Searches in Lepton Final States

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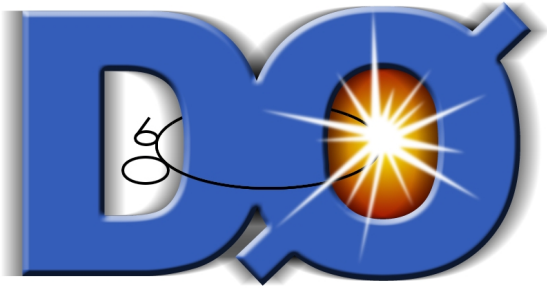
Rutgers University

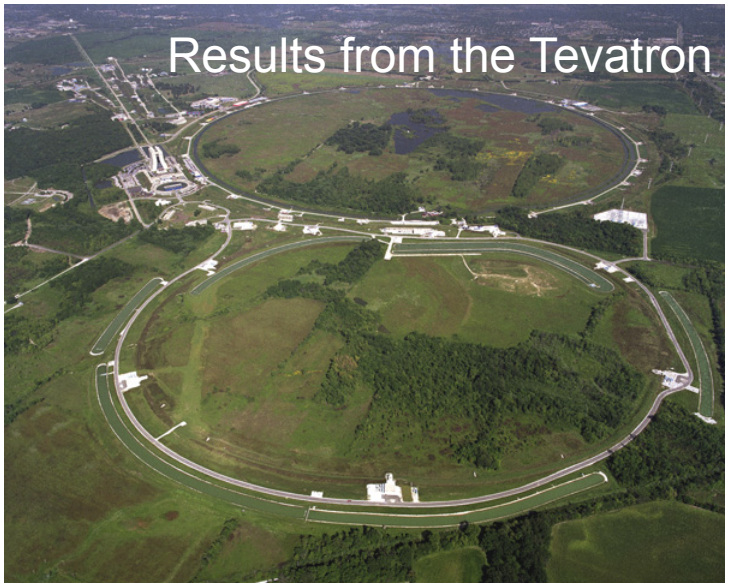
For the CDF and DØ collaborations

Rencontres de Moriond EW 2008

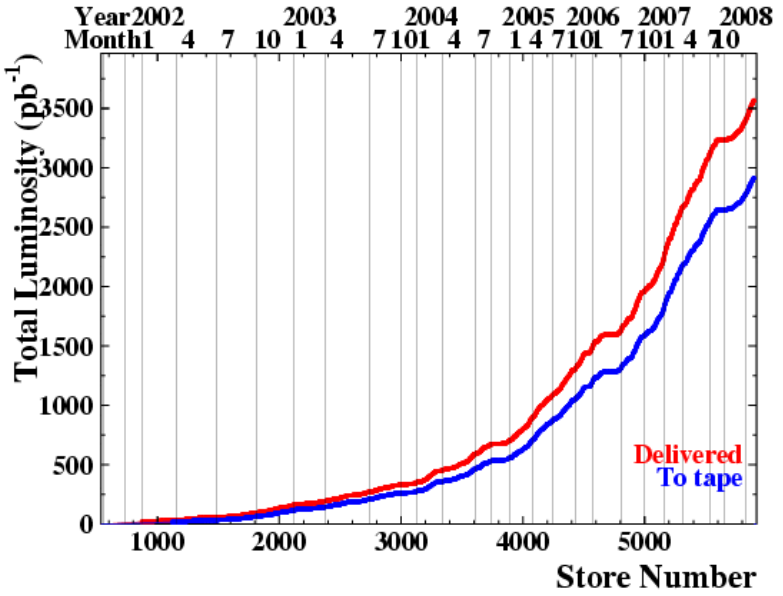
La Thuile, 1-8 March 2008



Outline

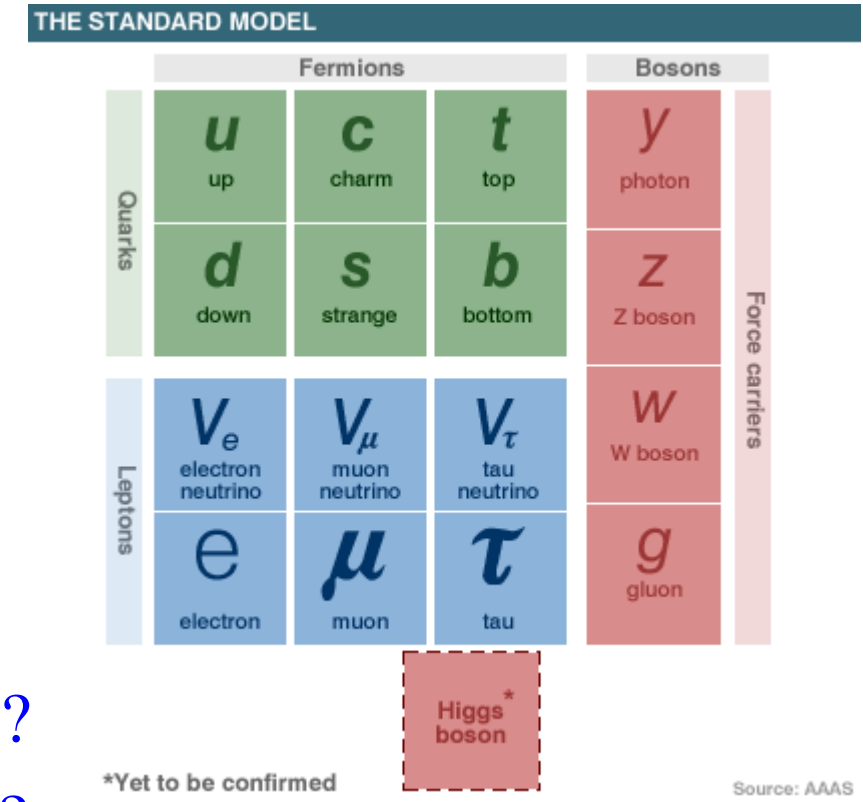


- Introduction
- Susy Searches
- Non-Susy Searches
- Conclusions



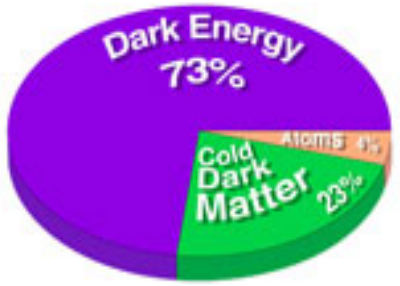
Beyond the Standard Model

The Standard Model has been tested with high precision.



BUT,

- Including gravity ?
- Explaining Dark Matter/Dark Energy ?
- Why three generations, 19 parameters?
- Understanding matter-antimatter asymmetry
- What about the hierarchy problem ?

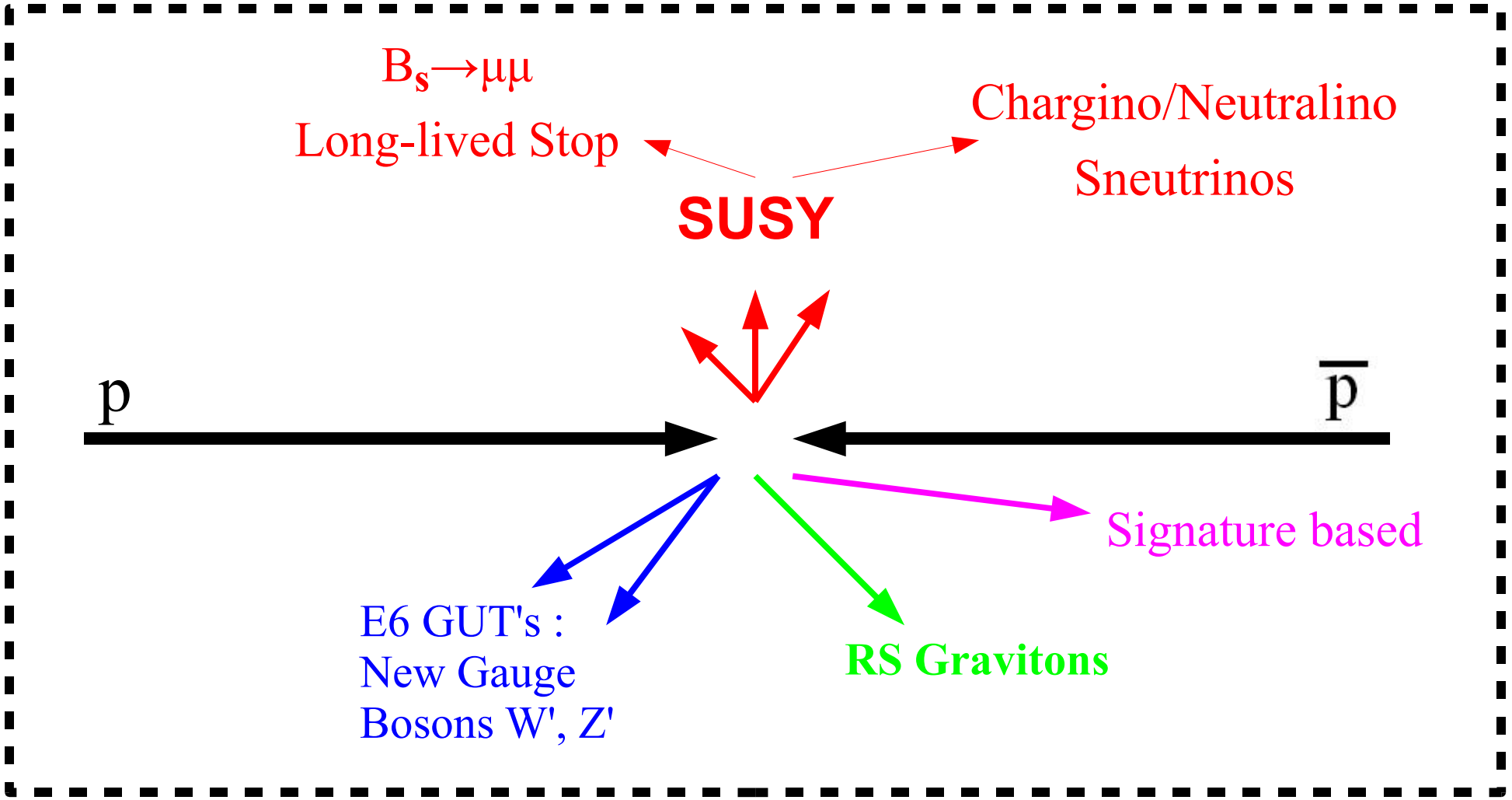


Beyond the Standard Model with Leptons

Clean Signatures

Low Backgrounds

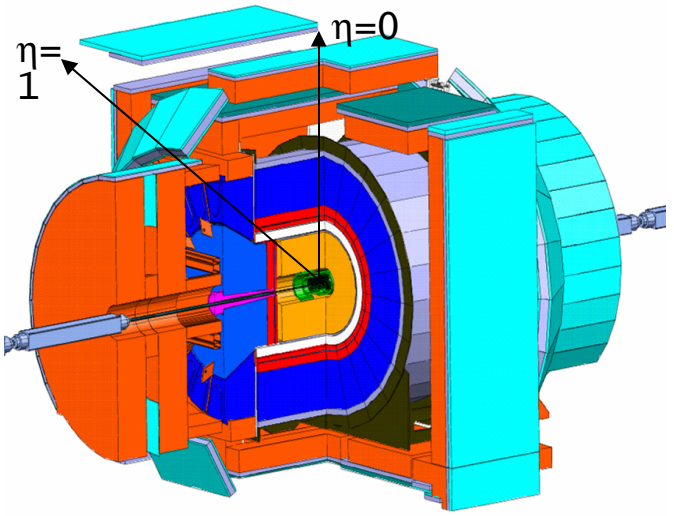
Many Models

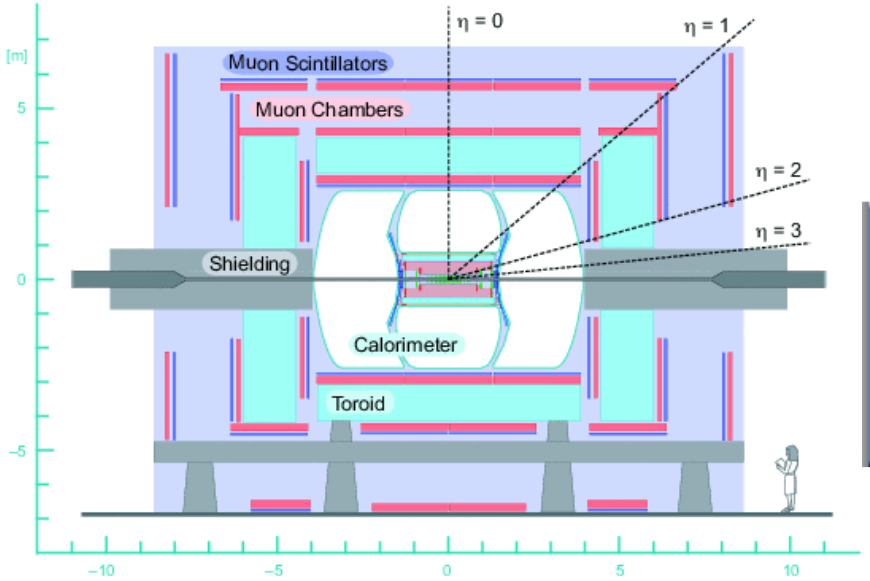


Detectors : CDF & DØ

Multipurpose detectors :

