



The Latest CMS News and Perspectives for Run 3

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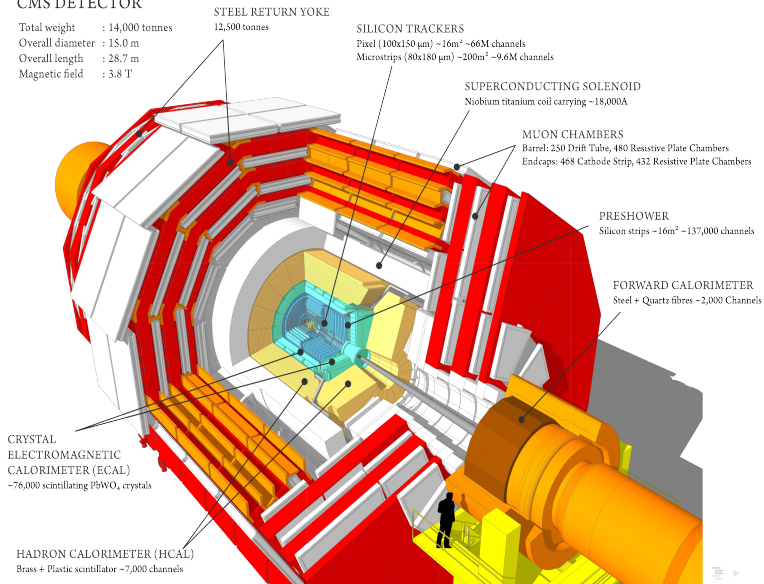
On Behalf of the CMS Collaboration



The CMS Detector

CMS DETECTOR

Total weight : 14,000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T



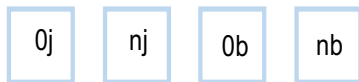
What do we search for?

- Depending on the signal model, we search for different combinations of leptons, photons, jets and, b-jets.
- We also use characteristics of each event to discriminate possible signals from SM processes: displaced vertices, missing transverse momentum (energy) E_T^{miss} , etc.
- In addition, we reconstruct observables based on the topology of the signal process under study: H_T , m_T , α_T etc.

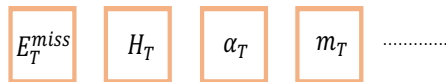
X number of leptons and
or photons



Veto jets (j) and/or b-jets (b)
and/or select nj or nb jets



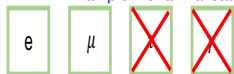
Use some observables based
on the topology of the event



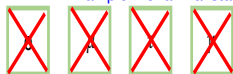
What do we search for?

- As a general rule of thumb, we search for an enhancement of events with respect to the expected background processes from the SM.
- If there is agreement between the background expectation and the observed data, limits are set at 95% CL on the production cross section of such models.

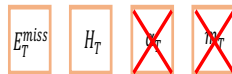
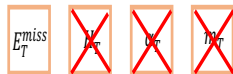
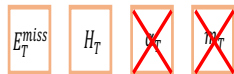
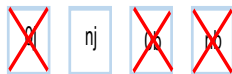
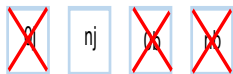
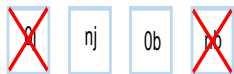
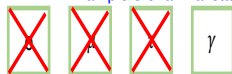
Example 1 of a final state



Example 2 of a final state



Example 3 of a final state





Dijet Pair 1:
 $pt = 3.49 \text{ TeV}$
 $mass = 1.88 \text{ TeV}$

PF Jet 1,
 $pt = 2.218 \text{ TeV}$
 $eta = 0.27$
 $phi = 1.47$

PF Jet 3,
 $pt = 1.733 \text{ TeV}$
 $eta = 0.21$
 $phi = 2.45$

Physics Analyses Highlights!

$pt = 1.408 \text{ TeV}$
 $eta = -0.74$
 $phi = -1.17$

Dijet Pair 2:
 $pt = 3.45 \text{ TeV}$
 $mass = 1.86 \text{ TeV}$

PF Jet 2,
 $pt = 2.042 \text{ TeV}$
 $eta = 0.29$
 $phi = -1.27$

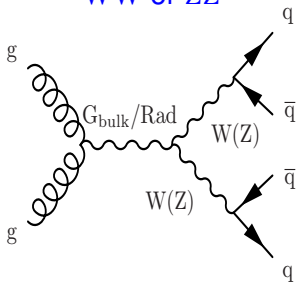
CMS Experiment at LHC, CERN
Data recorded: Sat Oct 28 12:41:12 2017 EEST
Run/Event: 305814 / 971086788
Lumi section: 610

Resonant and Non-Resonant Production of New Particles

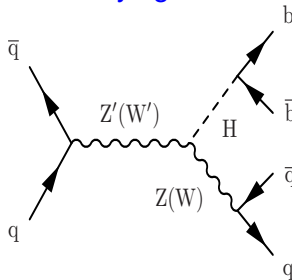
Search for new heavy resonances decaying to WW , WZ , ZZ , WH , or ZH pairs in all-jets final states - Submitted to Phys. Lett. B

Resonances decaying to a VV or VH boson pair with masses above 1.3 TeV, using 138 fb^{-1} of luminosity and $\sqrt{s} = 13 \text{ TeV}$

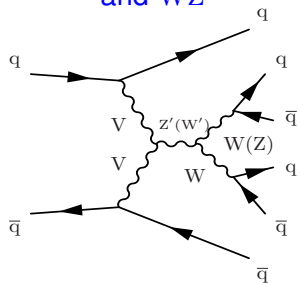
gg produced graviton or radion decaying to WW or ZZ



$q\bar{q}$ produced Z' decaying to HZ

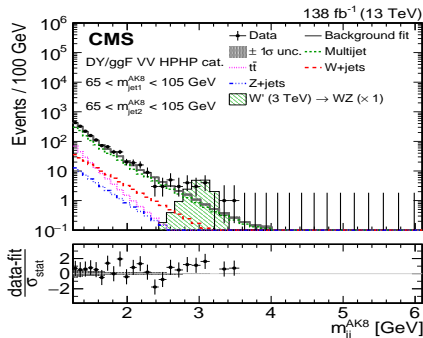
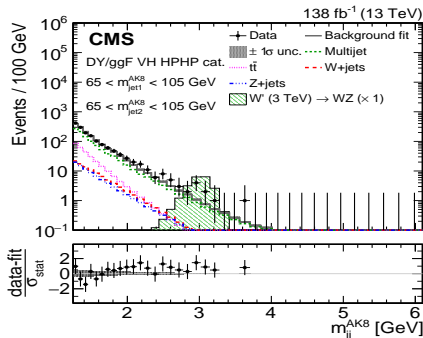


VBF produced Z' and W' decaying to WW and WZ



Analysis details

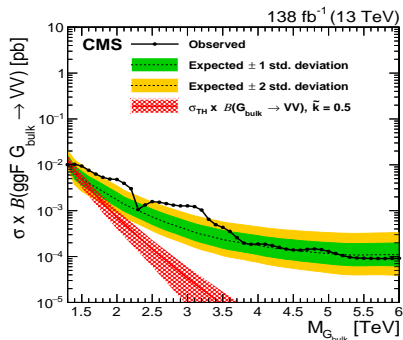
- Each boson decay is clustered as a single large-radius jet.
- We search for two large-radius jets ($R = 0.8$) with $p_T > 200$ GeV and $|\eta| < 2.5$. For VBF production two additional jets ($R = 0.4$) are considered ($p_T > 30$ GeV, $|\eta| < 5.0$, and $|\Delta\eta^{AK4}| > 4.5$).



