Searches for Physics Beyond the Standard Model at the LHC

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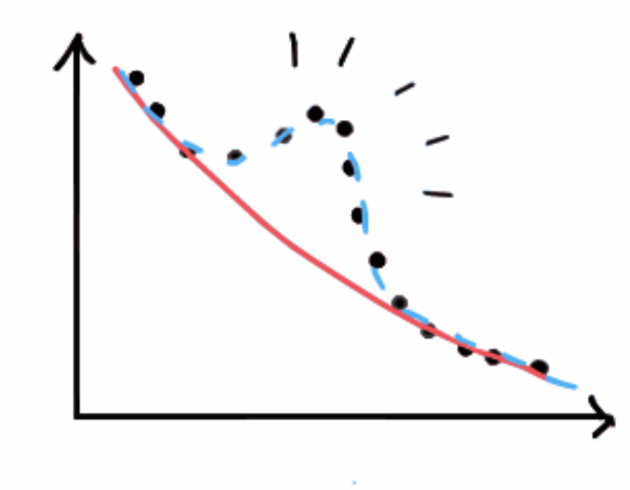
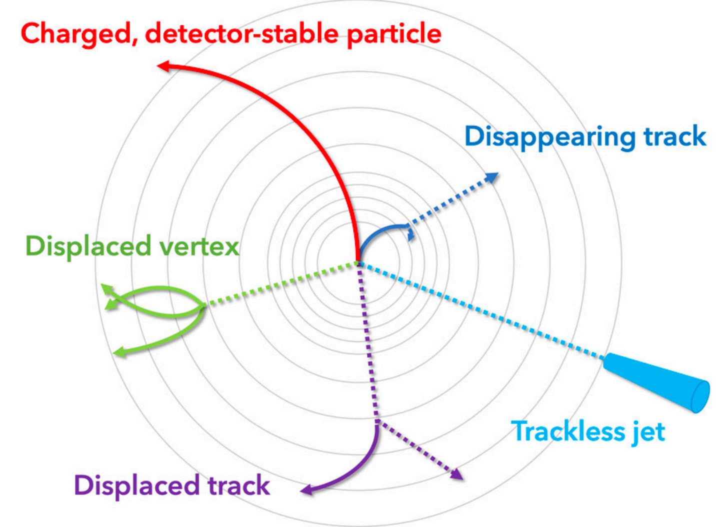
On behalf of the ATLAS, CMS and LHCb collaborations

Introduction

- Direct searches for BSM phenomena → Evidence of new physics
  - Resonant searches
  - Non-resonant searches
  - Unconventional signatures

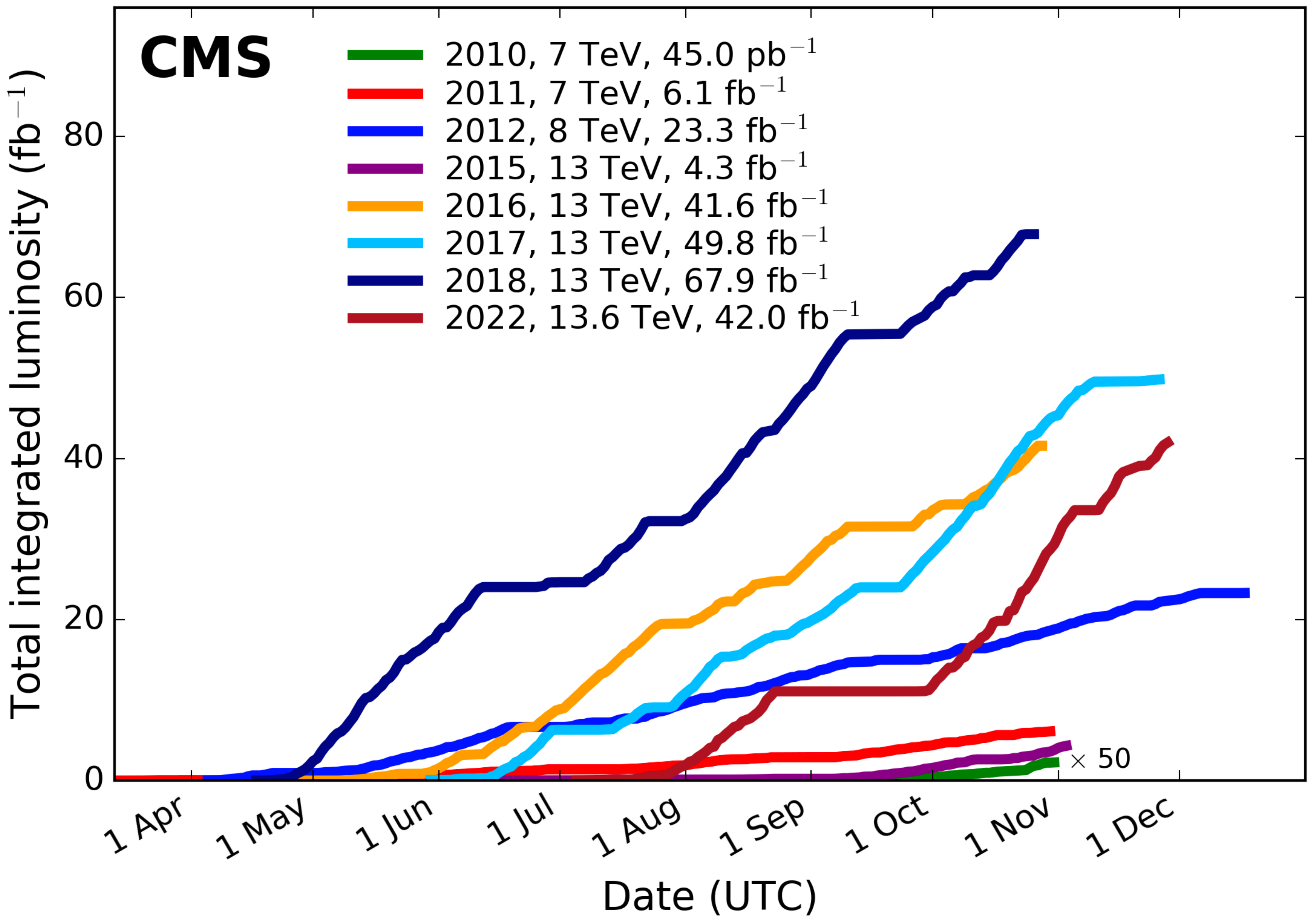


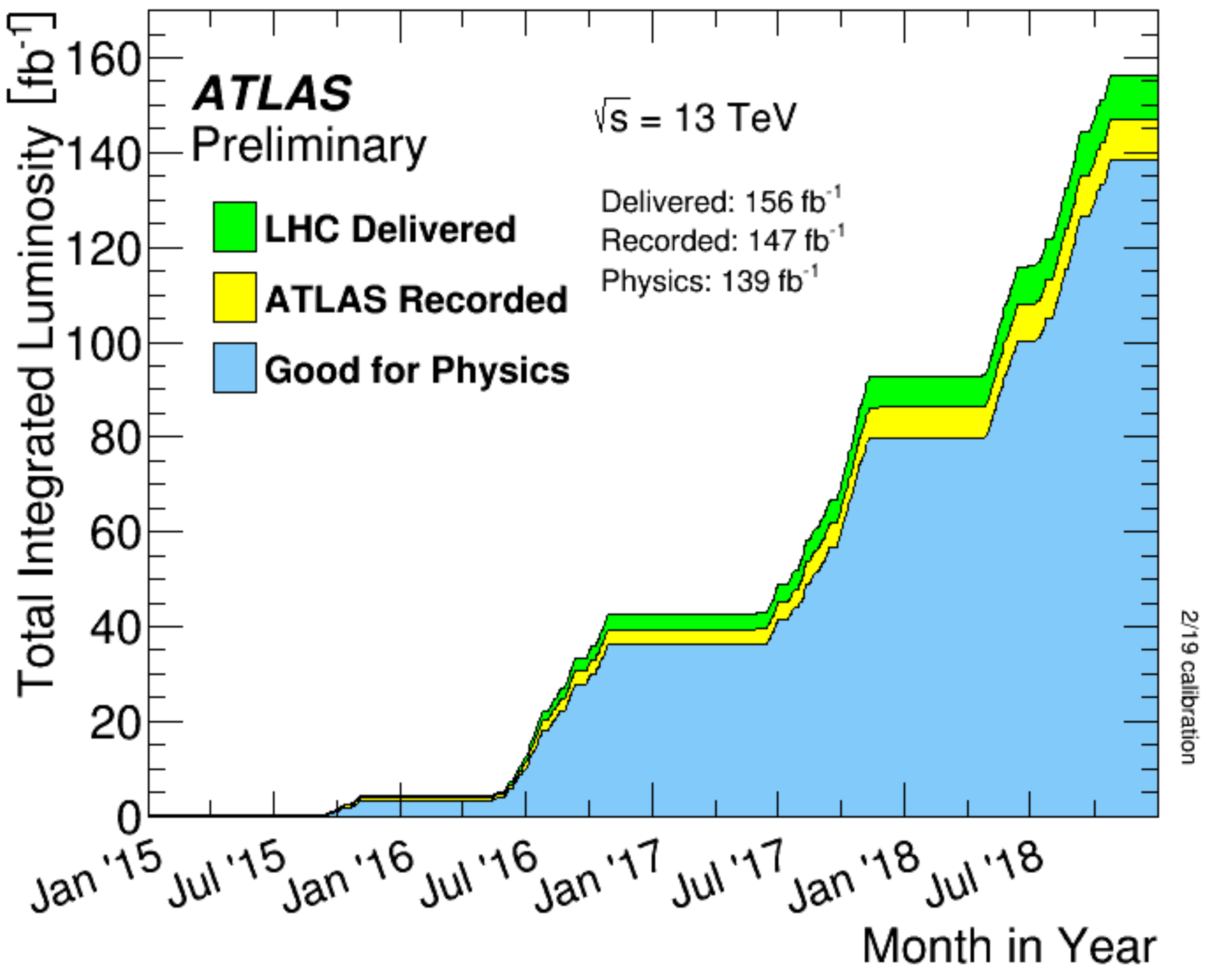


- New methods and tools have been developed: data scouting, boosted jet tagging, etc.
- Focus mainly on recent results made public with the 13 TeV dataset.
- Complete set of public BSM results:
  - ATLAS:
    - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HDBSPublicResults
    - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults
    - https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults
  - CMS:
    - https://twiki.cern.ch/twiki/bin/view/CMS/B2G
    - https://twiki.cern.ch/twiki/bin/view/CMS/SUS
    - https://twiki.cern.ch/twiki/bin/view/CMS/EXOTICA
  - LHCb:
    - https://lhcbproject.web.cern.ch/lhcbproject/Publications/LHCbProjectPublic/Summary_QEE.html

LHC Run 2

- The LHC has been operating at $\sqrt{s}$ = 13 TeV in 2015−2018 (Run 2).
- It delivered a dataset corresponding to about 160 fb^{-1}.
- About 140 fb^{-1} of physics-quality data recorded by each ATLAS & CMS.
- The ATLAS, CMS and LHCb detectors have been working spectacularly with virtually no degradation in performance over the years.





Diphoton Resonance Searches

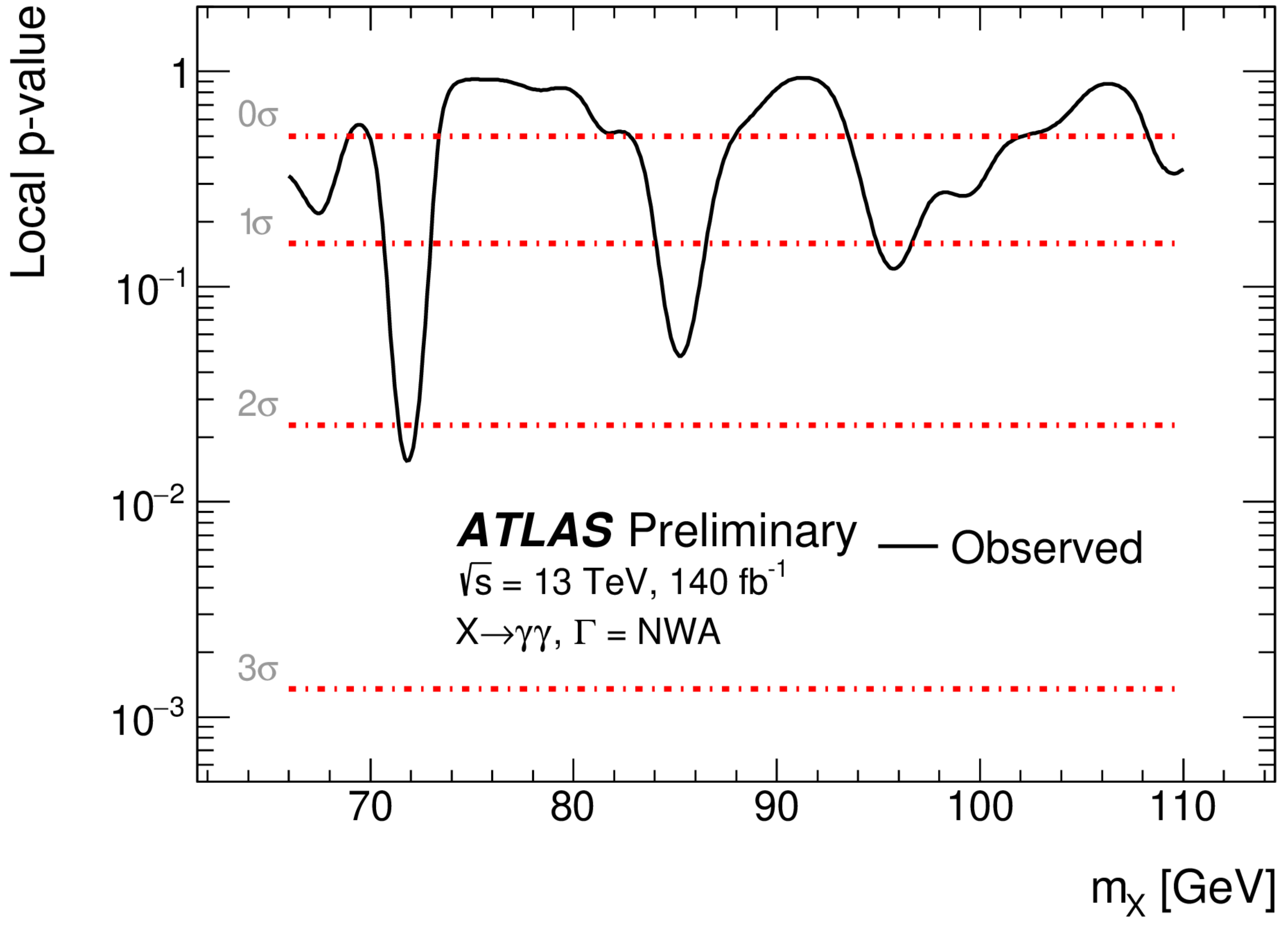
CMS-PAS-HIG-20-002

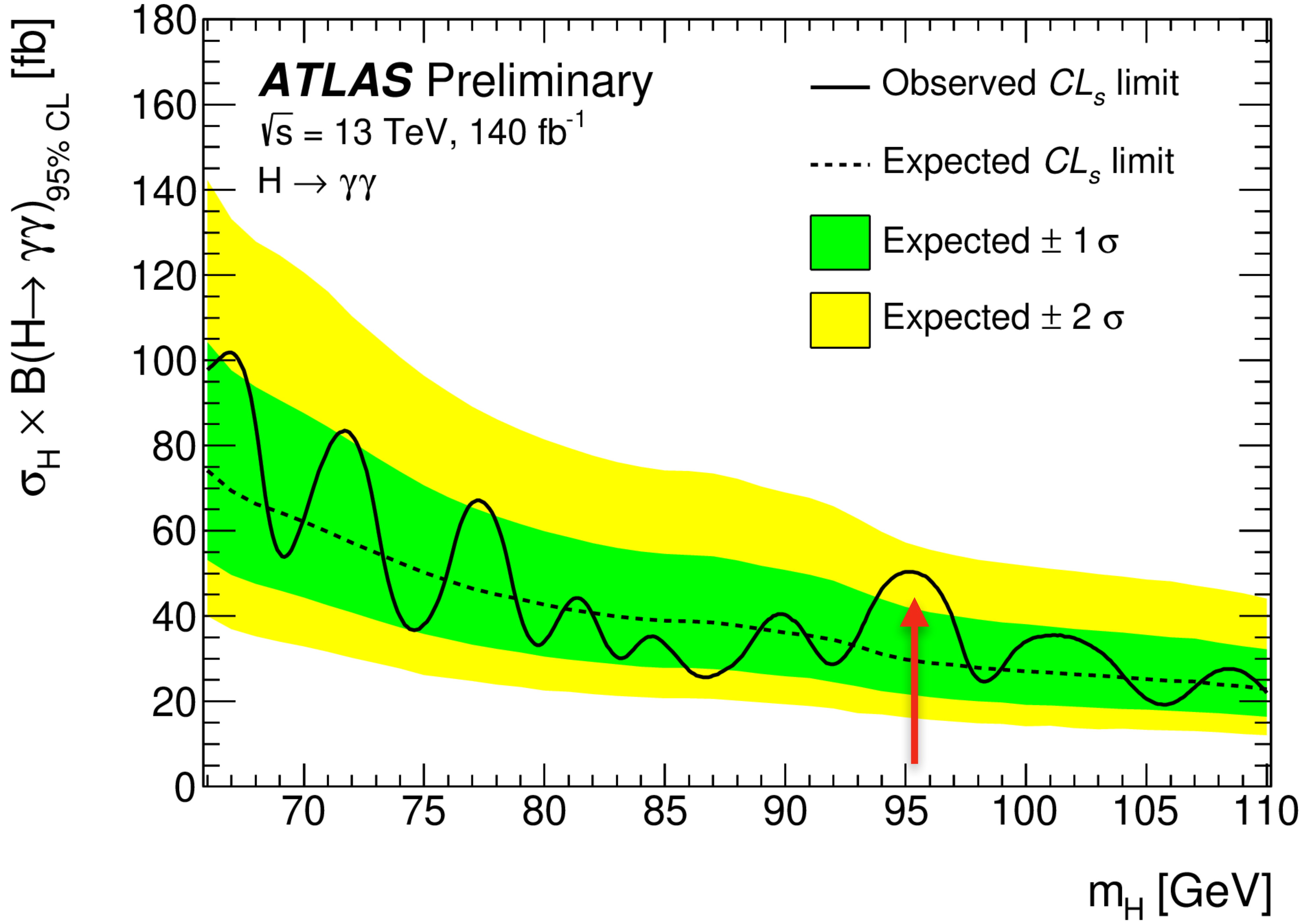
- Many extensions to the Higgs sector of the SM motivate additional spin-0 bosons.
- Search for diphoton resonance − additional Higgs boson decaying to a pair of photons.
- First search for new diphoton resonances in the mass range between 70 and 110 GeV.
- CMS: 1.35σ global (2.9σ local) excess at m_X = 95.4 GeV.

Diphoton Resonance Searches

ATLAS-CONF-2023-035

- Search focuses on light, spin-0 bosons decaying to two photons in the 66 to 110 GeV mass range.
- Both a model-independent search for a generic spin-0 particle and a model-dependent search for an additional low-mass Higgs boson are performed.
- No significant excess is observed, and an upper limit is set on total (fiducial) cross-section times branching ratio from 8 to 53 fb (19 to 102 fb) for the model-independent (model-dependent) result.
- ATLAS: 1.7σ local excess at m_X = 95.4 GeV.



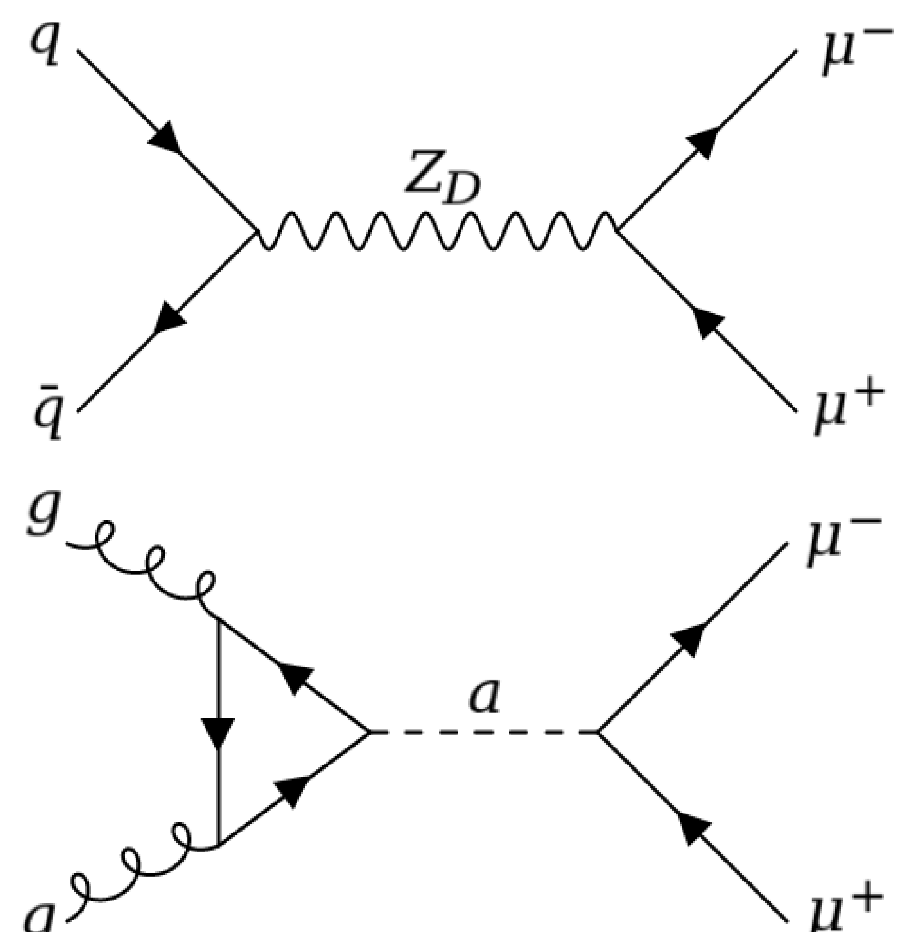


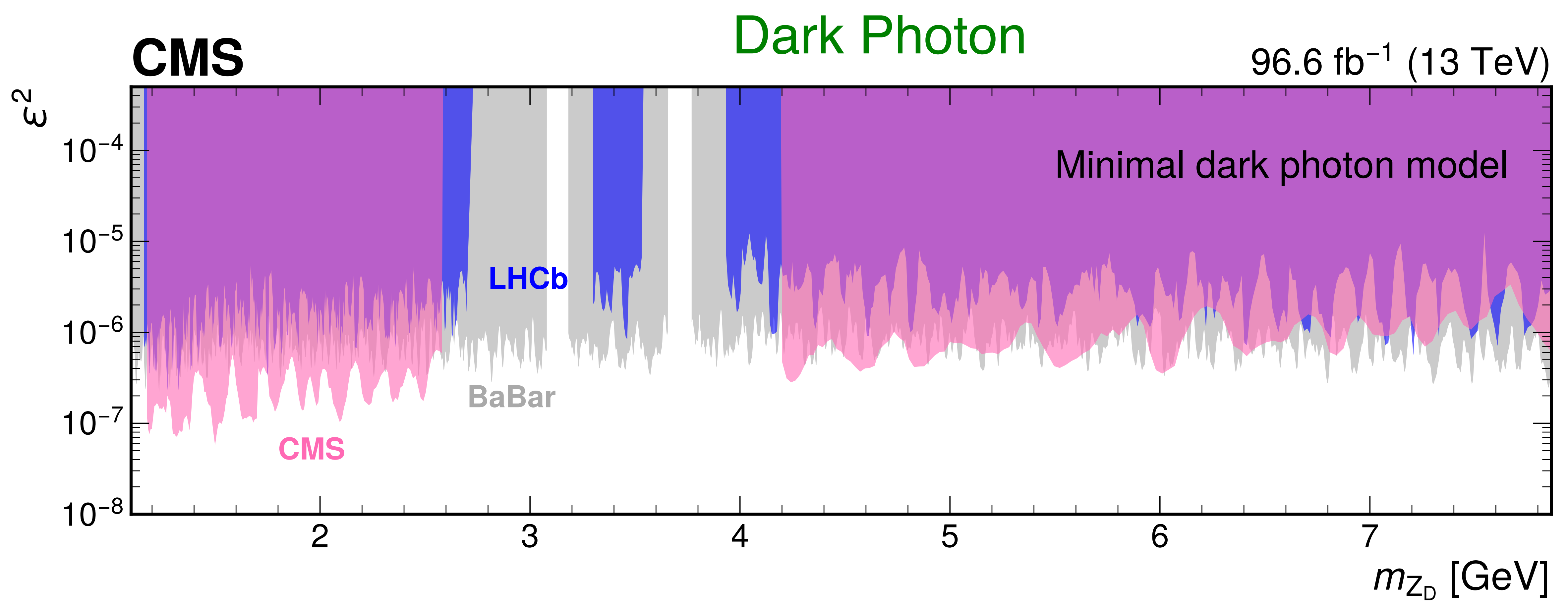
Dilepton Resonances

LHCb: PRL 124 (2020) 041801

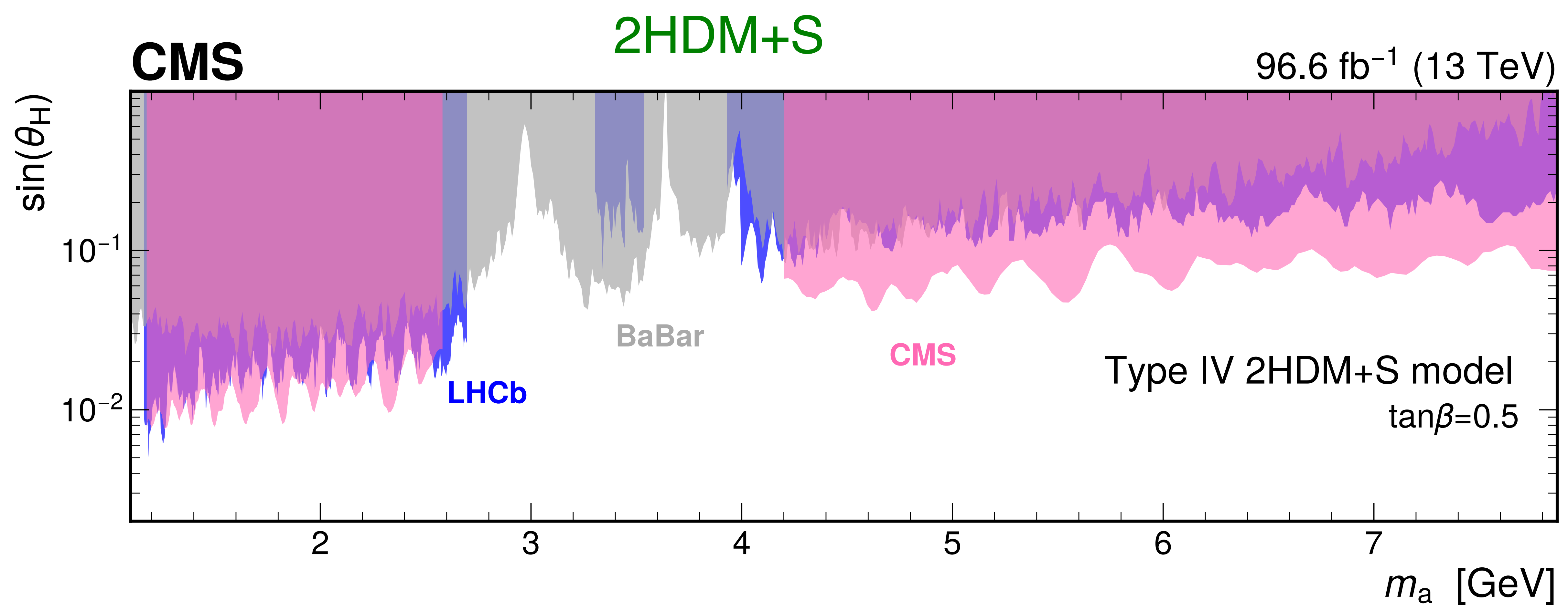
CMS: arXiv:2309.16003 (submitted to JHEP)

- Search for direct production of low-mass dimuon resonances.
- Exploits a dedicated high-rate trigger stream that records events with two muons with transverse momenta as low as 3 GeV but does not include the full event information.
- Look for narrow peaks in the dimuon mass spectrum in the ranges of 1.1 − 2.6 GeV and 4.2 − 7.9 GeV.
- No significant excess observed.
  - Limits are set for a minimal dark photon model and for a scenario with two Higgs doublets and an extra complex scalar singlet (2HDM+S).





Values of the squared kinetic mixing coefficient ε² in the dark photon model above 10^{-6} are excluded.



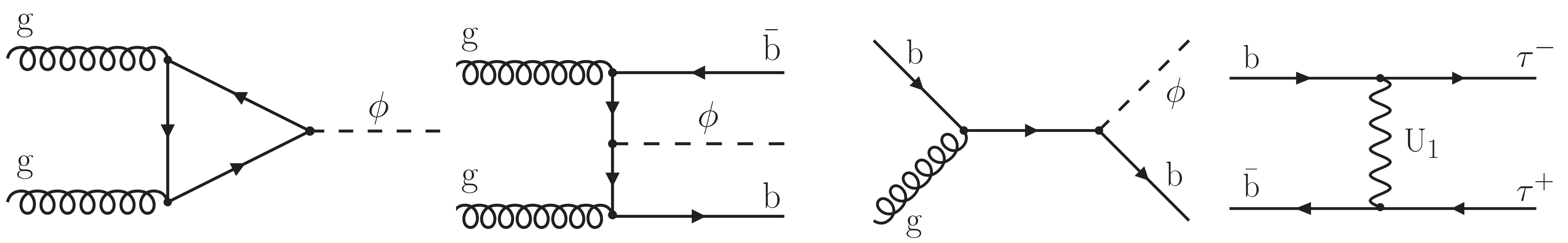
Values of the mixing angle $\sin(\theta_H)$ above 0.08 are excluded for tanβ=0.5.

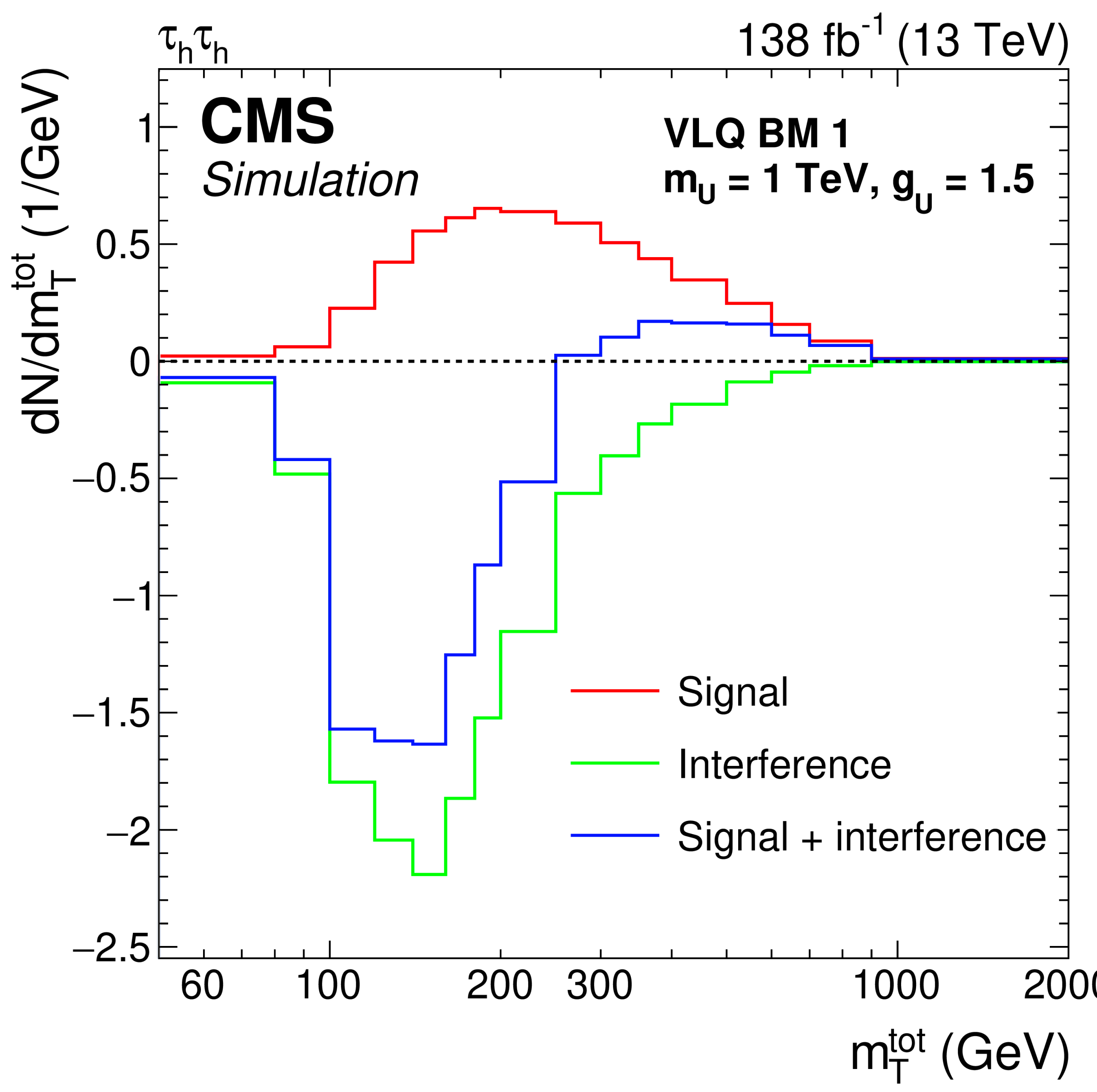
Dilepton Resonance Searches

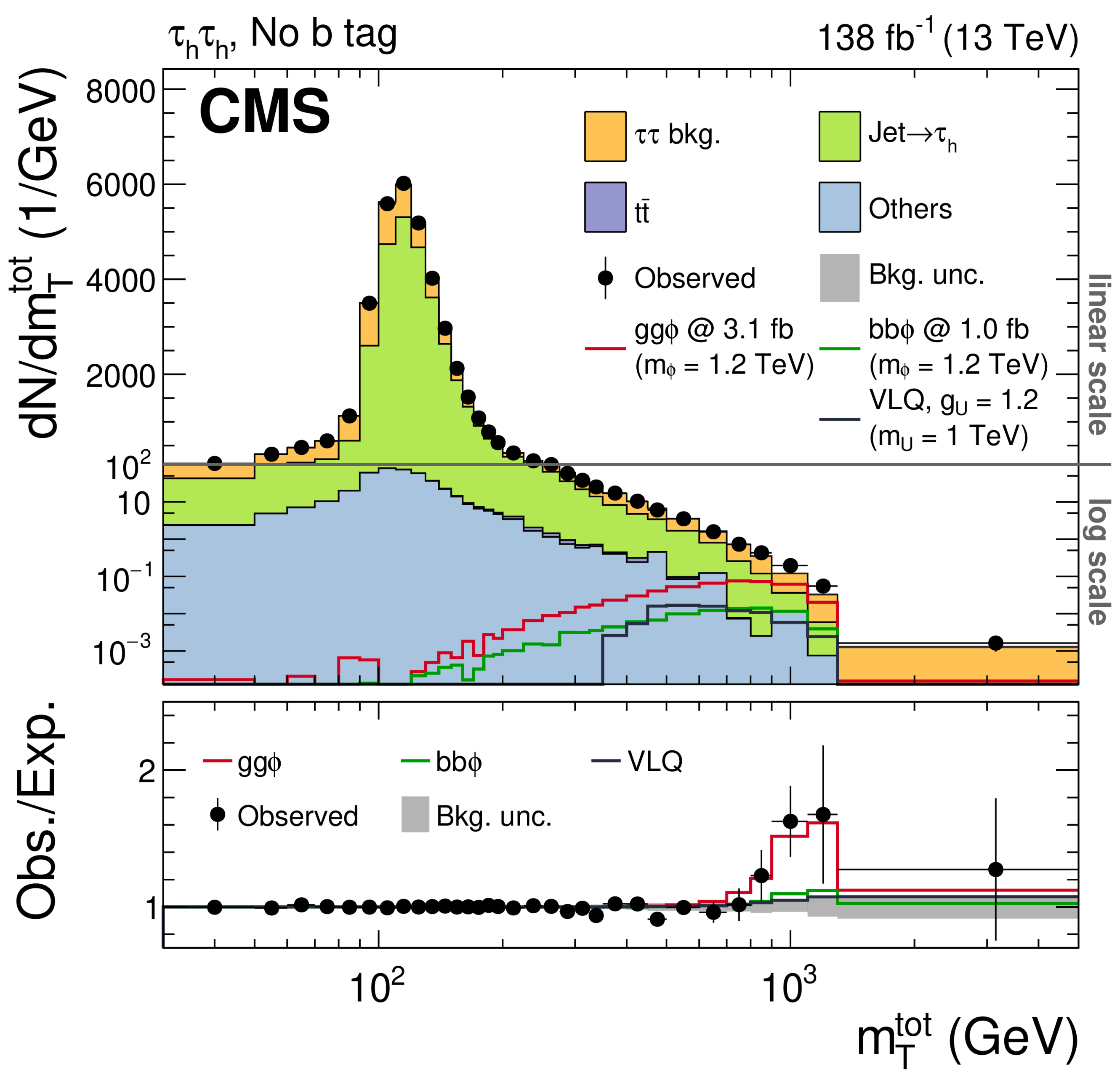
- Search in di-τ mass spectrum is motivated from additional Higgs in the context of MSSM.
  - via gluon fusion ($gg \rightarrow \phi$) or in associate production with b quarks

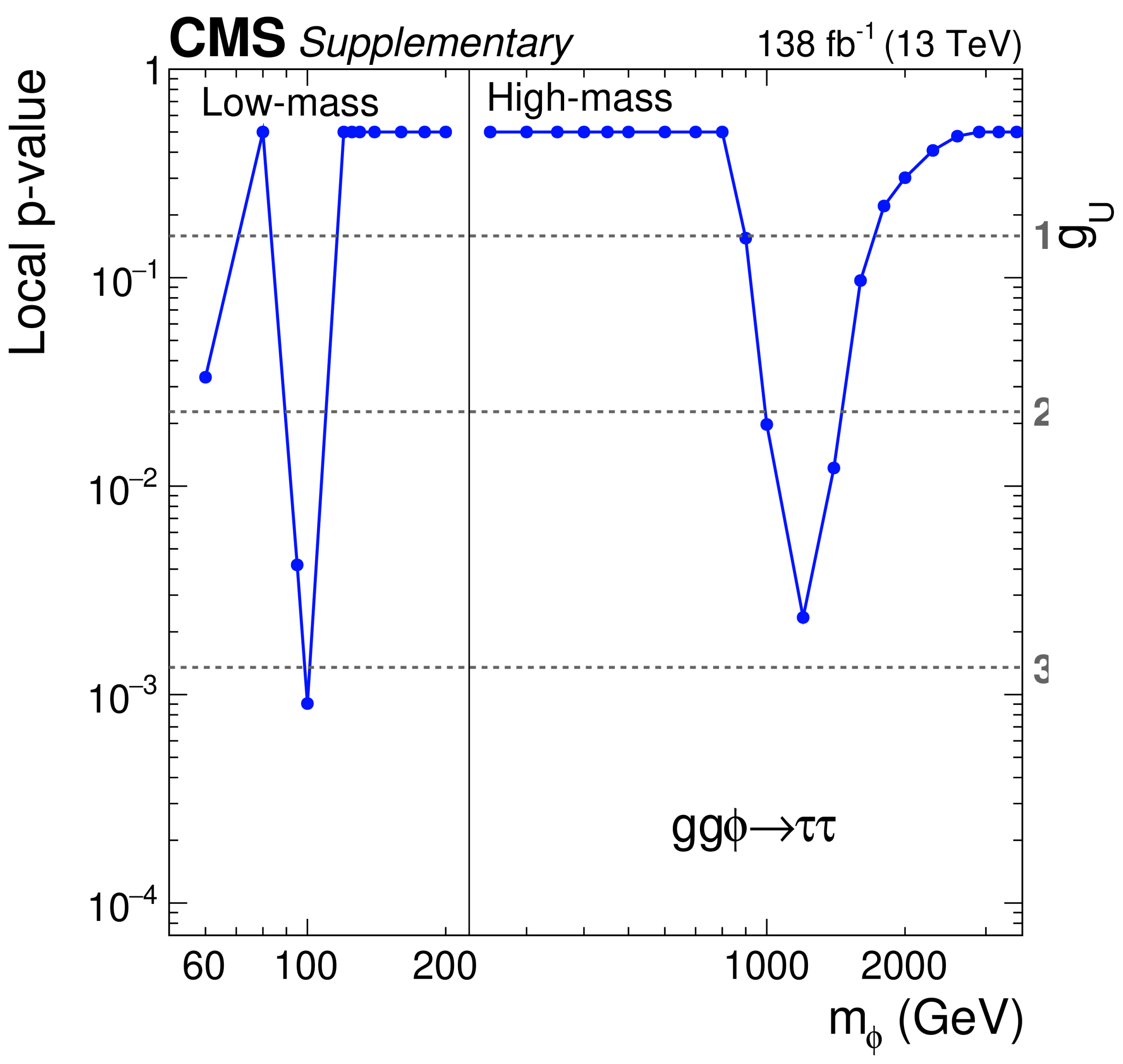
CMS: JHEP 07 (2023) 073

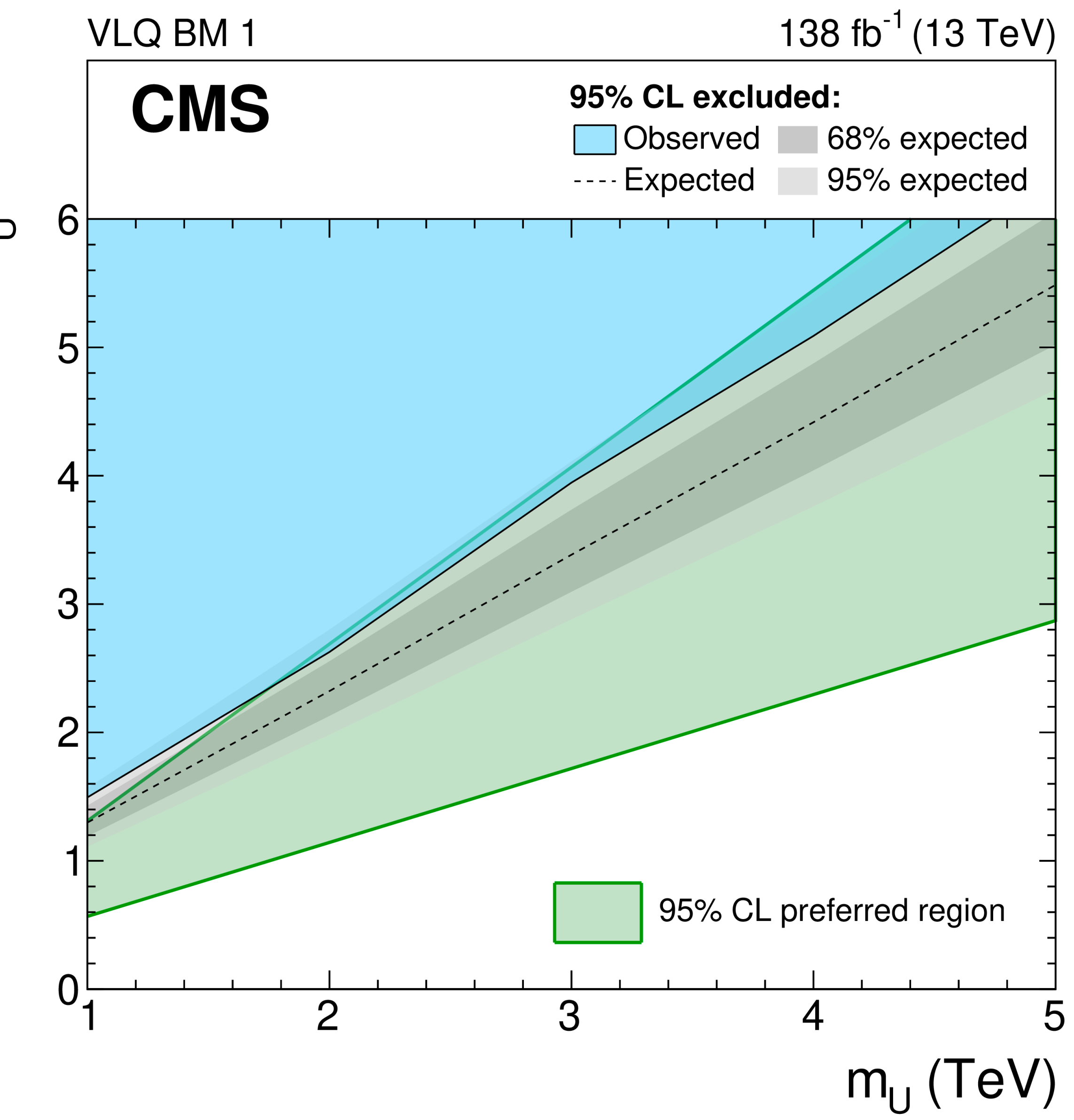
- Interference with the SM $\tau\tau$ continuum is taken into account.
- Two excesses observed:
  - at 0.1 and 1.2 TeV with local p-values equivalent to about three standard deviations.









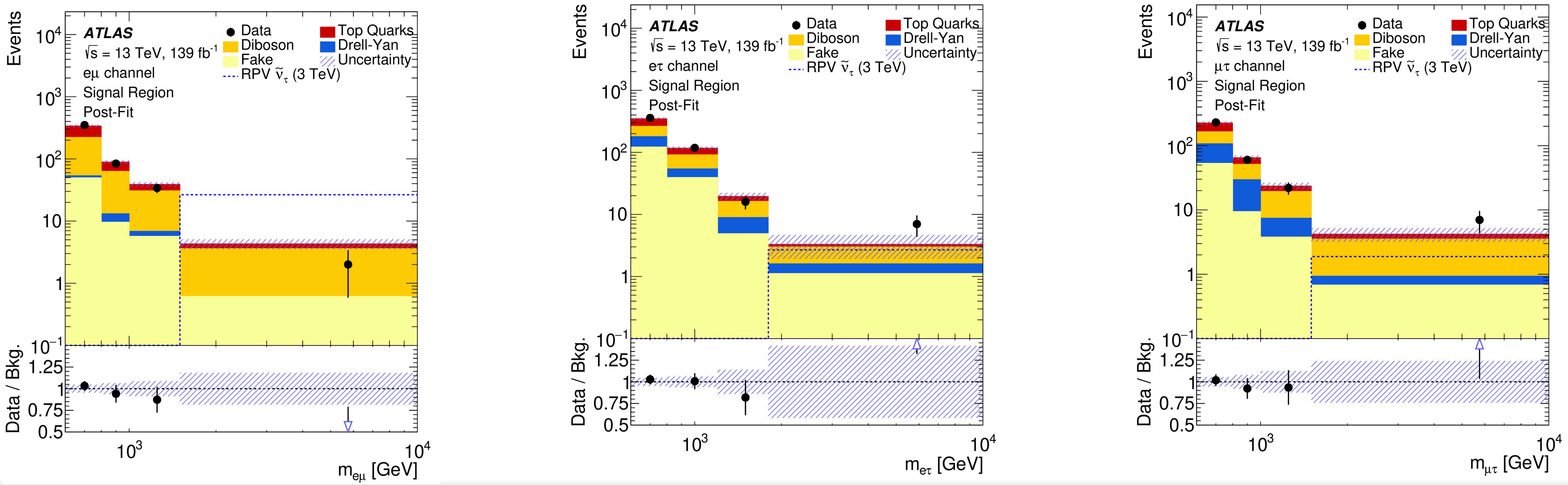


Dilepton Resonance Searches

ATLAS: arXiv:2307.08567 (submitted to JHEP)

- Search for resonant eμ, eτ, μτ production.
- Models: LFV Z′, scalar neutrinos in RPV SUSY, and Quantum Black Holes (QBH ADD/RS).
- Signature: 2 back-to-back leptons, no b-jets.
- No significant excesses observed.

