Search for stealth supersymmetry with photons or leptons, jets, and low MET

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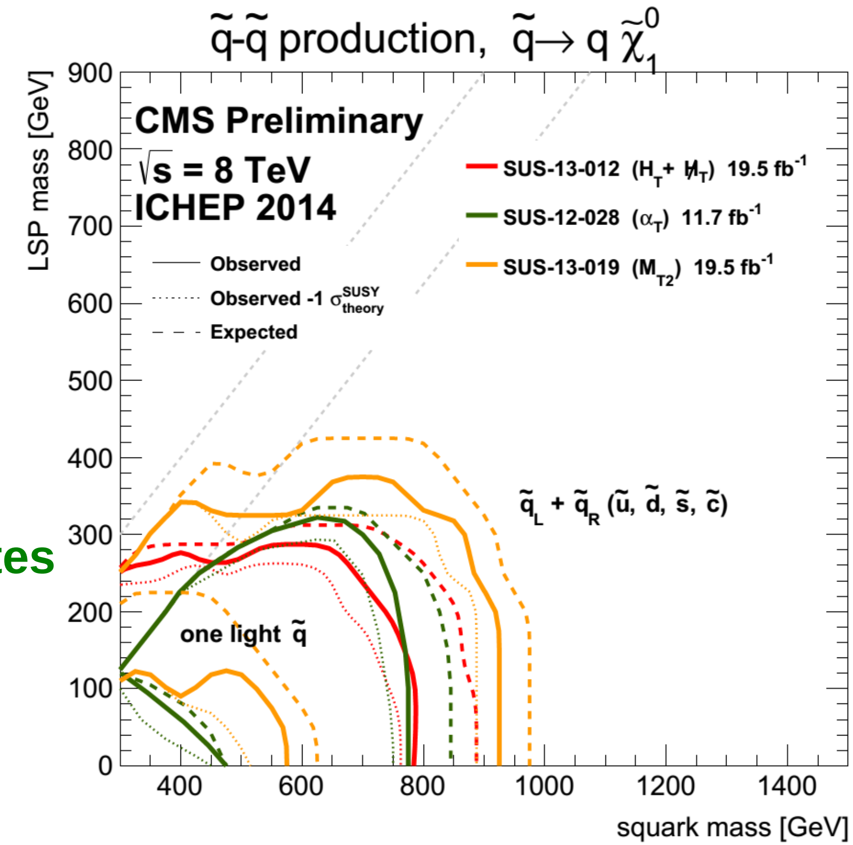
Supersymmetry at the LHC

- **Most SUSY models assume kinematically accessible gluino/squark, non-compressed spectrum, R-parity conservation**
  - **Typical signatures include:**
    - **Large MET from stable LSP**
    - **High object multiplicity**
- **8 TeV SUSY searches:**
  - **Most SUSY models with significant MET excluded out to squark/gluino masses ~ 1 TeV**
  - **Conversely, many low-MET topologies remain largely uncovered**
    - **Limits in high-MET final states motivate complementary searches**

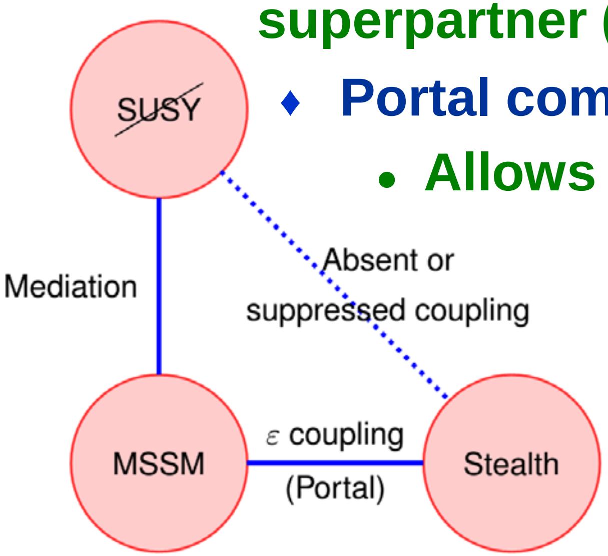


Could SUSY be hiding?

