



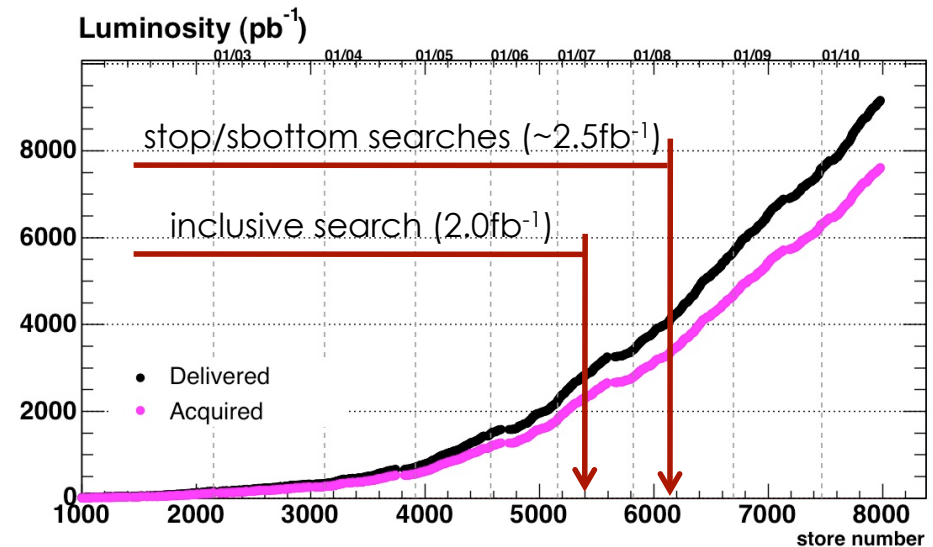
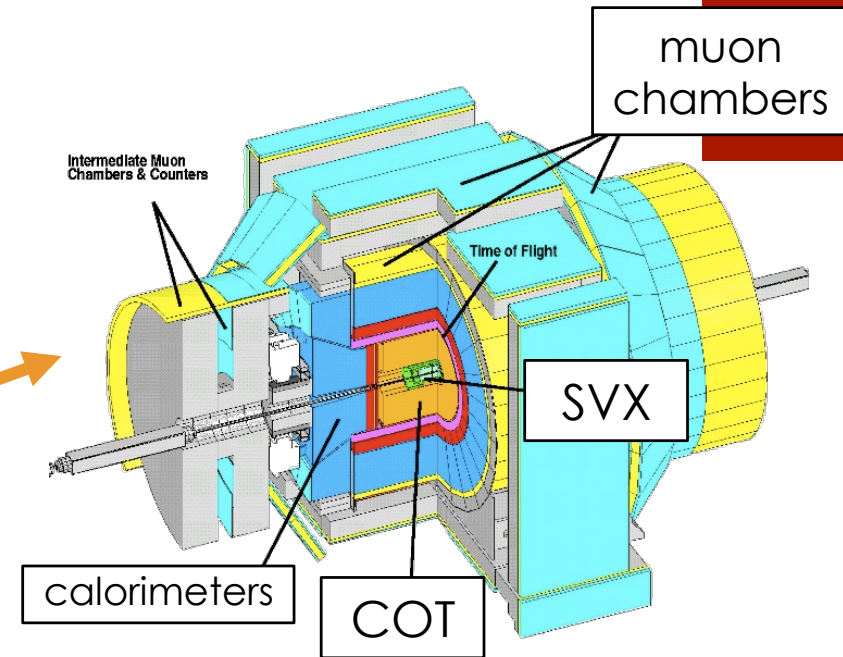
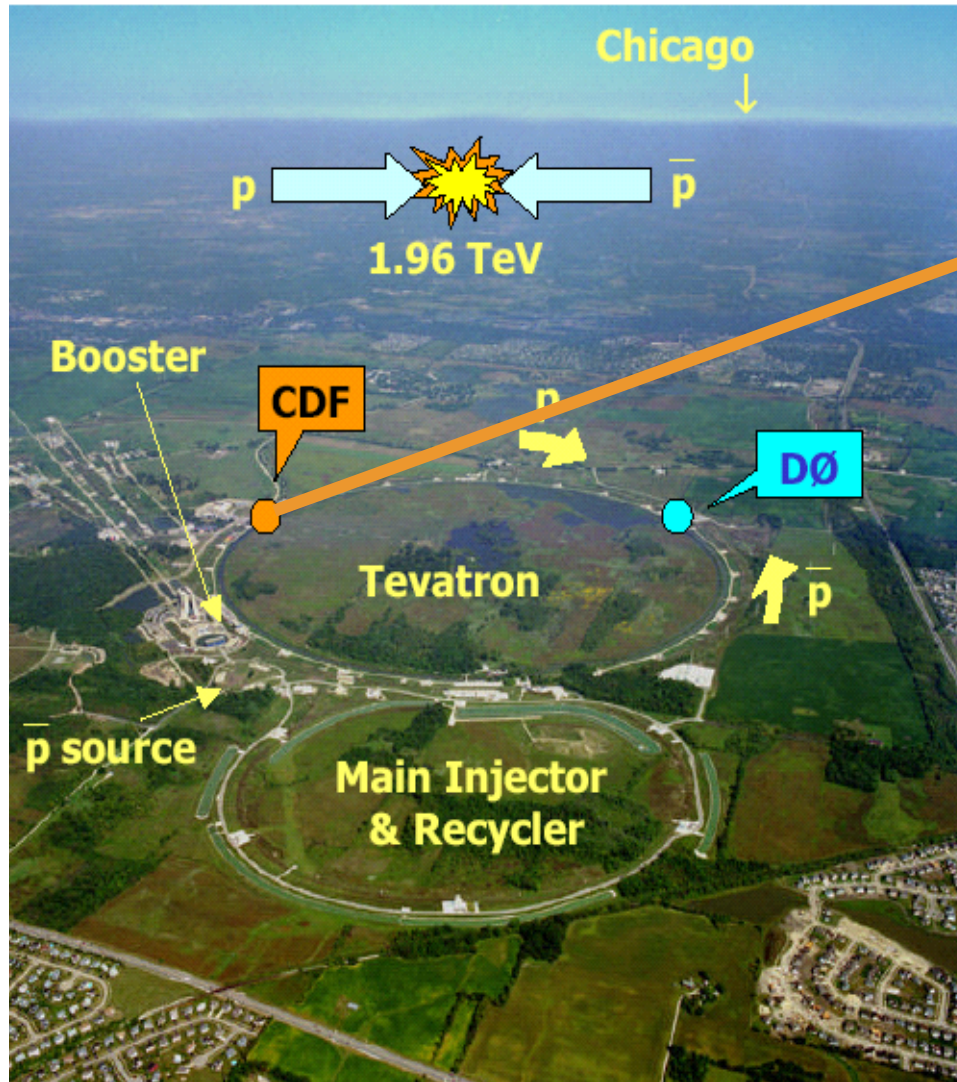
Searches for Gluinos and Squarks in Events with Jets and MET at CDF

