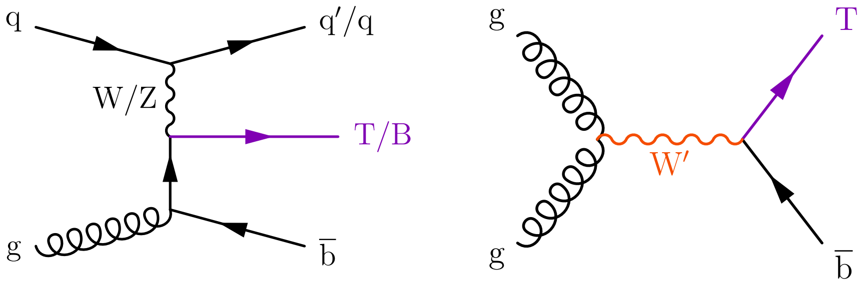
10.1016/j.physrep.2024.09.012

- They come up in many extensions to the SM to address the hierarchy and naturalness problems.
- Their left- and right-handed components transform in the same way under the electroweak symmetry group.
- Their masses do not arise from Yukawa couplings ⇒ not constrained by Higgs cross-section measurements.
- Flavours: T (+2/3), B (-1/3), $X_{5/3}$ (+5/3) and $Y_{4/3}$ (-4/3).
- Generally assumed to decay into a 3[rd] generation SM quark and either a W, Z or Higgs boson.



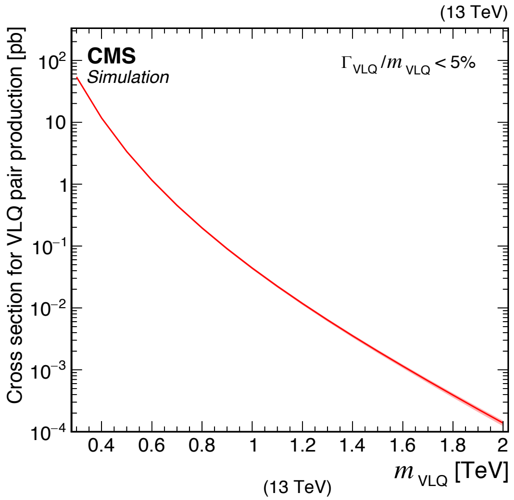
Pair production

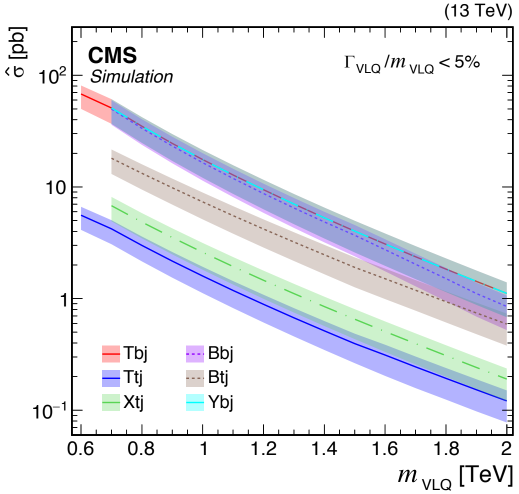
Dominant at low masses



Single production

Model dependent (couplings)
Via EW processes or new interactions





Vector-like quark searches (2/2)

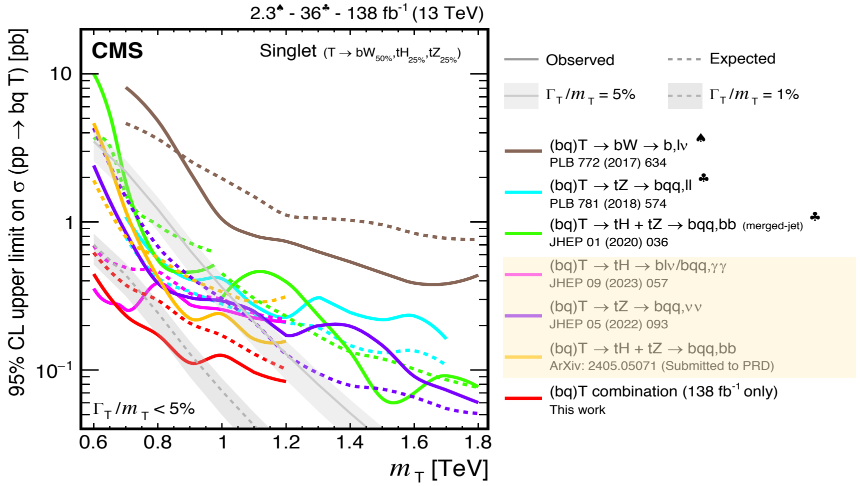
10.1016/j.physrep.2024.09.012

Combination of single T searches

- Decay modes considered:

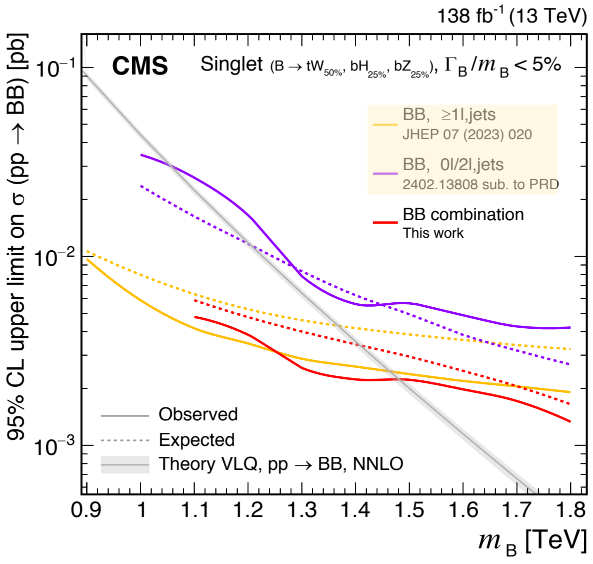
tH { $H \longrightarrow \gamma\gamma$, $H \longrightarrow bb$ }   **tZ** { $Z \longrightarrow \nu\nu$, $Z \longrightarrow bb$ }

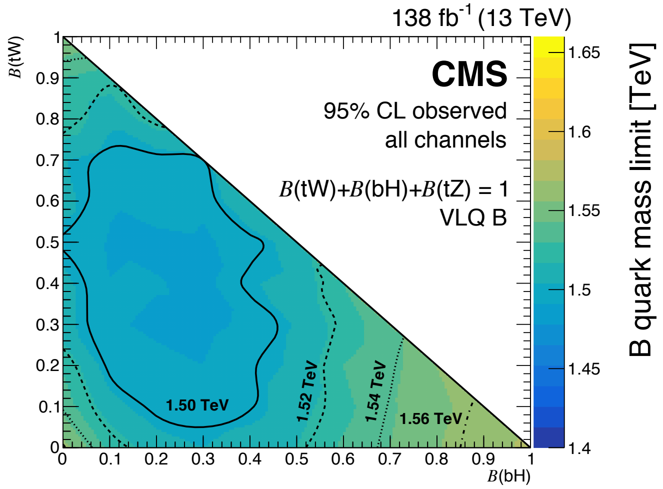
- Mutually exclusive final states ⇒ statistically independent observations.
- Only NWA scenarios included in the combination.



The upper limits on the cross section as a function of m_T in a singlet scenario show that the combination significantly improves the sensitivity.

