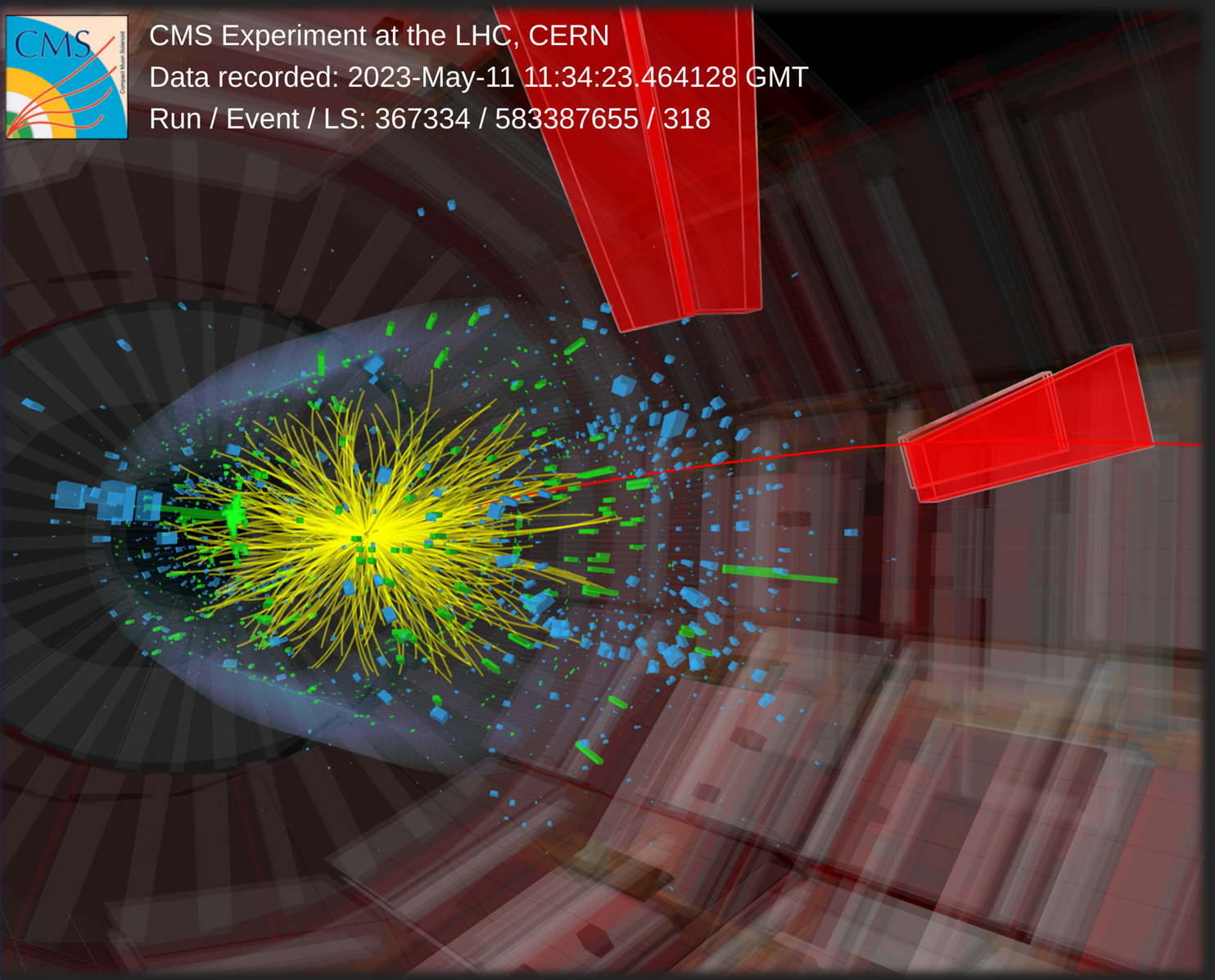


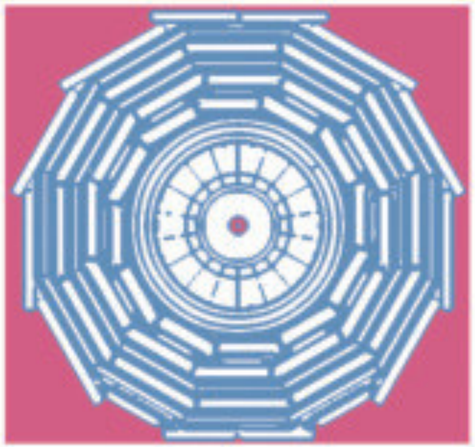
CMS Status and Overview

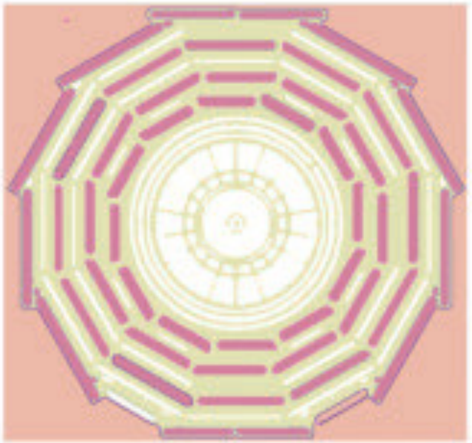
Lucia Silvestris, INFN-Bari
on behalf of the CMS Collaboration

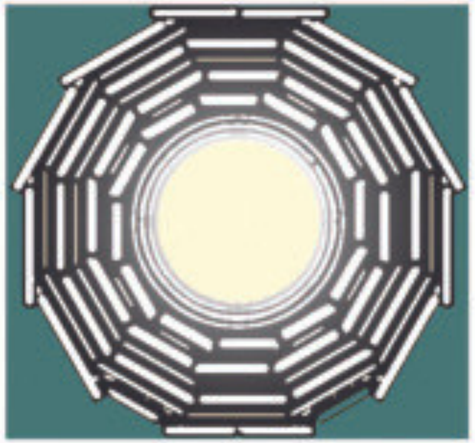
May 22 LHCP 2023

with many thanks to the organizing committee for this wonderful place and conference

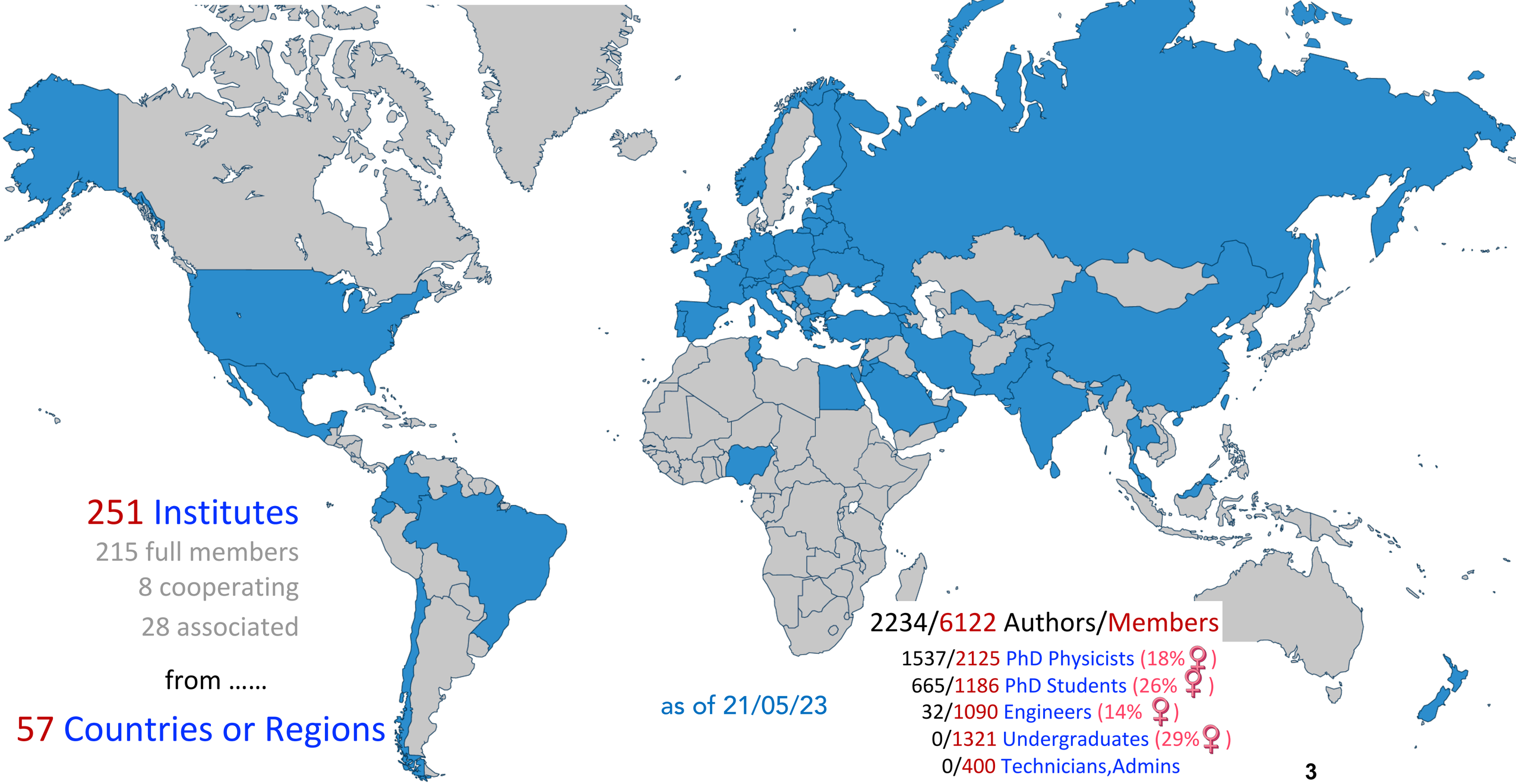
CMS Collaboration







The CMS Collaboration



251 Institutes

215 full members

8 cooperating

28 associated

from ……

57 Countries or Regions

as of 21/05/23

2234/6122 Authors/Members

1537/2125 PhD Physicists (18% ♀)

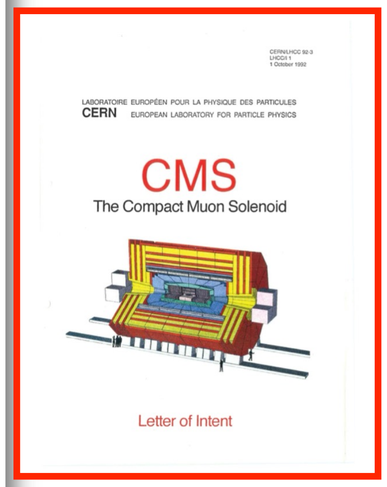
665/1186 PhD Students (26% ♀)

32/1090 Engineers (14% ♀)

0/1321 Undergraduates (29% ♀)

0/400 Technicians,Admins

CMS @ 30

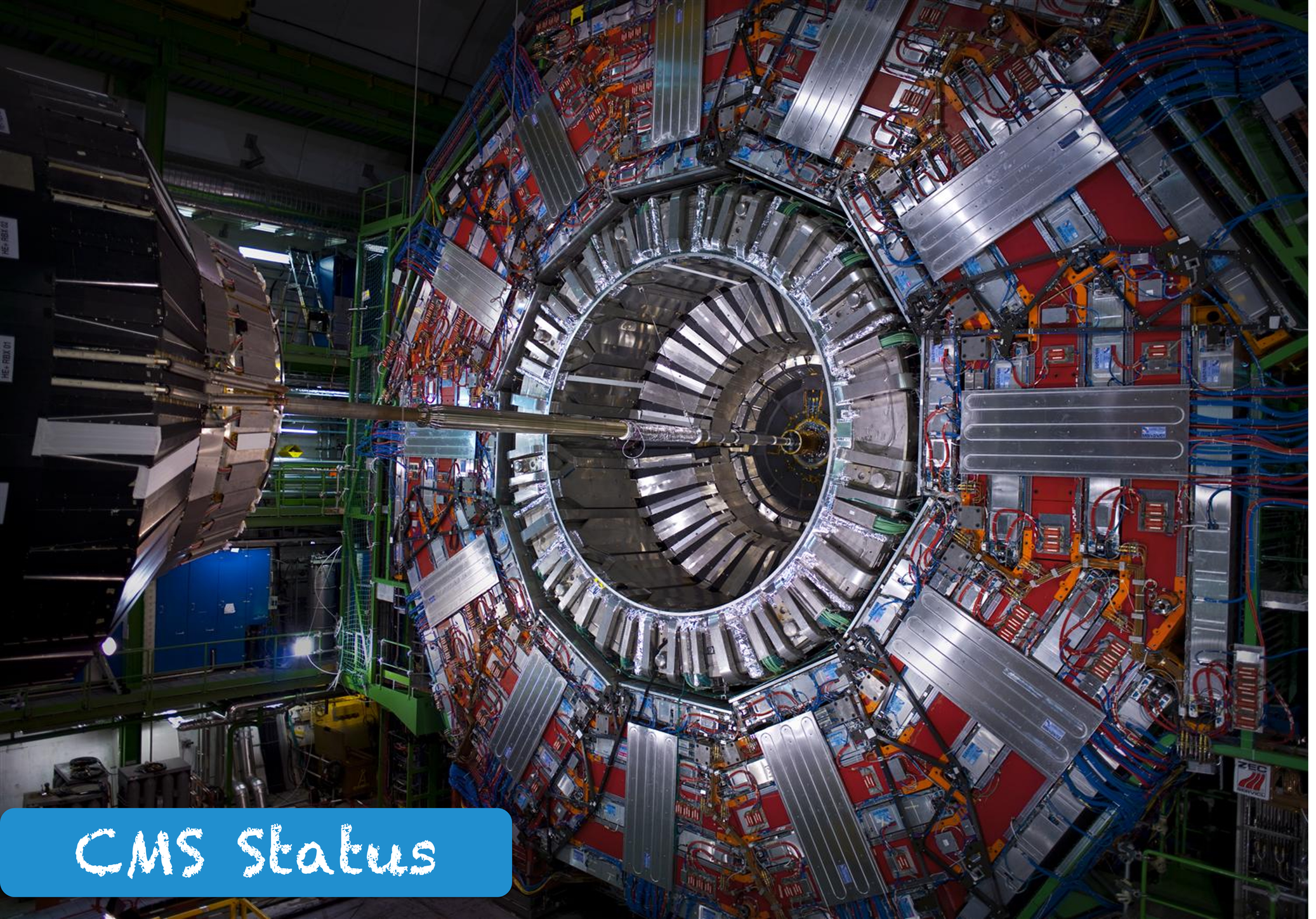


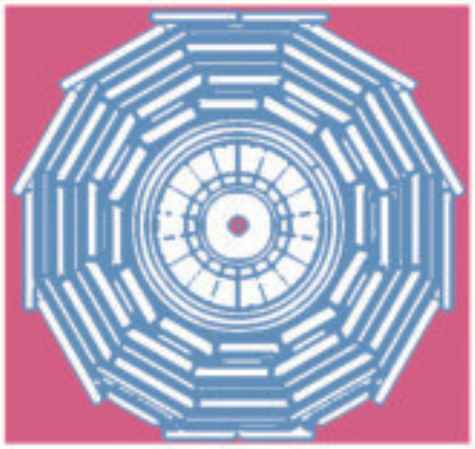
[30 Years of CMS
Video history project]

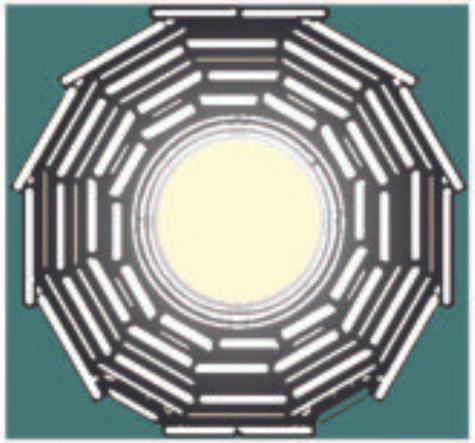
The CMS Collaboration remains a vibrant and diverse community after 30 years and we look forward to the opportunities of the Run 3 and HL-LHC era

First post-COVID outside CMS Week was held in Saint-Malo, France.
A successful return to pre-COVID activities and meetings.

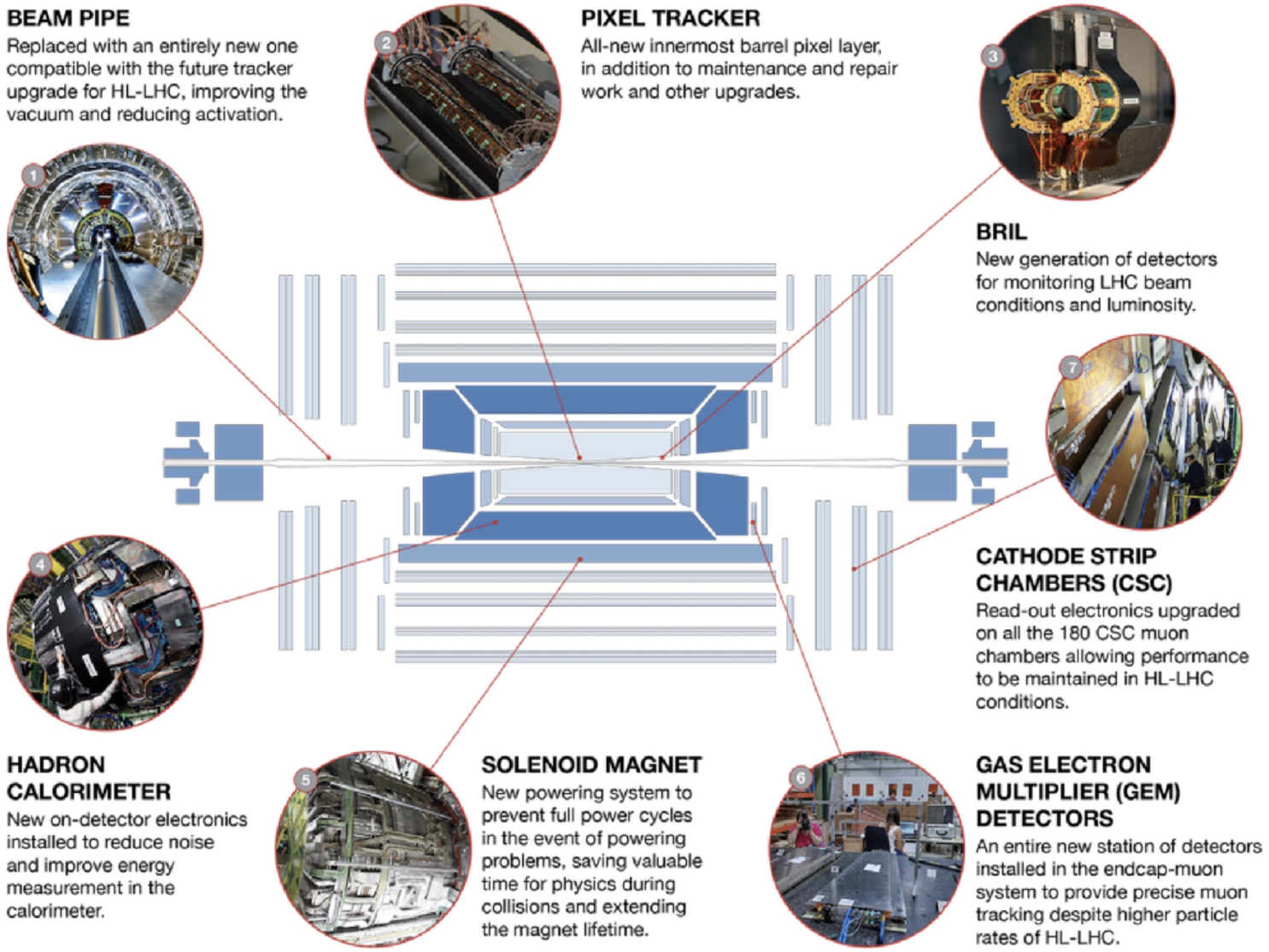
CMS Status







CMS in Run 3

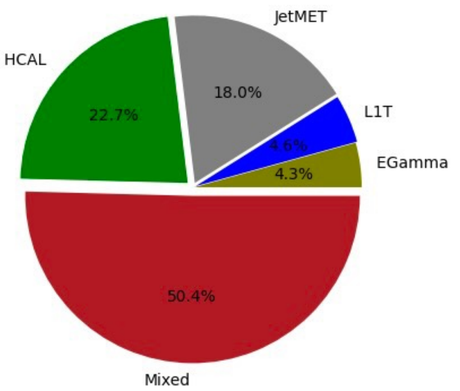


Completion of the Phase 1 upgrades and start of the Phase 2 upgrades.

