JOINT INSTITUTE FOR NUCLEAR RESEARCH

Physics Studies with the CMS experiment and the second phase of detector upgrade for operation in high luminosity conditions (2026-2030)

JINR Theme 02-1-1083-2009

Project Leader: V.Yu. Karjavine
Project Deputy Leader: S.V. Shmatov
Project Scientific Leader: V.A. Matveev

Current projects

CMS. Physics research at the LHC. 02-1-1083-1-2010/2025
CMS detector upgrade. 02-1-1083-2-2010/2026

62nd Meeting of the Programme Advisory Committee
June 23 2025

JINR in CMS

JINR has been actively involved in the CMS project during **more then 30 years**

- carrying out the **CMS physics research program**
- **design, construction, operation and upgrade of the detectors for the CMS endcap region**
- **maintaining the efficient operation** of the CMS detector and participating in experimental data taking

The main contribution of JINR was focused on

- Endcap Hadron Calorimeter (HCAL)
- Forward Muon Station (ME1/1)

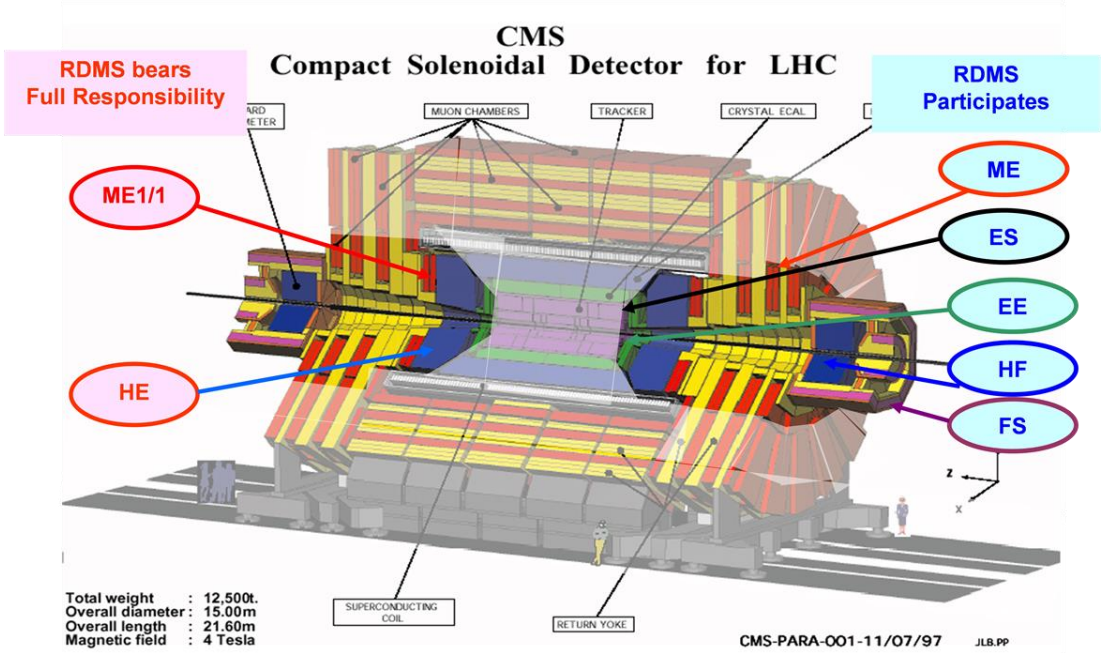
Two periods of **CMS upgrade** during LHC technical long stops:

- 2013–2015 (Long Stop 1, **LS1**)
- 2019–2022 (Long Stop 2, **LS2**)

the goal is – to ensure efficient operation of all systems at the LHC luminosity up to 2 $x10^{34}cm^{-2}c^{-1}$ with a design value of proton-proton collision energy up to 13.6 TeV

The research program was performed within **RDMS Collaboration**, bringing together physicists from more than twenty institutes from Russia and Member States of Joint Institute for Nuclear Research

This days: JINR + Armenia, Belarus, Georgia, Uzbekistan (DMS)



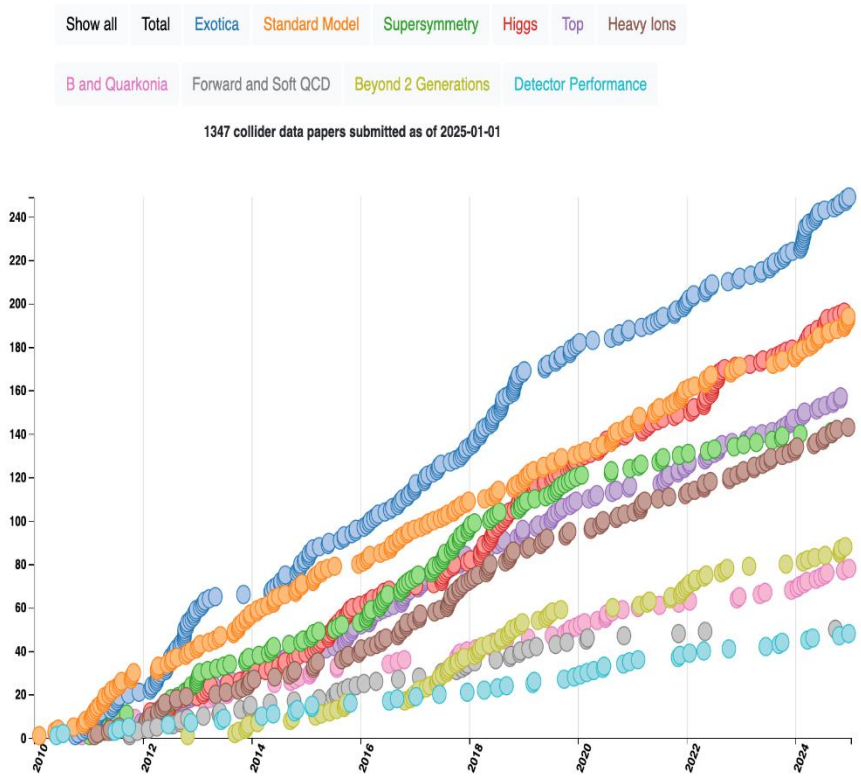
JINR Publications in 2020-2025

- The full list of CMS collaboration publications for 2010-2025, authored by JINR representatives (42 authors for this days), includes 425 scientific CMS papers.
- JINR physicists made a defining contribution to the preparation of 93 scientific papers including:
  - ✓ 14 papers published by CMS in refereed journals
  - ✓ 45 paper in refereed journals (non-CMS papers related with the Project)
  - ✓ 5 chapters in monographs
- The results of the work were presented in more than 115 reports at various conferences, workshops, and seminars:
  - ✓ LHCP (2020, 2025), ICHEP (2020), Conference of SNP NPD RAS (2020, 2024, 2025), Lomonosov Conference on Elementary Particle Physics (2021, 2023), NUCLEUS (2021, 2022, 2024), PANIC (2021), QFTHEP (2022), GRID (2021, 2023), CHEP-Yerevan (2023), LHC Days in Split (2024), SILAFAE (2024), etc
- 2 doctoral dissertations, 1 candidate dissertation

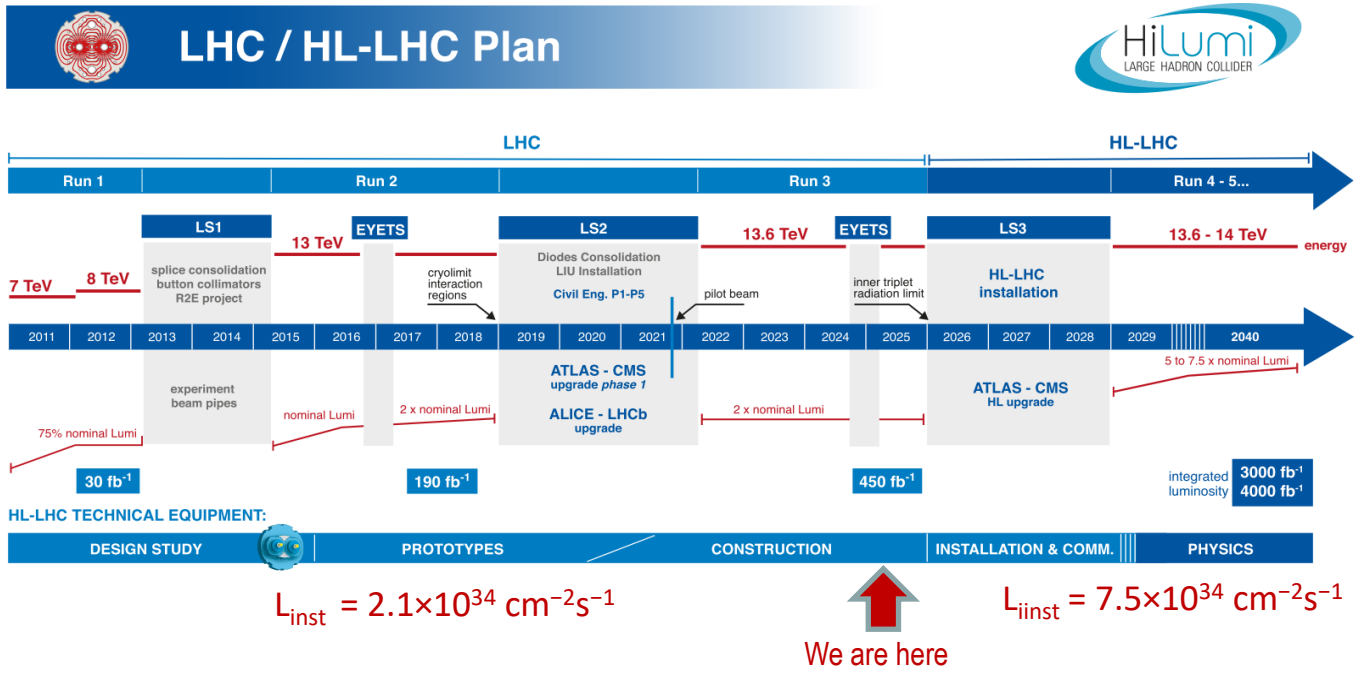
~40 talks were presented by young scientists

CMS publications statistics

- 1373 papers based on collision data (RUN-1/RUN-2/RUN3) submitted so far.
- 30 papers published so far in 2025

