



LHC Physics Discussion: Highlights from ICHEP

23 July 2018

O. Turkot

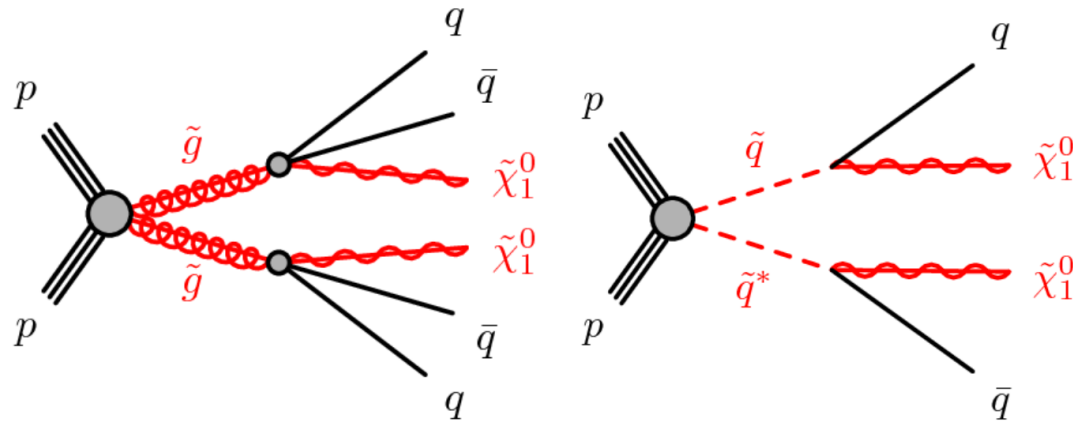
한국
ICHEP 2018

**SUSY +
Exotics**

BSM

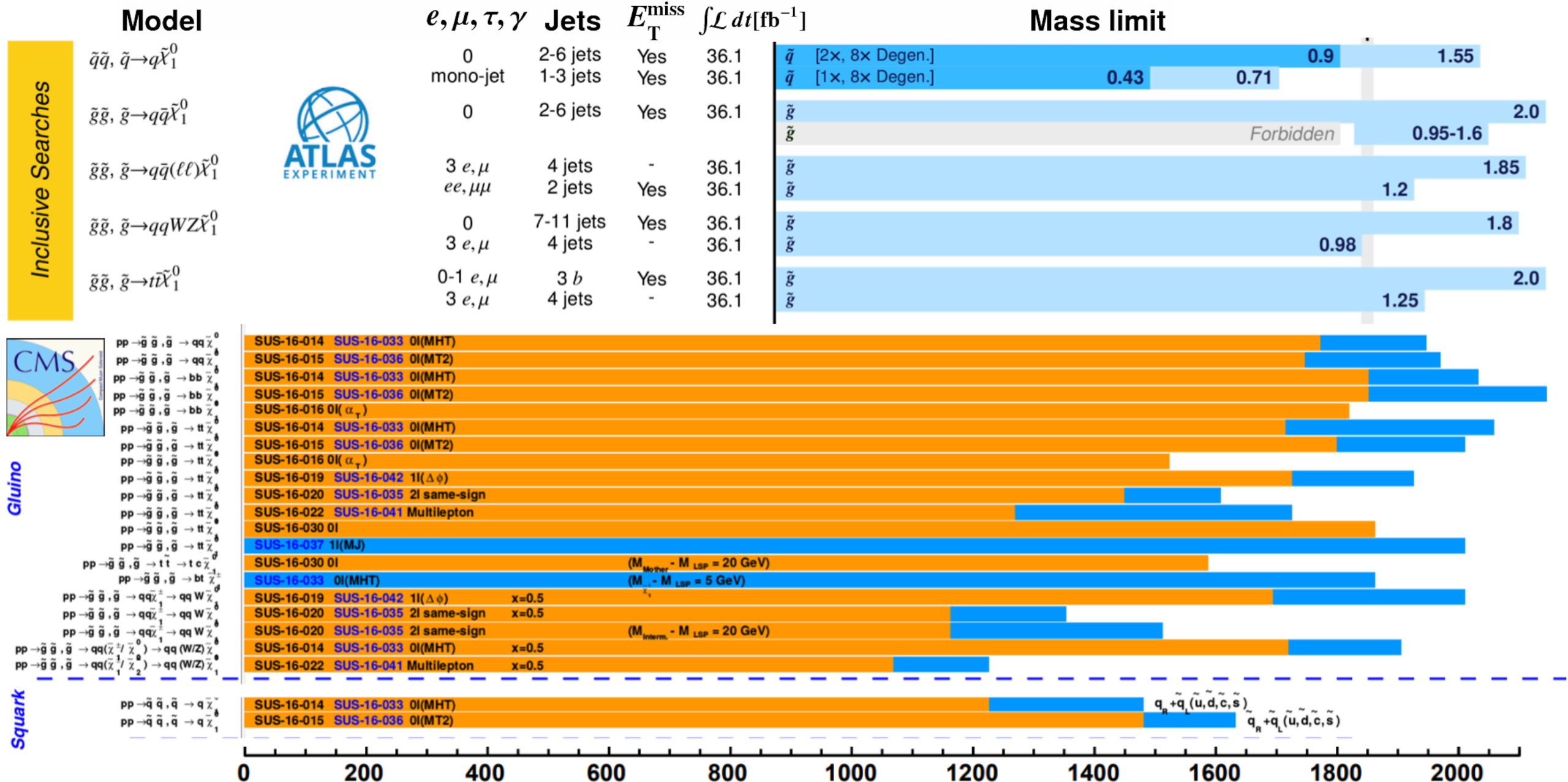
SUSY

Gluinos and squarks

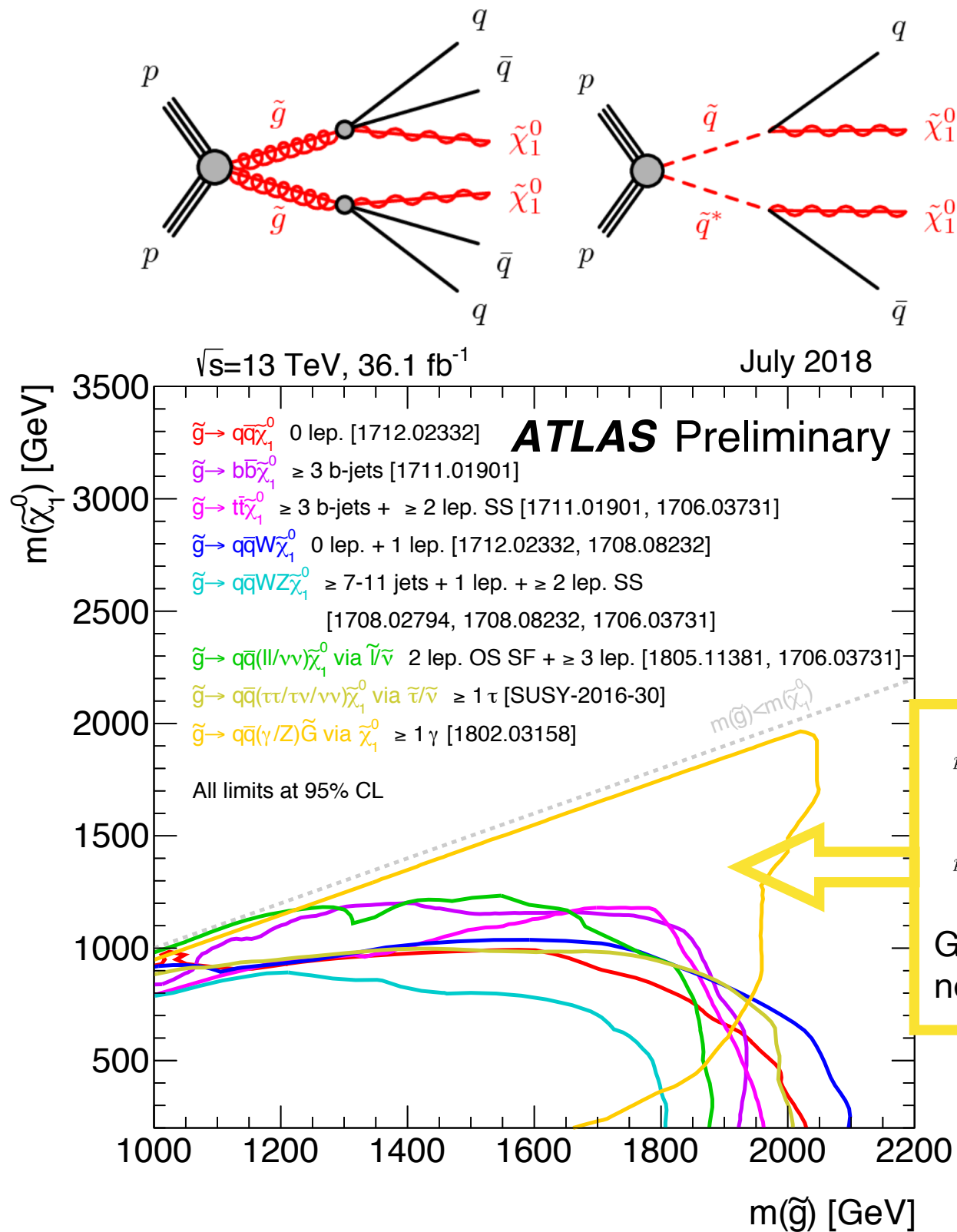


⇒ Largest expected cross section.

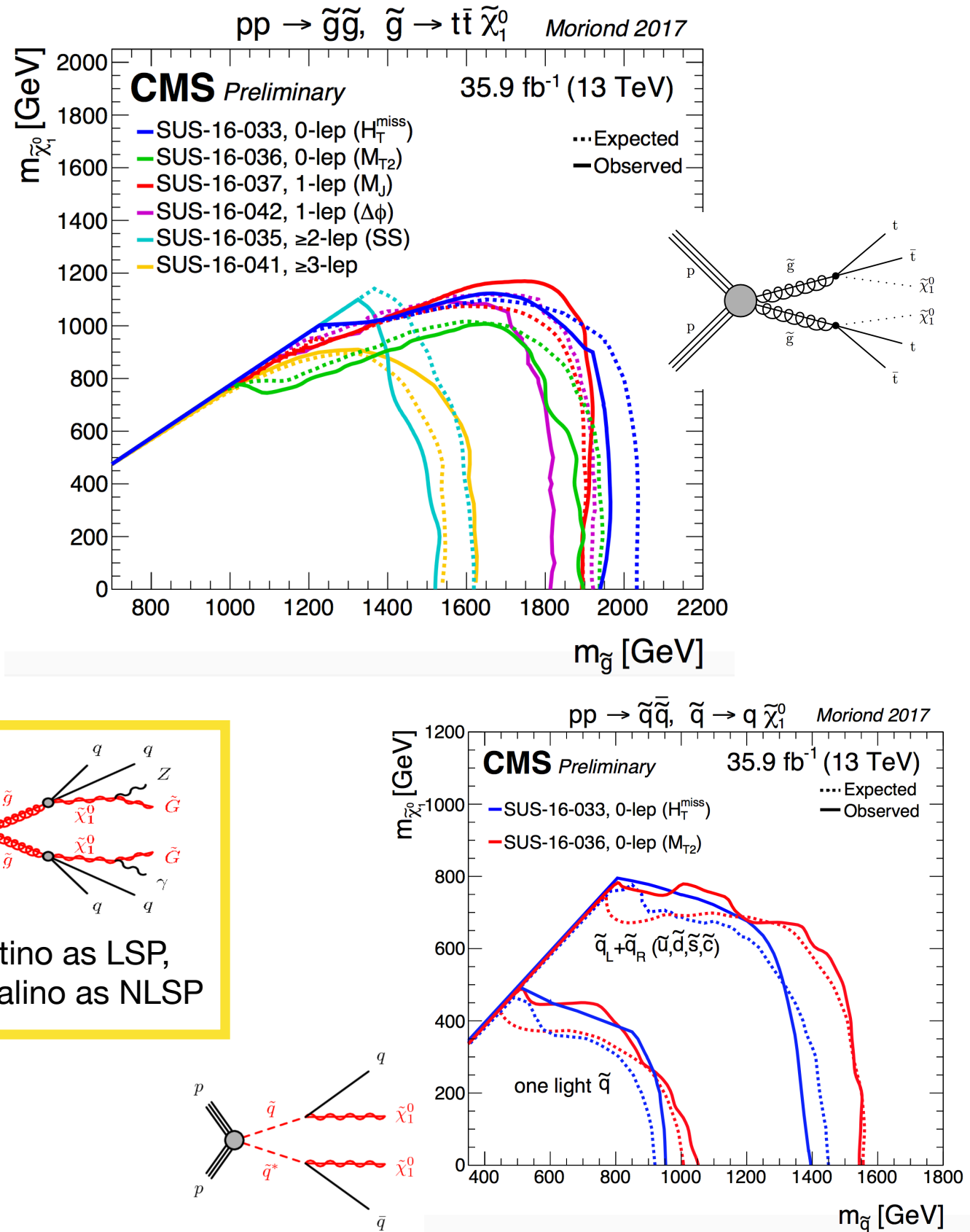
⇒ Limits reach 2 (1.5) TeV for most of the gluinos (squarks) models.



Gluinos and squarks

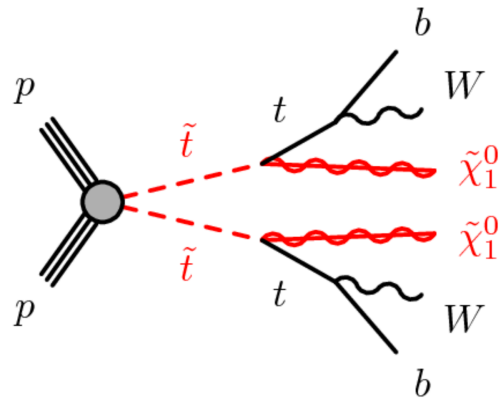


Hernan Wahlberg "Searches for squarks and gluinos in final states involving dark matter candidates with ATLAS"

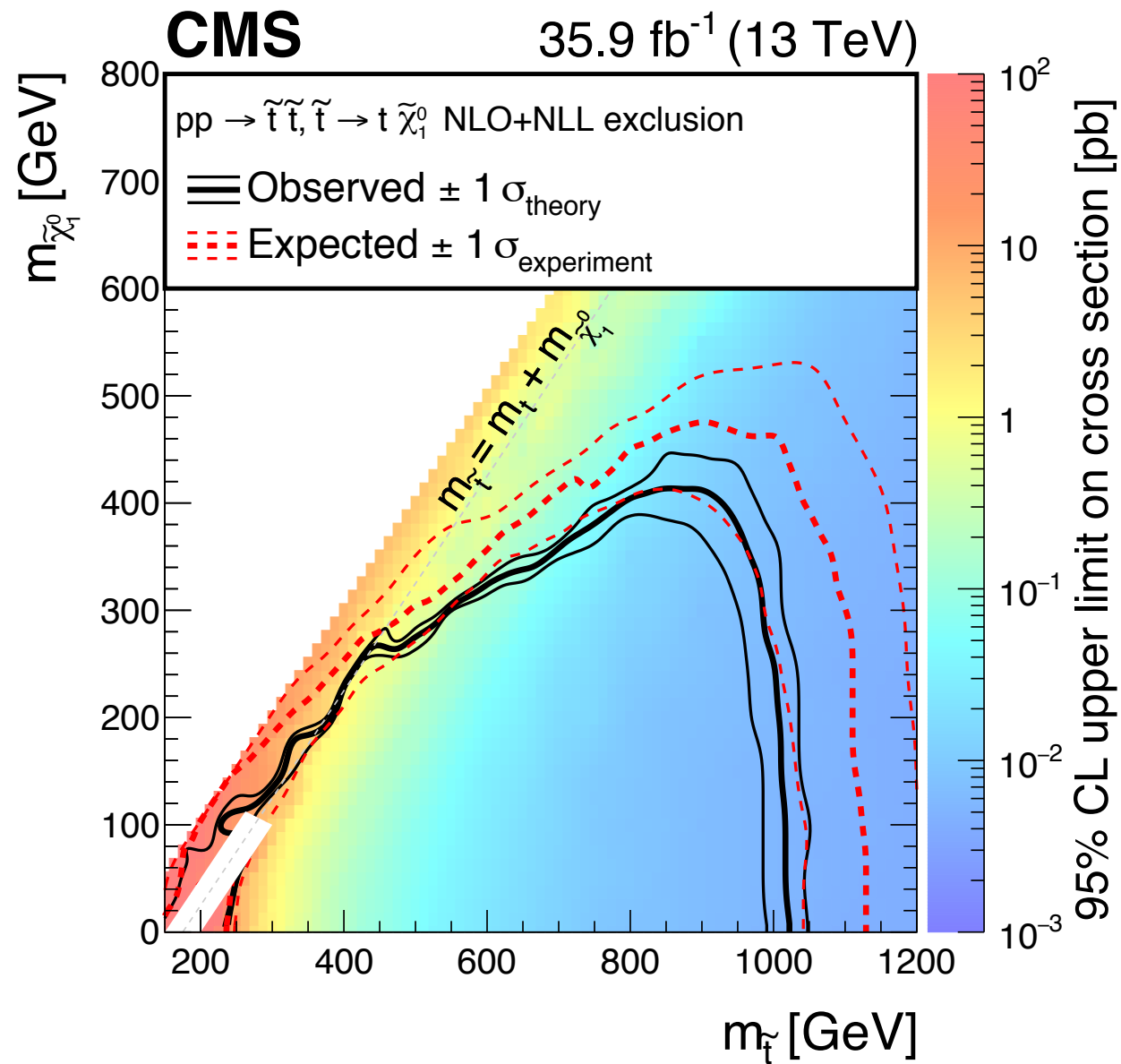


Ana Ovcharova "Searches for strongly-produced SUSY at CMS"

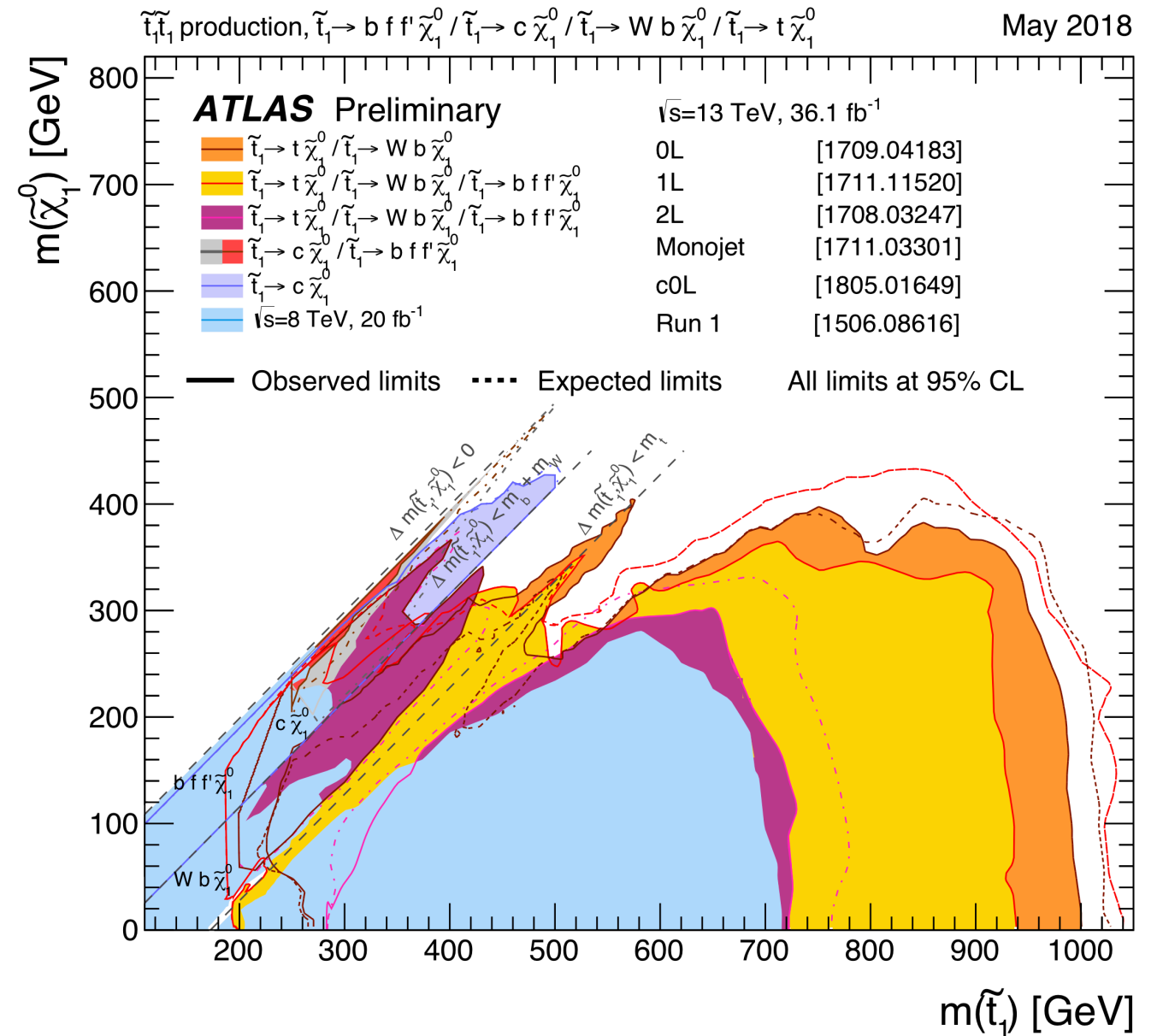
Stop



⇒ Light stop needed for the natural SUSY.

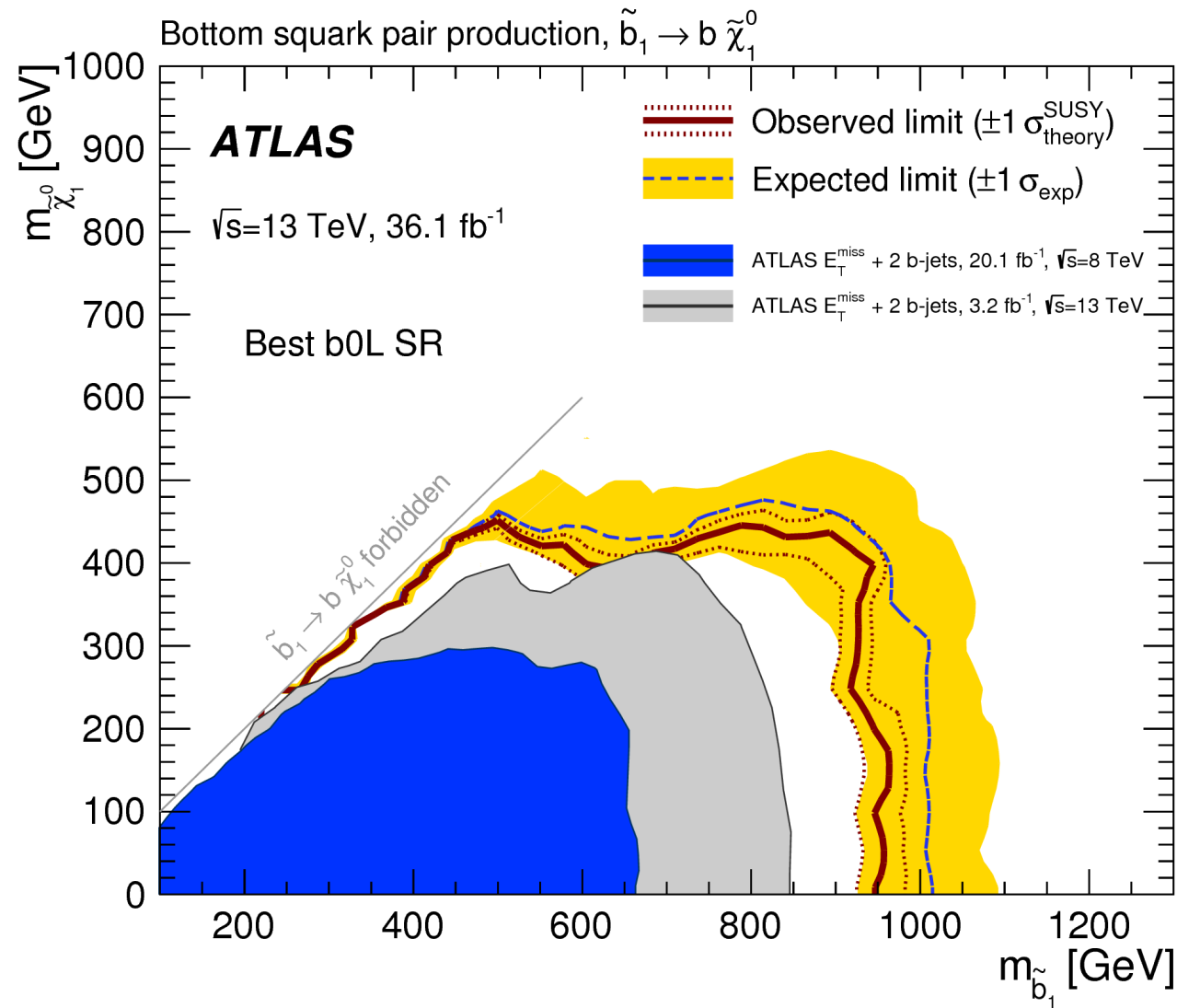
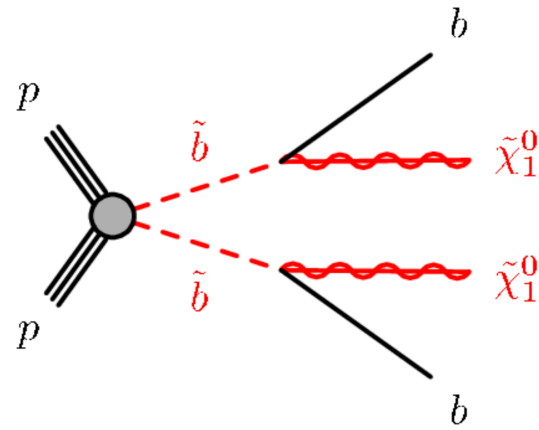


Rishi Patel "Searches for SUSY with boosted objects at CMS"

