Constraining Stealth SUSY with illuminated fat jets

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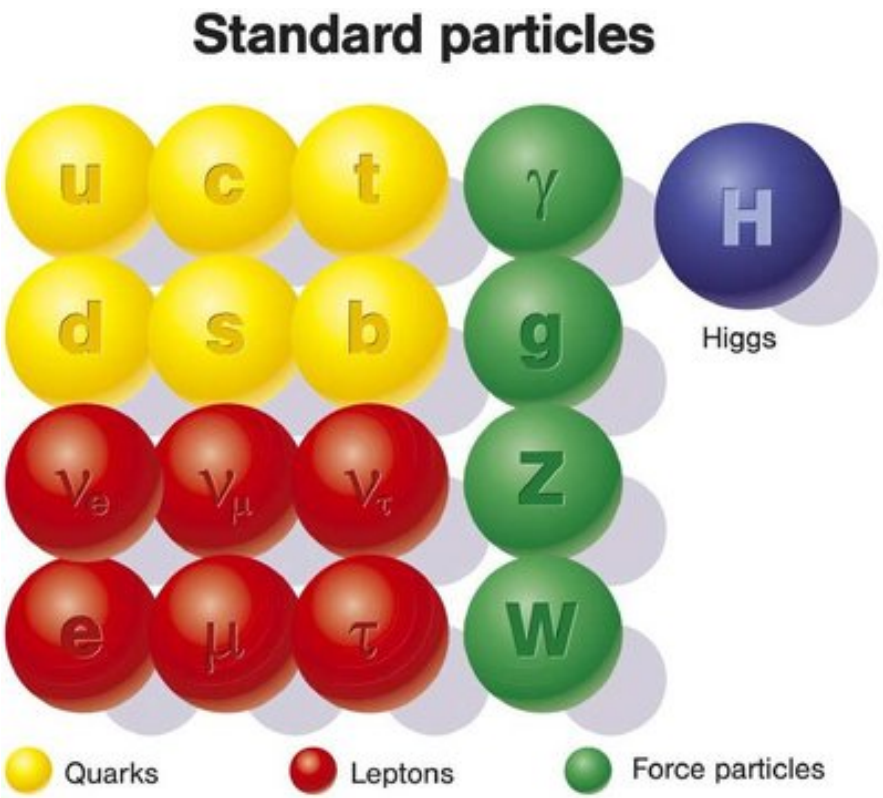
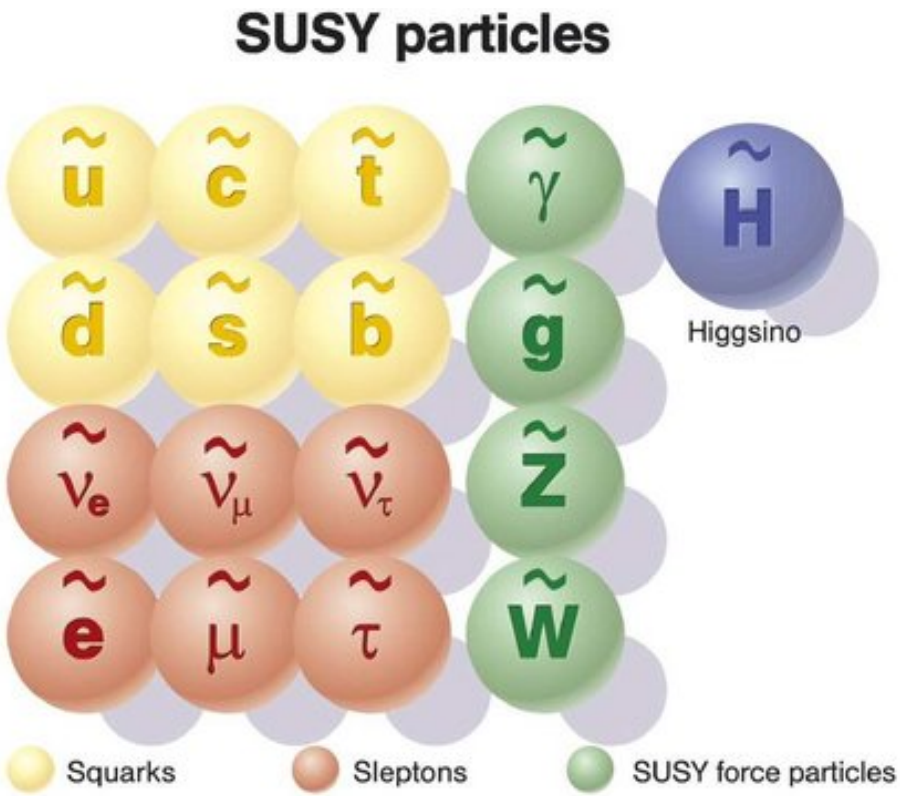
Supersymmetry





Where is SUSY?