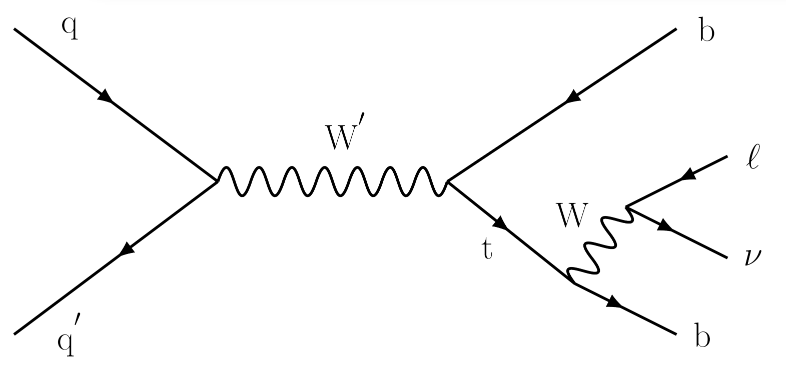
Model	Observed (expected) 95% CL lower limit [TeV]		
	$e\mu$ channel	$e\tau$ channel	$\mu\tau$ channel
LFV Z'	5.0 (4.8)	4.0 (4.3)	3.9 (4.2)
RPV SUSY $\tilde{\nu}_\tau$	3.9 (3.7)	2.8 (3.0)	2.7 (2.9)
QBH ADD $n = 6$	5.9 (5.7)	5.2 (5.5)	5.1 (5.2)
QBH RS $n = 1$	3.8 (3.6)	3.0 (3.3)	3.0 (3.1)

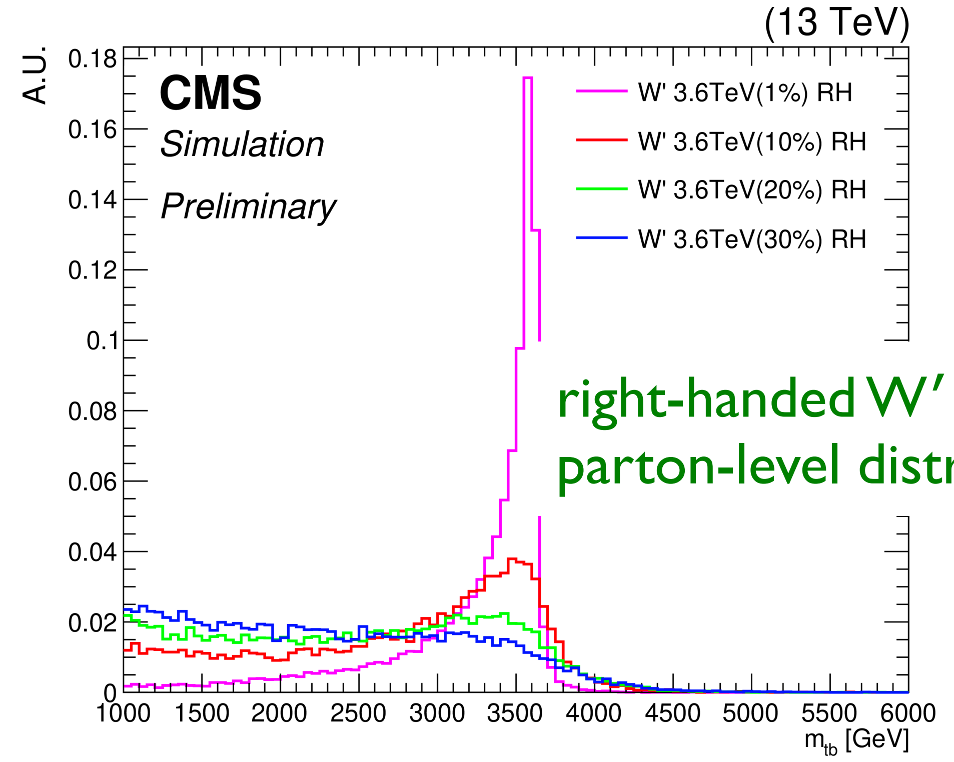


Heavy Vector Bosons

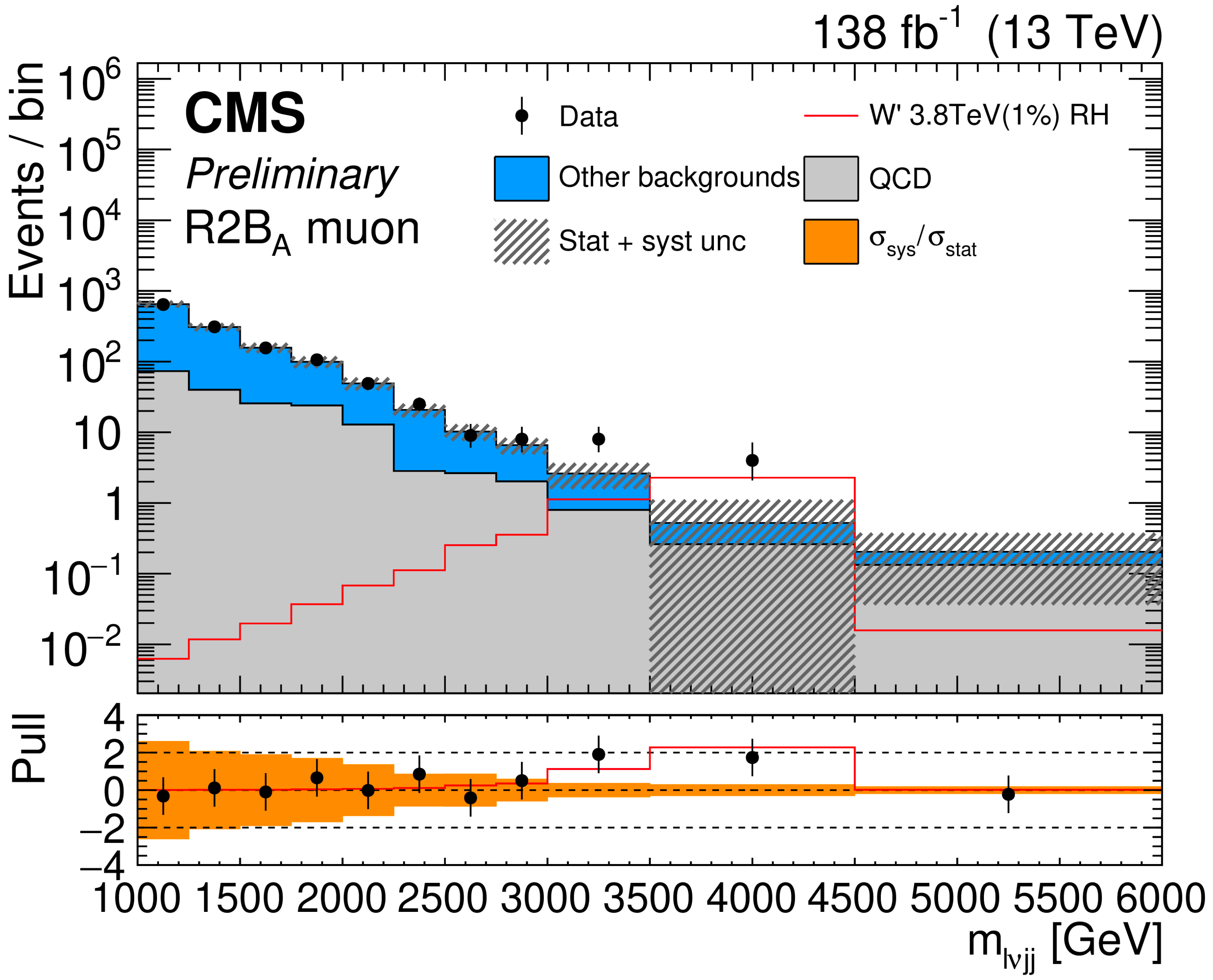
CMS-PAS-B2G-20-012

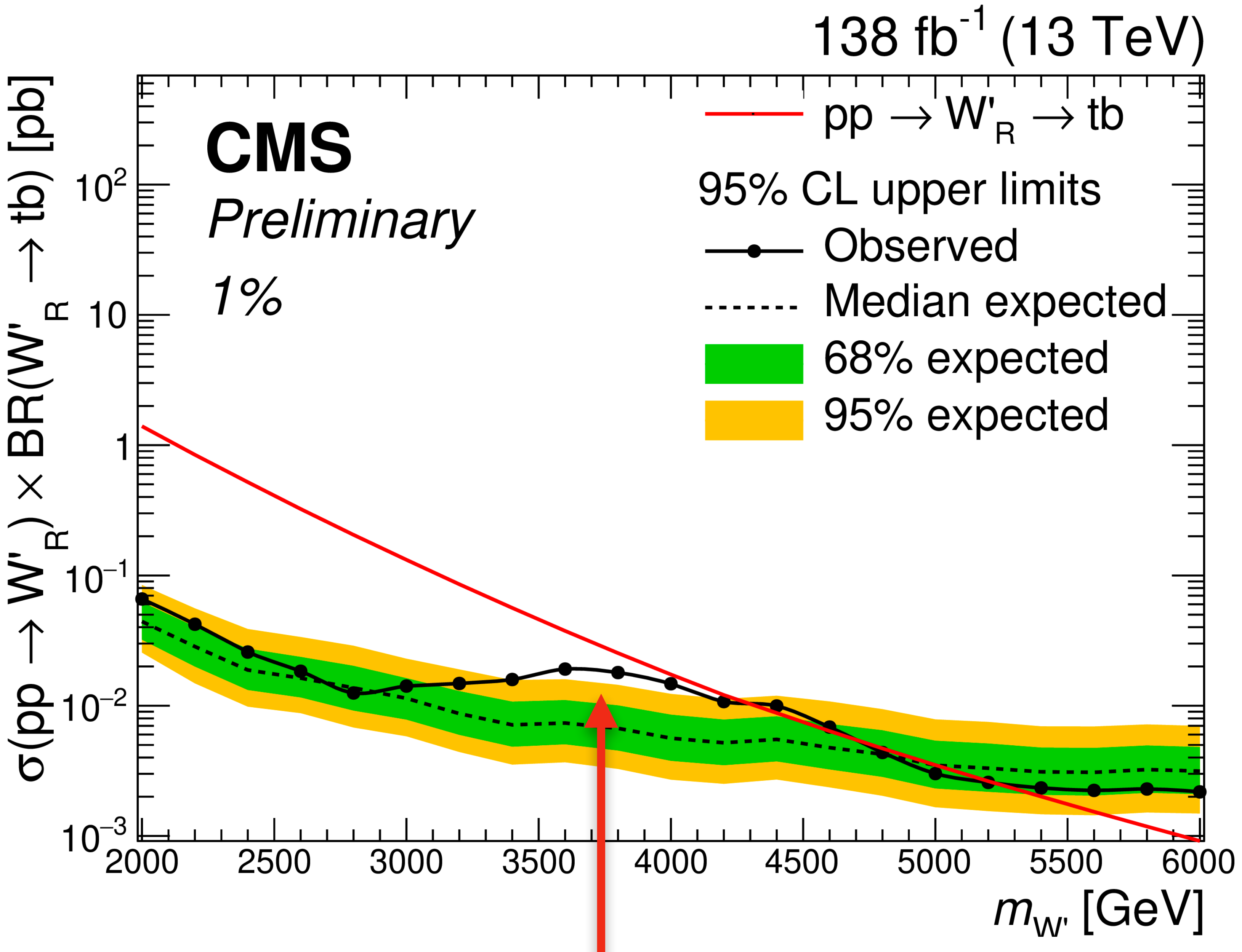
- Search for heavy SM-like W′ resonance.
  - Decaying to the third generation quarks.
  - Considering mass range 2 − 6 TeV, different width and chirality.
  - Neutrino momentum from imposing that the lepton-neutrino pair is equal to m_W.
- Limits are set considering decay widths of up to 30% of the W′ boson mass.
  - W′ bosons with masses below 3.9 and 4.3 TeV are excluded.
  - Largest observed excess is for a W′ mass of 3.8 TeV with 1% rel. decay width.

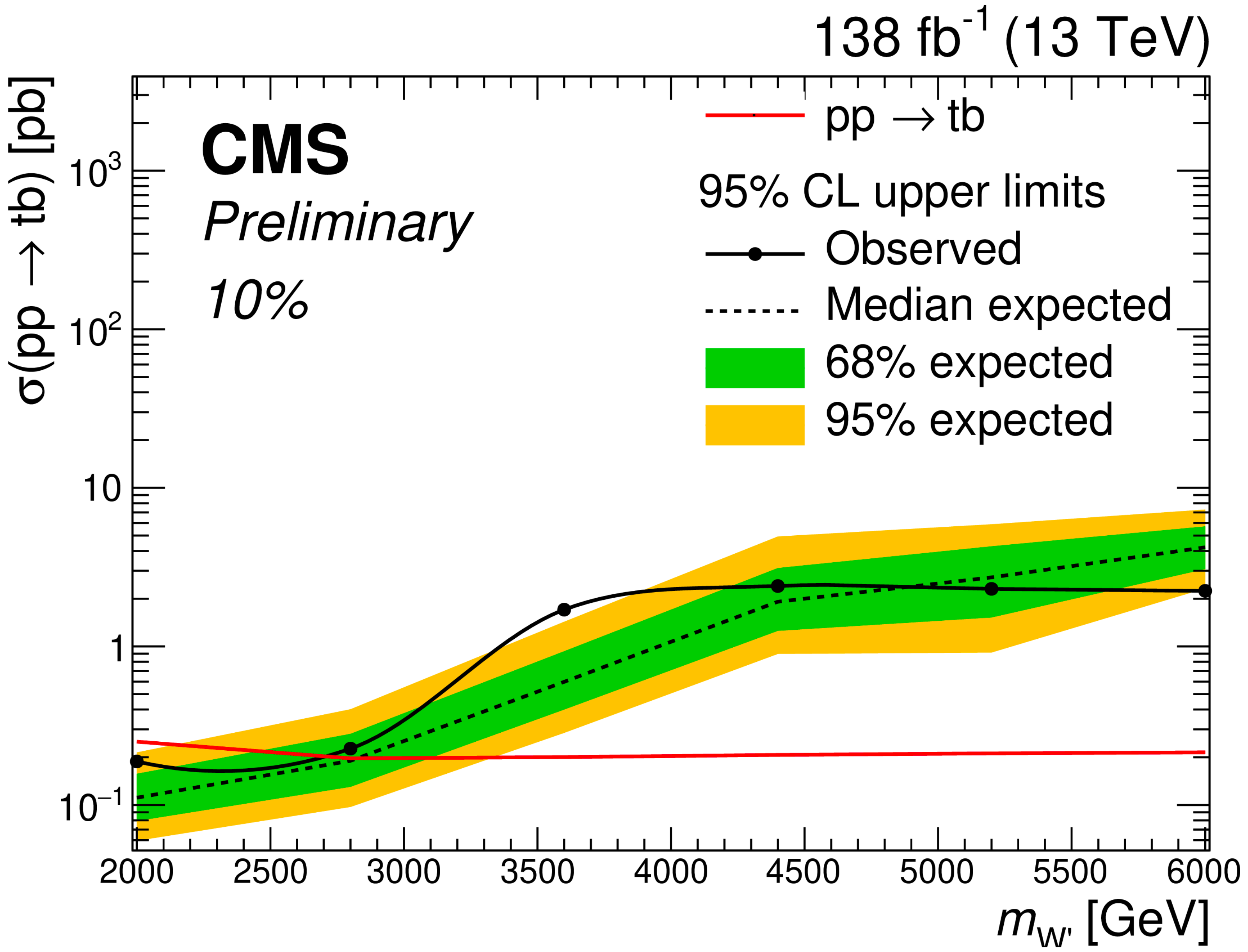




right-handed W′
parton-level distribution



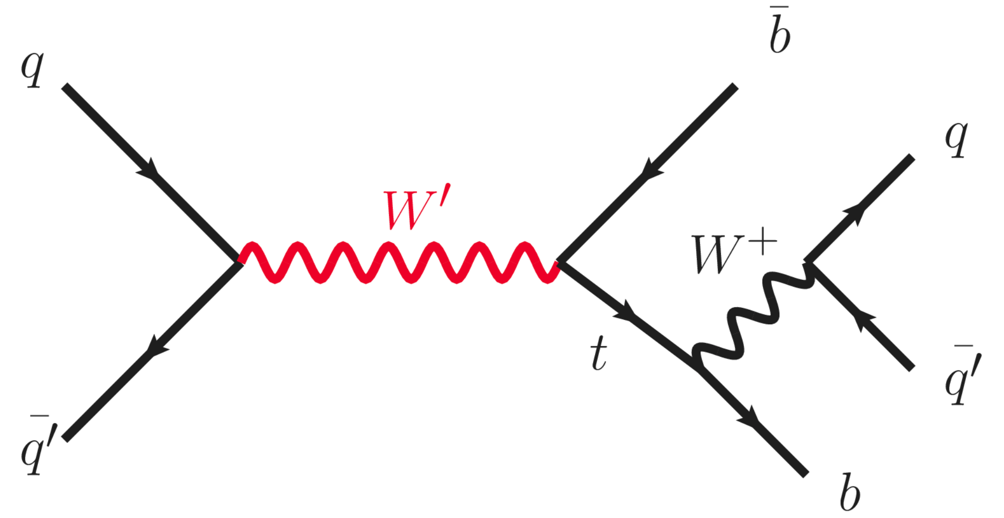




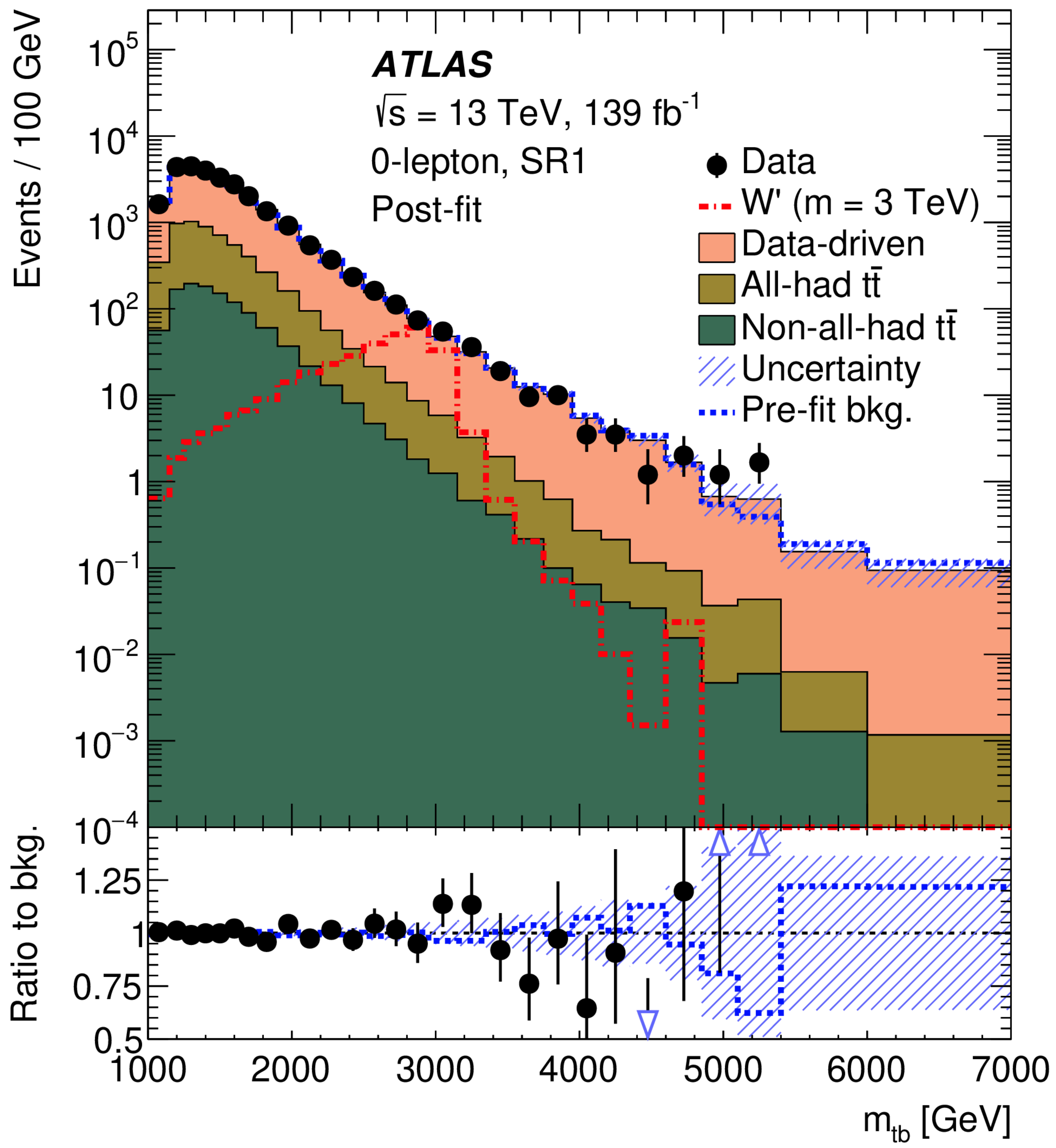
Heavy Vector Bosons

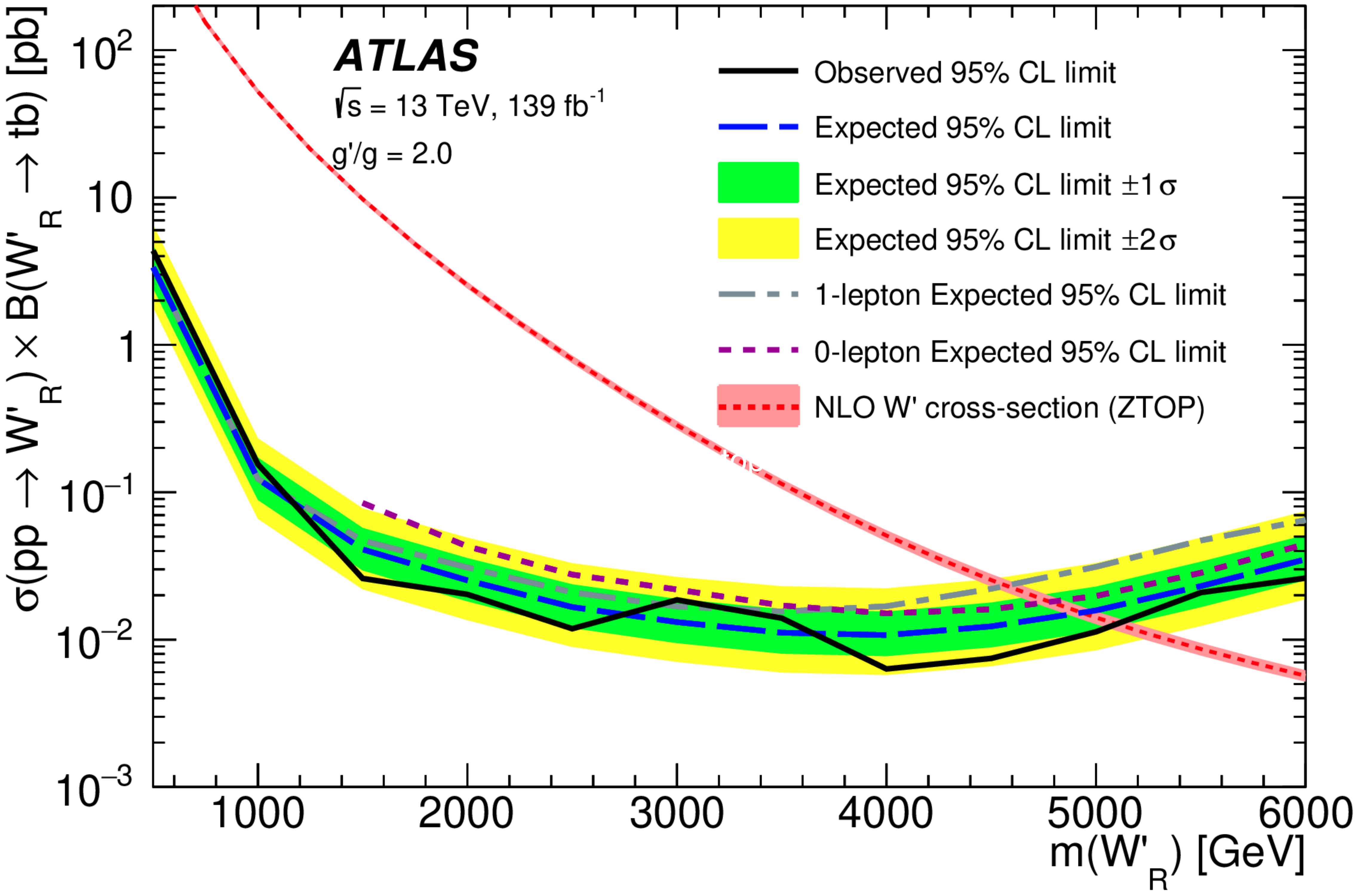
ATLAS: arXiv:2308.08521 (submitted to JHEP)

- Search for heavy vector bosons decaying to 3rd generation quarks.
- Benefits from improvements in reconstruction of top-quarks and b-jets at high p_T.
- Probing W′ with masses up to ~5 TeV.



invariant mass top & b-jet

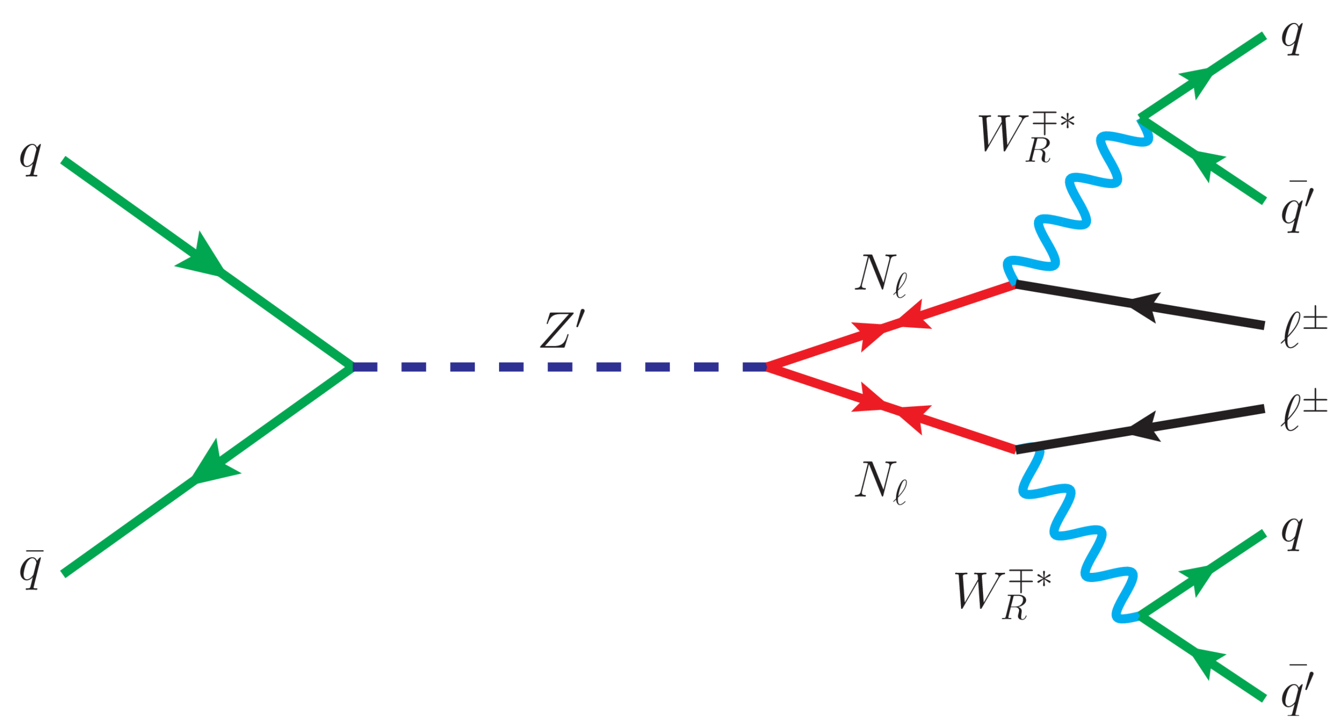


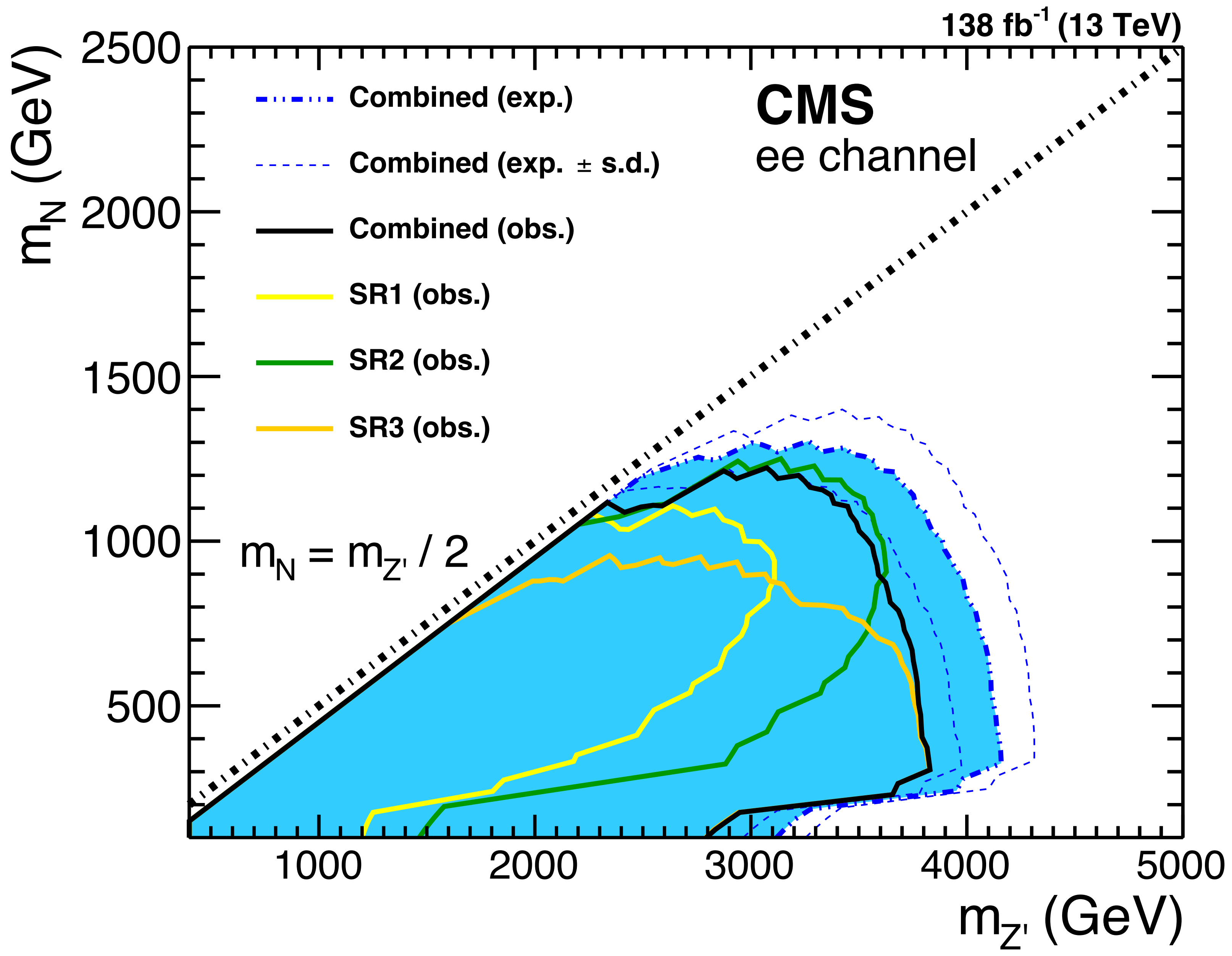


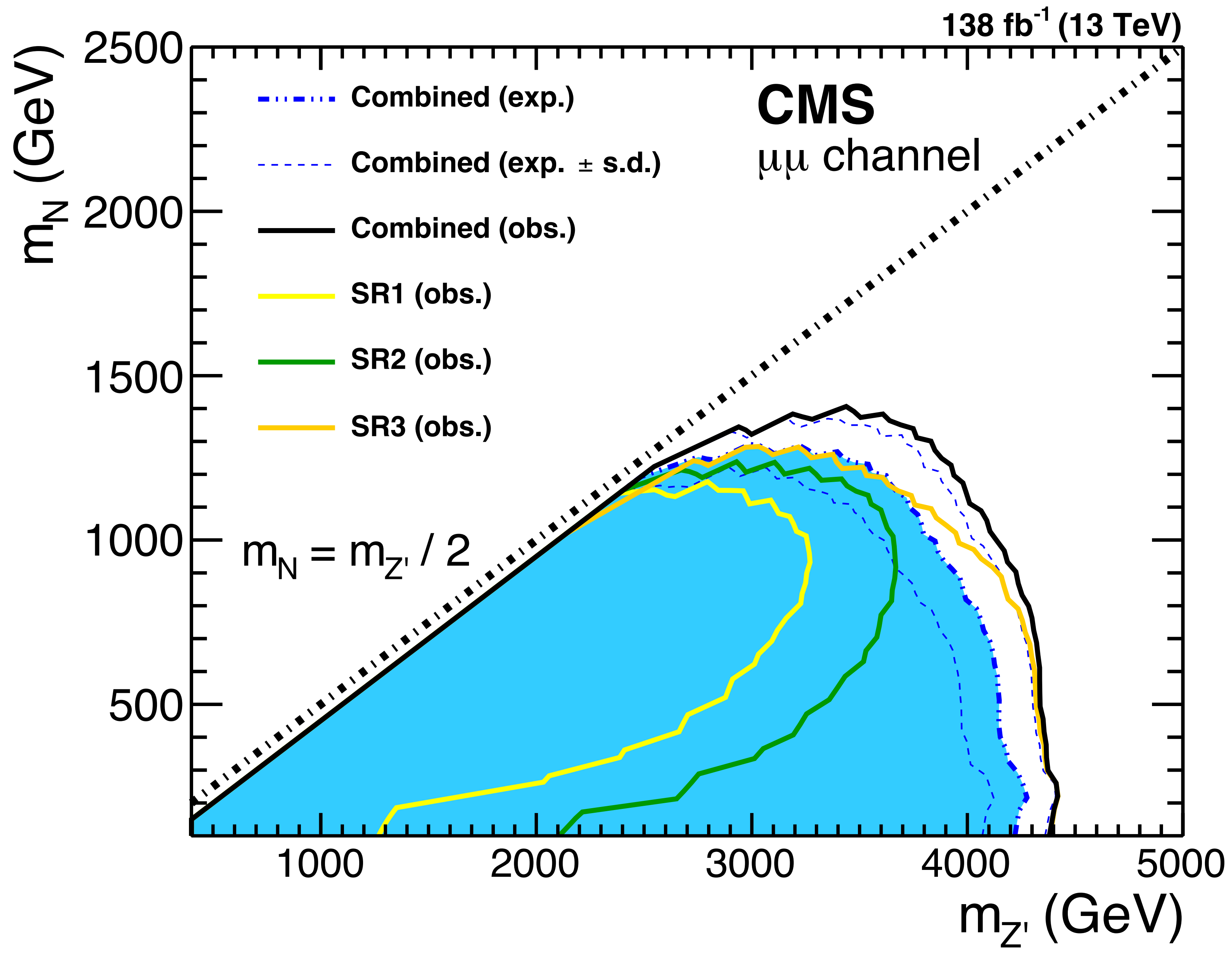
Heavy Neutral Bosons

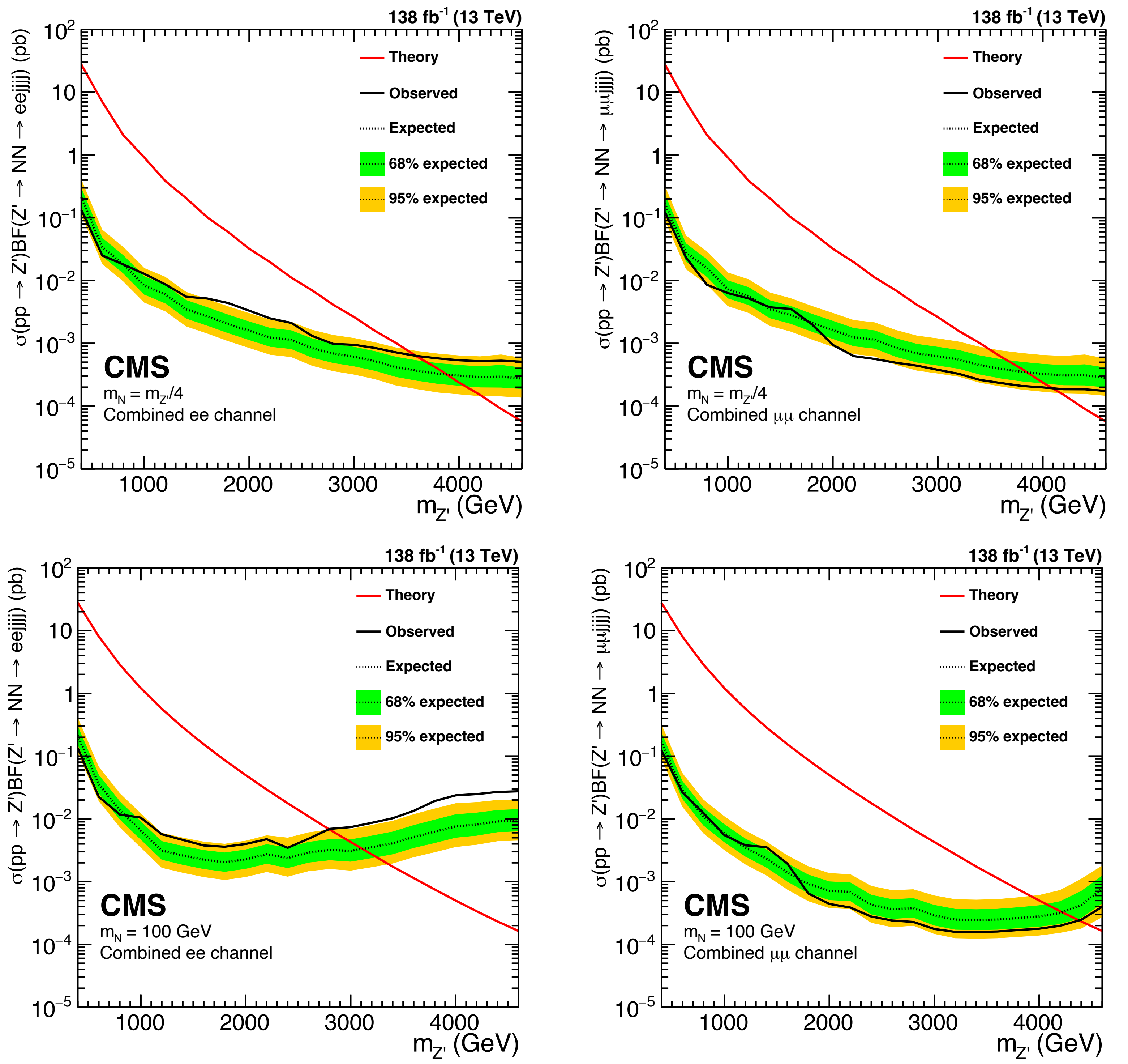
CMS: arXiv:2307.06959 (submitted to JHEP)

- Search for Z' bosons decaying to pairs of heavy Majorana neutrinos.
  - Search for an excess in the invariant mass distribution of the final-state objects, two same-flavor leptons (e or μ) and at least two jets.
- No significant excess of events beyond the expected background.
  - Upper limits are set on the product of the Z' production cross section and its branching fraction to a pair of N, as functions of N and Z' masses.
  - The observed upper limit on $m_{Z'}$ reaches up to 4.42 TeV.





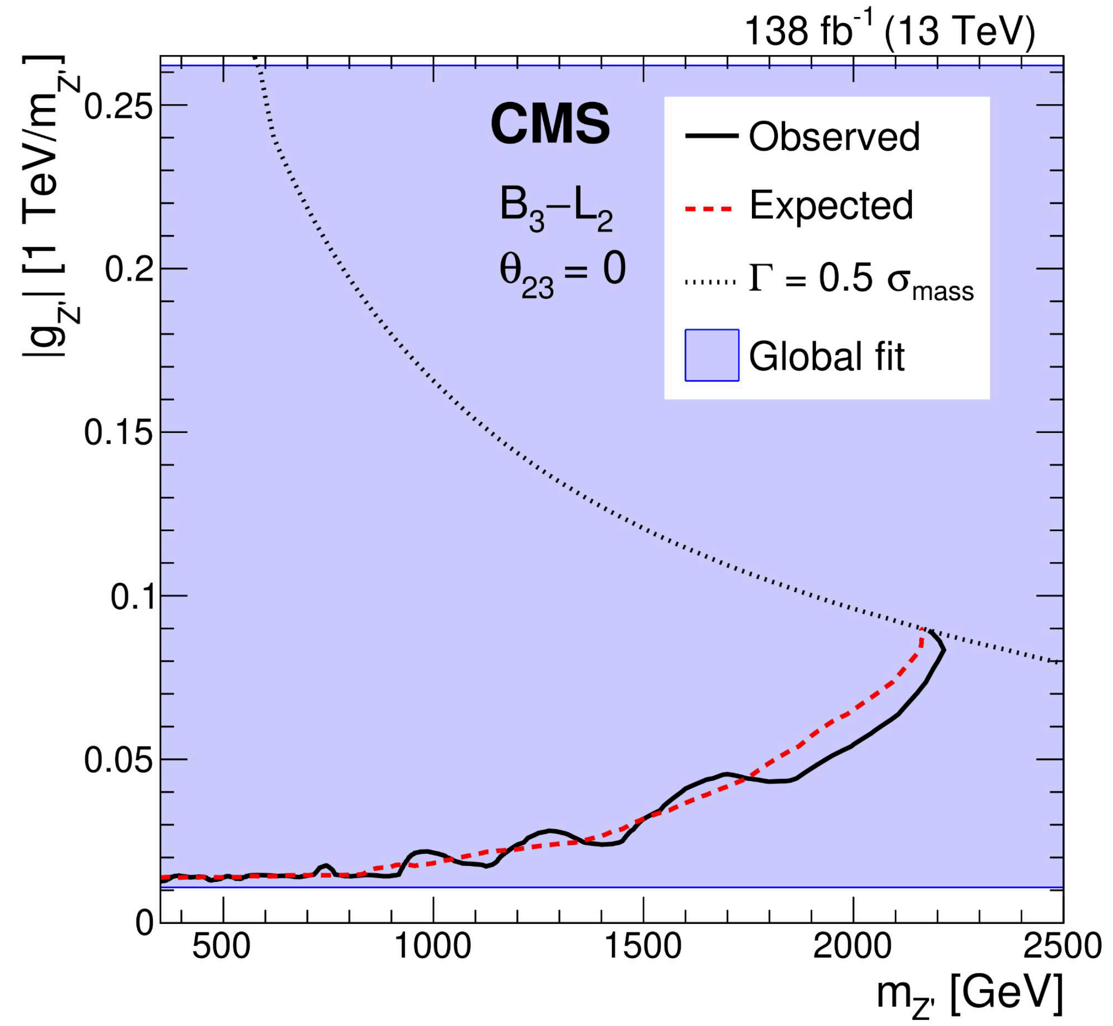


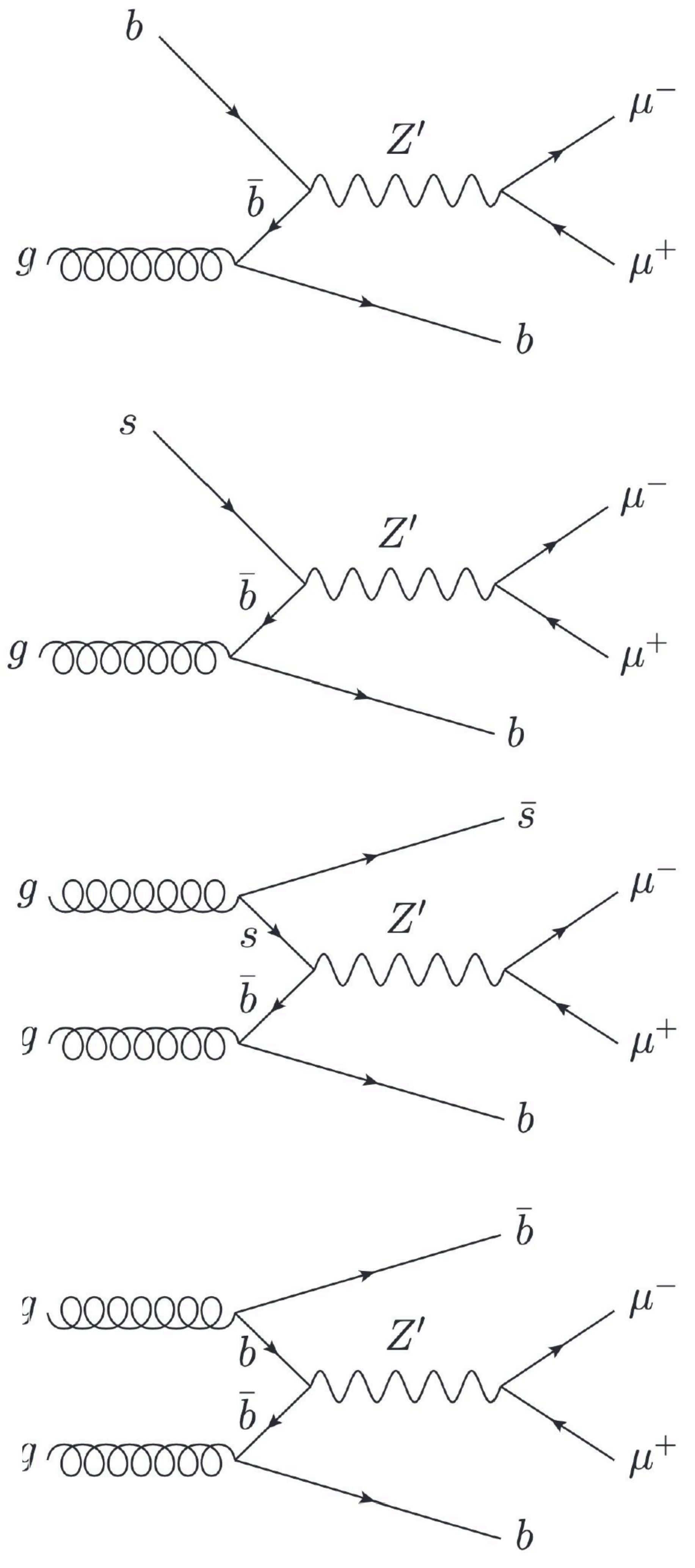


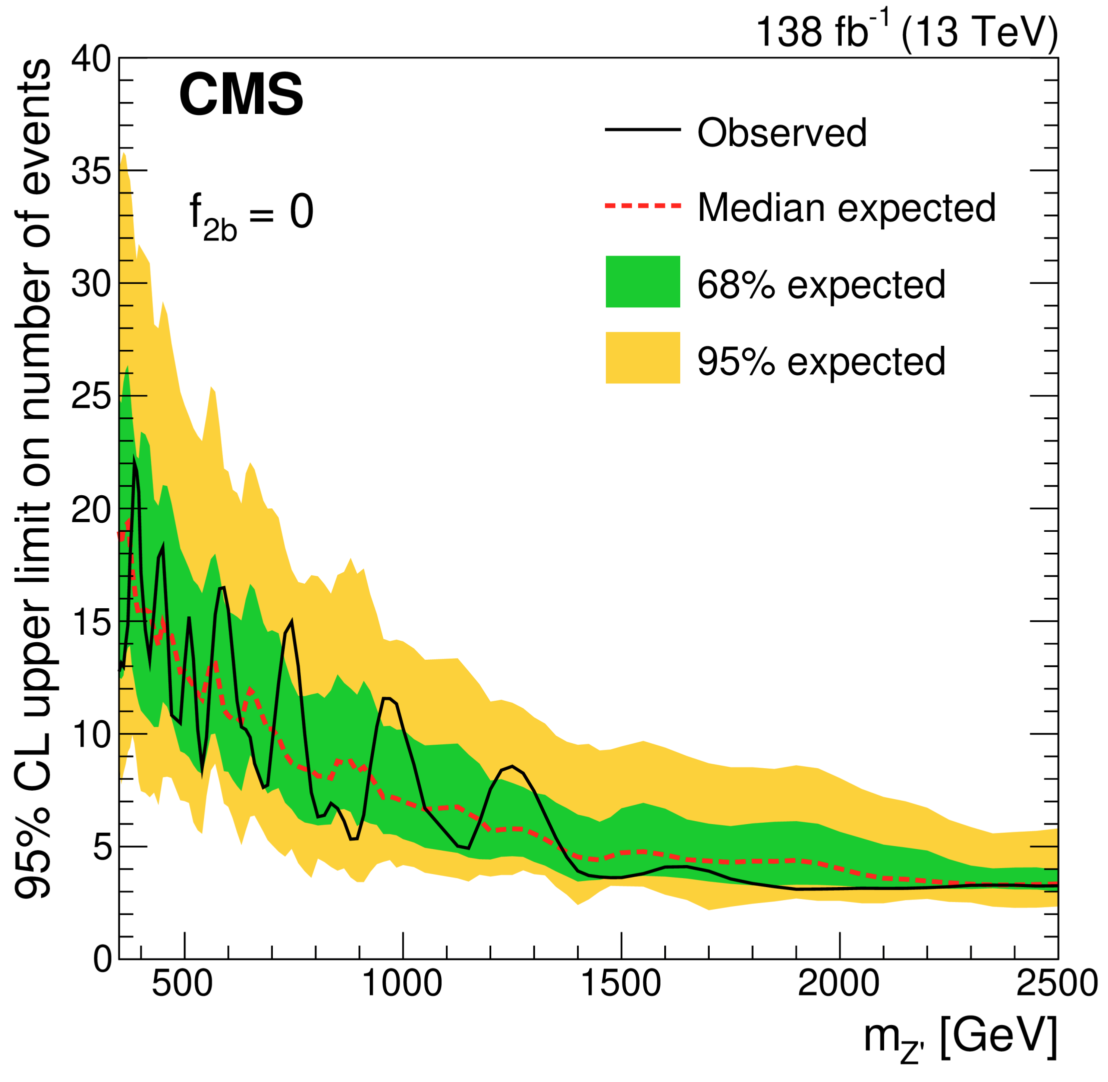
Dileptons + b-Jets

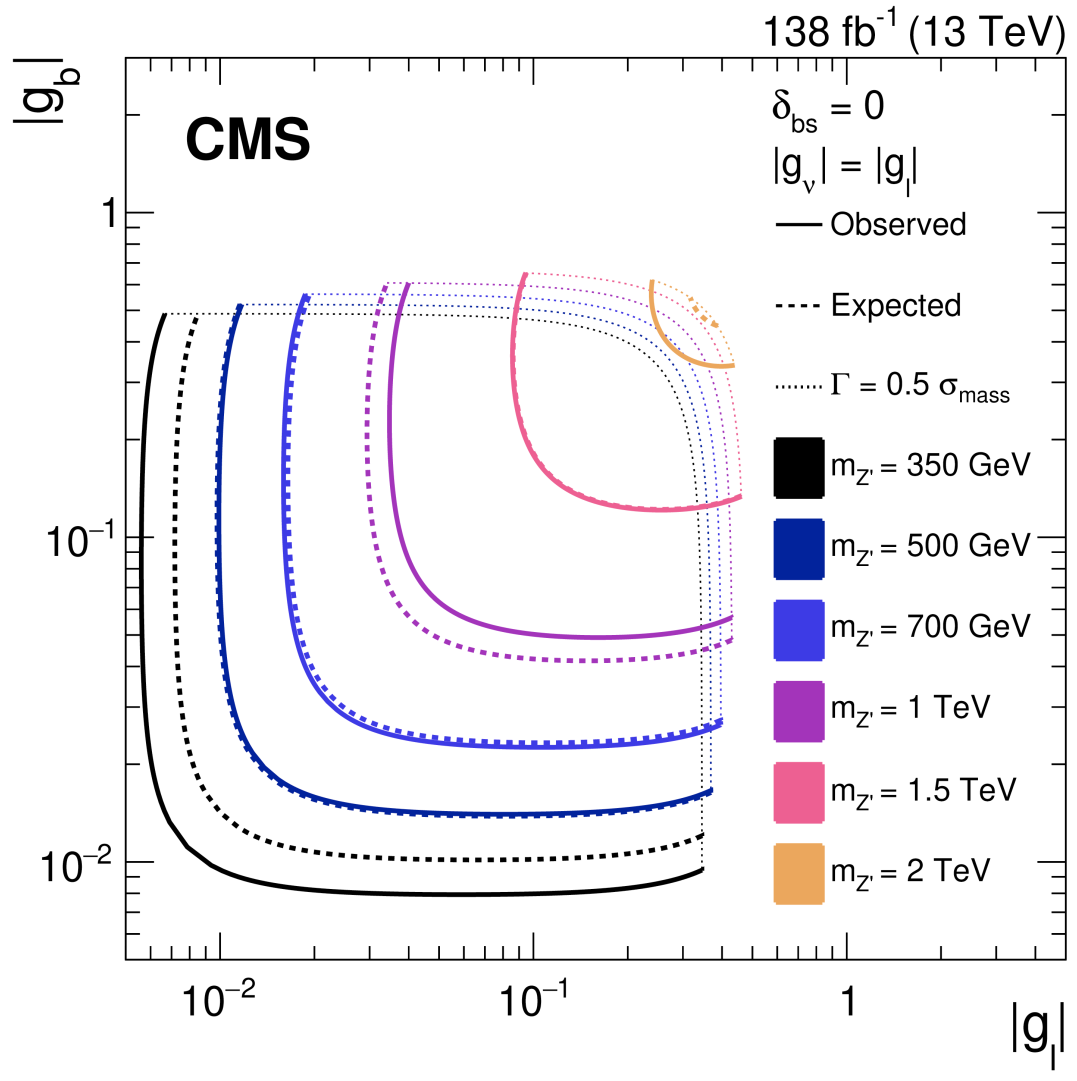
CMS: arXiv:2307.08708 (accepted by JHEP)

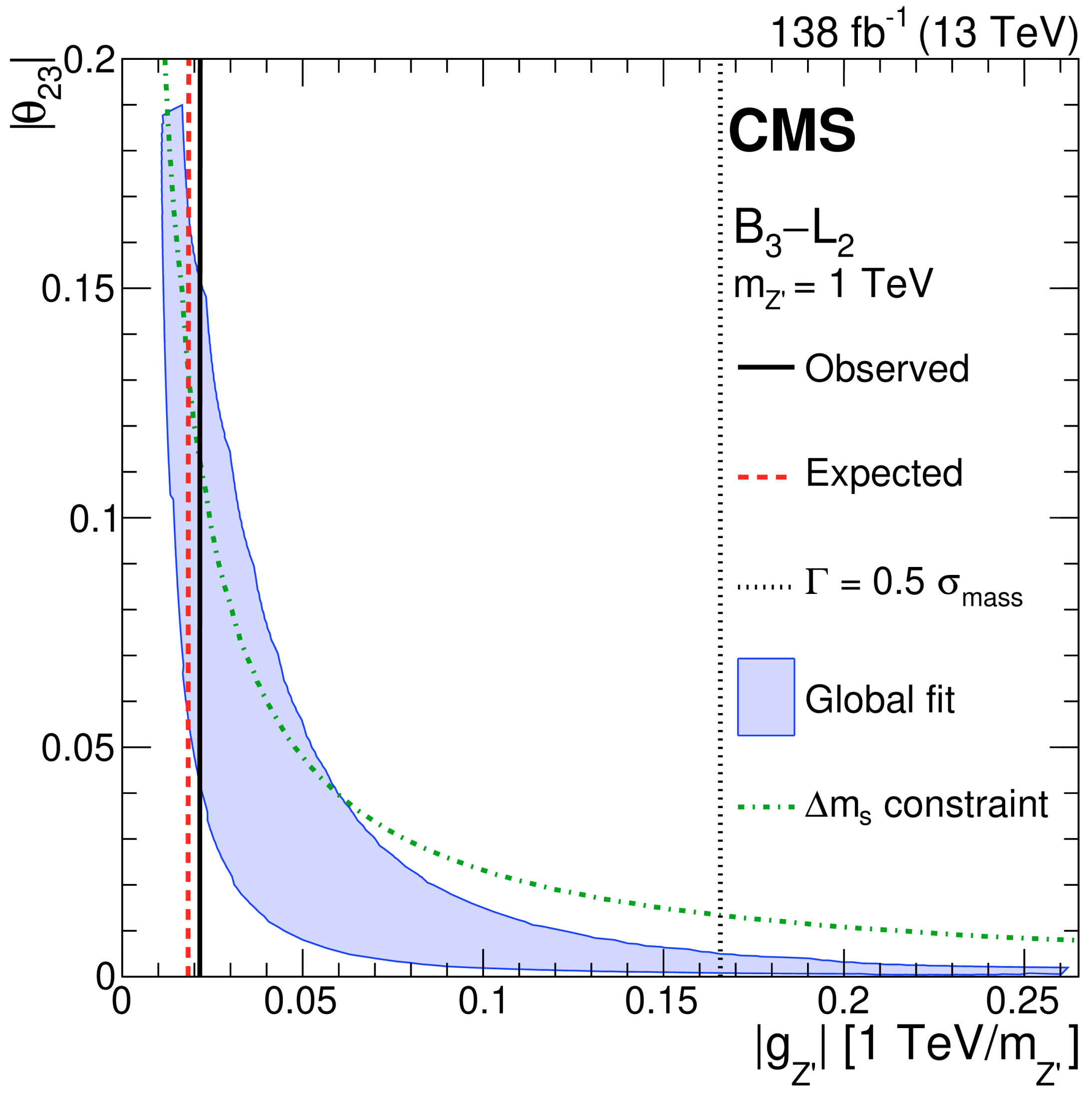
- Search for new neutral vector boson (Z′) decaying to a dimuon pair produced in association with at least one b-jet.
- Strongly disfavors DY events by presence of b-quark.
- Sensitivity to mass of 350 GeV ≤ $m_{Z'}$ ≤ 2.5 TeV.
- Constraints are set on a specific Z′ model (B_3-L_2).
  - Most of the allowed parameter space is excluded for a Z′ boson with 350 < $m_{Z'}$ < 500 GeV, but large regions of the parameter space are also excluded at higher masses.







