Searches for squarks and gluinos at DØ

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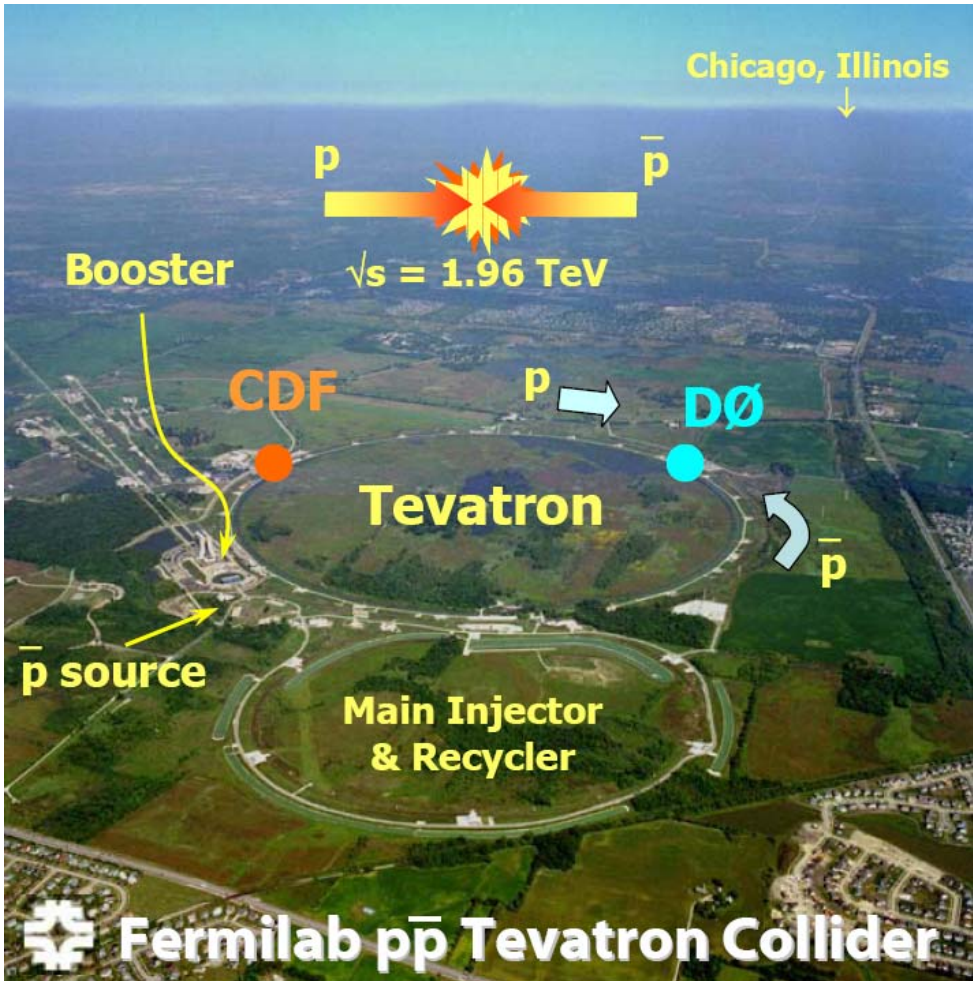
Outline

- Jets and MET topology:
  - Searches for squarks and gluinos
  - T-odd quarks search
  - Stop in cc+MET
- Stop search in leptons and jets events
- Conclusions



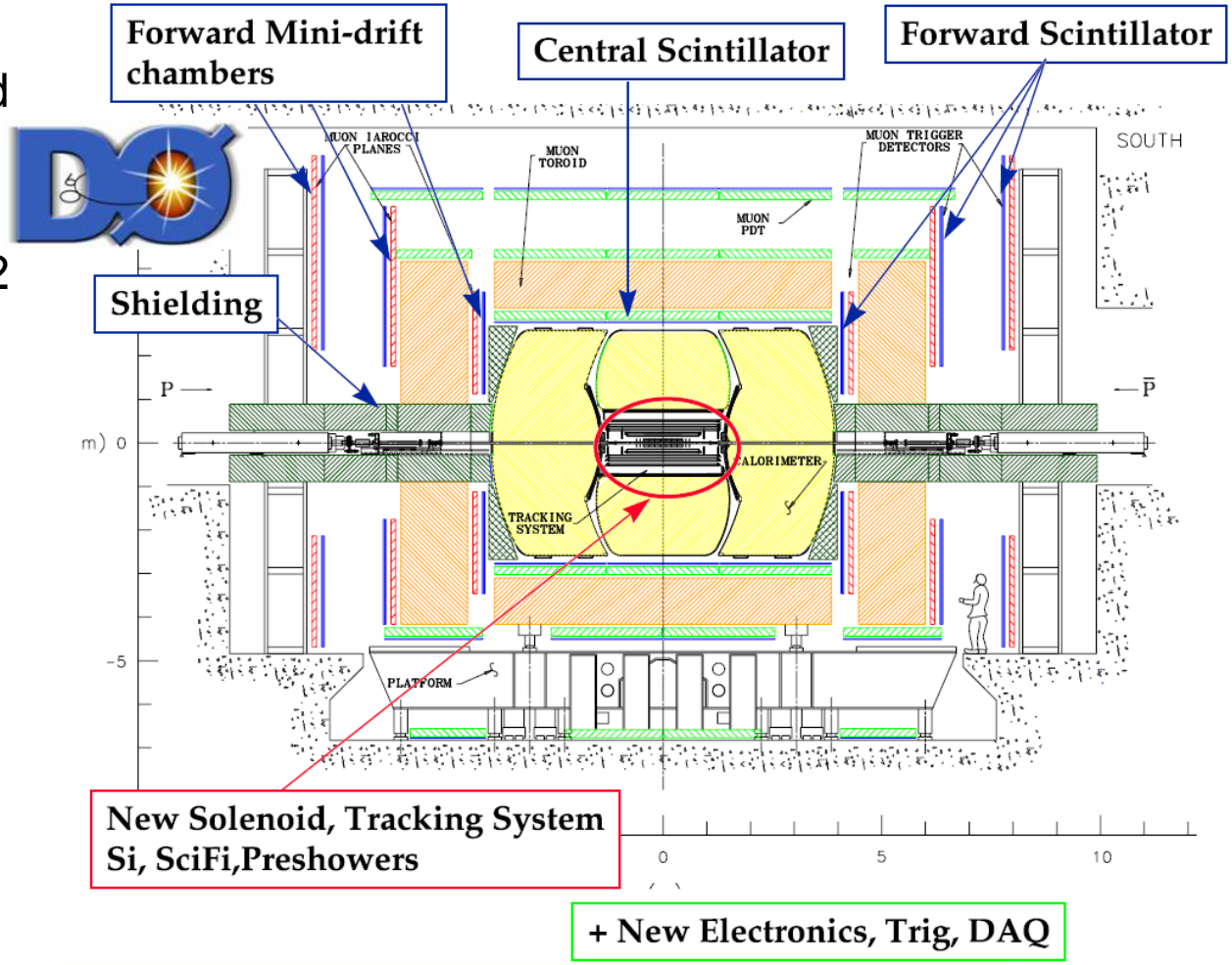
Only results obtained after the last summer conferences are shown