- DY/ggF VH: Excess of data events in the 1.7–3.2 TeV range.
- DY/ggF VV: Excess of data events in the 2.0–3.0 TeV range.

95% CL upper limits

- A maximum local significance of 3.6σ is observed at masses of 2.1 and 2.9 TeV under the $W' \rightarrow WZ$ hypothesis.
- The excess remains above 2σ when increasing the V +jets and $t\bar{t}$ BKG uncertainties or using a looser (10%) $q\bar{q}$ tagger.
- With the look-elsewhere effect, the global significance is 2.3σ .

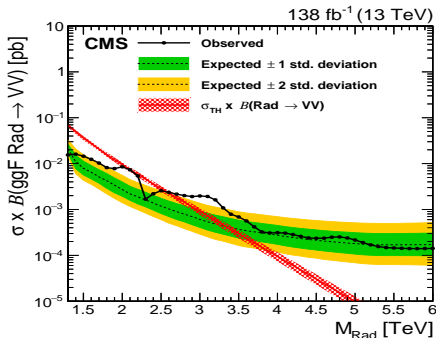


● Kaluza–Klein bulk graviton:

- 1 Spin-2 boson.
 - 2 $\tilde{k} = k \frac{8\pi}{M_{Pl}}$
- k is the unknown curvature scale of the extra dimension.
 - We use $\tilde{k} = 0.5$ (resonance width smaller than detector resolution).

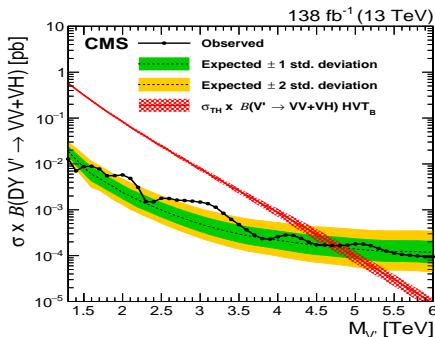
95% CL upper limits

- **Radion model:** r_C , compactification radius, and λ_R , ultraviolet cutoff.
- We consider: $k\pi r_C = 35$ and $\lambda_R = 3$ TeV.



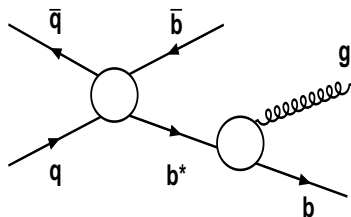
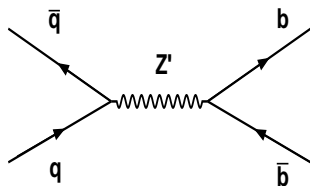
- **HVT model:** heavy vector triplet.

- 1 $g_V = 3$, $c_H = 0.98$, and $c_F = 1.02$.
- 2 $g_V = 1$, $c_H = 1 - 3$, and $c_F = 0$.



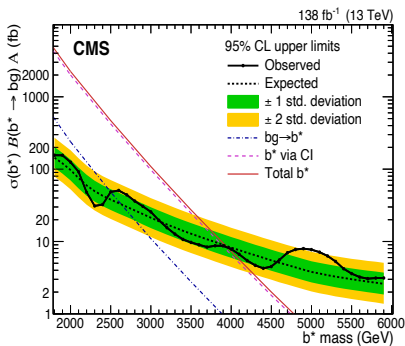
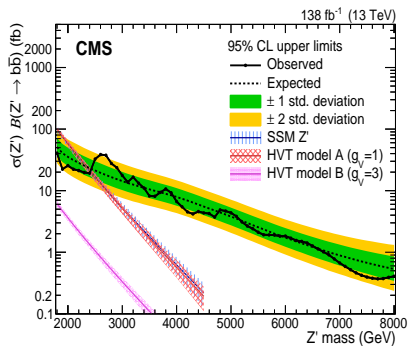
Search for narrow resonances in the b-tagged dijet mass spectrum - Accepted in Phys. Rev. D

- Two benchmark scenarios (narrow resonances):
 - ① Z' : $q\bar{q} \rightarrow Z' \rightarrow b\bar{b}$
 - ② Excited b (b^*): Single b^* and contact interaction $q\bar{q} \rightarrow b^*b$
- Events divided into categories:
 - ① b^* : At least one b jet is required.
 - ② Z' : 3 categories: 2b, 1b, & μ .
- μ category: Neither jet passes the b tag selection, but at least one jet contains a μ . This enriches heavy-flavor jets, mitigating the loss of signal due to b tagging efficiency.



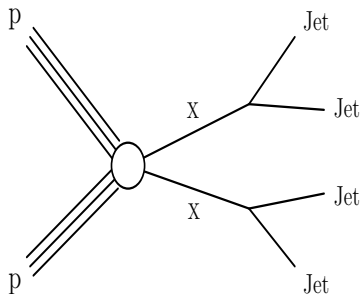
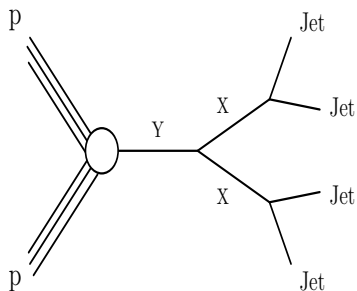
95% CL upper limits

- Limits on $\sigma \times \mathcal{B}$ (left) and for different coupling strengths (right).
- ① **Model A (HVT):** Coupling strengths of the HV bosons to SM bosons and fermions are of the same order.
- ② **Model B (HVT):** Couplings to fermions are suppressed with respect to the couplings to bosons.



Search for resonant and nonresonant production of pairs of dijet resonances - Accepted in JHEP

- We search for a pair of jets coming from the decay of a new particle, X.
- Resonant and non-resonant production is explored.

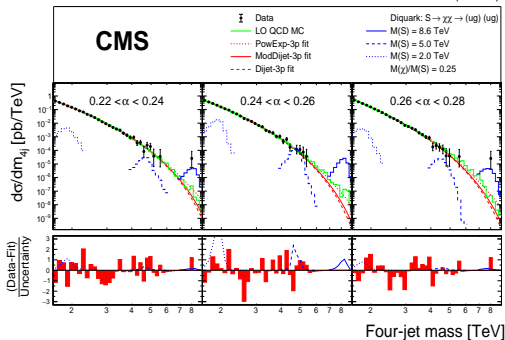


- **We consider pairs of resolved dijet resonances, X, where both jets within each dijet resonance are individually reconstructed.**
- The analysis is sensitive to high resonance masses.

