LHC vs. Non-trivial squark spectra

Andreas Weiler
(DESY)

LHCb workshop
CERN
17/4/12

with Michele Papucci, Josh Ruderman (LBL Berkely)
Gilad Perez, Rakhi Mahbubani (CERN)

high p_T

- What have we learned about the squark masses after 5 1/fb ?
- Are all colored sparticles > 1 TeV?
- Is supersymmetry still providing a solution to the naturalness problem?

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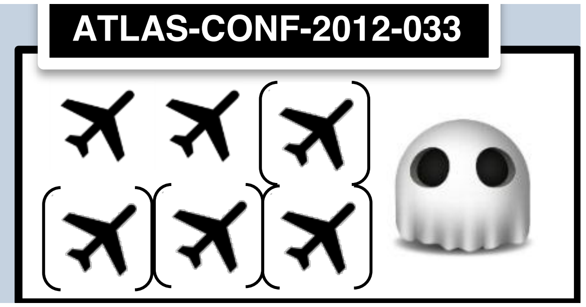
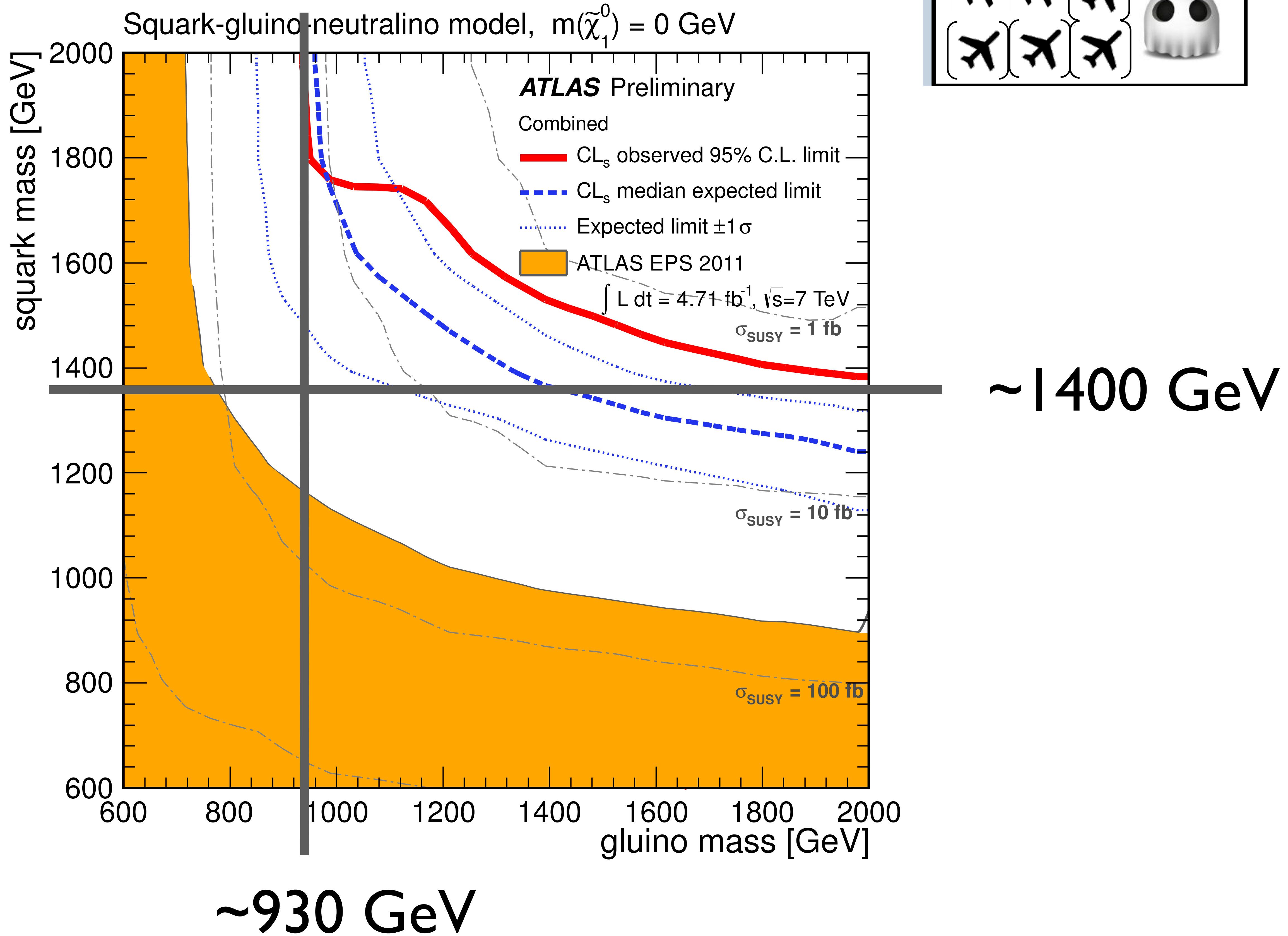
low p_T

- Flavor input: which squark spectrum is allowed?
- Flavor output: MFV splitting or more? Manage expectations for low p_T observables.

4.7 /fb Susy, post-Moriond





Avoiding m_{SUSY} > TeV *

- R-parity violation?
- Stealth susy?
- Compressed susy? (ISR?)
- bottom-up natural spectrum! → this talk
- other options? → also this talk

* colored objects

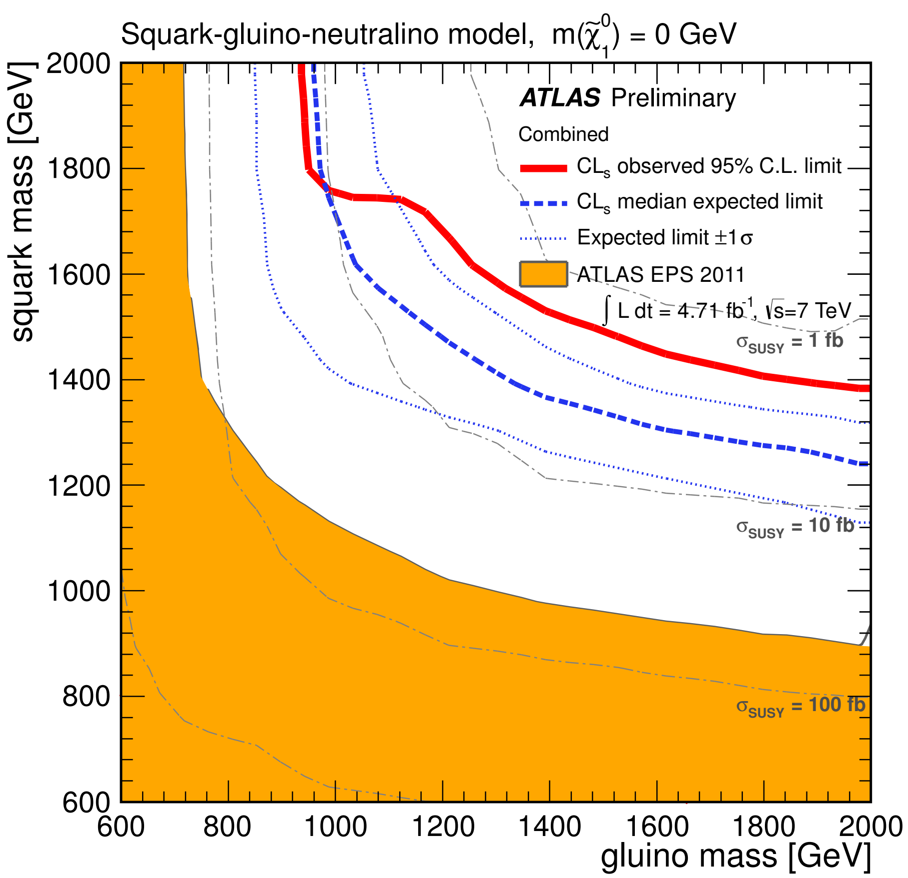
Light light-flavor squarks

work in progress with

Michele Papucci, Josh Ruderman *(LBL Berkely)*
Gilad Perez, Rakhi Mahbubani *(CERN)*

to appear this month

1st & 2nd geneneration squark limits



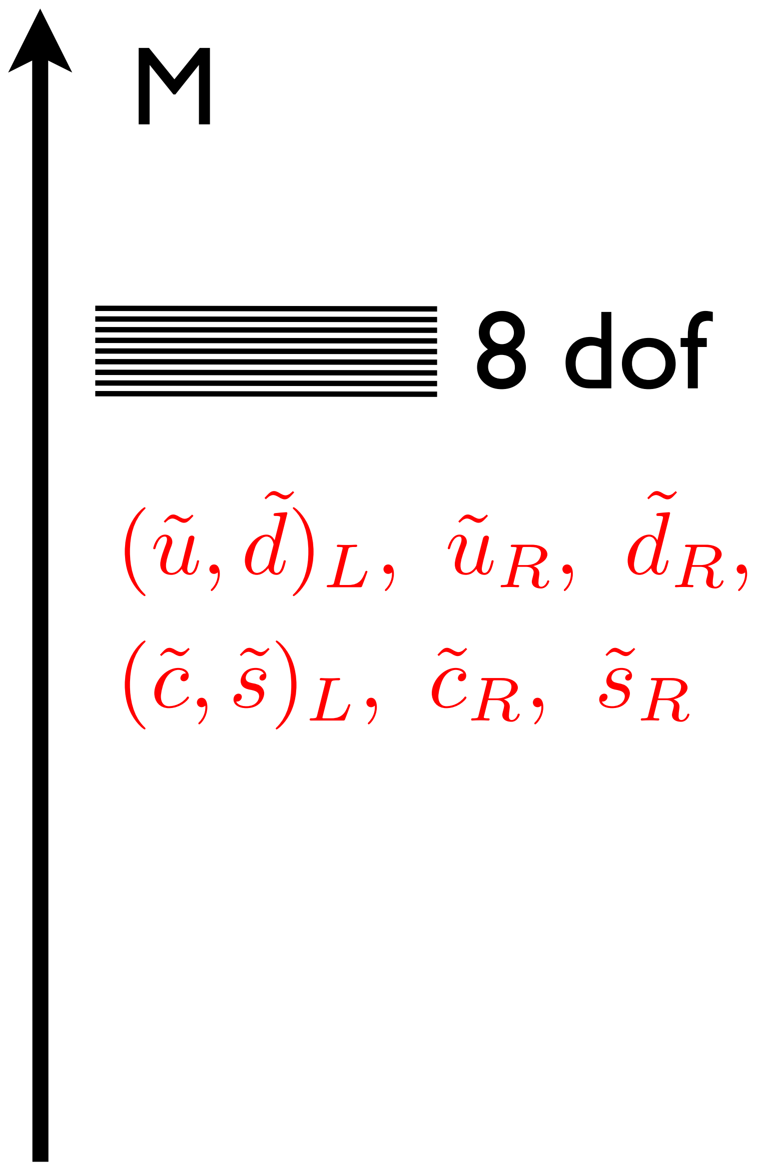
Light squarks > 1.4 TeV?

Assumptions?

What is driving the limit?

Holes in the net?

Do 1st & 2nd gen' squarks have to be degenerate?



- Because of flavor constraints? Not really.

spectrum in ATLAS/CMS plots

UTfit 08, Isidori, Perez, Nir '10

Operator	Bounds on Λ in TeV ($c_{ij}=1$) Re	Bounds on Λ in TeV ($c_{ij}=1$) Im	Bounds on c_{ij} ($\Lambda = 1$ TeV) Re	Bounds on c_{ij} ($\Lambda = 1$ TeV) Im	Observables
$(\bar{s}_L\gamma^\mu d_L)^2$	9.8×10^2	1.6×10^4	9.0×10^{-7}	3.4×10^{-9}	Δm_K; ϵ_K
$(\bar{s}_R\, d_L)(\bar{s}_L d_R)$	1.8×10^4	3.2×10^5	6.9×10^{-9}	2.6×10^{-11}	Δm_K; ϵ_K
$(\bar{c}_L\gamma^\mu u_L)^2$	1.2×10^3	2.9×10^3	5.6×10^{-7}	1.0×10^{-7}	Δm_D; $\lvert q/p\rvert, \phi_D$
$(\bar{c}_R\, u_L)(\bar{c}_L u_R)$	6.2×10^3	1.5×10^4	5.7×10^{-8}	1.1×10^{-8}	Δm_D; $\lvert q/p\rvert, \phi_D$
$(\bar{b}_L\gamma^\mu d_L)^2$	5.1×10^2	9.3×10^2	3.3×10^{-6}	1.0×10^{-6}	Δm_{B_d}; $S_{\psi K_S}$
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Very strong suppression! New flavor violation must either approximately (exactly?) follow SM structure…

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… or exist only at very high scales (*10^2 - 10^5* TeV)

Generic light flavor squarks

- E.g. CPV in K-K mixing, severe constraints:

$$\frac{1}{\Lambda^2}(\bar{s}_R d_L)(s_L d_R) \rightarrow \quad \Lambda > 3.2 \times 10^5\,\mathrm{TeV}$$

- Generic 1-2 squark mass splittings small

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mass splitting

(m=1TeV)

q	ij	$(\delta^q_{ij})_{MM}$	$\langle\delta^q_{ij}\rangle$
d	12	0.03	0.002
d	13	0.2	0.07
d	23	0.6	0.2
u	12	0.1	0.008

Isidori et. al '10

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mass splitting

If mixing is O(1) → small $\Delta m_{\tilde{q}} / m_{\tilde{q}}$

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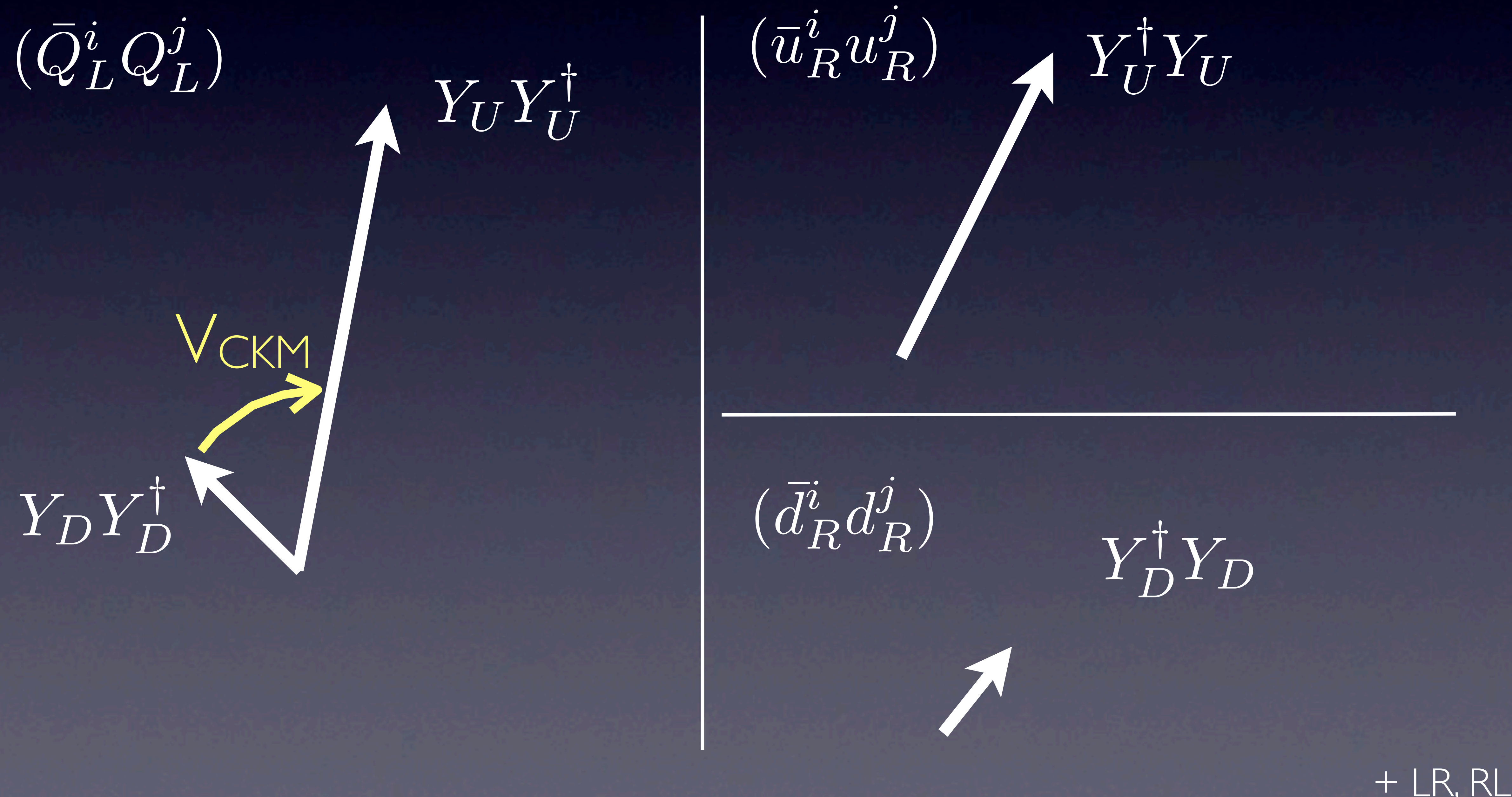
Flavor and CP in the SM

Yukawa matrices Y_U & Y_D encode flavor violation



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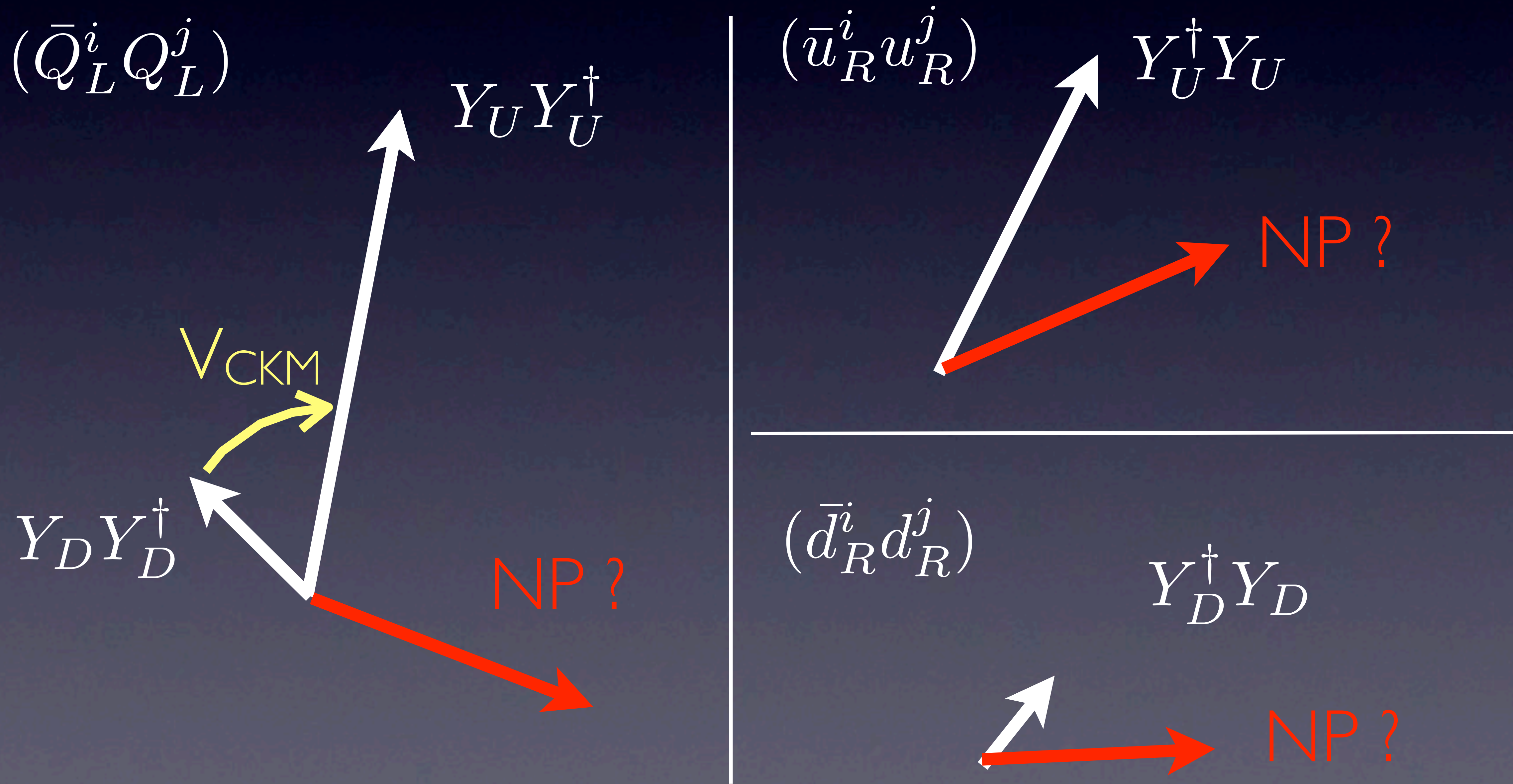
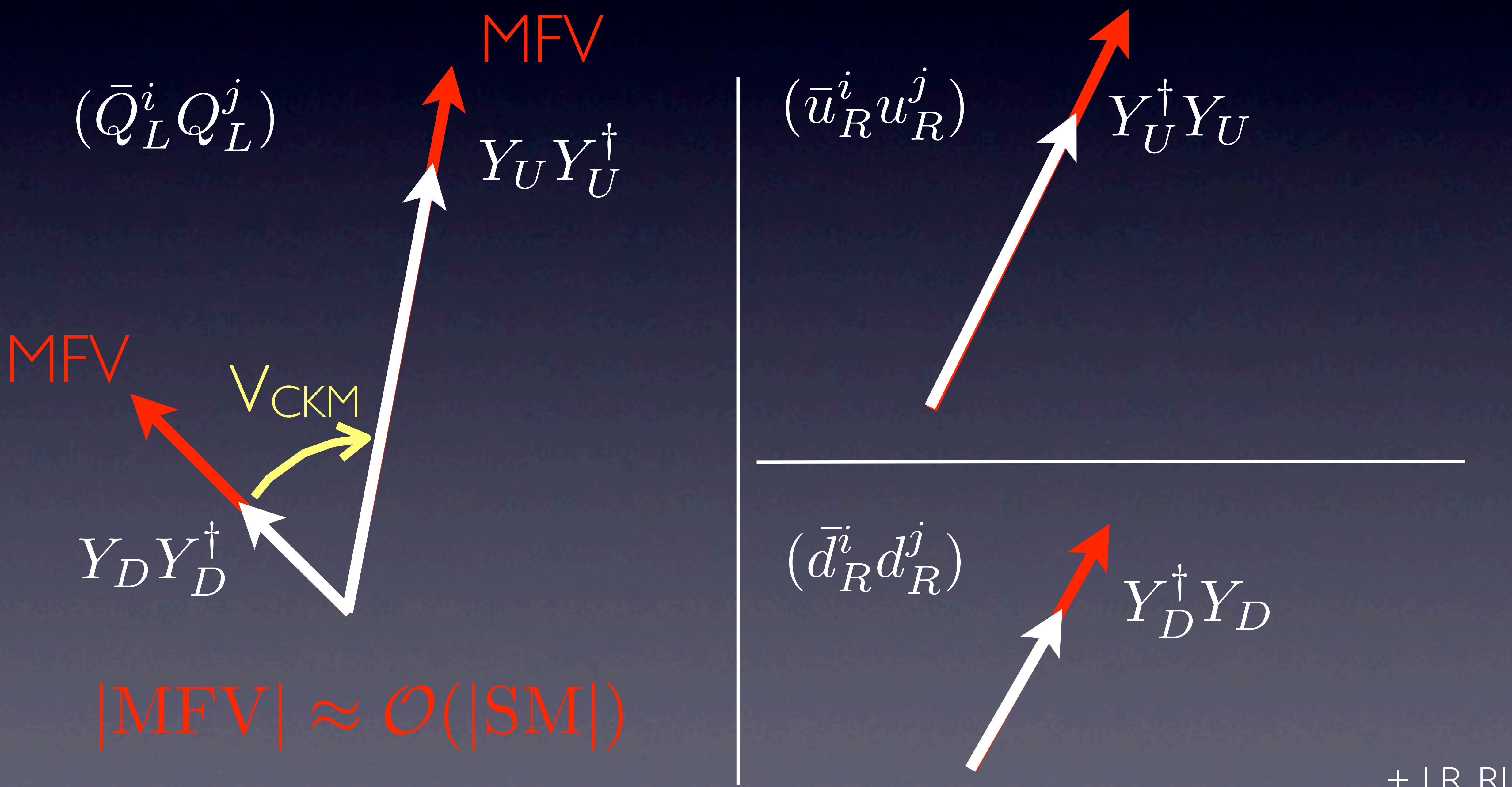


+ LR, RL

Minimal flavor violation

Chivukula Georgi; Buras et. al; D'Ambrosio et. al

New particles/interactions, but flavor structure ~ V_{CKM}



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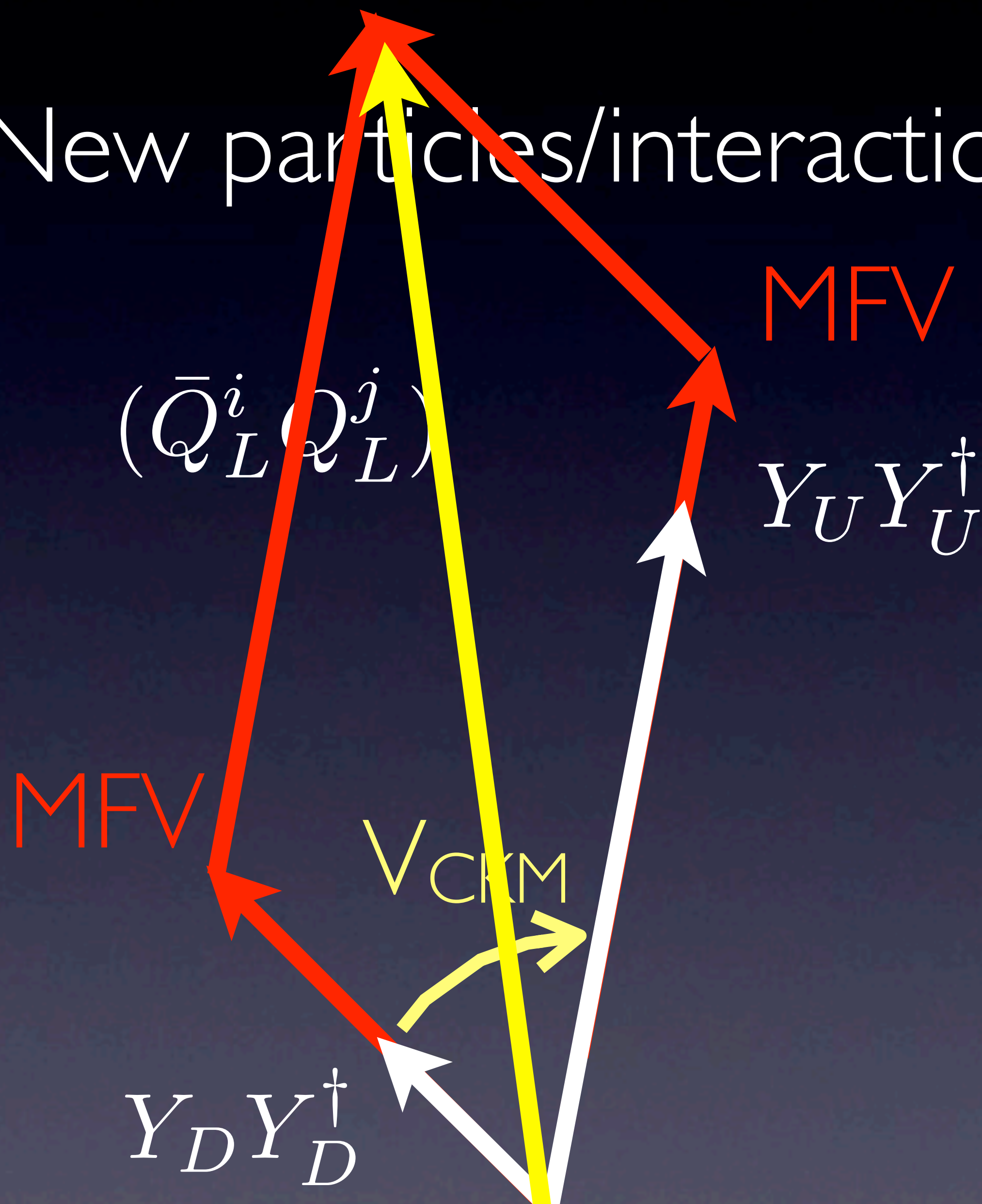
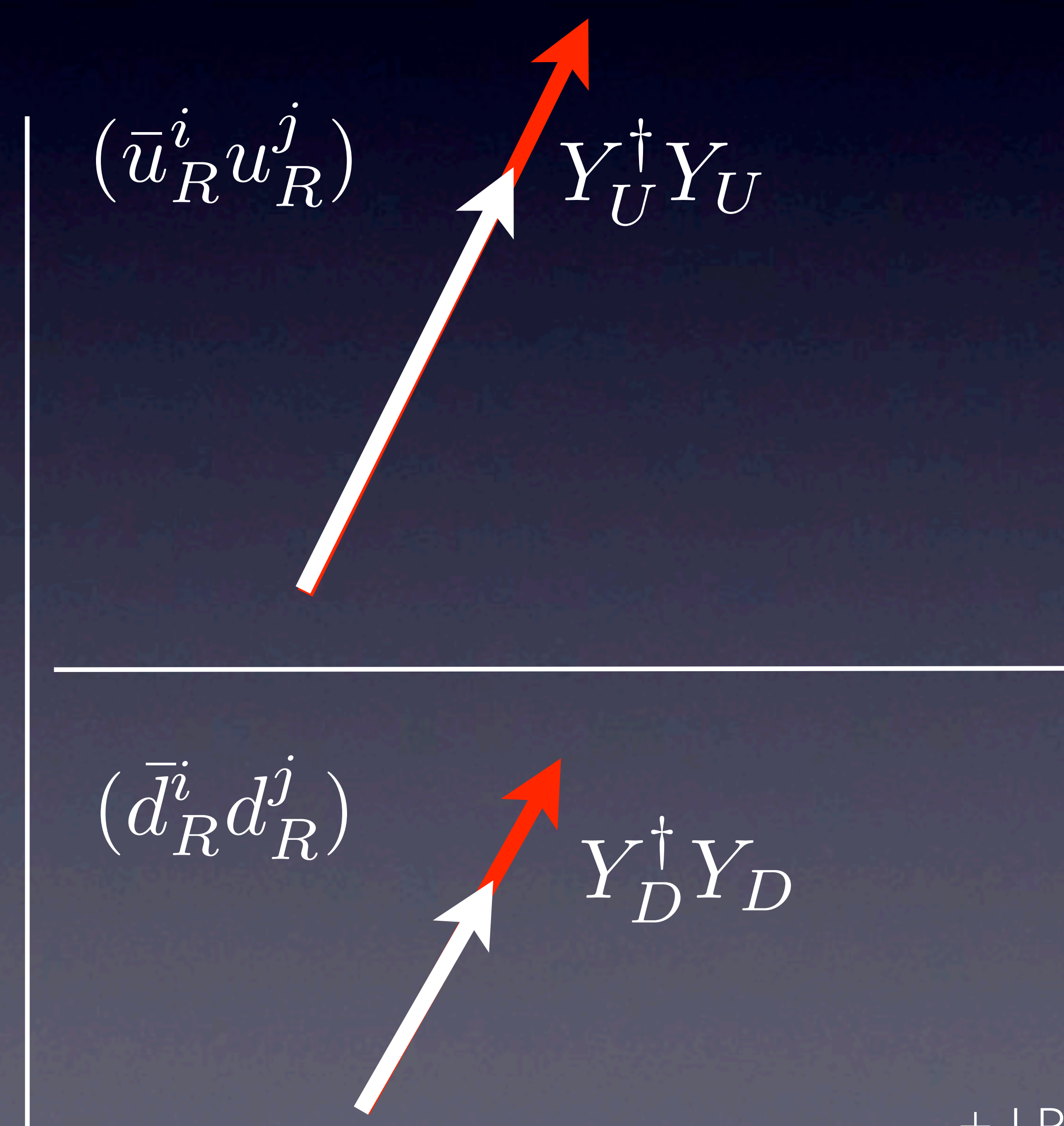


