Batavia , IL

Searches for Squarks and Gluinos with the D0 detector

DeKalb, IL

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On behalf of the D0 collaboration

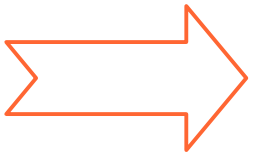
DPF 2009

2009 Meeting of the Division of Particles and Fields of the American Physical Society

Introduction.

$SU(3)_C$ X $SU(2)_L$ X $U(1)_Y$

Quarks	Bosons
Leptons	

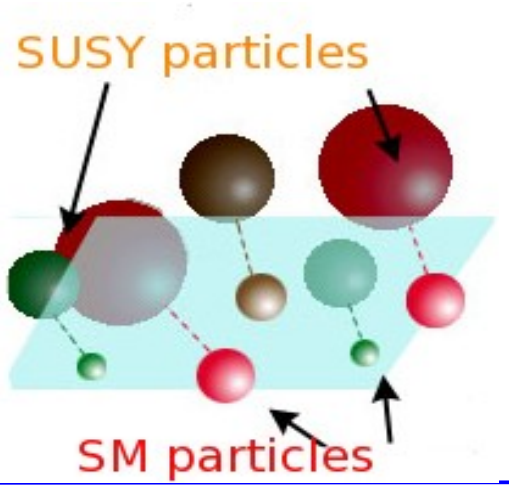


sBosons	sFermions
$\tilde{q}_L, \tilde{q}_R$	$\tilde{g}$
$\tilde{\nu}$	$\tilde{\gamma}, \tilde{Z}, \tilde{W}^{\pm}$
$\tilde{l}_L, \tilde{l}_R$	$\tilde{H}_1^0, \tilde{H}_2^+, \tilde{H}_1^-, \tilde{H}_2^0$
$\tilde{q}_1, \tilde{q}_2$	$\tilde{\chi}_i^{\pm}$ $\tilde{\chi}_i^0$

SUSY (fermion<->boson) **MSSM, conserved R-parity = $(-1)^{3(B-L)+2s-1}$**

General properties

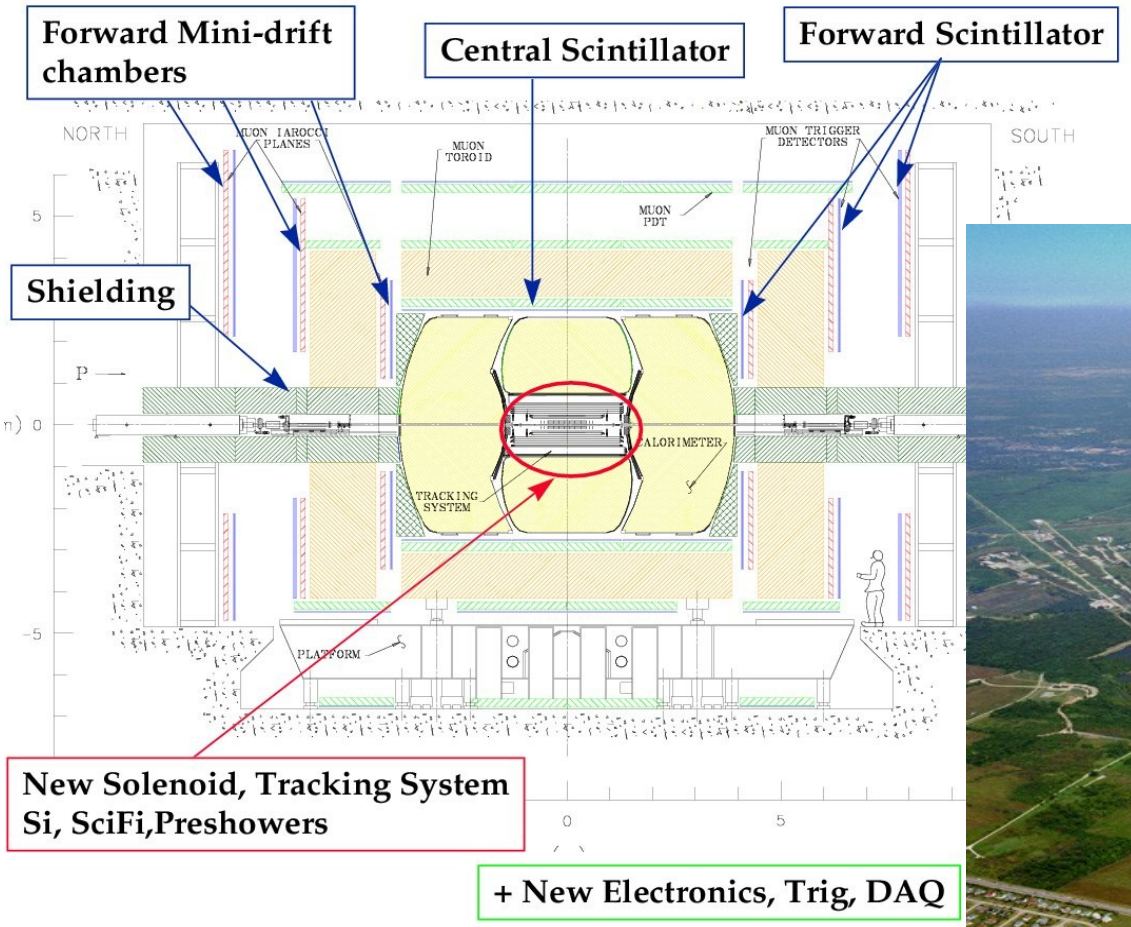
- pair production of SUSY particles (~ same mass as SM)
- decay to SM particles and the LSP (the lightest SUSY particle)
- the LSP is stable



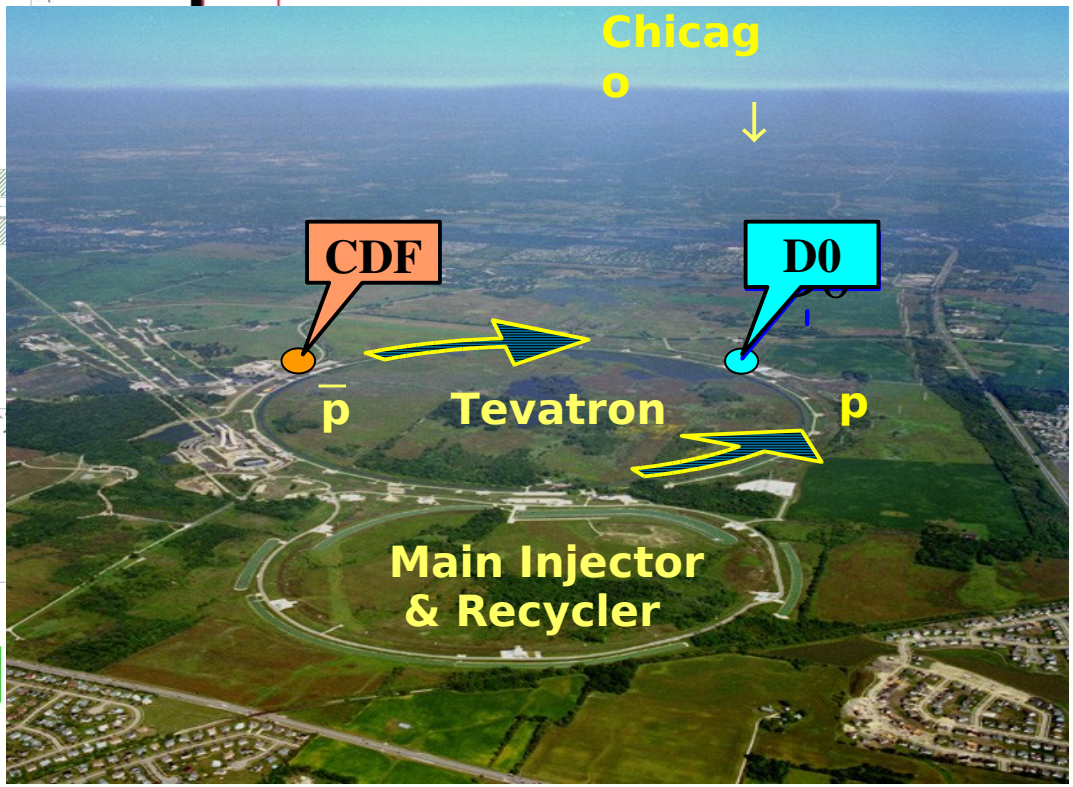
Experimental signature

(D0) leptons, jets and missing energy

The D0 experiment Run II $p\bar{p}$ @ 1.96 TeV



Run IIa 2001-2005
extended muon and new tracking system



RunIIb - started 2006
tracking and trigger systems upgrade

1 - 4 fb^{-1}
for results in this talk

Outline.

