The Higgs boson and beyond at the CMS experiment

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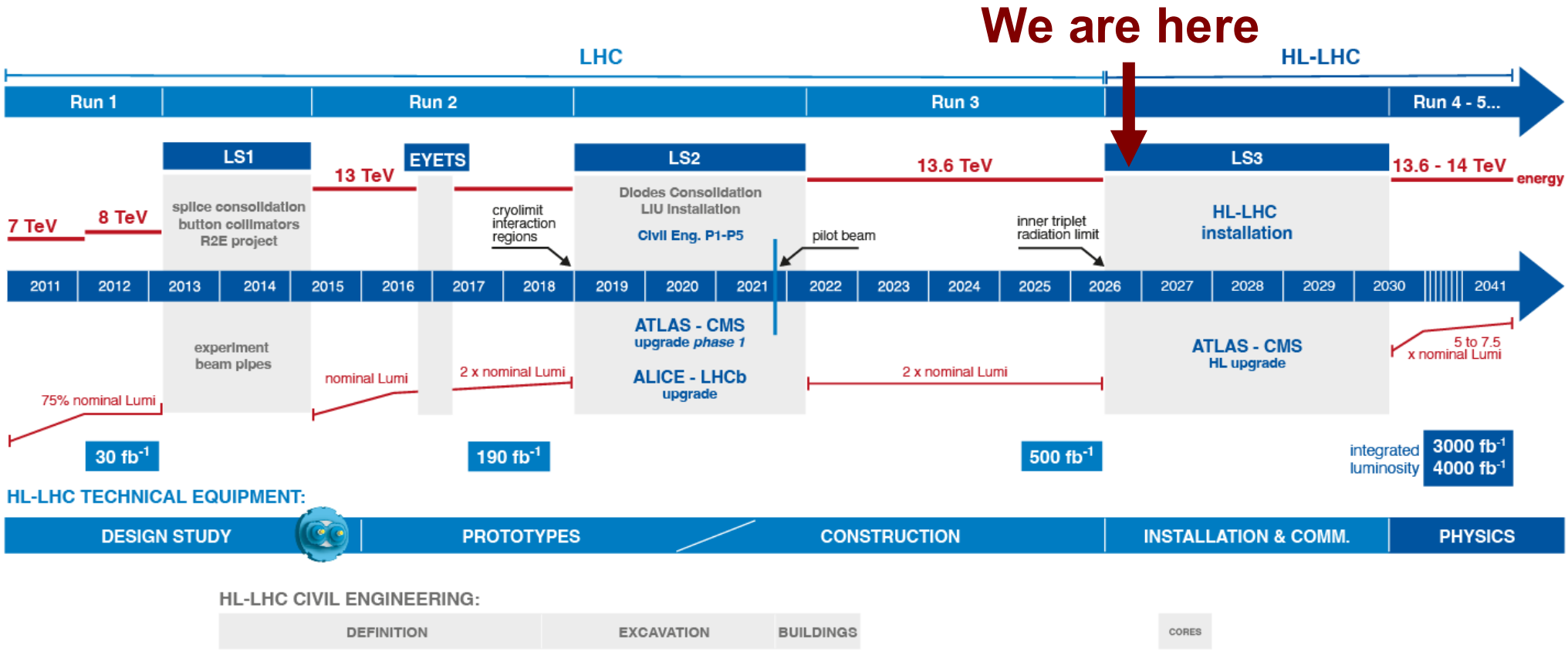
on behalf of the CMS collaboration

Aug. 27, 2026

The CMS collaboration

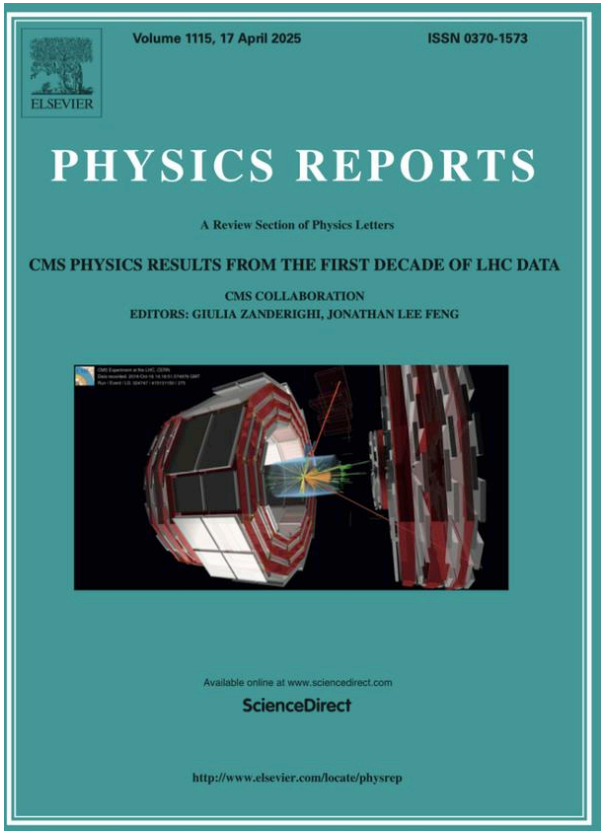
LHC / HL-LHC Plan

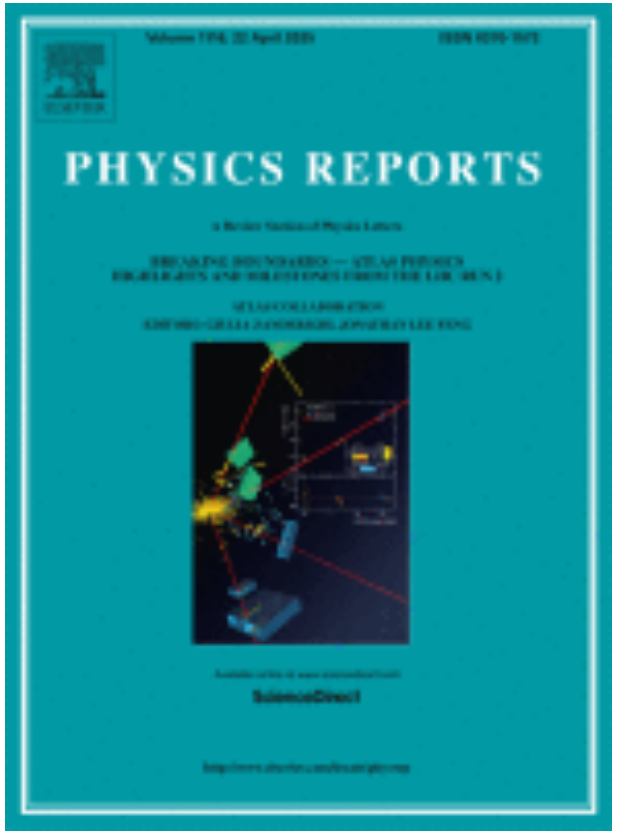


We have been taking data for ~15 years

Physics Results from the first decade

3000+ papers submitted for publications for ATLAS and CMS





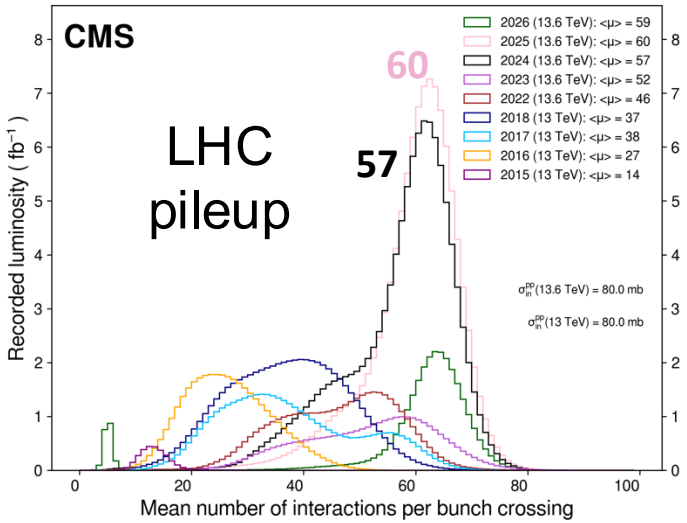
- Dark sector searches
- Overview of high-density QCD studies
- Stairway to discovery: a report on the CMS program of cross section measurements
- Review of top quark mass measurements
- Searches for Higgs boson production through decays of heavy resonances
- Review of searches for vector-like quarks, vector-like leptons, and heavy neutral leptons
- Enriching the physics program of the CMS experiment via data scouting and data parking

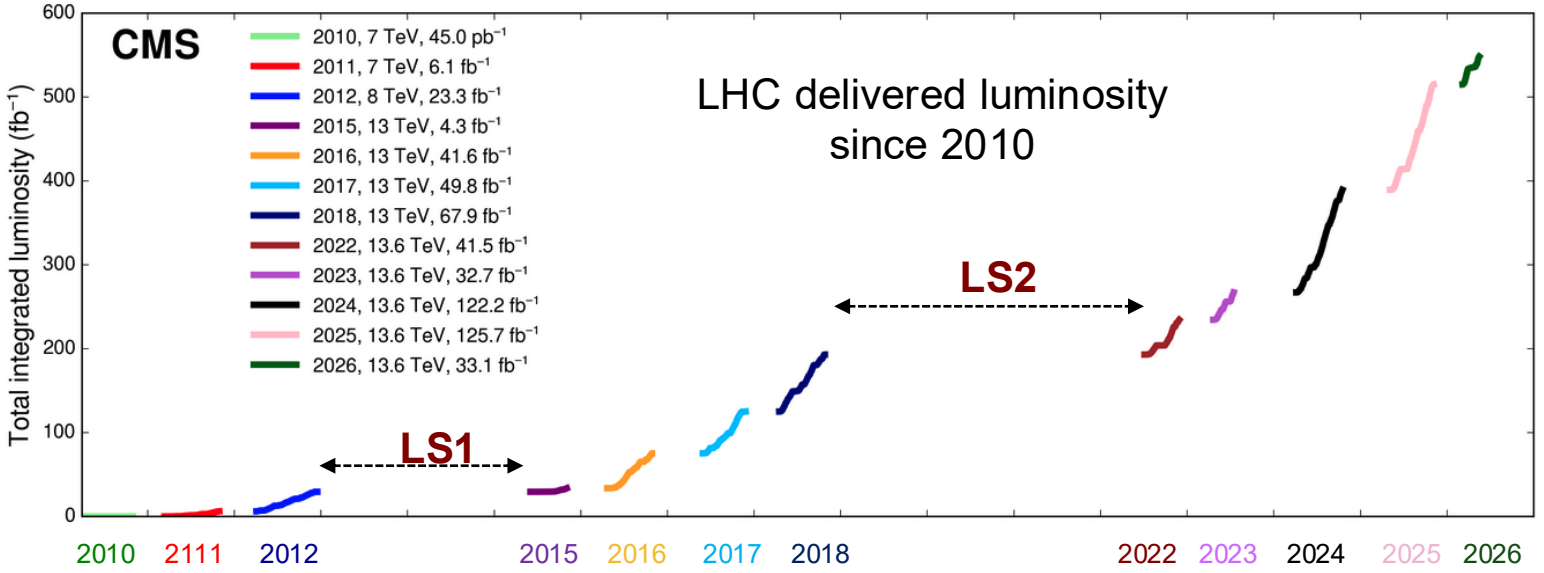
13 comprehensive reviews by the ATLAS and CMS collaborations

LHC performance

Run3 pp collisions @13.6TeV

- Excellent performance: data-taking efficiency (92%), data quality, performance of LHC
- All detectors in smooth data taking mode
- Full mitigation of dead-time from ageing detector





Recorded: 504 fb^{-1}

Run 3: 355 (13.6 TeV)

Run 2: 164 (13 TeV)

Run 1: 6 (7 TeV) + 23 (8 TeV)

Introduction

- Making progress through multiple frontiers made possible by the outstanding performance of the LHC and versatility of the CMS detector

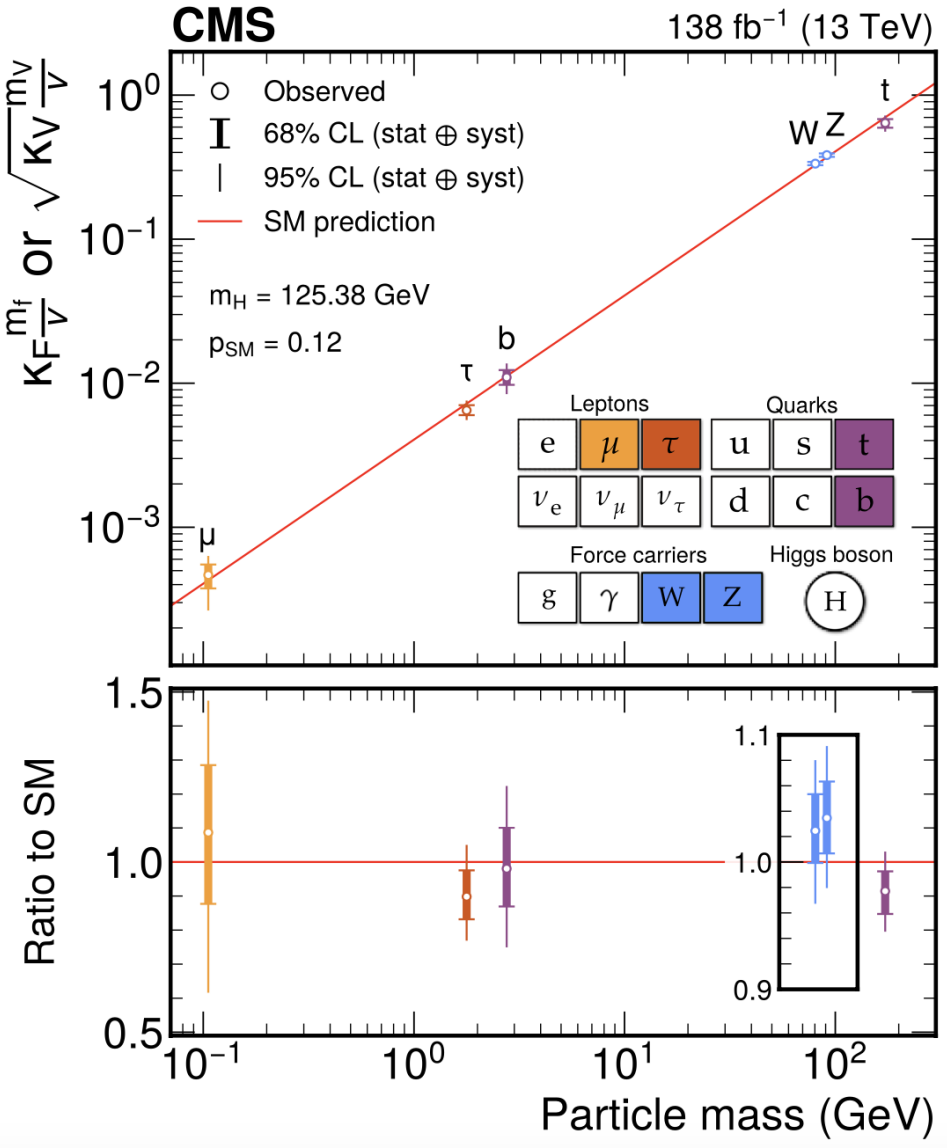
Run 1:
- Higgs boson discovery
- SUSY searches (exclude large parameter space),
- Probing QGP

Run 2:
- Study Yukawa couplings (observe 3rd gen., evidence of 2nd gen.)
- Observe VBS
- Heavy flavour physics ($B \rightarrow \mu\mu$)

- Next:
  - Precision physics
  - Higgs boson
  - Top quark
  - Searches
  - Flavour
  - Heavy Ions

The Higgs boson

2602.18611



Higgs and BSM

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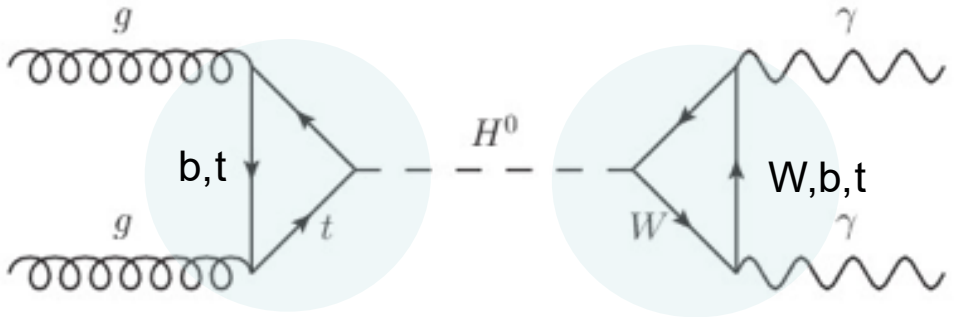
- Is there BSM physics hidden in the “Higgs sector”?

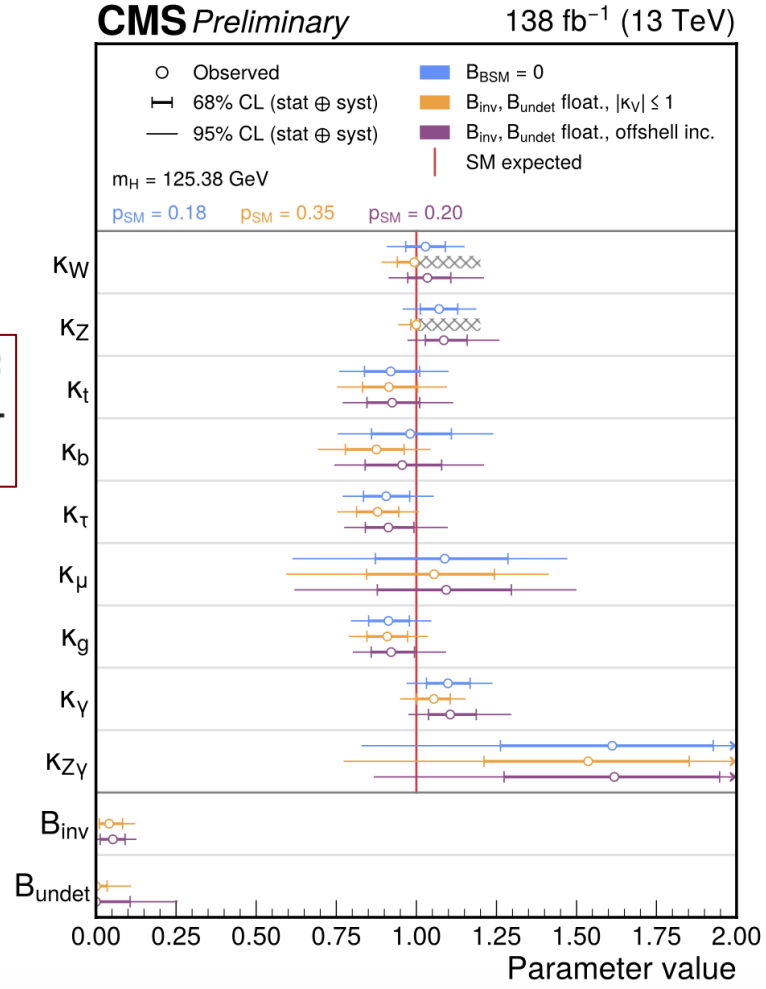


$$(\sigma \cdot \mathrm{BR})\,(gg \to H \to \gamma\gamma) \;=\; \sigma_{SM}(gg \to H) \cdot \mathrm{BR}_{SM}(H \to \gamma\gamma) \cdot \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_H^2}$$

Experimental approach

- parametrize deviations wrt SM in production and decay

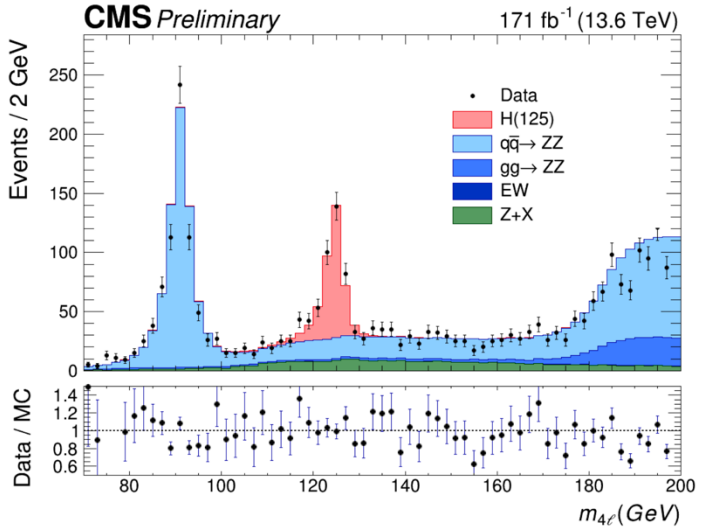
⇒ loops are sensitive to BSM physics

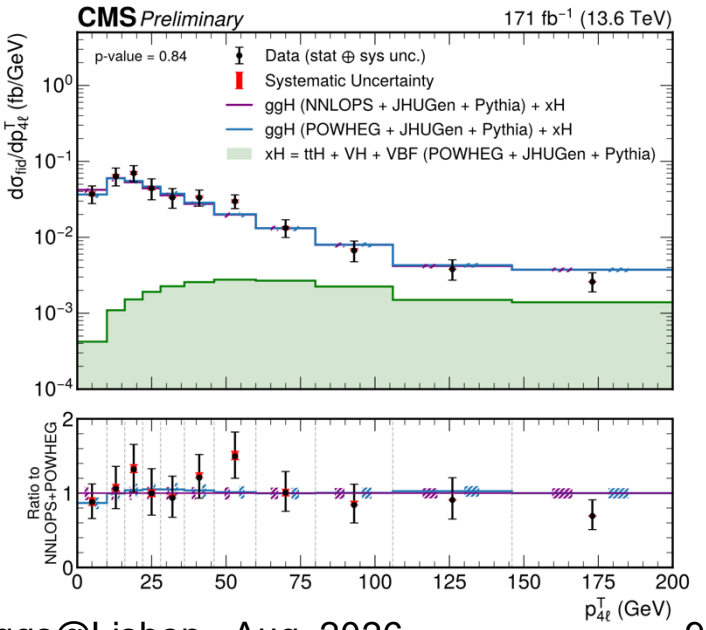


Higgs boson in Run3

2504.17755, HIG-25-015

- 5 main decay channels
  - ZZ, $\gamma\gamma$, WW, $\tau\tau$, bb
  - Most accurate measurements in $\gamma\gamma$ and ZZ
- Progress since Higgs discovery (July 2012)
  - Observation in boson and fermion channels
  - Precise mass measurement (~125 GeV)
  - Improving precision of coupling measurements
  - Differential distributions
  - 2nd generation fermions
  - Study of rare decays
- A long journey ahead





Ultimate precision

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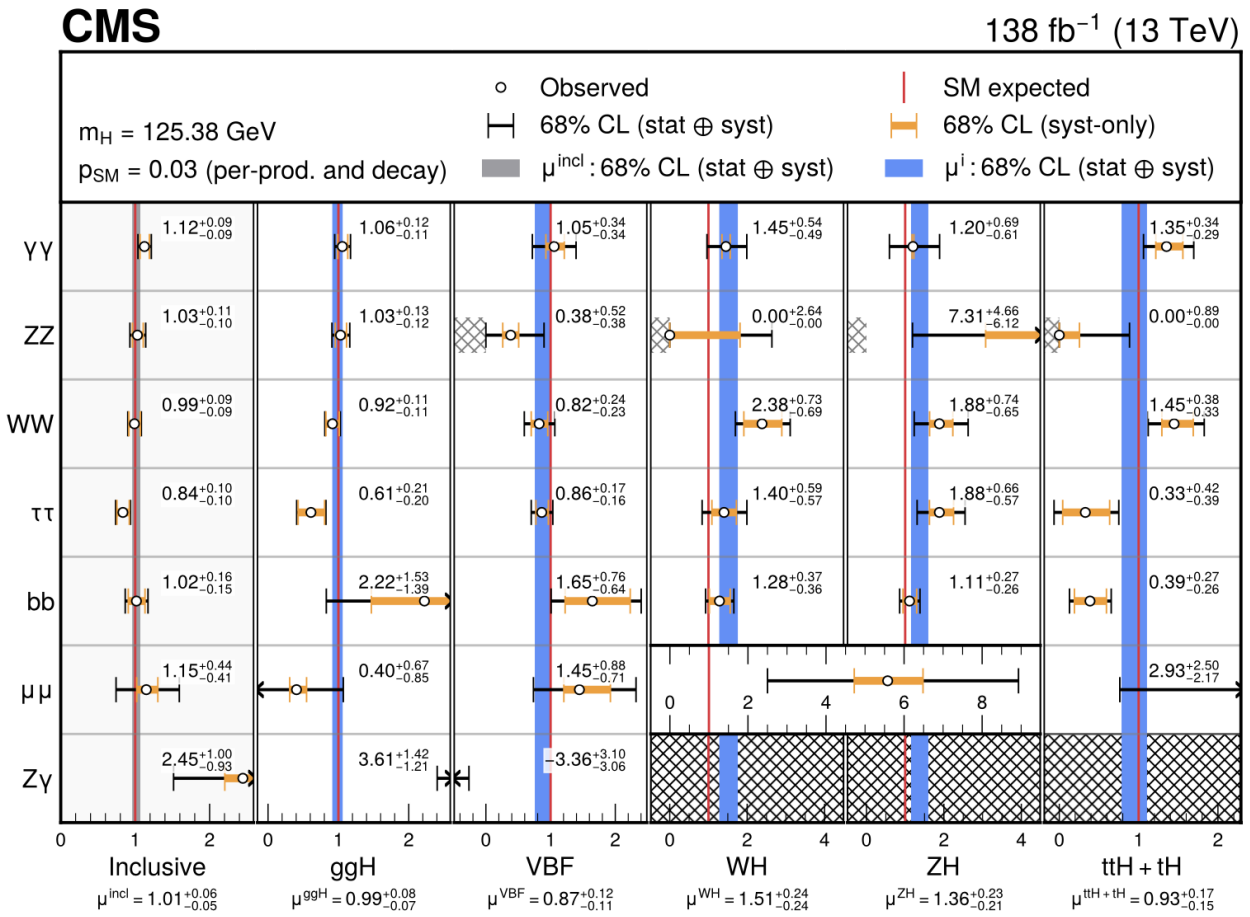
- Combination of production and decay modes
- Simultaneous measurement of O(100) cross sections