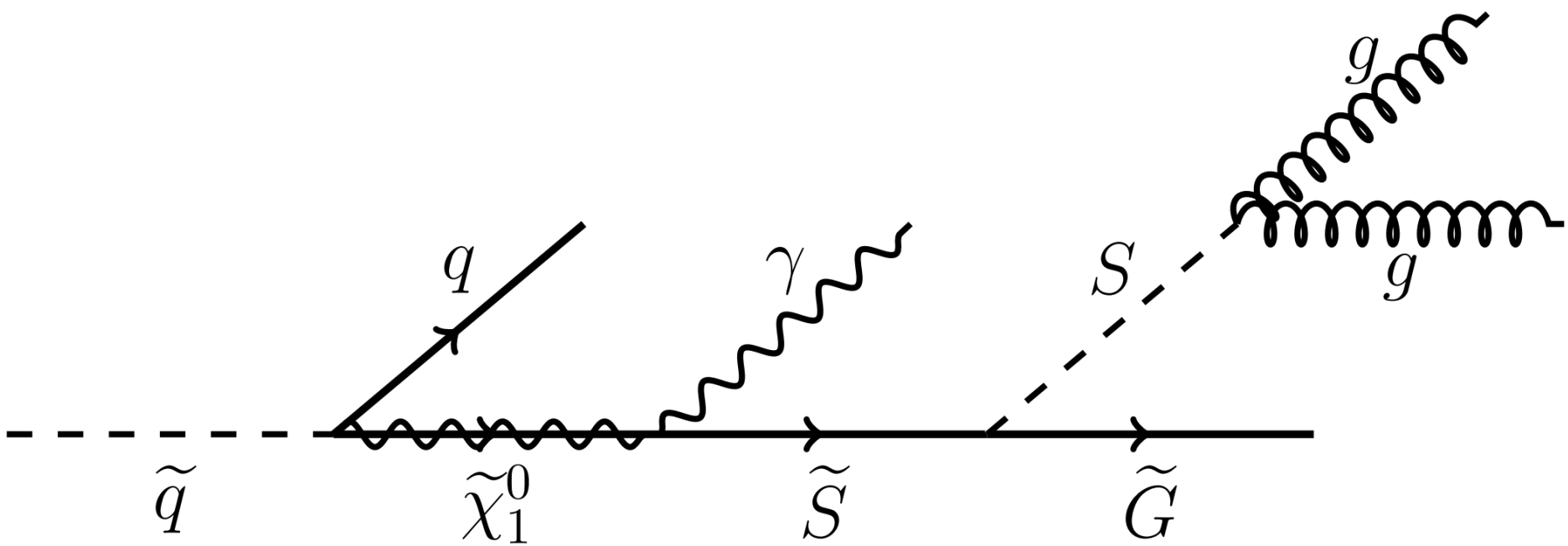
- The LHC has collected data for more than eight years, but no clear signal in favor of SUSY has emerged so far

- A plethora of SUSY models exist with very different signatures that may hide from standard searches (R-parity violation, long decay chains, squeezed spectrum, **stealth SUSY**)

Stealth SUSY? What is this?

- A lot of searches for new physics rely on large amounts of missing transversal energy ($\not{E}_T$) so a possible approach to avoid the typical constraints is to reduce $\not{E}_T$ as much as possible
- In "stealth" scenarios, $\not{E}_T$ is avoided due to a peculiar mass configuration, for example, as follows
  - The lightest "visible sector" SUSY particle (LVSP) decays into a lighter hidden sector SUSY particle ($\tilde{S}$)
  - $\tilde{S}$ decays to its SM partner (with a **near mass degeneracy**) and the true LSP
  - This near mass degeneracy leaves little phase space for the true LSP to carry momentum

Squark Decay in Stealth SUSY



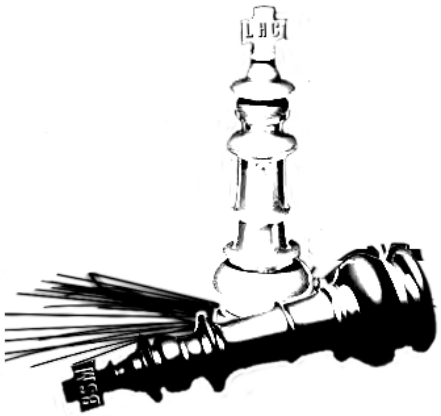
$$\tilde{q} \to q(\tilde{\chi}_1^0 \to \gamma(\tilde{S} \to \tilde{G}(S \to gg)))$$

