Non SUSY Searches at the Tevatron

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On behalf of the CDF and DØ collaborations

XXXIXth Rencontres de Moriond
QCD and Hadronic Interactions
La Thuile, 28 March- 3 April

Outline

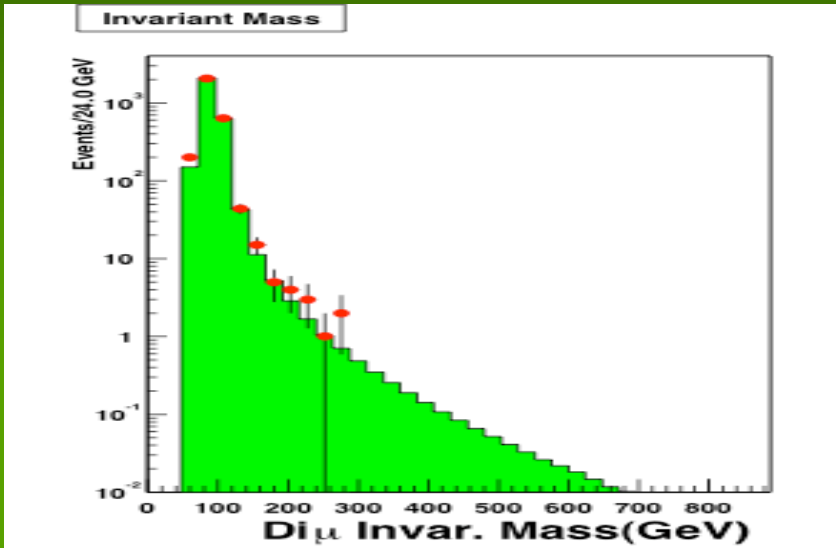
- ee/μμ Analysis
  - Z′, Extra Dimensions, Technicolor, SUSY, etc.
- eμ Analysis
- eeγ
  - Excited Leptons
- e/μ + Jets
  - Leptoquarks (First and Second generations)
- Jets + Missing Tranverse Energy (MET)
  - Leptoquarks (All generations)
- Jet + Missing Transverse Energy(MET)
  - Extra Dimensions
- Conclusions

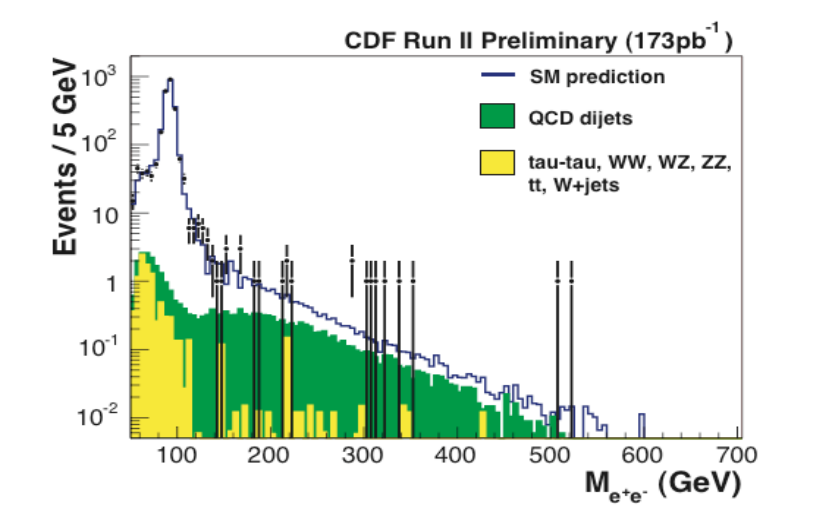
Dilepton High Mass Analyses

- Search for resonances in high invariant mass

- Results can be interpreted under many different models:
  - Z' (E6, sequential, little higgs)
  - Large Extra Dimensions
  - Randall Sundrum
  - Technicolor
  - SUSY
  - Etc

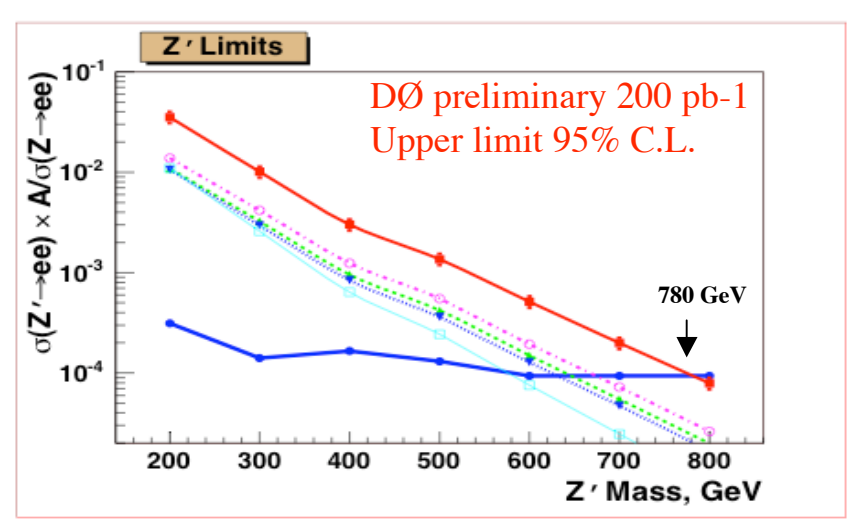
- CDF and DØ has slightly different approach:
  - **CDF** : Calculate the acceptances and resonances for 3 different spin assumption(0,1,2) and applied to many models.
  - **DØ:** Calculate the acceptances and resonances for each specific model





