Search for new physics at the Tevatron

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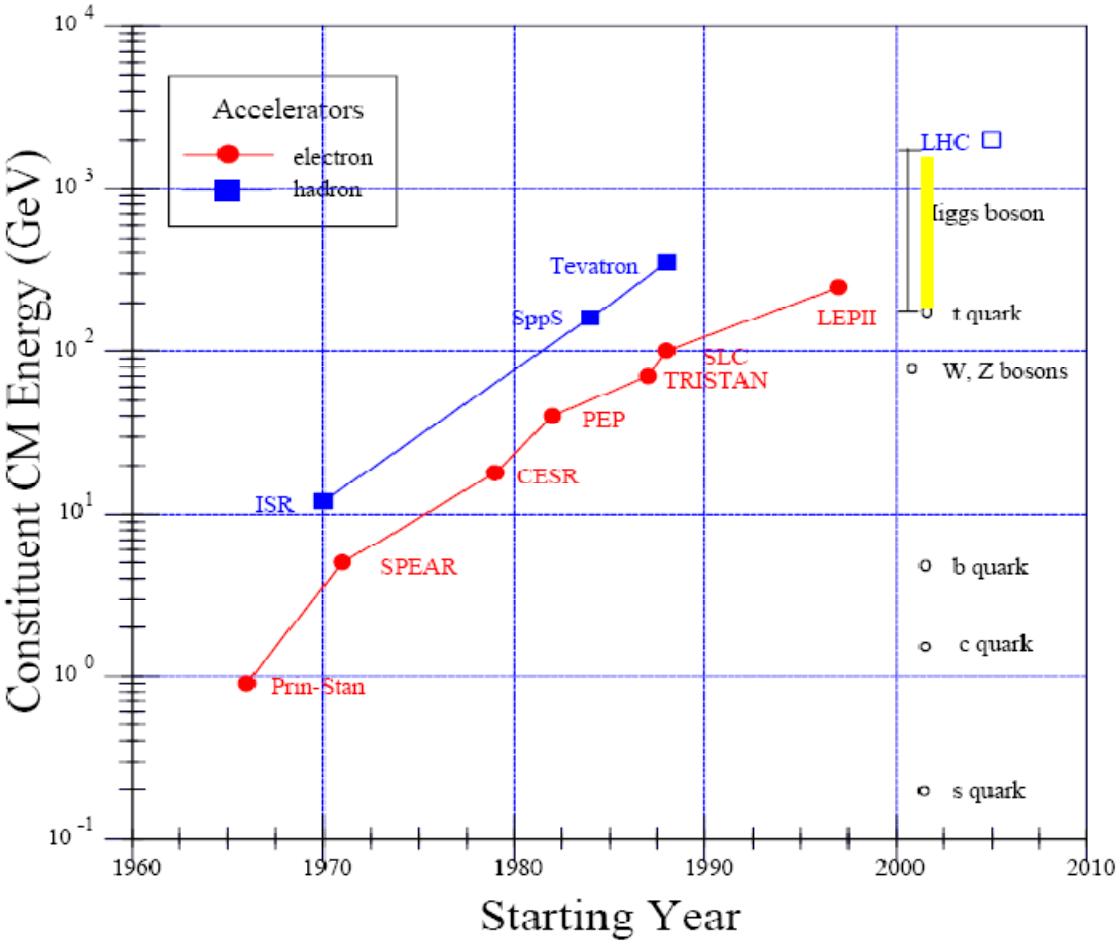
IFT/UNESP

On behalf of DZero and CDF collaborations

Tev Energy Scale

- Why is the TeV scale special?
  - It is the scale of EW symmetry breaking
  - We don´t know how masses are generated
  - In the Standard Model the Higgs mechanism is evoked (Barbara´s talk)
- New Physics Beyond Standard Model?
  - Supersymmetry
  - Extra Dimensions
  - Other models

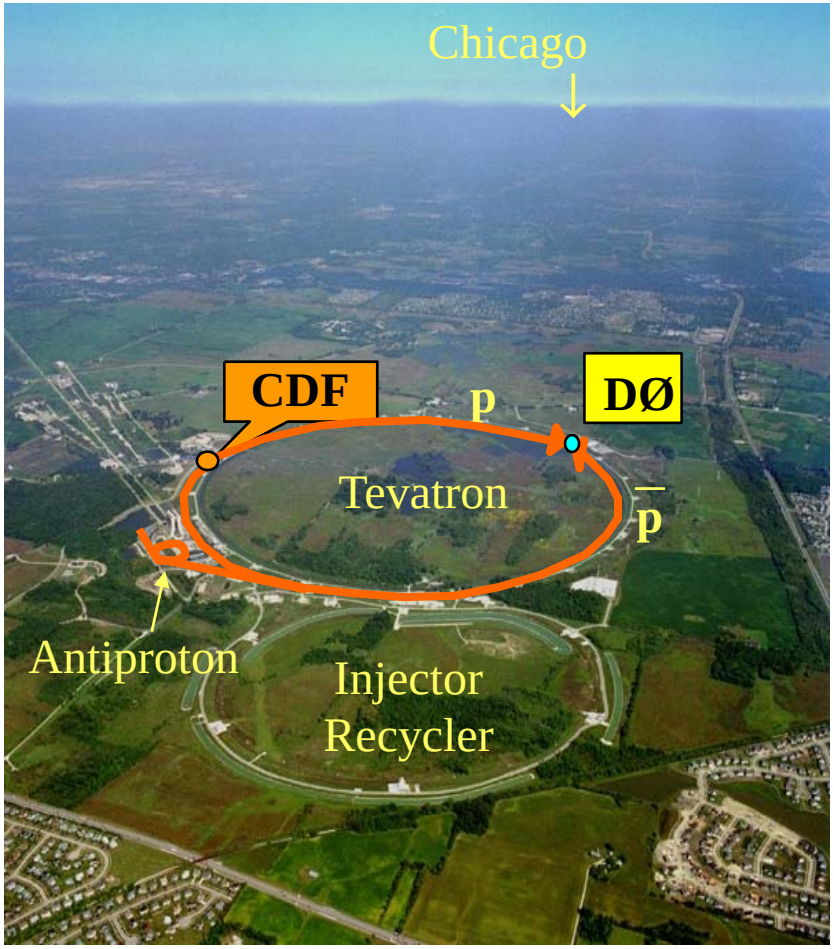
Past and Future Accelerators



Tevatron Run II

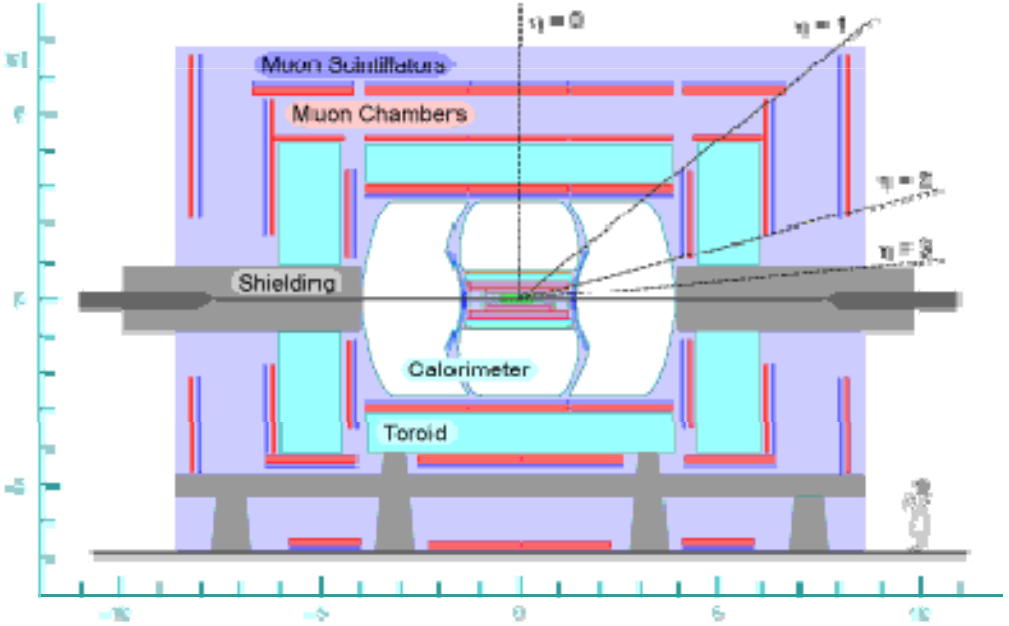
Still at the Energy Frontier

- Accelerator
  - $p\bar{p}$
  - 1.96 TeV
  - L = 4-5 fb^{-1} to be analyzed. In this talk 1-3 fb^{-1} results will be presented
- Detectors
  - Good coverage
  - Good particle identification

