Search for new Physics at Tevatron

Outline:

- Introduction
- Search for new Physics
  - ✔ Model driven
  - ✔ Signature based

Do we need New Physics?

Present "Observational" Evidence for New Physics

- NEUTRINO MASSES ☆☆☆
- DARK MATTER ☆☆☆
- MATTER-ANTIMATTER ASYMMETRY ☆☆
- INFLATION ☆

A. Masiero IFAE 2010

What kind of New Physics?

At Tevatron

- High Mass Resonances (Z', W', Graviton, Sneutrino, Axigluon)
- SUSY
- Technicolor
- New or Excited Fermions
- LeptoQuarks
- Extra Dimensions

Search for New Physics

The breaking mechanism determines the phenomenology and the search strategies:

Model Driven:

- theory driven, optimize analysis to the searches
- explore large region of parameter space

Signature Based:

- search for unusual final states (not SM)
- optimize selections to minimize background
- interpret the results in term of several models

Global Searches:

- maximize the parameter space coverage
- less sensitivity but can give hint on possible deviation from SM

Experimental Approach

- Lepton-only final states
  - e/μ identification well understood
  - τ id more complex
  - straightforward and efficient approach to search for anomalies
- MET and/or Photons
  - wealth of models and exotic process
  - detector effect are important, need to be understood
- Jets and Heavy Flavor
  - more complex signatures
  - Need to maintain high S/B

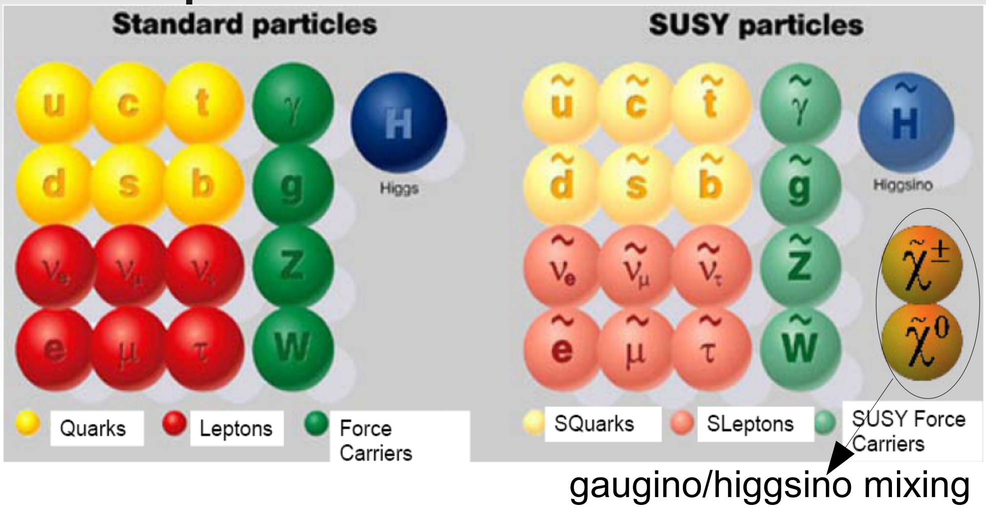
Model Driven Searches

SUperSYmmetry

- Standard Model is theoretically incomplete
- SUSY: spin-based symmetry that relates Fermions to Bosons

Q|Boson> = Fermion

Q|Fermion> = Boson



- Define R parity: $(-1)^{3(B-L)+2s}$

  R=1 SM particles

  R=-1 MSSM partners

If conserved, provides

Dark Matter Candidate

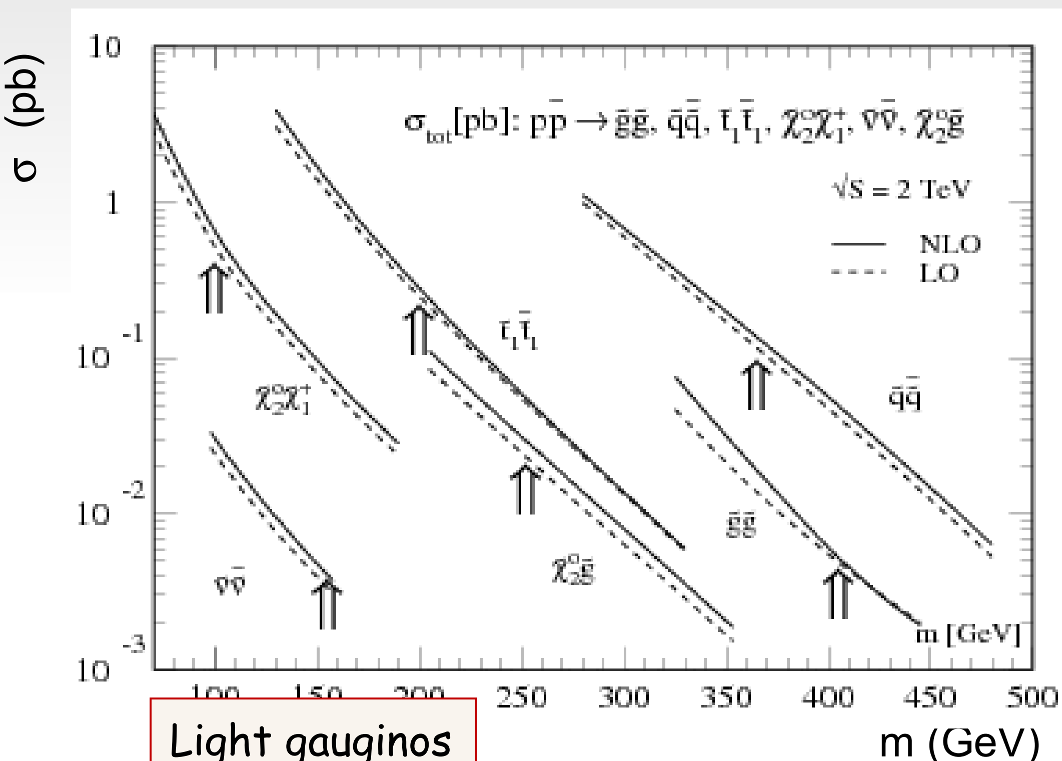
(Lightest Supersymmetric Particle)

- No SUSY particles found yet
  - SUSY must be broken -> models depend on many parameters even in "minimal" models

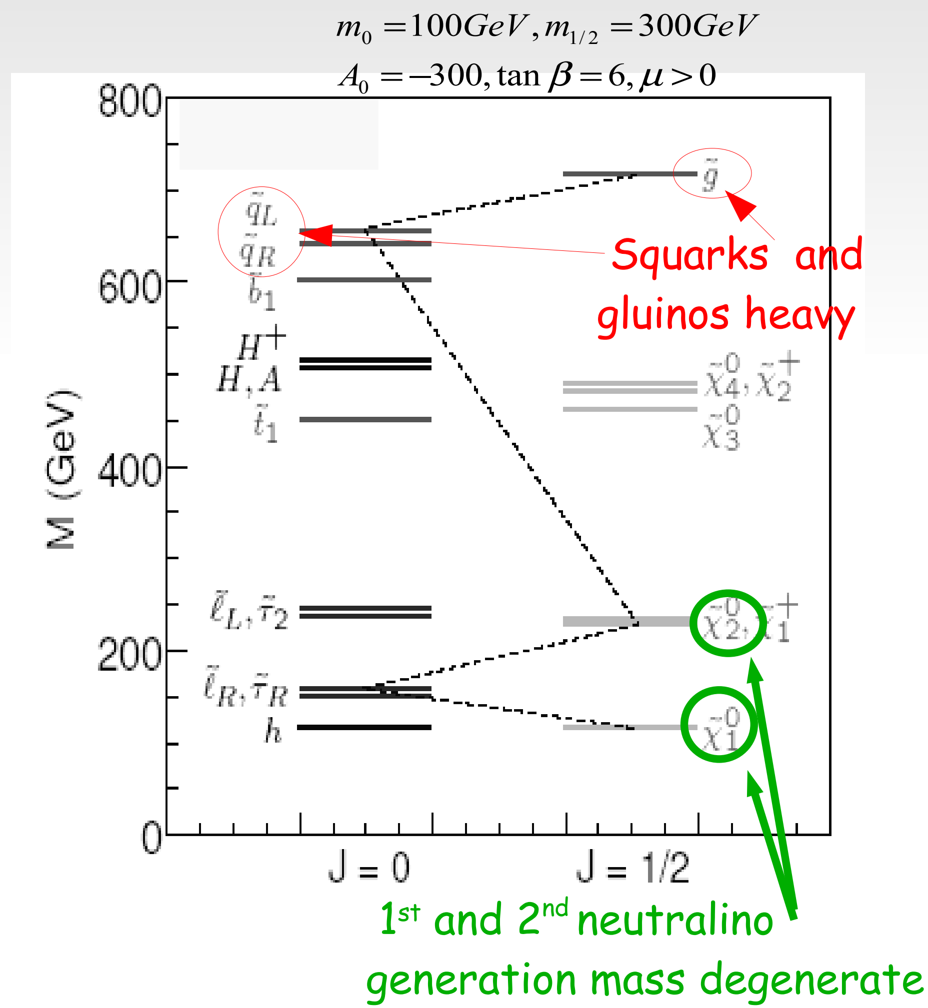
"Standard" SuSy

Consider production with the highest cross sections

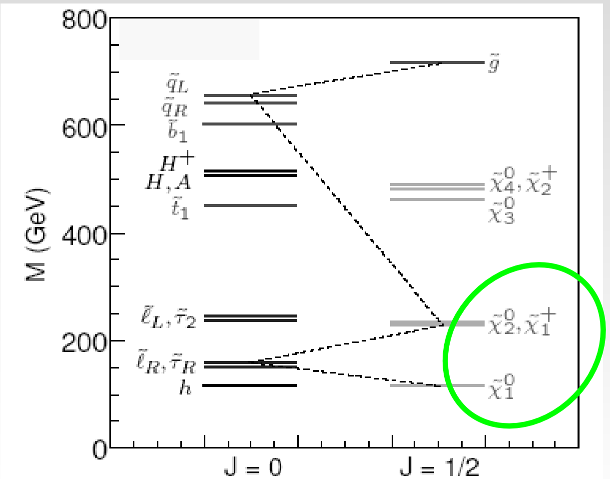
Small masses (chargino/neutralinos) or large couplings (squark/gluino)



Light gauginos also expected



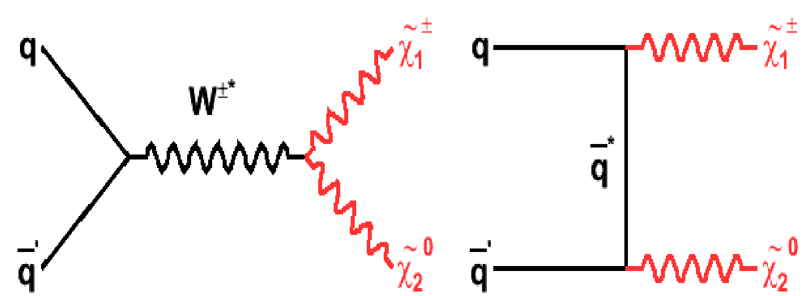
$\tilde{\chi}^0_2\tilde{\chi}^\pm_1$ Production: Trilepton

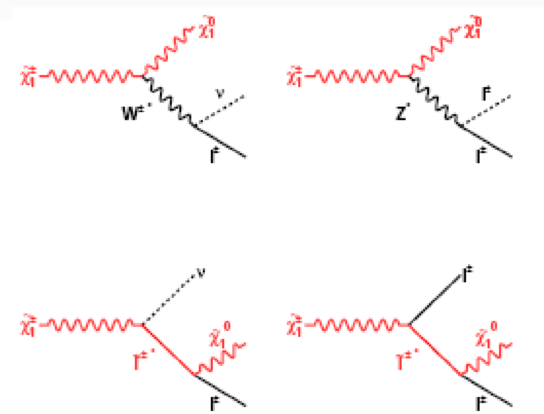


Assume R^p conservation and

$\tilde{\chi}^0_1$ is LSP (light stable particle)

Low cross section: $\sigma \times Br < 0.5$ pb





Clean signature:

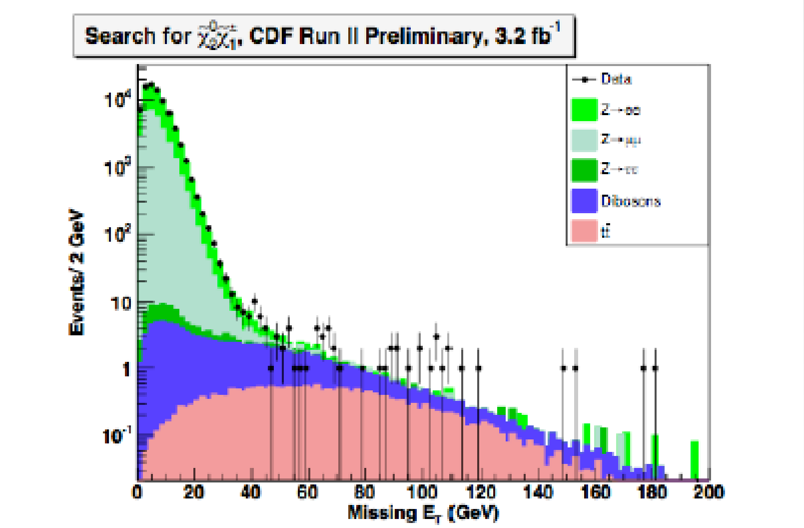
- 3 isolated leptons
- MET due to ν
- no jets
- Z veto

Main Background:

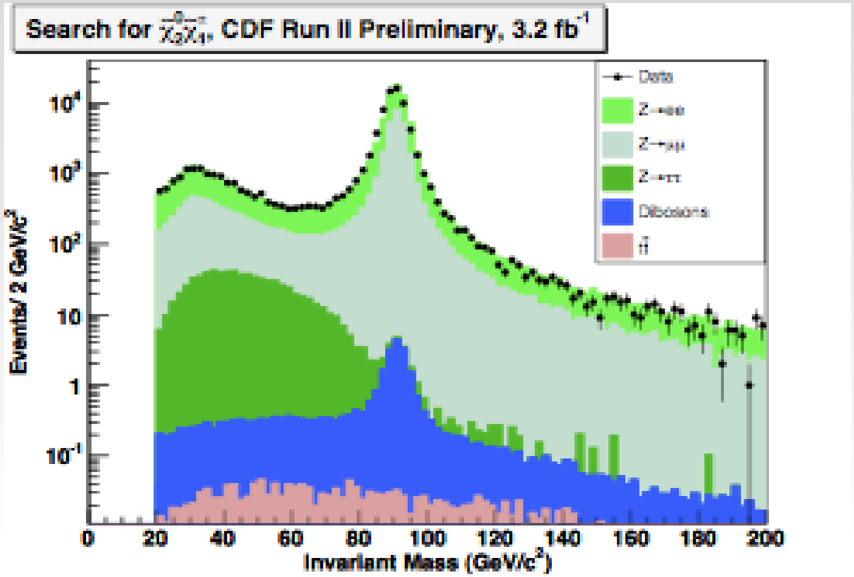
Z+γ, tt, di-bosons: WW, ZZ

Determined with MC checked with dilepton data

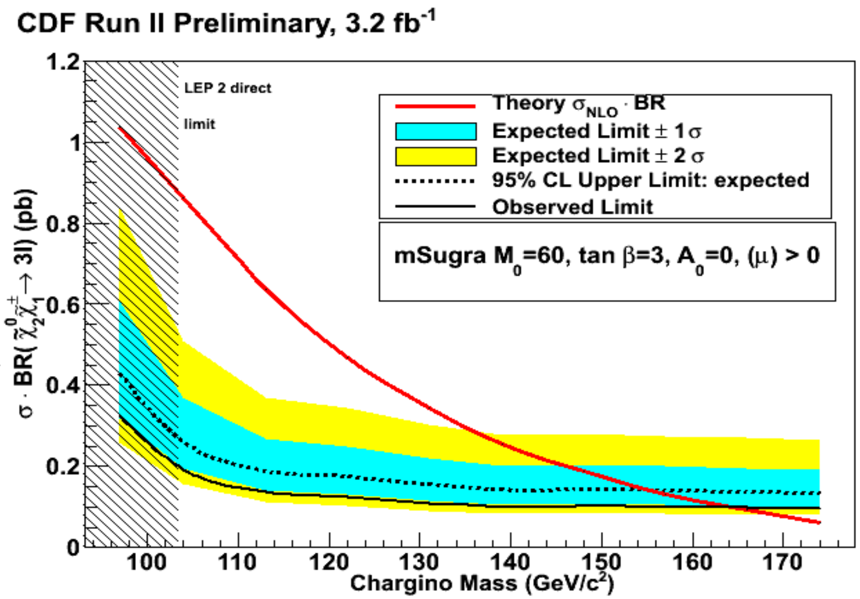
$\tilde{\chi}^0_2\tilde{\chi}^\pm_1$ Production: Trilepton



Data and MC agree



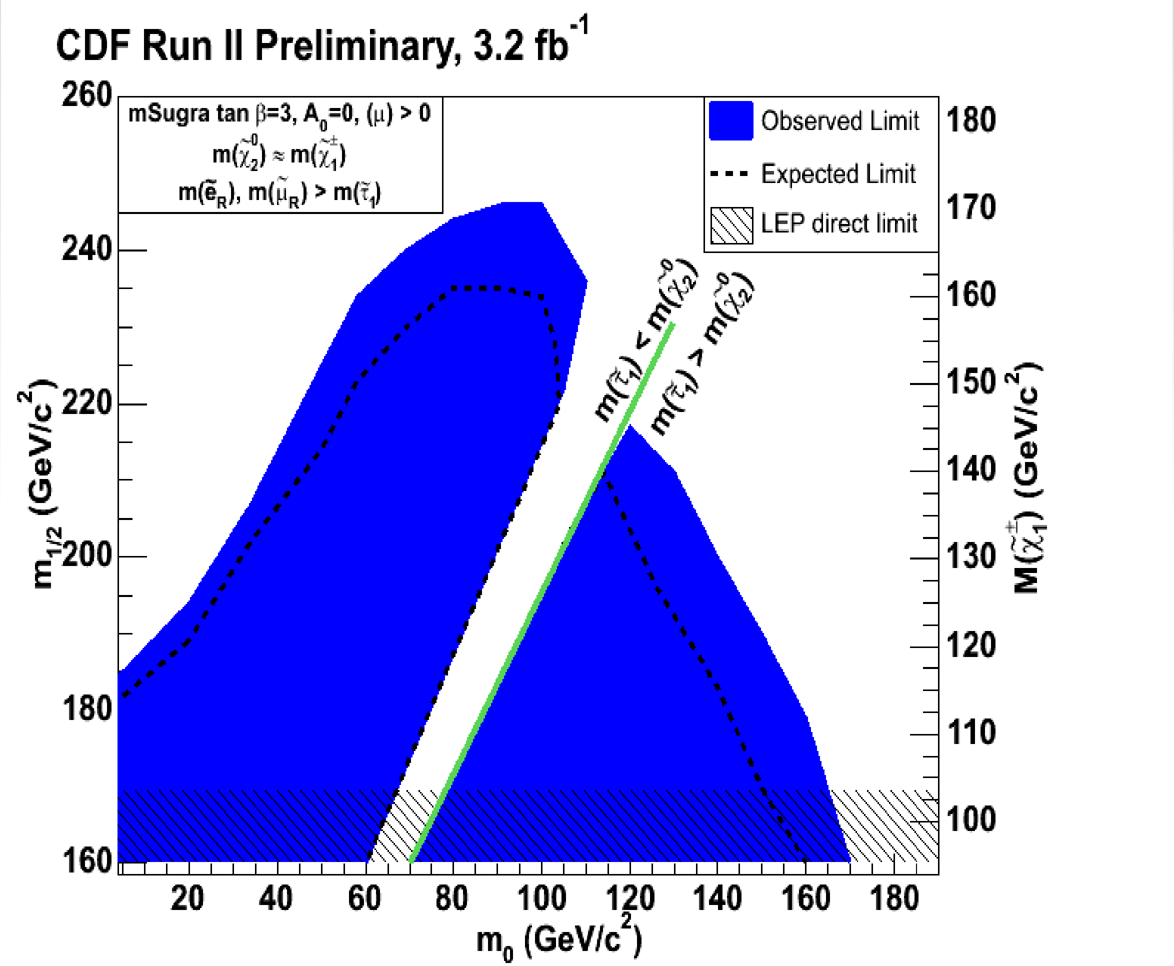
Control regions in MET vs $M_{\ell\ell}$ phase-space



Excluded regions where measured $\sigma\times BR <$ theoretical value.

Chargino $m\chi^\pm_1 < 164$ (155 Exp.) GeV is excluded

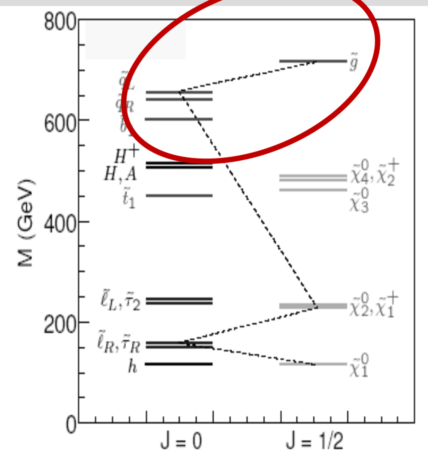
MSugra limits

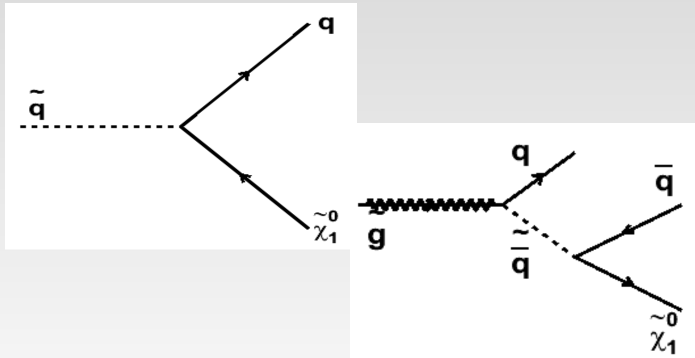


m0: universal scalar mass

m1/2 universal gaugino mass

Search for squark and gluino





Process:

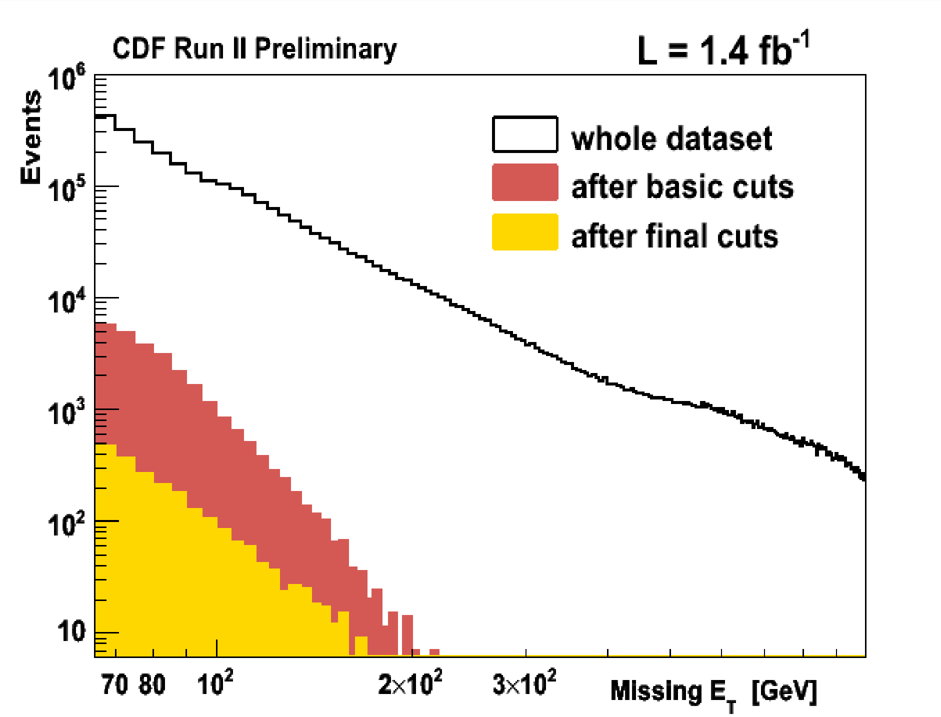
$\tilde{q}\tilde{q} \rightarrow qq\tilde{\chi}_1^0\tilde{\chi}_1^0$ $(m_q < m_g)$

