Beyond standard model searches at CMS: Highlights and prospects

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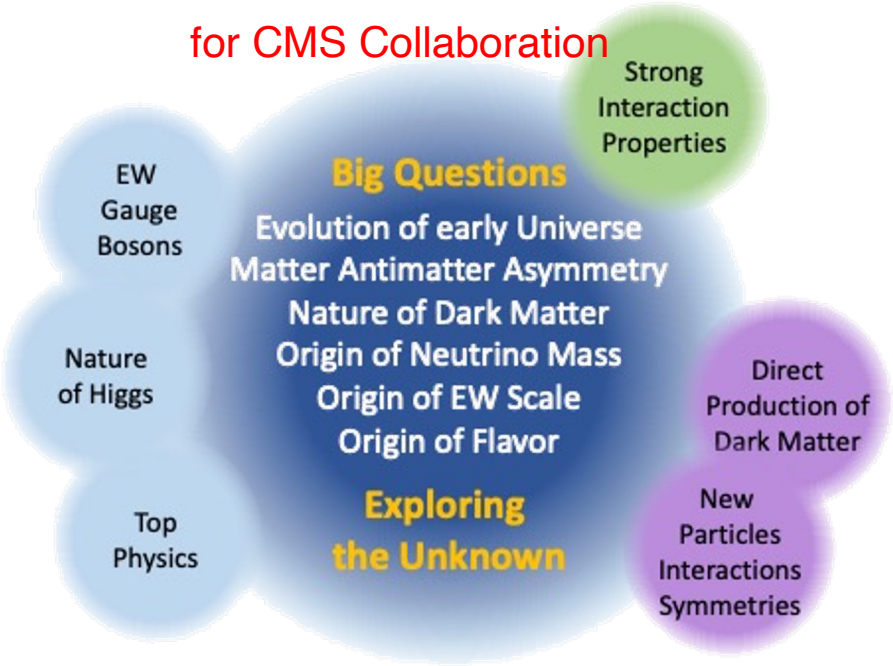
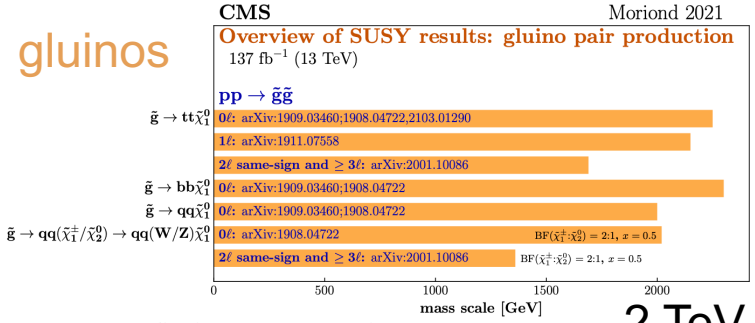
University of Wisconsin

for CMS Collaboration



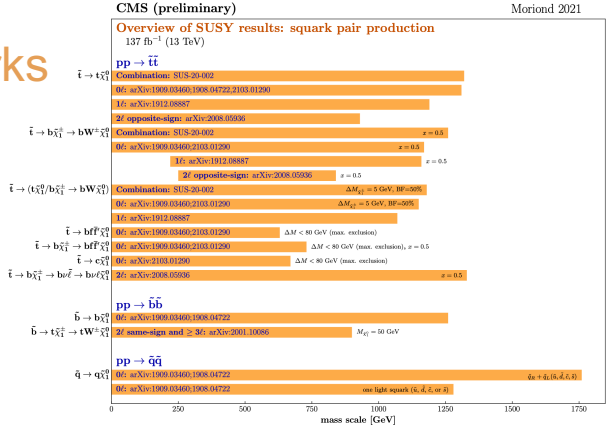
Gluino-pairs, Squark-pairs, Diboson-Resonances, Heavy Fermions

