Searches for Scalar Top and Bottom Quarks at the Tevatron

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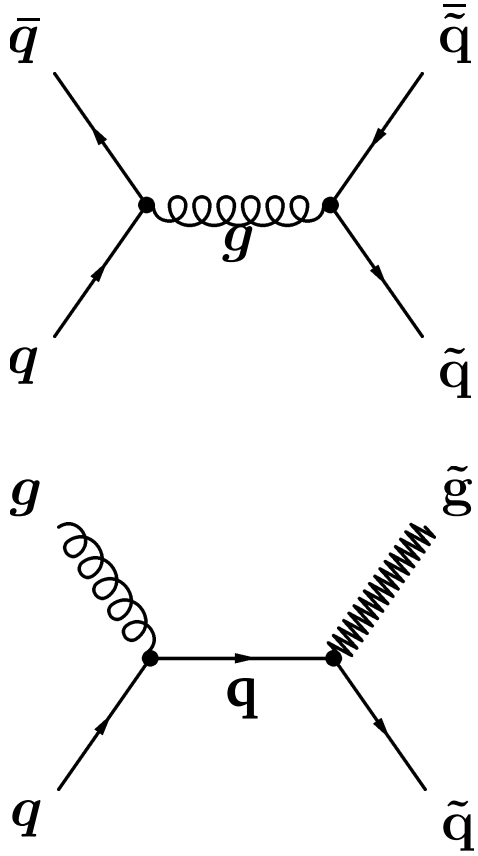
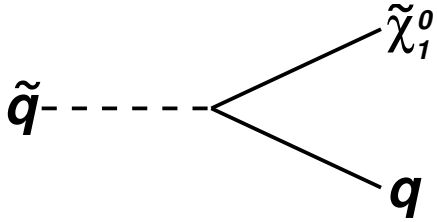
Scalar Quark Production

- large cross-section for pair-production of scalar quarks at hadron colliders:
  - Tevatron, $\sqrt{s} = 1.96\,\mathrm{TeV}$: $\sigma(\tilde{q}\bar{\tilde{q}}) \sim 1\,\mathrm{pb}$
  - $\int \mathrm{d}t\mathcal{L} = 800 - 900\,\mathrm{pb}^{-1}$ collected on tape
  - up to $340\,\mathrm{pb}^{-1}$ in analyses presented here
- large Higgs Yukawa couplings to 3$^{\mathrm{rd}}$ generation (esp. t) induce large mixing of SUSY partners of t_L, t_R (b_L, b_R)
  $\rightarrow$ lightest scalar top $\tilde{t}_1$ possibly much lighter than other squarks
  $\rightarrow$ light $\tilde{b}_1$ expected at large $\tan\beta$

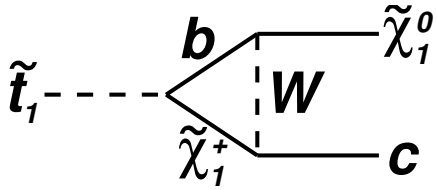


Squark Decays

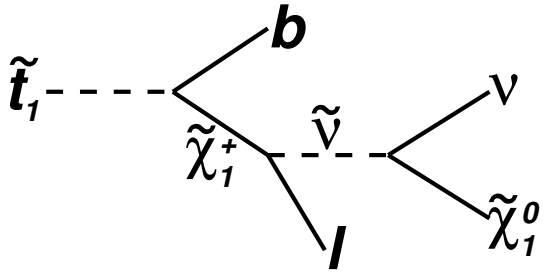
- $\tilde{q} \rightarrow q\tilde{\chi}_1^0$
  - topology: 2 jets + missing transverse energy ($\not\!\!E_t$)
  - see A. Munar's talk: "Search for Squarks and Gluinos"



- $\tilde{b} \rightarrow b\tilde{\chi}_1^0$
  - efficient background suppression by requiring b-tag



