

CMS-PAS-SUS-23-008

Search for dark matter produced in association with a pair of bottom quarks in CMS

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on behalf of CMS Collaboration

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Introduction and Motivation

📌 Search for dark matter produced in association with a pair of bottom quarks in p-p collisions at $\sqrt{s} = 13$ TeV with the CMS detector using full Run2 data

📌 **2HDM + a model [CERN-LPCC-2018-02]**

◆ Minimal particle content and gauge invariant

◆ Variety of MET signatures

◆ mono-jet, mono-H, mono-tt, **mono-bb**

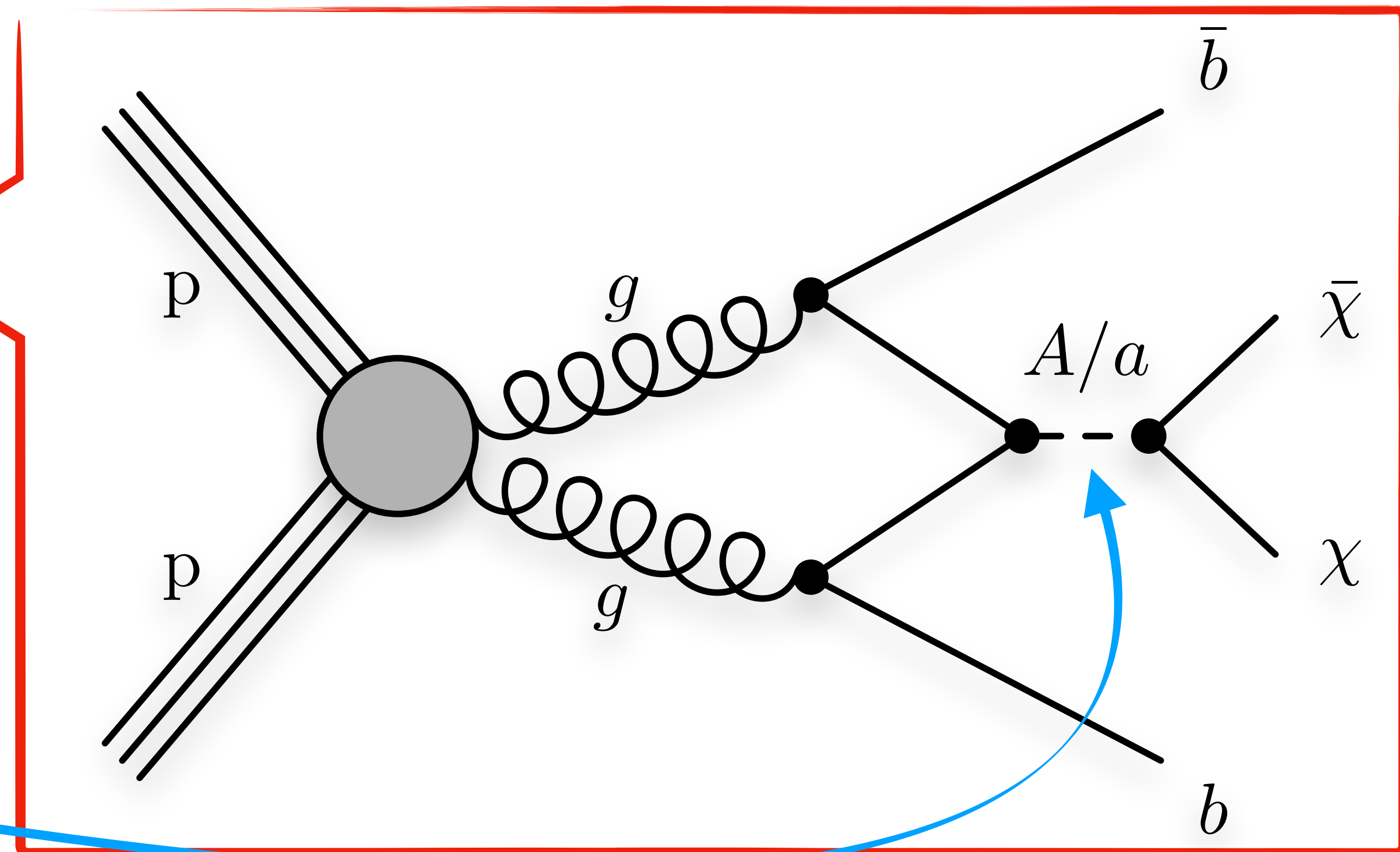
◆ Particle content:

● Two scalars: h (SM Higgs), H

● Pair of charged scalars: H^\pm

● Two pseudoscalars: **A, a**

● Dirac fermion DM: χ



Model Parameters

With 14 free parameters in total

Masses

$$m_H = 125 \text{ GeV}$$

$$m_H, m_{H^\pm}, m_A, m_a, m_\chi$$

Mixing Angles

- ✓ Between h and H : α
- ✓ Between A and a : θ
- ✓ VEV ratio of Higgs Doublet: $\tan \beta$

Quartic Coupling

$$\lambda_3, \lambda_{P1}, \lambda_{P2}$$

Benchmark Parameters

$$\left\{ \begin{array}{l} m_H = m_{H^\pm} = m_A = 600 \text{ GeV}, \\ \lambda_3 = \lambda_{P1} = \lambda_{P2} = 3, m_\chi = 1 \text{ GeV}, \\ \cos(\beta - \alpha) = 0, \tan \beta < 50 \end{array} \right\}$$

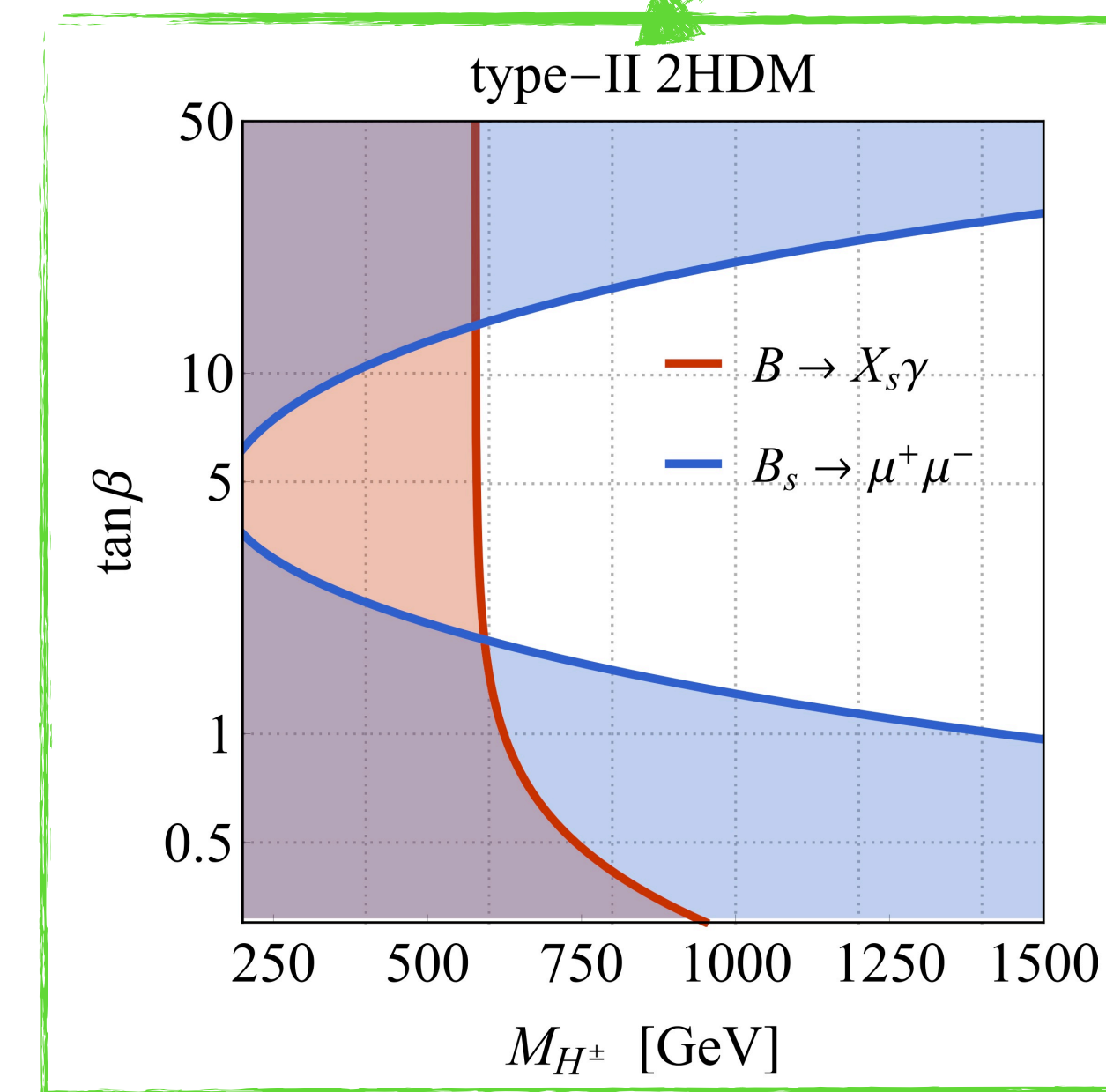
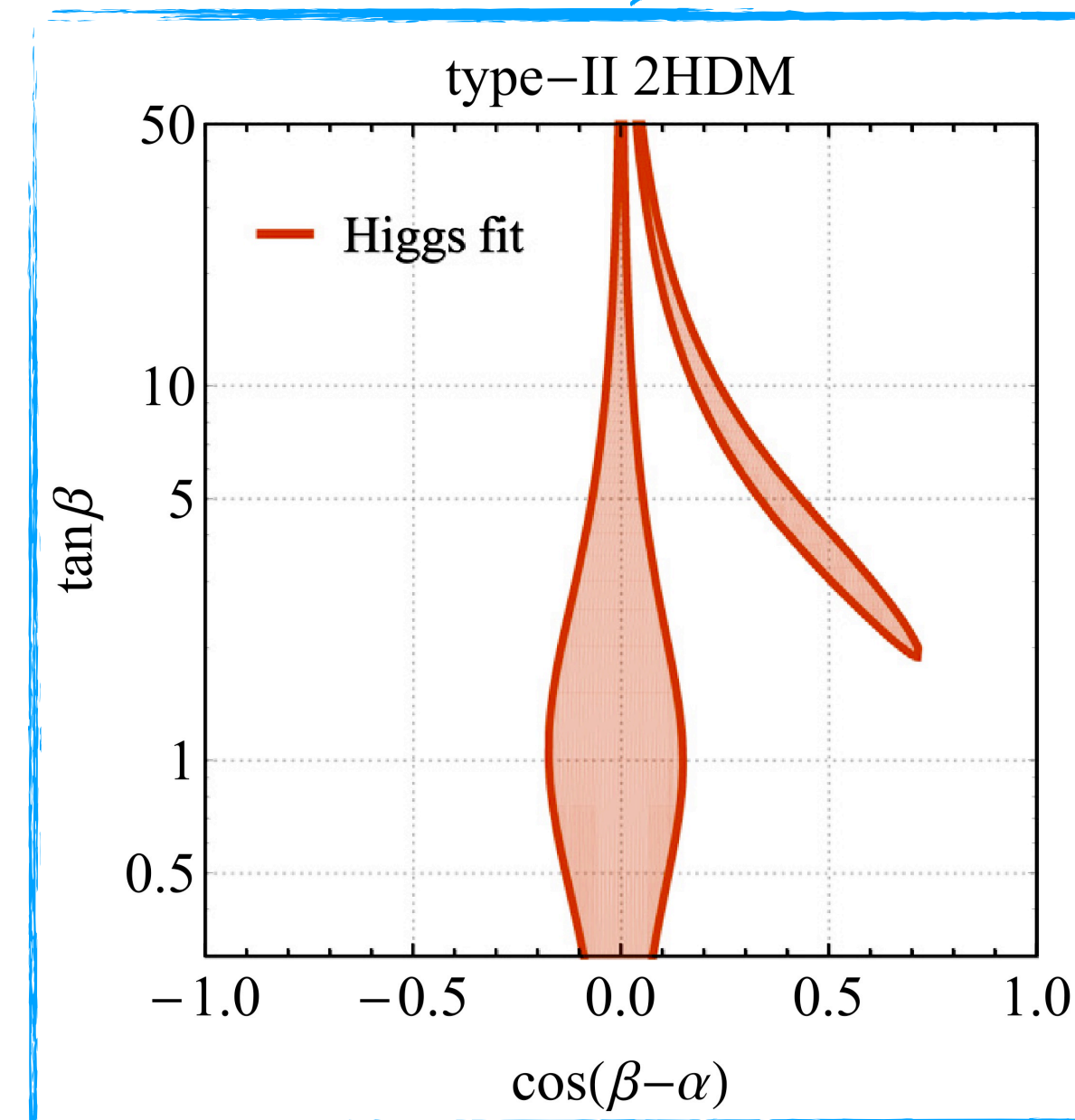
With various constraints

