Overview of BSM interpretations from Run1 precision top measurements and Run2 perspectives

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ATLAS SUSY Searches* - 95% CL Lower Limits

Status: Moriond 2014

ATLAS Preliminary

$\int \mathcal{L}\,dt = (4.6 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\,dt[\mathrm{fb}^{-1}]$	Mass limit			Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)$=0.5($m(\tilde{\chi}_1^0)$+$m(\tilde{g})$)	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta$ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$	1.28 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2014-001
	GGM (wino NLSP)	1 $e,\mu+\gamma$	-	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H})$>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	275-430 GeV	$m(\tilde{\chi}_1^\pm)$=2 $m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-210 GeV	$m(\tilde{\chi}_1^0)$ =$m(\tilde{t}_1)$-$m(W)$-50 GeV, $m(\tilde{t}_1)$<<$m(\tilde{\chi}_1^\pm)$	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$	215-530 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$	290-600 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	140-465 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	700 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$)	1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	420 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e,μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	285 GeV	$m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$	270 GeV	$m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e,μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e,\mu+\tau$	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e,μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q})$=$m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$	350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e,μ (SS)	2 b	Yes	14.3	sgluon	350-800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

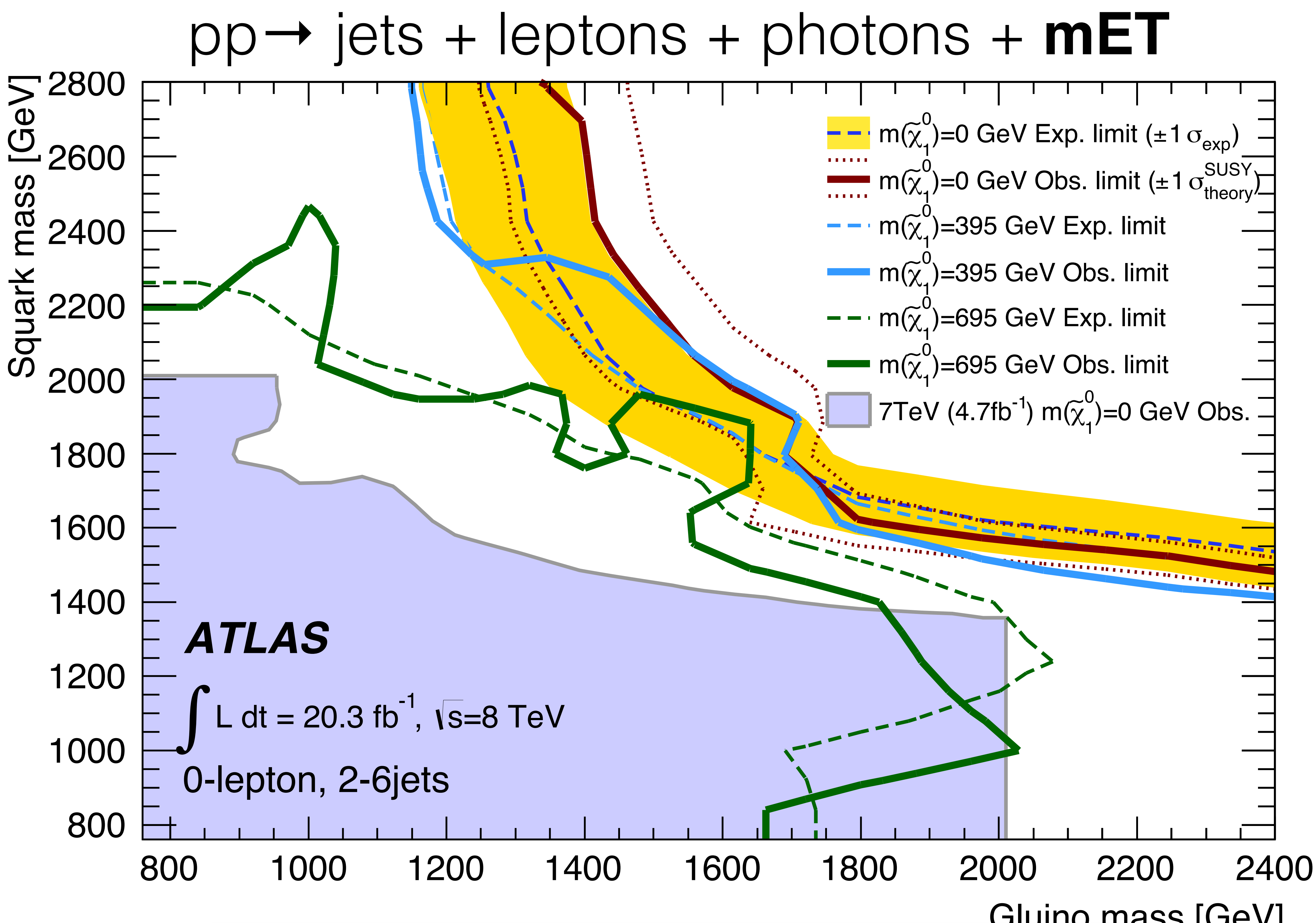
10^{-1} 1 **Mass scale [TeV]**

$\sqrt{s}$ = 7 TeV full data

$\sqrt{s}$ = 8 TeV partial data

$\sqrt{s}$ = 8 TeV full data

No signs of new physics yet



direct limits: M_{SUSY} > 1 TeV

Not covered

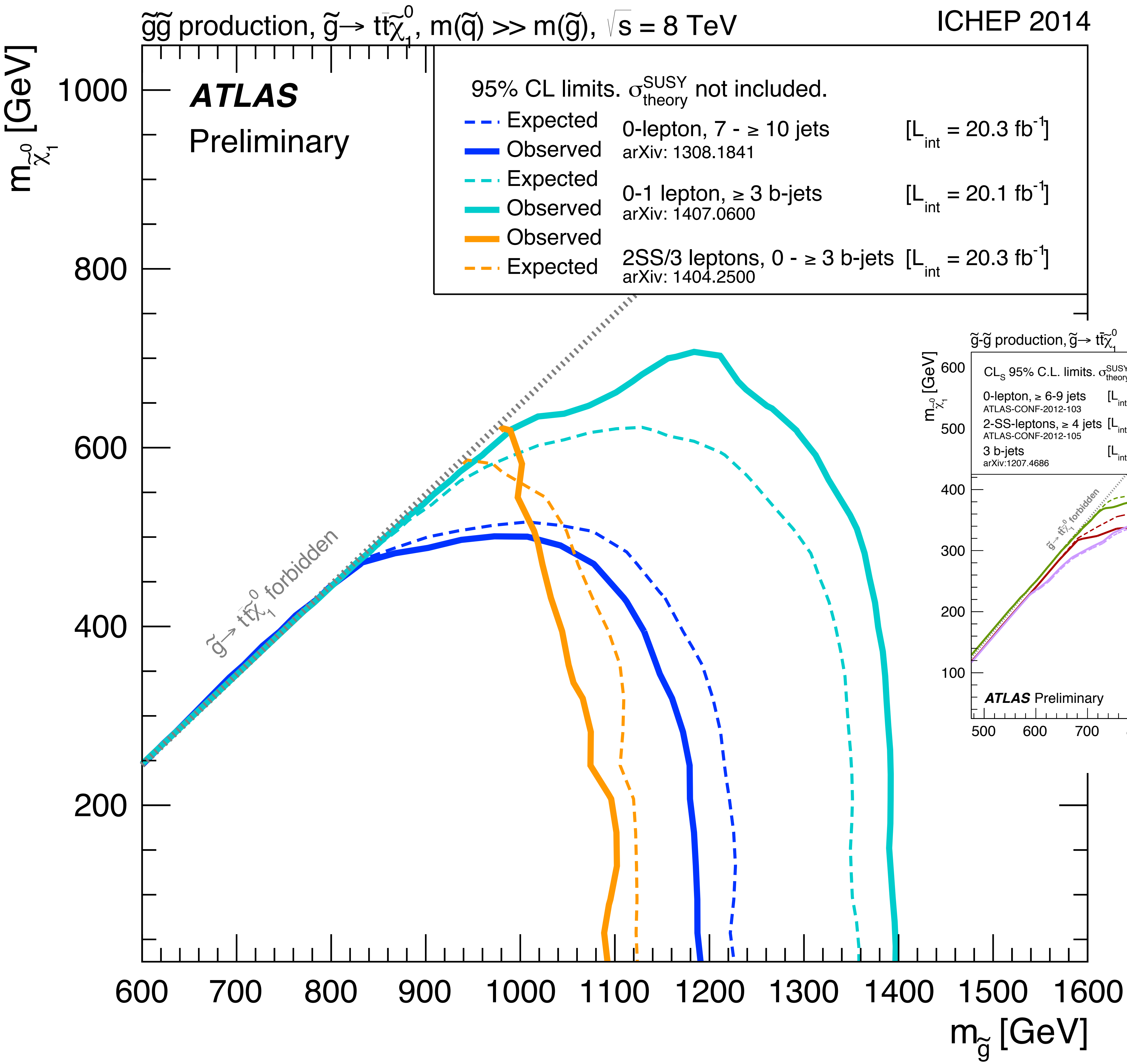
“closed” games

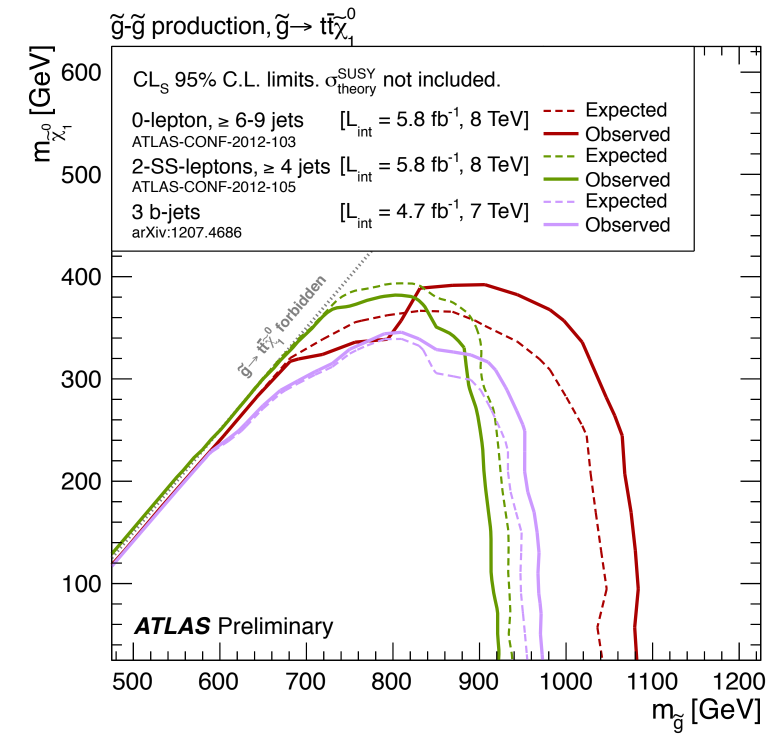
- $\tilde{g} \to tt\chi$

indirect limits

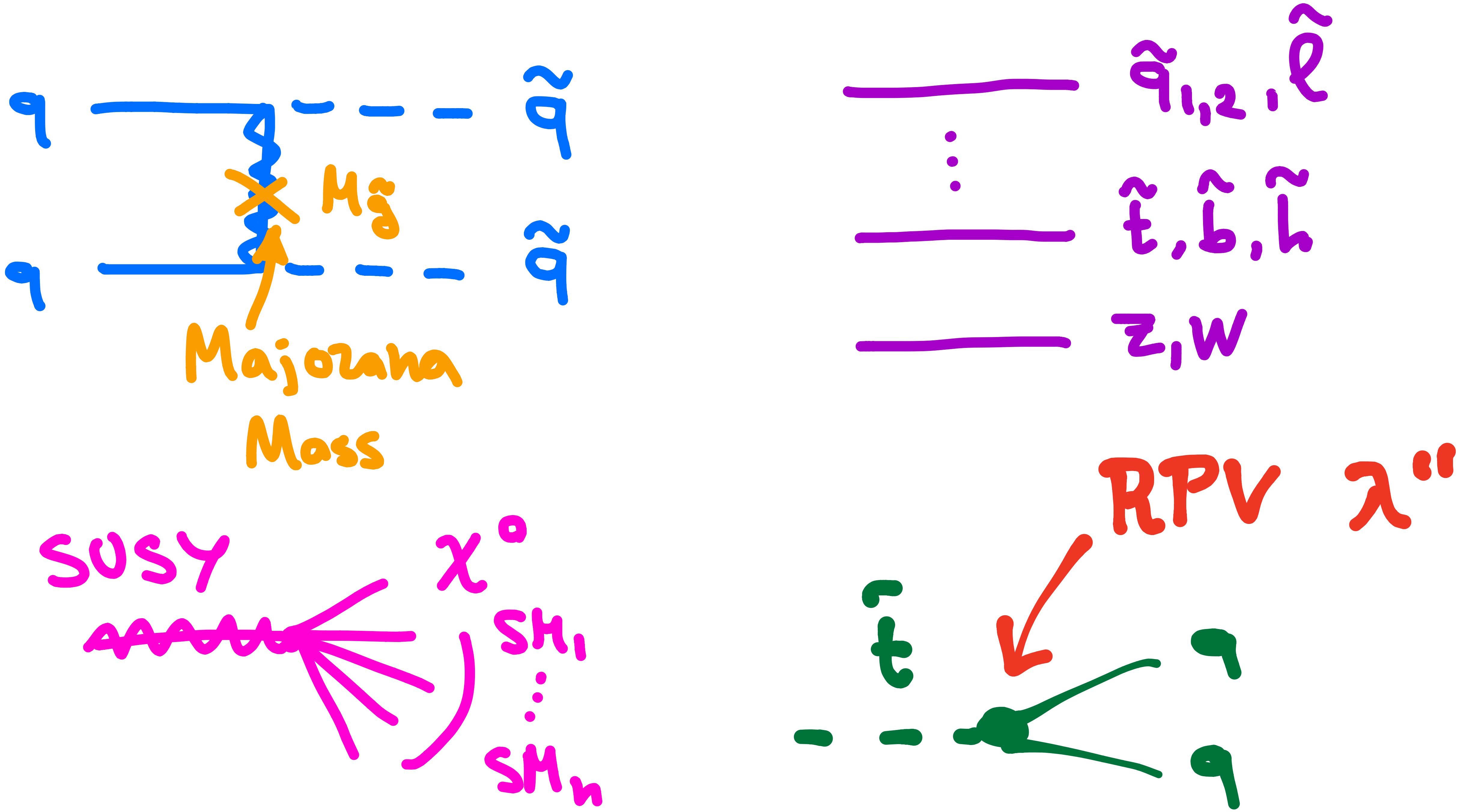
- ttZ, $tt\gamma$, …
- $G_{\mu\nu}\, t\sigma_{\mu\nu} t$ ($\sigma(tt)$ 1210.2570, CMS-TOP-14-005 $\Delta\phi(\ell\ell)$, boosted 1412.6654)
- $G_{\mu\nu}\, T'\sigma_{\mu\nu} t$ (CMS-PAS-B2G-12-014 and alike)
- …

$\tilde{g} \rightarrow tt\chi$

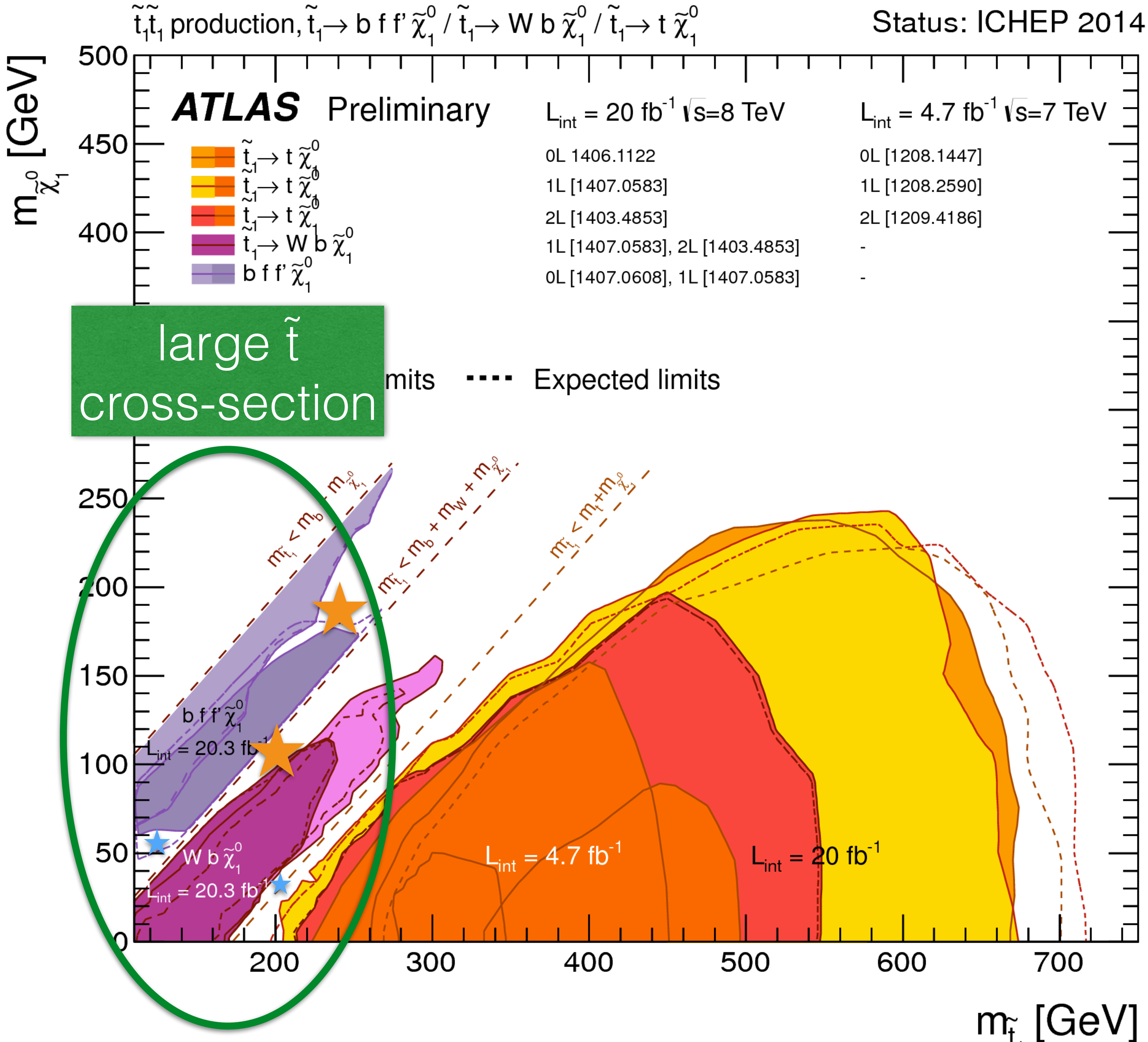




Theory Options



more subtle signals ⇒ precision

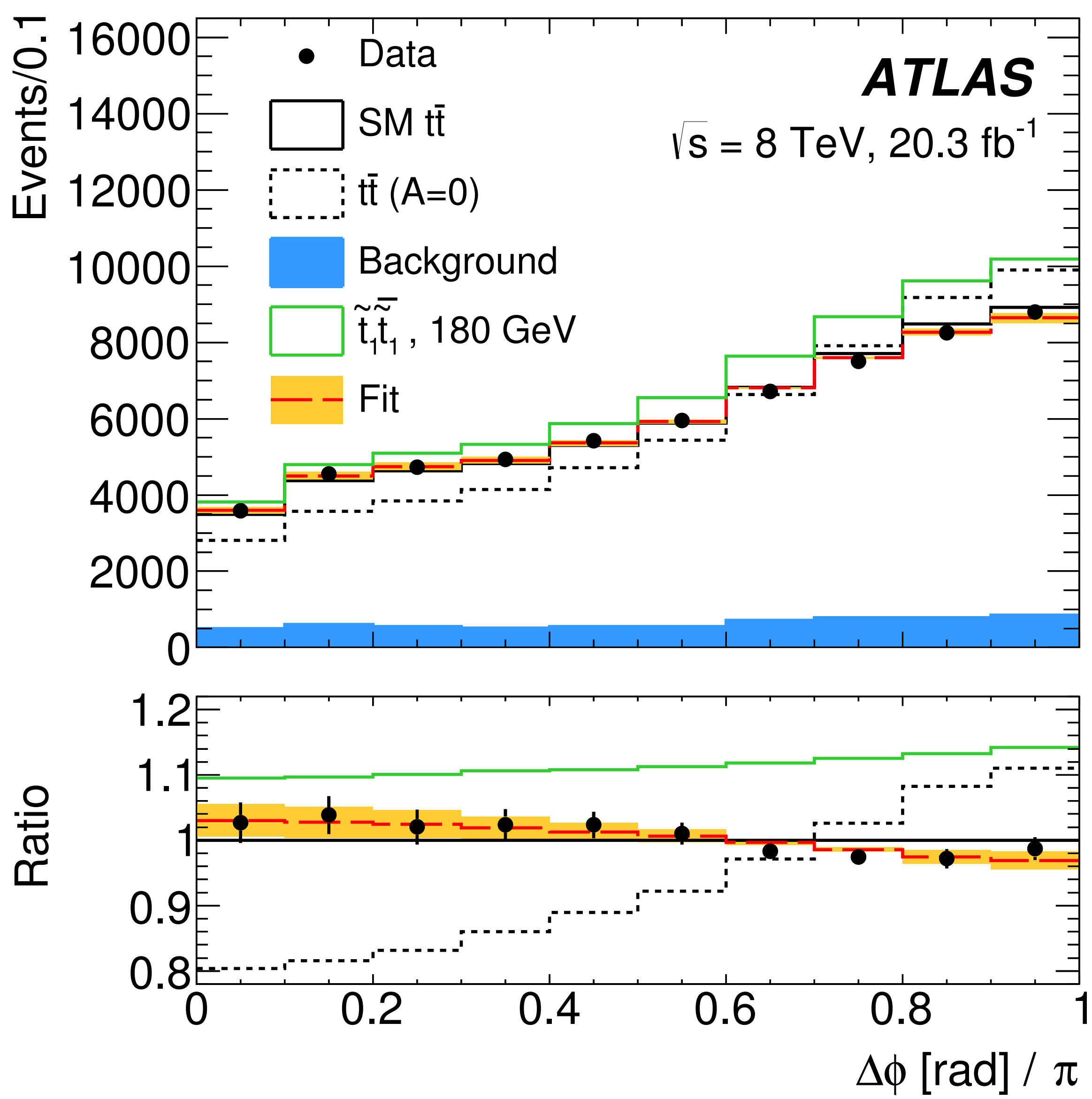


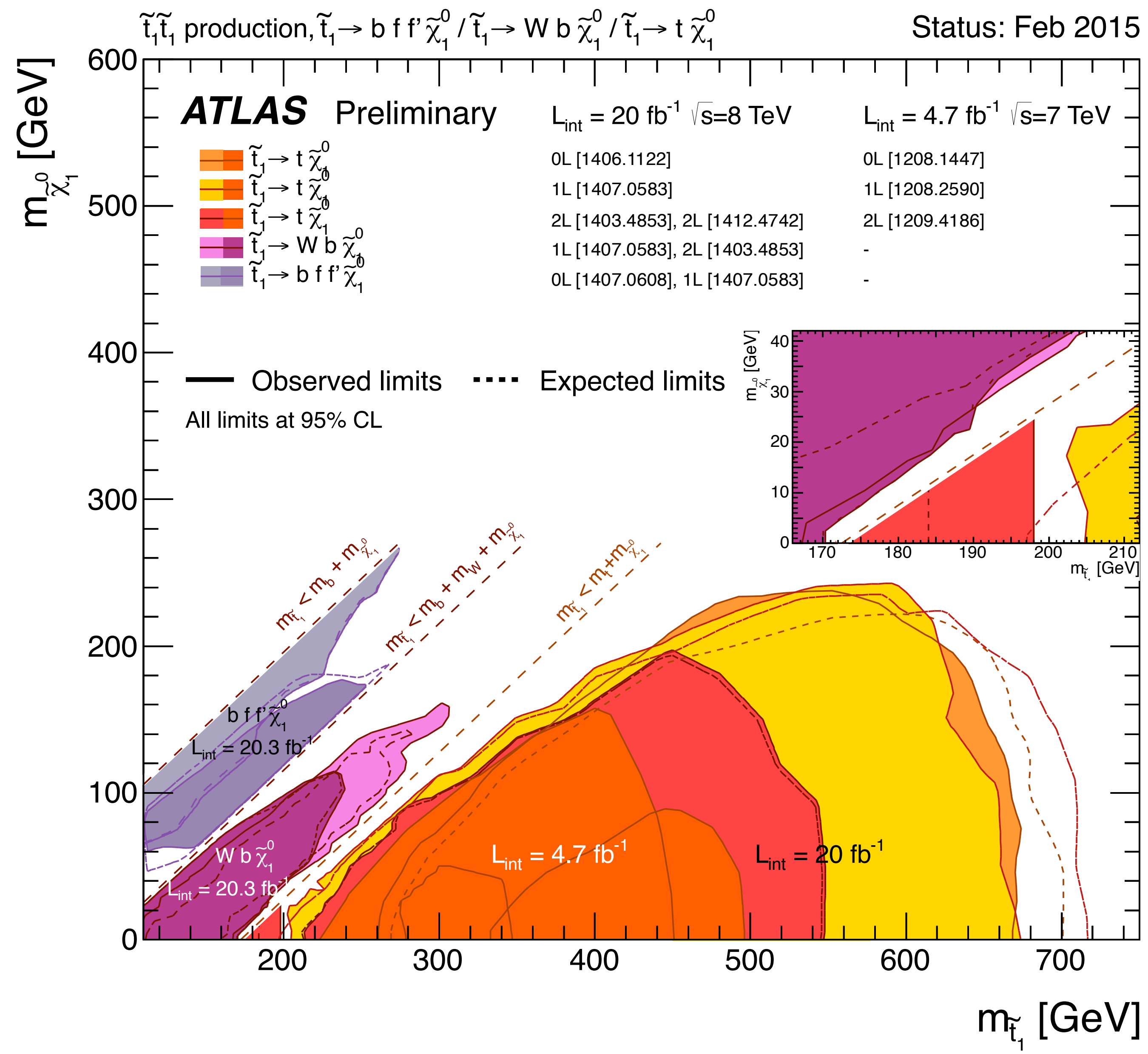
$\tilde{t}_1\tilde{t}_1$ production, $\tilde{t}_1 \rightarrow b f f' \tilde{\chi}_1^0$ / $\tilde{t}_1 \rightarrow W b \tilde{\chi}_1^0$ / $\tilde{t}_1 \rightarrow t \tilde{\chi}_1^0$
Status: ICHEP 2014
ATLAS Preliminary
L_{int} = 20 fb^{-1} $\sqrt{s}$=8 TeV
L_{int} = 4.7 fb^{-1} $\sqrt{s}$=7 TeV
$\tilde{t}_1 \rightarrow t \tilde{\chi}_1^0$ 0L 1406.1122 0L [1208.1447]
$\tilde{t}_1 \rightarrow t \tilde{\chi}_1^0$ 1L [1407.0583] 1L [1208.2590]
$\tilde{t}_1 \rightarrow t \tilde{\chi}_1^0$ 2L [1403.4853] 2L [1209.4186]
$\tilde{t}_1 \rightarrow W b \tilde{\chi}_1^0$ 1L [1407.0583], 2L [1403.4853] -
$b f f' \tilde{\chi}_1^0$ 0L [1407.0608], 1L [1407.0583] -
large $\tilde{t}$ cross-section
mits
Expected limits
$m_{\tilde{t}_1} < m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} < m_b + m_W + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} < m_t + m_{\tilde{\chi}_1^0}$
$b f f' \tilde{\chi}_1^0$
L_{int} = 20.3 fb^{-1}
$W b \tilde{\chi}_1^0$
L_{int} = 20.3 fb^{-1}
L_{int} = 4.7 fb^{-1}
L_{int} = 20 fb^{-1}
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
0
50
100
150
200
250
400
450
500
200
300
400
500
600
700

Run2 $\simeq$ Subtle New Physics

Δϕ(ℓℓ)

1205.5808 1412.4742+ATLAS-CONF-2014-056



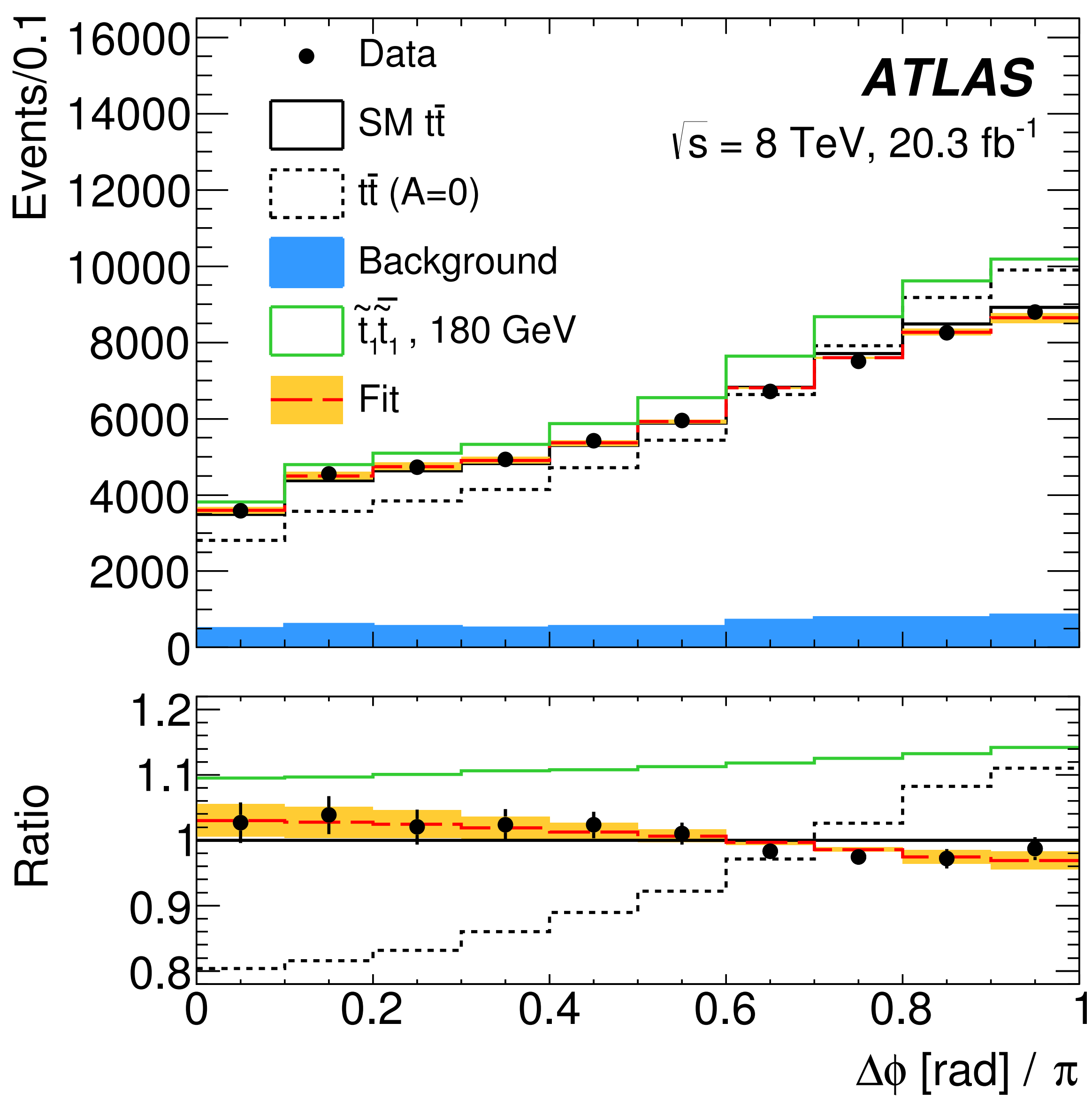


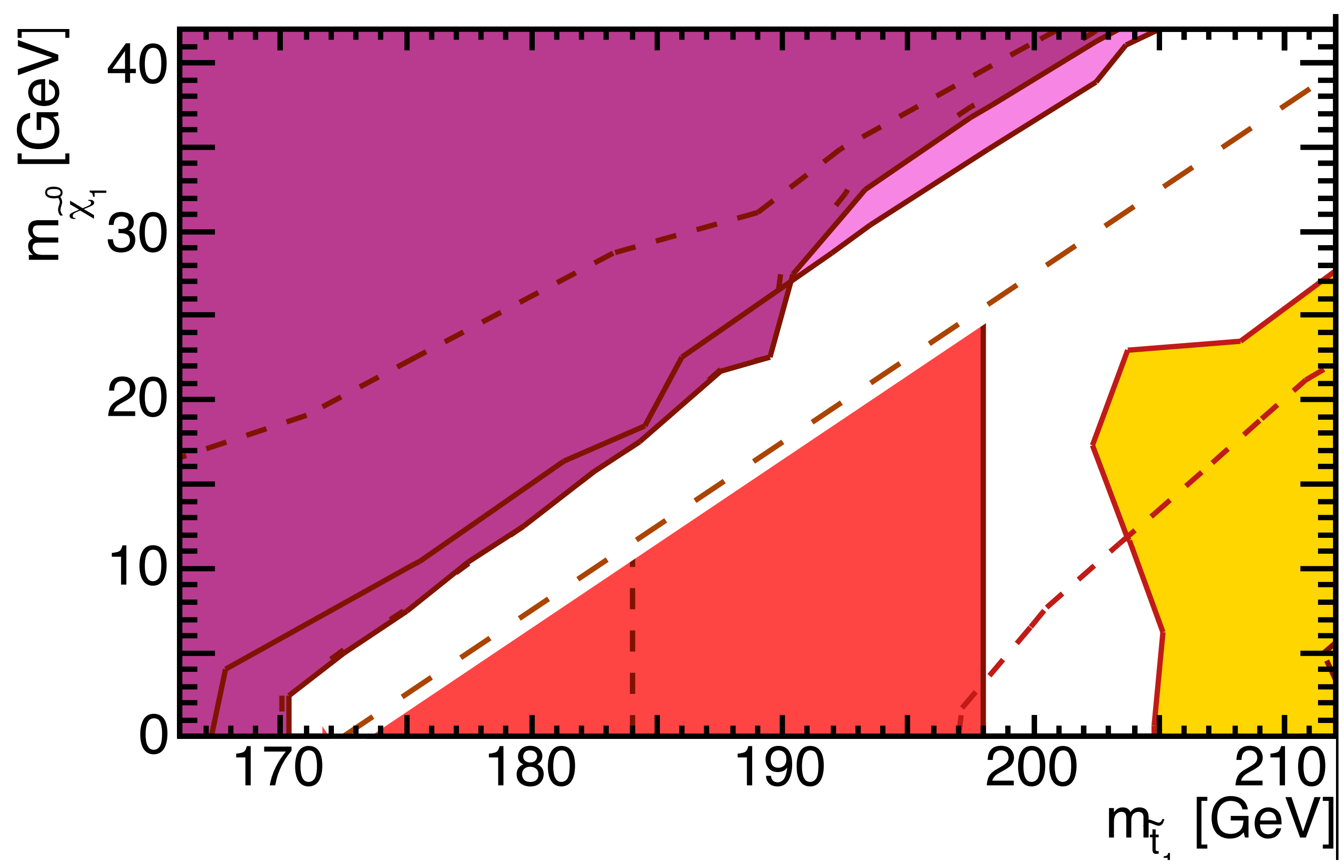
unfolded precision distribution?

any “alternative” way to package it?