Combination of BB searches

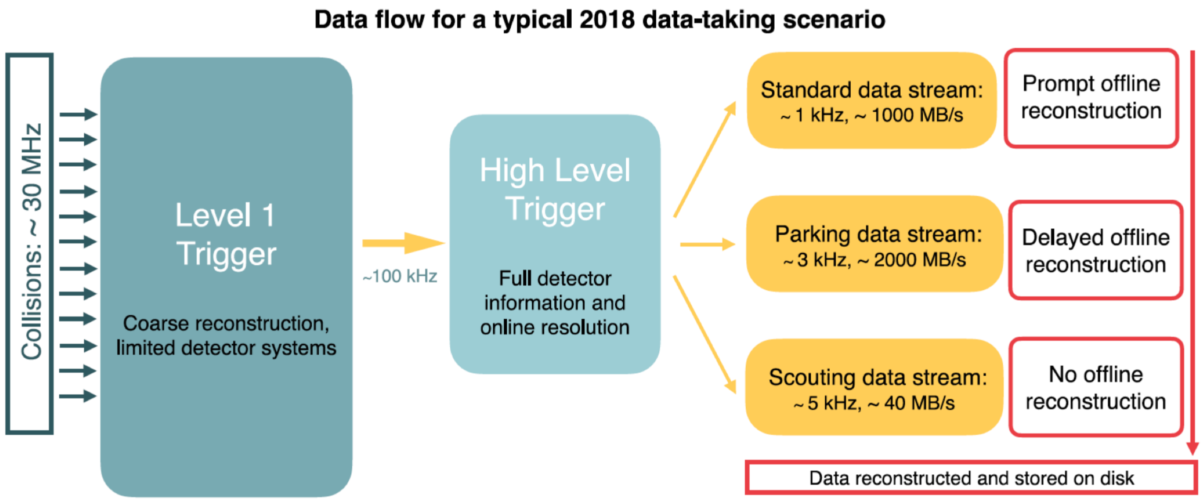




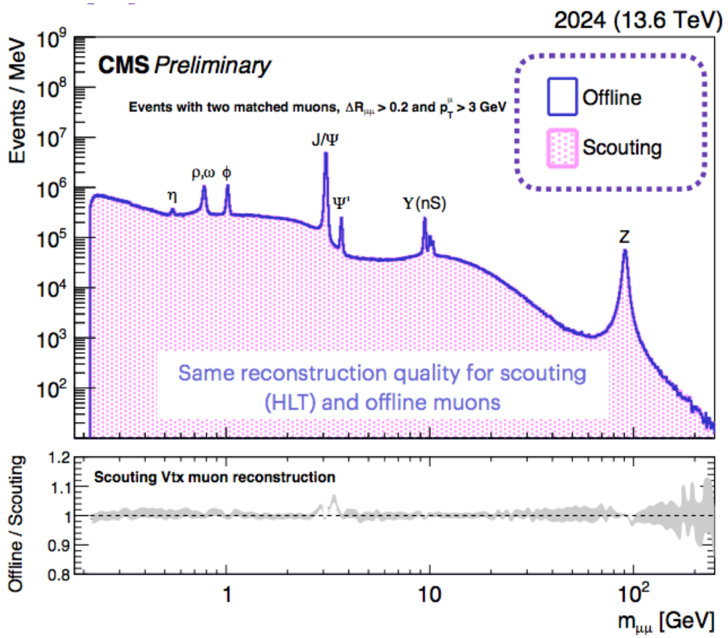
- Mutually exclusive lepton selection criteria. Final states:
  hadronic, **single-lepton**, **same-sign dilepton**, **opposite-sign dilepton**, **multilepton**
- Depending on the assumed branching fraction is the gain in sensitivity from the combination.
- BB production is excluded for masses below 1.49 TeV ⇒ significant increase w.r.t. any of the individual searches.

Scouting & Parking

10.1016/j.physrep.2024.09.006



Parking: raw data are recorded and subsequently processed for analysis much later in time (between data-taking periods).



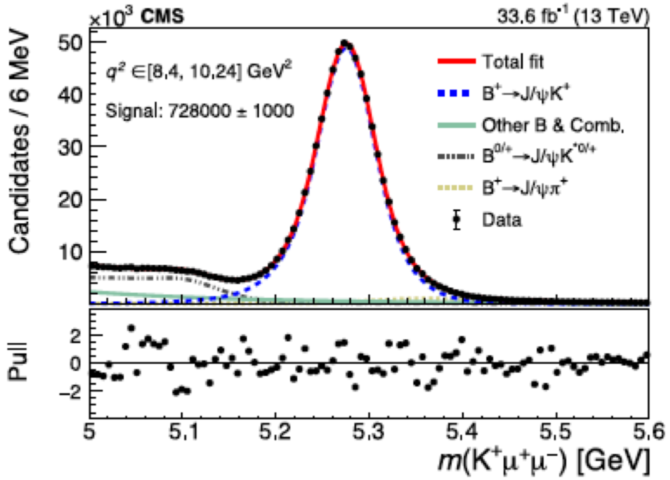
Scouting: Going beyond the designed trigger constraints by lowering thresholds. Record reduced information at high rates, opening up otherwise inaccessible low-mass phase space.

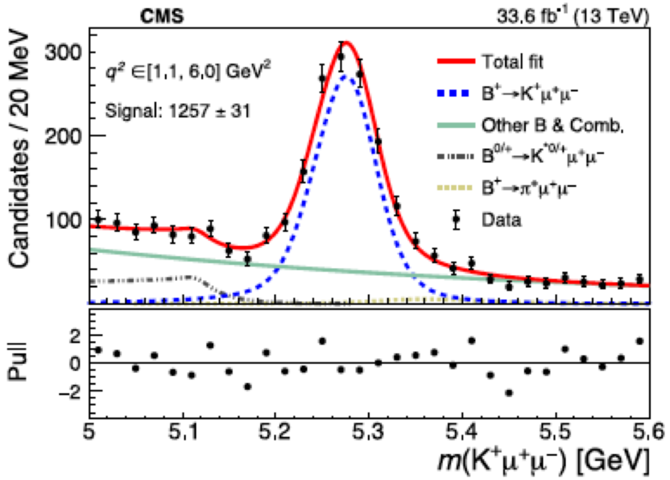
CMS-DP-2025-025

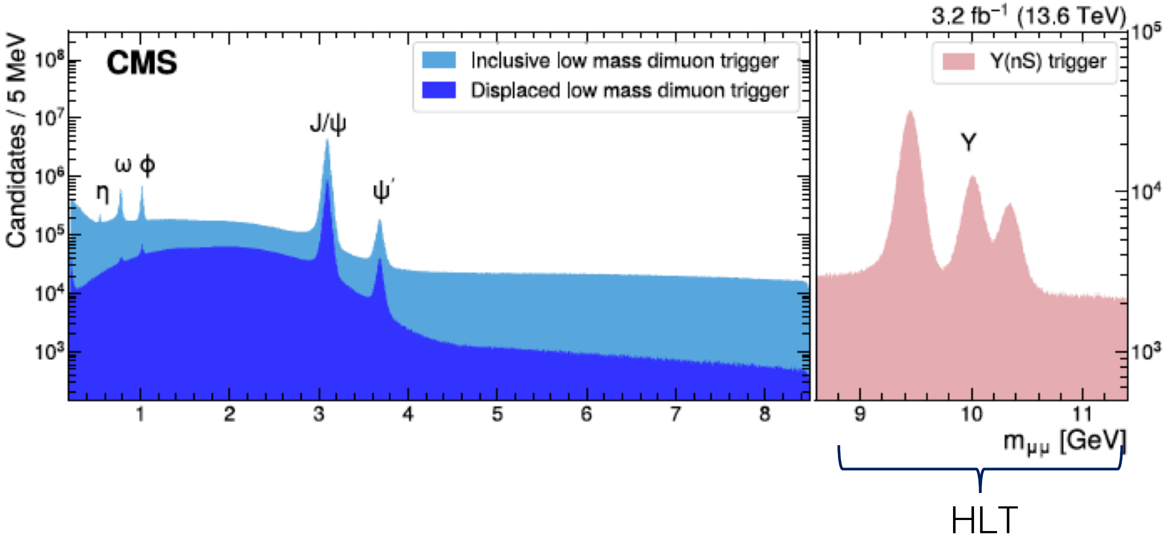
B physics in parking dataset

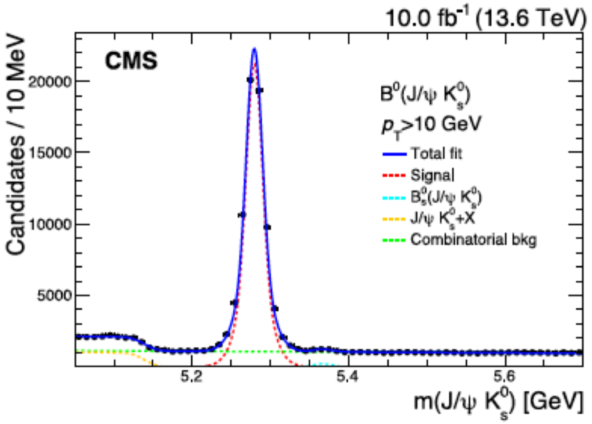
10.1016/j.physrep.2024.09.006

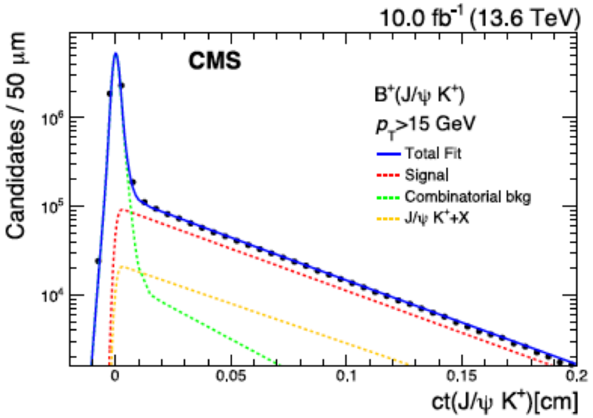
The data set provides access to BSM models with low-mass states and/or very rare decays, a parameter space complementary to the one offered by data sets that serve the high-p_T searches typical at the LHC, and thus substantially extends the reach of the CMS physics program.





