

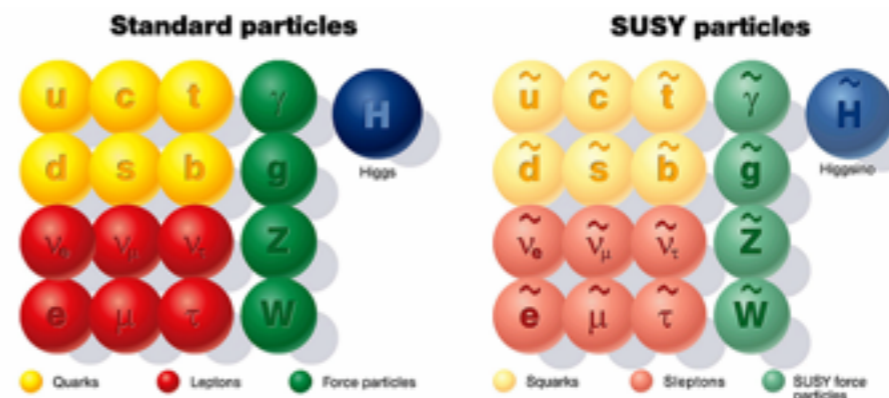
# Searches for supersymmetry at CMS using the $a_T$ variable

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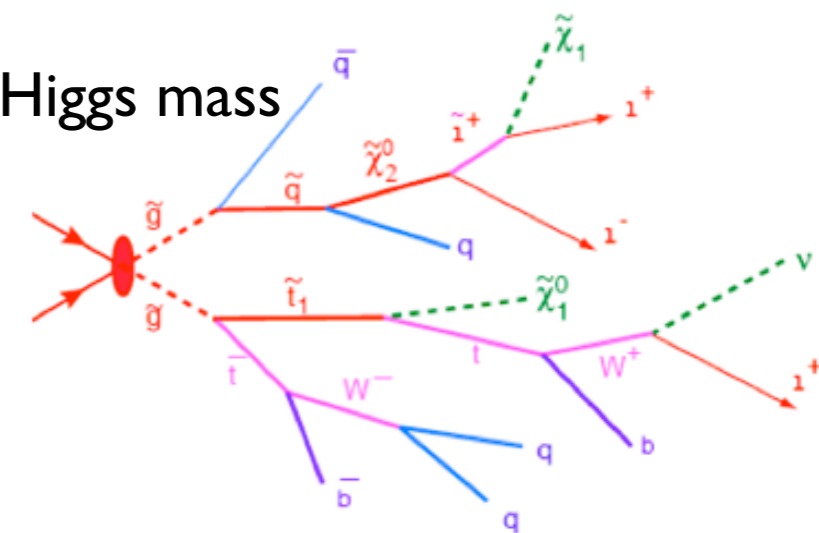
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Supersymmetry searches are an active area of research at LHC

- Theoretically well-motivated
- Dark matter candidate (LSP) under assumption of conservation of R-parity
- Solves hierarchy problem
  - ie, cancellation of quadratically divergent loop corrections to Higgs mass



Signal expected to manifest itself through events with jets and large missing  $E_T$ .

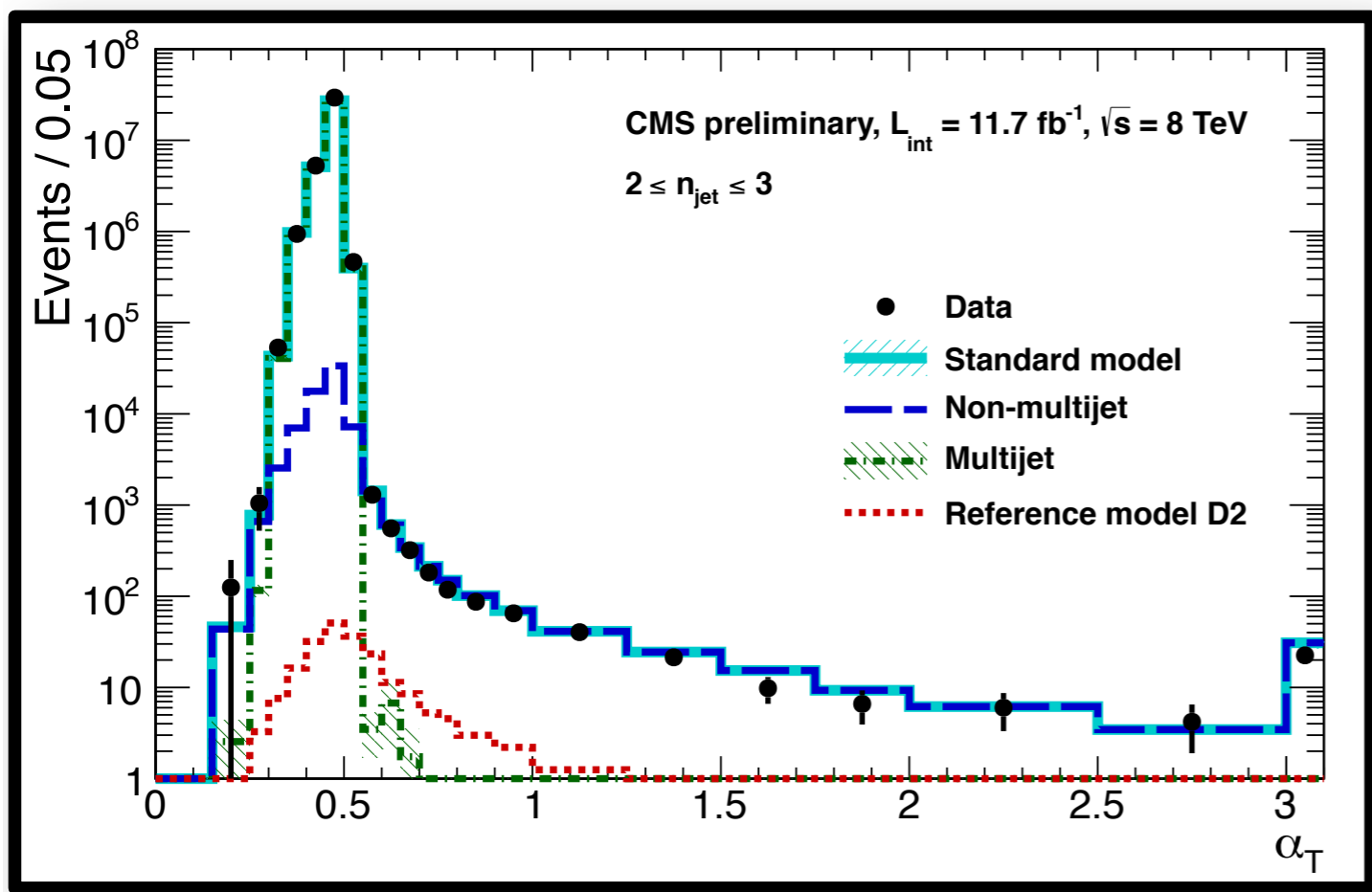


In absence of signal at 7TeV, change in focus from "constrained models defined at GUT scale" to "natural SUSY".