$\Delta\phi(\ell\ell)$

1205.5808 1412.4742+ATLAS-CONF-2014-056





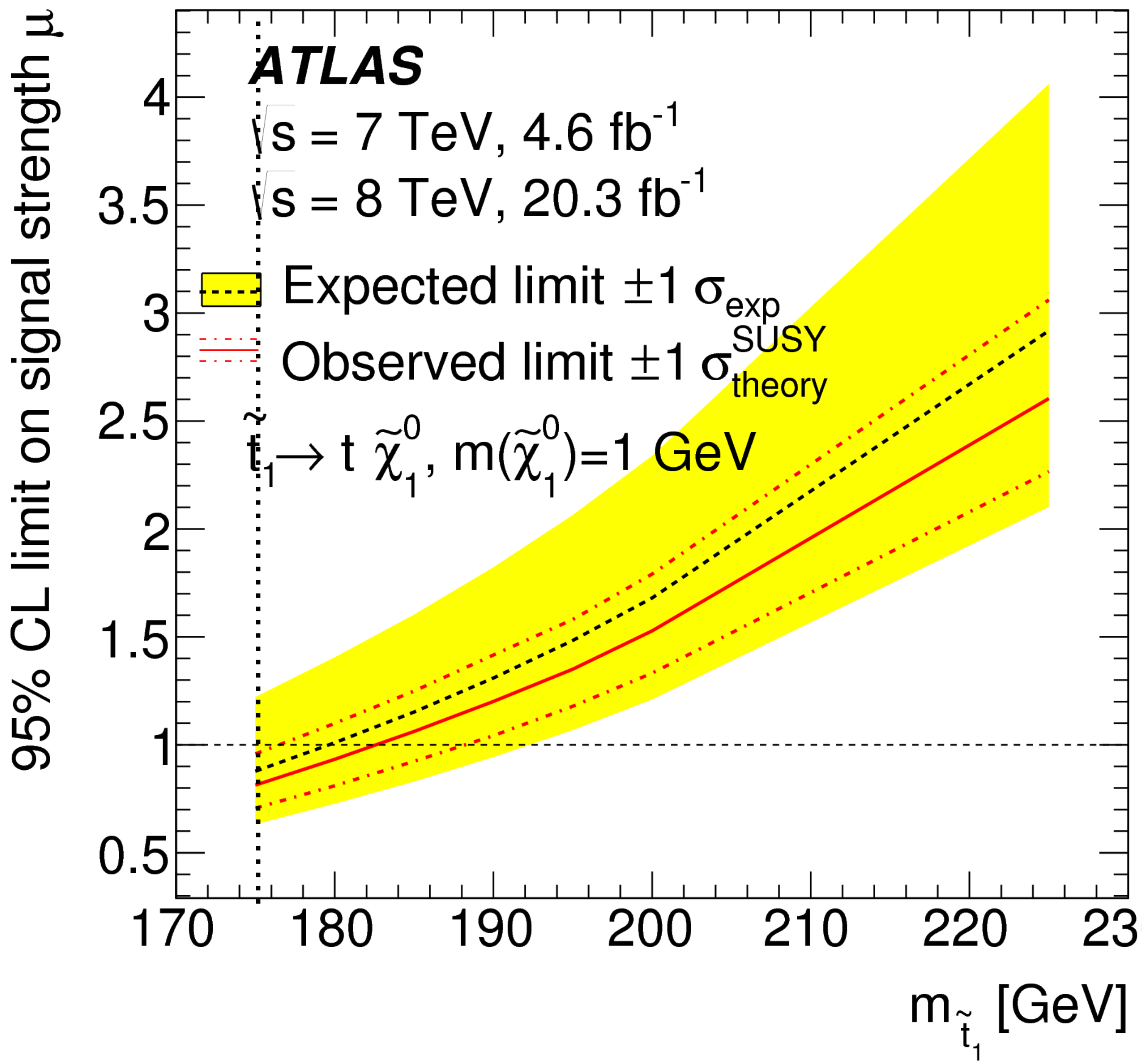
unfolded precision distribution?

any “alternative” way to package it?

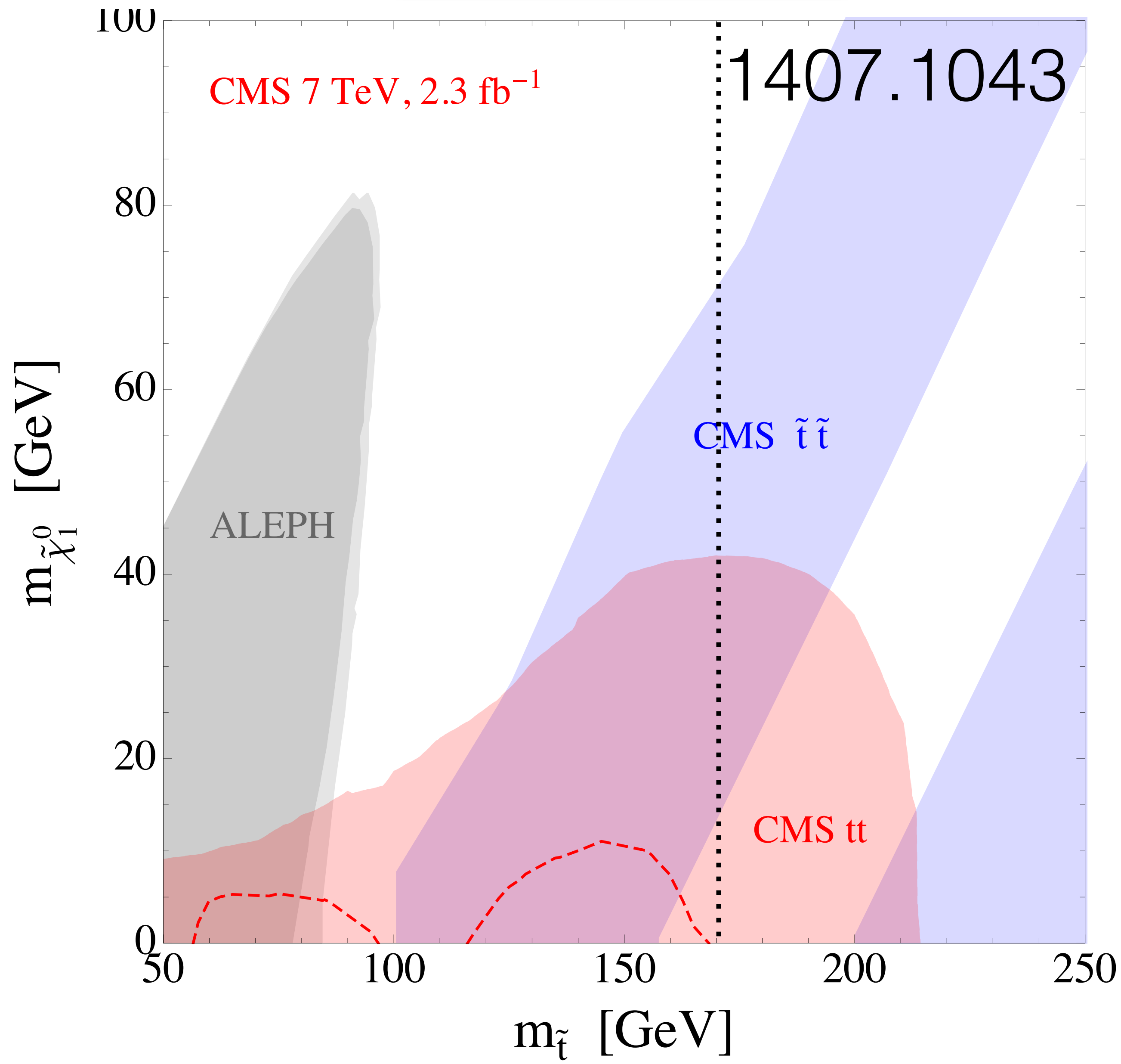
σ(t$\bar{t}$)

1407.1043 + 1406.5375

light stop effects on top cross-section

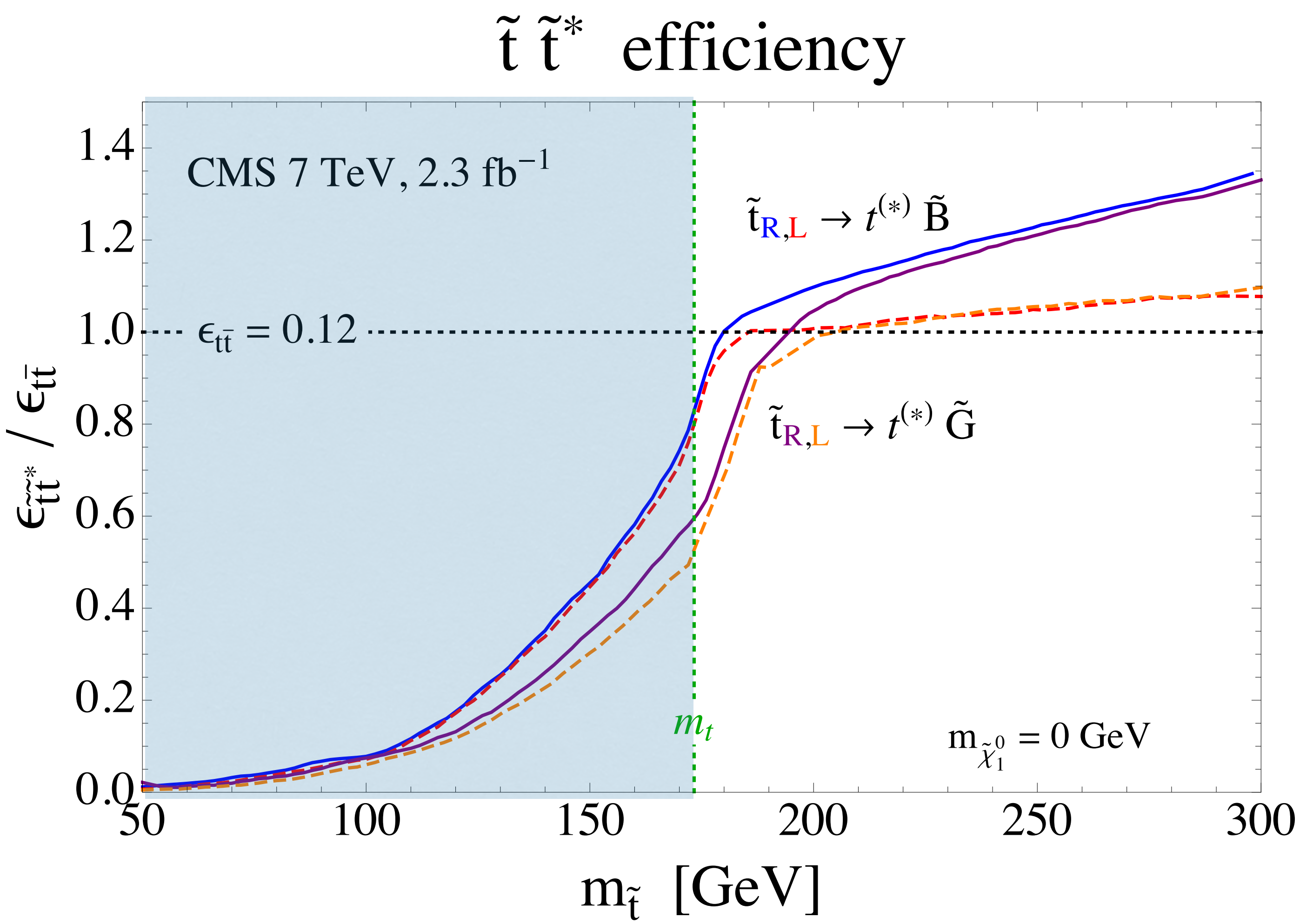


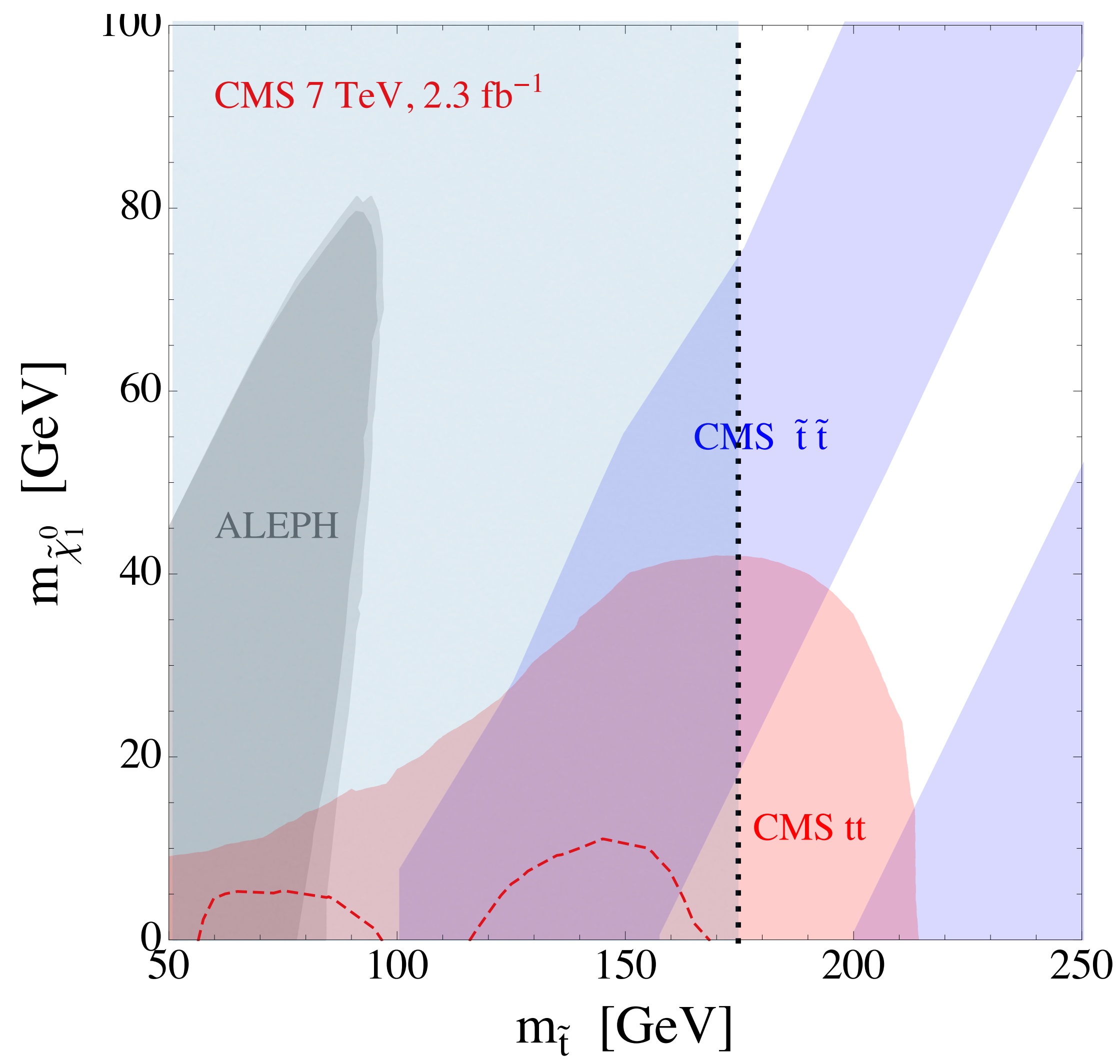
mχ ≠ 1 GeV



$\sigma(t\bar{t})$: $m_{\tilde{t}} < m_t$

1407.1043



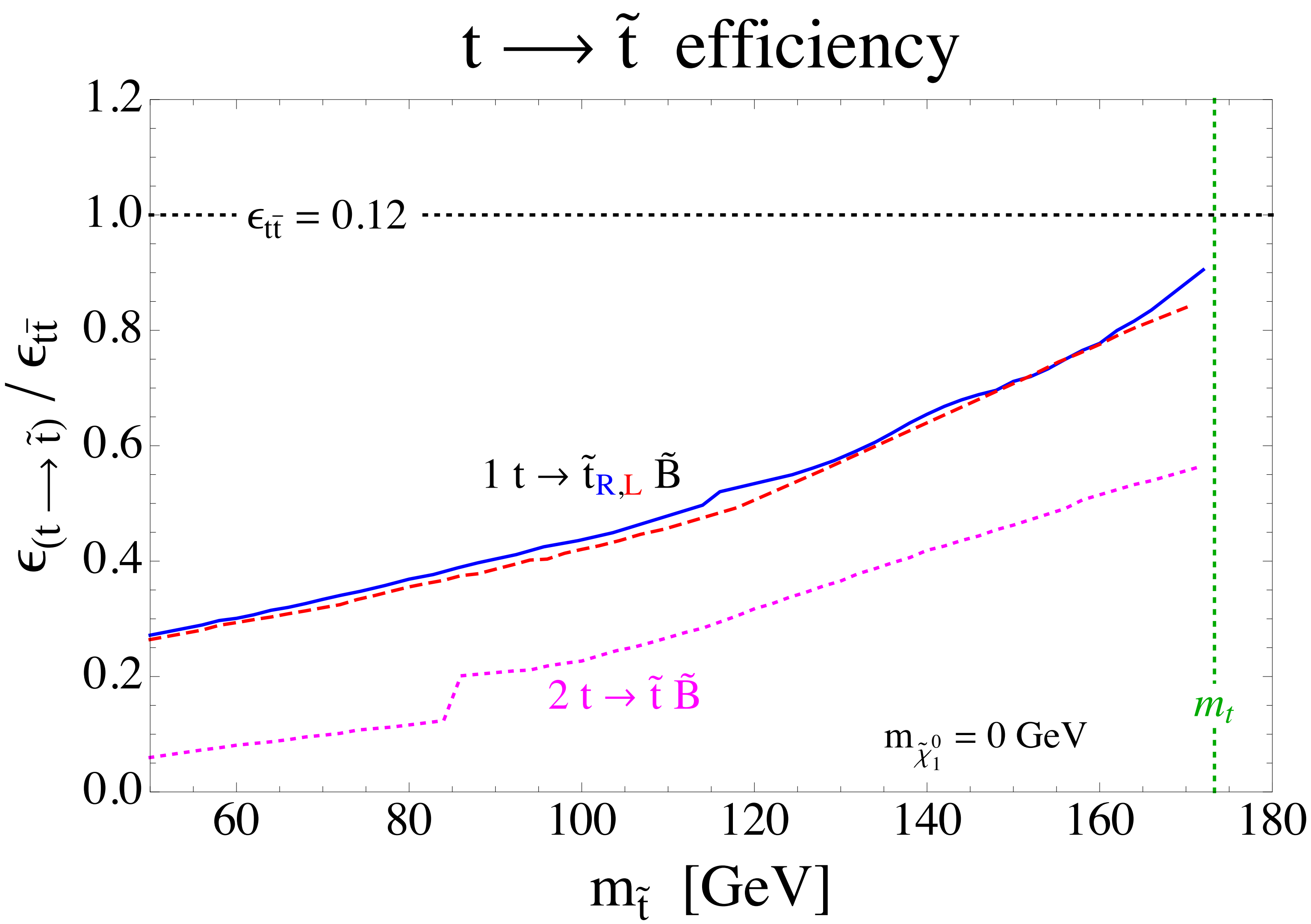


extend explored $\tilde{t}$ mass range below m_{top}

$\sigma(t\bar{t})$: $m_{\tilde{t}} + m_{\chi} < m_t$

1407.1043 + hep-ph/9605340

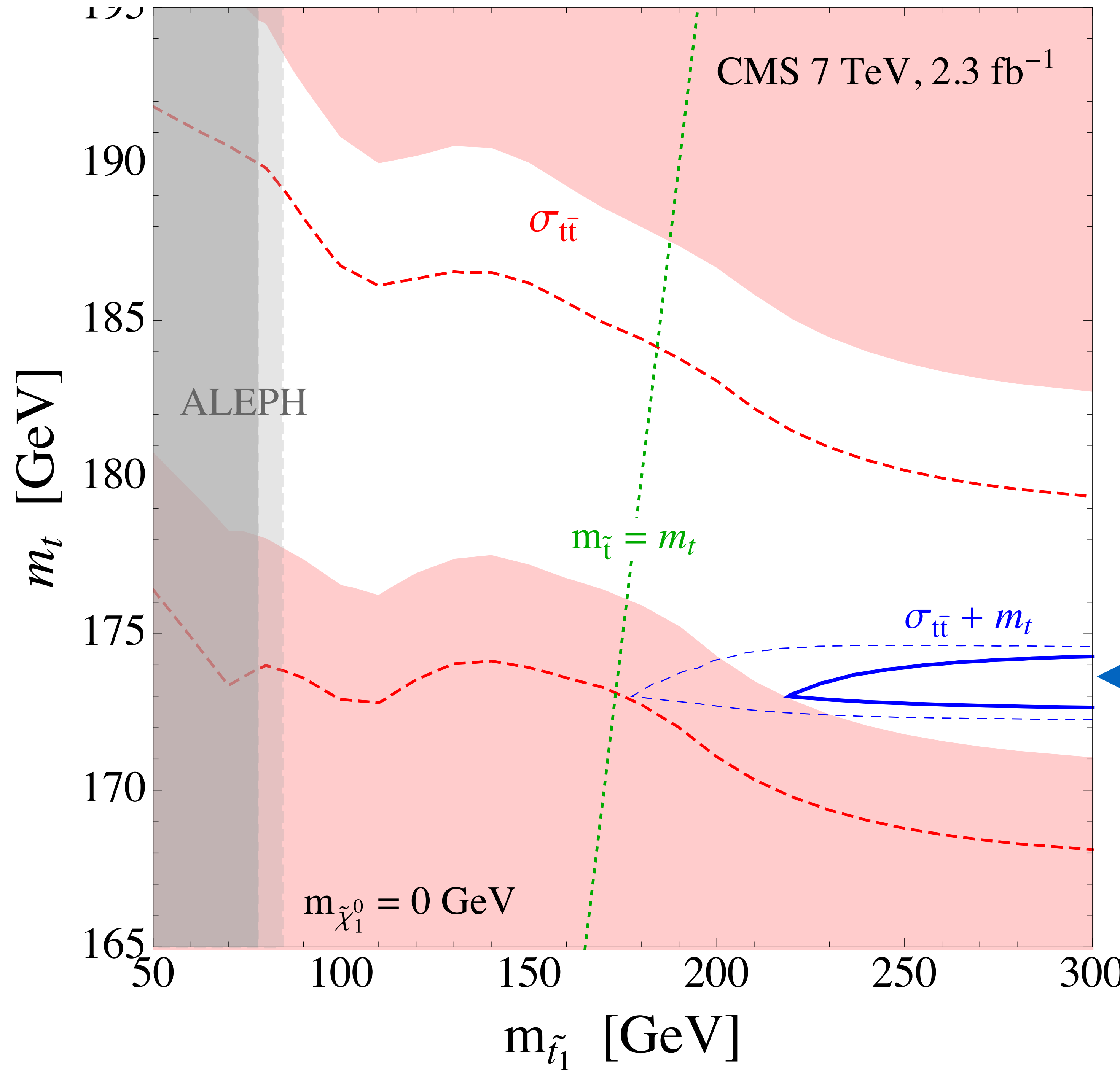
B(t→ t̃χ) can be sizable

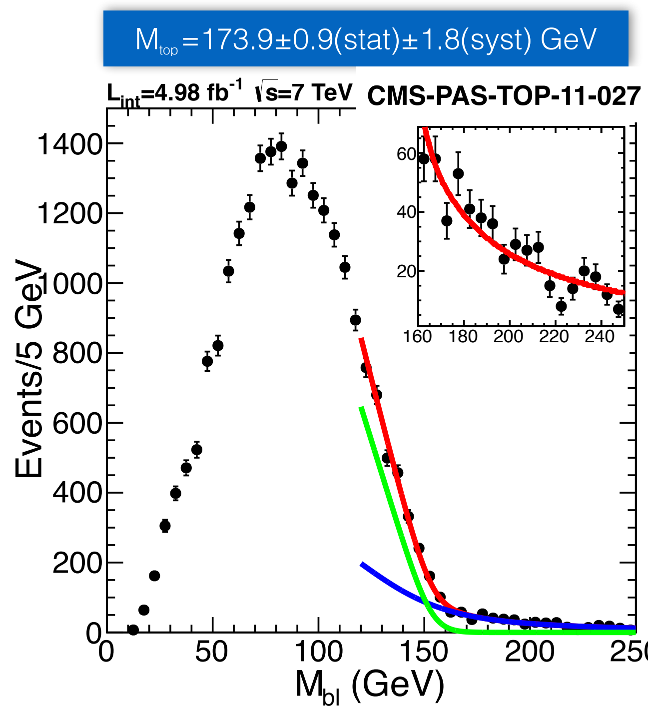


more on distributions later …

σ(tt̄)

1407.1043

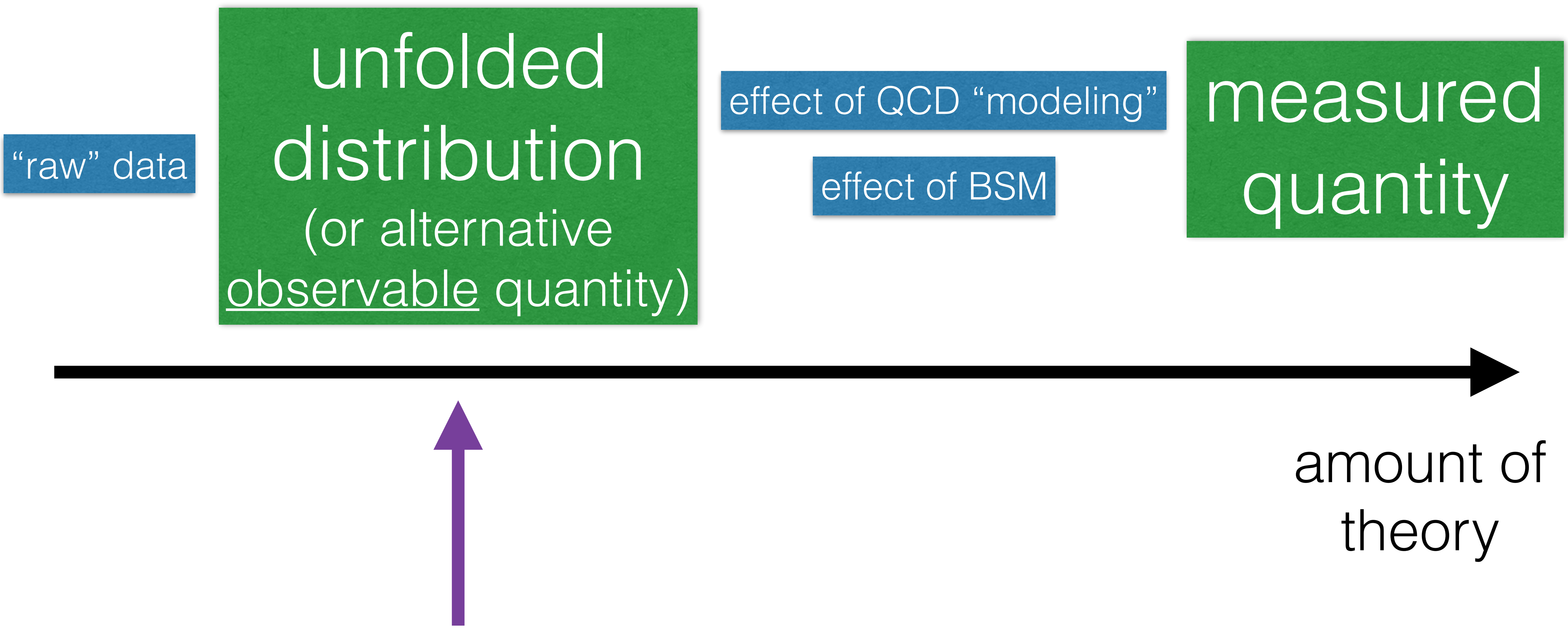




from end-point 1304.5783

interplay with top **mass** measurement

Of measurements and interpretations



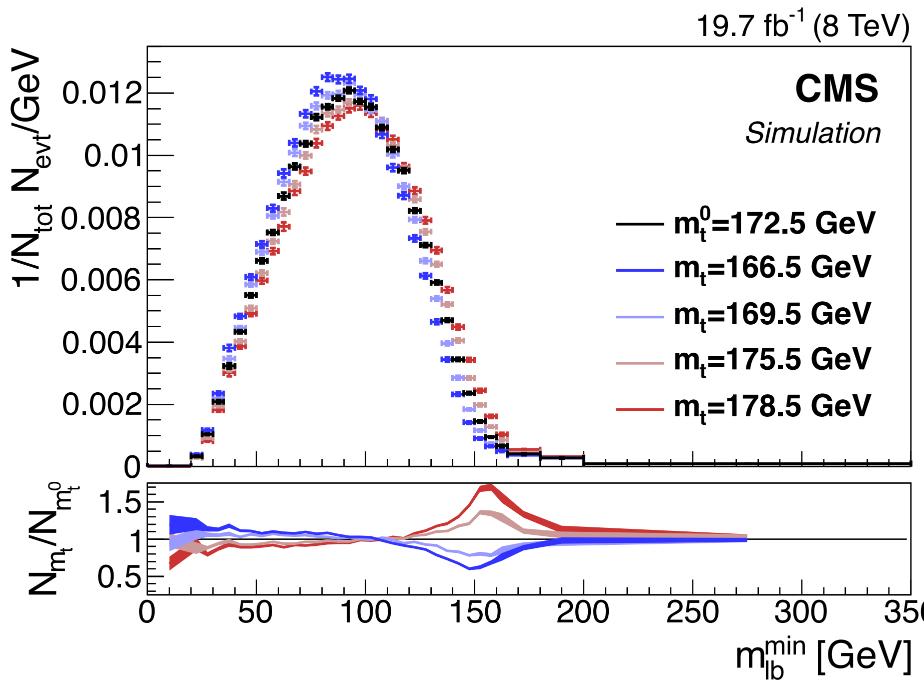
“theory free” quantities are very useful for **re**-interpretations

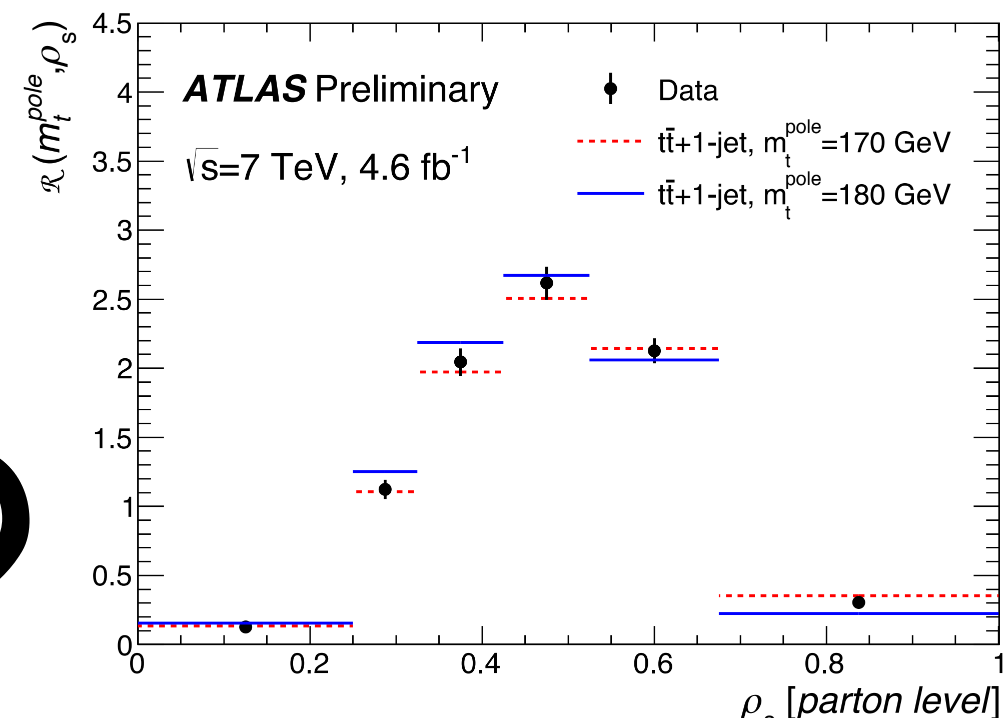
similar role of “simplified” models furnished with efficiency maps for searches

(Un)folding

Q: how much are “transfer matrix” theory dependent?