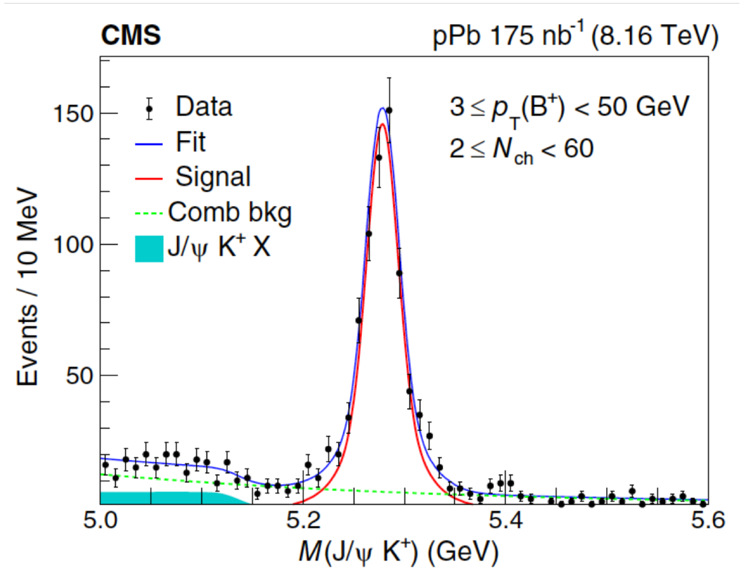


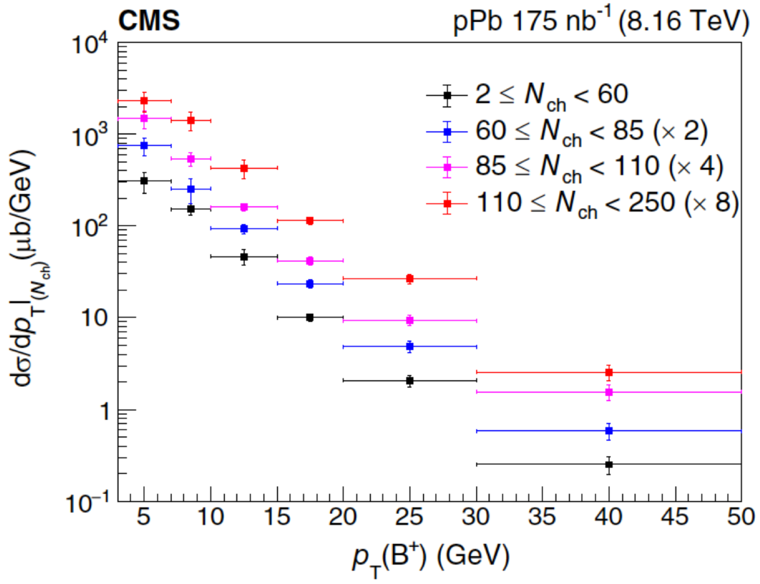




Flavour physics in Heavy Ions (1/2)

10.1103/PhysRevLett.134.111903





Heavy quarks are invaluable tools for studying QGP as they experience the entire lifetime of the medium, allowing them to probe the media properties throughout its evolution.

The analysis focuses on the measurement of the B+ differential cross section in pPb collisions, in the decay channel:

$$B^+ \rightarrow J/\psi K^+$$

Di-muon channel

The B^+ cross section has been measured for the first time in different bins of charged-particle multiplicity in pPb collisions, revealing a rising trend in the B^+ production with increasing charged-particle multiplicity.

Flavour physics in Heavy Ions (2/2)

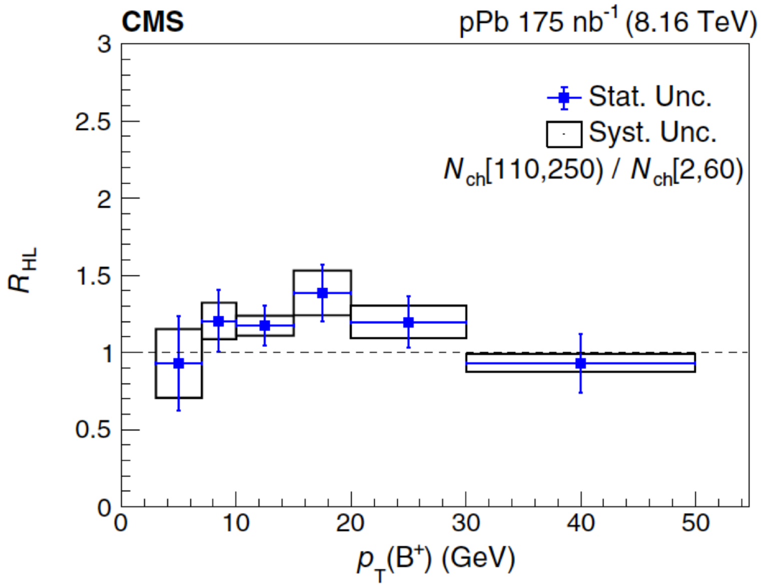
10.1103/PhysRevLett.134.111903

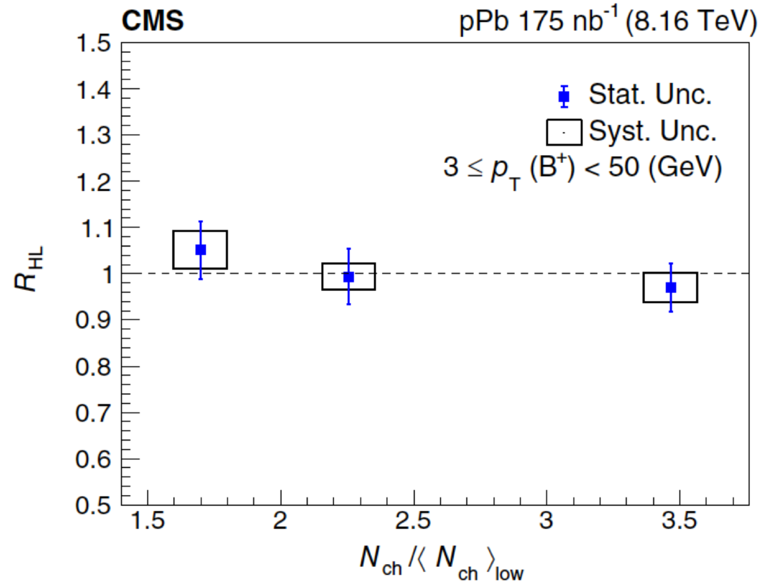
$$R_{\mathrm{HL}} = \frac{\langle N_{\mathrm{coll}} \rangle|_{\mathrm{low}}}{\langle N_{\mathrm{coll}} \rangle|_{\mathrm{high}}} \frac{(d\sigma/dp_{\mathrm{T}})|_{\mathrm{high}}}{(d\sigma/dp_{\mathrm{T}})|_{\mathrm{low}}}$$

This observable is defined as the ratio of cross sections for events at high multiplicity to those at low multiplicity, scaled by the corresponding number of binary collisions in two multiplicity bins.

$$R_{\mathrm{HL}} = \frac{(d\sigma^{B^+}/dp_{\mathrm{T}})|_{\mathrm{high}}}{(d\sigma^{B^+}/dp_{\mathrm{T}})|_{\mathrm{low}}} \Bigg/ \frac{(d\sigma^{Z}/dp_{\mathrm{T}})|_{\mathrm{high}}}{(d\sigma^{Z}/dp_{\mathrm{T}})|_{\mathrm{low}}}$$

The production of Z bosons is expected to scale with the number of binary collisions and be void of any final-state medium effects; thus, the ratio of Z boson cross sections can be used to determine the scaling factor.





The observed ratios are consistent with unity within uncertainties for all event selections studied, setting constraints on possible presence of medium effects in the B^+ meson production.

Particle correlations in UPC (1/2)

10.1016/j.physletb.2023.137905

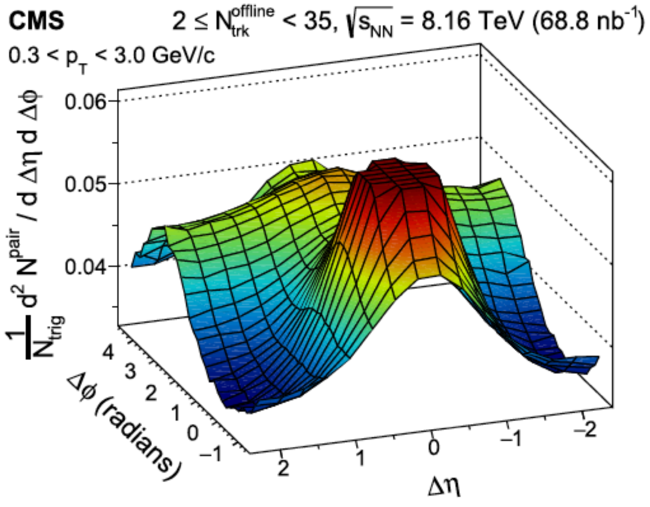
Search for collective effects in γp events from ultra-peripheral collisions in pPb => Measure azimuthal correlations between particles far apart in rapidity.