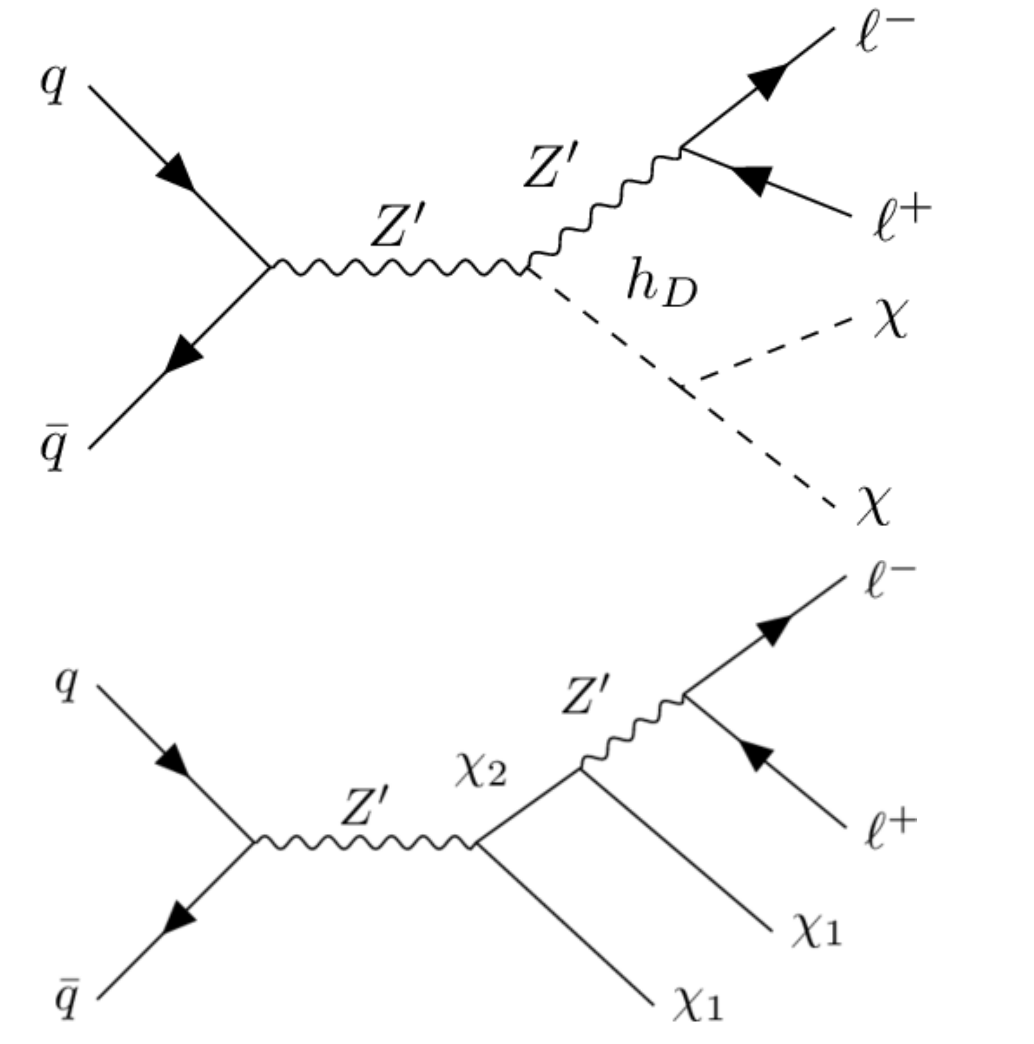




Dileptons + MET

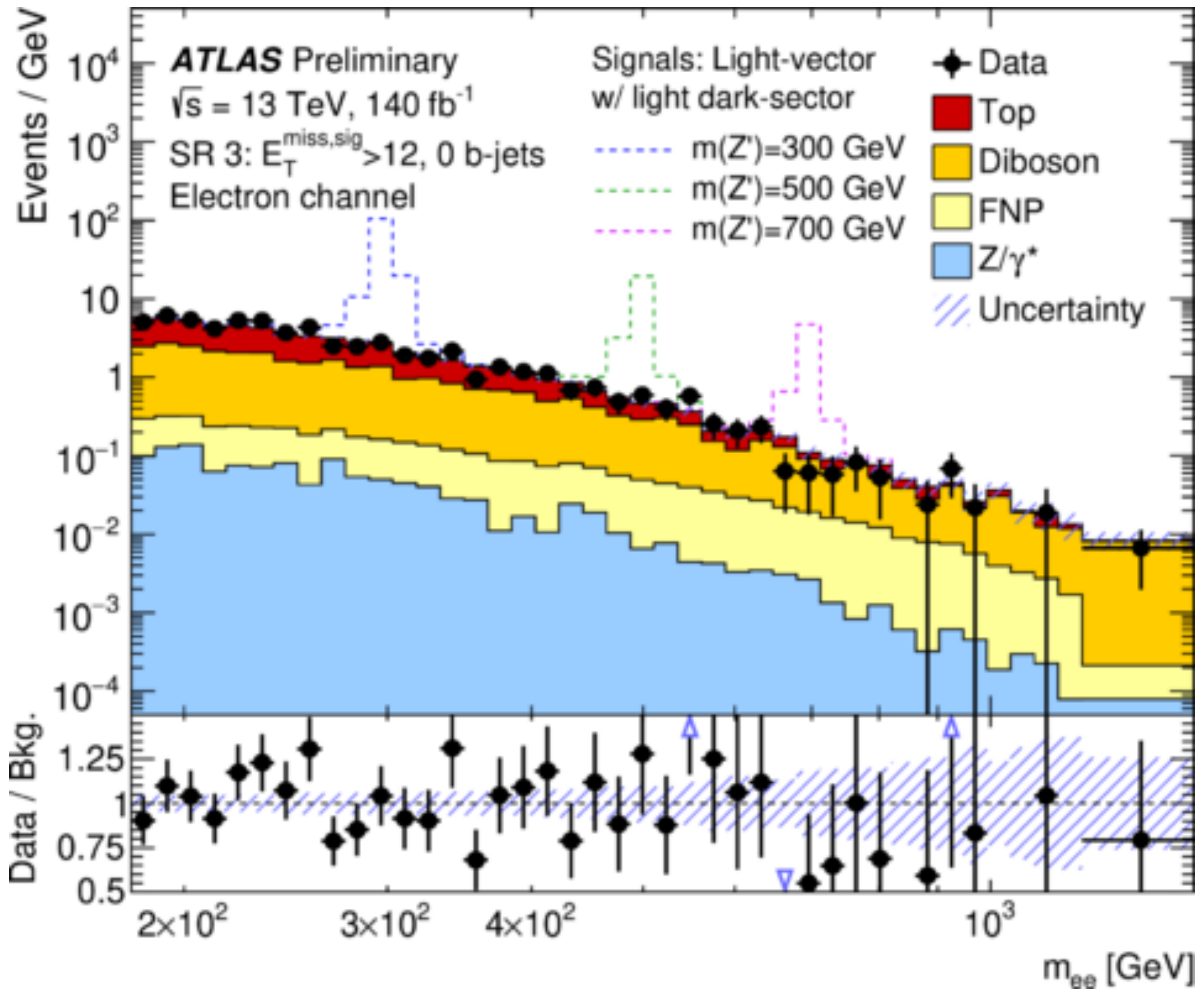
ATLAS-CONF-2023-045

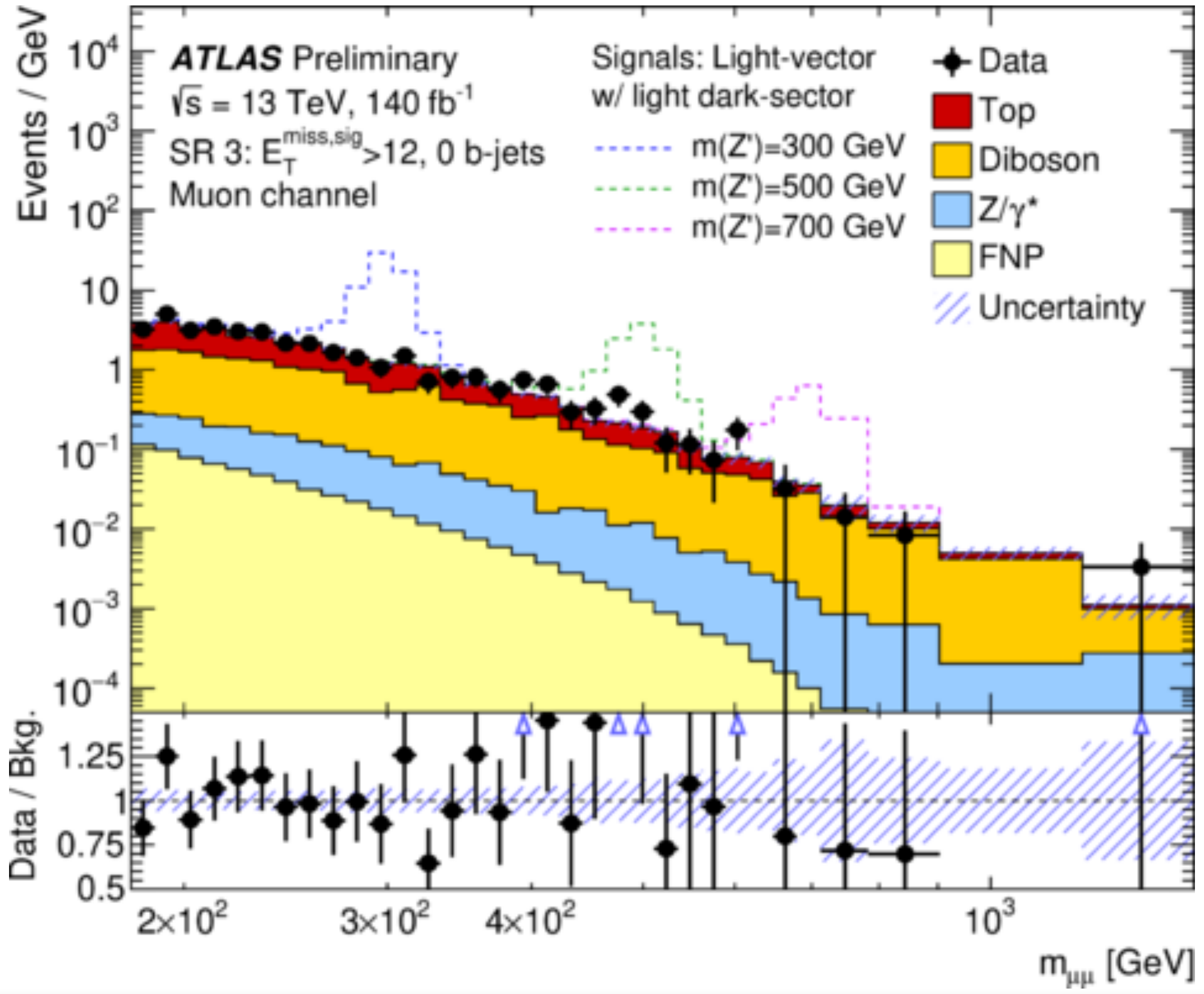
- Search for dark matter particles produced in association with a new neutral vector boson.
- Decays of the Z′ boson to same-flavour light leptons ($e^+e^-/\mu^+\mu^-$) are studied for Z′ masses above 200 GeV.
- No significant excess over the SM prediction is observed.
  - The results are interpreted for several dark-Higgs and light-vector benchmark model scenarios.
  - Cross-section limits are set considering each benchmark scenario, as well as limits on the coupling of the Z′ with leptons.



	Dark Higgs	Light Vector
Light dark-sector	$m_\chi = 5$ GeV	$m_{\chi_1} = 5$ GeV
	$m_{h_D} = 125$ GeV	$m_{\chi_2} = m_{\chi_1} + m_{Z'} + 25$ GeV
Heavy dark-sector	$m_\chi = 5$ GeV	$m_{\chi_1} = m_{Z'}/2$
	$m_{h_D} = m_{Z'}$	$m_{\chi_2} = 2m_{Z'}$

Benchmark model	Limit	Cross Section [pb] *ee*	Cross Section [pb] *μμ*	Lepton Coupling *ee*	Lepton Coupling *μμ*
Light Vector – light dark-sector	Expected	2.5×10^{-4}	4.6×10^{-4}	0.019	0.026
	Observed	3.6×10^{-4}	9.4×10^{-4}	0.023	0.037
Light Vector – heavy dark-sector	Expected	1.3×10^{-4}	2.1×10^{-4}	0.11	0.14
	Observed	1.9×10^{-4}	4.7×10^{-4}	0.13	0.20
Dark Higgs – light dark-sector	Expected	5.8×10^{-4}	1.0×10^{-3}	0.017	0.022
	Observed	8.9×10^{-4}	2.0×10^{-3}	0.021	0.031
Dark Higgs – heavy dark-sector	Expected	1.6×10^{-4}	2.4×10^{-4}	0.076	0.094
	Observed	2.3×10^{-4}	5.3×10^{-4}	0.091	0.14

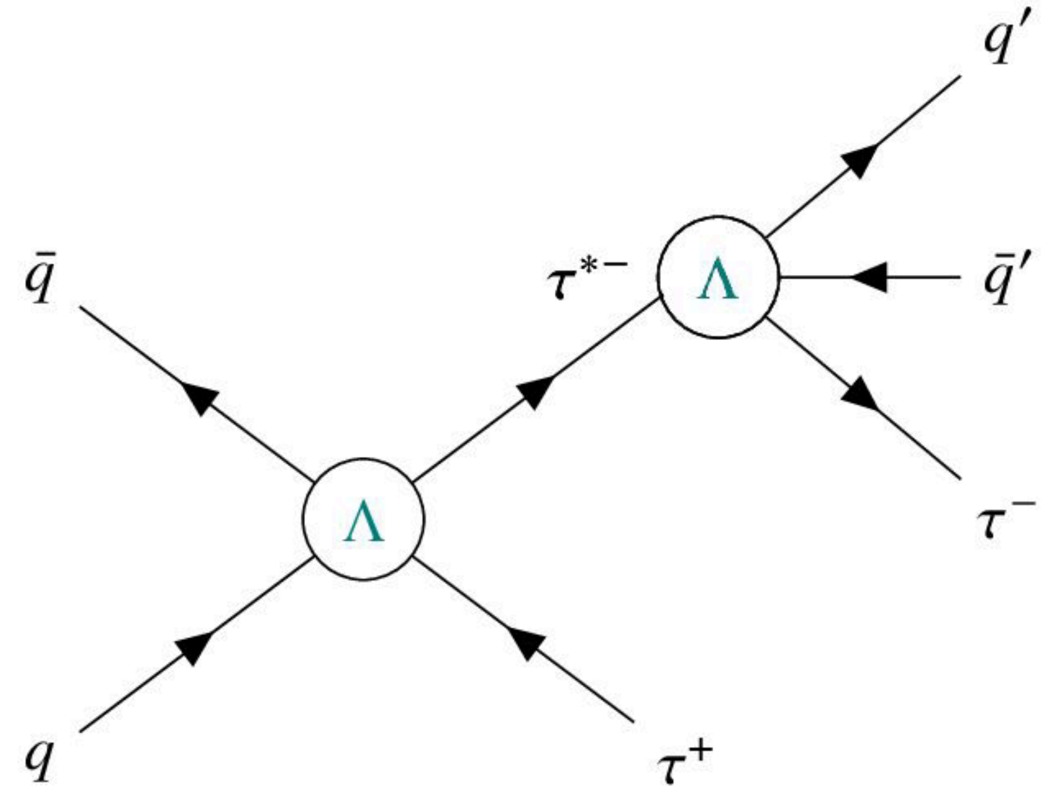




Excited Taus

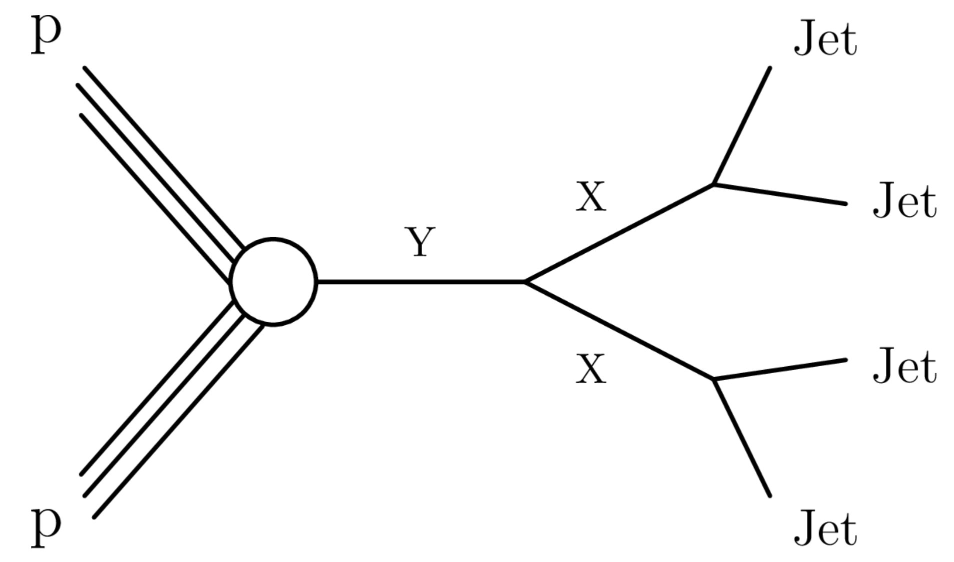
ATLAS: JHEP 06 (2023) 199

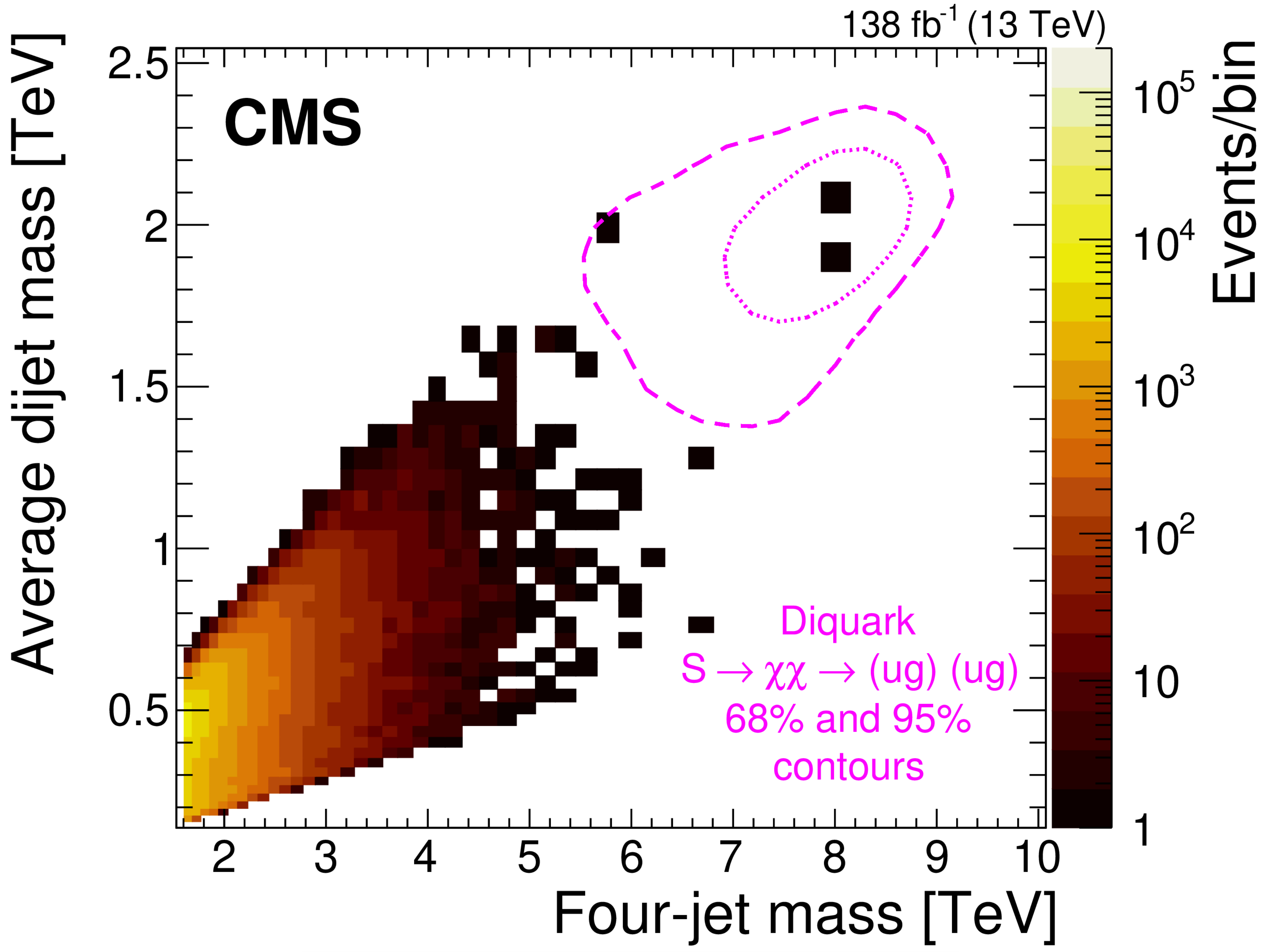
- Search for excited τ-lepton and leptoquarks.
- $\tau\tau jj$ final state: events with two hadronically decaying τ-leptons and two or more jets.
- 4-fermion contact interaction production and decay.
- Leptoquarks with masses below 1.3 TeV are excluded.



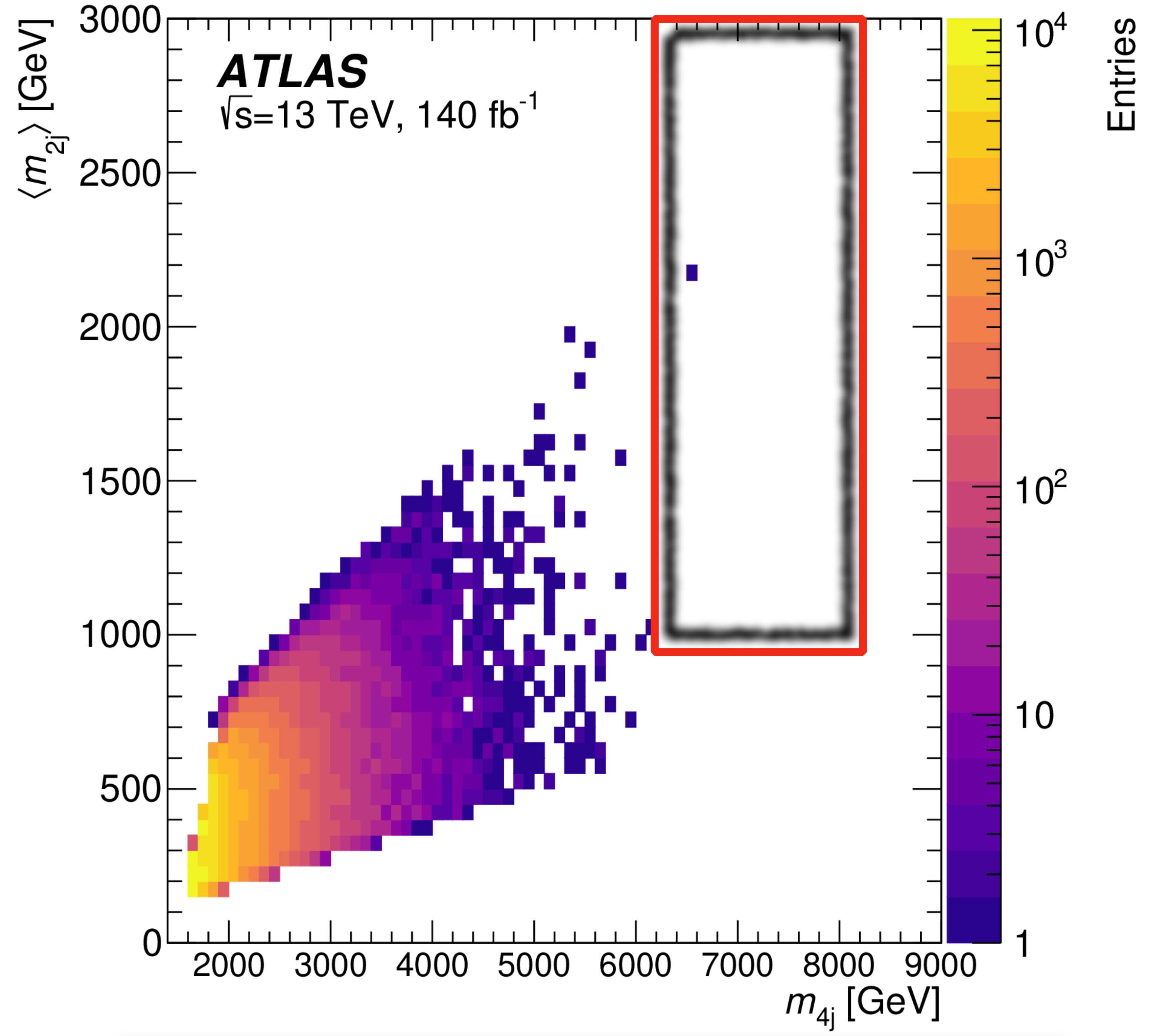
Multi-Jet Resonance Searches

- Search for resonance Y decaying to resonance X decaying to di-jets, Y → XX → 4j.
- Bump hunt in $m_{4j} \approx m_Y$ and the average di-jet system $\langle m_{2j} \rangle \approx m_X$.
- CMS: 1.6σ global (3.9σ local) excess at m(Y,X) = (8,2) TeV.
- ATLAS: No events observed around 8 TeV.





CMS: JHEP 07 (2023) 161



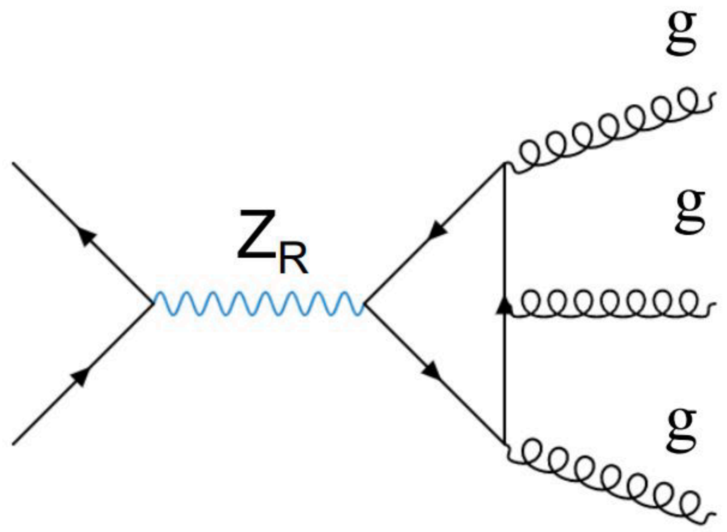
ATLAS: arXiv:2307.14944
(submitted to PRD)

Multi-Jet Resonance Searches

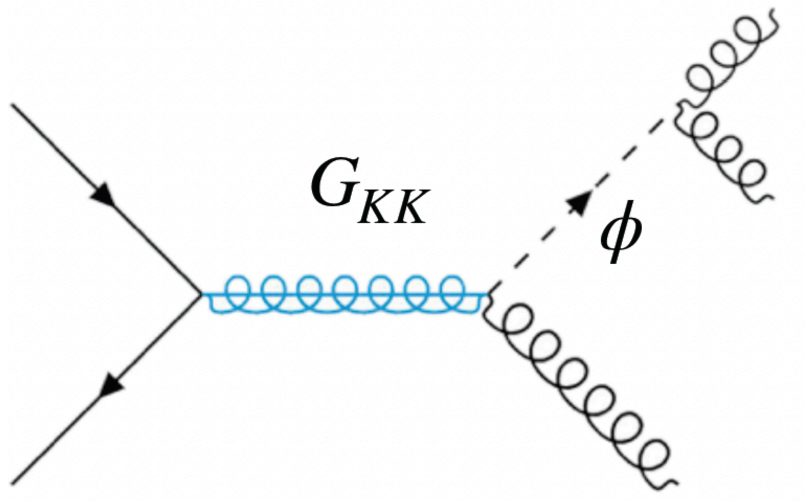
CMS-PAS-EXO-22-008

- Search for narrow tri-jet resonances.
- Direct 3-body decay of a right-handed Z_R boson, both with narrow width.
- Cascade decay of an initial resonance X, a Kaluza-Klein gluon or an excite quark q*, with intermediate resonance Y.
- Extend di-jet search techniques to tri-jet case probing mass range $m_{3j} \approx 1.75 - 9$ TeV.

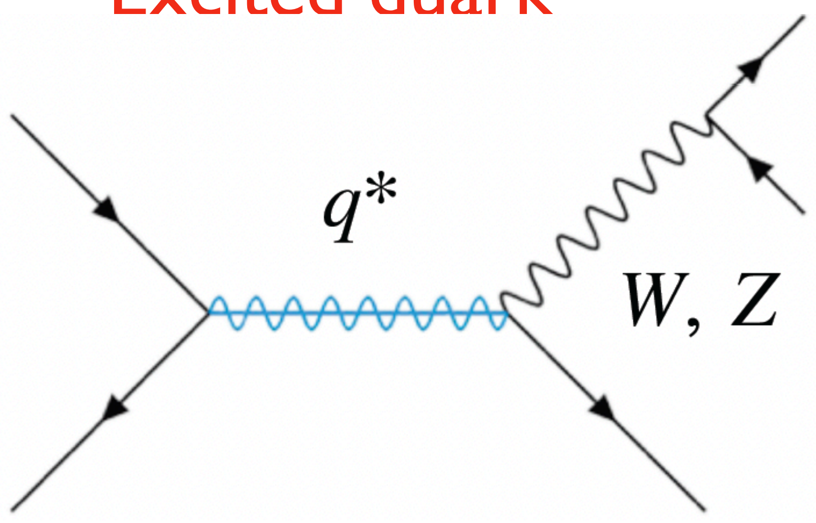
Right-handed Z boson

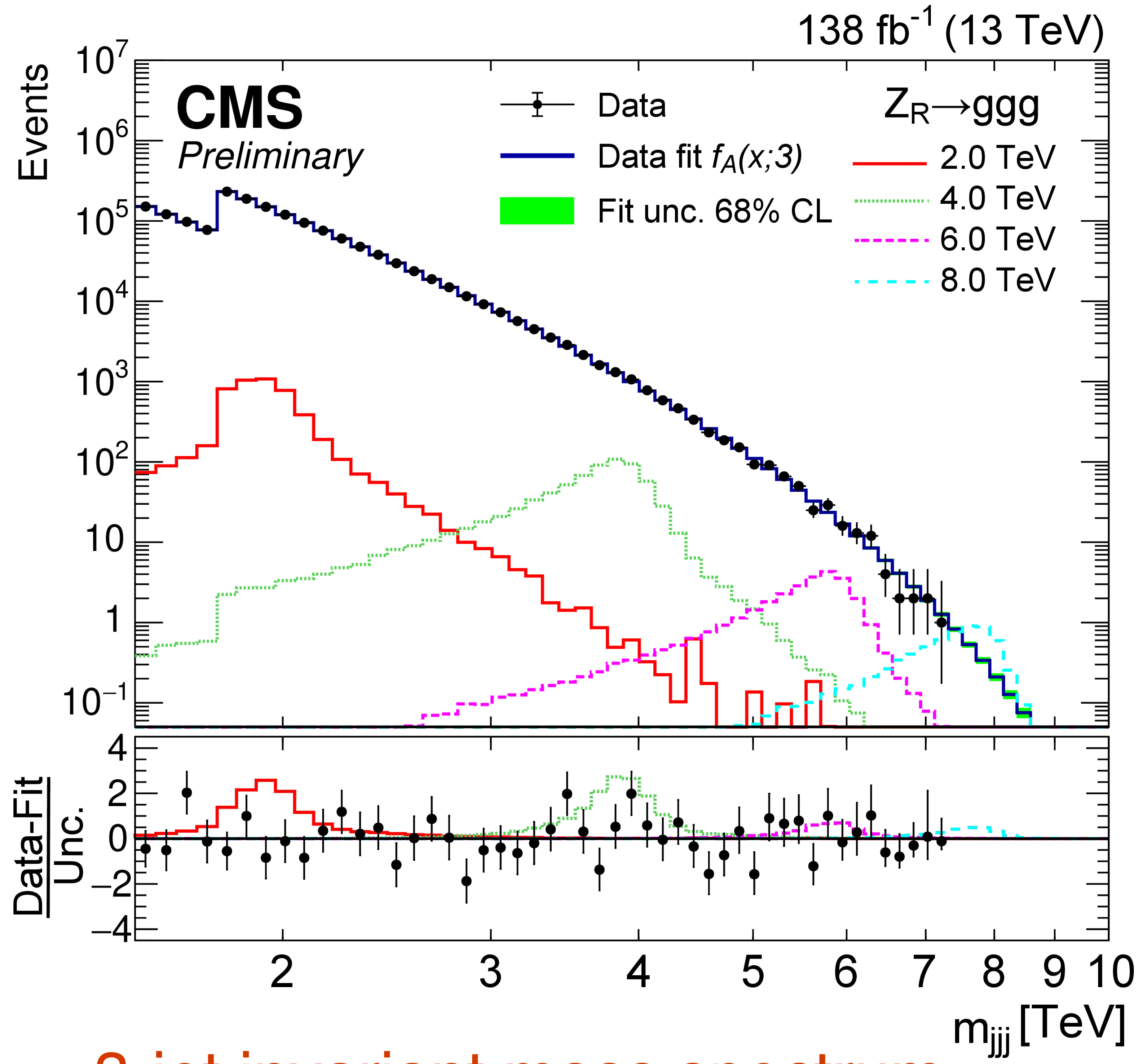


Kaluza-Klein gluon

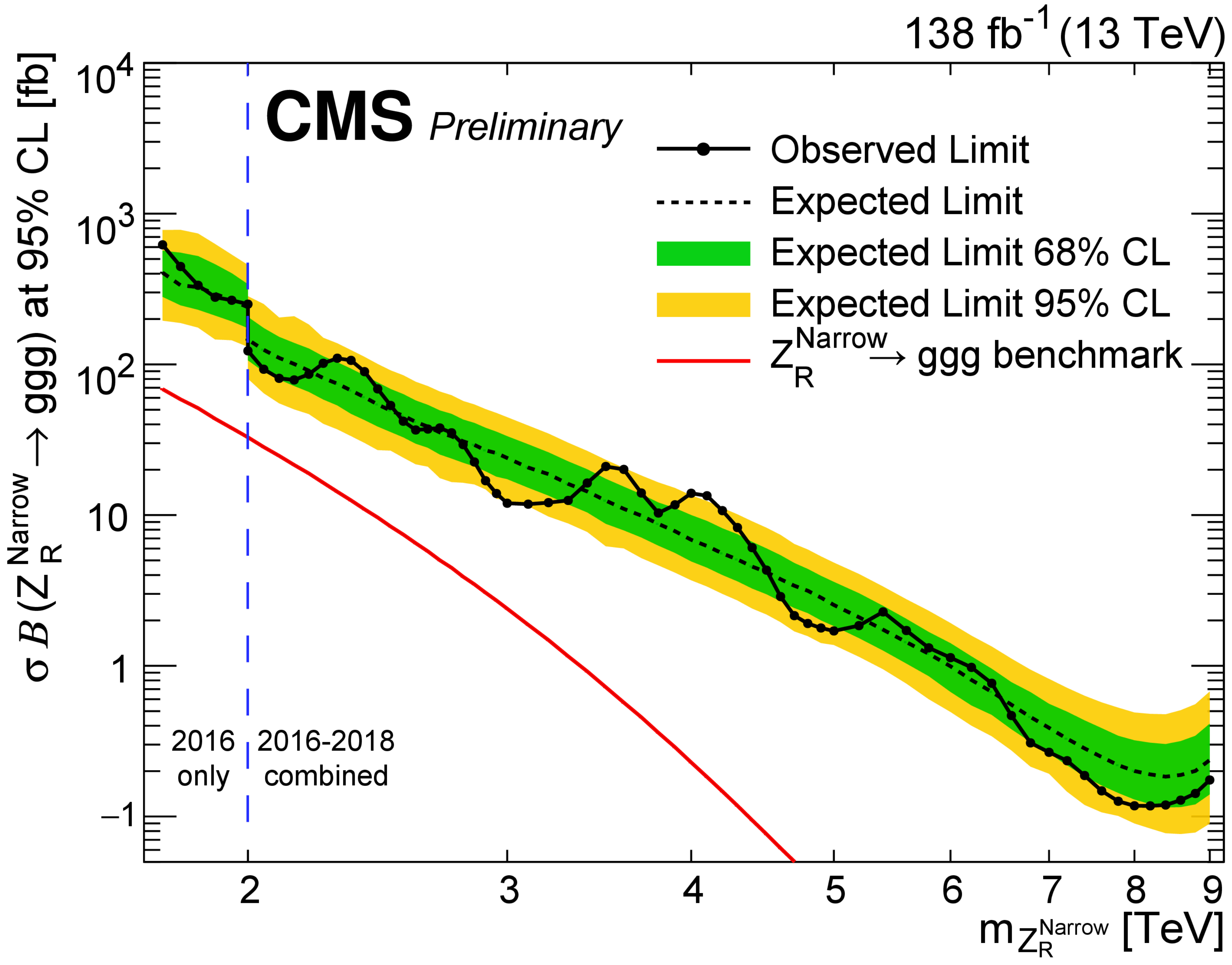


Excited quark





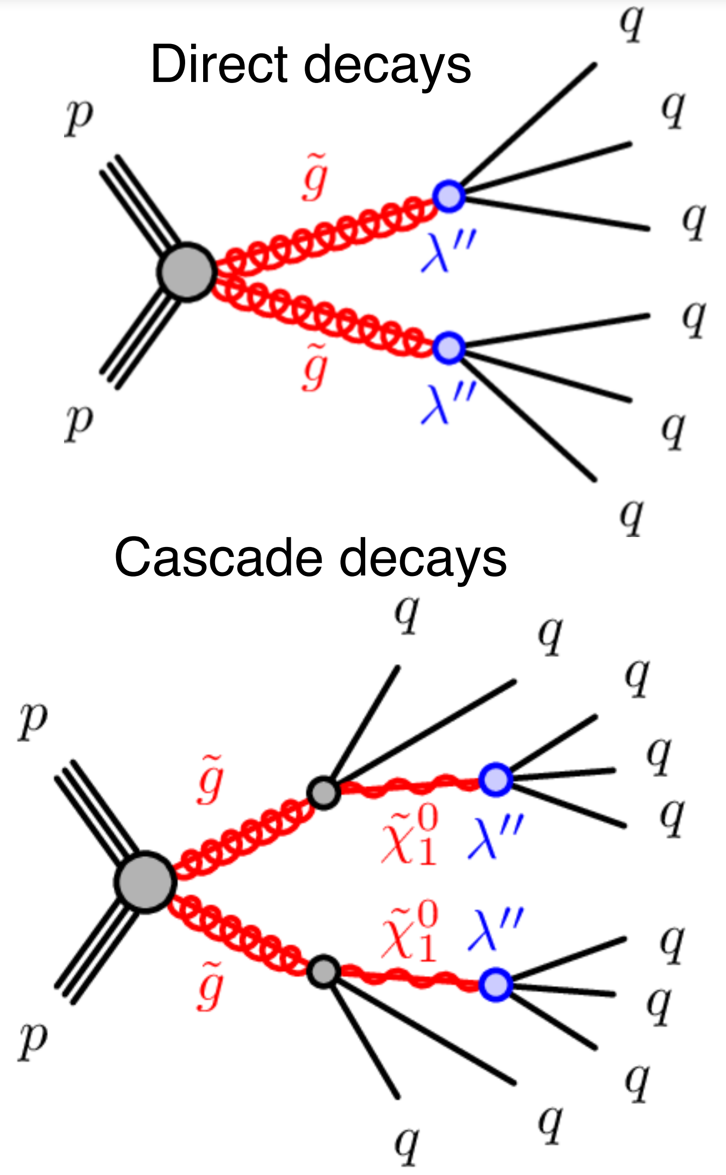
3-jet invariant mass spectrum

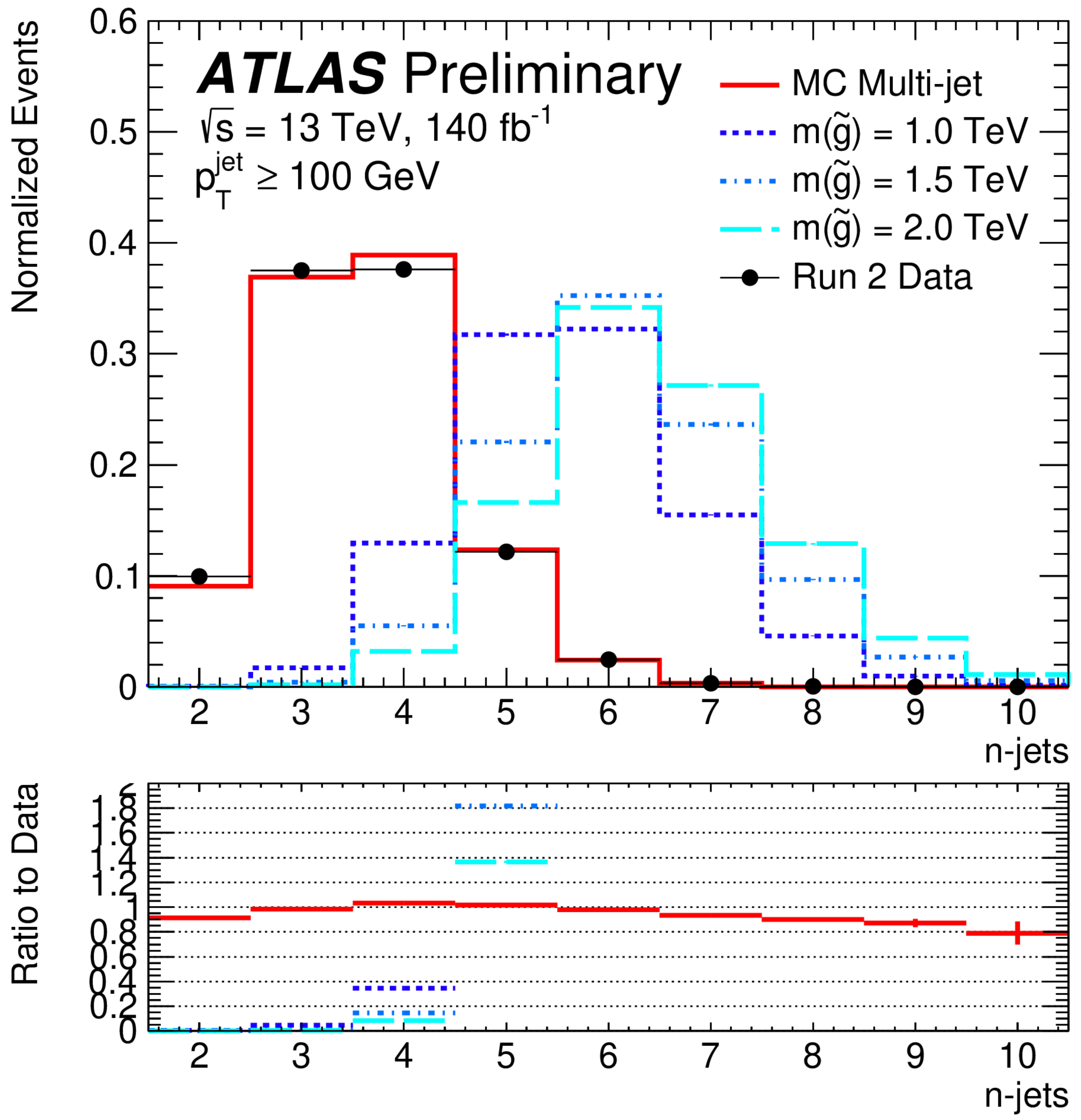


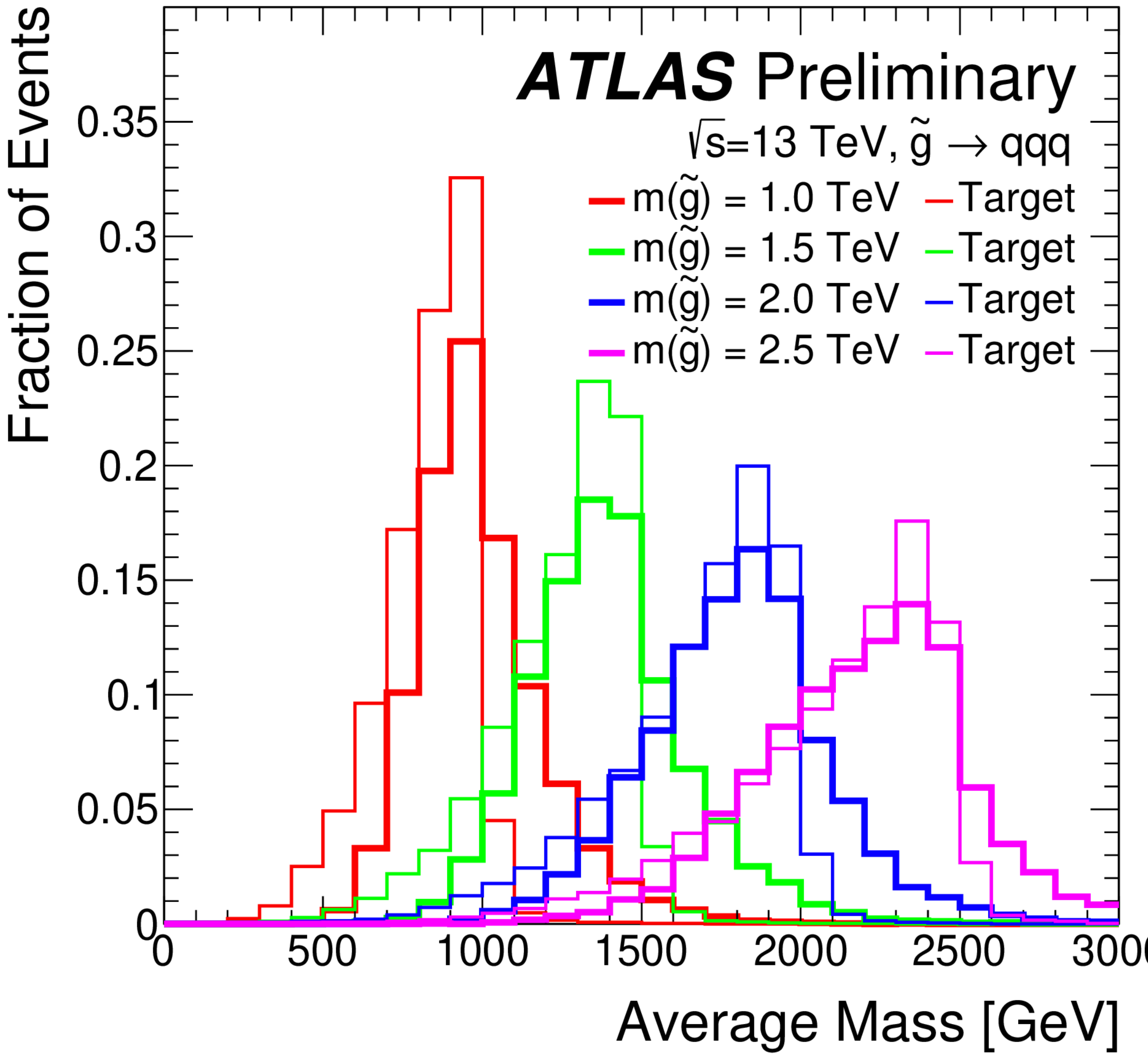
Multi-Jet Resonance Searches

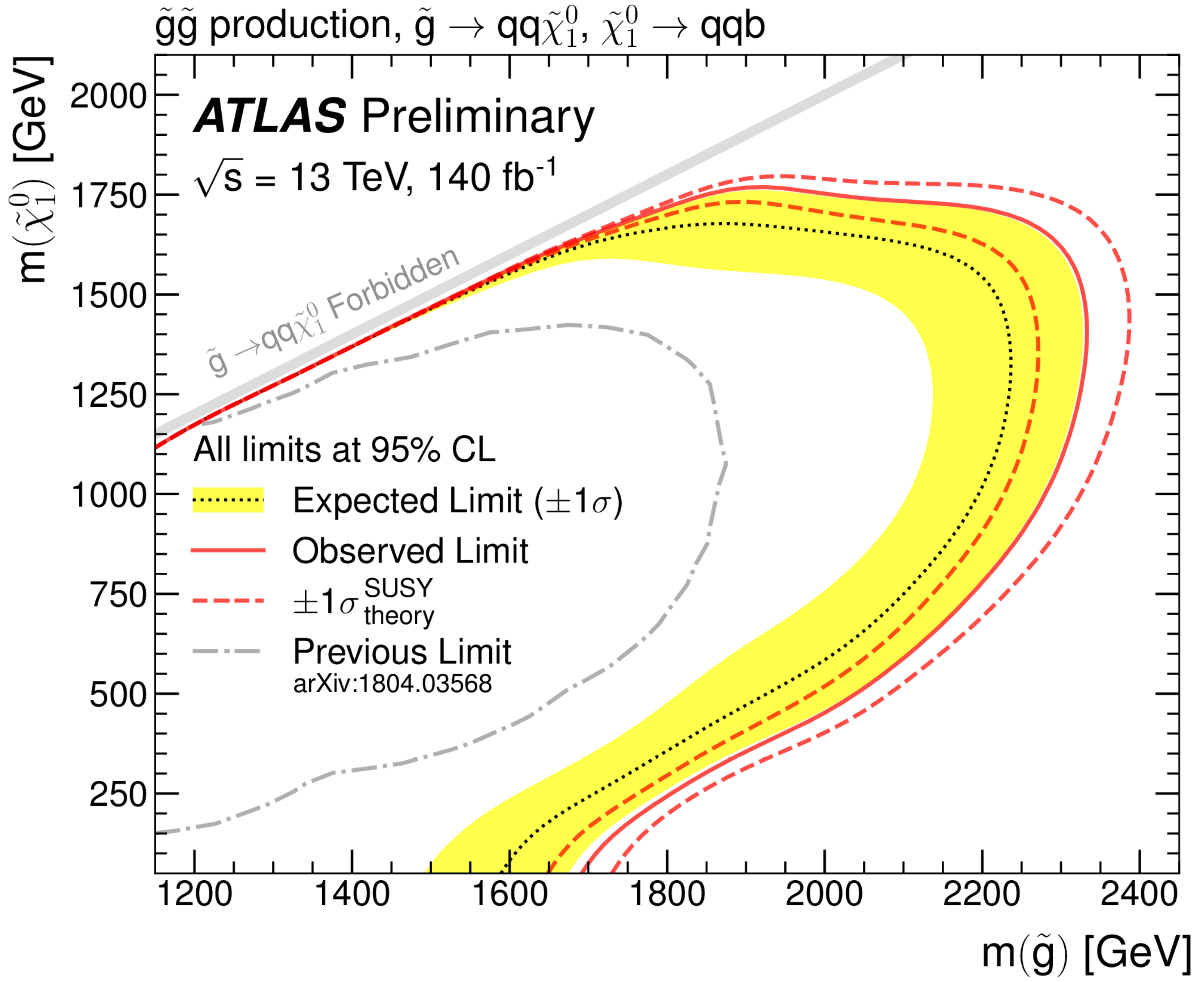
ATLAS-CONF-2023-049

- Search for pair-produced multijet signals: tri-jets, high jet multiplicity.
- New analysis techniques with ML for jet assignment.
- Major improvement in sensitivity compared to previous result.





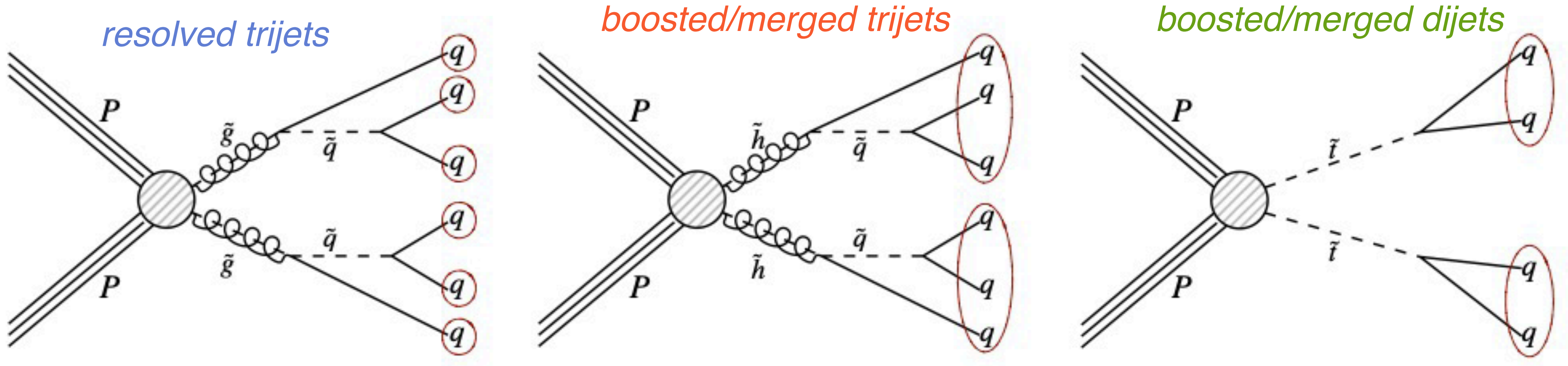




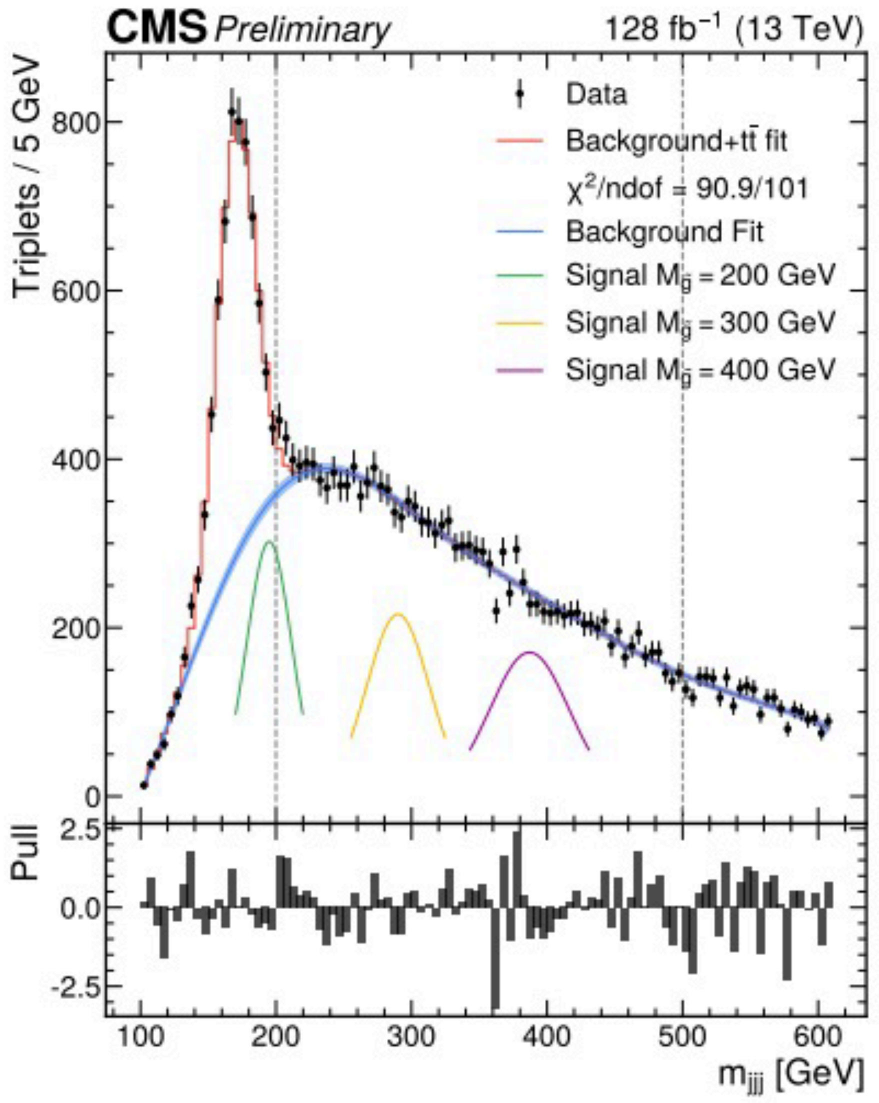
Multi-Jet Resonance Searches

CMS-PAS-EXO-21-004

- Search for pair-produced multijet signatures, measuring the average mass distribution of pairs of trijets, and pairs of merged dijets.
  - Pair production of higgsinos, gluinos, and top squarks, in the RPV supersymmetric framework is considered.
- Uses scouting dataset: saves only event data reconstructed by the high-level trigger ⇒ improves sensitivity.
- Extend prior exclusions on RPV squarks & gluinos to low masses ~70 – 200 GeV.