$\tilde{\chi}_1^0$ - "bino-like" LVSP

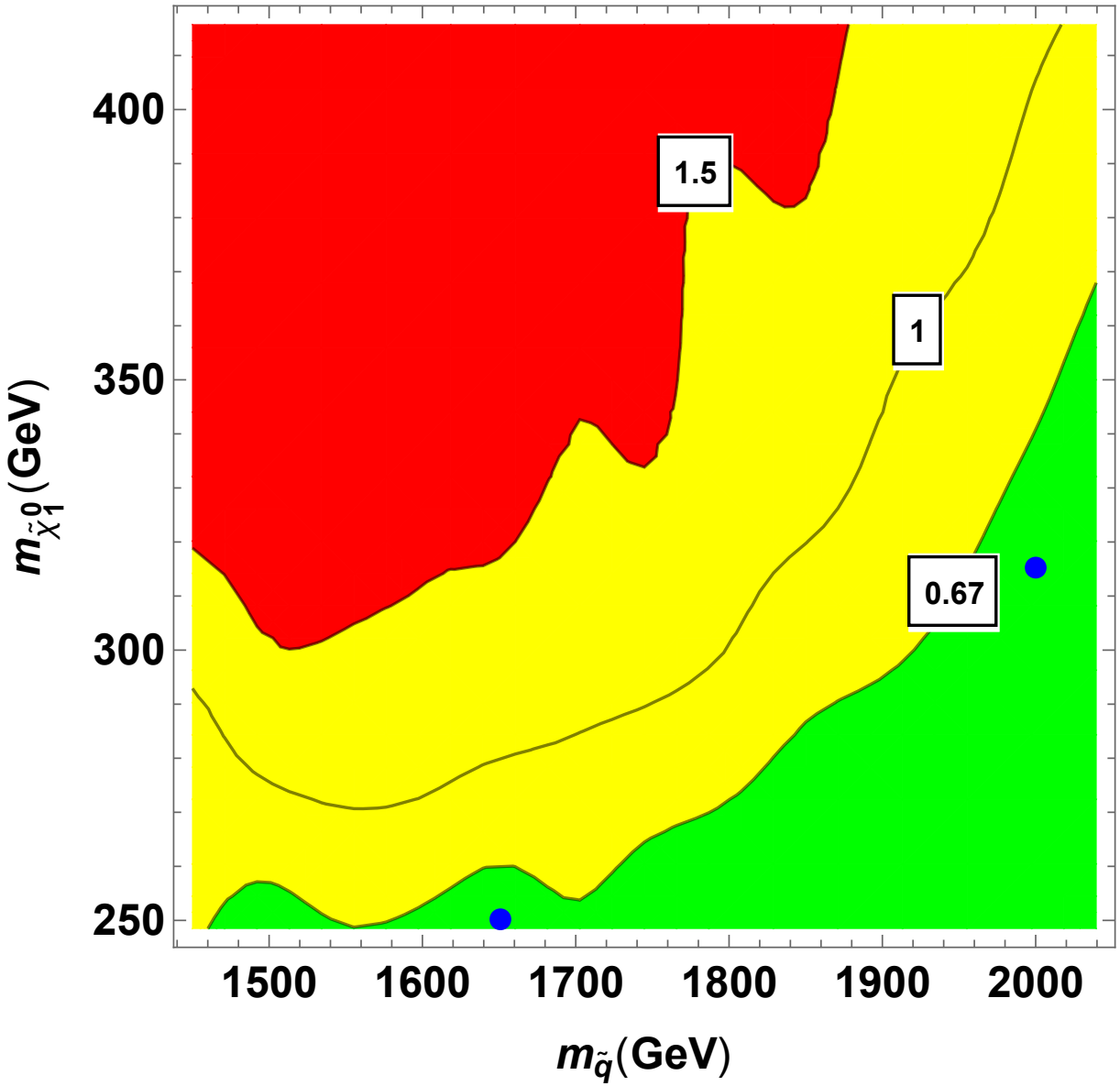
$\tilde{S}$ - fermionic "singlino" superpartner of the singlet state S (these comprise the hidden sector). We used 100 GeV and 95 GeV for $\tilde{S}$ and S respectively