gluinos

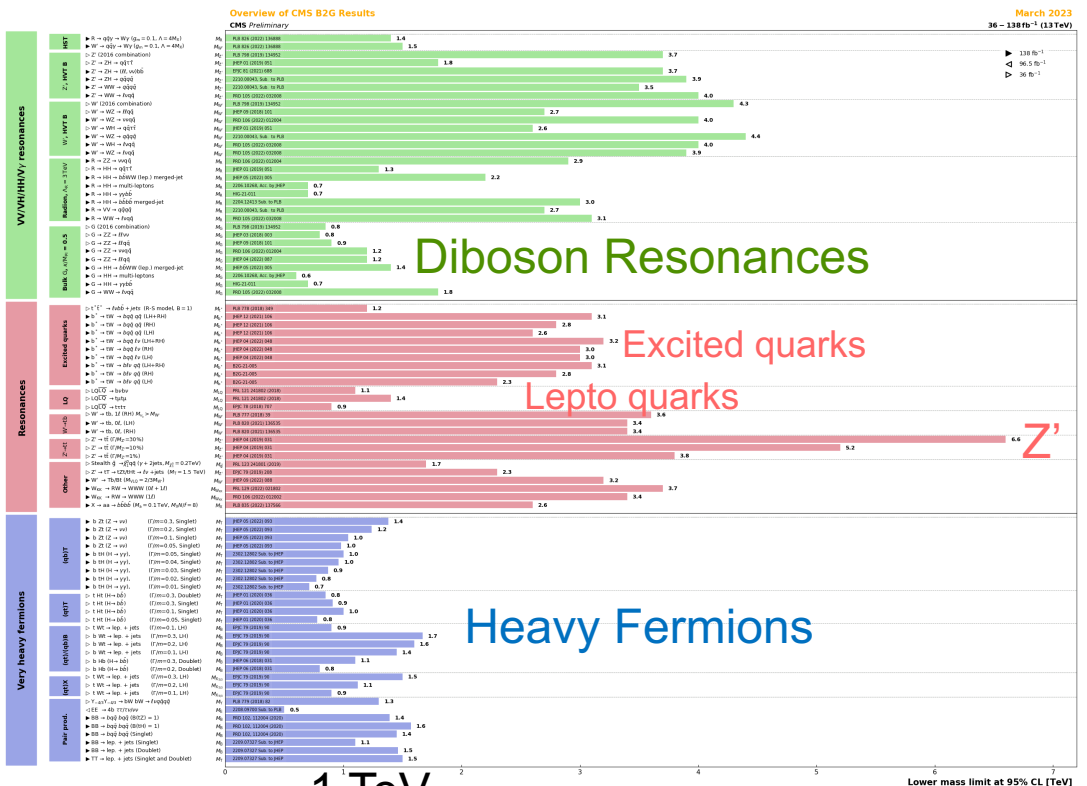


2 TeV

squarks



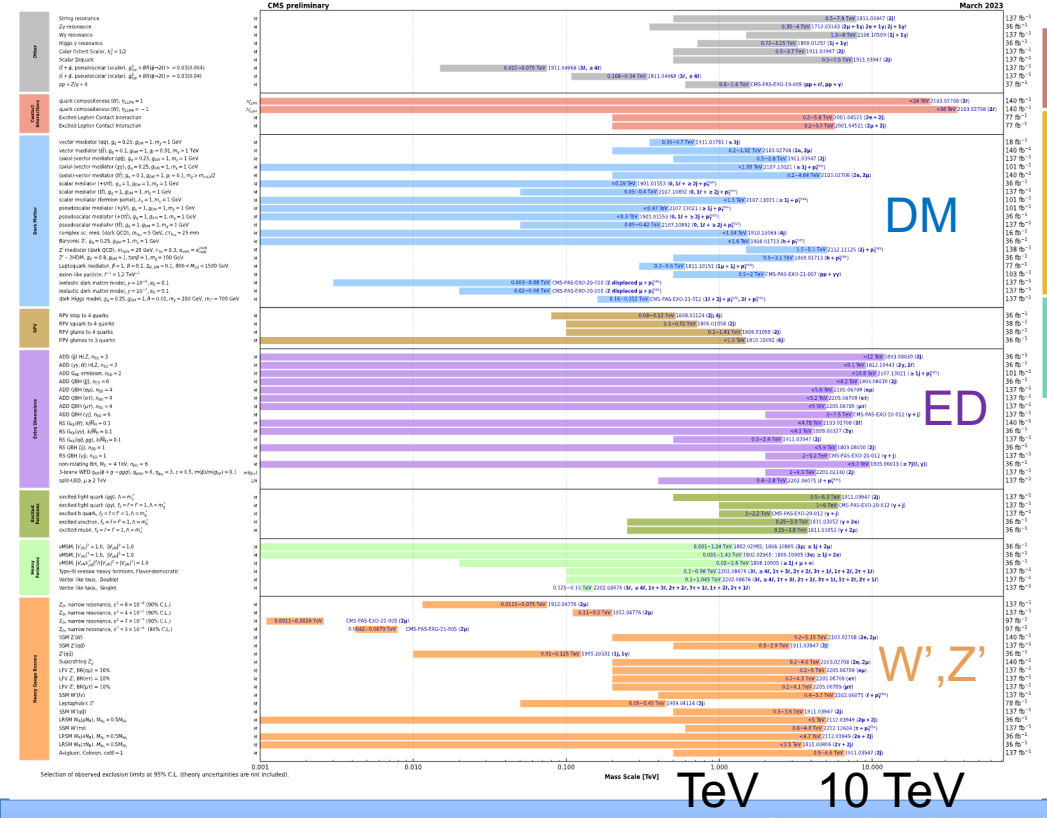
1 TeV

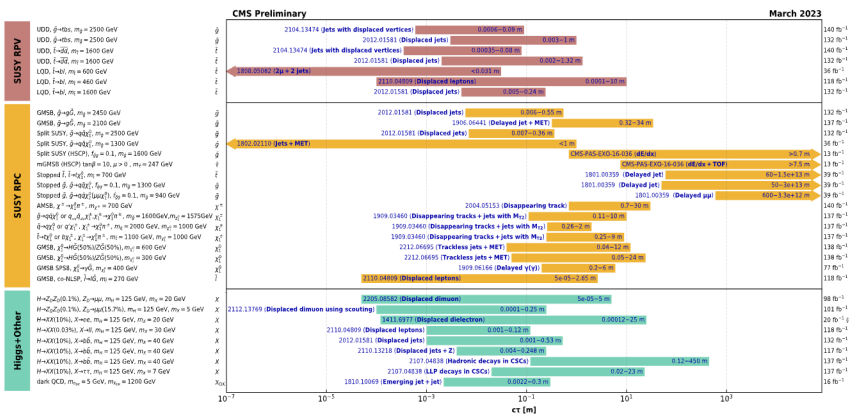


1 TeV

7 TeV

Summary of Exotica From Snowmass





There is a LOT of material to chose from, and fill hours.

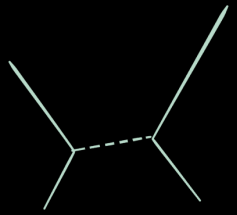
Will present an eclectic set of topics relevant for LCs it being LCWS-2023

One of Nathaniel's Seven Questions

A Yukawa Force?

Someone asked, how about off-diagonal Yukawas?

Yukawa force between fundamental particles: never seen until now



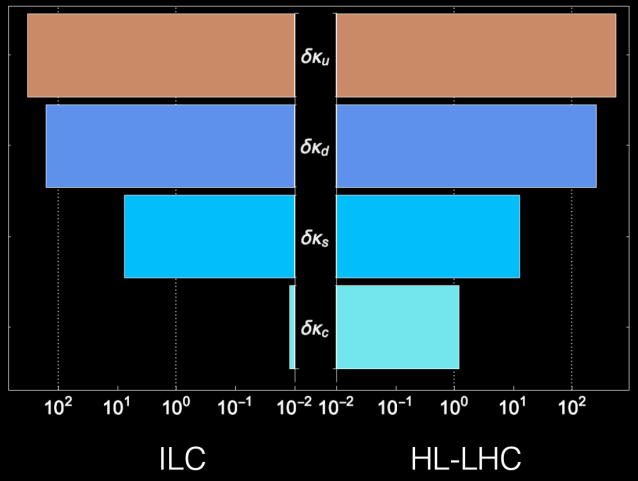
$$\frac{V_{\text{Higgs}}(r)}{V_{\text{Weak}}(r)} \sim \frac{y^2}{g^2} e^{-(m_h - m_Z)r}$$

Established by >5σ observation of ttH, H→bb and H→ττ in LHC Run 2

"Is this any less important than the discovery of the Higgs boson itself? My opinion: no, because fundamental interactions are as important as fundamental particles"

— G. Salam

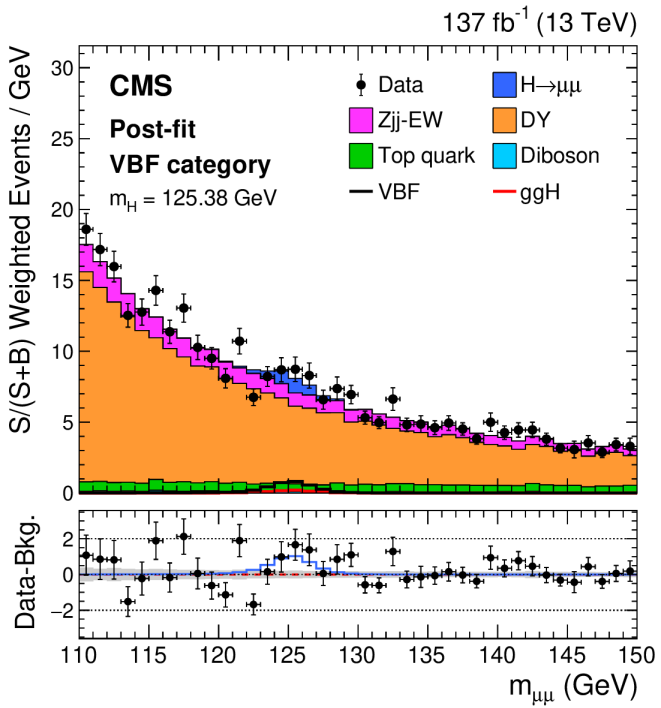
Focus now on 2nd generation. Lightness makes flavor puzzle compelling, couplings could hold key to flavor puzzle.

