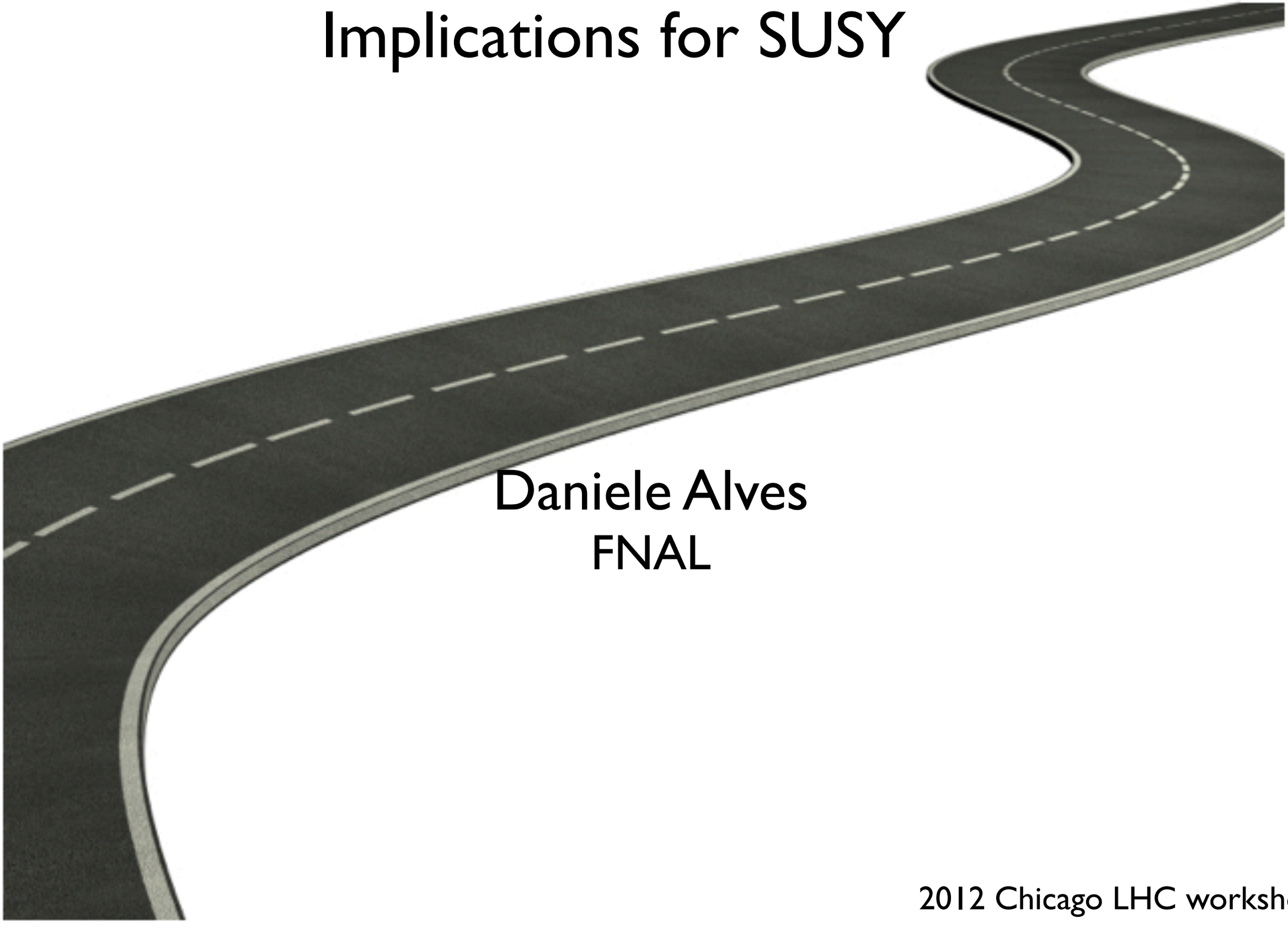
Multilepton Searches: Implications for SUSY

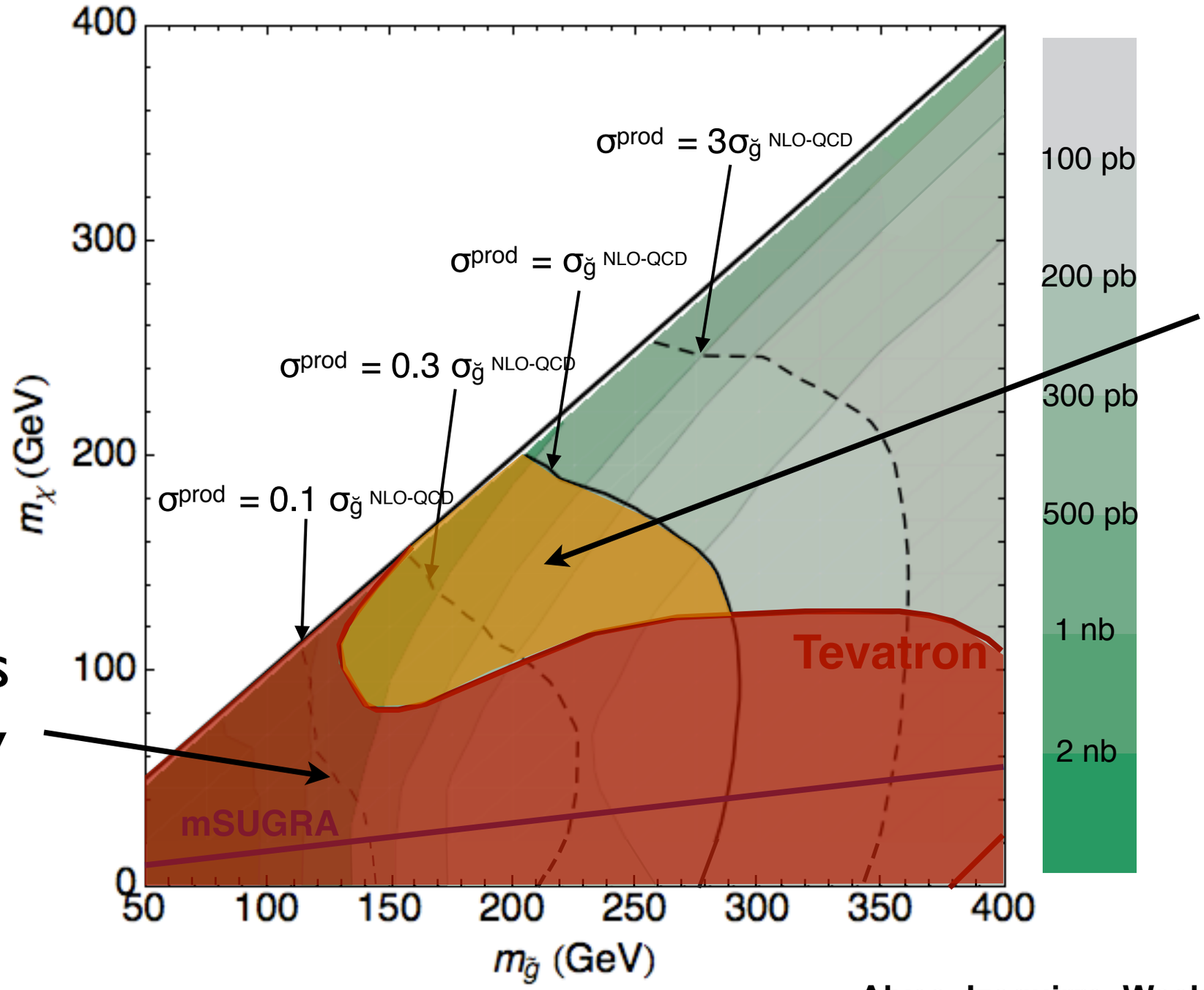


Daniele Alves
FNAL

2012 Chicago LHC workshop

Multileptons in Perpective

With 70 nb^{-1}, LHC extended Tevatron sensitivity on gluinos → jets + MET



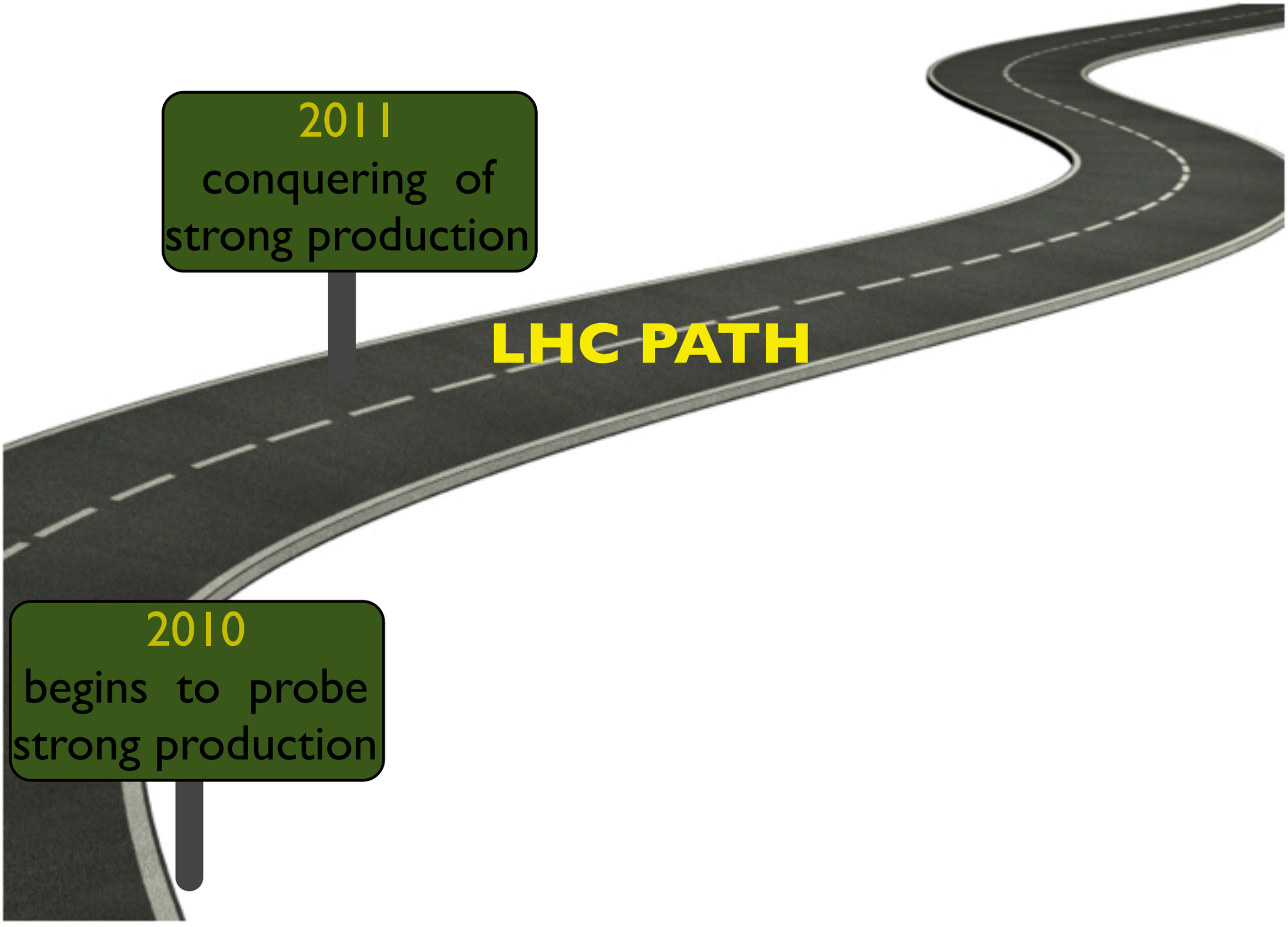
LHC's extended reach

Tevatron's sensitivity

Alwall, Lisanti, Wacker (2008)

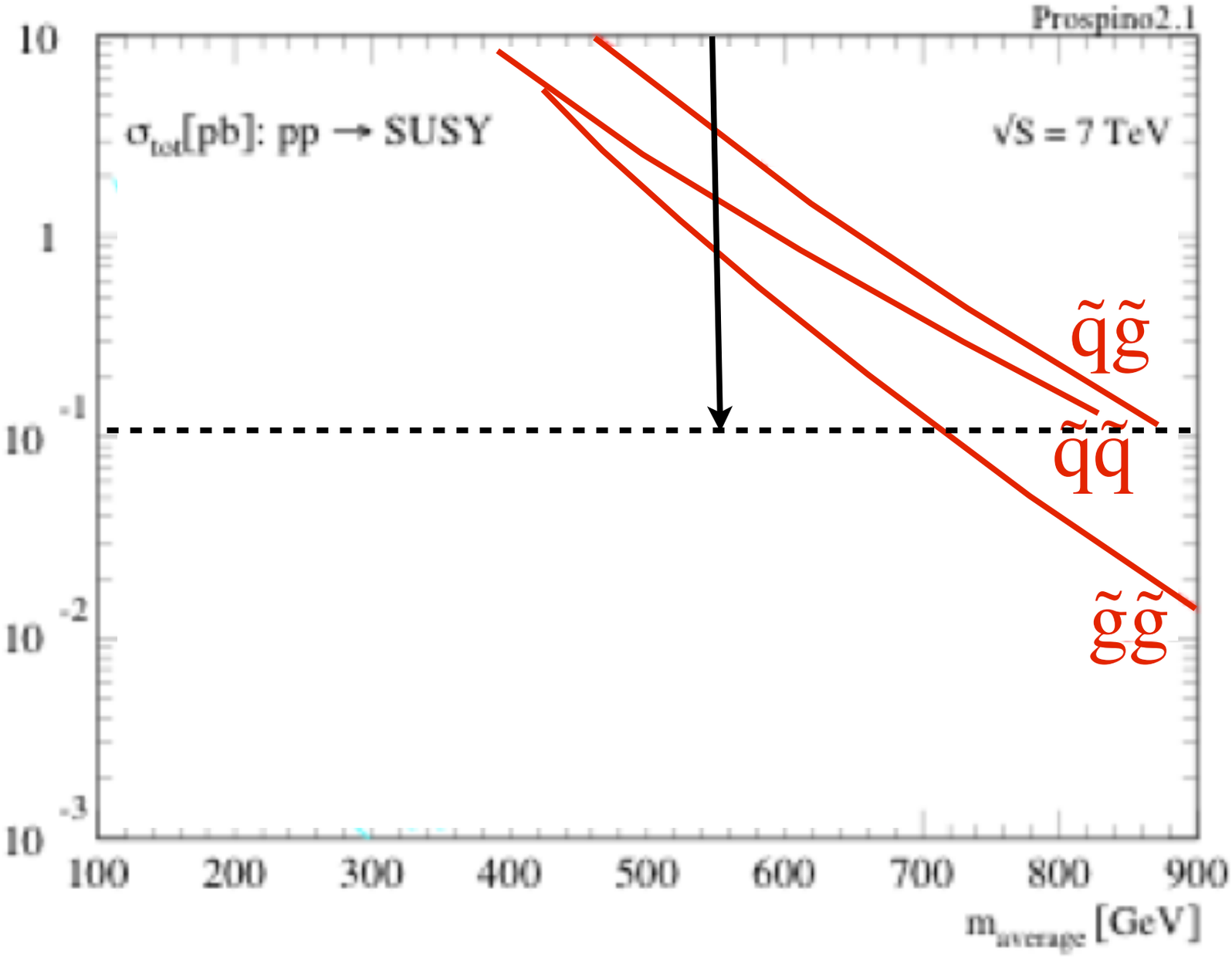
Alves, Izaguirre, Wacker (2010)

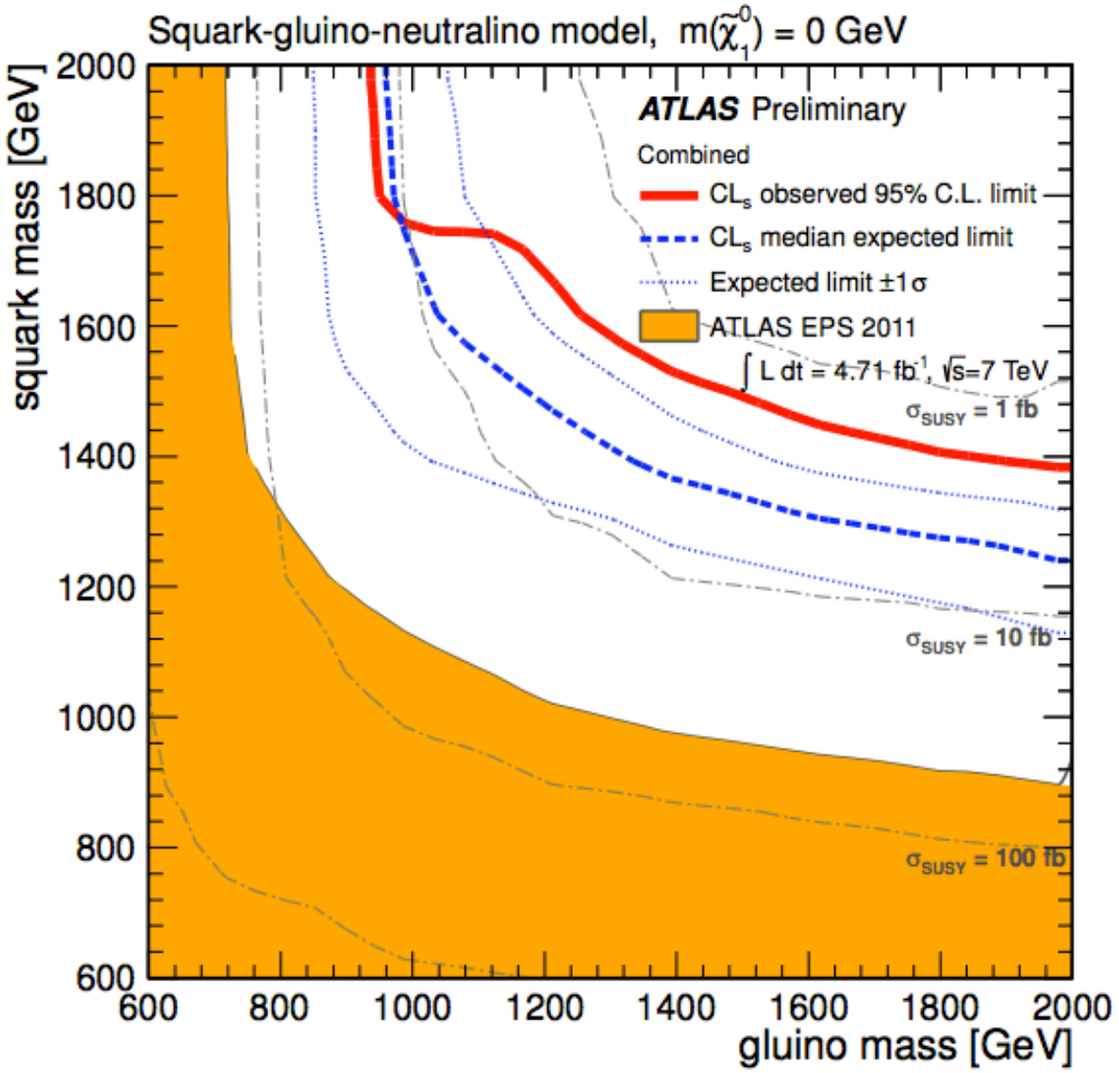
Multileptons in Perpective

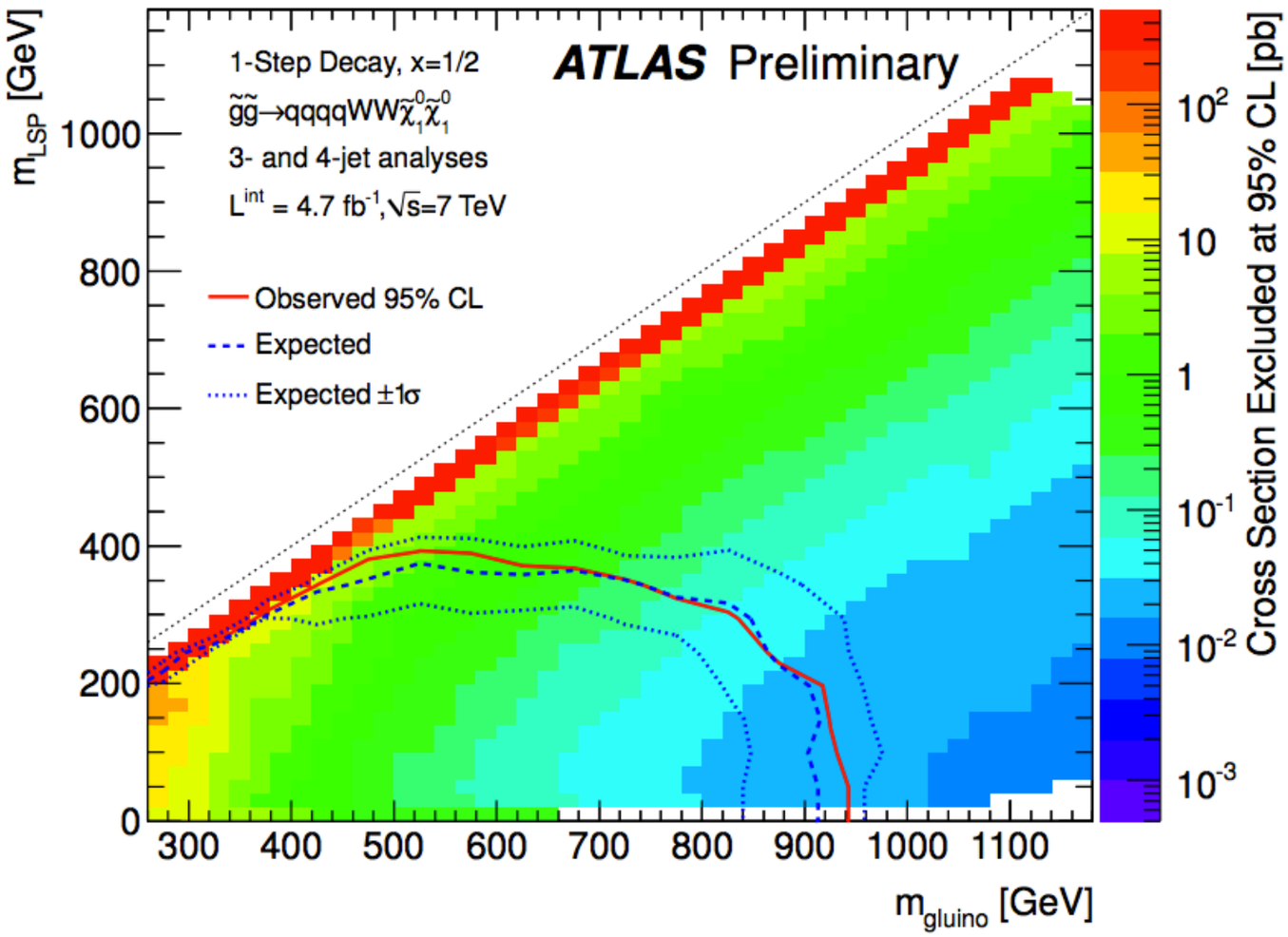


2011: Conquering Strong Production

5/fb of luminosity → probe σ~O(100 fb)





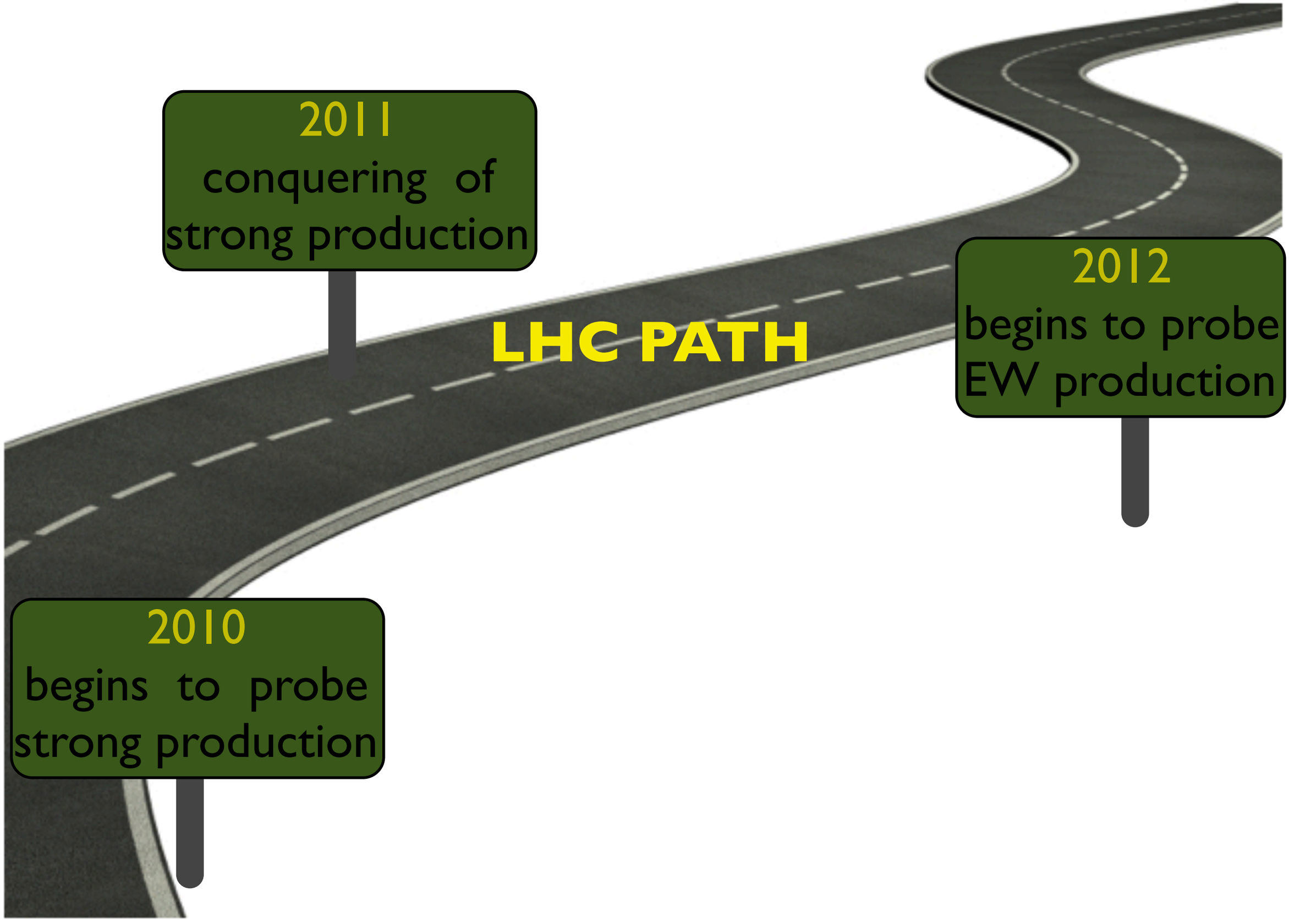


2012: more luminosity will improve limits, but not drastically

at some point searches become dominated by systematics

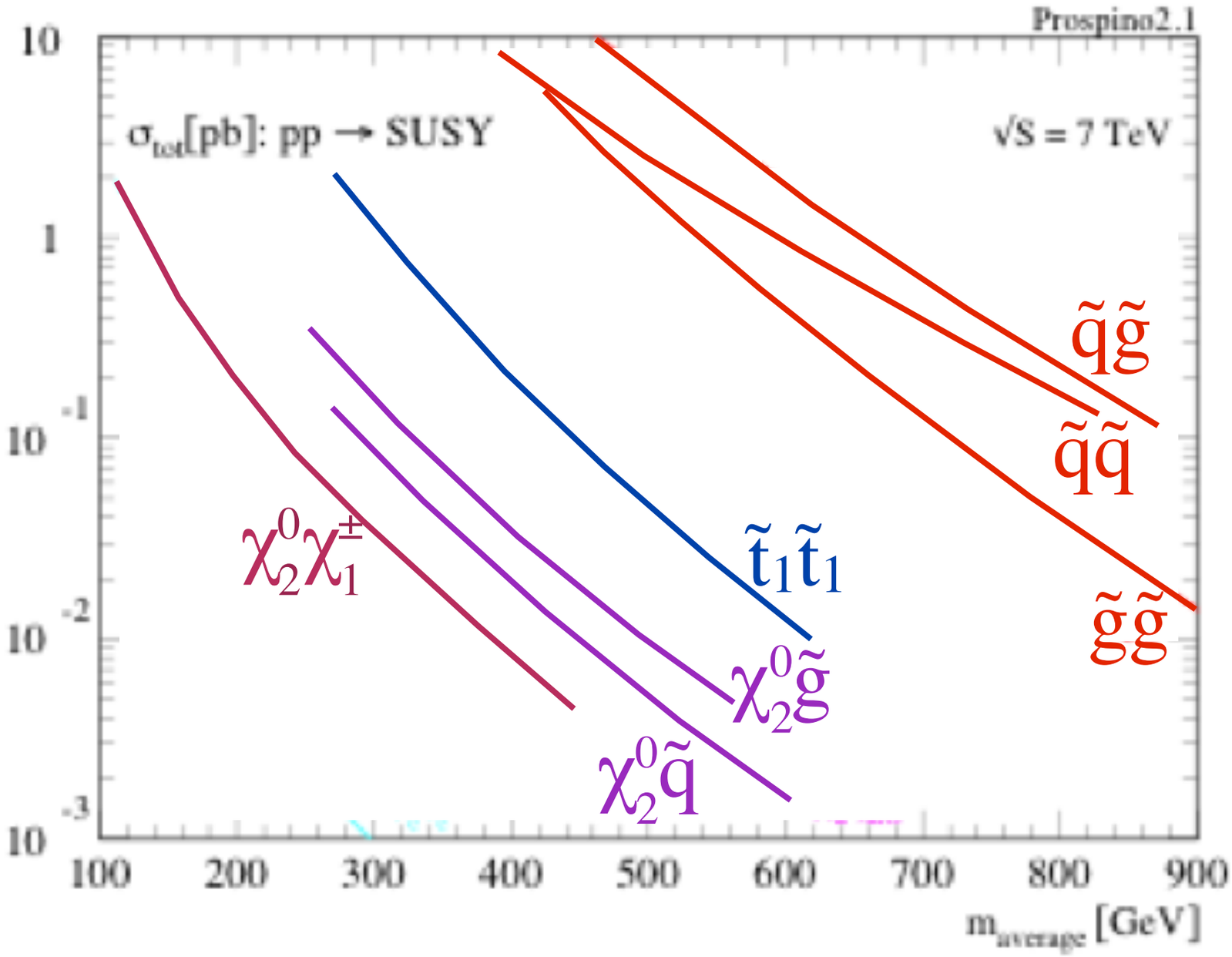
going to 13 TeV will open new territory

Multileptons in Perpective



2012: LHC will begin to probe EW production

few 10/fb of luminosity → probe σ~O(10 fb)



