NON-INCLUSIVE SEARCHES FOR SQUARKS AND GLUINOS AT THE TEVATRON

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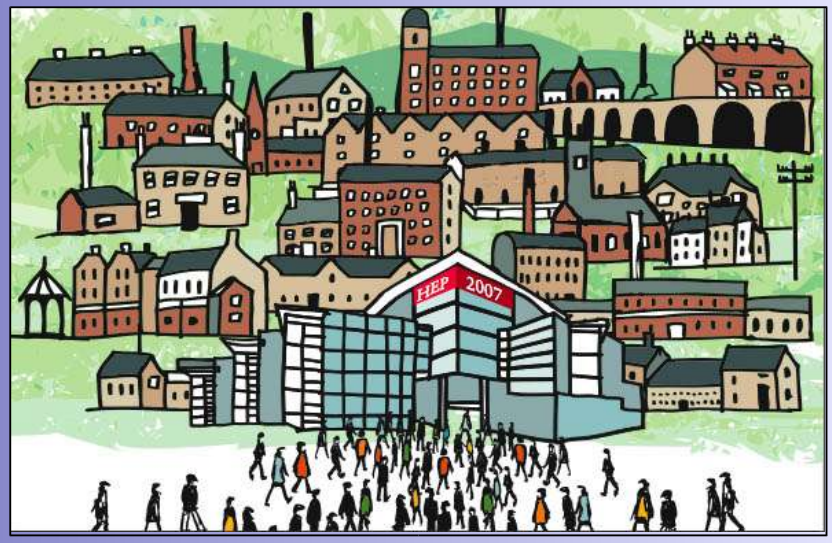


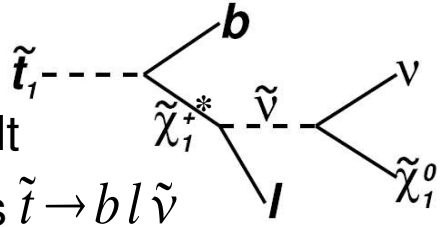
INTRODUCTION TO THE ANALYSES

- large mixing in the third generation of sfermions
- dedicated searches aimed at specific mass hierarchy
- RPC hypothesis (pair produced SUSY particles, large MET)

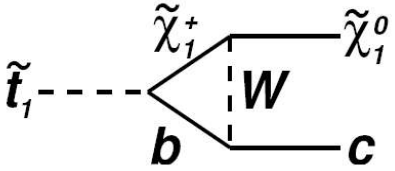
Note : following limits are at 95% C.L.

stop:

- 2-body decays ($\tilde{t}_1 \to t\tilde{\chi}^0_1, \tilde{t}_1 \to b\tilde{\chi}^+_1$) kinematicaly difficult
- NLSP $\tilde{\nu}$, $m(\tilde{\chi}^+_1) > m(\tilde{t}) > m(\tilde{\nu}) > m(\tilde{\chi}^0_1)$ 3 body decays $\tilde{t} \to b\,l\,\tilde{\nu}$
- NLSP stop, stop decay via FCNC dominates $\tilde{t}_1 \to c\tilde{\chi}^0_1$



2 b-jets + 2 l + MET
400 pb^{-1}



2 c-jets + MET
new DØ update!

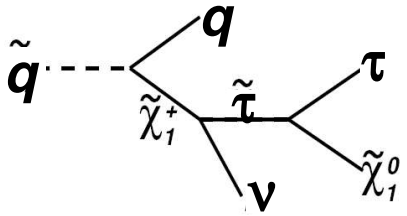
sbottom:

- NLSP sbottom (high tanβ), $\tilde{b}_1 \to b\tilde{\chi}^0_1$

2 b-jets + MET
~350 pb^{-1}

gluinos :

- if sbottom is lighter than gluinos, $\tilde{g} \to b\tilde{b}$



4 b-jets + MET
~160 pb^{-1}

generic (heavy) squarks:

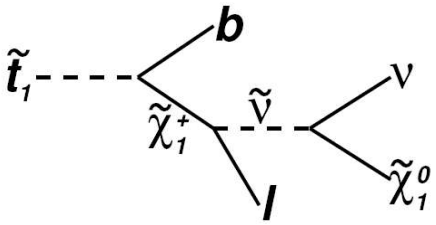
- stau is the lightest slepton (high tanβ); search for cascade decay to taus

2 jets + τ(s) + MET
brand new !

STOP :: 2 b-jets + 2 leptons + MET

μμ and eμ channels

L_{int} ~400 pb^{-1}



Selection:

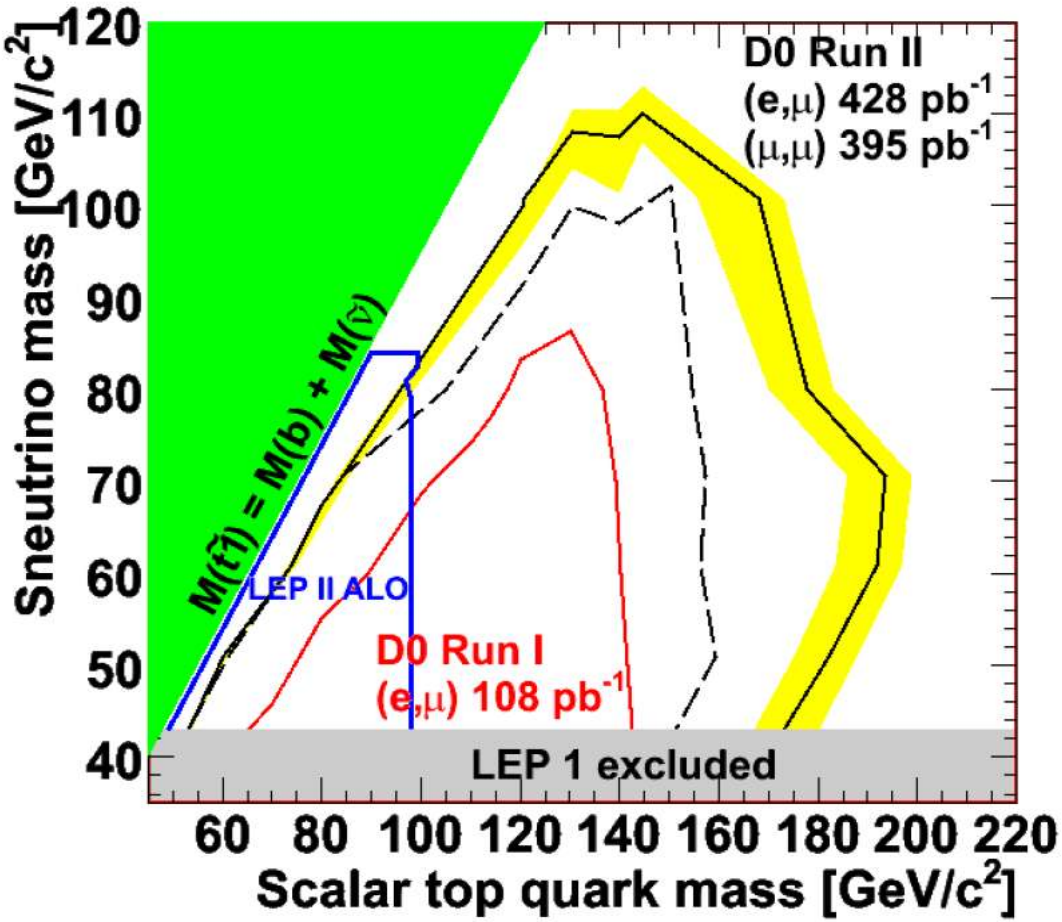
- 2 leptons identified
- low pT cuts on leptons (6-10 GeV)
- μμ: 1 b-tagged

Combination:

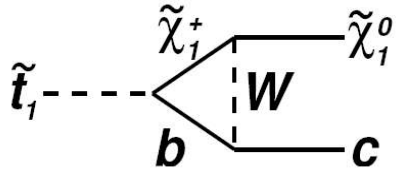
- generic MSSM, $BR(\tilde{t} \to bl\nu\ \tilde{\chi}^0_1) = 100\%$
- equal BR to all lepton flavours
- largest excluded masses:

$$m(\tilde{t}) > 186\,GeV \text{ for } m(\tilde{\nu}) > 71\,GeV$$
$$m(\tilde{\nu}) > 107\,GeV \text{ for } m(\tilde{t}) > 145\,GeV$$

Channel	Total bkg	Data	(110,80)	(145,50)
eμ	37.1 +/- 2.7 +/- 1	34	26 +/- 1.5 + 0.3 – 0.0	17.3 +/- 6 0.6 +/- 0.2
μμ	2.9 +/- 0.4 +/- 0.1	1	3.1 +/- 0.2 +0.2 -0.0	3.3 +/- 0.4 +0.4 – 0.3

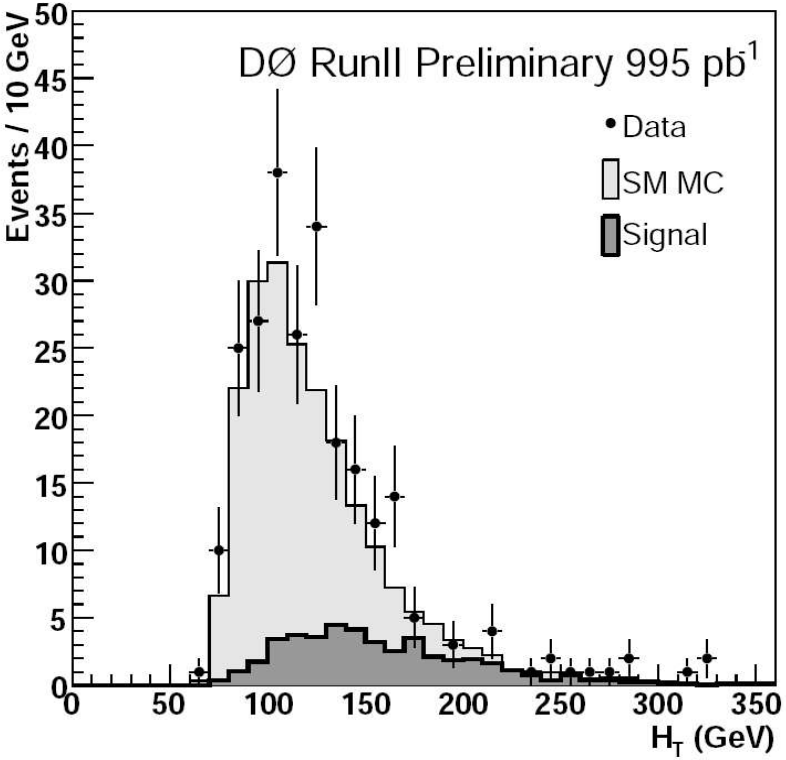


STOP :: 2 c-jets + MET



Data set:

- DØ: jets+MET, L_{int}=360 pb^{-1} [PLB 645 (2007)]
- **!! HOT OFF THE PRESS !! DØ L_{int}= 995 pb^{-1}**
- CDF: jets+MET, L_{int}=295 pb^{-1} [CDF note 8411]



Main backgrounds:

- W(lν)+jets, Z(νν)+jets (multijet QCD events)

Selection (very similar for the 3 analyses):

- exactly 2 jets (pT> 40, 20 GeV), MET > 60 GeV
- veto on isolated leptons and isolated tracks
- jets-MET angular correlations (mismeasured jets)
- **loose b-tag jet** (increase c quark efficiency, eff. LF~ 6%)
- optimisation (per stop mass): HT, MET, Φ(jet1,jet2,MET)

Main systematics:

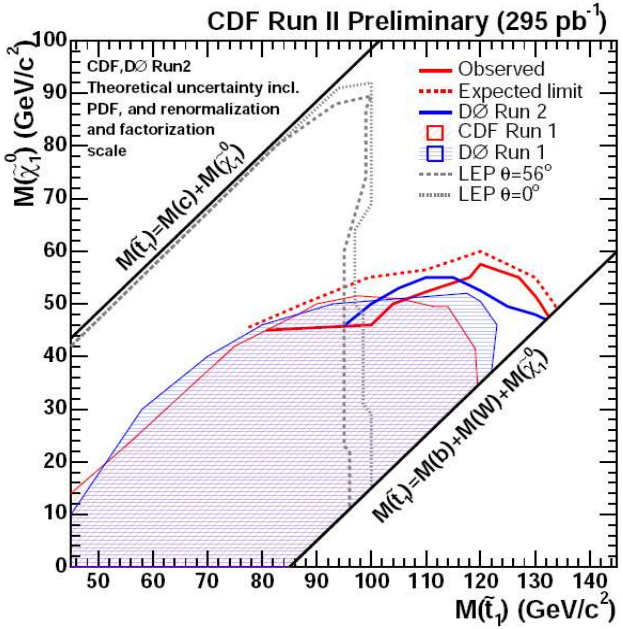
- signal : JES (8%)
- background: normalisation (10%)

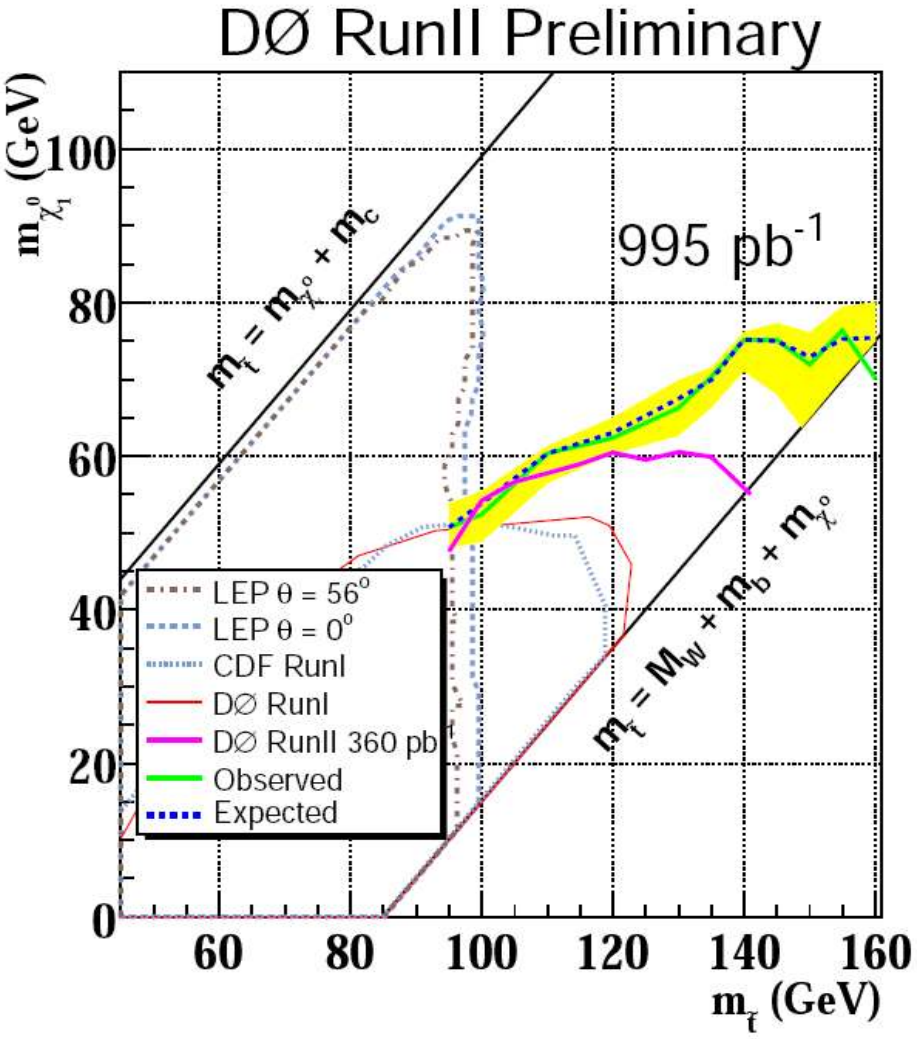
Stop mass	Expected	Data
95-130	81.9 +/- 4.0 + 13.9 – 14.1	83
135-145	57.0 +/- 3.1 + 8.6 – 8.7	57
150-160	64.2 +/- 3.2 + 9.0 – 9.1	66
signal(160,80)	26+8+/-1.63	-

STOP :: 2 c-jets + MET

Results:

- generic MSSM, $BR(\tilde{t}_1 \to c\tilde{\chi}^0_1)$=100%
- large improvement over previous searches
- sensitivity to $m(\tilde{t})\, upto\, 149\, GeV\ for\, m(\tilde{\nu}) = 63\, GeV$





SBOTTOM :: 2 b-jets + MET

Data set:

- DØ: L_{int}=310 pb^{-1} [PRL 97 171806 (2006)]
- CDF: L_{int}=295 pb^{-1}

Selection: (CDF and D0)

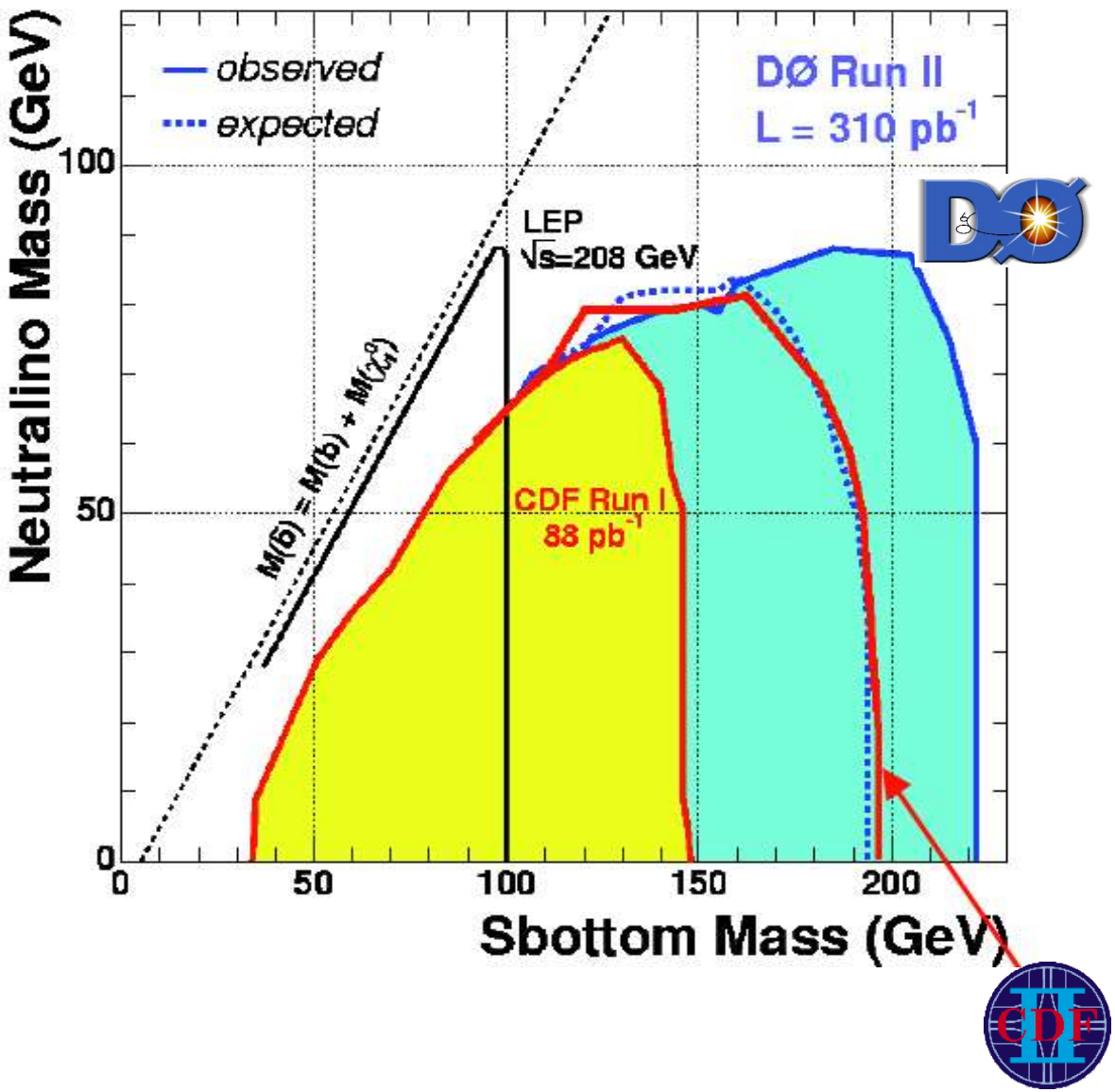
- similar as stop search
- the b-tagging is tightened (**>=1 b-tag jet**)
- optimisation per sbottom mass

Background:

- QCD, W(τν)/Z(νν) + jets, top-pair

Results:

- data and SM expectations are consistent
- generic MSSM, $BR(\tilde{b}_1 \to b\tilde{\chi}^0_1)$ =100%



SQUARKS :: 2 jets + taus + MET

!! HOT OFF THE PRESS !!

