Search for Supersymmetry Using Like-Sign Dilepton Events at CDF

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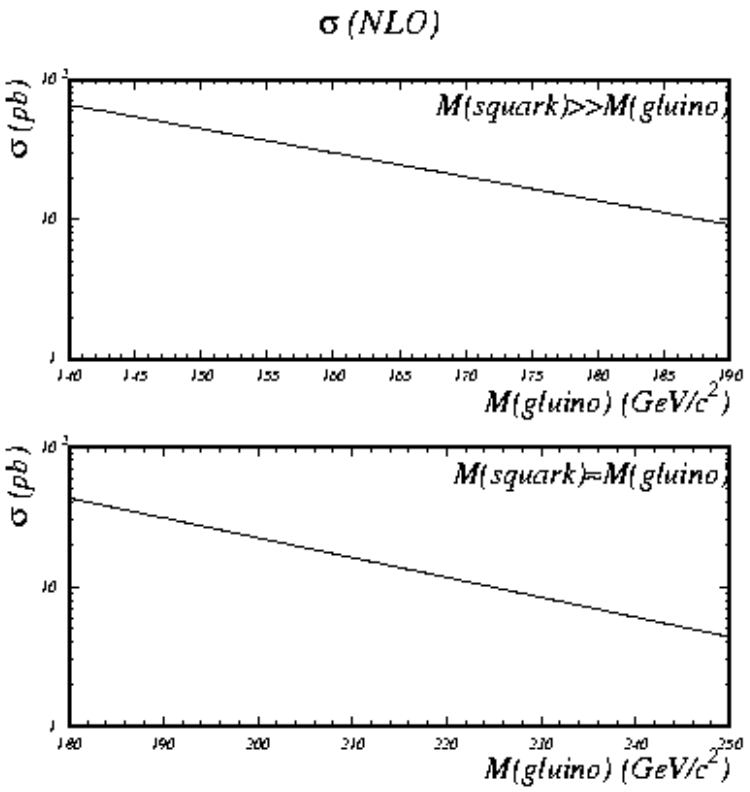
- Conclusion

Supersymmetry (SUSY)

- ▷ ISAJET 7_20 (LO) $\tilde{g}\tilde{g}$ $\tilde{q}\tilde{q}$ $\tilde{q}\tilde{g}$
- ▷ R-Parity Conservation
- ▷ 5 degenerate squarks (no $\tilde{t}$'s)
- ▷ NLO cross-section from PROSPINO program
- ▷ MSSM Parameters
  - ⇒ $\tan\beta = 2$
  - ⇒ $\mu = -800$ GeV
  - ⇒ $A_t = \frac{\mu}{tan\beta}$
  - ⇒ $A_b = \mu \tan\beta$
  - ⇒ $M_{A_0} = 500$ GeV/c^2
- ▷ Supergravity Inspired
  - ⇒ $\tilde{\ell}$ masses : RGE's :

$$\left.\begin{aligned} M^2_{\tilde{\ell}_L} &= M^2_{\tilde{q}} - 0.73 M^2_{\tilde{g}} - 0.27 M^2_Z \cos 2\beta \\ M^2_{\tilde{\ell}_R} &= M^2_{\tilde{q}} - 0.78 M^2_{\tilde{g}} - 0.23 M^2_Z \cos 2\beta \\ M^2_{\tilde{\nu}_L} &= M^2_{\tilde{q}} - 0.73 M^2_{\tilde{g}} + 0.5 M^2_Z \cos 2\beta \end{aligned}\right\}$$

Gluino/Squark Cross-Sections



Production Cross-Sections Include :