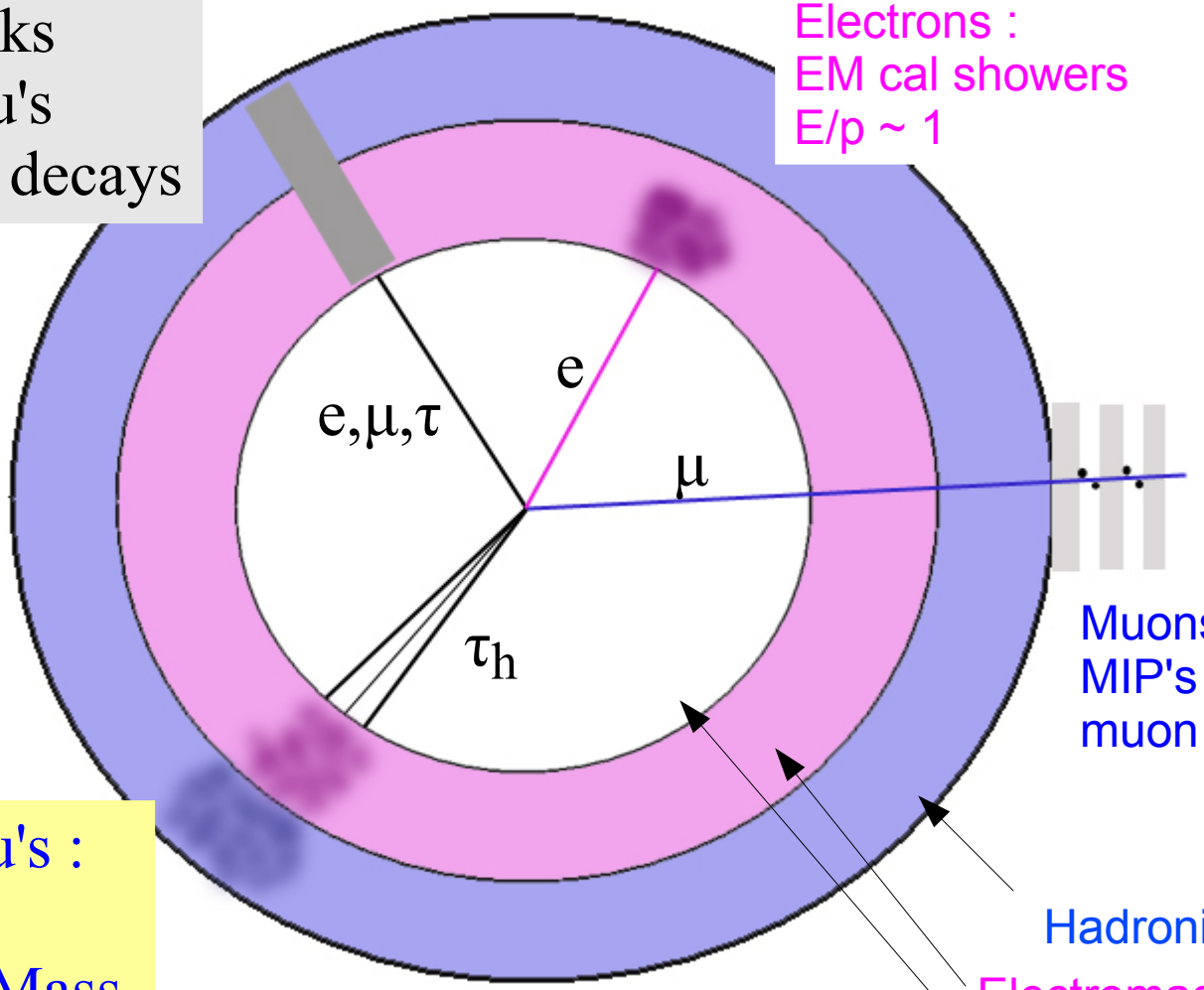
- Central Tracker
- Electromagnetic (EM)
  & Hadronic (Had) Calorimeters
- Muon Systems





Identifying Leptons

Isolated tracks
proxy for tau's
'single-prong' tau decays



Electrons :
EM cal showers
E/p ~ 1

Muons :
MIP's , signal in
muon systems

Reconstructed tau's :
Narrow jets
Correct invariant Mass

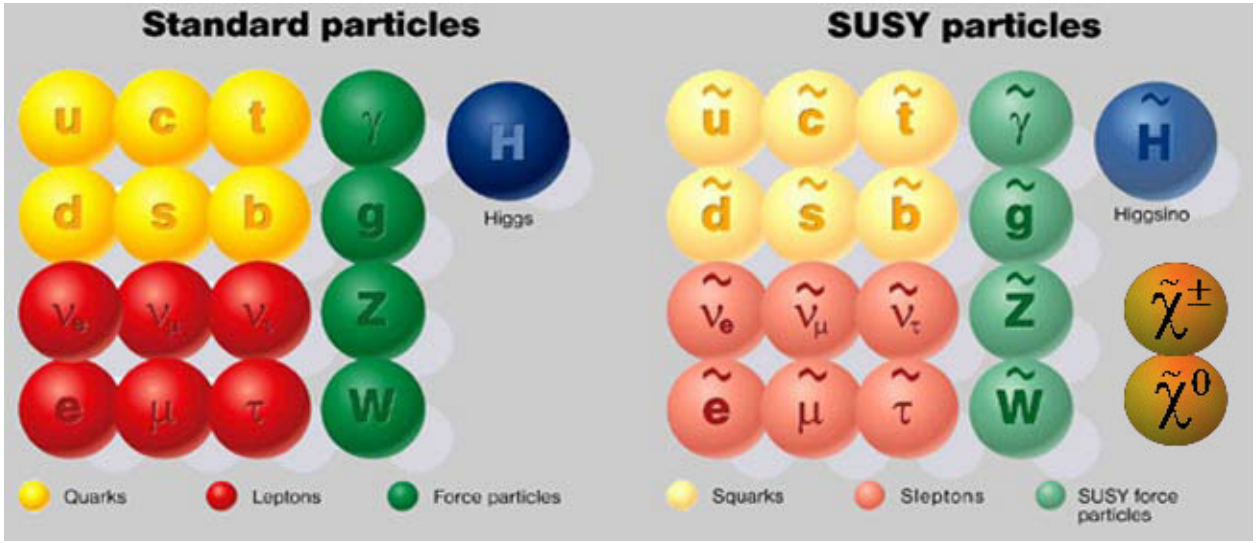
Hadronic calorimeter

Electromagnetic calorimeter

Central Tracker

Supersymmetry

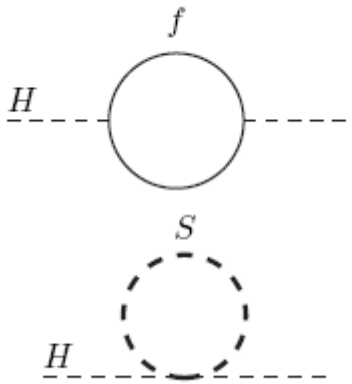
Proposes a new symmetry
Fermions ↔ Bosons



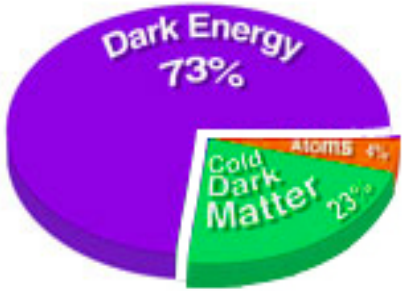
R-parity can be conserved or not!