Computational Tools Used

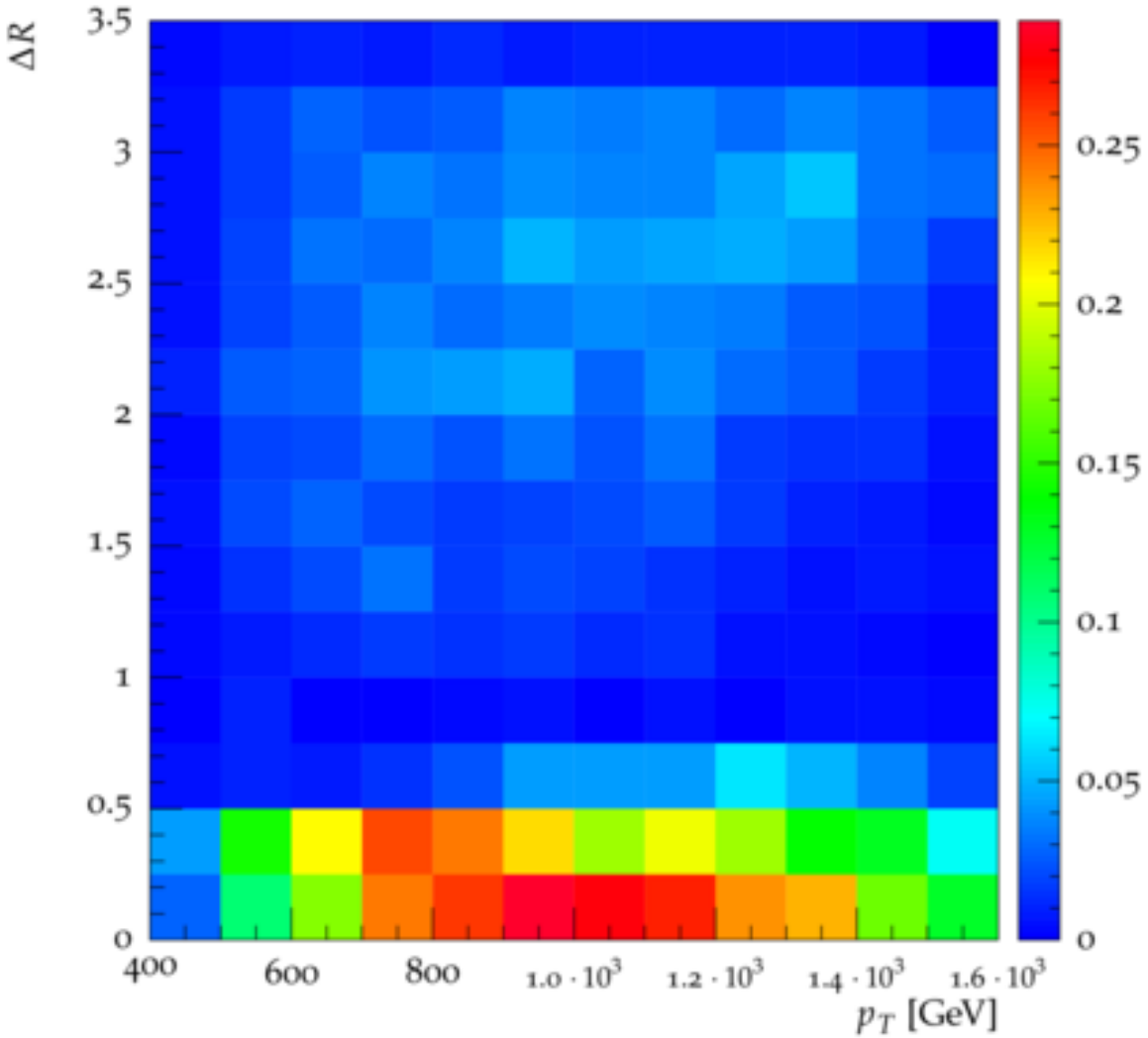
- Generate events using **Pythia + Madgraph** (with a modified decay table)
- Select benchmark points allowed by **CheckMATE**
- Analyze selected benchmark points and pick events with large-radius jets containing a photon using **Rivet**



Exclusion Plot via CheckMATE + Benchmark Points



Is the fat jet illuminated?

