Recent BSM results from CMS

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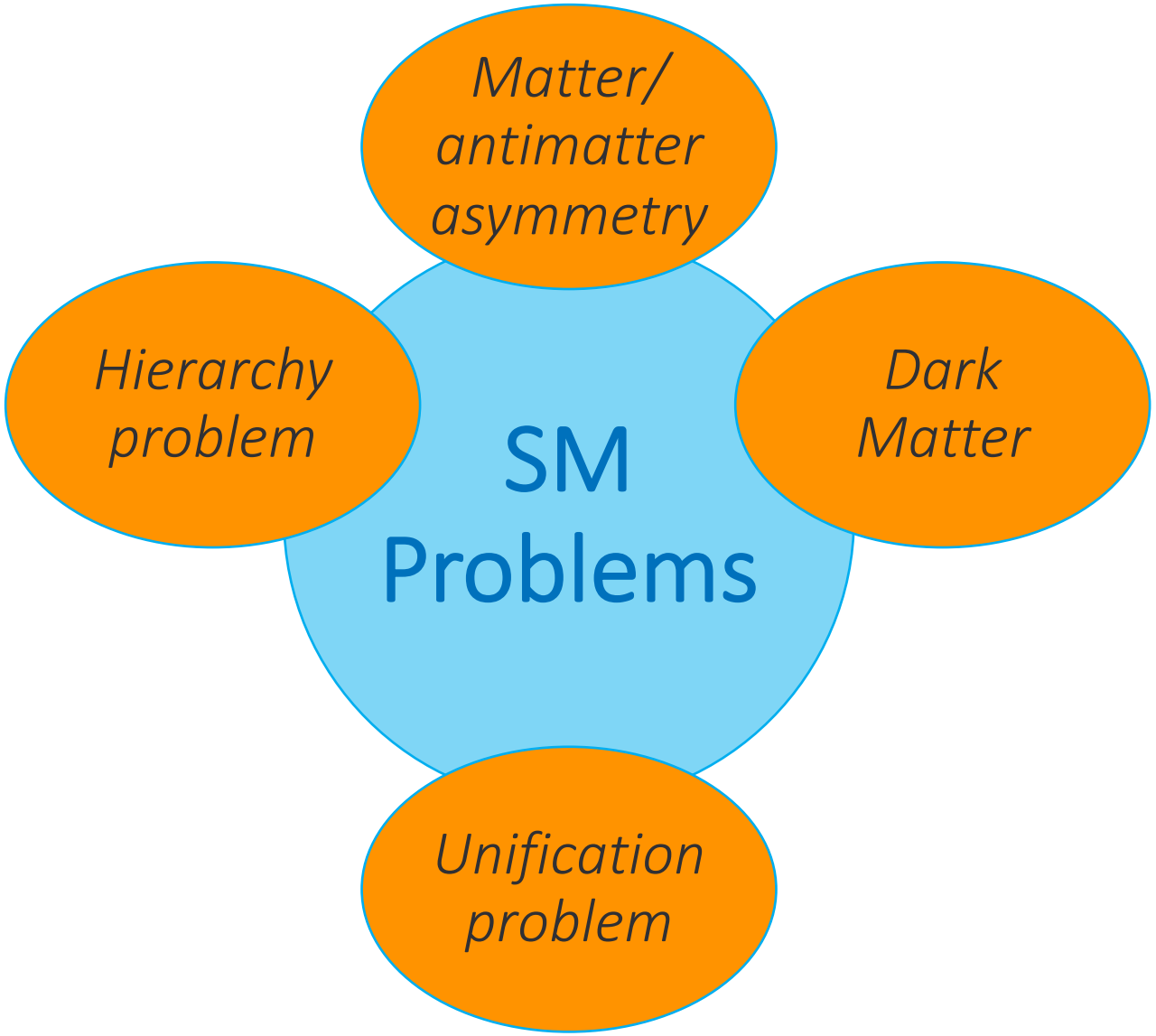
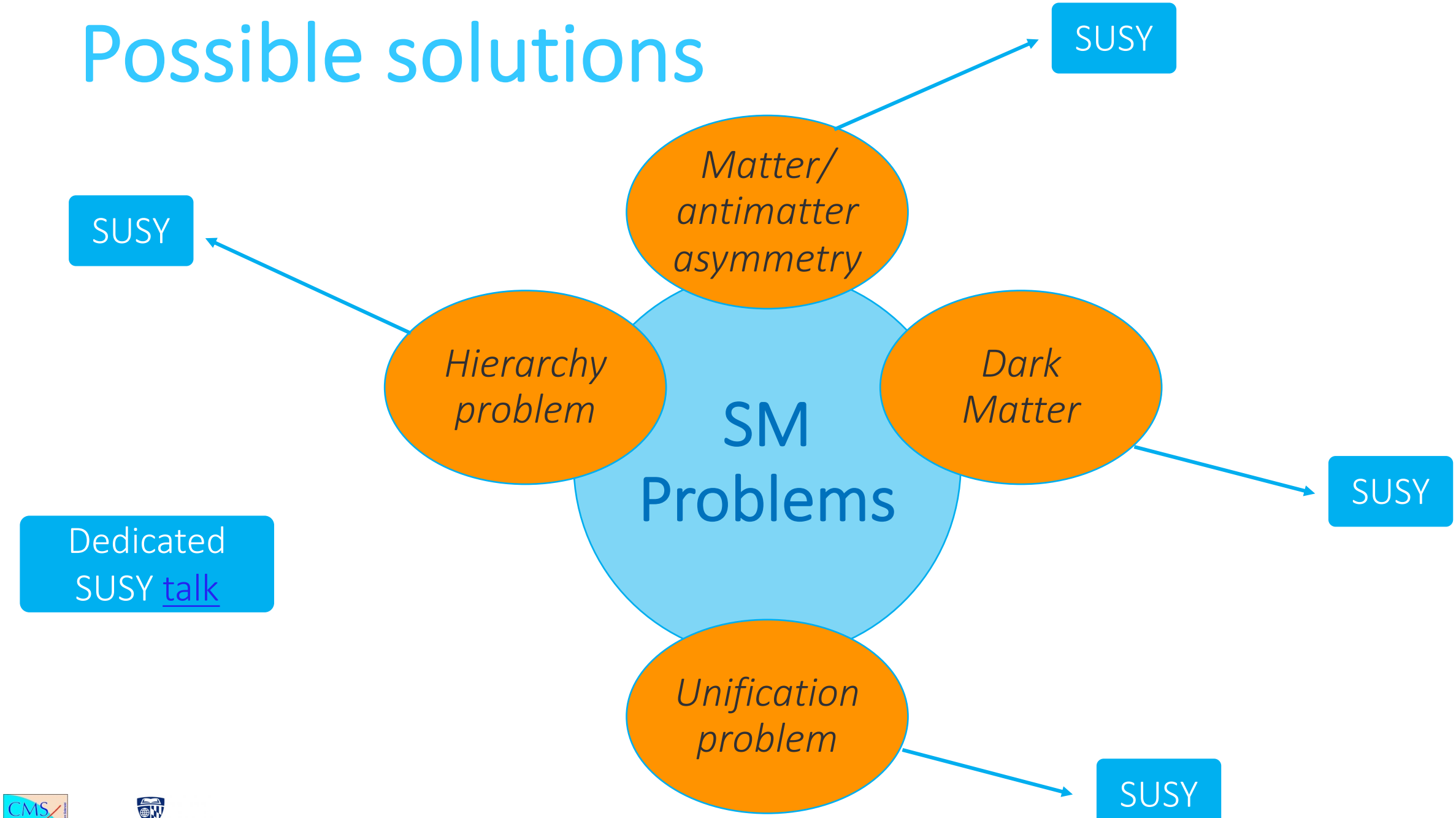
[1]Johns Hopkins University, USA

CIPANP2022

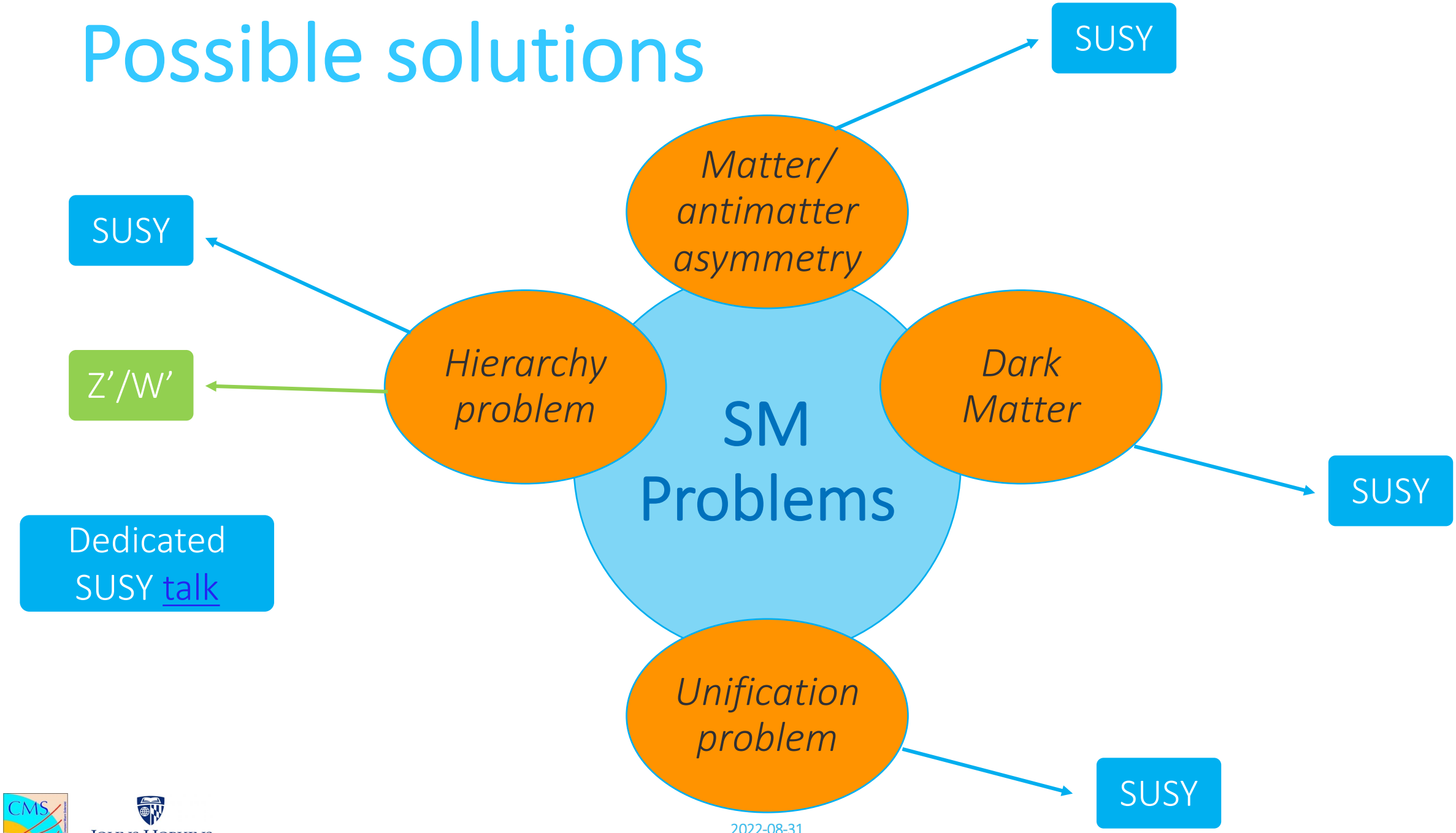
Need for Beyond Standard Model (BSM)