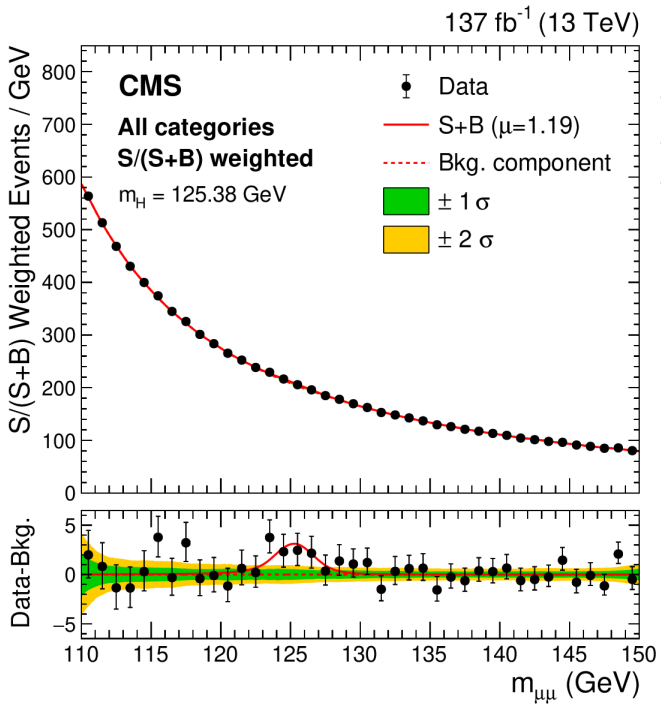


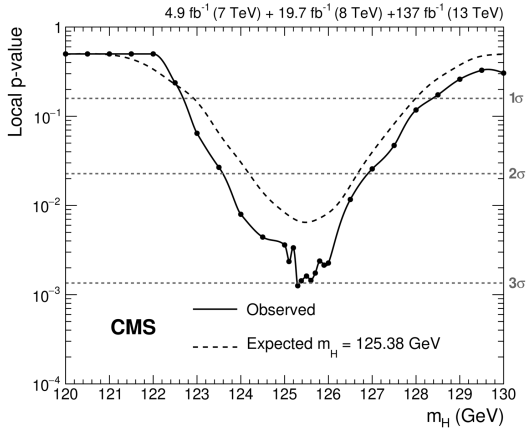
Evidence for Second Generation Yukawa

Albeit in the lepton sector

JHEP 01 (2021) 148







Continue to profit from excellent CMS muon resolution

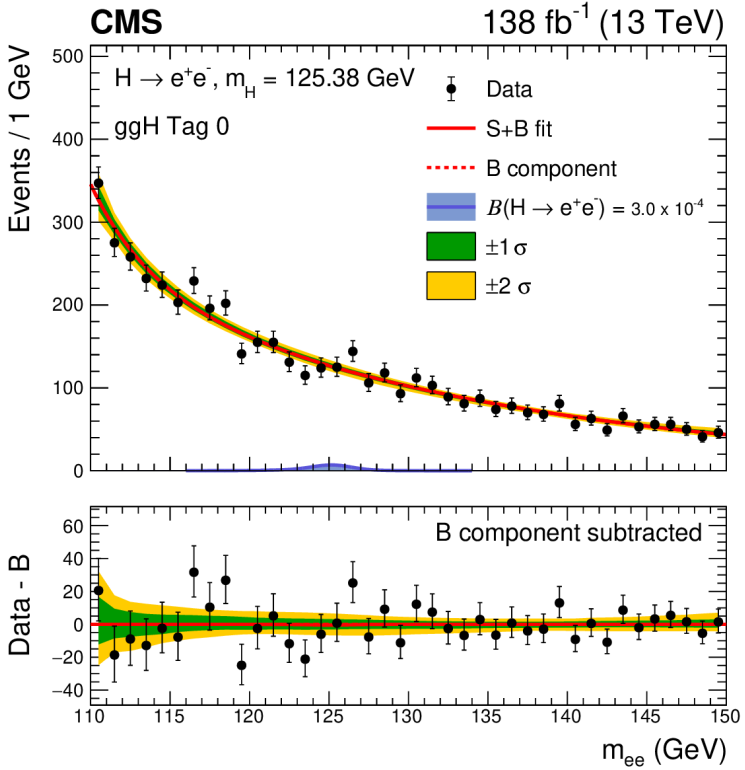
Run-3: >5σ

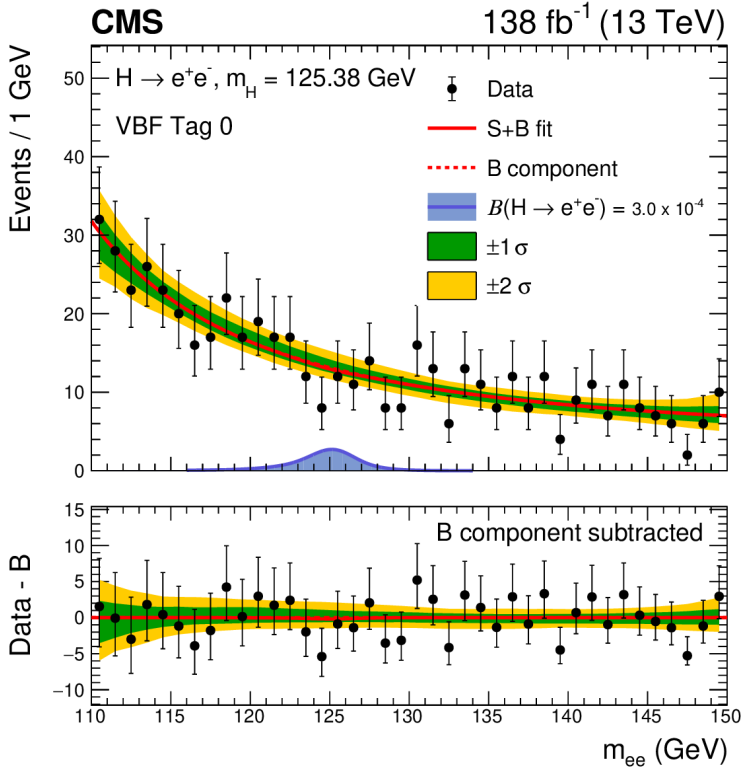
HLLHC: $\Delta\kappa_\mu \sim 5\%$

First Generation Yukawa

arXiv:2208.00265

Again in the lepton sector – if we see something it has to be BSM!

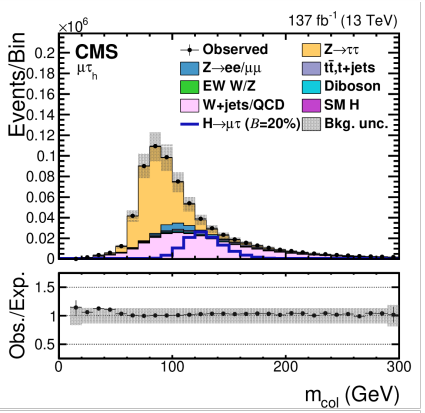


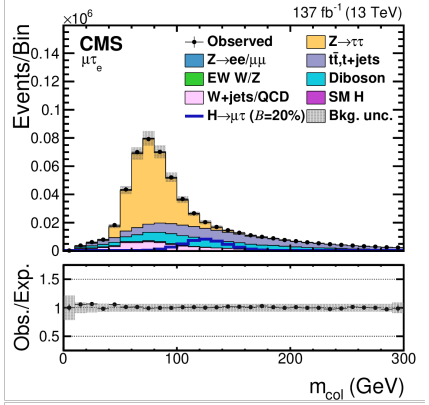


No one talks about Y_e other than FCC-ee special run

LFV: $H(125) \to \mu\tau, H(125) \to e\tau$

Phys. Rev. D 104 (2021) 032013





Challenges:

Significant backgrounds

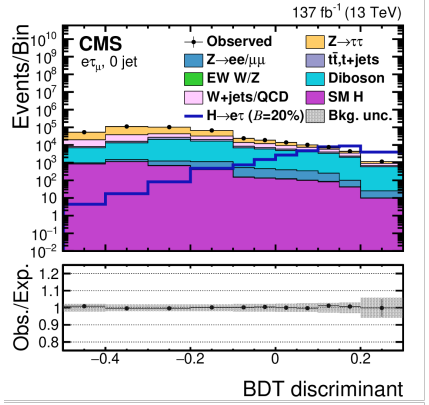
Single lepton triggers

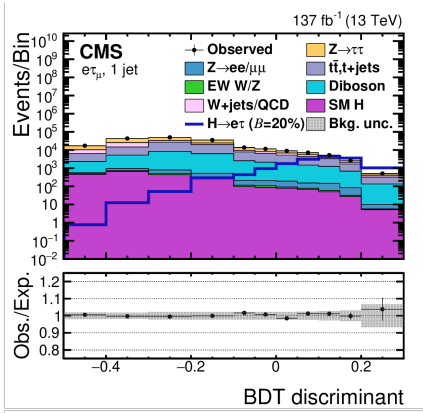
→

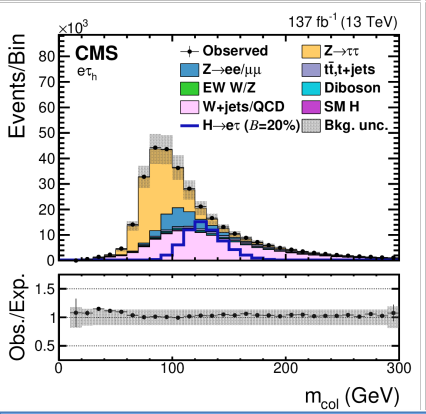
Embedded samples for $Z \to \tau\tau$

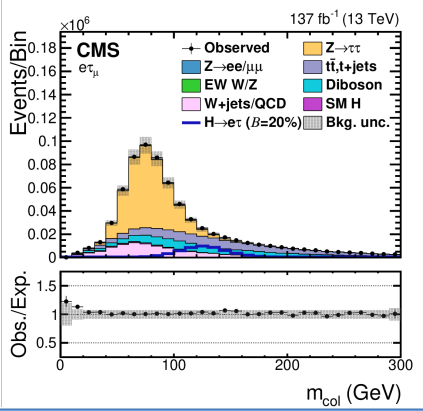
ML-based isolation

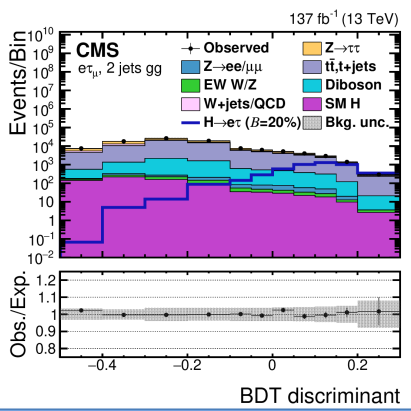
ML-based discriminators

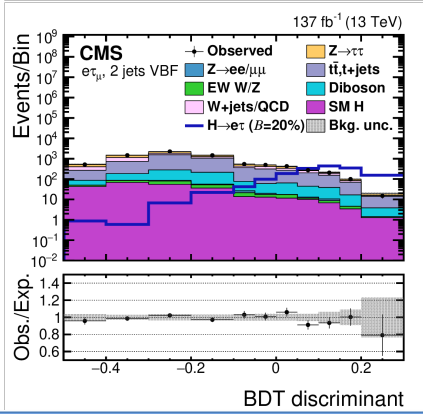






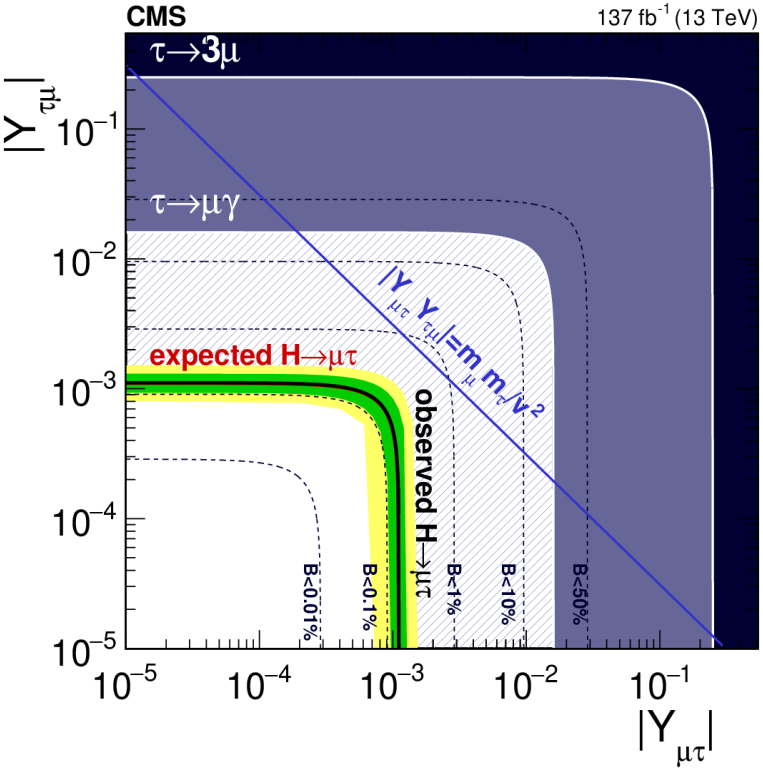


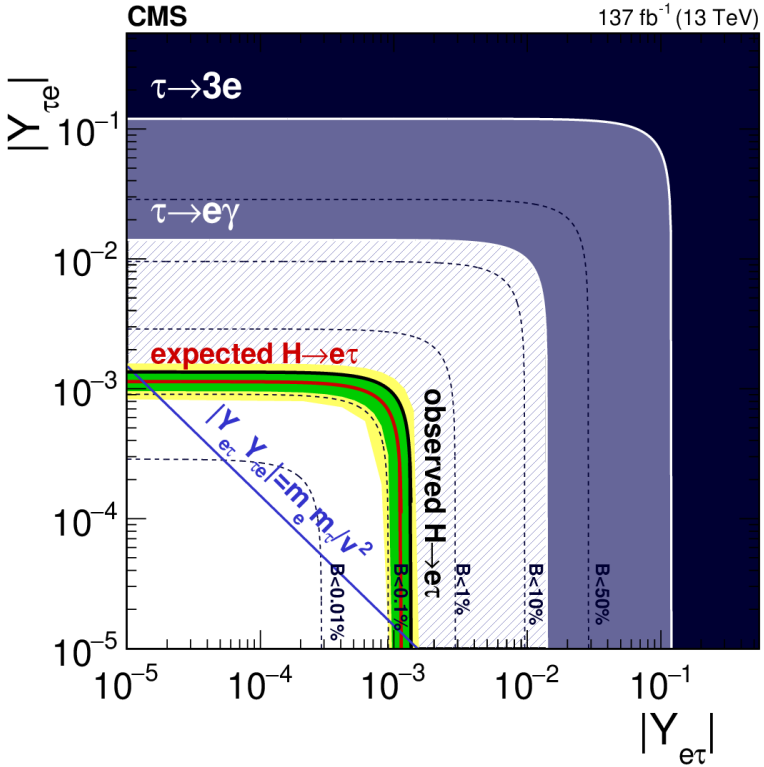




LFV: $H(125) \rightarrow \mu\tau, H(125) \rightarrow e\tau$

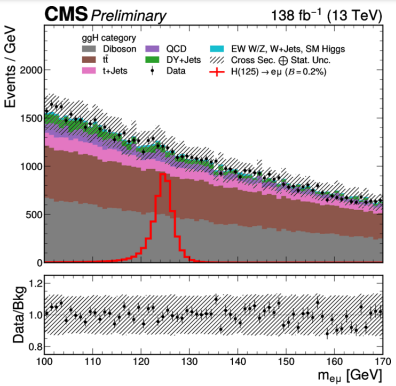
Phys. Rev. D 104 (2021) 032013

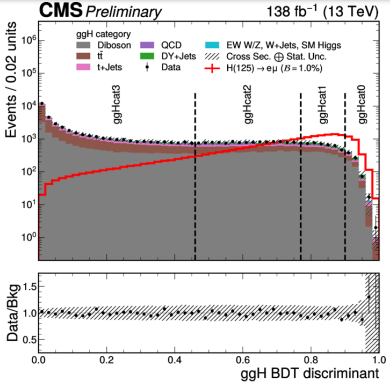




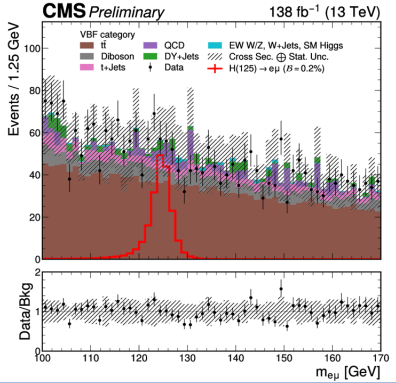
LFV: How about $H(125) \rightarrow e\mu$?