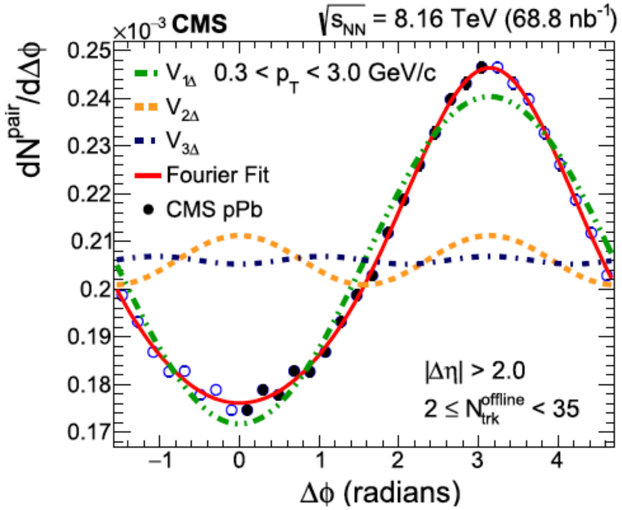
“Ridge” has been observed in pPb and high-multiplicity pp events, but so far not in smaller systems:

e^+e^-, ep, γPb

$$\frac{1}{N_{\rm trig}}\frac{{\rm d}^2N^{\rm pair}}{{\rm d}\Delta\eta{\rm d}\Delta\phi} = B(0,0)\frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$

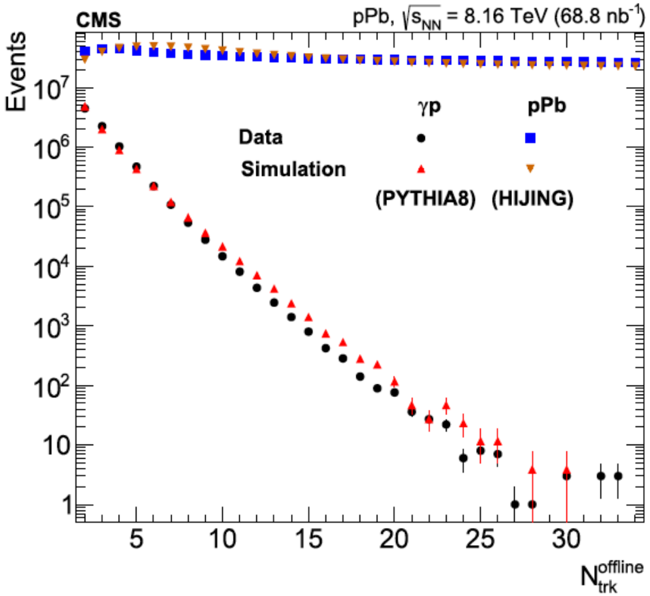
γp enhanced





Unlike typical pPb collisions, which produce particles at both positive and negative rapidity, γp events are expected to be very asymmetric in the laboratory frame.

=> A rapidity gap is defined as a continuous region with low detector activity.



Two-particle azimuthal correlations can be characterized by their Fourier components ($V_{n\Delta}$).

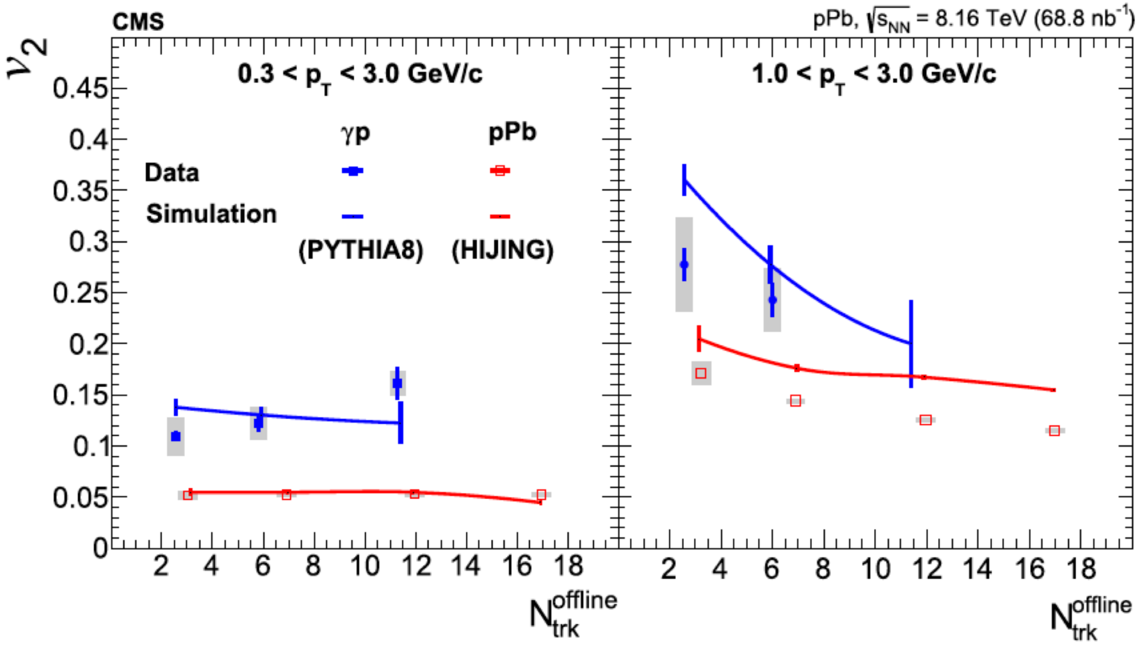
Particle correlations in UPC (2/2)

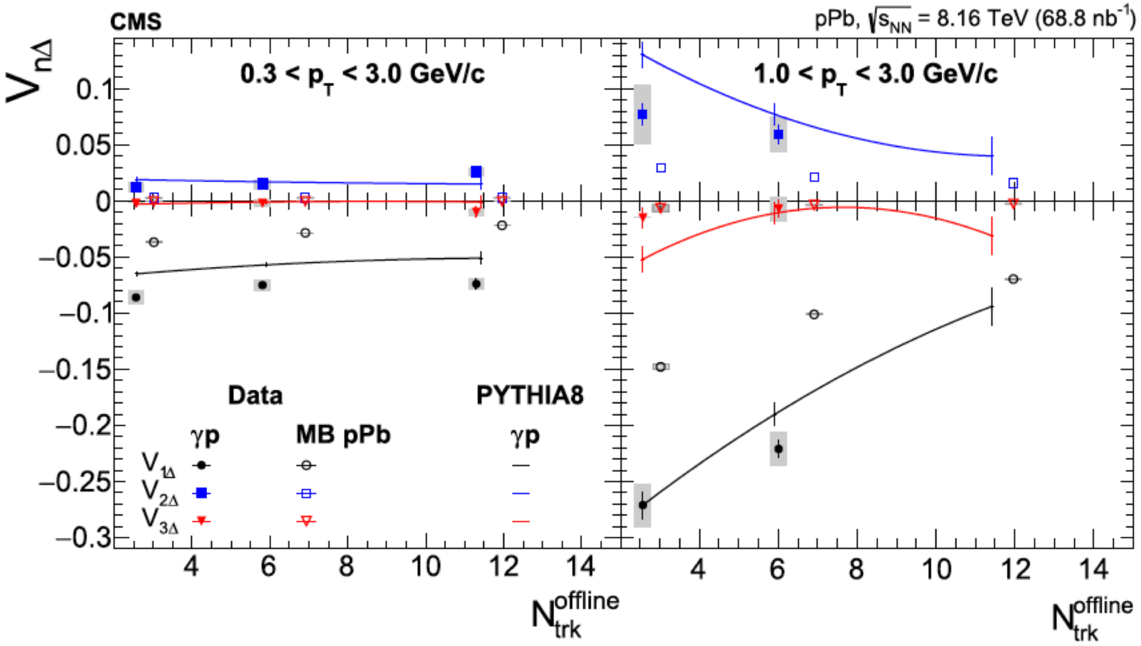
10.1016/j.physletb.2023.137905

p_T range				
		$2 \le N_{trk}^{offline} < 5$	$5 \le N_{trk}^{offline} < 10$	$10 \le N_{trk}^{offline} < 35$
	$V_{1\Delta}$	-0.086 ± 0.006	-0.075 ± 0.005	-0.074 ± 0.007
$0.3 < p_T < 3.0$ GeV/c	$V_{2\Delta}$	0.012 ± 0.004	0.015 ± 0.004	0.026 ± 0.006
	$V_{3\Delta}$	-0.002 ± 0.001	-0.002 ± 0.004	-0.010 ± 0.006
		$2 \le N_{trk}^{offline} < 5$	$5 \le N_{trk}^{offline} < 35$	
	$V_{1\Delta}$	-0.271 ± 0.021	-0.221 ± 0.017	
$1.0 < p_T < 3.0$ GeV/c	$V_{2\Delta}$	0.077 ± 0.027	0.059 ± 0.017	
	$V_{3\Delta}$	-0.015 ± 0.009	-0.007 ± 0.013	

In all p_T and multiplicity ranges, $V_{1\Delta}$ is negative, $V_{2\Delta}$ is positive with a smaller magnitude than $V_{1\Delta}$, and $V_{3\Delta}$ is consistent with zero. The magnitudes of both $V_{1\Delta}$ and $V_{2\Delta}$ increase with p_T.

At a given p_T and track multiplicity, v_2 is larger for γp-enhanced events than for MB pPb interactions. Predictions from the Pythia8 model describe well the data within uncertainties. This suggests the data are dominated by noncollective effects.