Dilepton High Mass(ee, μμ)

- Two lepton with Et(Pt)>25 GeV at least one central lepton
  - DØ uses mass window cuts and counting experiment
  - CDF fit the M_{ll} spectrum



- CDF/DØ set limits for low-energy E6 models using dilepton events

	channel	L (pb^{-1})	Z_I 95%C.L (GeV)	Z_χ 95%C.L (GeV)	Z_ψ 95%C.L (GeV)	Z_η 95%C.L (GeV)
CDF	ee	200	570	610	625	650
	μμ	126	425	455	465	495
DØ	ee	200	575	640	650	680

- CDF has interpreted this result in the Little Higgs model (littlest higgs model)
  - Predict a heavy neutral boson Z_h decaying into dileptons
  - Relevant parameter is the mixing angle cotθ

ee: $M_{Z'_h}$ >825 GeV (cotθ= 1.0)
μμ:$M_{Z'_h}$ >790 GeV (cotθ= 1.0)

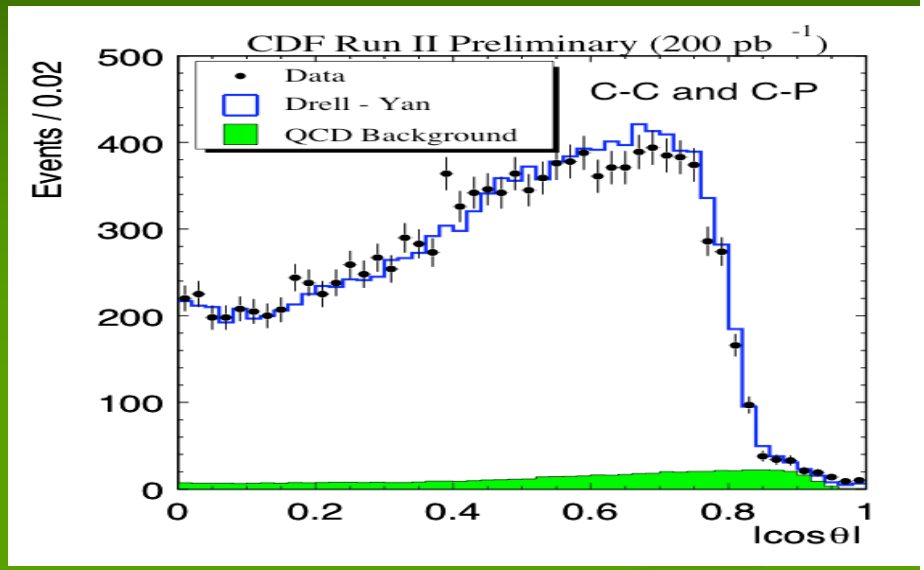
Dilepton High Mass(ee,μμ)

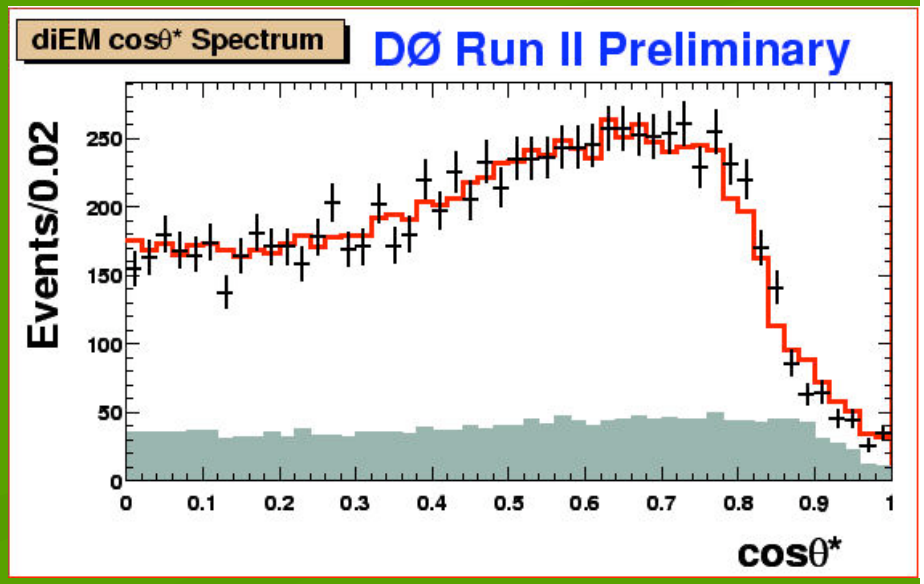
- **Large Extra Dimensions ADD (GRV convention)**
  - $M_{pl}^2 = (M_{pl}^{|3+N|})^{N+2} R^N = M_s^{N+2} R^N$
  - N>=3 only tested at colliders
  - The cross section is parameterized in terms of
    - $\eta = \lambda / M_s^4$