- **Searches for Squarks and Gluinos:**
  - Jets + MET, **PLB, 660, 449 (2008) , 2.1 fb^{-1}**
  - Jets + tau + MET, **arXiv0905.4086**

- **Search for Stop Quarks production:**
  - 2 Jets + eμ + MET, **3.1 fb^{-1}**

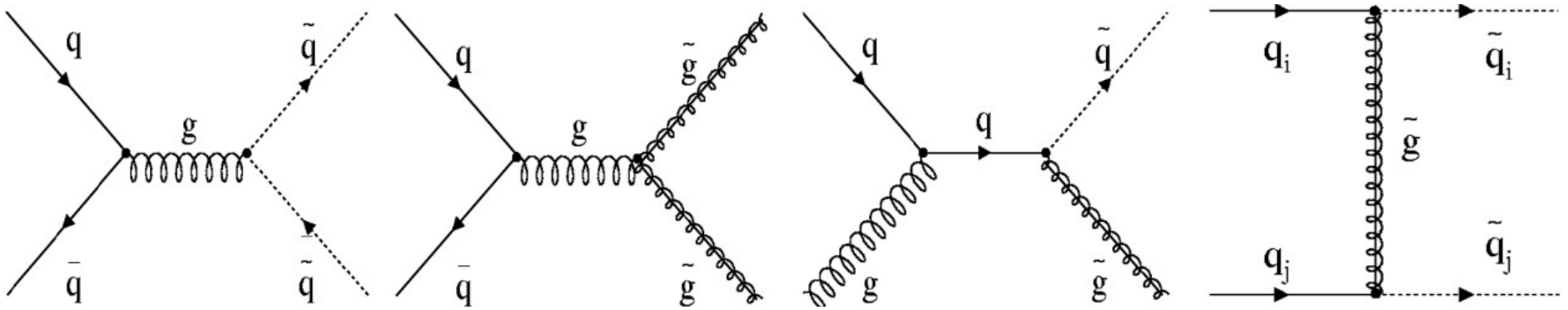
  http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/NP/N67

- **Search for Sbottom Quarks production:**
  - 2 Jets + MET, **4.0 fb^{-1}**

  http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/NP/N68

Squarks and Gluinos (mSUGRA , tanβ=3, A_0=0, mu<0)

- Gluino, Squark or Squark+gluino pair production by strong interaction

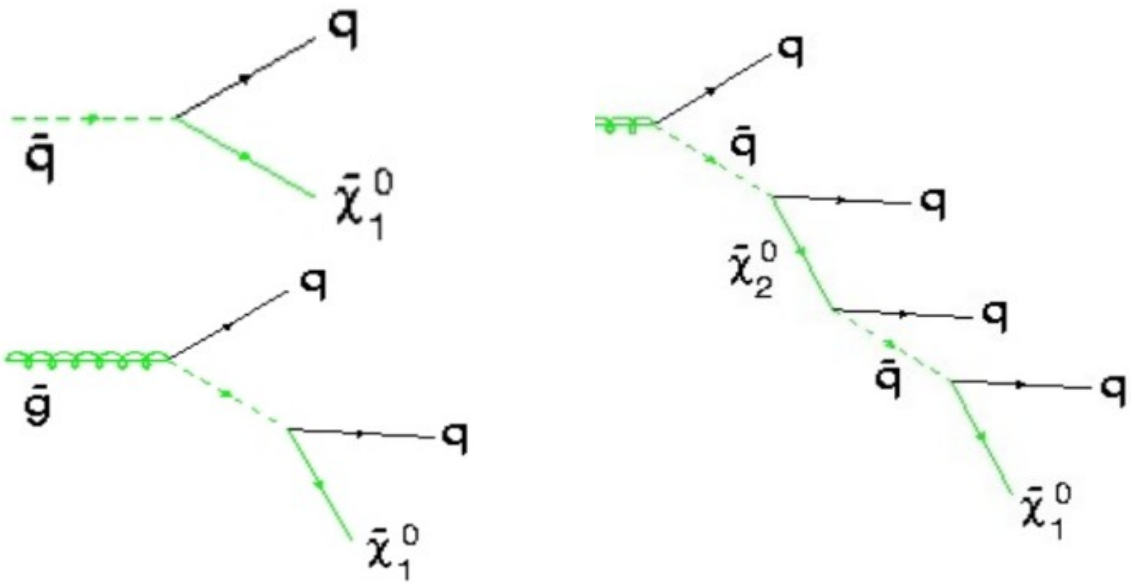


- Number of jets depends on squarks and gluino mass relationships

m(squark)<m(gluino),
>=2jets+MET

m(squark)≈m(gluino),
>=3jets+MET

m(squark)>m(gluino),
>=4jets+MET



2, 3, or 4+ jets with the LSP (neutralino) -> Jets+MET triggers

Squarks and Gluinos (2.1 fb^{-1} jets+MET inclusive)

Signal selection

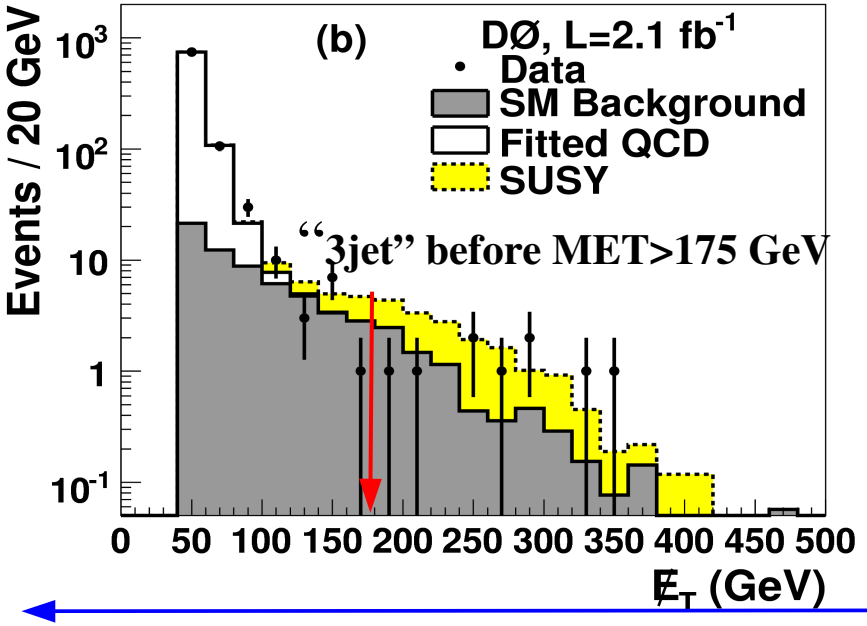
2/3/4 jets (+MET) channels

MET-jets angular kinematic

HT,MET optimized vs expected upper limit on the x-section

Backgrounds

W/Z+jets, **ttbar,** QCD



Preselection cut		All analyses	
$\not\!\!E_T$		$\geqslant 40$	
|Vertex z pos.|		< 60 cm	
Acoplanarity		$< 165°$	
Selection cut	**"dijet"**	**"3-jets"**	**"gluino"**
Trigger	dijet	multijet	multijet
pT (GeV)	$Jet_{1,2} \geq 35$	$Jet_{1,2,3} \geq 35$	$Jet_{1,2,3} \geq 35$, $Jet_4 \geq 20$
	isol. lept veto	- against W(lnu)	backgrounds
$\Delta\phi(\not\!\!E_T, \text{jet}_1)$	$\geqslant 90°$	$\geqslant 90°$	$\geqslant 90°$
$\Delta\phi(\not\!\!E_T, \text{jet}_2)$	$\geqslant 50°$	$\geqslant 50°$	$\geqslant 50°$
$\Delta\phi_{\min}(\not\!\!E_T, \text{any jet})$	$\geqslant 40°$	–	–
H_T	$\geqslant 325$	$\geqslant 375$	$\geqslant 400$
$\not\!\!E_T$	$\geqslant 225$	$\geqslant 175$	$\geqslant 100$