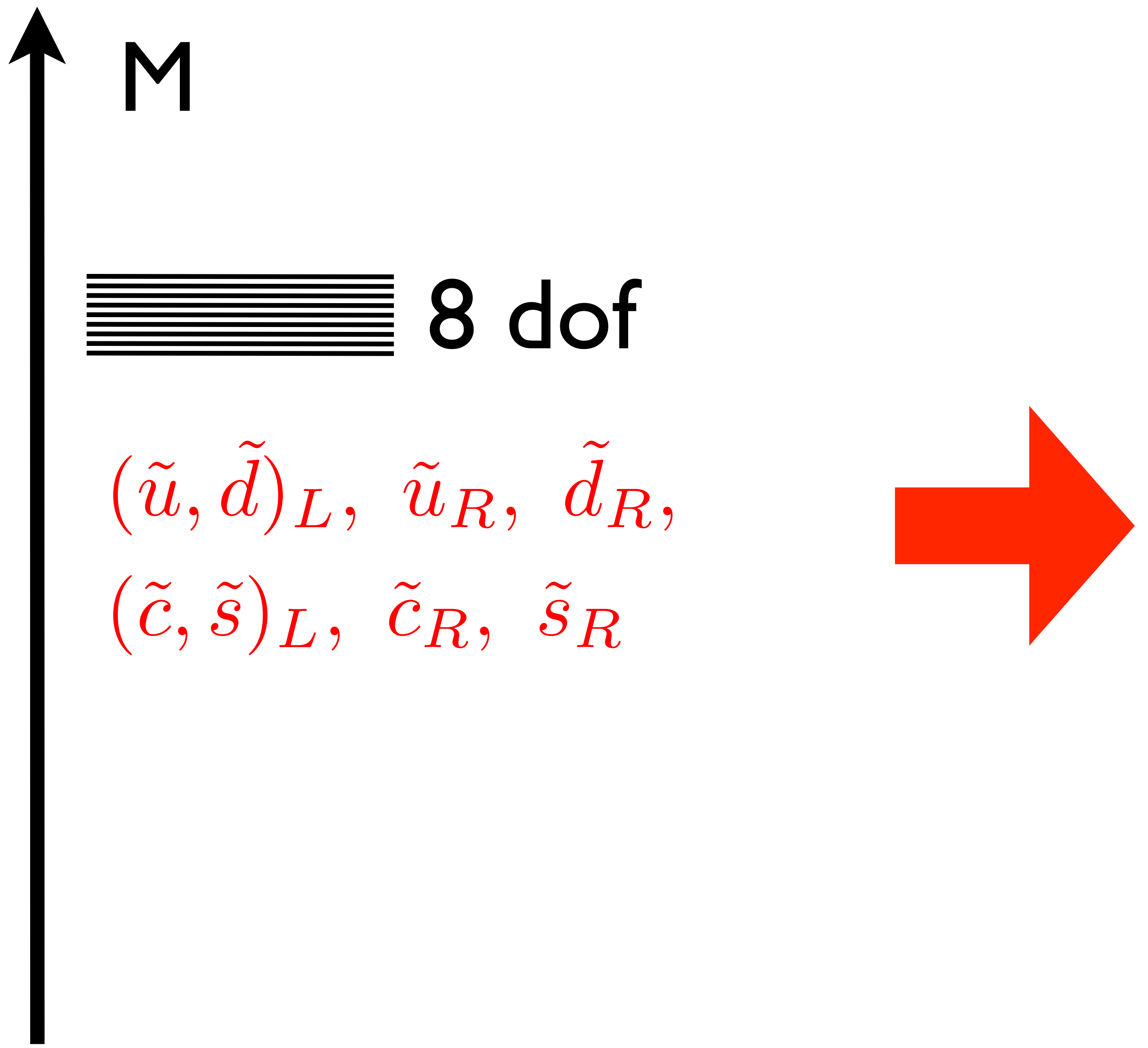
$$|\mathrm{MFV}| \approx \mathcal{O}(|\mathrm{SM}|)$$



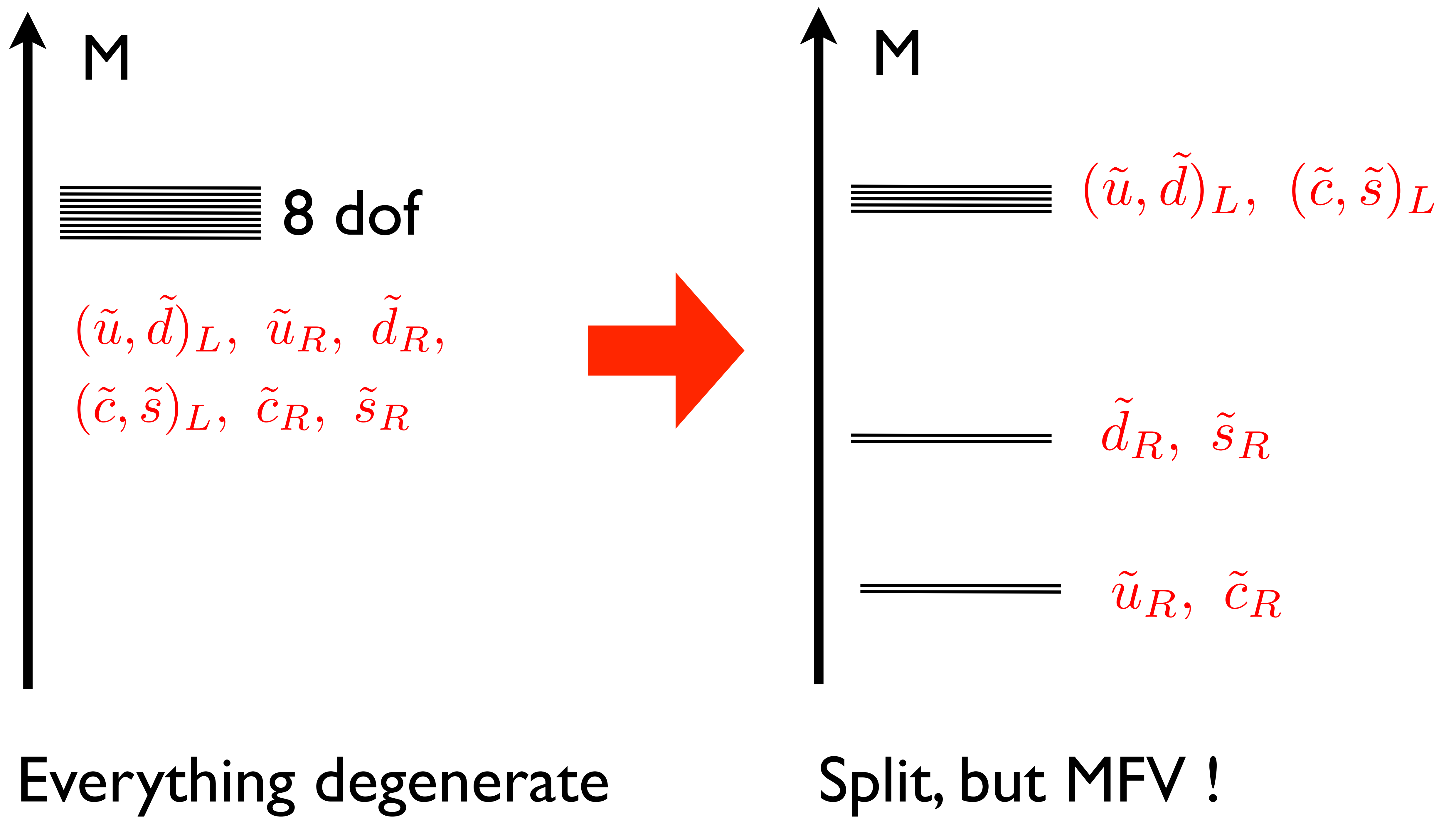
+ LR, RL

MFV

- Trivial: Squark masses same for all three generations but split between $\tilde{Q}_L, \ \tilde{u}_R, \ \tilde{d}_R$
- Split among generations but split like in SM: mass-differences $\propto Y_{U,D} \sim (0,0,1)$



Everything degenerate


M
8 dof
$(\tilde{u},\tilde{d})_L,\ \tilde{u}_R,\ \tilde{d}_R,$
$(\tilde{c},\tilde{s})_L,\ \tilde{c}_R,\ \tilde{s}_R$
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M
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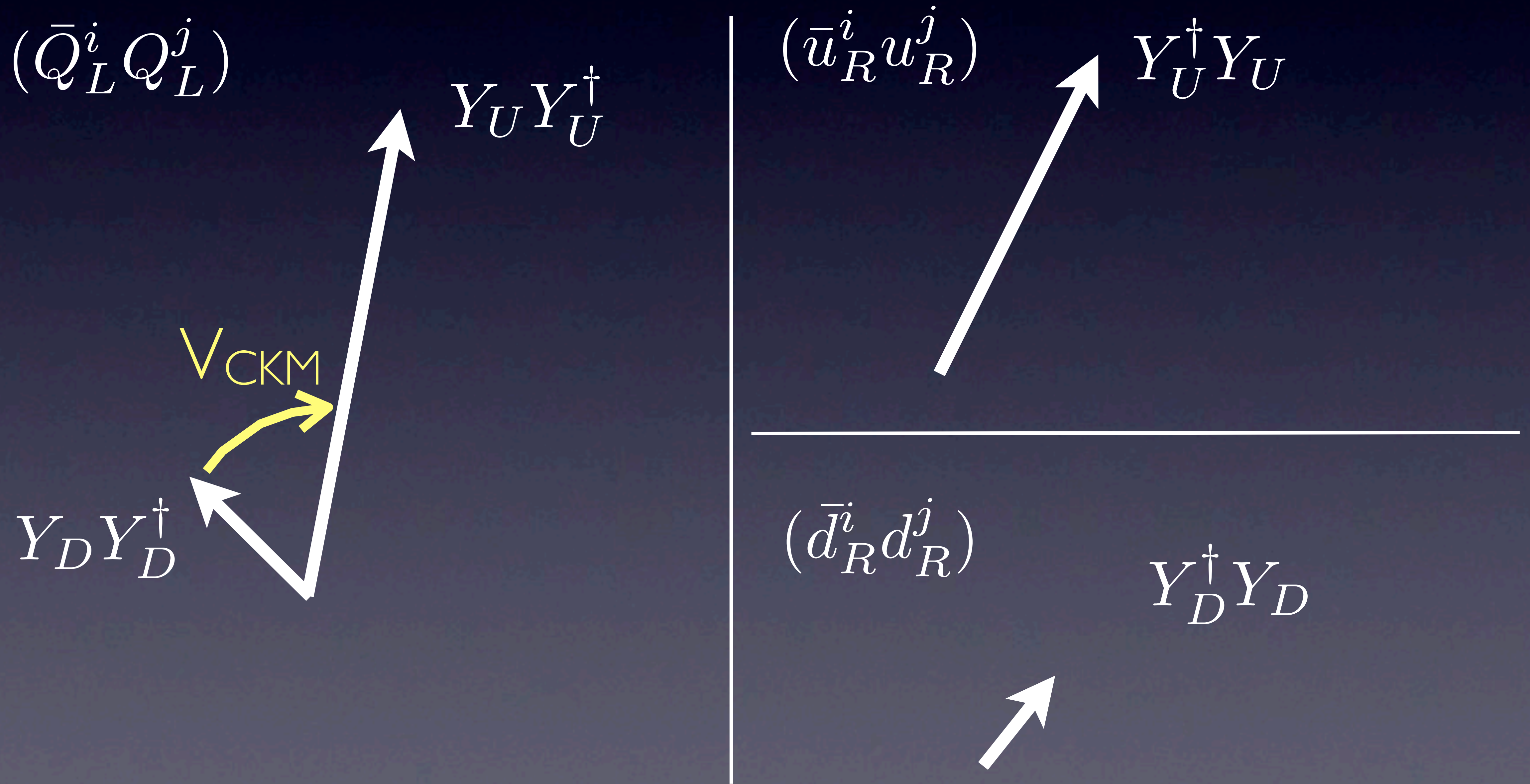
$\tilde{d}_R,\ \tilde{s}_R$
$\tilde{u}_R,\ \tilde{c}_R$
Split, but MFV !

NP Flavor dynamics

Dynamics (e.g. $U(1)_{horiz.}$) generates hierarchies in masses & mixings. Consequence: partial alignment with SM



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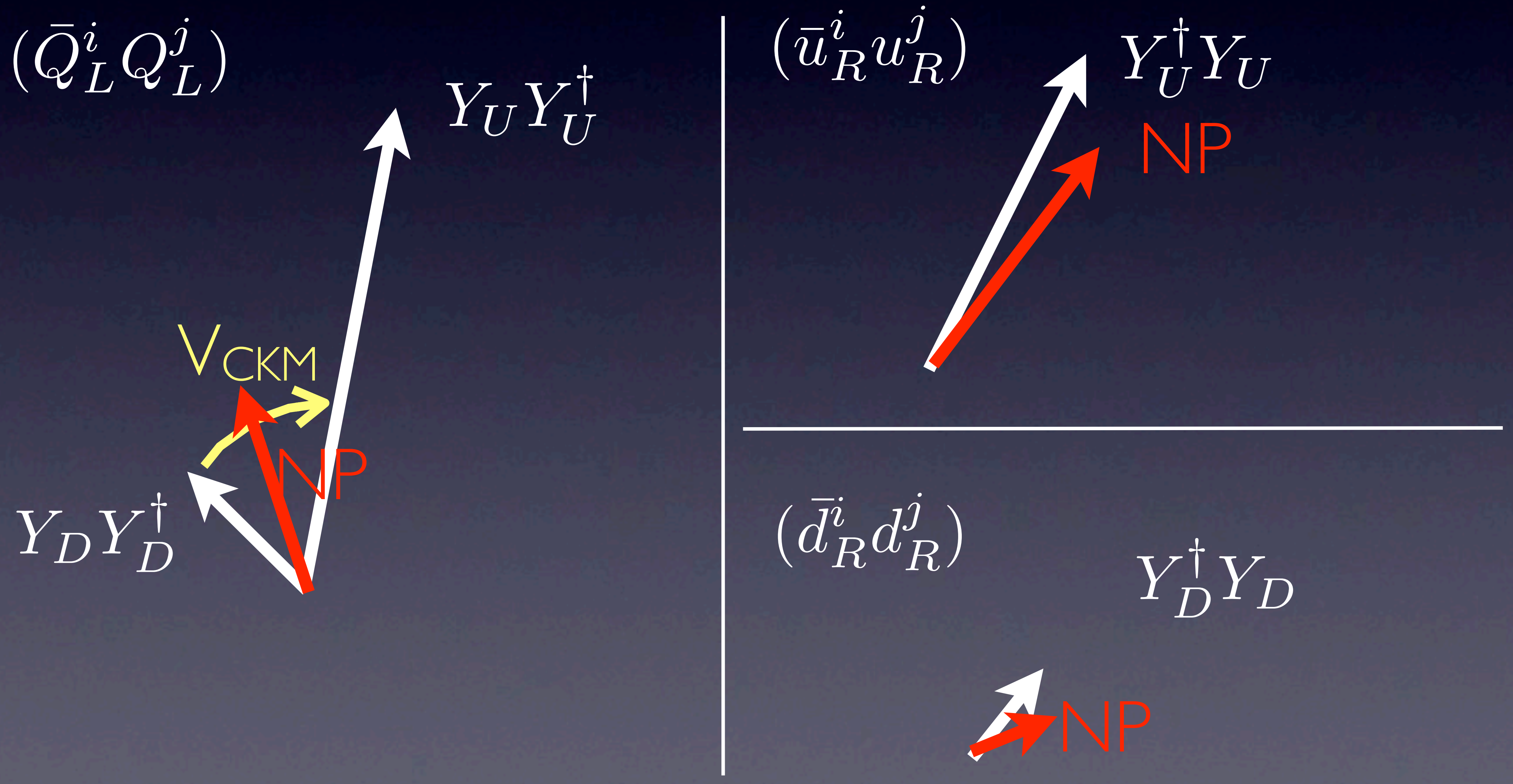

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Alignment

- Right handed squarks can be arbitrarily split
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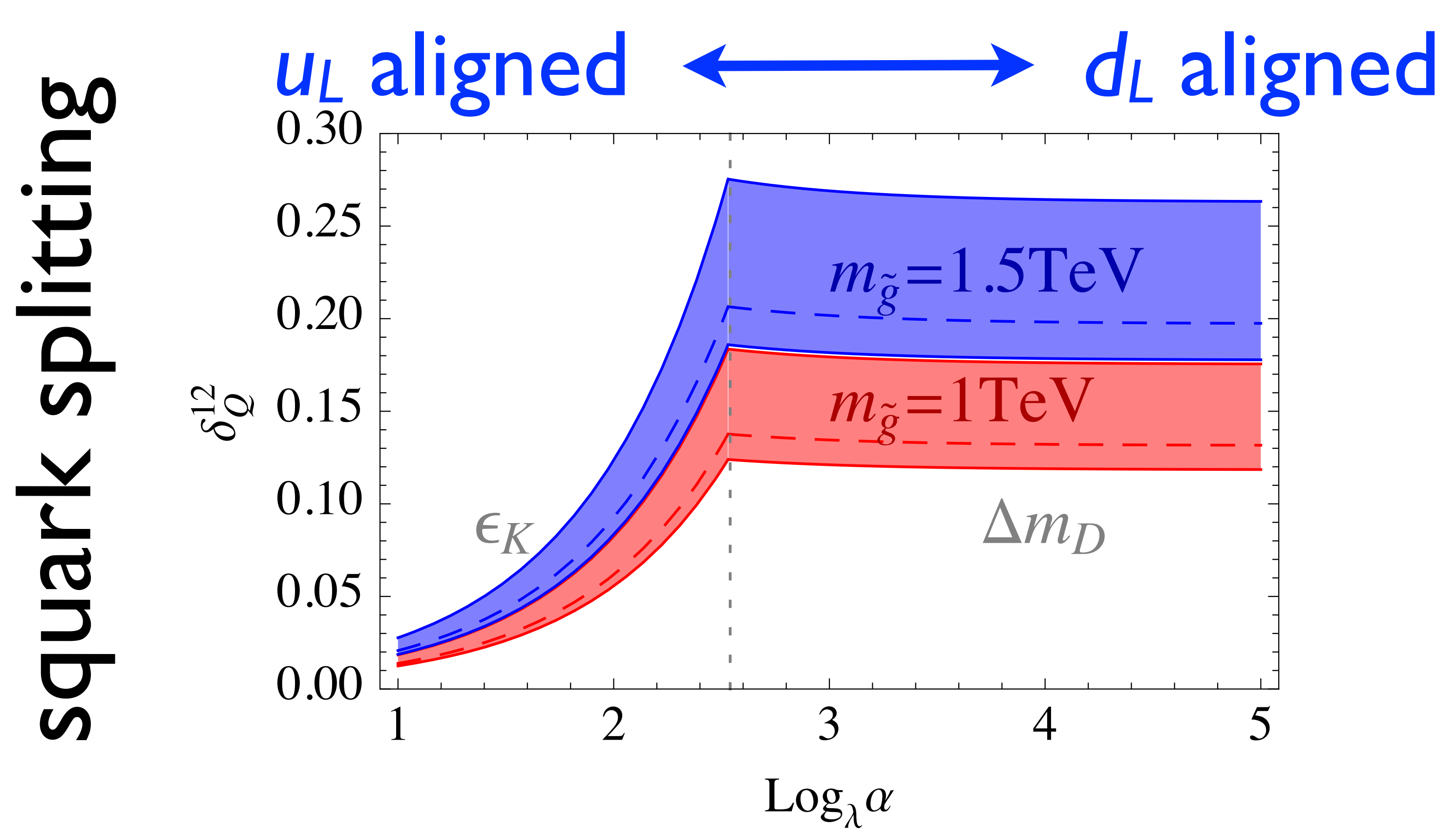

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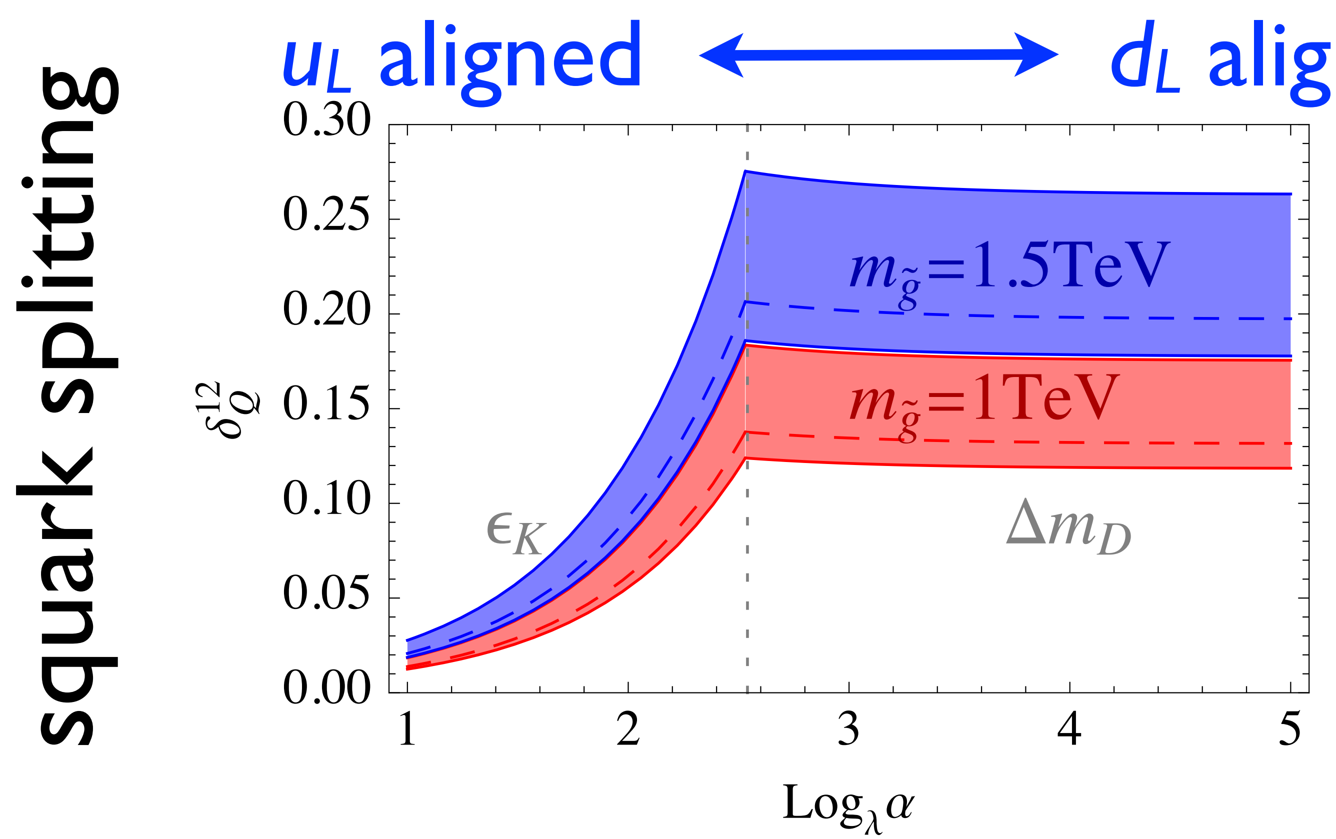

Example:

m_{gluino} = 1.3 TeV

m_{Q1} = 550 GeV

m_{Q2} = 950 GeV

→ see Jernej Kamenik's talk

Flavor vs. squark masses: summary

- Generic 1-2 splitting has to be small, BUT:
- Can split vertically: split irrep's, but MFV
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mixing / misalignment between
SM Yukawas and squark mass matrices

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If by symmetry: K_{ij} ~ diagonal => O(1) mass splitting allowed!