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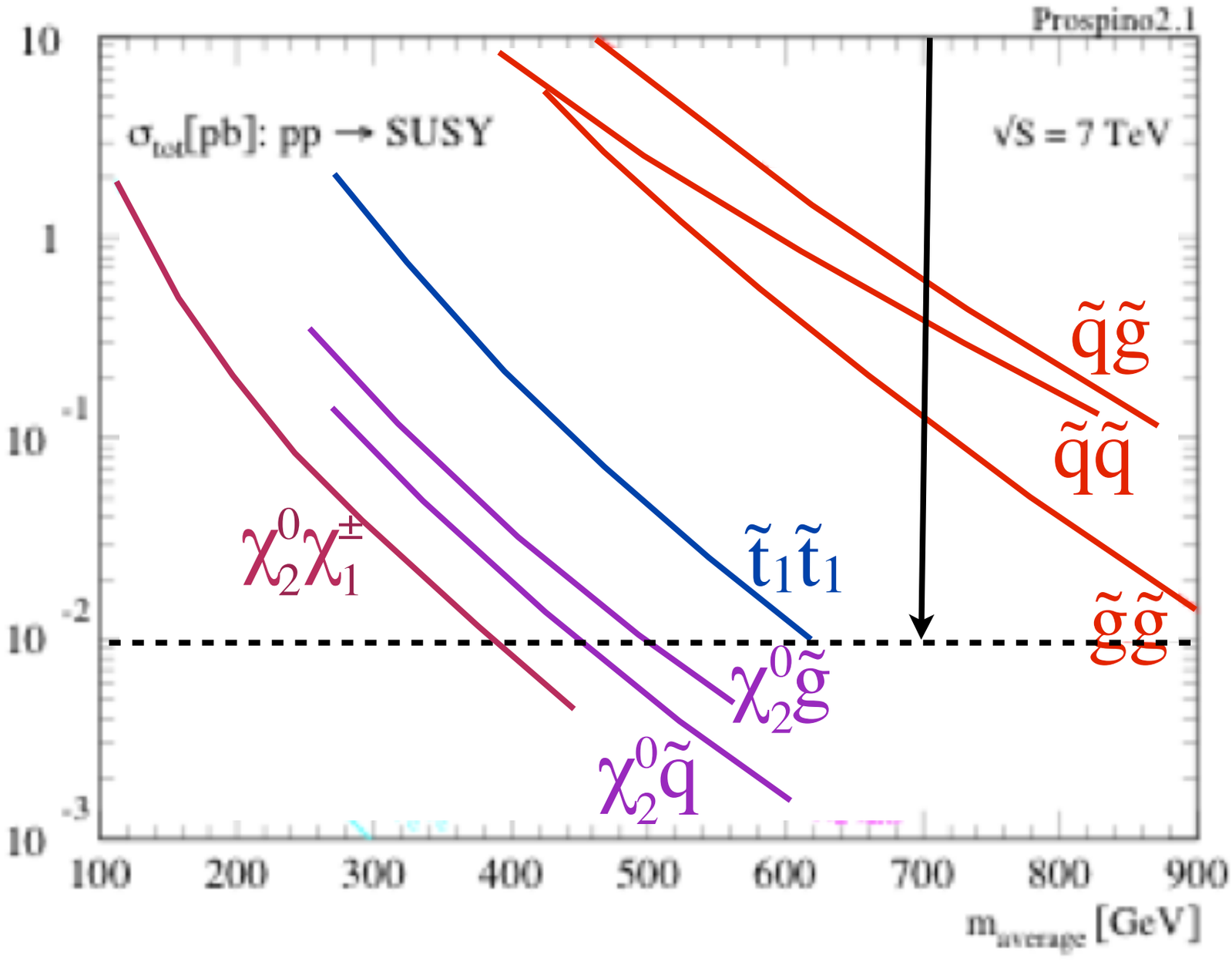


PRODUCTION

Strong

$\sigma \sim 0.01\text{-}1000$ pb

Electroweak

$\sigma \sim 0.01\text{-}1$pb

DECAY

hadronic

leptonic

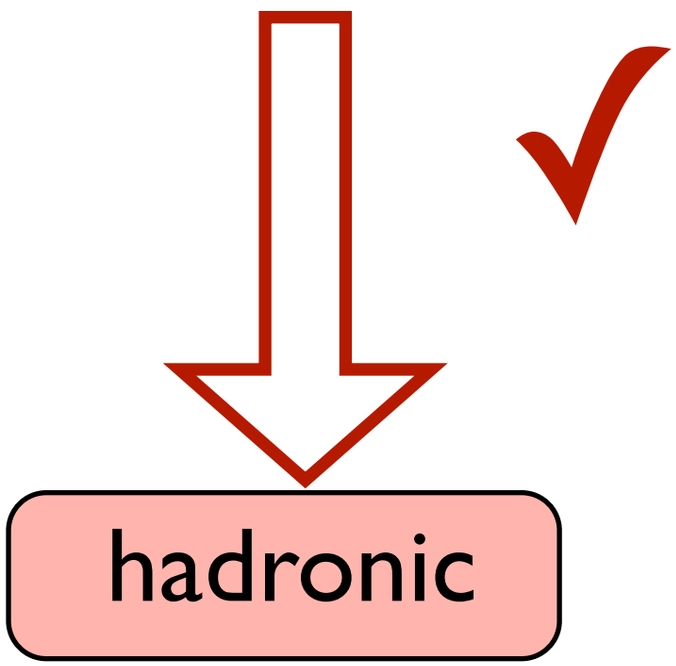
PRODUCTION

Strong

$\sigma \sim 0.01\text{-}1000$ pb

Electroweak

$\sigma \sim 0.01\text{-}1$pb



hadronic

DECAY

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σ ~ 0.01-1000 pb

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??

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DECAY

hadronic

leptonic

OUTLINE

→ Multilepton bounds on strong production

→ R-parity preserving
→ RPV

→ Multilepton bounds on elecroweak production

→ R-parity preserving
→ RPV

→ Interlude: Simplified Models

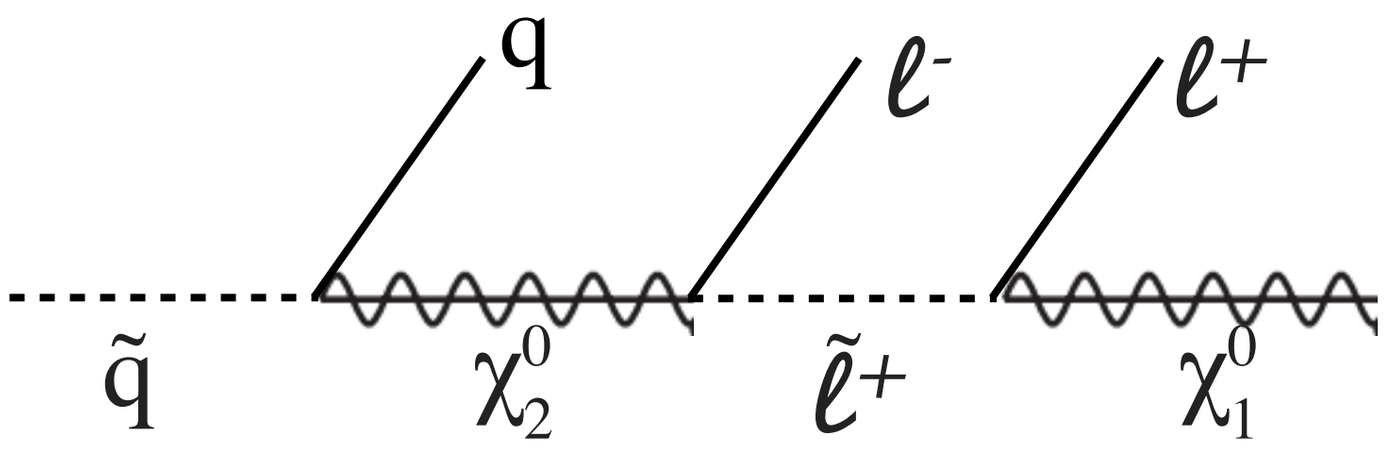
→ Wish list of Simplified Model plots

→ Concluding remarks

Multileptons and Strong Production

ATLAS trilepton search with 35/pb

PMSSM



Multileptons and Strong Production

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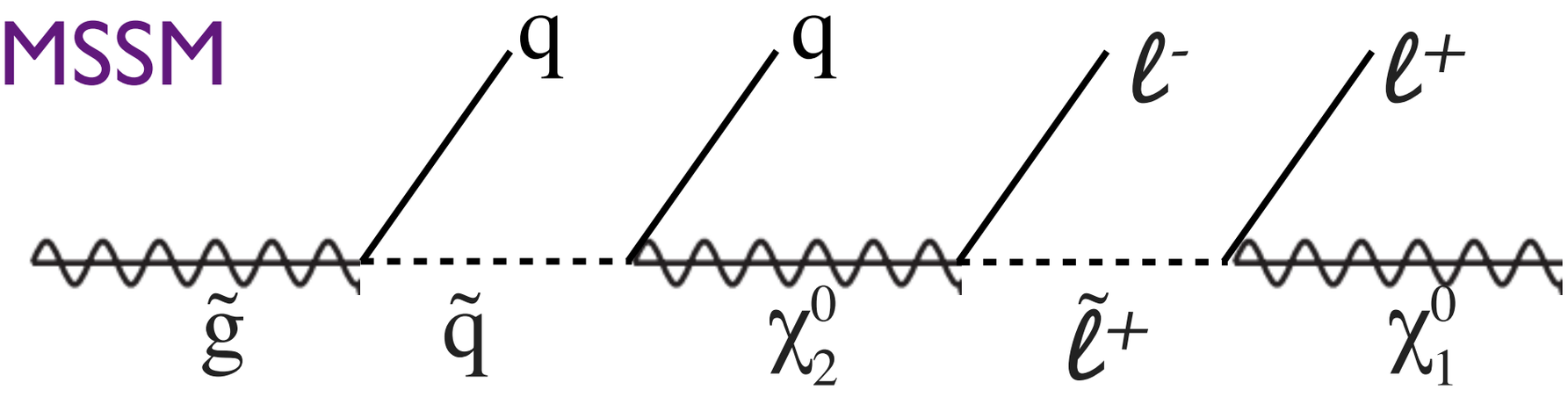

Multileptons and Strong Production

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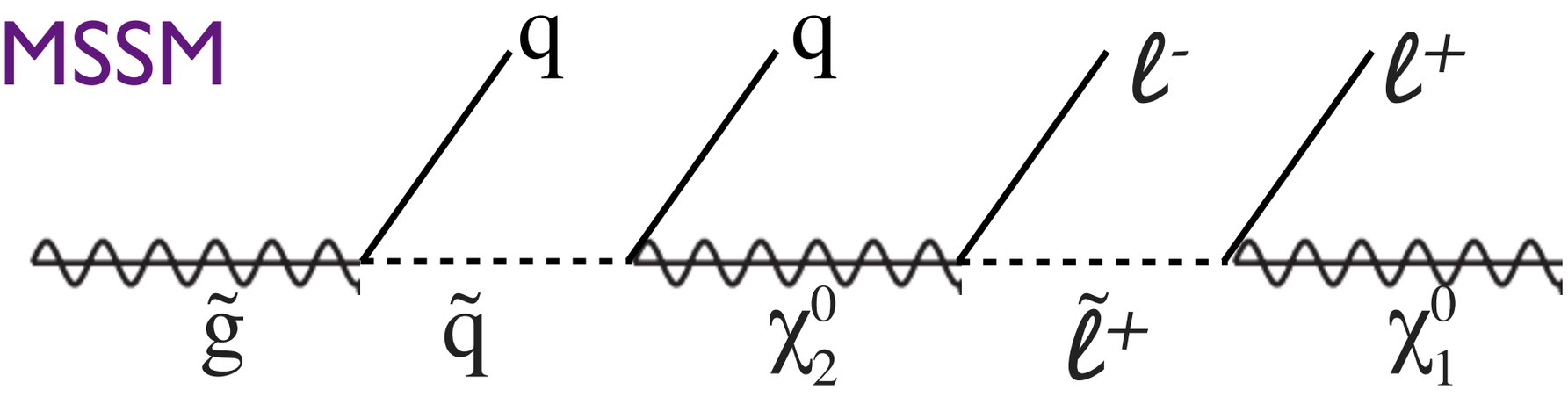

$m_A = 1$ TeV

$\mu = 1.5x \min(m_{go}, m_{sq})$

$\tan\beta = 4$

$A_t = A_b = A_l = \mu/\tan\beta$

$m_{3rd\text{-}sf} = 2$ TeV

$m_{1st\text{-}sq} = m_{2nd\text{-}sq}$

$m_{1st\text{-}sl} = m_{2nd\text{-}sl}$

Multileptons and Strong Production

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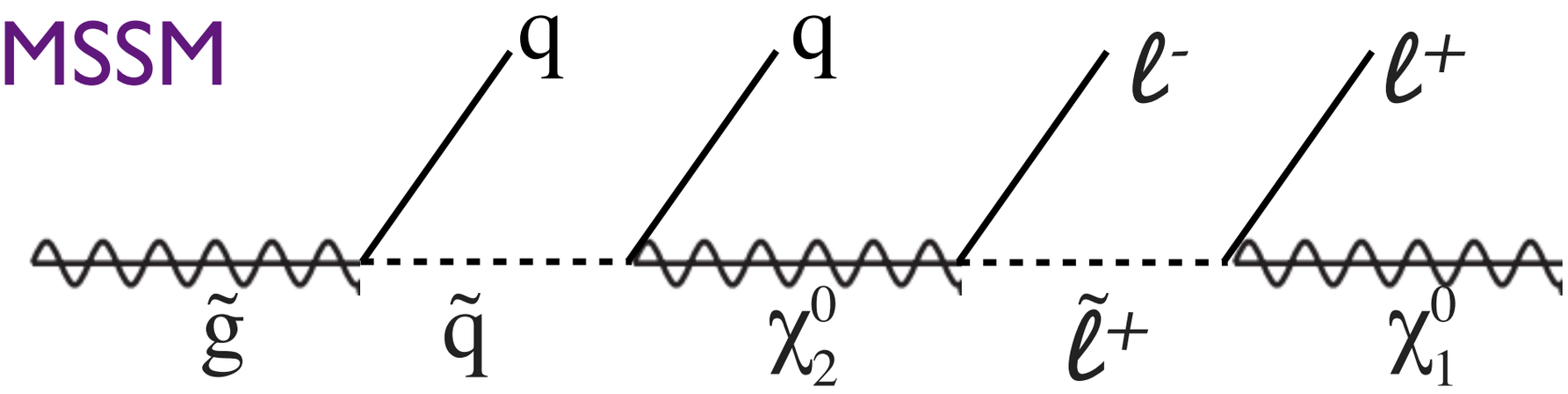

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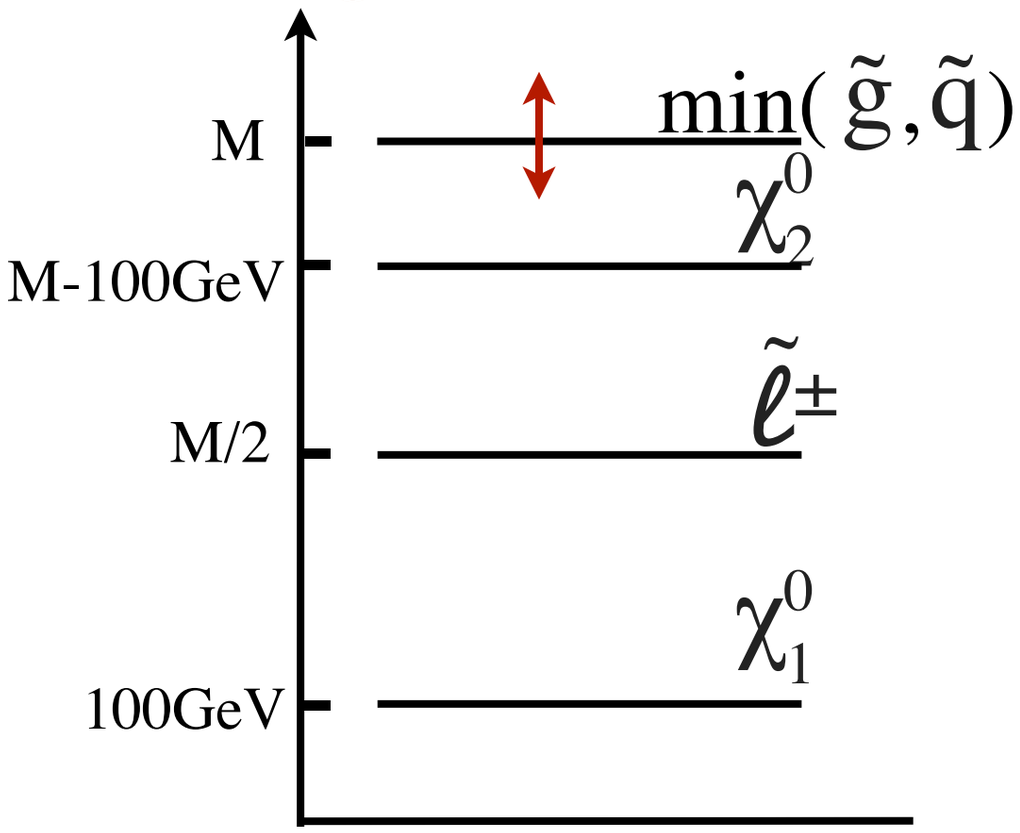
"light neutralino"



Multileptons and Strong Production

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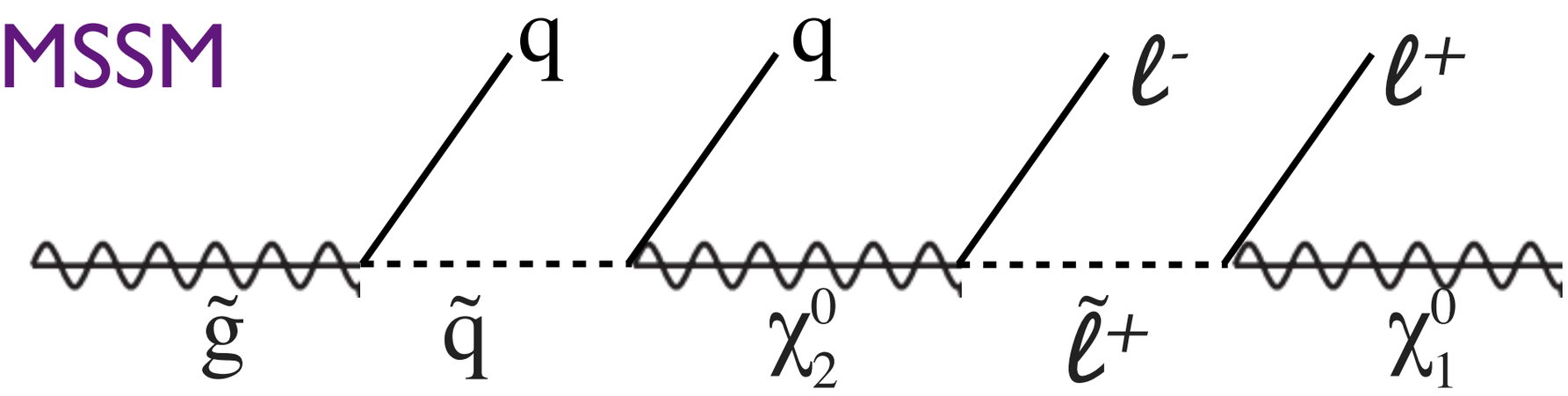
PMSSM



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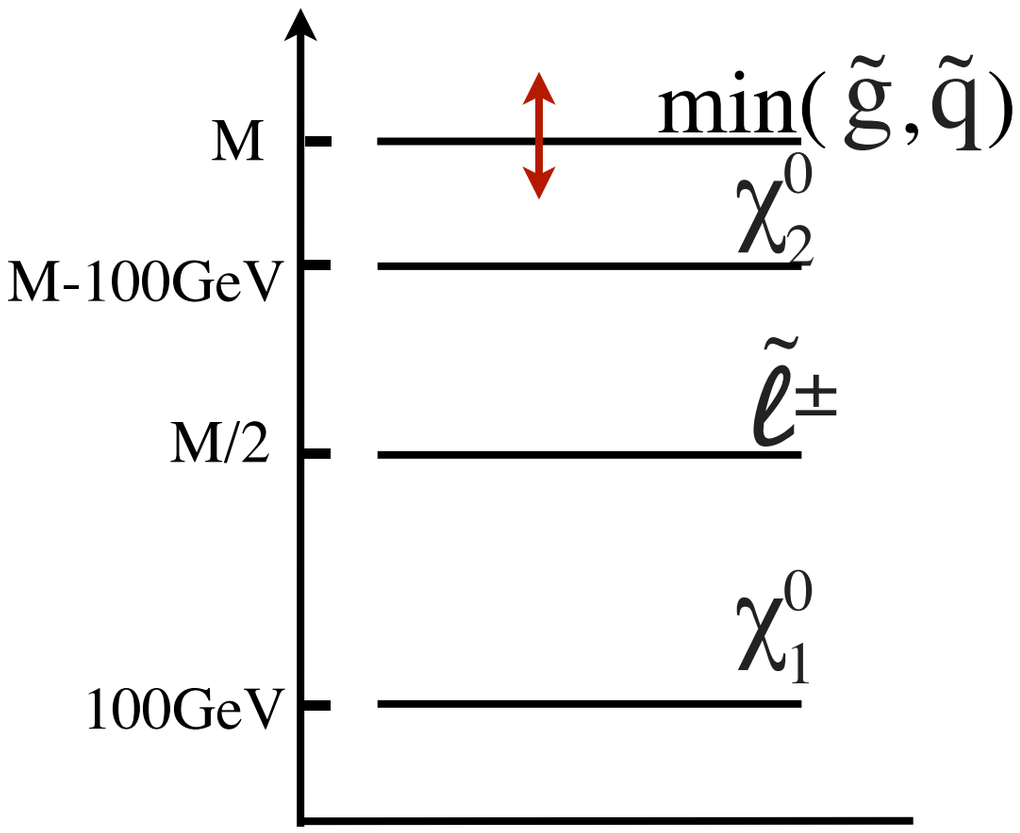
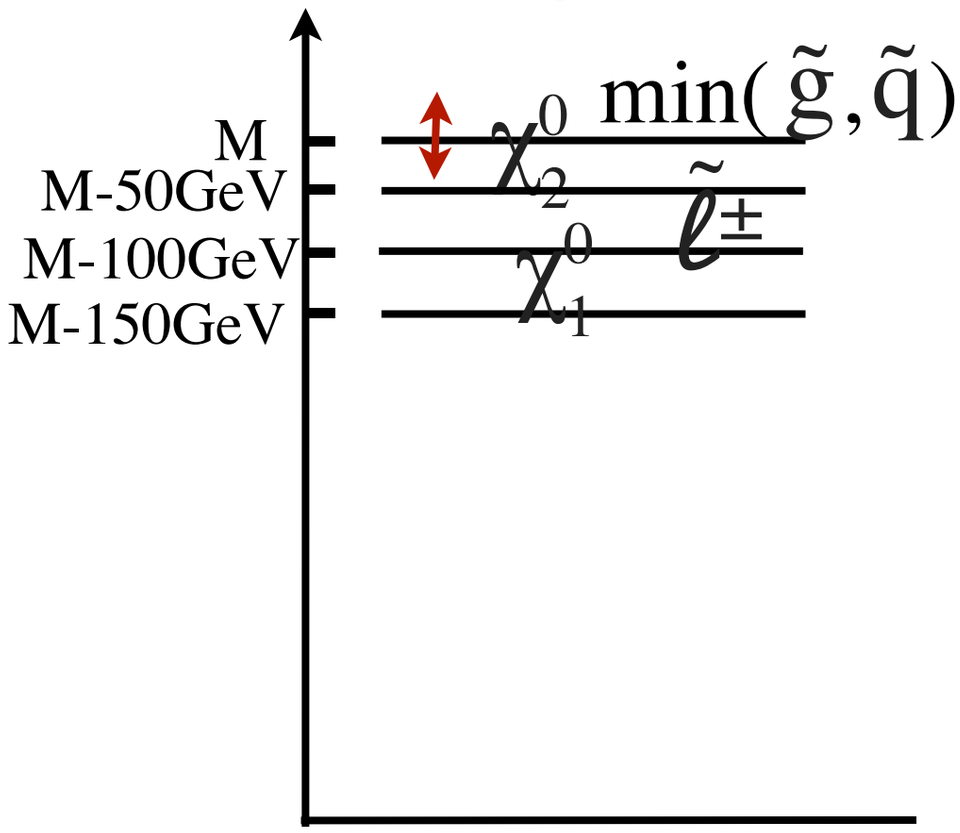
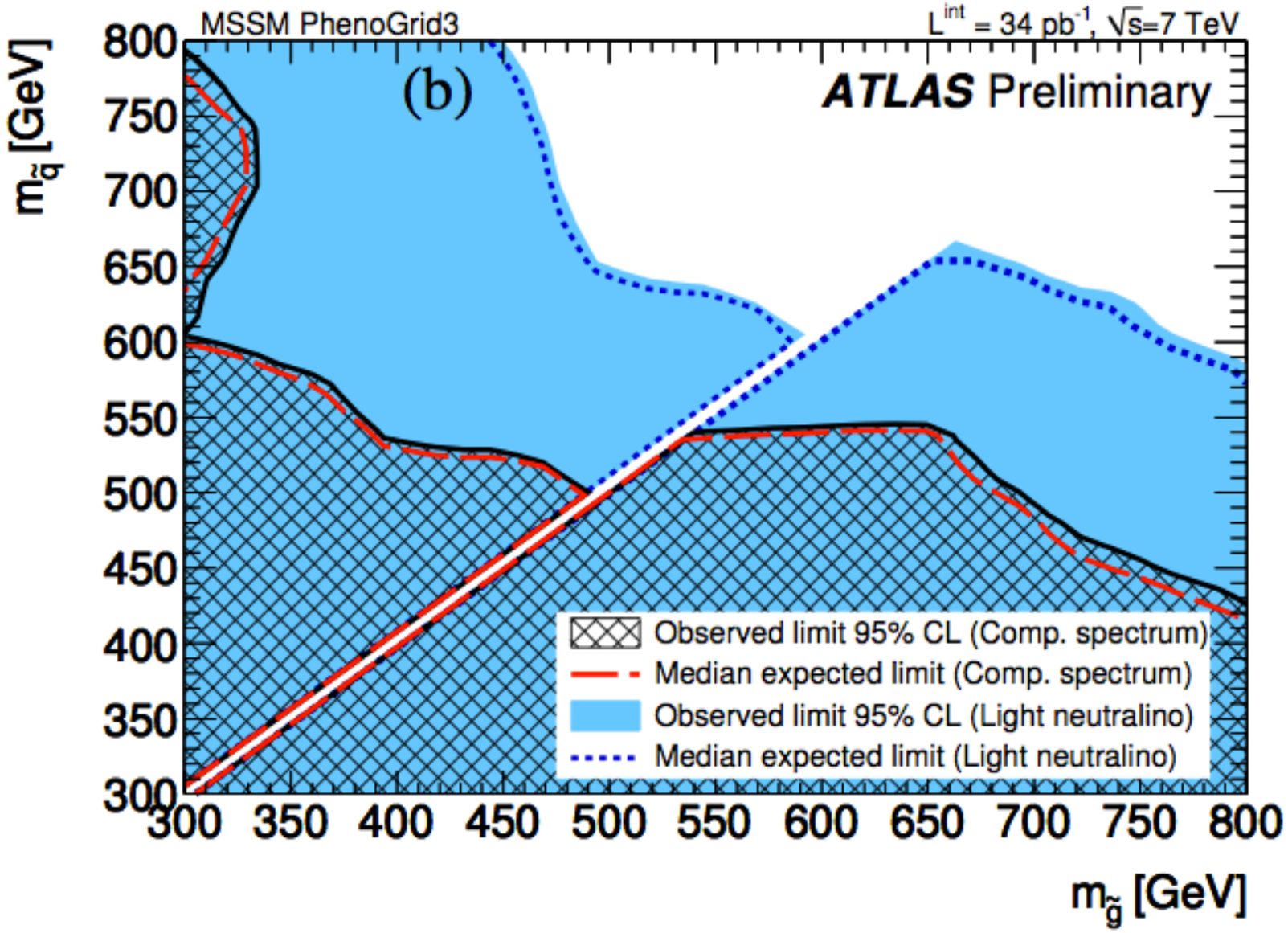


"compressed"



Multileptons and Strong Production

ATLAS trilepton search with 35/pb



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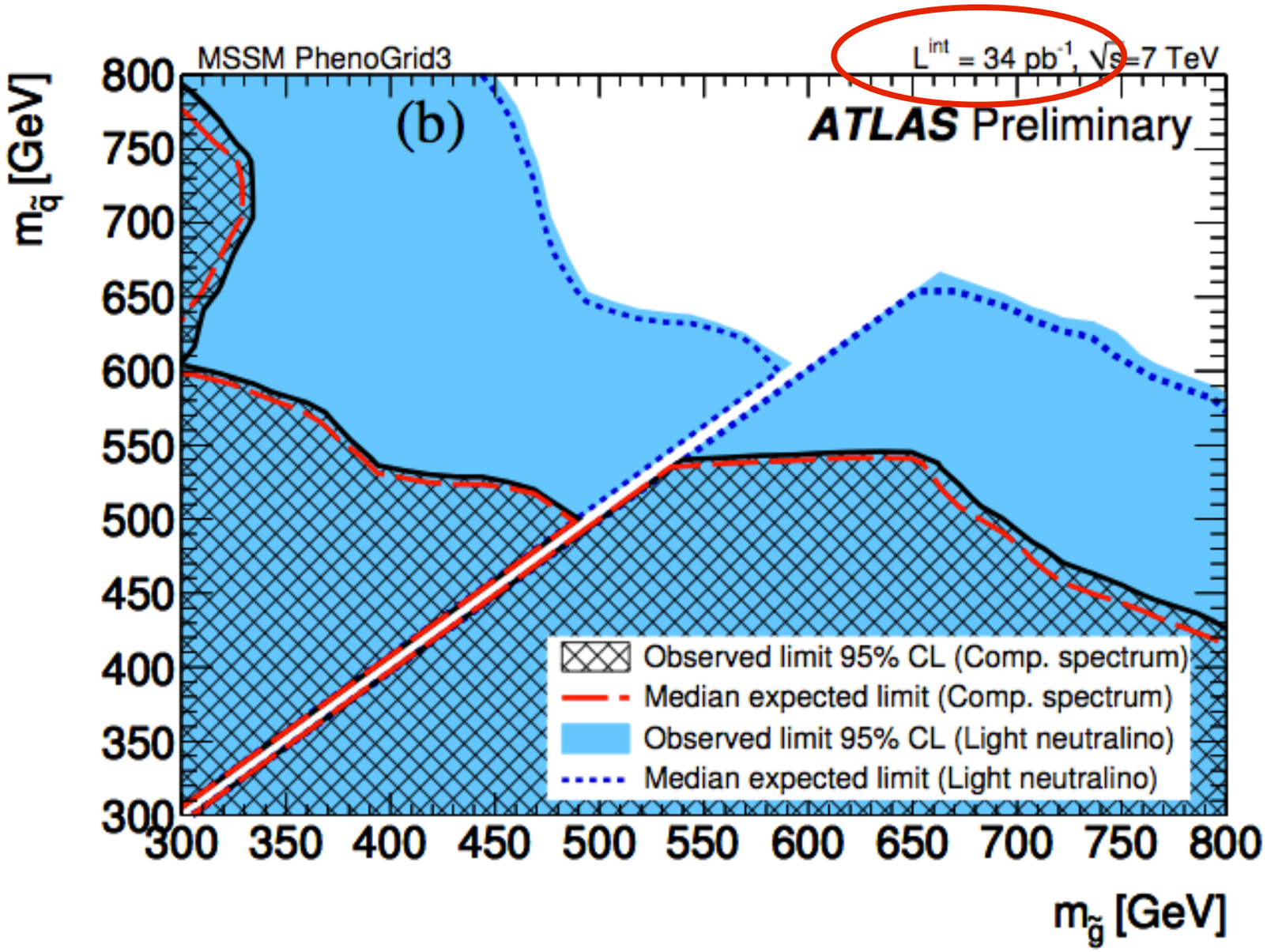