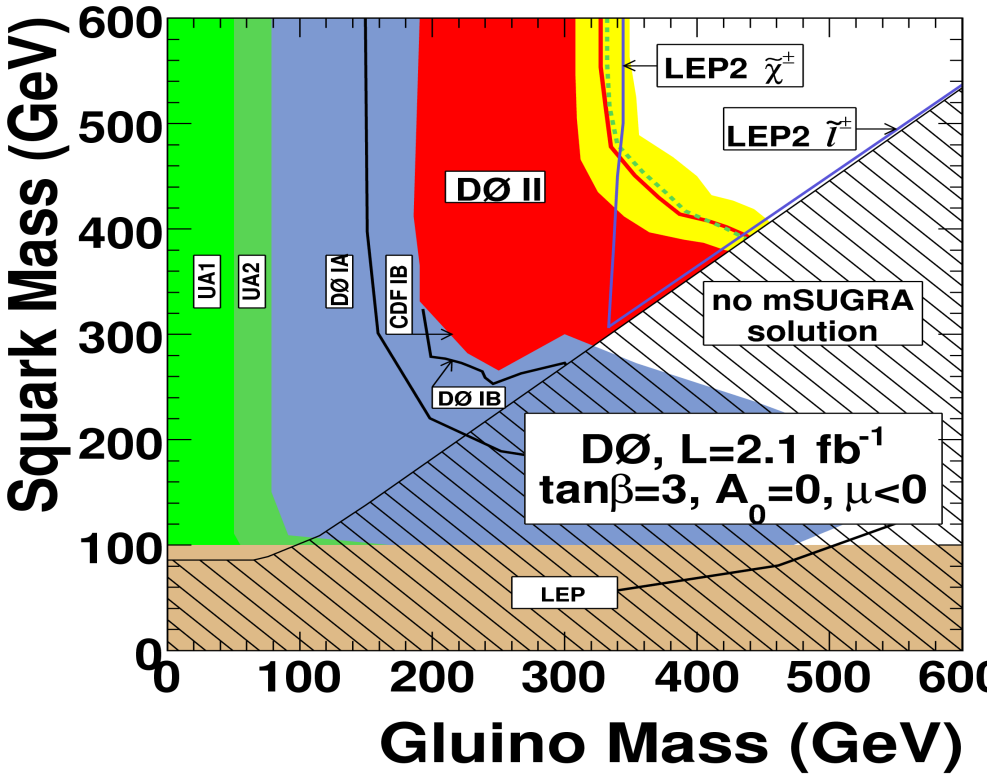
Selection	data	Bkg
>=2 jets	11	11.1+/-1.2+2.9-2.3
>=3 jets	9	10.0+/-0.9+3.1-2.1
>=4jets	20	17.7+/-1.1+5.5-3.3

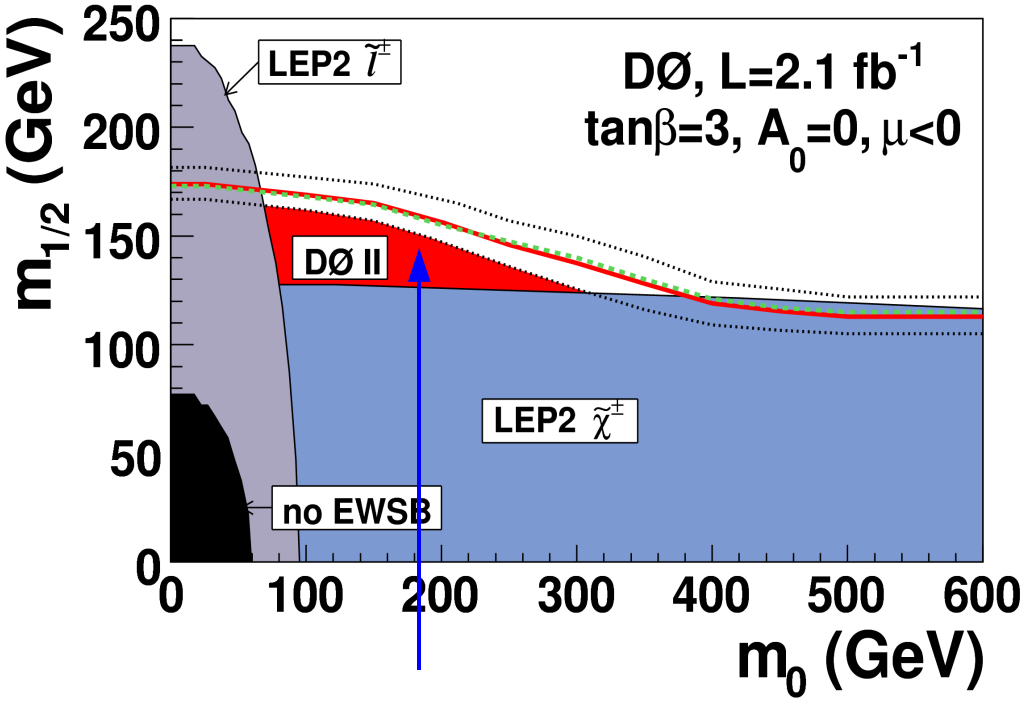
Selected events consistent with background estimates

Squarks and Gluinos (2.1 fb^{-1} jets+MET inclusive)

95% C.L. limits set on squark and gluino masses and mSUGRA parameters

PLB, 660, 449 (2008)





Improvement vs LEP2 results

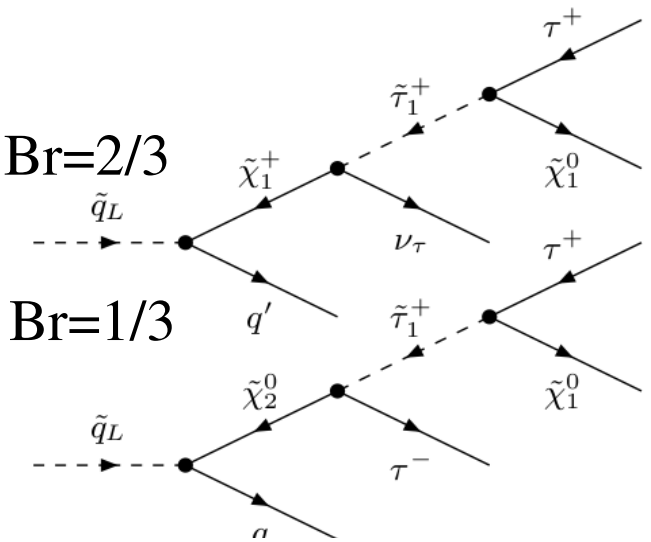
Excluded:

M(squark) < 379 GeV, M(gluino) < 308 GeV

(most conservative hypothesis accounting PDF and RF scale uncertainty on the signal NLO cross-section)

masses up to 390 GeV for M(squark)≈M(gluino)

Squarks and Gluinos (1.0 fb^{-1} jets+tau(s)+MET inclusive)