$\tilde{q}\tilde{g} \rightarrow qqq\tilde{\chi}_1^0\tilde{\chi}_1^0$ $(m_q \sim m_g)$

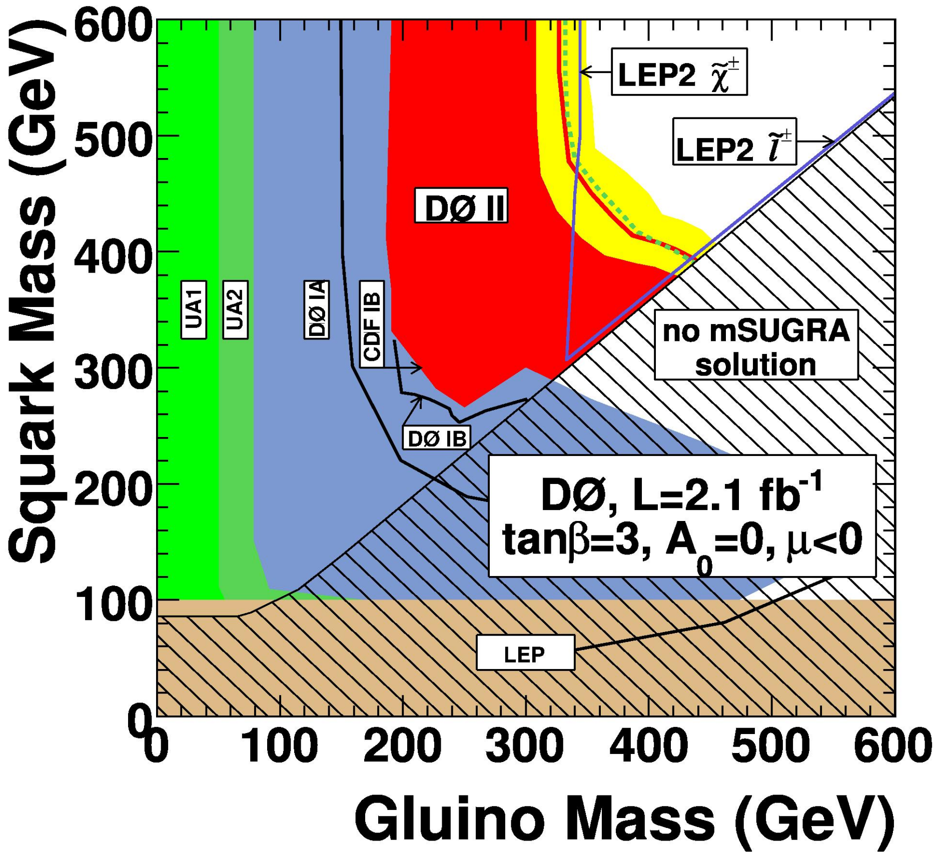
$\tilde{g}\tilde{g} \rightarrow qqqq\tilde{\chi}_1^0\tilde{\chi}_1^0$ $(m_q > m_g)$

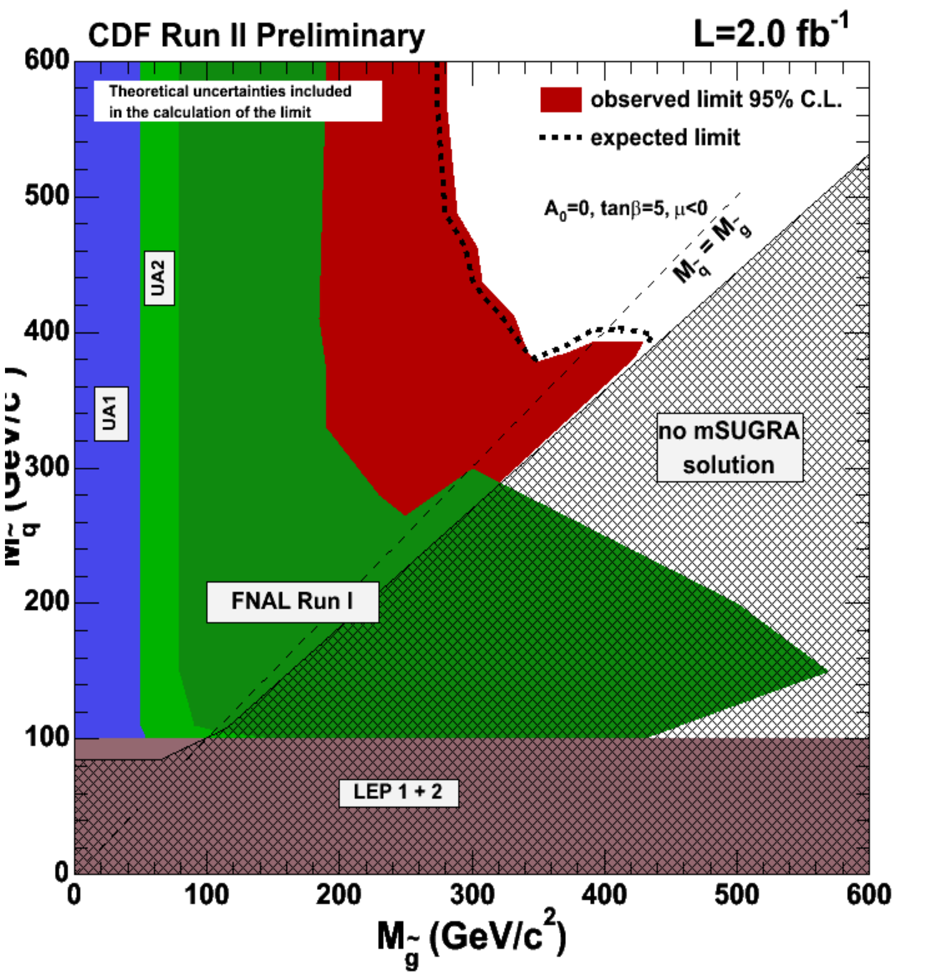
Final states with Jets+MET

- MET > 70 GeV
- At least two/three/four jets with ET > 25 GeV
- $\Delta\varphi$ (MET-jet)> 0.7 (first two/three leading jets)
- No reconstructed Z from tracks
- Background: QCD W/Z+jets

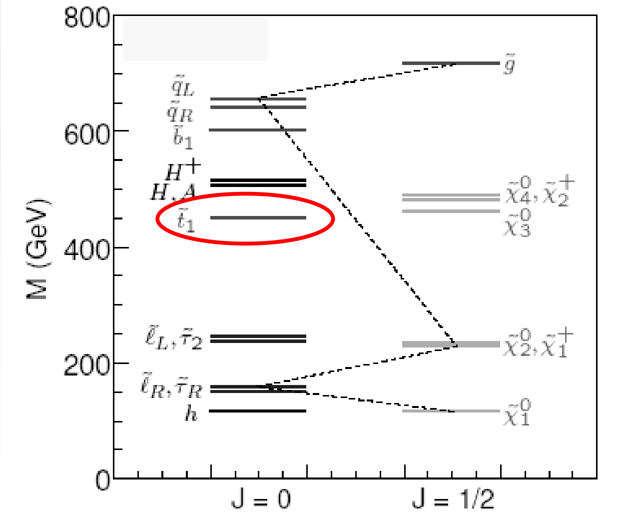


Search for squark and gluino: Results



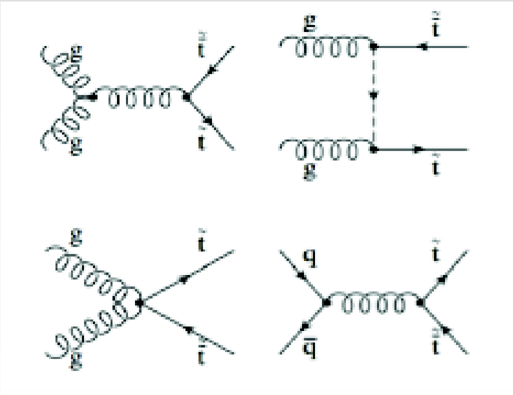


Search for Stop



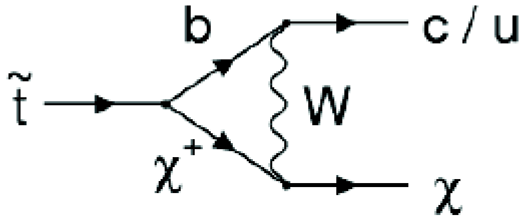
Lightest of the squark

It can be lighter than Top

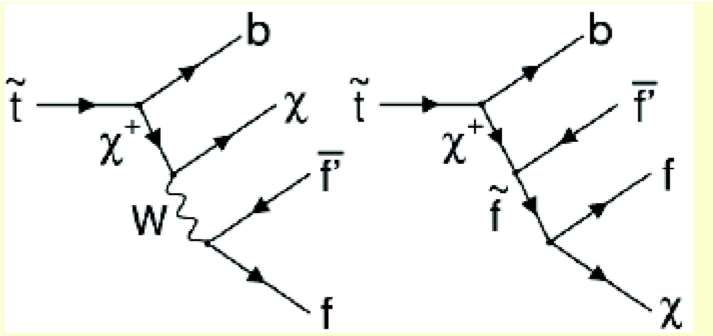


Assumptions: R^p conserved and $m_{stop} < m_{top}$

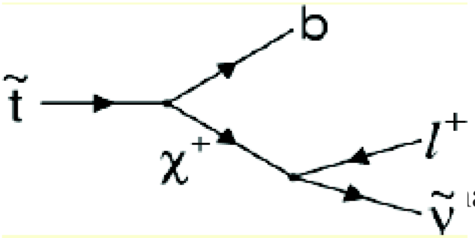
1) $\tilde{t}_1 \rightarrow c\,\tilde{\chi}_1$



2) $\tilde{t}_1 \rightarrow b\,\tilde{\chi}_1^{\pm} \rightarrow bW^{\pm}\,\tilde{\chi}_0$

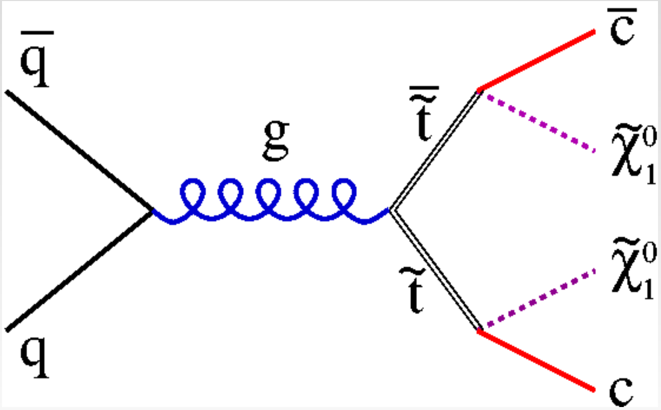


3) $\tilde{t}_1 \rightarrow bl\,\tilde{\nu}$



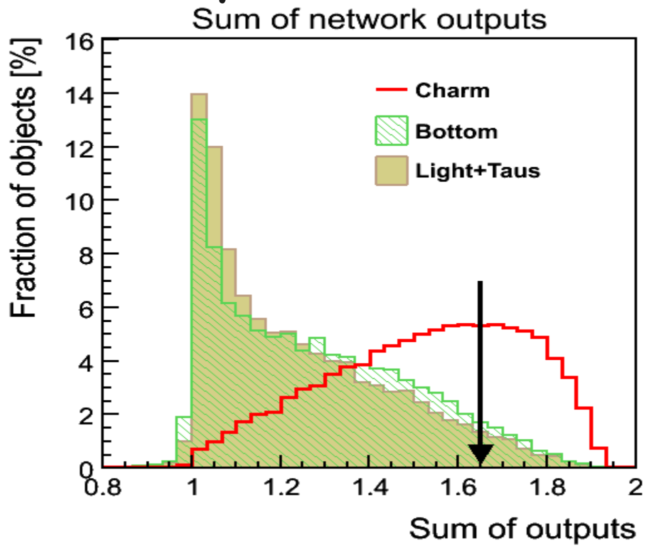
Search for Stop $\tilde{t}_1 \rightarrow c\,\tilde{\chi}_1$