DØ experiment in RunII

- General purpose detector, with ~4π angular coverage

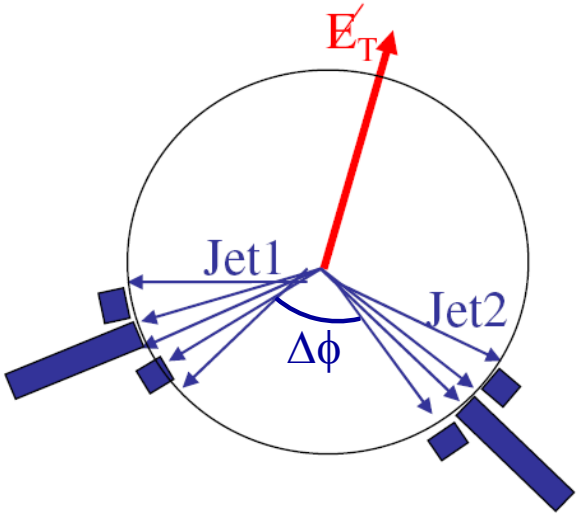
- Central-tracking system within a 2T magnetic field
- LAr calorimeter with a central section and two end calorimeters $|\eta| \leq 4.2$
- Muon system covering $|\eta| < 2$

- Recent updates:
  LØ for SMT, new L1Cal trigger system
- Current average data taking efficiency is ≥90%



Acoplanar jet topology

- Searches presented in this talk are in the topology of two or more acoplanar jets and large missing transverse energy



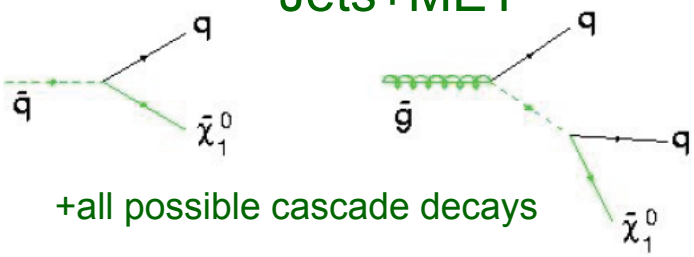
- Data has been collected with a set of triggers specifically designed for these topologies:
  - a trigger for acoplanar dijet + missing Et, missing Et > 30 GeV and acoplanar cuts
  - a trigger for multijet+MET, missing Et > 25 GeV and at least 3 jets

- Main backgrounds:
  - Physics: *Z/W*+jets ($Z \rightarrow \nu\nu$ irreducible), di-boson, top
  - Instrumental: mismeasured missing Et together with QCD jets

Squarks and gluinos – analysis strategy

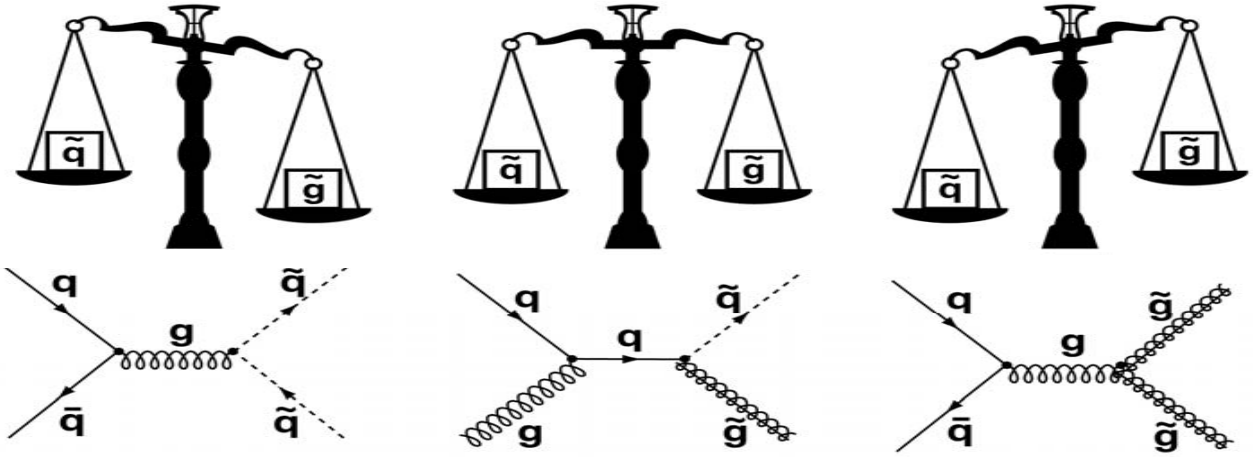
- Strong productions leads to large cross sections
- With neutralino as LSP, decay into jets and MET

Jets+MET



+all possible cascade decays

- 3 analyses optimized for 3 benchmarks regions of mSUGRA parameter space (with R-parity conservation) :



Dijet analysis
$\tilde{q}\bar{\tilde{q}} \rightarrow q\tilde{\chi}_1^0\bar{q}\tilde{\chi}_1^0$

