



3rd Generation CMS Results



Steven Lowette

University of California, Santa Barbara

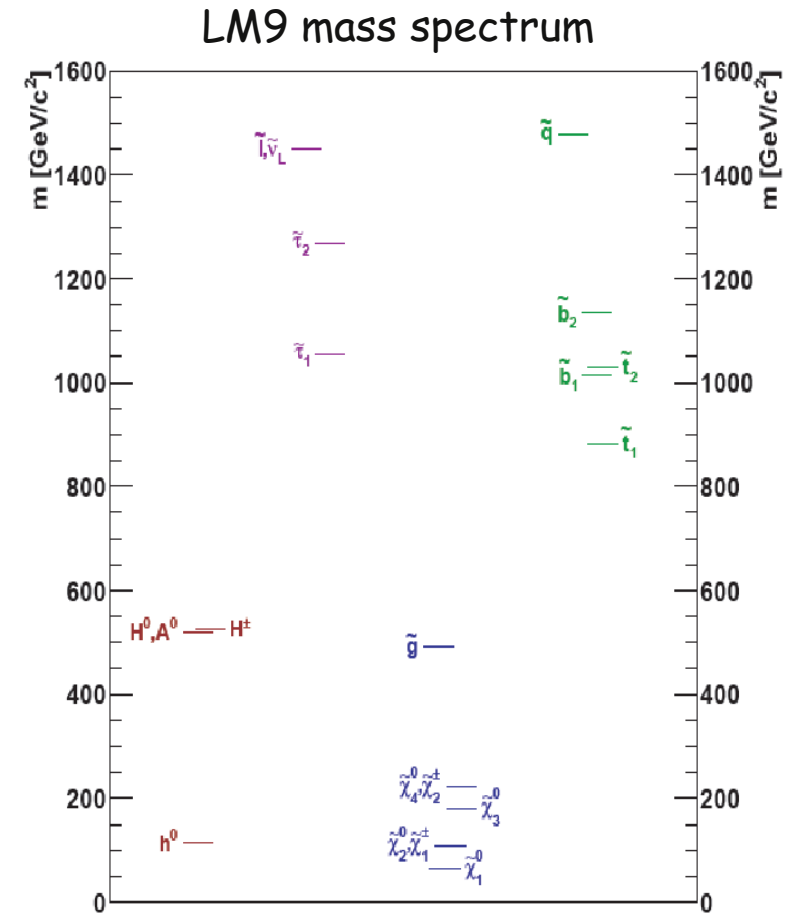
on behalf of the CMS Collaboration

Outline

- ♦ introduction
- ♦ $MT2+b$
- ♦ MET+b
- ♦ interpretation
- ♦ outlook

Introduction

- ♦ 3rd generation is special
 - expected light, stabilizing the Higgs
 - mixing because of large top Yukawa
 - couples strongest to Higgs/Higgsino
- ♦ final states with b's and MET arise from direct stop/sbottom production, or from gluino decays
- ♦ with 2010 LHC data CMS published a dedicated inclusive hadronic search with b-jets
 - arxiv:1106.3272 ; JHEP 1107:113 (2011)
- ♦ also in 2011 searches have been inclusive so far
 - go after the signature with b-jets, not a particular model
 - use b-enriched models (eg. LM9 in CMSSM) as a guideline
- ♦ two all- hadronic analyses today, with 1.1 fb^{-1}
 - MT2+b and MET+b
- ♦ for latest CMS results with taus, see previous workshop
 - <http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=141983>



MT2+b selection

♦ search variable **MT2**:
$$M_{T2} = \min_{p_T^{X(1)} + p_T^{X(2)} = p_T^{\text{miss}}} \left[\max \left(m_T^{(1)}, m_T^{(2)} \right) \right]$$

- extension of MT for pair produced particles
- endpoint at value of primary sparticle mass for sparticle → visible particles + neutralino
 - signal events with MT2 value at the endpoint have a correct LSP mass estimation

