Searches for New Physics at the LHC

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on behalf of the ATLAS and CMS Collaborations

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MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Cofinanciado por la Unión Europea
AGENCIA ESTATAL DE INVESTIGACIÓN

IFAE Institut de Física d'Altes Energies
EXCELENCIA SEVERO OCHOA

ATLAS EXPERIMENT
CMS

EUROPEAN PHYSICAL SOCIETY EPS HEP2025 MARSEILLE 07 11 JULY 2025

The Standard Model of Particle Physics

… and beyond ?

No gravity!

No verified theory of quantum gravity

No dark matter!

But needed to explain astrophysical observations

Not enough matter-antimatter asymmetry!

To explain dominance of matter today

No neutrino masses!

Are they Dirac or Majorana particles?

Why 3 fermion generations?

Underlying symmetry connecting quark and lepton sectors?

No dark energy!

The universe is in accelerated expansion
invisible source of energy?

No naturalness!

Higgs field parameters seem highly fine-tuned

Why hierarchical Yukawa coupling?

Why is the top quark so heavy?

Exploring all extensions of the SM

- The sea of beyond the SM theories is vast and difficult to cover in 30 min

Dark Sector

<Insert model here>

Two-Higgs-Doublet models

Heavy Neutrinos

Supersymmetry

<Insert model here>

Vector-like fermions

<Insert model here>

<Insert model here>

Quantum Black Holes

Leptoquarks

Exploring all extensions of the SM

special edition

- The sea of beyond the SM theories is vast and difficult to cover in 30 min
- Focus only on **brand-new results** released for this conference NEW
- New **Run-3 results**, accessing new corners of the **phase-space,** improving **tagger performances,** explore **new models** and **signatures** in the detector

Dark Sector

<Insert model here>

Two-Higgs-Doublet models

Heavy Neutrinos

Supersymmetry

<Insert model here>

Vector-like fermions

<Insert model here>

<Insert model here>

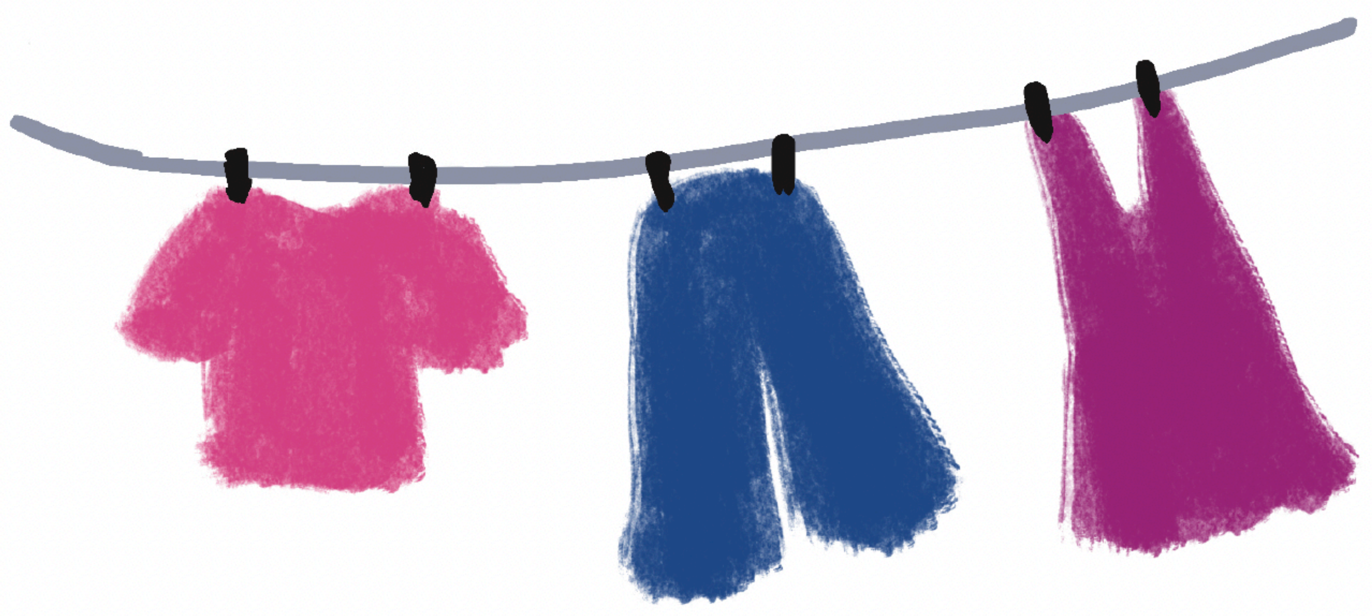
Quantum Black Holes

Leptoquarks

more than just a laundry list

more than just a laundry list

display the latest searches to unveil BSM physics



Heavy fermions & ℓq-coupled bosons

-

vector-like quarks
leptoquarks

-

Vector-like quarks

- Hypothetical spin-½ coloured particles
- LH and RH components transform the same way under SM gauge group
- Mass not from Yukawas, evade Higgs constraints on 4th gen quarks

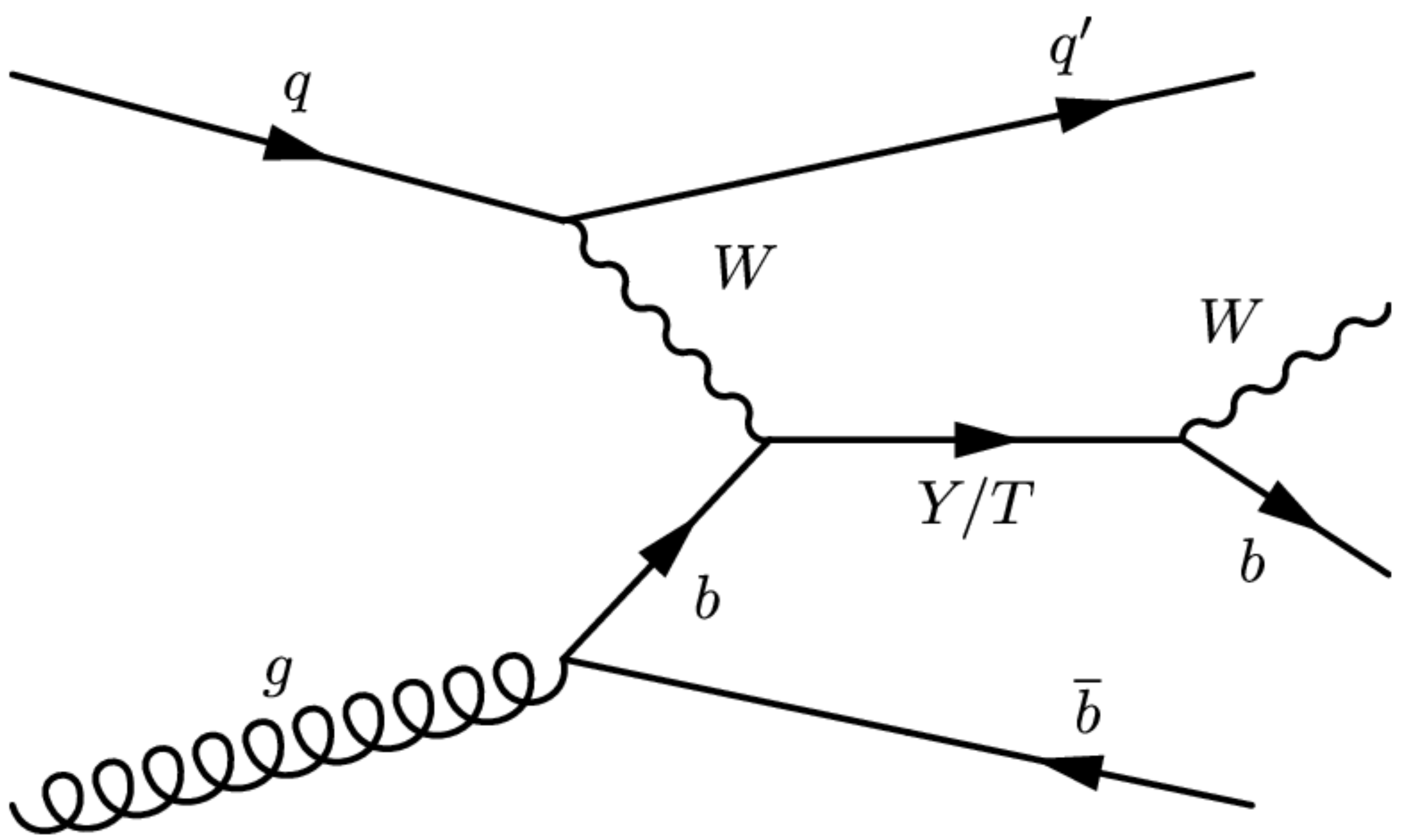
Leptoquarks

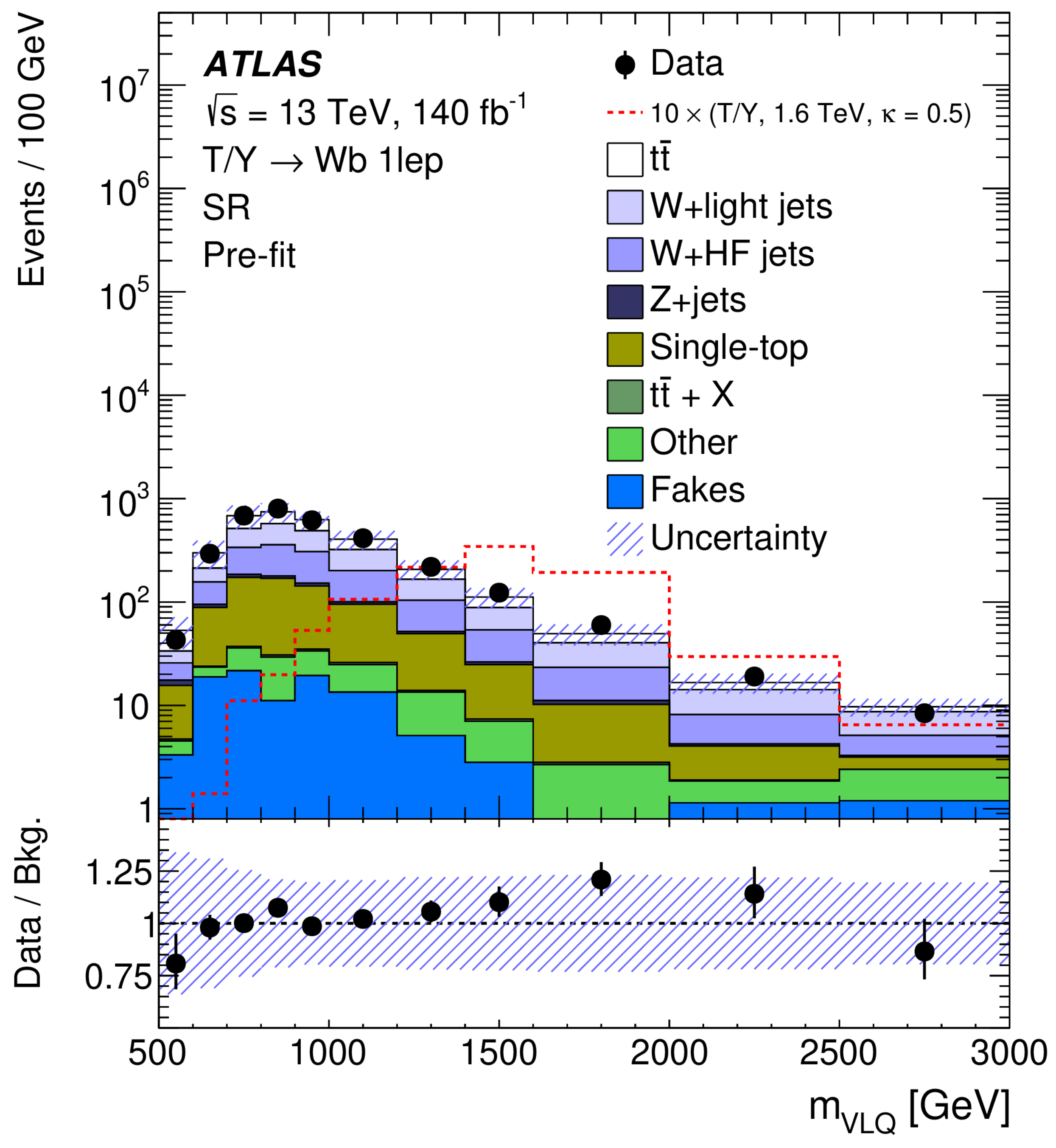
- Colour triplet bosons with fractional electric charge
- Carry both lepton and baryon number
- Can enable violation of lepton flavour universality

VLQ: T/Y → Wb (1ℓ)

CERN-EP-2025-098, submitted to JHEP

- Search for singlet-**T** with BR (Wb:Zt:Ht) = (½:¼:¼) and **Y** in a (T, B, Y) triplet (100% decay to Wb)
  - Focus on **Wb** decay mode, with coupling-strength parameter **κ**
- Single lepton channel (from W leptonic decay)
- Main backgrounds: tt̄ + single top, W+jets
- **Single top SM diagrams can interfere with signal** (singlet-T, triplet-Y)
  - Dealt with by matrix-element level reweighting
  - Statistical model: $\mu \times S + \sqrt{\mu} \times I + B$
- SR, tt̄ CR and W+jets CR each split in 3 bins of p_T^W
  - Better control on some systematics (e.g. W+jets modelling) and overall better sensitivity than merged
  - **Fit m_{VLQ} discriminant**



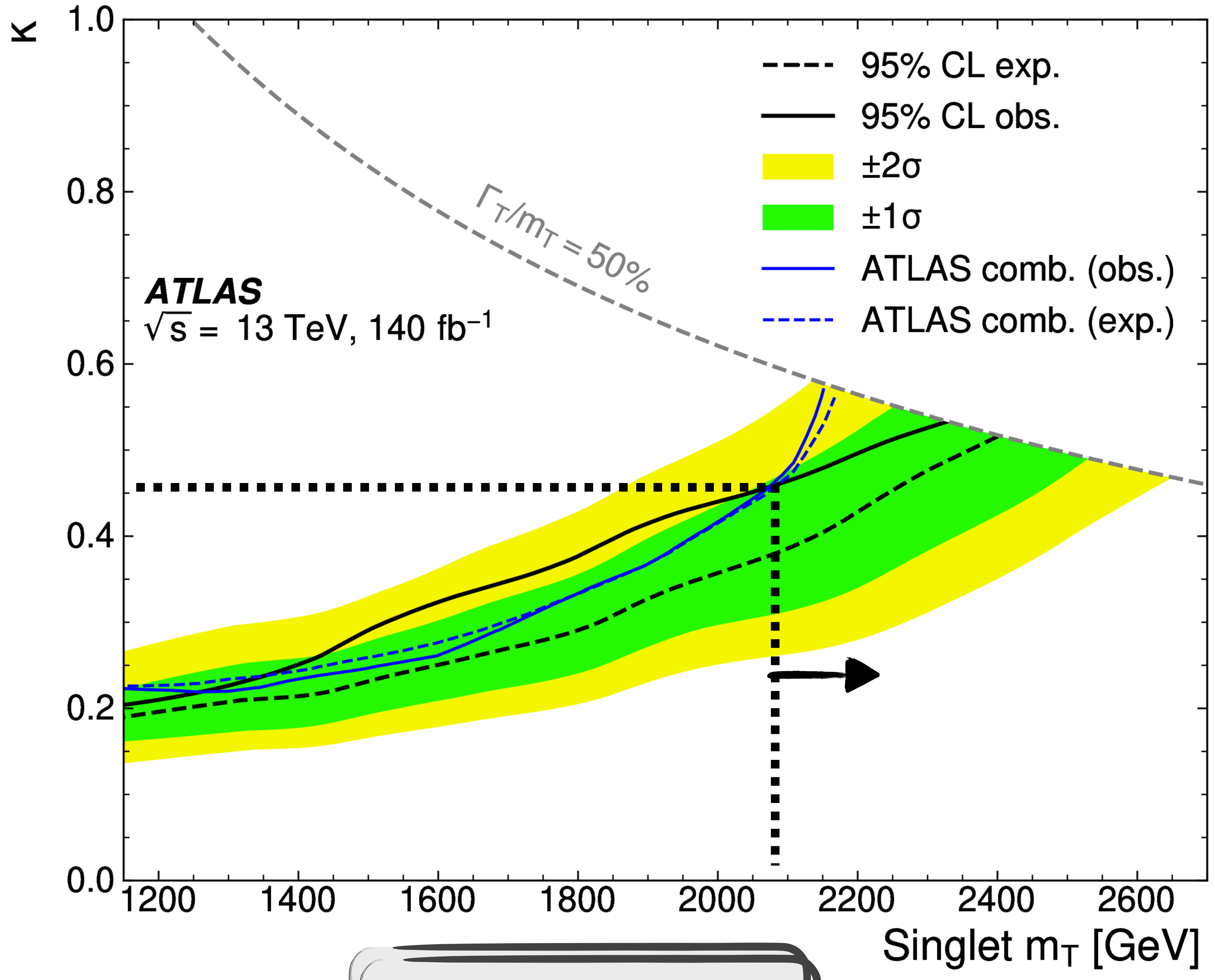


VLQ: T/Y → Wb (1ℓ)

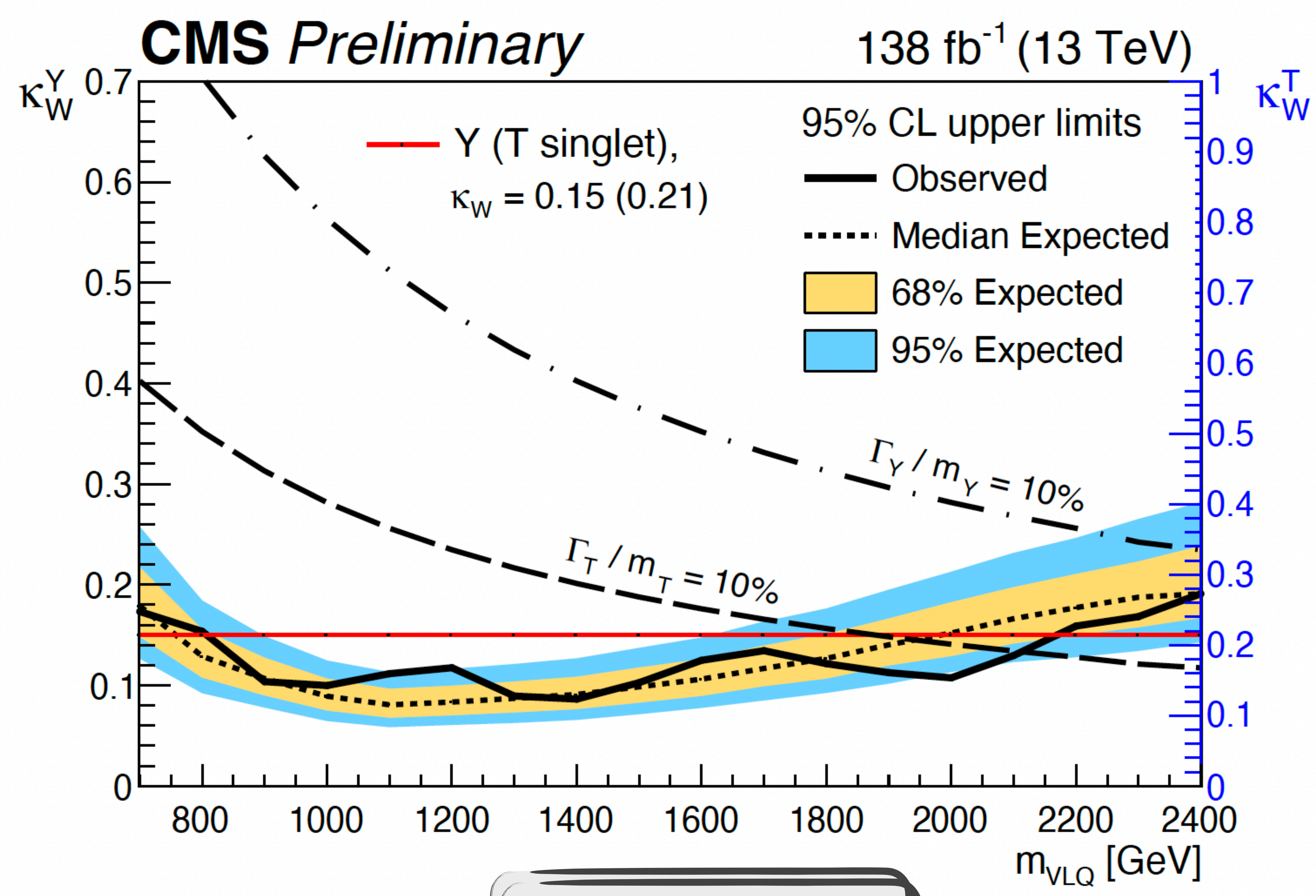
CERN-EP-2025-098, submitted to JHEP

CMS-PAS-B2G-22-004

- This search extends the limit above m_T ~ 2100 GeV wrt. previous ATLAS combination (PRD 111 (2025) 012012), whereas ATLAS search in the fully-hadronic channel remains with more stringent limits on Y in most of the phase space (JHEP 02 (2025) 075)



See Monika's talk

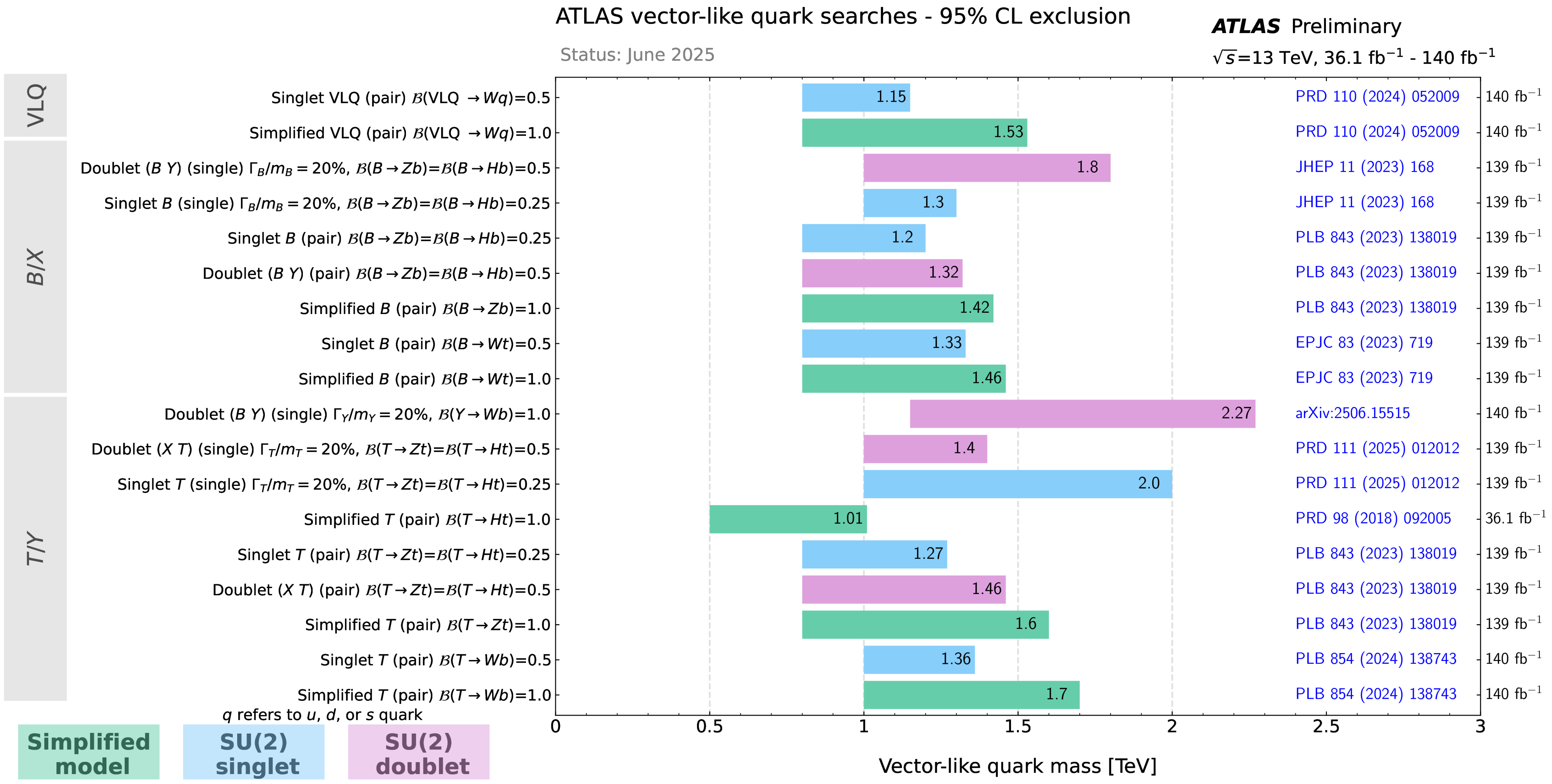


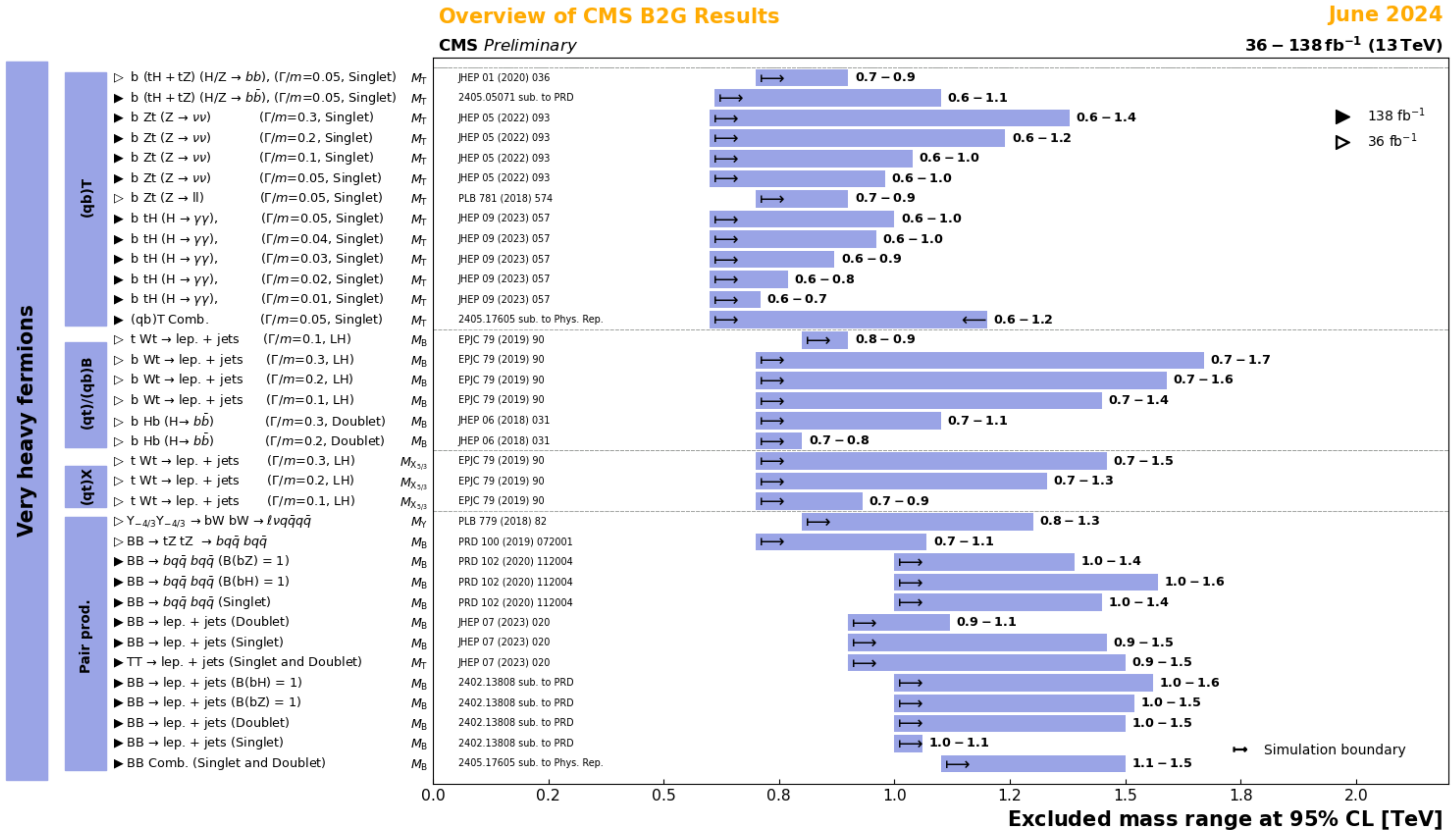
See Di's talk

VLQ summary

ATL-PHYS-PUB-2025-03

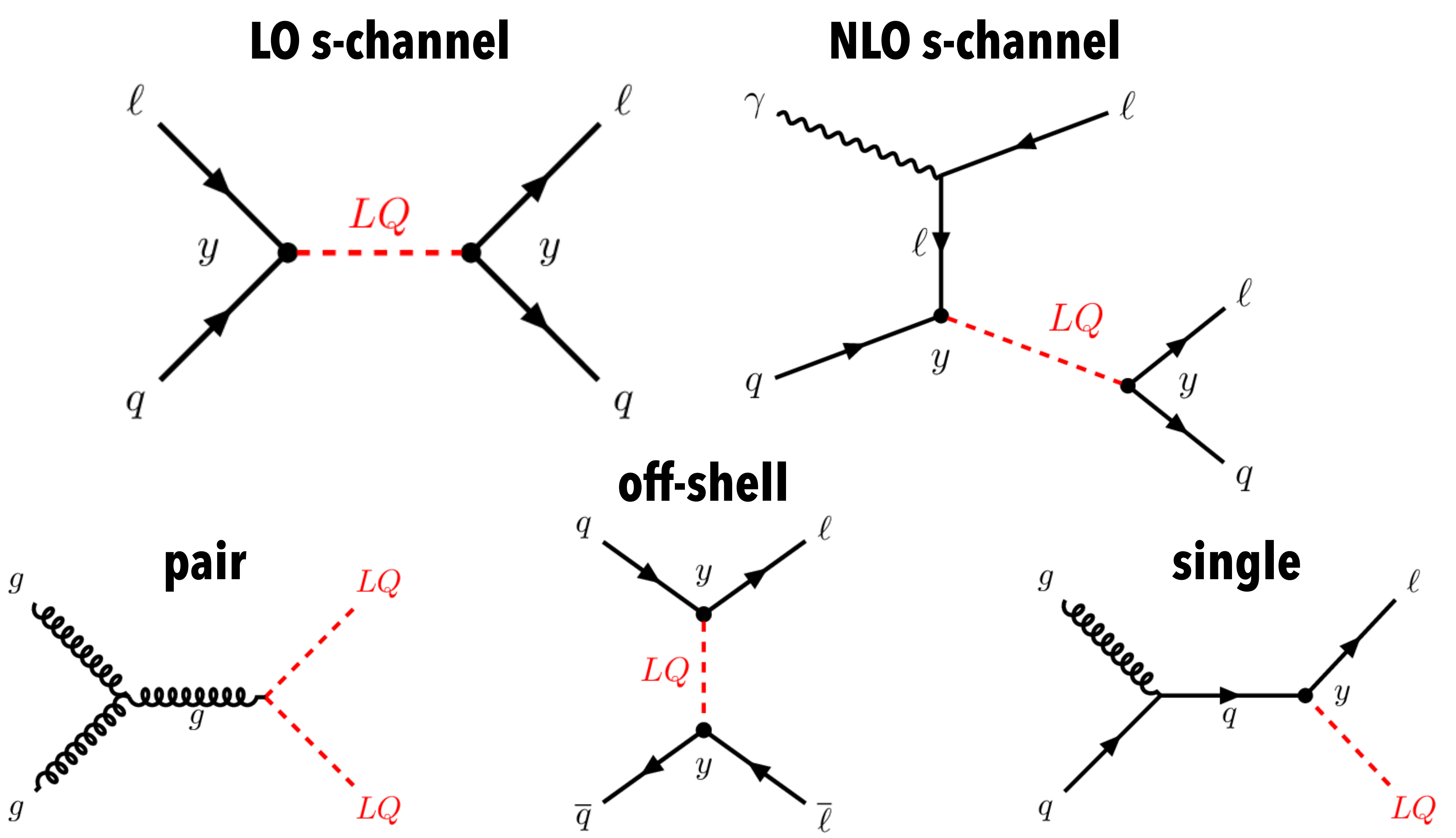
CMS summary (2024)



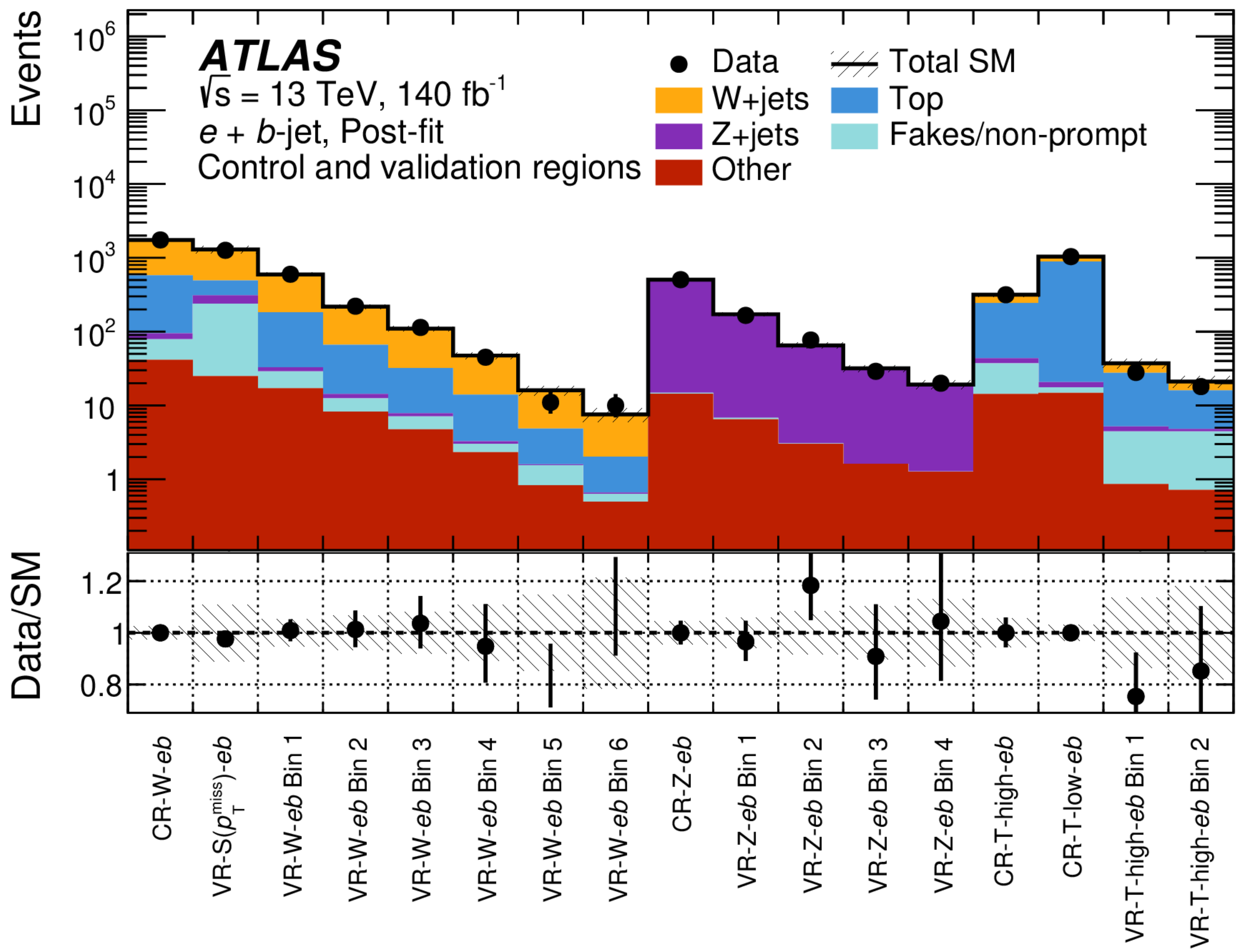


Resonant s-channel LQ

- First ATLAS search for resonant, s-channel prod. of LQs via lepton PDFs, LQ decay to 1 lepton + 1 jet
- **"NLO" contributions** via **photon PDF** motivate also targeting 2-lepton (+jet) final states
  - Common to t-channel and single LQ production as well



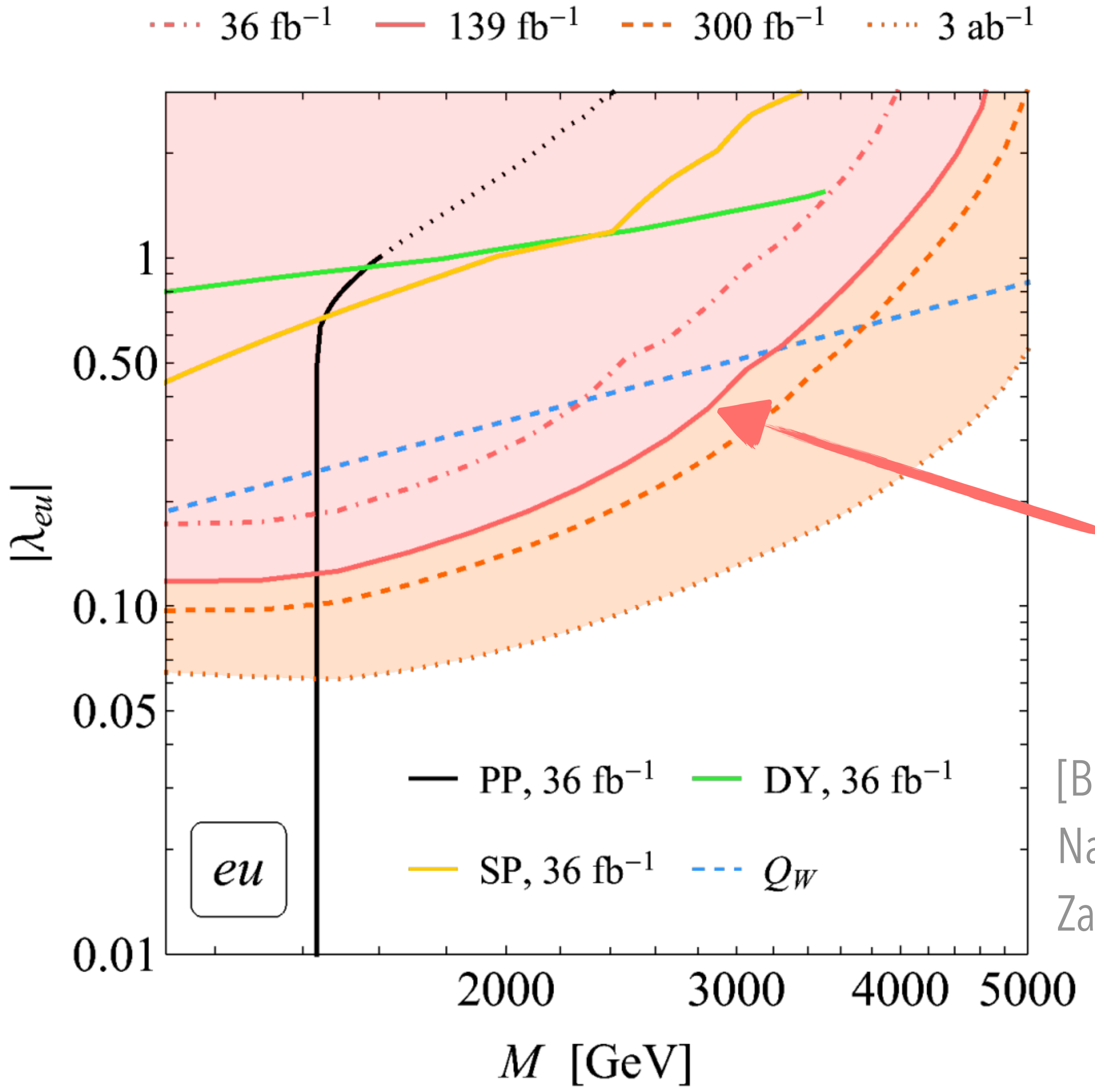
- Final states: e+light-jet, μ+light-jet, e+b-jet, μ+b-jet
- Using Run 2 (140 fb^{-1}) + partial Run 3 (55 fb^{-1}) datasets
- Fit m_{lj} distributions
- $t\bar{t}$, W+jets and Z+jets normalisation factors free-floating



Resonant s-channel LQ

CERN-EP-2025-142, submitted to JHEP

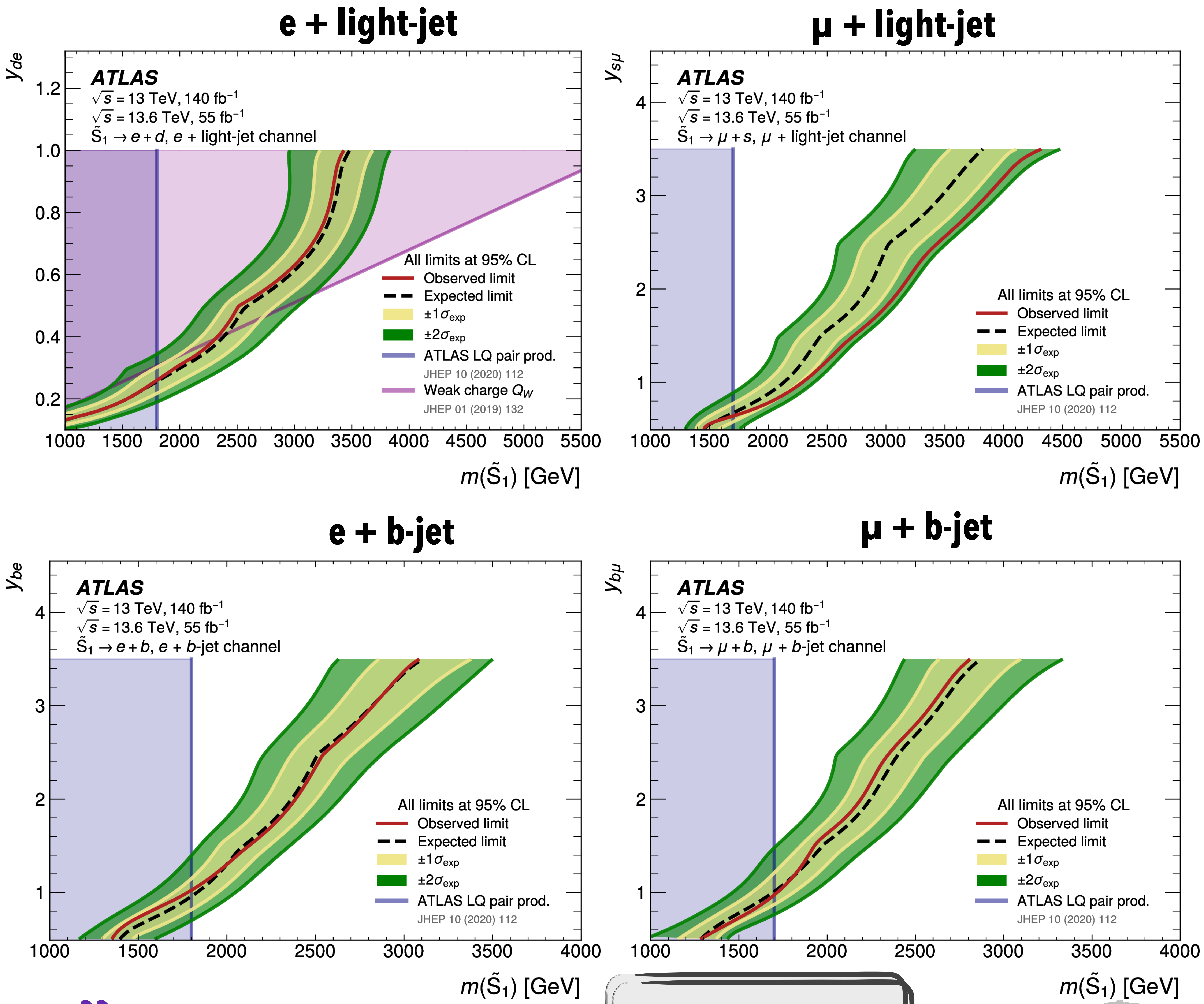
- Results interpreted within minimal $\tilde{S}$-model framework, where only a single LQ coupling is non-zero



access high mass & high coupling!