Analysis strategy

- We use as production benchmark models:
 - ① Resonant: $uu \rightarrow S \rightarrow XX \rightarrow (ug)(ug)$ ($S \rightarrow$ scalar diquark).
 - ② Nonresonant: $pp \rightarrow \tilde{t}\tilde{t}^* \rightarrow (\bar{d}\bar{s})(ds)$ (RPV SUSY model, $\mathcal{B}(ds) = 1$).
- Use jet trigger that plateaus at $H_T > 1050$ GeV.
- The four jets with the largest p_T are used to construct jet pairs.
- Additionally we require: $(\frac{|m_1 - m_2|}{m_1 + m_2}) < 0.1$

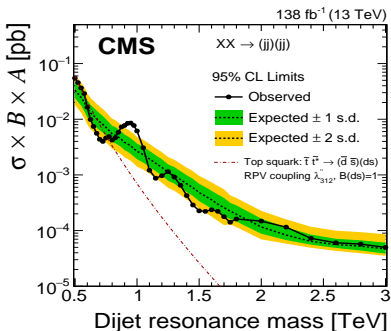
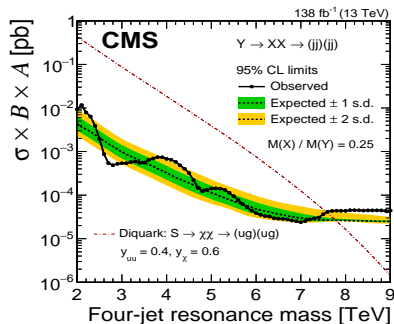
138 fb⁻¹ (13 TeV)



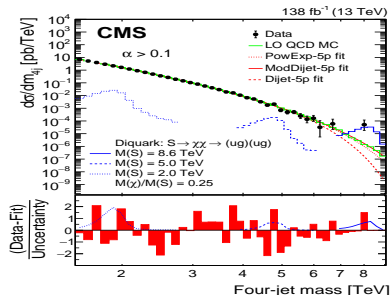
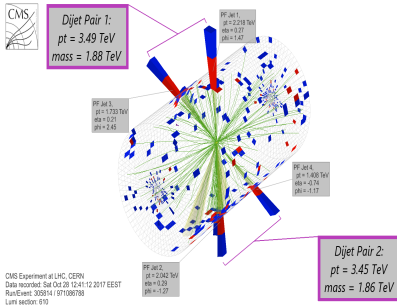
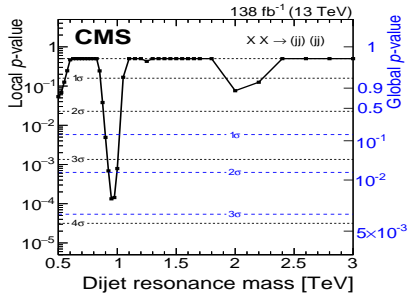
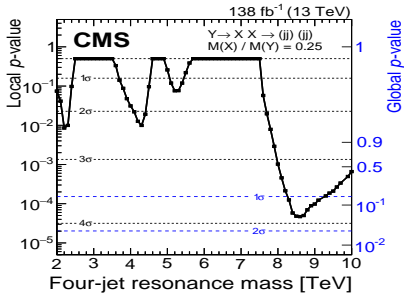
- $\alpha = \bar{m}_{jj}/m_{4j}$
- $d\sigma/dm = p_0 \exp^{p_1 x} / x^{p_2}$
- $d\sigma/dm = p_0 (1 - x^{1/3})^{p_1} / x^{p_2}$
- $d\sigma/dm = p_0 (1 - x)^{p_1} / x^{p_2}$
- $x = m/\sqrt{s}$

95% CL upper limits

- For the resonant case, we use the m_{4j} distribution in 13 bins of α .
- For the nonresonant scenario, we use the m_{jj} distribution in 3 bins of α .
- The fit is done simultaneously for all the bins of α .

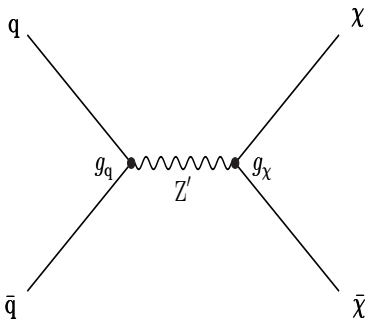


Local p -values and event displays



Search for resonant production of strongly coupled dark matter -Published in JHEP, 06/2022

- We consider resonant production of dark matter: $q\bar{q} \rightarrow Z' \rightarrow \chi\bar{\chi}$



- Leptophobic Z' mediator from a $U(1)$ broken symmetry.
- g_q (g_χ) coupling to SM (dark) quarks.
- Dark quarks form bound states called dark hadrons (DHs), which may be either stable or unstable.

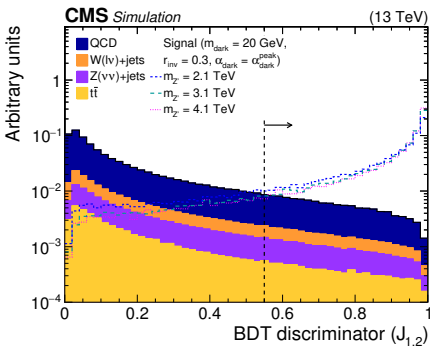
- Unstable DHs decay to SM quarks while stable DHs are DM candidates.
- This leads to collimated mixtures of visible and invisible particles (“semivisible” jets (SVJ)).
- We search for two jets and p_T^{miss} , aligned with one of the jets.

Analysis strategy

- We pre-select events with at least two high p_T ($p_T > 200$ GeV) central jets ($|\eta| < 2.4$), with $m_T > 1.5$ TeV, $R_T = (p_T^{\text{miss}}/m_T) > 1.5$ TeV, $\Delta\eta(J_1, J_2) < 1.5$, among other criteria.

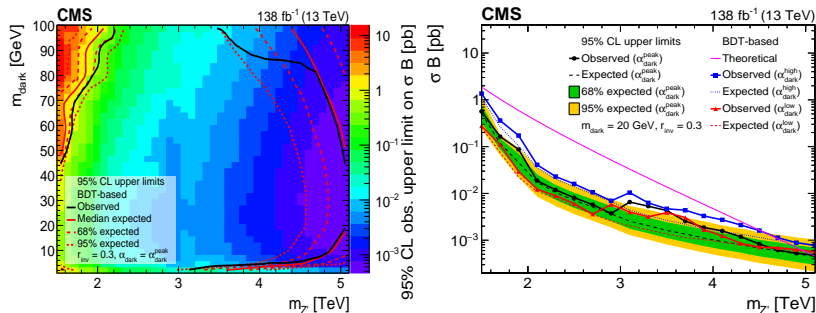
$$m_T^2 = m_{JJ} + 2p_T^{\text{miss}}[\sqrt{m_{JJ}^2 + p_{T,JJ}^2} - p_{T,JJ}\cos(\Delta\phi_{JJ,\text{miss}})]$$

- In addition, we use a BDT to improve signal-BKG rejection.



- QCD is the dominant BKG.
- $t\bar{t}$, W+jets and W+jets are subdominant BKGs.
- We divide the phase-space for the search in a low and high R_T SR.
- The m_T distribution is the main observable to search for signal.