- Motivation supported by discovery of Higgs Boson
- Final state with large number of tops, bottoms, W-Bosons
- Address fine-tuning problem

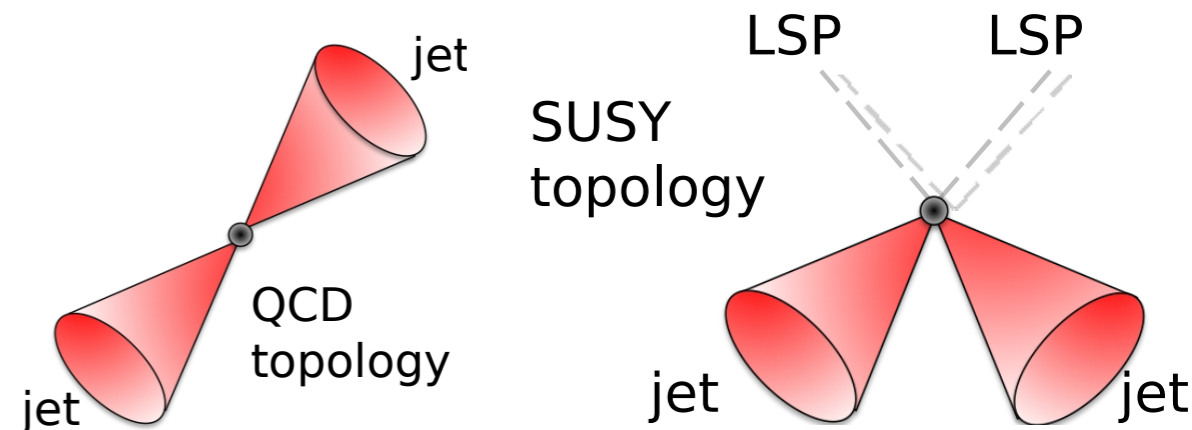
A search based around the dimensionless variable  $\alpha_T$

- Hadronic final states give largest branching fractions, however huge QCD background.
- QCD multi-jet event background suppressed to a negligible level by kinematic variable  $\alpha_T$ .



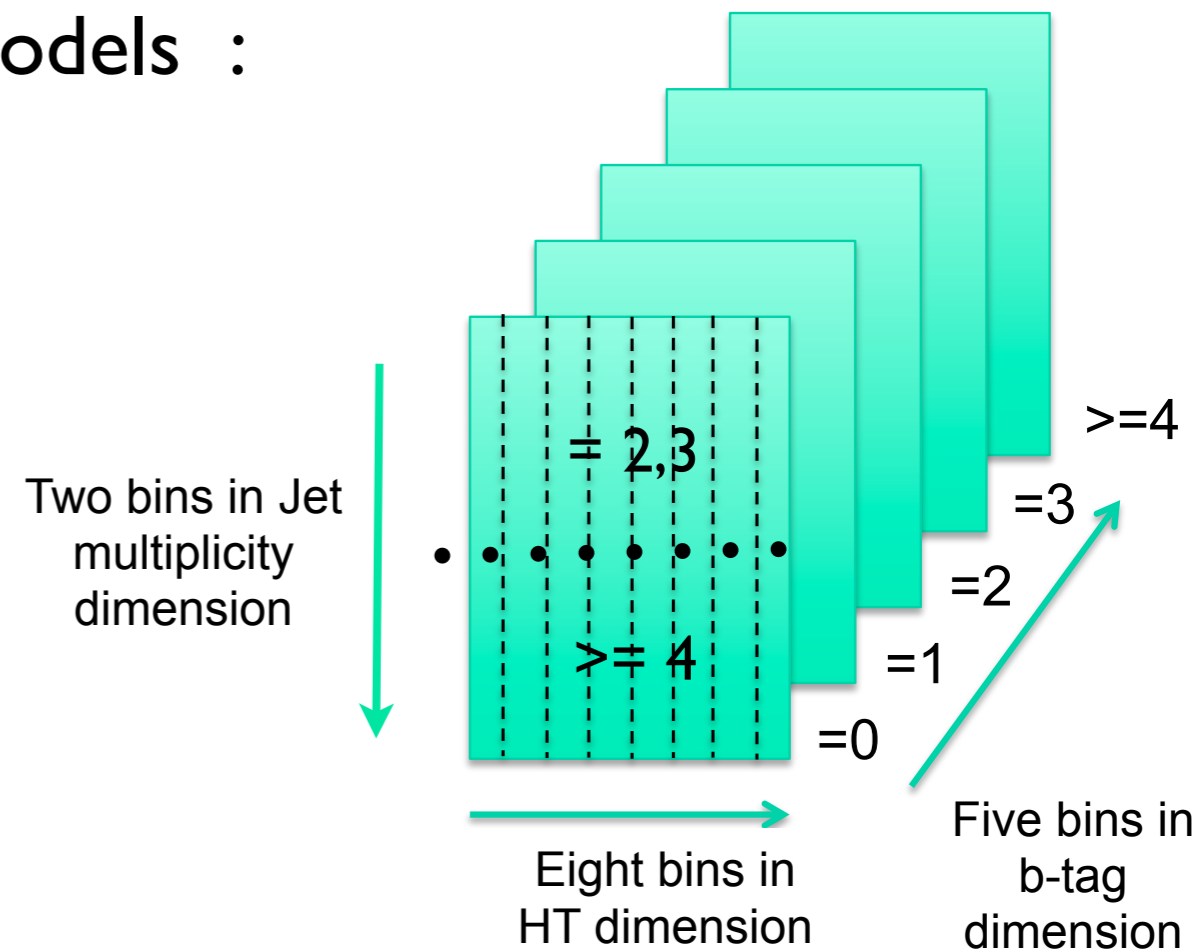
$$\alpha_T = \frac{E_T^{\text{jet}2}}{M_T} = \frac{1}{2} \times \frac{1 - (\Delta H_T / H_T)}{\sqrt{1 - (H_T^{\text{miss}} / H_T)^2}}$$

di-jet
multi-jet



$a_T$  search sensitivity to a variety of SUSY models :

- $b$ -jet enriched final states (Natural SUSY)
- $q\bar{q}$  and  $g\bar{g}$  production
- large mass splittings and compressed spectra



## Event Selection

- High  $p_T$  jets ( $p_T > 50$  GeV  $|\eta| < 3$ )
- Dedicated electron and muon ( $> 10$  GeV) and photon ( $> 25$  GeV) vetoes
- $a_T > 0.55$  and further dedicated event cleaning requirements

SM backgrounds are EWK processes with real missing  $E_T$

- W + jets,
- tt + jets
- Z  $\rightarrow$   $\nu\nu$  + Jets
- Small contribution from single top, DiBoson and DY processes

Backgrounds estimated from kinematically similar EWK rich control samples binned identically to signal region. Extrapolation to the hadronic signal region through ‘transfer factors’