Multileptons and Strong Production

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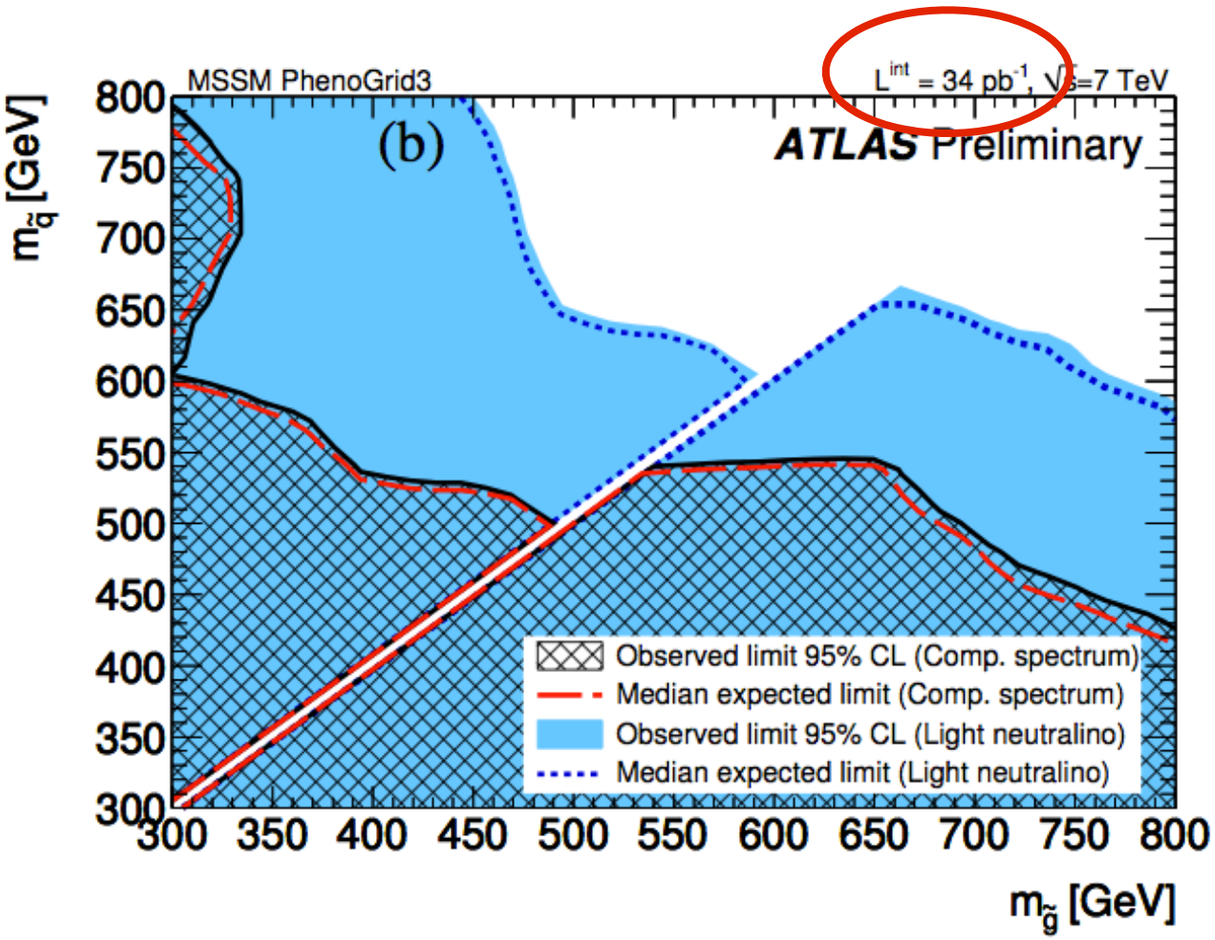

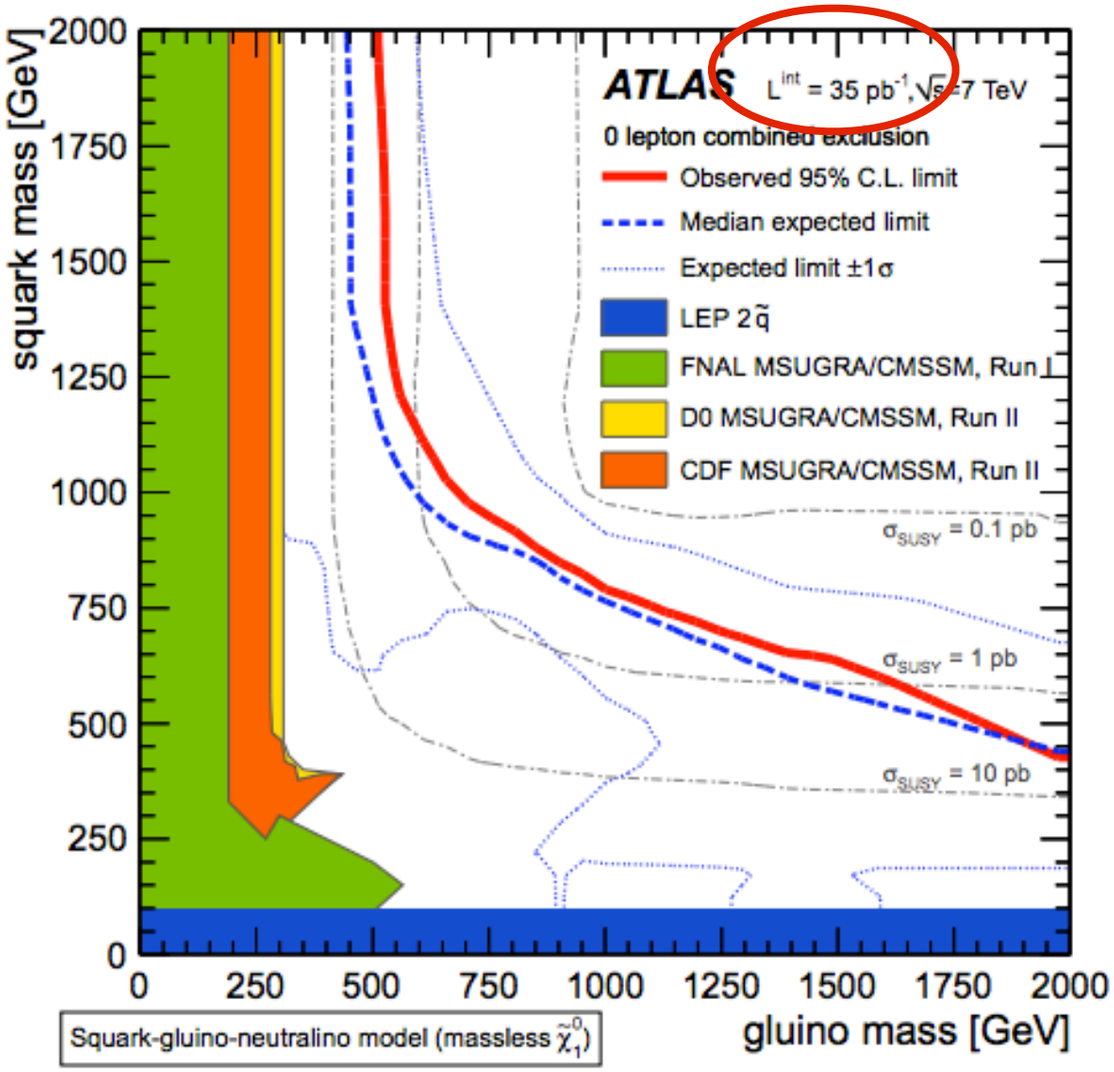

Multileptons and Strong Production

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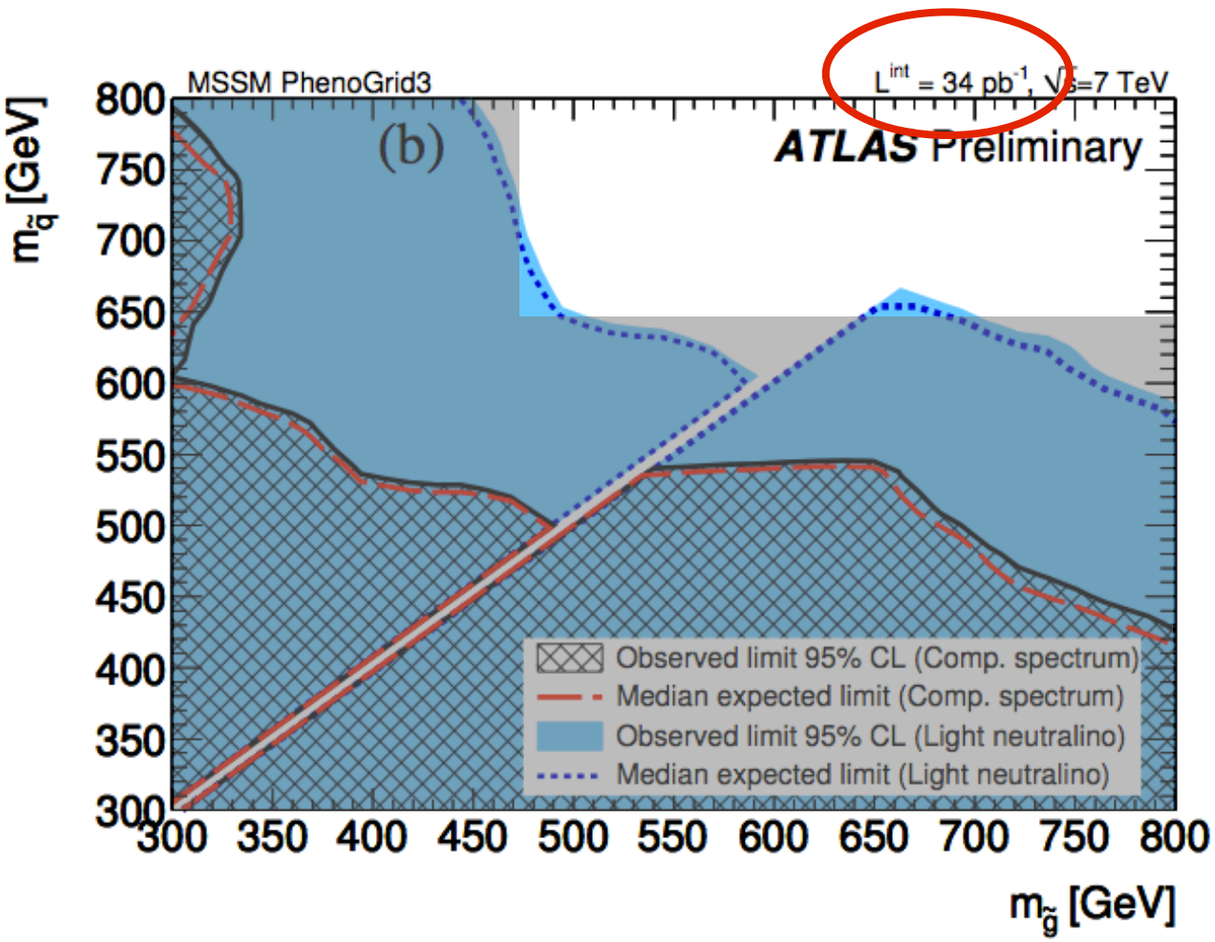
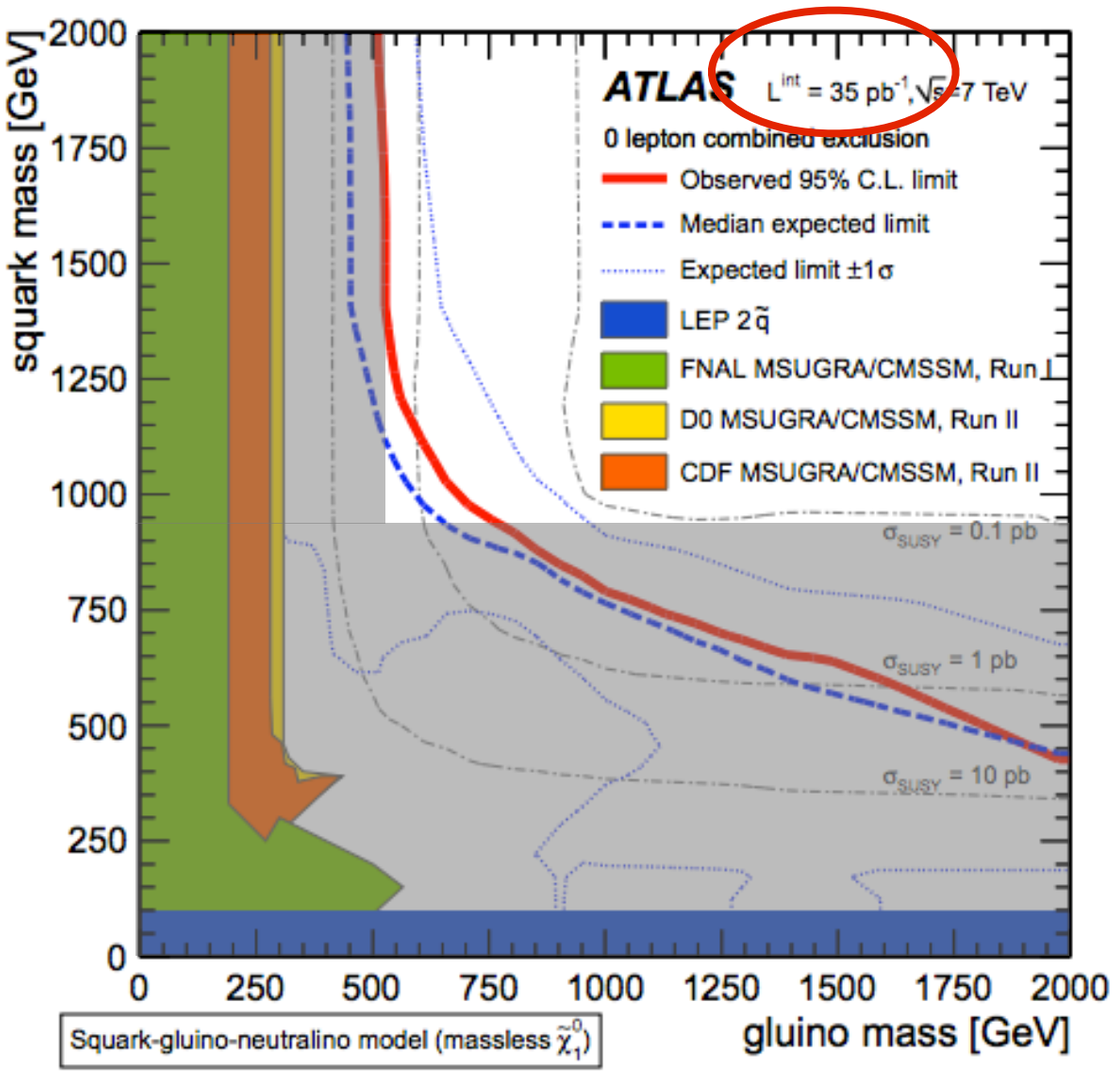
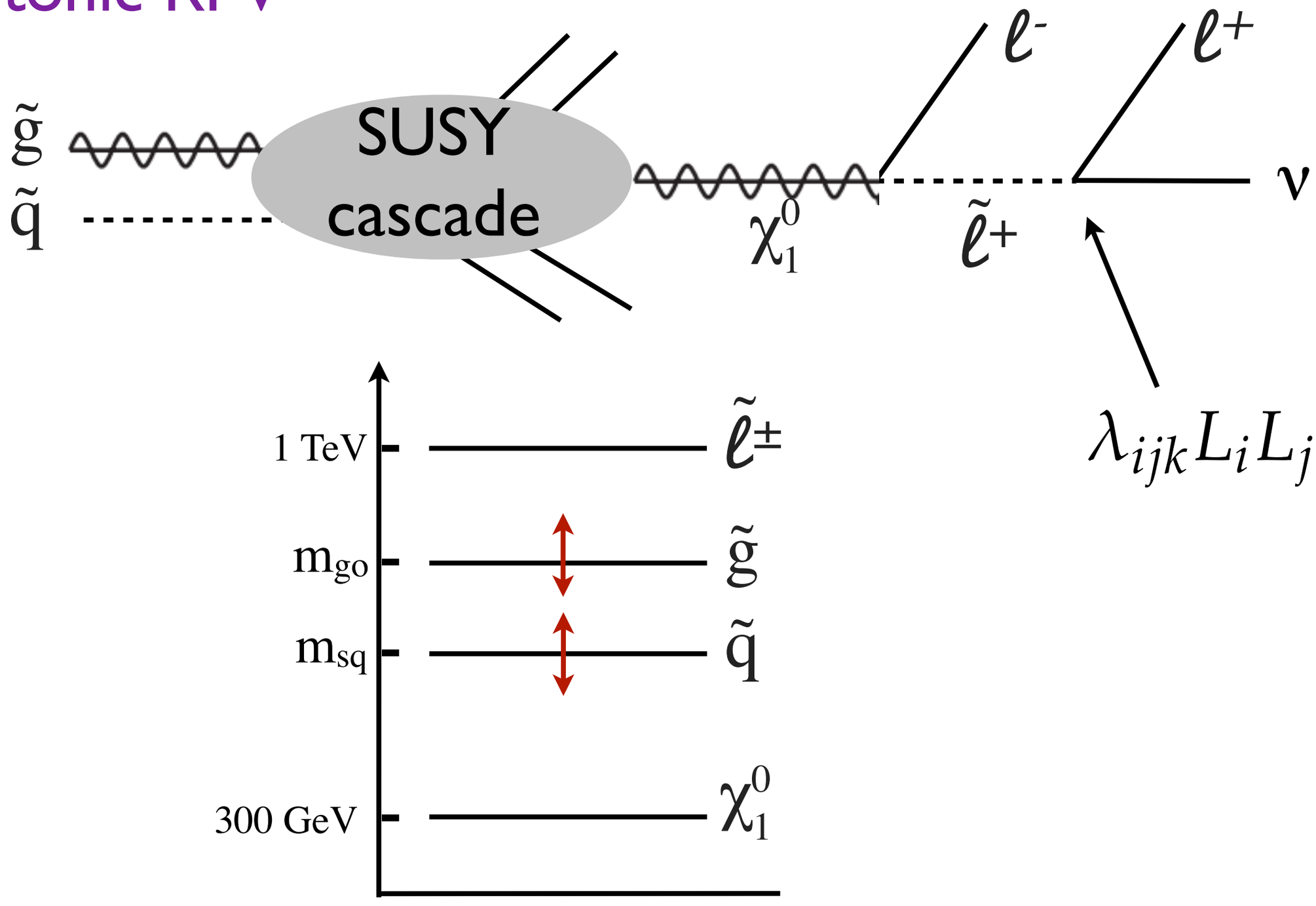




Multileptons and Strong Production

CMS multilepton search with 35/pb

leptonic RPV



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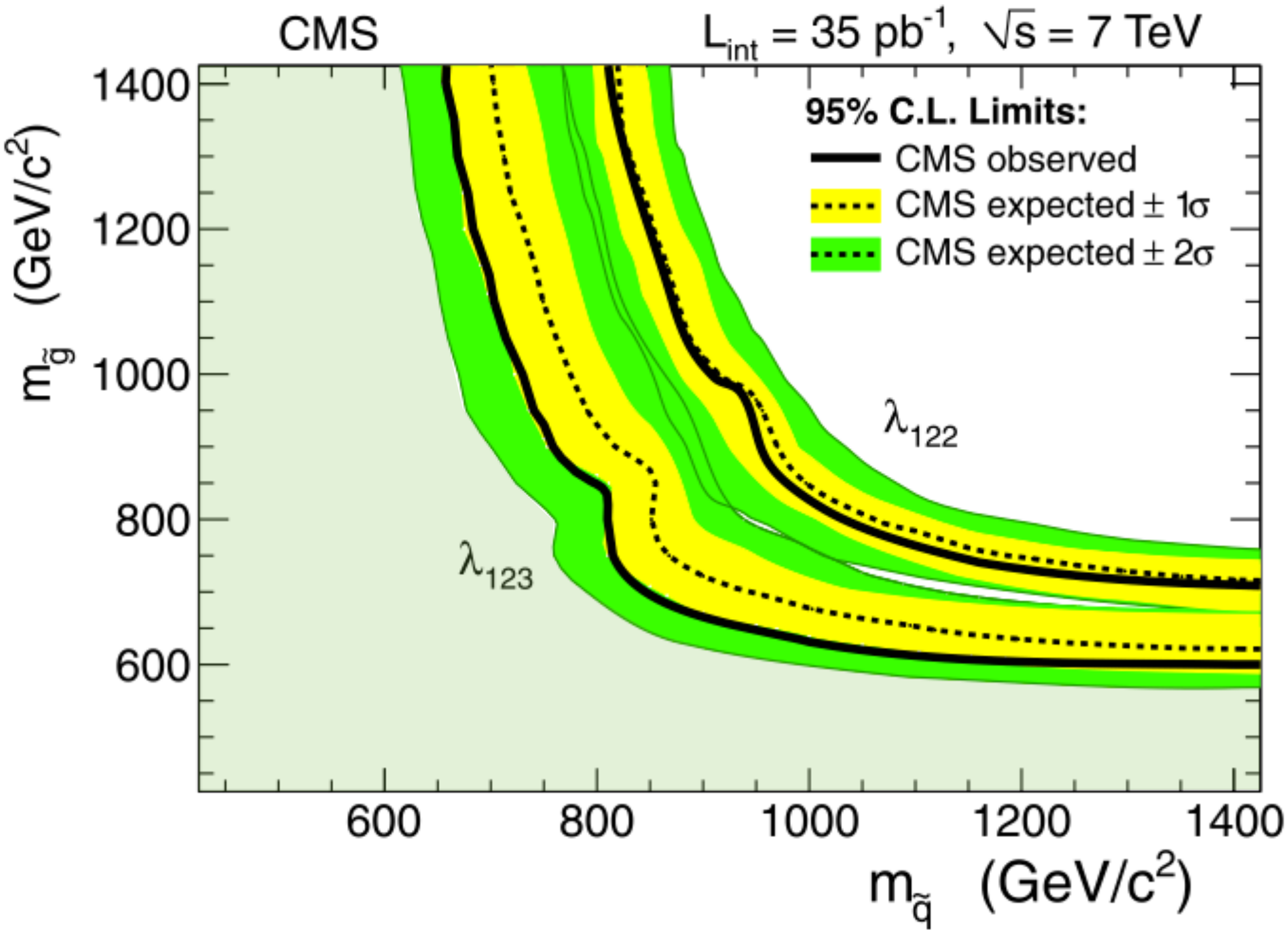

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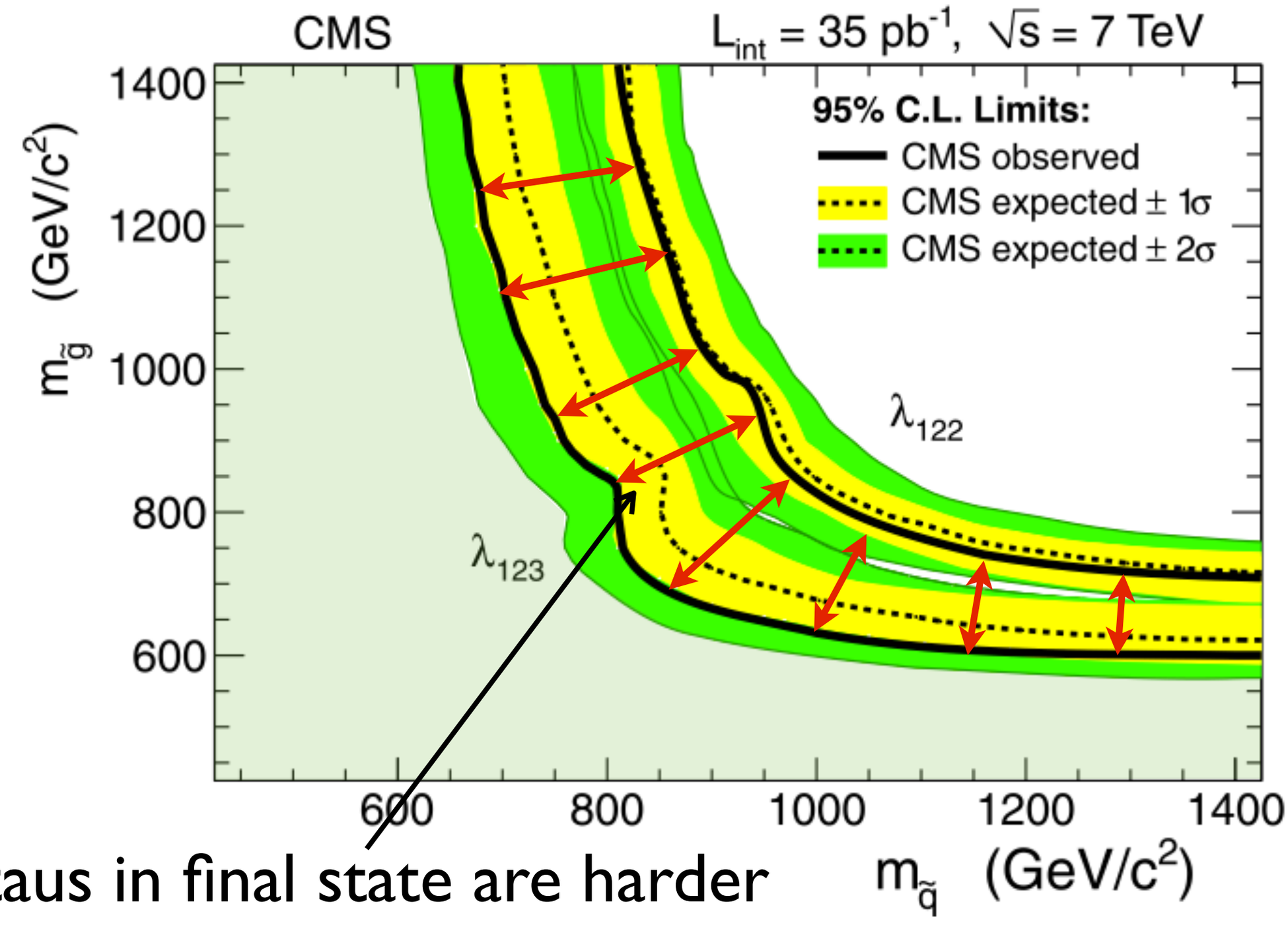
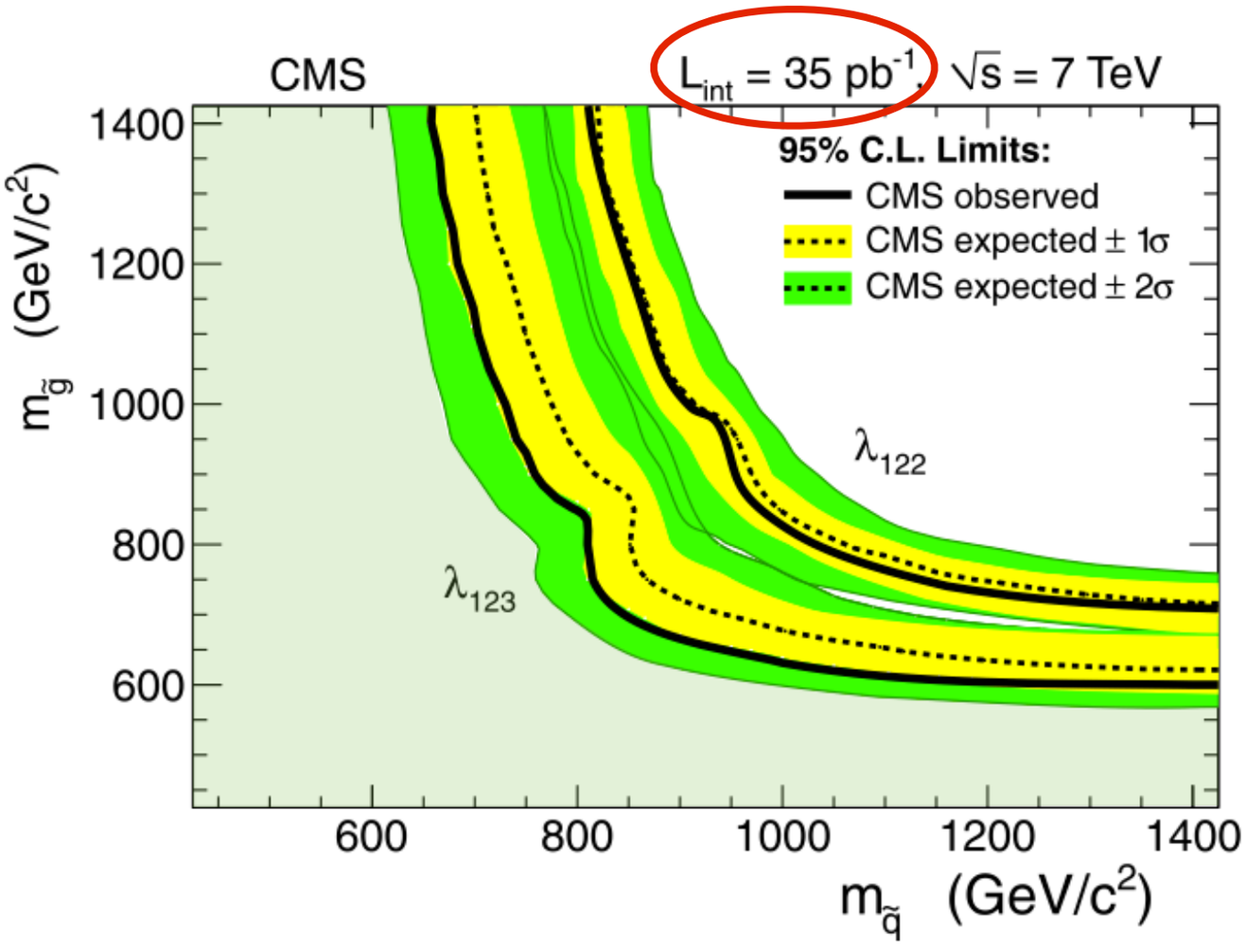
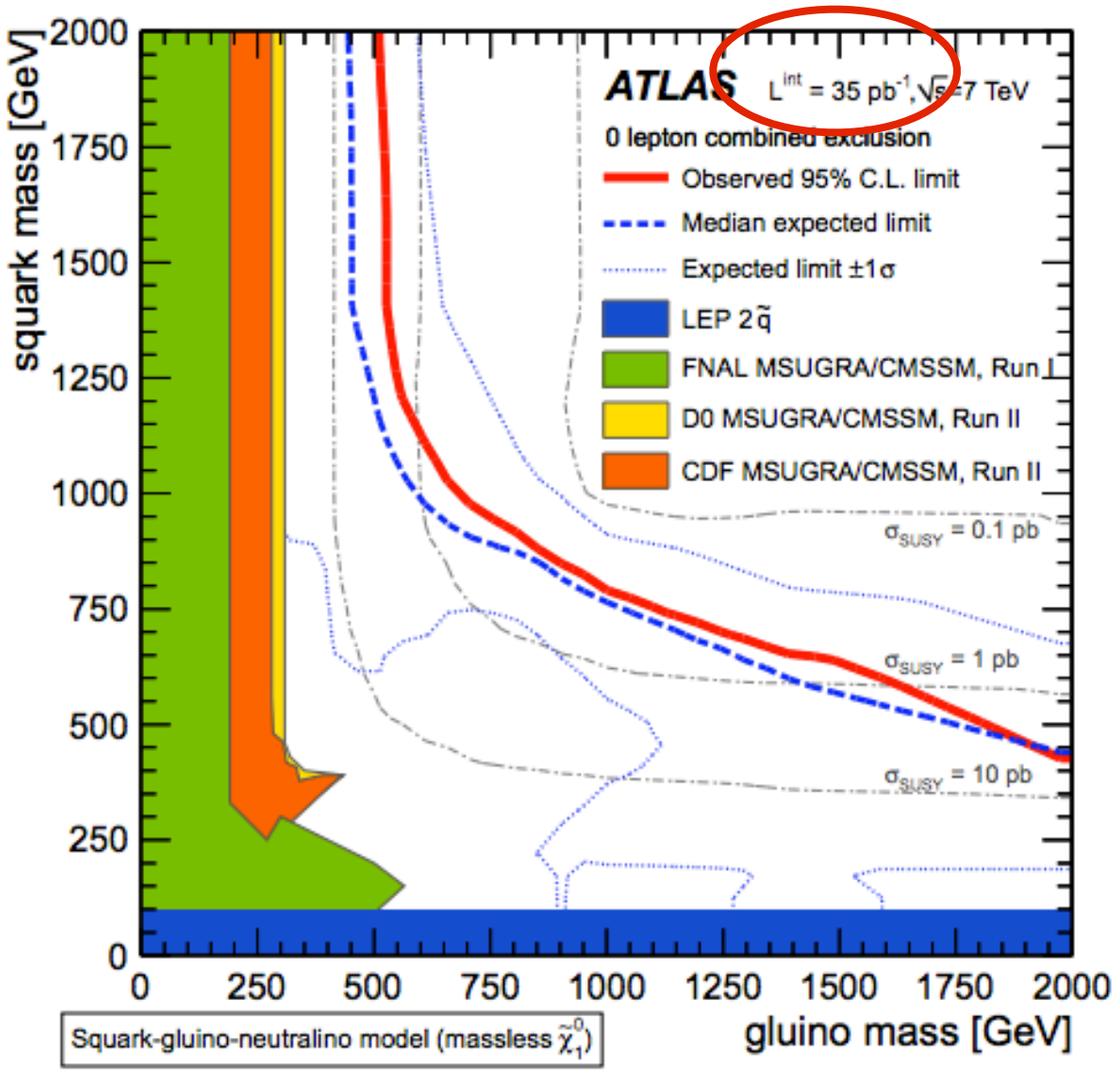