- ▷ $\tilde{g}\tilde{g}$, $\tilde{q}\tilde{q}$, $\tilde{q}\tilde{g}$

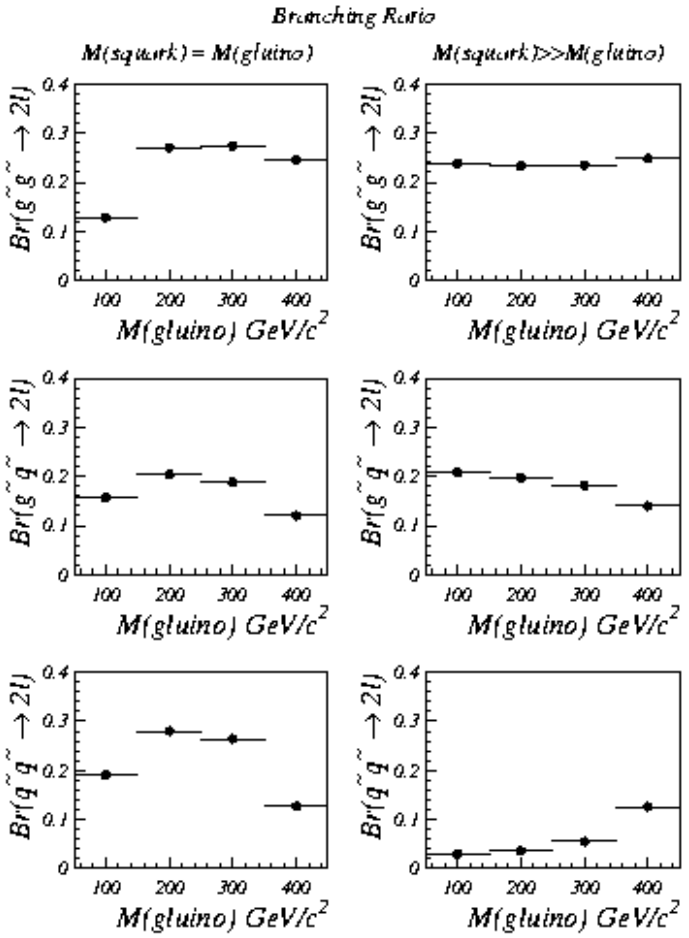
PROSPINO

- ▷ **NLO Cross-Section Program**
- ▷ **W. Beenakker, R. Höpker, M. Spira, P. Zerwas**
- ▷ **http://home.cern.ch/~mspira/proglist.html**

Branching Ratios

Branching Ratios Include :

▷ $\tilde{g}\tilde{g}, \tilde{q}\tilde{g}, \tilde{q}\tilde{q} \rightarrow 2\ell$

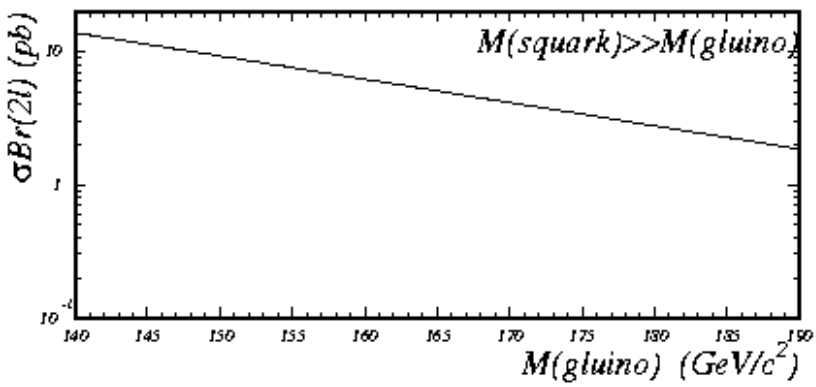


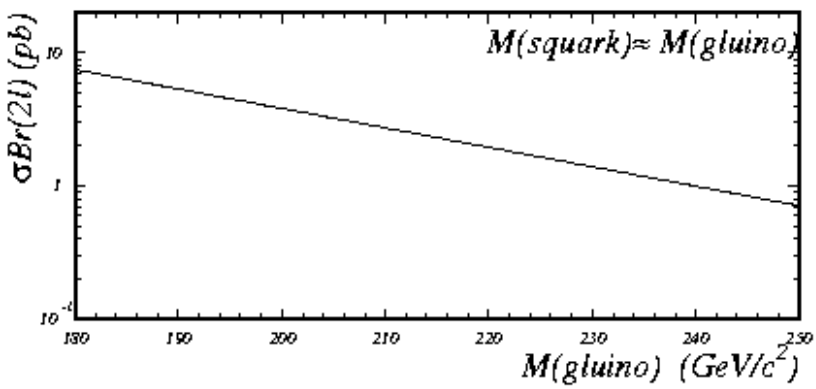
▷ BR at Low Mass: $\tilde{\chi}_2^0$ & $\tilde{\chi}_1^{\pm}$ decay to $\tilde{\nu}_\ell$