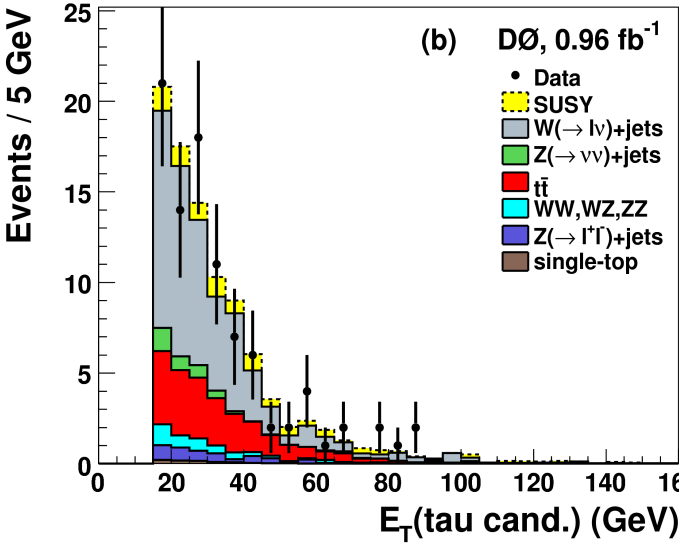
Production – squarks
Large mixing – stau1 could be NLSP
Signature – 2 jets + ≥1 tau +MET

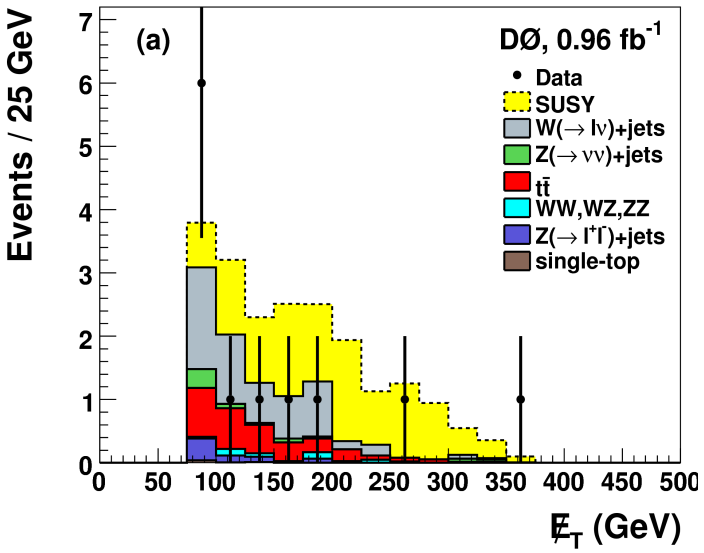
Signal Selections:

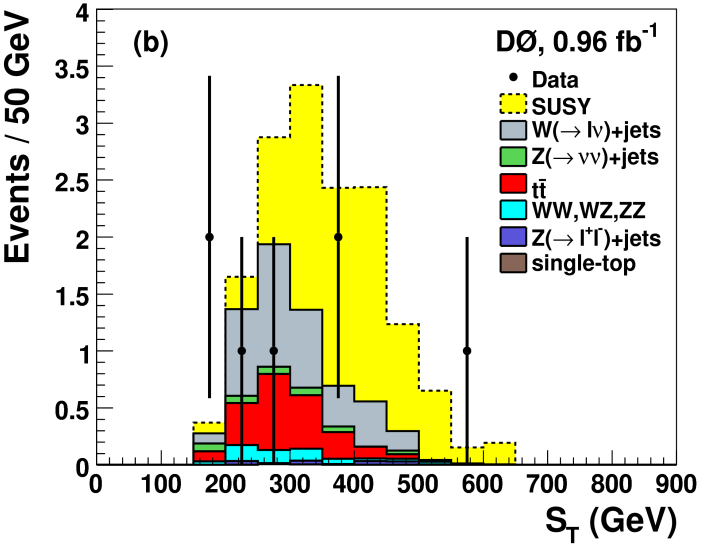
Tau(s) – narrow isolated jet with E_T > 15 GeV

Jets+MET as in inclusive analyses, no lepton veto

Optimization on MET and ST=$p_T(jet_1)+p_T(jet_2)+p_T(\tau)$







After (MET>175 GeV, ST>325 GeV): Data=3, Bkg.=2.3+/-0.4+/-0.7(sys)

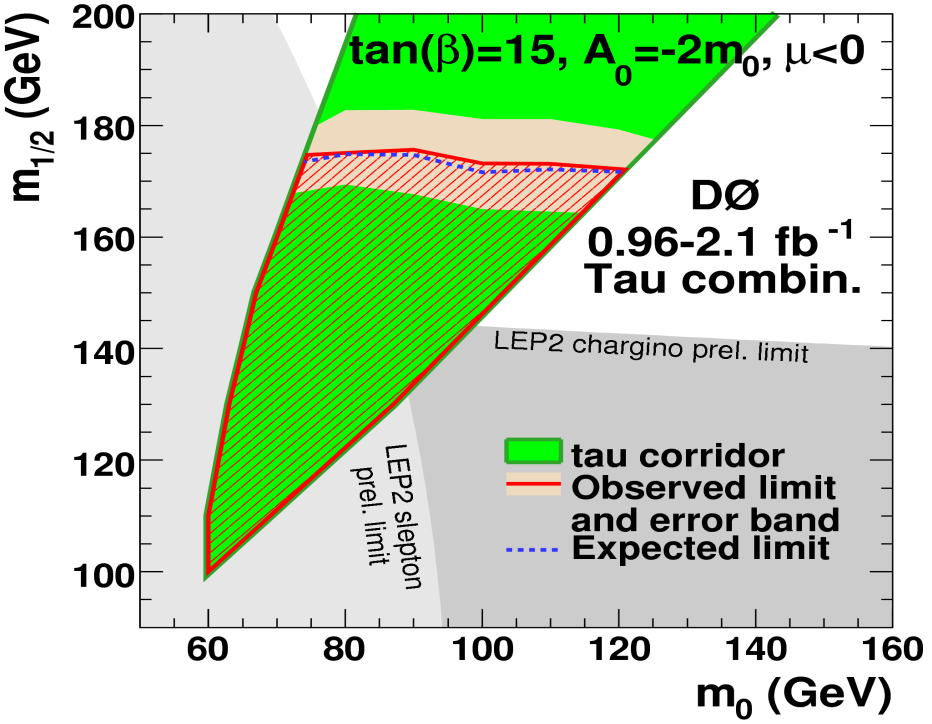
agreed with SM predictions (QCD negligible)

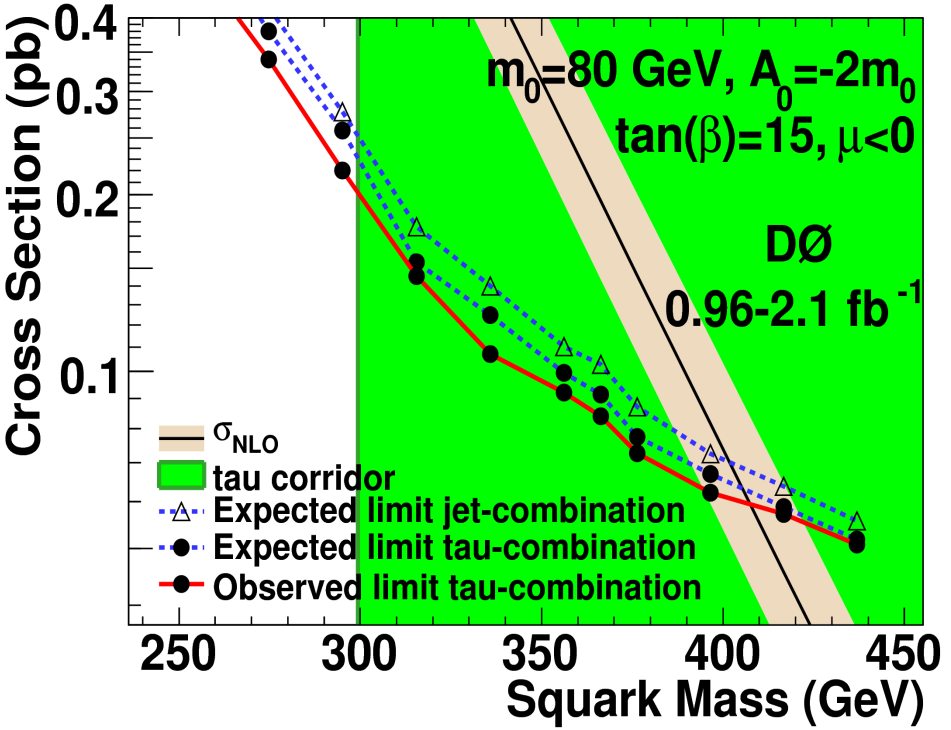
Squarks and Gluinos (1.0 fb^{-1} jets+tau+MET inclusive)