taus in final state are harder

Multileptons and Strong Production

CMS multilepton search with 35/pb





Multileptons and Strong Production

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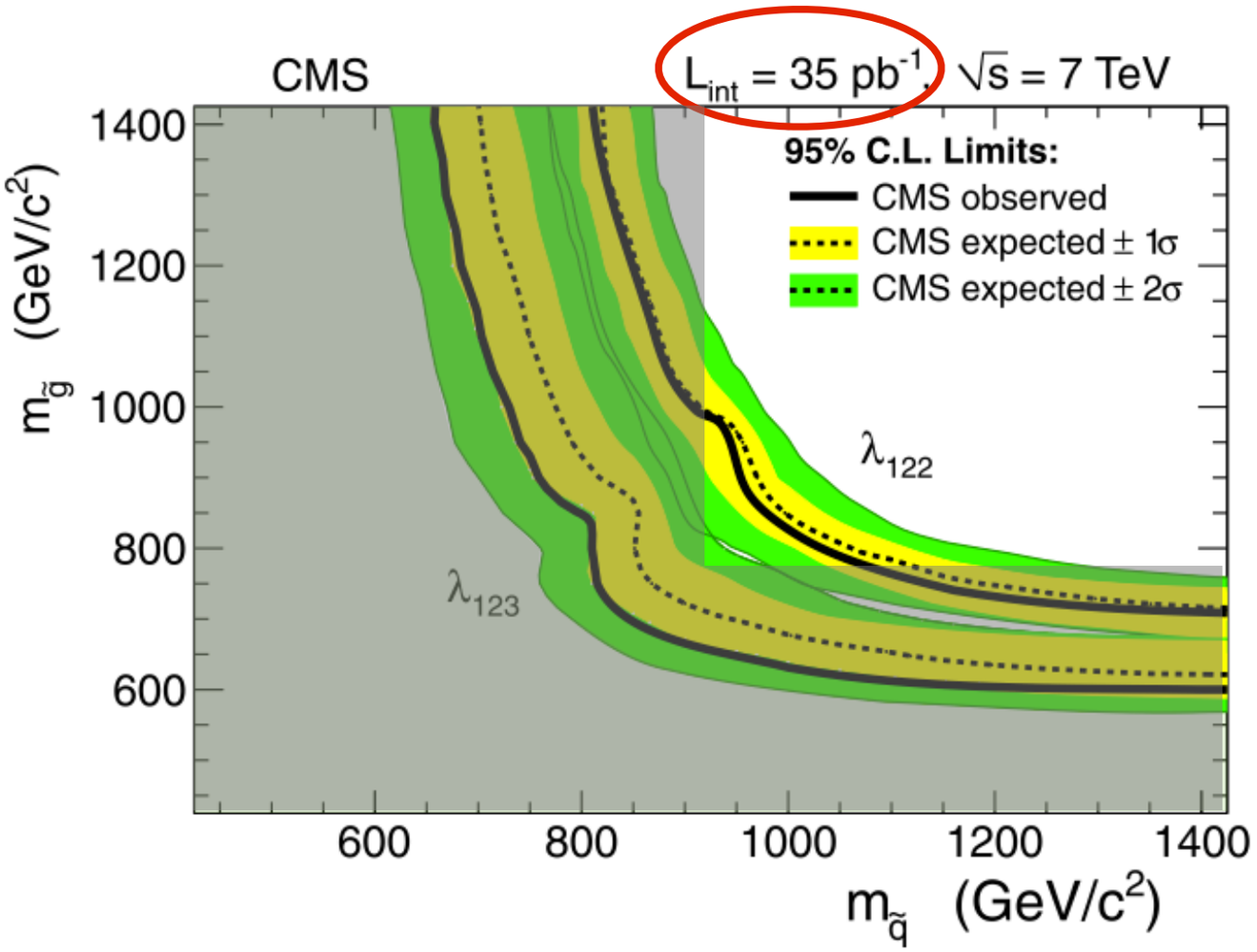
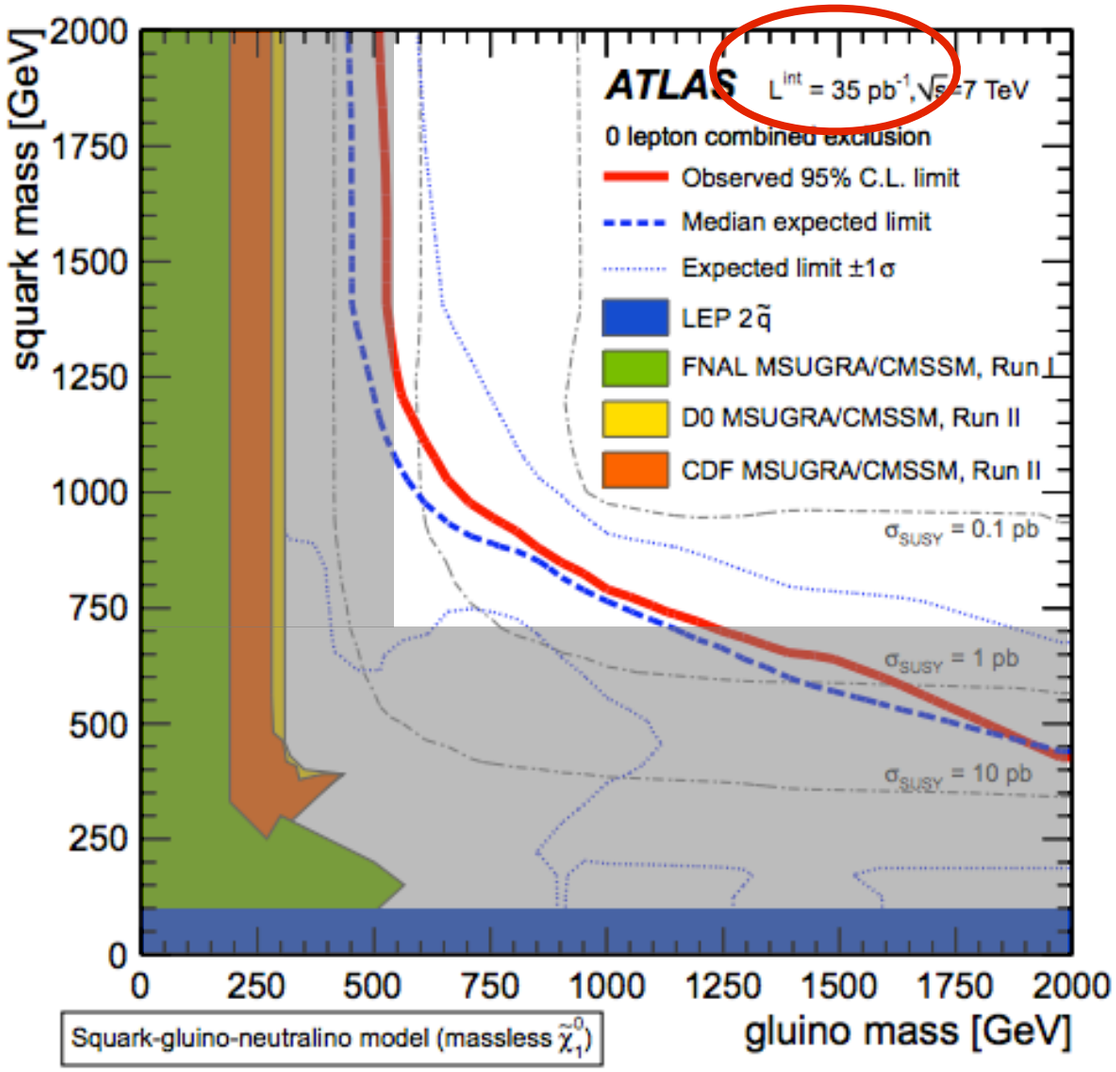
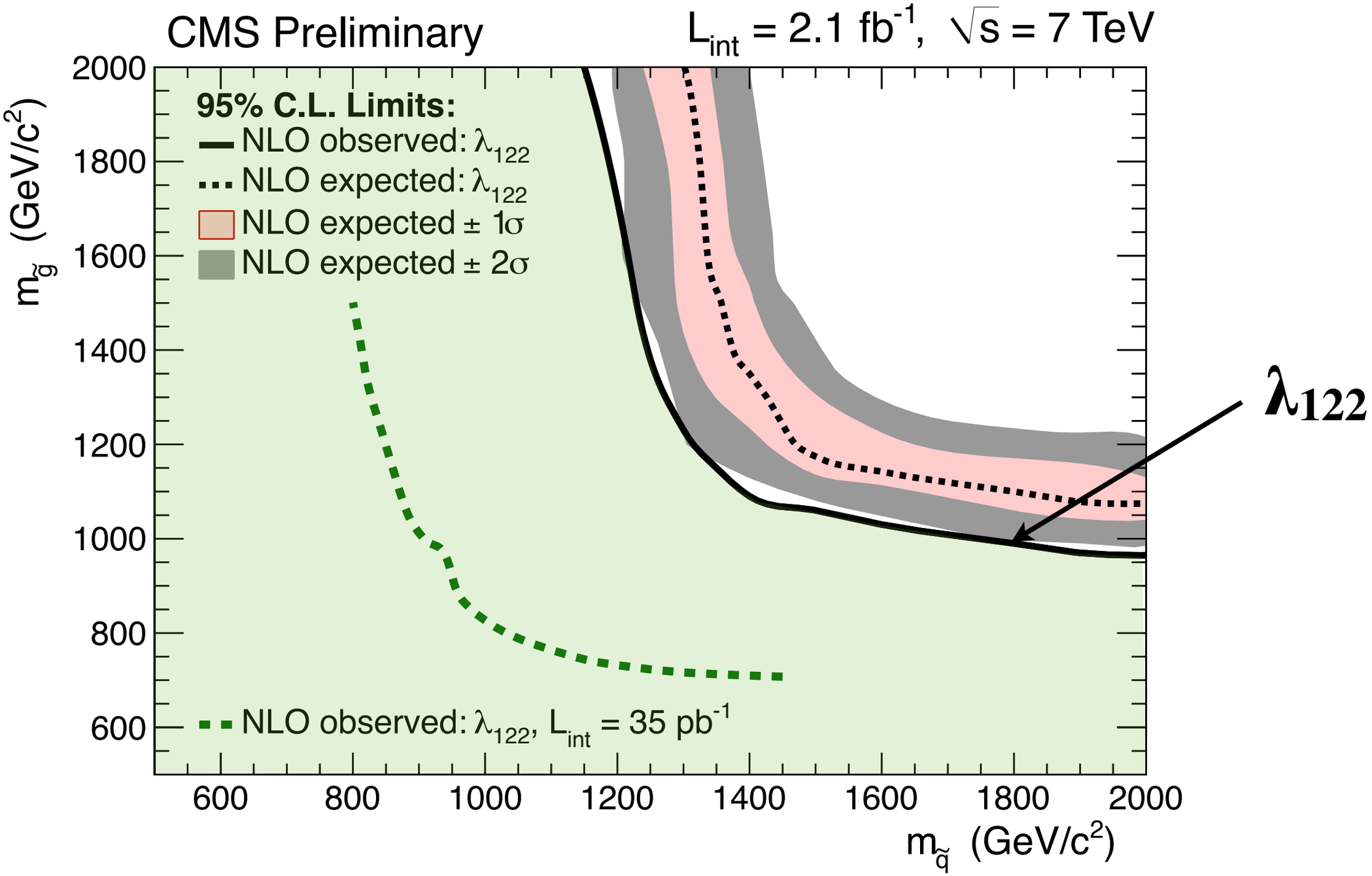




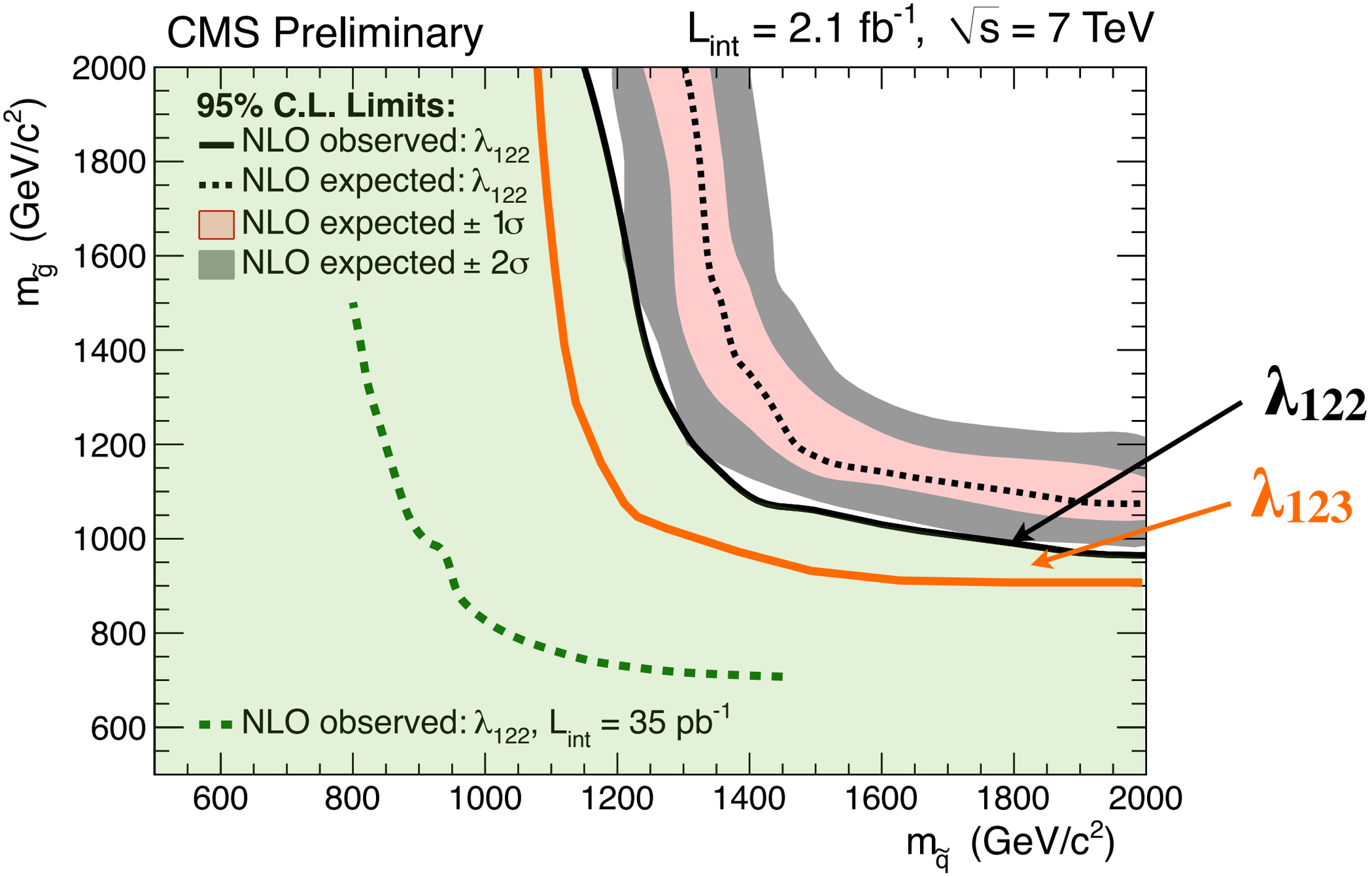
Multileptons and Strong Production

CMS multilepton search with 2/fb



Multileptons and Strong Production

CMS multilepton search with 2/fb



Multileptons and Strong Production

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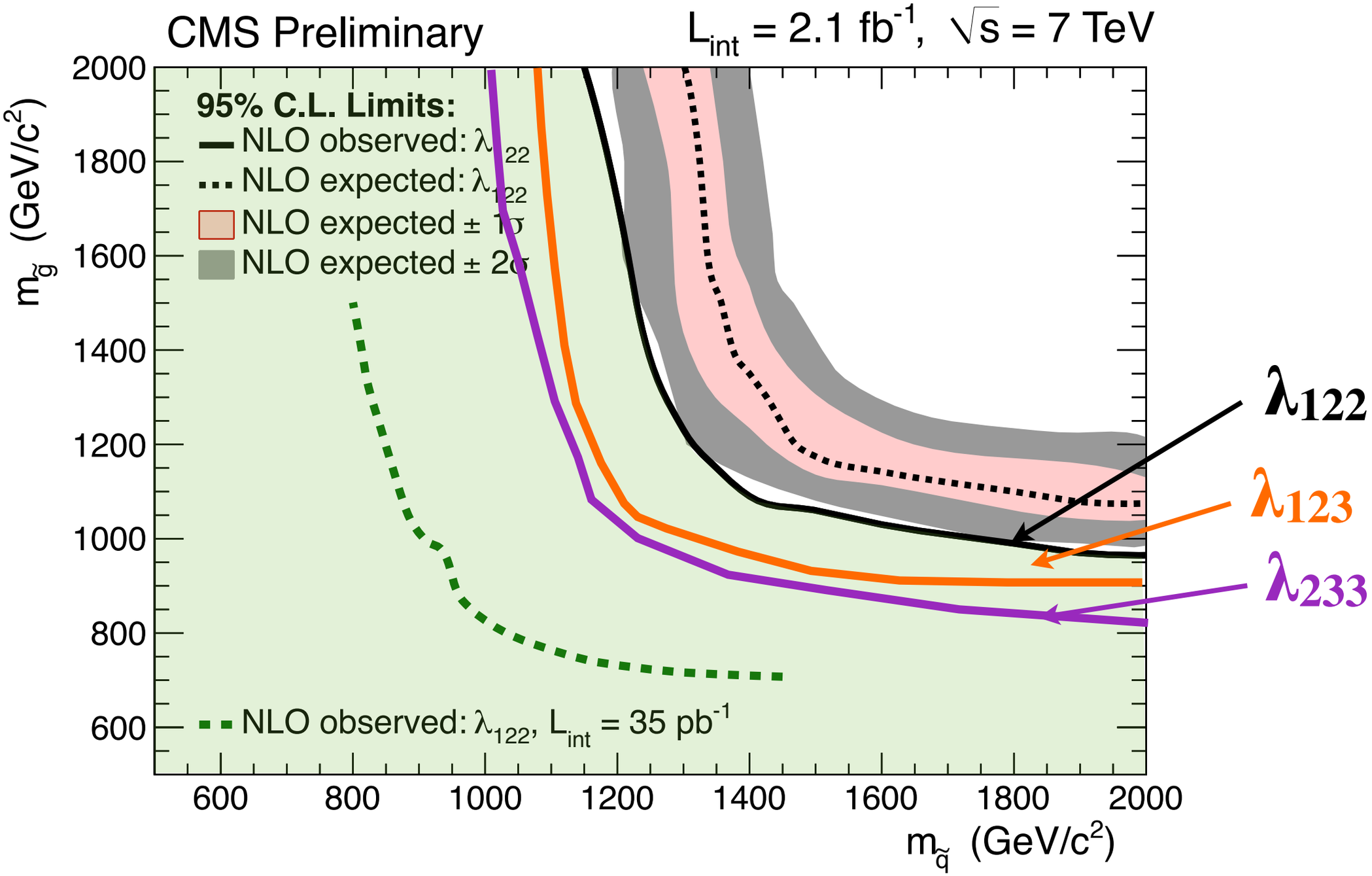
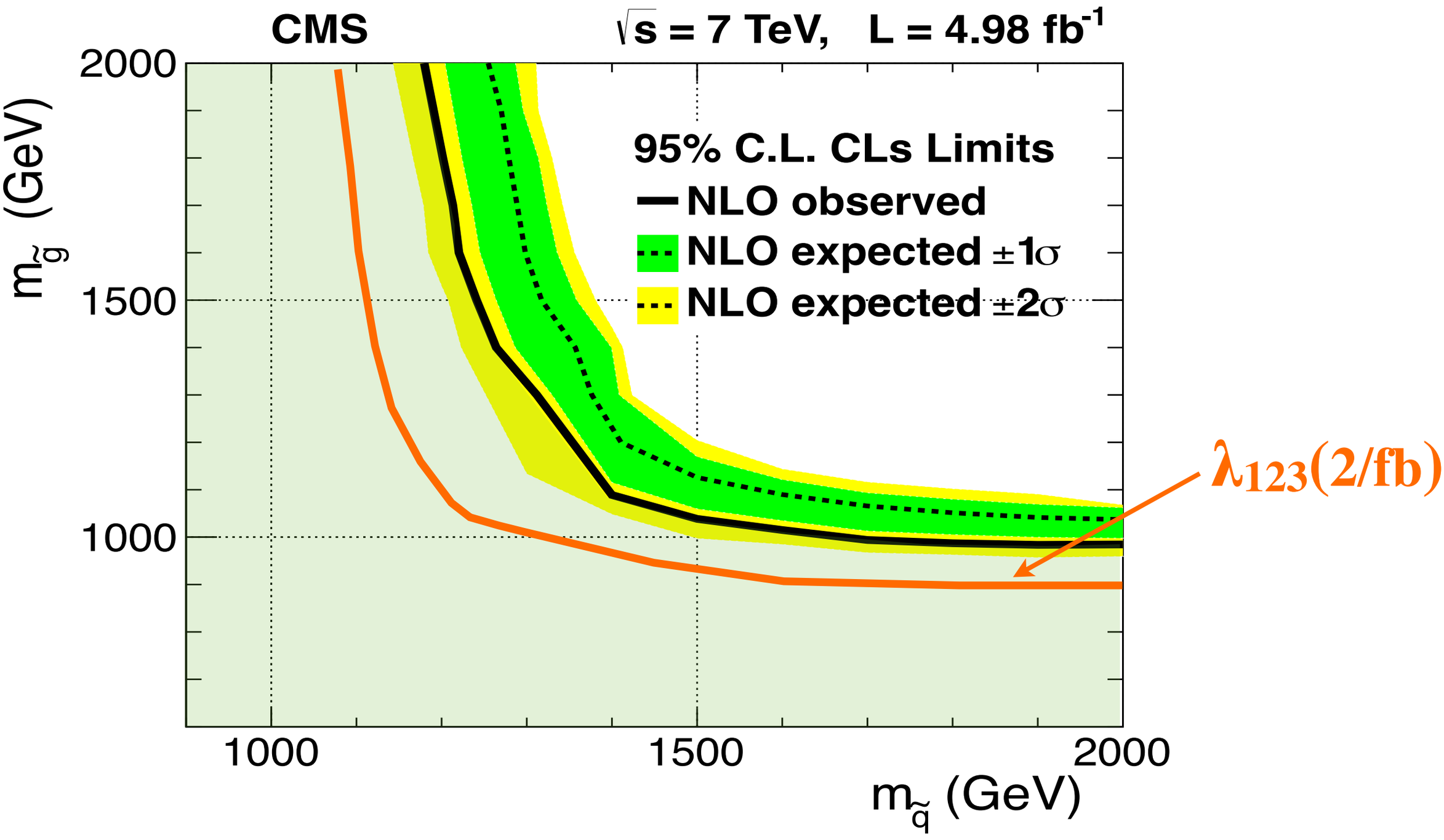