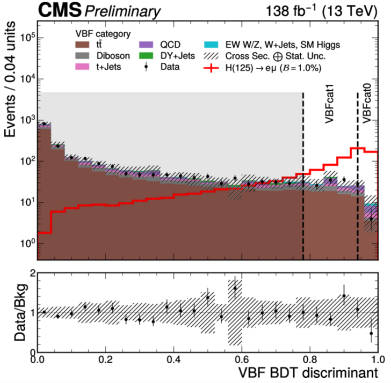
CMS-HIG-22-002

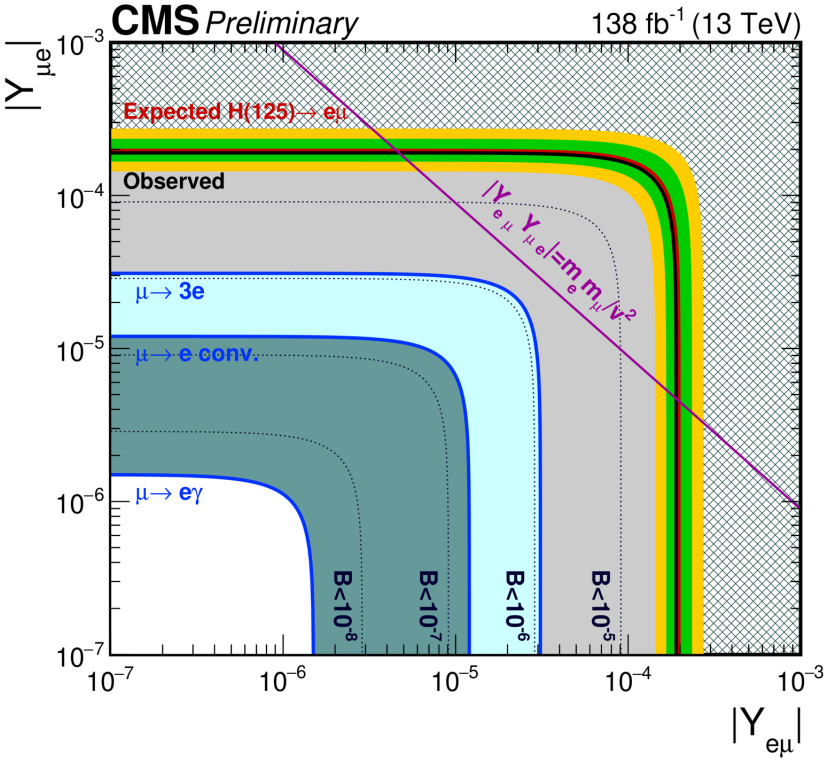




ML Discriminators →

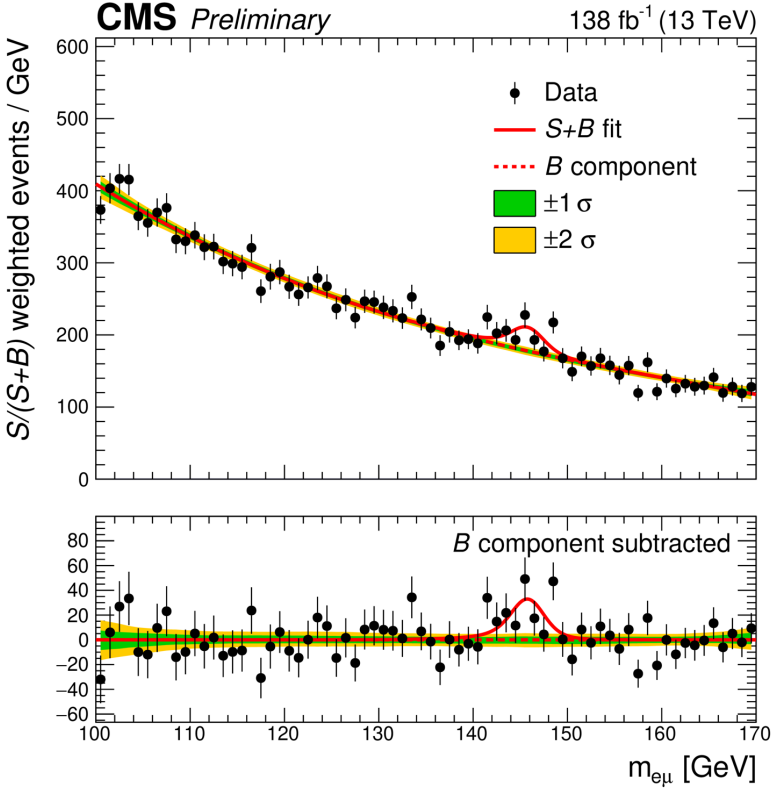


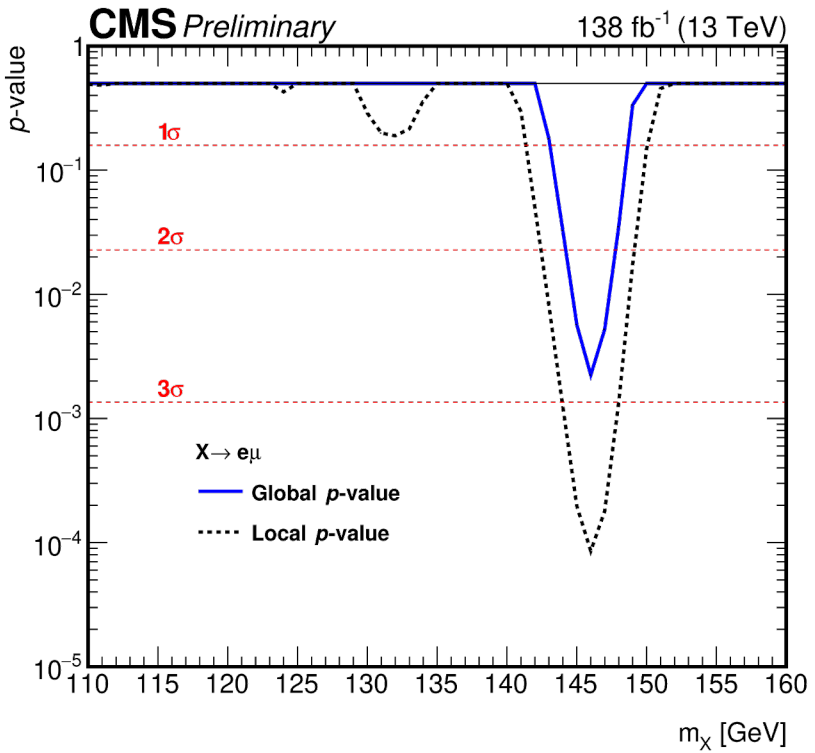




LFV: Well $X \rightarrow e\mu$?

CMS-HIG-22-002

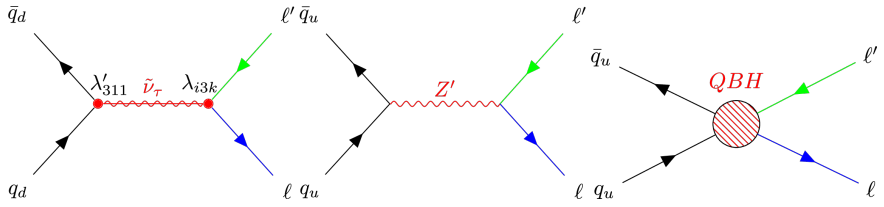


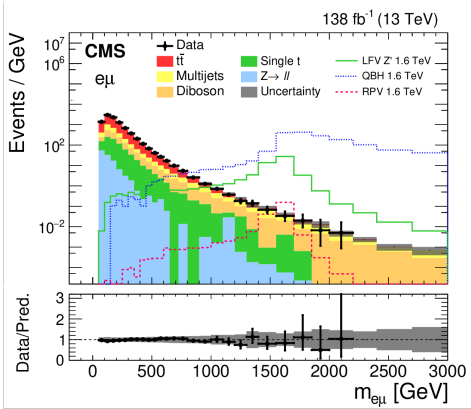


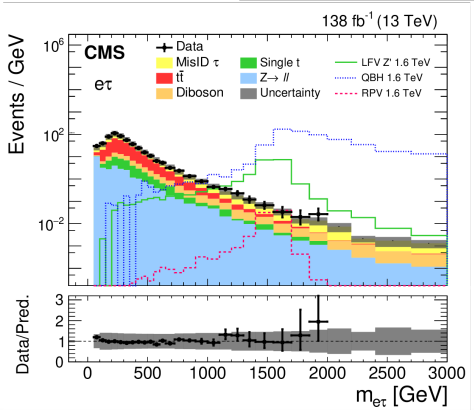
Awaiting more data … Stay-tuned for Run-3