CDF: 2 electron E_t>25 GeV
Fit to the M_{ee} spectrum

DØ: 2 EM objects(e/γ) E_t>25 GeV
2 μ P_t>25 GeV
2D Fit to the M_{ll} and cosθ*

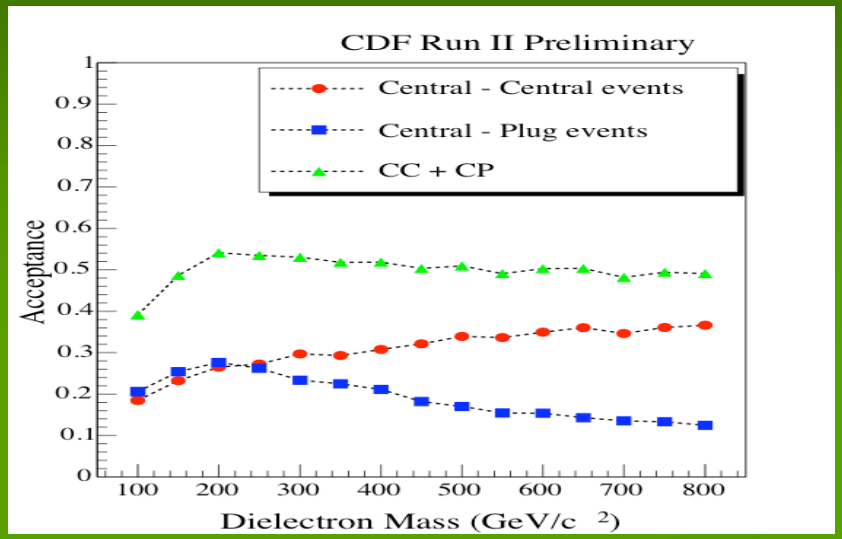
	DØ		CDF	
	L (pb)	95%C.L (TeV)	L (pb)	95%C.L (TeV)
diEm	200	1.36	200	1.11
diEm (I+II)		1.43		
μμ	100	0.880		





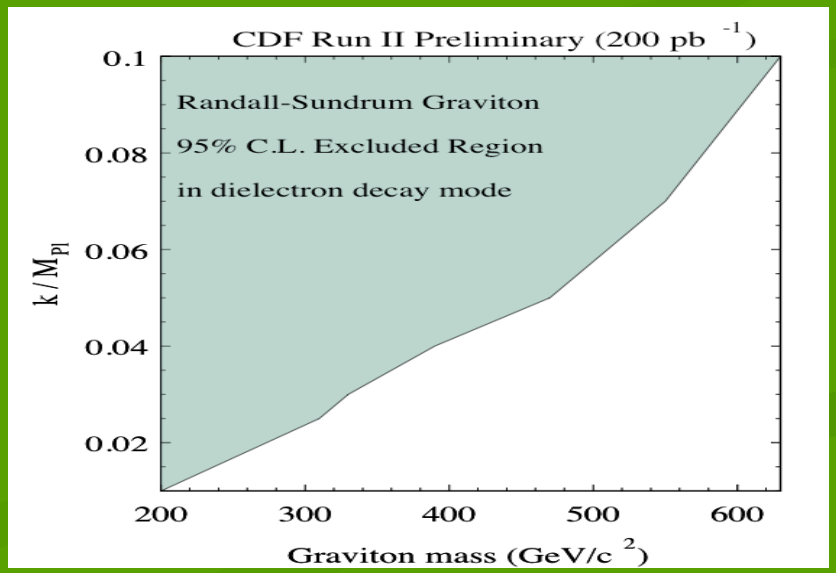
Dilepton High Mass(ee,μμ)

- CDF interpret as Randall-Sundrum graviton
  - 1 highly curved extra dimension
  - Gravity localised in the ED
  - Excited Kaluza-Klein graviton
    - Decays to leptons
  - Relevant parameters: k/Mpl