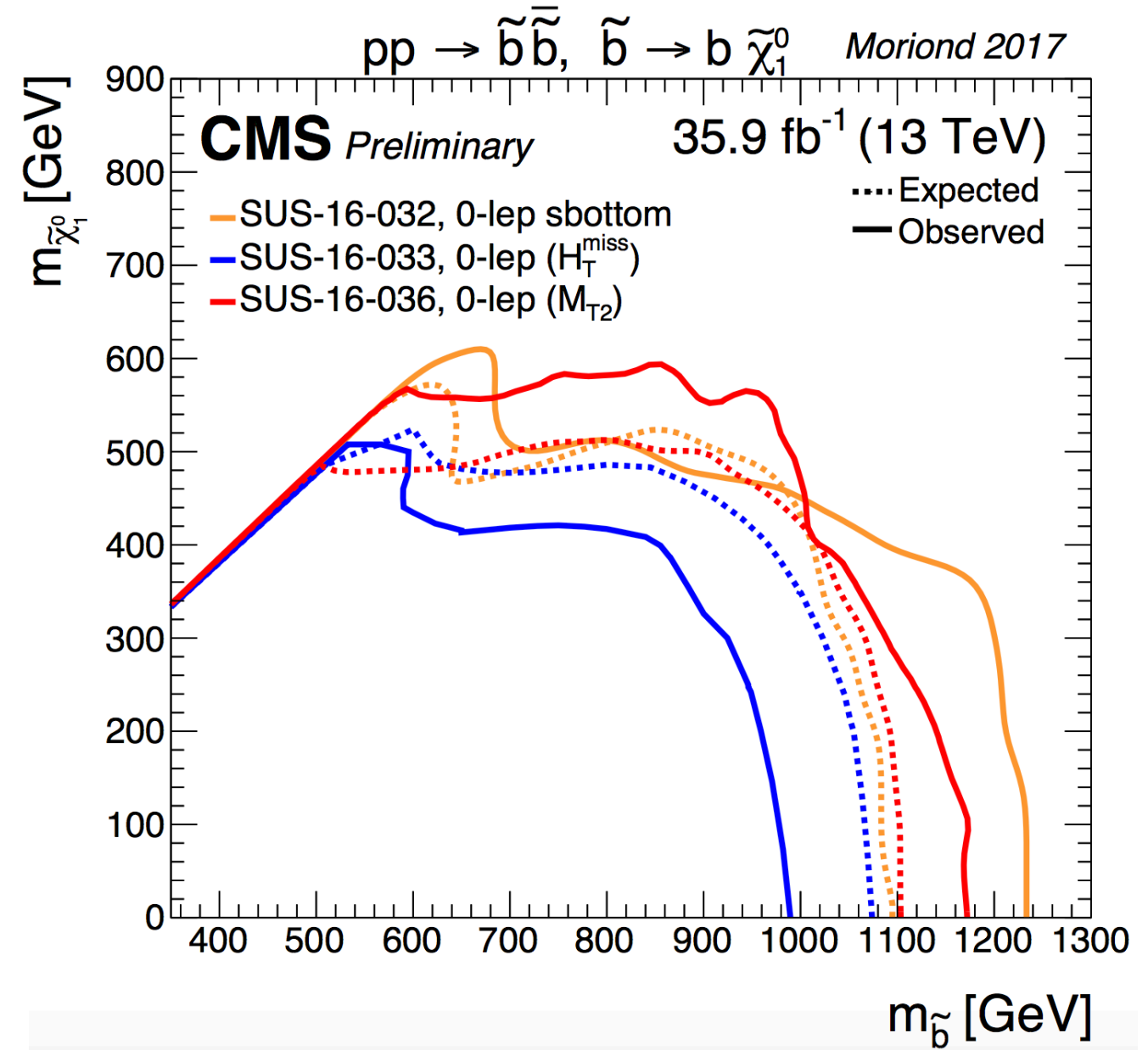


Giacomo Polesello "Searches for direct pair production of stops and sbottoms with the ATLAS detector"

Sbottom

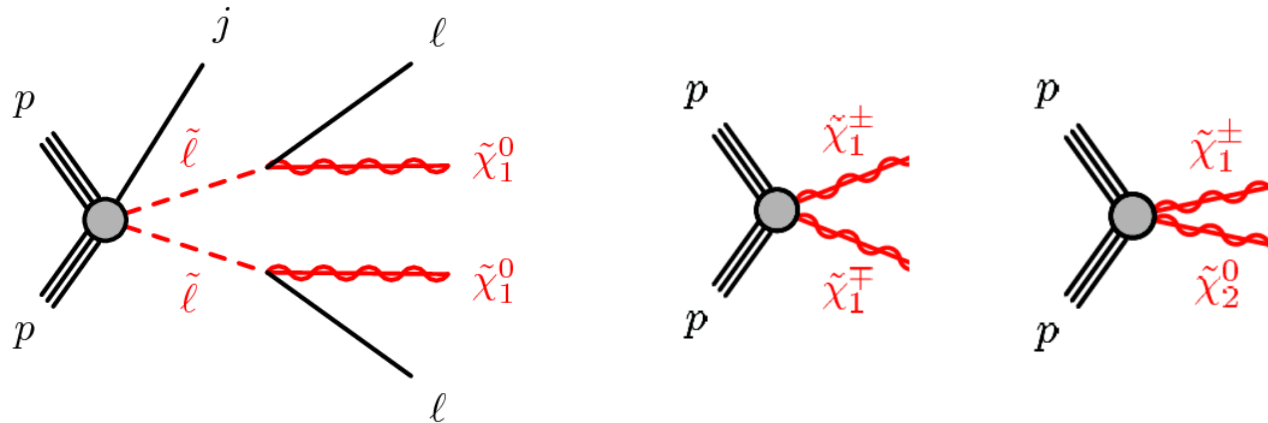


Giacomo Polesello "Searches for direct pair production of stops and sbottoms with the ATLAS detector"



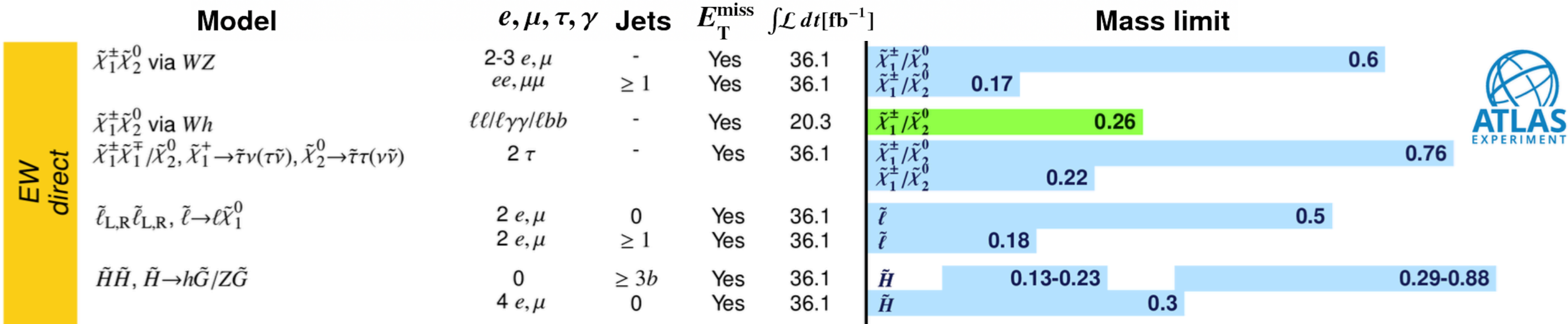
Ana Ovcharova "Searches for strongly-produced SUSY at CMS"

Electroweak processes



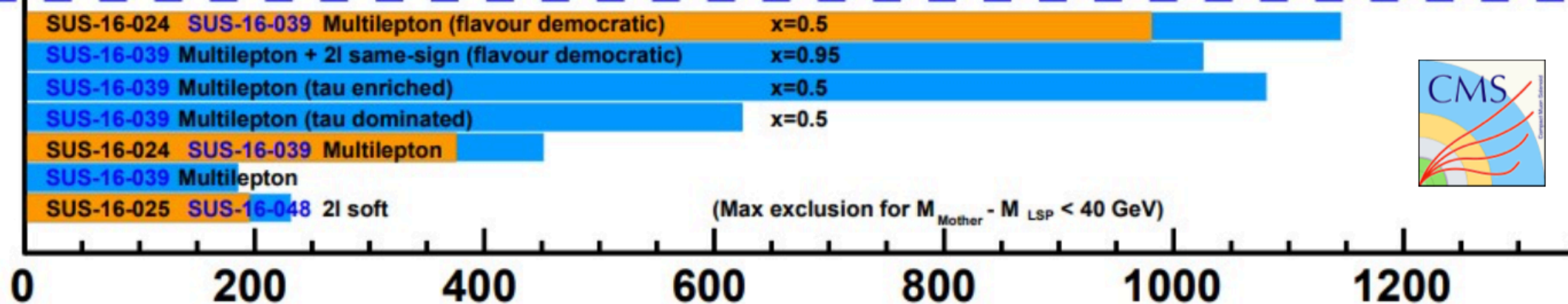
⇒ Low cross section expected.

⇒ Limits strongly vary between models.

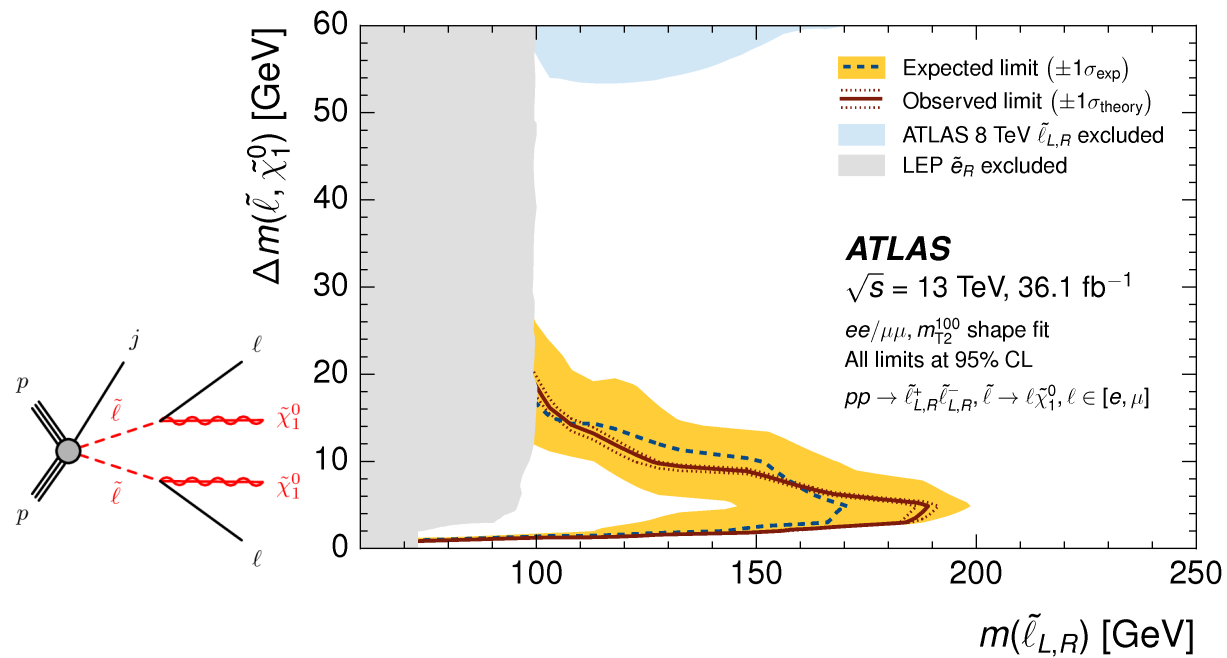


EWK Gauginos

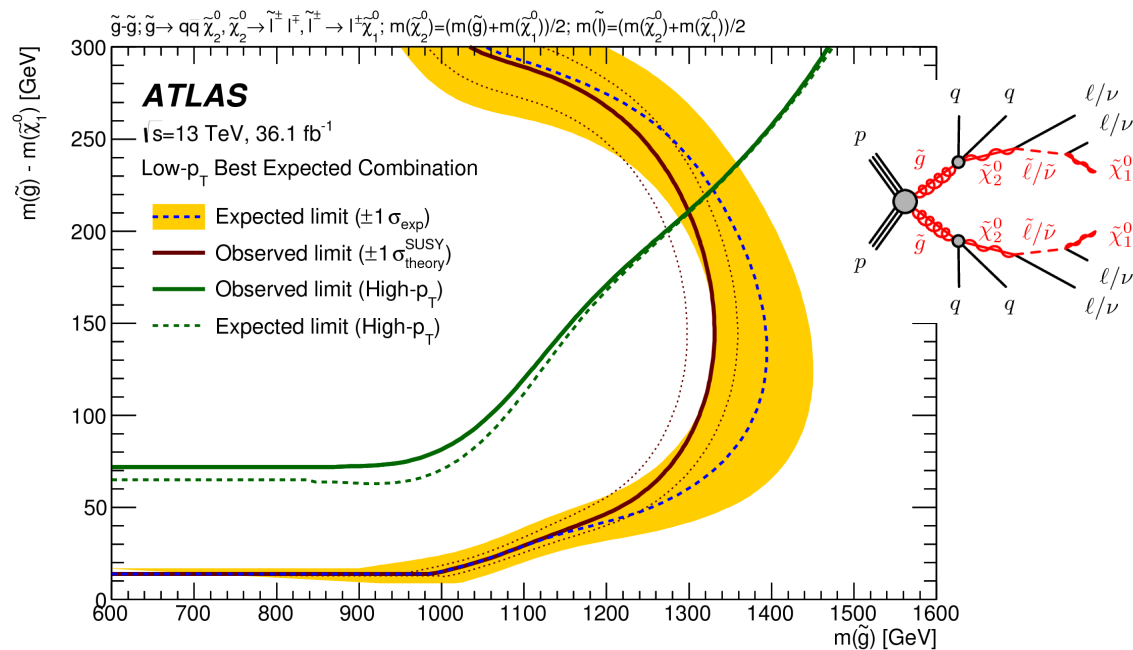
$pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \text{III } \nu \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \text{III } \nu \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \text{II } \nu \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow \tau \tau \nu \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow W Z \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow W H \tilde{\chi}_1^0 \tilde{\chi}_2^0$
 $pp \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_2^0 \rightarrow W Z \tilde{\chi}_1^0 \tilde{\chi}_2^0$



Sleptons

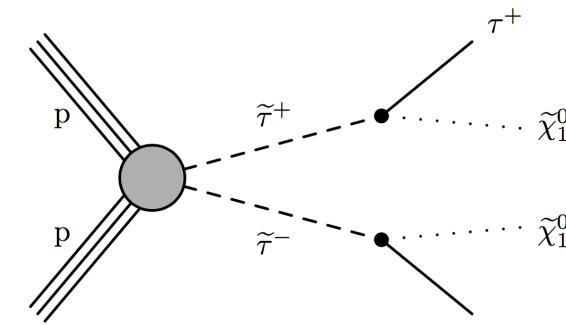


Margherita Primavera "Searches for sleptons with the ATLAS detector"

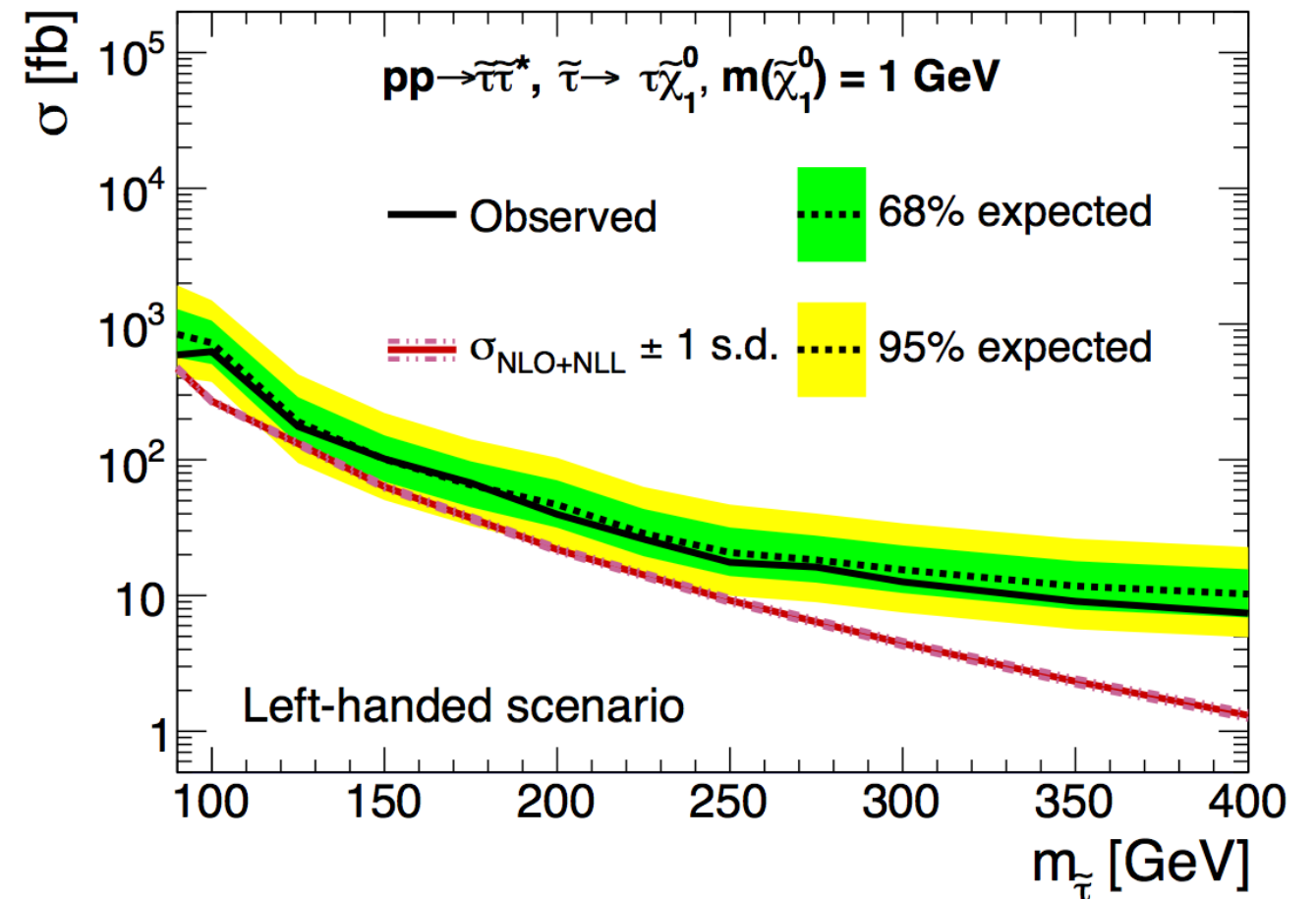


Mark Hodgkinson "Reconstruction techniques in supersymmetry searches in the ATLAS experiment"

- ⇒ Stau is expected to be lightest slepton.
- ⇒ Two tau leptons required in the final state.



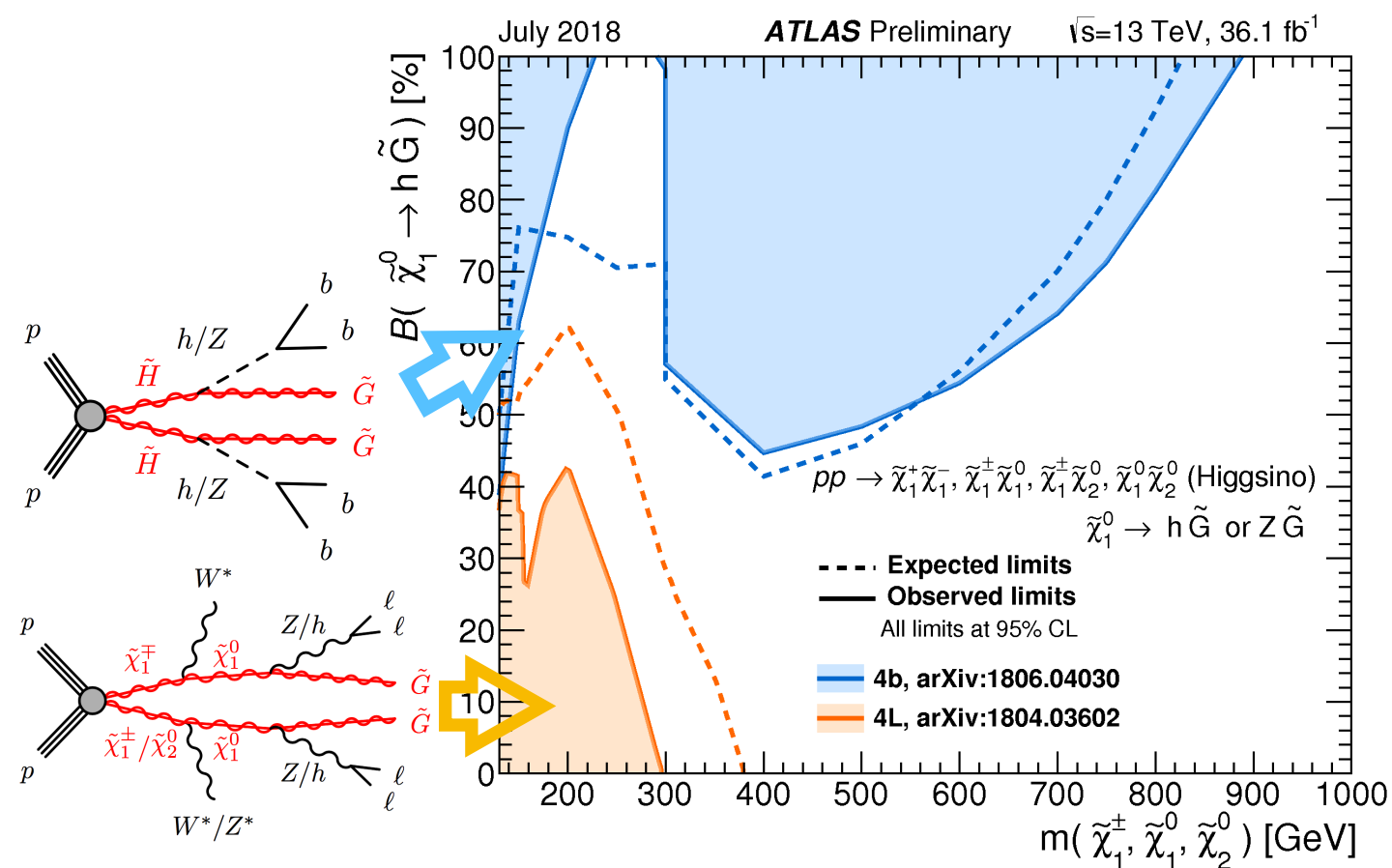
CMS 35.9 fb⁻¹ (13 TeV)



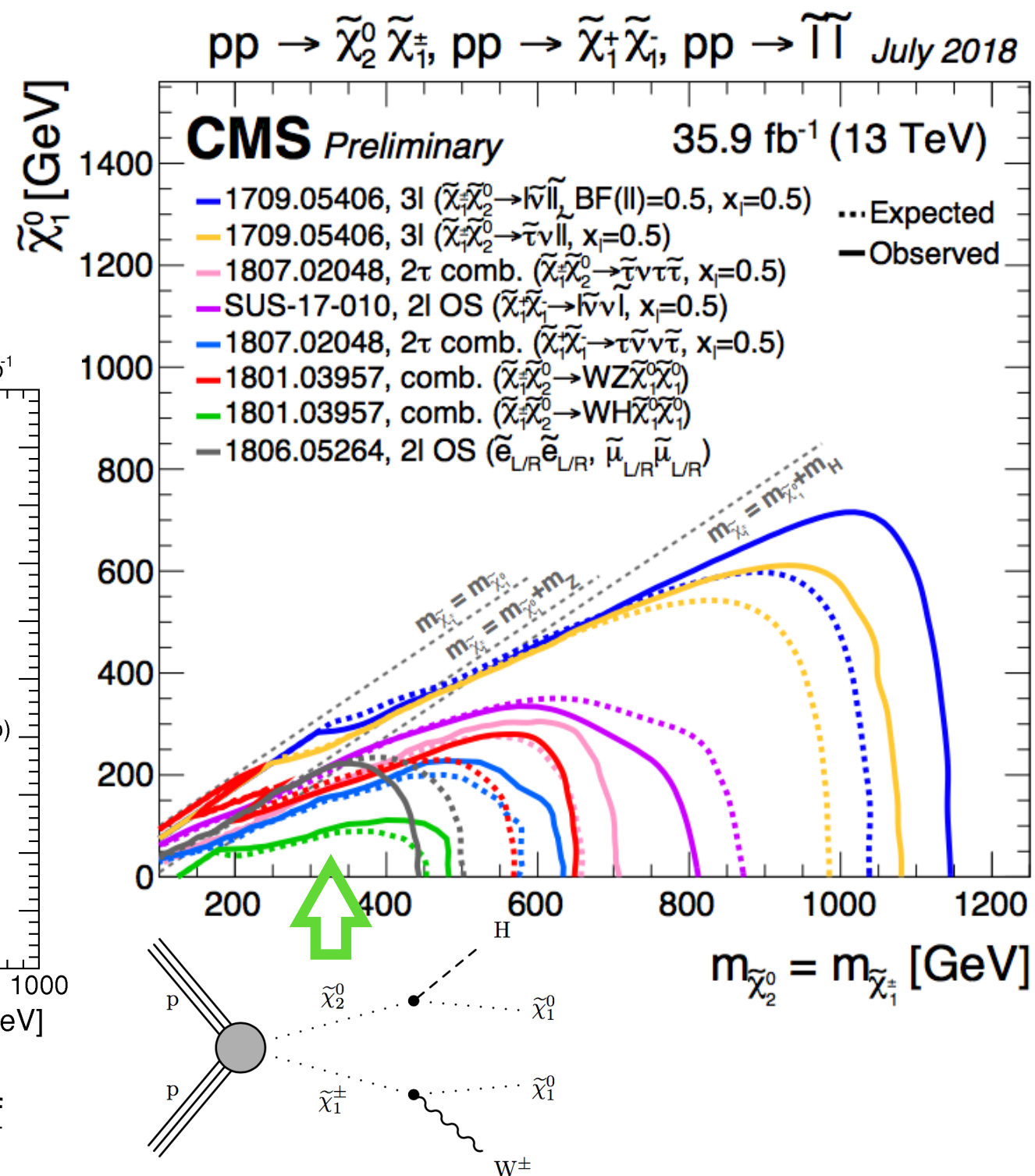
Valentina Dutta "Searches for electroweakly produced supersymmetry with CMS"

Searches with Higgs production

⇒ Higgs now used to probe electroweak production of supersymmetry.