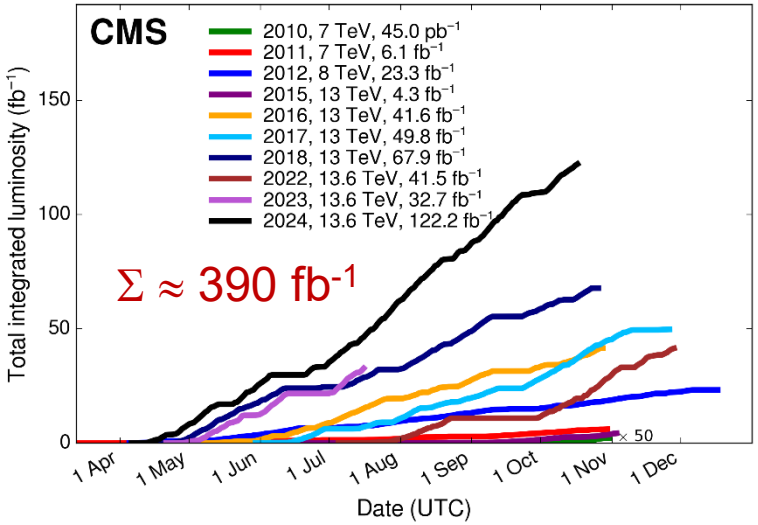


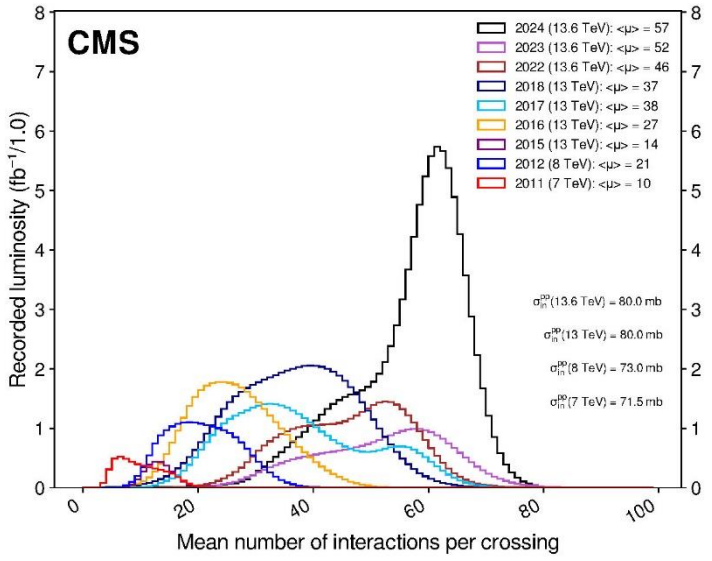
LHC Timeline and Data That We Have



$L_{inst} = 2.1\times10^{34}\ cm^{-2}s^{-1}$ $L_{iinst} = 7.5\times10^{34}\ cm^{-2}s^{-1}$

We are here





- CMS Dataset RUN2
  - ✓ ~163 fb^{-1} of proton-proton collisions @ 13 TeV is delivered
  - ✓ 151.78 fb^{-1} is recorded by CMS (data-taking efficiency ~93%)
- CMS Dataset RUN3
  - ✓ 196.35 fb^{-1} is already delivered @ 13.6 TeV during the RUN3
  - ✓ 180.84 fb^{-1} is recorded by CMS (data-taking efficiency ~92%)
  - ✓ number of pp interactions per beam crossing: ⟨PU⟩ = 57 for 2024
- ~260 fb^{-1} it is expected @ 13.6 TeV for the end of the RUN3 (450 fb^{-1}, in total for RUN1/2/3)
- pPb and PbPb Runs

CMS Data Quality Information
https://twiki.cern.ch/twiki/bin/view/CMSPublic/DataQuality

Goals and Tasks of the Project

The main goals of the project

- development and implementation of a research program for precision testing of the Standard Model (SM) and searches for new physics beyond SM (BSM)
- maintenance and upgrade of the CMS experiment to ensure its efficient operation in HL–LHC mode, including participation in the construction of High Granularity Calorimeter (HGCal) and upgrade of the CMS endcap muon station ME1/1

Main five tasks which are define the project structure

- **development and realization of the CMS physics research program** focused on searches for new physics beyond the Standard Model, studies of Higgs boson properties, and other SM tests
- **CMS detector upgrades for HL–LHC operation**, including participation in the construction of the High-Granularity Calorimeter (HGCal) and continued upgrades of the CMS Endcap Muon system detector
- **operation and maintenance of detectors**, providing of their operational reliability and experimental data taking quality
- **development of methods and algorithms** for physical object reconstruction and event selection
- **development of software for the distributed data processing and analysis system** based on grid technologies, ensuring reliable and uninterrupted operation of JINR grid infrastructure for the CMS experiment (Tier-1 and Tier-2 centers)

JINR Team Obligations

- **Participants:** 60 from JINR; 12 from JINR member-states (DMS), 20 members of JINR associated personnel
- **11 young researchers**: 6 PhD Students from JINR, 5 PhD Students from DMS.
- **Authors:** 23 from JINR and 3 from DMS (21 paid by JINR and 5 unpaid PhSt.)
  16 from RF Institutions - ex CMS members

- **JINR team obligations in 2025**
  - Detectors maintenance and operation
  - JINR Tier-1 and Tier-2 centers robust operation
  - Experimental Physics responsibilities (EPR), due for an author is 4.0 months tasks (including shifts), 165.5 FTE-months in 2025, central shifts – 9.51

- **JINR EPR 2024 results**

  Work Due: 96.91, Work + Shifts: 109.88

  Central Shifts – 11.55, EPR Shifts – 6.881

  EPR Works – 103.0

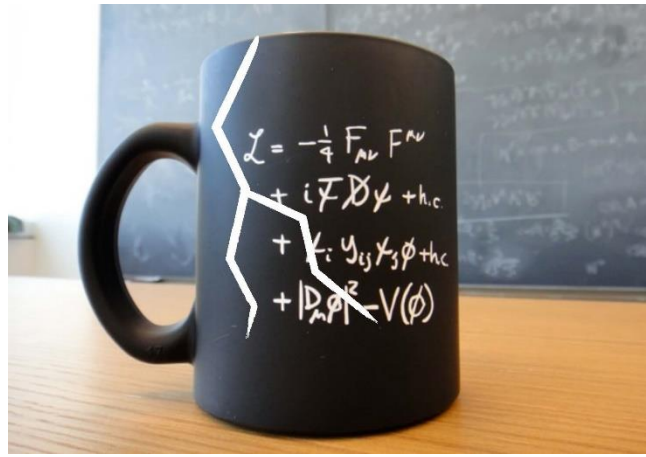
  Ratio done/expected: 1.13

- **Participation in CMS upgrade**
  - Phase1 upgrade of HCAL and Endcap Muon system
  - Phase2: Construction of the High Granularity Calorimeter. Endcap Muon system upgrade.
- **Participation in physics analysis and software development**
- **CMS duties executed by JINR physicists**
  - HCAL Technical Coordination
  - Co-convening the CMS Generator group
  - CMS data managers for Tier-1 and Tier-2 sites.
  - Deputy Chairman of the CMS Conference Committee
  - Participation in Analysis Review Committee (ARC) and Institutional publication review (IR).
  - Members of institution and collaboration boards.

JINR Activity in the CMS Physics Analysis

Searching for Physics Beyond the Standard Model

- Channels with a pair of leptons (extended gauge models, scenarios with additional spatial dimensions, models with dark matter, testing of lepton universality, search for LFV processes, etc.)
- Channels with a pair of leptons/b-quarks and missing transverse energy ET (dark matter, extended Higgs sector)
- Multiple jet/lepton/photon production (microscopic black hole scenarios)



Testing the predictions of the Standard Model (EWK and QCD processes)

- Precision measurements of the characteristics of the Drell-Yan process (cross-sections, angular characteristics)
- Discovery and study of the properties of the Higgs boson (4l, 2b)
- Study of the characteristics of QCD jets (cross-sections, fragmentation functions, etc.)
- B-physics

Heavy Ion Physics

- Multiple particle production

Algorithms and Software

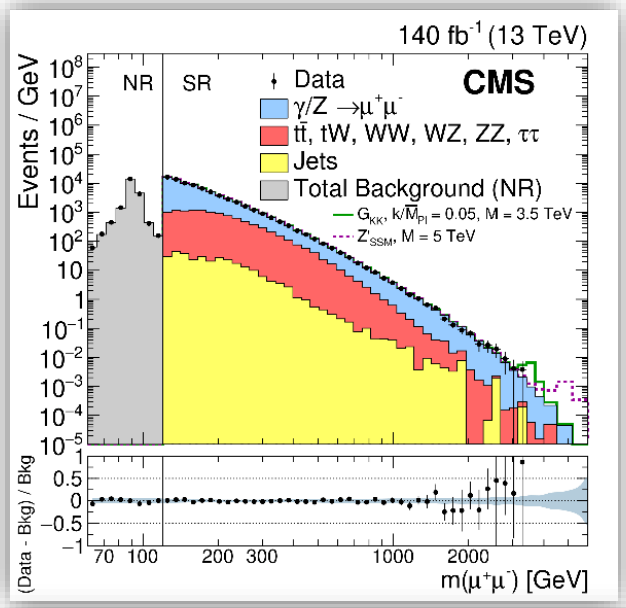
- Development of algorithms for high-momentum muons reconstruction. Muon hit reconstruction and segment builder.

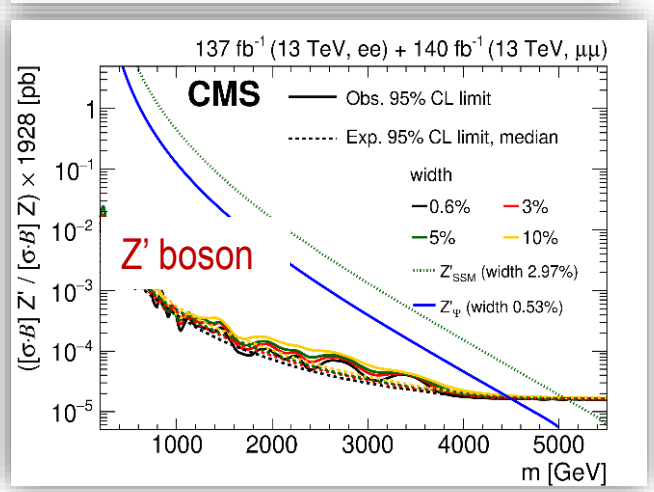
Searches for Heavy Resonances

New Physics ($Z'/Z_{KK}/G_{KK}$) contributions to SM processes

$$R_\sigma = \frac{\sigma(pp \to Z' + X \to l^+l^- + X)}{\sigma(pp \to Z^0 + X \to l^+l^- + X)}$$

Dileptons, full RUN2 data





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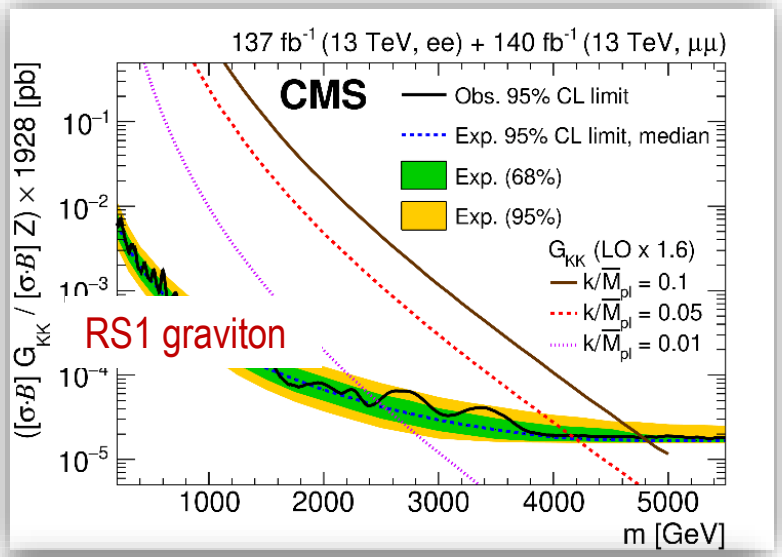