Signal strength dominated by theory uncertainties

$$\mu = 1.01^{+0.06}_{-0.05}$$

Towards precision measurements

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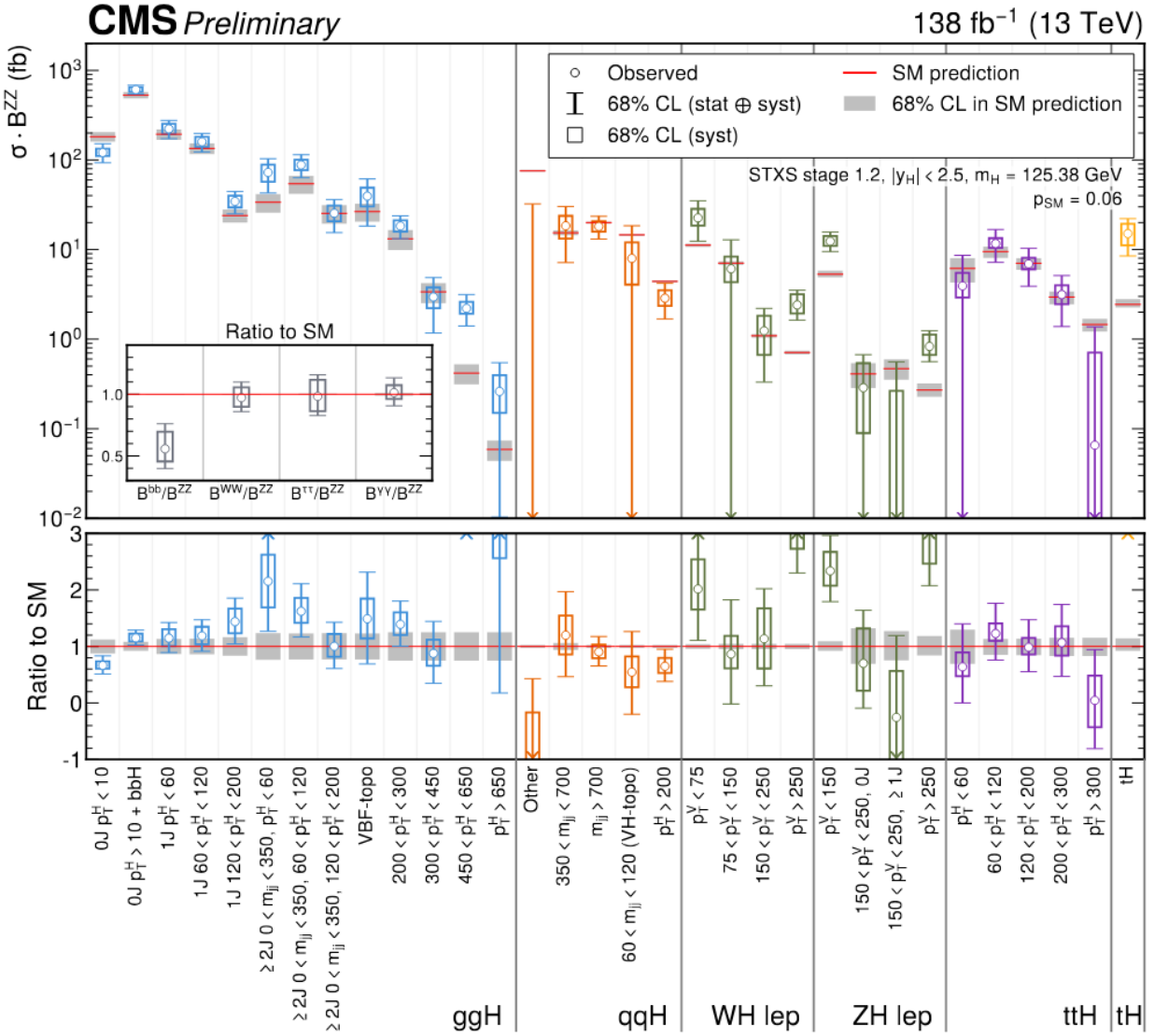
- Study Higgs boson production with increased granularity
- Perform differential measurements in the STXS framework
- A few *small* deviations

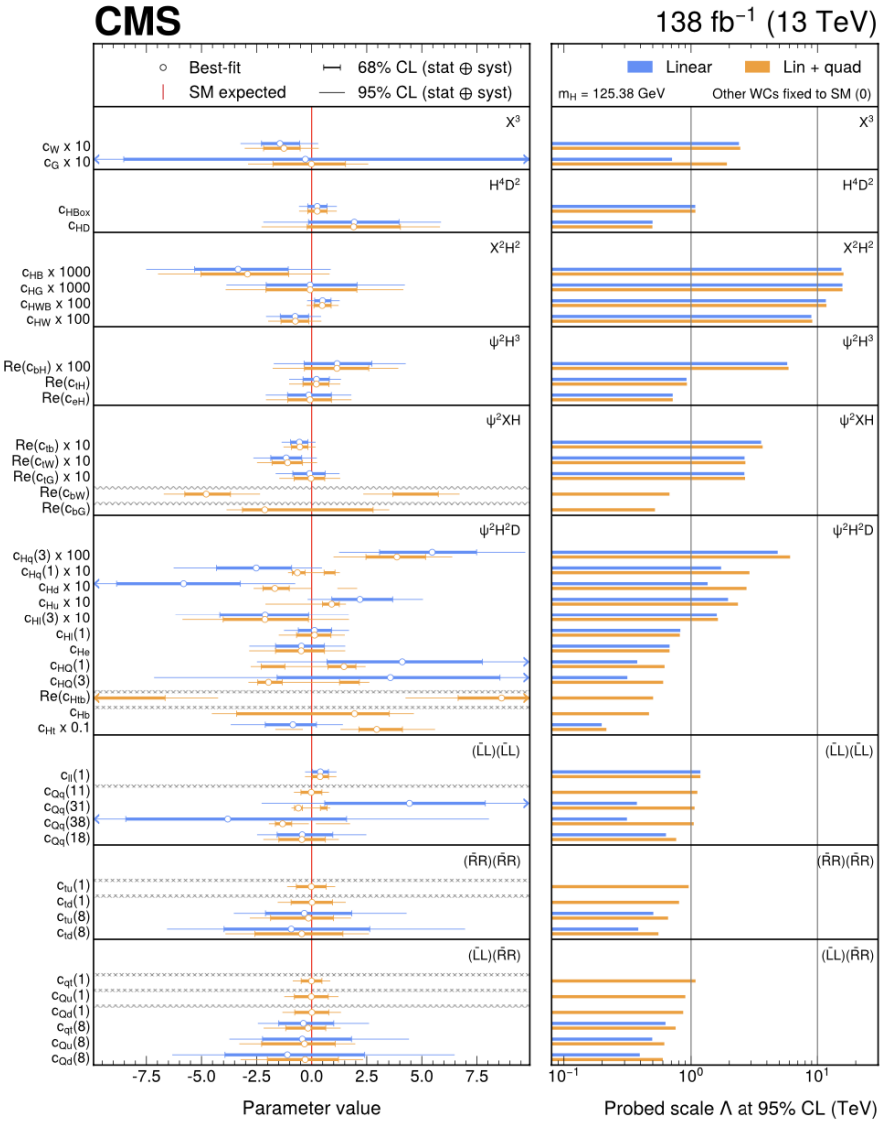


SMEFT interpretation

2602.18611

- Results are interpreted in EFT to constrain NP
- Assuming the existence of unknown theory at energy scale Λ ($\Lambda \gg E_{LHC}$), NP can manifest through effective interaction btw SM fields
- Effective lagrangian

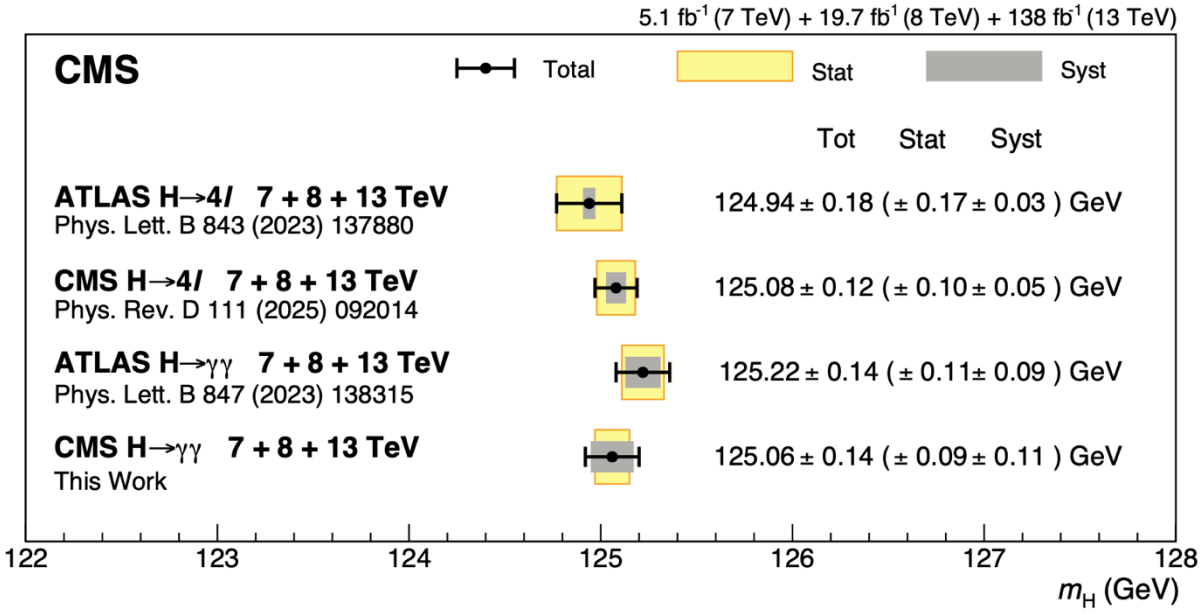
$$\mathcal{L}_{SMEFT} = \mathcal{L}_{SM} + \sum_{i=5}^{\infty} \sum_{j=0}^{N_i} \frac{c_j^{(i)}}{\Lambda^{i-4}} O_j^{(i)}$$



Higgs mass and width

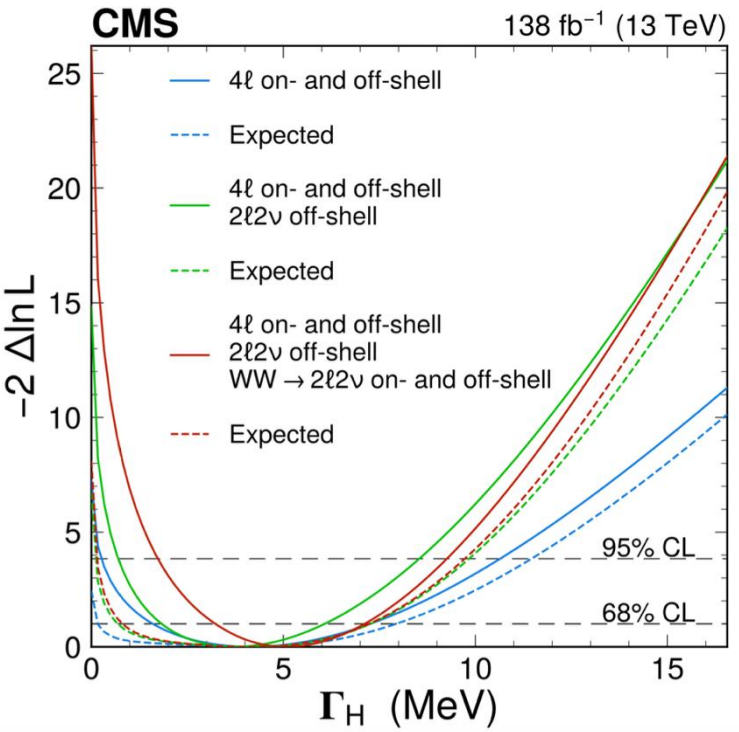
2409.13663, HIG-25-004, 2607.28396, 2607.23352

- H(4ℓ) small BR but clean final state
- H($\gamma\gamma$) improved m_H measurement
- Improved m_H through better detector calibration, understanding of systematics
- Most precise single-channel measurement (per-mil precision)



- Couplings and width sensitive probes of NP
- Off-peak to on-peak ratio proportional to Γ_H

$$\Gamma_H = 5.1^{+2.0}_{-1.8}\,\text{MeV}$$

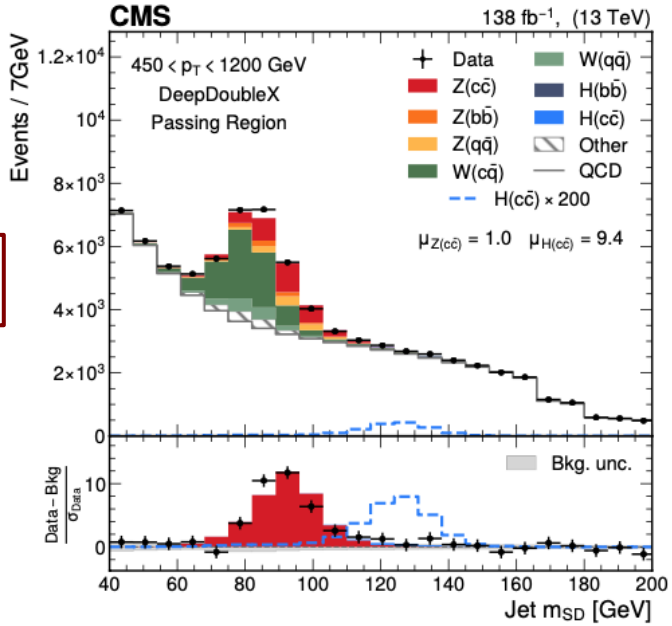


ttH(cc)

2205.05550, 2211.14181, 2508.14988, 2509.22535

- Provide direct access to charm Yukawa coupling, y_c
- H(cc): low cross section, large bkg
  - Validate c-tagging using Z+jets, VZ(cc) production
- ttH(cc) associated production
  - All ttbar decays (0L, 1L, 2L)
- Use improved ML tools
  - Jet flavour id, event classification
- Simultaneous reconstruction: ttZ(bb), Z(cc), H(bb), H(cc)

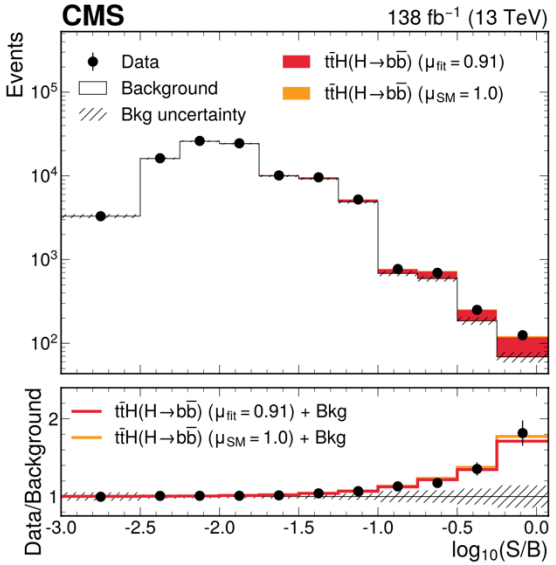
$$\mu_{\mathrm{VZ}(\mathrm{Z}\to\mathrm{c\bar{c}})} = 1.01^{+0.23}_{-0.21}$$



$$\mu_{\mathrm{t\bar{t}Z}(\mathrm{Z}\to\mathrm{c\bar{c}})} = 1.02^{+0.79}_{-0.84}$$

$$\mu_{\mathrm{t\bar{t}Z}(\mathrm{Z}\to\mathrm{b\bar{b}})} = 1.47^{+0.45}_{-0.41}$$

$$\mu_{\mathrm{t\bar{t}H}(\mathrm{H}\to\mathrm{b\bar{b}})} = 0.91^{+0.26}_{-0.22}$$



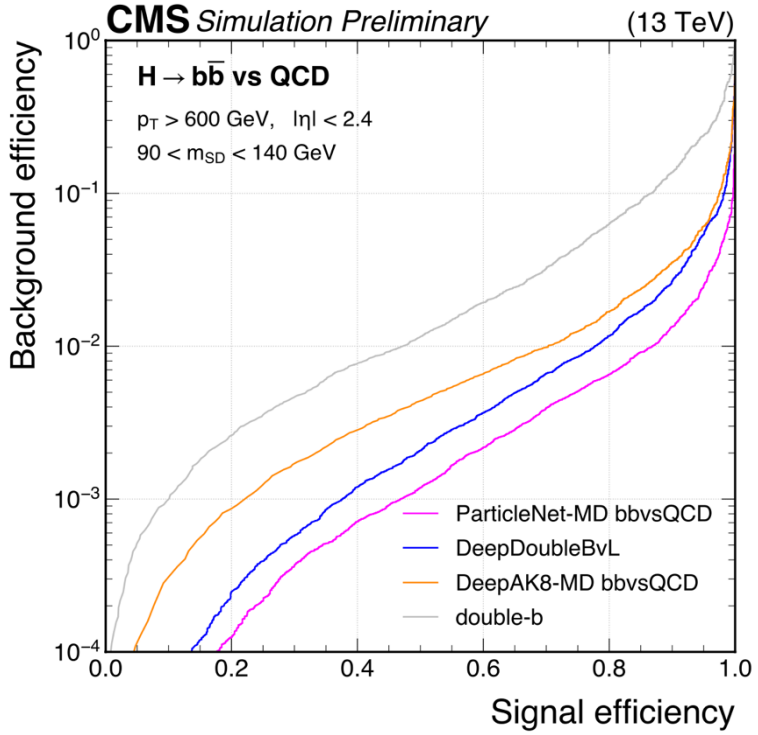
$$ttH(cc): \kappa_c < 3.5(2.7)$$

- Reached HL-LHC projections
- 20% better sensitivity when combined with VH(cc)
- Most stringent constraint to date

Boosted tagging

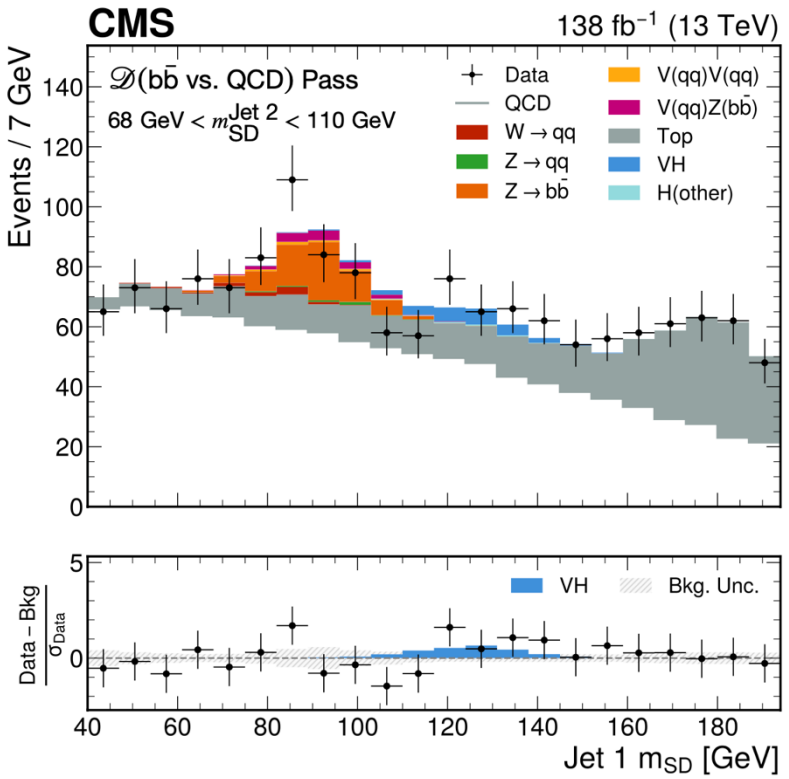
BTV-22-001, DP-2024-055, 2202.03772, 2601.05362

- Identifying the particle generating the jet is suitable task for ML
- Use ParticleNet-MD (graph NN) or Particle Transformer (ParT) to identify hadronic decays of highly boosted particles
- Validate with Z→bb events



- Boosted Higgs: VH (H→bb)
- ParticleNet-MD used
- Use VZ(bb) to validate method

$$\mu_{VH} = 0.72^{+0.75}_{-0.71}, \mu_{VZ} = 0.09^{+0.63}_{-0.63}$$

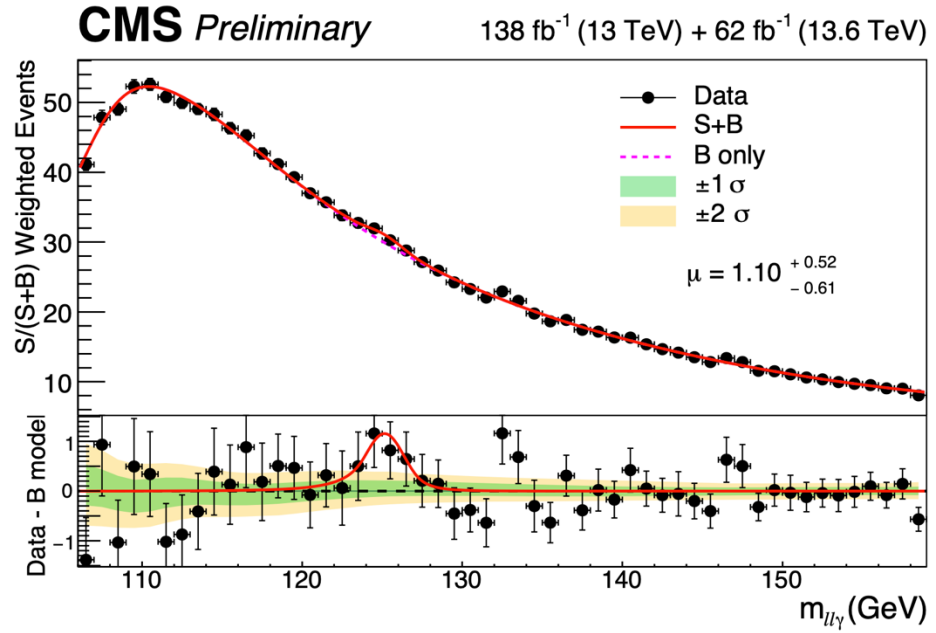


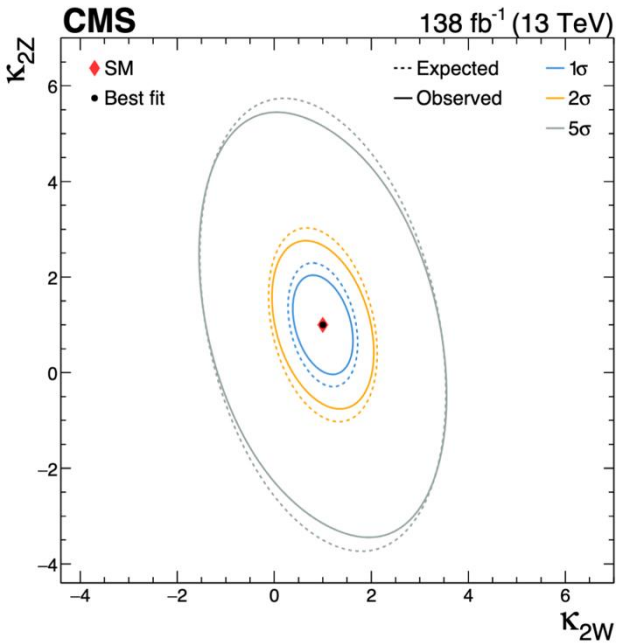
Rare production modes

HIG-25-010, 2604.24531

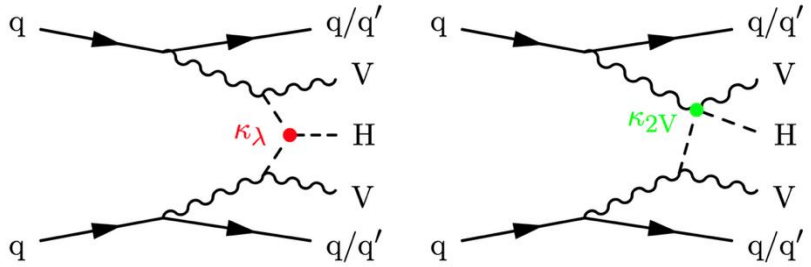
- Rare H→Z($\ell\ell$)γ decay
  - Use separate processes: ggF, VBF, associated production
  - Signal extracted from fit to $\ell\ell\gamma$ inv. mass
  - 1.9(2.3)σ obs(exp)

$$\mu = 1.10^{+0.52}_{-0.61}\ (1.00^{+0.49}_{-0.46})$$





- VVH(bb) sensitive to self (k_λ) and quartic (k_{2V}) couplings
  - H reconstructed as large-cone jet



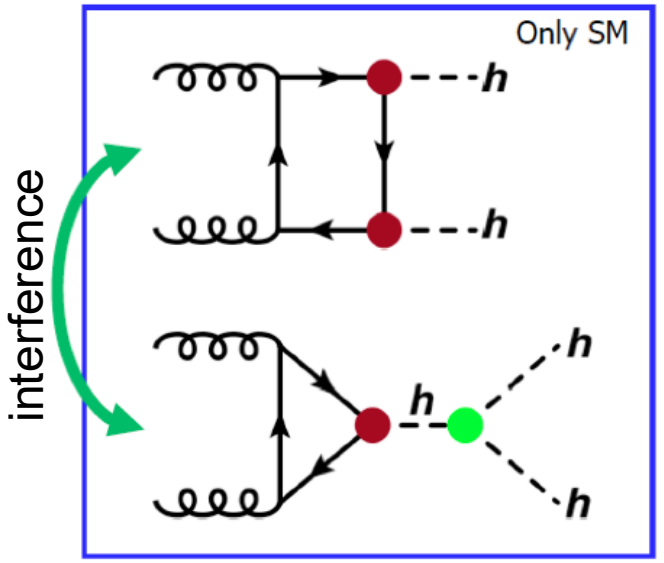
Di-Higgs searches

- Self-coupling measurement
- Destructive interference in SM
  - Could be altered in BSM
  - If constructive, it could be large enhancement
- In SM, only σ=31(34)fb at 13(13.6) TeV
- Study different final states