Multileptons and Strong Production

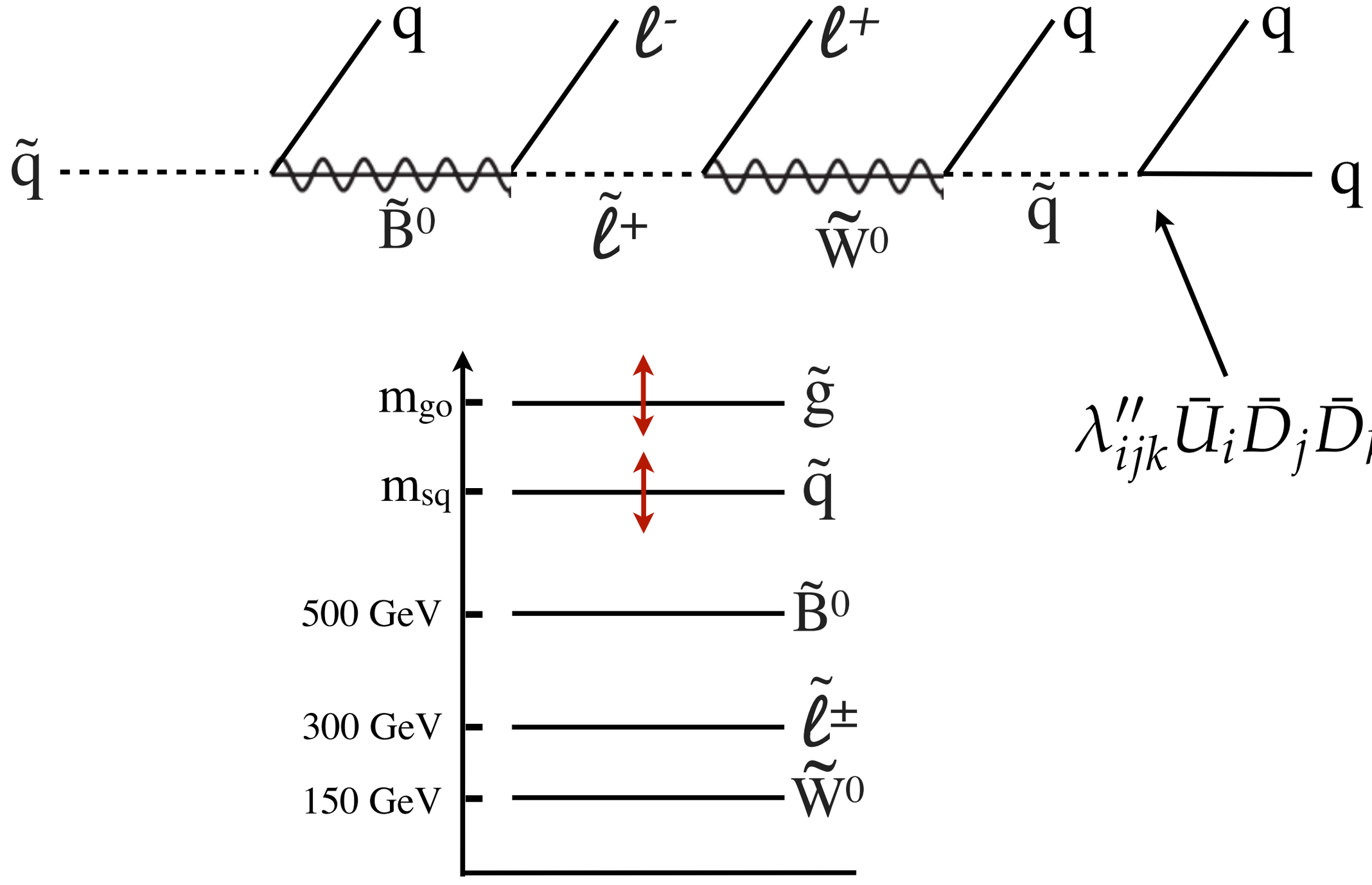
update with 5/fb



Multileptons and Strong Production

CMS multilepton search with 2/fb

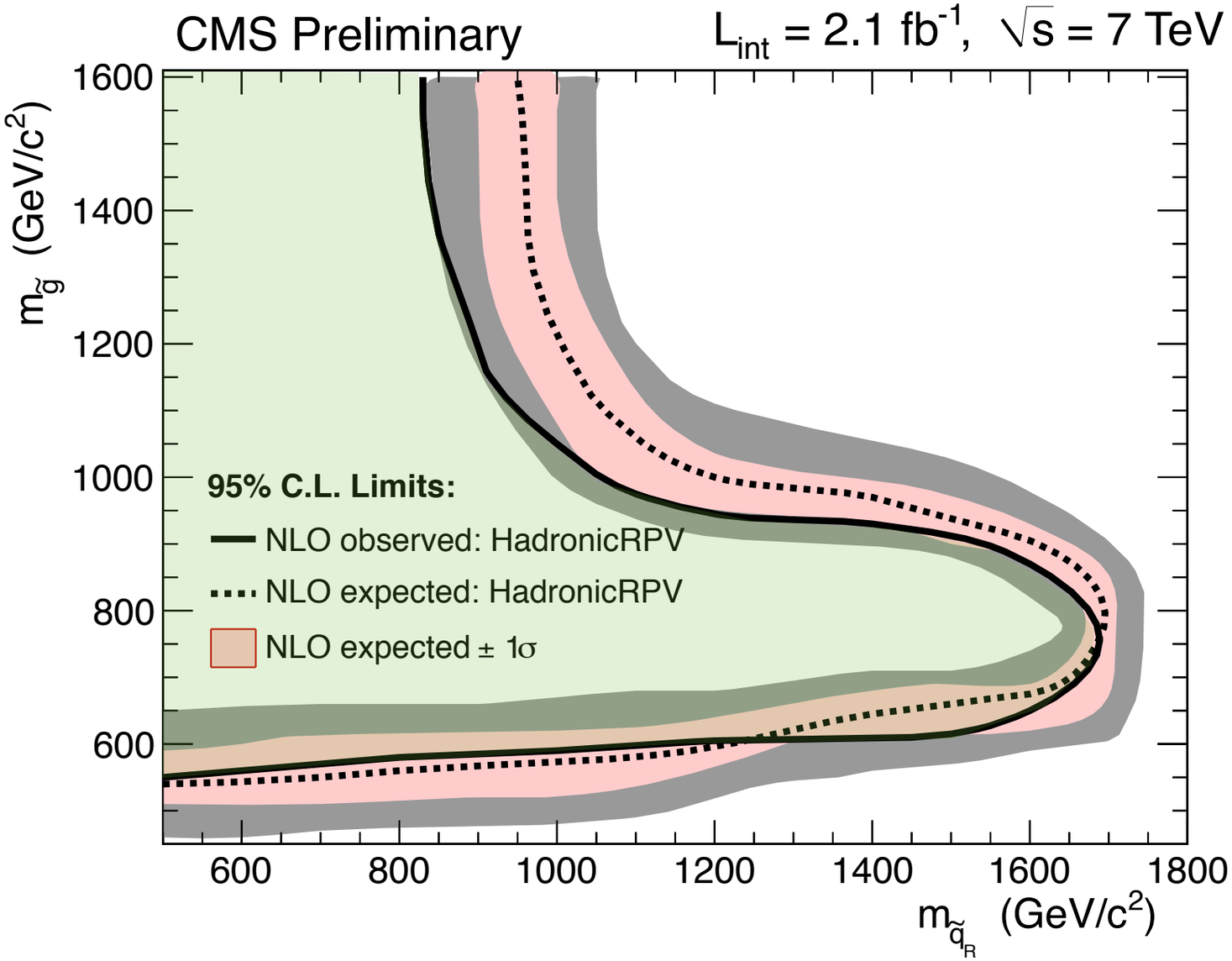
hadronic RPV



Multileptons and Strong Production

CMS multilepton search with 2/fb

hadronic RPV: $\lambda''_{ijk}\bar{U}_i\bar{D}_j\bar{D}_k$



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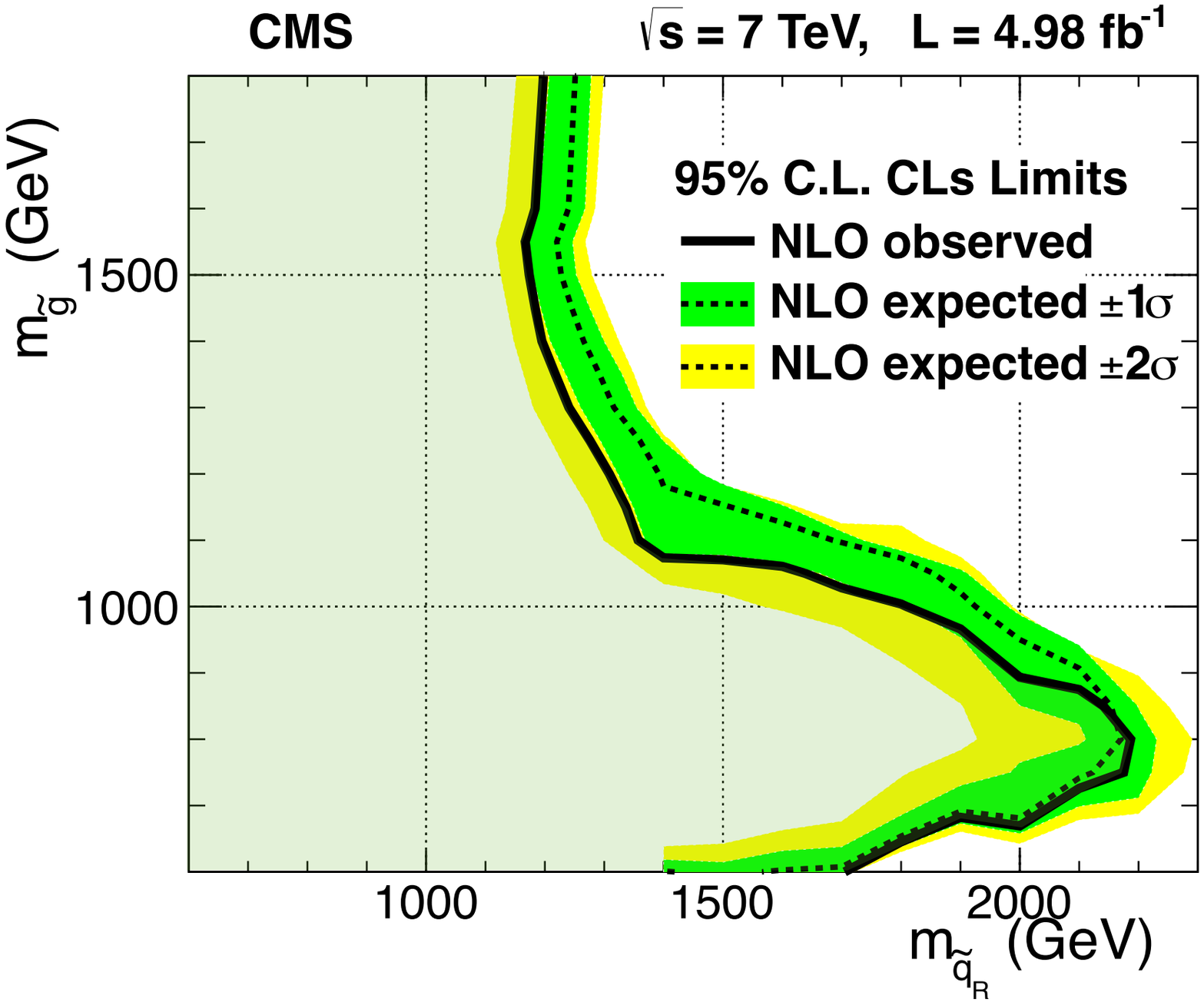

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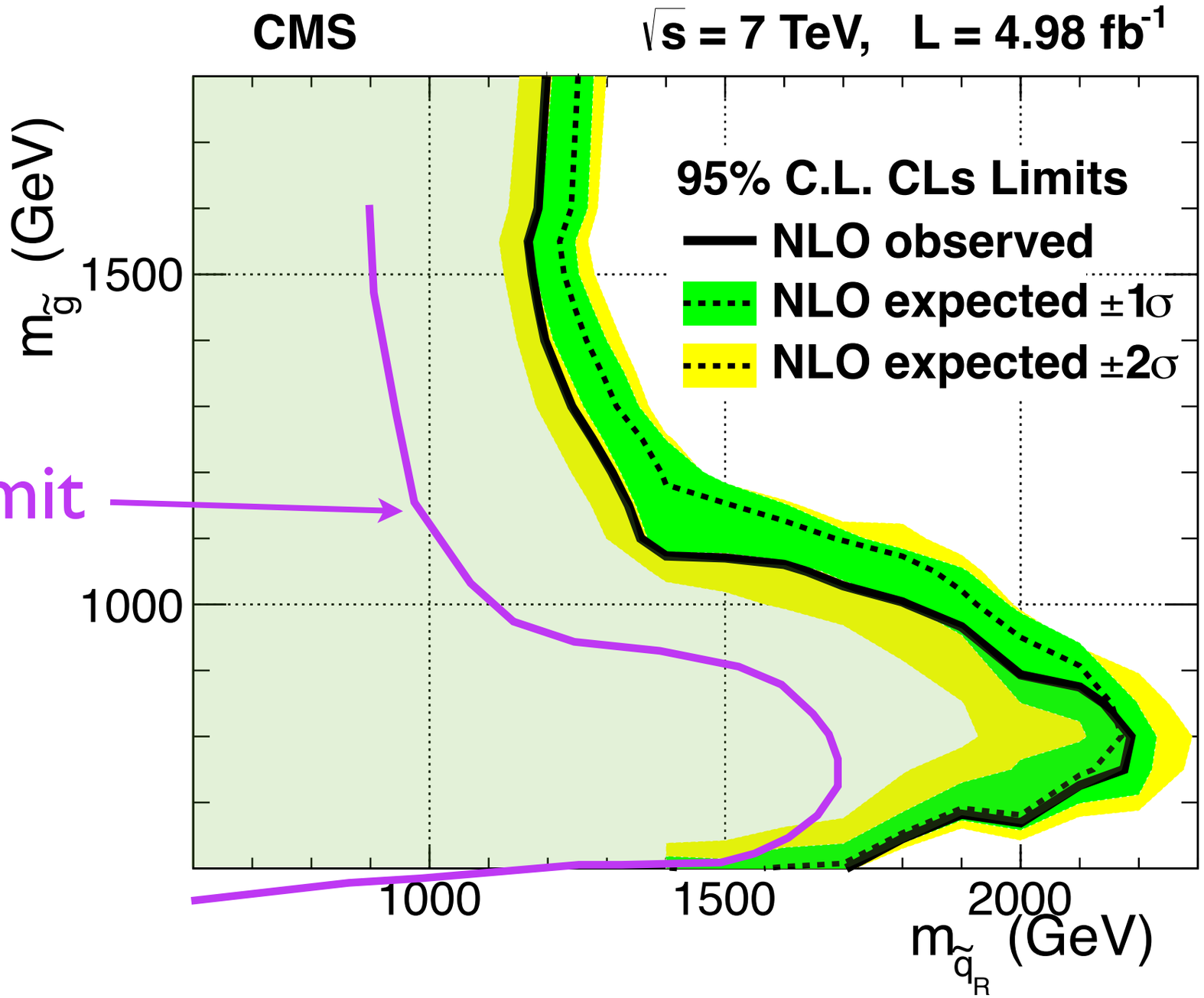
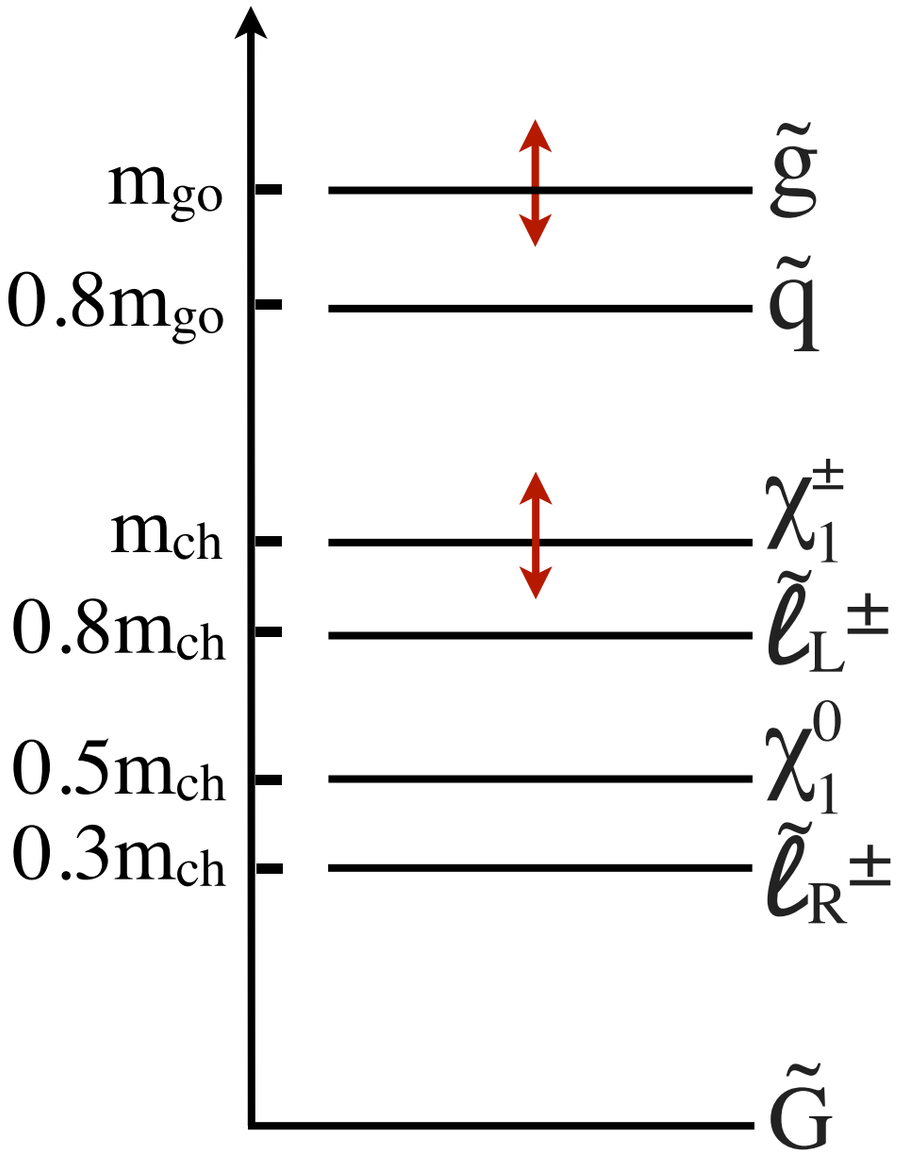
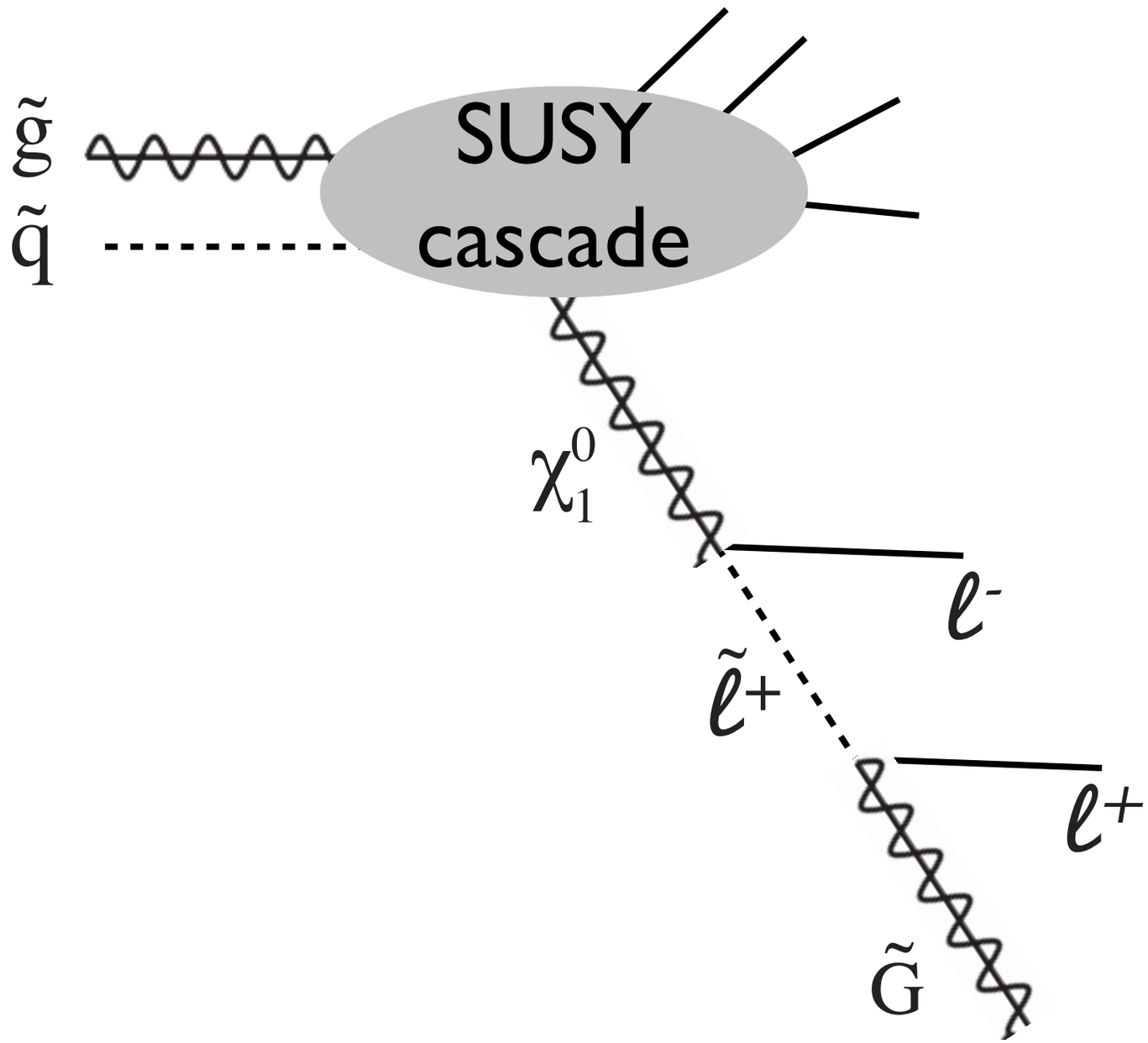


Multileptons and Strong Production

CMS multilepton search with 35/pb

slepton co-NLSP in GMSB





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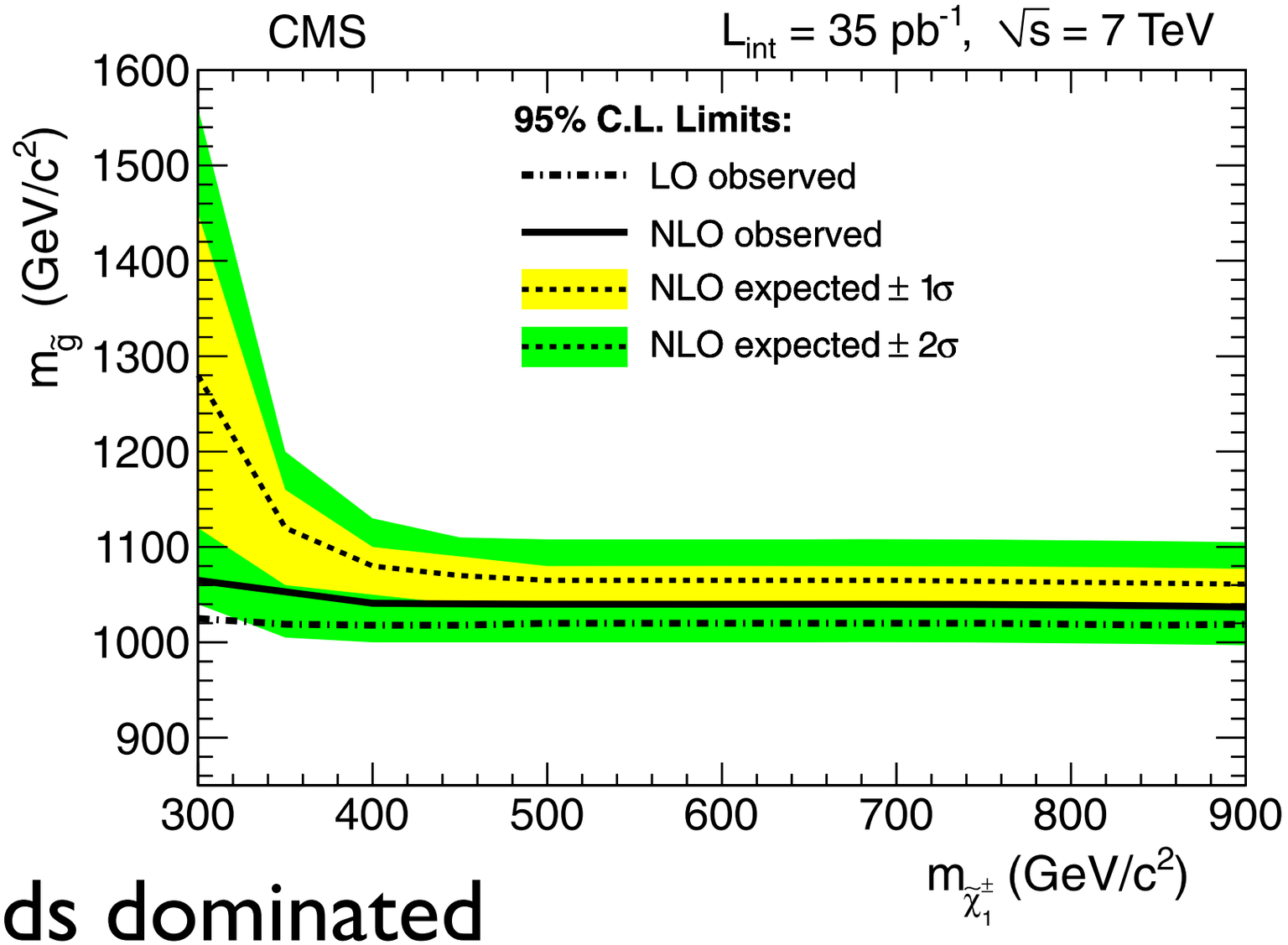
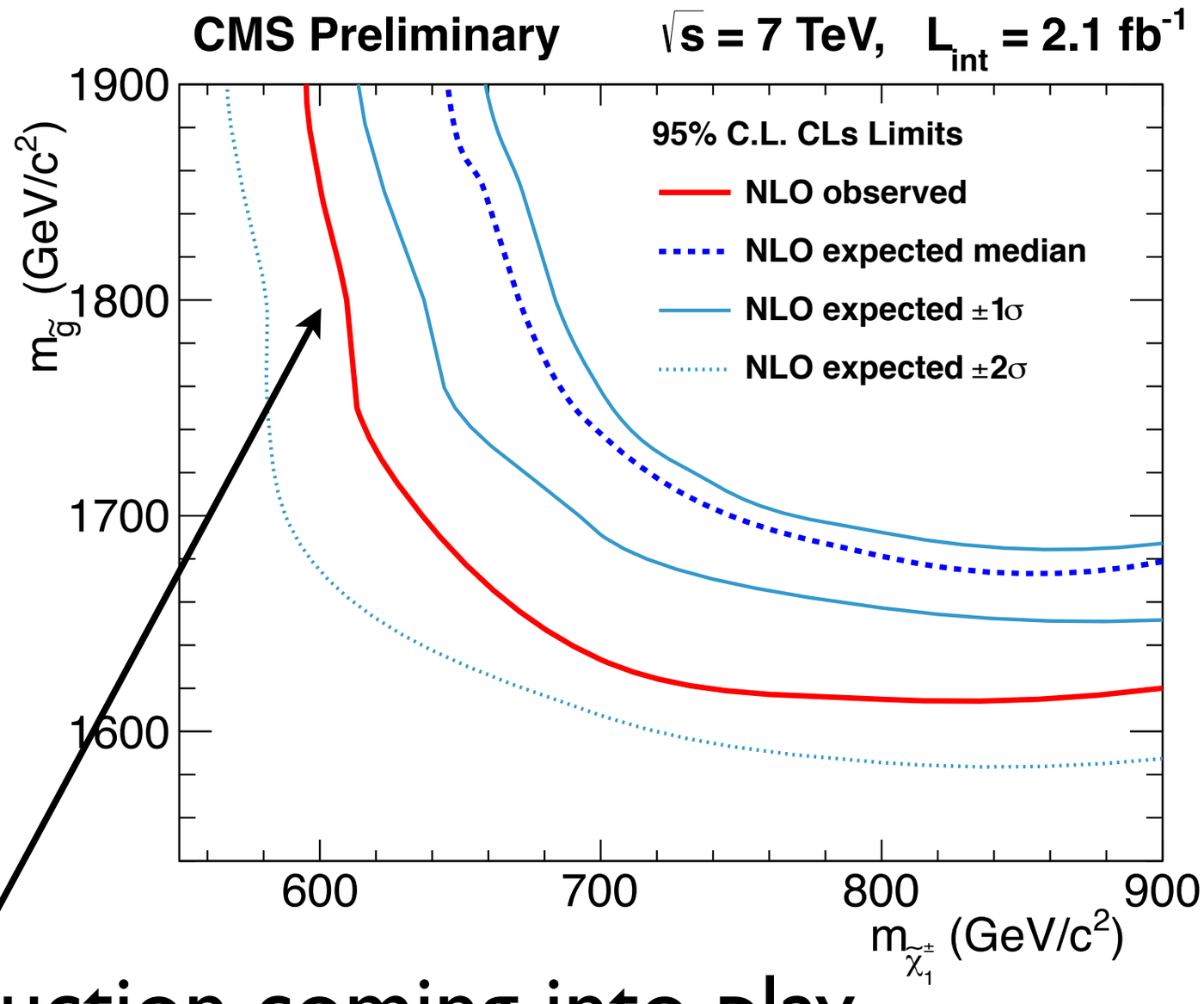