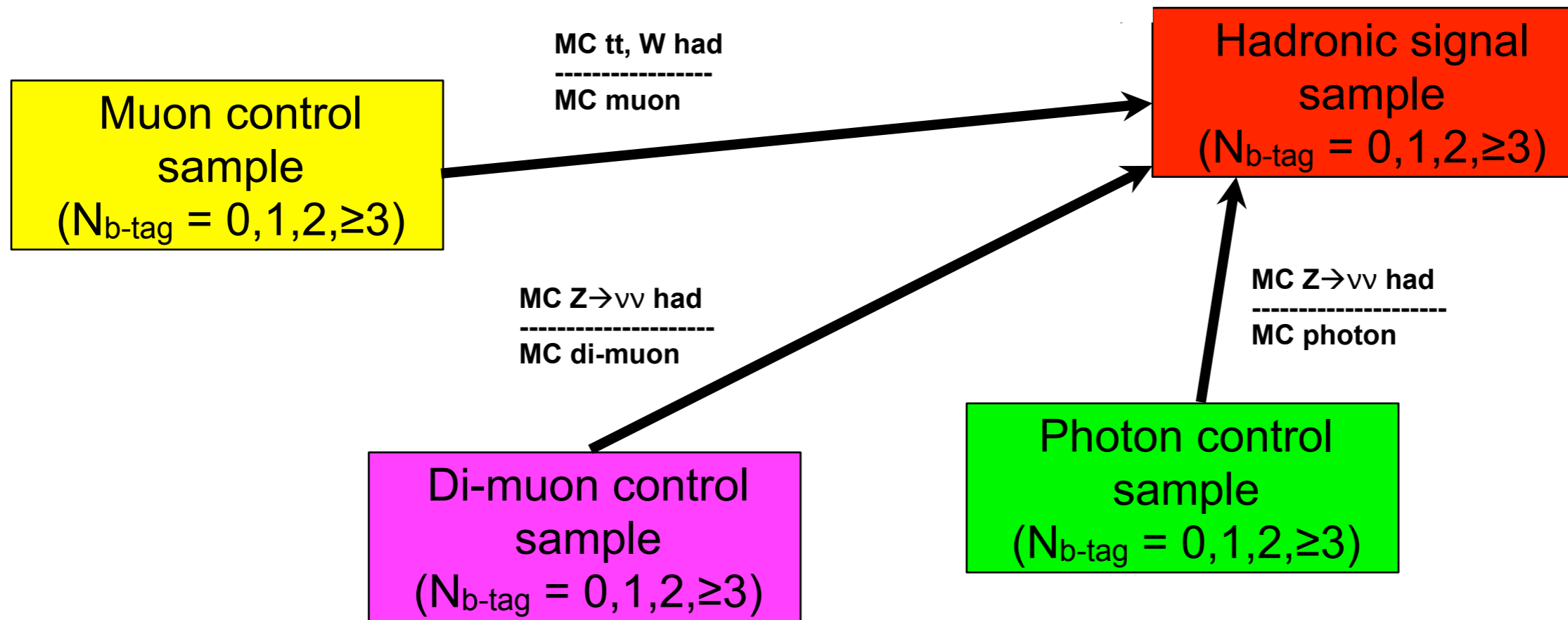
- 3 control regions defined

- Single Muon - W+jets, tt + jets + (DiBoson, top, DY)
- Single Photon - Z  $\rightarrow$   $\nu\nu$  + Jets
- DiMuon - Z  $\rightarrow$   $\nu\nu$  + Jets