95% C.L. limits set in mSUGRA model ($\tan\beta$=15, A_0=-2m_0, μ<0)

(arXiv0905.4086)

combination with 2.1 fb-1 Jets+MET analysis - tau is also detected as jet:
10% gain in x-section





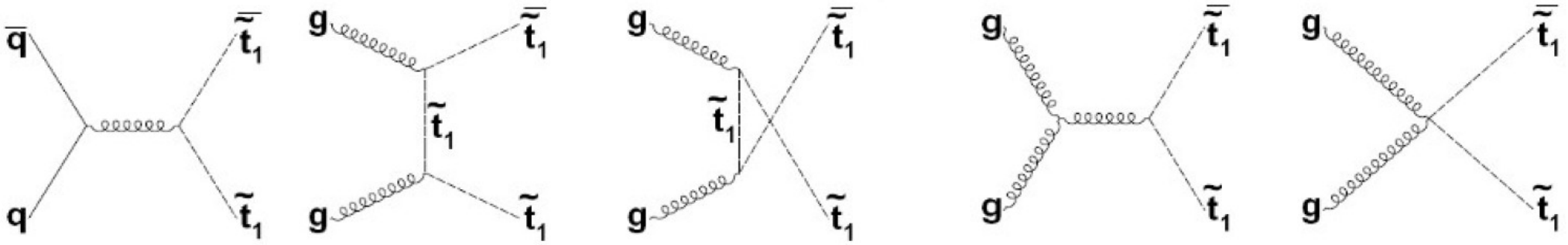
Excluded: M(squark) < 400 GeV

(most conservative hypothesis accounting PDF and RF scale uncertainty on the signal NLO cross-section)

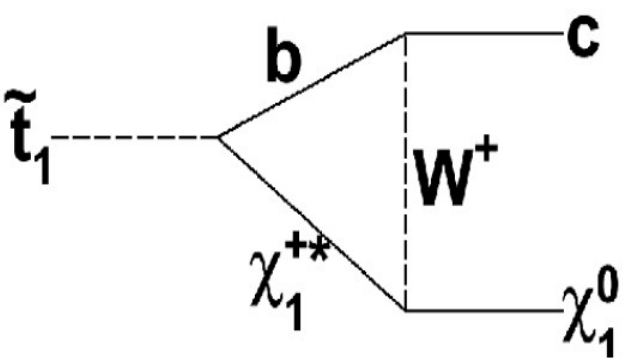
The limit set exceeds the LEP2 limits

Stop quarks (MSSM)

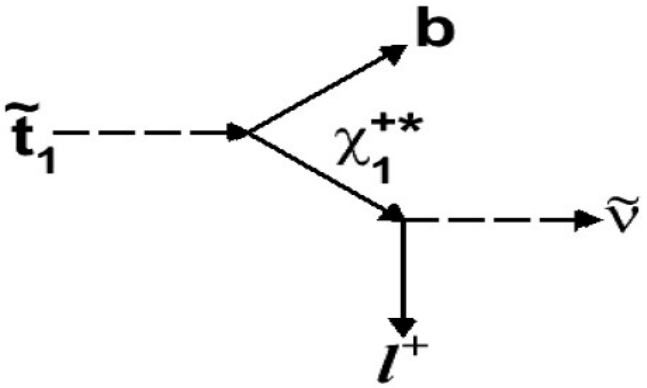
- Production in pairs : qq annihilation, gg fusion



- Decay (stop could be light, forbidden stop->b+chargino; stop->top+neutralino)



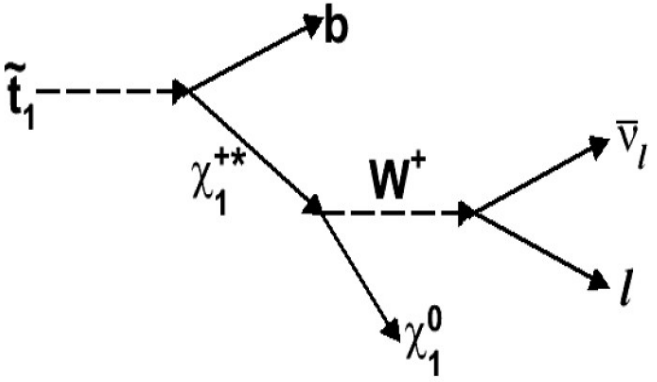
2 body decays



3 body decays

2jets+eμ+MET

(sneutrino is LSP)



4 body decays

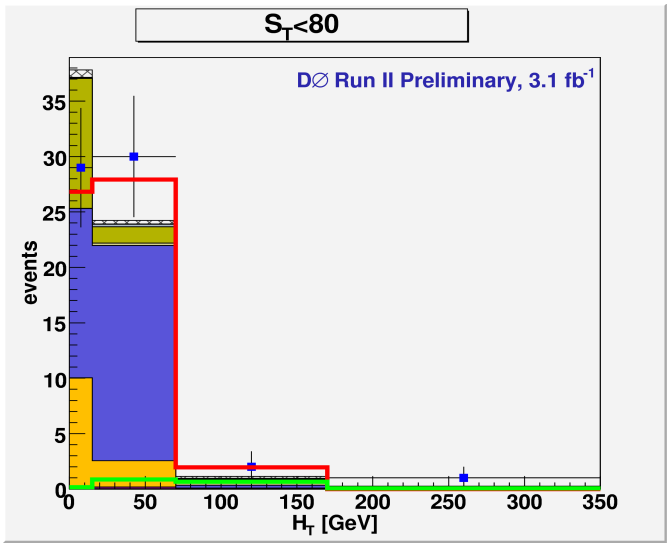
Stop quarks (3.1 fb^{-1} 2jets+eμ+MET)

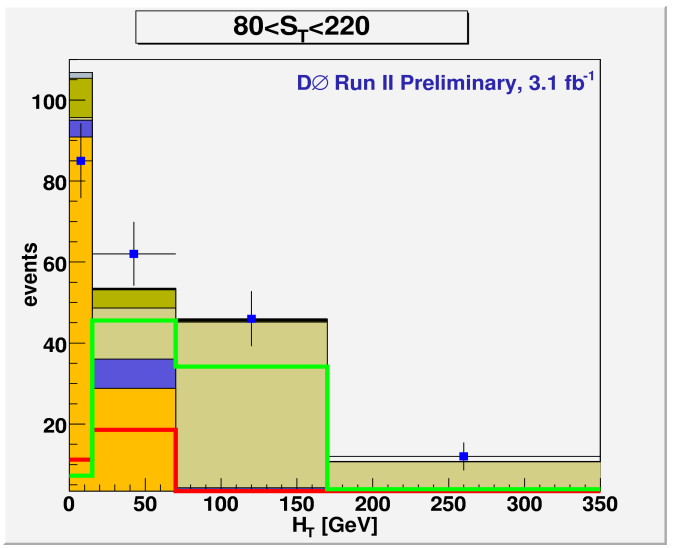
Backgrounds: **Z(ττ)–>e,μ+νν,** WW, ttbar, W+jets