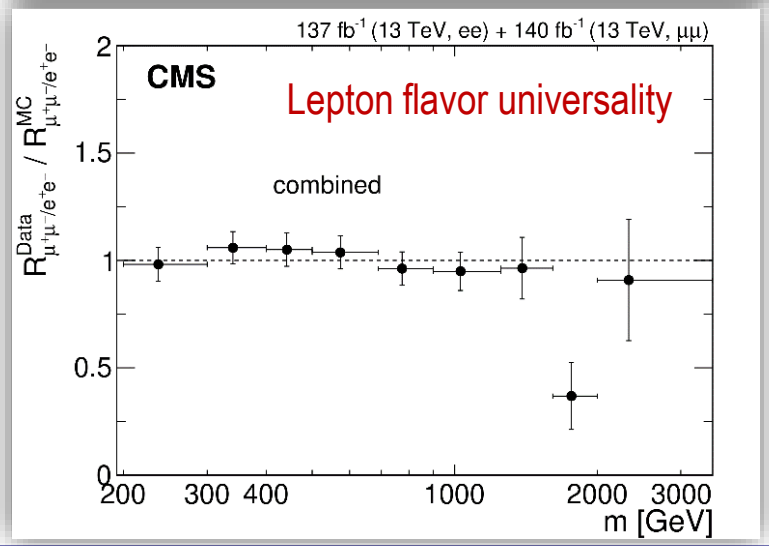

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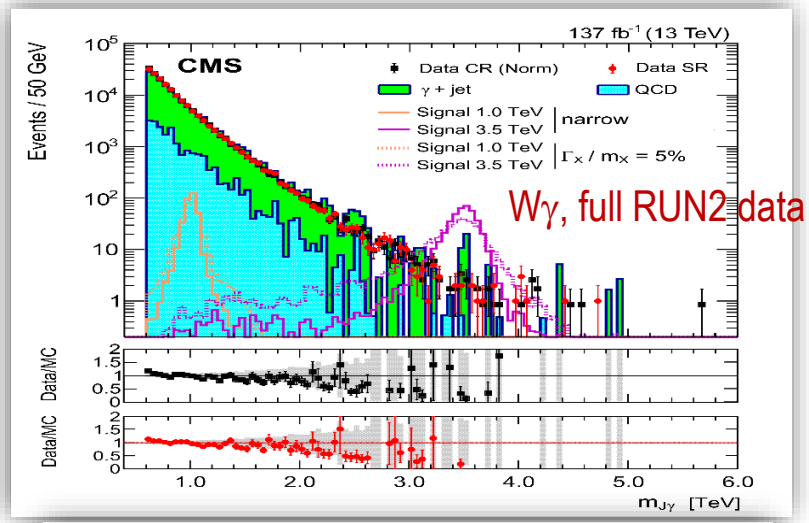
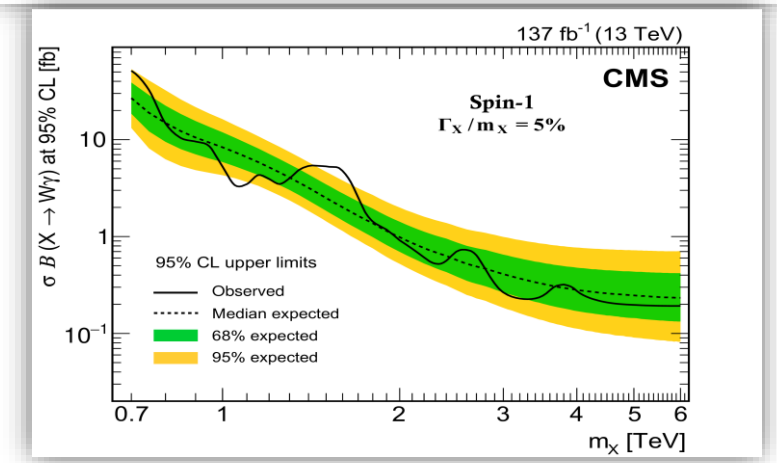


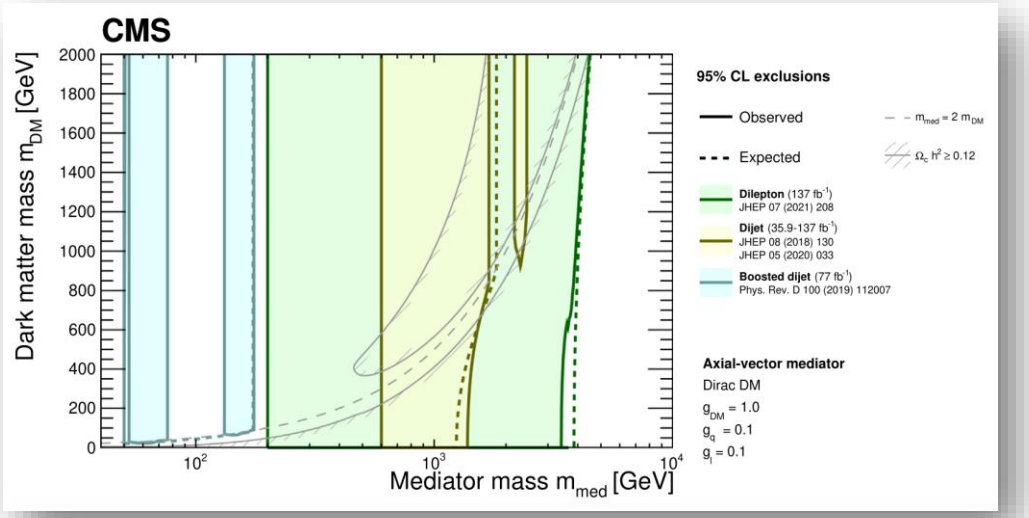


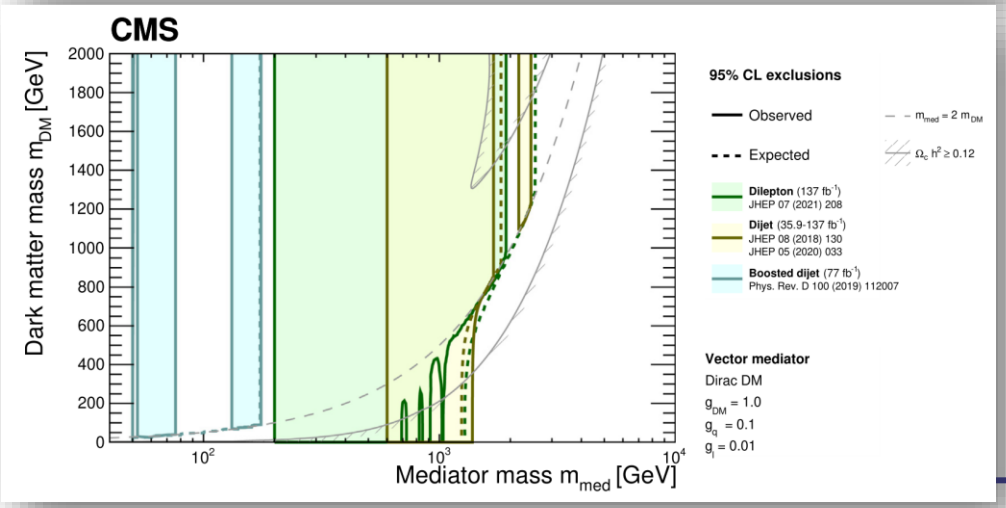
Benchmark heavy scalar (vector) triplet bosons with masses between 0.75 (1.15) and 1.40 (1.36) TeV are excluded at 95% CL

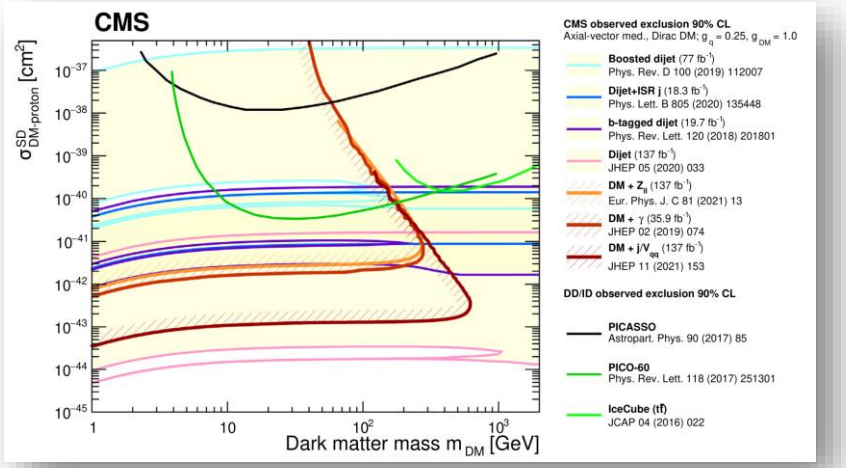
Dark Matter Searches in Dijets+Dileptons

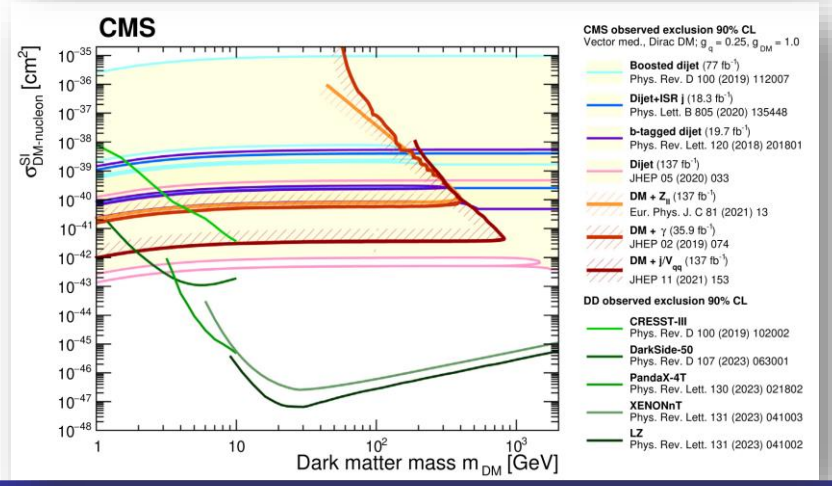
We consider a model that assumes the existence of a single DM particle that interacts with the SM particles through a spin-1 mediator, which can be either a vector or axial-vector boson.

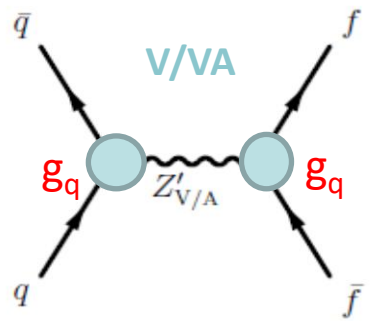
- vector mediator with small couplings to leptons, $g_{DM} = 1.0$, $g_q = 0.1$, $g_l = 0.01$
- axial-vector mediator with equal couplings to quark and leptons: $g_{DM} = 1.0$, $g_q = g_l = 0.1$



