

Search for new physics at the Tevatron

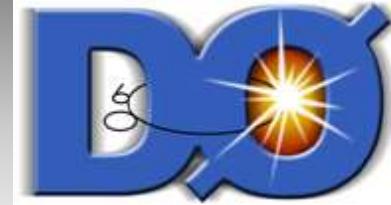


Pedro Mercadante
IFT/UNESP

On behalf of DZero and CDF collaborations

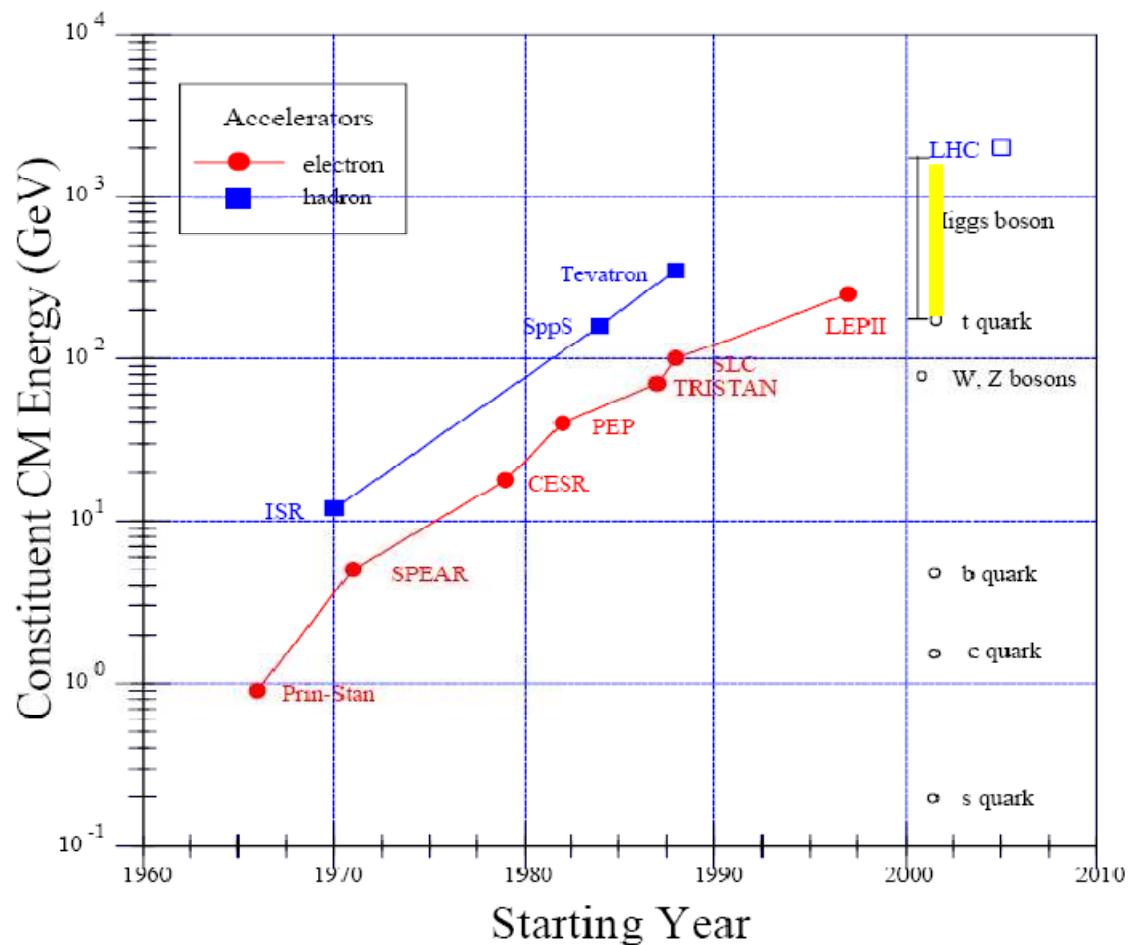


Tev Energy Scale



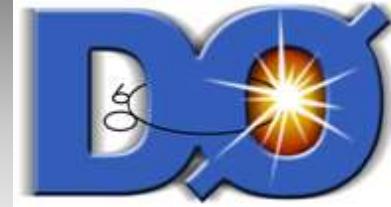
- Why is the TeV scale special?
 - It is the scale of EW symmetry breaking
 - We don't know how masses are generated
 - In the Standard Model the Higgs mechanism is evoked
(Barbara's talk)
- New Physics Beyond Standard Model?
 - Supersymmetry
 - Extra Dimensions
 - Other models

Past and Future Accelerators

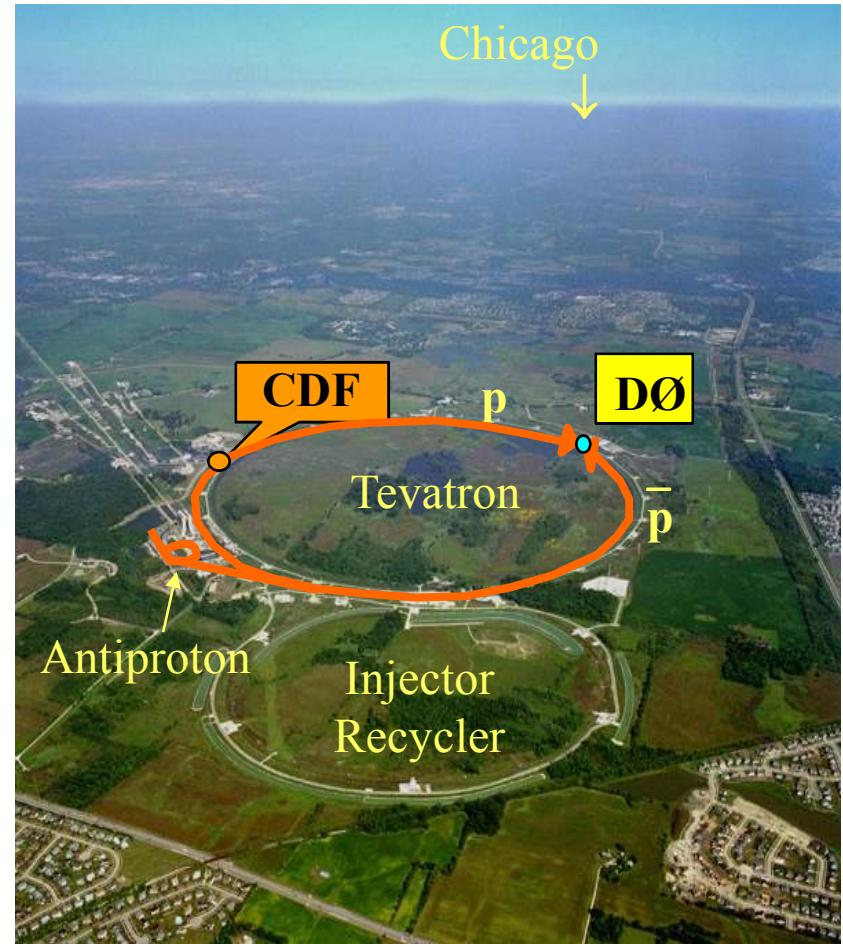


Tevatron Run II

Still at the Energy Frontier

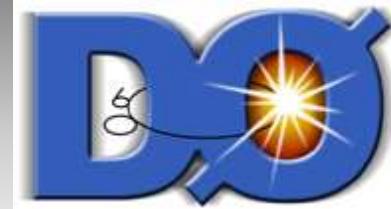


- Accelerator
 - $p\bar{p}$
 - 1.96 TeV
 - $L = 4-5 \text{ fb}^{-1}$ to be analyzed. In this talk 1-3 fb^{-1} results will be presented
- Detectors
 - Good coverage
 - Good particle identification