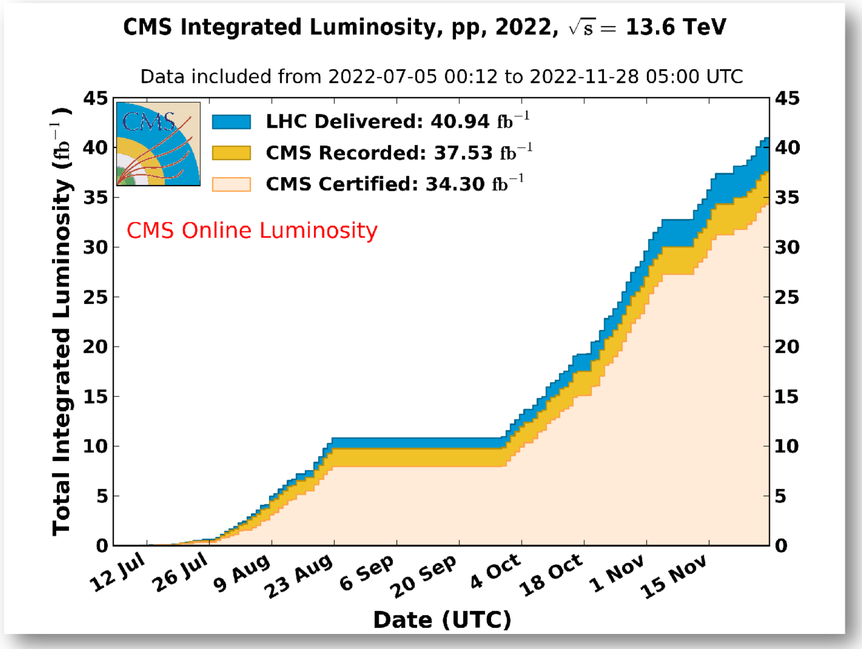
- Phase 1: HCAL barrel readout, new barrel inner pixel (layer 1)
- Phase 2: First of GEM chambers installed, upgraded CSC electronics for HL-LHC, new beam pipe.
- added GPUs to the HLT nodes.
- Demonstrator for Phase 2 muon drift tube electronics and Beam Radiation, Instrumentation and Luminosity (BRIL) demonstrators installed.

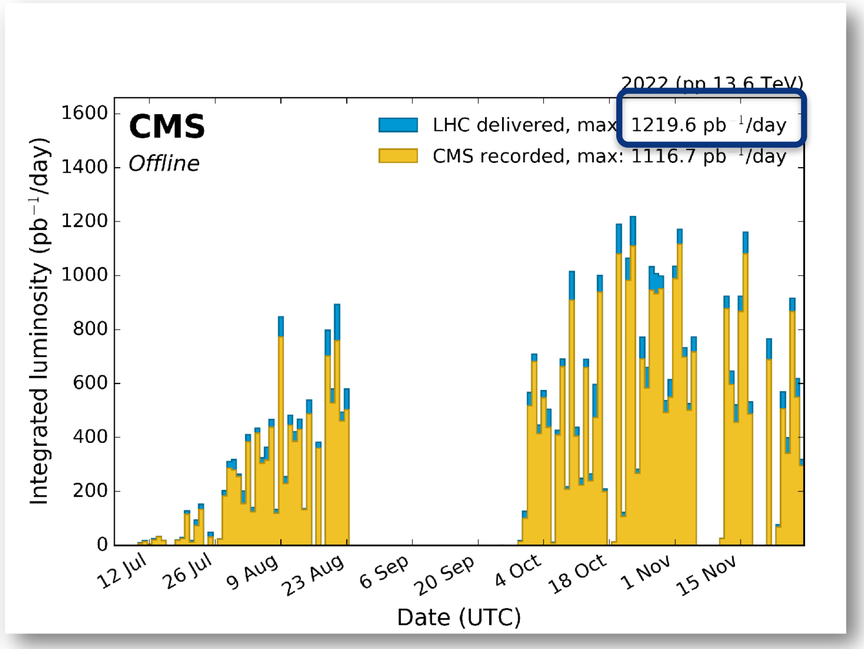
2022 pp Run

Fraction of Exclusive Loss from Each CMS Subsystem



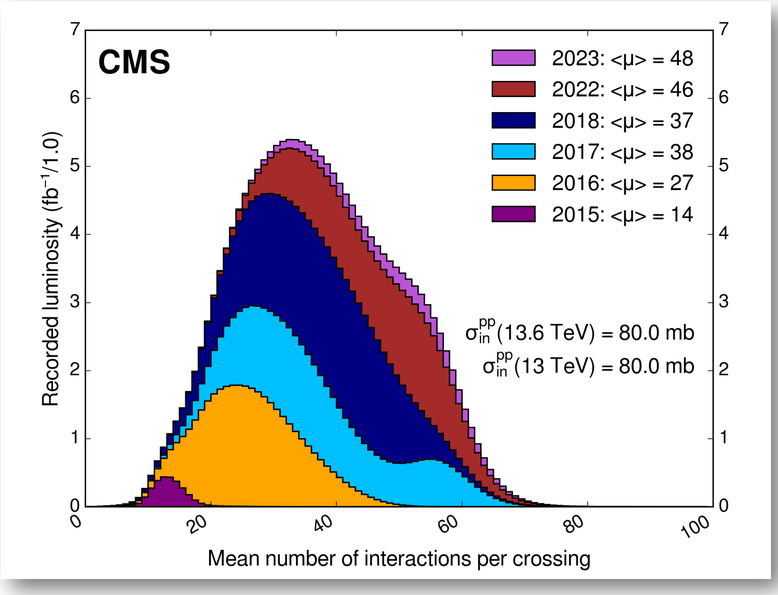
13.6 TeV pp collision data ~ 41fb^{-1} in 2022 with
data taking ~92% and data certified for physics (for all/tracking detectors) > 91%/98%





Pile-Up (PU) distribution

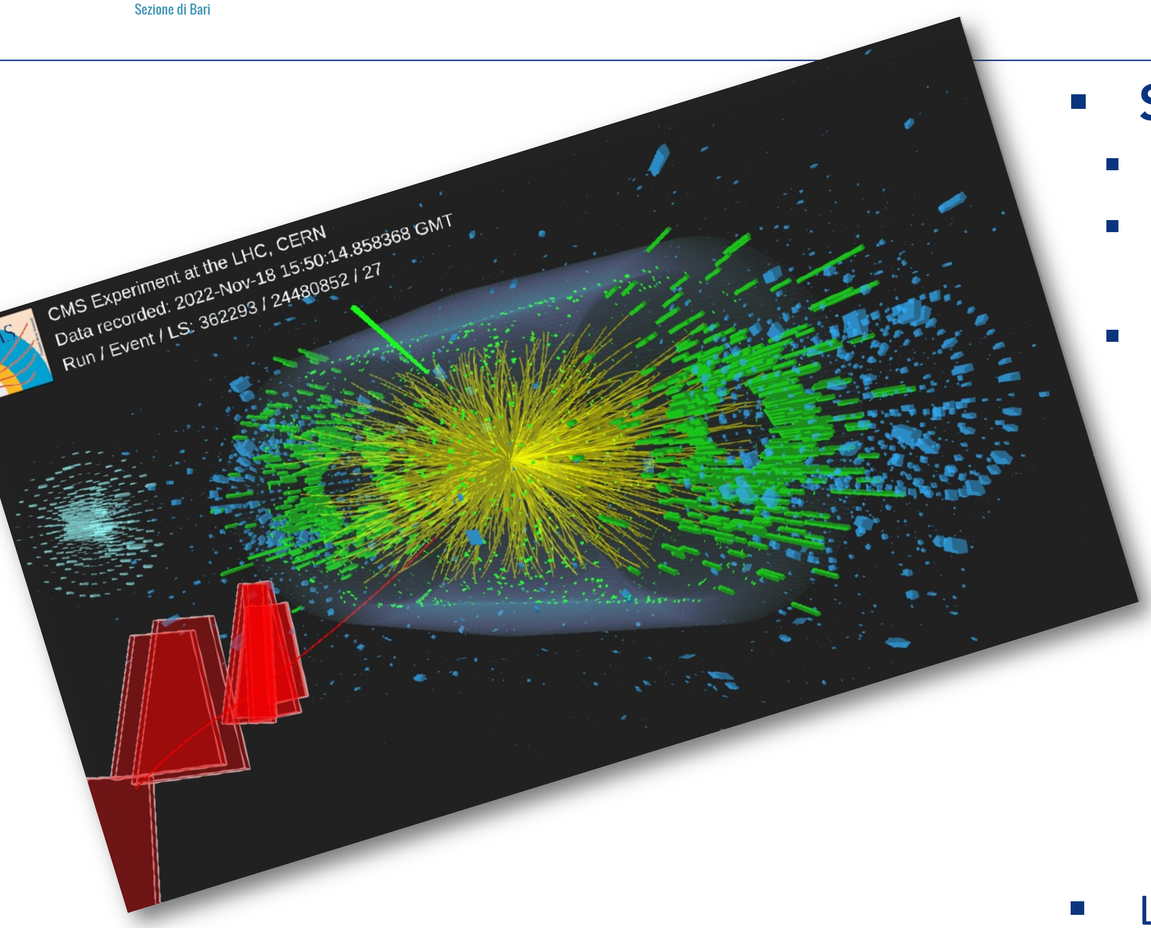
as of 22/05/23



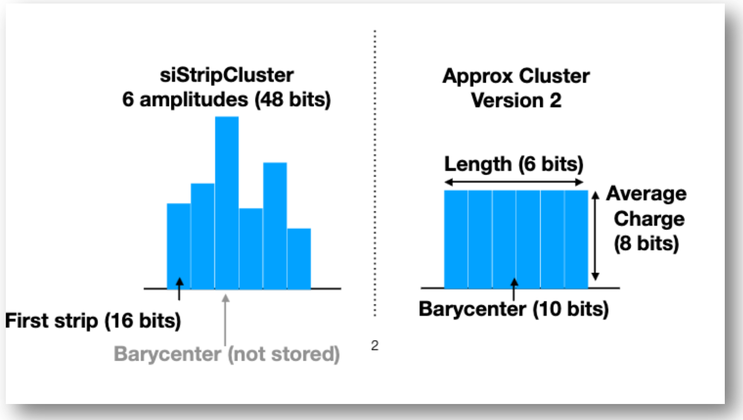
Link to the public Data Quality twiki page here

Link to the public luminosity twiki page here

Short PbPb test in 2022



- **Successful commissioning in 2022:**
  - L1 + HLT triggers commissioned
  - ECAL, pixels and strip tracker readout configuration for Heavy Ions implemented
  - Tested new RAW format for silicon strip clusters with substantial reduction in size



- LHC delivered 0.4 ub^{-1}, CMS recorded 0.3 ub^{-1}

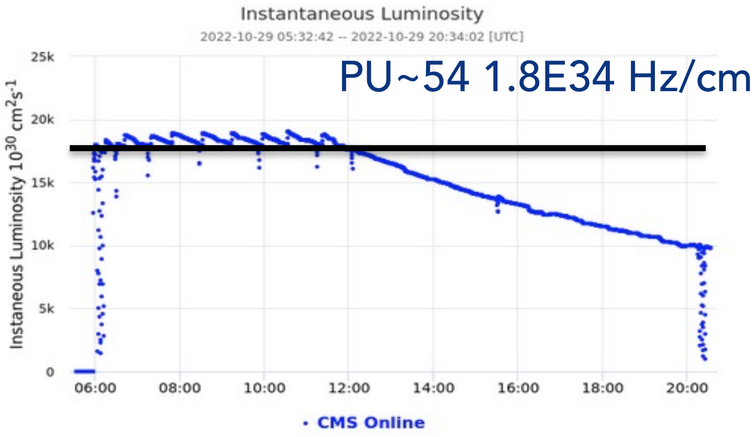
This was an exceptional start to Run 3 Heavy Ion (HI) program and has prepared CMS well for the HI run that will start in September.

2023 Run Preparation

Expecting ~70/75 fb^{-1} of pp running with a PU at 60

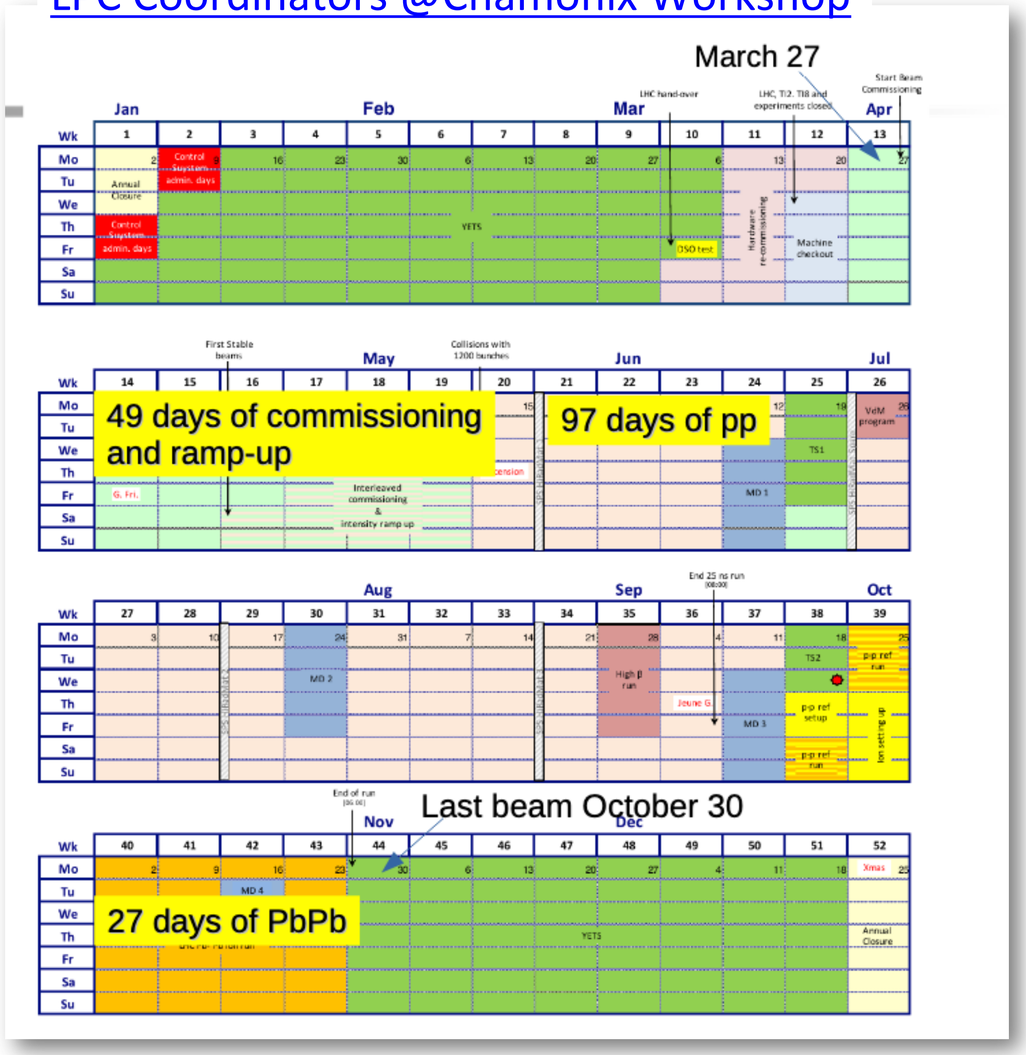
- Overall integrated luminosity depends on LHC availability.
- The levelling time is foreseen to increase substantially in 2023.

Typical fill in 2022
6h levelling/12h fill



- In 2022, the LHC established that PU≥60 is possible during Run 3.
- CMS has been studying the optimal pp running conditions for the CMS physics program.
  - Many opportunities and a few challenges ==> updated the trigger strategy
- Studies show that CMS can handle these running conditions.

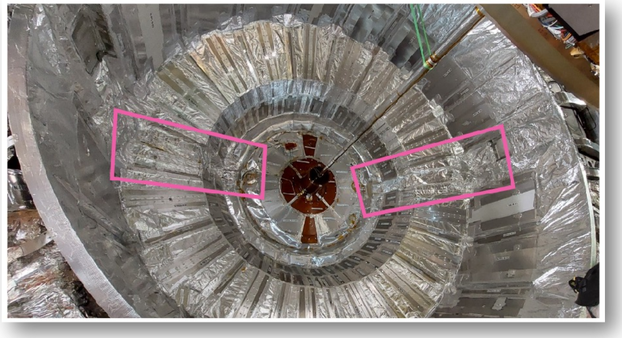
[LPC Coordinators @Chamonix Workshop]



CMS Detector Status

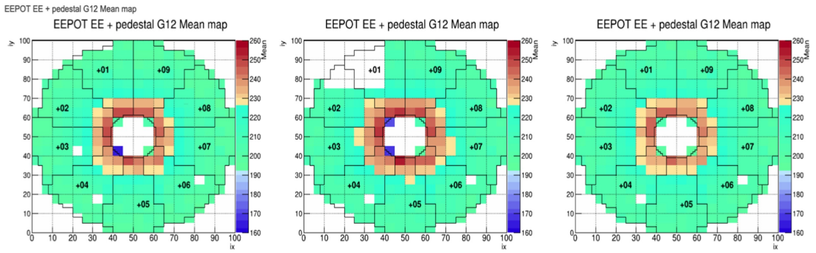
Successful Year End Technical Stop (YETS)

- maintenance and repairs as planned.