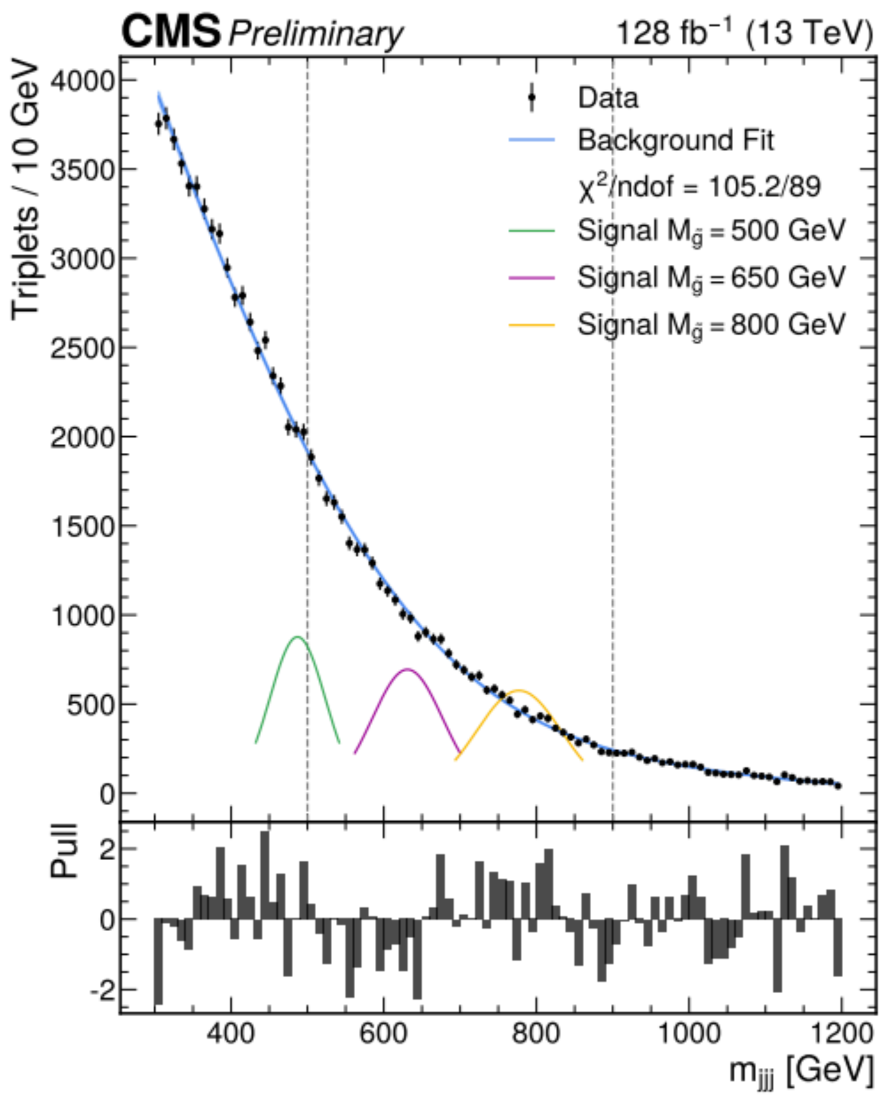


resolved trijets

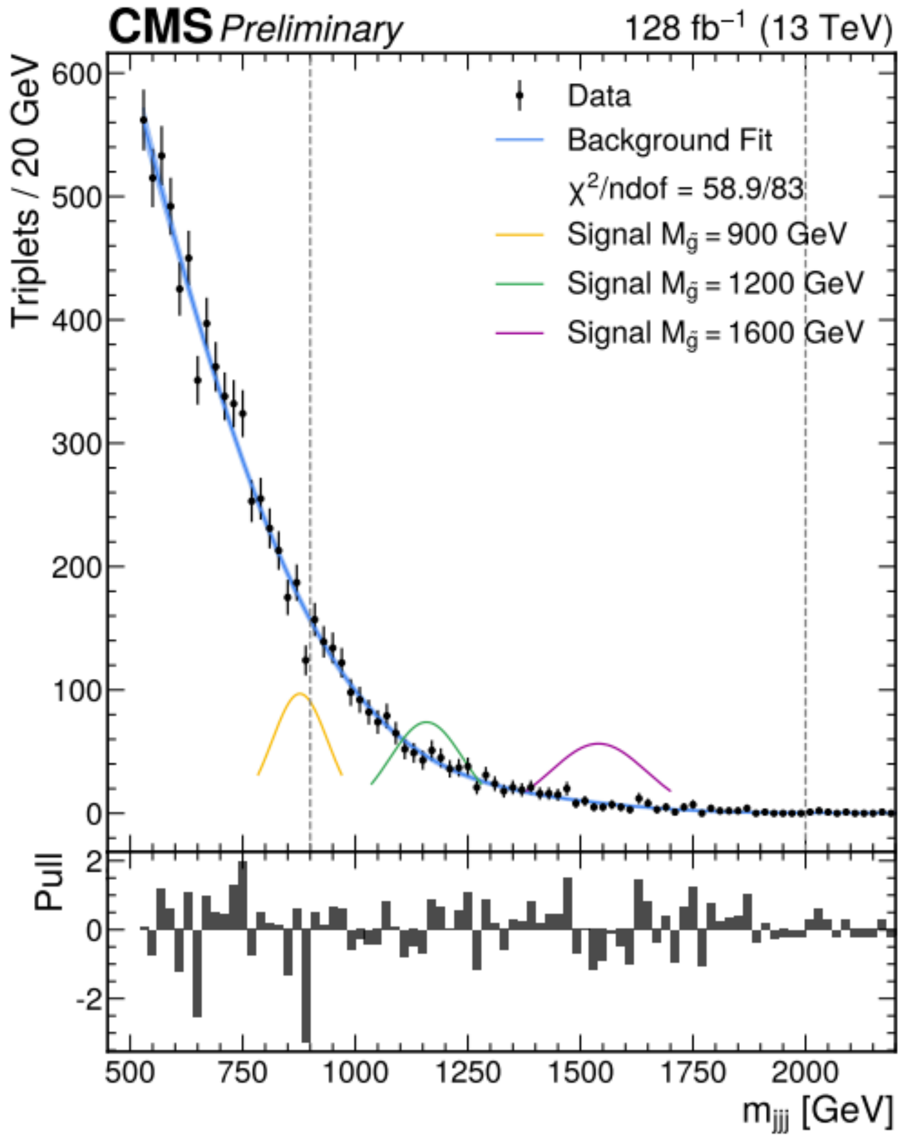


3-jet invariant mass spectrum

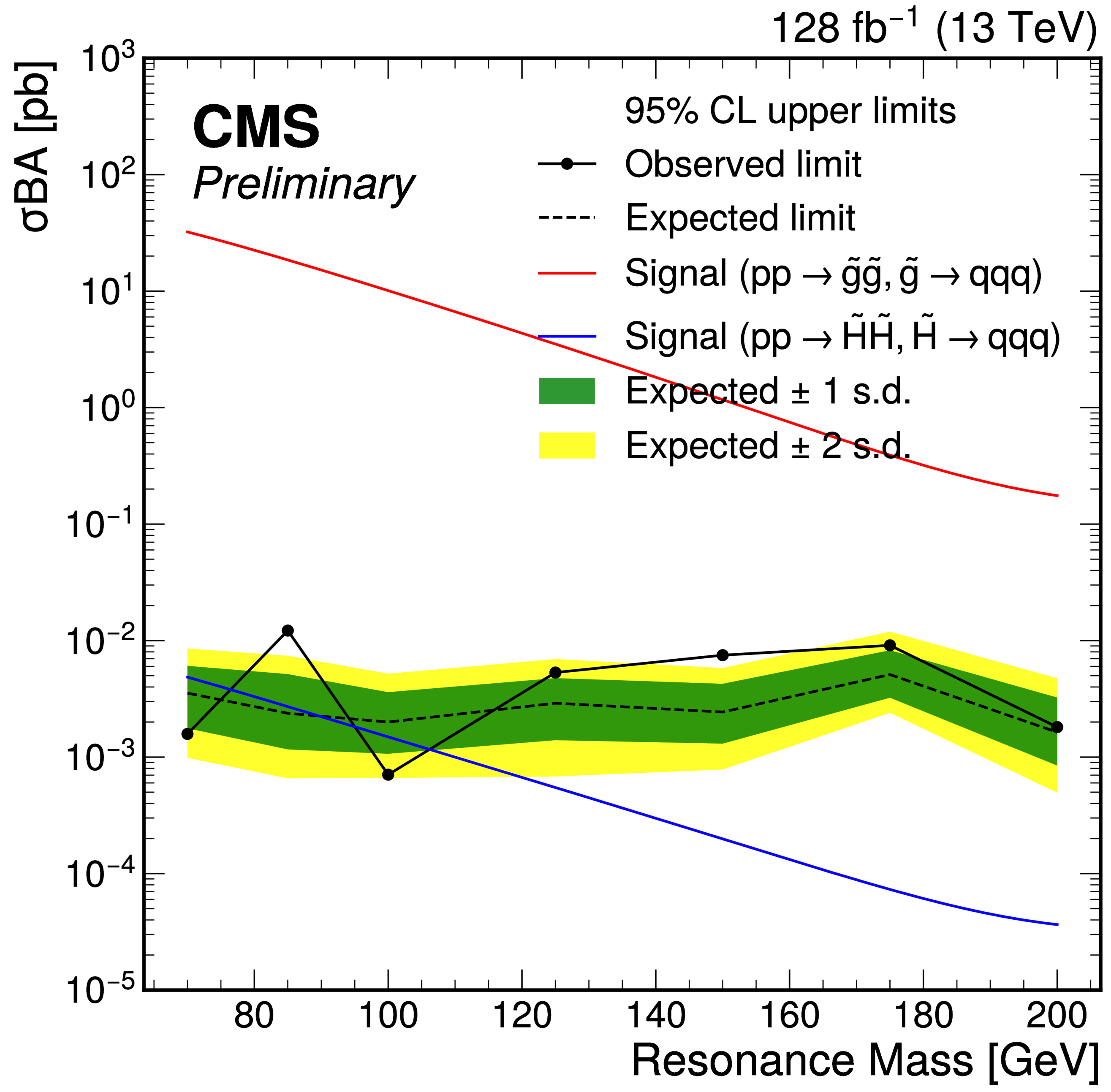
boosted/merged trijets



boosted/merged dijets



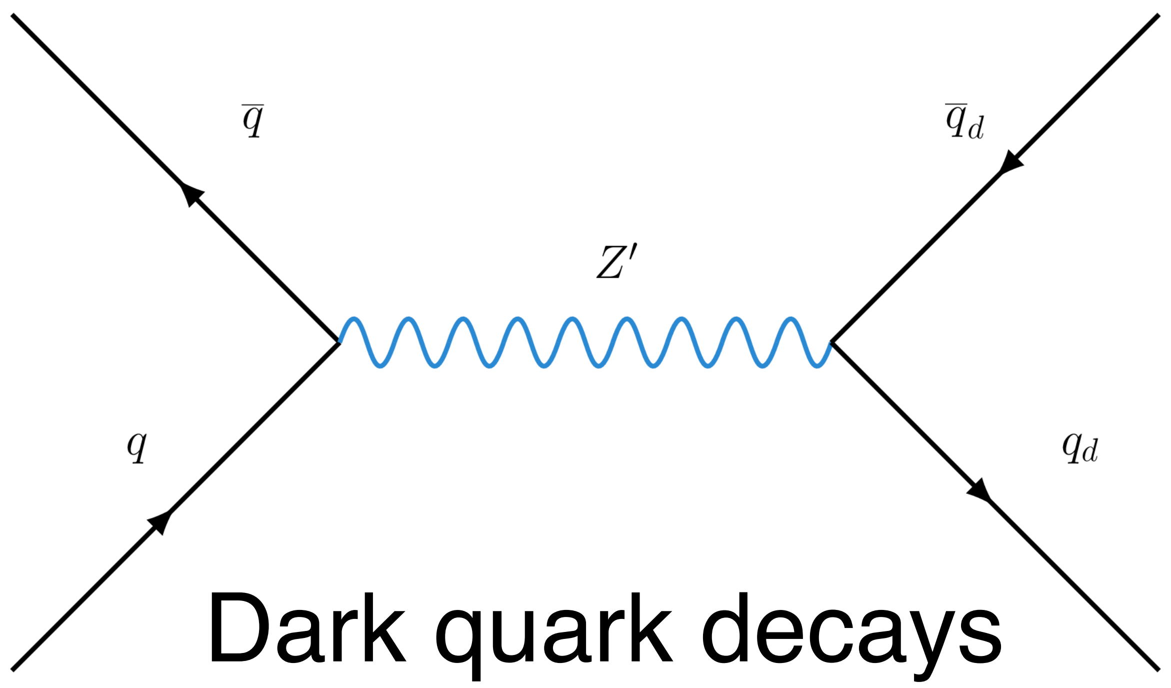
pair produced merged three quark resonances



Multi-Jet Resonance Searches

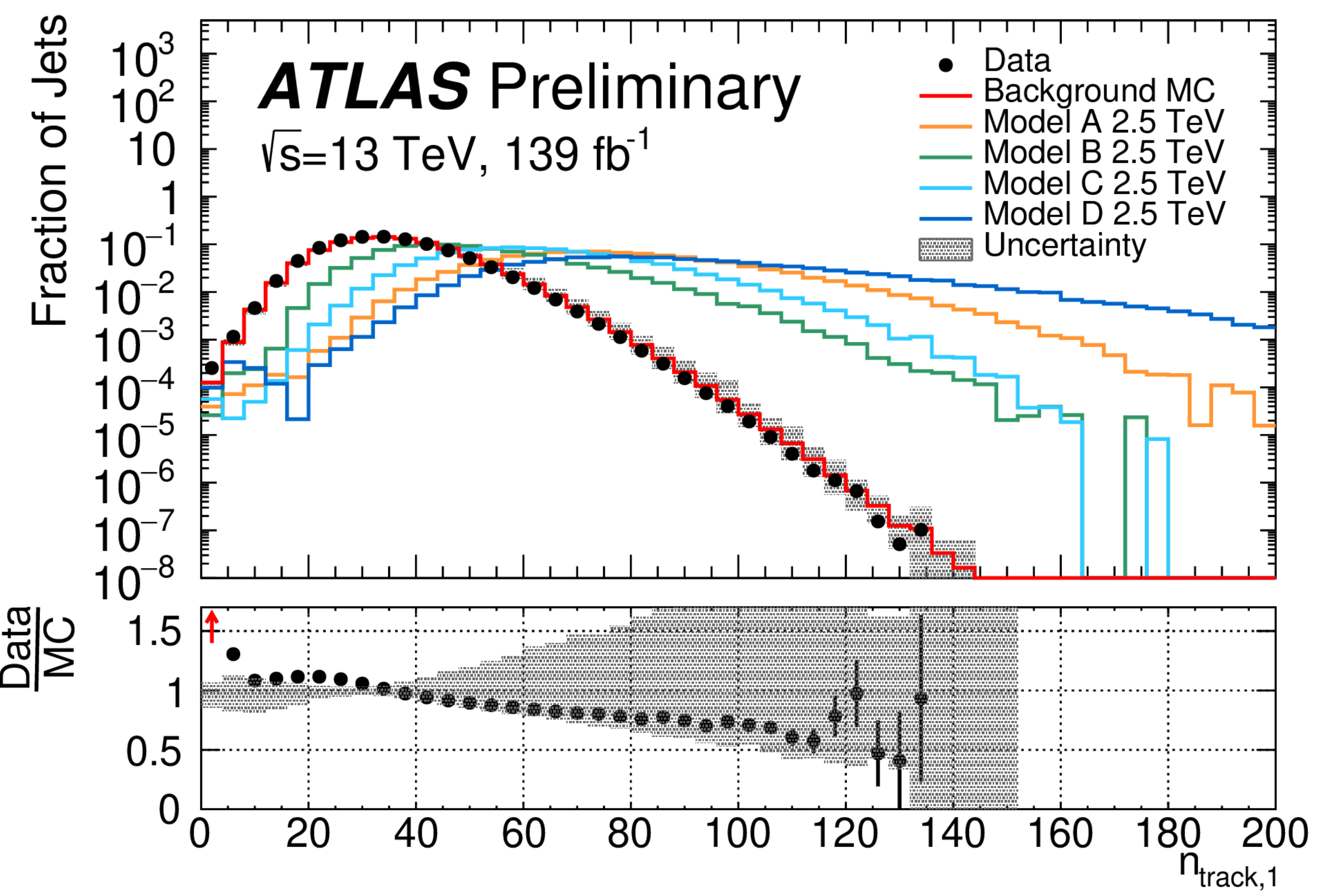
ATLAS-CONF-2023-047

- Search for exotic di-jet signatures − jets with high charged-particle multiplicity.
- Explores QCD-like dark sector scenarios with dark jets.
- Extend di-jet search techniques to dark jets probing mass range up to ~3 TeV.

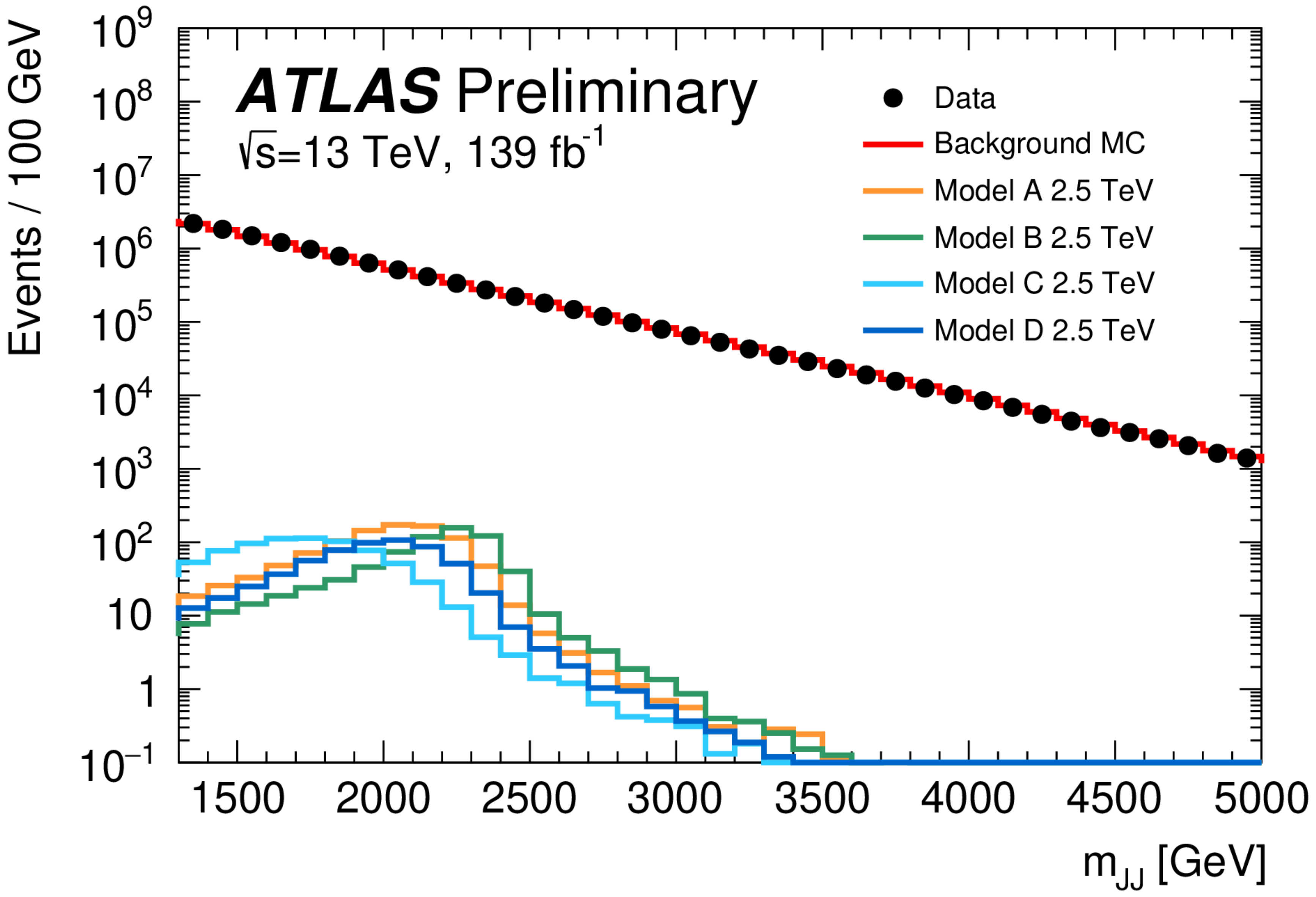


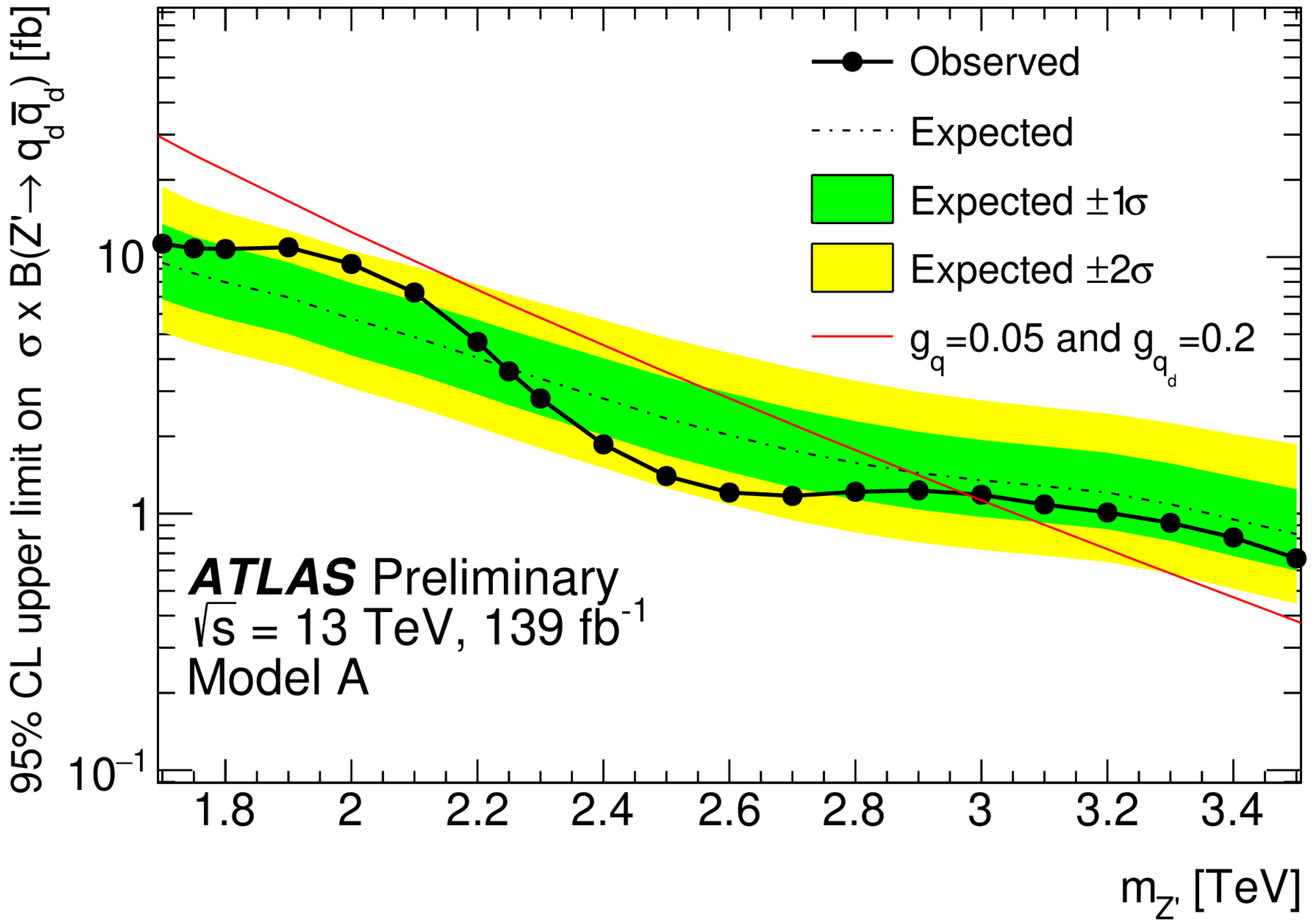
Dark quark decays

Track multiplicity



Dark jet pair invariant mass

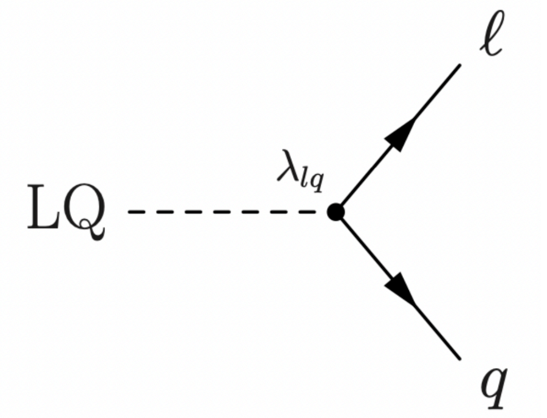


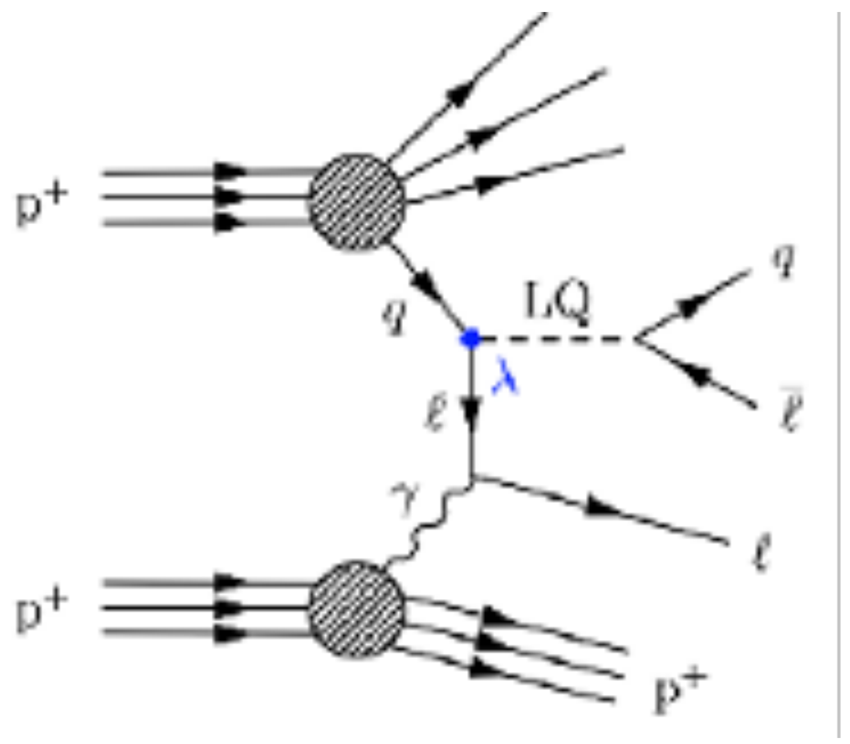


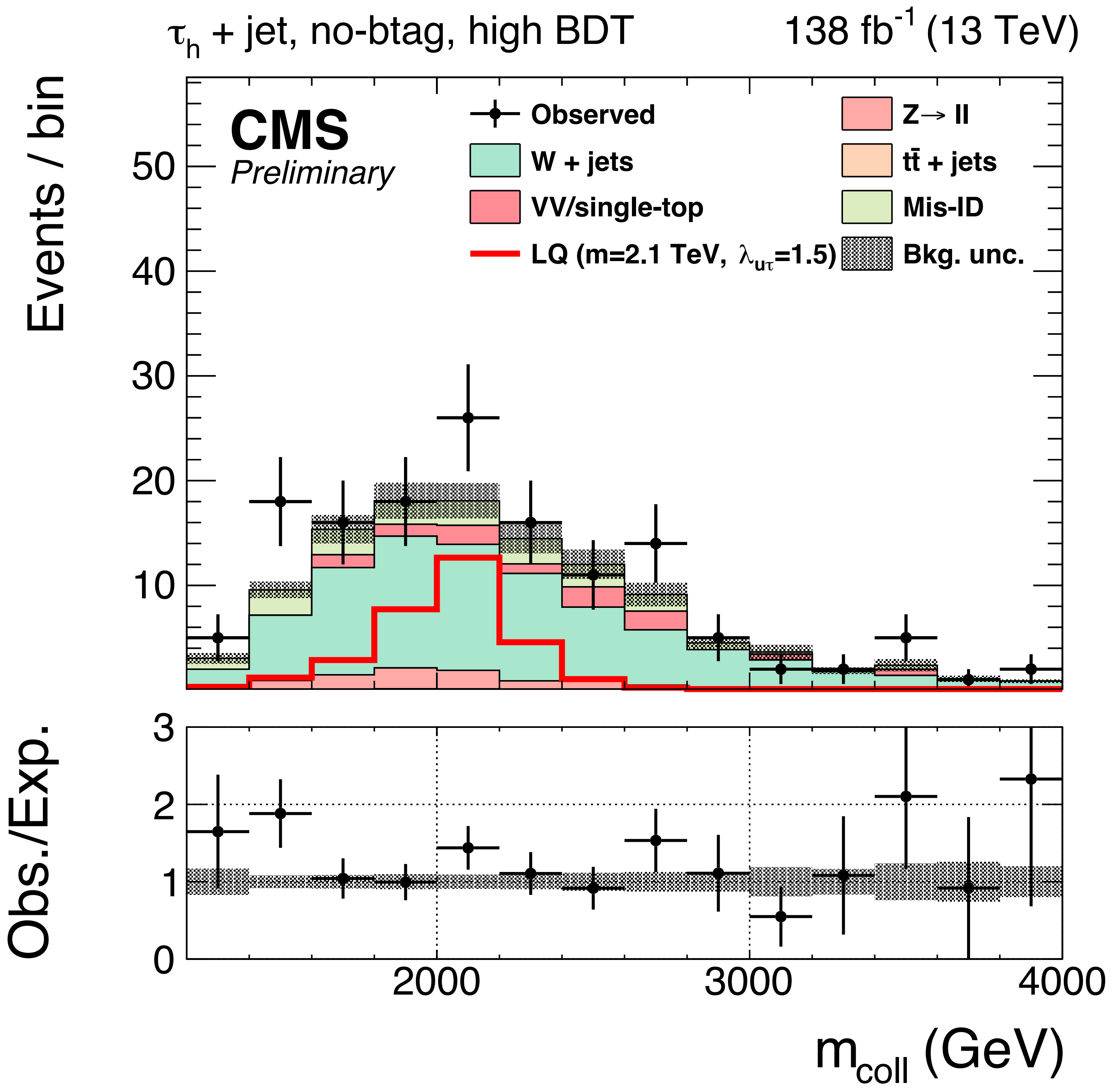
Searches for Leptoquarks

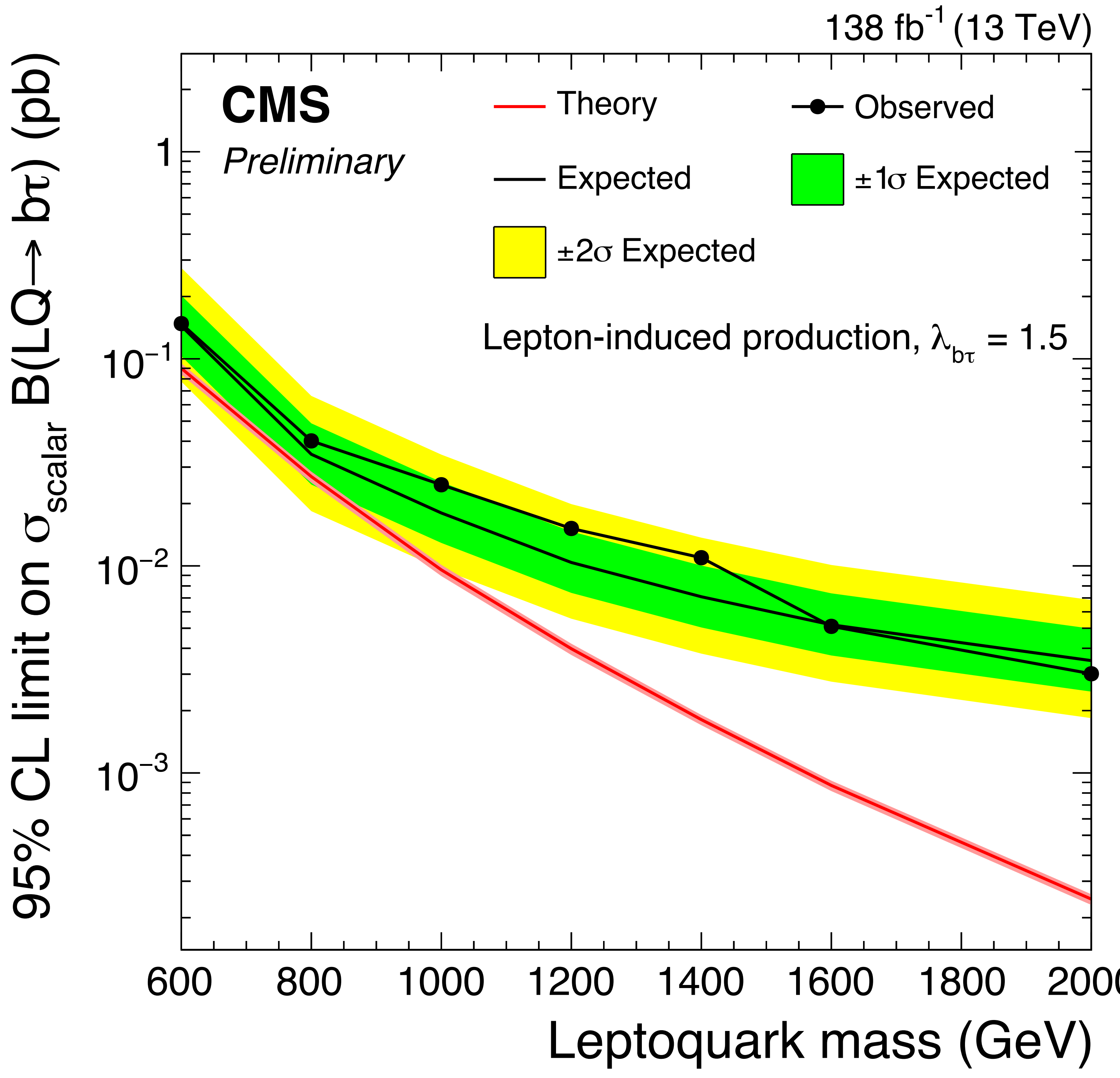
CMS: arXiv:2308.06143 (submitted to PRL)

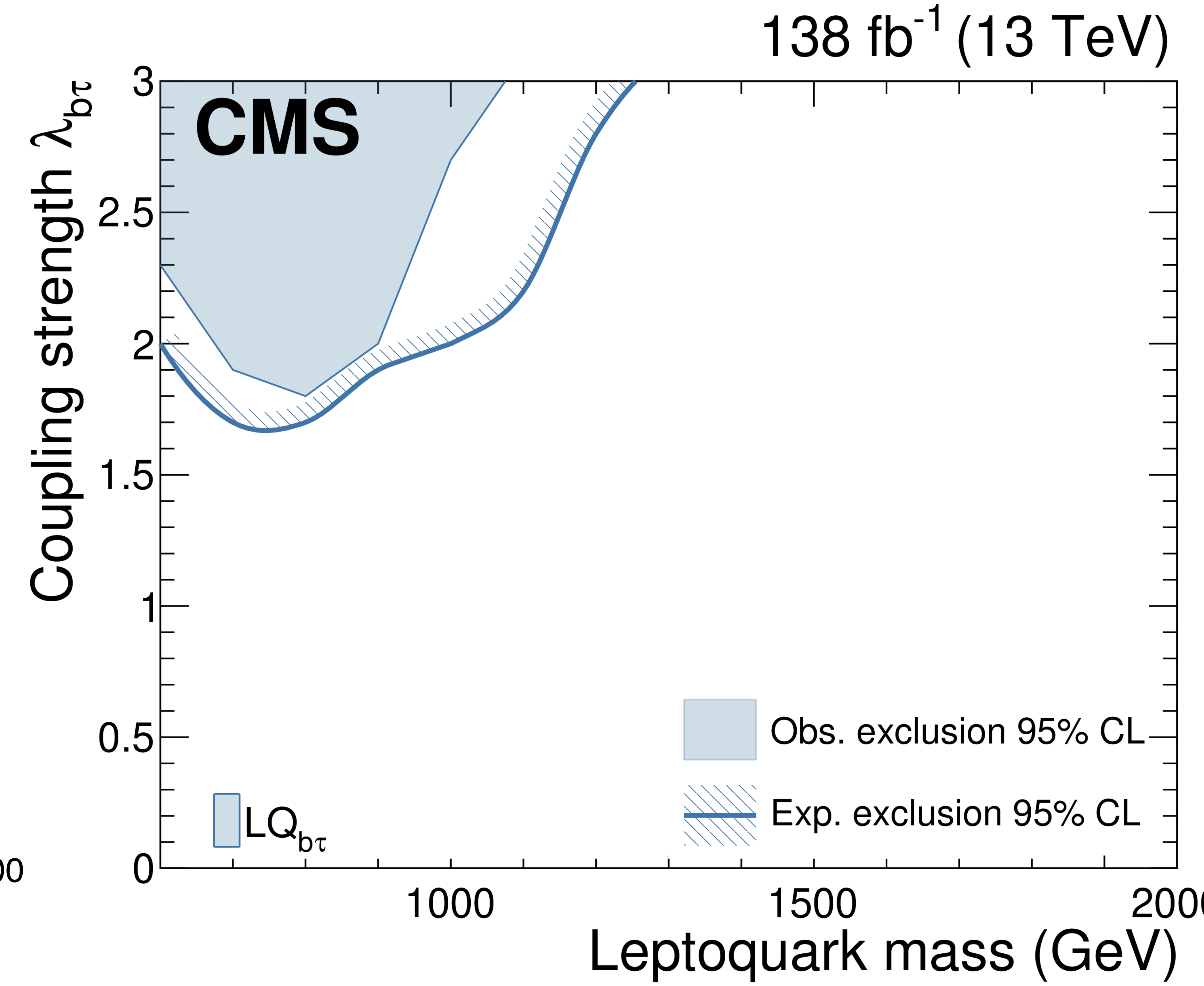
- Lepton-induced production of singly produced LQs coupling to τ.
- LQ produced from the collision of a quark and a lepton inside the proton.
- Using final states: $(\tau_e, \tau_\mu, \tau_h)$ + (jet, b-jet).
- Signature of two high-p_T muons and two high-p_T b-jets.







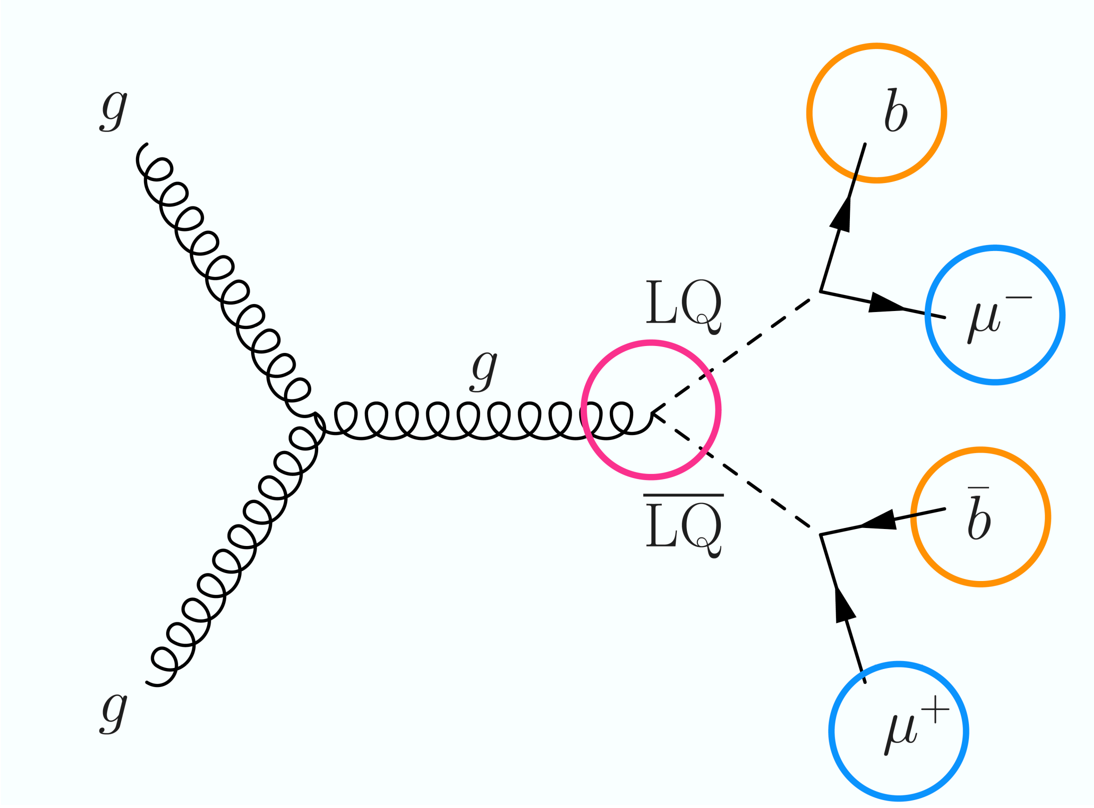


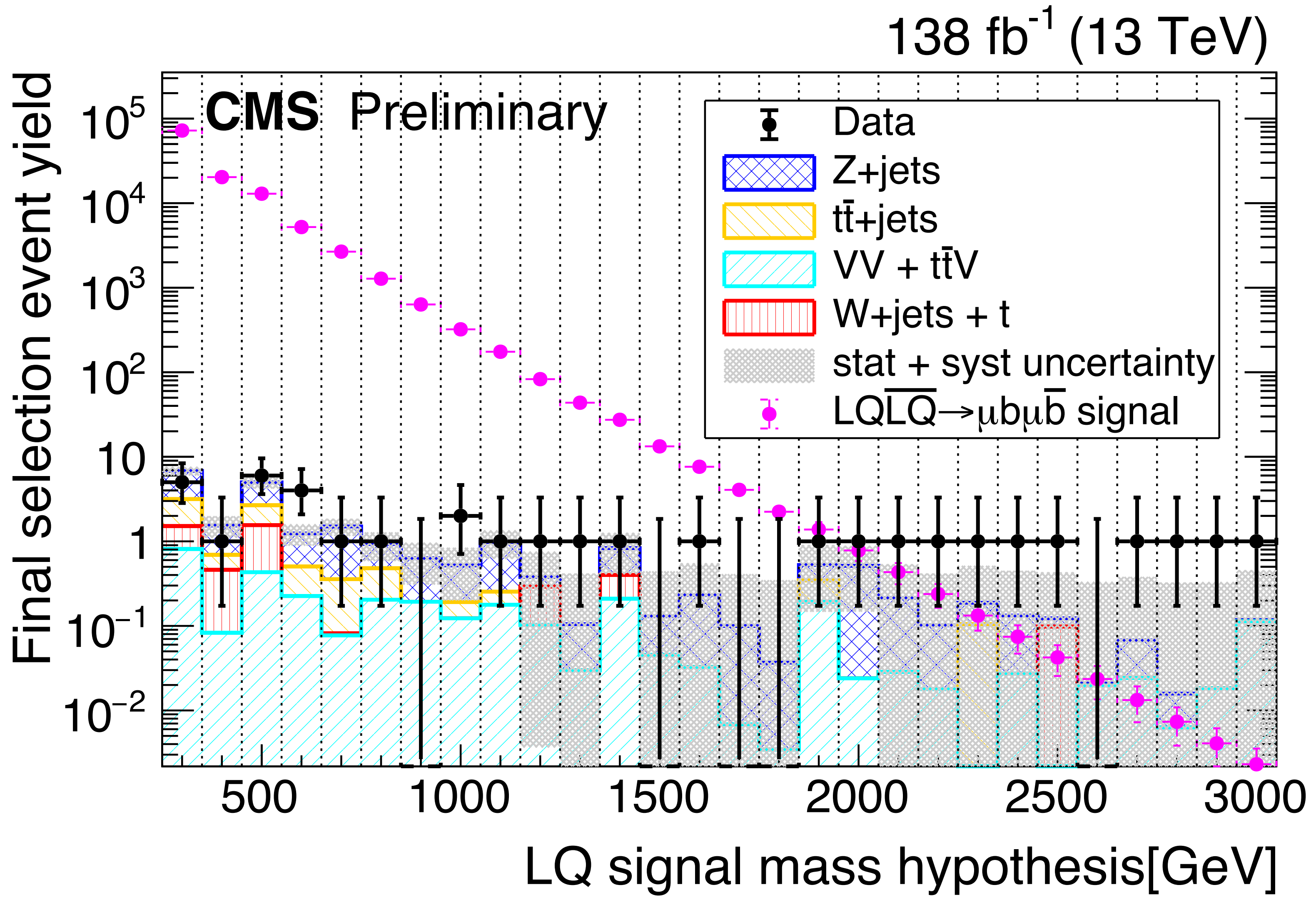


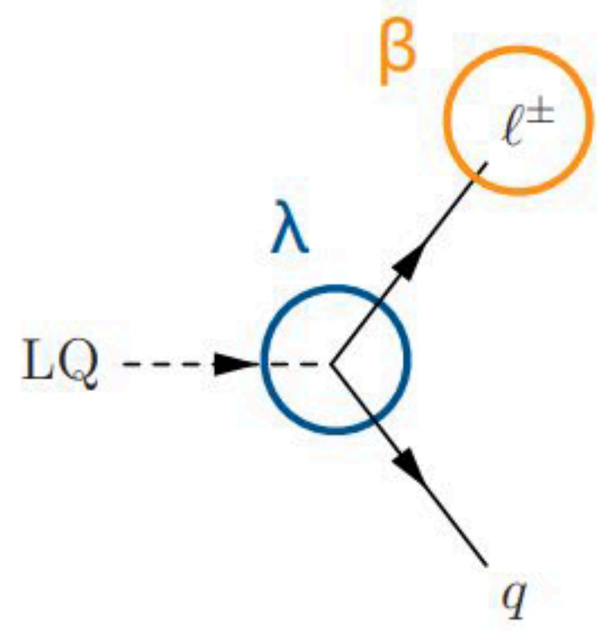
Searches for Leptoquarks

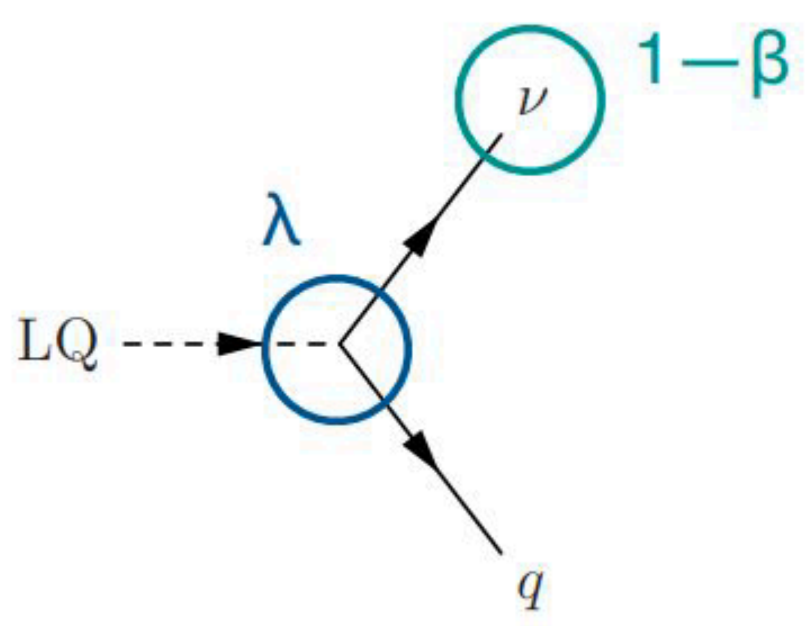
CMS-PAS-EXO-21-019

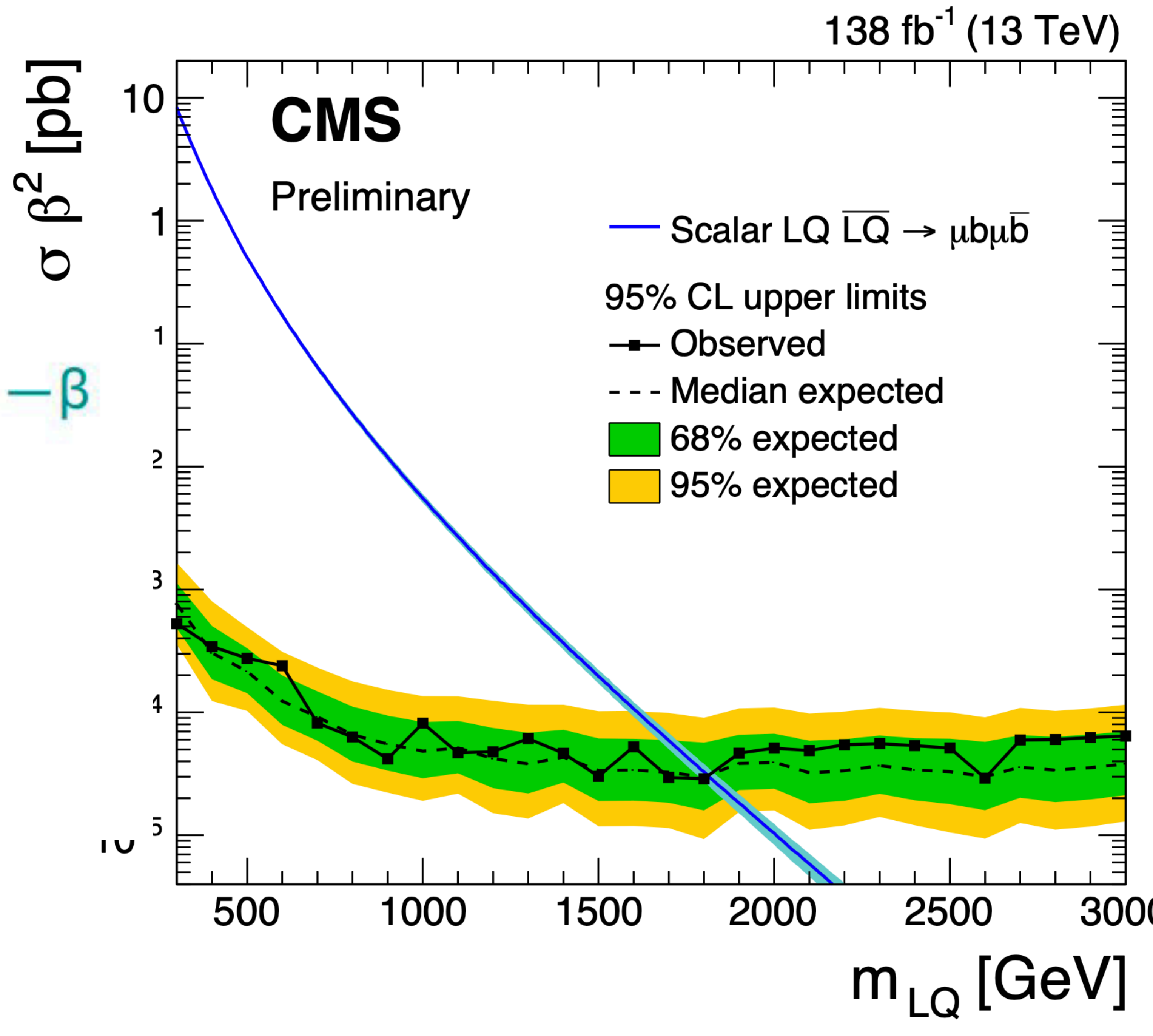
- Search for pair-produced scalar leptoquarks decaying to muons and bottom quarks.
  - force β=1 (no decays to neutrinos).
- Pair-production not sensitive to LQ-lepton-quark coupling strength λ_{LQ}.
- No longer constrained to uni-generational LQ couplings.
  - B factory and muon g-2 measurements motivate searches.
- Unique signature: Two high-p_T muons and two high-p_T b-jets.
  - Main backgrounds $Z\rightarrow\mu\mu$ with lost μ events.
- No excess observed: Exclusion limit 1810 GeV.