$R_p = -1^{B+ L+ 2s}$

Solves the hierarchy problem

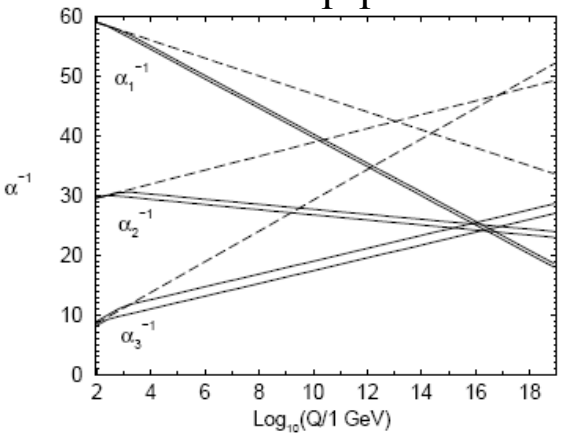


Possibly a dark matter candidate, if R_p conserved



Unifies gauge couplings

hep-ph/9709356



Search for Chargino-Neutralino

Pair production of Chargino, Neutralino & subsequent decay to leptons

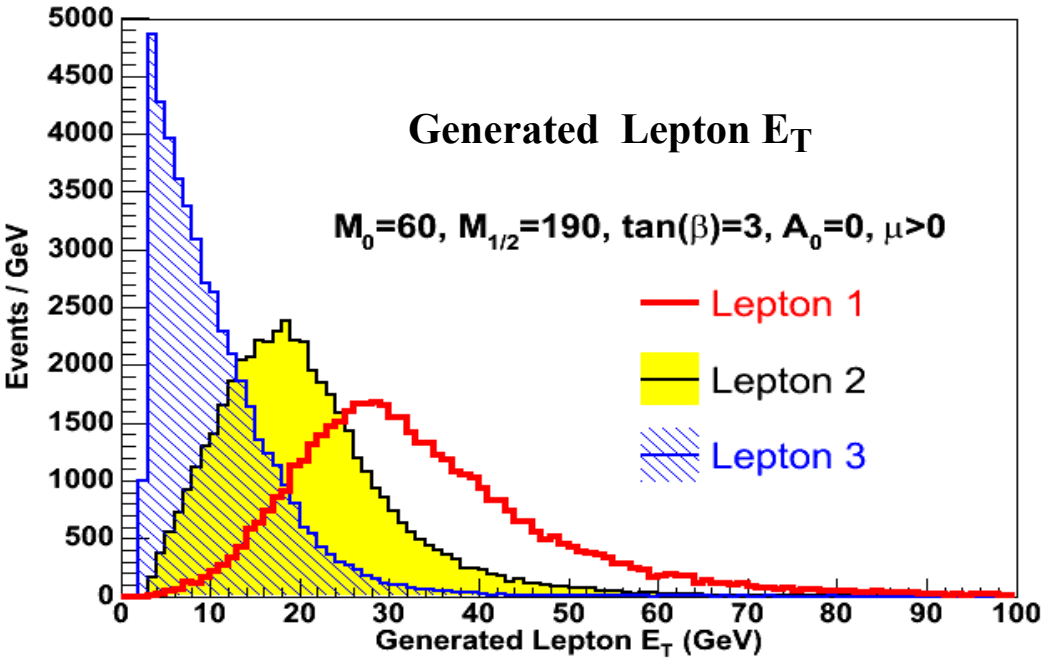
R_p is conserved

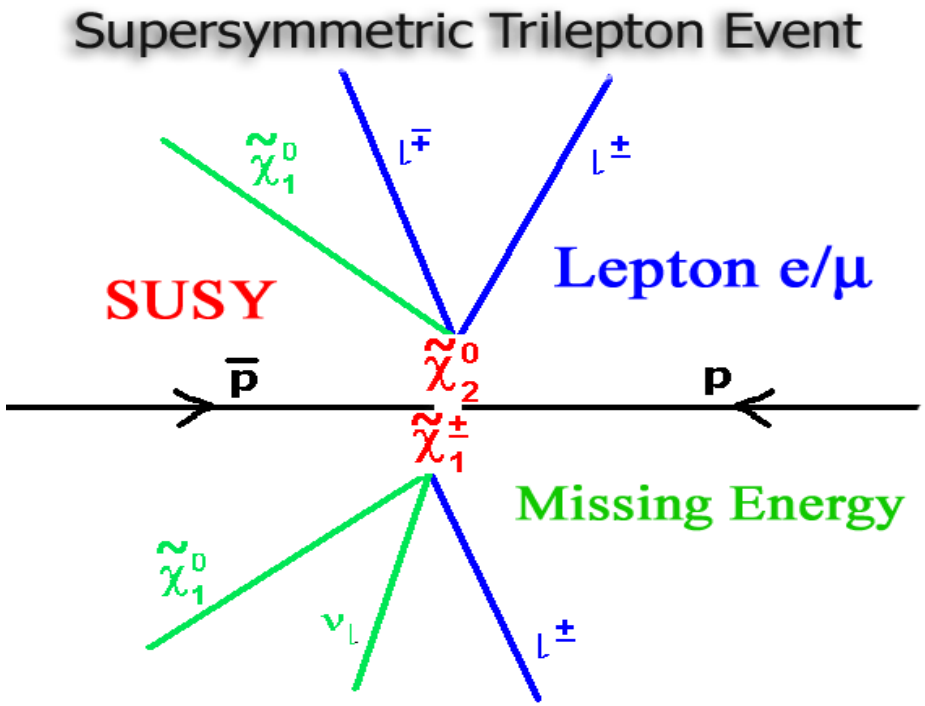
Three leptons + MET

Electrons

Muons

Isolated Tracks





Distinctive signature with Low SM backgrounds

Search for Chargino-Neutralino

Exclusive channels ordered by signal purity

Find three tight leptons

Else, two tight leptons(t) and a loose lepton(l).

Else, one tight and two loose leptons.

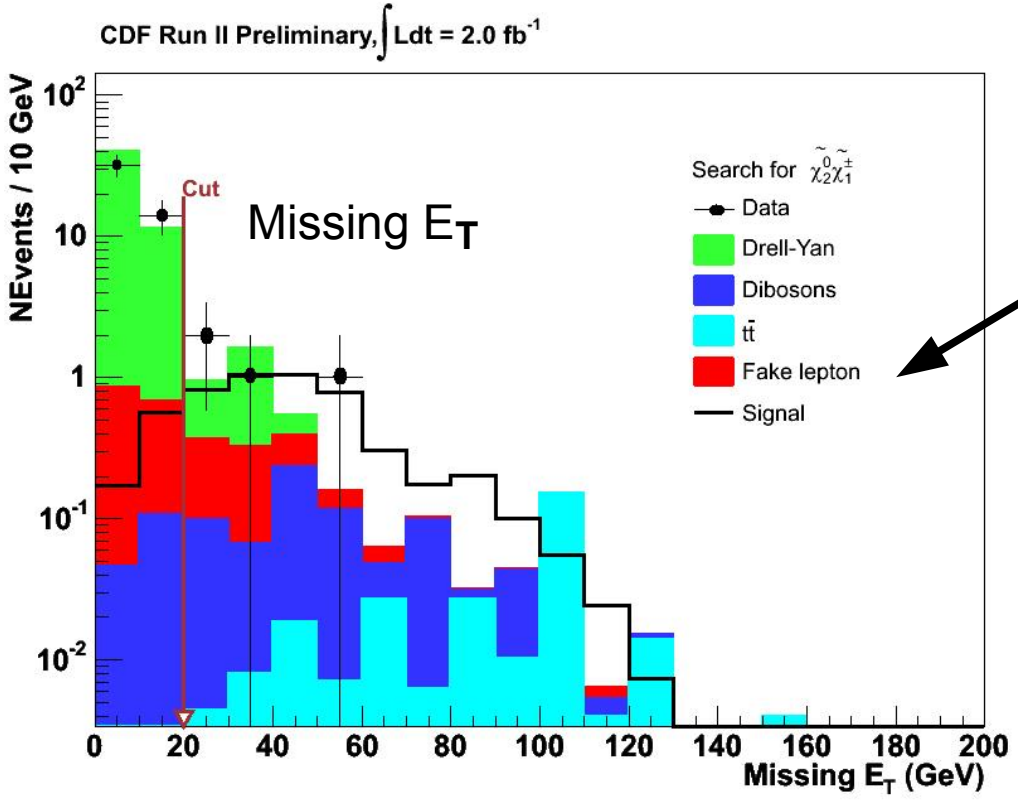
Else, two tight leptons and one track(T).

Else, one tight, one loose lepton and one track.

Lepton E_T requirements 15, 5, 5 GeV

NEW **L = 2.0 fb^{-1}**

Channel	Signal	Bkgd	Data
ttt	2.3±0.3	0.5±0.1	1
ttl	1.6±0.2	0.3±0.04	0
tll	0.7±0.1	0.1±0.03	0
3 leptons	4.6±0.6	0.9±0.2	1
ttT	4.4±0.6	3.2±0.7	4
tlT	2.4±0.3	2.3±0.6	2
2 leptons + Track	6.8±0.9	5.5±1.1	6

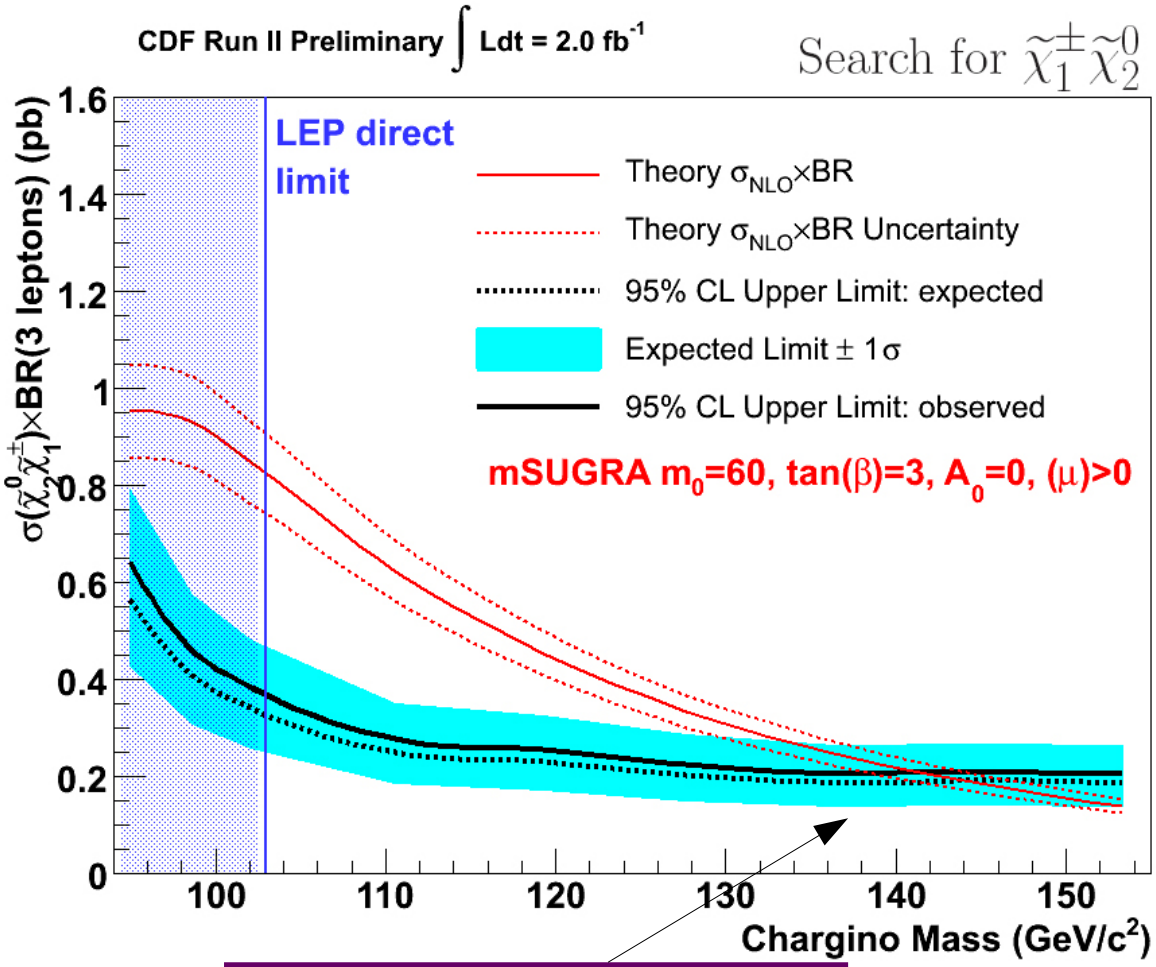


Signal mSUGRA with parameters
m_0=60, $m_{1/2}$=190, tan(β)=3, A_0=0, μ >0

Search for Chargino-Neutralino

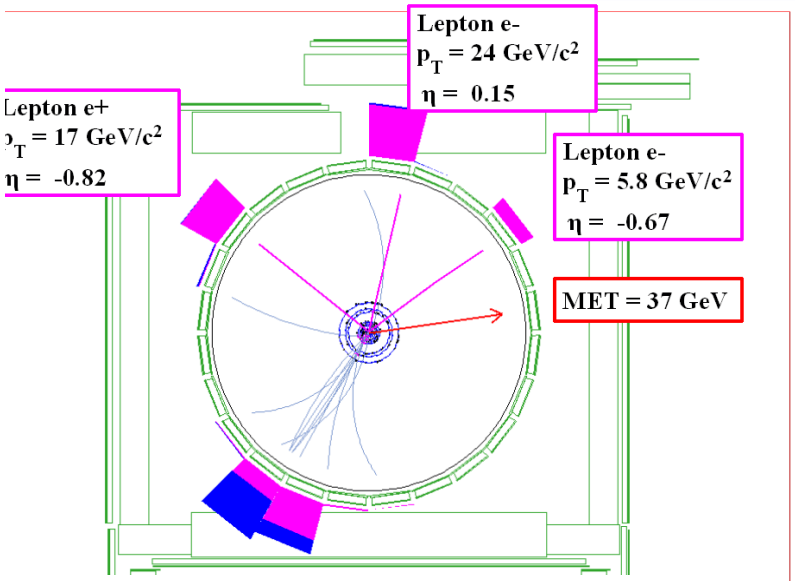
First Chargino Mass Limit in mSUGRA scenario at Tevatron !