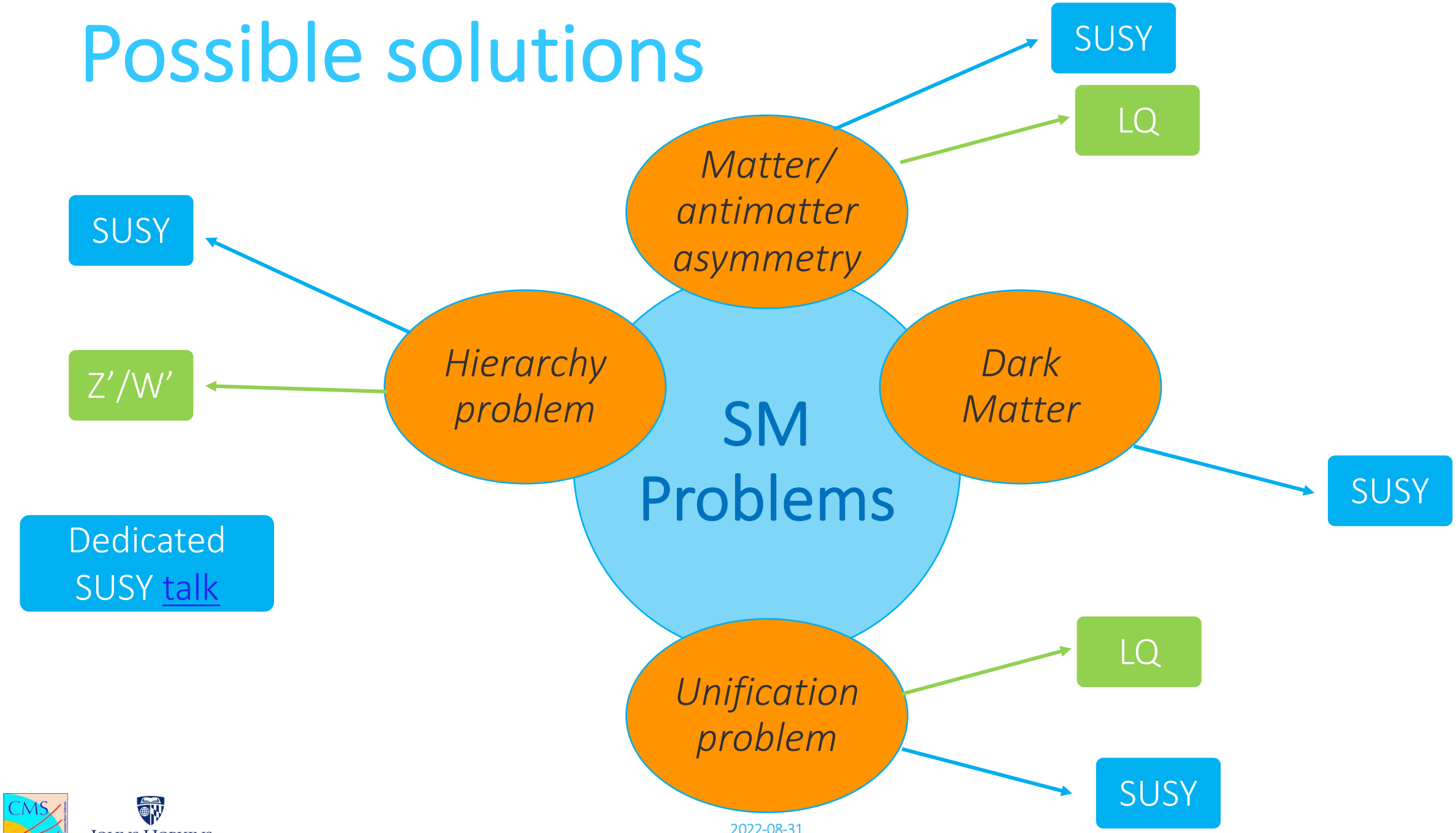
Possible solutions



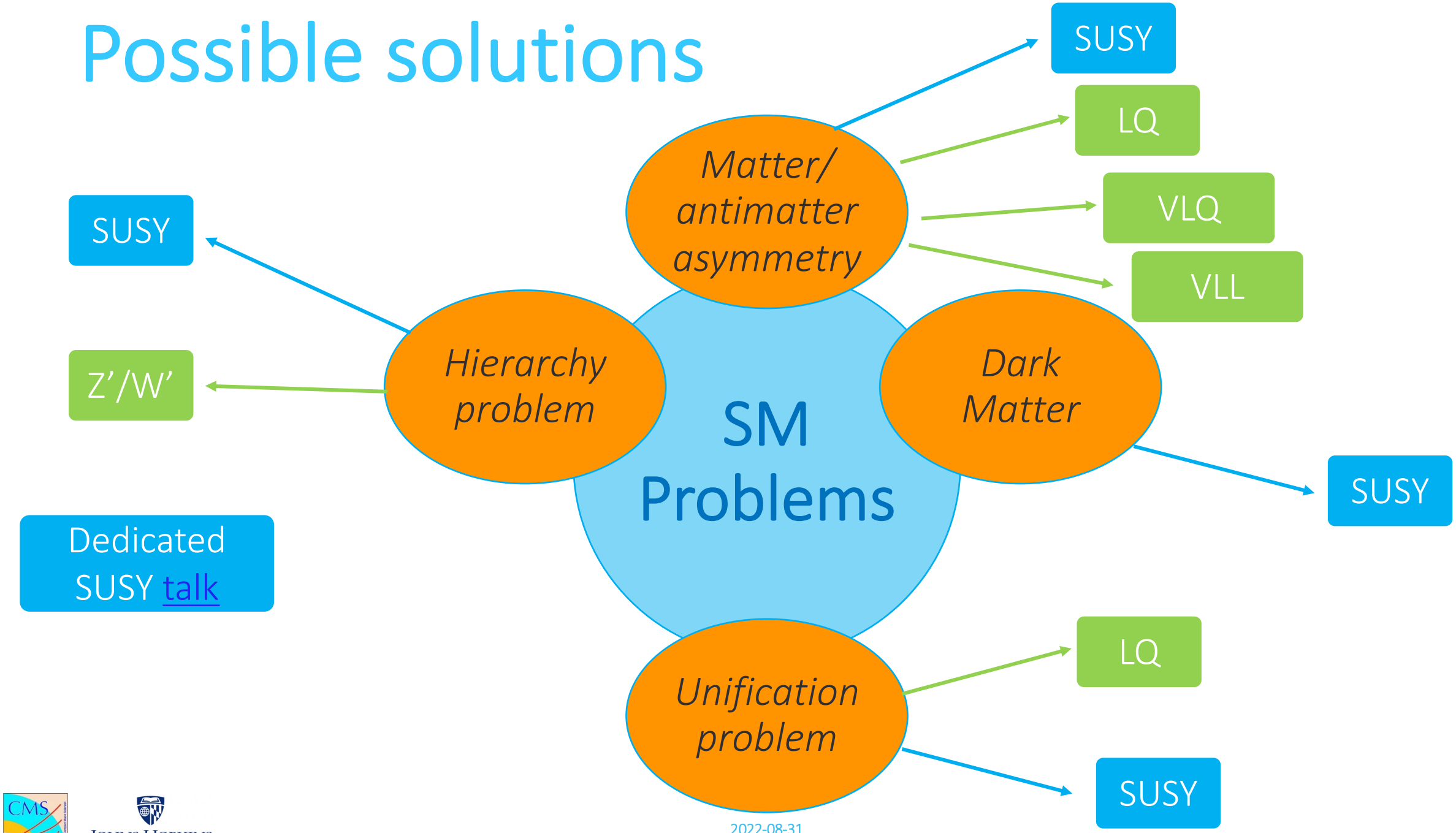
Possible solutions



Possible solutions

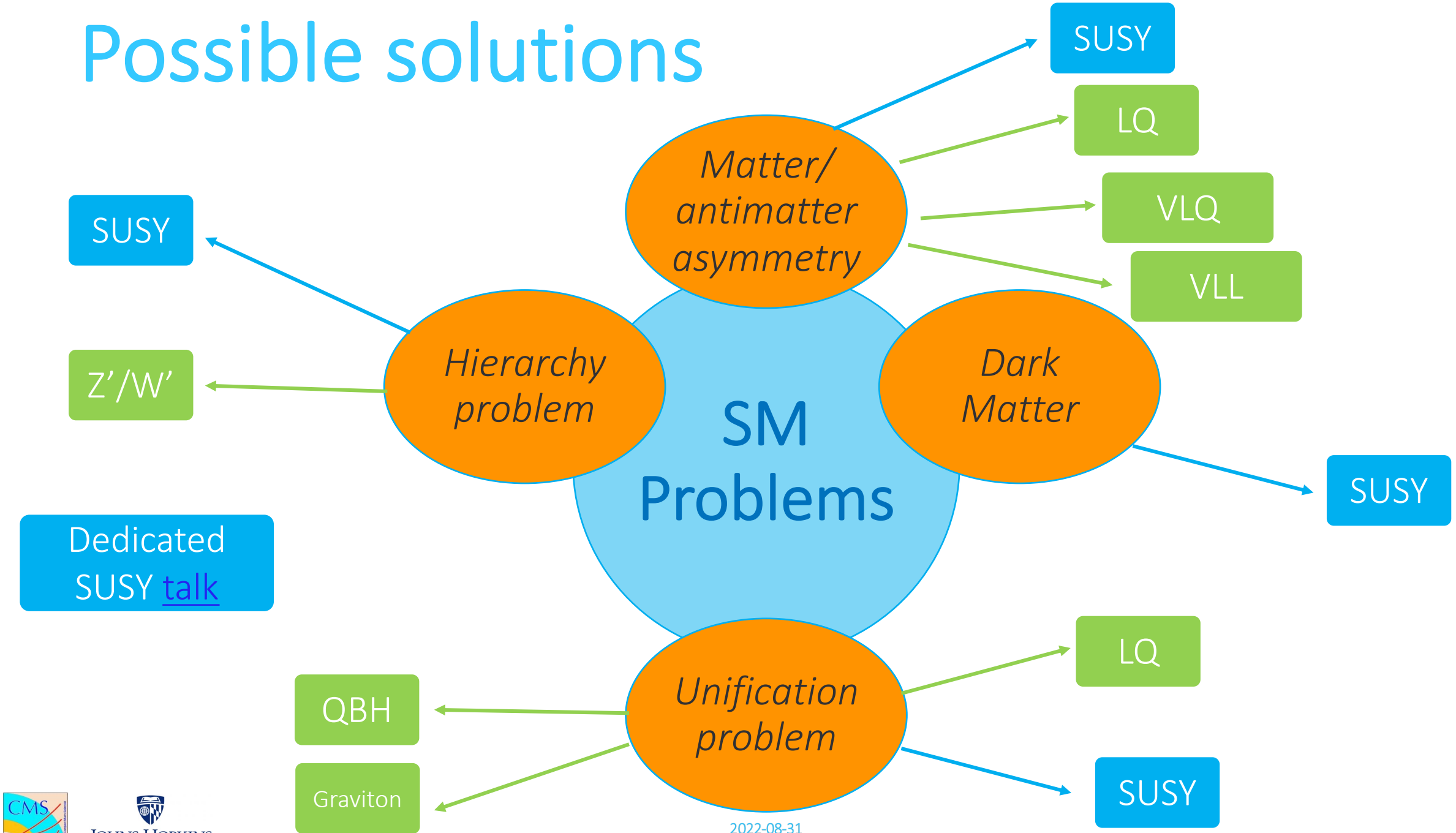


Possible solutions



Dedicated SUSY talk

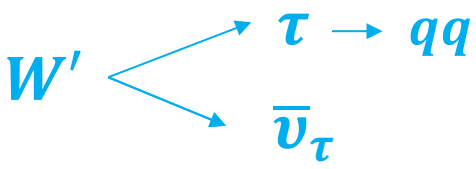
Possible solutions



Dedicated SUSY talk

Signatures covered in this talk

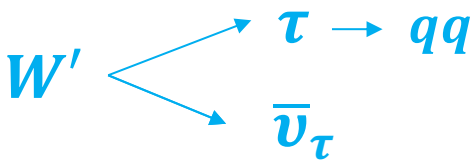
W', QBH, LQ



EXO-21-009

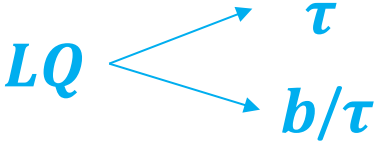
Signatures covered in this talk

W', QBH, LQ



EXO-21-009

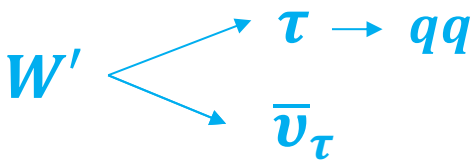
LQ, VLQ



EXO-19-016

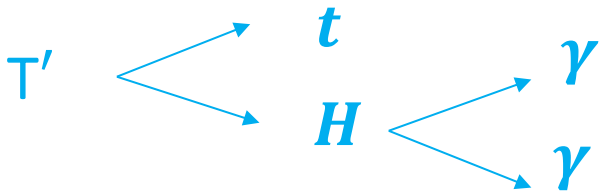
Signatures covered in this talk

W', QBH, LQ



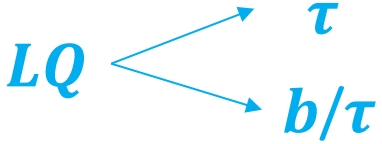
EXO-21-009

VLQ



B2G-21-007

LQ, VLQ



EXO-19-016

Signatures covered in this talk

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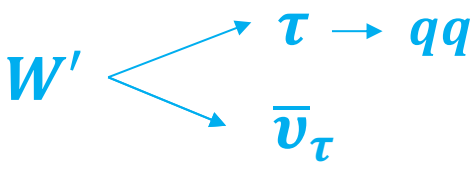
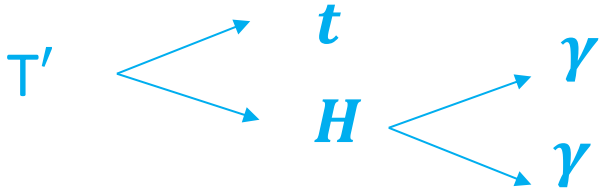


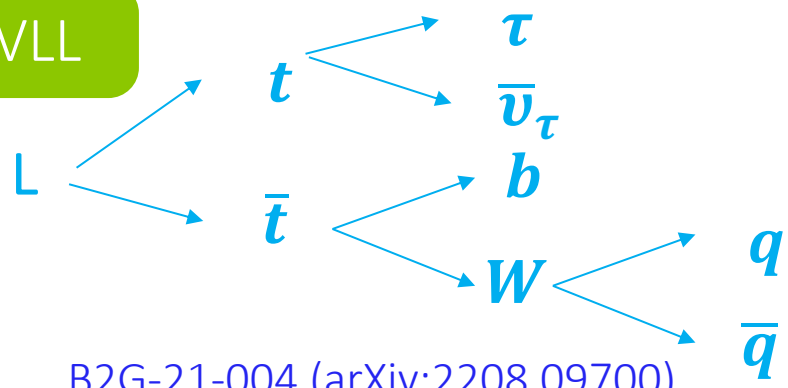
EXO-21-009

VLQ



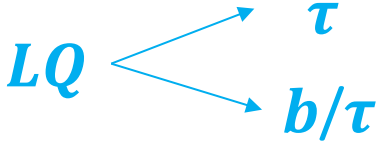
B2G-21-007

VLL



B2G-21-004 (arXiv:2208.09700)

LQ, VLQ



EXO-19-016

Signatures covered in this talk

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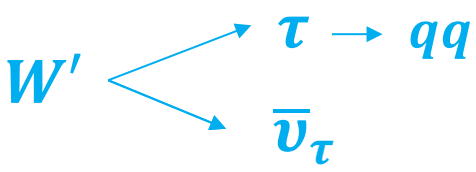
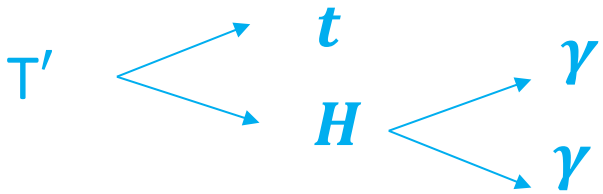


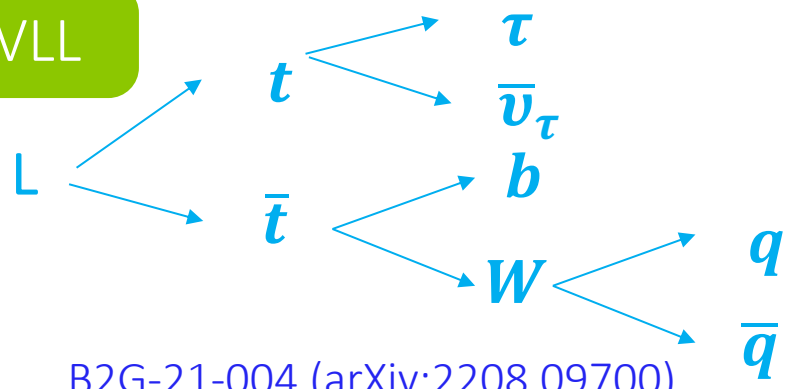
EXO-21-009

VLQ



B2G-21-007

VLL



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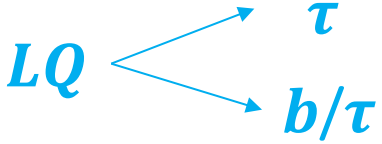


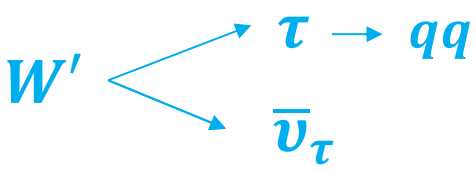
EXO-19-016

Z'/W'

B2G-20-009

BSM in the τ + missing transverse momentum final state

W', QBH, LQ



EXO-21-009

Tau tagger:

Deep-Tau ID: Neutral network (NN)

Discriminator:

$$m_{\mathrm{T}} = \sqrt{2\, p_{\mathrm{T}}^{\tau_{\mathrm{h}}}\, p_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos\Delta\phi(\vec{p}_{\mathrm{T}}^{\,\tau_{\mathrm{h}}}, \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}))}$$

Background prediction:

MC based + data driven mis-ID rates

EXO-21-009

BSM in the τ + missing transverse momentum final state

W', QBH, LQ

$W' \rightarrow \tau \rightarrow qq$

$W' \rightarrow \overline{\nu}_{\tau}$

EXO-21-009

Tau tagger:

Deep-Tau ID: Neutral network (NN)

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$$m_{\mathrm{T}} = \sqrt{2\, p_{\mathrm{T}}^{\tau_{\mathrm{h}}}\, p_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos\Delta\phi(\vec{p}_{\mathrm{T}}^{\,\tau_{\mathrm{h}}}, \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}))}$$

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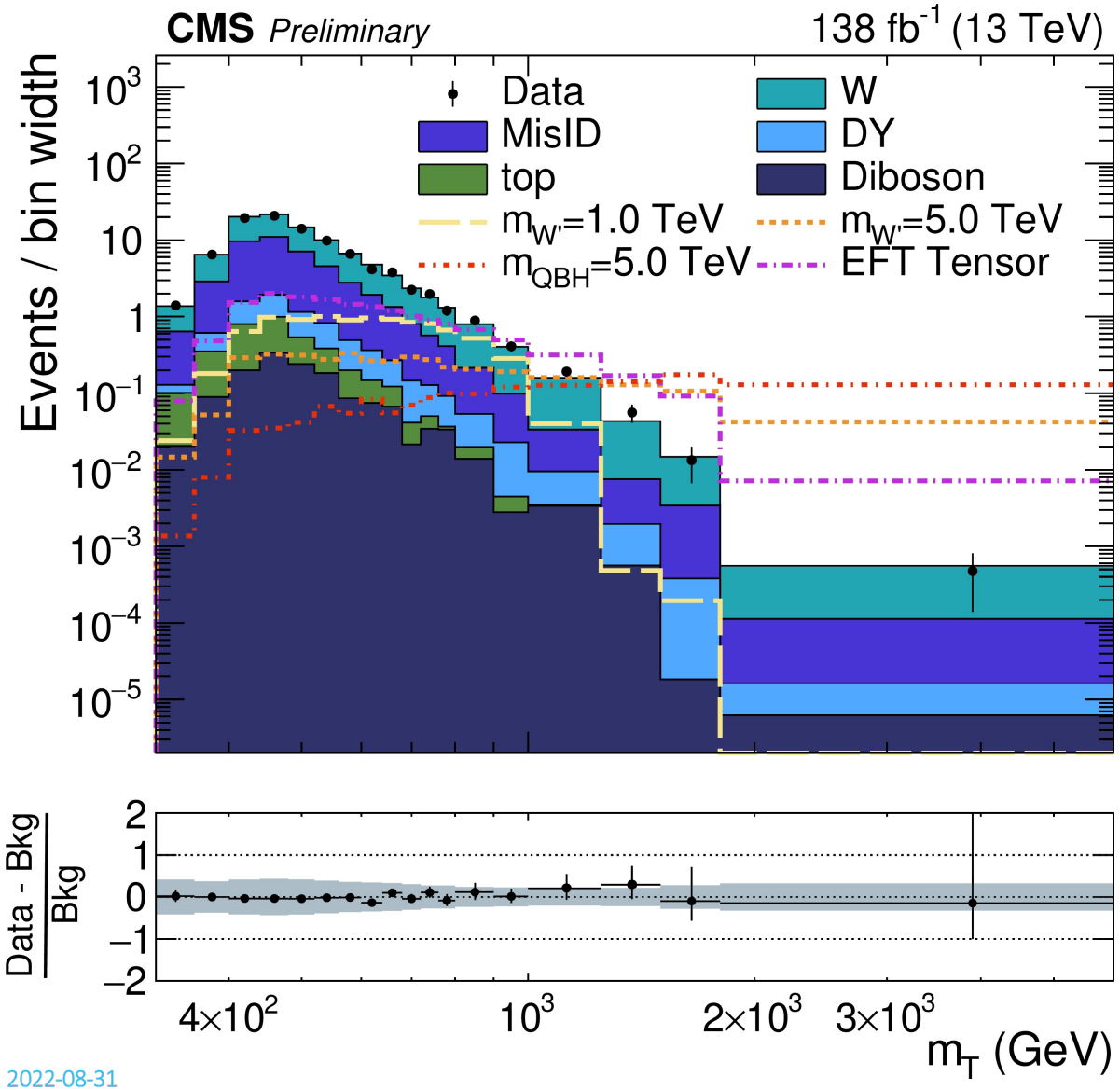
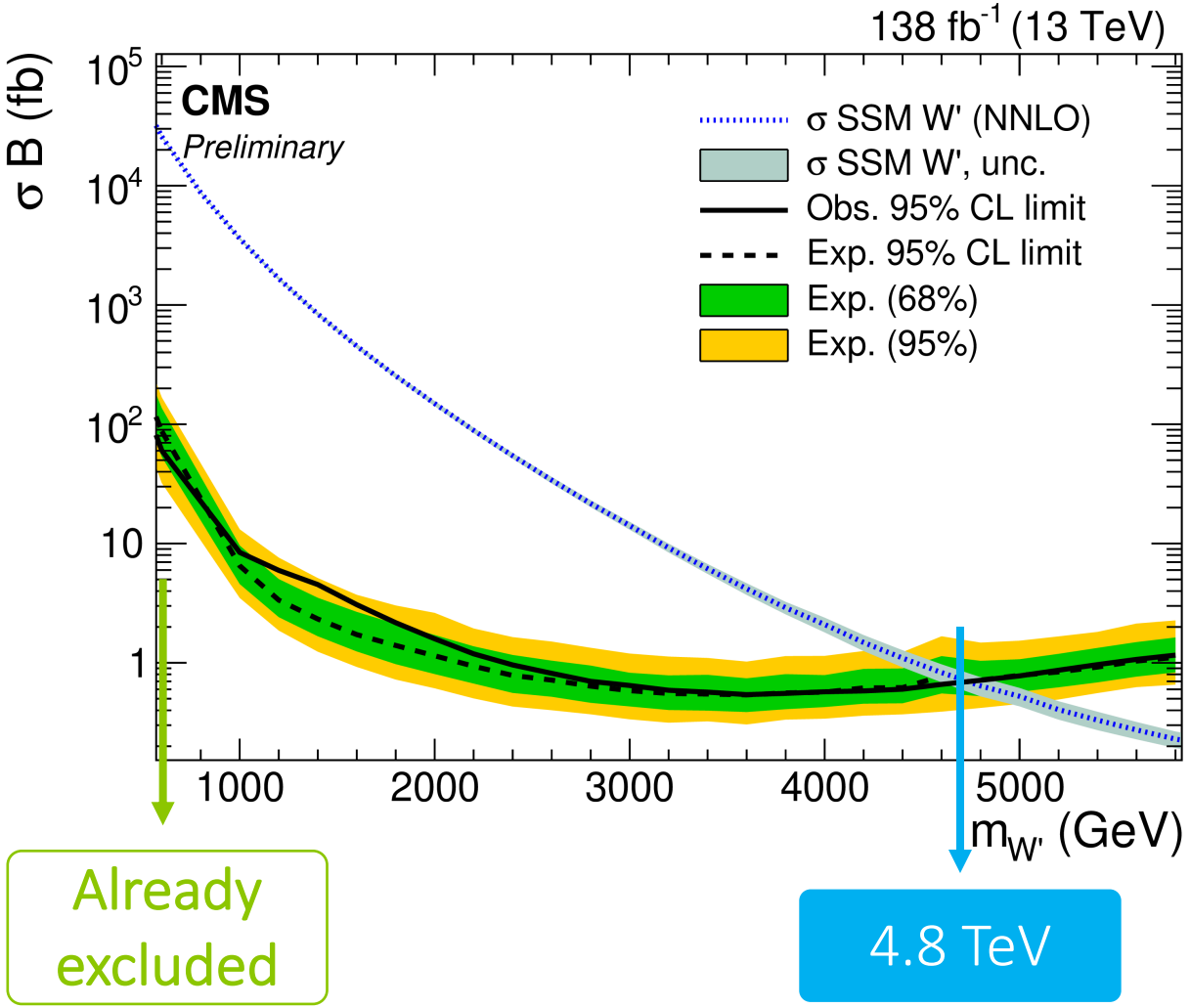