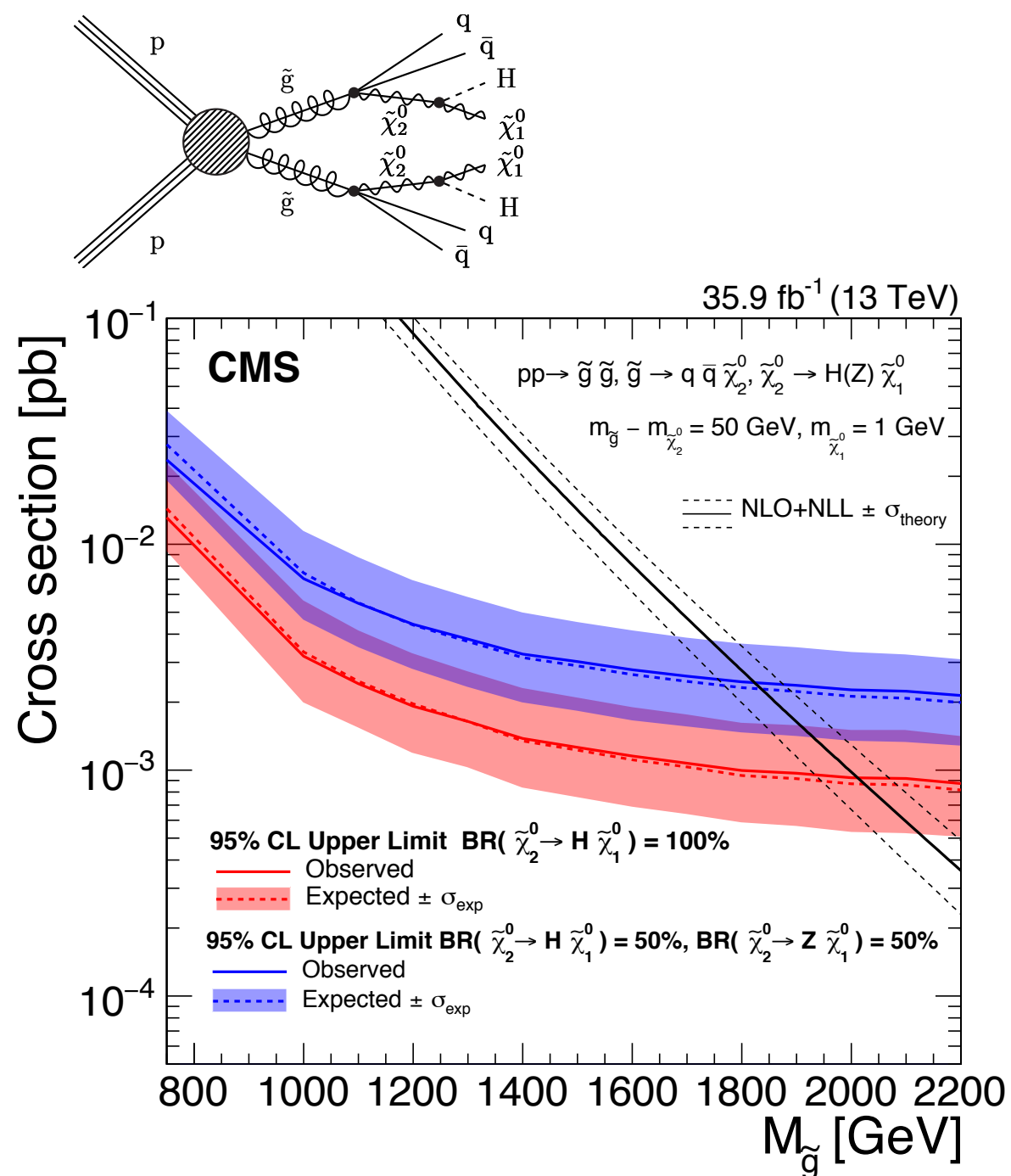


Zinonas Zinonos "Searches for electroweak production of supersymmetric gauginos and sleptons at LHC"

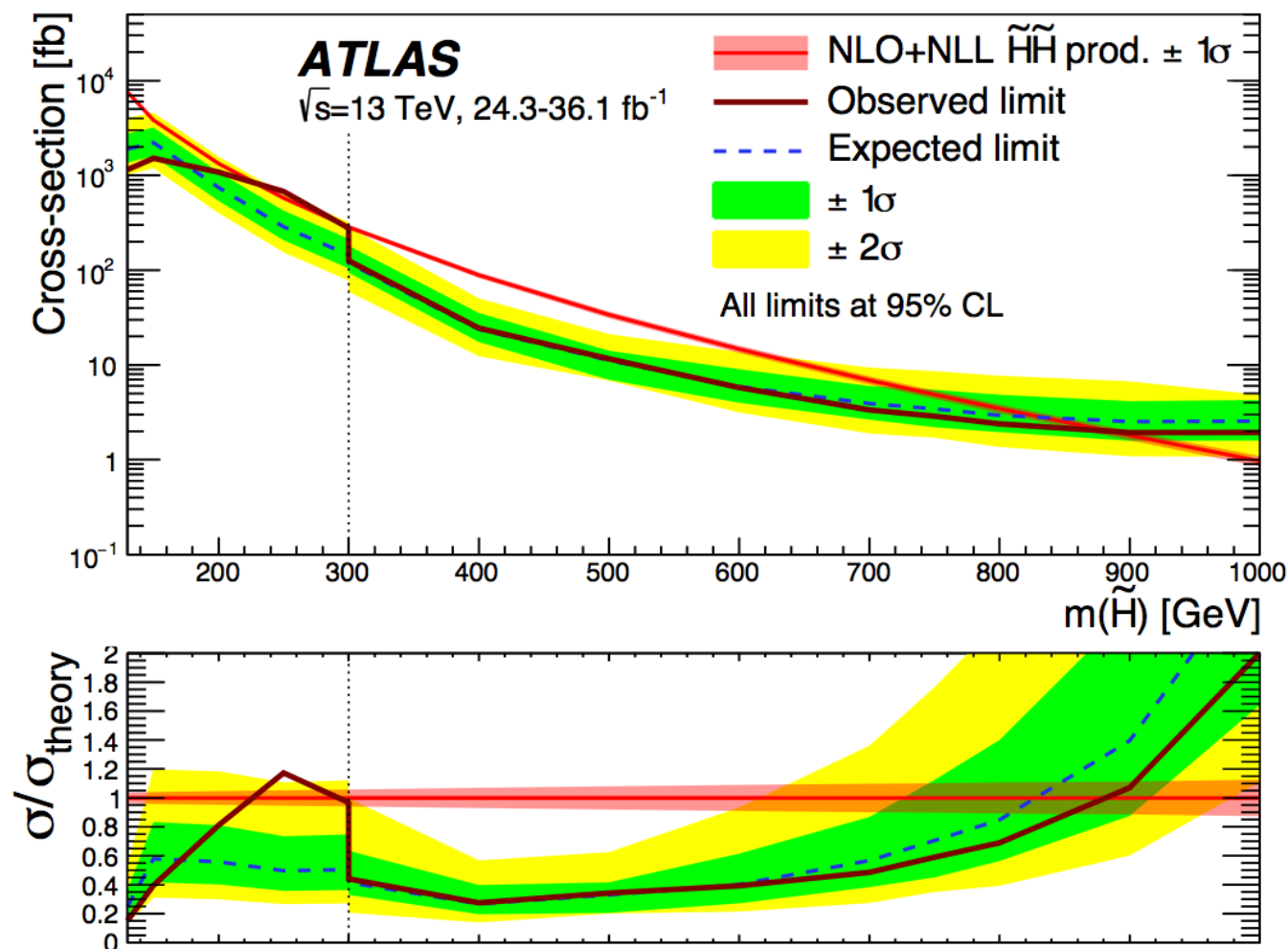
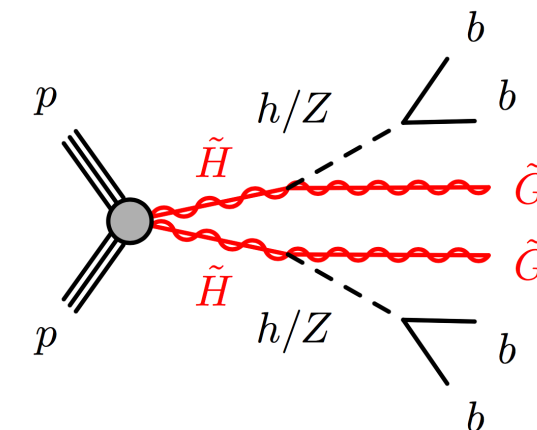


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Searches with Higgs production



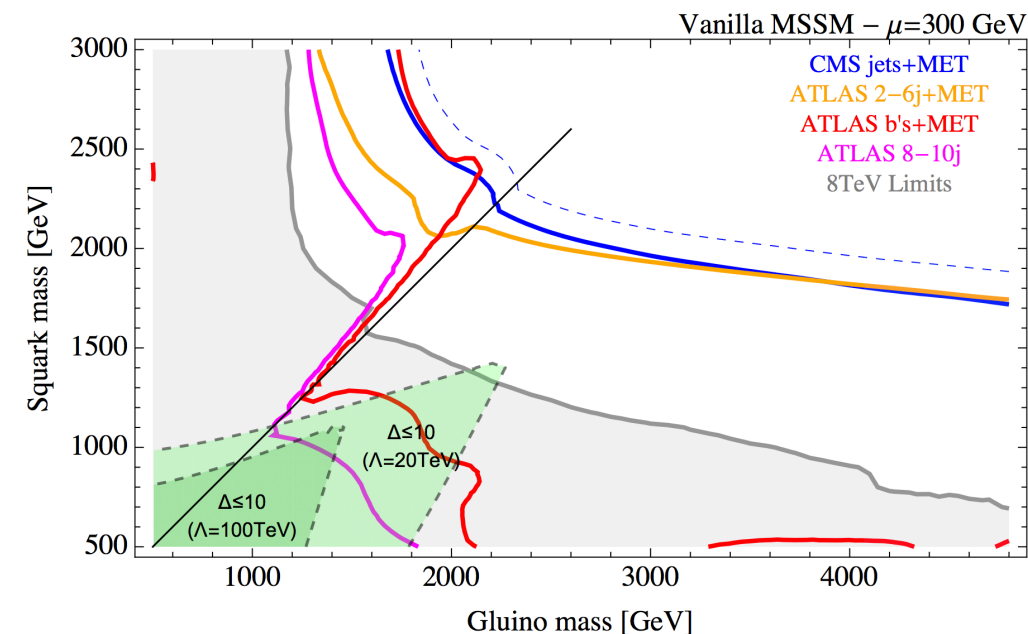
Rishi Patel "Searches for SUSY with boosted objects at CMS"



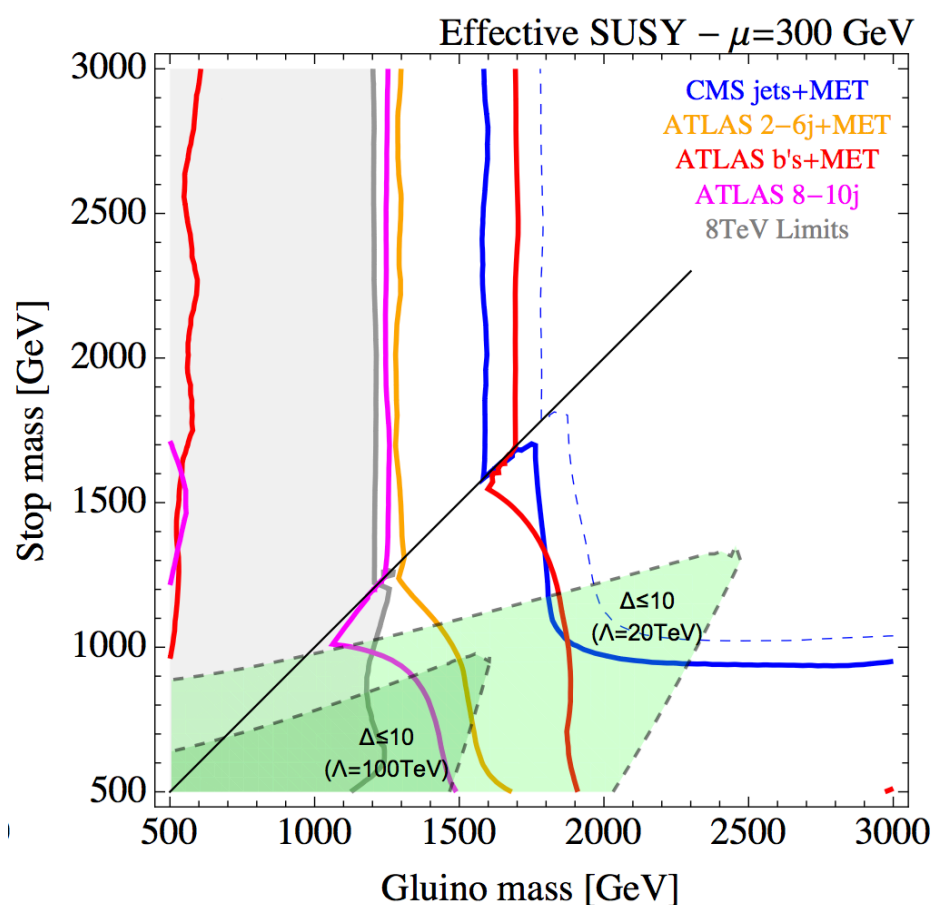
Anyes Taffard "Searches for electroweak production of supersymmetric particles involving the Higgs boson and the higgsino with ATLAS"

Natural SUSY

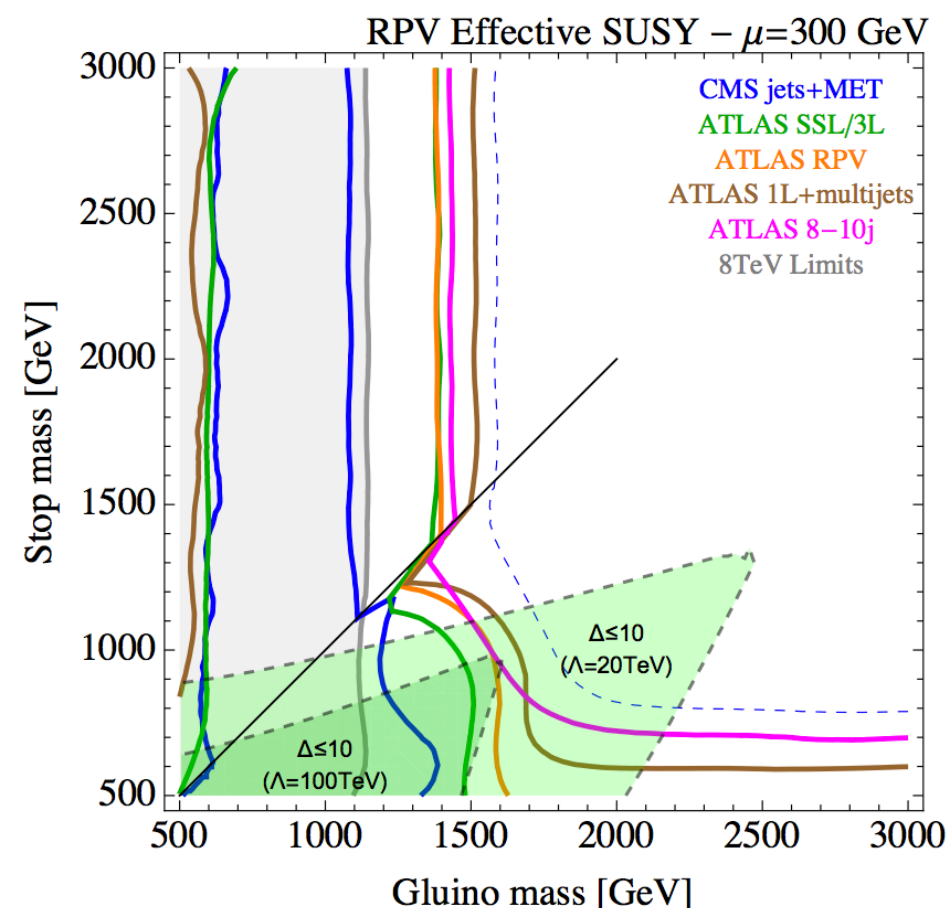
- ⇒ Reinterpretation of the SUSY results presented at ICHEP'16, based on 13 fb^{-1}
- ⇒ “Vanilla” models already excluded
- ⇒ Natural SUSY models with high MET have a very limited possible mass space left.
- ⇒ Alternative searches with large multiplicities of high- p_T jets instead of MET still offer significant unexplored phase-space.



MSSM with light higgsinos, gluinos, and flavor-degenerate squarks

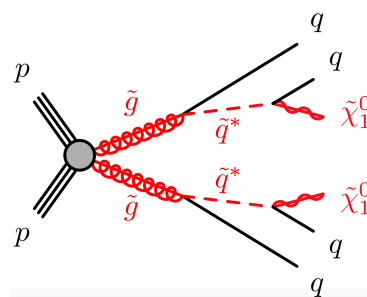
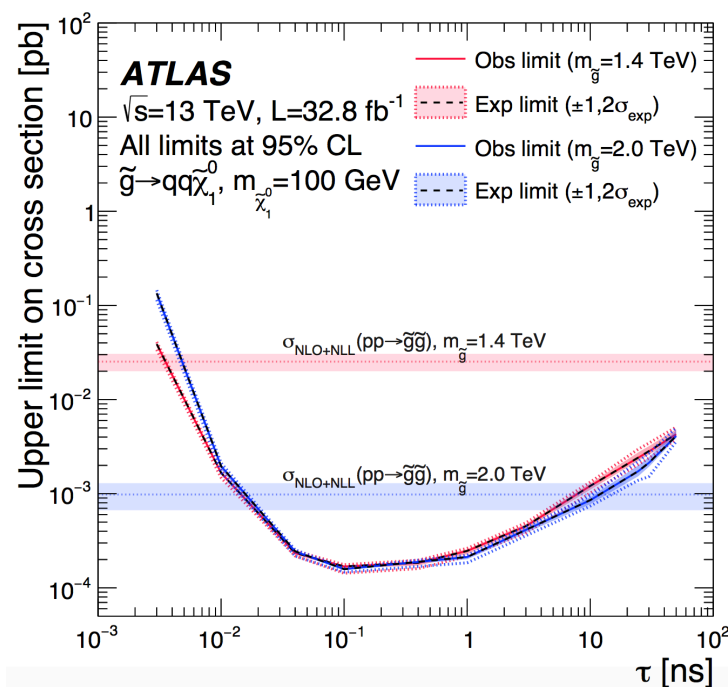


First and second generation squark masses set to 5 TeV, high MET.



Unstable higgsino, stop and left-handed sbottom are light, while rest of the squarks are decoupled at 5 TeV.

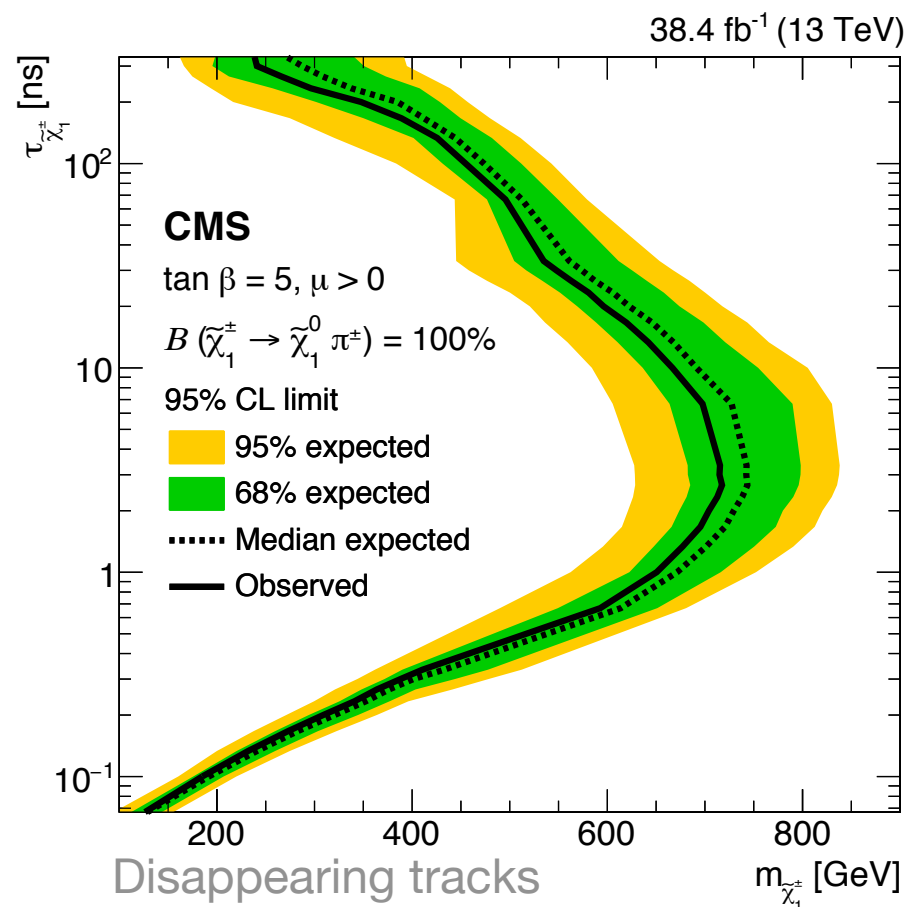
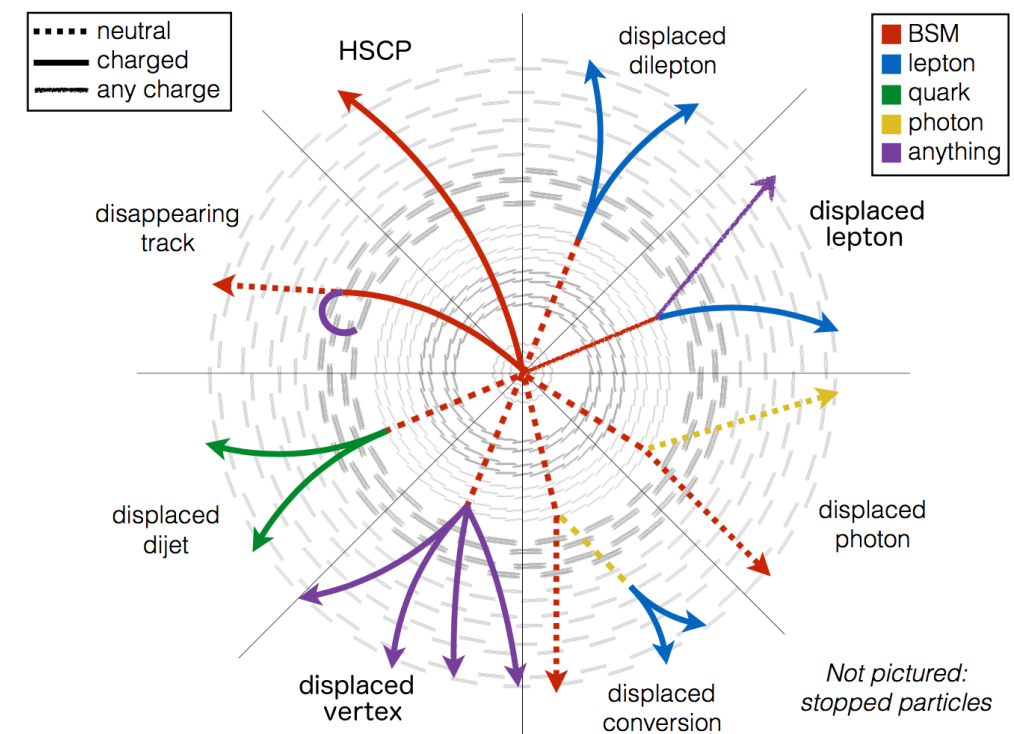
Displaced vertices and disappearing particles



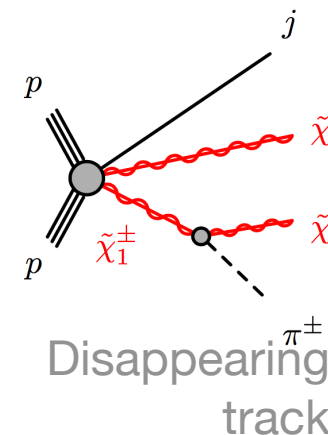
Displaced vertex

Marianna Testa "Search for New Physics through the Reconstruction of Challenging Signatures with the ATLAS detector"