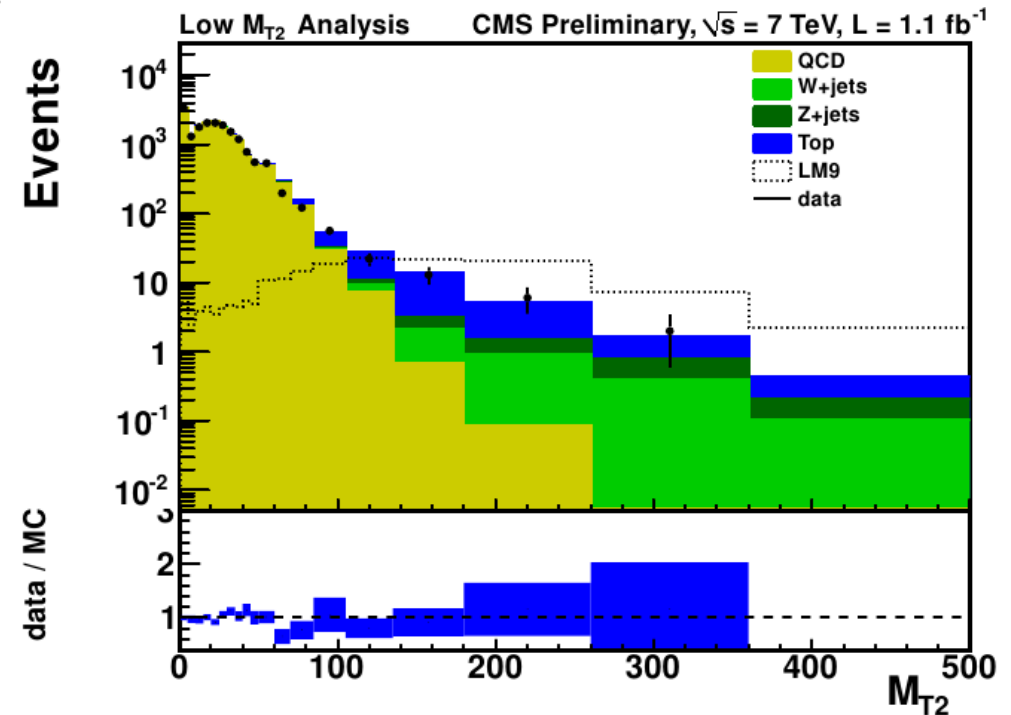
♦ two search regions

- high MT2 region: $MT2 > 400 \text{ GeV}$
- low MT2 region: $MT2 > 150 \text{ GeV} + \text{b-jet}$

♦ use high eff. sec. vtx. b-tag algorithm

♦ main other low MT2 selections

- $HT > 650 \text{ GeV}$ (driven by trigger)
- $p_T j_{1,2} > 100 \text{ GeV}; p_T j_{3+} > 20 \text{ GeV}$
 - ≥ 4 jets
- $MET > 30 \text{ GeV}$, not aligned to any jet
- lepton veto



MT2+b backgrounds and results

- ♦ **top (and W) background dominant**
 - lost lepton and hadronic tau MC validated in control region then propagated to signal region
- ♦ **Z→neutrinos background: irreducible**
 - validation with photon/Z ratio in control region
- ♦ **QCD background negligible**
 - predicted by extrapolating untagged to b-tagged sample with flat btag eff vs MT2
- ♦ **no significant excess observed**
 - LM9: 42.9

Process	QCD	W+jets	Z+jets	Top	Other	Total Bkg.	data
After full selection	16857.5	27.8	14.8	445.3	24.6	17370	17370
MT2 > 80 GeV	58.8	7.5	5.5	61.4	0.0	133.3	131
MT2 > 100 GeV	10.1	5.2	4.6	36.9	0.0	56.9	49
MT2 > 120 GeV	3.0	3.6	3.9	23.3	0.0	33.8	26
MT2 > 135 GeV	0.8	2.7	2.6	15.8	0.0	21.9	21
MT2 > 150 GeV	0.2	2.2	1.8	10.8	0.0	15.0	19
MT2 > 165 GeV	0.1	1.7	1.6	7.6	0.0	11.0	12
MT2 > 200 GeV	0.0	0.9	1.2	3.3	0.0	5.4	5
MT2 > 250 GeV	0.0	0.5	0.7	1.5	0.0	2.7	2
MT2 > 300 GeV	0.0	0.3	0.3	0.5	0.0	1.2	0
MT2 > 350 GeV	0.0	0.1	0.1	0.2	0.0	0.4	0

MC BG expectation	Predicted BG	Data	expected σ^*BR UL	observed σ^*BR UL
15.0	10.6 ± 1.9 ± 4.8	19	0.014 pb	0.020 pb