3-jet analysis
$\tilde{q}\tilde{g} \rightarrow q\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$

Gluino analysis
$\tilde{g}\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0 q\bar{q}\tilde{\chi}_1^0$

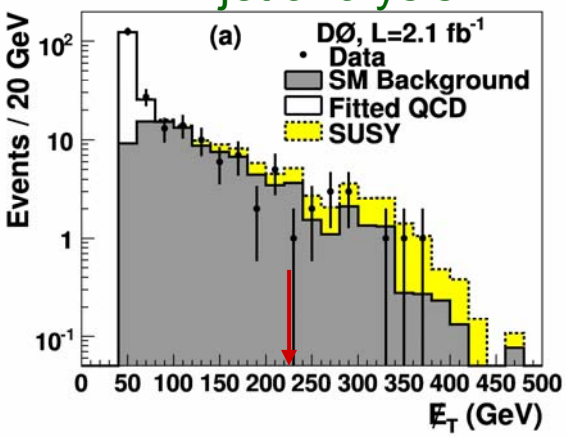
Squarks and gluinos – selection

- Very similar selection cuts for the three analyses:
  - up to 4 jets: pT > 35 GeV (20 GeV for 4th jet)
  - two leading jets in central CAL, acoplanar ($\Delta\phi<165^0$) and confirmed by tracks
  - veto on isolated electrons and muons
  - several MET vs jets isolation cuts

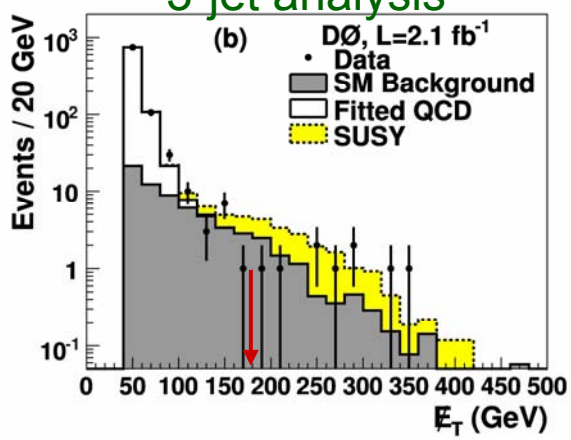
$$\mathrm{HT} = \sum_{jets} p_T$$

Dijet		3-jet		Gluino	
HT>325 & MET>225		HT>375 & MET>175		HT>400 & MET>100	
11	11.1±1.2+2.9-2.3	9	10.7±0.9+3.1-2.1	20	17.7±1.1+5.5-3.3