Signature:

- **not expoited yet** for SUSY searches at the Tevatron
- **2 jets + >= 1 tau (had) + MET**

Dataset:

- DØ: jets+MET trigger, $\mathbf{L_{int} = 960\ pb^{-1}}$

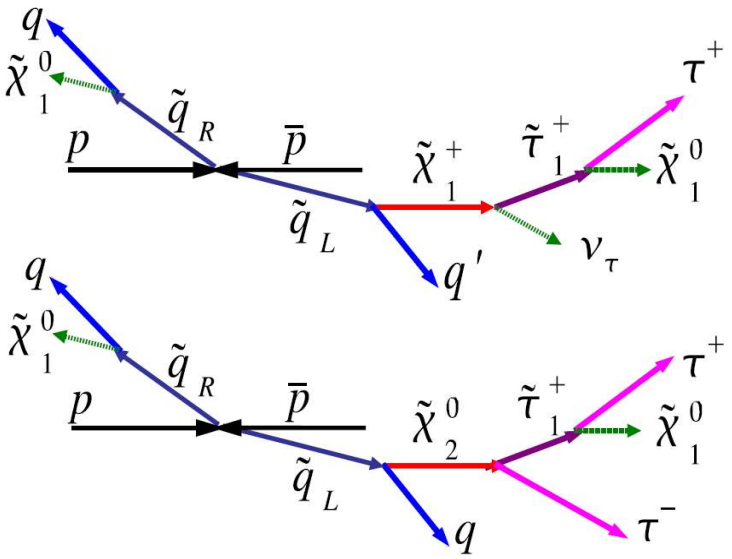
Selection:

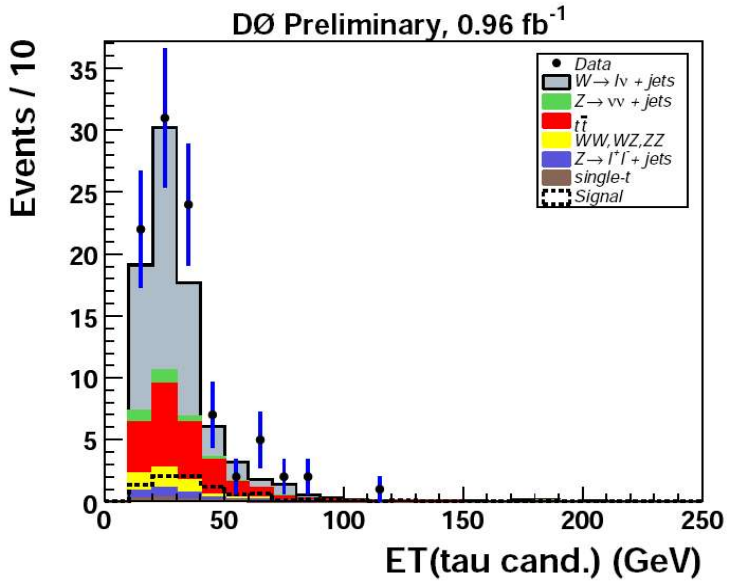
- jets and MET selection similar to the DØ inclusive search for squarks and gluinos (Xavi presentation), using dijet and multijet final states (no lepton veto)
- tau selection: hadronic tau identified (loose NN)
- optimisation on MET and $p_T(j_1)+p_T(j_2)+p_T(\tau)$

Main backgrounds:

- top-pair, W(τν)+jets (QCD multijet events)

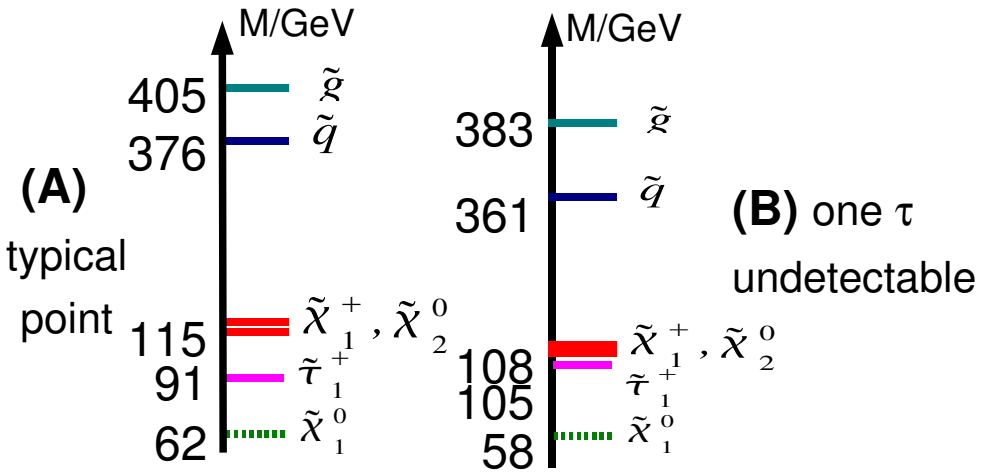
Main systematics: jet energy scale (up to 15%)





SQUARKS :: 2 jets + taus + MET

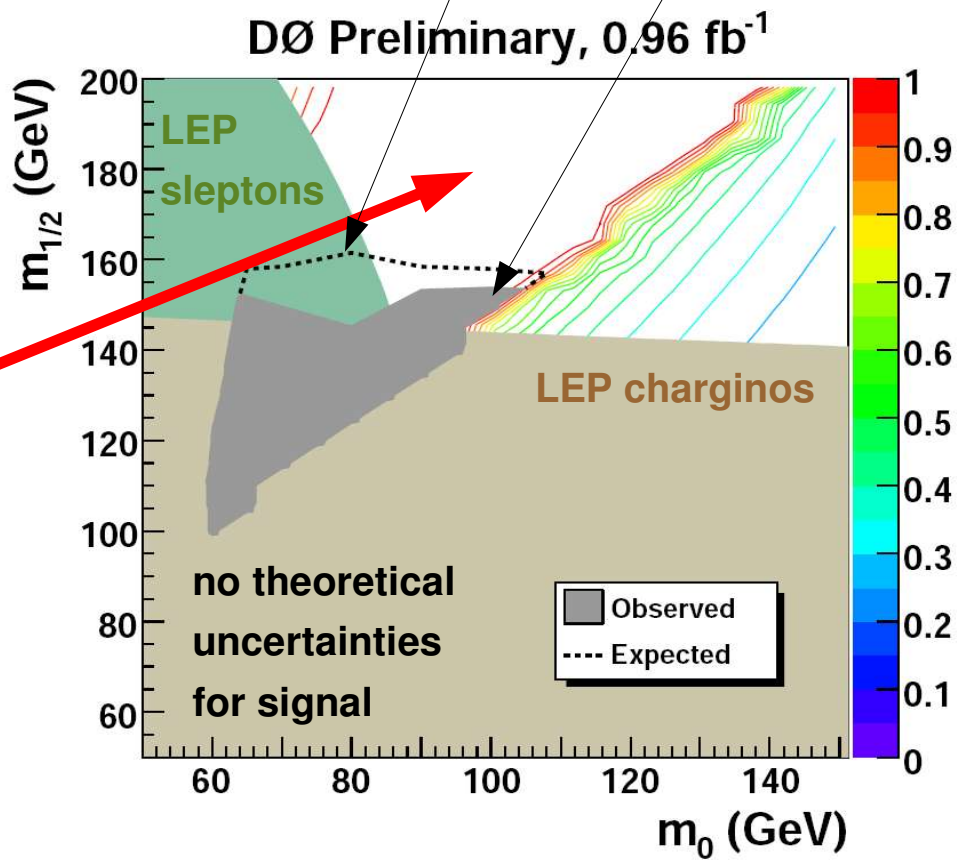
Signal: mSUGRA with enhanced decay to taus (A_0=-2m_0, tanβ=15, μ <0)



(A) typical point

(B) one τ undetectable

Data	SM expectations	Signal (A)	Signal (B)
2	1.7+/-0.3 +0.6-0.3	4.73 +/- 0.37	7.08+/-0.57



Results:

- **challenging final state**, good signal sensitivity
- excluded region restricted to the "**tau corridor**"
- squark masses up to 366 GeV are excluded (competitive with generic squark searches)
- important channel to **complement other SUSY searches** (squarks and gluinos in jets+MET, and direct chargino/neutralino production in 3 leptons)

CONCLUSION

- SUSY predicts a large variety of new particle mass hierarchies and couplings
- CDF and DØ try not to leave any stones unturned

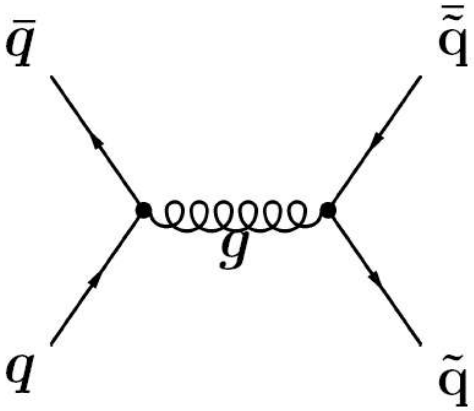
- No evidence for SUSY has been found yet
- CDF and DØ continue the quest

