Search for Sbottom from Gluino Decay at CDF

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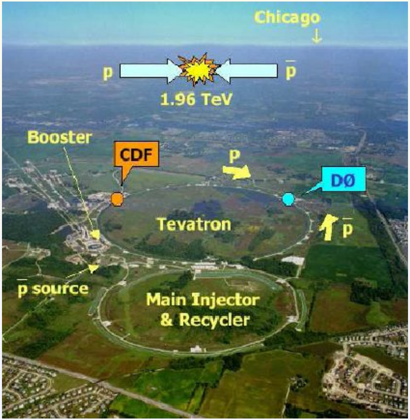
Outline

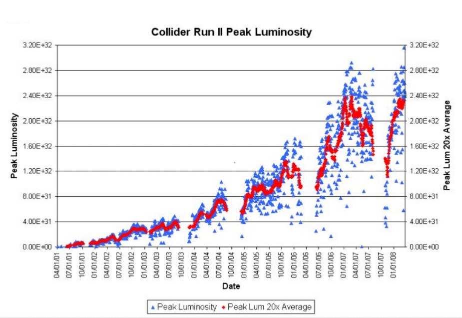
1. The Tevatron
2. CDF Detector
3. SUSY Framework
4. Validation Regions
5. Results
6. Conclusions

The Tevatron

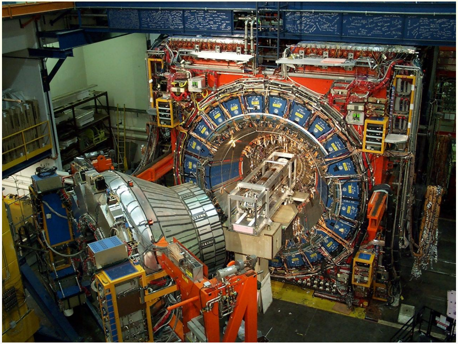
- $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV
- 36 $\times$ 36 bunches, 396 ns crossing period



- Initial instantaneous luminosity record: 3.15 $\times 10^{32}$cm^{-2}s^{-1}
- Delivered luminosity $>$ 3.8 fb^{-1} since March 2001 (Run II)



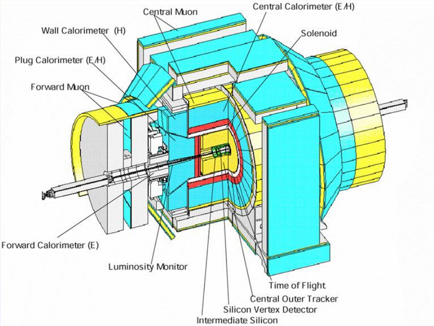
CDF Run II



General purpose collider experiment

- Silicon inner tracker
- Multi-wire outer tracker
- Solenoid: 1.4 T field
- Calorimeter
- Muon chambers

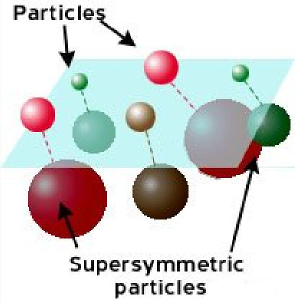
Dimensions:
10m $\times$ 10m $\times$ 25m



Theoretical Framework

Supersymmetry is a symmetry between bosons and fermions which is introduced as an exact symmetry at high energies in several theoretical models.

- Each particle in Nature would have a superpartner in SUSY
- Double the Standard Model (SM) particle spectrum
- SUSY has to be broken at low energies



Theoretical Framework

- R-parity is a new multiplicative quantum number:

R-parity

$R_P = (-1)^{2S+3B+L}$
B is the baryon number, L is the lepton number and S is the spin.

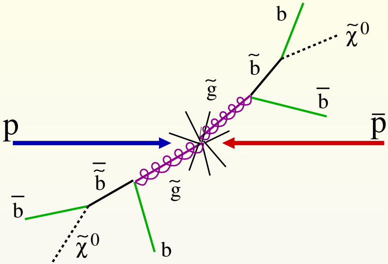
In R-parity conserving SUSY:

- The SUSY particle with smallest mass (LSP) cannot decay and is stable $\Rightarrow$ Dark Matter candidate
- The SUSY particles are produced in pairs

What are we searching for?

- Gluino decaying into sbottom
- $p\bar{p} \rightarrow \tilde{g}\tilde{g} \rightarrow b\tilde{b}b\tilde{b} \rightarrow bb\tilde{\chi}^0 bb\tilde{\chi}^0$

Analysis Features



Final State:

- 4 b-jets
- MET (from $\tilde{\chi}^0$)

- Process strongly dependent on the $\tilde{g}$ cross section production
- Test in the SUSY region $m_t, m_{\tilde{\chi}^+} > m_{\tilde{b}} > m_{\tilde{\chi}^0}$
- $\tilde{g} \rightarrow b\tilde{b}$, $\tilde{b} \rightarrow b\tilde{\chi}^0$ with 100% B.R.

