Non SUSY searches at the TeVatron

Laurent Duflot

Laboratoire de l'accélérateur Linéaire – Orsay - France

for the CDF and D0 collaborations

Introduction

- To perform searches at the TeVatron, one has to find handles to control the huge QCD background
  - electrons and muons
  - missing ET
  - b-tagging
  - taus

Most of the results presented here are based on leptonic final states

- To cover many theoretical scenarios, define standard samples and derive specific analyses or interpretations
  - di-electron, di-photon and di-muon samples
    - direct search (mass peak) : Randall-Sundrum ED, Z',technicolor, etc
    - indirect search : Large Extra Dimensions (Arkani-Hamed, Dimopoulos, Dvali), TeV^{-1} ED, compositeness, etc
- Other theoretical models investigated : W', leptoquarks, etc...

The di-electron samples

- Good energy resolution at high momentum (calorimeter)
- Easy to trigger in the high pT region
- The challenge is to control and understand QCD background : measured from data as MC simulation not reliable at that level of precision

- ~ 200 pb^{-1}
- two electrons with pT>25 GeV/c
  - central-central and central-plug
  - relatively loose requirements:
    - high efficiency
    - significant QCD background, measured on data (sidebands)
- di-photon sample

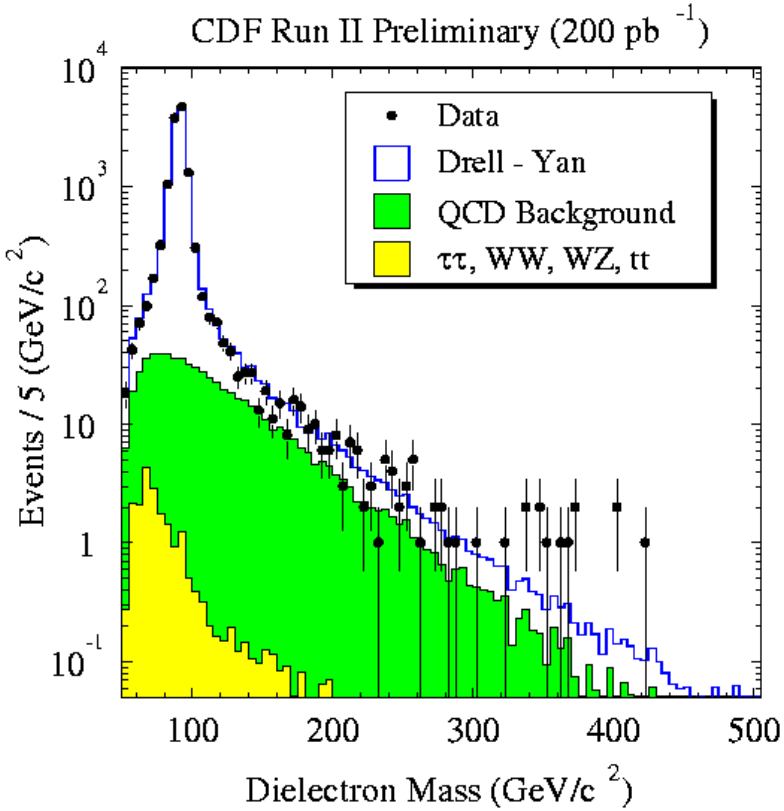
- ~ 200 pb^{-1}
- two electrons with pT>25 GeV/c
  - central-central and central-endcap
  - relatively tight requirements:
    - medium efficiency
    - low QCD background, measured on data (anti-e cuts, shape, fit)
- di-photon sample