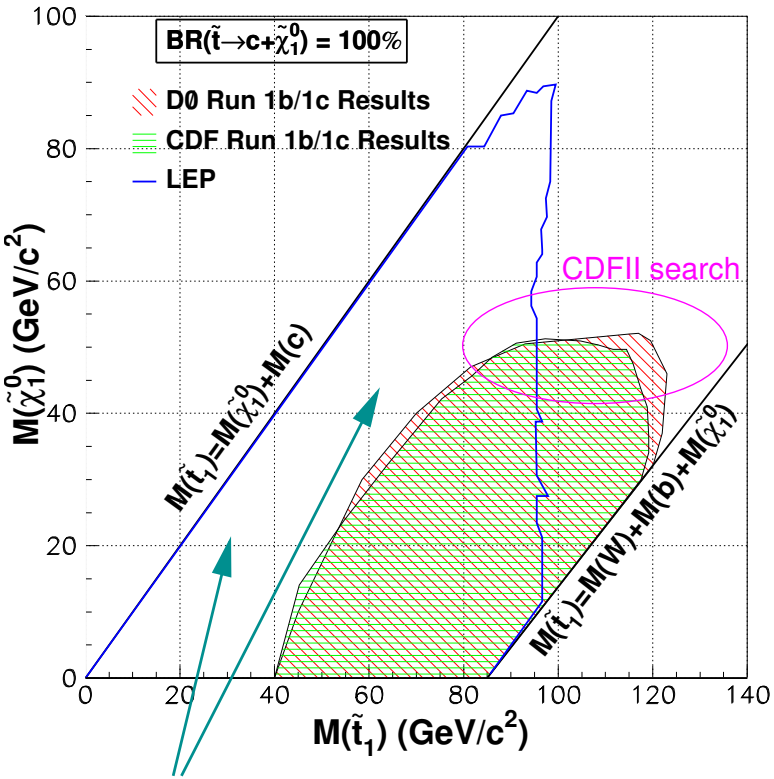
- $\tilde{t}$ decays
  - two-body decays $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$, $\tilde{t}_1 \rightarrow b\tilde{\chi}_1^+$ kinematically forbidden (in accessible parameter region)
  - $\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$ loop induced
  - $\tilde{t}_1 \rightarrow bl\tilde{\nu}$ ($M(\tilde{\nu}) > 43.7\,\text{GeV}$, LEP)



Searches for Stop: $\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$

- selection: 2 jets (possibly incl. heavy-flavor (HF) tag), $\not\!\!E_t$, isolated lepton veto
  - CDF (2000): w/ HF-tag
  - DØ (2004): w/o HF-tag
- backgrounds:
  - $W(\rightarrow l\nu) + 2$ jets (l not identified)
  - $Z(\rightarrow \nu\bar{\nu}) + 2$ jets
  - QCD multi-jet
- signal: generic MSSM, vary $M(\tilde{t})$, $M(\tilde{\chi}_1^0)$ assume $BR(\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0) = 100\%$