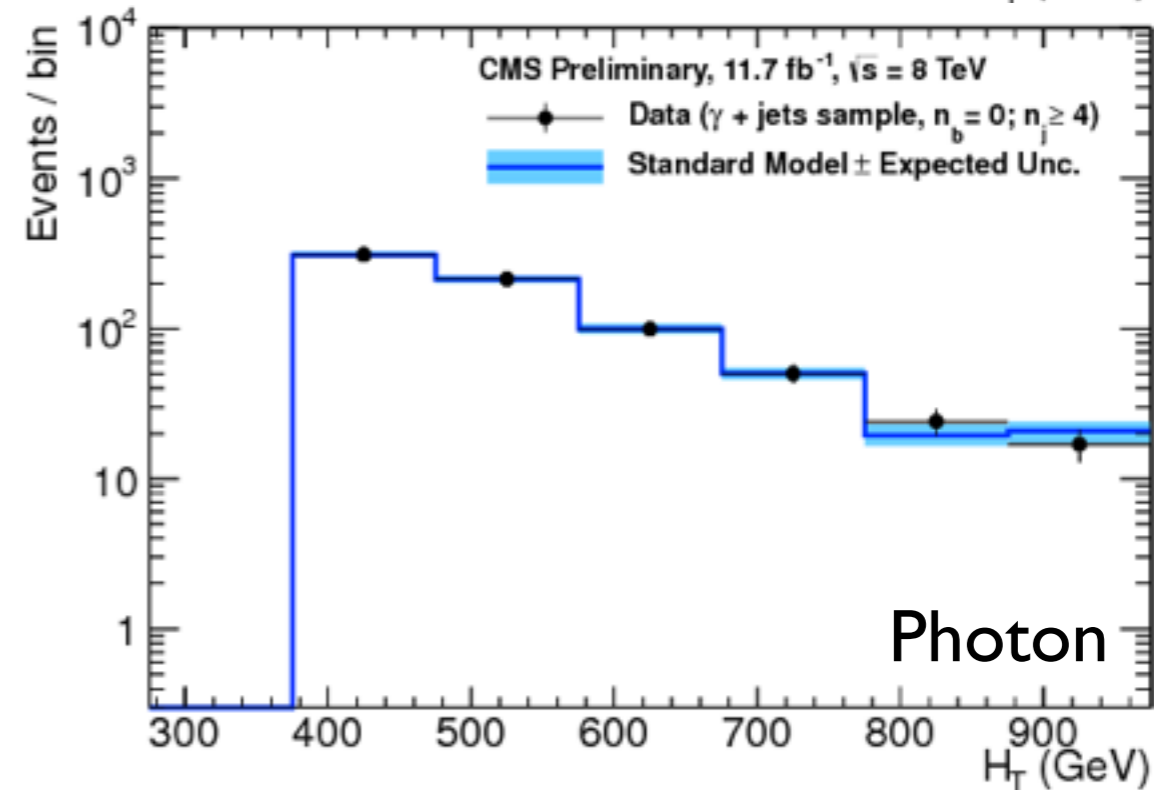
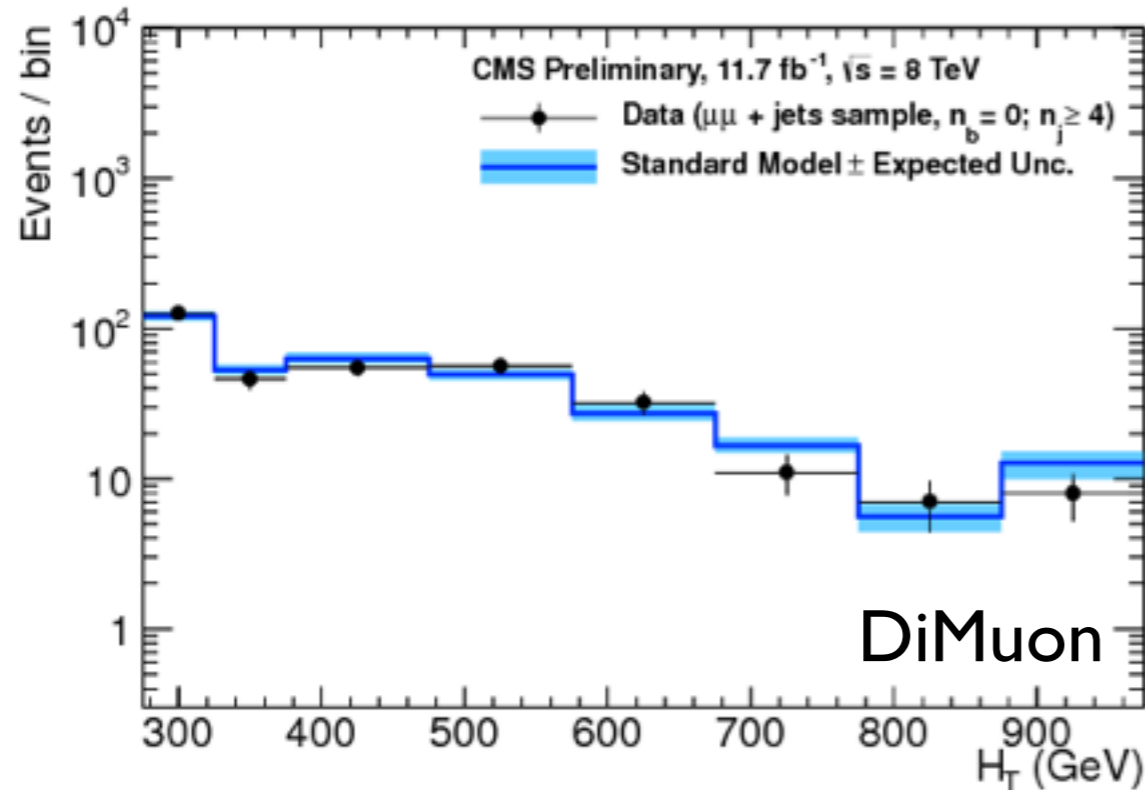
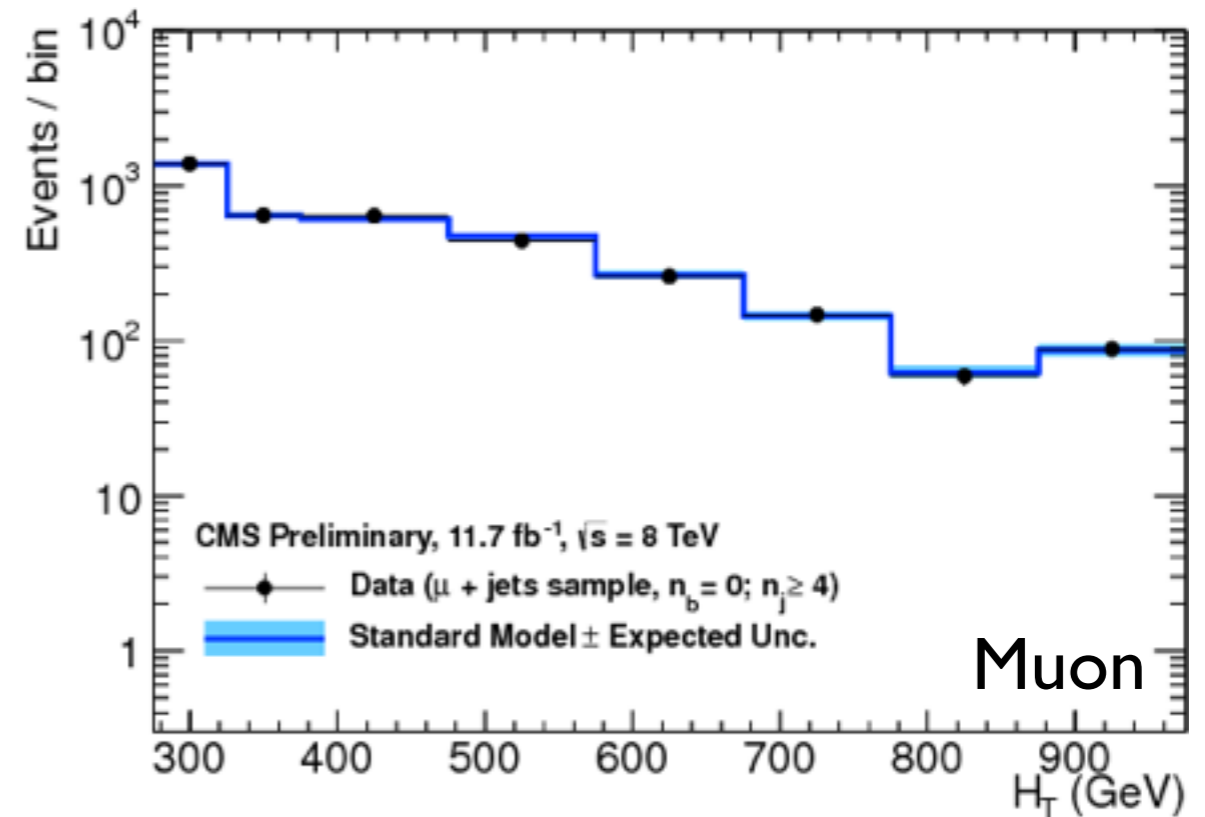
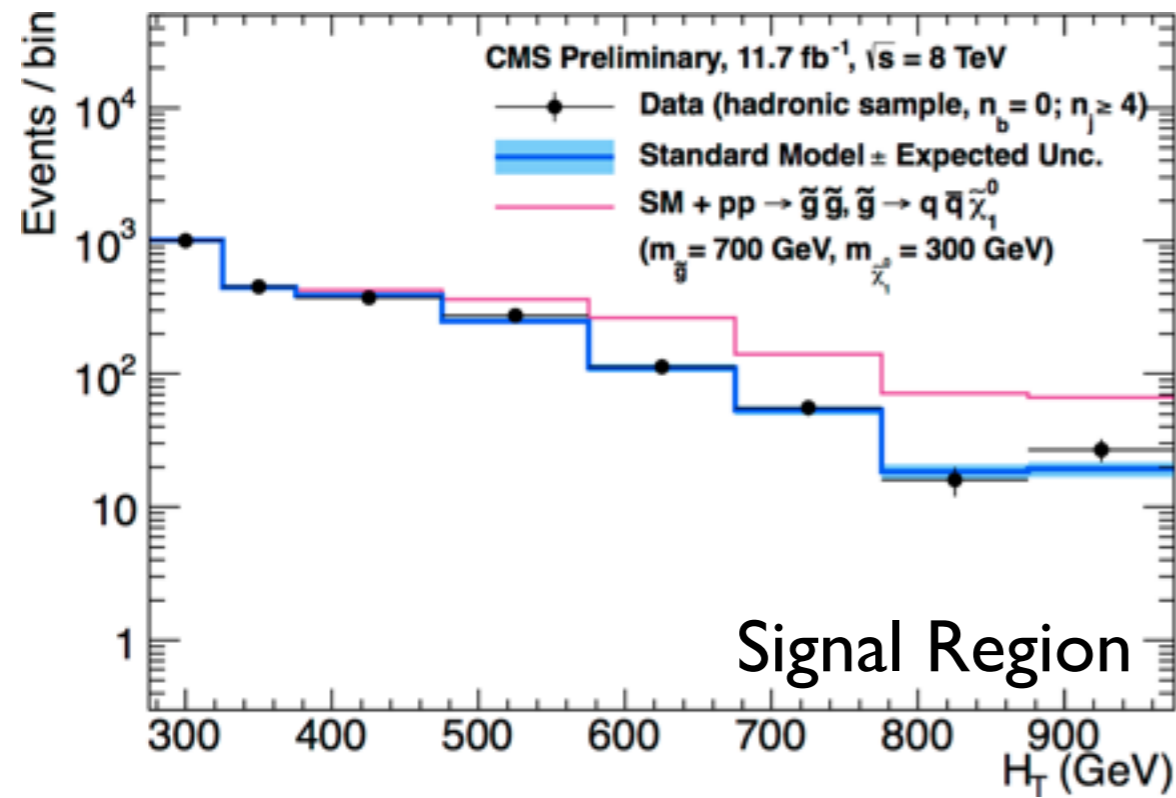
$$N_{\text{pred}}^{\text{signal}} = N_{\text{obs}}^{\text{control}} \times \frac{N_{\text{MC}}^{\text{signal}}}{N_{\text{MC}}^{\text{control}}}$$

- Any potential biases, ( Mis-modelling, PU effects, Minimise reliance on MC etc) will largely cancel
- Series of closure tests established to determine systematic uncertainties to these translation factors

Transfer factors are used to extrapolate from control samples to signal region. Simultaneous fit across all samples to produce results.



Interpretation of results made through simplified model spectra (SMS) assume a single production and decay channel and are used to interpret results of the searches.