- Powerful techniques were developed for such difficult final states at hadron collider (b-ID, tau-ID)
- It builds confidence for the future.

http://www-d0.fnal.gov/Run2Physics/WWW/results.htm
http://www-cdf.fnal.gov/physics/physics.html

BACKUP SLIDES

SQUARKS AND LEPTONS



$$m(\tilde{\chi}_1^+) > m(\tilde{t}) > m(\tilde{\nu}) > m(\tilde{\chi}_1^0)$$

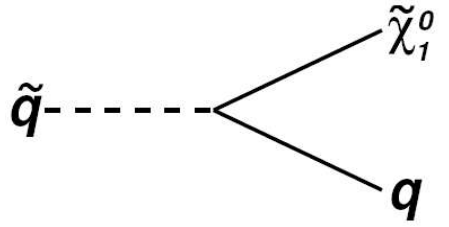
$$m(W) + m(b) + m(\tilde{\chi}_1^0) > m(\tilde{t}) > m(c) + m(\tilde{\chi}_1^0)$$

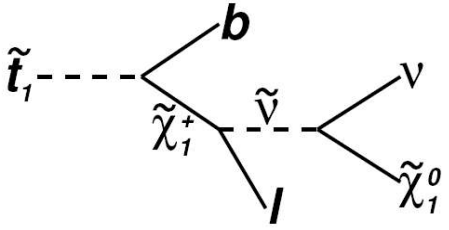
$$M^2_{\tilde{f}_{1,2}} = \frac{1}{2}[(M^2_{\tilde{f}_L} + M^2_{\tilde{f}_R}) \mp \sqrt{(M^2_{\tilde{f}_L} - M^2_{\tilde{f}_R})^2 + a^2_{\tilde{f}} m^2_f}]$$

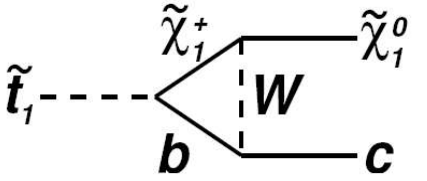
$$a_{\tilde{t}} = A_U - \mu / \tan\beta$$

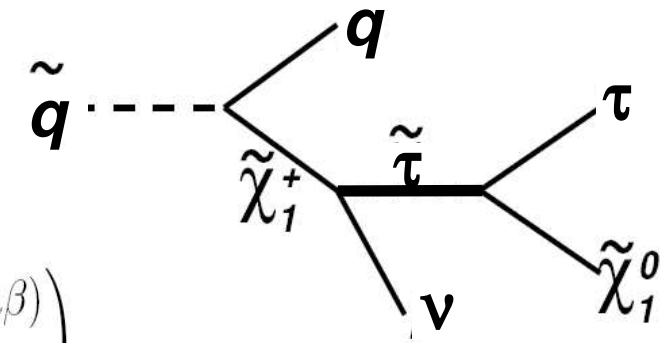
$$a_{\tilde{b}} = A_D - \mu * \tan\beta$$

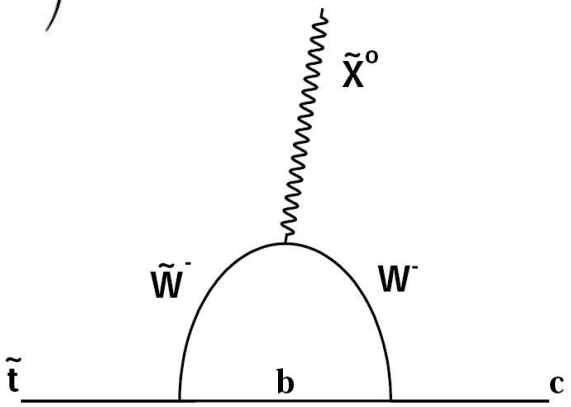
$$\begin{pmatrix} M^2_{\tilde{\ell}_L} + m^2_\ell & m_\ell \times (A_\ell - \mu \tan\beta) \\ m_\ell \times (A_\ell - \mu \tan\beta) & M^2_{\tilde{\ell}_R} + m^2_\ell \end{pmatrix}$$







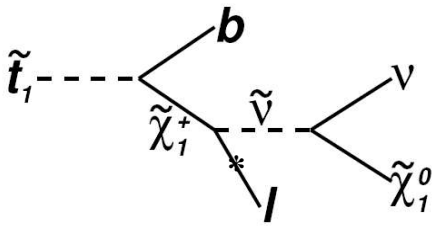




STOP :: 2 b-jets + 2 leptons + MET

Data set:

- muon triggers
- L_{int} ~ 400 pb^{-1}



μμ channel

Background:

- top-pair, Z(μμ), QCD (multijets)

Selection:

- 2 opposite charge μ, isolated, low pT cuts (8, 6 GeV), separated from MET; anti-Z cut Mμμ
- Njet >=1(15 GeV), 1 b-tagged
- HT shape (top-pair dominates) to extract limits
- low BR but low background level

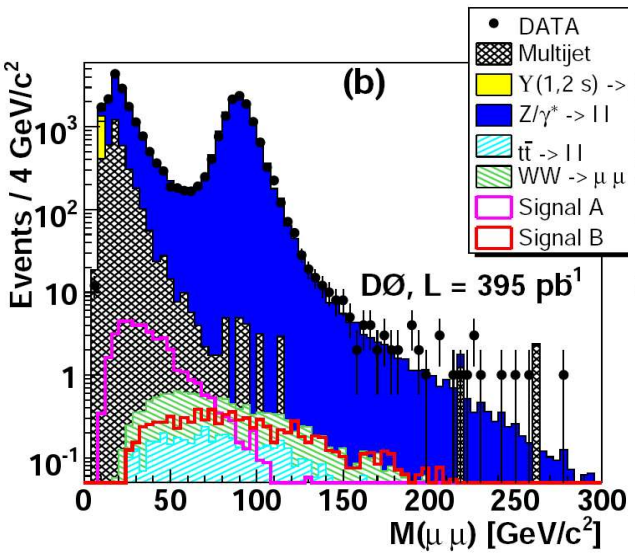
eμ channel

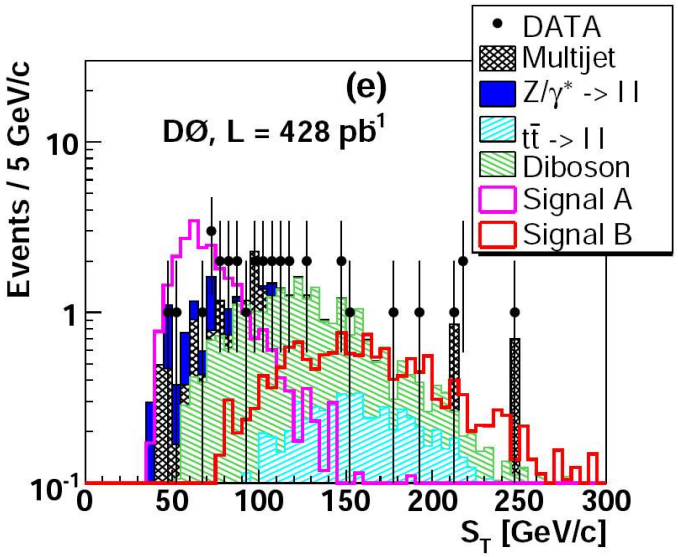
Background:

- WW, top-pairs, QCD, Z(ττ)

Selection:

- >=1 muon and >=1 electron (pT> 8,10 GeV), opposite charge, isolated, away from MET
- MET>15 GeV, M_T(μ,MET)>15 GeV
- p_T(e)+p_T(mu)+MET and HT shapes are used to extract limits





STOP :: 2 b-jets + 2 leptons + MET

Main systematics:

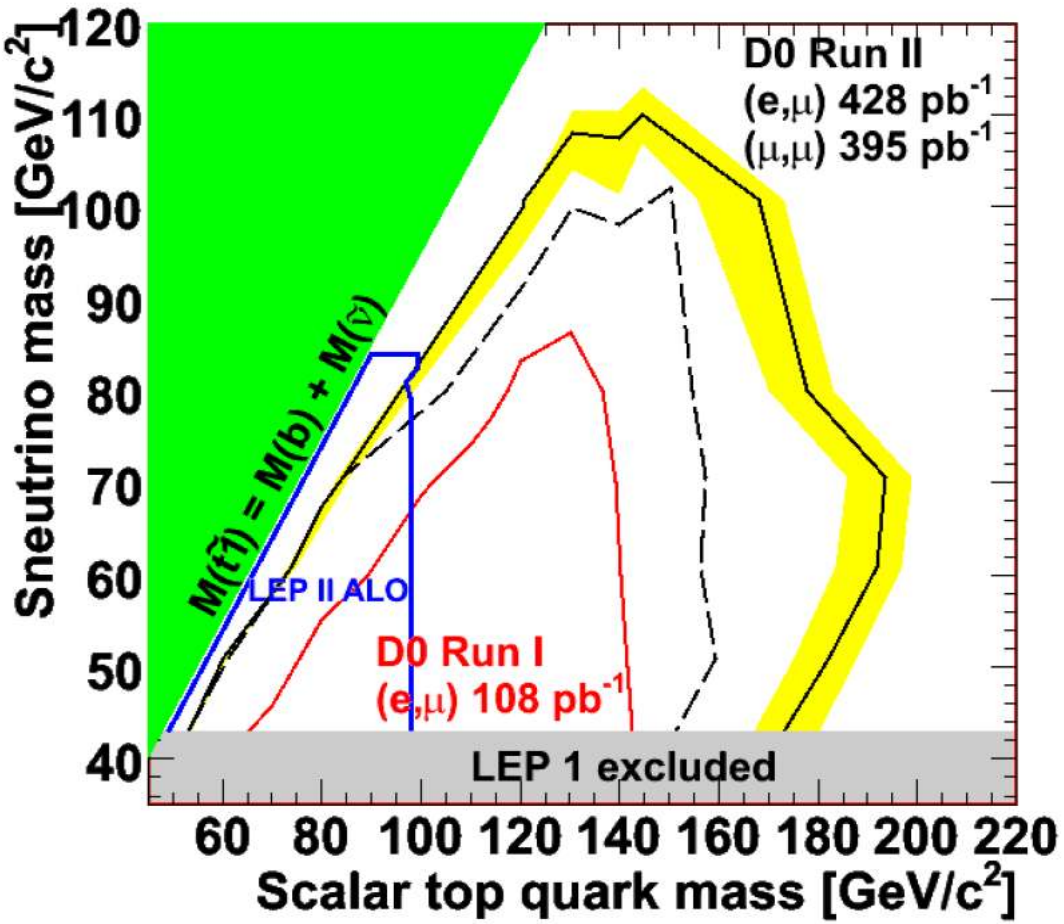
JES: 4-22%, jets ID 4-16%, b-tag: 1-11%

Channel	Total bkg	Data	(110,80)	(145,50)
eμ	37.1 +/- 2.7 +/- 1	34	26 +/- 1.5 + 0.3 – 0.0	17.3 +/- 6 0.6 +/- 0.2
μμ	2.9 +/- 0.4 +/- 0.1	1	3.1 +/- 0.2 +0.2 -0.0	3.3 +/- 0.4 +0.4 – 0.3