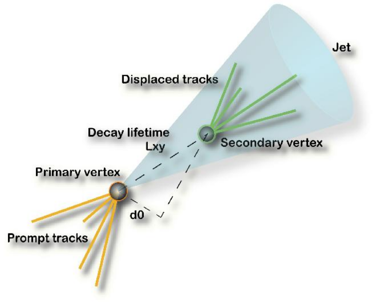
- Pros:
  - Distinctive signature
- Assumptions:
  - M($\tilde{g}$) $\Rightarrow$ low enough to be produced at Tevatron
  - M($\tilde{g}$) $\Rightarrow$ larger than M($\tilde{b}$)

MET is the missing transverse momentum due to particles not detected (i.e. neutrinos), in our case due to $\tilde{\chi}^0$

Analysis Description

Search in the MET inclusive sample by using $\mathcal{L} = 1.8\ \mathrm{fb}^{-1}$ of data

- MET sample $\Rightarrow$ contaminated with non-physics backgrounds (beam effects, cosmics...)
- Multijet environment
- b-tagging
- Large backgrounds:
  - Inclusive Multijets $\Rightarrow$ from DATA
  - “Mistags” $\Rightarrow$ spurious tagging (from DATA)
  - $t\bar{t}$ production, single top, EWK boson production estimated with MC



Background Rejection

Basic Cuts

- At least 1 central jet $\Rightarrow |\eta| \leq 0.9$
- MET $\geq$ 70 GeV $\Rightarrow$ to guarantee 100% trigger efficiency
- Dijet selection $\Rightarrow$ against beam-related backgrounds

QCD Rejection

- $\Delta\phi(MET, jets) \geq 0.7$ Remove events with mismeasured jets (MET aligned to the direction of one of the jets)

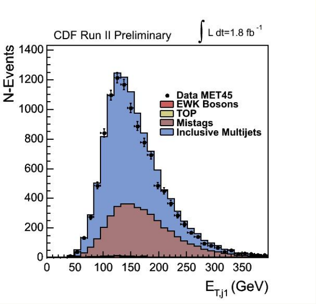
EWK Rejection

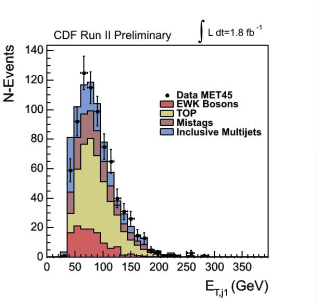
- Reject events with electrons misidentified as jets
- No leptons in the final state

The recipe to find the gluino $\Rightarrow$

Validation Regions

- 3 Control Regions:
  - Inclusive Multijet region: MET aligned with the 2nd Jet
  - Lepton region: At least 1 lepton required
  - Pre-optimization region: benchmark point to optimize sensitivity





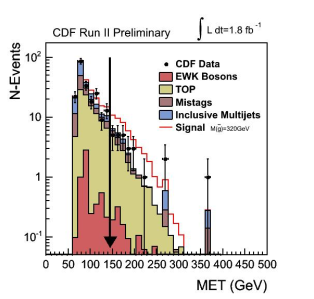
CDF Run II Preliminary

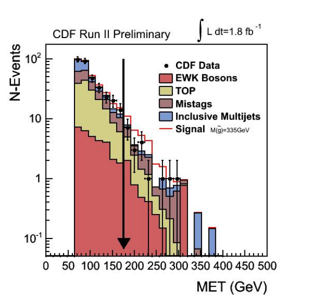
Region	QCD Region	Lepton Region	Preoptimization Region
Boson production	66.0	108	382
Diboson production	3.0	16	46
Top pair production	54.2	337	750
Single top production	4.5	27	59
HF QCD Multijets	7880	165	1414
Light-flavour contamination	3966	145	841
Total expected	11970 ± 4190	798 ± 120	3490 ± 1010
Observed (1.78 fb^{-1})	11231	769	3484

Optimization

- Two diferent optimizations used to maximize $S/\sqrt{B}$:
  - $M(\tilde{g}) = 320$, $M(\tilde{b}) = 250$, $M(\tilde{\chi}) = 60 \Rightarrow$ Large Δm
  - $M(\tilde{g}) = 300$, $M(\tilde{b}) = 280$, $M(\tilde{\chi}) = 60 \Rightarrow$ Small Δm
- Large Δm:
  - MET $\geq$ 145 GeV
  - Number of Jets ≥ 3
- Small Δm:
  - MET $\geq$ 175 GeV
  - Number of Jets ≥ 2