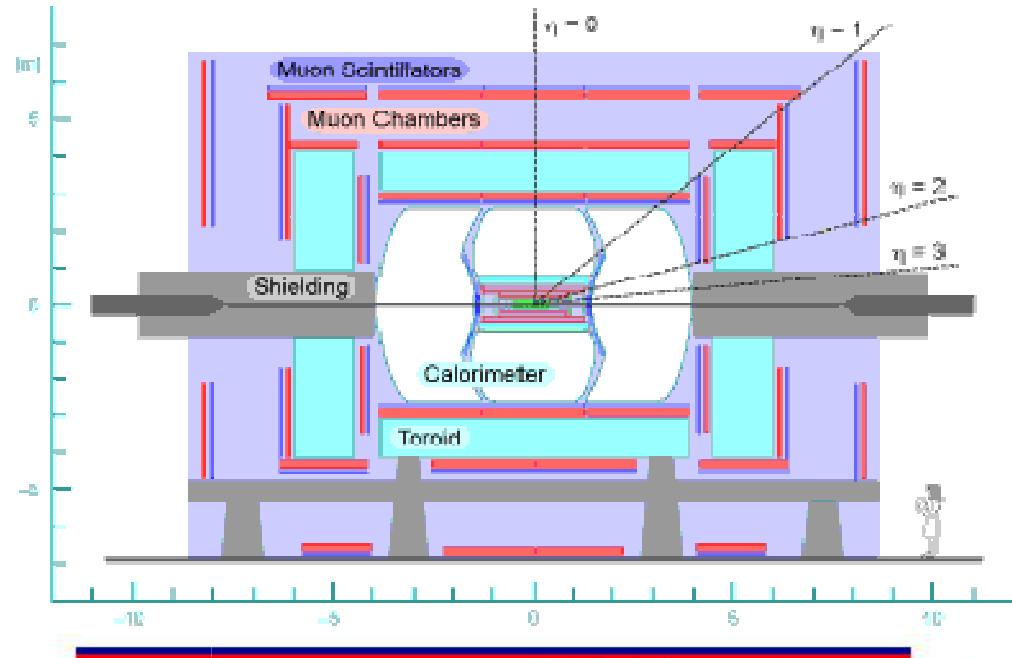




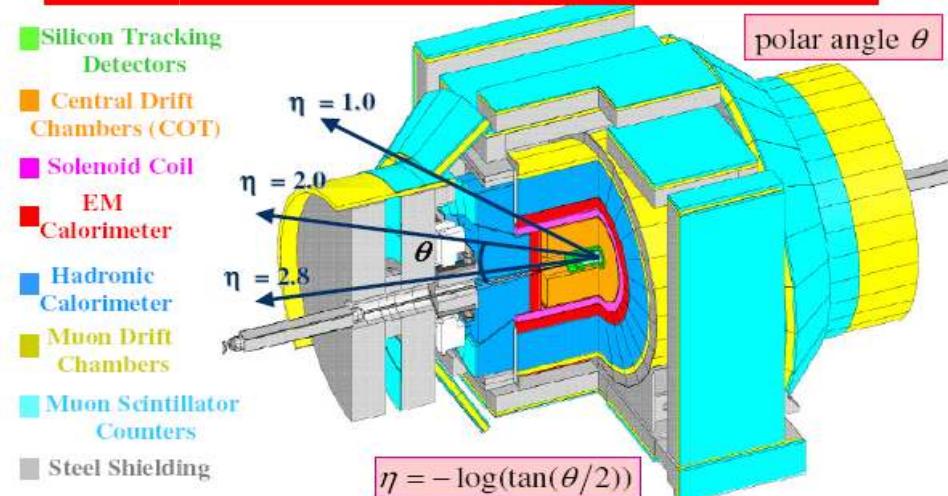
Detectors

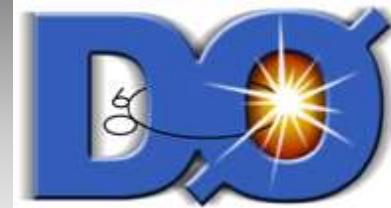


DZero Detector

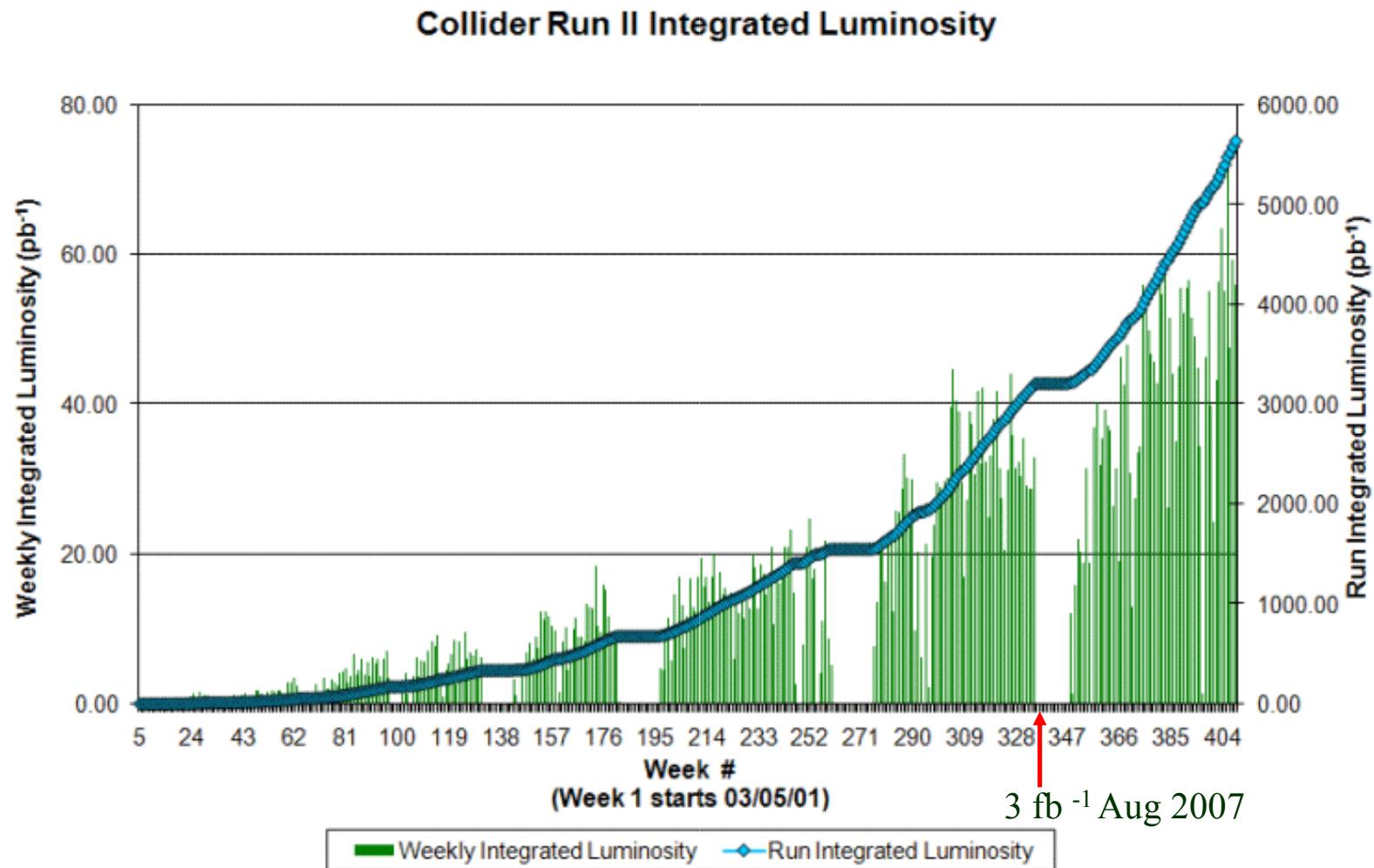


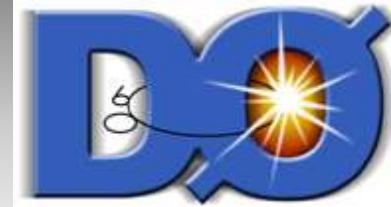
CDF Detector





Integrated Luminosity





Supersymmetry

The MSSM

Minimal supersymmetric model

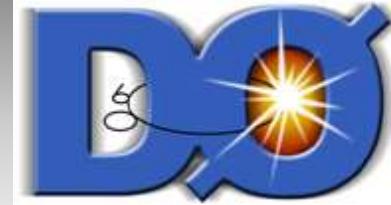
- Two Higgs doublet SM + Superpartners
 - μ parameter
 - $\tan \beta$
 - Superpotential
- Soft Terms**
- Scalar Masses (m_0)
 - Gauginos Masses ($m_{1/2}$)
 - Trilinear (A) Parameter
 - Bilinear (B) Parameter

$$\begin{aligned} W = & \mu H_d H_u + f_l L H_d E + f_d Q H_d D + f_u Q H_u U \\ & + \lambda' L L E + \lambda' L Q D + \lambda'' L Q D + \varepsilon L H_u \end{aligned}$$



Supersymmetry

Which SUSY?

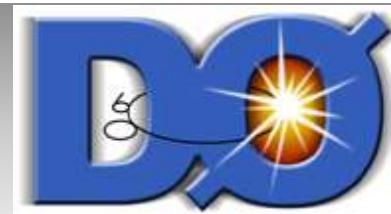


- mSUGRA (Constrained MSSM)
 - $m_0, m_{1/2}, \tan \beta, A, \text{sign } \mu$
 - gluino + squark
 - gluino + sbottom
 - trilepton
- AMSB and GMSB
- R parity Violation Models

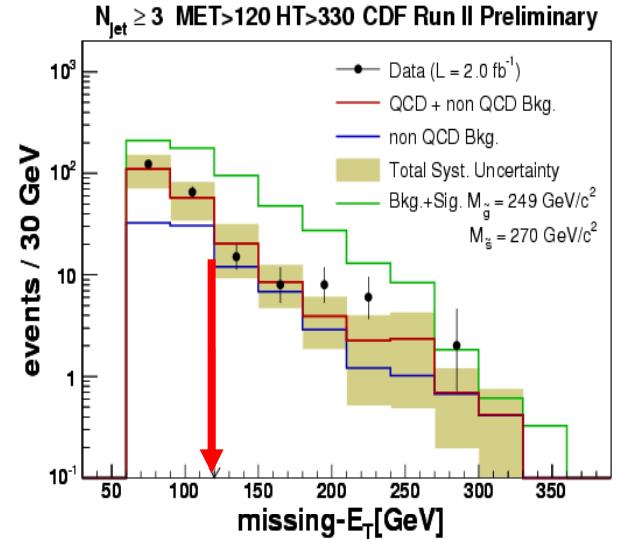


mSugra

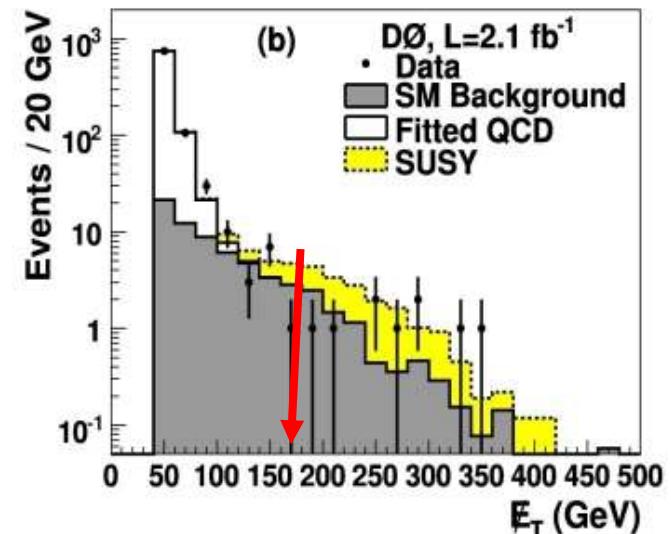
gluinos (jet + missing E_T) cdf arXiv:0811.2512