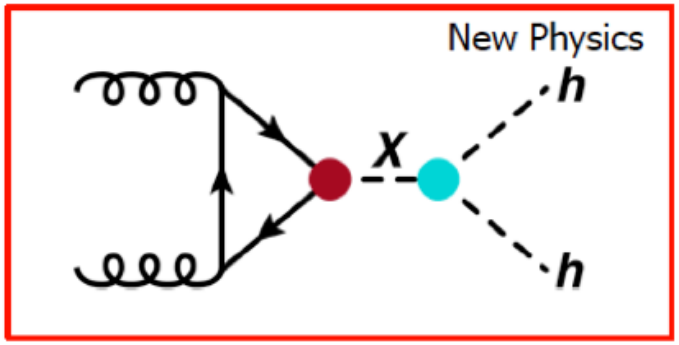
(X→)hh→		BR	Mass scale
	bbbb	34%	High
	bbττ	7.3%	
	bbWW	27%	
	bbγγ	0.26%	Low

$$V(h) = V_0 + \underbrace{\frac{1}{2}m_H^2 h^2}_{\text{Mass Term}} + \underbrace{\lambda_{hhh} v h^3}_{\text{HH production}} + \underbrace{\frac{1}{4}\lambda_{hhhh} h^4}_{\text{HHH production}}$$

non-resonant production

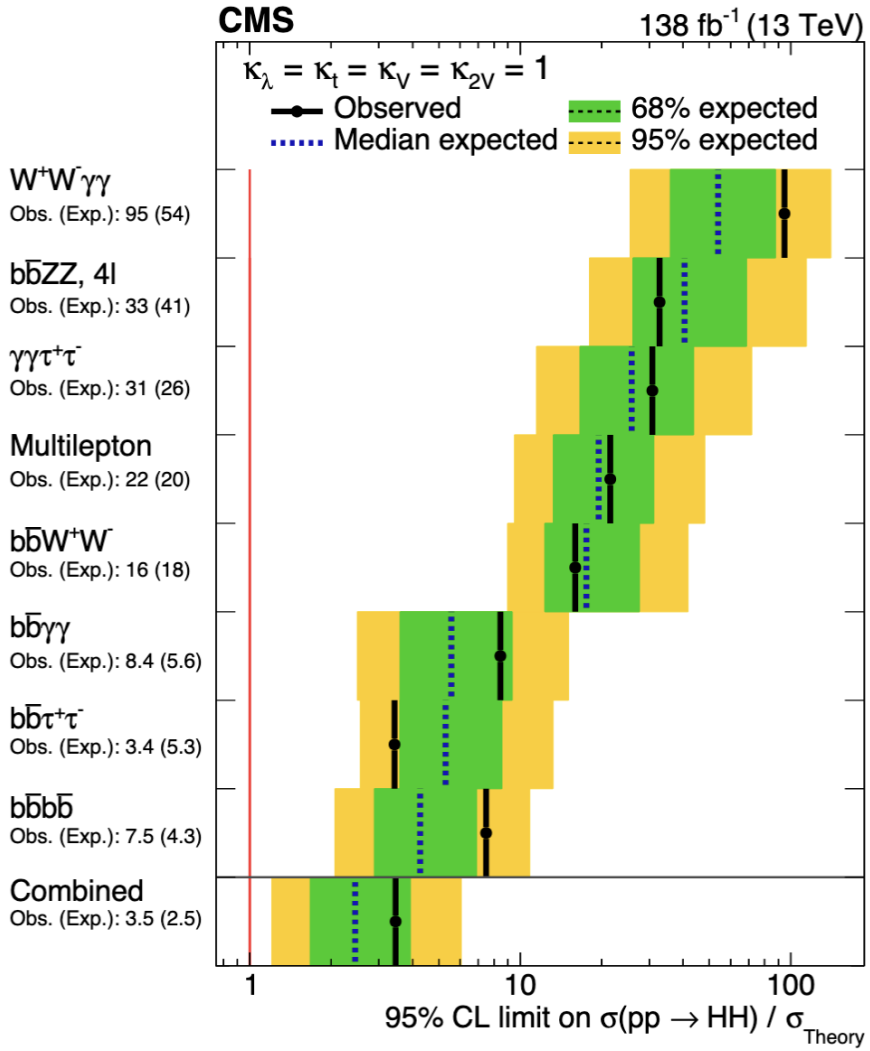


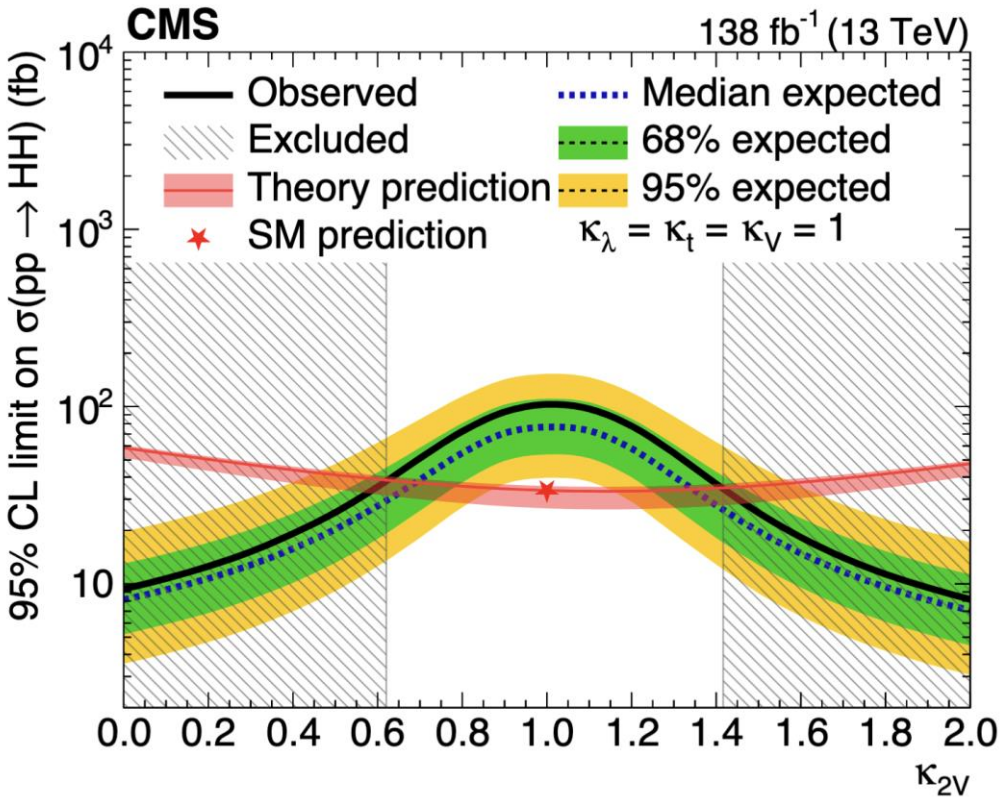
resonant production



Higgs self-coupling

2510.07527, 2602.23991





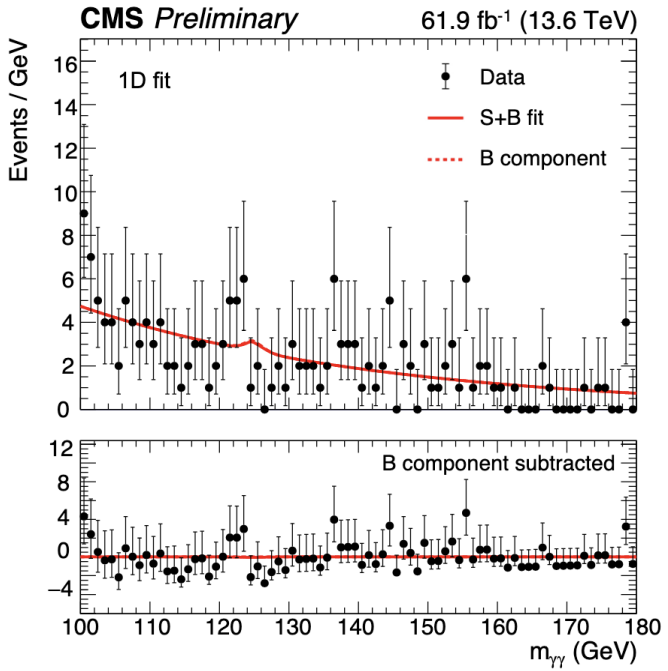
- $k_\lambda \in [-1.4, 6.4]$ @95%CL
- $k_{2V} \in [0.6, 1.4]$ @95%CL

⇒ Run2 ATLAS+CMS combination: $\mu_{HH} \leq 2.5\ (1.7)$

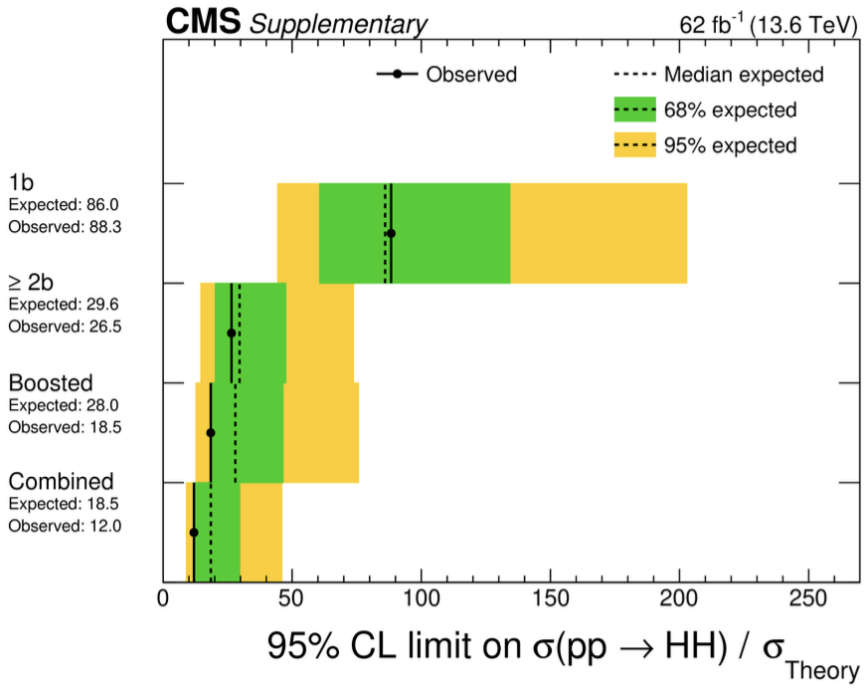
HH @ Run3

HIG-25-007, 2604.02127

- bbγγ
  - Trigger on photon pair
  - 2AK4 b-jets, 1 AK8 bb-jet
  - Improved m_{jj} w/dedicated DNN
  - 1D ($m_{\gamma\gamma}$), 2D ($m_{\gamma\gamma}$, m_{jj}) fits
  - 7.4(8.7) x σ_{SM} obs (exp)
  - +15% wrt lumi-scaled Run2



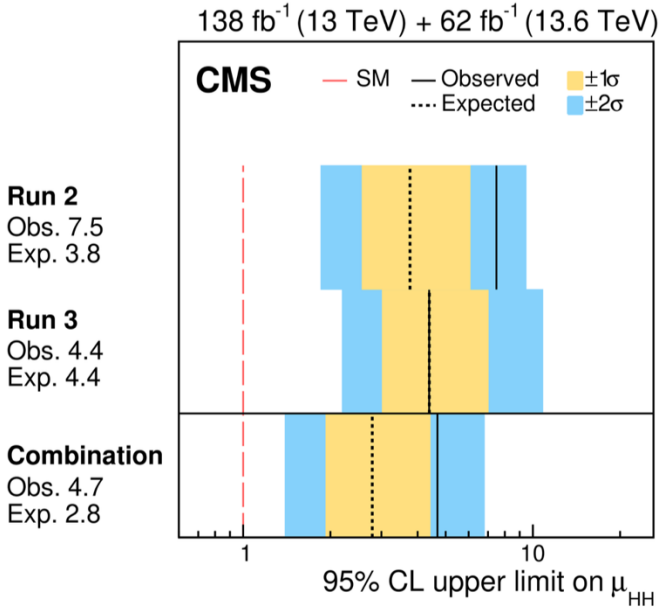
- bbWW(2ℓ2ν)
  - Trigger on leptons
  - Bkg modelled with MC
  - Use NN multi-classifier
  - 12(18.5) x σ_{SM} obs (exp)
  - +50% wrt lumi-scaled Run2

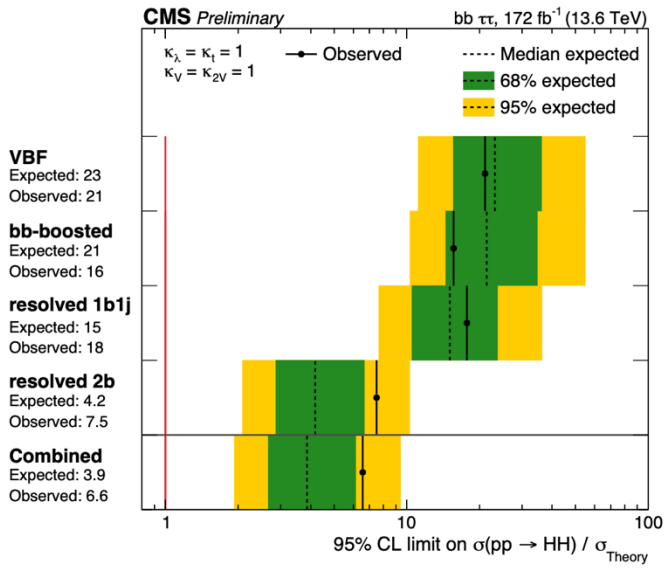


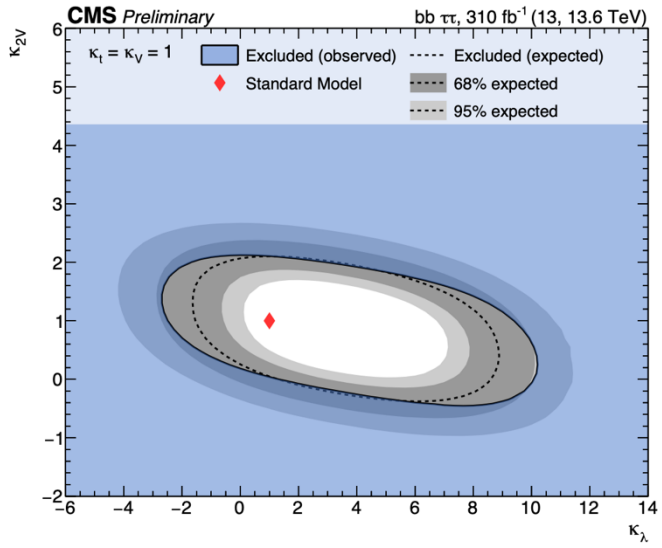
HH @ Run3 (cont.)

2604.27044, HIG-25-008

- bbbb
  - Resolved and merged topologies
  - DD bkg prediction
  - Run3: 4.4(4.4) x σ_{SM} obs (exp)
  - +45% wrt lumi-scaled Run2
- bb$\tau\tau$
  - Trigger on leptons
  - Bkg modeling MC+DD
  - Categorization on H(bb), H($\tau\tau$) topology
  - Signal extraction with ggF, VBF DNNs
  - Run3: +20% wrt lumi-scaled Run2
  - Run2+Run3: 3.9(3.0) x σ_{SM} obs (exp)



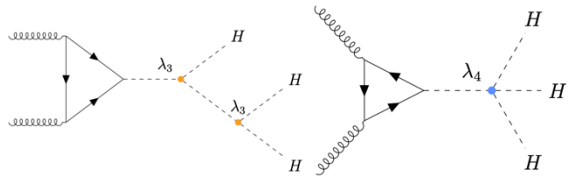




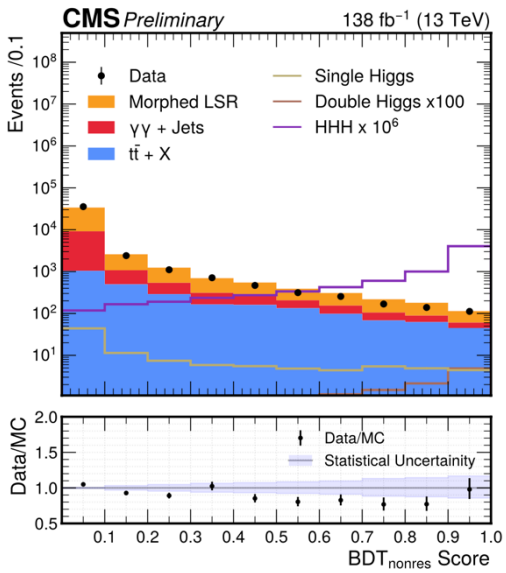
HHH and ttHH production

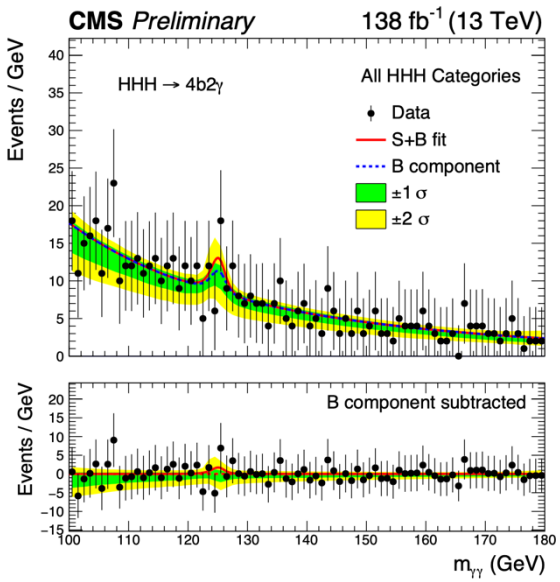
HIG-24-015, HIG-24-016

- Search for HHH production at 13TeV
  - 4b2γ final state (BR~0.2%)
  - Parametrized wrt λ_3 and λ_4 couplings
- In SM, σ=0.079fb@13TeV

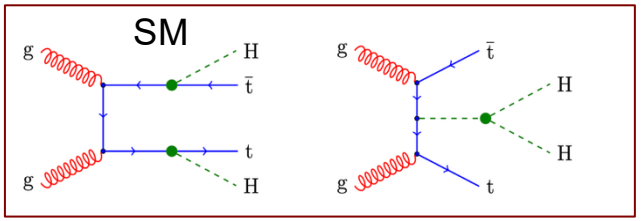


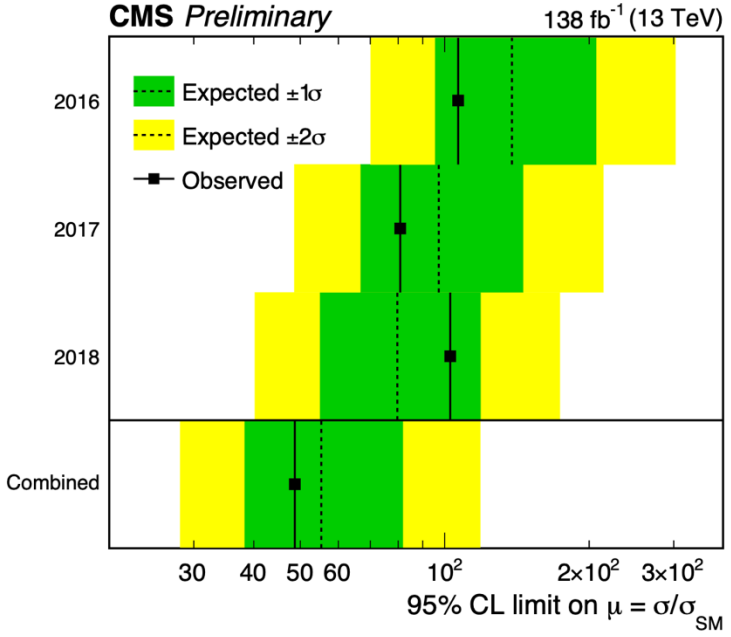
$$\sigma(gg \to HHH) < 243.96(152.0^{+199.3}_{-80.47})\ \text{fb}$$





- Search in tt(SL)HH(4b) channel
  - 1 lepton+≥5(4) (b-)jets
  - DNN event classifier (9 classes)
- Results interpreted in HEFT

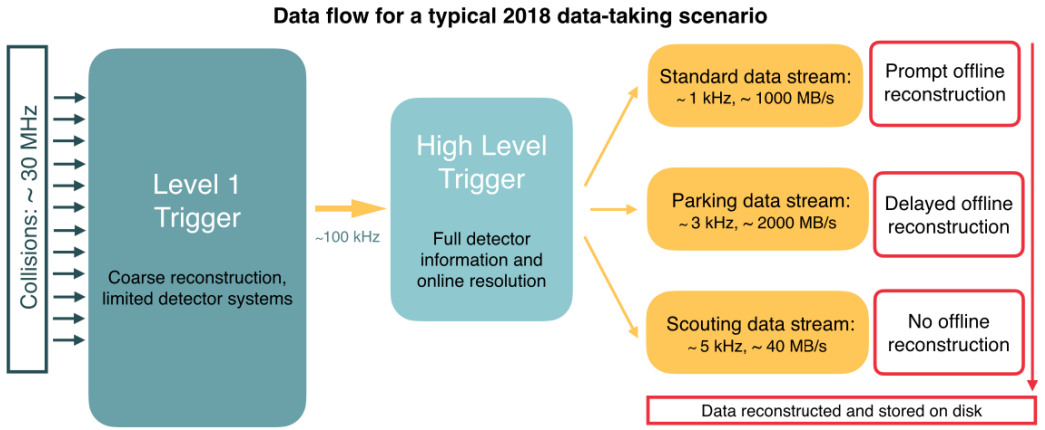


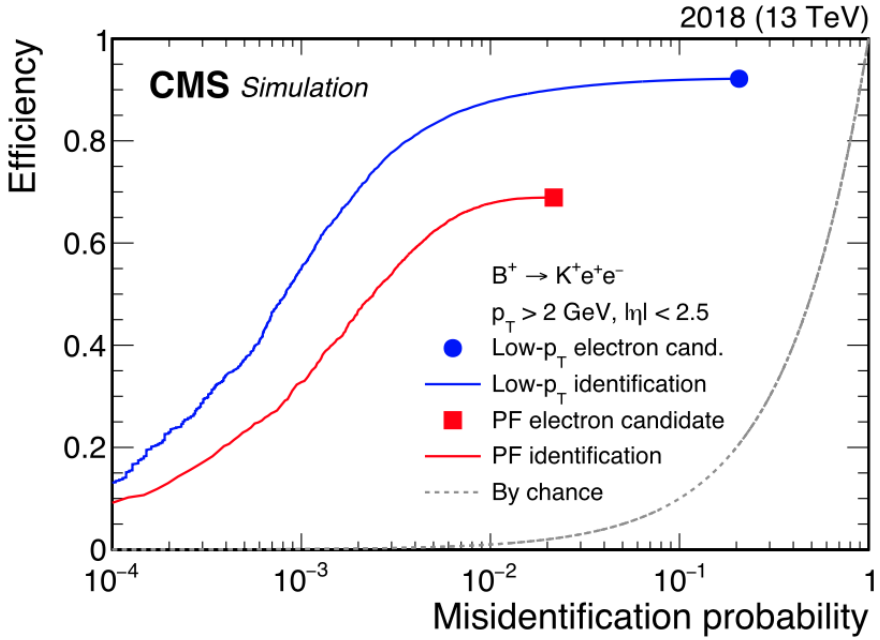


Expanded datasets

Phys.Rep.1115(2025)678

- A new paradigm to explore flexibility of CMS trigger and DAQ, low-p_T (di)muon triggers, low p_T electron ID, innovative techniques
  - Data Parking: full event info, delayed reconstruction
  - Data Scouting: write minimal info to reduce event size, write data at higher rate
- Innovative concept of parking of 2018 yielded ~12B events with about 10^{10} b hadron decays (~10 times the BaBar/Belle decade-long statistics in less than half a year!)

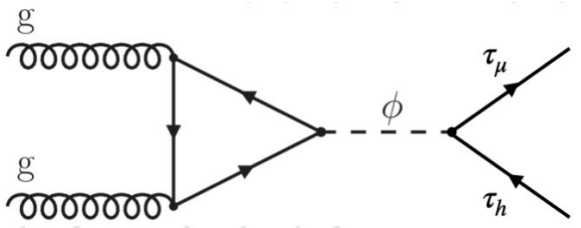


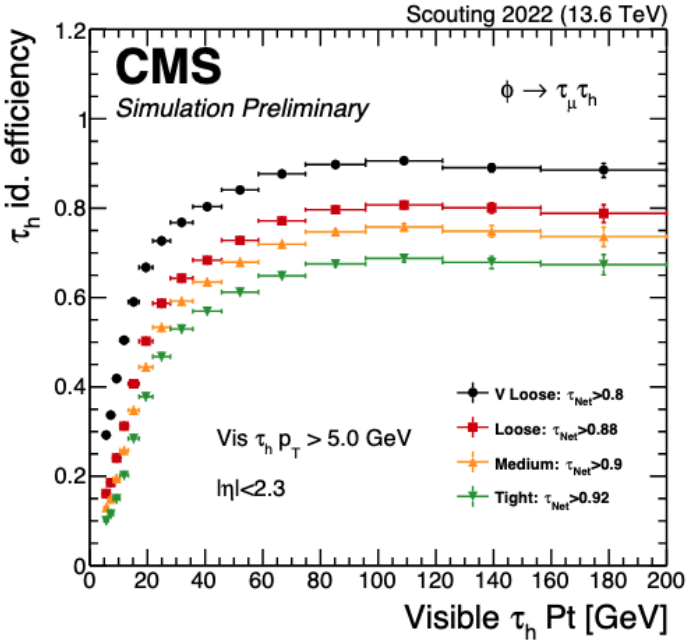


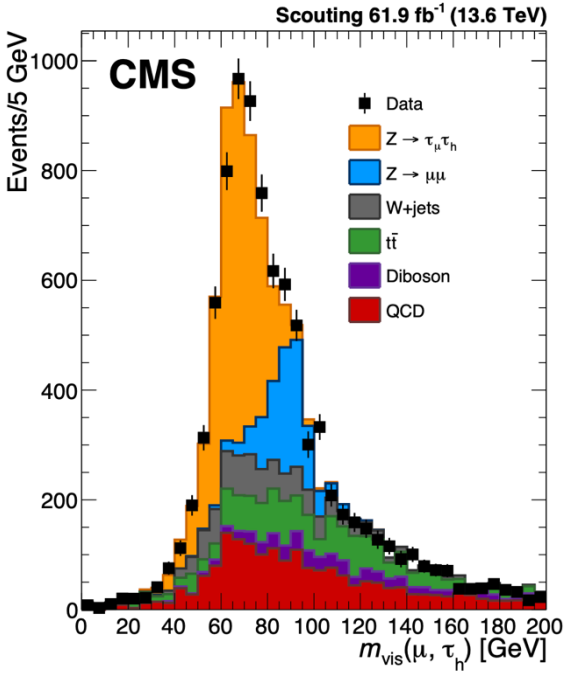
Low mass resonance: ττ

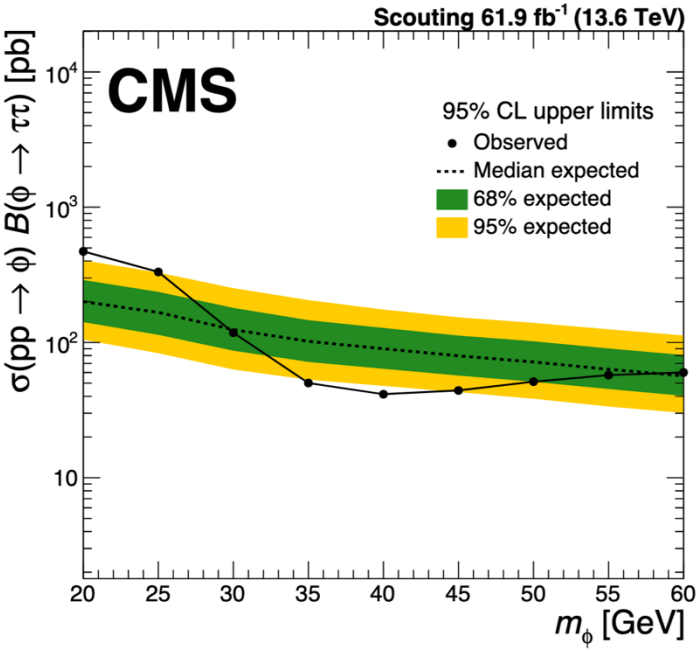
2605.25103

- Search for low mass resonance decaying to ττ
- Use data scouting in Run3
  - Probe mass range 20-60 GeV
  - Use novel DNN(TauNet) τ Id algorithm
  - Improve efficiency for low p_T τ : $p_T(\tau)$>7GeV
- No significant excess for new scalar ϕ