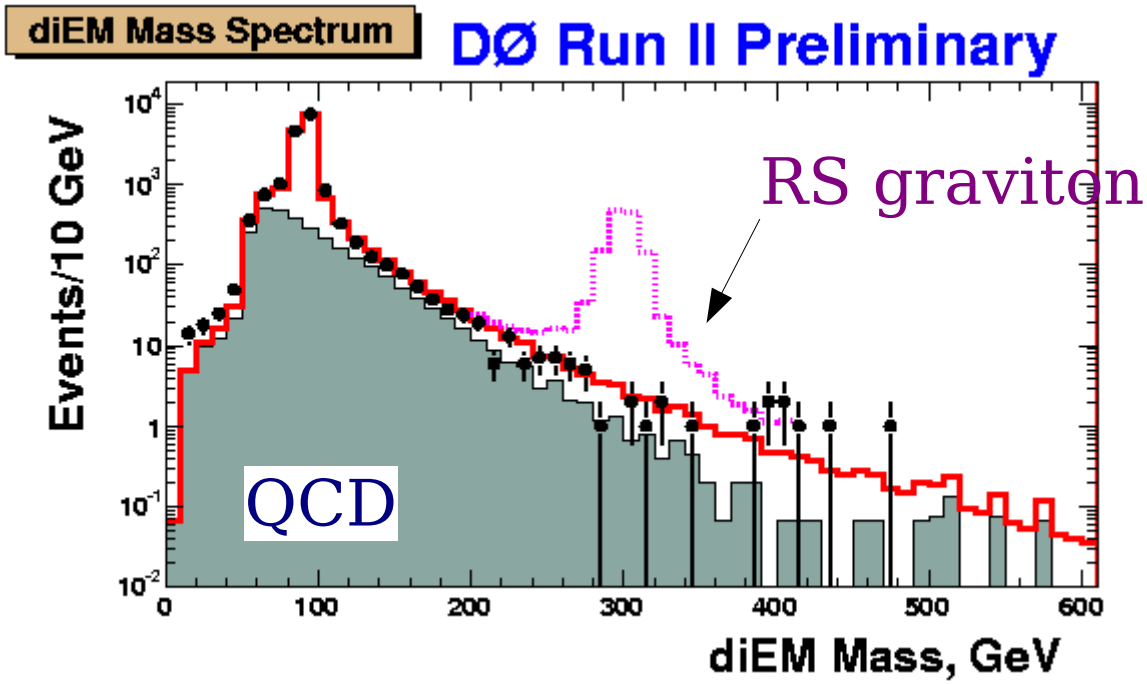
The di-muon samples

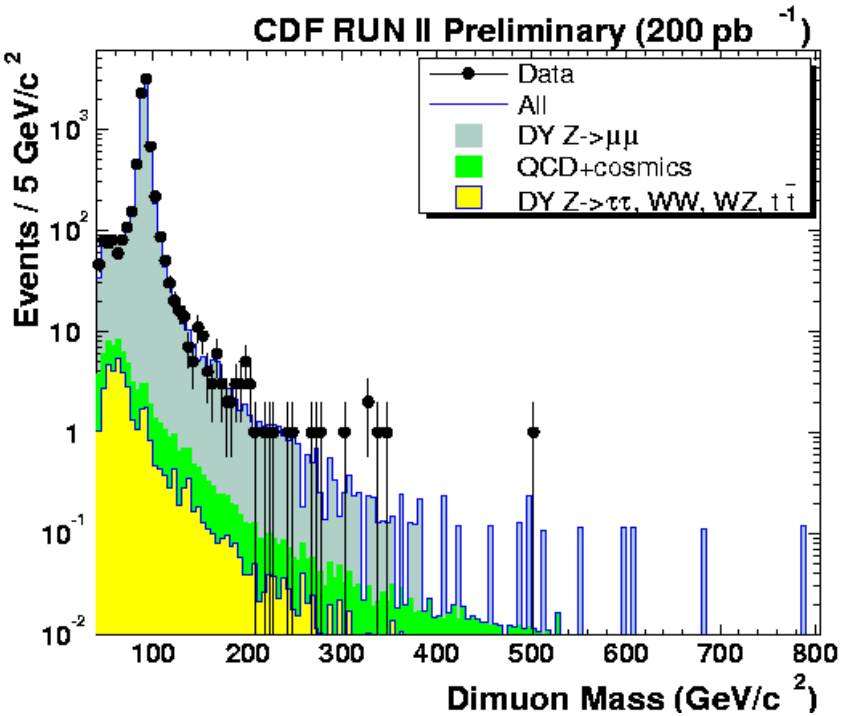
- Resolution gets worse at high pT (tracker)
- The QCD background is not important for isolated muons
- Reduce and estimate cosmic background (timing, etc)

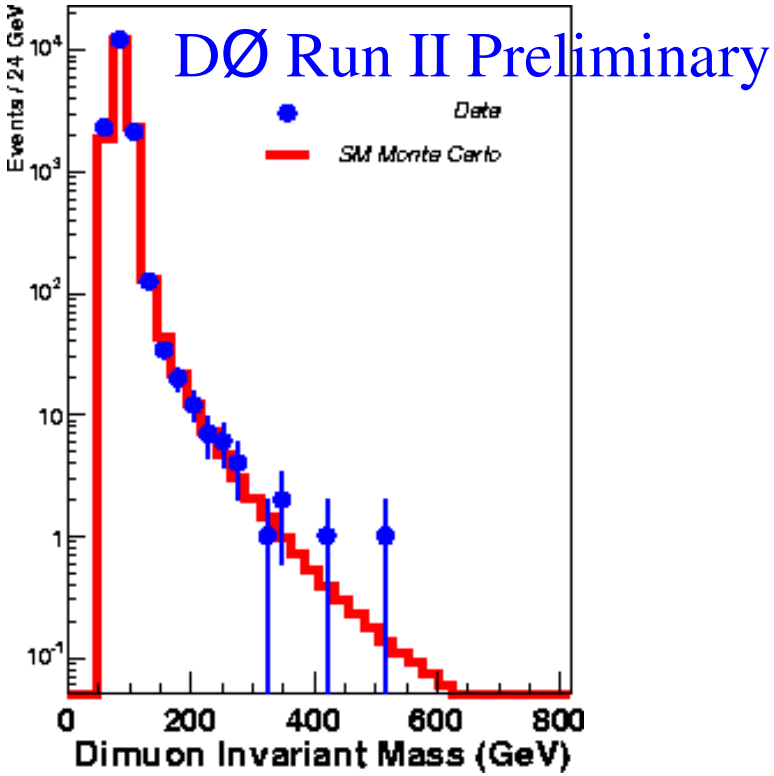
- ~ 200 pb^{-1}
- two muons with pT>20 GeV/c
  - one in central region $|\eta|<1.0$
  - other has COT track ($|\eta|<1.5$)

- ~ 250 pb^{-1}
- two muons with pT>15 GeV/c
  - poor resolution at high pT: refit muon pTs to equal pT


CDF Run II Preliminary (200 pb^{-1})
Data
Drell - Yan
QCD Background
ττ, WW, WZ, tt
Events / 5 (GeV/c^2)
Dielectron Mass (GeV/c^2)


diEM Mass Spectrum
DØ Run II Preliminary
RS graviton
QCD
Events/10 GeV
diEM Mass, GeV


CDF RUN II Preliminary (200 pb^{-1})
Data
All
DY Z->μμ
QCD+cosmics
DY Z->ττ, WW, WZ, $t\bar{t}$
Events / 5 GeV/c^2
Dimuon Mass (GeV/c^2)


DØ Run II Preliminary
Data
SM Monte Carlo
Events / 24 GeV
Dimuon Invariant Mass (GeV)

MC – data agreement

TABLE I: Expected number of background events compared with data.