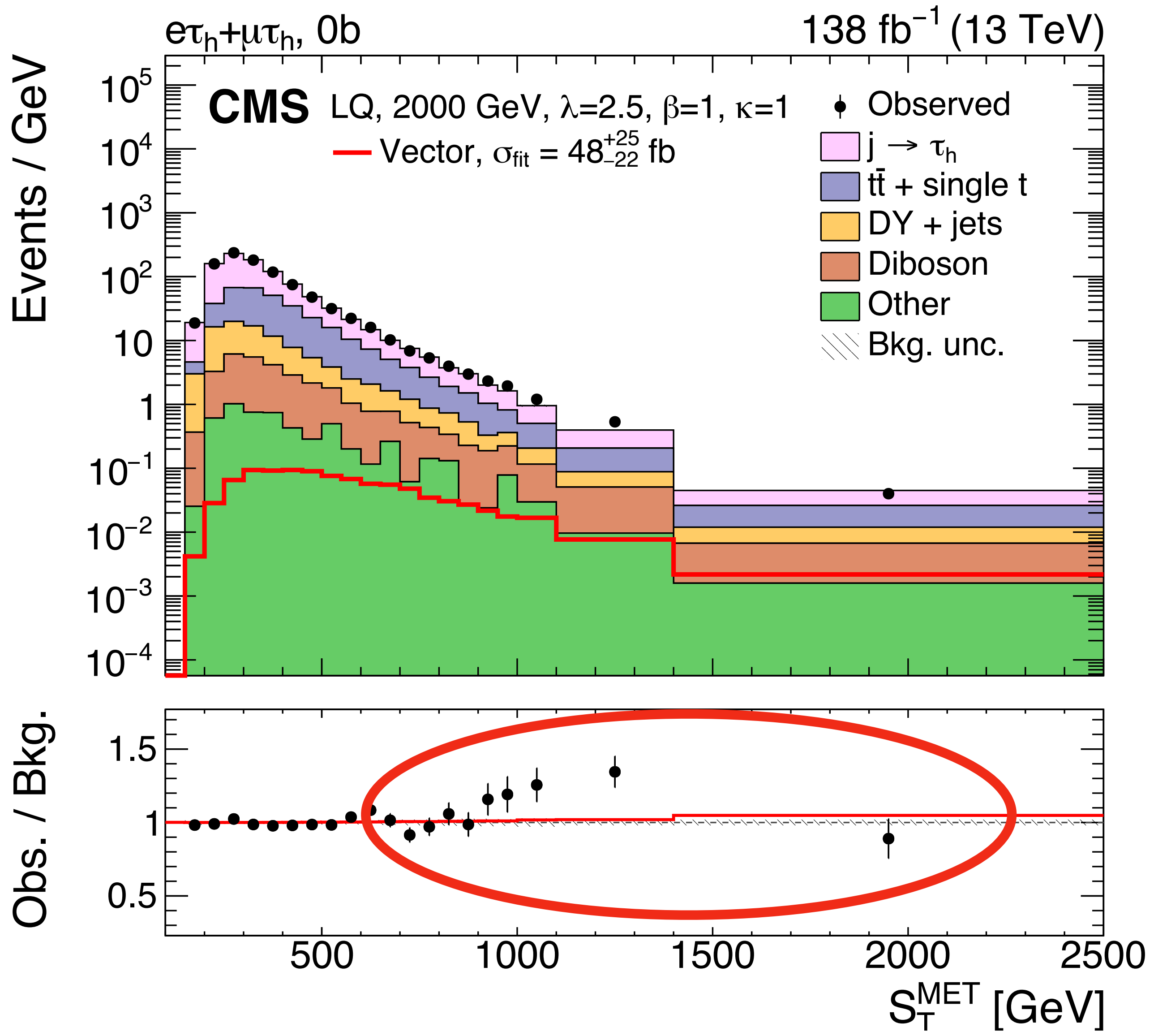


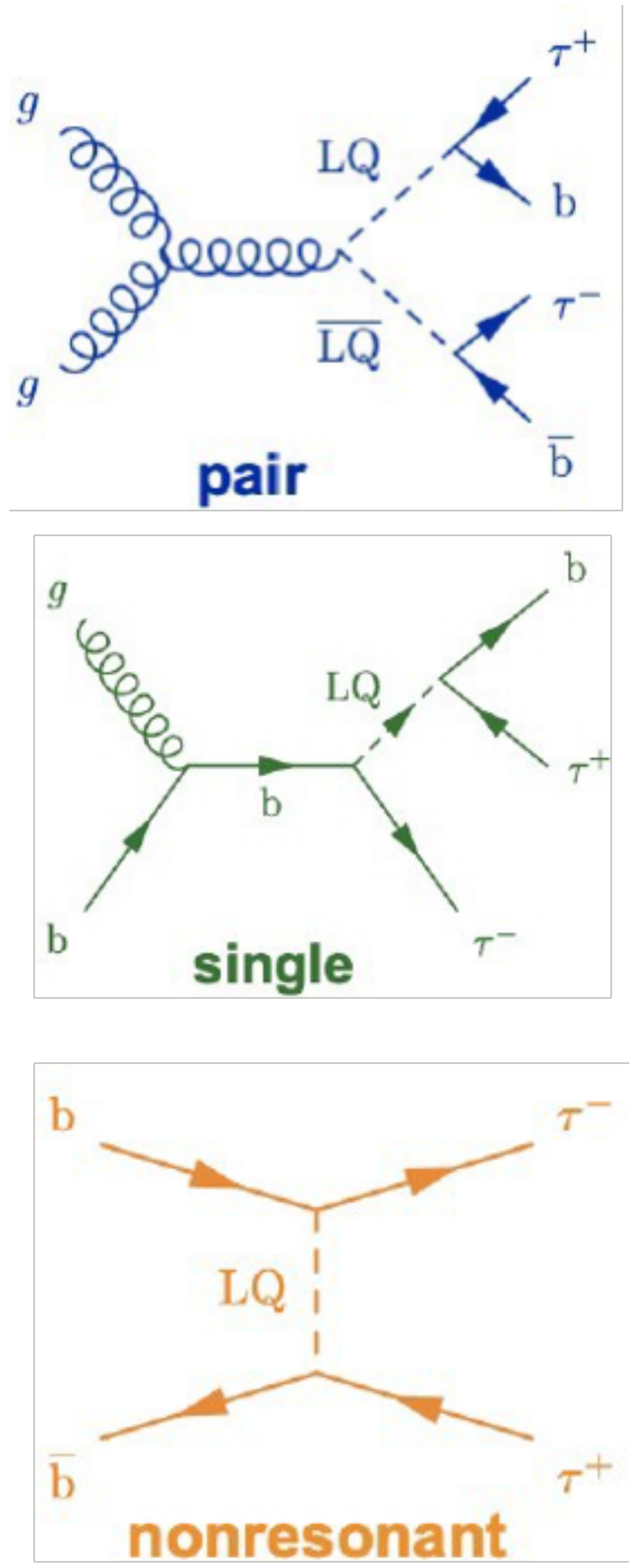


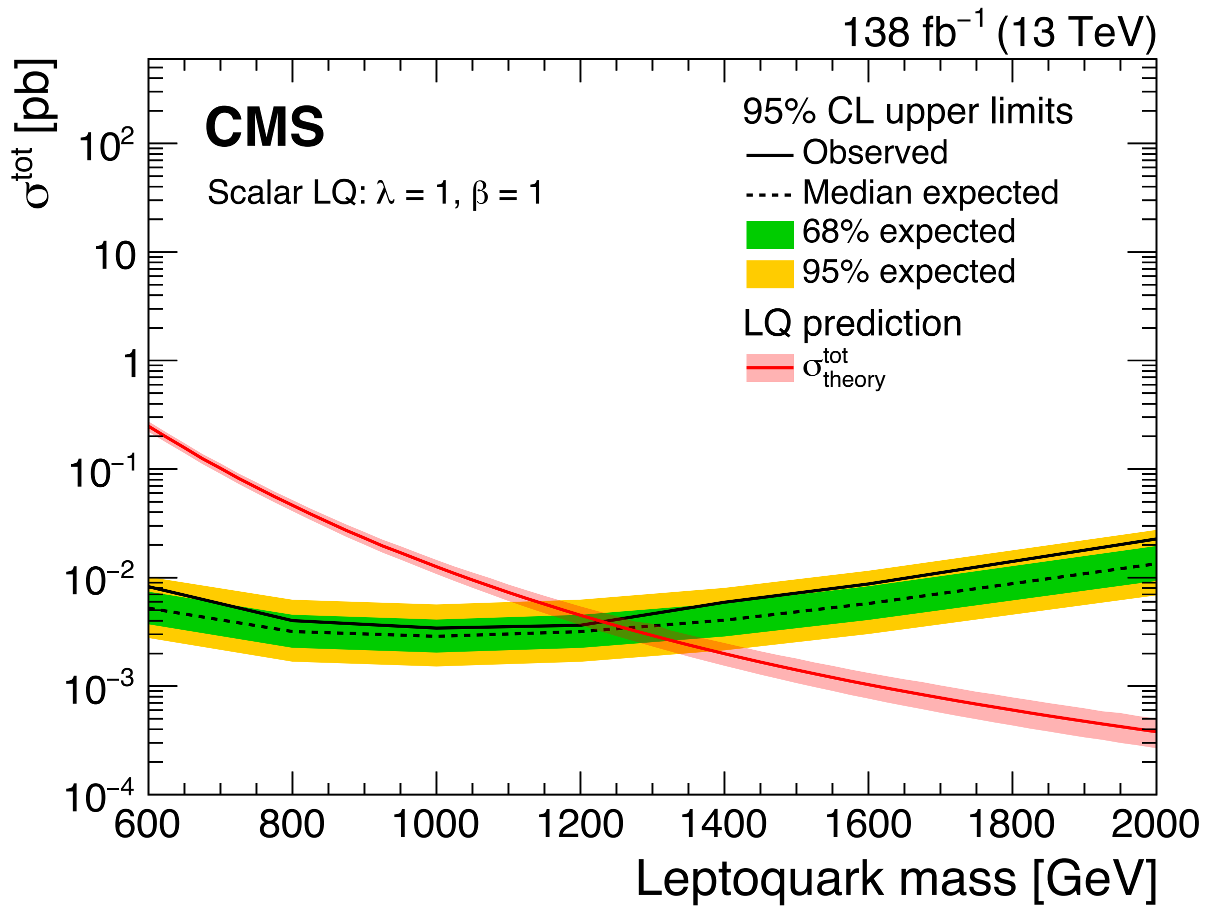
Searches for Leptoquarks

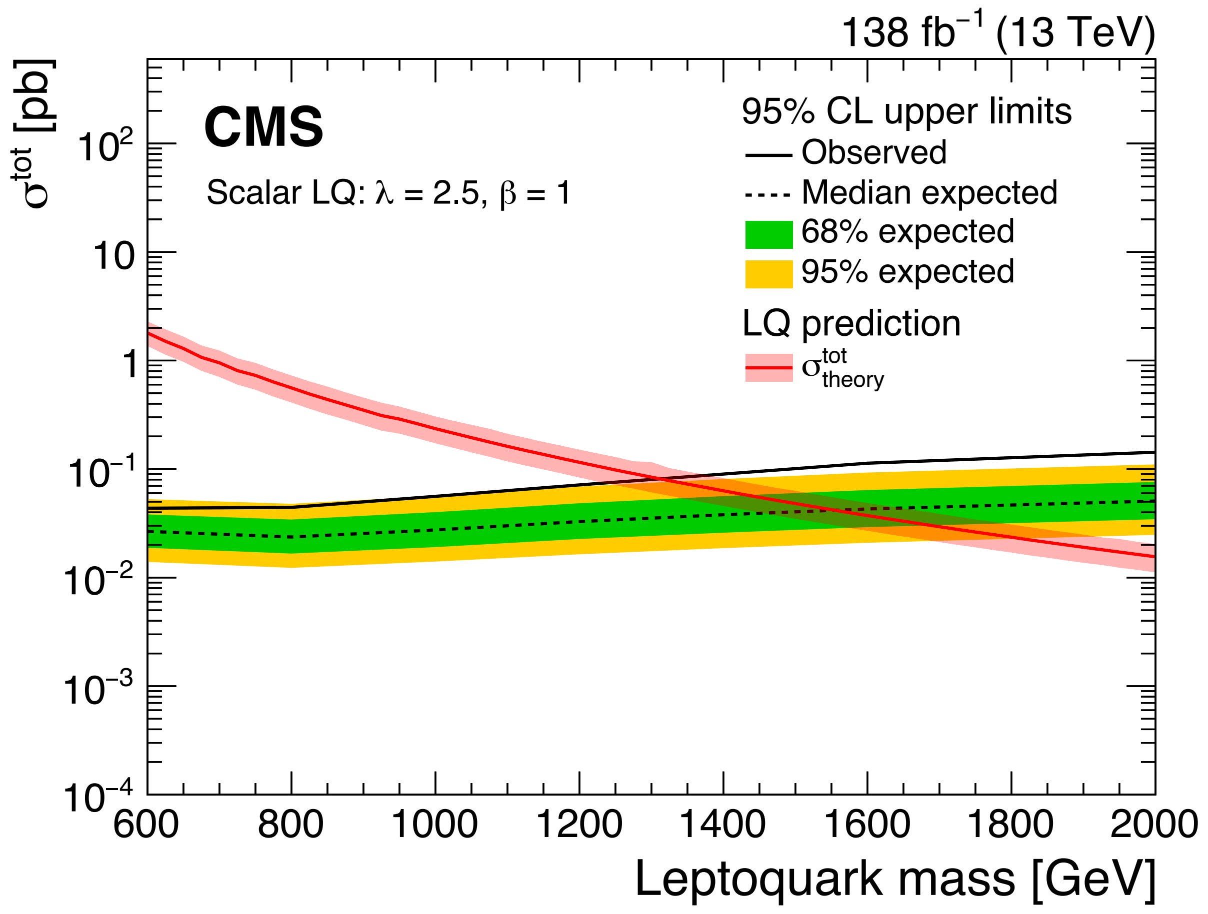
CMS: arXiv:2308.07826 (submitted to JHEP)

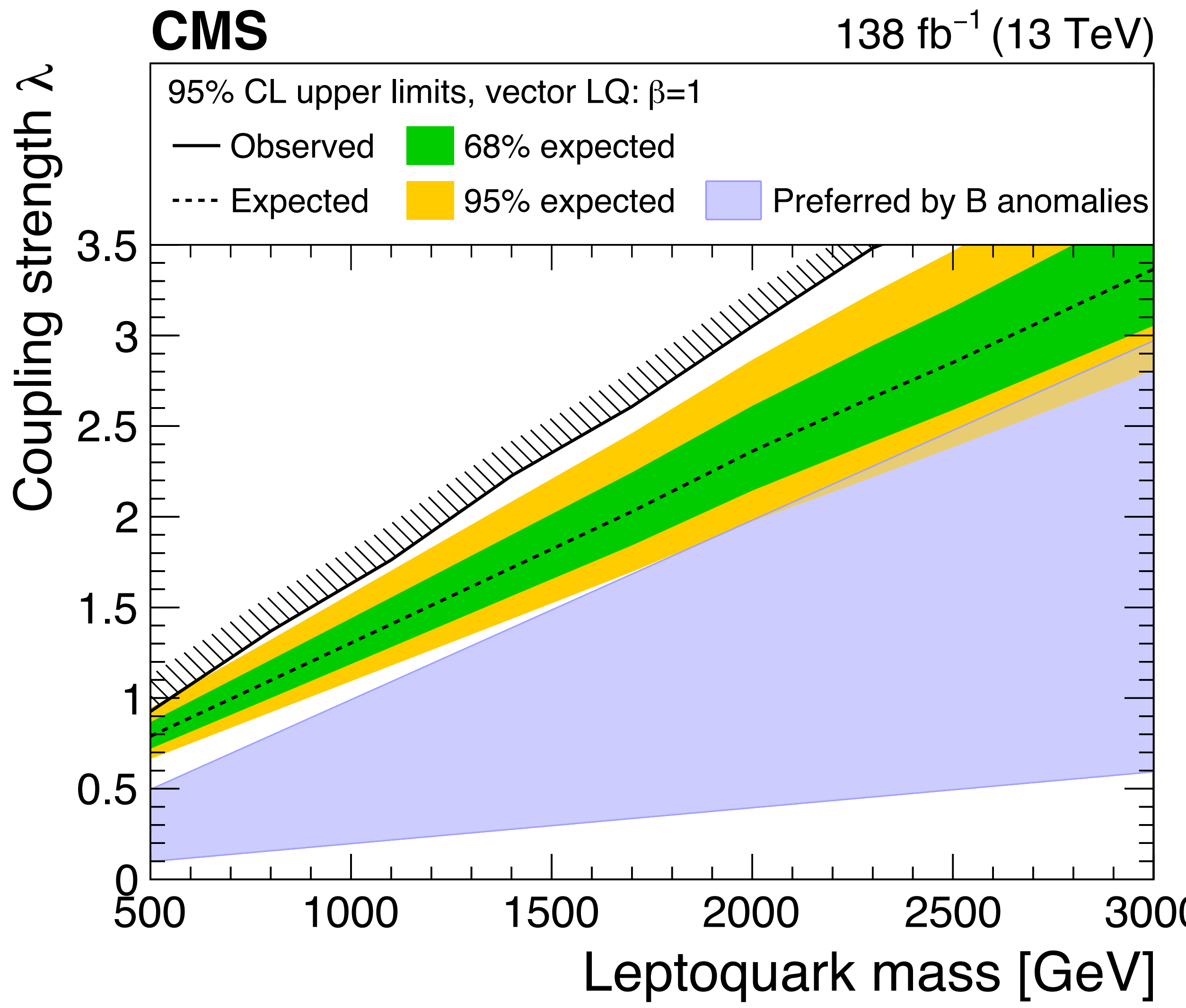
- Search for leptoquarks in 3rd generation with τ and bottom quarks.
- Updates in recent submitted paper:
  - fake tau model
  - minor backgrounds added
- Excess is most prominent in non-resonant LQ production.
  - probes high mass
  - at high S_T^{MET} with 1 jet but 0 b-tags ➡ 3.4 – 3.7σ
- Not compatible with signal model of 100% LQ→bτ.









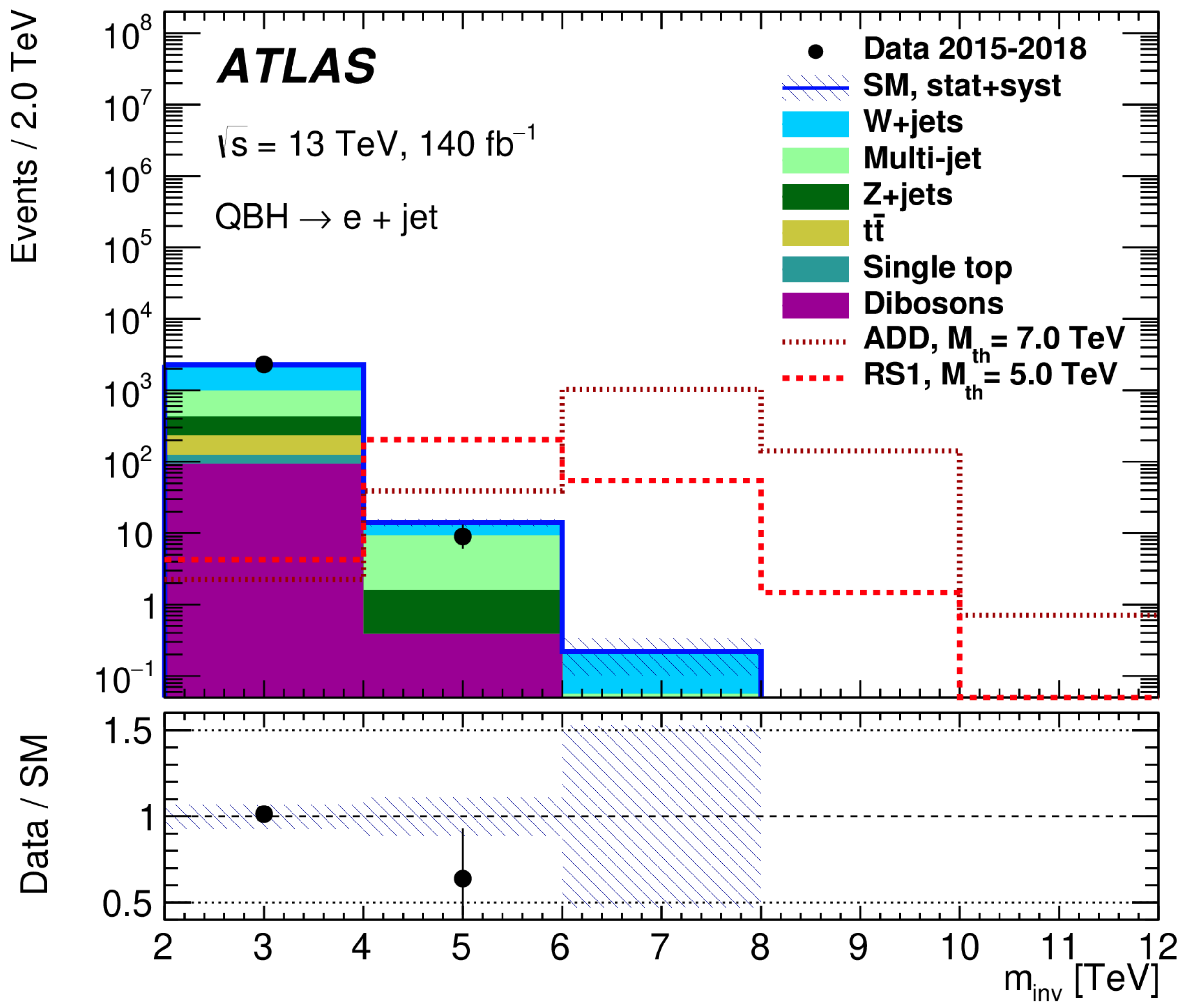


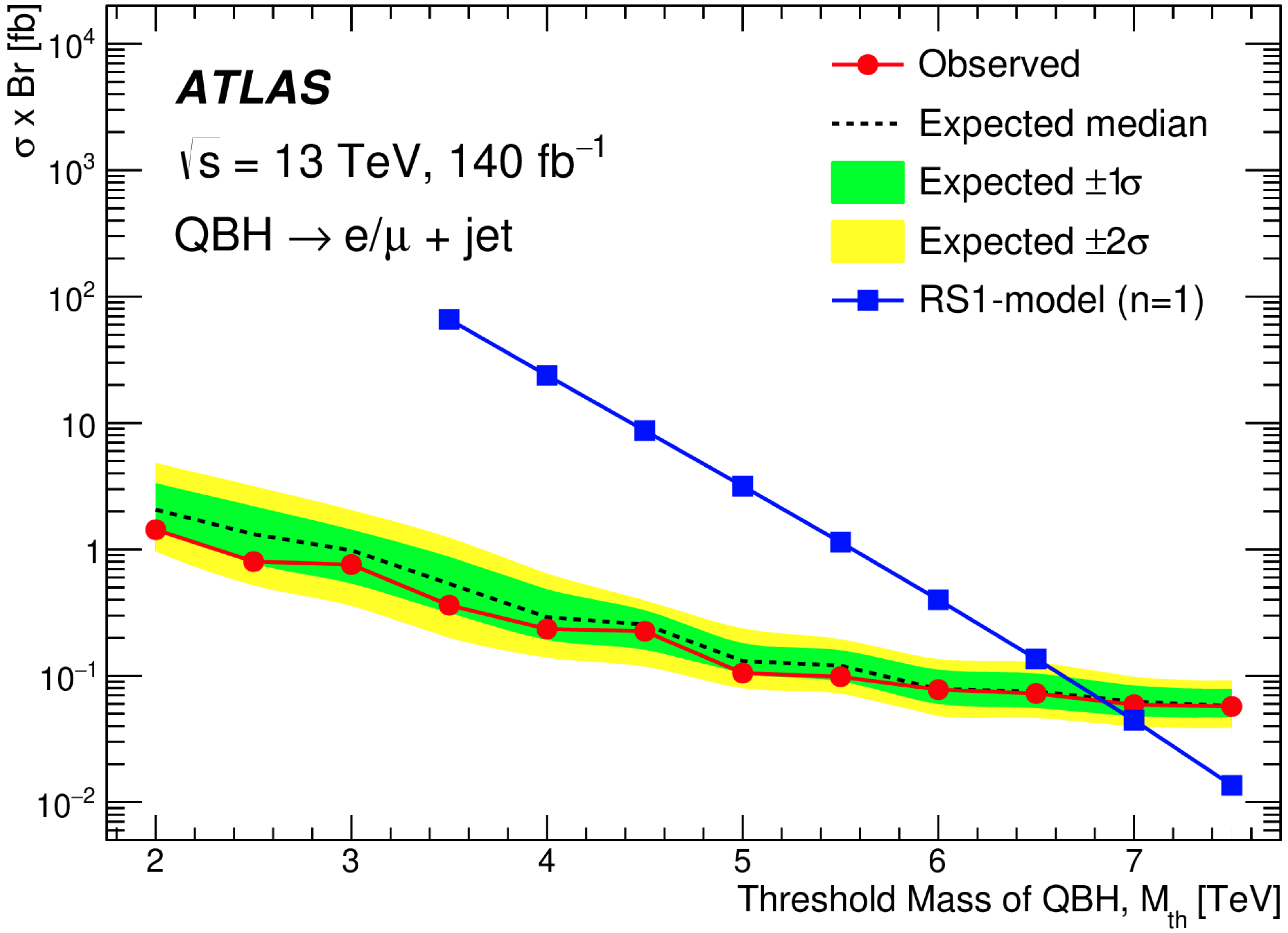
Lepton + Jet Resonance Searches

- Search for resonance in e/μ + jet invariant mass spectrum.
- Motivated by quantum black holes arising in low-scale quantum gravity models.
- Signature: 1 light lepton & 1 jet (p_T>130 GeV each).
- Probing quantum black hole masses up to ~7 TeV.

ATLAS: arXiv:2307.14967
(submitted to PRD)

Invariant mass of lepton and jet

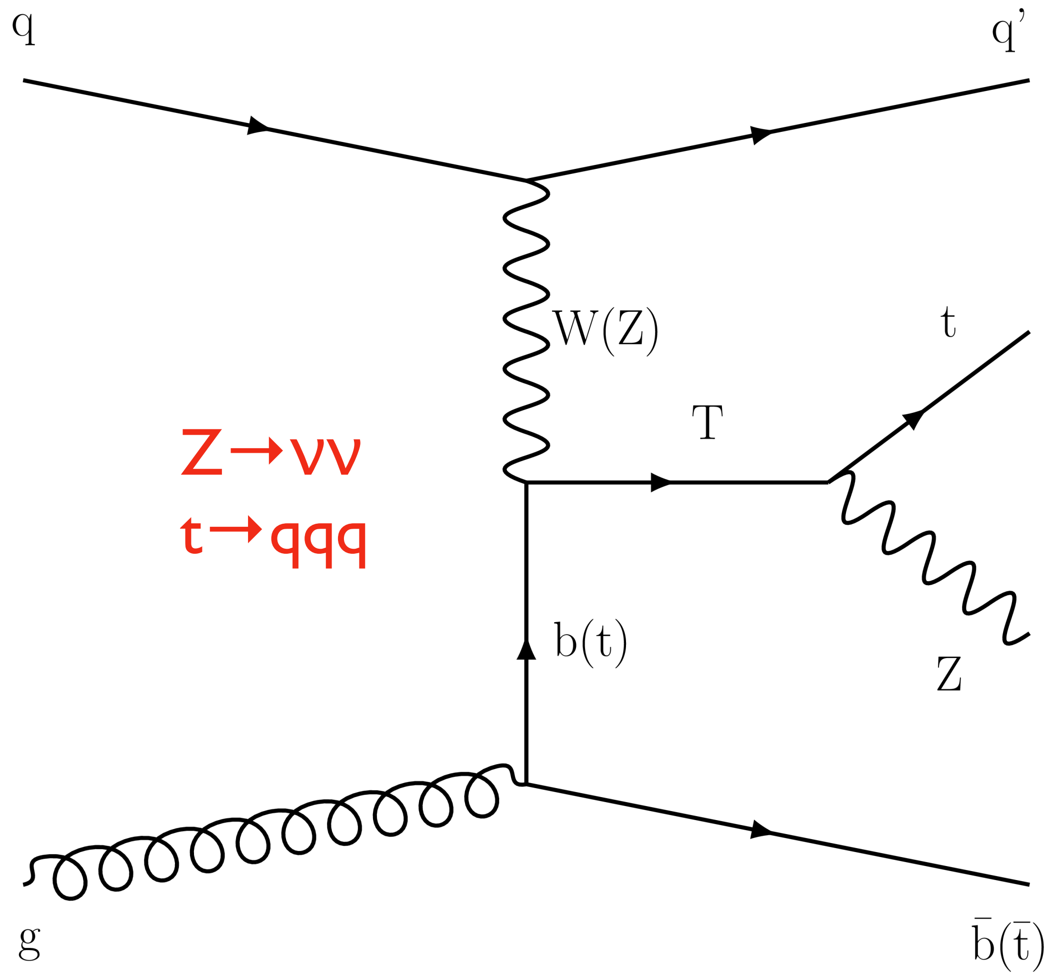




Vector-Like Quarks

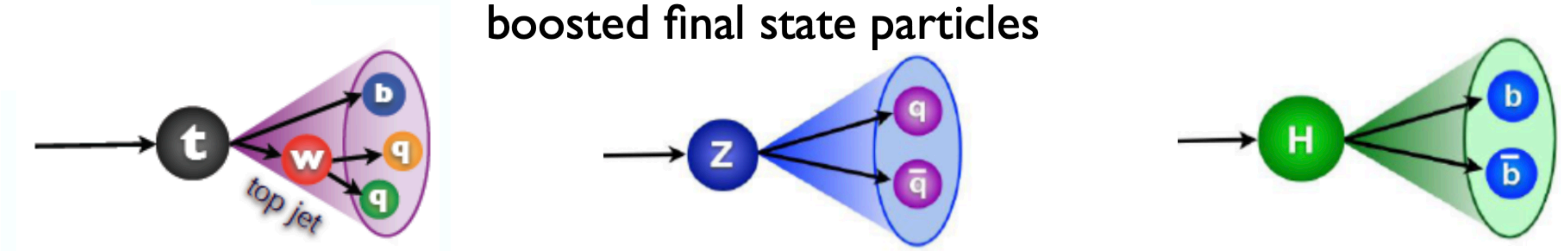
CMS: JHEP 05 (2022) 093

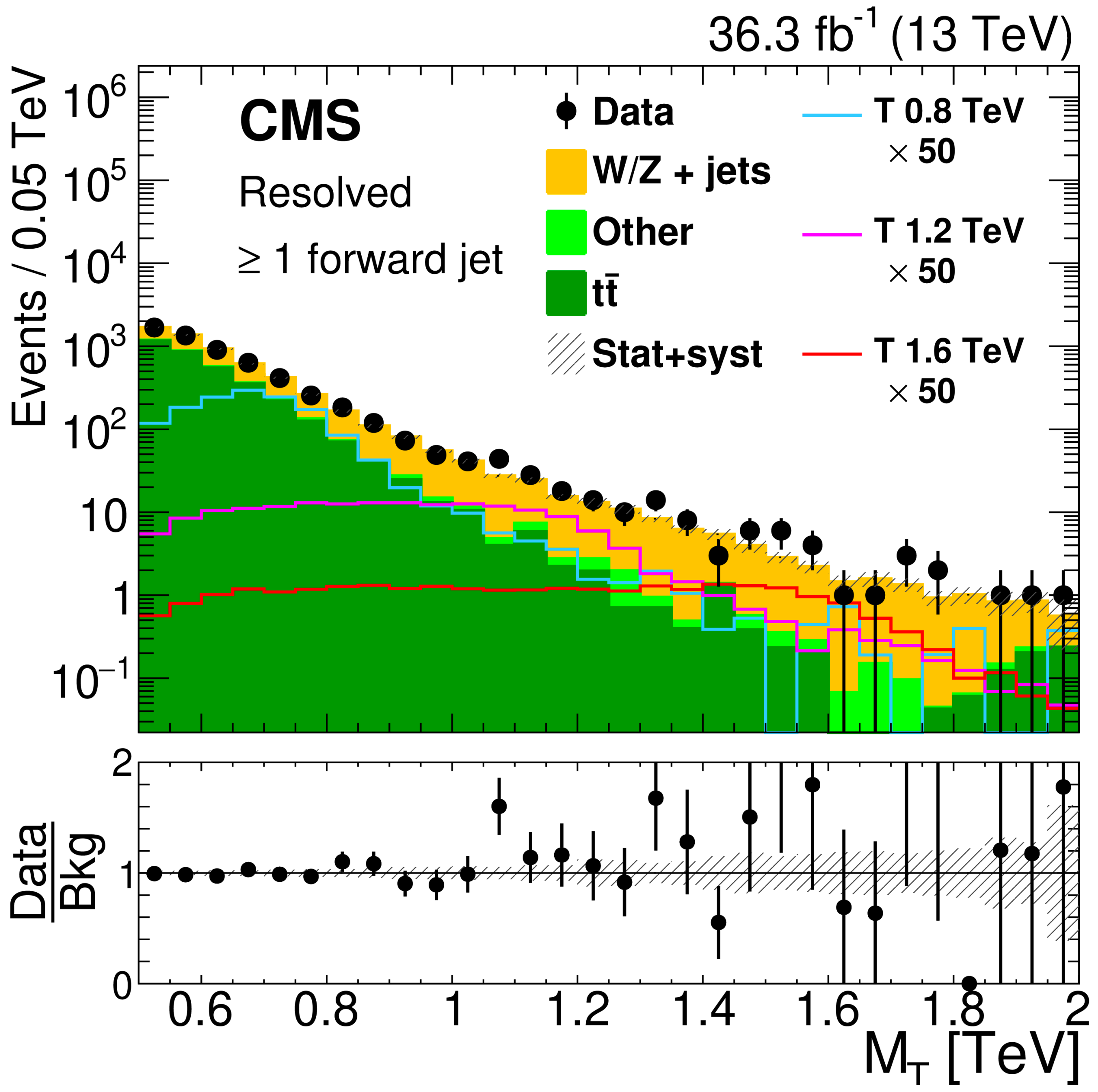
- VLQ could solve hierarchy problem.
- Searching in 0.6 – 1.8 TeV mass range; multiple width scenarios.
- Depending on T mass considering resolved and merged topologies.
- Largest excess around 1.4 TeV for narrow width with significance: 2.5σ (2.2σ).

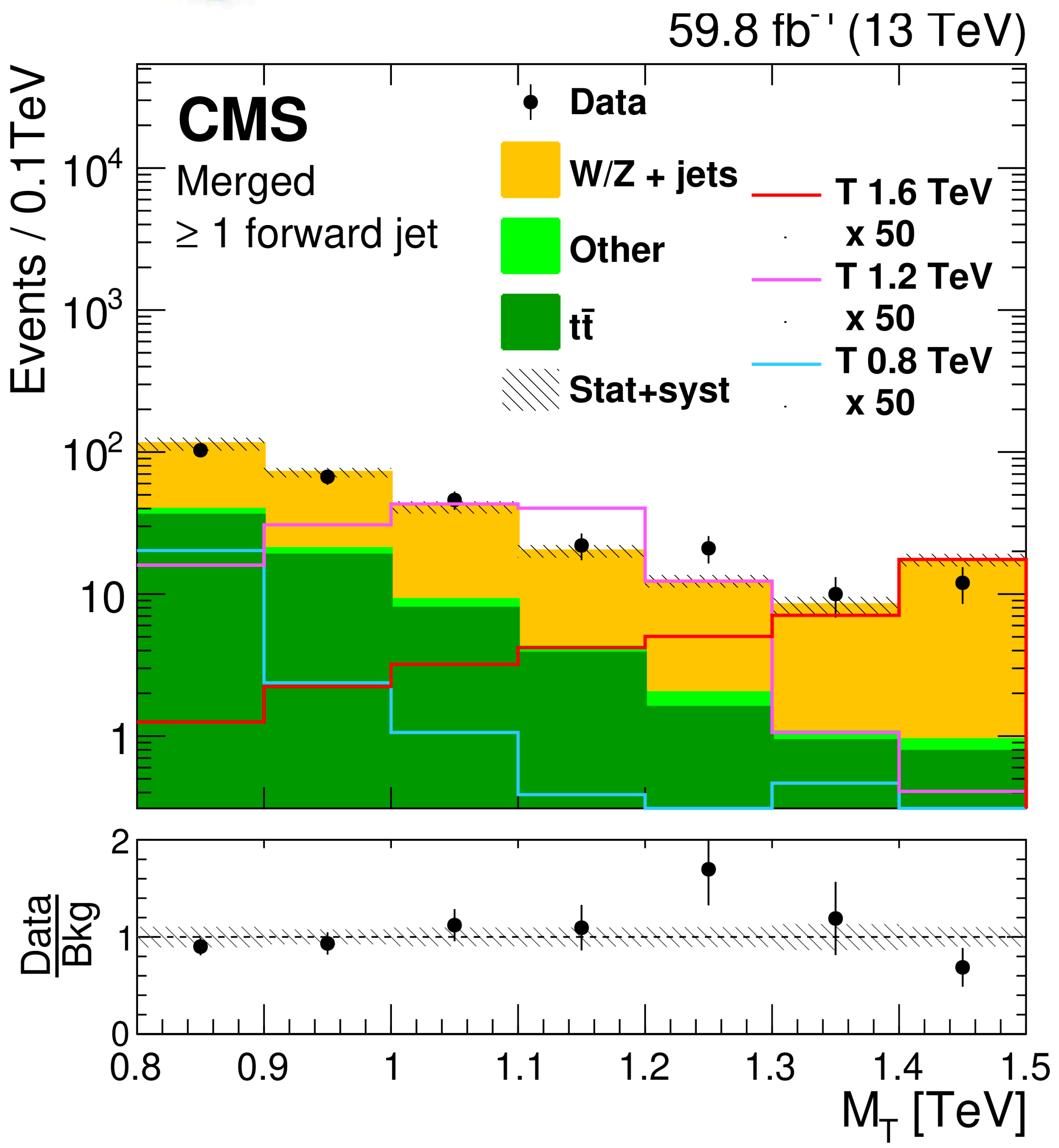


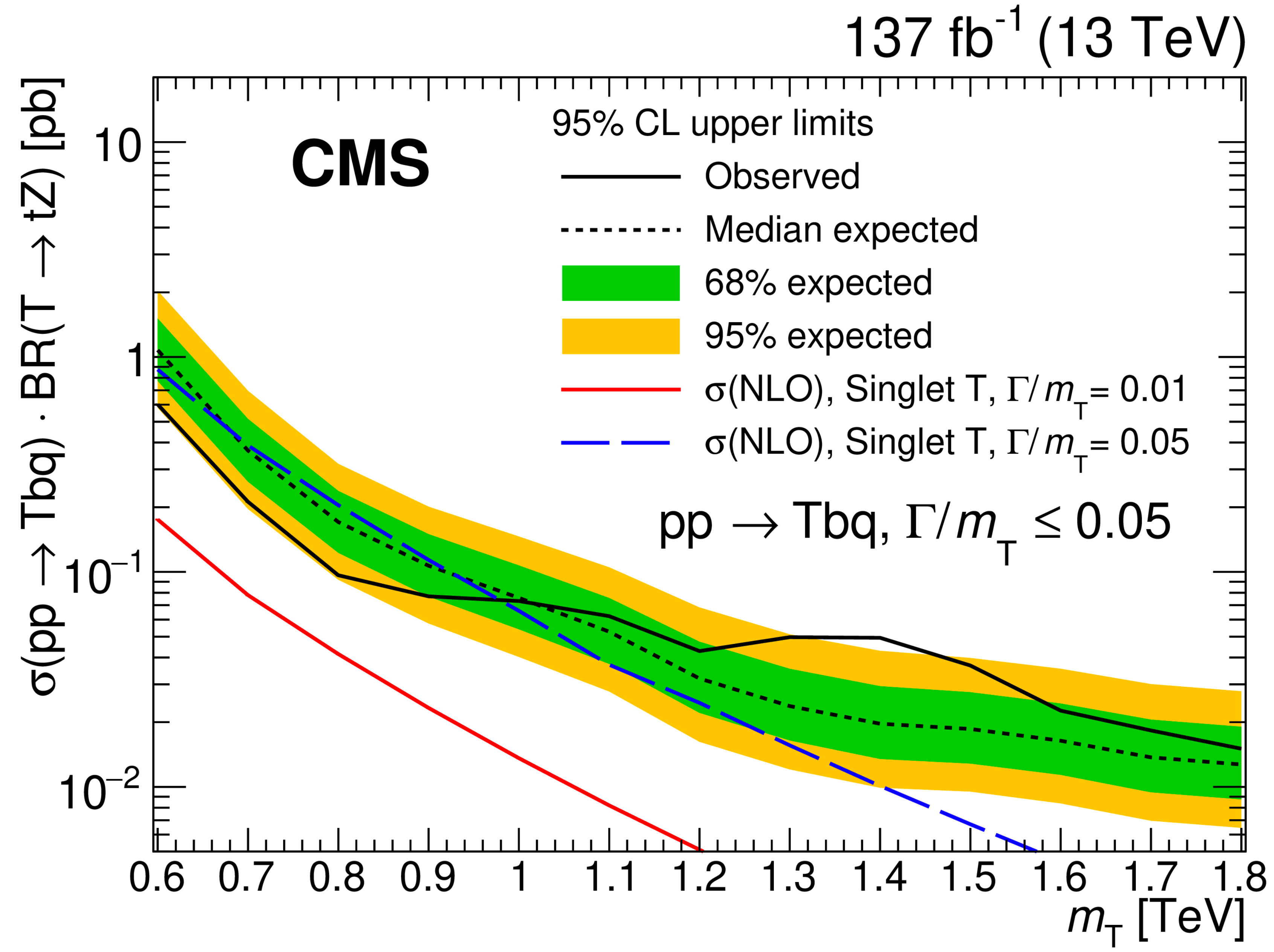
Z→νν
t→qqq

boosted final state particles





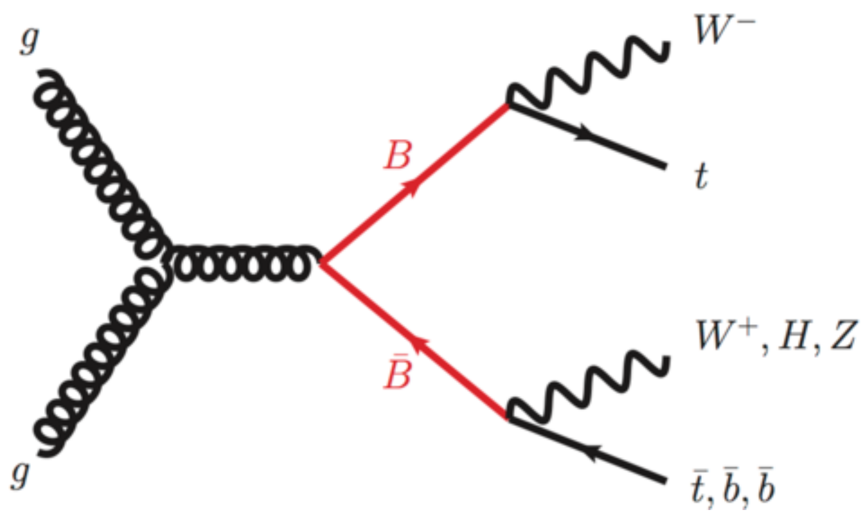


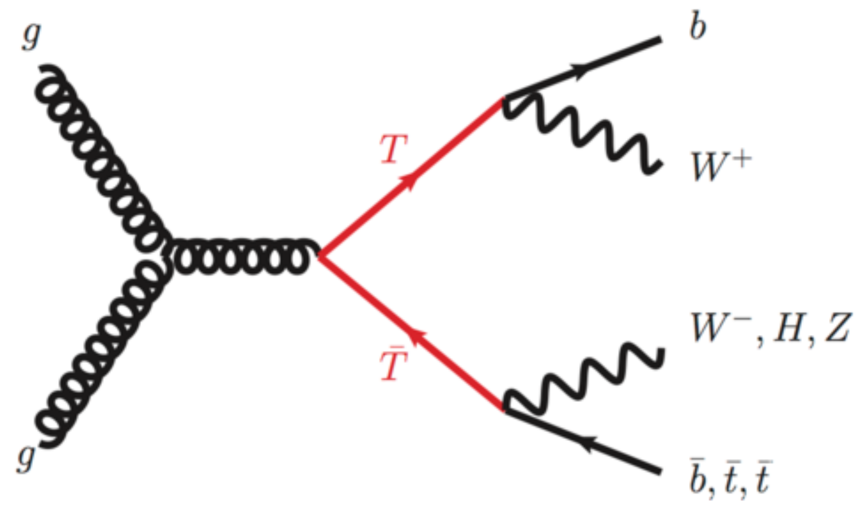


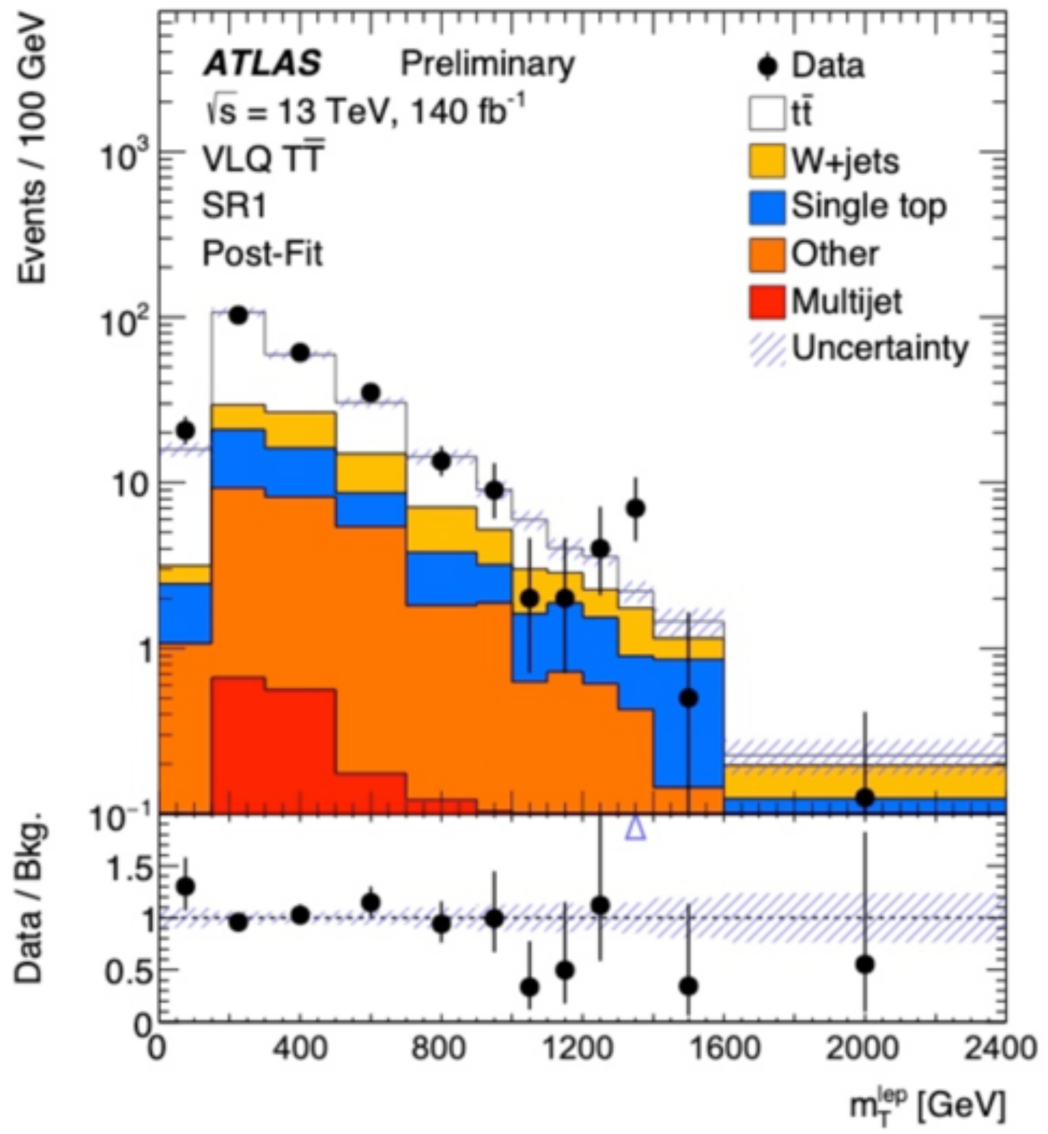
Vector-Like Quarks

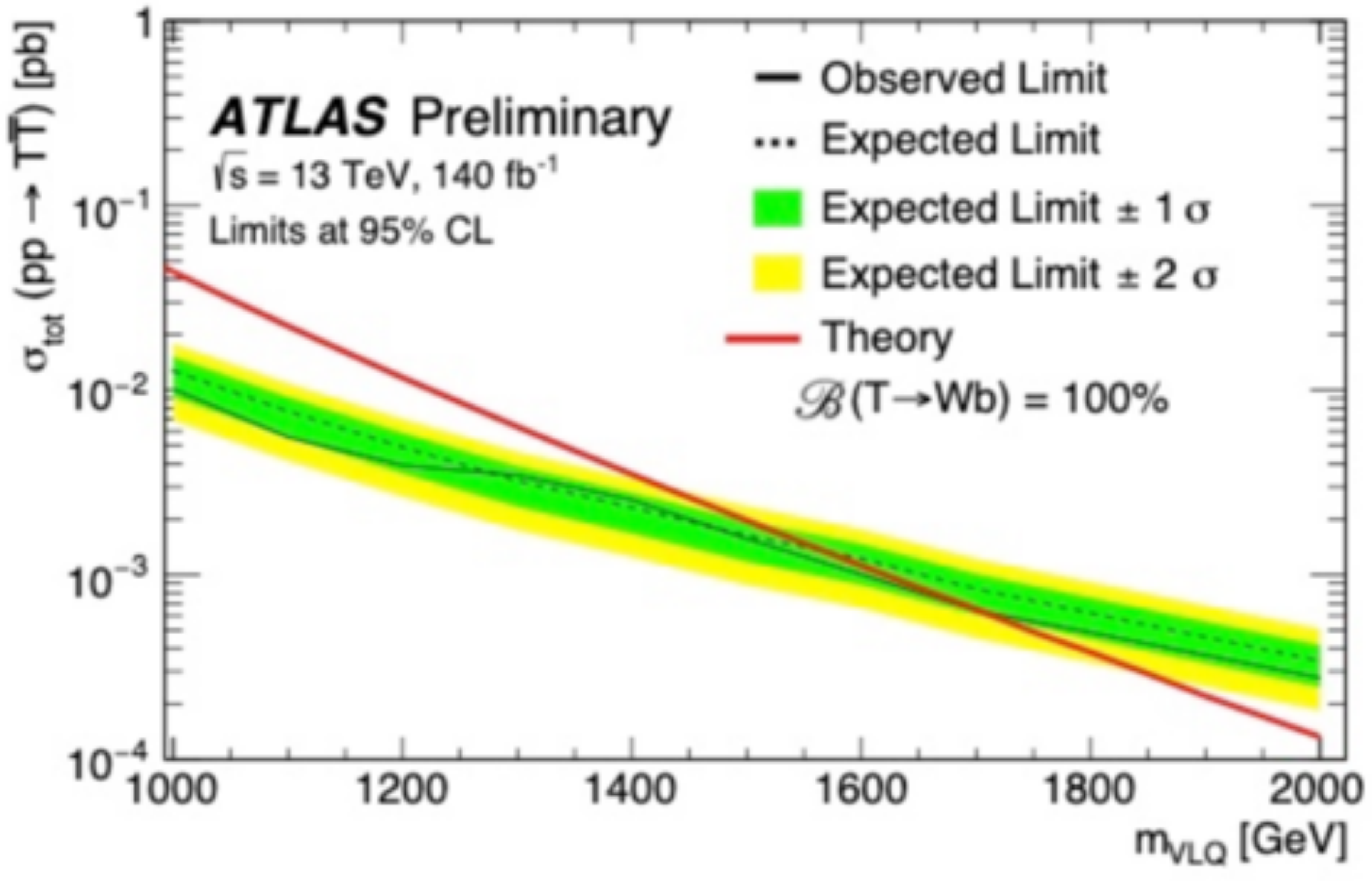
ATLAS-CONF-2023-070

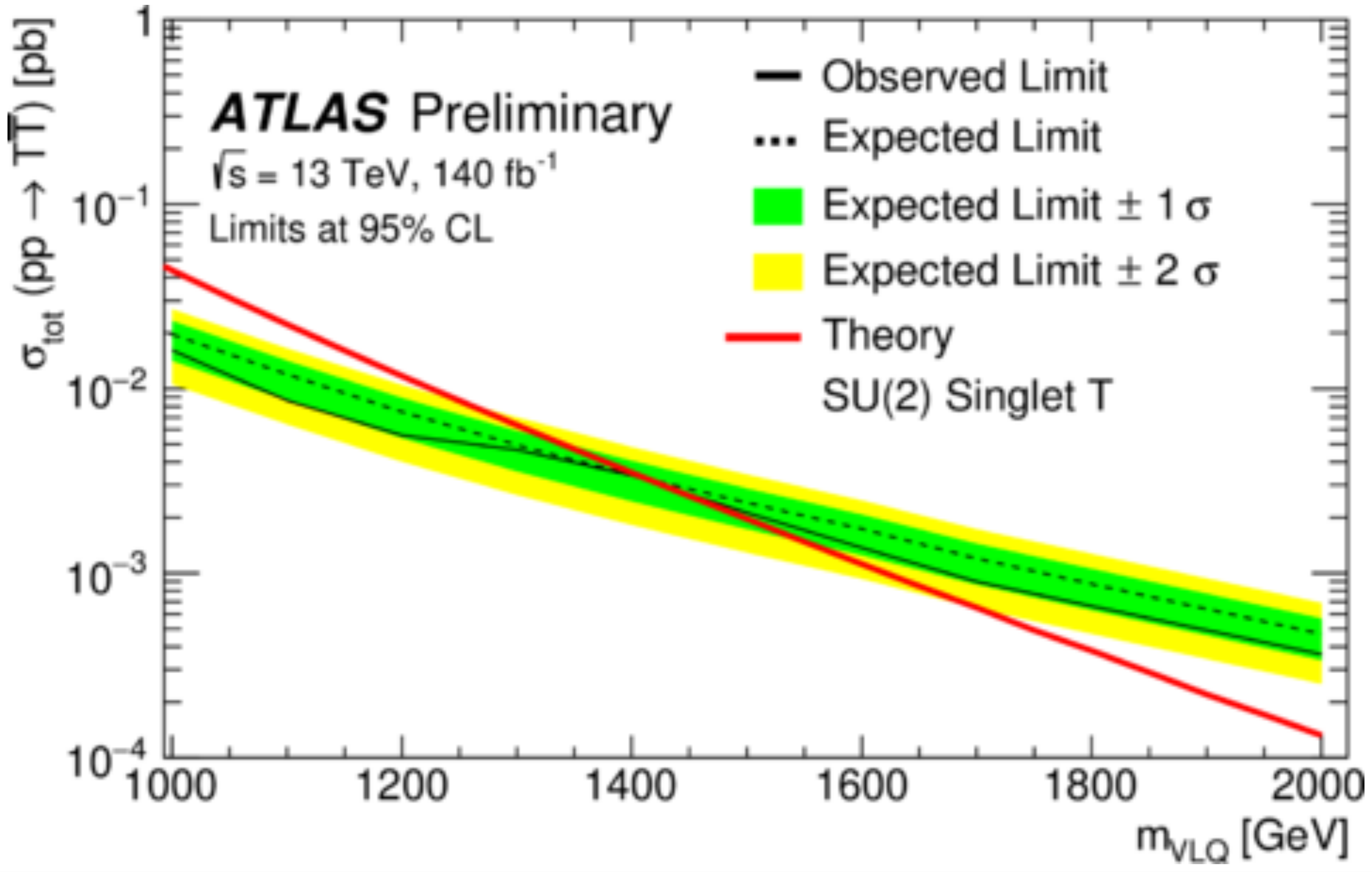
- Search for pair-produced heavy vector-like quarks in the lepton+jets final state.
  - Optimized for $T \to Wb$ quark, with one W boson decaying leptonically and the other hadronically.
- Events with one high-p_T electron or muon, large missing transverse momentum, a large-radius jet identified as a W boson, and multiple small-radius jets, at least one of which is b-tagged.
- Vector-like quarks with $Br(T \to Wb)$=100% are excluded for masses below 1.7 TeV.
  - These limits can also be applied to vector-like Y quarks decaying to Wb.