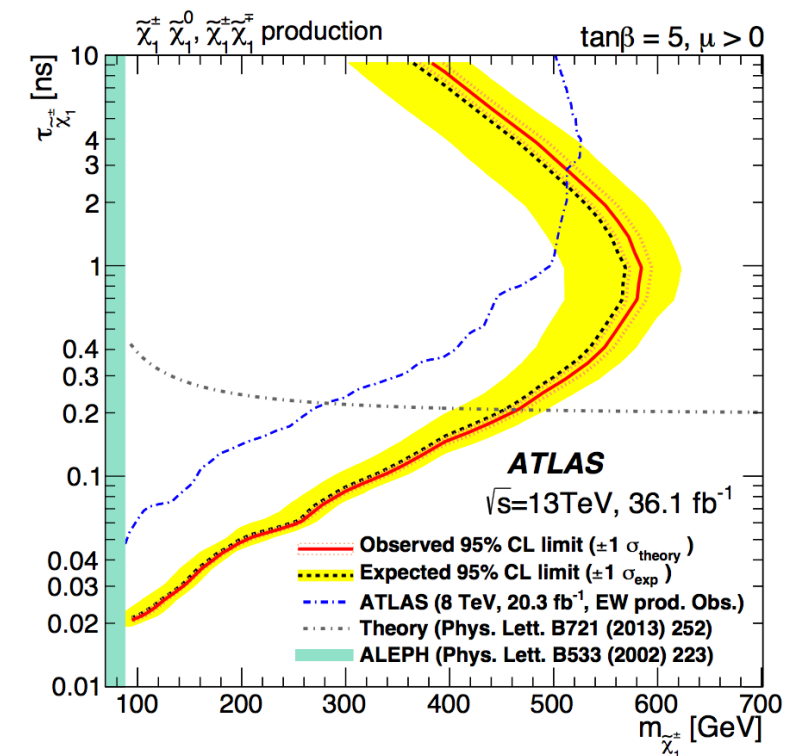
Image by J. Antonelli, ICHEP 2016



Disappearing tracks



Disappearing track

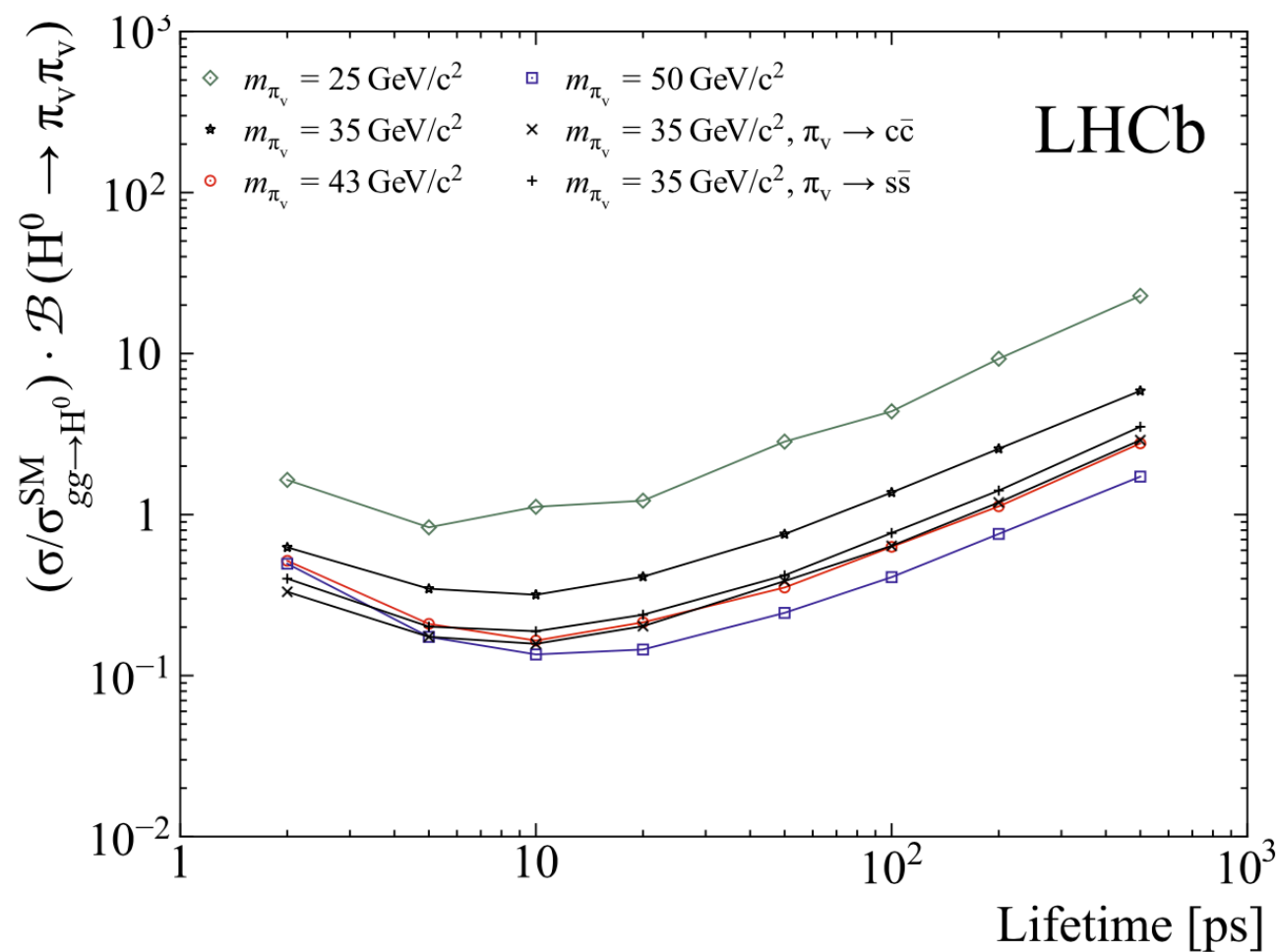
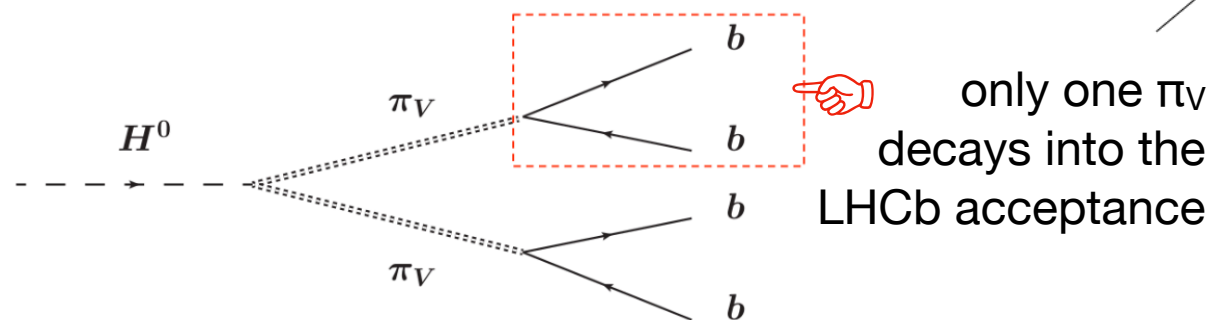
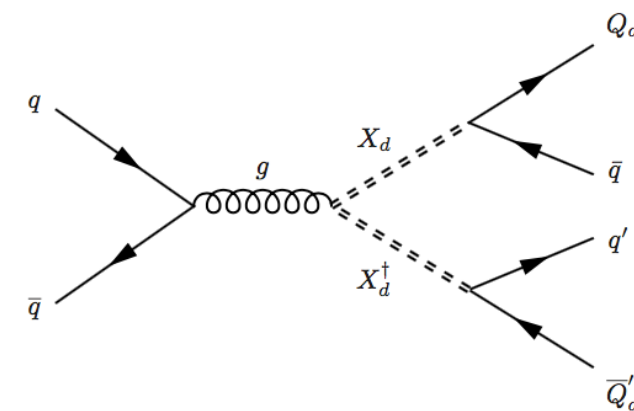
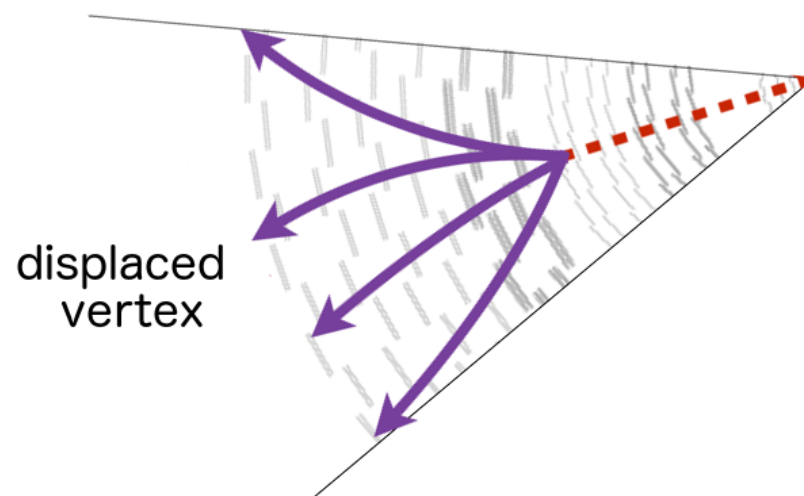


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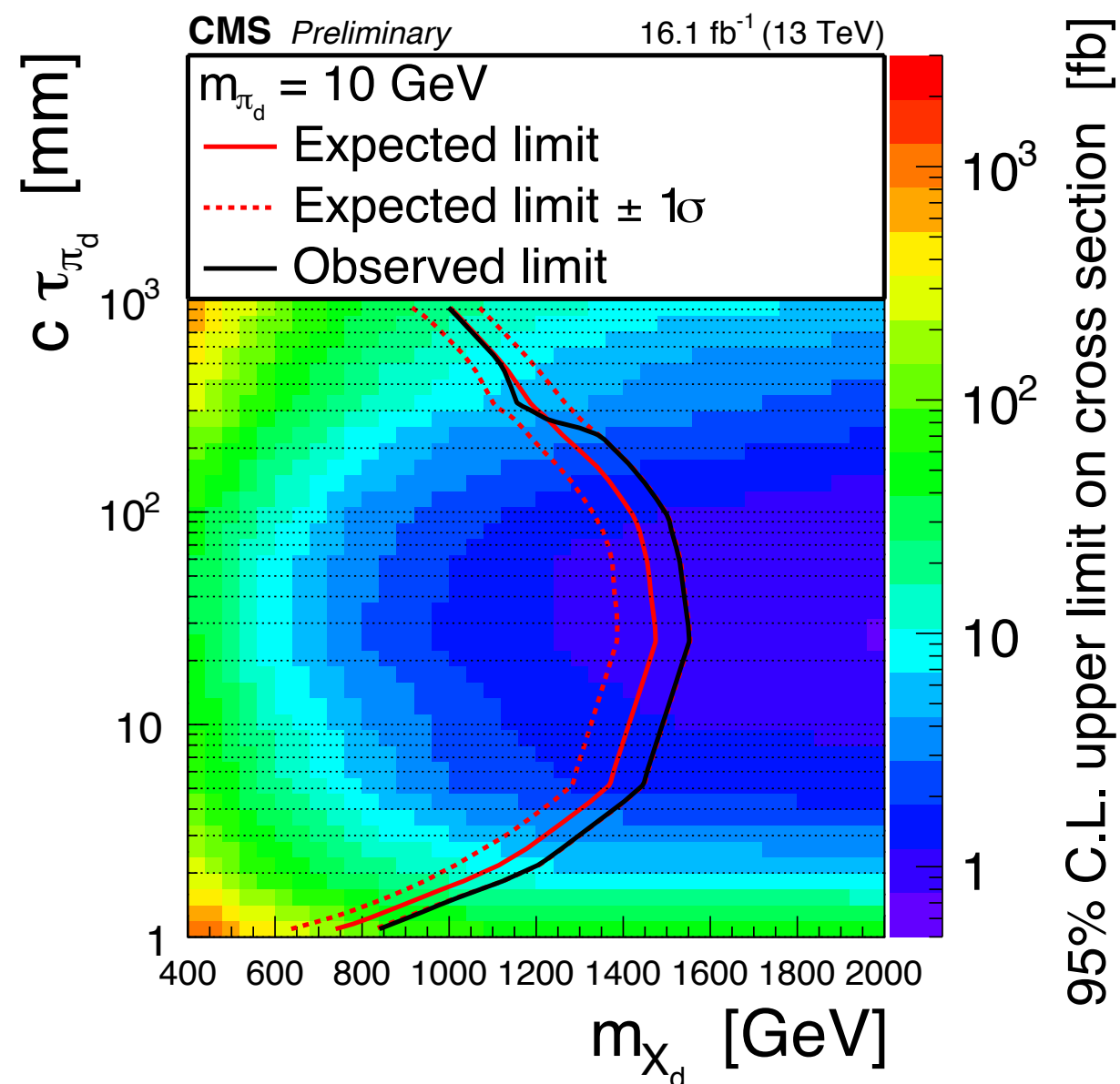
Alberto Escalante Del Valle "Searches for long-lived particles and other non-conventional signatures at CMS"

Exotics

Long-lived particles

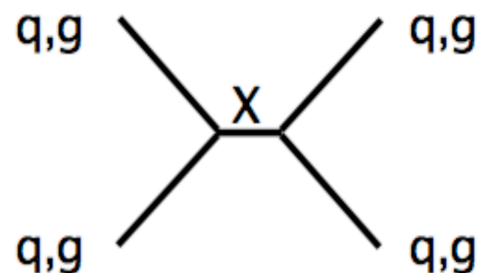


Carlos Vazquez Sierra "Searches for Long Lived Particles at LHCb"

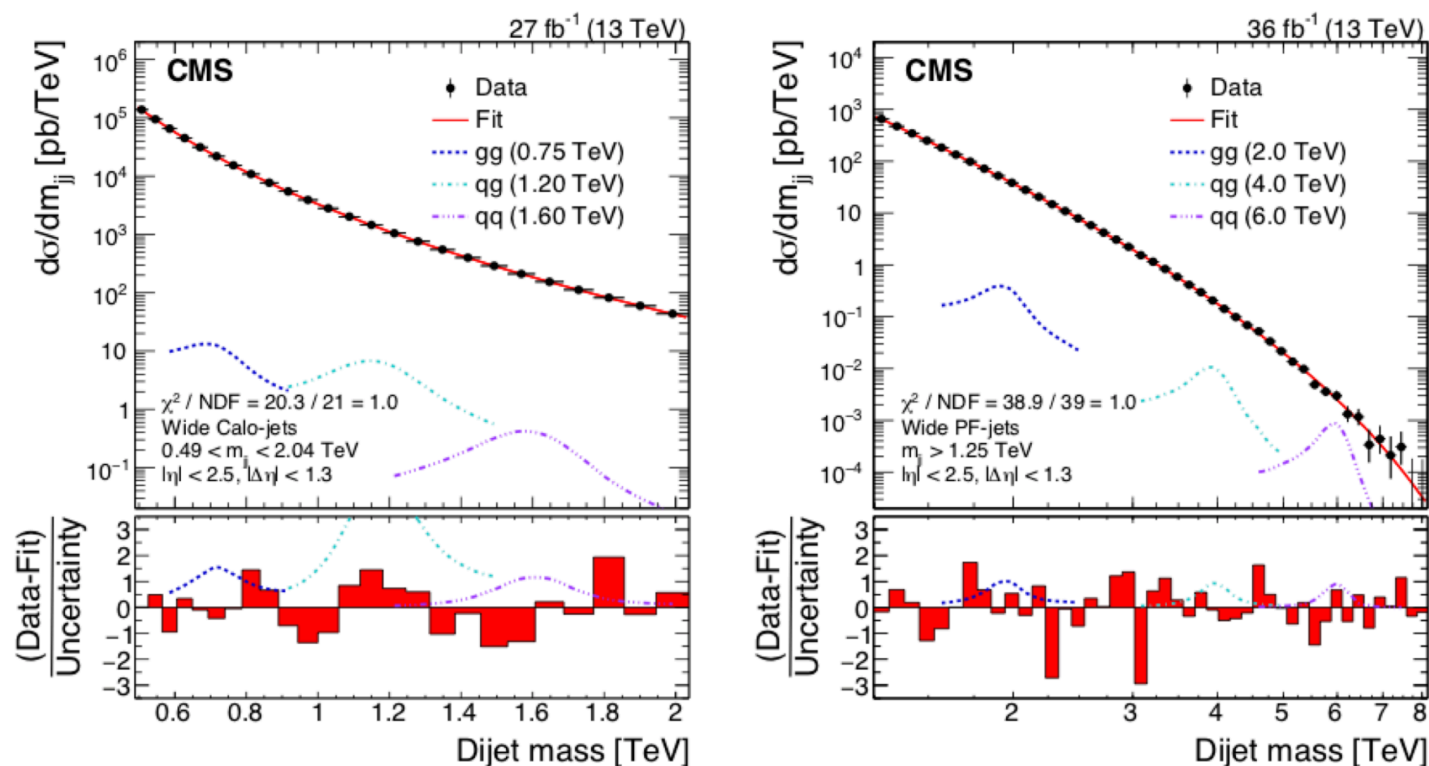
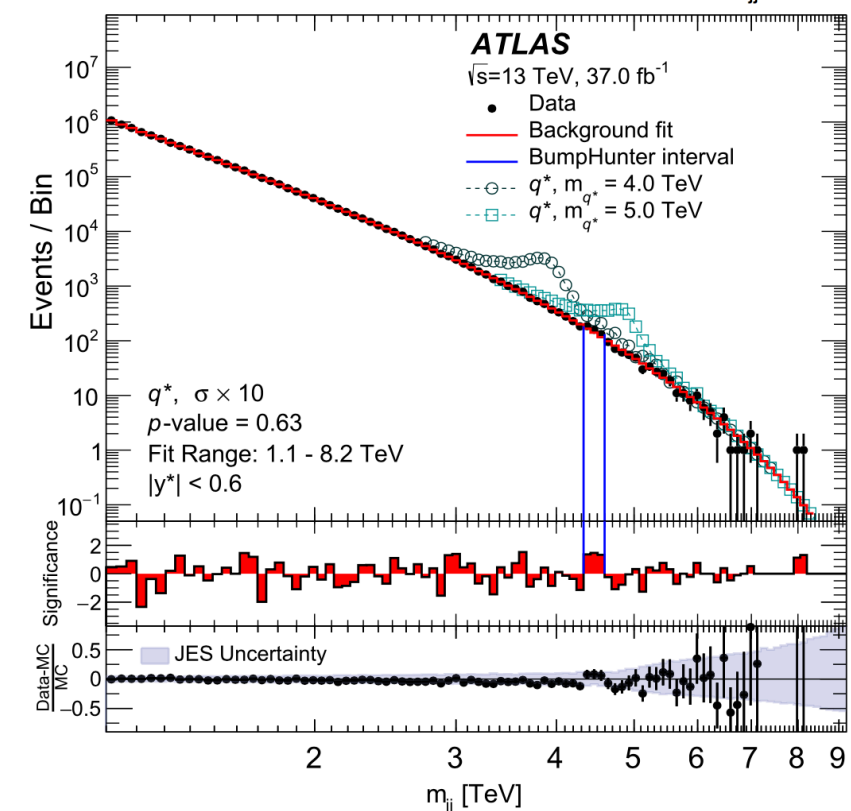
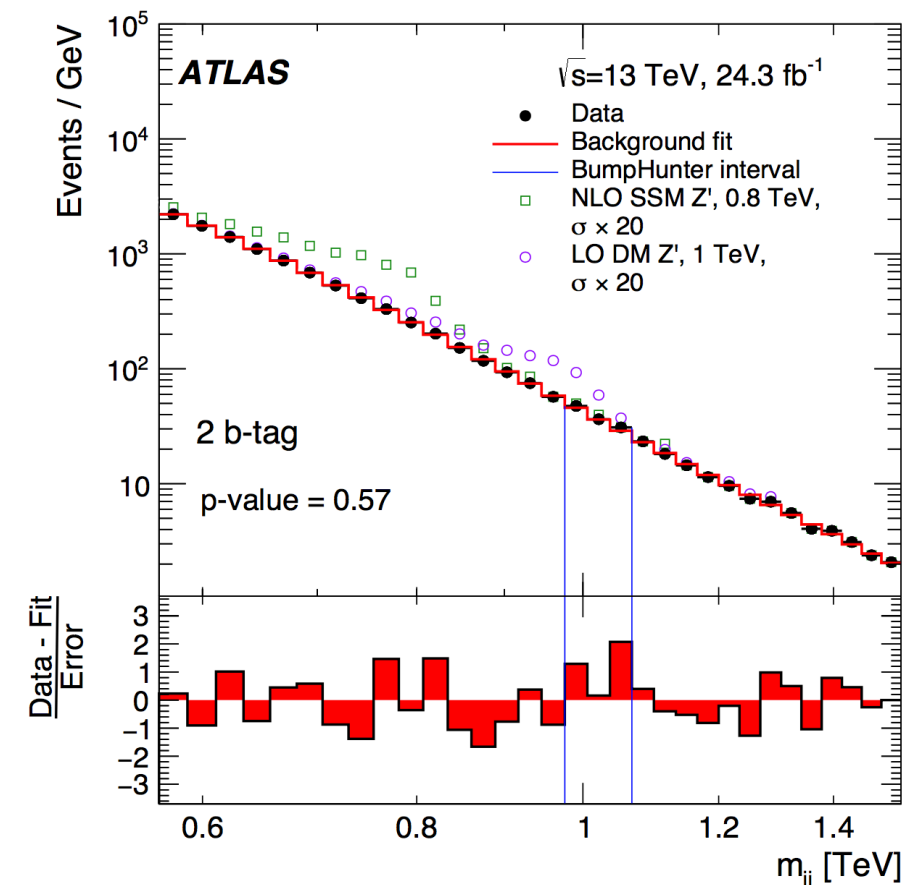


Alberto Escalante Del Valle "Searches for long-lived particles and other non-conventional signatures at CMS"

Dijet resonances



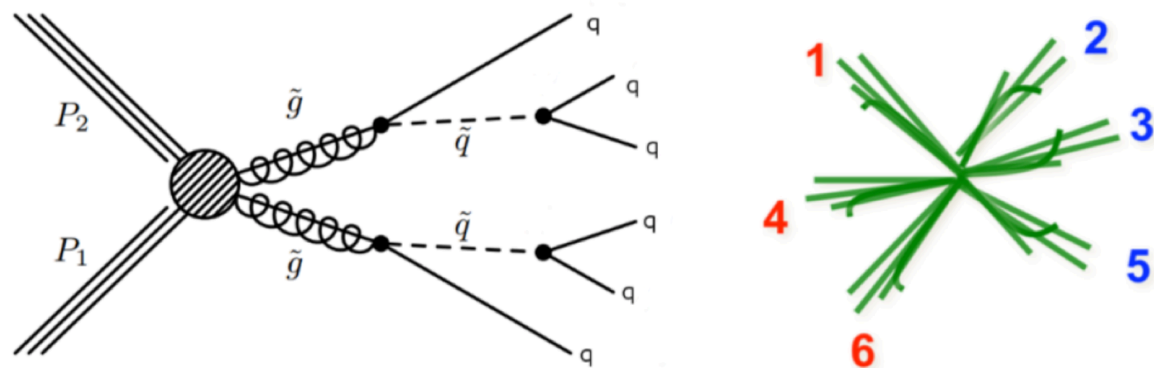
- ⇒ Signal should appear as a peak in the mass spectrum - clear experimental signature.
- ⇒ Very strong limits on high masses already - statistics increase is not expected to give breakthrough anymore.
- ⇒ Looking also at the intermediate and low mass regions.



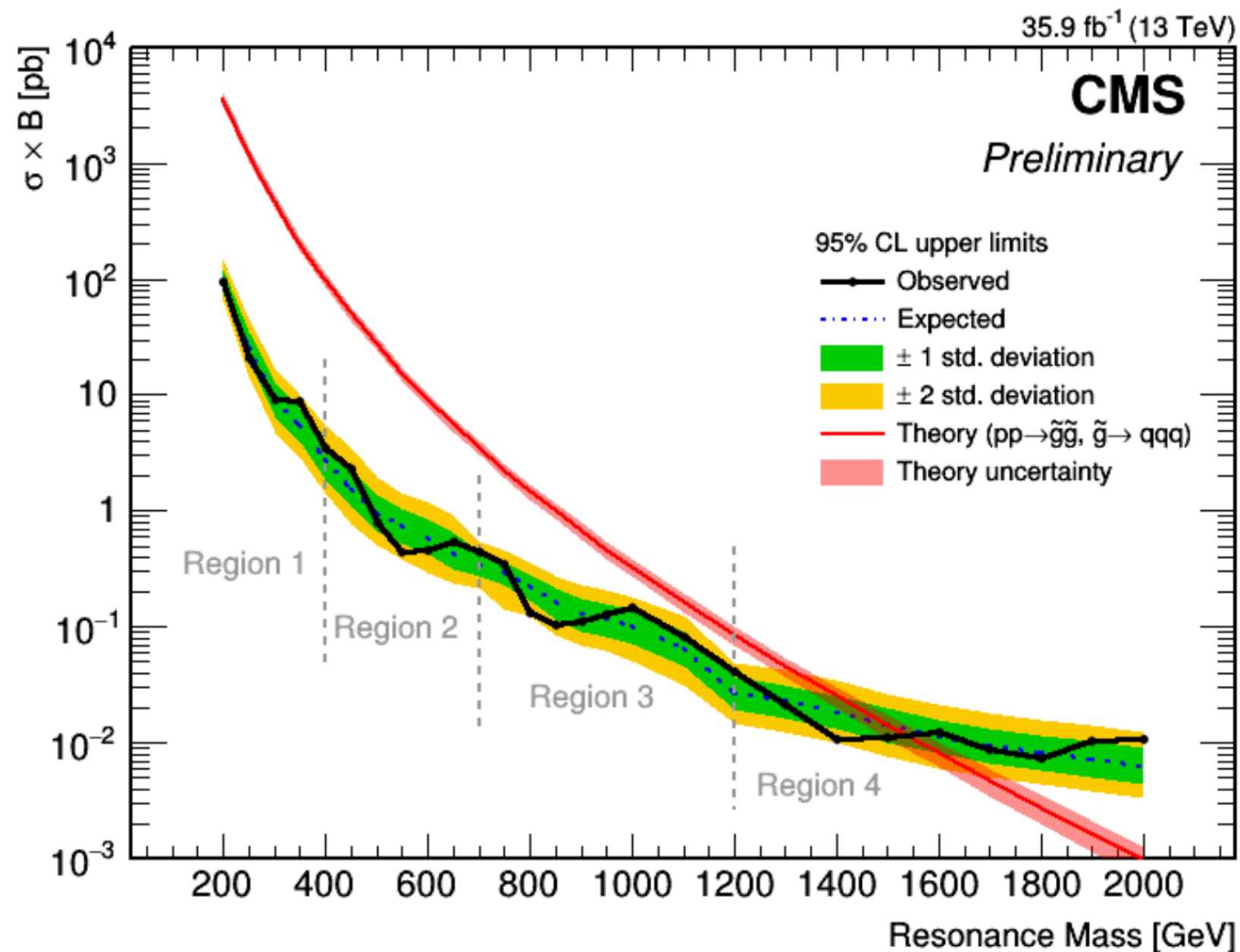
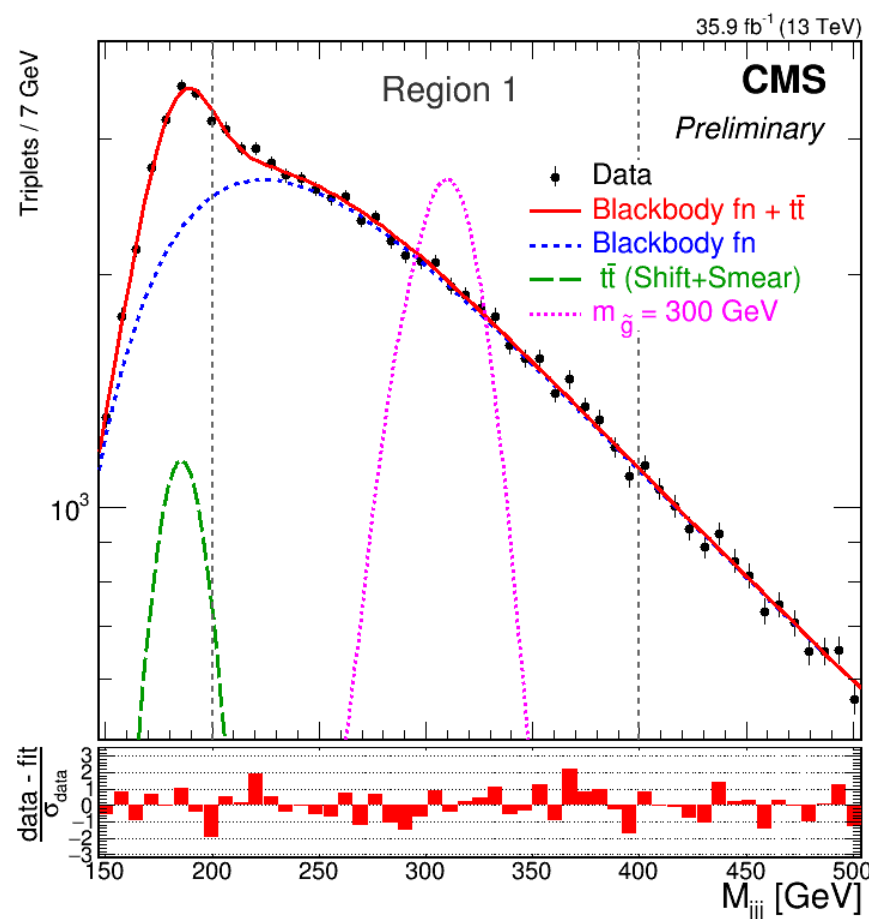
Sung Won Lee "Searches for new physics in dijet and multijet final states"