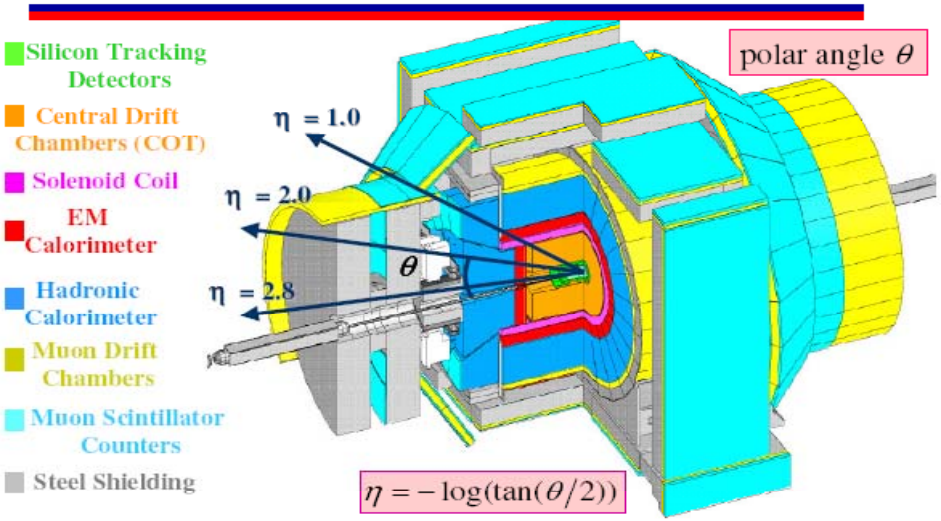


Detectors

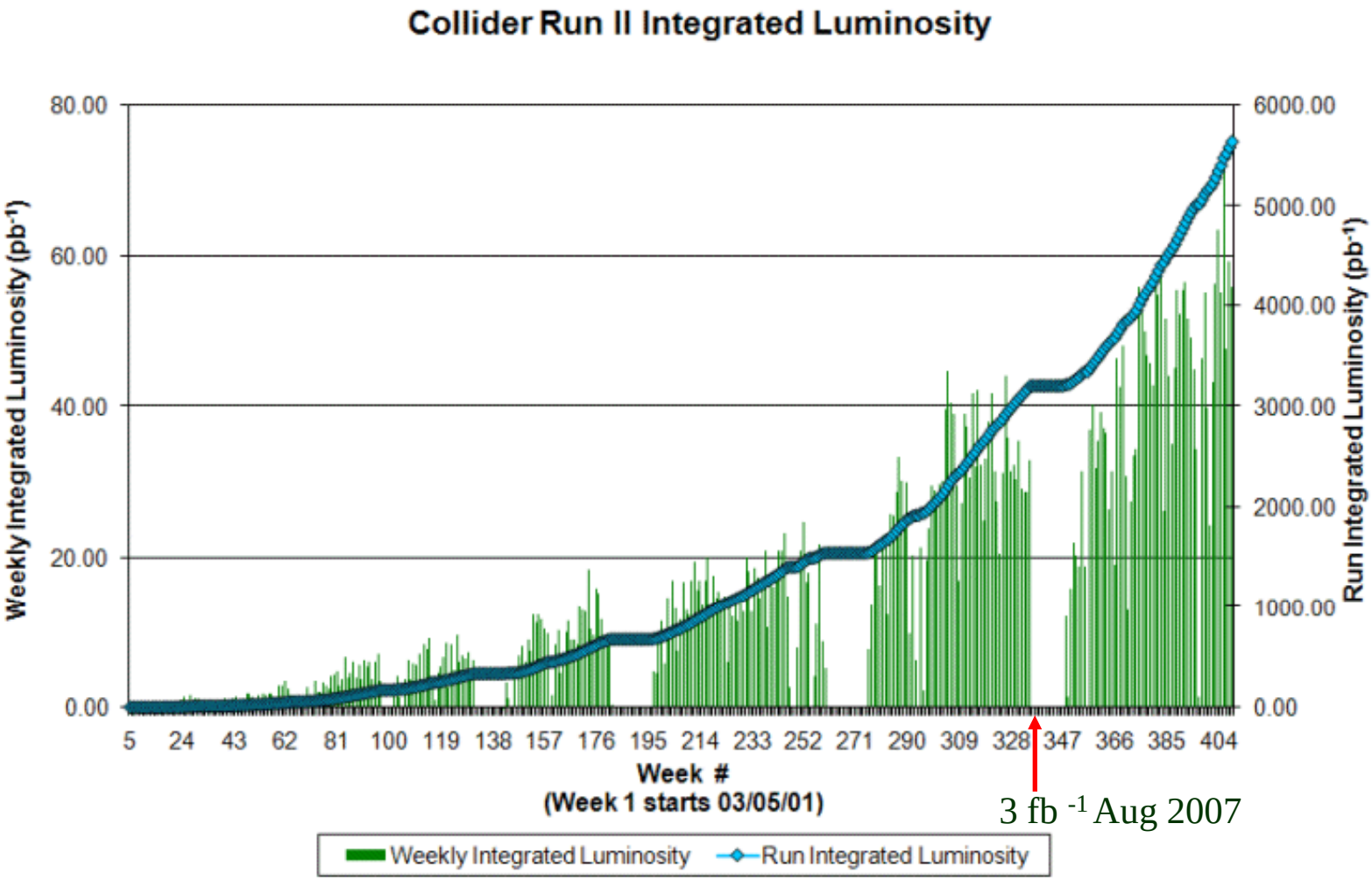
DZero Detector



CDF Detector



Integrated Luminosity



The MSSM

Minimal supersymmetric model

- Two Higgs doublet SM + Superpartners
- μ parameter
- tan β
- Superpotential

Soft Terms

- Scalar Masses (m_0)
- Gauginos Masses ($m_{1/2}$)
- Trilinear (A) Parameter
- Bilinear (B) Parameter

$$W = \mu H_d H_u + f_l L H_d E + f_d Q H_d D + f_u Q H_u U$$
$$+ \lambda LLE + \lambda' LQD + \lambda'' LQD + \varepsilon L H_u$$

Supersymmetry

Which SUSY?

- mSUGRA (Constrained MSSM)

  m_0, $m_{1/2}$, tan β, A, sign μ

  – gluino + squark

  – gluino + sbotton

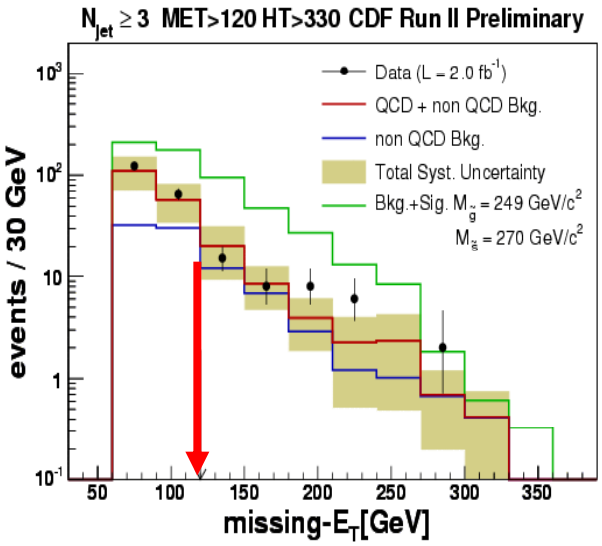
  – trilepton

- AMSB and GMSB
- R parity Violation Models

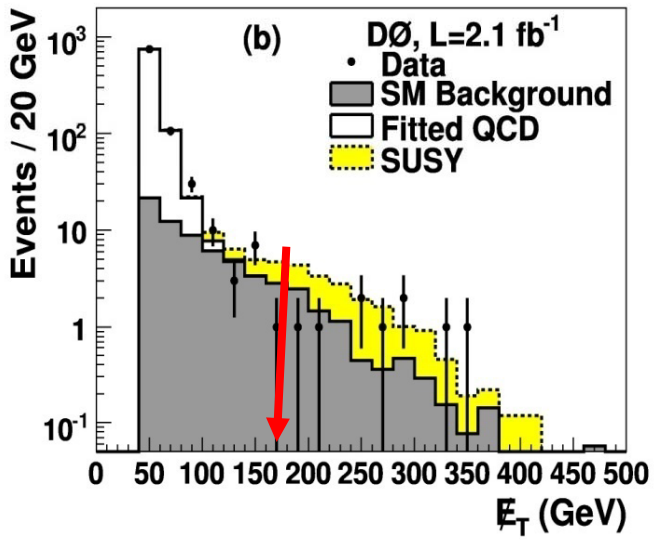
mSugra

gluinos (jet + missing E_T) cdf arXiv:0811.2512

- General search: gluino + squarks production
- Jets + missing E_T
  - Missing E_T
  - 2,3,4 Jets; p_T > 25 GeV
  - Angles
  - Lepton veto