▷ BR at High Mass: $\tilde{\chi}_1^{\pm}$ hadronic decays increase

Cross-Section × Branching Ratio

$\sigma^{NLO}\ Br(2l)$





Event Selection

- ▷ 2 Leptons
  - ⇒ $p_T(\ell_1) \geq 11$ GeV/c
  - ⇒ $p_T(\ell_2) \geq 5$ GeV/c
  - ⇒ $ISO^{cal}_{0.4} \leq 4$ GeV
  - ⇒ $ISO^{trk}_{0.4} \leq 4$ GeV/c
  - ⇒ $|\eta^{det}_{\ell}| \leq 1.1$
- ▷ 2 or more jets
  - ⇒ Cone Size $\Delta R = 0.4$
  - ⇒ $E_T \geq 15$ GeV
  - ⇒ $|\eta^{det}_{j}| \leq 2.4$
- ▷ Missing E_T
  - ⇒ Corrected for all μ/jets
  - ⇒ $\not{E}_T \geq 25$ GeV

Data Reduction

CDF Preliminary (106 pb^{-1})

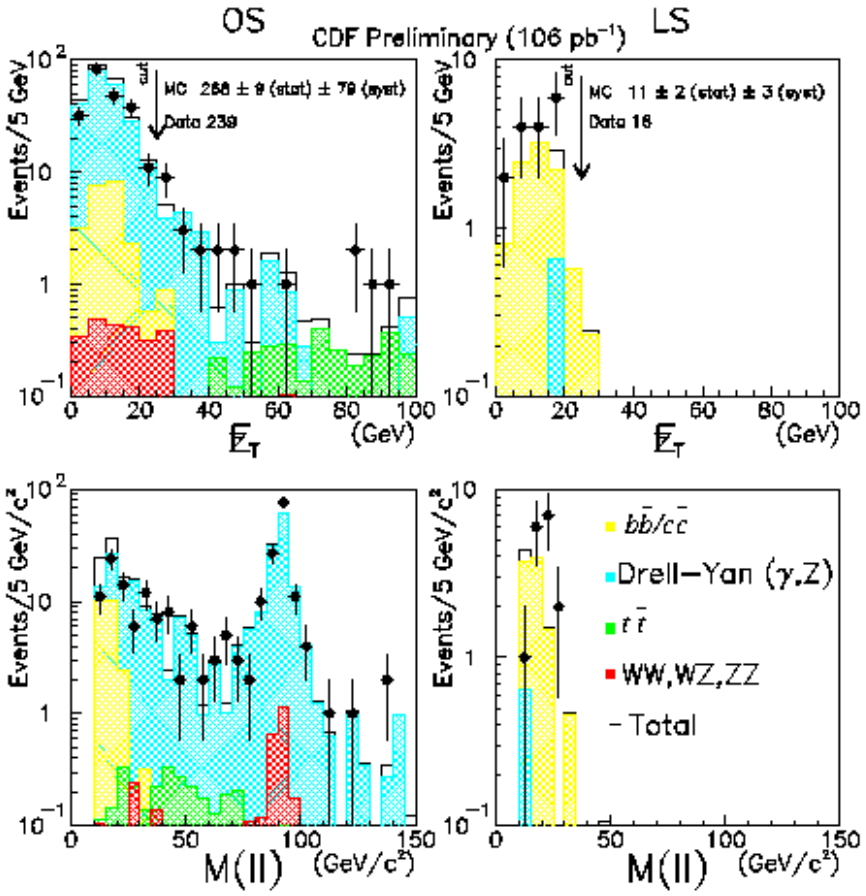
Data Selection	Total	OS		LS	
		$ee+\mu\mu$	$e\mu$	$ee+\mu\mu$	$e\mu$
Run I Dilepton Trigger	515,699				
Dilepton-Dijet Dataset	350	294	31	10	15
$M_{\ell,\ell'} < 12$ GeV/c^2 Removal	255	216	23	6	10
Z^0 veto	128	89	23	6	10
$\not\!\!E_T \geq 25$ GeV	19	9	10	0	0