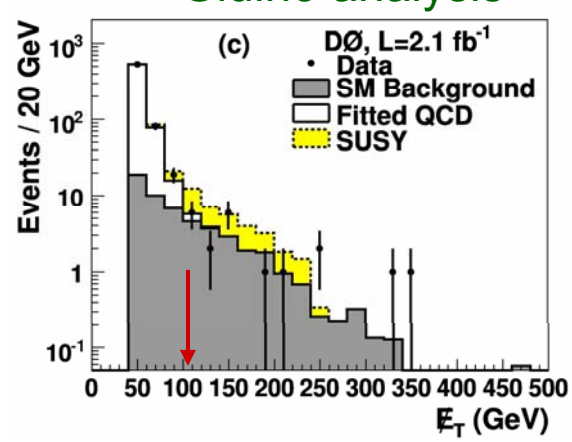
Dijet analysis



3-jet analysis



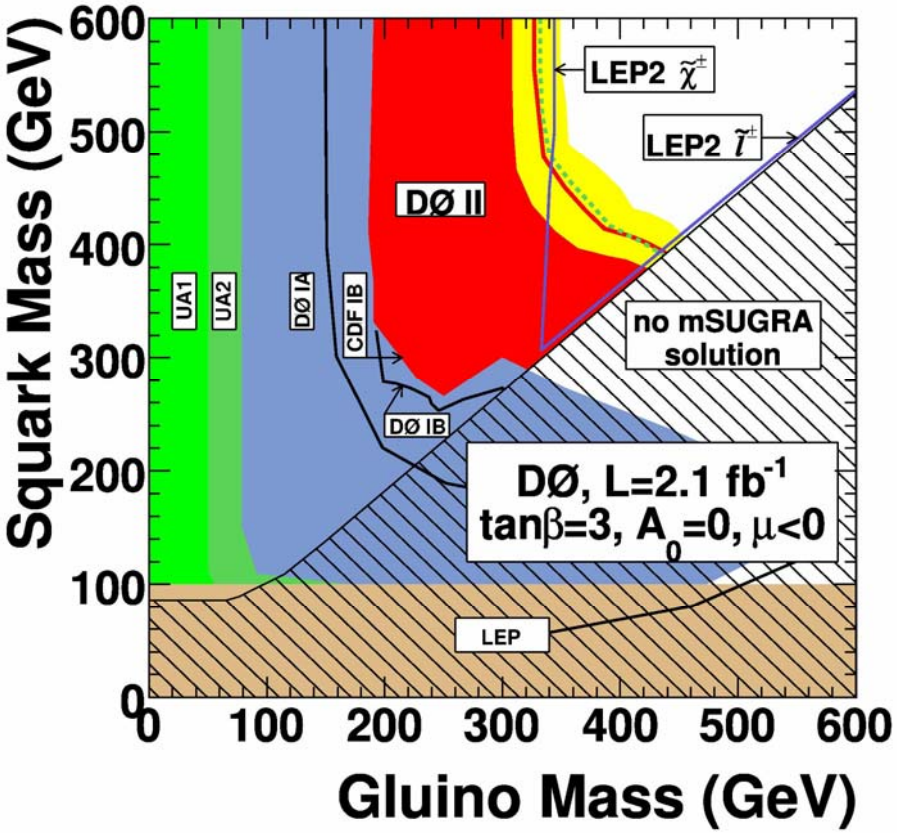
Gluino analysis



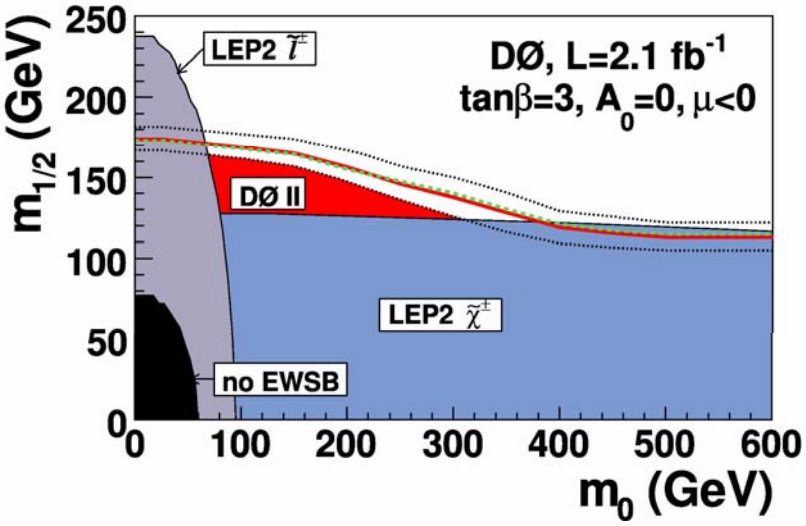
- QCD estimated from the sideband: MET < 60 GeV (and found to be negligible)

Squarks and gluinos – exclusion limits

- Mass limits and constrains on the mSUGRA parameters at Λ_{GUT} for $\tan(\beta)=3$, $A=0$, $\mu<0$
- Yellow band: PDF (and RF scale) uncertainty on the NLO signal xsection (25-75%) due to the poor knowledge of the gluon at high *x*



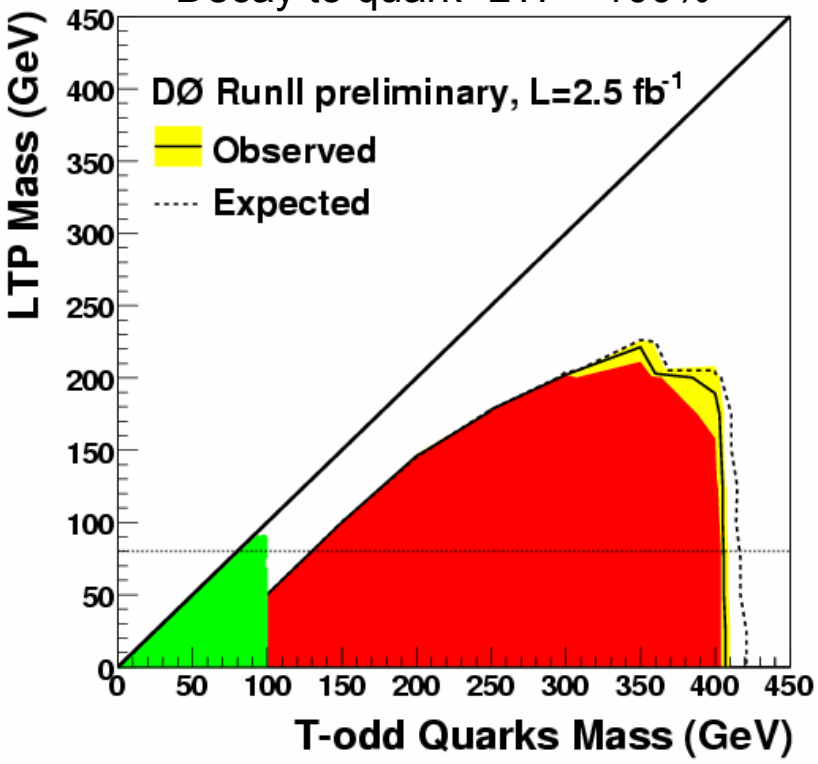
	M(Gluino)		M(Squark)	
	obs.	exp.	obs.	exp.
σ(min)	308	312	379	377
σ(nom)	327	332	392	391
σ(max)	349	354	406	404



Search for T-odd quarks

- The particle spectrum of the Little Higgs model with T-parity has a similar experimental signature to SUSY models, but T-odd particles have the same spin as their SM partners
- T-quarks decay into a quark and the lightest T-odd particle (LTP) in most of the parameter space available at the Tevatron. The LTP is a dark matter candidate, stable and weakly interacting

Decay to quark+LTP ~100%

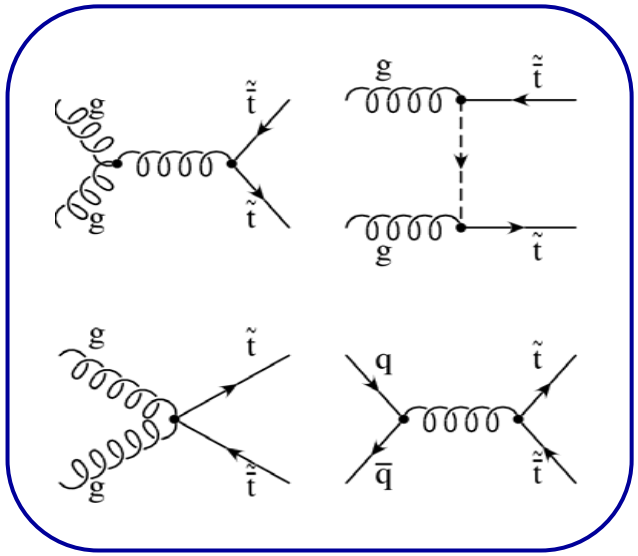


- Selection like the di-jet analysis, but with more data and veto on isolated tracks
- Several HT-MET cut combinations to optimally scan the mass plane

- Largest excluded T-quark mass: 404 GeV
- Most stringent direct limits to date on the T-quarks mass