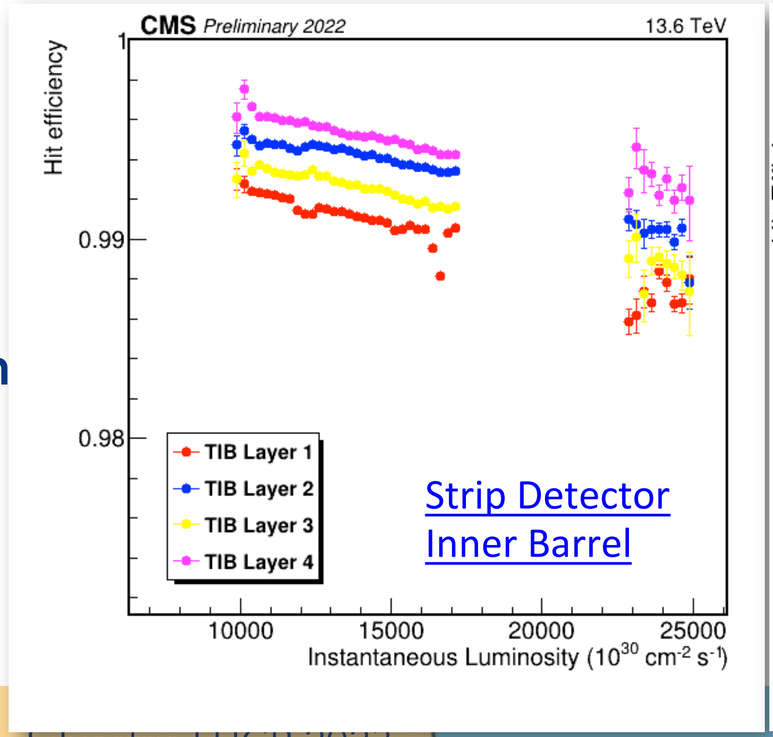
ECAL Pedestals

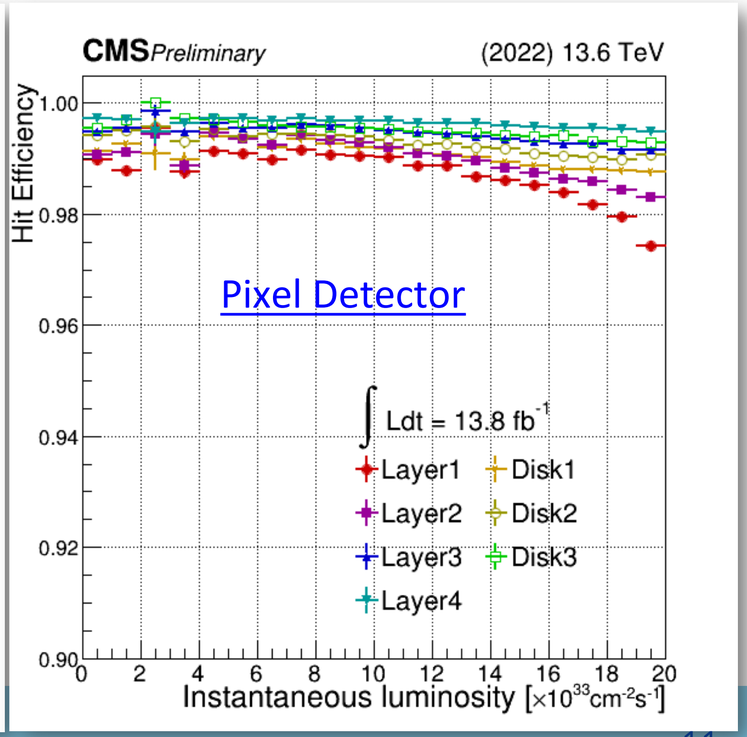
Before the incident | After the incident | After the fix - YETS



From High PU tests in 2022, we gained an understanding of the impact on tracker efficiencies at high instantaneous luminosity

- Strip Tracker shows **linear continuation** at higher luminosities,
- Pixel Layer 1 **well behaved up to design luminosity of 2 x 10^{34}.**

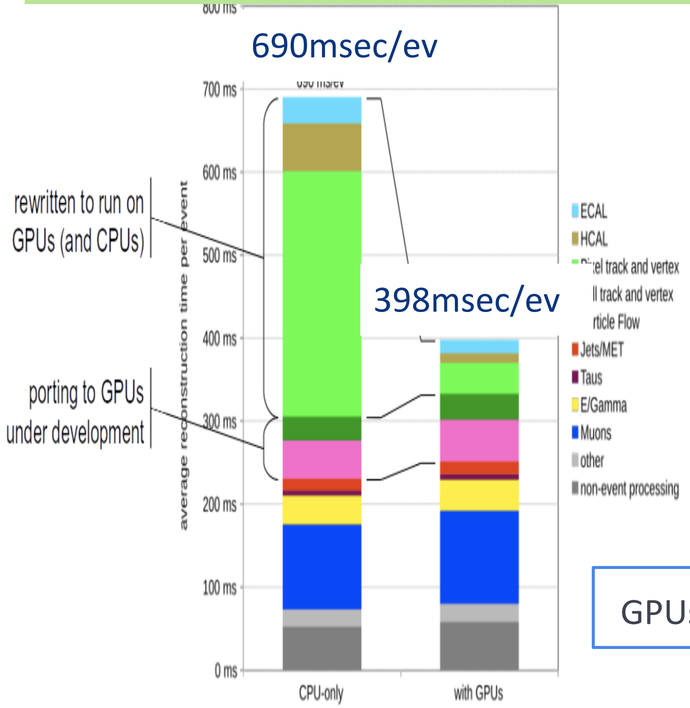




2022 data taking and 2023 Run Preparation

DAQ/HLT

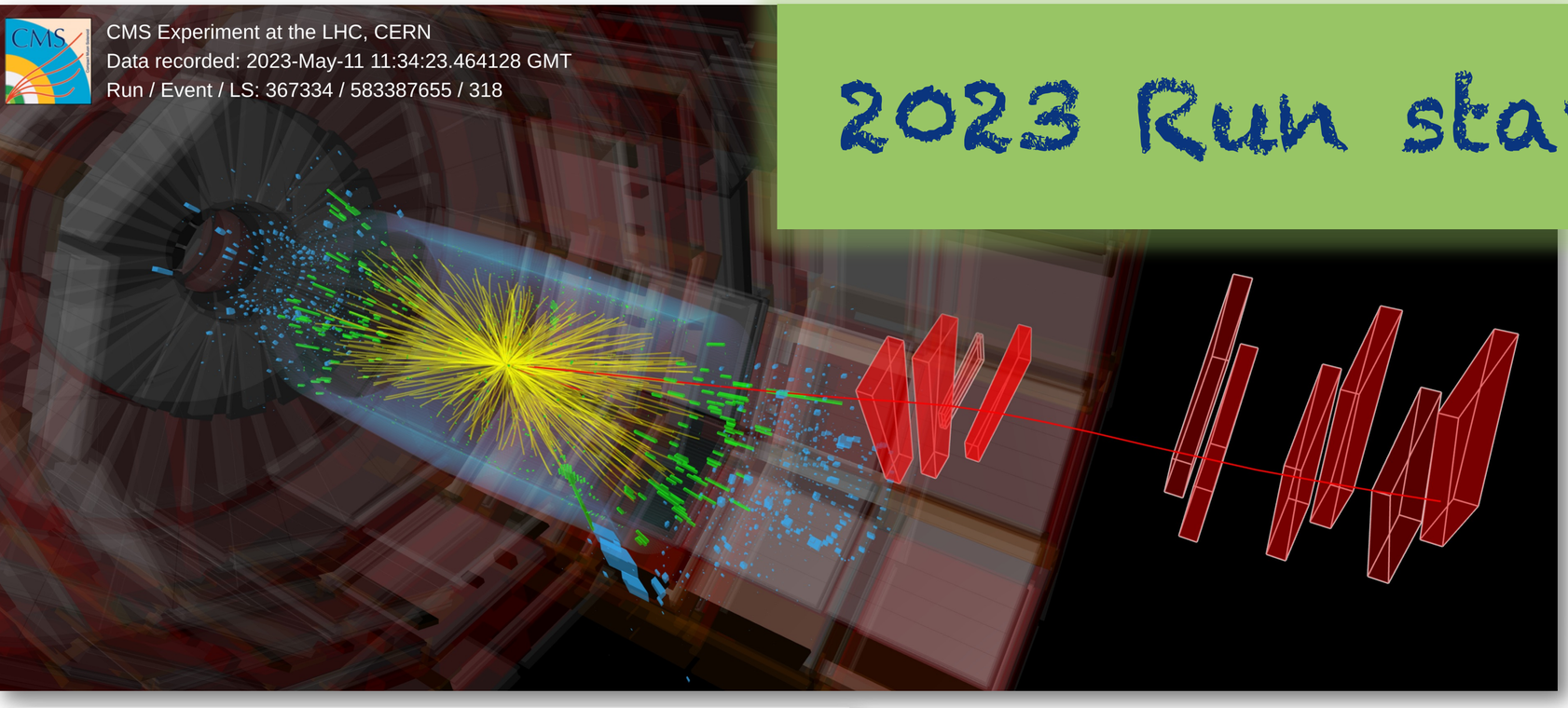
- Successful transition to a hybrid CPU + GPU system
- Significant reduction in processing time and corresponding increase in physics reach and performance
- Running GPU-enable trigger menus since start of 2022.
- Toward heterogeneous computing enviroment in progress from NVIDIA CUDA to Alpaka (portability library)



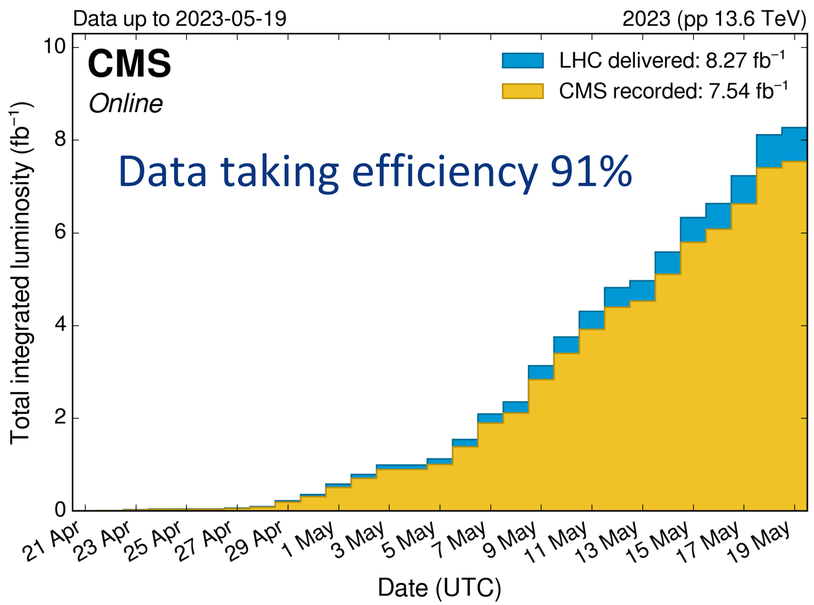
GPUs corresponds to 40% of offload

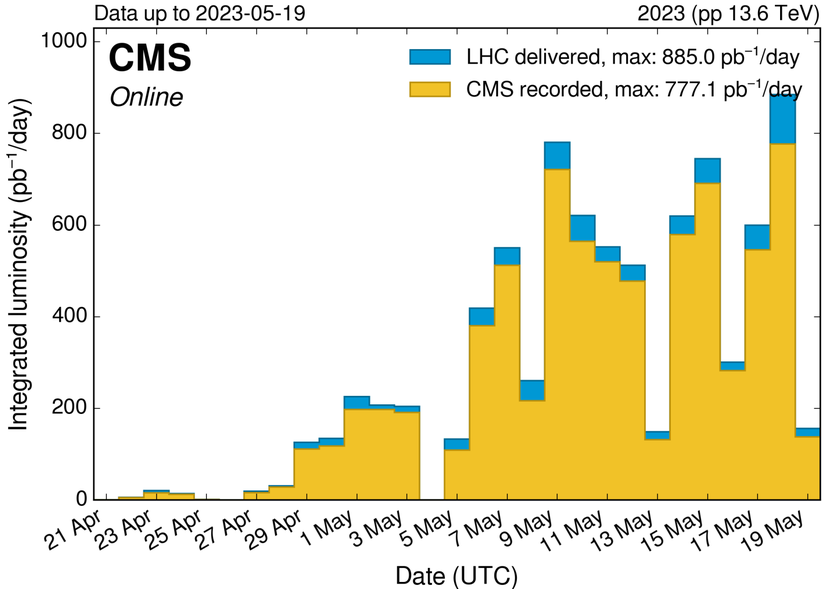
Trigger

- CMS can run at 110kHz !
  - allowing more to be recorded for a small price in deadtime
- L1 Trigger menus enhanced with optimized Bs→μμ seed, new τ→3μ seed, reduced HTT thresholds for HH→4b, W→ 3π, exclusive and inclusive VBF parking seed.
- High Level Trigger menus starting from 2022 menu with additional parking (VBF, HH→4b, LLP)
  - 2.5 kHz (prompt) + 3 kHz (parking) + 30 kHz (scouting) on average
  - Scouting will profit from newly seeds (i.e. low threshold HTT, dijet mass, dimuon, dielectron etc seeds)
- HLT timing not a showstopper at PU 60.



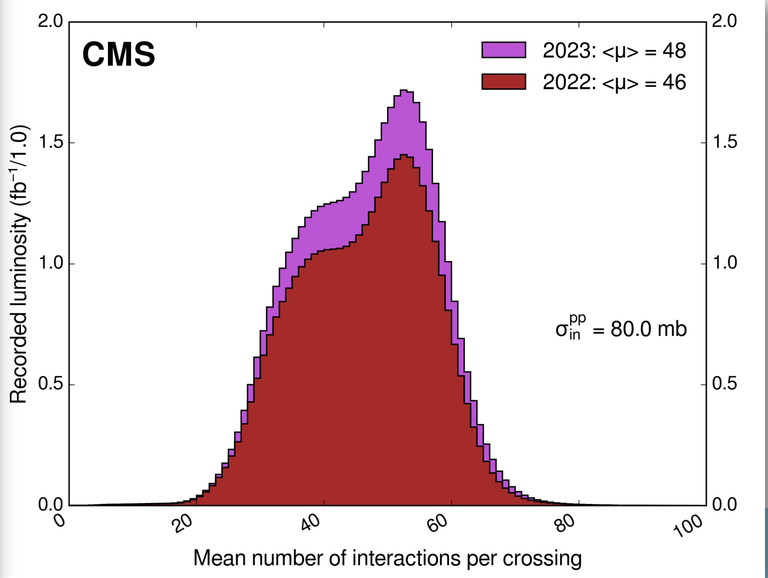
2023 Run started!





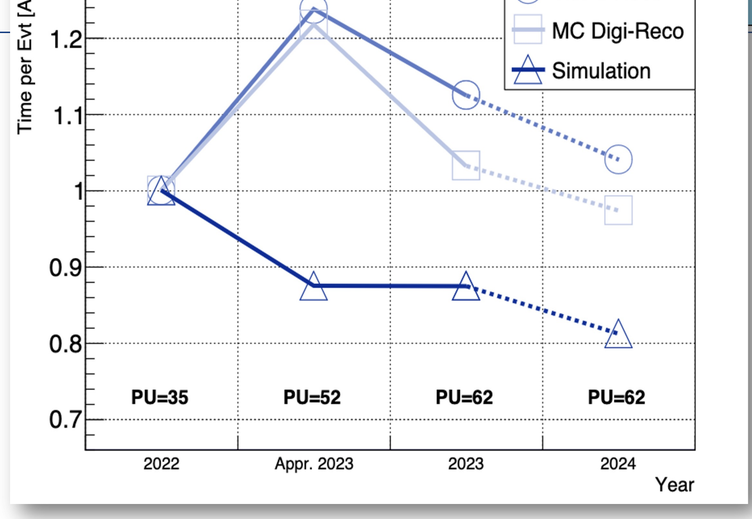
Pile-Up distribution

as of 22/05/23



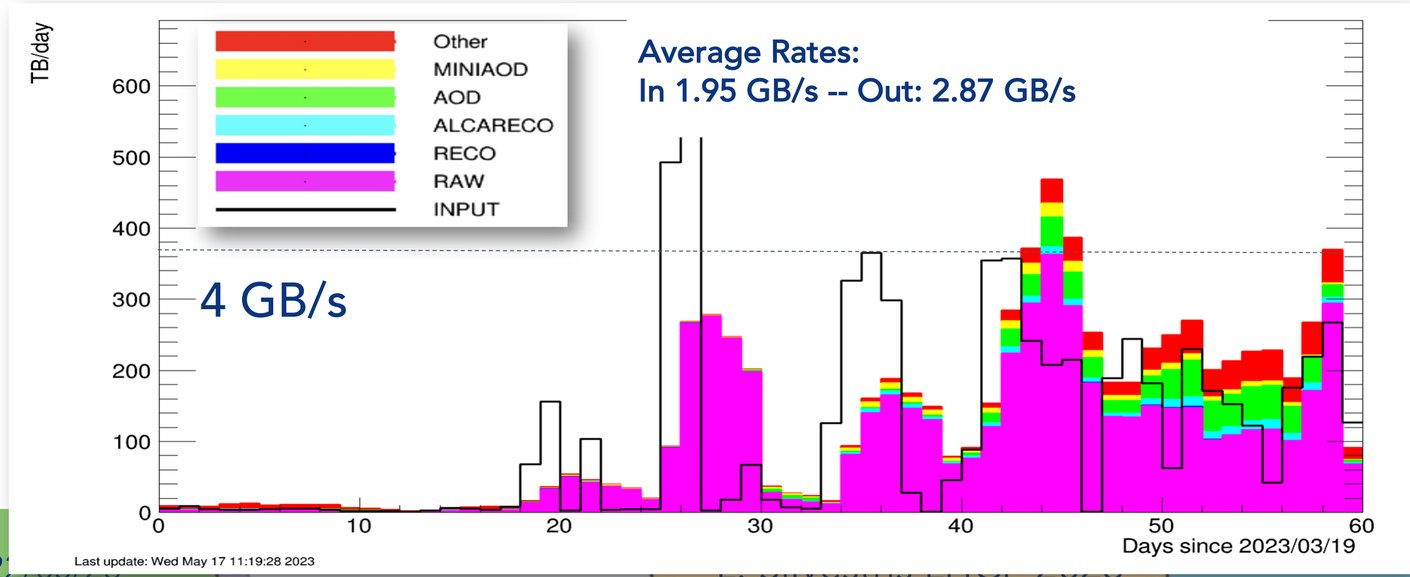
Offline/Computing: Initial Performance in 2023

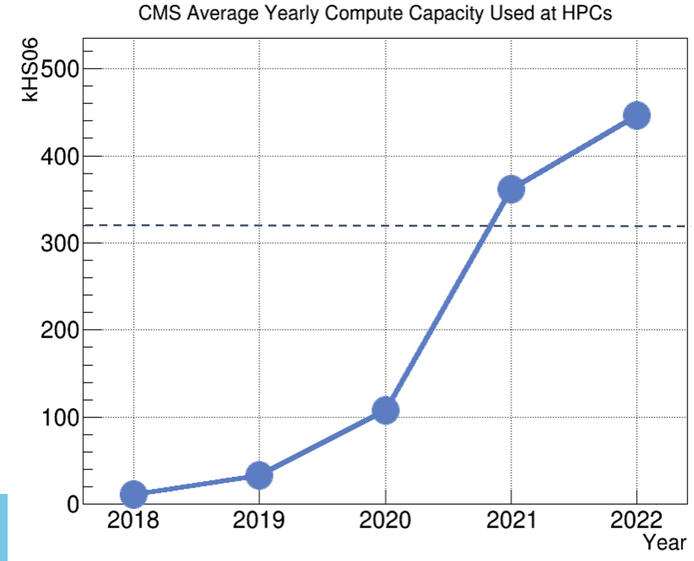
- The Tier-0 is already promptly processing data volumes similar to those at the end of 2022.
- CMS is well prepared to maximise the luminosity collected, even with the increased pileup:
  - Improved software performance over last year
  - Fully utilizing the old Run 2 HLT farm as an extension of the Tier-0
  - Ability to exploit compute capacity at HPC centres for the entire palette of central production workflows