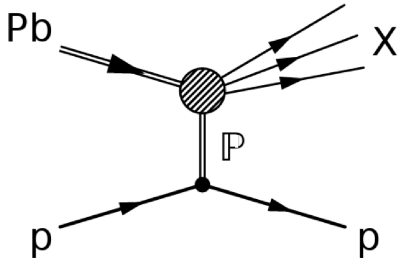


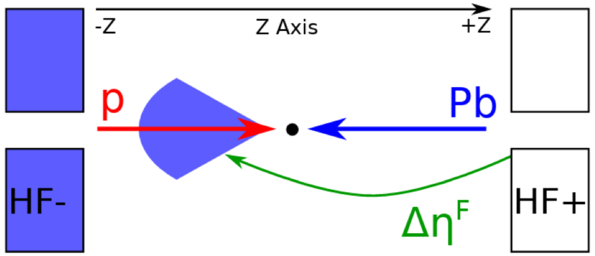
Dependence of 2pc on rapidity gap

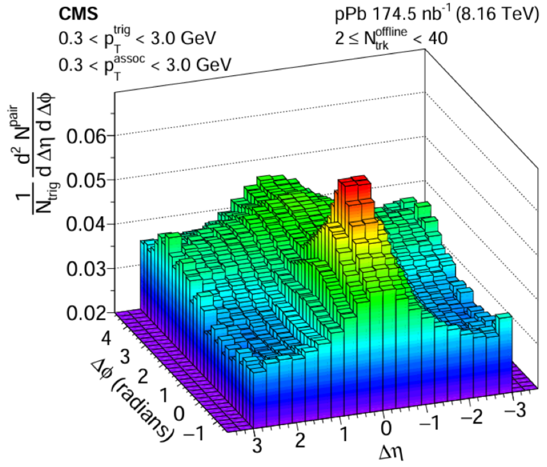
Submitted to Phys. Rev. C

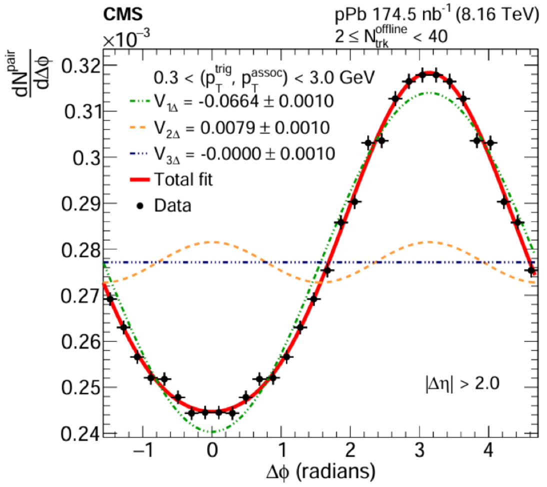
Moisés León Coello (UNISON)

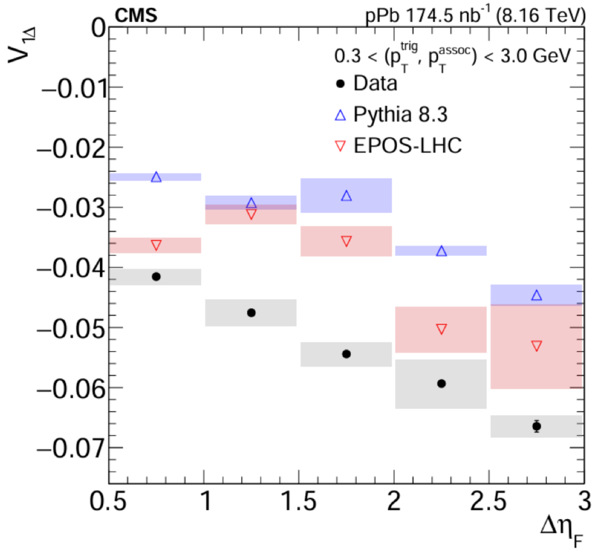
- The study aims to understand the origin of collective flow observed in small collision systems like proton-lead (pPb).
- Events are selected by requiring energy deposition in one of the forward calorimeters and no activity in the forward calorimeter on the opposite side (**rapidity gap**).
    - Enhance color-singlet exchanges (like pomeron-lead interactions).

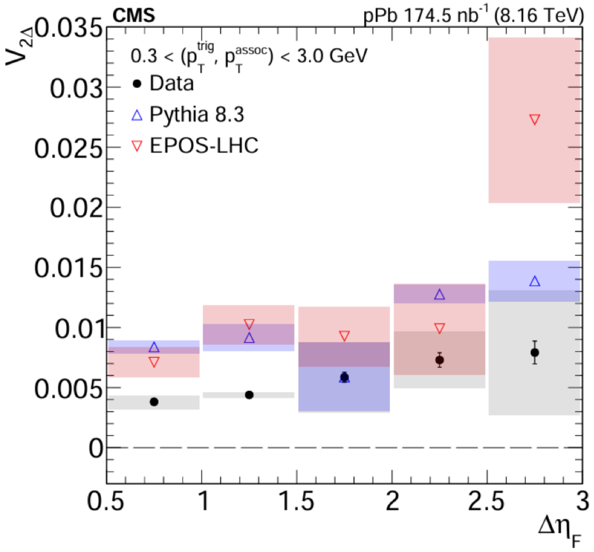












- No "ridge-like" structure is visible in this diffraction-enhanced sample.
- The $V_{1\Delta}$ coefficients were found to be negative and decrease with gap width, while $V_{2\Delta}$ increases monotonically.
- Elliptic flow coefficients (v_2) are consistent with zero in many bins, leading to the derivation of upper limits.

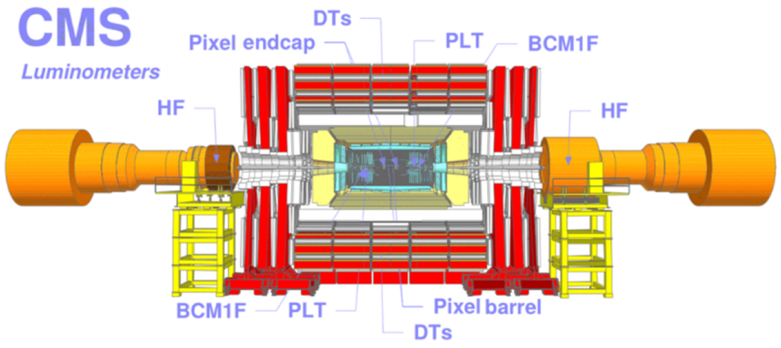
This study provides a reference for models predicting reduced collective response when multiparton interactions are suppressed.

Run 2 luminosity measurement (1/2)

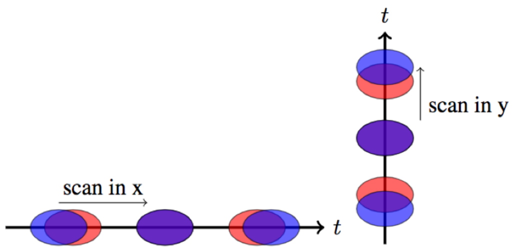
CMS PAS LUM-20-001

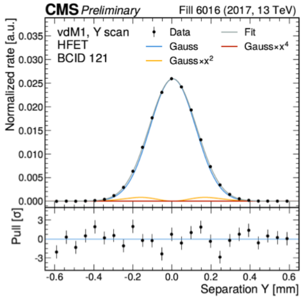
Instantaneous luminosity $\mathcal{L}(t)$ is defined as the number of collisions per unit area per unit time. It can be determined via:

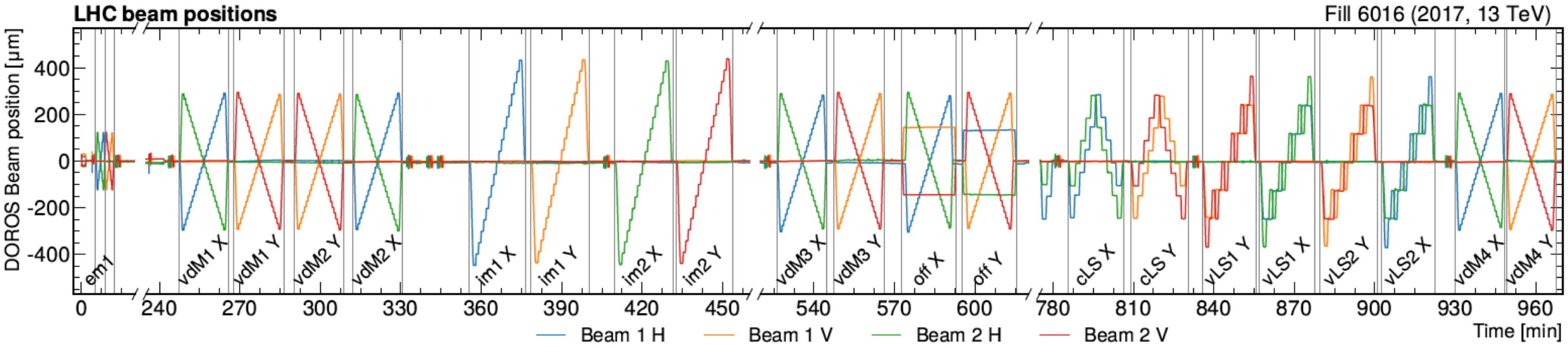
$$\mathcal{L}(t) = R(t)/\sigma_{\text{vis}}$$