Signature:
2 c-jets at least one jets tagged
+ MET from neutralino
Background: QCD. Evaulated using data

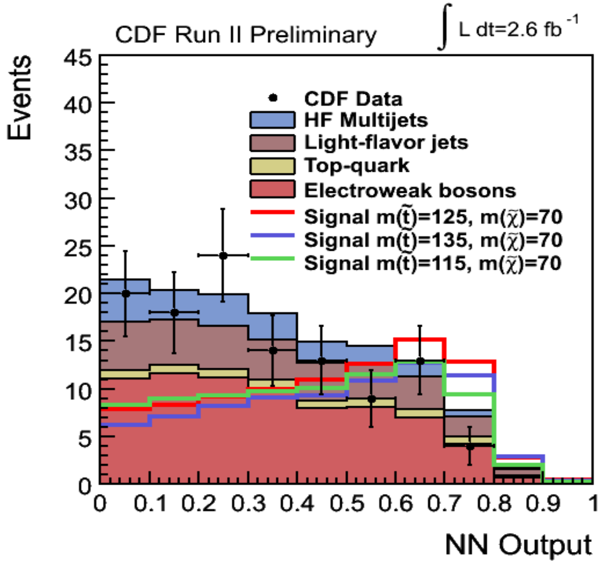


Use two NN to separate:

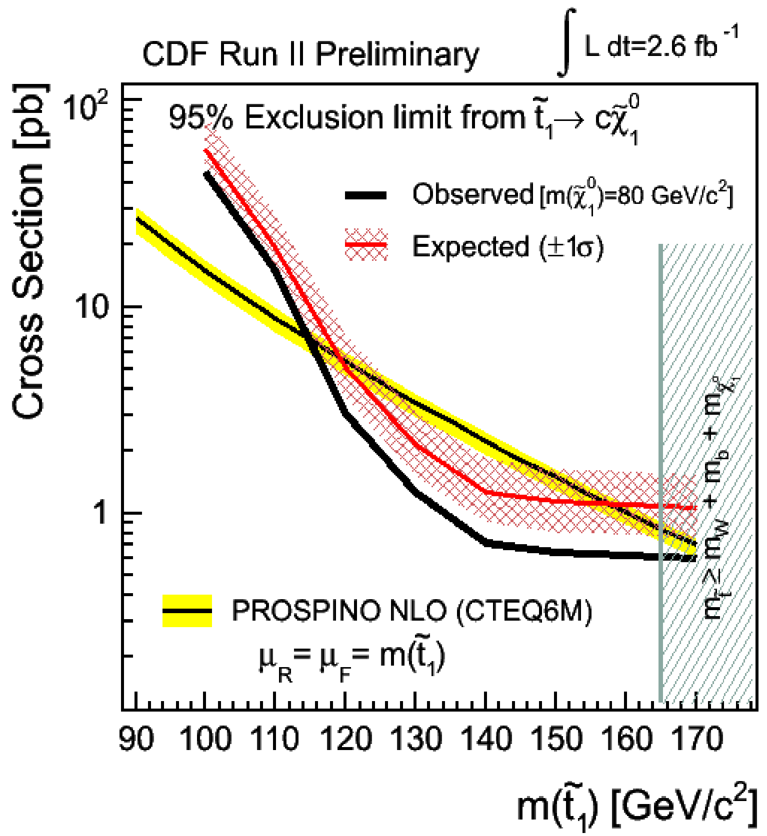
Heavy flavors

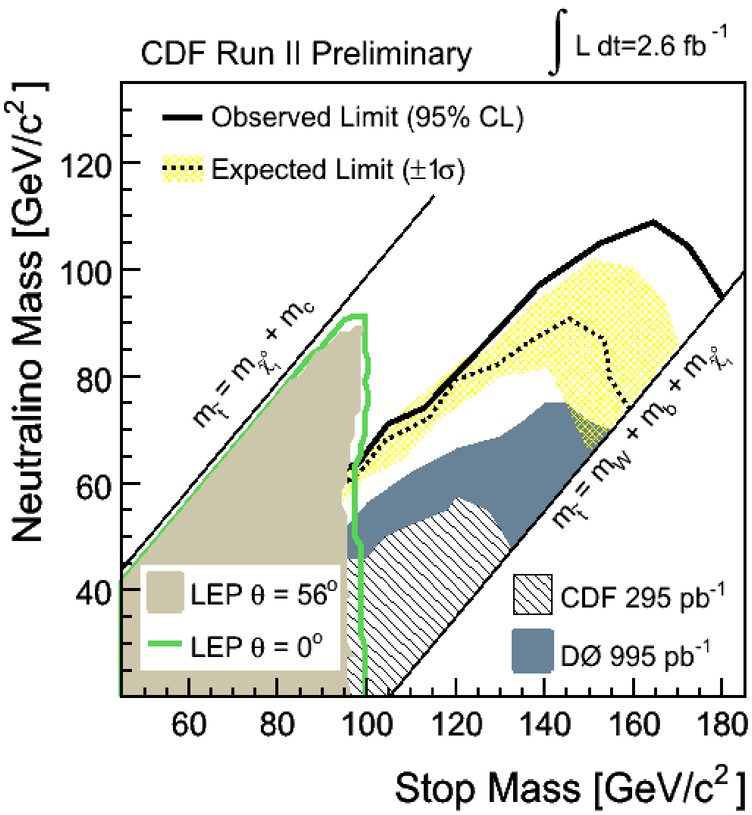


Signal from background



Stop Results



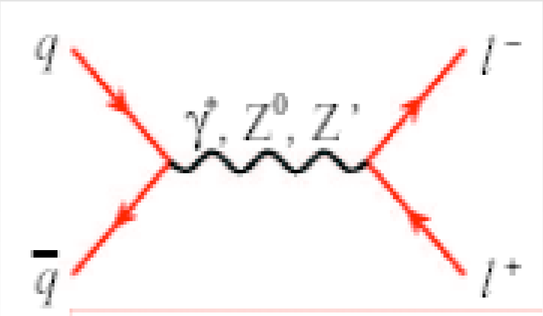


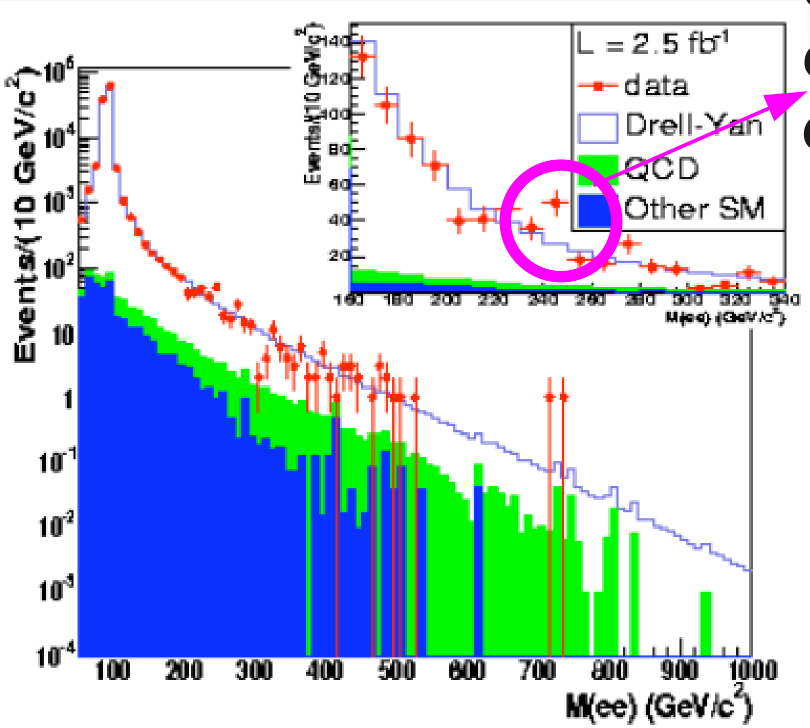
Signature Based Searches

Di-leptons searches:Starting Point

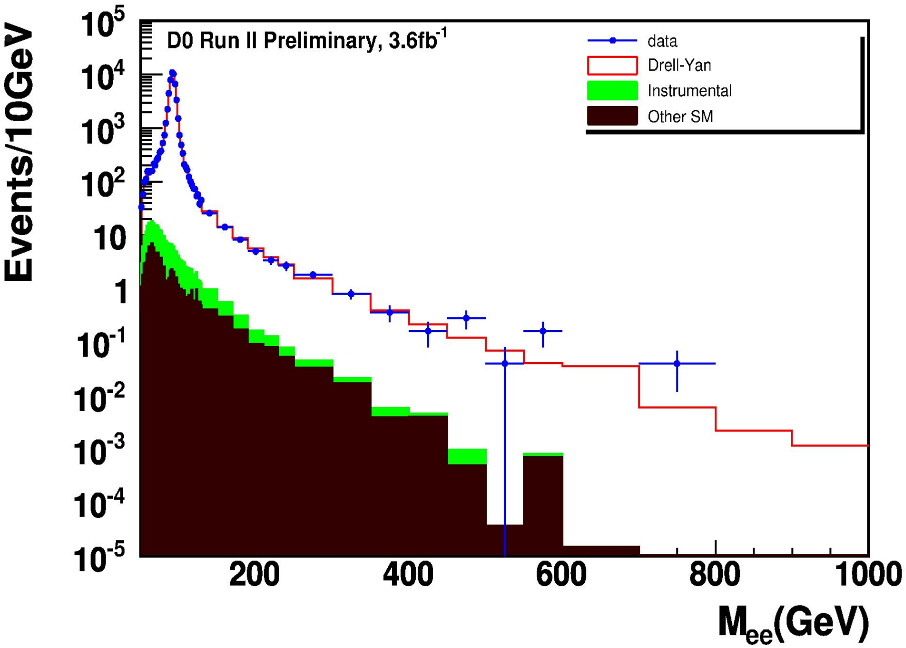
Search for resonances in ee/μμ above 150 GeV

- lepton id well under control
- Z peak used as reference
- clean events





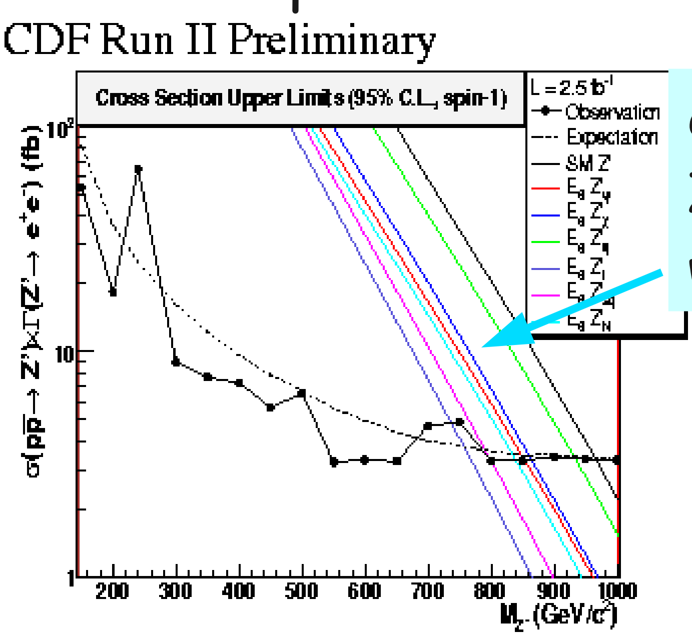
Excess?
3.8 standard deviations over SM



New Phyiscs Searches with Di-leptons

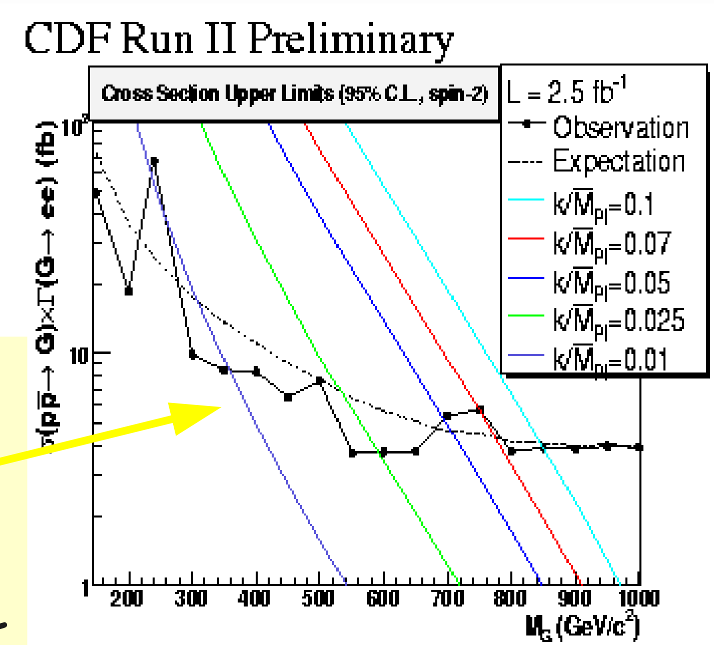
New Physics limits

- understand very well data spectrum in term of SM process
- calculate new signal acceptances and trigger efficiencies
- derive the number of expected new physics events
- if no events found in data calculate 95% CL cross section limit and set particle mass limit