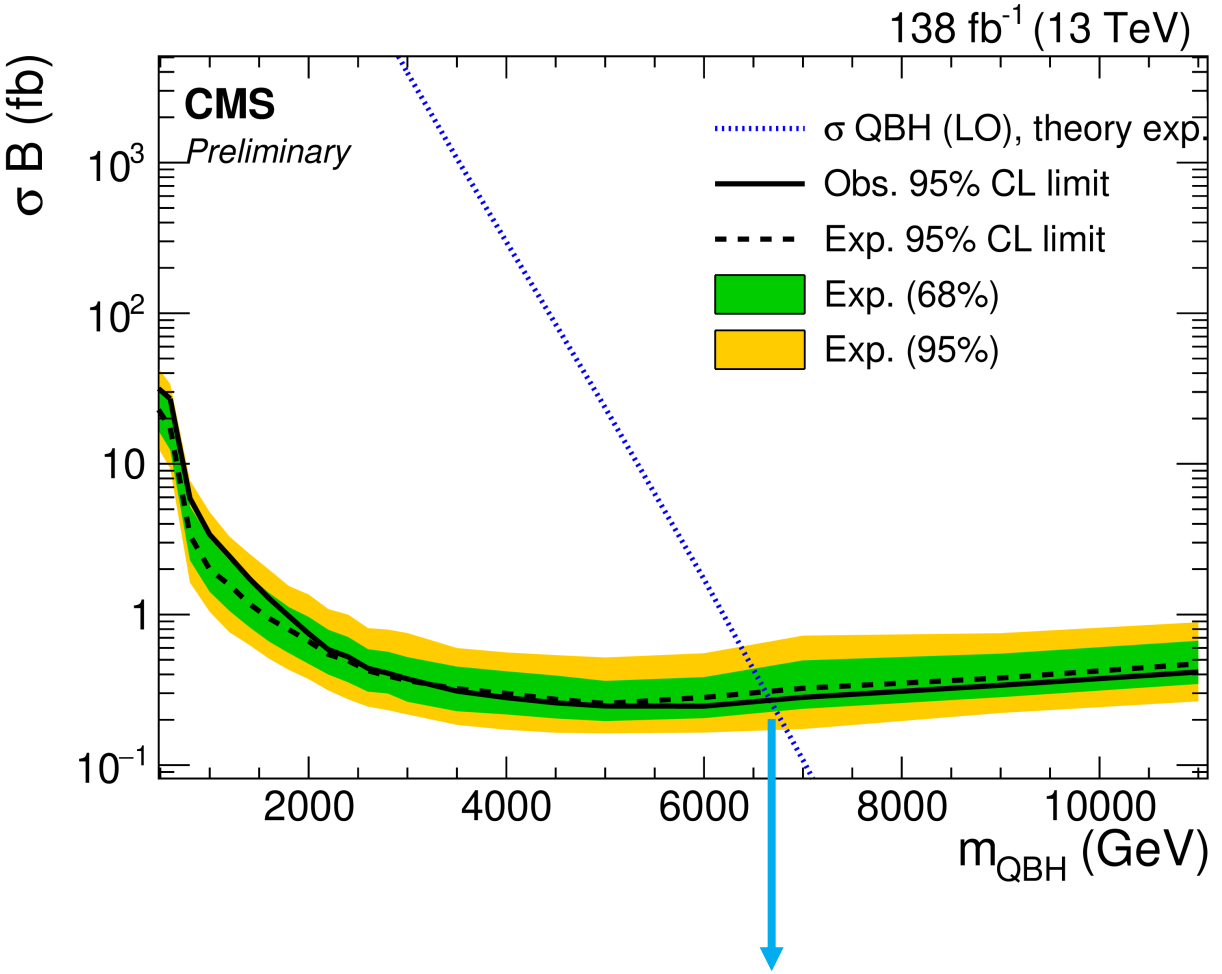
EXO-21-009

Exclusion limits for W’ and QBH



Already excluded

4.8 TeV

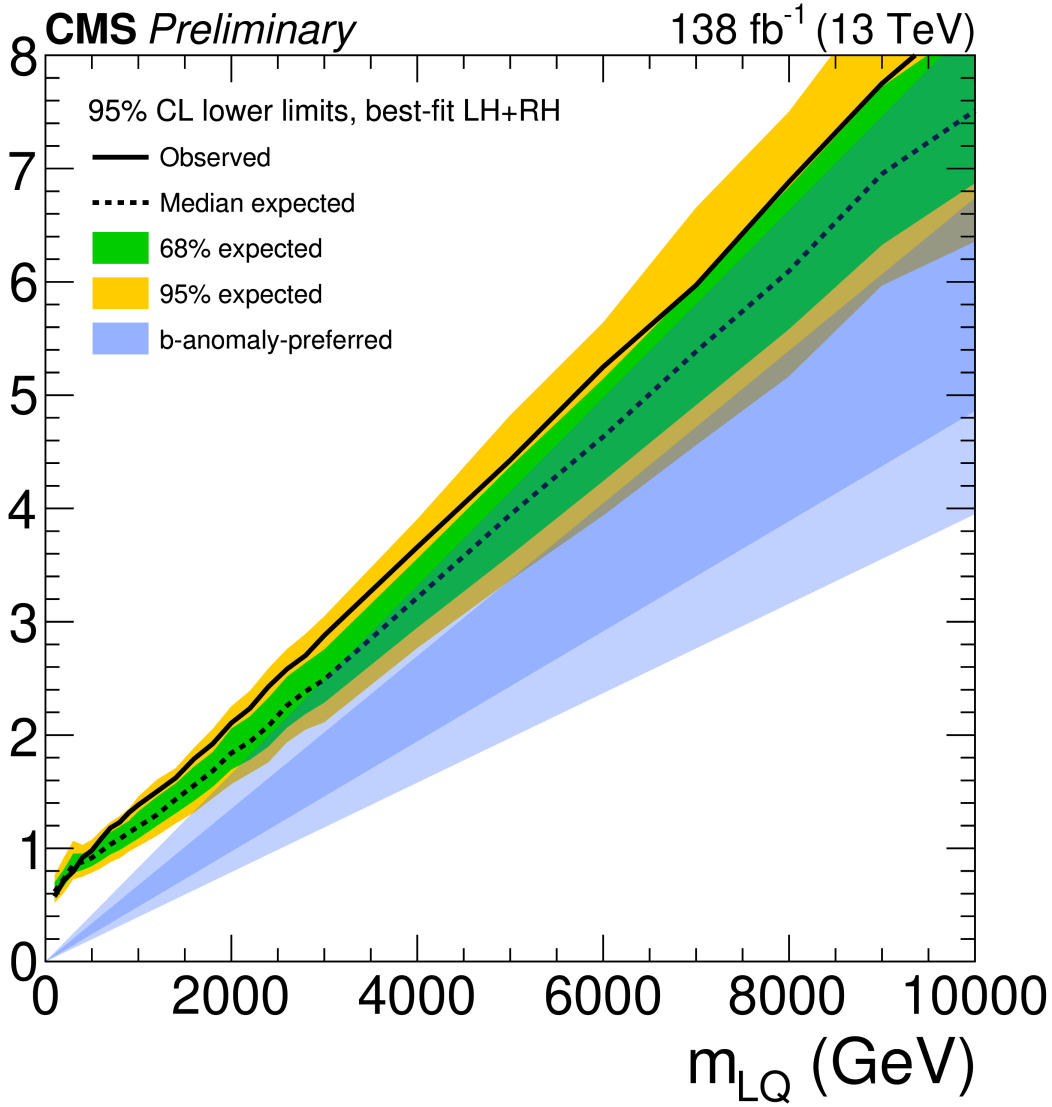


6.6 TeV

EXO-21-009

Exclusion limits for LQ

LQ coupling to SM fermions



Exclusion limits for LQ

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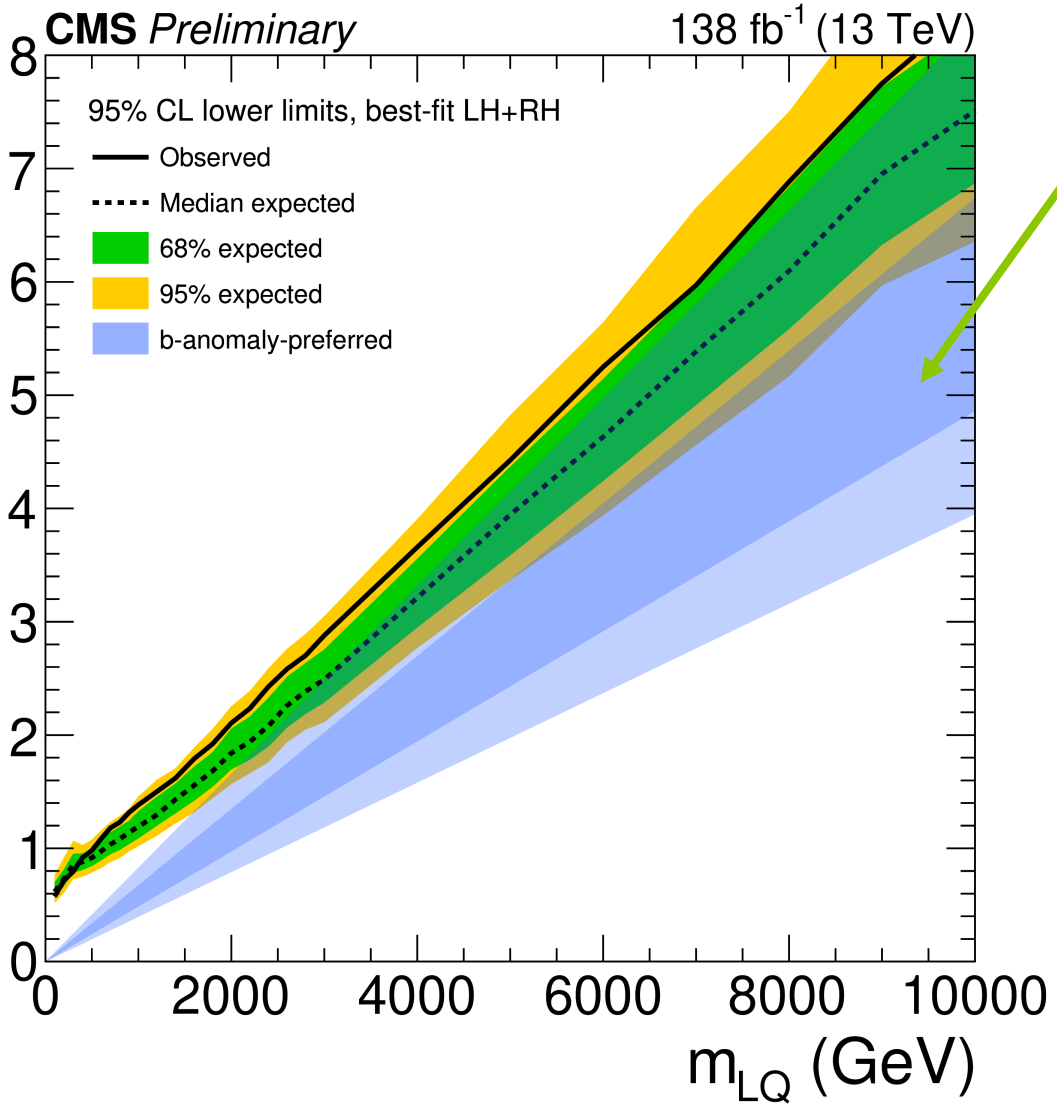


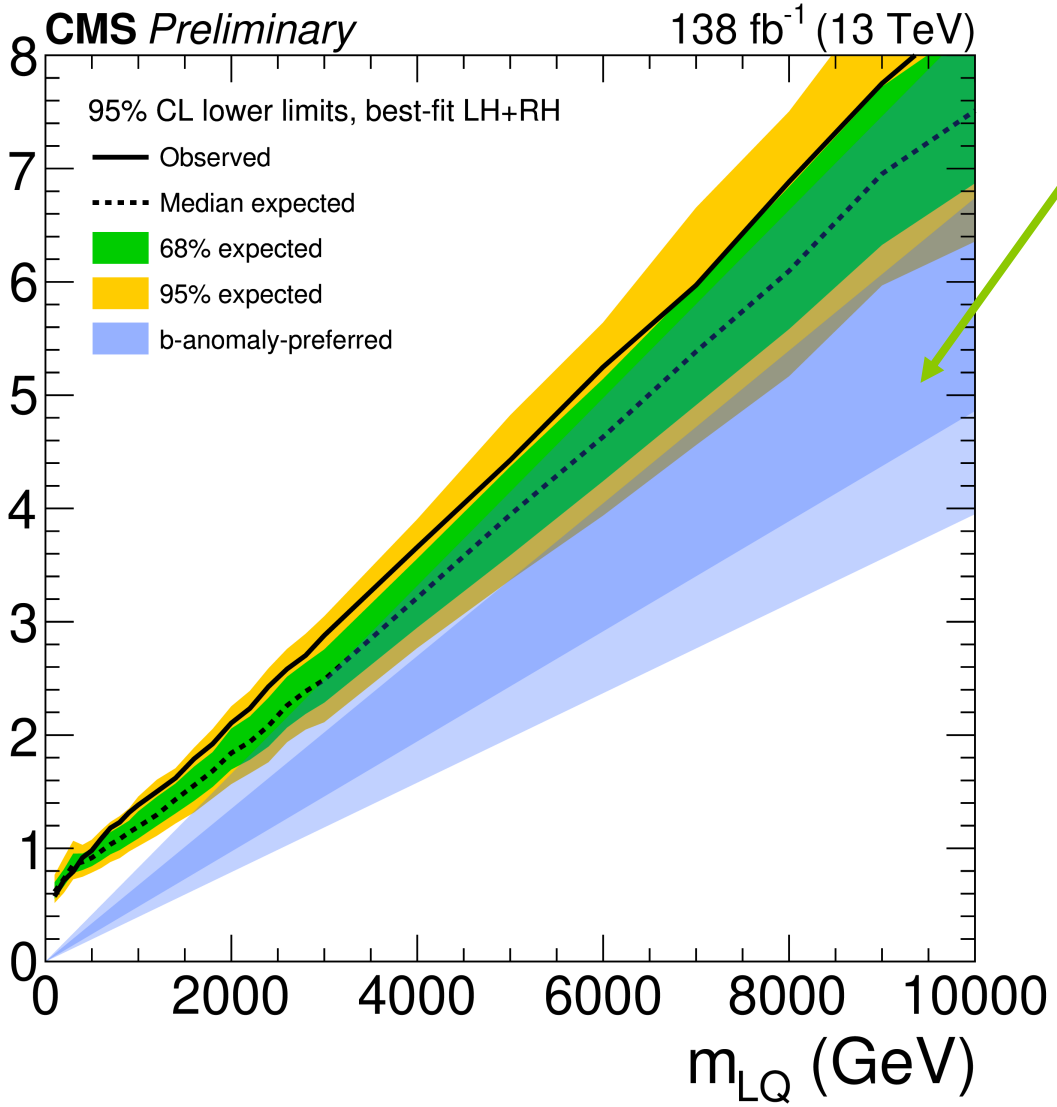
Based on the latest $R_{K^{(*)}}$ and $R_{D^{(*)}}$ results from LHCb, Belle, etc

$$R_{\mathrm{K}^{(*)}} = \frac{\mathcal{B}(\mathrm{B} \to \mathrm{K}^{*}\mu\mu)}{\mathcal{B}(\mathrm{B} \to \mathrm{K}^{*}\mathrm{ee})}$$

$$R_{D^{(*)}} = \frac{\Gamma(B \to \mathrm{D}^{*}\tau\nu)}{\Gamma(B \to \mathrm{D}^{*}\ell\nu)}$$

Exclusion limits for LQ

LQ coupling to SM fermions



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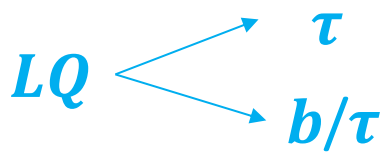
Significant LQ phase space excluded!

Scaling m_T distribution to 500/fb: LQ explanation of the BPH anomaly to be probed directly in Run-3

Leptoquarks coupling to third-generation fermions

LQ, VLQ



EXO-19-016

b-tagger:

DeepCVS: DNN extension of combined secondary vertex algo

Discriminator:

$$S_{\mathrm{T}}^{\mathrm{MET}} \equiv p_{\mathrm{T}}^{1} + p_{\mathrm{T}}^{2} + p_{\mathrm{T}}^{j} + p_{\mathrm{T}}^{\mathrm{miss}}$$

b-tagged jets

Angular separation between two taus

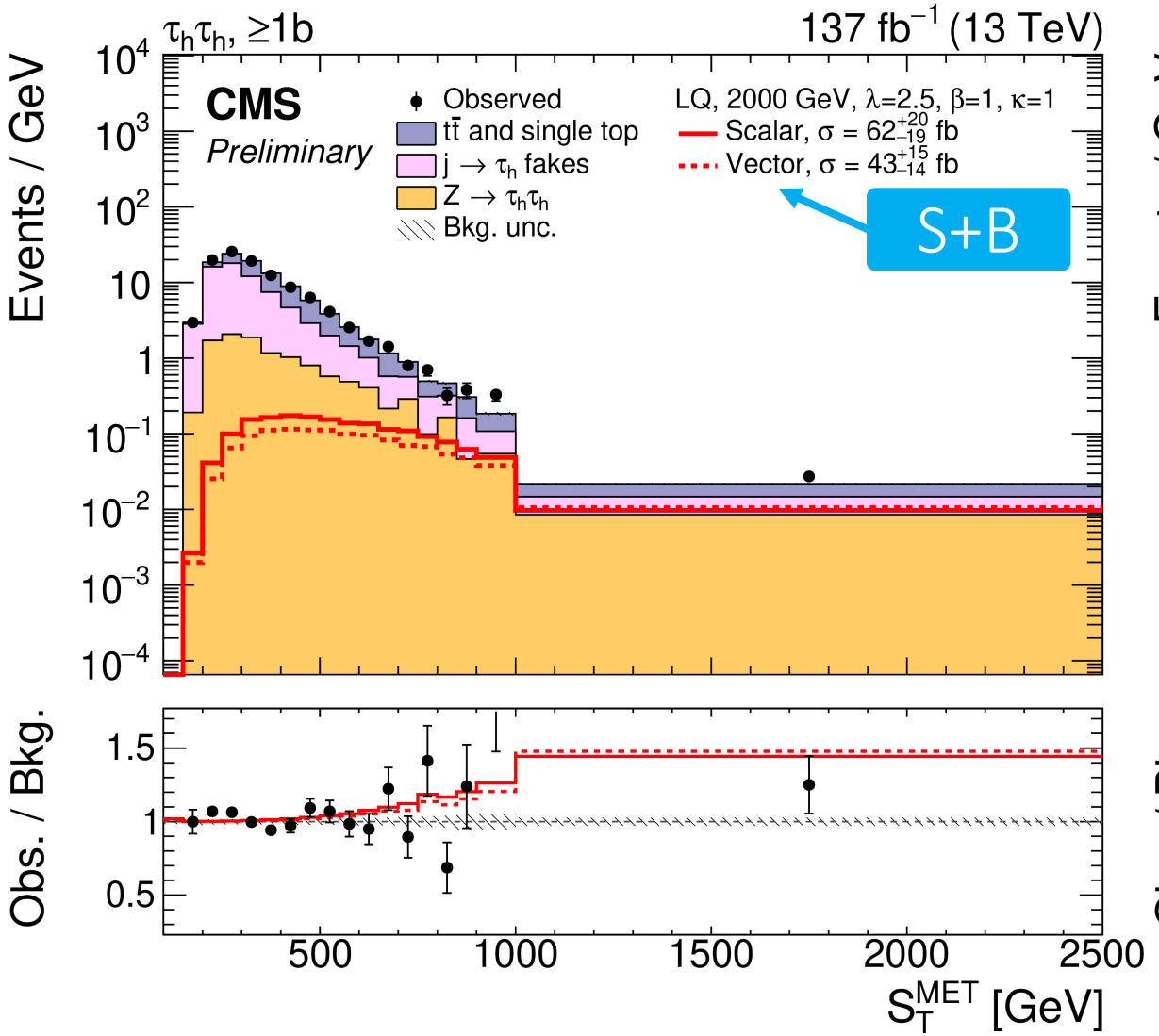
$$\chi = \exp(2y^{\star}) \qquad y^{\star} = \tfrac{1}{2}|y_1 - y_2|$$