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



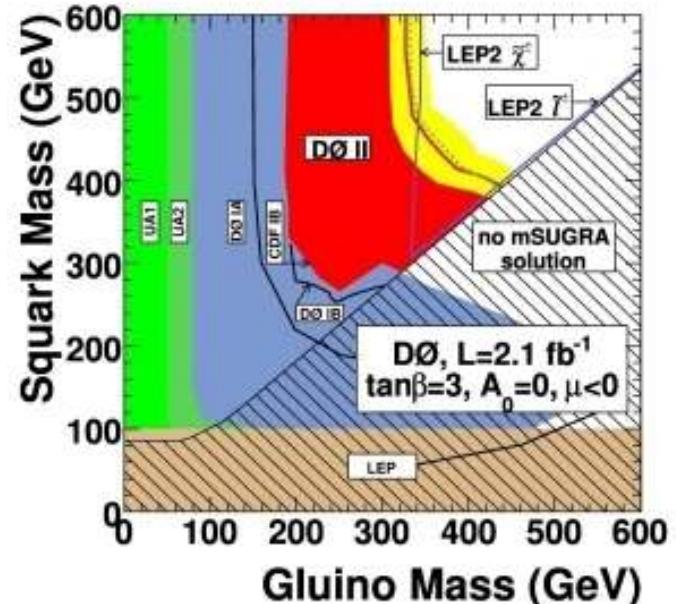
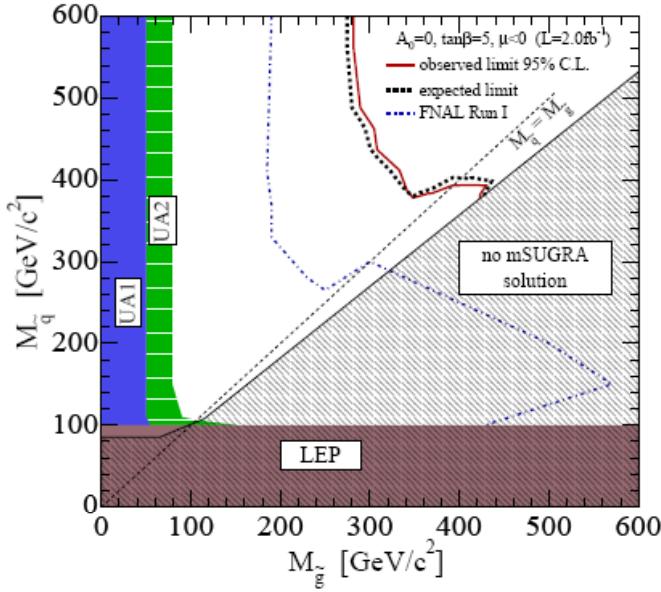
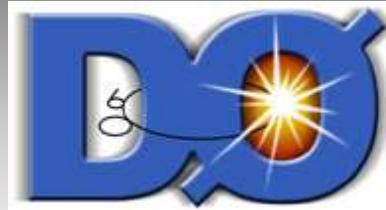
	2 jets	3 jets	4 jets(gluino)
CDF	$H_T > 330, E_T > 180 \text{ GeV}/c^2$	$H_T > 330, E_T > 120 \text{ GeV}/c^2$	$H_T > 280, E_T > 90 \text{ GeV}/c^2$
Data	18	38	45
Expected SM	16 ± 5	37 ± 12	47 ± 17
D0	$H_T > 330, E_T > 225 \text{ GeV}/c^2$	$H_T > 375, E_T > 175 \text{ GeV}/c^2$	$H_T > 400, E_T > 100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



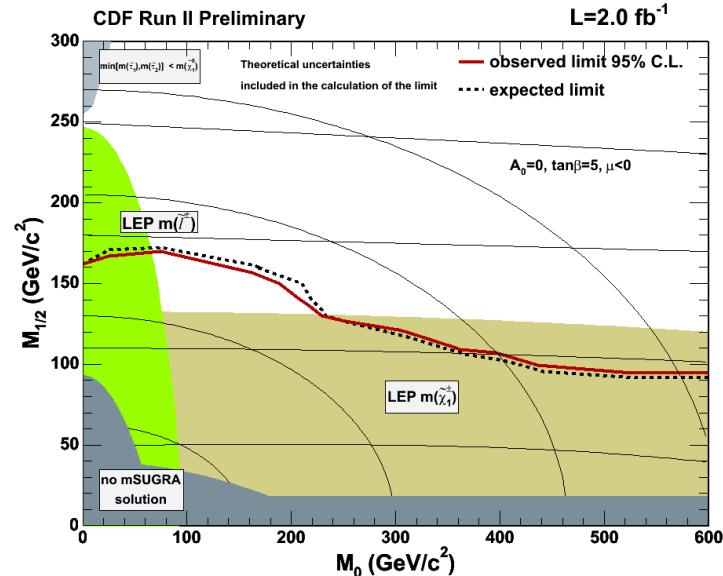
PLB 660,449



Results

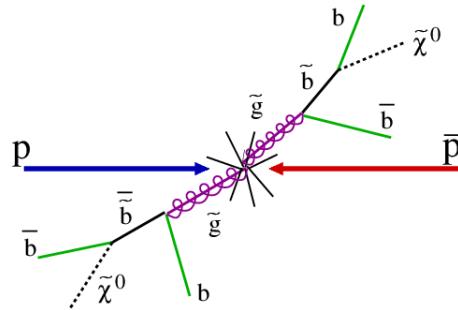


- Results on squark and gluino mass.
 - For squark mass = gluino mass
-> $m > 392 \text{ GeV}$
- Results in the plane $m_0 \times m_{1/2}$
- DZero has similar limits

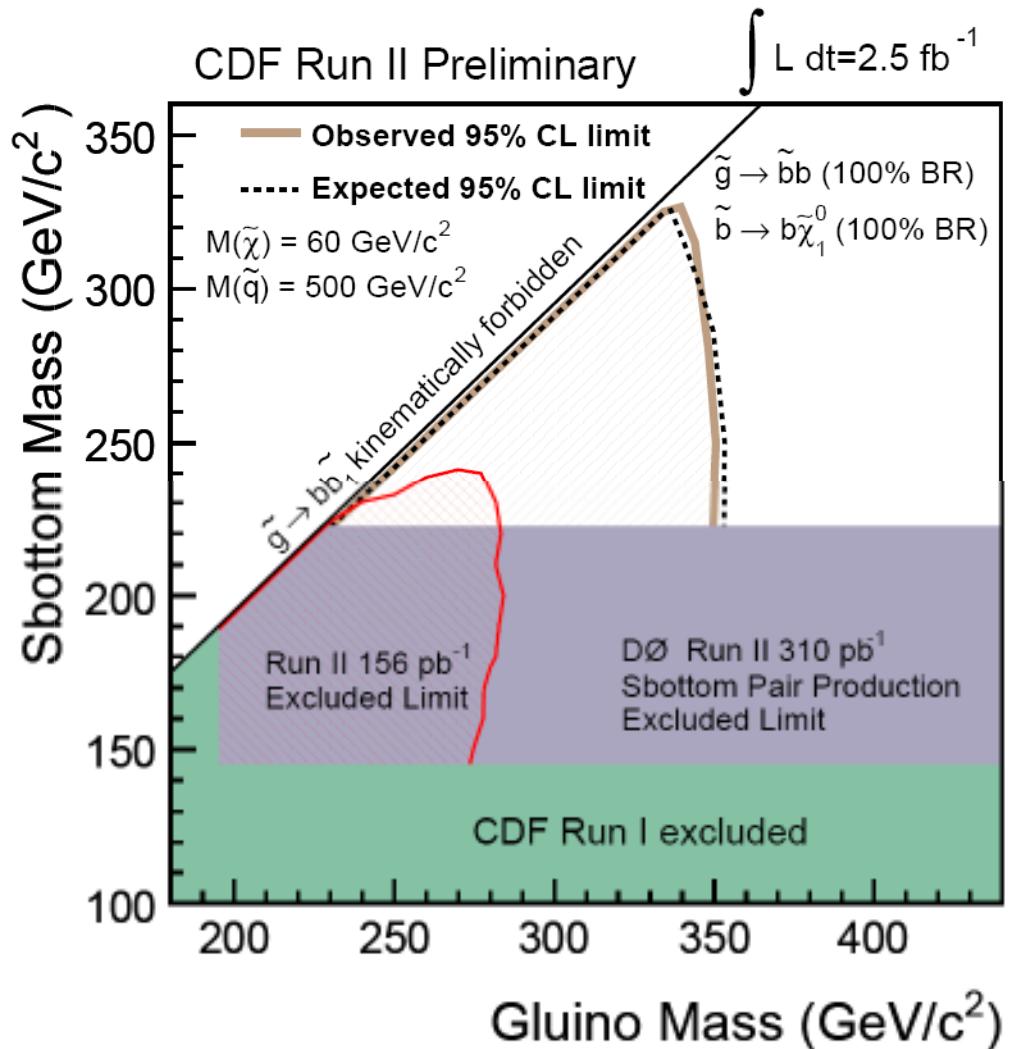


mSugra gluinos (b-jet + missing E_T)

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

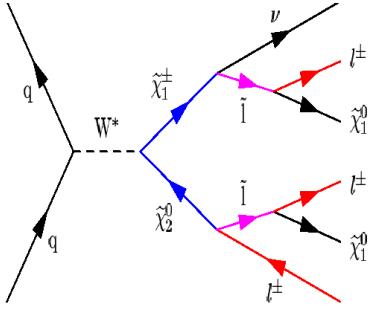


- Gluino \rightarrow Sbottoms
- Jets + missing E_T
 - 2 jets
 - 1 b tag
 - 2 b tag