- **Hiding in the theory**
  - **Large splitting between squark/gluino and LSP: Low jet multiplicity with large p_T hierarchy**
  - **Ewkino models: EWK SUSY production dominant; reduced hadronic activity**
  - **Cascade decays with many soft jets**
- **Hiding in the experiment: SUSY may have low MET**
  - **R-parity violation: No stable LSP**
  - **Compressed spectra: balanced LSP momenta**
  - **Stealth SUSY: Hidden sector leads to light, soft LSP**

Stealth SUSY

- **Is it possible to produce low-MET SUSY without R-parity violation or coincidentally compressed spectra?**
- **Ingredients of stealth SUSY:**
  - **Hypothesize stealth sector: Collection of fields that feel small SUSY breaking**
    - **Particles nearly mass degenerate with superpartners**
    - **Minimally must include singlet state and singlino superpartner (S, $\widetilde{S}$)**
  - **Portal communicating between MSSM and stealth sector**
    - **Allows decay of lightest visible sector superpartner**
  - **Light R-odd state (typically gravitino) produced from stealth decay (e.g. $\widetilde{S} \rightarrow \widetilde{G}S$)**
    - **Light and soft, carries away little MET**

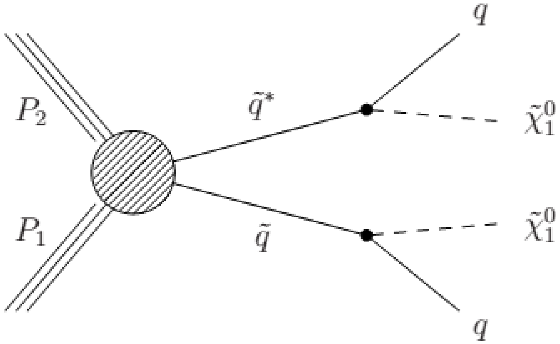


$M_{\text{SUSY}} \sim M_{\text{EWK}}$

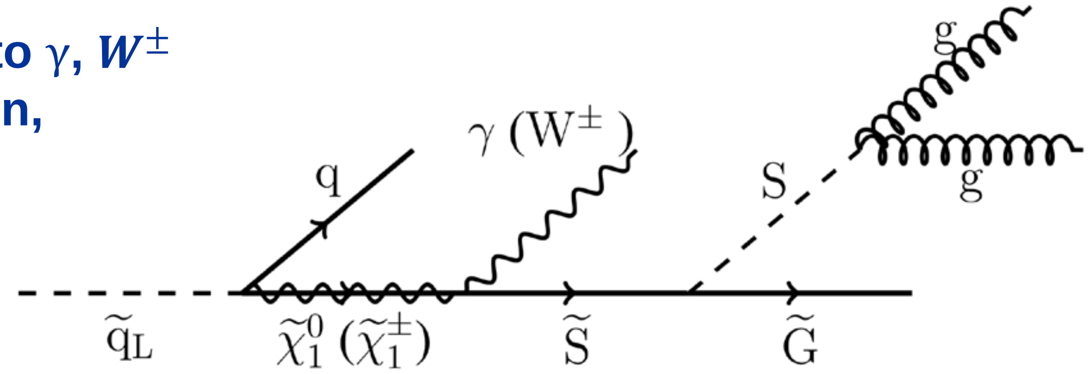
$M_{\not{SUSY}} \sim \varepsilon M_{\text{EWK}}$

Stealth model

- **Start with disquark production with $\tilde{q} \to q\tilde{\chi}_1$**
  - $\tilde{\chi}_1$ decays to stealth sector, produces gauge boson, jets, soft $\tilde{G}$
    - Photon analysis: $\tilde{\chi}_1$ decays to γ
    - Lepton analysis: $\tilde{\chi}_1$ decays to $W^{\pm}$ with leptonic W decay



- **Minimal stealth sector, only singlet and singlino, with $\tilde{S} \to S\tilde{G}$**
  - Small $\tilde{S} - S$ mass splitting held constant at 10 GeV, $M_{\tilde{S}}$ = 100 GeV
    - Lepton analysis: $\tilde{\chi}_1$ fixed to half squark mass
    - Photon analysis: Full plane of squark/neutralino masses
  - Gravitino taken to be massless
  - Branching fractions to γ, $W^{\pm}$ set to unity for photon, lepton analysis