Seiberg & Nir

1st & 2nd gen' squarks degenerate

$$\tilde{Q}_1 \qquad \tilde{Q}_2 \qquad \tilde{Q}_3$$

$$\begin{pmatrix} \tilde{u}_L \\ \tilde{d}_L \end{pmatrix} \qquad \begin{pmatrix} \tilde{c}_L \\ \tilde{s}_L \end{pmatrix} \qquad \begin{pmatrix} \tilde{t}_L \\ \tilde{b}_L \end{pmatrix}$$

$$\tilde{u}_R \qquad \tilde{c}_R \qquad \tilde{t}_R$$

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assumption in ATLAS/CMS plots

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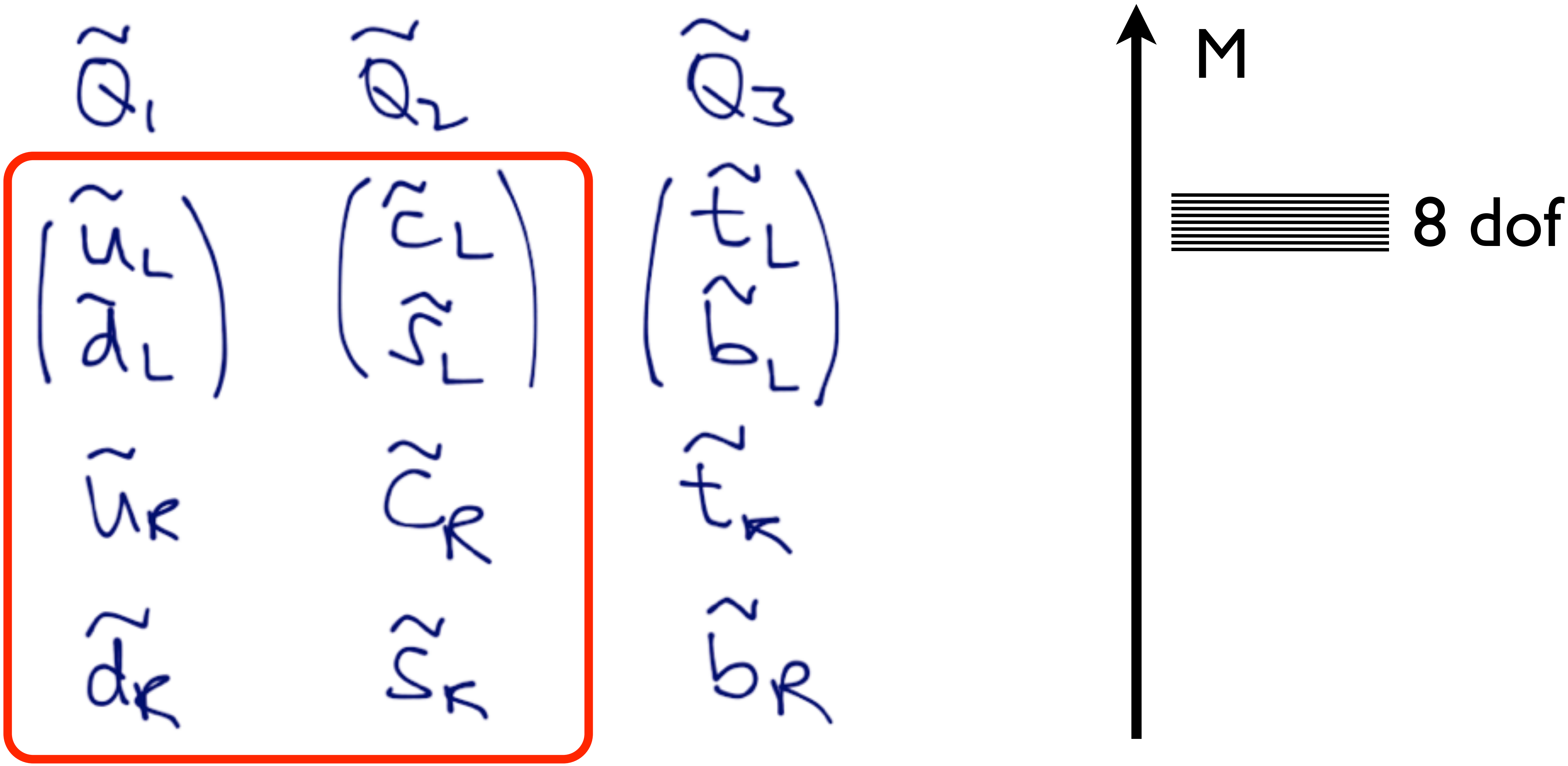


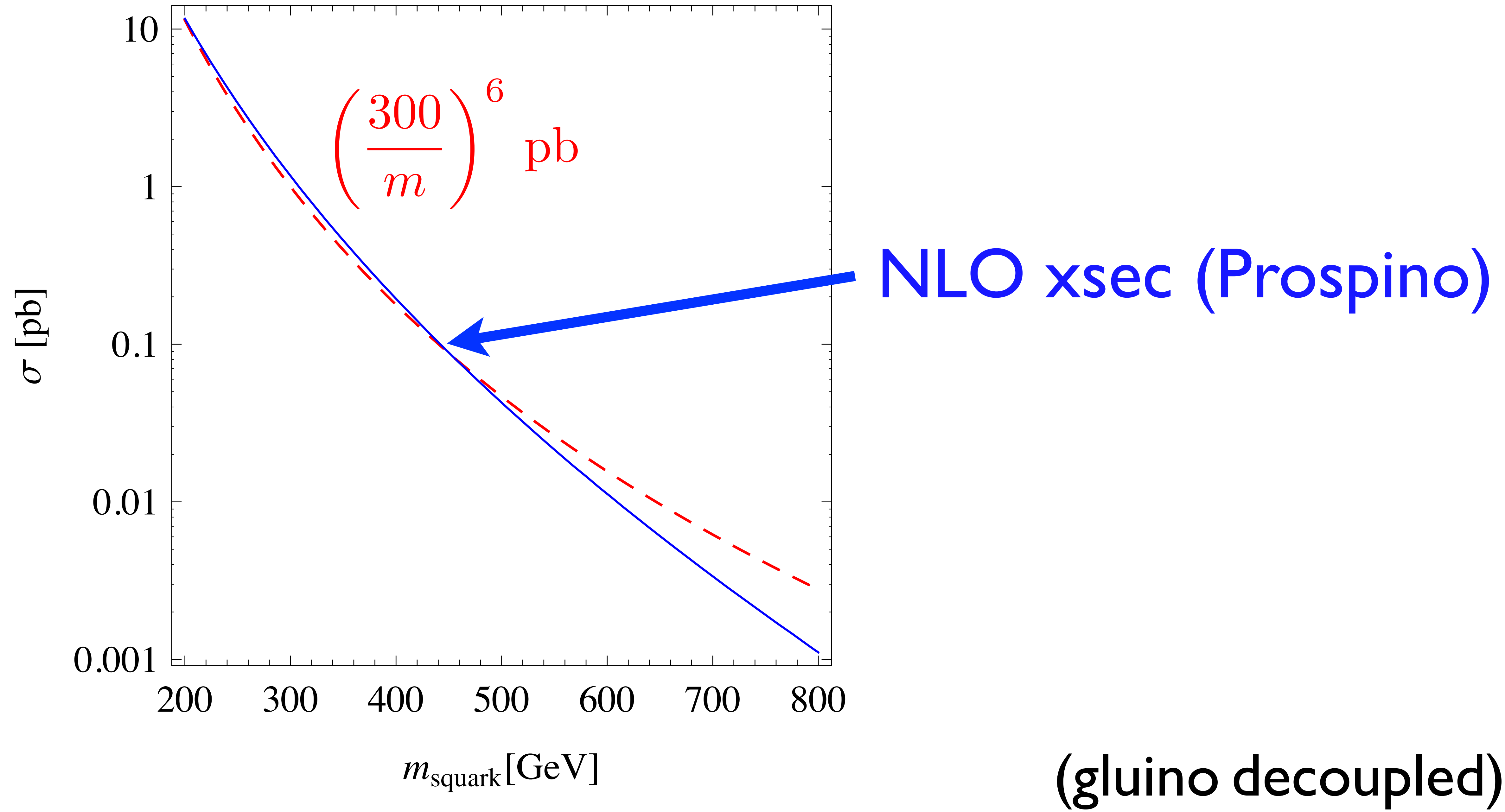
assumption in ATLAS/CMS plots

Does it matter if we relax the degeneracy assumption?

Naive answer: no so much.

Cross-sections vs. mass

$$\sigma(pp \to \tilde{u}_R \tilde{u}_R^*) \propto \frac{1}{m^6}$$ (roughly)



(gluino decoupled)

Back of the envelope estimate

Cross-sections roughly scale like ~1/m^6.

Example: 8 light squarks → 2 light squarks

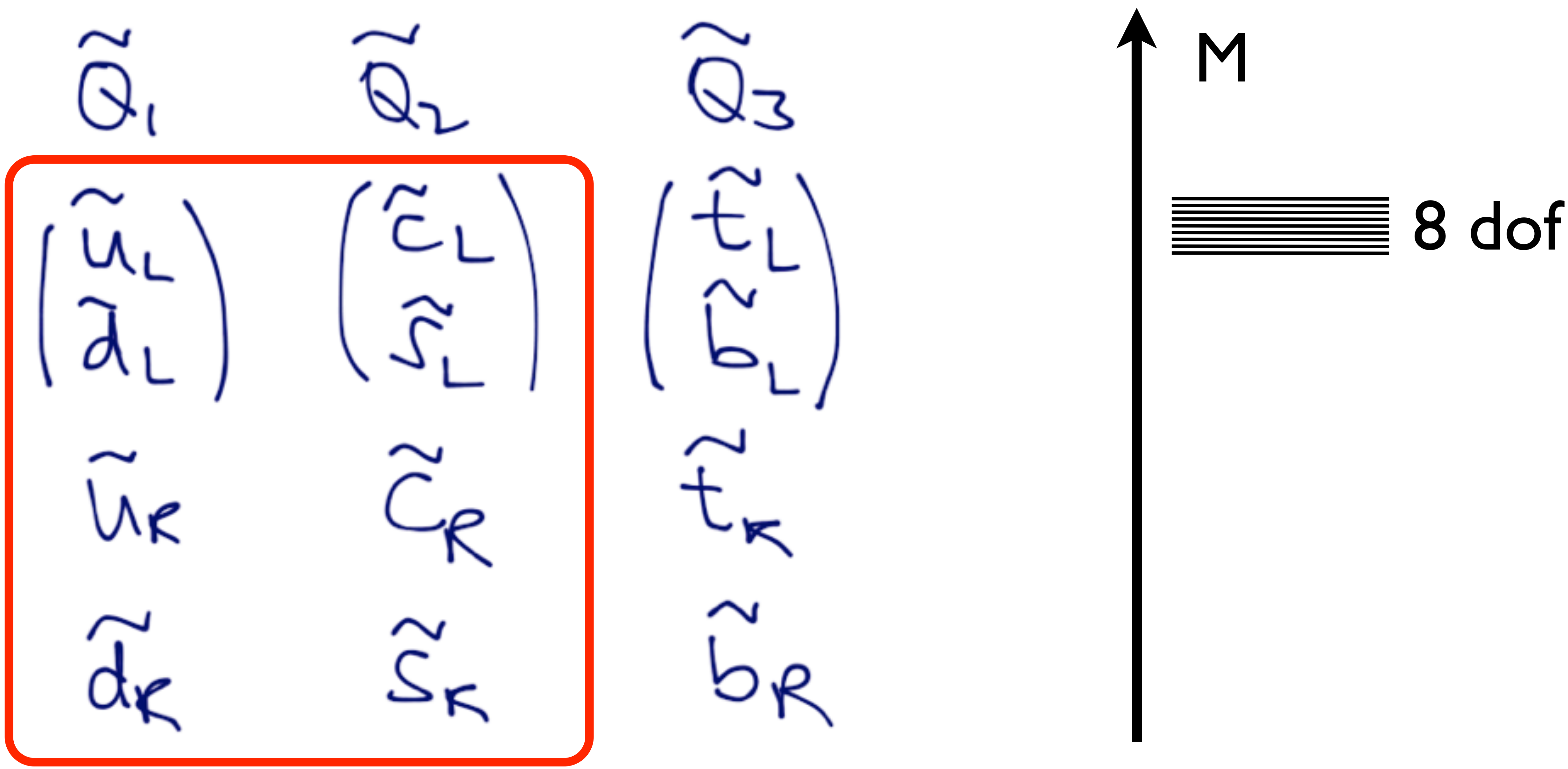
Shift limit only by $\sim 4^{1/6} - 1 \approx 25\%$

→ too naive!

Dedicated study needed because:

- Production cross-section can be flavor dependent (if gluino is not fully decoupled)
- Experimental efficiencies for light squarks are not very good (ISR, production momentum, geometry …)

Known case: 1st & 2nd gen' squarks degenerate



assumption in ATLAS/CMS plots

How can we extract limits on non-degenerate 1st and 2nd gen' squarks from experimental searches?

DYI limits

CERN-PH-EP-2011-145

Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in $\sqrt{s} = 7$ TeV proton-proton collisions

The ATLAS Collaboration

Example:
jets+ MET 1.041/fb

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signal bins

Signal Region	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet	High mass
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 130	> 130	> 130	> 130
Leading jet p_{T}	> 130	> 130	> 130	> 130
Second jet p_{T}	> 40	> 40	> 40	> 80
Third jet p_{T}	–	> 40	> 40	> 80
Fourth jet p_{T}	–	–	> 40	> 80
$\Delta\phi(\mathrm{jet}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$	> 0.3	> 0.25	> 0.25	> 0.2
m_{eff}	> 1000	> 1000	$> 500/1000$	> 1100

Bgd's are left to the experimentalists… stay out of control regions!

Process	Signal Region				
	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet, $m_{\mathrm{eff}} > 500$ GeV	$\geq$ 4-jet, $m_{\mathrm{eff}} > 1000$ GeV	High mass
Z/γ+jets	$32.3 \pm 2.6 \pm 6.9$	$25.5 \pm 2.6 \pm 4.9$	$209 \pm 9 \pm 38$	$16.2 \pm 2.2 \pm 3.7$	$3.3 \pm 1.0 \pm 1.3$
W+jets	$26.4 \pm 4.0 \pm 6.7$	$22.6 \pm 3.5 \pm 5.6$	$349 \pm 30 \pm 122$	$13.0 \pm 2.2 \pm 4.7$	$2.1 \pm 0.8 \pm 1.1$
$t\bar{t}$+ single top	$3.4 \pm 1.6 \pm 1.6$	$5.9 \pm 2.0 \pm 2.2$	$425 \pm 39 \pm 84$	$4.0 \pm 1.3 \pm 2.0$	$5.7 \pm 1.8 \pm 1.9$
QCD multi-jet	$0.22 \pm 0.06 \pm 0.24$	$0.92 \pm 0.12 \pm 0.46$	$34 \pm 2 \pm 29$	$0.73 \pm 0.14 \pm 0.50$	$2.10 \pm 0.37 \pm 0.82$
Total	$62.4 \pm 4.4 \pm 9.3$	$54.9 \pm 3.9 \pm 7.1$	$1015 \pm 41 \pm 144$	$33.9 \pm 2.9 \pm 6.2$	$13.1 \pm 1.9 \pm 2.5$
Data	58	59	1118	40	18

Table 2: Fitted background components in each SR, compared with the number of events observed in data. The Z/γ+jets background is constrained with co regions CR1a and CR1b, the QCD multi-jet, W and top quark backgrounds by control regions CR2, CR3 and CR4, respectively. In each case the first (sec quoted uncertainty is statistical (systematic). Background components are partially correlated and hence the uncertainties (statistical and systematic) on the background estimates do not equal the quadrature sums of the uncertainties on the components.

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Z/γ+jets	32.3 ± 2.6 ± 6.9	25.5 ± 2.6 ± 4.9	209 ± 9 ± 38	16.2 ± 2.2 ± 3.7	3.3 ± 1.0 ± 1.3
W+jets	26.4 ± 4.0 ± 6.7	22.6 ± 3.5 ± 5.6	349 ± 30 ± 122	13.0 ± 2.2 ± 4.7	2.1 ± 0.8 ± 1.1
$t\bar{t}$+ single top	3.4 ± 1.6 ± 1.6	5.9 ± 2.0 ± 2.2	425 ± 39 ± 84	4.0 ± 1.3 ± 2.0	5.7 ± 1.8 ± 1.9
QCD multi-jet	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.73 ± 0.14 ± 0.50	2.10 ± 0.37 ± 0.82
Total	62.4 ± 4.4 ± 9.3	54.9 ± 3.9 ± 7.1	1015 ± 41 ± 144	33.9 ± 2.9 ± 6.2	13.1 ± 1.9 ± 2.5
Data	58	59	1118	40	18

Table 2: Fitted background components in each SR, compared with the number of events observed in data. The Z/γ+jets background is constrained with co regions CR1a and CR1b, the QCD multi-jet, W and top quark backgrounds by control regions CR2, CR3 and CR4, respectively. In each case the first (sec quoted uncertainty is statistical (systematic). Background components are partially correlated and hence the uncertainties (statistical and systematic) on the background estimates do not equal the quadrature sums of the uncertainties on the components.

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upper bound on signal xsec

Bgd's are left to the experimentalists…

stay out of control regions!

Process	Signal Region				
	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet, $m_{\mathrm{eff}} > 500$ GeV	$\geq$ 4-jet, $m_{\mathrm{eff}} > 1000$ GeV	High mass
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$t\bar{t}$+ single top	$3.4 \pm 1.6 \pm 1.6$	$5.9 \pm 2.0 \pm 2.2$	$425 \pm 39 \pm 84$	$4.0 \pm 1.3 \pm 2.0$	$5.7 \pm 1.8 \pm 1.9$
QCD multi-jet	$0.22 \pm 0.06 \pm 0.24$	$0.92 \pm 0.12 \pm 0.46$	$34 \pm 2 \pm 29$	$0.73 \pm 0.14 \pm 0.50$	$2.10 \pm 0.37 \pm 0.82$
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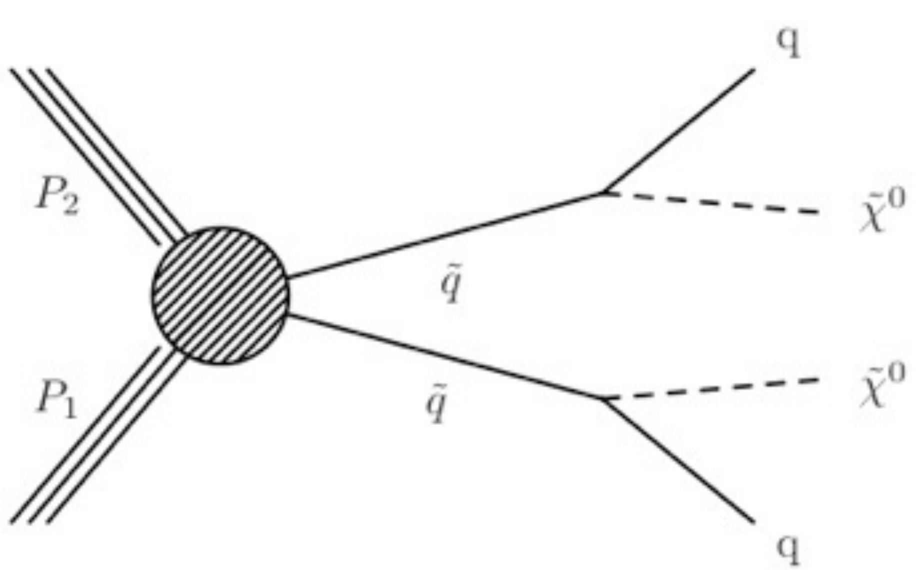
upper bound on signal xsec

"Only" need efficiency x Acceptance of the signal bins for your model...

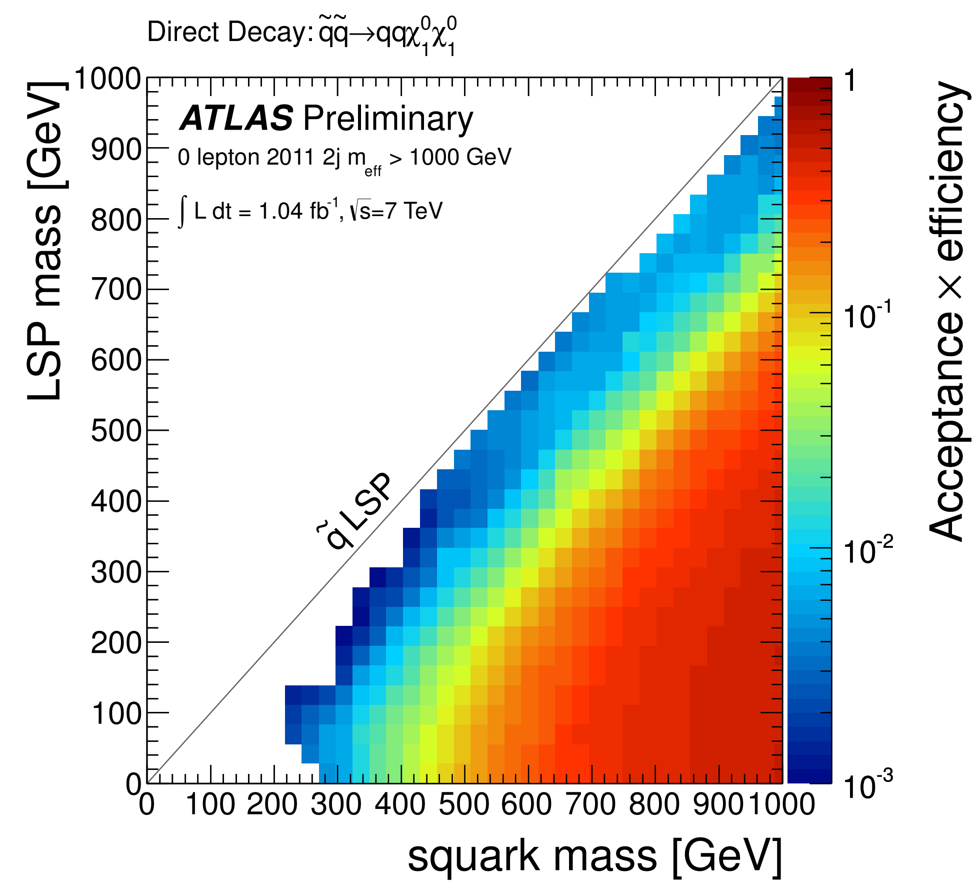
LIMIT!

Simplified Models to the rescue!

- Luckily ATLAS and CMS provide efficiencies for simplified models (so far only for 1/fb)

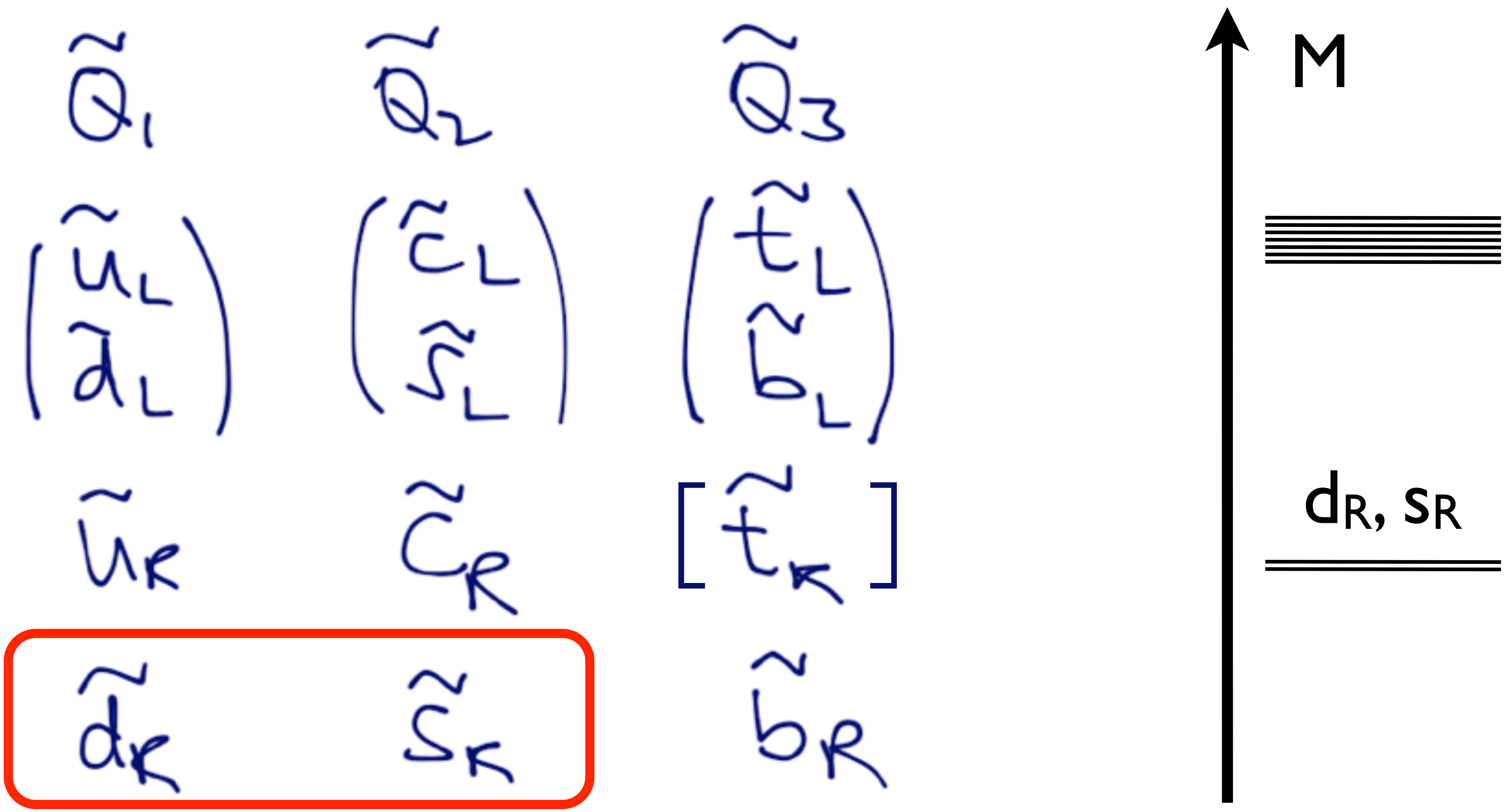


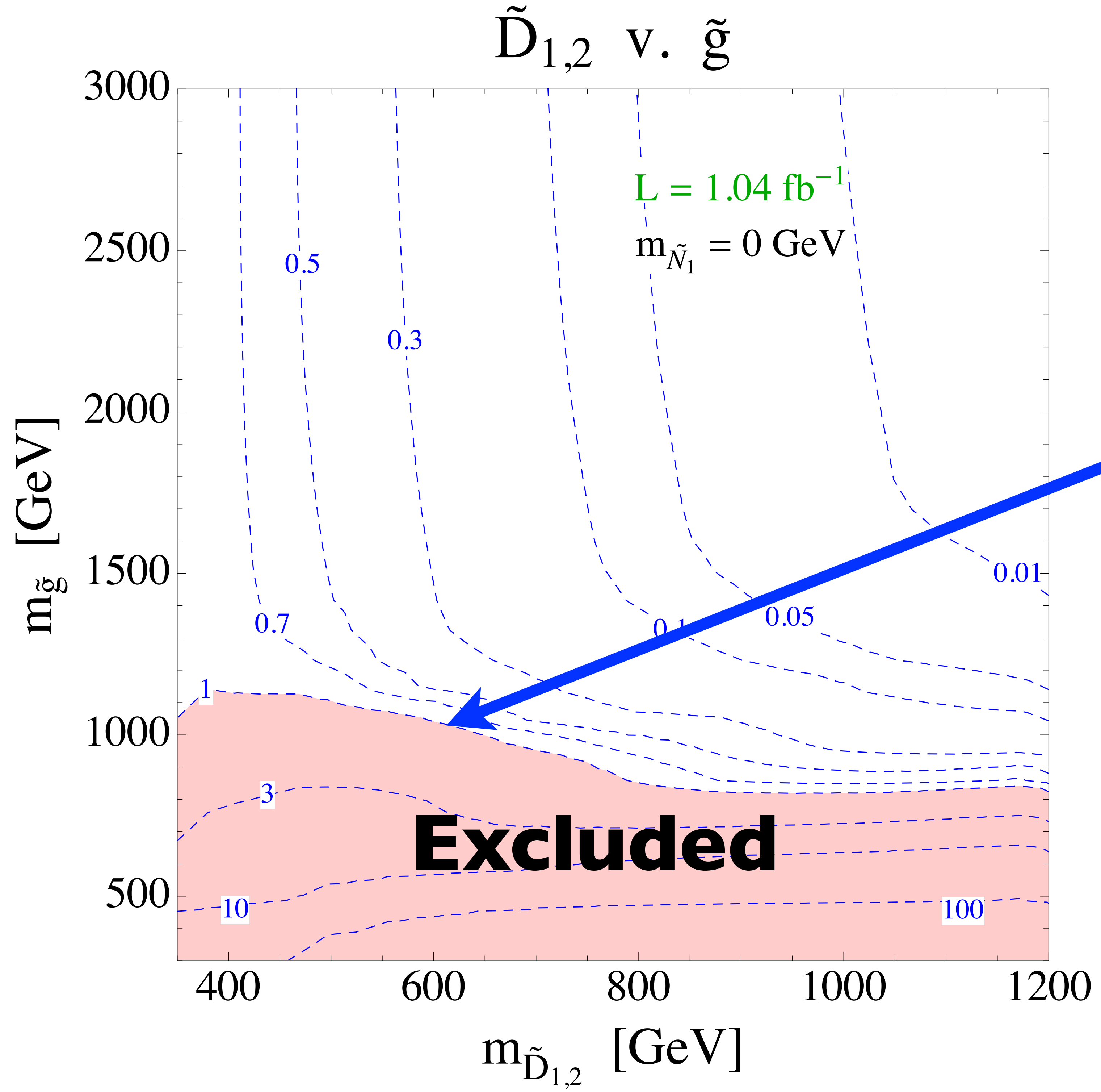
simplified topology



e.g. [CMSPublic/PhysicsResultsSUS11004]() or [ATLAS-CONF-2011-155/]()
Thanks for providing root files, HEPDATA,...