CMS-PAS-TOP-14-014 Q: Where to stop? ATLAS-CONF-2014-053





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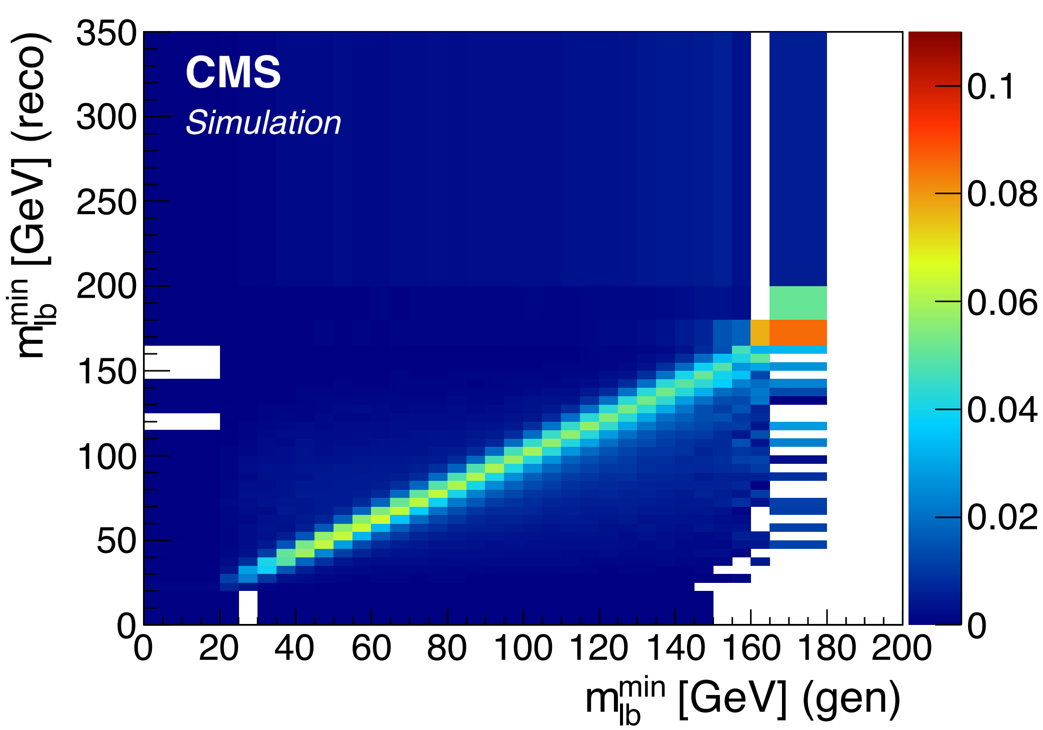
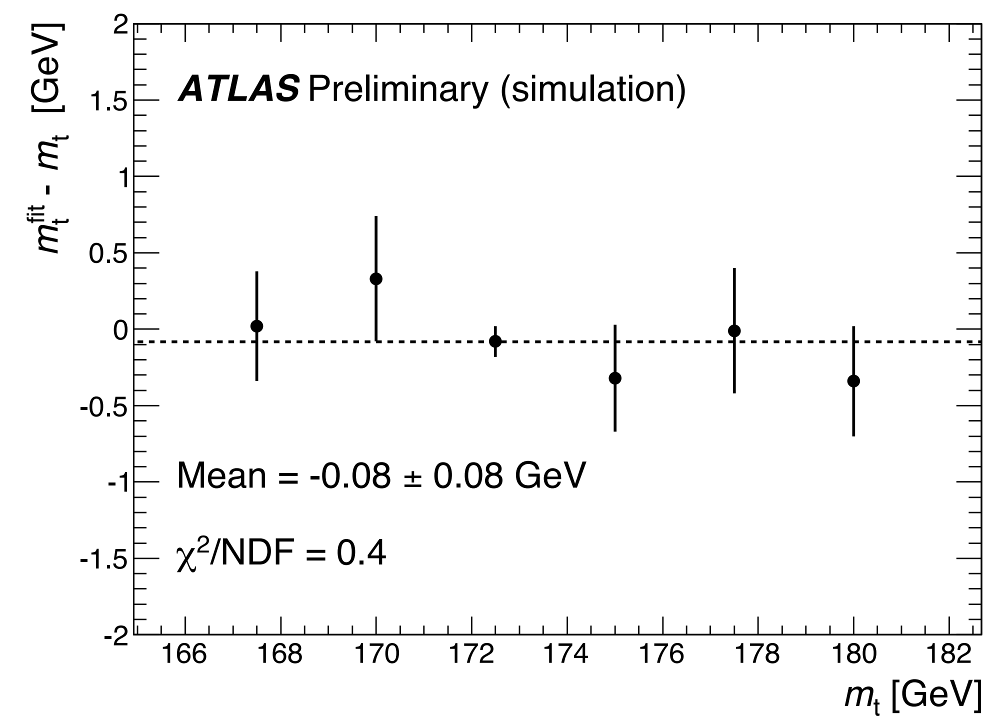
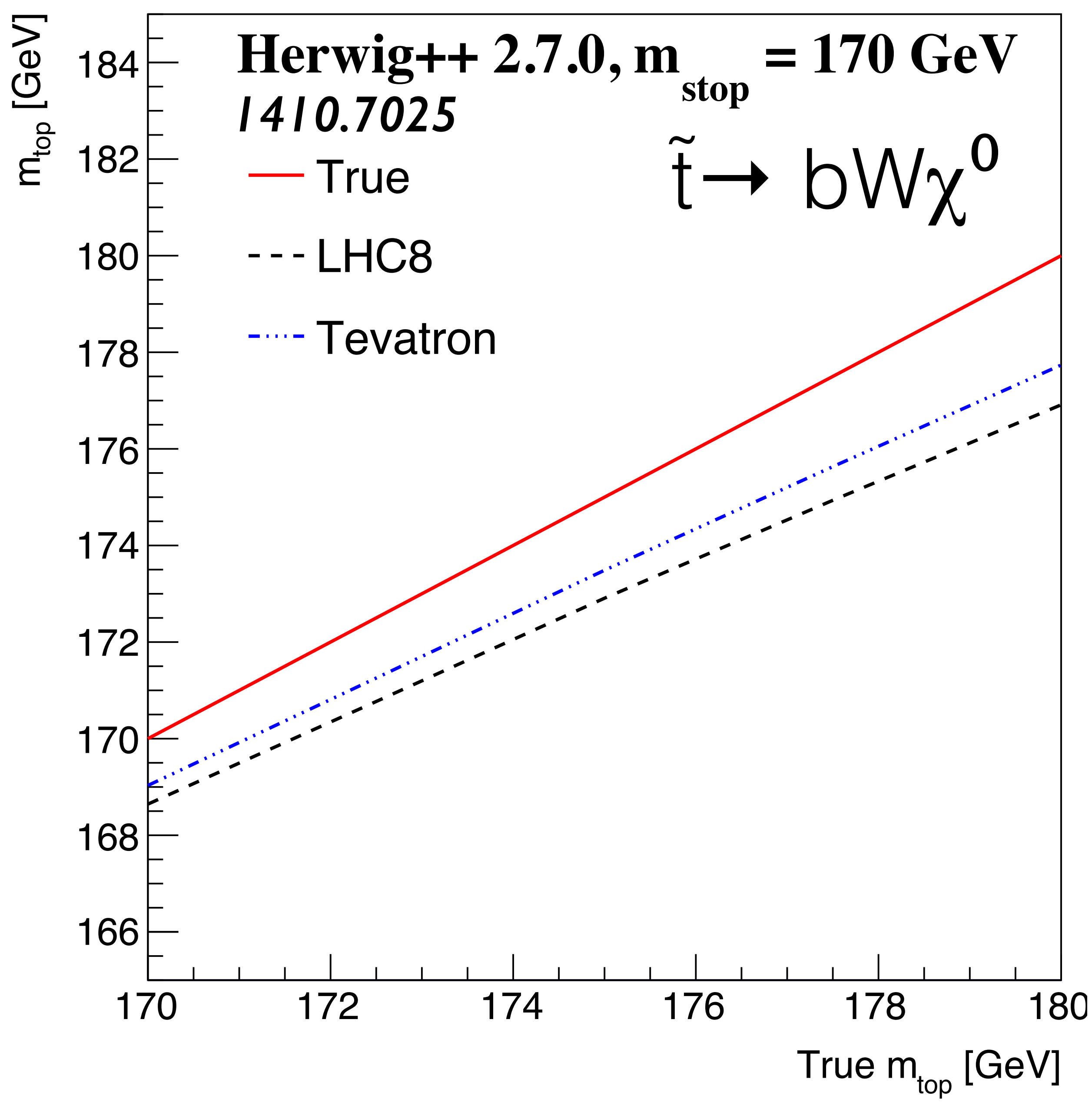


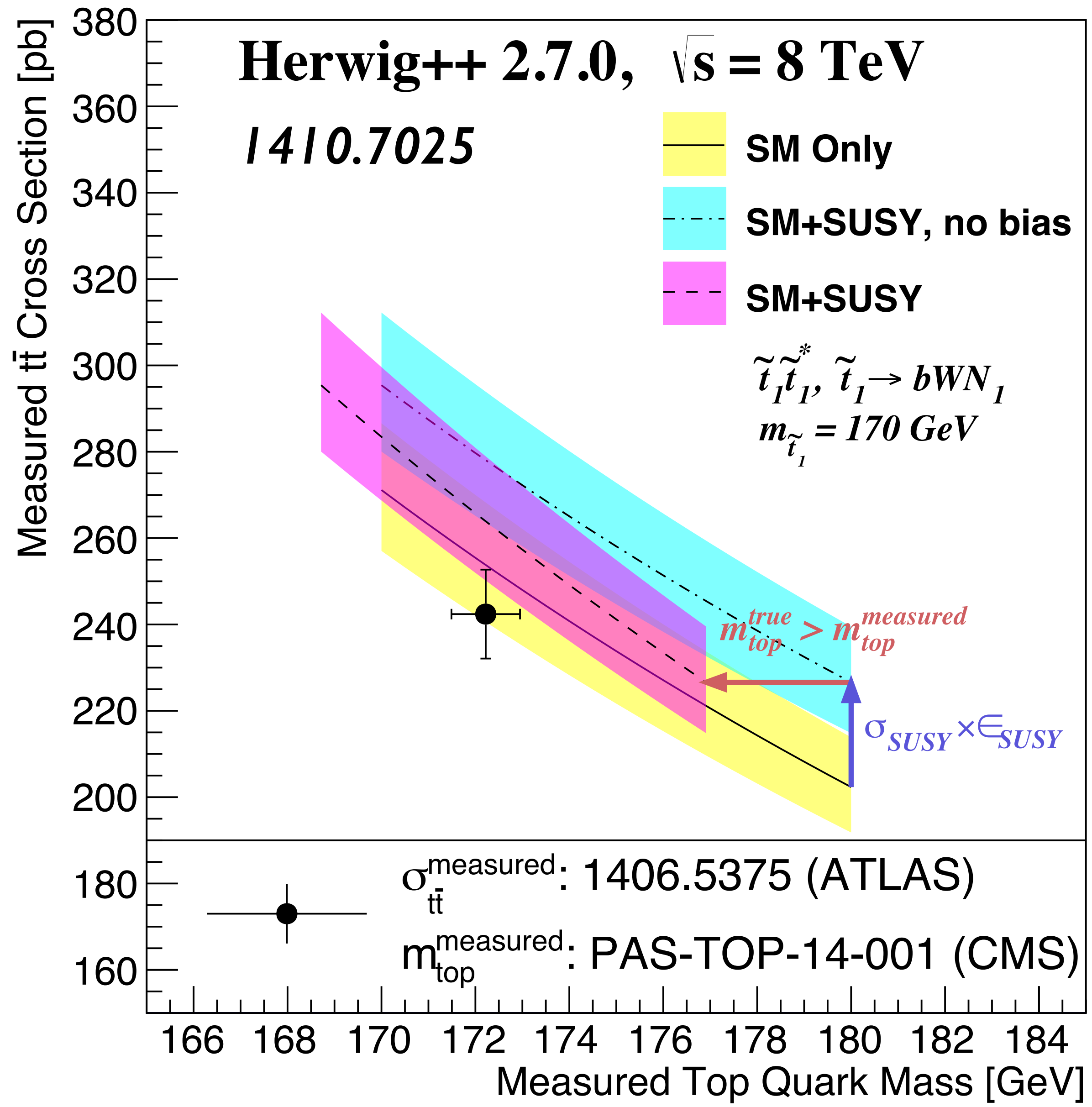


Top mass affected by BSM? 1410.7025

"proxy" for the kinematic fit used in the present "best" measurements

m_{top} from m_{bjj} that minimizes $$\chi^2 = \frac{(m_{j_1 j_2 b_1} - m_{b_2 l \nu})^2}{(20\ \mathrm{GeV})^2} + \frac{(m_{j_1 j_2} - m_W)^2}{(10\ \mathrm{GeV})^2},$$





mass potentially shifted by ~1 GeV

Distributions used for top mass should be well under control

↓

Suitable to look for subtle effects

my guess for $\tilde{t} \to t\chi^0$

- max($m_{b\ell,min}$) (truly?) unaffected
- m_{T2} larger end-point
- E_b affected by top polarization (maybe small)
- $p_{T\ell}$, L_{xy}, s(ttj), affected by top boost (maybe small)

To know the answer we need to see signal injections

New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello

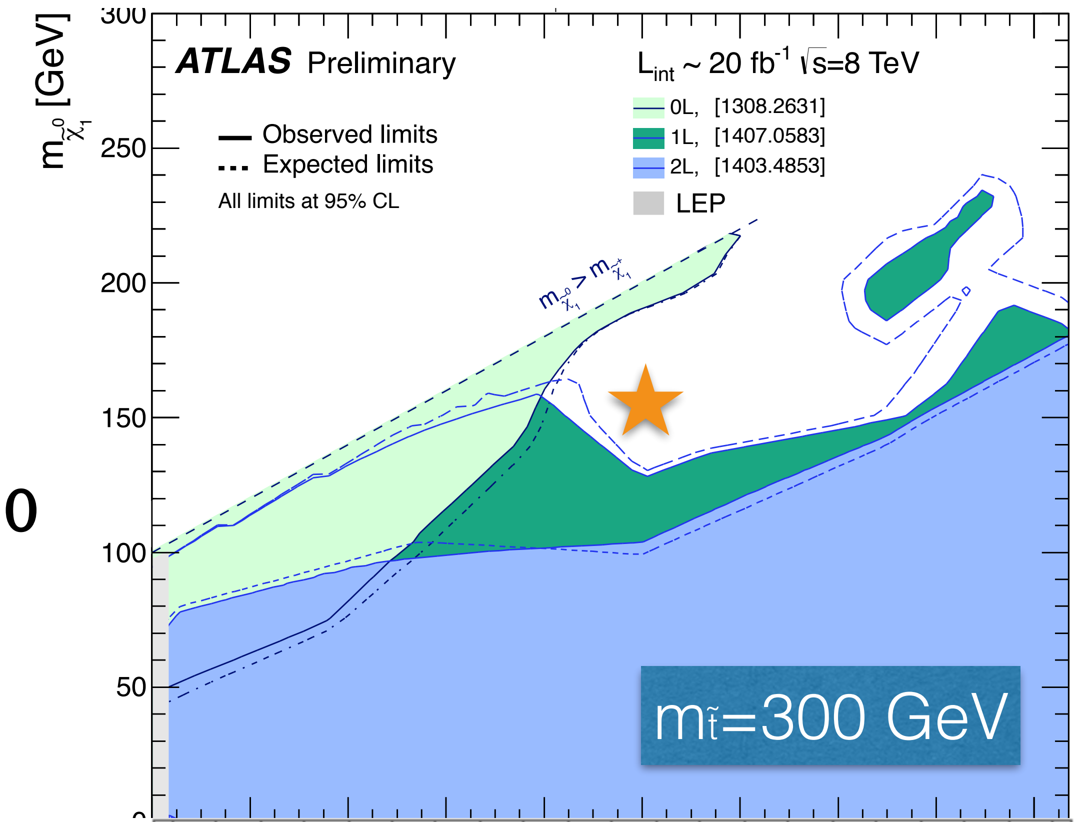
E_b and $m_{b\ell}$ behave differently

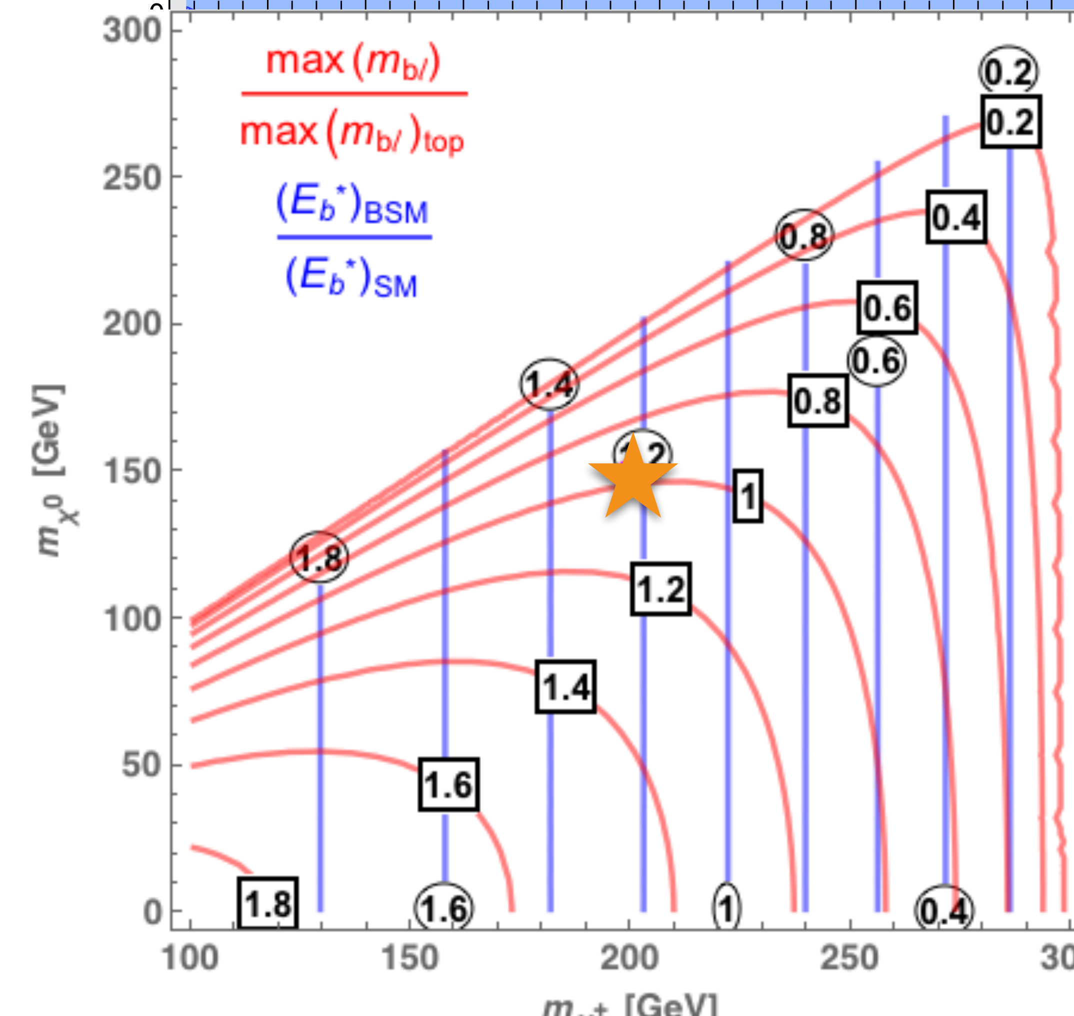
$t \to bW \to b\ell\nu$ ➡ $\tilde{t} \to b\,\chi^+ \to b\ell\nu\chi^0$

$$m_{b\ell}^{max}\Big|_{m_b=0} = \sqrt{\frac{(m_{\tilde{t}}^2 - m_{\chi^+}^2)(m_{\chi^+}^2 - m_{\chi^0}^2)}{m_\chi}}$$