- $m_A, m_a, m_\chi, \sin \theta, \tan \beta$

The heavier (A) and lighter (a) pseudo-scalar couple to SM and DM particles

- $-iy_\chi (A \sin \theta + a \cos \theta) \bar{\chi} \gamma_5 \chi$

$g_{b\bar{b}A}$ and $g_{b\bar{b}a}$ couplings are $\tan \beta$ -enhanced



Analysis Strategy

📌 Signal categories based on 1 or 2 b-jets with veto on leptons and photons

- Optimised event selections

- $p_T^{\text{miss}} > 250 \text{ GeV}$, Jet $p_T > 30 \text{ GeV}$,

- $\Delta\phi(\text{jet}, p_T^{\text{miss}}) > 0.5$

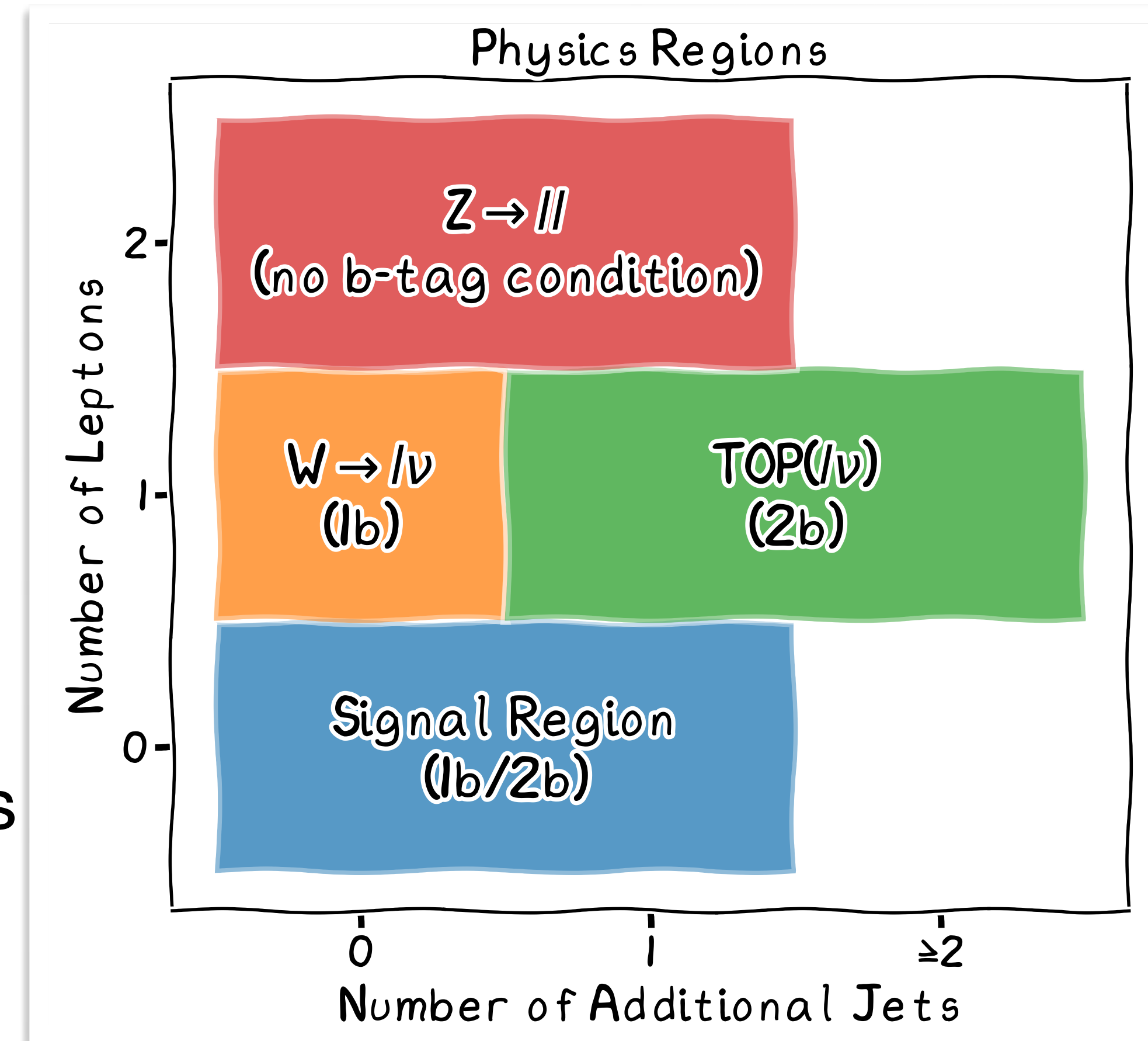
📌 Background Estimation

- Dedicated control regions for dominant backgrounds based on number of leptons