Run I analyses

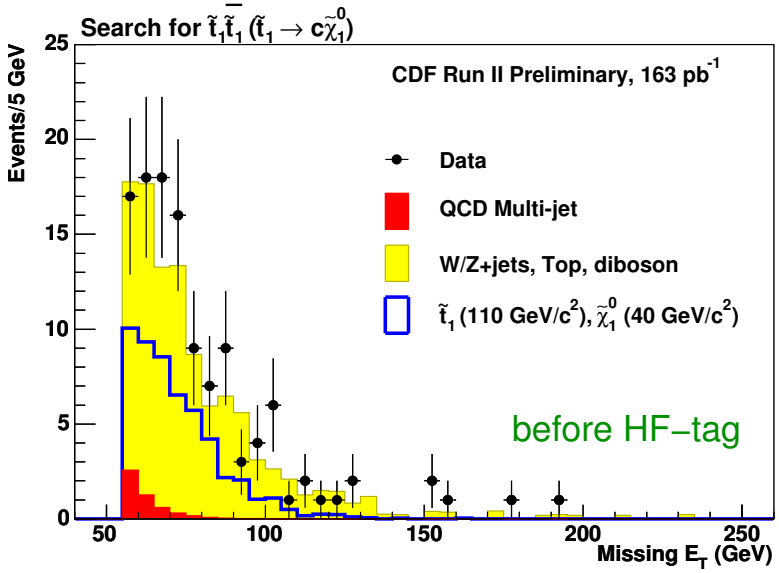


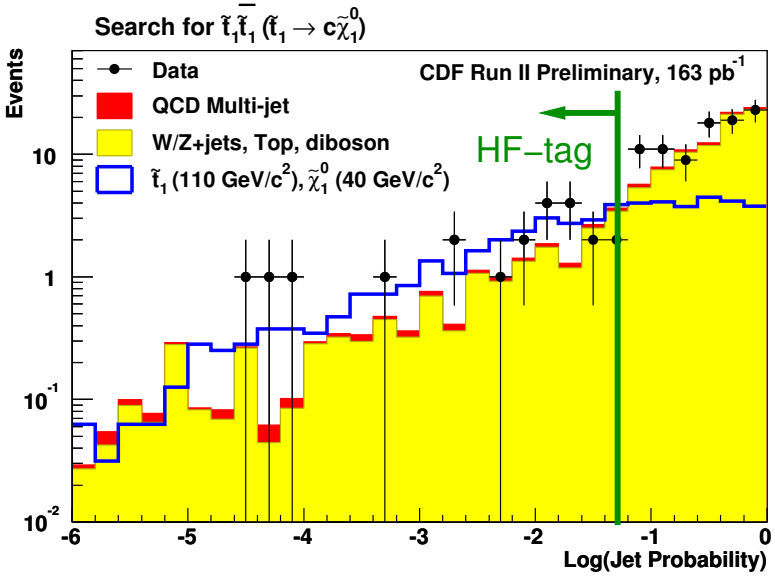
limited sensitivity due to minimal jet ET requirement, D0: ET(jet1) > 25 GeV, ET(jet2) > 10 GeV

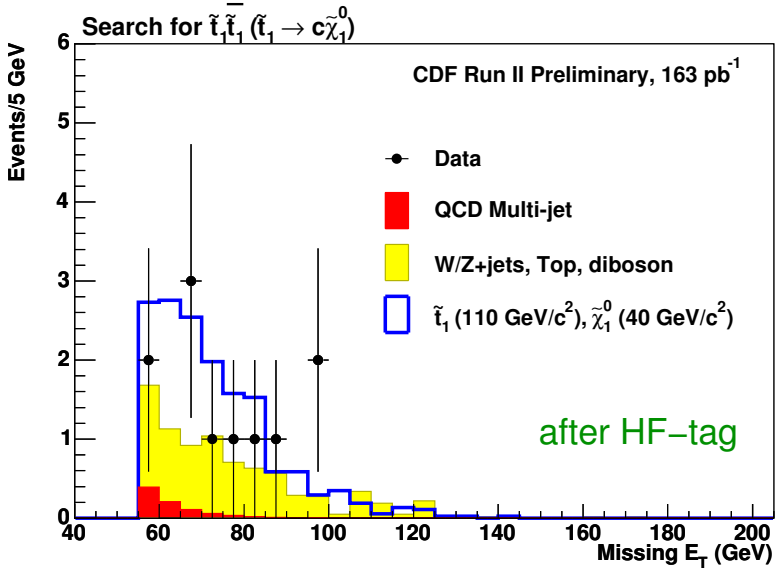
all limits shown: 95% C.L.

Run II Search for $\tilde{t}_1 \to c\tilde{\chi}_1^0$

- $L = 163\,\mathrm{pb}^{-1}$
- selection: $E_T(j_1) > 35\,\mathrm{GeV}$, $E_T(j_2) > 25\,\mathrm{GeV}$, $\not\!\!E_t > 55\,\mathrm{GeV}$
- tag one charm jet with small probability that jet originates from primary vertex (based on track IP)