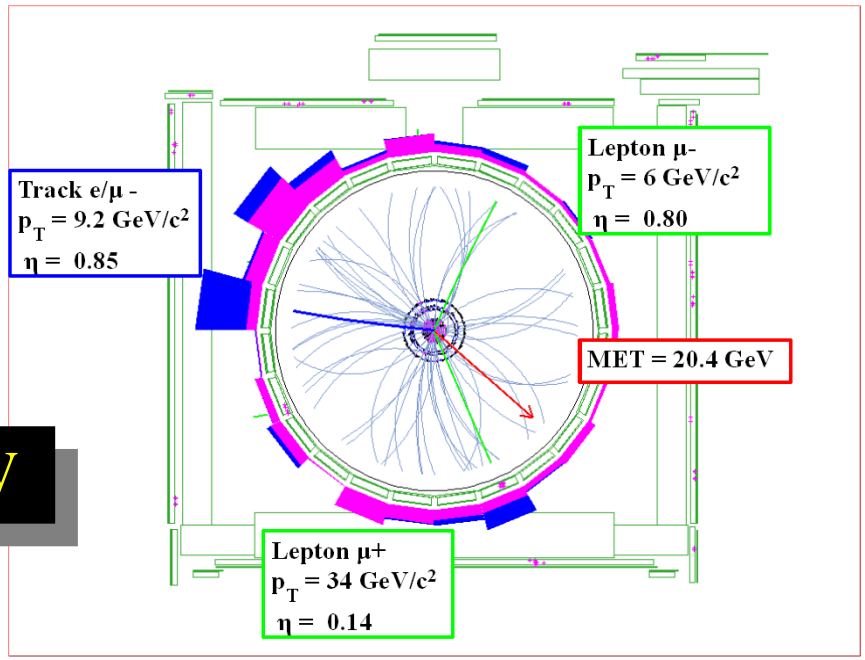
L = 2.0 fb^{-1}



We exclude Charginos with mass < 140 GeV/c^2

NEW





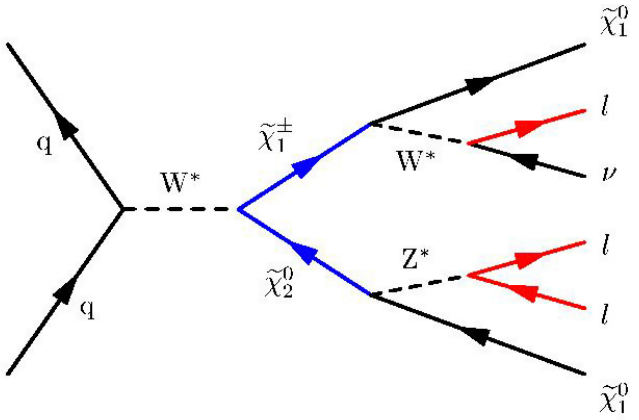
Search for Chargino-Neutralino

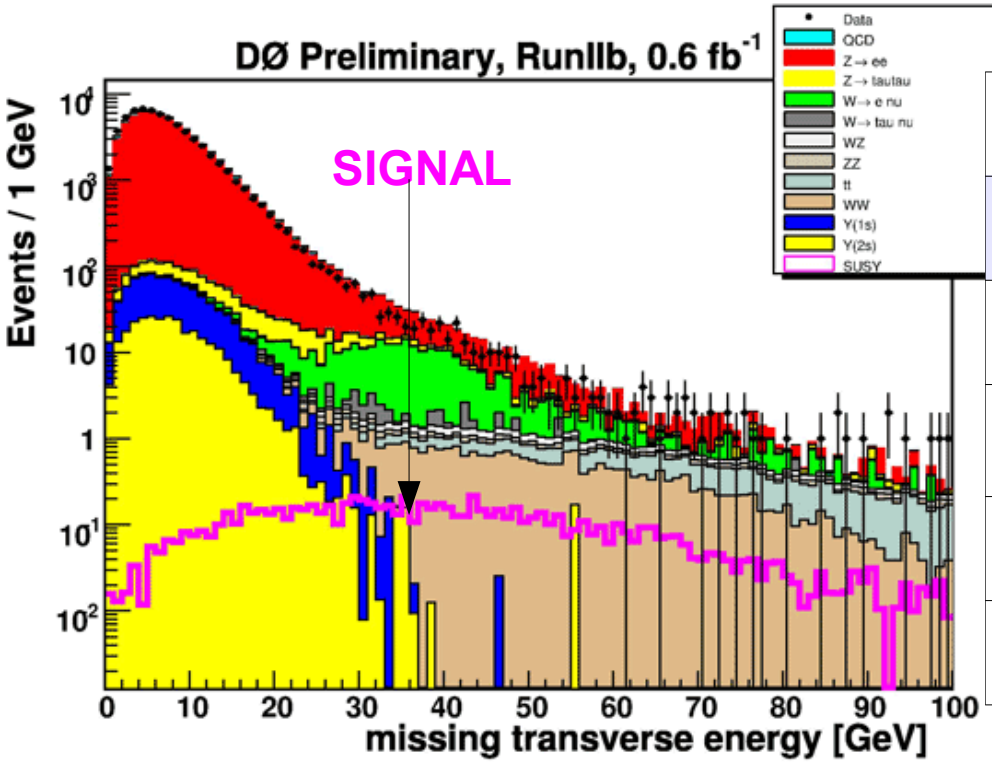
Chargino-Neutralino decaying to leptons as before....

Searches in analysis channels by lepton flavors

ee + Track, μμ + Track, eμ + Track with 1.1 fb^{-1}

ee + Track updated to 1.7 fb^{-1} ⟷ **NEW**



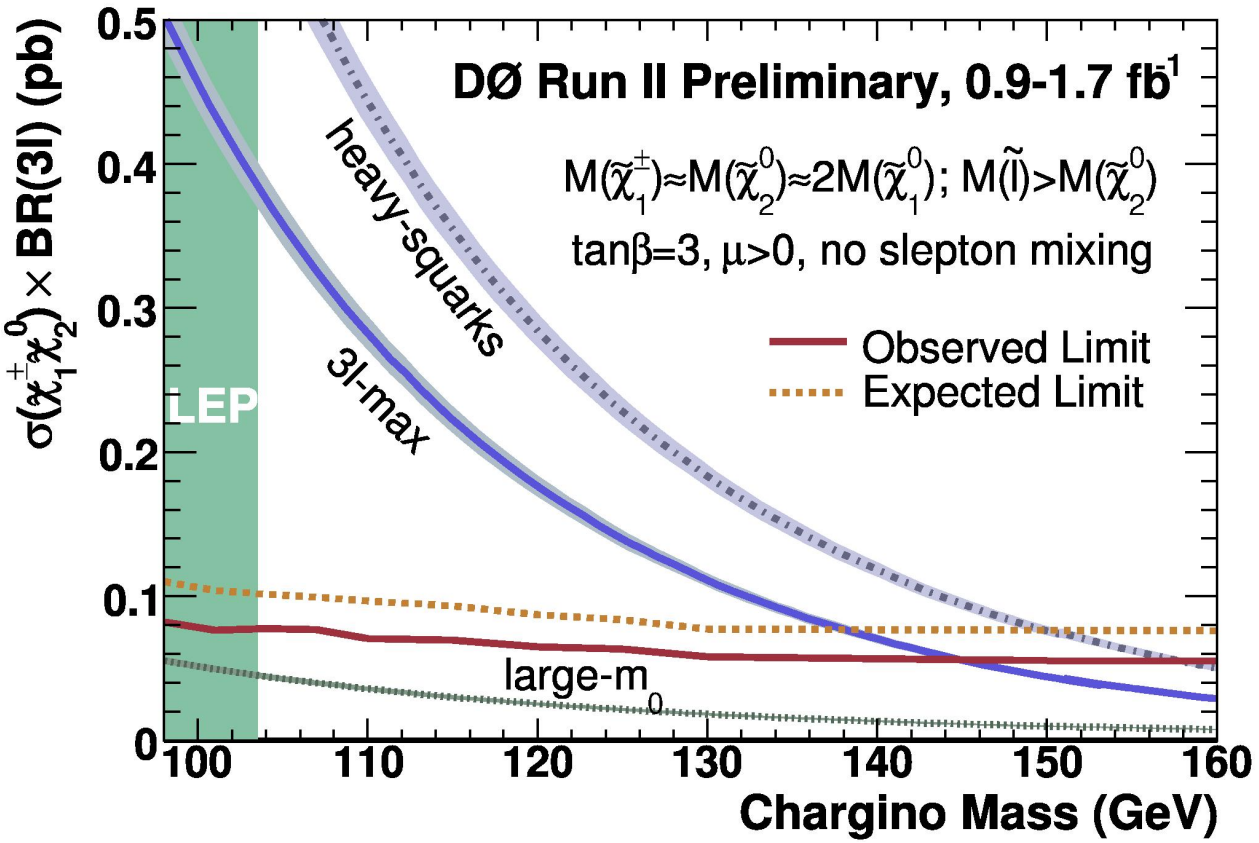


Channel	Signal	Background	Observed
ee + T	0.5-2.1	1.0±0.3	0
ee + T	1.7-4.7	0.8±0.7	0
μμ + T	0.5-2.5	$0.3\pm^{1.3}_{0.3}$	2
eμ + T	2.0-2.6	0.9±0.4	0
$\mu^{\pm}\mu^{\pm}$	0.6-3.8	1.1±0.4	1

Signal mSUGRA no slepton mixing
m_0=88-121, $m_{1/2}$=182-221, tan(β)=3, A_0=0, μ >0

Search for Chargino-Neutralino

No slepton-mixing scenario : Most stringent limits !



3l-max :
M(slepton)>M(chargino)

Large-m_0 :
W/Z exchange dominates

heavy-squarks :
maximal cross-section

Chargino mass excluded below 145 GeV/c^2 in 3l-max model

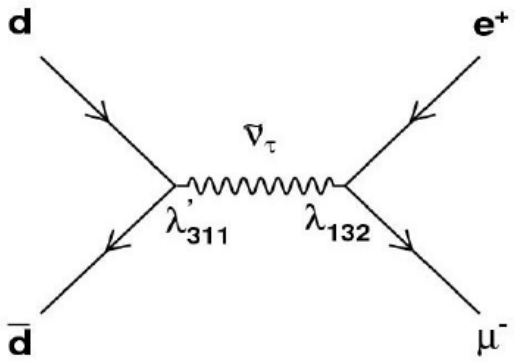
arXiv:0711.3207

Search for tau sneutrino

L = 1.0 fb^{-1}

Hunt for mass bump in opp-charged eμ mass, $M_{e\mu}$

R_p not conserved



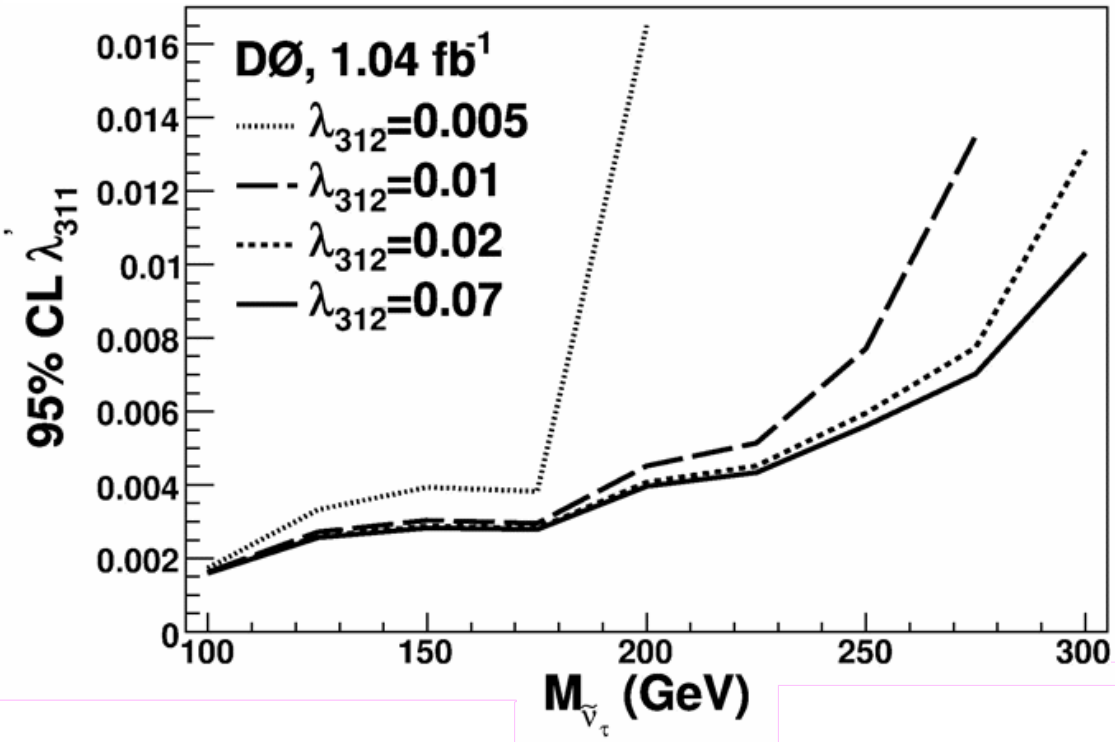
$\tilde{\nu}_\tau$ is LSP

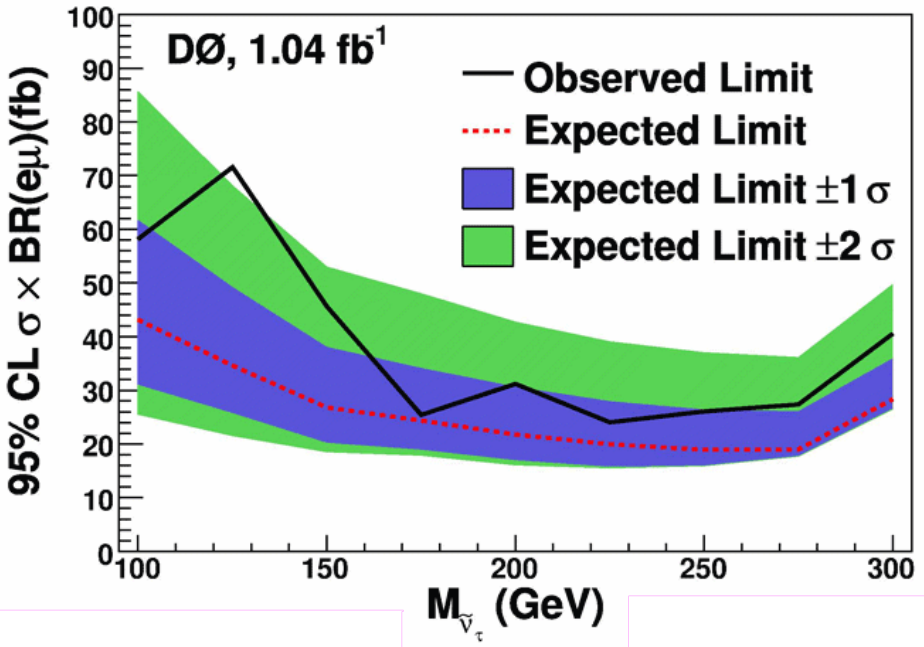
$\lambda'_{311}, \lambda_{132} \neq 0$

Electron E_T > 30 GeV

Muon p_T > 25 GeV/c

SM Background	Data
$Z/\gamma^* \rightarrow \tau\tau$	42.9 ± 4.2
WW	13.7 ± 1.5
t-tbar	1.4 ± 0.3
WZ	1.2 ± 0.2
Total background	**59.2 ± 5.3**
Data	68