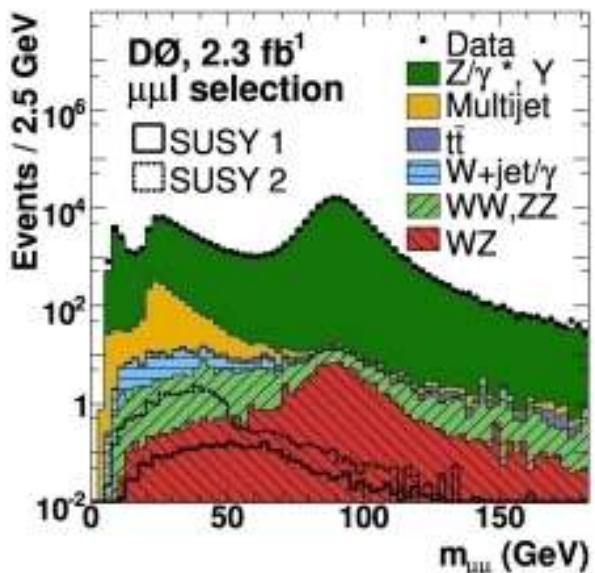


Charginos (trileptons)

D0 arXiv:0901.0646



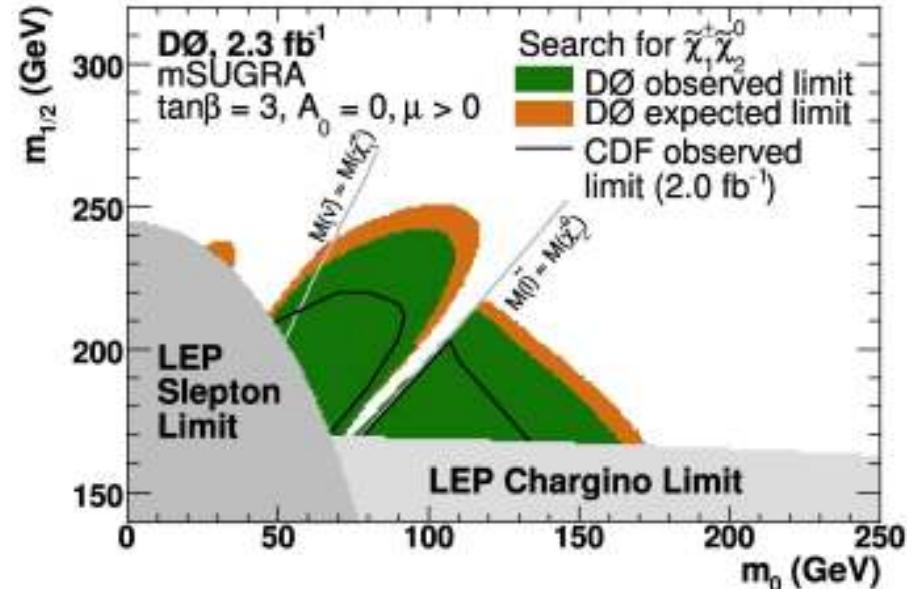
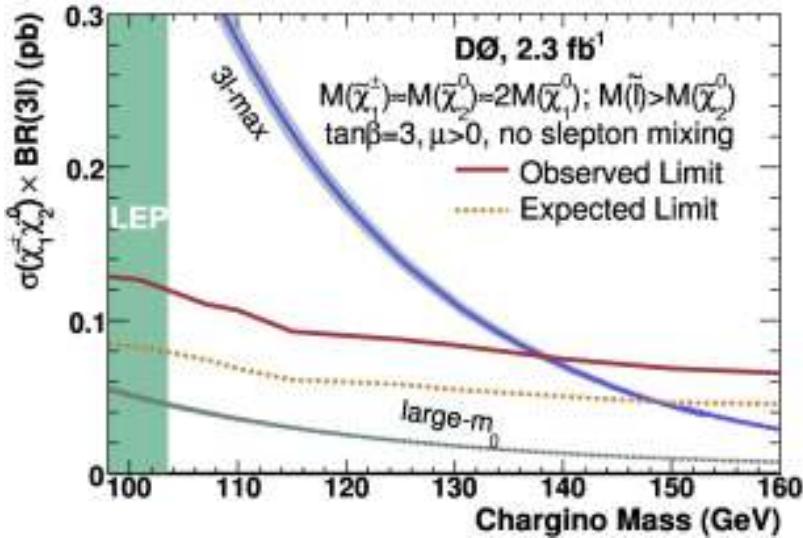
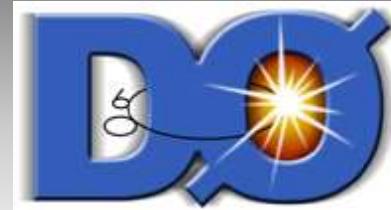
- Trilepton Signal: Clean signal
- Model dependent
- 4 channels $p_{Tl} > 12, 8 \text{ GeV}$
 - e,e,l
 - e,μ,l
 - μ, μ,l
 - μ,τ,l
- In all channels the extra lepton is a track





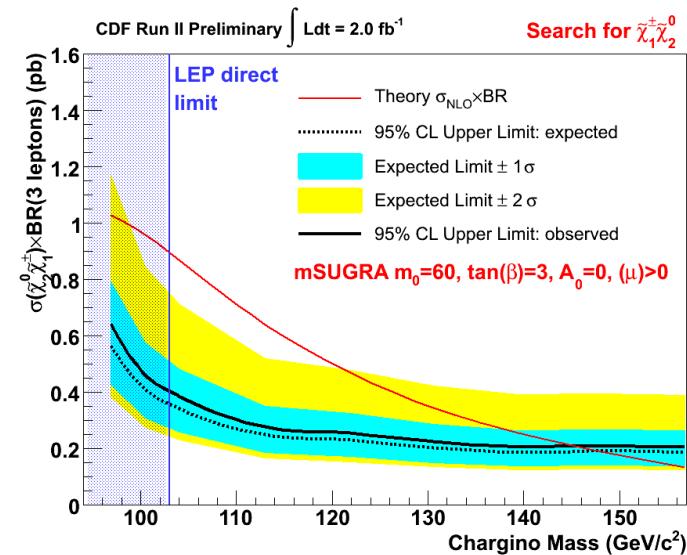
mSugra

Charginos (trileptons)



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

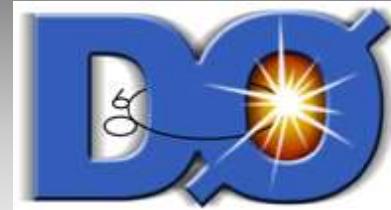
http://www-cdf.fnal.gov/physics/exotic/r2a/20080110.trilepton_dube/



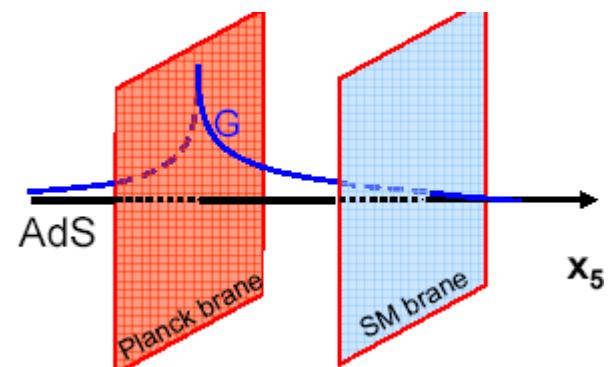
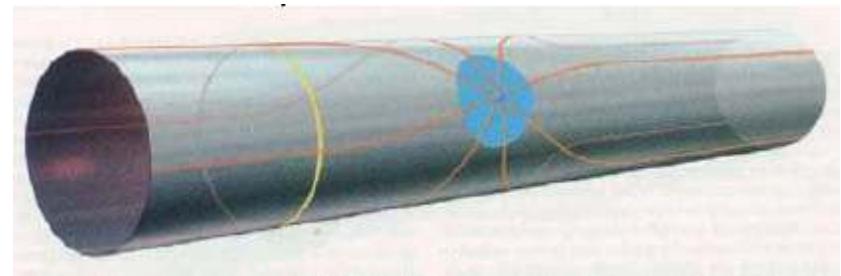


Extra Dimensions

Are there new extra Dimension?