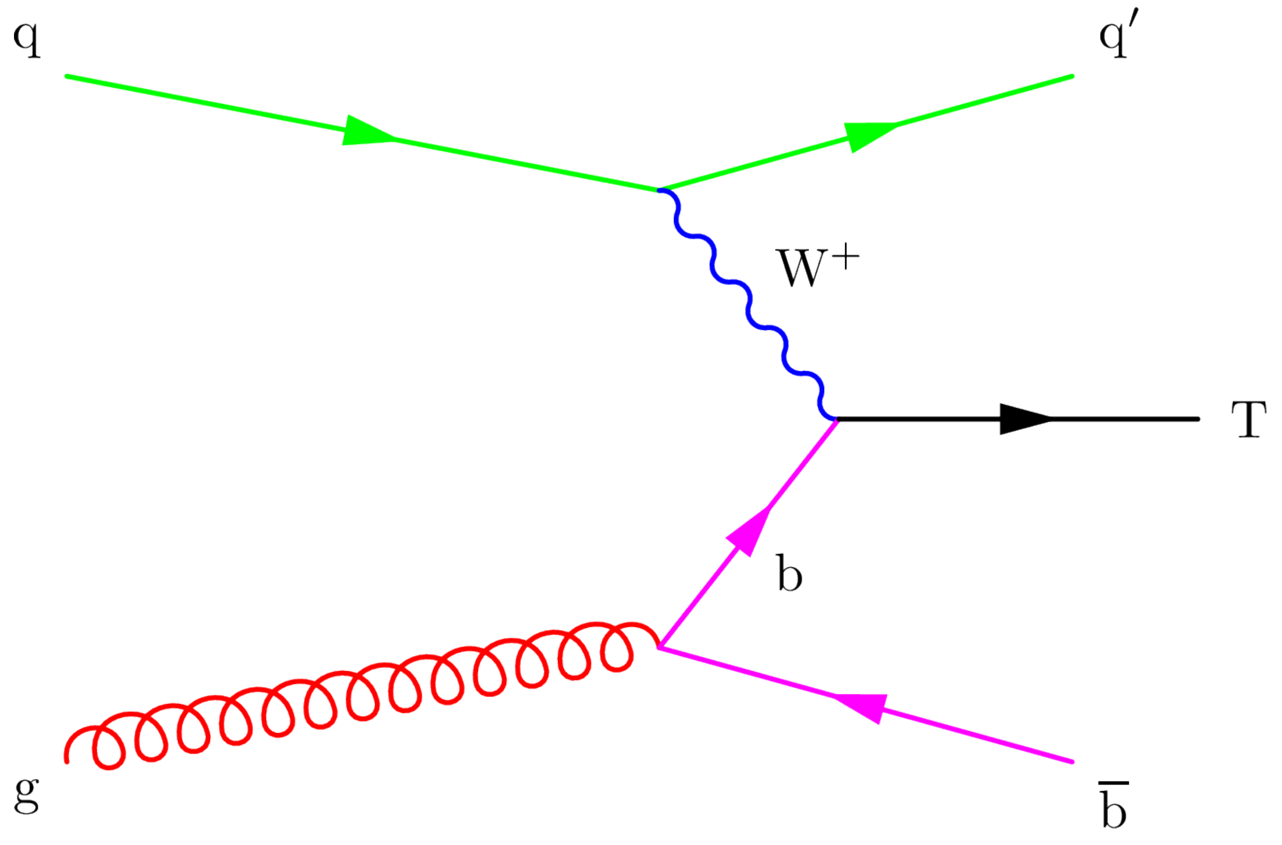


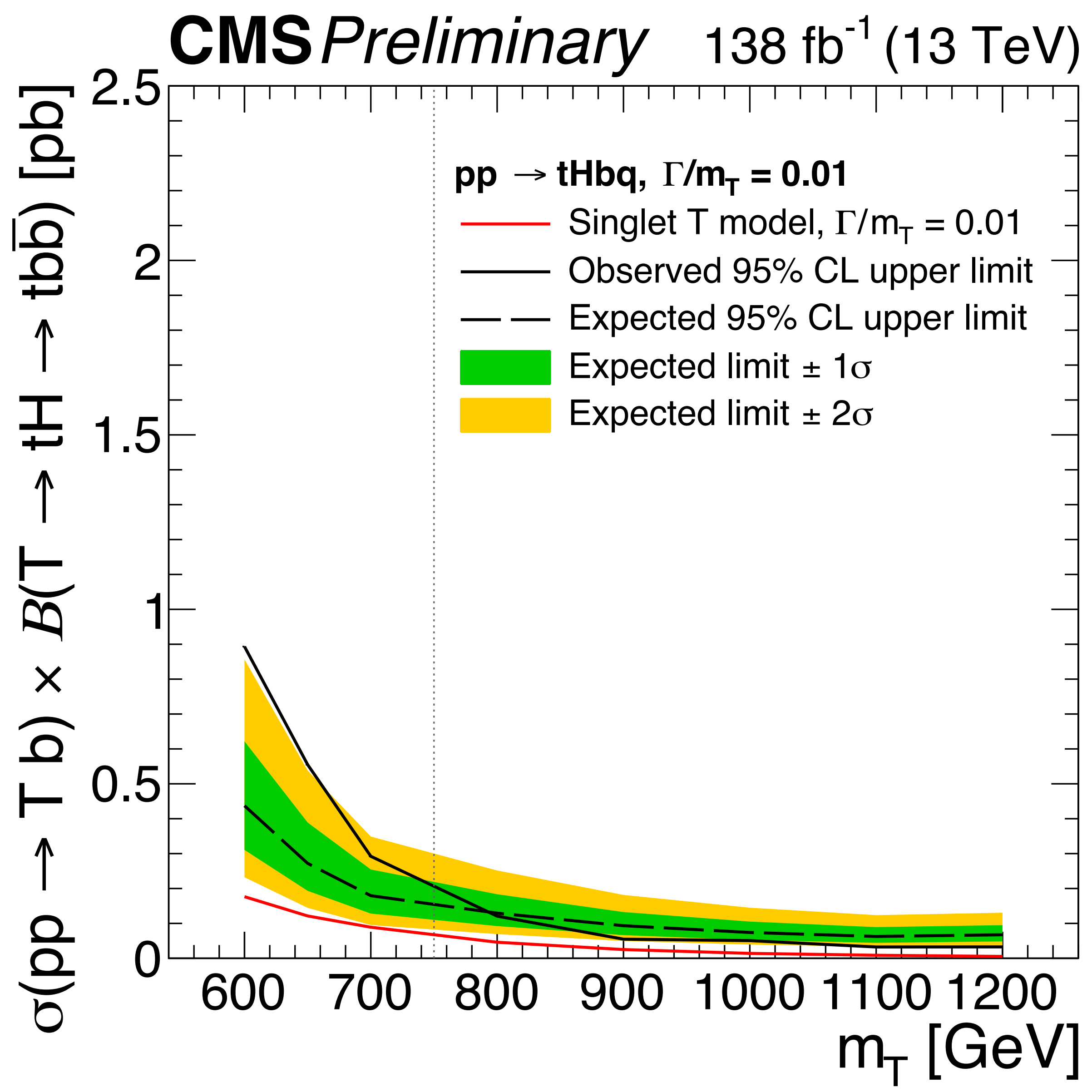


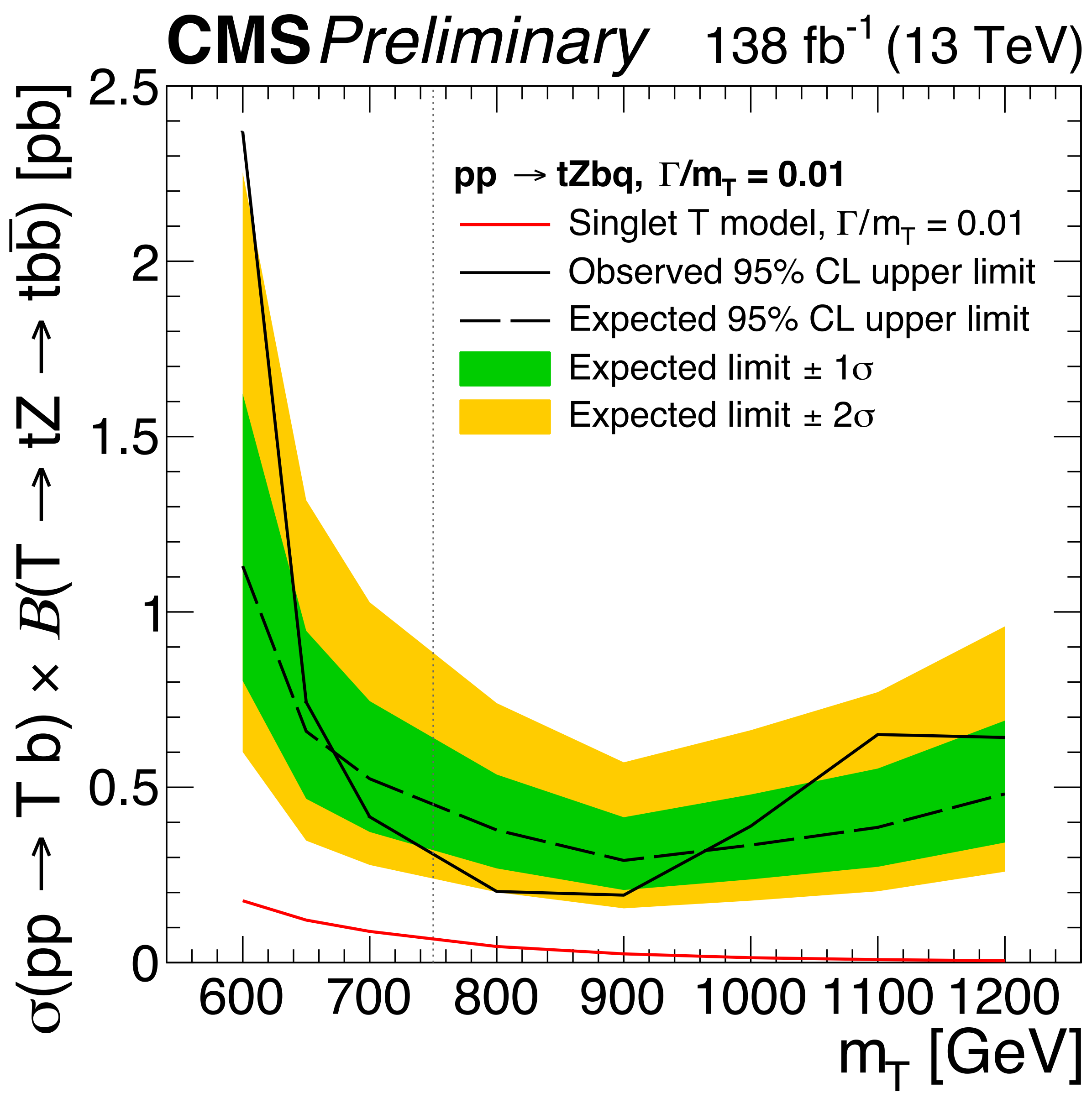
Vector-Like Quarks

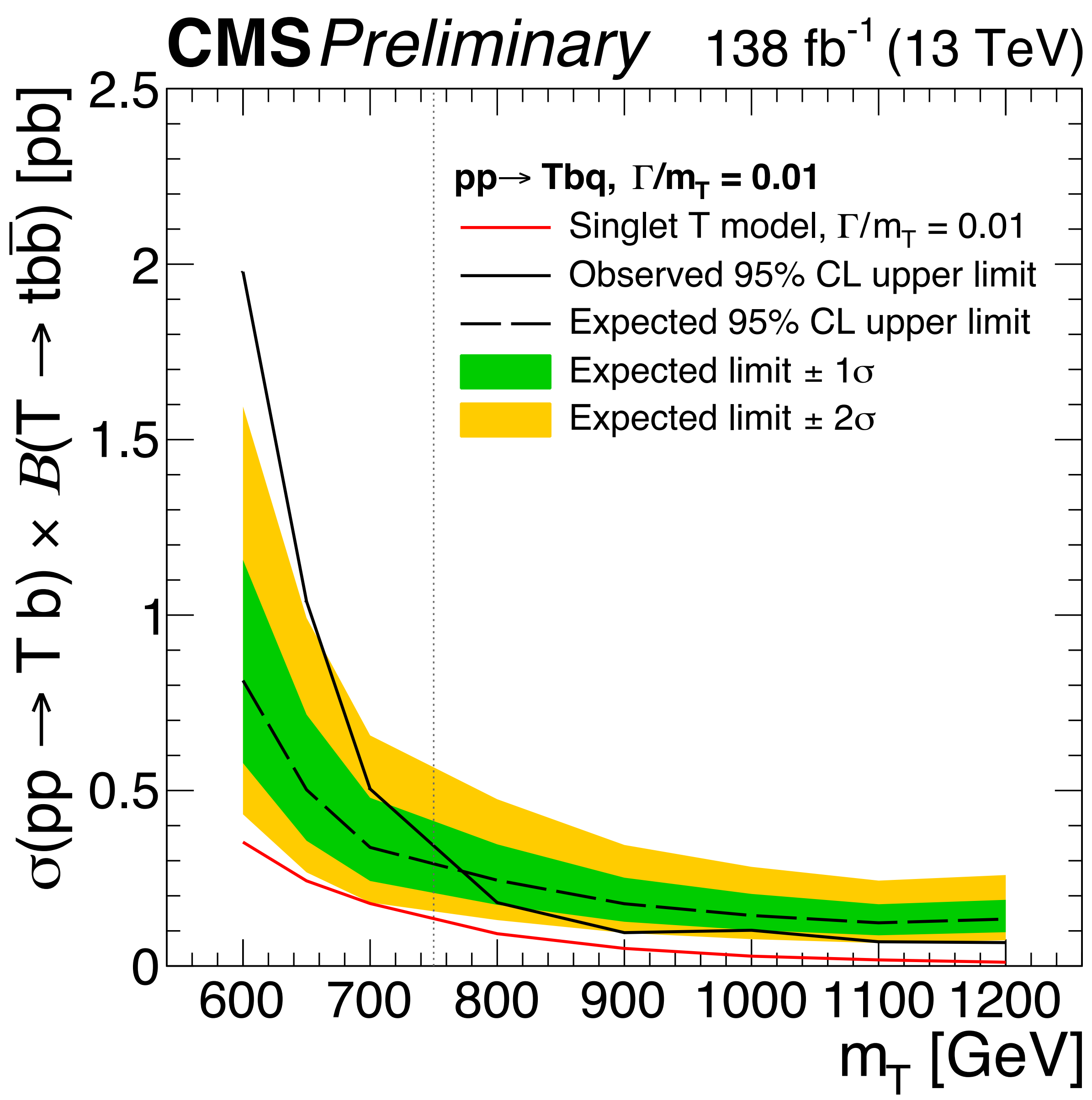
CMS: JHEP 05 (2022) 093

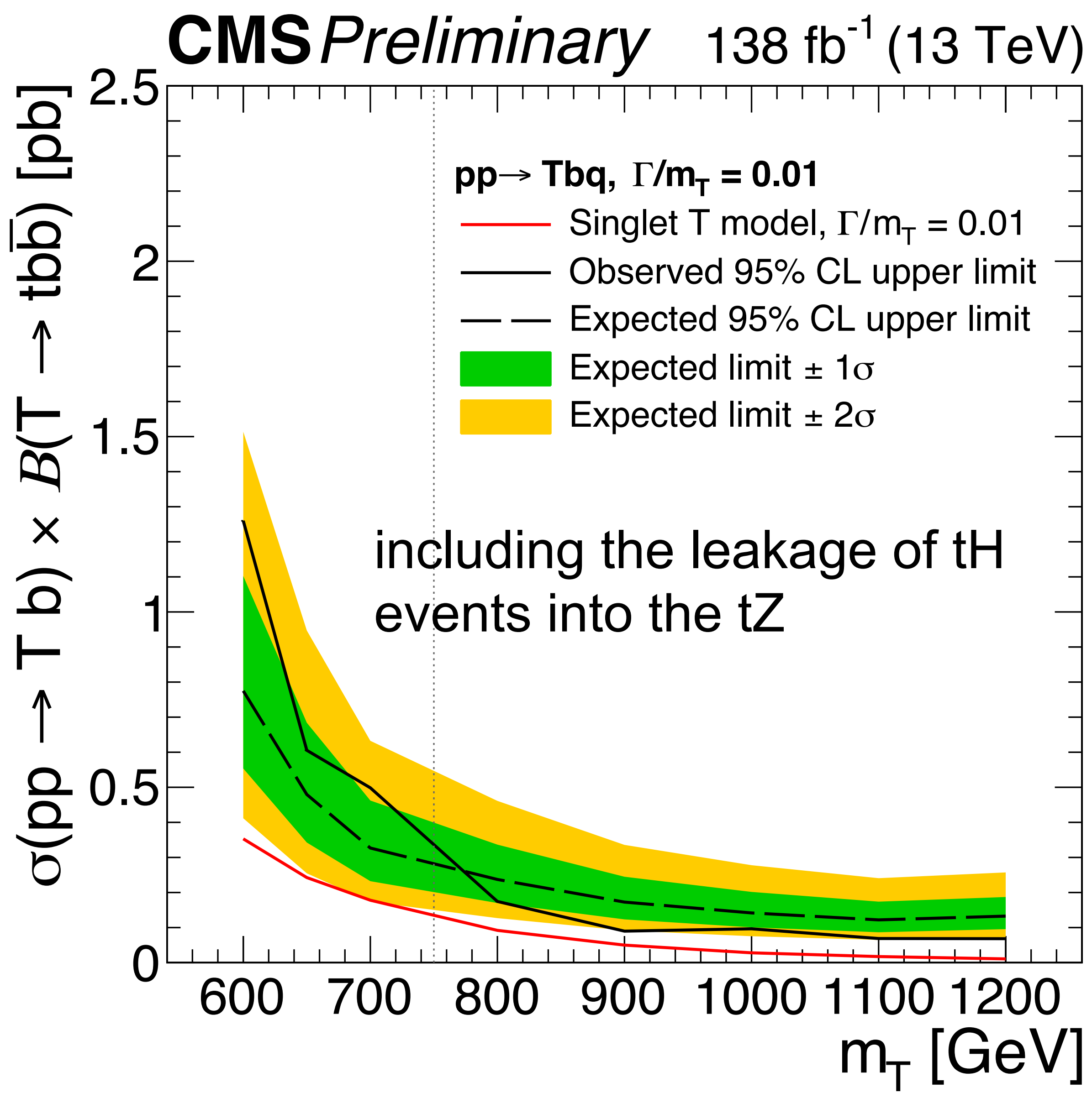
- Search for electroweak production of a single vector-like quark (T) in association with a bottom quark.
  - T decaying to tH or tZ; fully hadronically.
  - Event kinematics and the presence of jets containing b hadrons are used to reconstruct the hadronic decays of the t and Higgs or Z boson.
- Probing VLQ masses up to the TeV scale.
- For T masses from 600 to 1200 GeV, the upper limits on the production cross section of a T produced in association with a b and decaying via a t and a Higgs or Z boson range from 1260 to 68 fb.







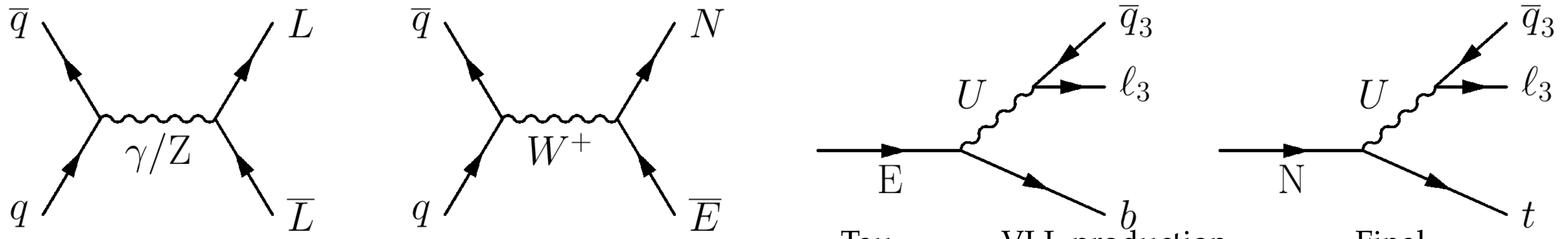




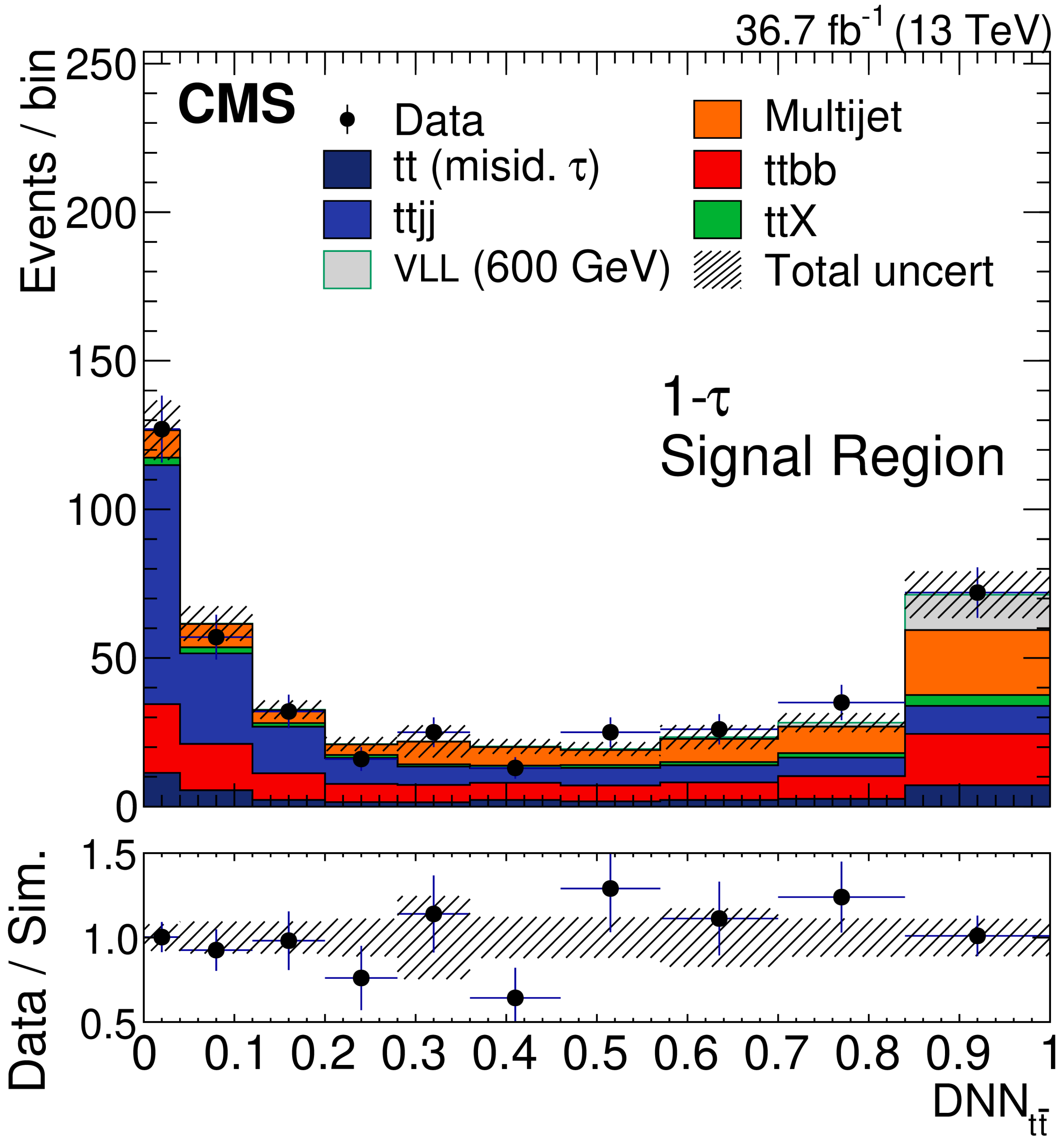
Vector-Like Leptons

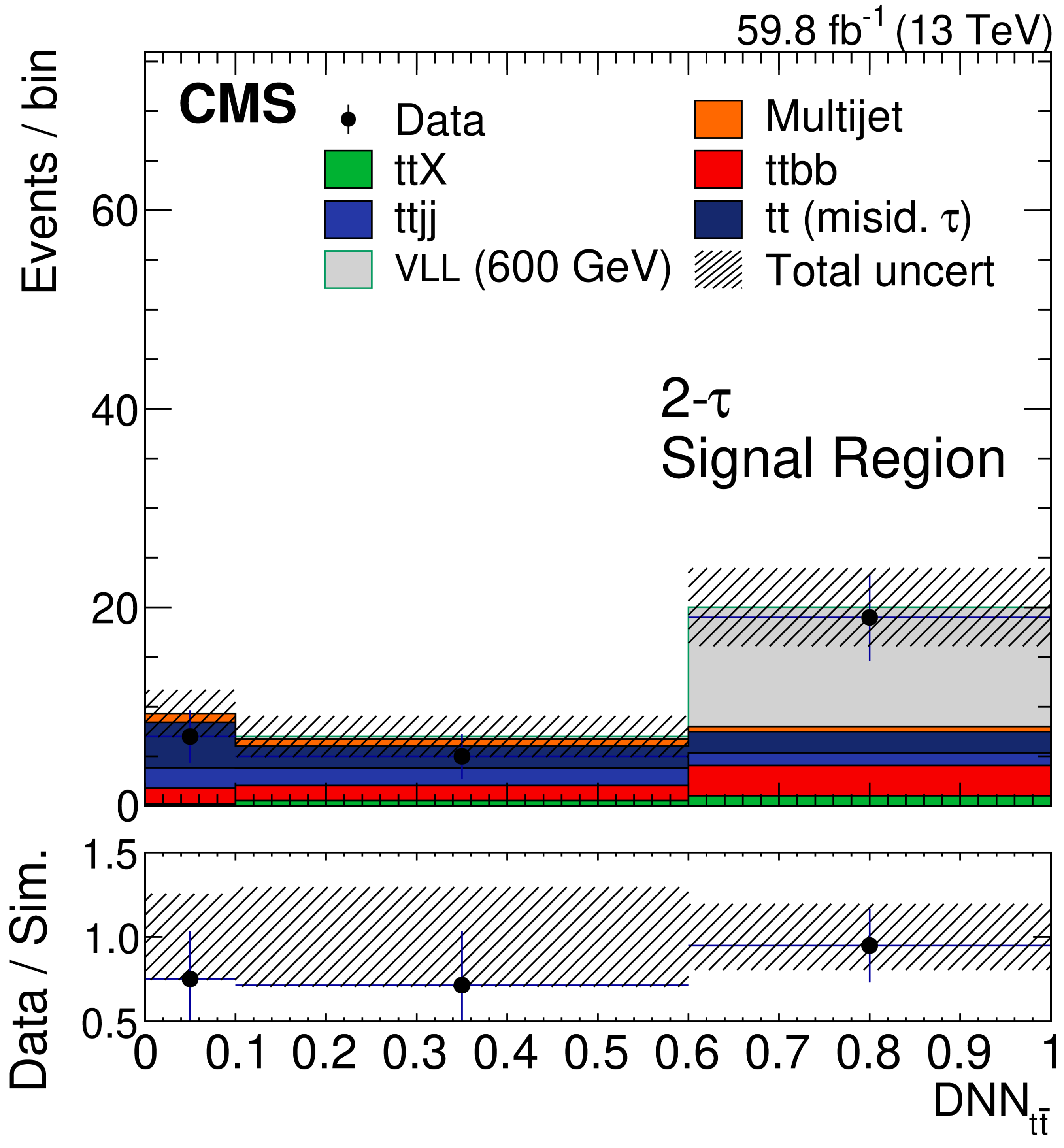
CMS: arXiv:2208.09700

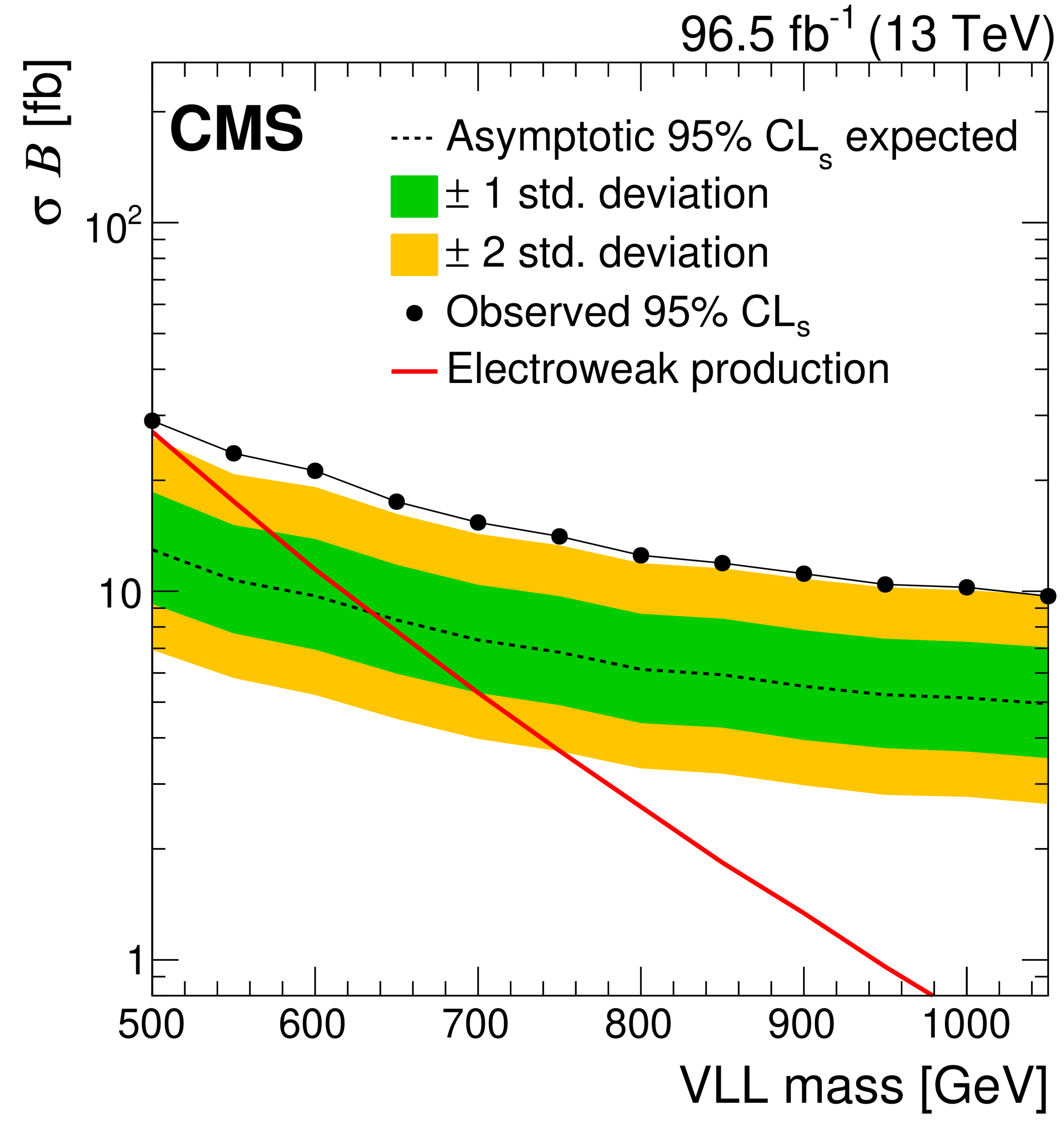
- Motivated from flavour anomalies.
  - VLL decay via vector leptoquarks, which couple dominantly to the third generation.
  - Categorize by number of b-jets and τ-leptons.
  - Using DNN to discriminate against QCD and tt backgrounds.
- Excess of events at 600 GeV with 2.8σ.



Tau multiplicity	VLL production + decay mode	Final state
0 τ	$EE \to b(t\nu_\tau)b(t\nu_\tau)$	$4b + 4j + 2\nu_\tau$
	$EN \to b(t\nu_\tau)t(t\nu_\tau)$	$4b + 6j + 2\nu_\tau$
	$NN \to t(t\nu_\tau)t(t\nu_\tau)$	$4b + 8j + 2\nu_\tau$
1 τ	$EE \to b(b\tau)b(t\nu_\tau)$	$4b + 2j + \tau + \nu_\tau$
	$EN \to b(t\nu_\tau)t(b\tau)$	$4b + 4j + \tau + \nu_\tau$
	$EN \to b(b\tau)t(t\nu_\tau)$	$4b + 4j + \tau + \nu_\tau$
	$NN \to t(b\tau)t(t\nu_\tau)$	$4b + 6j + \tau + \nu_\tau$
2 τ	$EE \to b(b\tau)b(b\tau)$	$4b + 2\tau$
	$EN \to b(b\tau)t(b\tau)$	$4b + 2j + 2\tau$
	$NN \to t(b\tau)t(b\tau)$	$4b + 4j + 2\tau$



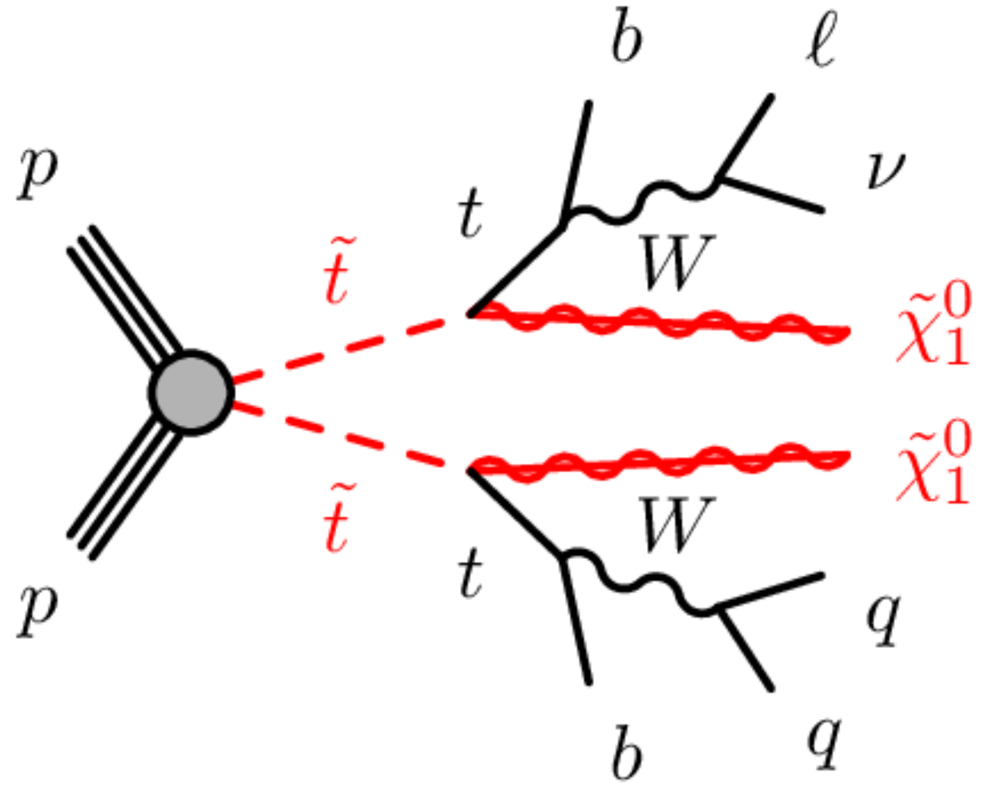


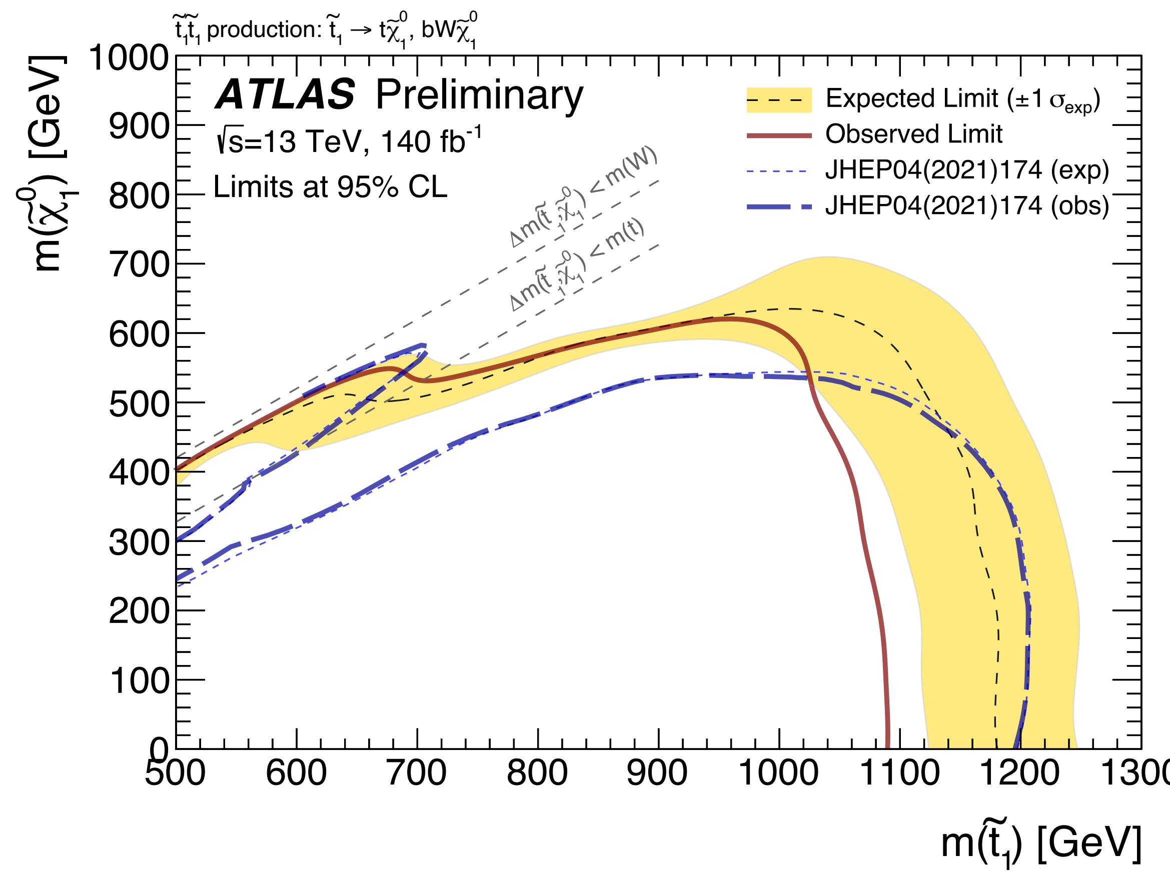


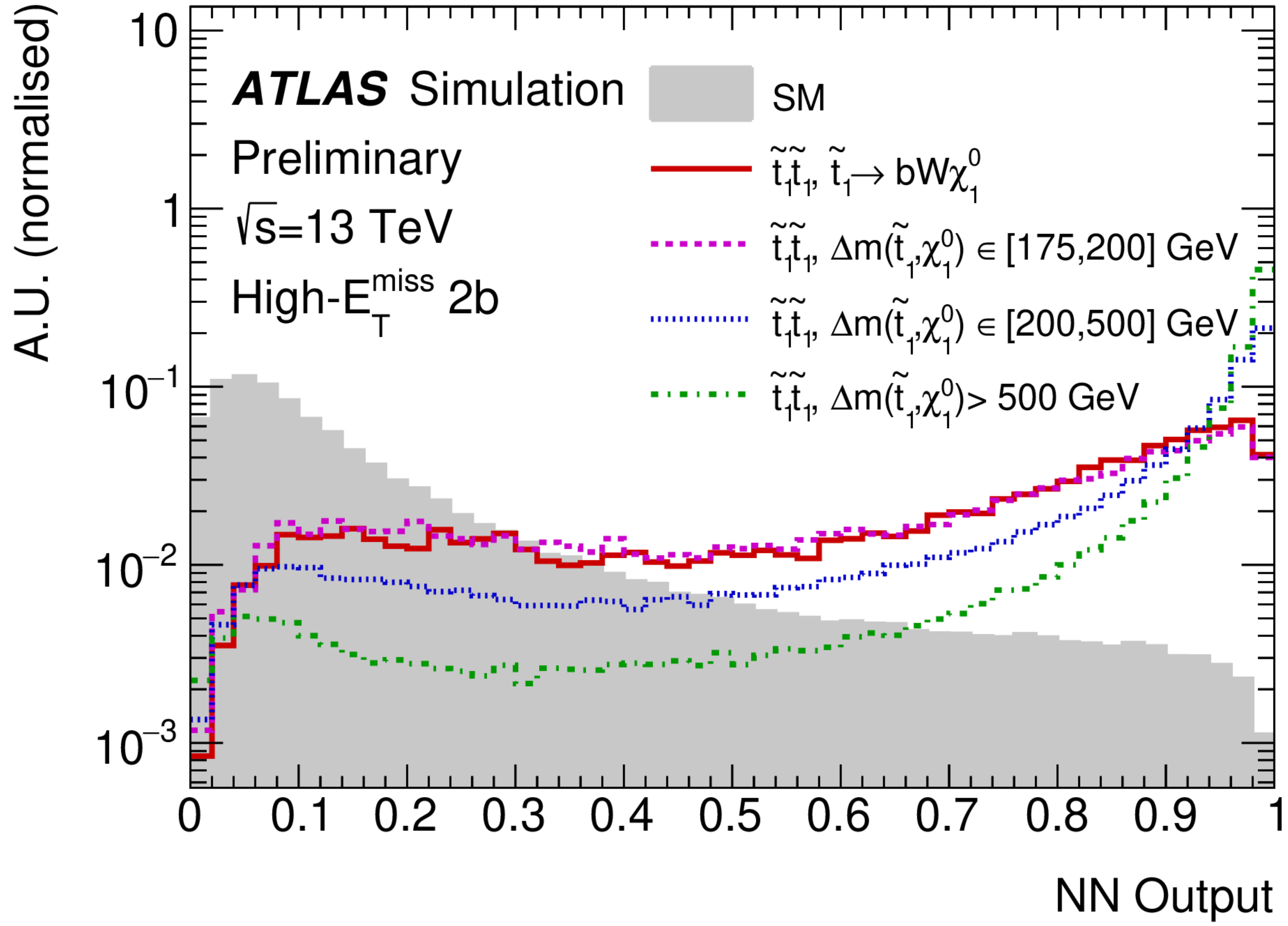
Searches for SUSY Stops

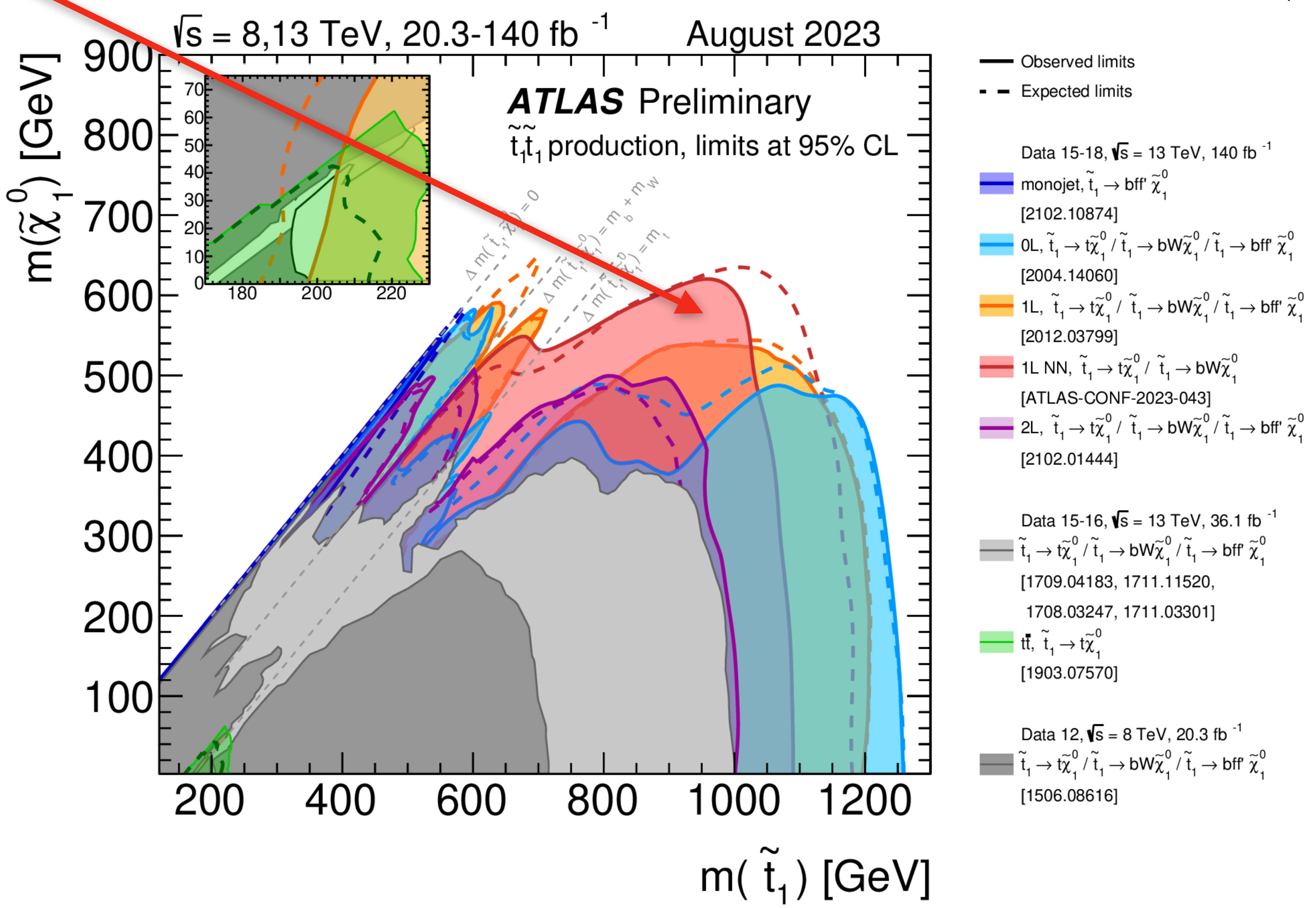
ATLAS-CONF-2023-043

- Stop production in $t\bar{t} + E_{\mathrm{T}}^{\mathrm{miss}}$ final states.
- Improved analysis techniques.
- Sensitivity gains for $m_{\tilde{t}} \approx m_{\tilde{\chi}_1^0} + m_t$.
- Probing $m_{\tilde{t}} < 1200$ GeV and $m_{\tilde{\chi}_1^0} < 600$ GeV.