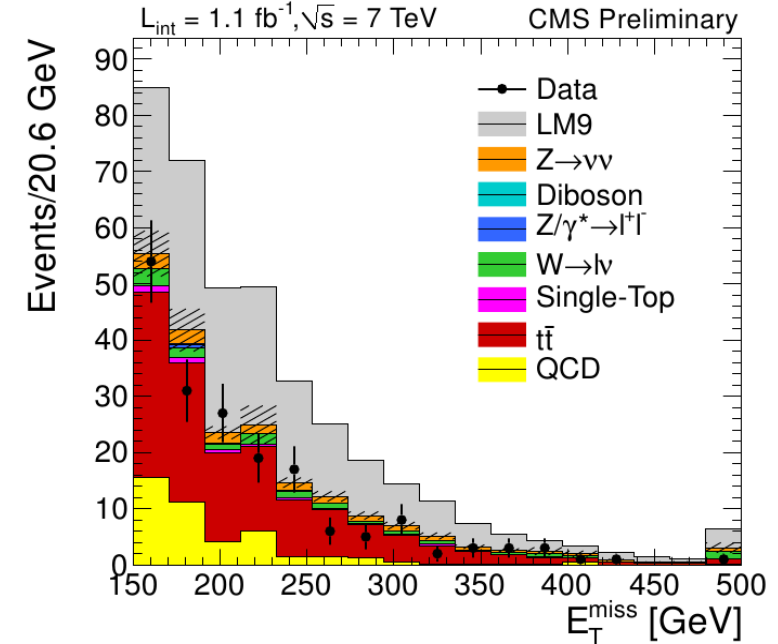
PAS-SUS-11-006

1.1fb^{-1}

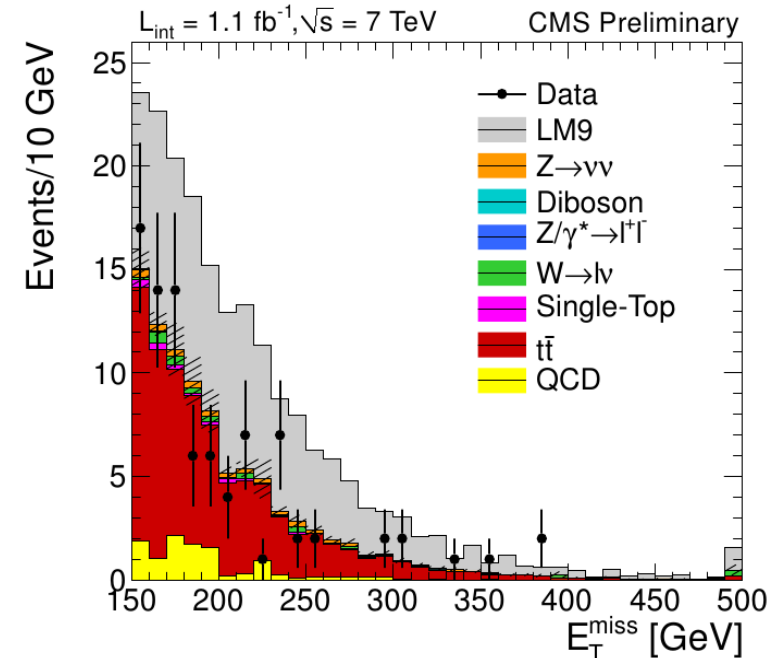
MET+b selection

- ♦ search variable MET
- ♦ four search regions
 - loose selection: $HT > 350, MET > 200\text{ GeV}$
 - tight selection: $HT > 500, MET > 300\text{ GeV}$
 - both with ≥ 1 and ≥ 2 b-tags
- ♦ use high eff. sec. vtx. b-tag algorithm
- ♦ main other selections
 - HT+MHT trigger
 - ≥ 3 jets $p_T > 50\text{ GeV}$
 - b-tagged jets $p_T > 30\text{ GeV}$
 - MET not aligned to jets
 - uses novel resolution-normalized $\Delta\phi(\text{jet}, \text{MET})$ variable
 - lepton veto