95% CL upper limits

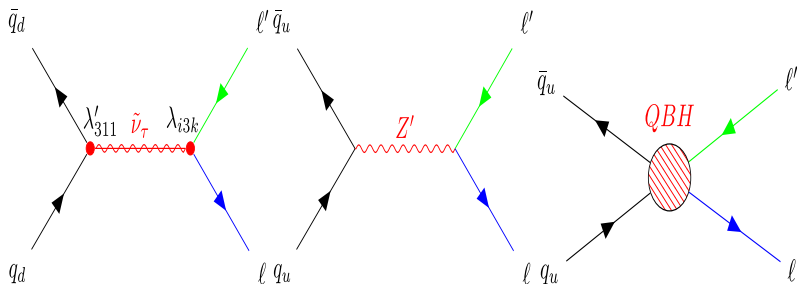


- We are able to exclude $1.5 < Z' < 5.1 \text{ TeV}$, depending on the signal parameters.
- α_{dark} : coupling strength of the dark QCD force:

$$\alpha_{\text{dark}}(\Lambda_{\text{dark}}) = \pi / (b_0 \ln(Q_{\text{dark}} / \Lambda_{\text{dark}})), \quad b_0 = (11 N_c^{\text{dark}} - 2 N_f^{\text{dark}}) / 6$$

$$N_c^{\text{dark}} = 2, \quad N_f^{\text{dark}} = 2, \quad Q_{\text{dark}} = 1.0 \text{ TeV}$$

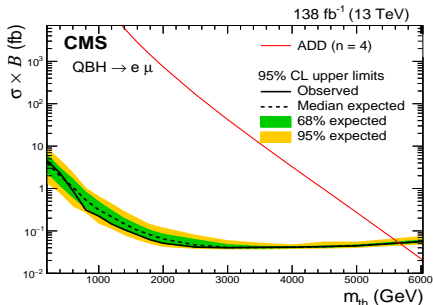
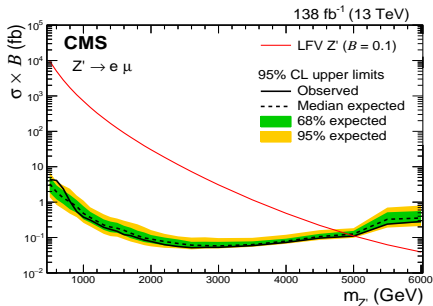
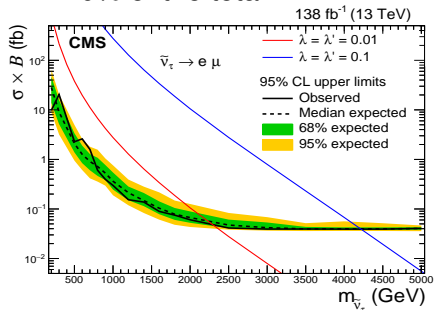
Search for heavy resonances and quantum black holes in $e\mu$, $e\tau$, and $\mu\tau$ final states - Submitted to JHEP



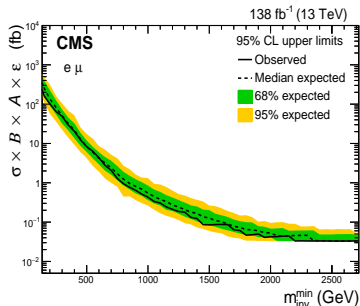
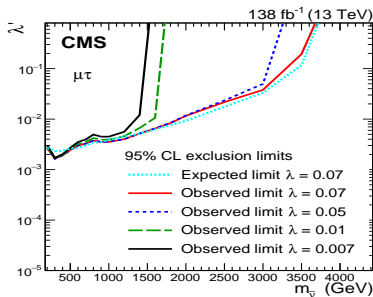
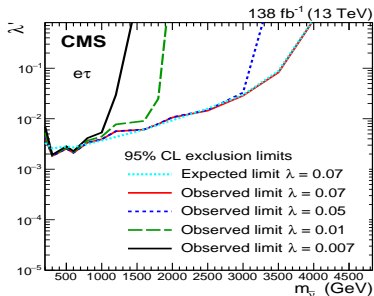
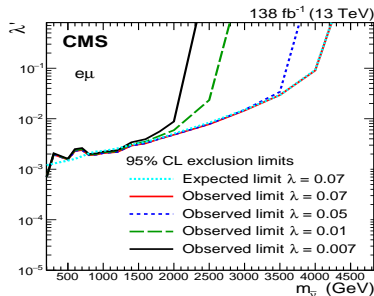
- In this search we probe lepton flavor violation (LFV), using $e\mu$, $e\tau$, and $\mu\tau$ final states.
- Results are interpreted using three different scenarios:
 - ① $\tilde{\nu}_\tau$ in RPV SUSY: $W_{RPV} = \frac{1}{2}\lambda_{ijk}L_iL_j\bar{E}_k + \frac{1}{2}\lambda'_{ijk}L_iQ_j\bar{D}_k$
 - ② Heavy gauge Z' bosons: **SSM couplings.**
 - ③ Quantum black holes (QBHs): **Spin-0, colorless and neutral.**

95% CL upper limits

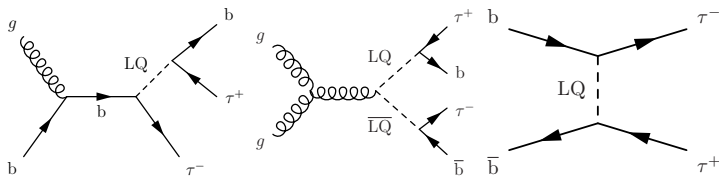
- The $\tilde{\nu}_\tau$, Z' , and QBH samples are generated at LO, using the *calcHEP*, *PYTHIA*, and *QBH* 3.0 MC.
- The width of the Z' is taken as 3% of its mass. LVF decays are assumed to account for 10% of the total BF.



95% CL upper limits

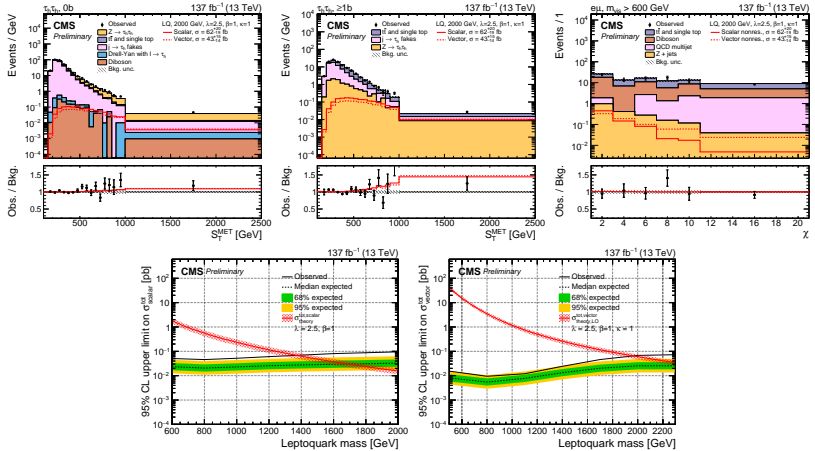


Search for a third-generation leptoquark coupling to a τ lepton and a b quark through single, pair and nonresonant production - CMS PAS



- Signal samples are generated such that the LQ couples to b quark and τ lepton with a coupling strength λ .
- Benchmark models with scalar and vector LQs are considered.
- For resonant production we use the $S_T^{MET} = p_T^1 + p_T^2 + p_T^j + p_T^{miss}$
- For non-resonant production we use $\chi = \exp(2y^*)$, where $y^* = \frac{1}{2}|y_1 - y_2|$.