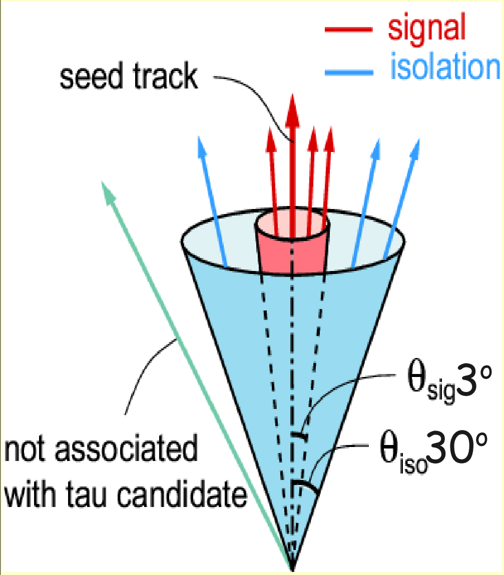


exclude 95%CL
Z' with SM coupling
with mass <966 GeV

Randall-Sundrum
graviton with
mass< 850 GeV
excluded at 95%CL



Tau final states searches

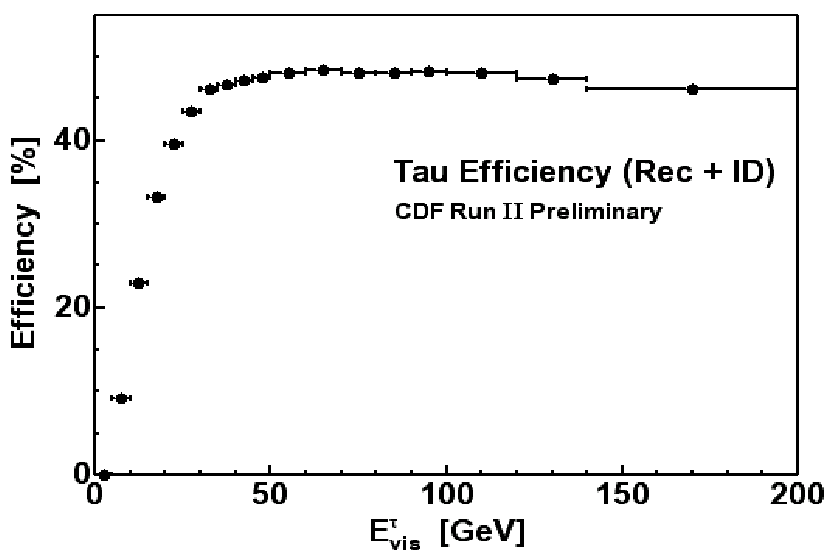


Di-taus:

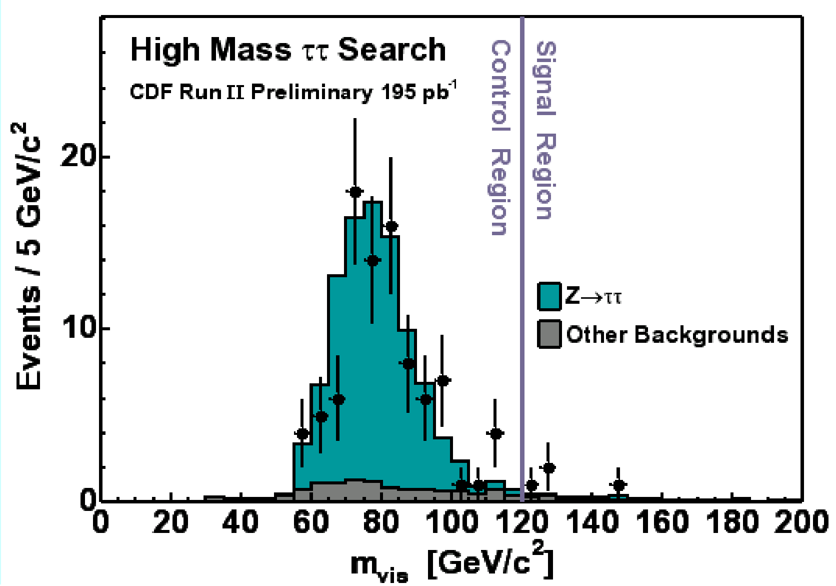
τ->lνν

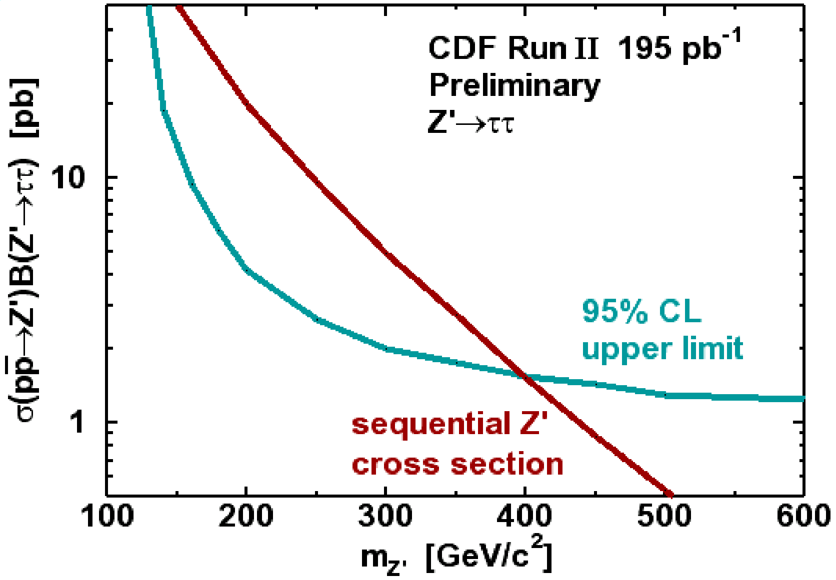
τ->hadrons

1 or 3 tracks in an isolated cone



Z'->ττ

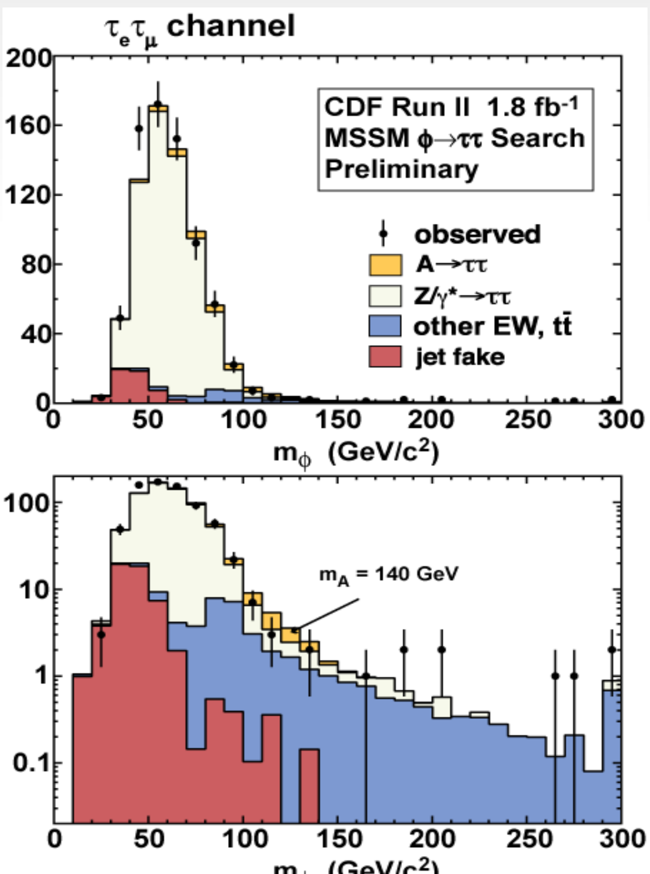


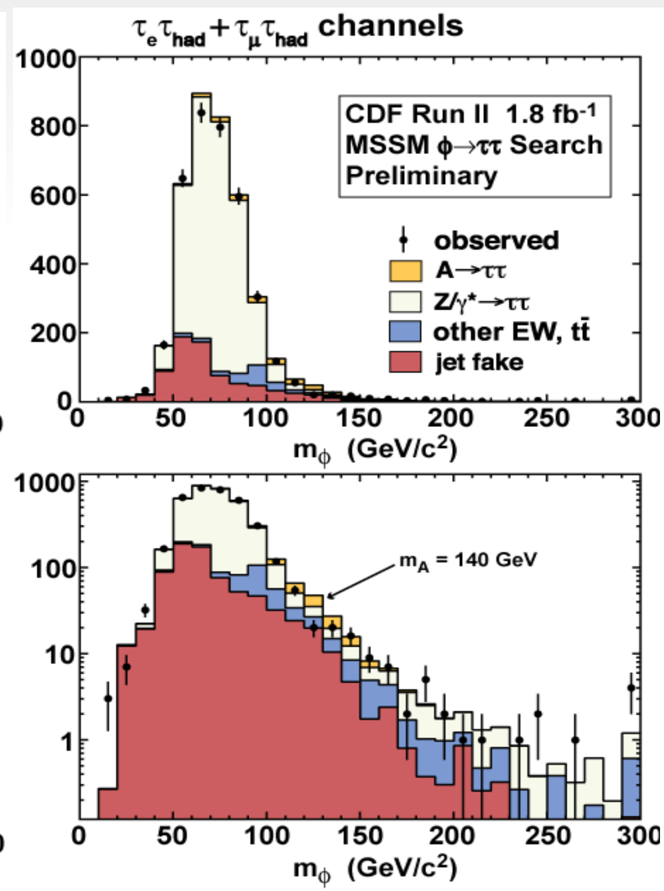


$\Phi\rightarrow\tau\tau$ searches

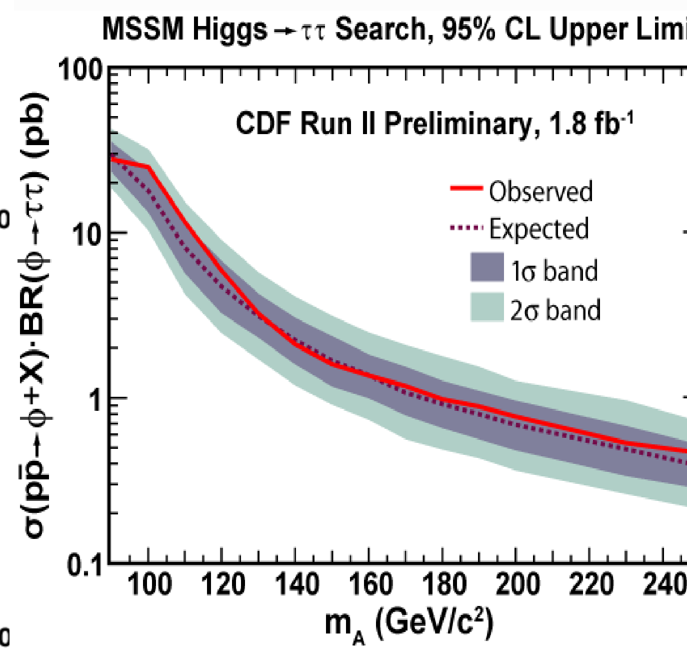
In the Minimal Supersymmetric Standard Model at high tan(β) Higgs neutral sector simplifies: A and h/H are ~degenerate, Φ