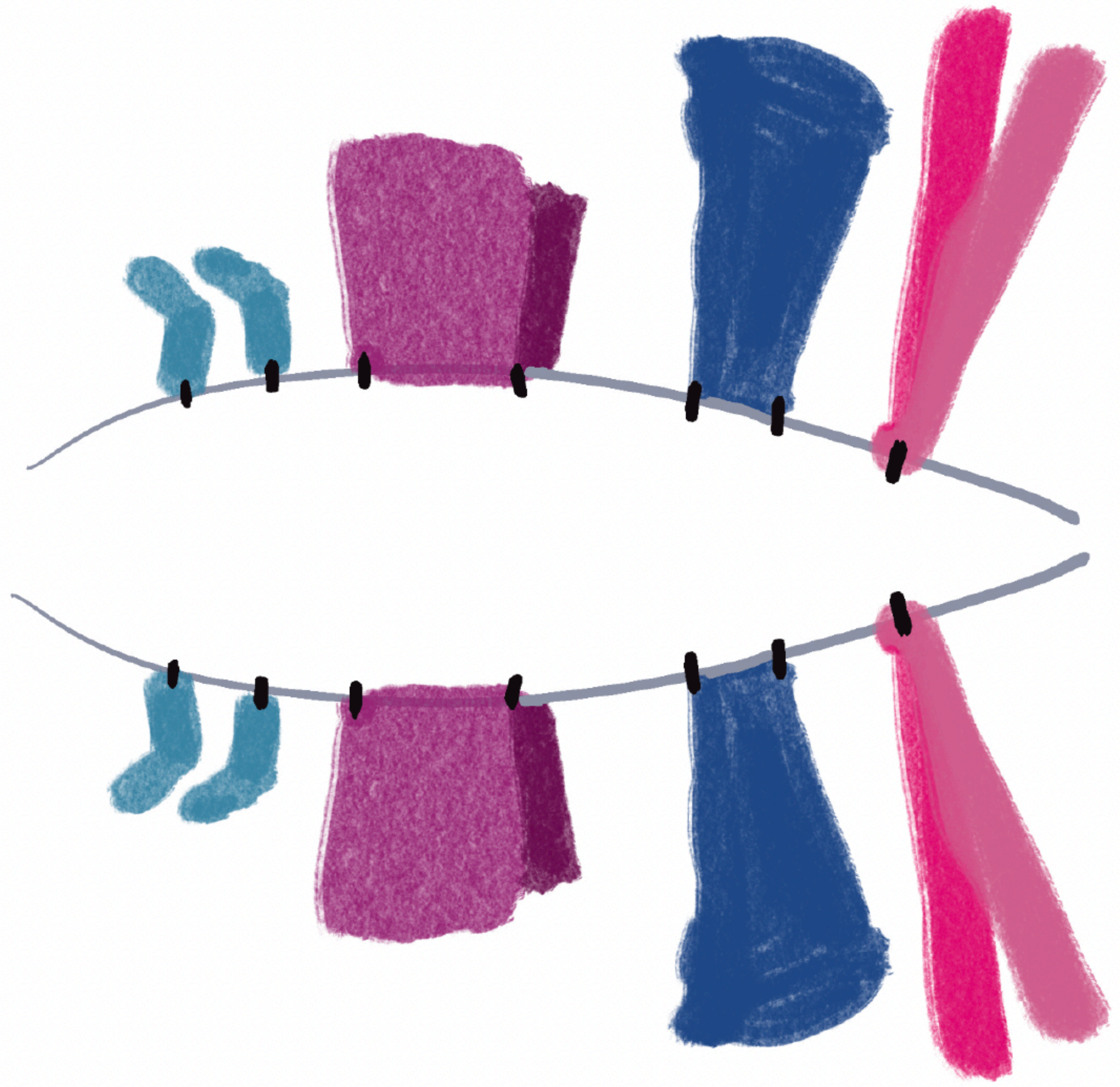
[Buonocore, Haisch, Nason, Tramontano & Zanderighi, 2005.06475]

- Stringent exclusion limits on LQ masses when combining Run 2 and partial Run 3 data:
  - m($\tilde{S}_1$) below **3.4 TeV** (y = 1.0) and **3.1 TeV** (y = 3.5) excluded for e + light-jet and e + b-jet, respectively
  - m($\tilde{S}_1$) below **4.3 TeV** (y = 3.5) and **2.8 TeV** (y = 3.5) excluded for μ + light-jet and μ + b-jet, respectively



See ATLAS Highlights by Fabio

See Monika's talk



Supersymmetry

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squarks & sgluinos
RPV SUSY 1ℓ + multi-(b)jets
stop / bino-wino annihilation LLP

-

- A superpartner for every SM particle
- Fermion superpartners of the Higgs and weak gauge bosons can be WIMP dark matter
- Gauge couplings unify at a single GUT scale
- Elegant solution to the hierarchy problem

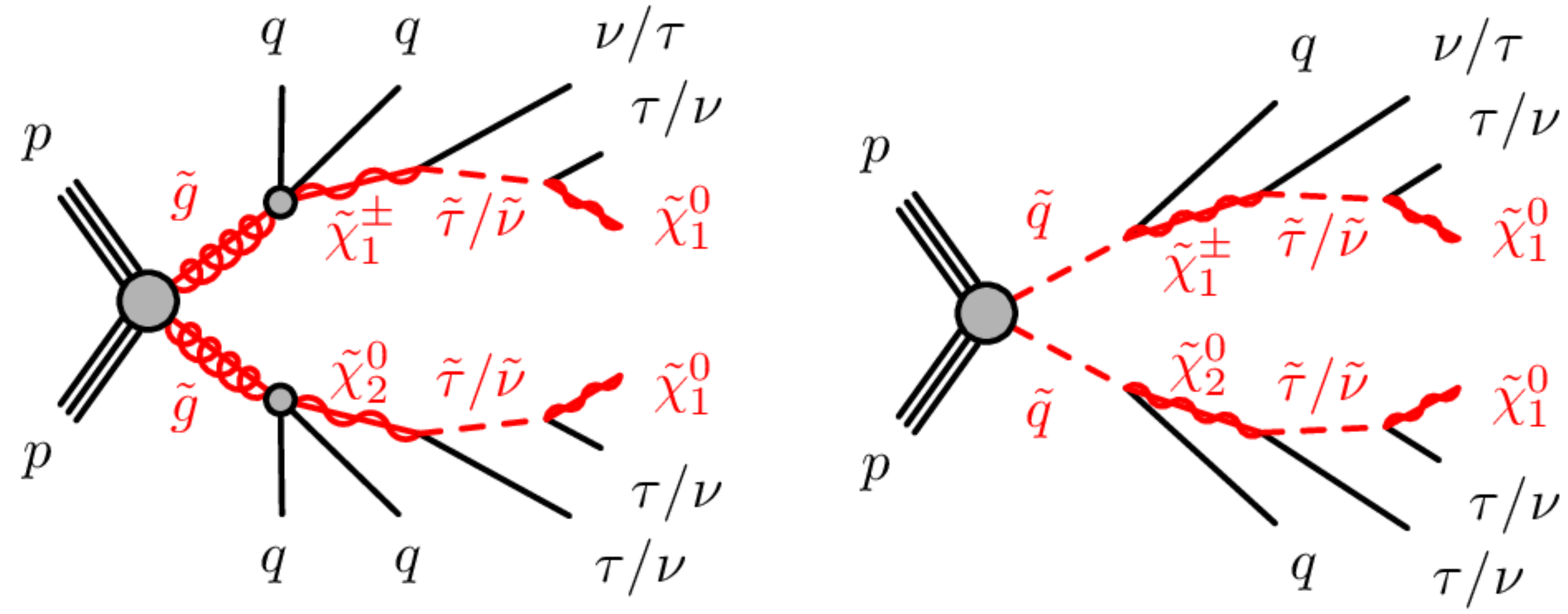
- R-parity-conserving (RPC): superpartners are pair-produced and Lightest Supersymmetric Particle (LSP) is stable → E_T^{miss} in the final state
- R-parity-violating (RPV): the LSP is allowed to decay into SM particles, voiding the E_T^{miss} signature

RPC squarks & gluinos: $\tau+E_T^{miss}$

CERN-EP-2025-132, submitted to EPJC

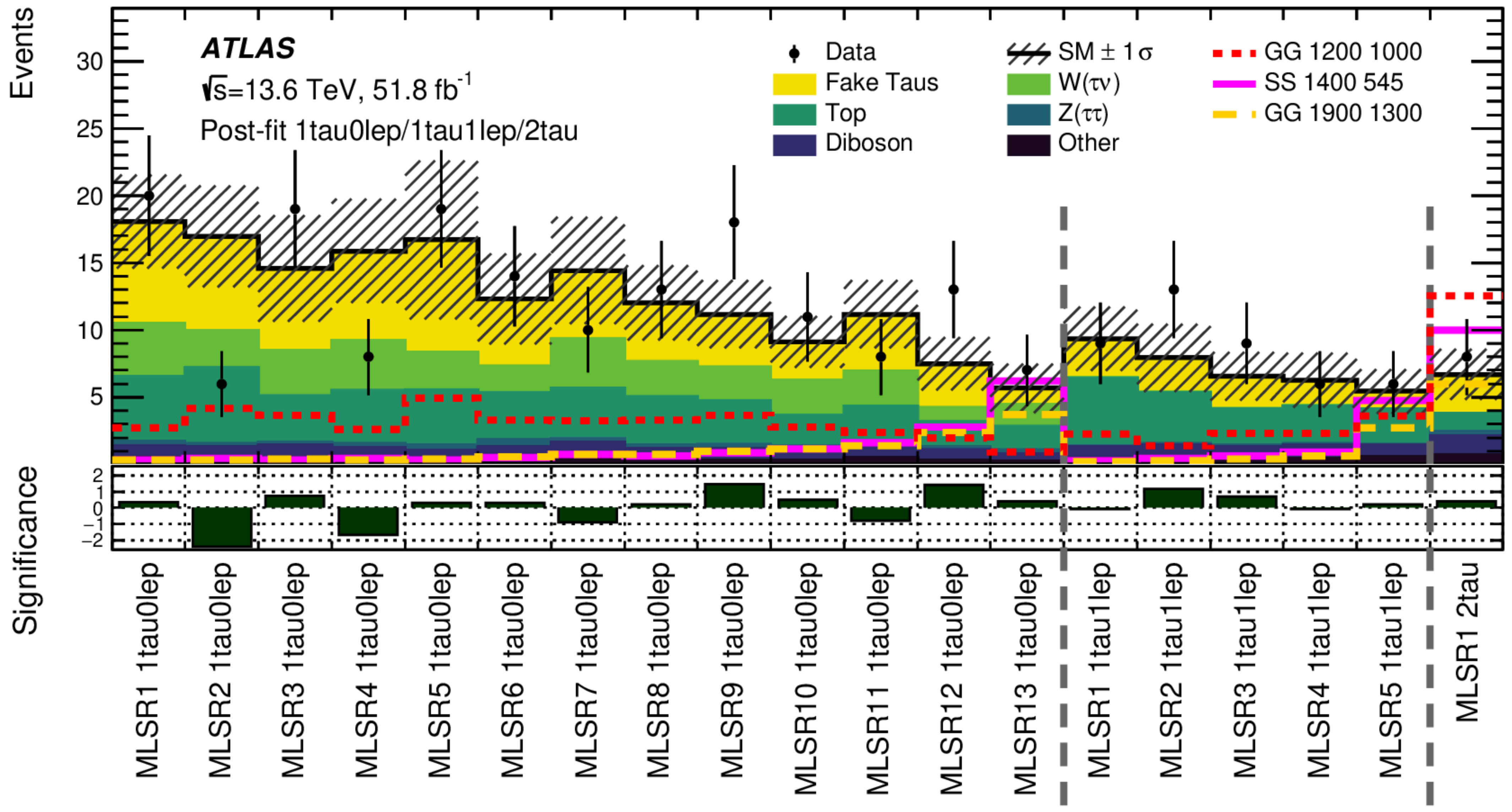
ATLAS EXPERIMENT

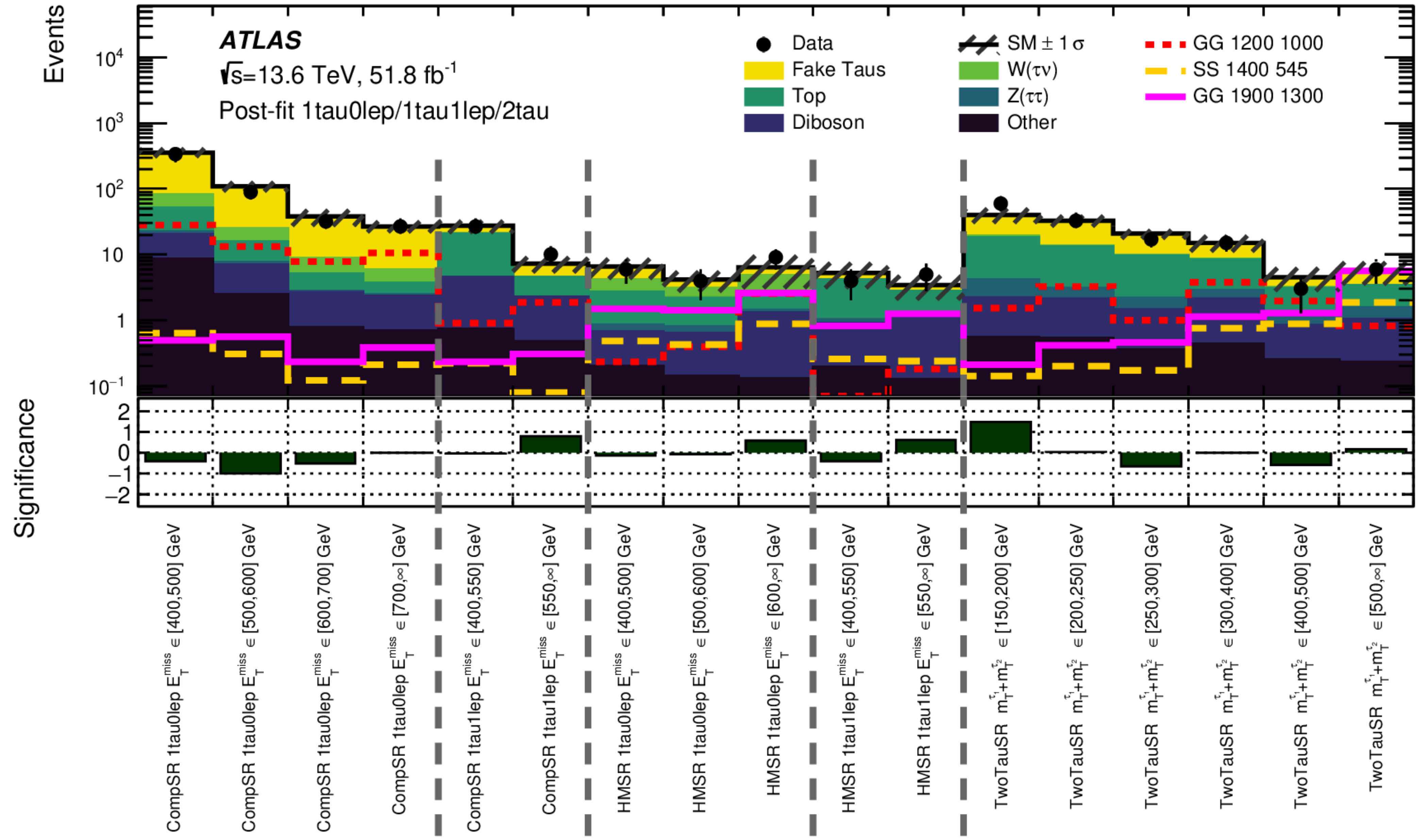
- Search for strongly pair produced squarks and gluinos decaying to τ, jets and E_T^{miss}
- Common cascade decay in MSSM
- Using Run 2 (140 fb^{-1}) + partial Run 3 (51.8 fb^{-1}) datasets
- Event selected with E_T^{miss} triggers



stable SUSY particle

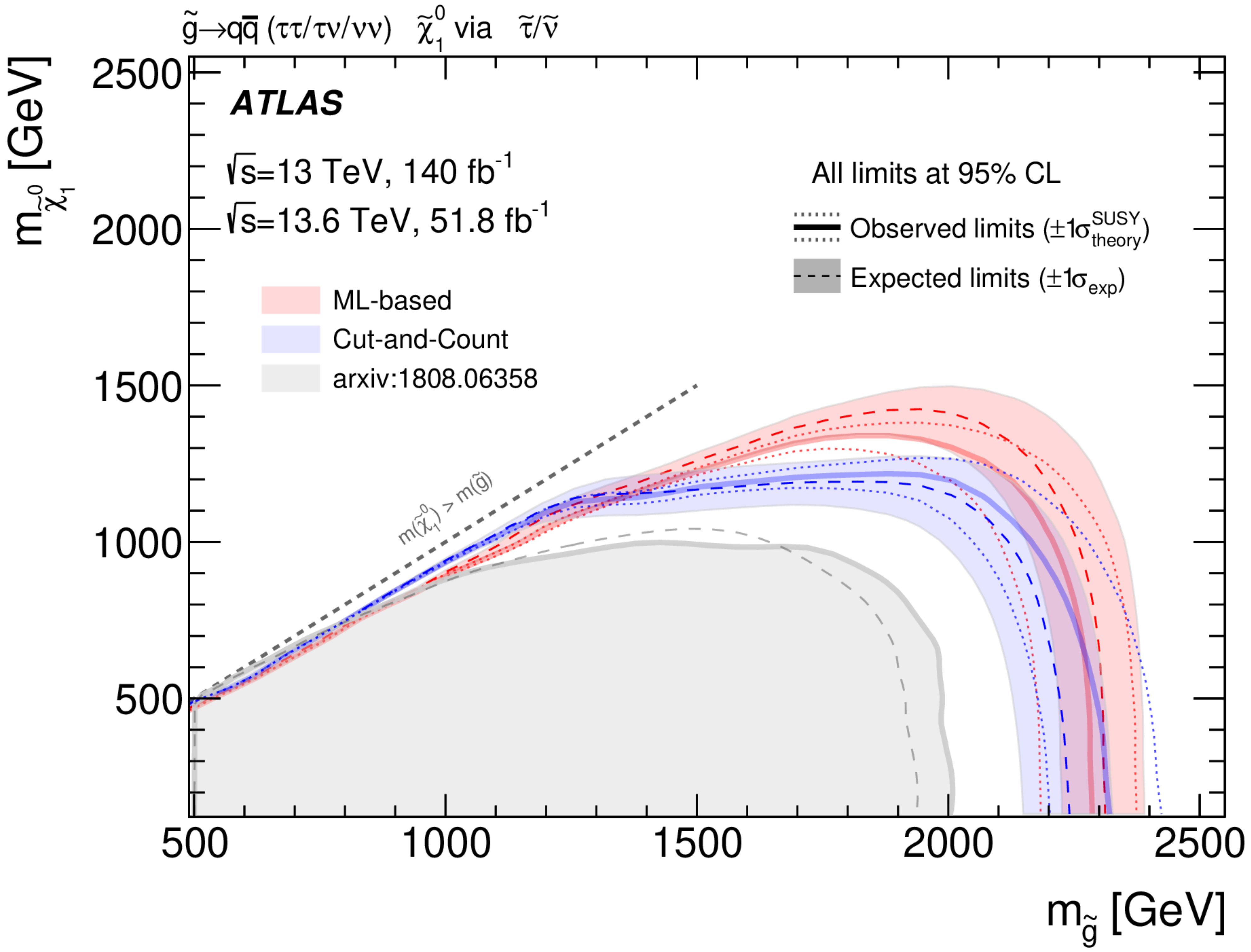
- **Machine-Learning based:**
  - Regions defined with **multiclass-classifier**
  - Channels: $1\tau0\ell$, $1\tau1\ell$, $2\tau0\ell$
- **Cut-and-count based:**
  - 1τ compressed, 1τ high mass, 2τ high-mass
  - E_T^{miss} fitted in 1τ SRs and $m_T^{\tau1}+m_T^{\tau2}$ in 2τ SRs

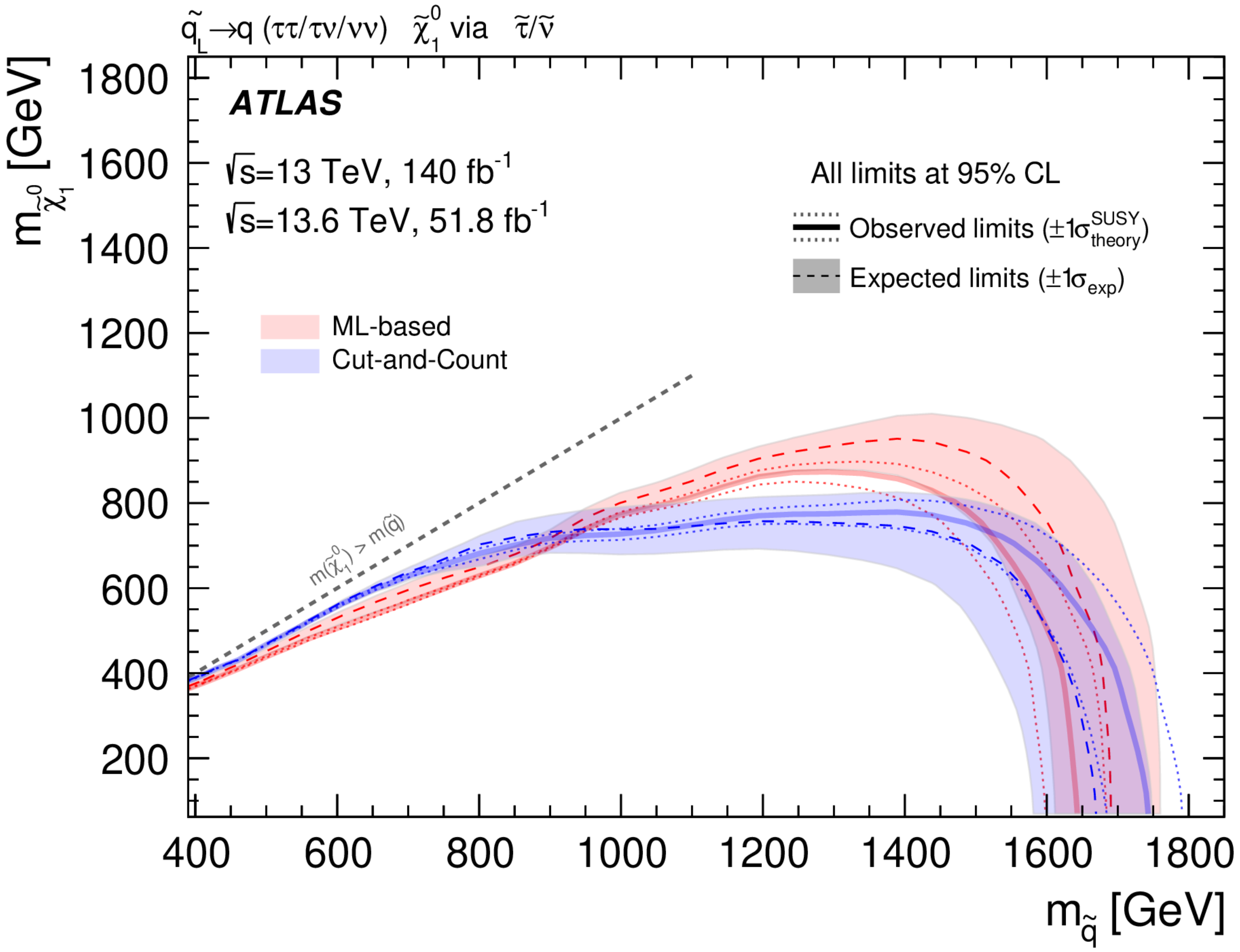




RPC squarks & gluinos: $\tau+E_T^{miss}$

- For **gluino** pair production models, gluino masses excluded below 2.25 GeV, and LSP masses excluded below 1.35 TeV for gluino masses around 2 TeV
- For **squark** pair production models, squark masses excluded up to 1.7 TeV, and LSP masses up to 0.85 TeV
- The cut-and-count-based approach slightly better in **compressed** region thanks to dedicated optimised region



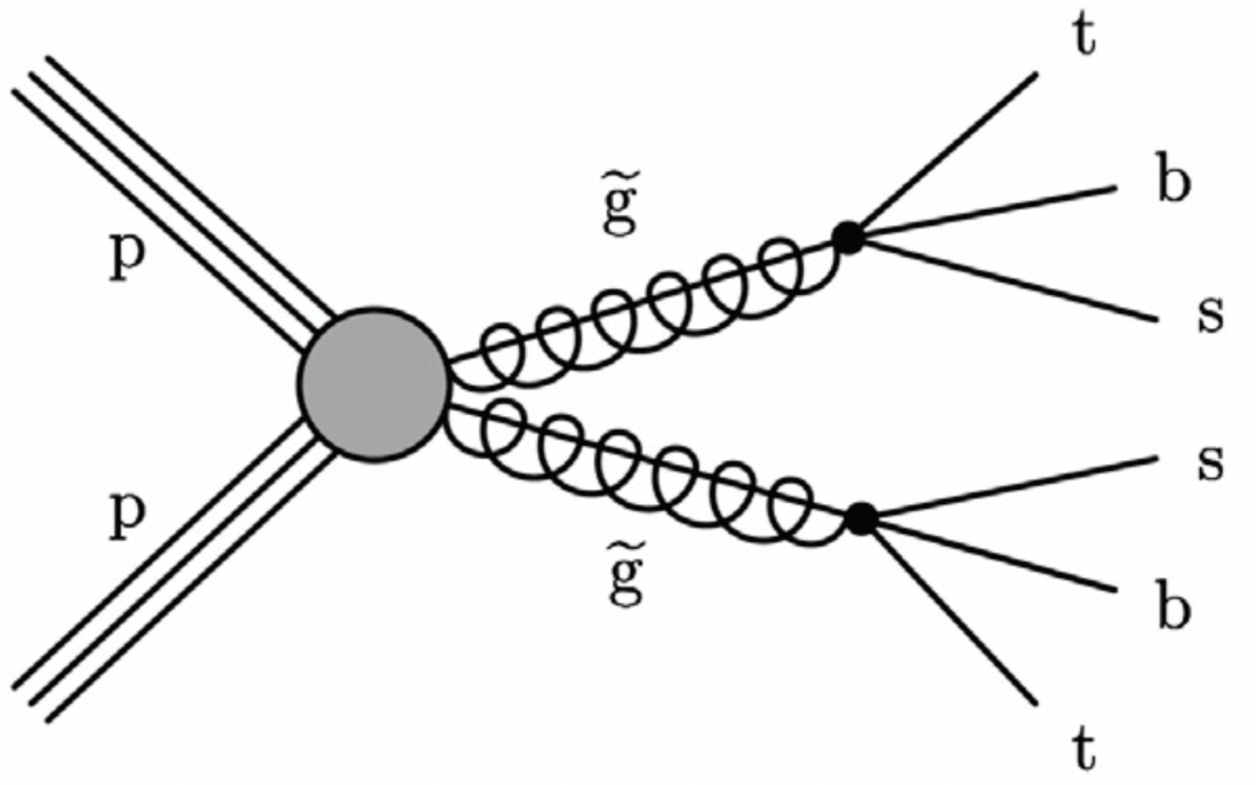


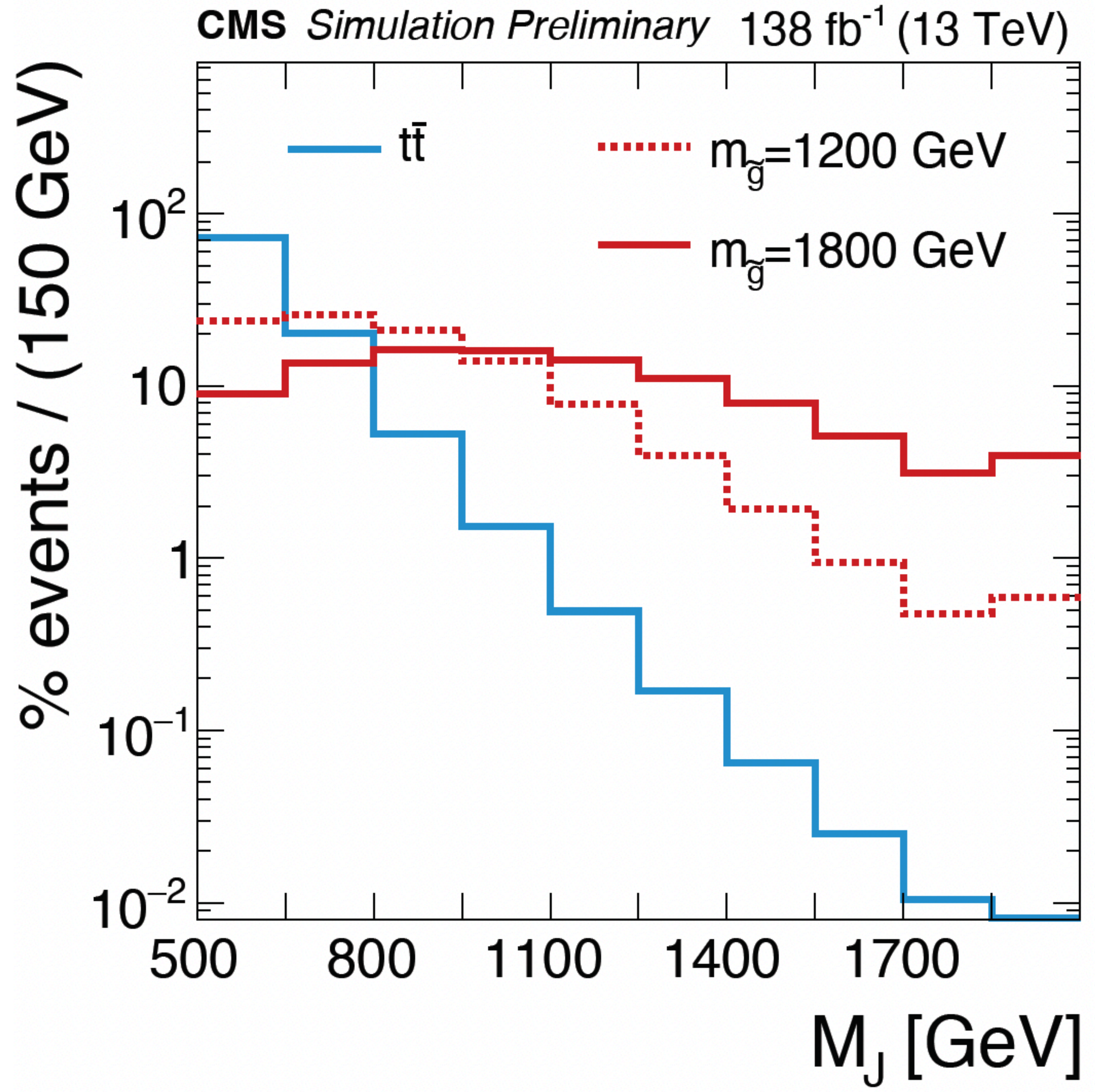
See ATLAS Highlights by Fabio

RPV SUSY 1ℓ + multi-(b)jets

SUS-21-005

- Search for BSM with **high jet and b-jet multiplicities** in the single-lepton final state, without a requirement on E_T^{miss}
- Focus on **gluino pair production**, where each gluino decays to a top, a bottom, and a strange quark via the λ''_{332} coupling (RPV)
- The **scalar sum of the large-radius jet masses (M_J)** templates are fitted to data in bins of N_{jet} and N_{bjet}
  - Determine the normalisation of the main backgrounds (QCD, W+jets, and $t\bar{t}$) in each (N_{jet} and N_{bjet}) bin
- **Data-driven correction factors** are derived in 3 M_J regions (500-800, 800-1100, ≥ 1100) GeV

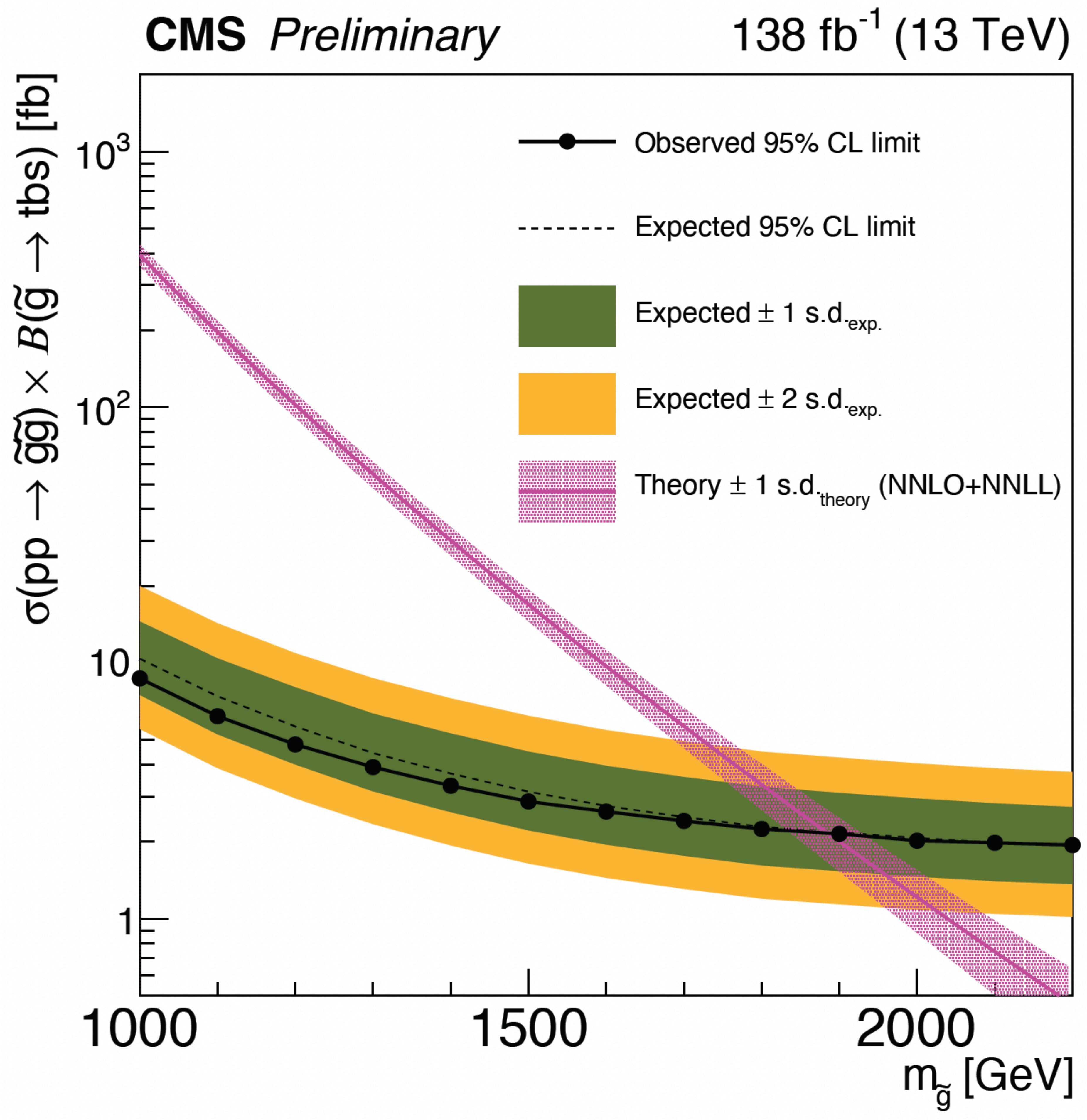




RPV SUSY 1ℓ + multi-(b)jets

SUS-21-005

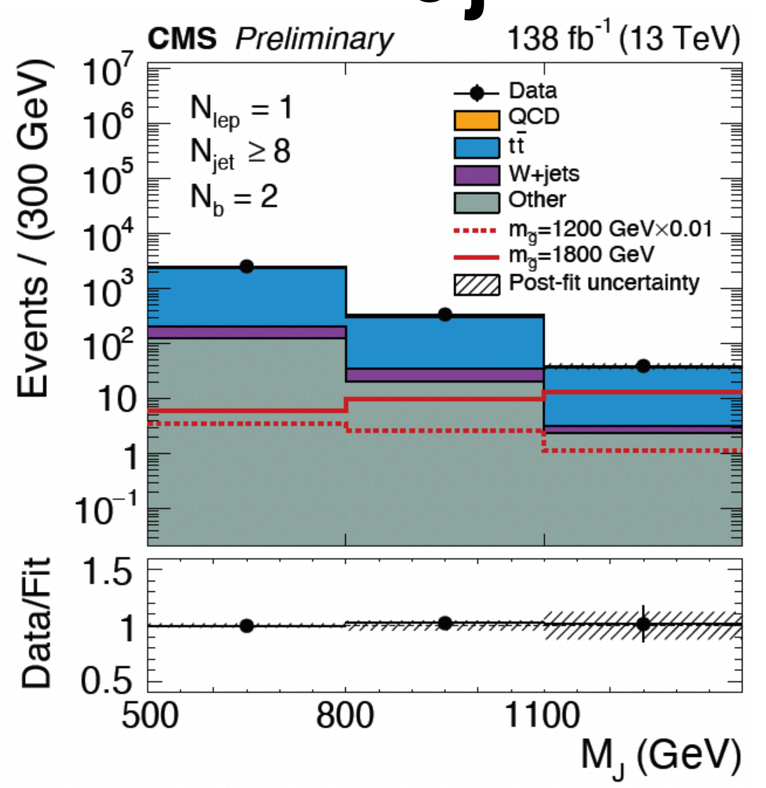
- Gluinos are excluded up to a mass of 1890 GeV at the 95% confidence level



N_b	N_{jet} 4 – 5	6 – 7	≥ 8
0	CR	CR	CR
1	CR	CR	CR
2	CR	CR	SR
3	CR	SR	SR
≥ 4	CR	SR	SR

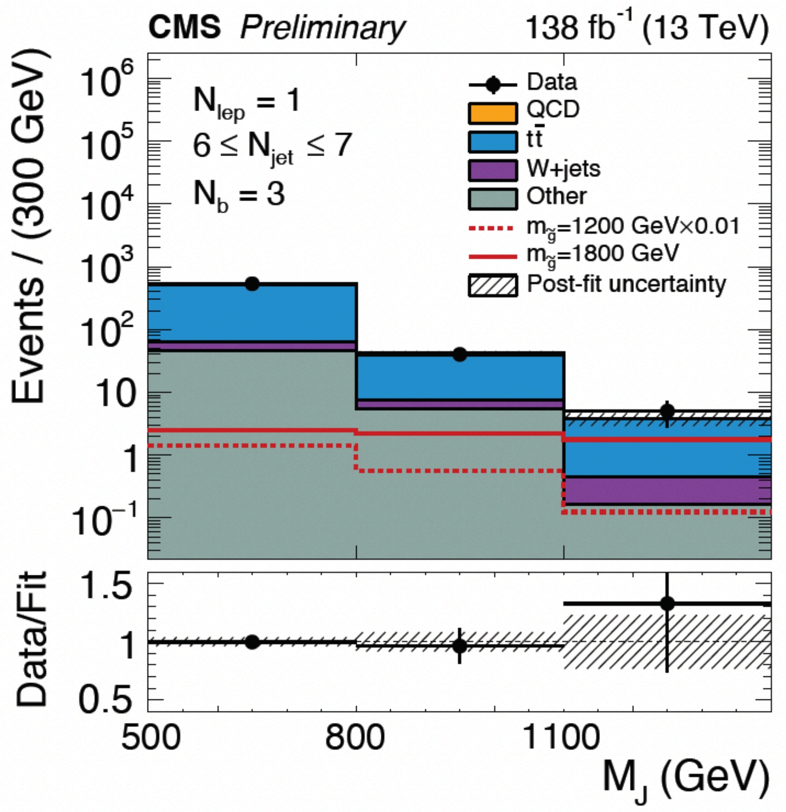
≥ 8 j

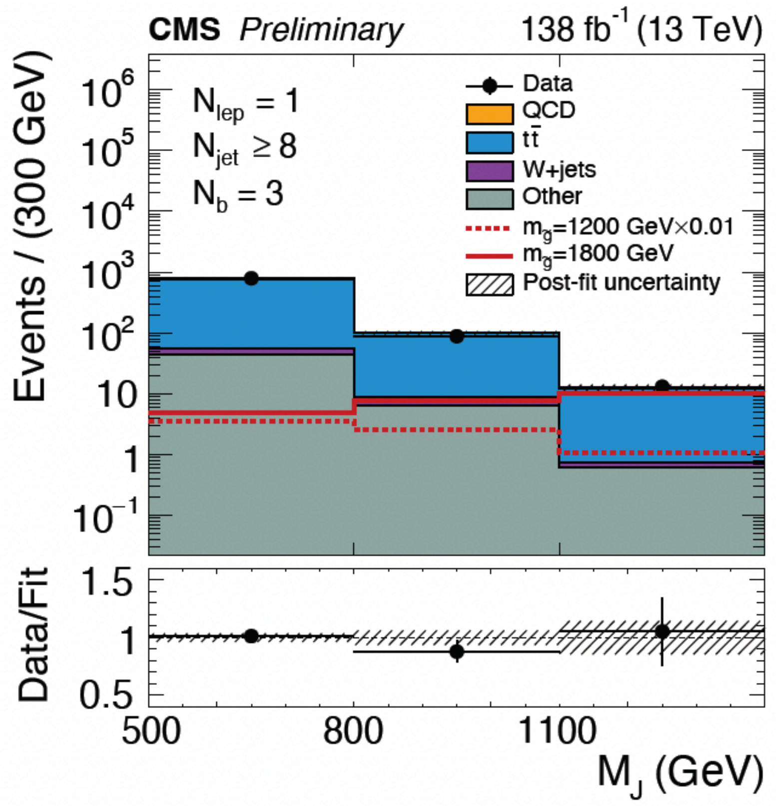
2 bj



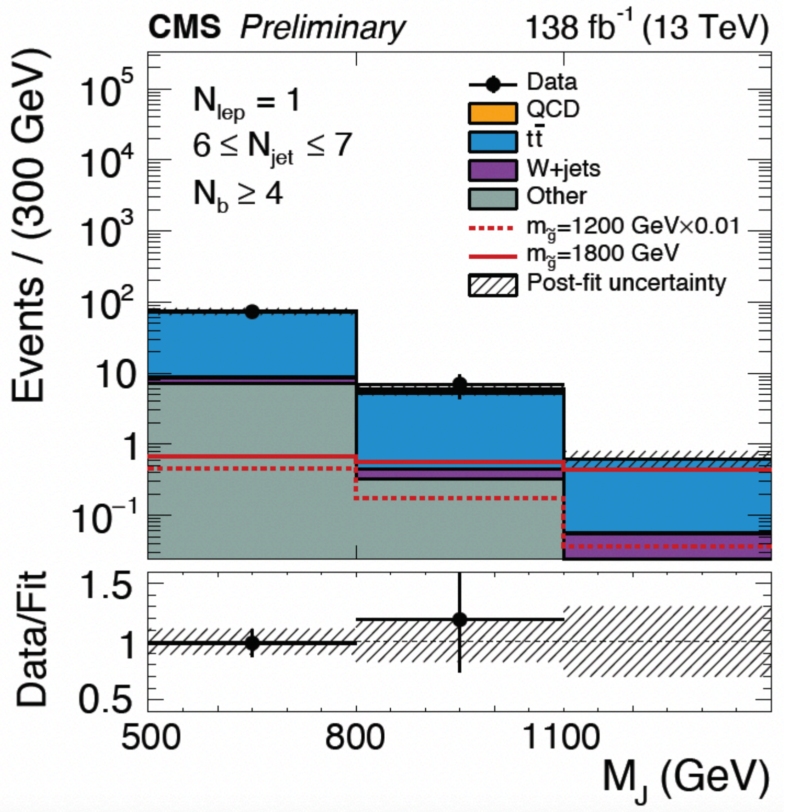
6-7 j

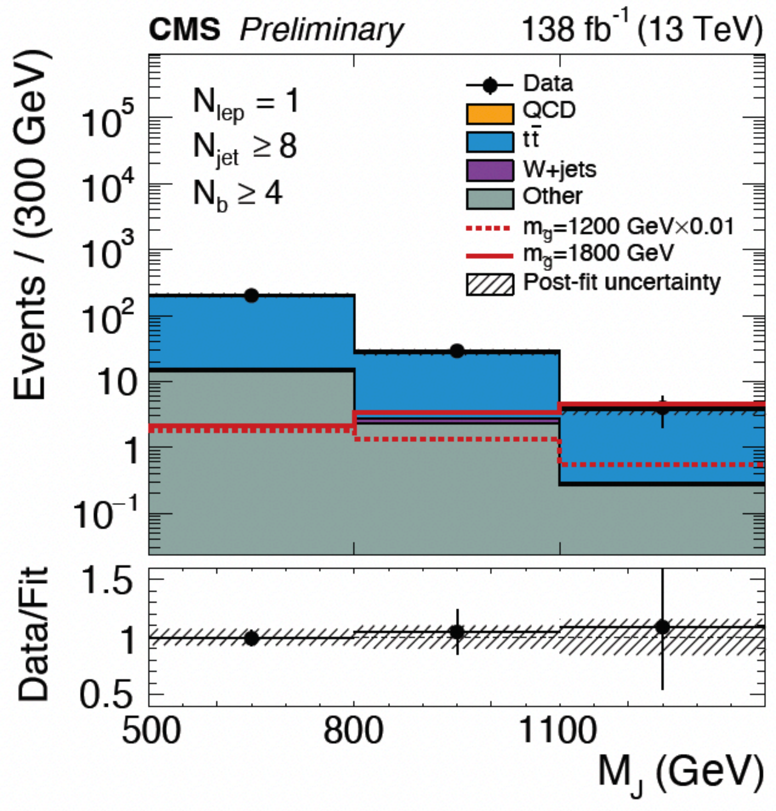
3 bj





≥ 4 bj



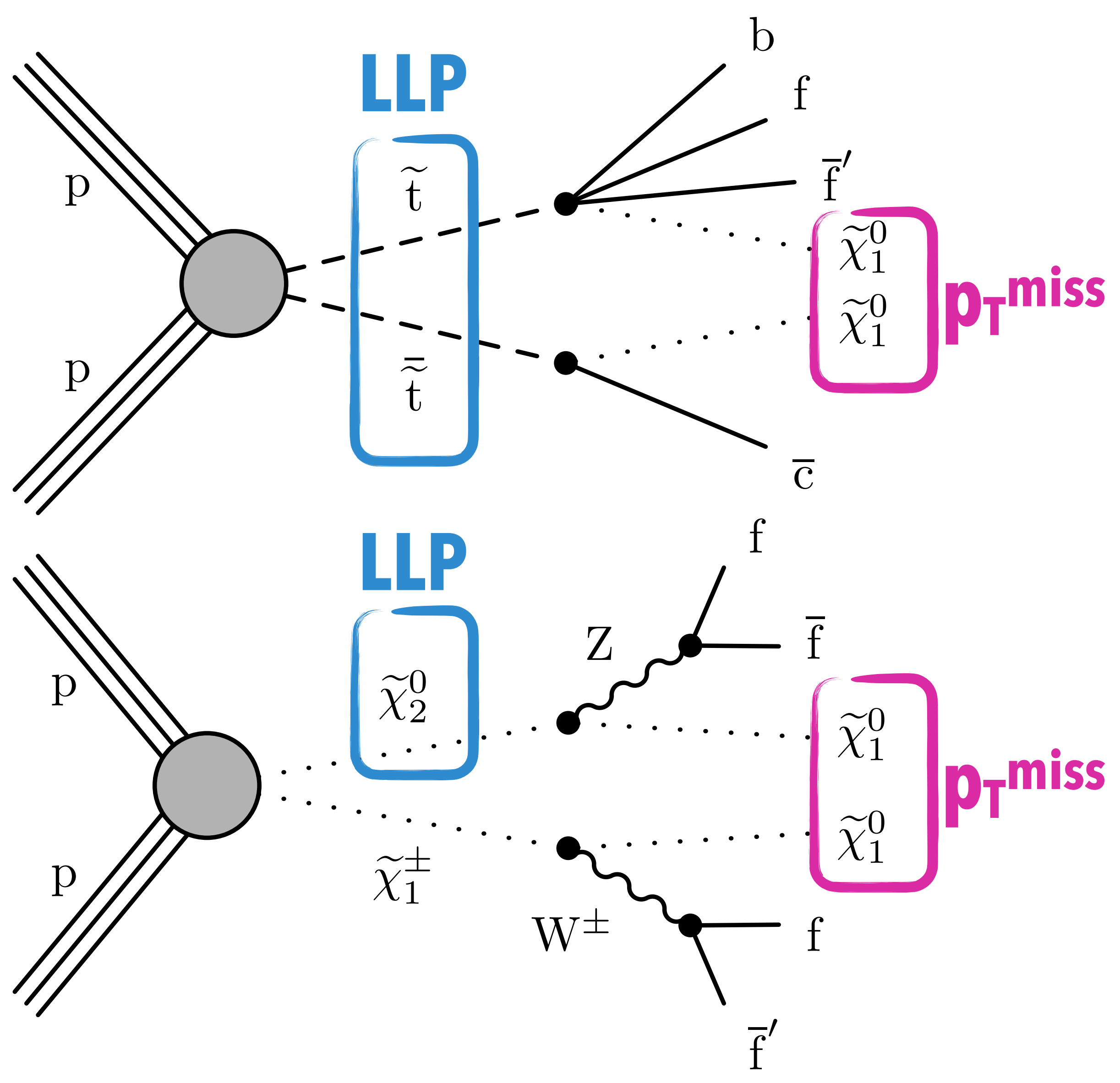


See Sezen's talk

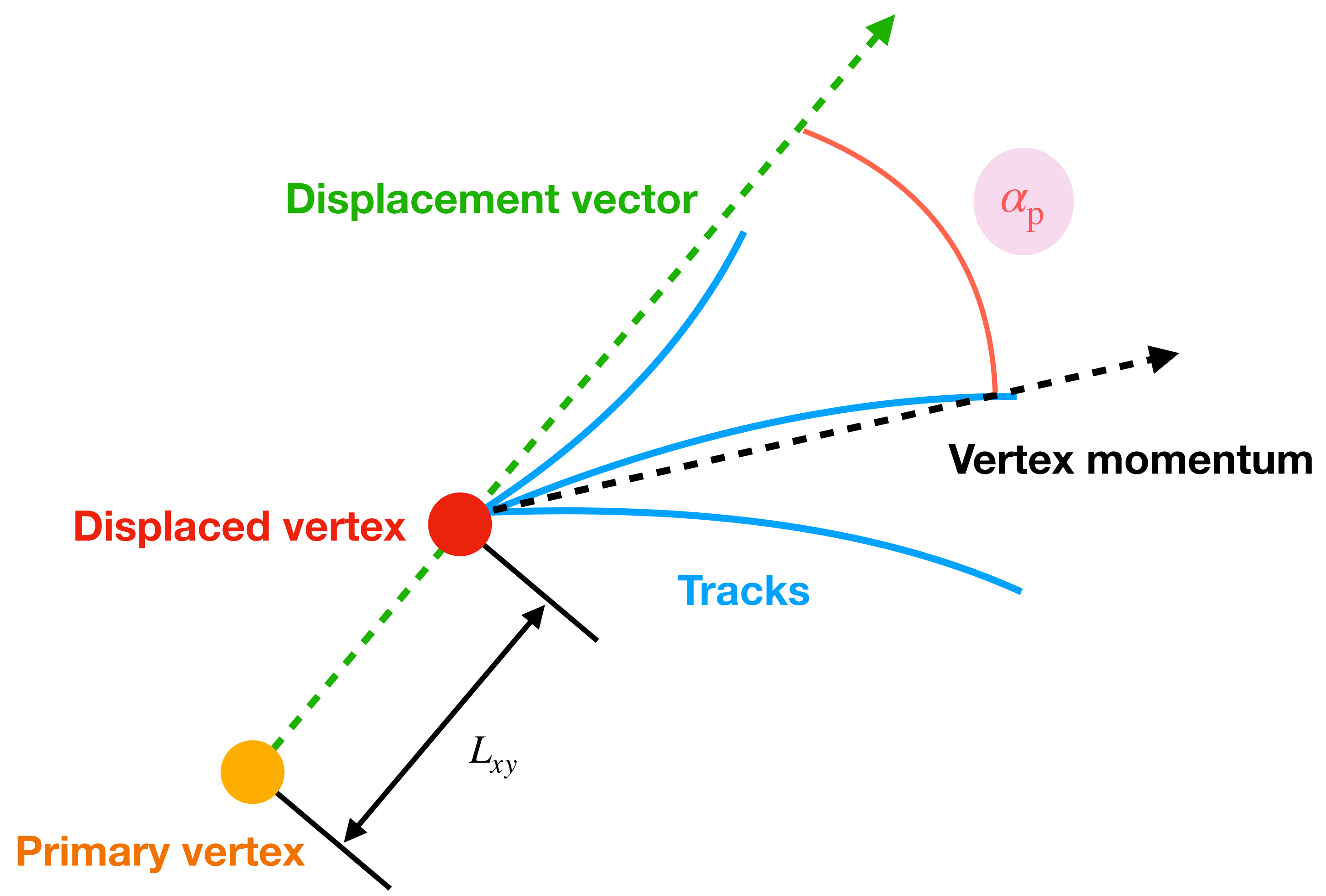
SUSY co-annihilation with LLP

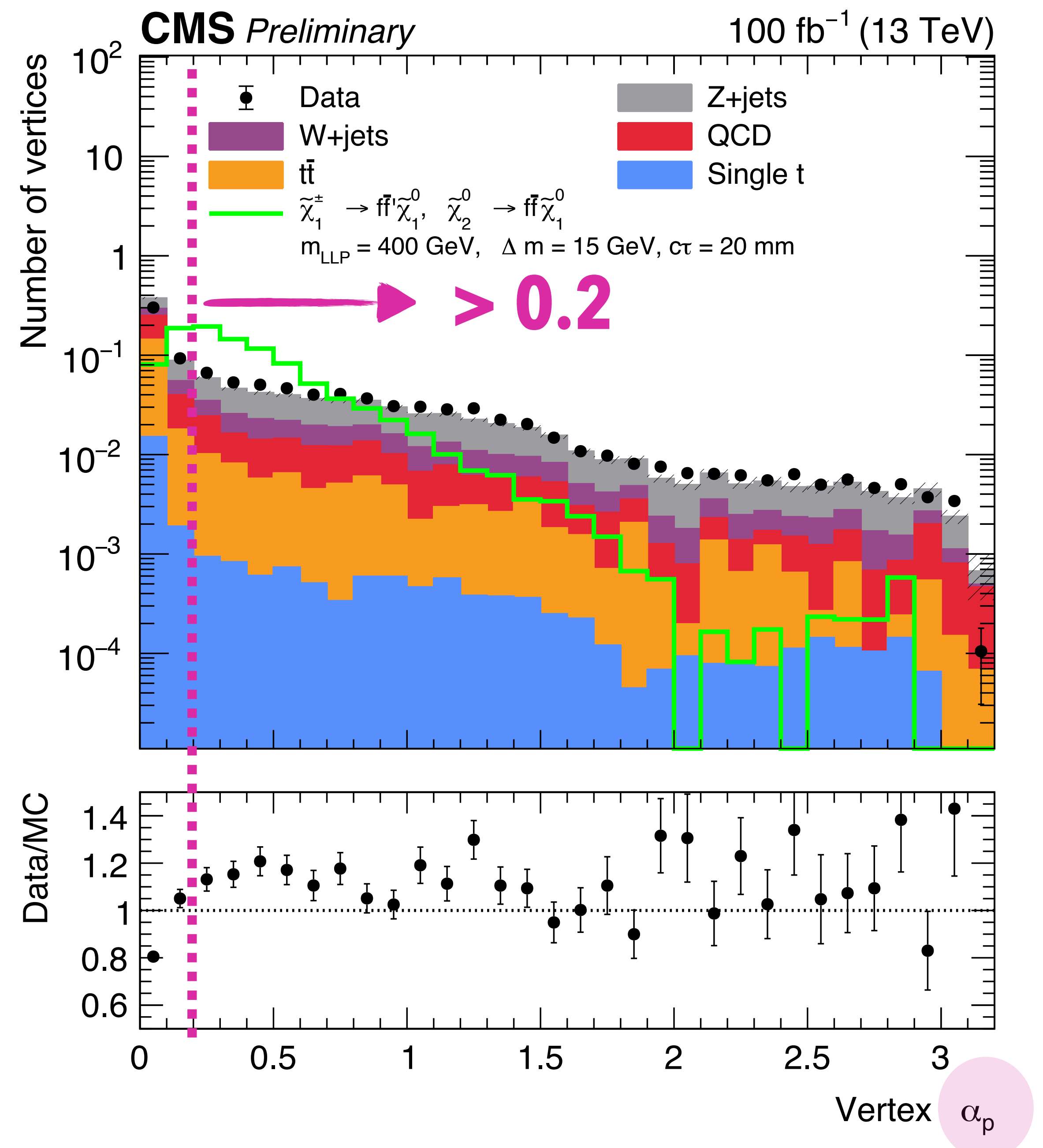
CMS-PAS-EXO-24-033

- Search for LLPs in signatures of **low-p_T displaced vertices**, p_T^{miss}, and an ISR jet
- Co-annihilation scenarios characterised by a **long-lived** next-to-lightest SUSY particle (NLSP) with a **mass difference of <u>less than 25 GeV</u>** relative to the lightest SUSY particle (LSP)
  - **Top squark scenario:** the **NLSP** is a **top squark**, while the LSP is a bino-like neutralino
  - **Bino-wino scenario:** the **NLSPs** are **long-lived wino** like neutralino and **prompt wino-like** chargino, and the LSP remains a bino-like neutralino
  - First LHC search sensitive to this regime!