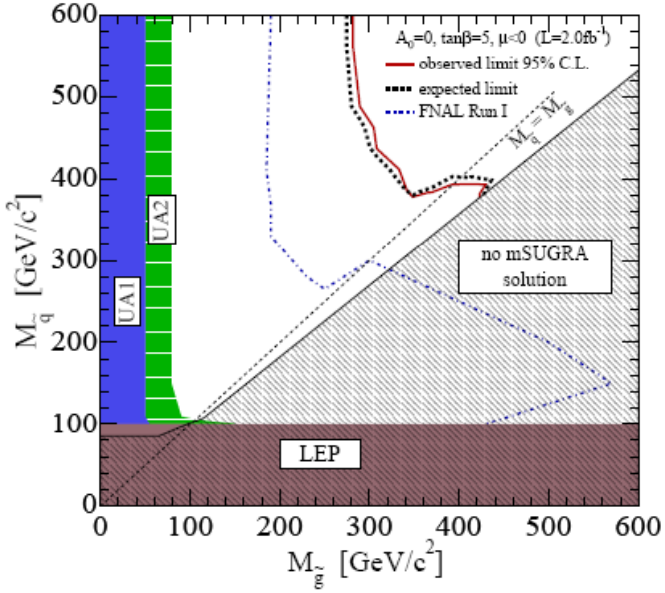


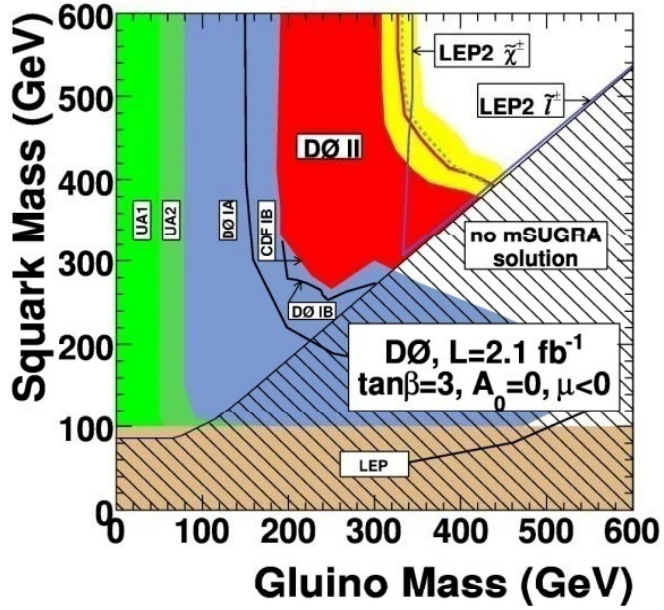
	2 jets	3 jets	4 jets(gluino)
CDF	H_T>330, E_T>180GeV/c^2	H_T>330, E_T>120GeV/c^2	H_T>280, E_T>90GeV/c^2
Data	**18**	**38**	**45**
Expected SM	**16±5**	**37±12**	**47±17**
D0	H_T>330, E_T>225GeV/c^2	H_T>375, E_T>175GeV/c^2	H_T>400,E_{T_2}>100GeV/c
Data	**11**	**9**	**20**
Expected SM	**11.1±1.2**	**10.7±0.9**	**17.7±1.1**



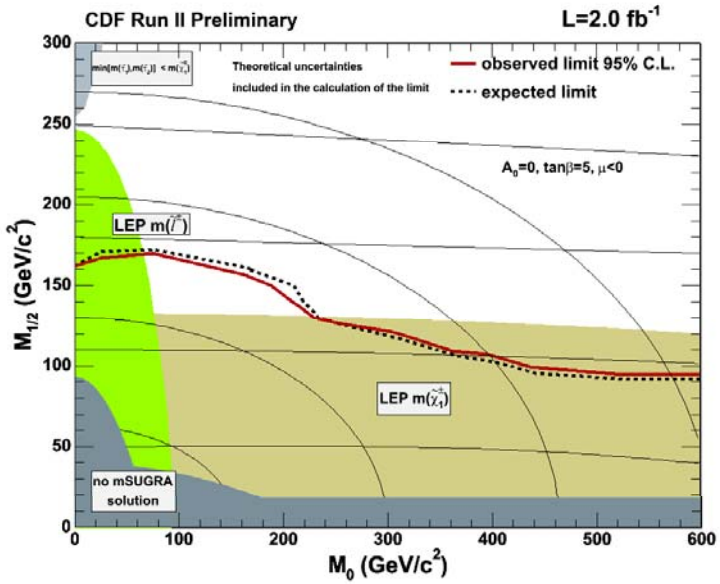
PLB 660,449

Results



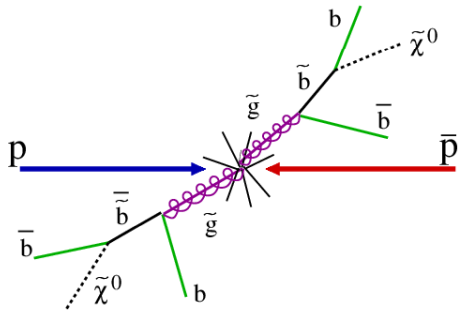


- Results on squark and gluino mass.
  - For squark mass = gluino mass
    -> m > 392 GeV
- Results in the plane m_0 X $m_{1/2}$
- DZero has similar limits

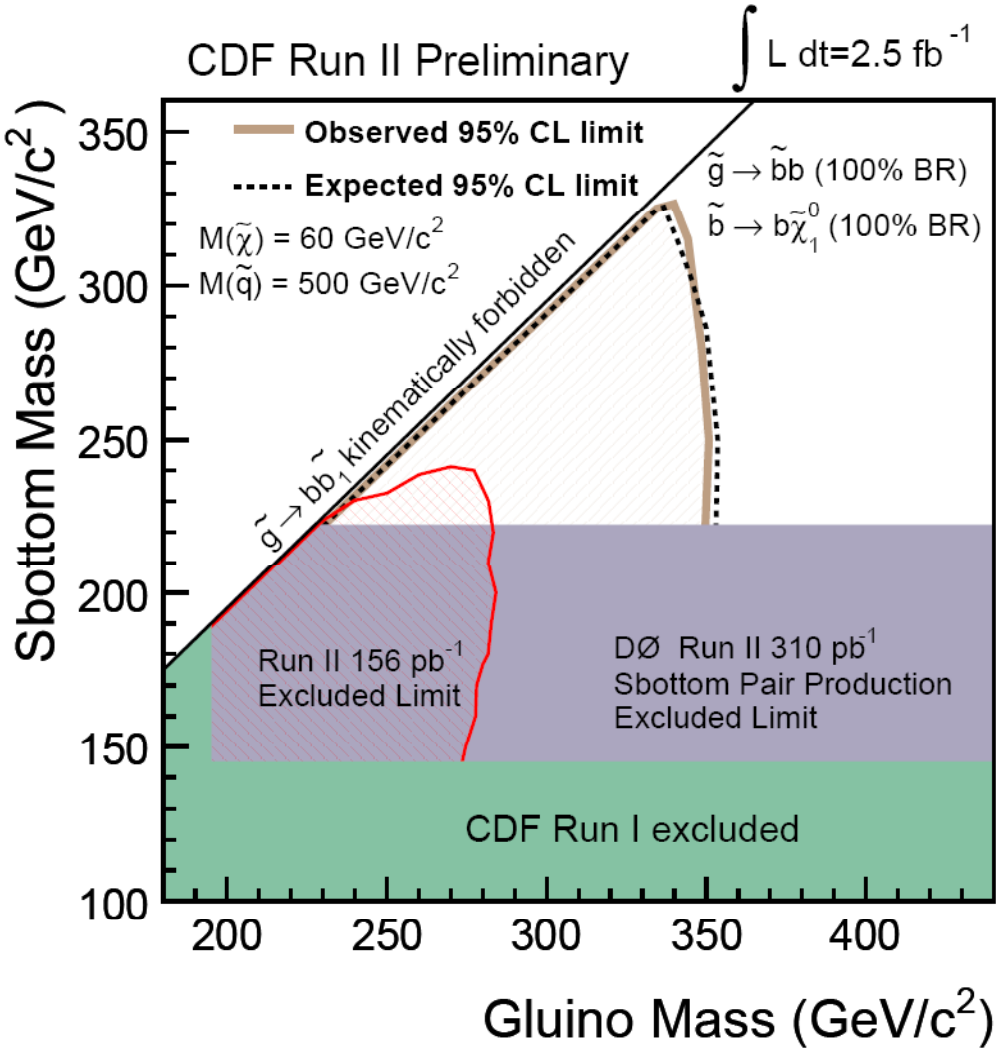


mSugra
gluinos (b-jet + missing E_T)