Φ->b$\bar{b}$ (90%), Φ->$\tau^+\tau^-$ (10%). Φ->$\tau^+\tau^-$ searched looking at visible mass:





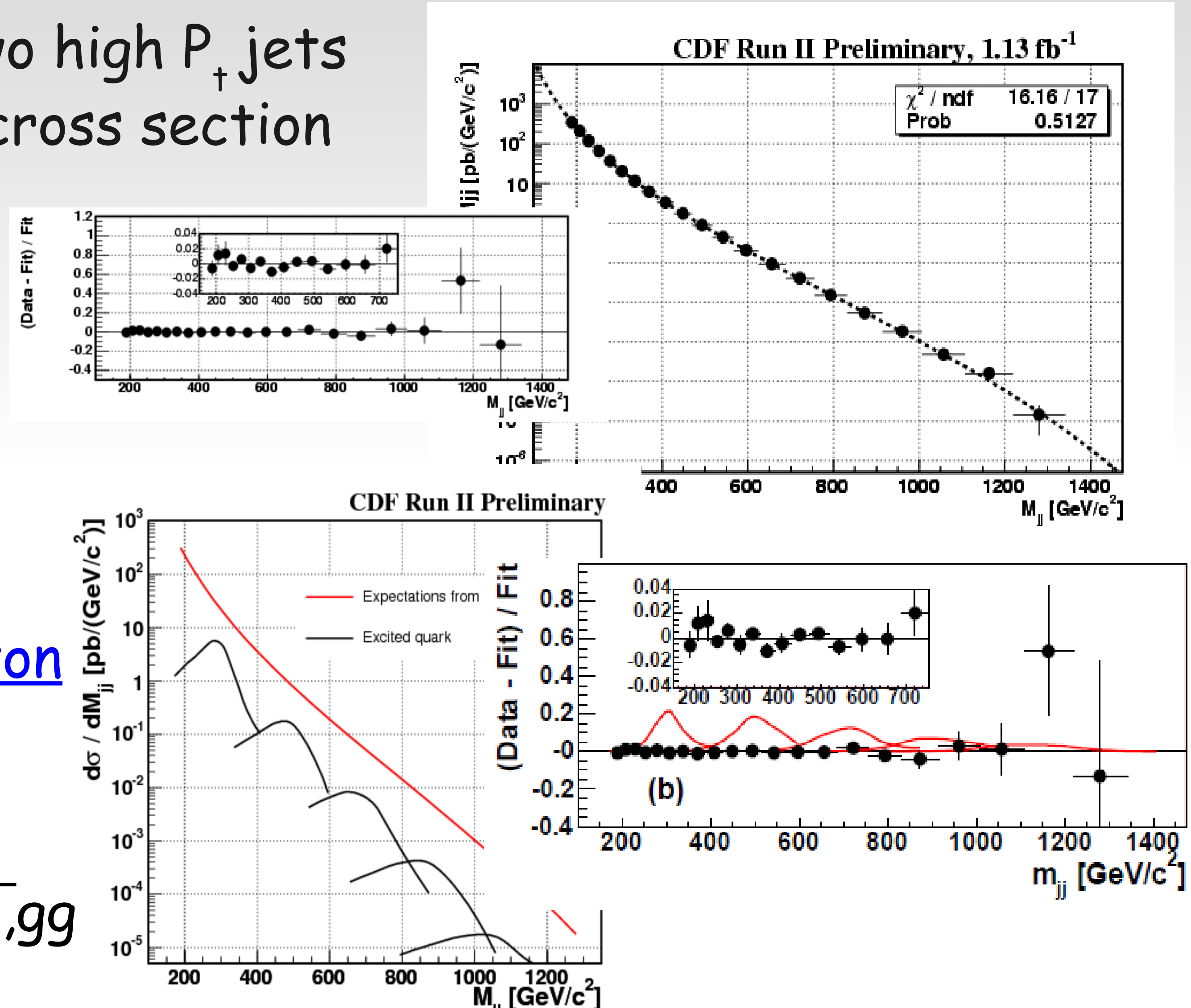
combined limit



Di-jets Final States:mass bumps

Selects events with two high P_t jets

Look for bumps in M_{jj} cross section



Excited quarks

q*->qg

m(q*)=300, 500, 700, 900, 1100 GeV/c^2.

Randall-Sundrum graviton

g_{RS}->$q\bar{q}$ g_{RS}->gg

Technicolor models:

color-octet technip->$q\bar{q}$,gg

Di-jets Final States:mass bumps cont'd

Red:

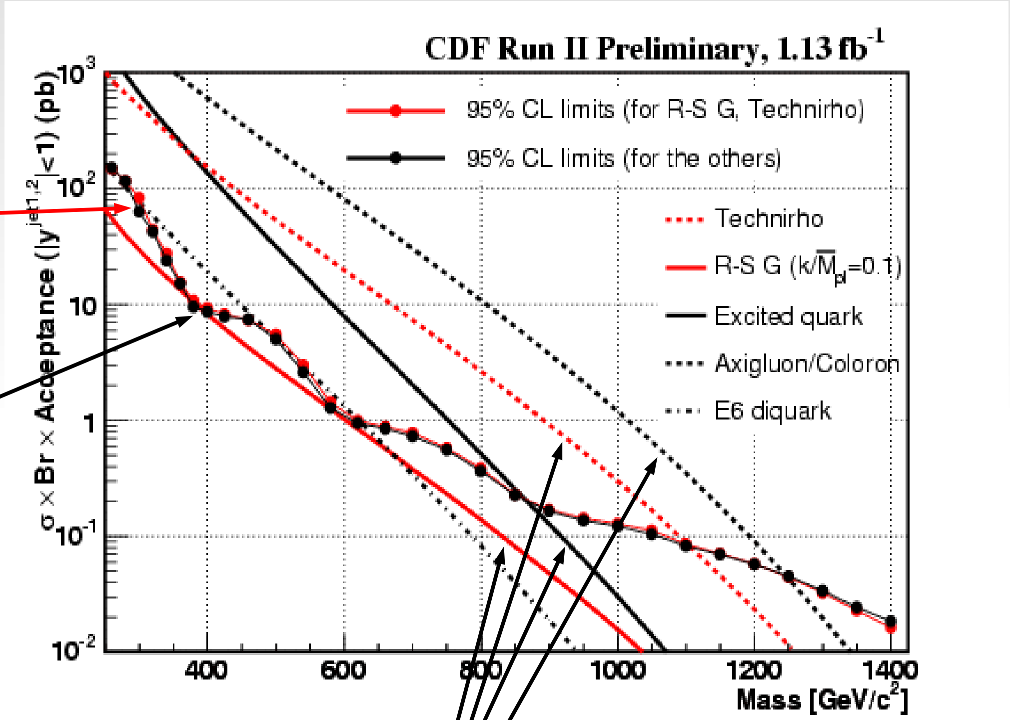
limits on:

- Randall-Sundrum graviton
- color-octet techni-ρ

Black

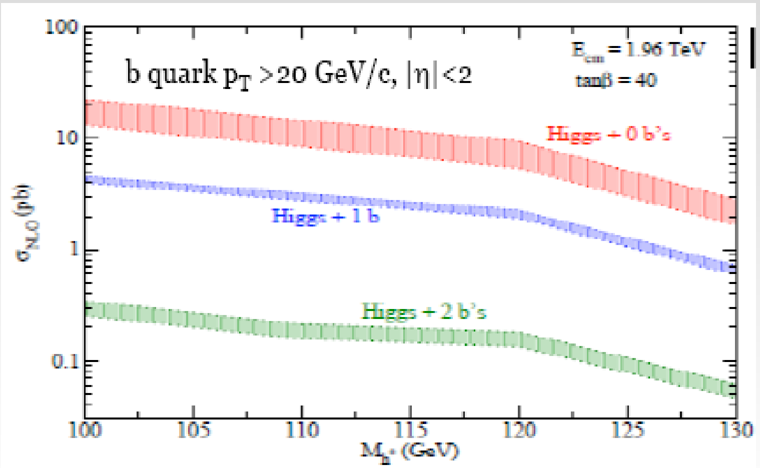
limits on:

- excited quark
- axigluon
- flavor-universal coloron,
- E6 diquark



These limits are compared with theoretical predictions

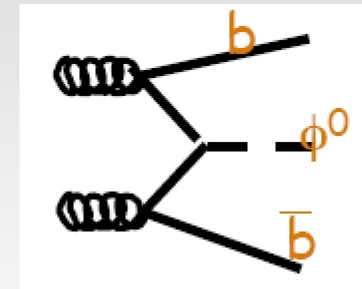
Di-jets Final States: $b\bar{b}$



Inclusive bb hard due to QCD bck

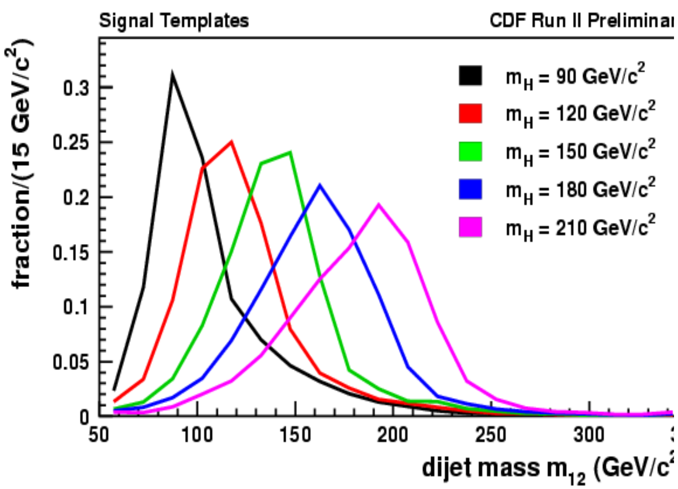
Require a 3[d] b-jets

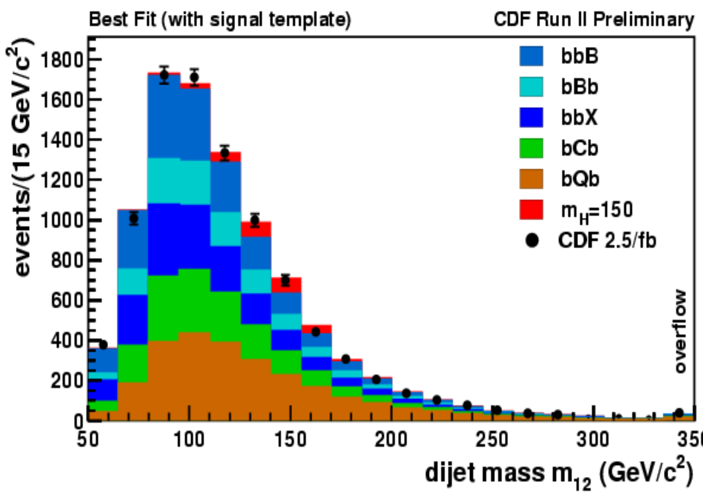
Good compromise between signal and background rate

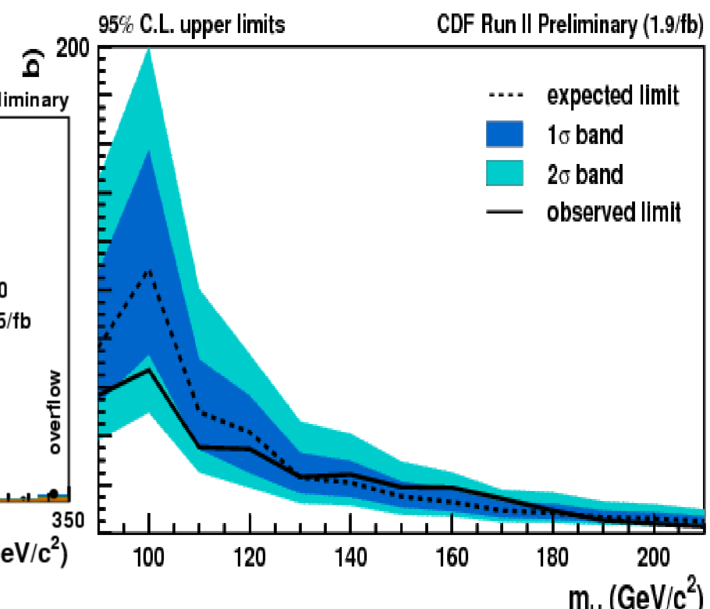


M_{12}, inv. mass 2 leading jets separate signal from background

Result:







Leptoquarks searches

Leptoquarks are proposed as link among quarks and leptons, with fractionally-charged color-triplet bosons carrying both lepton and baryon quantum numbers. Leptoquarks appear in a wide range of theories, including SU(5) grand unification, superstrings, SU(4) Pati-Salam, and compositeness models.