- Reconstruct displaced vertices using a customised reconstruction algorithm



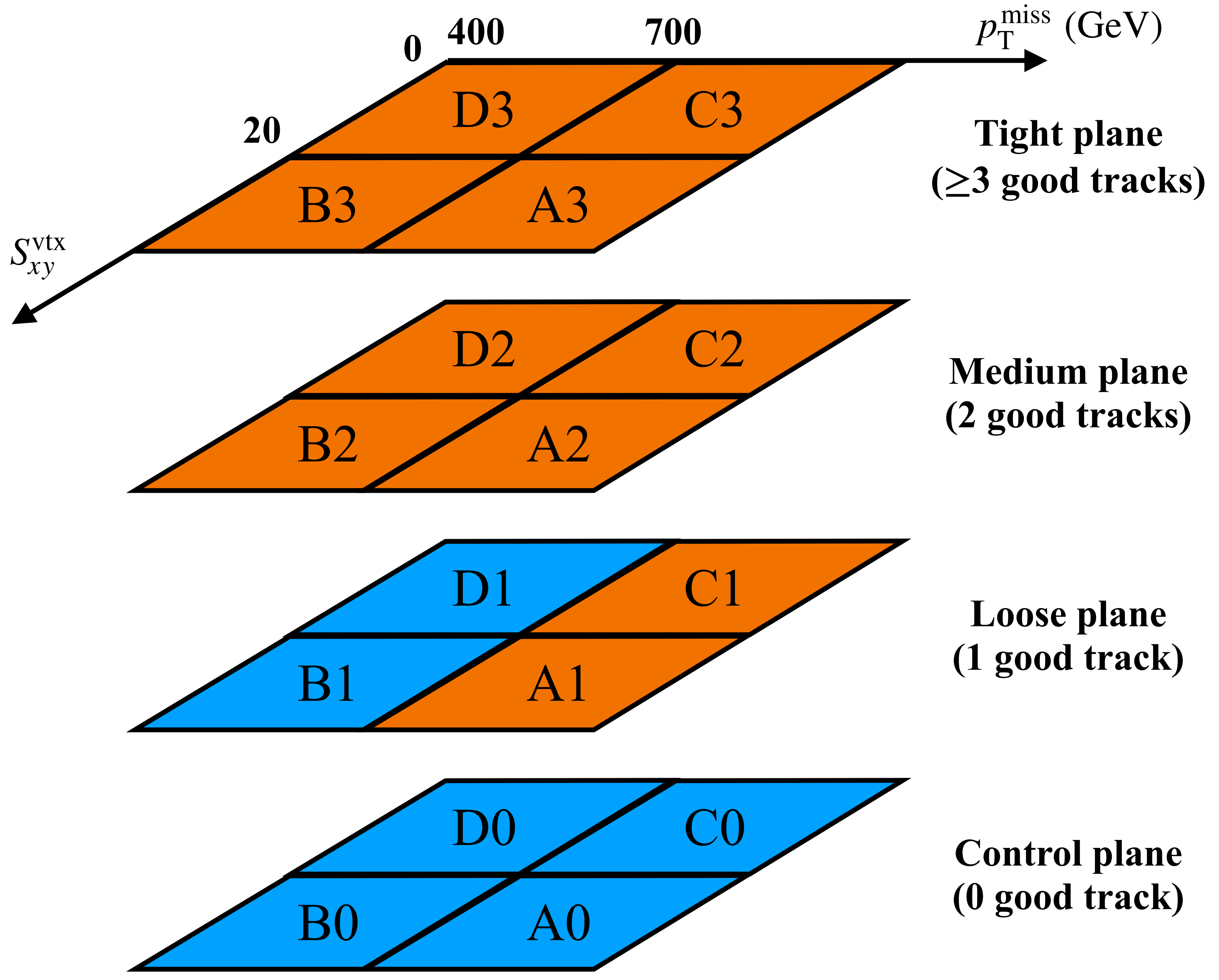


SUSY co-annihilation with LLP

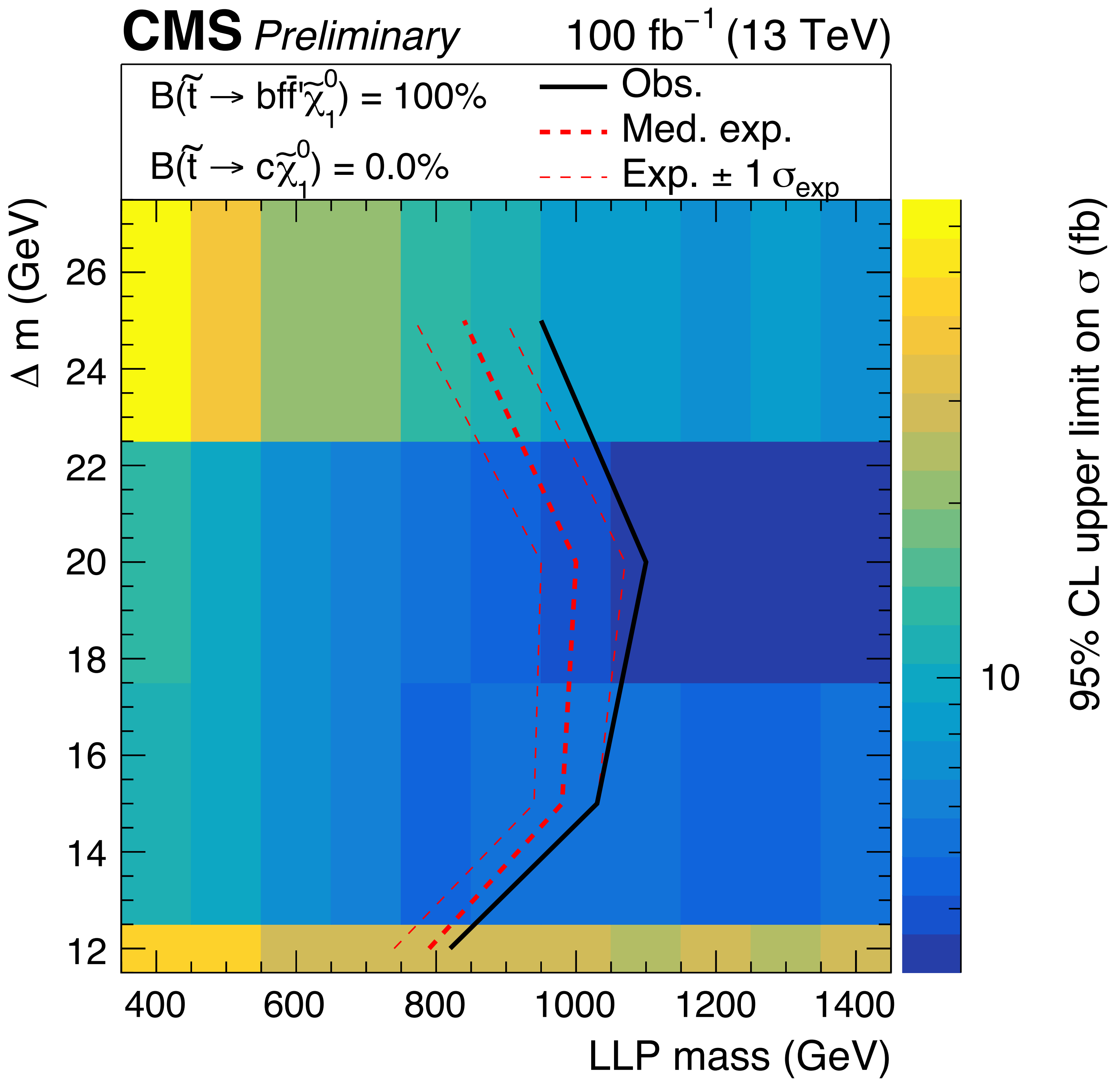
CMS-PAS-EXO-24-033

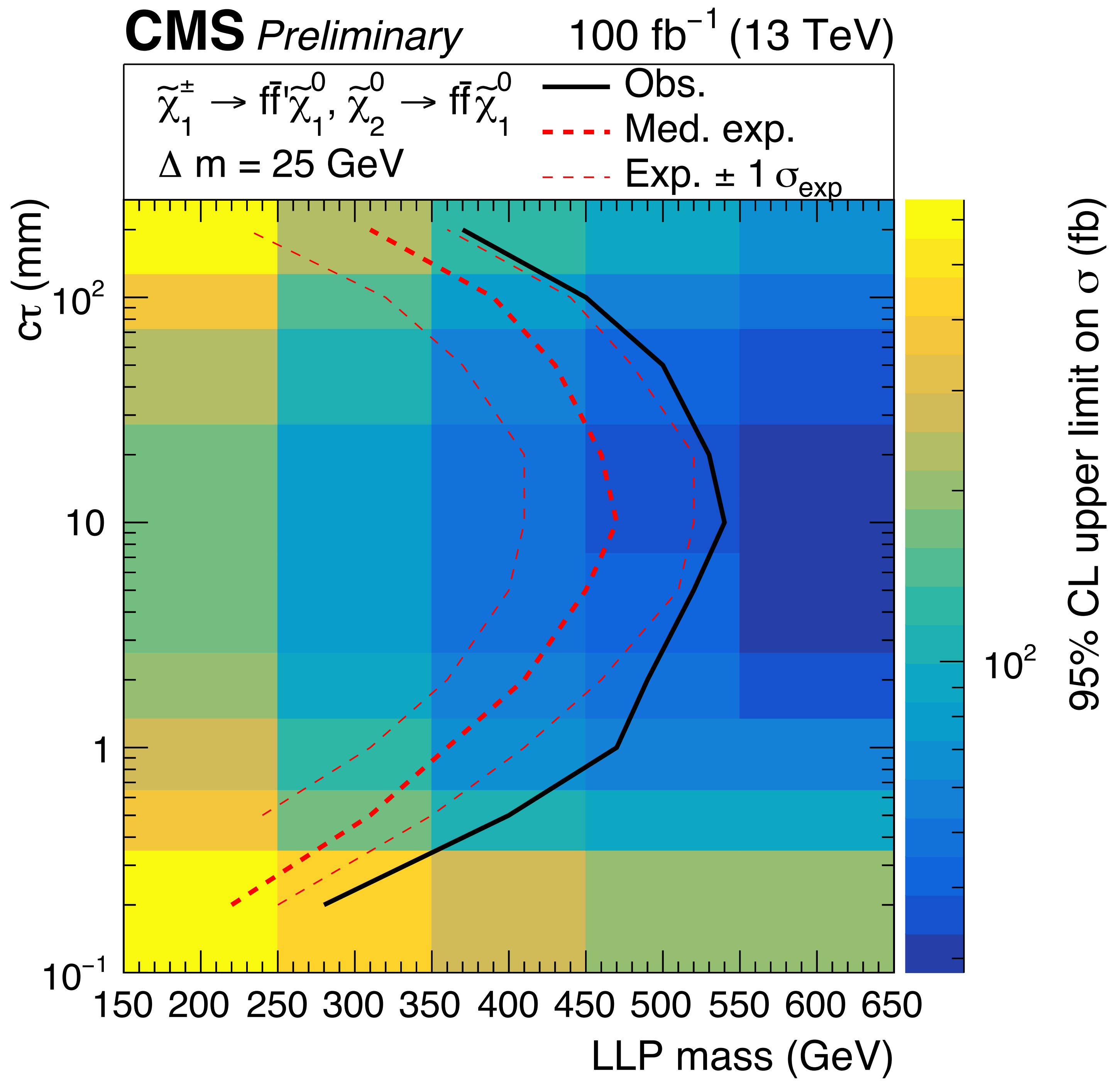
S_{xy}^{vtx} =
ratio between vertex L_{xy}
and its uncertainty

signal regions
control regions



- It excludes top squark masses less than 400–1100 GeV and wino-like neutralinos with masses less than 220–550 GeV, depending on signal parameters
  - Most stringent limits to date





See Eric's talk

BSM (in) Higgs

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exotics H decays
X→SH→bbγγ
X→YH→VV(4q)bb

-

Two-Higgs-doublet-model (2HDM)

- Extension of the electroweak Higgs sector by another scalar doublet
- Pheno contains a charged Higgs, a pseudoscalar and two neutral scalars, flavour-changing neutral currents, and more possibilities for CP violation and baryogenesis

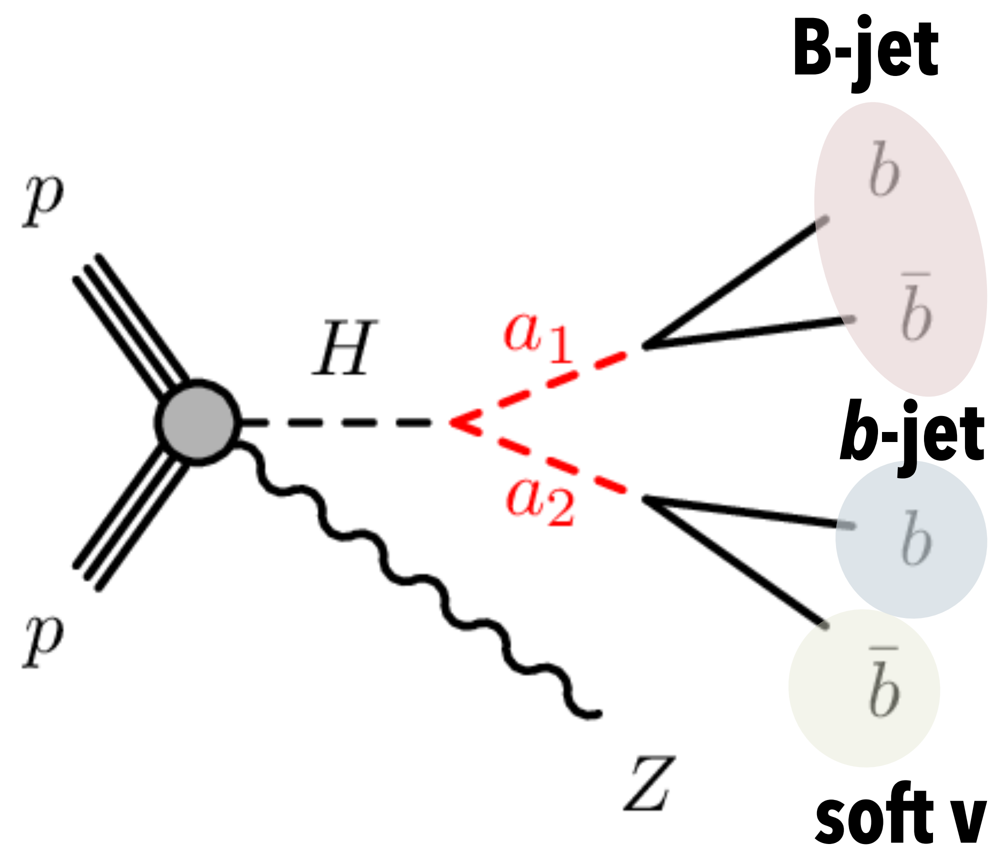
Exotic Higgs decays

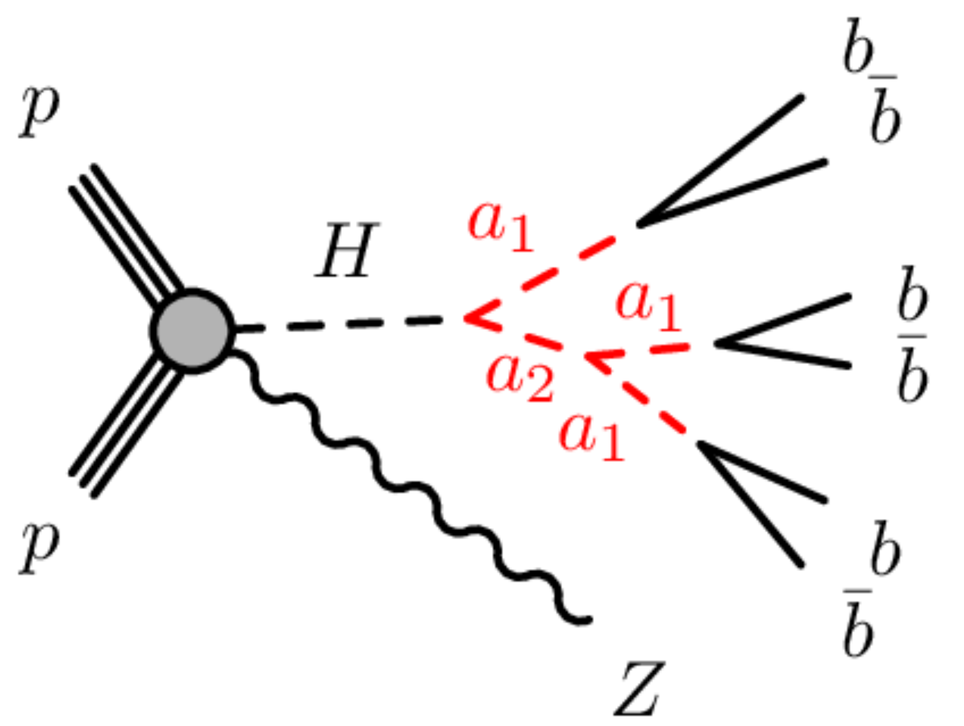
- Higgs boson decays are particularly sensitive to new physics due to the small total width
- Models predicting new light scalar(s) can lead to exotic Higgs decays, e.g.: $H \rightarrow a_1 a_2 \rightarrow 4b$ **or** $H \rightarrow a_1 a_2 \rightarrow a_1 a_1 a_1 \rightarrow 6b$

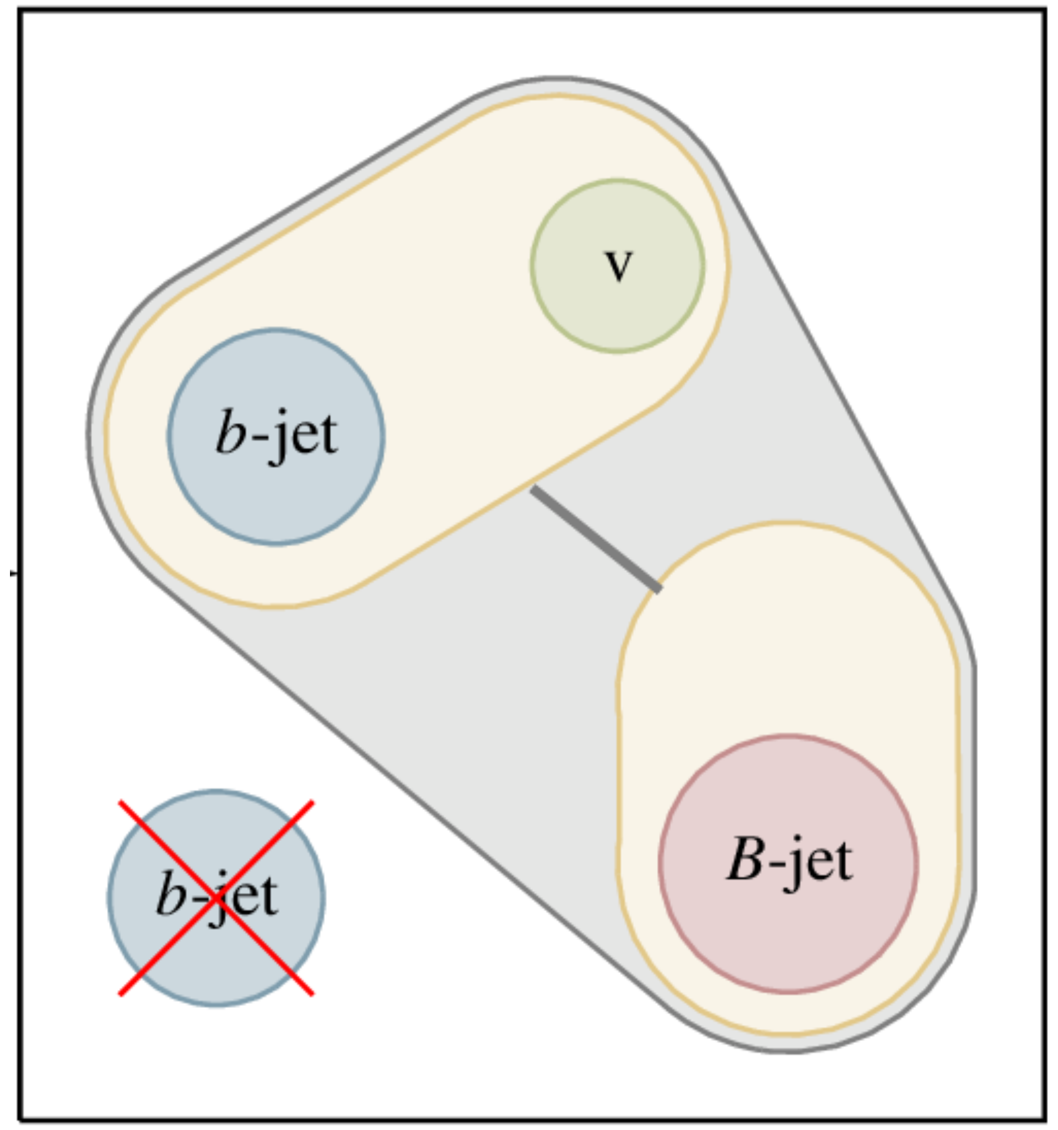
ZH ($H \to aa \to 4b/6b$)

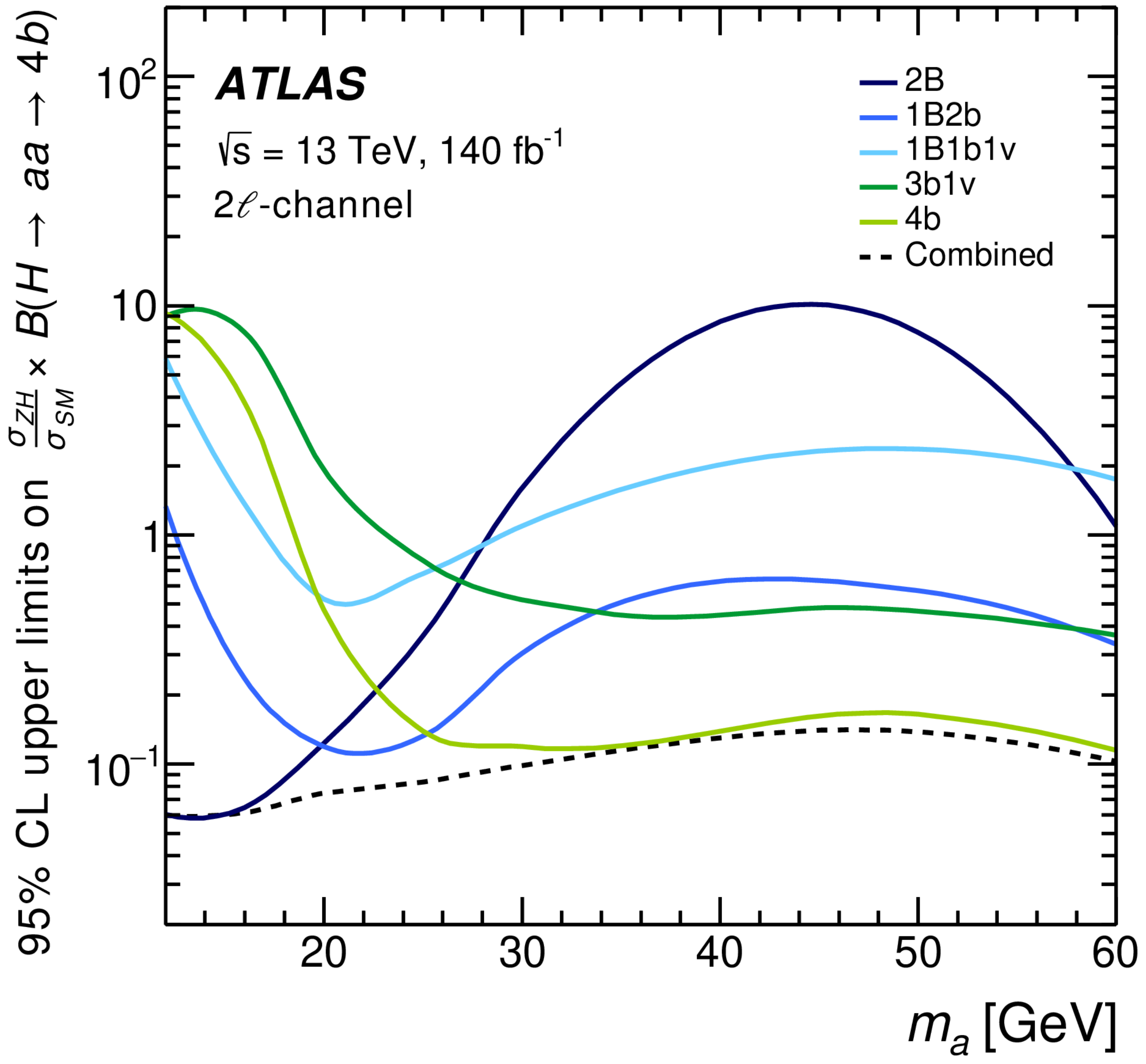
CERN-EP-2025-121, submitted to PRD

- Searches for exotic Higgs decays to new light pseudoscalar *"a"*
  - $b\bar{b}$ dominant decay mode
- Target ZH production, with:
  - **Z→ℓℓ** (2ℓ, leptonic triggered)
    - **2ℓ4b** and **2ℓ6b:** BDT for S-vs-B in each SR
  - **Z→νν** (0ℓ, E_T^{miss} triggered)
- Using **two ATLAS b-taggers:** covers merged (B), intermediate, and resolved (b) regimes
- Additionally, use of **soft secondary vertices** reconstructed outside of jets (v)





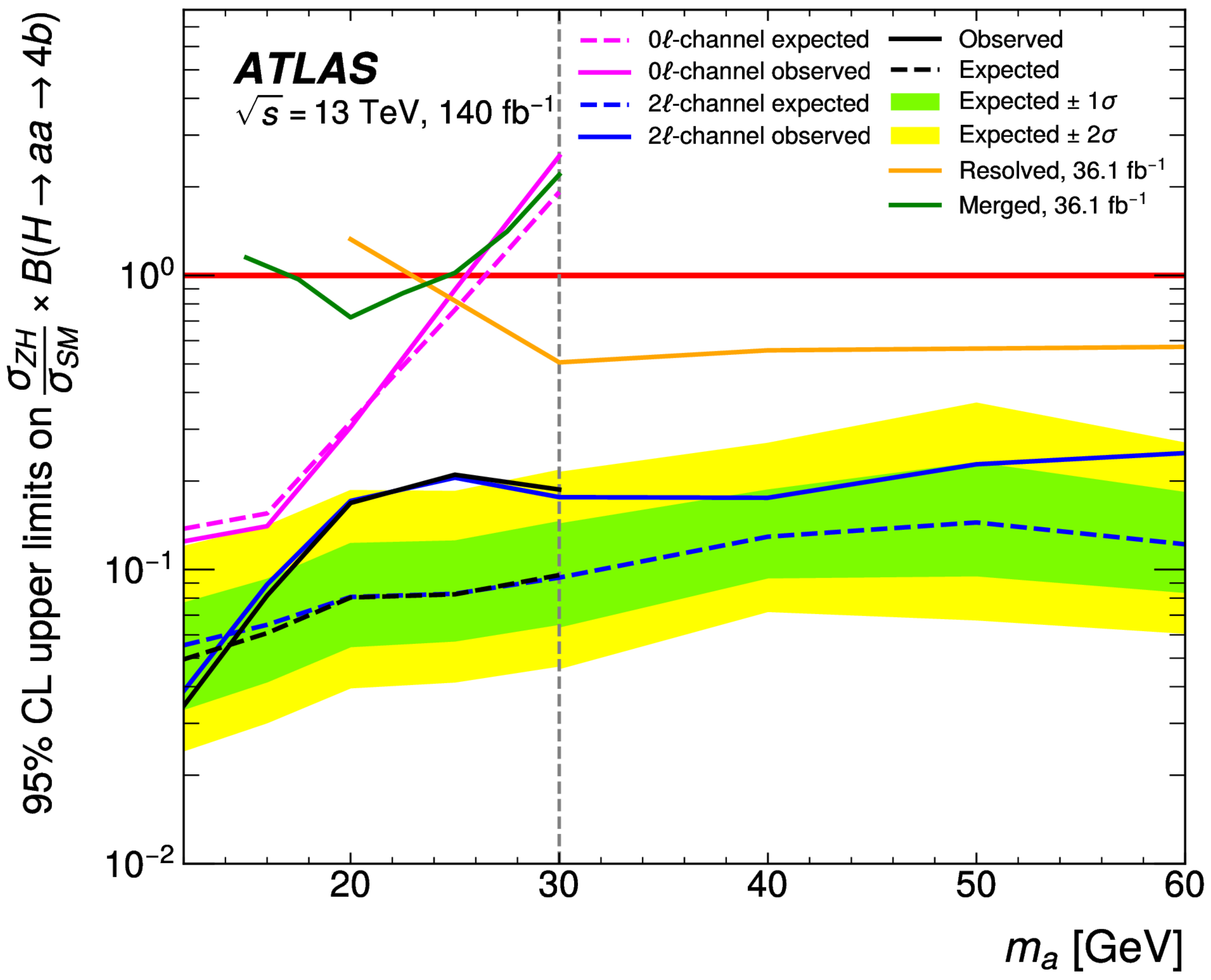


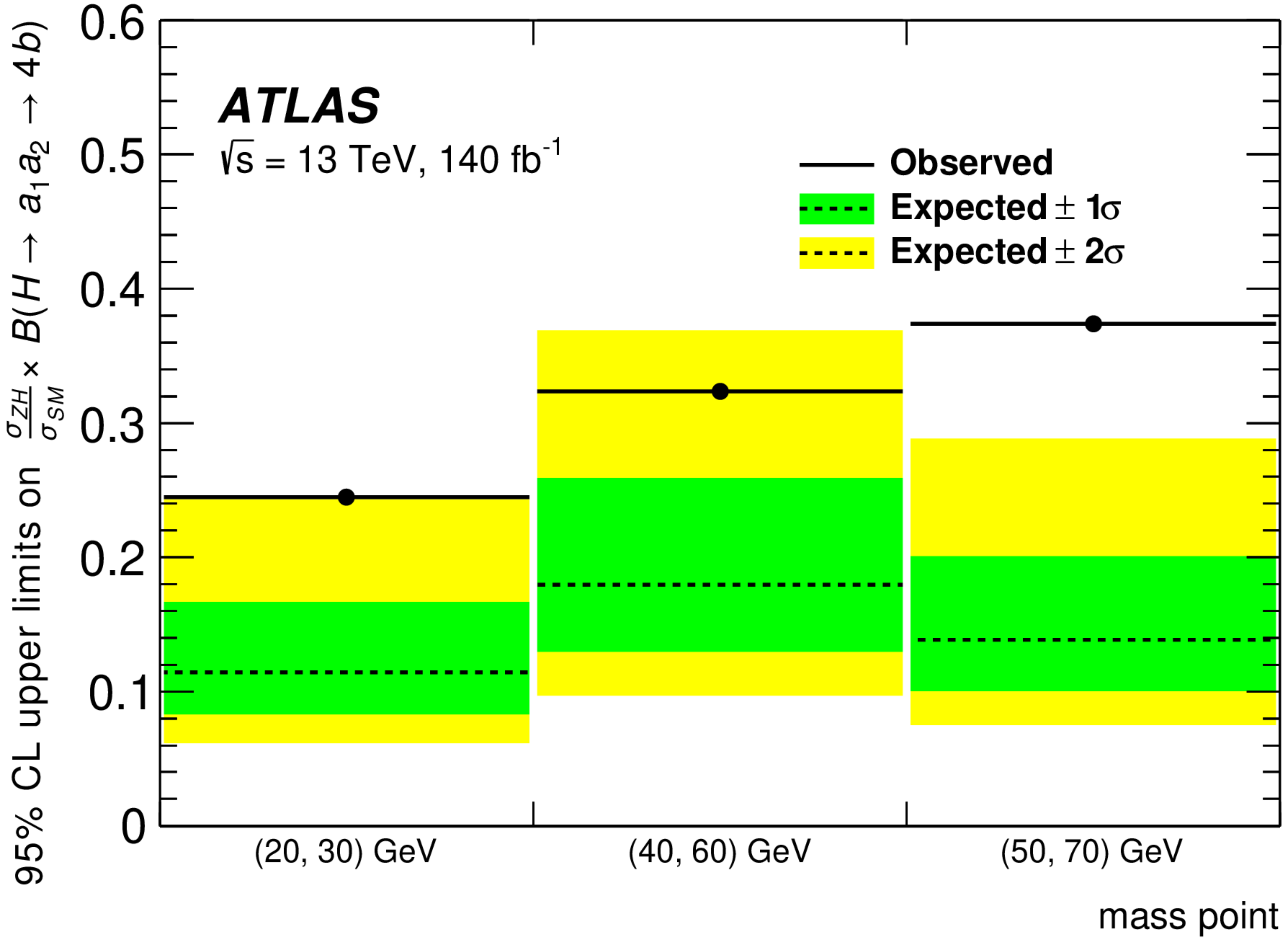


ZH (H → aa → 4b/6b)

CERN-EP-2025-121, submitted to PRD

- Most stringent limits of this model to date
- First search to consider two additional scalars with different masses, including a cascade decay to 6b, and to consider the Z→$\nu\nu$ channel
- Largest deviations in 4b regions in the 2ℓ channel, with local (global) significance of **2.83 (2.04) σ** for m_a= 25 GeV and **3.28 (2.57) σ** for (m_{a1} ,m_{a2}) = (50, 70) GeV