Split squarks w/ different quantum numbers (vertical)





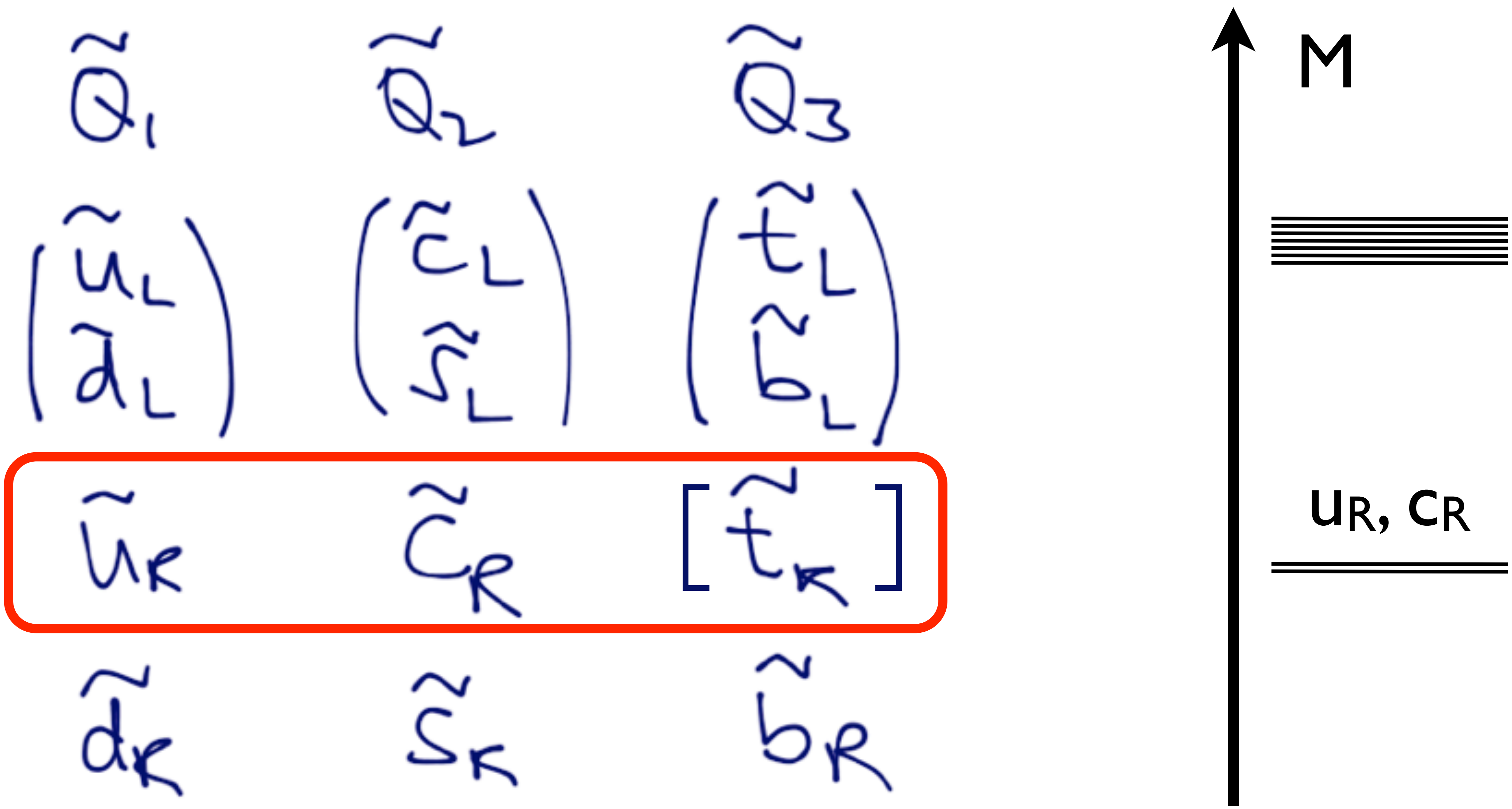
Contours of

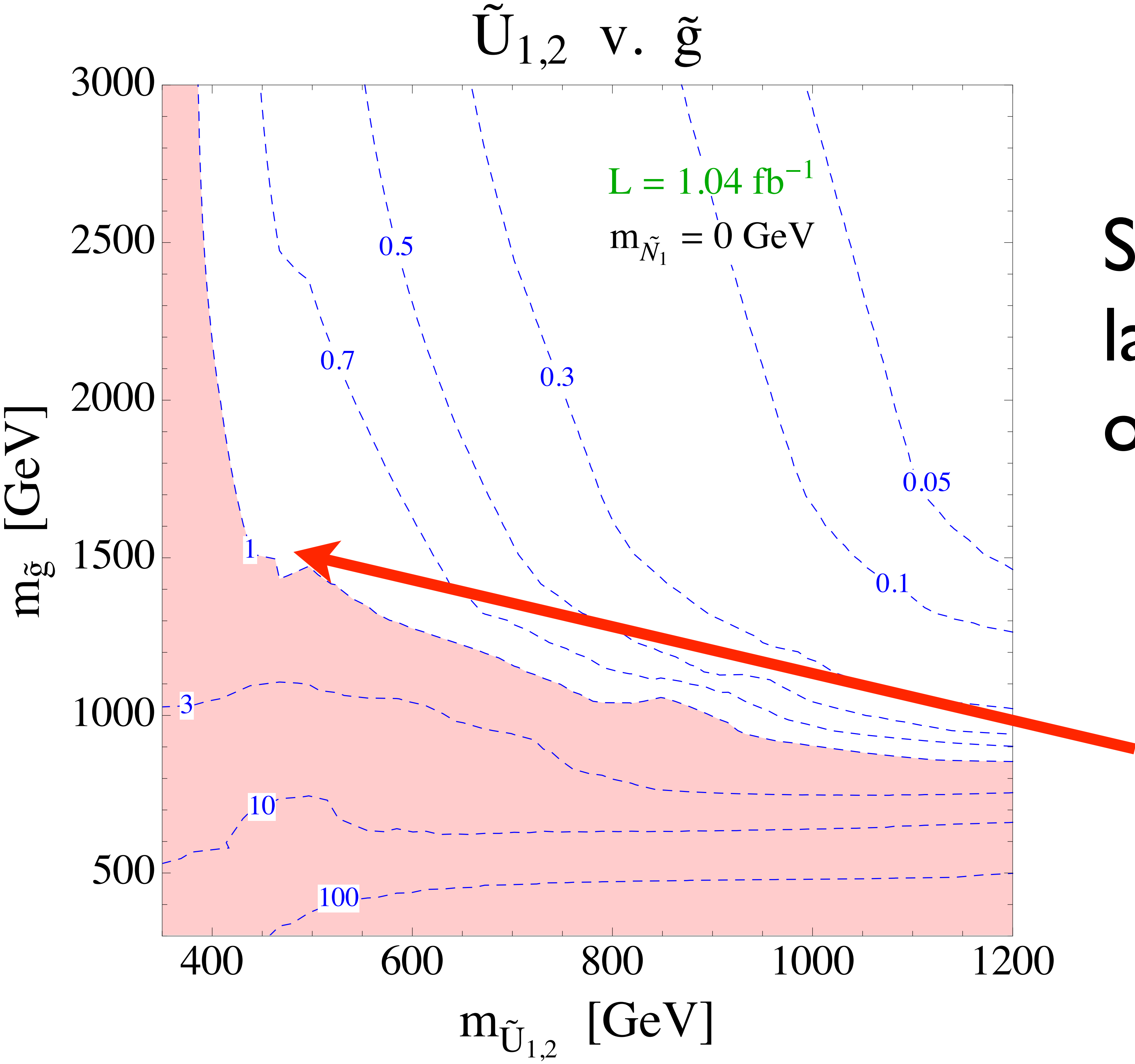
$\sigma/\sigma_{\rm limit}$

Exclusion (at 95CL) if this is = 1

For $m_{\rm gluino}$ > 1.2 TeV, no limit on squarks masses.

Split squarks w/ different quantum number (vertical)



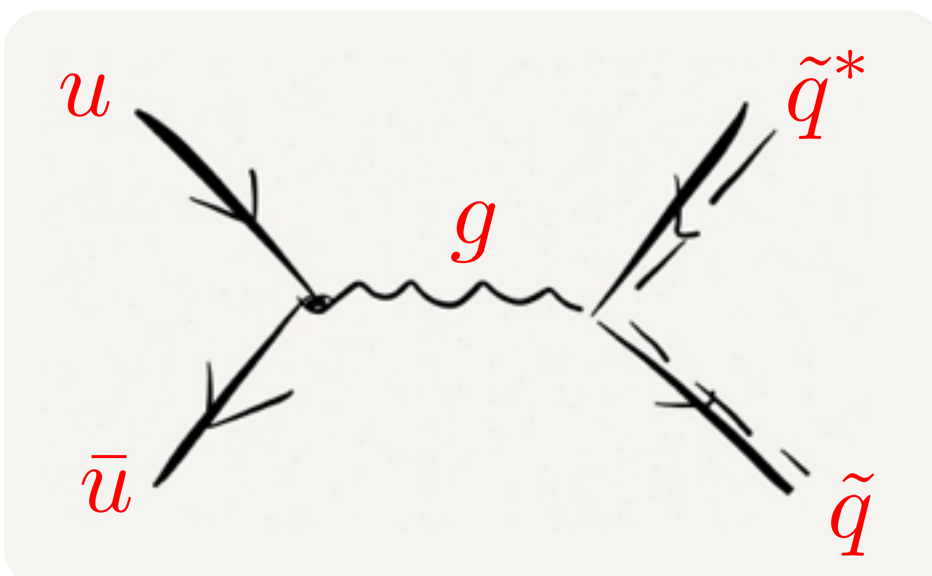


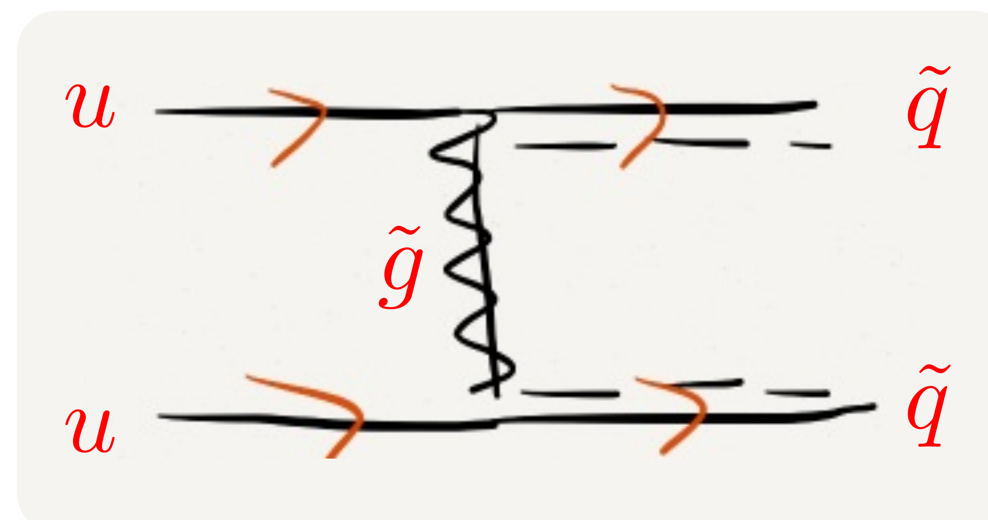
Stronger limits, later decoupling of gluino

Why much more sensitive to gluino mass? →

What is driving the strong ATLAS/CMS limit?

Squark - Squark production:

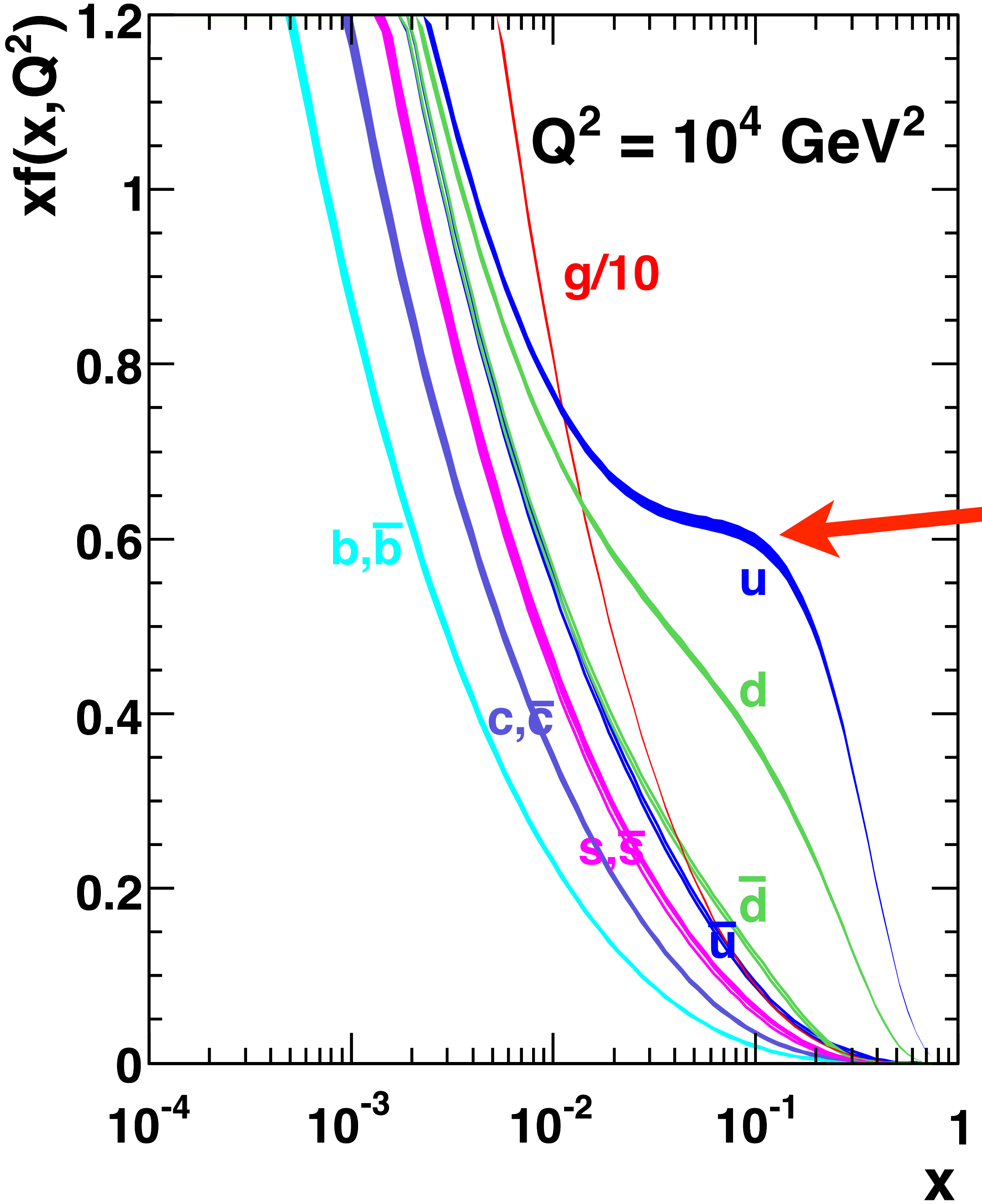


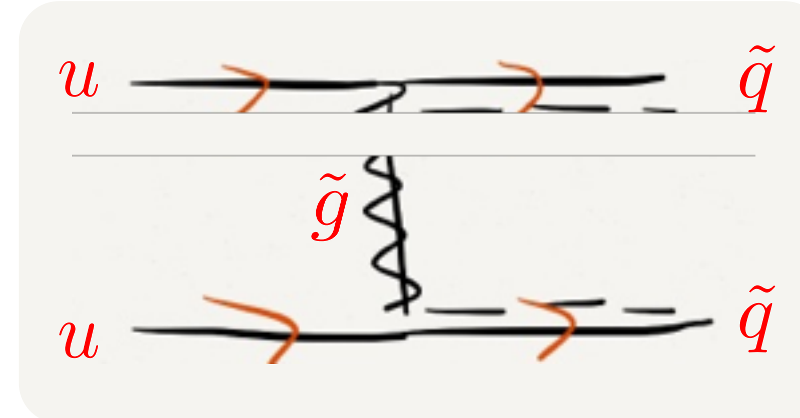


Independent of squark flavor (and gluino mass)

Majorana nature of gluino allows **u u** initial state!

Simple d.o.f rescaling





access to large up quark pdf

$$E \approx x \cdot 7\,\mathrm{TeV}$$

$$\frac{1}{m_{\tilde{g}}} \tilde{q}\tilde{q}\, u_R u_R$$ dim5 op.

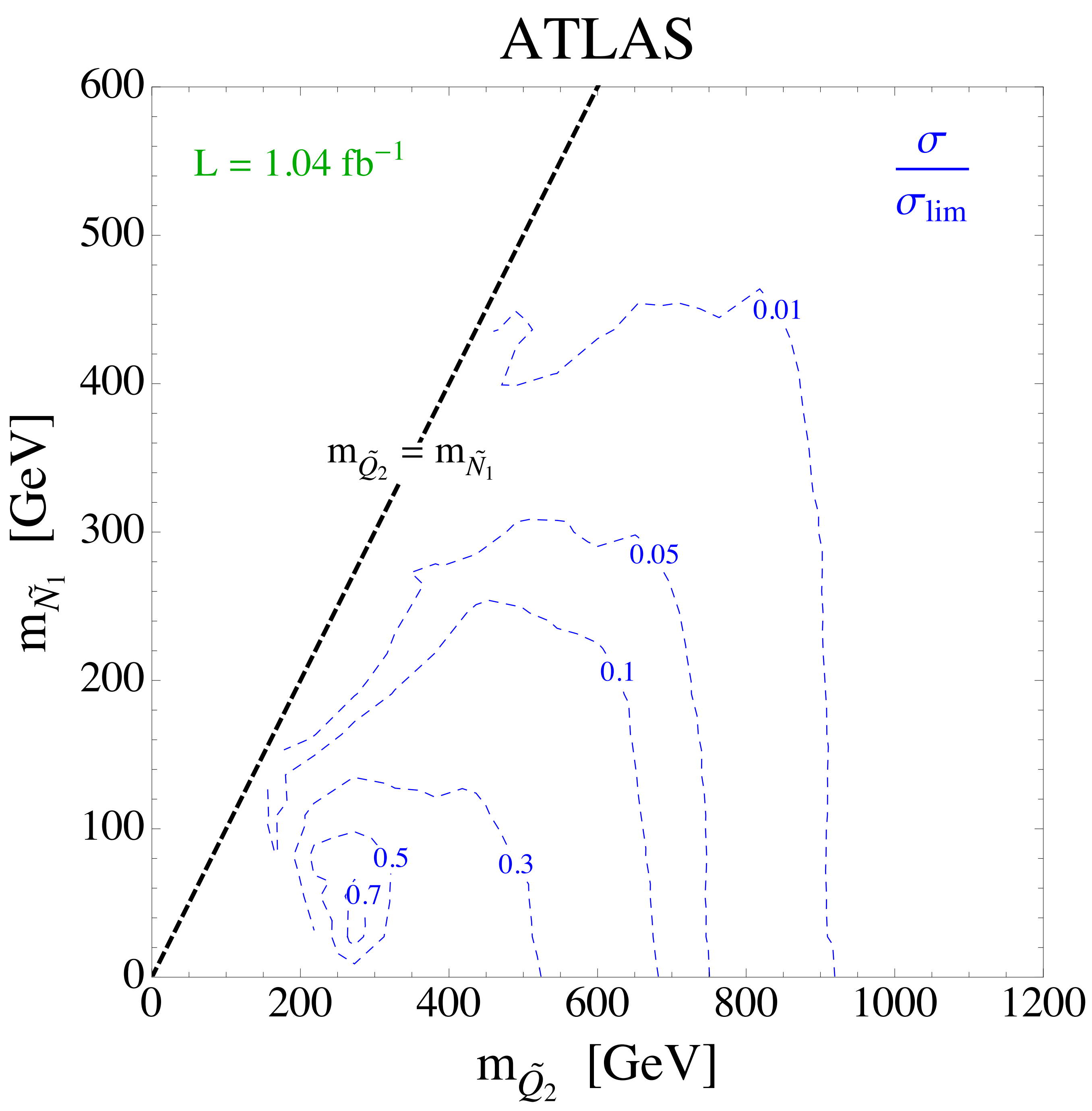
$$\rightarrow \quad \sigma \sim 1/m_{\tilde{g}}^2$$

slow decoupling

Aligned LH squarks

	$\tilde{Q}_1$	$\tilde{Q}_2$	$\tilde{Q}_3$
Squarks	$\begin{pmatrix} \tilde{u}_L \\ \tilde{d}_L \end{pmatrix}$	$\begin{pmatrix} \tilde{c}_L \\ \tilde{s}_L \end{pmatrix}$	$\begin{pmatrix} \tilde{t}_L \\ \tilde{b}_L \end{pmatrix}$
	$\tilde{u}_R$	$\tilde{c}_R$	$\tilde{t}_R$
2 d.o.f	$\tilde{d}_R$	$\tilde{s}_R$	$\tilde{b}_R$

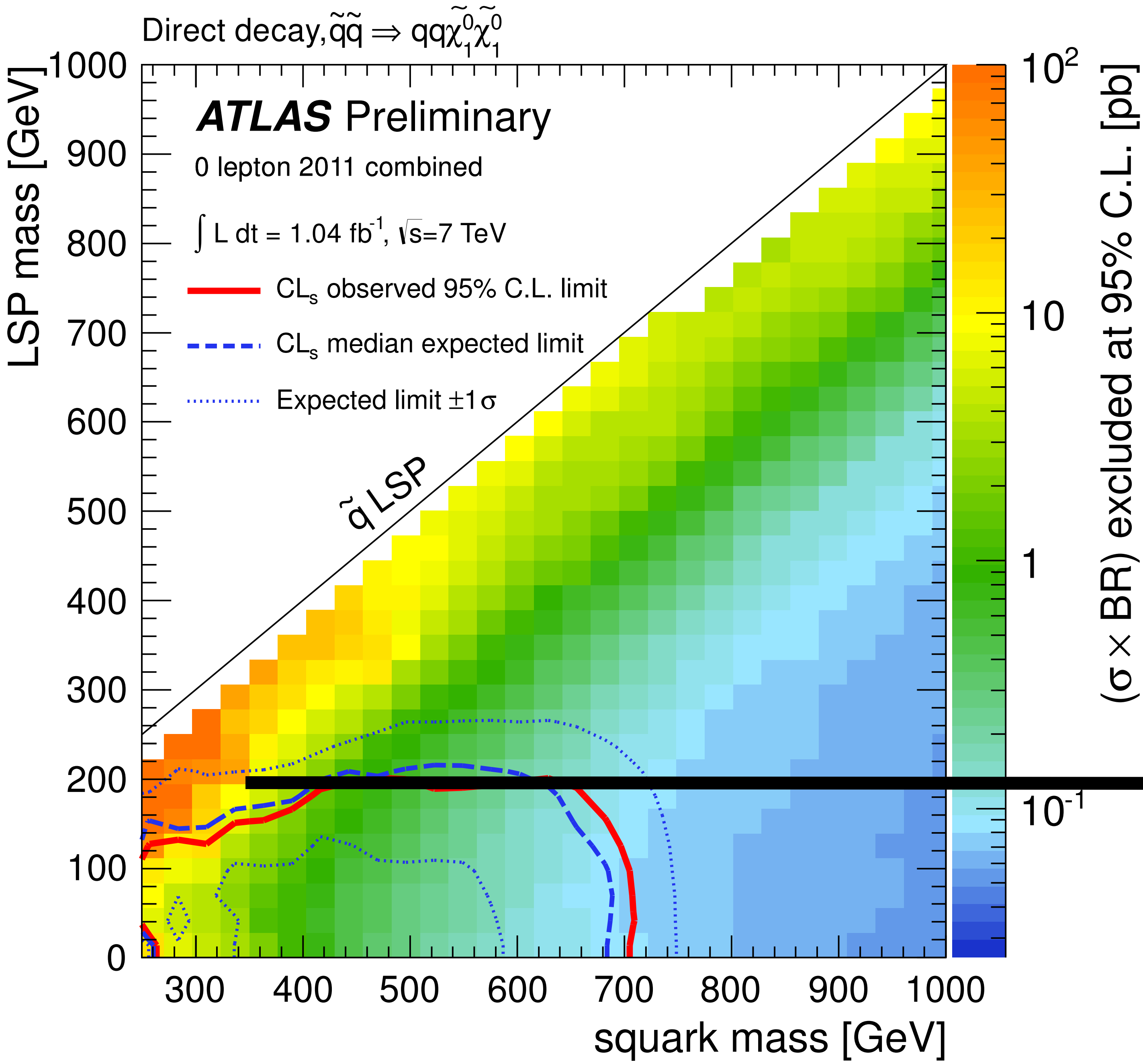
No limit on LH 2nd gen' squark



Is there a 300 GeV squark hiding in the data?

Efficiencies

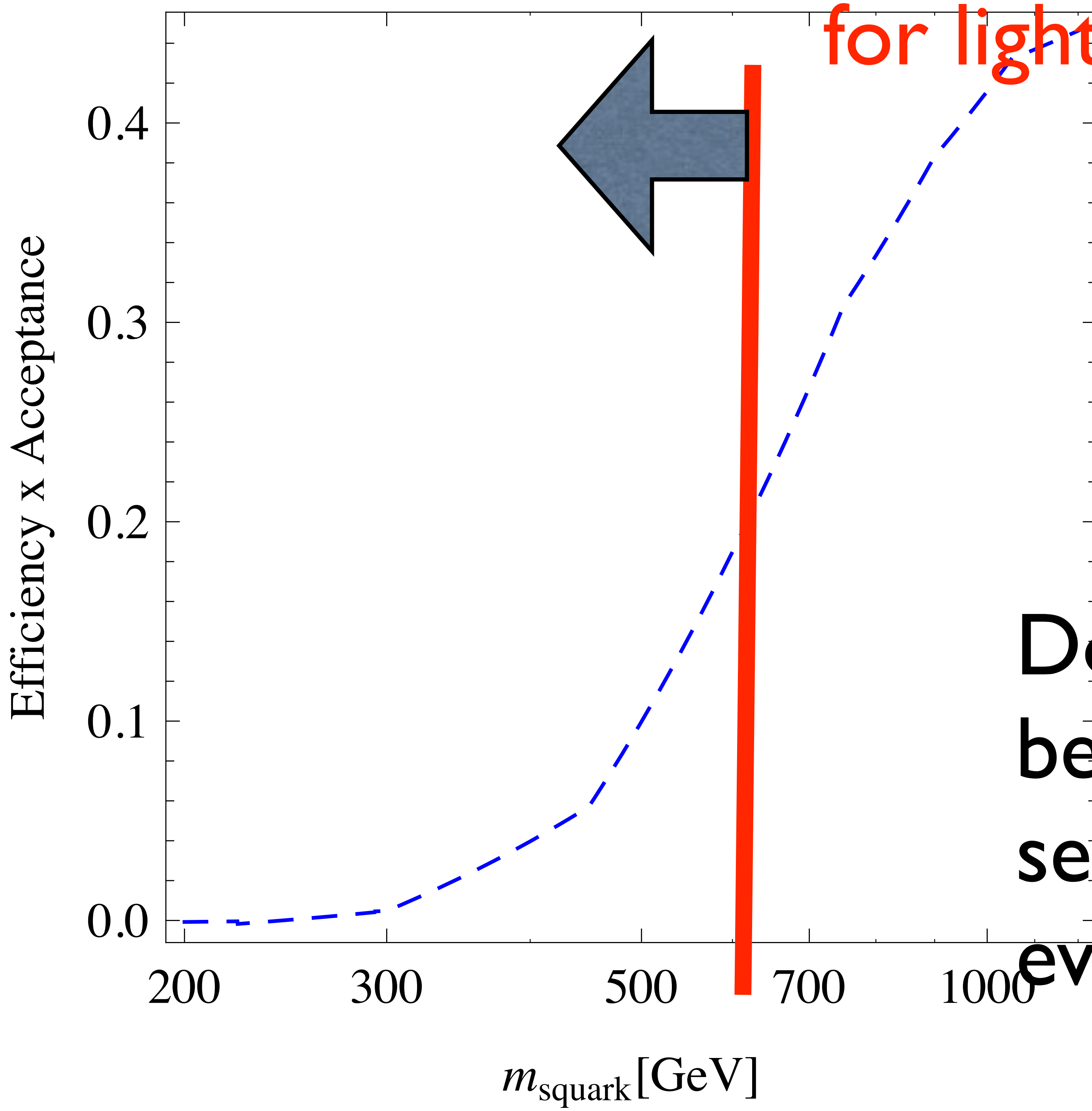
Searches become inefficient for light squarks



$$\sigma \times A \times \epsilon \approx const.$$

Efficiencies

Searches are inefficient for light squarks



Example: ATLAS 1/fb 2jet, Meff > 1TeV, m_{LSP} = 0GeV

Do no expect it to be much better for higher luminosity searches (> 5 /fb) b/c even harder cuts used

Todo

- No efficiency maps available yet for 5 /fb searches. We will simulate and validate using monte-carlo mockups (see part 2 on how to do that) to check limits
- We do not expect different conclusions because light squarks increasingly inefficient

work in progress with
Michele Papucci, Josh Ruderman (LBL Berkely)
Gilad Perez, Rakhi Mahbubani (CERN)

Summary part 1

- Squarks spectra can be vertically and horizontally split.
- Limits for 1st gen' squarks very dependent on gluino mass, for heavy gluino almost no limit
- Are there light squarks hiding in the data?
- Need dedicated light squark searches!