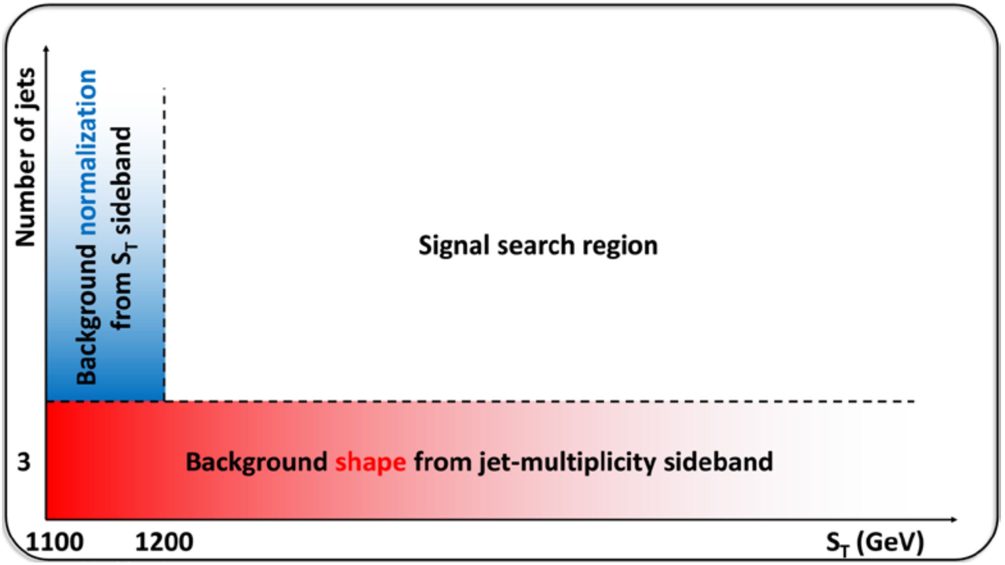
Background estimation for γ analysis

- **S_T: Scalar sum of p_T of all objects**

$$S_T = \text{MET} + \sum_{\gamma} E_T + \sum_{\text{jets}} p_T$$

Region	Function	N_j	S_T (GeV)
Search	Signal	≥ 4	> 1200
N_j sideband	Bkg shape	3	> 1100
S_T sideband	Bkg norm	≥ 4	1100 – 1200

- **Shape of background S_T distribution independent of number of final state objects**



- **Background shape from jet-multiplicity sideband**
- **Background normalization from S_T sideband**
- **Use normalized shape to predict number of background events with S_T above threshold**

S_T scaling in γ analysis

- **Area-normalized S_T distributions for control (1γ) and simulated search (2γ) region**
  - **Scaling holds well in both regions**