http://www-cdf.fnal.gov/physics/exotic/r2a/20080821.bbmet_gluinosbottom/

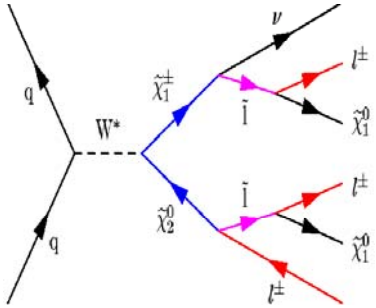


- Gluino -> Sbottons
- Jets + missing E_T
  - 2 jets
  - 1 b tag
  - 2 b tag



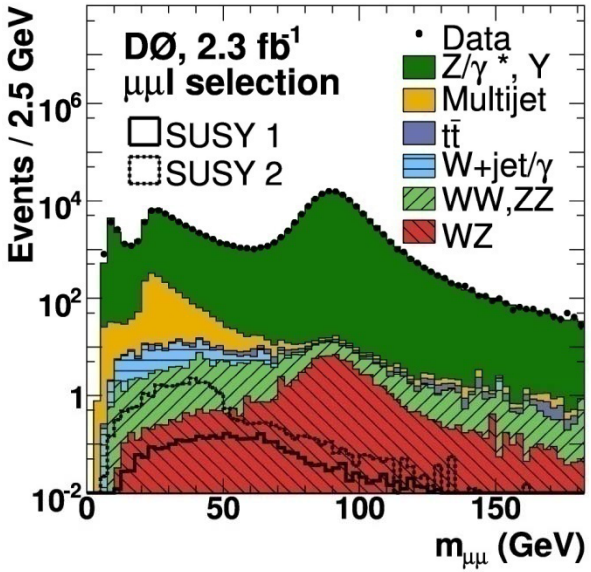
mSugra

Charginos (trileptons) D0 arXiv:0901.0646



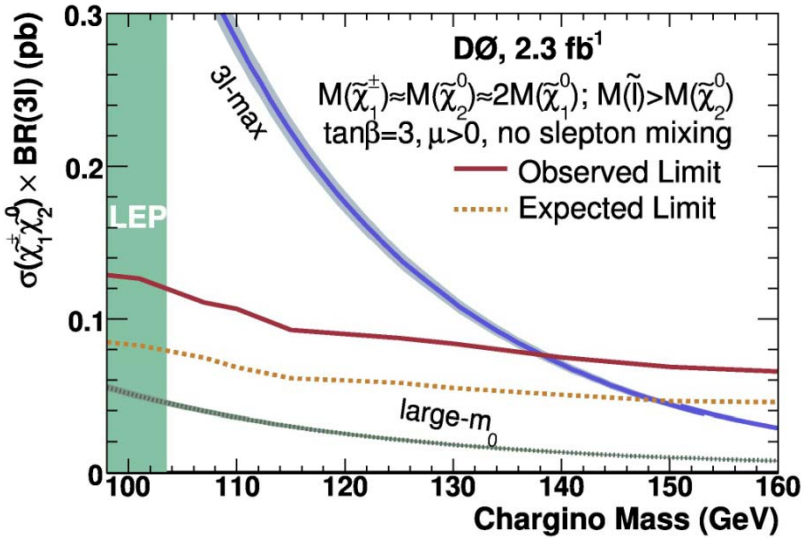
- Trilepton Signal: Clean signal
- Model dependent
- 4 channels $p_{Tl} > 12, 8$ GeV
  - e,e, l
  - e,μ,l
  - μ, μ, l
  - μ ,τ, l
- In all channels the extra lepton is a track

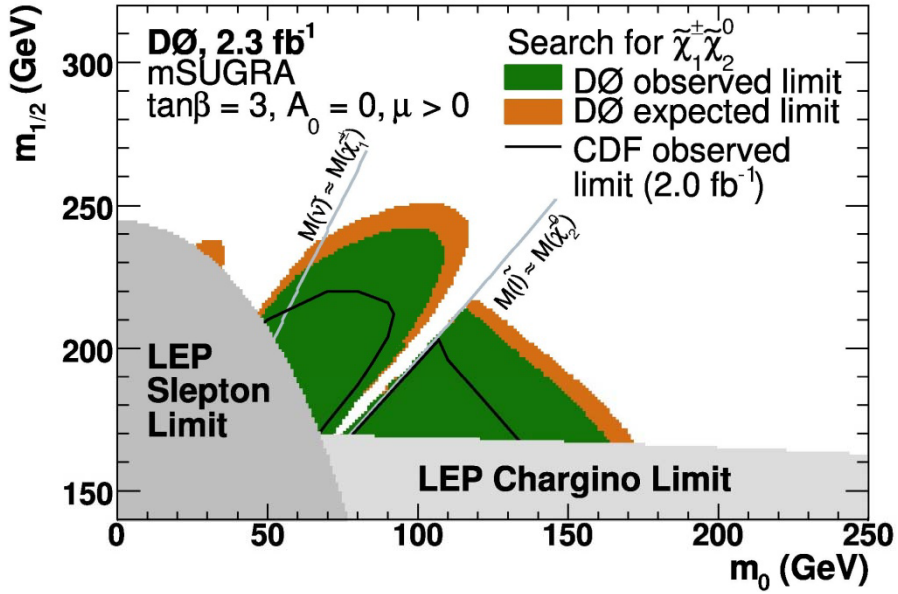
- Cuts:
  - Two set of p_T cut
  - Invariant mass, angular cut
  - Transverse mass, missing E_T, jet veto
  - Track p_T
  - Invariant mass l-track



mSugra

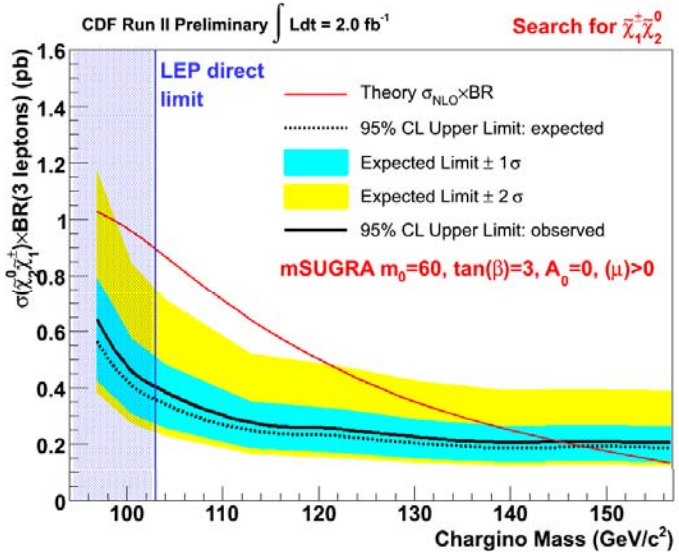
Charginos (trileptons)





- Limits for σ X BR
- Best limits on the context of mSugra
- Similar search from CDF published with 2 fb $^{-1}$

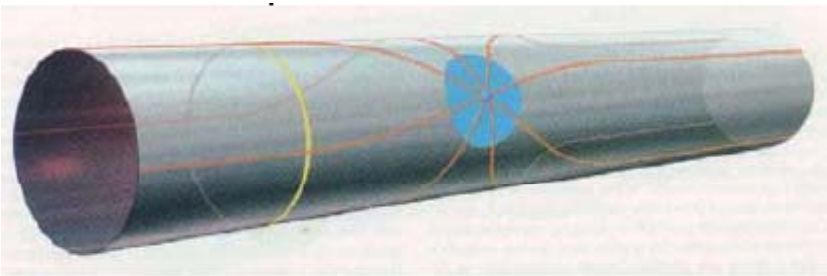
http://www-cdf.fnal.gov/physics/exotic/r2a/20080110.trilepton_dube/

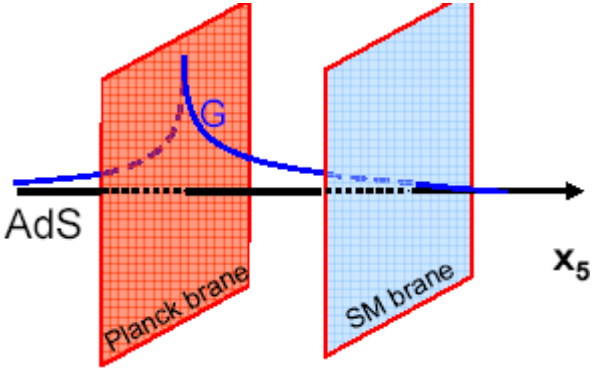


Extra Dimensions

Are there new extra Dimension?

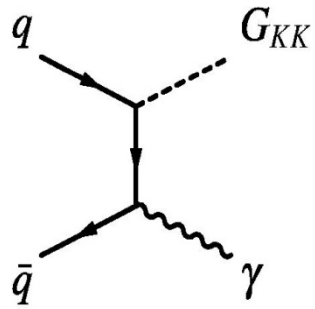
- Large Extra Dimensions (ADD models)
  - Only gravity propagates in the extra dimensions
  - Direct signal: missing ET from the sum of KK states propagating in the bulk
  - Indirect signal: sum of KK towers modify the production of SM particles
- Universal Extra Dimensions
  - All particles can propagate in the extra dimensions. All particle have new excited states
  - Signals are similar to those of SUSY
- Randall Sundrum models
  - Excited states of gravitons are heavy. Might be produced and decay in pairs of SM particles