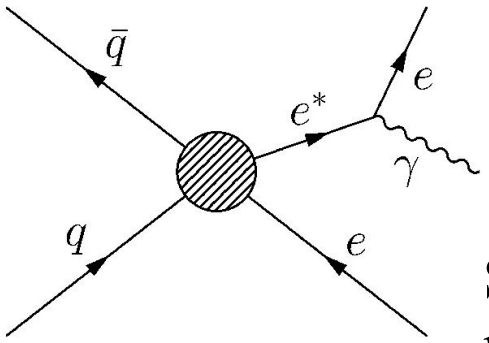


Non-SUSY Searches

Excited Electrons e*

L = 1.0 fb^{-1}

arXiv:/0801.0877



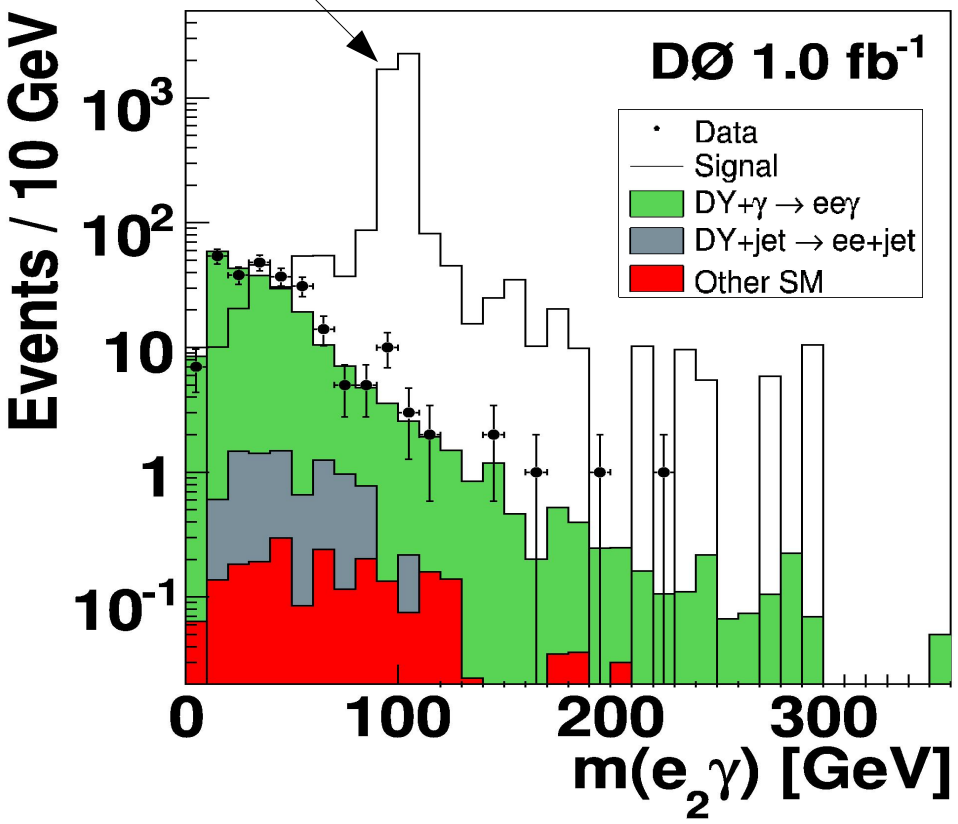
Electrons $E_T > 25, 15$ GeV
Photon $E_T > 15$ GeV

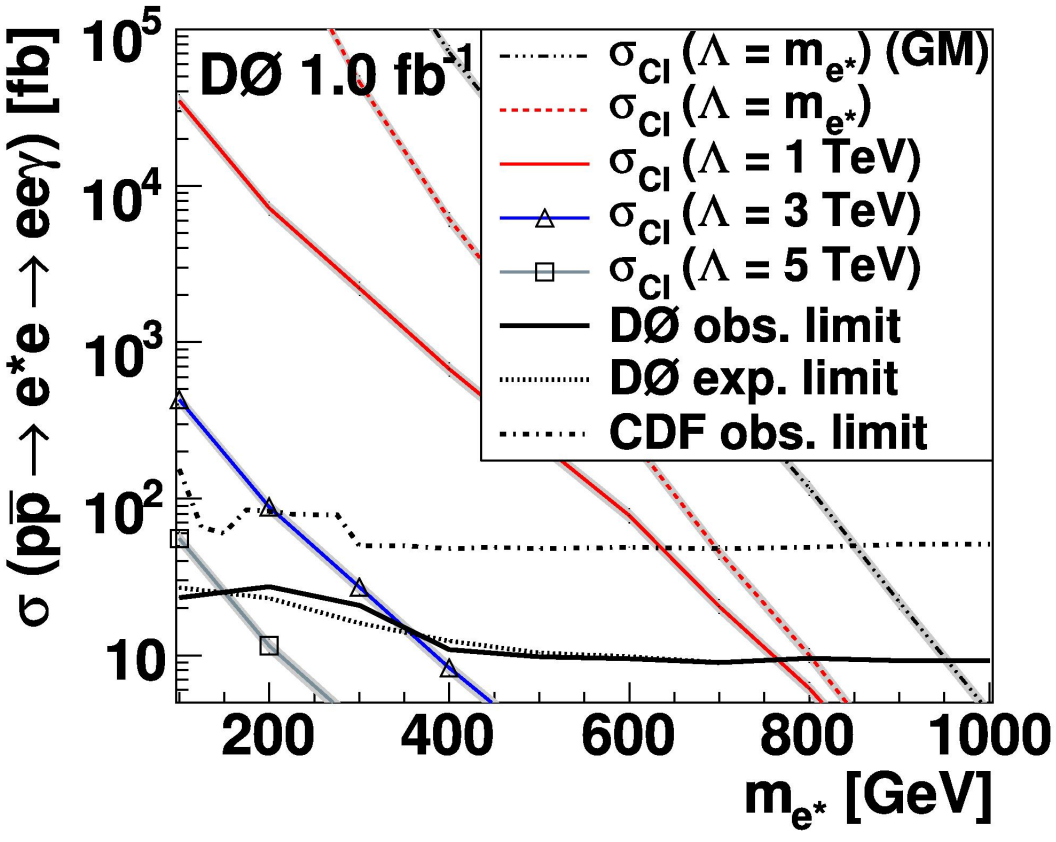
Compositeness could explain fermion mass hierarchy

Selection optimized for e* mass using $\Delta R_{e\gamma}$ and $M_{e\gamma}$

$M(e^*) > 756$ GeV/c^2 for $\Lambda = 1$ TeV

M_{e^*}=100GeV





New Gauge Bosons - Z'

L = 2.5 fb^{-1}

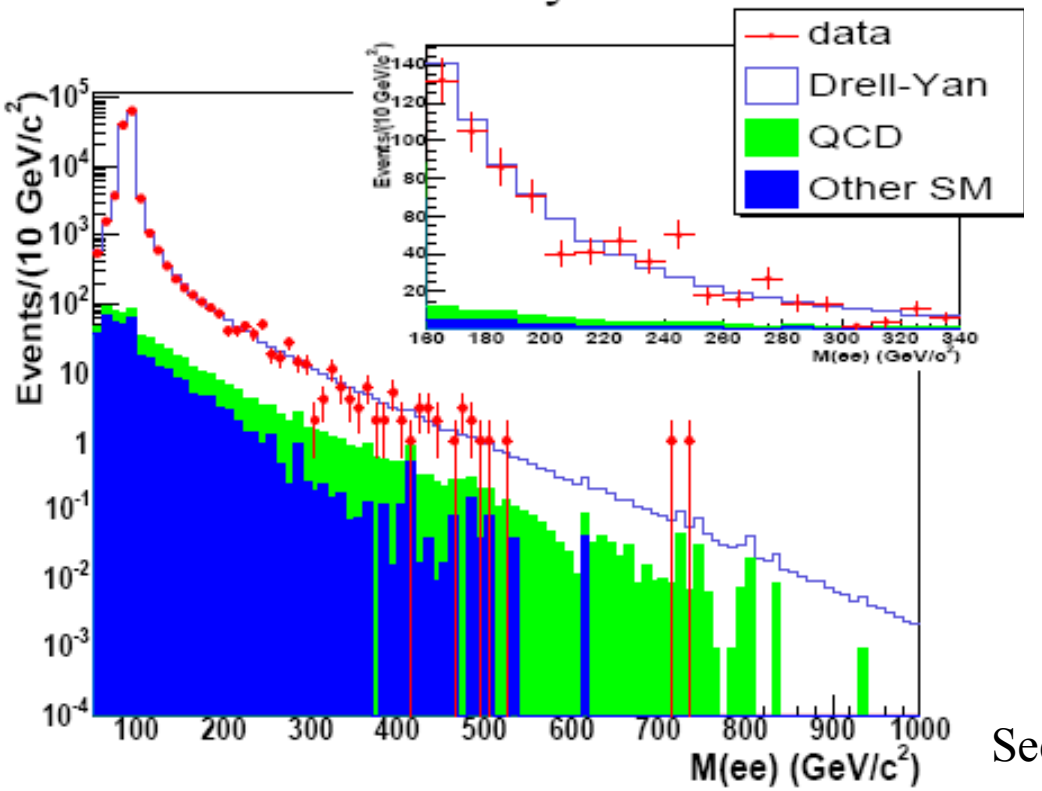
NEW

Search for narrow resonance in dielectron mass spectrum
$150 < M_{ee}$ (GeV/c^2) < 1050

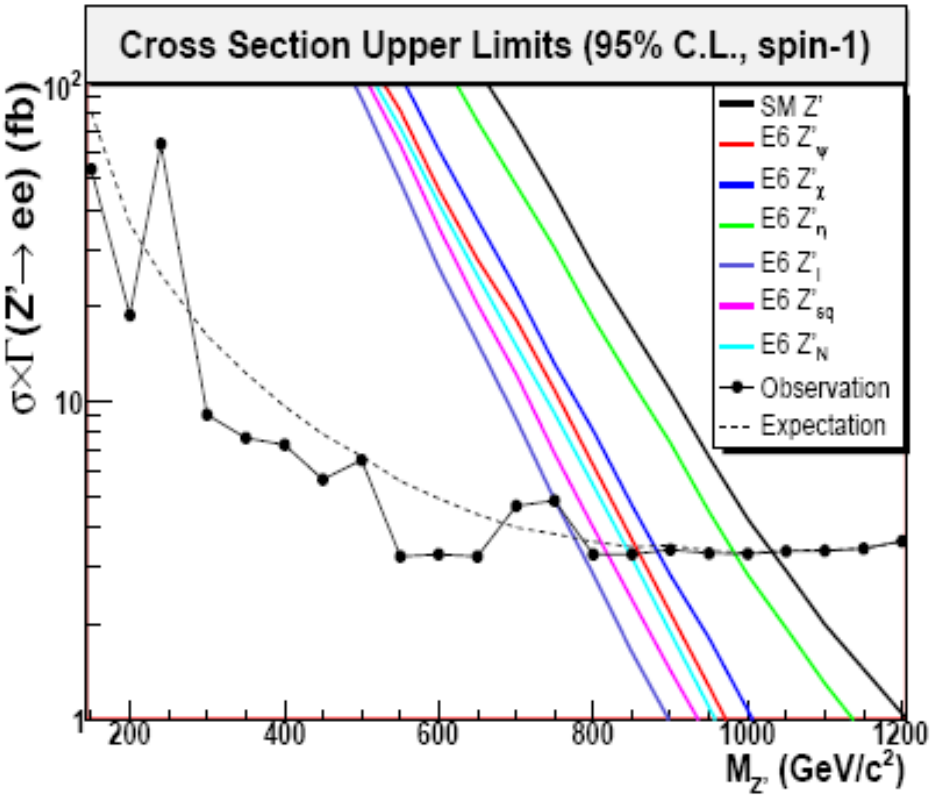
Electrons $E_T > 25$ GeV

Limits on E6 Z' bosons (752-983 GeV/c^2)
SM-like Z' excluded below 1032 GeV/c^2

CDF Run II Preliminary



CDF Run II Preliminary



See Michel Jaffre's talk for RS graviton interpretation

New Gauge Bosons – W '