Gianluca De Lorenzo, IFAE Barcelona
on behalf of the CDF Collaboration

Outline

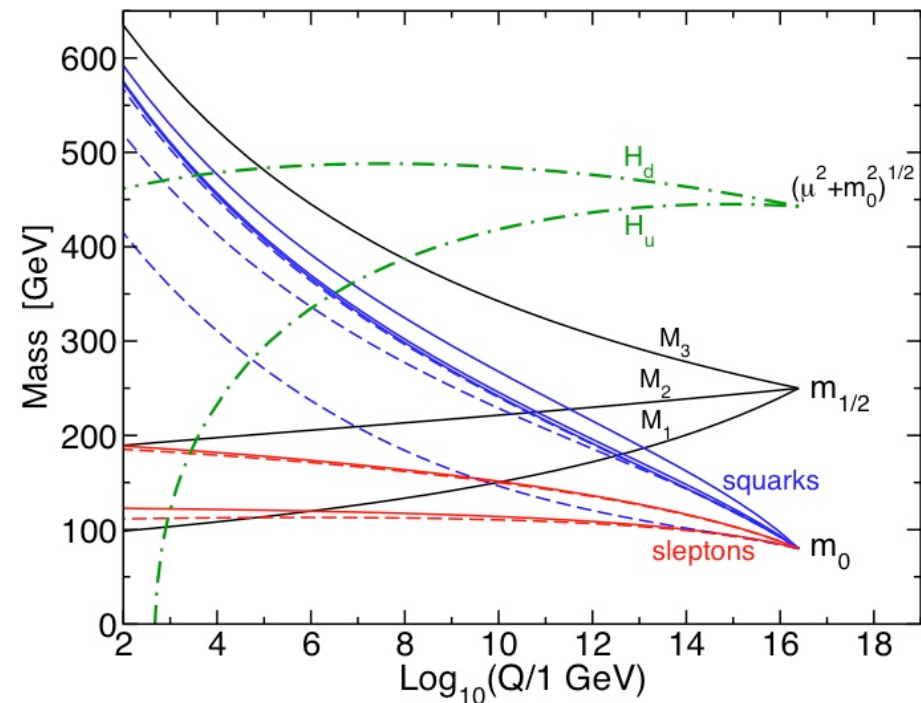
- Experimental Setup.
- Gluinos and Squarks in mSUGRA.
- Inclusive Search for Gluino/Squark Production [*PRL 102,121801 (2009)*].
- Gluino-Mediated Sbottom Production [*PRL 102,221801 (2009)*].
- Stop/Sbottom Searches:
 - Direct Sbottom Production in MET + b-jets [*PRL 105,081802 (2010)*].
 - Direct Stop Production in MET + c-jets.
 - Direct Stop Production in Di-Lepton Events [*PRL 104,251801 (2010)*].

Tevatron and CDF



The mSUGRA Framework

- Benchmark framework for squark/gluino searches.
- Highly predictive scenario with only 5 free parameters.
- Masses and coupling constants unify at GUT scale.
- TeV spectrum derived with RGE.



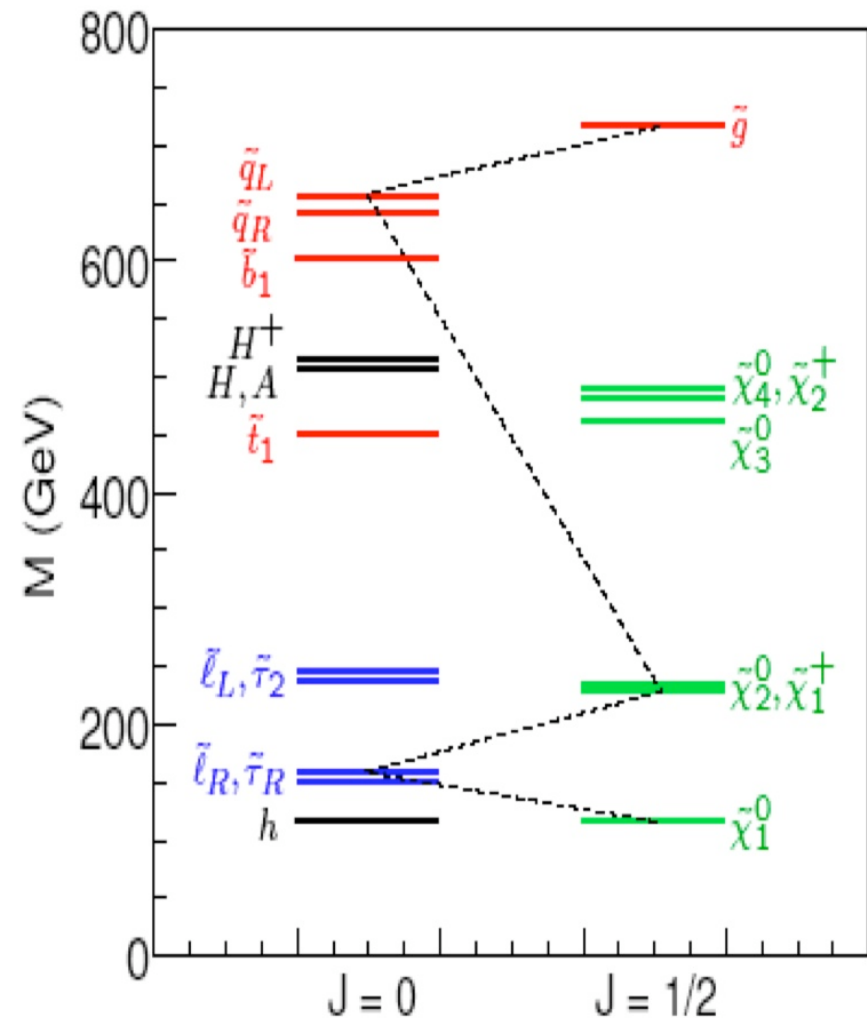
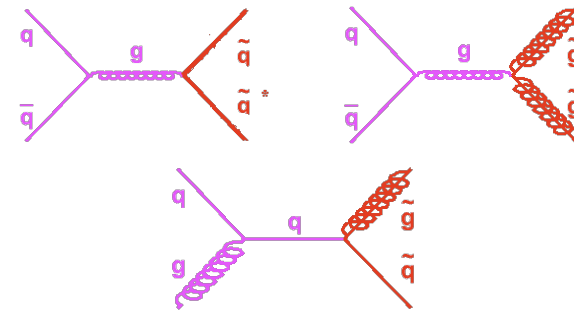
mSUGRA parameters:

- | | |
|----------------------------------|--|
| 1. M_0 common scalar mass | 3. A_0 common trilin. scalar coupling |
| 2. $M_{1/2}$ common gaugino mass | 4. $\text{sign}(\mu)$ Higgs mass parameter |
| | 5. $\tan\beta$ Higgs mixing parameter |

Squark and Gluino in mSUGRA

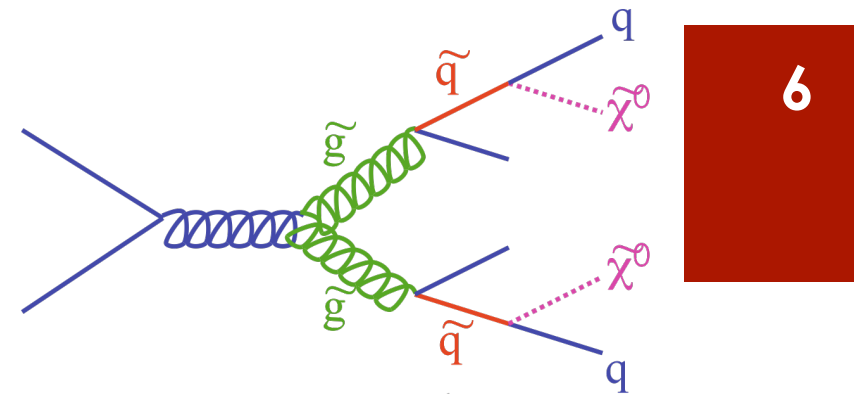
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- Conservation of R-parity:
 - Pair production of gluinos and squarks.
 - Lightest neutralino $\tilde{\chi}_1^0$ is LSP.
- For $\tan \beta < 10$
 - First 2 generation squarks and sbottom are mass degenerate.
 - $M_{\tilde{q}} > 0.85 M_{\tilde{g}}$.
- Search for 3rd generation squarks in constrained MSSM scenarios with enhanced production of light sbottom or stop.

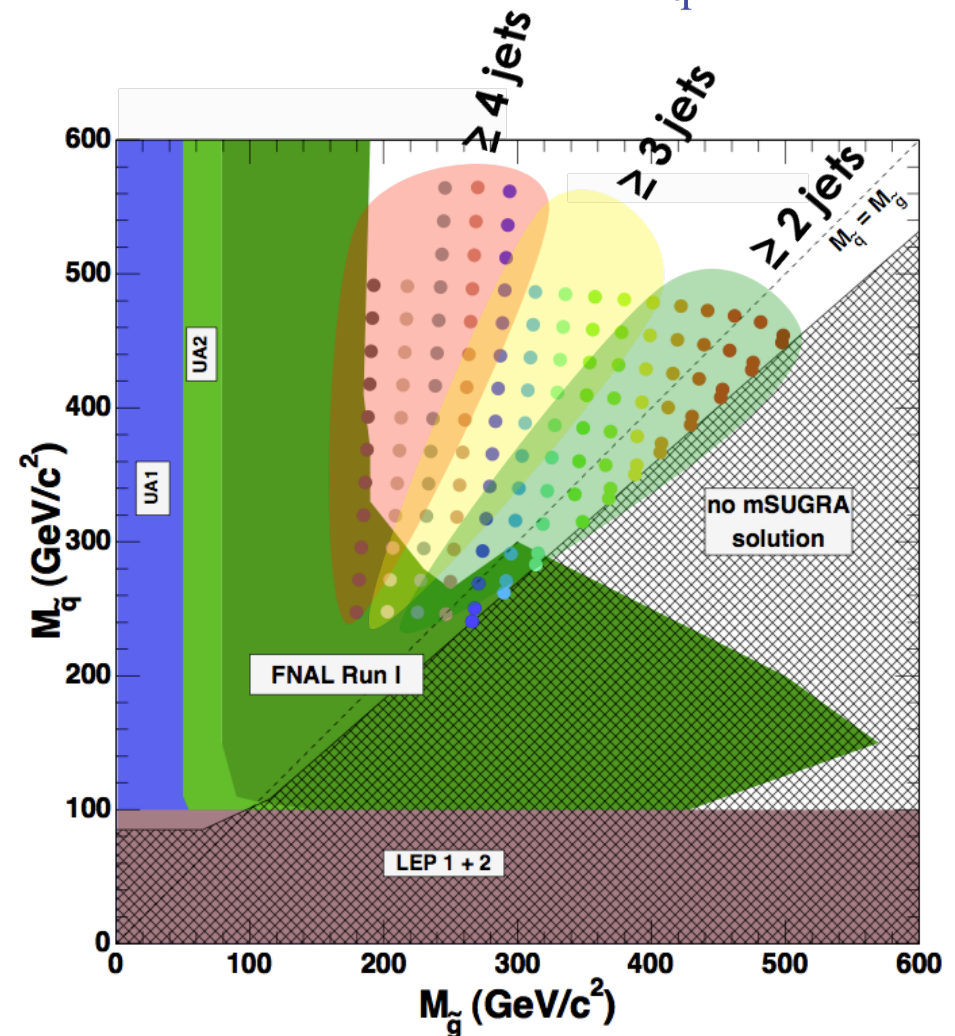


Inclusive Search for Gluino/Squark

- mSUGRA: $A_0=0$, $\mu < 0$, $\tan \beta = 5$: scan gluino/squark masses via variation of $M_0 - M_{1/2}$.
- 132 MC samples generated with ISASUGRA in PYTHIA Tune A.
- 5 squarks degenerate, stop production not considered.
- R_p conserved: final state with MET + jets.
- Jet multiplicity depends on gluino/squark masses.
- 3 analyses with MET + $\geq 2, 3, 4$ jets final state for best sensitivity across the plane.