1st Generation	2nd Generation	3rd Generation
$LQ\,\overline{LQ} \rightarrow e^- e^+ q\bar{q}$	$LQ\,\overline{LQ} \rightarrow \mu^+ \mu^- q\bar{q}$	$LQ\,\overline{LQ} \rightarrow \tau^+ \tau^- q\bar{q}$
$LQ\,\overline{LQ} \rightarrow e^{\pm} \nu_e q_i q_j$	$LQ\,\overline{LQ} \rightarrow \mu^{\pm} \nu_\mu q_i q_j$	$LQ\,\overline{LQ} \rightarrow \tau^{\pm} \nu q_i q_j$
$LQ\,\overline{LQ} \rightarrow \nu_e \nu_e q\bar{q}$	$LQ\,\overline{LQ} \rightarrow \nu_\mu \nu_\mu q\bar{q}$	$LQ\,\overline{LQ} \rightarrow \nu_\tau \nu_\tau q\bar{q}$

Final states with:
-jets
-leptons
-neutrinos (MET)

Leptoquarks searches cont'd

First generation:

* di-electrons + jets
* electron + MET + jets
* MET + jets

Main background:
W+jets, top, Z+jets

Second generation:

* di-muons + jets
* muon + MET + jets
* MET + jets

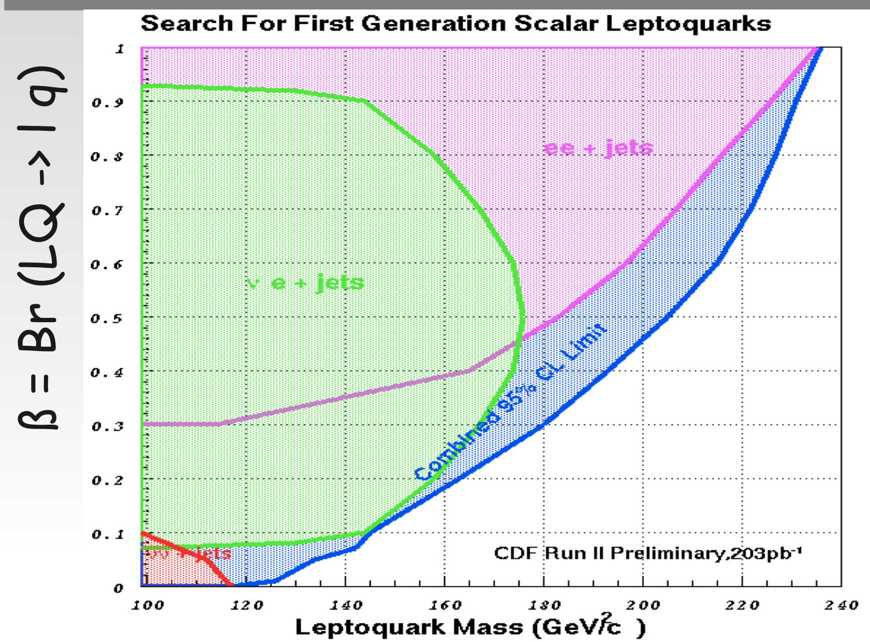
Main background:
W+jets, top, Z+jets

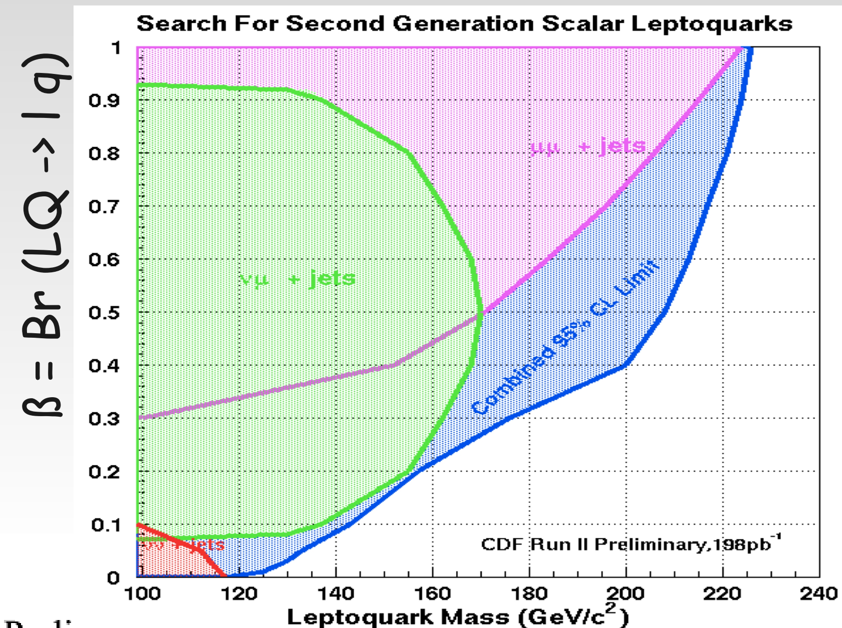
Third generation:

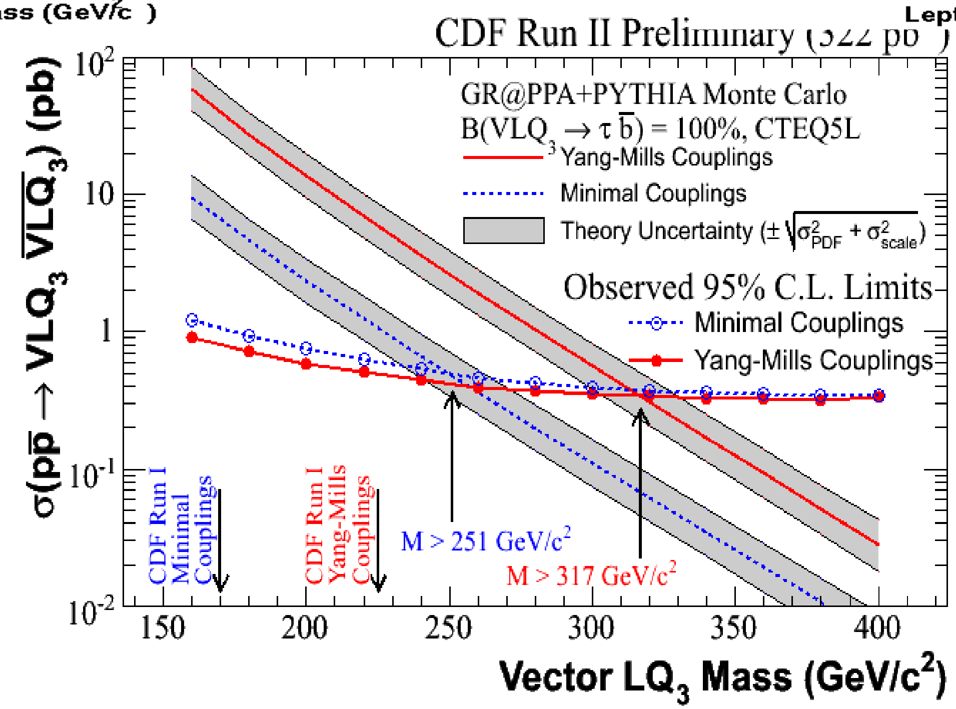
* di-taus + jets
* tau + MET + jets
* MET + jets

Main background:
W+jets, Z, QCD

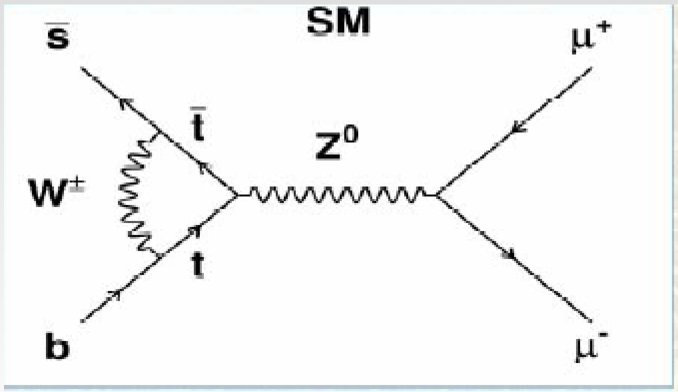
Leptoquarks searches: Results



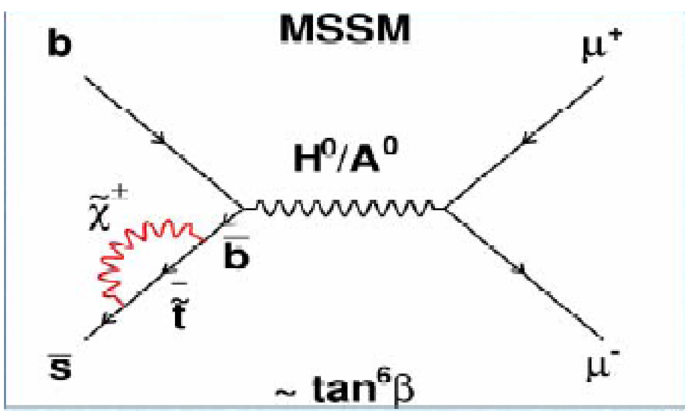




Non Standard SUSYSearches: $B_s \to \mu\mu$



SM: BR = 3.86×10^{-9}



SUSY enhance $\sim(\tan\beta)^6$

Various SM extentions predict enhancements by one to three orders of magnitude.

Some models attempt to explain:

-deviation of the muon (g-2),

-neutrino oscillations,

-Bs oscillation phase

-dark matter/dark energy results.