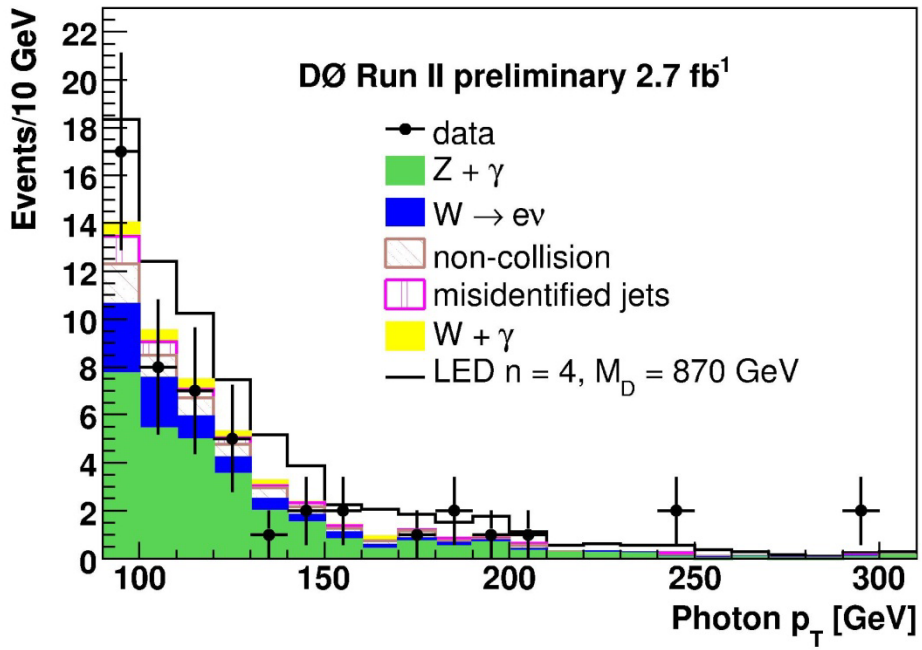


Large Extra Dimensions

Direct signal: photon + missing E_T D0 PRL **101**, 011601



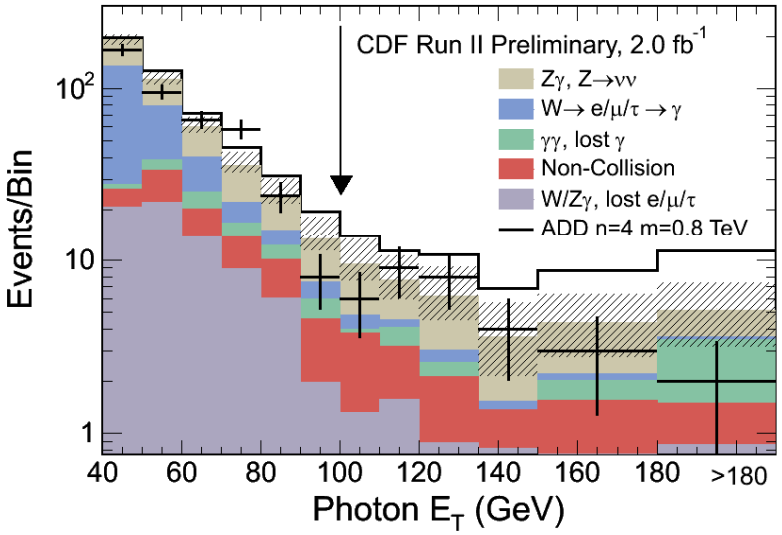
- Selection
  - p_T > 90 GeV, missing E_T > 70 GeV
  - No jets (p_T > 15 GeV), no Leptons (muons, tracks with p_T > 8 GeV)

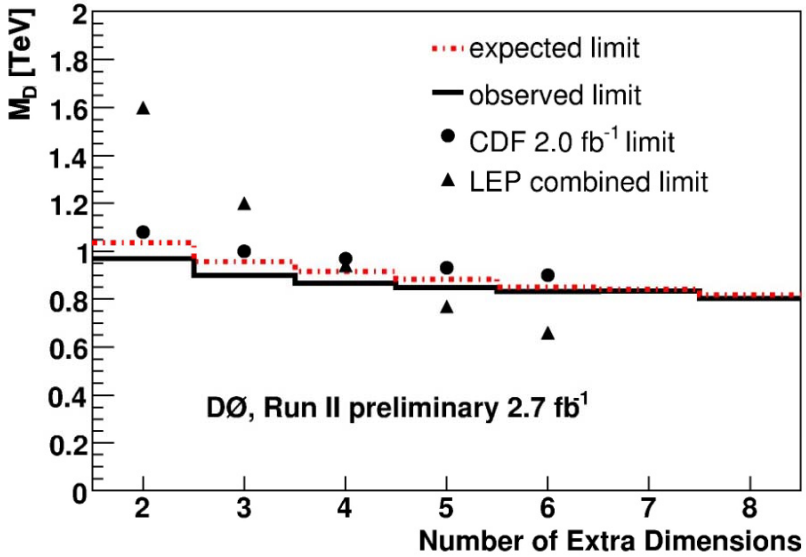


- Background
  - Non Collision
  - Miss identified jet
  - Z + gamma

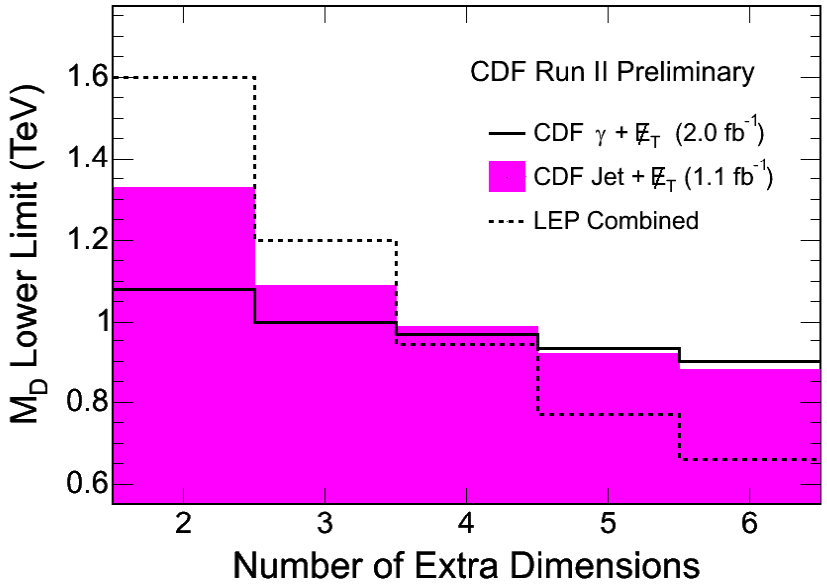
51 Data Events 49.9 expected

Limits





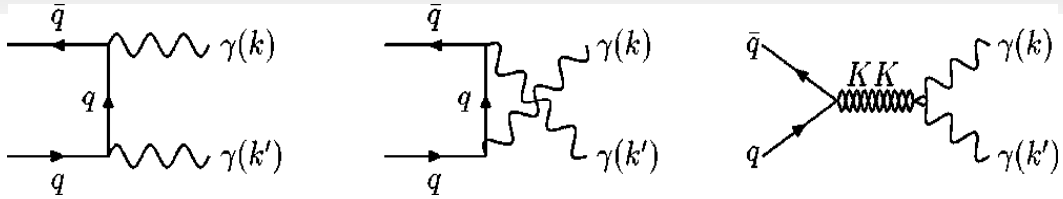
- Limits are set depending on the number of extra dimension
- For n=2,3,4 M > 970, 899, 867 GeV
- CDF has similar results (PRL 101, 181602)



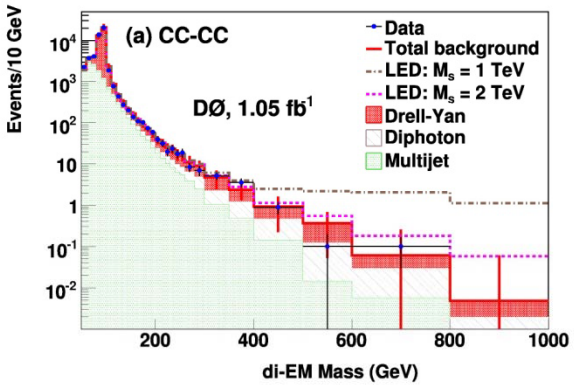
LED

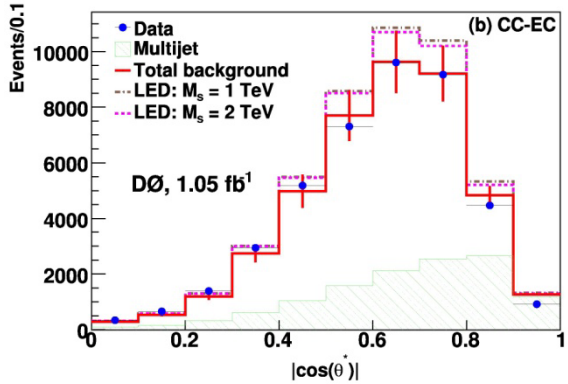
D0 arXiv:0809.2813

Virtual Graviton exchange: Diphotons and dielectrons



- Sensitive to the cutoff
- Selection:
  - Eletromagnetic (EM) cluster with P_T > 15 GeV
  - Central and end cap cluster (CC-EC)
- Background
  - Drell Yan and γ γ production
  - Multijet





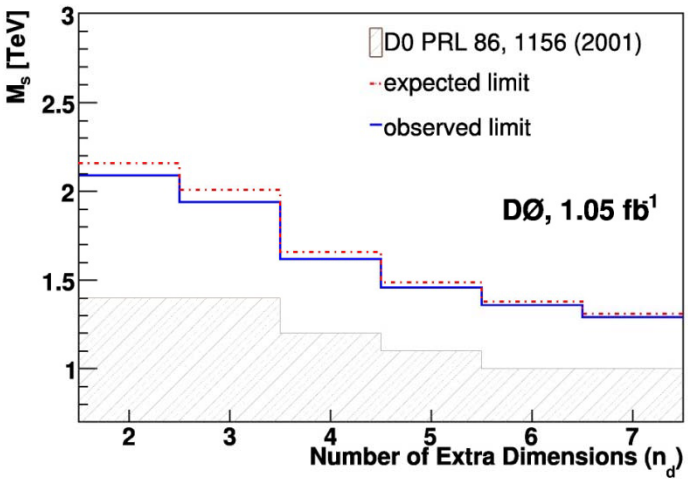


TABLE III: Observed and expected lower limits at the 95% C.L. on the effective Planck scale, M_s, in TeV.