$$E_b^* = \frac{m_{\tilde{t}}^2 - m_{\chi^+}^2}{2\,m_{\tilde{t}}}$$

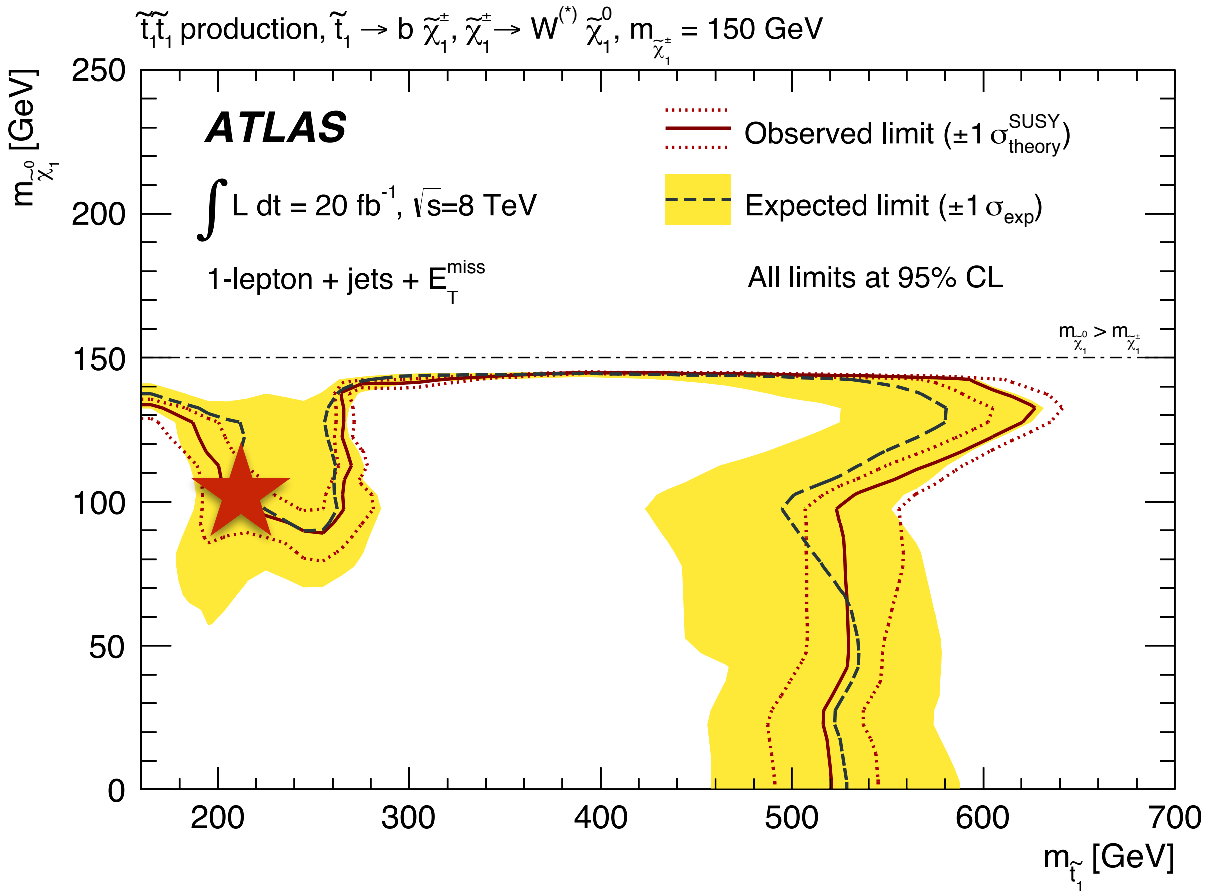
★ **Harder E_b, softer $m_{b\ell}$**

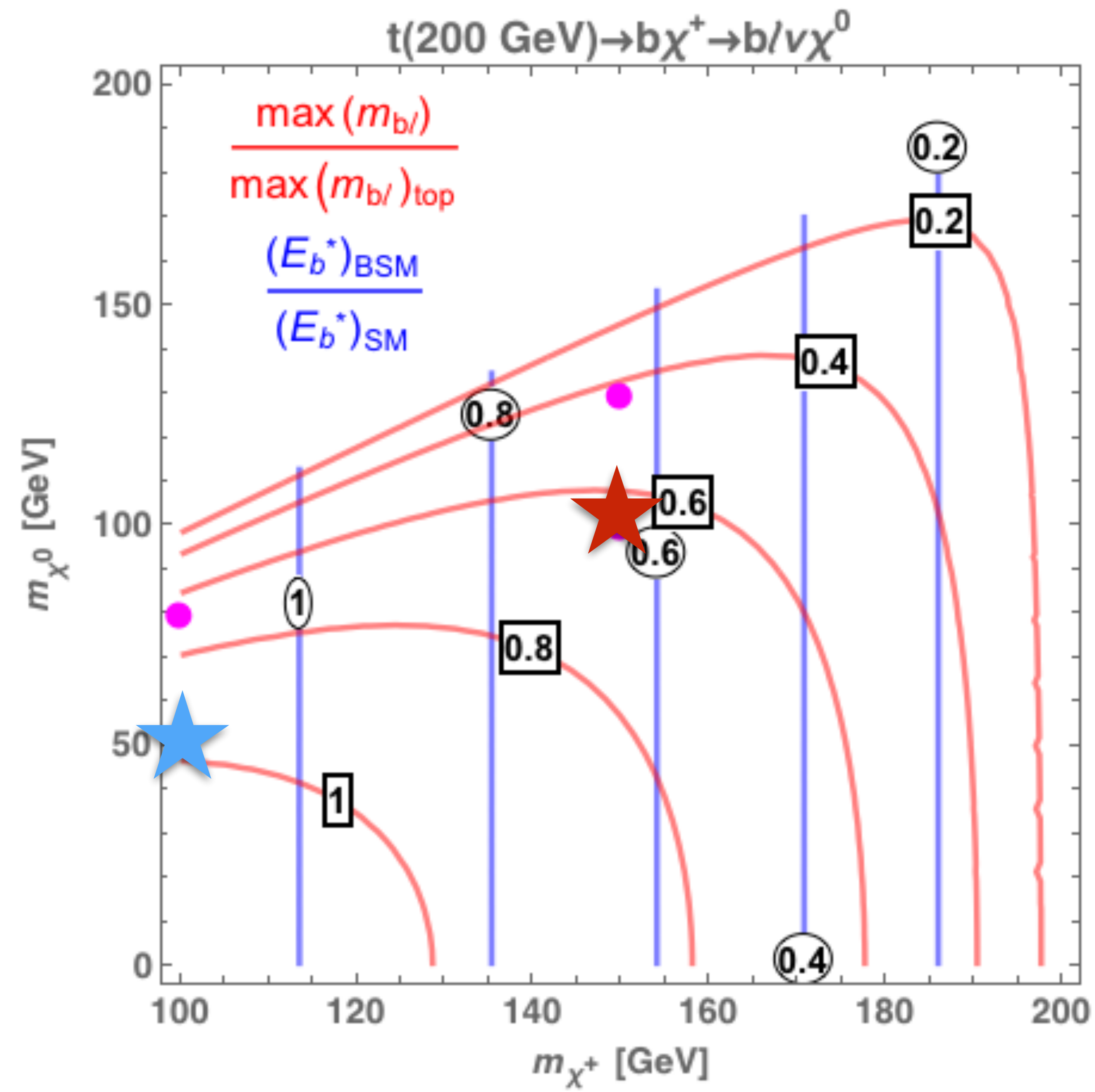


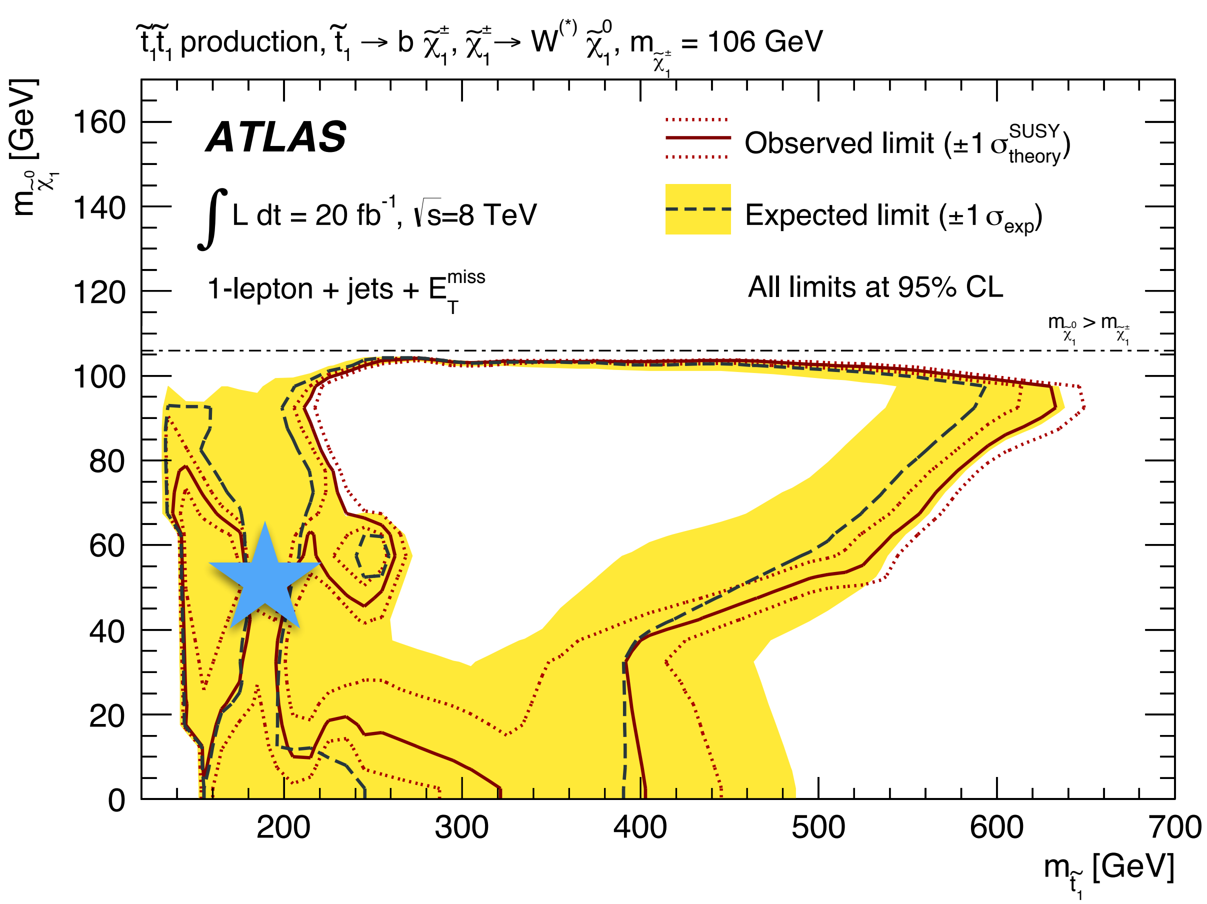


New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello





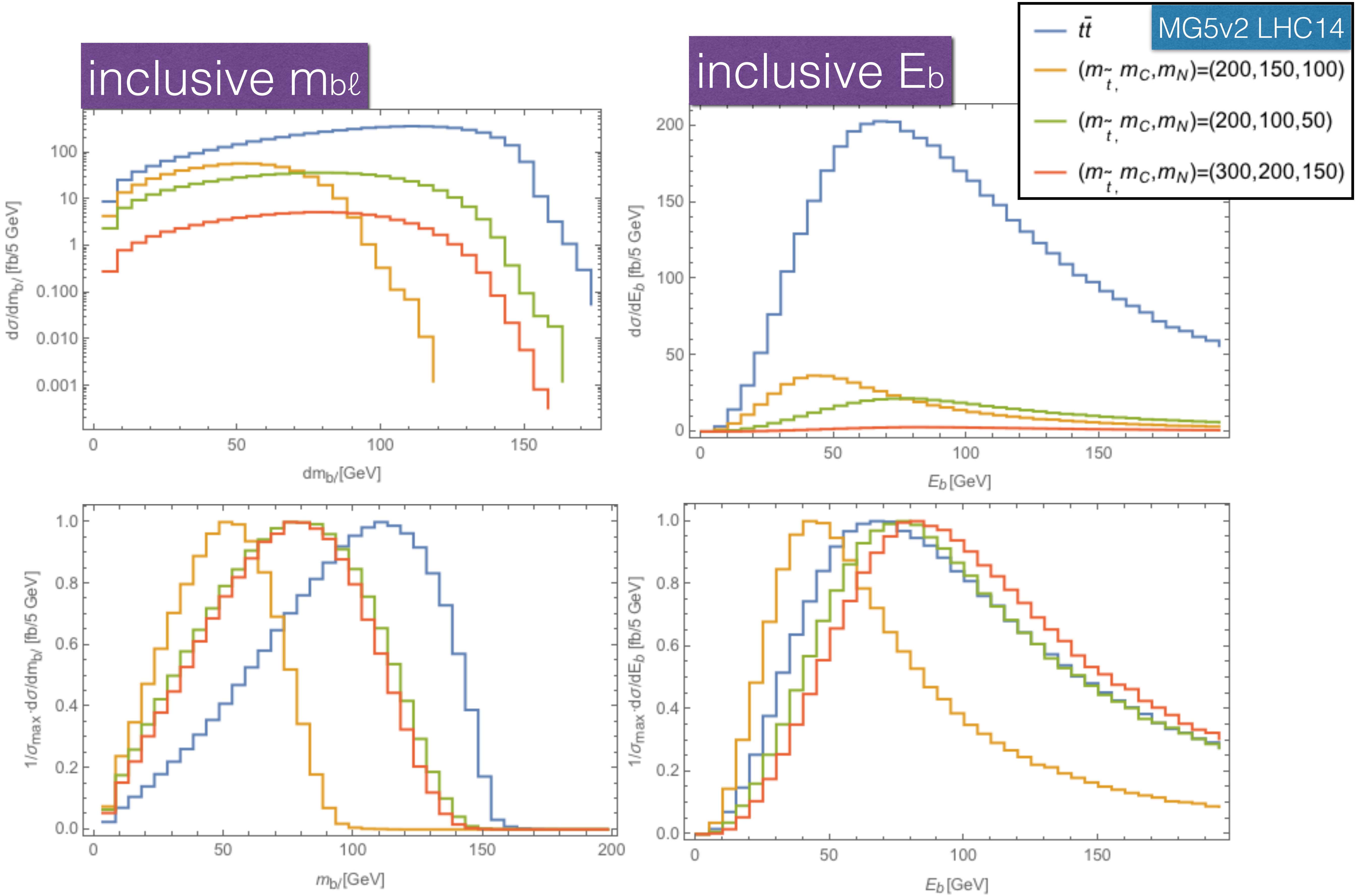


★ harder E_b, softer $m_{b\ell}$

★ softer E_b, softer $m_{b\ell}$

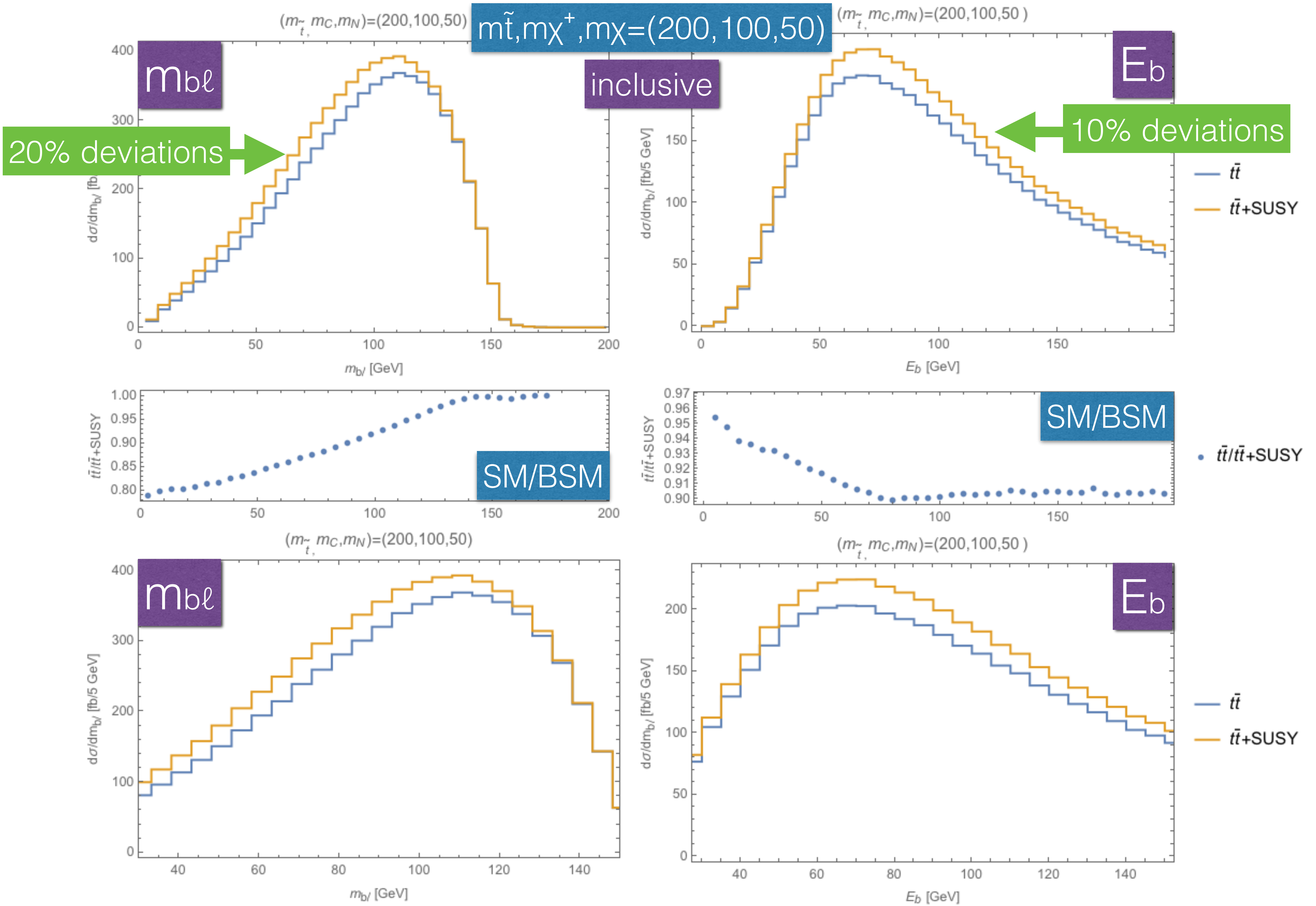
New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello



New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello



New physics effect on $m_{b\ell}$ and E_b

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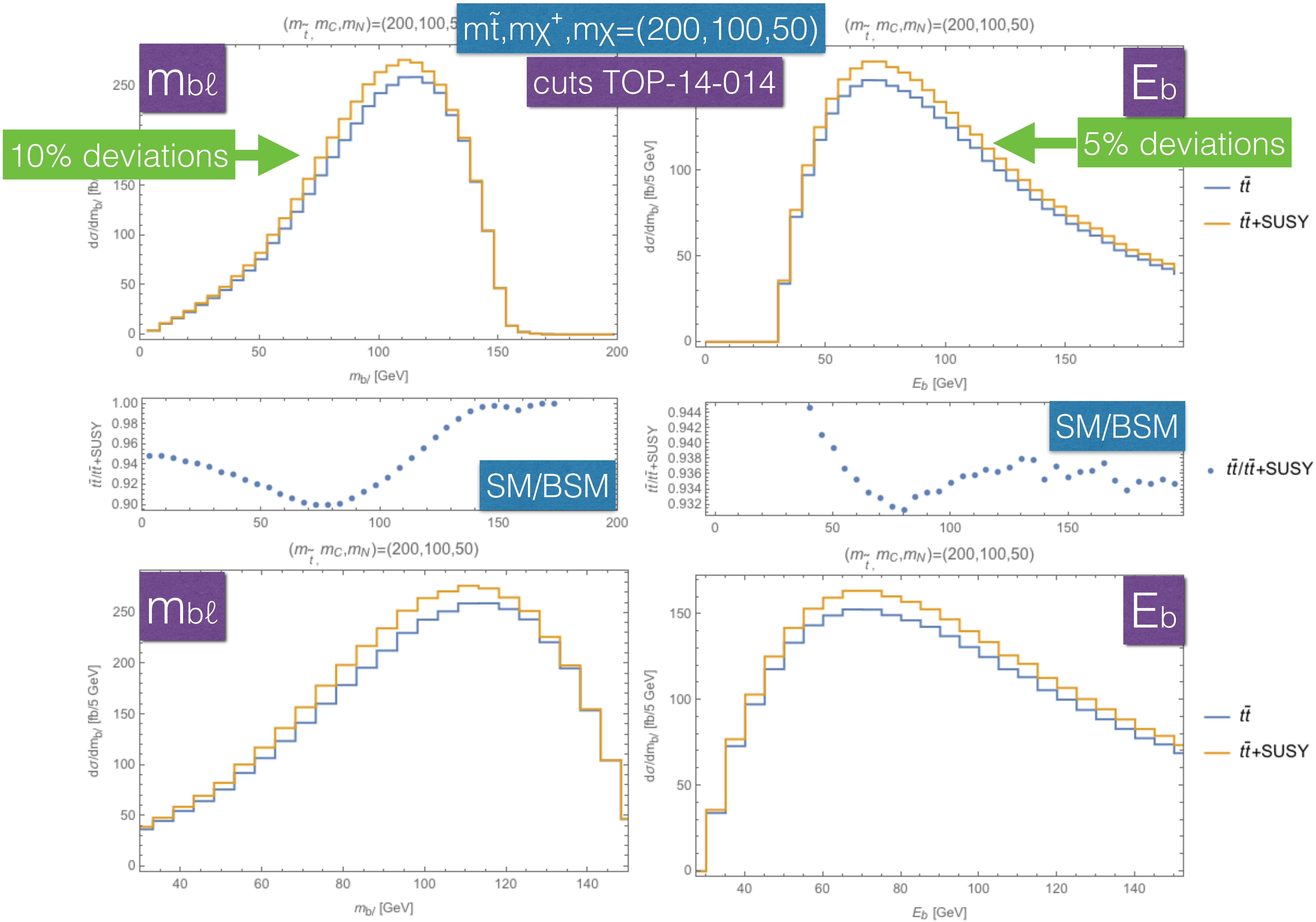
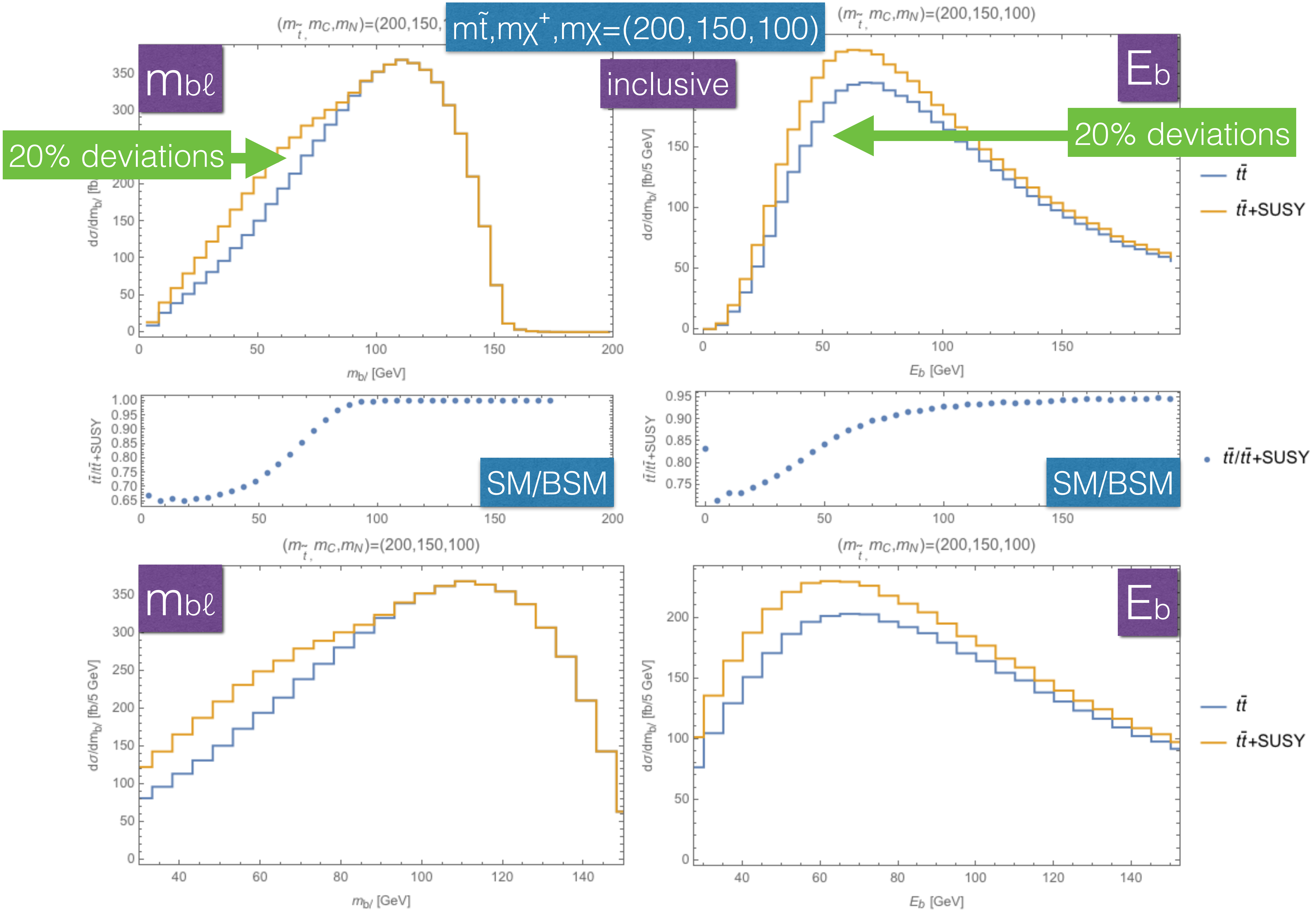


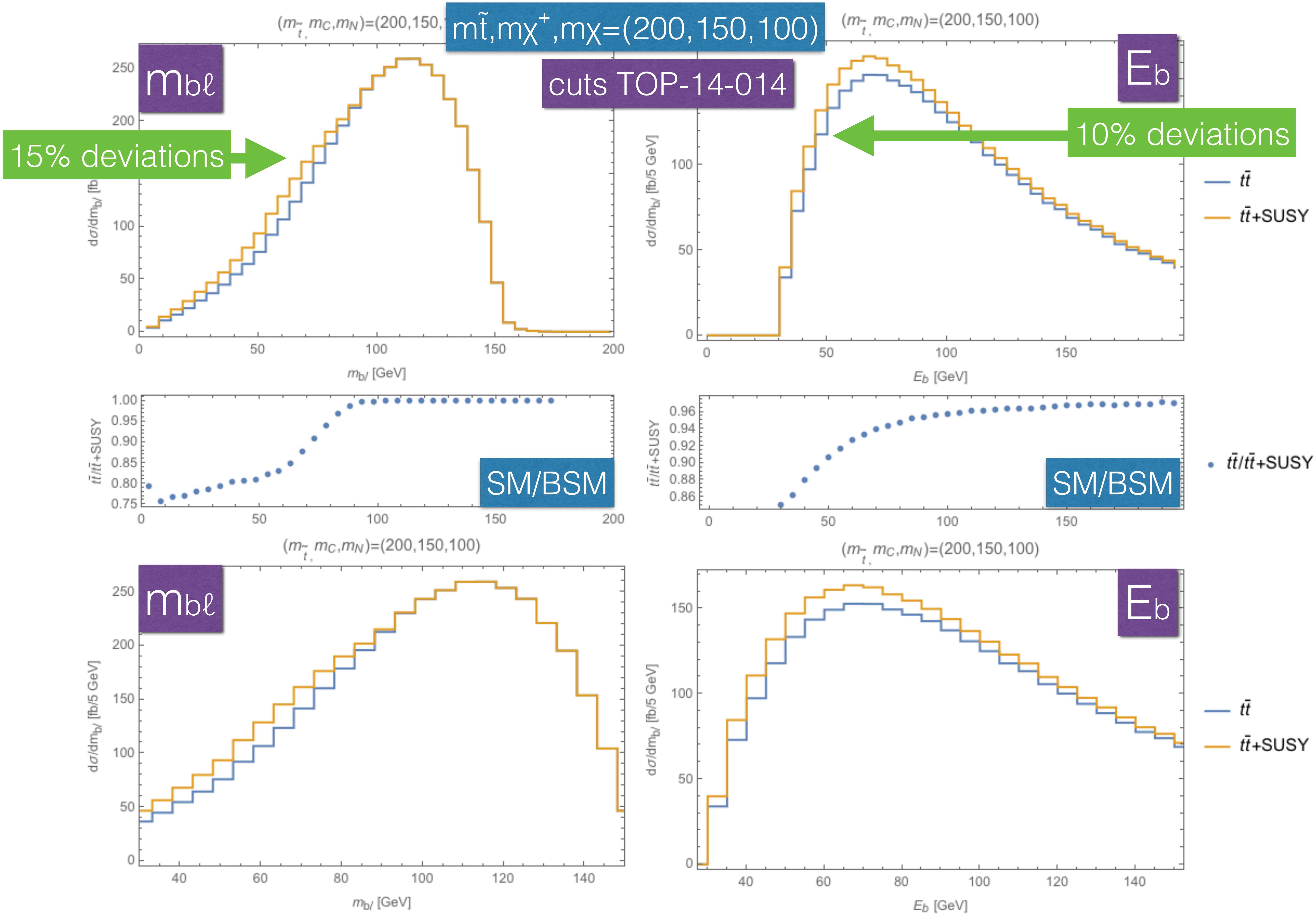
New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello



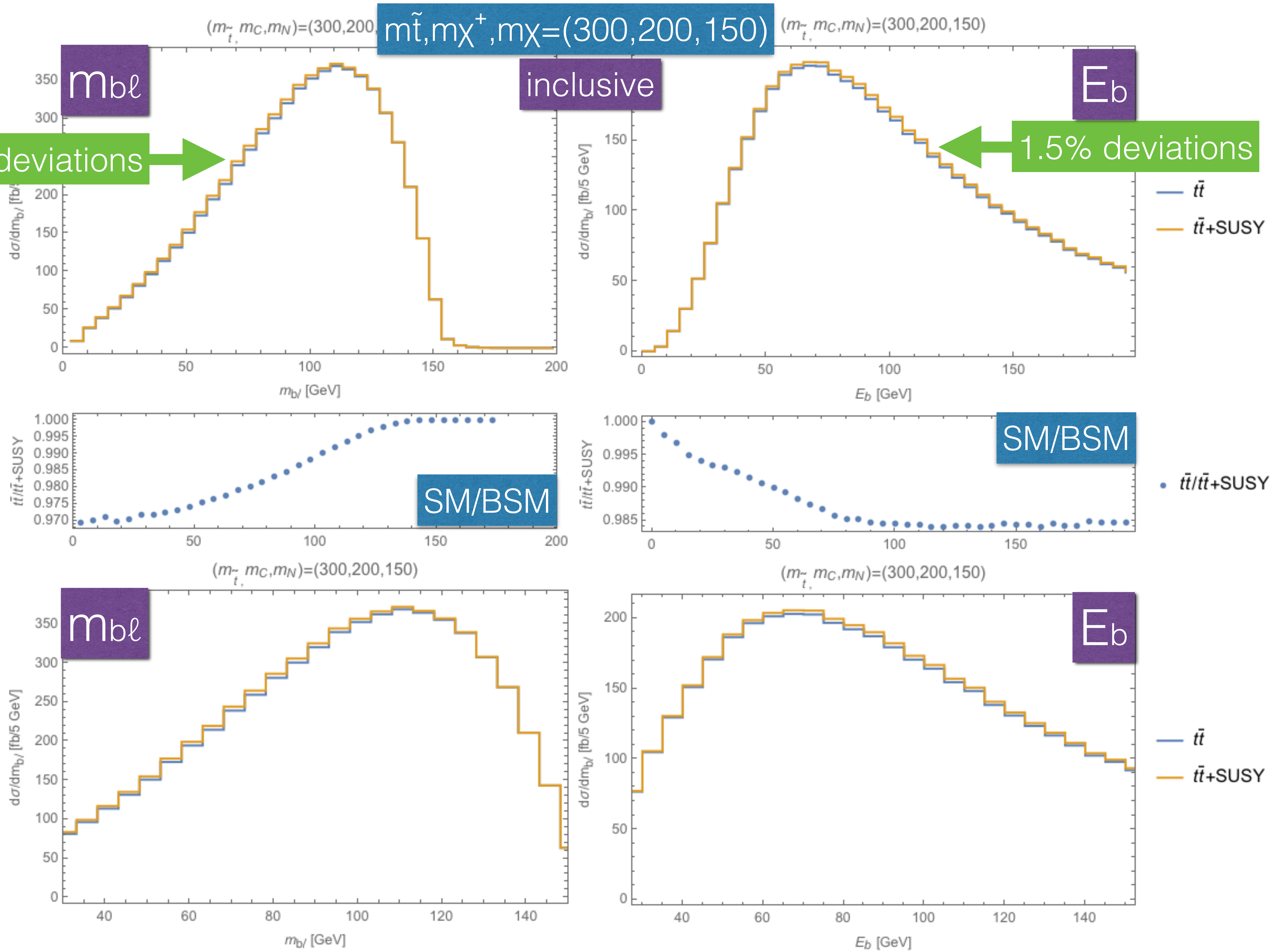
New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello



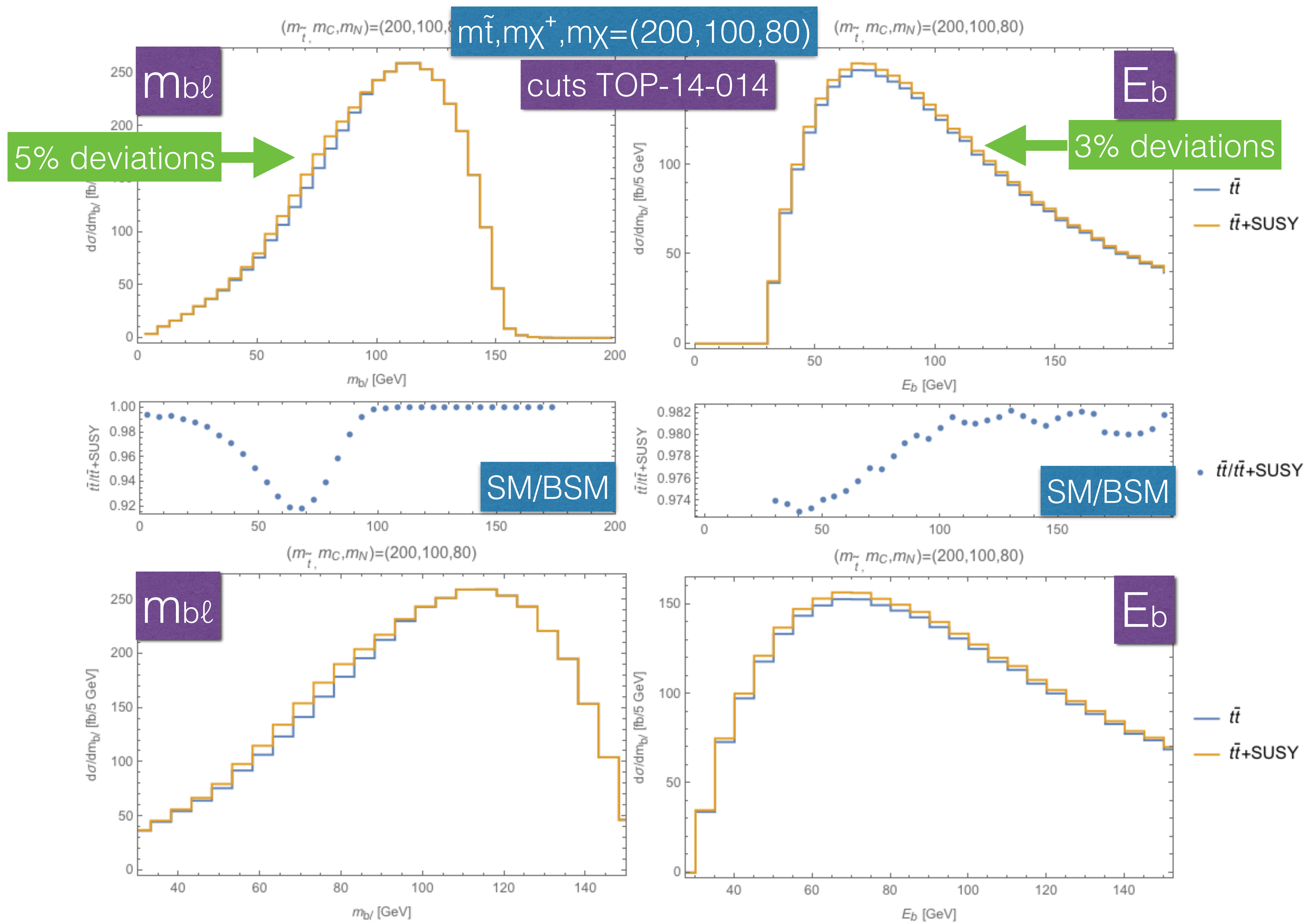
New physics effect on mbℓ and Eb

discussion with G. Polesello



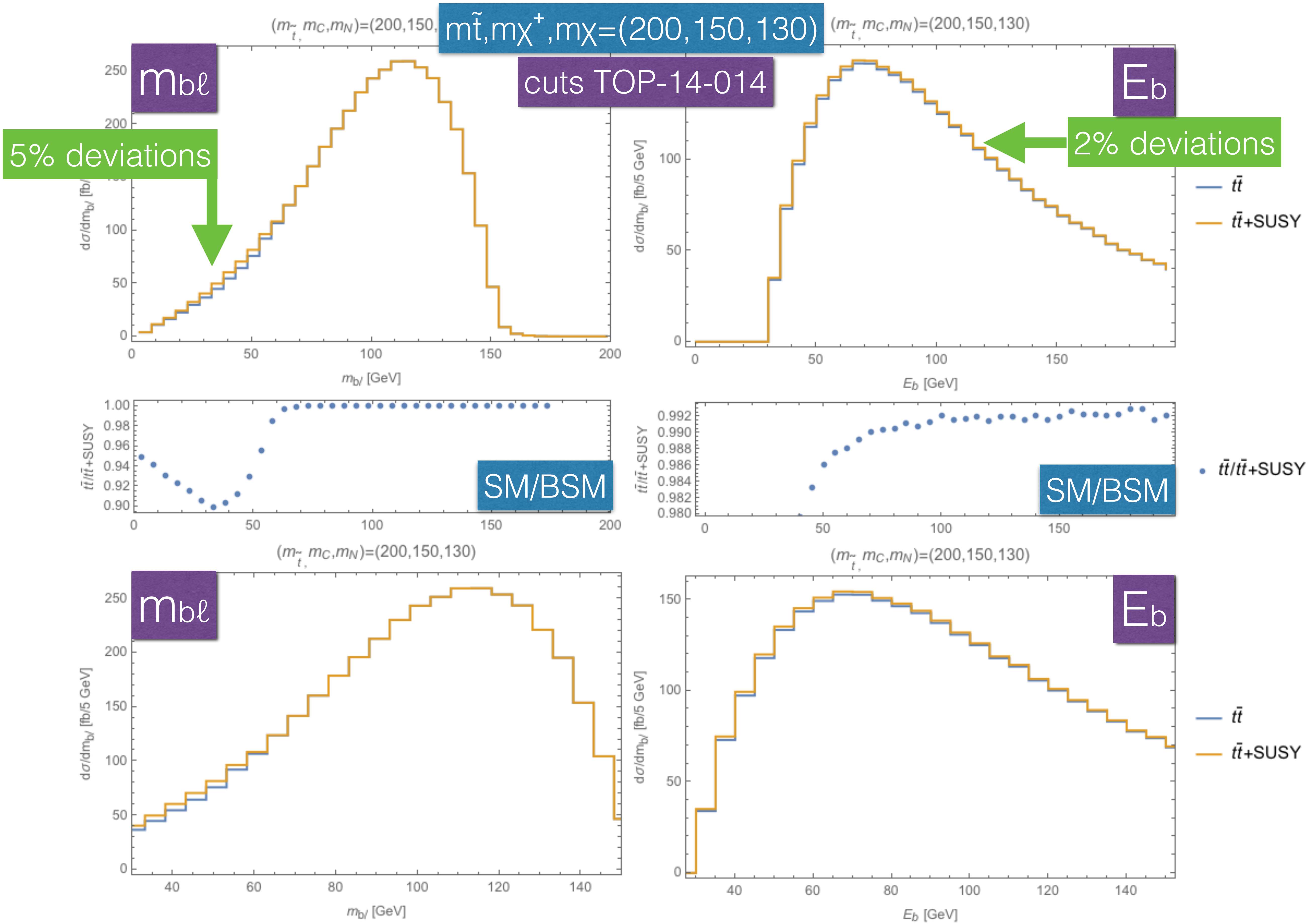
New physics effect on $m_{b\ell}$ and E_b