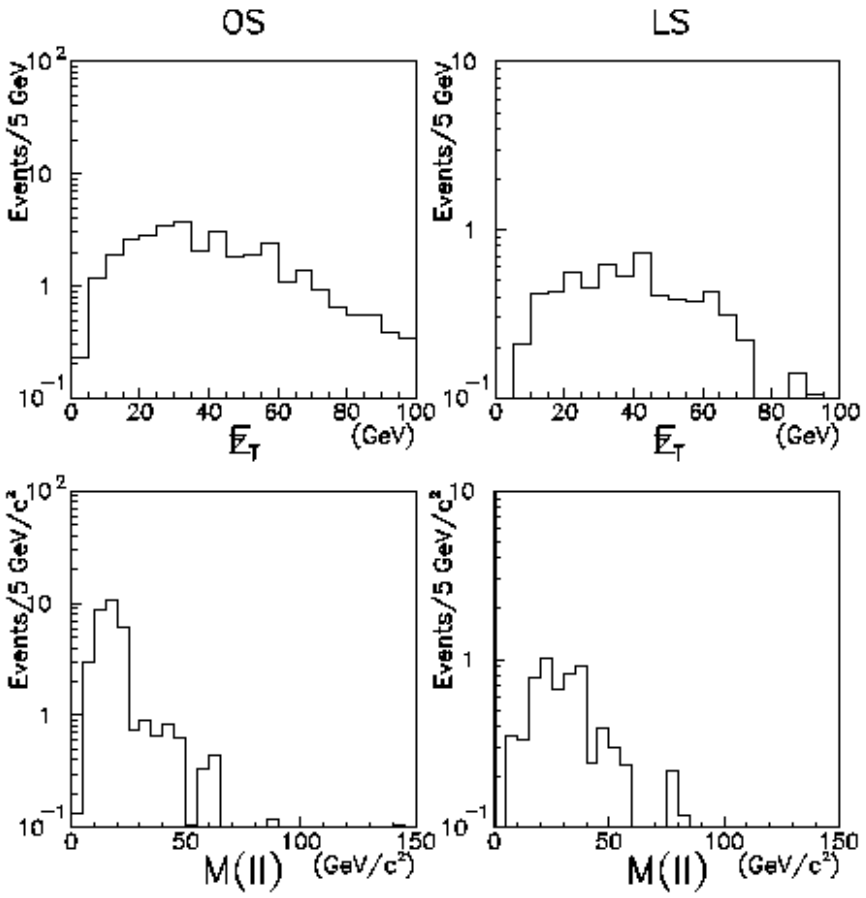
CDF Preliminary (106 pb^{-1})

Source	Opposite Sign	Like Sign
Drell-Yan (γ,Z)	$8.7 \pm 0.9 \pm 2.9$	$0.00 \pm 0.01 \pm 0.01$
$t\bar{t}$	$4.0 \pm 0.3 \pm 1.0$	$0.08 \pm 0.04 \pm 0.02$
$b\bar{b}/c\bar{c}$	$0.9 \pm 0.9 \pm 0.2$	$0.23 \pm 0.23 \pm 0.06$
$WW/WZ/ZZ$	$0.5 \pm 0.1 \pm 0.1$	$0.24 \pm 0.10 \pm 0.01$
Total	$14.1 \pm 1.3 \pm 3.1$	$0.55 \pm 0.25 \pm 0.06$
Data	19	0

- **Opposite/Like-Sign Events After $\not\!\!E_T \geq 25$ GeV.**
- **Background Estimate Does Not Include Misidentified Leptons.**

Background & Data




OS
LS
Events/5 GeV
$\not{E}_T$ (GeV)
Events/5 GeV/c²
M(ll) (GeV/c²)

Total Uncertainty on Acceptance

CDF Preliminary (106 pb^{-1})

$M_{\tilde{q}} \gg M_{\tilde{g}}$			
$M_{\tilde{g}}$ (GeV/c^2)	160	180	200
Lepton Isolation	11%	11%	11%
Gluon Radiation	1%	5%	4%
Trigger Efficiency	2%	4%	3%
Lepton ID	2%	2%	2%
Jet Energy Scale	4%	5%	3%
Luminosity	4%	4%	4%
MC Statistics	10%	14%	13%
Total	16%	20%	18%

$M_{\tilde{q}} \simeq M_{\tilde{g}}$			
$M_{\tilde{g}}$ (GeV/c^2)	220	240	260
Lepton Isolation	11%	11%	11%
Gluon Radiation	10%	8%	8%
Trigger Efficiency	3%	4%	4%
Lepton ID	2%	2%	3%
Jet Energy Scale	1%	1%	1%
Luminosity	4%	4%	4%
MC Statistics	5%	15%	25%
Total	17%	21%	29%