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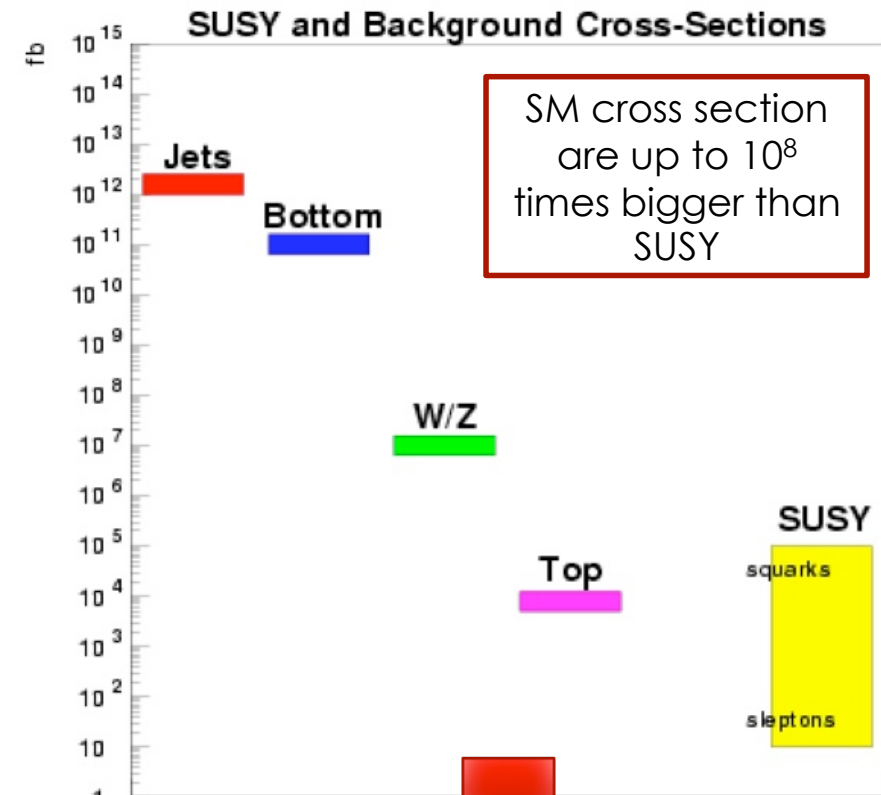
Inclusive Search for Gluino/Squark

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- List of SM backgrounds:
 - QCD multijet events.
 - W/Z + jets decays.
 - Diboson WW/WZ/ZZ decays.
 - Top decays.
- Processes with MET from:
 - Escaping neutrinos.
 - Undetected leptons.
 - Jet energy mismeasurement.

Final Selection Cuts

[GeV]	MET	HT	$E_T(\text{jet } 1)$	$E_T(\text{jet } 2)$	$E_T(\text{jet } 3)$	$E_T(\text{jet } 4)$
≥ 4 jets	90	280	95	55	55	25
≥ 3 jets	120	330	140	100	25	---
≥ 2 jets	180	330	165	100	---	---

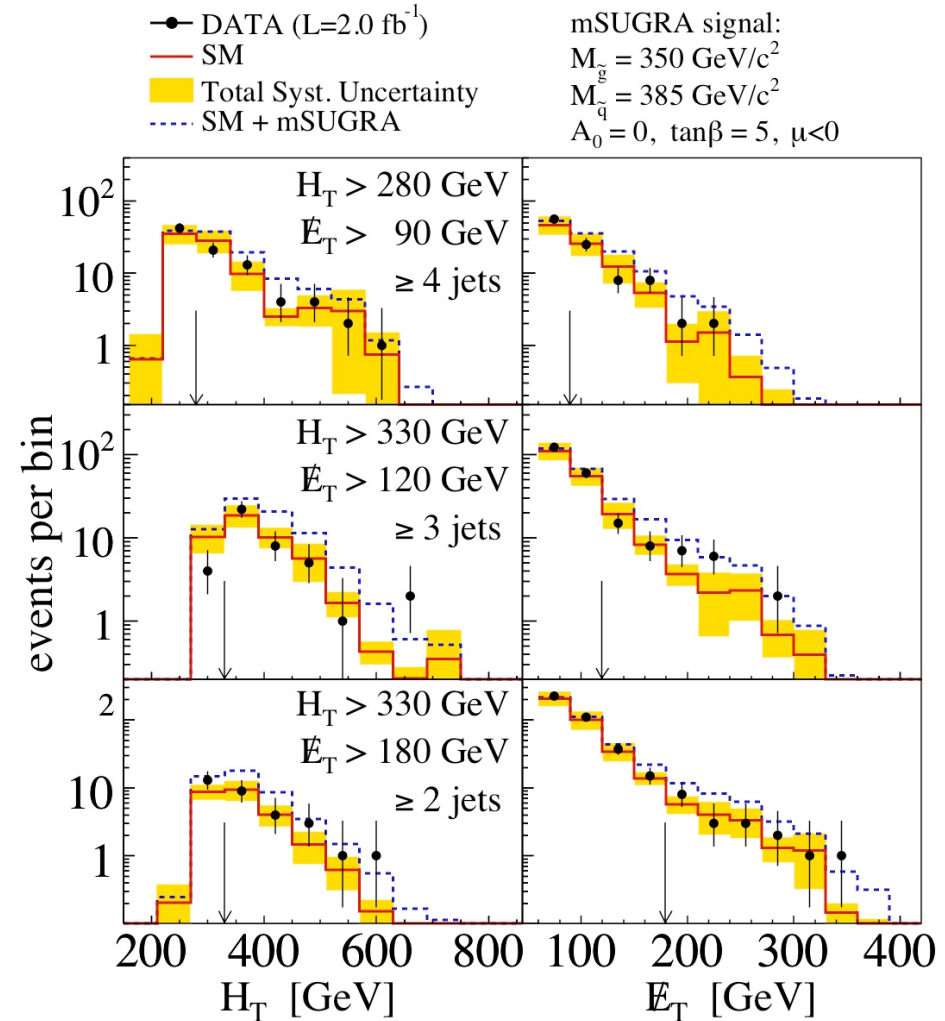
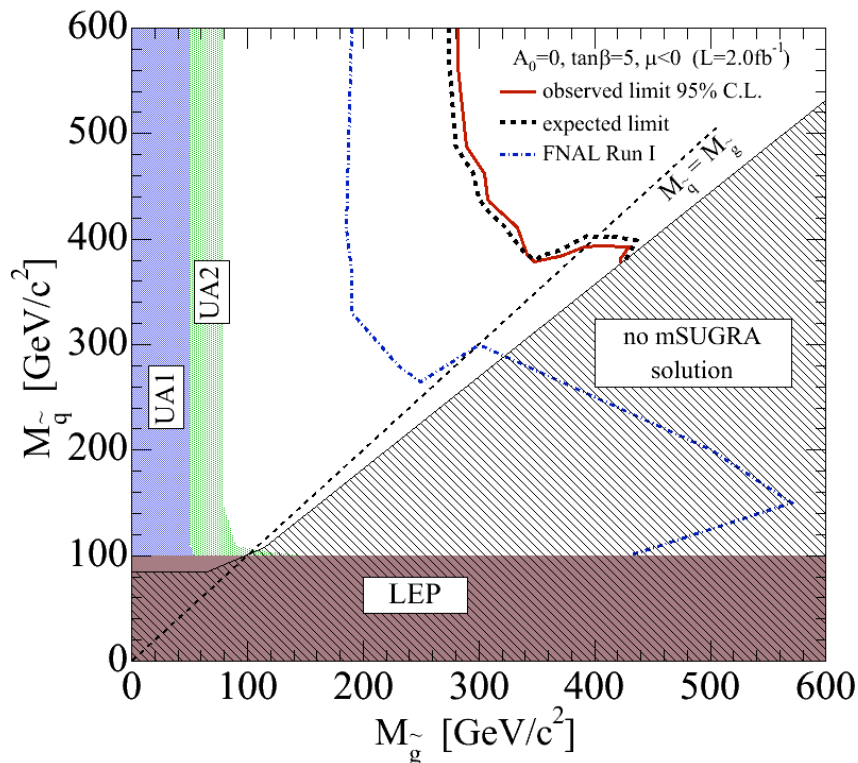