discussion with G. Polesello

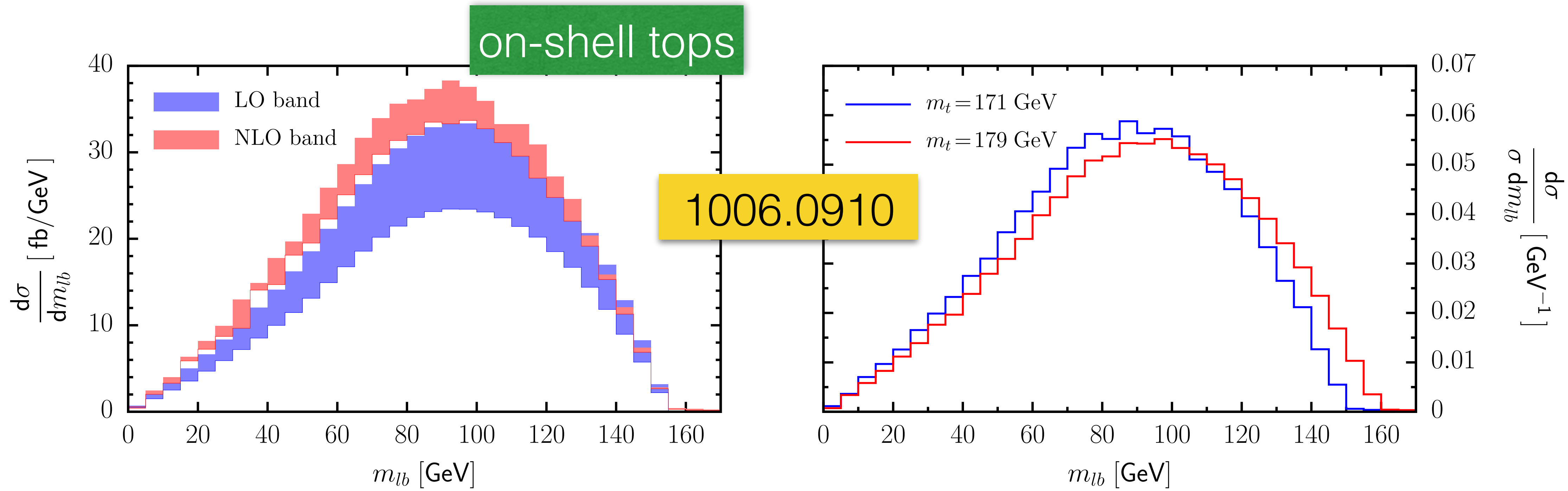


New physics effect on $m_{b\ell}$ and E_b

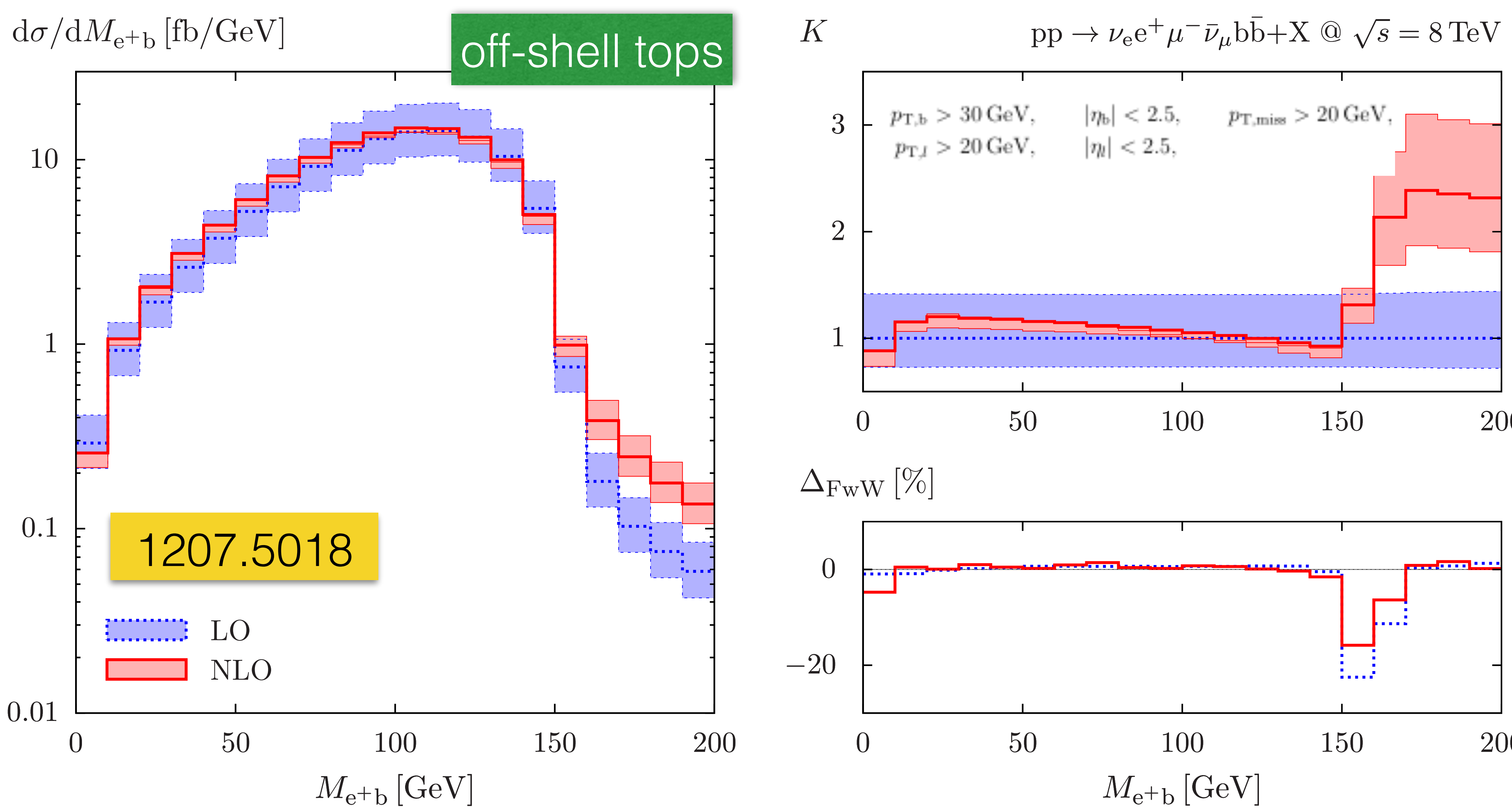
discussion with G. Polesello



$m_{b\ell}$ at NLO

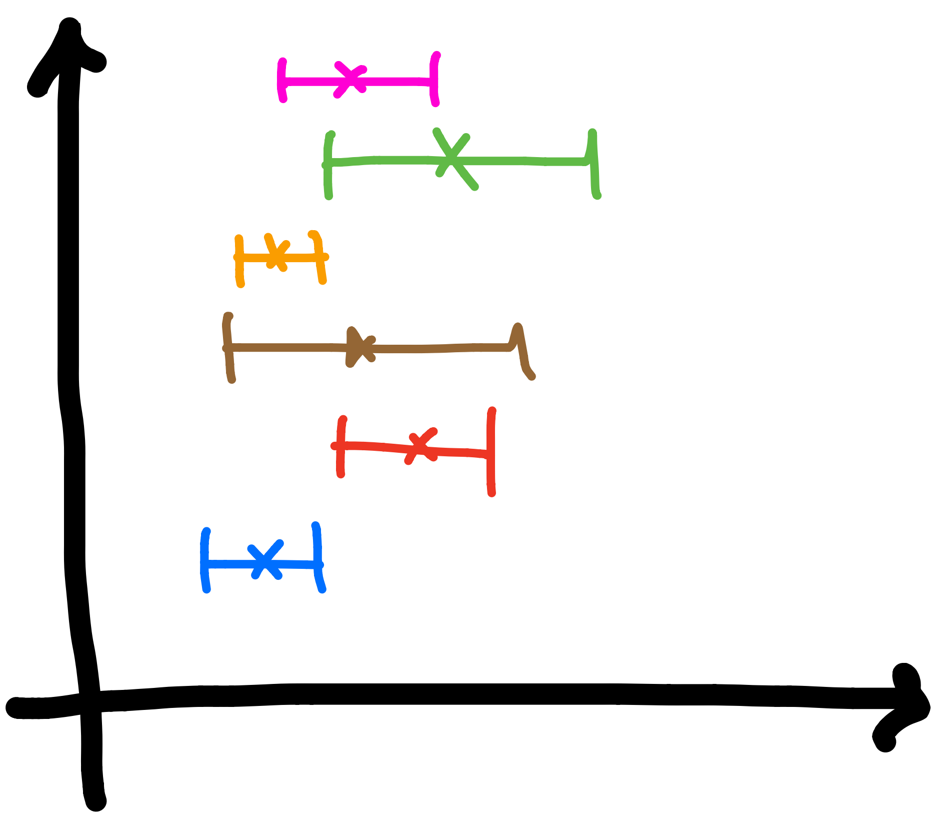


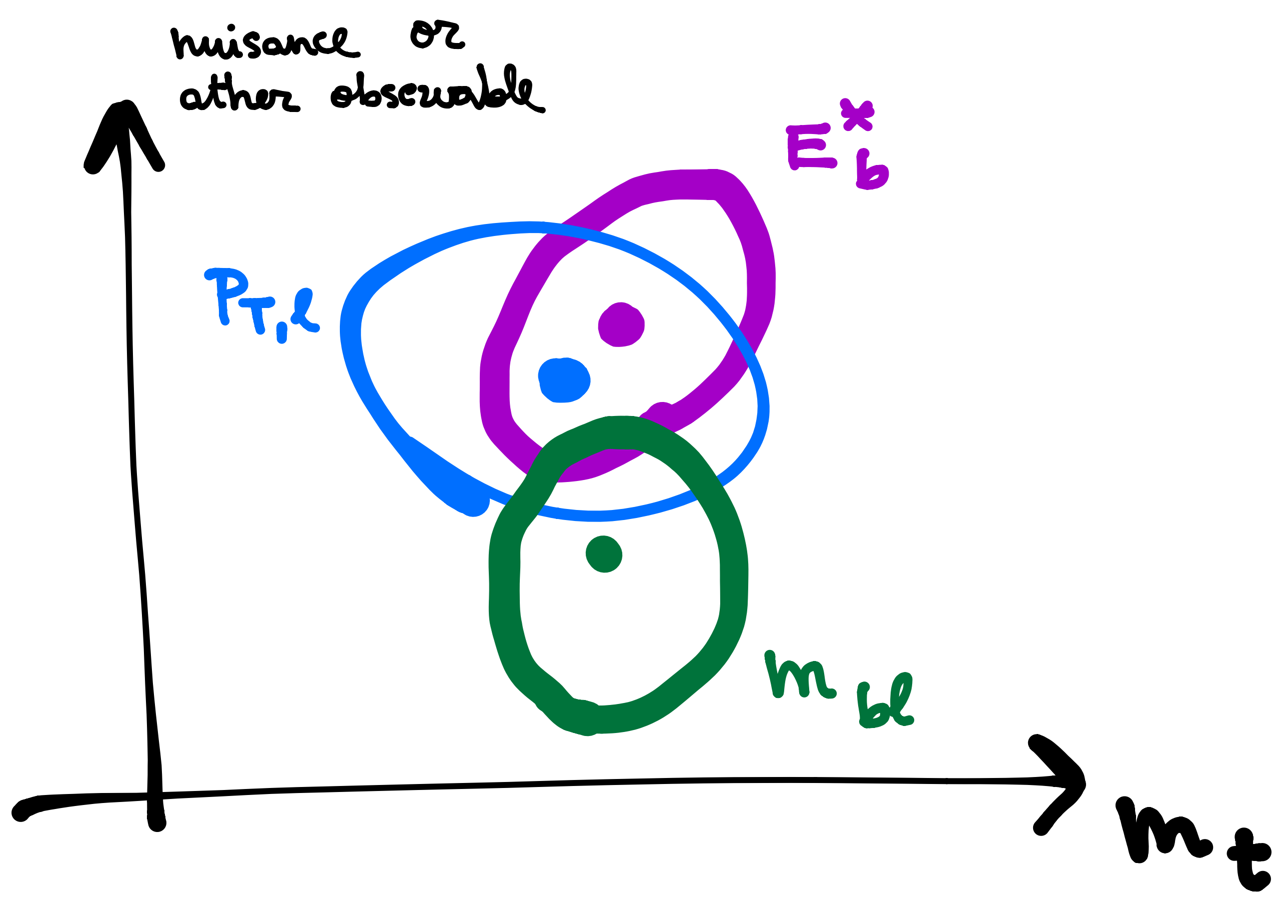
on-shell tops
1006.0910
LO band
NLO band
$m_t = 171$ GeV
$m_t = 179$ GeV
$\frac{d\sigma}{dm_{lb}}$ [fb/GeV]
$\frac{1}{\sigma}\frac{d\sigma}{dm_{lb}}$ [GeV^{-1}]
m_{lb} [GeV]



off-shell tops
1207.5018
$d\sigma/dM_{e^+b}$ [fb/GeV]
LO
NLO
K
$pp \to \nu_e e^+ \mu^- \bar{\nu}_\mu b\bar{b} + X$ @ $\sqrt{s} = 8$ TeV
$p_{T,b} > 30$ GeV, $|\eta_b| < 2.5$, $p_{T,miss} > 20$ GeV,
$p_{T,l} > 20$ GeV, $|\eta_l| < 2.5$,
Δ_{FwW} [%]
M_{e^+b} [GeV]

Many measurements

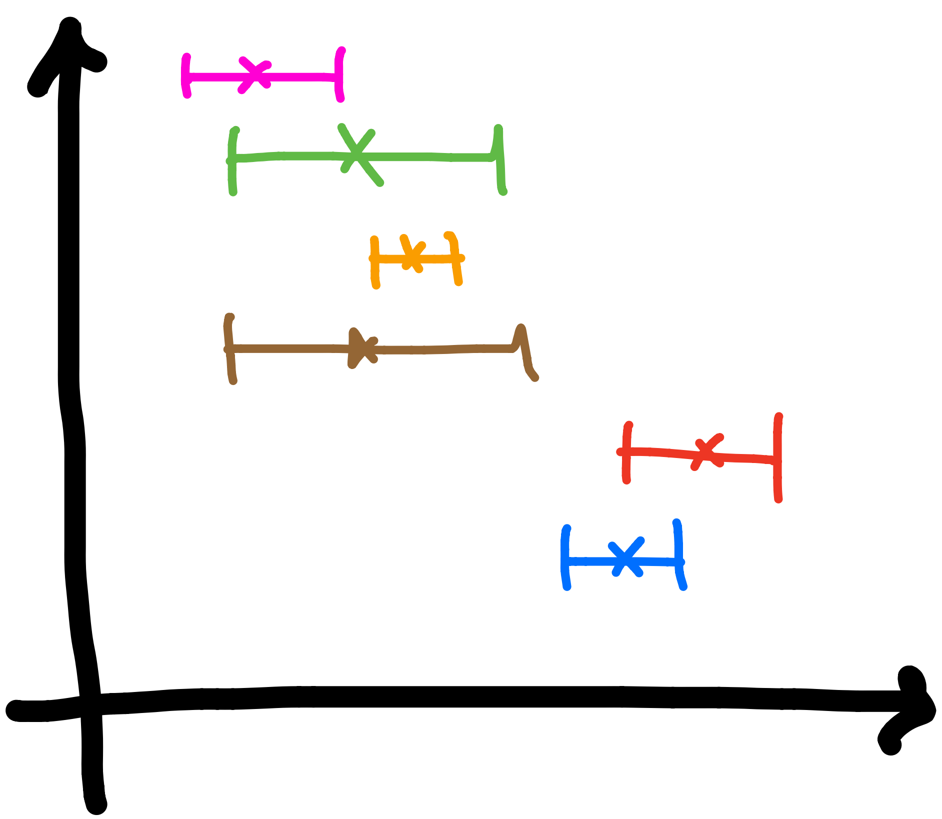


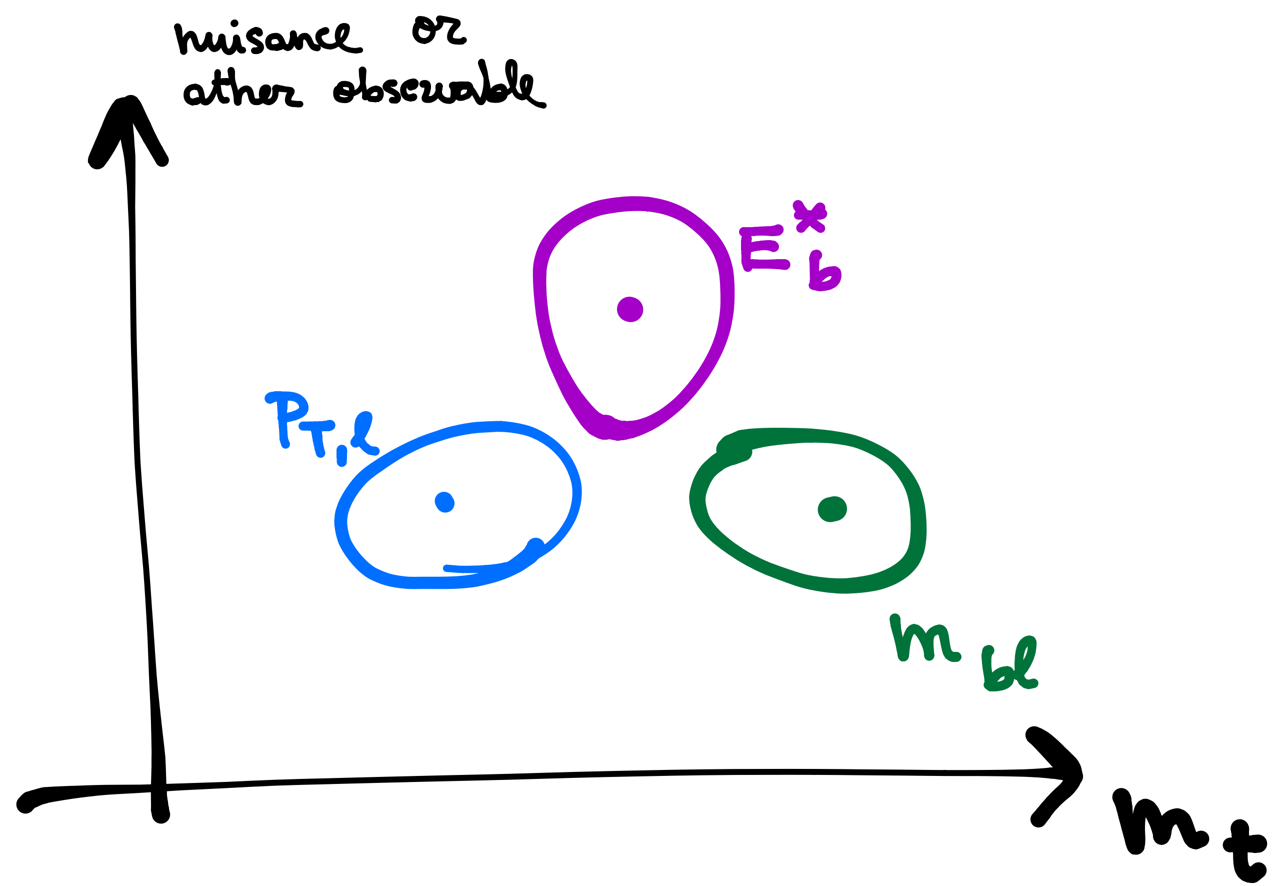


The strength of the future LHC top mass measurement will build on the **diversity of methods**
⇒ not very useful to talk about "*single best measurement*"

Many measurements

due to different hypothesis, different mass measurement methods can result in significantly disagreeing measurements: **QCD or new physics effect?**





The strength of the future LHC top mass measurement will build on the **diversity of methods**
⇒ not very useful to talk about "*single best measurement*"

top decays to BSM

top as a “portal”

Direct production of light new physics:

- $t \to bH^+ \to b\tau\nu$ (CMS-PAS-HIG-12-052)
- $t \to \tilde{t}\,\chi$ (also in σ(tt))

Indirect test through higher dimensional operators:

- $t \to cZ$, cH (and $c \to q$)
- $t \to bc\ell$ (BNV 1107.3805, 1310.1618)
- $t \to ff'\ell_i\ell_j$ (LFV)
- $t \to qW$ (1404.2292)
- $t \to bbc$ (1407.1724,1407.1725)

- Generic (SM is tiny)
- can be done → need to be done
- indirect test, but some models in the reach (e.g. *cZ, cH*)

Direct production of light states

despite being light, new physics can have

- low cross-section (EW states)
- subtle signatures (hadronic states)

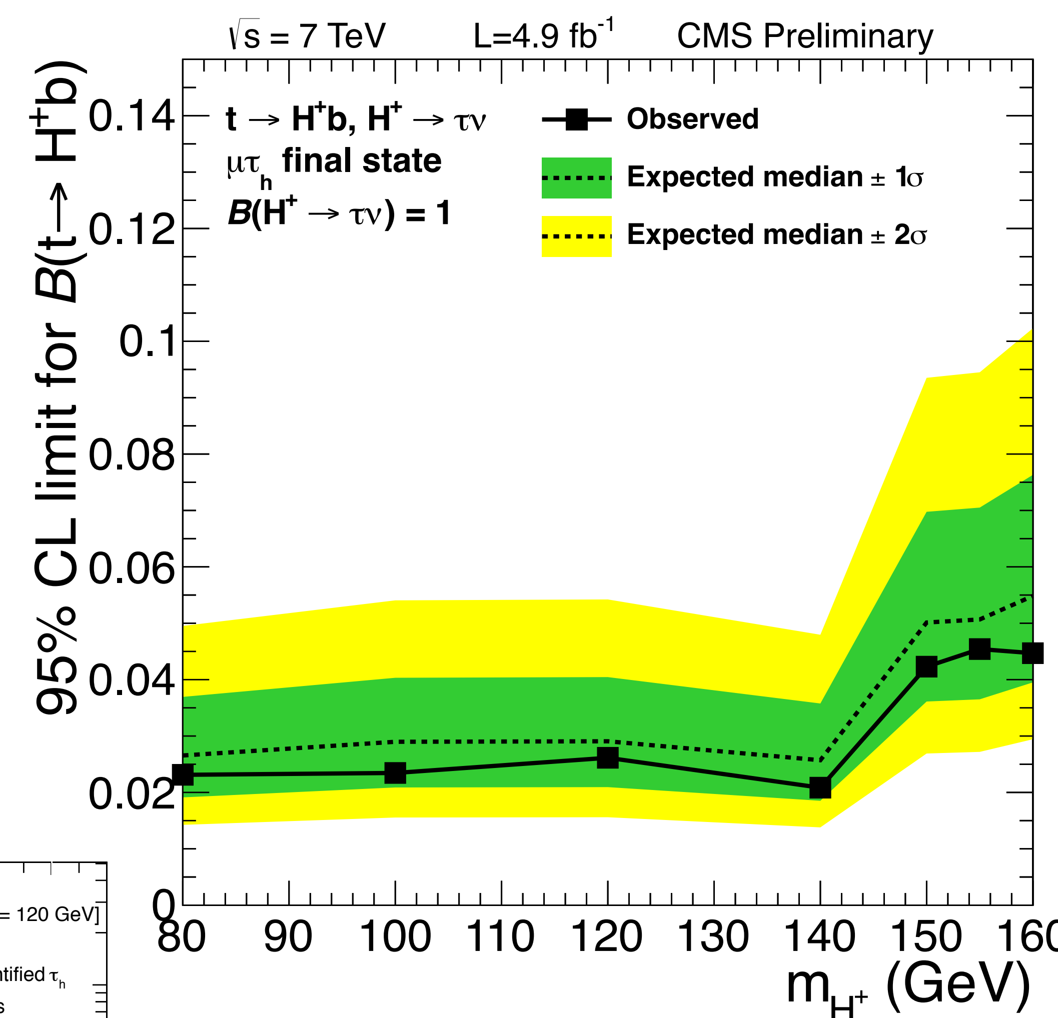
$pp \to t\bar{t}$ becomes a **trigger** and a **source** for new physics

$t \to bH^+ \to b\tau\nu$ (CMS-PAS-HIG-12-052)

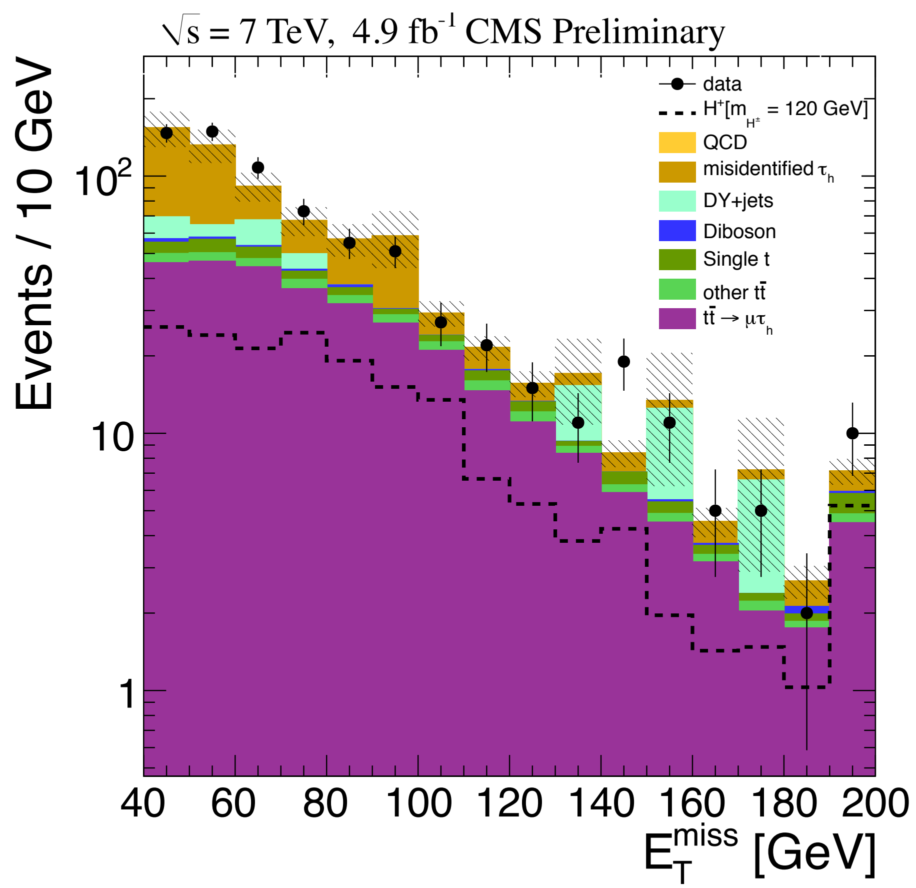
“inclusive” selections

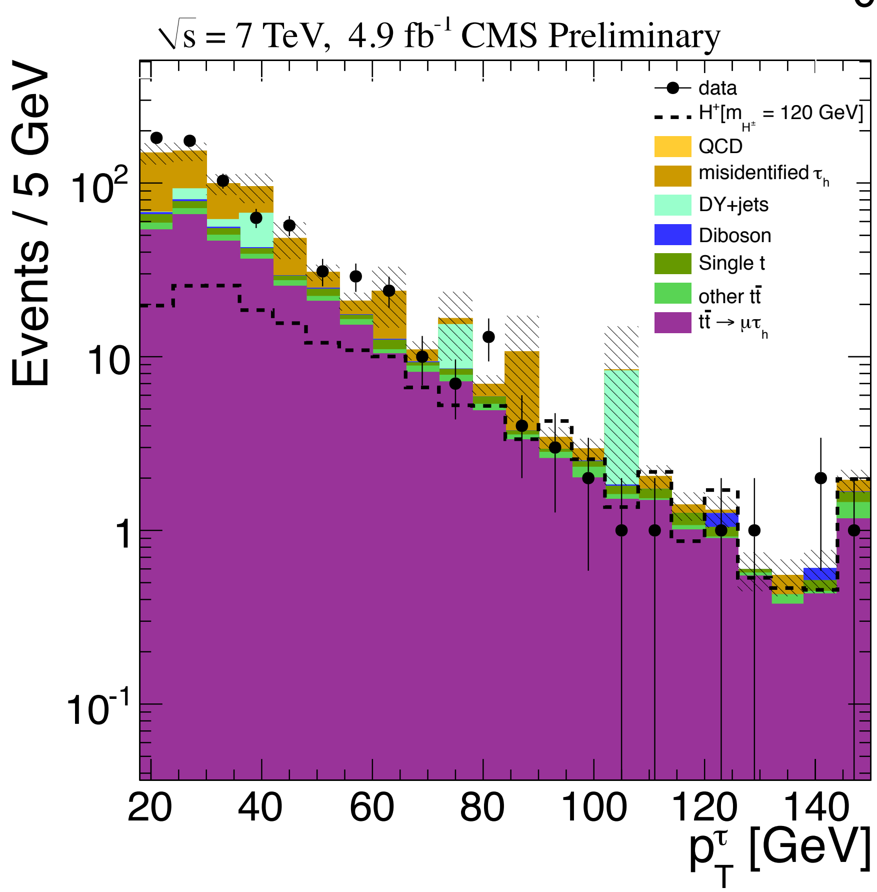
$\varepsilon(tt \to \tau\ell) \sim 0.01$

- μ: $p_T > 30$ GeV $\eta < 2.1$
- τ_h: $p_T > 20$ GeV $\eta < 2.4$
- jet: $p_T > 30$ GeV $\eta < 2.4$
- $n_b \geq 1$
- mET>40 GeV



bound below Br(W→τν)