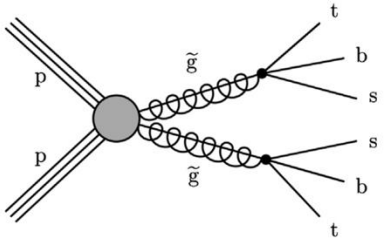


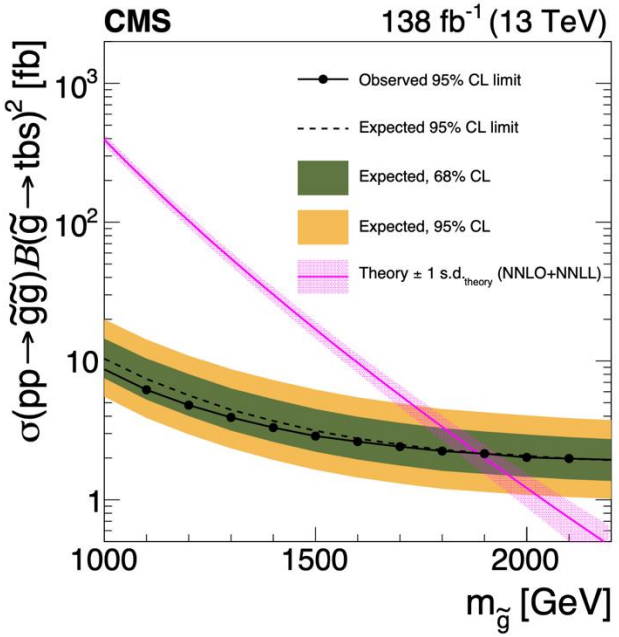


Searches for NP

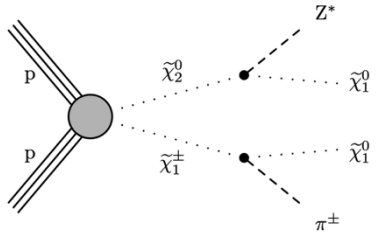
2606.09567, 2604.25604

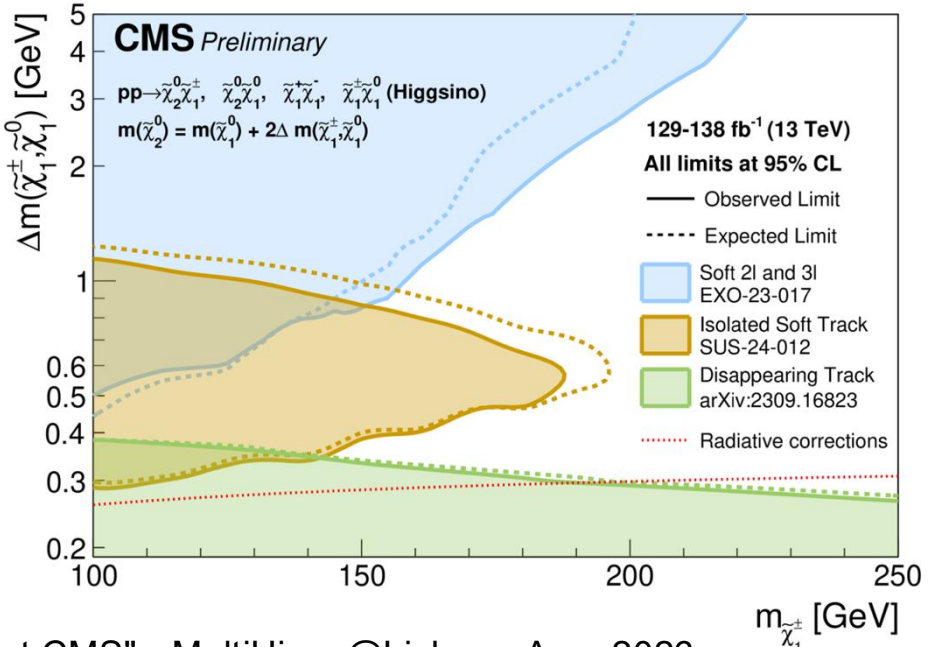
- Search for 1 lepton+multi-jets+≥2 b-jets
  - Top quarks and multiple jets in final state
  - Sensitive variables: N_{jet}, $N_{b\text{-}jet}$, M_J
- Limits on RPV SUSY models





- Search for EWKinos in compressed spectrum scenario in multi-lepton events
  - Events with soft isolated tracks and large MET
  - Small mass difference btw lightest SUSY particles
- Limits on chargino-neutralino in RPV models

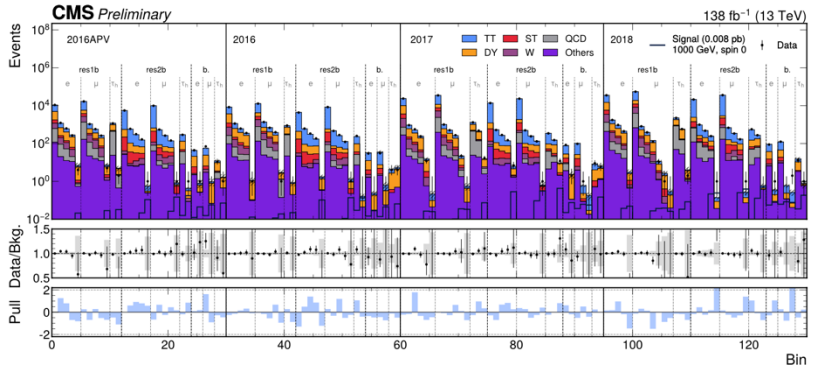


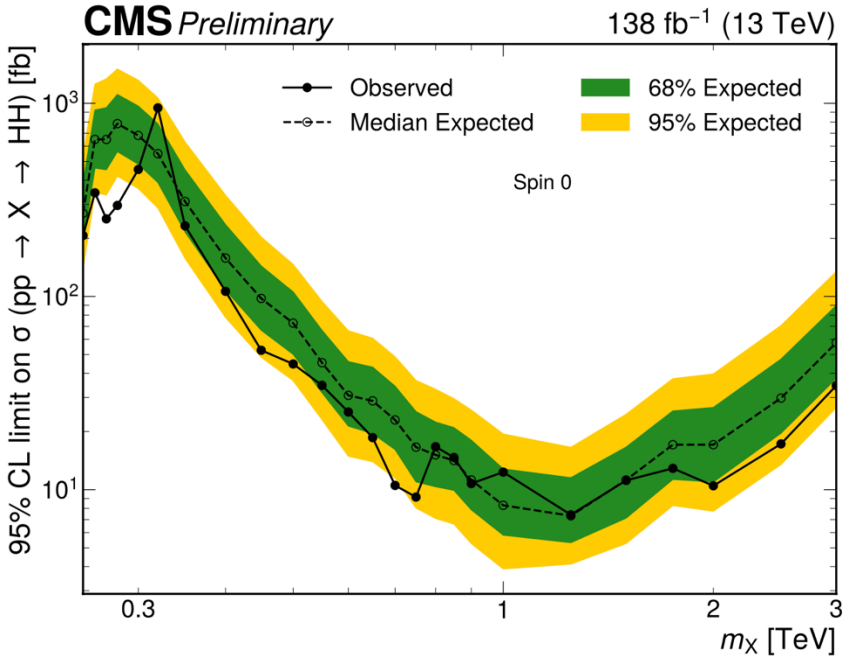


Heavy resonances

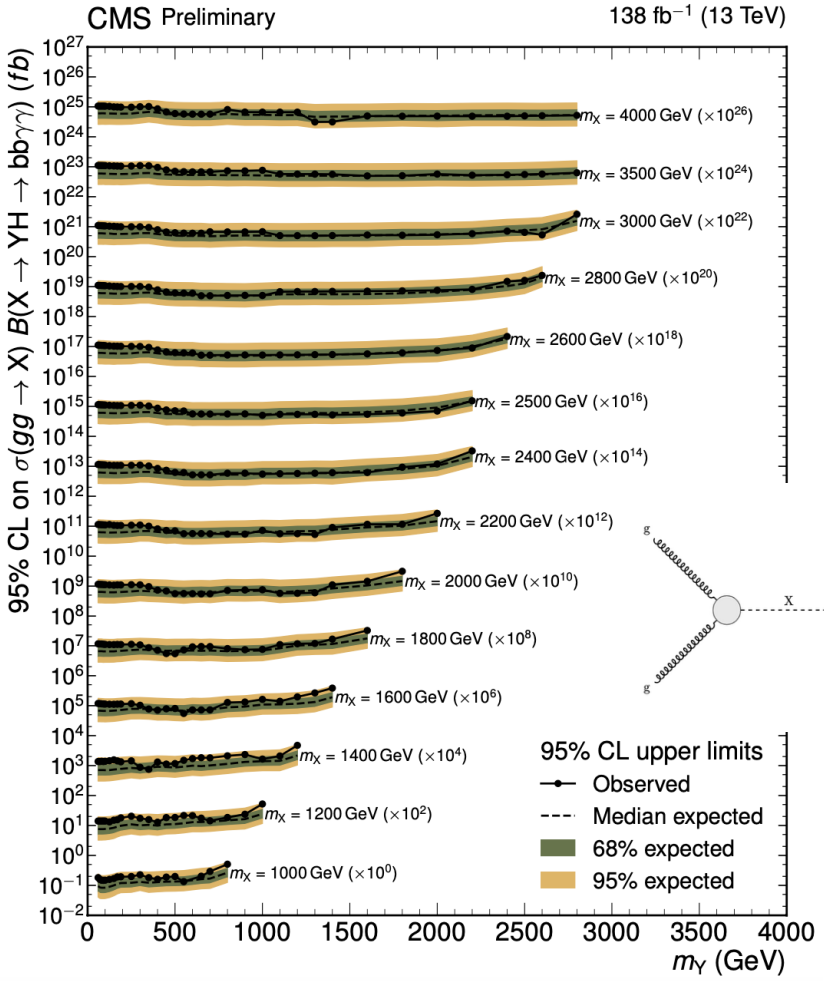
B2G-24-011, B2G-24-019

- Search for: X→HH→bbττ





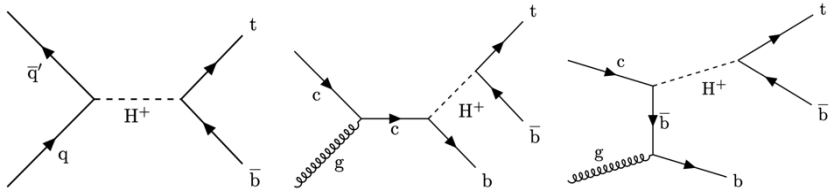
- Search for H and a new scalar particle Y: X→HY→γγbb

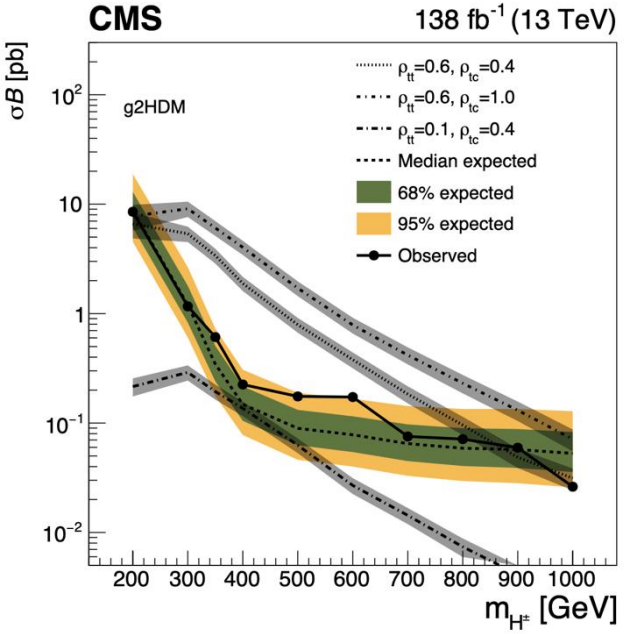


Charged Higgs

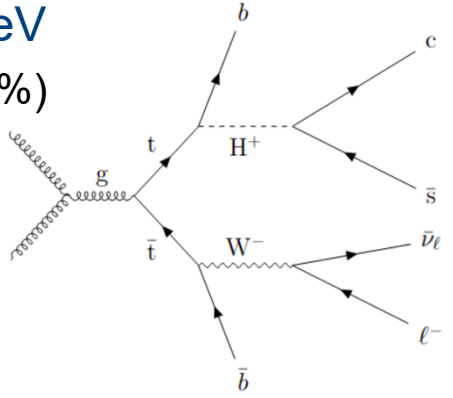
2512.24471, 2604.27795

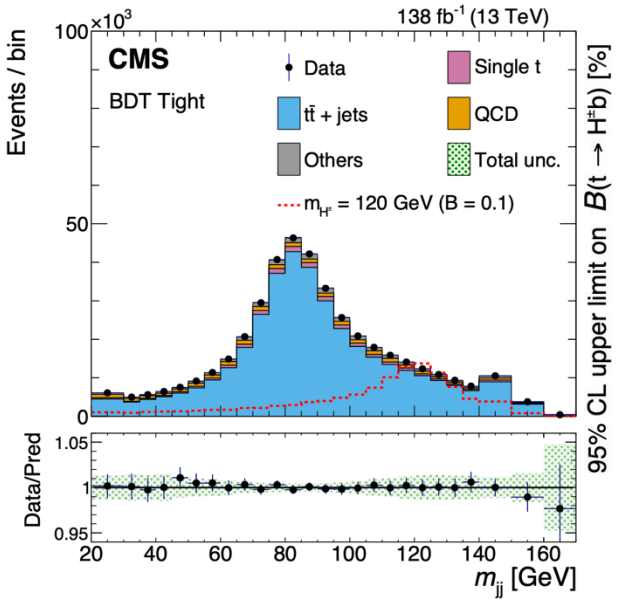
- Search for heavy $H^+ \to tb$
  - 1 lepton+MET+≥2 b-jets
  - Simult. pDNN fit in 2 (e,μ) channels, 5 SRs
- Heavy $H^{\pm}$: m_H=0.2-1TeV
  - Local excess of 2.4σ at m_H=0.6 TeV

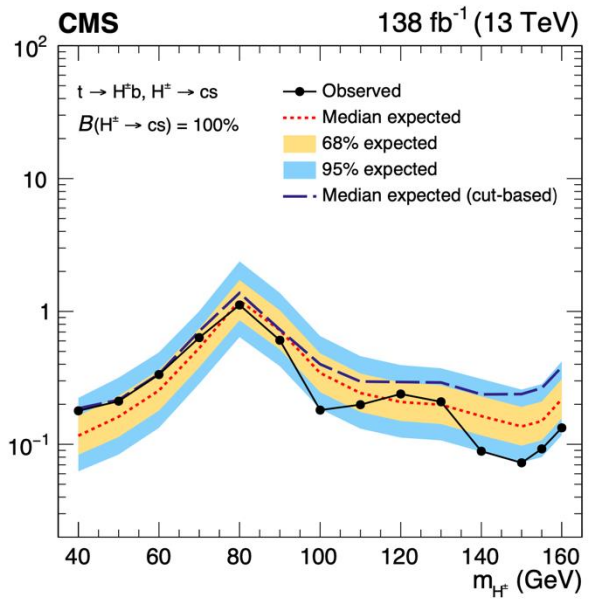




- Search for light $H^+ \to cs$
  - 1 lepton+MET+≥(2)4 (b-)jets
- Light $H^{\pm}$: m_H=40-160 GeV
  - dominant bkg is ttbar (90%)
  - probe 2 light-flavour-jet invariant mass



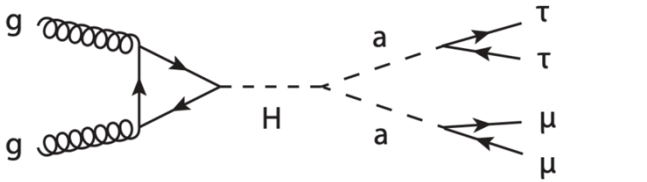


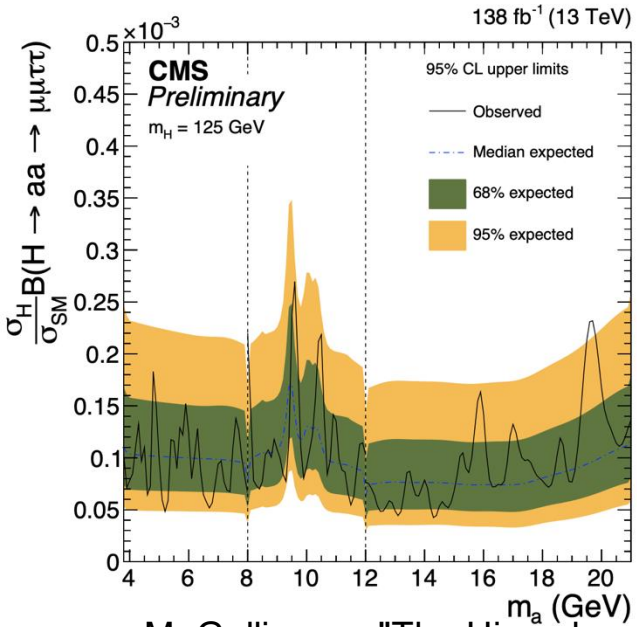


non-SM Higgs decays

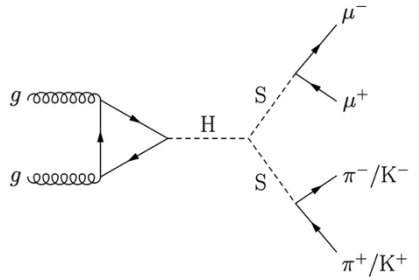
SUS-23-005, 2605.27875

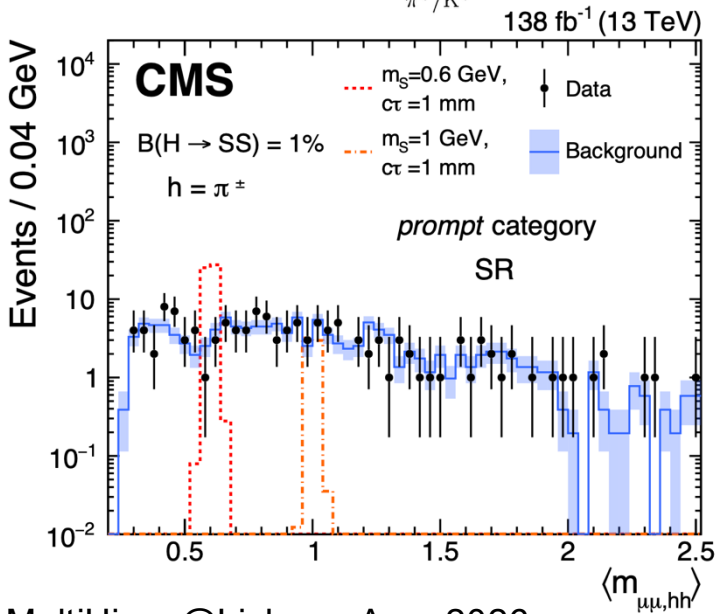
- In 2HDM+a, H→aa→μμττ
  - if $m_H \gg m_a$, *a* boosted
  - Leptons from a→ℓℓ collimated
  - DeepDiTau classifier to identify merged $\tau_h\tau_h$
- Sensitivity down to m_a=3.6 GeV





- Search for light scalar in H decays
  - prompt/LL scalar
  - Collimated muon pair, charged hadrons
- Improves sensitivity, m_S=0.4-2.0 GeV

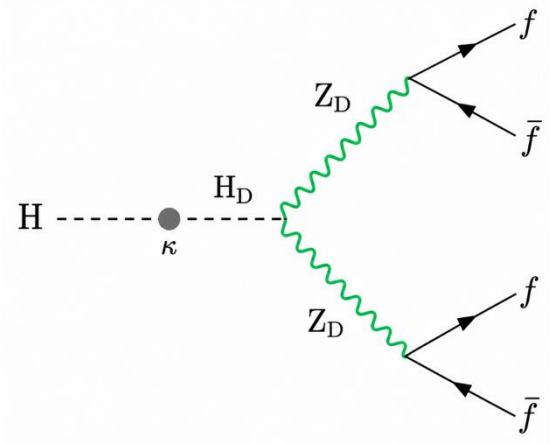


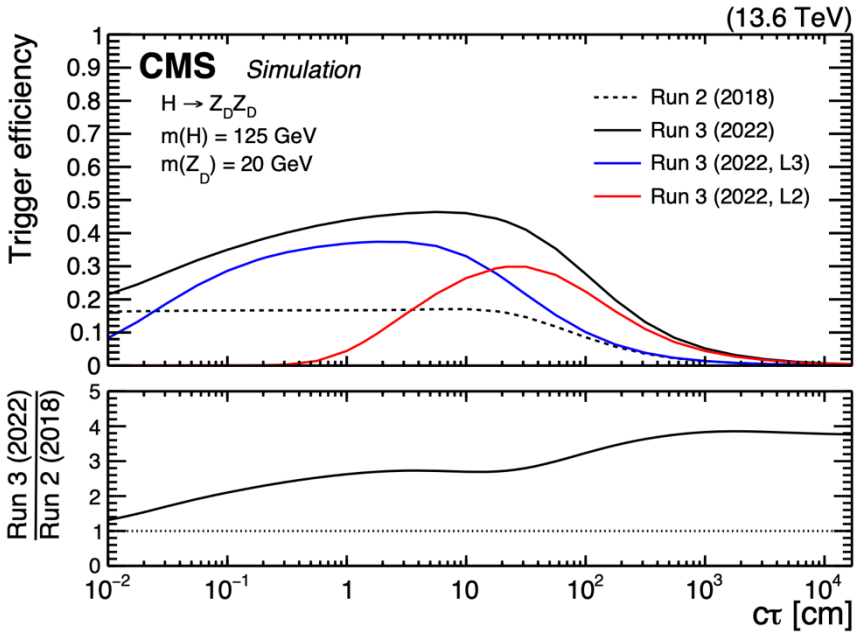


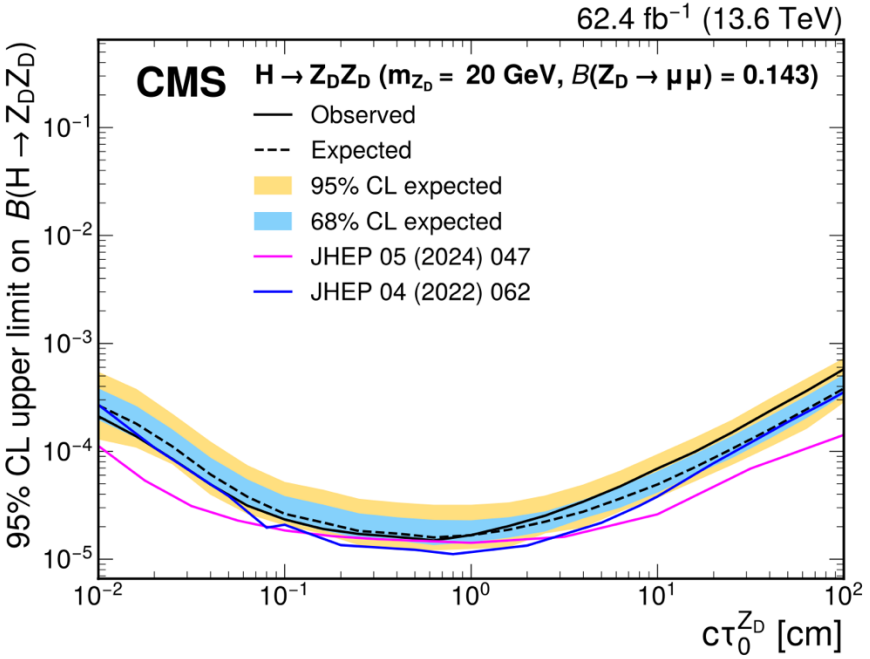
Long-lived: Higgs portal

2601.17576, 2402.14491, 2606.25840

- Production of long-lived dark photons Z_D via Higgs portal
  - H-H_D mixing with parameter κ
  - Use improved dimuon trigger stream (data scouting)
- Higgs decaying to long-lived scalars
  - Scalars decay to fermion final states in the muon chambers
  - Displaced dimuon originating from secondary vertex

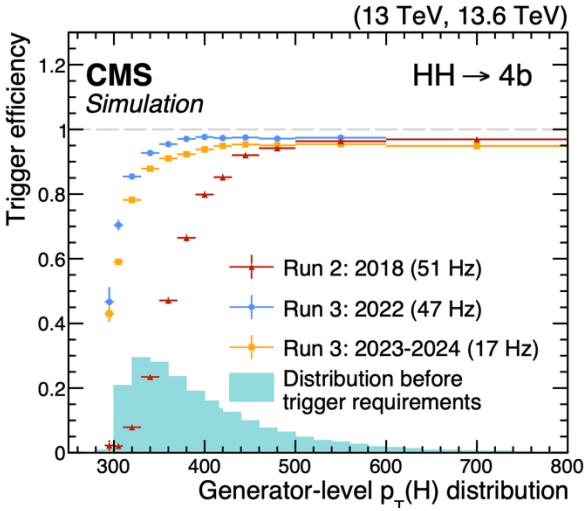






Run 3 improvements

2604.27044, 2608.18331, BTV-25-002, DP-2023-050, DP-2024-064, DP-2024-052, DP-2024-066



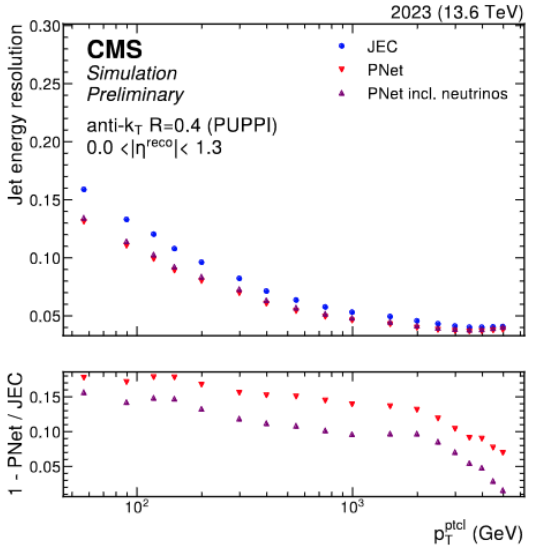
Trigger:

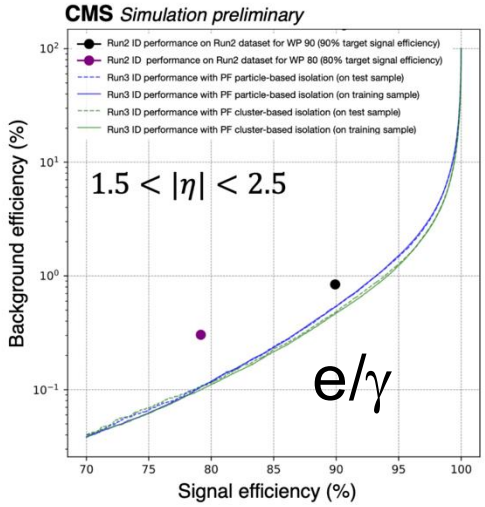
- ML (ParticleNet, DeepTau)
- Added data streams ("parking")
- Lower p_T threshold (4b, bb$\tau\tau$)