$$\sigma_{\text{vis}} = 2\pi \frac{R(0,0)}{N_1 N_2} \Sigma_x \Sigma_y$$

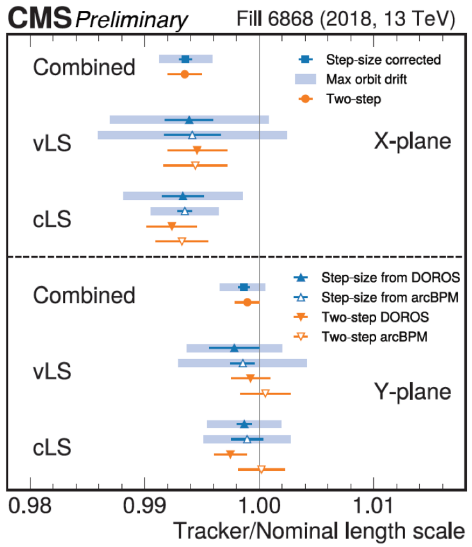


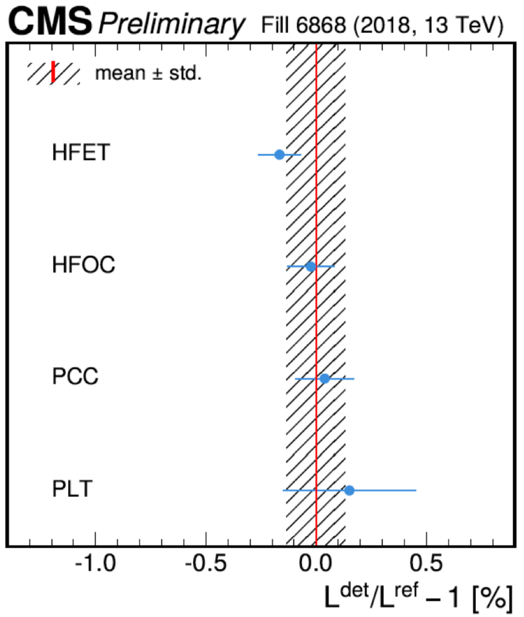


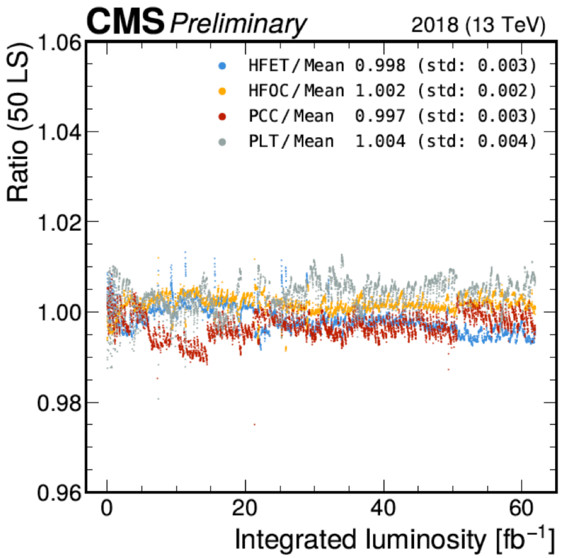


Run 2 luminosity measurement (2/2)

CMS PAS LUM-20-001



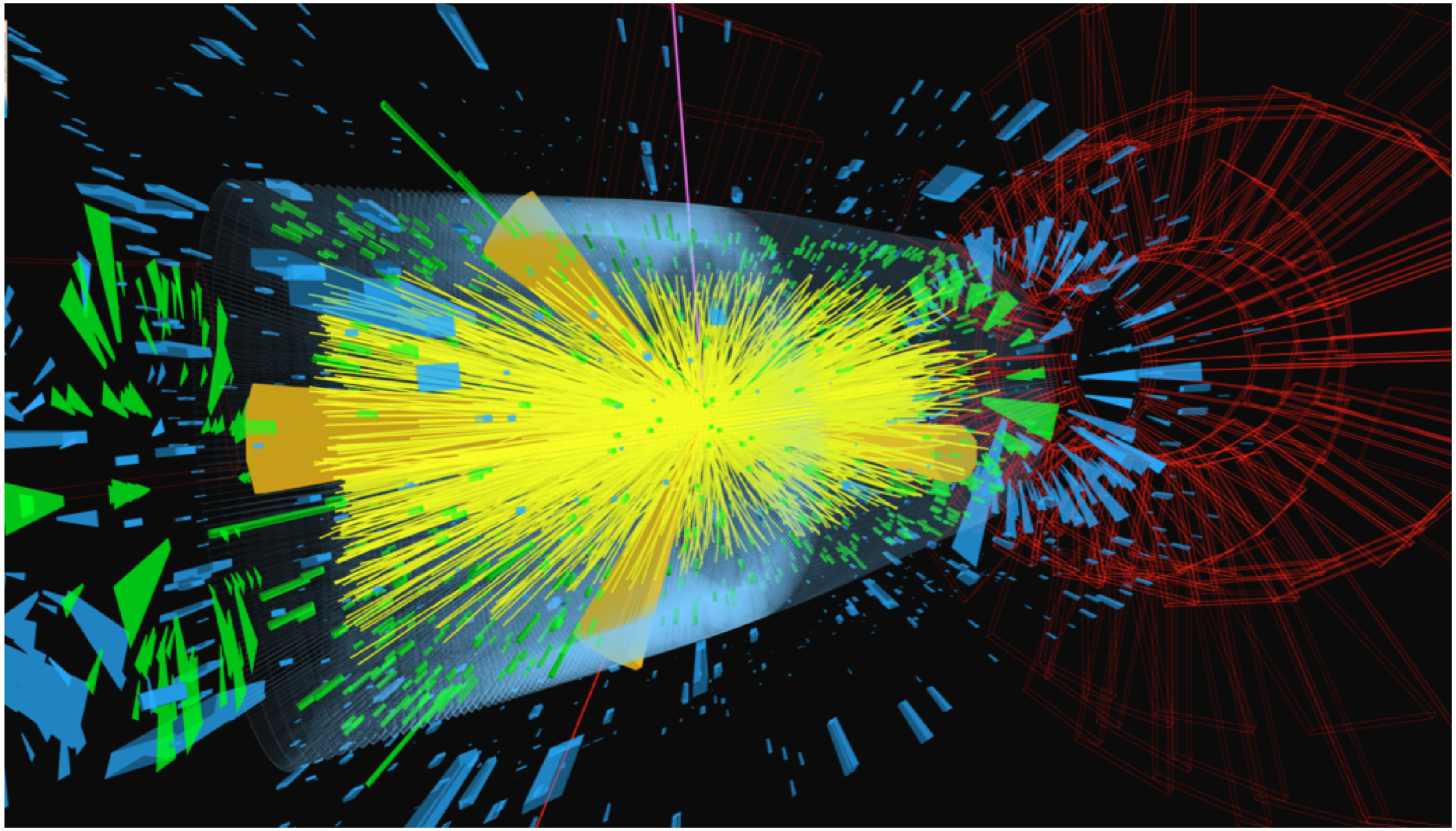




Source	2017 [%]	2018 [%]
Normalization		
Beam current normalization	0.2	0.2
Ghost and satellite charges	0.06	0.07
Beam-beam effects	0.29	0.30
Orbit drift	0.09	0.19
Length scale calibration	0.15	0.18
Transverse factorizability	0.33	0.36
Scan to scan variation	0.26	0.27
Bunch to bunch variation	0.1	0.1
Cross-detector consistency at vdM	0.17	0.14
Integration		
Cross-detector consistency per year	0.19	0.30
Linearity	0.51	0.42
Total normalization uncertainty	0.61	0.66
Total integration uncertainty	0.54	0.52
Total uncertainty	0.82	0.84

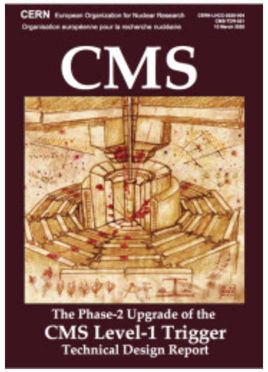
When combined with the 2015–2016 data sets at the same center-of-mass energy, the relative precision of the total integrated luminosity is **0.73%**, representing the most precise luminosity measurement ever achieved at bunched-beam hadron colliders.

The road ahead

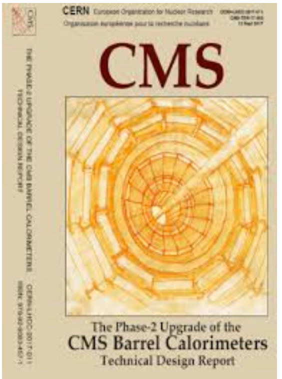


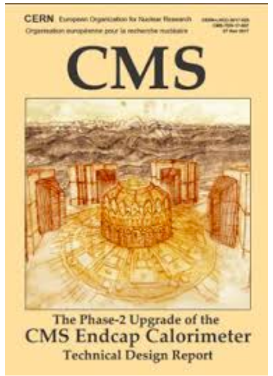
CMS Phase II Simulation. Event display of a VBF Higgs boson on top of 200 pile-up collisions.