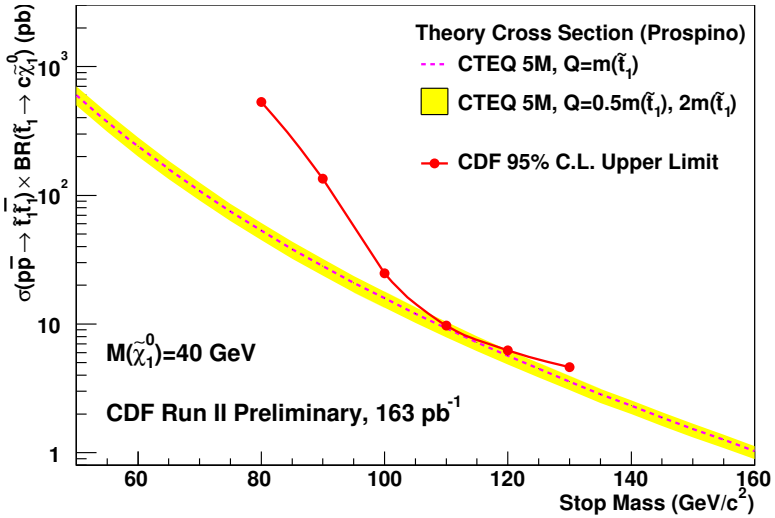


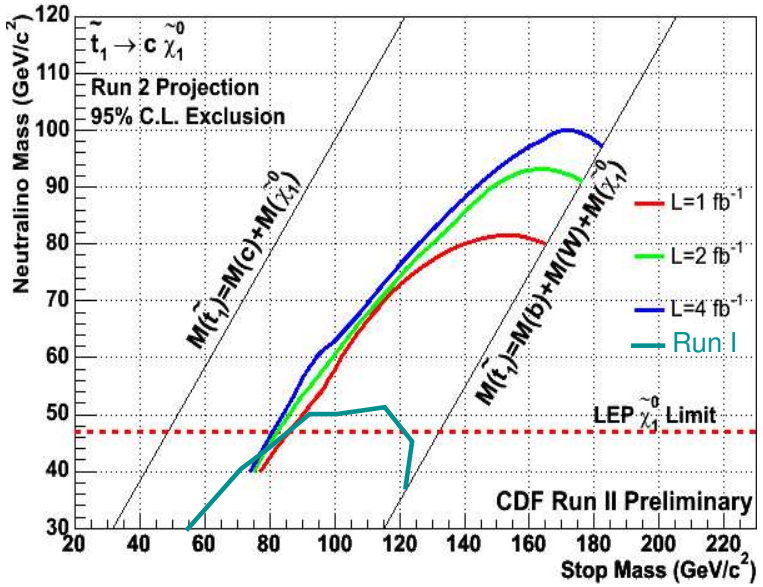


Results and Projections

HF-tag	no	yes
SM	$105^{+11.8}_{-11.2}$	$8.3^{+2.3}_{-1.7}$
Data	119	11

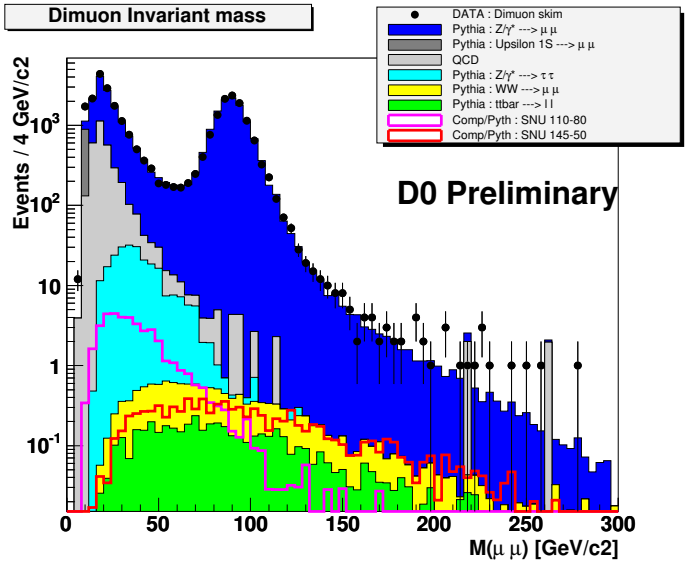
- upper cross-section limits, but no additional exclusion in $(M(\tilde{t}), M(\tilde{\chi}_1^0))$-plane
  - higher $\not\!\!E_t$ trigger threshold
  - larger jet energy scale error
- Run II projections based on $L = 1,\ 2,\ 4\,\mathrm{fb}^{-1}$ promising