Huge background reduction needed!

SM expected yields from MC samples.

Inclusive Search for Gluino/Squark

- Good agreement between DATA and SM expectation in 2.0 fb^{-1} .
- 95% CL exclusion limits:
 - $M_{\tilde{g}} > 392 \text{ GeV}/c^2$ when $M_{\tilde{q}} \sim M_{\tilde{g}}$.
 - $M_{\tilde{g}} > 280 \text{ GeV}/c^2$ for any $M_{\tilde{q}}$.



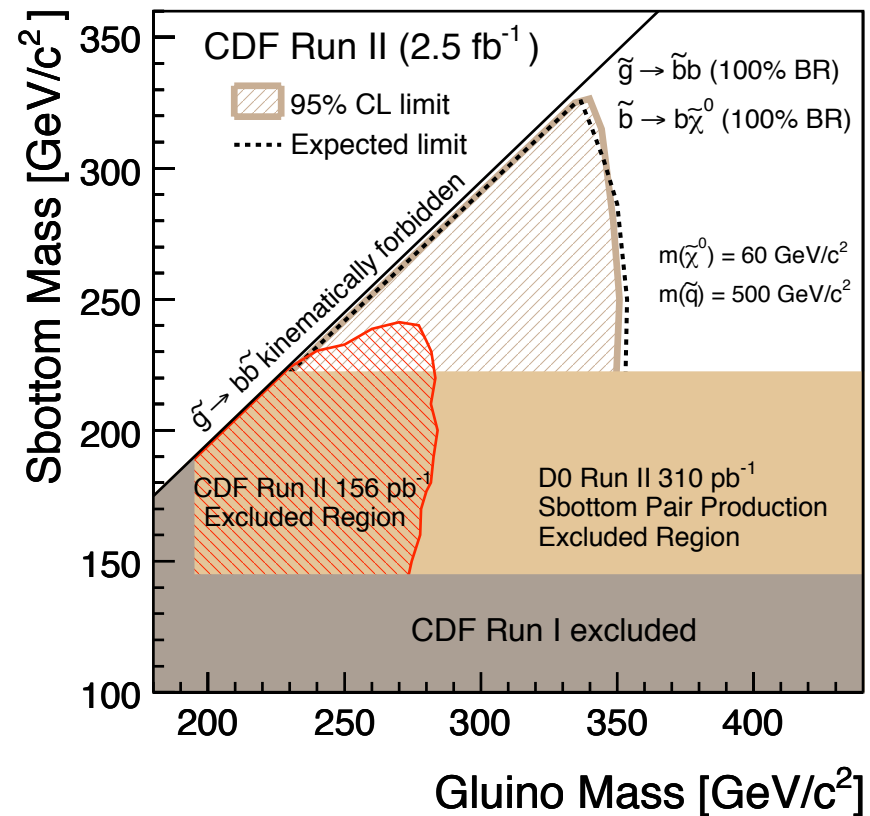
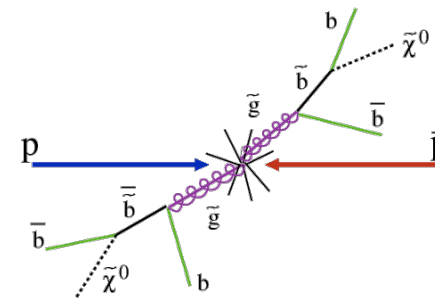
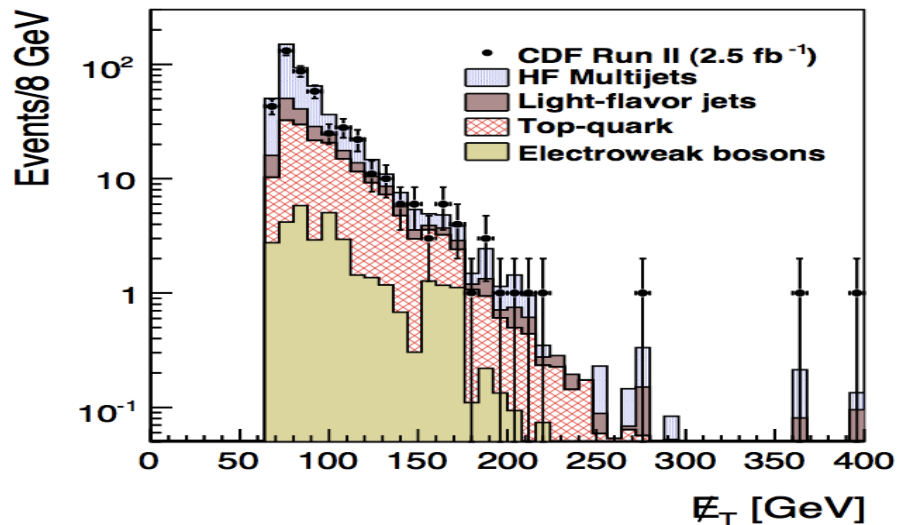
Systematic uncertainties:

- 30% on bkg, dominated by JES (25%) and ISR/FSR (10%) in MC simulation.
- 20% on sig, dominated by JES (15%) and ISR/FSR (5%).

Gluino-Mediated Sbottom Production

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- Signature of 4 b-jets and MET.
- Events have $\text{MET} > 70 \text{ GeV}$ and 2 b-tagged jets.
- 2 signal regions optimized for large and small $\Delta M = M_{\tilde{g}} - M_{\tilde{b}}$.
- Final selection based on NN-algorithm.
- Good agreement DATA - SM, 95% CL limit:
 - $M_{\tilde{g}} > 350 \text{ GeV}/c^2$ for any $M_{\tilde{b}}$

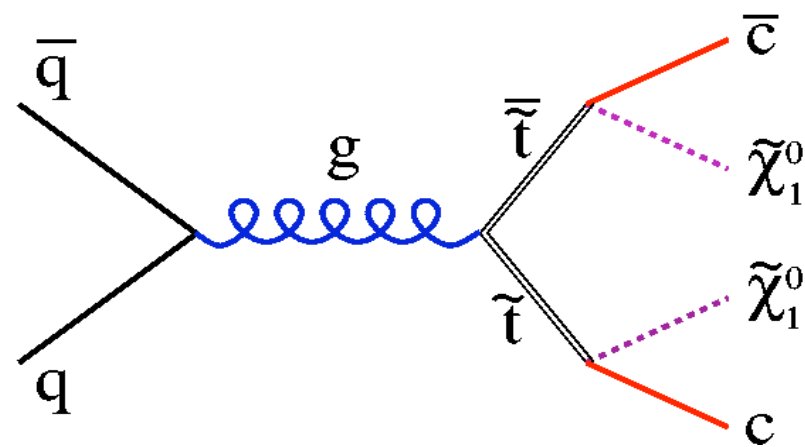
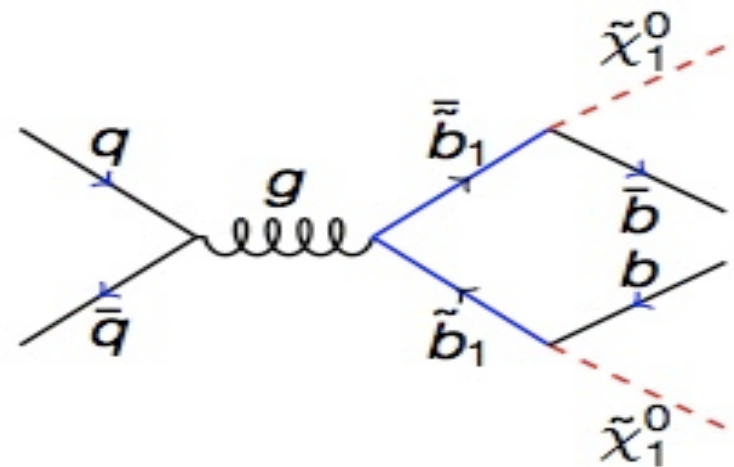


Systematic uncertainties:

- 30% on background and signal dominated by JES and mistag rate uncertainty.