The road ahead

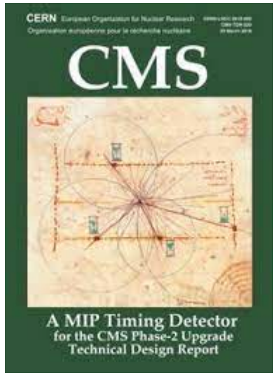


L1-Trigger
Tracks in L1 at 40 MHz
Particle flow selection
750 kHz L1 output
40 MHz data scouting

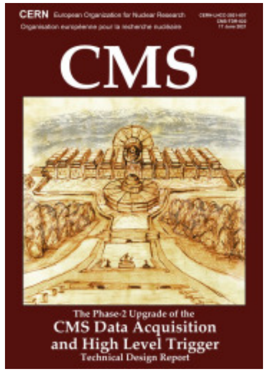




Barrel and Endcap calorimeters
ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV.
ECAL and HCAL new BE boards
3D showers and precise timing
Si, Scint+SiPM in Pb/W-SS

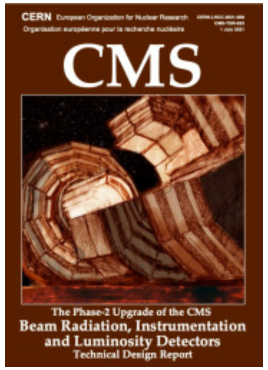


MIP Timing Detector
Precision timing with:
Barrel layer – Crystals and SiPMs
Endcap layer – low gain avalanche diodes

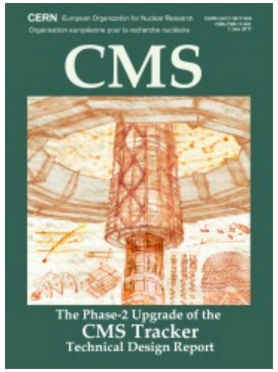


DAQ & HLT
Full optical readout
Heterogeneous architecture
60 TB/s event network
7.5 kHZ HLT output

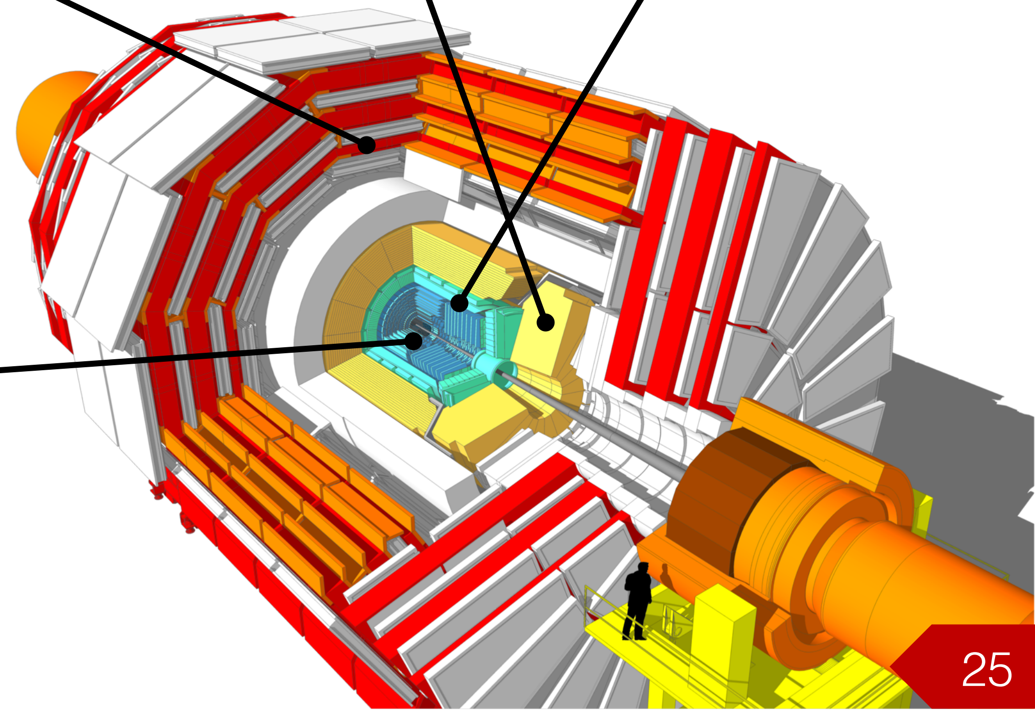
Muon system
DT & CSC new FE/BE readout
RPC BE electronics
New GEM/RPC in 1.6 < η < 2.4
Extended coverage to η of 3



BRIL
Beam abort & timing
Beam-induced background
Bunch-by-bunch luminosity
Neutron and mixed-field radiation monitors



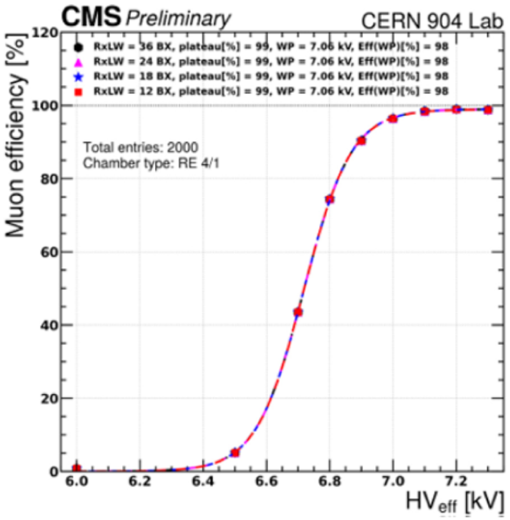
Tracker
Si-strip and pixels increased granularity
Design for tracking in L1 trigger
Extended coverage to η of 3.8



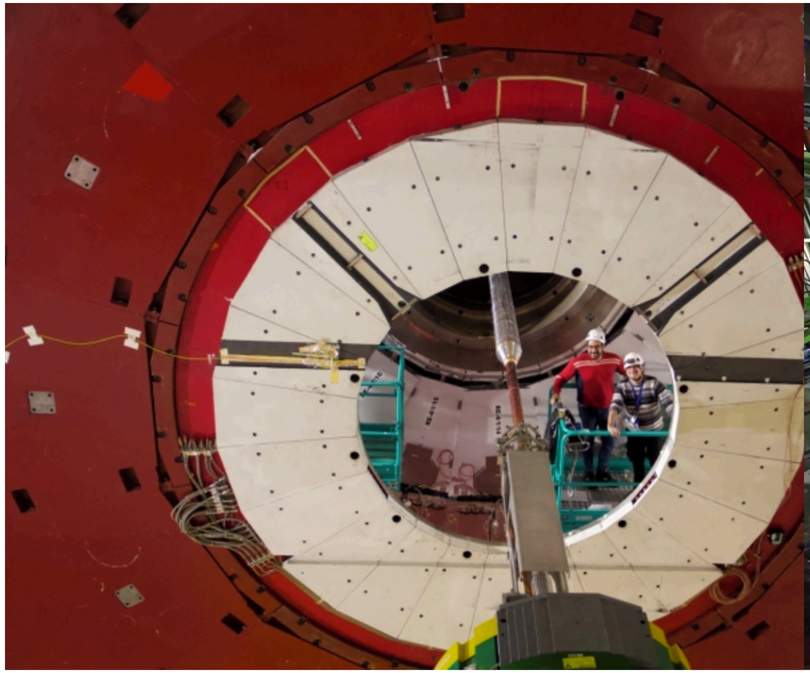
iRPC for Phase-2 (1/3)

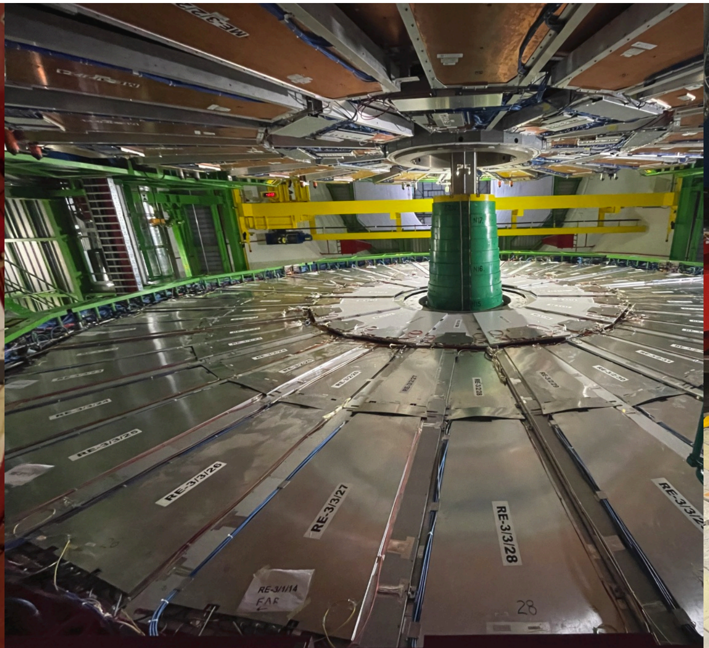
10.1016/j.nima.2025.170484

From construction…



To installation!