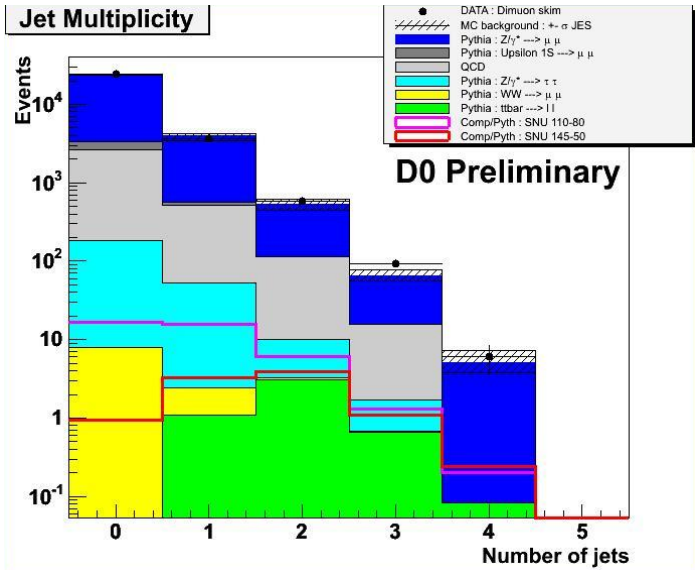




Search for Stop: $\tilde{t}_1 \to bl\tilde{\nu}$

- preferred channel: $e\mu$ (+jets)
- here: $\mu\mu$ channel
  - BR factor 2 lower
  - background from Z/Drell-Yan much higher
- selection:
  $p_T(\mu_1[\mu_2]) > 8\,[6]\,\text{GeV}$
  1 jet with $E_T(j) > 15\,\text{GeV}$
  2-dim cut on $\not\!\!E_t$, $\Delta\phi(\mu_1, \not\!\!E_t\ )$
  Z-veto
  b-tag based on jet lifetime prob.
- $L = 340\,\text{pb}^{-1}$

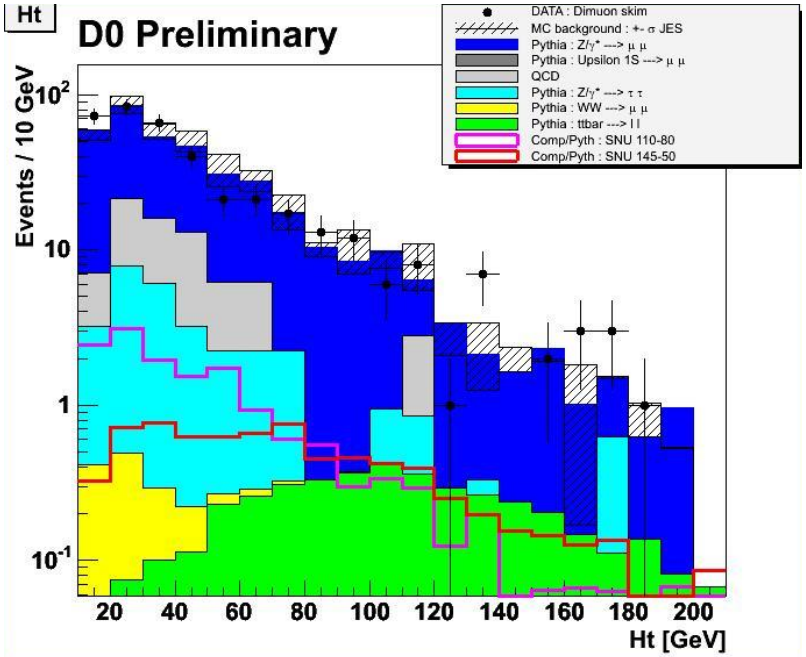




Discrimination from t Background

- after cuts:
  - $t\bar{t}$ dominates background (2.3 out of 2.9)
  - 1 event left in data
- use shape of $H_T = \sum_{\text{jets}} E_T$ distribution to discriminate between $t\bar{t}$ and $\tilde{t}$-signal
- cross-section limit calculated with likelihood ratio method (T. Junk)
- assume $BR(\tilde{t} \to bl\tilde{\nu}) = 100\%$