tight, 1 b tag



loose, 2 b tags



MET+b backgrounds and results

PAS-SUS-11-006

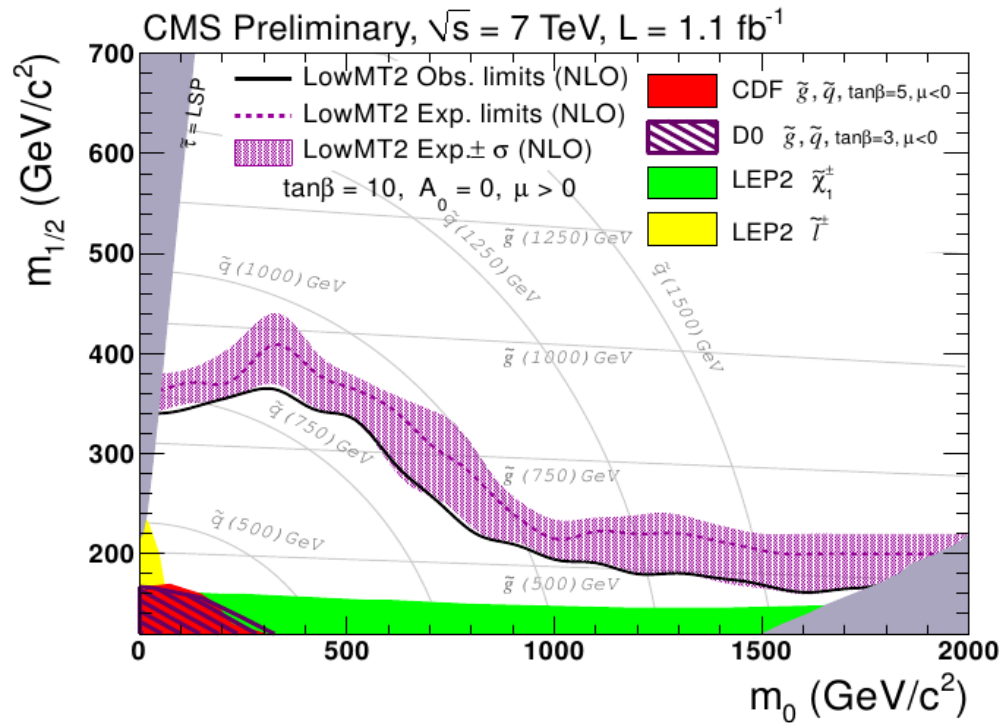
1.1fb^{-1}

- ♦ **top (and W) background dominant**
 - use MET shape in 1-lepton control sample as template for 0-lepton case
 - cross check with independent method
- ♦ **Z→neutrinos background: irreducible**
 - extrapolation of data-driven translation of Z→l+l- control sample
- ♦ **challenge with high-pT b-tagging**
 - currently very large uncertainty
 - signal b-tag efficiency assumed 0 for $p_T(b) > 350\text{GeV}$
- ♦ **QCD background negligible**
 - estimated exploiting absence of correlation between resolution-normalized $\Delta\phi(\text{jet}, \text{MET})$ variable and MET
- ♦ **background predictions in all search regions agree with data**