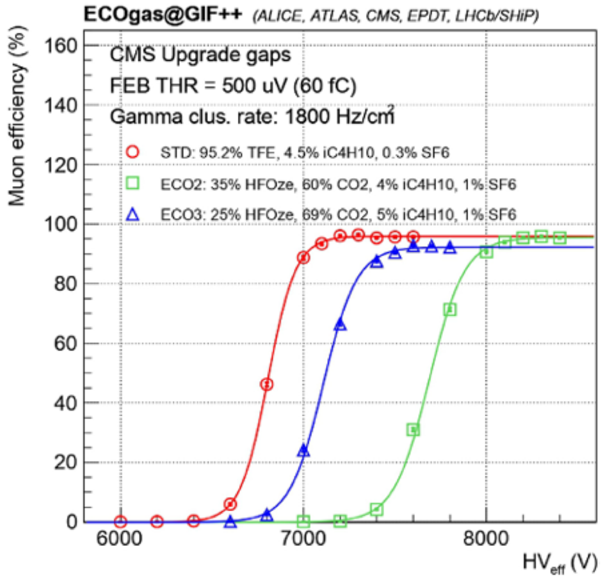


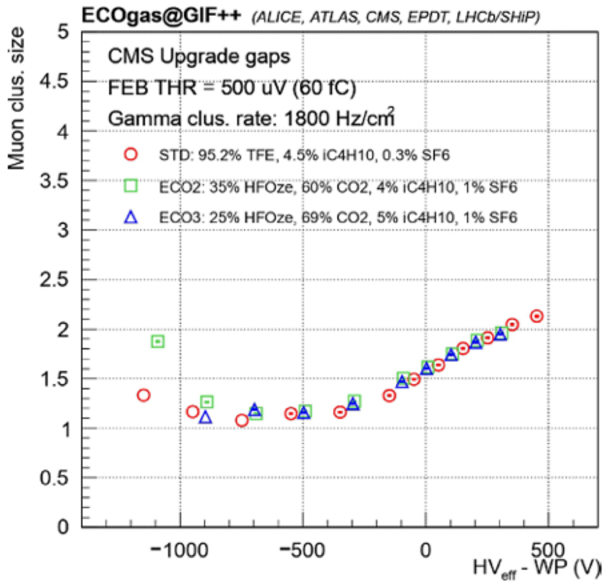
iRPC for Phase-2 (2/3)

10.1016/j.nima.2024.169510

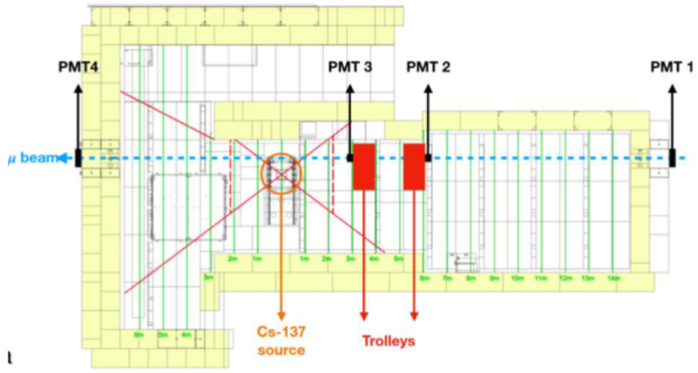
Dalia Ramírez Guadarrama (IBERO)

Other studies

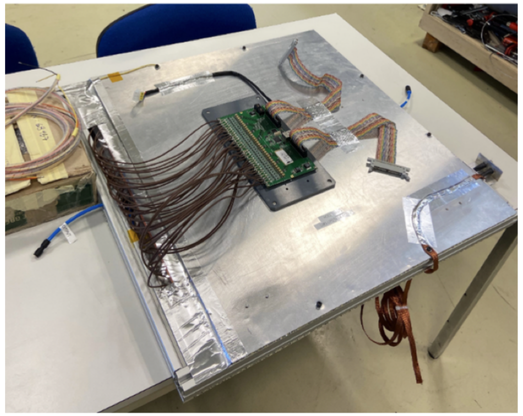




Componente	CMS	ECO2	ECO3
Hexafloruro de azufre (SF_6)	0.3%	1%	1%
Isobutano (i-C_4H_{10})	4.5%	4%	5%
Ácido hipofluoroso (HFO)	–	35%	25%
Dióxido de carbono (CO_2)	–	60%	69%
TFE ($C_2F_4H_2$)	95.2%	–	–
GWP (Global Warming Potential)	1434.55	476	527



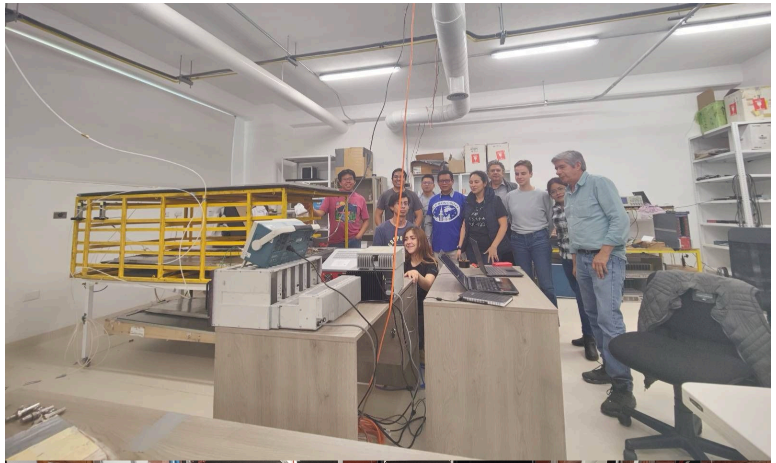
The performance of an iRPC-like detector using eco-friendly gas mixtures was compatible with the standard operational performance.



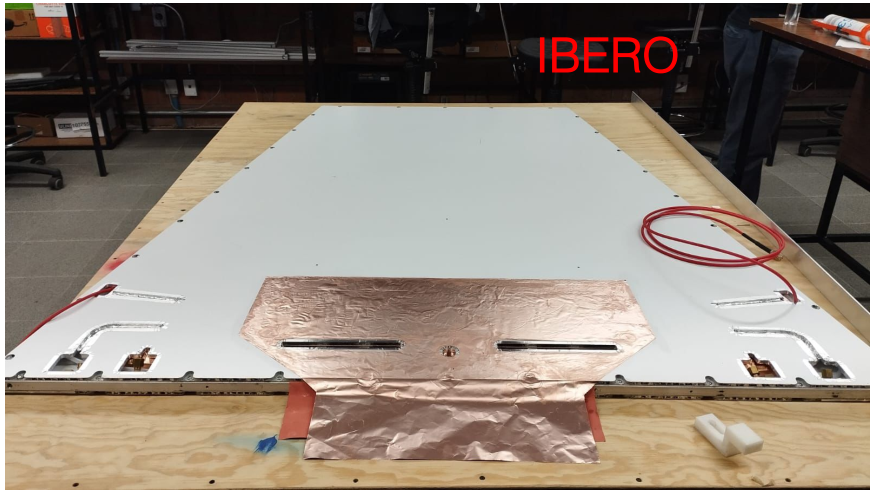
iRPC for Phase-2 (3/3)

Both labs have successfully assembled their first iRPC.
-- FEBs are coming in the next weeks.

These are the **first CMS detectors built in Mexico**!

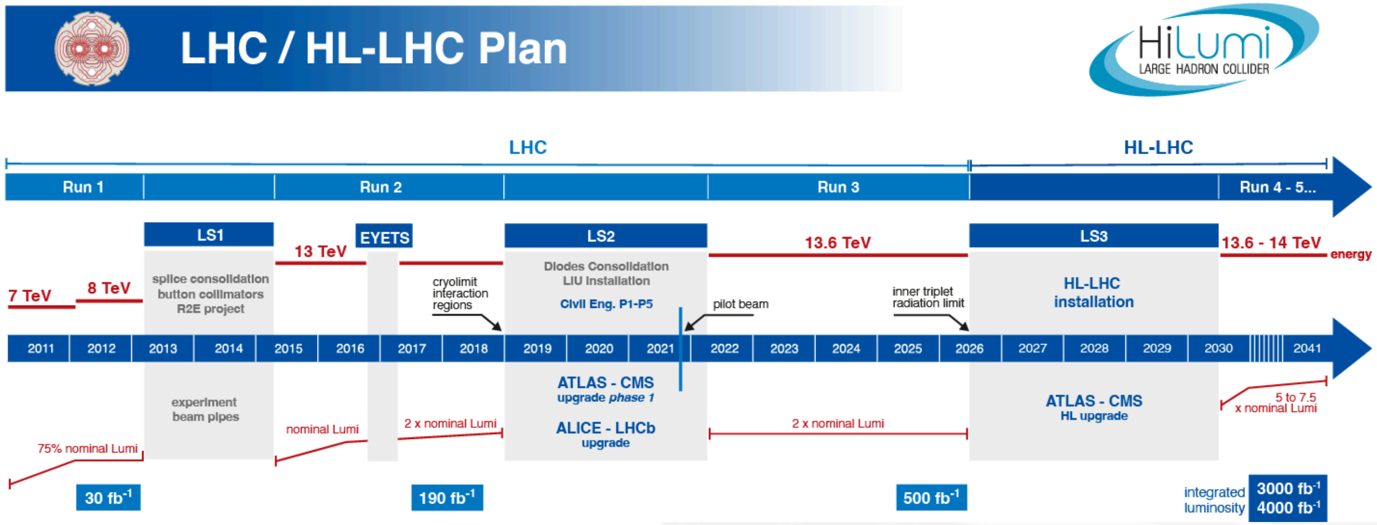


Mexican RPC Labs
(BUAP, IBERO)



Summary

- Excellent performance of machine & experiment has led to a plethora of nice physics results. Today only a handful were shown, totally biased based on personal interests.
- The Mexican community in CMS plays a leading role both in physics analysis and in operation/performance.
- We are almost halfway through the LHC adventure, but there is still plenty to do.



Thanks!