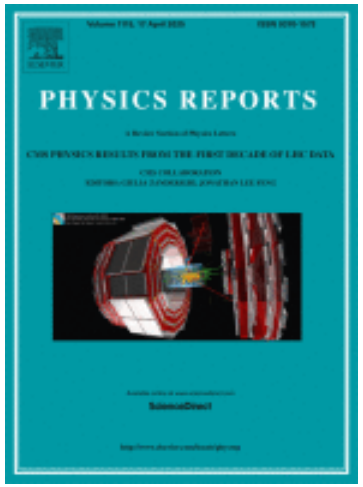






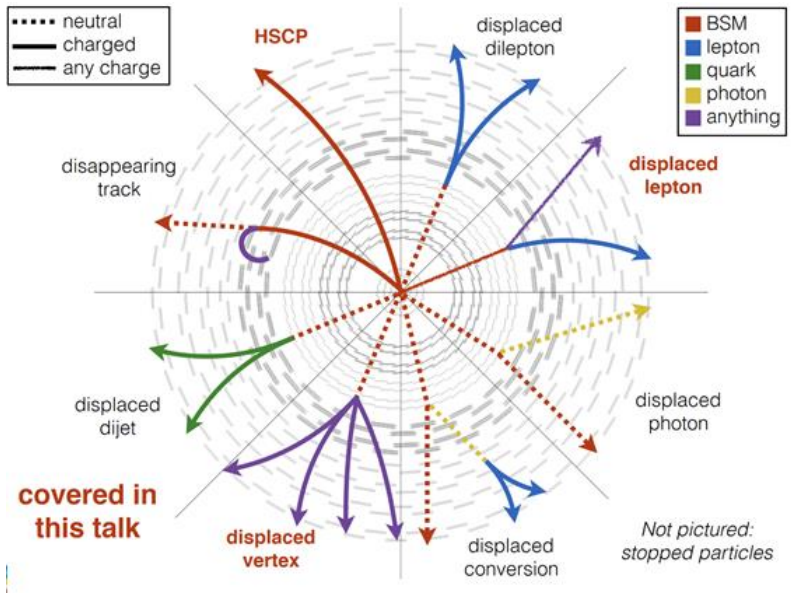


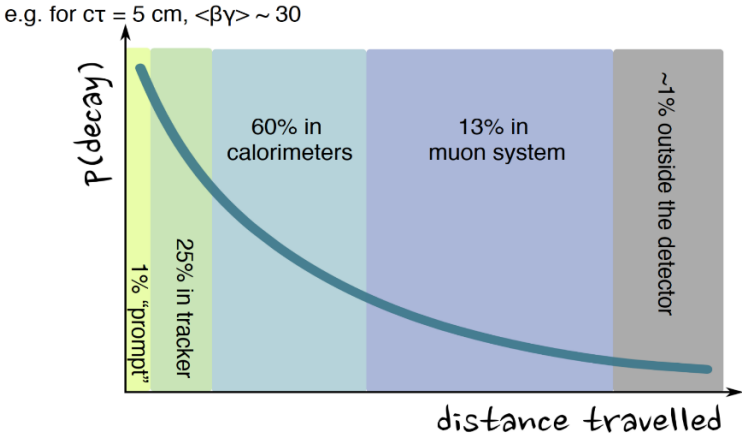
CMS physics results from the first decade of LHC data Physics Report, 1115, 1-772 (17 April 2025)



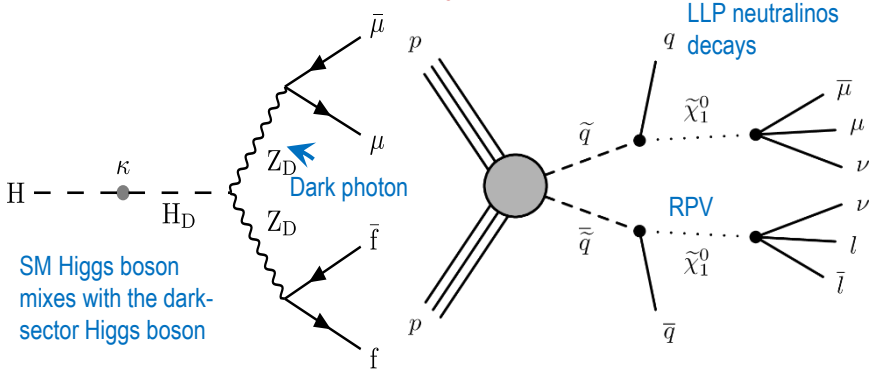
Long-lived Particles with Dimuons (Displaced Dimuons)

New (unconventional) topologies!

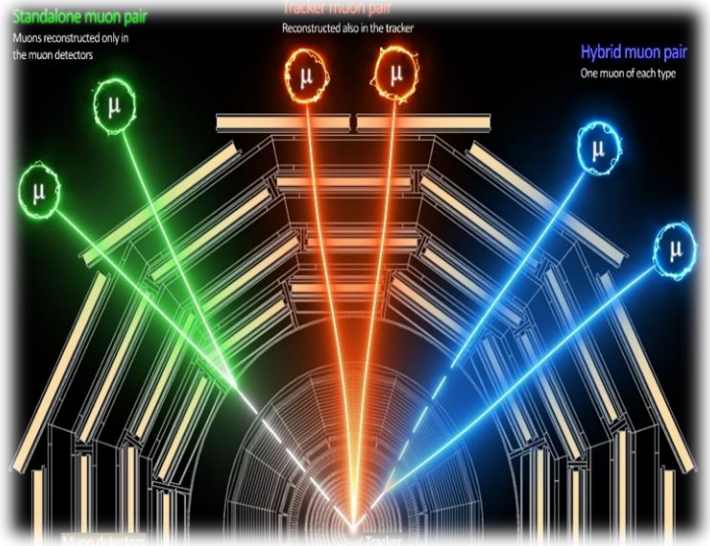




Ex., dark photon and long-lived neutralinos decays



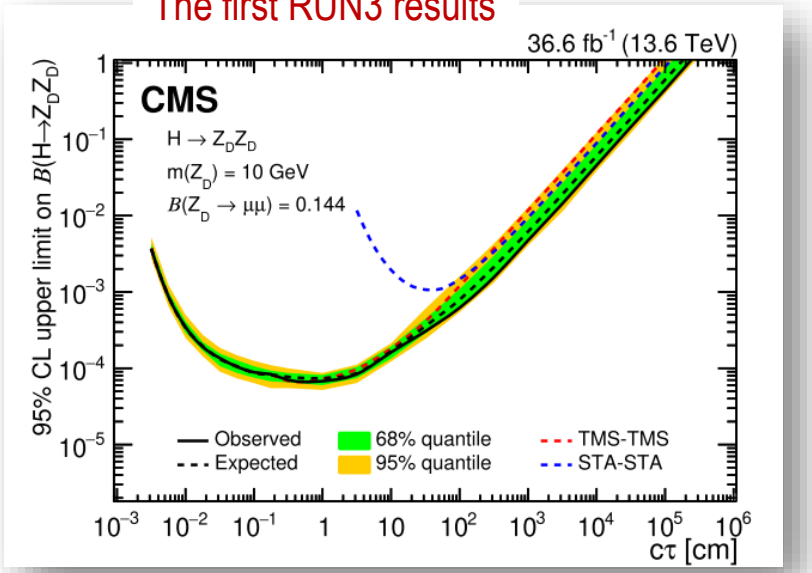
- a proper lifetime $c\tau_0$ is greater than or comparable to the characteristic size of the (sub)detectors



Long-lived particles (LLP) may have decay lengths up to several meters

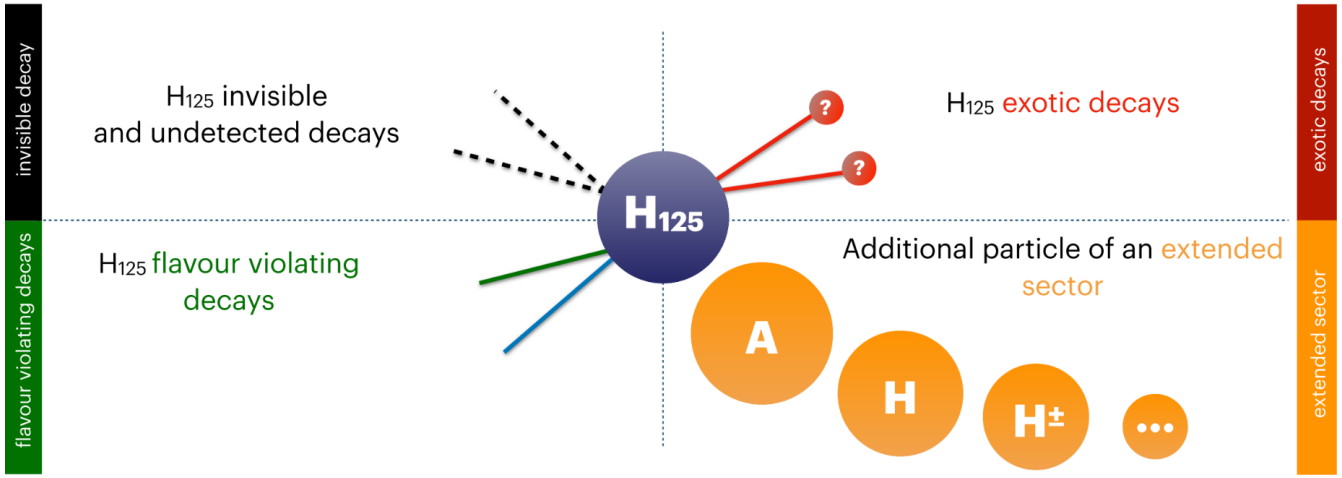
⇒ traveling through the inner detector layers without leaving any trace

The first RUN3 results

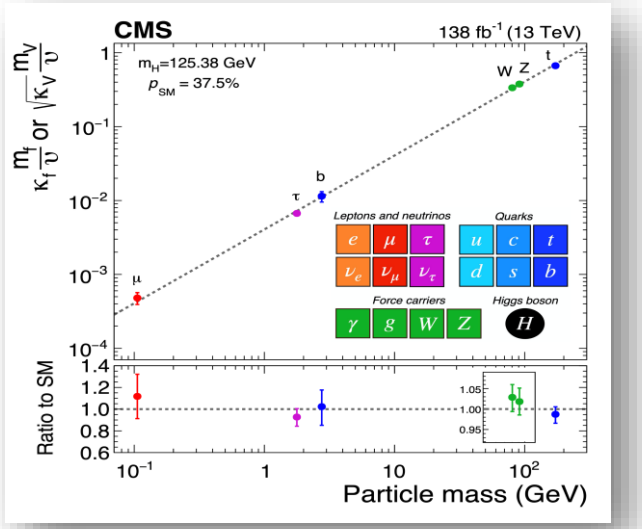


JHEP05 (2024) 047

Higgs Boson as a Tool to Search for the New Physics



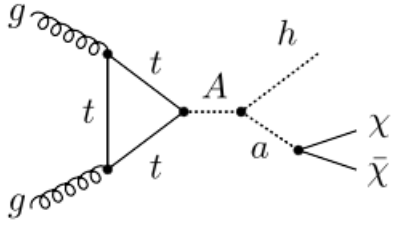
Universality is a powerful test of the validity of the underlying physics

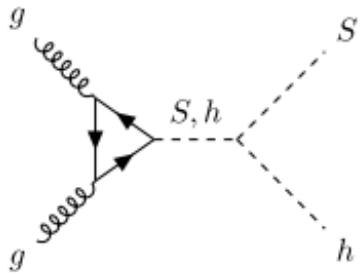


"New" physics objects ⇒ new decay channels!