$t \to bc\ell$ 1310.1618

“exclusive” selections

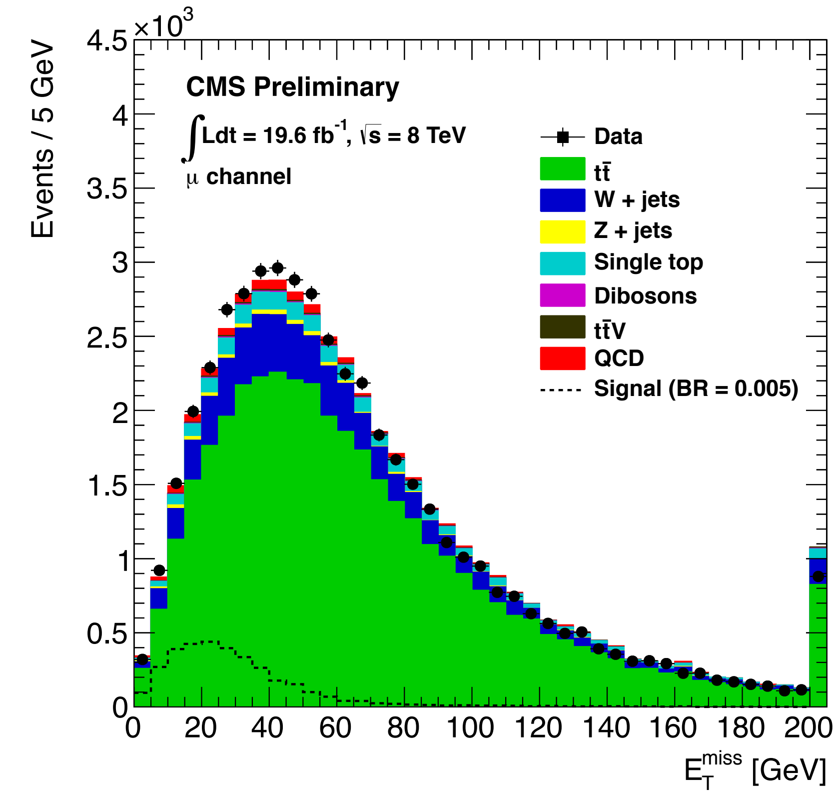
ε(basic→tight)~0.05

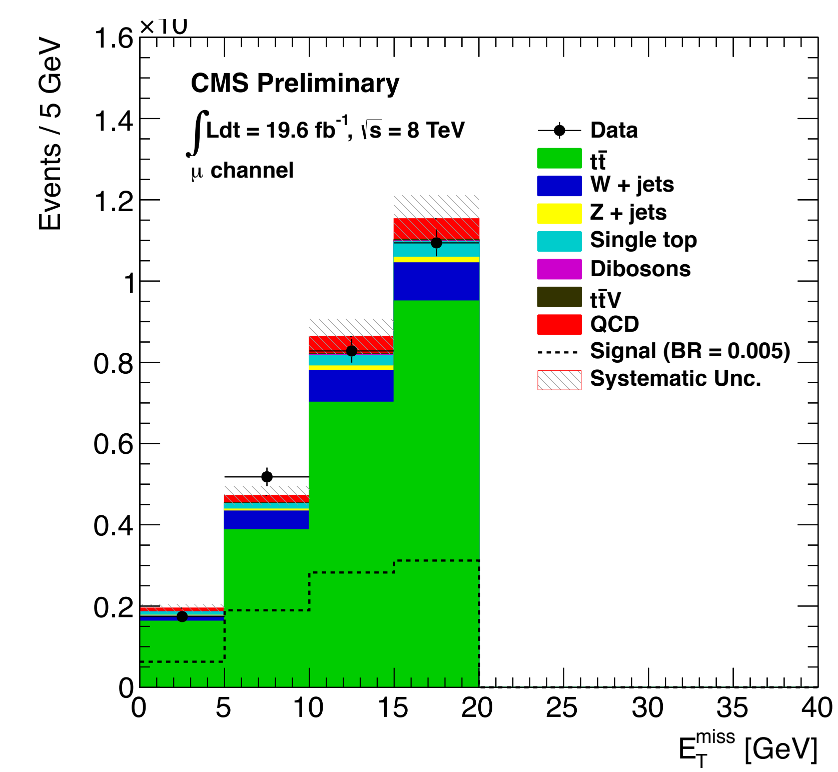
basic

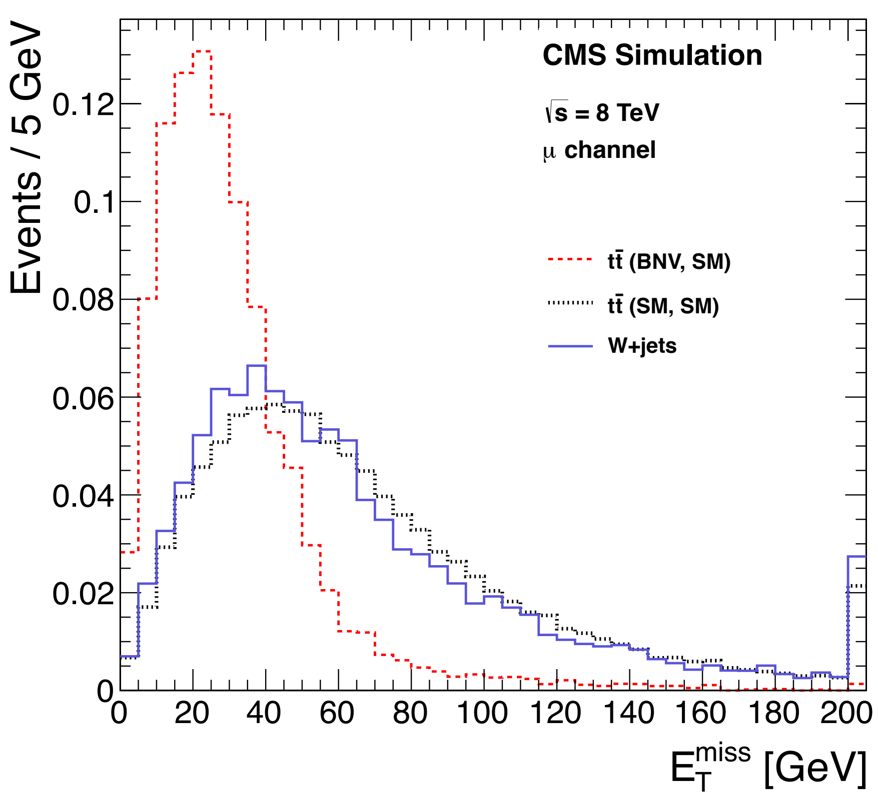
- μ: p_T>25 GeV η <2.1
- jet: p_T>70,55,40,30,30 GeV η <2.4
- n_b≥1

tight

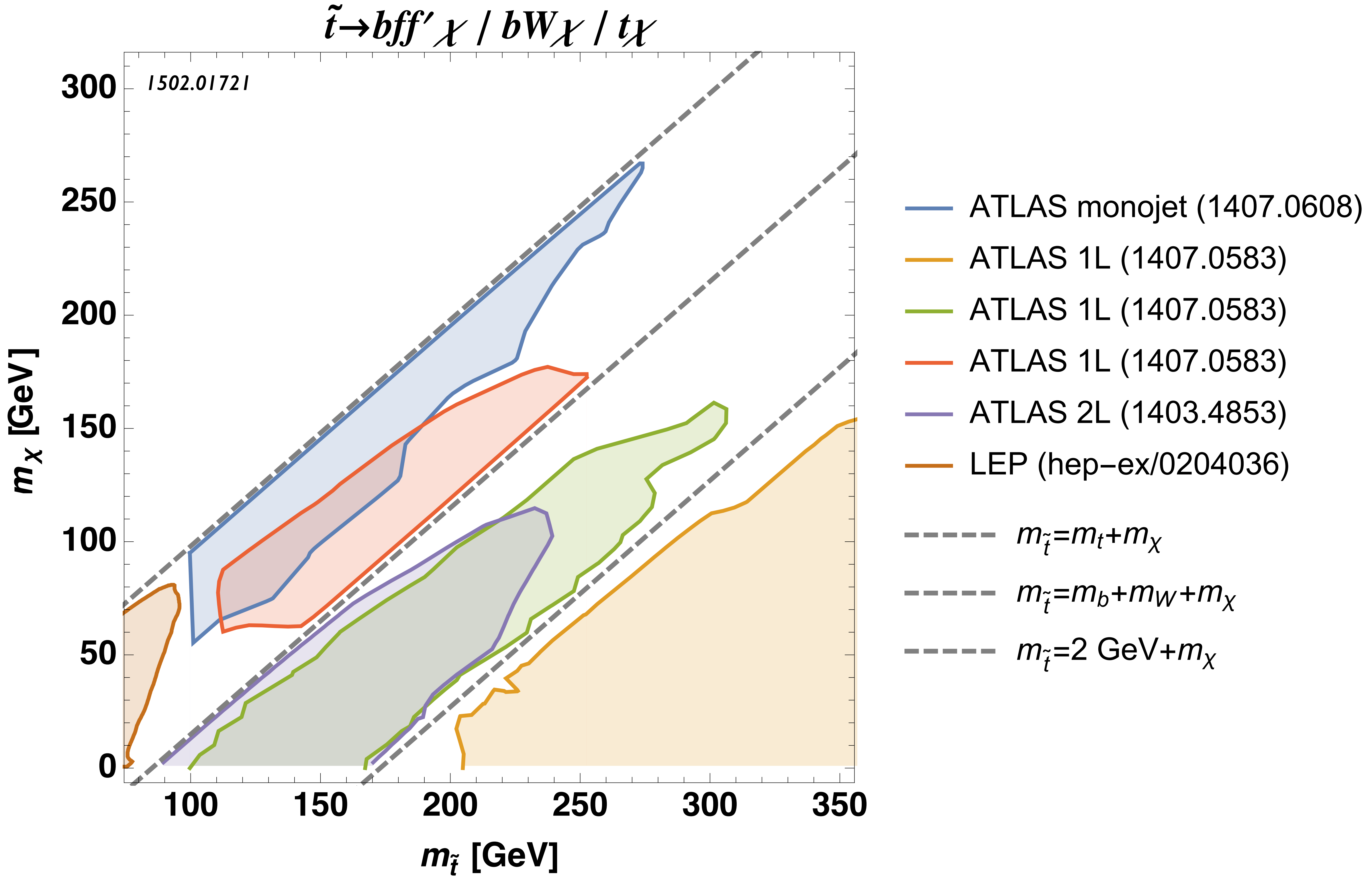
- mET<20 GeV
- kinematic goodness-of-fit



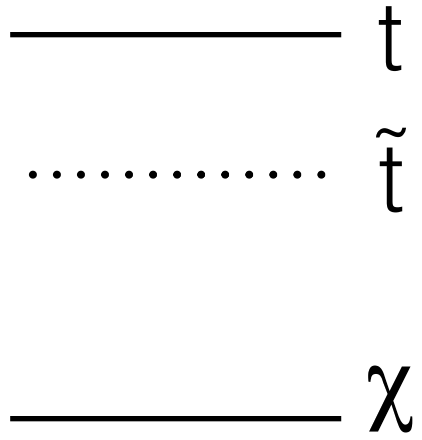




bound Br≲0.002
much below Br(W→τν)



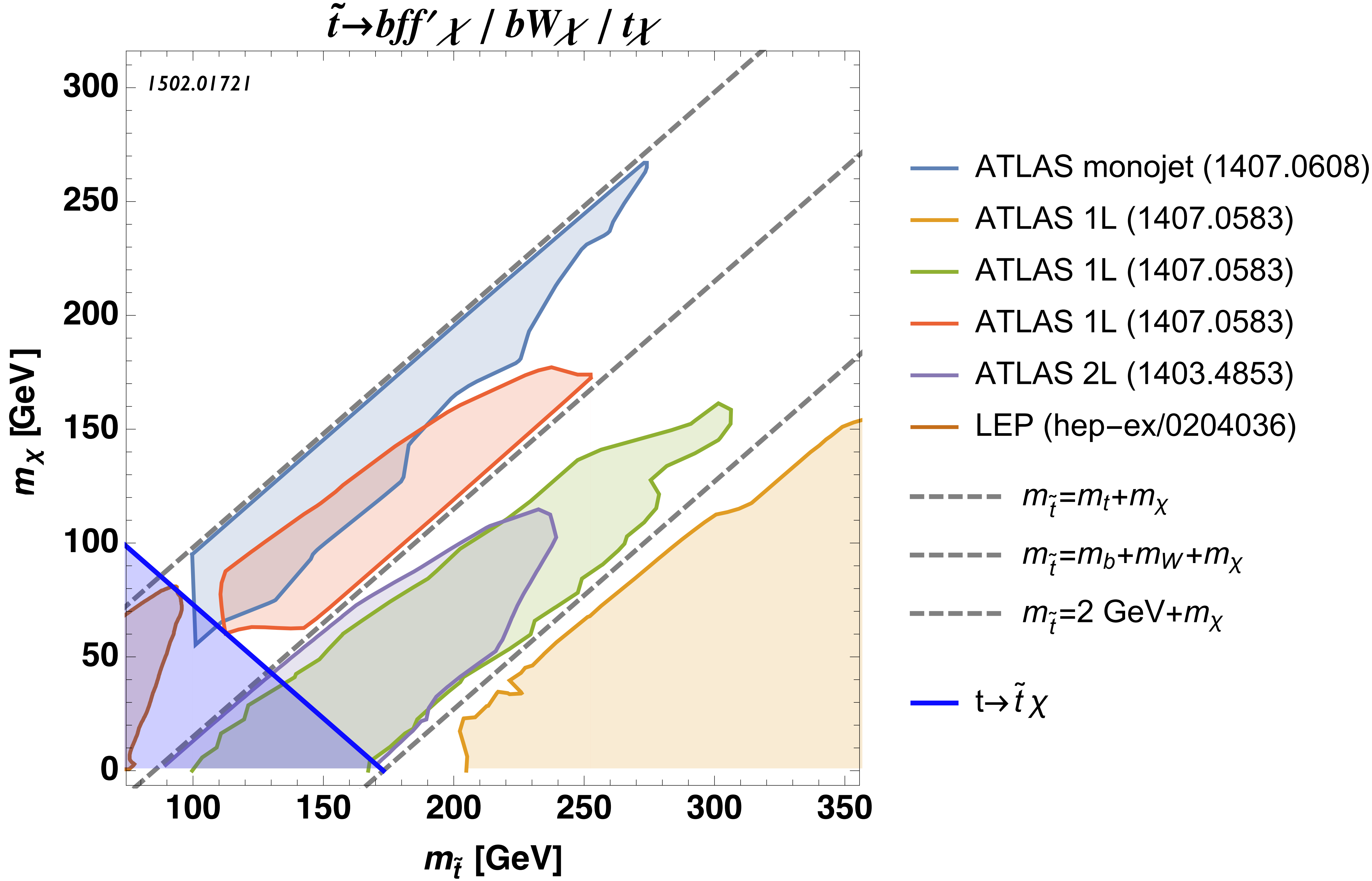
$\tilde{t}\to bff'\chi$ / $bW\chi$ / $t\chi$
1502.01721
m_χ [GeV]
$m_{\tilde{t}}$ [GeV]
0
50
100
150
200
250
300
100
150
200
250
300
350
ATLAS monojet (1407.0608)
ATLAS 1L (1407.0583)
ATLAS 1L (1407.0583)
ATLAS 1L (1407.0583)
ATLAS 2L (1403.4853)
LEP (hep−ex/0204036)
$m_{\tilde{t}}=m_t+m_\chi$
$m_{\tilde{t}}=m_b+m_W+m_\chi$
$m_{\tilde{t}}$=2 GeV+m_χ



$t \to \tilde{t}\chi \to b\, ff'\, \chi\chi$

An orthogonal playground

Ferretti, RF, Petersson, Torre, in progress
1407.1043 + hep-ph/9605340



Ferretti, RF, Petersson, Torre, in progress

t

$t \to \tilde{t}\chi$

Br($t \to \tilde{t}\chi$) can be 5% for χ=Bino

$\tilde{t}$

$\tilde{t} \to b\, f f' \chi$

χ

stable LSP

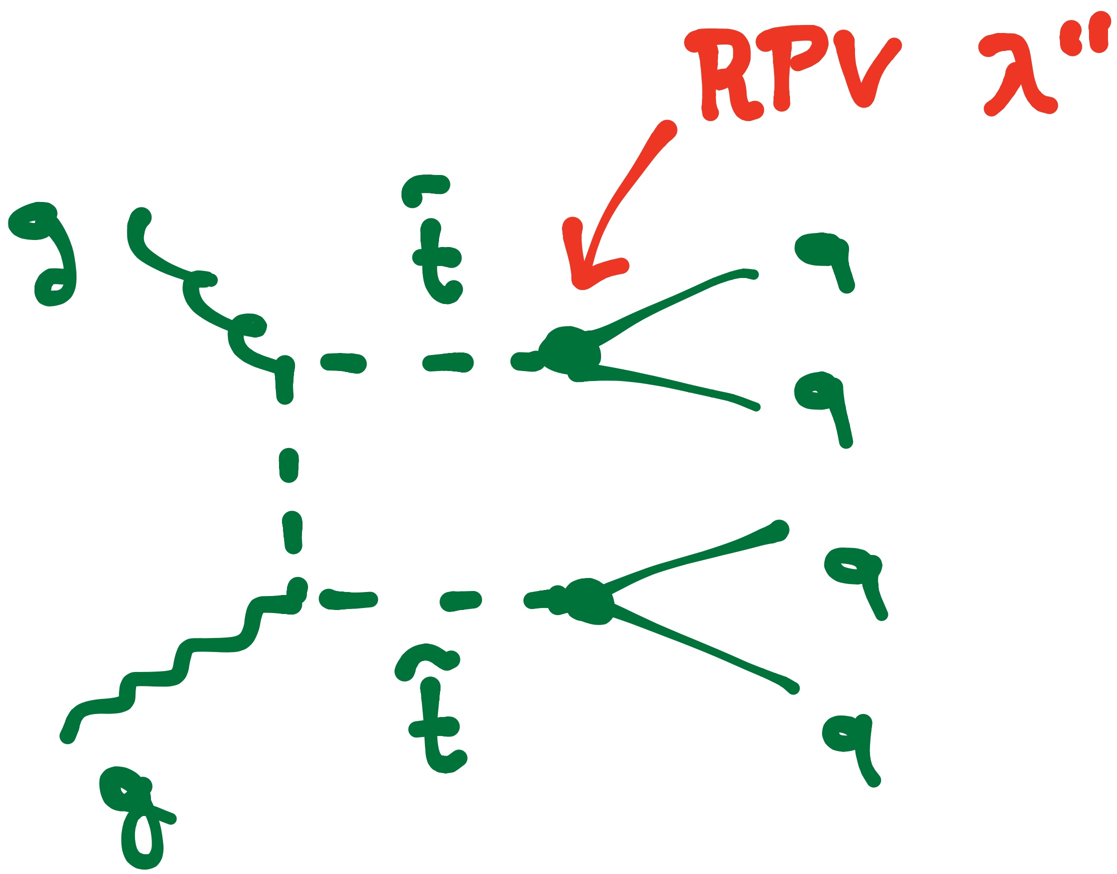
softer visible products

$t \to \tilde{t}\chi \to b\, f f' \chi\chi$

soft challenge

Top as a trigger

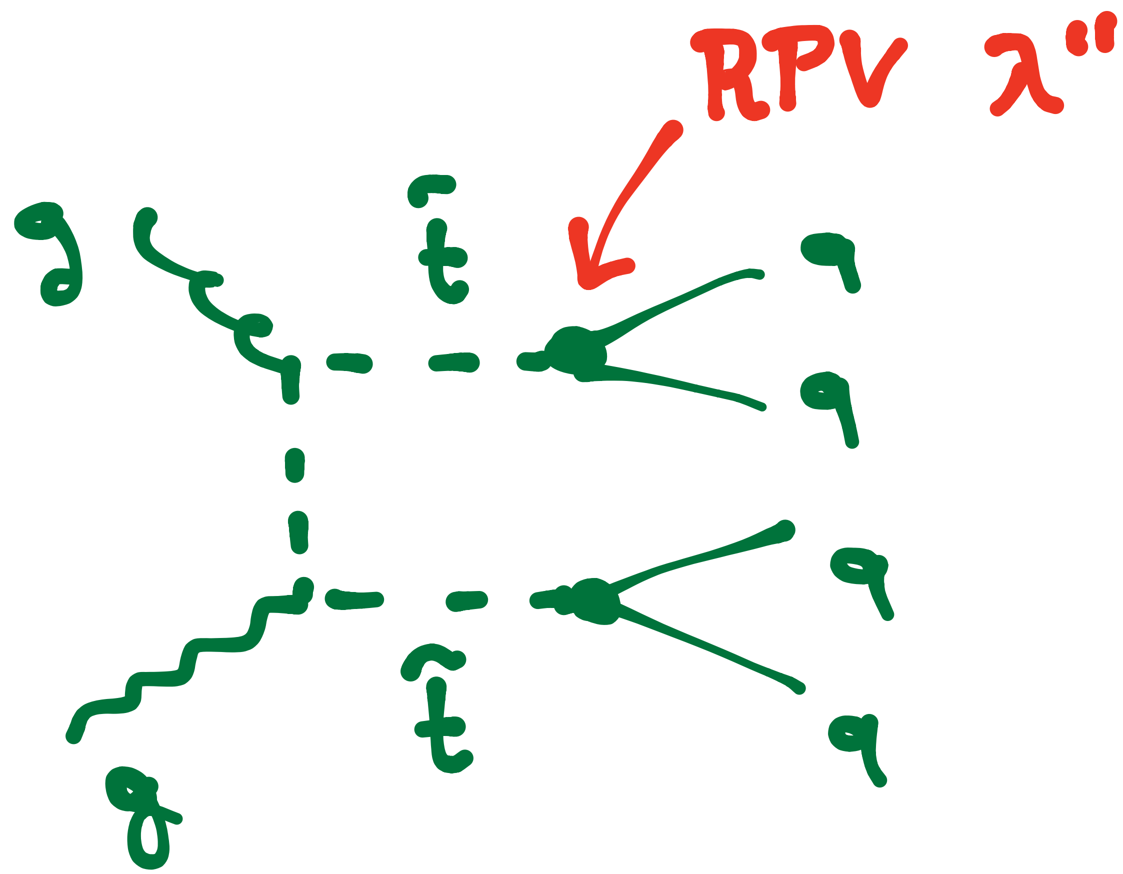
hadronic stops in RPV SUSY



large QCD cross-section for direct production

Top as a trigger

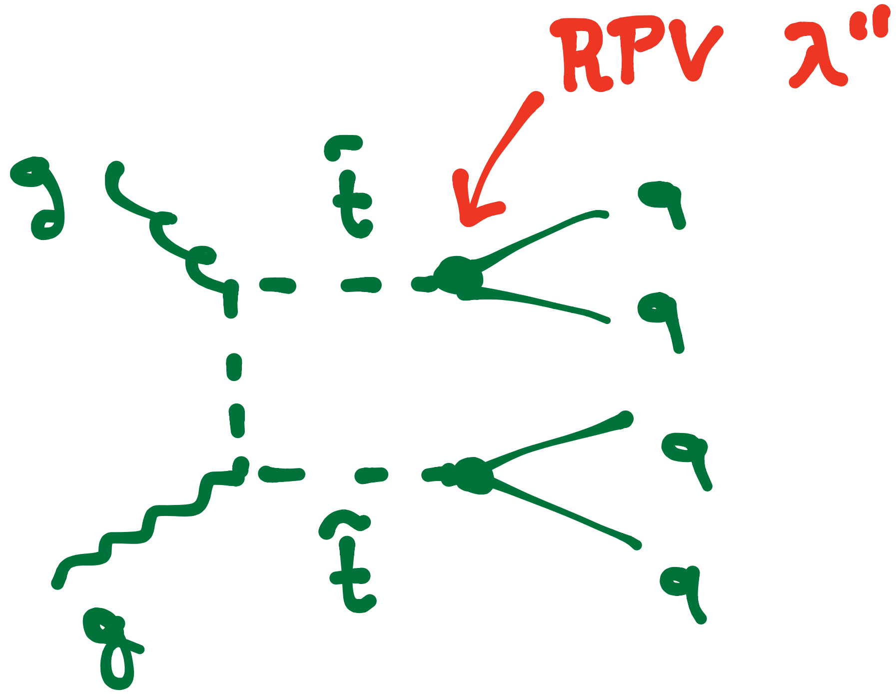
hadronic stops in RPV SUSY



large QCD cross-section for direct production

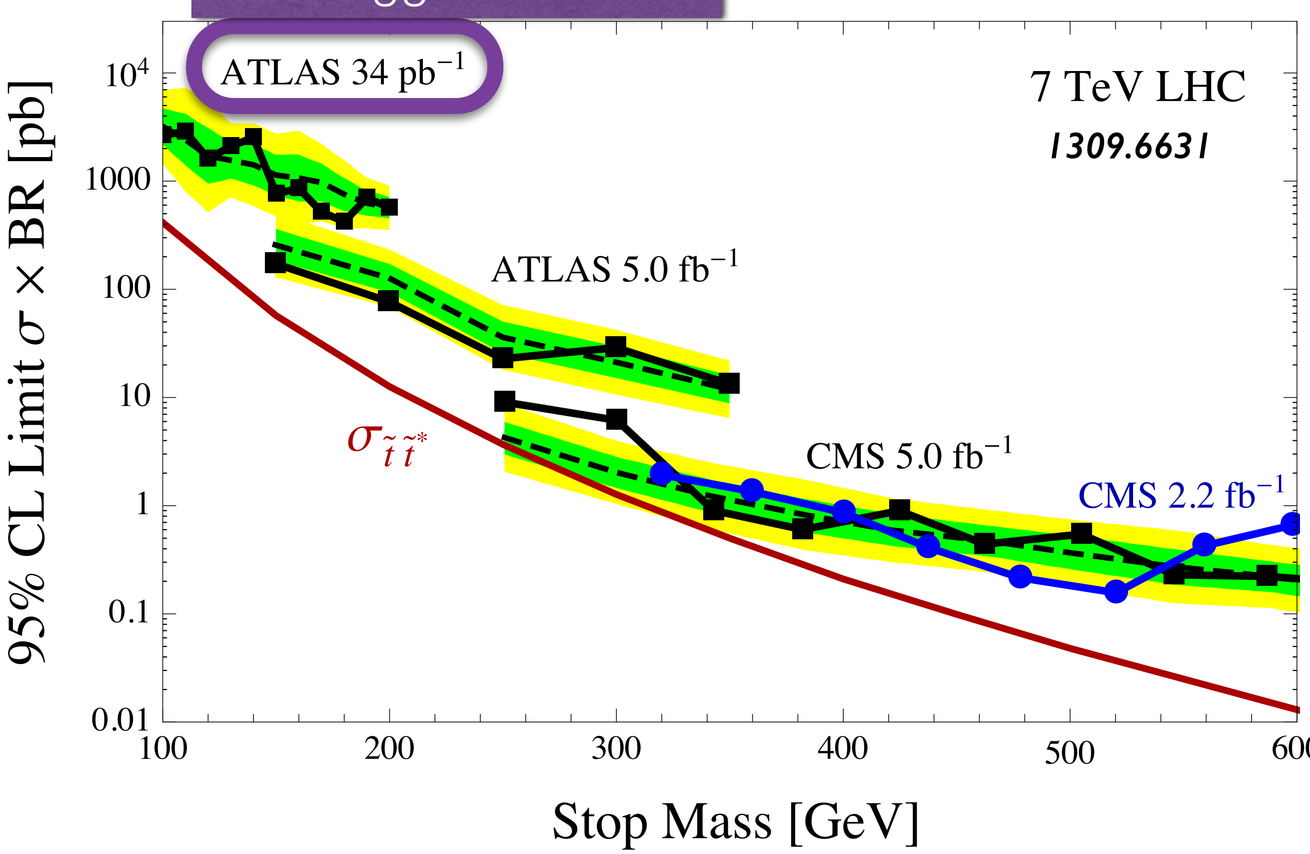
larger QCD background!