L = 1.0 fb^{-1}

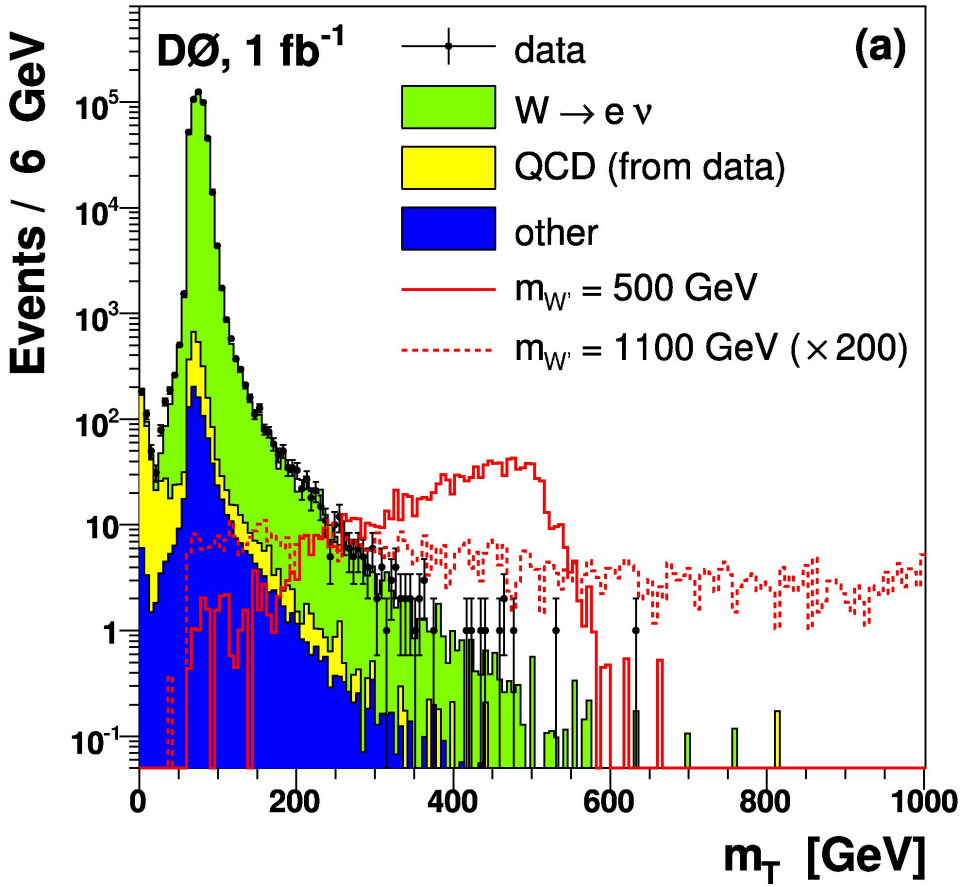
Search for W' → eν

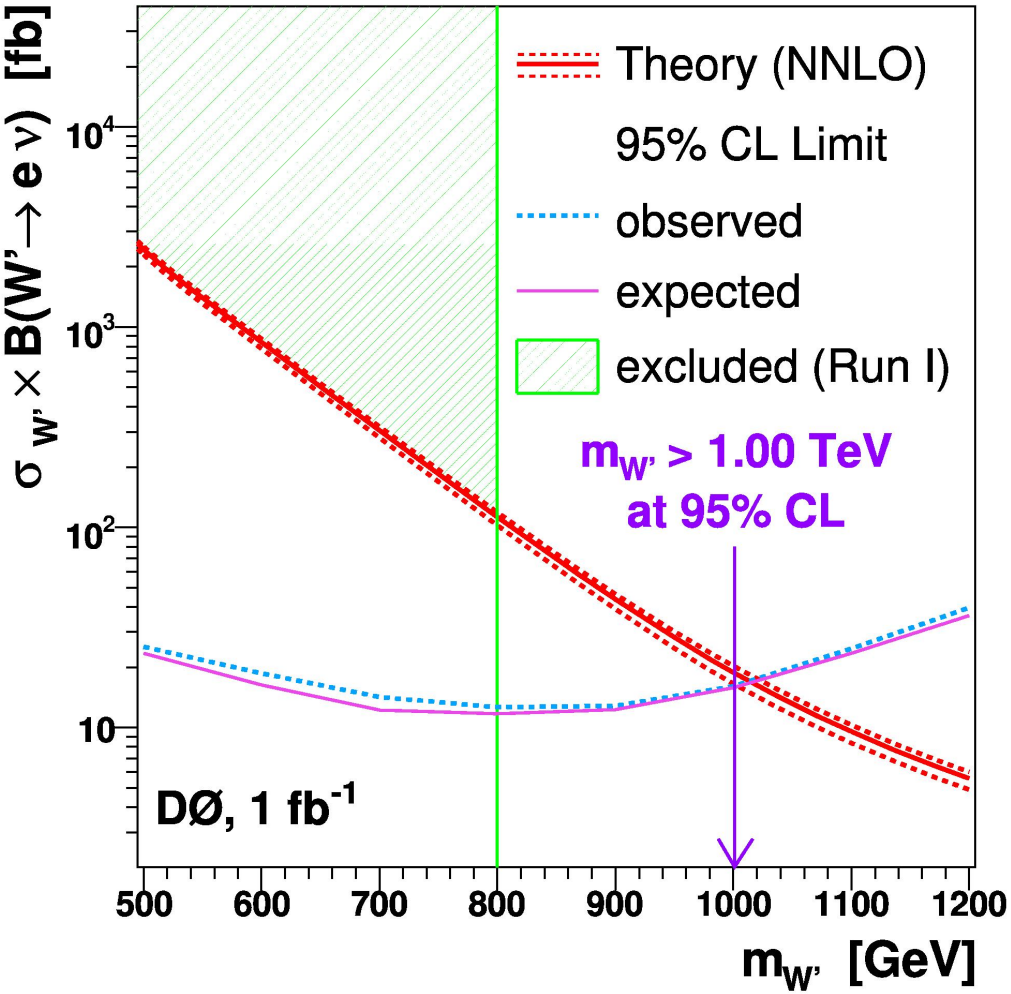
Phys. Rev. Lett. **100**, 031804 (2008)

Ele E_T > 30 GeV, Met > 30 GeV

M(W') > 1 TeV

Search the tail of transverse mass M_T(eν) distribution (M_T>140 GeV)





Rich Set of Lepton Searches

SUSY

Chargino/Neutralino

Sneutrinos

Heavy squarks

$B_s \rightarrow \mu\mu$

Long-lived stop

Scalar stop

Non - SUSY

Compositeness

Right handed quarks

Leptoquarks

High Mass Resonances

Extra-dimensions

Randall-Sundrum Gravitons

Summary

CDF and DØ have looked at 2fb^{-1} of Tevatron collisions

- Searches that are model dependent : generic SUSY, RPV-SUSY, New gauge bosons, RS Gravitons
- Signature based searches
- No new physics yet – but that constrains and motivates new theories

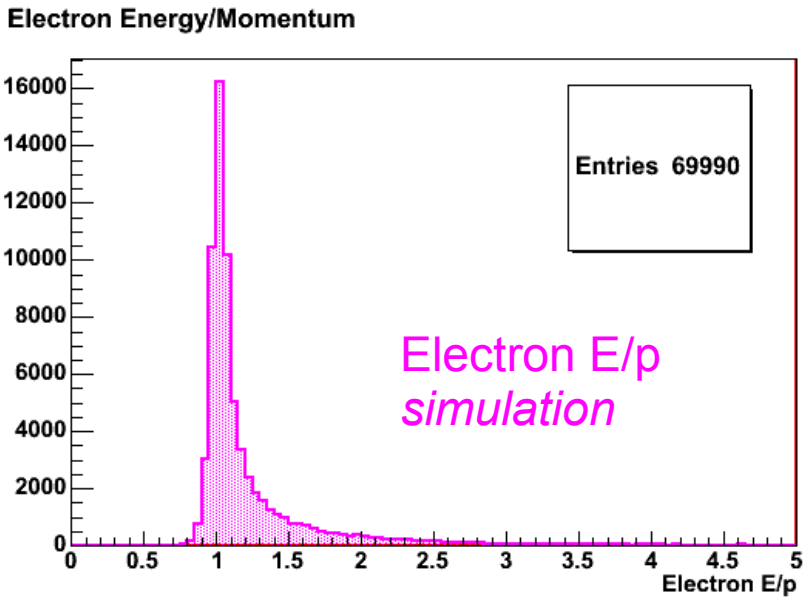
Expect more data soon

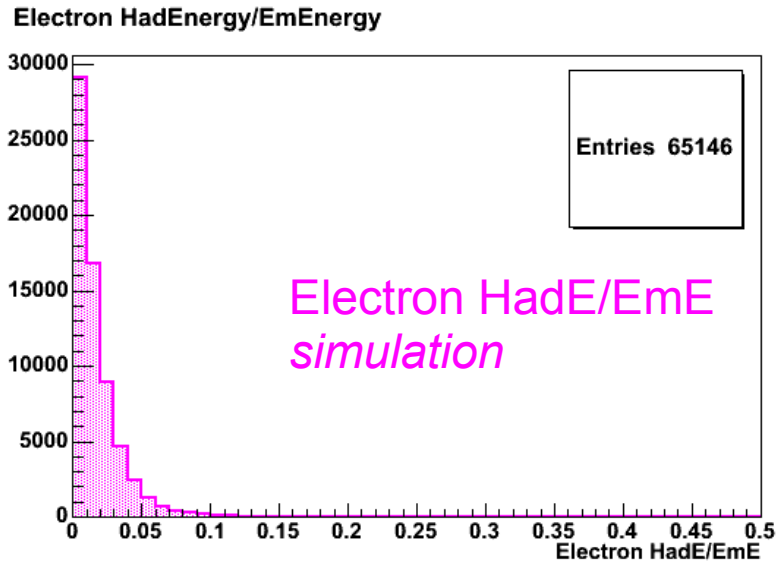
http://www-cdf.fnal.gov/physics/exotic/exotic.html