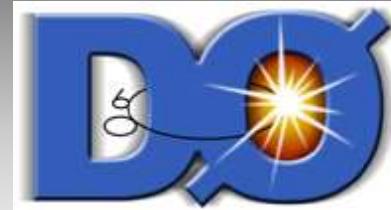


- Large Extra Dimensions (ADD models)
 - Only gravity propagates in the extra dimensions
 - Direct signal: missing ET from the sum of KK states propagating in the bulk
 - Indirect signal: sum of KK towers modify the production of SM particles
- Universal Extra Dimensions
 - All particles can propagate 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

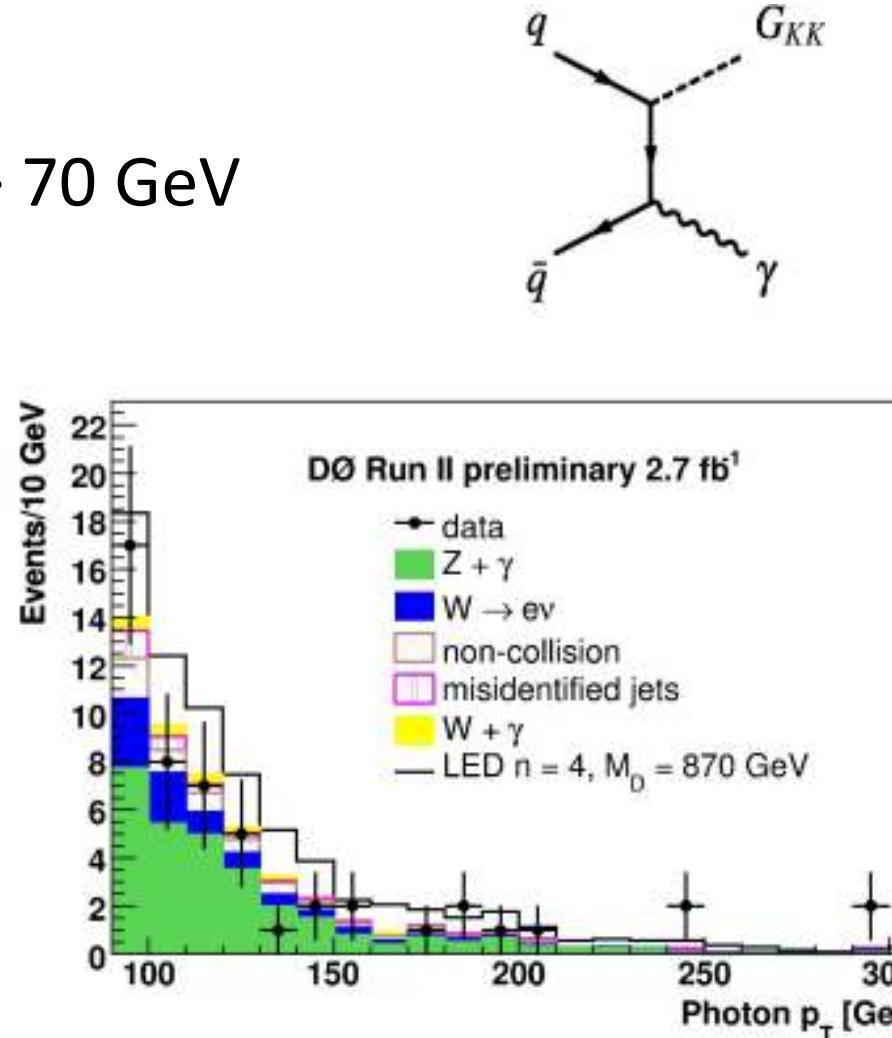
D0 PRL 101, 011601

- Selection

- $p_T > 90 \text{ GeV}$, missing $E_T > 70 \text{ GeV}$
- No jets ($p_T > 15 \text{ GeV}$),
no Leptons (muons,
tracks with $p_T > 8 \text{ GeV}$)

- Background

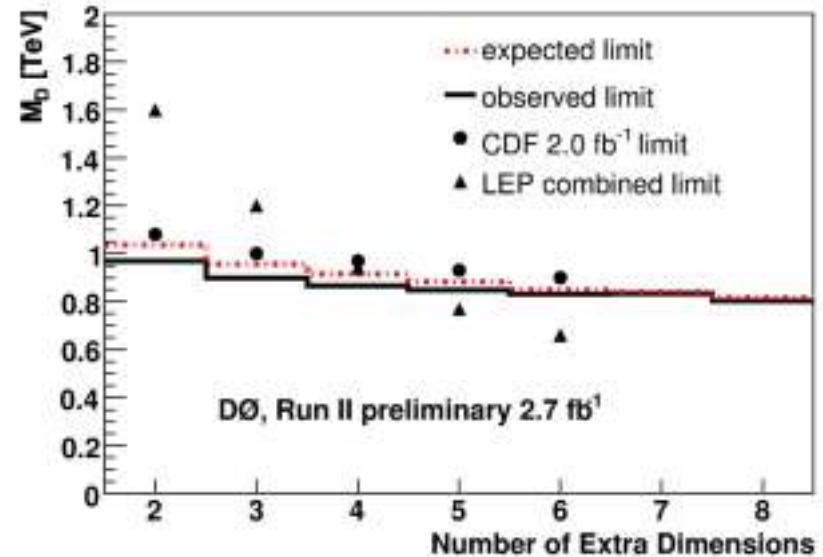
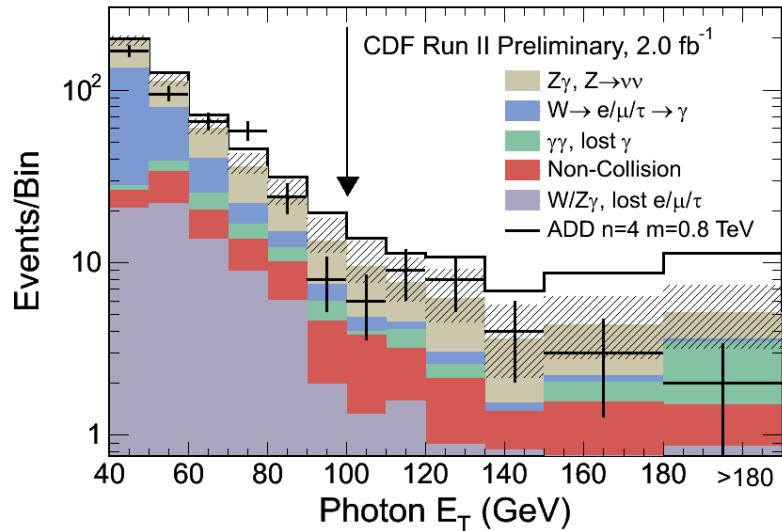
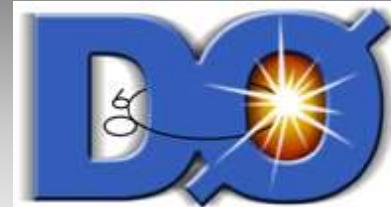
- Non Collision
- Miss identified jet
- $Z + \gamma$



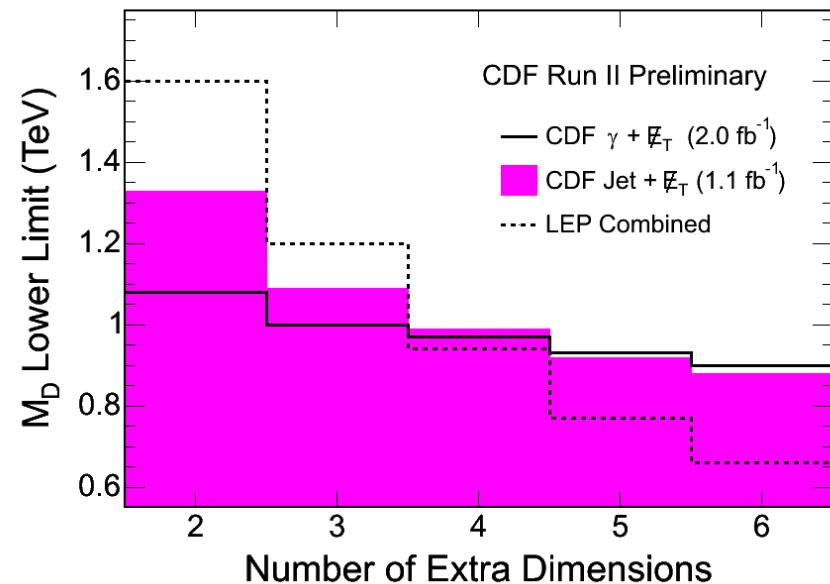
51 Data Events 49.9 expected



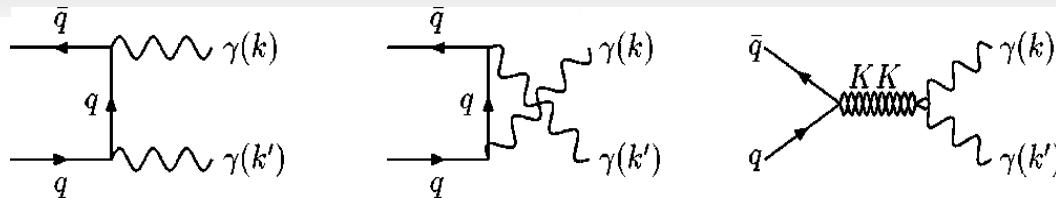
Limits



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



Virtual Graviton exchange: Diphotons and dielectrons



- Sensitive to the cutoff
- Selection:
 - Electromagnetic (EM) cluster with $P_T > 15 \text{ GeV}$
 - Central and end cap cluster (CC-EC)
- Background
 - Drell Yan and $\gamma\gamma$ production
 - Multijet

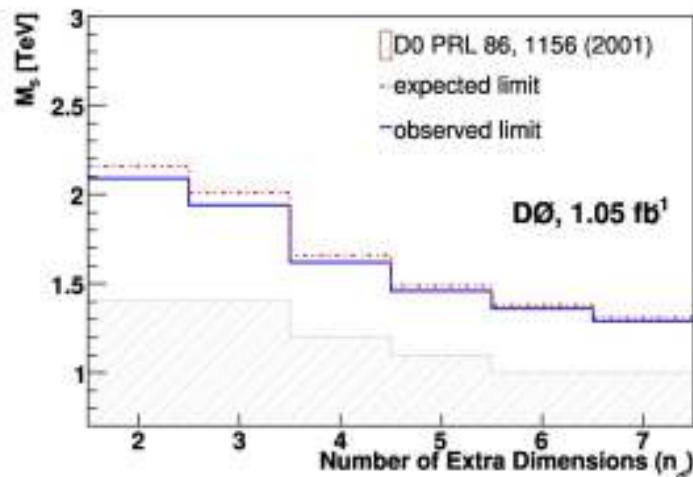
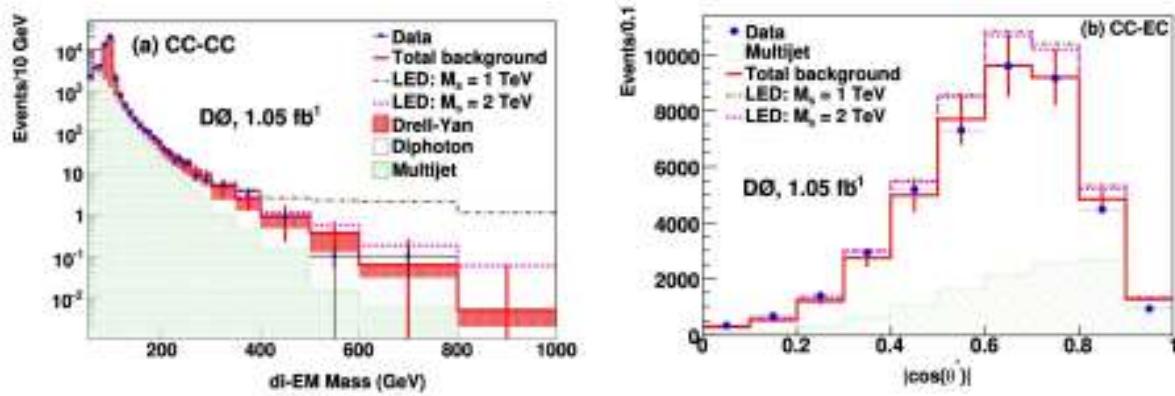


TABLE III: Observed and expected lower limits at the 95% C.L. on the effective Planck scale, M_s , in TeV.