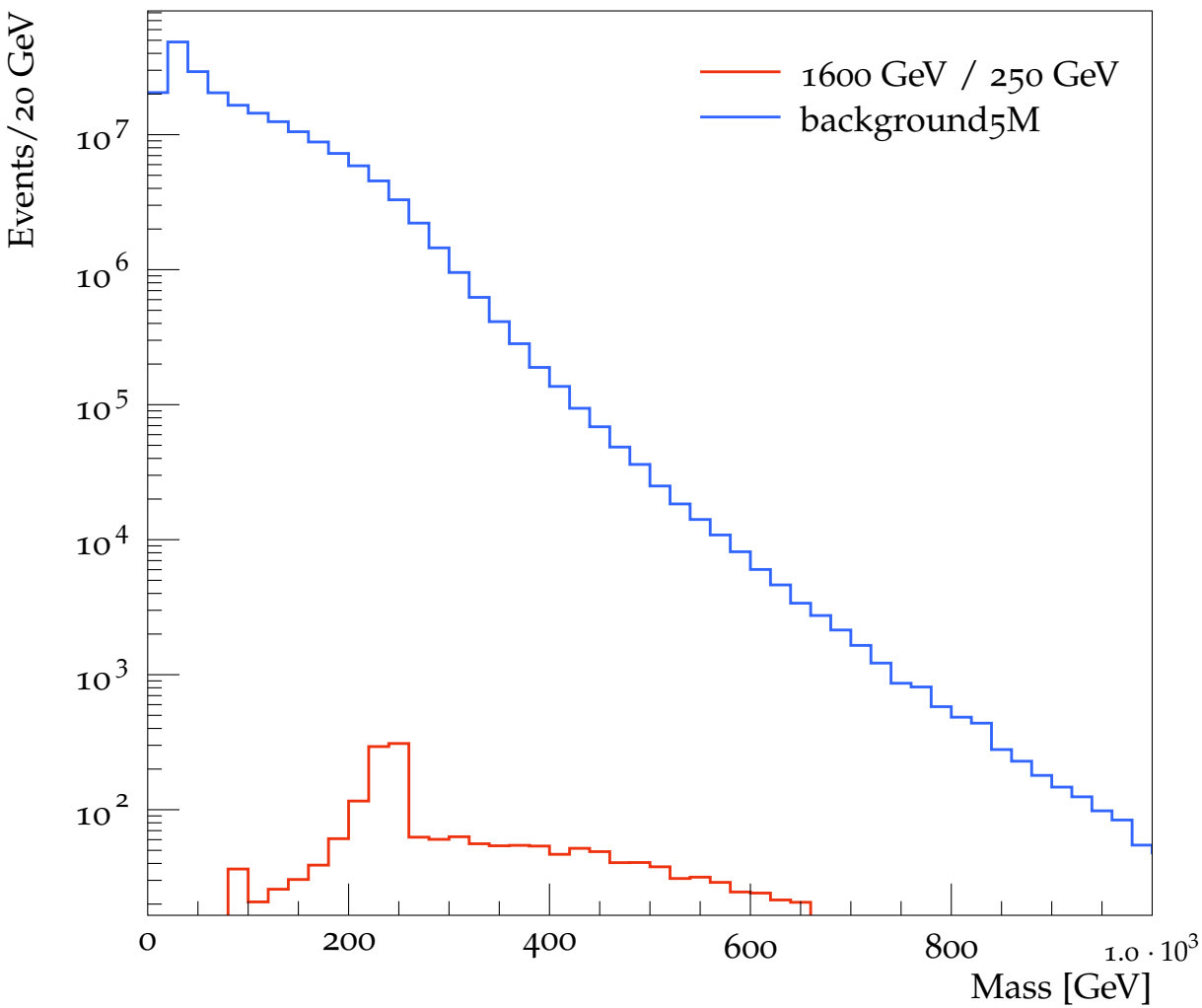


Backgrounds and Normalization

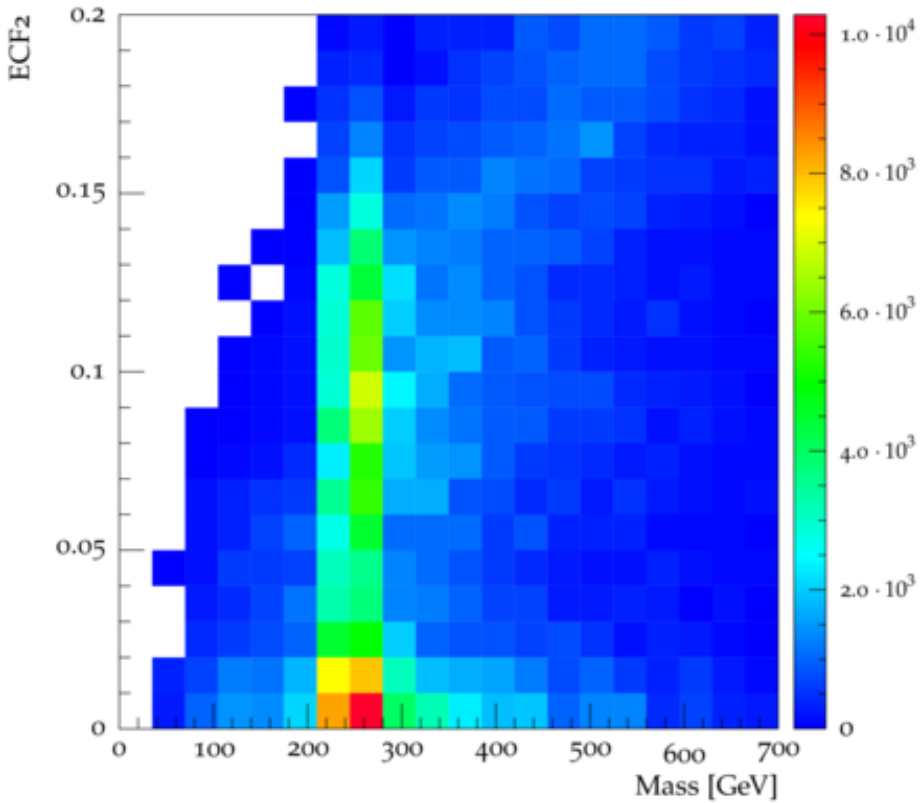
- Standard Model backgrounds comprised of multijets, $\gamma +$ jets, $W+$ jets, and $Z+$ jets were generated using Pythia ($t\bar{t} + Z$, $t\bar{t} + W$, $Z + \gamma$, and $W + \gamma$ backgrounds were also considered have negligible contributions)
- The mass distributions were then normalized to their respective cross sections using a **total integrated luminosity of** 150 fb^{-1} (Run 2).