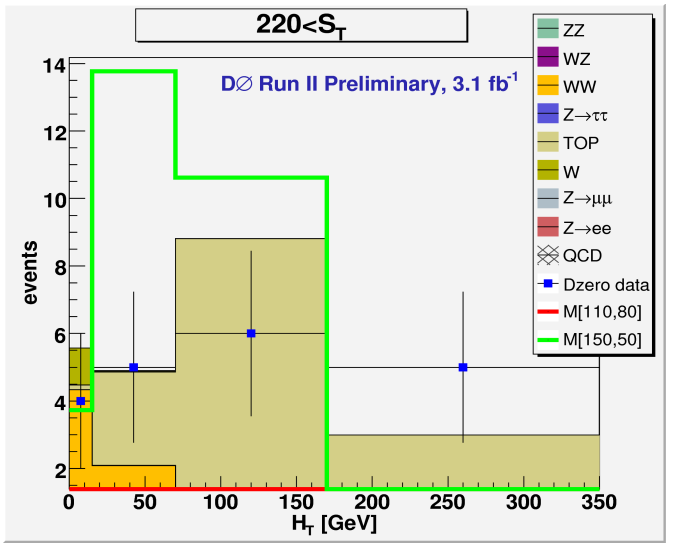
Signal selection: **ΔM(st1,sneutrino) determines the kinematic**

pT(e)>15 GeV, pT(μ)> 8 GeV, (MET-e,μ) angular differences, MET>18 GeV

BG total	$1905\ ^{+121}_{-161}$	$880\ ^{+52}_{-67}$	$303\ ^{+16}_{-20}$
data	1925	807	288
(150,50)	$161\ ^{+19}_{-21}$	$129\ ^{+15}_{-17}$	$122\ ^{+14}_{-16}$
(110,80)	$195\ ^{+24}_{-29}$	$140\ ^{+17}_{-21}$	$89\ ^{+11}_{-13}$



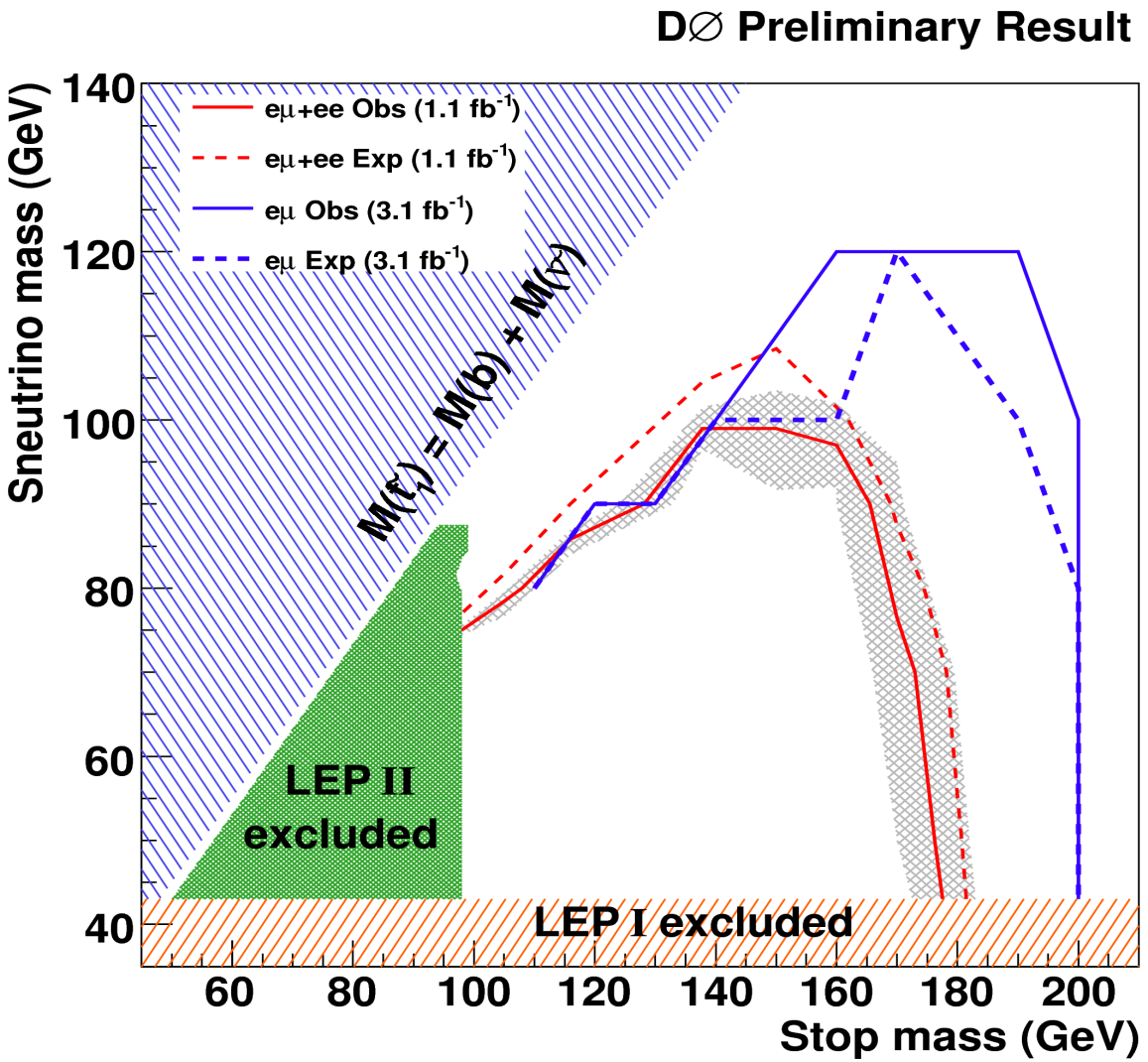




Limit setting – combine input from the (ST,HT) bins – gain sensitivity to signal

Stop quarks (3.1 fb^{-1} 2jets+eμ+MET)

95% Confidence Level Exclusion Limit in (m_stop,m_sneutrino) plane

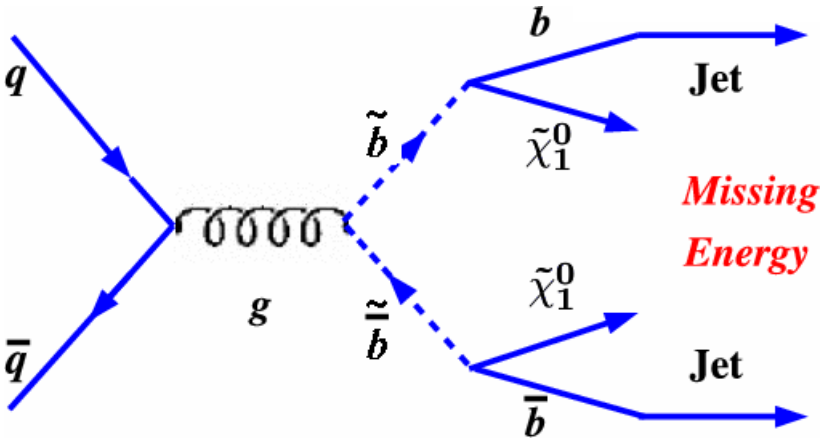


m_stop < 200 GeV for large ΔM(st1,sneutrino) signals

Extended exclusion area compare to the previous D0 result

Sbottom quarks (4.0 fb^{-1} , 2 b-jets+MET)

$$p + \bar{p} \rightarrow \tilde{b}_1 \bar{\tilde{b}}_1 \rightarrow b\tilde{\chi}_1^0 \bar{b}\tilde{\chi}_1^0$$



Decay : Assume

$m_{\tilde{b}_1} > m_b + m_{\tilde{\chi}_1^0}$ **and** $m_{\tilde{b}_1} < m_t + m_{\tilde{\chi}_1^\pm}$