Part 2: Natural susy

Everything is natural; if it weren’t, it wouldn’t be.

M. Bateson

- Bottom-up naturalness reminder
- Current limits?

Natural EWSB & SUSY

MSSM,NMSSM, DMSSM, ...

Fine-tuning of (Higgs mass)^2

$$\frac{m^2_{Higgs}}{2} = -|\mu|^2 + \ldots + \delta m^2_H$$

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MSSM, NMSSM, DMSSM, ...

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Higgsinos

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$$\frac{m^2_{Higgs}}{2} = -|\mu|^2 + \ldots + \delta m^2_H$$

Higgsinos

1loop $\delta m^2_H|_{stop} = -\frac{3}{8\pi^2} y_t^2 \left(m^2_{U_3} + m^2_{Q_3} + |A_t|^2 \right) \log\left(\frac{\Lambda}{\text{TeV}}\right)$

stops, sbottom$_L$

2loop $\delta m^2_H|_{gluino} = -\frac{2}{\pi^2} y_t^2 \left(\frac{\alpha_s}{\pi}\right) |M_3|^2 \log^2\left(\frac{\Lambda}{\text{TeV}}\right)$

gluino

Bottom-up natural spectrum

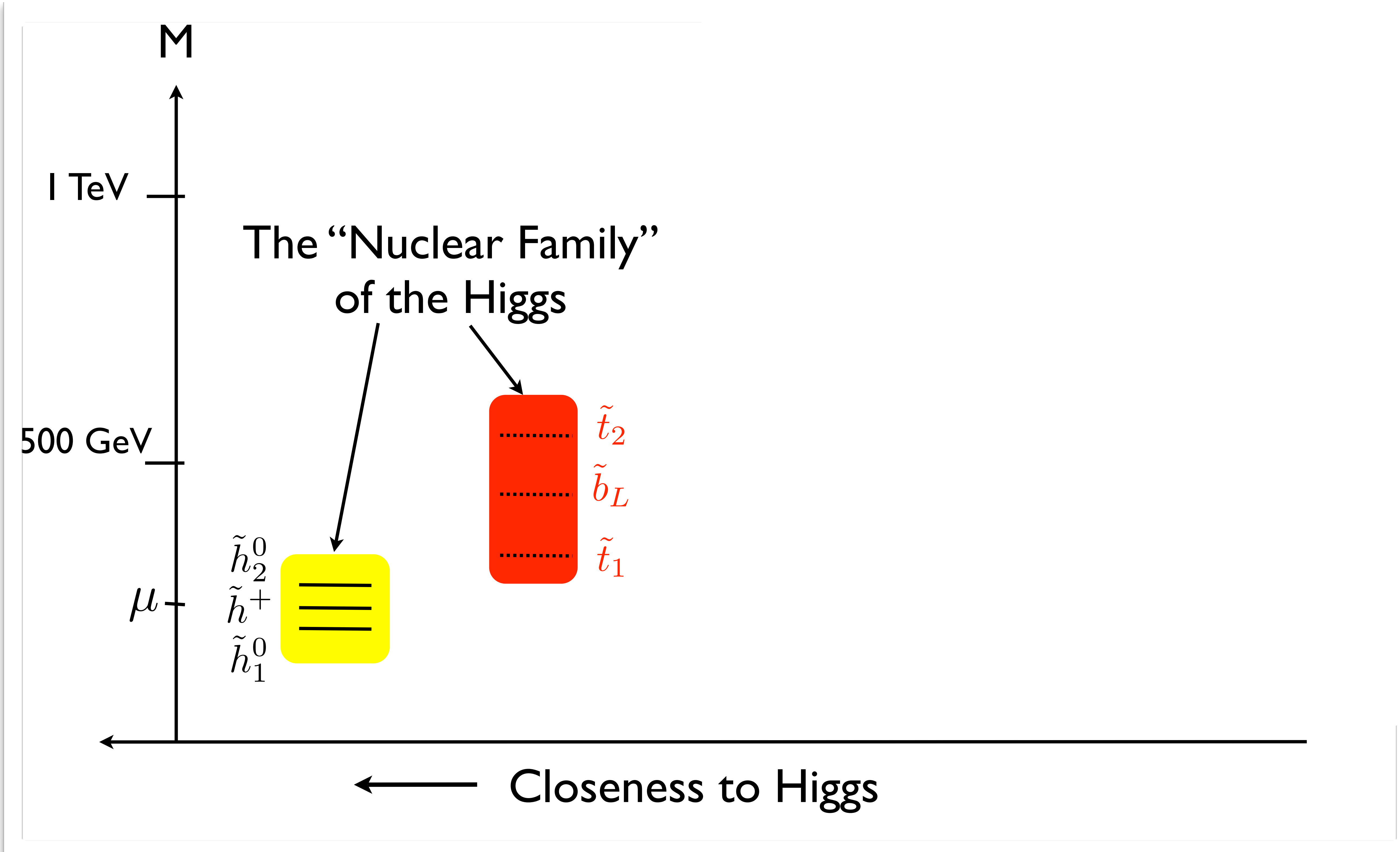

Fig. from L.Hall's talk

Bottom-up natural spectrum

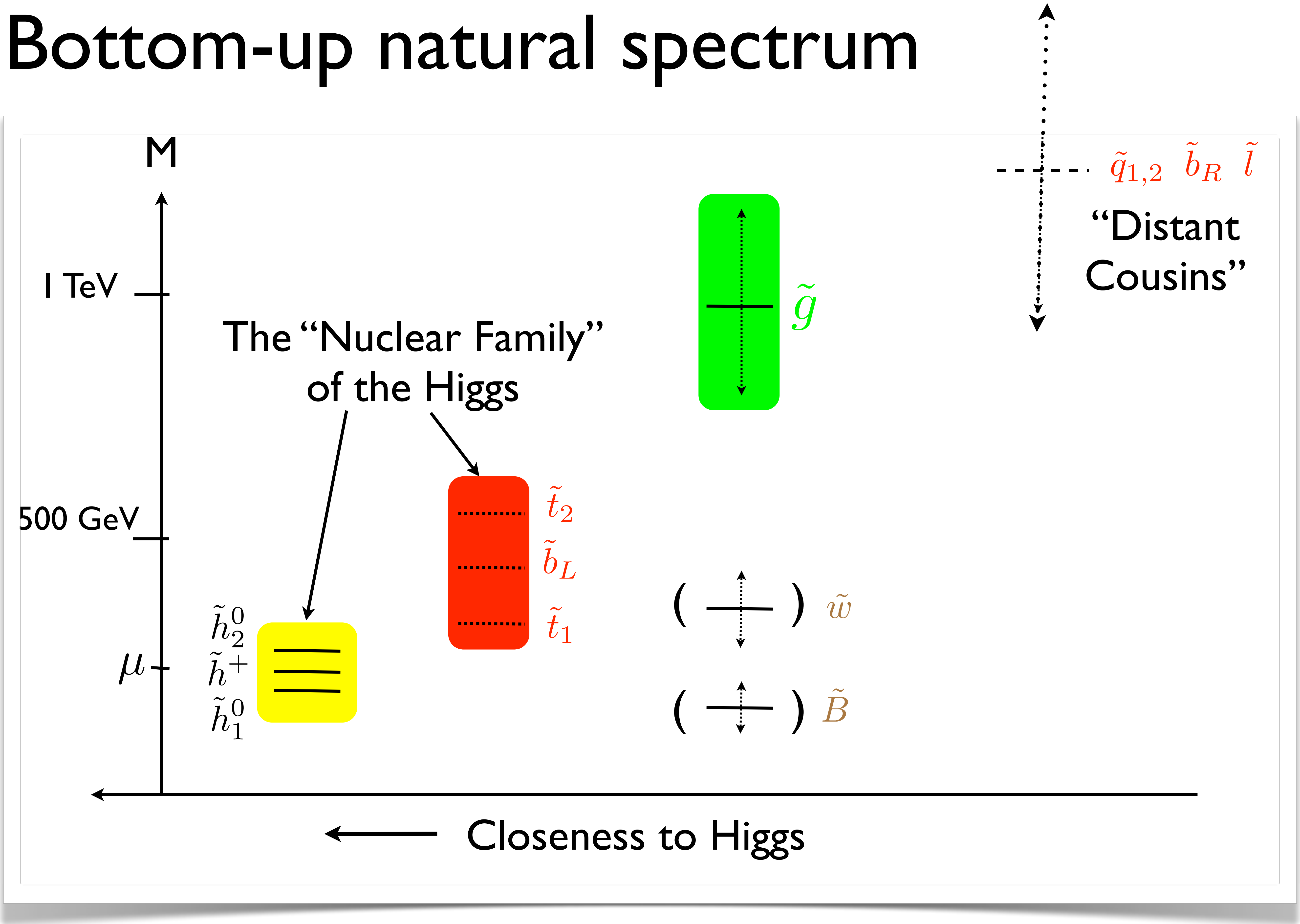

Fig. from L.Hall's talk

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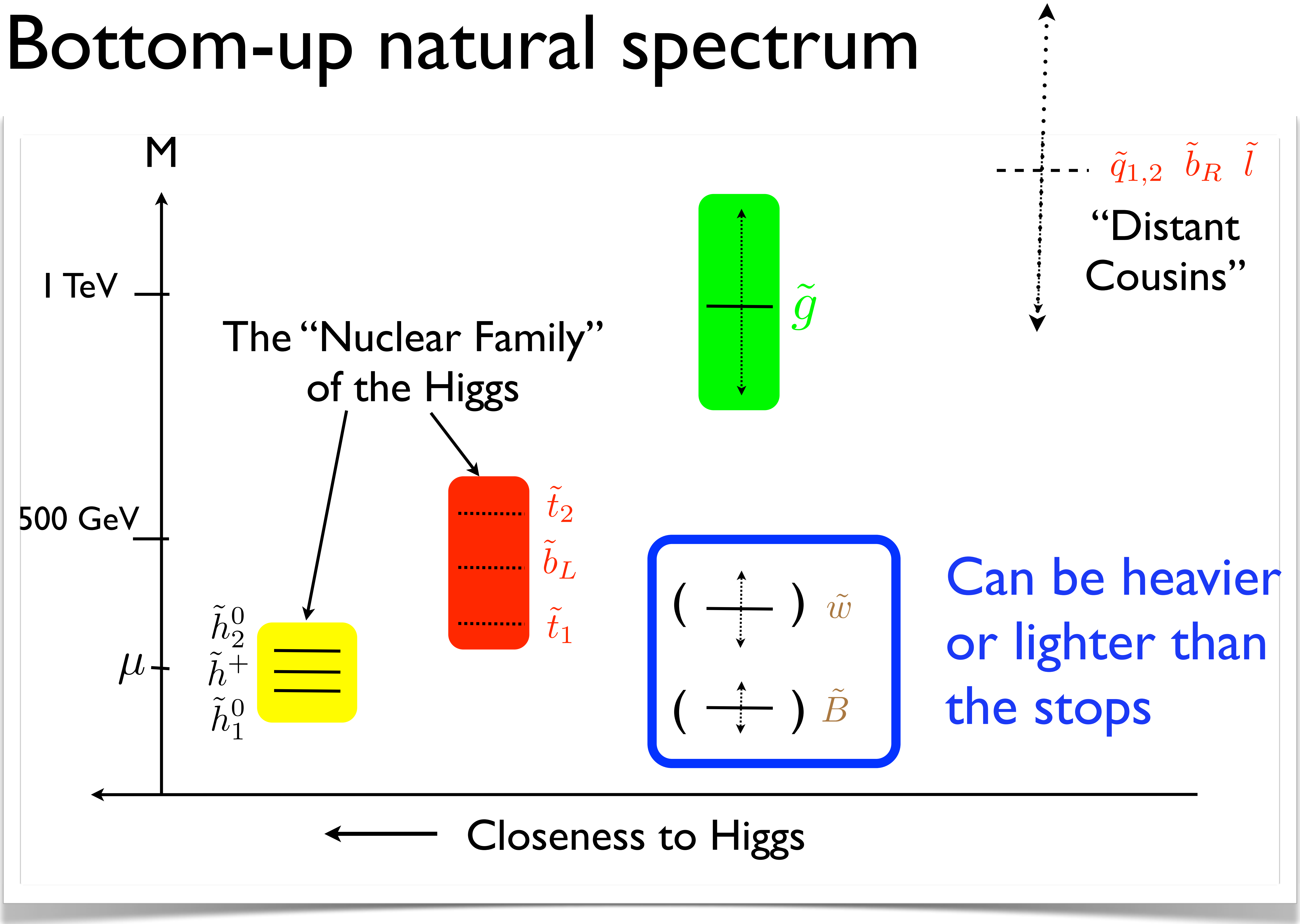
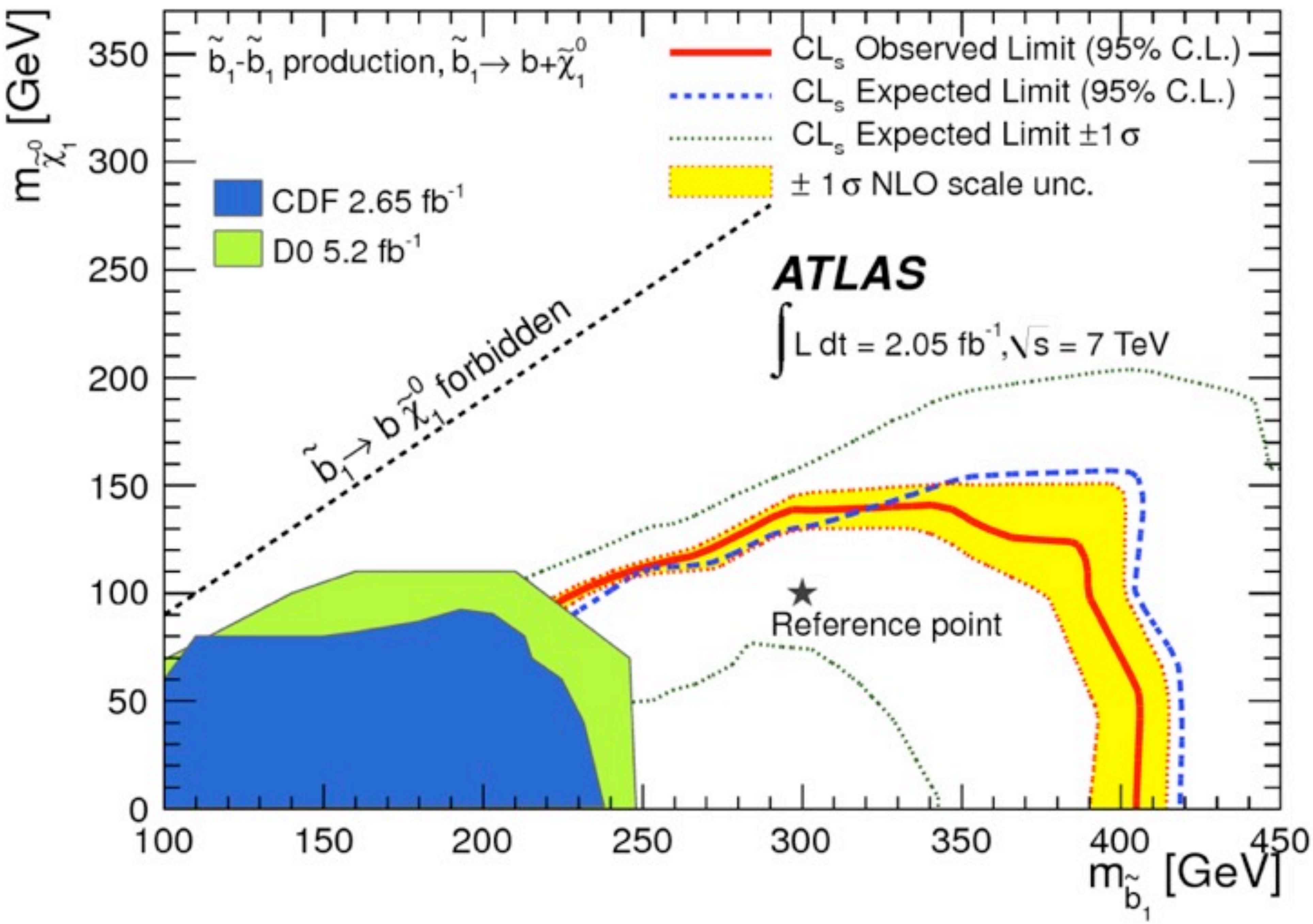
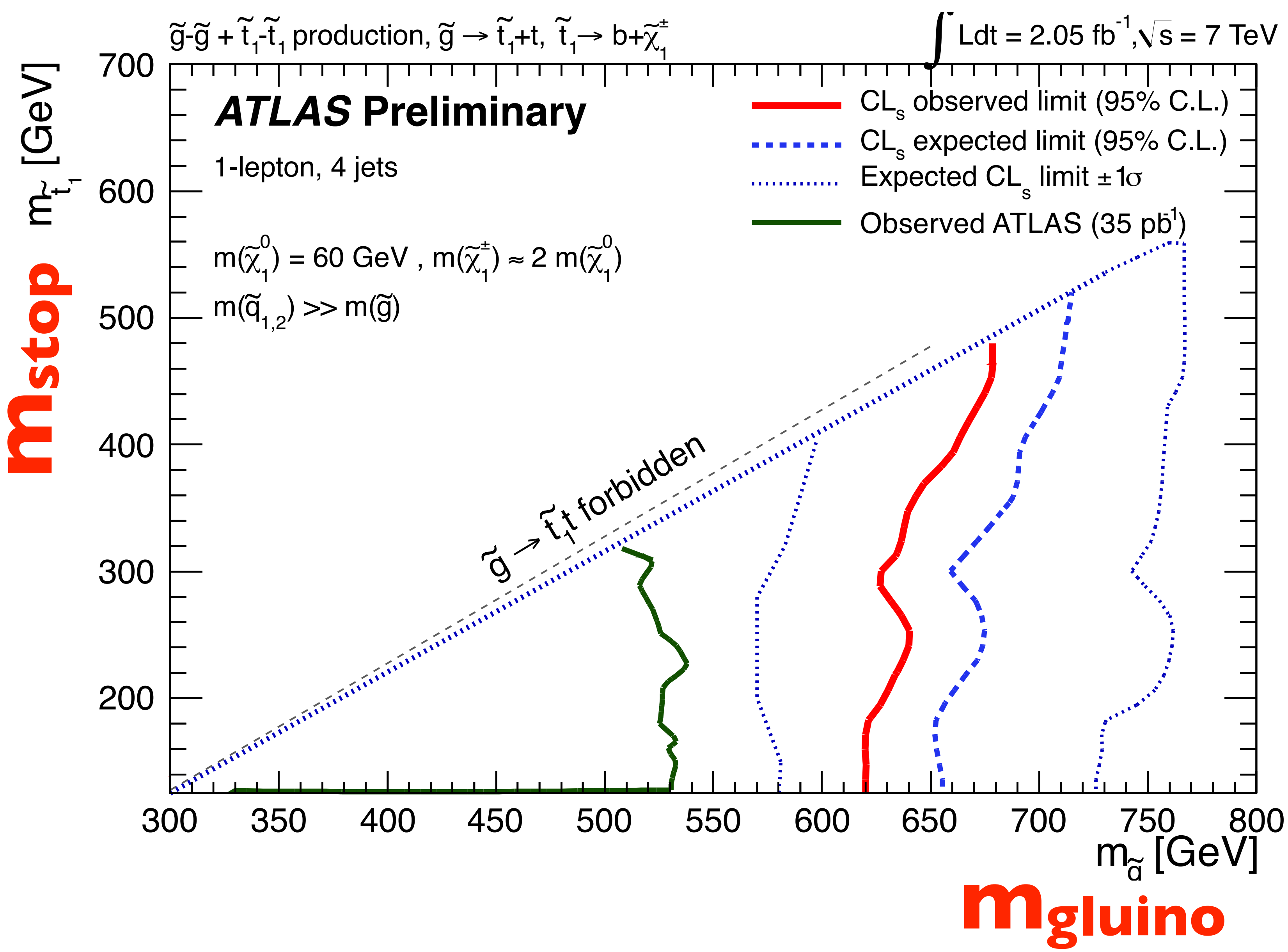