Andrea Coccaro "Searches for New Phenomena in Dijet Events with the ATLAS Detector"

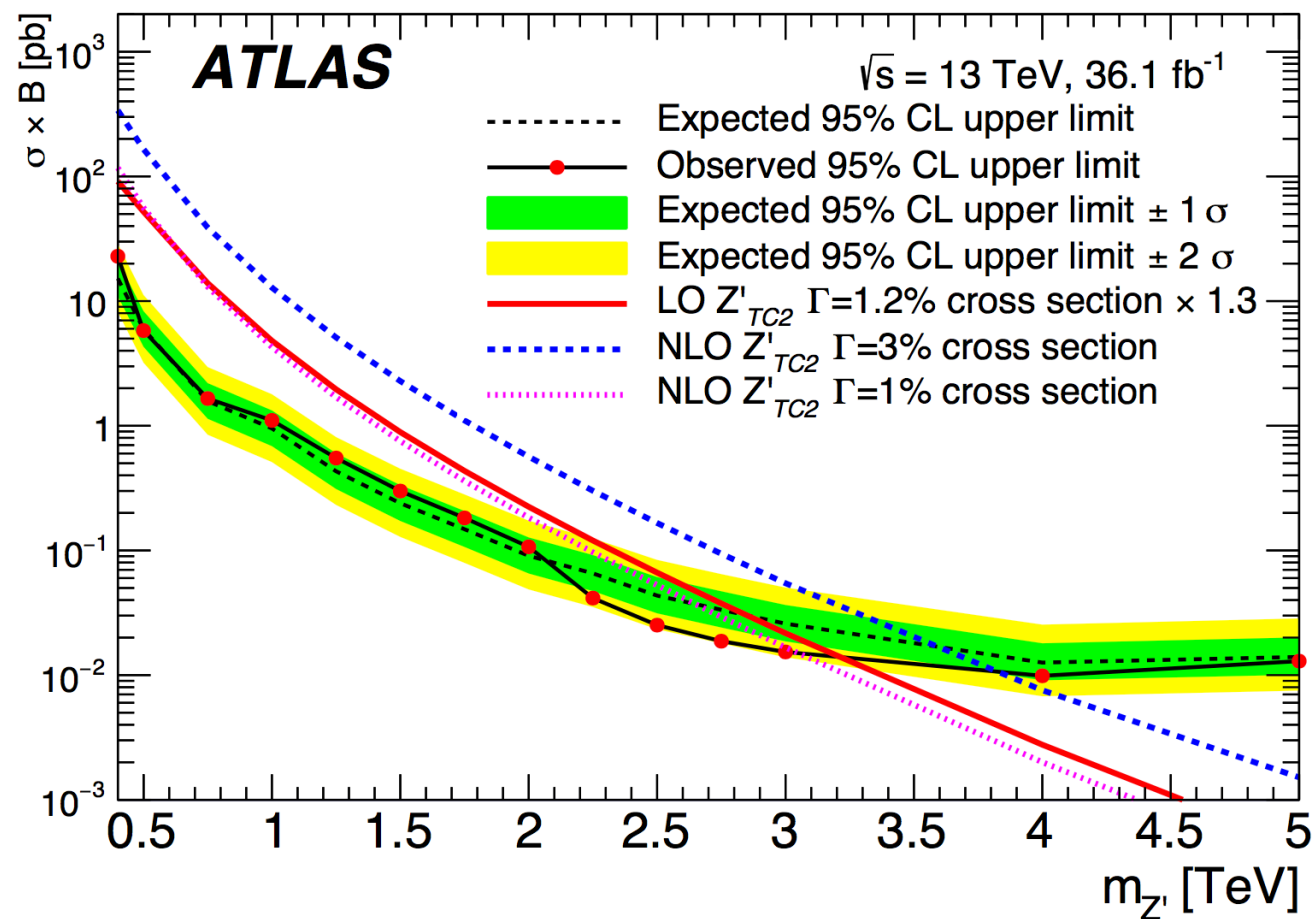
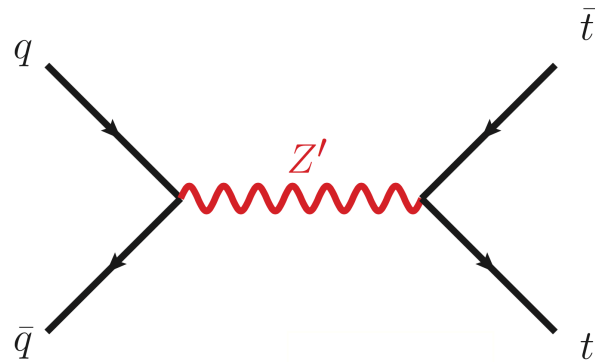
Pair-produced 3-jet resonance



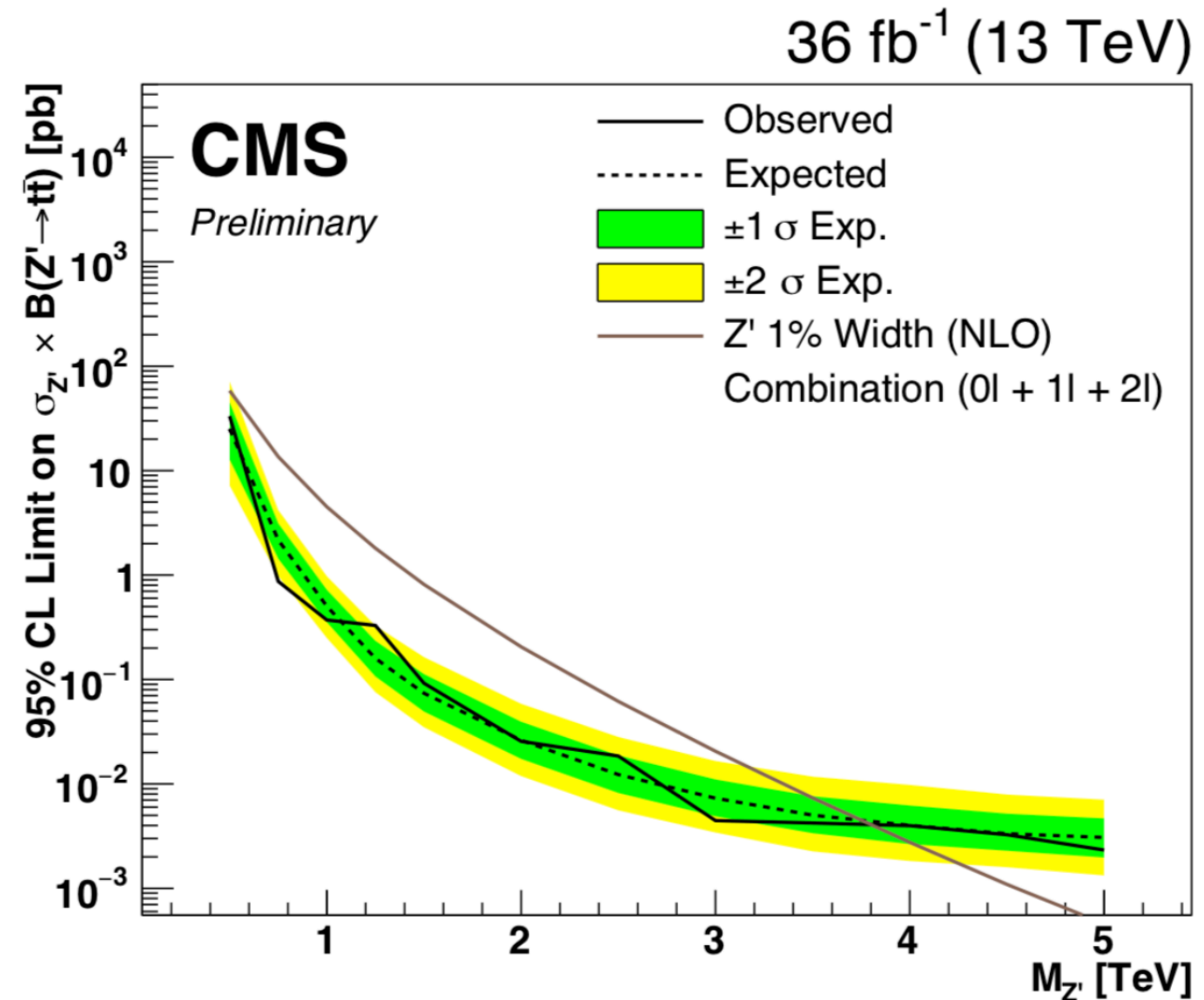
Search separately optimised for 4 mass ranges from 200 GeV to 2 TeV.



Resonances with the third generation quarks

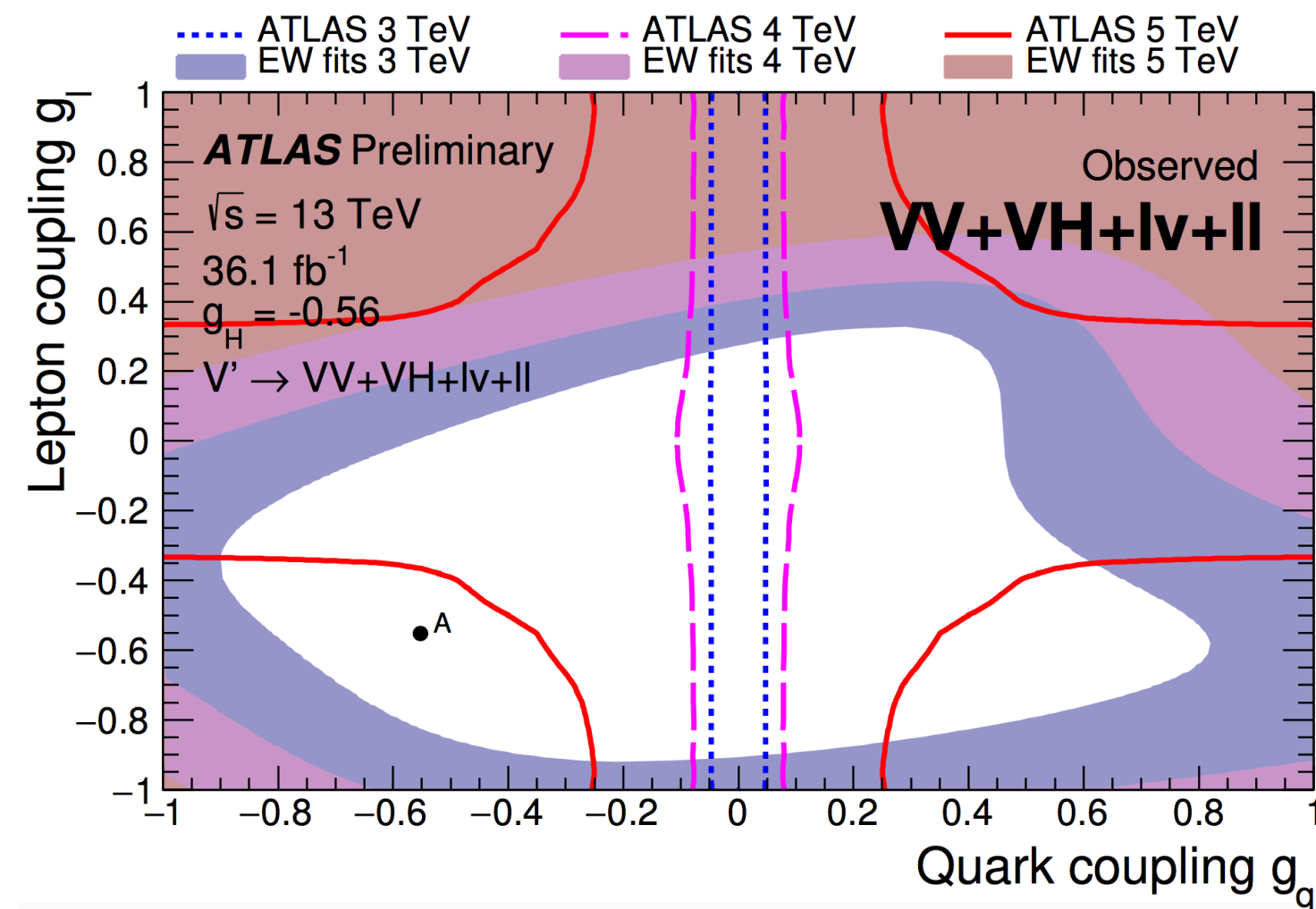
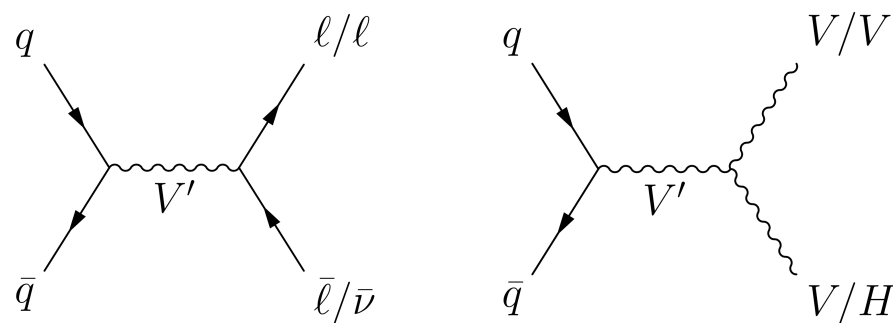


Farida Fassi "Searches for heavy resonances decaying to top quarks with the ATLAS detector"

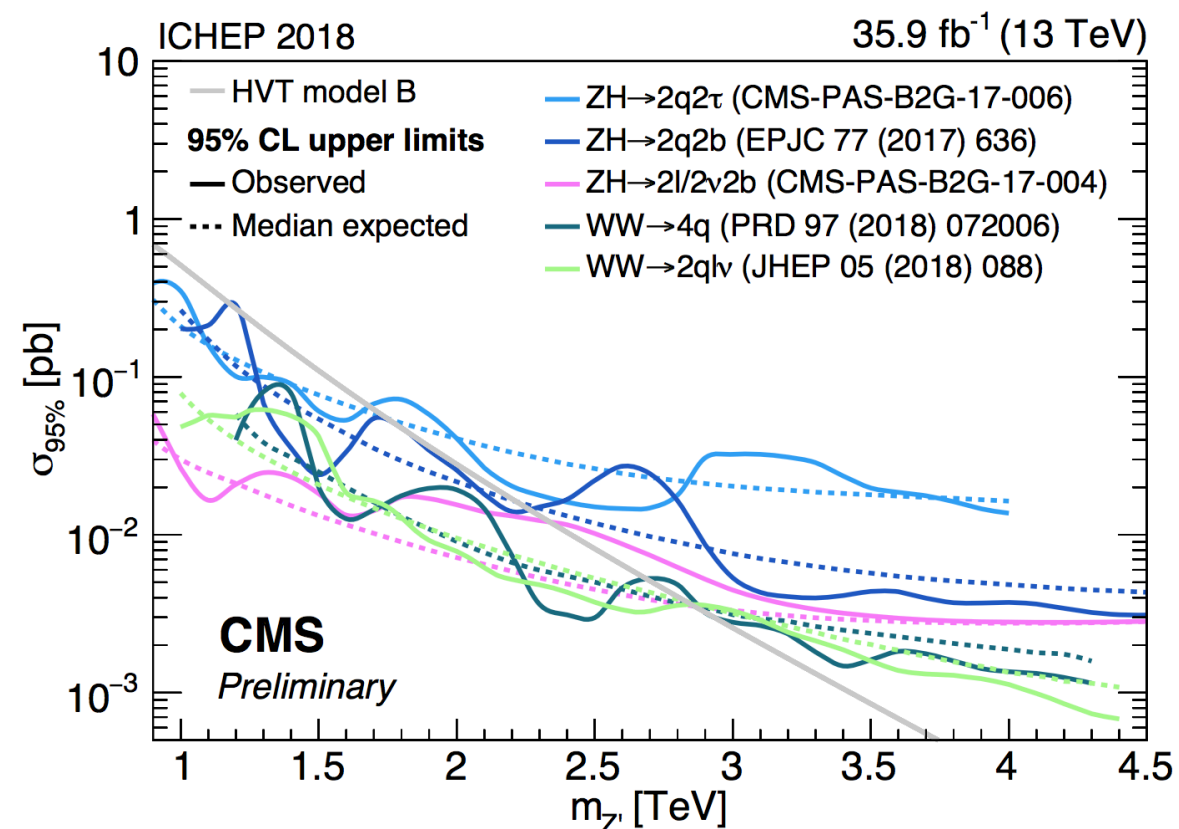
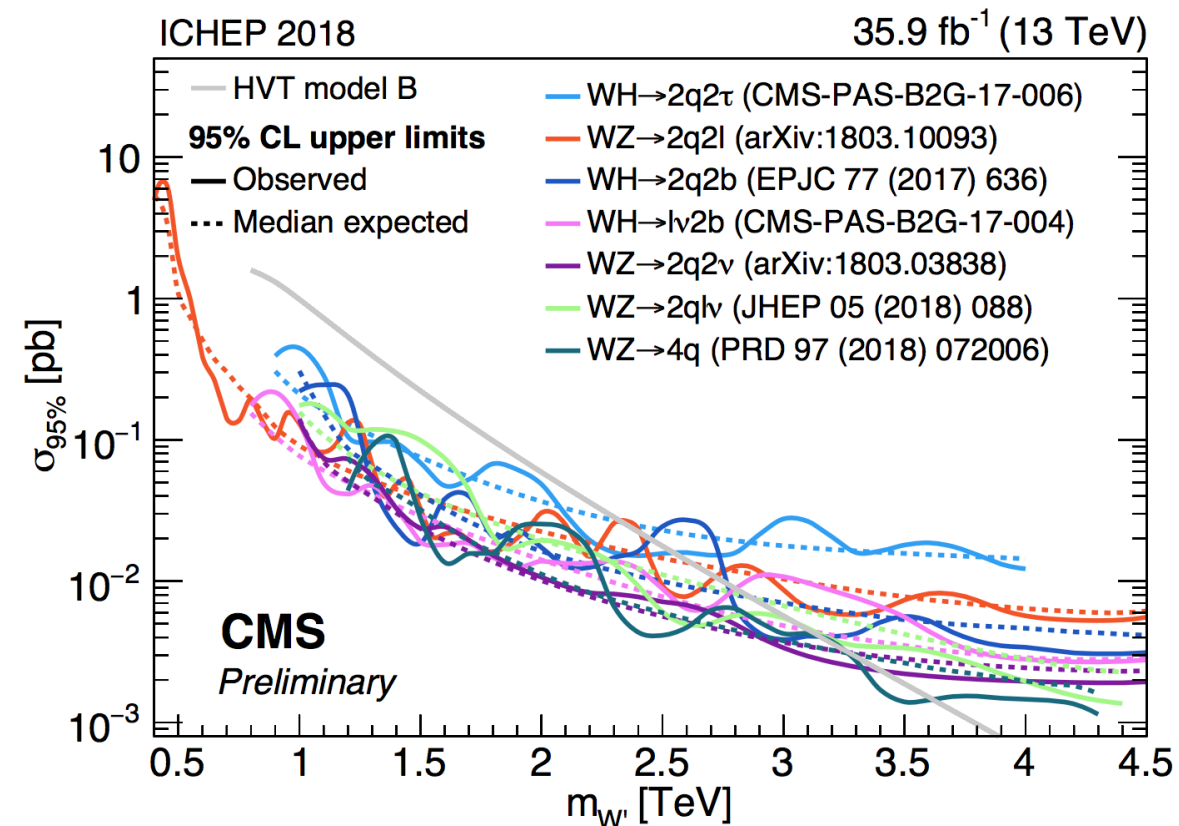


Kevin Nash "Search for new resonances coupling to third generation quarks at CMS"

Heavy resonances

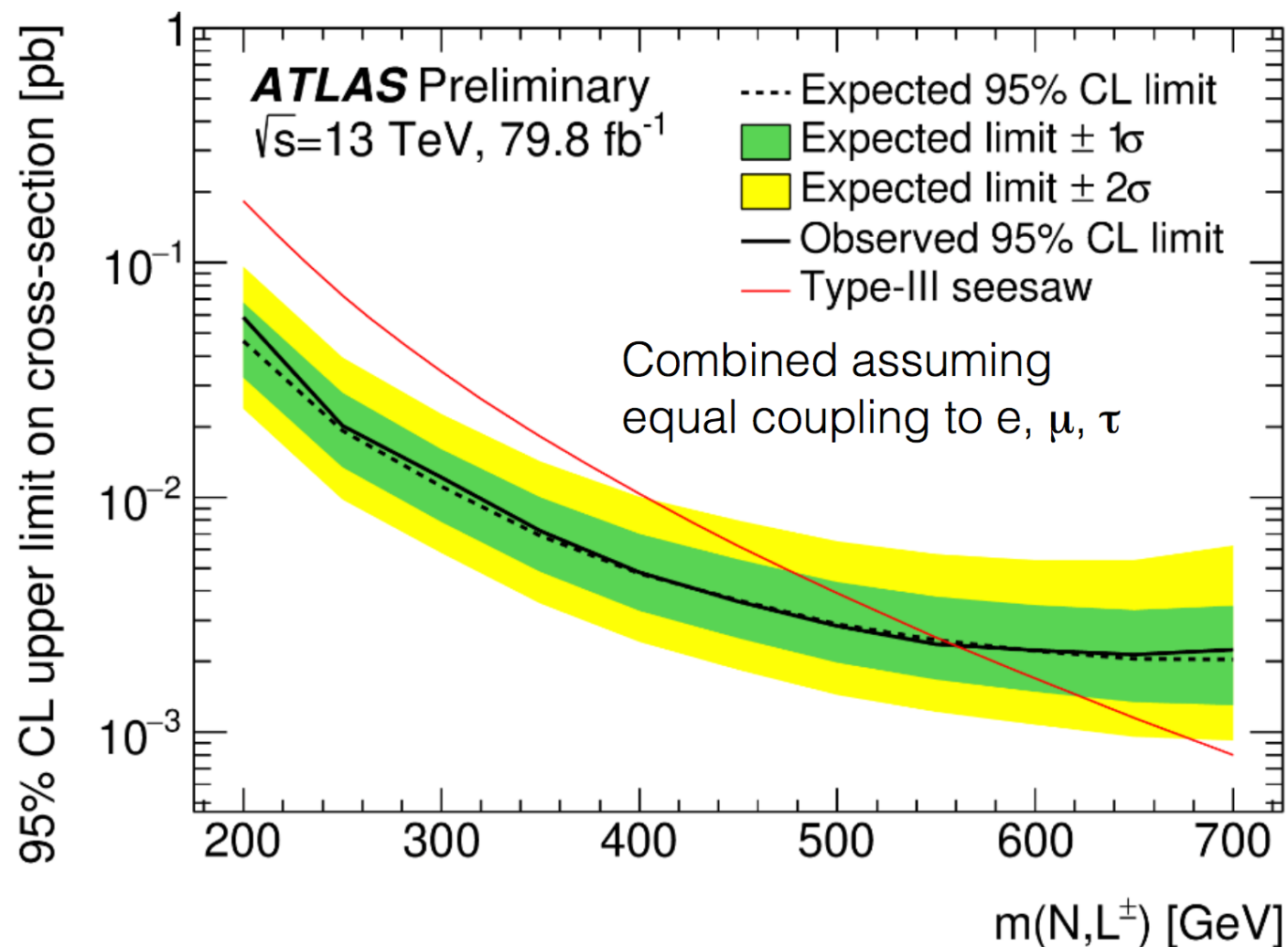
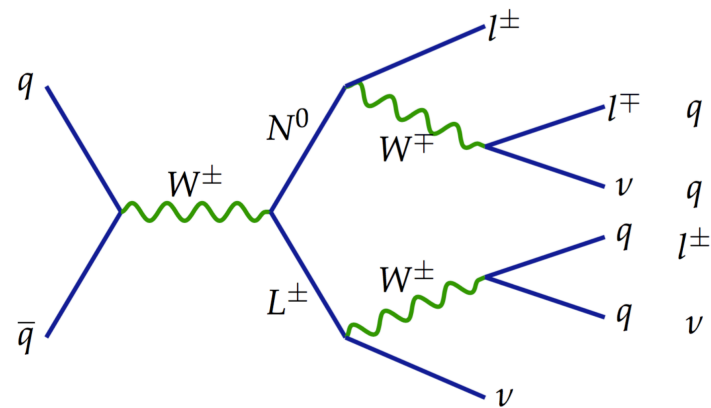


Stéphane Willocq "Complementarity of ATLAS Searches for s-channel Resonance Production in Bosonic and Leptonic Final States"