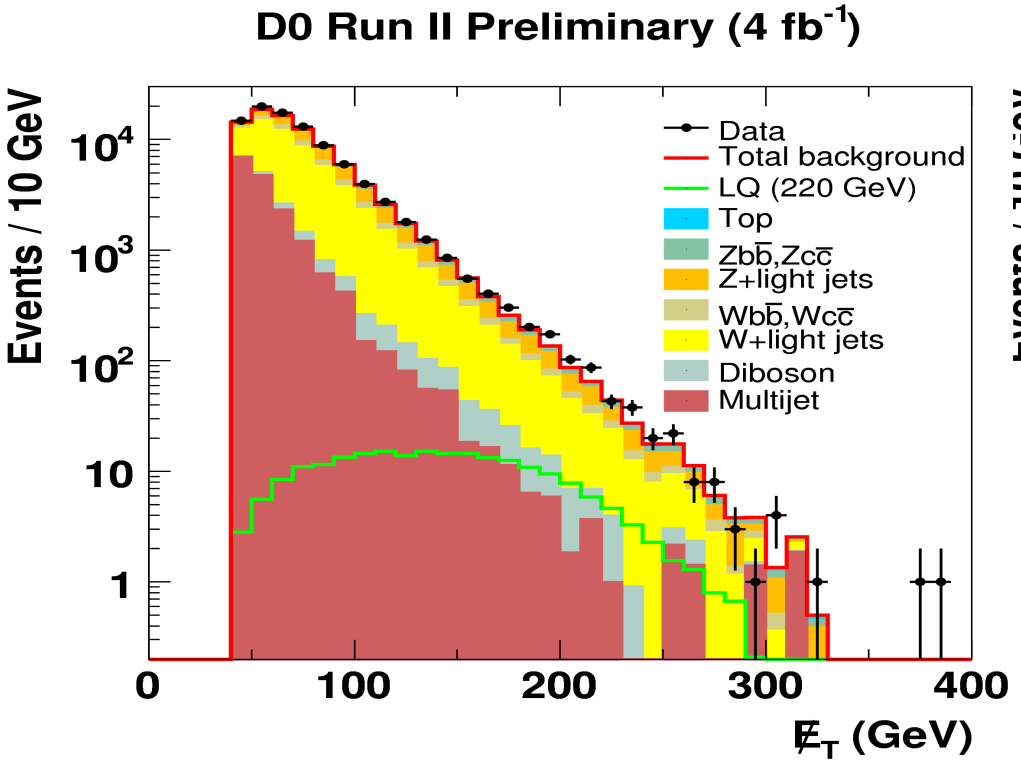
Br($\tilde{b}_1 \rightarrow b\chi^0_1$)=100%

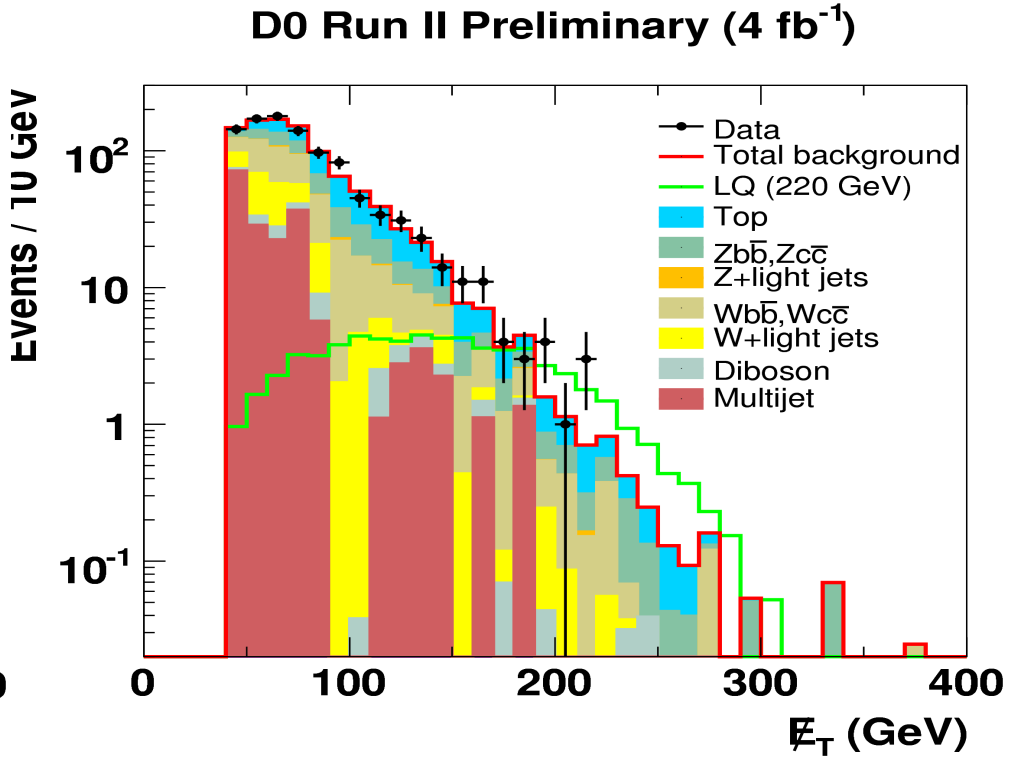
Signal	$m_{\tilde{b}_1} = (80 - 260)$ GeV, $m_{\tilde{\chi}_1^0} = (0 - 95)$ GeV
DATA	**Jets + MET triggers**
Backgrounds	**W(lν)+jets (non-reconstruted lepton), Z(νν)+jets, WW,WZ, ZZ, top pairs/single production multijet production (estimated from data)**

Sbottom quarks (4.0 fb^{-1} , 2 b-jets+MET)

Signal selections : MET> 40 GeV

- 2,3 jets: $E_T > 20$ GeV, $(E_T^{jet1} + E_T^{jet2})/(\Sigma_{jets} E_T) > 0.9$
- $\Delta\phi_{min}(\not\!\!E_T, jets) > 0.6$ rad, $\not\!\!E_T > -40 \times \Delta\phi_{min}(\not\!\!E_T, jets) + 80$, $\Delta\phi(\not\!\!E_T, \not\!\!p_T) < \pi/2$
- Double b-tag (Neural Net algorithm using track and vertex information)
- MET,HT cut optimized vs expected upper 95% C.L. limit on the x-section





MET distributions before and after b-tagging

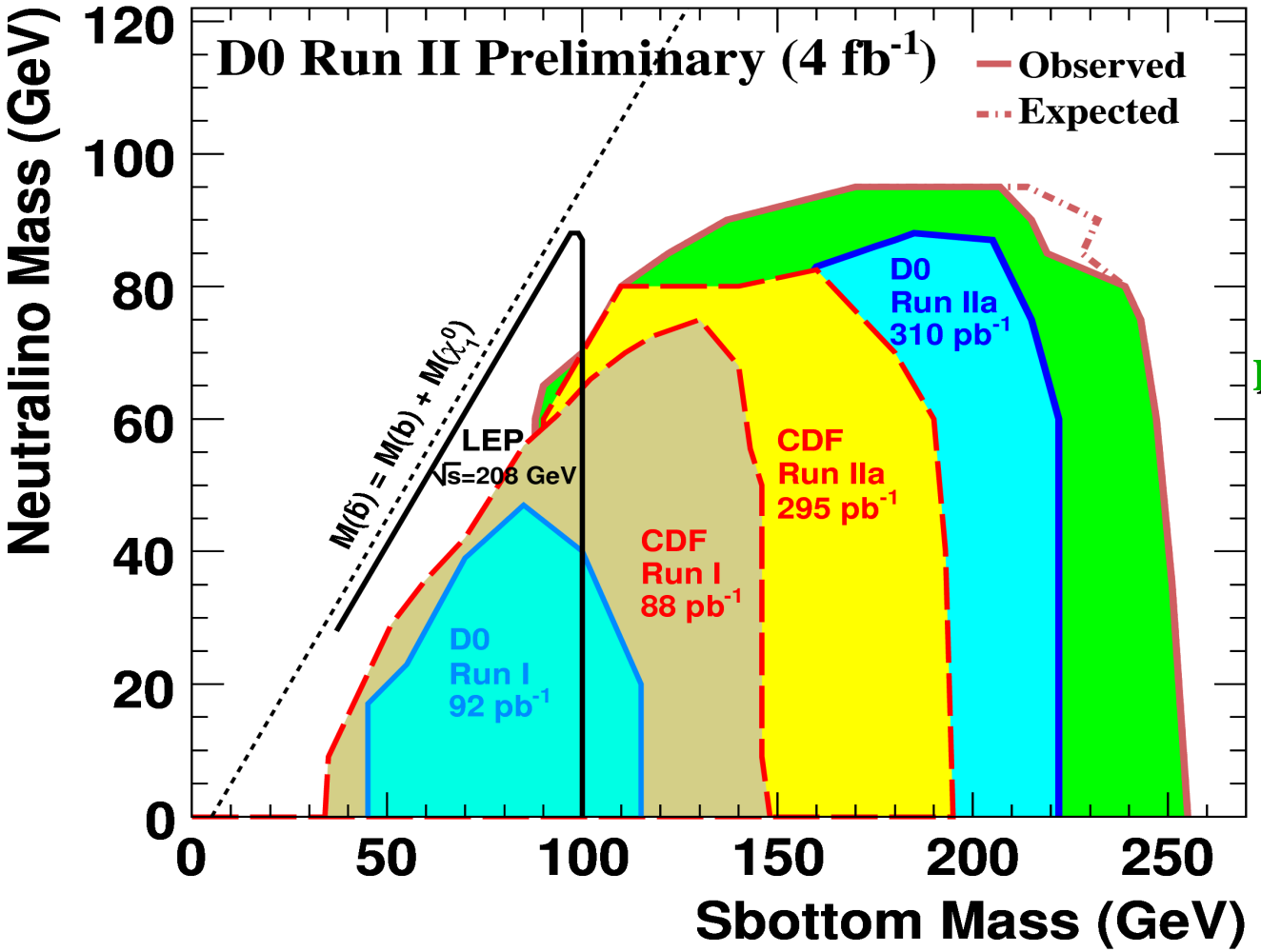
Sbottom quarks (4.0 fb^{-1} 2 b-jets+MET)