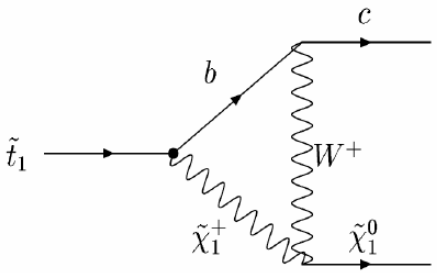
Stop searches at DØ

- Stop particles are expected to be the lightest squarks in SUSY theories
- Pair production through strong processes
- With the same mass, σ(stop) 10 times smaller than σ(top), spin ½ vs spin 0
- Numerous search channels
- Depend on dominant decay mode

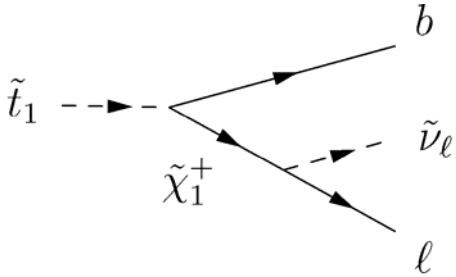


- In this talk, depending on the MSSM parameters, two search channels considered:

Heavy flavor+MET:
cc+Met



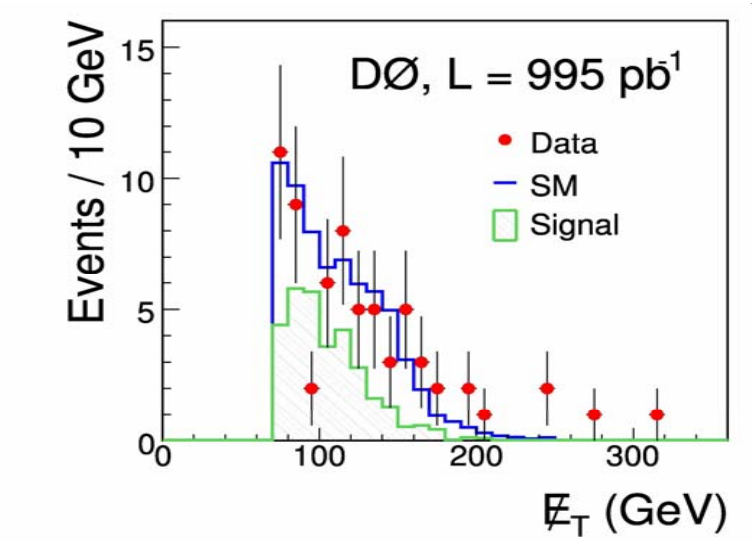
Leptons+jets:
eμ+2b+MET

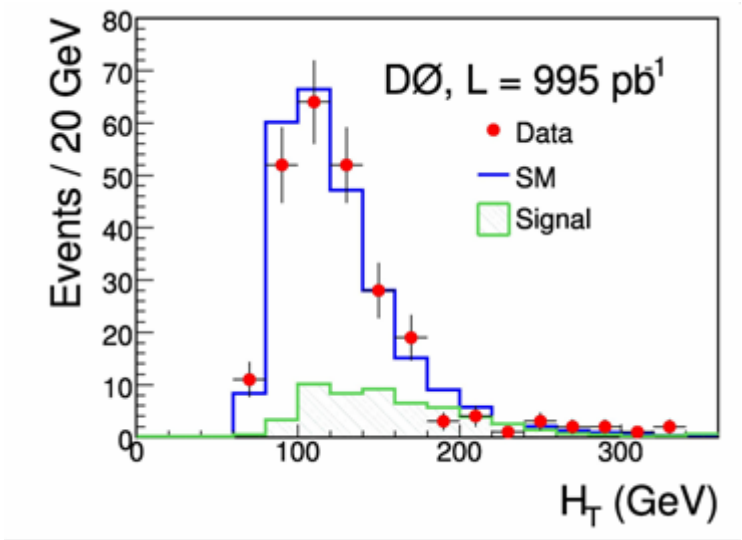


Stop search in cc+MET

- Signature is two acoplanar charm jets and missing transverse energy
- Selection cuts:
  - Two jets and veto on leptons and isolated tracks
  - Several MET and HT cuts to reduce QCD background

- At least one jet to be HF tagged with DØ's NN tagging tool
- NN output kept loose to get $\varepsilon_{charm} \approx 30\%$ (while $\varepsilon_{mistag} \approx 6\%$)