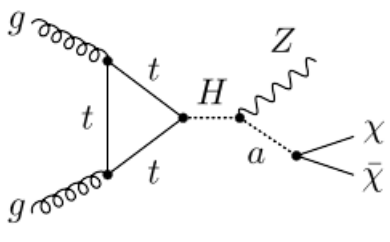
- ✓ combinations of physics objects (leptons/photons/jets) and Missing Transverse Energy (MET)

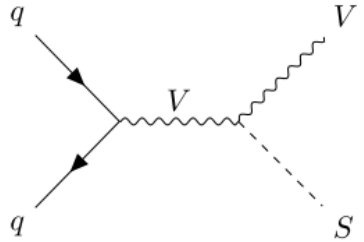
h (→ bbar) + a (→ χχ) = bbar + MET

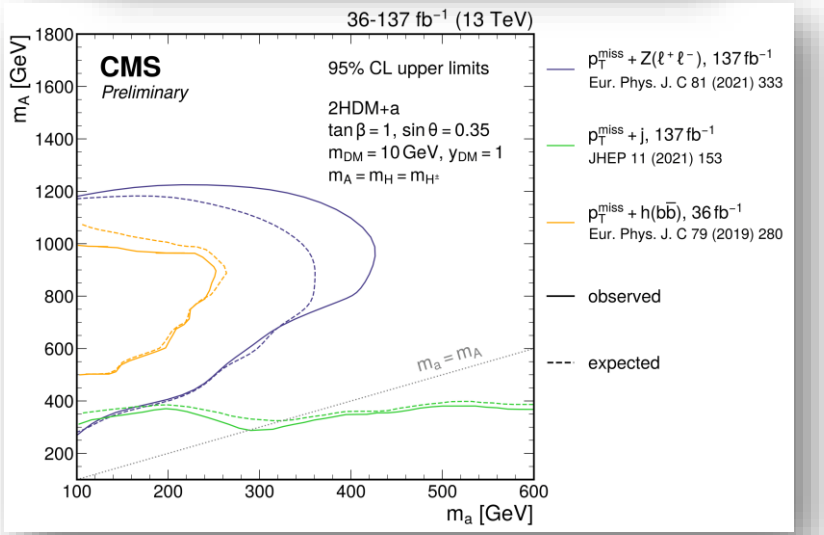




Z + a (→ χχ) = Z (→ ll) + MET





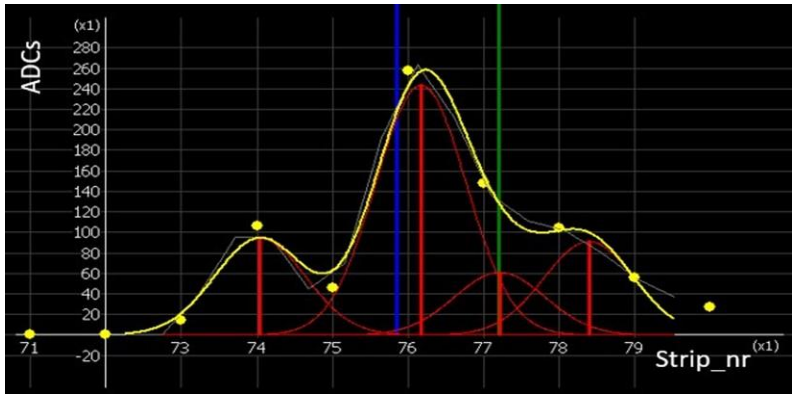


The most stringent limits on mass parameters of non-minimal Higgs scenarios, ex. 2HDM+s

New Algorithms and Selection Methods

Muon reconstruction and Selection

- high-momentum muons reconstruction and triggering, including AI methods
- muon tracks reco for HGCal testing and study of an efficiency of HGCal sensor elements
- Hits and track segments in Cathode Strip Chambers, CSC



HGCal based algorithms

- particle-flow algorithms for reconstruction of energy flows (information from all detector systems) $\Rightarrow$ MET reco
- jet structure, charged particle multiplicity inside jets

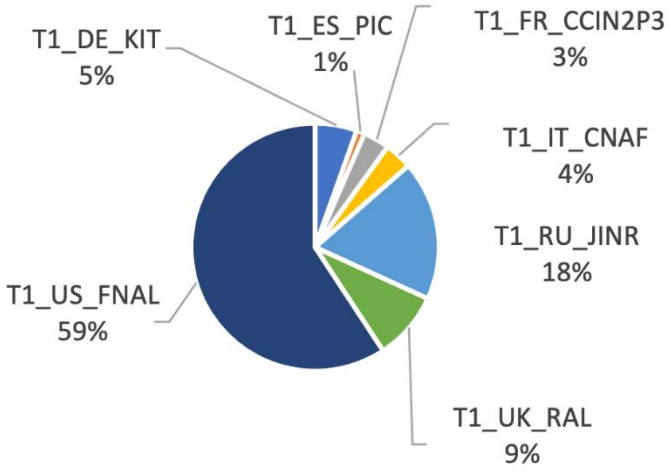
Simulation of Physics Processes and Detector Facility

- data cards of model parameters for the number of physics generators (EGM, dark matter scenarios, extended Higgs sector, Drell-Yan production, etc)
- full chains of MC mass production
- HGCal test facilities
- HGCal working release in CMSSW

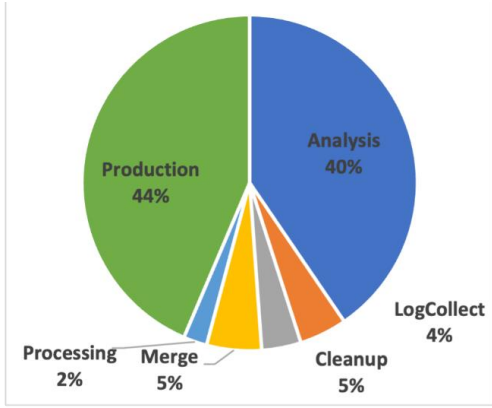
JINR in WLCG/CMS Computing

- JINR grid Tier-1 and Tier-2 centers extensively used for processing and storing CMS data, ensuring 100% availability and reliability of services.
- More than 2.1 billion events were successfully processed by JINR Tier-1 in 2024.
- The JINR Tier-1 is ranked the second place among all Tier-1 world centers for CMS (with 18.0%).

Events processed by Tier-1 world centers



Completed jobs ratio by JINR Tier-2 center



More than 1.2 million CMS jobs, above all Monte-Carlo production and analysis

Resources pledged in 2025

Edit	Federation	Tier	VO	Country	Year	Type	Pledge
	RU-JINR-T1	1	CMS	Russian Federation	2025	CPU	240000 HEPscore23
	RU-JINR-T1	1	CMS	Russian Federation	2025	Disk	13600 TBytes
	RU-JINR-T1	1	CMS	Russian Federation	2025	Tape	35000 TBytes
	JINR-LCG2	2	CMS	Russian Federation	2025	CPU	33358 HEPscore23
	JINR-LCG2	2	CMS	Russian Federation	2025	Disk	2500 TBytes
Edit	Federation	Tier	VO	Country	Year	Type	Pledge

JINR contribution to CMS Phase 1 Upgrade

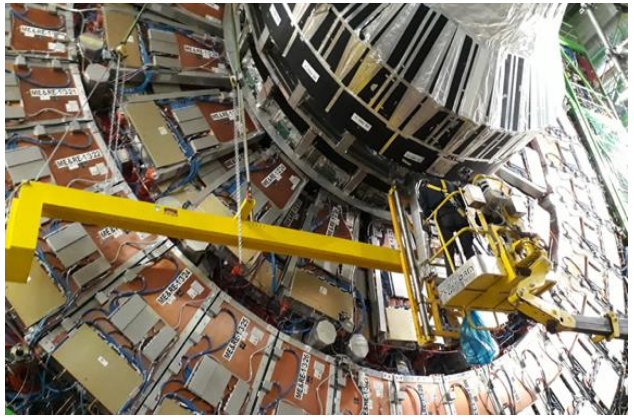
CMS Phase-1 upgrade task: to ensure reliable work of detectors in the **LHC design operation mode** at the energy of 13.6 TeV and instantaneous luminosity L= $1 \div 2 \times 10^{34}$ см$^{-2}$с$^{-1}$

- Phase-1 upgrade completed during periods of long shutdowns LS1 and LS2
- JINR contribute to the Muon Endcap and HCAL subsystems

Upgrade of the Endcap Muon System

LS1 period – restoring number of ME1/1 FE cards (were reduced on construction staging).

- 72 ME1/1 were disassembled, refurbished, tested and reinstalled
- New digital FE boards (DCFEBs) installed on the ME1/1 station - minimize dead time
- 3 DCFEBs instead of 1 at the bottom part of CSCs to restore the trigger up to η =2.4



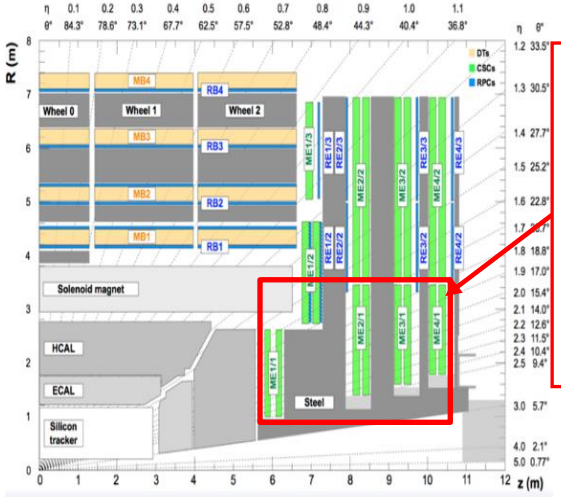
ME1/1 CSC installation

CSC upgrade infrastructure

CSC test stand

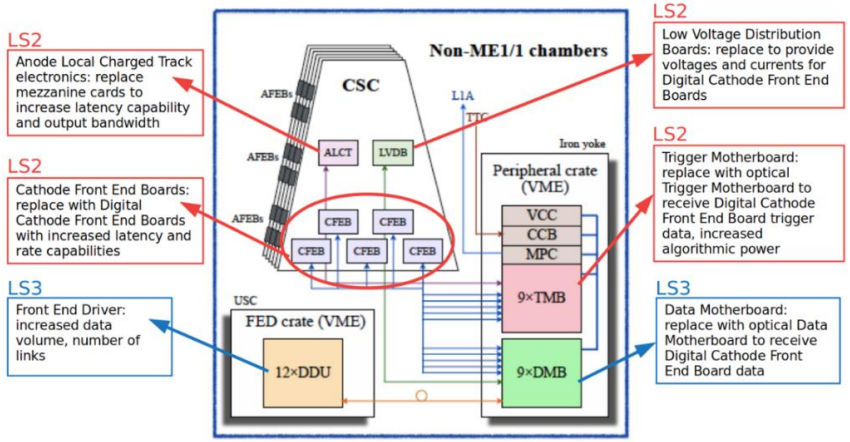
LS2 period - CSC electronics was replaced on detectors of the inner rings Endcap stations.

- 180 chambers of inner rings were upgraded with the new electronics to sustain HL-LHC conditions
- 72 ME1/1 CSCs were equipped with the new on-chamber cooling systems.



Inner rings stations : ME1/1, ME2/1, ME3/1, ME4/1

Total 180 CSCs

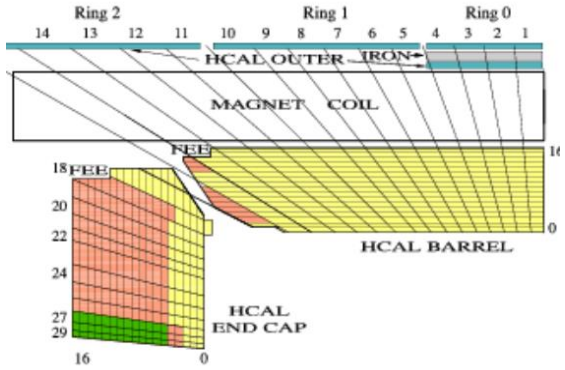


Major part of CSC Phase-2 upgrade completed in LS2.

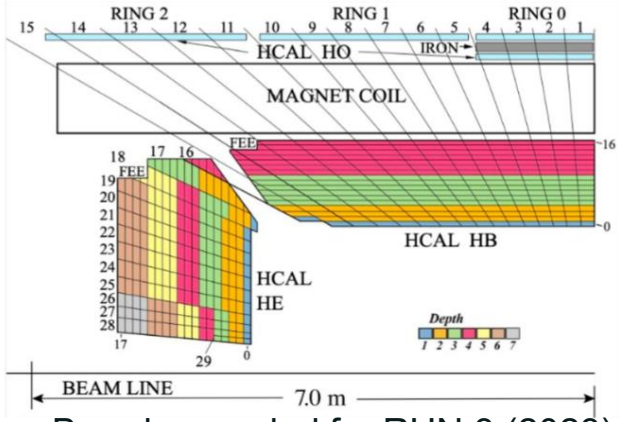
Upgrade of the Hadron Calorimeter, HCAL

HCAL upgrades LS1, LS2 periods

- **Hybrid photodetectors(HPD) replaced with new silicon multipliers (SiPM)**
  - 3 times higher photon detection efficiency, 200 times higher gain
  - Increase dynamic range, rate capability, sub-ns timing, muon ID
- **Finer depth segmentation 4 in barrel, up to 7 in endcap**
  - Number of channels increase by factor ~2.5;
  - Depth dependent calibration.