Direct Sbottom/Stop Production

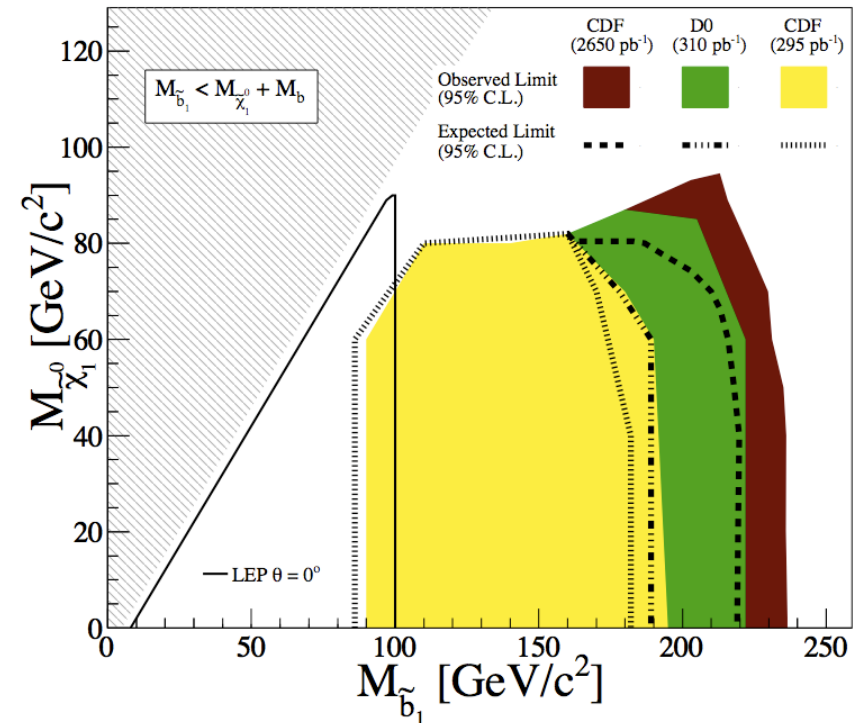
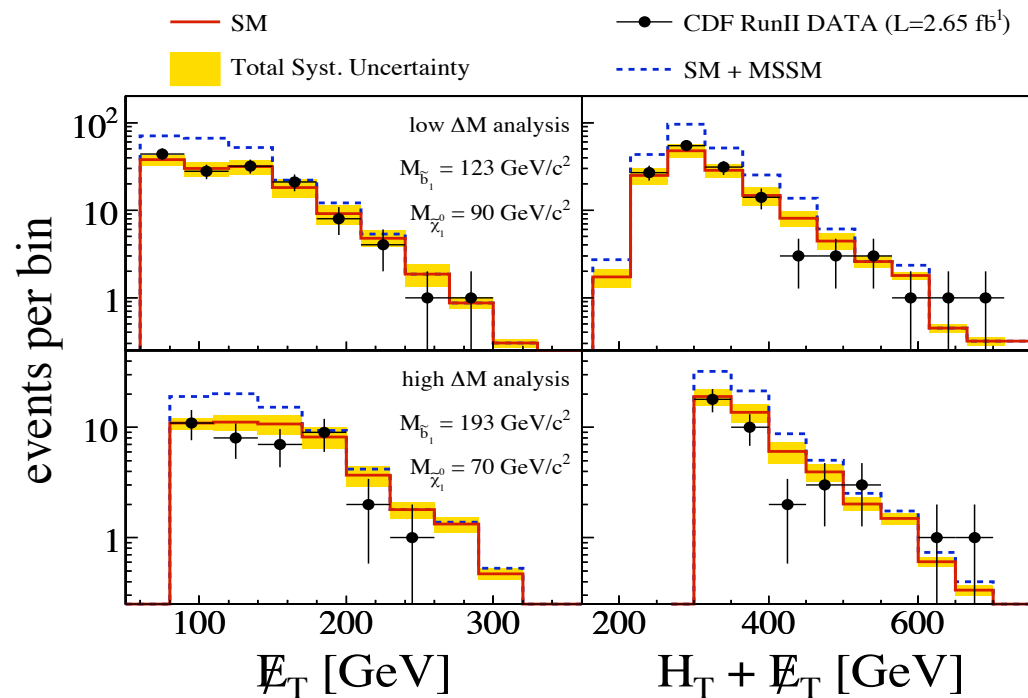
- Search for 3rd generation squarks in dedicated MSSM scenarios with enhanced production of light sbottom or stop.
- Final state MET from lightest neutralinos (LSP).
- Signature with heavy flavor b/c jets from sbottom/stop decay.
- Selection employs heavy flavor tagging based on secondary vertex identification.



Search for Direct Sbottom Production

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- Constrained MSSM scenario with MET + 2 b-jets final state.
- QCD and mistags from DATA, other bkg from MC.
- Two signal regions optimized for best sensitivity: high/low $\Delta M = M_{\tilde{b}} - M_{\tilde{\chi}}$
- No hint for SUSY: 95% CL exclusion limit:
 - $M_{\tilde{b}} > 230 \text{ GeV}/c^2$ for $M_{\tilde{\chi}} < 70 \text{ GeV}/c^2$.



Systematic uncertainties:

- 20% on bkg, dominated by uncertainty on mistag rate and normalization of heavy flavor MC samples.
- 30% on sig, dominated by JES and theoretical uncertainty on PDF and renormalization scale

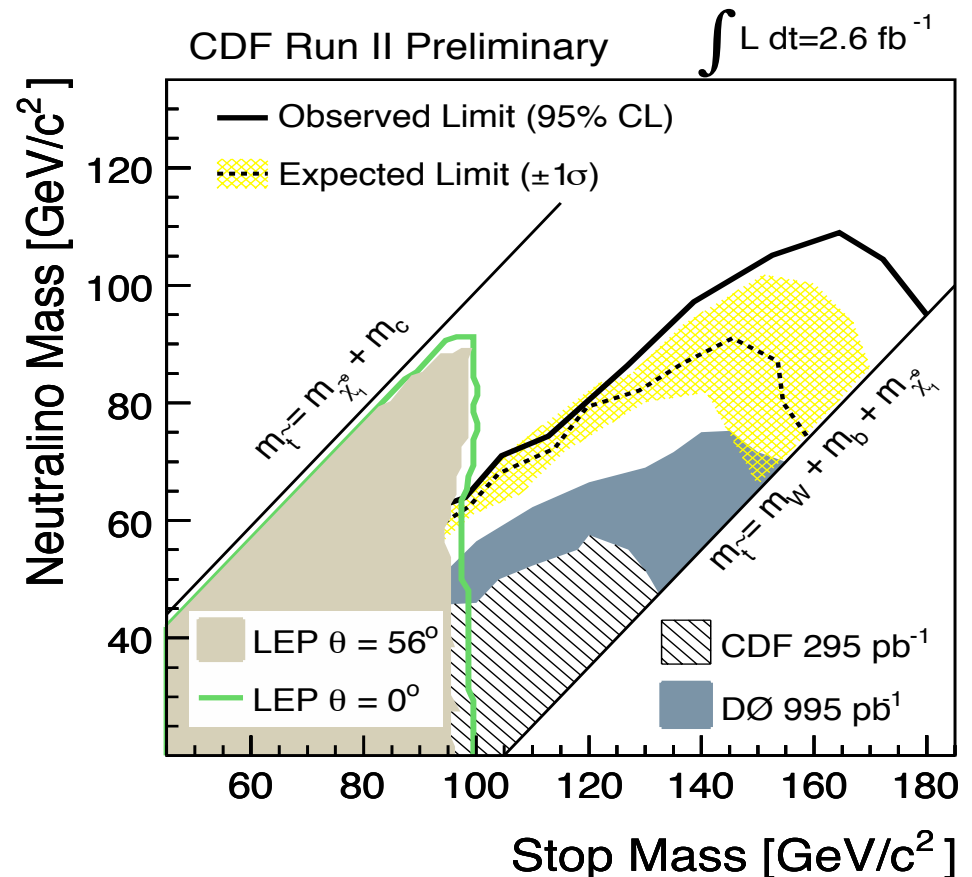
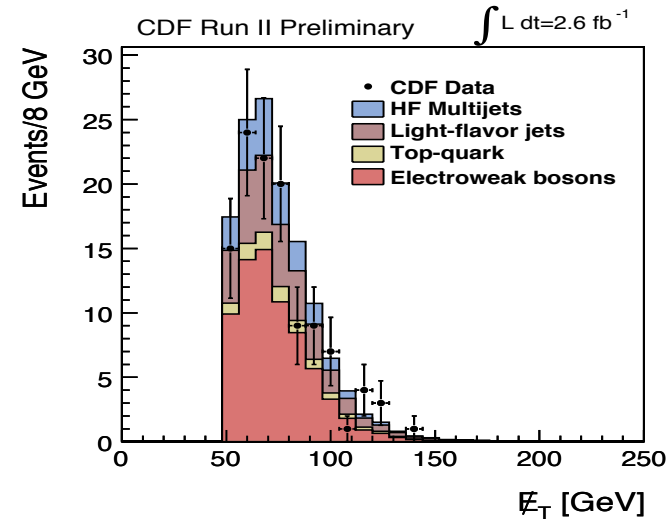
Search for Direct Stop Production