What do we want to achieve?

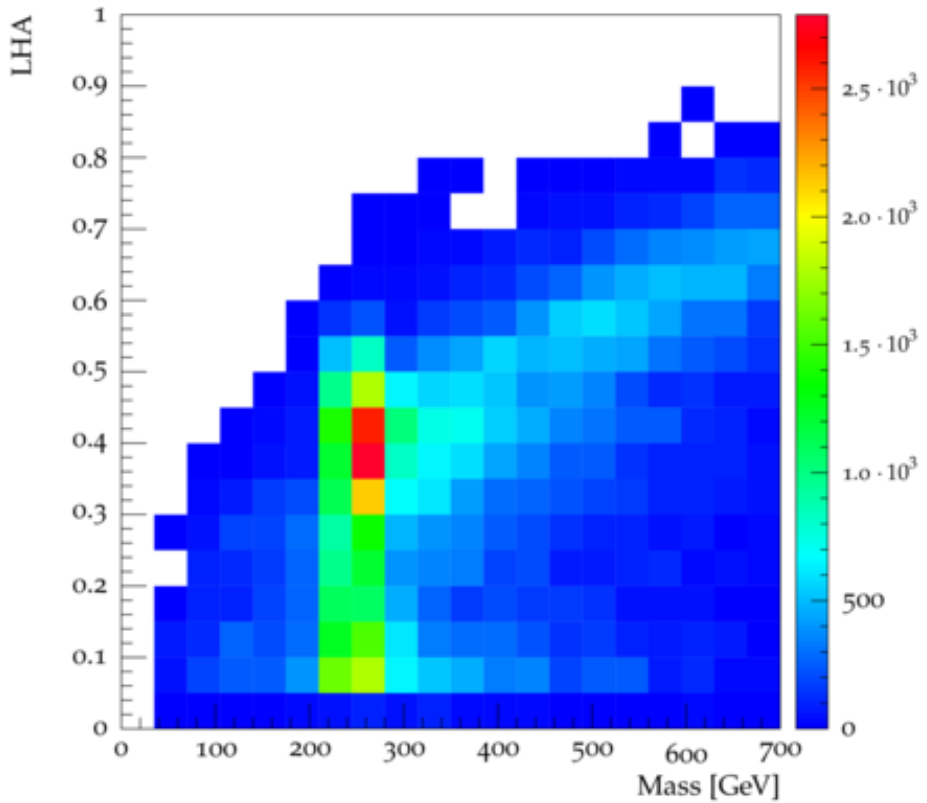
Eliminate background while preserving signal!



Try Jet Substructure



(a) ECF2 versus bino mass.



(b) LHA versus bino mass.

Summary of kinematic cuts & selection criteria

Jets are clustered using anti-k_T algorithm with $R = 1.0$ then trimmed

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Kinematic cuts

- Photon: $p_T > 200$ GeV, $|\eta| < 2.0$
- Jets: $p_T > 450$ GeV, $|\eta| < 1.5$

Selection criteria

- Photon multiplicity > 1
- $\Delta R_{j_1,\gamma} < 1$
- Large-radius jet multiplicity > 3