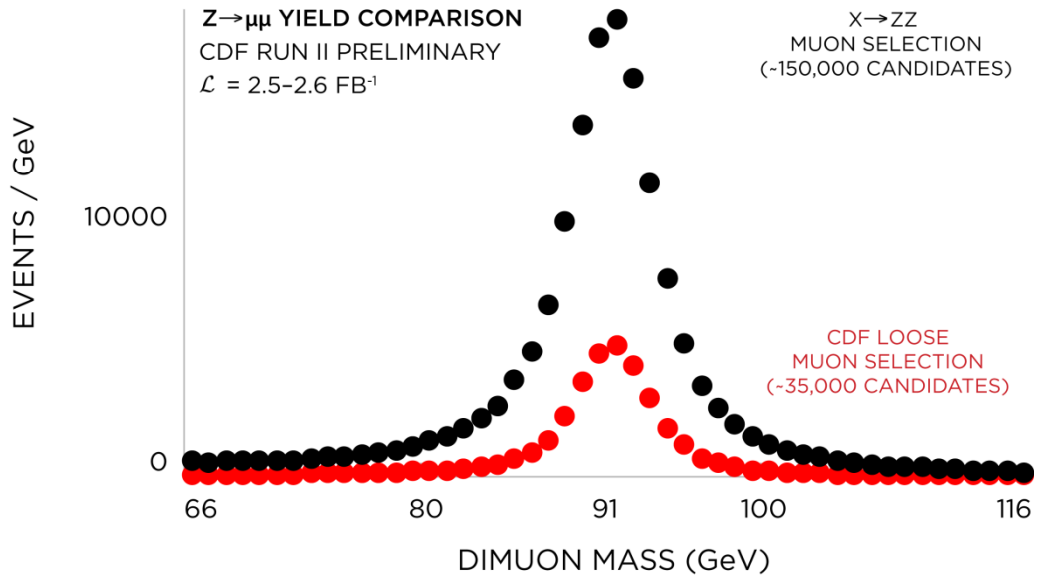
	GRW	HLZ					
n_d		2	3	4	5	6	7
Obs.	1.62	2.09	1.94	1.62	1.46	1.36	1.29
Exp.	1.66	2.16	2.01	1.66	1.49	1.38	1.31

Randall-Sundrum

ZZ resonance

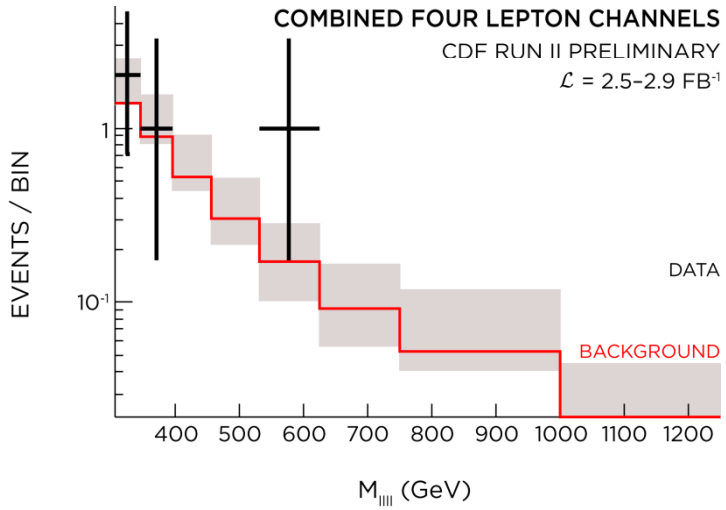
http://www-cdf.fnal.gov/~boveia/blessing/public/public.html

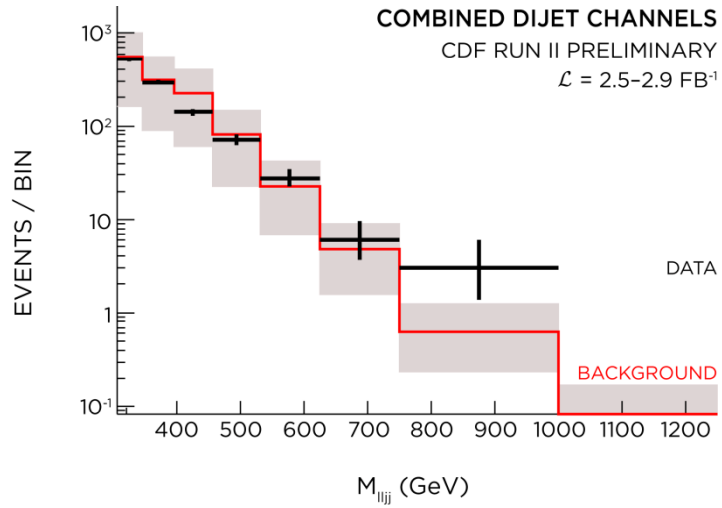
- G -> ZZ
  - eeμμ
  - μμ μμ
  - eeee
  - eejj
- Loose requirement for e and muons
  - Trigger e or μ: p_T > 20 GeV
  - Relaxed lepton (e, μ) + 2 jets (p_T > 10 GeV) or 2 relaxed lepton
- Estimate the bg from side bands



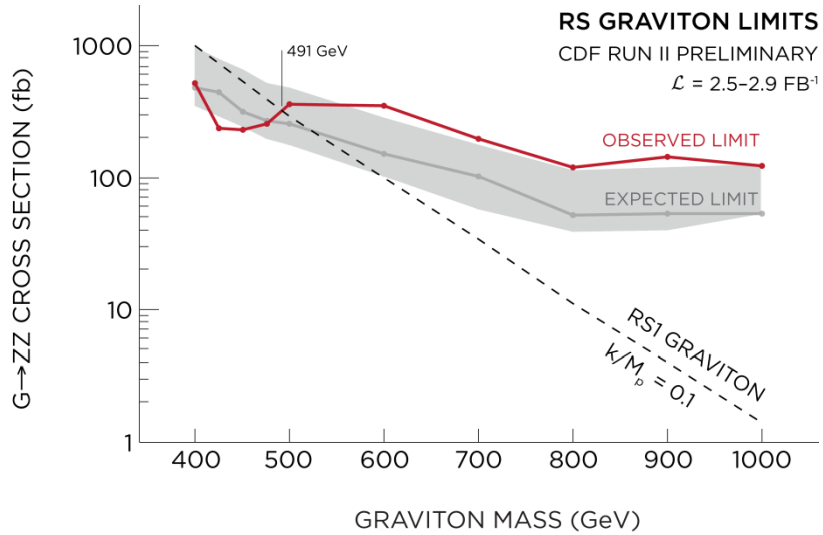
$$\chi^2_{ZZ} = \frac{(M_Z^{(1)} - 91.187\ \mathrm{GeV})^2}{\sigma^2_{M^{(1)}} + \sigma^2_\Gamma} + \frac{(M_Z^{(2)} - 91.187\ \mathrm{GeV})^2}{\sigma^2_{M^{(2)}} + \sigma^2_\Gamma}$$

Results





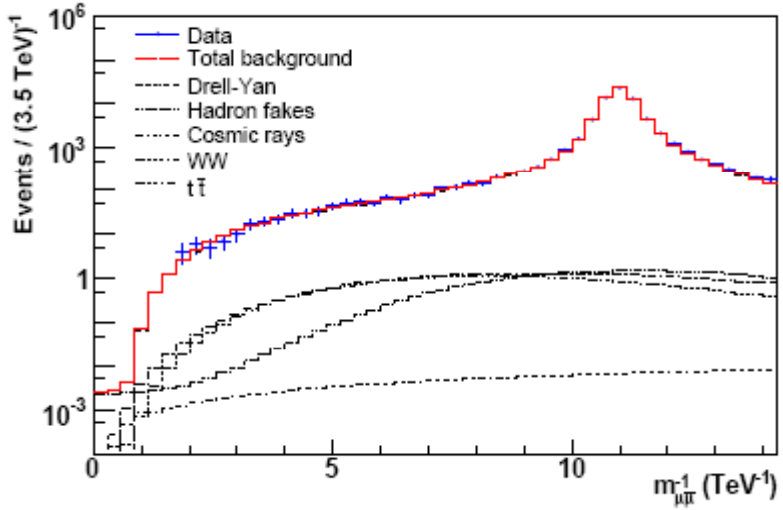
- Model independent results for M_x > 300 GeV
- In the Randall Sundrum framework leads to M > 491 GeV (k/M_{pl} = 0.1)

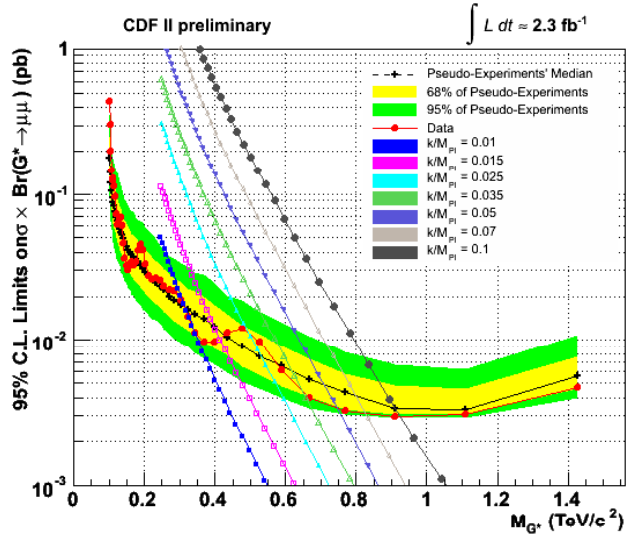


Di Muon
(Randall Sundrum)

CDF arXiv:0811.0053

- 2 Muon channel
- Selection
  - 2 muons
  - pt > 30 GeV
  - eta < 1
- Bg
  - Drell Yan
- Results
  - Spin2 (RS) mass > 921 GeV ($k/M_{pl} = 0.1$)
  - Spin 1 (Z´) mass > 1030 GeV
  - Spin 0 (sneutrino) mass > 810 GeV (λ*BR=0.01)