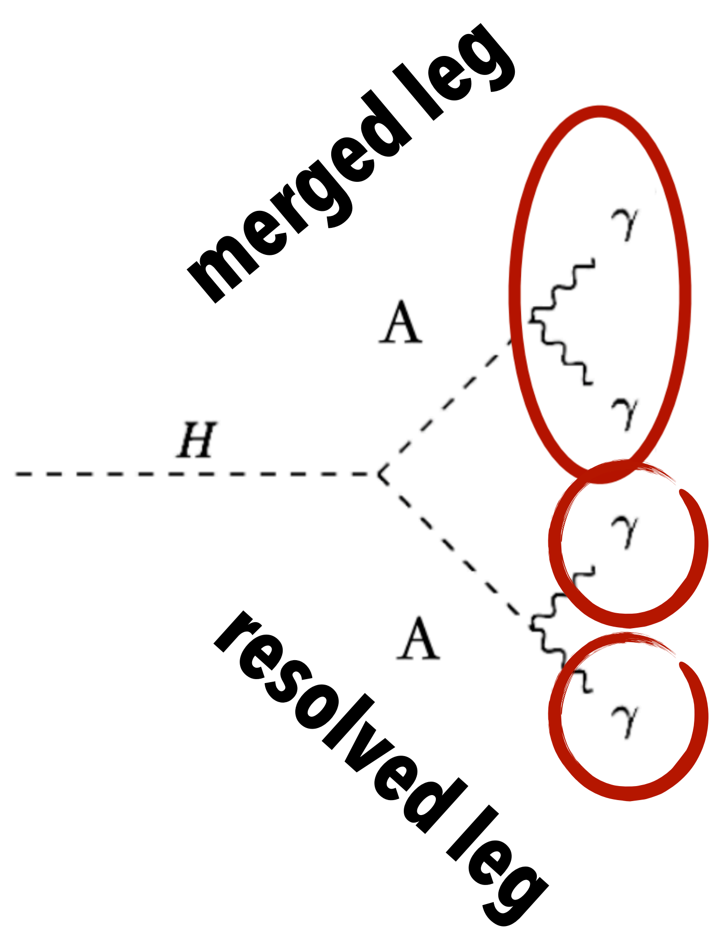


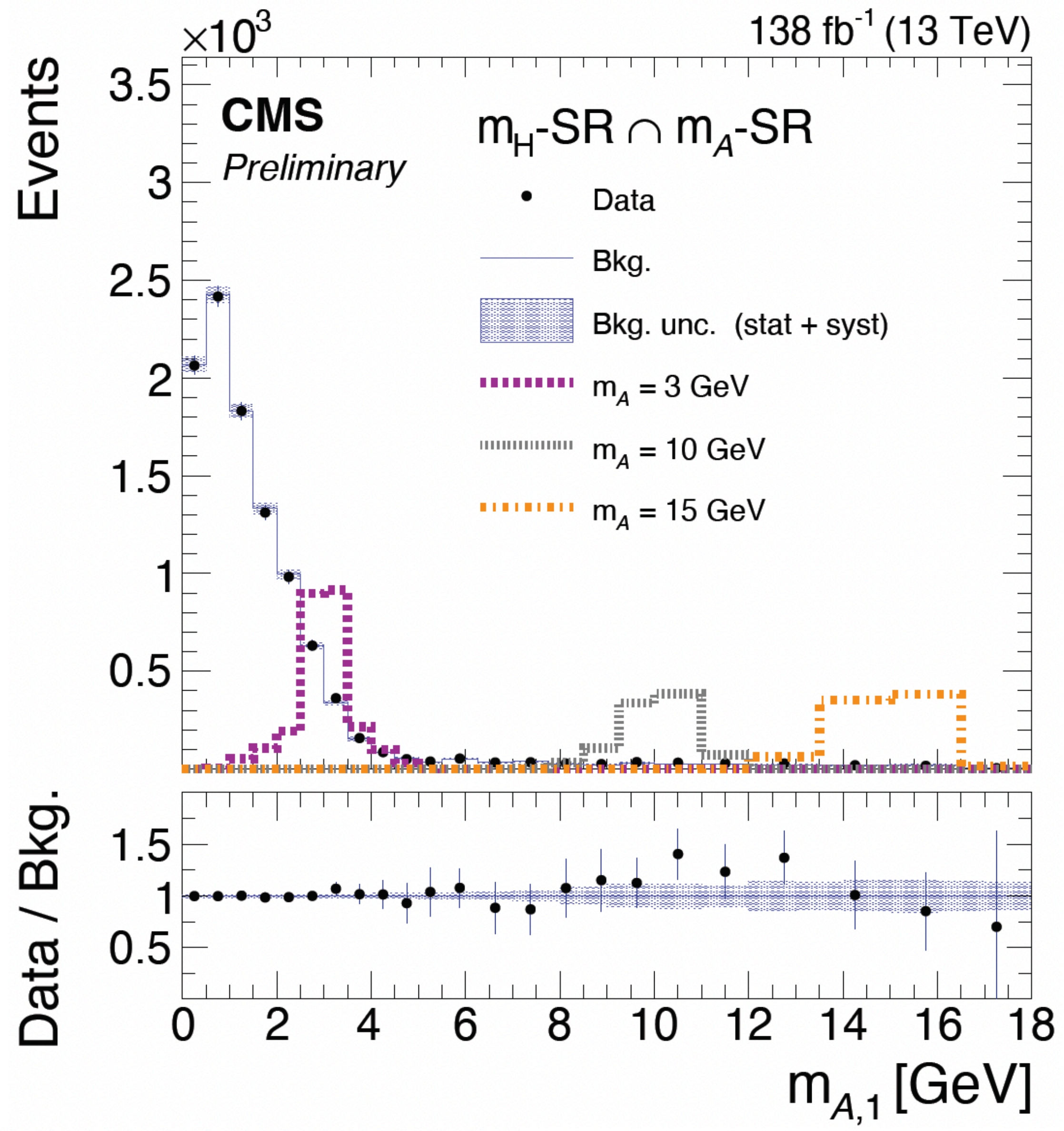


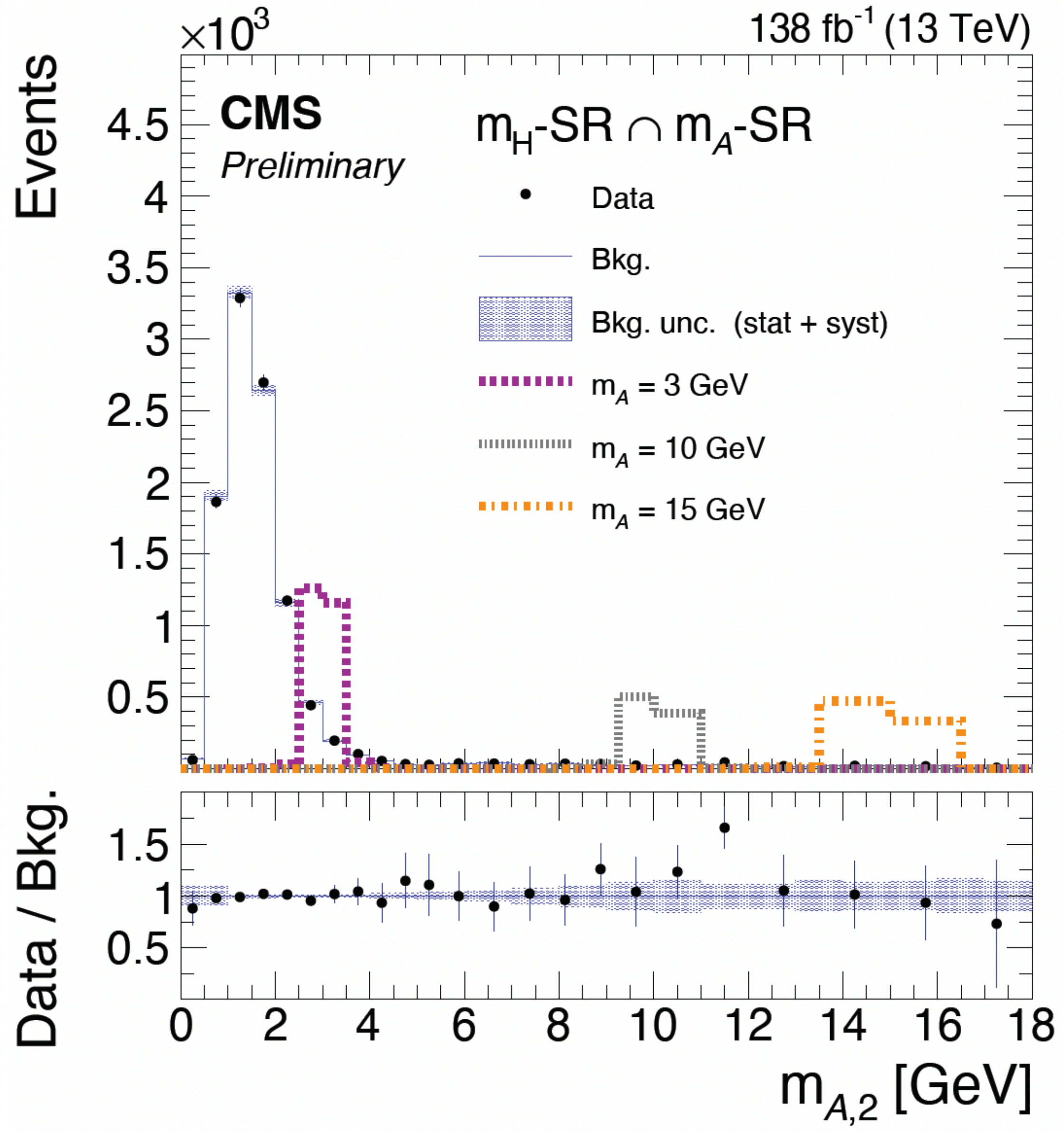
See Judith's talk

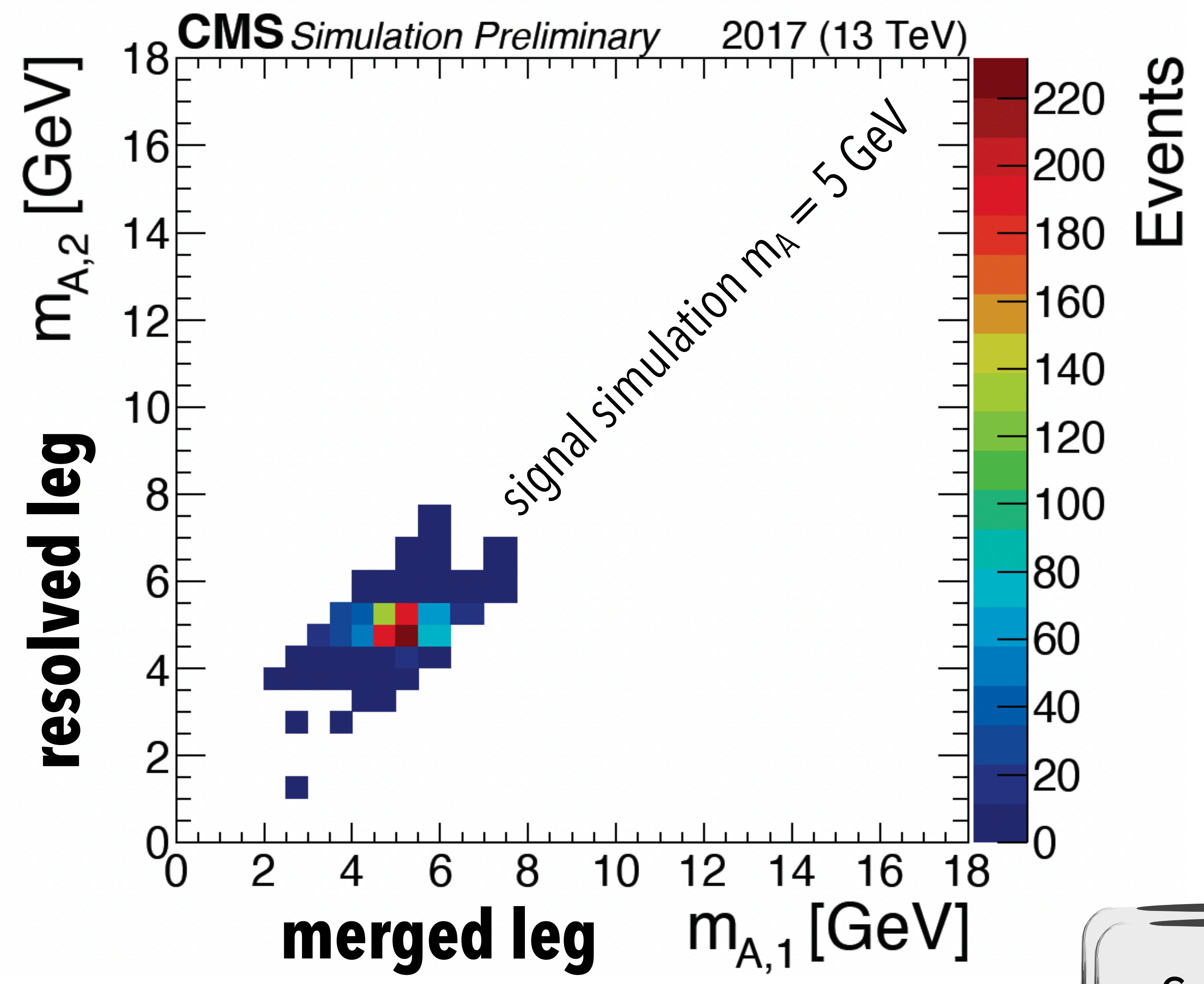
H → AA → 4γ

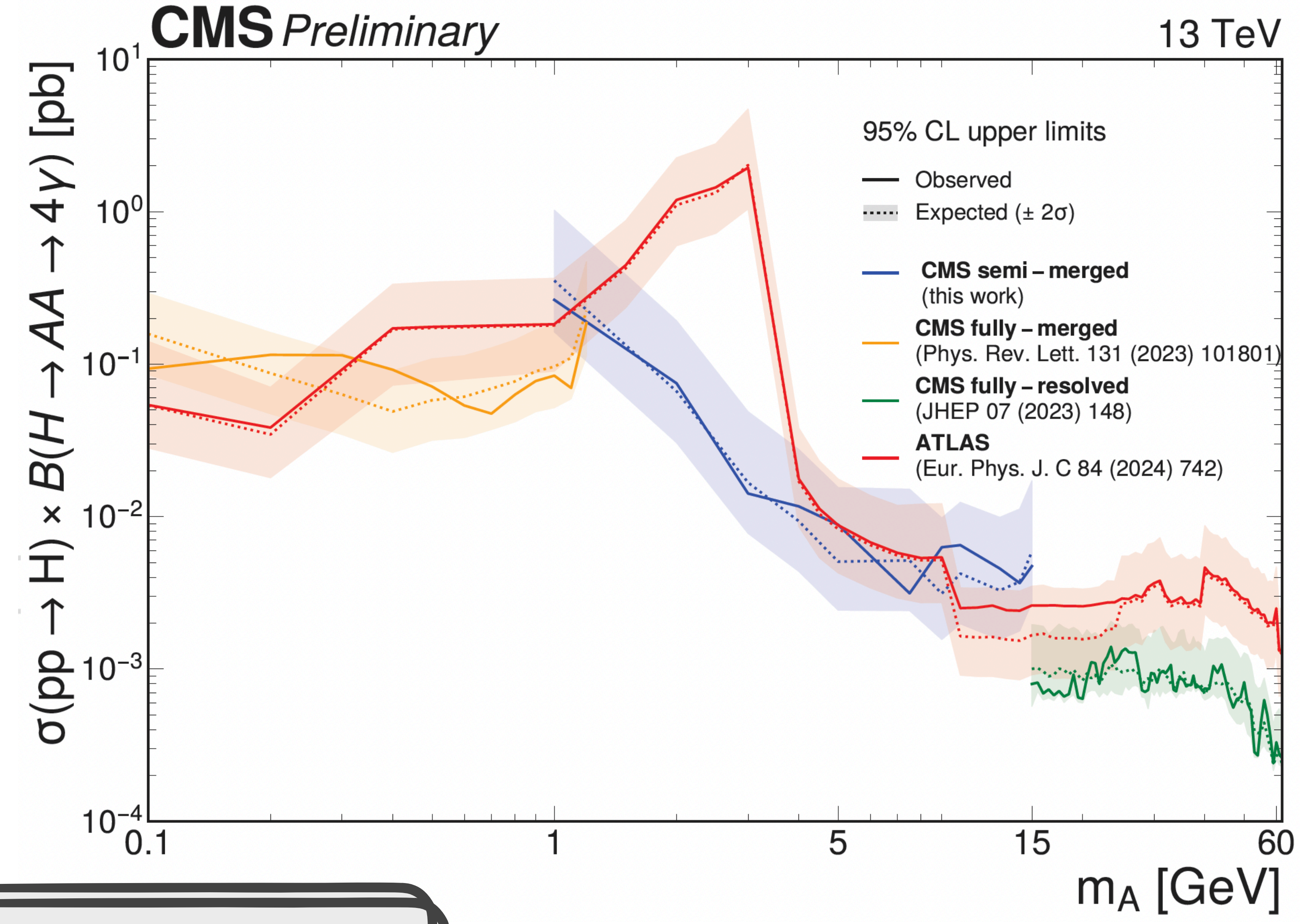
- Search for exotic Higgs decay to a pair of light pseudo-scalars H → AA with A → γγ
- Focus on **three photon-like** objects in the final state, to bridge the gap in the **$1 < m_A < 15$ GeV** mass range
- Novel deep-learning-based **mass reconstruction technique** developed: reconstructs m_A from pattern of energy deposits in ECAL crystals
- Signal and sideband regions defined along two axes:
  - Tri-photon mass $m_{\gamma\gamma\gamma}$ axis
  - 2D-m_A template axis
- Most stringent limits to date in the majority of the mass range explored









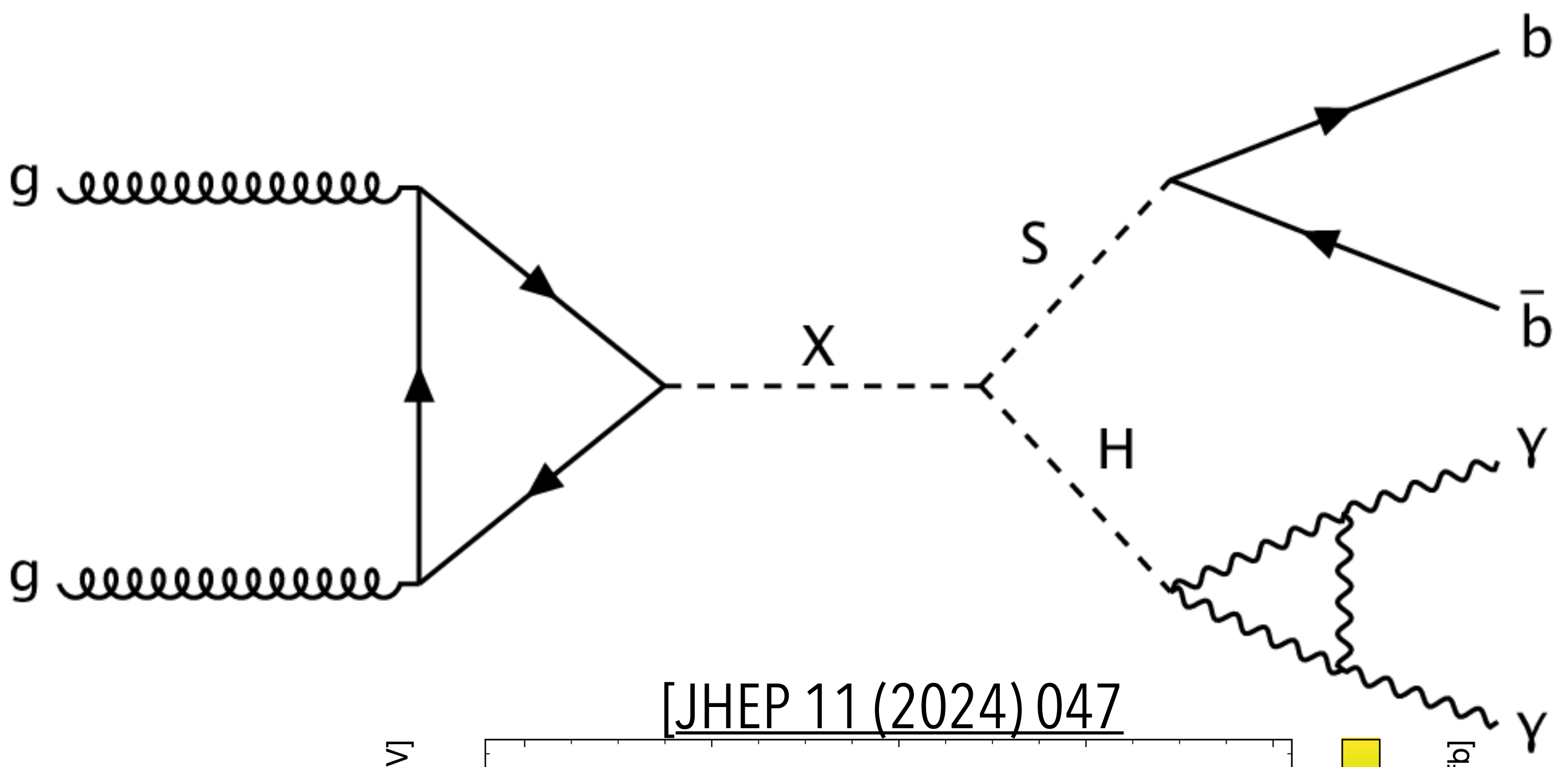


See Abhirami's talk

X➔SH➔bbɣɣ

ATLAS-CONF-2025-009

ATLAS EXPERIMENT

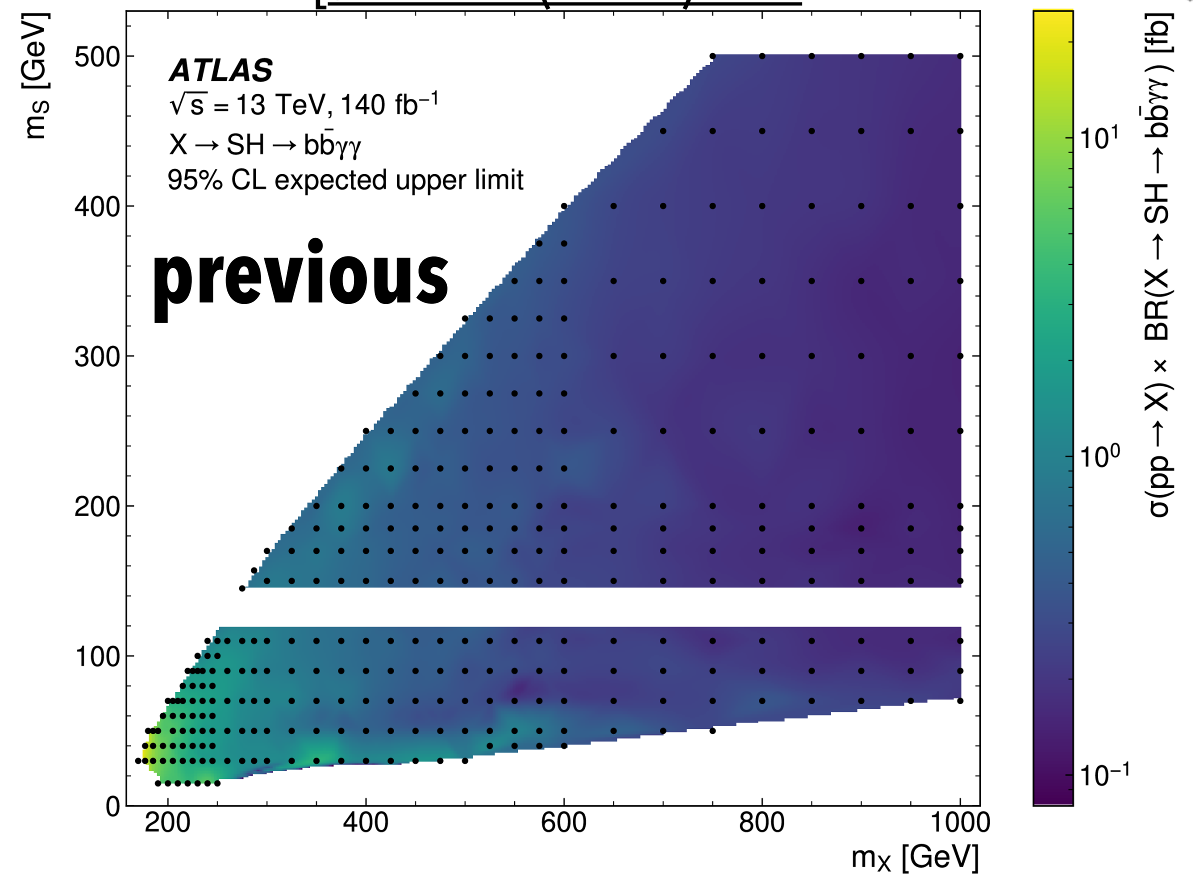


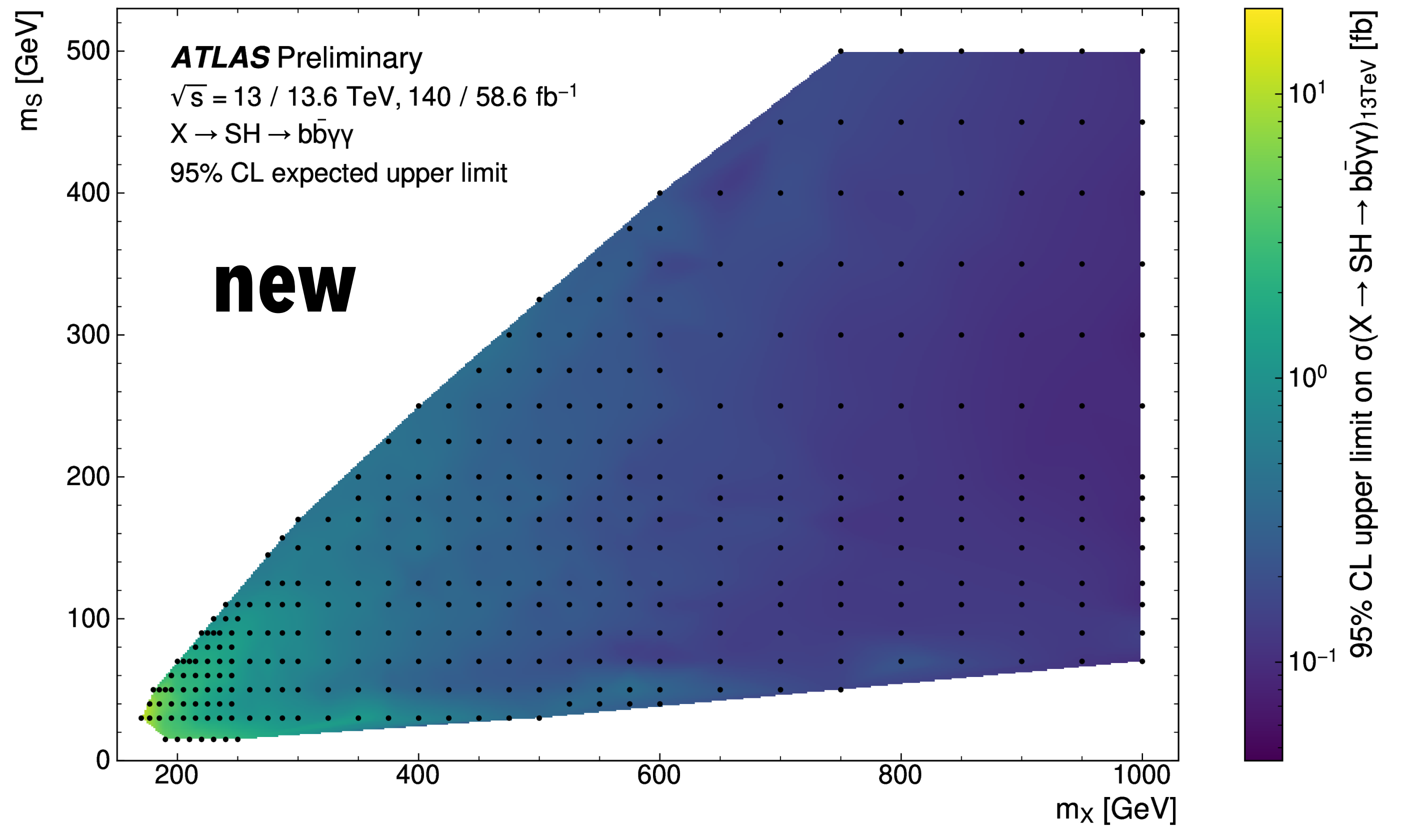
- Search for the resonant production of a heavy scalar X decaying into a SM Higgs boson and a lighter scalar S through X➔SH➔bbɣɣ
- Using Run 2 (140 fb^{-1}) + partial Run 3 (58.6 fb^{-1}) datasets
- Main backgrounds: continuum di-ɣ non-resonant production and Higgs processes with H➔ɣɣ

- Main updates wrt. previous results:
  - Changing from DL1r to **GN2 b-tagger**
  - **$m_{\gamma\gamma}$ requirement** changed from 120–130 GeV to 122.5–127.5 GeV

- Two SRs based on the number of b-tagged jets, using PNNs
- Expected limits on $\sigma_{13\ \mathrm{TeV}}$ are 15% to 73% lower than previous result (largest improvements on low-mass region)
- Inclusion of early Run 3 dataset improves sensitivity by 9-30%

[JHEP 11 (2024) 047

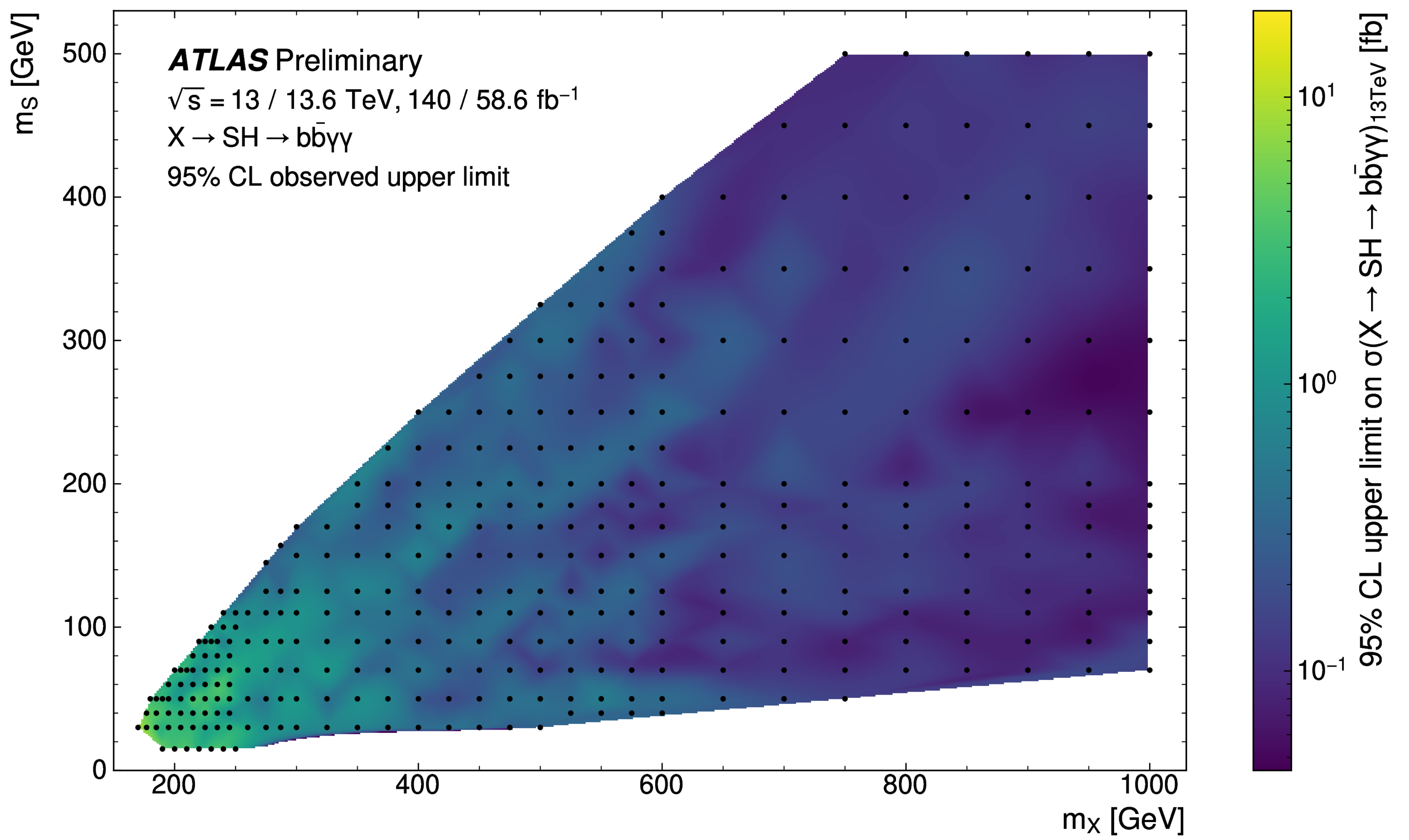




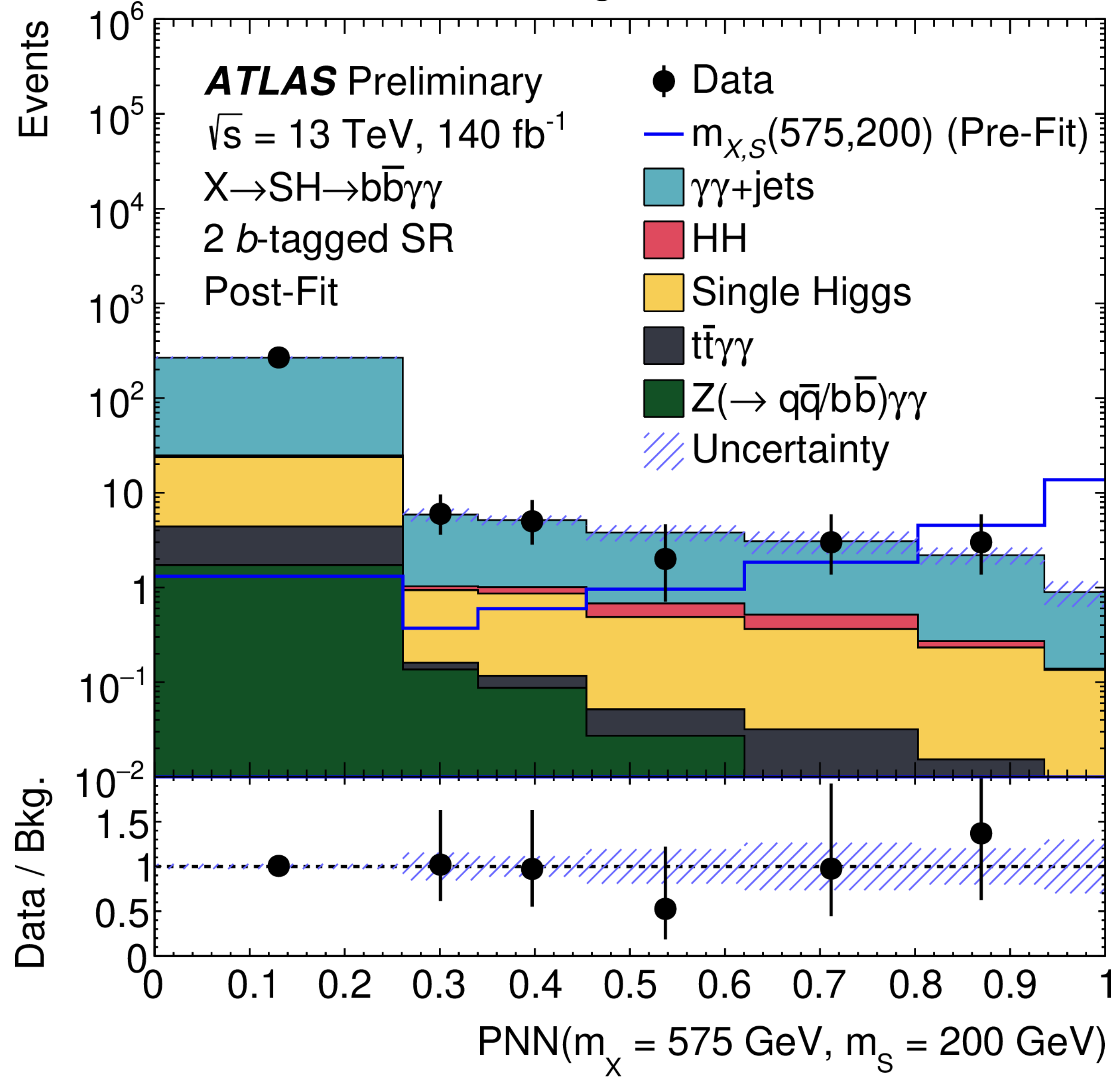
X→SH→bbγγ

ATLAS-CONF-2025-009

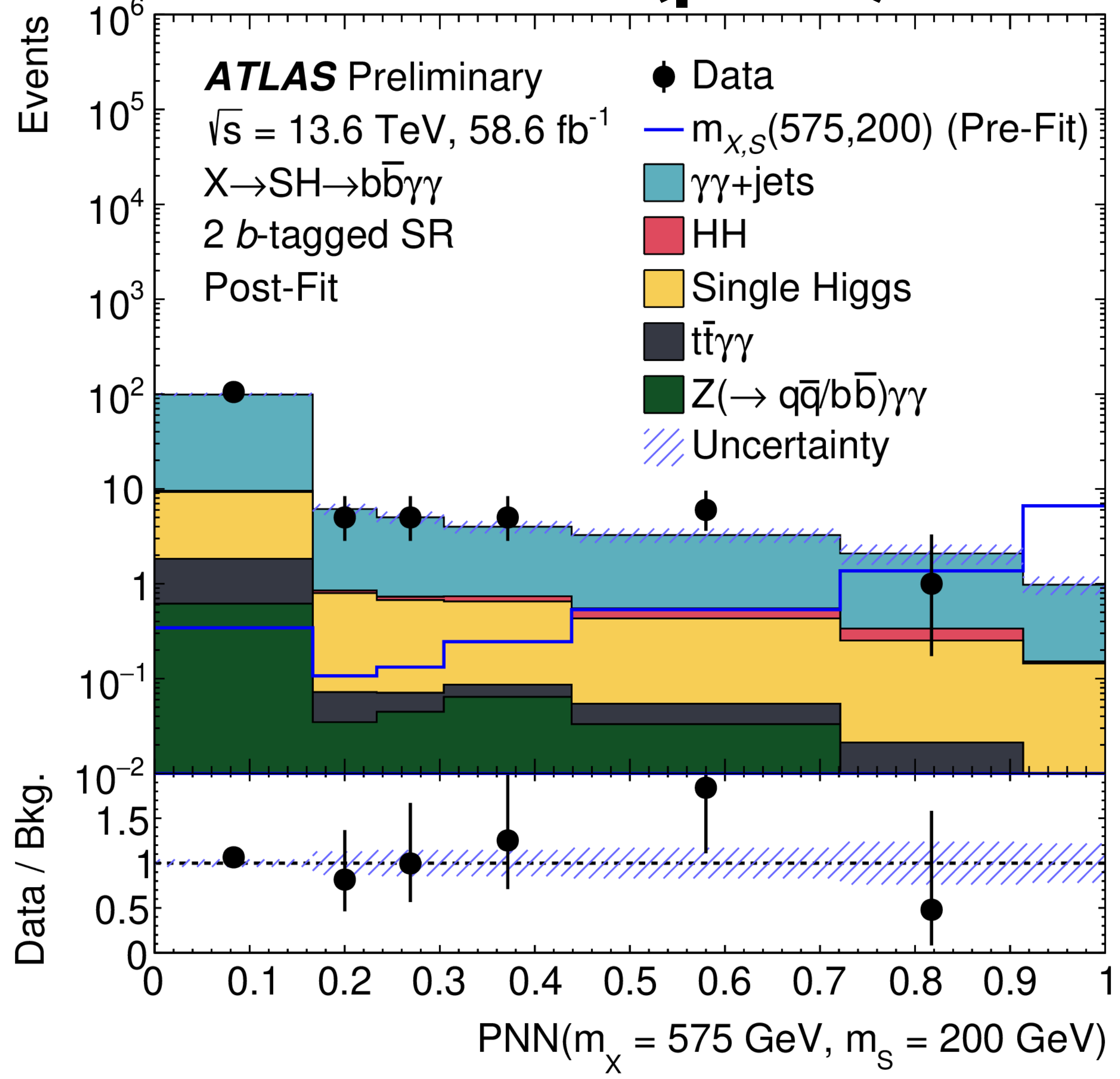
- Largest deviation from the B-only hypothesis from previous results:
  - ATLAS [JHEP 11 (2024) 047]: $(m_X, m_S) = (575, 200)$ GeV with a local (global) significance of 3.5 (2.0) σ
  - CMS [JHEP 05 (2024) 316]: $(m_X, m_S) = (650, 90)$ GeV with a local (global) significance of 3.8 (2.8) σ
- No similar deviation as previous ATLAS result, neither in Run 2 nor Run 2 + Run 3



Run 2

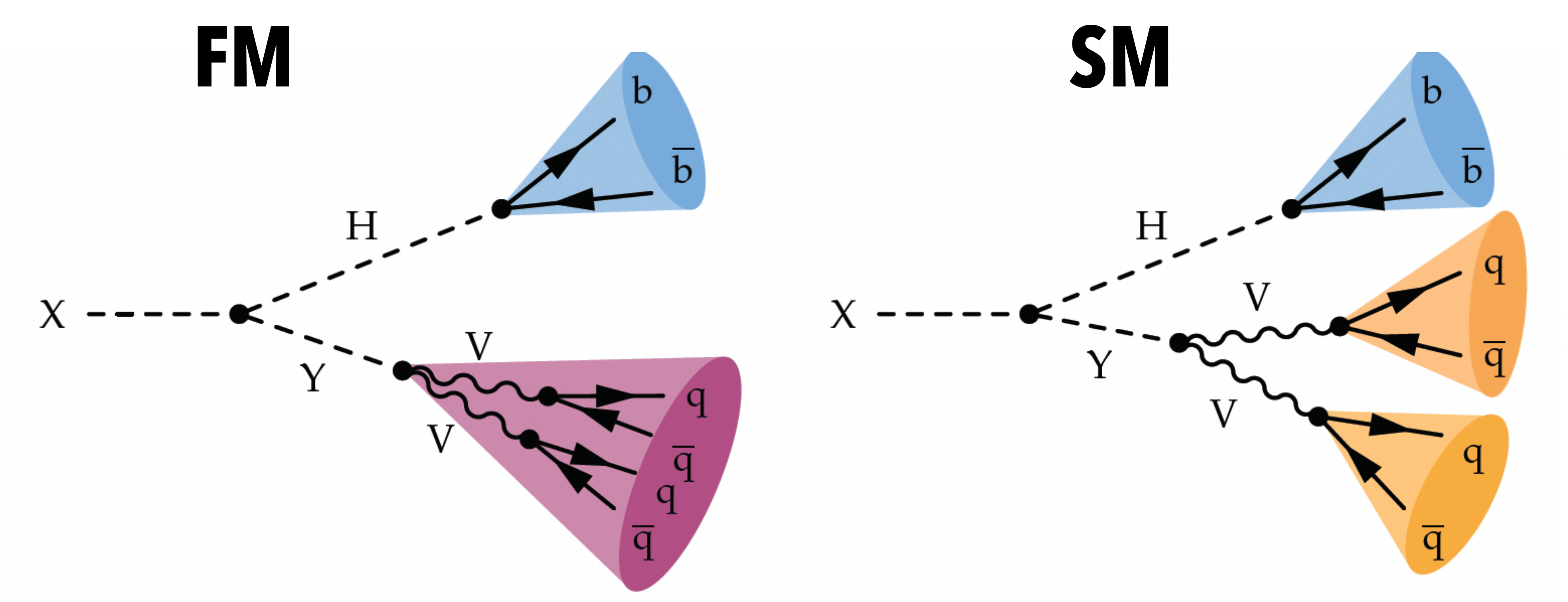


Run 3 (partial)

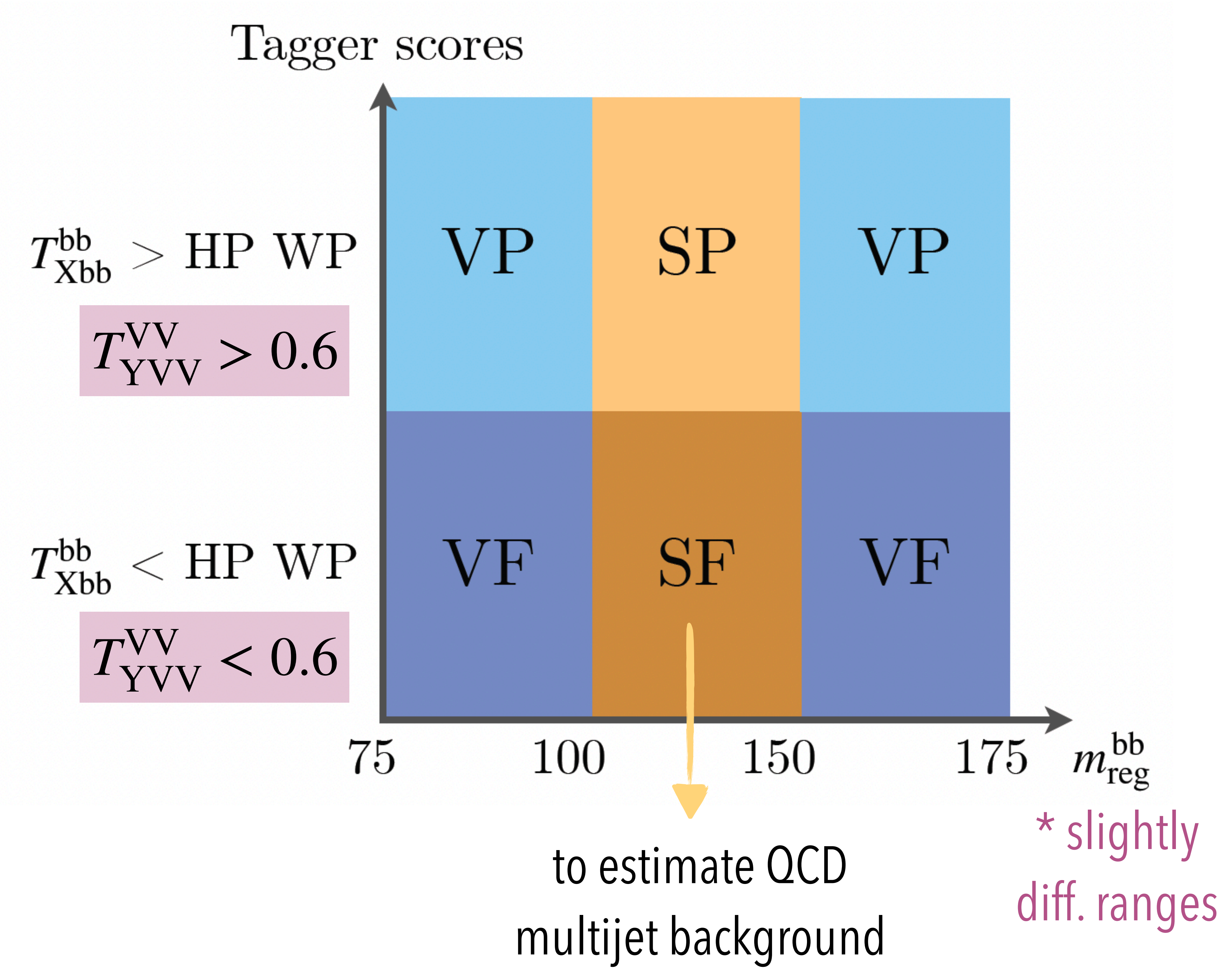


See Yanlin's talk

X→YH→VV(4q)bb



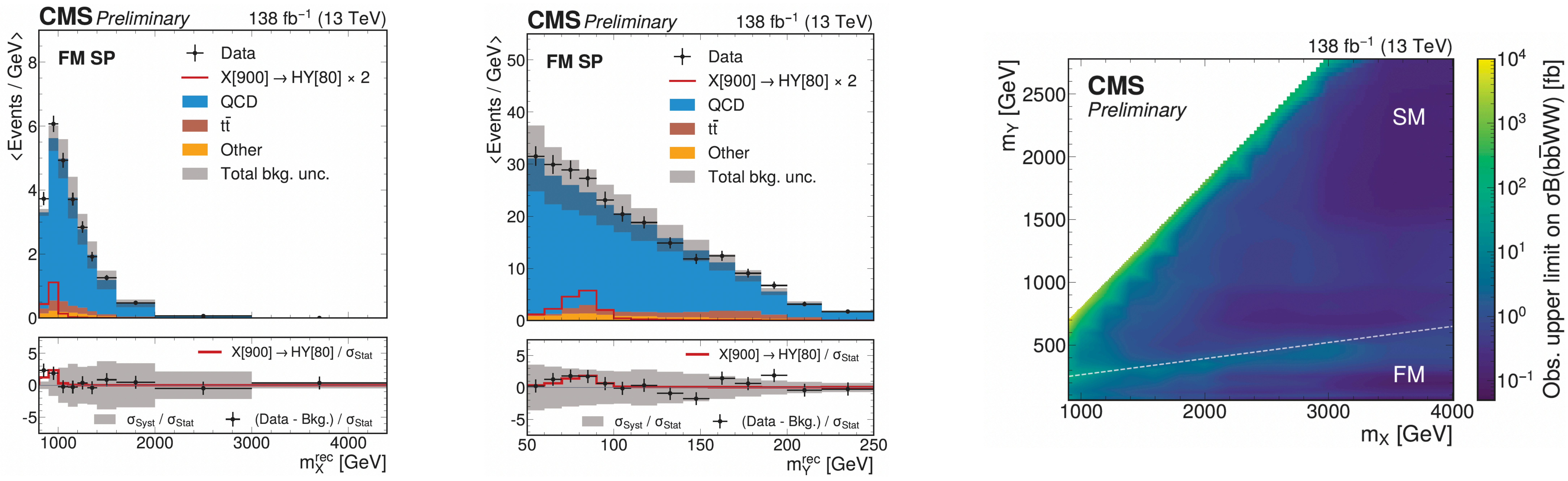
- First search at the LHC for scalar resonances in all-hadronic bbVV final state and asymmetric cascade decays in the bbVV final state
- Lorentz-boosted regime: H→bb̄ decay can be reconstructed as a single large-area jet, and Y→VV→4q as one Y→4q **("fully-merged", or FM)** or two V→qq̄ jets **("semi-merged", or SM)**
- Events selected with H_T and large-area jet triggers
- Machine-learning-based **jet identification** and **mass reconstruction** algorithms:
  - Novel attention-based **"particle transformer"** for Y→4q discrimination
- 2D binned maximum likelihood fit performed to the observed m_X^{rec} and m_Y^{rec} distributions, simultaneously in fail **(F)** and pass **(P)** regions



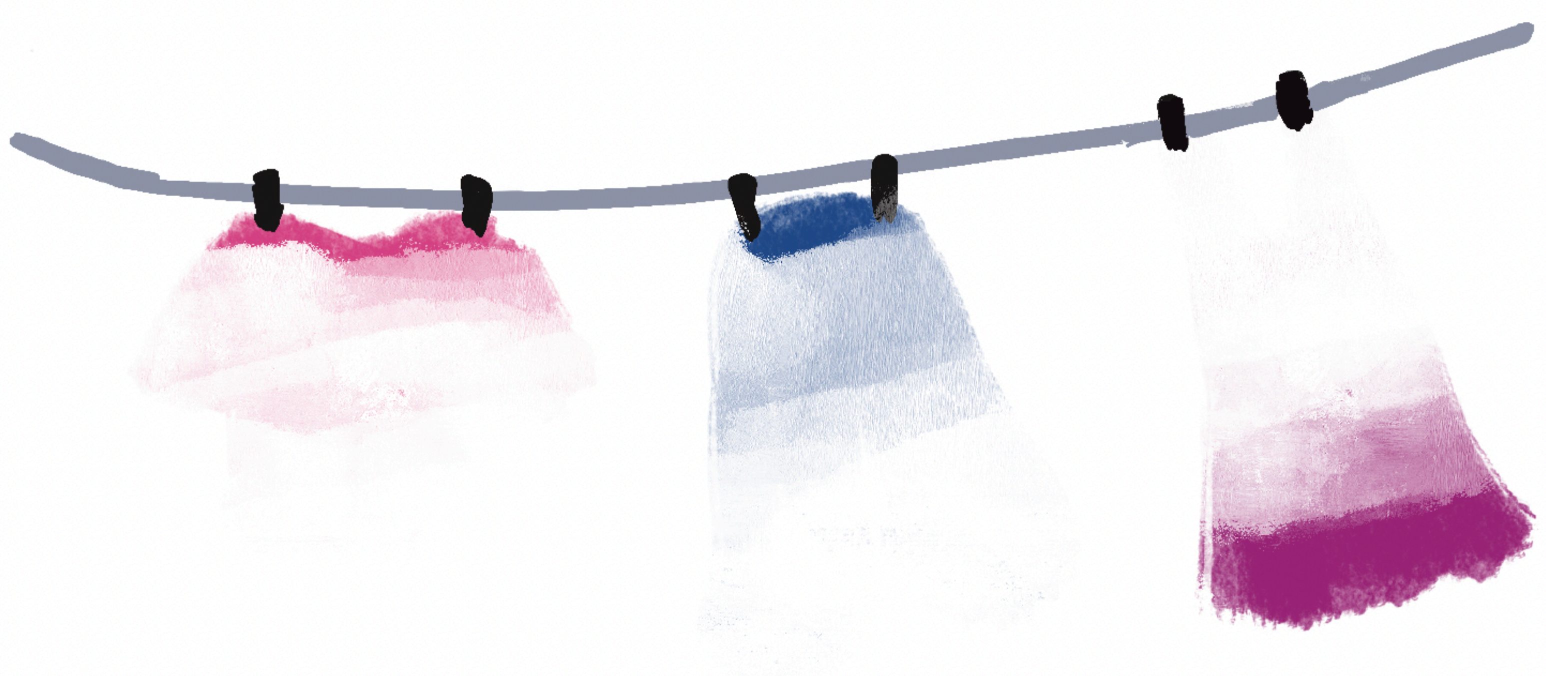
X→YH→VV(4q)bb

B2G-23-007

- Largest deviation from the background-only hypothesis is observed for m_X = 900 GeV and m_Y = 80 GeV with a local (global) significance of **3.3 (< 1.0) σ**
- Upper limits as low as 0.1 fb are derived at the 95% confidence level for various mass points



See Ilias' talk



Dark Sector

-

dark H multi-b
dark γ and H (LLP to μ)

-

Dark Higgs model

- Naturally satisfies observed relic density
- Massive DM and Z′ from dark sector Higgs mechanism