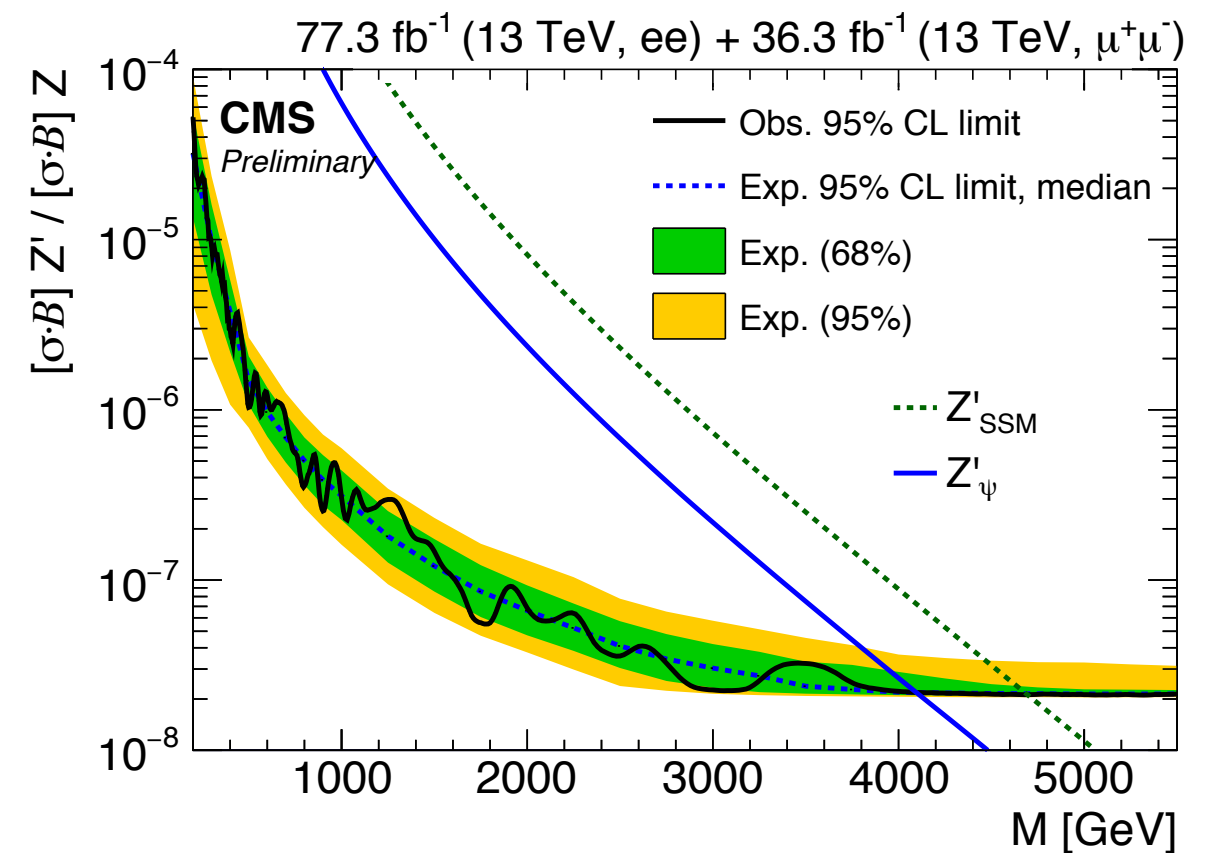
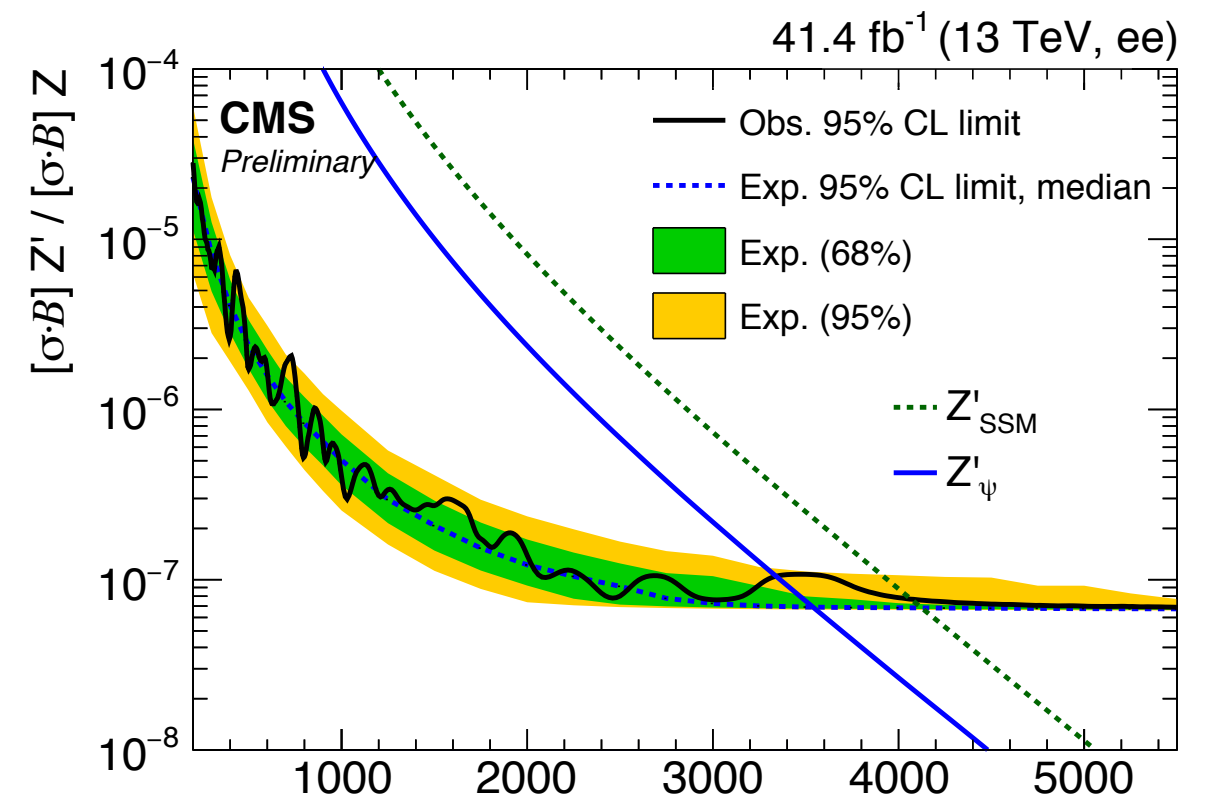


Simon Regnard "Searches for heavy resonances decaying into Z, W and Higgs bosons at CMS"

Resonances with leptons in the final state

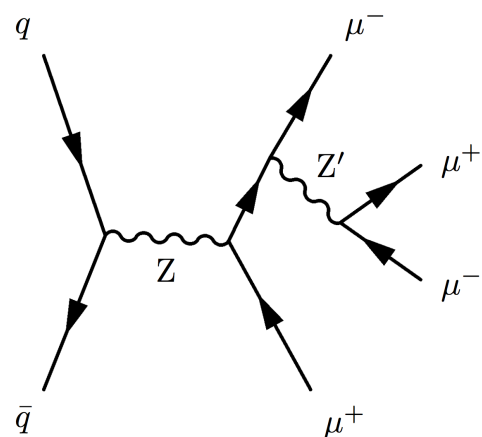


Borut Paul Kersevan "Searches for new phenomena in leptonic final states using the ATLAS detector"

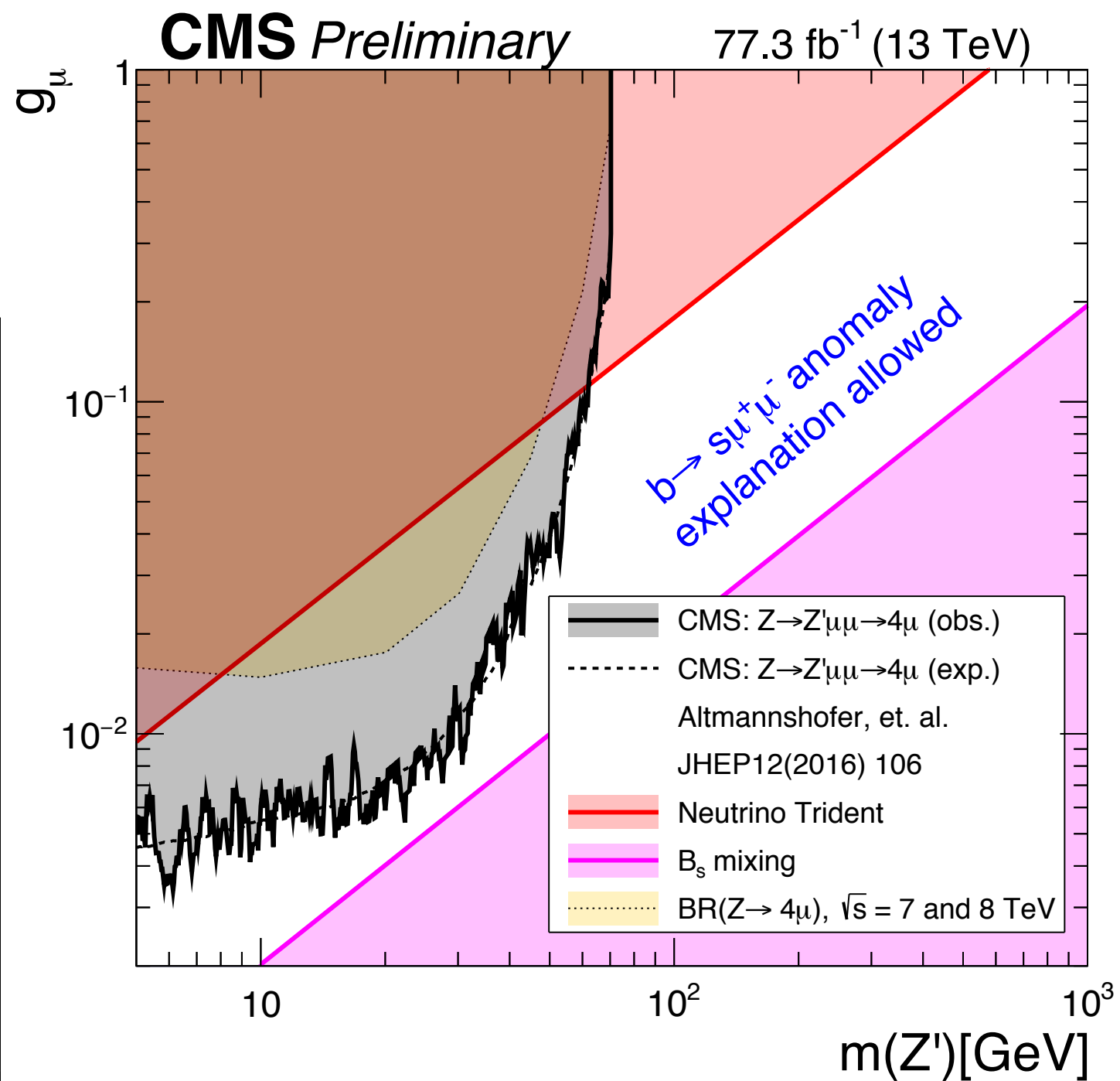
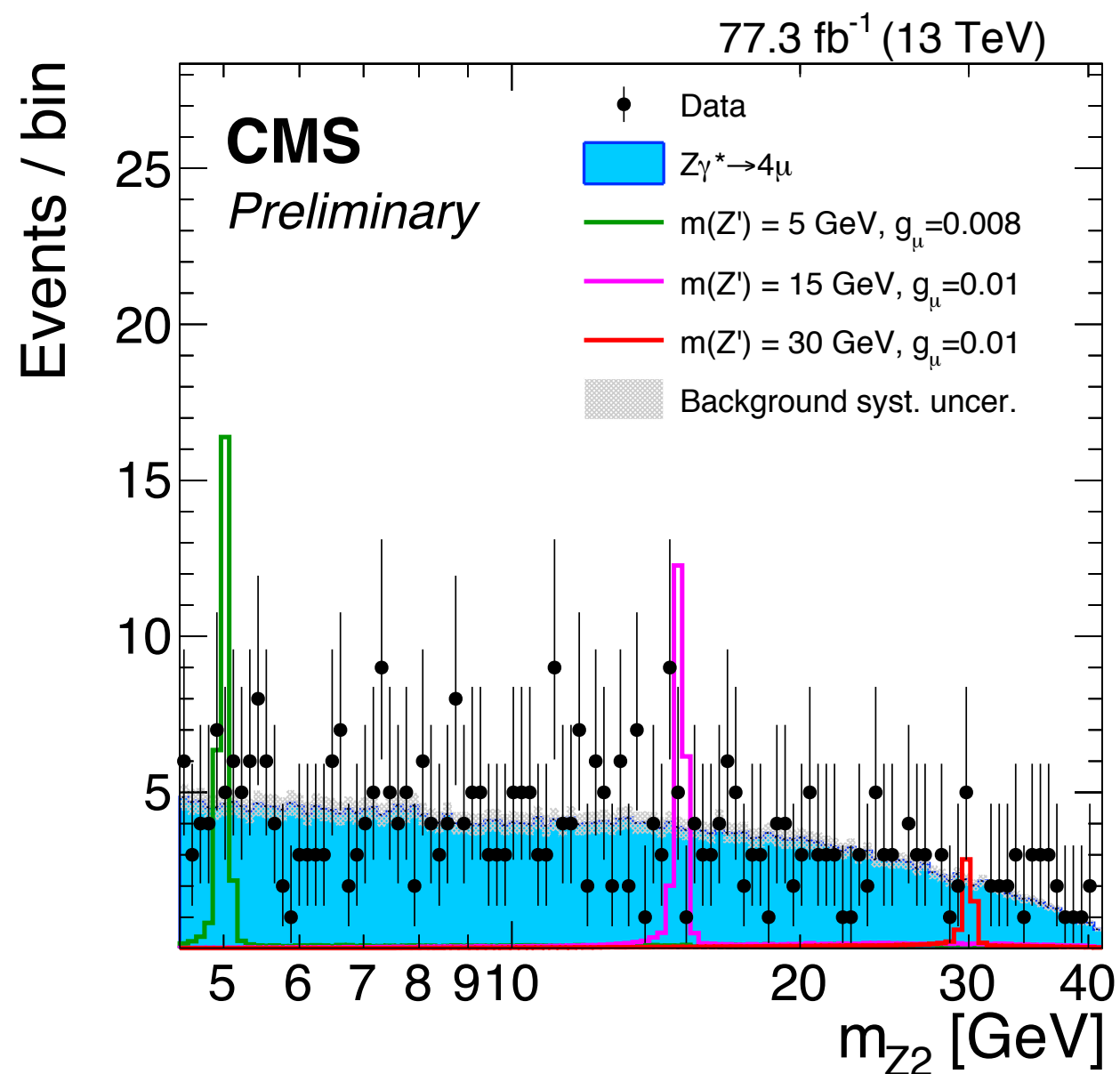


Benjamin Radburn-Smith "Searches for new heavy resonances in final states with leptons and photons at CMS"

Light Z' boson



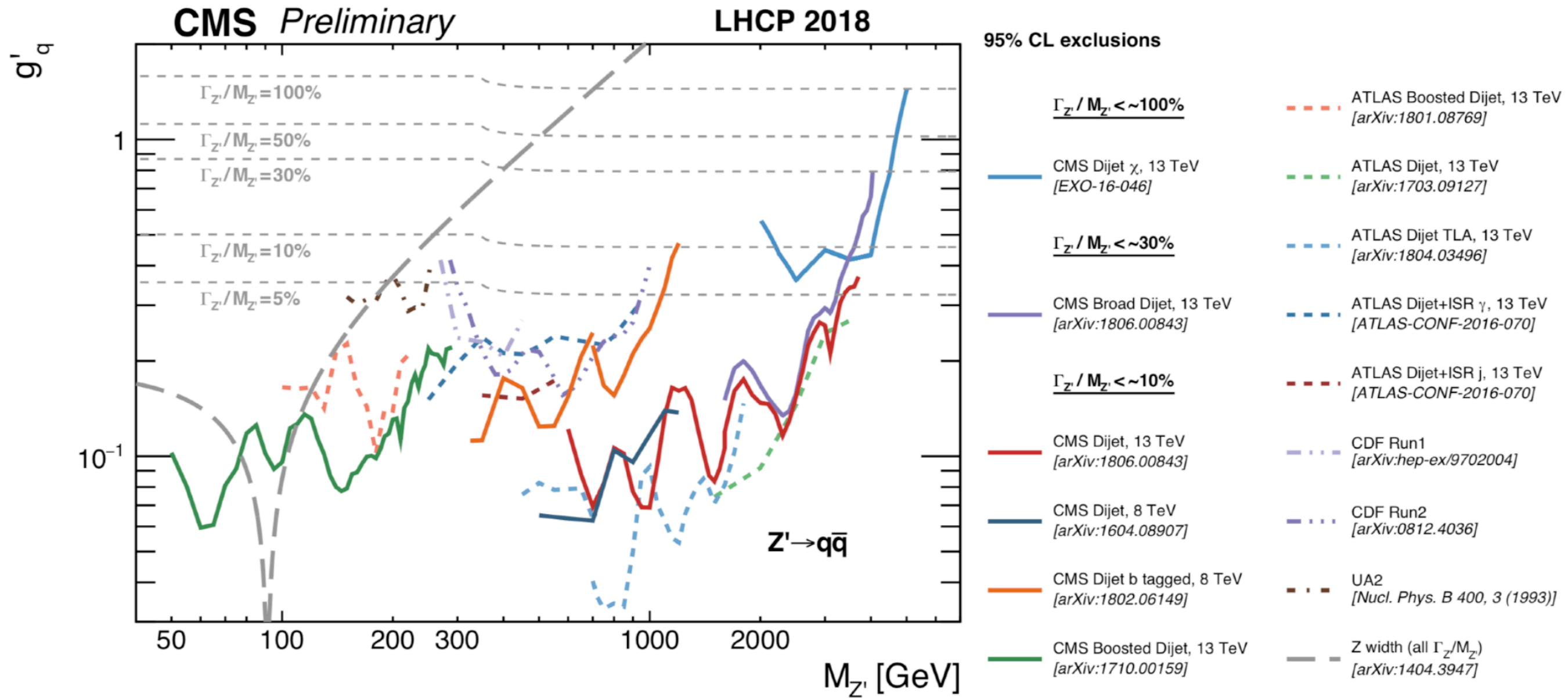
⇒ Search for new gauge boson below the Z mass.



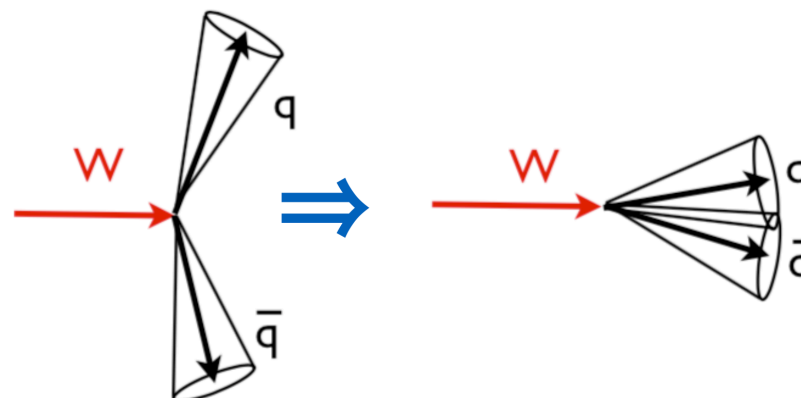
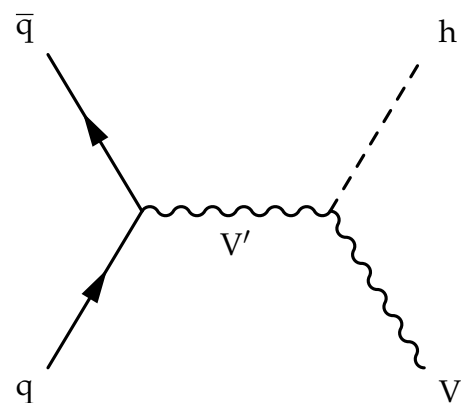
Shahram Rahatlou "CMS + LHCb highlights"

Dijet CMS+Atlas

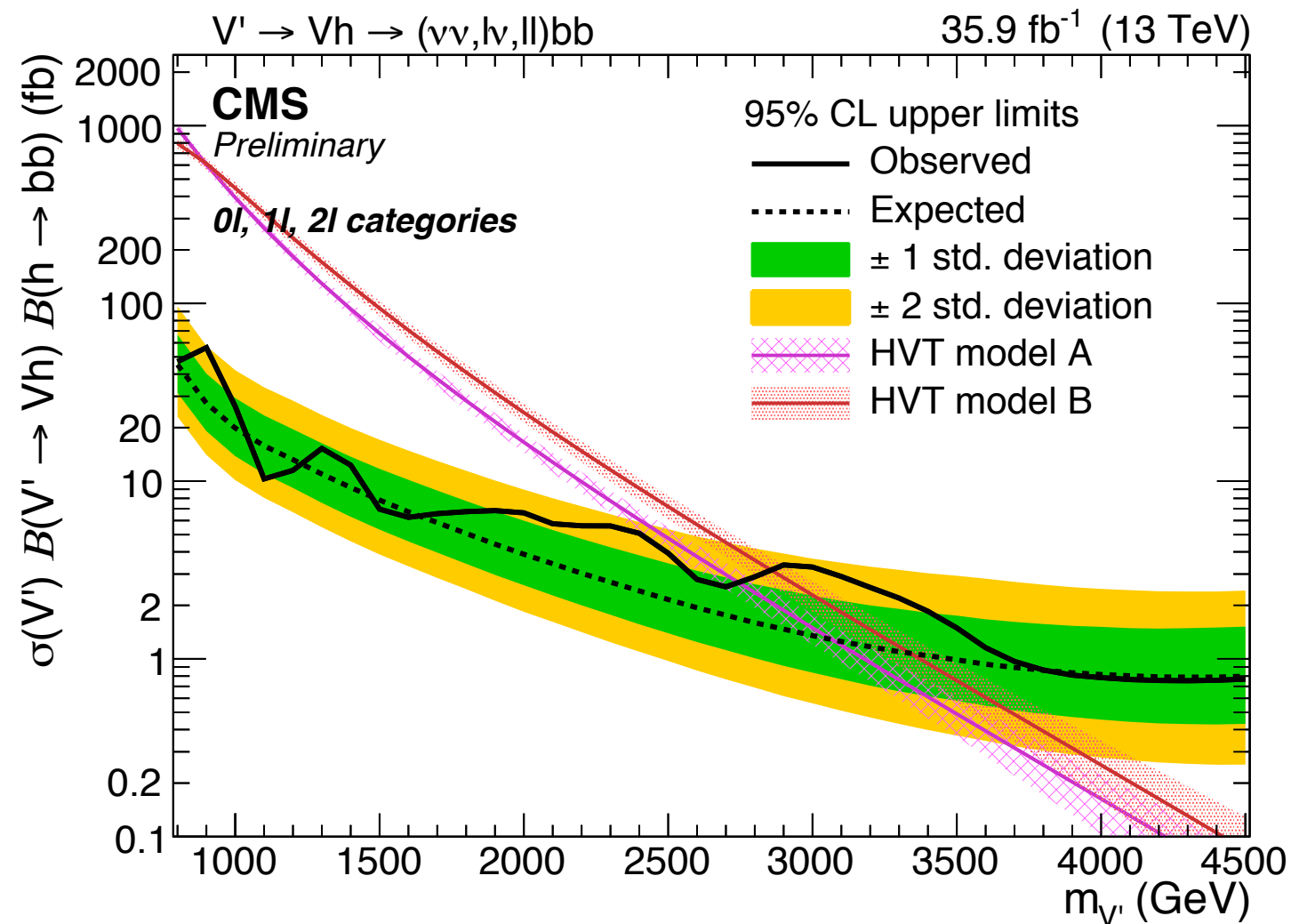
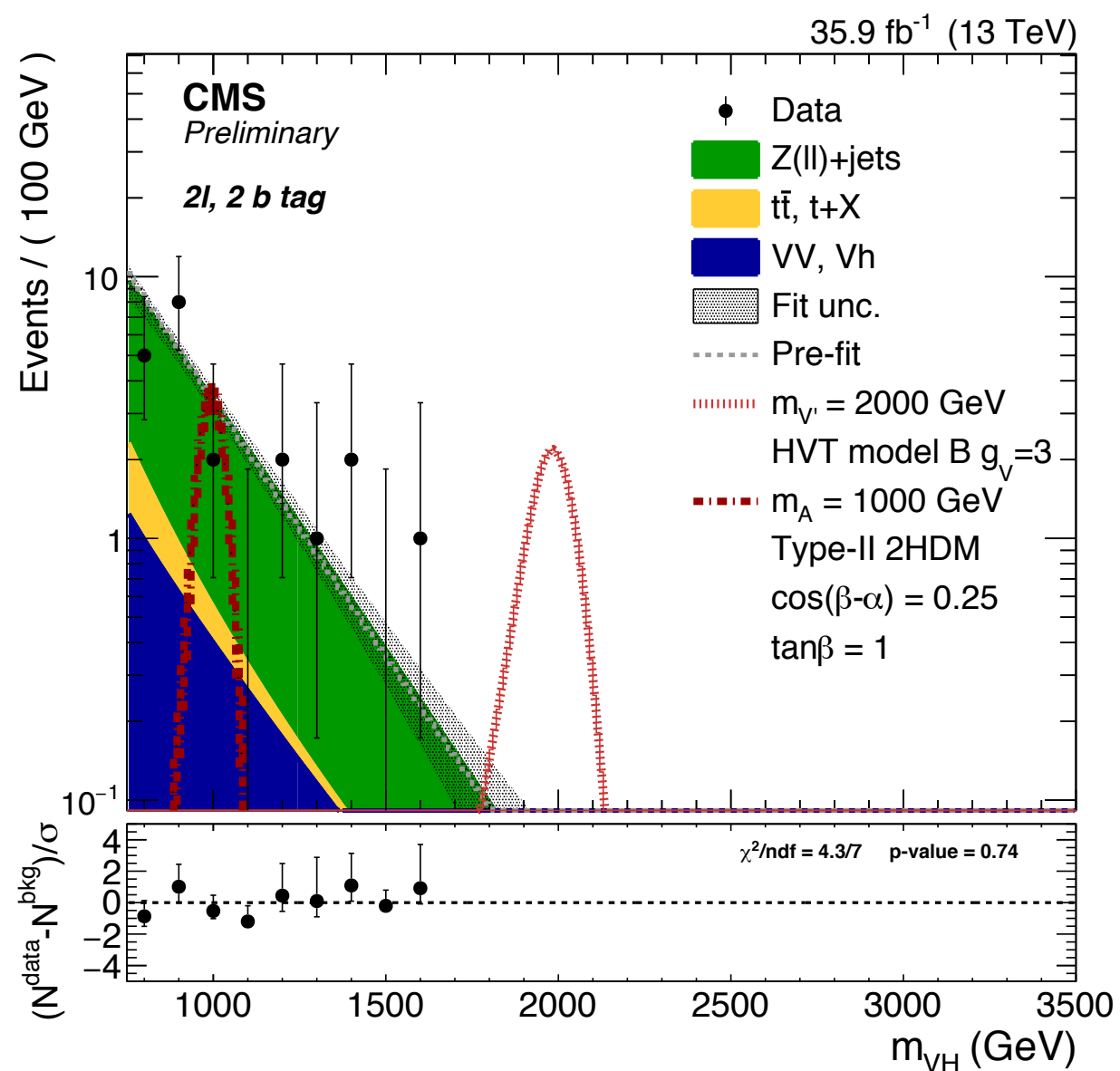
⇒ Combined limits are now covering the whole range.