Mass	ee observed	ee expected	$\mu\mu$ observed	$\mu\mu$ expected
GeV/c^2	events	background	events	background
M > 150	184	193.5 ± 99.2	58	55.3 ± 2.5
M > 200	70	68.1 ± 33.3	18	20.9 ± 1.0
M > 300	14	10.7 ± 4.3	6	5.2 ± 0.3
M > 400	3	2.1 ± 0.7	1	2.3 ± 0.2
M > 500	0	0.5 ± 0.1	1	1.2 ± 0.1

ee + μμ

Minimum M_{EM-EM}	Bck, CC-CC	N Events, CC-CC	BCK, CC-EC	N Events, CC-EC	BCK, overall	QCD bck.	Data
50 GeV	9254	9300	6851	6802	16106	2823	16102
100 GeV	775	833	1129	1067	1904	893	1900
150 GeV	120	119	249	185	368	212	304
200 GeV	41.6	41	68.1	42	110	51	83
250 GeV	17.7	19	23.7	14	41.3	15	33
300 GeV	8.2	10	9.1	4	17.3	4.6	14
350 GeV	4.5	6	3.6	2	8.1	1.6	8
400 GeV	2.6	4	1.8	1	4.4	0.9	5
450 GeV	1.6	1	1.0	0	2.6	0.7	1
480 GeV	1.2	0	0.69	0	1.9	0.6	0

TABLE II: Comparison between the data and expected background for events above certain diEM mass cutoffs. Middle two columns show the number of candidate events and predicted background above the diEM mass listed in the first column. Note an additional systematic error of 7–20% on the background prediction, depending on the mass.