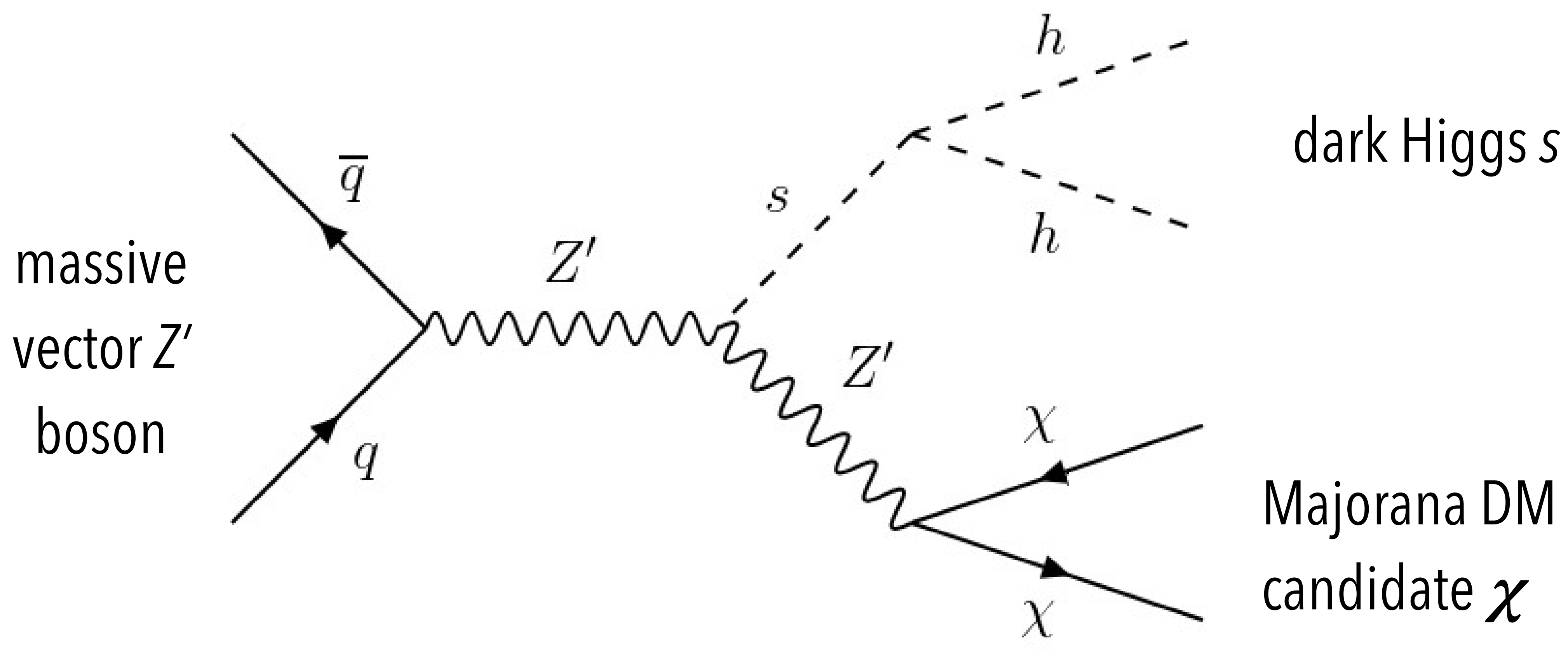
Dark Photon

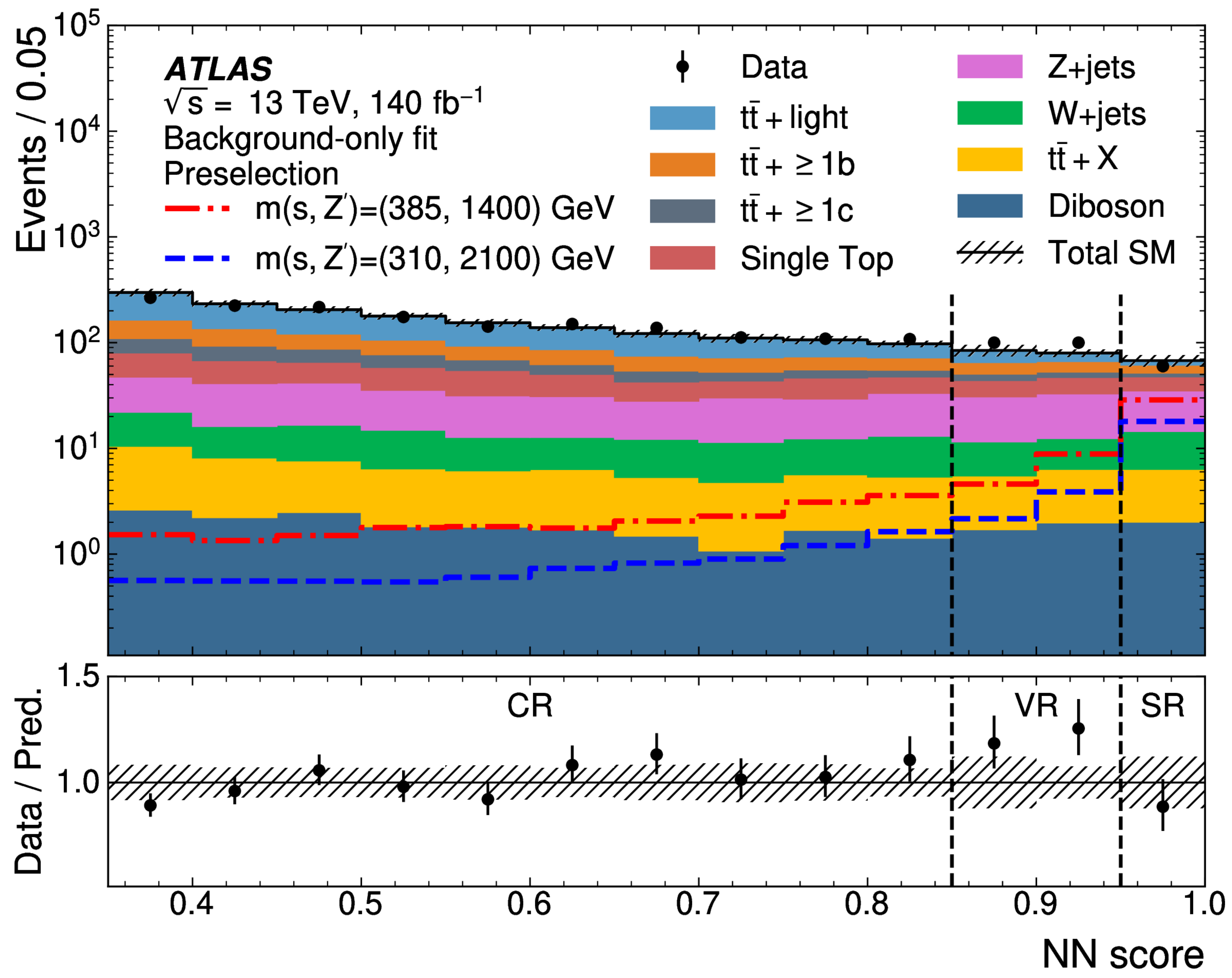
- Z_D, mediator of a broken dark U(1) gauge theory that kinetically mixes with SM hypercharge
- If the dark U(1) is broken by hidden-sector Higgs mechanism, then mixing between dark and SM Higgs bosons also allows exotic decay $h \rightarrow Z_D Z_D$

Dark Higgs, multi-b + p_T^{miss}

CERN-EP-2025-141 (submitted to JHEP)

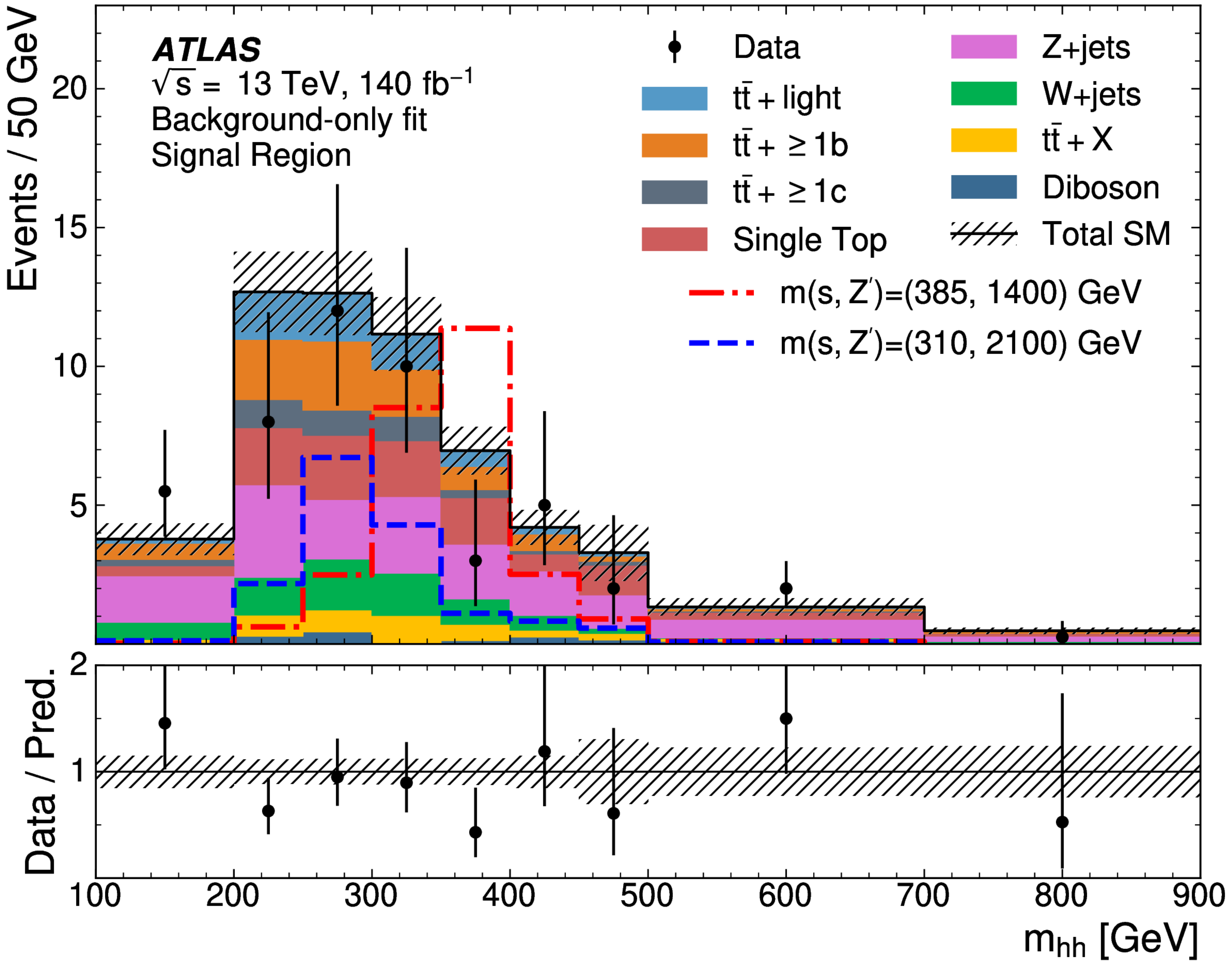
- First search for resonant hh + E_T^{miss} at the LHC
- Resonant topology, 4b back-to-back with p_T^{miss}
  - Selections made on p_T^{miss}-based variables
  - Pair b-jets to form Higgs candidates
  - Define control, validation and signal regions with NN score
- Perform fit and statistical interpretation on fully reconstructable dark Higgs mass **(m_{hh} distribution)**
- Normalisation factors for tt̄+≥1b, tt̄+light and Z+jets are free-floating

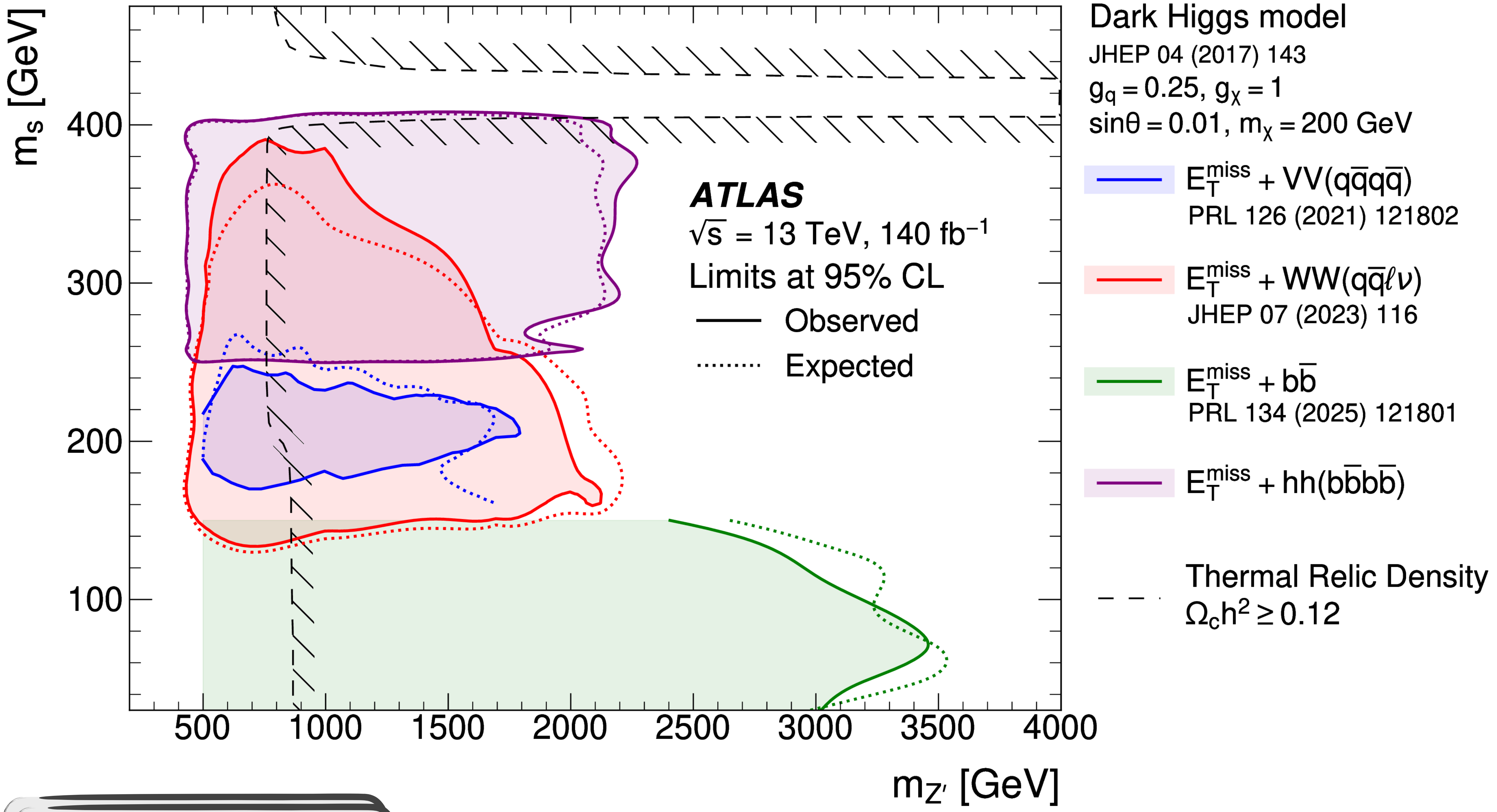




Dark Higgs, multi-b + p_T^{miss}

- Upper limits are derived on BSM particle masses for 250 < m_s < 400 GeV, excluding Z′ masses up to 2.3 TeV
- Significantly extends existing constraints in this mass region from previous analyses
- Complement other lower-mass dark Higgs boson searches, searches for extended Higgs sectors and other collider DM searches



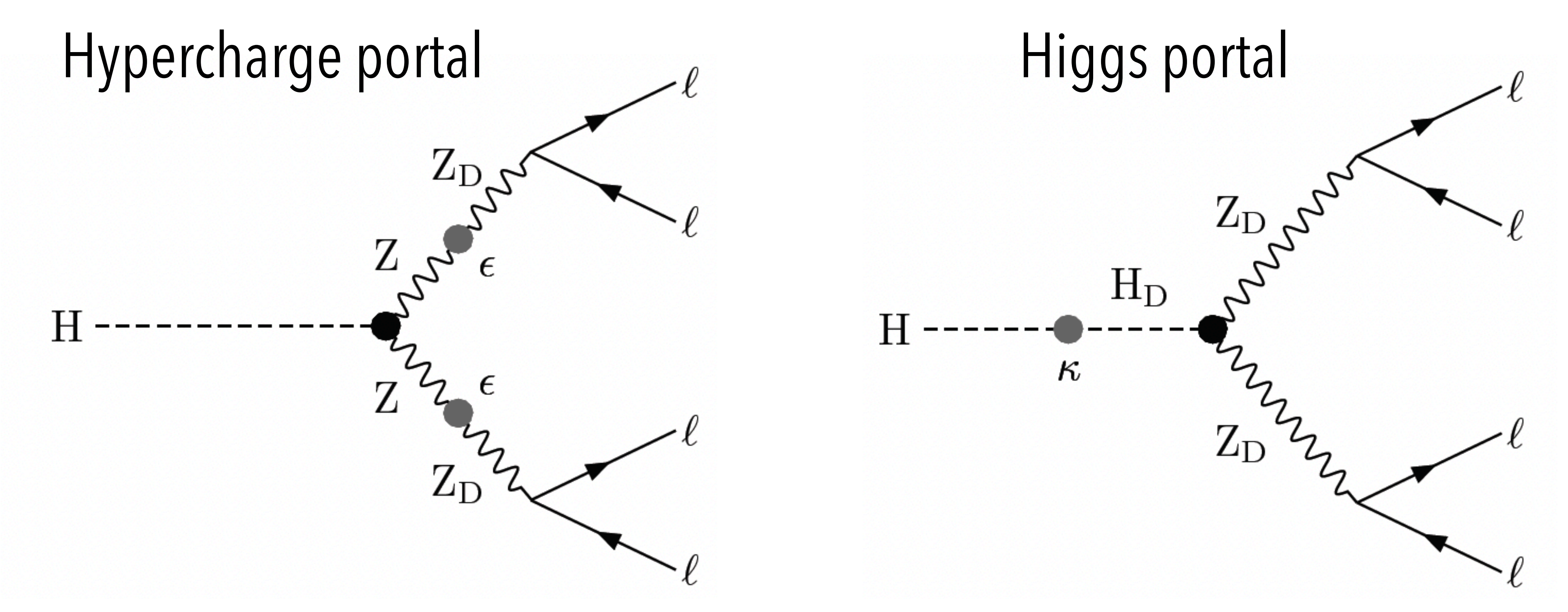


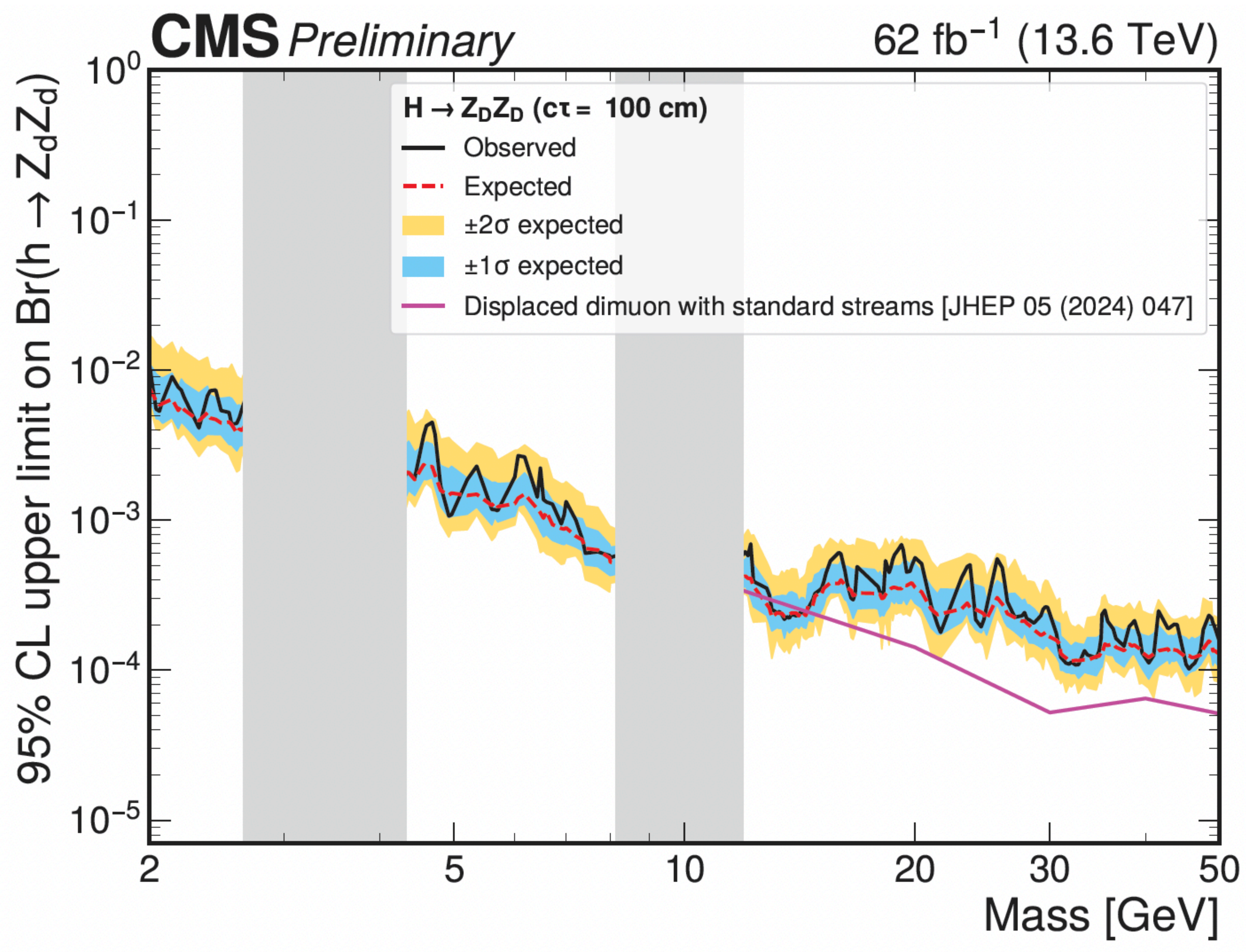
See Pantelis' talk

Dark Photon LLP to μ

EXO-24-016

- Search for displaced multi-muon resonances
- BSM models where a Higgs boson decays to **long-lived dark particles**
  - The hidden sector may interact with SM either through **hypercharge portal**, or **Higgs portal** via a dark Higgs boson H_D
- Analysed 2022+2023 Run 3 dataset (62.6 fb^{-1})
- Events classified in **four-muon** with *overlapping vertex* or *multivertex*, and **di-muon** with pointing or not pointing (to the secondary vertex) topologies
- **Dedicated di-muon trigger stream *(scouting)*** with low p_T thresholds, recorded at high rate by retaining reduced amount of information
  - Explore otherwise inaccessible phase space at **low di-muon mass** and **non-zero displacement** from the PV (masses below 10 GeV for the first time in a displaced muon analysis!)





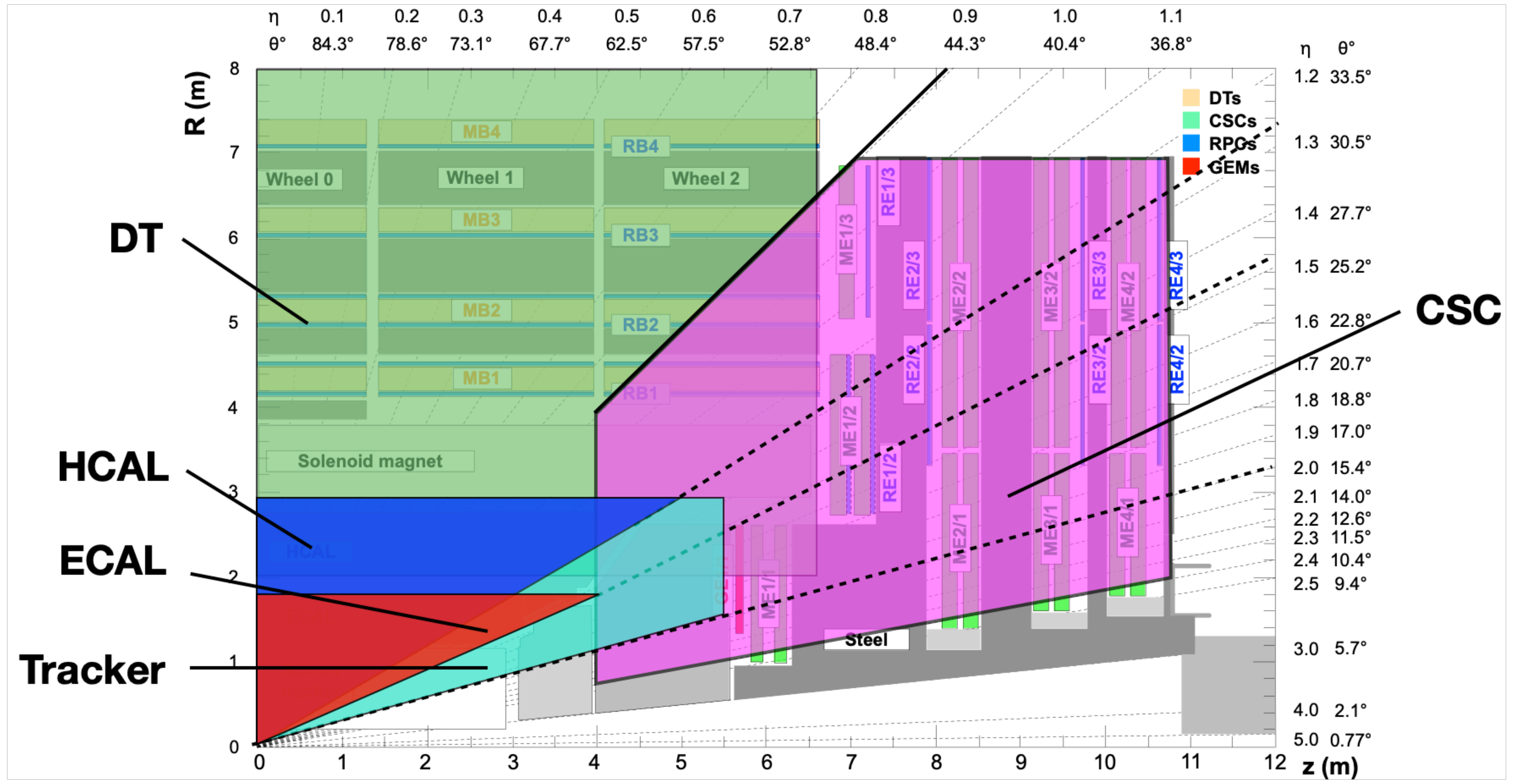
LLP triggers

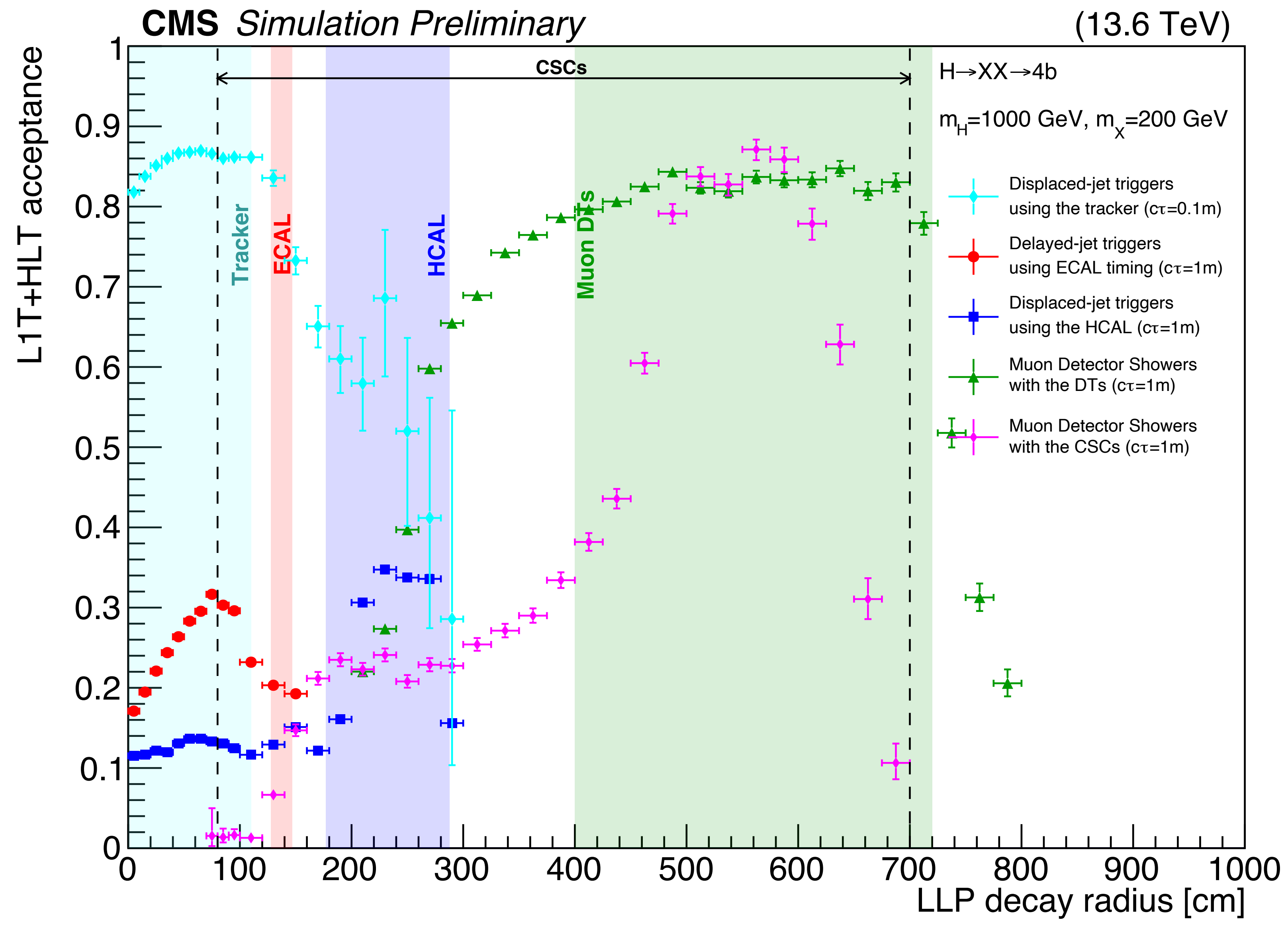
EXO-23-016

- Dedicated triggers targeting LLPs enable increased sensitivity to wide variety of signal models
- During Run 3, variety of such triggers were introduced and/or improved compared to Run 2
- Capitalise on different CMS subdetectors, hence can target different phase space in LLP searches
- The powerful complementarity of the program is shown using Twin Higgs model as a benchmark

Data	Total rate [Hz]	Pure rate [Hz]
Standard	393	311
Parking	234	182
Scouting	4200	3800
Full reconstruction: standard or parking	586	389

- Calculated from one run in 2024 data for pile-up 63.6 and instantaneous luminosity of 2.1×10^{34}
- Total rate: **OR of LLP HLT trigger paths**, accounting for overlaps
- Pure rate: total rate not saved by any other HLT path



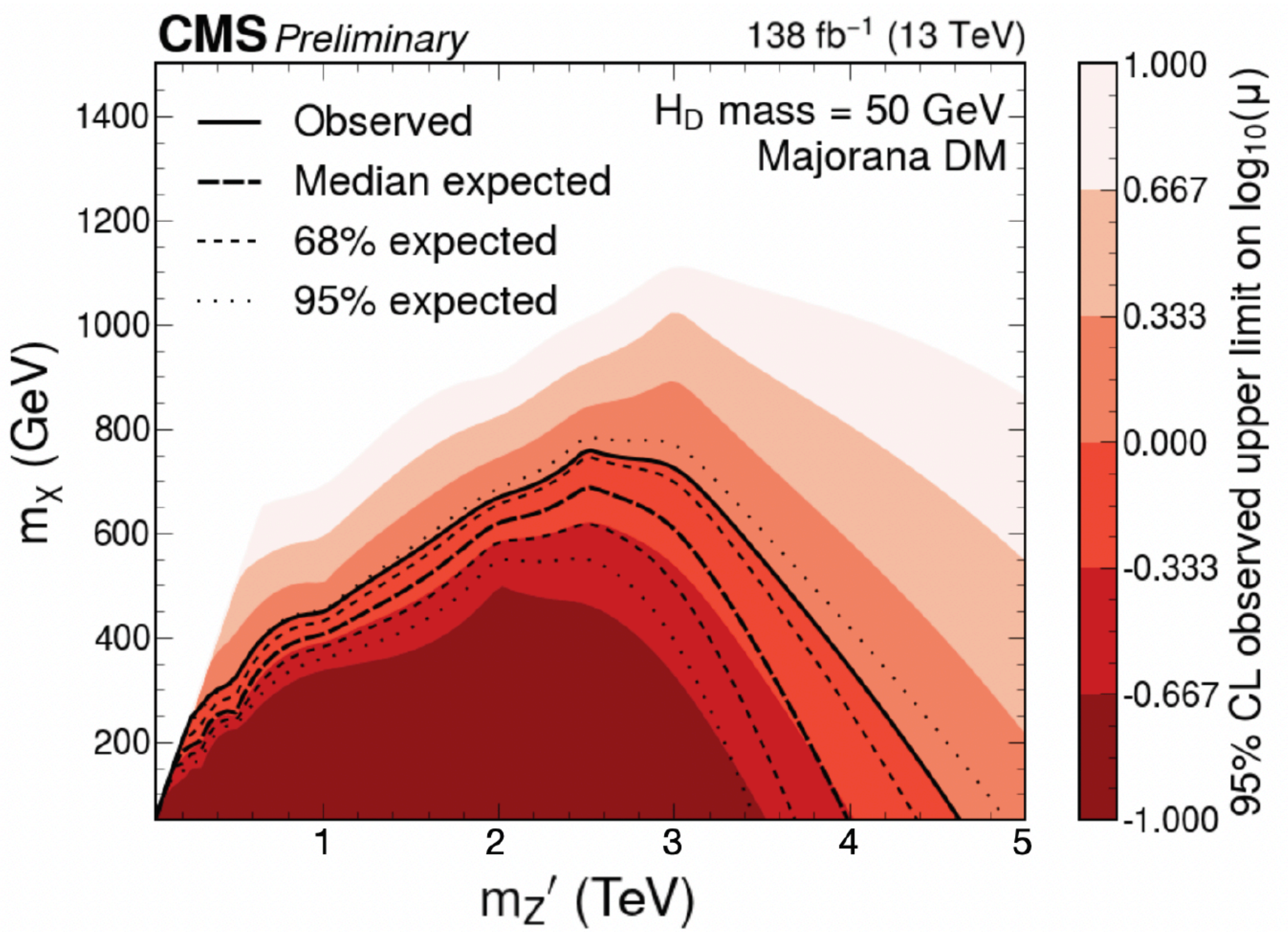


See Eric's talk

Even more new results (but not enough time to cover them)

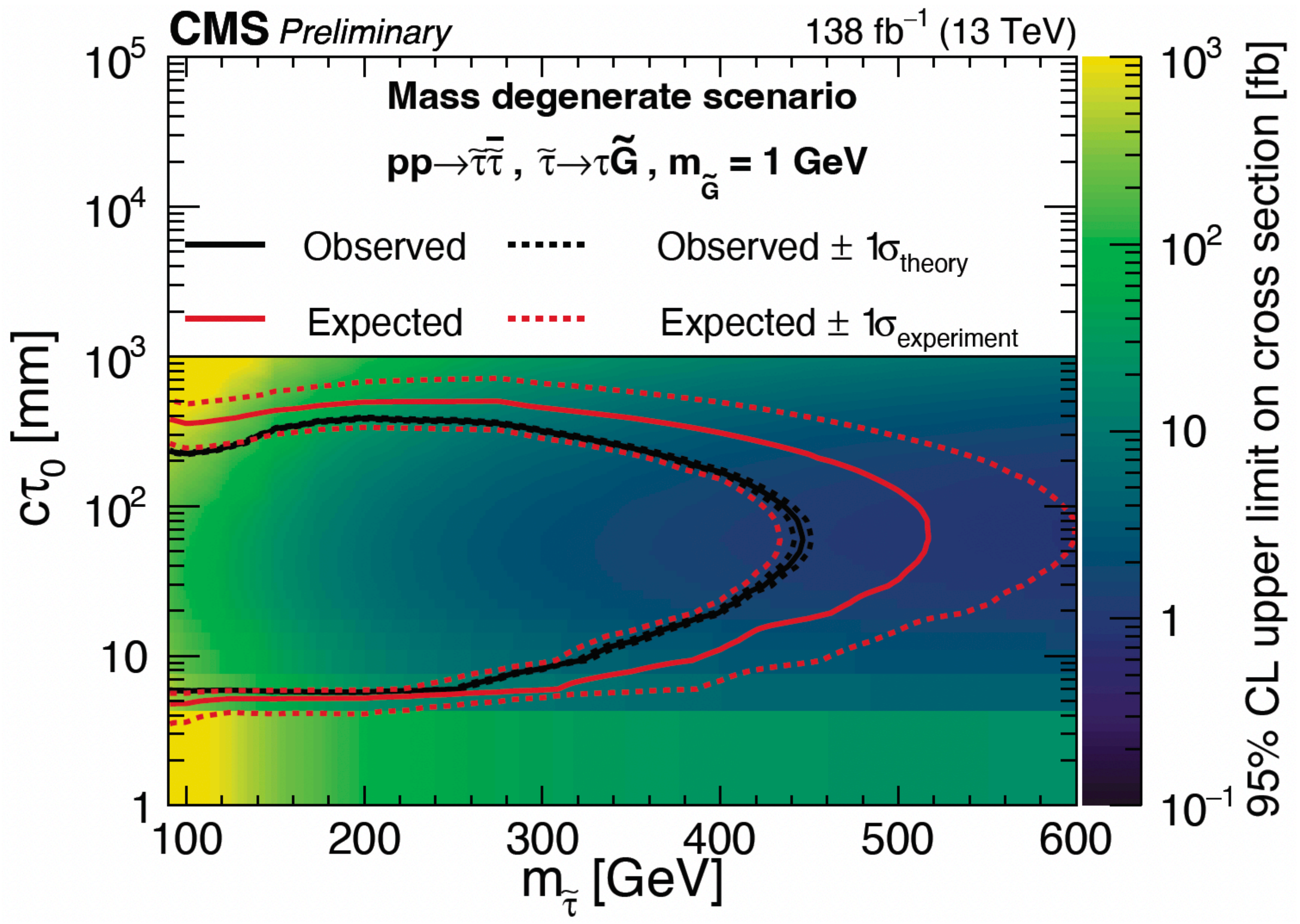
- **SUS-23-013: dark Higgs to $b\bar{b}$**
  - 95% CL limits on signal strength for dark Higgs boson masses below 160 GeV set for the first time with CMS data

See Sushil's talk



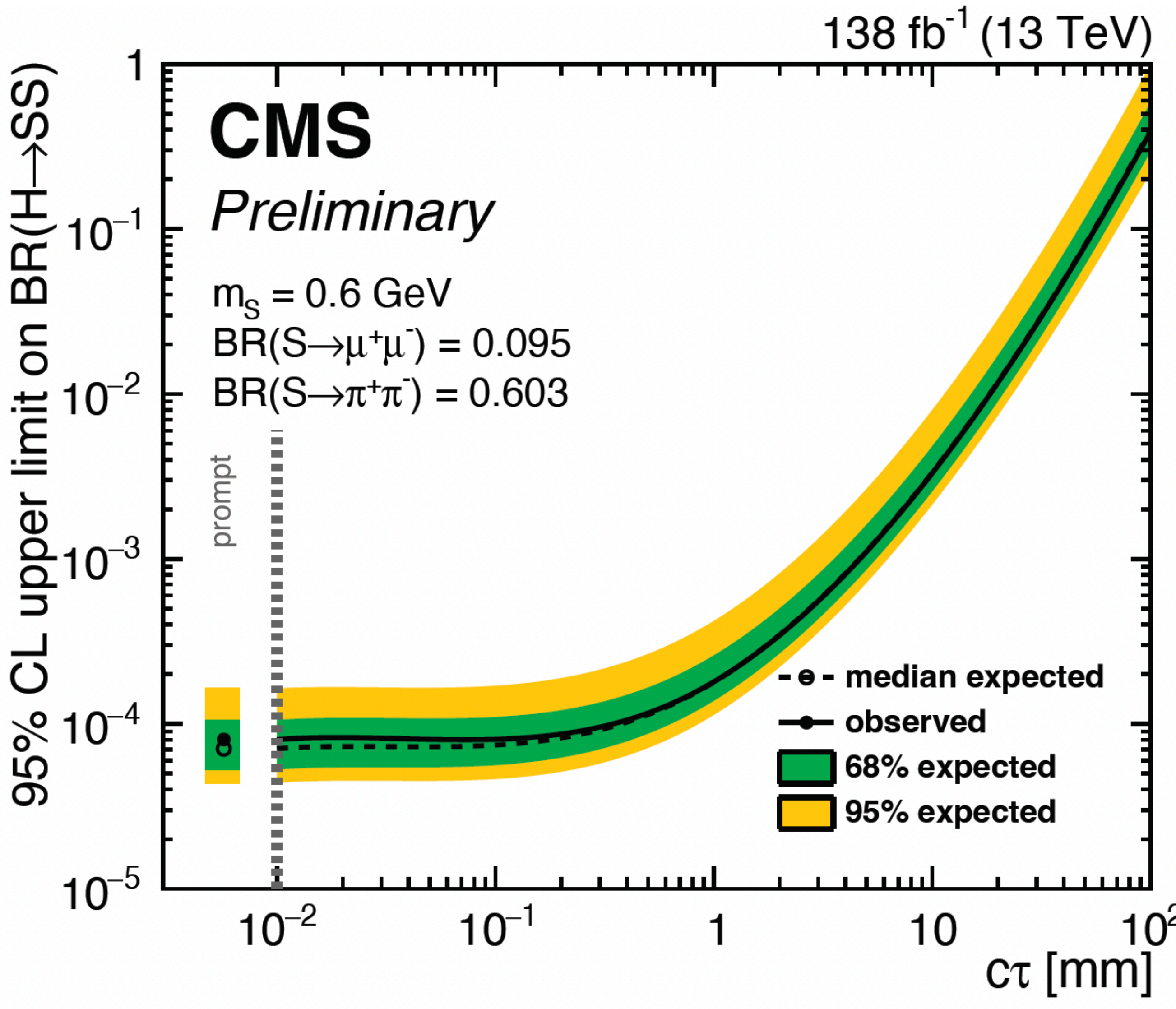
- **EXO-24-020: long-lived $\tilde{\tau}$ using a NN-based displaced τ tagger**
  - First search for direct production of long-lived $\tilde{\tau}$ decaying within tracker volume

See Eric's talk



- **EXO-24-034: light scalars via the Higgs portal decaying to μ and hadron pairs**
  - Improves sensitivity to very light scalar masses (0.4 - 2 GeV) and demonstrates novel approach to probe hadronic decay mode for light scalars

See Eric's talk



Conclusions

- **What** we search for has evolved
  - Investigate **new models** (more complete, less vanilla)
  - The **Dark Sector** is in the spotlight! Many interesting signatures to explore

- **How** we search for BSM has evolved
  - Explore **uncovered phase spaces**
  - **Improved object reconstruction**
  - **LLPs** targeted, multiple signatures in detectors

- We continue in **discovery-mode**
  - High priority to follow up with Run 3 dataset on **excesses** observed with Run 2 dataset (+ reanalysing Run 2)
  - Without disregarding **legacy** searches with Run 3 dataset
- Run 3 dataset only shyly used in recent searches
  - It takes time to understand thoroughly new dataset
  - **New results with partial Run 3 dataset gaining momentum!**

- Expect a total of Run 2 + Run 3 dataset of **500 fb^{-1}**
  - Continue being *creative* and lively discussing opportunities with theorists
    - **First edition of the new SEARCH conference series in October 2025**
    - **First LHC BSM WG assembly meeting in November 2025**

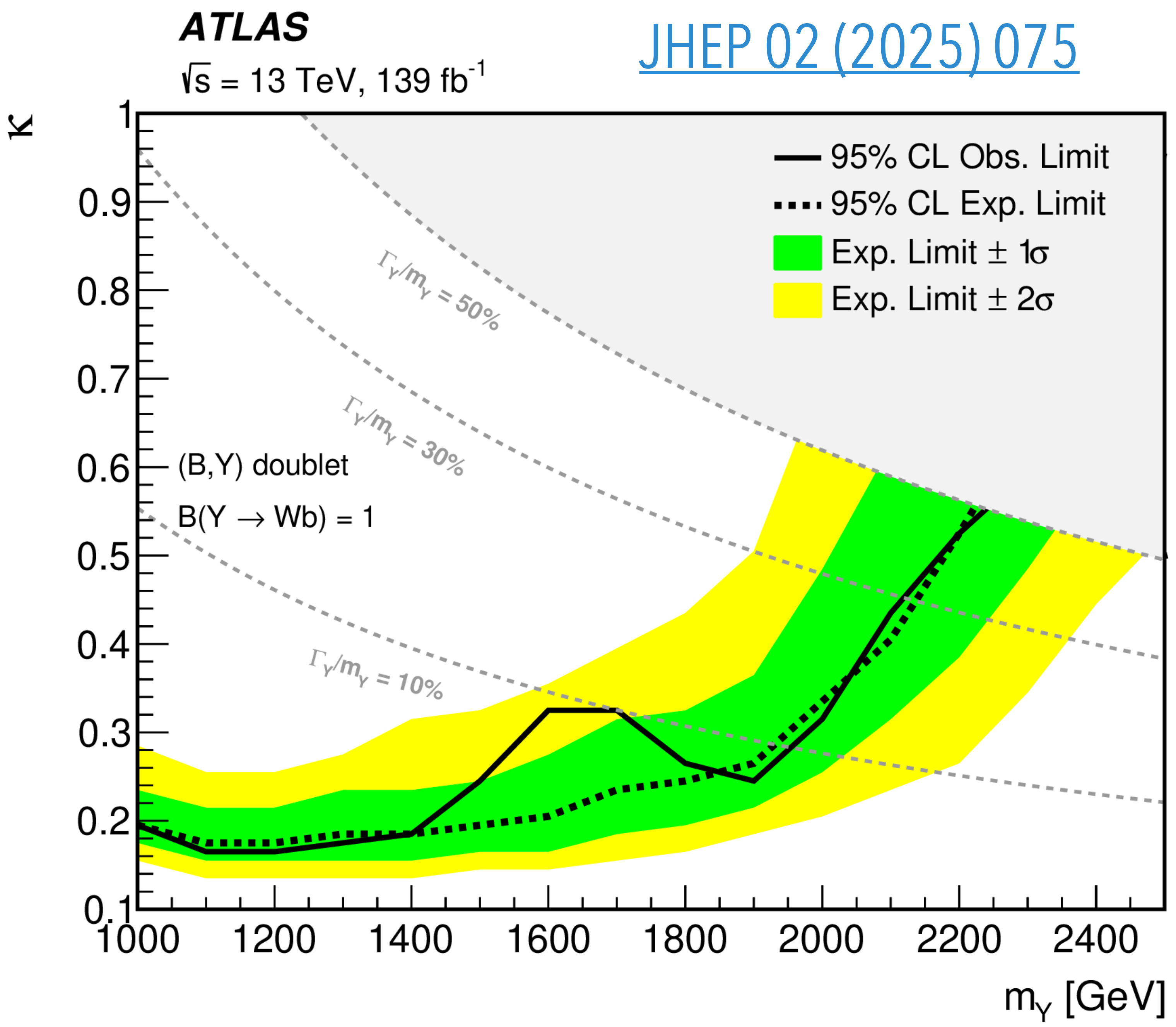
Thanks for your attention!