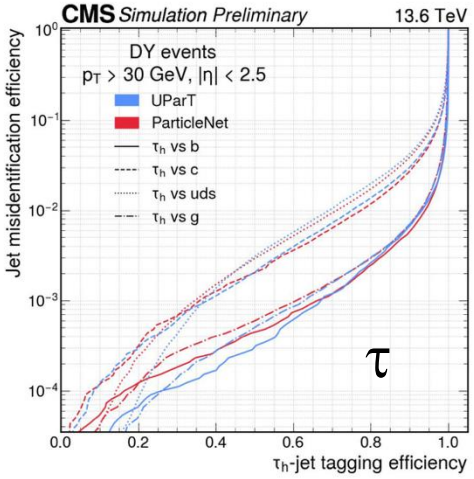
Reconstruction:

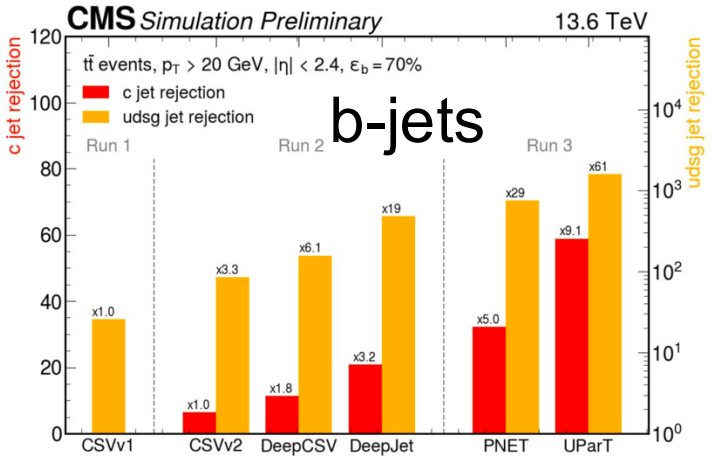
- Jet p_T regression (ParticleNet)

$\Rightarrow$ Improves resolution ~15%





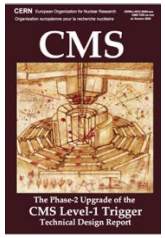




Improved triggers, scale factors, reconstruction, MVA optimization, etc.:

$\Rightarrow$ Large improvements in electron/γ/τ/b ID and udsg (charm) rejection

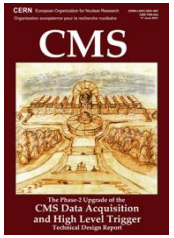
Preparing for HL-LHC



L1-Trigger

https://cds.cern.ch/record/2714892

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



DAQ & High-Level Trigger

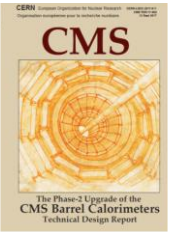
https://cds.cern.ch/record/2759072

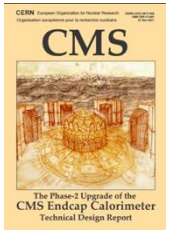
- Full optical readout
- Heterogenous architecture
- 60 TB/s event network
- 7.5 kHz HLT output

Barrel Calorimeters

https://cds.cern.ch/record/2283187

- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards

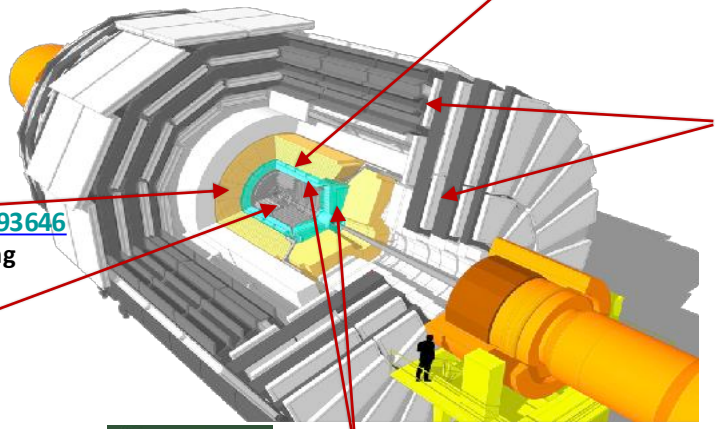




Calorimeter Endcap

https://cds.cern.ch/record/2293646

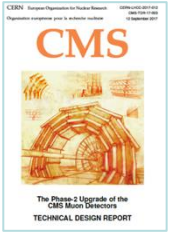
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

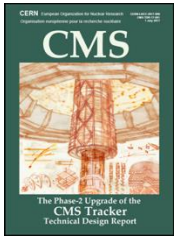


Muon systems

https://cds.cern.ch/record/2283189

- DT & CSC new FE/BE readout
- RPC back-end electronics
- New GEM/RPC $1.6 < \eta < 2.4$
- Extended coverage to $\eta \simeq 3$

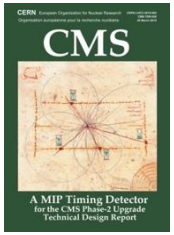




Tracker

https://cds.cern.ch/record/2272264

- Si-Strip and Pixels increased granularity
- Design for tracking in L1-Trigger
- Extended coverage to $\eta \simeq 3.8$



MIP Timing Detector

https://cds.cern.ch/record/2667167

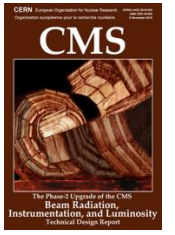
Precision timing with:

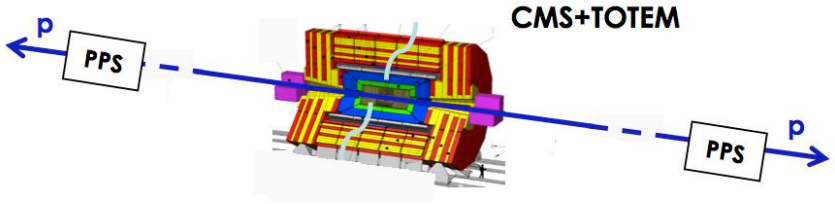
- Barrel layer: Crystals + SiPMs
- Endcap layer:
  Low Gain Avalanche Diodes

Beam Radiation Instr. and Luminosity

http://cds.cern.ch/record/2759074

- Beam abort & timing
- Beam-induced background
- Bunch-by-bunch luminosity:
  1% offline, 2% online
- Neutron and mixed-field radiation monitors



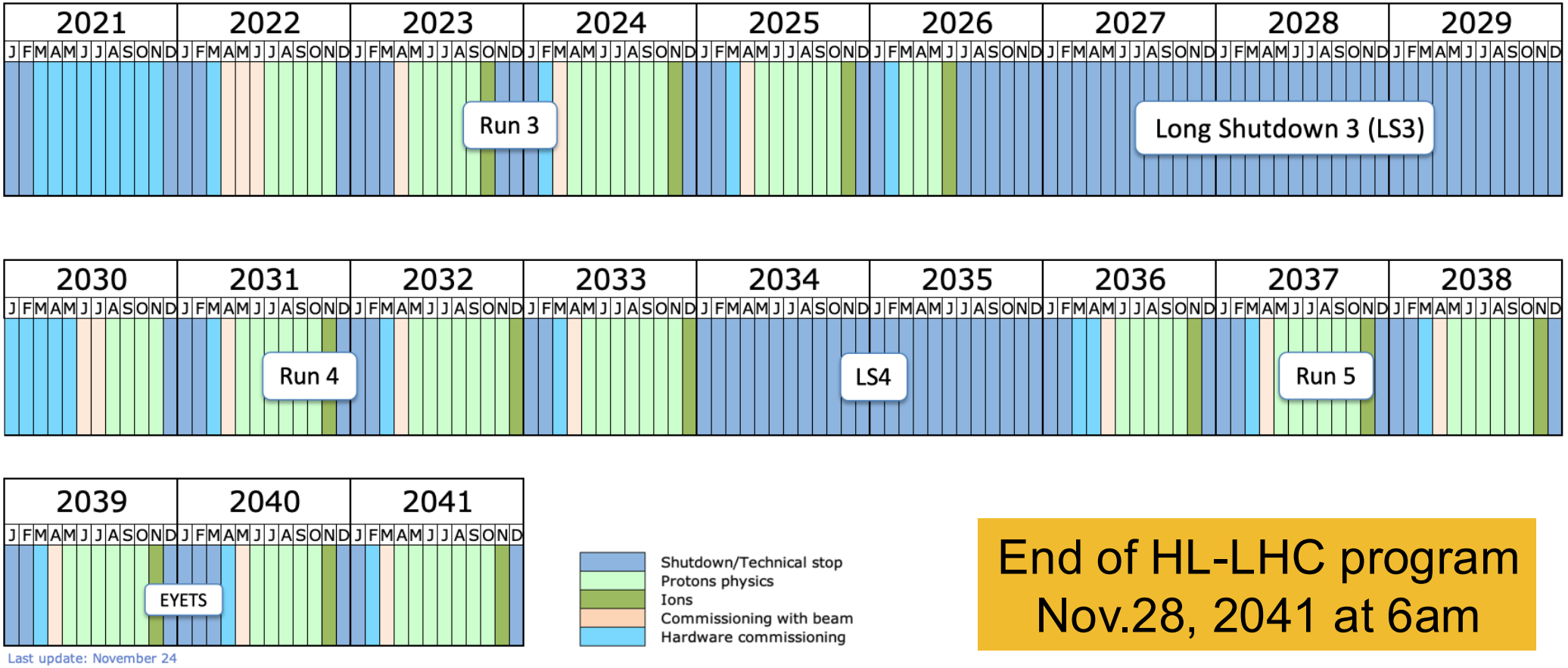


Precision Proton Spectrometer

https://cds.cern.ch/record/2750358

- New RP stations at 196, 220, 234, (420) m
- Timing and tracking

Stay tuned!



End of HL-LHC program
Nov.28, 2041 at 6am

Summary

- Comprehensive program of SM tests and BSM searches
- Precision and reach already exceeded expectations
- Latest results on several fronts:
  - SM, Top, Higgs, rare processes, searches, etc.
  - Improved analysis techniques and new tools crucial to enhance sensitivity beyond statistics
- No clear signal for NP, a few deviations
- Great progress in the first 15+ years
- Large samples collected
  - Full Run2+Run3 dataset (~0.5/ab)
  - Preparations for HL-LHC at full speed

⇒ Probing the SM in unexplored regions with studies of rare processes and precise measurements

A few remarks

We are in a golden age of particle physics:

- Large data samples to explore and to collect (HL+HL-LHC)
- Excellent experimental conditions (complex detectors taking data with high efficiencies, impressive algorithms, excellent collider performance, etc)
- Upgrade detector program with innovative technologies in full swing
- Undefined physics panorama needs updated standard model

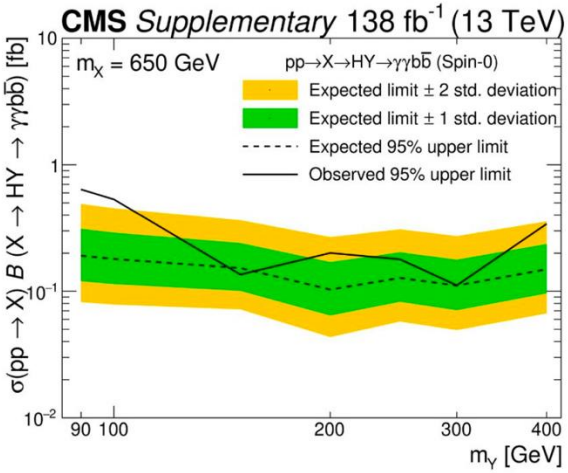
Improved precision and reach with full exploitation of (HL-)LHC data

Questions?

THANK YOU FOR YOUR ATTENTION!

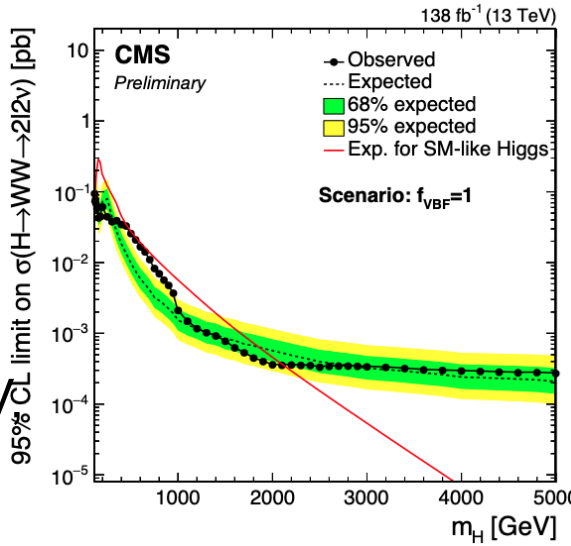
A few small deviations

arXiv:2310.01643, CMS-HIG-20-016, arXiv:2208.02717, arXiv:2405.18149

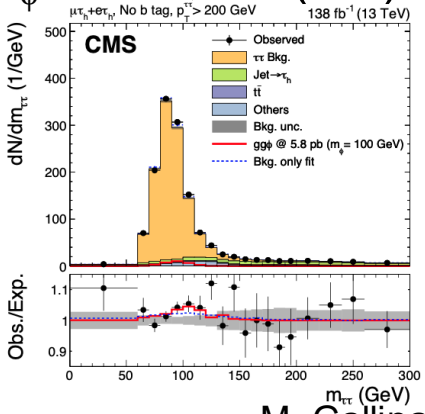


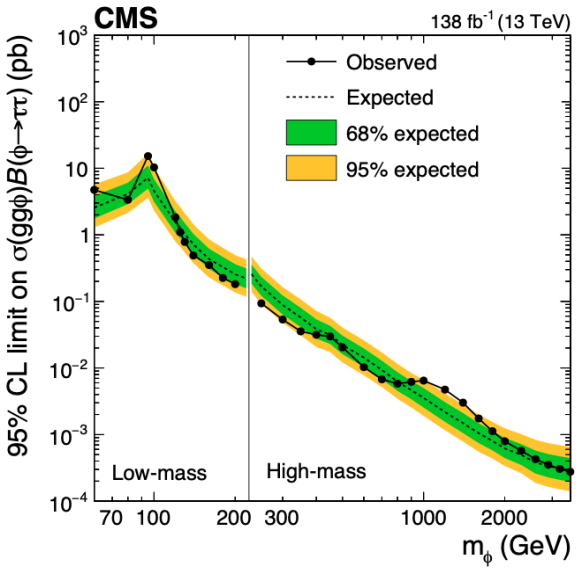
X→Y(bb)H(γγ)
m_X,m_Y =(650, 90) GeV
3.8(2.8)σ local(global)

Heavy Higgs:
X→WW (2ℓ2ν)
at m_X=650GeV
3.8(2.6)σ

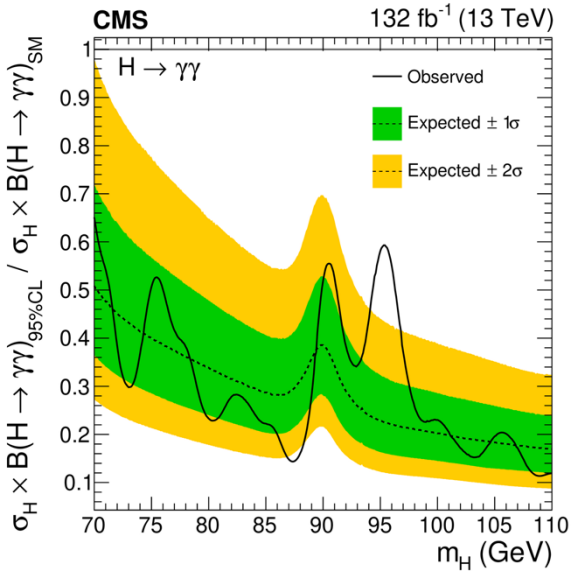


Scalar: ϕ→ττ
m_ϕ~100GeV 3.1(2.7)σ
m_ϕ~1TeV, 2.8(2.2)σ





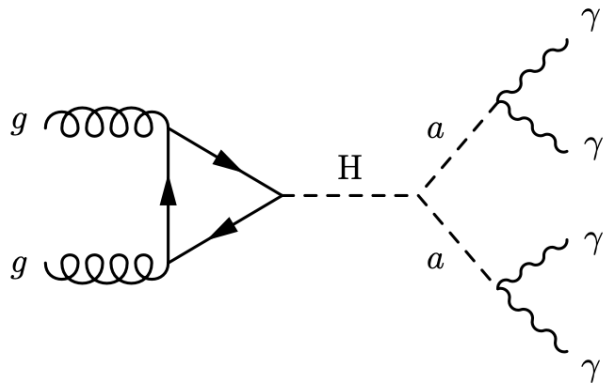
Light Higgs:
h→γγ at
m_h~95GeV,
2.9(1.3)σ



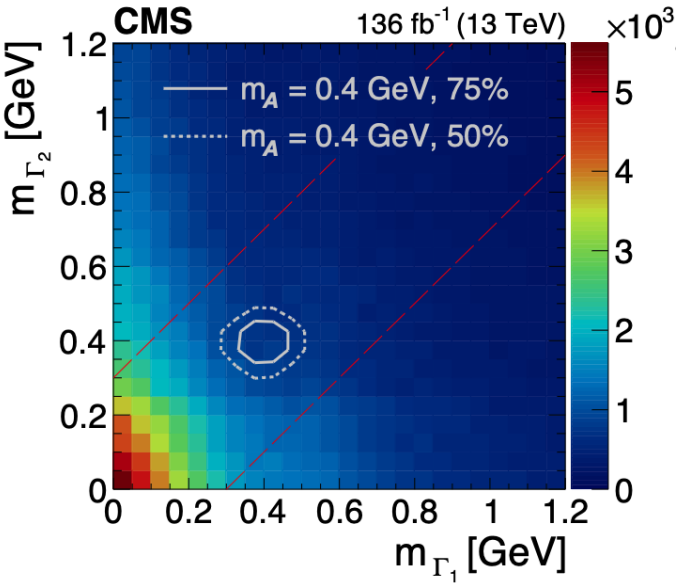
Exotic decays: H→aa→4γ

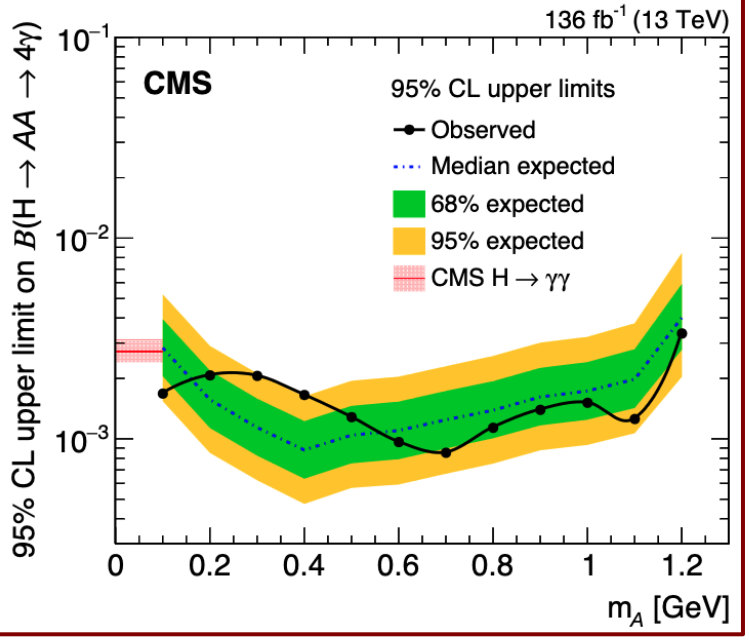
2209.06197, 2208.01469, 2601.00183

- Exotic Higgs decay to light pseudo-scalar A
  - Motivated in BSM extensions (ALPs, DM, etc)
  - (semi-)merged γγ reconstructed as single γ-like object
  - Resolved and boosted topologies
- Model-independent search

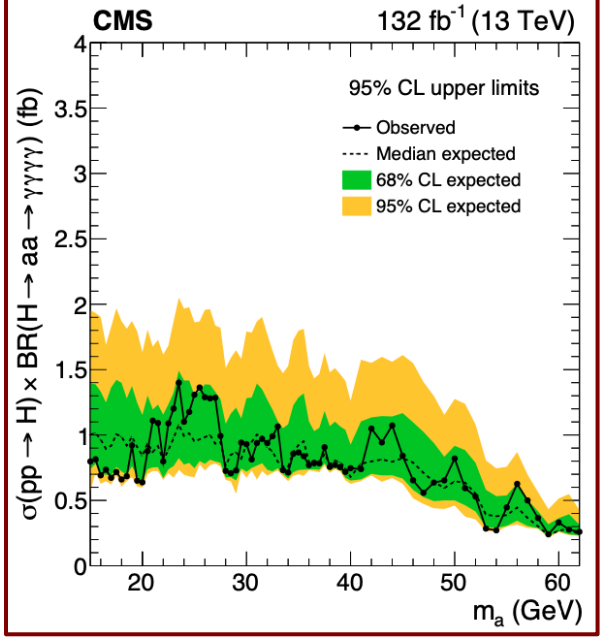


boosted





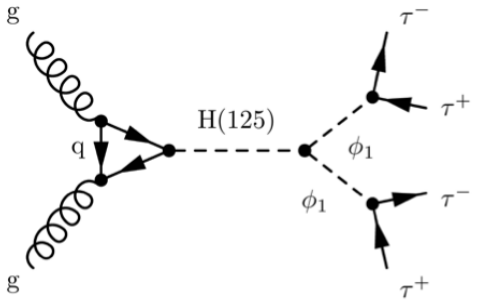
resolved

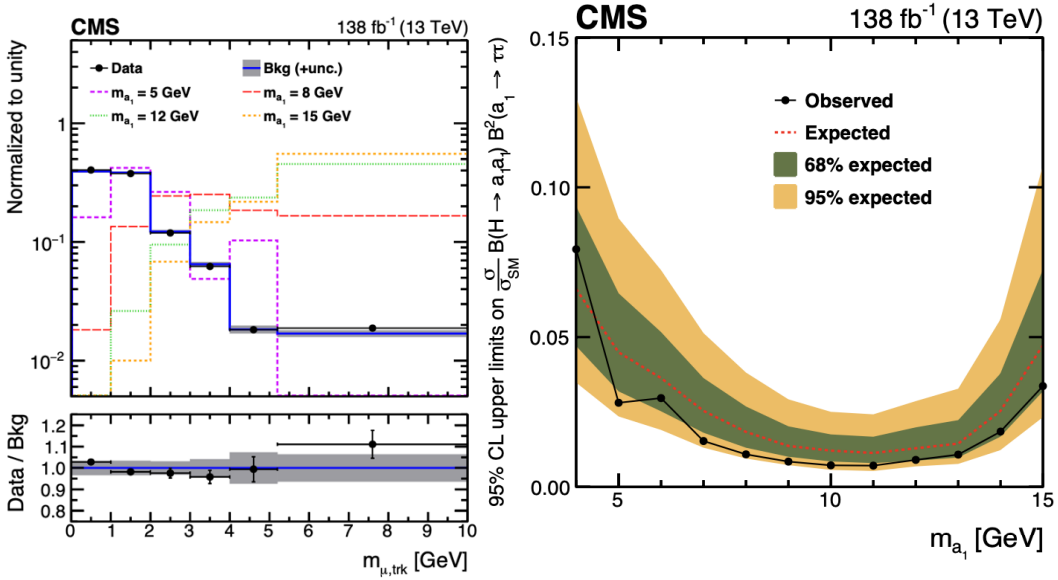


non-SM Higgs decays

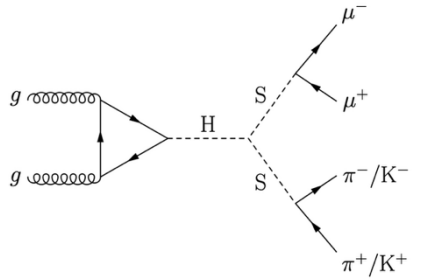
2508.06947, 2605.27875

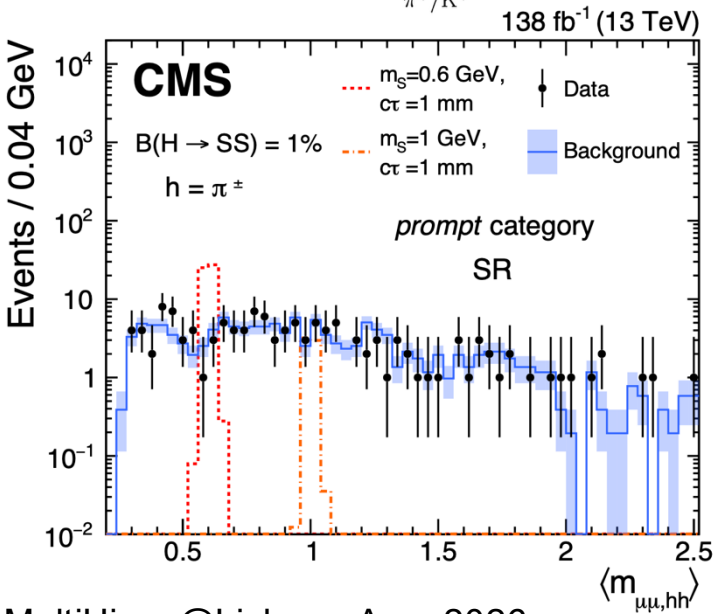
- Search for light pseudoscalar
  - Challenging τ ID (low p_T)
- Reconstruct μ-track invar. mass
  - SS dimuon sample (removes DY, ttbar)





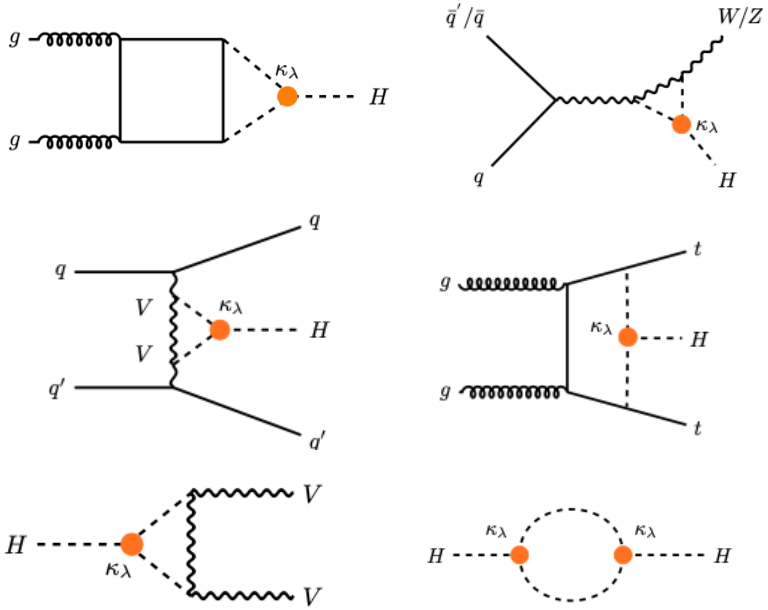
- Search for light scalar in H decays
  - prompt/LL scalar
  - Collimated muon pair, charged hadrons
- Improves sensitivity, m_S=0.4-2.0 GeV