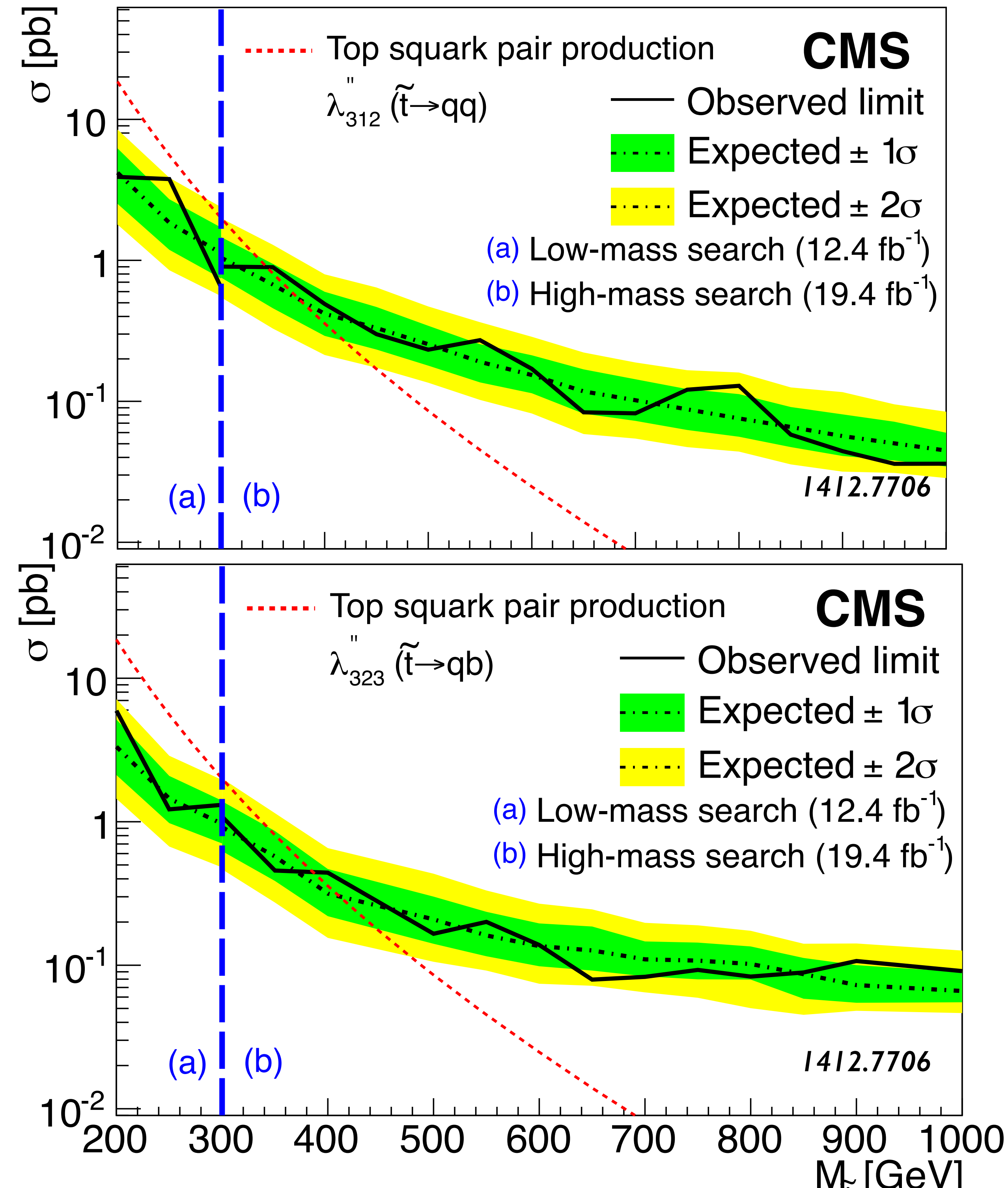
Light is difficult



trigger is a killer at low mass

lower trigger thresholds

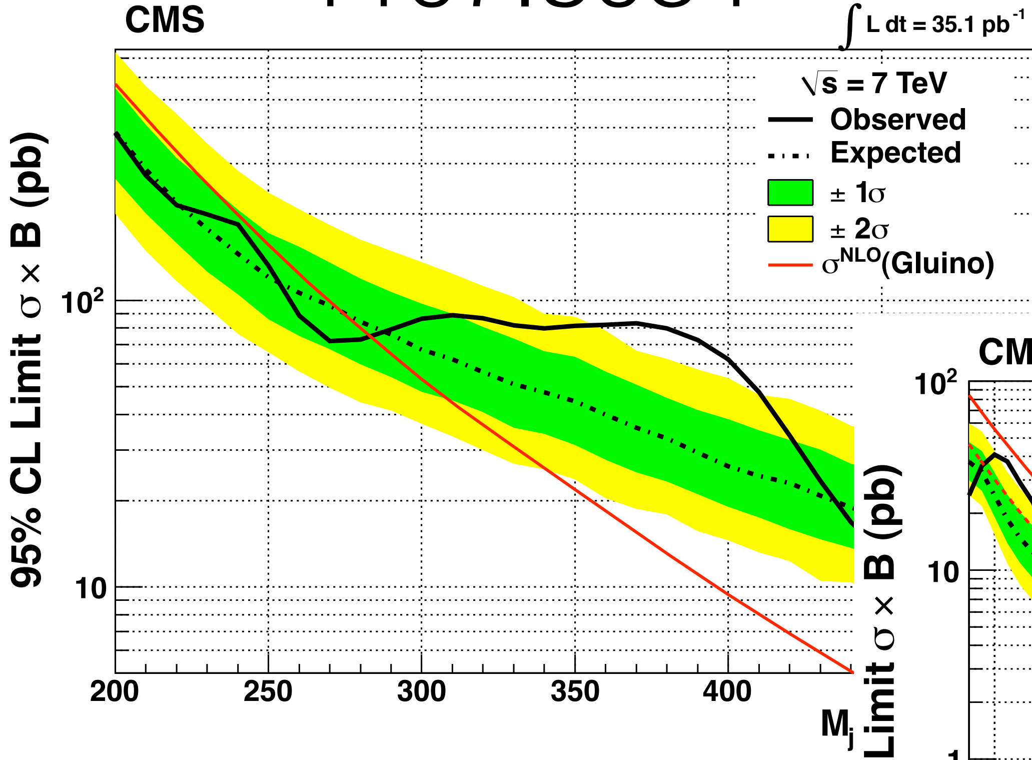




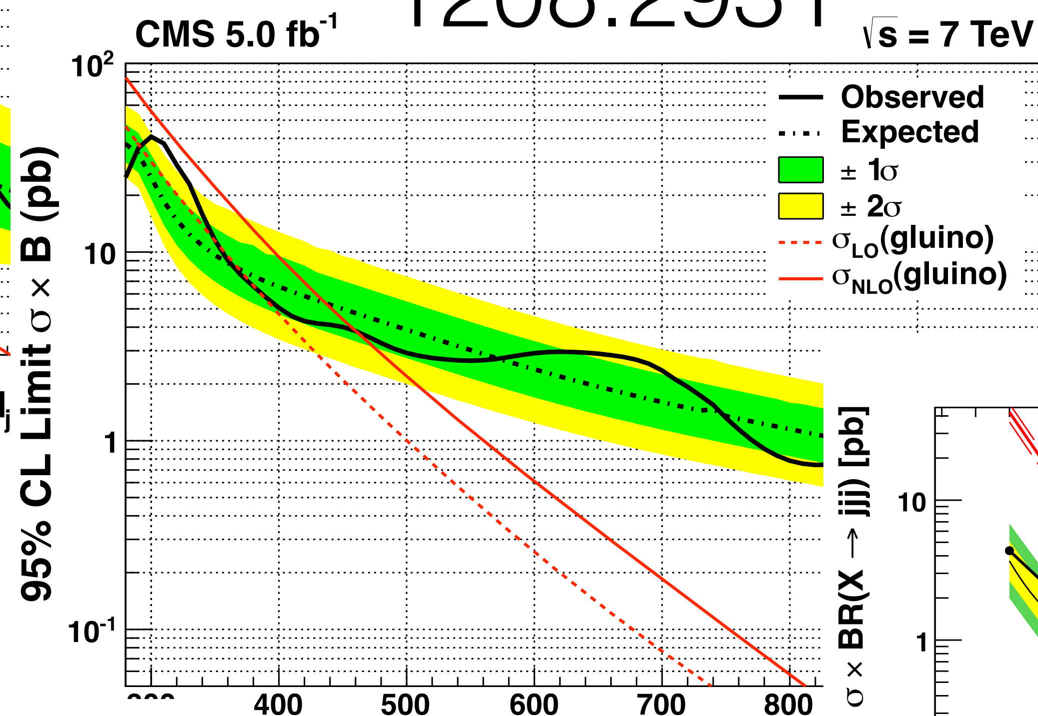
Light is difficult

$\tilde{g} \rightarrow jjj$

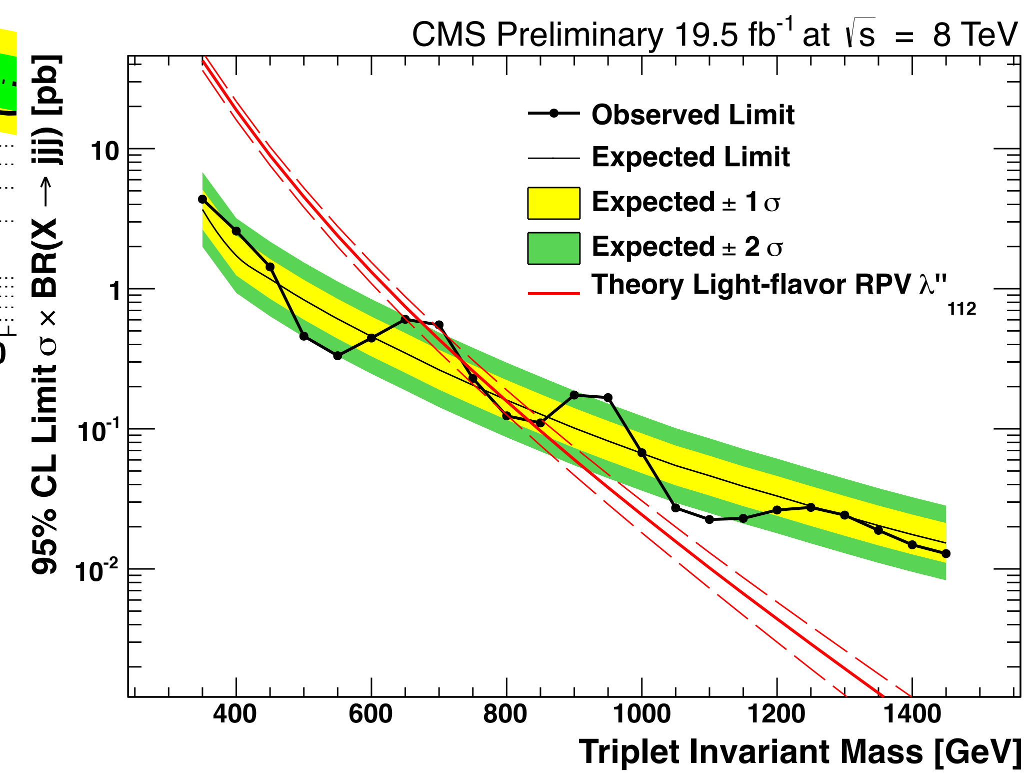
1107.3084

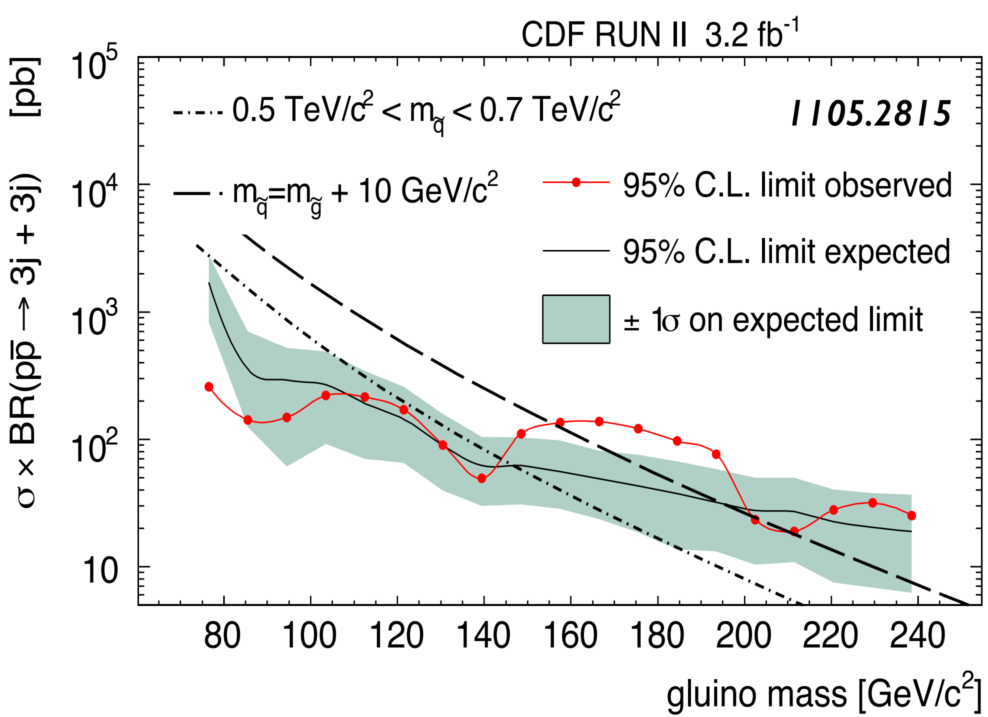


1208.2931



EXO-12-049





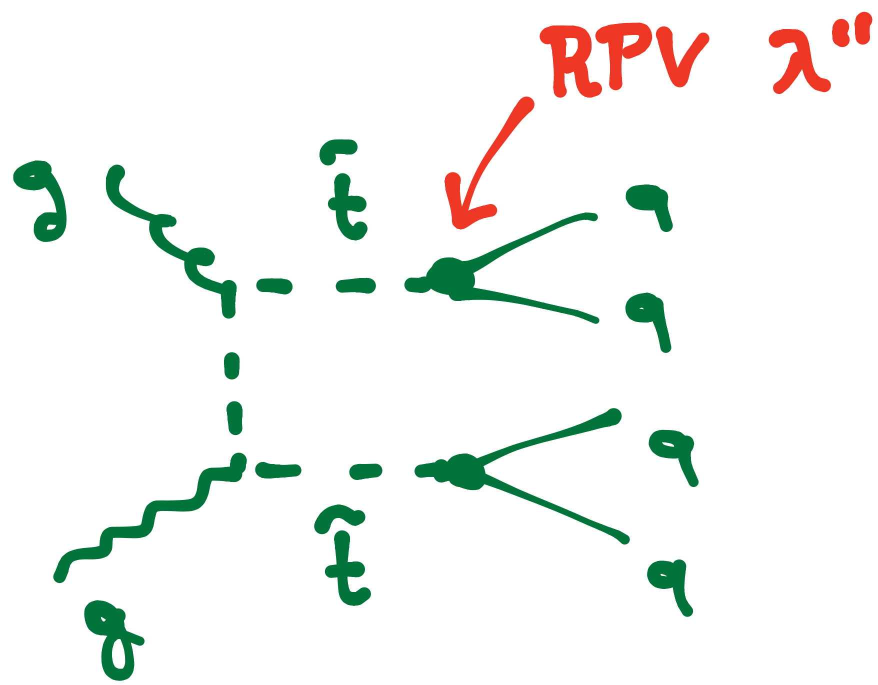
trigger is a killer at low mass

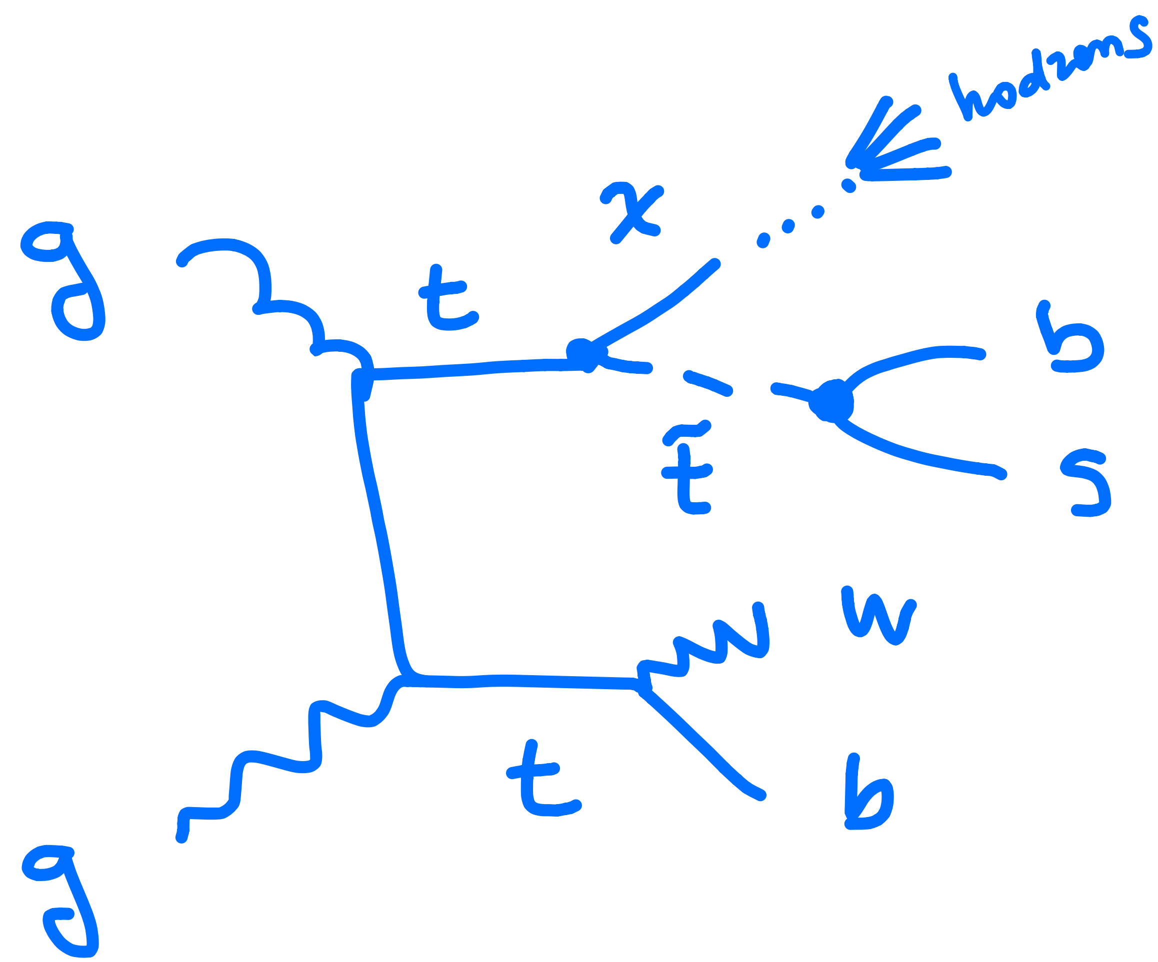
Top as a trigger

discussion with Ferretti, RF, Petersson, Torre

stops from top in RPV SUSY

hadronic stops in RPV SUSY





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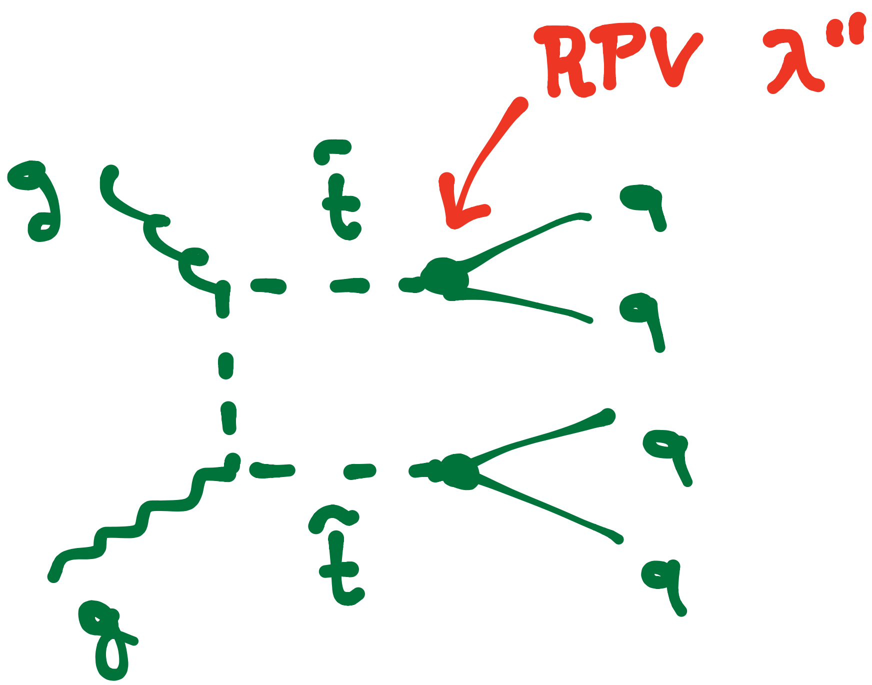

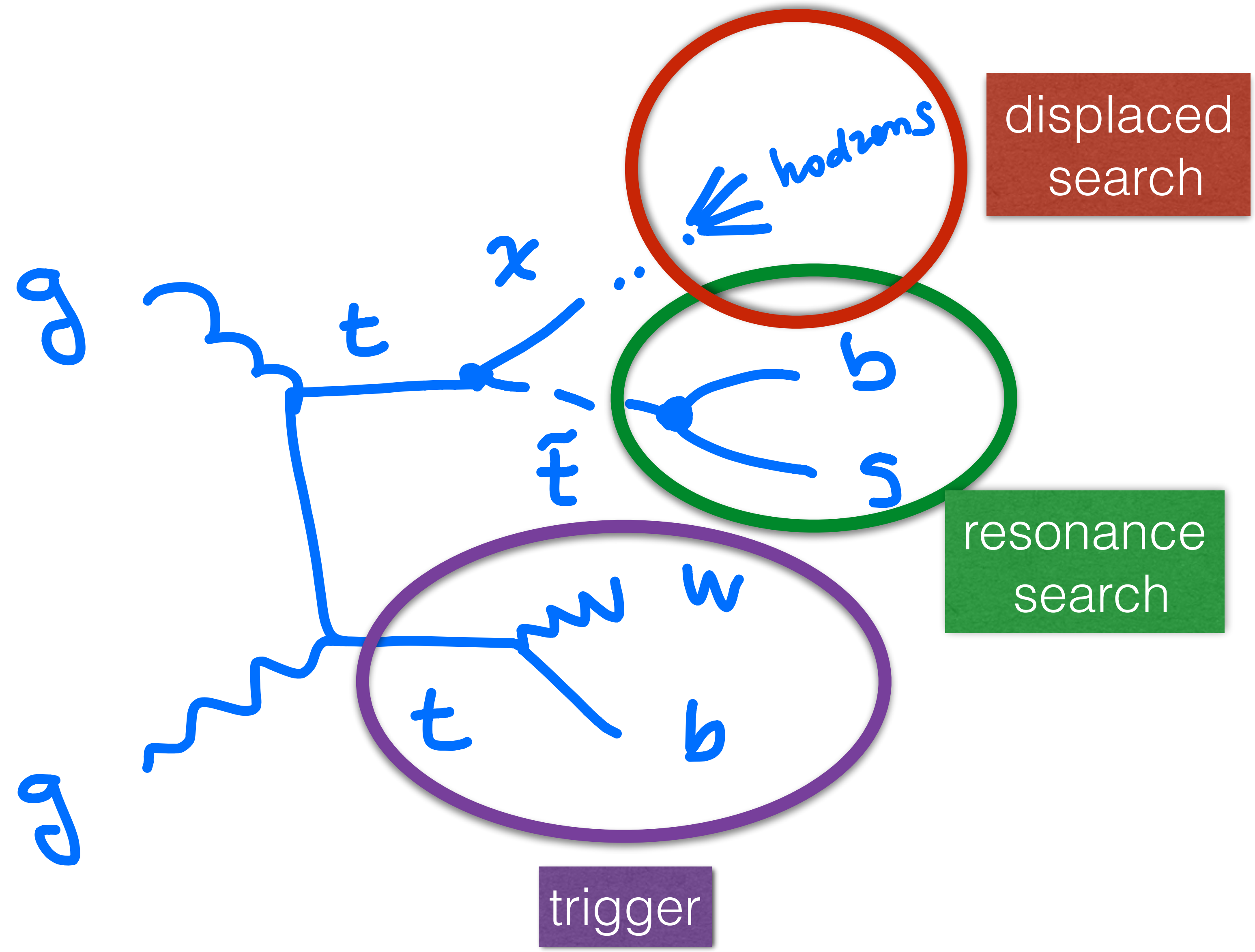

Top as a trigger

discussion with Ferretti, RF, Petersson, Torre

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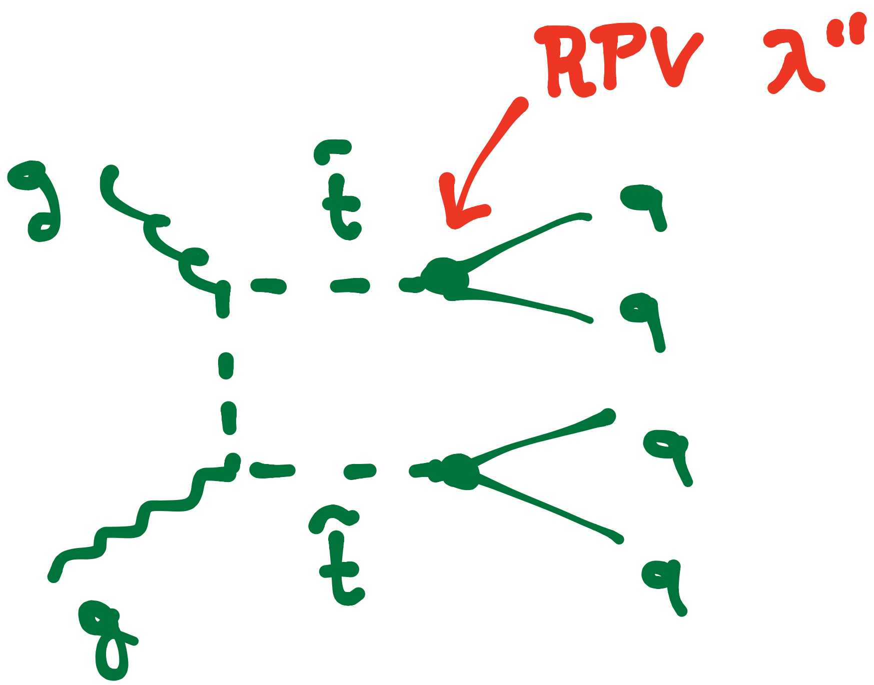
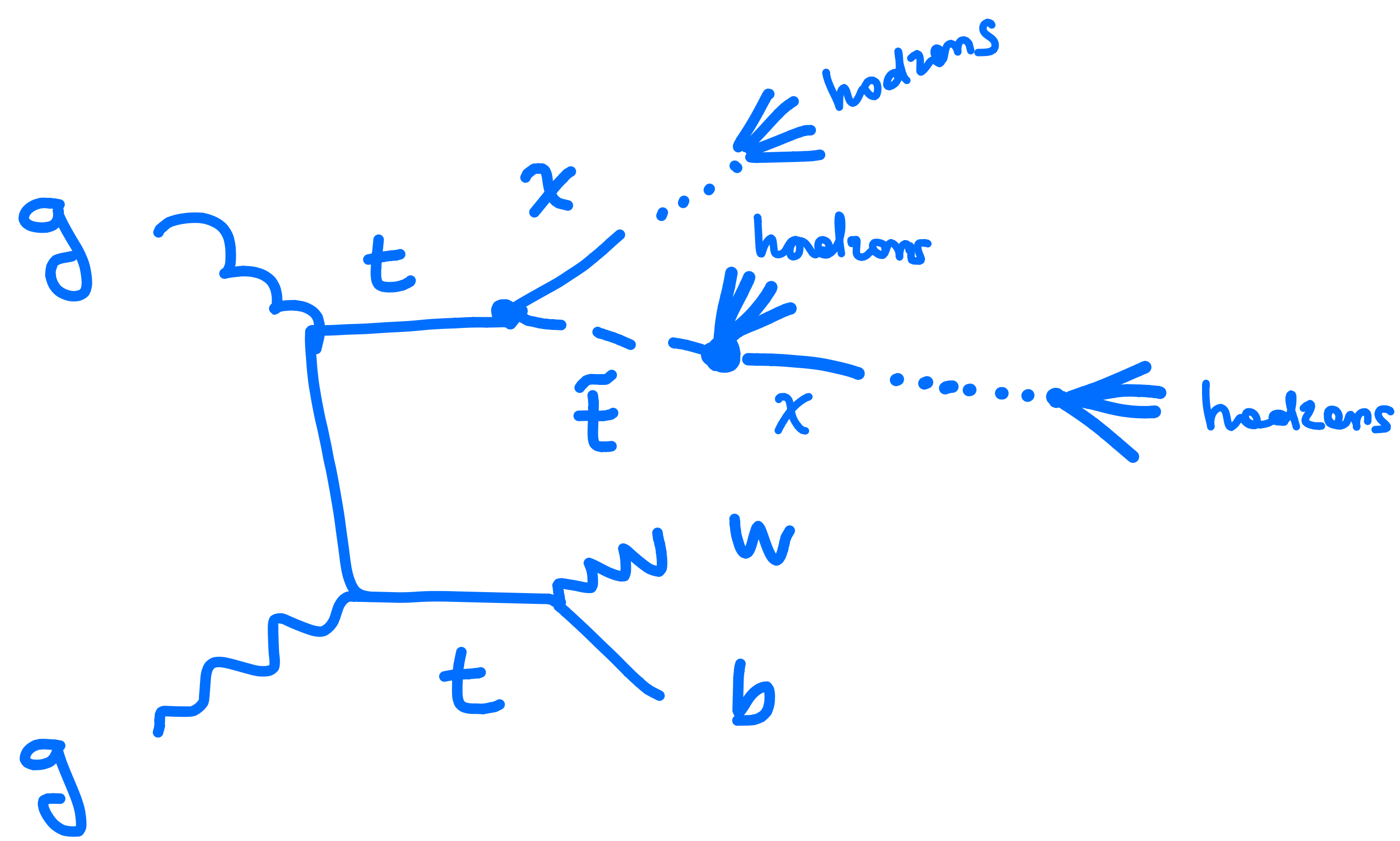


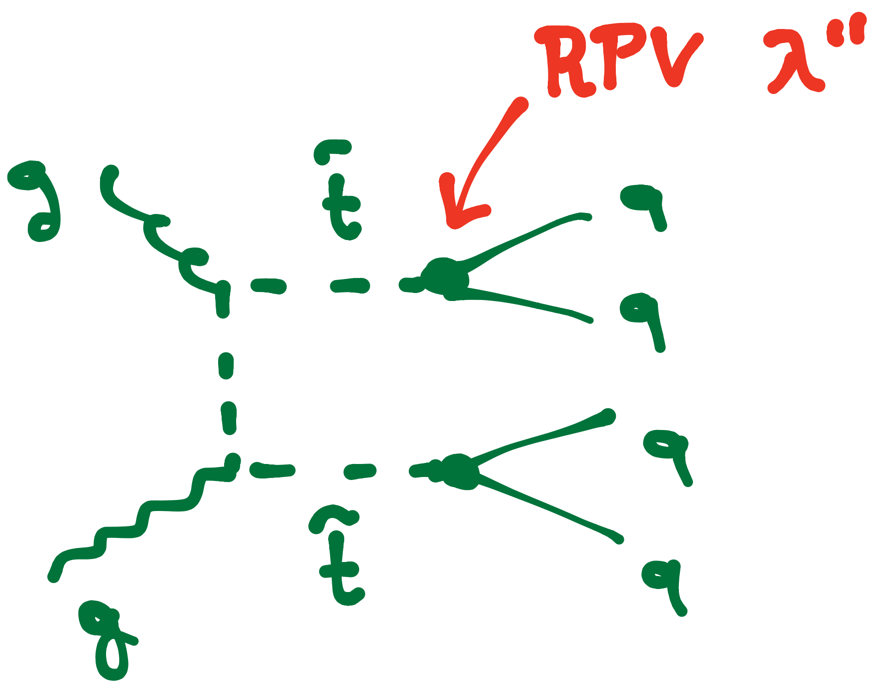
stops from top in RPV SUSY



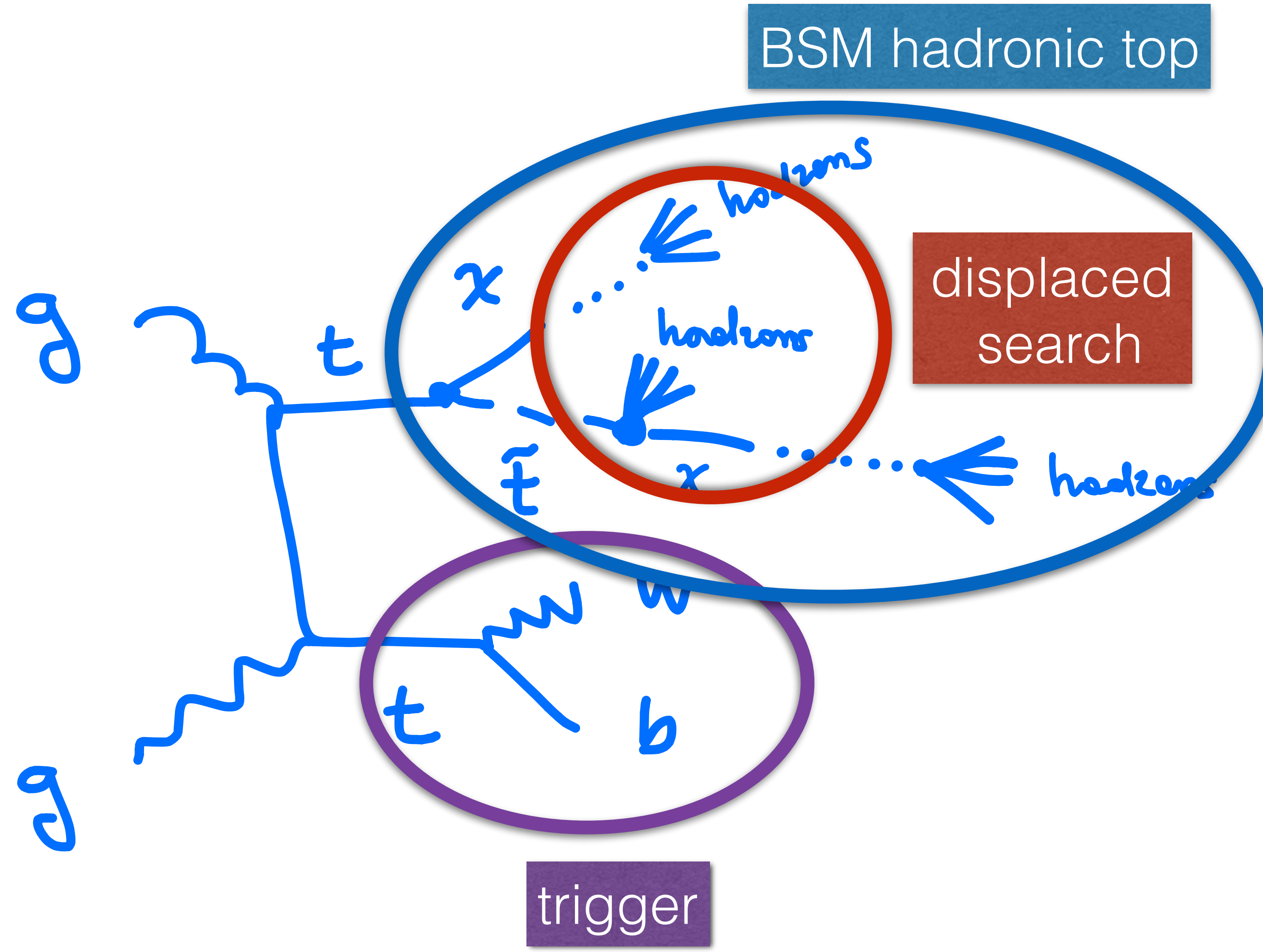
Top as a trigger

discussion with Ferretti, RF, Petersson, Torre

hadronic stops in RPV SUSY



stops from top in RPV SUSY



Conclusions

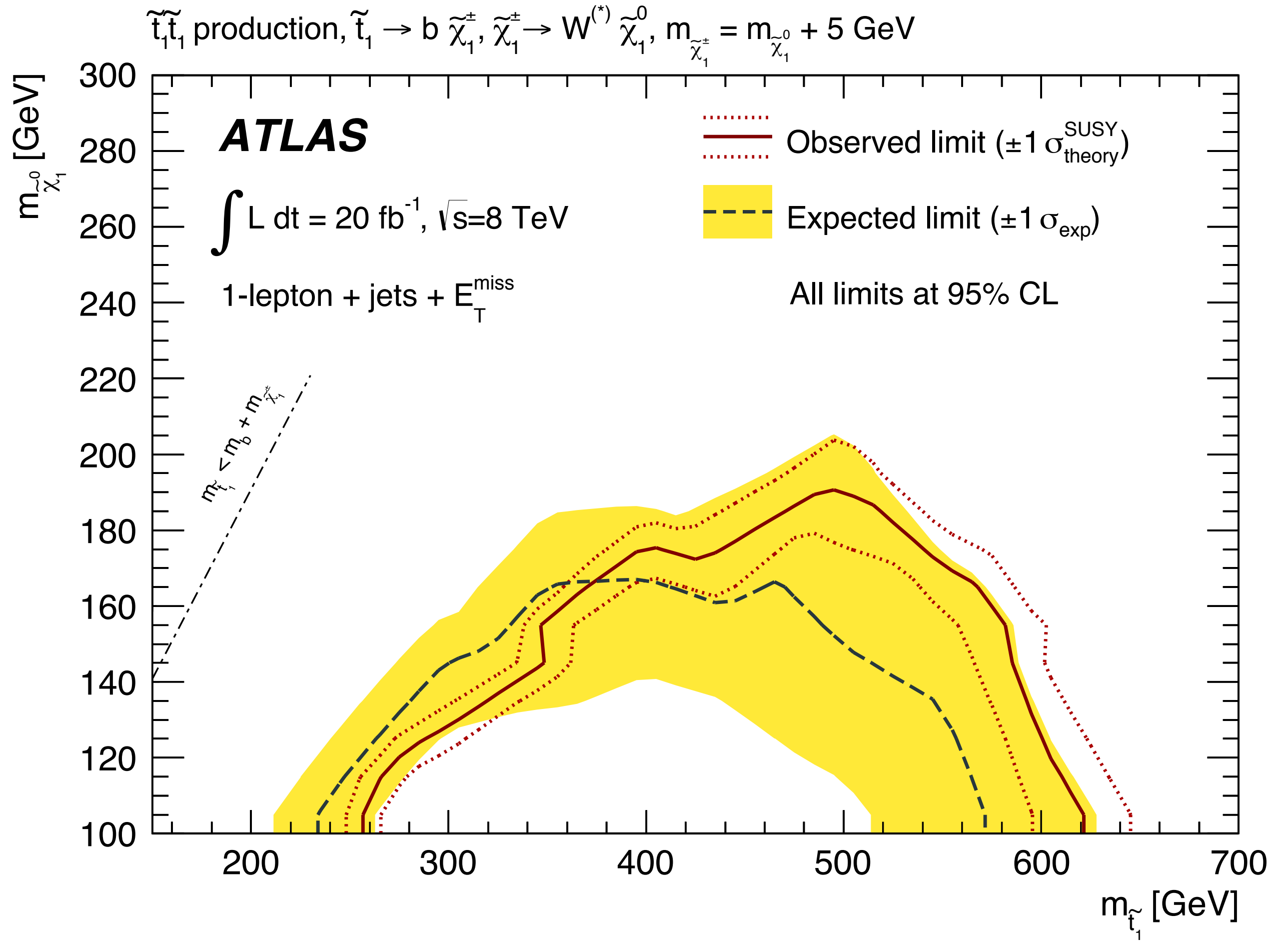
- precision observables sensitive to BSM exist (σ_{tt}, $\Delta\phi(\ell\ell)$, m_{top}, …)
- observables ≠ measurement
  measurement = interpretation = theory
- **“soft” new physics (mass~m_{top})** may be hard for searches
- $m_{\tilde{t}} < m_t$ and $m_{\tilde{t}} < m_t - m_\chi$ very worth looking at
- **precision is an asset**
- BSM **signal injections** in top mass measurements
- **top as a source** of new physics, also **trigger**