- MSSM scenario with conserved R_p with $\text{BR}(\tilde{t}_1 \rightarrow c \tilde{\chi}_1^0) = 100\%$.
- Final state with 2 c-jets and MET.
- NN-based flavor separator algorithm to enhance the c-tagging efficiency.
- QCD and mistags from DATA, other bkg from MC simulation.
- Sensitivity optimized with NN-based selection.
- No hint for SUSY, 95% CL limit:
 - $M_{\tilde{t}} > 180 \text{ GeV}/c^2$ (with $M_{\tilde{\chi}} \sim 90 \text{ GeV}/c^2$)

Systematic uncertainties:

- 20% on bkg and 25% on signal dominated by the uncertainty on mistag rate and flavor separator algorithm.

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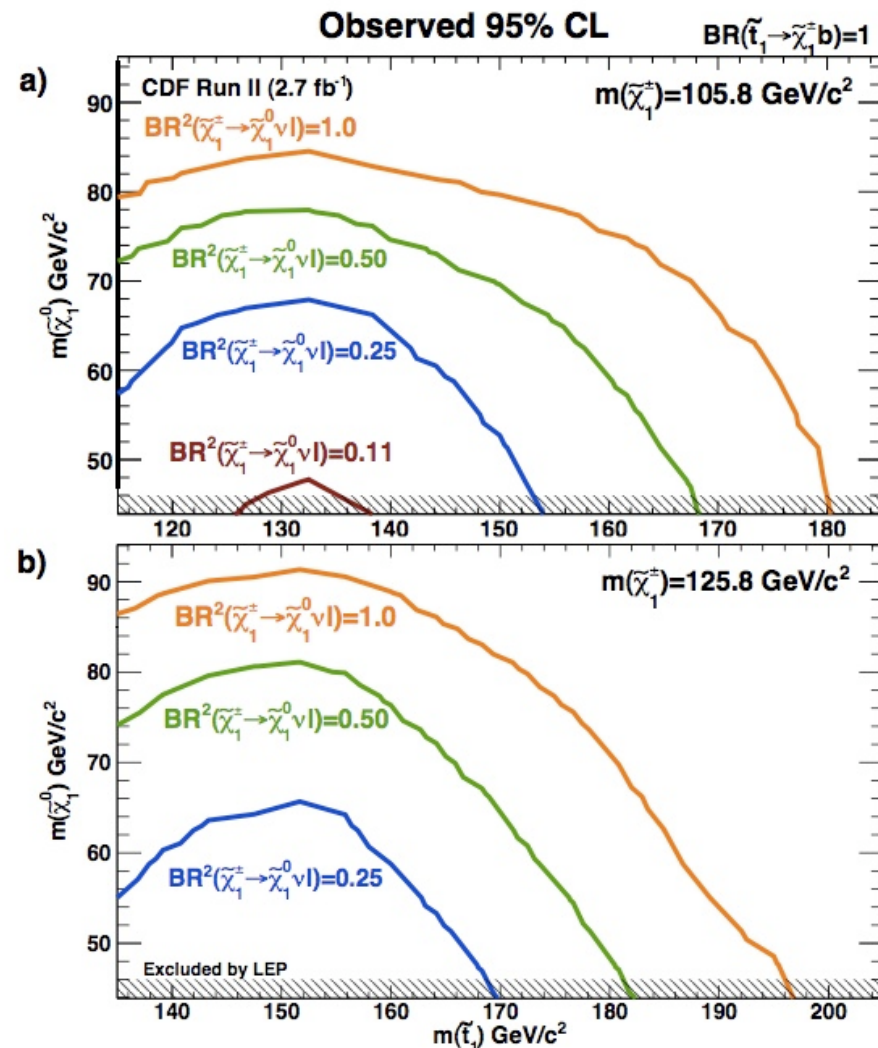


Search for Direct Stop Production in Di-Lepton Channel

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$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^\pm \rightarrow b\tilde{\chi}_1^0 l \nu$$

- Mimicking $t\bar{t}$ signature.
- Final state with 2 opposite charged leptons, 2 b-jets, and large MET from neutrinos and neutralinos.
- Selection based on lepton identification and b-tagging.
- Good agreement DATA - SM: exclusion limits extracted for different values of $\text{BR}(\tilde{\chi}_1^\pm \rightarrow \tilde{\chi}_1^0 \nu \ell^\pm)$.



Conclusion

- Presented a summary of the results of searches for squarks and gluinos in events with MET + jets at the CDF experiment with up to 2.7 fb^{-1} of data.
- Exclusion limits on inclusive squark/gluino production in mSUGRA:
 - excluded gluino/squark masses up to $390 \text{ GeV}/c^2$ when $M_{\tilde{g}} \approx M_{\tilde{q}}$
 - excluded gluino mass up to $280 \text{ GeV}/c^2$ for any squark mass.
- Exclusion limits on sbottom/stop production in dedicated MSSM scenarios:
 - excluded light sbottom masses up to $230 \text{ GeV}/c^2$
 - excluded light stop masses up to $180 \text{ GeV}/c^2$
- Hunt for gluinos and squarks is still open.

backup slides

mSUGRA at LHC