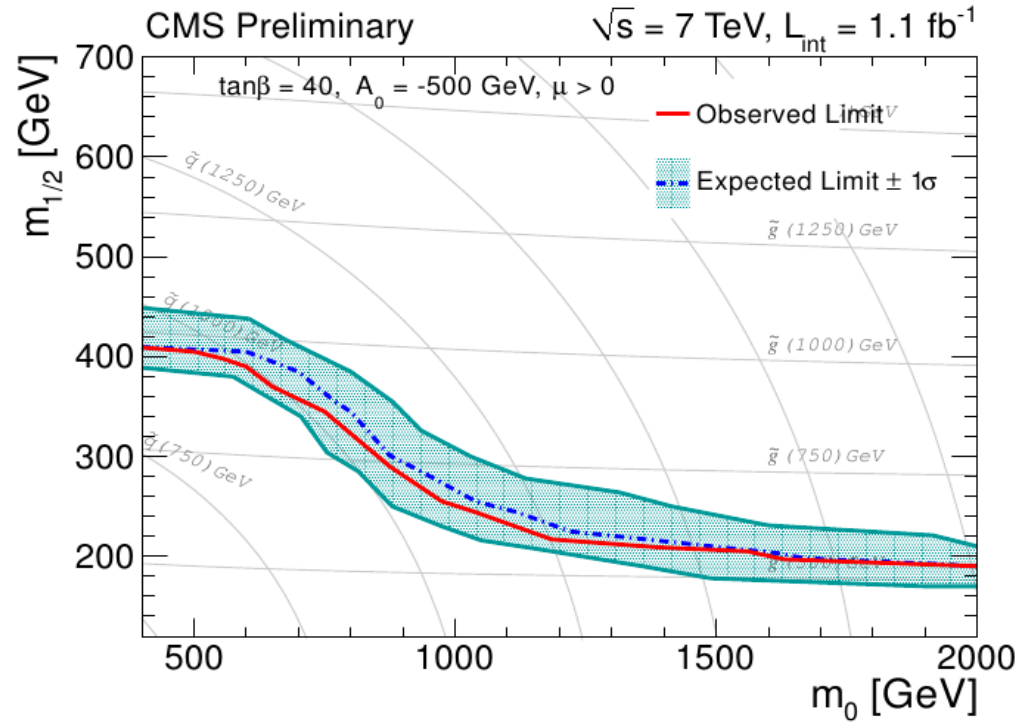
	Loose search region		Tight search region	
	$\geq 1\text{ b}$	$\geq 2\text{ b}$	$\geq 1\text{ b}$	$\geq 2\text{ b}$
QCD	$9 \pm 1 \pm 9$	$0.0 \pm 0.4^{+5.8}_{-0.0}$	$0.2 \pm 0.2^{+0.5}_{-0.2}$	$0.1 \pm 0.1^{+0.4}_{-0.1}$
top and W+jets	$108 \pm 18 \pm 13$	$24 \pm 7 \pm 5$	$13 \pm 5 \pm 4$	$7 \pm 4 \pm 3$
top and W+jets cross-check	—	—	$17.0 \pm 5.7 \pm 2.1$	$5.9 \pm 3.5 \pm 1.3$
Z → $\nu\bar{\nu}$	$24 \pm 11 \pm 4$	$2.6 \pm 2.9 \pm 2.0$	$5.0 \pm 1.6 \pm 2.0$	$0.2 \pm 0.4 \pm 0.5$
Total SM	$141 \pm 21 \pm 16$	$25.8 \pm 7.4^{+7.8}_{-5.2}$	$18.2 \pm 5.3 \pm 4.5$	$7.3 \pm 4.0 \pm 4.3$
Data	155	30	20	5

Interpretation in the CMSSM

MT2+b



MET+b



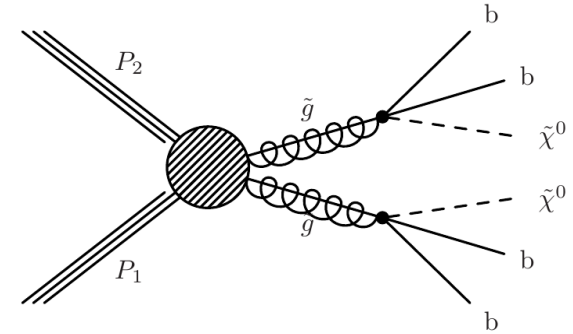
note: $\geq 1b$ 'tight' selection best everywhere

♦ similar limits

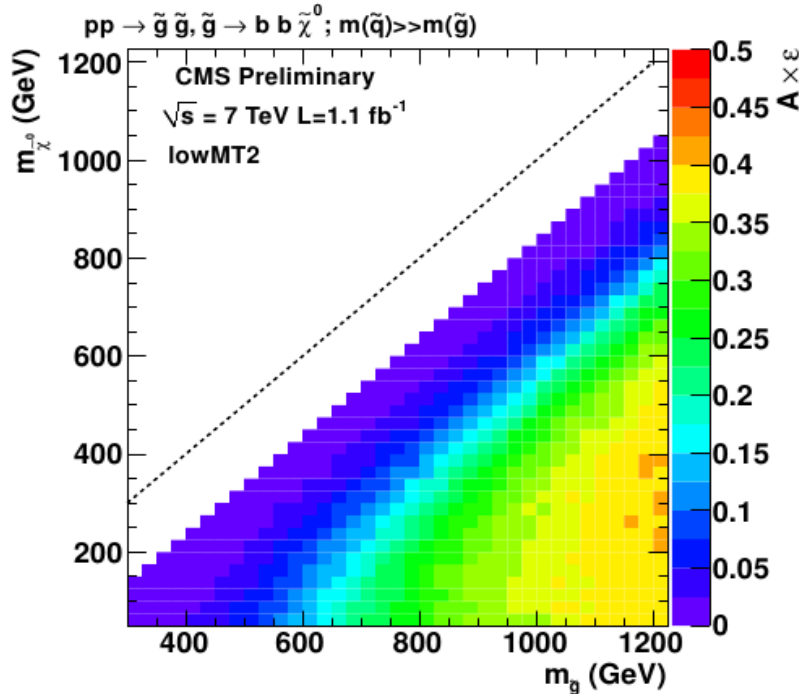
→ note though: MT2+b with $\tan\beta=10$, MET+b with $\tan\beta=40$