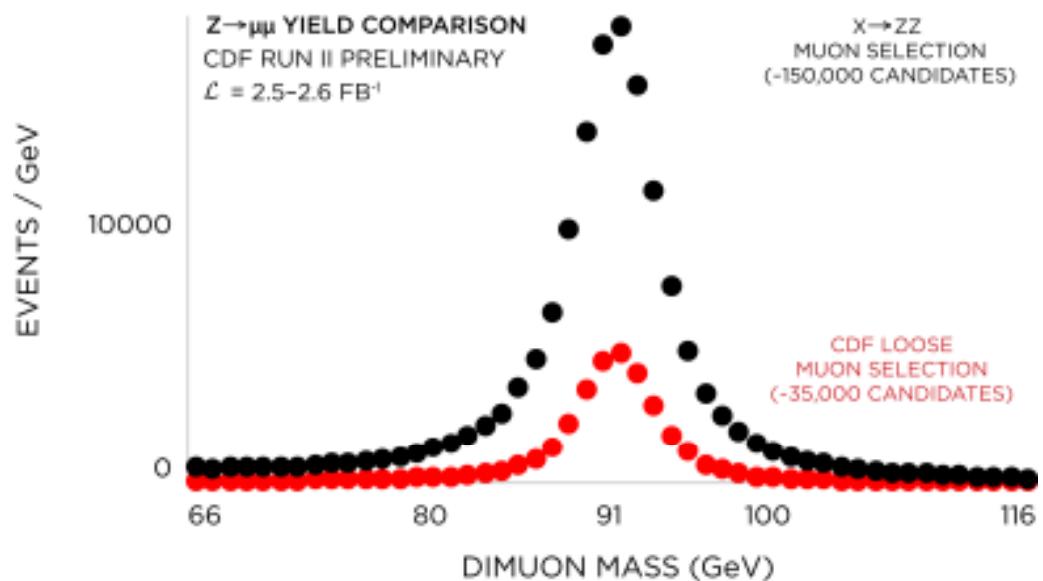
	GRW	HLZ						
		n_d	2	3	4	5	6	7
Obs.	1.62		2.09	1.94	1.62	1.46	1.36	1.29
Exp.	1.66		2.16	2.01	1.66	1.49	1.38	1.31

Randall-Sundrum

ZZ resonance

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

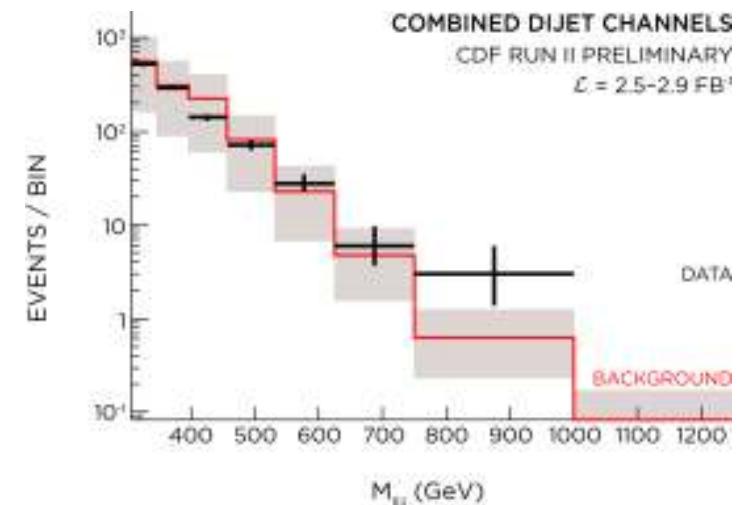
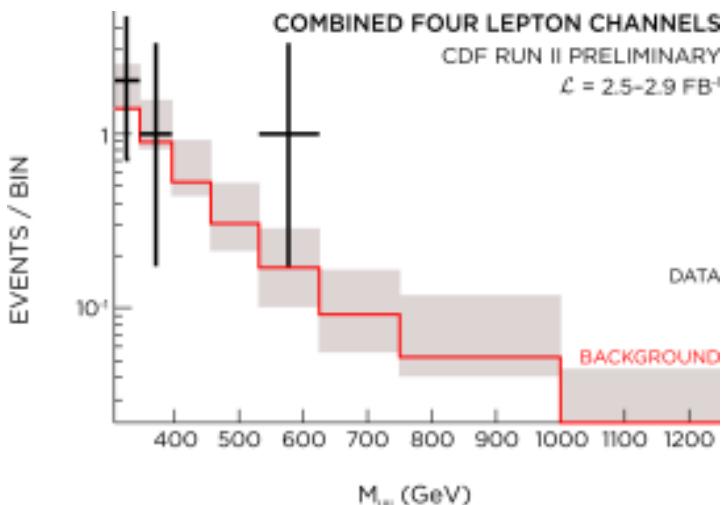
- $G \rightarrow ZZ$
 - ee $\mu\mu$
 - $\mu\mu \mu\mu$
 - eeee
 - eejj
- Loose requirement for e and muons
 - Trigger e or μ : $p_T > 20$ GeV
 - Relaxed lepton (e, μ) + 2 jets ($p_T > 10$ GeV) or 2 relaxed lepton
- Estimate the bg from side bands



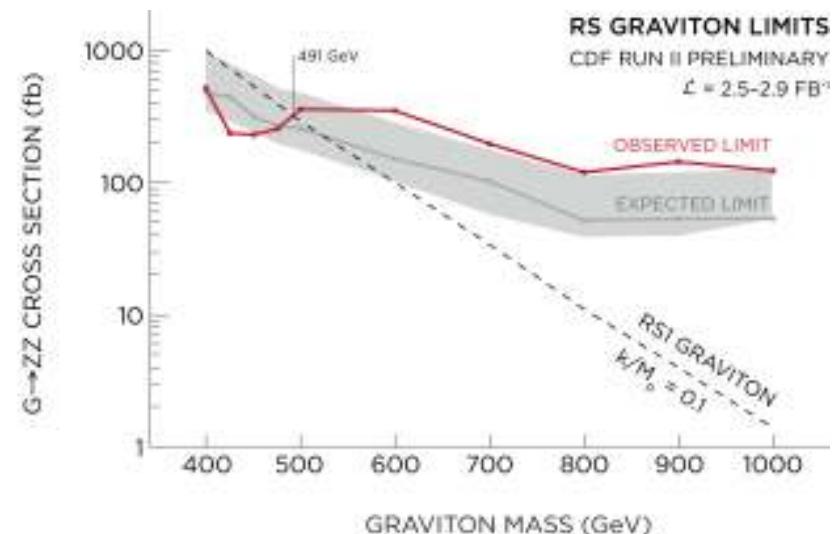
$$\chi^2_{ZZ} = \frac{(M_Z^{(1)} - 91.187 \text{ GeV})^2}{\sigma_{M^{(1)}}^2 + \sigma_\Gamma^2} + \frac{(M_Z^{(2)} - 91.187 \text{ GeV})^2}{\sigma_{M^{(2)}}^2 + \sigma_\Gamma^2}$$



Results



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

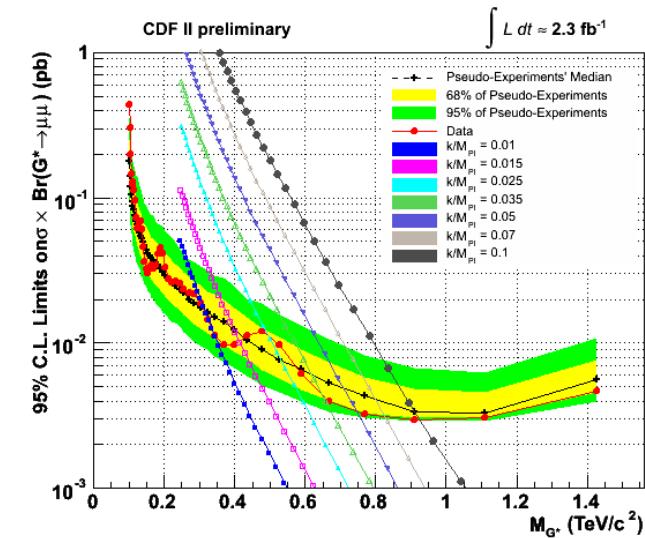
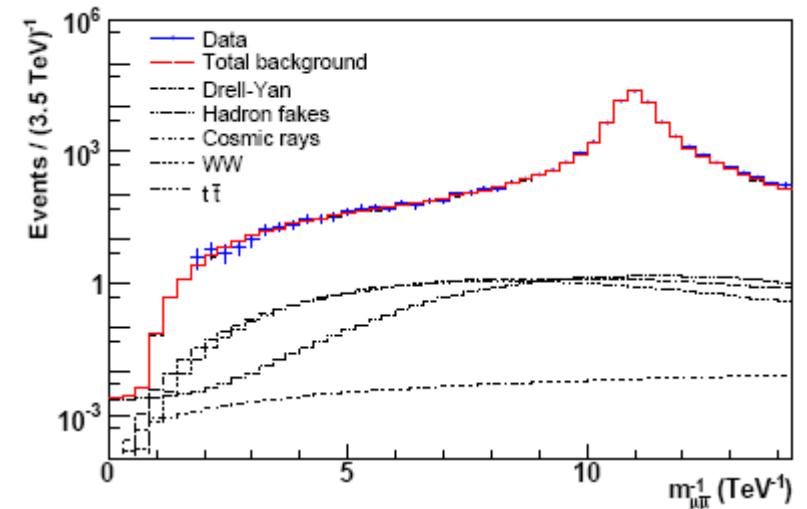