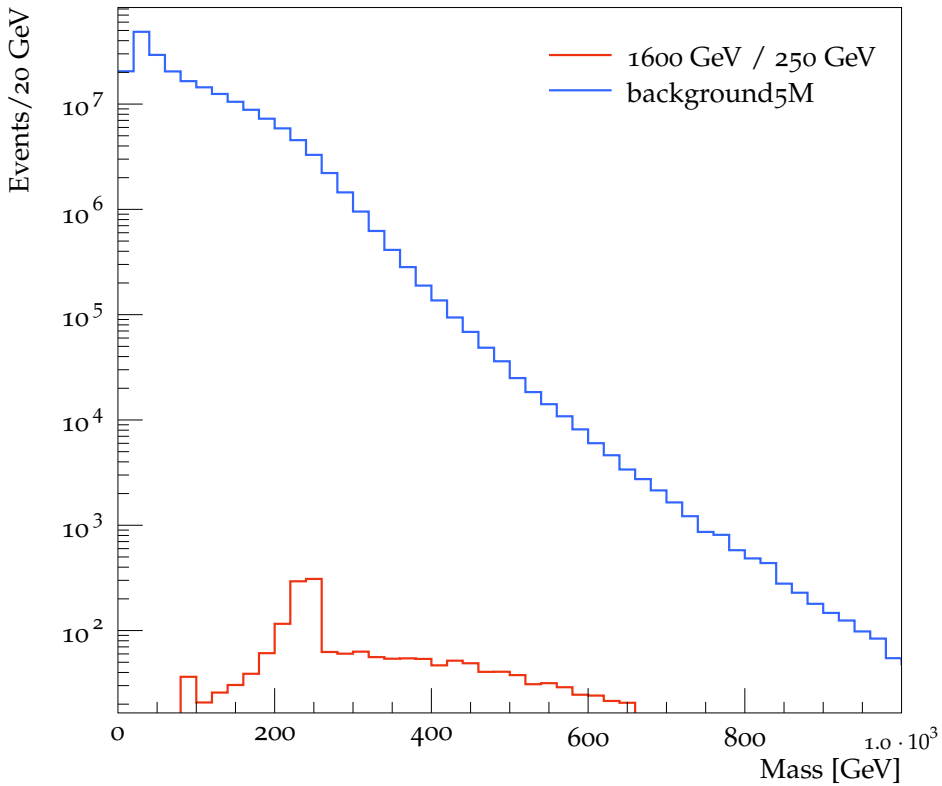
We look at the mass distribution of the leading-mass large-radius jet following the criteria above

Cutflow

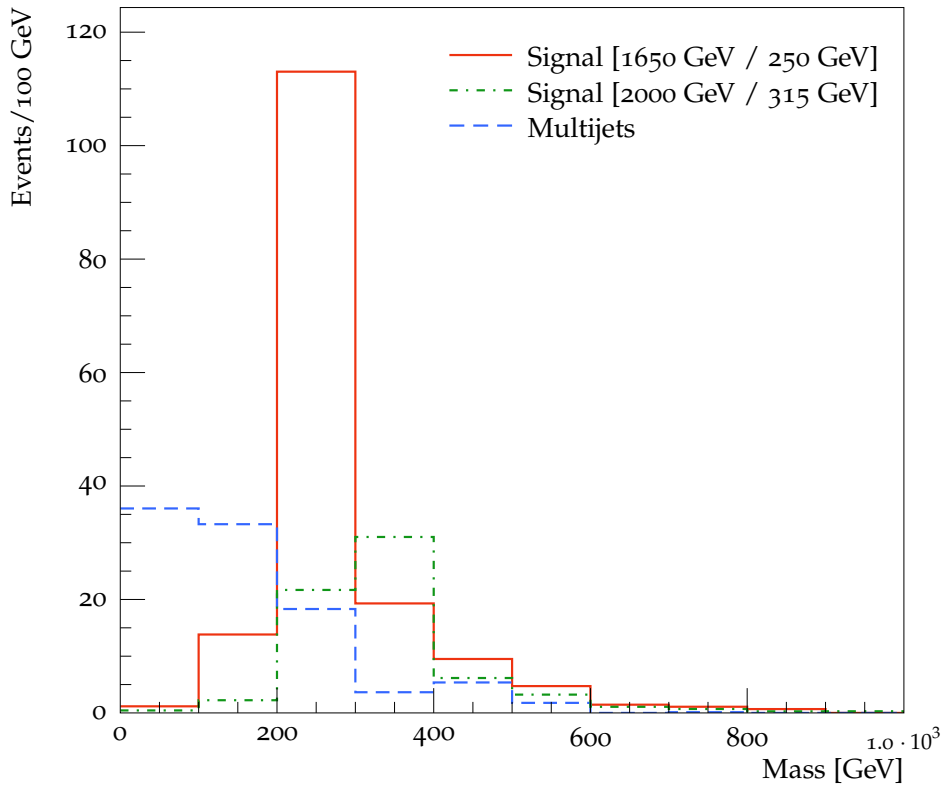
The following values are for the BP $m_{\tilde{q}} = 1650$ GeV / $m_{\tilde{\chi}_1^0} = 250$ GeV.
The events are normalized using an integrated luminosity of 150 fb^{-1}.