CDF uses acceptances

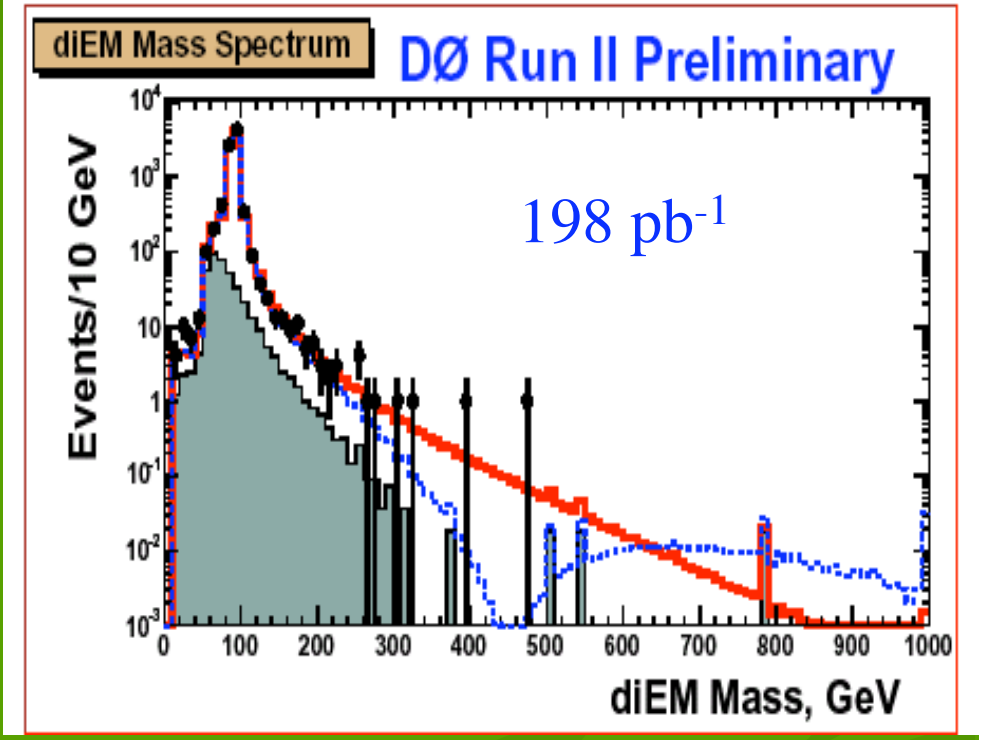
from spin2 case



Set upper limits at 95% C.L.
ee: M_G >625 GeV (k/M_{pl}= 0.1) @ 200 pb^{-1}
μμ:M_G>475 GeV (k/M_{pl} = 0.1) @ 126 pb^{-1}

Dilepton High Mass(ee,μμ)

- DØ has done a search for TEV^{-1} Extra dimensions
  - Chiral fermions in 3D
  - SM bosons propagates in extra δ>0 dimensions, and are equivalent to KK towers with Masses
    - $M^2_n = M_o^2 + n^2M^2_c$
  - Gives rise to mixing among SM boson and the nth modes of W/Z



First direct search

At 95%C.L M_c > 1.12 TeV

Indirect searches:

LEP: > 6.6 TeV; all: > **6.8 TeV**

μe Analysis

- DØ has done model independent search in eμ channel
- Search for an excess over the SM prediction in the kinematic space
- Look at the Missing E_T, sensitive to new Physics
- Set upper limits at 95 % C.L.