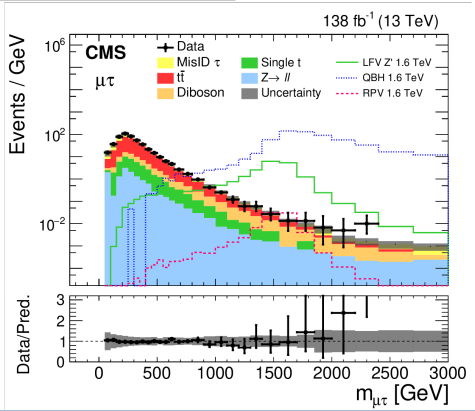
LFV: Very High Mass Objects

arXiv:2205.06709







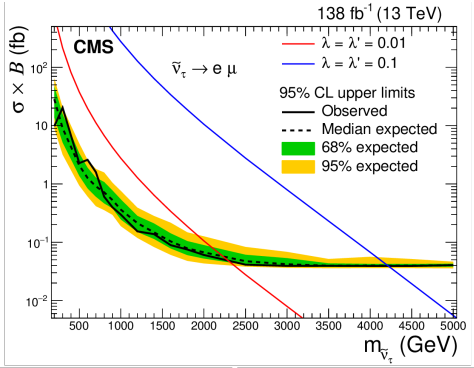


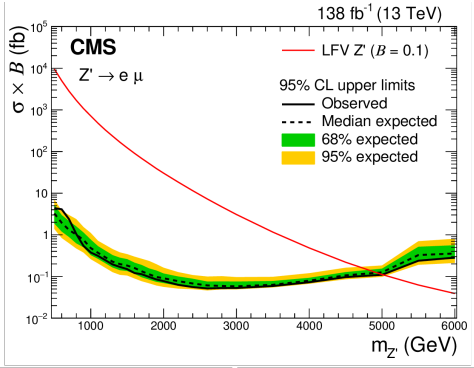
Push to multi-TeV masses

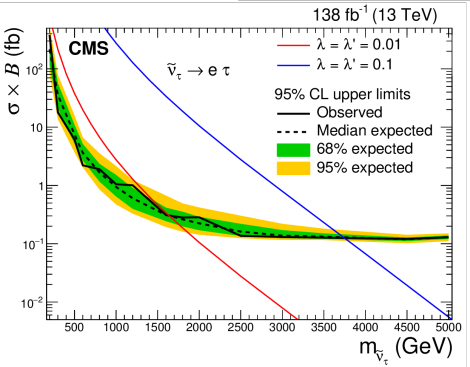
LHC shines when it comes to measuring very high P_T leptons

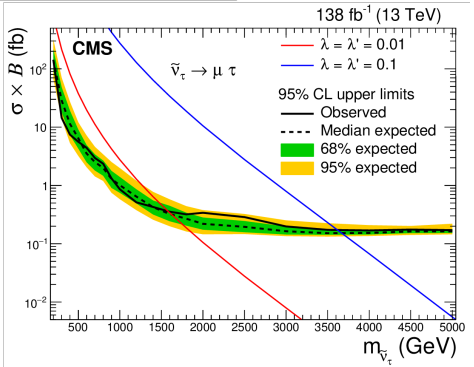
LFV: Sneutrino or Z' Interpretations

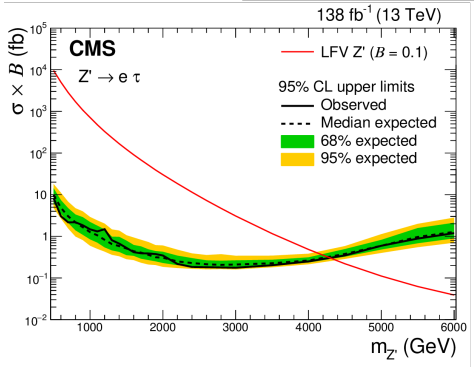
arXiv:2205.06709

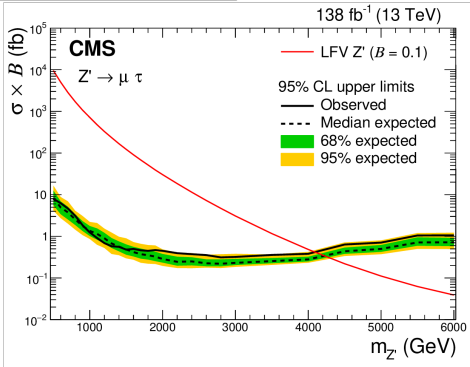










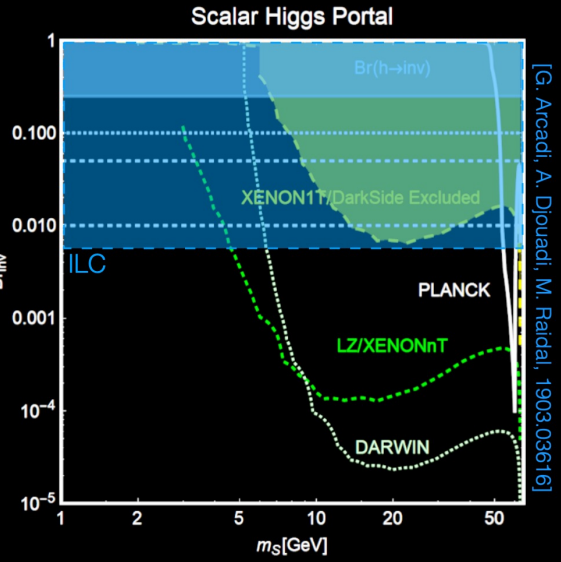


Another of Nathaniel's Seven Questions

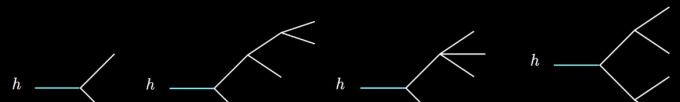
A portal to the dark sector?

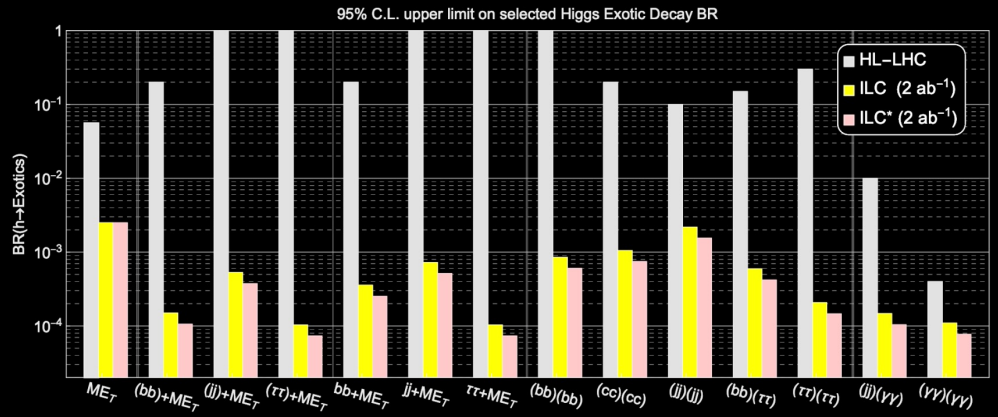
$$\mathcal{L} \supset |H|^2 \mathcal{O}$$

Higgs a (the?) primary portal for coupling to SM-neutral sectors



[G. Arcadi, A. Djouadi, M. Raidal, 1903.03616]