- Minor backgrounds are estimated by MC

📌 Signal Extraction

- Simultaneous fit on signal and control Region



Analysis Region Categorisation based on leptons and number of additional Jets

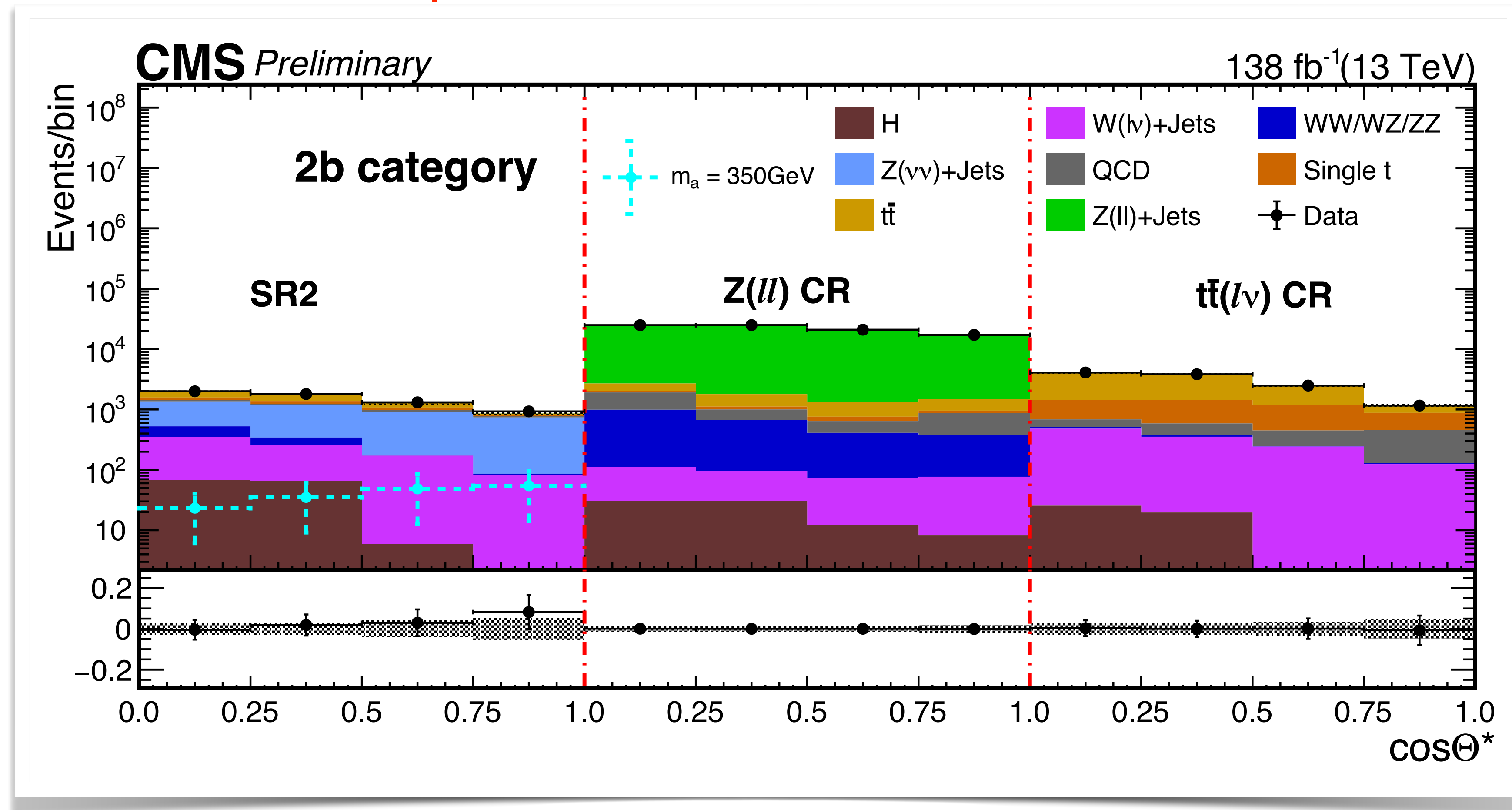
Results

With $\cos\Theta^* = \left| \tanh \left(\frac{\eta_{\text{Jet1}} - \eta_{\text{Jet2}}}{2} \right) \right|$ as the main observable

Very good agreement with DATA in both signal and control regions

No significant excess has been observed

1b category in backup



Interpretation

Observed 95% CL 1D-limits are placed on the lighter pseudoscalar m_a , 2D-limits are placed on $m_a - \tan\beta$ plane.