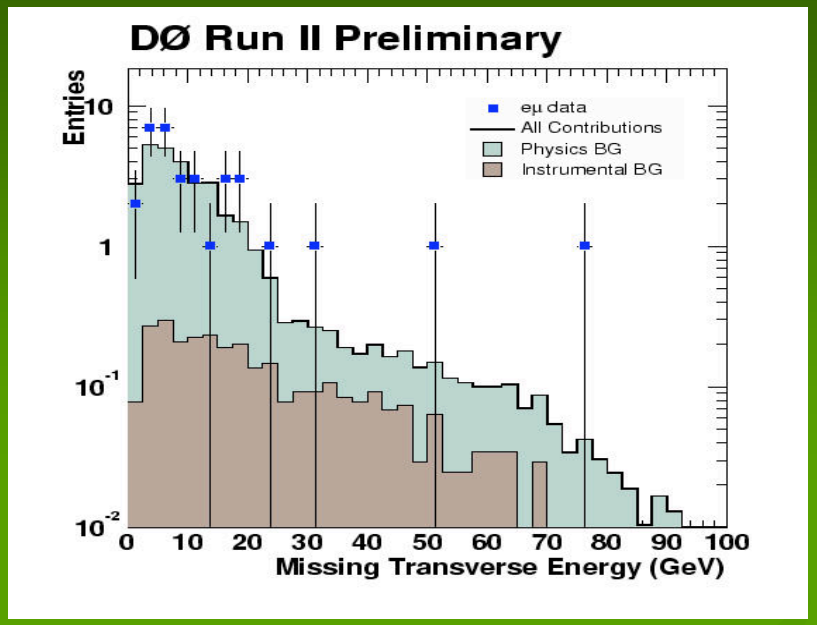
$\mathcal{L}$ = 98 pb^{-1}

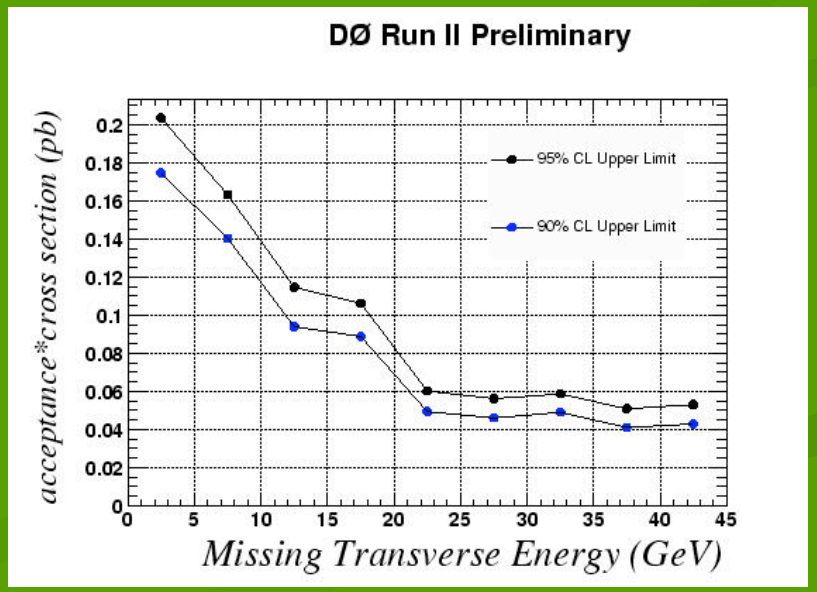
1 electron E_t>25 GeV

1 muon Pt>25 GeV

Good fiducial volume

0/1 jet

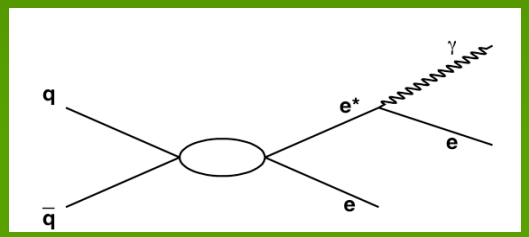


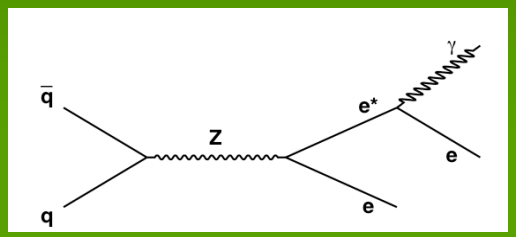


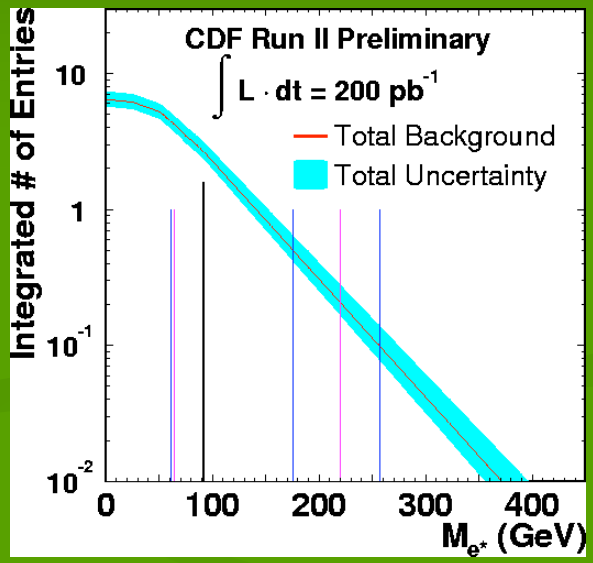
eeγ Analysis

- CDF has done a search for excited electron, predicted in many compositeness models
- Produce via contact or gauge mediated interactions

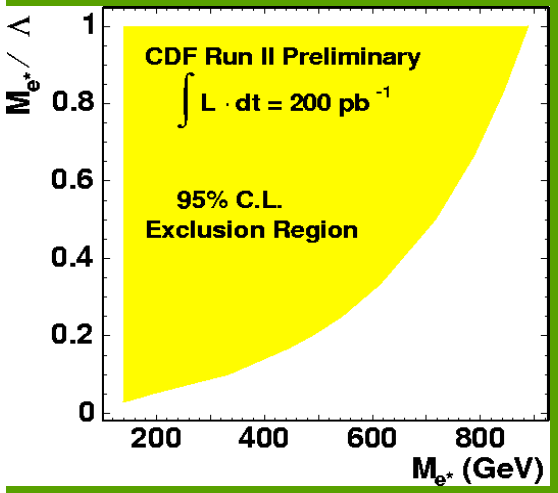
L = 200 pb-1
2 electron /γ,
At least one Central electron
Expected $2.98^{+0.4}_{-0.3}$; observed: 3

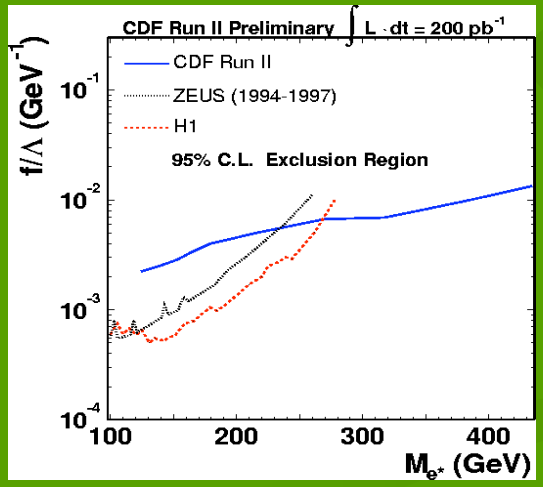






- The cross section depends on e* mass and Λ





first time search

Contact interaction:

At 95% C.L. Me*>889GeV (Me* = Λ)

Gauge mediated:

At 95% C.L. Me*>208GeV (Me*= Λ)