Interpretation in simplified models

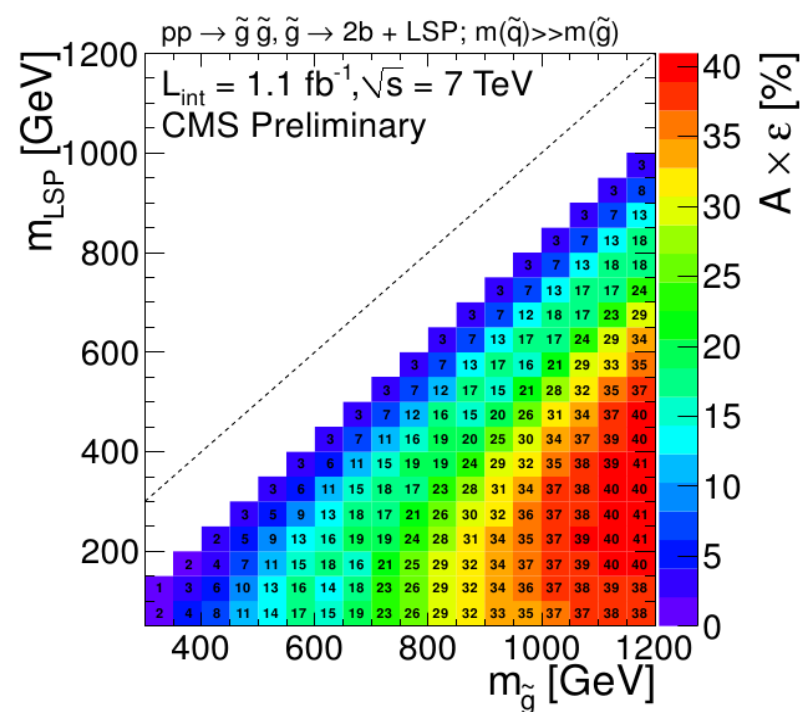
- interpret in generalizable building blocks
 - also: provides insight in the effects of kinematic extremes on our analyses
- in this case we used $pp \rightarrow \tilde{g}\tilde{g} \rightarrow bbb\tilde{\chi}^0\tilde{\chi}^0$ (aka T1bbbb)
- efficiency \times acceptance for the signal selection