Endcap upgrade before 2018



Barrel upgraded for RUN 3 (2023)

- **New front-end and back-end electronics**
  - increase Particle Flow capability and 1-level trigger.
  - Enable new triggers (e. g. long lived particles).
  - Better timing information (0.5ns resolution);
  - Encoding an energy value into 8 bits instead of 6 bits as now;
  - Increase a bandwidth of data transfer from 1.6 Gbit/s to 4.8 Gbit/s.

Commissioning of HCAL electronics

JINR contribution to CMS Phase 2 Upgrade

CMS Phase-2 upgrade task: to ensure reliable work of detectors in the **High Luminosity LHC operation mode (HL-LHC)** at the energy of 13.6 TeV and instantaneous luminosity L= 5-7$\times 10^{34} cm^{-2} c^{-1}$

The Phase-2 upgrade will be done during LS3 long shutdown

JINR will contribute in High Granularity Calorimeter (HGCal) project.

- Design and construction of the HGCAL silicon and scintillator cassettes test facility
- Development of the HGCAL LV power supply system prototype

JINR will Participate in the Endcap Muon system upgrade.

- ME1/1 CSC upgrade and maintenance
- Design and construction of the new ME1/1 Patch Panel
- Design and construction of new tooling for ME1/1 CSC assembly and installation
- CSC longevity study and searches for eco friendly gas mixtures R&D.

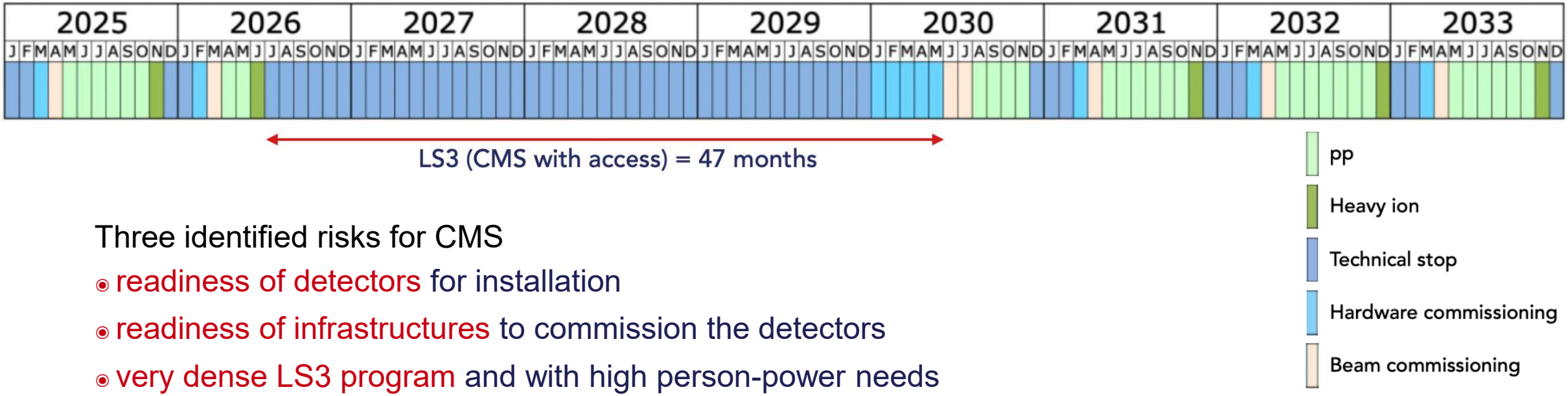
New LS3 Schedule

Key dates for New Schedule from CERN Directorate (3 Oct 2024)

Operation in 2026
- Short YETS 2025/26
- Operate LHC until end of June (with possibly Heavy Ion run in June)
- Operate injectors until September

Start of Run 4 in 2030
- Hardware commissioning in January
- Closure of experimental caverns mid-May
- Beams in the machine in June

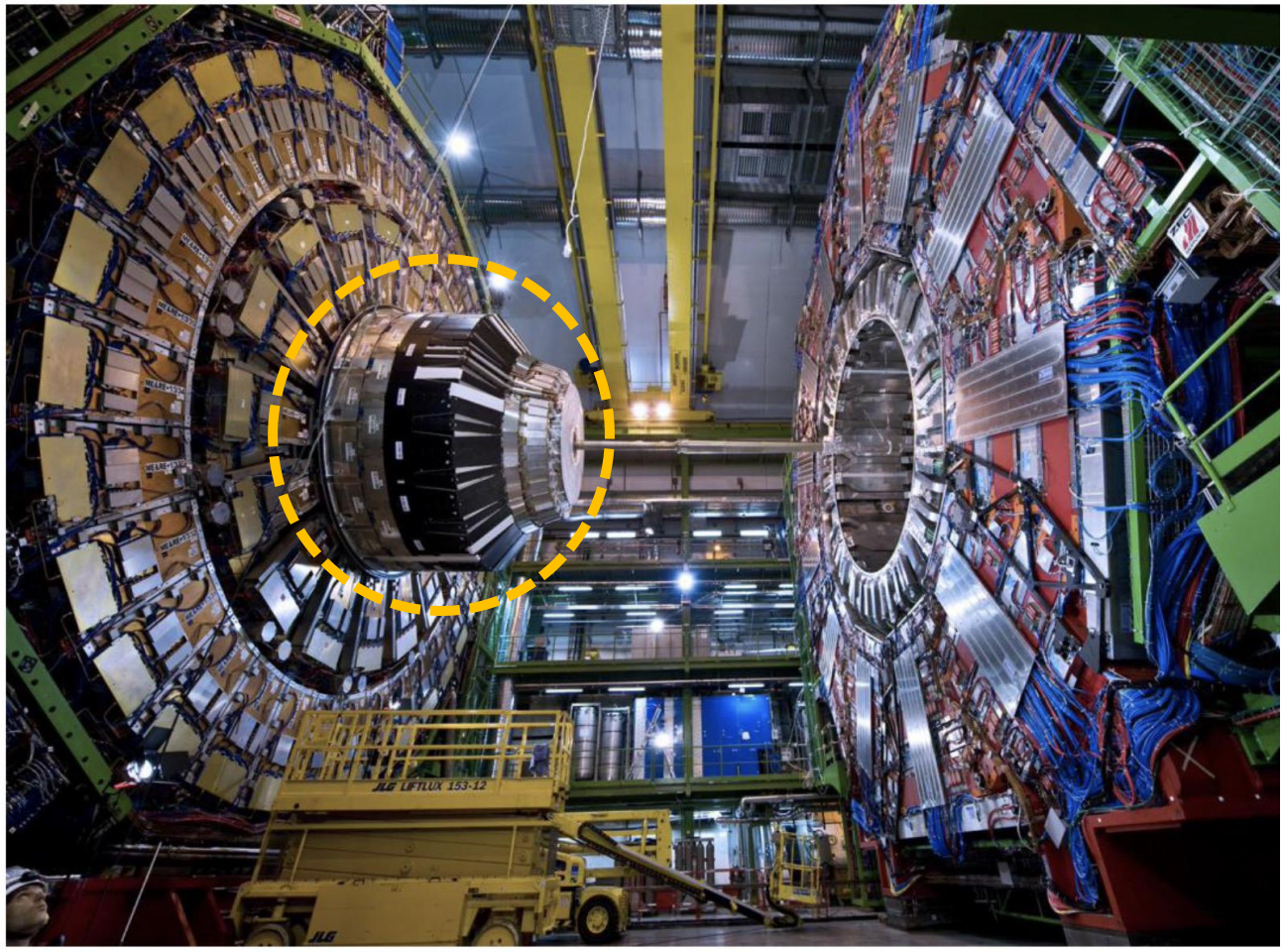
Post-LS3
- LS4 moved from 2033/34 to 2034/35
- LS5 to become an EYETS



Three identified risks for CMS
- readiness of detectors for installation
- readiness of infrastructures to commission the detectors
- very dense LS3 program and with high person-power needs

High Granularity Calorimeter (HGCal)

- HGCal will replace the present Endcap Calorimeter (ECAL and HCAL) and Preshower sub-systems.
- Installation during next Long Shutdown (LS3) of LHC (lowering Q3 2027)

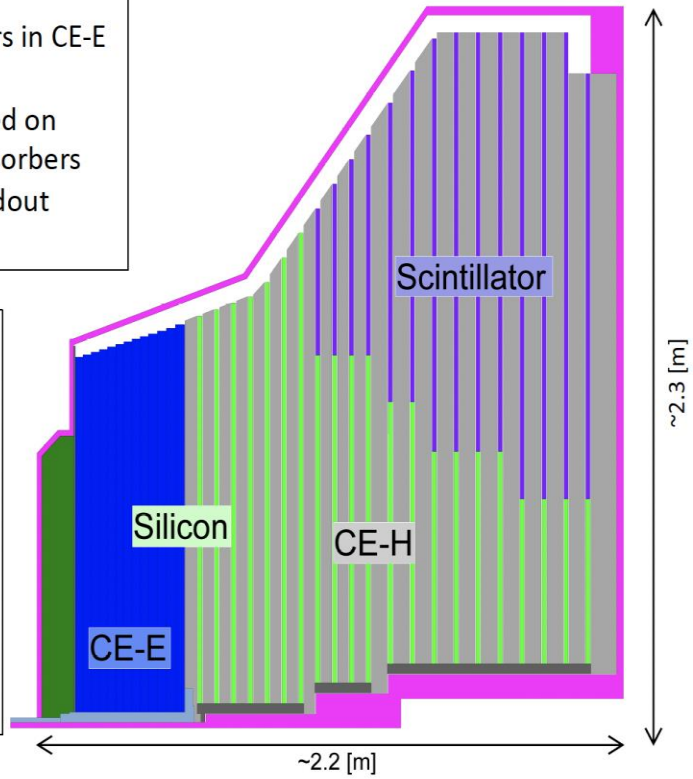


Active Elements:

- Hexagonal modules based on Si sensors in CE-E and high-radiation regions of CE-H
- "Cassettes": multiple modules mounted on cooling plates with electronics and absorbers
- Scintillating tiles with on-tile SiPM readout in low-radiation regions of CE-H

Key Parameters:

Coverage: $1.5 < |\eta| < 3.0$
~215 tonnes per endcap
Full system maintained at -30°C
~620m^2 Si sensors in ~26000 modules
~6M Si channels, 0.6 or 1.2cm^2 cell size
~370m^2 of scintillators in ~3700 boards
~240k scint. channels, 4-30cm^2 cell size
Power at end of HL-LHC:
~125 kW per endcap