ee + γγ

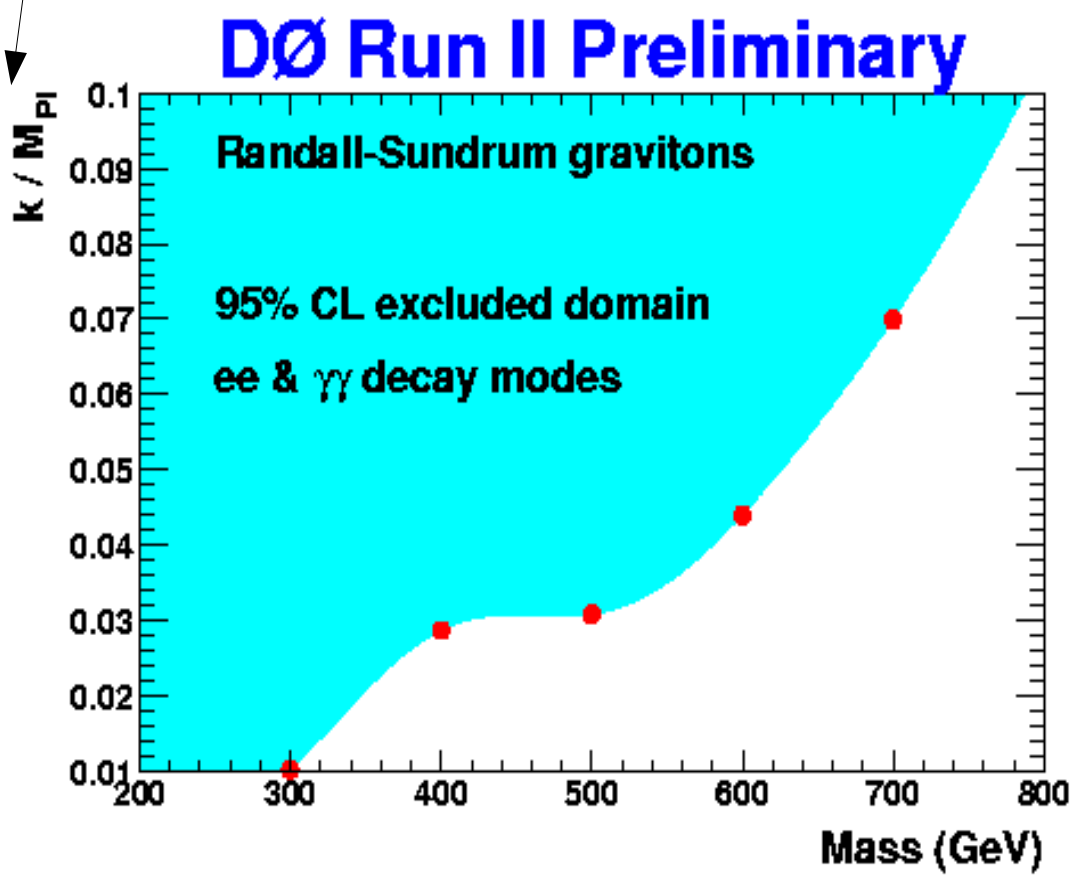
Interpretation

direct search (mass peak) : Randall-Sundrum ED, Z', technicolor, etc

indirect search : Large Extra Dimensions, TeV^{-1} ED, compositeness, etc

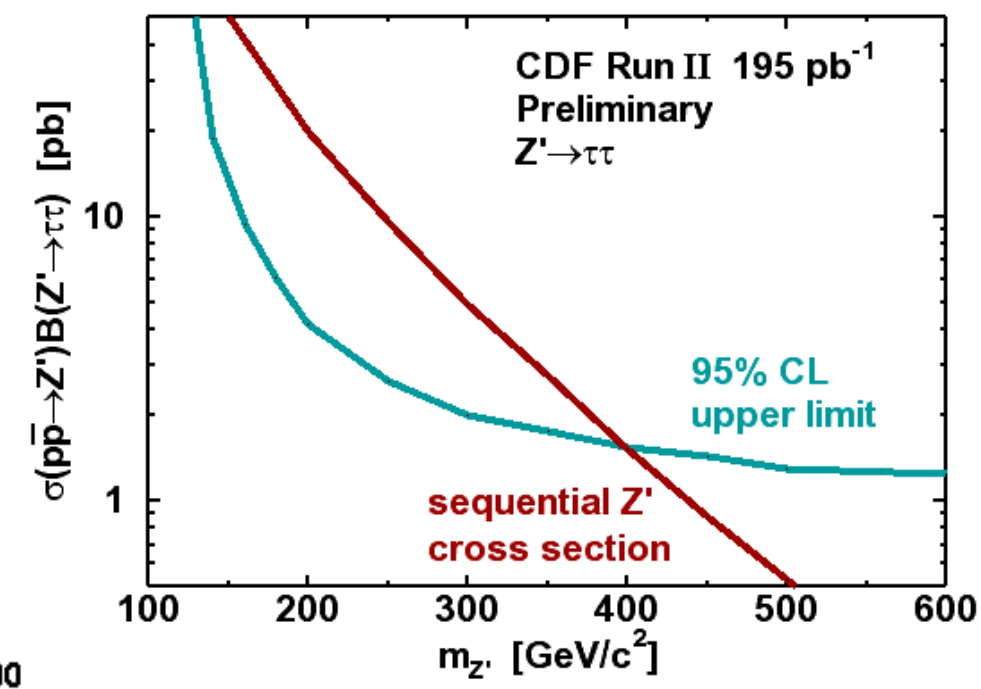
two examples:

coupling to SM field



$M_{Z'} > 815$ GeV/c^2 (ee+μμ)

$Z' \rightarrow \tau\tau$



Interpretation (2)

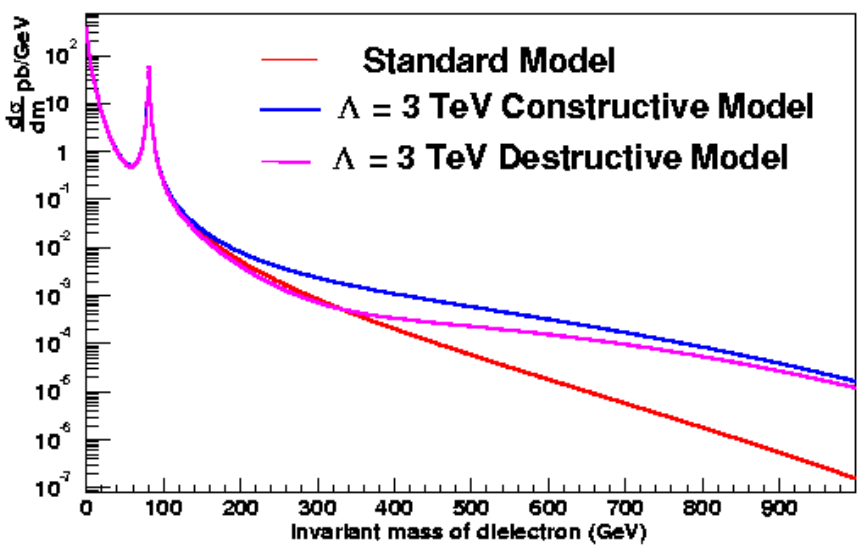
Deriving limits on Large Extra Dimensions (some models)

best limits on LED !

GRW [4]	HLZ [5]						Hewett [6]
	n=2	n=3	n=4	n=5	n=6	n=7	$\lambda = +1/\lambda = -1$
1.36	1.56	1.61	1.36	1.23	1.14	1.08	1.22/1.10

TABLE IV: Lower limits at 95% CL on the fundamental Planck scale, M_S, in TeV.