bounds dominated
by strong production

Multileptons and Strong+EW Production

updated with 2/fb

slepton co-NLSP in GMSB

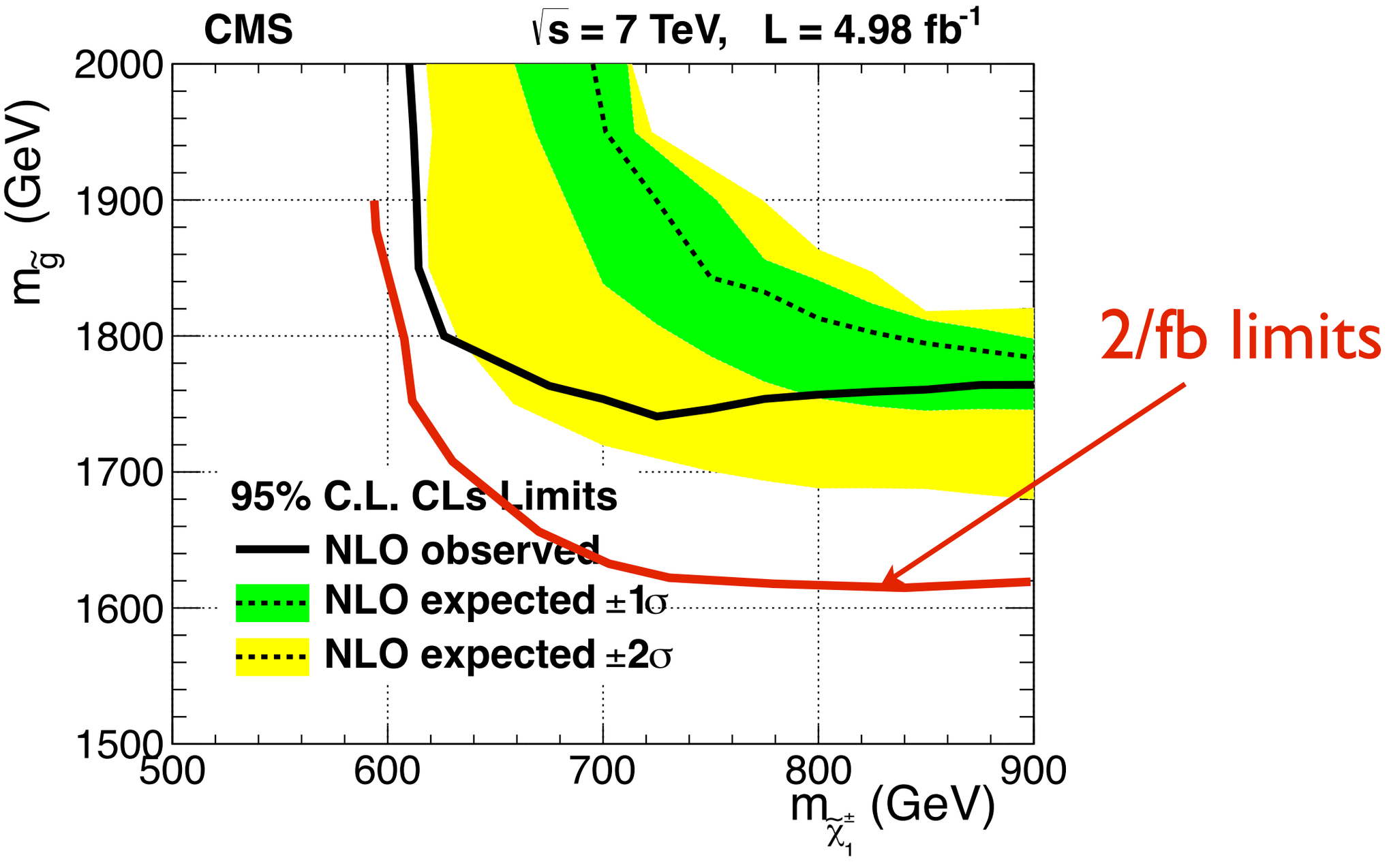


EW production coming into play

Multileptons and Strong+EW Production

updated with 5/fb

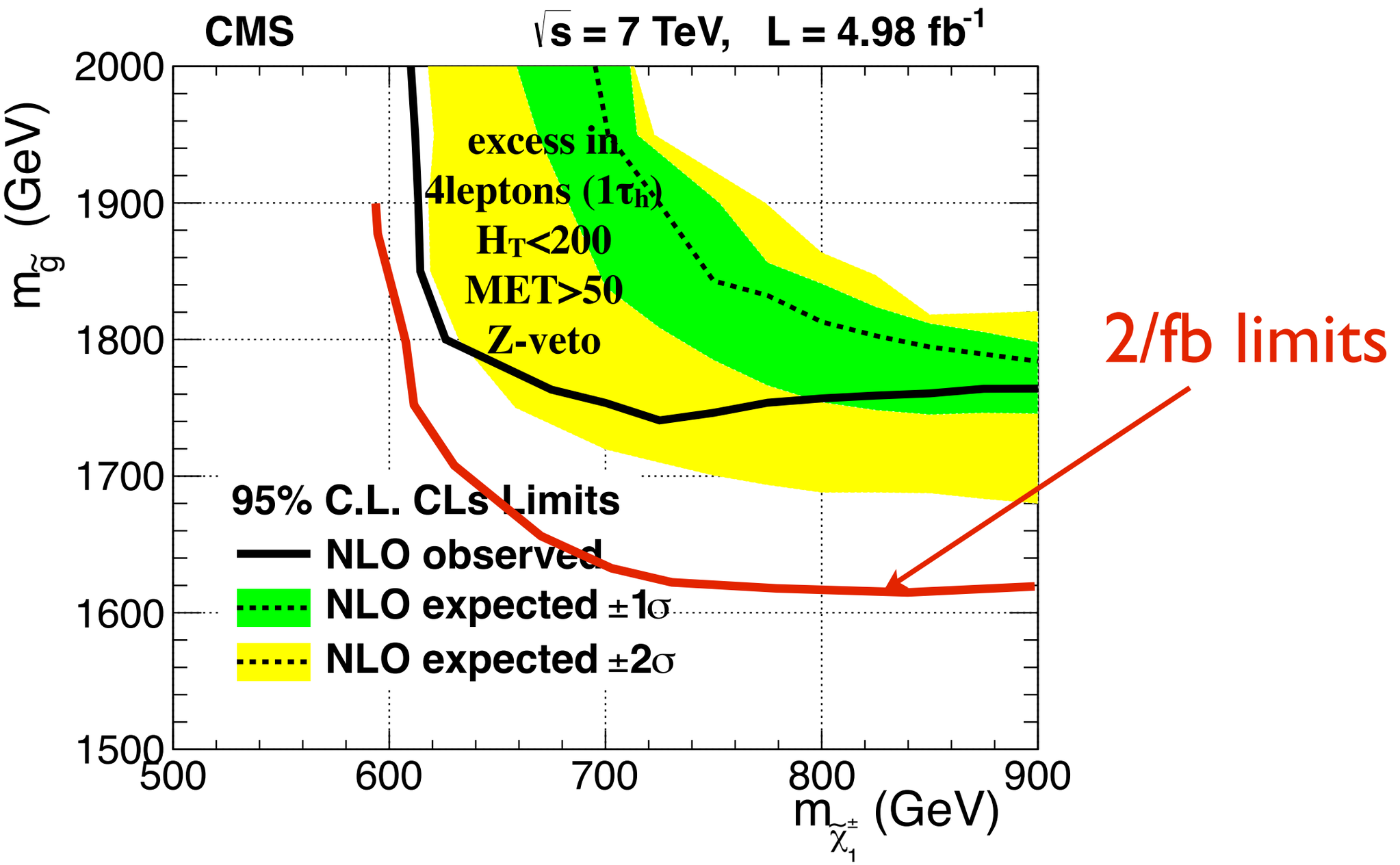
slepton co-NLSP in GMSB



Multileptons and Strong+EW Production

updated with 5/fb

slepton co-NLSP in GMSB



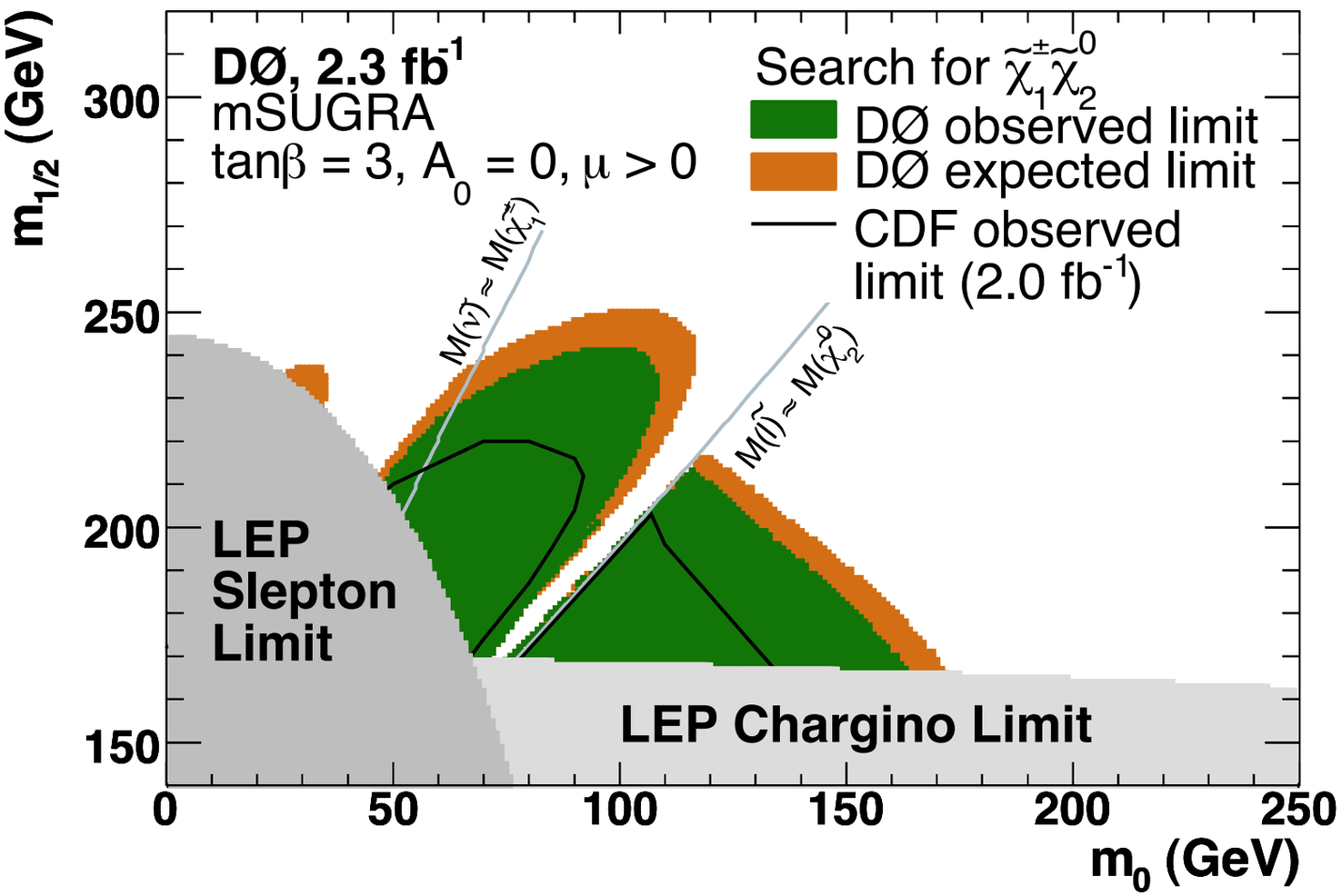
Multileptons and Strong Production

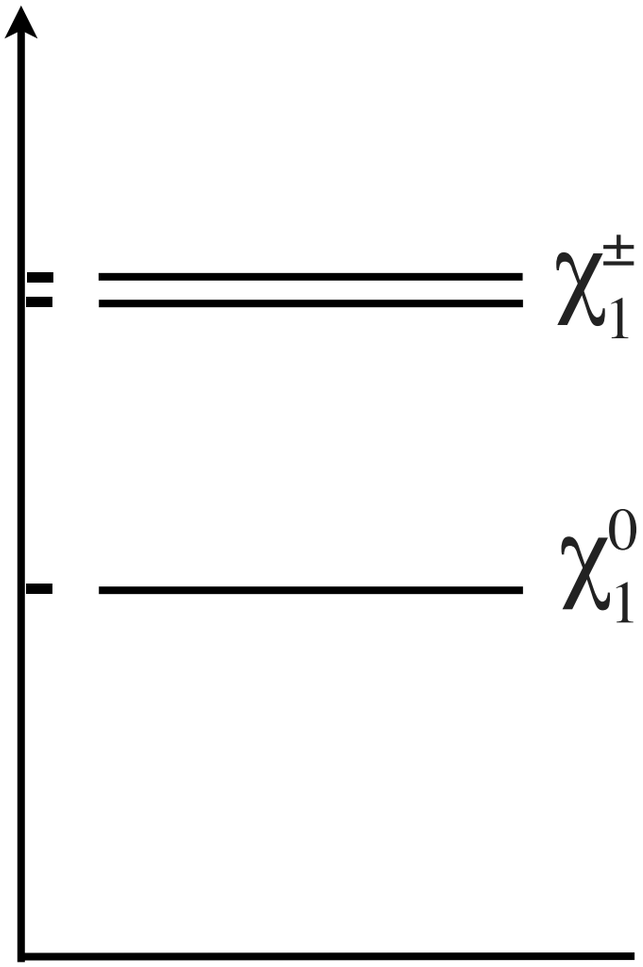
update with 5/fb

Selection	N(τ_h)=0 obs	N(τ_h)=0 expected	N(τ_h)=1 obs	N(τ_h)=1 expected	N(τ_h)=2 obs	N(τ_h)=2 expected
4 Lepton results						
4ℓ E_T^{miss} >50, H_T >200, no Z	0	0.018 ± 0.005	0	0.09 ± 0.06	0	0.7 ± 0.7
4ℓ E_T^{miss} >50, H_T >200, Z	0	0.22 ± 0.05	0	0.27 ± 0.11	0	0.8 ± 1.2
4ℓ E_T^{miss} >50, H_T <200, no Z	1	0.20 ± 0.07	3	0.59 ± 0.17	1	1.5 ± 0.6
4ℓ E_T^{miss} >50, H_T <200, Z	1	0.79 ± 0.21	4	2.3 ± 0.7	0	1.1 ± 0.7
4ℓ E_T^{miss} <50, H_T >200, no Z	0	0.006 ± 0.001	0	0.14 ± 0.08	0	0.25 ± 0.07
4ℓ E_T^{miss} <50, H_T >200, Z	1	0.83 ± 0.33	0	0.55 ± 0.21	0	1.14 ± 0.42
4ℓ E_T^{miss} <50, H_T <200, no Z	1	2.6 ± 1.1	5	3.9 ± 1.2	17	10.6 ± 3.2
4ℓ E_T^{miss} <50, H_T <200, Z	33	37 ± 15	20	17.0 ± 5.2	62	43 ± 16
3 Lepton results						