http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm

BACKUP

Identifying Leptons : electrons

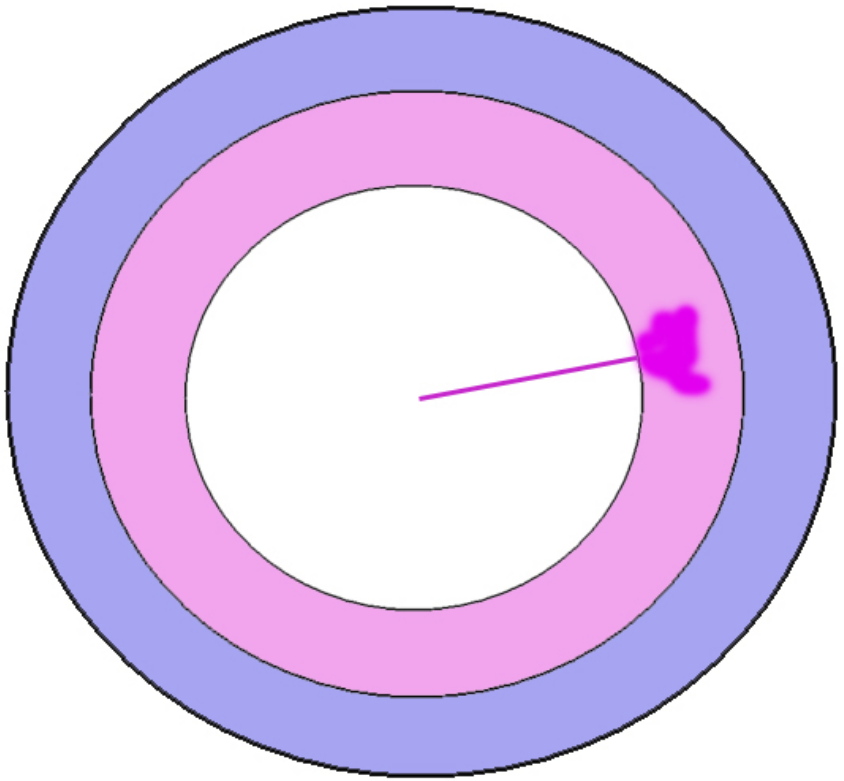




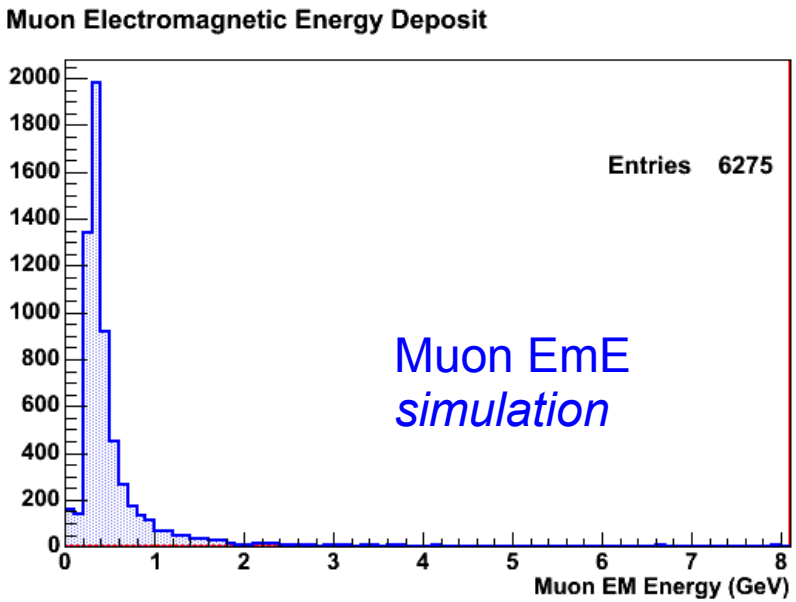
Hadronic calorimeter

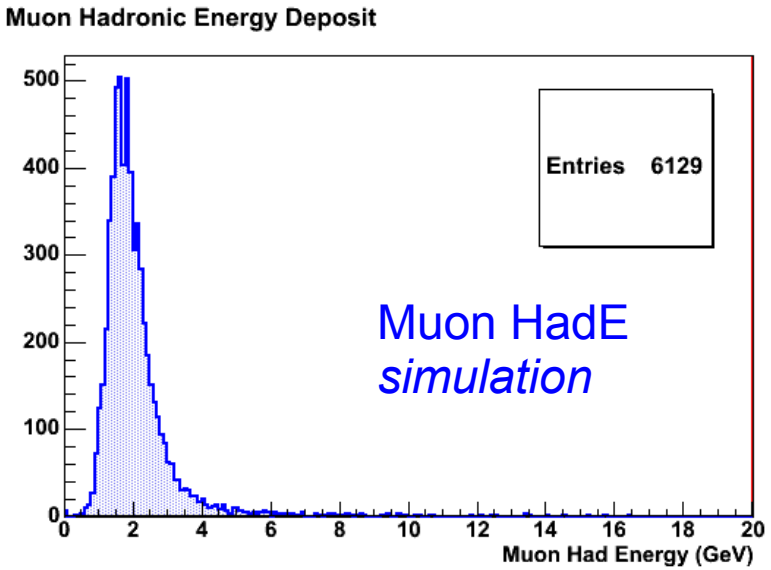
Electromagnetic calorimeter

Central Tracker



Identifying Leptons : muons

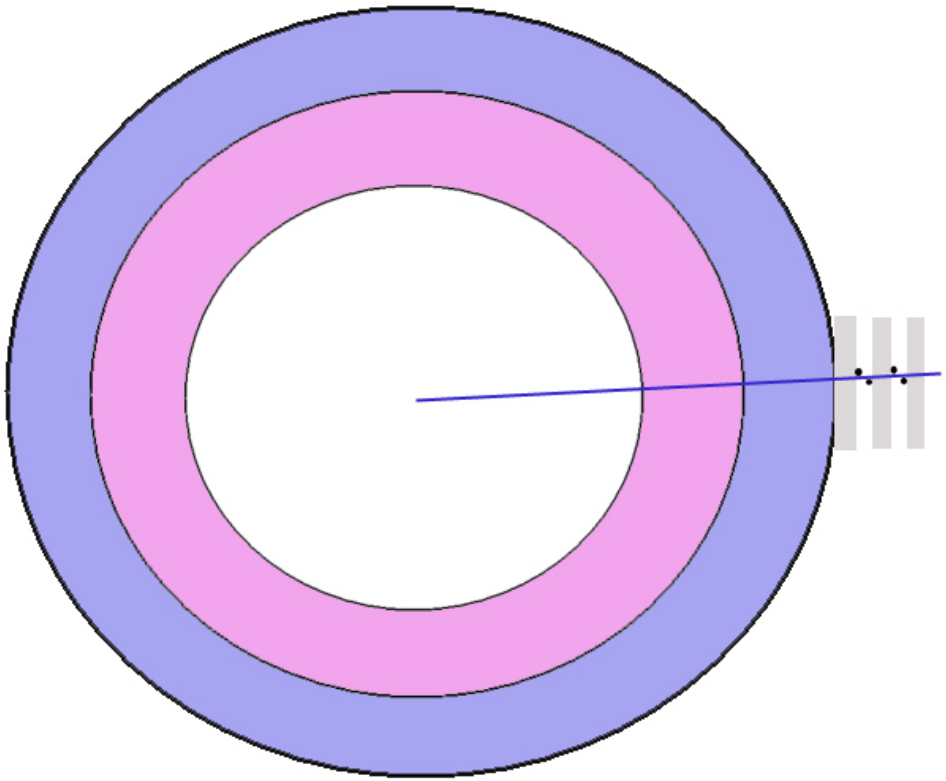




Hadronic calorimeter

Electromagnetic calorimeter

Central Tracker



Identifying Leptons : tau's

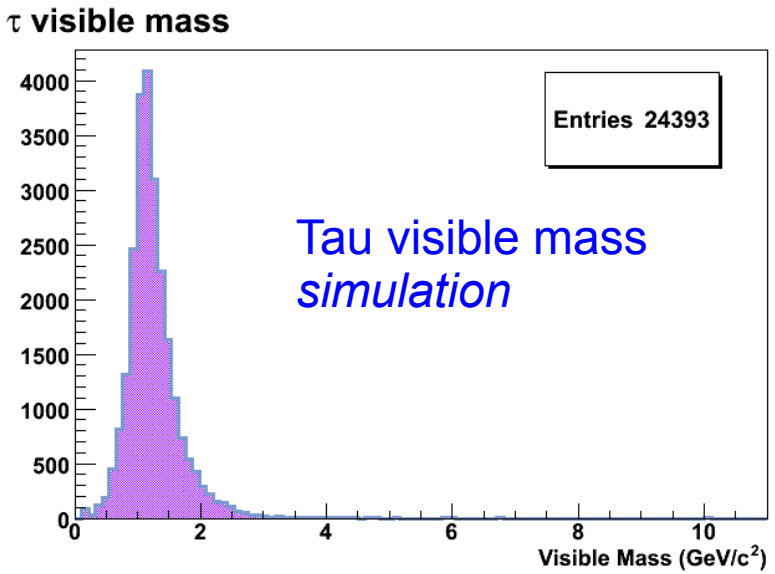
when they don't decay to electrons or muons

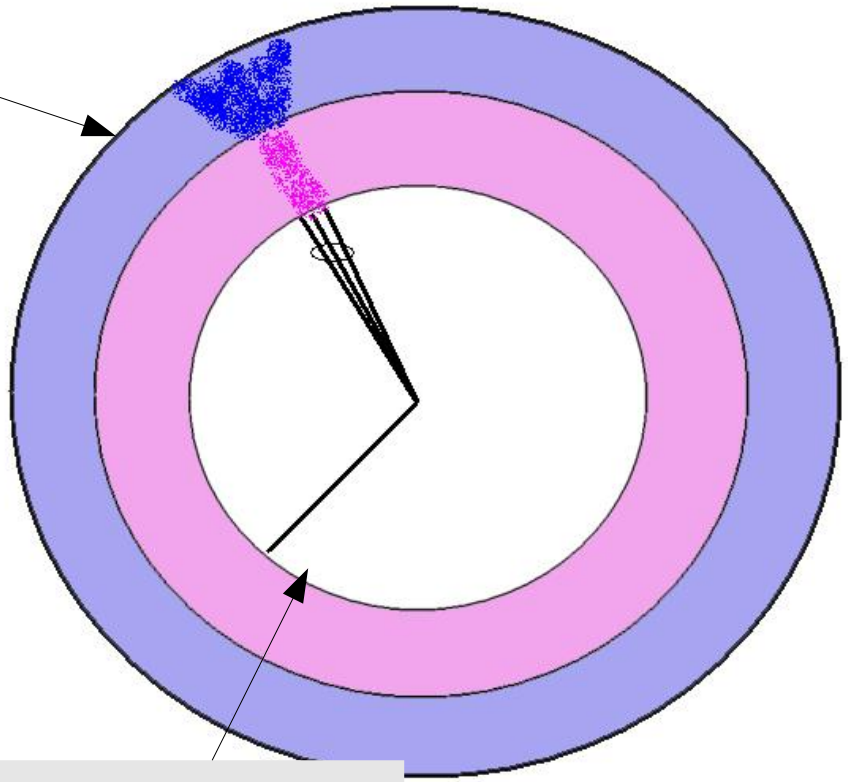
Hadronic calorimeter

Electromagnetic calorimeter

Central Tracker

Fully reconstructed tau's
Narrow jets
Right invariant Mass



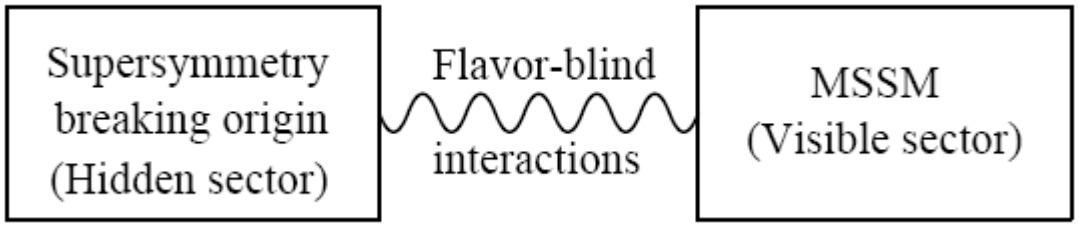


Isolated tracks
proxy for tau's
'single-prong' tau decays

Supersymmetric particles

SUSY is broken, sparticles at different masses from particles

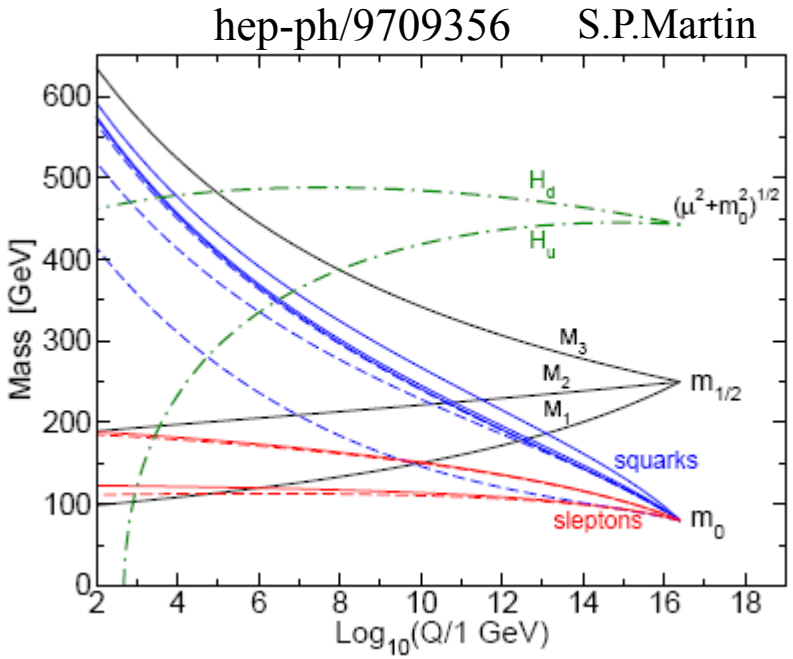
SUSY is broken using soft-terms, gives us MSSM with more than 100 parameters