MT2+b

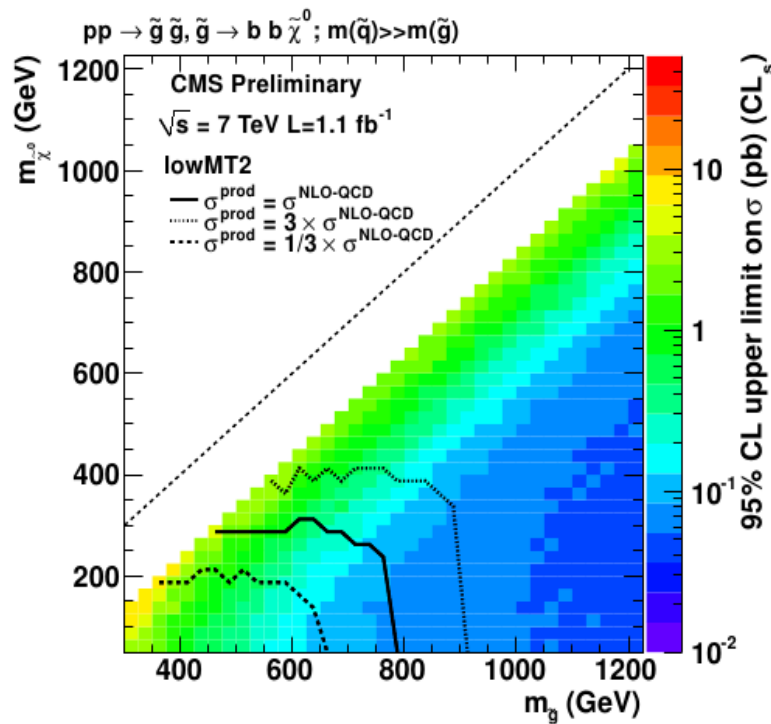


MET+b

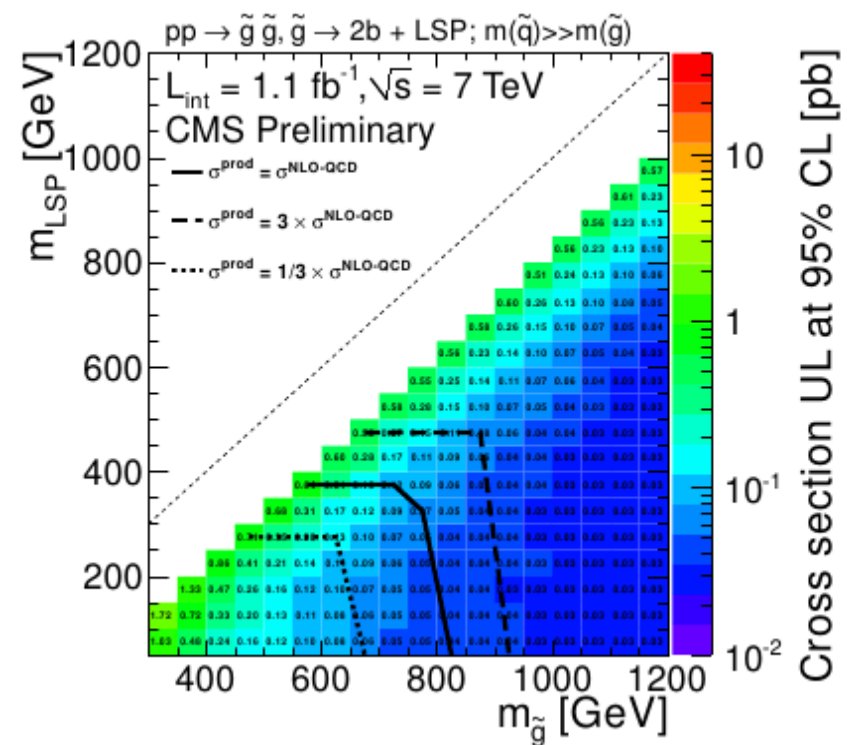


- cross section \times BR upper limits as function of gluino and LSP mass
 - exclusion curves to guide the eye wrt reference cross section