Several software improvements in the pipeline aiming production in `24

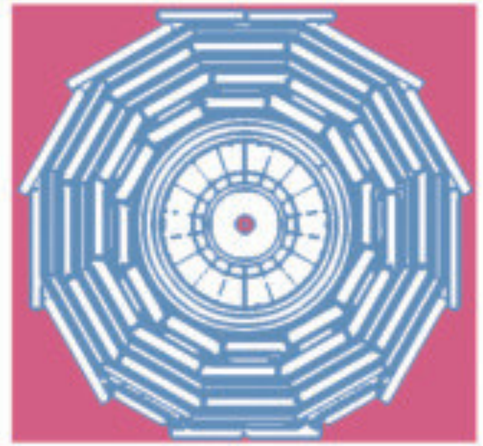
Tier-0 Processing Rates

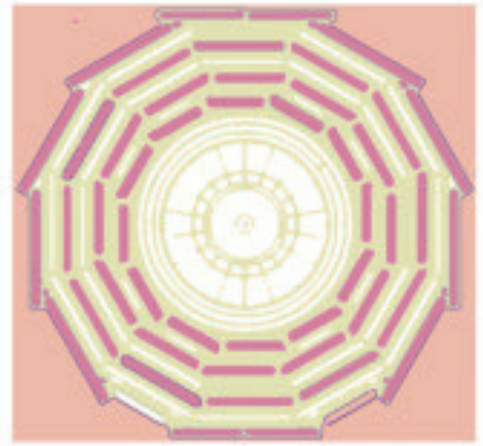


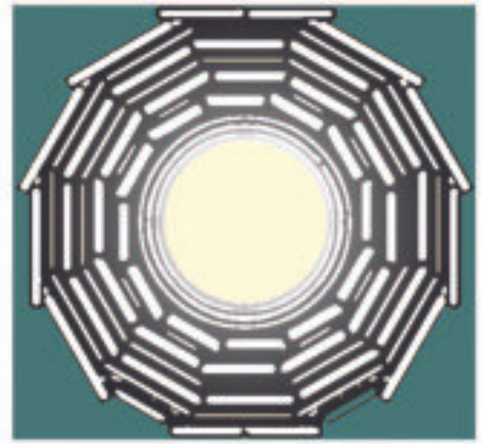


Public material and recent physics results

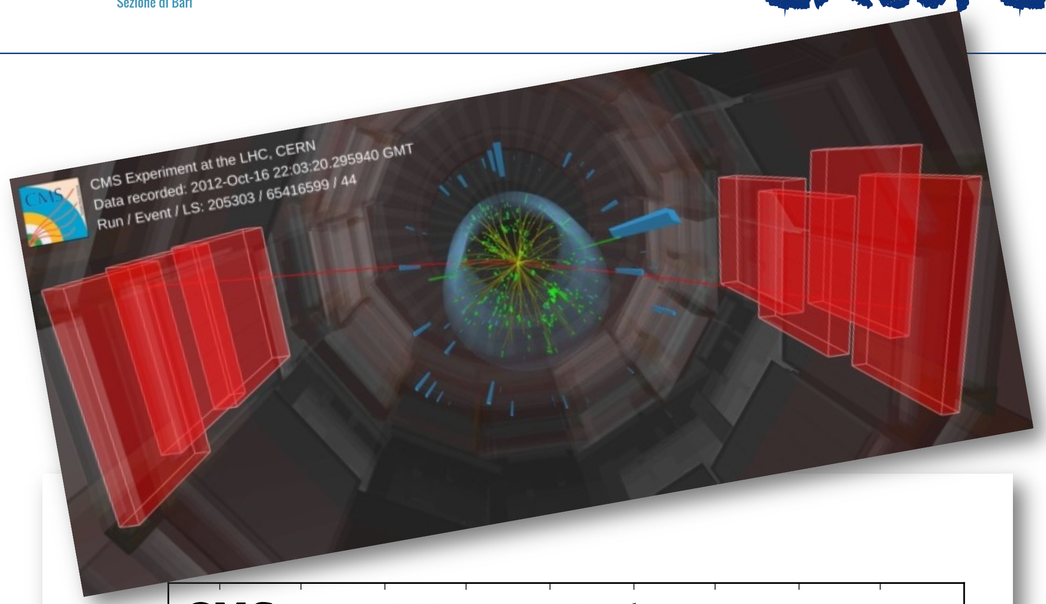
(just as teasers and spoilers: all details given during the conference by the real experts)

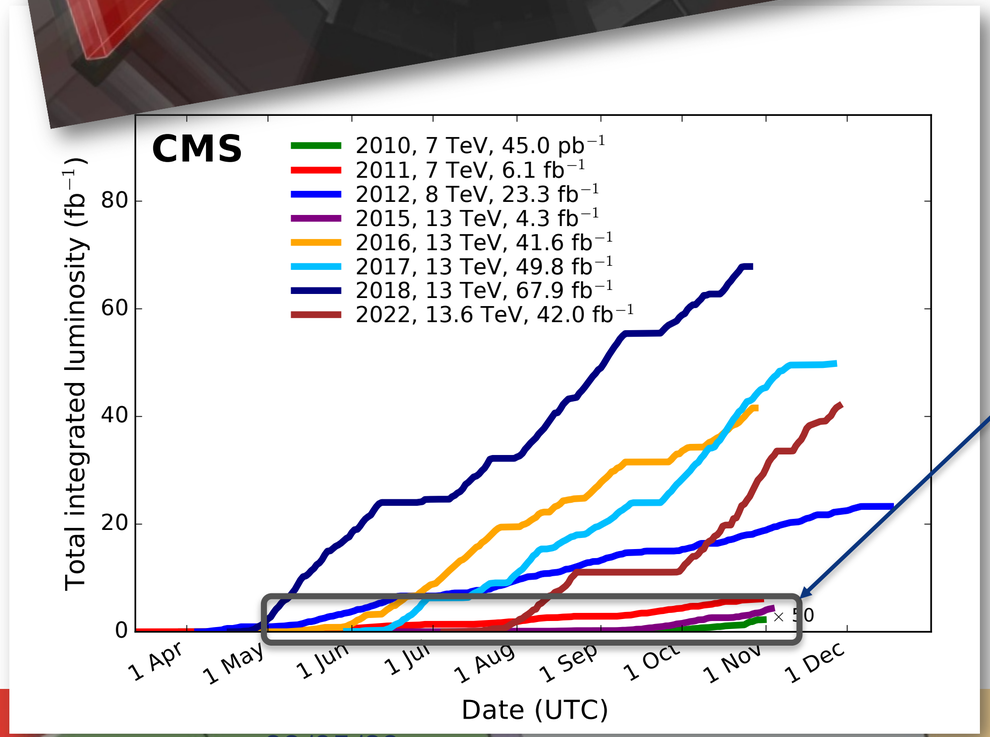






CMS completed the release of the entire Run-1 pp data





$\mathcal{L}$~30fb^{-1}

- All p-p data from Run1 are now available through the CERN Open Data portal
- In December 2022, CMS released 491 TB of collision data collected during 2012. A first important milestone in the process started in 2014 with the very first release of research-grade open data in experimental particle physics.
- Completing the release of Run-1 data within 10 years after data taking reaffirms our commitment to the CMS Open Data policy.
- Fostering reusability: Analysis code examples to extract physics objects from these data are now included as CERN Open Data Portal records.
- Also tutorials: CMS Open Data workshops.

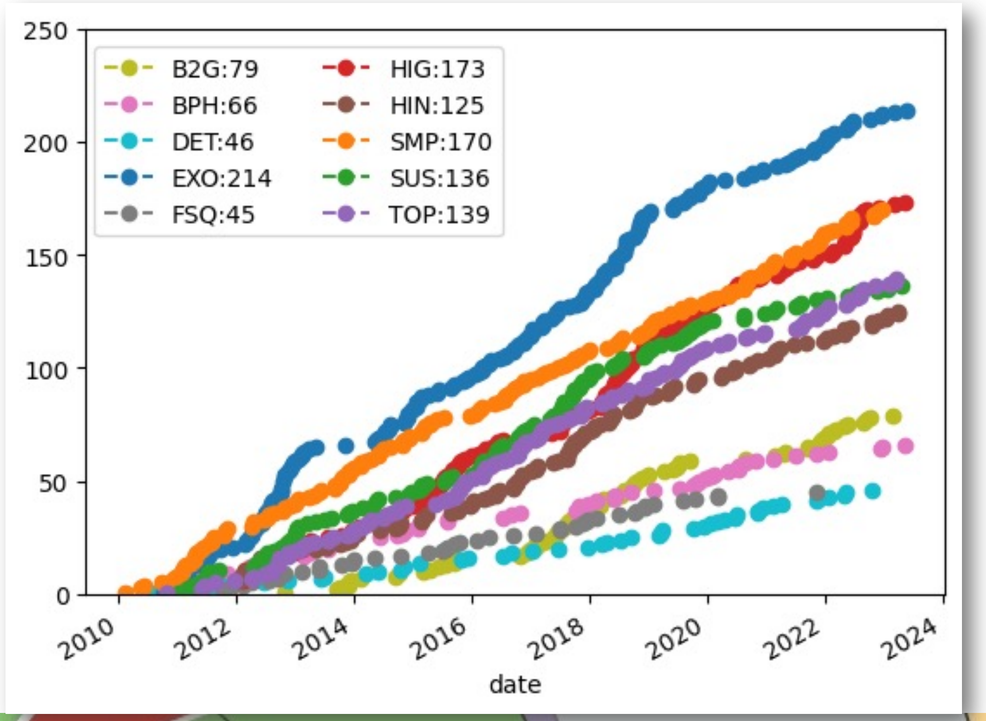
https://cms.cern/news/cms-completes-release-its-entire-run-1-proton-proton-data

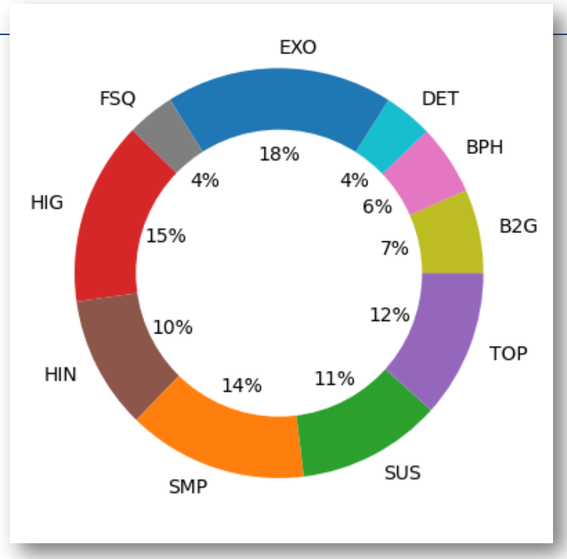
CMS Publications

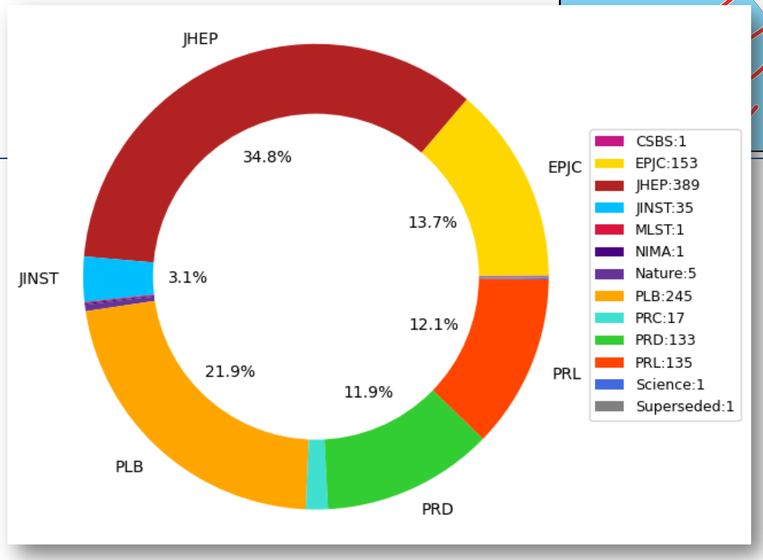
1218 CMS papers
1142 published

1194 papers based on collision data
1117 published

as of 22/05/23

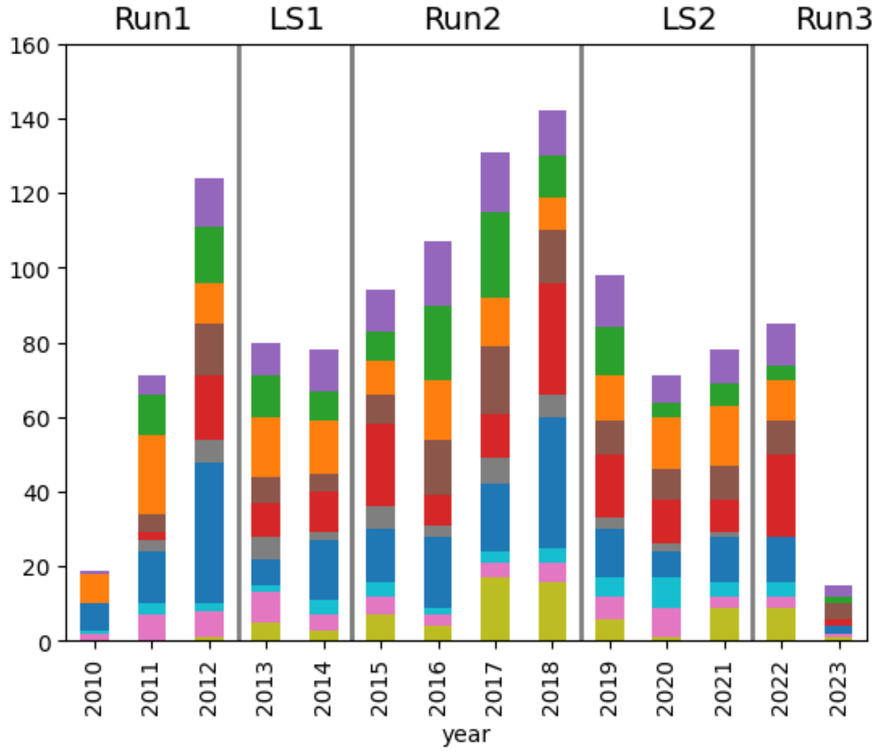






CMS titles
- 600 “Search”
- 52 “Observation”
- 21 “Evidence”
- 336 “Measurement”
- 42 “Study”

CMS with friends
- ATLAS: 6 (5 JHEP, 1 PRL)
- LHCb: 1 (Nature)
- TOTEM: 5 (1 JHEP, 3 EPJC, 1 JINST)



http://cms-results.web.cern.ch/cms-results/public-results/publications-vs-time/

CMS New Physics Results @ LHCP

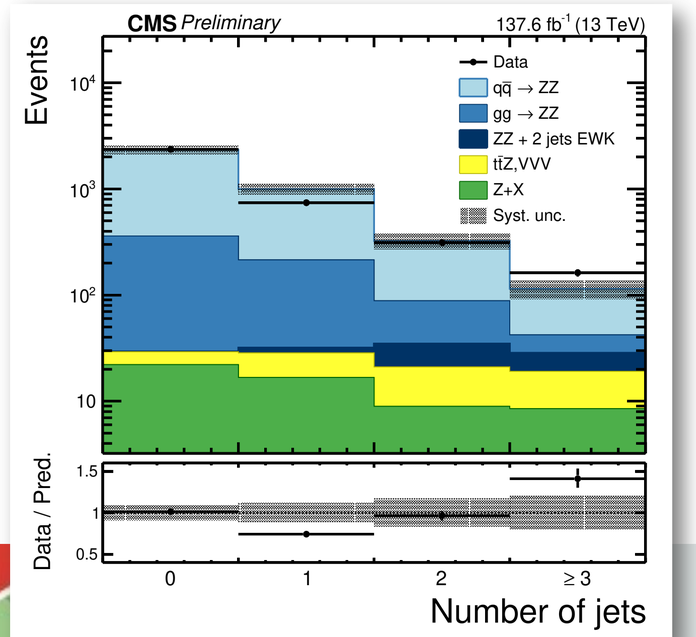
Topics	Cadi line	Title	Plenary
Measurements	CMS-PAS-SMP-22-001	Measurement of the differential ZZ(4l)+jets cross sections	Q. Lu Fri afternoon
New observations and evidences	HIG-23-002	ATLAS-CMS combination of $H\to Z\gamma$	C. Arcangeletti Fri morning
	CMS-PAS-BPH-22-002	Observation and branching ratio measurement of $\Lambda^0_b\to J/\psi\,\Xi^-\,K^+$	R. Jones Mon afternoon
	CMS-PAS-TOP-22-008	Search for SM tWZ process in multi-lepton final states	M. Quinnan Fri afternoon
Searches for New Physics	CMS-PAS-EXO-22-016	Search for a high mass dimuon resonance associated with b quark	M. Lu Wed morning
	CMS-PAS-EXO-22-018	Search for leptoquarks produced in ℓ-q collisions and coupling to τ leptons	K. Kwok Thu morning
	CMS-PAS-EXO-22-008	Search for narrow trijet resonances	M. Lu Wed morning
	CMS-PAS-BPH-21-005	Search for lepton flavor violating $\tau\to 3\mu$	R. Jones Mon afternoon
	CMS-PAS-SUS-21-006	Search for long-lived SUSY with disappearing tracks	L.Shchutska Thu morning
	CMS-PAS-TOP-22-007	Searches for Lorentz invariance violation with tt dilepton final state at 13 TeV	T. Stevenson Fri morning
Objects	CMS-PAS-MUO-22-001	Machine learning techniques for muon identification and isolation	Poster session

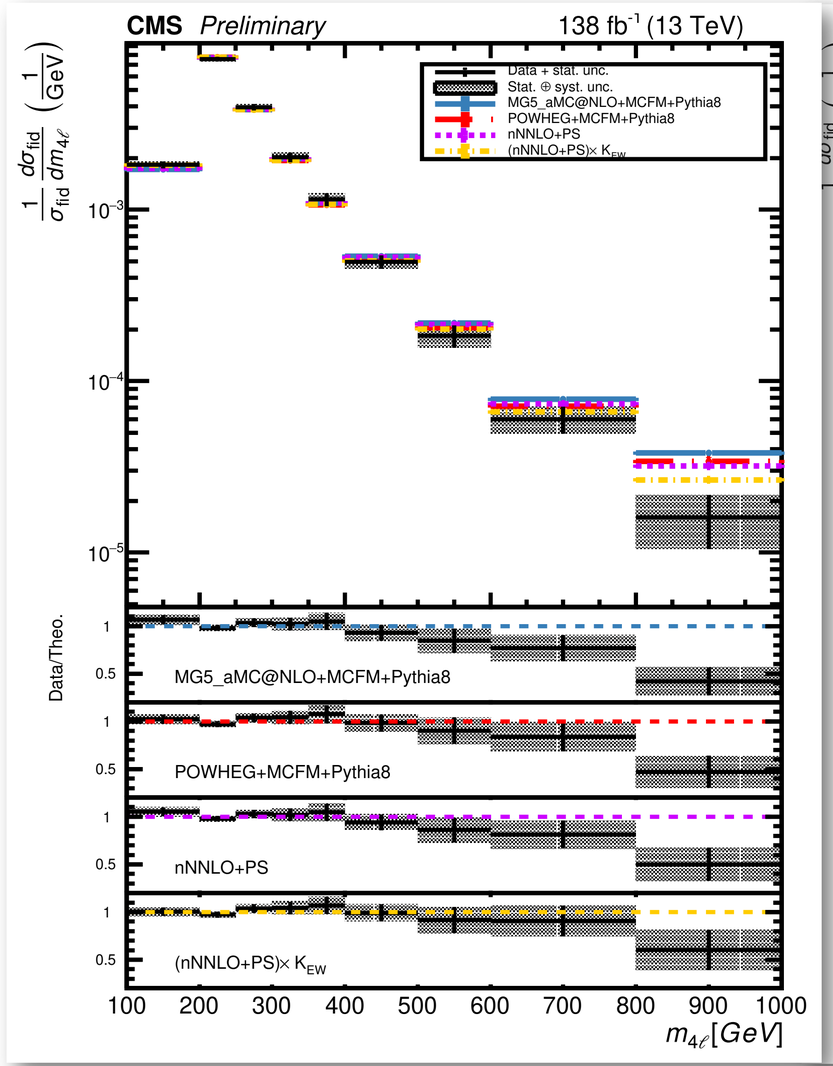
Measurement of the differential ZZ(4l)+jets cross sections

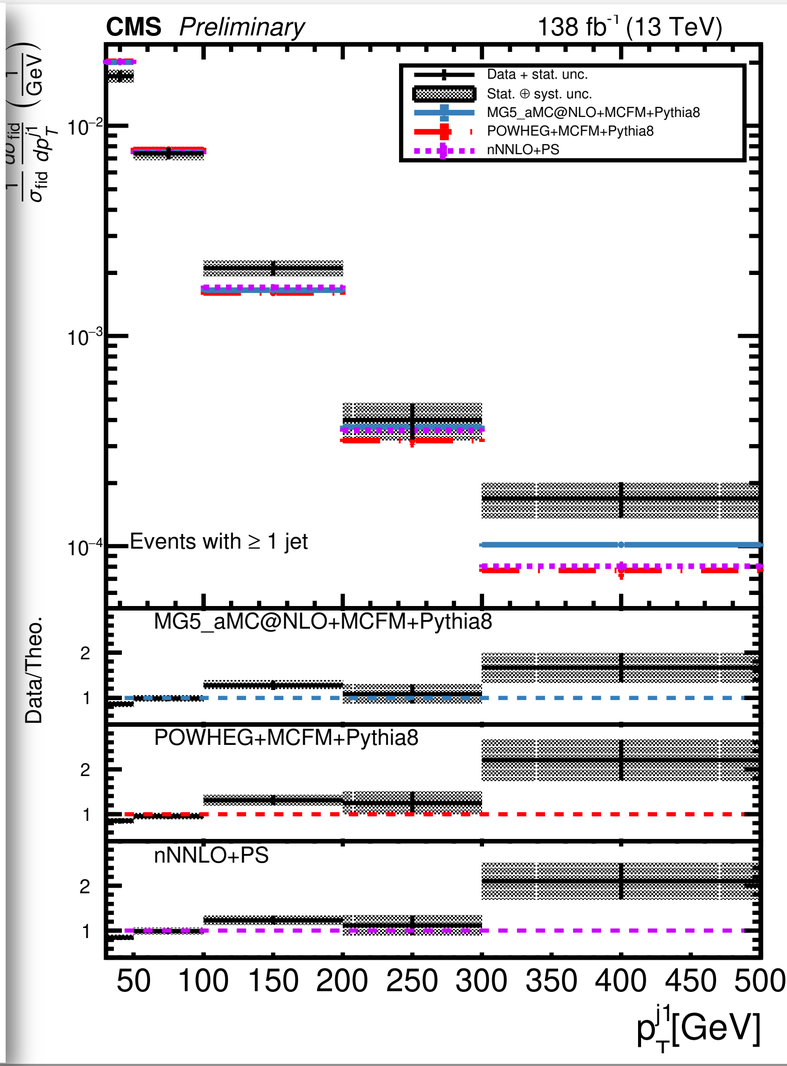
CMS-PAS-SMP-22-001

4l events in association with jets

- Both on-shell (Z) and off-shell (Z) productions in association with jets are considered
- Differential distributions are measured and compared to (N)NLO predictions
  - adding full Run 2 data reduced uncertainties by about factor of 2 mainly in the last bins.