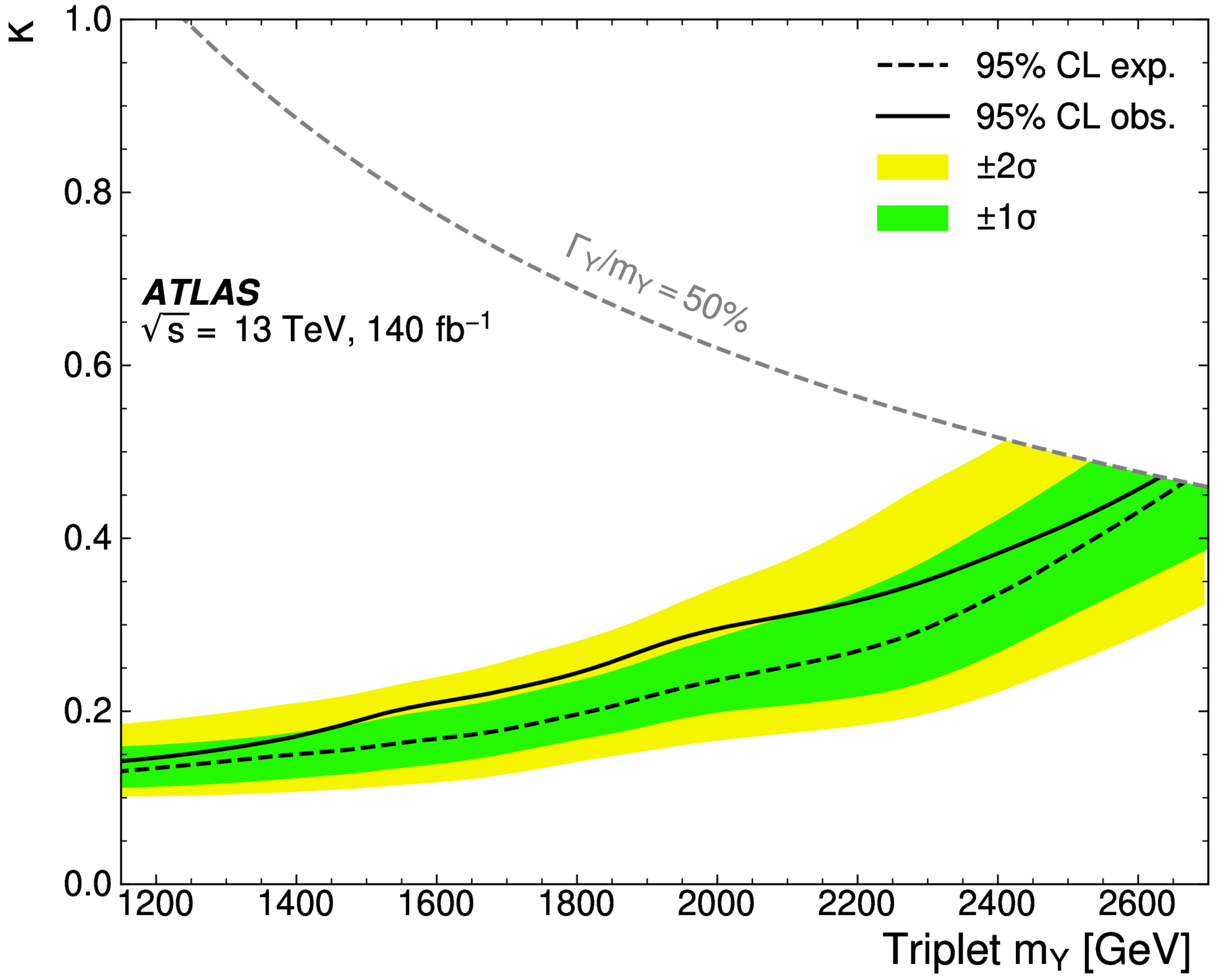
Back Up

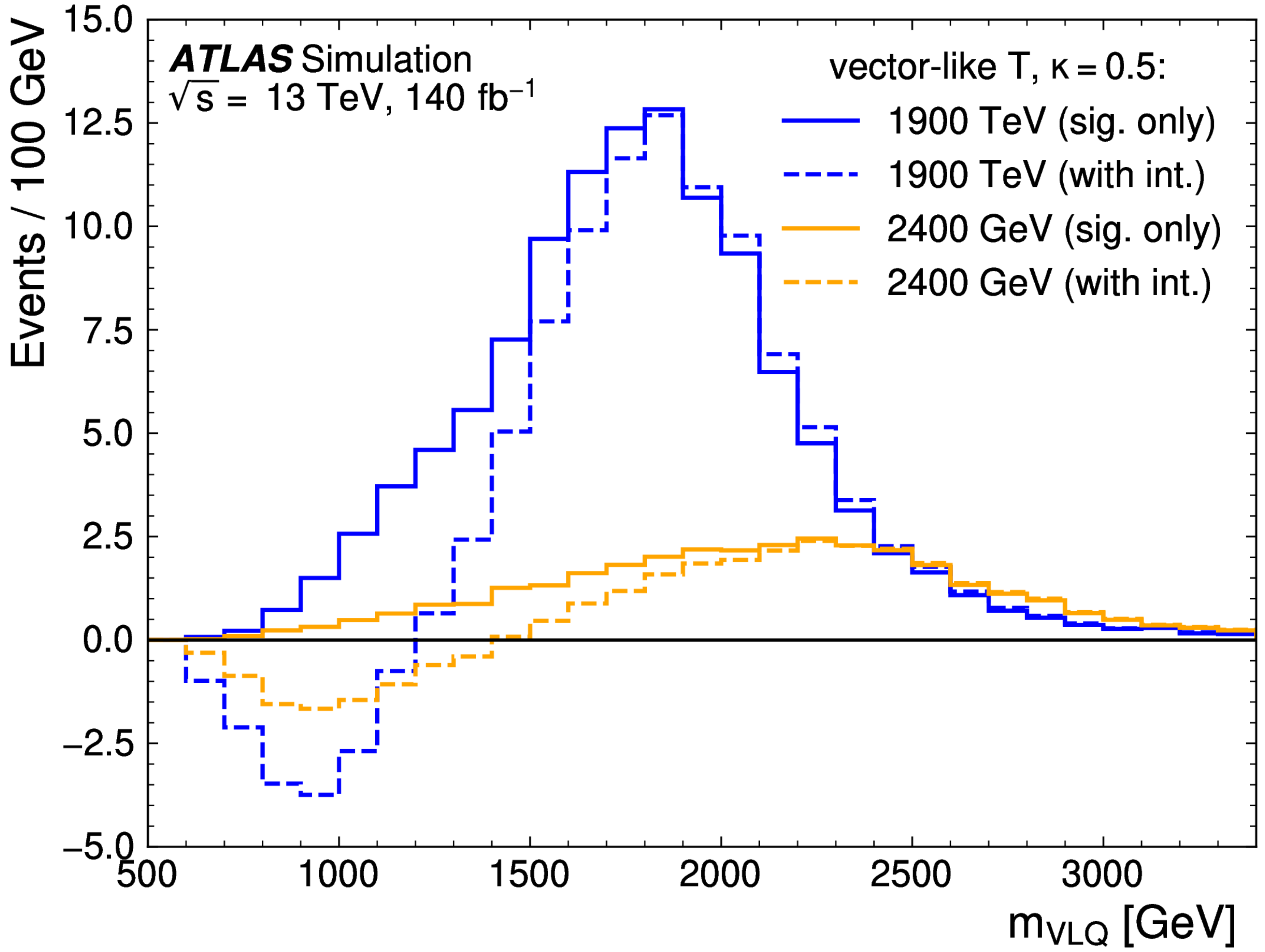
VLQ: T/Y → Wb (1ℓ)

CERN-EP-2025-098, submitted to JHEP

Fully-hadronic T/Y → Wb search
JHEP 02 (2025) 075



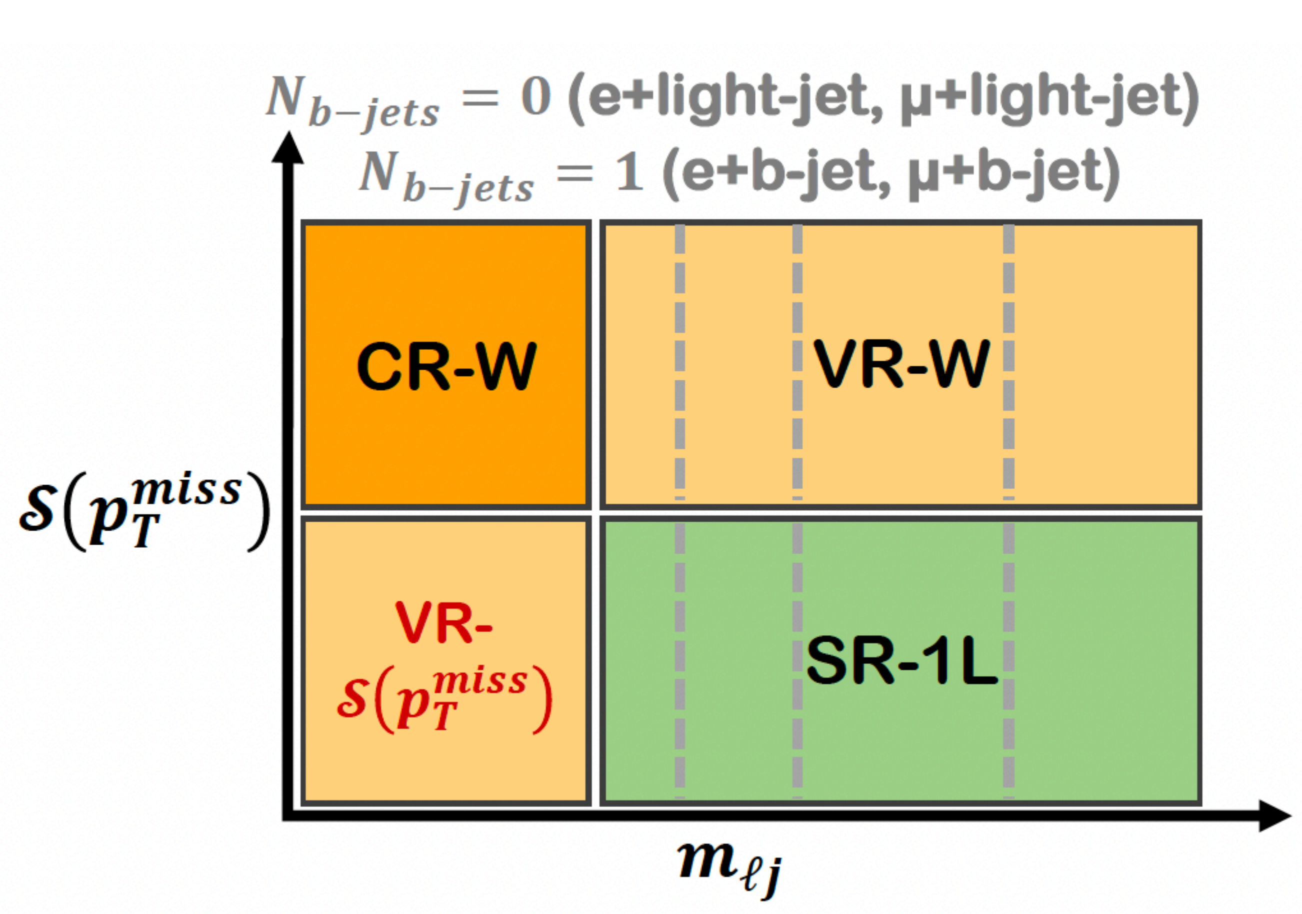


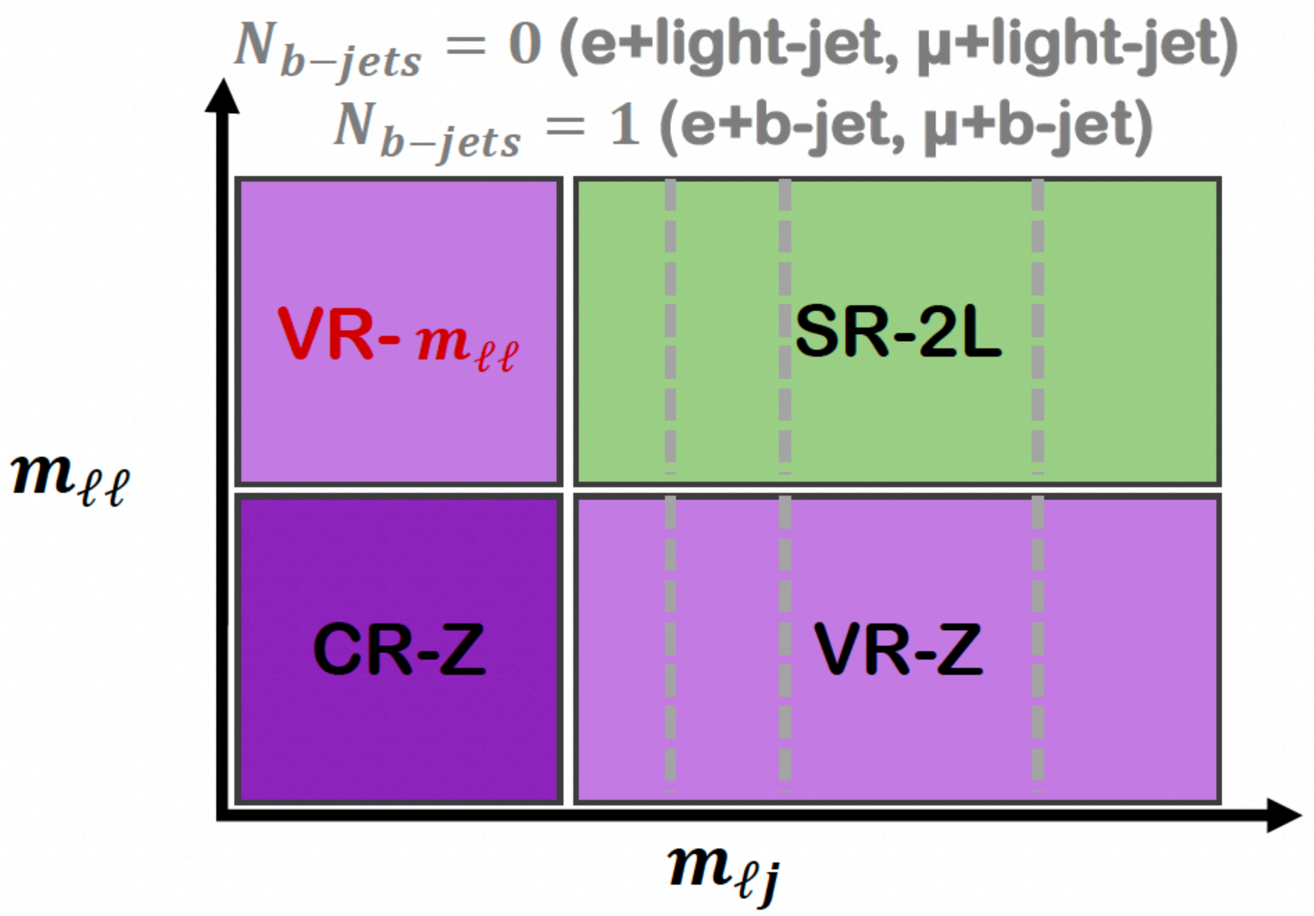


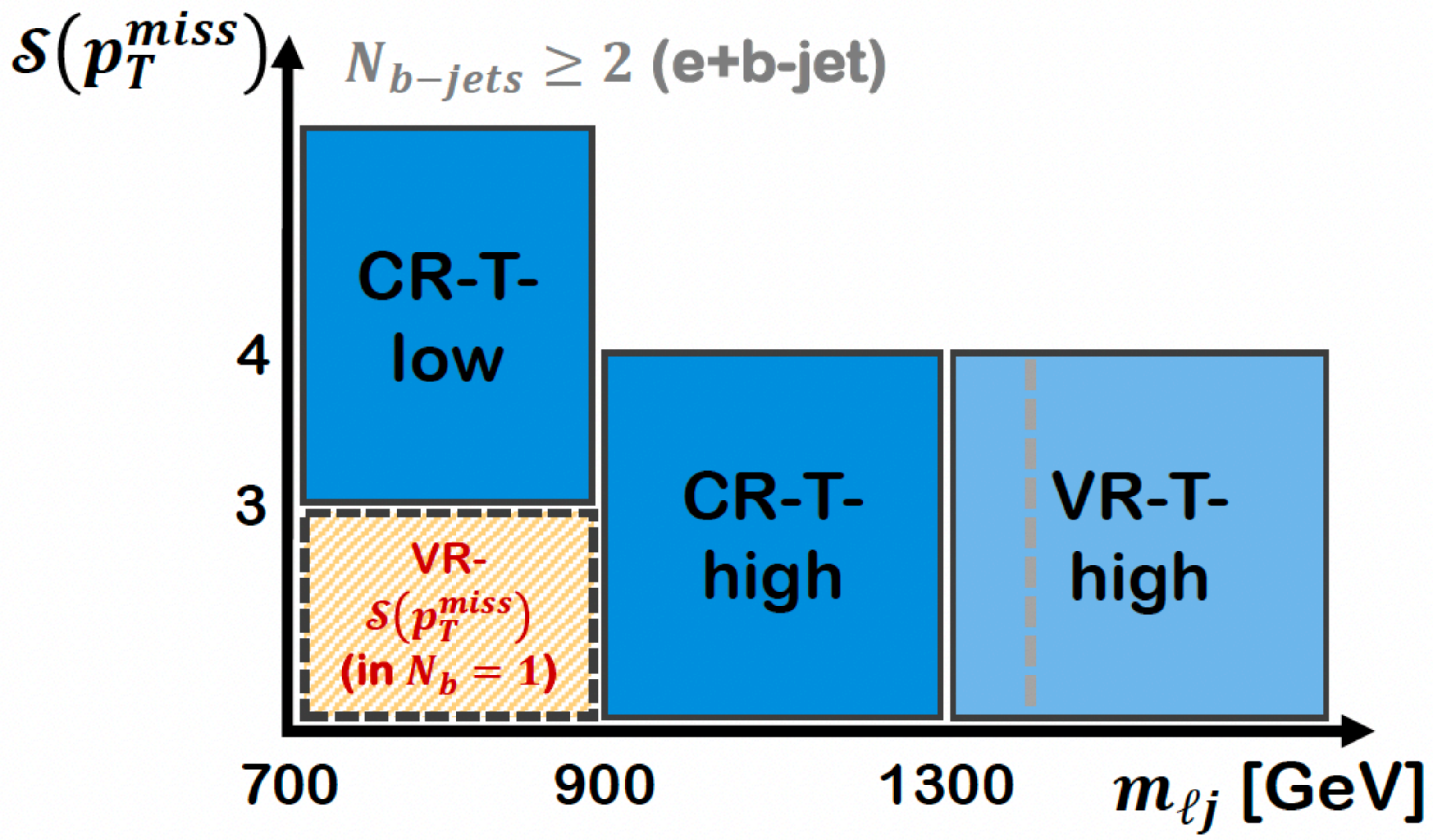
Resonant s-channel LQ

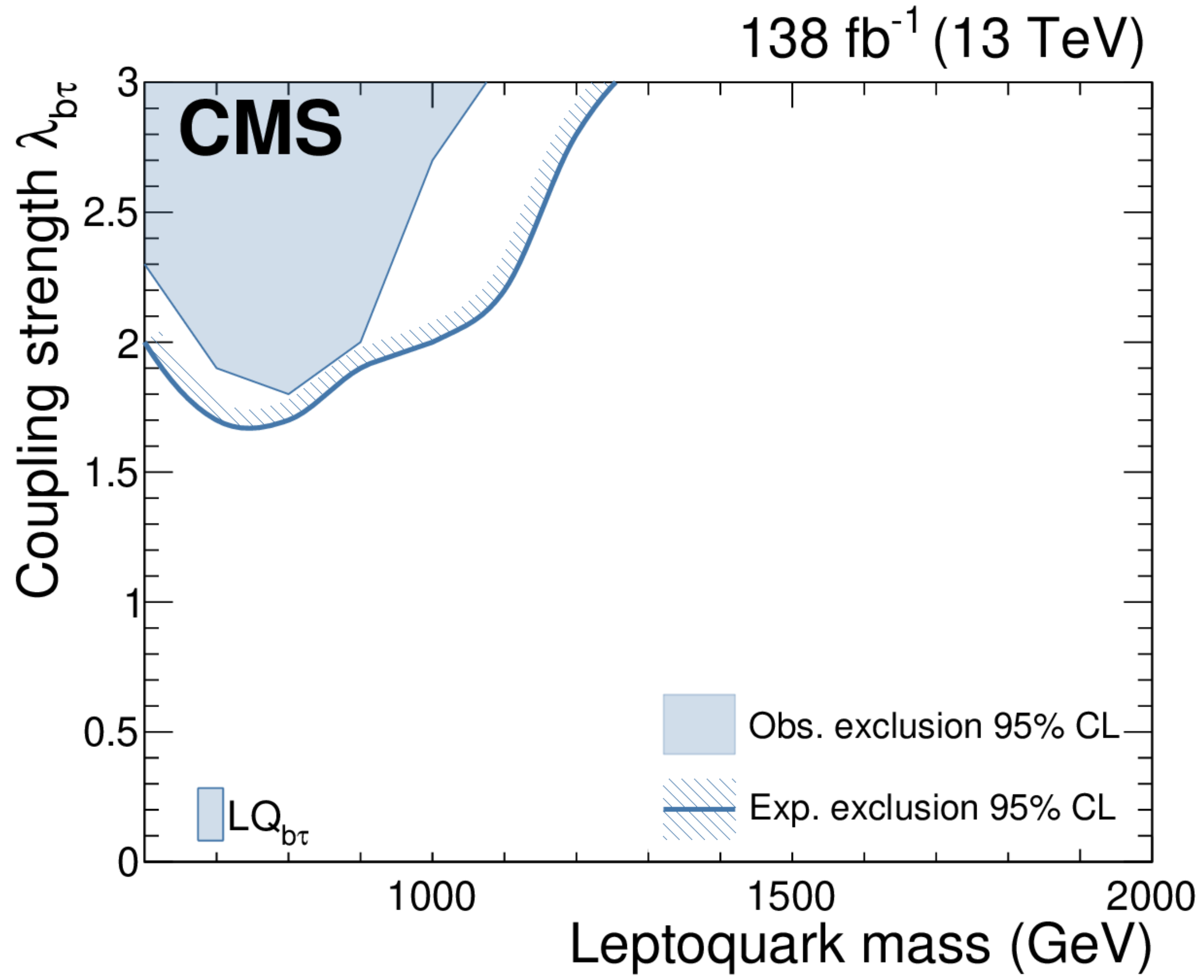
CERN-EP-2025-142, submitted to JHEP

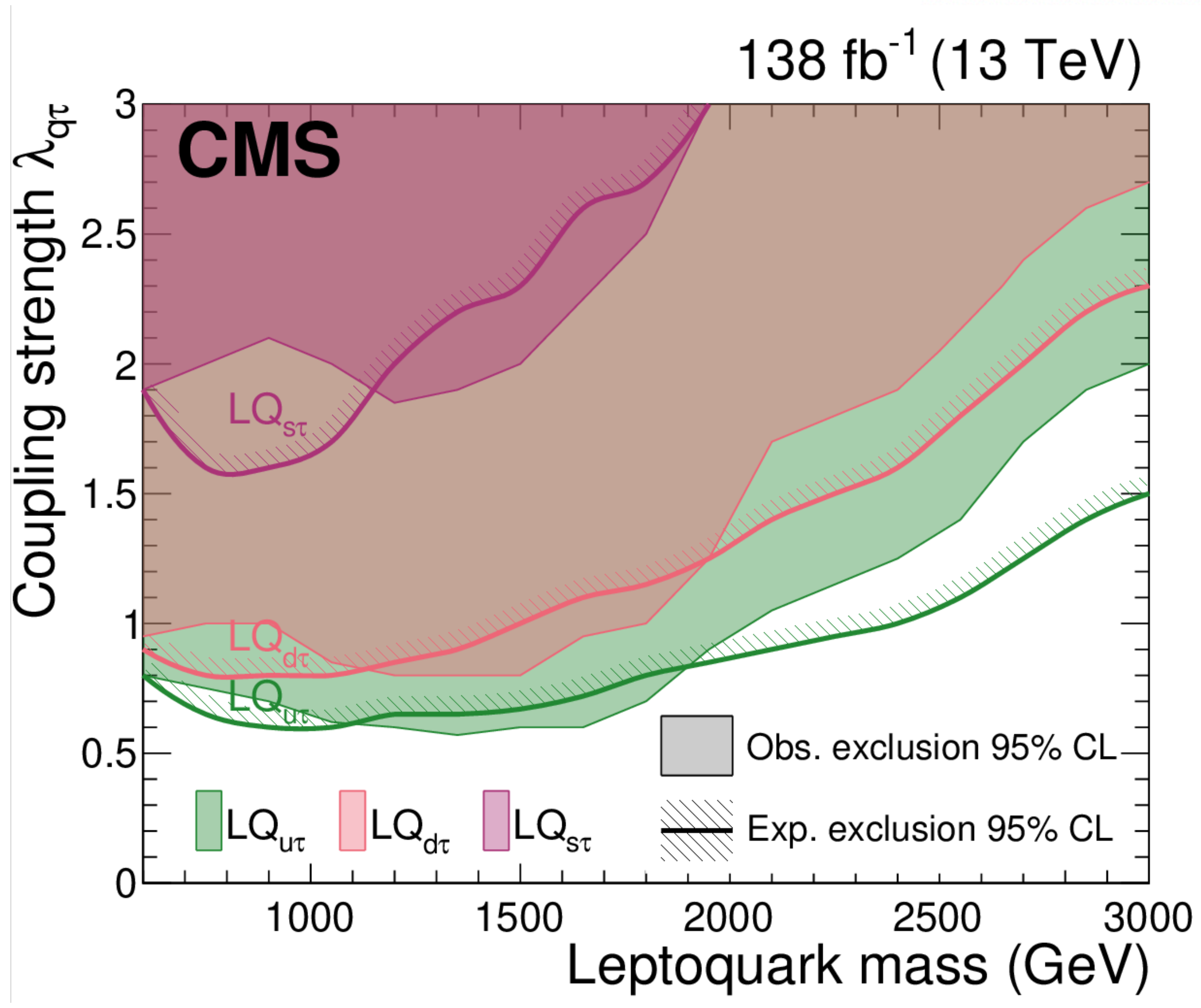
example CRs and VRs: e + b-jet



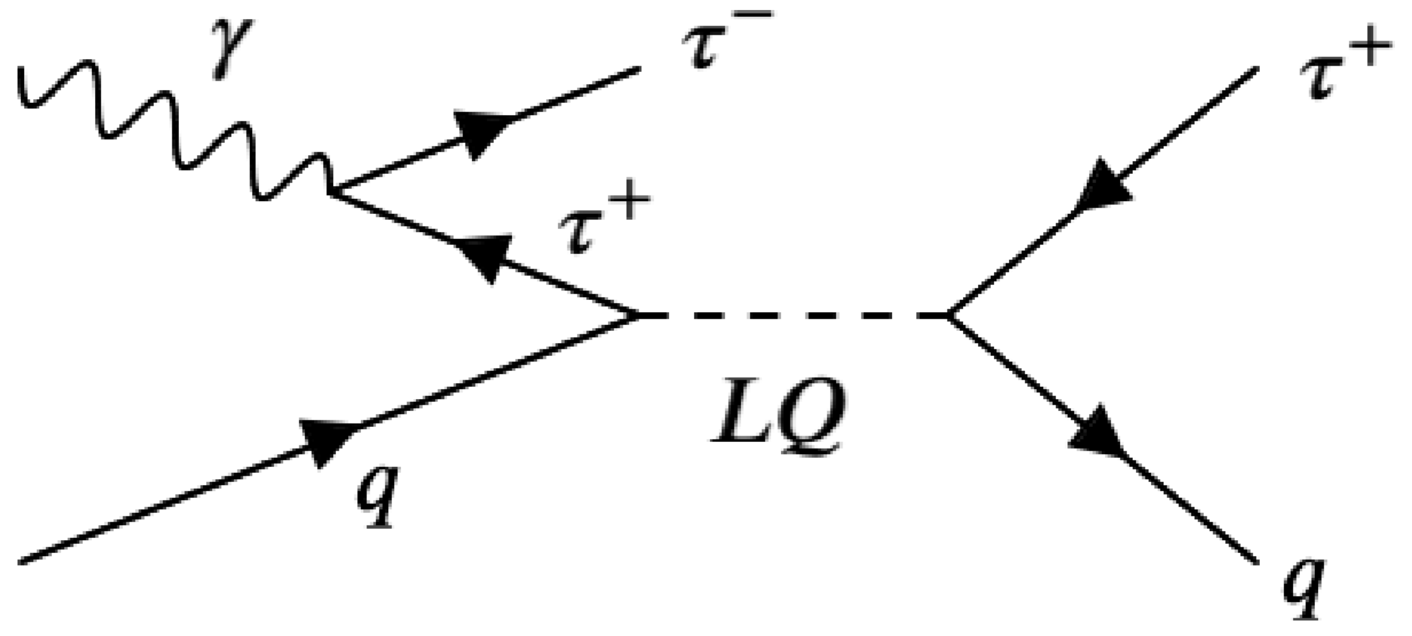








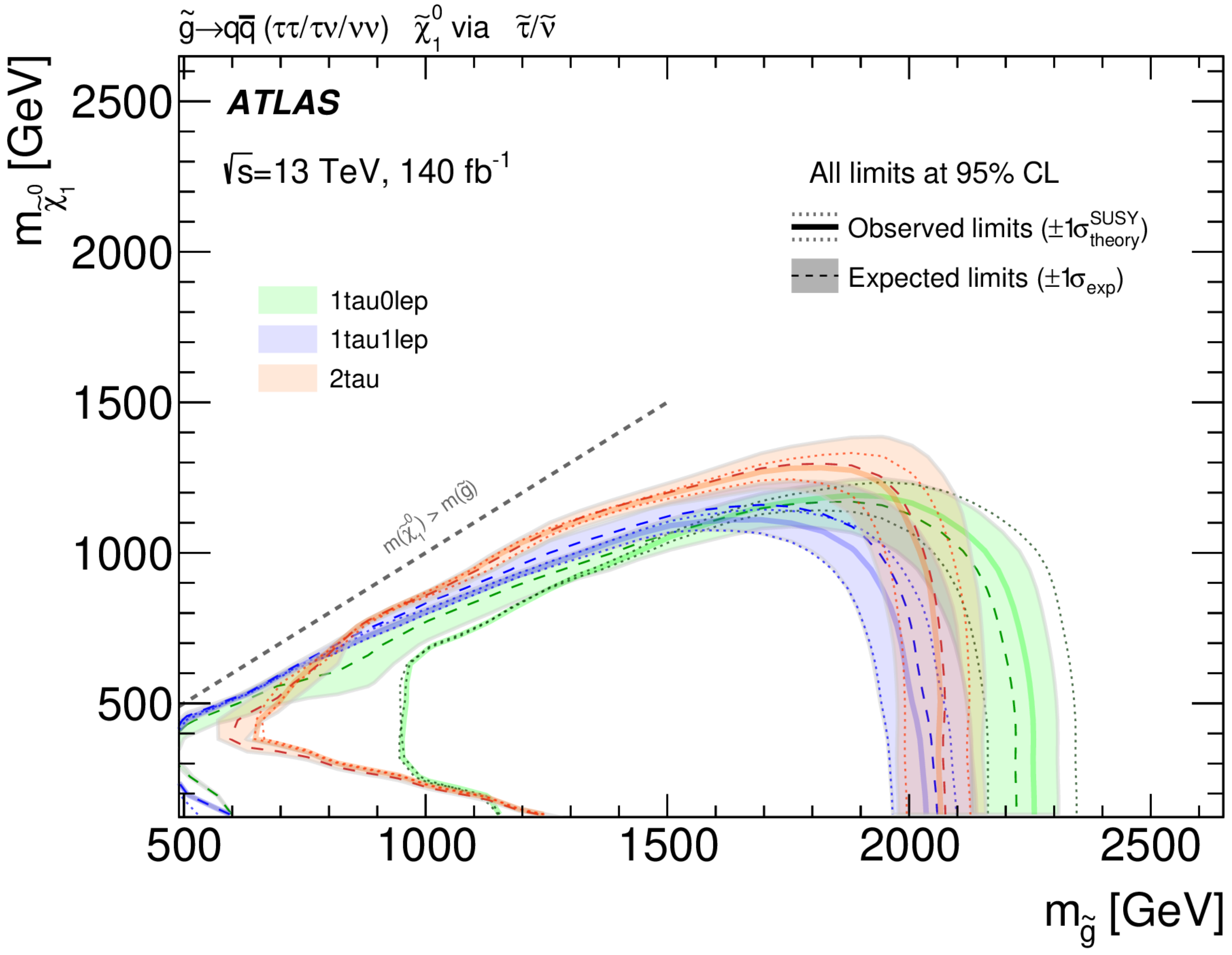
Phys. Rev. Lett. 132 (2024) 061801

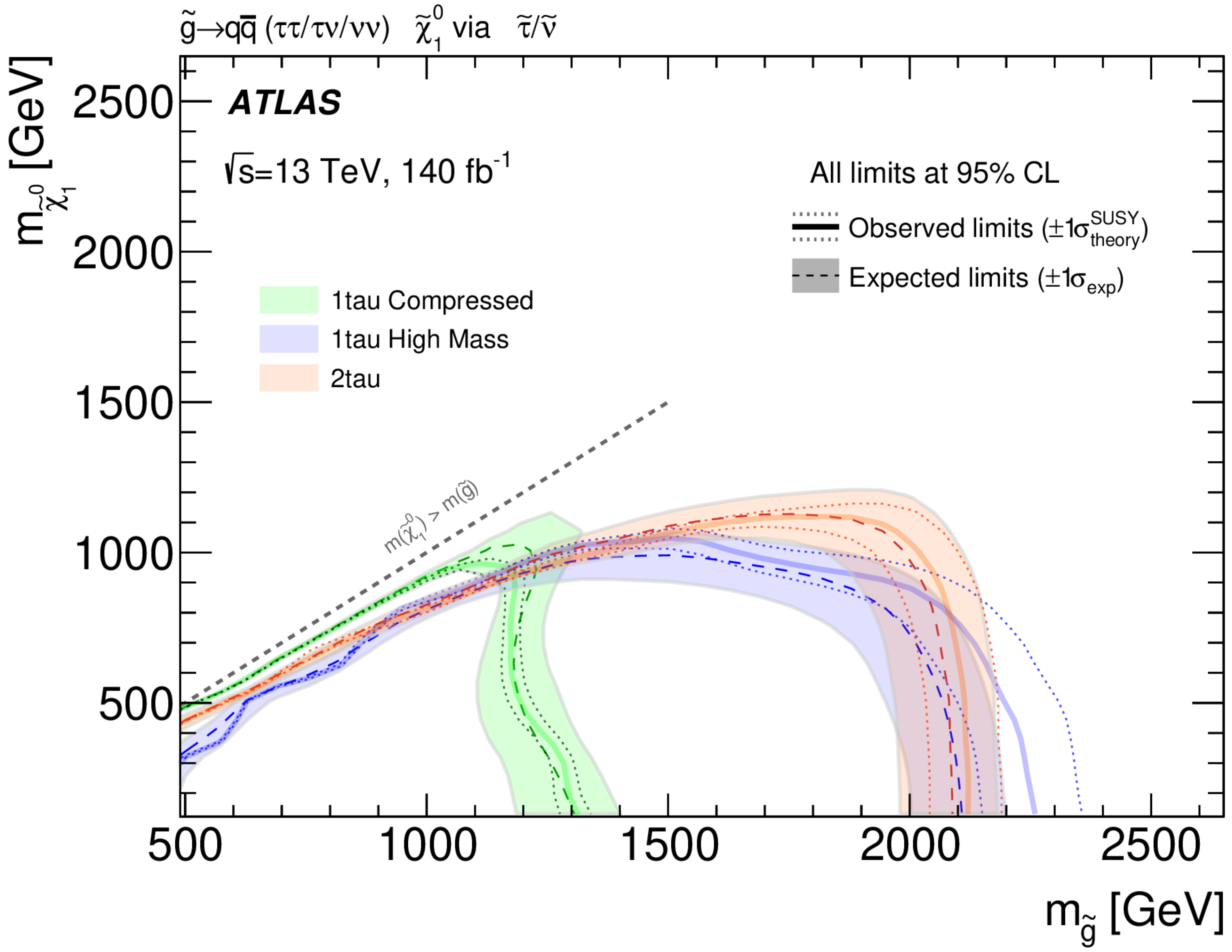


RPC squarks & gluinos: $\tau+E_T^{miss}$

CERN-EP-2025-132, submitted to EPJC

	Compressed SR		High Mass SR		TwoTau SR
Channel	1TAU0LEP	1TAU1LEP	1TAU0LEP	1TAU1LEP	2TAU
$N_e + N_\mu$	$= 0$	≥ 1	$= 0$	≥ 1	–
N_τ	$= 1$				2
E_T^{miss} [GeV]	> 400				> 200
H_T [GeV]	–		> 1000		> 800
N_{jets}	≥ 2		≥ 3		≥ 3
$p_T^{\tau_1}$ [GeV]	< 45		> 45		–
$m_T^{\tau_1}$ [GeV]	> 80	–	> 250	> 120	–
$m_T^{\tau_1} + m_T^{\ell_1}$ [GeV]	–	> 350	–	> 350	–
$m_T^{\tau_1} + m_T^{\tau_2}$ [GeV]	–	–	–	–	> 150

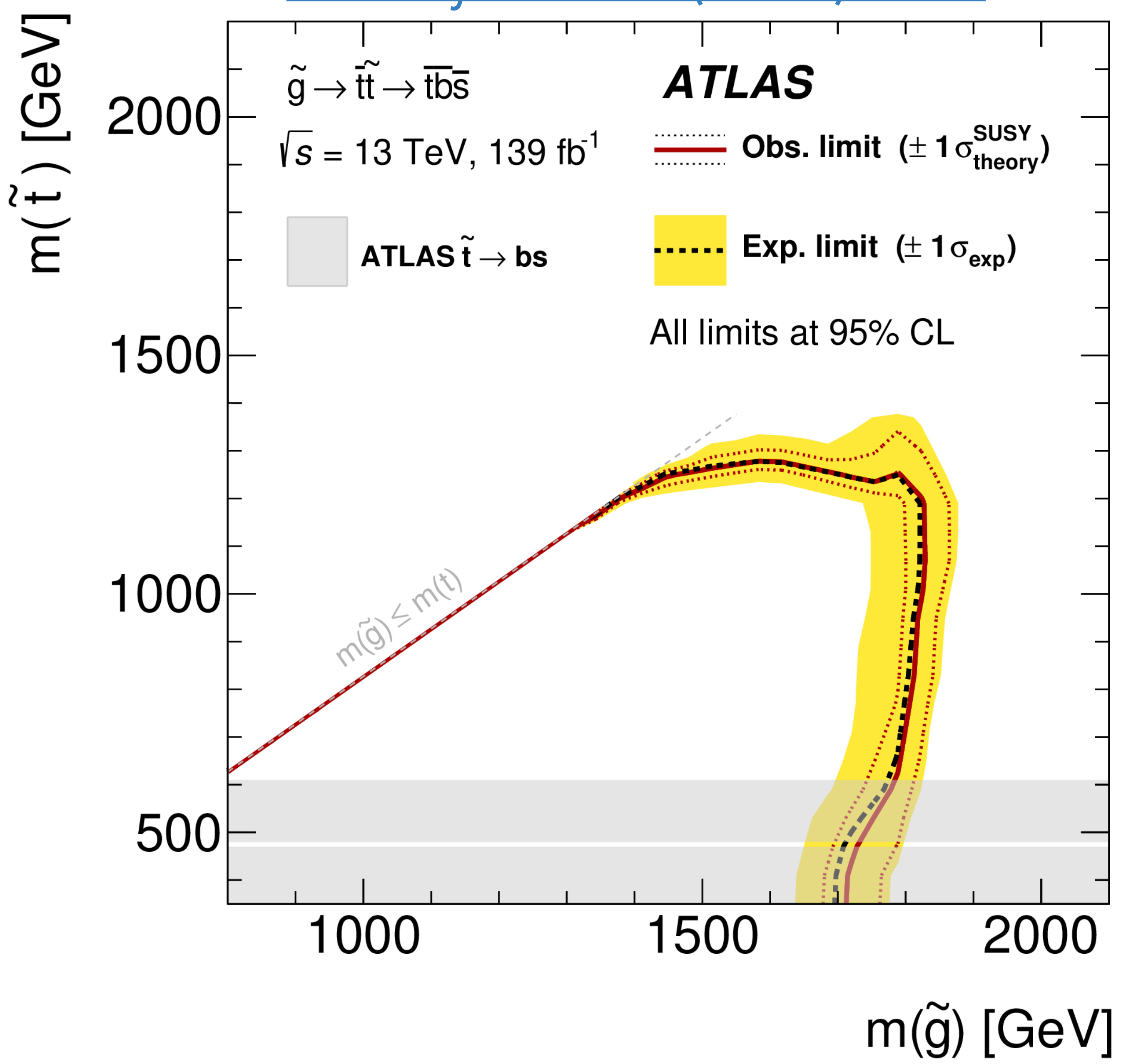


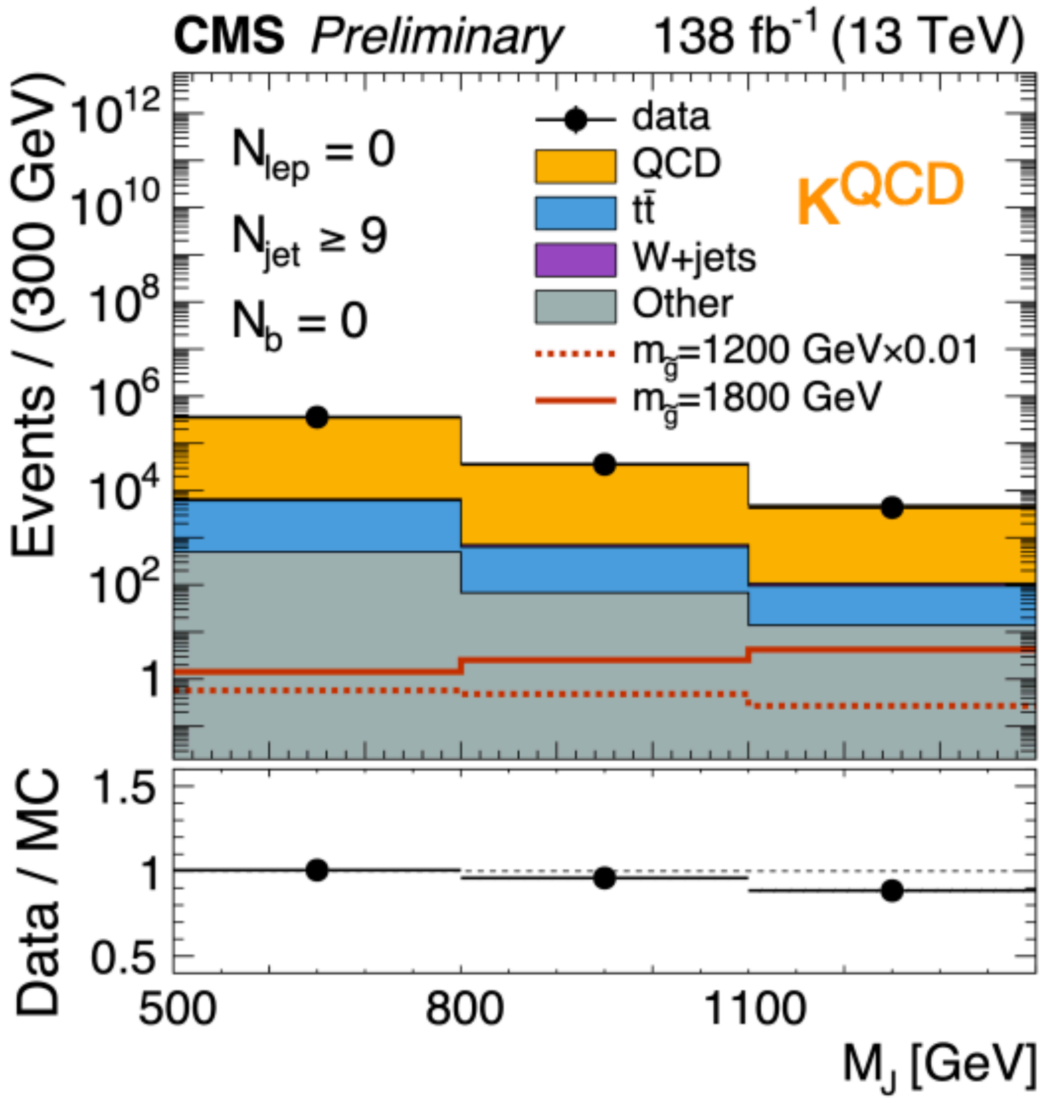


RPV SUSY 1ℓ + multi-(b)jets

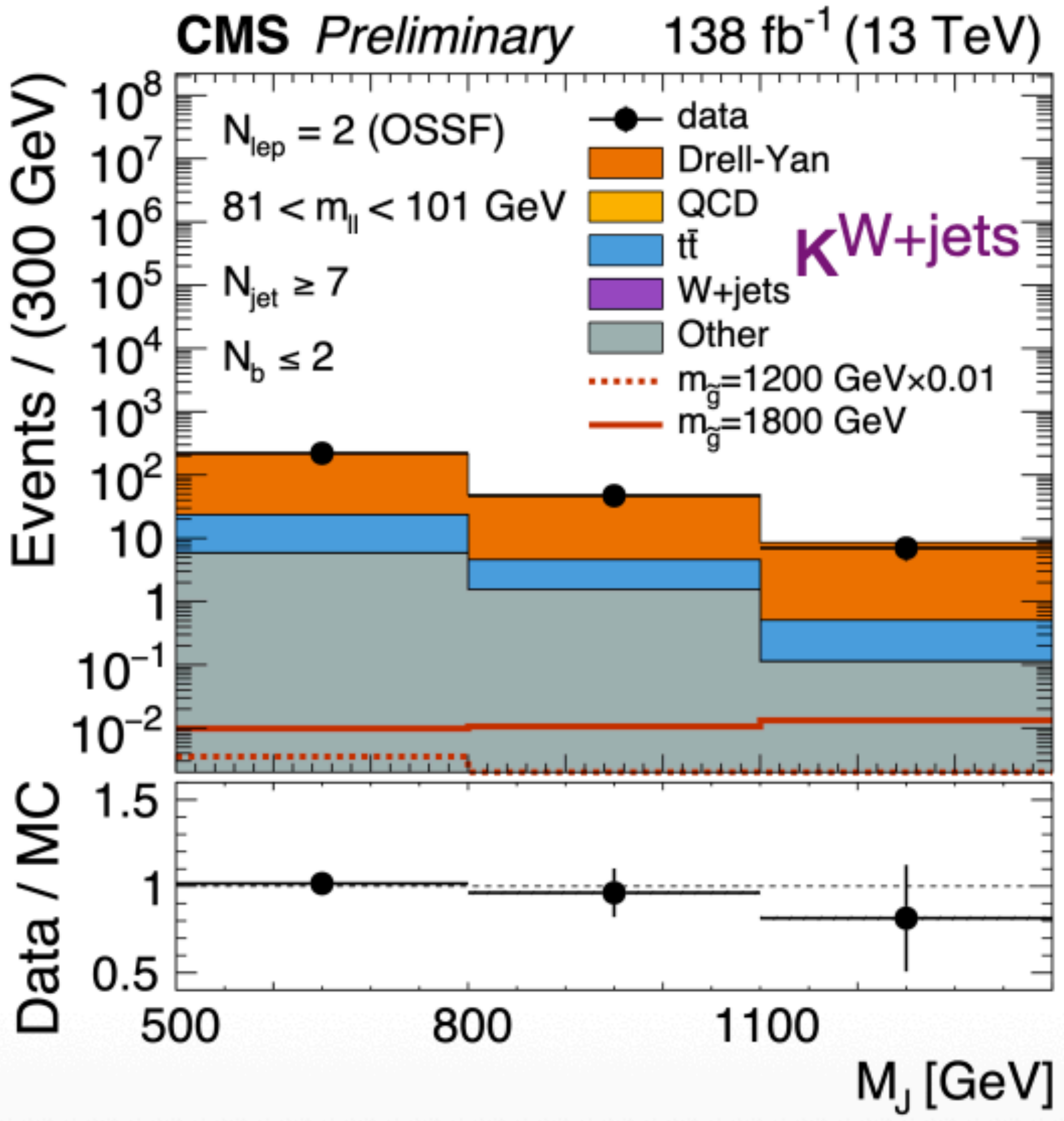
SUS-21-005

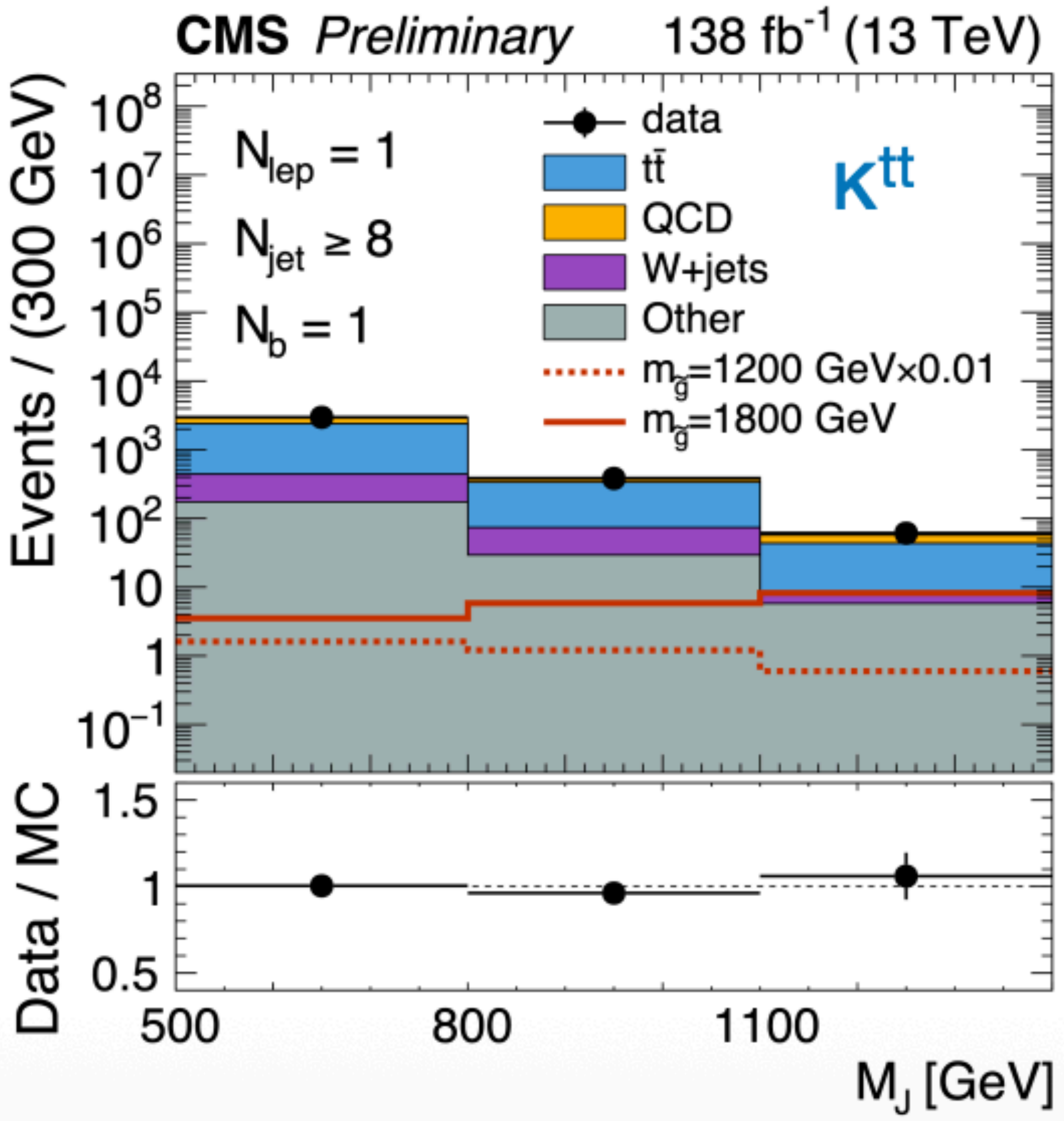
[Eur. Phys. J. C 81 (2021) 1023]