Results

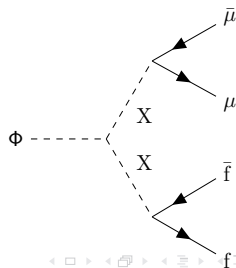
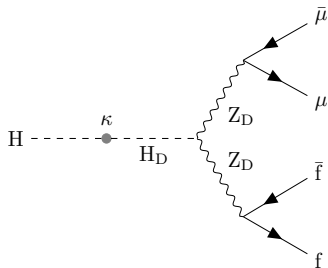


- The data agree with the SM expectation within 2 s.t.d for $\lambda = 1.5$.
- For a LQ mass of 2 TeV and a $\lambda = 2.5$, an excess with a significance of 3.4 s.t.d is observed.

Long-Lived Particles

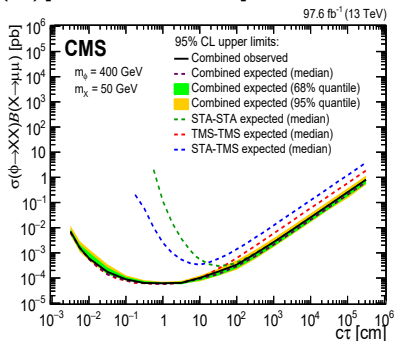
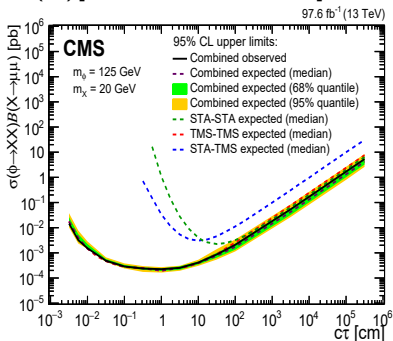
Search for long-lived particles decaying to a pair of muons - Accepted in JHEP

- We search for an exotic massive LLP decaying to a pair of **oppositely charged muons**, referred to as a “**displaced dimuon**”.
- Two signal models are used as benchmarks:
 - 1 Hidden Abelian Higgs model (HAHM): Include additional $U(1)_D$ symmetry, broken by dark Higgs (H_D), with hypothetical dark photons (Z_D) as mediators. For small values of $Z - Z_D$ kinematic mixing, the Z_D is long-lived.
 - 2 Simplified model, in which a non-SM Higgs boson decays to a pair of long-lived exotic heavy neutral scalar bosons.



95% CL upper limits

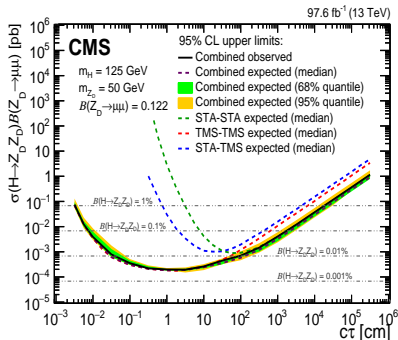
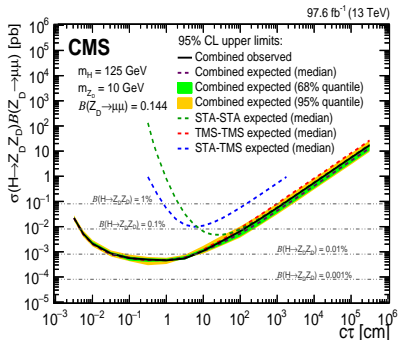
- We set upper limits on the production cross section, $\sigma(\Phi \rightarrow XX)$, times BF, $B(X \rightarrow \mu\bar{\mu})$, as function of the decay length ($c\tau$).
- The limits are set for different ranges of masses:
 $m(\Phi)[125 \text{ GeV} \rightarrow 1 \text{ TeV}]$ and $m(X)[20 \rightarrow 350 \text{ GeV}]$.



- **The search is sensitive to a broad range of $c\tau$ ($30 \mu\text{m} \rightarrow 1 \text{ km}$).**
- **Most restrictive limits for $c\tau$ between 0.1 mm and 10–100 m,** excluding $\sigma(\Phi \rightarrow XX)B(X \rightarrow \mu\bar{\mu})$ smaller than 1 fb.

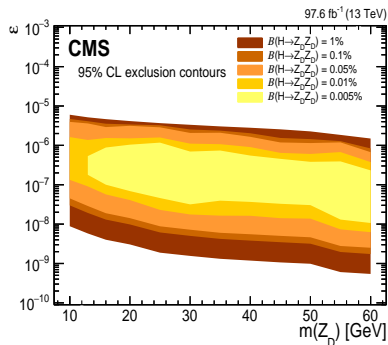
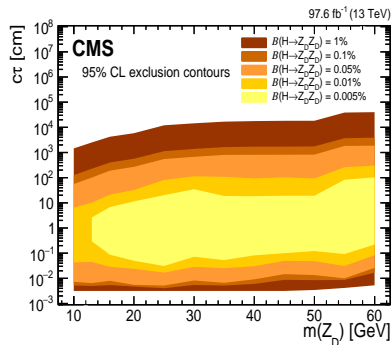
95% CL upper limits

- The signal samples are produced considering small values of $Z - Z_D$ kinematic mixing: $\epsilon (2 \times 10^{-9} \rightarrow 10^{-6})$.
- The limits are set for different Z_D masses: $m(Z_D)[10 \rightarrow 60 \text{ GeV}]$.



95% CL upper limits

- Our previous results can be translated into limits on the kinetic mixing ϵ .



- Our analysis excludes a wide range of ϵ values, between 9×10^{-9} and 6×10^{-6} at $m(Z_D) = 10$ GeV and between 5×10^{-10} and 1.5×10^{-6} at $m(Z_D) = 60$ GeV for $B(H \rightarrow Z_D Z_D) = 1\%$.

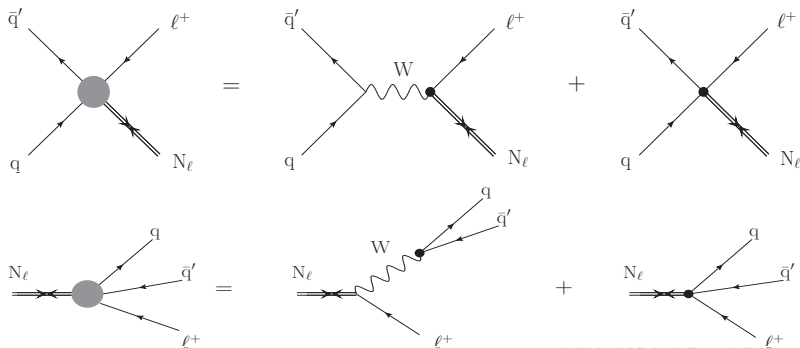
Briefing on additional BSM Searches

Search for a heavy composite Majorana neutrino in events with dilepton signatures from proton-proton collisions at $\sqrt{s} = 13$ TeV - Submitted to PLB

- We consider the composite neutrino model:

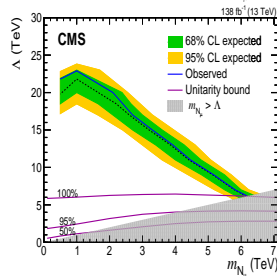
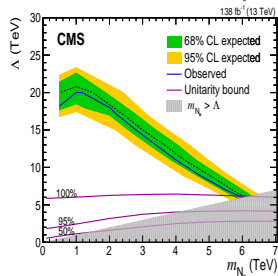
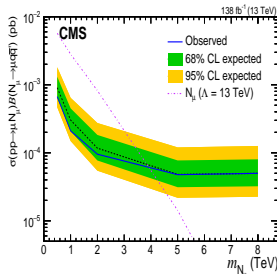
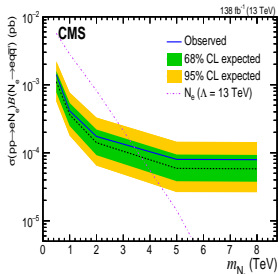
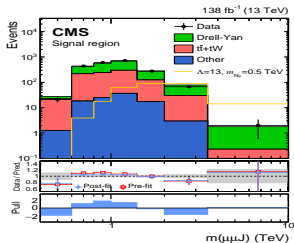
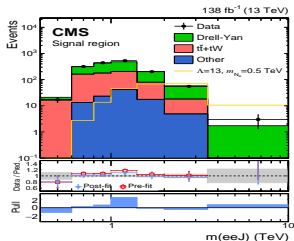
$$\mathcal{L}_{GI} = \frac{gf}{\sqrt{2}} \bar{N} \sigma^{\mu\nu} (\partial_\mu W_\nu) P_L^\ell + h.c., \quad \mathcal{L}_{CI} = \frac{g_*^2 \eta}{2} \bar{q}' \gamma^\mu P_L q \bar{N} \gamma_\mu \ell + h.c.$$

- The fermion interaction is the sum of the gauge and contact contributions.



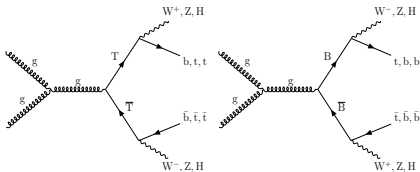
Analysis strategy and 95% C.L limits

We focus on $e\bar{e}q\bar{q}$ and $\mu\bar{\mu}q\bar{q}$ final states.



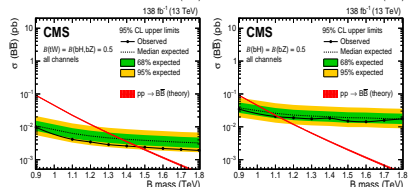
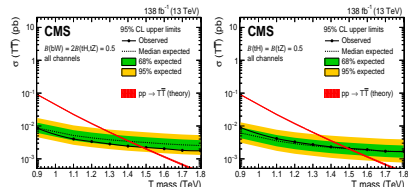
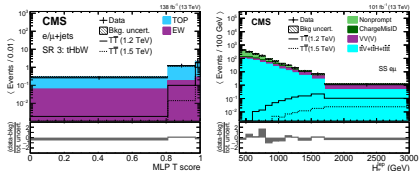
The gray shading indicates the region where $m_{N_\ell} > \Lambda$, and the 3 magenta lines represent the fraction of the signal that satisfies the unitarity condition in the EFT.

Search for pair production of vector-like quarks in leptonic final states - Submitted to JHEP



- VLQs are hypothetical fermions whose left- and right-handed components transform identically under the SM electroweak gauge group $SU(2)_L \times U(1)_Y$.
- This chiral symmetry allows a mass term in the \mathcal{L} .
- VLQs could cancel out m_H quantum loop corrections.
- We search for final states with e^+e^- or $\mu^+\mu^-$'s.

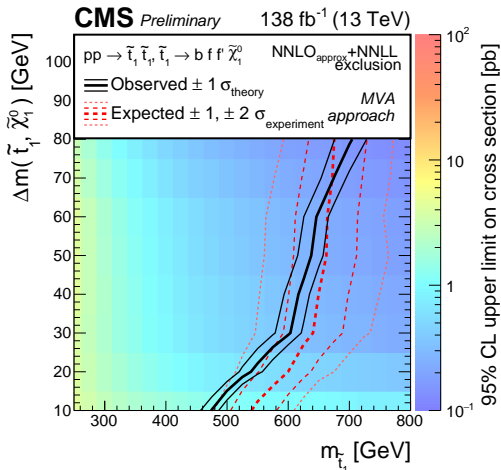
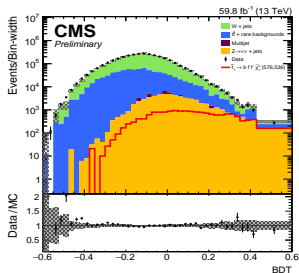
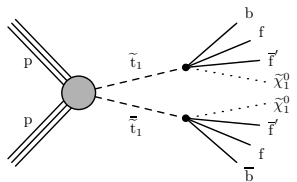
Use a multi-layer perceptron (MLP) for 1ℓ channels



Channel	Overall	Event selection	
		CR	SR
1ℓ	1 tight ℓ	—	—
	$p_T(\ell) > 55 \text{ GeV}$	—	—
	0 other loose ℓ , $p_T > 10 \text{ GeV}$	—	—
	$p_T^{\text{miss}} > 50 \text{ GeV}$	—	—
$SS\ 2\ell$	≥ 3 large-radius jets	—	—
	—	max MLP not VLQ	max MLP is VLQ
	—	2 VLQ candidates	—
	—	—	—
3ℓ	2 tight $SS\ \ell$	—	—
	$p_T(\ell) > 40 \text{ GeV}, 30 \text{ GeV}$	—	—
	≥ 4 small-radius jets	—	—
	$M(\ell\ell) > 20 \text{ GeV}$	—	—
3ℓ	$M(ee)$ outside 76–106 GeV	—	—
	—	$H_T^{\text{HP}} < 1000 \text{ GeV}$	$H_T^{\text{HP}} > 1000 \text{ GeV}$
	$p_T(\ell) > 30 \text{ GeV}$	—	—
	$M(\text{OSSF } \ell\ell) > 20 \text{ GeV}$	—	—
3ℓ	≥ 1 b-tagged jet	—	—
	$p_T(\text{b jet}) > 45 \text{ GeV}$	—	—
	—	3 loose ℓ	≥ 3 tight ℓ GeV
	—	2 small-radius jets	\geq small-radius jets

Search for top squarks decaying via the four-body mode in single-lepton final states - CMS PAS

- Target 4-body \tilde{t}_1 decays, allowed when $m(\tilde{t}_1) - m(\tilde{\chi}_1^0) < m(W)$:
Select events with exactly one e or μ , p_T^{miss} , and jets (use BDT).