Di Muon

(Randall Sundrum)

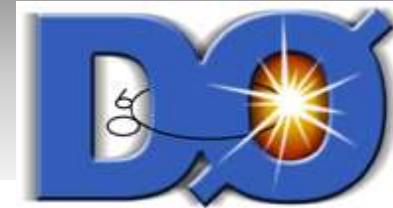
CDF arXiv:0811.0053

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





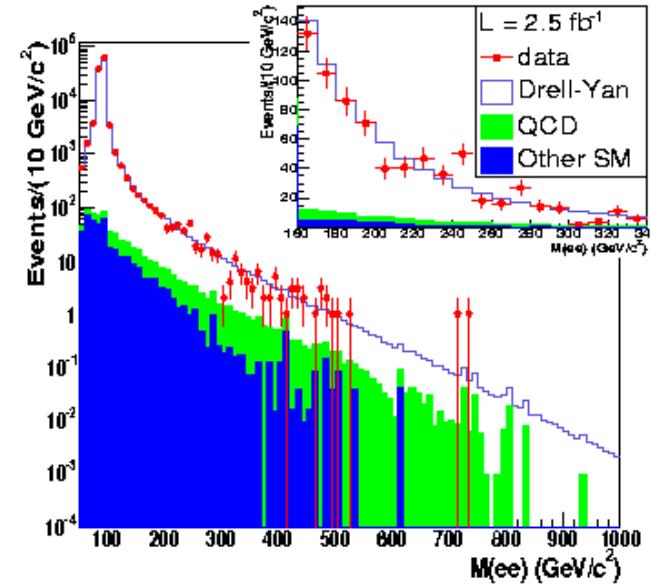
Di Electrons (Randall Sundrum)



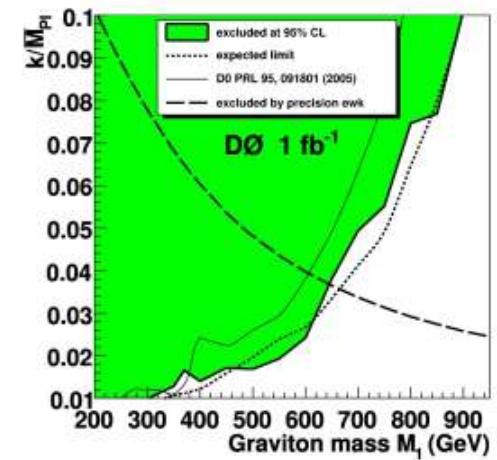
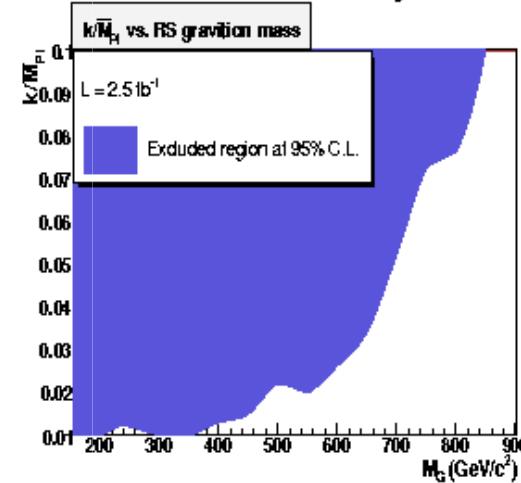
http://www-cdf.fnal.gov/physics/exotic/r2a/20080306.dielectron_duke/pub25/duke.html

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

CDF Run II Preliminary



CDF Run II Preliminary



PRL 100, 091802

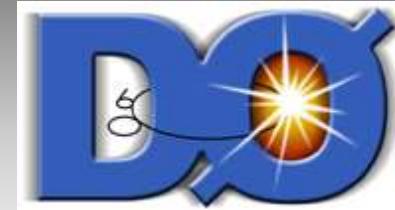
Lishep 2009

Pedro Mercadante

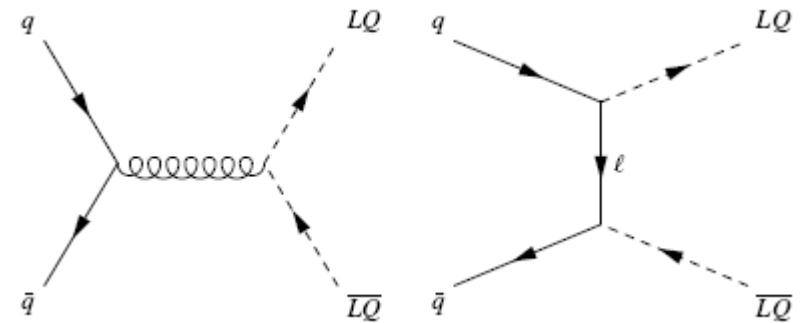
21



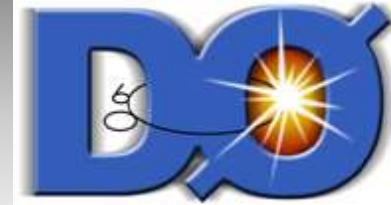
Leptoquarks (lepton + quark signal)



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

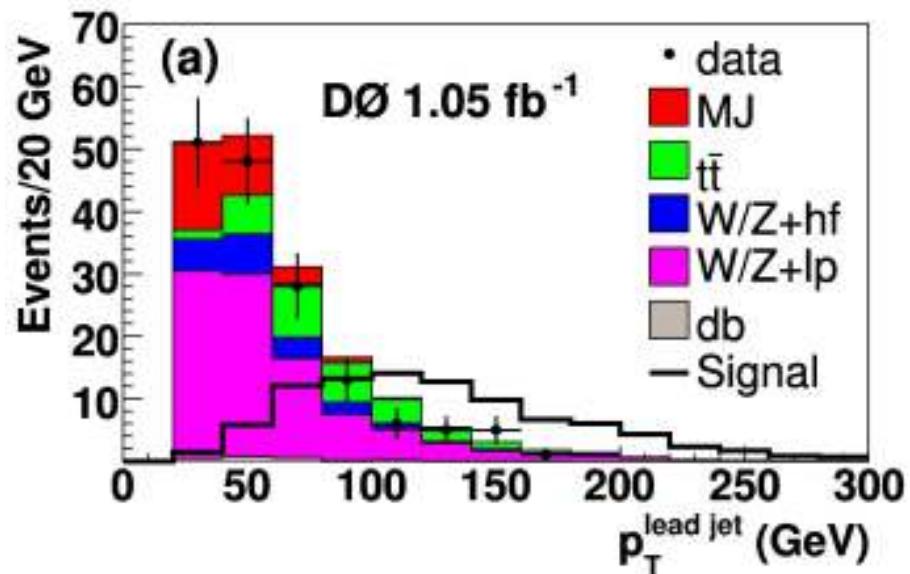


Third Generation LQ



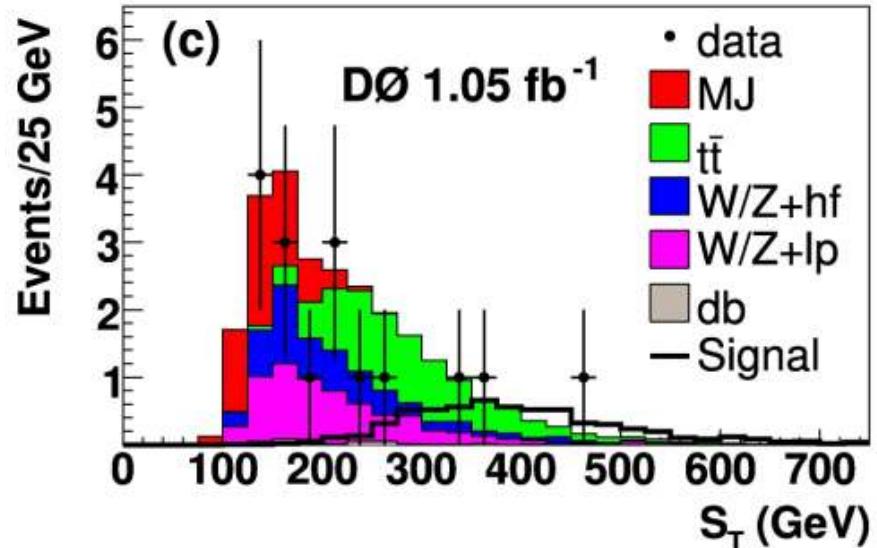
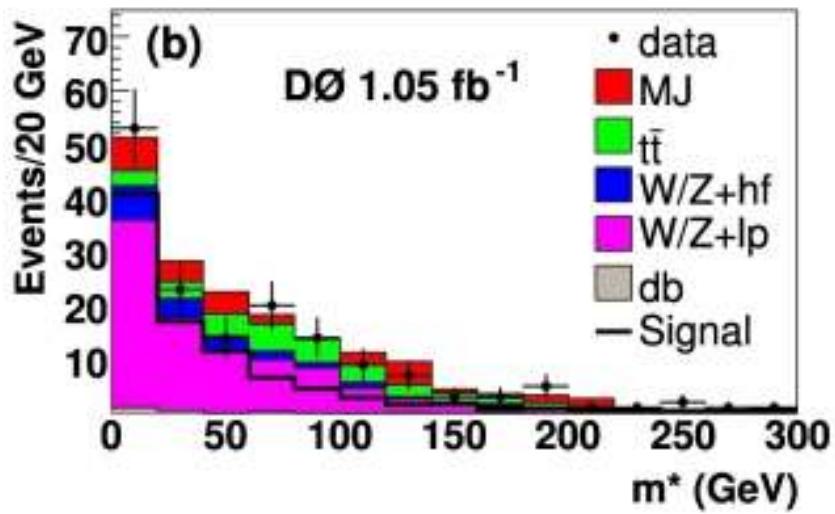
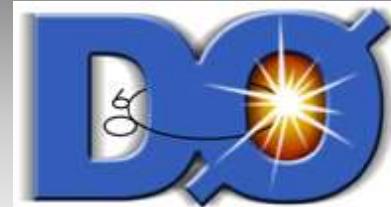
D0 arXiv:0806.3527