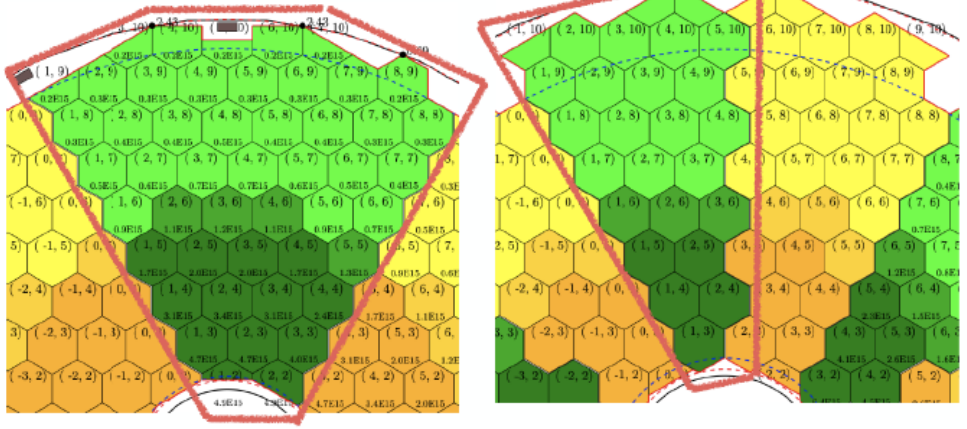


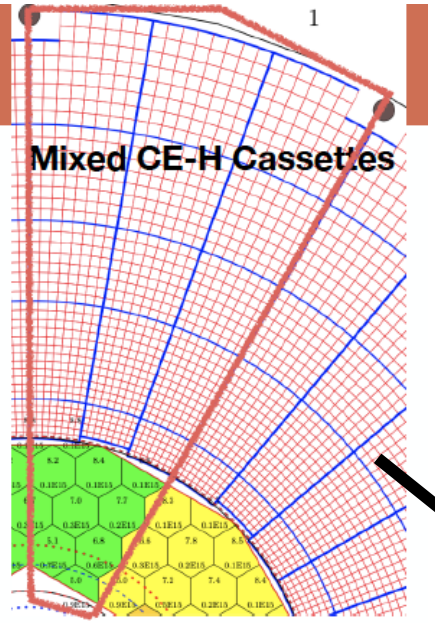
Electromagnetic calorimeter (**CE-E**): **Si**, Cu & CuW & Pb absorbers, 26 layers, 27.7 X_0 & ~1.5λ
Hadronic calorimeter (**CE-H**): **Si** & **scintillator**, steel absorbers, 21 layers, ~8.5λ

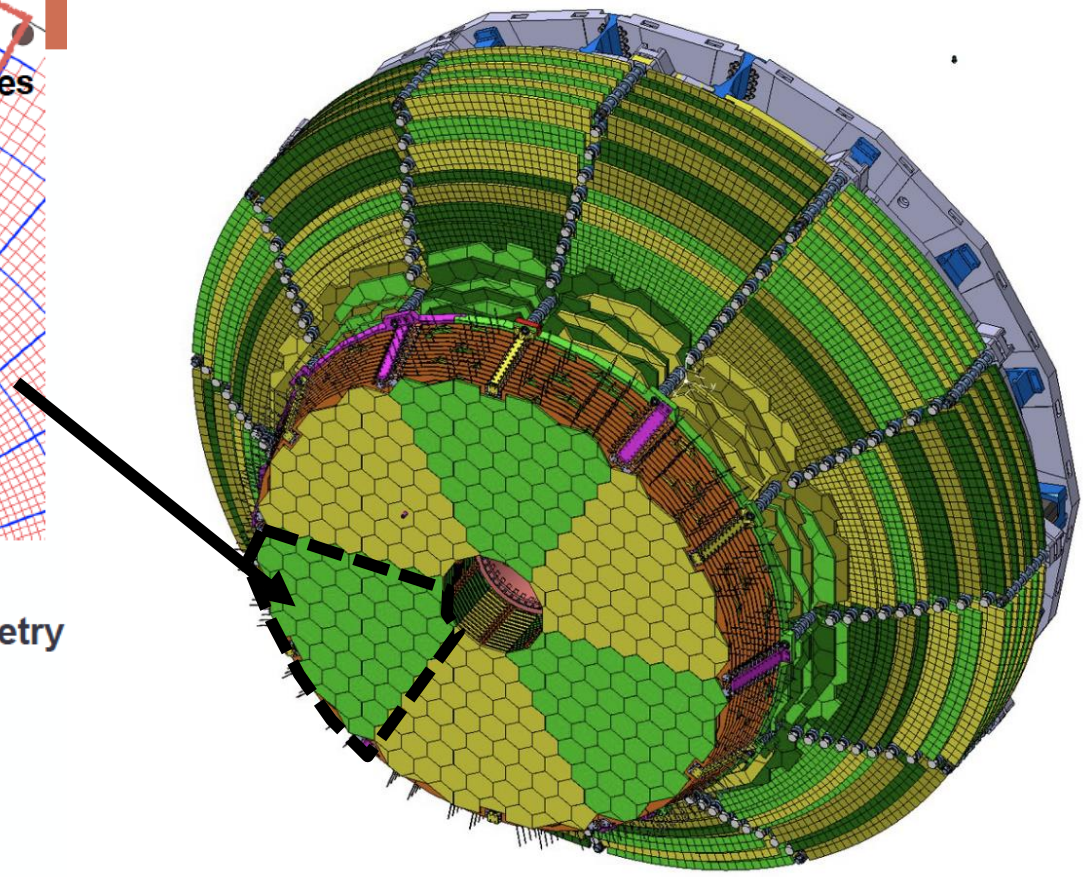
HGCal Main Active Elements (Cassettes)

Cassettes: 30- or 60-degree segments, integrating modules and ancillary electronics on a copper cooling plate

Layout of Modules







- **Wafer-centered geometry**
  - 60-degree rotational symmetry
- **60-degree cassettes**
- **double sided**
- **26 layers -> 13 designs**

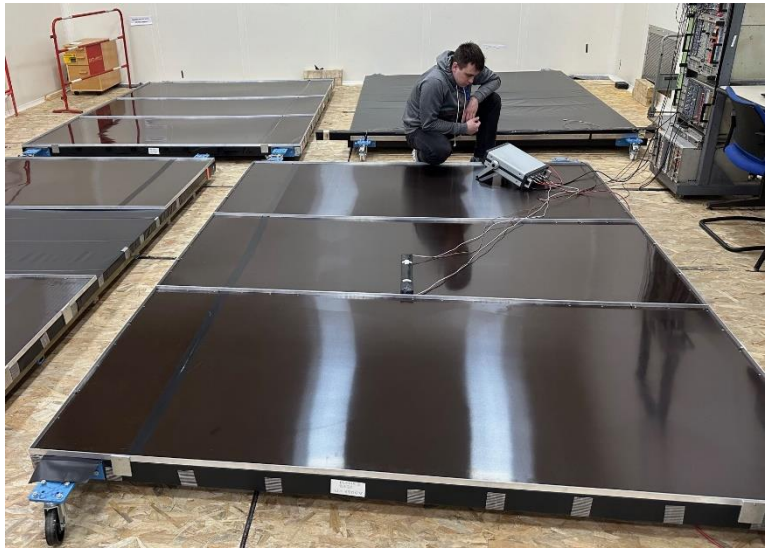
- **Wafer-centered geometry**
  - 60-degree rotational symmetry
- **30-degree cassettes**
- **single sided**
- **7 layers -> 14 designs**

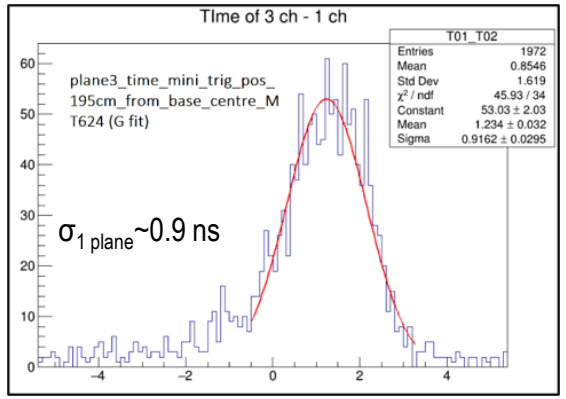
- **Corner-centered geometry**
  - 120-degree rotational symmetry
- **30-degree cassettes**
- **single sided**
- **14 layers -> 40 designs**

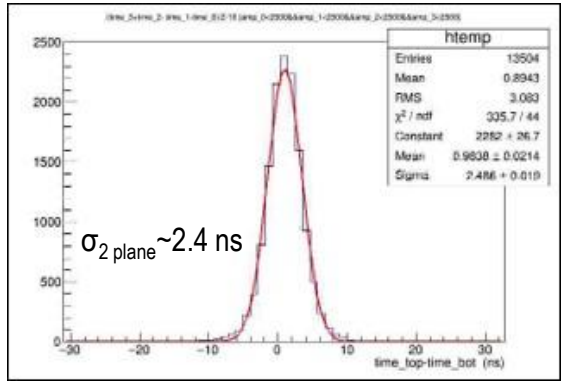
Setup for HGCal Cassettes Testing

2 Cold rooms were assembled at SX5 CERN

Commissioning of the scintillation trigger planes.







Test setup includes:

- Racks for cassettes (inside cold rooms)
- Supporting frames for cassettes
- Scintillation trigger planes (on top and bottom of rooms)
- Readout electronics

Cassette on the supporting frame

- Plane efficiency of ~98%.
- 1 plane time resolution ~0.9 ns.
- Time resolution of 2 planes ~3ns.

- Triggers frequency in the fourfold coincidence mode: 130-160 Hz
  - corresponds to ~3000 triggers per 1cm^2 in 10 days
  - matches with the simulation: 10 days cassettes test cycle required minimum 1000 triggers per 1cm^2

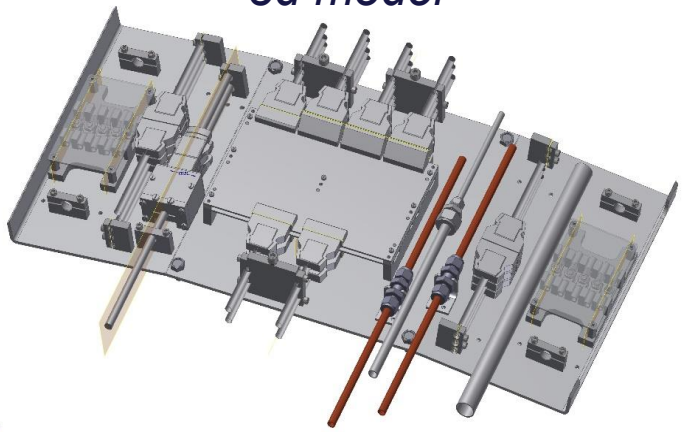
Plan to have the test facility is ready for operation by the middle of 2025

Preparation to the Phase-2 ME1/1 CSC Upgrade in LS3

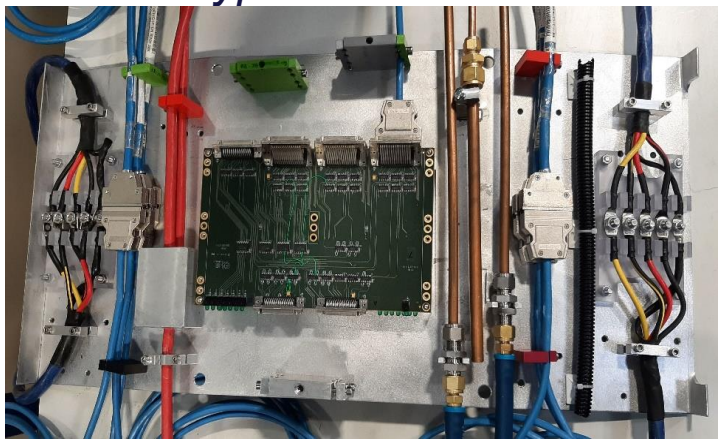
- ✓ **ME1/1 Patch Panel** redesigned to fit more rigid envelope for endcap detectors cables and services in the CMS Phase-2 configuration
- ✓ 80% parts for 36 ME1/1 PP have been constructed