MT2+b

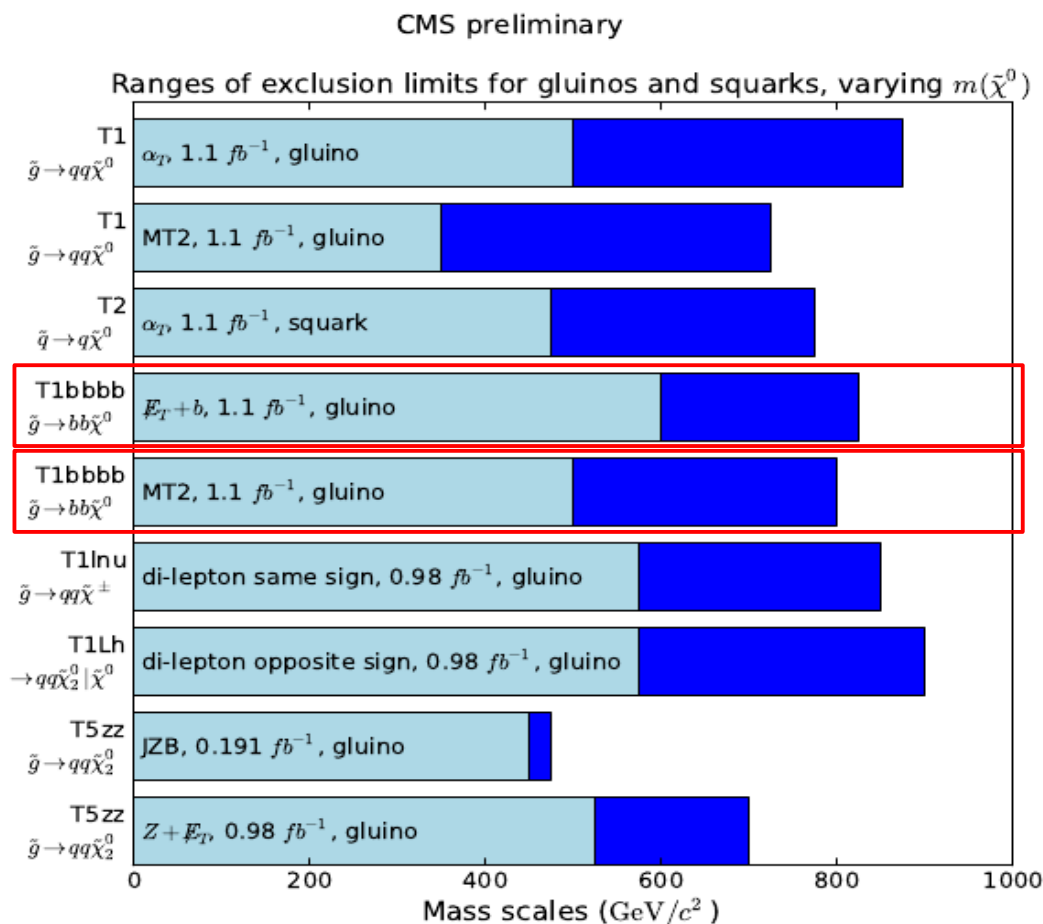


MET+b



- loose selection with 2 b-tags works best for compressed spectrum close to diagonal
- note: results too close to diagonal are very sensitive to ISR
 - we choose not to show results there because of ISR uncertainty

- ◆ gluino mass exclusion range



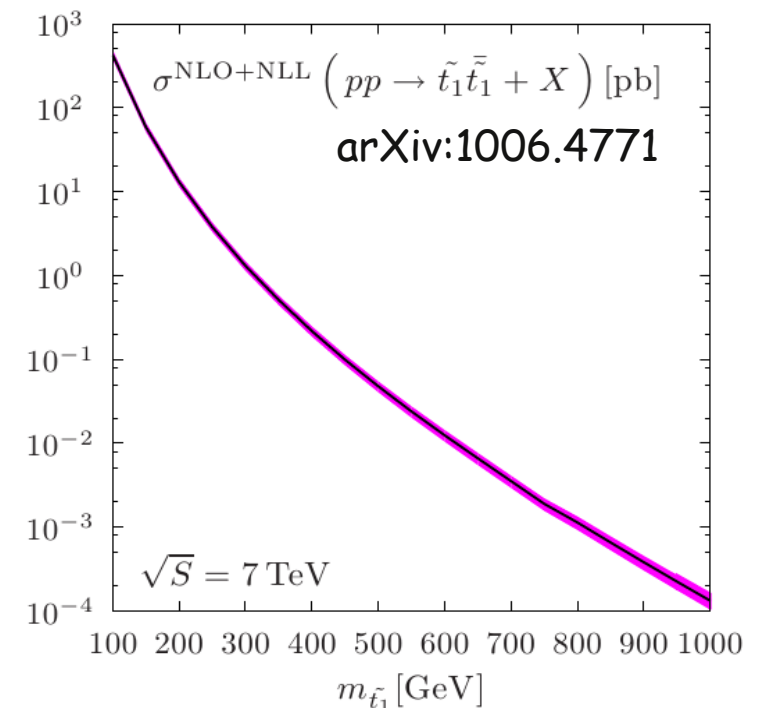
For limits on $m(\tilde{g}), m(\tilde{q}) > m(\tilde{g})$ (and vice versa), $\sigma^{prod} = \sigma^{NLO-QCD}$.

$$m(\tilde{\chi}^\pm), m(\tilde{\chi}_2^0) \equiv \frac{m(\tilde{g}) + m(\tilde{\chi}^0)}{2}$$

$m(\tilde{\chi}^0)$ is varied from $0 GeV/c^2$ (dark blue) to $m(\tilde{g}) - 200 GeV/c^2$ (light blue).

Outlook

- ♦ two *CMS* searches for inclusive hadronic final states with b-quarks presented
- ♦ SMS interpretation with 3-body gluino heavy-flavour decay
 - we exclude gluino masses up to $\sim 800 \text{ GeV}$
- ♦ next in line interpretation with top quark and intermediate sbottom topologies
- ♦ and then, of course, direct stop production
 - with 5 fb^{-1} of data on tape we're in the game
 - $m(\text{stop}) = \quad \quad \quad 200 / \quad 400 / \quad 600 \text{ GeV}$
 - # stop pairs: $\sim 60000 / \sim 1000 / \sim 60$
- ♦ several challenges
 - the lighter, the more it looks like $t\bar{t}b$
 - not much MET to play with
 - the heavier, the less inefficiency you can afford
 - trigger not necessarily straightforward
 - top reconstruction comes with inefficiency
 - and not useful in decays with intermediate sbottoms
 - ...
- ♦ will be a challenging but exciting target!





Stay tuned!