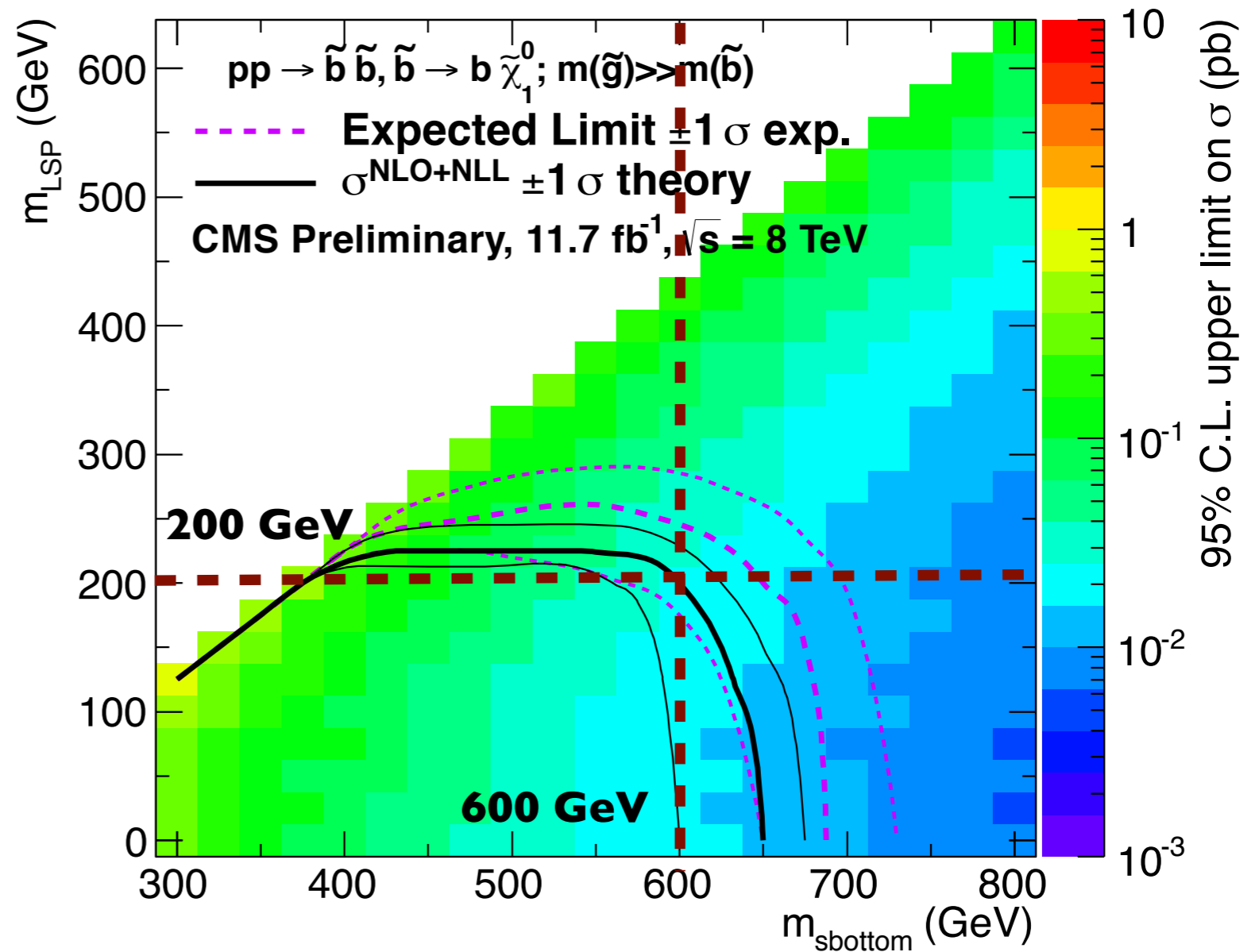
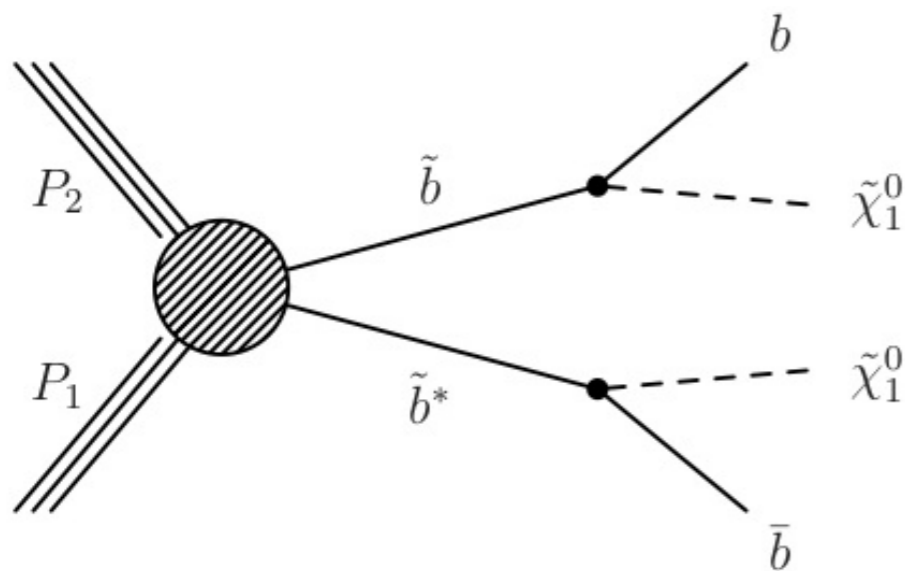
The colour scale represents the upper limit on the cross-section (pb) assuming 100% branching ratio.