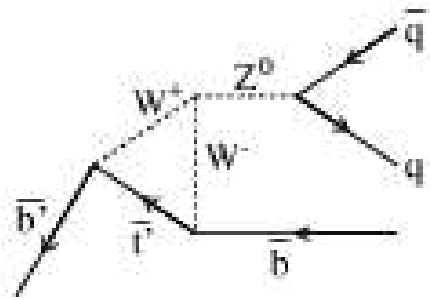
Effect of compositeness on di-lepton production



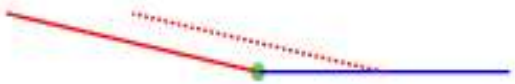
- di-electron analysis with 270 pb^{-1}
- di-muon analysis with 400 pb^{-1}
- Limits on scale range from 4 to 10 TeV depending on type of coupling

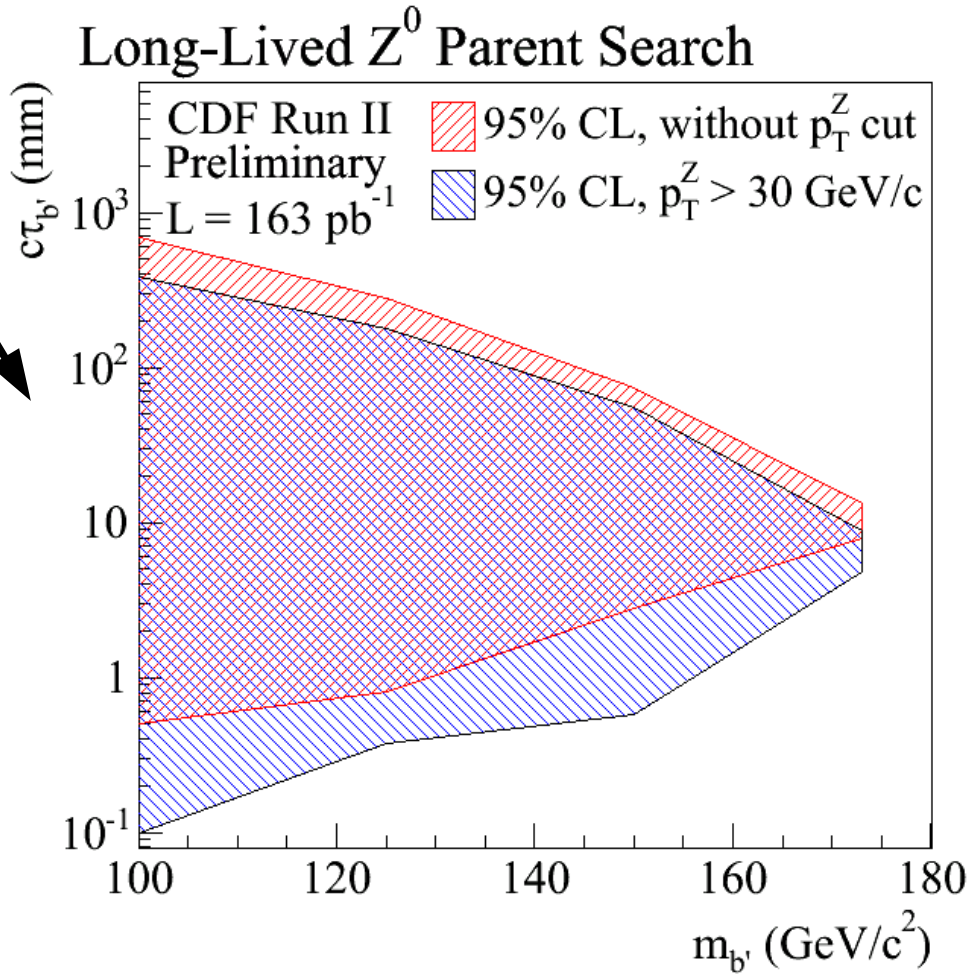
Search for a Z from long lived parents

- Scenarios
  - Z in decays from GMSB SUSY
  - 4th gen b' below top (benchmark)
- selection
  - 2 muons pT>20
  - select Z mass region
  - tight track quality criteria
  - reconstruct Z decay vertex
  - $\Delta\Phi<175^{o}$ to reduce prompt Z background with mismeasurements
  - pT(Z)>30 and L_{xy}>0.03cm (L_{xy} is the transverse decay length), 3 evts observed, 1.1±0.8 expected
  - OR: L_{xy}>0.1cm 2 evts observed, 0.72±0.27 expected