Process	Pretag	b-tag	$msig > 5$, $-0.1 < A < 0.2$, $\Delta\phi(\not\!\!E_T, jets) > 0.6$ rad	Low $\not\!\!E_T$: $X_{jj} > 0.9$, $E_T^{jet1} > 20$ [GeV], $\not\!\!E_T > 40$ [GeV], $H_T > 60$ [GeV]	High $\not\!\!E_T$: $X_{jj} > 0.9$, $E_T^{jet1} > 50$ [GeV], $\not\!\!E_T > 130$ [GeV], $H_T > 230$ [GeV]
Diboson	1951 $\pm$ 8	33 $\pm$ 1	30 $\pm$ 1	17 $\pm$ 1	0.3 $\pm$ 0.1
$W(\rightarrow l\nu)$+ light jets	52604 $\pm$ 87	154 $\pm$ 7	133 $\pm$ 7	85 $\pm$ 6	0.3 $\pm$ 0.1
$Wc\bar{c}, Wb\bar{b}$	6577 $\pm$ 24	275 $\pm$ 4	245 $\pm$ 4	128 $\pm$ 3	1.7 $\pm$ 0.3
$Z(\rightarrow ll)$ + light jets	14457 $\pm$ 67	10 $\pm$ 2	8 $\pm$ 2	7 $\pm$ 2	0
$Zc\bar{c}, Zb\bar{b}$	3274 $\pm$ 19	165 $\pm$ 3	155 $\pm$ 3	109 $\pm$ 2	2.2 $\pm$ 0.3
Top	1703 $\pm$ 3	285 $\pm$ 1	240 $\pm$ 1	73 $\pm$ 0	2.9 $\pm$ 0.1
Multijet	140565 $\pm$ 384	776 $\pm$ 29	169 $\pm$ 15	73 $\pm$ 10	0
Total background	221131	1699 $\pm$ 31	981 $\pm$ 17	493 $\pm$ 12	7.1 $\pm$ 0.4
# data events	221131	1814	998	483	7
Signal (acceptance, %)					
$M_{LQ} = 220$ GeV	237 $\pm$ 2 (42.3)	68 $\pm$ 1 (12.0)	63 $\pm$ 1 (11.2)	—	17.0 $\pm$ 0.5 (3.0)
$(m_{\tilde{b}_1}, m_{\tilde{\chi}^0})$=(240,0) GeV	139 $\pm$ 1 (44.2)	40 $\pm$ 1 (12.7)	36 $\pm$ 1 (11.5)	—	11.4 $\pm$ 0.2 (3.6)
$(m_{\tilde{b}_1}, m_{\tilde{\chi}^0_1})$=(100,60) GeV	4416 $\pm$ 95 (7.4)	996 $\pm$ 39 (1.7)	906 $\pm$ 37 (1.5)	610 $\pm$ 29 (1.0)	—

- **Low E_T - soft cuts, restricted by SM kinematic**
- **High E_T signals – stronger requirements on the missing and transverse energies, improved sensitivity**

No excess observed after all cuts

Sbottom quarks (4.0 fb^{-1} 2 b-jets+MET)



Excluded sbottom mass for $m(\chi^0_1)$=0 GeV @ 95% C.L. :

m(sb) < 253 GeV

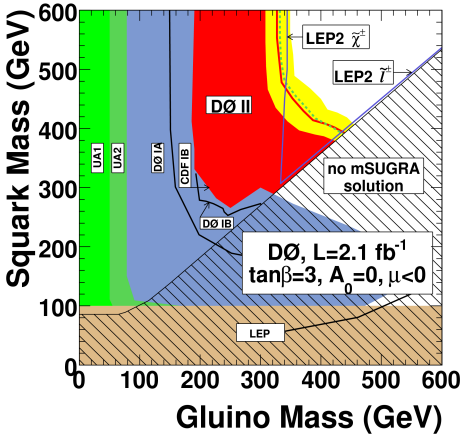
SBottom: improved constraints in the $(m_{\tilde{b}_1}, m_{\tilde{\chi}^0_1})$ mass plane

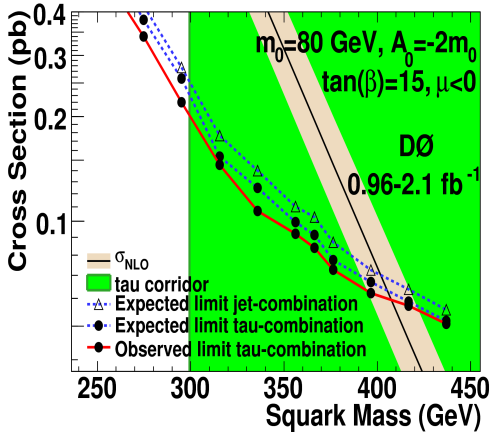
Summary

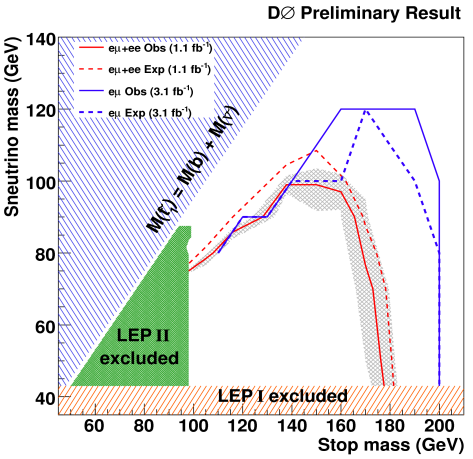
- **Presented resent results from D0 searches for squarks and gluinos in 1-4 fb^{-1} data samples**

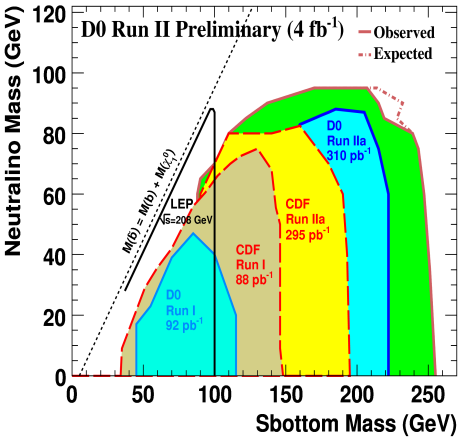
- **No signs of SUSY observed yet,**

  set of 95% C.L. exclusion limits have been obtained, improving previous Tevatron results









Backup Slides

D0 operations