## Direct squark production

### T2bb

Njet :  $\leq 3$

Btag : 1,2

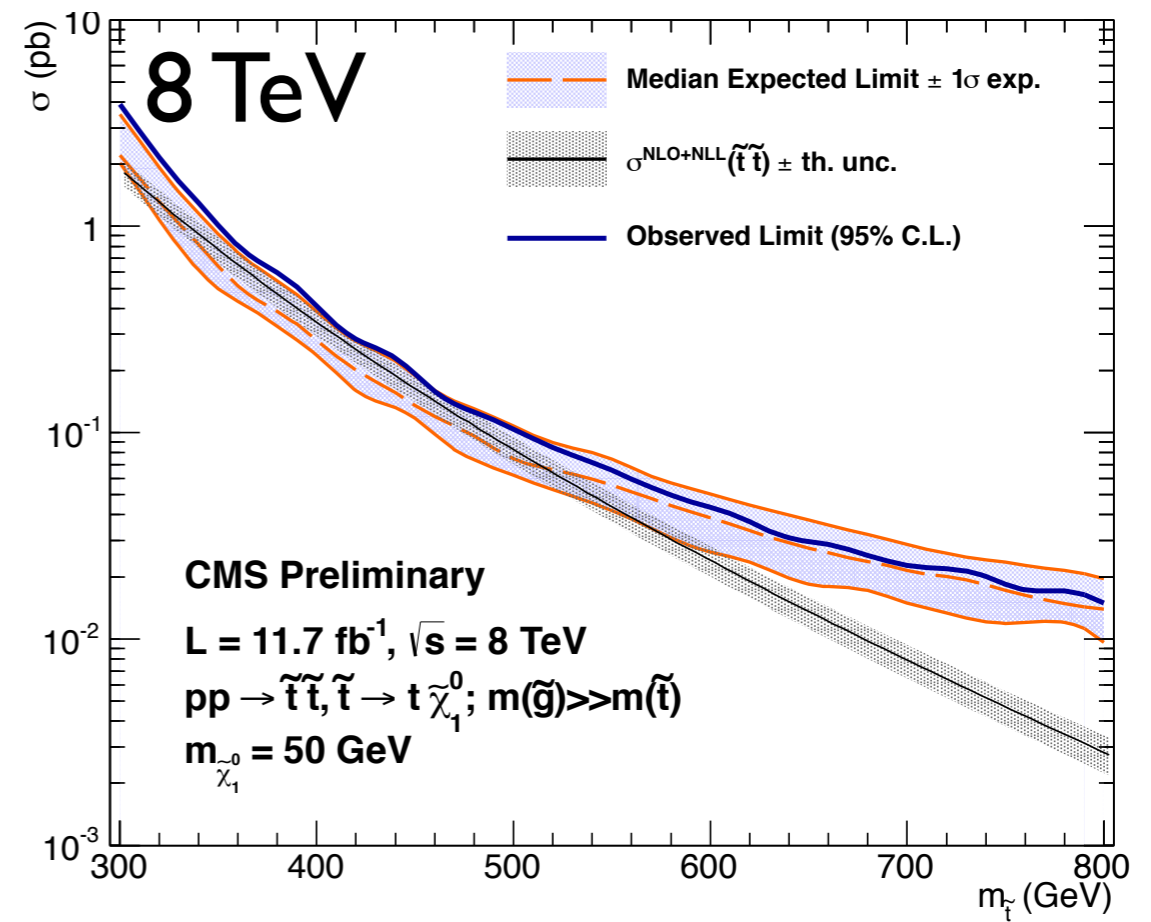
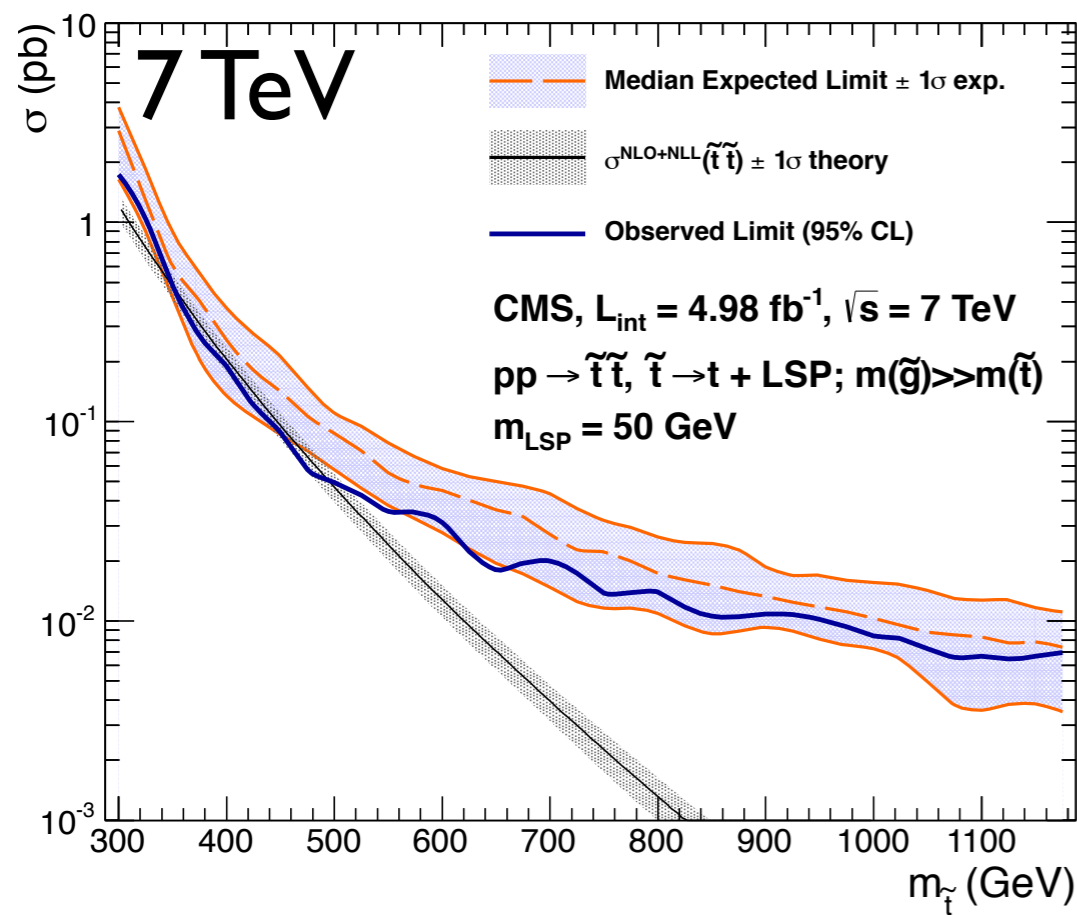
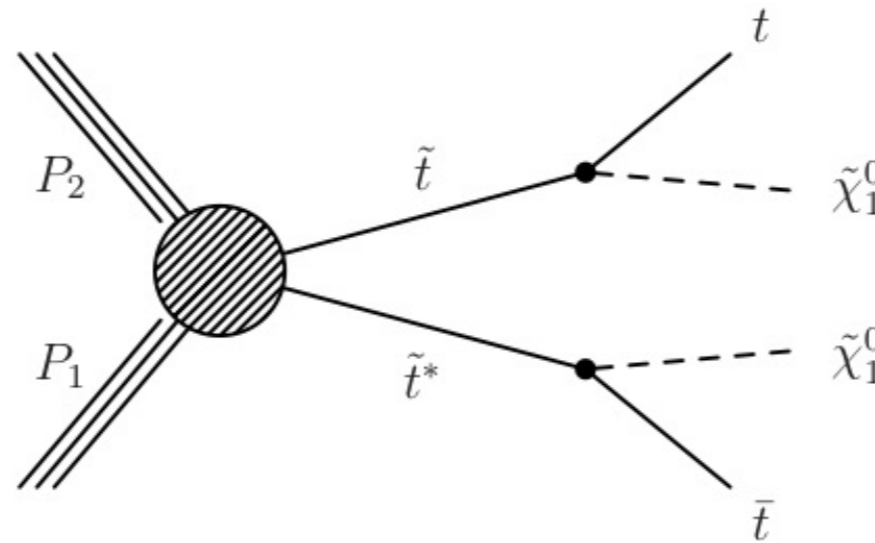