mismeasurement from back-to-back tracks



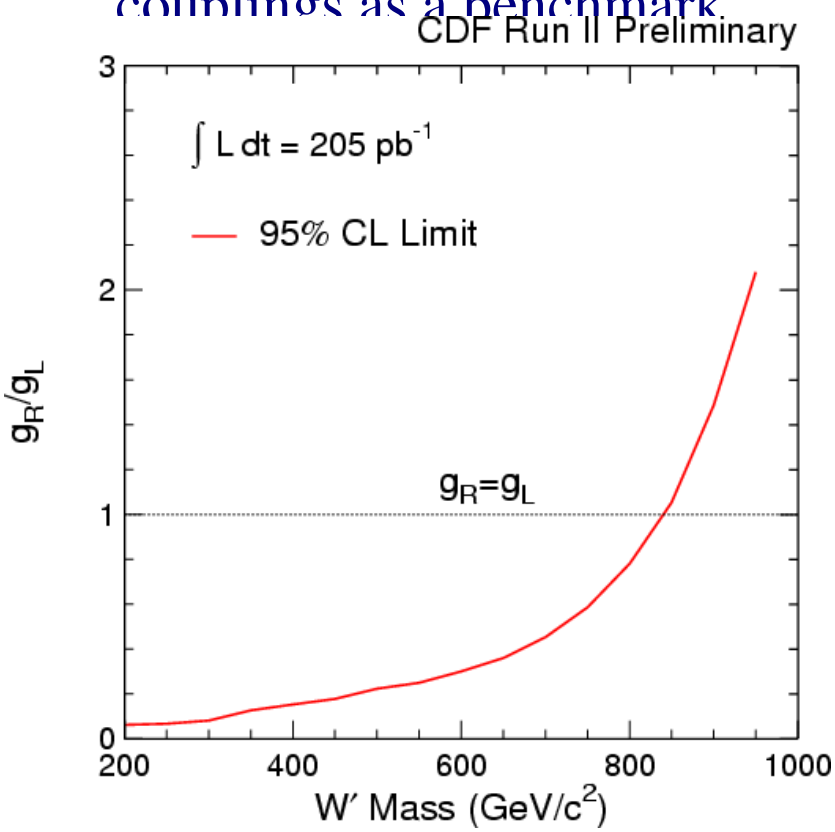


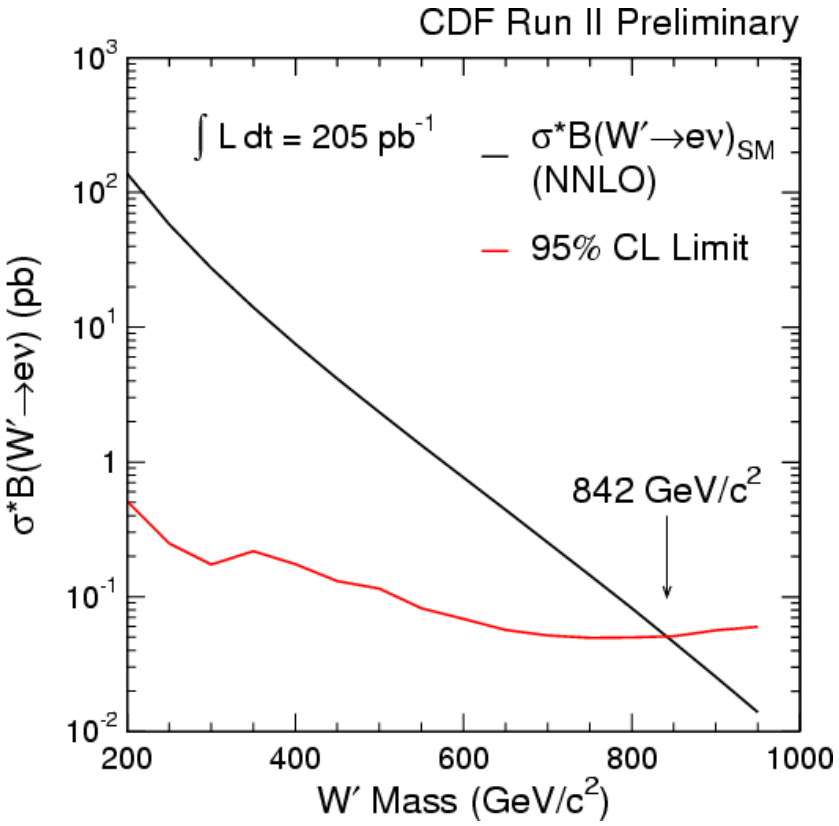
Search for a W'

- one isolated electron pT>25
- MET>25
- against QCD :
  - 0.4 < pT/MET< 2.5
- Use W' boson with V+A couplings as a benchmark

dominant systematics:
PDF and electron energy scale

assuming SM coupling strength
$M_{W'}$>842 GeV/c^2





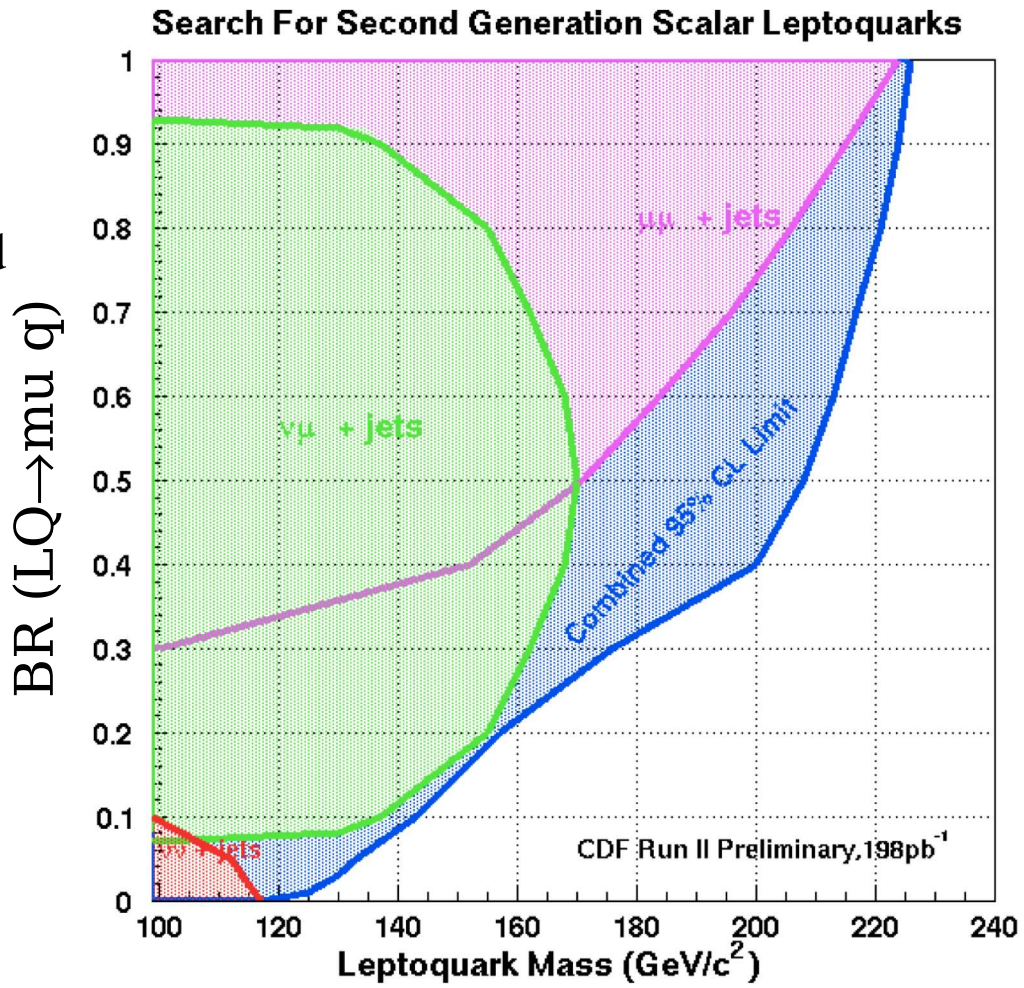
Pair production of 2nd generation leptoquarks