	Signal (0.0127 pb)	Multijet (8.70×10^3 pb)	Photons + jets (8.067 pb)	W + jets (1.397×10^4 pb)	Z + jets (6.182×10^3 pb)
No Cuts	1744	1.26×10^9	9.76×10^6	2.09×10^9	9.26×10^8
Photon multiplicity >1	795	2.17×10^5	7.96×10^4	2.10×10^3	9.27×10^2
$\Delta R_{j_1,\gamma} < 1$	794	2.11×10^5	4.96×10^4	2.10×10^3	9.27×10^2
Large jet multiplicity >3	165	99	6	0	0
SR (200 – 300 GeV)	114	19	0	0	0

Mass Distribution



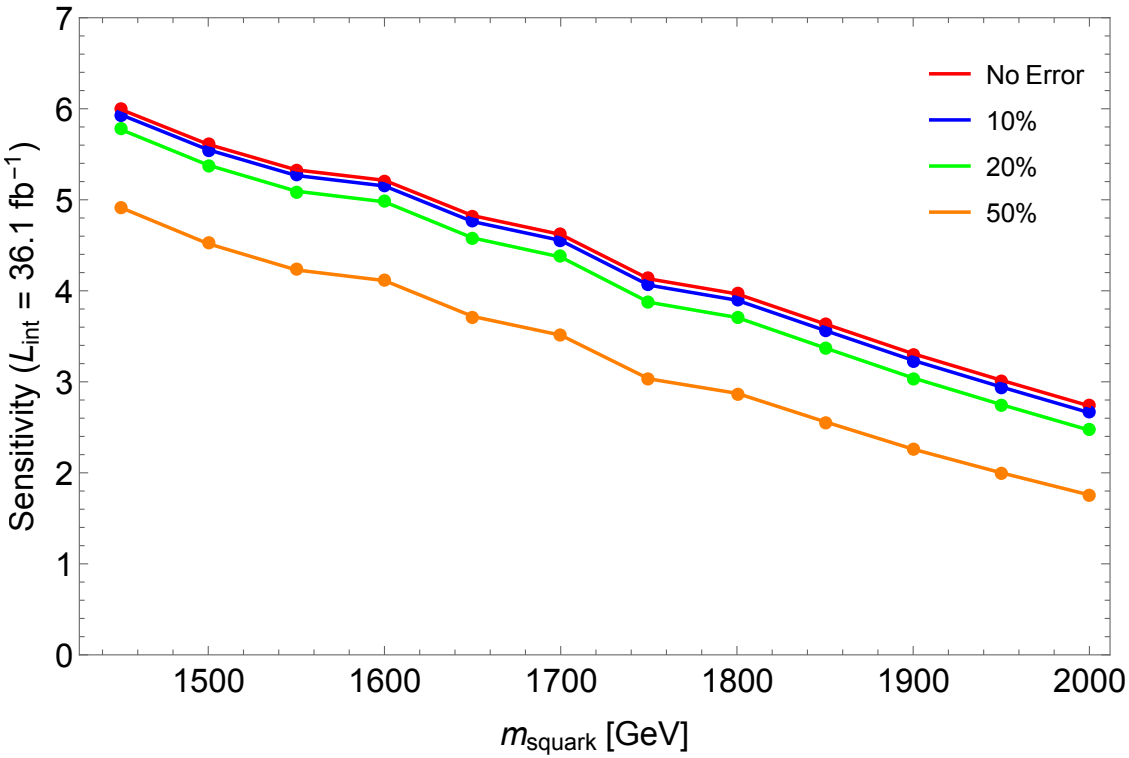
(a) Before cut



(b) After cut

Sensitivity using $S = s/\sqrt{s+b}$

Sensitivity plot for various squark masses and a bino mass of $m_{\tilde{\chi}_1^0} = 250$ GeV, scaled down to an integrated luminosity of 36.1 fb^{-1}.



For $m_{\tilde{q}} = 1650$ GeV, the strongest search is the atlas_1802_03158 analysis with $S = 1.48$ versus our analysis with $S = 4.85$.

Summary & Conclusions

- We investigated a stealth SUSY scenario which reduces the missing transverse energy, since a large amount of $\not{E}_T$ is typically present in signals probed by LHC
- We found that by requiring a high-transverse momentum photon within our large jet, we were able to reconstruct the "bino-like" $\tilde{\chi}_0^1$ mass,

$$m_{\tilde{\chi}_0^1} \approx M(\gamma gg)$$

- We did a simple sensitivity calculation of our signal over background and compared against the strongest existing search and found that our analysis has a better exclusion potential for the benchmark points considered

The End

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ABSTRACT

We investigate the discovery potential of a Stealth SUSY scenario involving squark decays by reconstructing the lightest neutralino decay products using a large-radius jet containing a high transverse momentum photon. Requirements on the event topology, such as photon and large-radius jet multiplicity result in less background than signal. We also estimated the sensitivity of our analysis and found that it has a better exclusion potential compared to the strongest existing search for the specific benchmark points considered here.

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