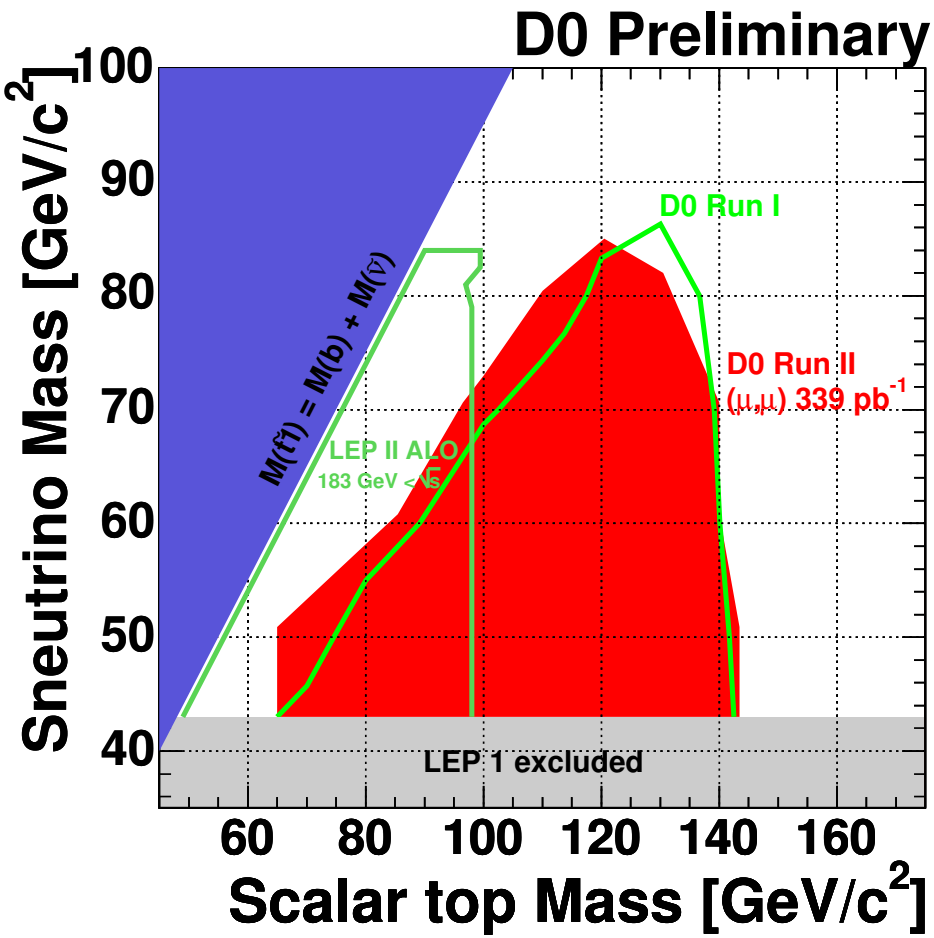
after presel. and $\not\!\!E_t > 20\,\text{GeV}$



H_T (GeV)	Background	Data
[0, 40]	$0.11 \pm 0.02^{+0.02}_{-0.01}$	0
[40, 80]	$0.89 \pm 0.43^{+0.09}_{-0.06}$	0
[80, 120]	$0.75 \pm 0.02^{+0.13}_{-0.09}$	0
[120, 160]	$0.56 \pm 0.02^{+0.07}_{-0.06}$	1
> 160	$0.57 \pm 0.02^{+0.08}_{-0.08}$	0

Exclusion Limit for $\tilde{t}_1 \rightarrow bl\tilde{\nu}$

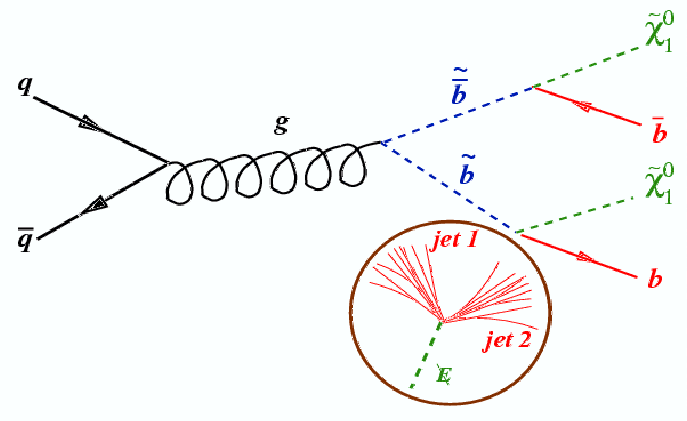
improvement in low $\Delta M(\tilde{t}, \tilde{\nu})$ region due to low p_T requirements, despite non-preferred channel

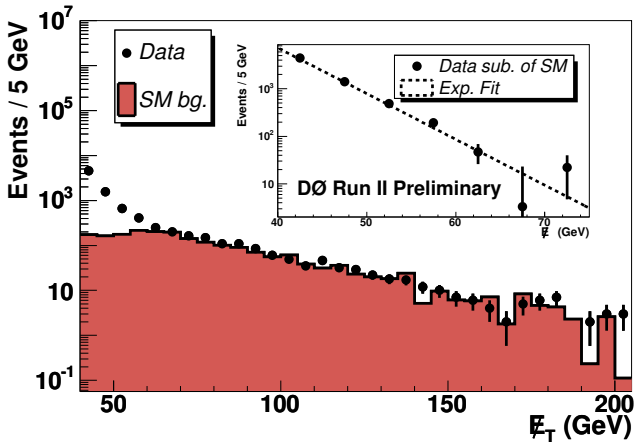


- expect significant extension of exclusion region by new analysis in $e\mu$ channel