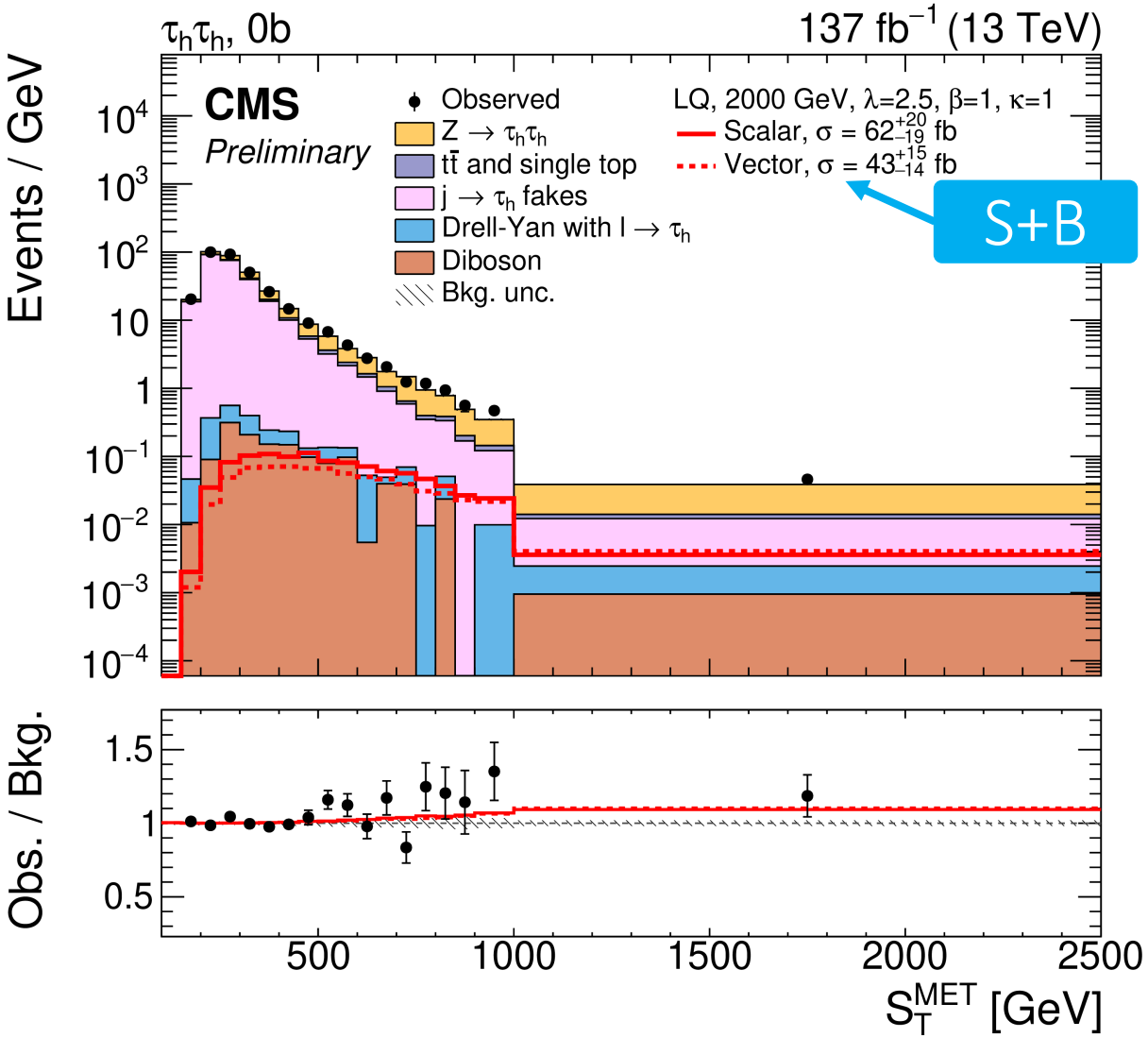
Flat for Rutherford scattering

Rapidities

Scalar $\sum p_T$ distributions

$$S_T^{MET} \equiv p_T^1 + p_T^2 + p_T^j + p_T^{miss}$$

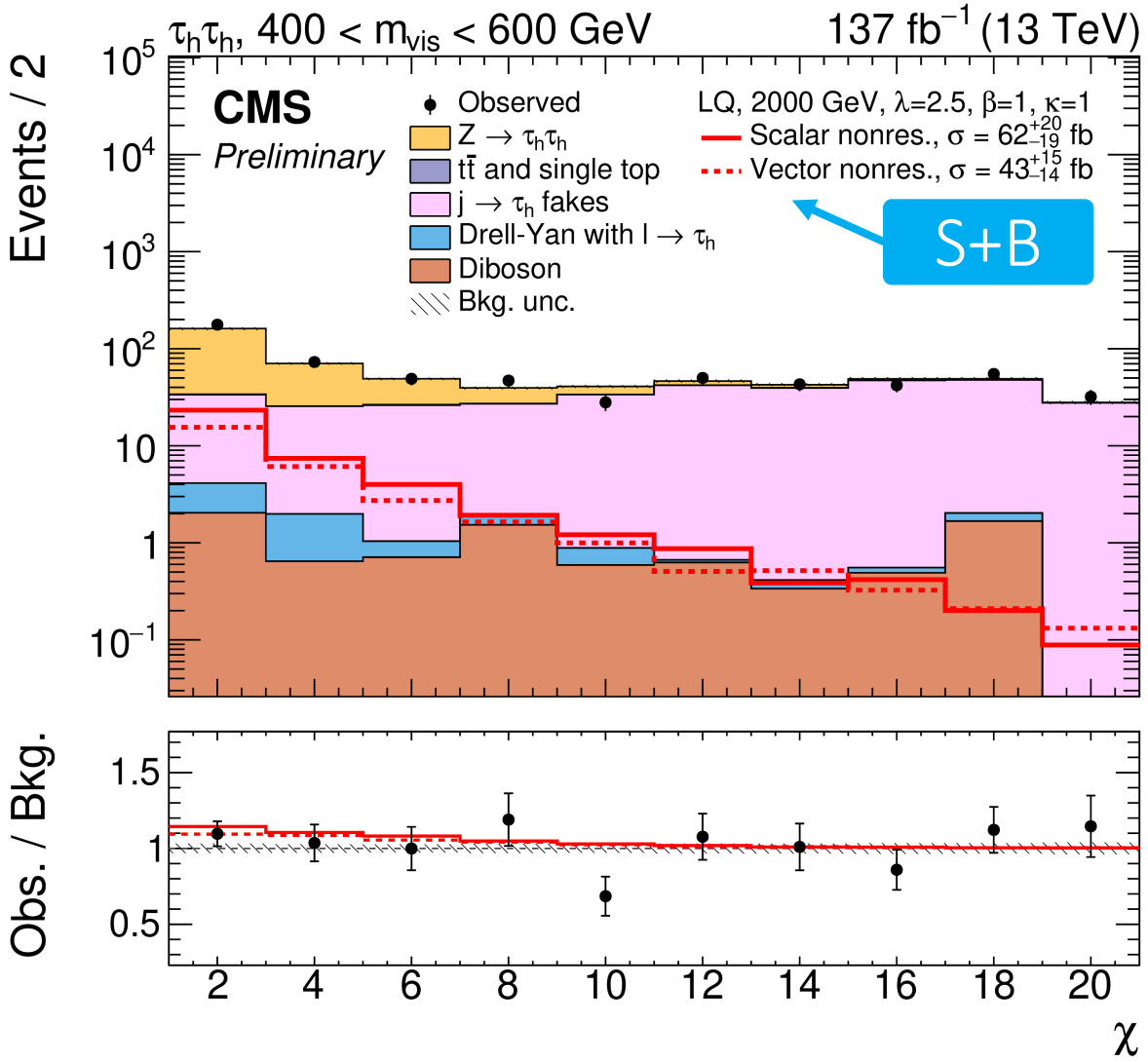


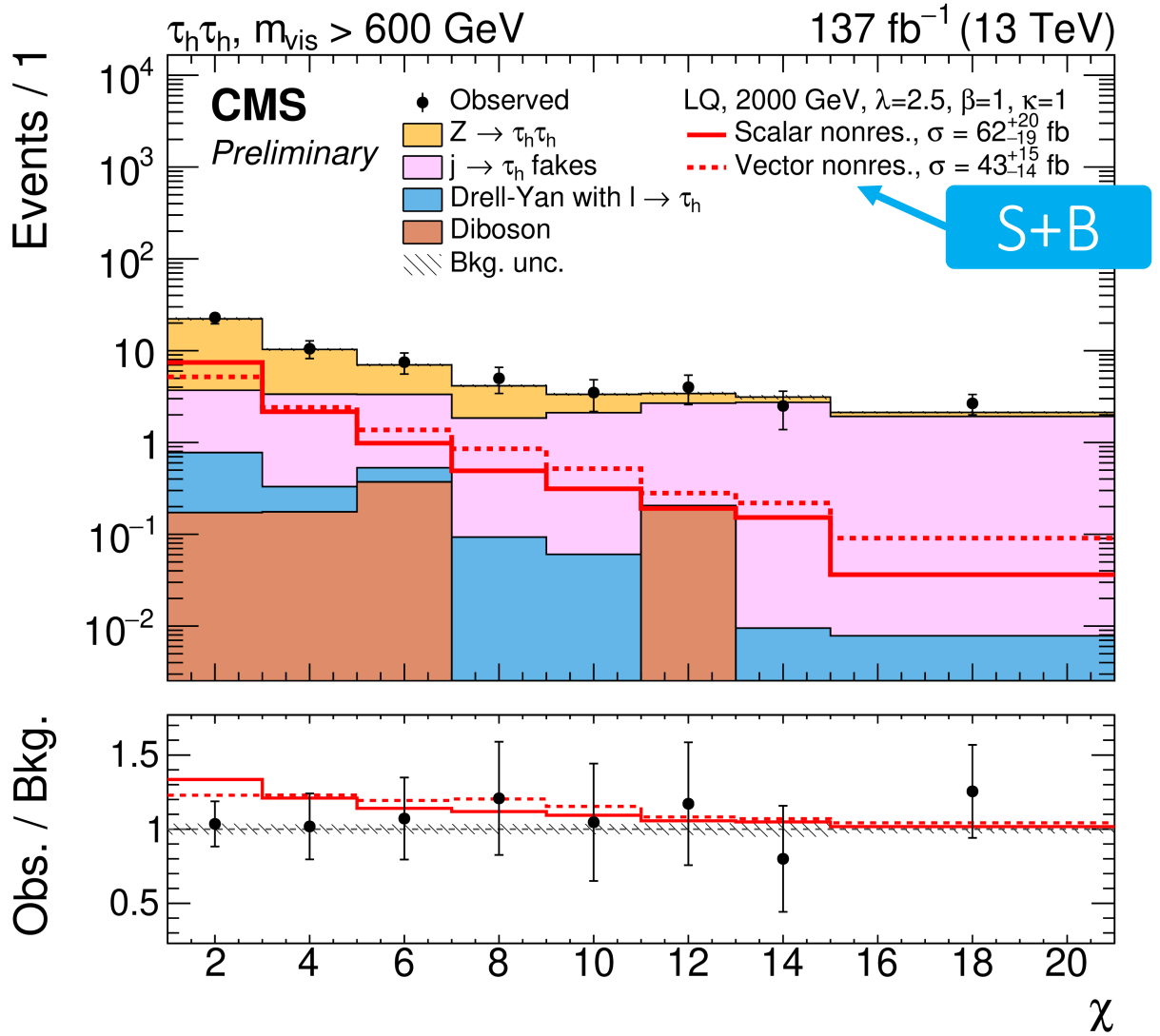


EXO-19-016

χ distributions

$$\chi = \exp(2y^\star)$$
$$y^\star = \tfrac{1}{2}|y_1 - y_2|$$





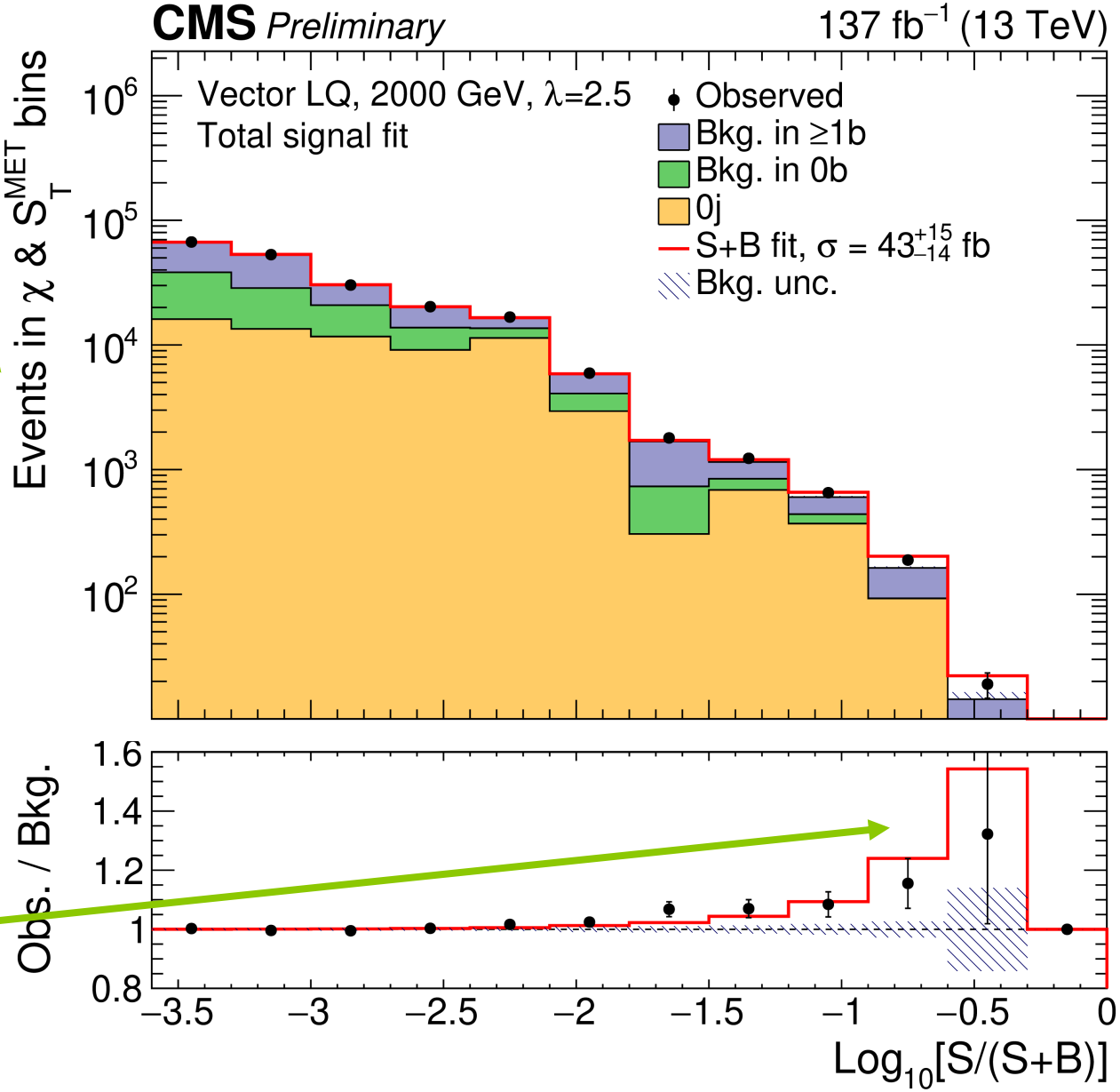
EXO-19-016

Mild excess

Count all bins

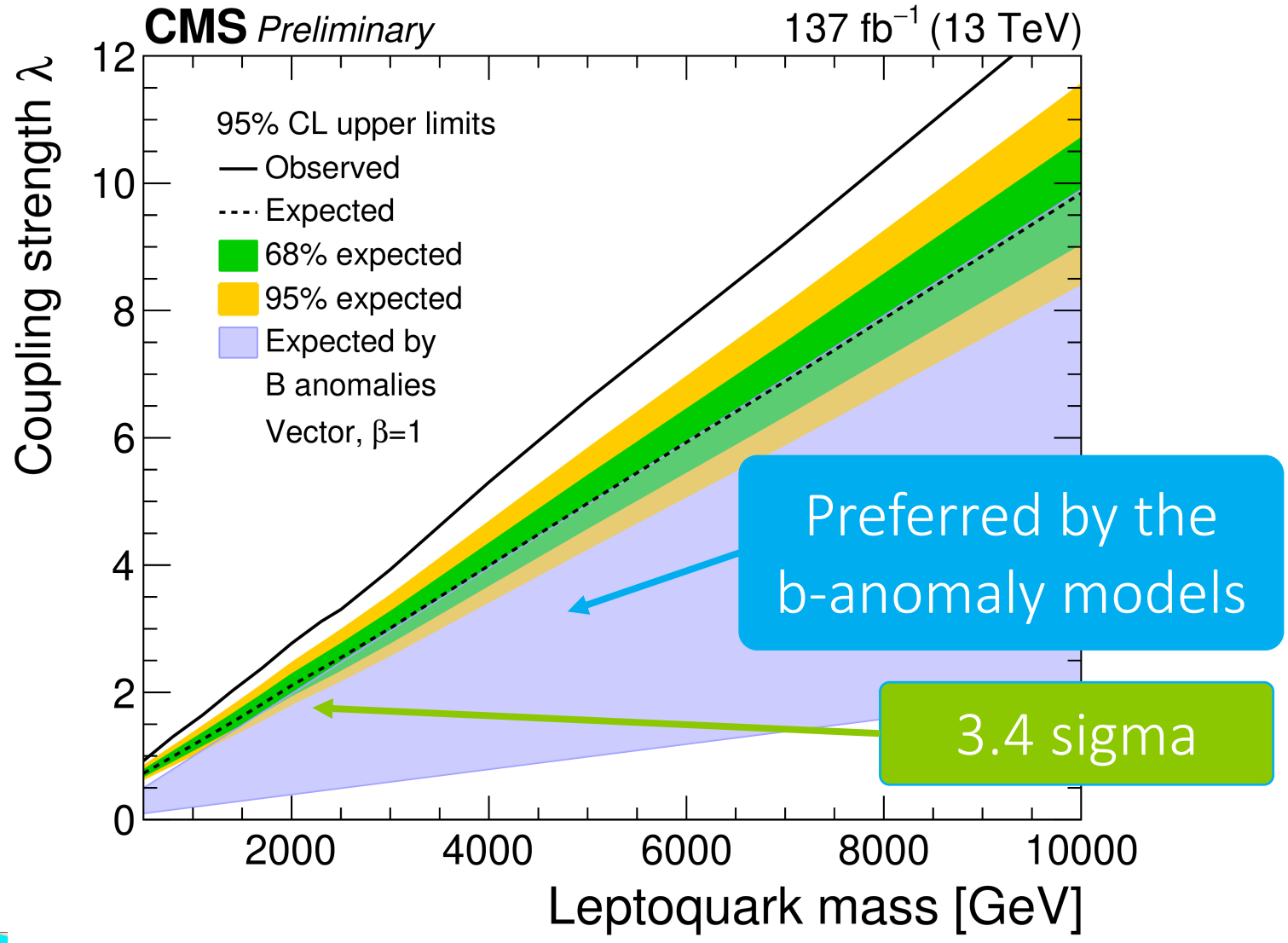
Computed from per bin postfit χ and S_T^{MET} distributions