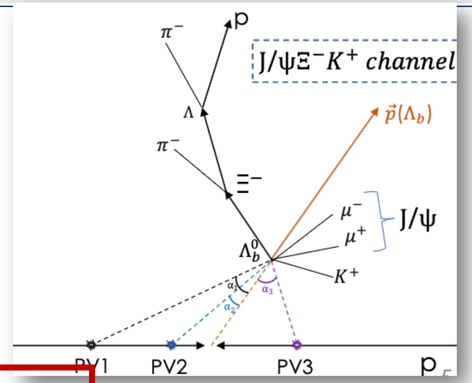


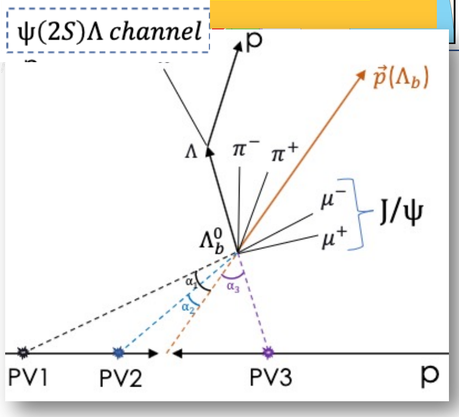


Observation and branching ratio measurement of $\Lambda^0_b \to J/\psi\,\Xi^-\,K^+$

CMS-PAS-BPH-22-002

- Multibody decays of b hadrons used to probe new meson production (candidates for pentaquarks, loosely bound molecular baryon-meson states, etc)
- This study reports the measurement of the ratio





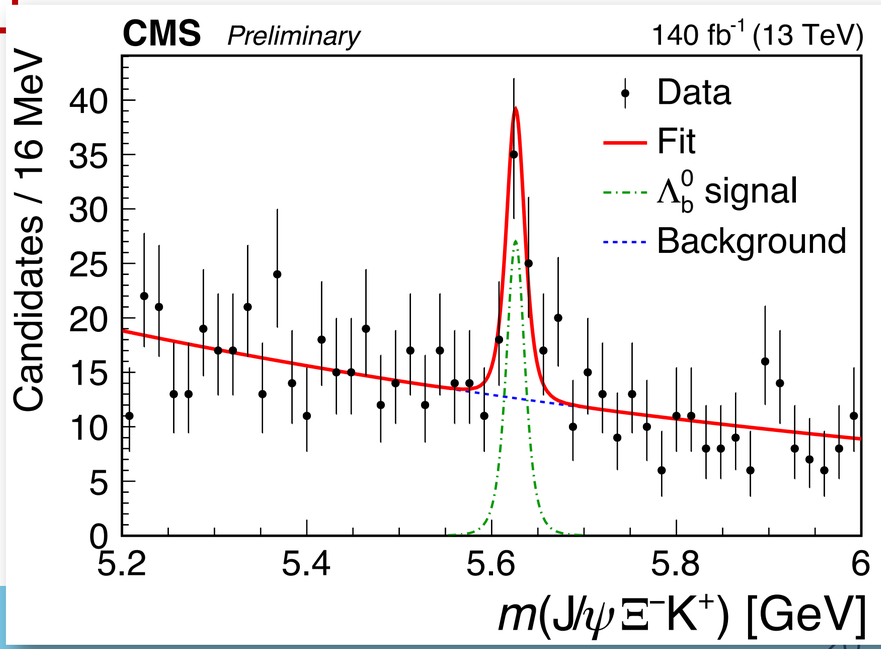
$$\mathcal{R} \equiv \frac{\mathcal{B}(\Lambda_b^0 \to J/\psi \Xi^- K^+)}{\mathcal{B}(\Lambda_b^0 \to \psi(2S)\Lambda)} = \frac{N(\Lambda_b^0 \to J/\psi \Xi^- K^+)}{N(\Lambda_b^0 \to \psi(2S)\Lambda)} \times \frac{\epsilon_{\psi(2S)\Lambda}}{\epsilon_{J/\psi \Xi^- K^+}} \times \frac{\mathcal{B}(\psi(2S) \to J/\psi \pi^+\pi^-)}{\mathcal{B}(\Xi^- \to \Lambda \pi^-)} = [2.5 \pm 0.8\,(\text{stat}) \pm 0.9\,(\text{syst})]\%$$

Ratio of the signal yields in data

Ratio of the total efficiencies from MC

Know branching fractions from PDG

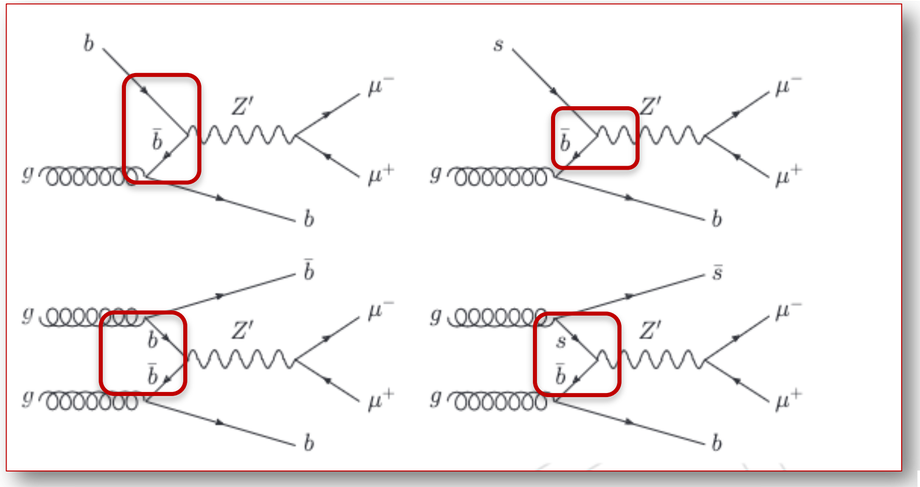
- $\Lambda^0_b \to J/\psi\,\Xi^-\,K^+$ decay observed with 5σ significance
  - First discovered multibody decay containing the $J/\psi\,\Xi^-$ system
- Open the possibility to search doubly-strange hidden-charm pentaquarks once more data are collected



Search for a high mass dimuon resonance associated with b quark

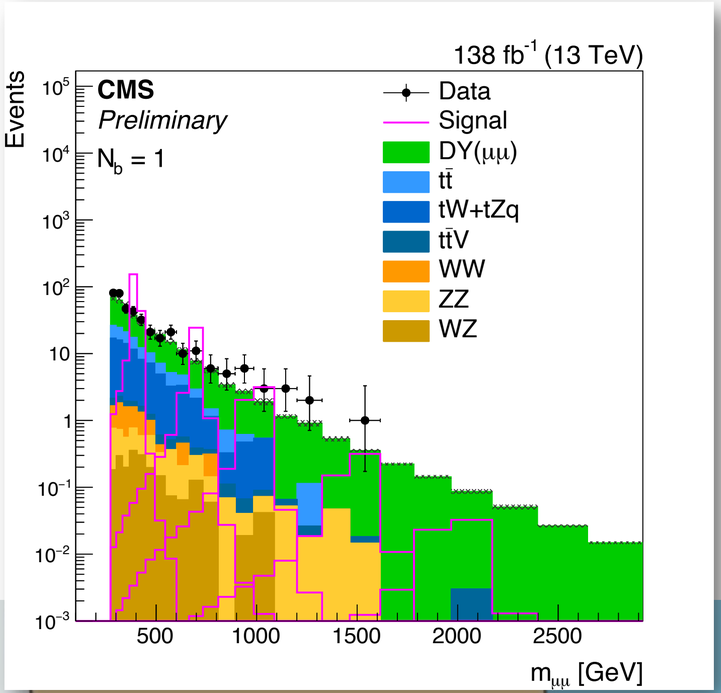
CMS-PAS-EXO-22-016

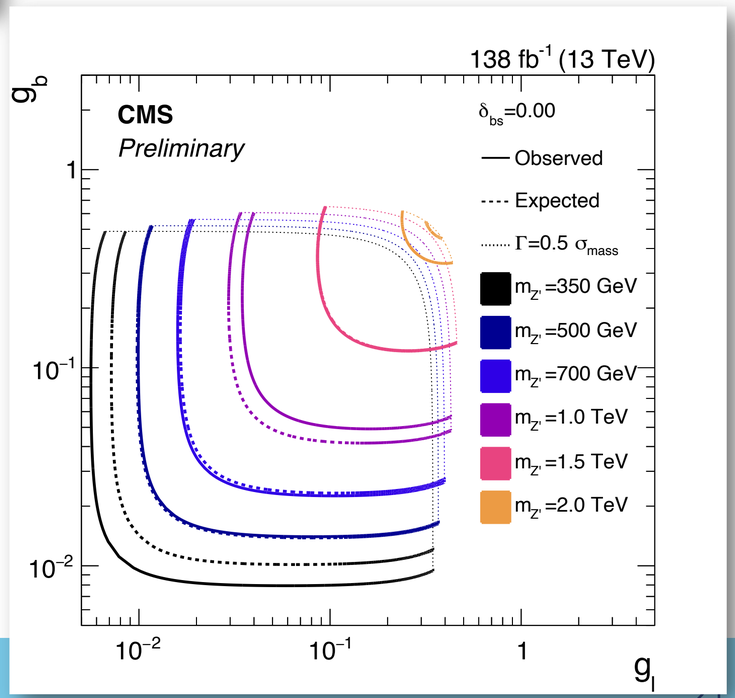
Probing one of the model that would have explained LHCb LFUV anomalies



$$\mathcal{L}_{BSM} = Z'_\eta \left\{ g_\ell \sum_{f=e,\mu,\tau} \bar{f}\gamma^\eta P_L f + g_\nu \sum_{f=\nu_e,\nu_\mu,\nu_\tau} \bar{f}\gamma^\eta P_L f + g_b \left[\bar{b}\gamma^\eta P_L b + \delta_{bs} \left(\bar{s}\gamma^\eta P_L b + \text{h.c.} \right) \right] \right\}.$$

- Analysis selection designed to suppress tt bkg,
  - main residual bkg from DY+b jets
- No excess observed
  - Limit set on narrow resonances in specific pheno model
    - most of the allowed parameter space is excluded for a Z′ boson with a mass ≤ 500 GeV while constraints are less stringent for higher Z′ mass hypotheses





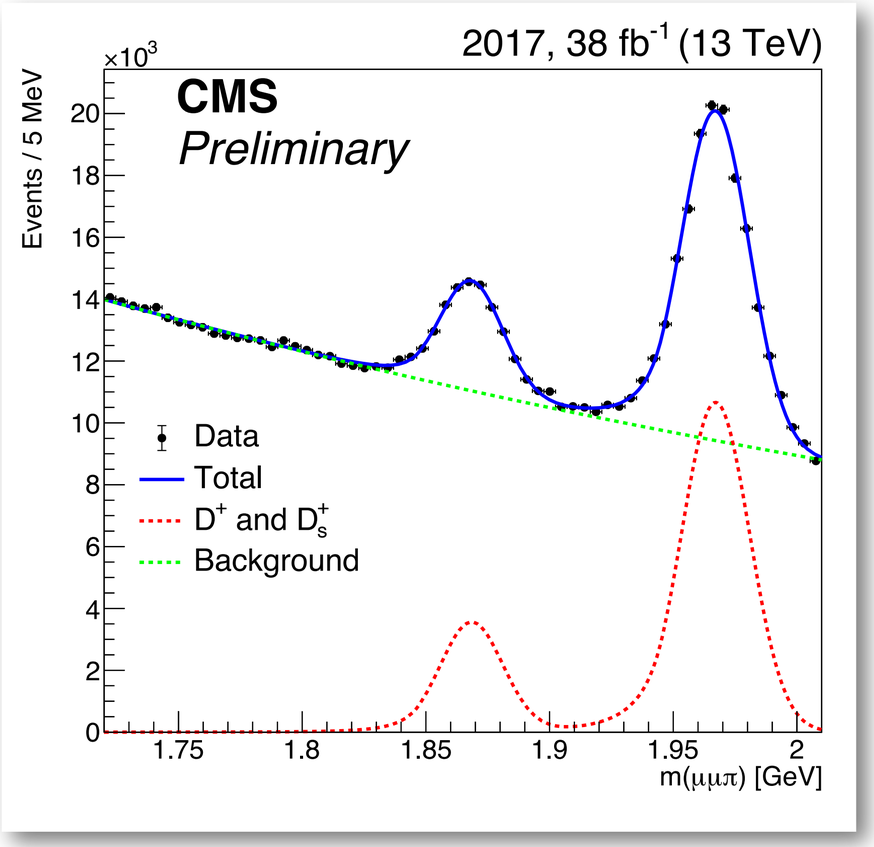
Search for lepton flavor violating tau in 3 muons

CMS-PAS-BPH-21-005

τ ⟶ 3μ decays: clean signature given by three muons final state.

Sources of τ leptons

- heavy flavour (HF) mesons ~10^{11} τ per/fb
  - low-pT and high |η| ⟶ less efficient trigger selection
  - more sensitive to fake signal muons from π's and K's
- production in the W channel ~10^{7} τ per /fb
  - harder spectra and more central decay ⟶ more efficient trigger selection
  - properties of W ⟶ τν bring additional handles for background suppression (large MET, low hadron activity, larger signal pT)
- multivariate (BDT) analysis for both channels



Observed (Expected) upper limits (with full run2)

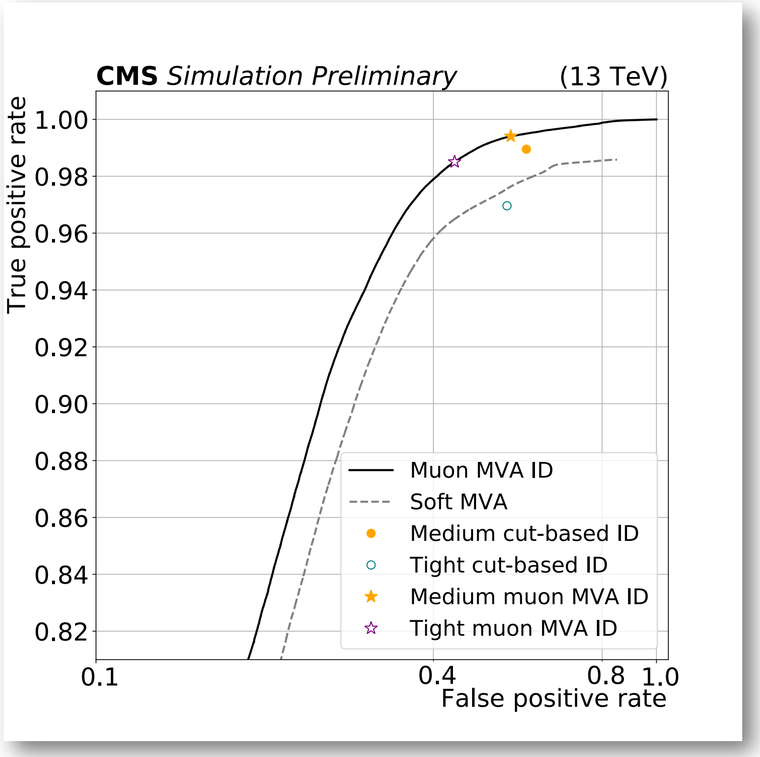
$\mathcal{B}^{Run2}(\tau \to 3\mu)$ 2.9 (2.4) x10^{-8} at 90% CL

Best $\mathcal{B}$ τ→3μ at the moment when comparing with hadron collider and BaBar experiment.