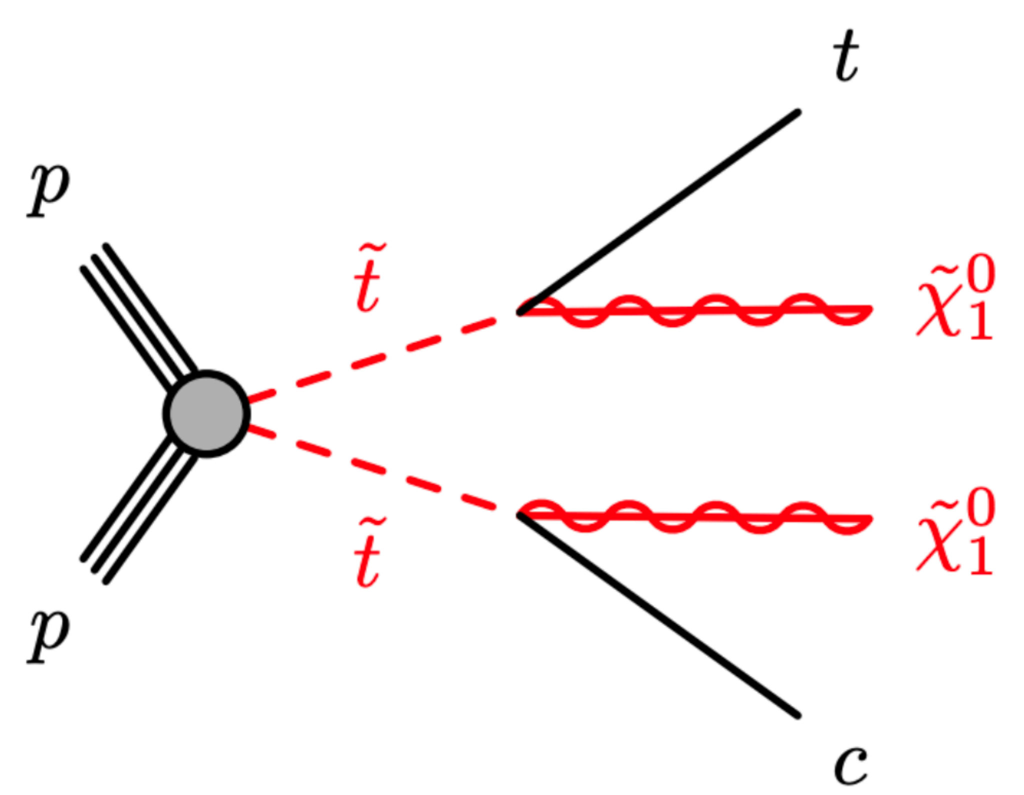


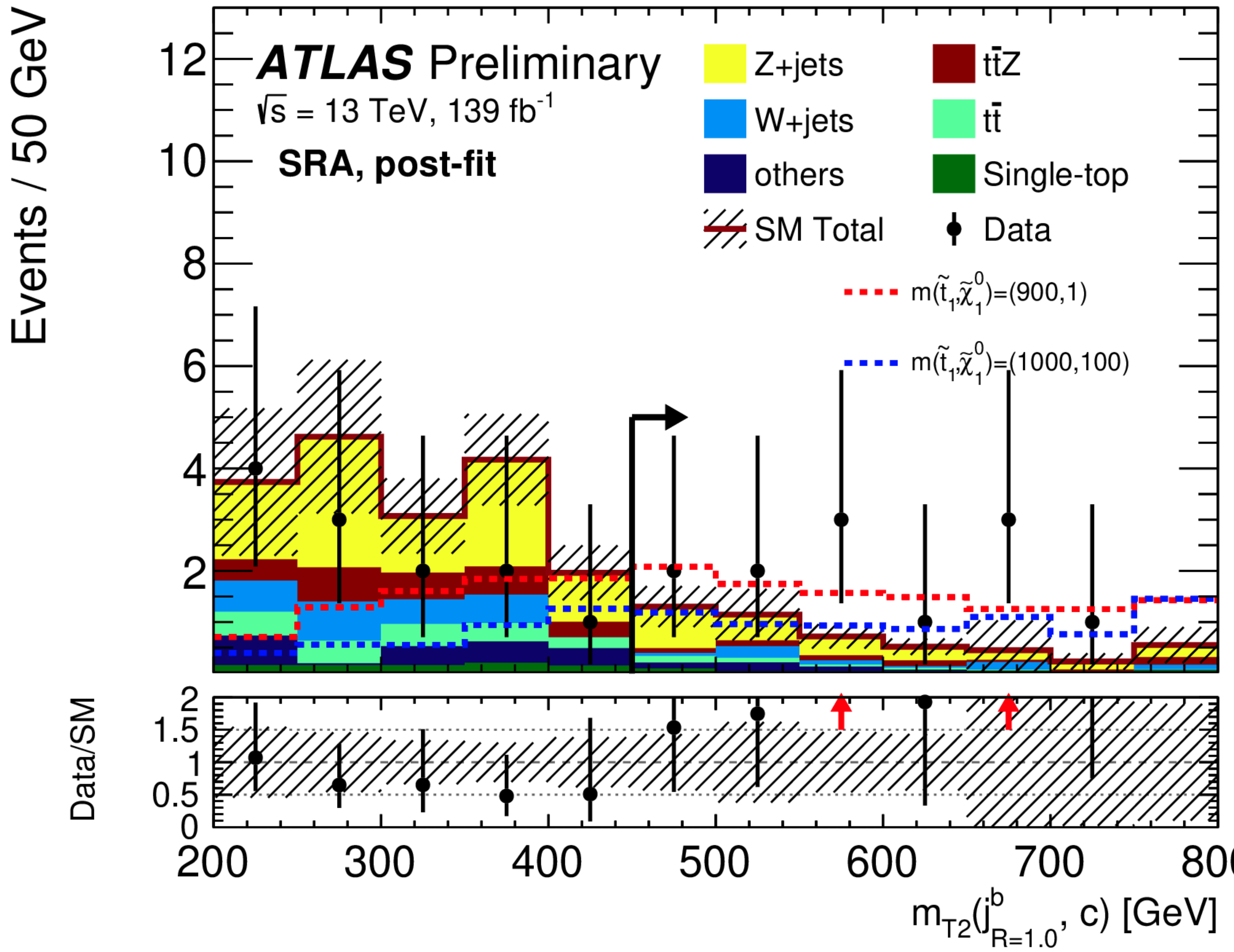


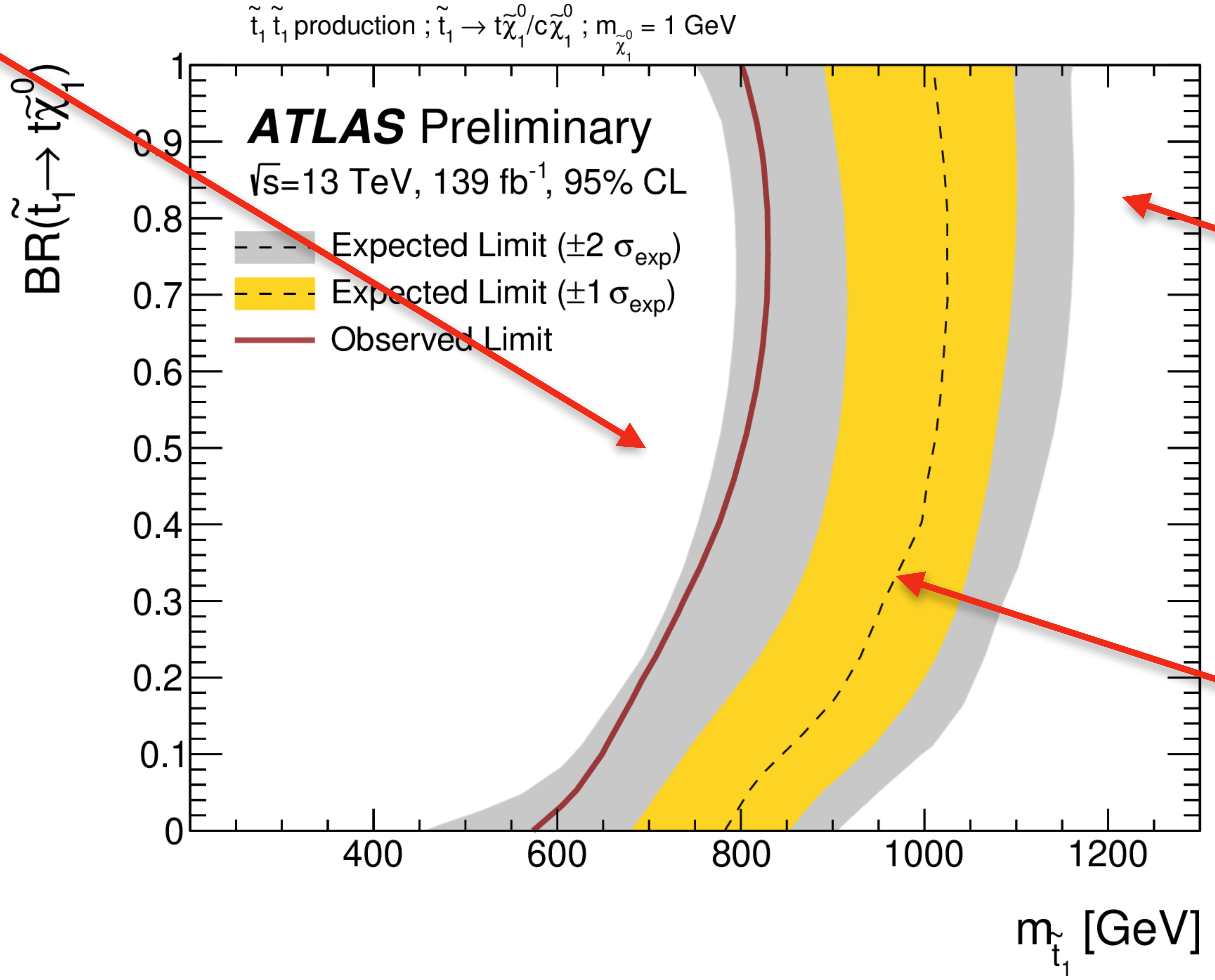
Searches for SUSY Stops

ATLAS-CONF-2023-058

- Exploring more complex SUSY scenarios – allow for minimal flavor violation.
- Search for 1 hadronic top + 1 charm jet + E_T^{miss} final states.
- Dedicated c-tagging working point optimized for the analysis.
- Search for tc + E_T^{miss} fills the gap between tt + E_T^{miss} & cc + E_T^{miss} searches.





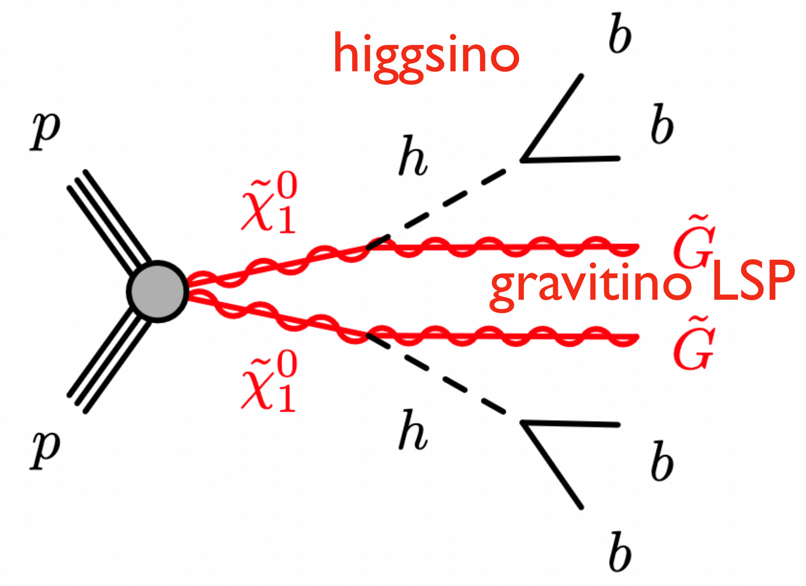


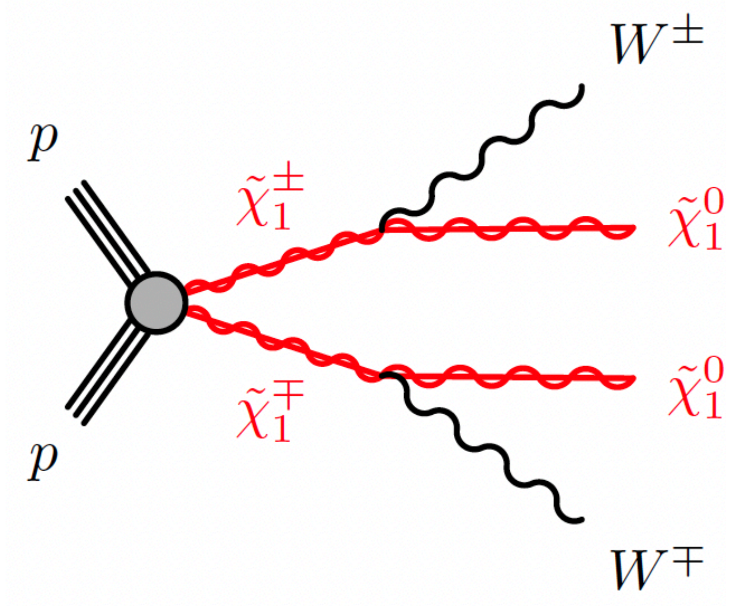
tt + E_T^{miss}
EPJC 80 (2020) 737

cc + E_T^{miss}
JHEP 09 (2018) 050

Searches for Electroweak SUSY

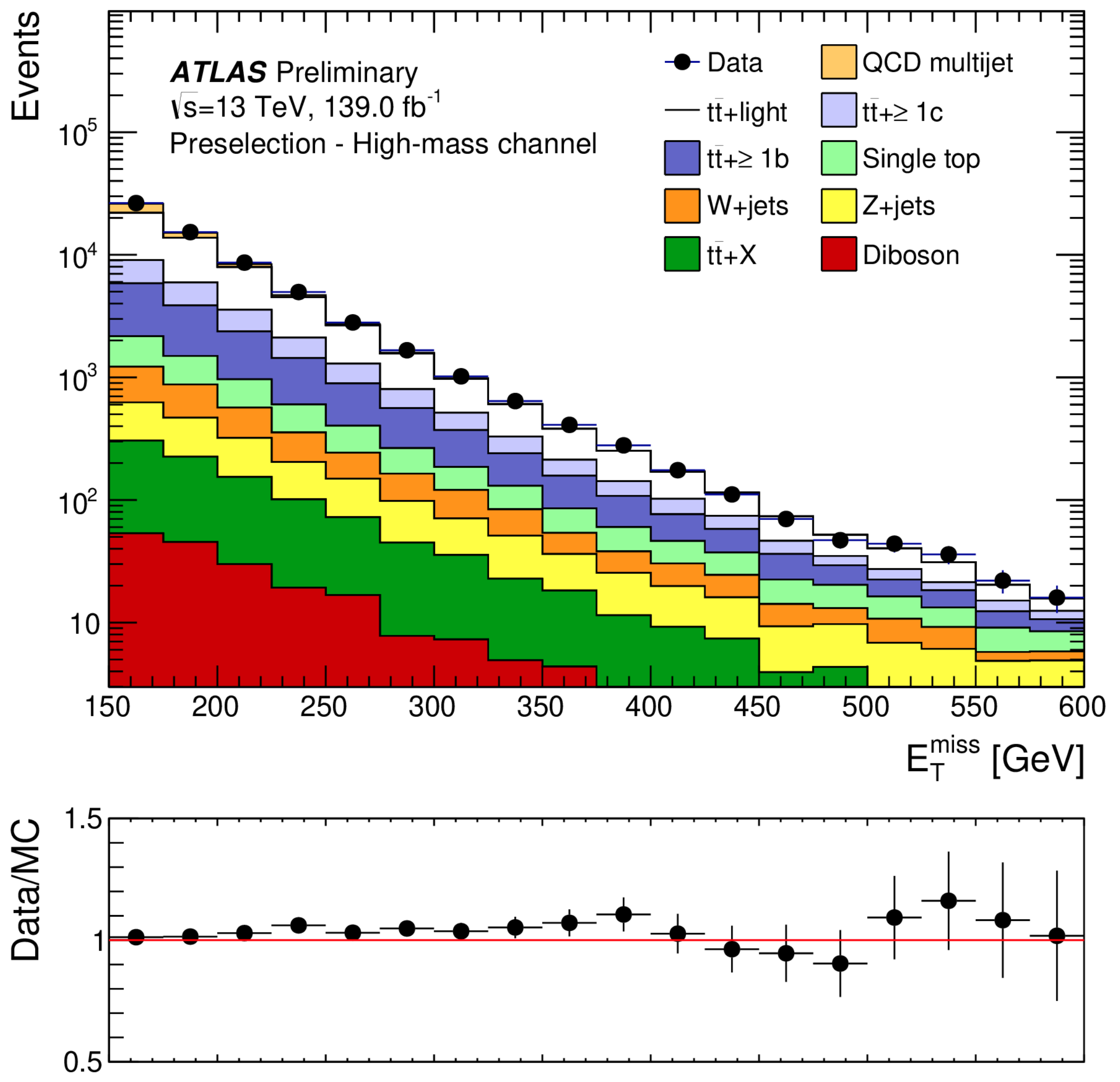
- Search for higgsino pairs decaying to Higgs bosons in Di-Higgs:
  - 4b-jets + E_T^{miss} final state.
- Highest mass reach of analyses targeting GMSB models.
  - reaching TeV scale.
- Combination of searches for chargino/ neutralino production decaying via Higgs, W and Z.
- Combination highlights complementary coverage of analyses & extends exclusion limits.

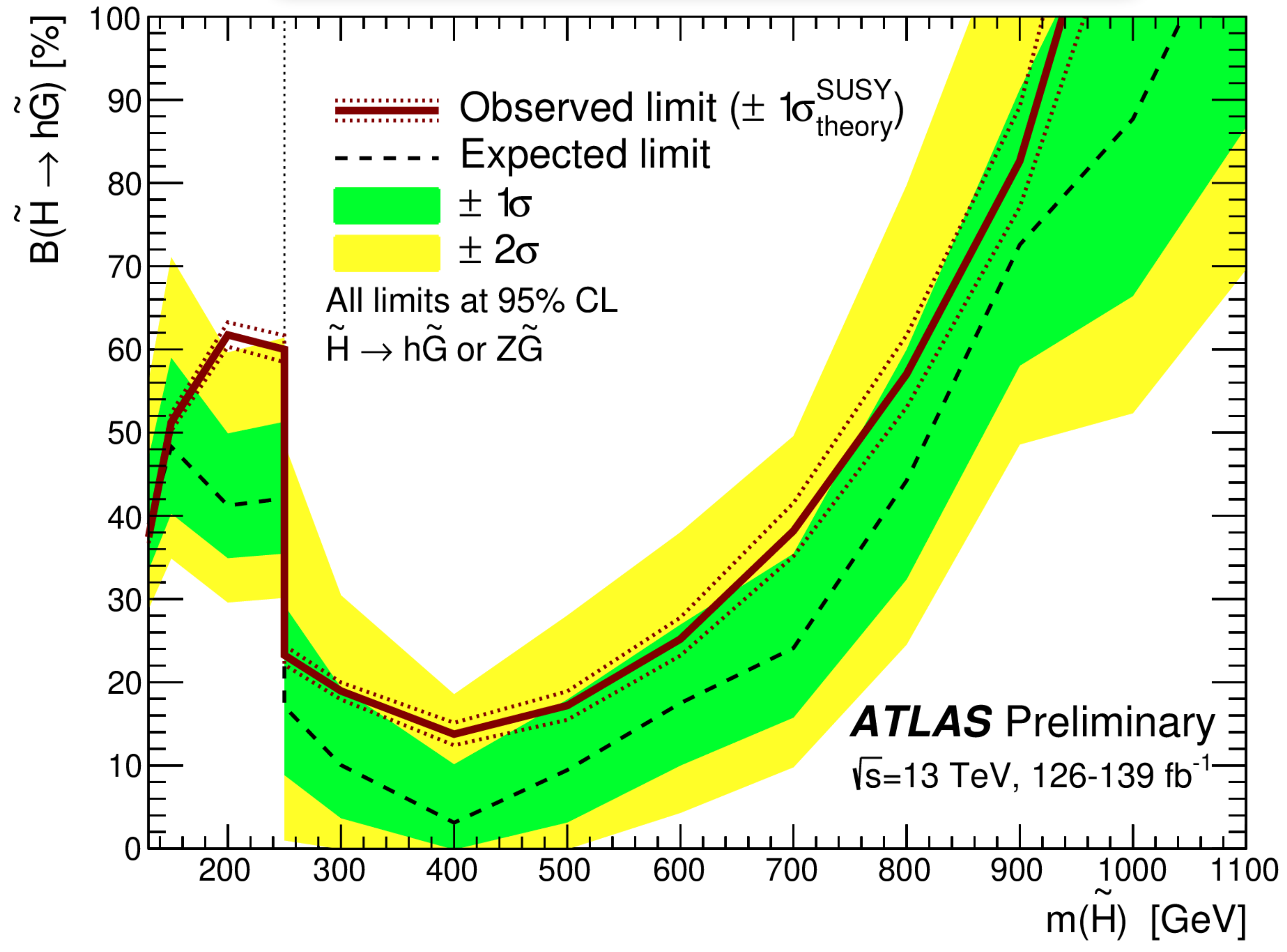


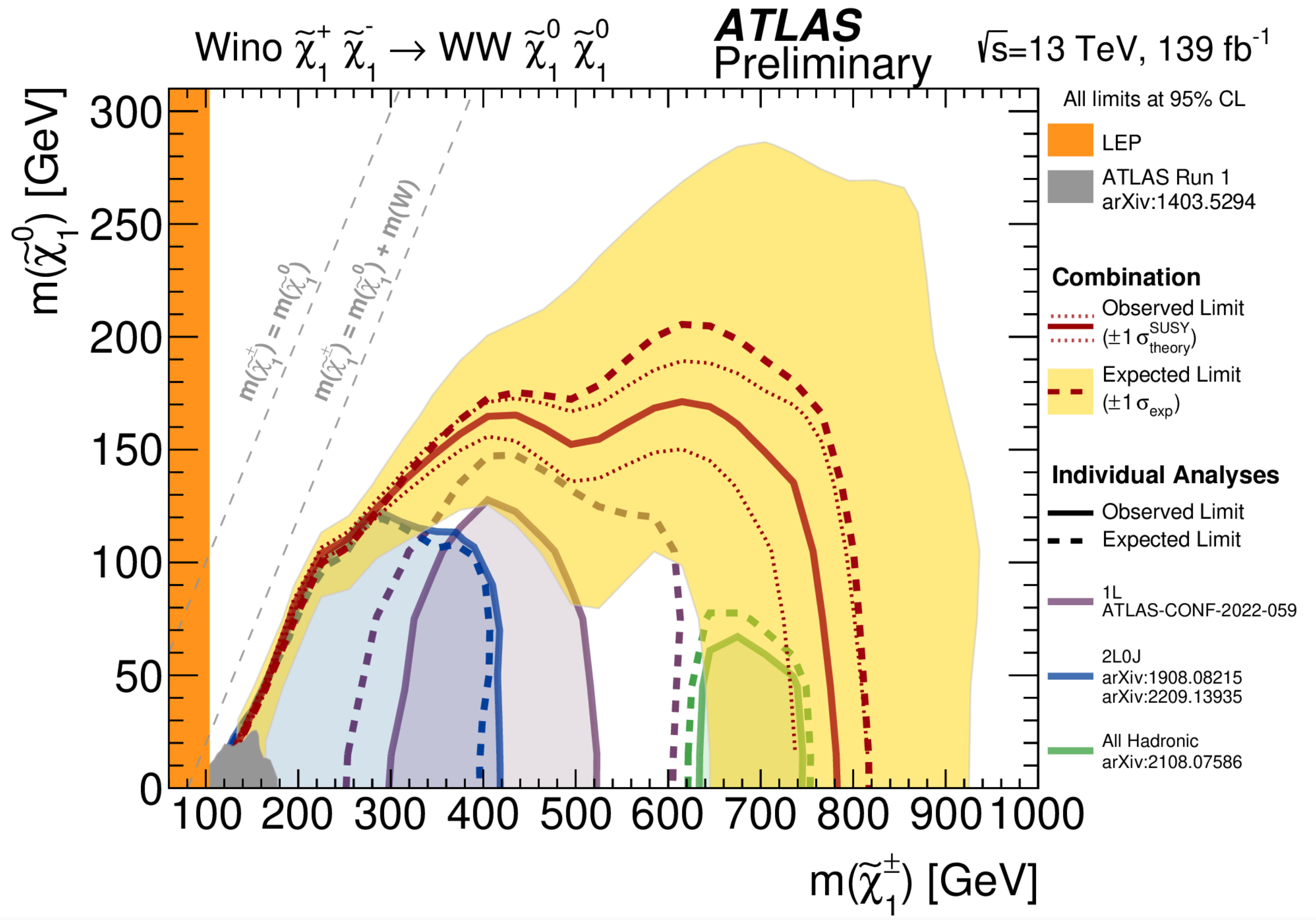


ATLAS-CONF-2023-046

ATLAS-CONF-2023-048



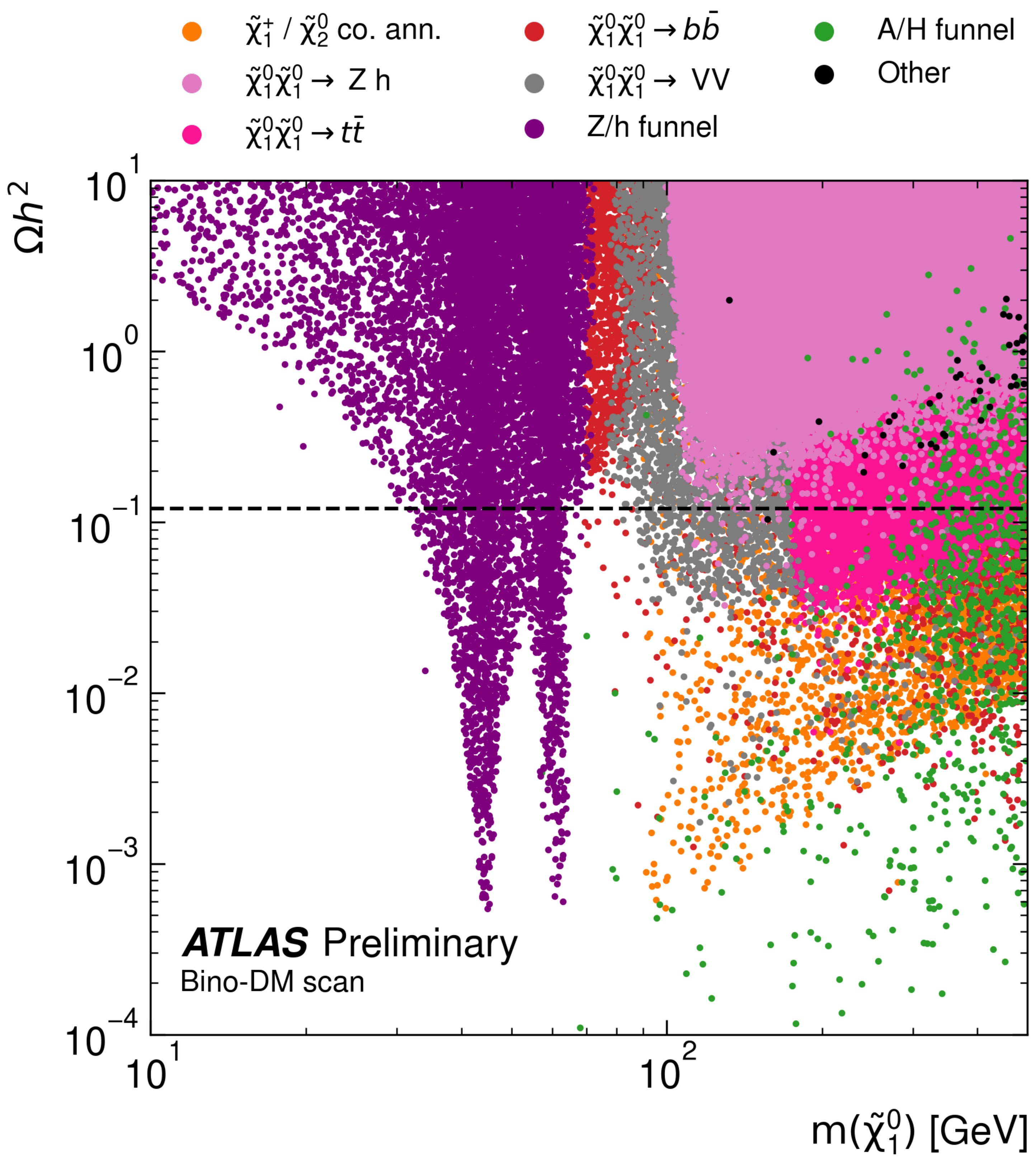


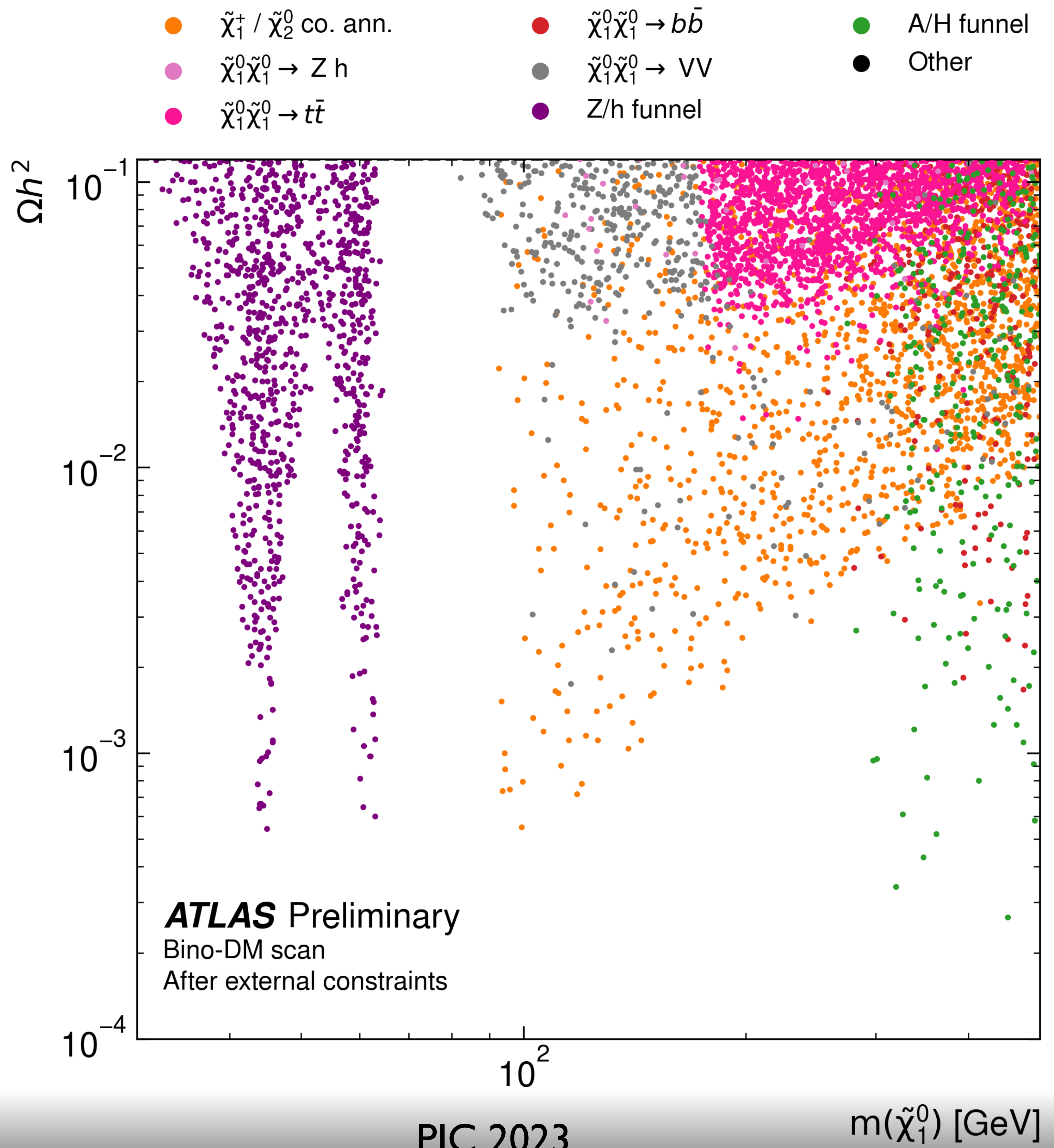


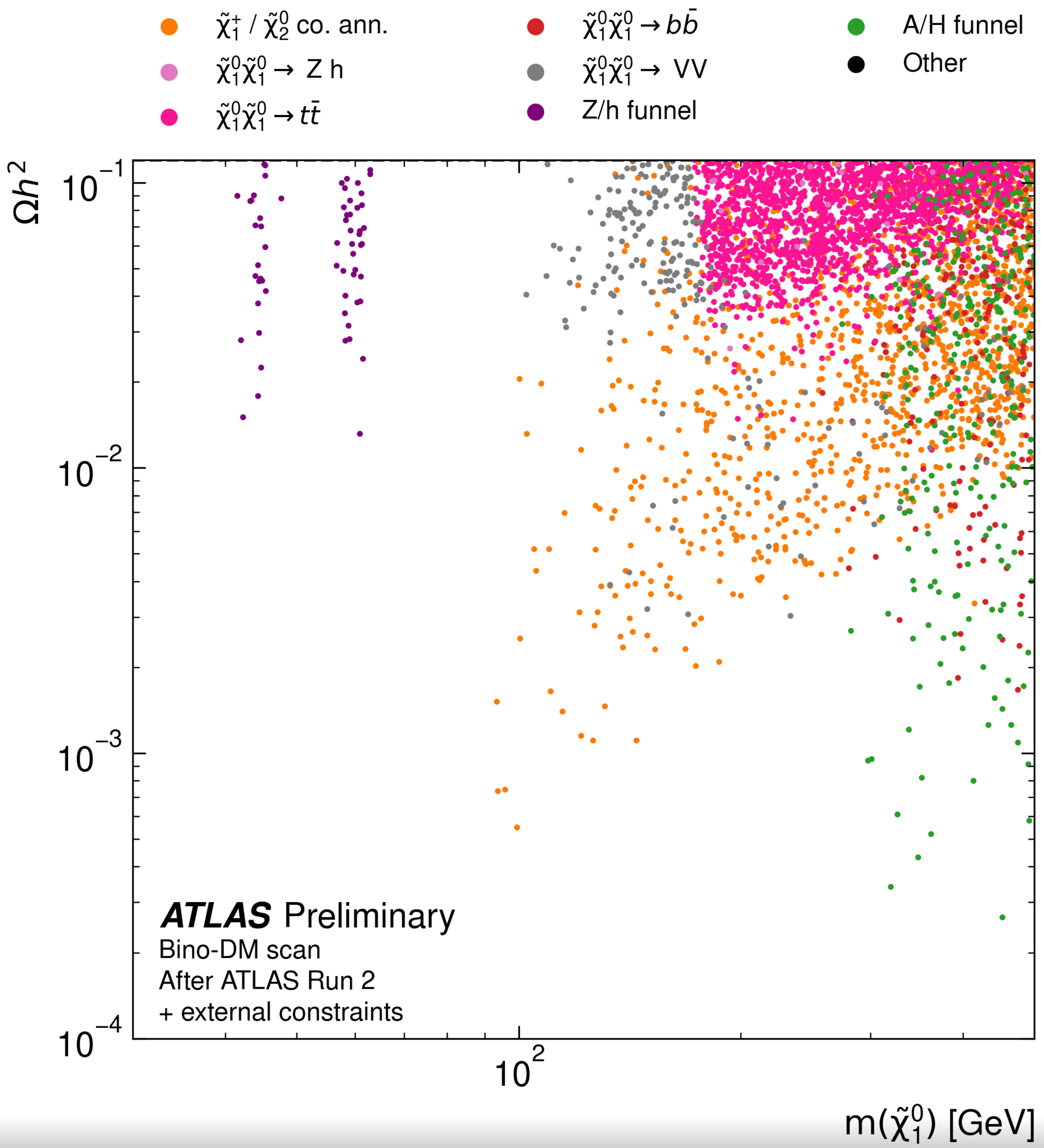
Searches for Electroweak SUSY

ATLAS-CONF-2023-055

- Scan the electroweak sector parameter space of Phenomenological Minimal Supersymmetry (pMSSM), impose LHC & external constraints.
  - Scan highlights gaps from simplified models.
- Complementary constraints from LHC searches on weakly-interacting SUSY particles that may be dark matter candidates.

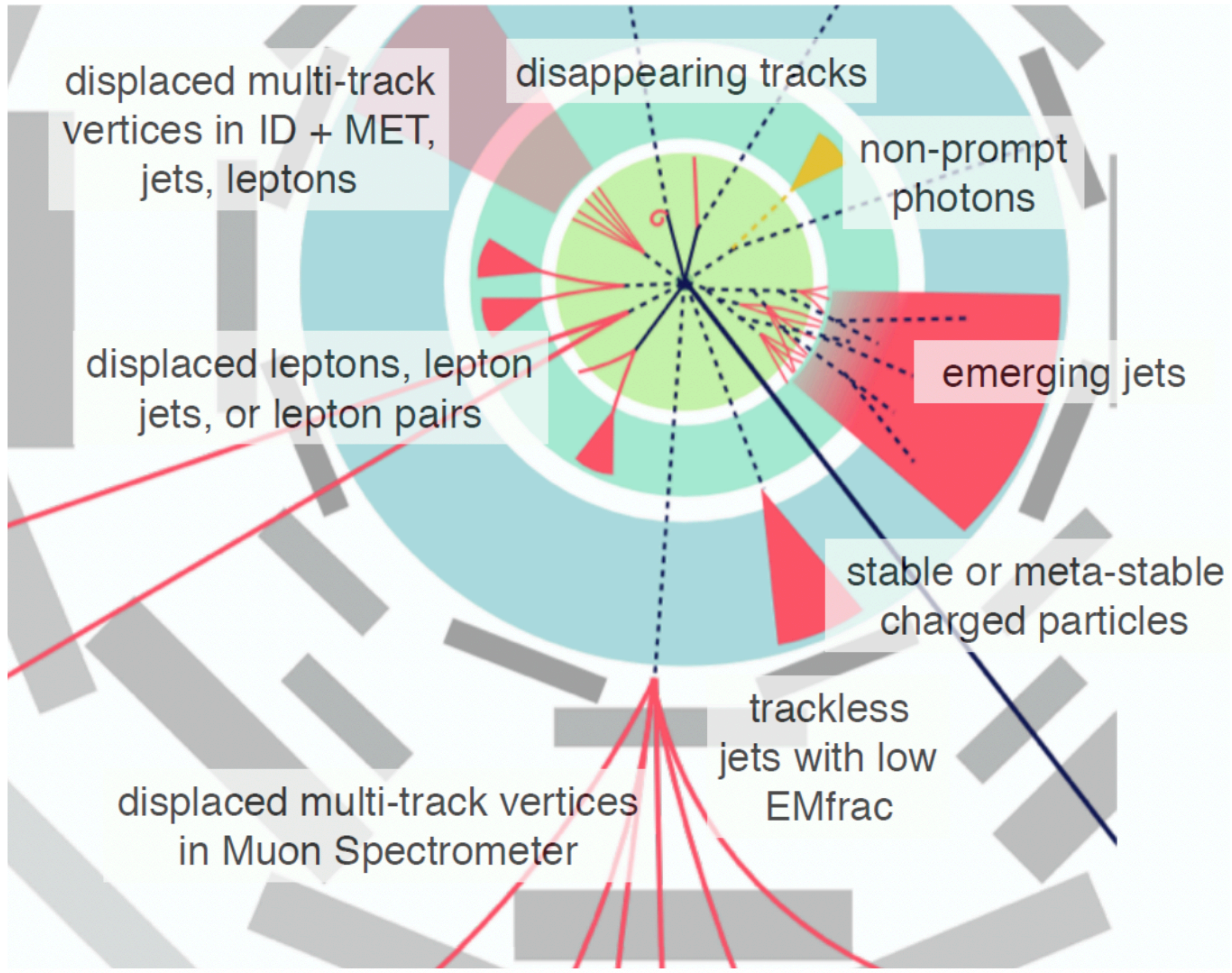




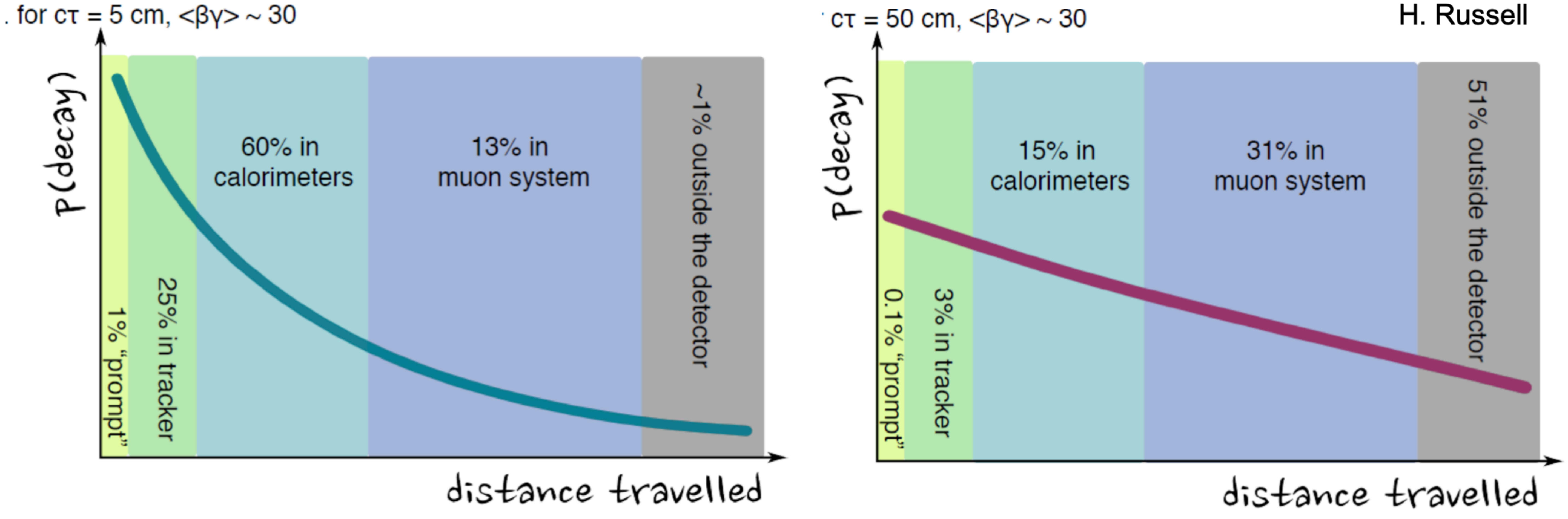


Unconventional Signatures

- Many searches for BSM physics with unconventional signatures:
  - Emerging jets, heavy charged Long Lived Particles (LLPs), delayed jets, displaced jets, disappearing tracks, displaced muons
- Signatures define search strategy
  - Could be light or heavy
  - Could travel fast or slow
  - Could decay to quarks, gluons, or leptons, or even invisible particles (missing transverse momentum)
- Main handles:
  - timing
  - displacement
  - ionization
- Every sub-system important



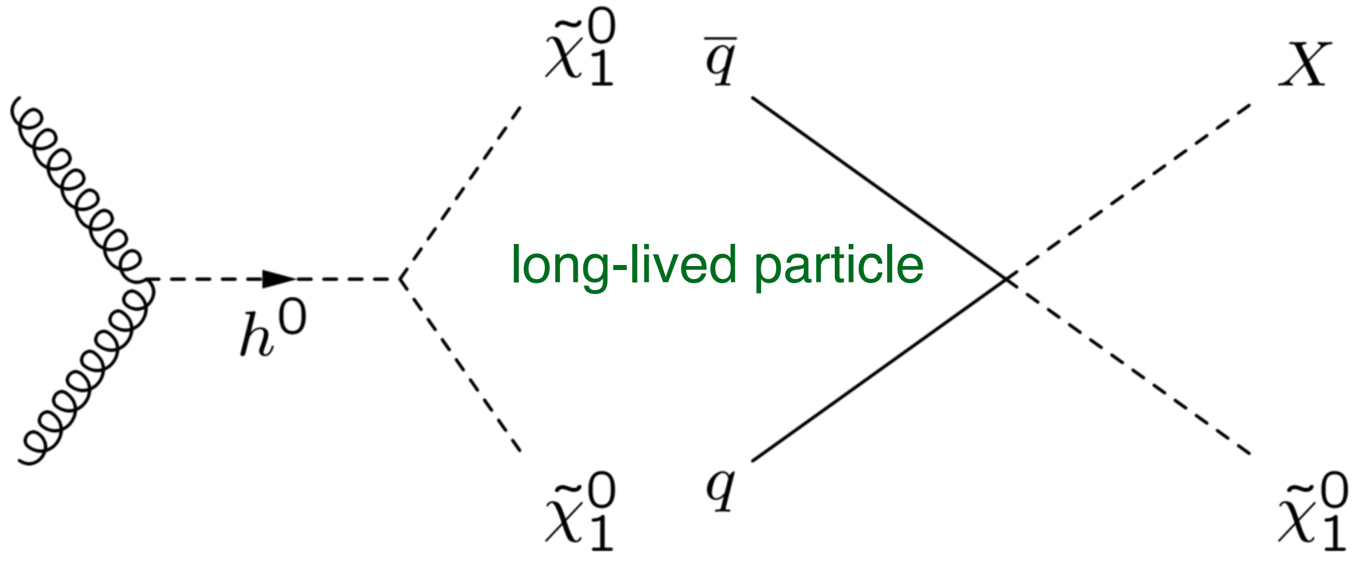
distance travelled $= \beta\gamma \times c\tau$



Long-Lived Massive Particle Search

- Search for a long-lived LSP that undergoes semi-leptonic decay $\tilde{\chi}^0_1 \to \mu^+ q_i q_j$
  - lifetimes ~ 5 – 200 ps
  - 30 < m_{h^0} < 200 GeV 10 < $m_{\tilde{\chi}^0_1}$ < $m_h/2$ GeV
- Long-lived decays result in displaced vertices including an isolated high-p_T muon.
- Pair production via decay of a Higgs-like boson.

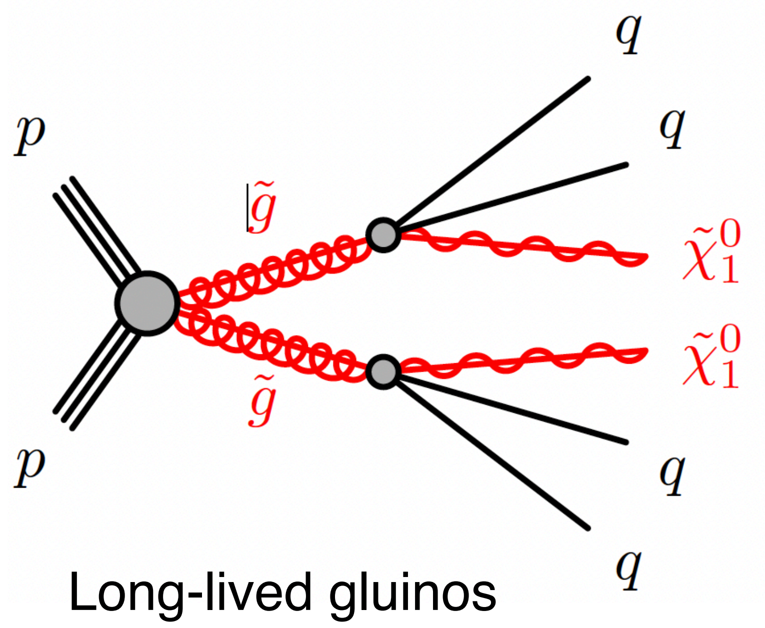
LHCb: EPJC 82 (2022) 373

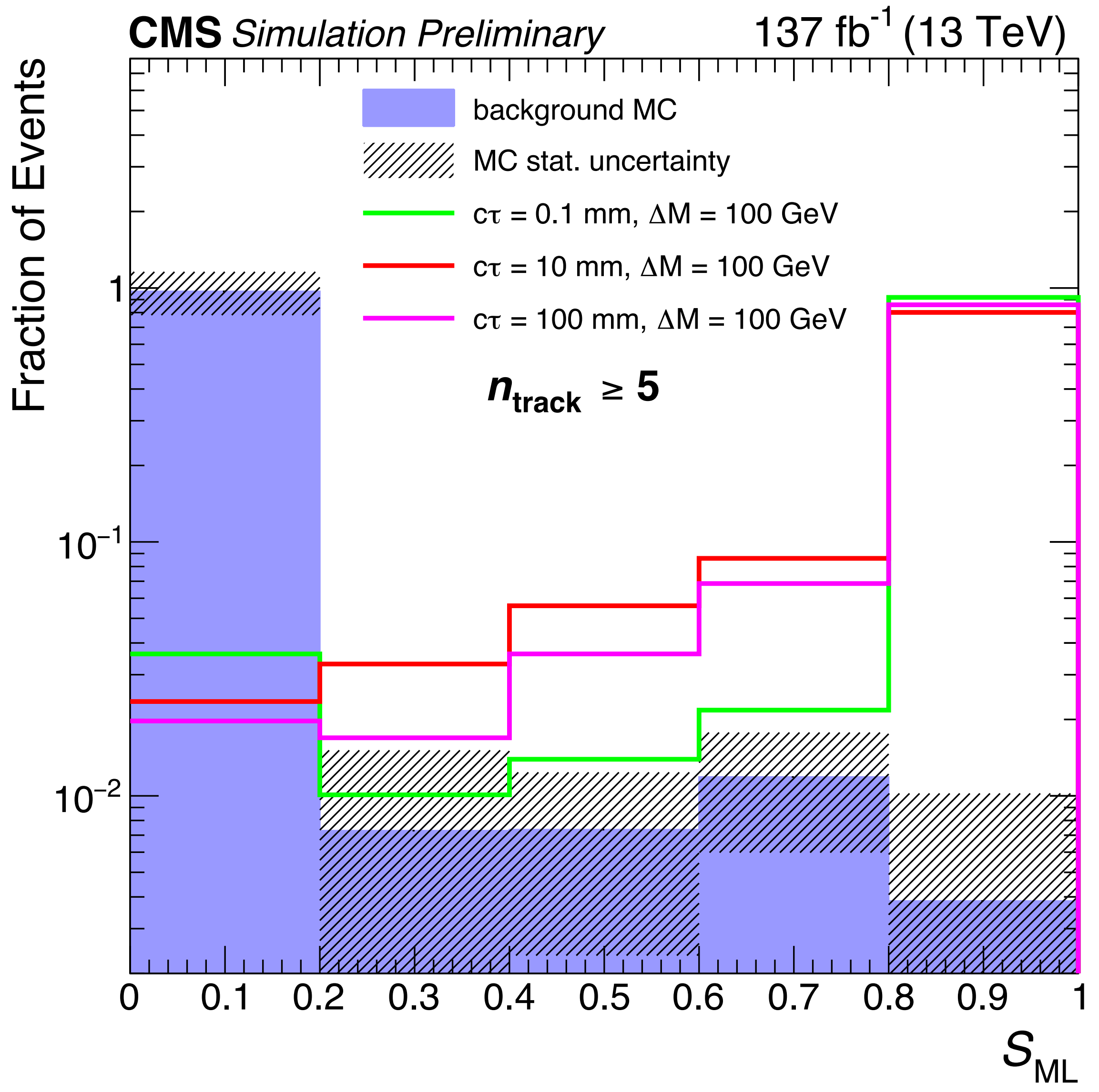


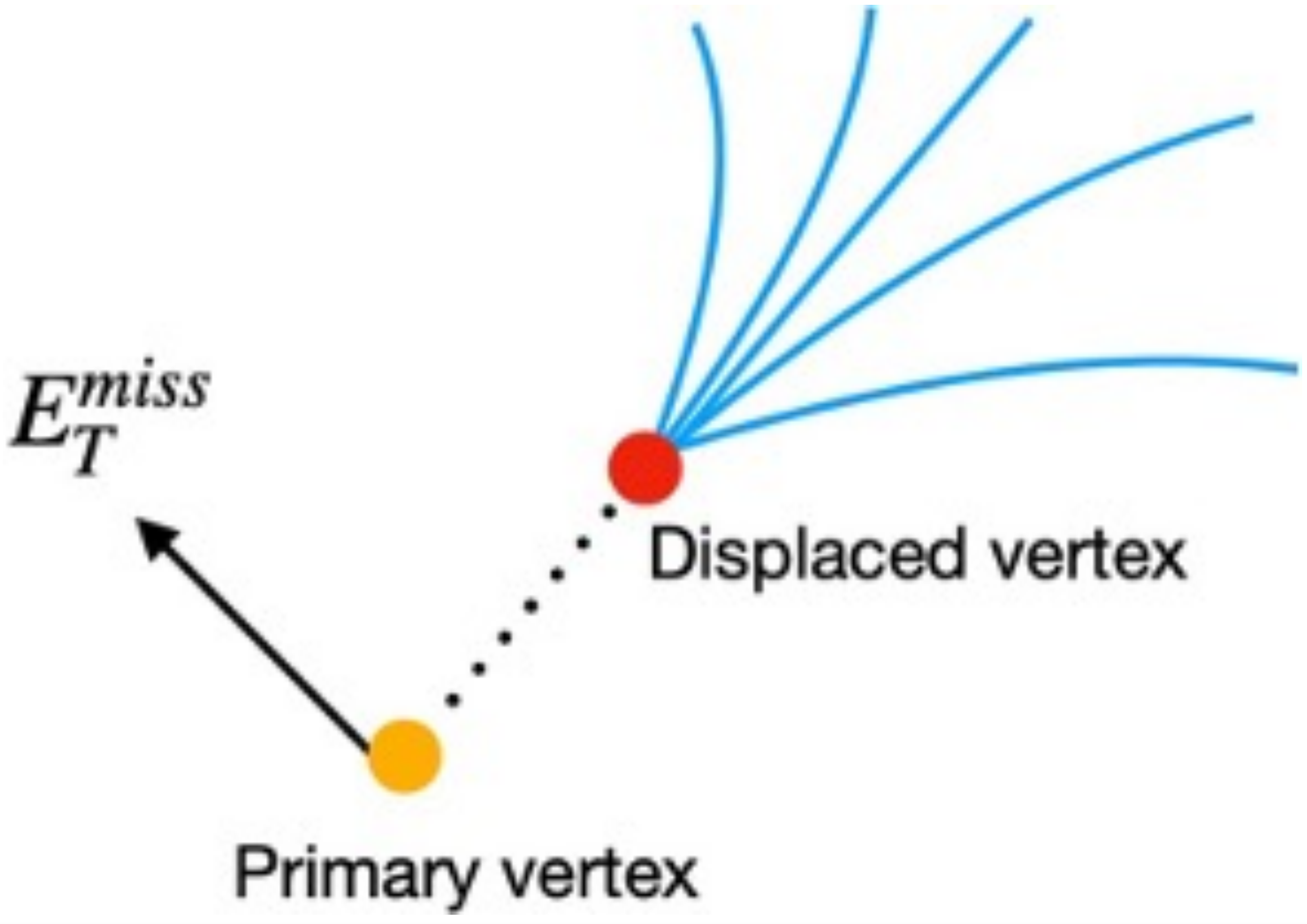
Searches for Long-Lived Particles

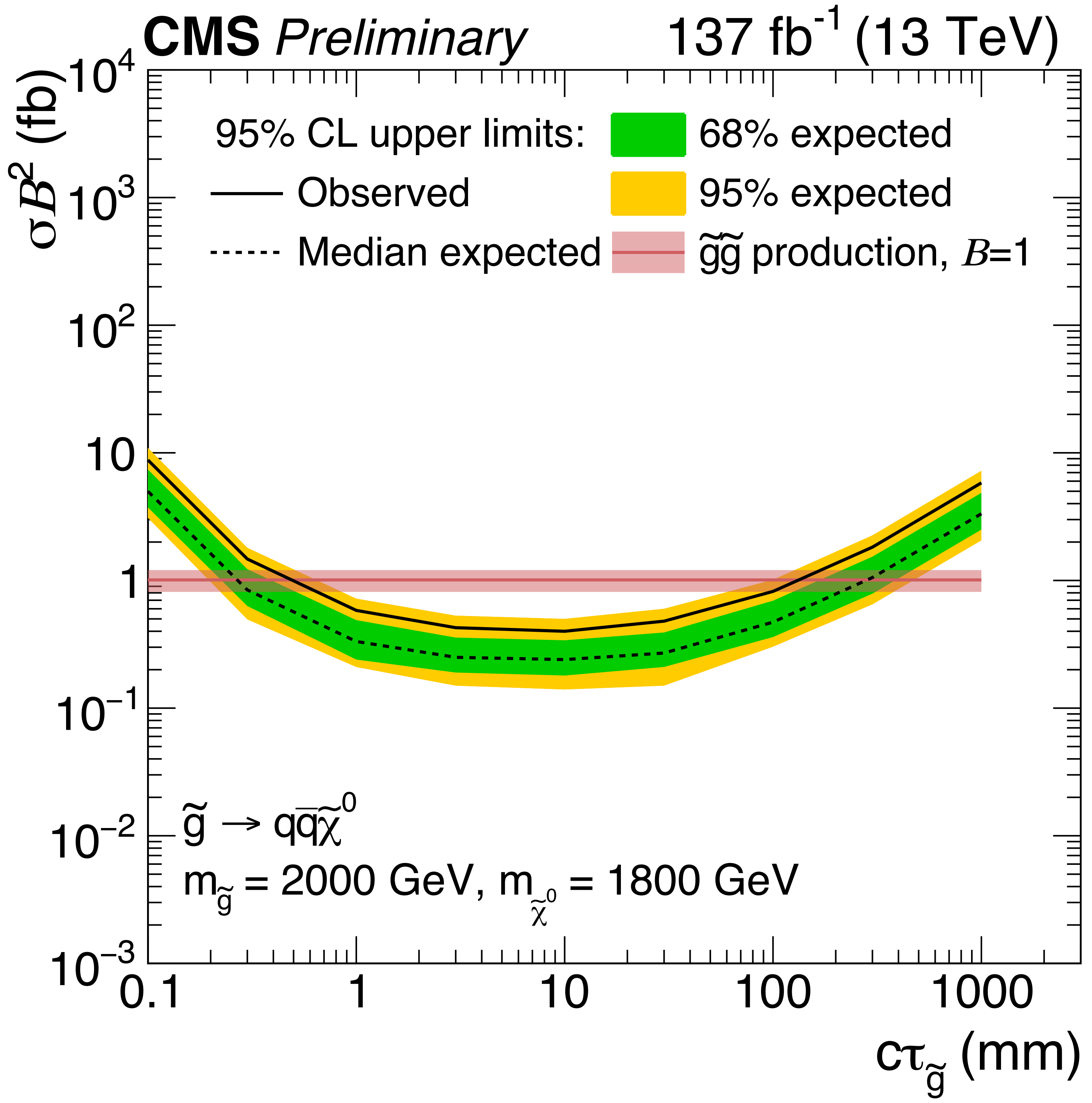
CMS-PAS-EXO-22-020

- Searches for long-lived particles have become a central topic of the CMS physics program.
- Cover final states that are less energetic and with relatively small lifetimes.
- Search for events with at least one displaced vertex (within beam pipe) + MET to allow wider range of lifetimes and softer final states.
- Reconstruct vertex using an interaction network based on graph neutral networks to reduce backgrounds.
- Excludes m ≲ 1.8 – 2 TeV for 1≲cτ ≲100 mm.