3.4 sigma



EXO-19-016

Mild excess in non-resonant $\tau\tau$ final state

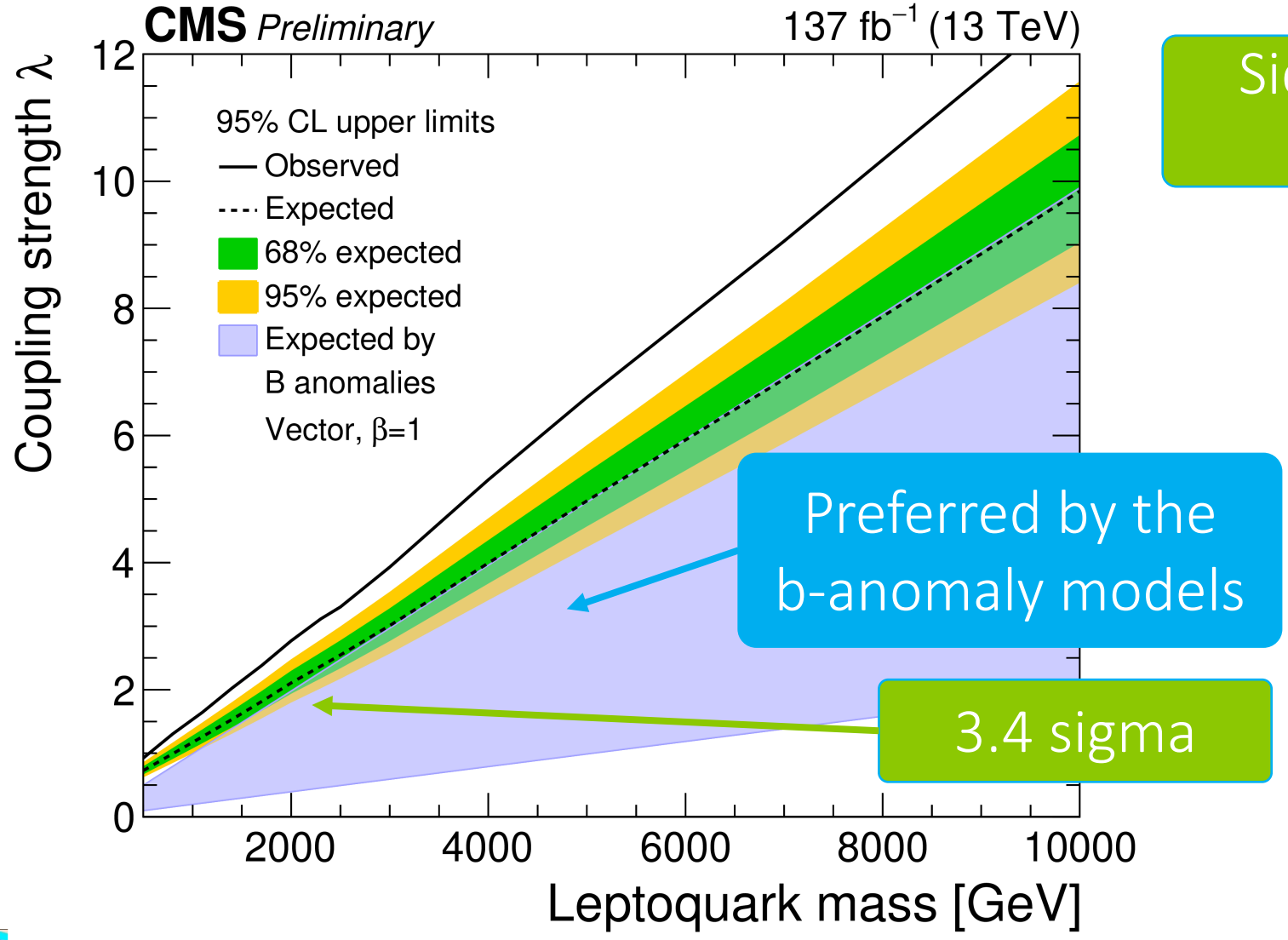


Preferred by the b-anomaly models

3.4 sigma

EXO-19-016

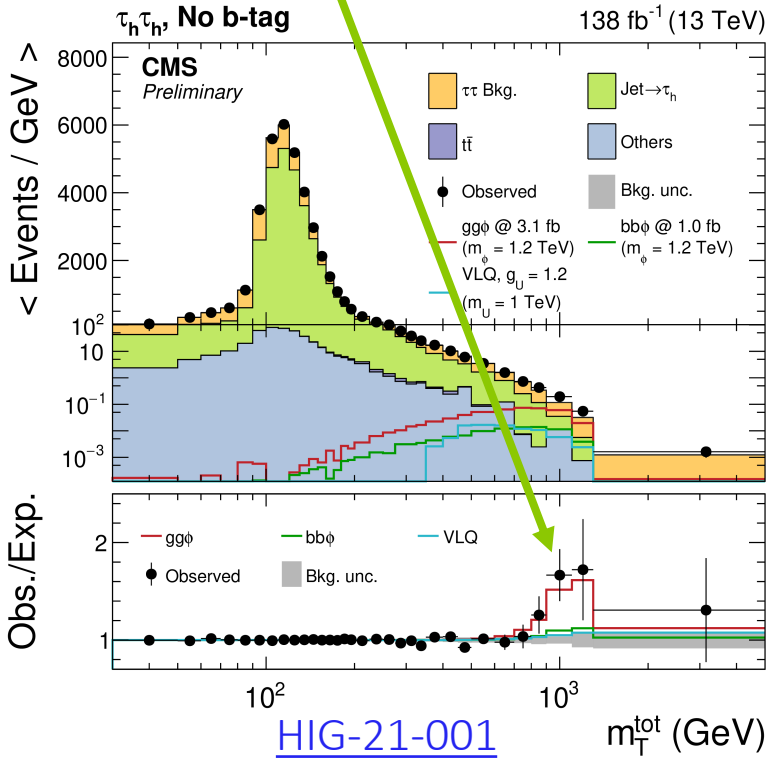
Mild excess in non-resonant $\tau\tau$ final state



Side note: H to $\tau\tau$ analysis sees this excess too

Preferred by the b-anomaly models

3.4 sigma

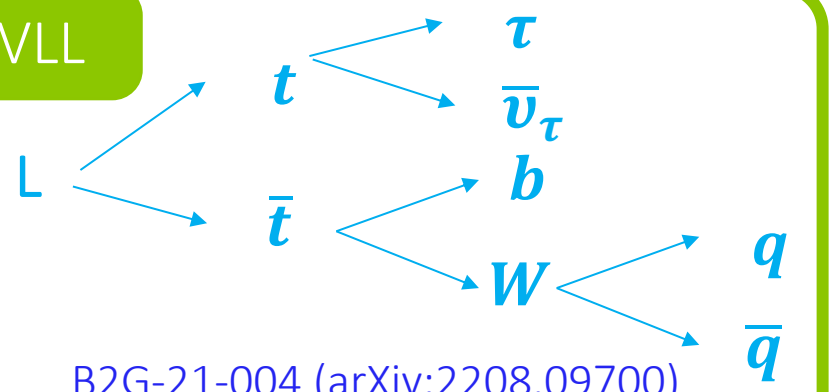


HIG-21-001

EXO-19-016

Vector-like leptons in ≥ 3b + N ττ final states

VLL



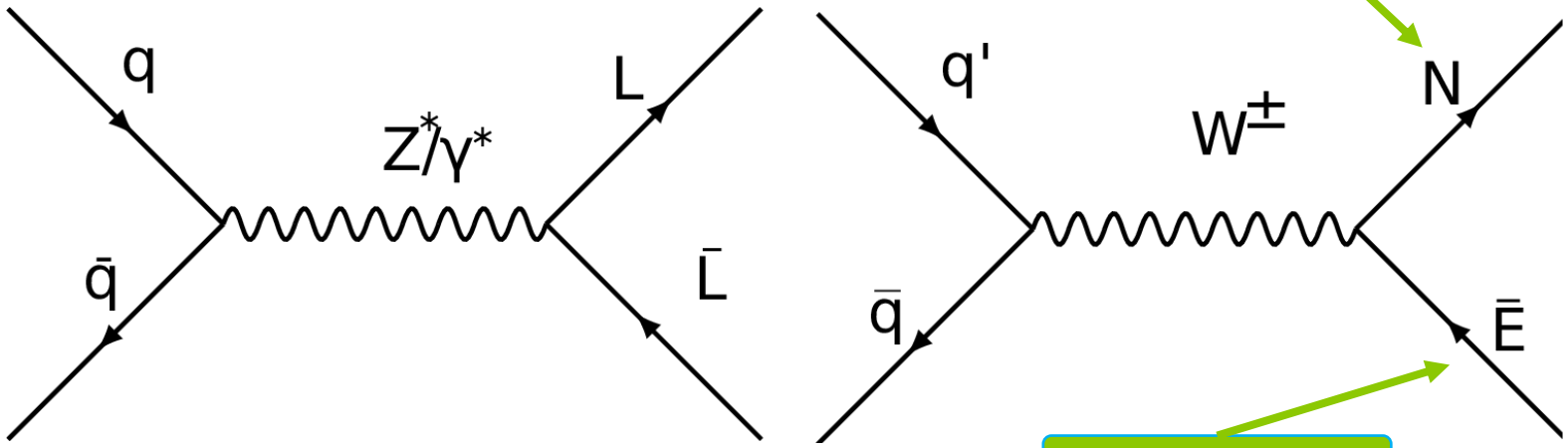
B2G-21-004 (arXiv:2208.09700)

New model: 4321

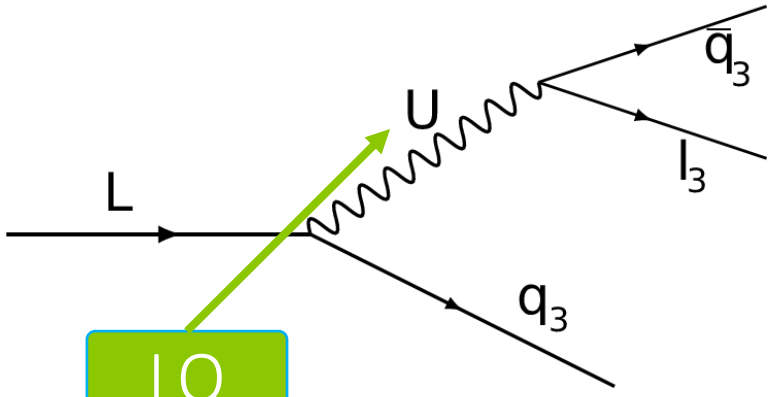
$\mathrm{SU}(4) \times \mathrm{SU}(3)' \times \mathrm{SU}(2)_L \times \mathrm{U}(1)'$

BPH motivated

neutral



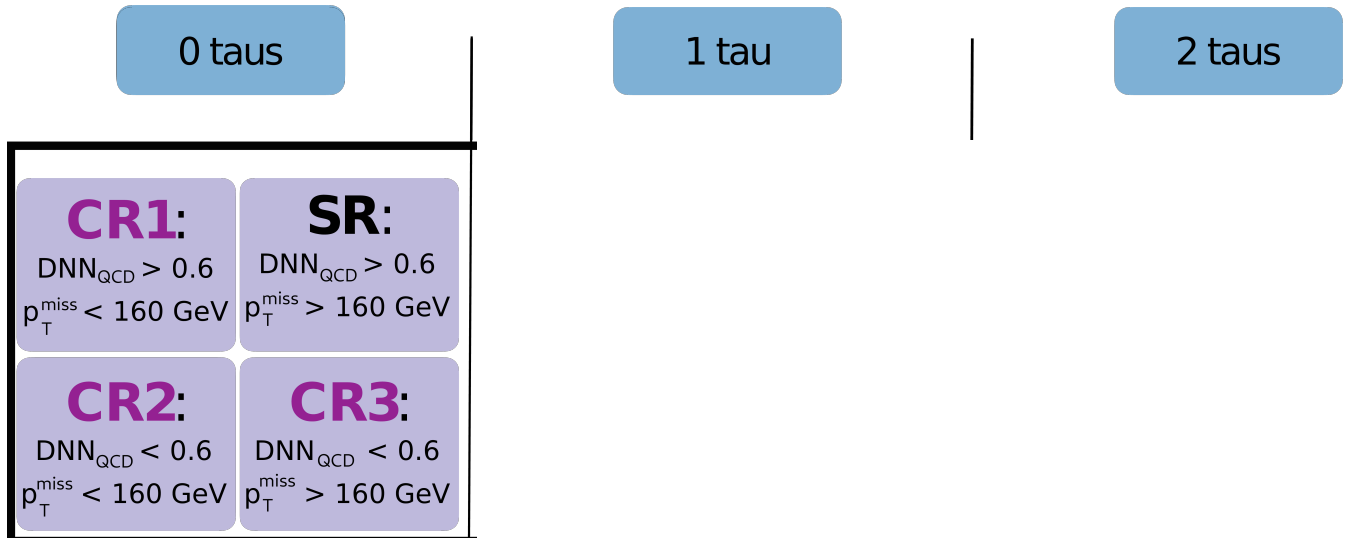
charged



LQ

Vector-like leptons in ≥ 3b + N ττ final states

Discriminator:



B2G-21-004 (arXiv:2208.09700)

Vector-like leptons in ≥ 3b + N ττ final states

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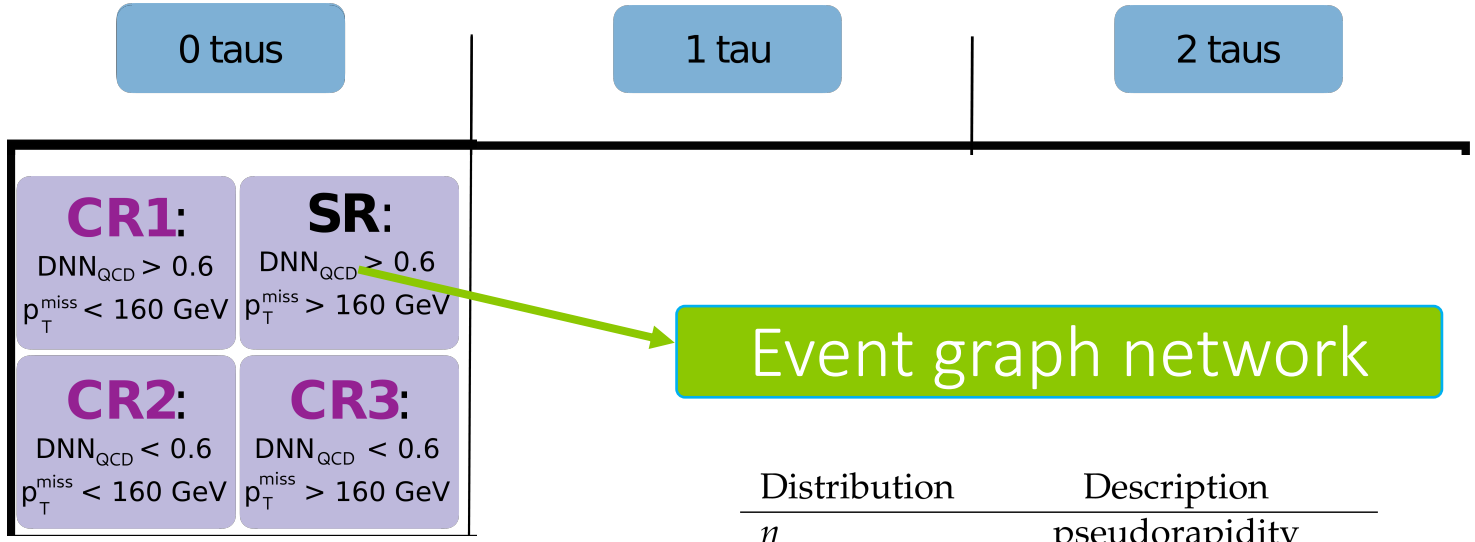
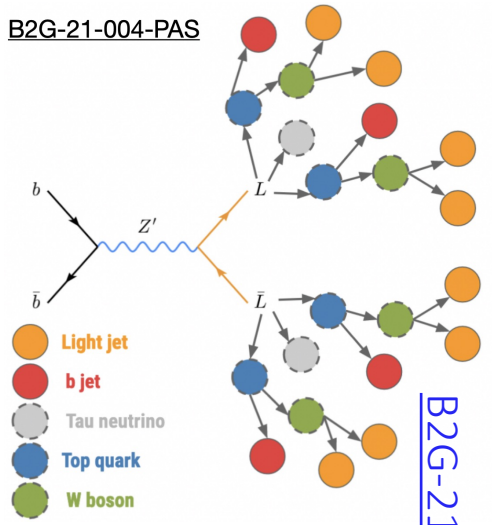


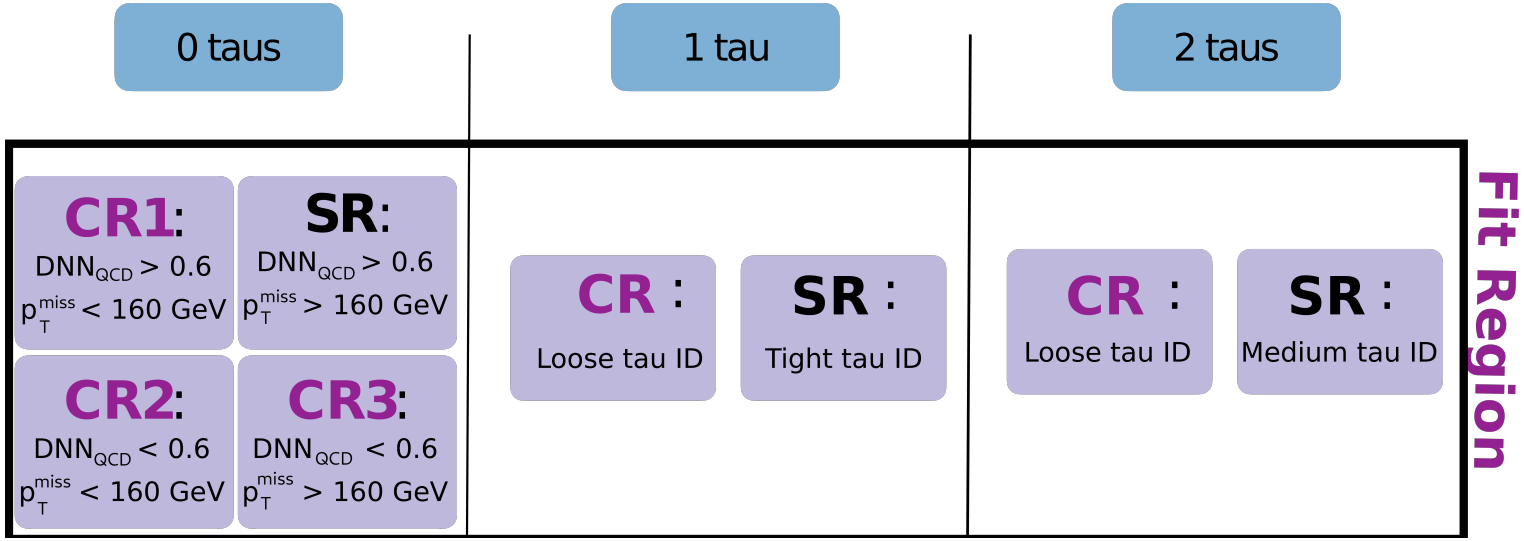
Distribution	Description
η	pseudorapidity
ϕ	azimuthal angle
$\log(p_{\mathrm{T}})$	logarithm of the p_{T}
$\log(m)$	logarithm of the mass
Q	charge
DeepJet	DeepJet classifier score



B2G-21-004 (arXiv:2208.09700)