Limit Calculation

$$N_{obs} = 0$$

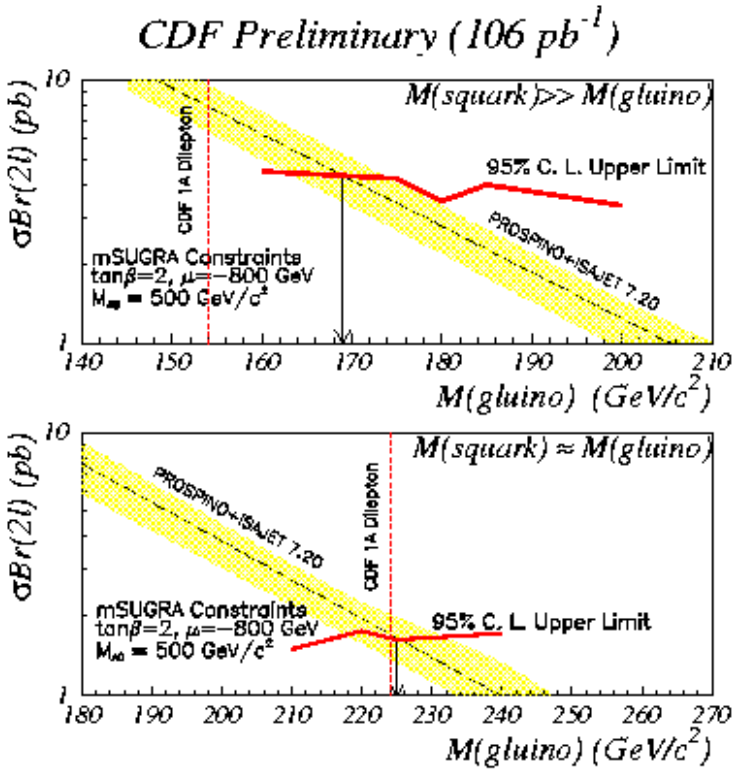
$$(\sigma \cdot BR)_{95\%CL} = \frac{N_{95\%CL}}{\epsilon^{tot} \int \mathcal{L}\, dt}$$

CDF Preliminary (106 pb^{-1})

$(M_{\tilde{g}}, M_{\tilde{q}})$	ϵ^{tot}	$N_{95\%CL}$	$(\sigma \cdot BR)$ (pb) 95 %CL	$(\sigma \cdot BR)$ (pb) theory
(160,500)	0.66%	3.1	4.5	6.3
(175,500)	0.70%	3.1	4.1	3.3
(180,500)	0.88%	3.2	3.5	2.8
(185,500)	0.74%	3.1	4.0	2.2
(200,500)	0.99%	3.2	3.3	1.2
(210,211)	2.0%	3.2	1.5	2.7
(220,221)	1.7%	3.2	1.8	1.9
(225,226)	1.7%	3.2	1.8	1.9
(239,240)	1.8%	3.3	1.7	1.0

Limits

⇒ **95% C.L. Limit**



⇒ $M_{\tilde{q}} \geq 169$ GeV/c^2; $\sigma \cdot BR \leq 4.1$ pb ($M_{\tilde{g}} \gg M_{\tilde{q}}$ and $Q^2 = m^2$)

⇒ $M_{\tilde{g}} \geq 225$ GeV/c^2; $\sigma \cdot BR \leq 1.7$ pb ($M_{\tilde{g}} \simeq M_{\tilde{q}}$ and $Q^2 = m^2$)

Conclusion

⇒ Run I Search for Dilepton Events From SUSY

⇒ Improved Upon Previous Limit

⇒ $M_{\tilde{g}} \geq 169$ GeV/c^2;
$\sigma \cdot BR \leq 4.1$ pb ;
($M_{\tilde{q}} \gg M_{\tilde{g}}$ and $Q^2 = m^2$)

⇒ $M_{\tilde{g}} \geq 225$ GeV/c^2;
$\sigma \cdot BR \leq 1.7$ pb
($M_{\tilde{q}} \simeq M_{\tilde{g}}$ and $Q^2 = m^2$)

⇒ With More Data and A Better Detector,

⇒ We May Discover SUSY in Run II !