ME1/1 Patch panel

3d model



Prototype



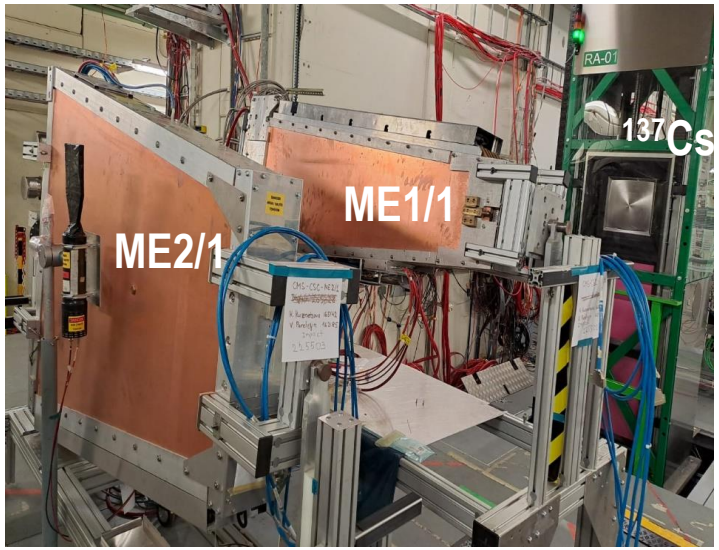
- ✓ **ME1/1 two loading machines** for extraction/installation of ME1/1 CSCs were constructed

Loading machines

Cathode Strip Chamber Performance Study @ HL-LHC

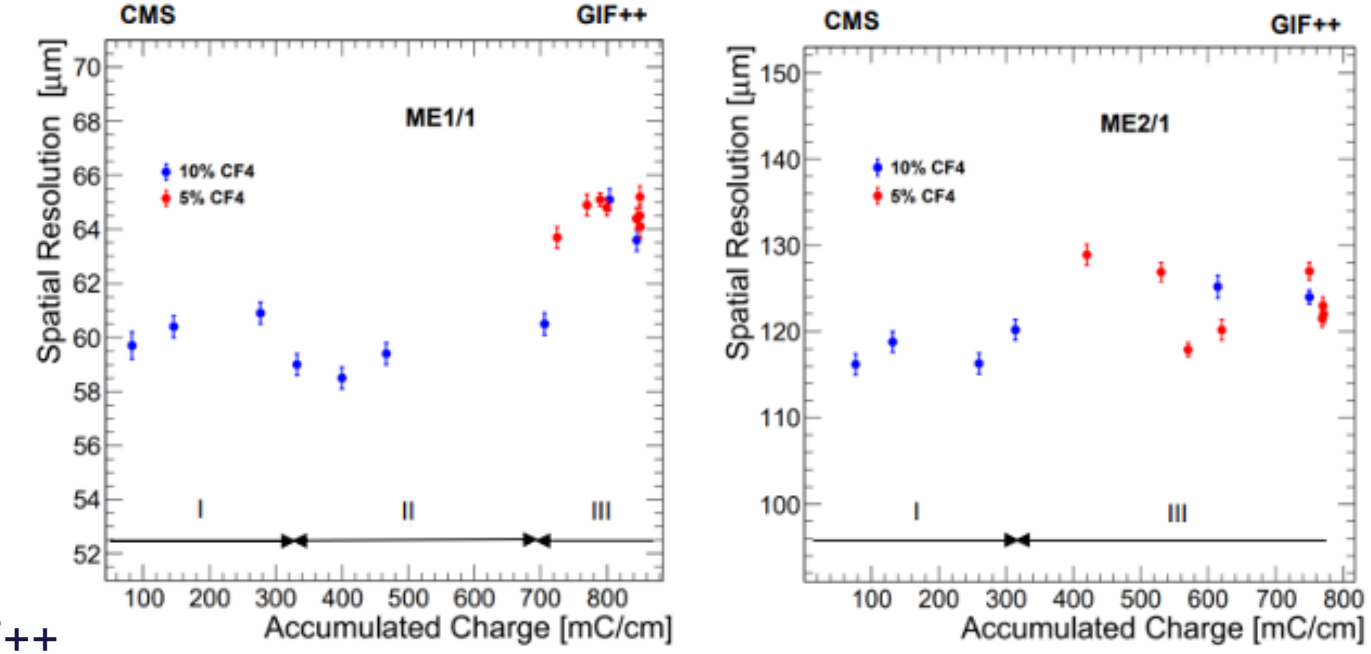
- **Cathode Strip Chamber Longevity Study @ GIF++**

Irradiation setup: ME1/1 and ME2/1 CSCs exposed with the 12 TBq ^{137}Cs gamma source at the GIF++ Facility (HV-ON on 4 layers and HV-OFF on 2 layers kept as reference).



ME CSCs irradiation setup at GIF++

CSCs spatial resolution as a function of the accumulated charge



No aging effects observed so far

- **Study of the CSC Parameters with new gas mixtures** (Mini CSCs 30 x 30 cm^2 were constructed)

Motivation: CSC use CF4 to protect anode wire from Si deposits, but it's Global Warning Potential (GWP) is too high: ~ 7000 x CO_2.

Plan for 2025

- **Continue RUN-2 and RUN-3 data analysis.**
  - Dimuons, Z + MET, bbar + MET, dimuons + MET to search for the new physics and test the SM.
  - Continue optimization of the hadronization model for the q/g jet fractions measurement.
- **Participation in 2025 RUN-3 data taking within JINR responsibilities.**
  - Participation in shifts.
  - Detectors operation and maintenance.
  - Detectors performance study.
- **Participation in Phase-2 HGCAL project.**
  - Launching of the HGCAL cassettes test facility.
  - Powering of the cassette's assembly facilities.
- **Participation in Phase-2 upgrade of Muon Endcap System.**
  - Preparation to the ME1/1 CSC upgrade during LS3.
  - Continue of the CSC detectors ageing effects study at GIF ++ facility.
  - Development and test of algorithms for reconstruction of the muon track segments.

Staffing Resources

LHEP – 32 (23.3 FTE), LIT – 22 (10 FTE), LTP – 5 (1.9 FTE), JINR Management – 1 (0.1 FTE)

№№ п/п	Category of employees	Core staff Amount of FTE	Associated Personnel Amount of FTE
1.	scientific staff	24,5	15,2
2.	engineers	7,9	0
3.	professionals	2,5	0
4.	employees	1	0
5.	workers		0
	Total:	**34,5**	**15,2**

A part of Associated personals will be reassigned as the JINR staff

LHEP: Aleksakhin V.Yu., Afanasyev S.V., Budkovsky D.V., Bunin P.D., Golunov A.O., Gorbunov I.N., Gorbunov N.V., Golova N.S., Ershov Yu.V., Kamenev A.Yu. Karzhavin V.Yu., Kilchakovskaya S.V., Kobylets L.G. Kozlov D. N., Kurenkov A.M., Kutinova O.V., Lanev A.V., Makankin A.M., Malakhov A.I., Milnov G.D., Perelygin V.V., Sakulin D.G., Smirnov V.A., Sukhov E.V., Ustinov V.V., Shalaev V.V., Shulga S.G., Zarubin A.V., Zhizhin I.A., Zaitsev A.A.

LIT: S.V. Shmatov, V.V. Korenkov, A.O. Golunov, A.G. Dolbilov, I.A. Kashunin, A. Khvedelidze, O.L. Kodolova, Yu.V. Korsakov, V.V. Mitsyn, A.N. Moibenko, A.N. Nikitenko, N.N. Voytishin, G.A. Ososkov, D.A. Oleynik, V.V. Palchik, A.Sh. Petrosyan, R. Semenov, I. Satyshev, K. Slizhevsky, T.A. Strizh, E.N. Tolochko, V.V. Trofimov

LTP: Kazakov D.I., Kozlov G.A., Savina M.V., Teryaev O.V., Zykunov V.A.

JINR Management: Matveev V.A.

Cost Estimate of the Project

Based on the official commitments of JINR

- MoU on the creation of the CMS detector (CERN-RRB-2024-039) and the corresponding addendums
  - Addendum No. 10 (CERN-MoU-2024-010)
  - Addendum No. 13 (CERN-MoU-2019-008)
  - Addendum No. 14 (CERN-MoU-2019-009)
  - Addendum No. 15 (CERN-MoU-2019-036)
- MoU on the participation of JINR in the HGCal CMS project (CMS2020-010).

Main cost items

Common funds

- Category A payment (M&O cat. A) for 24 authors: 1300 kUSD (260 kUSD per year)
- Category B payment (M&O cat. B): 365 kUSD (73 kUSD per year)

Deliverables

- Equipment deliverables cost: 962 kUSD (792 kUSD for Front-end tileboards and DAQ - contribution to CORE and 170 kUSD for HV cables production for ME1/1 CSCs – In-Kind category B contribution)
- Materials cost for Phase-2 upgrade of the muon system and HGCal: 500 kUSD (80 kUSD per year)

Visits

- Visits expenses for 5 years: 3450 kUSD (690 kUSD per year). Including 565 kUSD - will be accounted as In-Kind CORE for the HGCal, 1070 kUSD - will be accounted as In-Kind category B and 825 kUSD – upgrade works (2460 kUSD in total)
- **Full estimated cost of the project: 6577 kUSD**
- **Full amount of contribution in CORE, M&O cat.A, M&O cat.B: 1357 kUSD, 1300 kUSD, 1605 kUSD**

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Proposed schedule. Required resources. and Cost estimate

Names of costs, resources, sources of funding			Cost (thousands of dollars) resource requirements	Cost, distribution by year				
				1st year	2nd year	3rd year	4th year	5th year
		International cooperation (IC)	5115	1023	1023	1023	1023	1023
		Materials	500	100	100	100	100	100
		Equipment and third-party services (commissioning)	962	413	293	123	123	10
		Commissioning work						
Sources of funding	Budgetary resources	JINR budget *(budget items)*	6577	1536	1416	1246	1246	1133
	Extrabudgetary (supplementary estimates)	Contributions by co-contractors Funds under contracts with customers Other sources of funding						

Project Leader

Laboratory Economist

JOINT INSTITUTE FOR NUCLEAR RESEARCH

APPROVAL SHEET FOR PROJECT

NAME OF THE PROJECT: Physics research at the CMS experiment and the second phase of detector upgrade for operation in high luminosity conditions

SHORT NAME OF THE PROJECT: CMS

PROJECT CODE: _____

THEME CODE: 02-1-1083-2009

PROJECT LEADERS: Karjavine V.Y.

	SIGNATURE	NAME	DATE
AGREED JINR VICE-DIRECTOR		Кекелидзе В.Д.	12.05.25
CHIEF SCIENTIFIC SECRETARY		Nedelko S.	12.05.25
CHIEF ENGINEER		Сикач	12.05.25
LABORATORY DIRECTOR		Бутенко А.В.	07.05.25
CHIEF LABORATORY ENGINEER		Агапов	12.05.25
LABORATORY SCIENTIFIC SECRETARY		Смирнова	07.05.2025
THEME LEADER		Karjavine V.Y.	7.05.2025
PROJECT LEADER		Karjavine V.Y.	7.05.2025
APPROVED BY THE PAC			

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CMS

We ask JINR PAC for Particle Physics

to support the project

The Physics Studies with the CMS experiment and the second phase of detector upgrade for operation in high luminosity conditions.

for 2026-2030

Thank you for your attention!!!