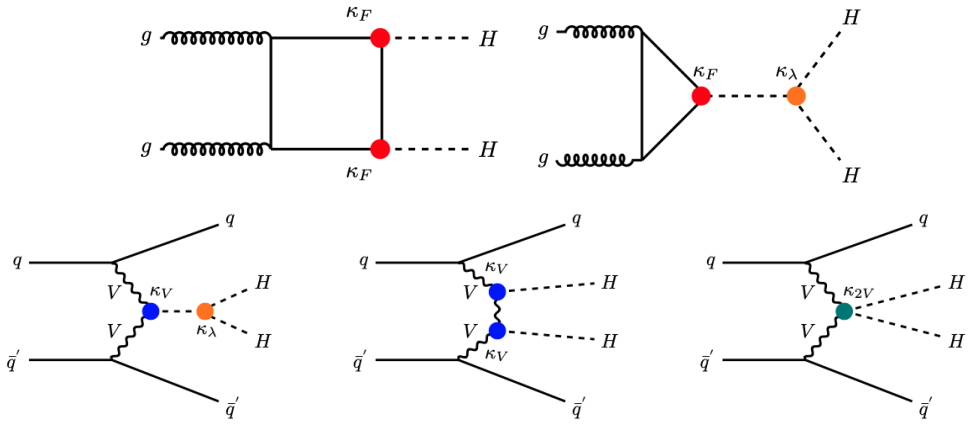




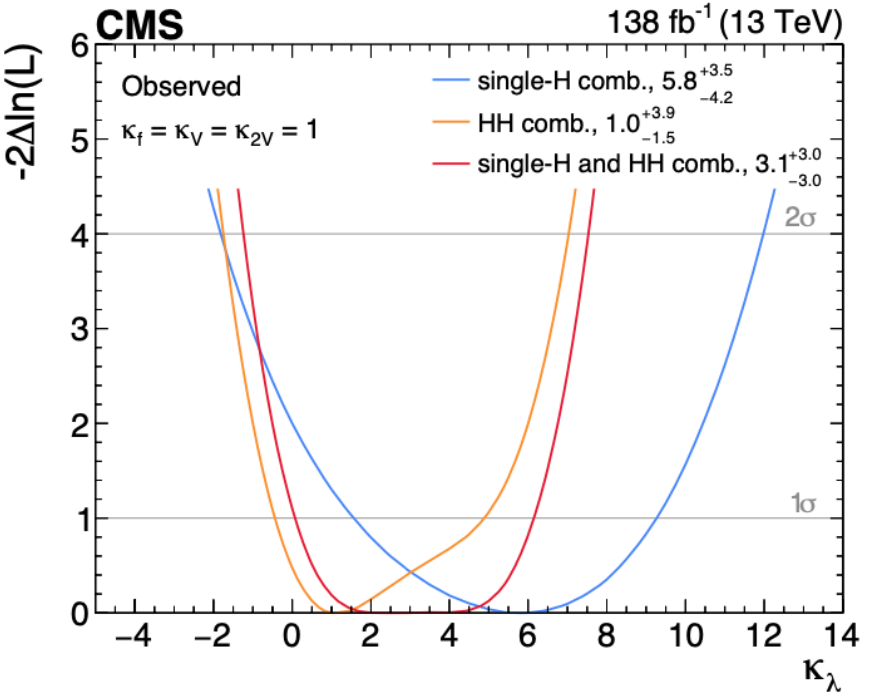
Self-coupling: H and HH

2407.13554



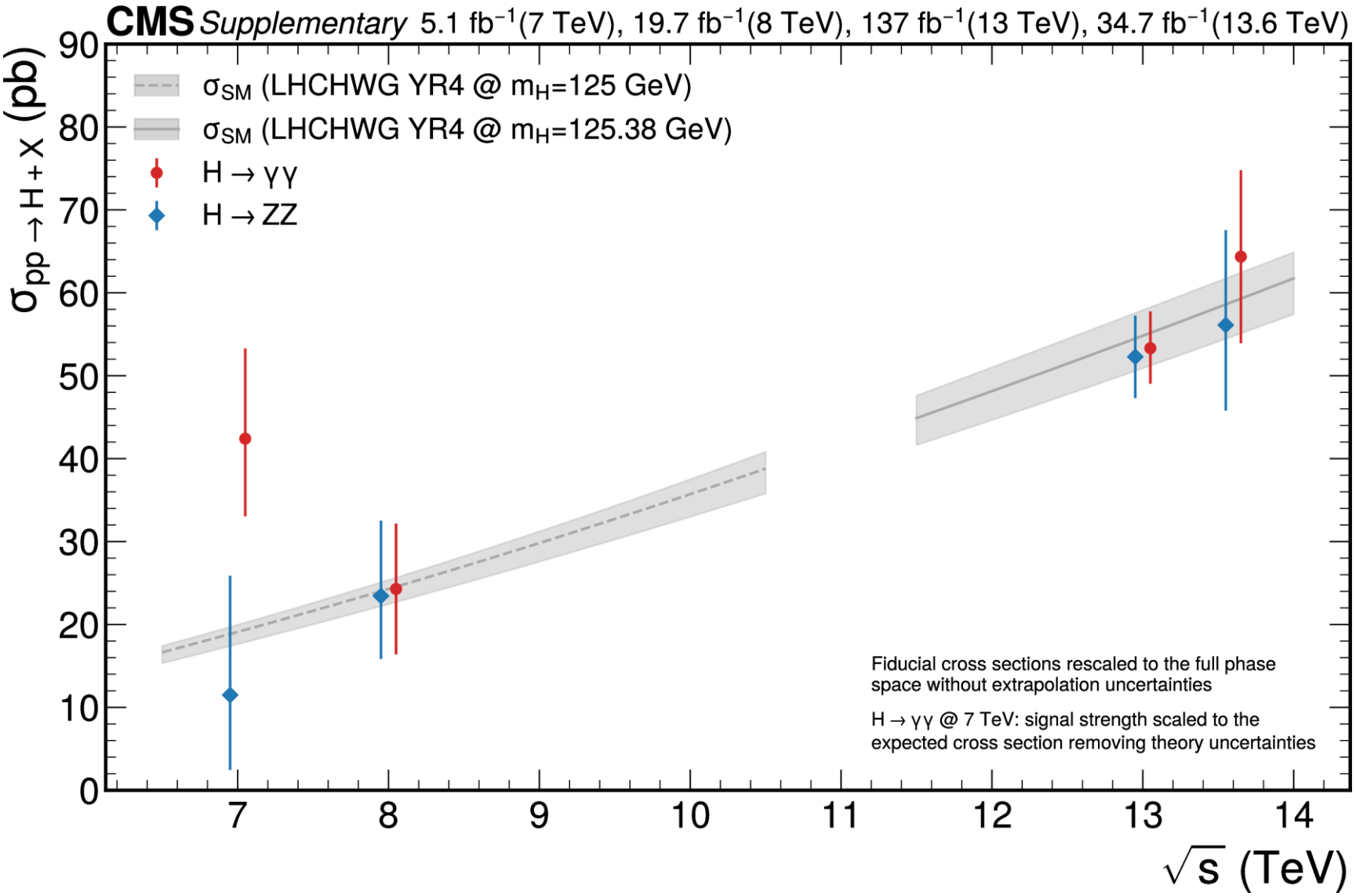


- Set constraints on H self-coupling
- Use H and HH results:
  - HHVV coupling (k_{2V}) affects VBF HH mechanism
  - H: Use NLO EWK corrections



Cross section vs √s

2504.17755



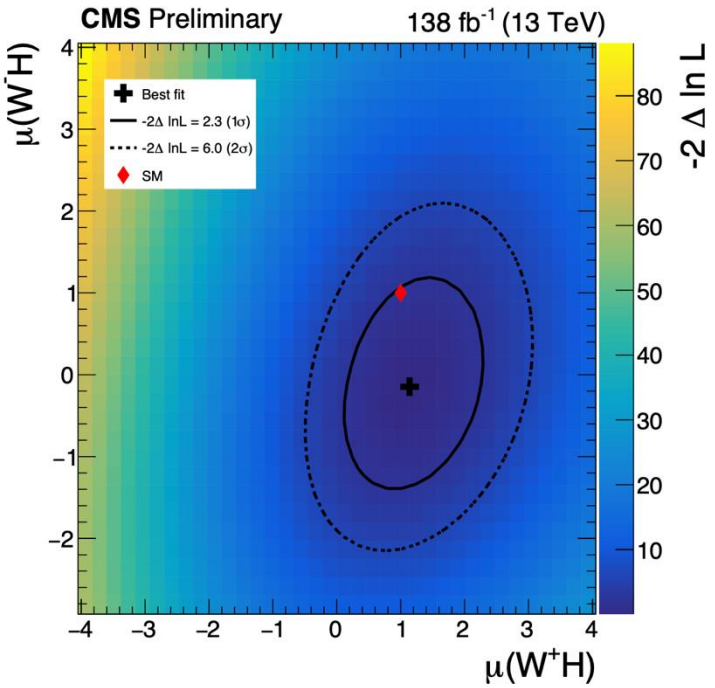
Rare production modes

CMS-HIG-24-019, 2604.24531

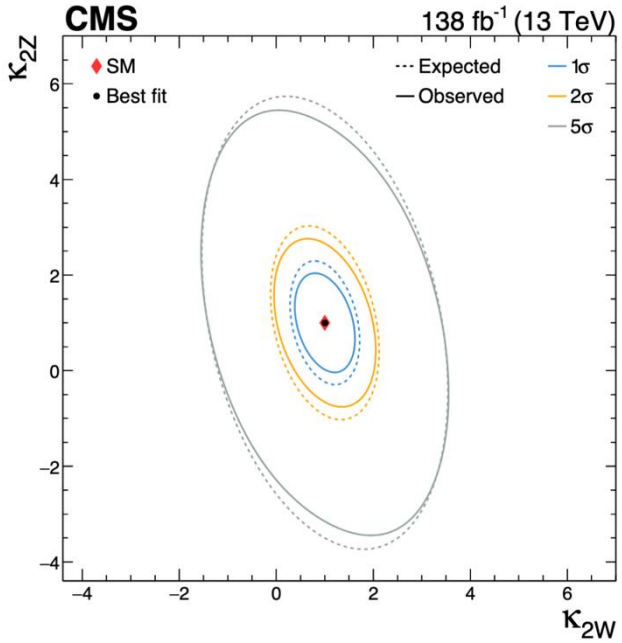
- First measurement of charge asymmetry in WH($\tau\tau$) production

$$A = \frac{\sigma(W^+H) - \sigma(W^-H)}{\sigma(W^+H) + \sigma(W^-H)}$$

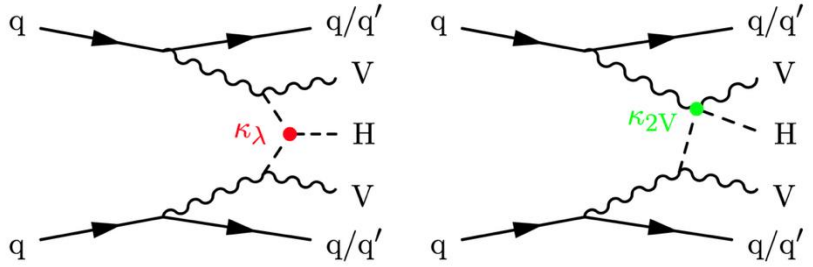
A=0.22 expected due to proton PDFs



- Results may be interpreted in terms of constraints on Yukawa couplings



- VVH(bb) sensitive to self (k_λ) and quartic (k_{2V}) couplings
  - H reconstructed as large-cone jet

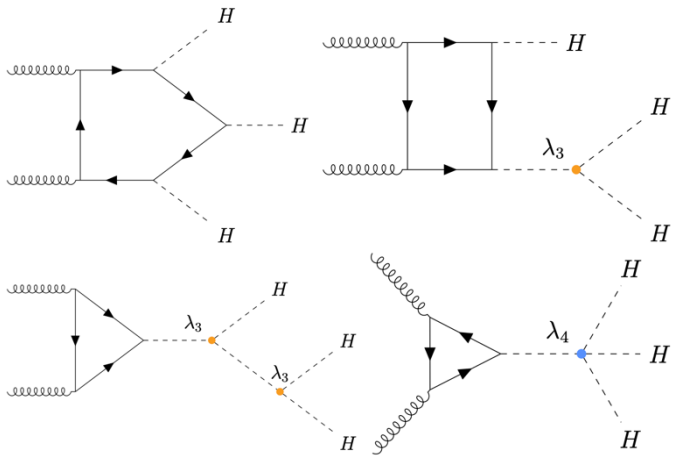


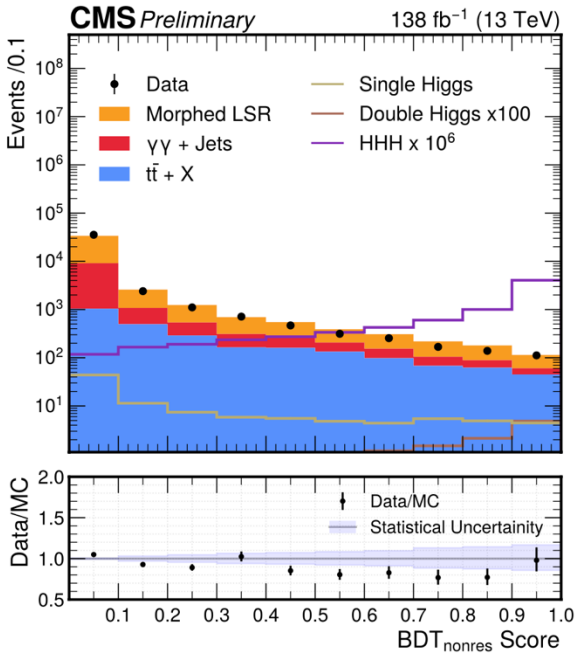
Triple Higgs production

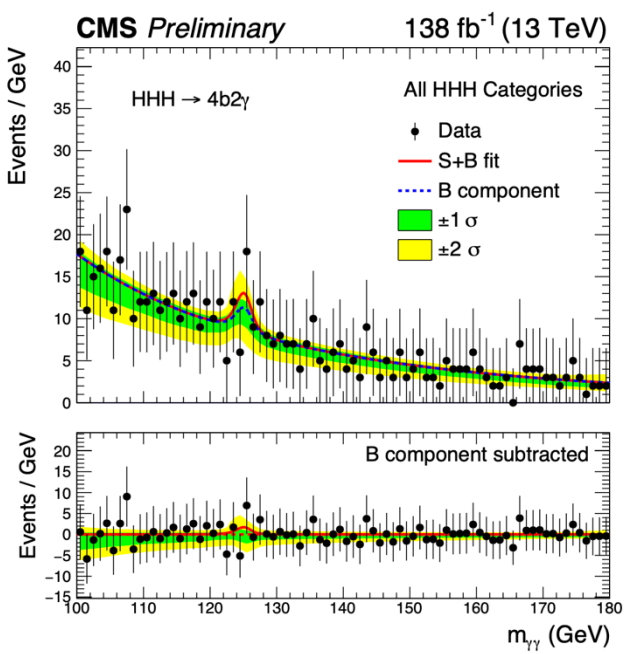
HIG-24-015

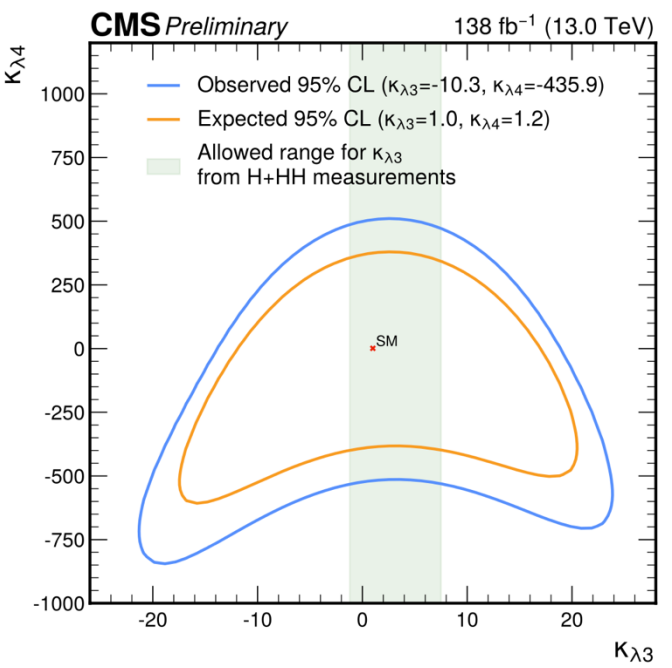
- Search for HHH production at 13TeV
  - 4b2γ final state (BR~0.2%)
  - Parametrized wrt λ_3 and λ_4 couplings
  - dominant bkg from ttH
- In SM, σ=0.079fb@13TeV

$$\sigma(gg \to HHH) < 243.96(152.0^{+199.3}_{-80.47})\ \text{fb}$$





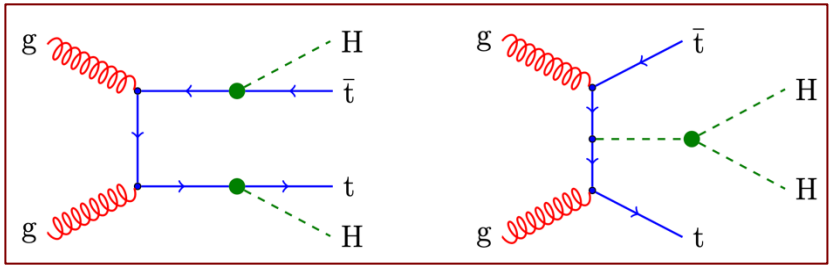




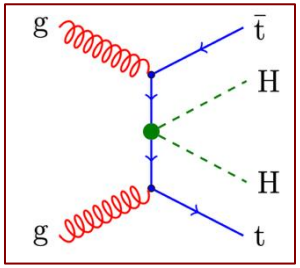
ttHH

HIG-24-016

- Search in tt(SL)HH(4b) channel
  - 1 lepton+≥5(4) (b-)jets
  - DNN event classifier (9 classes)
- Results interpreted in HEFT

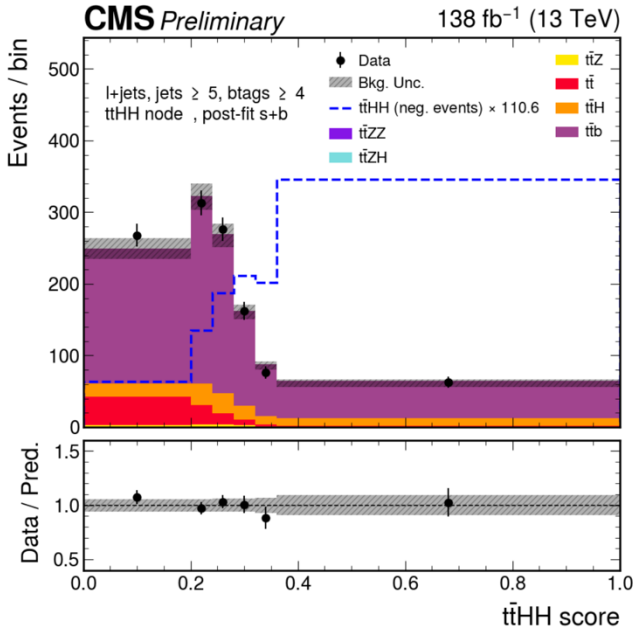


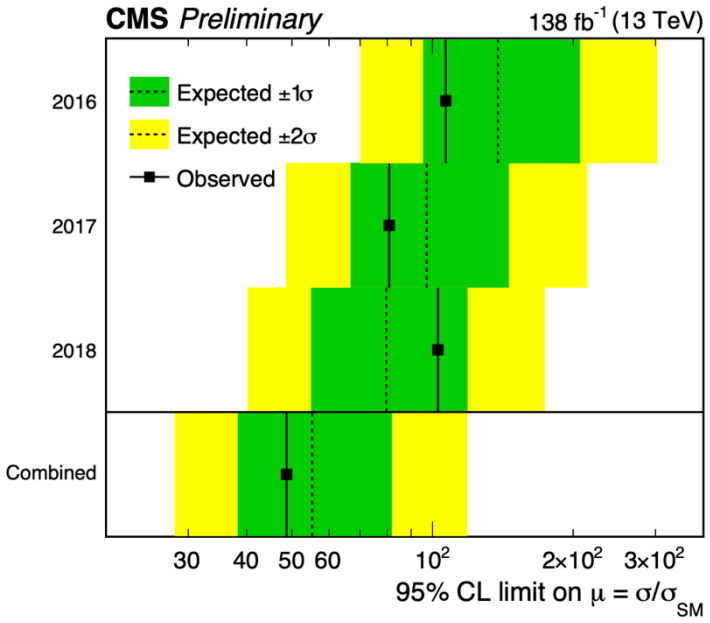
SM

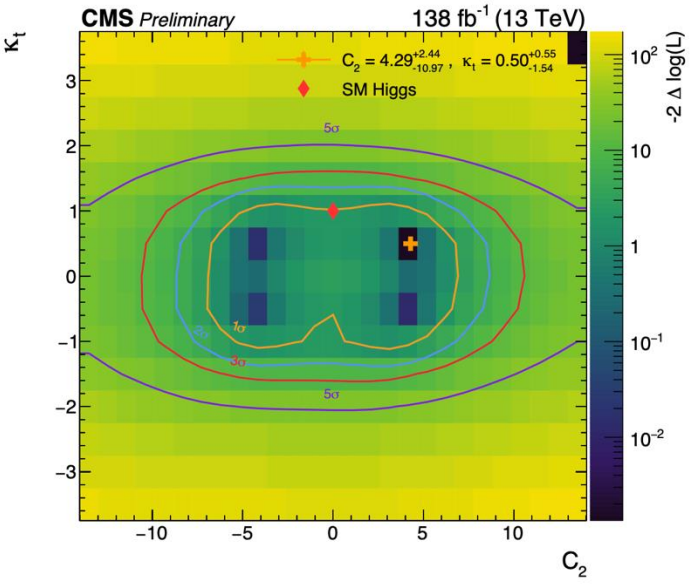


BSM

$$\sigma < 37(42)\ \text{fb obs(exp)},\ \mu = -9^{+26}_{-25}$$





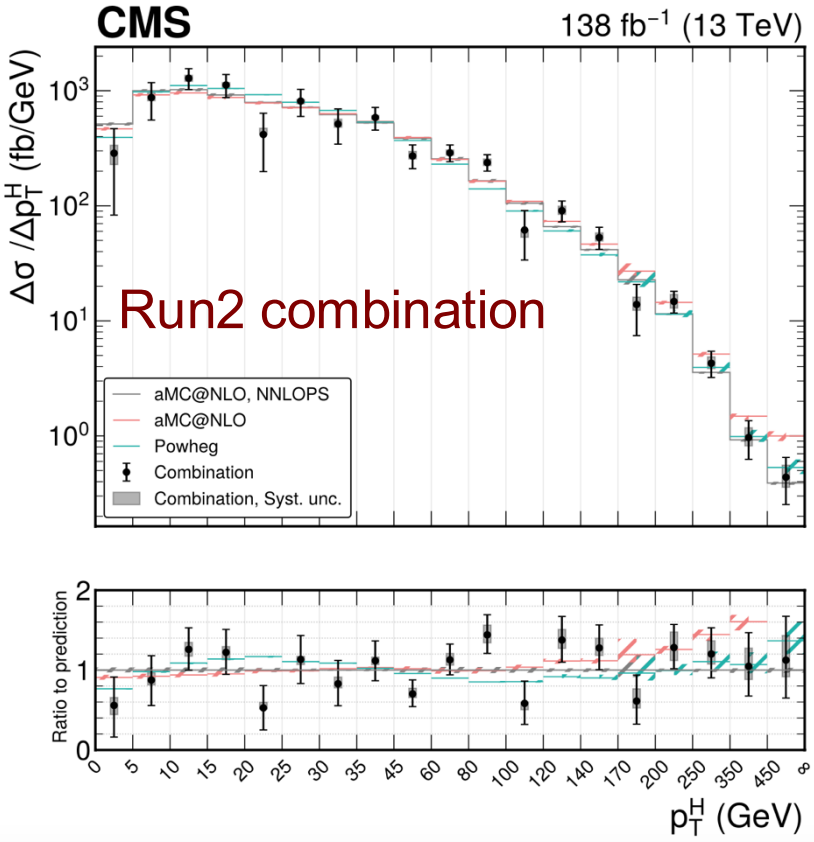


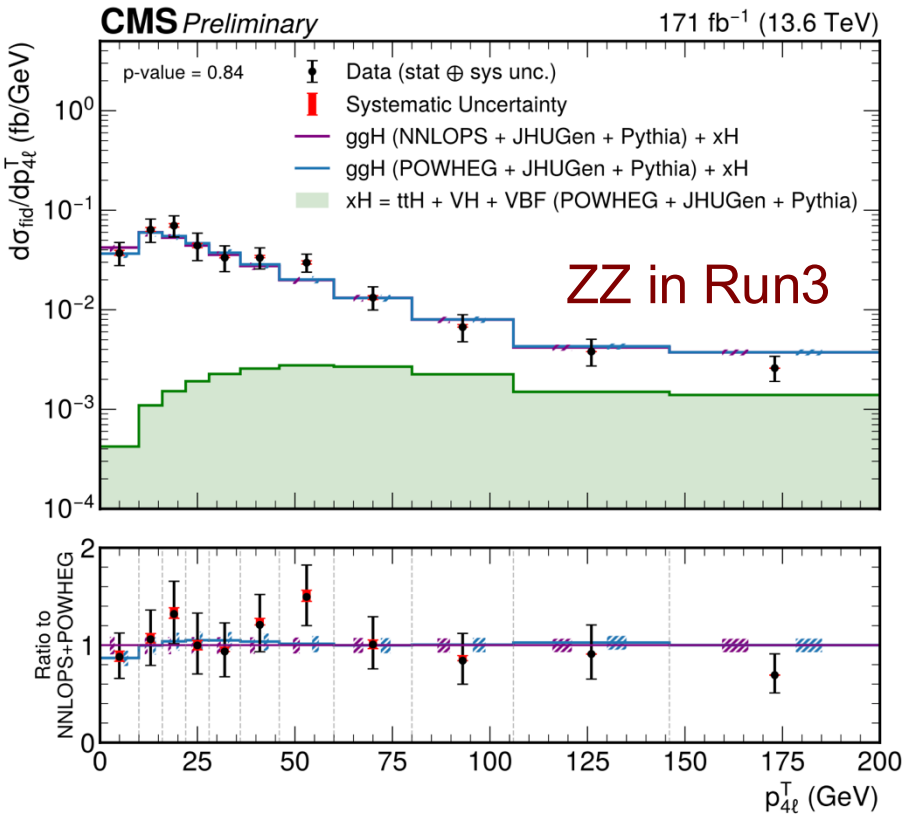
Differential distributions

2504.13081, HIG-25-015

- 1-D and 2-D variables measured in several channels
- BSM effects can be enhanced in tails of distributions
- Good agreement of data with predictions

$$\frac{1}{\sigma_{t\bar{t}}}\frac{d\sigma_{t\bar{t}}}{dX}$$

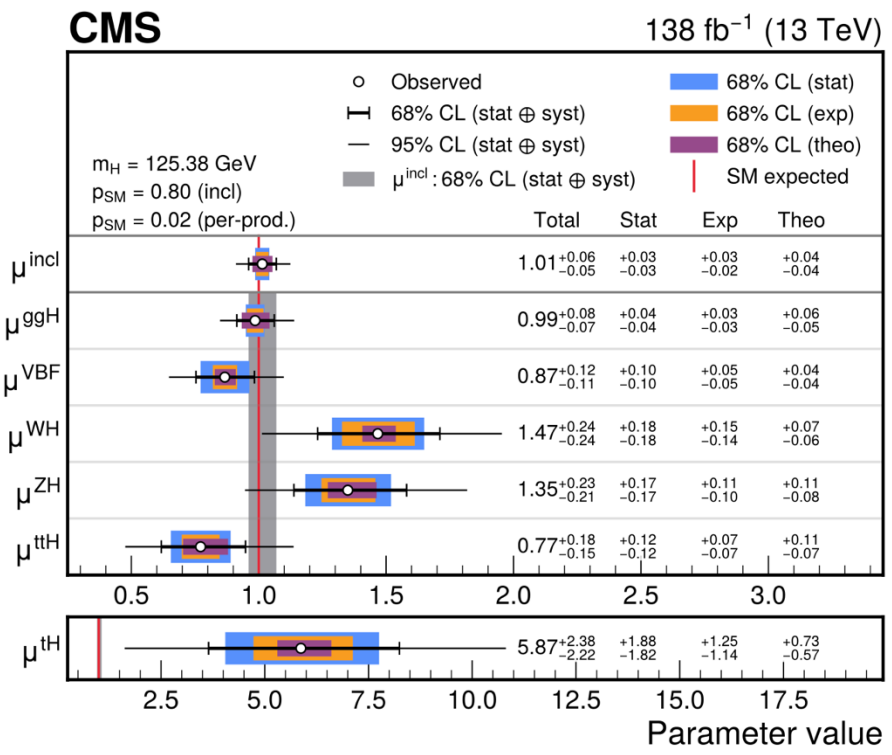


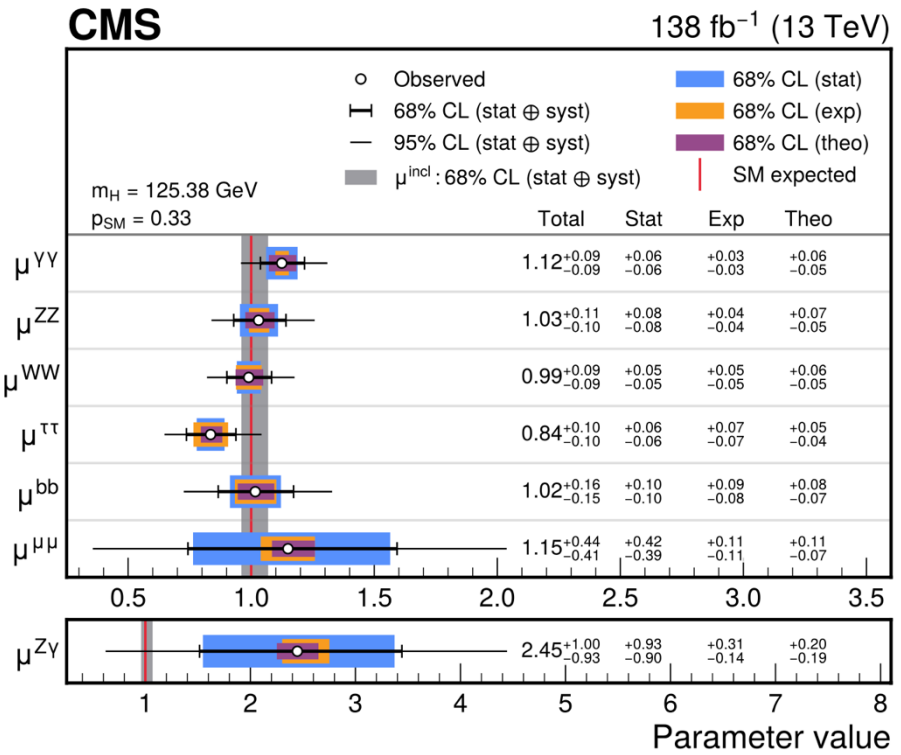


Couplings

2602.18611

- The Higgs boson discovery marked LHC Run 1
- Run 2 and Run 3 are eras of precision measurements
- Wide variety of final states explored
  - Each channel probes different phase space and brings complementary information
- All main decay modes have been measured (>5σ)