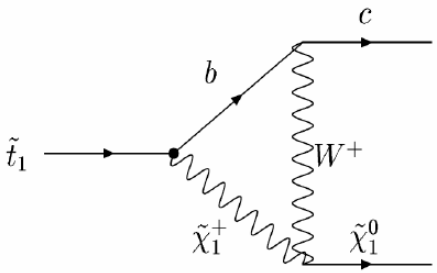




$m_{\tilde{t}} = 150$ GeV

$m_{\tilde{\chi}_1^0} = 70$ GeV

Stop search in cc+MET

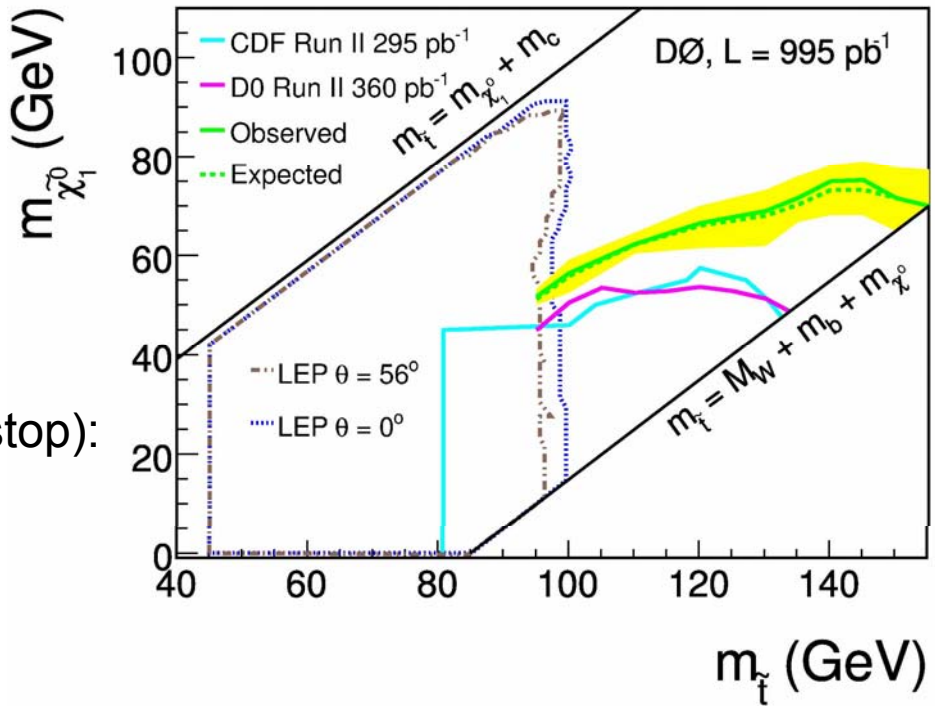


- Cuts on HT, MET and S = Δϕmin + Δϕmax for MET and jets are optimized for best expected limit on $m_{\tilde{\chi}_1^0}$ for given $m_{\tilde{t}}$

MET > 70 GeV in all cases

$m_{\tilde{t}}$	H_T	S	Observed	Predicted
$95-130$	>100	<260	83	$85.3 \pm 1.8^{+12.8}_{-13.0}$
$135-145$	>140	<300	57	$59.0 \pm 1.6^{+8.5}_{-8.8}$
$150-160$	>140	<320	66	$66.6 \pm 1.1^{+9.6}_{-10.0}$

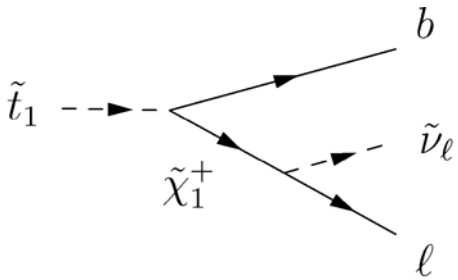
Kinematic region of interest for this search: decay into a charm quark and neutralino with ~100% branching fraction



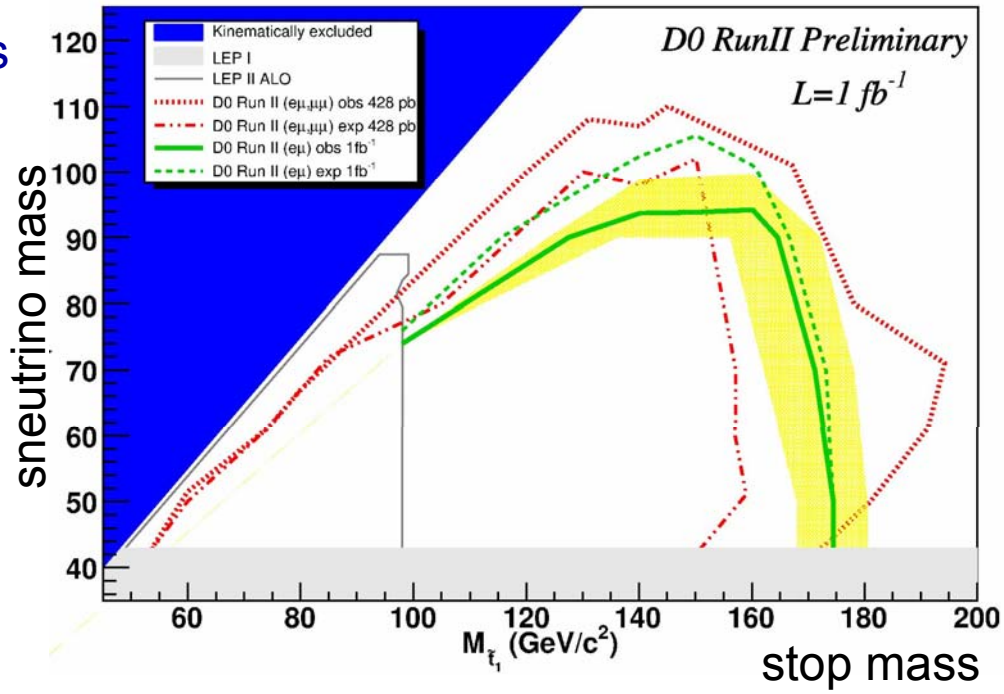
- Largest stop mass excluded by this analysis is 155 GeV, for a neutralino mass of 70 GeV
- With the theoretical uncertainty on σ(stop): 150 and 65 GeV, respectively

Stop search in eμ+2b+MET

- Assume sneutrino is LSP or NLSP
- $\tilde{t}_1 \rightarrow b\ell\tilde{\nu}_\ell$ with ~100% branching fraction
- e+μ has largest branching ratio and smallest backgrounds among the 3 decay modes



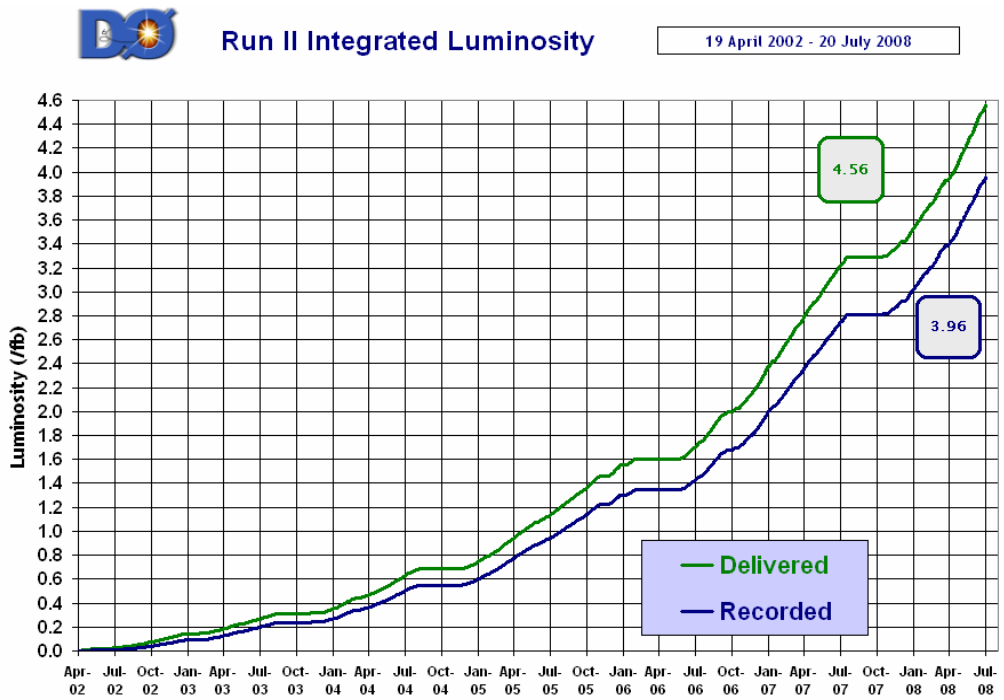
- Signal topology: two high pT leptons (e+μ), two jets and MET (sneutrino)
- Main backgrounds:
  - Physics: $Z\rightarrow\tau\tau$, diboson, top anti-top pair-production
  - Instrumental: misidentified leptons or jets, or mismeasured MET
- Selection cuts:
  - Events with an electron and muon
  - Jets, electron and muons required to be isolated from each other
  - Several MET based cuts