Excluding

upto

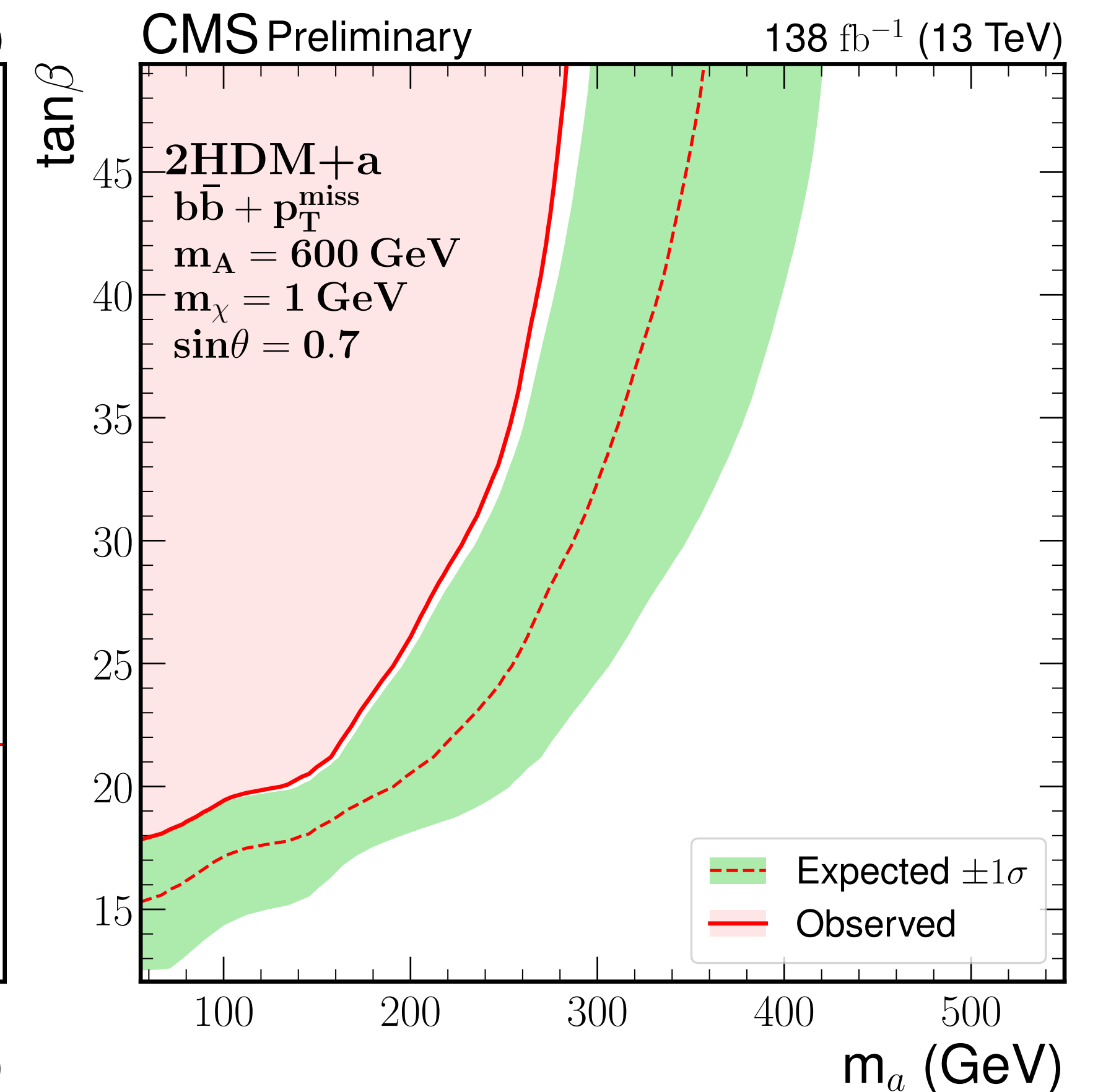