Search for Sbottom: $\tilde{b} \rightarrow b\tilde{\chi}_1^0$

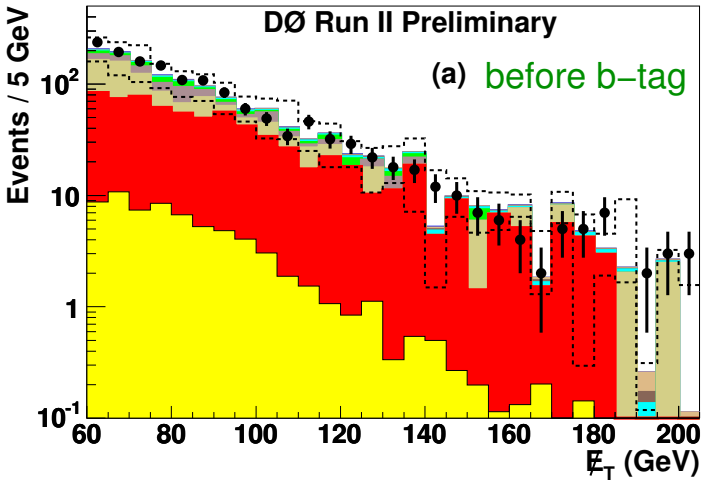
- signal: generic MSSM, vary $M(\tilde{b})$, $M(\tilde{\chi}_1^0)$
  assume $BR(\tilde{b} \rightarrow b\tilde{\chi}_1^0) = 100\%$
- dedicated trigger designed for $\not\!\!E_t$ + jets topologies, based on $\sum_{\text{jets}} \vec{p}_T$ and acoplanarity,
  $L = 310\, pb^{-1}$
- selection:
  - 2 or 3 jets, $\not\!\!E_t$
    cut depending on $M(\tilde{b})$:
    $E_T(j_1/j_2) >$ 40-70/15-40 GeV
    $\not\!\!E_t >$ 60-100 GeV
  - tight b-tag
  - veto events with isolated e, μ, track (τ)





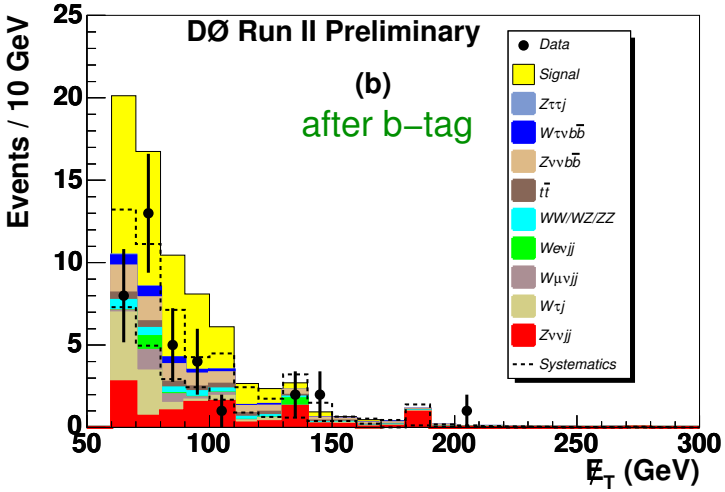
- QCD background at large $\not\!\!E_t$ vanishes
  $\rightarrow$ main bgd.: W/Z + jets

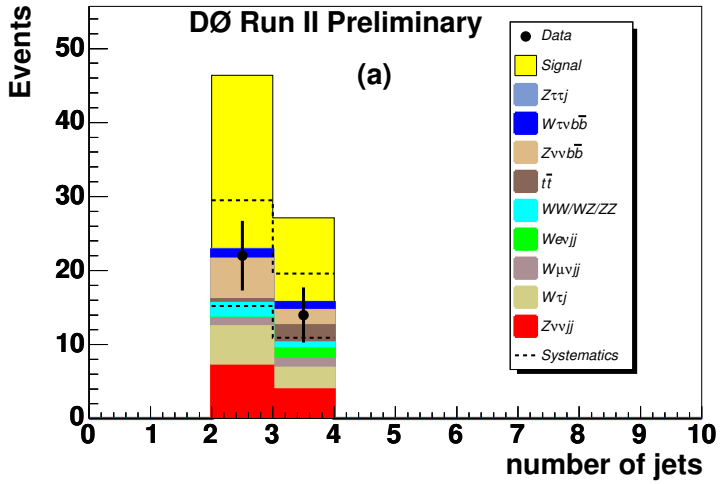
Search for Sbottom $\tilde{b} \rightarrow b\tilde{\chi}_1^0$