See Sezen's talk

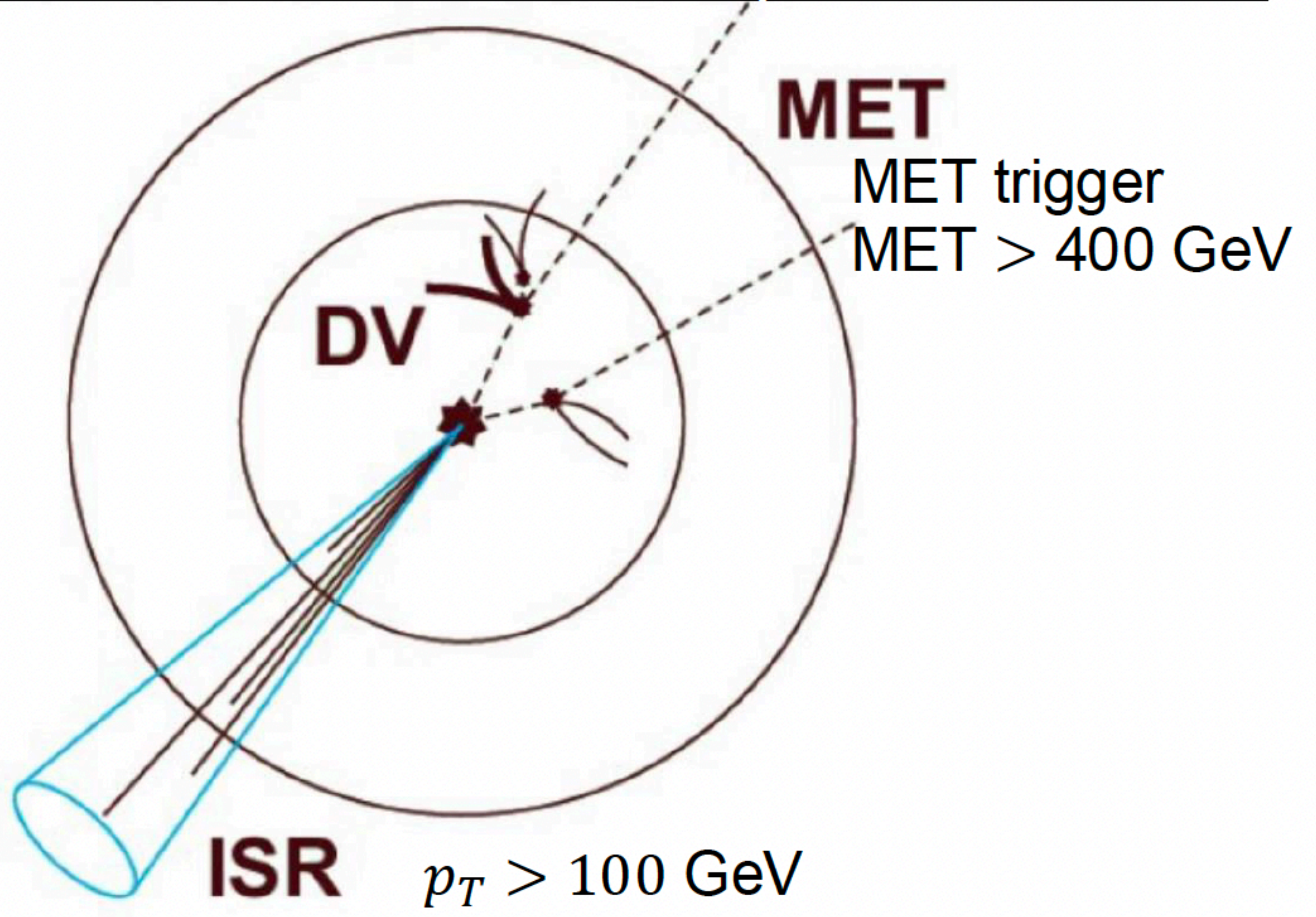




SUSY co-annihilation with LLP

CMS-PAS-EXO-24-033

ISR + MET + Soft Displaced Vertex



DV: ≥ 2 tr (pT > 0.5 GeV)

Veto on selected e,μ, Ɣ, τ

Non-standard track (pre)selection

Low p_T : > 0.5 GeV

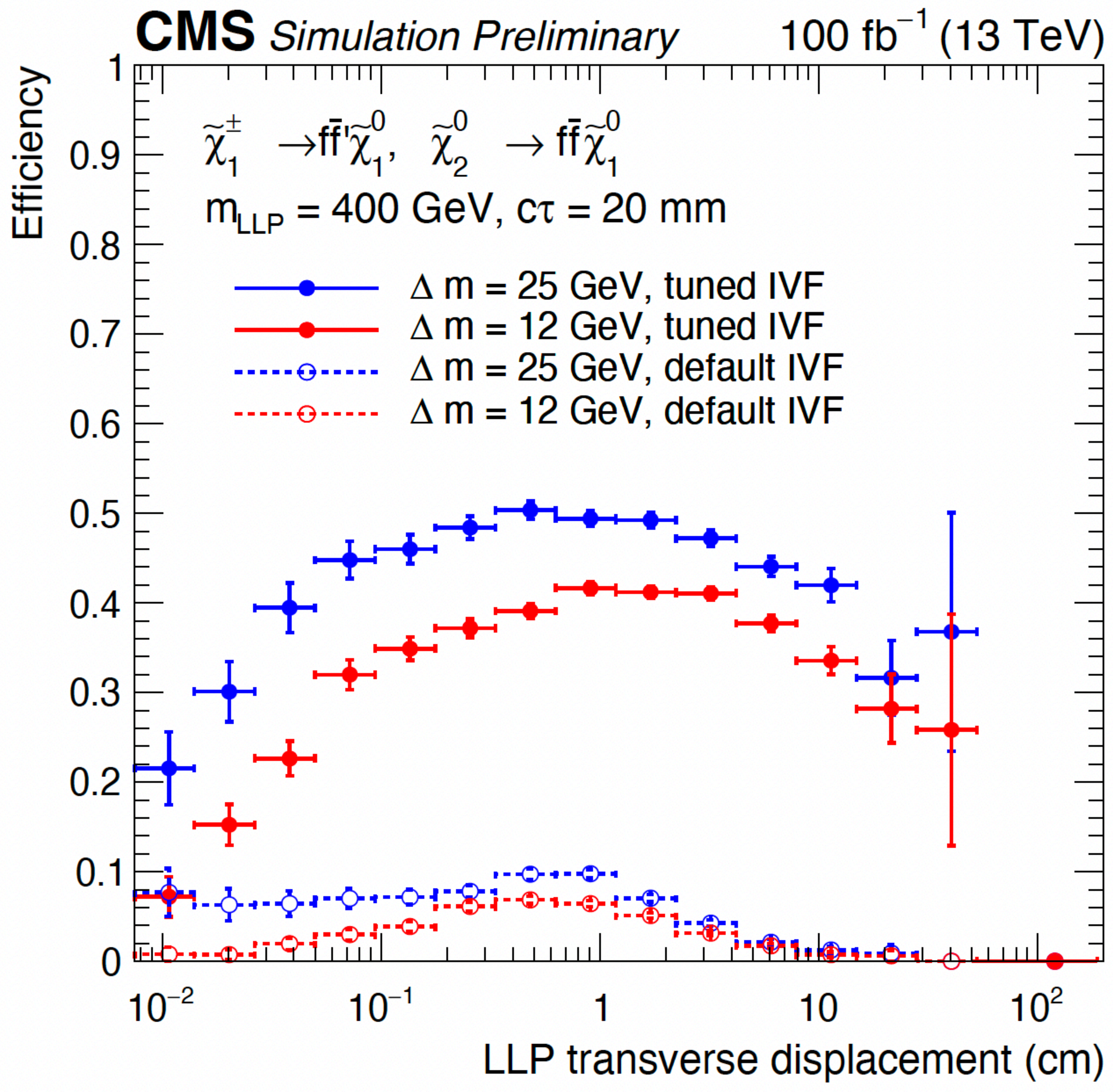
Displaced: $|d_{xy}|/\sigma_{d_{xy}}$ > (2) 4

Number of valid hits: > (6)13

Soft Displaced Vertex

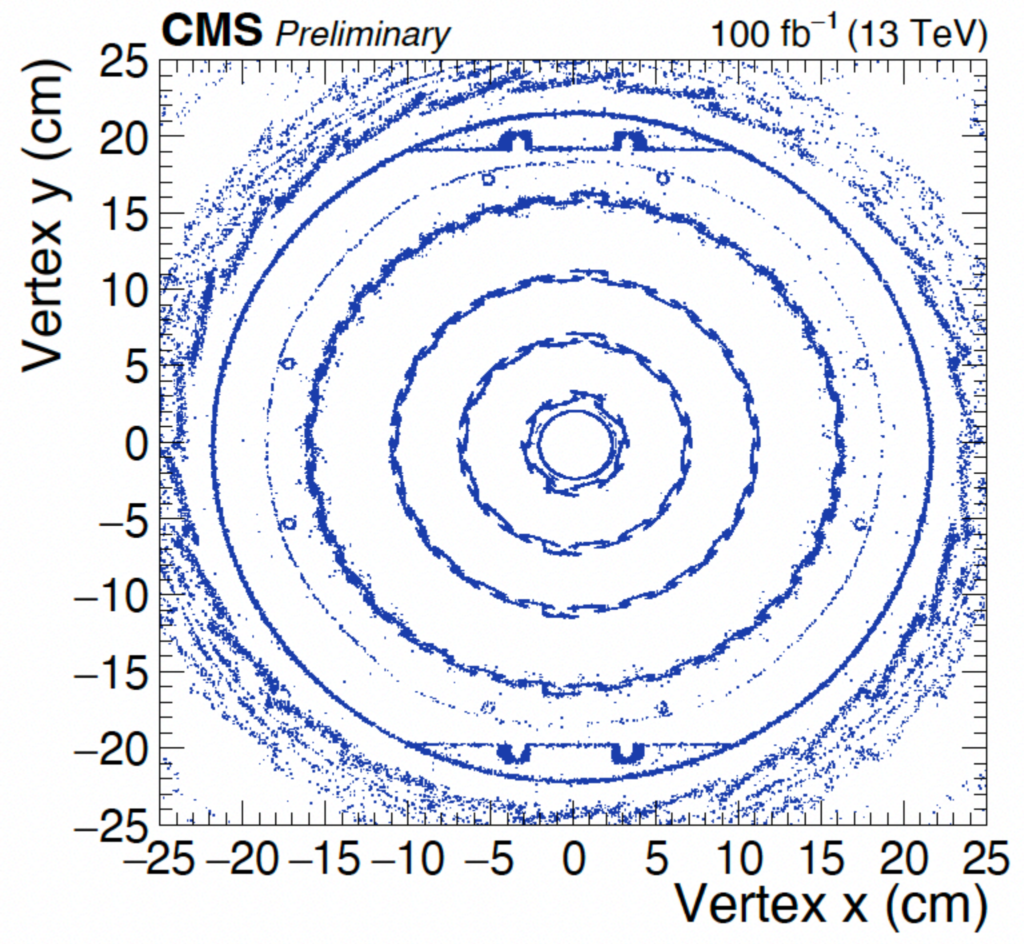
Inclusive Vertex Finder tuned for LLP

- Large opening angle
- Vertex momentum not pointing to primary vertex



Veto on tracker material region:

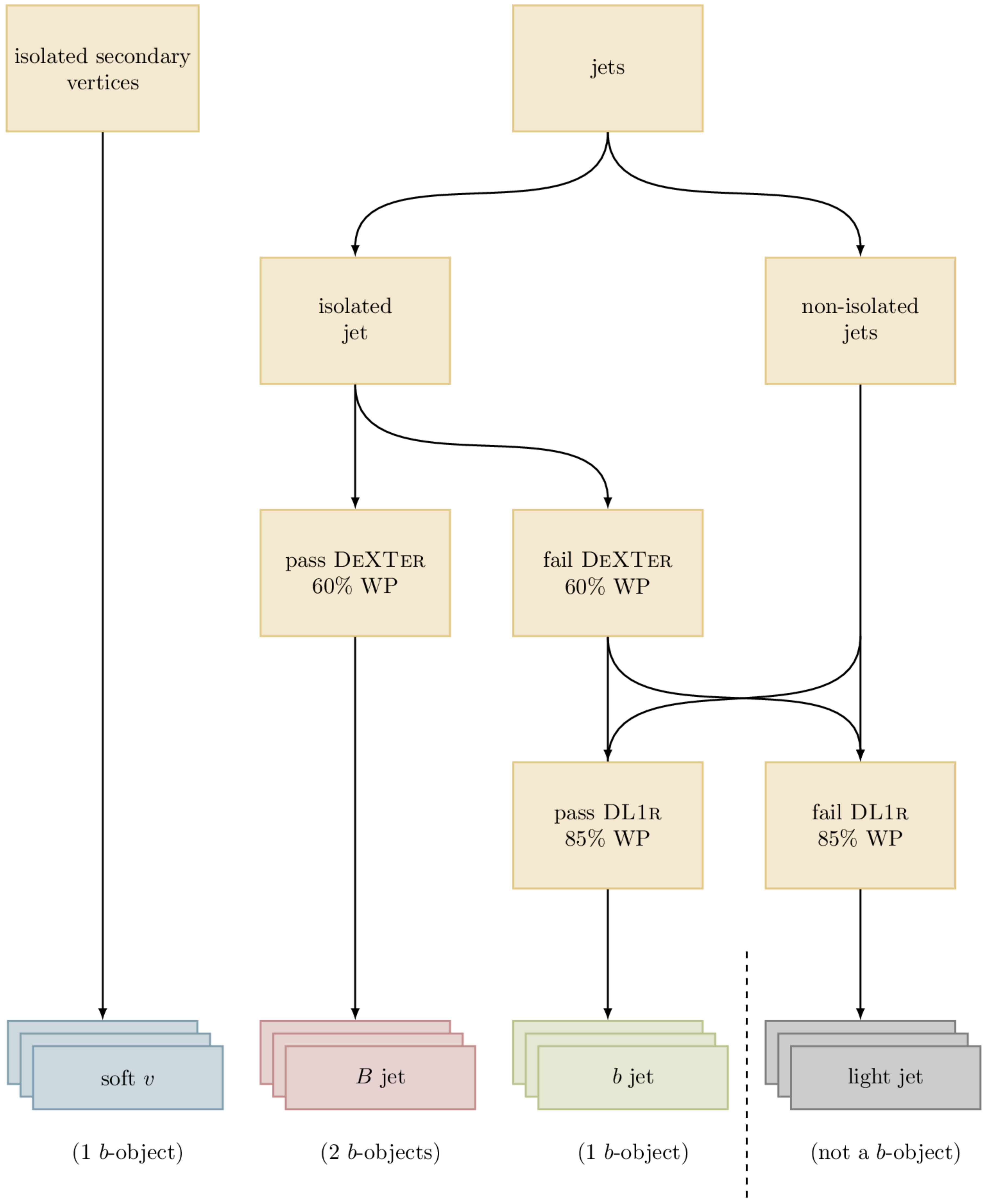
→ nuclear interaction is a source of background vertices

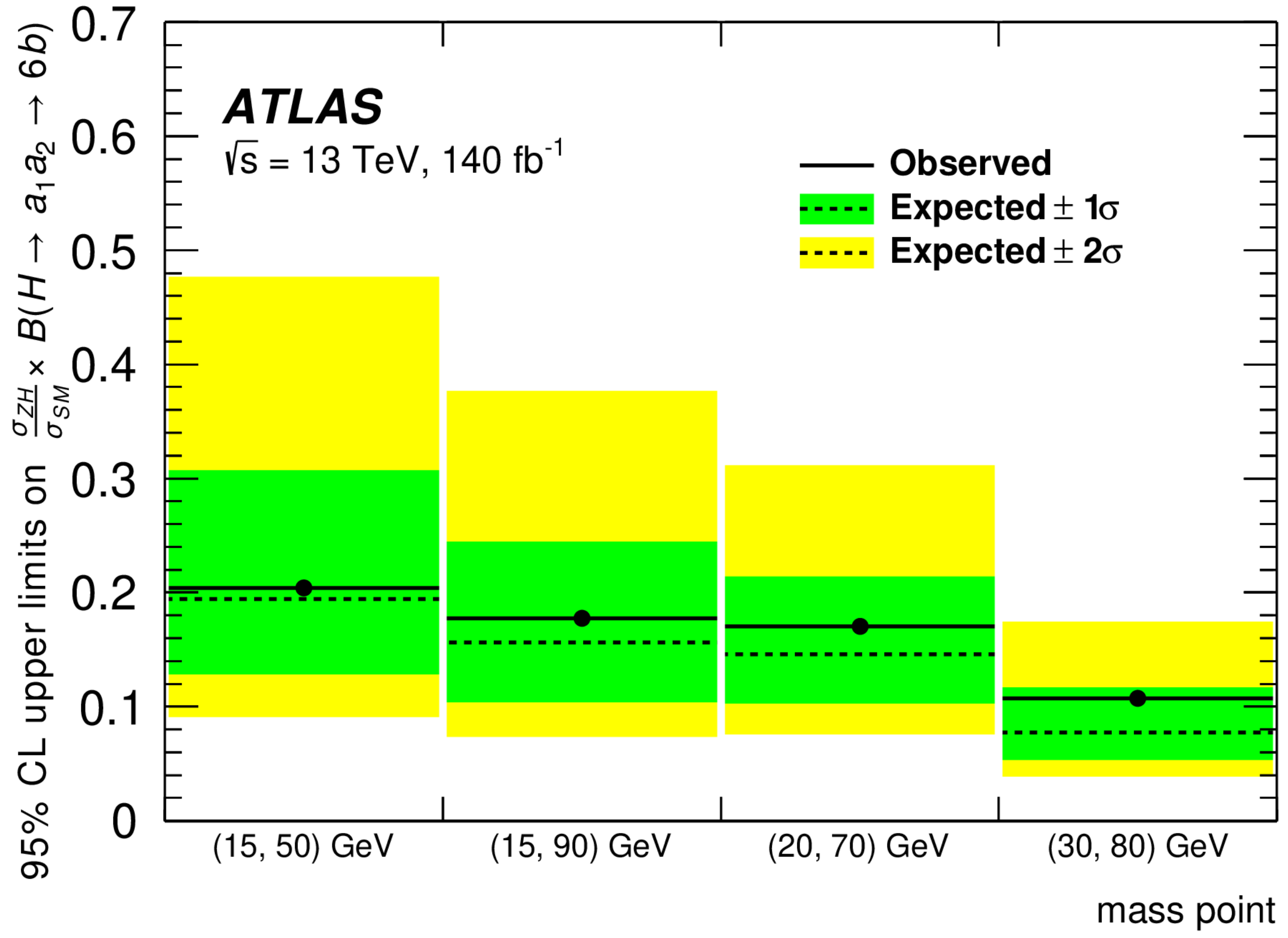


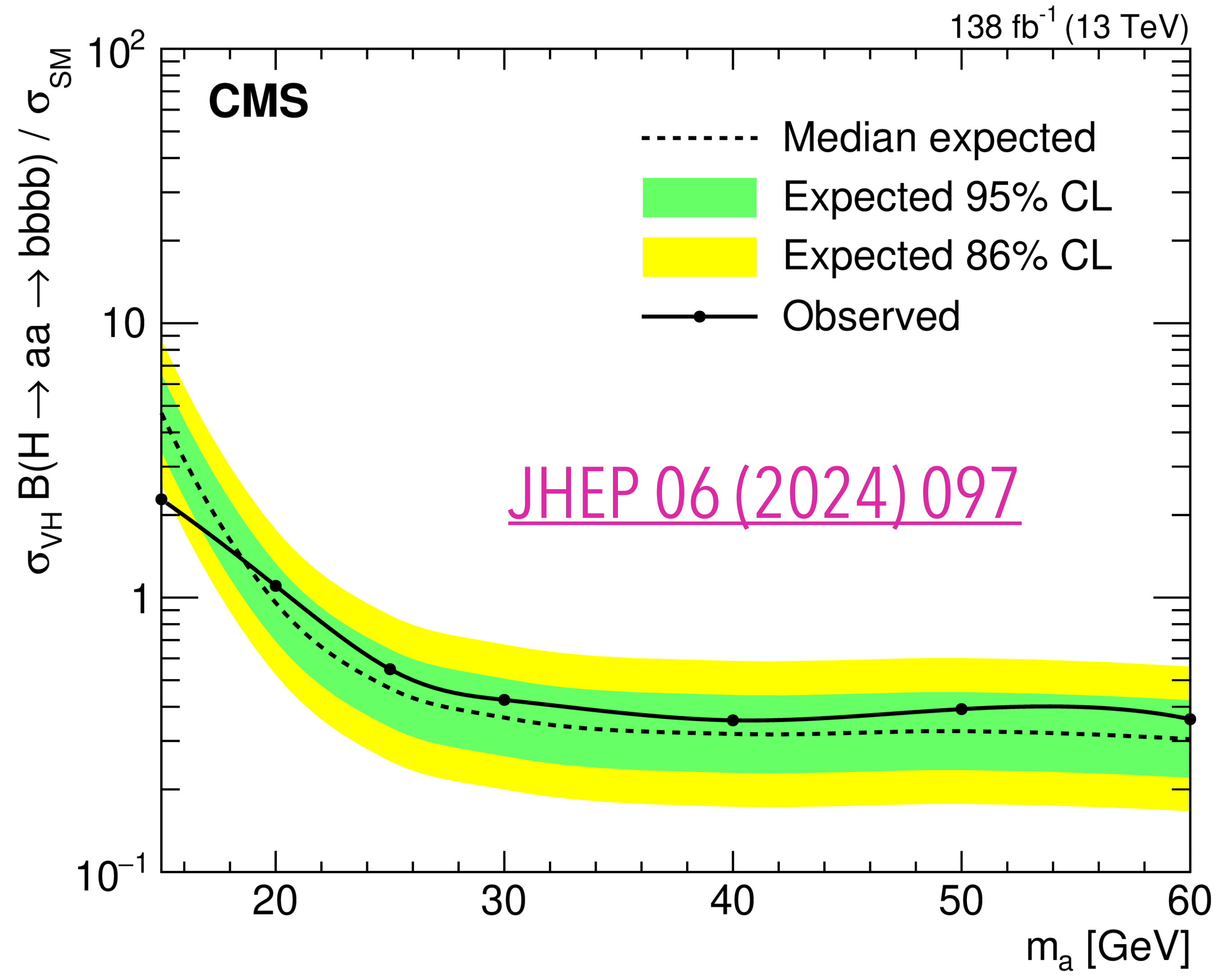
See Eric's talk

ZH (H → aa → 4b/6b)

CERN-EP-2025-121, submitted to PRD

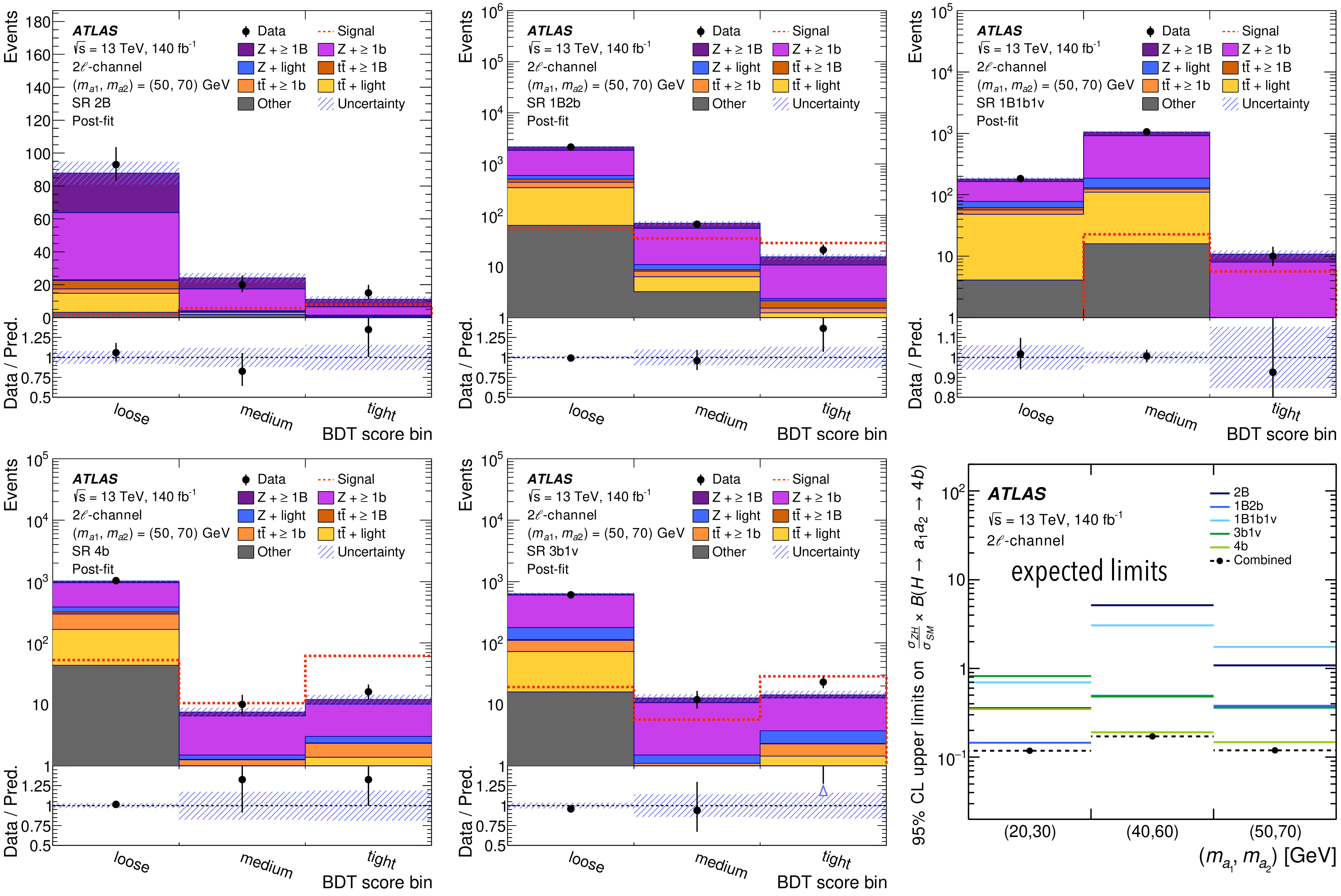






ZH (H → aa → 4b/6b)

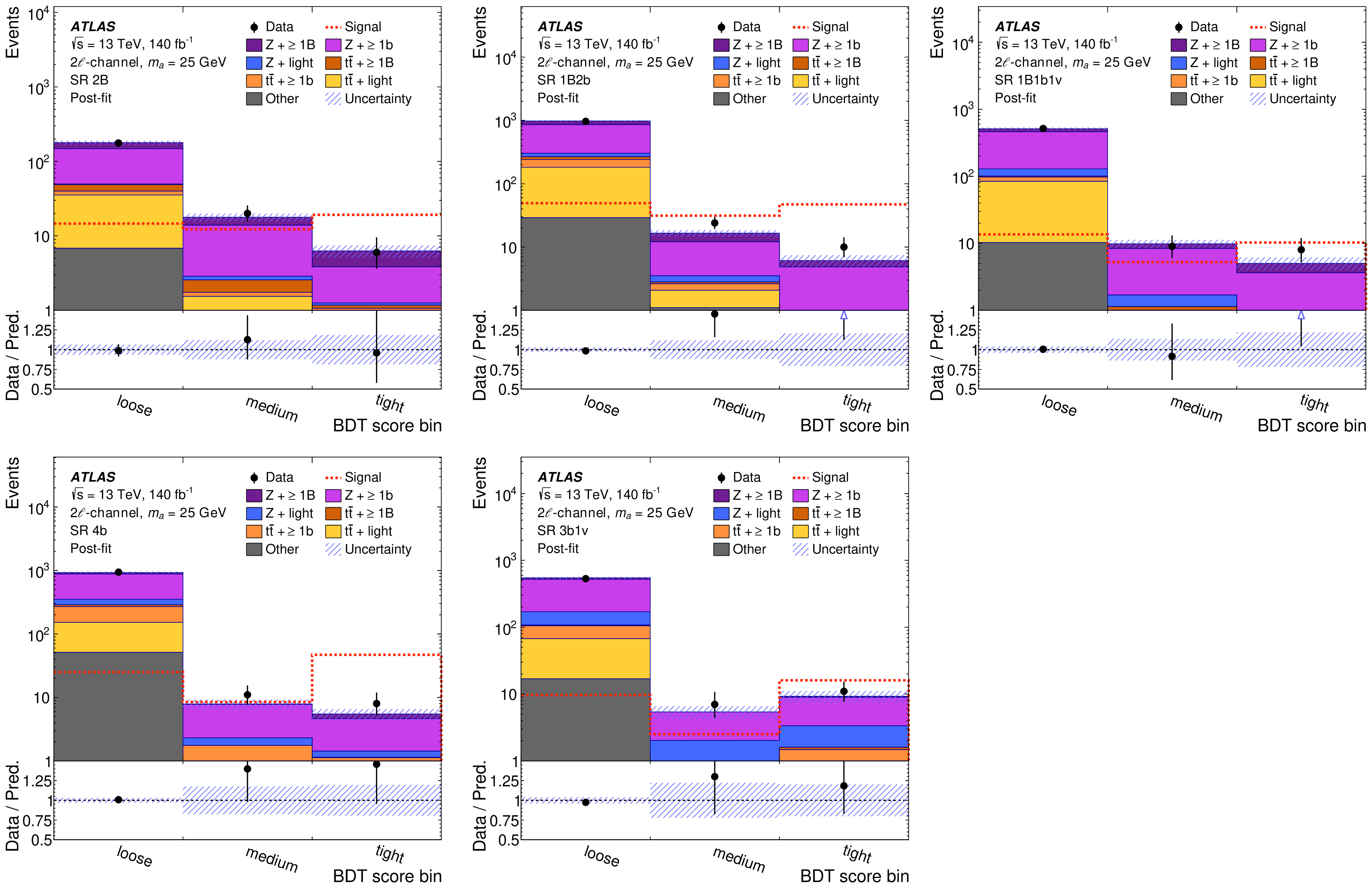
CERN-EP-2025-121, submitted to PRD



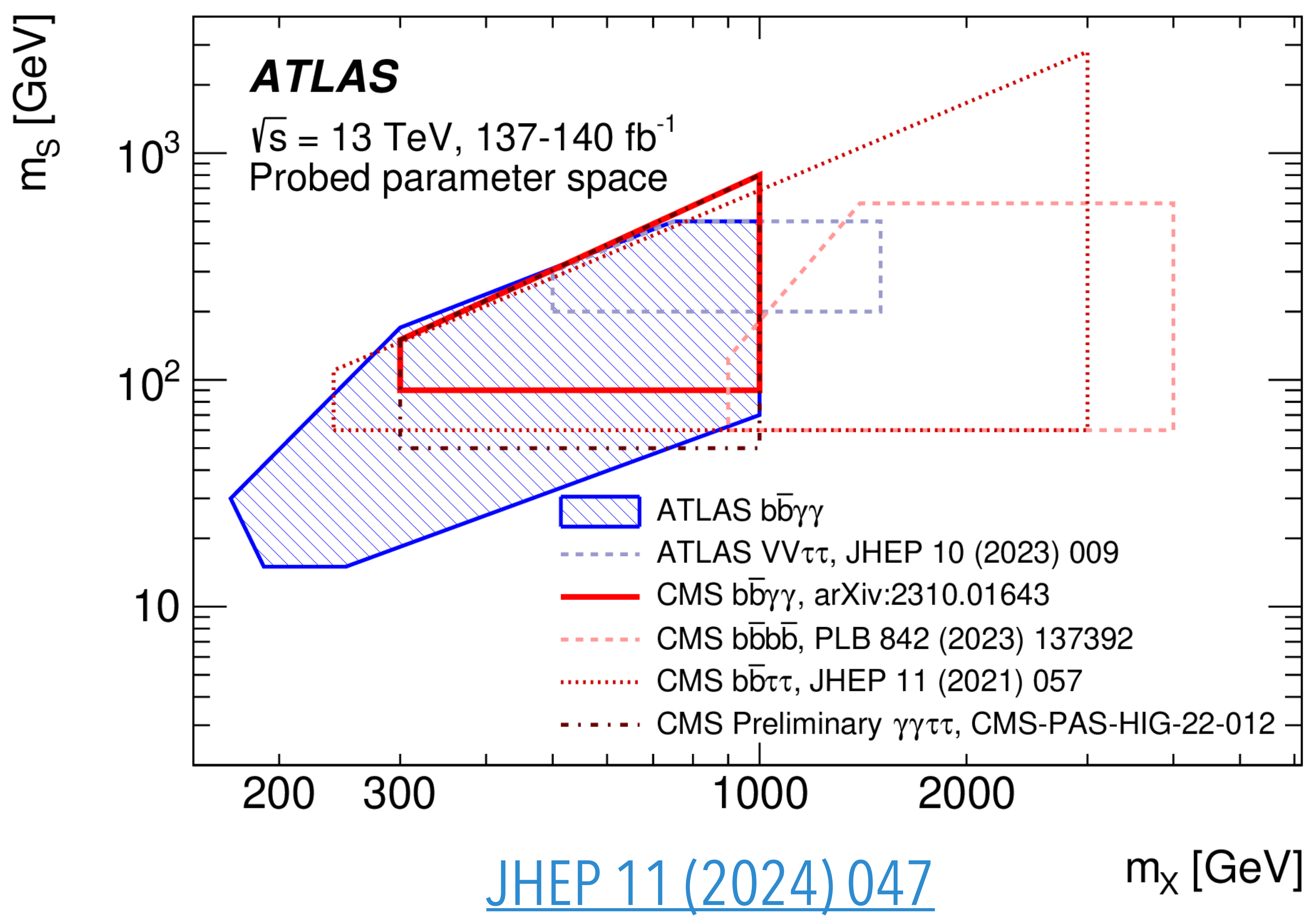
ZH (H → aa → 4b/6b)

CERN-EP-2025-121, submitted to PRD

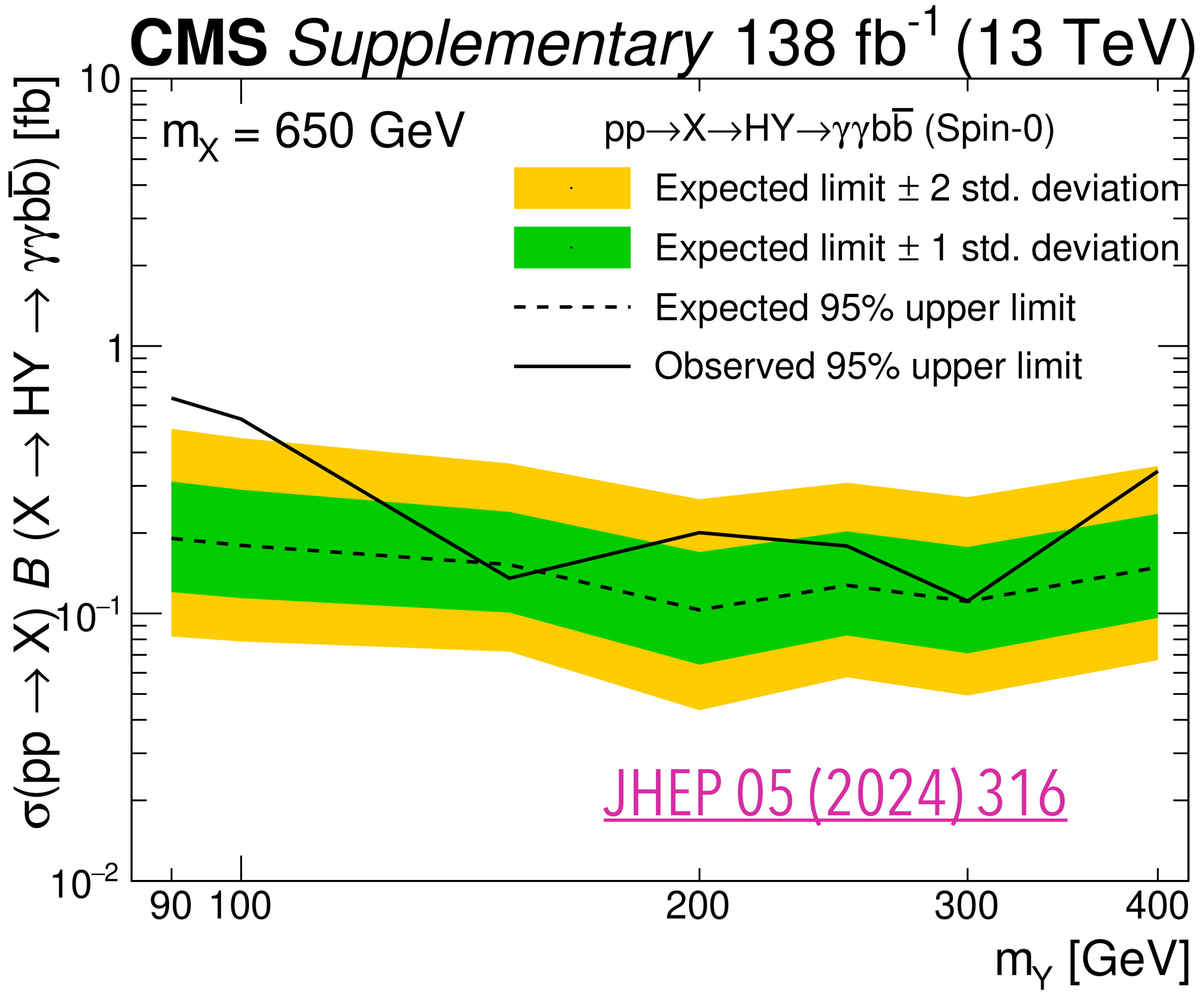
ATLAS EXPERIMENT



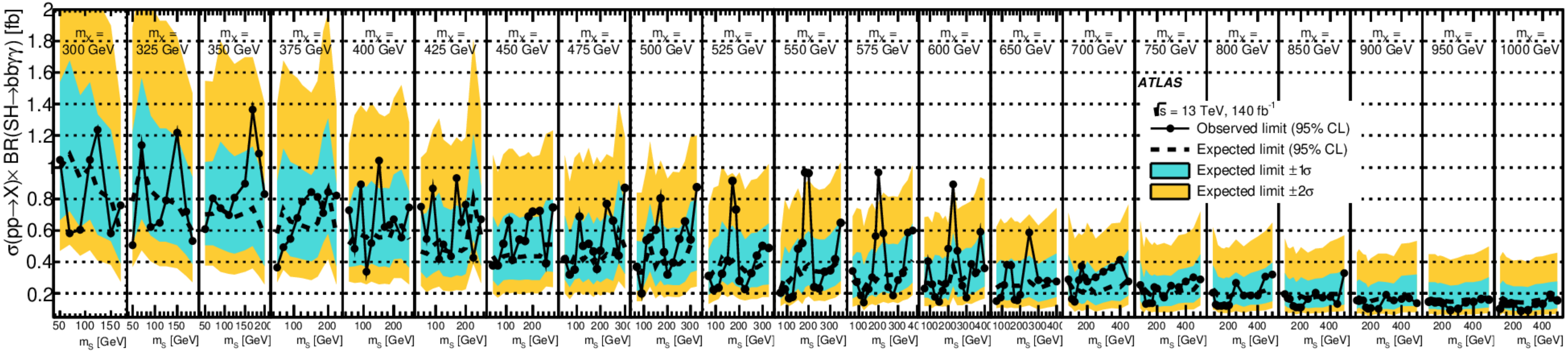
X→SH→bbγγ



JHEP 11 (2024) 047



JHEP 05 (2024) 316



X→YH→VV(4q)bb

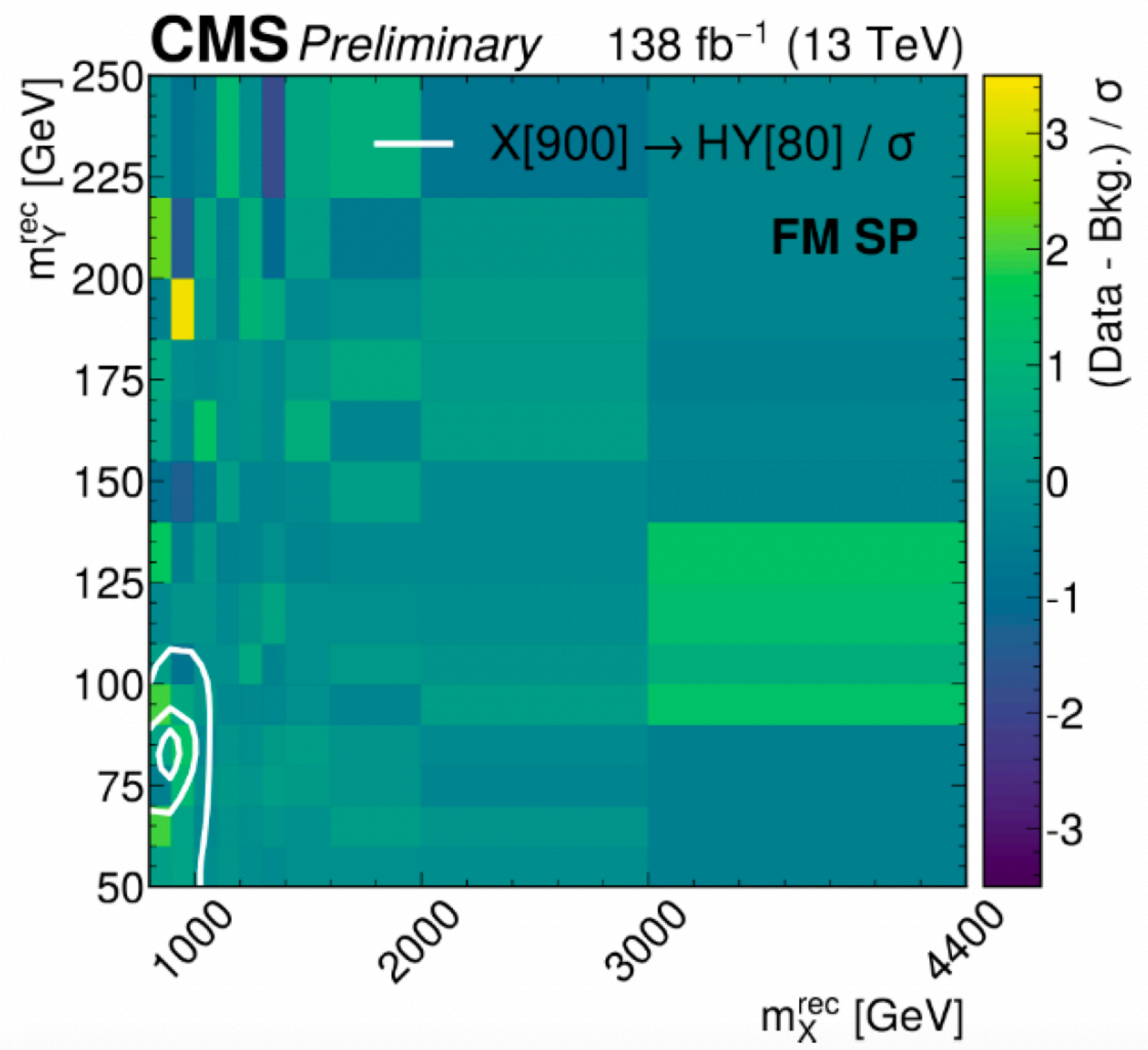
The analysis exploits **state-of-the-art substructure techniques and taggers to identify boosted final states**:

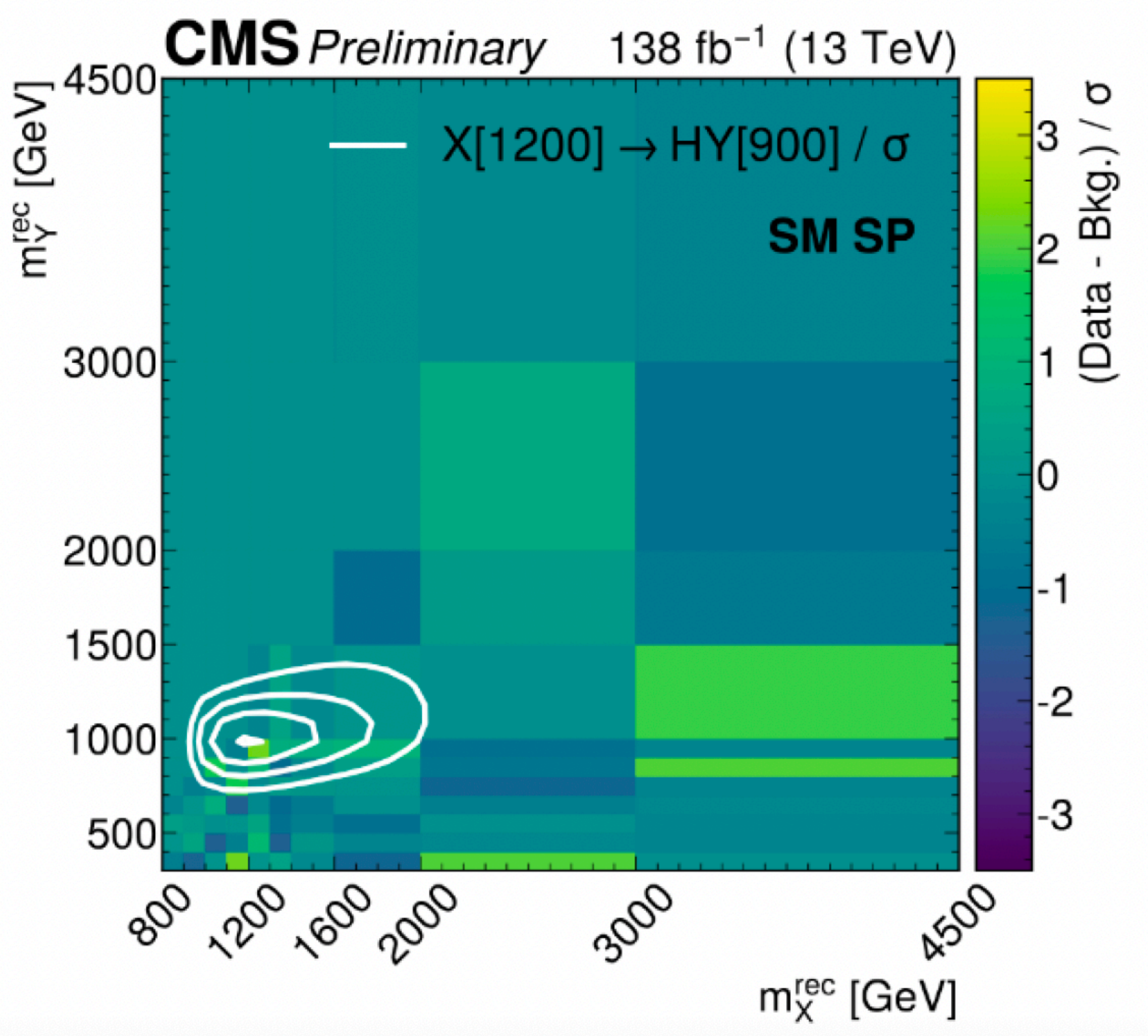
✓ **ParticleNET jet tagger for $H \to b\bar{b}$ and $V \to q\bar{q}$: the leading graph-based tagger in CMS** [PhysRevD.101.056019]

✓ **ParT jet tagger for $Y \to VV \to 4q$: novel attention-based "particle transformer"** [arXiv:2202.03772]

Data-driven background prediction:

- **Signal (SP, SF) and Validation (VP, VF)** regions are defined, with **Pass and Fail Modes** to predict background in a data-driven way.
- **[QCD prediction in SP] = [Data in SF] × $R(m_X, m_Y)$**
  - $R(m_X, m_Y)$ parametrized as 2D Bernstein polynomials





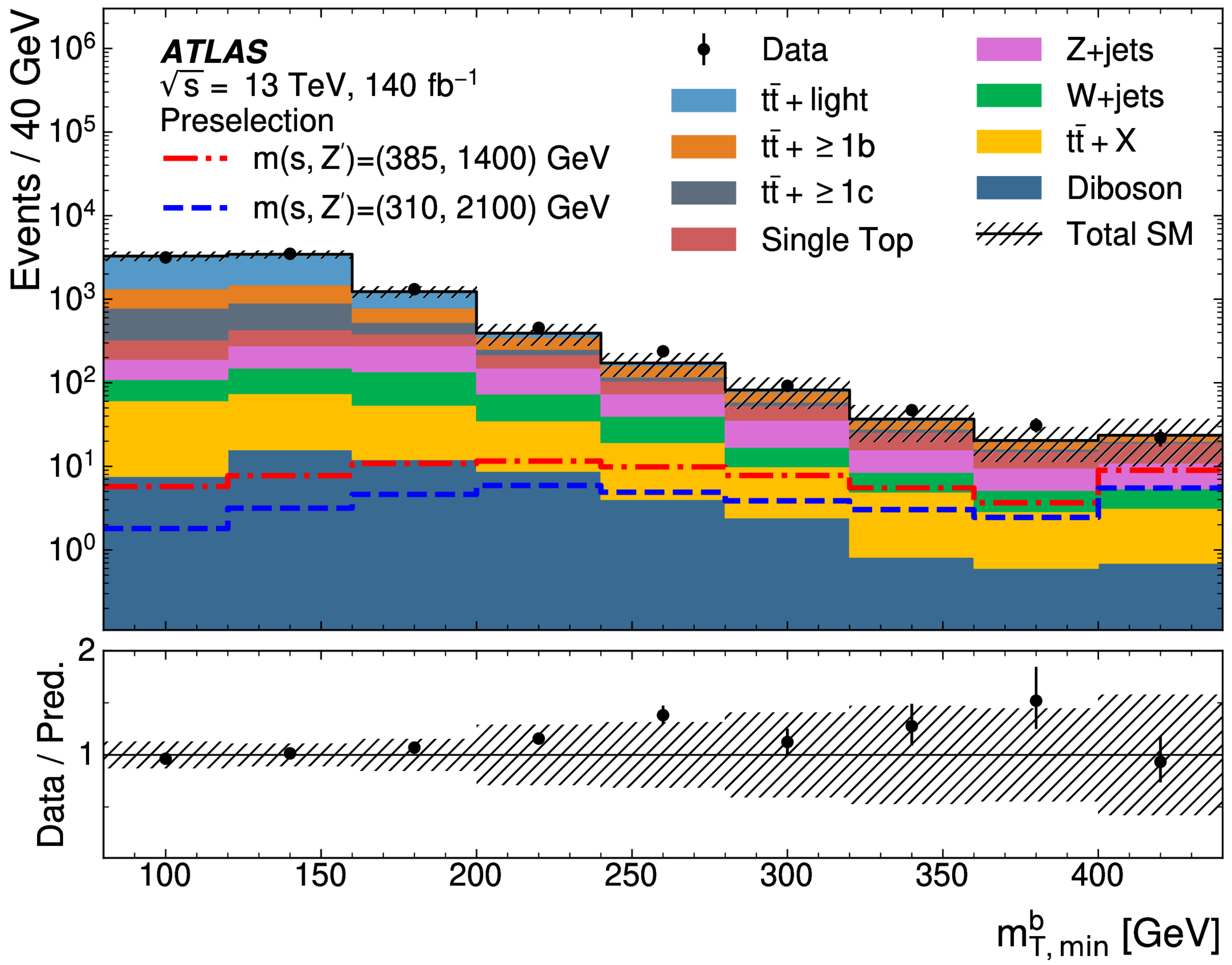
See Ilias' talk

Dark Higgs, multi-b + p_T^{miss}

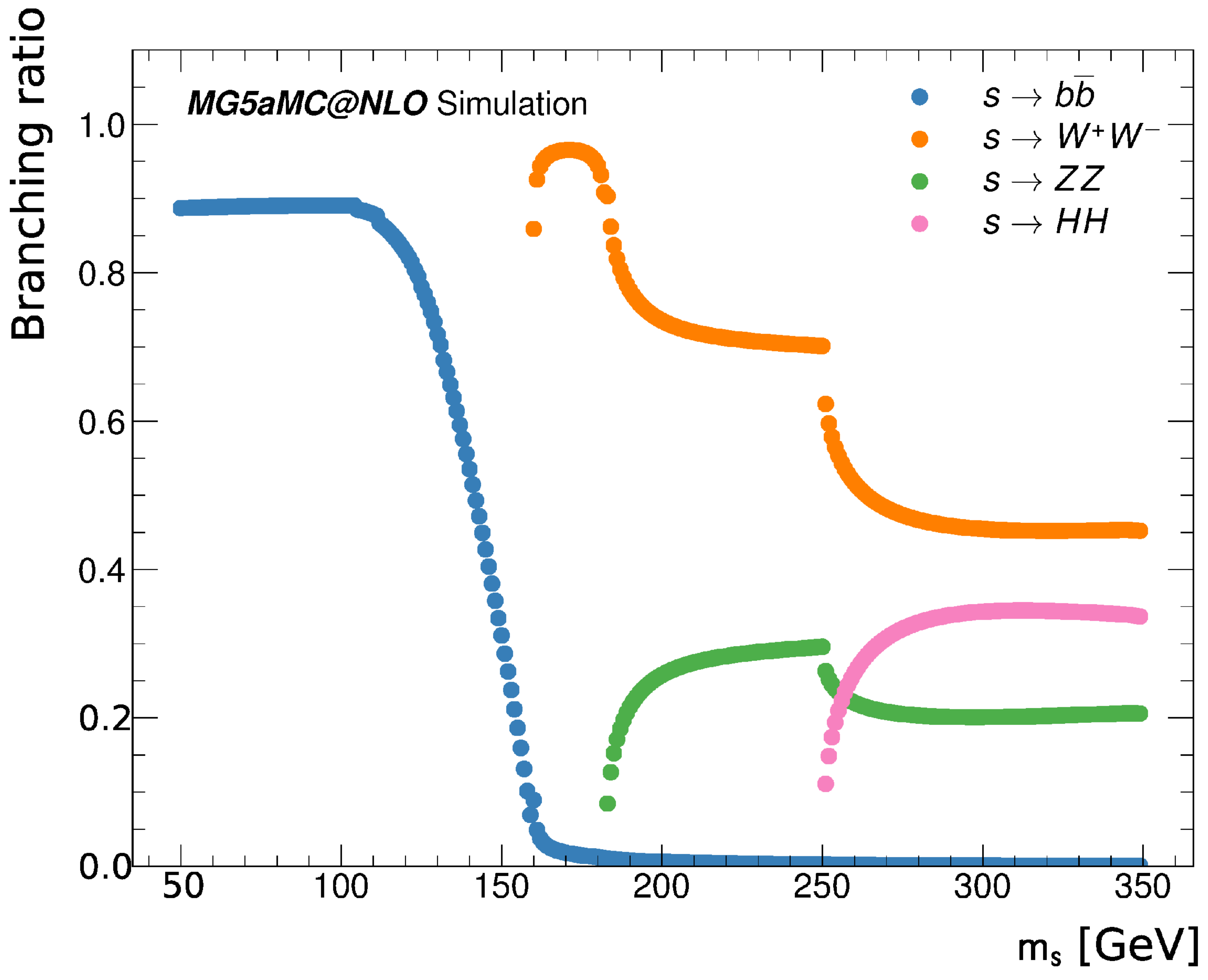
CERN-EP-2025-141 (submitted to JHEP)

ATLAS EXPERIMENT

- selections made on p_T^{miss}-based variables: $m^b_{T,min}$, $\Delta\phi^{4j}_{min}$ and $S(p_T^{miss})$



ATL-PHYS-PUB-2019-032



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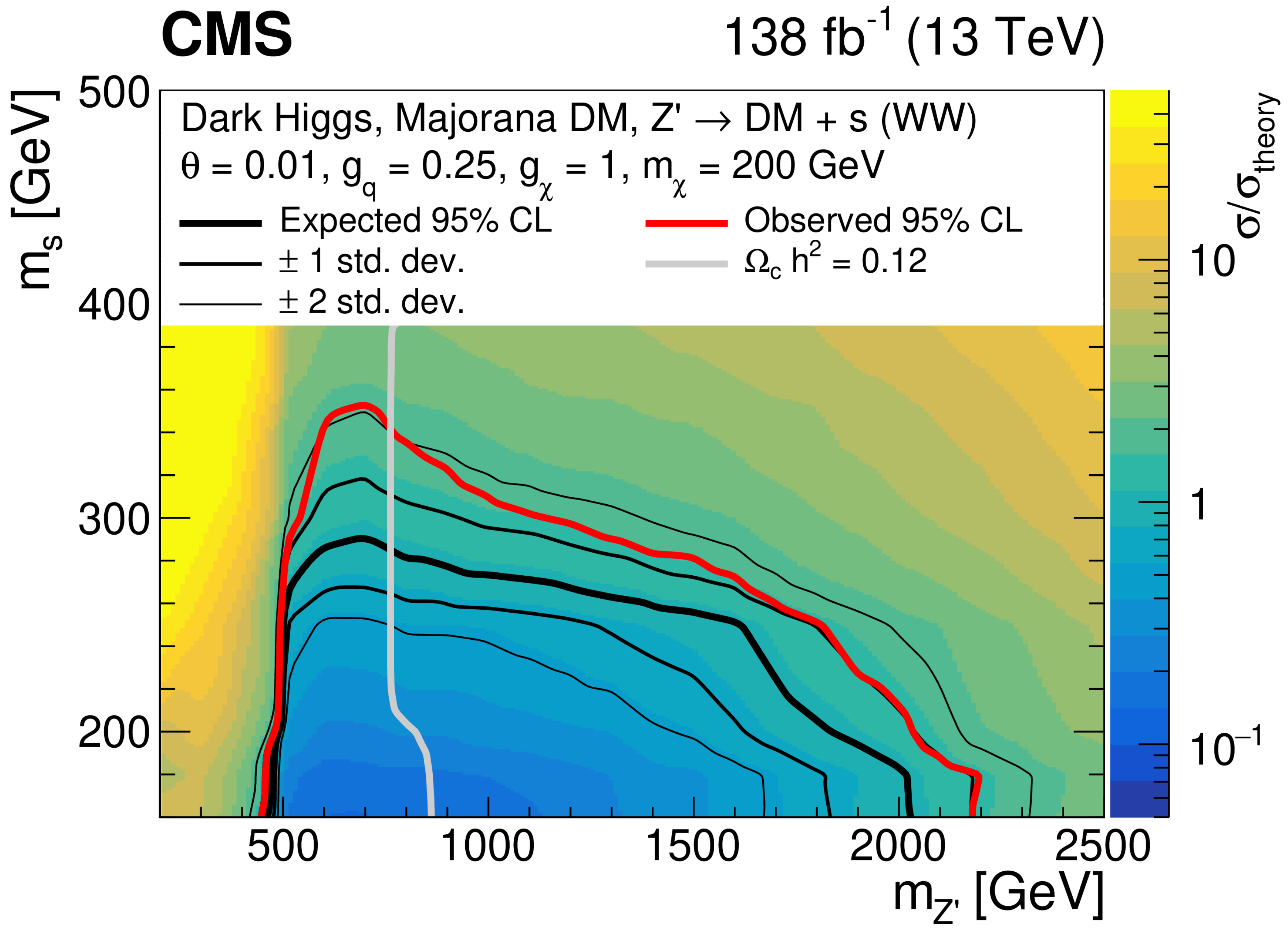


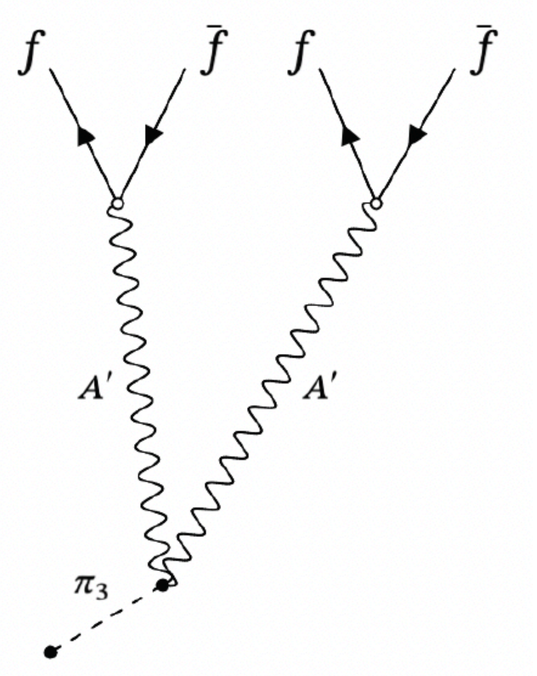
$$m^b_{\mathrm{T,min}} = \min_{1\le i\le 3} \sqrt{(p_{\mathrm{T}}(b_i) + p_{\mathrm{T}}^{\mathrm{miss}})^2 - (p_{\mathrm{x}}(b_i) + p_{\mathrm{x}}^{\mathrm{miss}})^2 - (p_{\mathrm{y}}(b_i) + p_{\mathrm{y}}^{\mathrm{miss}})^2}$$

Dark Photon LLP to μ

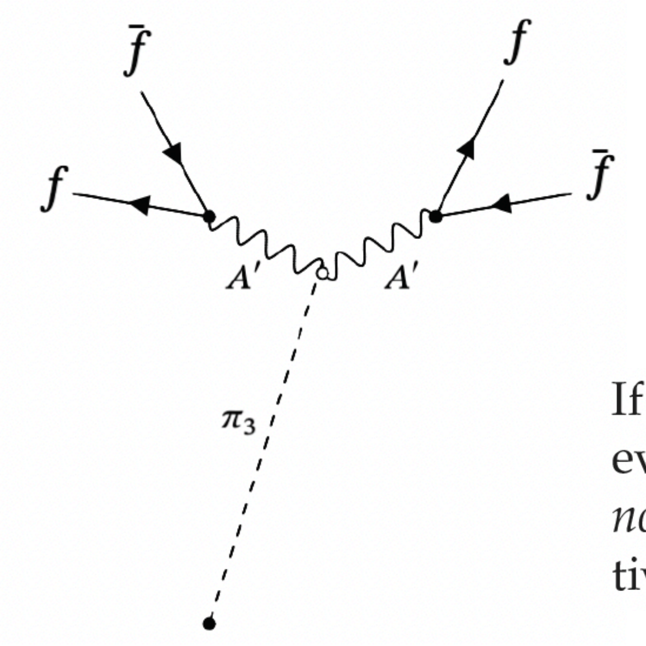
EXO-24-016

Dark Shower Scenarios:

Scenario A: long-lived A′

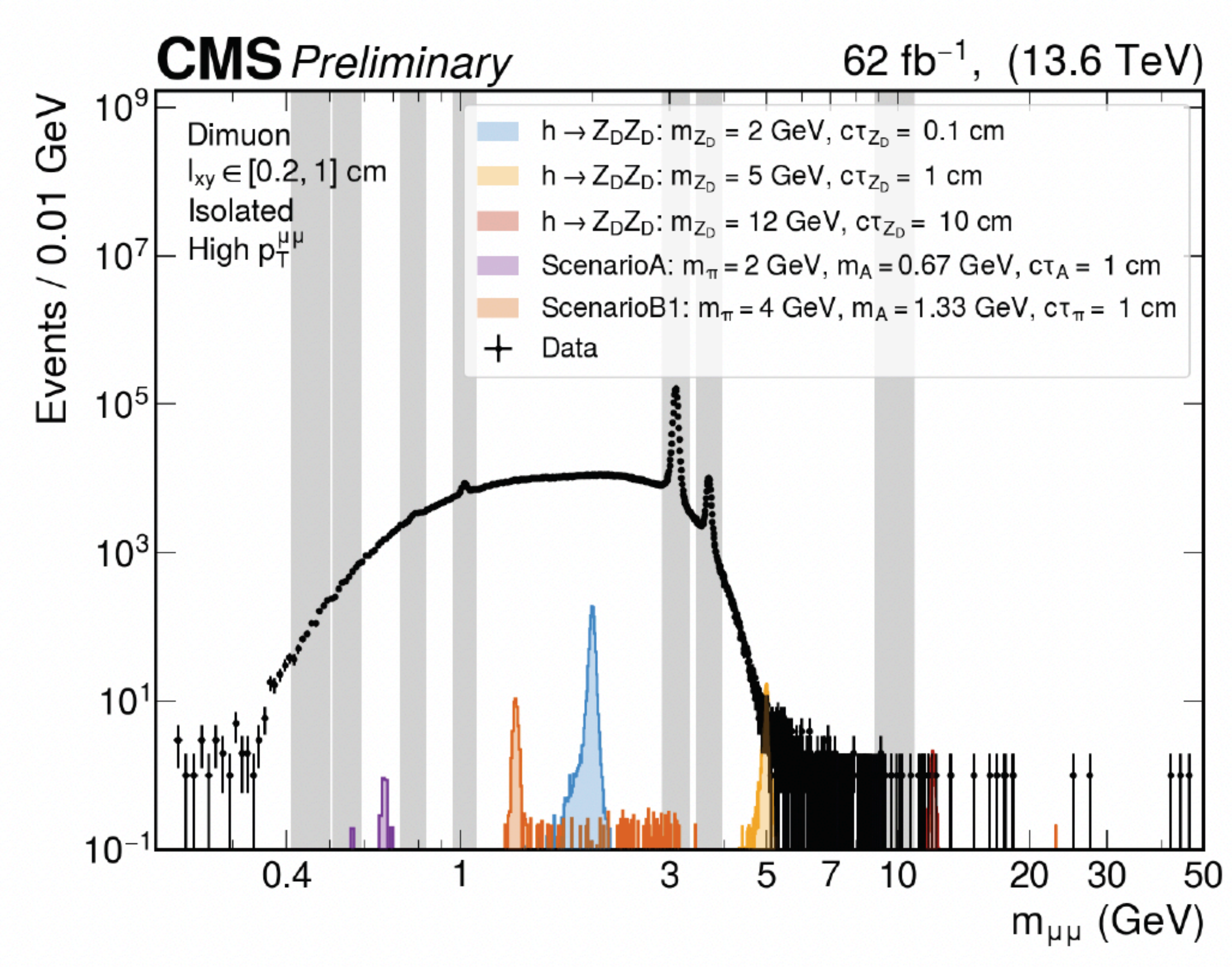


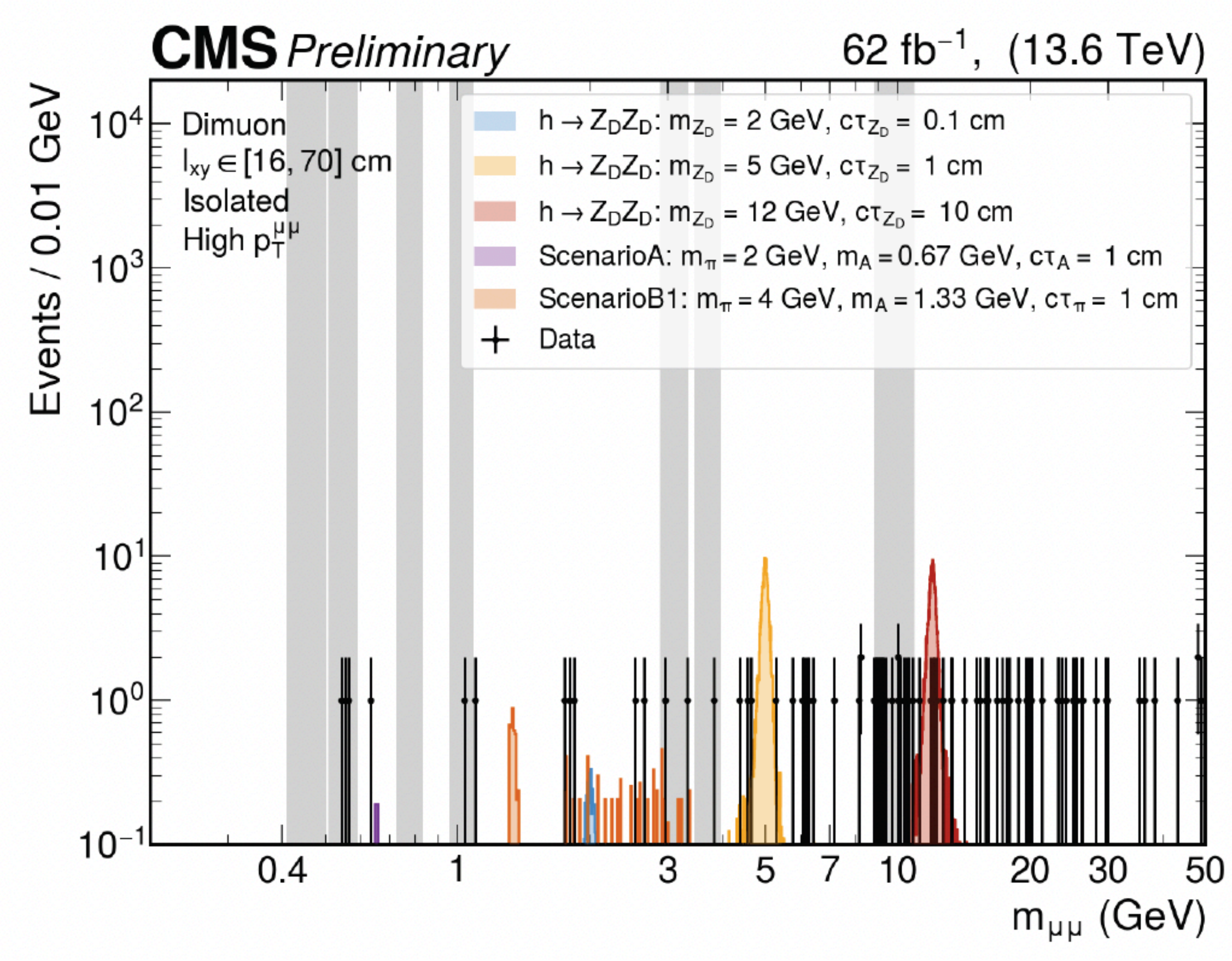
Scenario B1: long-lived π_3

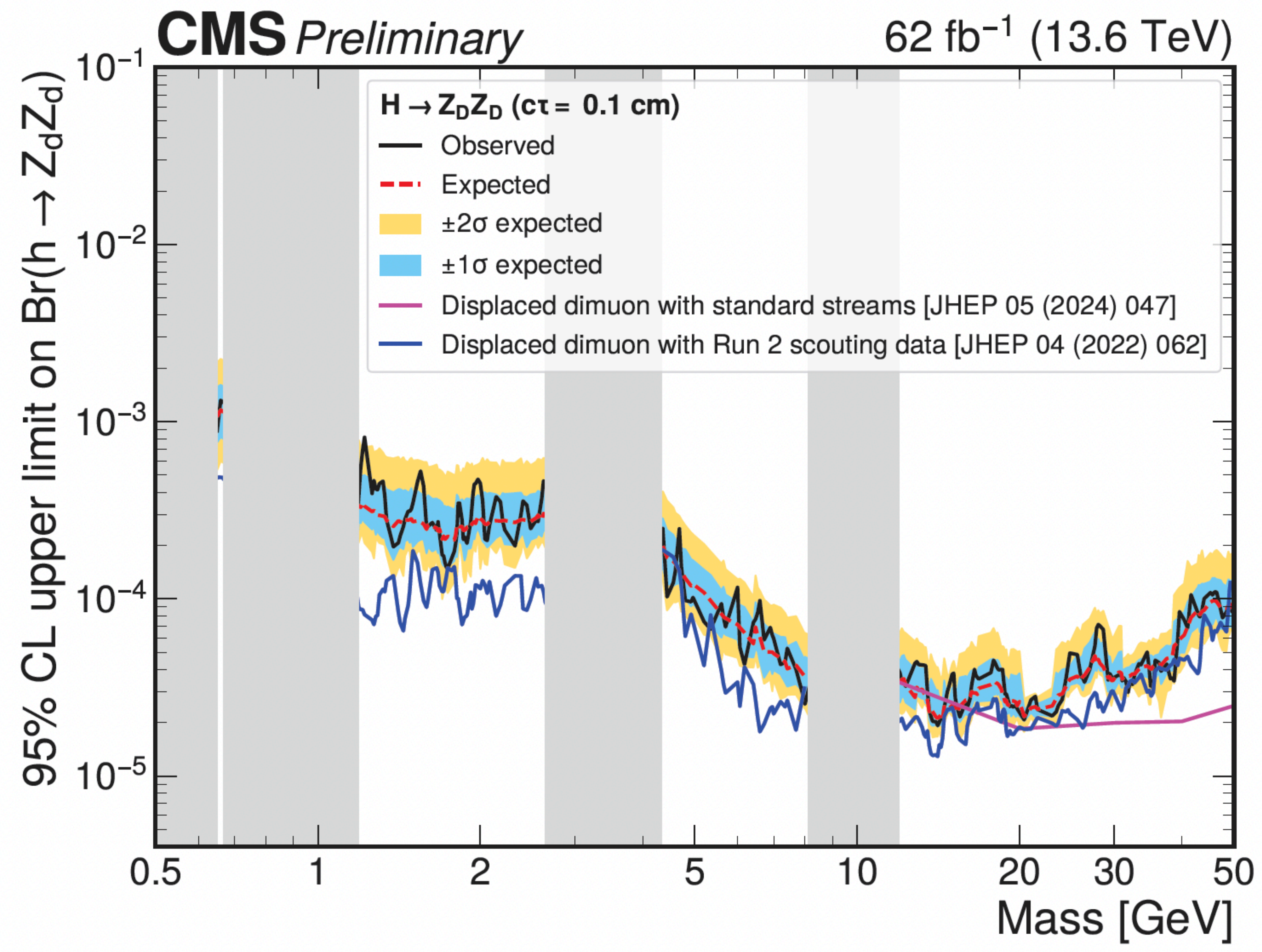


first analysis to study displaced dimuon vertices beyond 11 cm using scouting data

If only two muons from a SV are found, the event is categorized as a dimuon event. For dimuon events, we first define two orthogonal regions in $|\Delta\Phi(\mu\mu,\mathrm{SV})|$, distinguishing *pointing* and *nonpointing* topologies, with $|\Delta\Phi(\mu\mu,\mathrm{SV})| < 0.02$ and $0.02 < |\Delta\Phi(\mu\mu,\mathrm{SV})| < \pi/2$, respectively.







LLP triggers

EXO-23-016

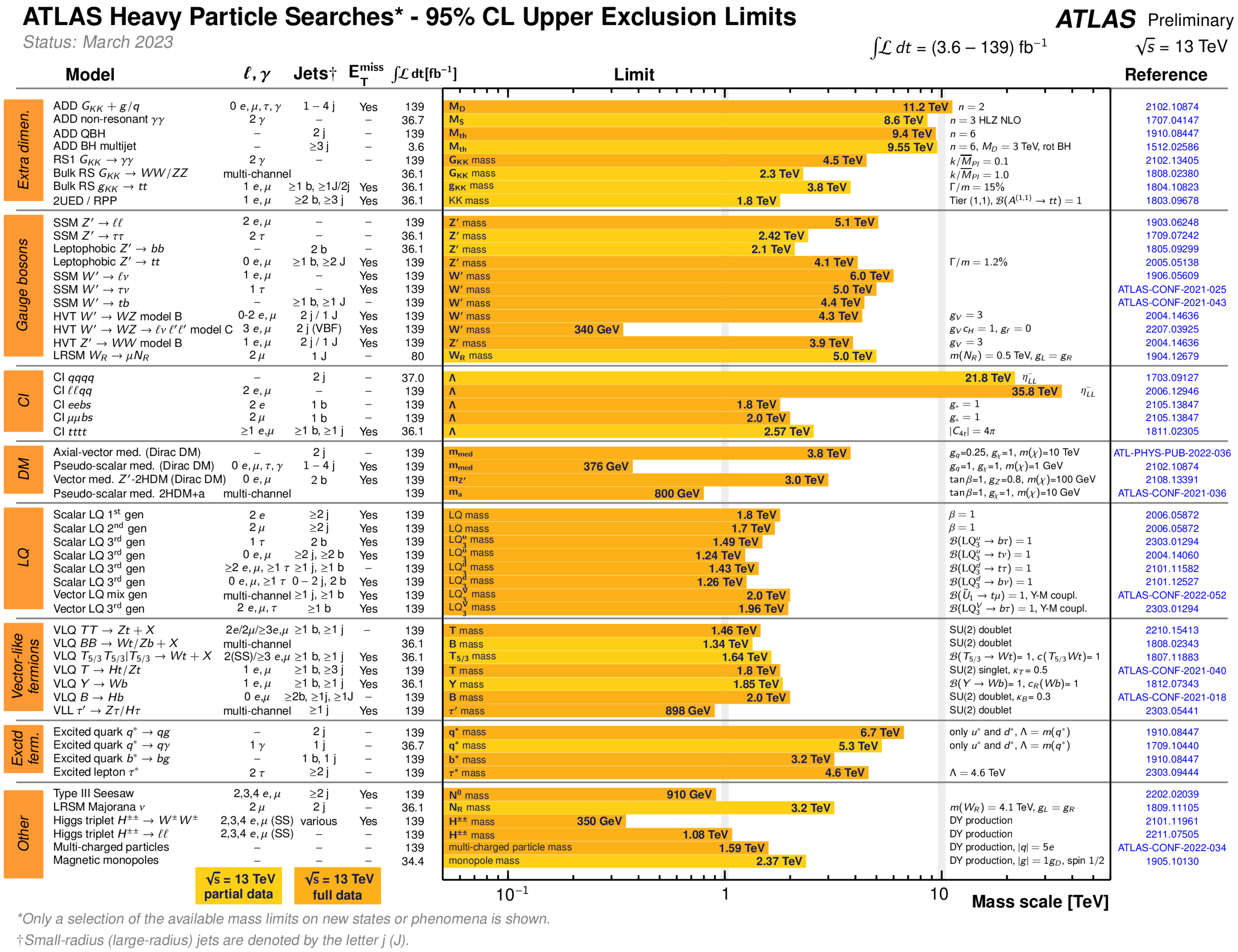
Table 2: The LLP triggers and their total rates at the HLT in Run 3, calculated from 2024 data for an instantaneous luminosity of 2.1×10^{34} cm^{-2}s^{-1}, with a mean PU of 63.6. Triggers implemented for the first time in Run 3 are indicated by a dagger (†). Rate values in parentheses correspond to the parked data rates; all others are standard data rates except for dimuon scouting. Nearly all rates shown have a statistical uncertainty of less than 1 Hz. "Disp." is used as an abbreviation for "displaced" and "req." is used as an abbreviation for "requirement". The terms used in this table are explained in the corresponding subsection within Section 6.

Triggered signature	Trigger description	HLT rate [Hz]
Disappearing track	$p_T^{miss} > 105$ GeV + $\geq$1 isolated track ($p_T > 50$ GeV)	4
Disp. tau	$\geq$2 disp. τ_h ($p_T > 32$ GeV, $d_0 > 0.005$ cm)† $\geq$1 disp. τ_h ($p_T > 24$ GeV) + $\geq$1 μ ($p_T > 24$ GeV)† $\geq$1 disp. τ_h ($p_T > 34$ GeV) + $\geq$1 e ($p_T > 34$ GeV)†	36
Disp. jet	$\geq$2 jet ($p_T > 40$ GeV, inclusive tagging req.) + $H_T > 430$ GeV $\geq$2 jet ($p_T > 40$ GeV, disp. tagging req.) + $H_T > 240$ GeV + $\geq$1 L1 μ ($p_T > 6$ GeV)	53 (163)
HCAL-based disp. and delayed jet	$\geq$2 jet ($p_T > 40$ GeV, displ. tagging req.) + $H_T > 170$ GeV† $\geq$2 jet ($p_T > 40$ GeV, inclusive. tagging req.) + $H_T > 200$ GeV† $\geq$1 jet ($p_T > 60$ GeV, neutral hadron energy fraction >0.7) + $H_T > 200$ GeV†	35
ECAL-based delayed jet	$\geq$1 inclusive and trackless jet†	37 (77)
Delayed diphoton	$\geq$2 ECAL superclusters (time >1 ns)†	15
Disp. photon + H_T	$\geq$1 γ ($p_T > 60$ GeV) + PF $H_T > 350$ GeV	12
Disp. single and dimuon	$\geq$2 L2 μ ($p_T > 10$ GeV, $d_0 > 1$ cm)† $\geq$2 L3 μ ($p_T > 16, 10$ GeV, $d_0 > 0.01$ cm)† $\geq$2 L2 μ ($p_T > 23$ GeV) $\geq$1 L2 μ ($p_T > 50$ GeV, $d_0 > 1$ cm)† $\geq$1 L3 μ ($p_T > 30$ GeV, $d_0 > 0.01$ cm)†	165
Double disp. L3 muon	$\geq$2 L3 μ ($p_T > 43$ GeV)	2
Disp. L3 muon+photon	$\geq$1 L3 μ ($p_T > 43$ GeV) + γ ($p_T > 43$ GeV) $\geq$1 L3 μ ($p_T > 38$ GeV, $d_0 > 1$ cm) + γ ($p_T > 38$ GeV)	5
Dimuon scouting	$\geq$2 scouting μ ($p_T > 3$ GeV)	4200
MDS in CSCs	$\geq$1 CSC cluster ($\geq$200/500 hits in outer/inner rings)† $\geq$2 CSC clusters ($\geq$75 hits)†	14
MDS in CSCs + X	$\geq$1 CSC cluster ($\geq$100 hits) + $\geq$1 e ($p_T > 5$ GeV)† $\geq$1 CSC cluster ($\geq$100 hits) + $\geq$1 L3 μ ($p_T > 5$ GeV)† $\geq$1 CSC cluster ($\geq$100 hits) + $\geq$1 τ_h ($p_T > 10$ GeV)† $\geq$1 CSC cluster ($\geq$50 hits) + $\geq$1 γ ($p_T > 20$ GeV)†	14
MDS in DTs	L1 $p_T^{miss} > 150$ GeV + $\geq$1 DT cluster ($\geq$50 hits)† $\geq$1 L1 CSC cluster + $\geq$1 DT cluster ($\geq$50 hits)†	9
Jet No-BPTX	$\geq$1 out-of-time jet ($E > 60$ GeV)	1
Muon No-BPTX	$\geq$1 out-of-time L2 μ ($p_T > 40$ GeV)	7

Summary: ATLAS Heavy Particles Searches

ATL-PHYS-PUB-2023-008

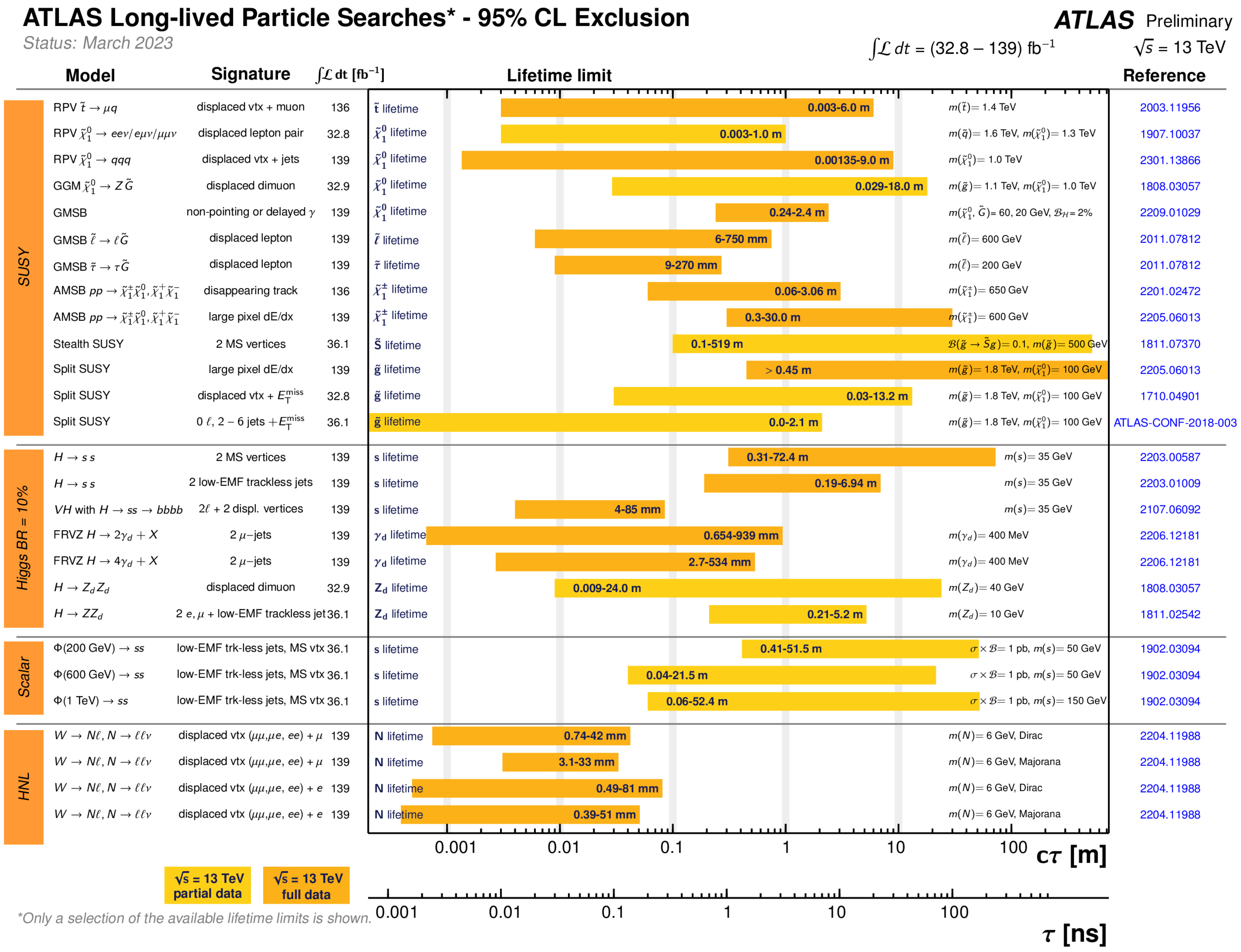
ATLAS EXPERIMENT



Summary: ATLAS LLP Searches

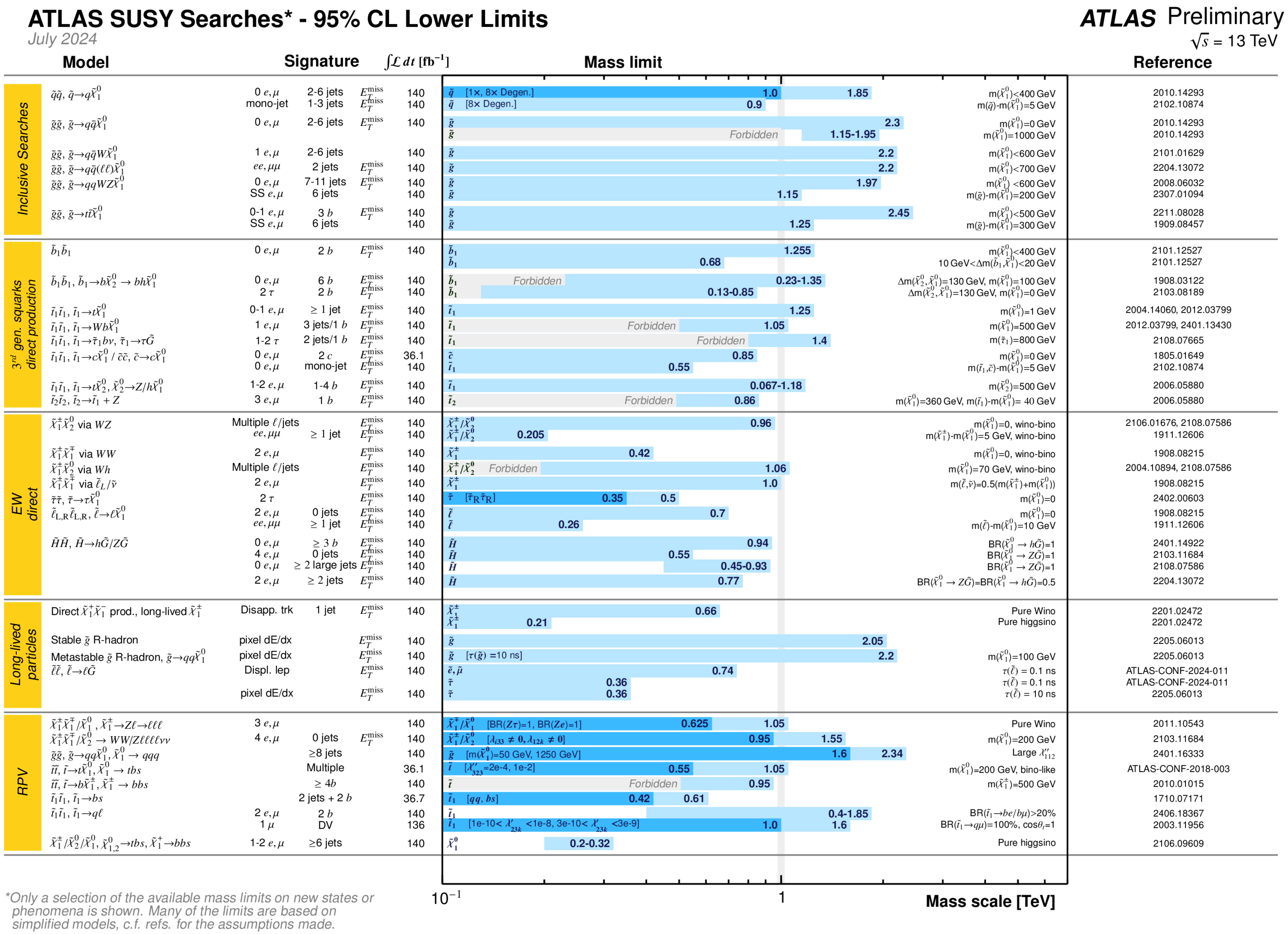
ATL-PHYS-PUB-2023-008

ATLAS EXPERIMENT



Summary: ATLAS SUSY Searches

ATL-PHYS-PUB-2024-014



Summary: CMS EXO Searches