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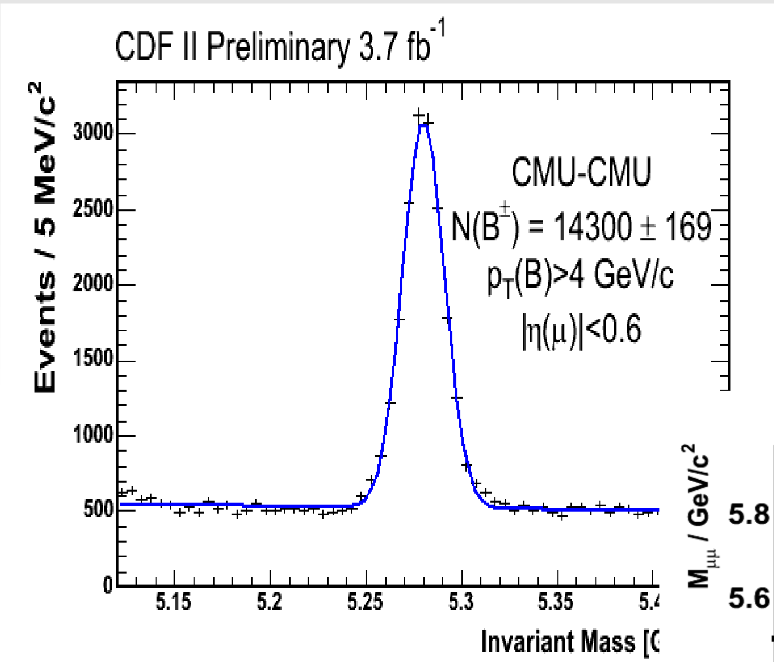
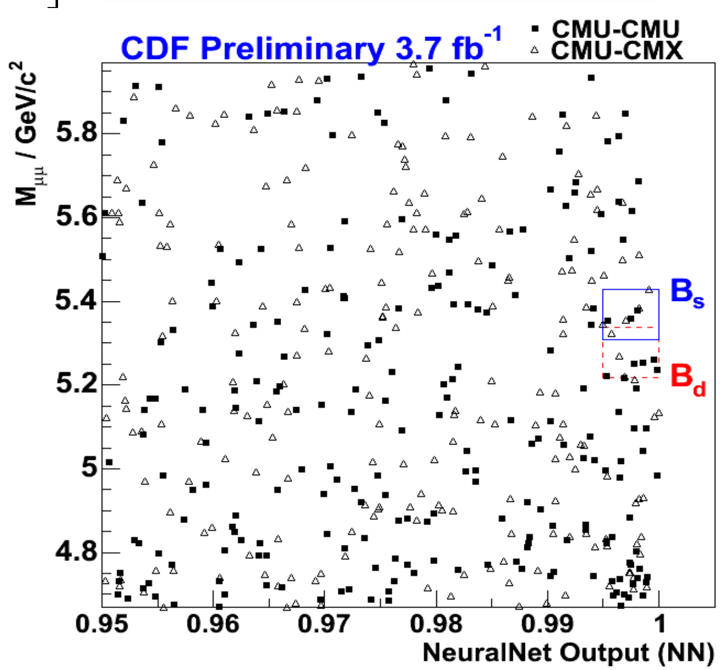
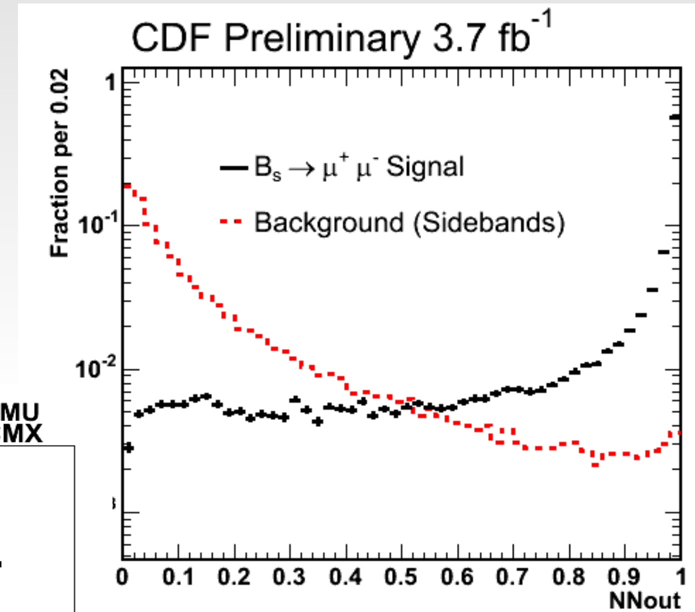
Non Standard SuSy Searches: $B_s \to \mu\mu$

Number of candidates $B_s \to \mu\mu$ normalized to the number of $B^+ \to J/\psi K^+$

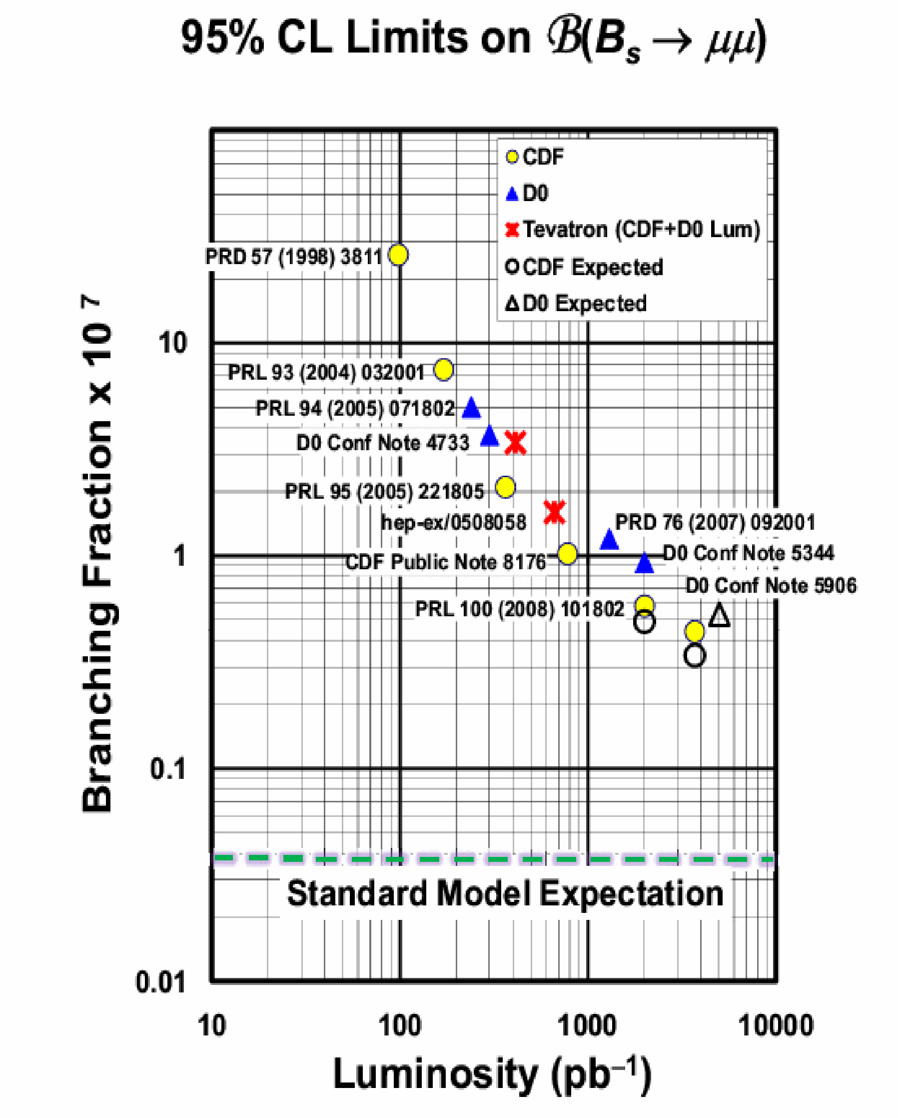






NN cut>0.95

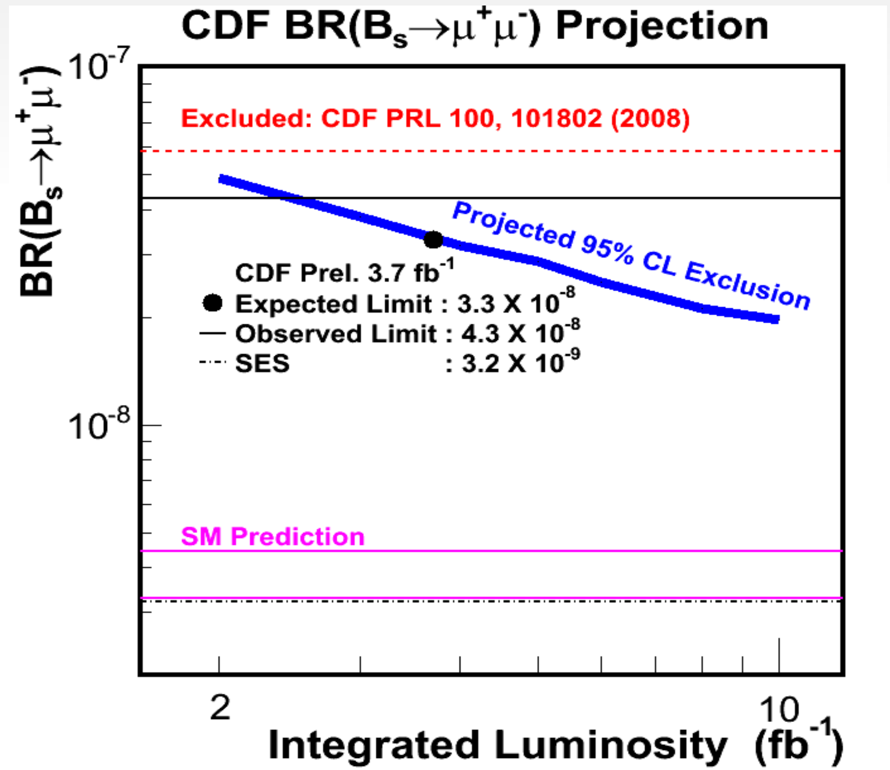
B_s->μμ Results



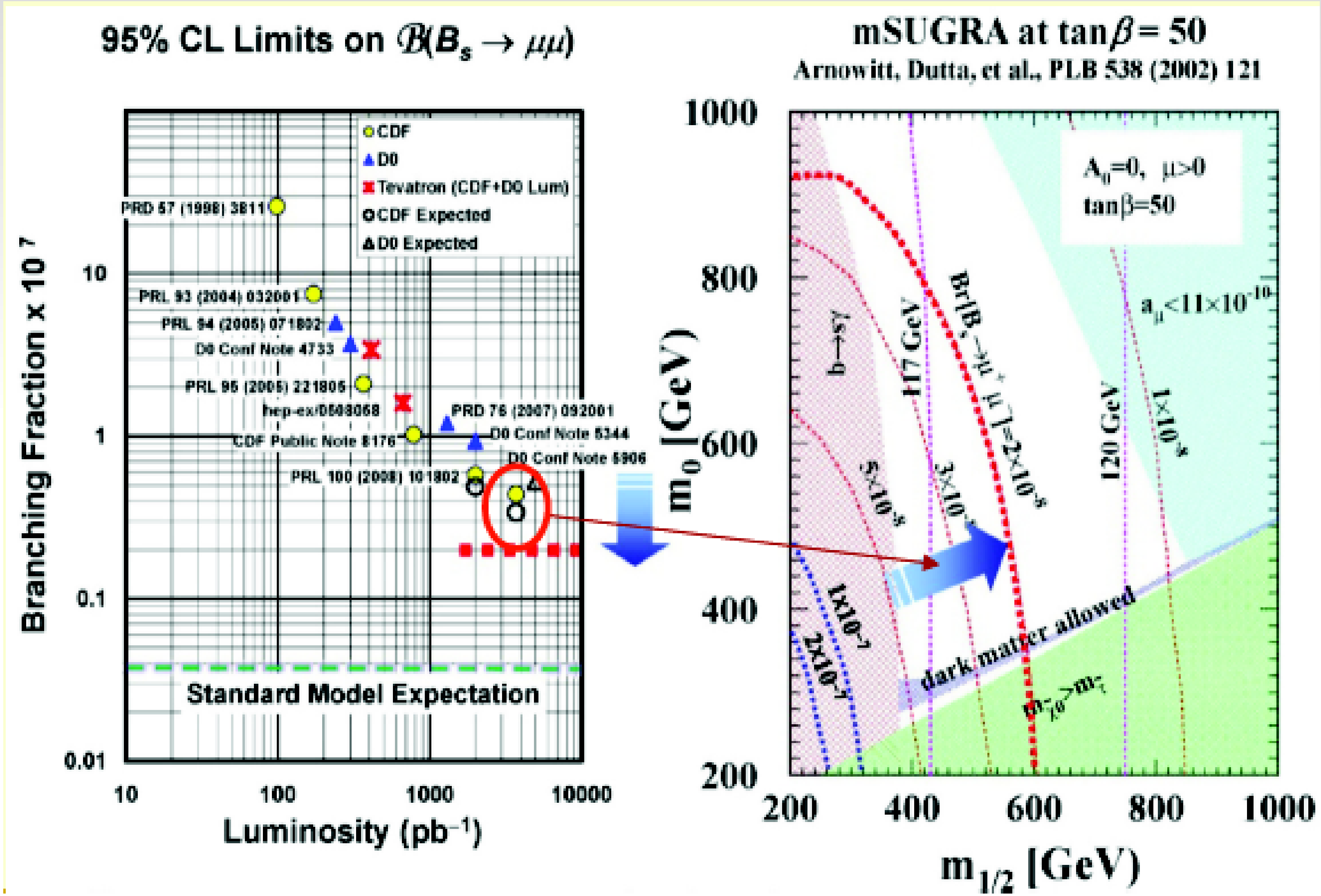
Current limit:

BR(Bs → μμ) < 4.3x10-8 @95% CL

BR(Bd → μμ) < 7.6x10-9 @95% CL



$B_s \to \mu\mu$ Results Implications



Is New Physics discovery possible for LHC?

The "energy desert" between electroweak and GUT scale is possible if Higgs is between 130 and 180 GeV

Ellis, Espinosa, Giudice, Hoecher, Riotto quoted by Masiero.