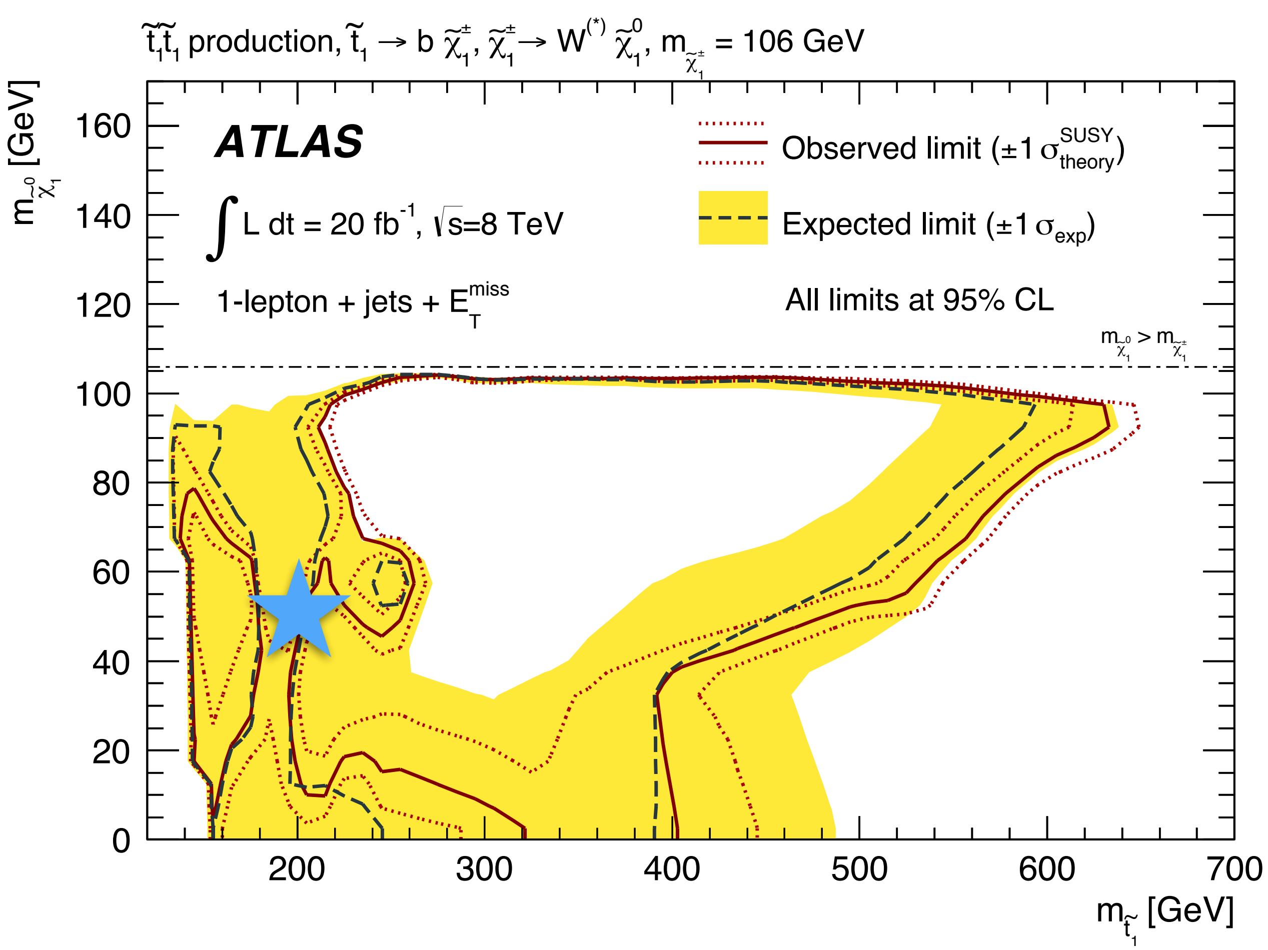
maybe interesting to look for BSM

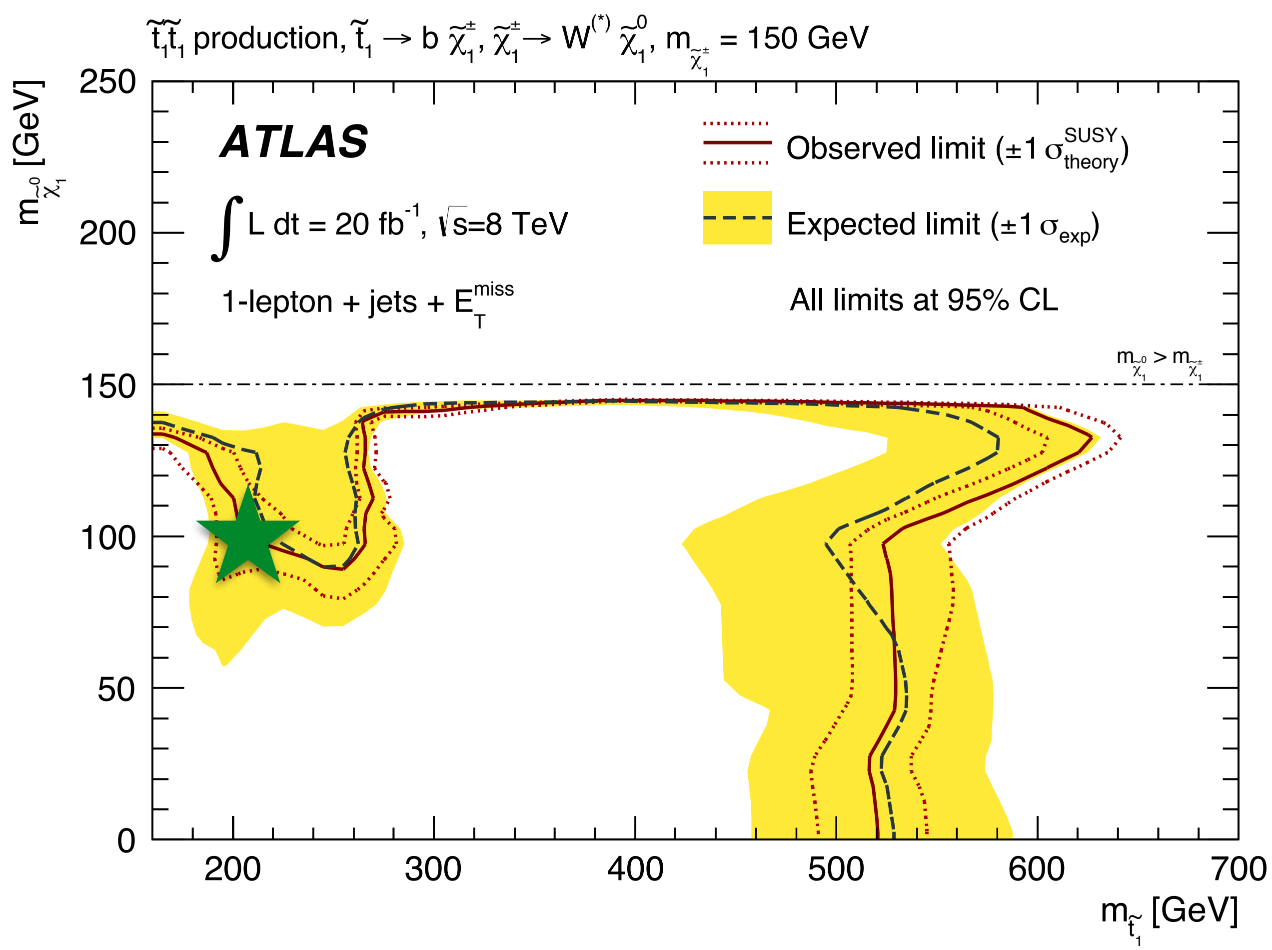
- rare or soft BSM decays of W and b into $\mathbf{t\bar{t}}$ sample
- rare or soft BSM associated to $\mathbf{t\bar{t}}$

Thank you!

Some Chargino bounds





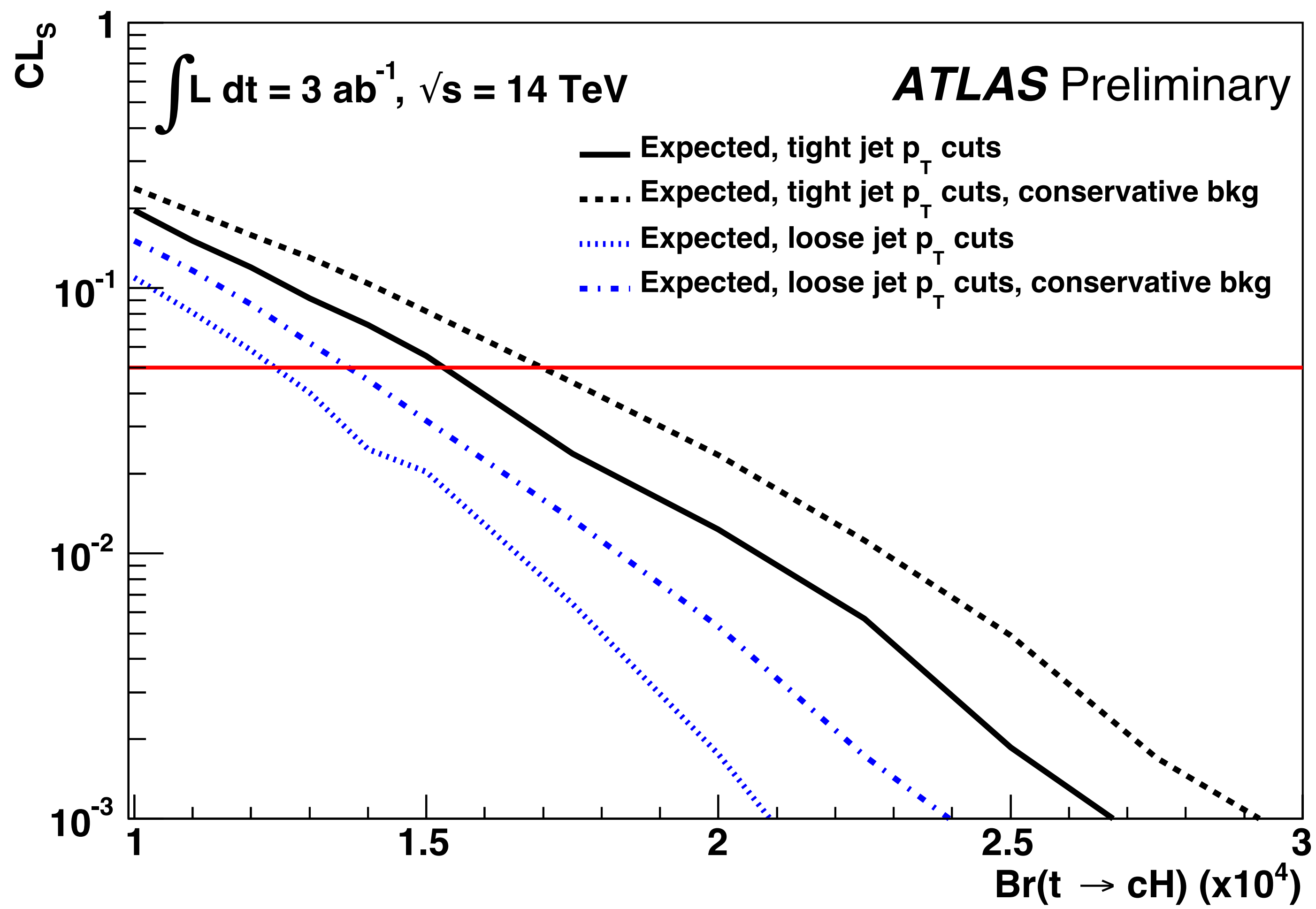


BSM Top FCNC overview

1311.2028, ATL-PHYS-PUB-2013-012, CMS-PAS-FTR-13-016

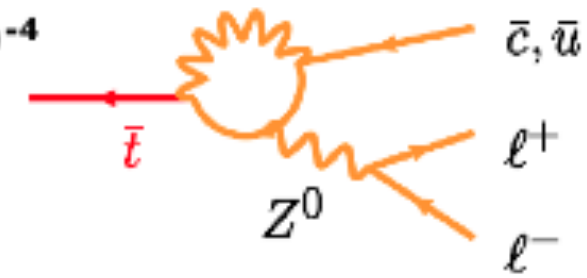
Process	SM	2HDM(FV)	2HDM(FC)	MSSM	RPV	RS
$t \to Zu$	7×10^{-17}	–	–	$\leq 10^{-7}$	$\leq 10^{-6}$	–
$t \to Zc$	1×10^{-14}	$\leq 10^{-6}$	$\leq 10^{-10}$	$\leq 10^{-7}$	$\leq 10^{-6}$	$\leq 10^{-5}$
$t \to gu$	4×10^{-14}	–	–	$\leq 10^{-7}$	$\leq 10^{-6}$	–
$t \to gc$	5×10^{-12}	$\leq 10^{-4}$	$\leq 10^{-8}$	$\leq 10^{-7}$	$\leq 10^{-6}$	$\leq 10^{-10}$
$t \to \gamma u$	4×10^{-16}	–	–	$\leq 10^{-8}$	$\leq 10^{-9}$	–
$t \to \gamma c$	5×10^{-14}	$\leq 10^{-7}$	$\leq 10^{-9}$	$\leq 10^{-8}$	$\leq 10^{-9}$	$\leq 10^{-9}$
$t \to hu$	2×10^{-17}	6×10^{-6}	–	$\leq 10^{-5}$	$\leq 10^{-9}$	–
$t \to hc$	3×10^{-15}	2×10^{-3}	$\leq 10^{-5}$	$\leq 10^{-5}$	$\leq 10^{-9}$	$\leq 10^{-4}$

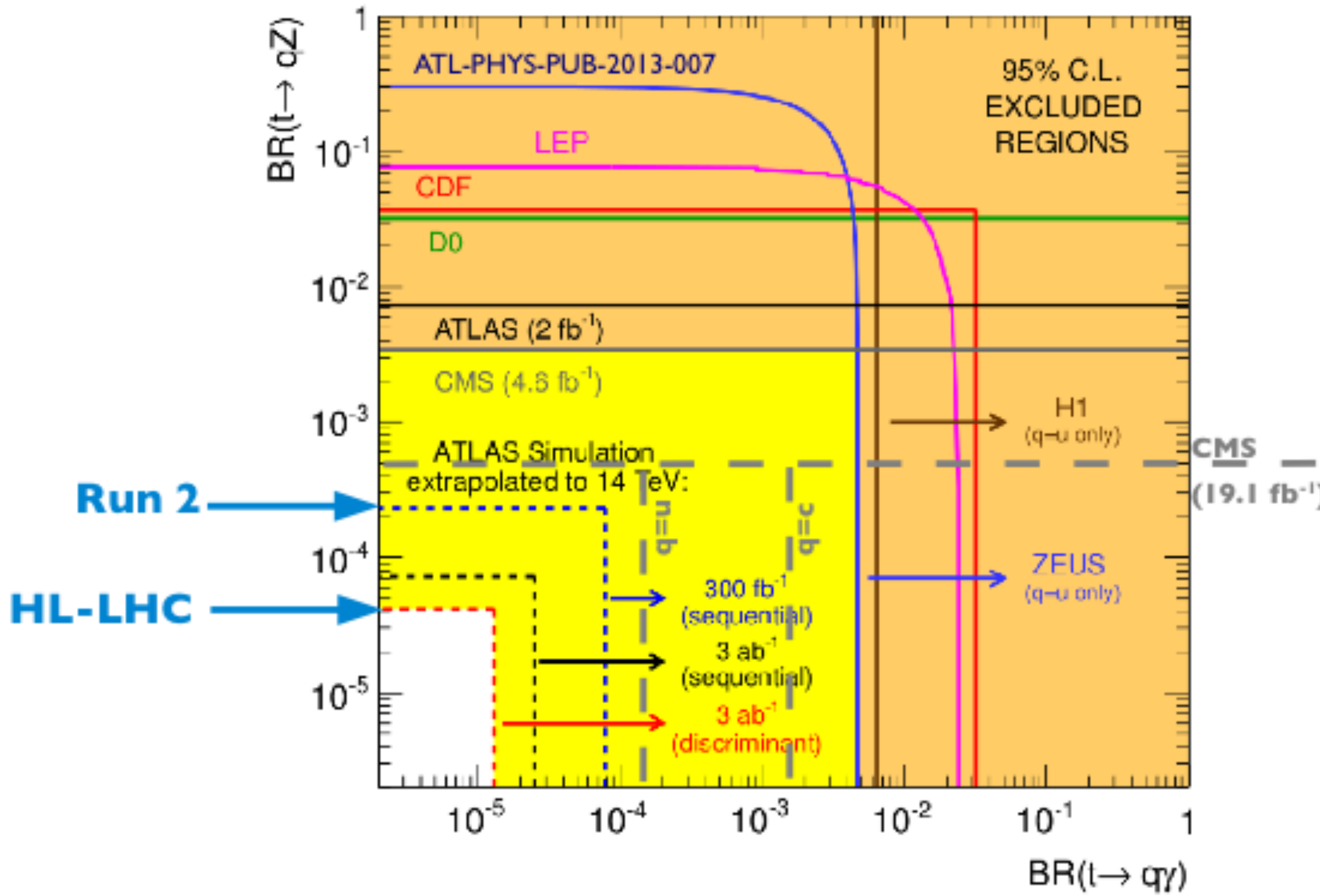
$t \to cH \to \gamma\gamma$



Couplings : FCNCs

- **BSM** models **may give** rise to **FCNC at the level of BR<10^{-4}**
  - would be at the level of 10^{-17}-10^{-12} in the SM
  - higher luminosity will definitely help to reach nearer BSM scenarios



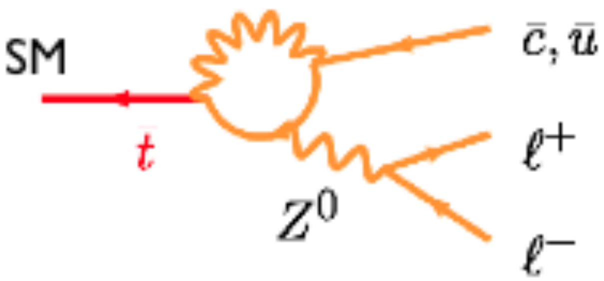


Higher reach in mass than the LHC will ever produce directly

from R. Chierici at GGI 2014

Couplings : FCNCs

- **BSM** models **may give** rise to **FCNC at the level of BR<10^{-4}**
  - via neutral bosons: Z, γ, gluons and Higgs : at the level of 10^{-17}-10^{-12} in the SM
  - higher luminosity will definitely help to reach nearer BSM scenarios



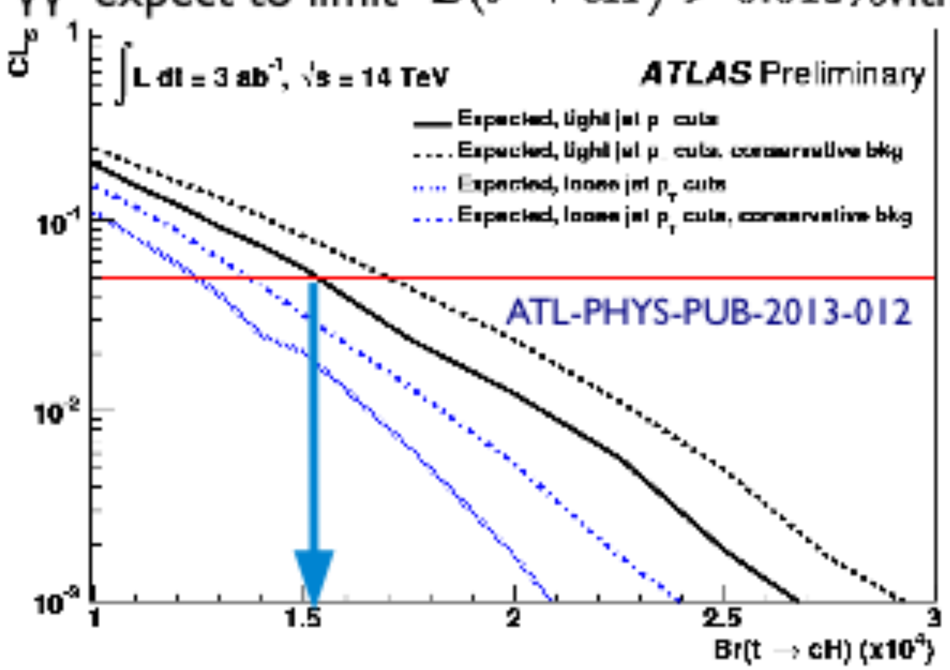
arXiv:1311.2028

Process	SM	2HDM(FV)	2HDM(FC)	MSSM	RPV	RS
$t \to Zu$	7×10^{-17}	–	–	$\lesssim 10^{-7}$	$\lesssim 10^{-6}$	–
$t \to Zc$	1×10^{-14}	$\lesssim 10^{-6}$	$\lesssim 10^{-10}$	$\lesssim 10^{-7}$	$\lesssim 10^{-6}$	$\lesssim 10^{-5}$
$t \to gu$	4×10^{-14}	–	–	$\lesssim 10^{-7}$	$\lesssim 10^{-6}$	–
$t \to gc$	5×10^{-12}	$\lesssim 10^{-4}$	$\lesssim 10^{-8}$	$\lesssim 10^{-7}$	$\lesssim 10^{-6}$	$\lesssim 10^{-10}$
$t \to \gamma u$	4×10^{-16}	–	–	$\lesssim 10^{-8}$	$\lesssim 10^{-9}$	–
$t \to \gamma c$	5×10^{-14}	$\lesssim 10^{-7}$	$\lesssim 10^{-9}$	$\lesssim 10^{-8}$	$\lesssim 10^{-9}$	$\lesssim 10^{-9}$
$t \to hu$	2×10^{-17}	6×10^{-6}	–	$\lesssim 10^{-5}$	$\lesssim 10^{-9}$	–
$t \to hc$	3×10^{-15}	2×10^{-3}	$\lesssim 10^{-5}$	$\lesssim 10^{-5}$	$\lesssim 10^{-9}$	$\lesssim 10^{-4}$

t → Z/h + c strongest potential for discovery stories at the LHC of flavour-violating or composite-Higgs models

Extrapolating JHEP 06 (2014) 008

- H → γγ expect to limit $\mathcal{B}(t \to cH) > 0.015\%$ with 3 ab^{-1}



Extrapolating PRL 112 (2014) 171802

- Limit $\mathcal{B}(t \to qZ) < 0.027\ (0.01)\%$ with 300 fb^{-1} (3ab^{-1})
- **If $\mathcal{B}(t \to qZ) > 0.02\%$ → 5σ discovery with 3ab^{-1}**

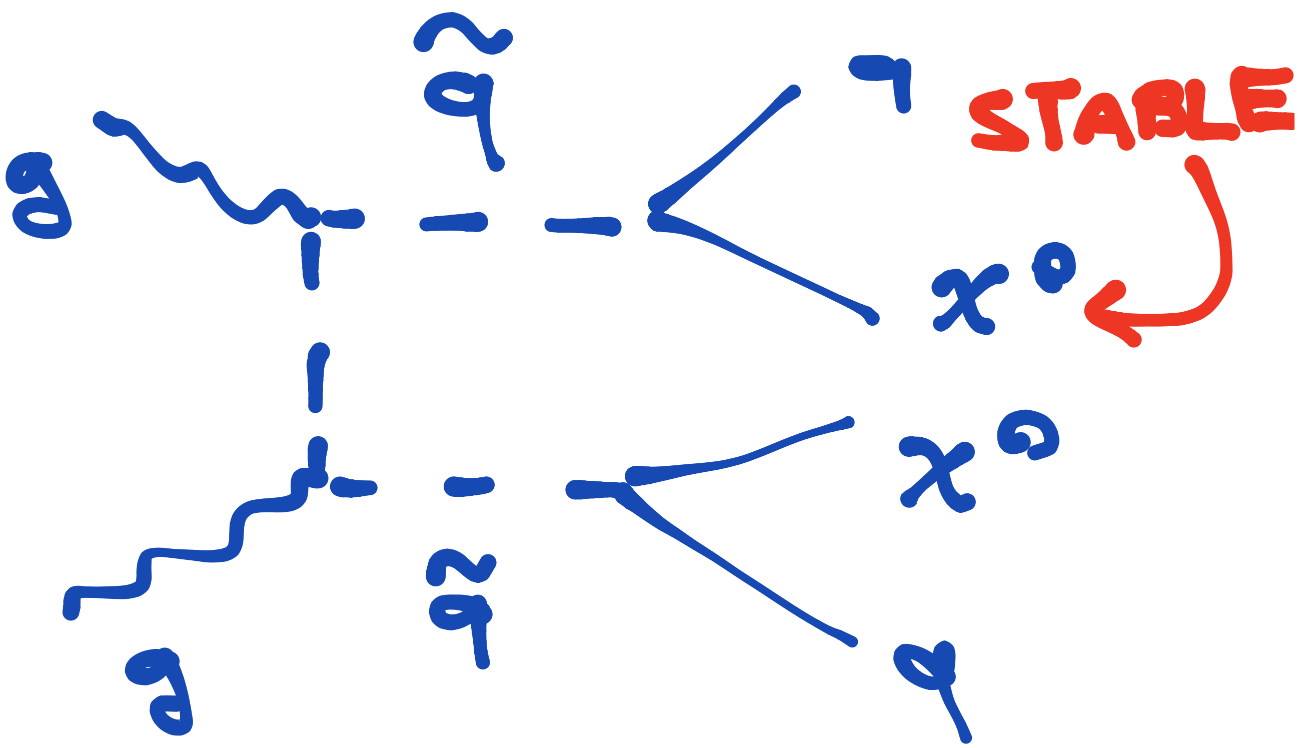
CMS-PAS-FTR-13-016

Uncertainty (%)	19.5 fb^{-1} @ 8 TeV	300 fb^{-1} @ 14 TeV	3000 fb^{-1} @ 14 TeV
Jet energy scale	13.5	3.5	3.4
$\not{E}_T$ resolution	3.2	3.2	3.2
MC Statistics	5.3	1.4	1.3
σ(tqZ)/ σ(Vtt)	3.1	1.0	0.8
b-tagging	17.7	4.5	4.2
Total	23	7	7

from R. Chierici at GGI 2014

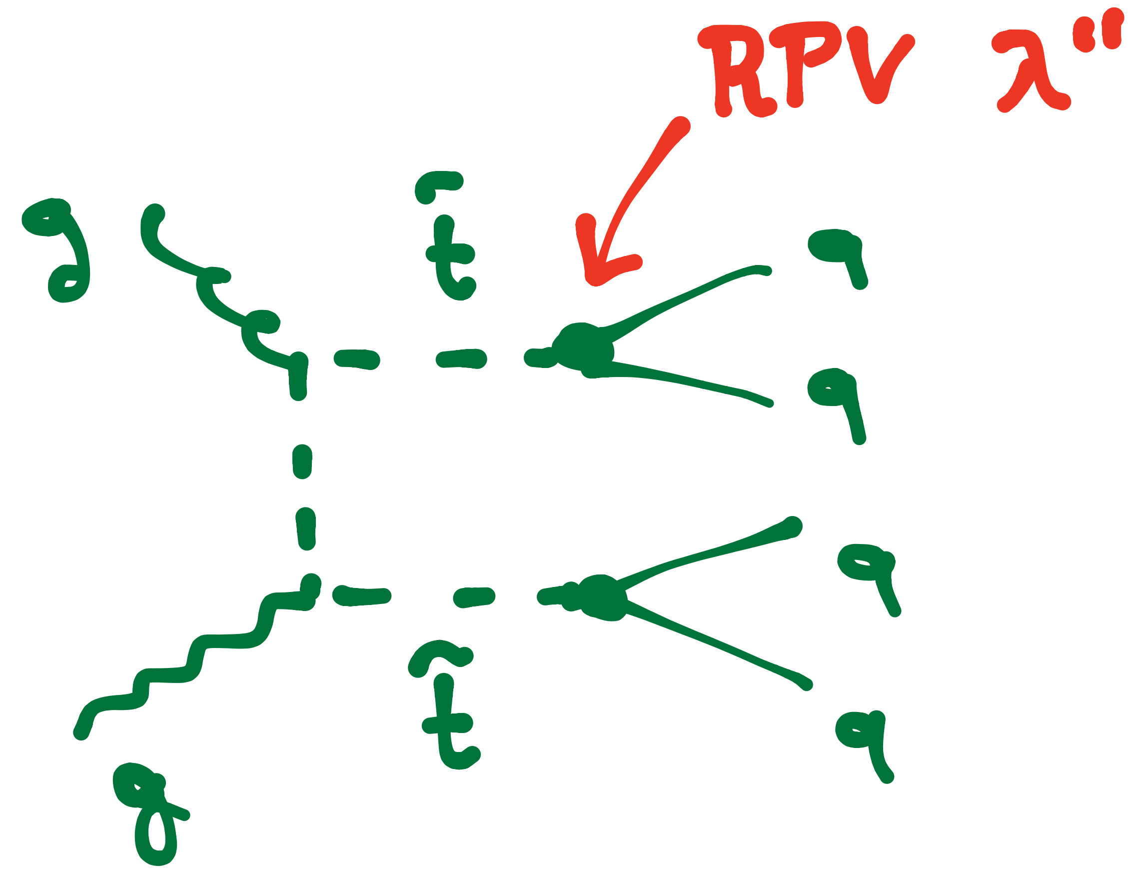
Squark production

RPC



jet + mET

RPV



multi-jet

RPV $\tilde{t}\, \chi^+ \chi^0$ simplified model