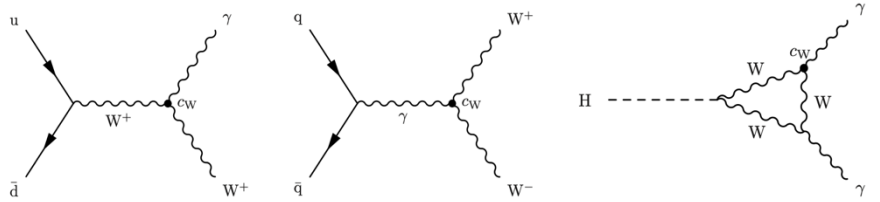


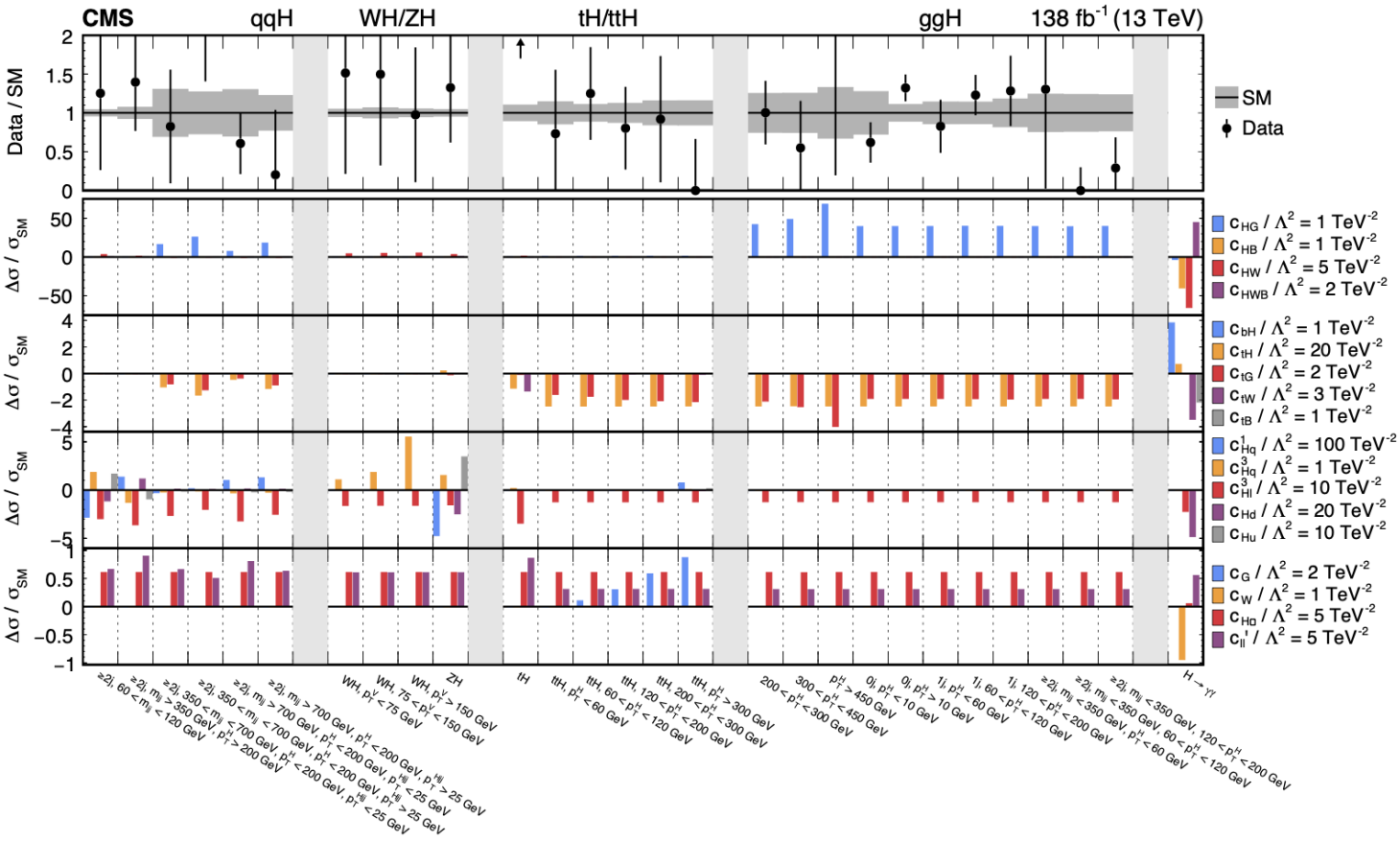


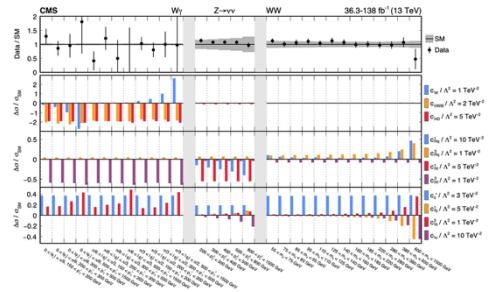
SMEFT interpretation (cont.)

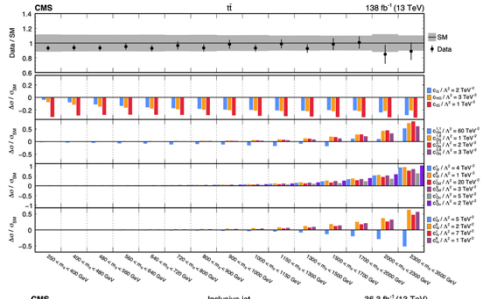
arXiv:2504.02958

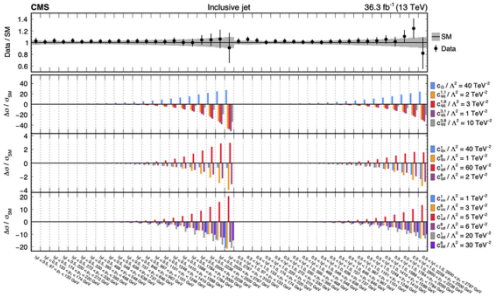
- Set constraints on Wilson coefficients
- Combined interpretation of Higgs, EWK, top, multijet measurements







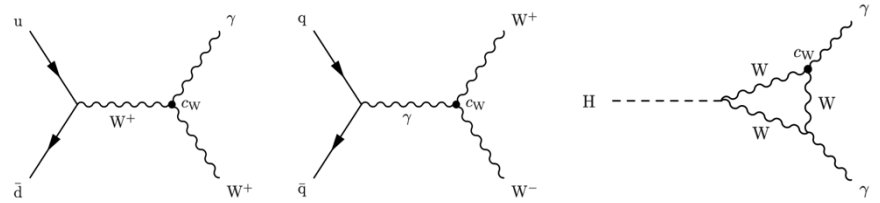


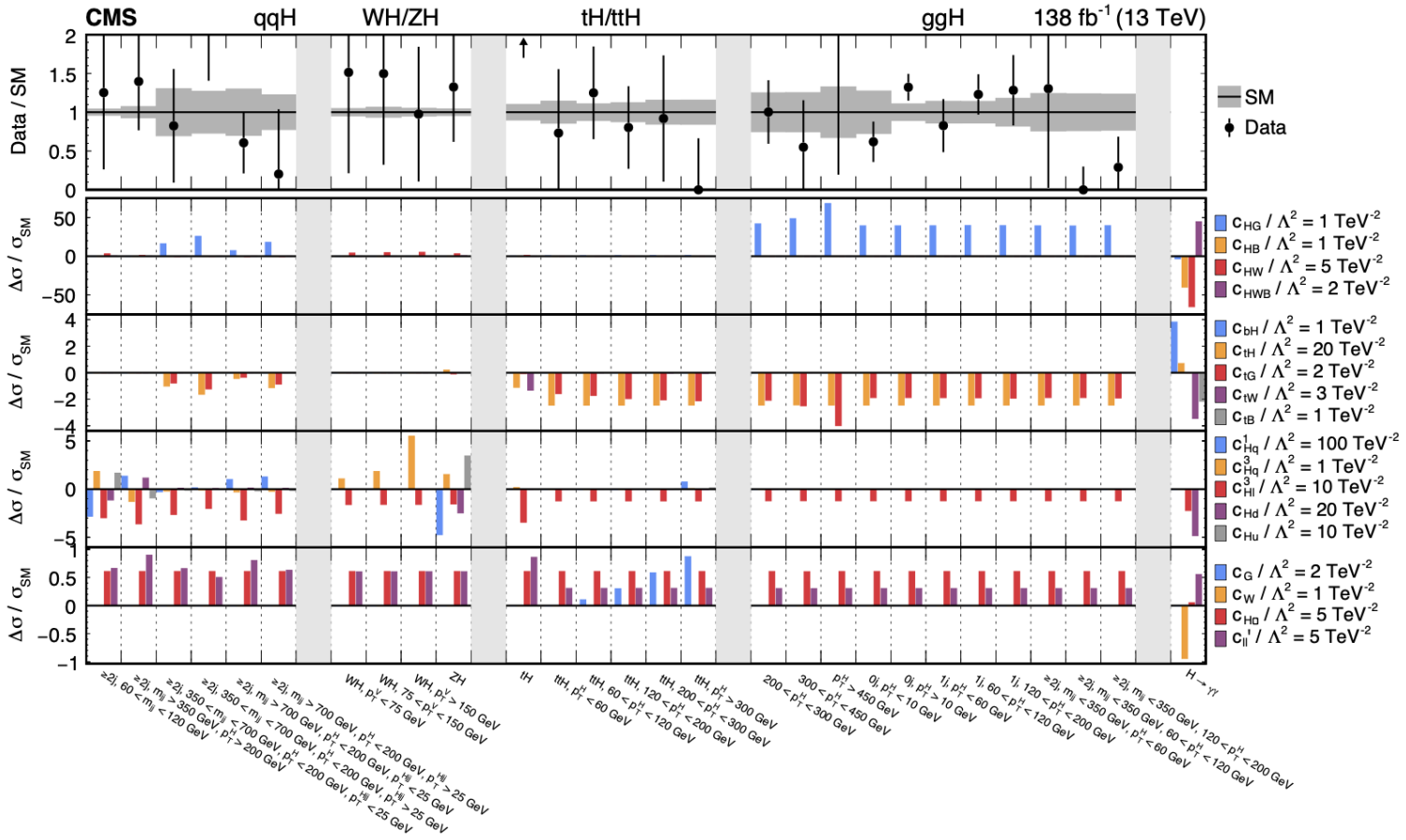


SMEFT interpretation (cont.)

2504.02958

- Set constraints on Wilson coefficients
- Combined interpretation of Higgs, EWK, top, multijet measurements

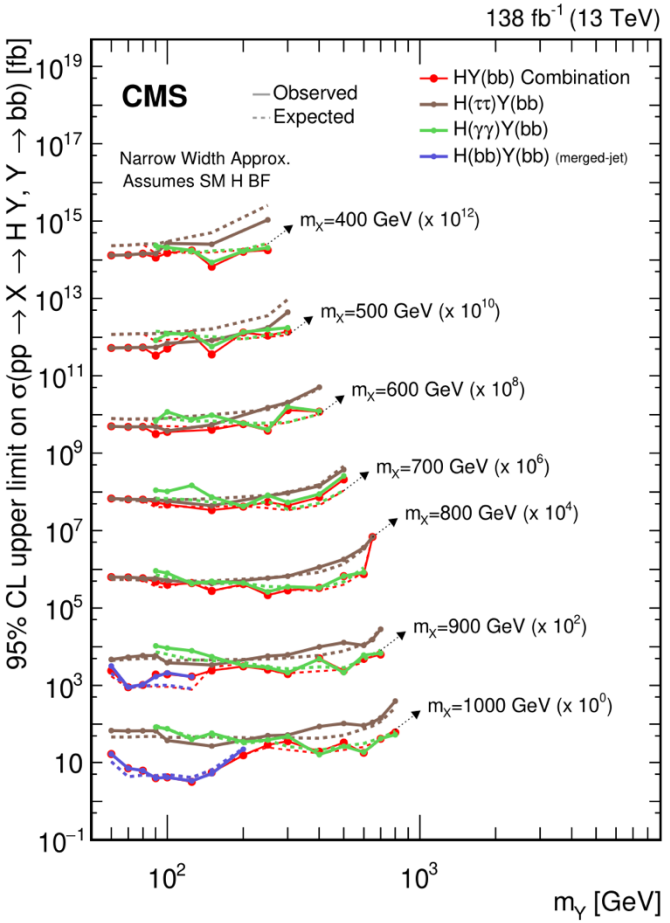




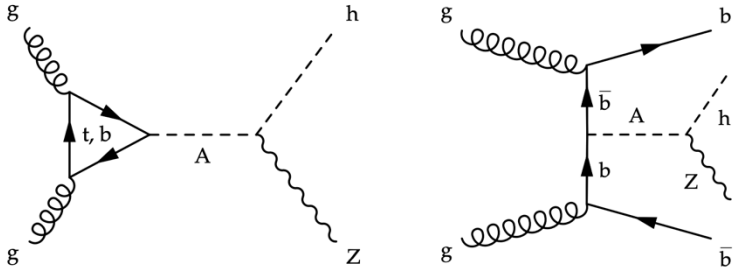
Heavy resonances

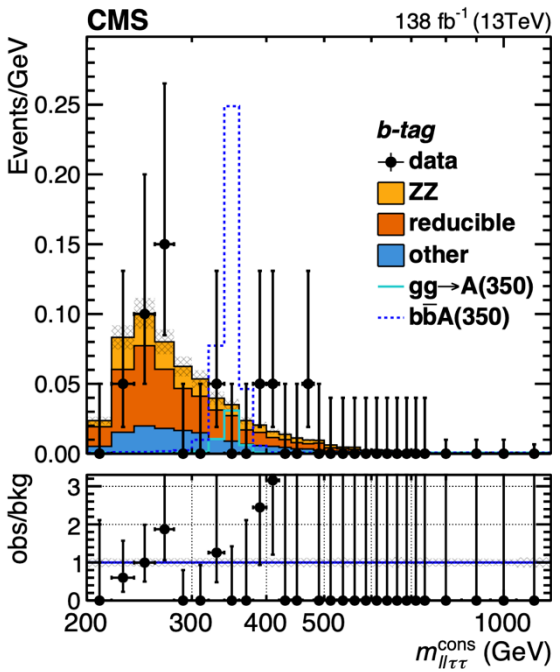
2403.16926, 2508.11494, 2501.14825

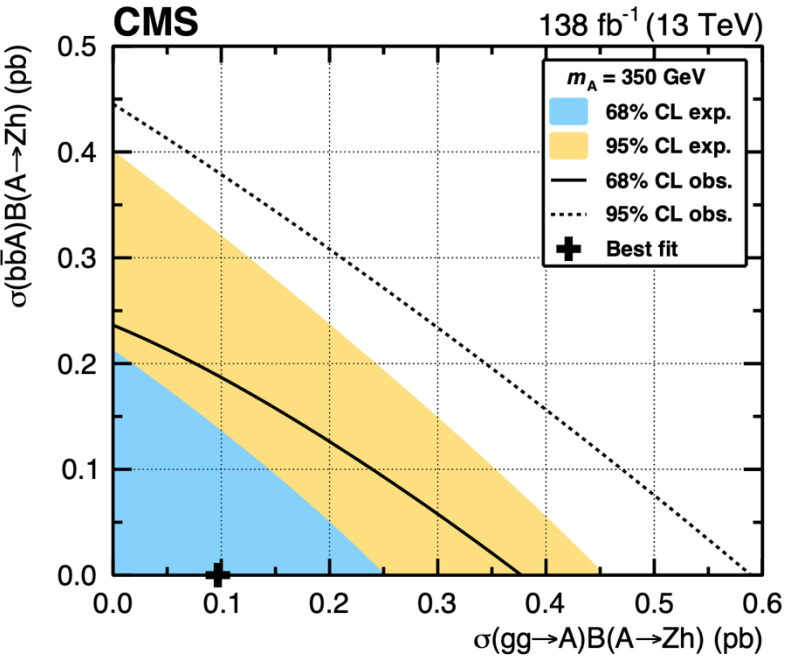
- Searches for Higgs through decays of heavy resonances
  - X→YH



- Search for a heavy pseudoscalar: A→H(ττ)Z(ℓℓ)



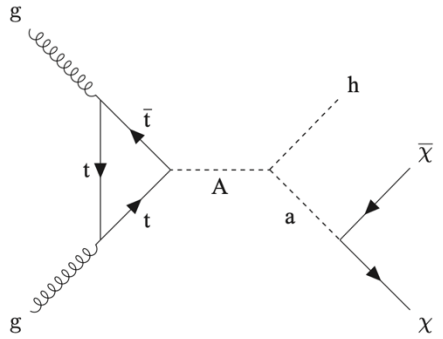


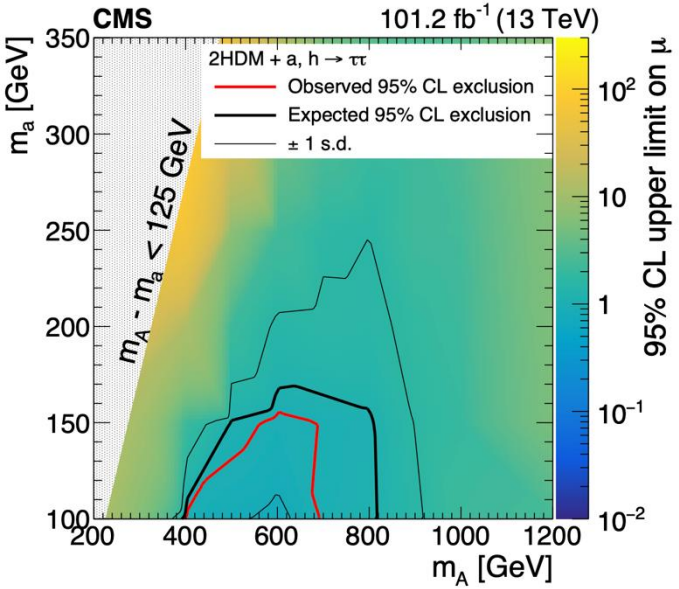


Dark Matter

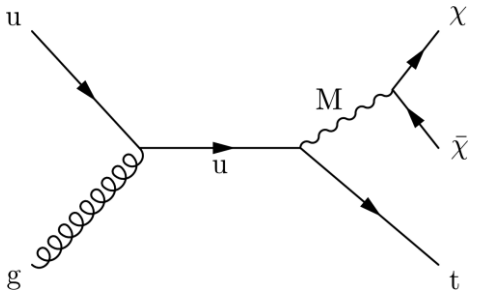
2506.04431, 2503.20033, 2604.20999

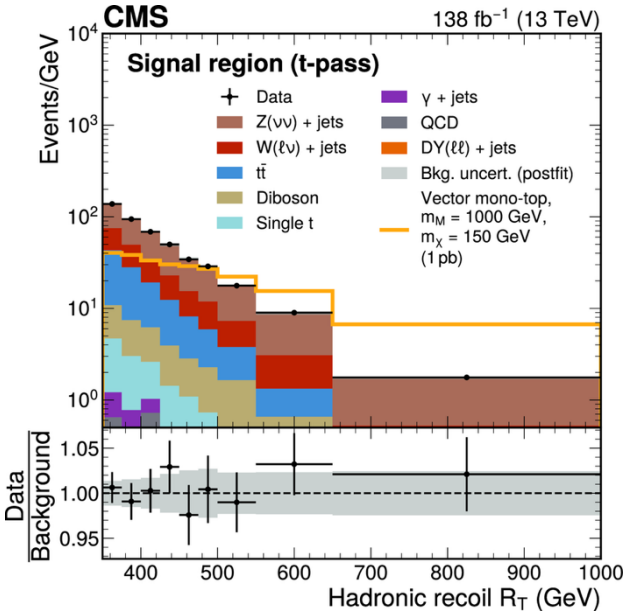
DM in association with Higgs($\tau\tau$)



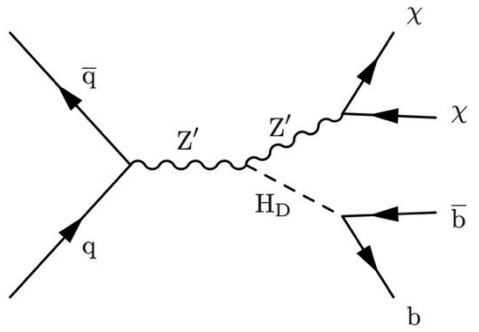


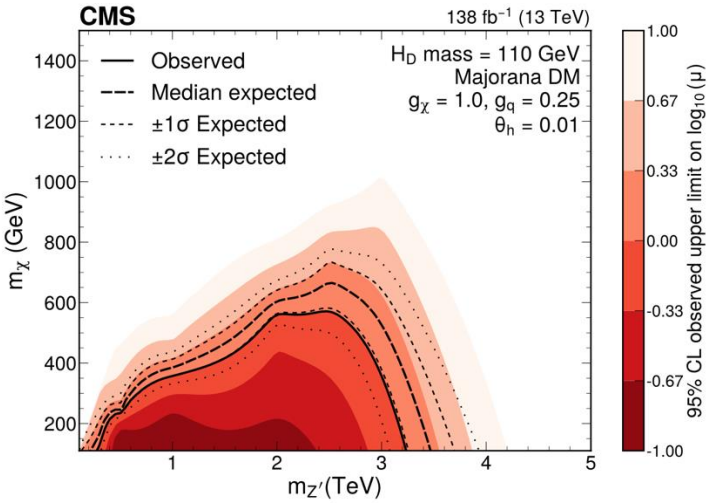
DM in association with top





DM in association with bs

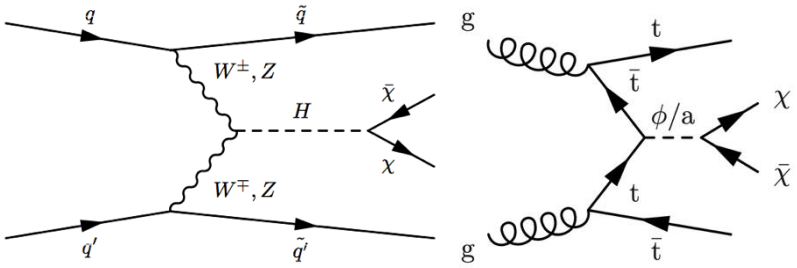


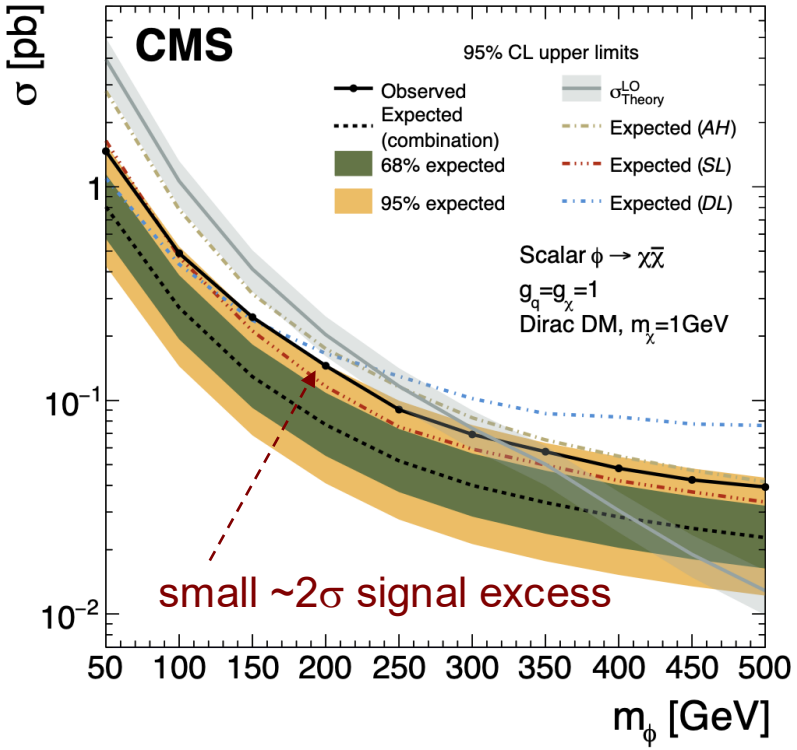


DM: Invisible decays

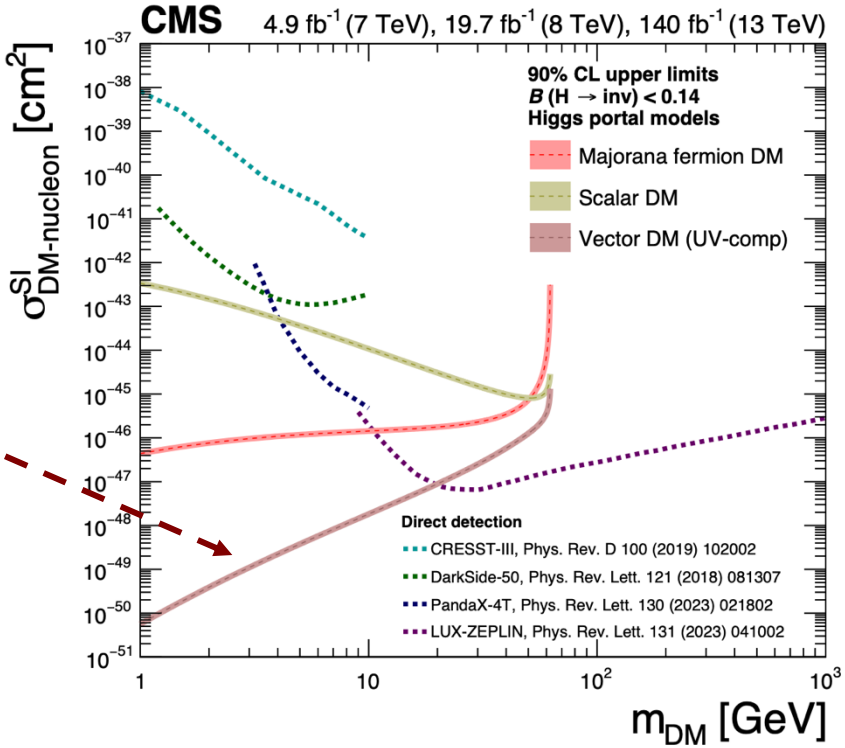
2405.13778, 2303.01214, 2505.05300

- In the SM, BR(H→inv) is ~0.1%
- Search for invisible decays in VBF and associated prod.
- Set limits on DM models
  - Upper limits: 0.15(0.08exp)@95%CL
- Limits interpreted in the context of Higgs portal models