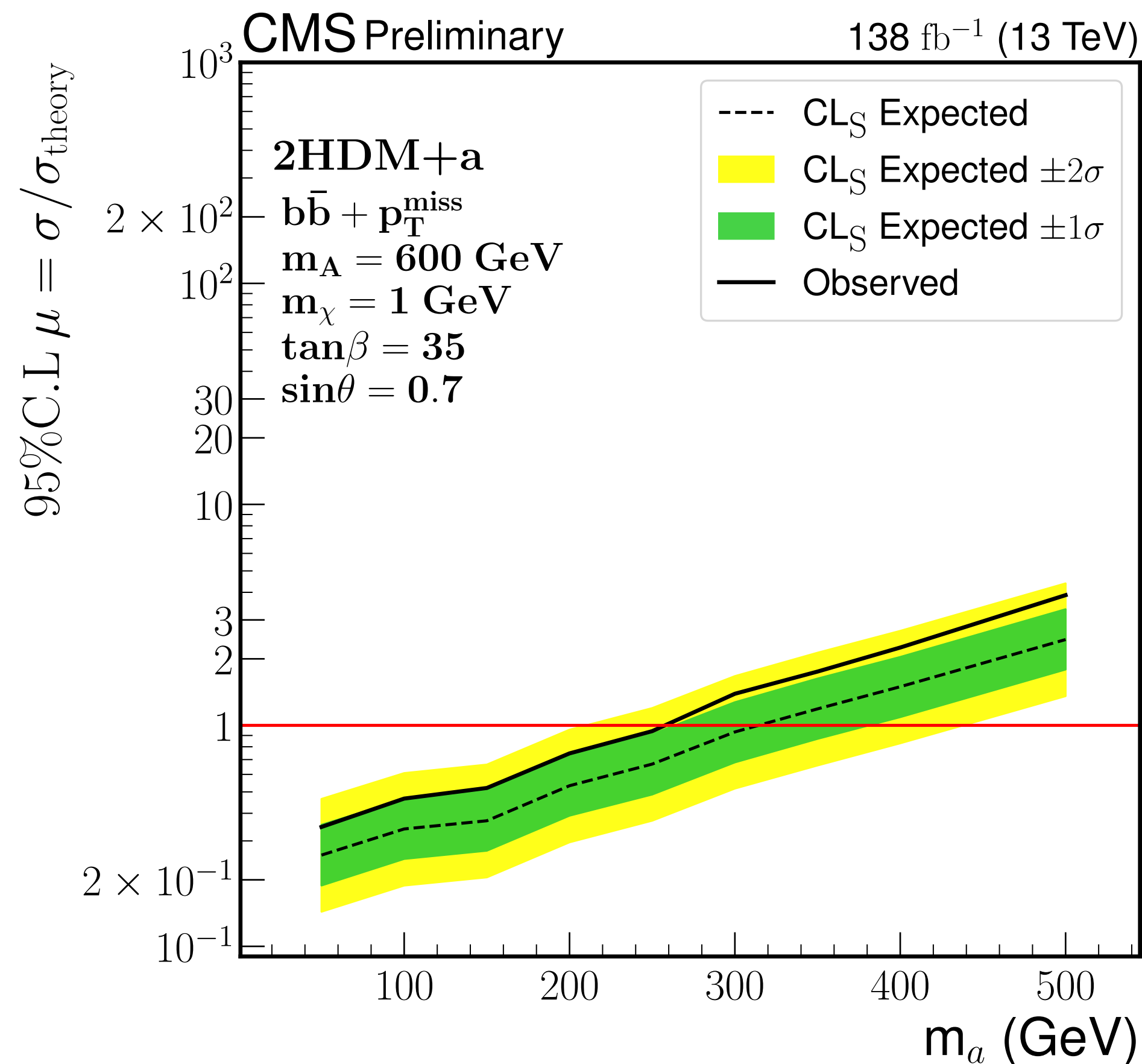
$m_a \sim 260 \text{ GeV}$