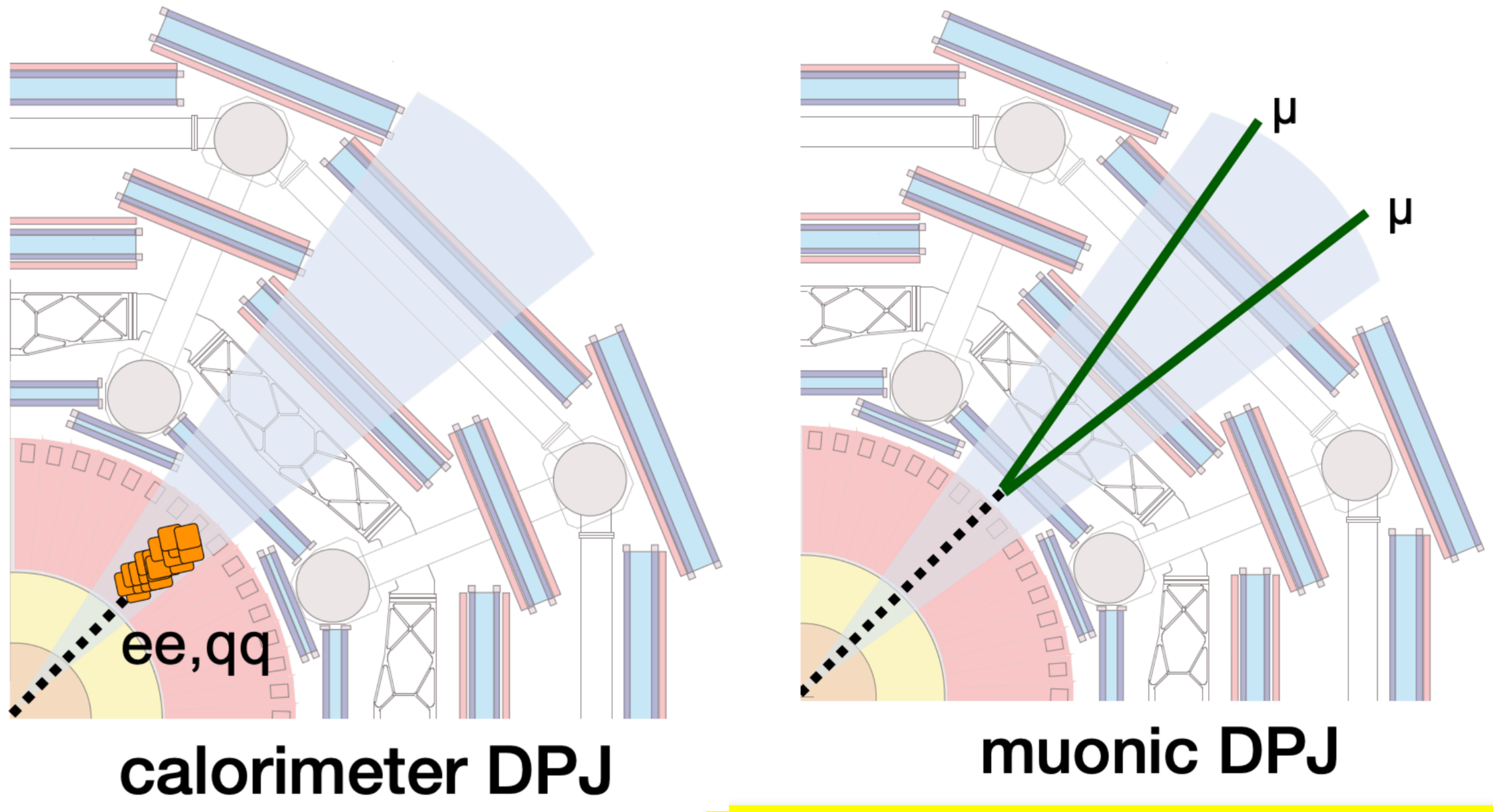




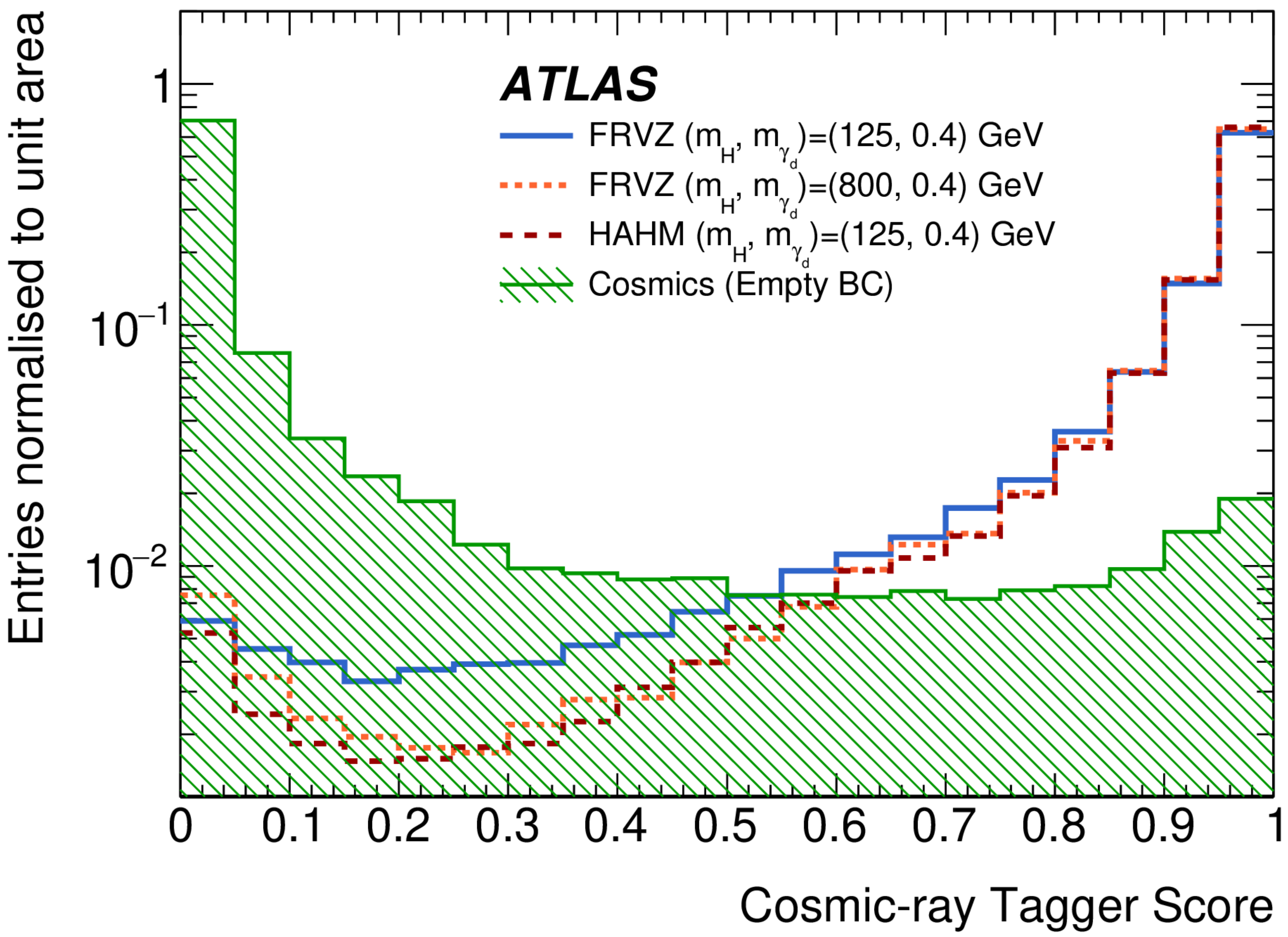


Searches for Displaced Lepton Jet

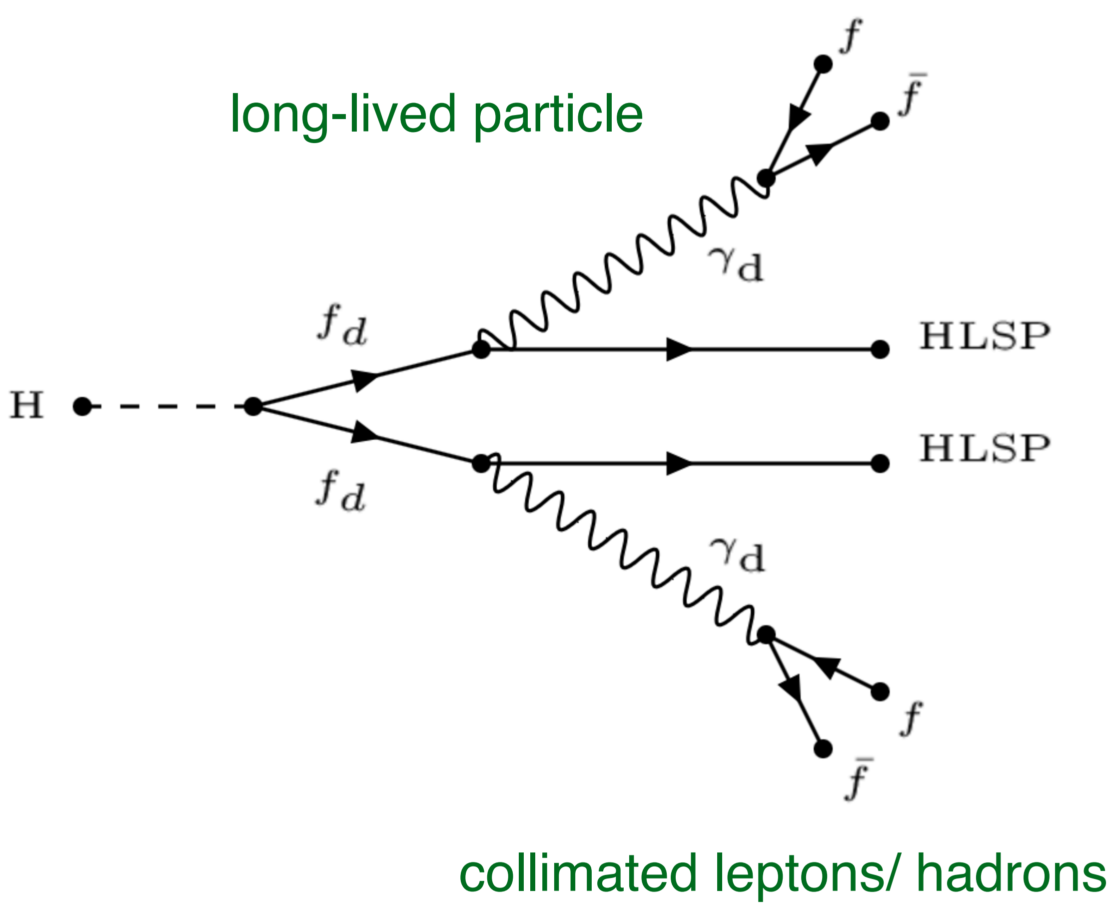
- Search for displaced collimated leptons or light hadrons in exotic Higgs decays.
- Target $m_{\gamma d}$ in MeV to GeV range.
- Dedicated taggers to reject main backgrounds.



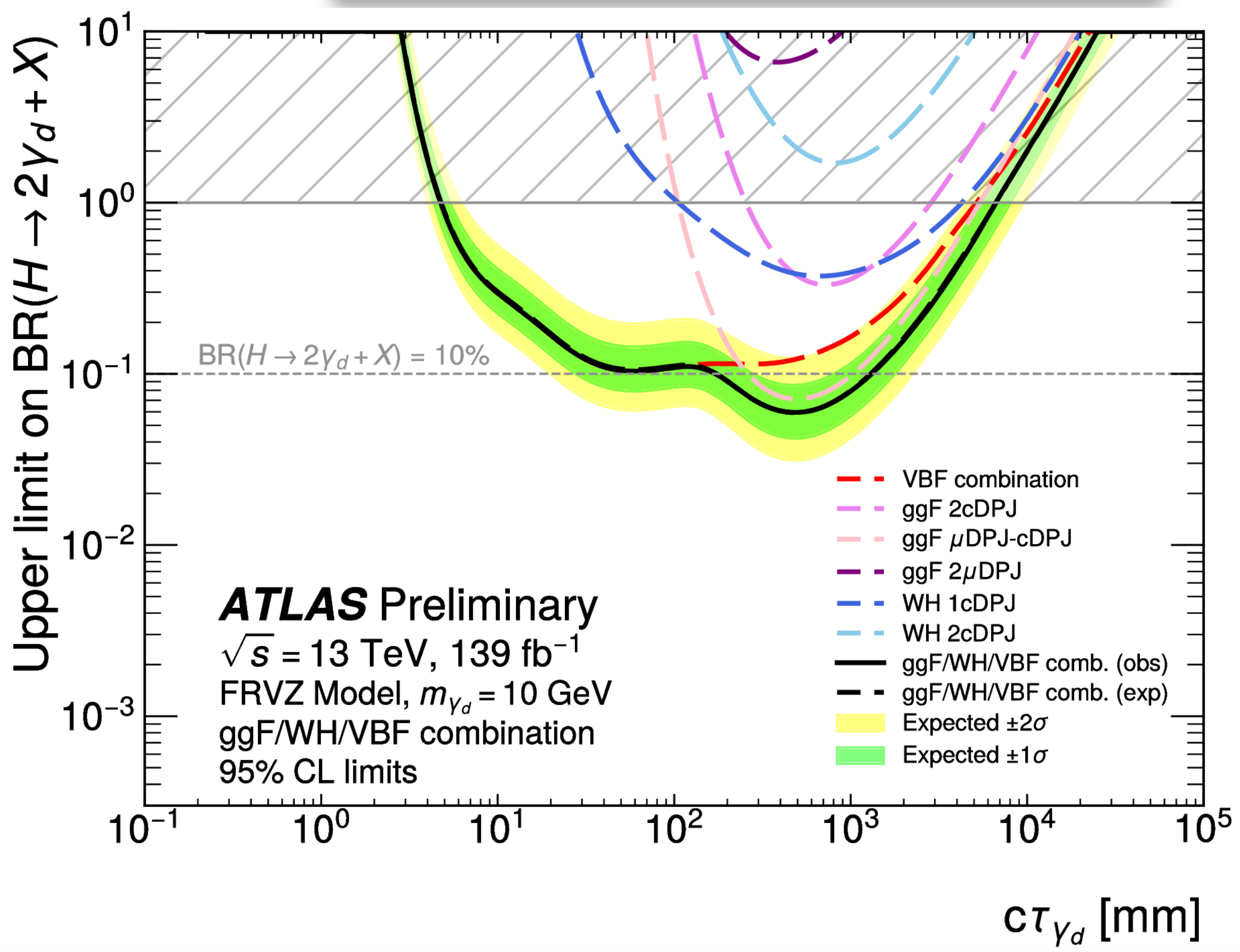
ATLAS: JHEP 06 (2023) 153



FRWZ dark photon model



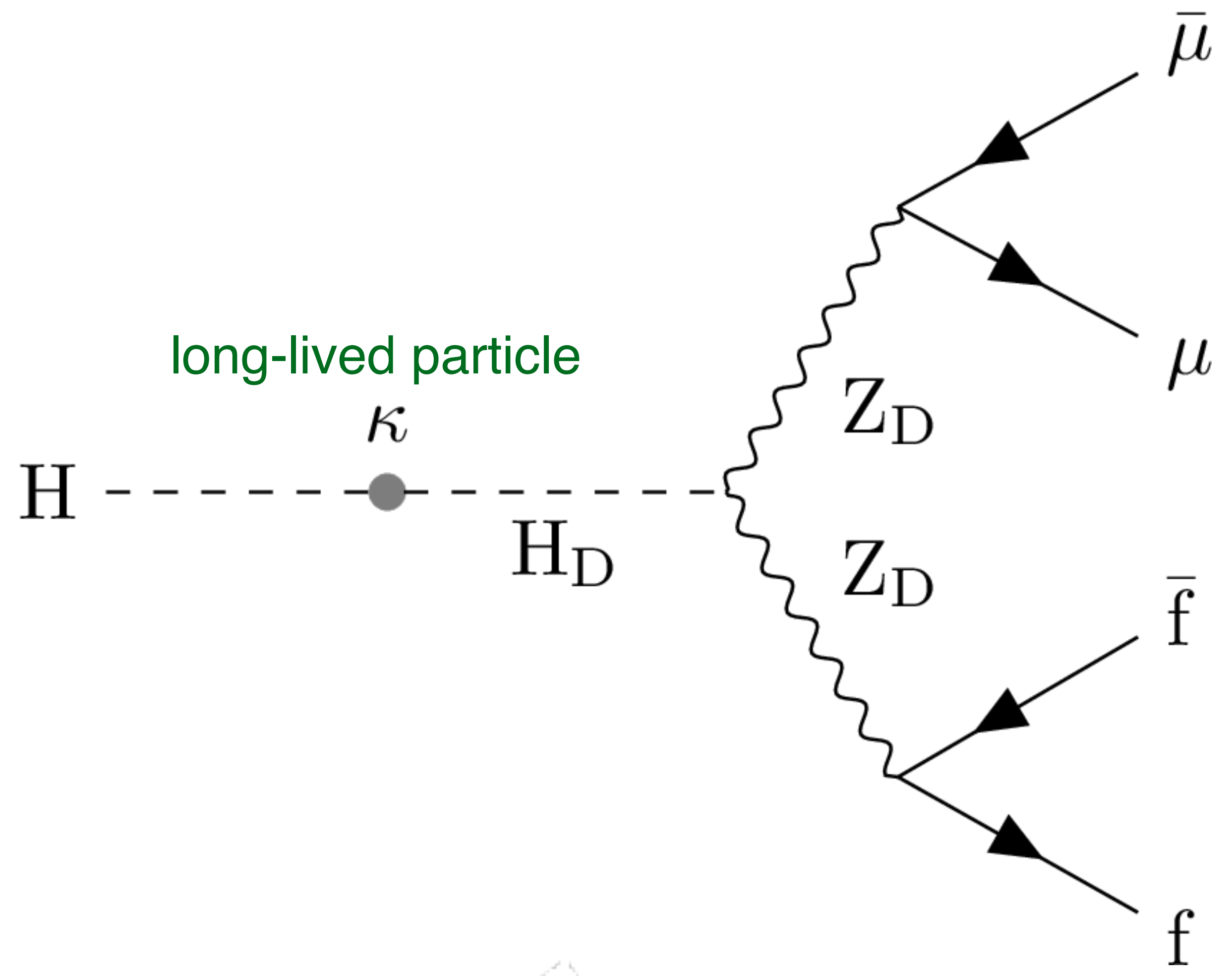
ATLAS-CONF-2023-051



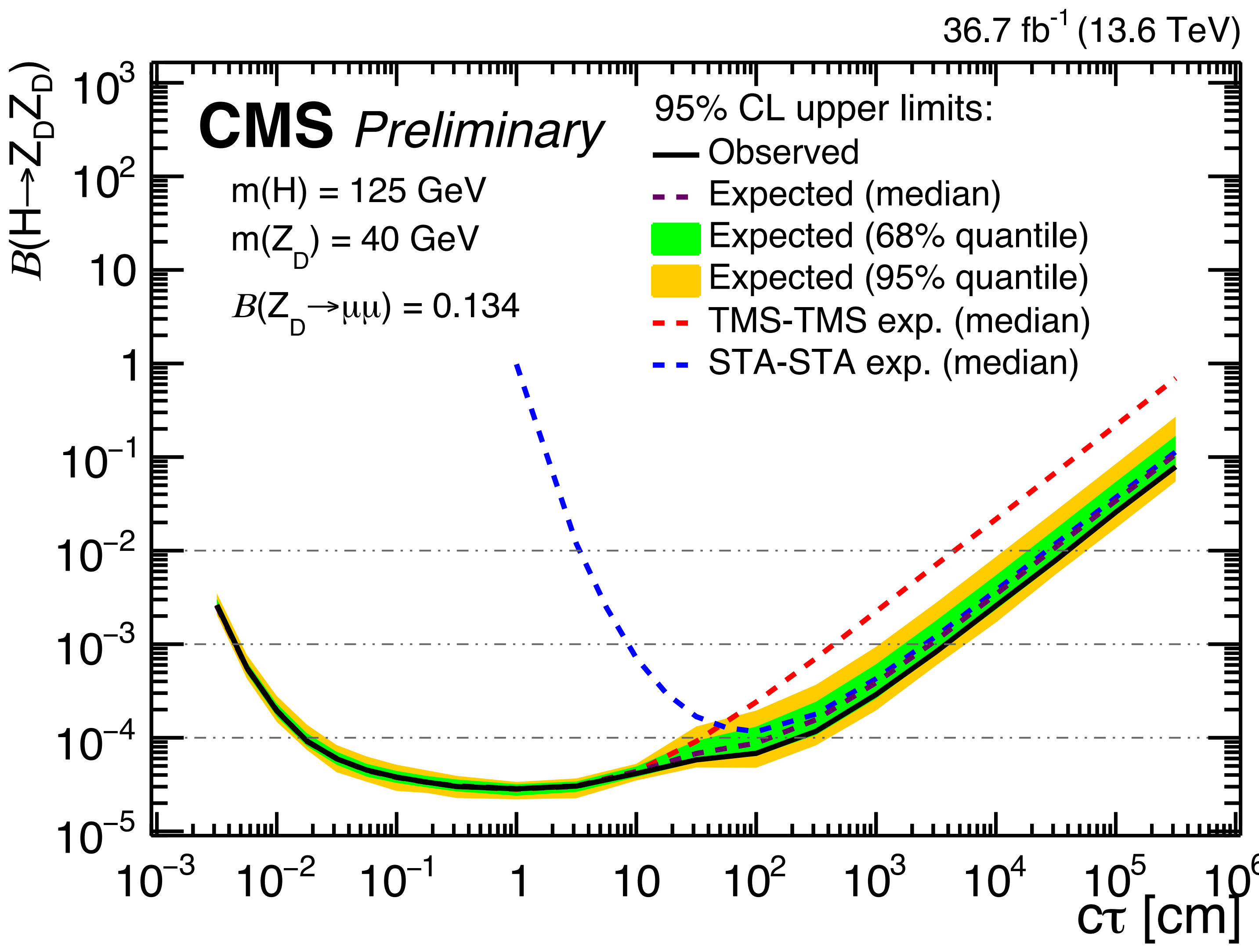
Searches for Displaced Muons

CMS-PAS-EXO-23-014

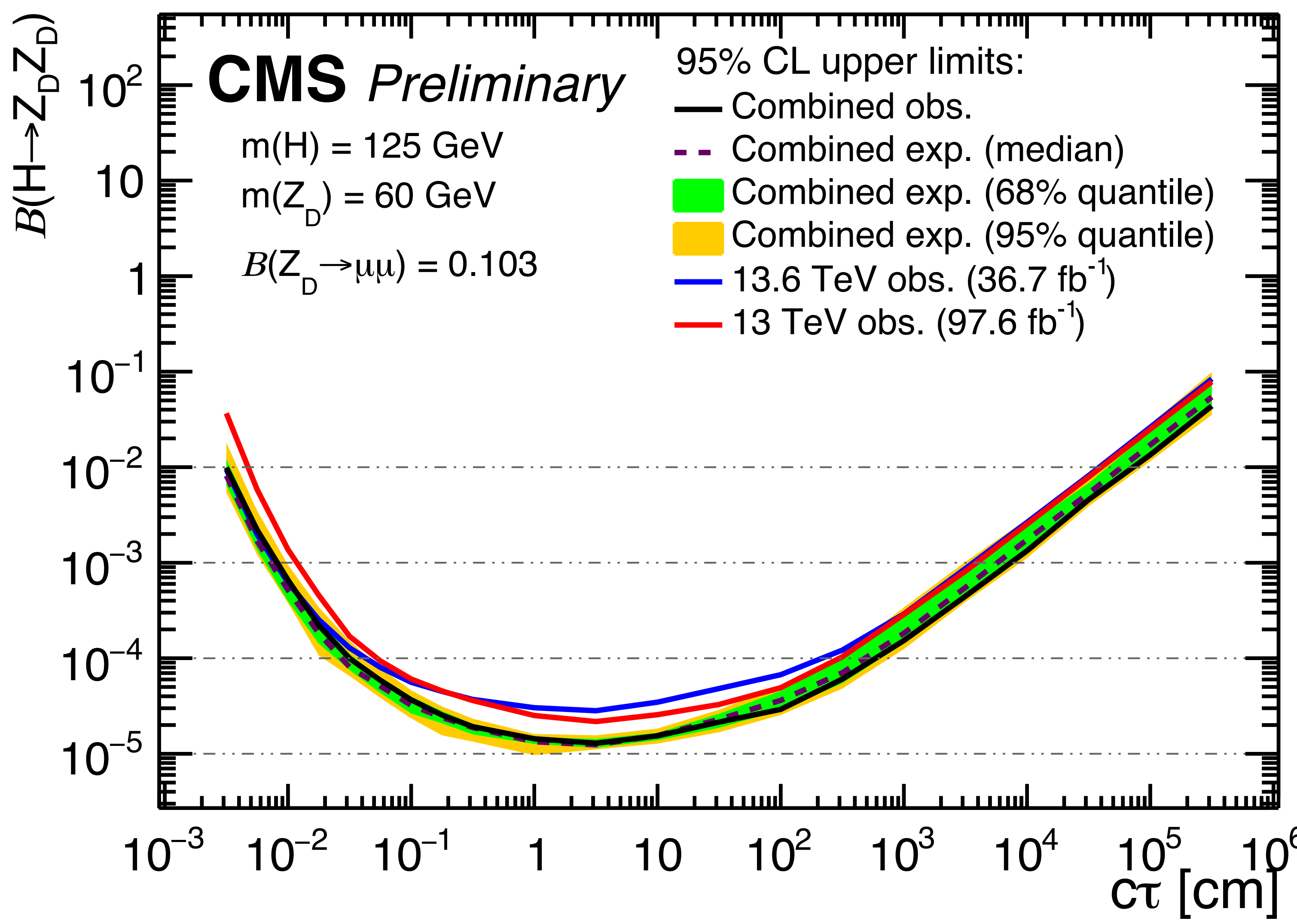
- Search for displaced muons − includes Run 3 data at $\sqrt{s}$ = 13.6 TeV from 2022.
- Target 10 ≲ m_{ZD} ≲ 60 GeV.
- Improved sensitivity from use of new triggers.
- Muon reconstruction:
  - Use only muon system (STA)
  - Muon reconstruction in both tracker & muon system (TMS)
- Gain in sensitivity from including Run 3 data.

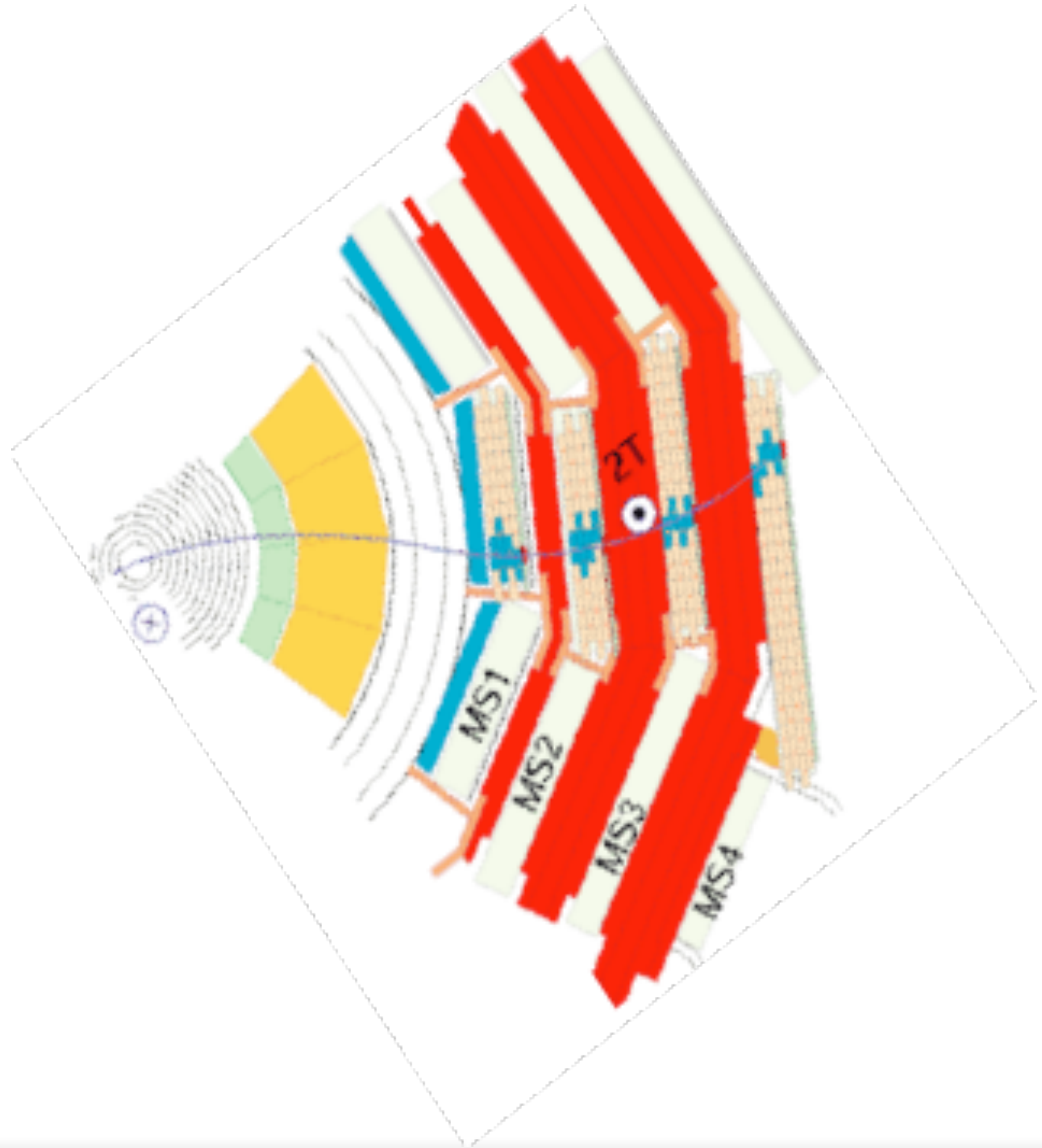


Combination of muon categories



Combination of Run 2 & Run 3

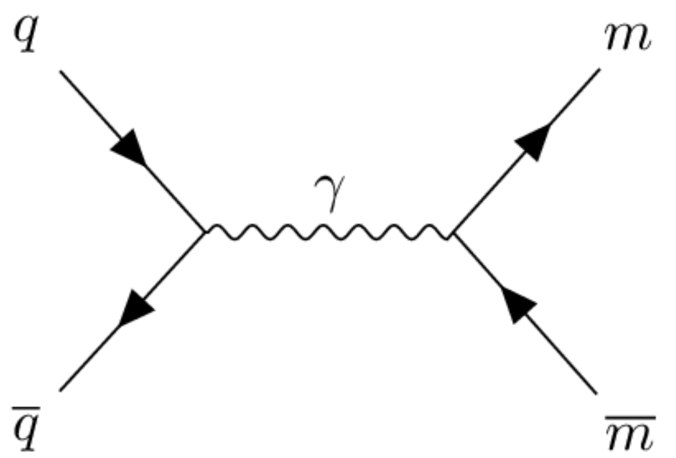


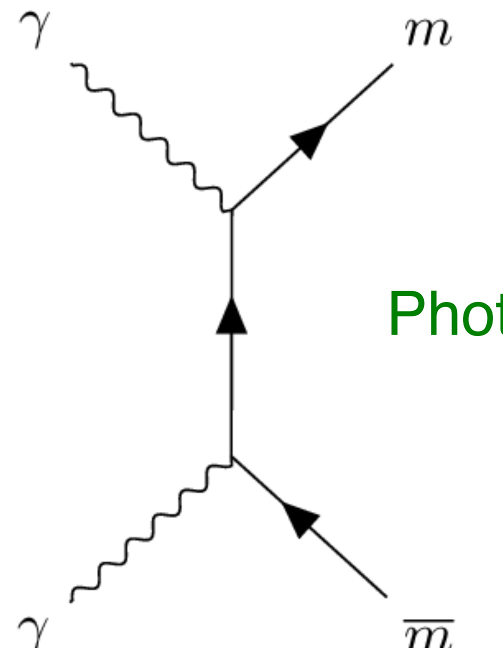


Search for Highly Ionizing Particles

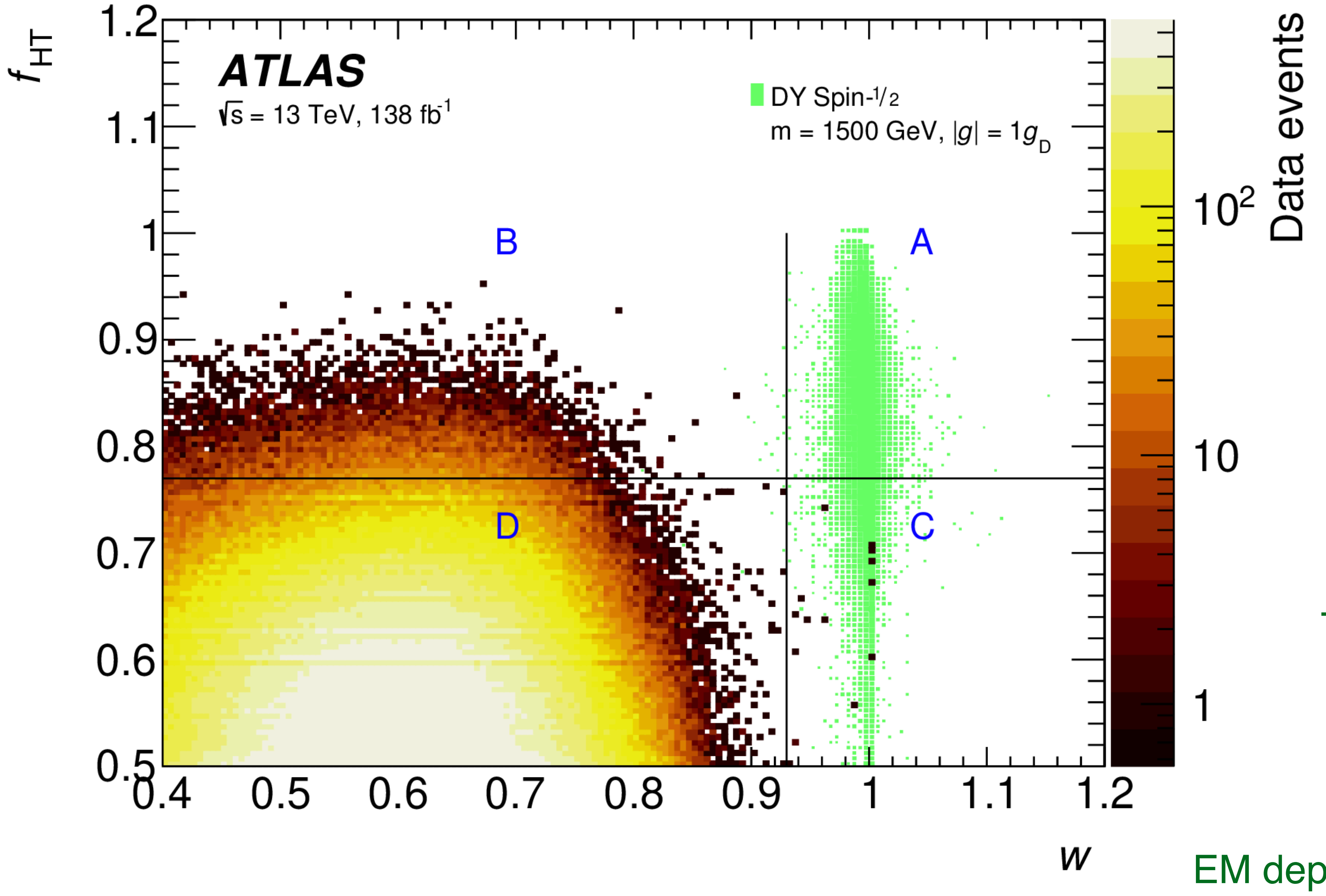
ATLAS: arXiv:2308.04835 (submitted to JHEP)

- Search for magnetic monopoles and stable particles with high electric charge.
- Limits on magnetic monopoles of charge $1g_D$ and $2g_D$ and high-electric-charge objects $20 \leq |z| \leq 100$, m~0.2 – 4 TeV.

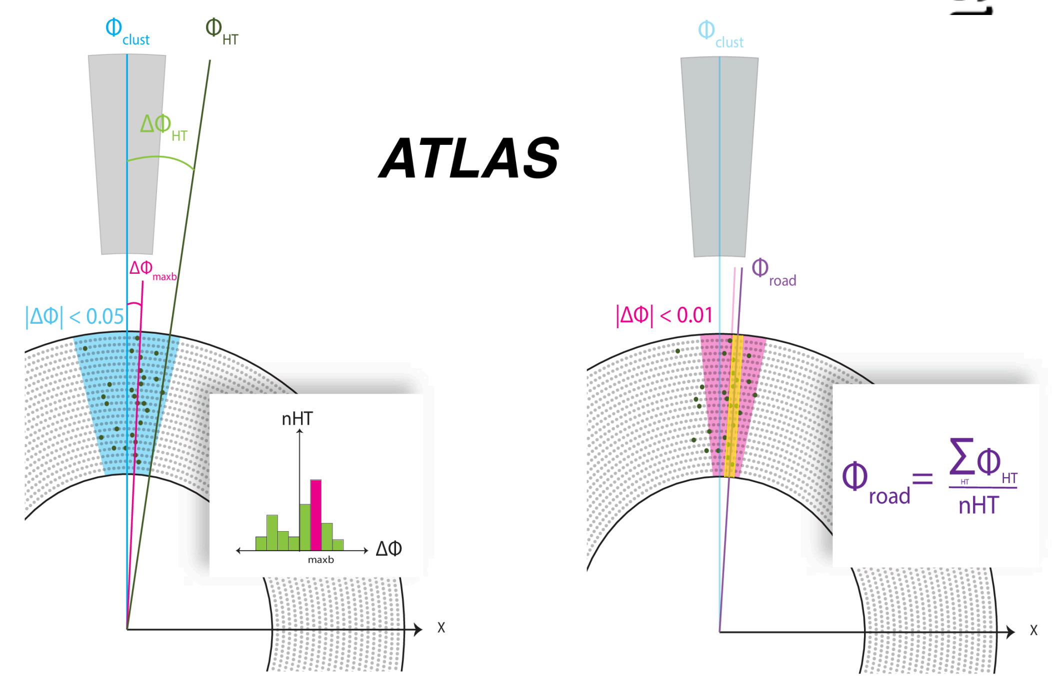




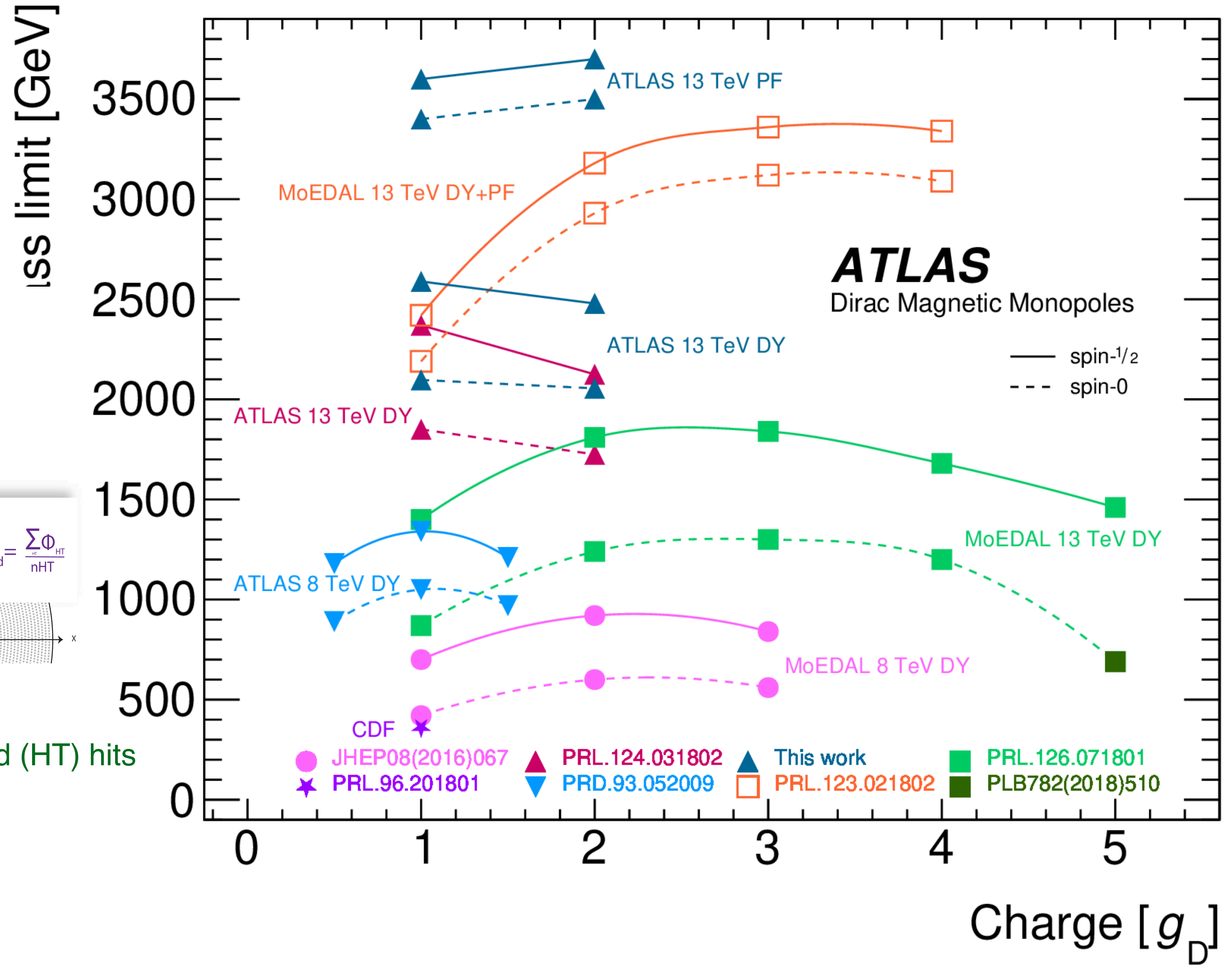
Photon Fusion (PF)



EM deposit with low lateral dispersion



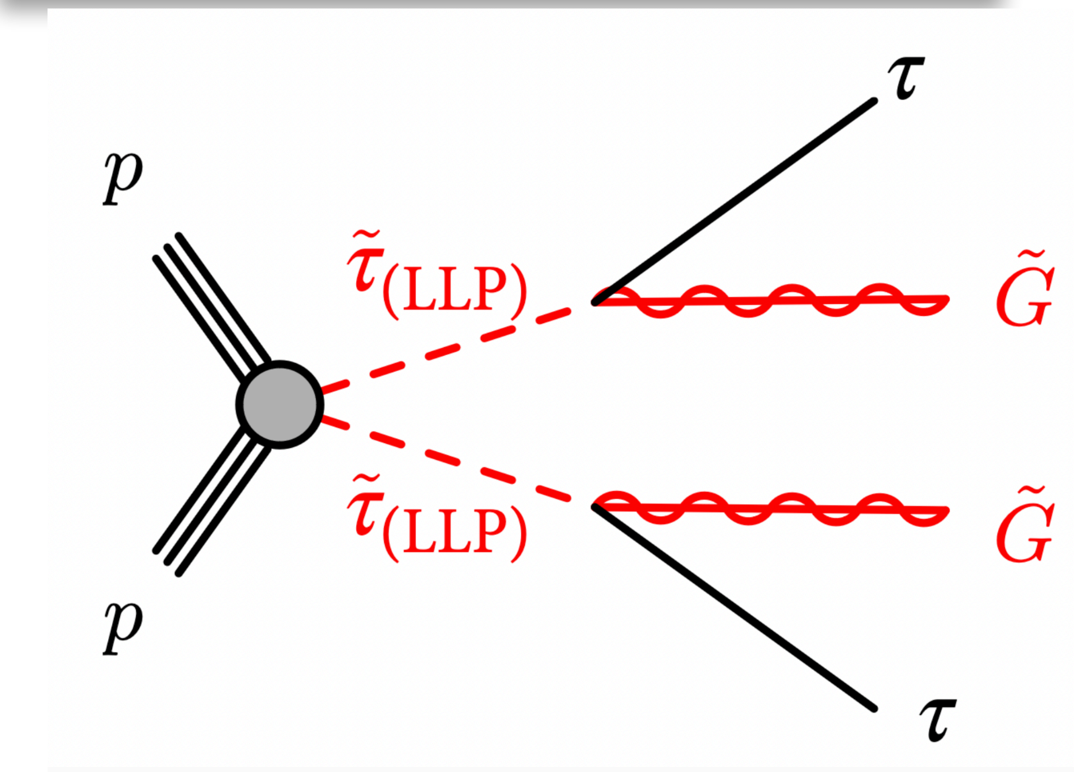
TRT with δ-rays produce High Threshold (HT) hits



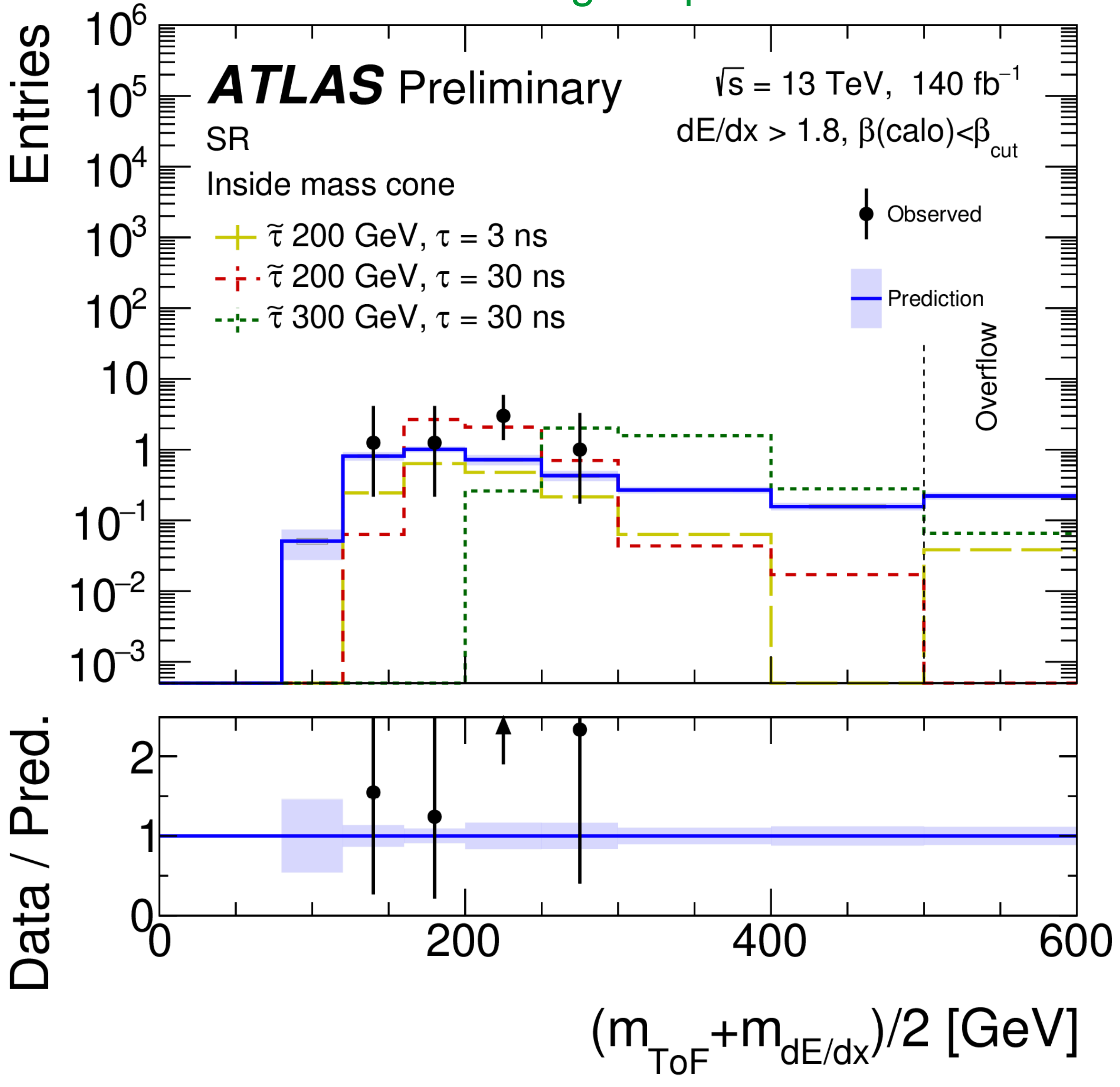
Search for Highly Ionizing Particles

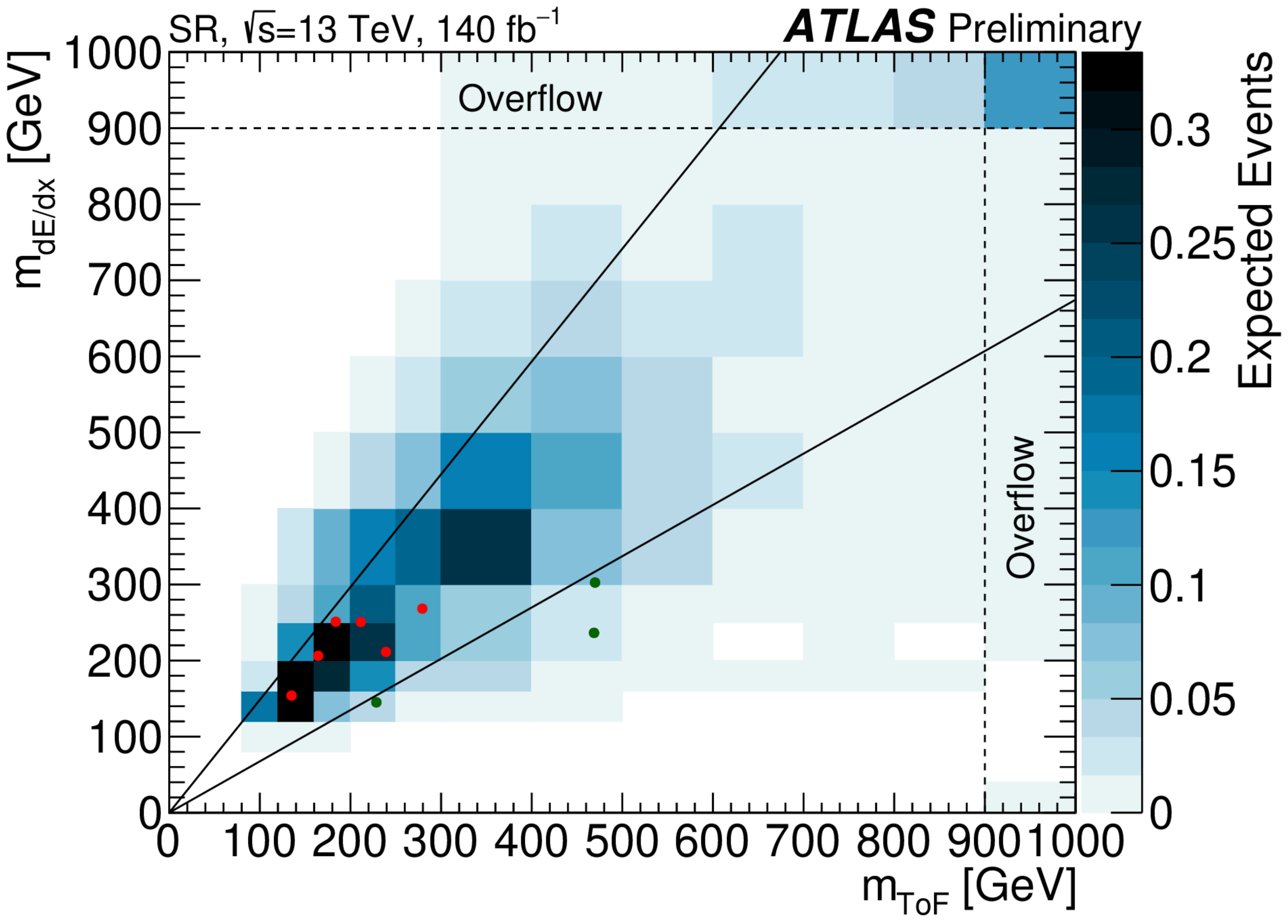
ATLAS-CONF-2023-044

- Search for heavy, long-lived, charged particles with large ionization energy loss.
- Constrain BSM scenarios with gluinos that form R-hadrons as well as sleptons & charginos.
  - target m > 100 GeV and τ > 3 ns.
- Determine βγ and the mass m = p/βγ using two independent methods.
  - pixel dE/dx and calorimeter TOF.



Mass from average of pixel dE/dx & ToF





Summary

- Extensive search program for BSM physics at the LHC.
  - LHC has a well calibrated dataset of 140 fb^{-1} from Run 2 at $\sqrt{s}$ = 13 TeV.
- Extending the sensitivity to new regimes.
  - Uncovered kinematics, both highest and lowest masses.
  - Use new reconstruction techniques: boosted methods, displaced decays, etc.
- Looking forward to even more exciting Run 3.
  - Searches using Run 3 at $\sqrt{s}$ = 13.6 TeV with ~60 fb^{-1} in 2022 & 2023 are ramping up.
- Much larger dataset expected from the HL-LHC after 2029.
  - Stay tuned for many more results!