- mu mu jet jet
  - 2 mu pT>25, sum pT>80
  - 2 jets pT>15, 30, sum pT>80
  - veto Z and low mass region
  - Sqrt((Et(jet1)+Et(jet2))² + (Pt (mu1)+Pt(mu2))²)
  - 2 events observed 1.9 expected (Drell-Yan, top, fake)
- mu nu jet jet
  - mu pT>25
  - 2 jets pT>30, sum pT>80
  - MET>60, isolated
  - M_T(mu,nu) > 120
  - cut a round LQ mass : 3 to 0 observed events, in agrement with expectations

~200 pb^{-1}

Br=1 M_{LQ}>~225 GeV

Br=0.5 M_{LQ}>~210 GeV



Pair production of 1st generation leptoquarks

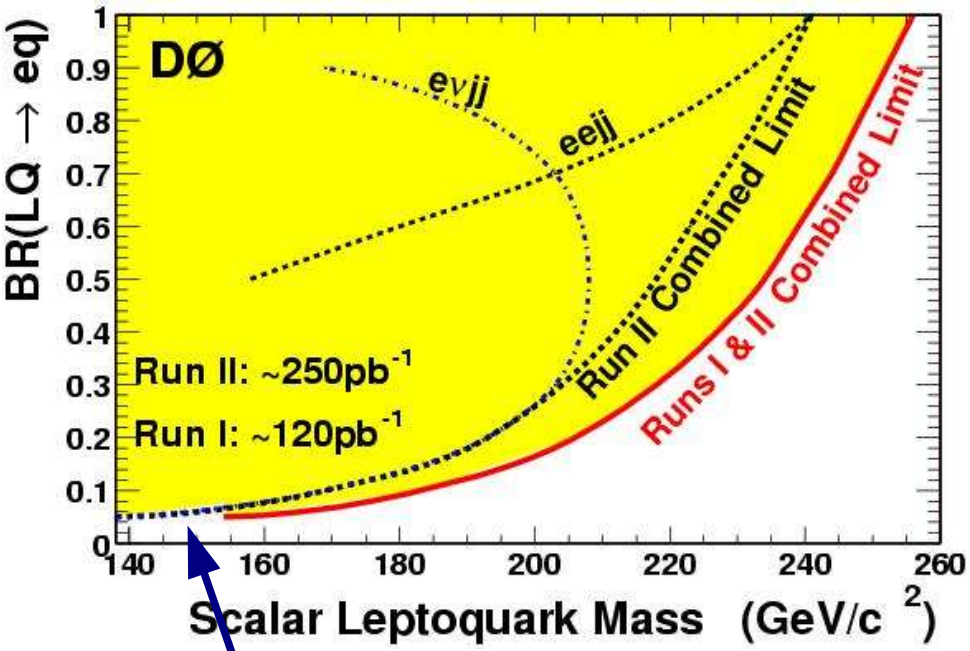
- e e jet jet channel :
  - 2 e ET>25 and 2 jets ET>20
  - veto around Z mass
  - sum e and jet ET > 450
  - 1 event observed 0.54 expected (Drell-Yan and QCD)
- e nu jet jet channel :
  - one tight central e pT>35
  - 2 jets pT>25
  - muon veto
  - M_T(e, MET) > 130
  - sum e, jet ET and MET > 330
  - 1 event observed and 3.6±1.2 (W+jets, QCD, top)
- Systematics : Jet Energy Scale,