Combination:

- equal BR to all lepton flavours
- generic MSSM, $BR(\tilde{t} \to bl\nu\ \tilde{\chi}^0_1) = 100\%$
- large improvements over previous Run I

- largest masses excluded:
  - $m(\tilde{t}) > 186\,GeV\ for\ m(\tilde{\nu}) > 71\,GeV$
  - $m(\tilde{\nu}) > 107\,GeV\ for\ m(\tilde{t}) > 145\,GeV$



SBOTTOM :: 2 b-jets + MET

Data set:

- DØ: jets+MET, L_{int}=310 pb^{-1} [PRL 97 171806 (2006)]
- CDF: jets+MET, L_{int}=295 pb^{-1}

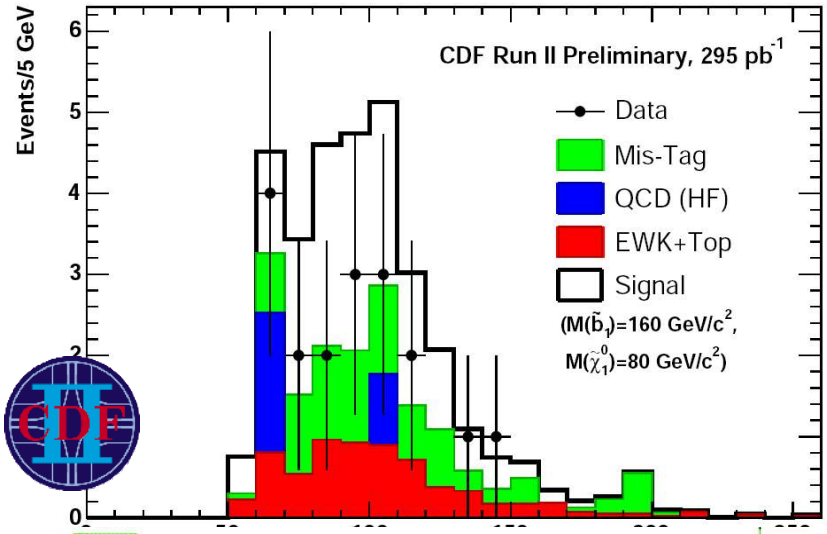
Background:

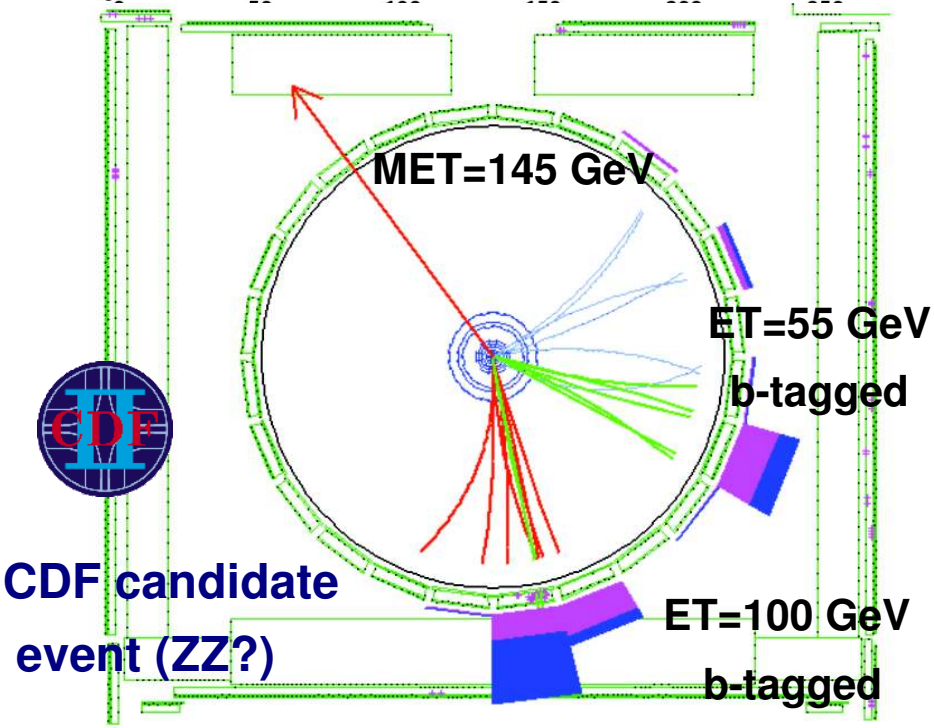
- QCD (multijets), W/Z + jets, top-pair

Selection (very similar for CDF and D0):

- high p_T jets, acoplanarity, large MET, MET and jets not aligned, leptons veto (e, mu, charged tracks), Njet=2 or 3, jets with >= 4 tracks only (CDF)
- **>=1 b-tag jet** (D0: eff. LF, c and b-jets = 0.1%, 5%, 30%; CDF: eff. c-,b-jet = 17%, 40%)
- cut values depend on sbottom mass ranges

Main systematics: b-tagging (~10%)





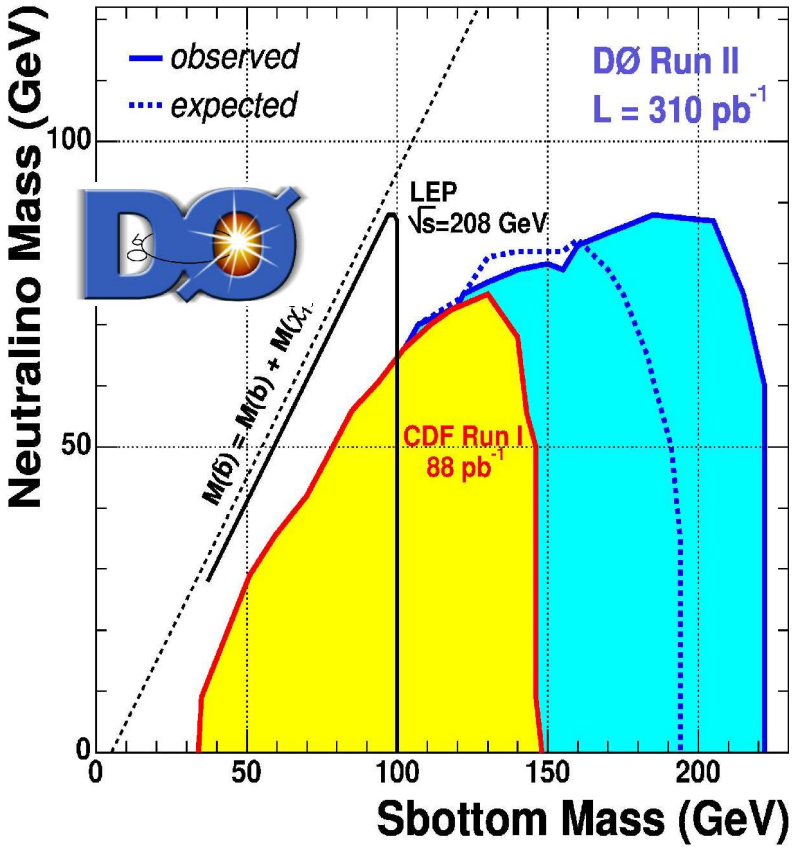
SBOTTOM :: 2 b-jets + MET

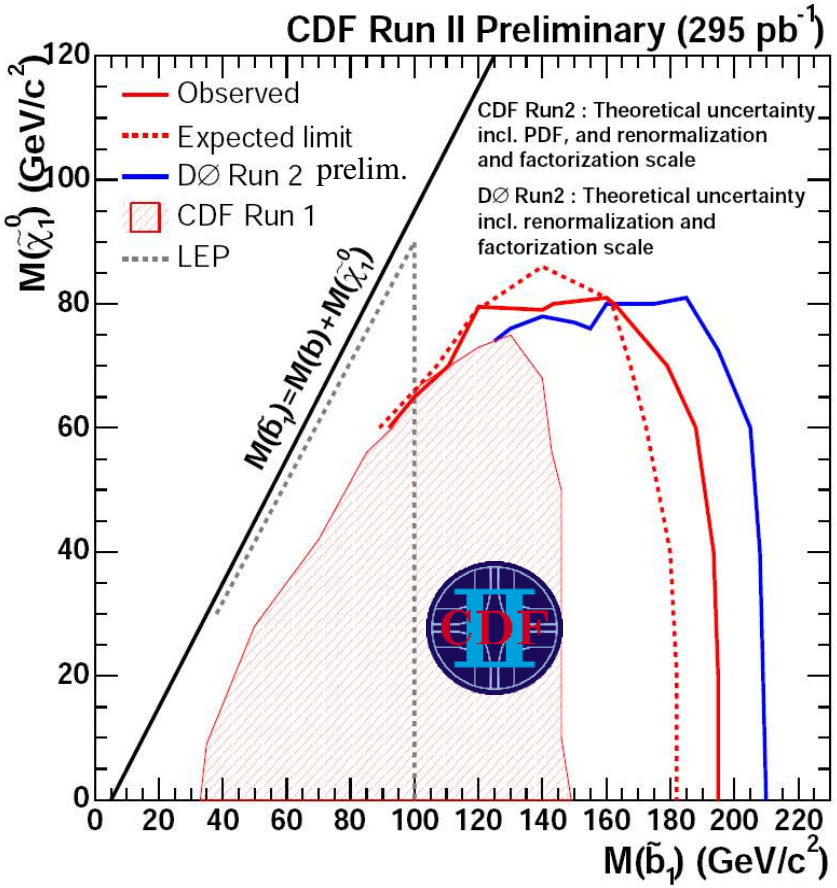
Main backgrounds:

- CDF: misidentified LF jets, QCD for low sbottom mass
- DØ: top-pair, Z(νν)+bb, Z(νν)+lf, W(τν)+lf

Results:

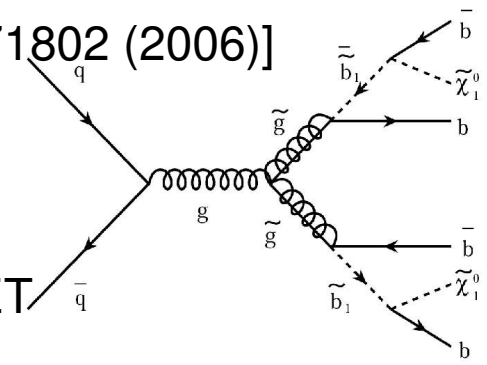
- data and SM expectations are consistent
- generic MSSM
- $BR(\tilde{b}_1 \to b\tilde{\chi}^0_1)$ =100%





GLUINOS :: 4 b-jets + MET

[PRL 96 (2006)171802 (2006)]



Data set:

- trigger jets+MET
- L_{int}=156 pb^{-1}

Background:

- top-pair, dibosons, QCD HF, W/Z+jets

Selection:

- MET>35 GeV, >= 3 jets away from MET, lepton veto
- =1 b-tag (MET>80 GeV) and >= 2 b-tag

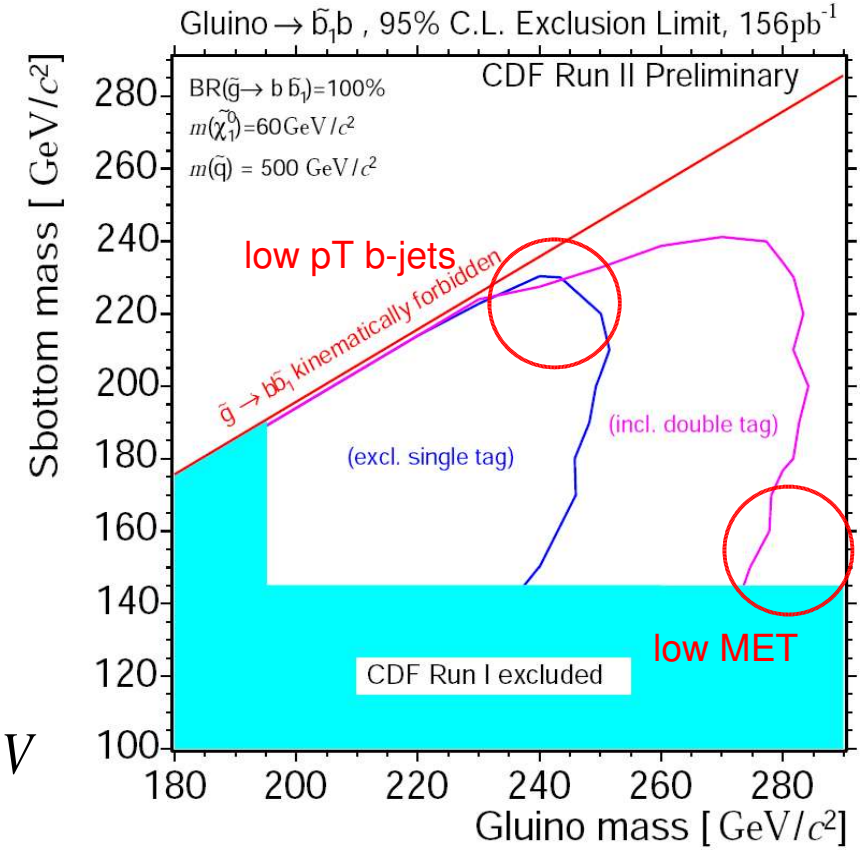
Main systematics:

- backgrounds: JES (up to 25%)
- signal: 2-tag b-tag eff. (14%), 1 b-tag JES (10%)

Results:

- better sensitivity with double tagged events
- M(χ_1^0) = 60 GeV; $m(\tilde{g})\, upto\, 280\, GeV\ for\, m(\tilde{b}) = 200\, GeV$

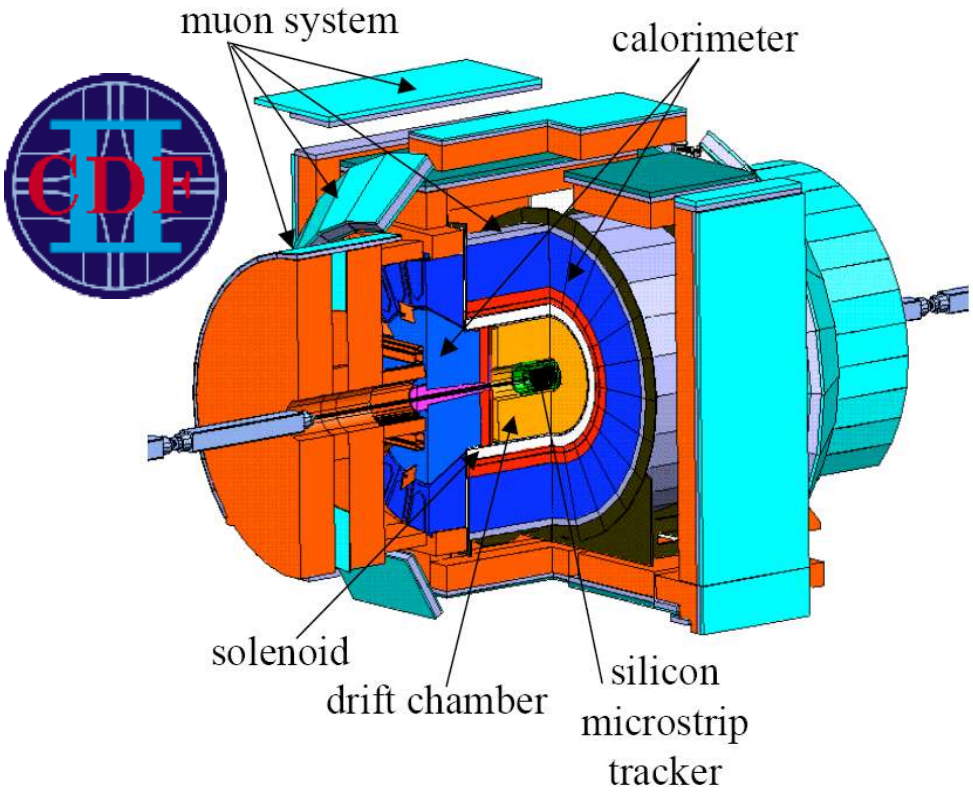
Process	Exclusive Single B-Tag	Inclusive Double B-Tag
W/Z+jets/Diboson	$5.66 \pm 0.76(stat) \pm 1.72(sys)$	$0.61 \pm 0.21(stat) \pm 0.19(sys)$
TOP	$6.18 \pm 0.12(stat) \pm 1.42(sys)$	$1.84 \pm 0.06(stat) \pm 0.46(sys)$
QCD-multijet	$4.57 \pm 1.64(stat) \pm 0.57(sys)$	$0.18 \pm 0.08(stat) \pm 0.05(sys)$
Total Predicted	$16.41 \pm 1.81(stat) \pm 3.15(sys)$	$2.63 \pm 0.23(stat) \pm 0.66(sys)$
Observed	21	4