## T2tt

Njet :  $\geq 4$

Btag : 2



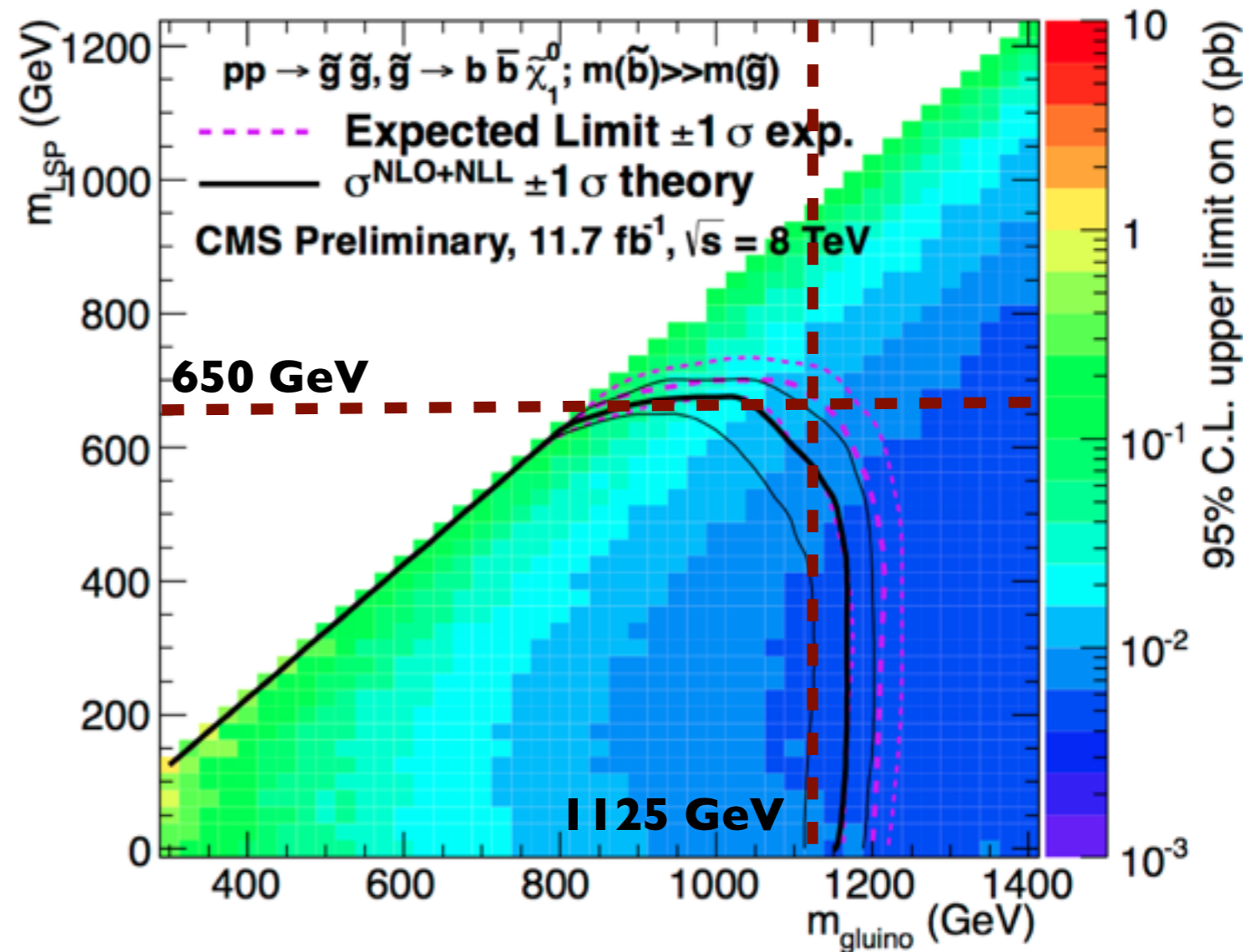
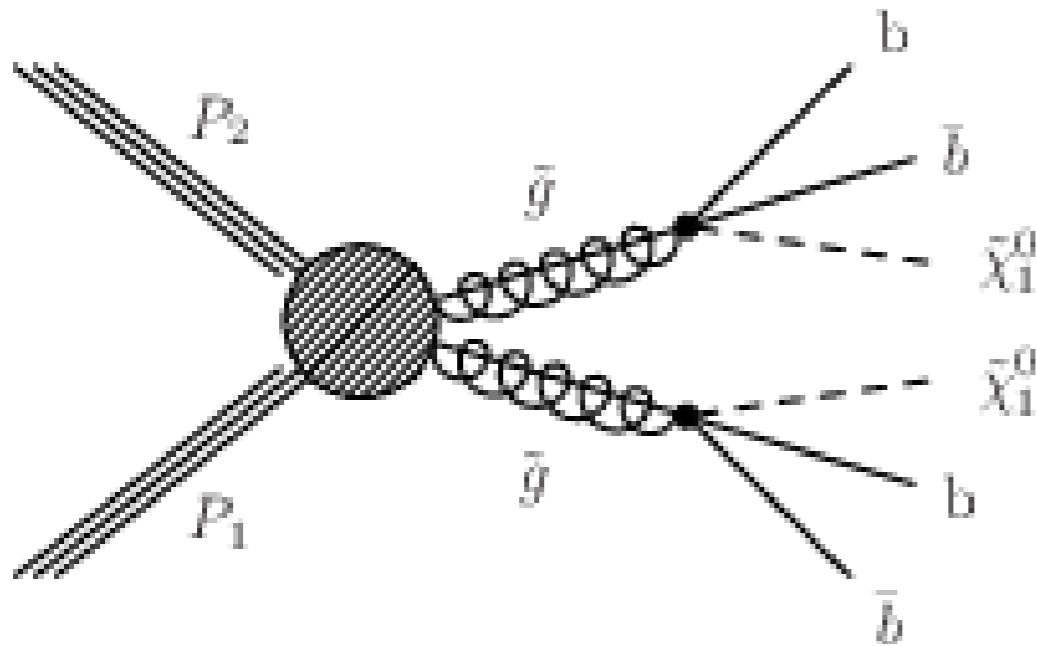
sbottom produced off-shell, large number of jets and b-jets in final state

## Glauino mediated production

### $T \bar{1} b b b b$

$N_{jet} : \geq 4$

$B_{tag} : 2, 3, \geq 4$



- No sign of SUSY at 8TeV
- Limits set in numerous Simplified model scenarios covering a range of possible SUSY signatures

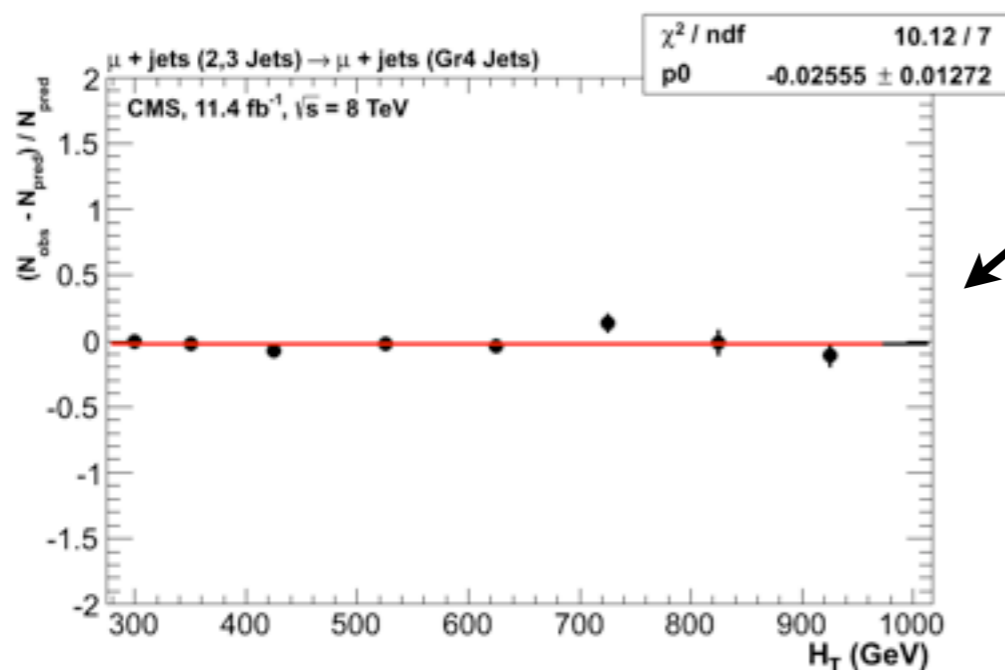
Observed (expected) mass limits on parent sparticle and LSP

	Model	$m_{\text{parent}}$	$m_{\text{LSP}}$
Direct production	$pp \rightarrow \tilde{q}\tilde{q}^* \rightarrow qq\chi^0\chi^0$	775 (850)	325 (350)
	$pp \rightarrow \tilde{b}\tilde{b}^* \rightarrow bb\chi^0\chi^0$	600 (675)	200 (250)
	$pp \rightarrow \tilde{t}\tilde{t}^* \rightarrow tt\chi^0\chi^0$	- (520)	- (100)
Gluino-mediated	$pp \rightarrow \tilde{g}\tilde{g} \rightarrow qqqq\chi^0\chi^0$	950 (1050)	450 (550)
	$pp \rightarrow \tilde{g}\tilde{g} \rightarrow bbbb\chi^0\chi^0$	1125 (1200)	650 (700)
	$pp \rightarrow \tilde{g}\tilde{g} \rightarrow tttt\chi^0\chi^0$	950 (1075)	325 (375)

- Will update to full dataset/data-parked (extending signal region coverage) to be analysed.