- LQ \rightarrow 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
 - $\tau^\pm \rightarrow \pi^\pm \pi^0 s \nu$, $p_T > 15$ GeV
 - $\tau^\pm \rightarrow \pi^\pm \pi^\pm \pi^\mp (\pi^0 s) \nu$, $p_T > 20$ GeV > 2 tracks

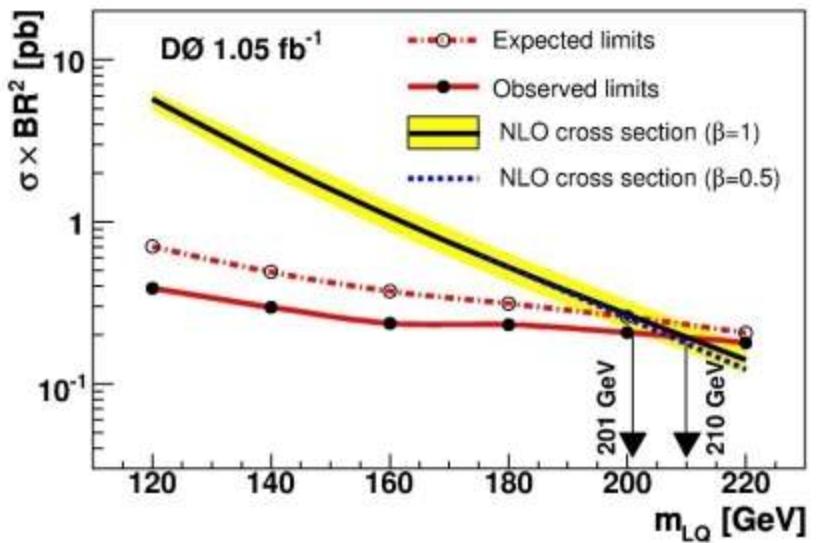


- Background
 - Multi jets
 - top pair production
 - W/Z + jets
 - Diboson

Results



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



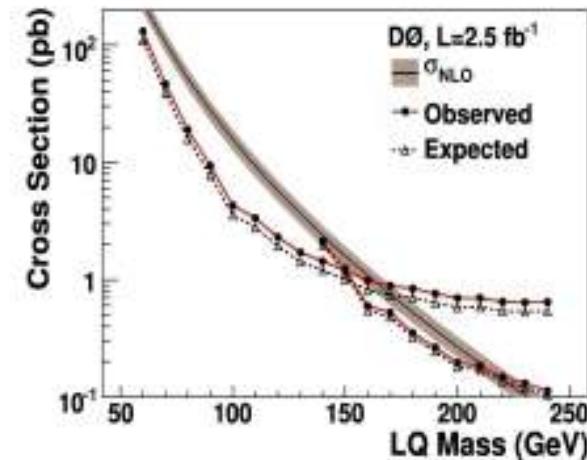
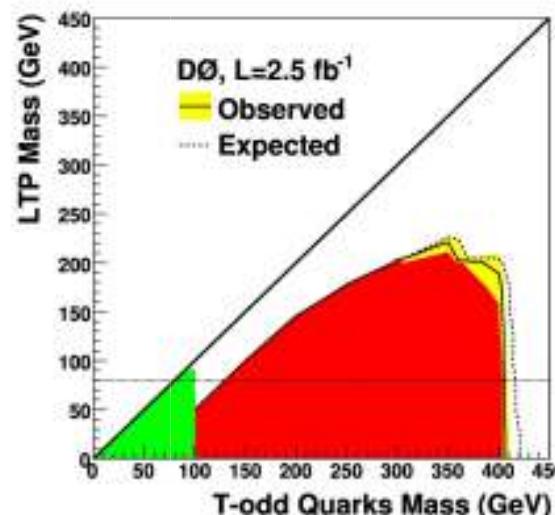
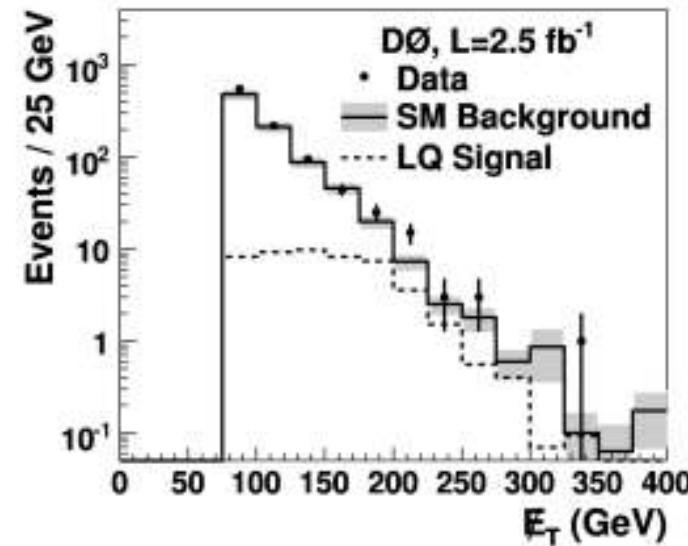
Acoplanar Topology

Leptoquarks and T-odd quarks



D0 arXiv:0806.3527

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

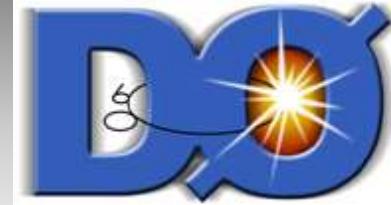


Results

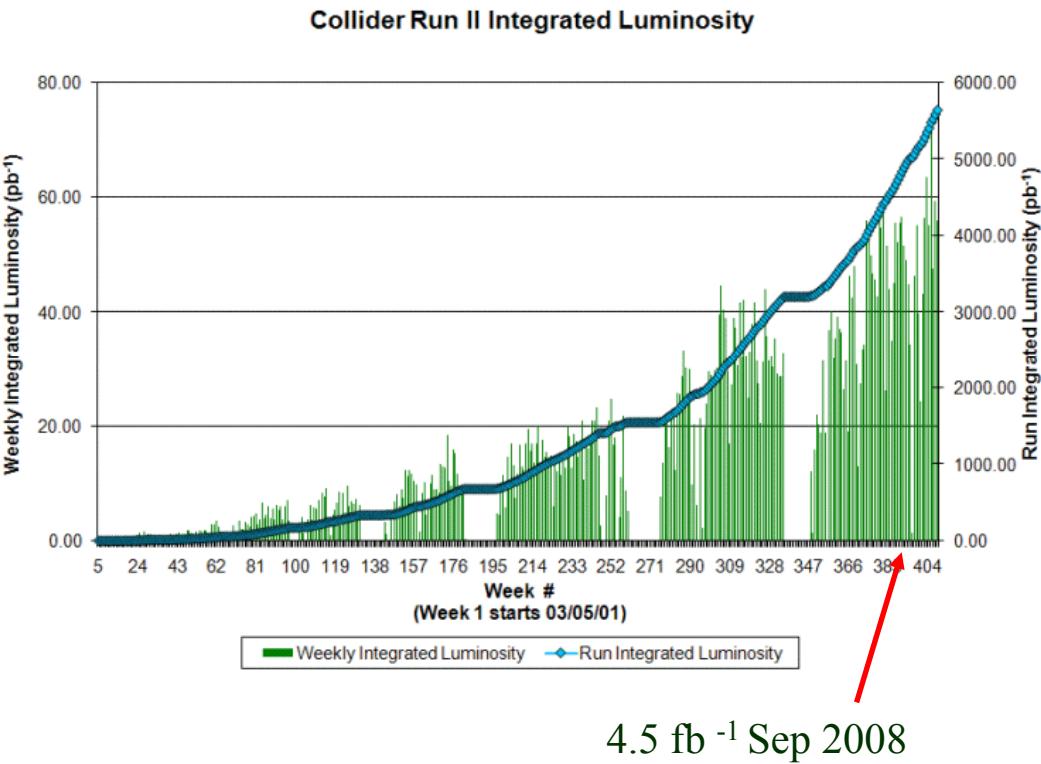
- Optimization in E_T and HT
- LQ mass $> 205 \text{ GeV}$
- T-odd quark mass $> 400 \text{ GeV}$



Conclusions



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



- 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