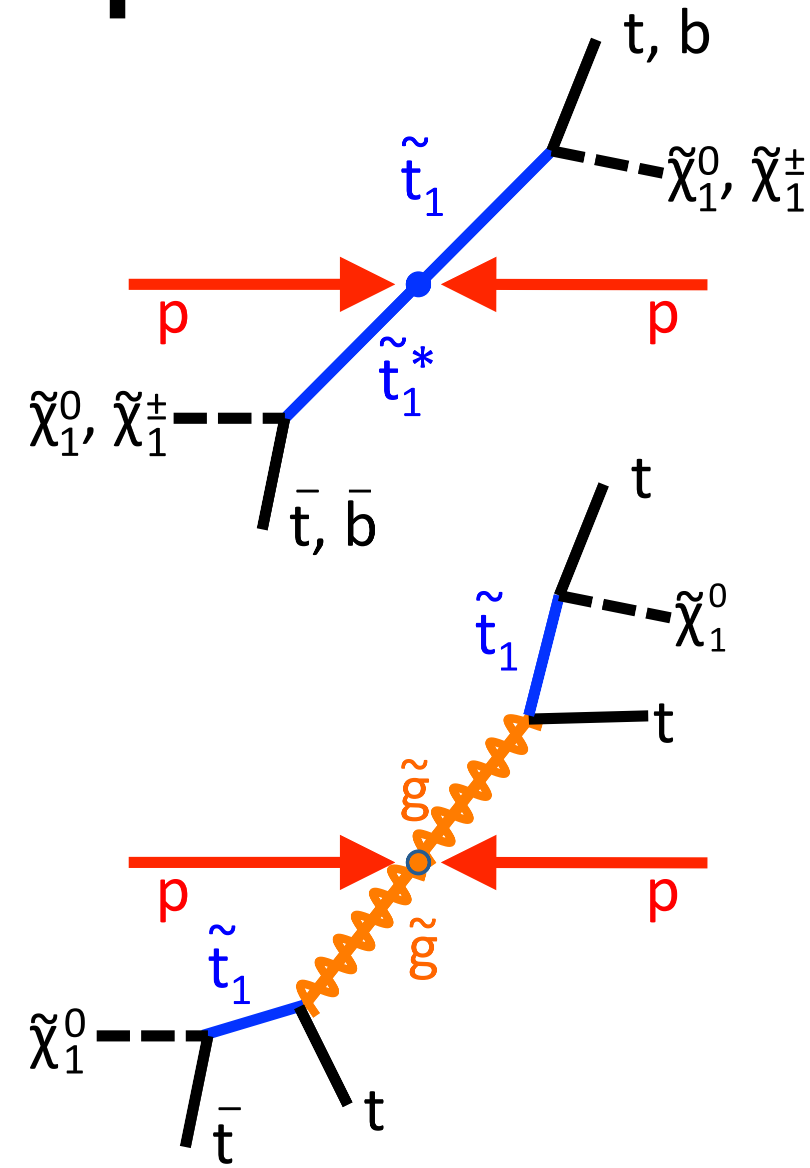
Fig. from L.Hall's talk

Latest on direct sbottoms



Latest limits on stops





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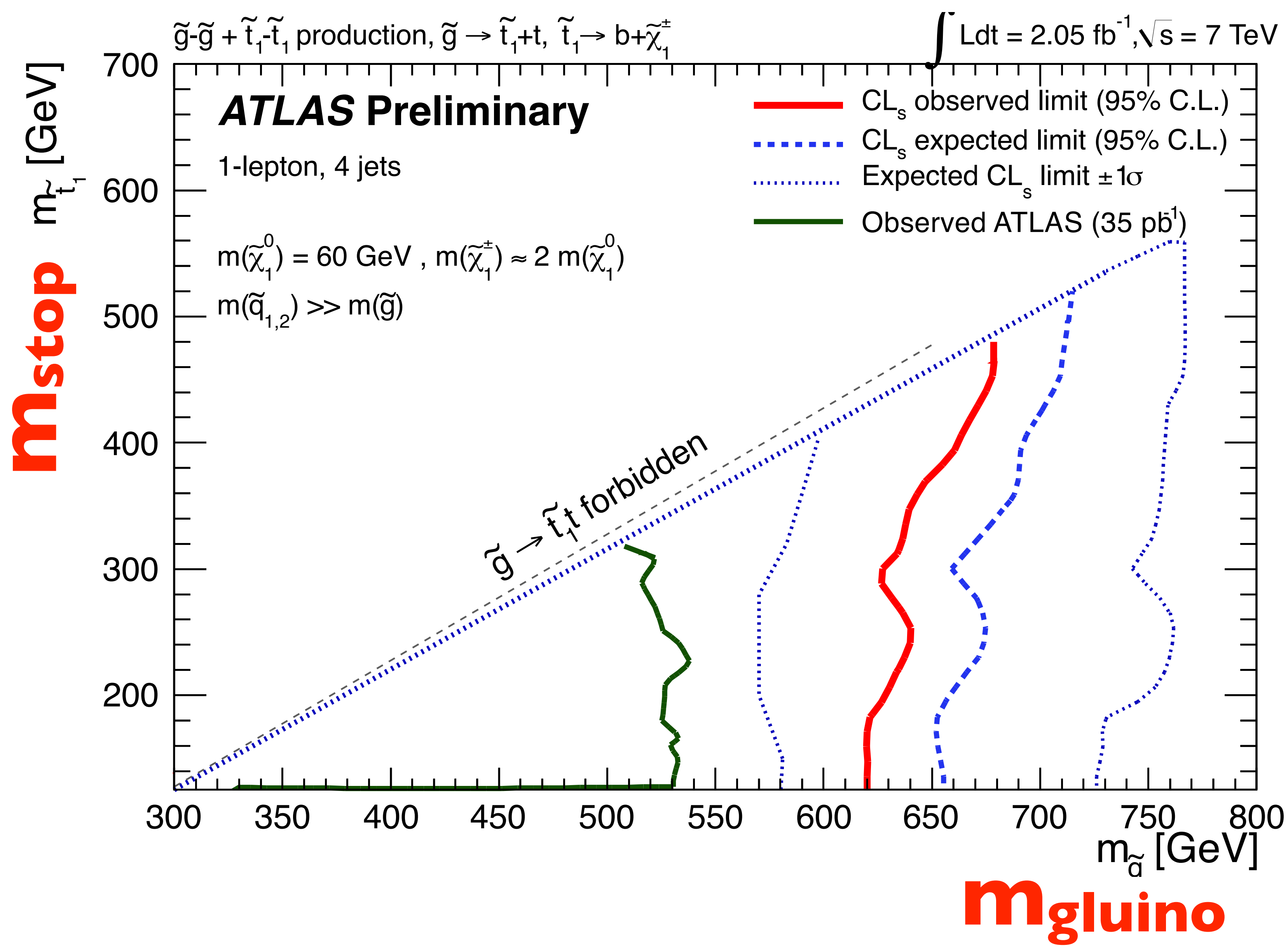
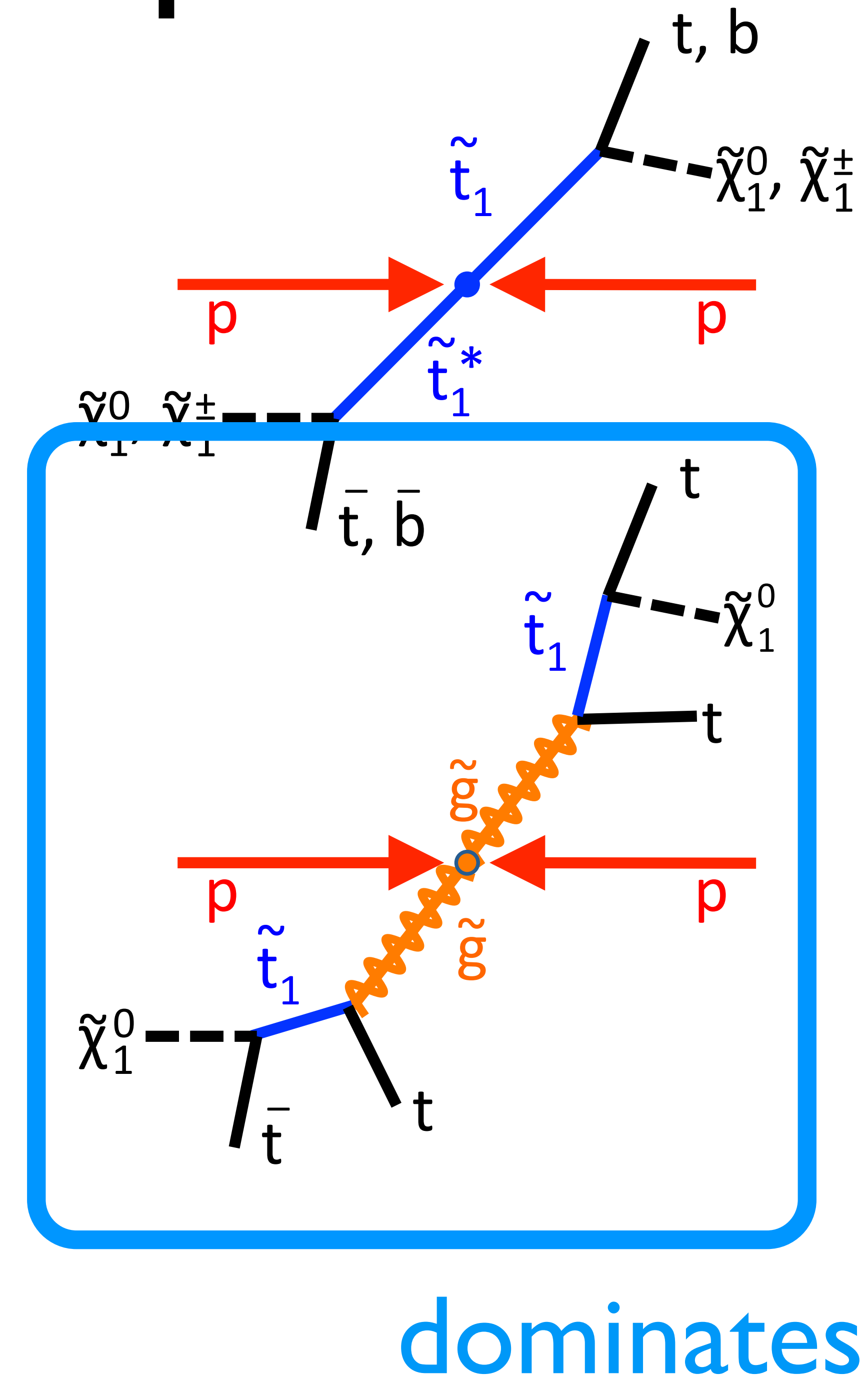
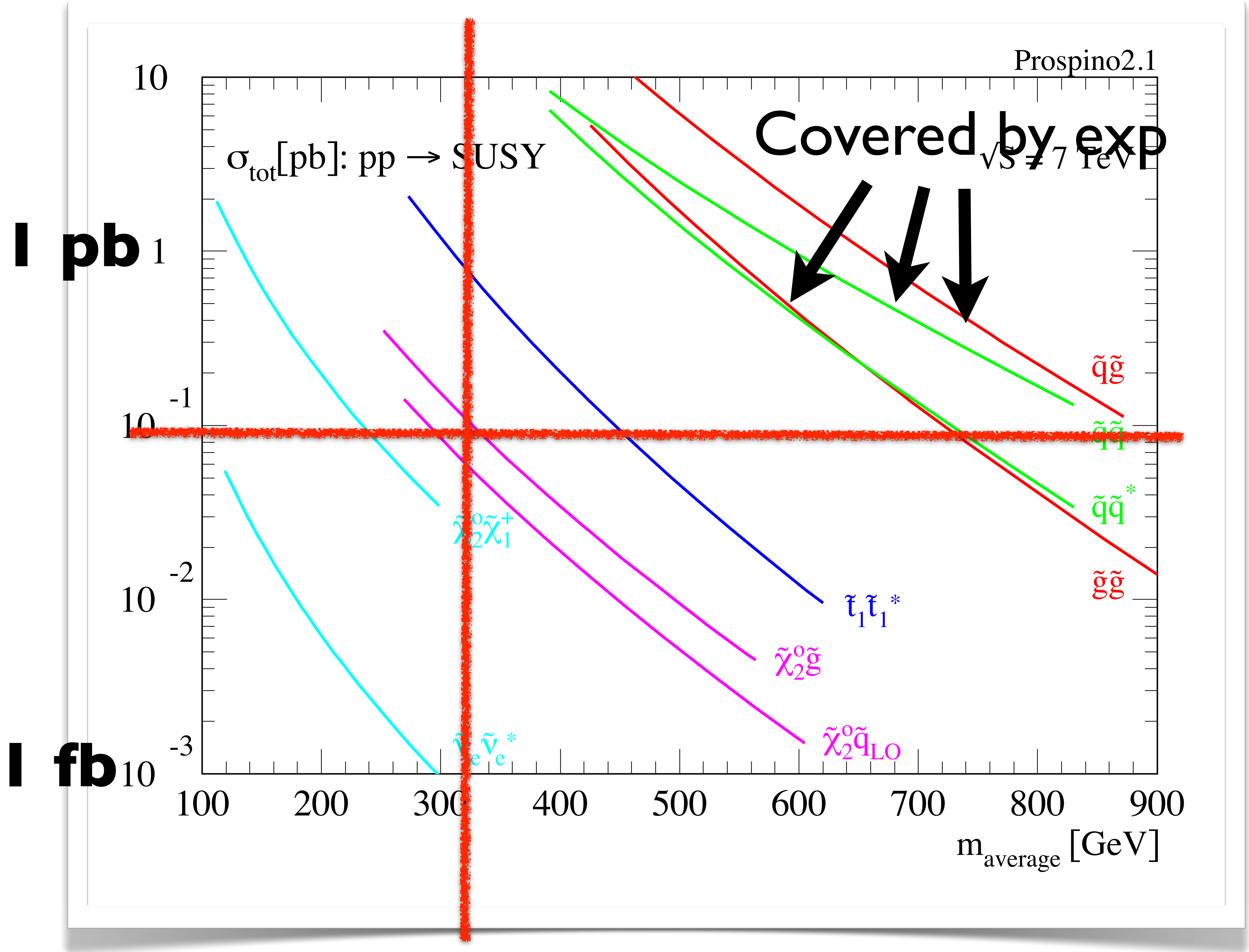




Direct stop prod. with O(1/fb) ?



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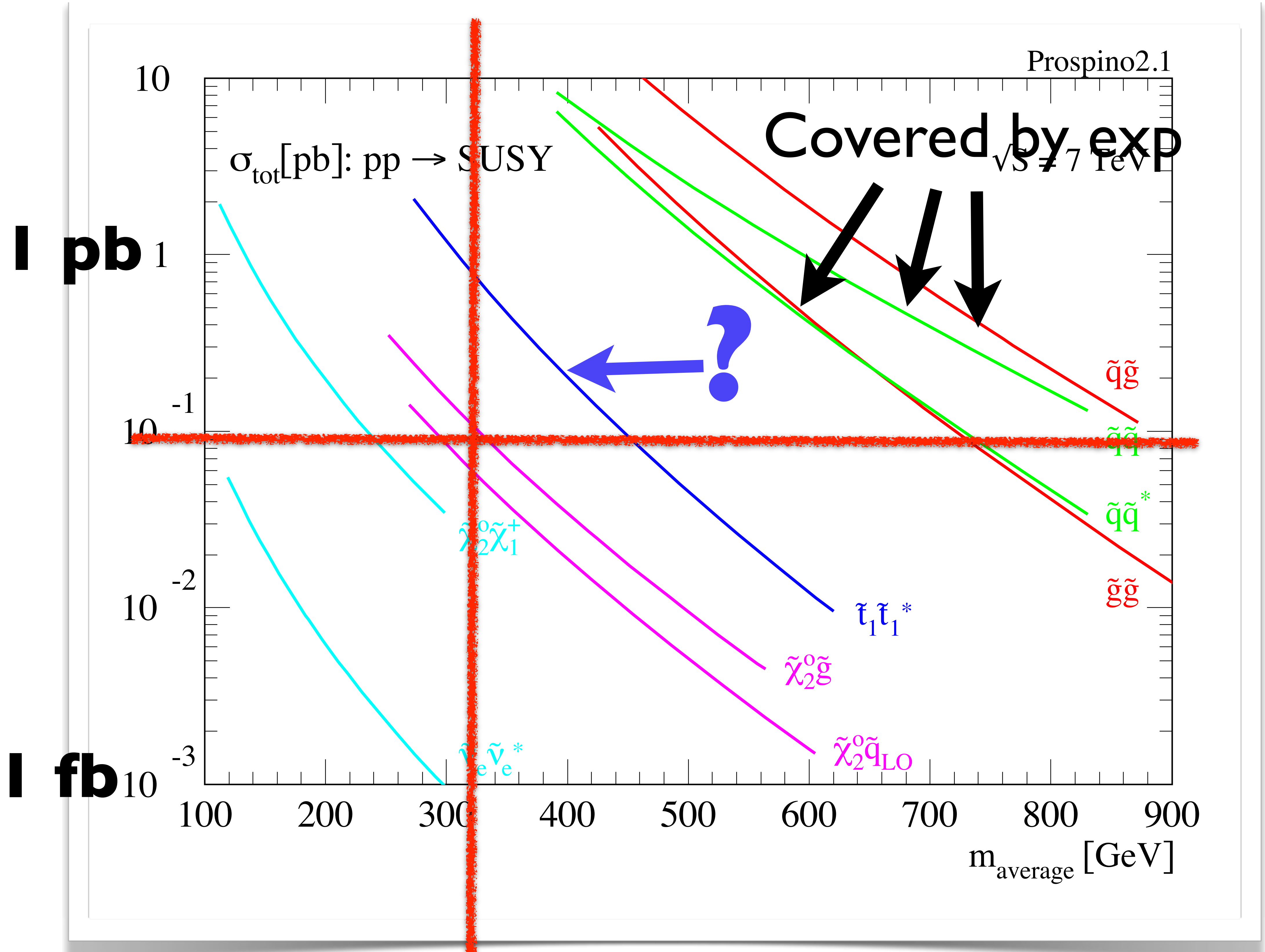


“The experiments haven’t covered my favorite model”

Relax & Wait?

vs.

* not his real attitude.

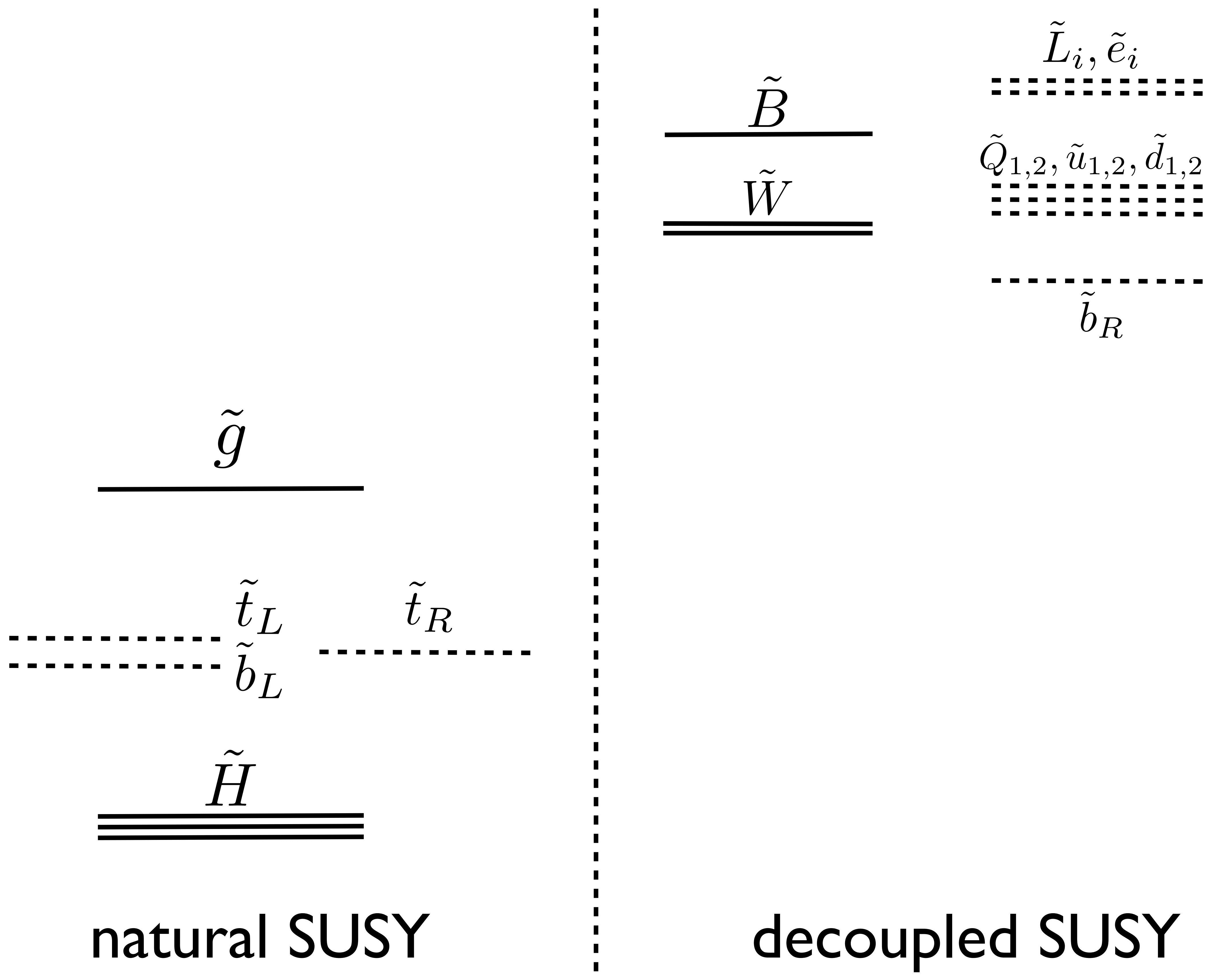
"The experiments haven't covered my favorite model"

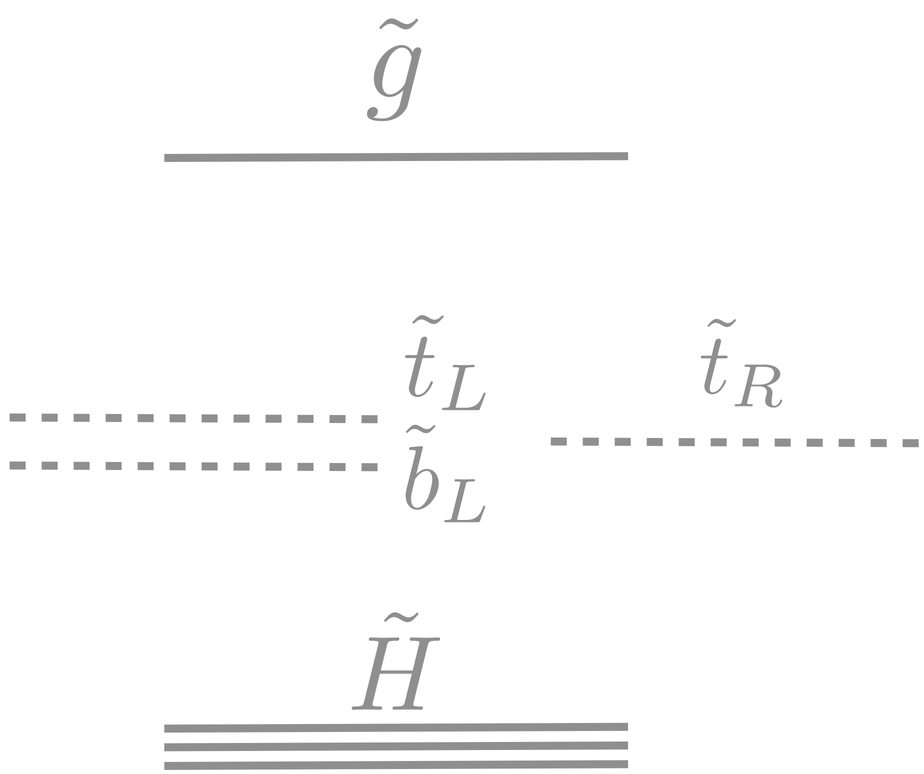
Relax & Wait?

vs.

Let's check!

* not his real attitude.


$\tilde{L}_i, \tilde{e}_i$
$\tilde{B}$
$\tilde{Q}_{1,2}, \tilde{u}_{1,2}, \tilde{d}_{1,2}$
$\tilde{W}$
$\tilde{b}_R$
$\tilde{g}$
$\tilde{t}_L$
$\tilde{t}_R$
$\tilde{b}_L$
$\tilde{H}$
natural SUSY
decoupled SUSY



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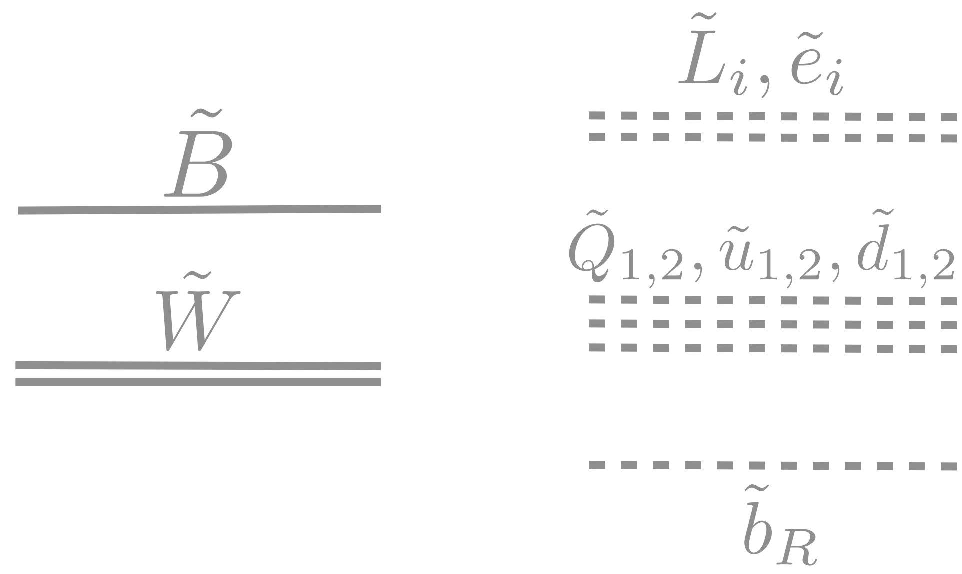

Our Limits

today: arXiv:1110.6926

M. Papucci, J. Ruderman, AW

decoupled SUSY

Large signature space

arXiv:1110.6926

	ATLAS			CMS		
	channel	$\mathcal{L}$ [fb^{-1}]	ref.	channel	$\mathcal{L}$ [fb^{-1}]	ref.
jets + $\not{E}_T$	2-4 jets	1.04	[1]	α_T	1.14	[11]
	6-8 jets	1.34	[2]	H_T, $\not{H}_T$	1.1	[12]
b-jets (+ l's + $\not{E}_T$)	$1b, 2b$	0.83	[3]	m_{T2} $(+b)$	1.1	[13]
	$b + 1l$	1.03	[4]	$1b, 2b$	1.1	[14]
				$b'b' \to b + l^{\pm}l^{\pm}, 3l$	1.14	[15]
				$t't' \to 2b + l^{+}l^{-}$	1.14	[16]
multilepton (+ $\not{E}_T$)	$1l$	1.04	[5]	$1l$	1.1	[17]
	$\mu^{\pm}\mu^{\pm}$	1.6	[6]	SS dilepton	0.98	[18]
	$t\bar{t} \to 2l$	1.04	[7]	OS dilepton	0.98	[19]
	$t\bar{t} \to 1l$	1.04	[8]	$Z \to l^{+}l^{-}$	0.98	[20]
	$4l$	1.02	[9]	$3l, 4l + \not{E}_T$	2.1	[21]
	$2l$	1.04	[10]	$3l, 4l$	2.1	[22]

non susy analyses

Large signature space

arXiv:1110.6926

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	$b + 1l$	1.03	[4]	~~$1b, 2b$~~	1.1	[14]
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	$t\bar{t} \to 2l$	1.04	[7]	OS dilepton	0.98	[19]
	$t\bar{t} \to 1l$	1.04	[8]	$Z \to l^{+}l^{-}$	0.98	[20]
	$4l$	1.02	[9]	~~$3l, 4l + \not{E}_T$~~	2.1	[21]
	~~$2l$~~	1.04	[10]	~~$3l, 4l$~~	2.1	[22]

non susy analyses

too recent

Bgd's are left to the experimentalists… stay out of control regions!

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	$\geq$ 2-jet	$\geq$ 3-jet	$\geq$ 4-jet, $m_{\text{eff}} > 500$ GeV	$\geq$ 4-jet, $m_{\text{eff}} > 1000$ GeV	High mass
Z/γ+jets	$32.3 \pm 2.6 \pm 6.9$	$25.5 \pm 2.6 \pm 4.9$	$209 \pm 9 \pm 38$	$16.2 \pm 2.2 \pm 3.7$	$3.3 \pm 1.0 \pm 1.3$
W+jets	$26.4 \pm 4.0 \pm 6.7$	$22.6 \pm 3.5 \pm 5.6$	$349 \pm 30 \pm 122$	$13.0 \pm 2.2 \pm 4.7$	$2.1 \pm 0.8 \pm 1.1$
tt+ single top	$3.4 \pm 1.6 \pm 1.6$	$5.9 \pm 2.0 \pm 2.2$	$425 \pm 39 \pm 84$	$4.0 \pm 1.3 \pm 2.0$	$5.7 \pm 1.8 \pm 1.9$
QCD multi-jet	$0.22 \pm 0.06 \pm 0.24$	$0.92 \pm 0.12 \pm 0.46$	$34 \pm 2 \pm 29$	$0.73 \pm 0.14 \pm 0.50$	$2.10 \pm 0.37 \pm 0.82$
Total	$62.4 \pm 4.4 \pm 9.3$	$54.9 \pm 3.9 \pm 7.1$	$1015 \pm 41 \pm 144$	$33.9 \pm 2.9 \pm 6.2$	$13.1 \pm 1.9 \pm 2.5$
Data	58	59	1118	40	18

Table 2: Fitted background components in each SR, compared with the number of events observed in data. The Z/γ+jets background is constrained with co regions CR1a and CR1b, the QCD multi-jet, W and top quark backgrounds by control regions CR2, CR3 and CR4, respectively. In each case the first (sec quoted uncertainty is statistical (systematic). Background components are partially correlated and hence the uncertainties (statistical and systematic) on the background estimates do not equal the quadrature sums of the uncertainties on the components.

[5] has improved the ATLAS reach at large m_0. The five signal regions are used to set limits on $\sigma_{new} = \sigma A \epsilon$, for non-SM cross-sections (σ) for which ATLAS has an acceptance A and a detection efficiency of ϵ [44]. The excluded values of σ_{new} are 22 fb, 25 fb, 429 fb, 27 fb and 17 fb, respectively, at the 95% confidence level.

upper bound on signal xsec

LIMIT!

Bgd's are left to the experimentalists...

stay out of control regions!

Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, $m_{\rm eff}$ > 500 GeV	≥ 4-jet, $m_{\rm eff}$ > 1000 GeV	High mass
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QCD multi-jet	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.73 ± 0.14 ± 0.50	2.10 ± 0.37 ± 0.82
Total	62.4 ± 4.4 ± 9.3	54.9 ± 3.9 ± 7.1	1015 ± 41 ± 144	33.9 ± 2.9 ± 6.2	13.1 ± 1.9 ± 2.5
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upper bound on signal xsec

"Only" need efficiency x Acceptance of the signal bins for your model...

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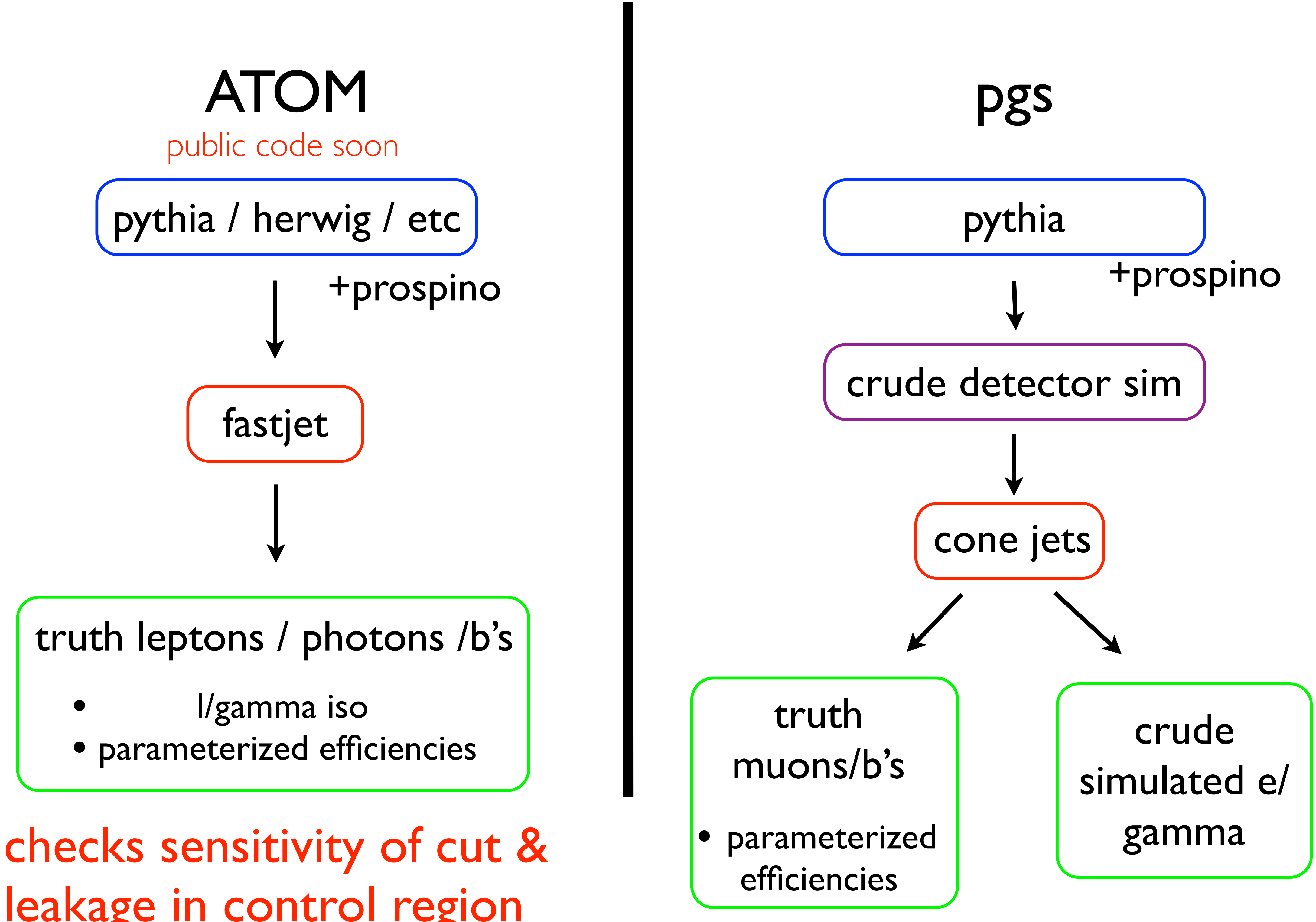
upper bound on signal xsec

"Only" need efficiency x Acceptance of the signal bins for your model…

LIMIT!

our pipelines



ATOM

an **A**utomated **T**ester **O**f **M**odels

(soon to be) Public Tool developed by

QCD/Jets: C. Bauer (Berkeley), C. Vermillion (Berkeley)

BSM: M. Papucci (Berkeley),
T. Volansky (Tel Aviv), A. W. (DESY)

Calibration

“theorist limits”

To calibrate compare:

1) key kinematical distributions
2) limits

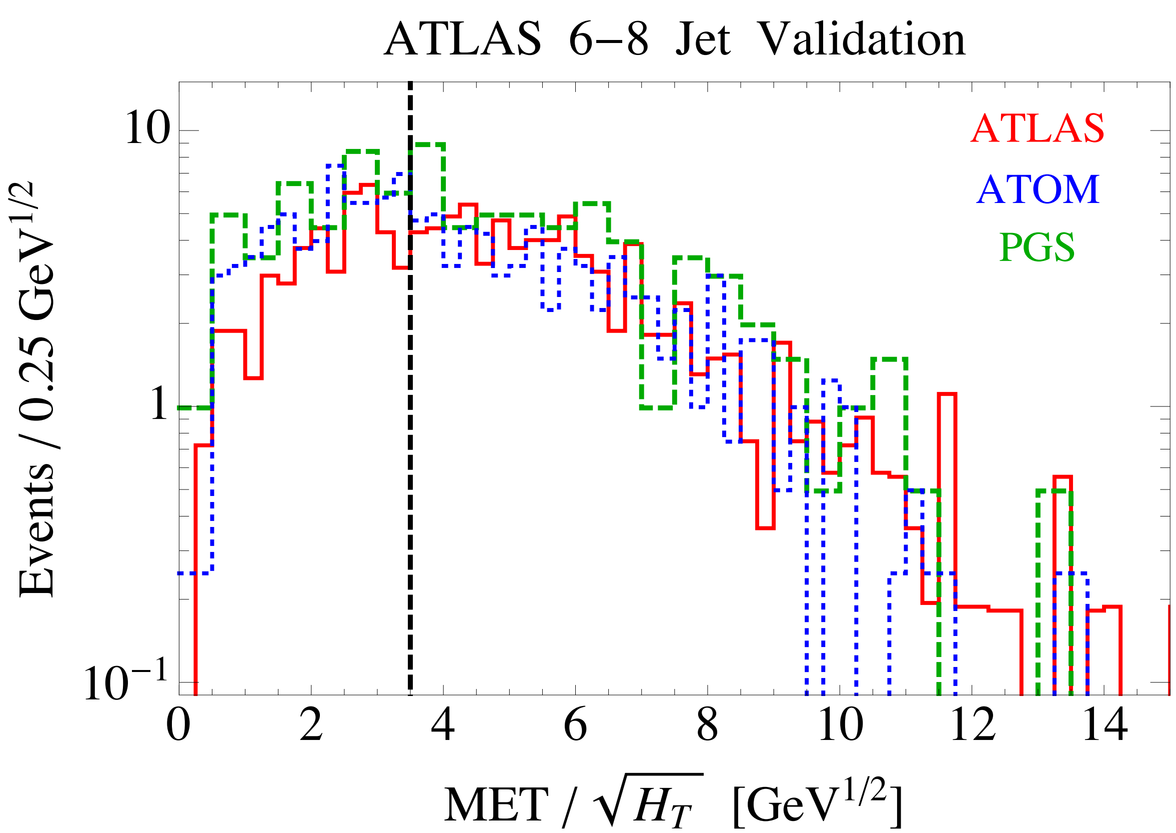
Calibration

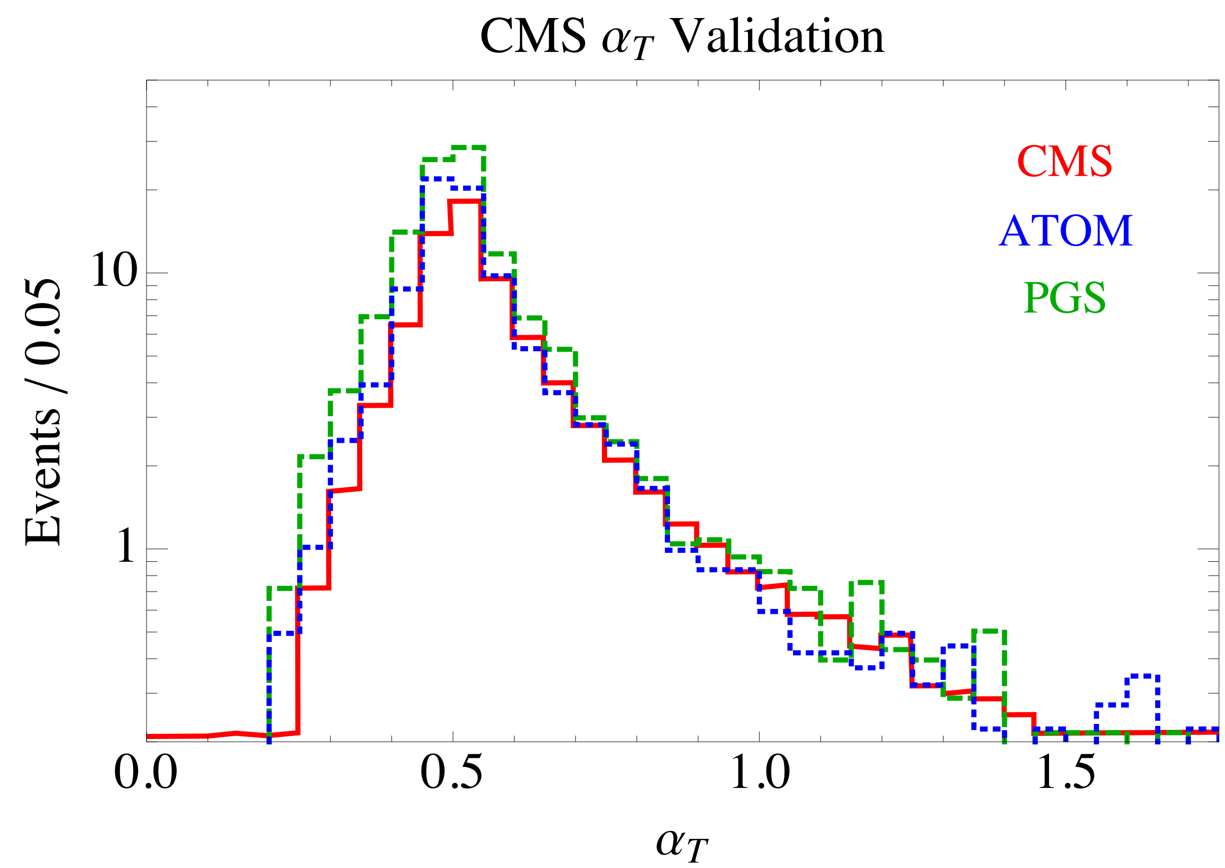
"theorist limits"

To calibrate compare:

1) key kinematical distributions
2) limits

simplified models work best!





Check:

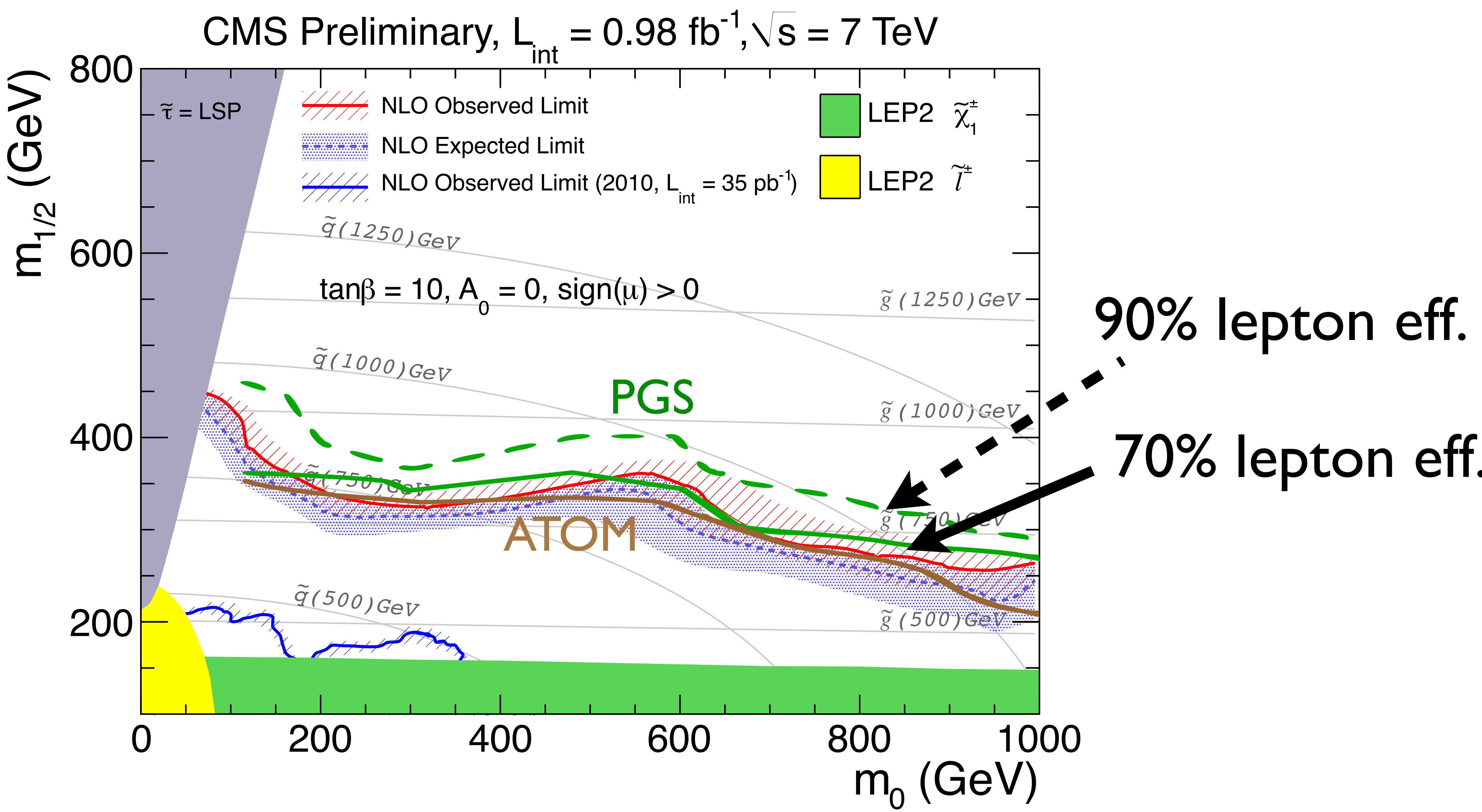
- kinematic distortions (shape)
- signal $\epsilon \times \mathcal{A}$ (normalization)

+ compare to all available limit plots…

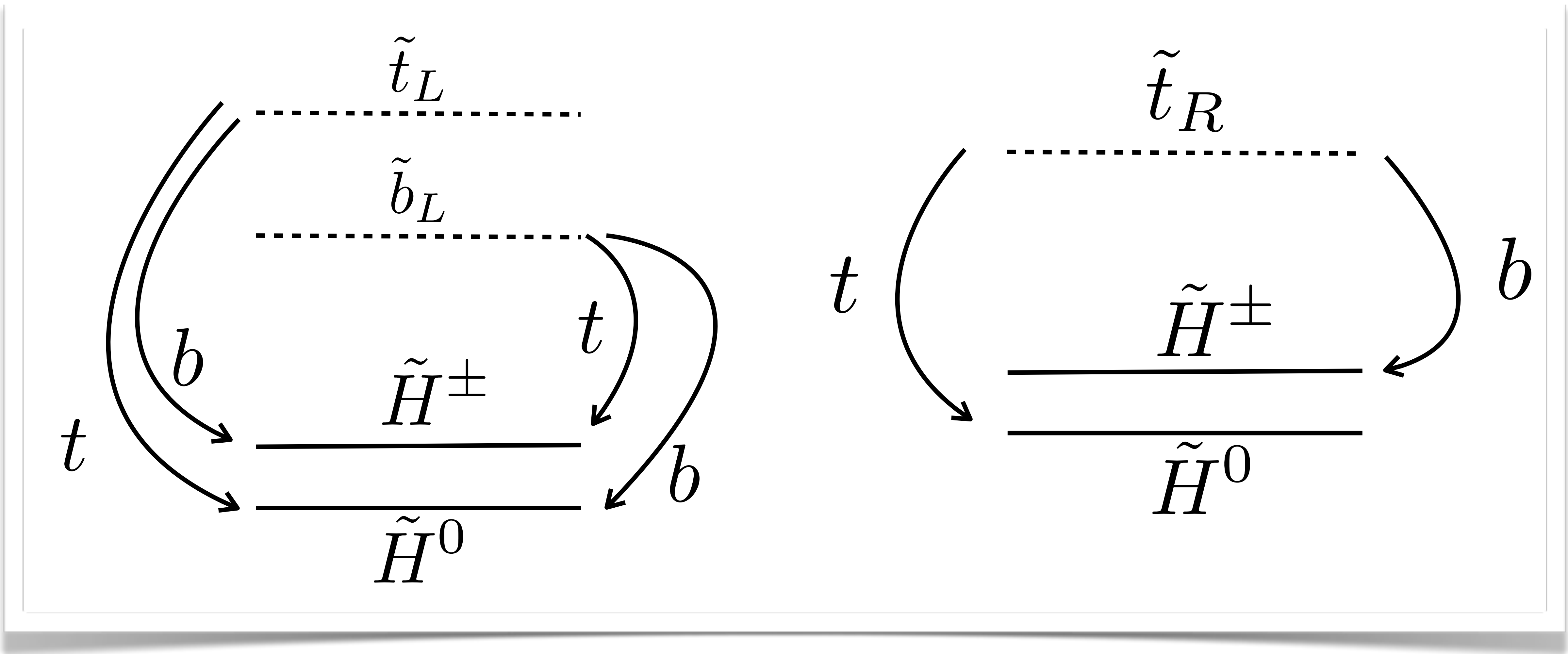
~ 50 GeV accuracy (usually better)

Compare limits

Example: Same-Sign dilepton by CMS



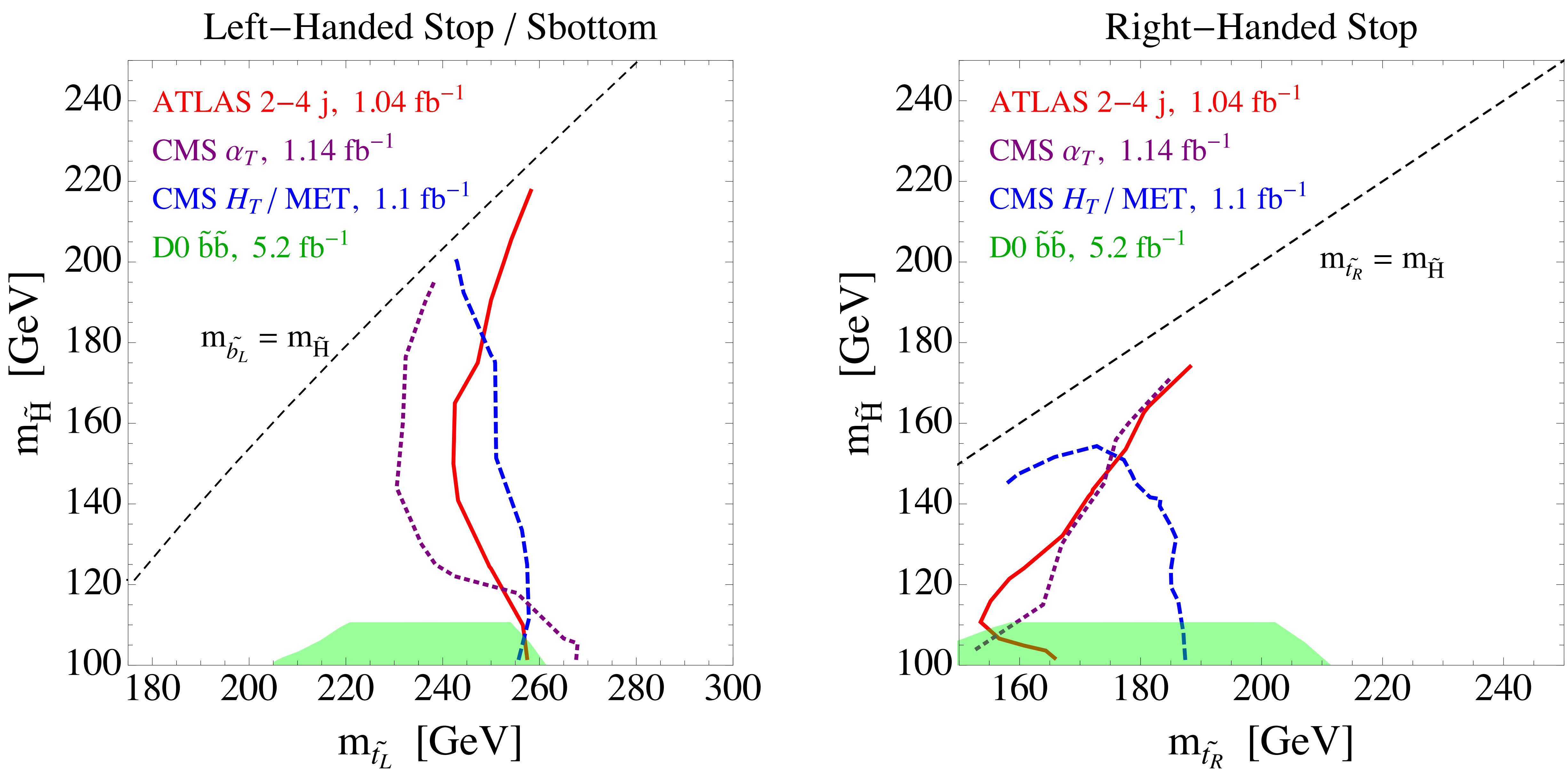
Stops (sbottom) + Higgsinos



Stops can act as "sbottom" (bjet+χ) !

Chargino-neutralino splitting irrelevant for present searches

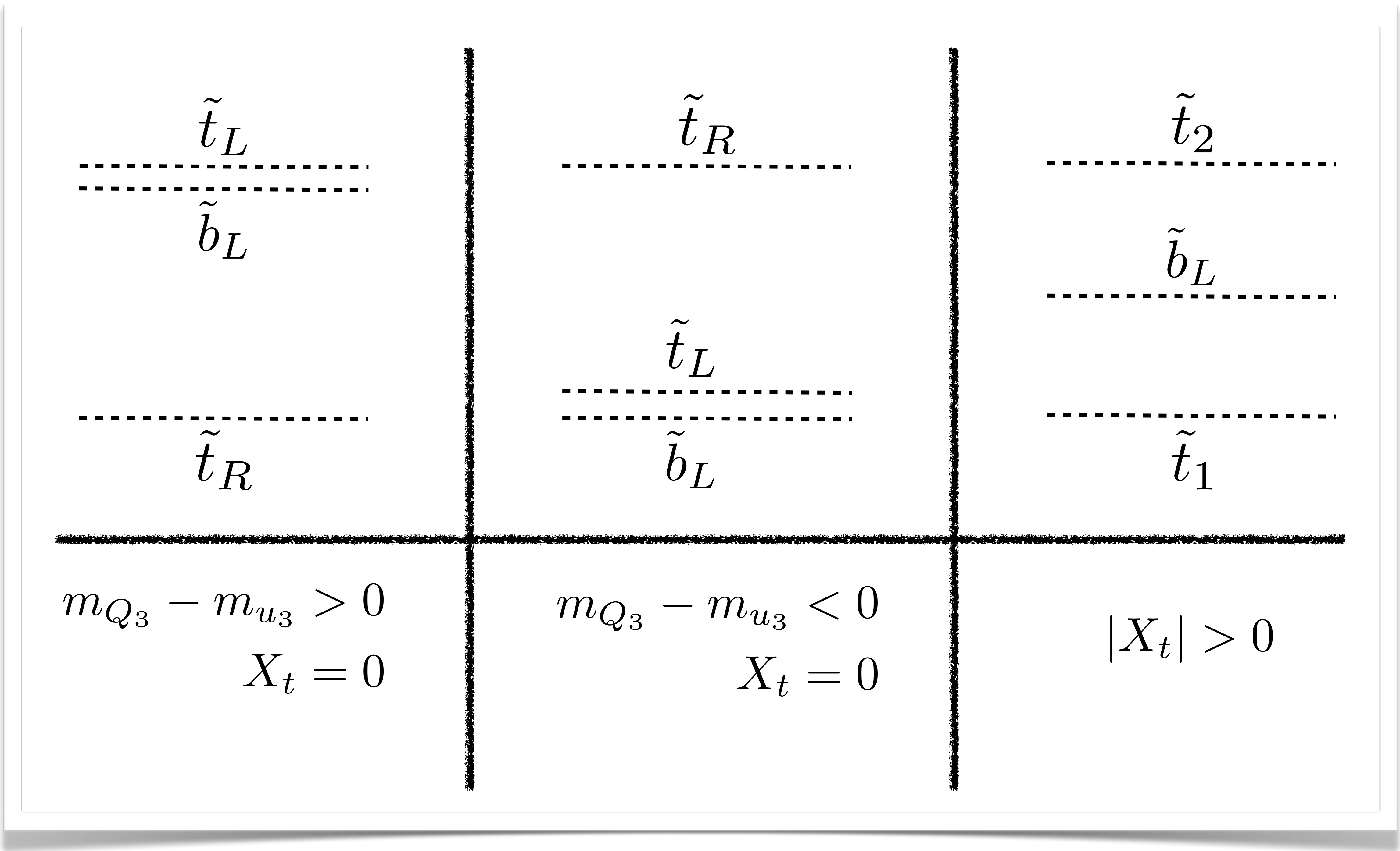
Stops (sbottom) + Higgsinos



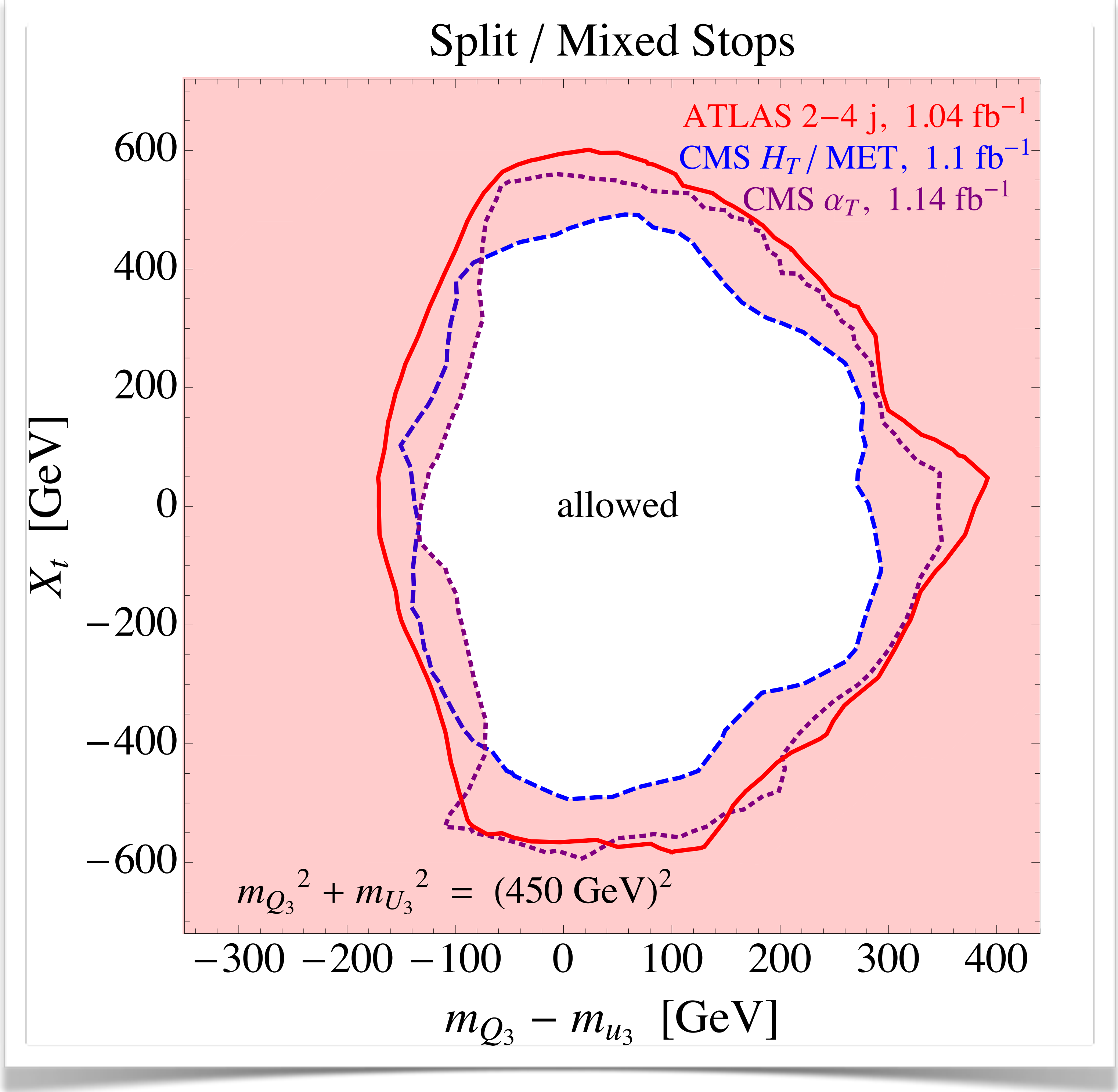
LHC surpasses Tevatron:

Strongest bounds from jets + MET

Un-Splitting the spectrum



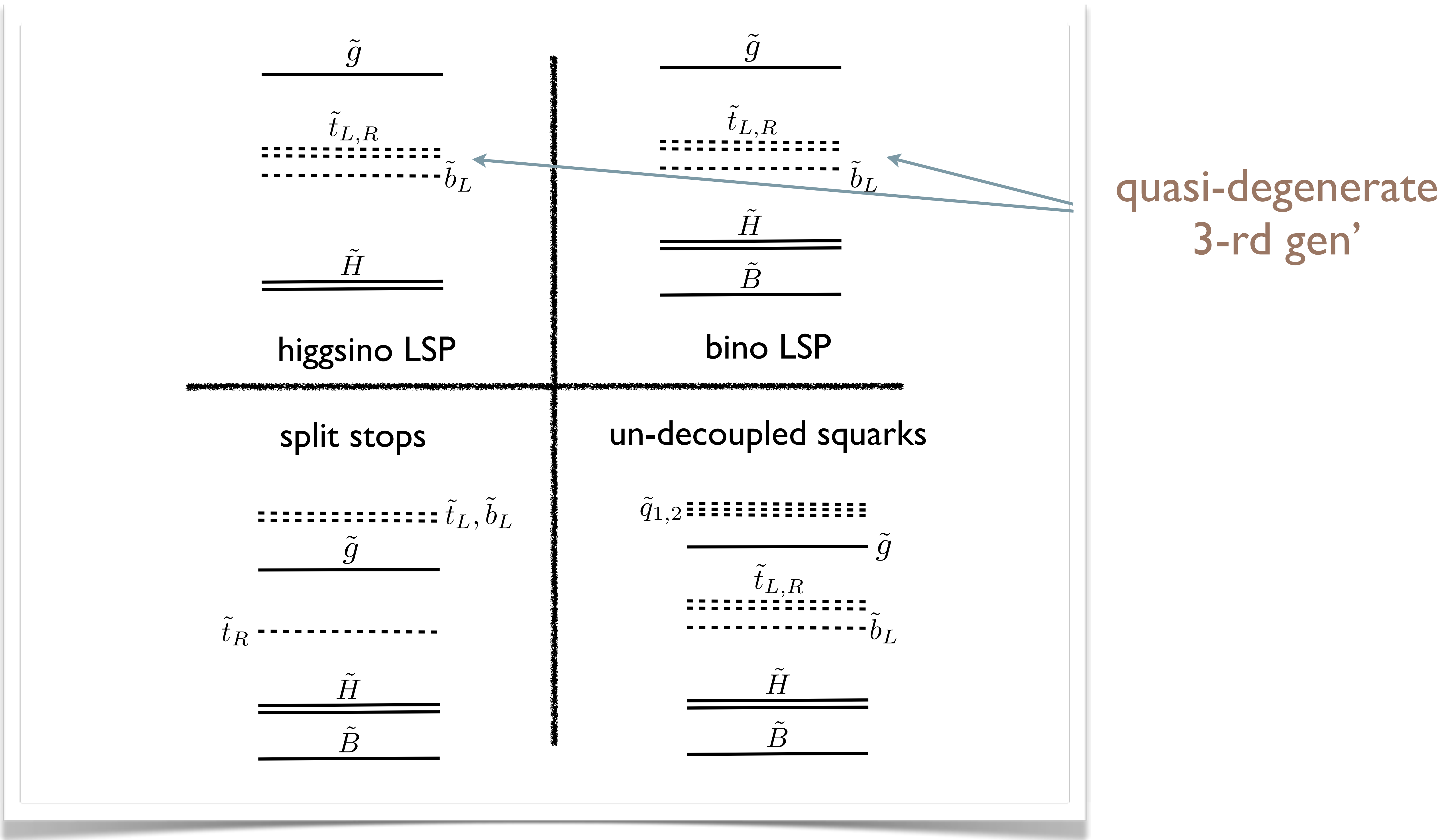
Un-Splitting the spectrum



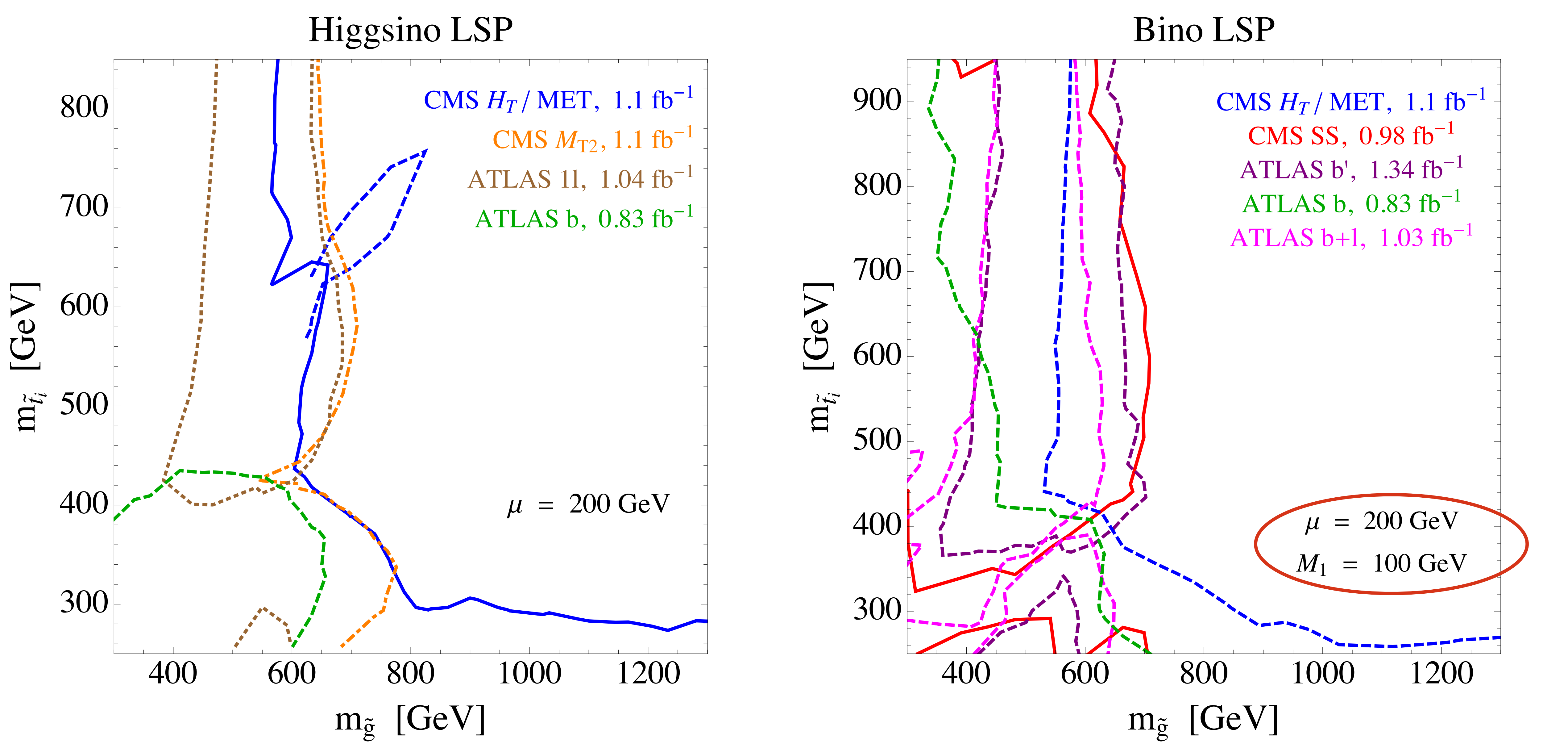
stronger bound on the left due to light sbottom