Use closure tests to determine data driven systematic uncertainties on translation factors

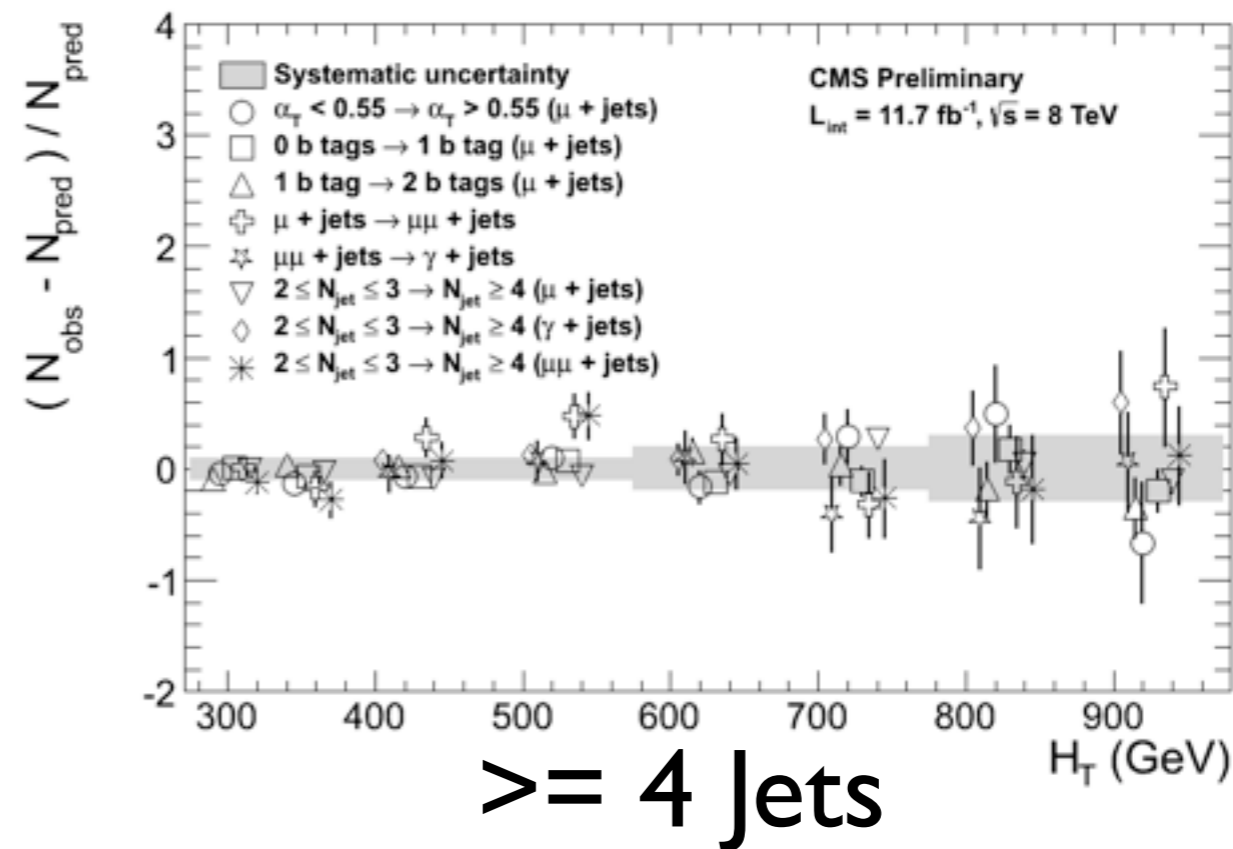
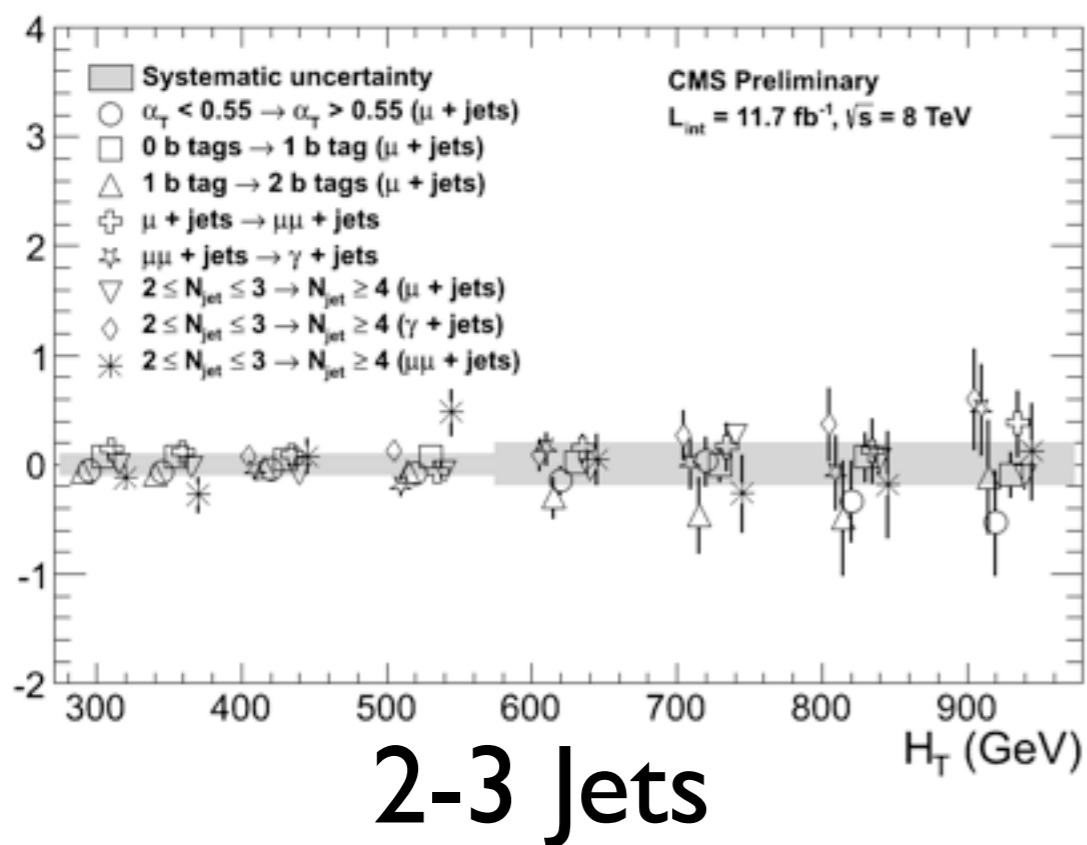
- Probe systematically all ingredients in translation factors (eg, modelling of kinematics)
- Use control samples to predict into other control region
- Ratio  $(N_{\text{obs}} - N_{\text{pred}}) / N_{\text{pred}}$  is plotted as a function of HT



- Inspect statistical consistency of predicted and observed yields
- Powerful tool to check for potential biases and HT dependence

## Tests performed

- Different control samples:  $\mu\mu + \text{jets} \rightarrow \gamma + \text{jets}$ ,  $\mu + \text{jets} \rightarrow \mu\mu + \text{jets}$ ,  $\mu + \text{jets} \rightarrow \gamma + \text{jets}$
- Different b-tag multiplicity bins
- MC modelling of AlphaT, different jet multiplicities...



Systematic uncertainty on translation factors

10% 10%, 10%, 20%, 20%

10% 10%, 10%, 20%, 30%