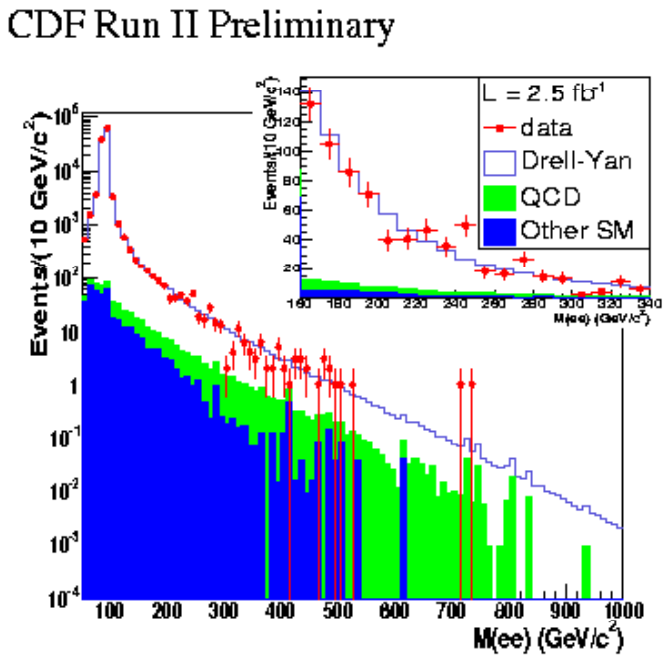


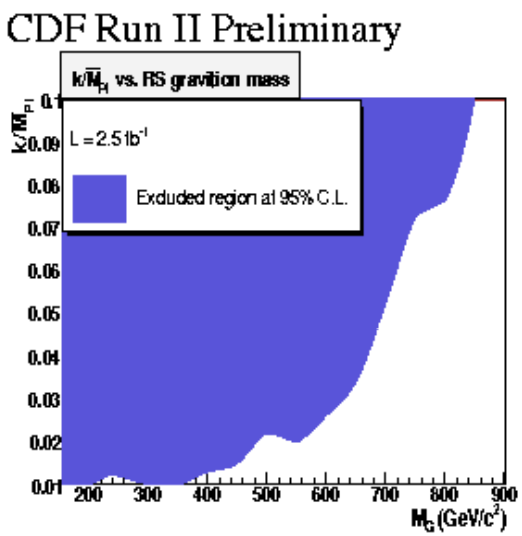
Di Electrons
(Randall Sundrum)

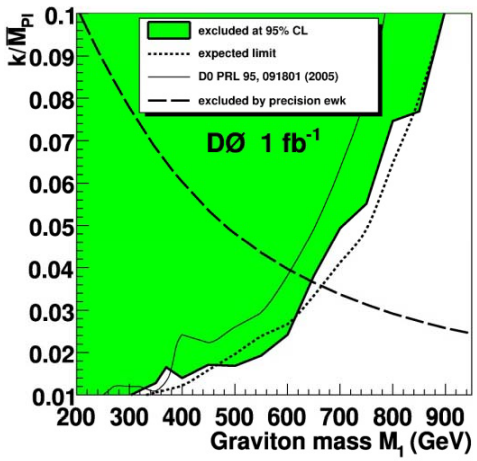
http://www-cdf.fnal.gov/physics/exotic/r2a/20080306.dielectron_duke/pub25/duke.html

- Selection
  - 2 electrons
  - $p_T > 25$ GeV
  - eta < 2
- Bg
  - Drell Yan
- Results
  - Spin 2 (RS) mass > 850 GeV ($k/M_{pl} = 0.1$)
  - Spin 1 (Z´) mass > 955 GeV
- Similar study from DZero
  - RS Graviton mass > 900 GeV ($k/M_{pl} = 0.1$)
  - 1 .1 fb^{-1}, ee+γγ signal

PRL 100, 091802

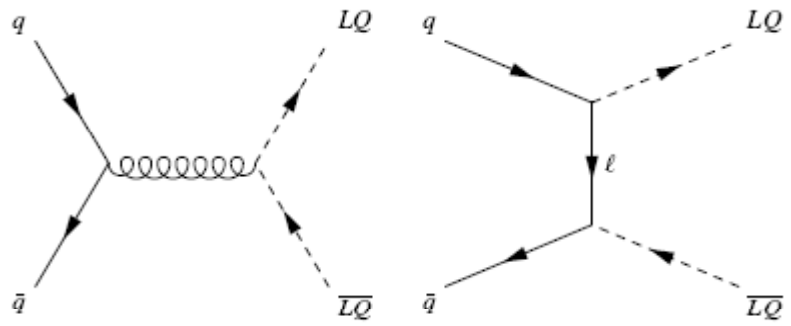






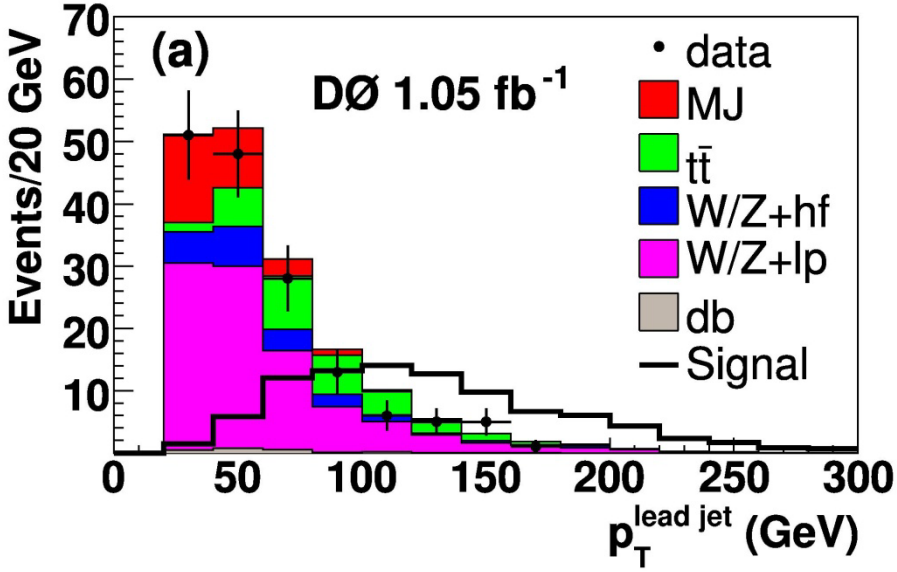
Leptoquarks (lepton + quark signal)

- Leptoquarks carries both color charge and lepton number
- Are present in several models
  - Compositness, GUT, Superstring
- Provides a clear signature
  - l+ jets
  - From FCNC suppression l+q should be of same generation



Third Generation LQ

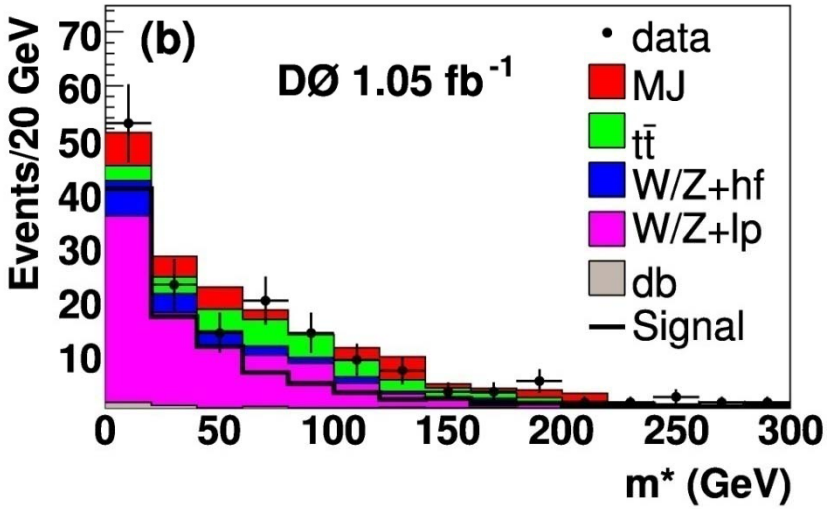
D0 arXiv:0806.3527

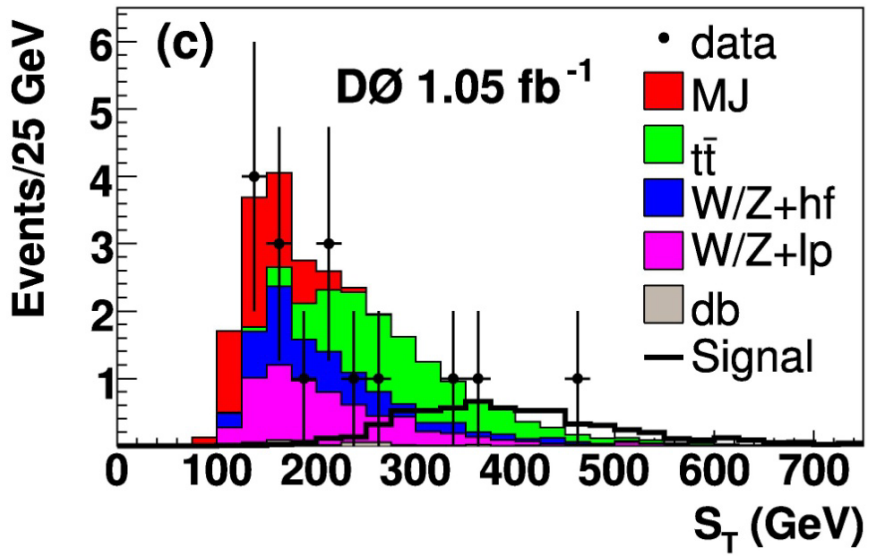


- LQ -> tau b
  - 2 b jets, 2 taus
- Pre selection
  - 2 jets, p_T > 20 GeV, eta < 2.5
  - 1 muon, p_T > 15, eta < 2
  - 1 hadronic tau (depend on decay mode)
    - $\tau^{\pm} \rightarrow \pi^{\pm}\nu$, p_T >15 GeV
    - $\tau^{\pm} \rightarrow \pi^{\pm}\pi^{0\prime}s\ \nu$, p_T >15 GeV
    - $\tau^{\pm} \rightarrow \pi^{\pm}\pi^{\pm}\pi^{\mp}(\pi^{0\prime}s)\nu$ p_T > 20 GeV > 2 tracks