Machine learning techniques for muon identification and isolation

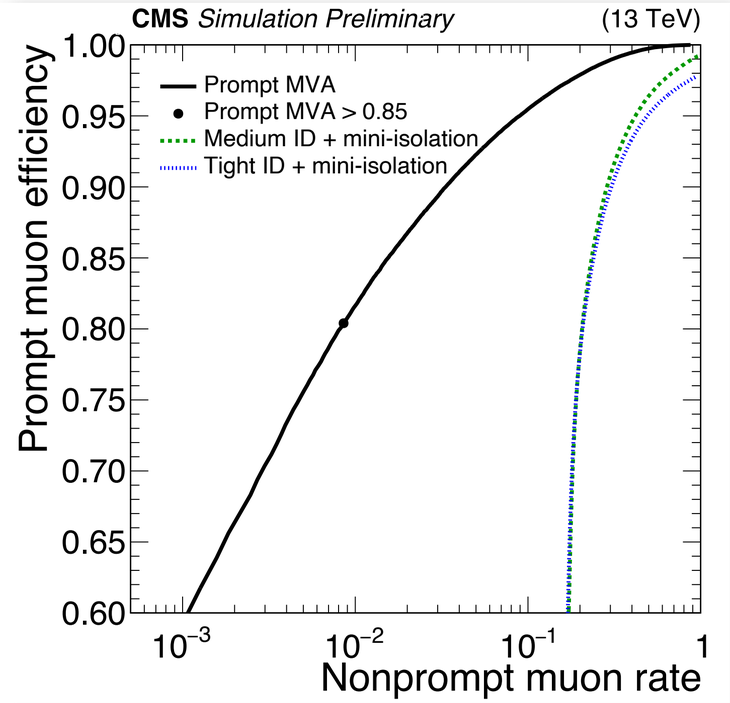
Describing Multivariate analysis (MVA)-based lepton selections

- one discriminating muons from fakes "Muon MVA ID"
  - Based on a Random Forest trained on high-level features
  - Removed any information related to PV (to make it useful both with prompt and displaced muons)
- one focusing on selecting prompt muons "Prompt muon MVA"
  - MVA ID used for ttH, 4t, etc.
  - Uses information to close-by jet to identify muons in b-jets as background
- Both substantially improve respect to cut-based selection



ROC curve for μ p_T>10 GeV

CMS-PAS-MUO-22-001

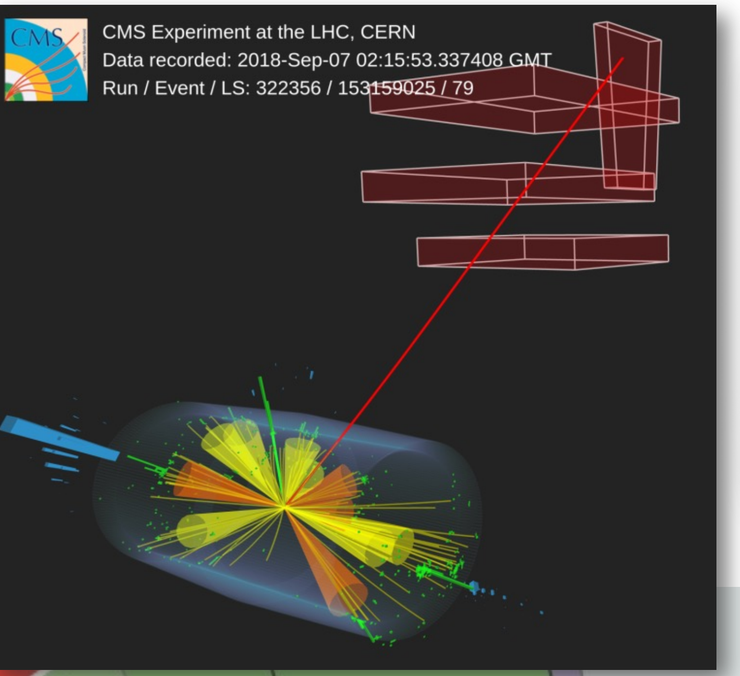


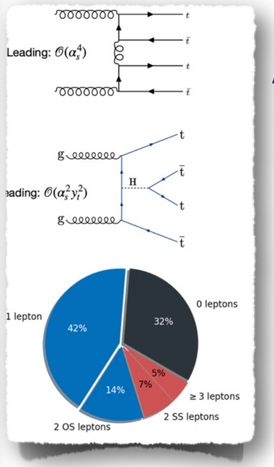
Observation of four top production

CMS-PAS-TOP-22-013
Physics Briefing

CMS observed the production of four-top quarks (@13 TeV)

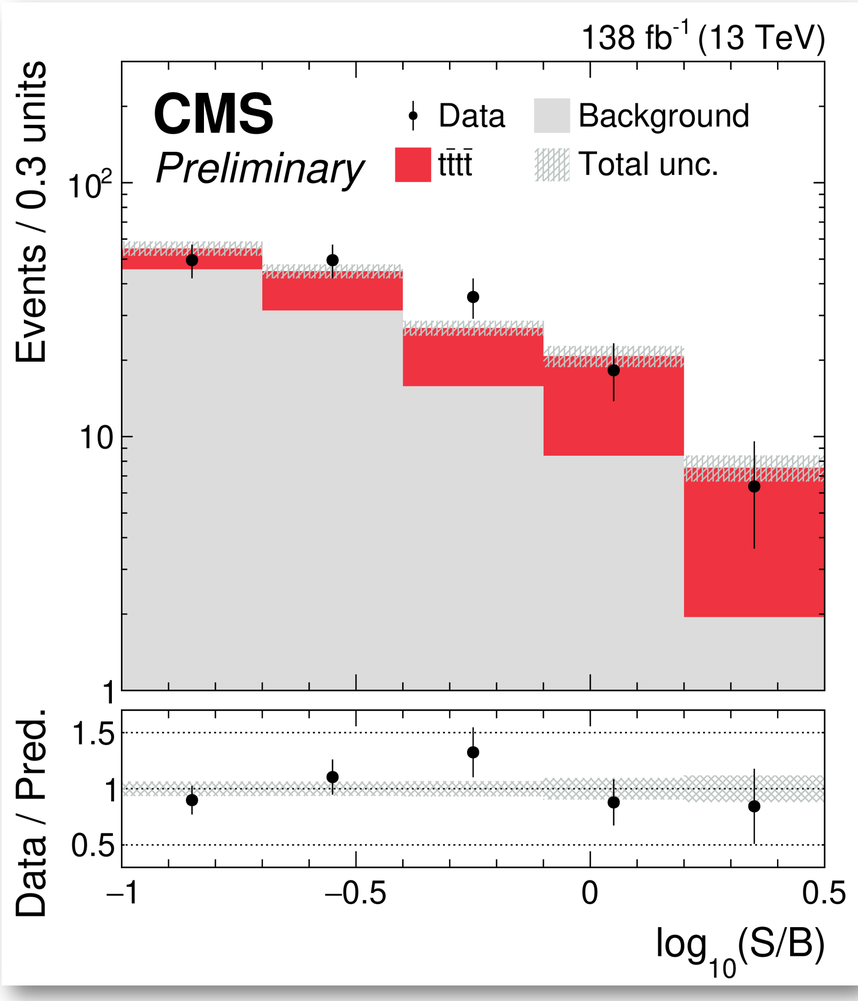
- Events: two same-sign, three, and four charged leptons (electrons and muons) and additional jets
  - Measured cross section $\left(t\bar{t}t\bar{t}\right)$: $17.9\ ^{+3.7}_{-3.5}(stat)\ ^{+2.4}_{-2.1}(syst) fb$
  - Result is in agreement with the SM predictions.
- Observed (expected) significance is 5.5 (4.9) standard deviations





Analysis improved using Machine Learning:

1. lepton ID
2. b tagging and
3. discrimination of signal and background DNN/BDT

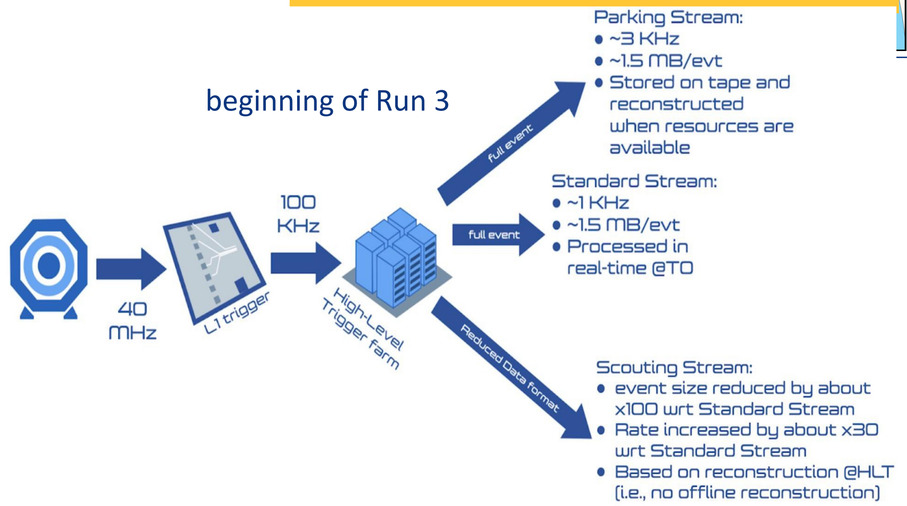


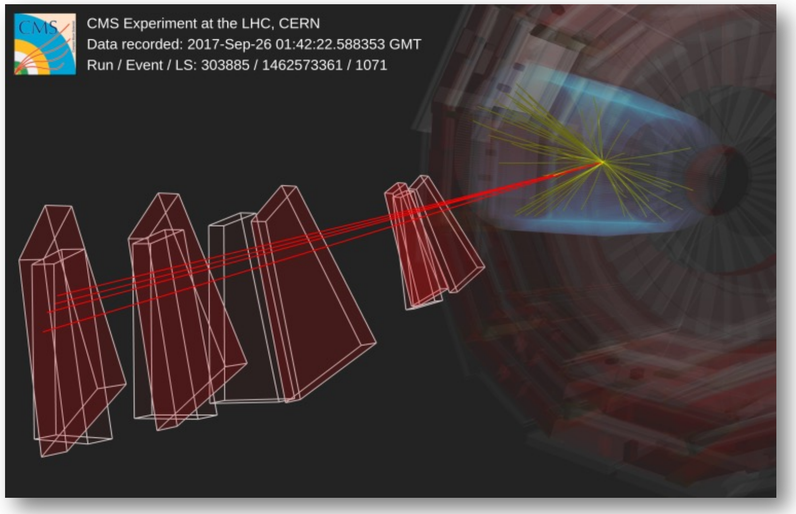
Observation of rare (10^{-9}) decay $\eta \to 4\mu$

CMS-PAS-BPH-22-003
Submitted to PRL
Physics Briefing

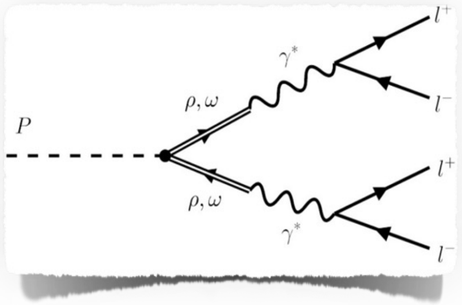
Probe low-mass 4μ (10^{-9}) region using high rate **HLT scouting DATA**

- BR measured wrt **η→2μ** (known with 14% precision)
- DATA filtered with loose triggers: two muons with transverse momenta as low as 3 GeV
- Need to understand detection efficiencies well
- **Expect improved precision with Run 3 scouting data**

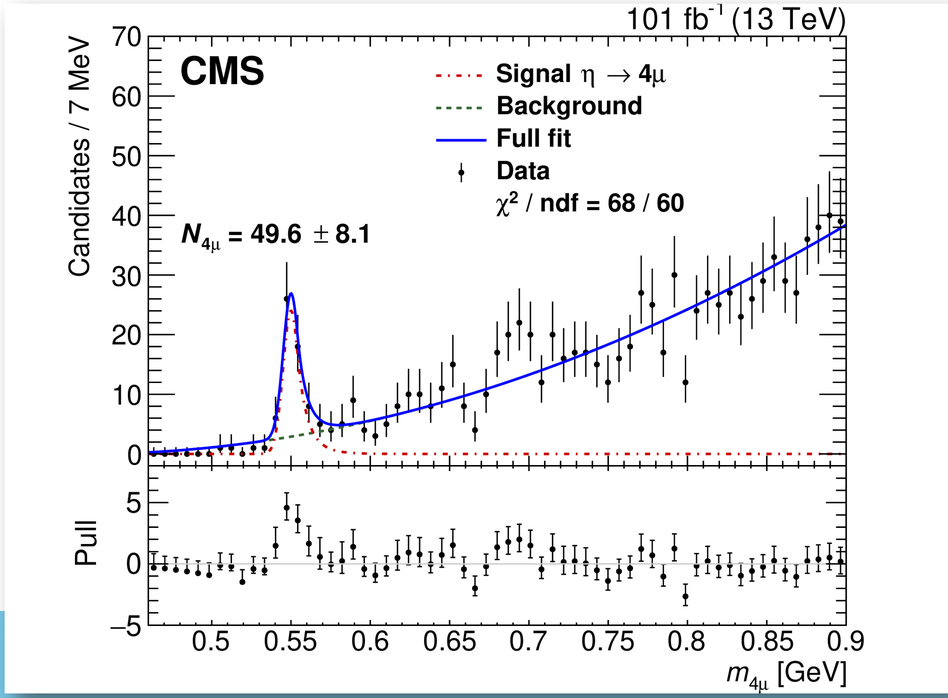




First observation of η→4μ decay.
Measured BR compatible with SM expectation



Expected theoretical value $(3.98 \pm 0.15) \times 10^{-9}$

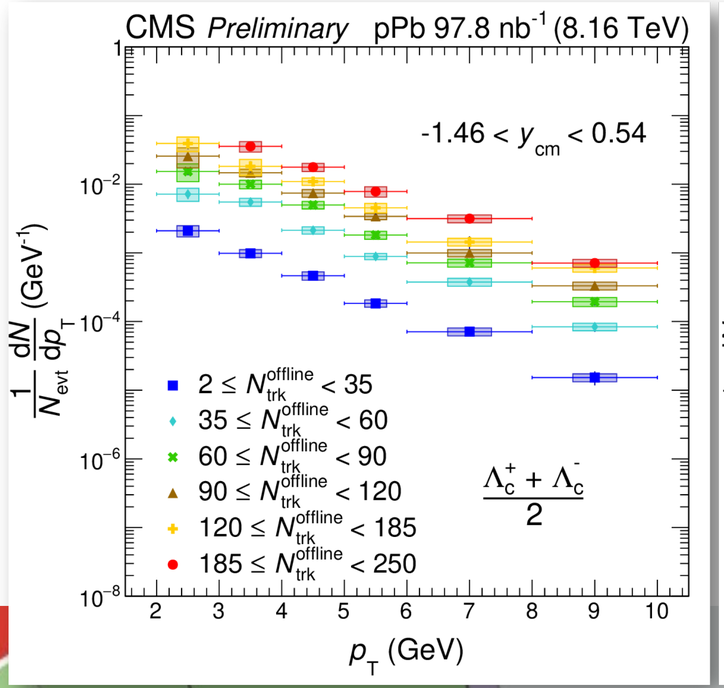


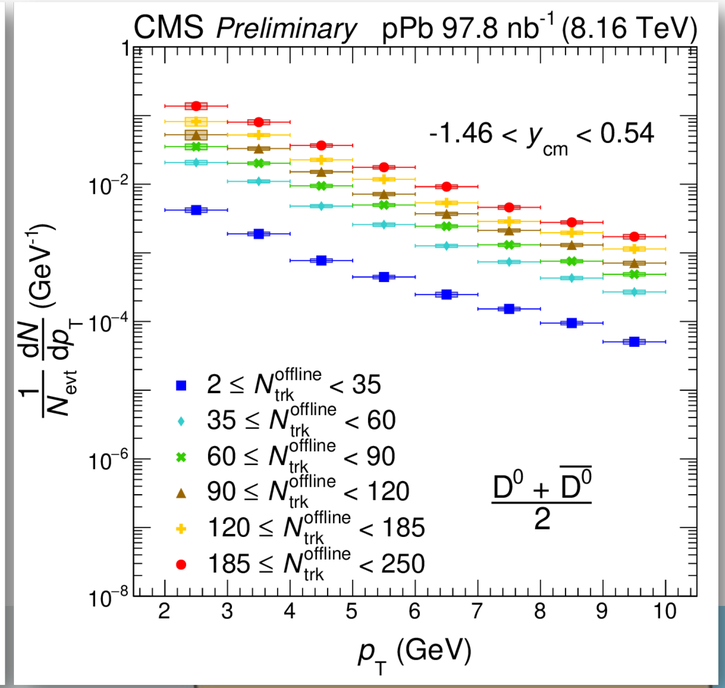
$$\mathcal{B}(\eta \to 4\mu) = (5.0 \pm 0.8\,(\text{stat}) \pm 0.7\,(\text{syst}) \pm 0.7\,(\mathcal{B}_{2\mu})) \times 10^{-9}$$

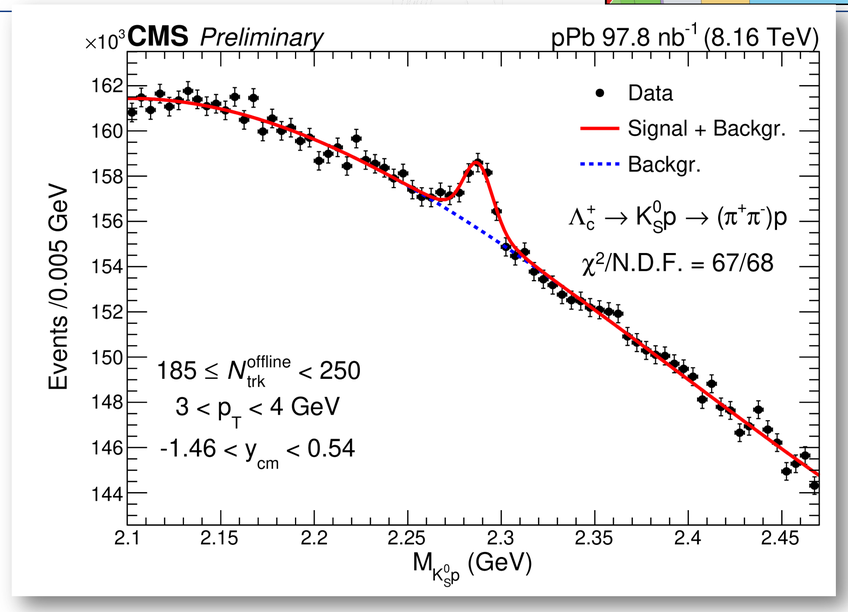
Multiplicity dependence of charm baryon and meson production

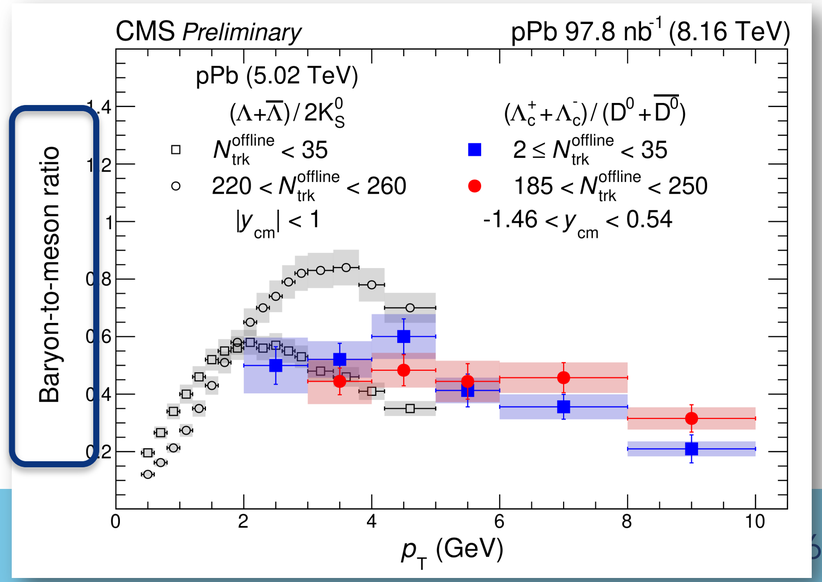
CMS-PAS-HIN-21-016

- Study D^0 ($\rightarrow K\pi$) and Λ_c^+($\rightarrow K_S\, p$) production as a function of track multiplicity in the event at 8.16 TeV pPb collisions
  - no strong dependence on multiplicity observed
  - observed difference wrt to previous results for light quarks
    - future studies for more detailed comprehension of the difference between heavy and light quarks.