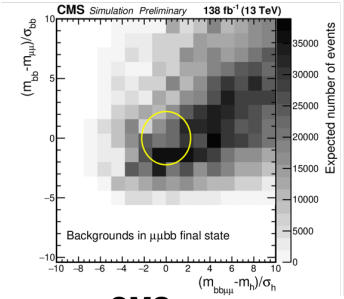


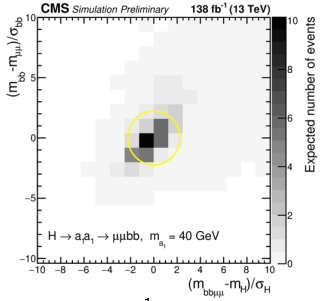
2HDM+S: $H(125) \rightarrow aa \rightarrow \mu\mu bb$

CMS-PAS-HIG-22-007

Challenges:

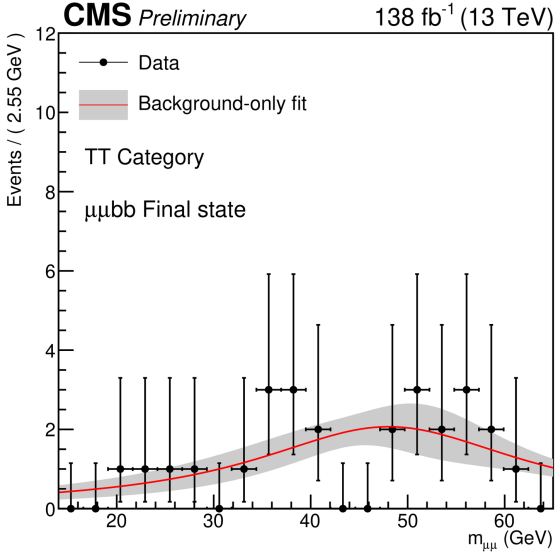
- High rate triggers
- Leptons from meson decays
- Large backgrounds
- Plethora of low P_T b-jets
- Combinatorics …

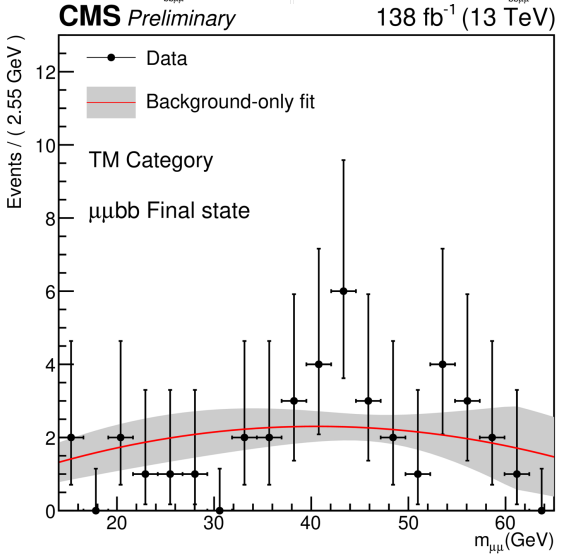


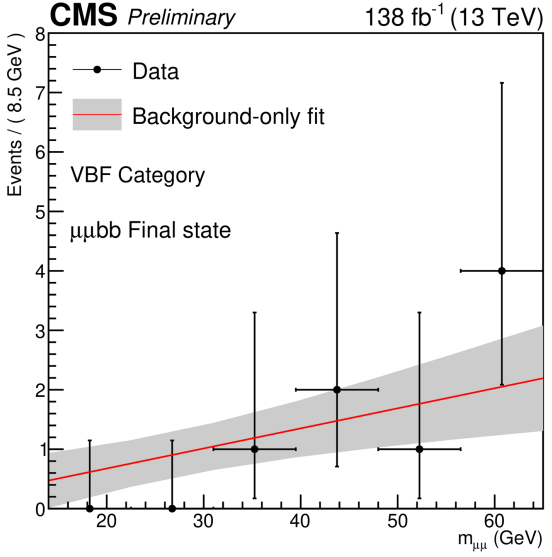


Mitigation:

- Take advantage of topology
- Categorize by b-tag quality
- Sort by production modes
- ML-Based isolation