Vector-like leptons in ≥ 3b + N ττ final states

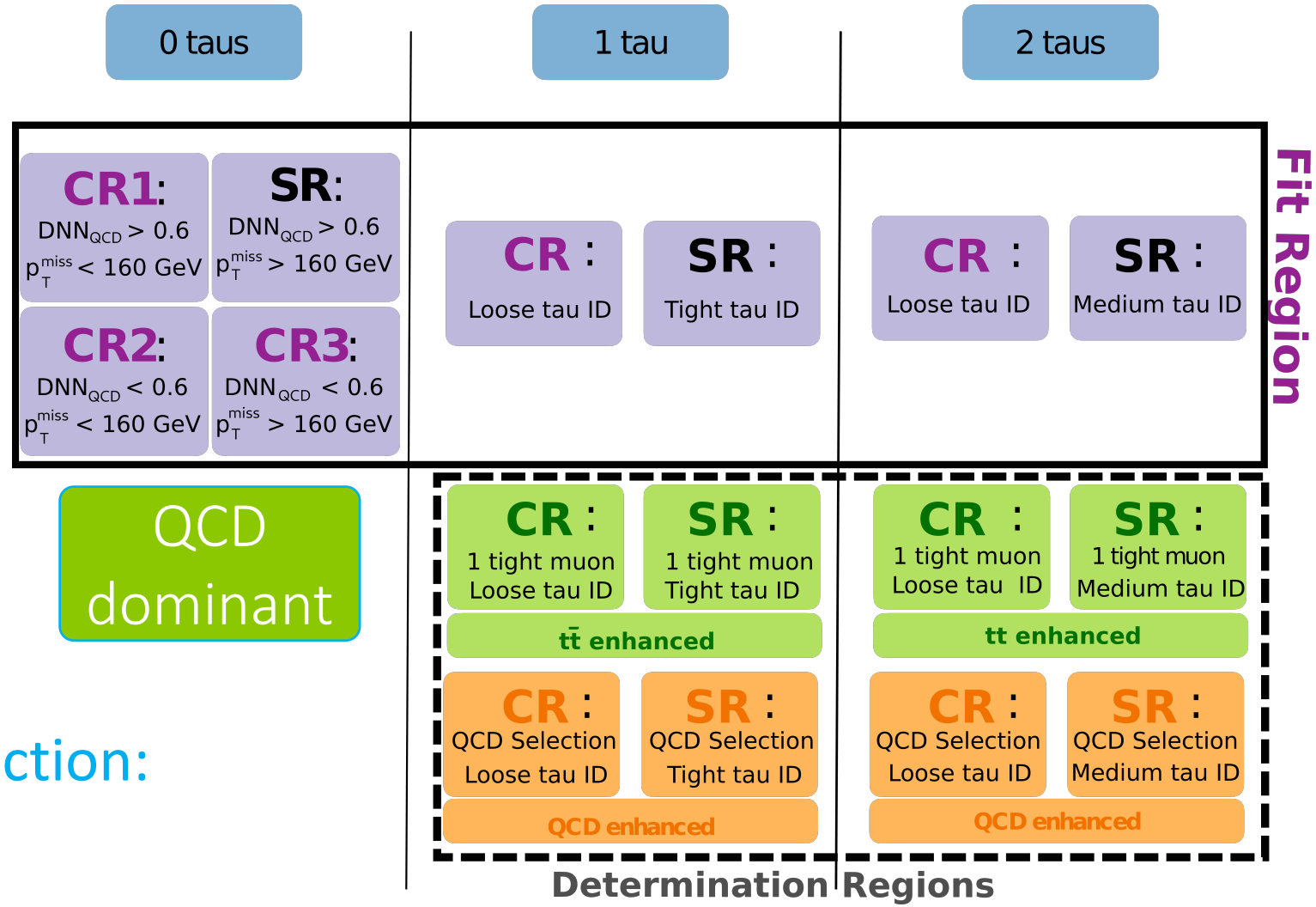
Discriminator:



B2G-21-004 (arXiv:2208.09700)

Vector-like leptons in ≥ 3b + N ττ final states

Discriminator:



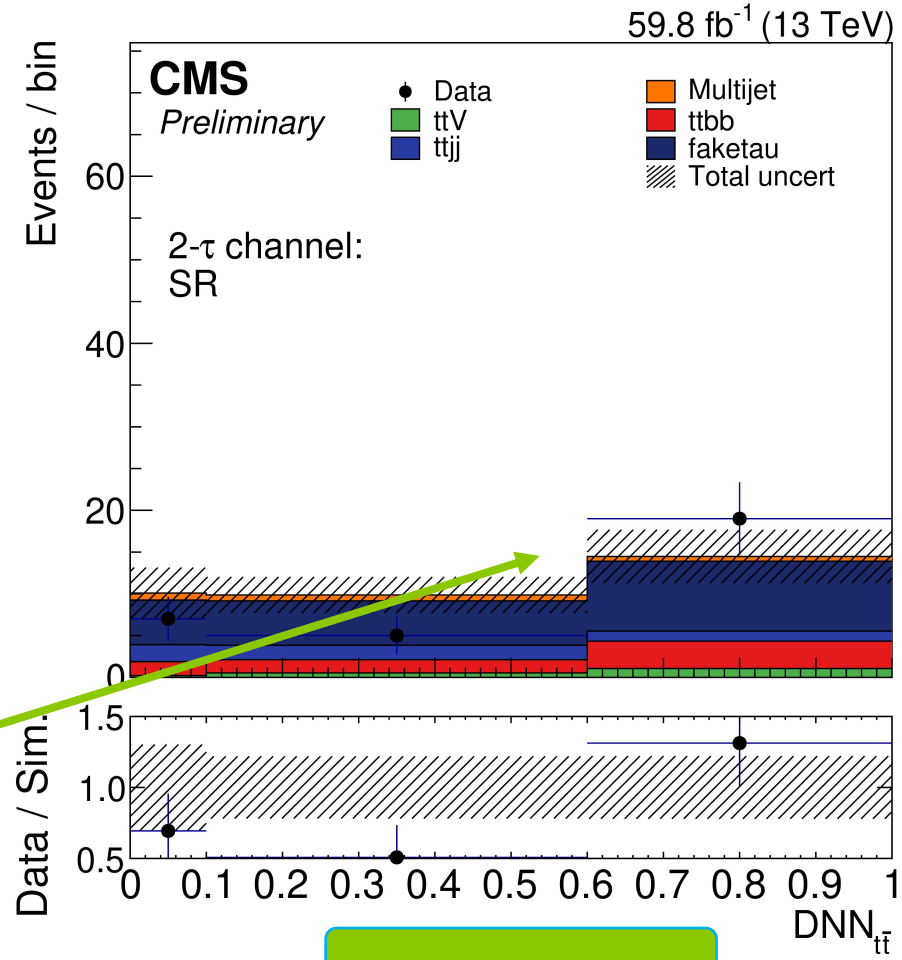
Background prediction:

B2G-21-004 (arXiv:2208.09700)

Mild excess!

2018-based

2 tau channel



2.8 sigma

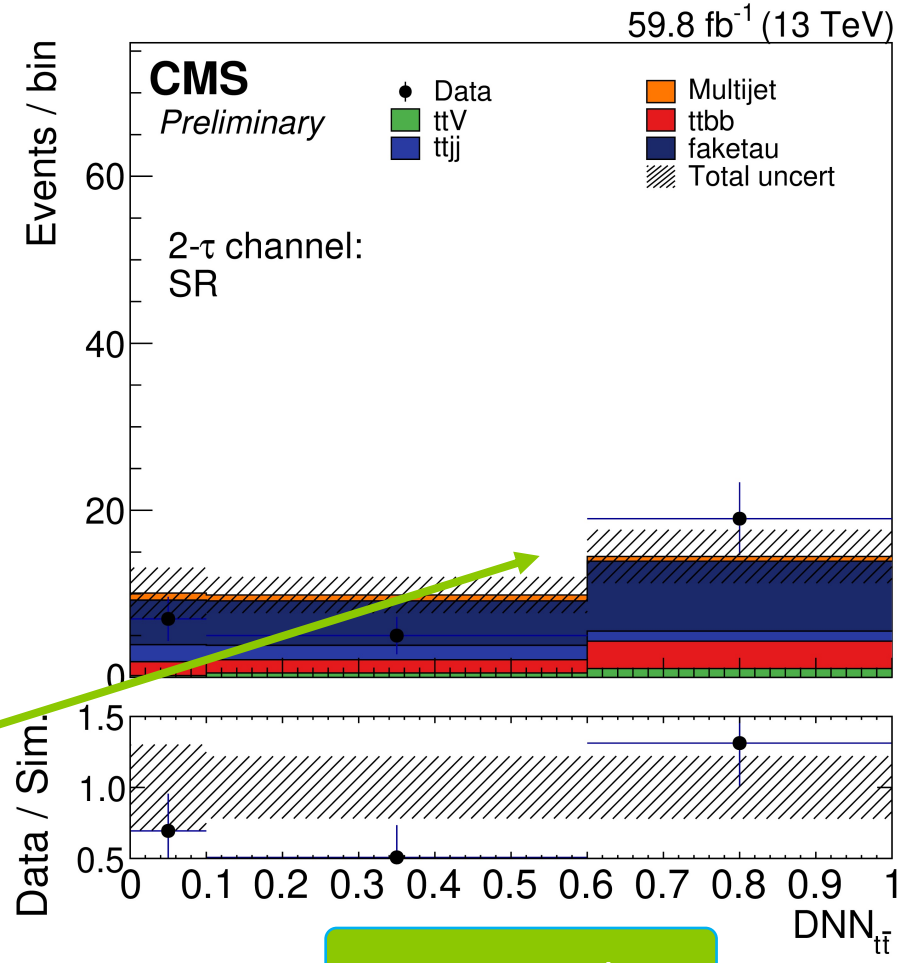
Bcg-only

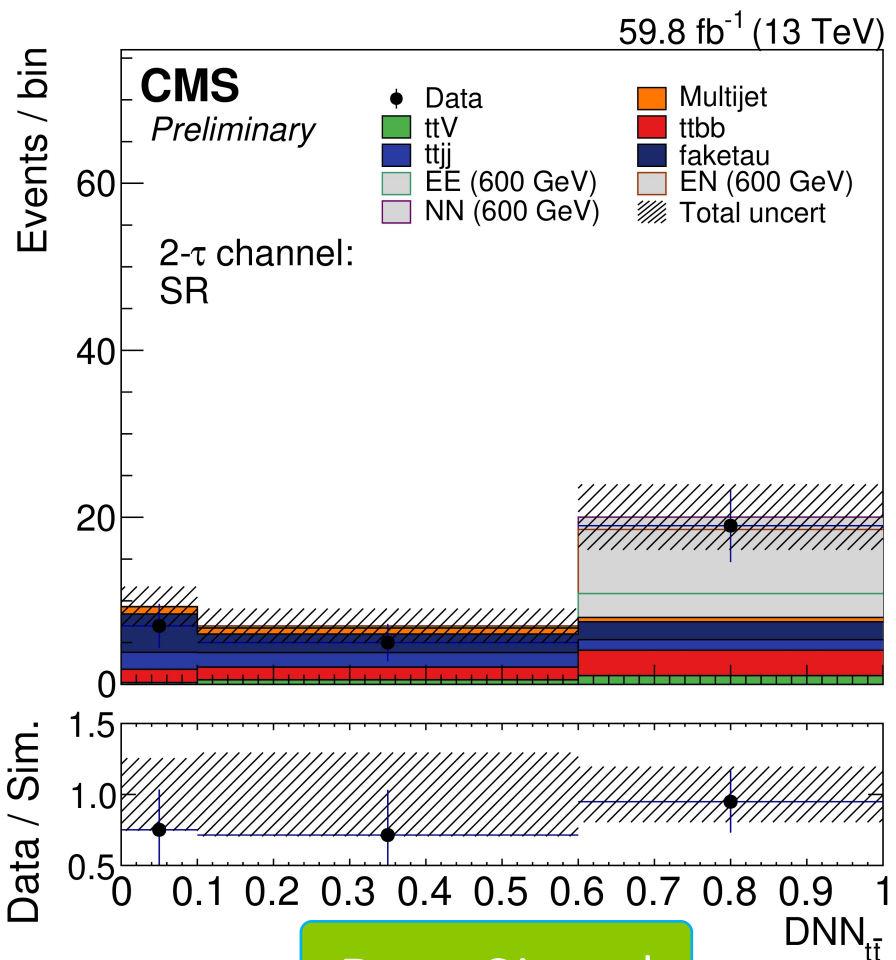
B2G-21-004 (arXiv:2208.09700)

Mild excess!

2 tau channel

2018-based





2.8 sigma

Bcg-only

Bcg+Signal

B2G-21-004 (arXiv:2208.09700)

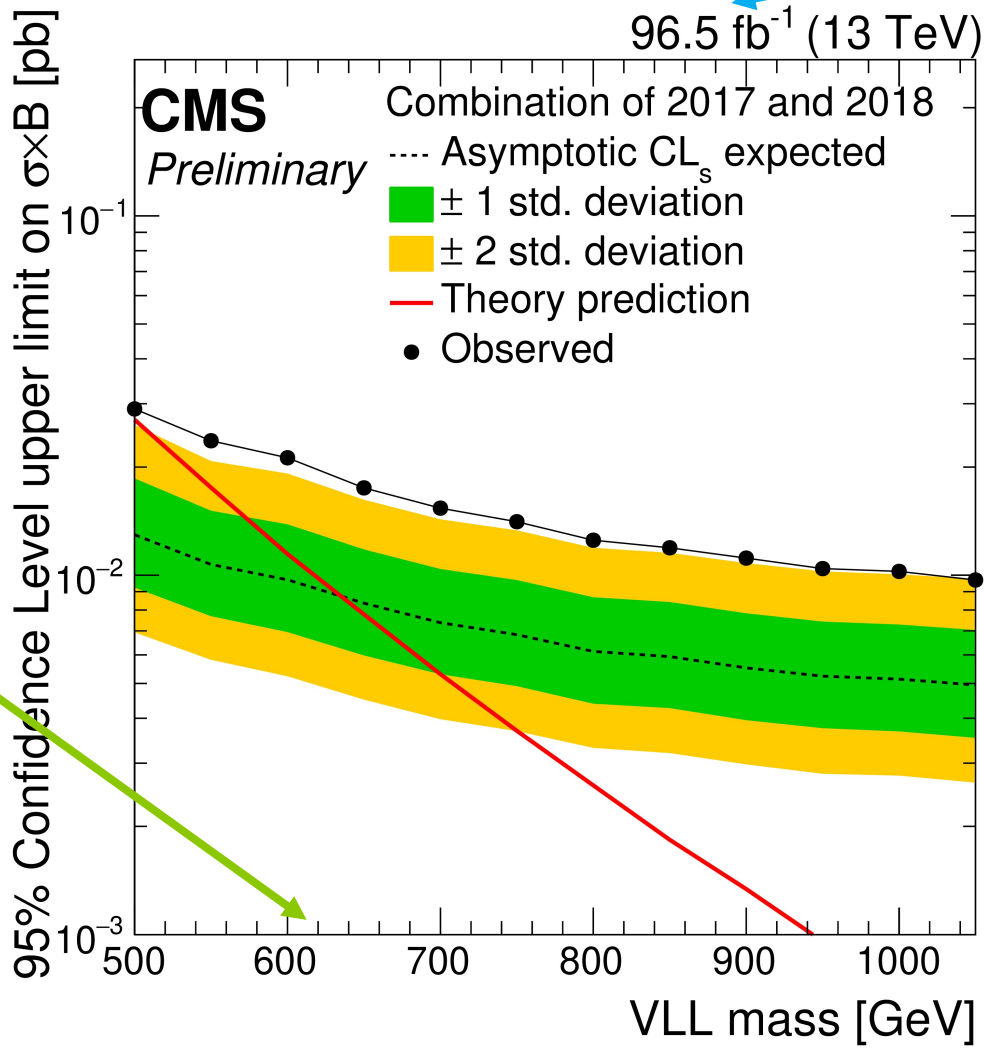
Exclusion limits

2017+2018-based

2 tau channel

Expected exclusion at 640 GeV

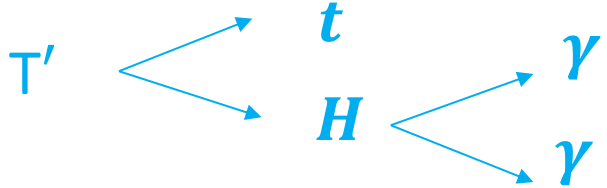
Observed excess consistent with 600 GeV VLL



B2G-21-004 (arXiv:2208.09700)

Vector-Like Quark in the di-photon final state

VLQ



B2G-21-007

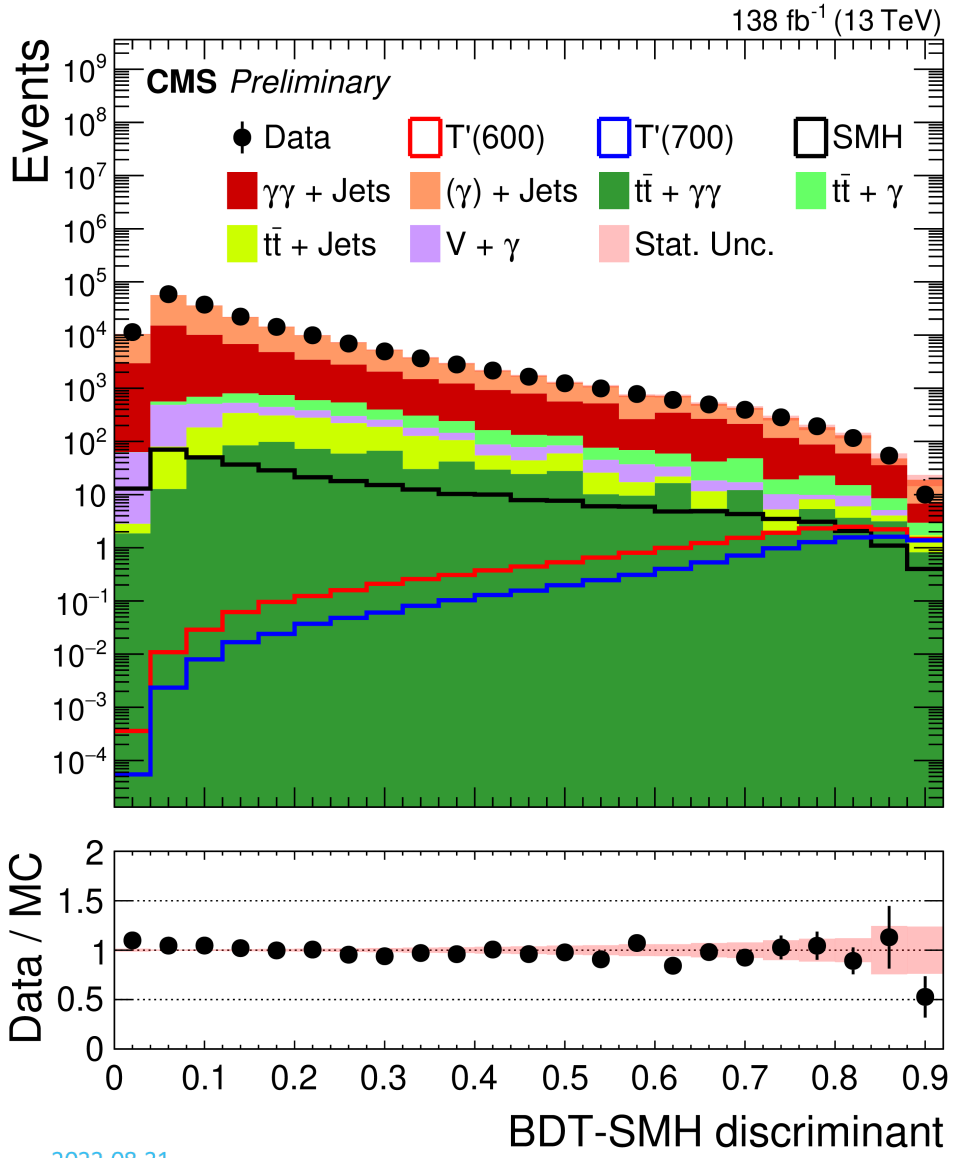
photon-tagger

MVA based on shower shape and the isolation

Discriminator:

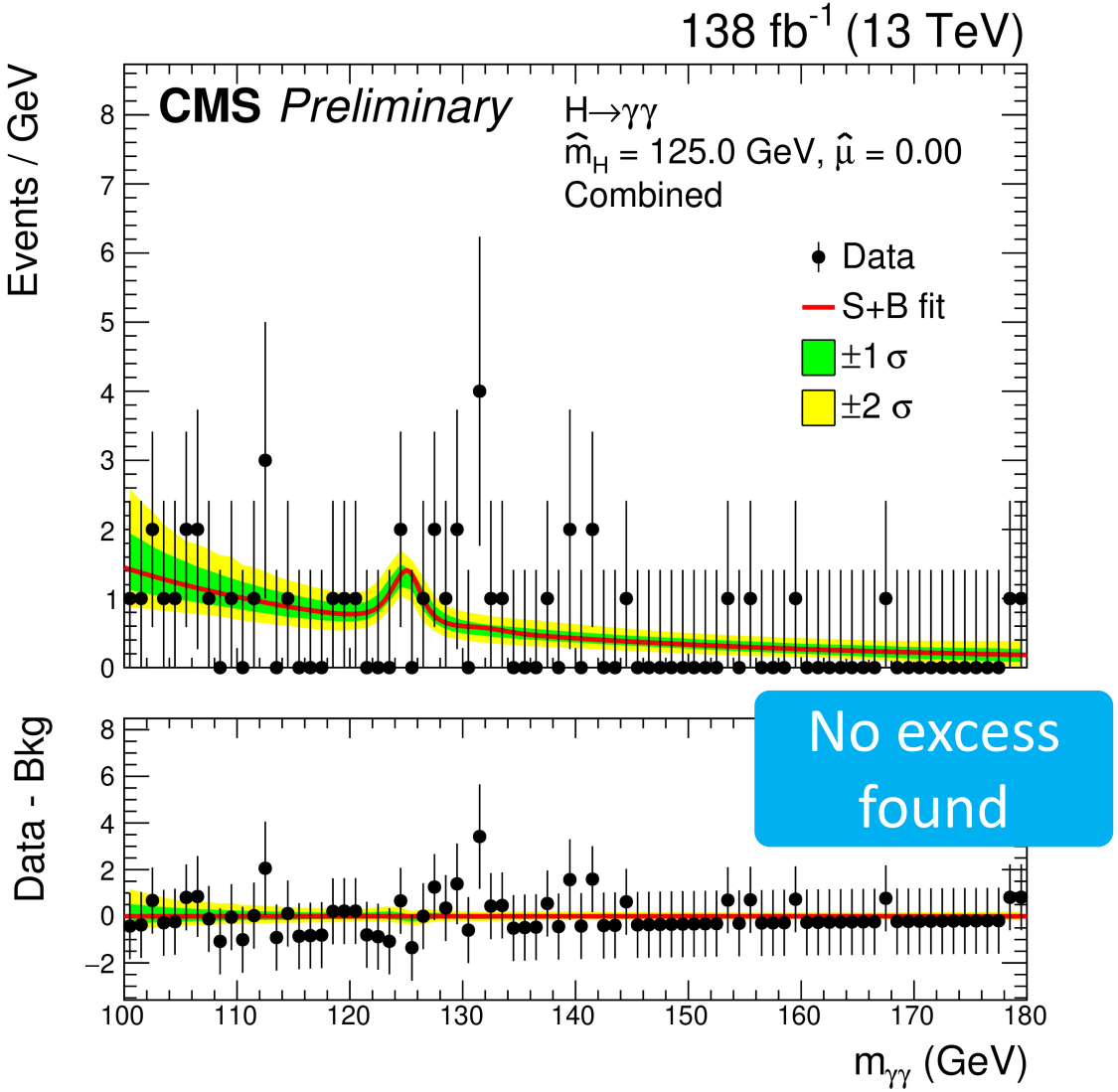
Boosted Decision Trees

Leptonic or hadronic t decay



B2G-21-007

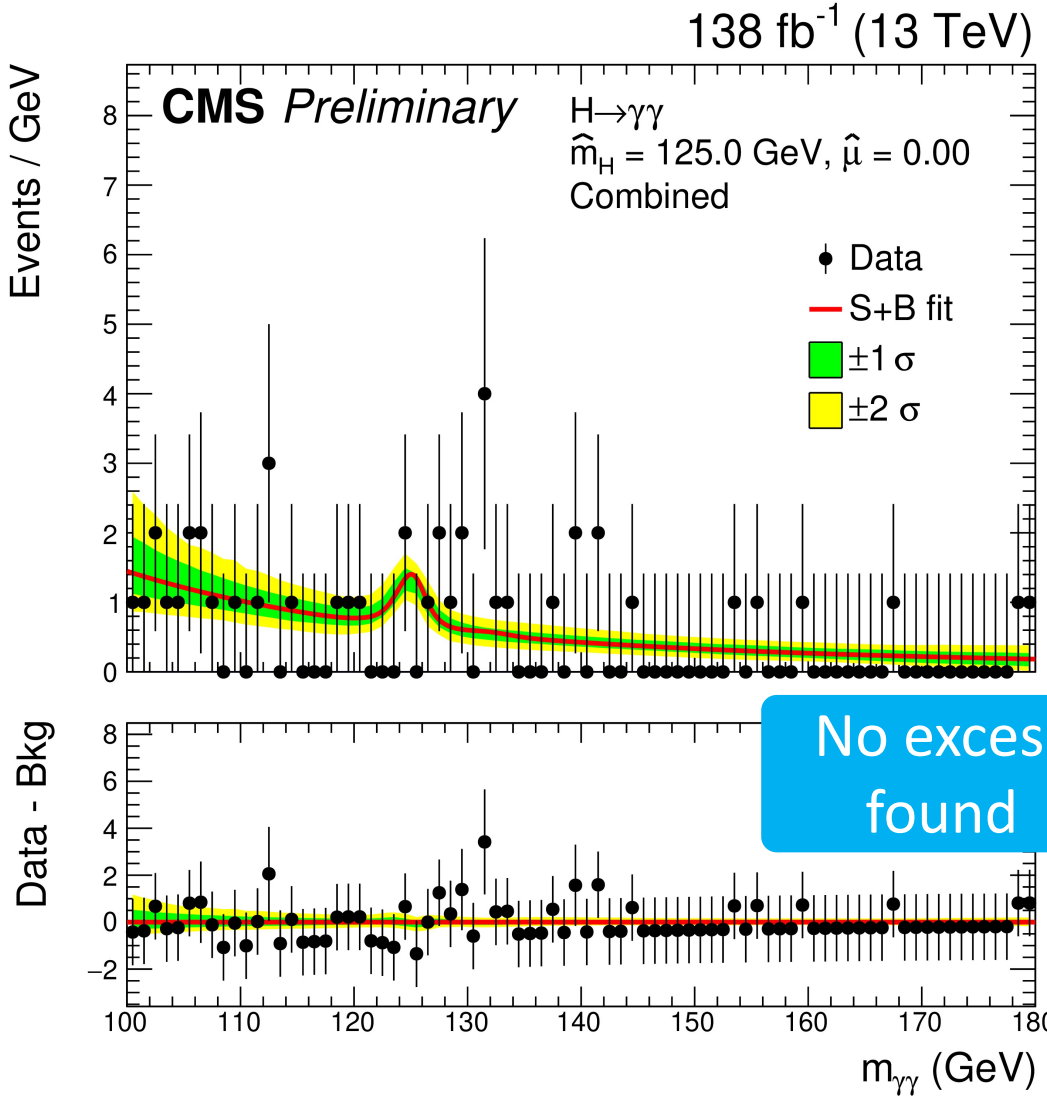
Exclusion limits



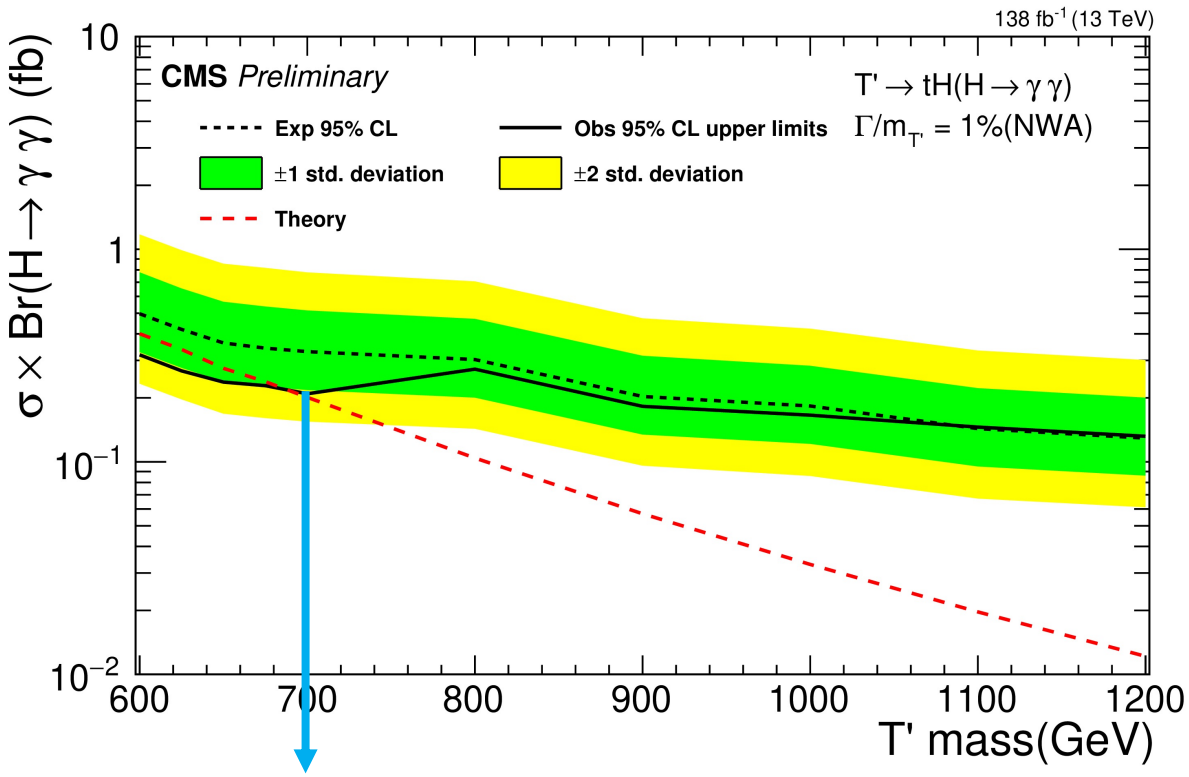
No excess found

B2G-21-007

Exclusion limits



No excess found



730 GeV

Increased sensitivity to up to 1 TeV

B2G-21-007

Heavy resonances decaying to boson pairs

Z'/W'

$X \rightarrow W/W/Z/W/Z$

$X \rightarrow W/Z/Z/H/H$

B2G-20-009

Identification

"groomed" mass of the jet and the DeepAK8 NN

Discriminator:

3D resonant signal

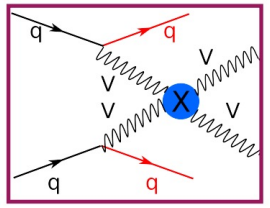
Background prediction:

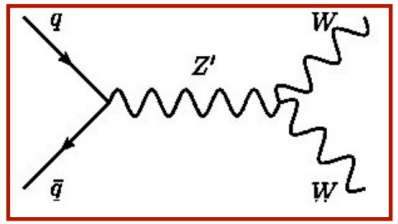
Data driven

Event categorization:

Defined a VBF and gg/DY categories

VBF





gg/DY

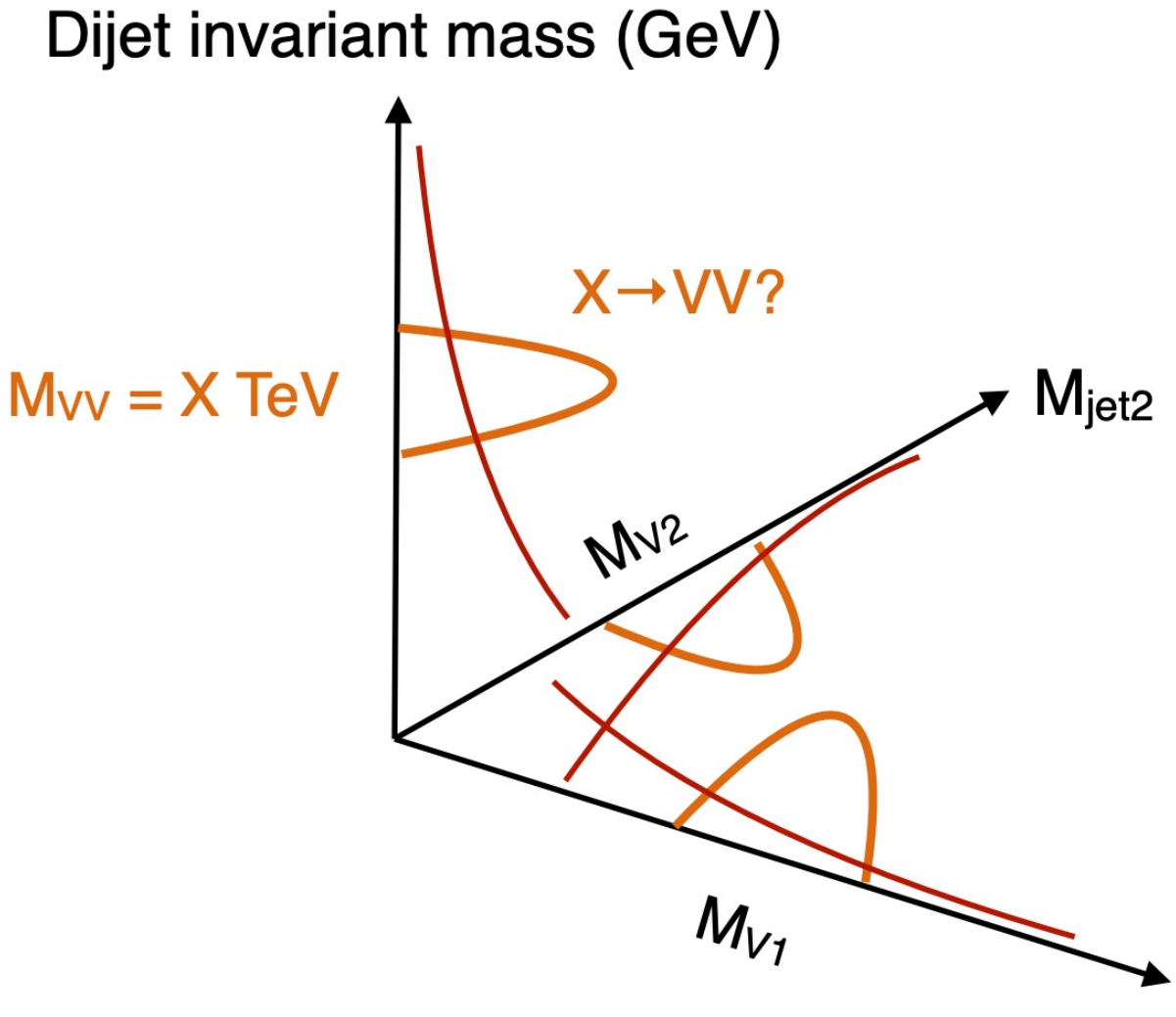
B2G-20-009

3D resonant signal

Signal: resonant in all 3 axis

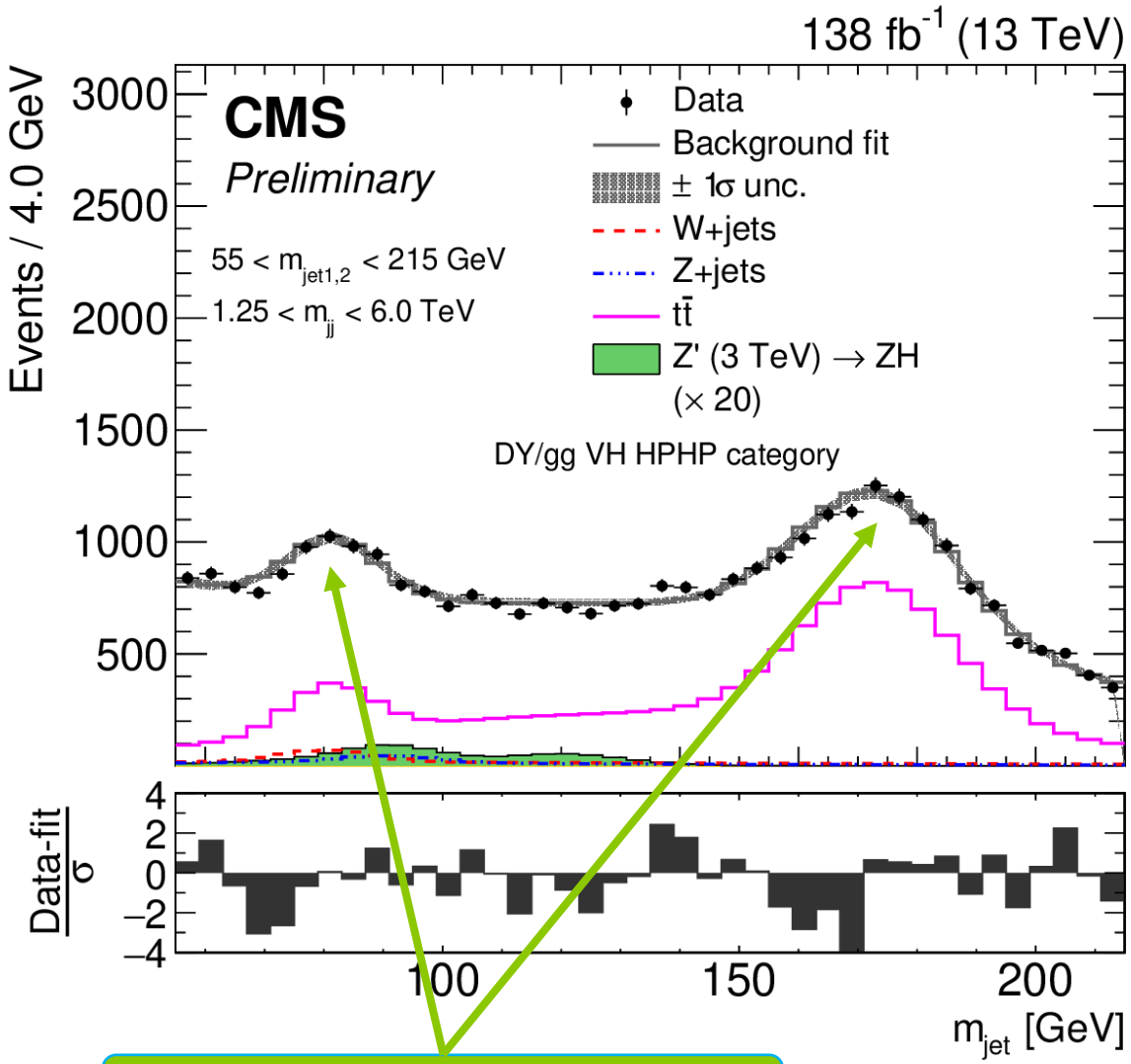
QCD: non-resonant in either axis

Partially resonant backgrounds (ttbar and W + jets): resonant in M_{jet1} and/or M_{jet2} but non-resonant in M_{jj}