Exploiting substructures



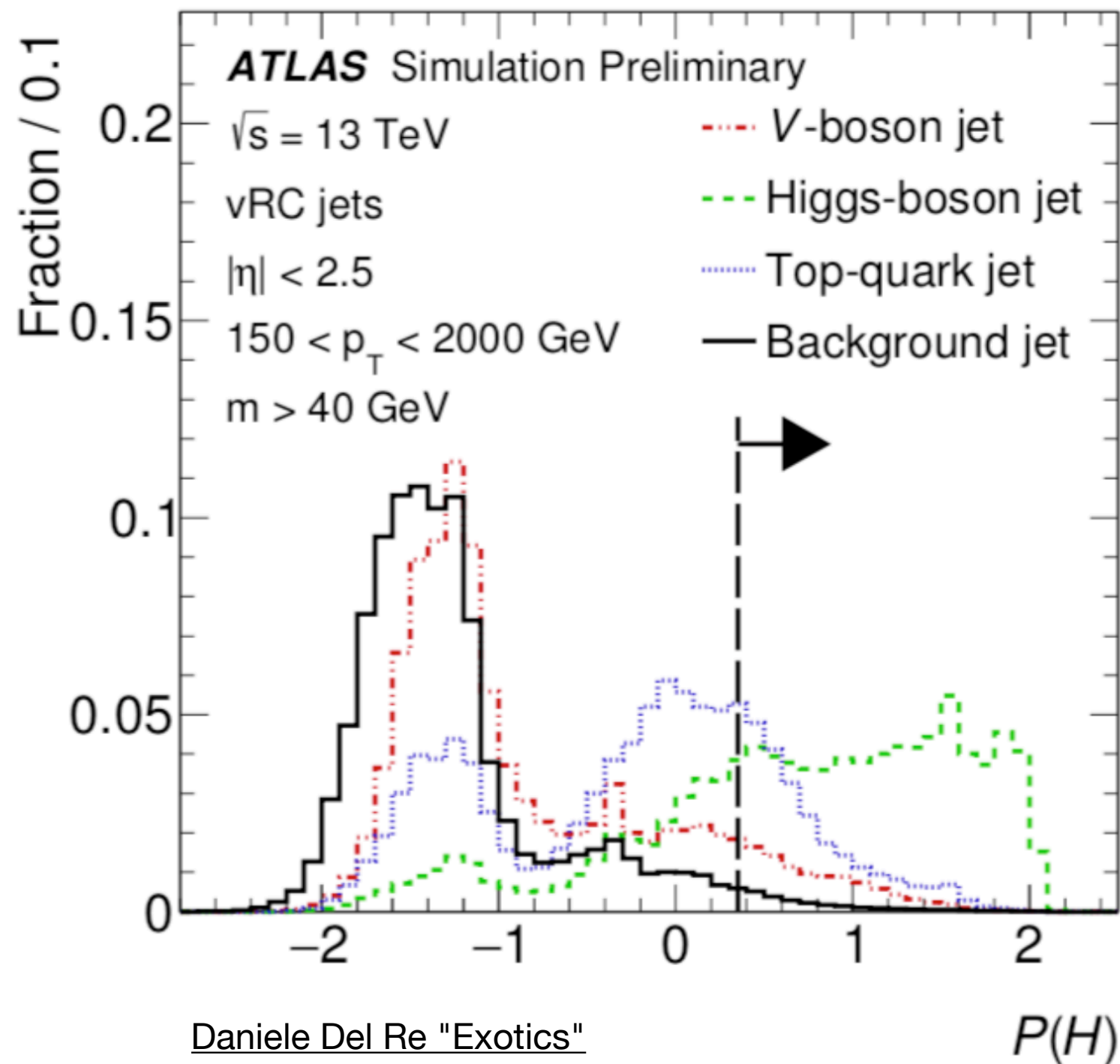
At large boost jets are merged.



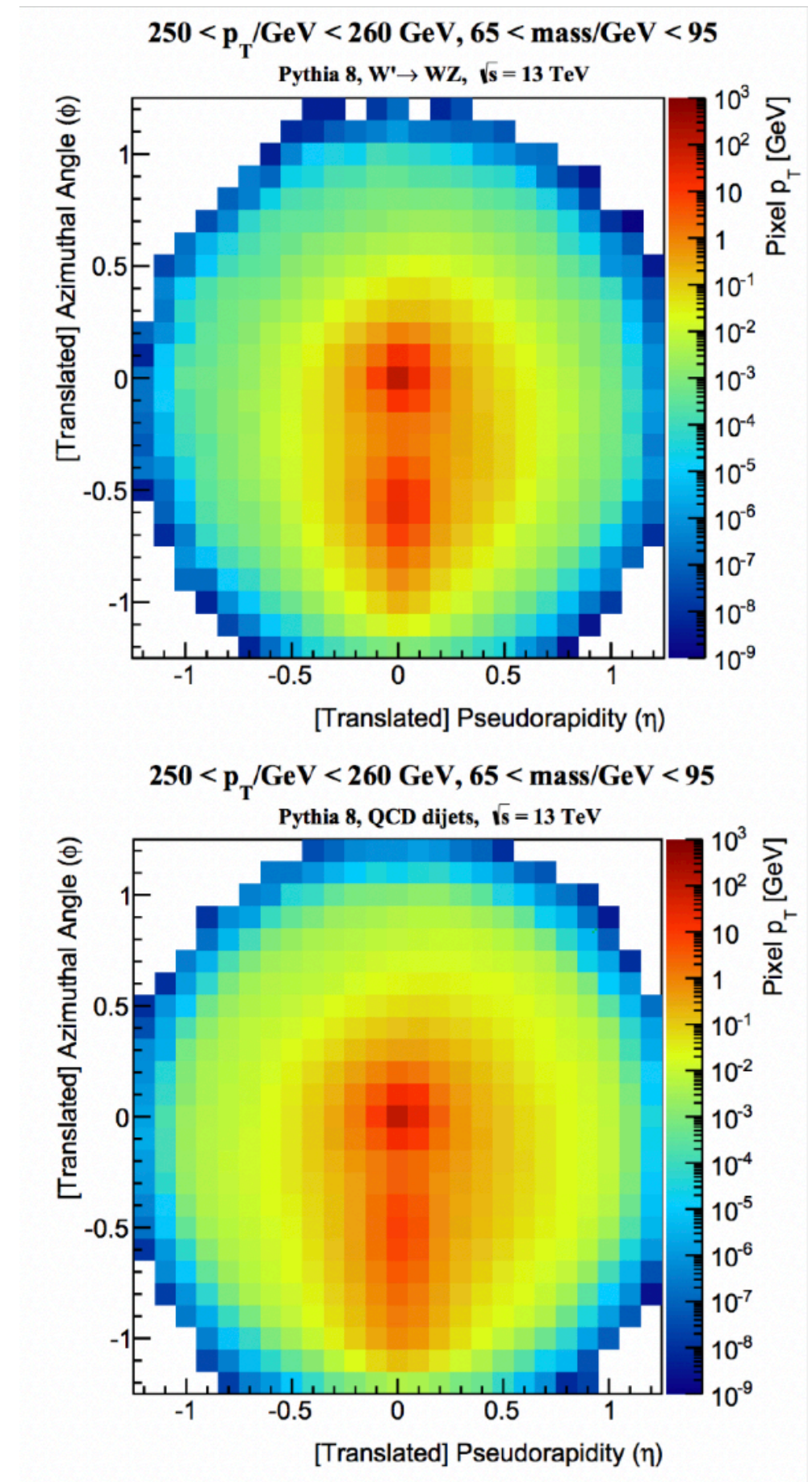
Daniele Del Re "Exotics"

Boosted jets analysis

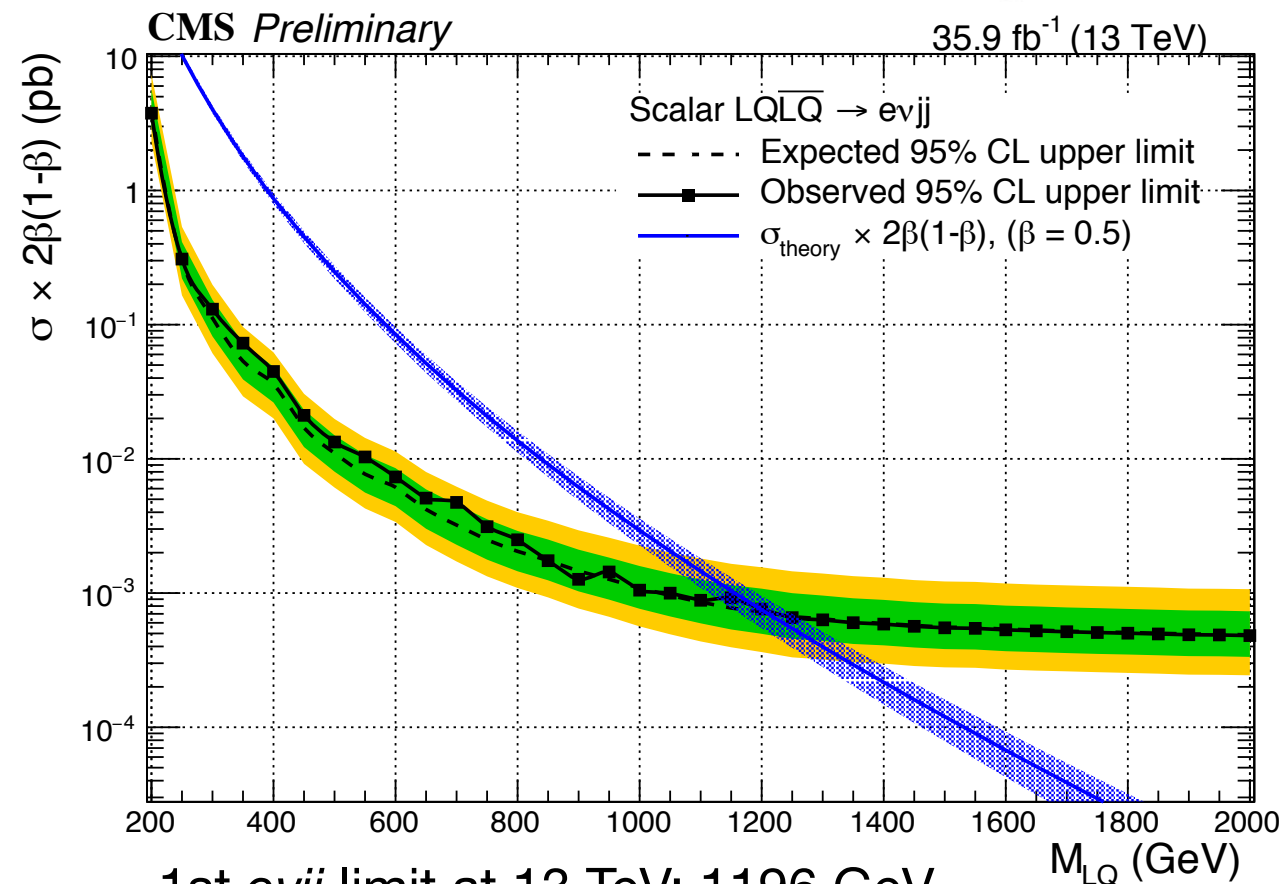
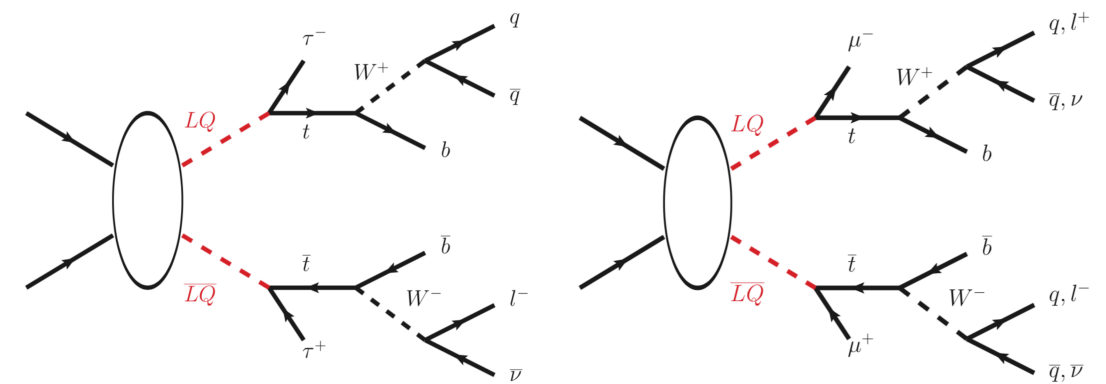
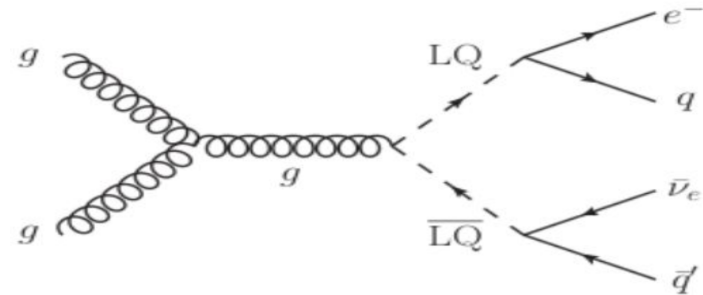
⇒ Boosted jets substructure analysed with deep learning and other algorithms.



Daniele Del Re "Exotics"



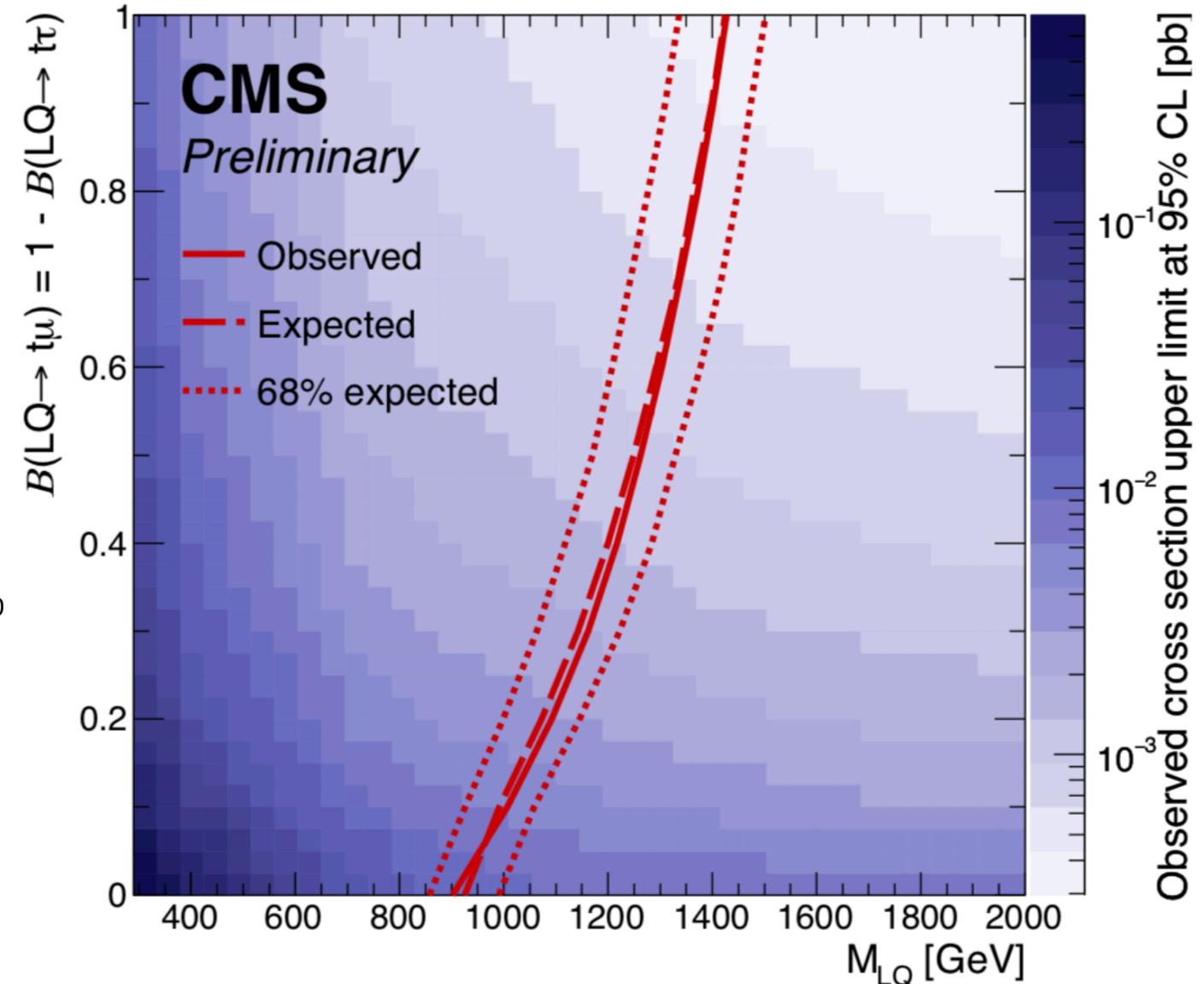
Leptoquarks



Muzamil Ahmad Bhat "Searches for new physics in lepton+jet final states"

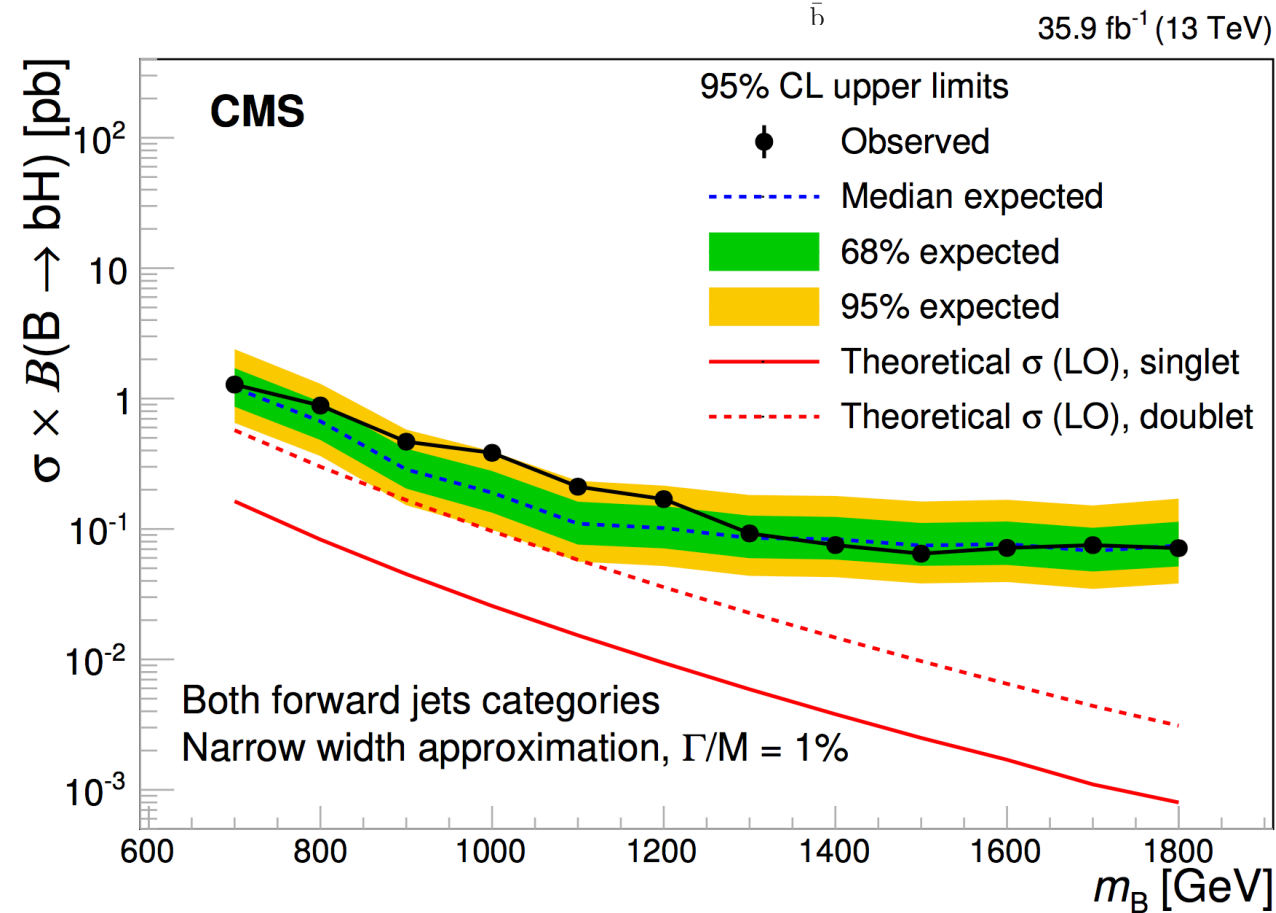
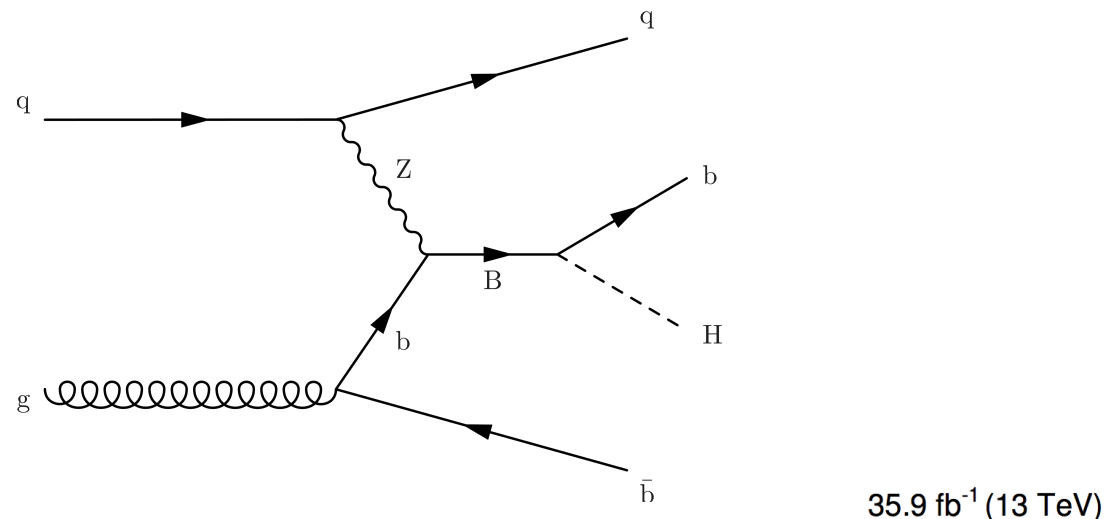
	95% C.L. limits		
	$\lambda_{\text{LQ}} / M_{\text{LQ}} \text{ (TeV}^{-1}\text{)}$		p_{SM}
Model	Measured	Expected	[%]
S_1^L	0.78 - 1.16	0.62	<0.01
V_o^L	-	0.44	0.4

OT "Search for contact interactions in inclusive ep scattering at HERA"

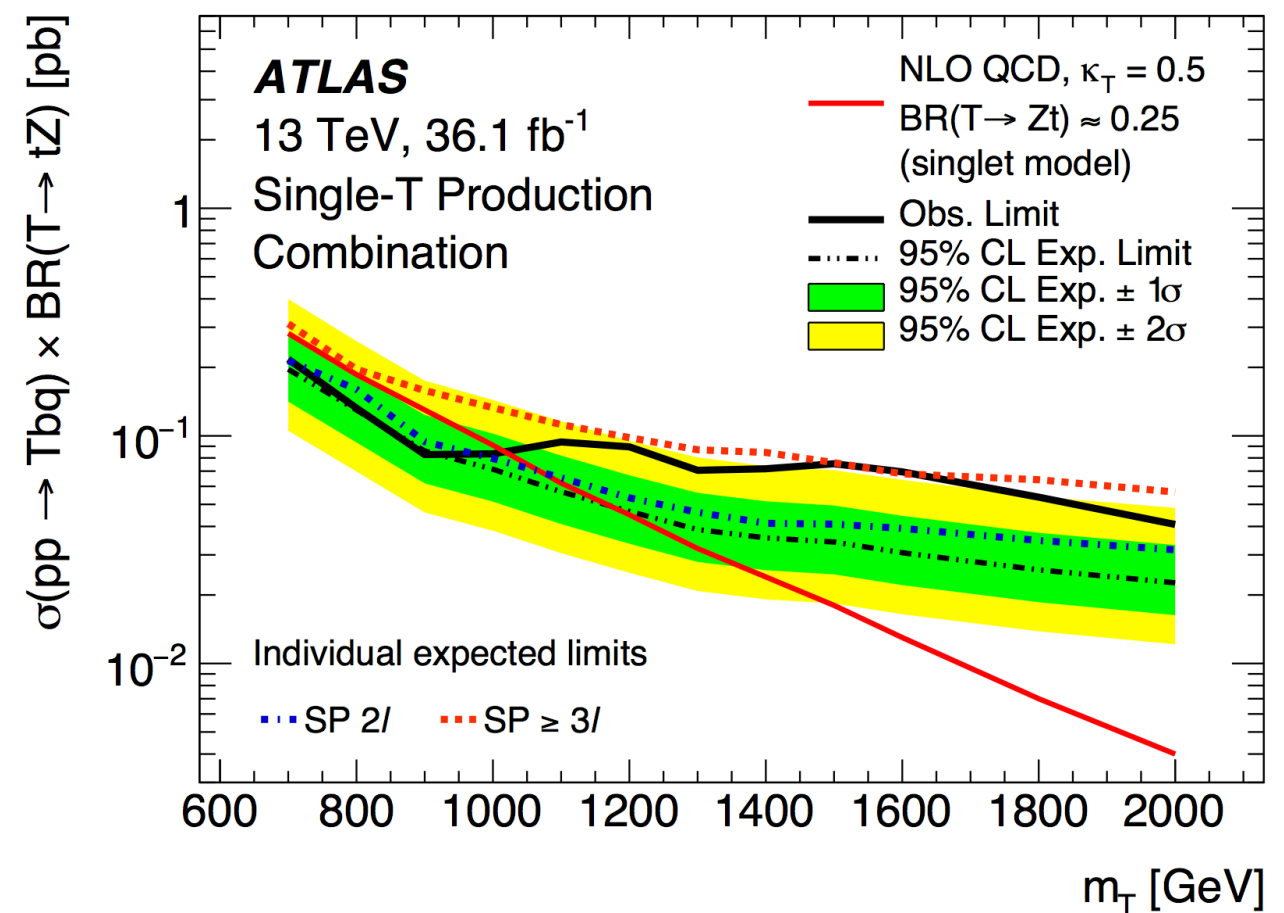
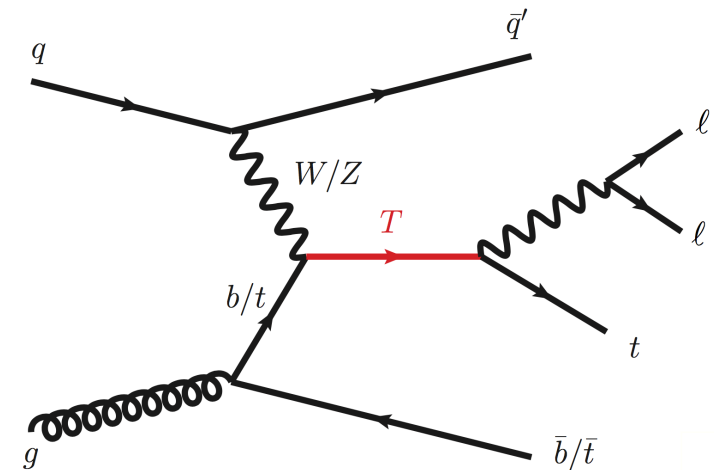