b-tag	no	yes
SM	1335 ± 48	38.6 ± 2.8
Data	1433	36
Signal	68.8 ± 2.3	35.0 ± 1.2

$M(\tilde{b}) = 140\,\text{GeV}$, $M(\tilde{\chi}_1^0) = 80\,\text{GeV}$

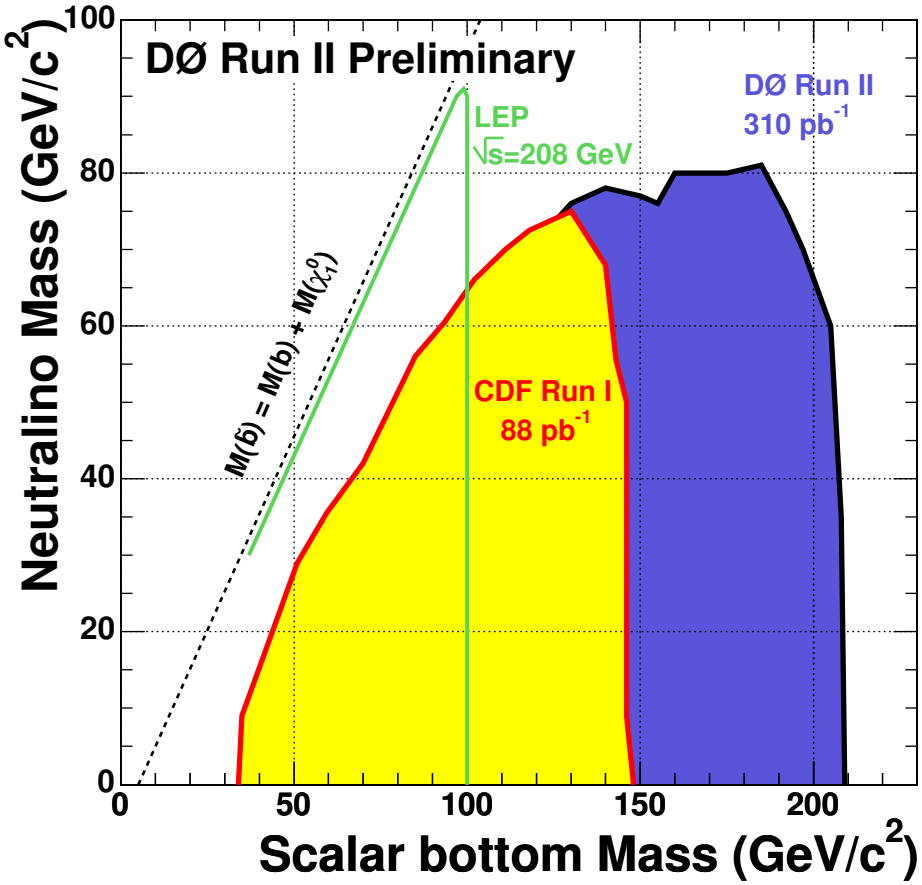




- dominating systematics: jet energy scale uncertainty

Exclusion Limit for $\tilde{b} \rightarrow b\tilde{\chi}_1^0$

optimization of $E_T(\text{jet})$ and $\not\!\!E_t$ cuts depending on $M(\tilde{b})$ and $\Delta M(\tilde{b}, \tilde{\chi}_1^0)$



$M(\tilde{b})$	low	medium	large
SM	38.6 ± 2.8	19.6 ± 1.7	4.40 ± 0.44
Data	36	15	2

Conclusions

- DØ and CDF collaborations have searched for $\tilde{b}$ and $\tilde{t}$ pair-production in generic MSSM models
  - assuming one dominating decay channel and interpreting exclusion in terms of masses of $\tilde{b}/\tilde{t}$ and decay products
- significantly increased exclusion regions compared to LEP and Tevatron Run I:
  - improved heavy-flavor tagging
  - ability to lower minimal lepton p_T
  - despite problem: jet energy scale uncertainty still larger than Run I ($\rightarrow$ expect improvements)
- results shown based on $L = 160 - 340\,\mathrm{pb}^{-1}$
  $\Rightarrow$ largely increased sensitivity with current ($\sim 1\,\mathrm{fb}^{-1}$) and full Run II dataset ($4 - 9\,\mathrm{fb}^{-1}$) and with inclusion of additional decay channels