Simplify further to get :

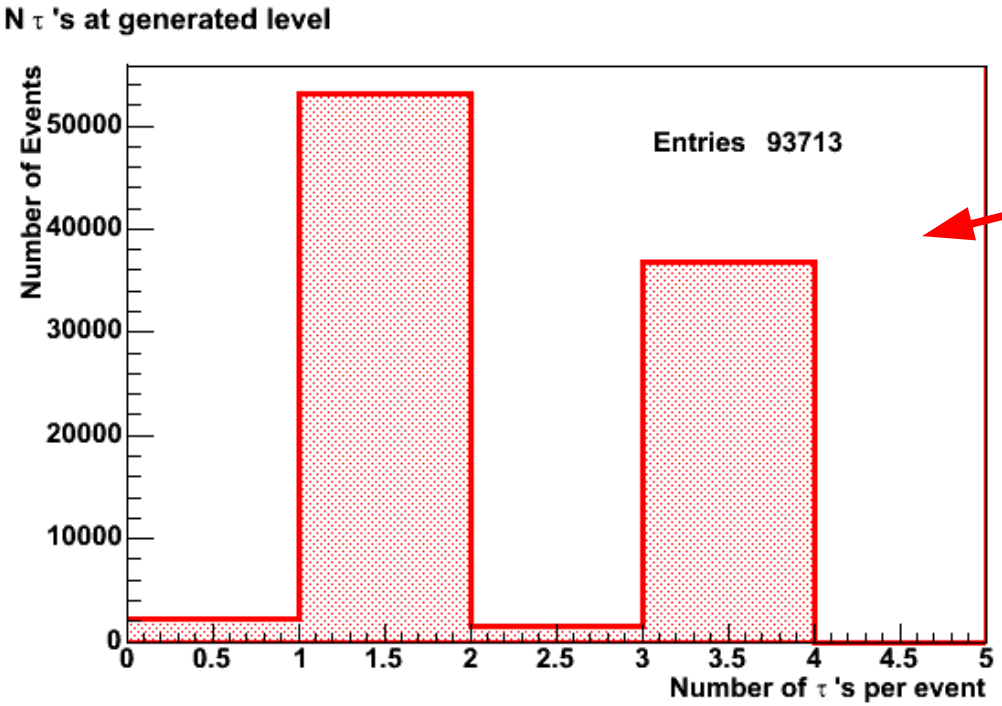
mSUGRA with 5 parameters

- Unified scalar mass : m0
- Unified gaugino mass : $m_{½}$
- Ratio of Higgs vev's : tan(β)
- Trilinear coupling : A0
- Higgsino mass parameter sign : sgn(μ)

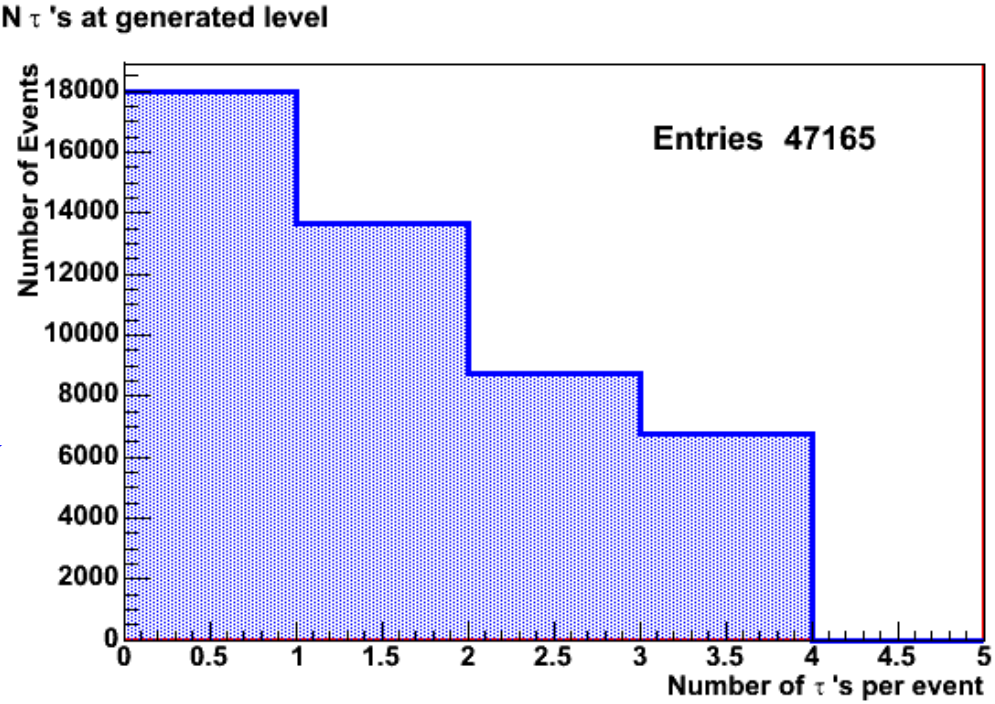


mSUGRA mixing and no-mixing

Number of tau's per event : Acceptance (hence limit) depends on this



mSUGRA
m_0=60, $m_{1/2}$=190, tan(β)=3
A_0=0 , sign(μ)=1

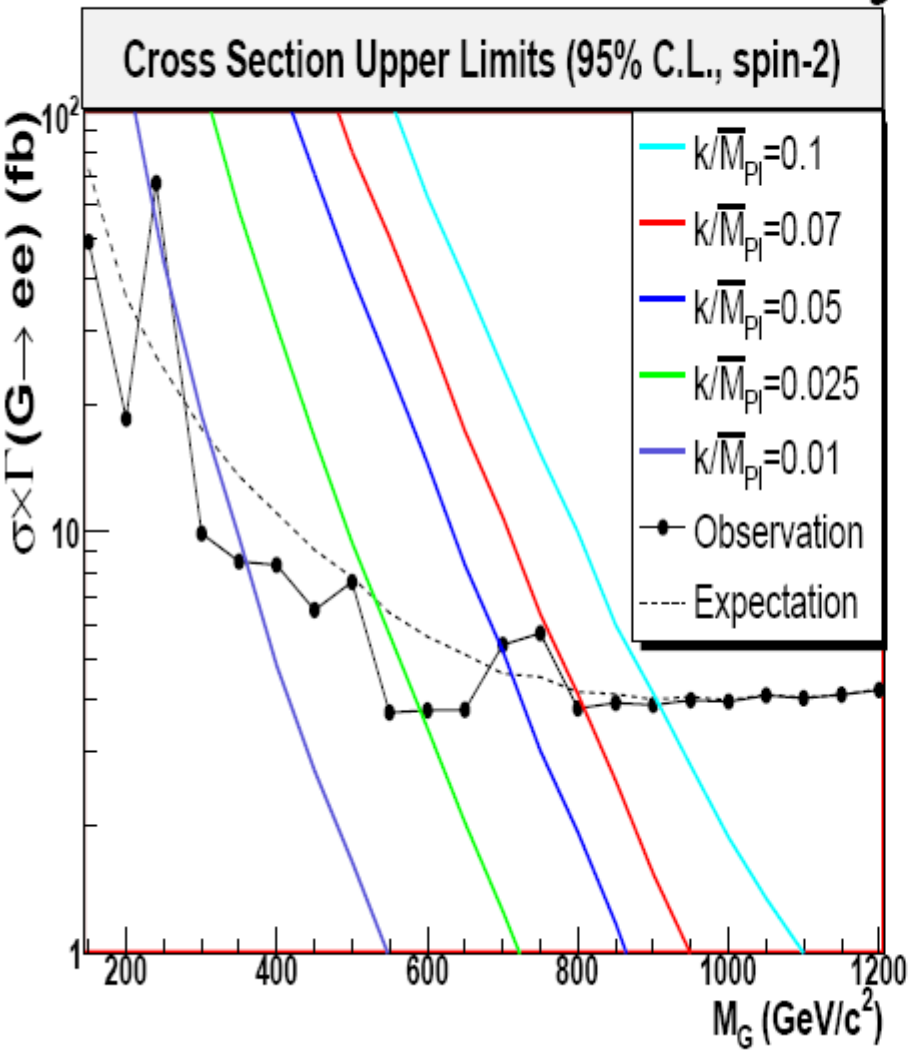


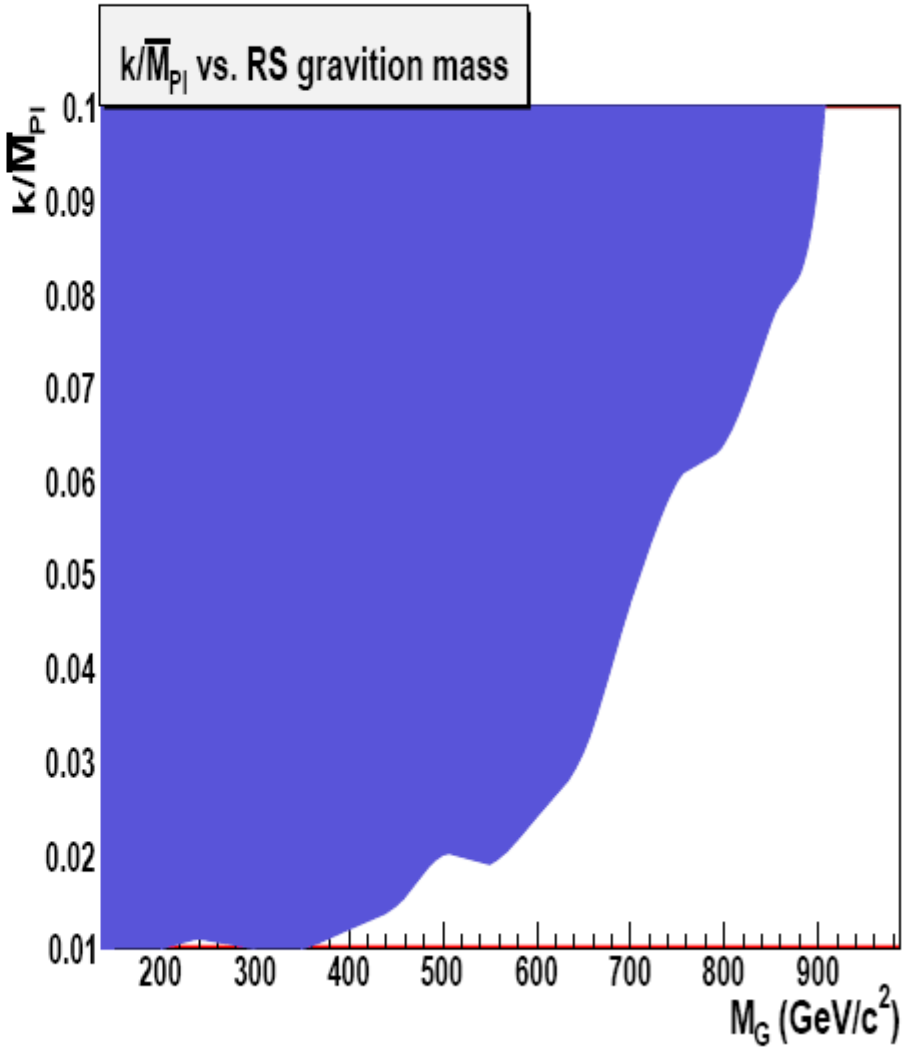
mSUGRA no-mixing
m_0=70, $m_{1/2}$=190, tan(β)=3
A_0=0 , sign(μ)=1

RS Graviton Search with dielectrons

L = 2.5 fb^{-1}

CDF Run II Preliminary





Randall Sundrum Gravitons

L = 1.0 fb^{-1}