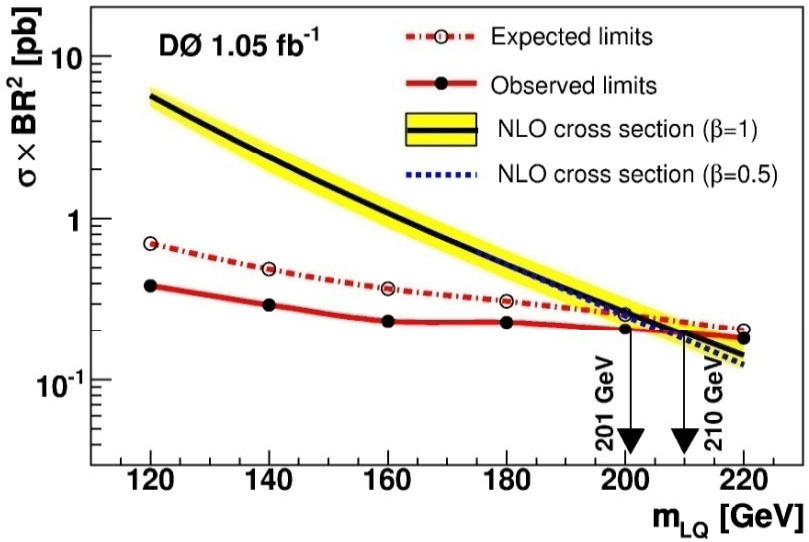
- Background
  - Multi jets
  - top pair production
  - W/Z + jets
  - Diboson

Results





- NN for tau identification
- $m^* = \sqrt{2E^{\mu}E^{\nu}(1-\cos\Delta\phi)}$
- NN for b identification
- Leptoquark mass > 210 GeV

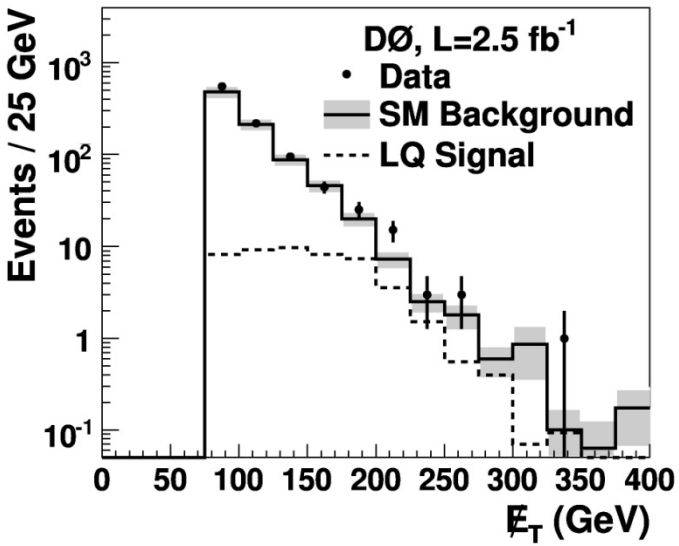


Acoplanar Topology

Leptoquarks and T-odd quarks

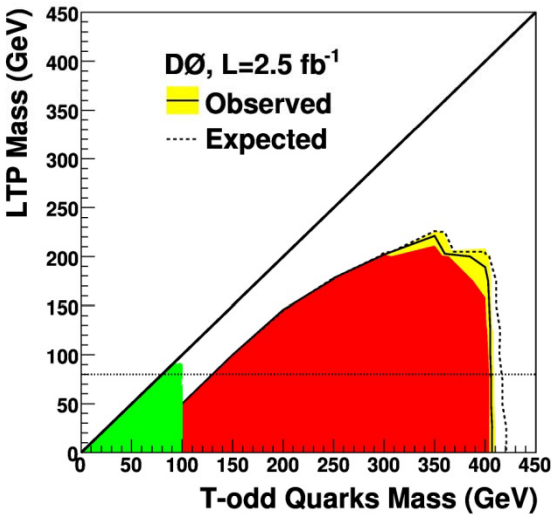
D0 arXiv:0806.3527

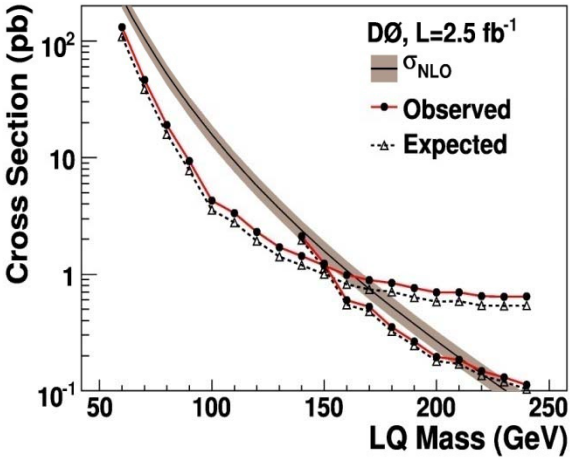
- Jets + Missing E_T
  - $E_T > 75$ GeV
  - $p_{T1}, p_{T2} > 35$ GeV
  - Angles
    - $J_1, E_T > 90^o$
    - $J, E_T > 50^o$
    - $J, E_T < 150^o$
  - Lepton Veto
- Backgrounds
  - W/Z + jets
  - Tt pair
  - WZ pair



Results

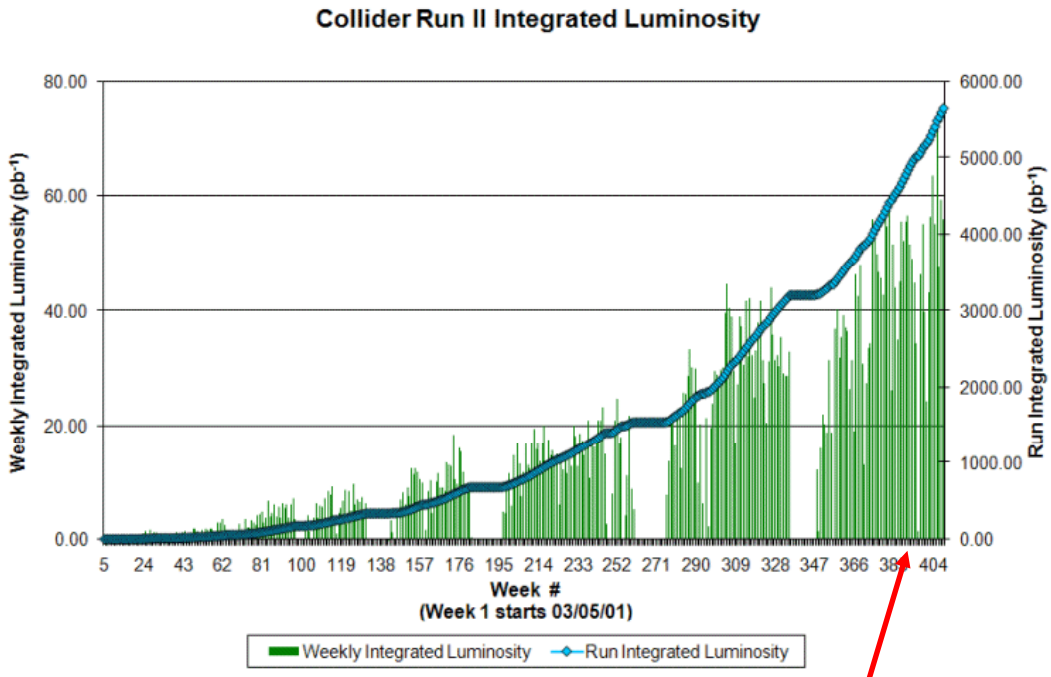
- Optimization in E_T and HT
- LQ mass > 205 GeV
- T-odd quark mass > 400 GeV





Conclusions

- The Tevatron is our best machine at the present
- At the present no evidence for new phenomena is observed (data for 2-3 fb^{-1})
- The data is being well understood
- New data is being analyzed (3-4.5 fb^{-1})



4.5 fb^{-1} Sep 2008

- Public webpages:
  - http://www-cdf.fnal.gov/physics/exotic/exotic.html
  - http://www-d0.fnal.gov/d0_publications/d0_pubs_list_runII_bytopic.html#np