in 1D &

upto

$\tan\beta \sim 50$

in 2D

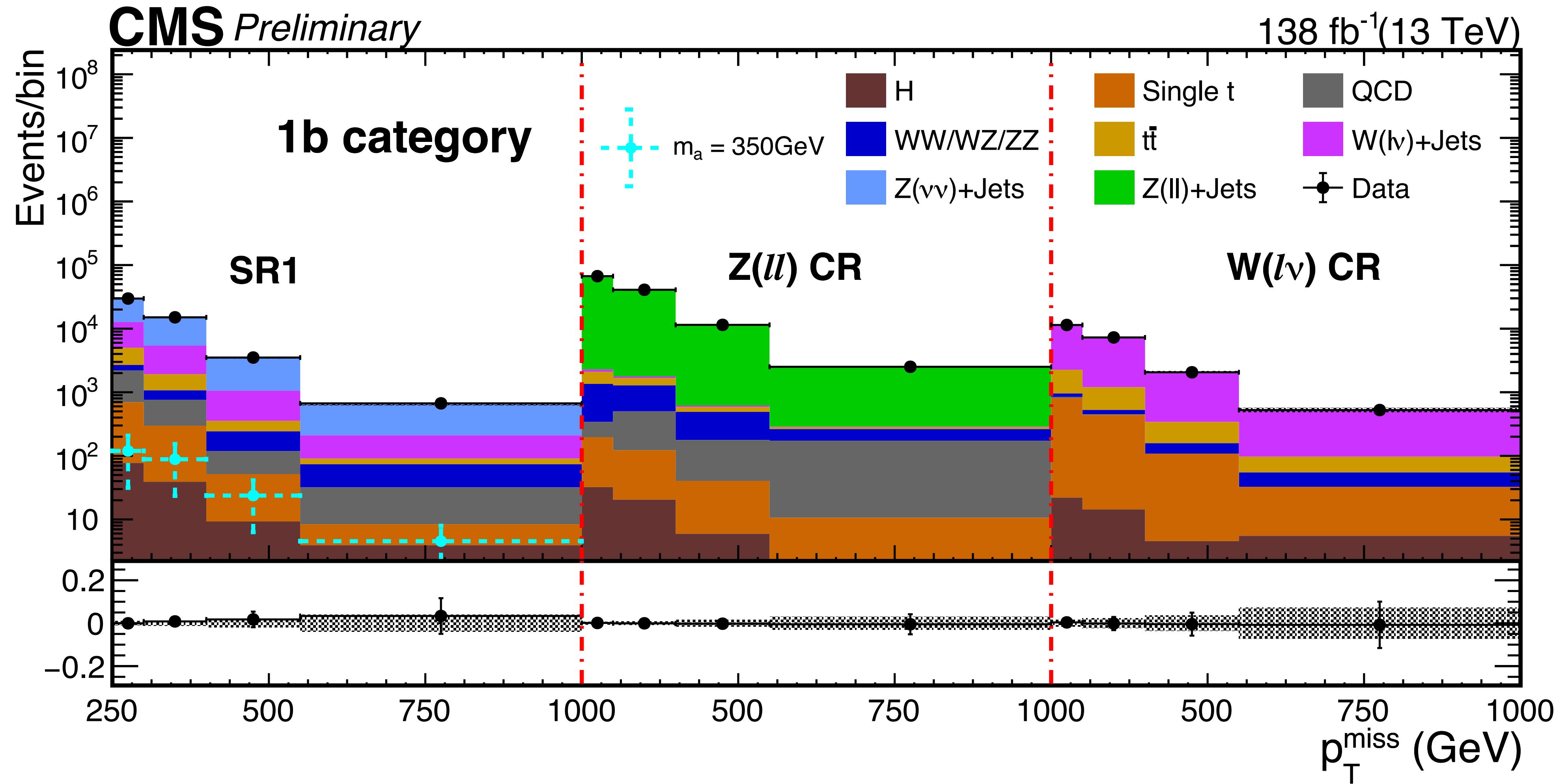


Summary

- 📌 A **new CMS search** for the production of dark matter in association with a pair of bottom quarks using 138 fb^{-1} data has been performed.
- 📌 **No significant excess observed over the SM prediction**
- 📌 First full Run2 search of DM at the LHC using the non-resonant mono- $b\bar{b}$ channel in the context of 2HDM+a
 - ✦ **Complementary to other mono+X searches due to $\tan\beta$ enhancement**

Thank You

Results



No significant excess has been observed

1b Category: With p_T^{Miss} observable

Interpretation

📌 Observed exclusion 95% CL limits for $m_a - \sin\beta$ and $m_a - m_\chi$ plane