Multileptons and EW Production

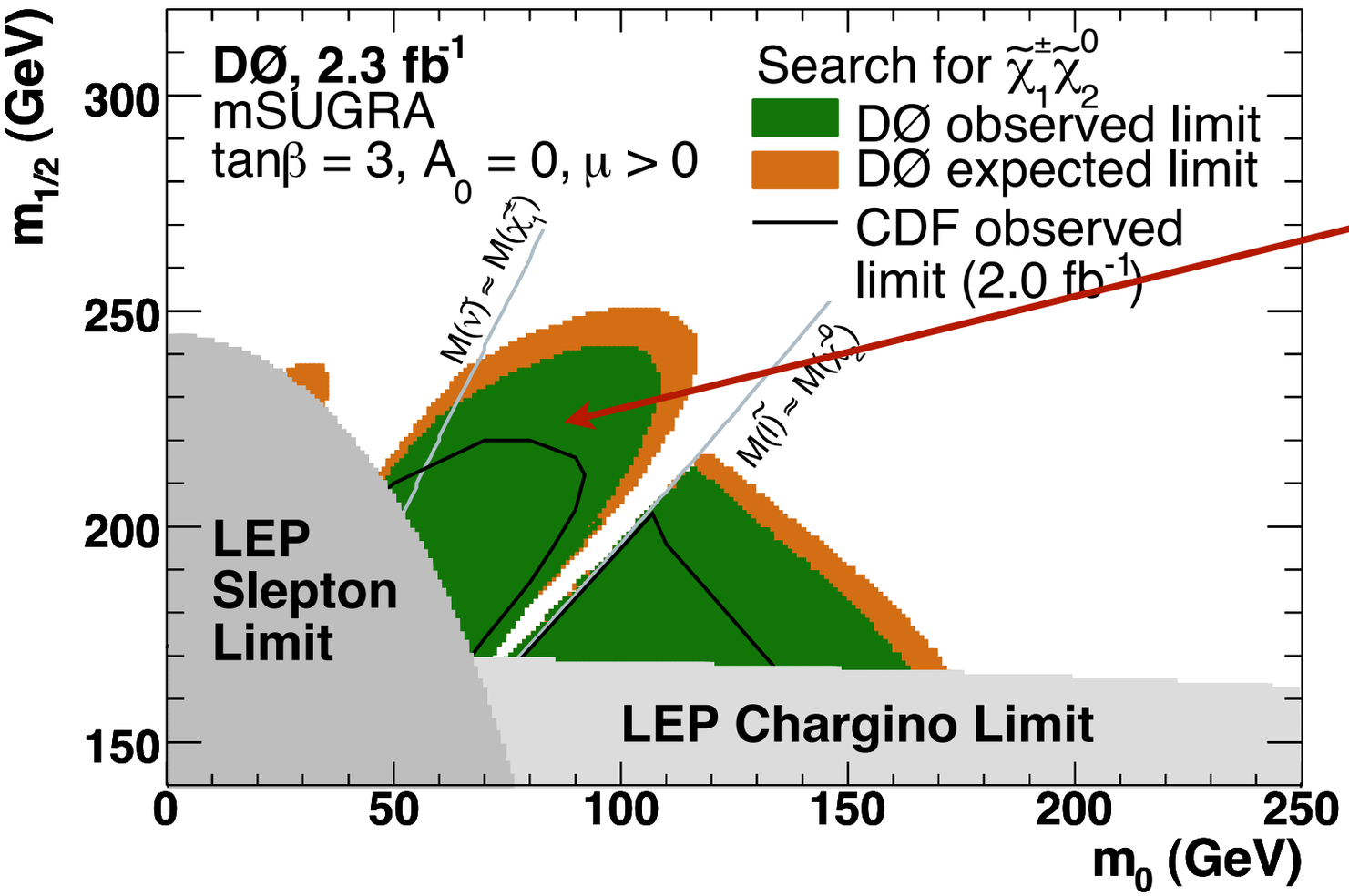
D0 multilepton search with 2.3/fb



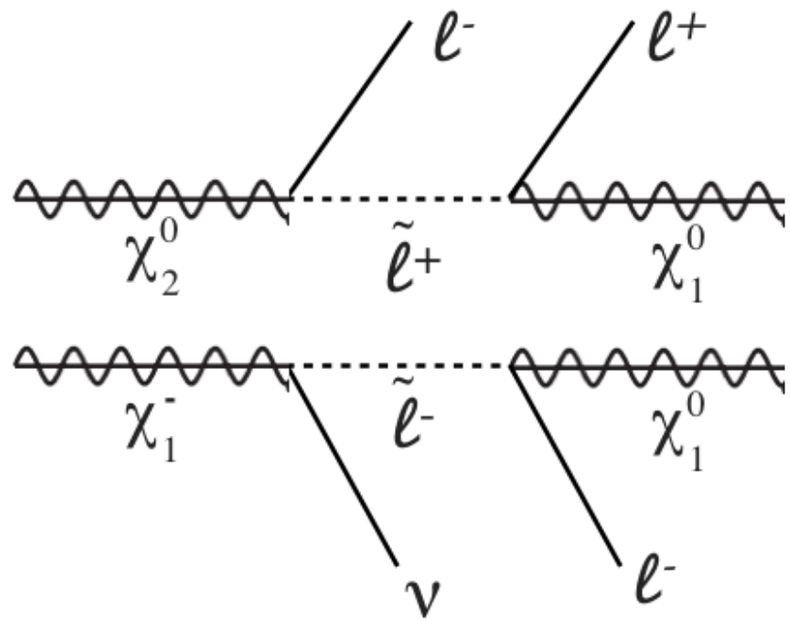


Multileptons and EW Production

D0 multilepton search with 2.3/fb

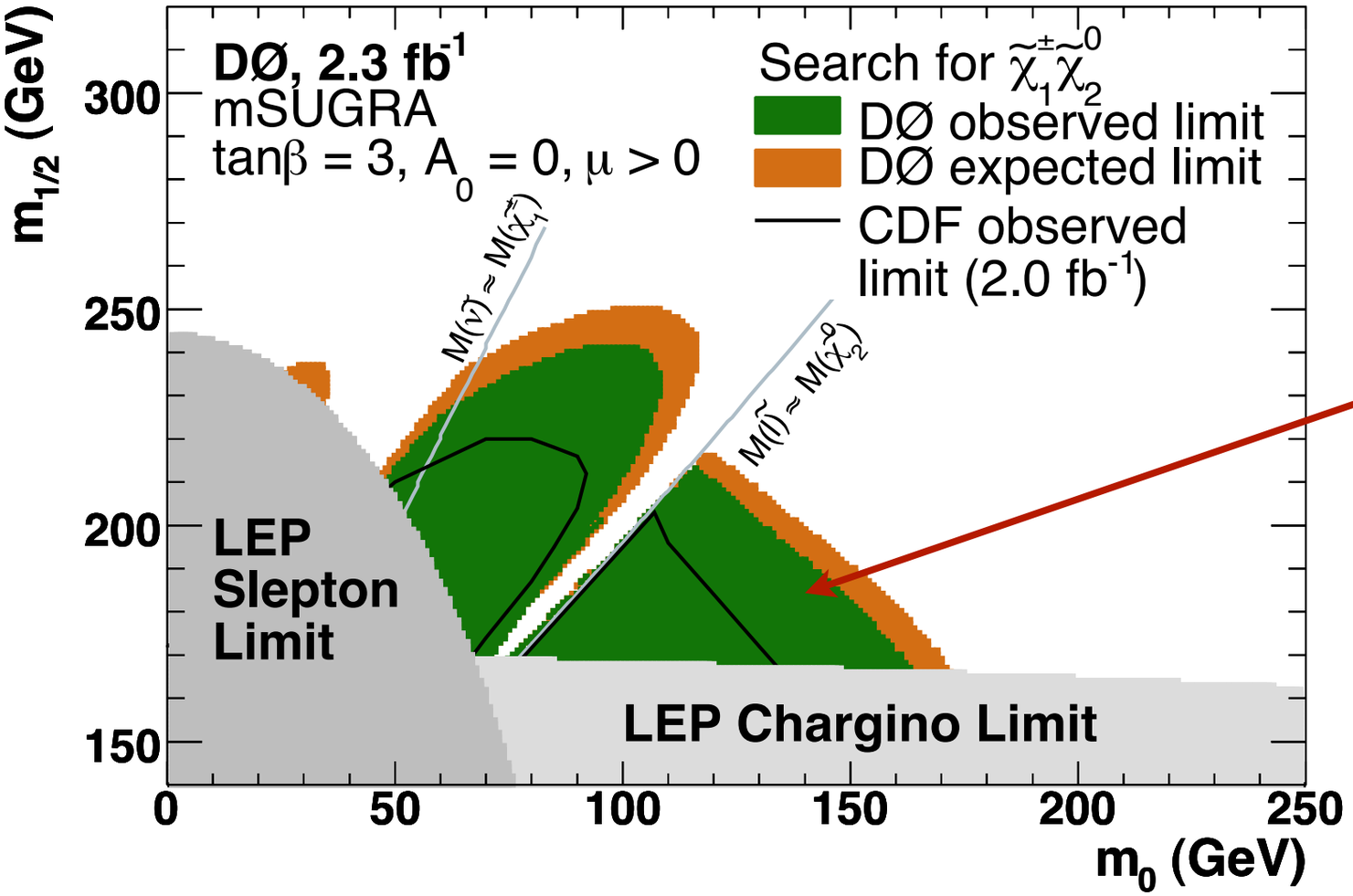


sleptons on-shell

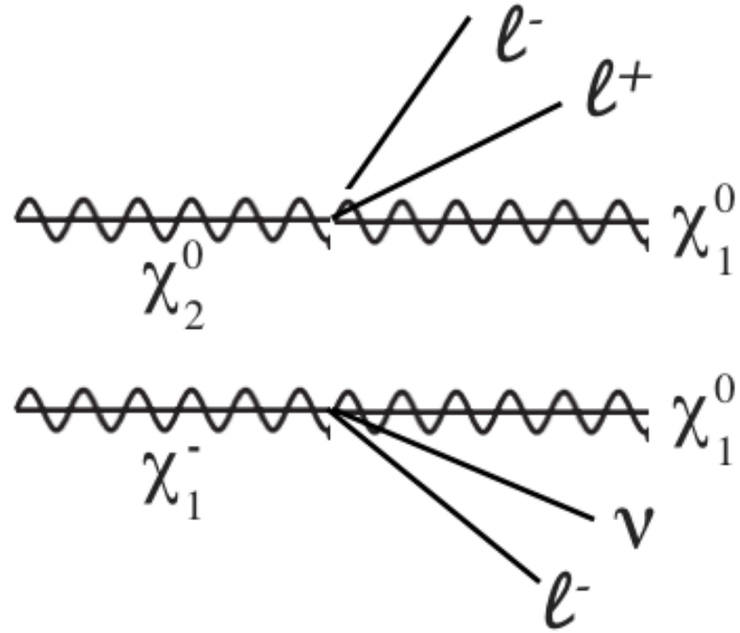


Multileptons and EW Production

D0 multilepton search with 2.3/fb

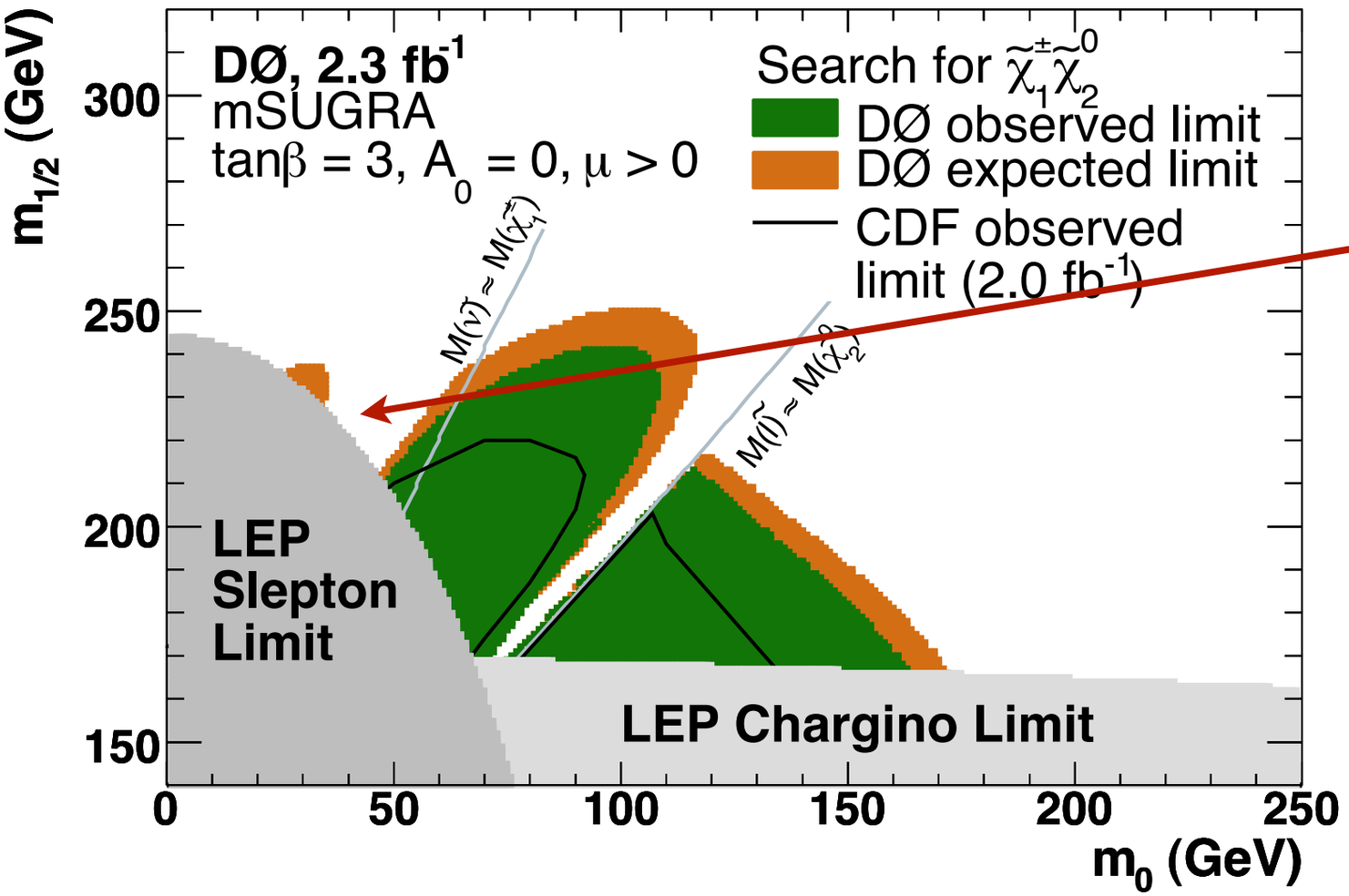


sleptons off-shell

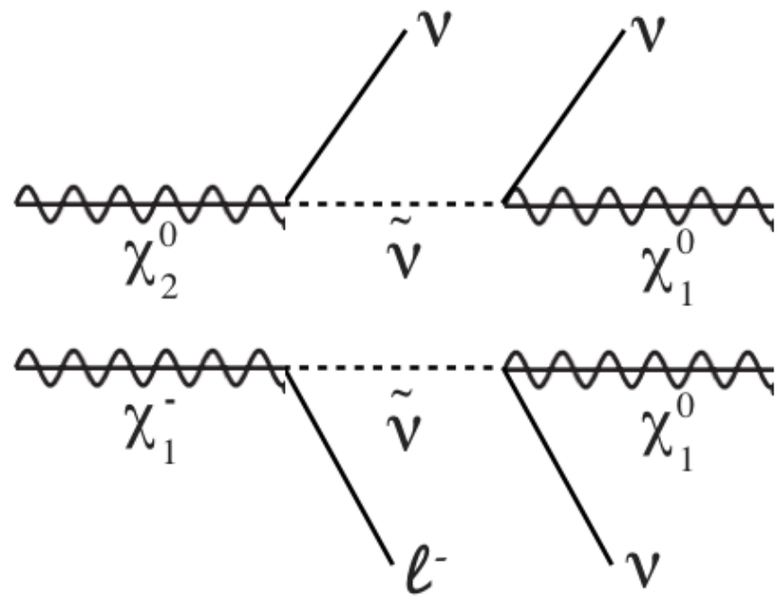


Multileptons and EW Production

D0 multilepton search with 2.3/fb

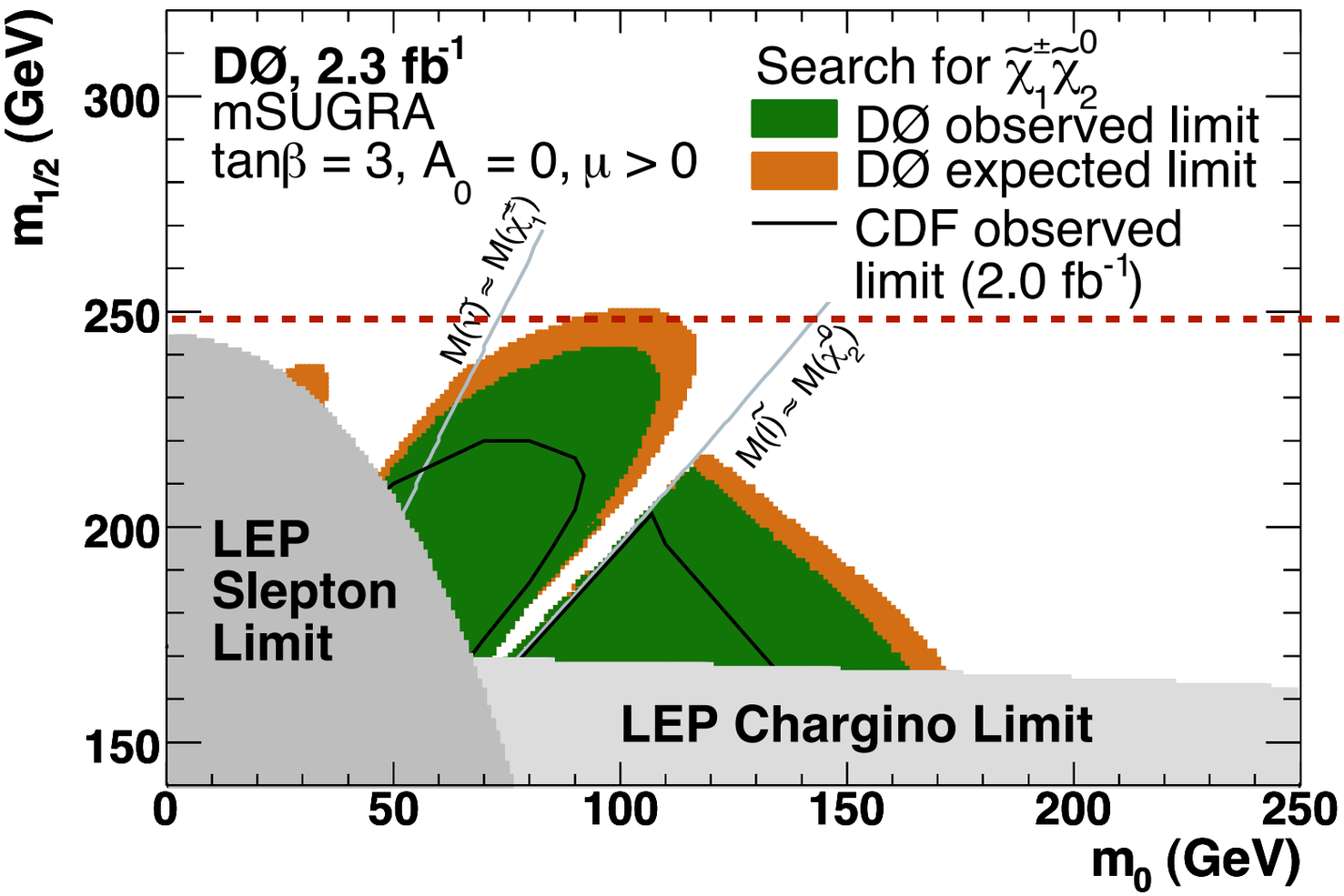


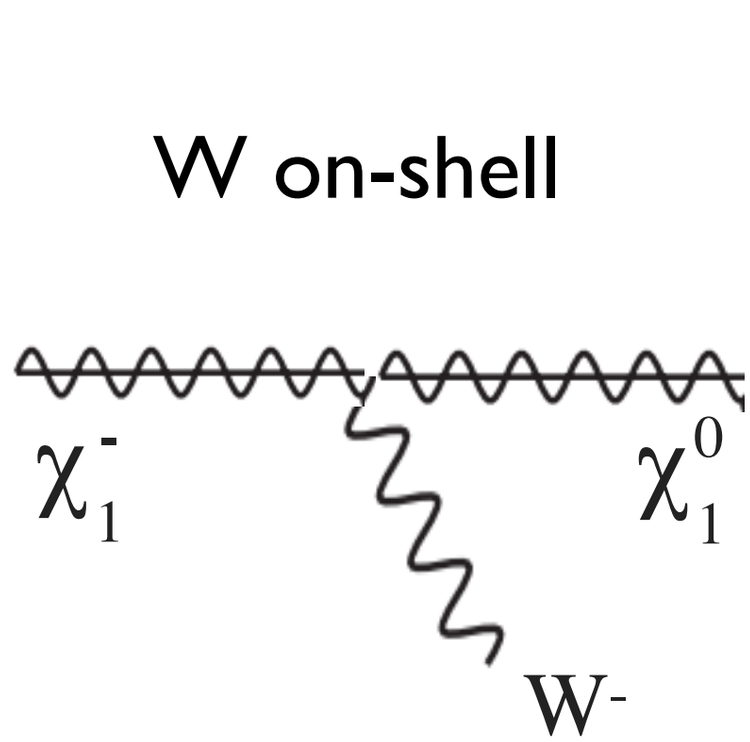
sneutrinos on-shell



Multileptons and EW Production

D0 multilepton search with 2.3/fb

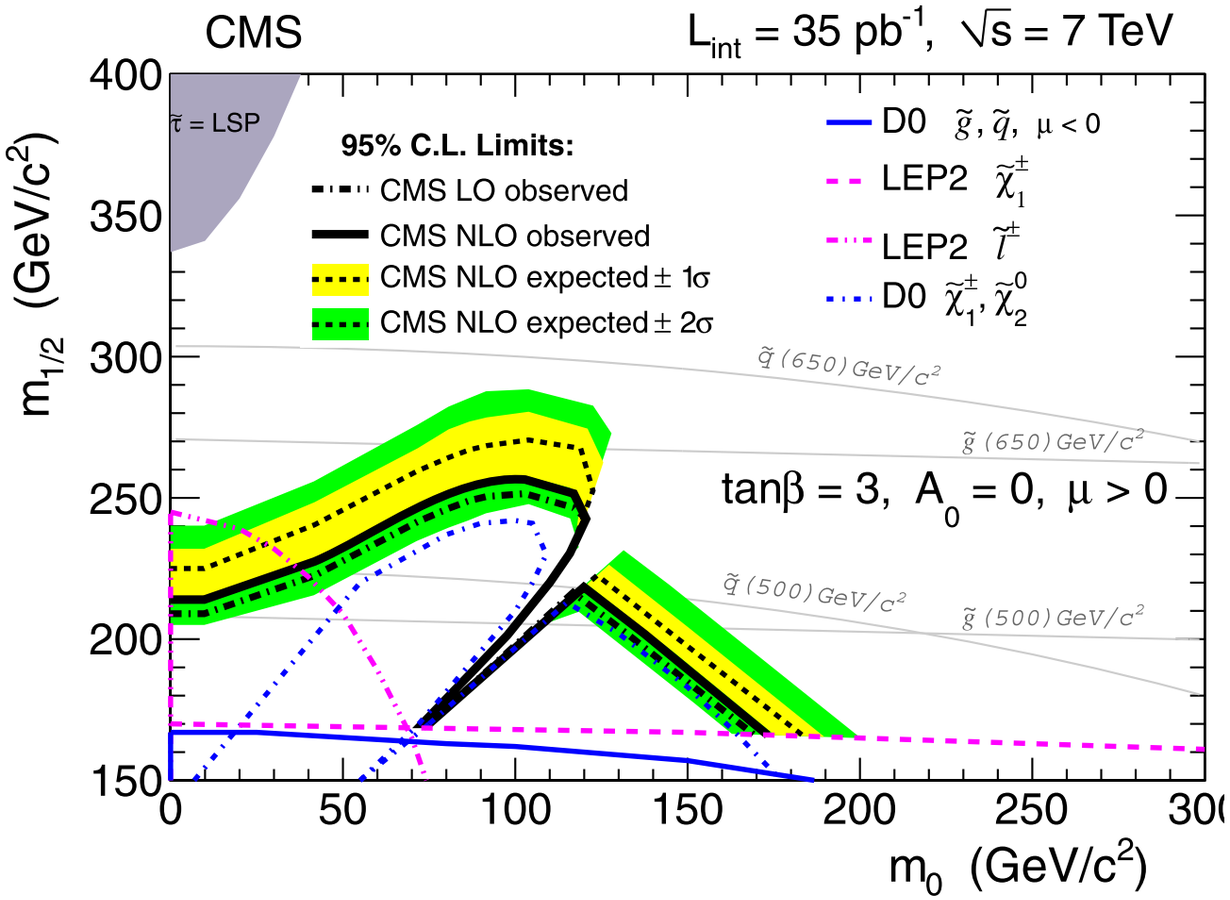


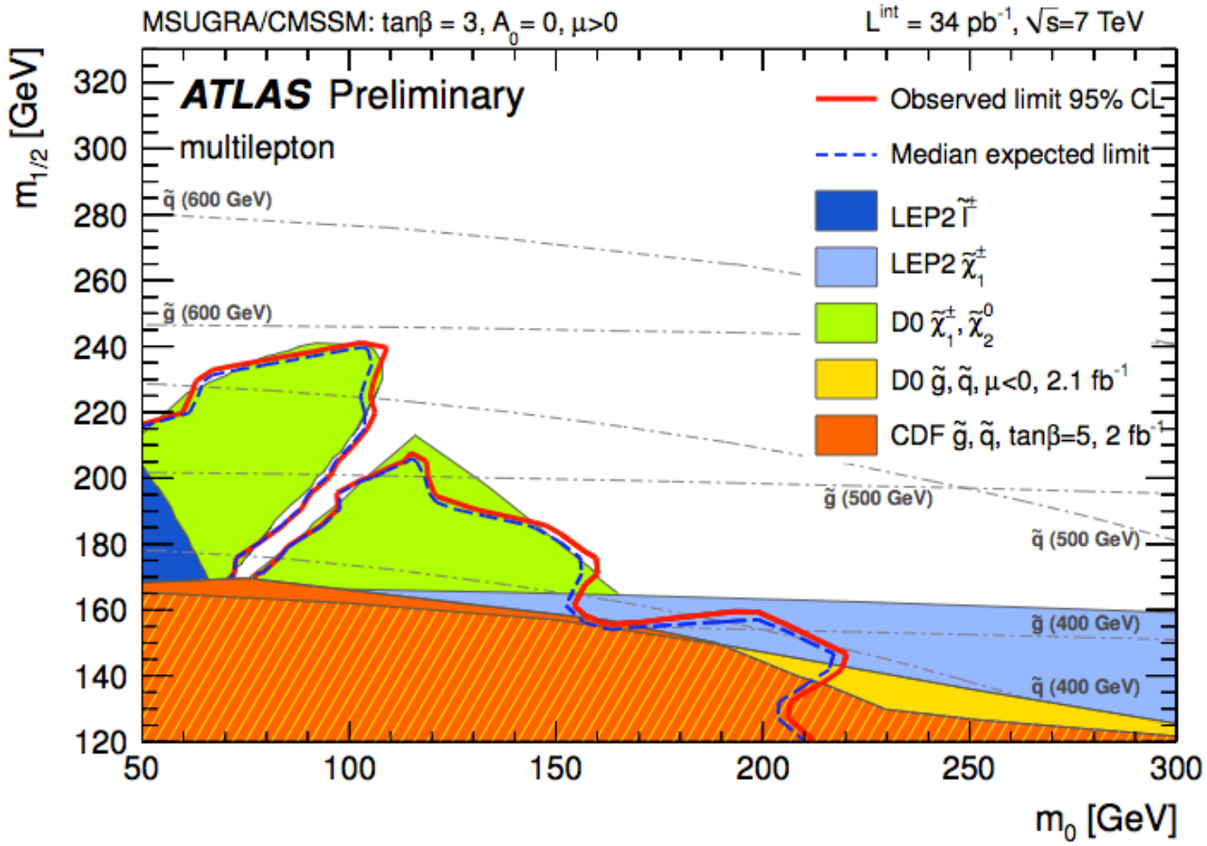


reduced Br to multileptons

Multileptons and ~~EWK~~ strong Production

CMS & ATLAS multilepton search with 35/pb

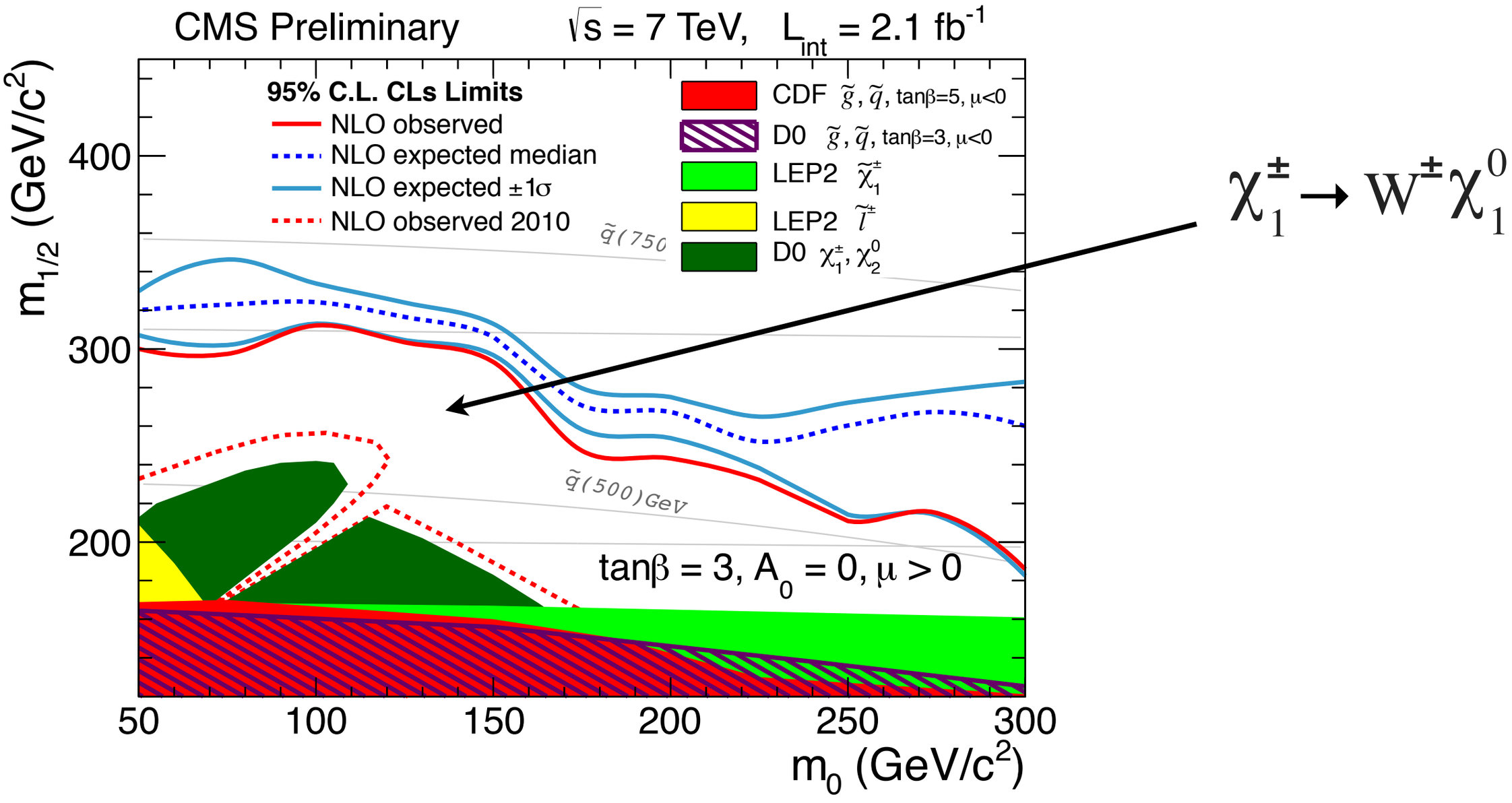




Multileptons and EW Production

? strong

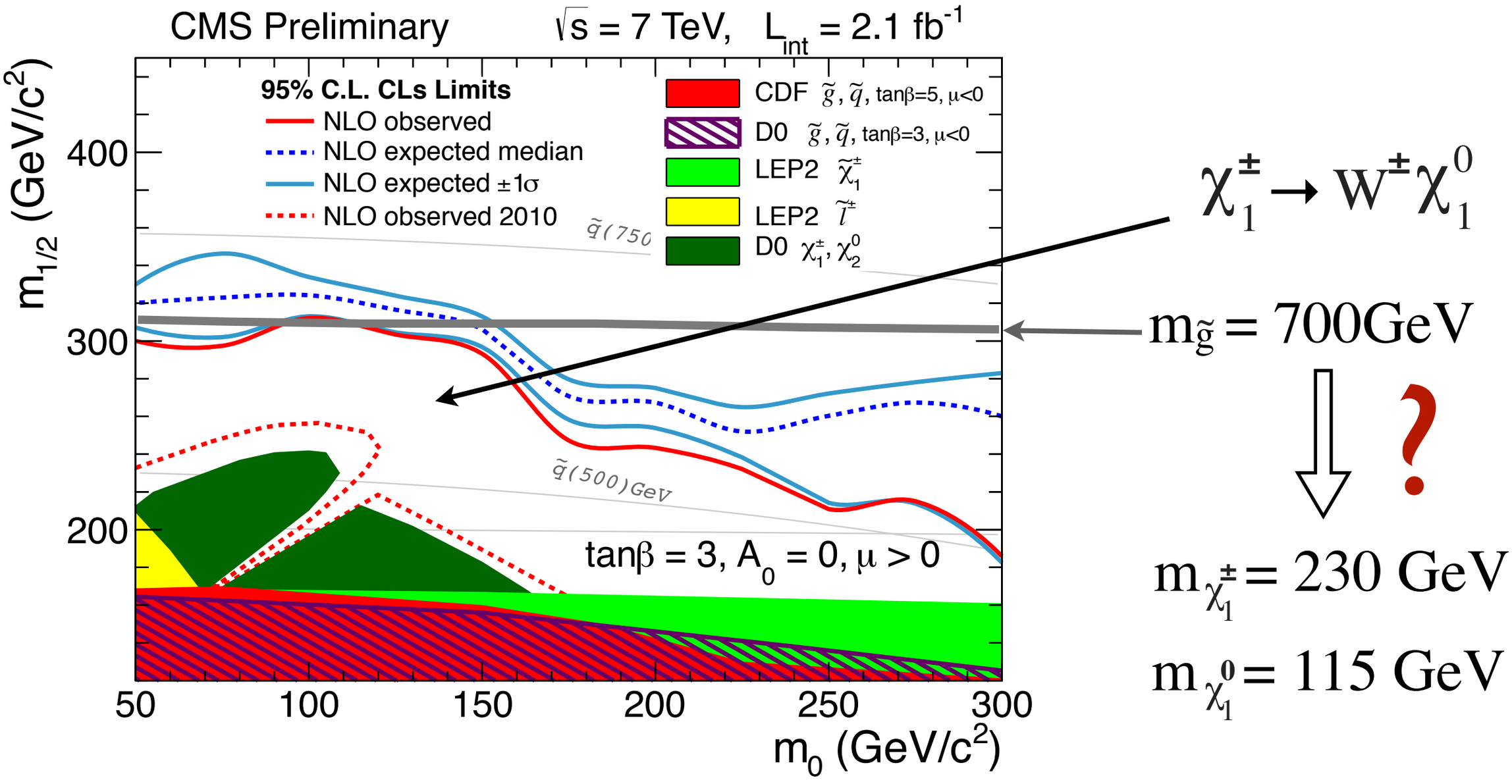
CMS multilepton search with 2/fb



Multileptons and EW Production

? strong

CMS multilepton search with 2/fb



$\chi_1^{\pm} \rightarrow W^{\pm}\chi_1^0$

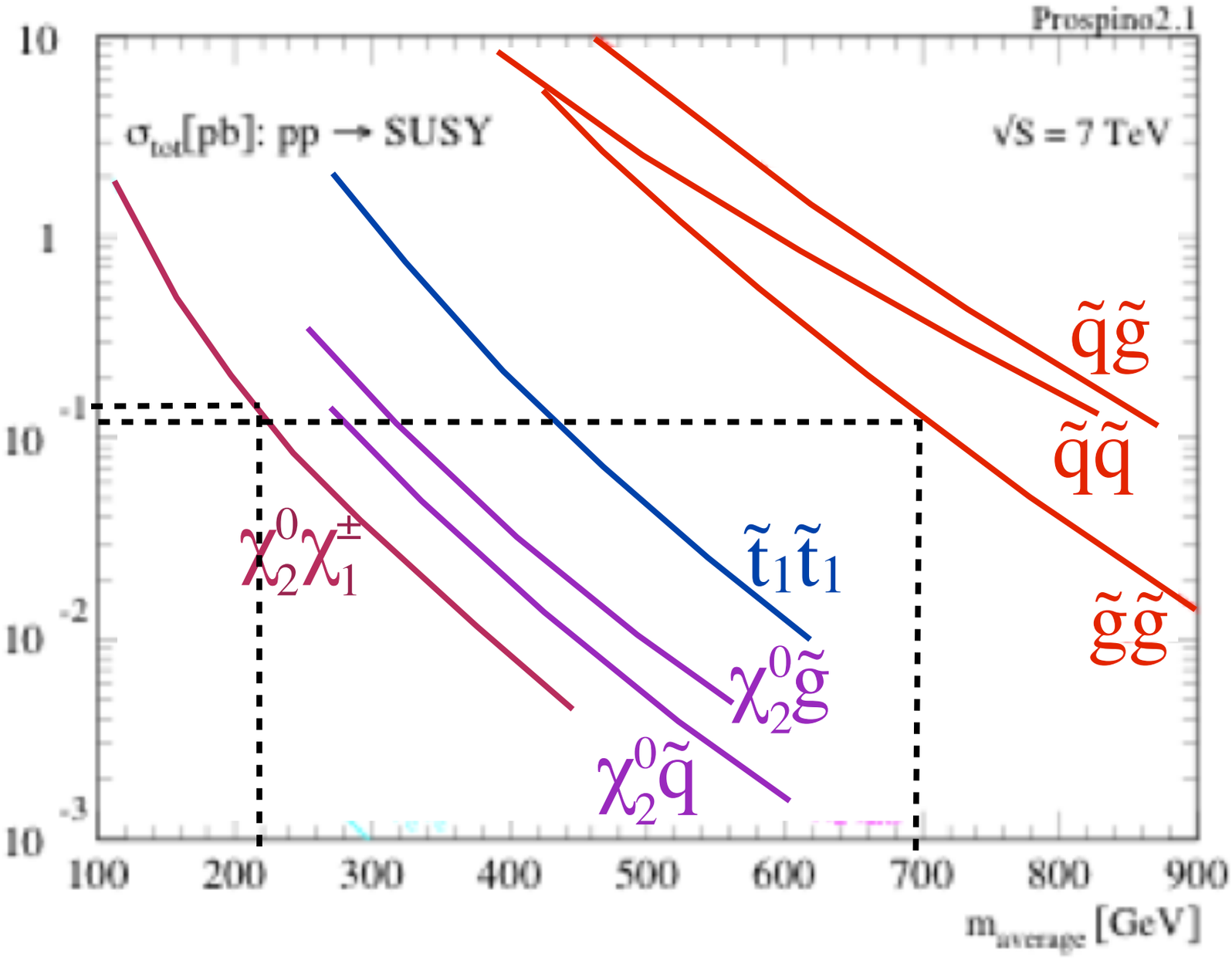
$m_{\tilde{g}} = 700\text{GeV}$

?

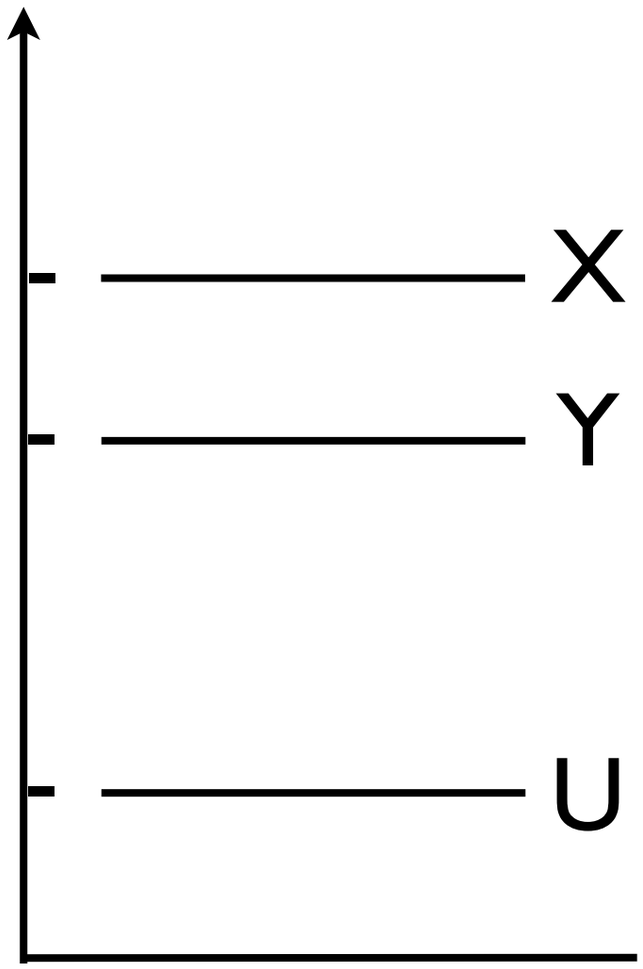
$m_{\chi_1^{\pm}} = 230$ GeV

$m_{\chi_1^0} = 115$ GeV

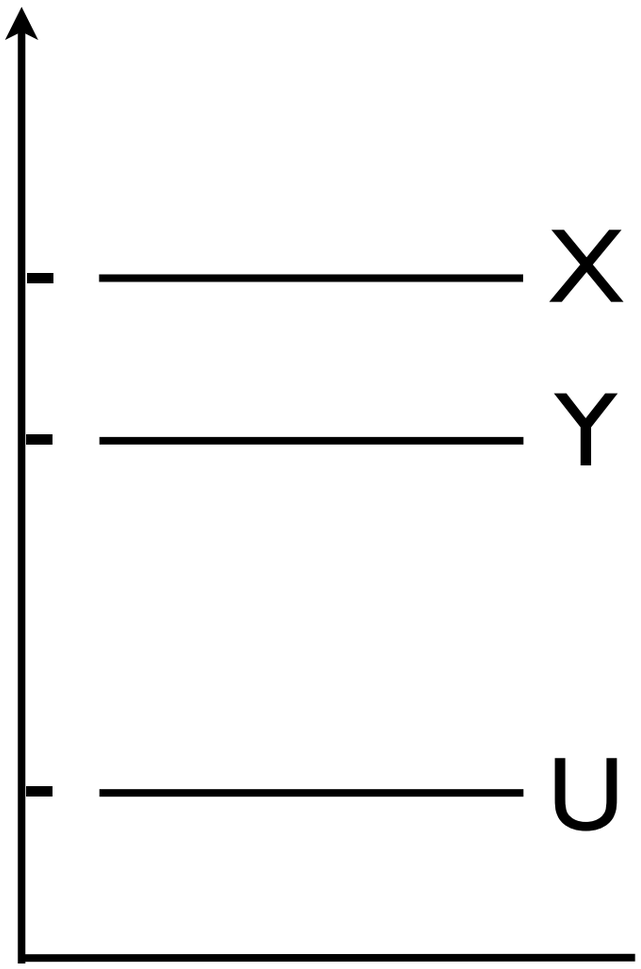
Strong or weak production?

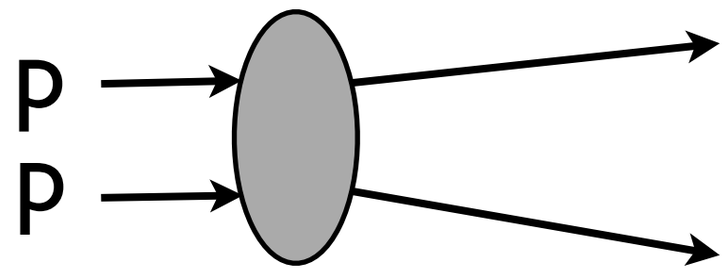


Simplified Models, please!



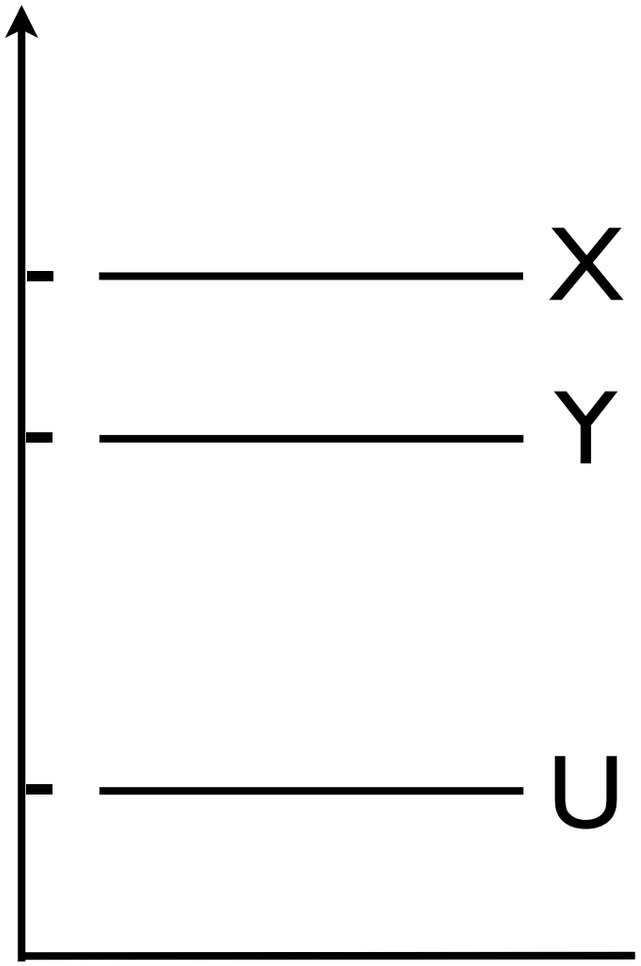
Simplified Models, please!

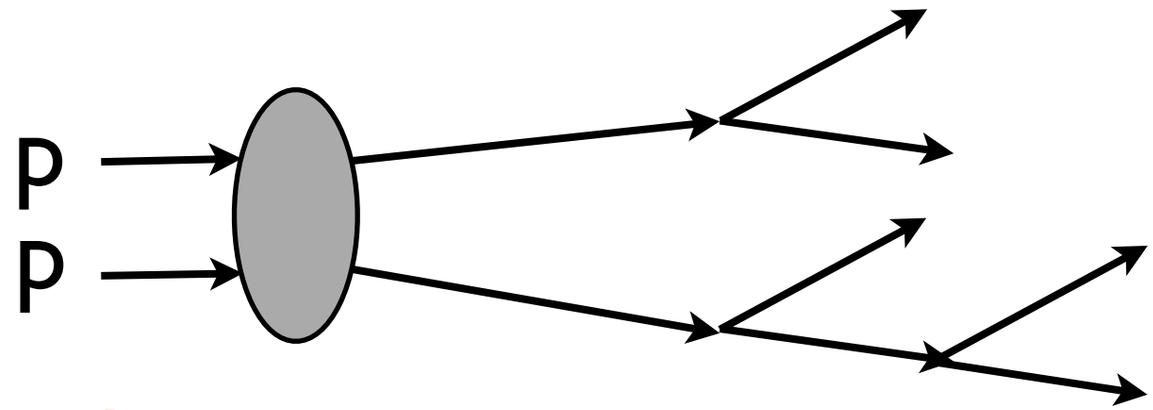




production

Simplified Models, please!