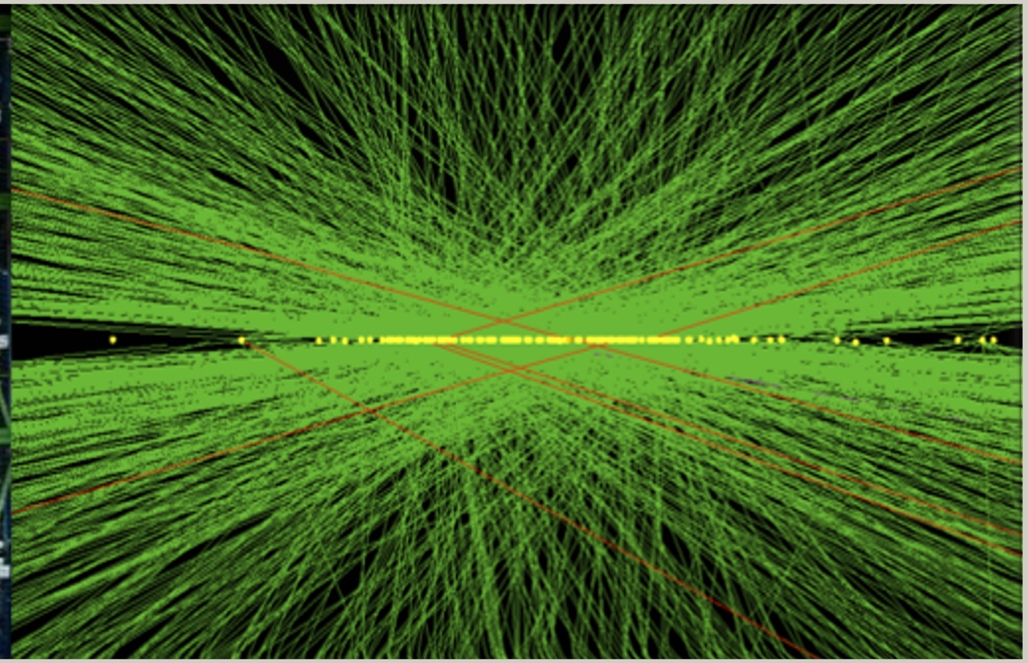


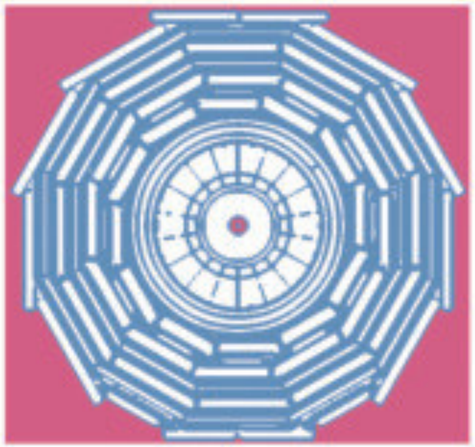


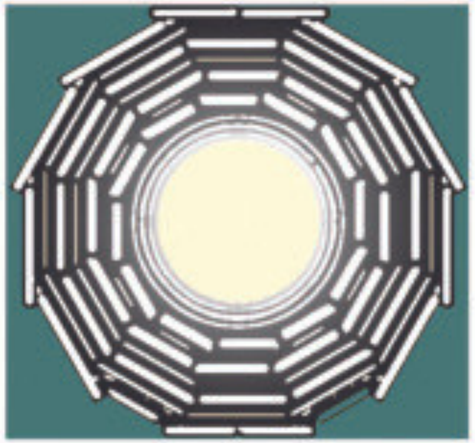




CMS detector upgrades



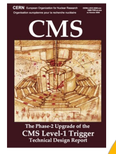




The CMS HL-LHC Upgrade

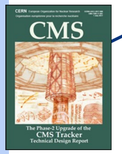
Technical proposal CERN-LHCC-2015-010 https://cds.cern.ch/record/2020886
Scope Document CERN-LHCC-2015-019 https://cds.cern.ch/record/2055167/files/LHCC-G-165.pdf

L1 Trigger/HLT/DAQ
https://cds.cern.ch/record/2283192
https://cds.cern.ch/record/2283193
- L1 40 MHz in/750 kHz out
- Tracking for PF-like selection
- HLT 7.5 kHz out

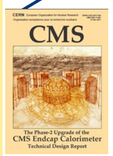


Beam Radiation and Luminosity
https://cds.cern.ch/record/2020886
- Bunch-wise Luminosity
- Beam Monitoring

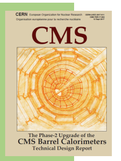
Tracker
https://cds.cern.ch/record/2272264
- Si Strip **O**uter **T**racker designed for L1 Track Trigger
- Pixelated **I**nner **T**racker extends coverage to $|\eta| < 3.8$



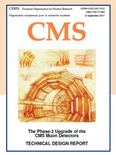
Calorimeter Endcap *Also known as HGCal*
https://cds.cern.ch/record/2293646
- Si, Scint + SiPM in Pb-W-SS
- 3D shower imaging with precise timing



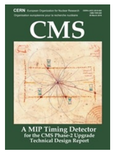
Barrel Calorimeters
https://cds.cern.ch/record/2283187
- ECAL single crystal granularity in L1 Trigger with precise timing for e/γ at 30 GeV
- ECAL and HCAL new back-end electronics



Muon Systems
https://cds.cern.ch/record/2283189
- DT & CSC new FE/BE readout
- New GEM/RPC $1.6 < |\eta| < 2.4$
- Extended coverage to $|\eta| < 3.0$



MIP Timing Detector
https://cds.cern.ch/record/2296612
- < 75 ps resolution
- Barrel: Crystals + SiPMs
- Endcap: LGADs



Also known as "Timing Layer" (TL)

Innovative and extremely challenging new capabilities to fully exploit HL-LHC luminosity
- **Level 1 track trigger**
- **Timing detector**
- **Highly granular endcap calorimeter**

INFN BARI
Istituto Nazionale di Fisica Nucleare
Sezione di Bari

CMS Upgrades

Recent CMS upgrade week, Labs show and ~150 visitors at P5

Included a lively poster session
with almost 60 contributions from students and postdocs

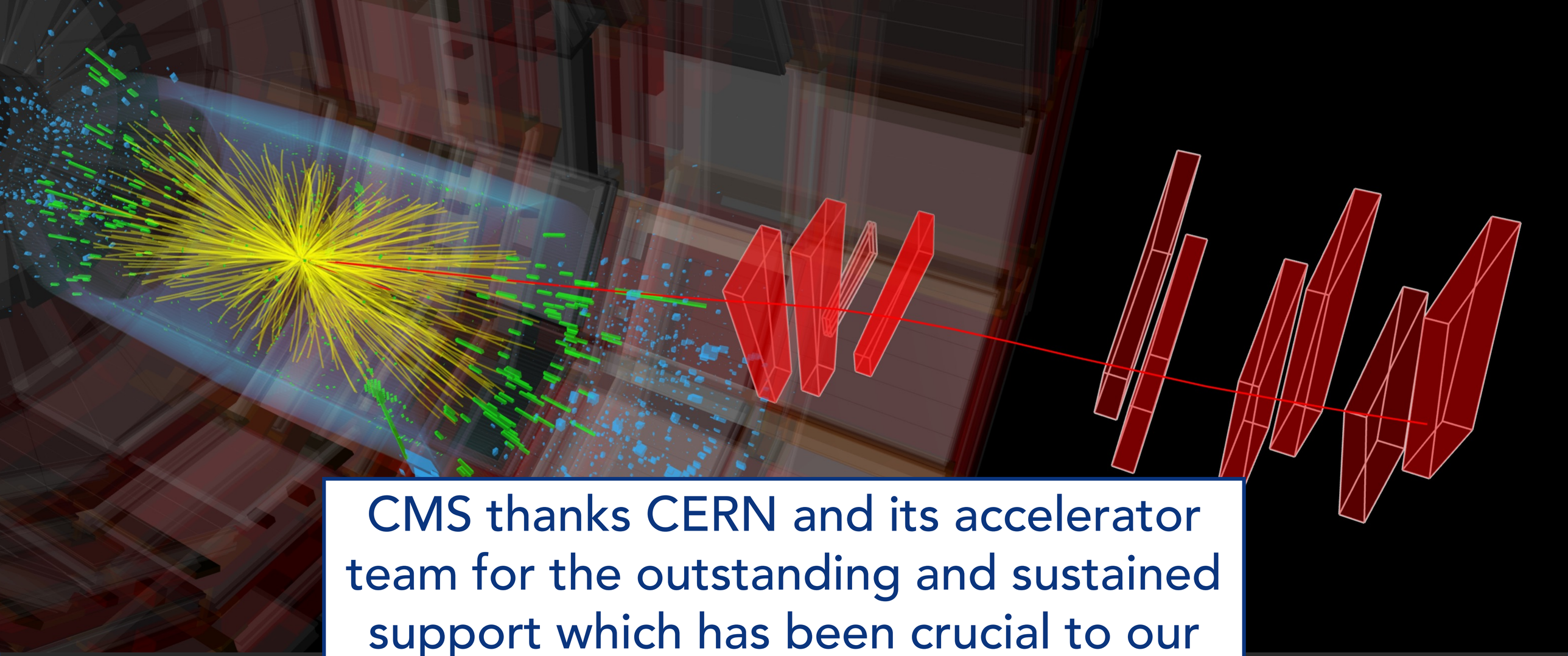
The detector upgrade projects are making good technical progress.

Many items are moving into production

J. Alimena Thu afternoon

Conclusions and outlook

- CMS had a successful 2022 run and Year End Technical Stop.
- CMS continue to produce physics results based on the extremely good data collected so far: the Higgs discovery was just the tip of the iceberg of an enormous physics program covering the full range of topics from SM precision measurements to creative new searches for particles beyond the Standard Model.
- CMS is ready for 2023 data taking with a strategy for operating at higher pileup and started the full pp physics acquiring data at high efficiency.
- CMS is getting prepared for the big jump (x10, a.k.a HL-LHC) and CMS upgrades are making good progress.
- **The key for the next years will be flexibility, new ideas, innovative data taking/triggers.**
- **CMS Collaboration is engaged in all these activities.** A big thank you to all our students, postdocs, faculty, scientific staff, computing experts, engineers, technicians, admins for making this happen.
- We are excited to present our results this week and we have ambitious plans for the future.



CMS thanks CERN and its accelerator team for the outstanding and sustained support which has been crucial to our continued success

Thank you for your attention !

CMS Collaborators at LHCP 2023

Plenary Session Speakers

- QCD measurements in pp collisions: from the underlying event to jets Armando Bermudez Martinez (CERN)
- Investigating interactions in the quark-gluon plasma with high pT probes Leticia Cunqueiro Mendez (Univ. Roma I and INFN)
- Non-resonant searchers at TeV scale Ka Hei Martin Kwok (FNAL)
- CMS upgrades Juliette Alimena (DESY)
- Top cross-section meansurements and rare ttX processes Melissa Quinnan (UC San Diego)
- Search for rare/BSM Higgs bosons decays and BSM Higgs sector Maxwell Chertok (UC Davis)
- Multiboson measurements Qiang Li (Peking Univ.)

Parallel Session Speakers

- Davide Zuolo
- David Walter
- Anshul Kapoor
- Henning Kirschenmann
- Antimo Cagnotta
- Hali Saka
- Sezen Sekmen
- Xuli Yan
- Raffaella Tramontano
- Ang Li
- Fabio Monti
- Vukasin Milosevic
- Toyoko Orimoto
- Li Yuan
- Saswati Nandan
- Vladimir Cherepanov
- Saptaparna Bhattacharya
- Giacomo Boldrini
- Ying An
- Daniel Savoiu
- Anna Feherkuti
- Stefanos Leontsinis
- Federica Colombina
- Kathryn Wendy Coldham
- Ashley Marie Parker
- Nicolas Pierre Chanon
- Silvano Tosi
- Maksim Sergeev
- Mate Csanad
- Keith Ulmer
- Sergey Polikarpov
- Davide Valsecchi
- Clara Ramon Alvarez
- Pallabi Das
- Ram Krishna Sharma
- Attila Jozsef Radl
- Mate Csanad
- Jose Enrique Palencia Cortezon
- Michael Pitt
- Emmanouil Vourliotis

Posters

- Fabian Stager
- Maksim Sergeev
- Tiziano Bevilacqua
- Fabio Luongo
- David Walter
- Clara Ramon Alvarez
- Andrea Trapote Fernandez
- Natascha Krammer
- Milos Vojinovic
- Alkis Papanastassiou
- Niels Van Den Bossche
- Melissa Quinnan
- Donato Troiano
- Neha Rawal
- Angela Zaza
- Stefanos Leontsinis
- Ying An
- Arun Madhu
- Caterina Aruta
- Zebing Wang
- Attila Jozsef Radl

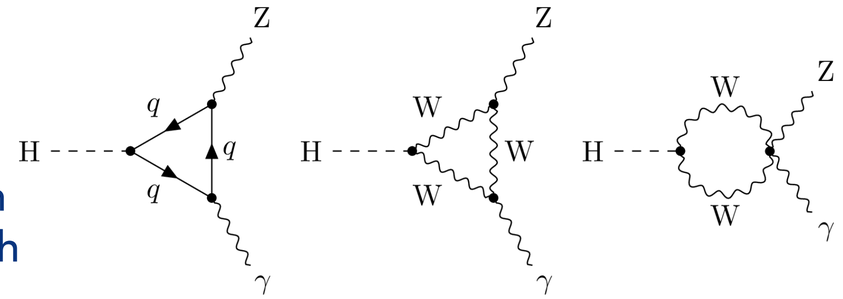
BACKUP

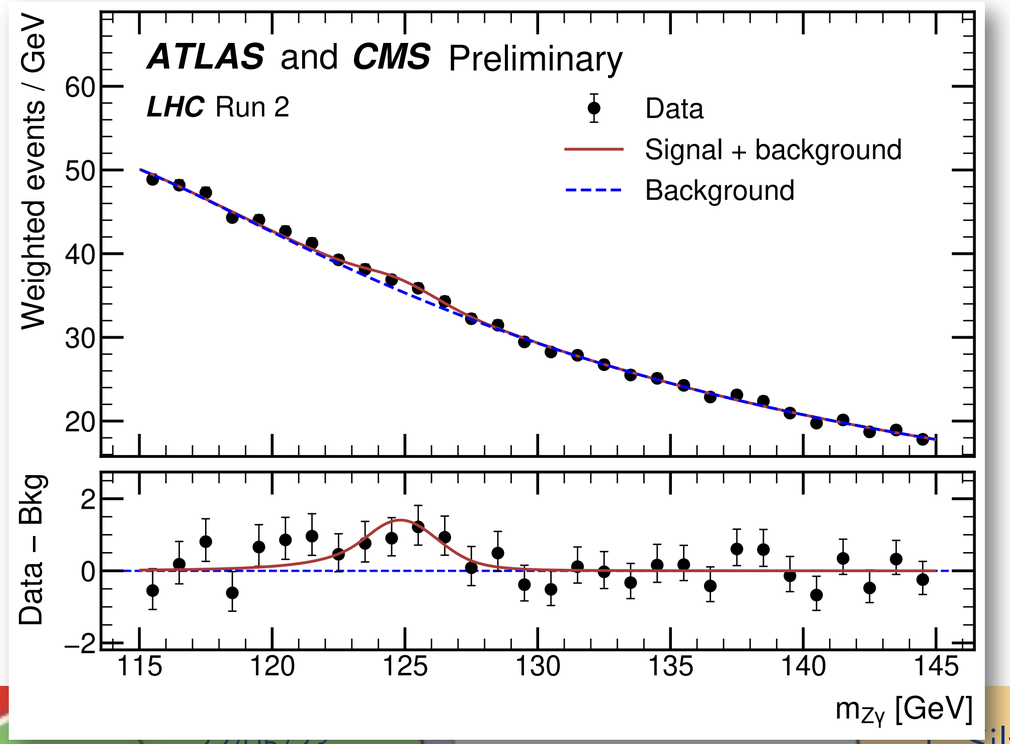
Evidence for the Higgs boson decay to a Z boson and a photon at the LHC

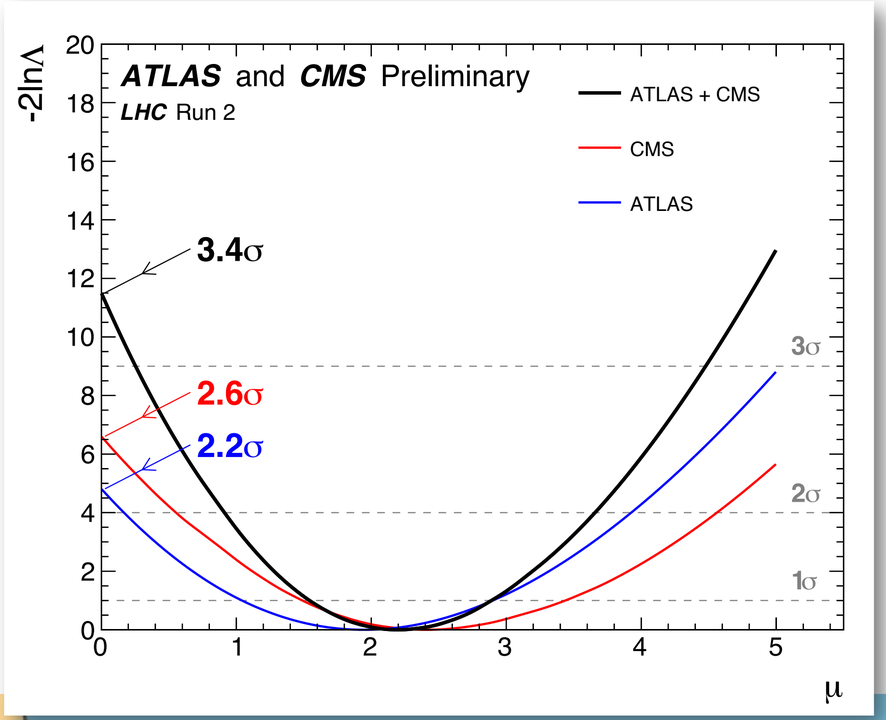
HIG-23-002

ATLAS and CMS

- Combined evidence of H->Zγ from ATLAS and CMS (previously published) results
- Similar analysis strategy. Correlated (TH) and uncorrelated (EXP) systematic uncertainties considered in the combination
- Observe evidence for a signal with 3.4σ significance (expected 1.6σ)
  - Observed signal cross section corresponds to 2.2 ± 0.7 times the SM cross section
  - The H->Zγ branching ratio is measured $(3.4 \pm 1.1) \times 10^{-3}$ compatible within 1.9σ with SM prediction





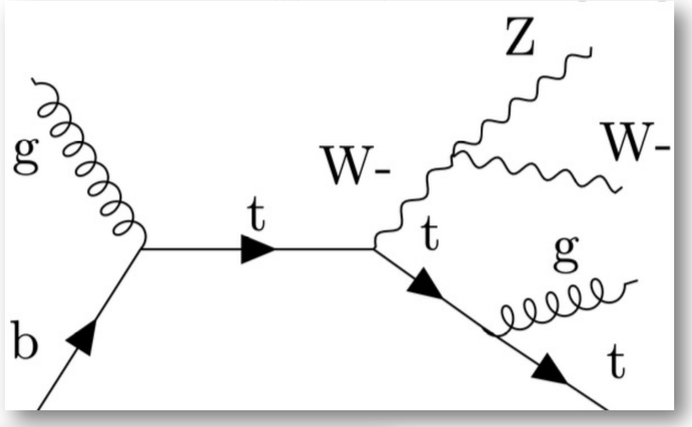


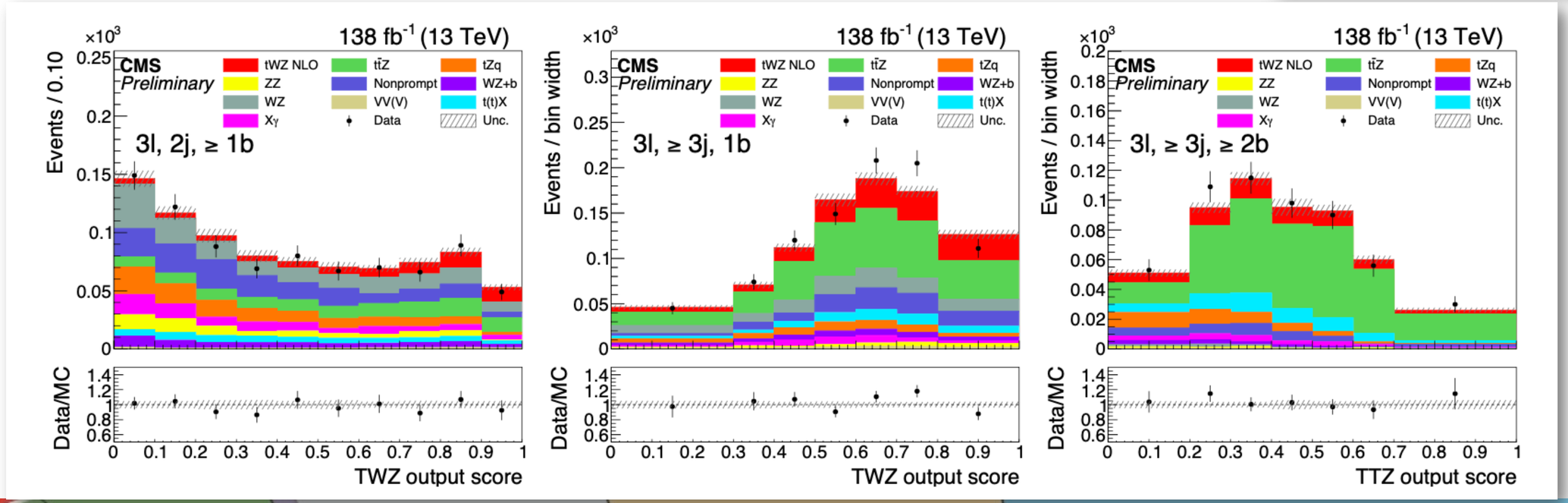
Search for SM tWZ process in multi-lepton final state