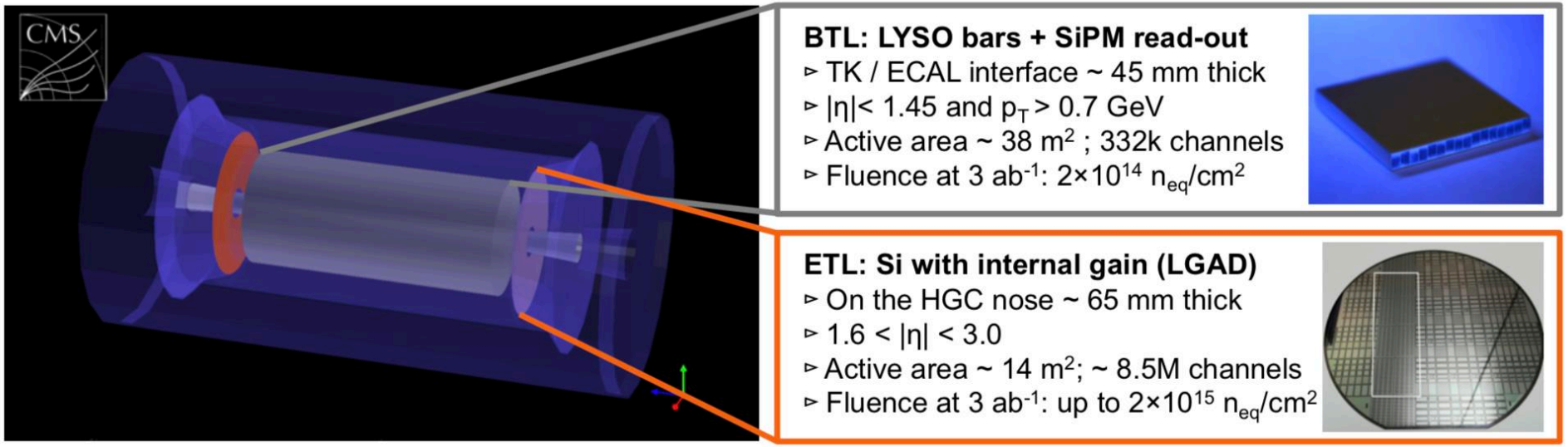
⇒ results complement direct searches at low masses (<5-10GeV)



MIP Timing Detector

CERN-LHCC-2019-003

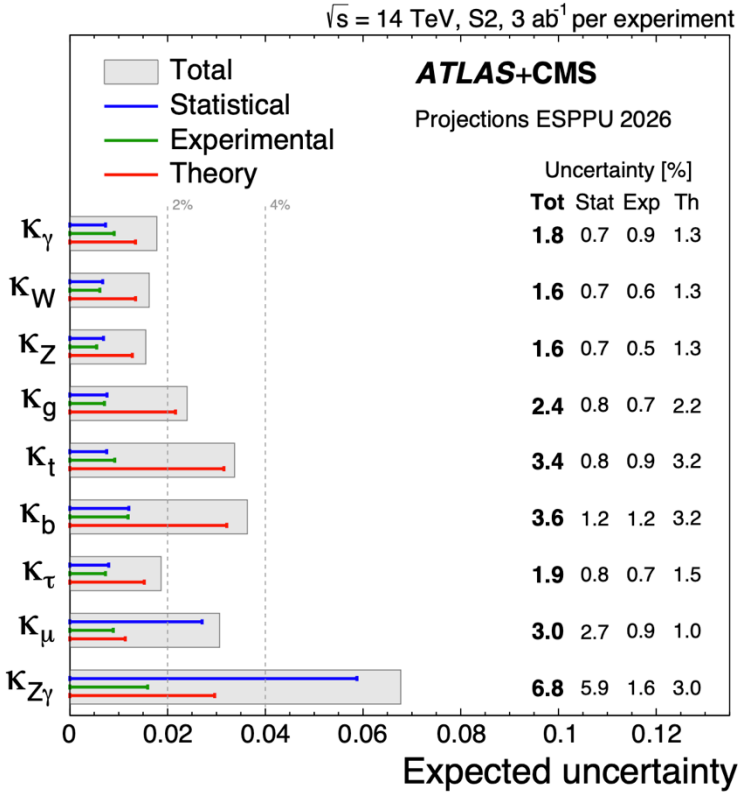
- High precision time measurement of MIPs
  - 30-40 ps at start, degrading to <60ps at 3000 fb^{-1}
  - Provide track-vertex association
  - Improve sensitivity to slow particles, add particle ID capabilities, etc.

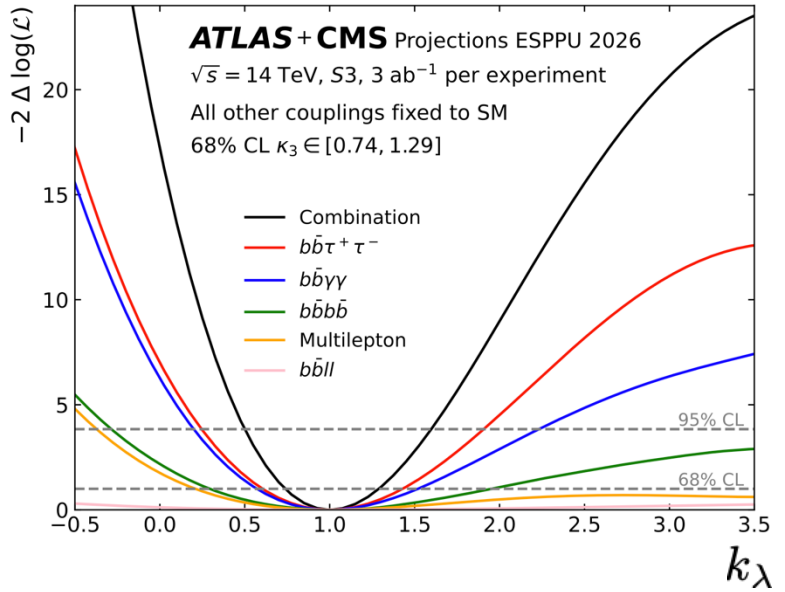


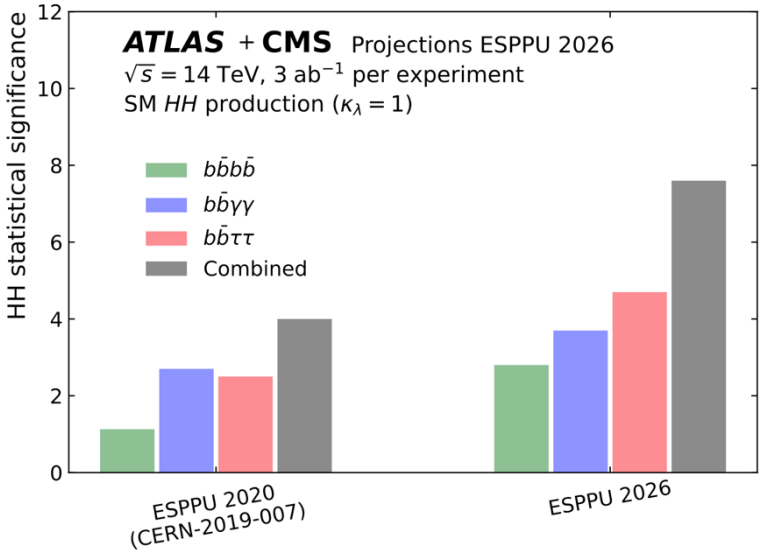
Looking ahead

2504.00672

Updated physics projections for ESPP



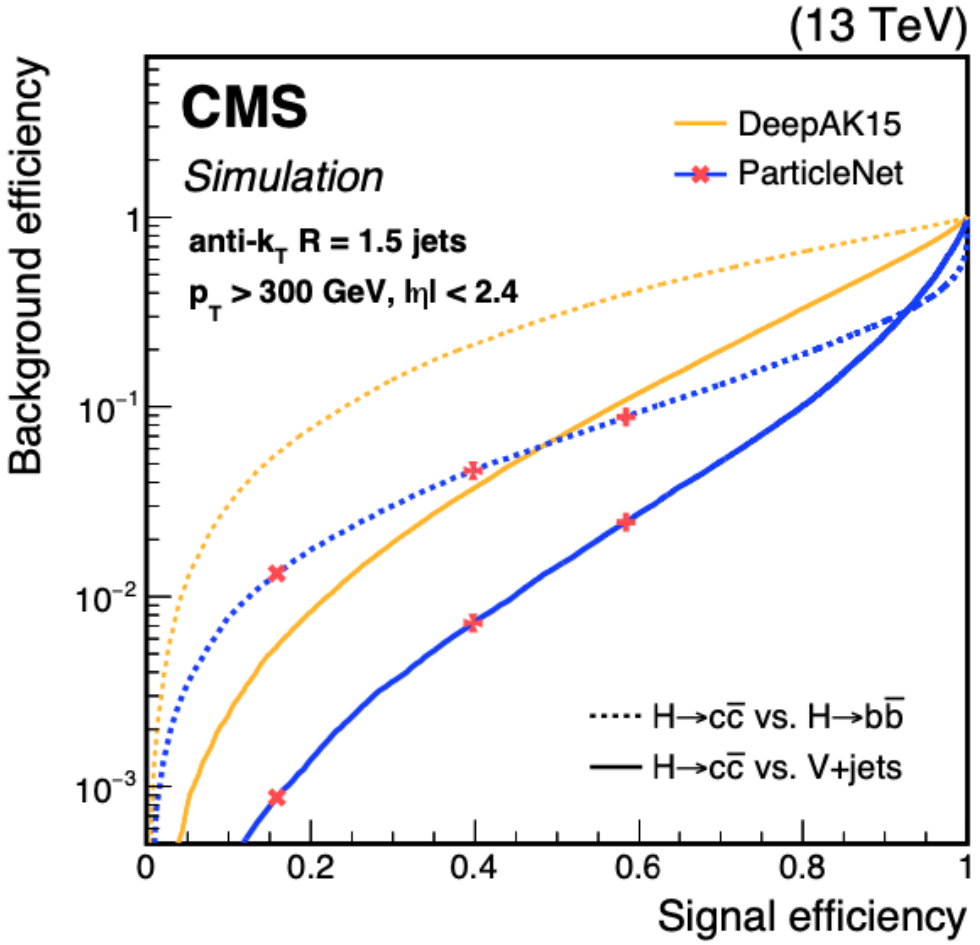




Evidence for HH production with 2ab^{-1} in CMS (S2)

Charm tagging

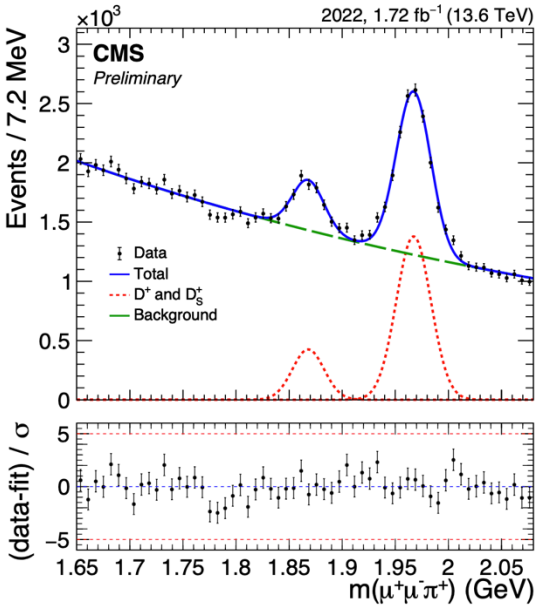
- ParticleNet: Use of PF and secondary vertices associated to large-R jets
- Exploits jet substructure, flavor, pileup with GNN
- Regression algorithm to improve mass reconstruction

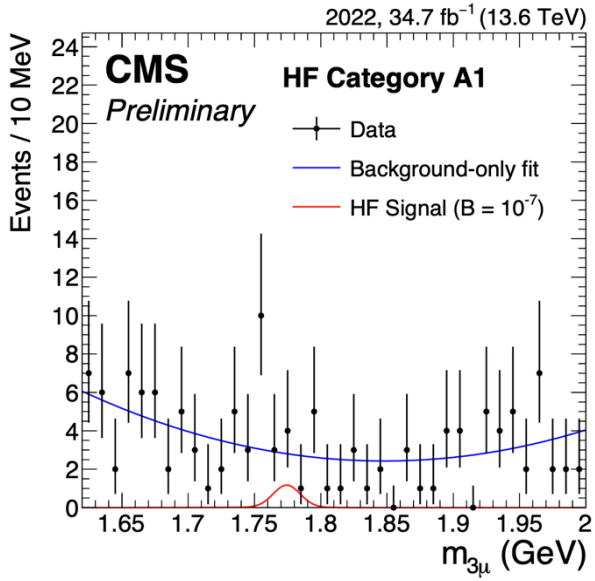


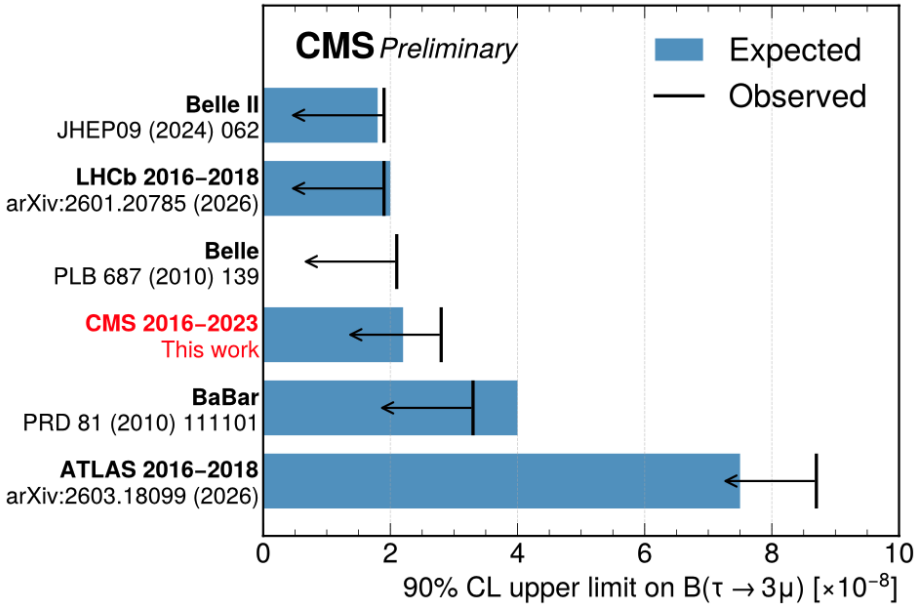
LFV: $\tau \longrightarrow 3\mu$

BPH-24-010

- LFV decay of $\tau \longrightarrow 3\mu$
- Use data parking
  - Rare decay in SM
  - τs from HF hadron decays (cs and bs) and EWK decays (Ws, Zs)
  - Validated using $D_s^+ \longrightarrow \phi\pi^+ \longrightarrow \mu^+\mu^-\pi^+$
- Run2+Run3(194fb^{-1}): BR<2.8(2.2) x10^{-8}



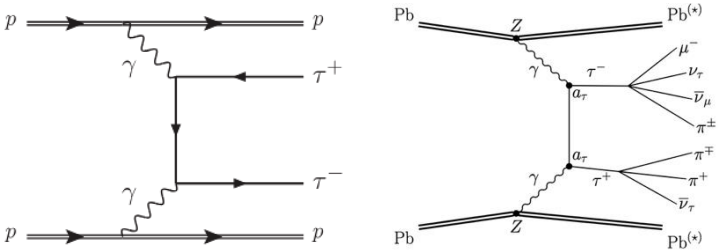


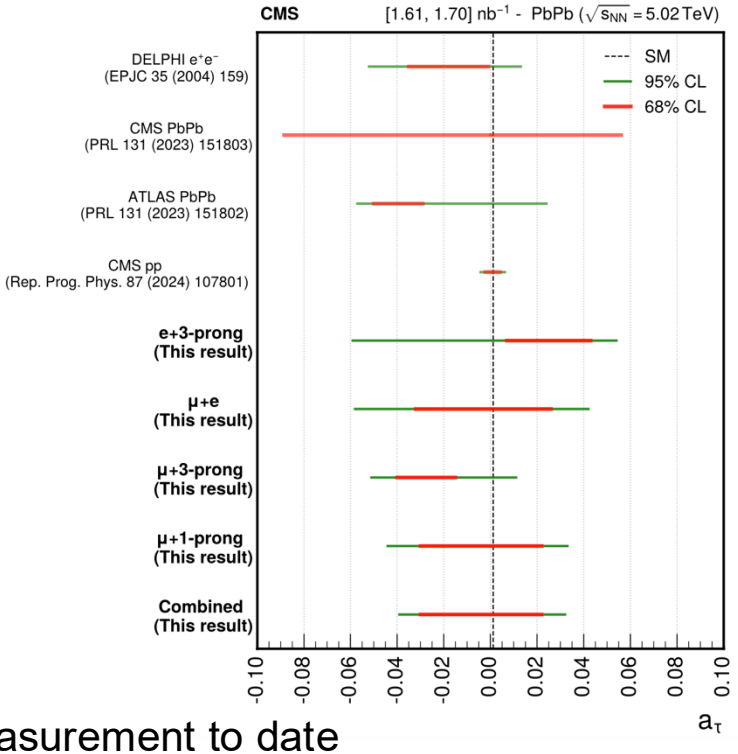


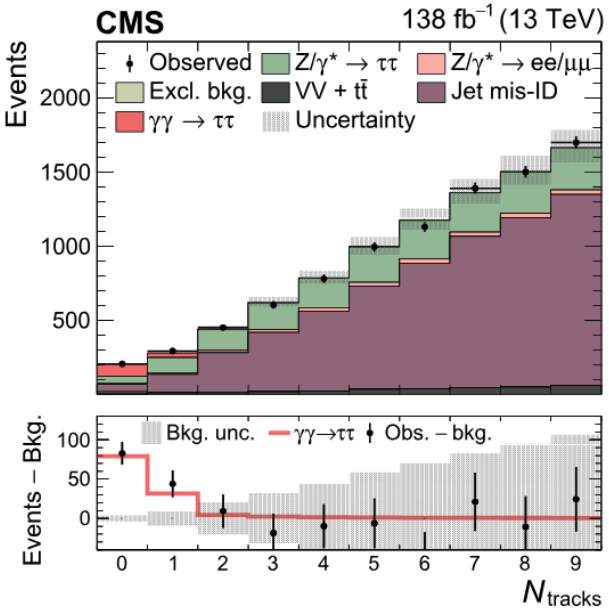
Tau lepton: g-2

2406.03975, 2607.20148

- Anomalous magnetic moment (a_τ) provides stringent tests of SM ⇒ sensitive to NP
- Use photon-photon collisions to probe exclusive τ lepton pair production
  - Exclusivity by requiring PV with ≤1 extra tracks
  - Use hadronic and leptonic τ decays
- LHC as photon collider (pp and PbPb collisions)
  - Dependence on Z^4 (Z=82 for Pb) enhances photo-production xsection







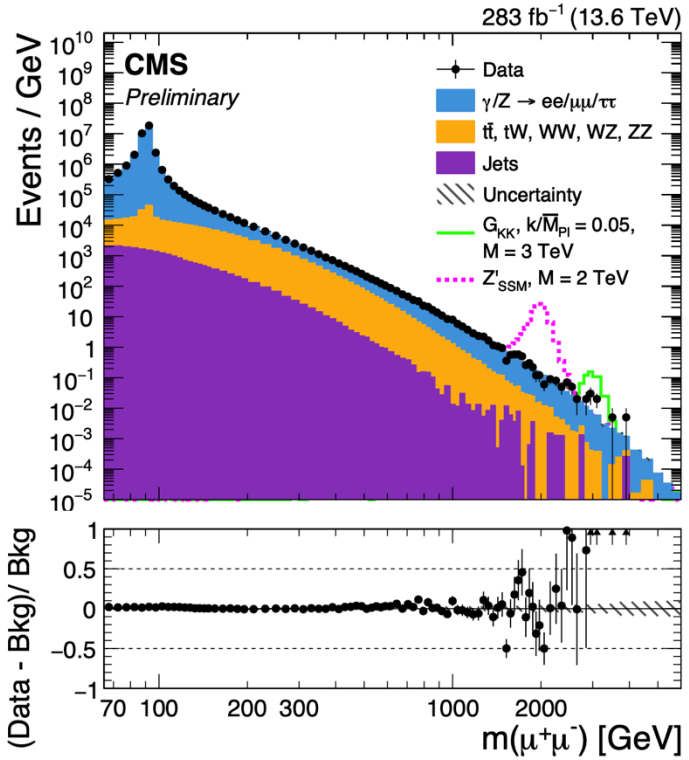
Most precise measurement to date

$$\sigma^{\text{fid}}_{\gamma\gamma\to\tau\tau} = 555^{+60}_{-14}\mu\text{b}$$

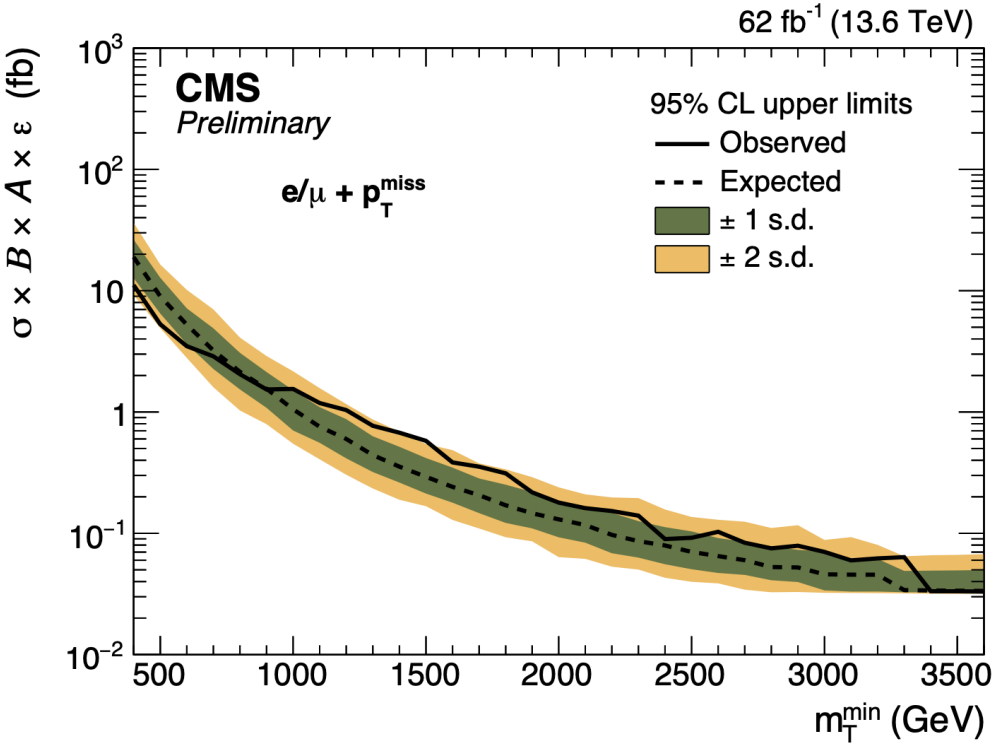
BSM “Classics”

EXO-25-021, EXO-24-021

- High-mass dilepton resonances
  - Based on 2022-25 Run3 (283 fb^{-1})
  - Electron and muon pairs
  - Wide mass range: 0.2-6 TeV
  - Most stringent $m_{Z'}$ limits: 5.6(5.8) TeV



- W′ decay to e/mu+pTmiss
  - Based on 2022-23 Run3 (62 fb^{-1})
  - Obs(exp) 95%CL $m_{W'}$ limit 5.9(6.2) TeV
  - Better than Run2 limits
  - Largely driven by higher c.o.m., trigger



Leptoquarks

B2G-25-011

- Probing coupling of third generation quarks to 1st/2nd generation leptons
- Use 2024-25 data
- Strongest limits on these models to date