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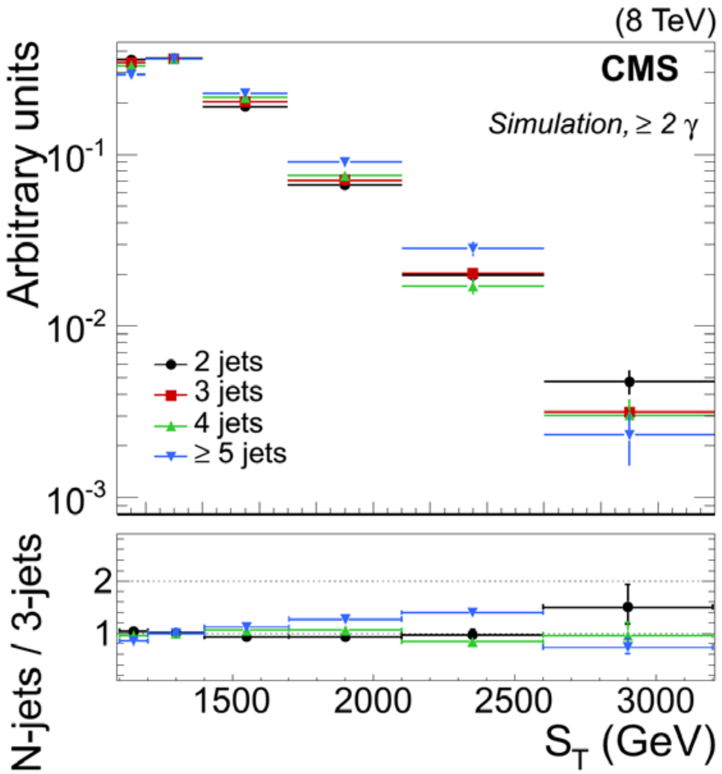
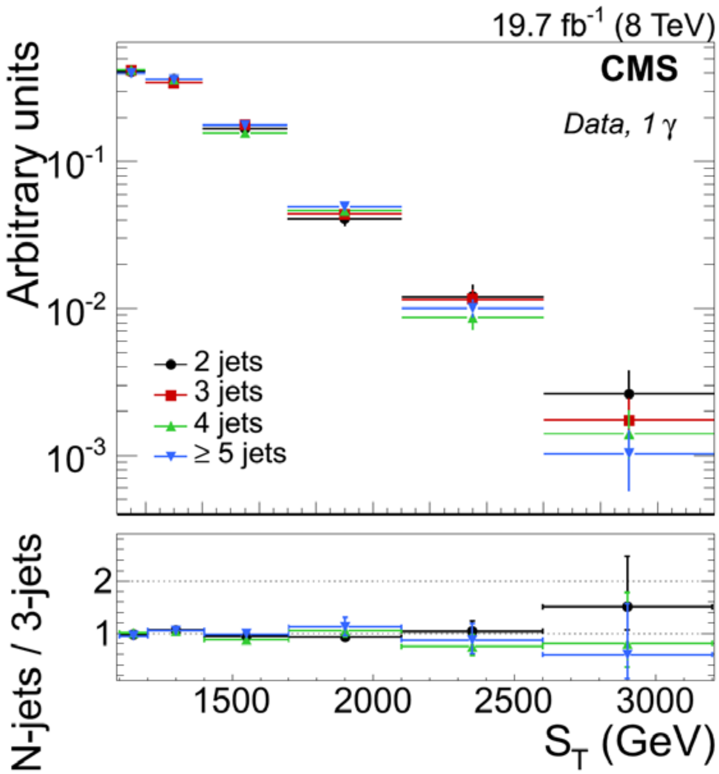
Search, MC

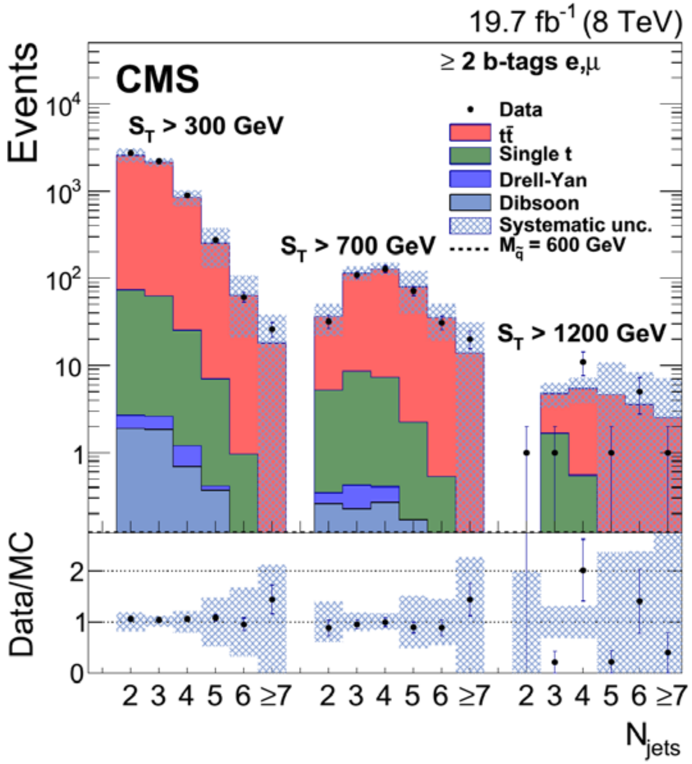


Control



Background estimation for $l^{\pm}$ analysis

- **Define search region in terms of N_{jets}, $N_{b\text{-}jets}$, lepton flavor, lepton charge**



Region	Leptons	N_{jet}	$N_{b\text{-}tags}$
Search	$e^{\pm}\mu^{\mp}$	≥ 4	0
Top shape	$e^{\pm}\mu^{\mp}$	≥ 2	≥ 2
Top norm	$e^{\pm}\mu^{\mp}$	< 4	0
DY	$\mu^{\pm}\mu^{\mp}$	≥ 2	0
Non-prompt	$e^{\pm}\mu^{\pm}$	≥ 2	0
Validation	$e^{\pm}\mu^{\mp}$	≥ 2	1