MET $\Rightarrow$ Variable with better separation power between signal and background





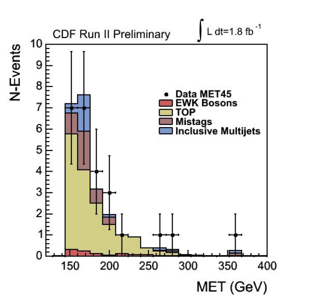
Results

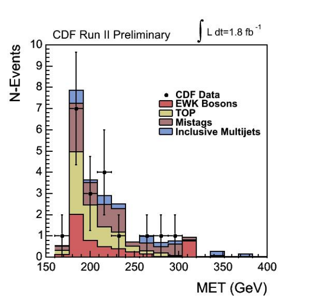
Good agreement between expected (from SM) and observed events

CDF Run II Preliminary

Region	(Large Δm) Optimization	(Small Δm) Optimization
EWK Boson production	1.1 ± 0.6	5.1 ± 2.6
Top pair production	15.7 ± 4.6	7.2 ± 1.7
Single top production	0.10 ± 0.04	0.11 ± 0.04
HF QCD Multijets	1.9 ± 1.4	2.2 ± 2.2
Light-flavour contamination	3.9 ± 1.1	7.4 ± 2.1
Total expected	22.7 ± 4.6	22.0 ± 3.6
Observed (1.78 fb^{-1})	25	19

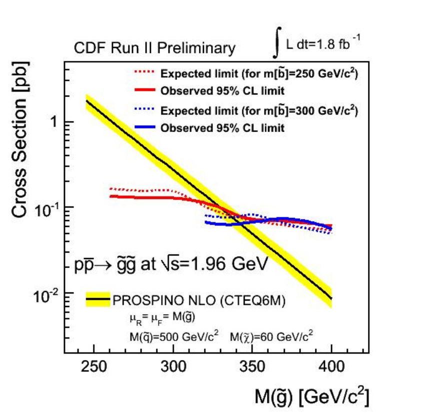
No evidence of SUSY has been found $\Rightarrow$ extract exclusion LIMIT

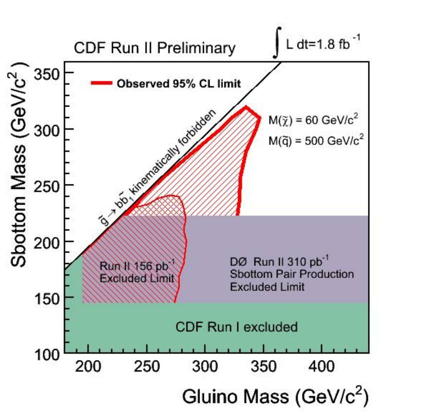




Observed Limits

Observed Limits at 95% C.L.





Excluded σ above 0.1 pb
($M(\tilde{g}) \sim 350$ GeV/c^2)

Limits translated to the gluino-sbottom mass plane

Conclusions

- SUSY search in the MET + b-jet channel has been performed
- 1.8 fb^{-1} of data with large MET used

- No evidence of SUSY in gluino decaying into sbottom dedicated search
- Good agreement with the SM
- Exclusion limit extracted for M($\tilde{\chi}^0$) = 60 GeV/c^2:
  - For a M($\tilde{b}$) = 250 GeV/c^2 $\Rightarrow$ M($\tilde{g}$) below 330 GeV/c^2 is excluded
  - For a M($\tilde{b}$) = 300 GeV/c^2 $\Rightarrow$ M($\tilde{g}$) below 340 GeV/c^2 is excluded

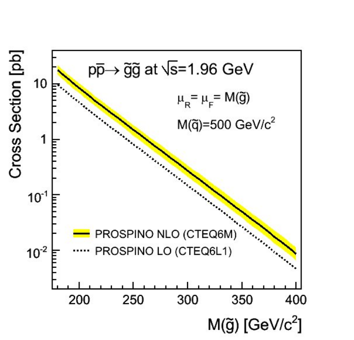
- Working on improving the sensitivity

Backup Slides

Analysis Features

Sbottom from gluino decay at CDF

- Process strongly dependent on the $\tilde{g}$ cross section production



- Test in the region $m_t, m_{\tilde{\chi}^+} > m_{\tilde{b}} > m_{\tilde{\chi}^0}$

- $\tilde{g} \to b\tilde{b}$, $\tilde{b} \to b\tilde{\chi}^0$ with 100% B.R.

- Feynman Diagrams (LO):