CMS-PAS-TOP-22-008

Search for rare single-top production mode

- Considers multilepton final states to isolate a sample with large purity
- Uses a Deep Neural Network to separate signal from background
- Observes a signal (first evidence) with 3.5 σ significance (expected 1.3 σ)
- Measured cross section is 0.37 ± 0.05 (stat) ± 0.10 (syst) pb
  - Compatible at ~2σ with theory prediction



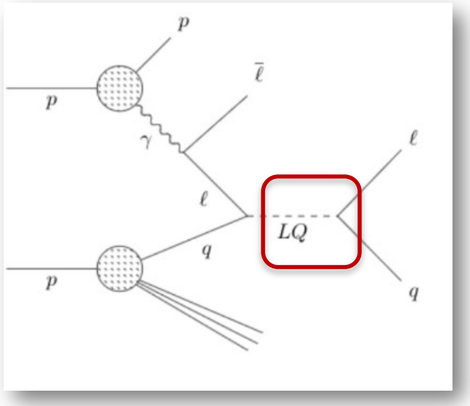


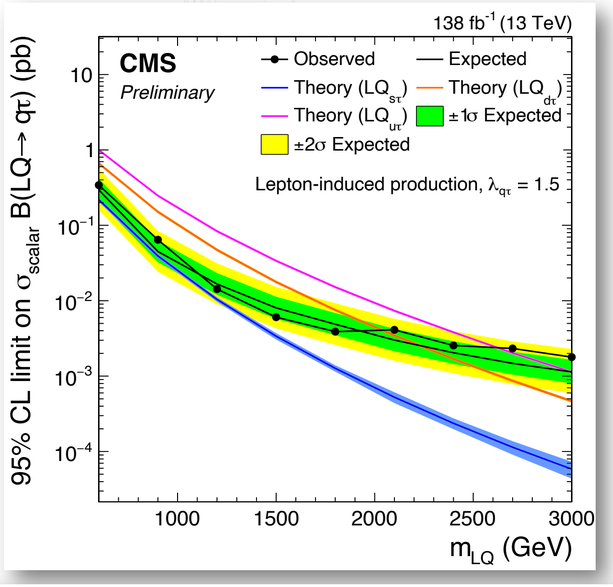
Search for leptoquarks produced in lq collisions and coupling to tau leptons

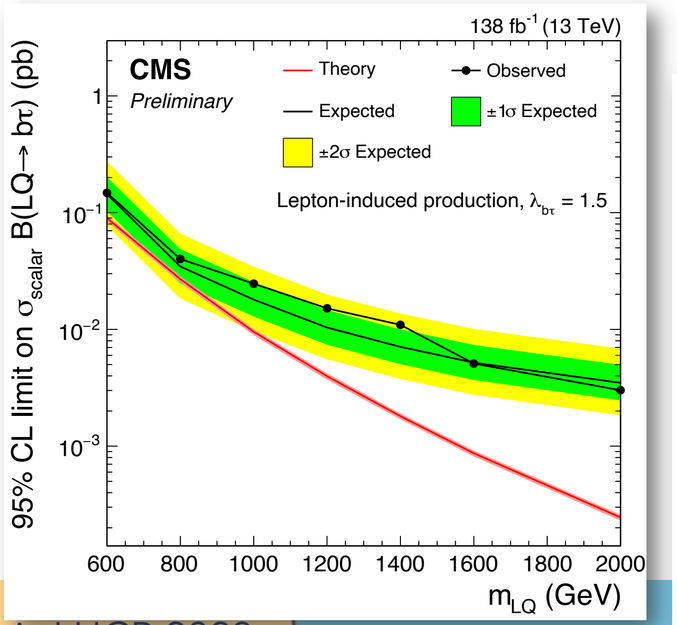
CMS-PAS-EXO-22-018

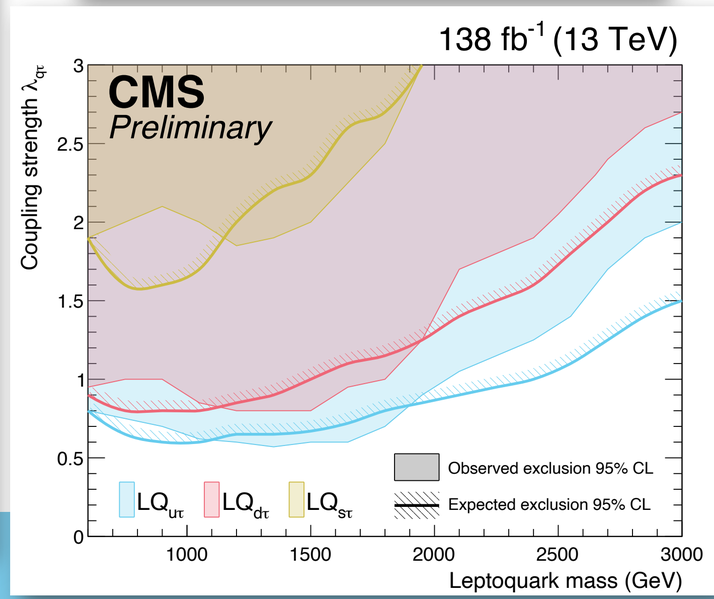
Mechanisms involving lq coupling to 3rd generation quarks and leptons could explain deviations from SM observed in several B meson decays.

- final state with a jet, significant missing transverse momentum, and a τ lepton reconstructed through its leptonic or hadronic decays.
- Limits are set on the leptoquark production cross section times branching fraction and interpreted as exclusions in the plane of the leptoquark mass and the coupling strength of the leptoquark-lepton-quark vertex.
- These results complement the constraints on the leptoquark-τ-b couplings and are the first limits for leptoquark-τ-u, leptoquark-τ-d, and leptoquark-τ-s couplings.









Search for narrow trijet resonances

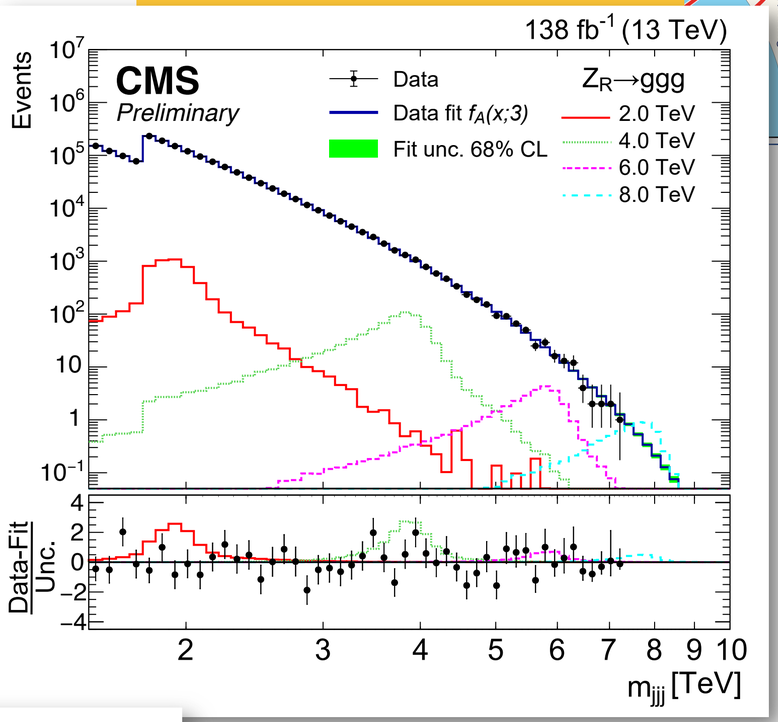
CMS-PAS-EXO-22-008

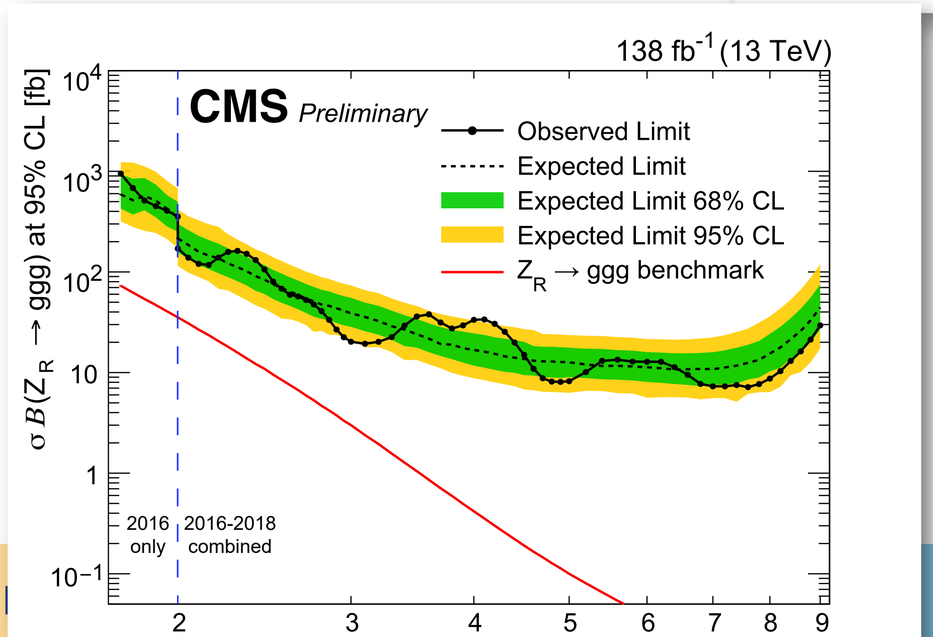
Search for new resonances decaying to three jets

- Predicted in several BSM models, e.g., excited quarks to qV -> 3q, Kaluza-Klein gluon -> Radion g -> 3g, etc.
- Analysis strategy follows established dijet bump-hunt searches
  - Model bkg with fit to data using empirical functions
  - Model signal from Monte Carlo

No evidence for a signal

Set first limits on 3j resonances at high mass (1.75-9.00 TeV), under different width assumptions for the resonance.





Search for supersymmetry in final states with disappearing tracks

Long lived charginos

The search for semi-stable charginos is performed over final states characterized by varying numbers of jets, b-tagged jets, electrons, and muons.

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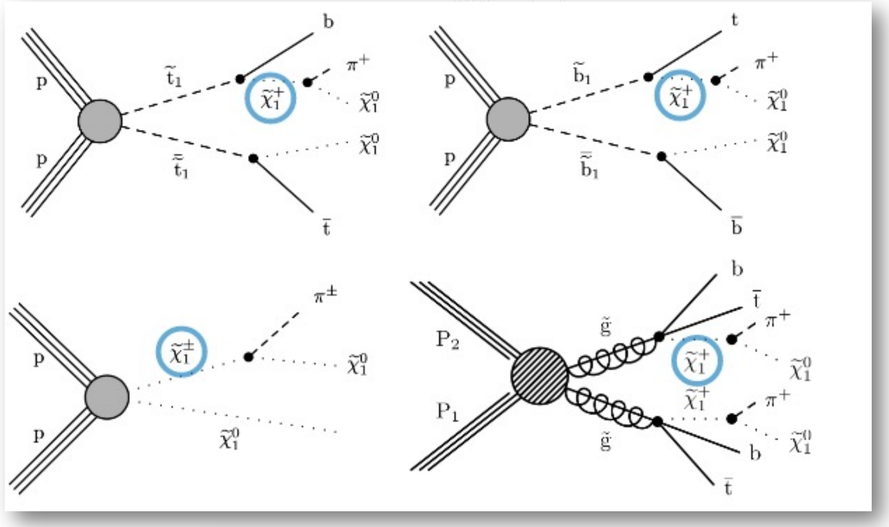
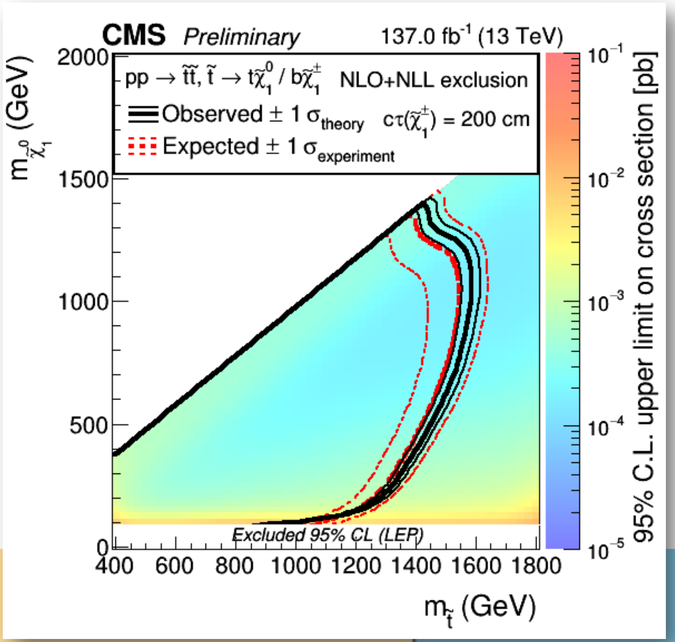
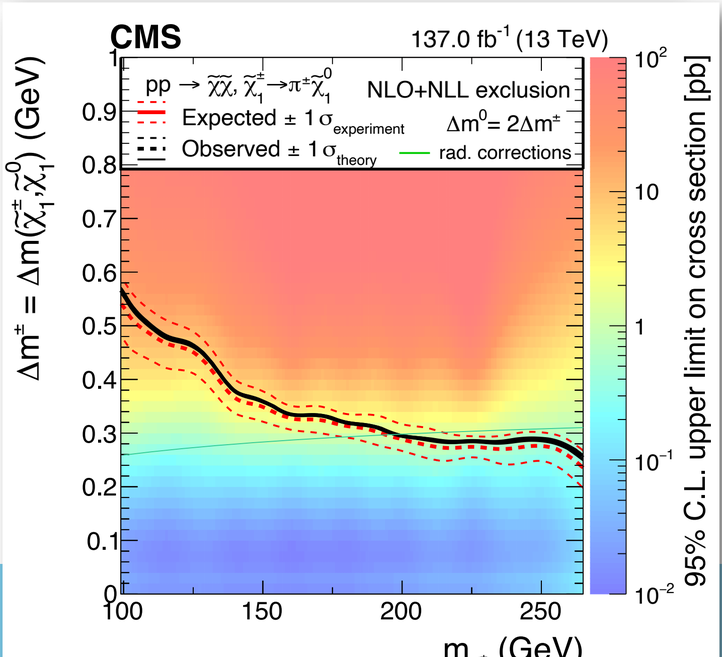


- The analysis targets a wide variety of possible production modes appearing in simplified models of R-parity conserving supersymmetry, including gluino, top squark, bottom squark, and electroweakino pair production
- The observed yields in the search region are found to be statistically consistent with the background-only hypothesis.
- no evidence for supersymmetry is found.

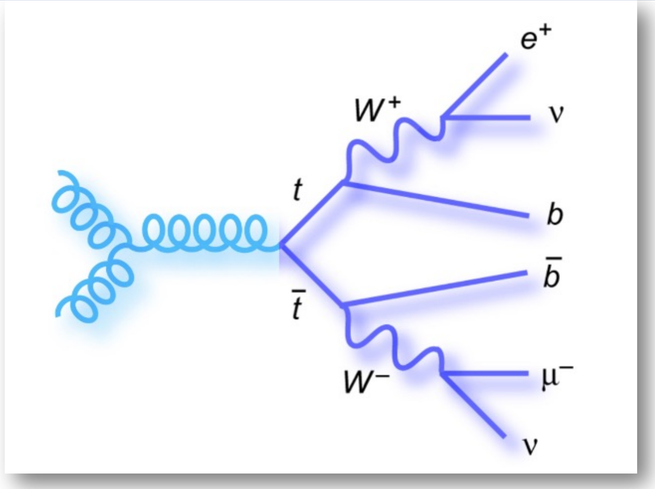


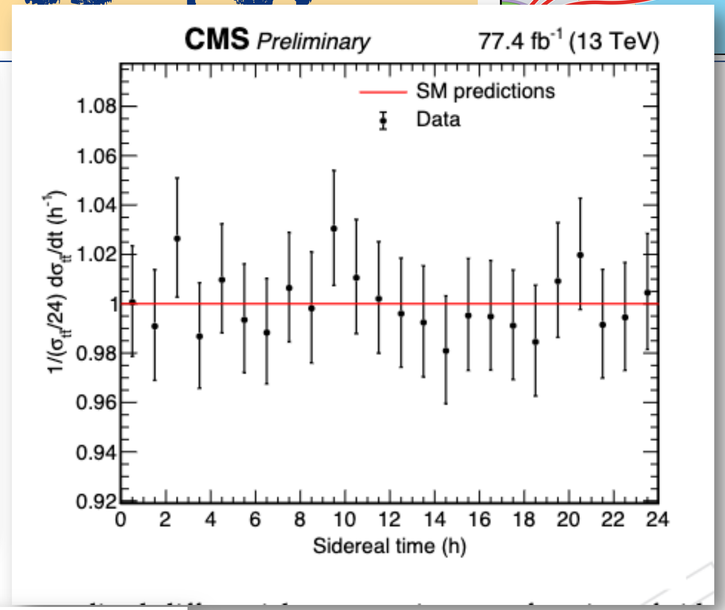


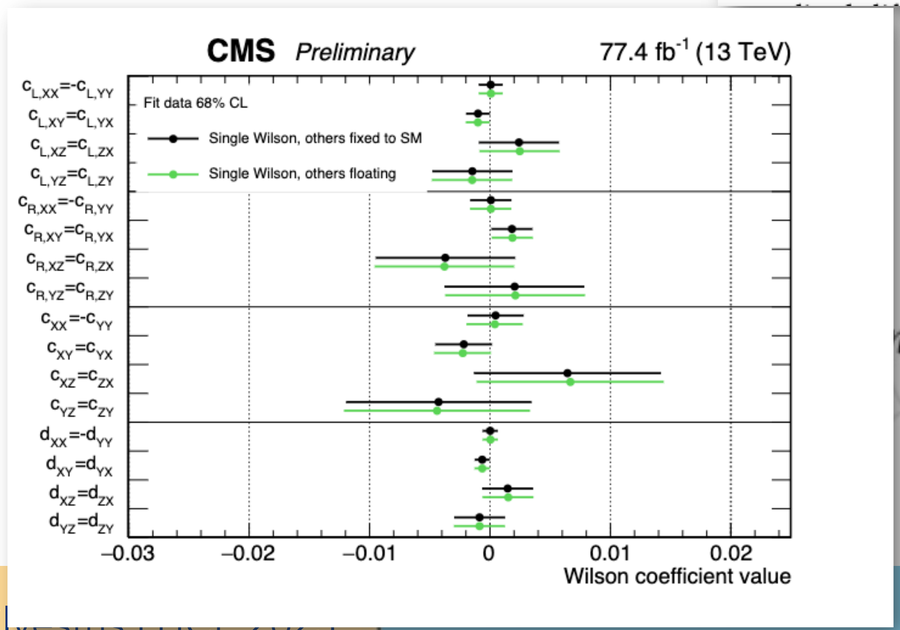
Searches for Lorentz invariance violation with tt dilepton final state at 13 TeV

In presence of Lorentz invariance violation, measurement outcome depends on when/where the measurement is carried out

- This can be formalized extending the SM Lagrangian with EFT operators explicitly breaking Lorentz symmetry
- One can put bounds on the coefficients of these operators, performing a measurement vs time
  - Different sidereal months, using the Sun rest frame as a locally inertial frame
- Bounds derived from tt production cross section measurement







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