B2G-20-009

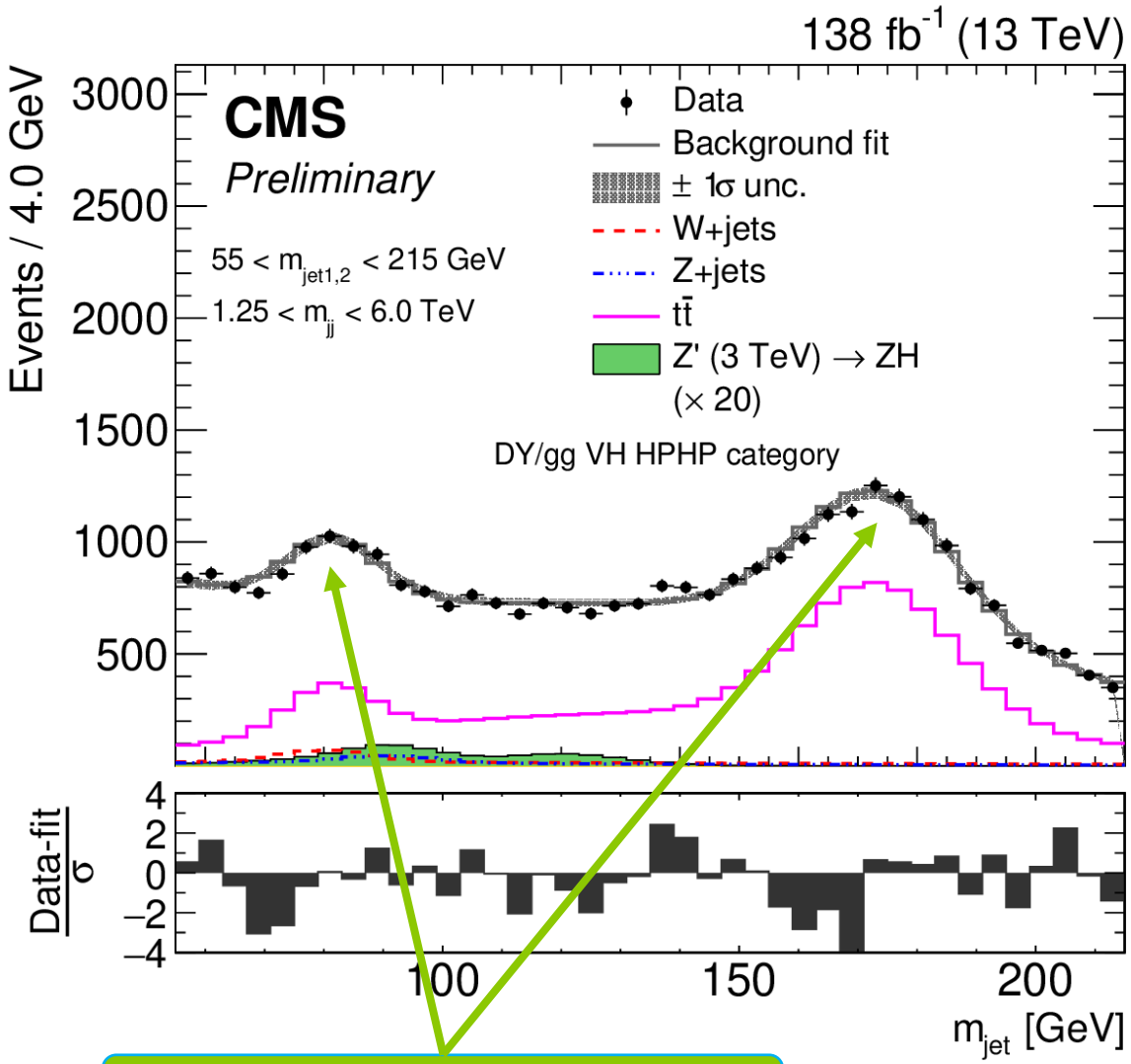
Data and background comparison

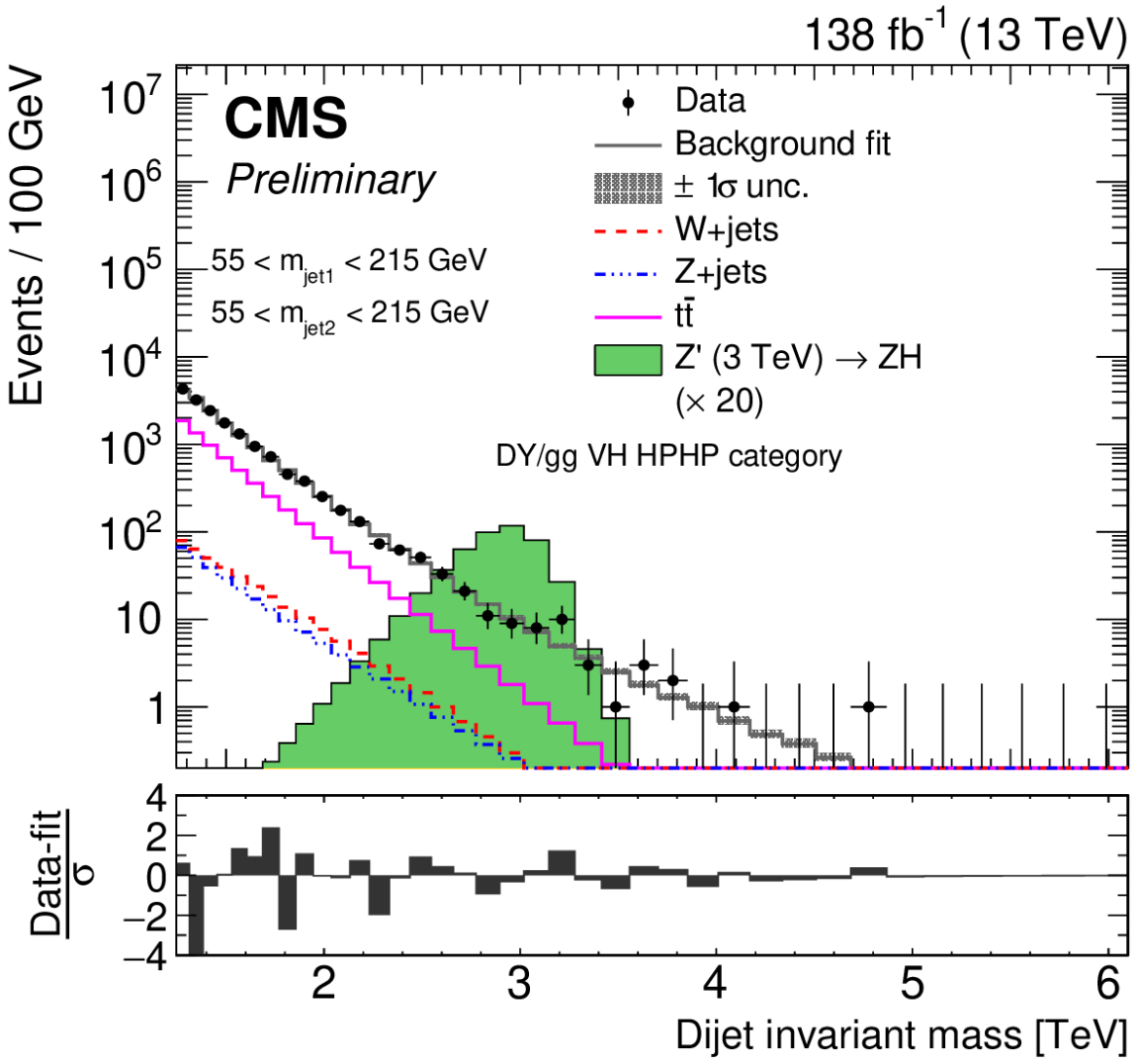


Partially resonant
(ttbar and W + jets)

B2G-20-009

Data and background comparison

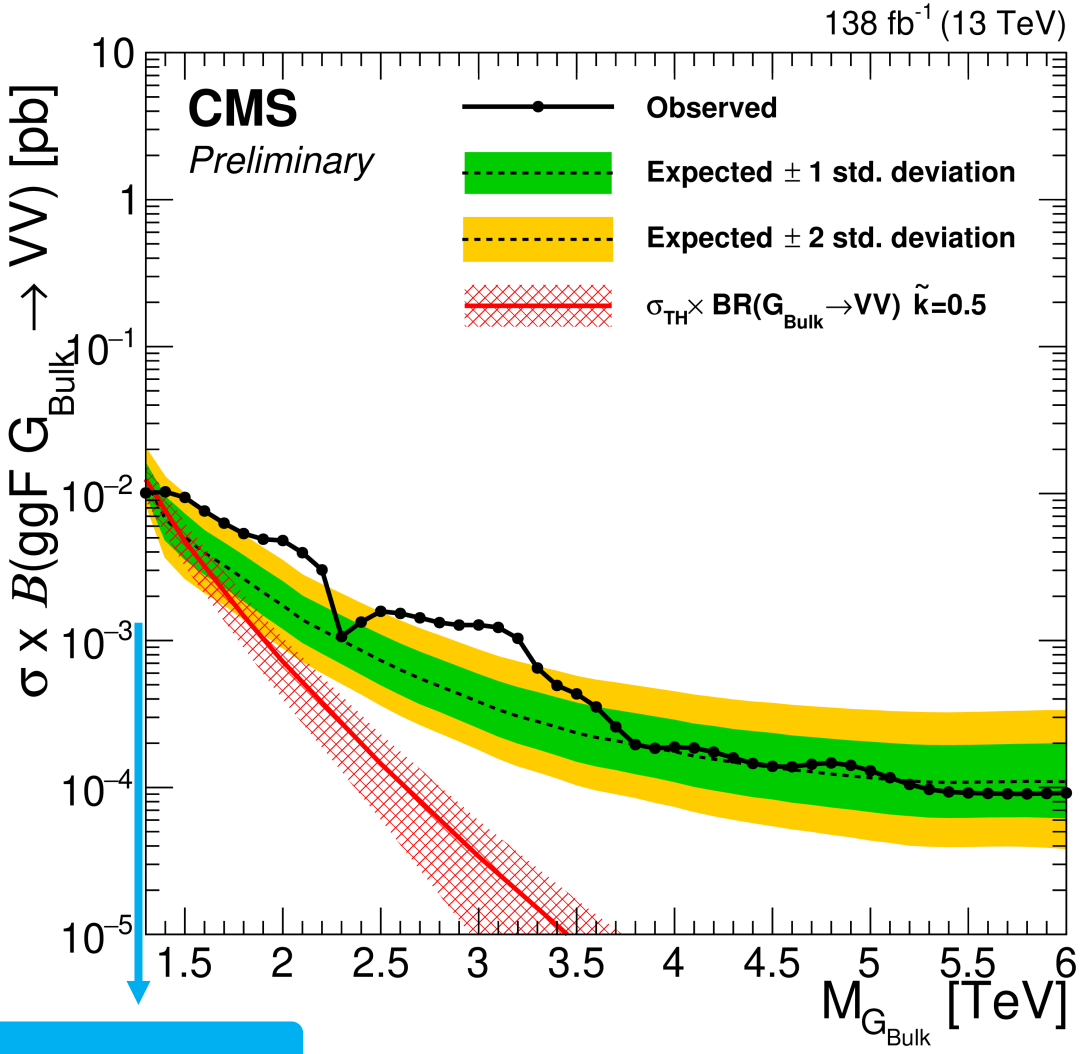




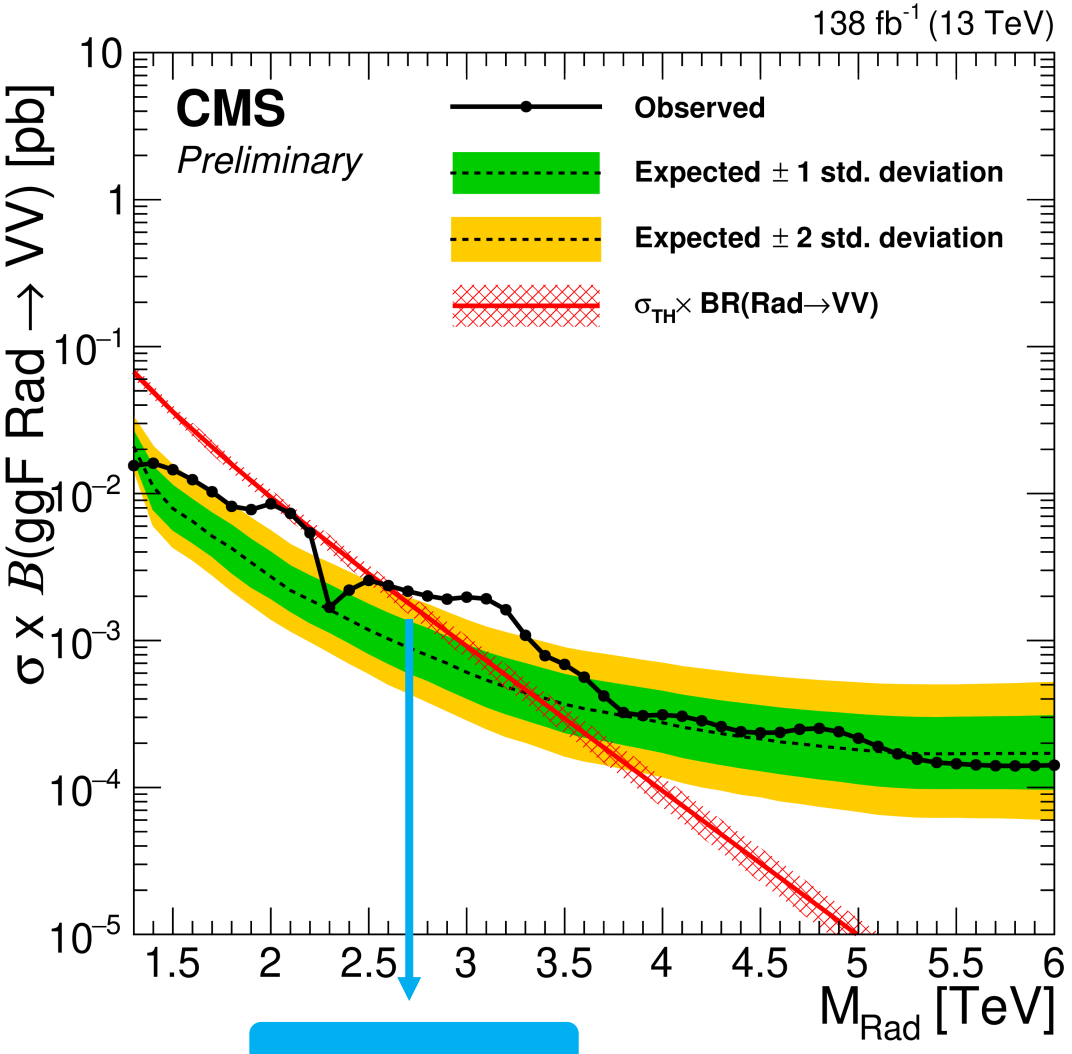
Partially resonant
(ttbar and W + jets)

B2G-20-009

Exclusion limits



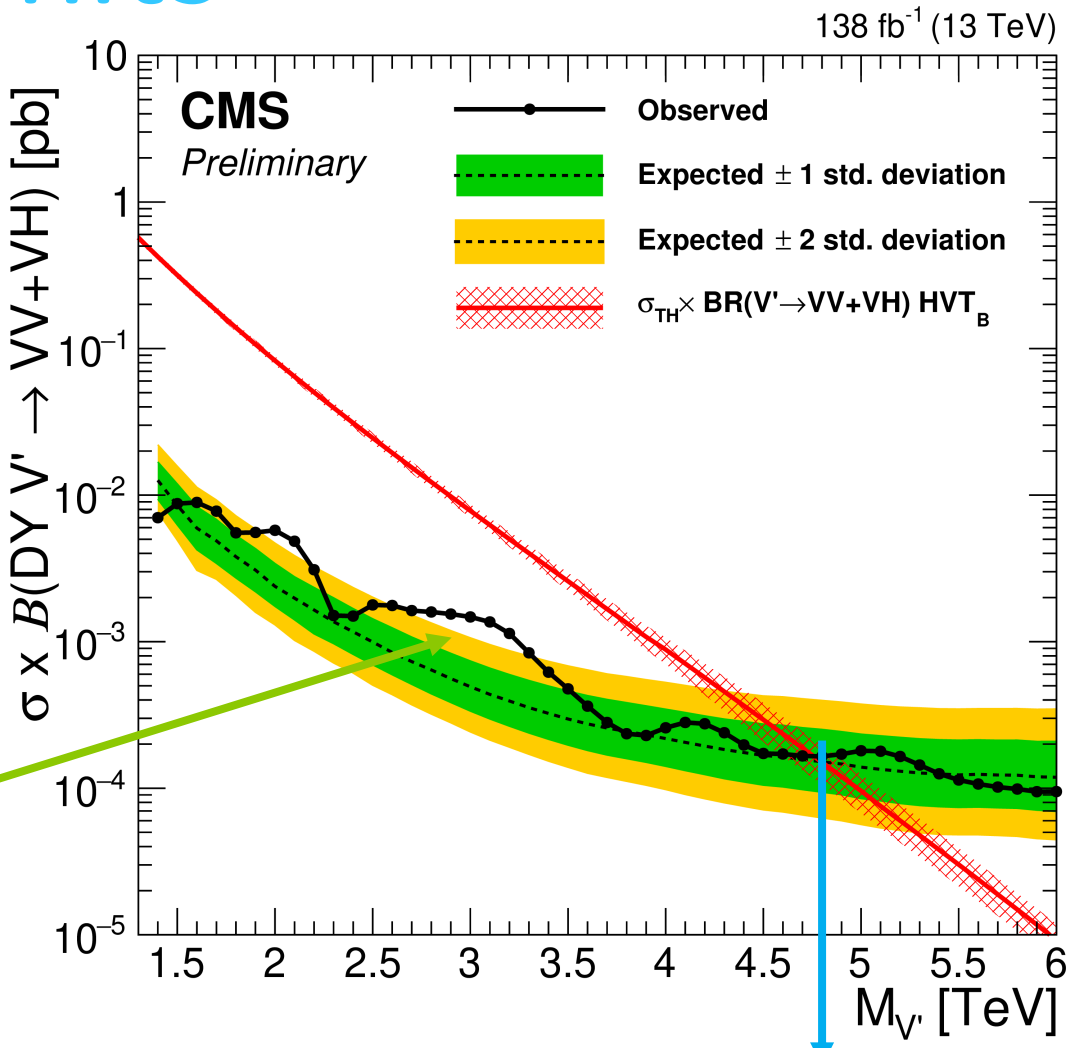
1.4 TeV



2.7 TeV

B2G-20-009

Exclusion limits



2.3 sigma

4.8 TeV

B2G-20-009

Conclusion

Presented several new BSM results from CMS

Showed results that have direct access to models explaining b-anomalies

Several mild excess is observed, otherwise strong limits were set

Run-3 just started: Exciting to see if the new data confirms these or not

The detector: Compact Muon Solenoid