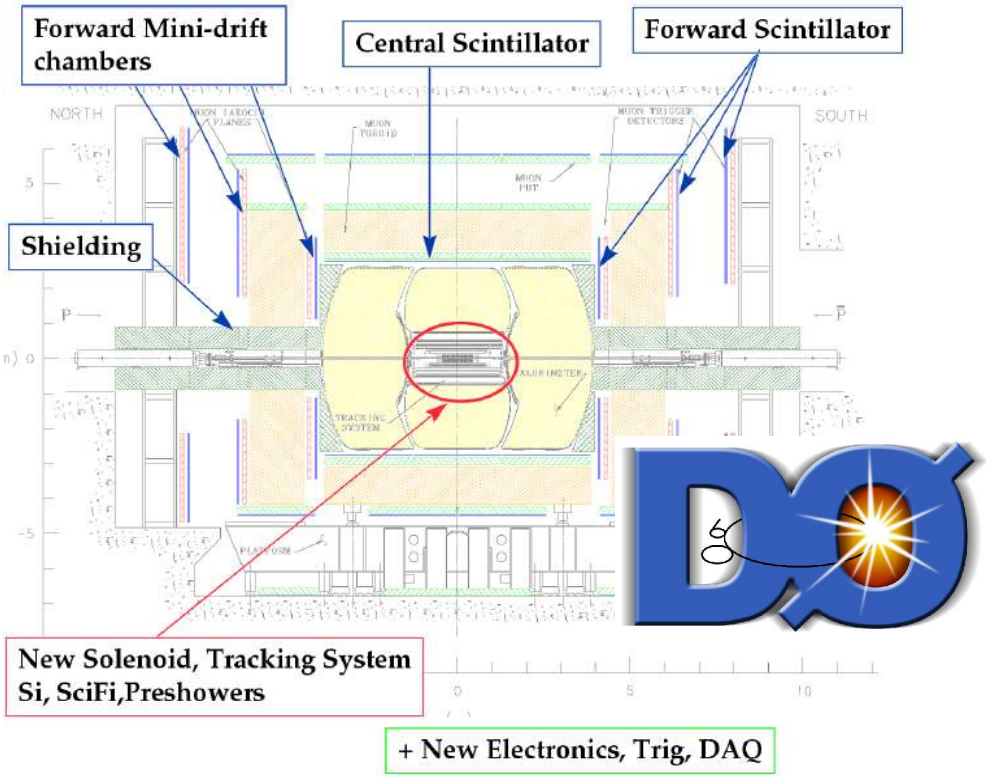


THE TEVATRON EXPERIMENTS

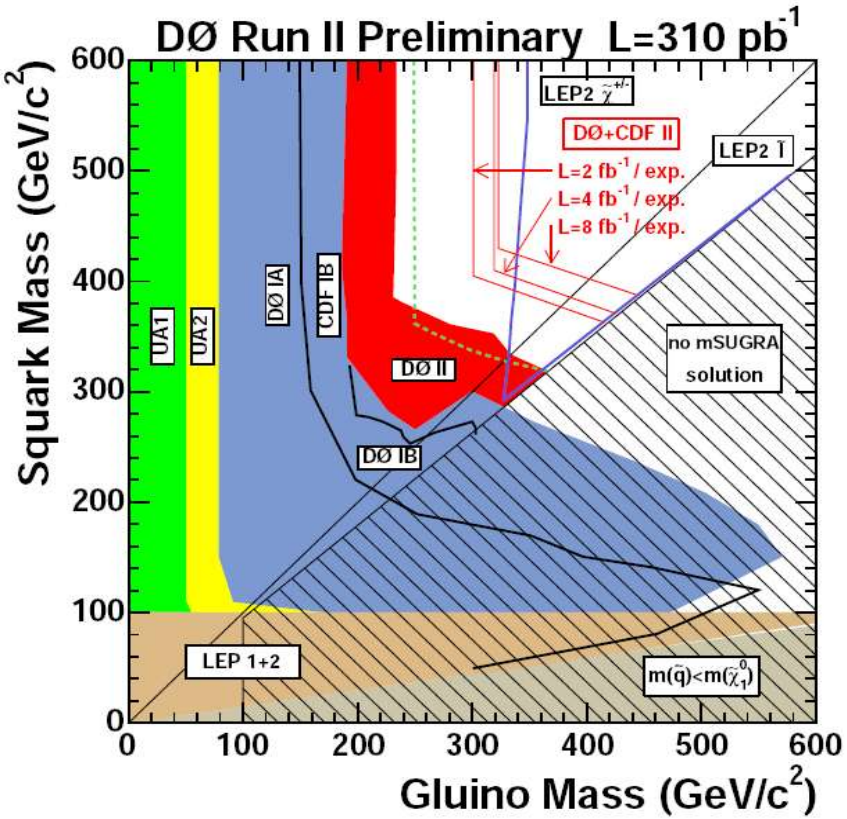
multi purpose detectors:

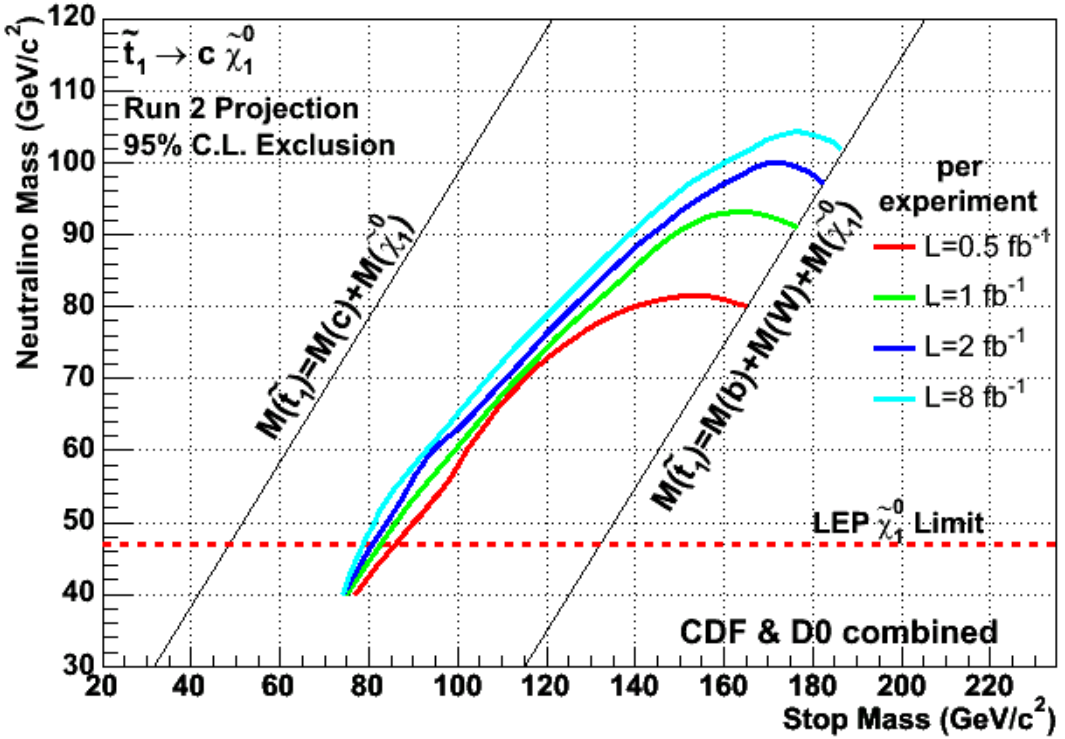
- electron, muon, tau
- jets and MET measurements
- heavy flavour tagging (displaced vertices,...)





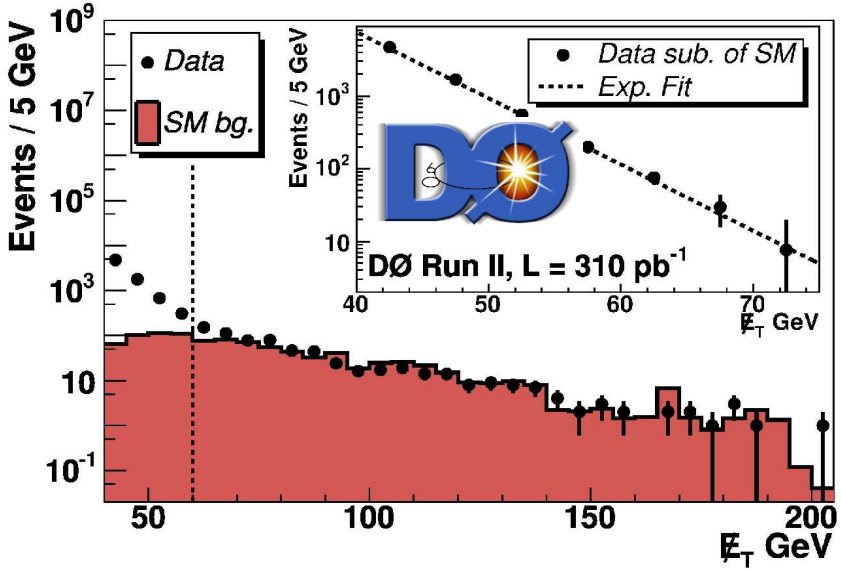
PROJECTIONS





http://www-cdf.fnal.gov/physics/projections/

SBOTTOM :: 2 b-jets + MET

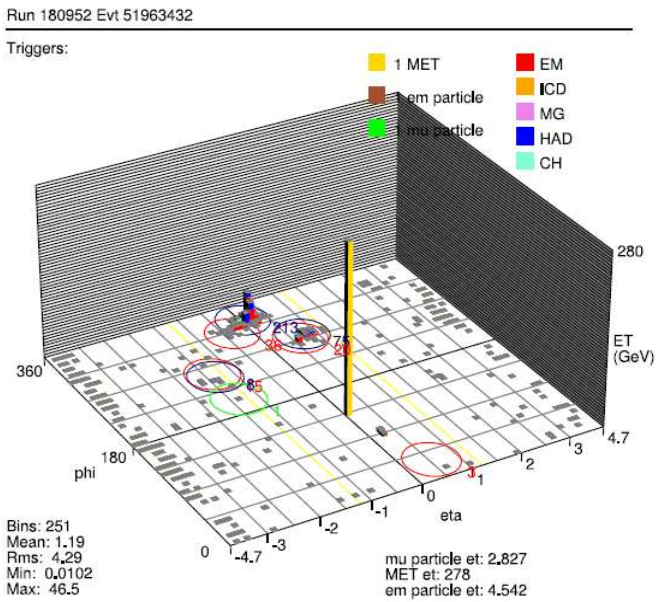


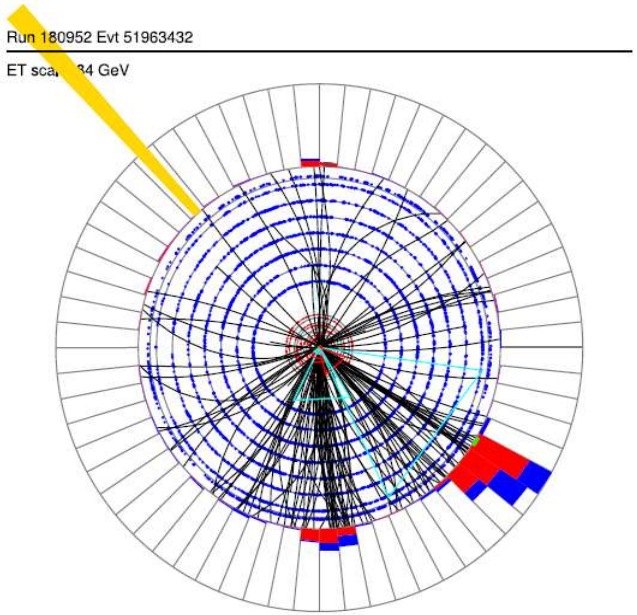
SQUARKS :: 2 jets + taus + MET

Data	2
SM predictions	1.68+/-0.24 +0.55-0.31
Signal (A)	4.73+/-0.37
Signal (B)	7.08+/-0.57