Lepton+Jets analysis

Dominant at Tevatron

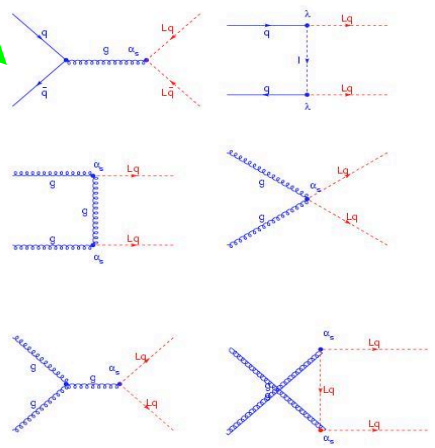
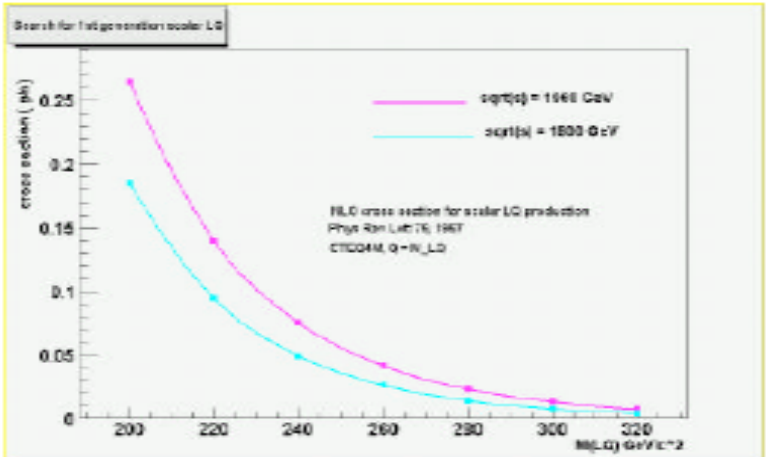


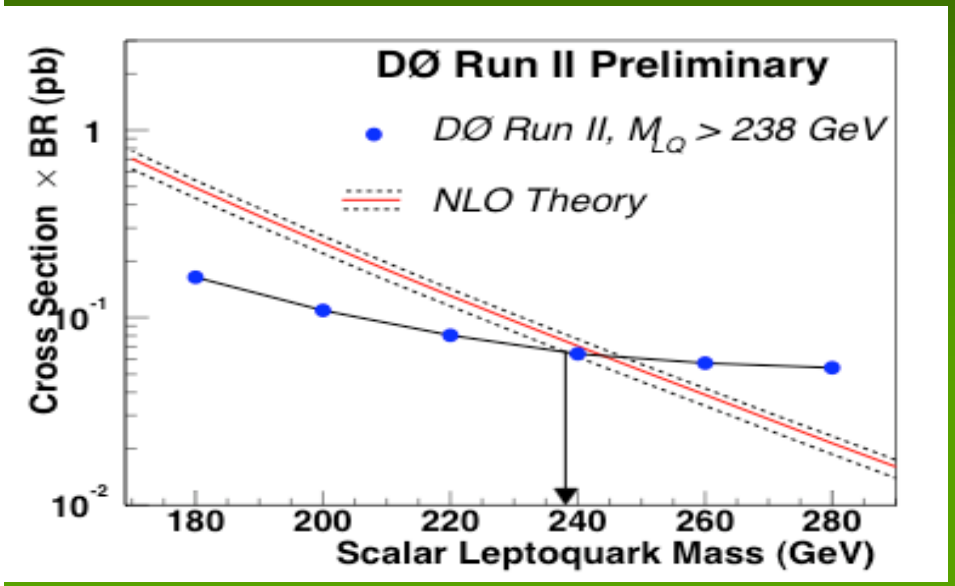
Figure 2.4: *Feynman diagrams for pair production of leptoquarks at hadron colliders.*

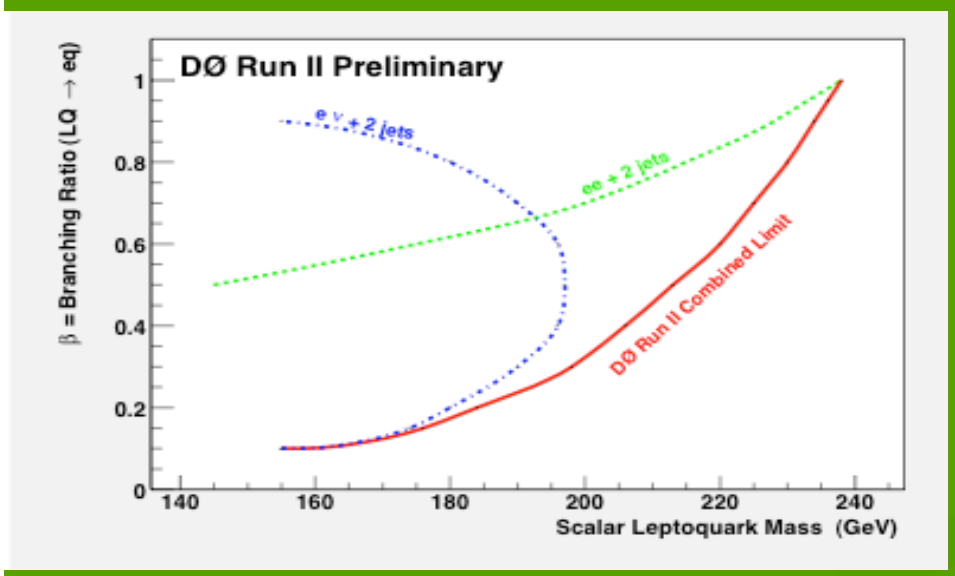


- Color triplet bosons with lepton and barion numbers, and fraction charge
- Predicted in several theories: GUT, technicolor, SUSY,etc
- Assume LQ couples to lepton and quark of same generation
- Pair produced at Tevatron
- LQ decays:
  - LQ ⇨ lq (l = e,μ,τ) β =1
  - LQ ⇨ νq β = 0
  - β= BR(LQ→lj)