- **Primary background contribution from top quarks**
  - **Correct MC shape of N_{jets} for top quarks**
  - **Shape from MC in 2 b-tag sample normalized to data**

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Results for γ analysis

- **Data and background prediction in search (2γ) region**
  - Background shape determined in 3-jet bin
  - Normalized in S_T sideband ($1100 < S_T < 1200$ GeV)
- **No significant excess observed**

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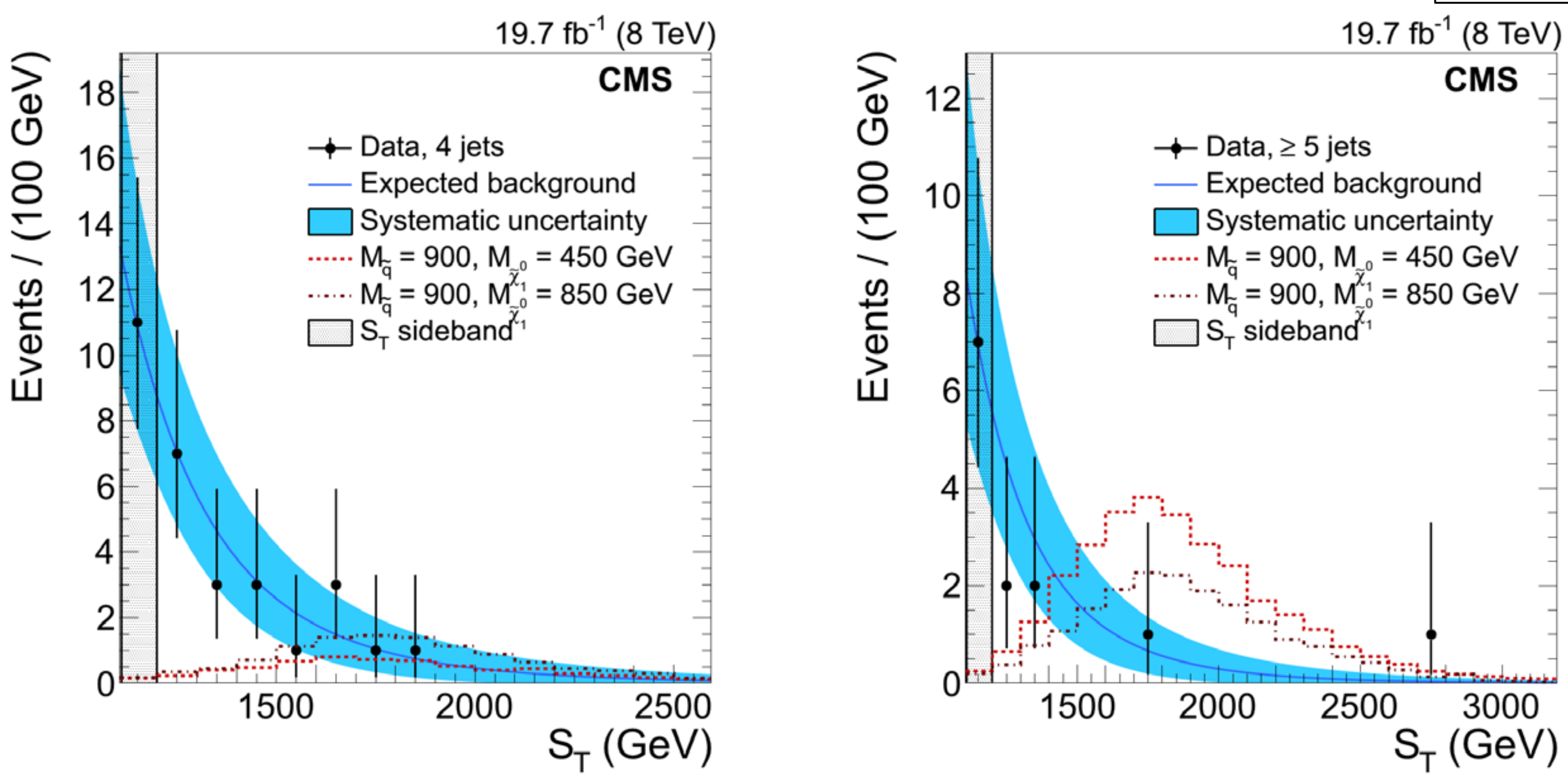
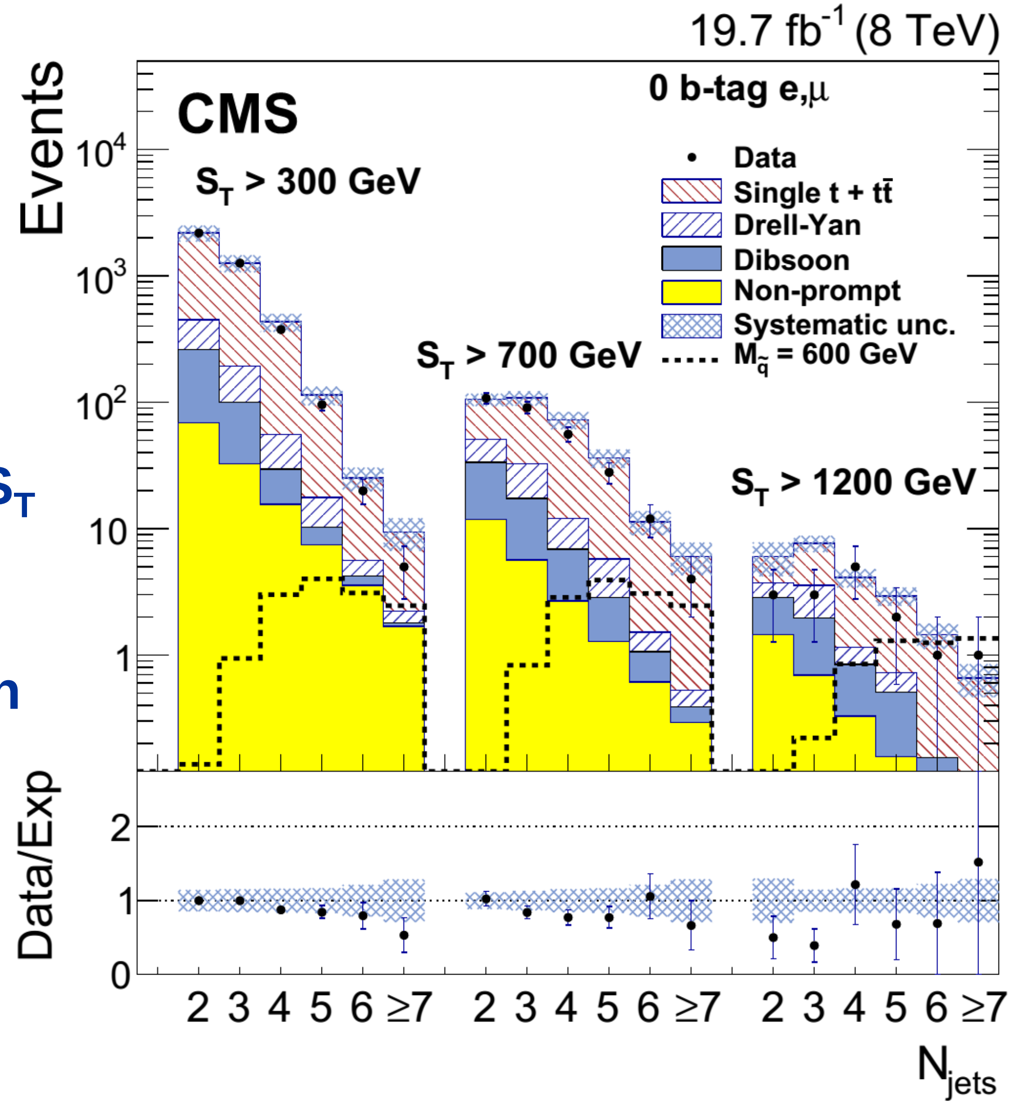


- **Observed data and background prediction in $e\mu$ final state with 0 b-tags**
  - Distributions shown for three optimized S_T thresholds
  - Data found to be in good agreement with background expectation



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Limits on stealth SUSY

- γ analysis: Limits on squark, neutralino masses in diphoton final states
  - Shape-based limit in 4 and ≥ 5 jet channels
- $l^{\pm}$ analysis: Limits on squark mass in $e\mu$ final states
  - Cut-and-count limit from optimized S_T threshold

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