Kevin Nash "Search for new resonances coupling to third generation quarks at CMS"

Vector-like quarks

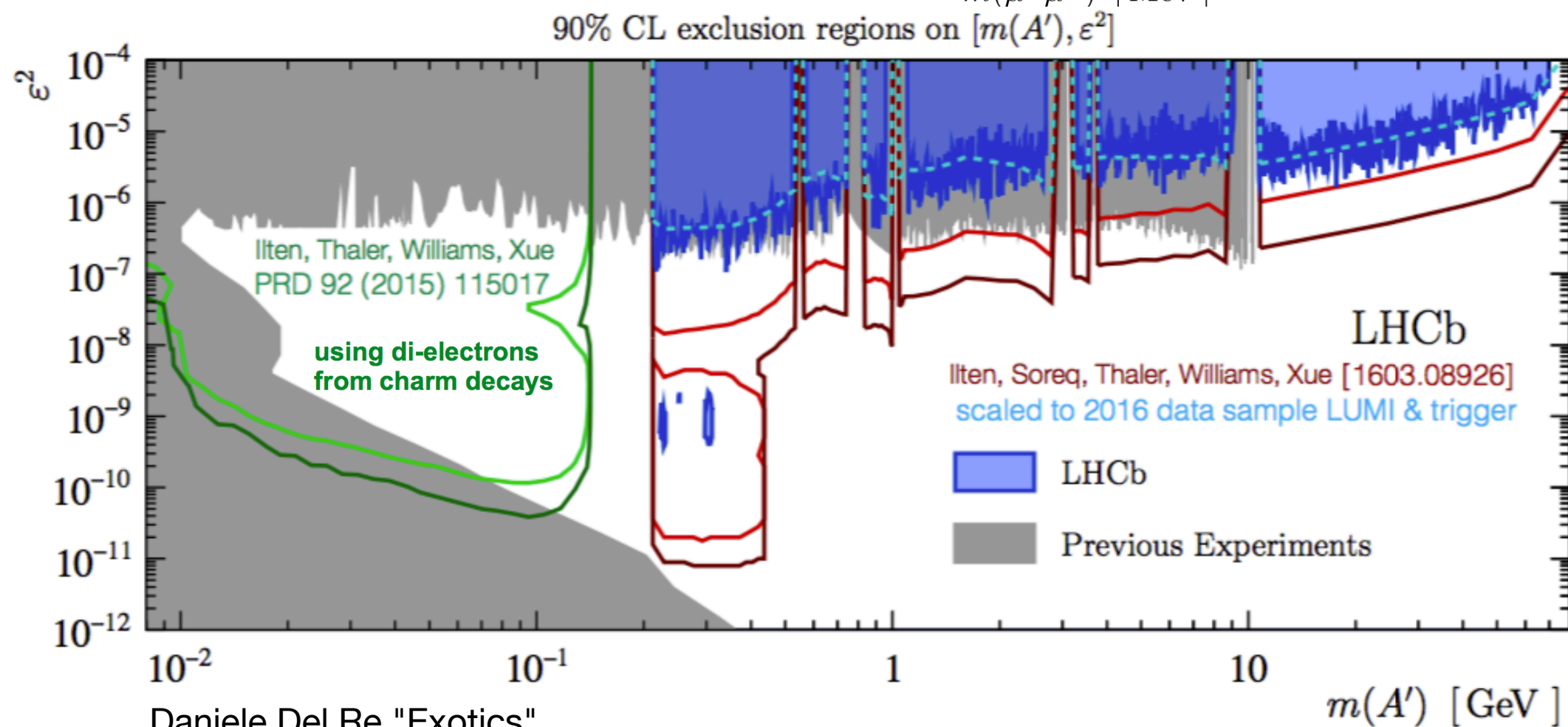
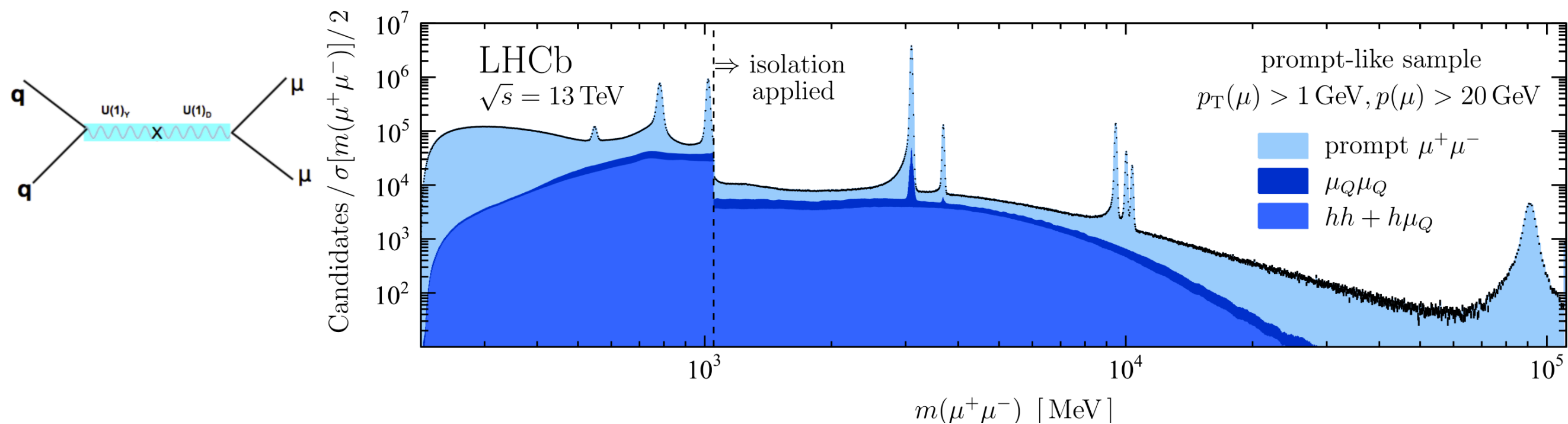


Justin Pilot "Searches for vector-like quarks at CMS"



Allison McCarn Deiana "Search for vector-like quarks with the ATLAS Detector"

Dark Photon

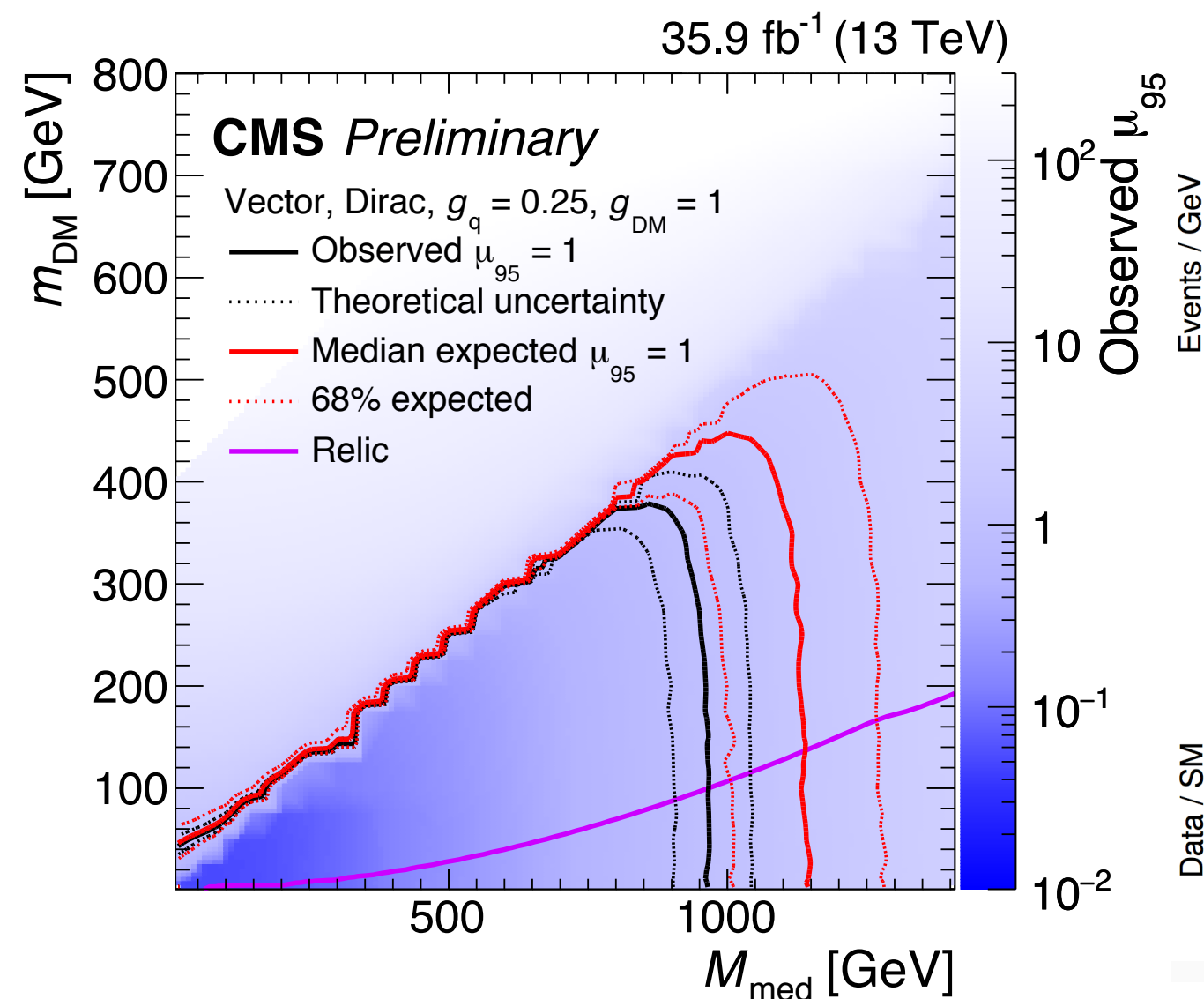
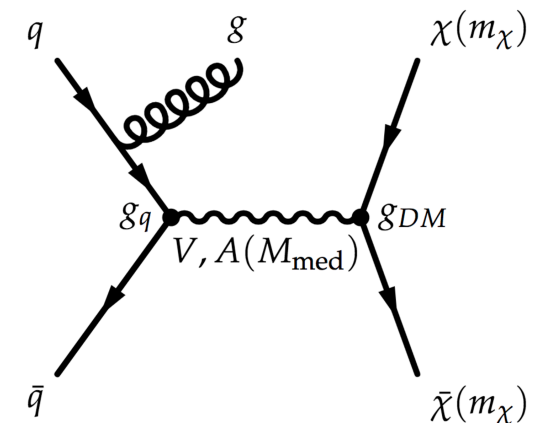
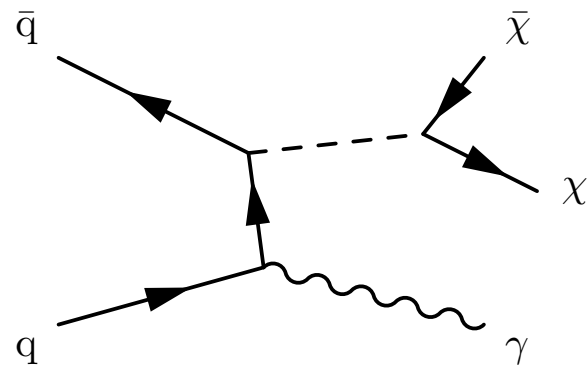


Dark Matter

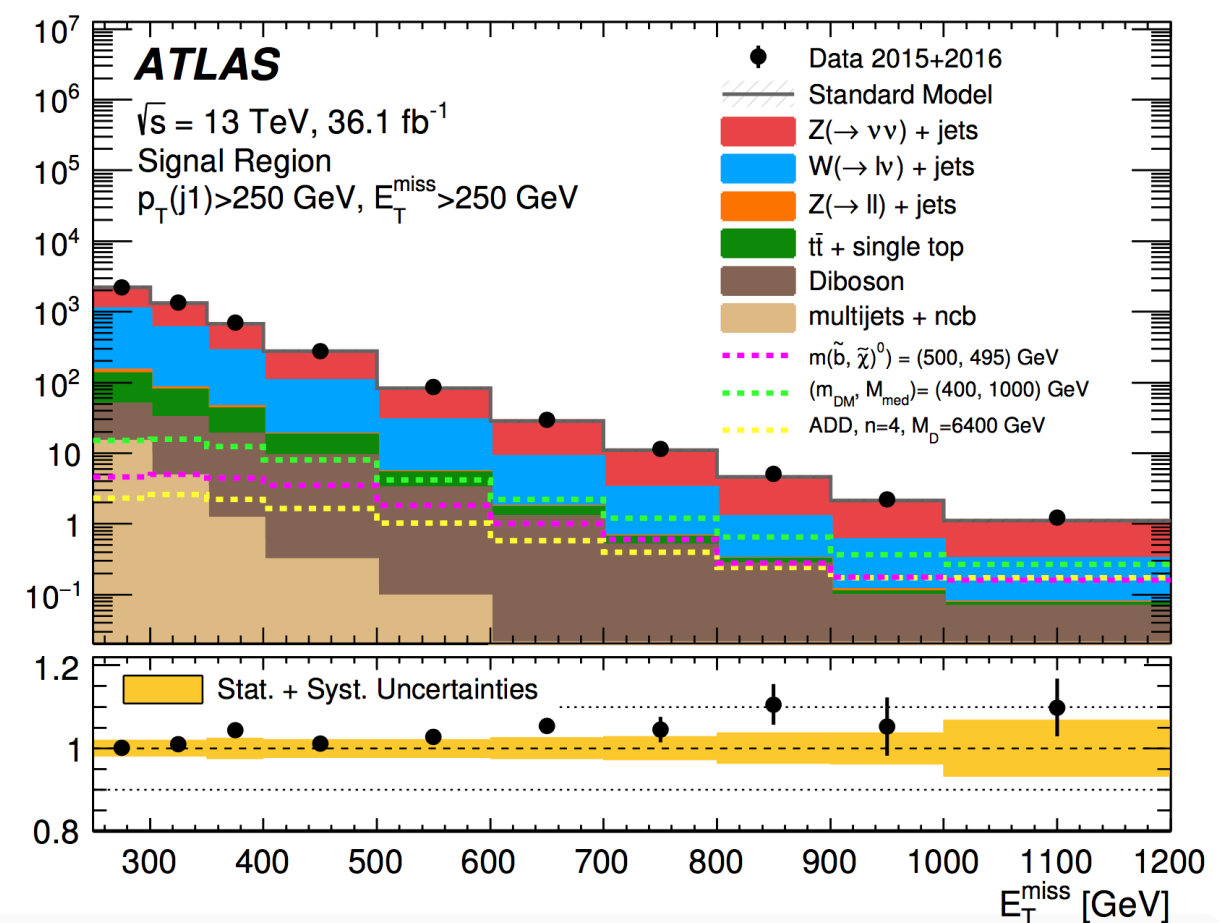
Spin-1 mediator

⇒ New massive mediator couples DM to SM.

⇒ Signal should appear as an excess in the tail of the MET distribution.



Andreas Albert "Searches for dark matter with CMS"

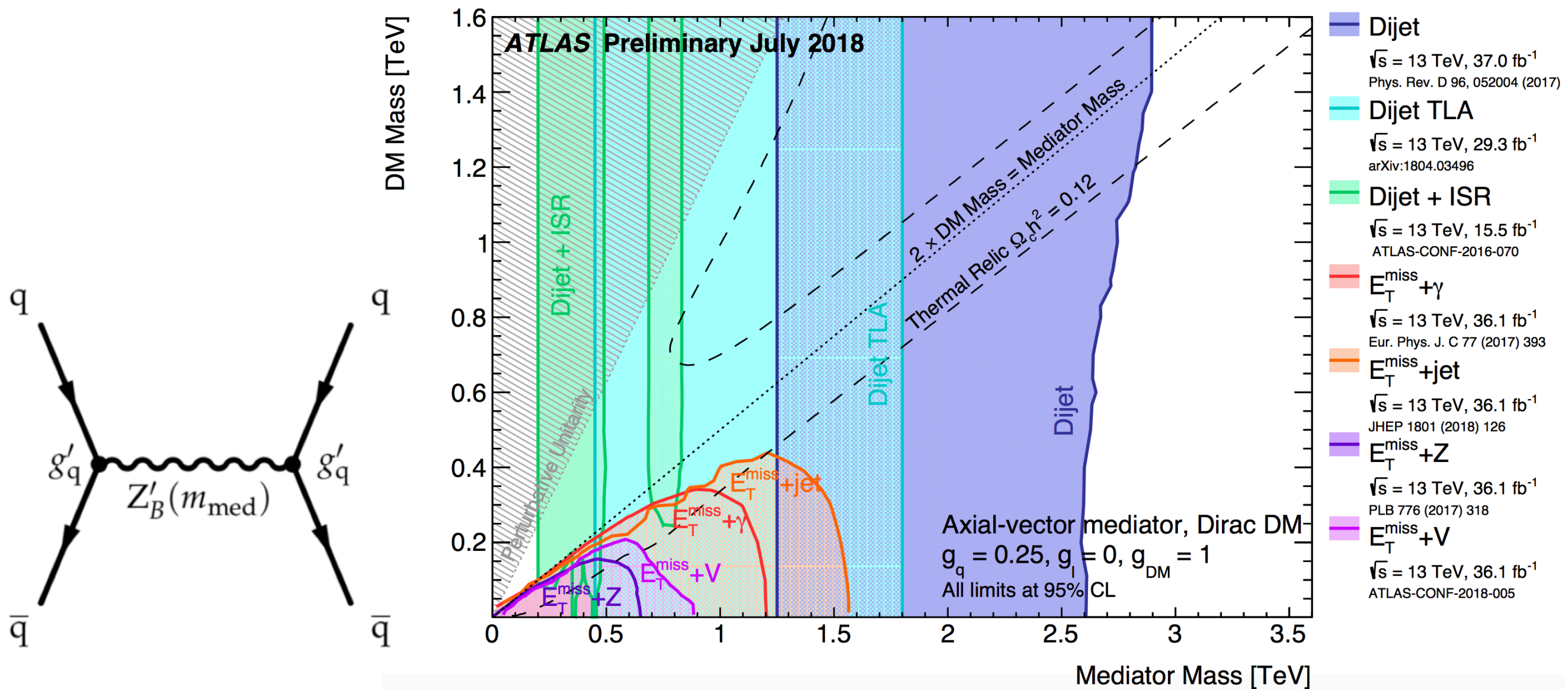


Emma Tolley "Dark Matter searches with the ATLAS Detector"

Dark Matter

Visible decay of the mediator

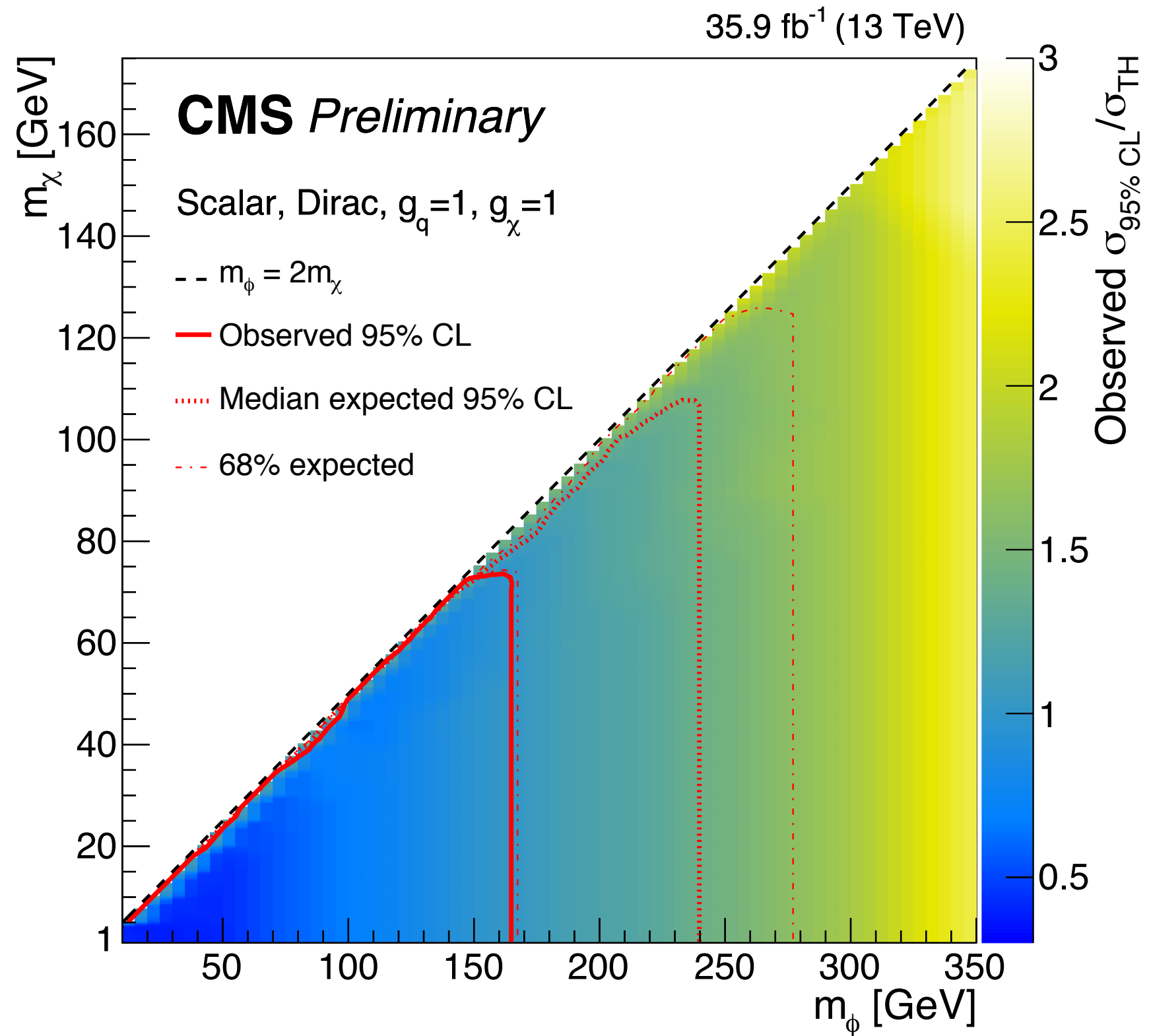
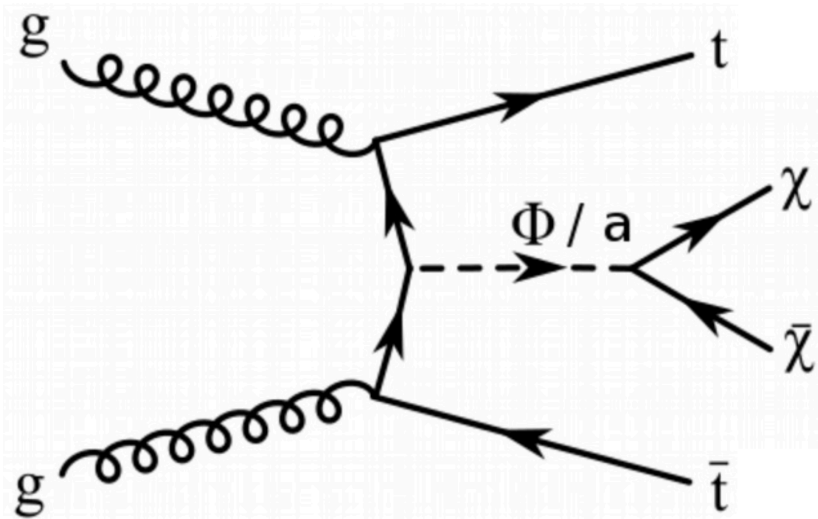
- ⇒ Mediator decays back to visible particles.
- ⇒ Signal should appear as a localised excess in di-fermion invariant mass.



Dark Matter

Spin-0 mediator

➤ Final states with top quarks are favoured due to coupling being proportional to the quark mass.



Summary

- No sign of new physics yet.
- Searches with 36 fb⁻¹ are under completion.
- First results with 80 fb⁻¹ dataset.
- There is still plenty of parameter space for searches:

Hadronic SUSY searches improve slowly but electroweak sector improve rapidly with accumulated LHC data, e.g. searches for electroweakinos or 1st and 2nd generation sleptons.

Similar improvements are expected in the searches for the exotic high mass resonances, as well as analyses techniques are developing.

For DM sensitivity gain is expected across most of the simplified models phase space and long-lived particles searches.