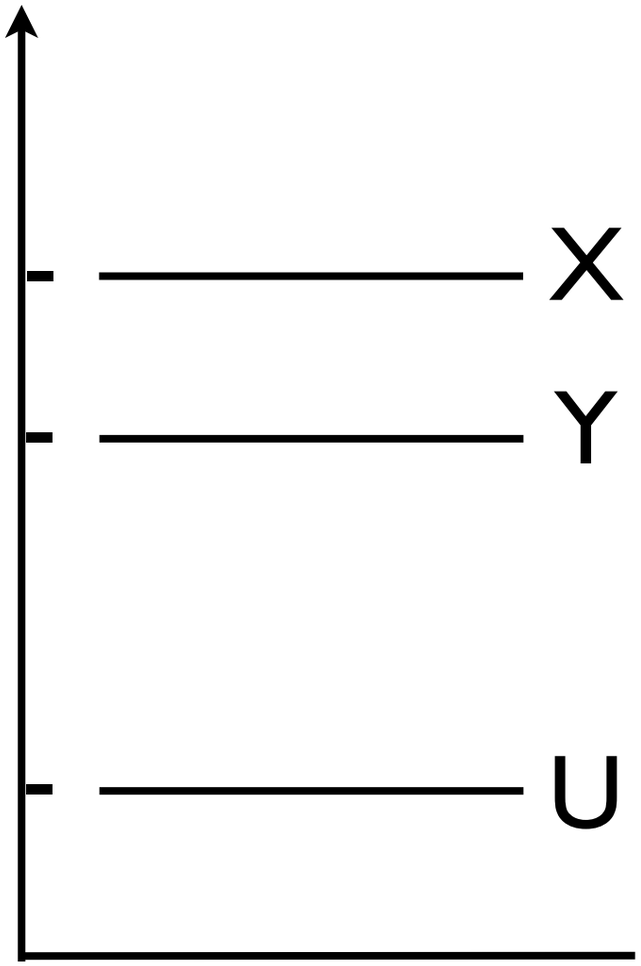


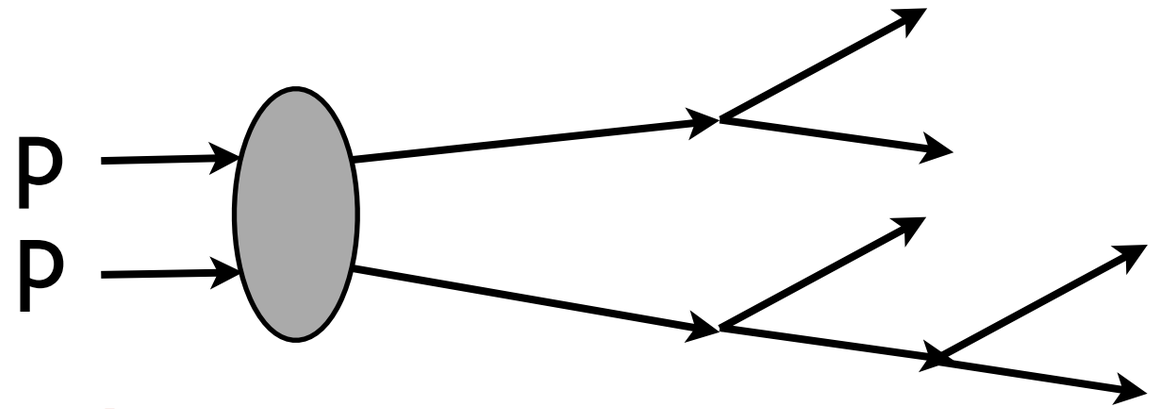


production

decay

Simplified Models, please!





production

decay

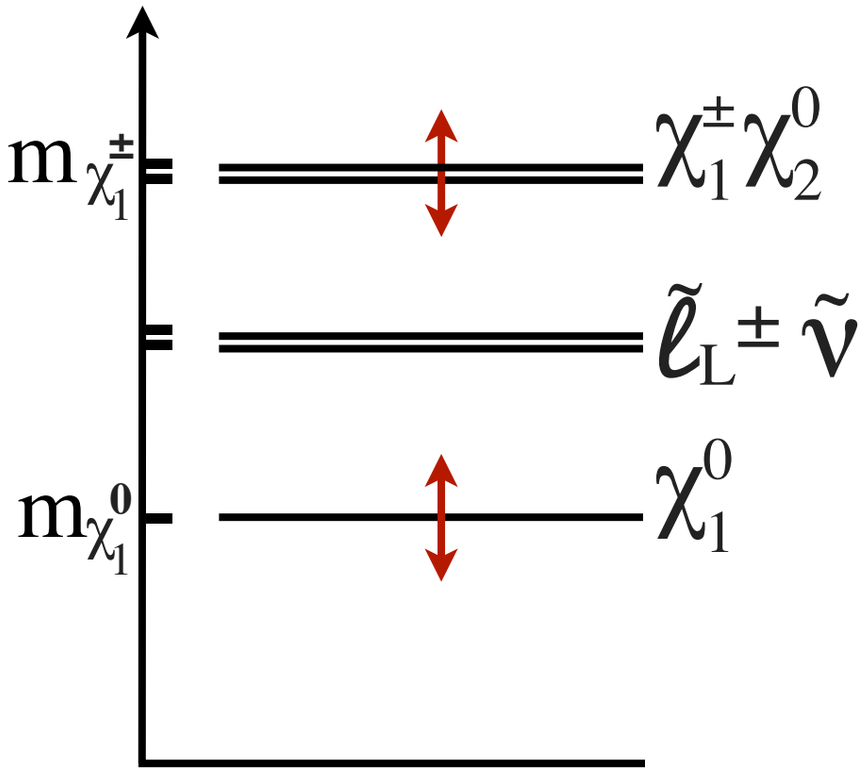
Free parameters:

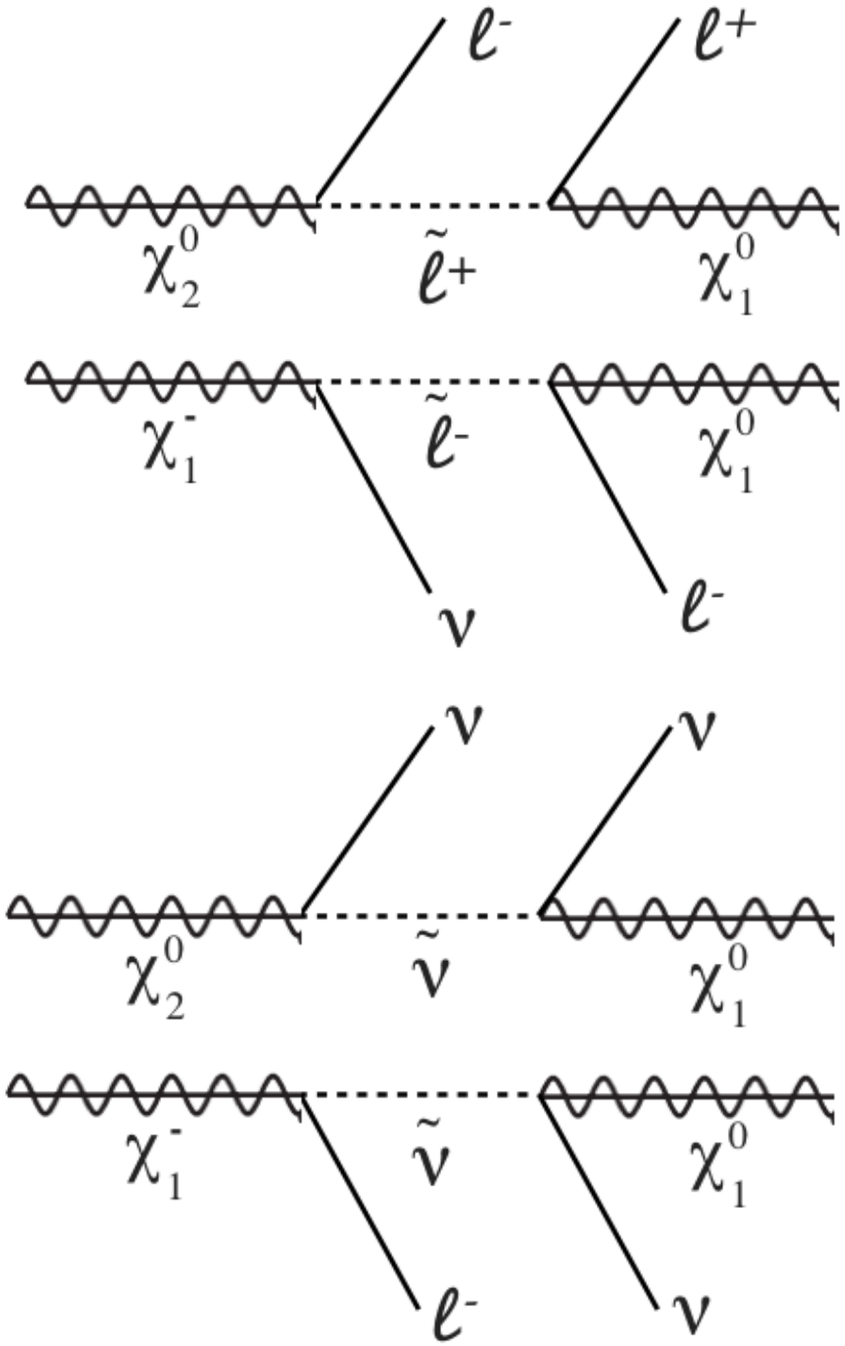
masses

$\sigma \times Br$

Multileptons and EW Production

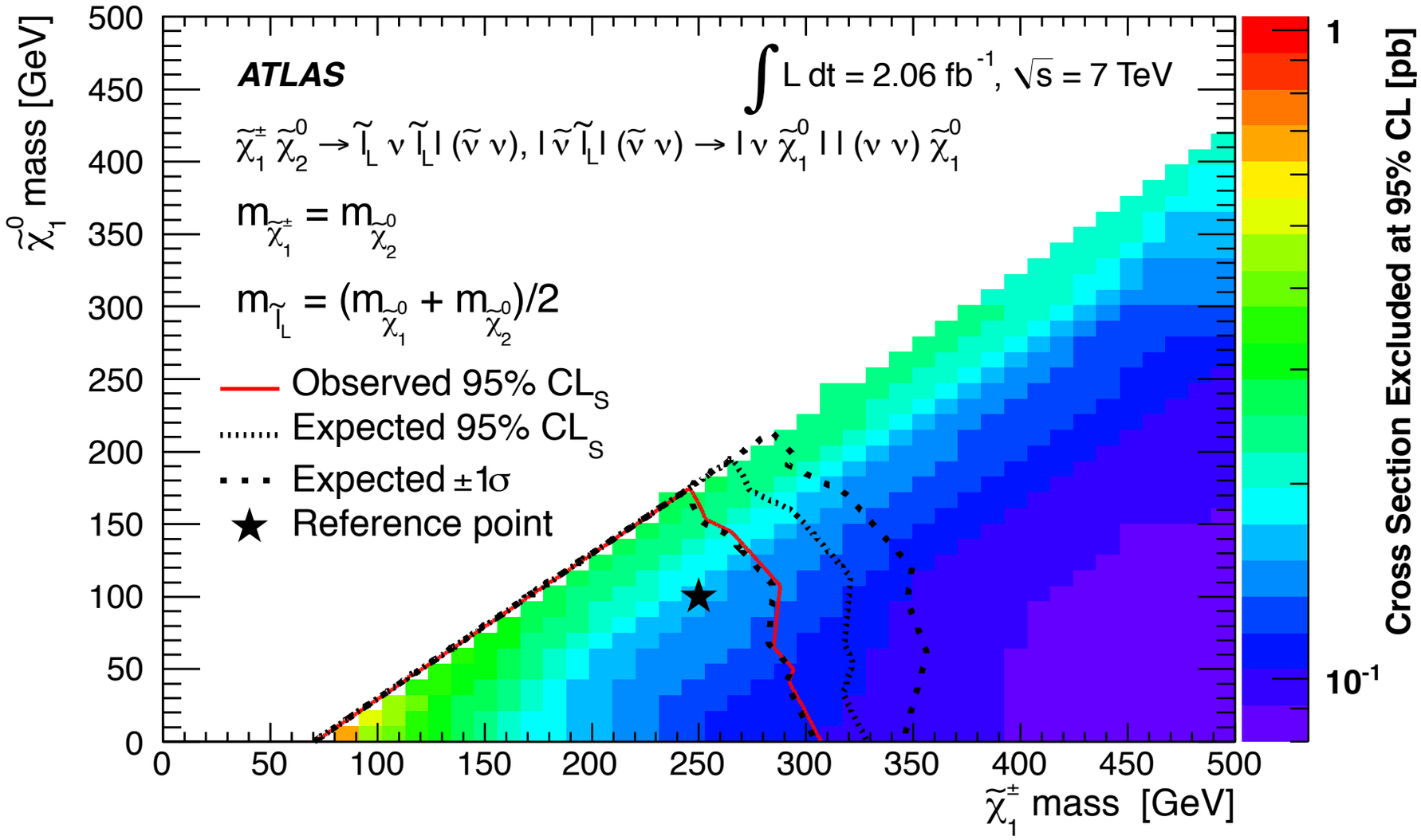
ATLAS multilepton search with 2/fb



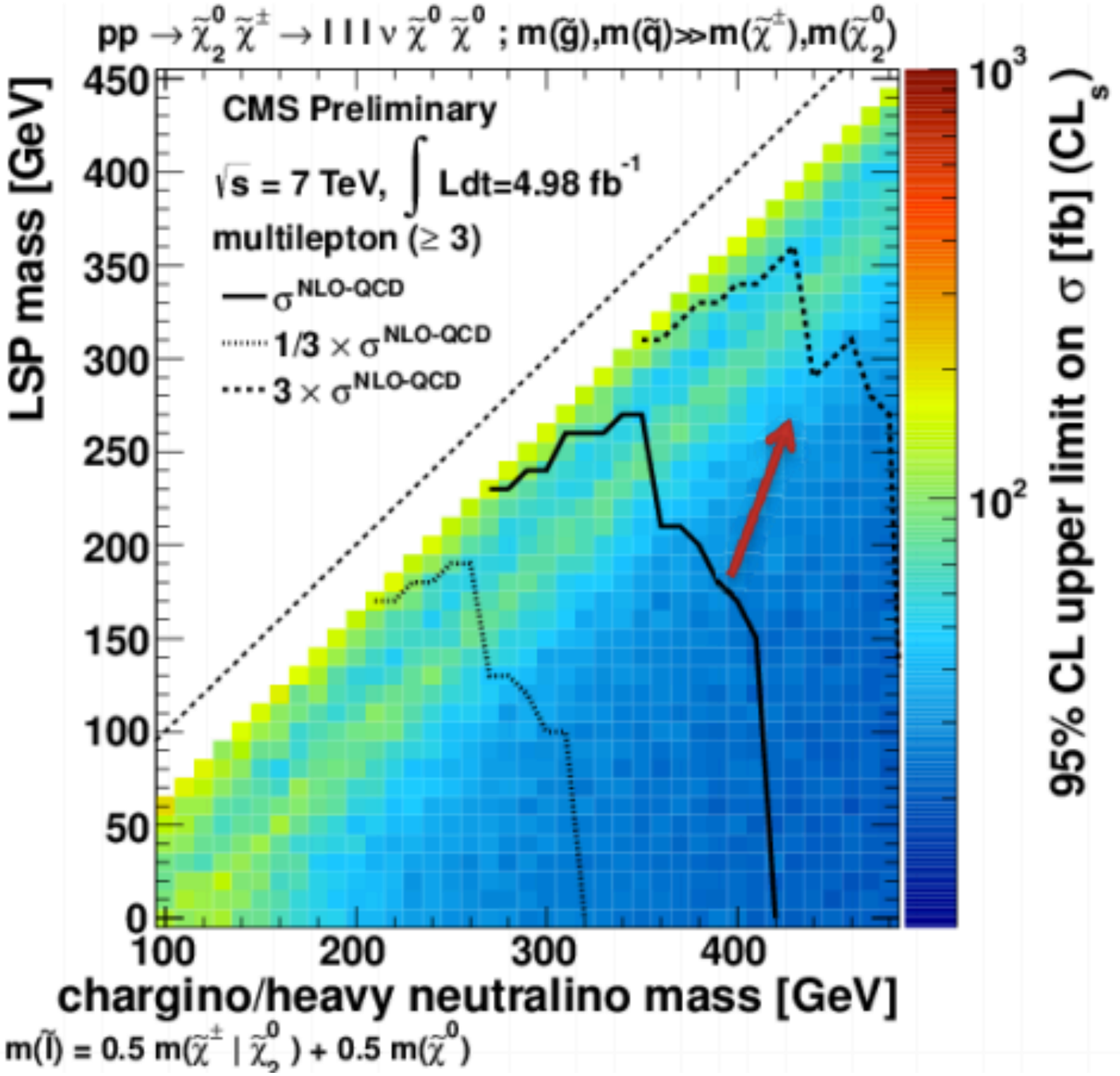


Multileptons and EW Production

ATLAS multilepton search with 2/fb



First Hand update from CMS! (5/fb)

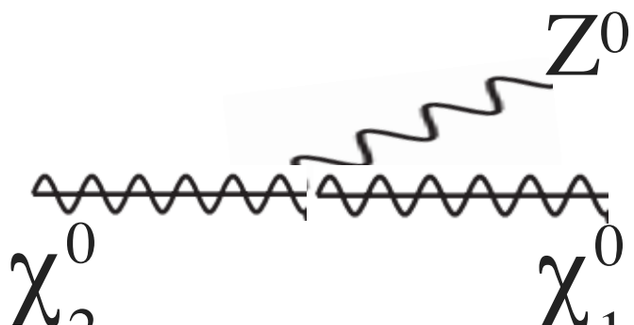


from Somalwar's talk

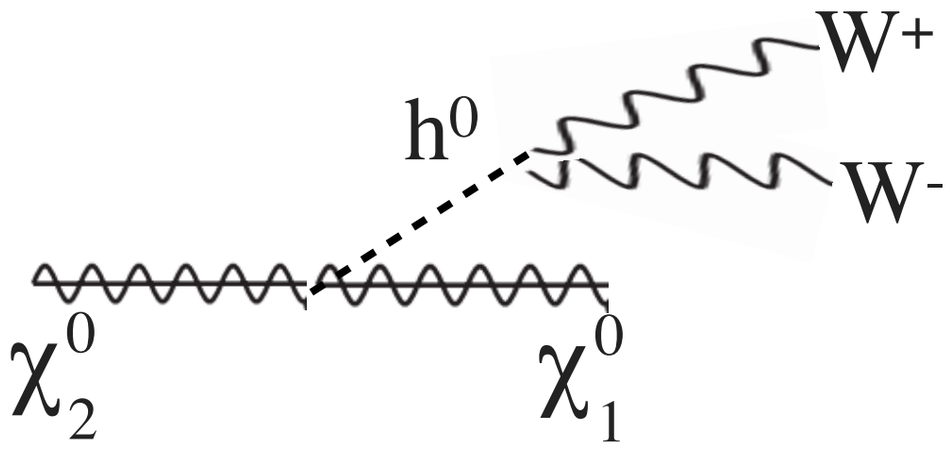
Challenging Cases

EW production + multileptons from $W^{\pm}$, Z^0, h^0 in final state

$Br(W^{\pm} \rightarrow \ell^{\pm} \nu)=20\%$



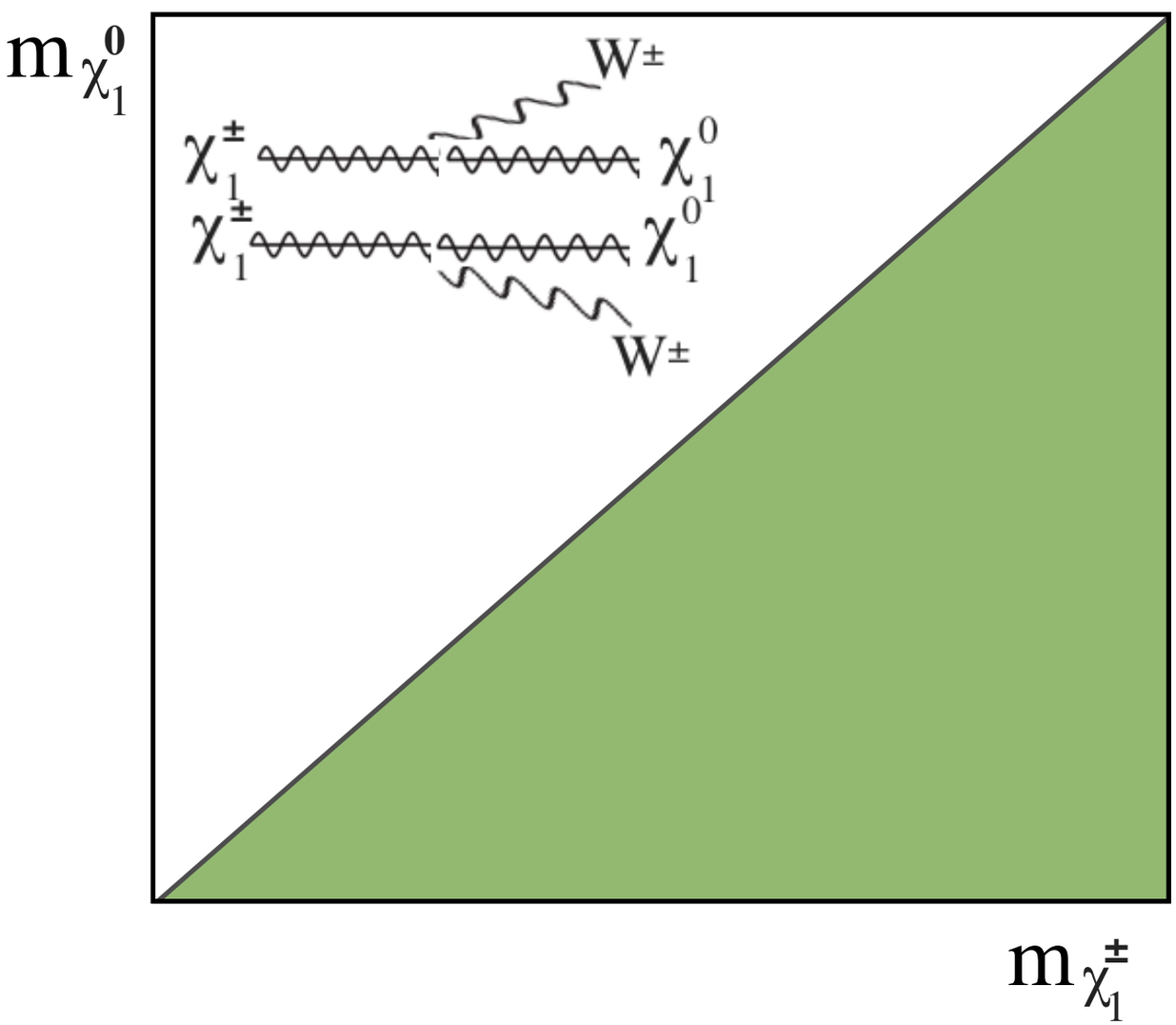
$Br(Z^0 \rightarrow \ell^+\ell^-)=6.7\%$



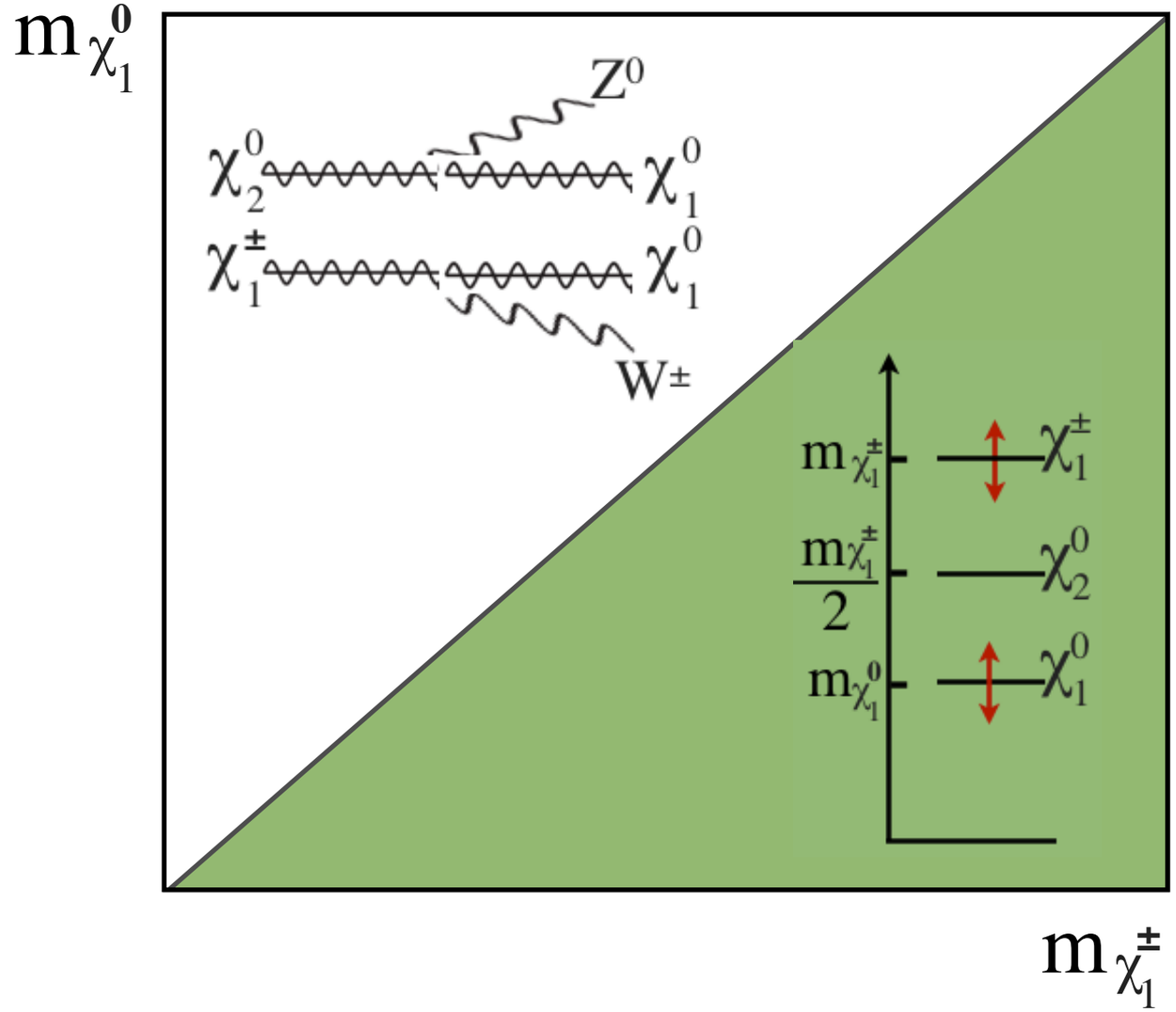
$Br(h^0 \rightarrow W^+W^-) \sim 20\%$ for $m_H = 125$ GeV

Simplified Model wish list

EW production + multileptons from W,± Z⁰, h⁰ in final state



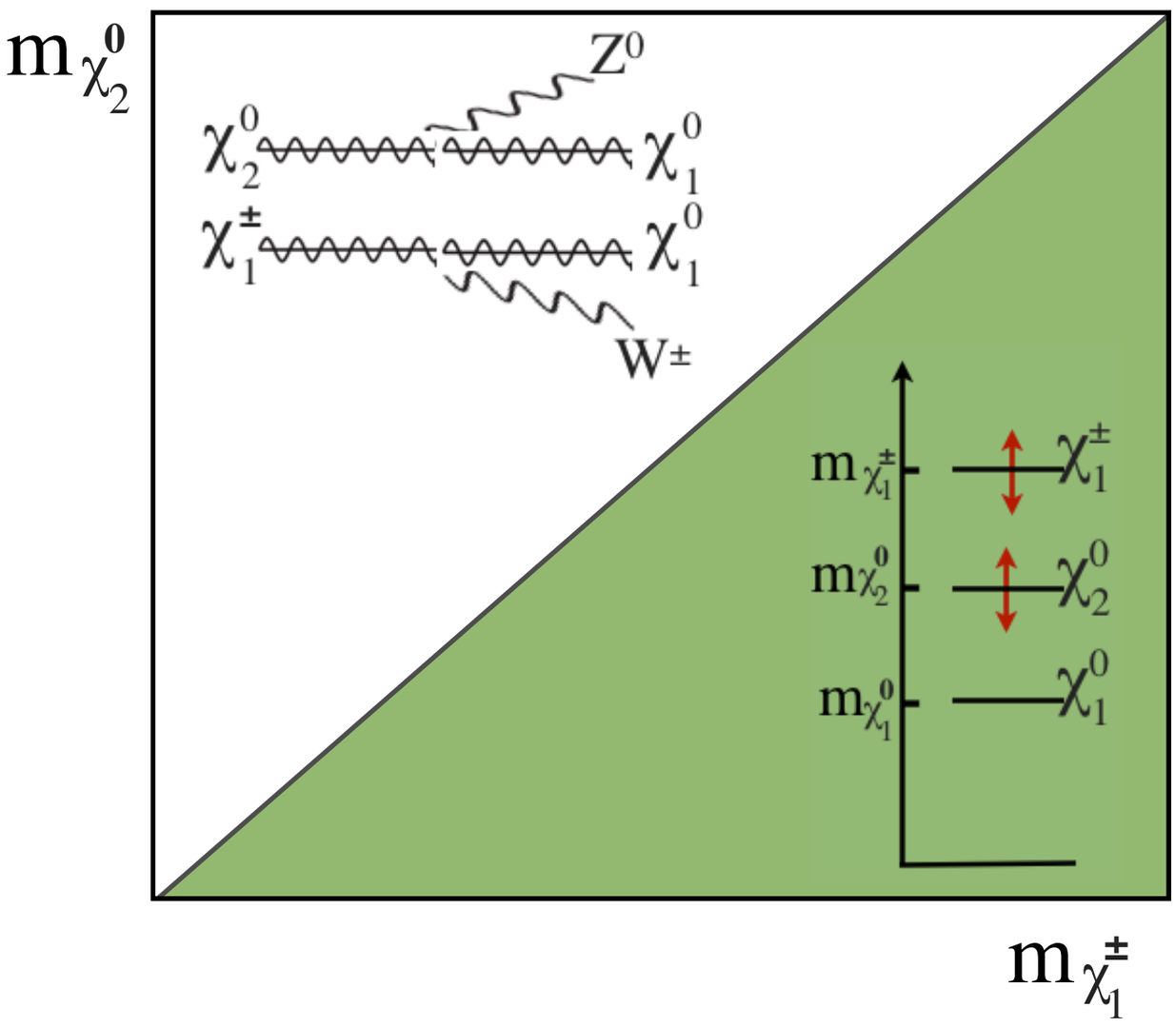
overall compression



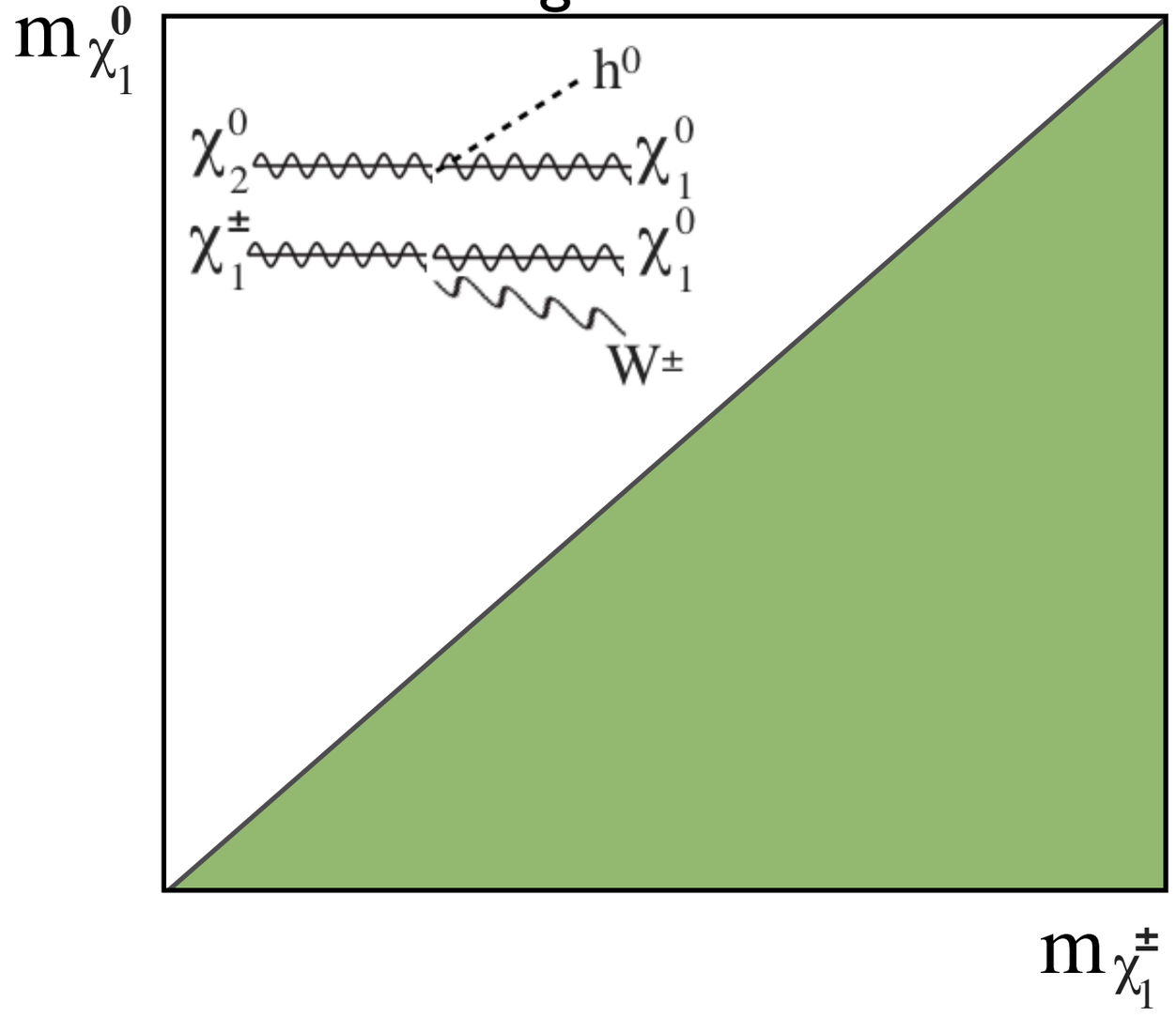
Simplified Model wish list

EW production + multileptons from $W^{\pm}$, Z^0, h^0 in final state

local compression



what happens when h^0 goes off-shell?



Summary

→ Strong production with multi-leptons in final state significantly constrained

→ limits competitive with searches in hadronic final states with large MET

→ EW production with BR=100% to multi-leptons already being constrained

→ best limits (high lepton mult., large splitting) in the range 600 GeV

→ EW production with reduced BR to multi-leptons: 2012 data may have something interesting to say!