Run II : 250 pb^{-1}

combined Run I + Run II

Br=1 M_{LQ}>256 GeV

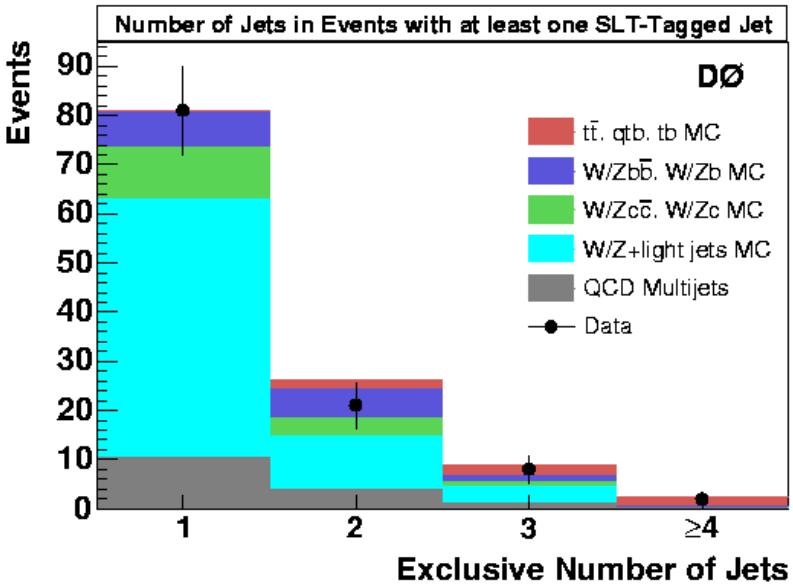
Br=0.5 M_{LQ}>234 GeV



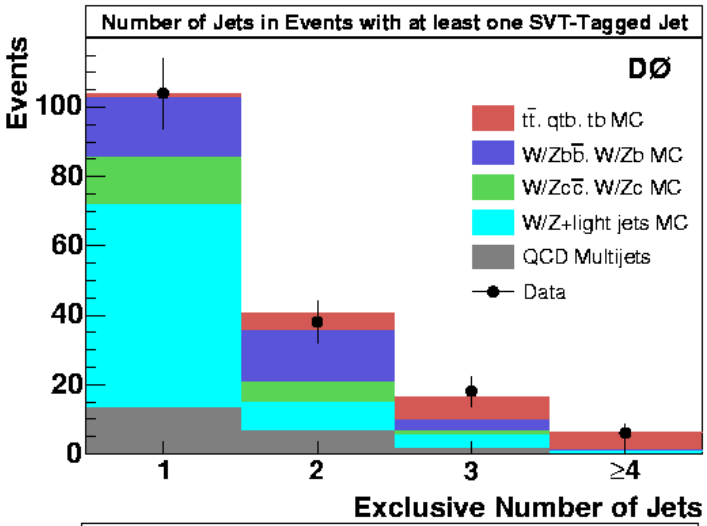
nu nu jet jet applies here also

Anomalous W+heavy flavor production

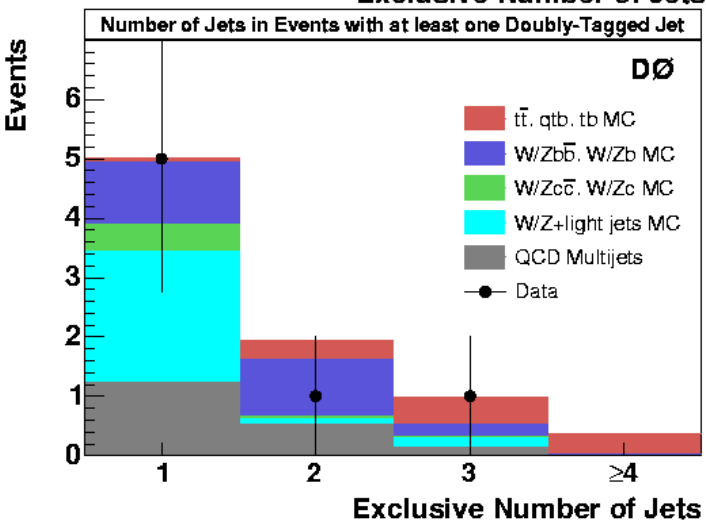
- 1 isolated electron pT>20 |η|<1.1 or 1 isolated muon pT>20 |η| <1.6
- MET>20, not aligned to lepton
- 40 < M_T(l,MET)<120
- b tagging, 2 algorithms:
  - SLT : muon tag and SVT : secondary vertex
- Syst: B tag, W+jets MC



SLT



SVT



SLT + SVT

- no excess, even double-tagged (CDF Run I), extract limits
- Wbb like : σ < 26.3 pb ~150 pb^{-1}
- top like: σ < 14.9 pb

What I did not talk about

- http://www-cdf.fnal.gov/physics/exotic/exotic.html
  - exited electron
  - technicolor in lnubb
  - magnetic monopole search
- http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm
  - extra dimensions in jets+MET
  - technicolor in di-electron and lnubb
- More details about the results presented here at the two locations above

Summary

- Comprehensive set of searches for new phenomena
- Leptonic (electron, muon) final states are a gold mine for searches at hadron colliders but should not simply focus on lepton efficiency :
  - understanding jet background
  - understanding cosmic background
  - understanding of the detector : Jet Energy Scale, etc
  - Even Z+jet and W+jet simulation is not to be taken for granted...
- Other signatures have been investigated
  - jets + MET
  - b tagging
  - tau
- Most analyses were based on ~200 pb^{-1} ,we have ~0.5 fb^{-1} on tape, about 0.8 fb^{-1} by the end of the year. Start counting in fb^{-1} ! A new era for searches at hadron colliders.