30% increase in cross section at RunII

e+Jets Analysis





First generation LeptoQuarks

- **eejj channel (β=1)**
  - Two isolated electron in fiducial region
  - Two jets
  - Remove events in the Z peak
  - $\Sigma(E_t(e_1)+E_t(e_2)+E_t(j_1)+E_t(j_2))>450$ GeV

  DØ observe 0 events w/ 175 pb^{-1}, expects 0.4±0.1

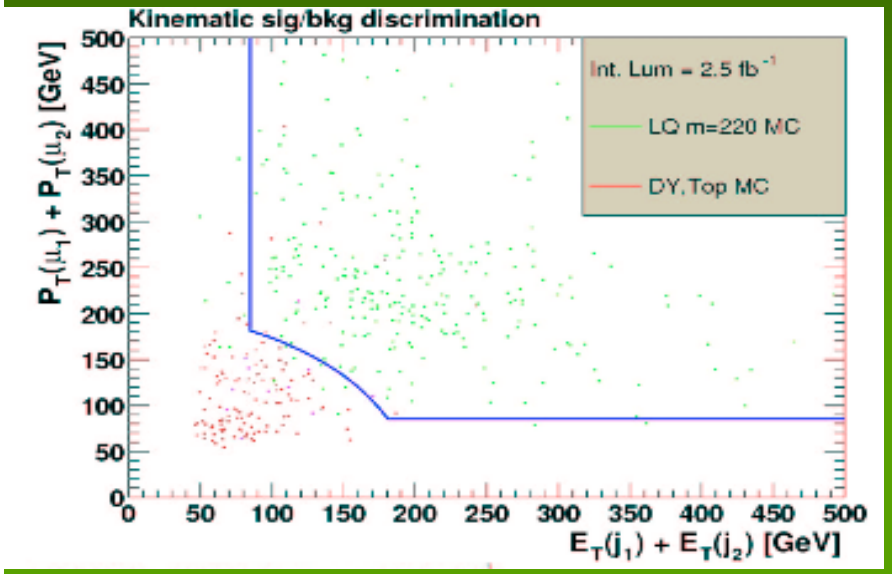
  Upper limit at 95%C.L M_{LQ}>238 GeV

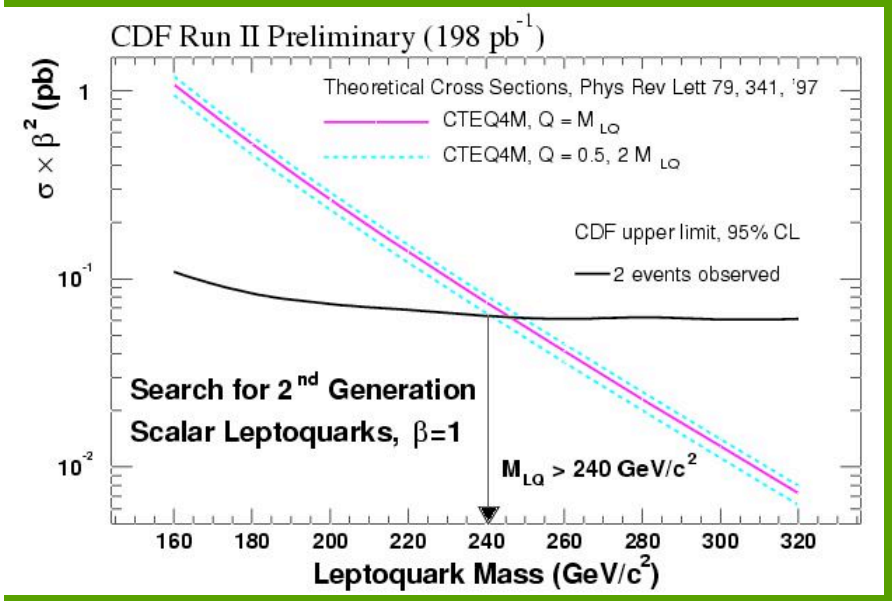
- **eνjj channel (β=0.5)**
  - Isolated central electron
  - Two jets
  - MET >30 GeV, $\Delta\Phi(e,MET)>0.7°$
  - $Mt(e\nu)>130$GeV
  - $\Sigma(E_t(e_1)+E_t(e_2)+E_t(j_1)+E_t(j_2))>330$ GeV

  DØ observe 2 events w/ 175 pb^{-1}, expects 4.7±0.9

  Upper limit at 95%C.L M_{LQ}> 194 GeV

μ + Jets Analysis





Second generation LeptoQuarks

- **μμjj channel (β=1)**
  - Two muons
  - 2 jets
  - Mμμ>15 (J/ψ,Υ)
  - Remove events in the Z peak
  - $\Sigma(E_t(j_1)+ E_t(j_2)) > 85$ GeV
  - $\Sigma(P_t(\mu_1)+ P_t(\mu_2)) > 85$ GeV
  - $\sqrt{\Sigma j(E_t)^2+ \Sigma\mu(P_t)^2} > 200$ GeV