Probing SM Physics

Measurement of $B_s^0 \rightarrow \mu^+ \mu^-$ decay properties and search for the $B^0 \rightarrow \mu^+ \mu^-$ decay - CMS PAS

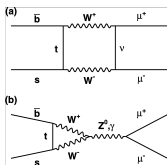


Figure from PLB article-CLICK

- In the SM the BFs (\mathcal{B}) for these decays are very small:
 $\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) = (3.66 \pm 0.14) \times 10^{-9}$
 $\mathcal{B}(B^0 \rightarrow \mu^+ \mu^-) = (1.03 \pm 0.05) \times 10^{-10}$
- We use $B^+ \rightarrow J/\psi K^+$ and $B^+ \rightarrow J/\psi \phi$ events as standard candles, to extract the signal \mathcal{B} s:

$$\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) = \mathcal{B}(B^+ \rightarrow J/\psi K^+) \frac{N_{B_s^0 \rightarrow \mu^+ \mu^-} \epsilon_{B^+ \rightarrow J/\psi K^+} f_u}{N_{B^+ \rightarrow J/\psi K^+} \epsilon_{B_s^0 \rightarrow \mu^+ \mu^-} f_s}$$

$$\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) = \mathcal{B}(B_s^0 \rightarrow J/\psi \phi) \frac{N_{B_s^0 \rightarrow \mu^+ \mu^-} \epsilon_{B_s^0 \rightarrow J/\psi \phi}}{N_{B_s^0 \rightarrow J/\psi \phi} \epsilon_{B_s^0 \rightarrow \mu^+ \mu^-}}$$

$$\mathcal{B}(B^0 \rightarrow \mu^+ \mu^-) = \mathcal{B}(B^+ \rightarrow J/\psi K^+) \frac{N_{B^0 \rightarrow \mu^+ \mu^-} \epsilon_{B^+ \rightarrow J/\psi K^+} f_u}{N_{B^+ \rightarrow J/\psi K^+} \epsilon_{B^0 \rightarrow \mu^+ \mu^-} f_d}$$

f_u , f_s and f_d are the B hadron production fractions

- We find the \mathcal{B} s to be:

$$\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) = [3.83^{+0.38}_{-0.36} (\text{stat})^{+0.19}_{-0.16} (\text{syst})^{+0.14}_{-0.13} (f_s/f_u)] \times 10^{-9},$$

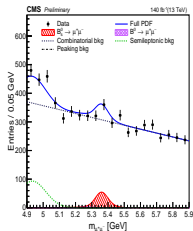
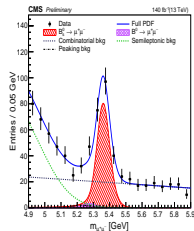
$$\mathcal{B}(B^0 \rightarrow \mu^+ \mu^-) = [0.37^{+0.75}_{-0.67} (\text{stat})^{+0.08}_{-0.09} (\text{syst})] \times 10^{-10}.$$

- Where we have used (from PDG and LHCb):

$$\mathcal{B}(B^+ \rightarrow J/\psi K^+) = (1.020 \pm 0.019) \times 10^{-3},$$

$$\mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-) = (5.961 \pm 0.033) \times 10^{-2}, \text{ and}$$

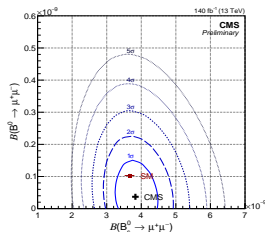
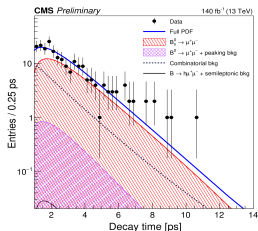
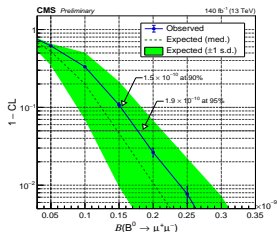
$$f_s/f_u = 0.231 \pm 0.008.$$



Results

- We also estimate the branching fractions using the $B_s^0 \rightarrow J/\psi\phi$ decays for the normalization.
- Using $\mathcal{B}(B_s^0 \rightarrow J/\psi\phi) = (1.018 \pm 0.050) \times 10^{-3}$ from LHCb:

$$\mathcal{B}(B_s^0 \rightarrow \mu^+\mu^-) = [3.95_{-0.37}^{+0.39}(\text{stat})_{0.22}^{+0.27}(\text{syst})_{0.19}^{+0.21}(\text{BF})] \times 10^{-9}$$



- Comparing LHCb, $\mathcal{B}(B_s^0 \rightarrow \mu^+\mu^-) = [3.09_{-0.43}^{+0.46}{}_{-0.11}^{+0.15}] \times 10^{-9}$, our result is about 1.2 s.t.d higher, more consistent with the SM.

Higgs physics! - Nature July 2022



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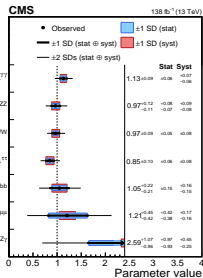
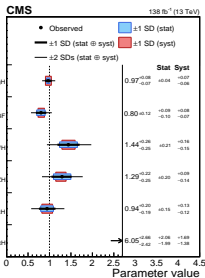
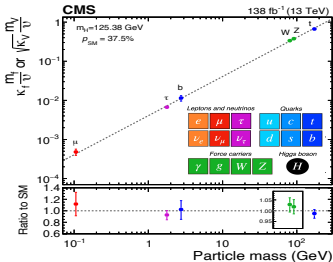
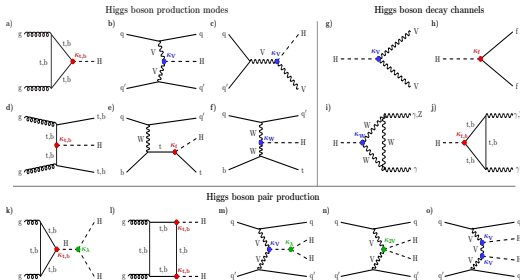
Article | Open Access | Published: 04 July 2022

A portrait of the Higgs boson by the CMS experiment ten years after the discovery

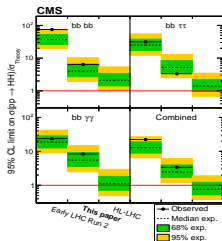
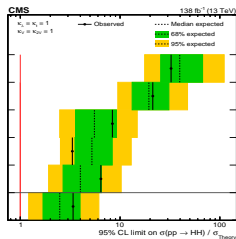
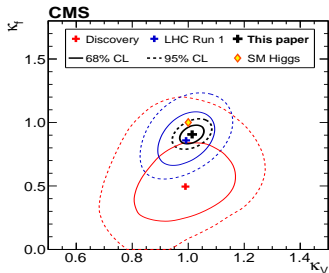
The CMS Collaboration

Nature 607, 60–68 (2022) | Cite this article

13k Accesses | 7 Citations | 411 Altmetric | Metrics



New results from Higgs physics!



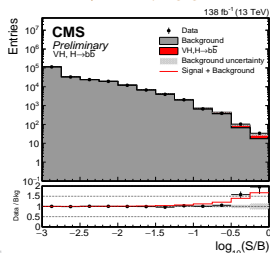
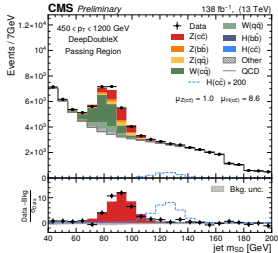
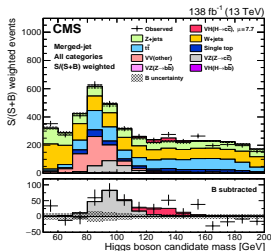
The cross section for Higgs boson pair production in the SM is extremely small, thus escaping detection at the LHC so far.