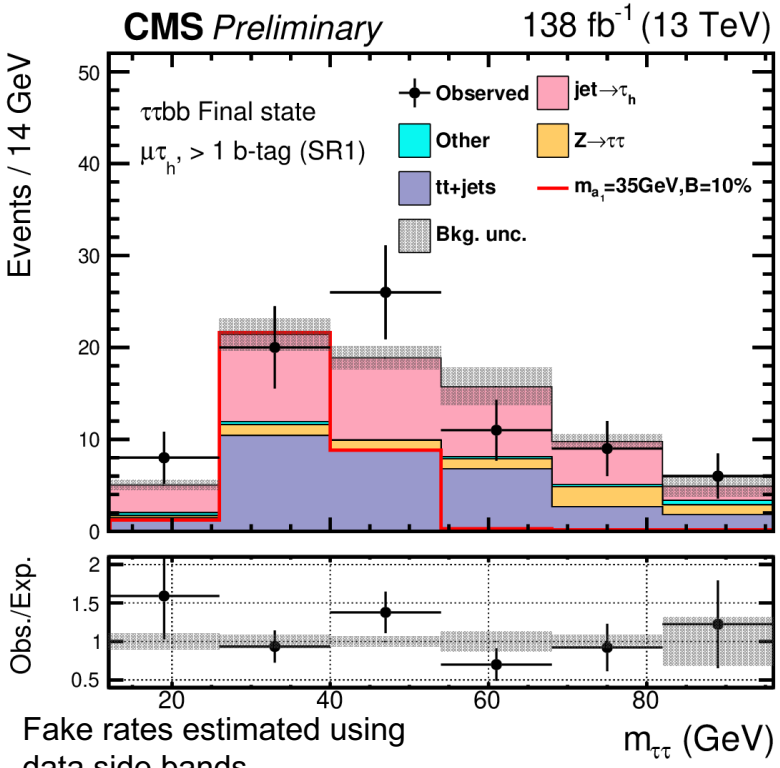




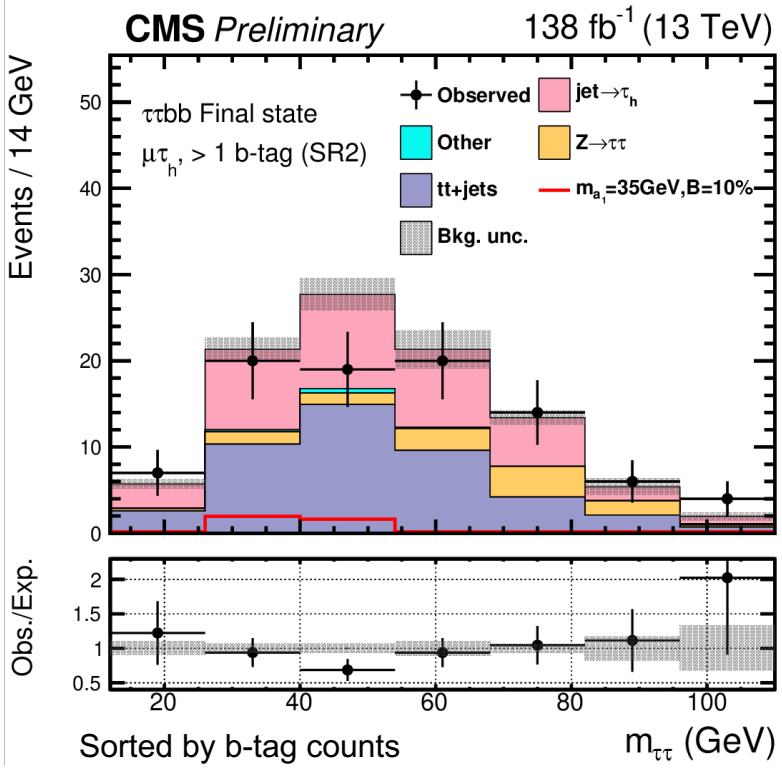


2HDM+S: $H(125) \rightarrow aa \rightarrow \tau\tau bb$

CMS-PAS-HIG-22-007



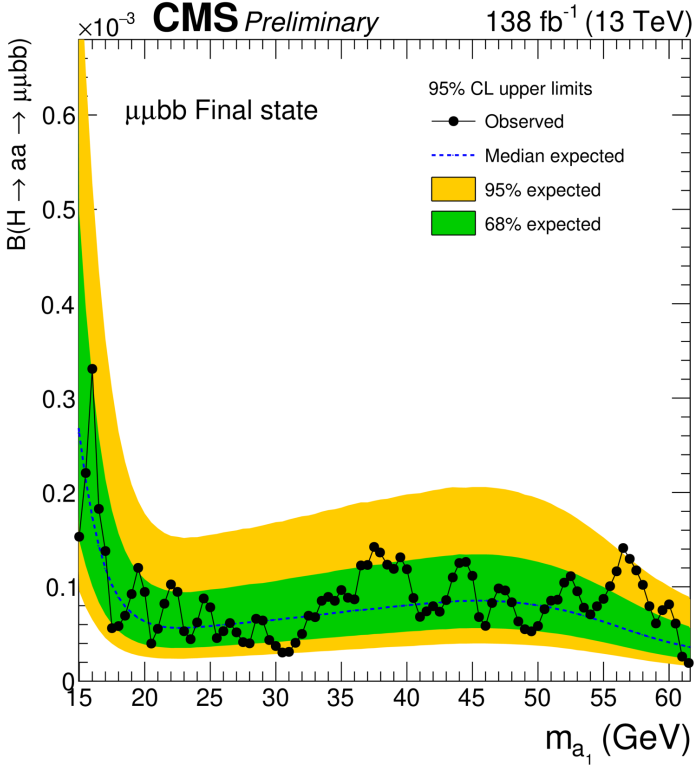
Fake rates estimated using data side bands

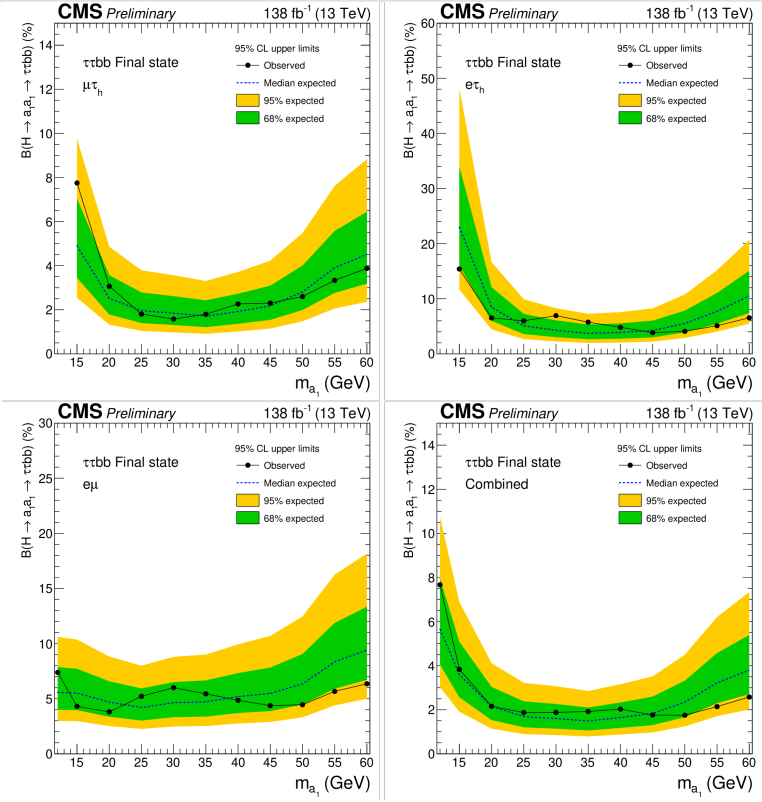


Sorted by b-tag counts
Separated by DNN-score thresholds

2HDM+S: $H(125) \rightarrow aa \rightarrow \mu\mu bb, \tau\tau bb$

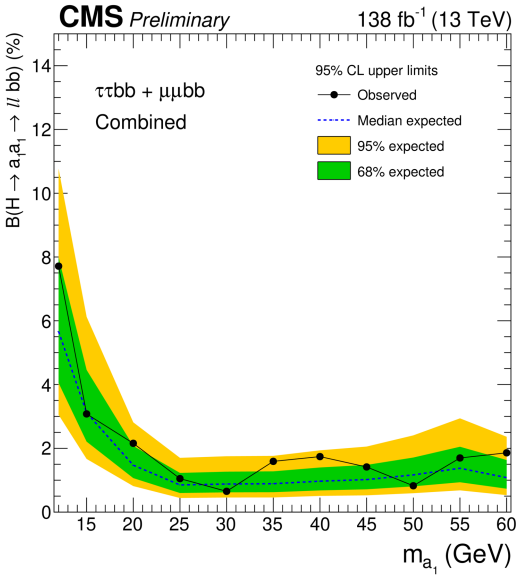
CMS-PAS-HIG-22-007

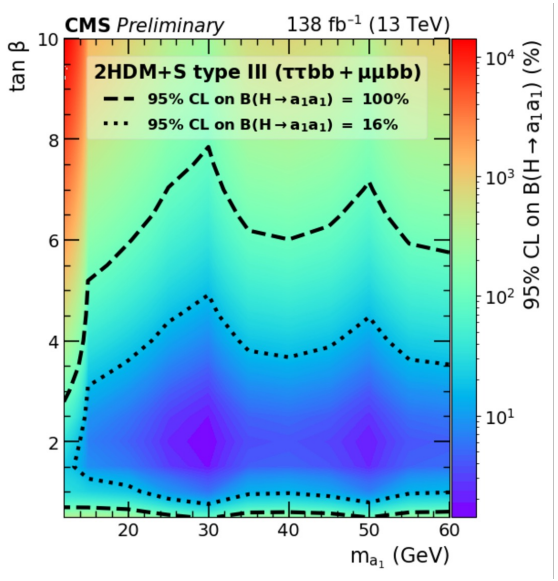


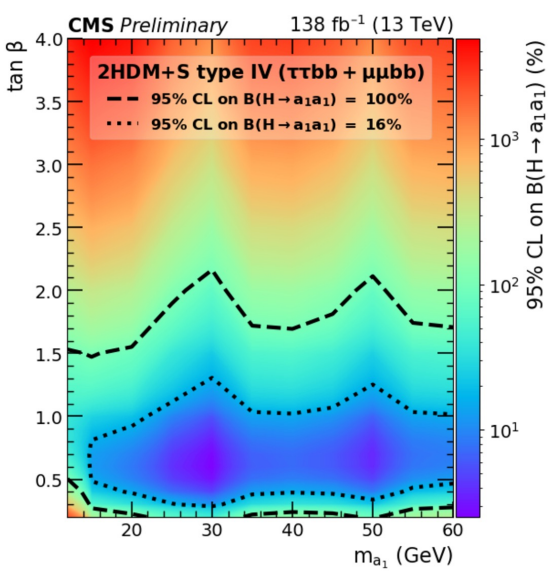


2HDM+S: $H(125) \rightarrow aa \rightarrow \mu\mu bb, \tau\tau bb$

CMS-PAS-HIG-22-007







Summary / Comments

CMS has explored very many beyond standard model physics signatures

- Nothing significant is yet to be seen
  - Strongly coupled sector is limited
- Searches with luminosity increases will provide improved coverage
  - Weakly coupled new physics will see most improvements
- An eclectic collection of BSM Higgs signatures is presented

HL-LHC luminosities will present challenges!

- Detector improvements should go far … when going gets tough …
  - Higher granularity upgrades, Higher trigger rates,
    Precision timing, … should help mitigate increasing pileup