candidate event

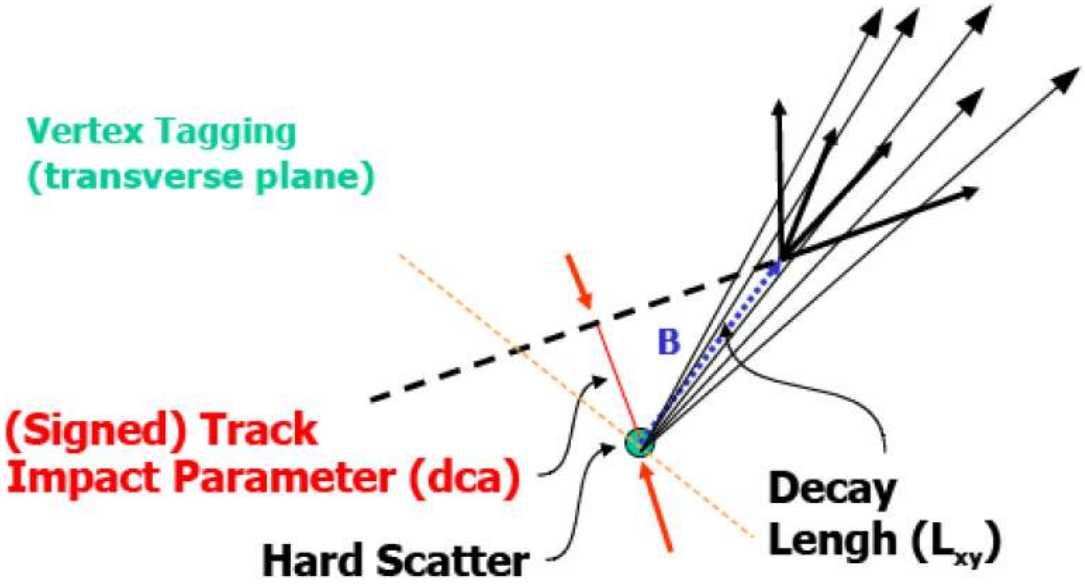
of highest MET

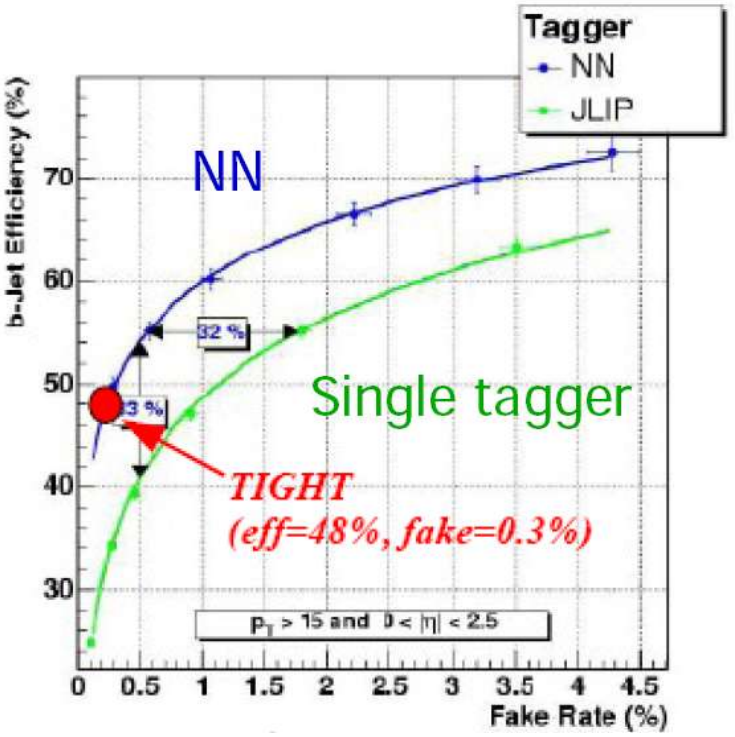




Object	E_T	η	ϕ
Jet 1	265.9	-0.207	5.66
Jet 2	105.9	0.539	4.77
Jet 3	14.75	-1.54	4.30
Tau 1 (type: 3)	15.05	-0.095	1.58
H_T	386.5		
$JJTH_T$	386.8		
MET	353.1		
EM particle	14.5	-0.050	1.54

b jet tagging

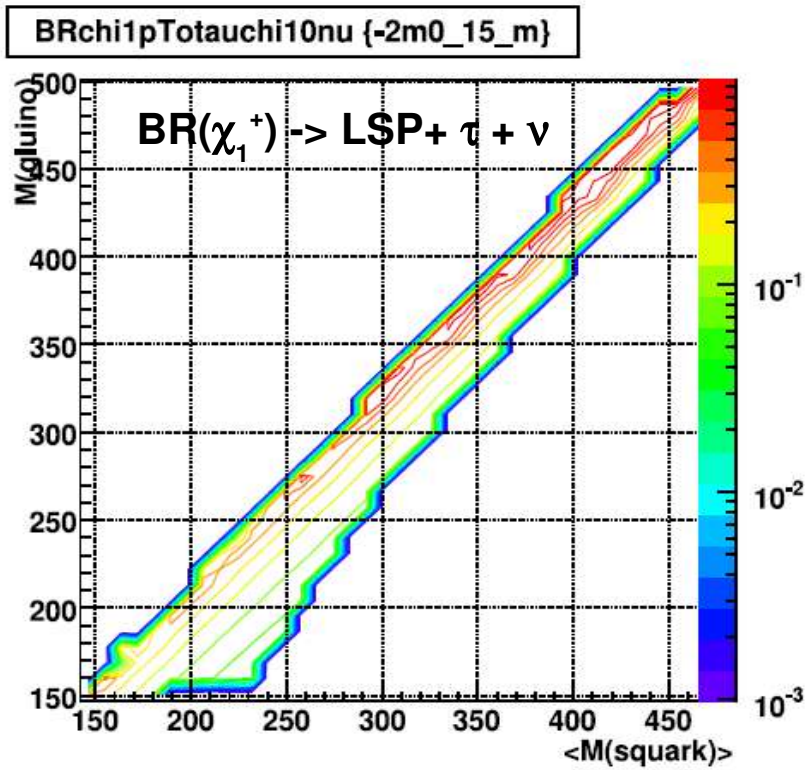




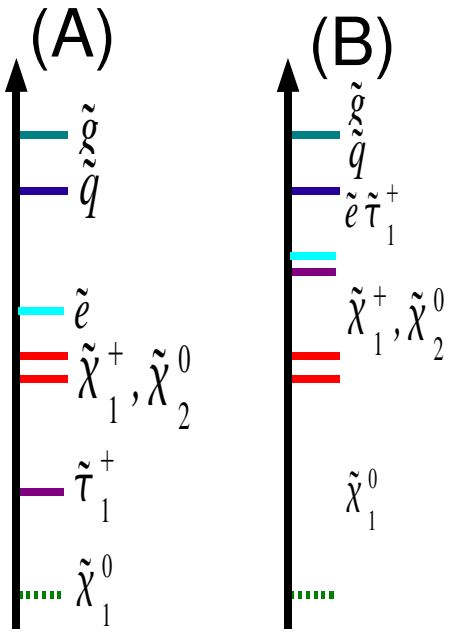
- several mature algorithms:
  - soft lepton tagging
  - impact parameter based
  - secondary vertex reconstruction

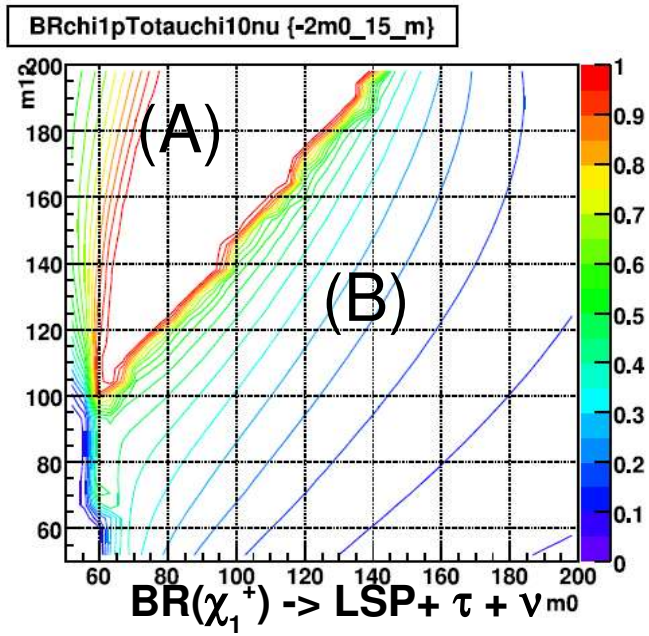
combined in a NN

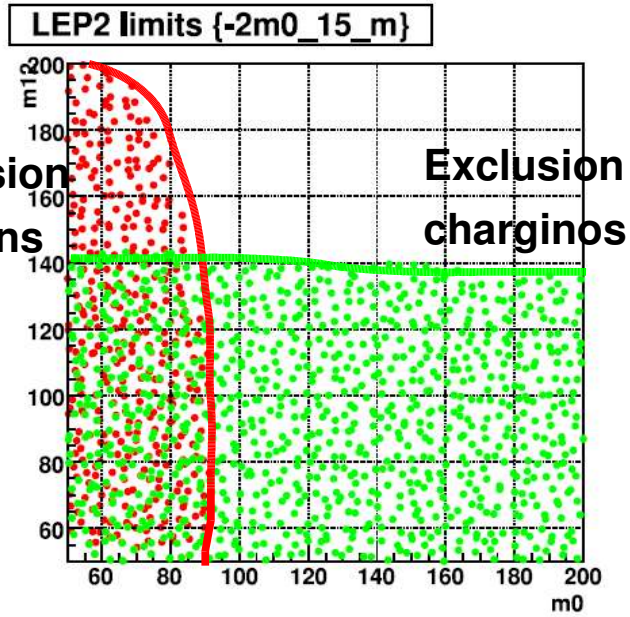
tau corridor



the « tau corridor »







Exclusion sleptons

Exclusion charginos

LEP2 limits :

- selectron: 100 GeV
- smuon : 97 GeV
- stau : 93 GeV
- chargino : 103 GeV

squarks and gluinos in Jets + MET