New results! Please see Alejandro's talk

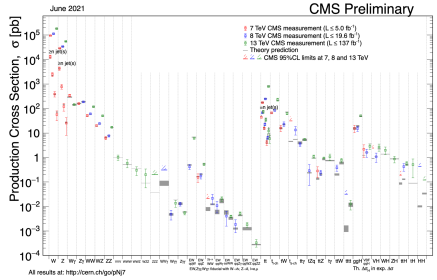
H → c \bar{c}

Boosted H → c \bar{c}

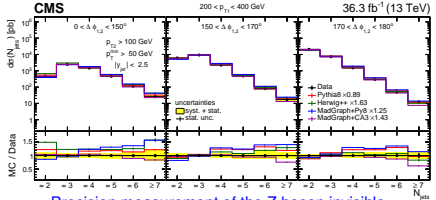
VH → b \bar{b}



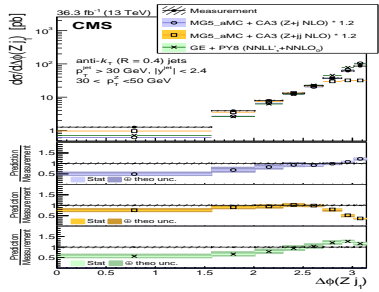
SM precision measurements



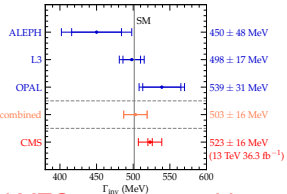
Measurements of jet multiplicity and jet transverse momentum in multijet events - Submitted to Eur. Phys. J. C



Azimuthal correlations in Z+jets - Submitted to Eur. Phys. J. C



Submitted to Phys. Lett. B

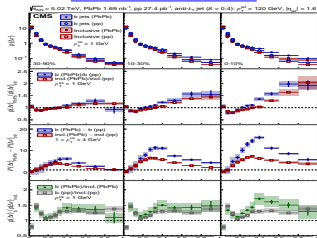


And YES, we are working on a high precision measurement of the W boson mass!

Heavy Ions: Briefing on recent analyses

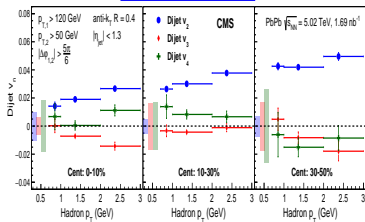
Search for medium effects using jets from bottom quarks in PbPb collisions

Submitted to Phys. Lett. B



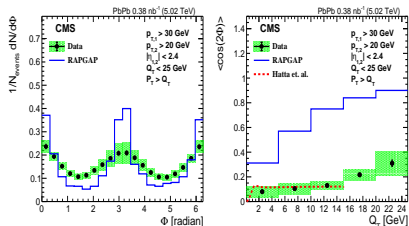
Azimuthal anisotropy of dijet events in PbPb collisions

Submitted to JHEP



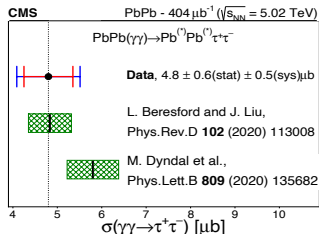
Azimuthal correlations within exclusive dijets with large momentum transfer in photon-lead collisions

Submitted to PRL



Observation of τ lepton pair production in ultraperipheral lead-lead collisions

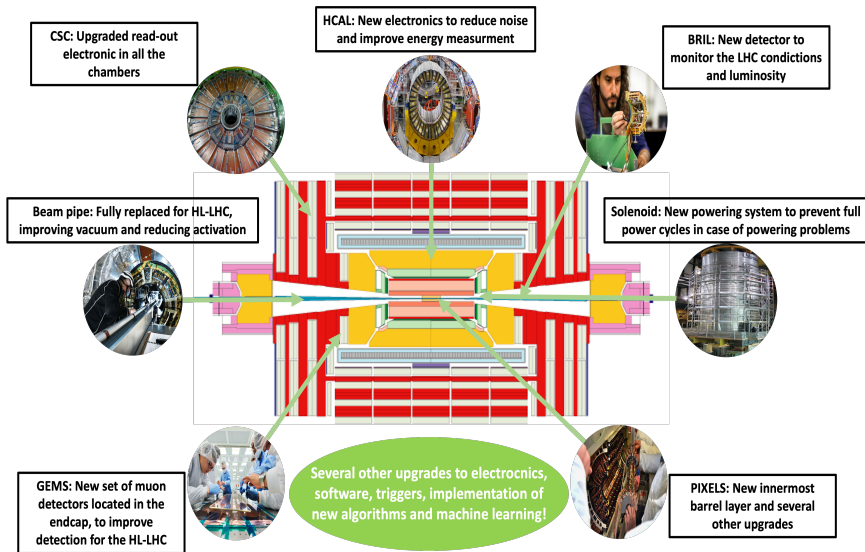
Accepted for publication in PRL





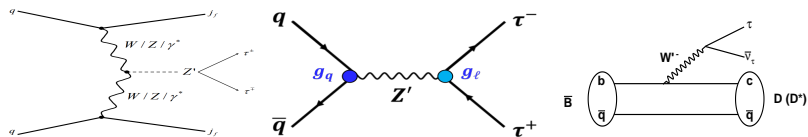
Our plans for the future....

CMS Upgrades

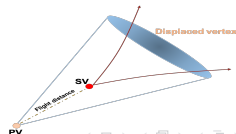
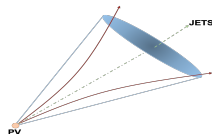


Some of our short term goals and plans

- Several more new results with Run2 data are just around the corner!



- **For Run-3 data: new triggers deployed, scouting (high rate trigger-objects analysis) and parking (opportunistic reco).**
- Over one billion fully-simulated events produced every week (from GEN to RECO).
- Increasing applications of machine learning techniques in [reconstruction and identification of particles](#) and in several different analyses.



Longer term plans...

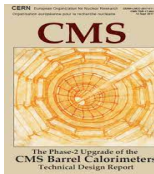
L1 Trigger

- Tracks in L1 trigger at 40 MHz
- PFlow - 750 kHz L1 output



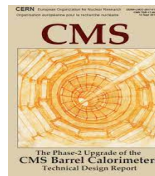
Barrel Calorimeters

- ECAL granular readout at 40 MHz
- New Back-End boards.



Tracker

- Increased granularity and coverage ($\eta \approx 3.8$)
- Design for tracking in L1-Trigger



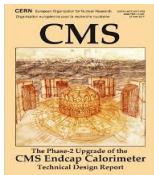
HLT/DAQ

- HLT output 7.5 kHz
- 40 MHz data scouting



End-cap Calorimeter

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



Muon system

- DT, CSC, RPC new boards
- Extended coverage ($\eta \approx 3$)



Summary

- CMS has produced many interesting results on a very broad set of searches, proving SM and BSM physics.
- We are publishing over 80 papers per years in top journals.
- **There are many interesting results with Run2 data that are on their way to be released (stay tuned!).**
- We have observed several $2\text{-}3\sigma$ deviations of data w.r.t to SM BKG predictions that we need to further investigate/understand: real signs of new physics? Statistical fluctuations? Bad BKG predictions?
- We have made many upgrades to the detector for Run3 and we are successfully collecting data.
- We are preparing for the HL-LHC and I personally believe that the best of CMS and the LHC is yet to come: we only need to be patient, collect more data, and keep working hard.

THANK YOU
GRACIAS
OBRIGADO