TeVatron bounds not shown b/c they have no sensitivity for m_{LSP} >110GeV

Adding gluinos



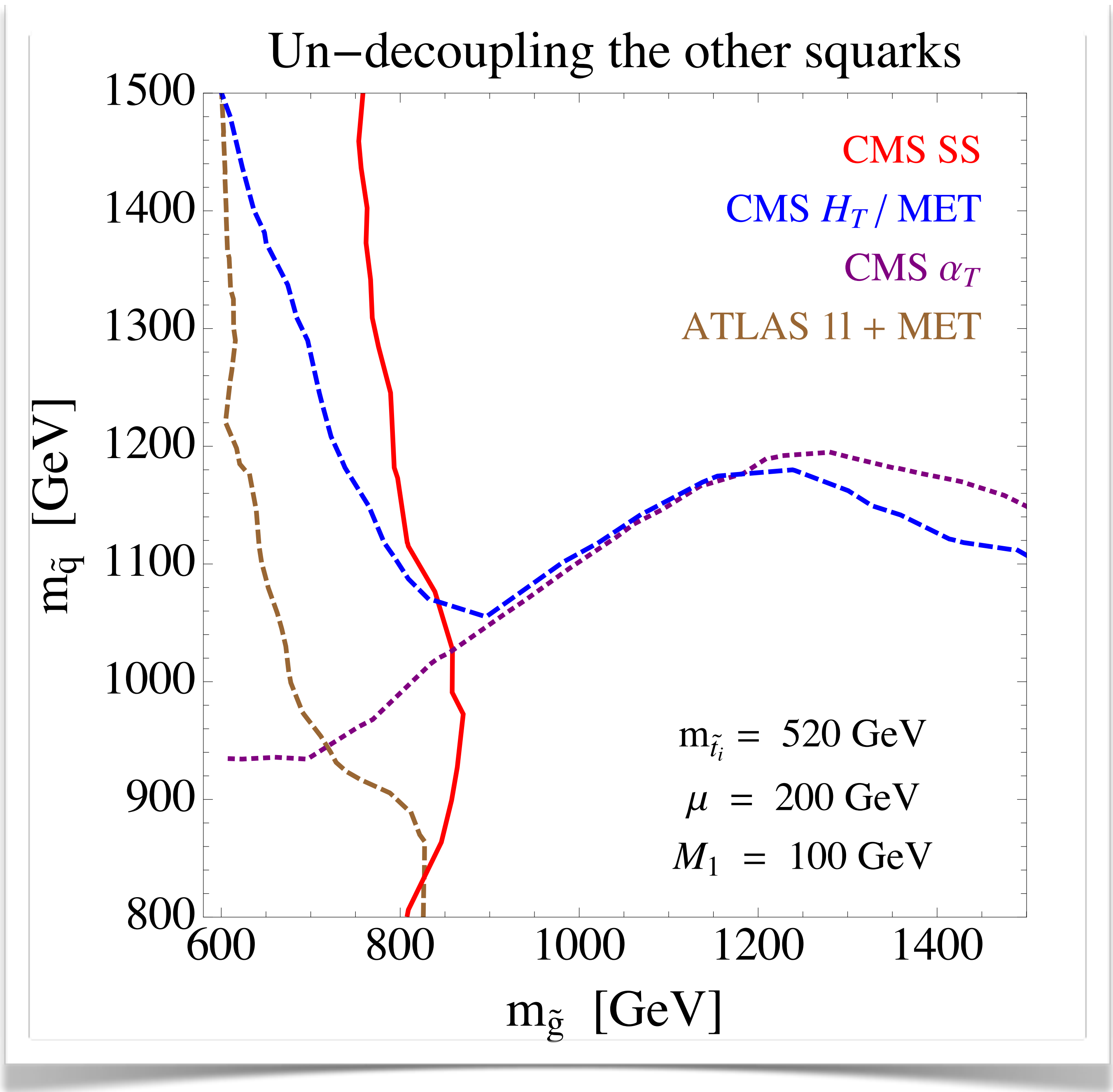
Adding the gluinos



Gluino bounded (again) by jets+MET, and 1lep searches

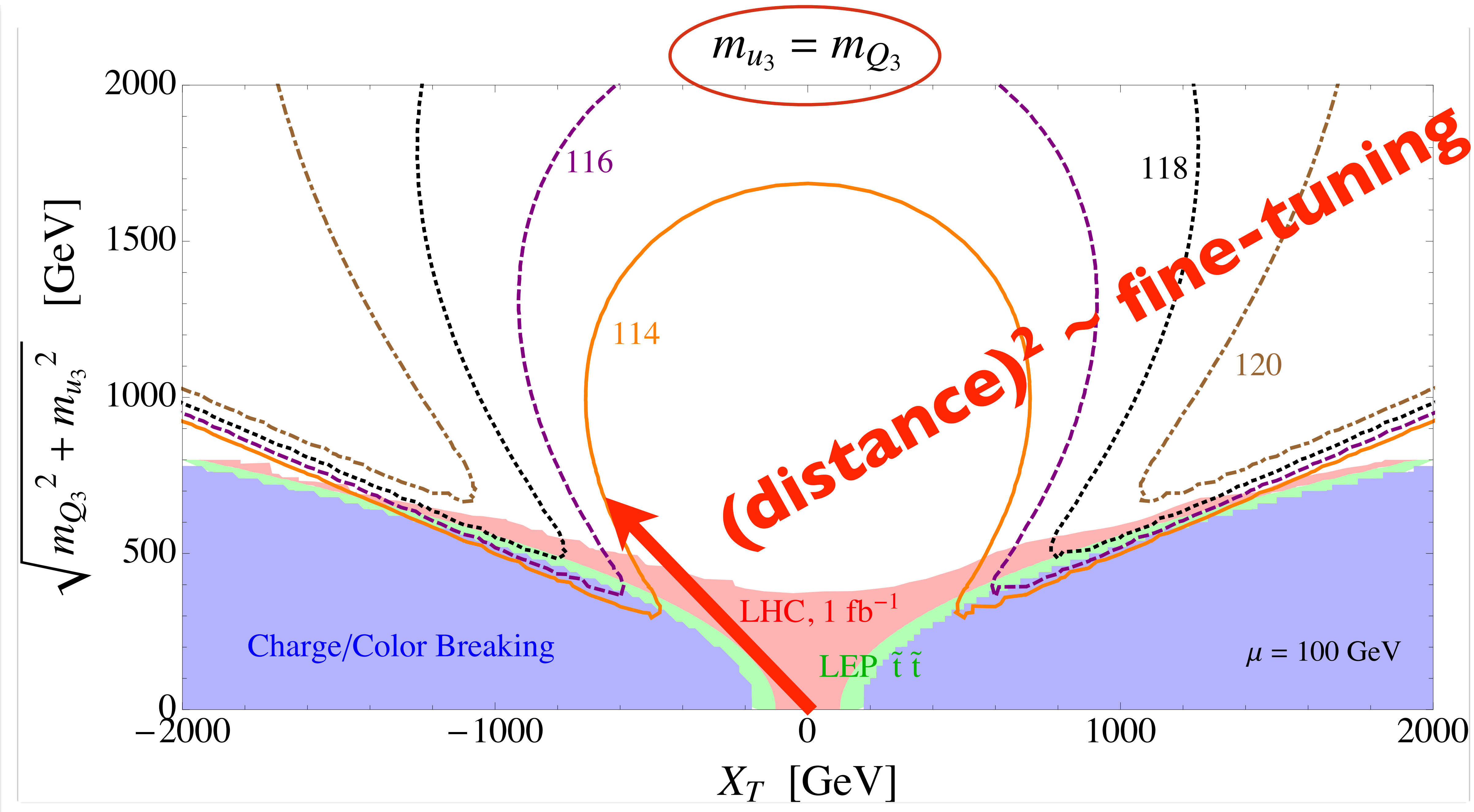
Gluino mostly bounded by Same Sign searches

Adding the squarks, too



- Bounds similar to the ATLAS/CMS plots (800GeV-1TeV)
- Decoupling not effective until 1.2-1.4 TeV

MSSM higgs: LEP2 tuning vs. direct stop

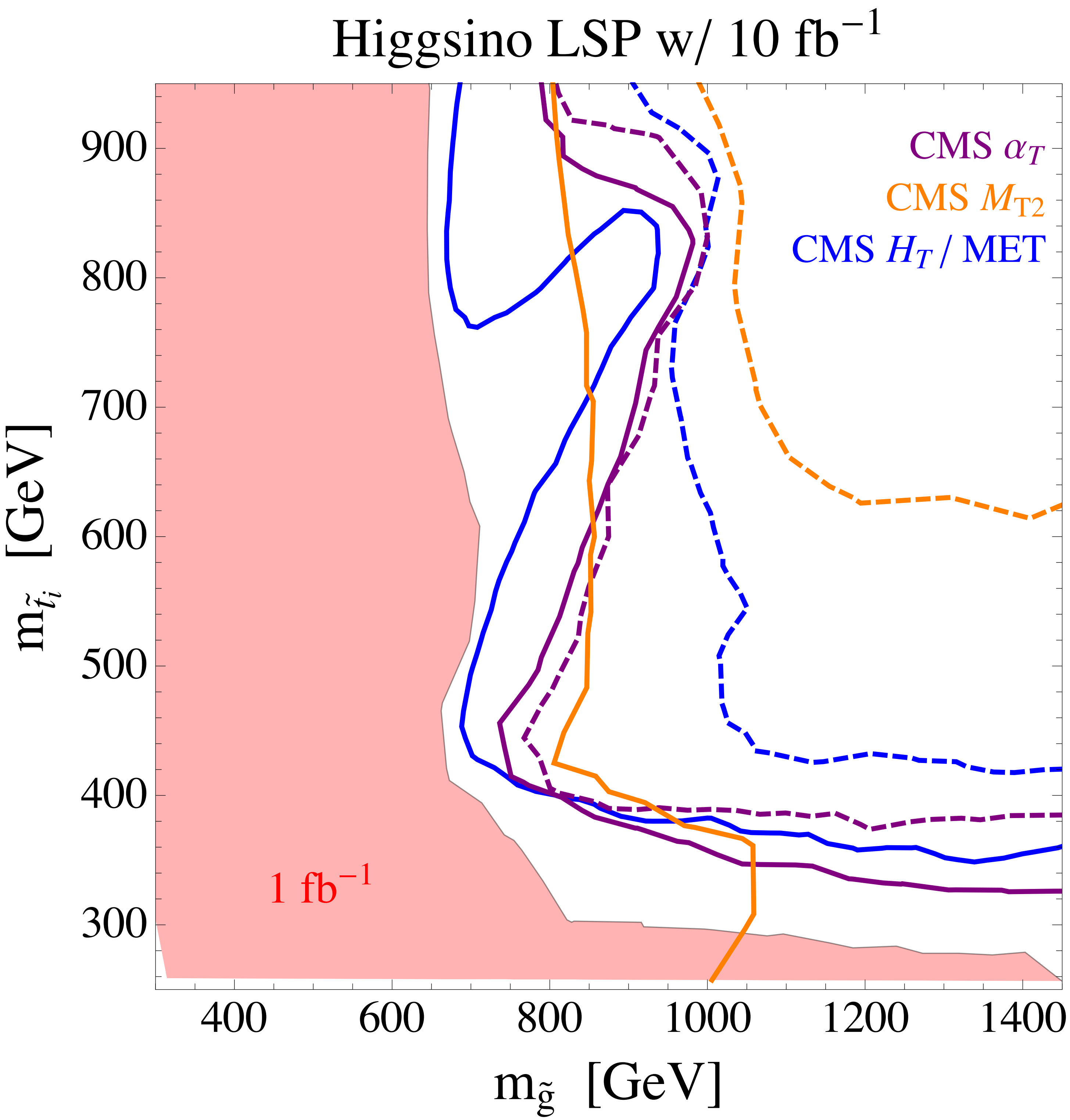


$$\delta m_H^2|_{stop} = -\frac{3}{8\pi^2} y_t^2 \left(m_{U_3}^2 + m_{Q_3}^2 + |A_t|^2\right) \log\left(\frac{\Lambda}{\text{TeV}}\right)$$

Conclusions

- Non-degenerate 1st & 2nd generation squarks poorly constrained, surprises in data? Dedicated experimental study!
- Next frontier: Heavy flavor themed naturalness, EW-inos
- Natural SUSY not in trouble yet (and won't be before shutdown).
- Most interesting scenario least constrained: (split squarks)=> most interesting for LHCb!

Projections?



dashed - perfect bgd's

solid - statistics improves, systematics same fraction

* Large uncertainty
* Targeted searches do likely better.

Les Houches recommendations

Searches for New Physics: Les Houches Recommendations for the Presentation of LHC Results

Coordinators: S. Kraml[1], S. Sekmen[2,3];

B.C. Allanach[4], P. Bechtle[5], G. Belanger[6], K. Benslama[7], C. Balazs[8], A. Belyaev[9,10], M. Dolan[11], B. Fuks[12], M. Campanelli[13], K. Cranmer[14], J. Ellis[3,15], M. Felcini[16], D. Guadagnoli[17], J.F. Gunion[18], S. Heinemeyer[16], M. Kadastik[19], M. Krämer[20], J. Lykken[21] F. Mahmoudi[3,22], M. Mangano[3], S.P. Martin[23,24,25], H. Prosper[2], T. Rizzo[26], T. Robens[27], M. Tytgat[28], A. Weiler[5]

underlined: editors

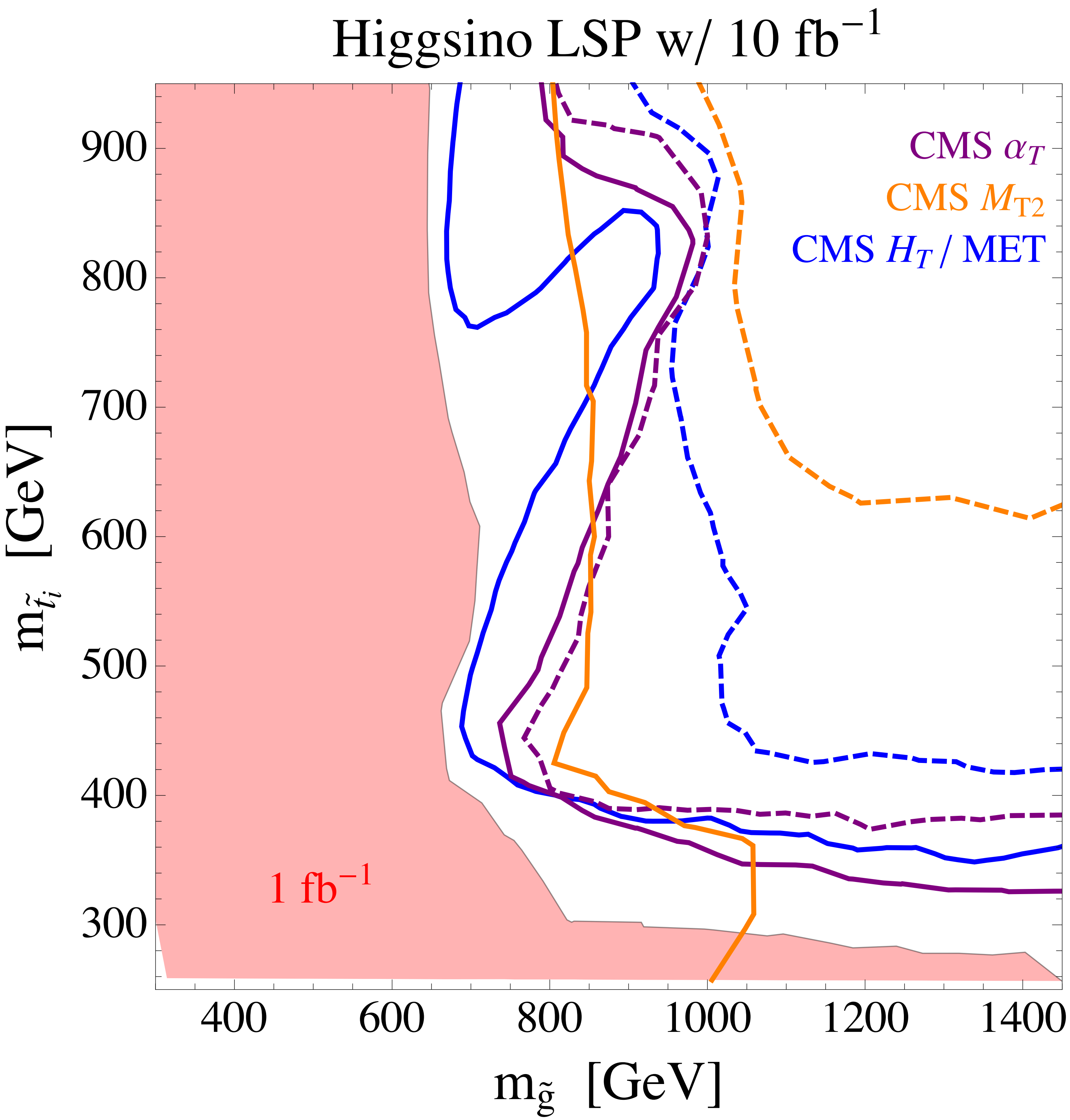
Abstract
We present a draft set of recommendations for the presentation of LHC results on searches for new physics, which are aimed at providing a more efficient flow of scientific information between the experimental collaborations and the rest of the high energy physics community, and facilitating the interpretation of the results in a wide class of models. Implementing these recommendations would aid the full exploitation of the physics potential of the LHC.

Please comment and consider signing the document.

https://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=173341

Backup

Projections?



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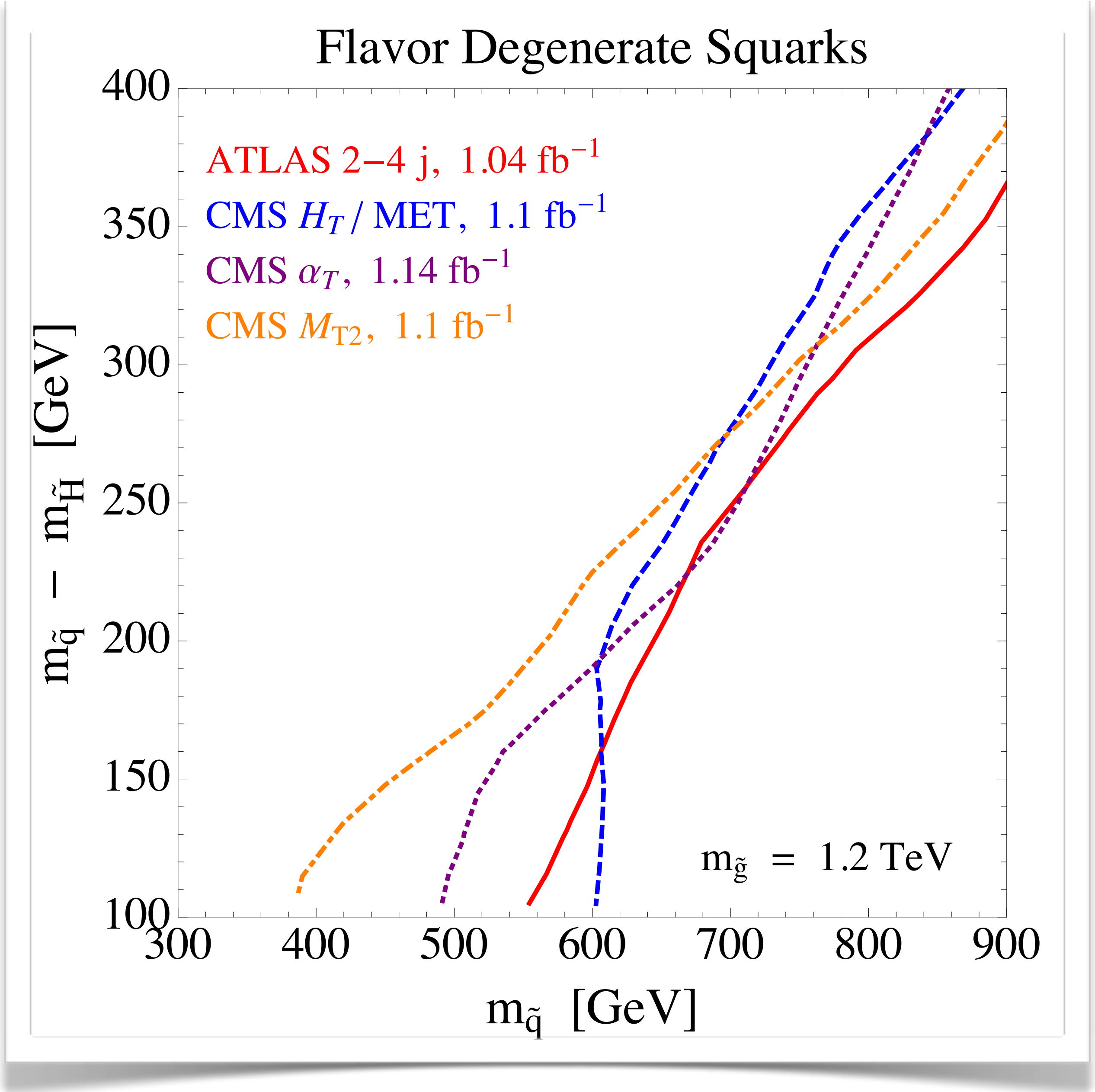
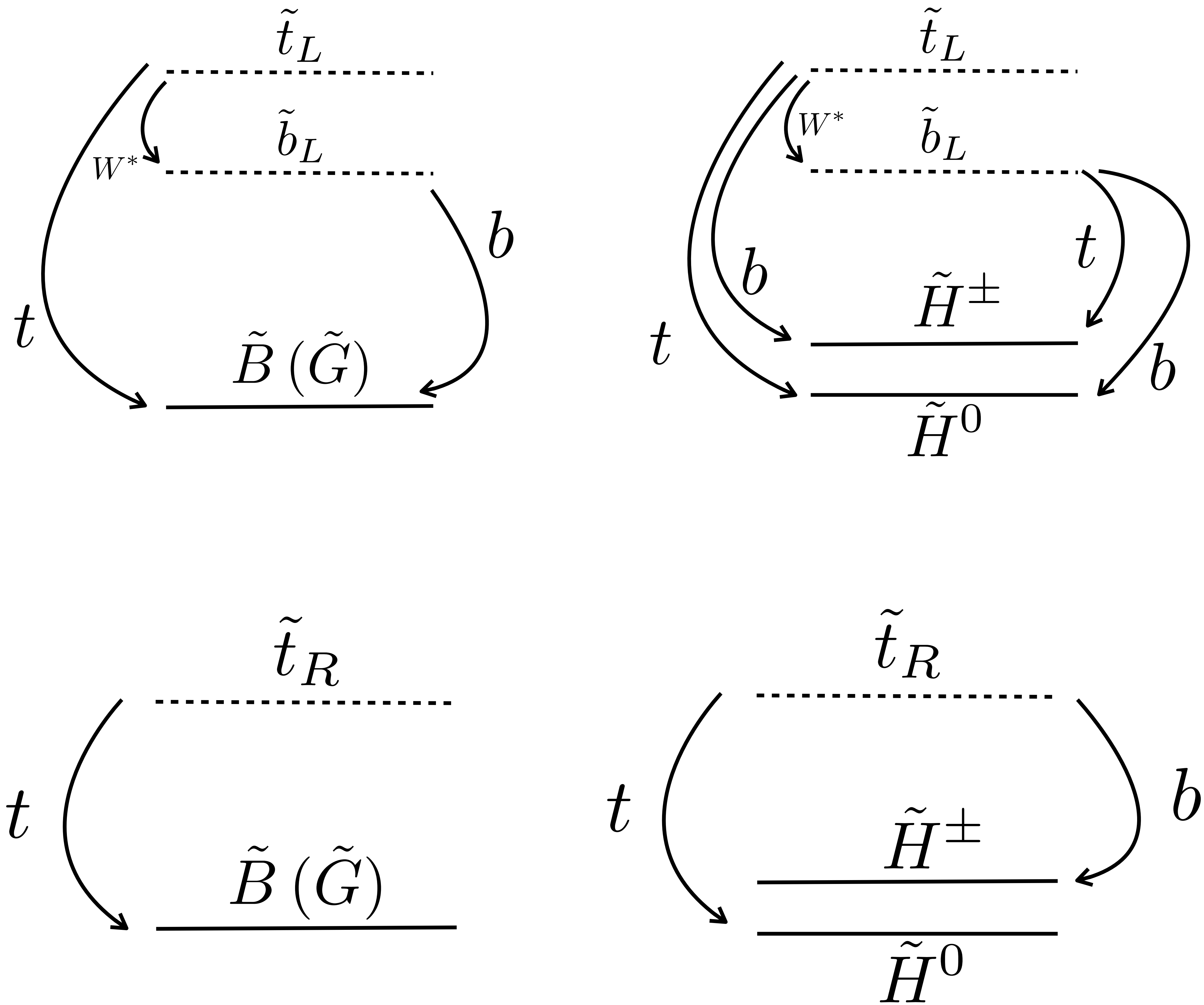
solid - statistics improves, systematics same fraction

* Large uncertainty
* Targeted searches do likely better.

Back to the flavor degenerate case



Hard to investigate more squashed spectra
(+ additional tuning due to squashing…)



$\tilde{t}_L$
$\tilde{b}_L$
W^*
t
b
$\tilde{B}\,(\tilde{G})$
$\tilde{t}_L$
$\tilde{b}_L$
W^*
t
b
t
b
$\tilde{H}^{\pm}$
$\tilde{H}^0$
$\tilde{t}_R$
t
$\tilde{B}\,(\tilde{G})$
$\tilde{t}_R$
t
b
$\tilde{H}^{\pm}$
$\tilde{H}^0$