For large sneutrino – stop mass differences a stop mass lower than 175 GeV is excluded

Conclusions

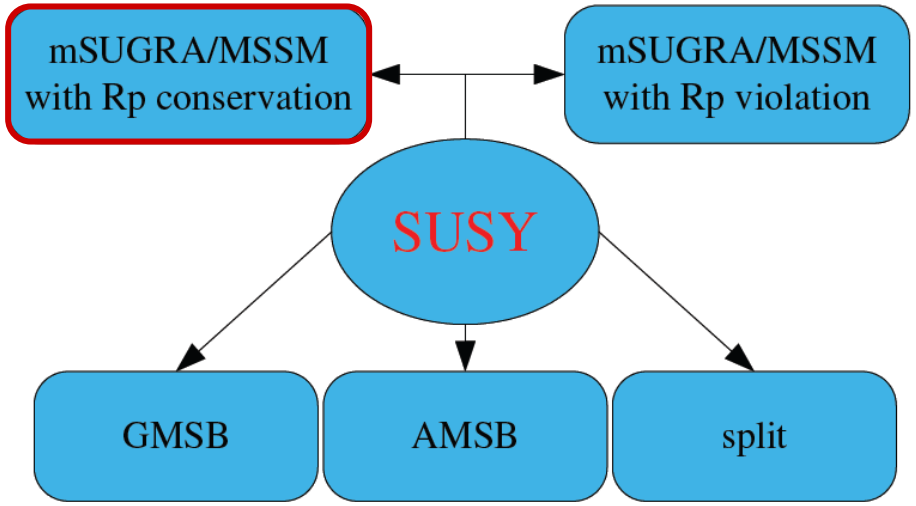
- Presented several searches for squarks and gluinos at the DØ detector
- First direct search for T-quarks at the Tevatron
- No sign of supersymmetry in up to 2/fb of data analyzed
- Constrains on various SUSY models become stronger
- New results should be available soon with a significantly larger data set



Backup slides

Supersymmetry

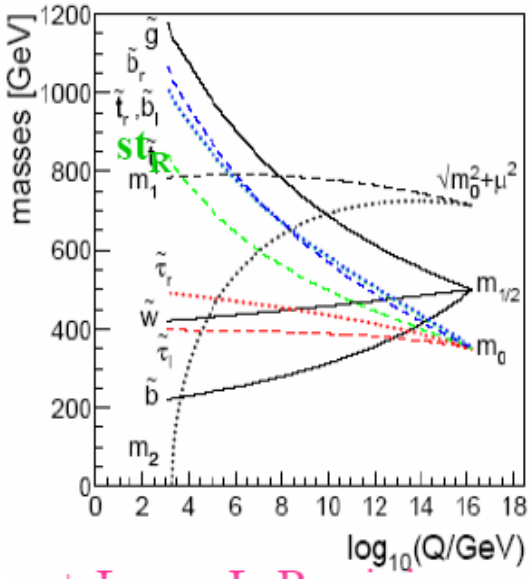
- Supersymmetric extensions of the SM offer solutions for many problems that cannot be solved within the SM, e.g. hierarchy problem
- Each SM particle has a SUSY partner which differ by ½ in spin
- SUSY must be broken. Various mechanisms exist, they influence the particle mass spectrum and SUSY signal topologies
- Large number of new parameters, reduced in constrained models
- mSUGRA, 5 parameters:
  - $\tan(\beta)$: v.e.v. ratio of the 2 Higgs Fields
  - m_0: scalar mass at GUT scale
  - $m_{1/2}$: gaugino mass at GUT scale
  - $\mathrm{sign}(\mu)$: Higgs mixing mass parameter
  - A_0: trilinear coupling at GUT scale



- Squarks (including stop) and gluinos searches in the jets and MET topology presented in this talk are in the framework of mSUGRA with R-parity conservation

Stop

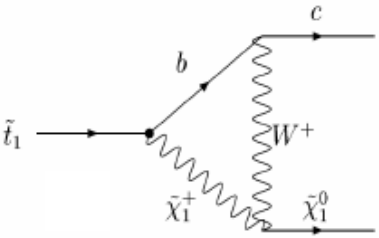
A light stop can be expected:
top-Yukawa impact in RGE



+ Large L-R mixing

Scenario commonly considered:

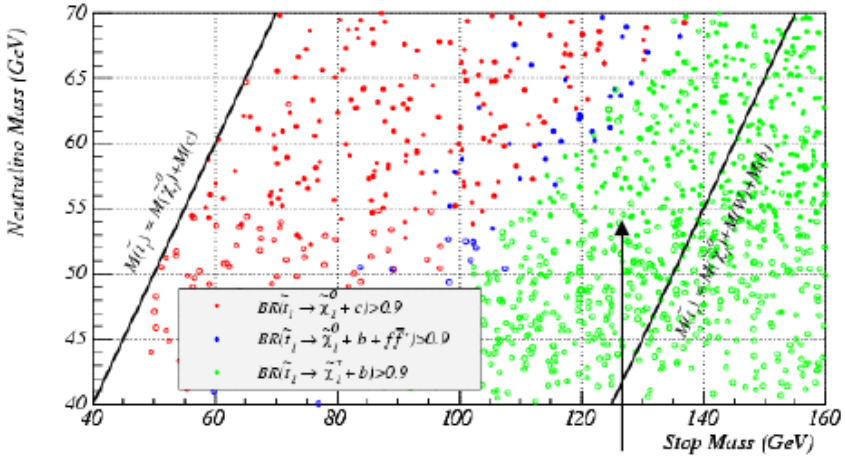
stop NLSP and χ LSP
with st→cχ (FCNC)



(relevant as long as m(st) < m(b)+m(W)+m(χ))

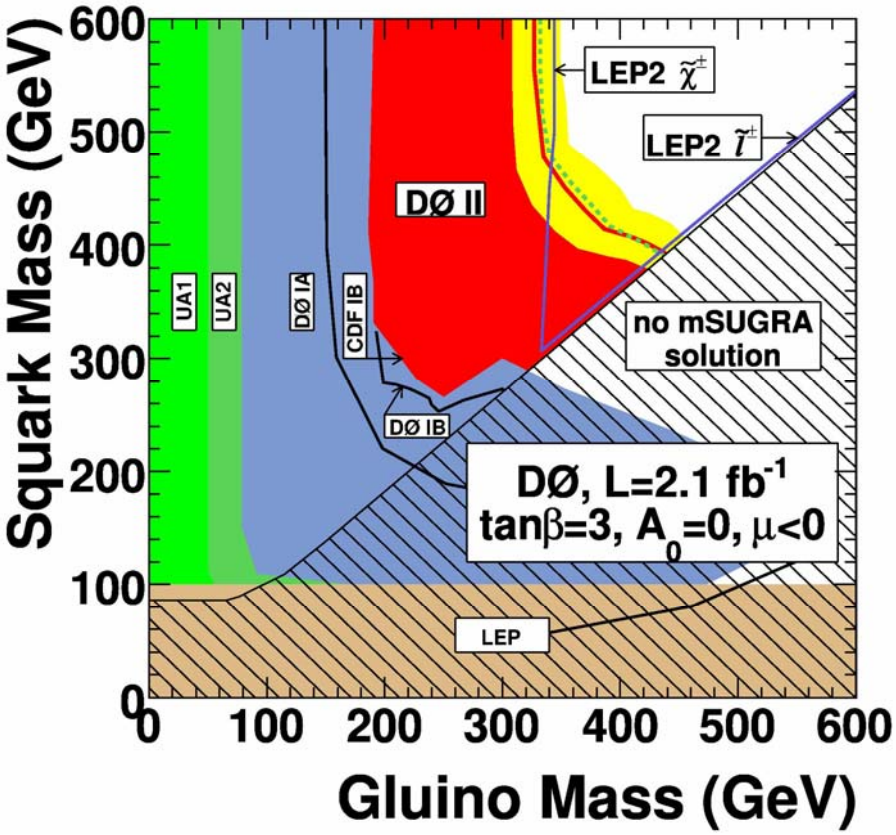
$\tilde{t}_1 \to c\,\tilde{\chi}^0$ $\tilde{t}_1 \to b\,\tilde{\chi}^0\, f\bar{f}'$ $\tilde{t}_1 \to b\,\tilde{\chi}^{+/-}$

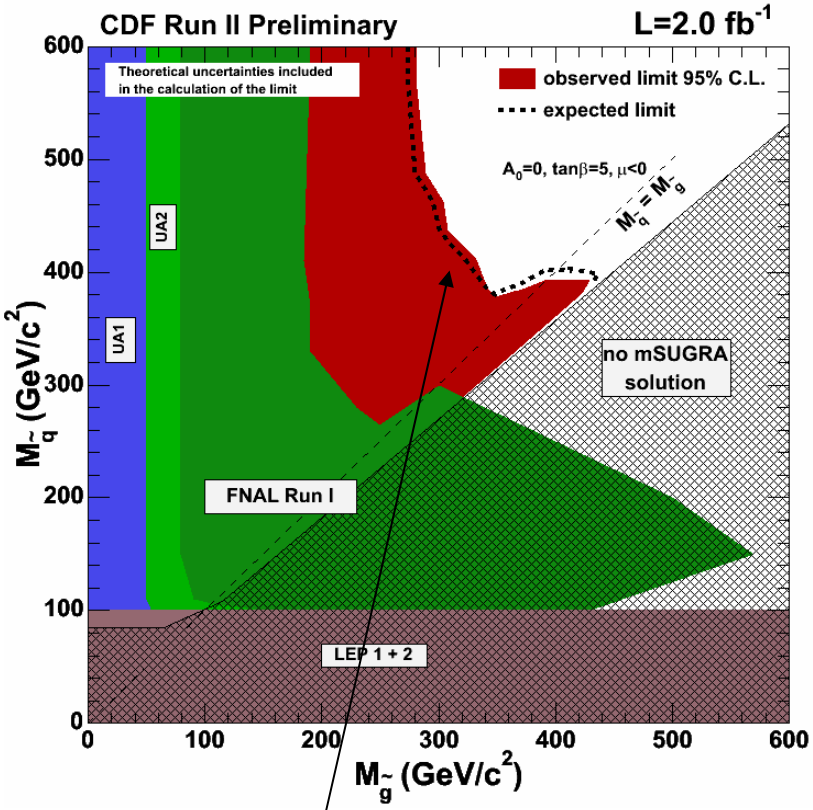
mSUGRA scan:
m_0 = 200 to 600 GeV (50 GeV step)
$m_{1/2}$ = 110 to 180 GeV (10 GeV step)
A_0 = –500 to –1000 GeV (100 GeV step)
tanβ = 3 and 10 to 50 (10 step)
Both signs of μ



(in SUGRA, M1 < M2 at GUT scale needed)

Squarks and gluinos at Tevatron





Theoretical uncertainties included in the limit calculation