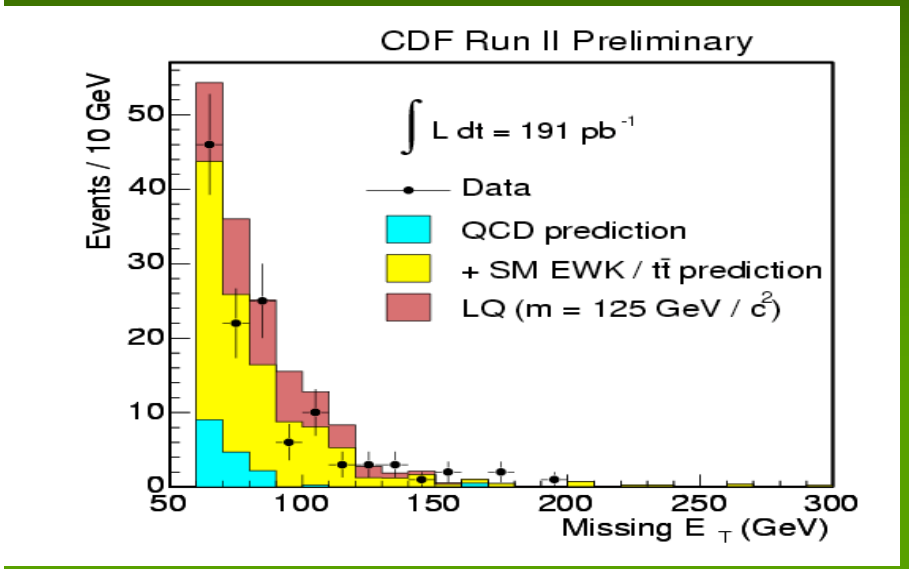
CDF observe 2 events w/~200 pb^{-1}

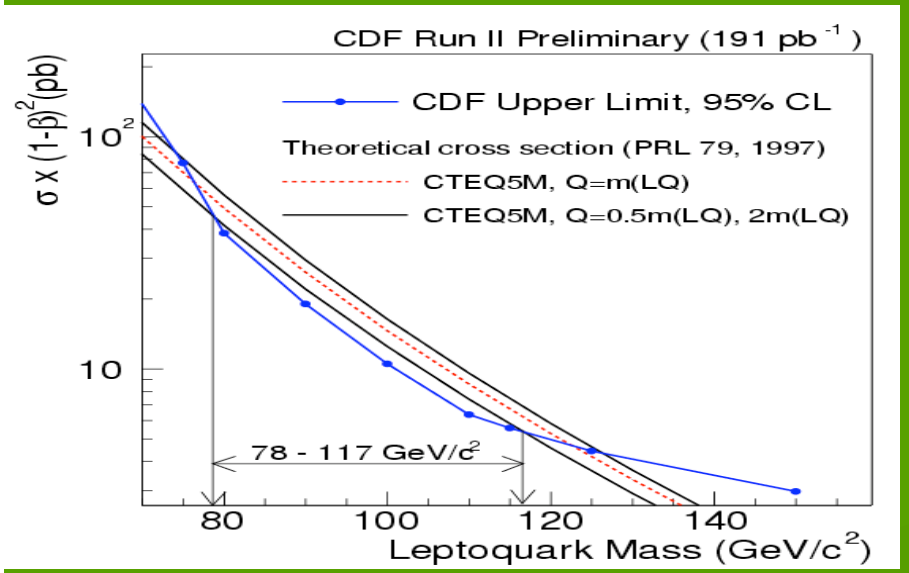
CDF expects 3.15±0.17

Upper limit at 95%C.L

M_{LQ}> 240 GeV (β=1)

Jets + Missing Transverse Energy





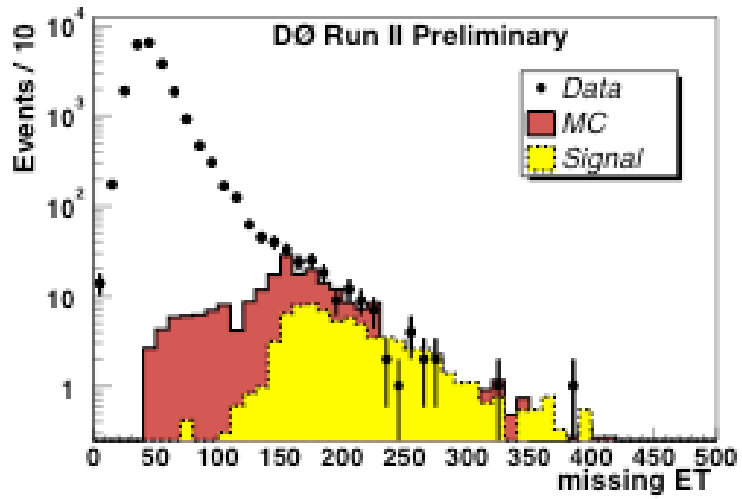
All generation LeptoQuarks

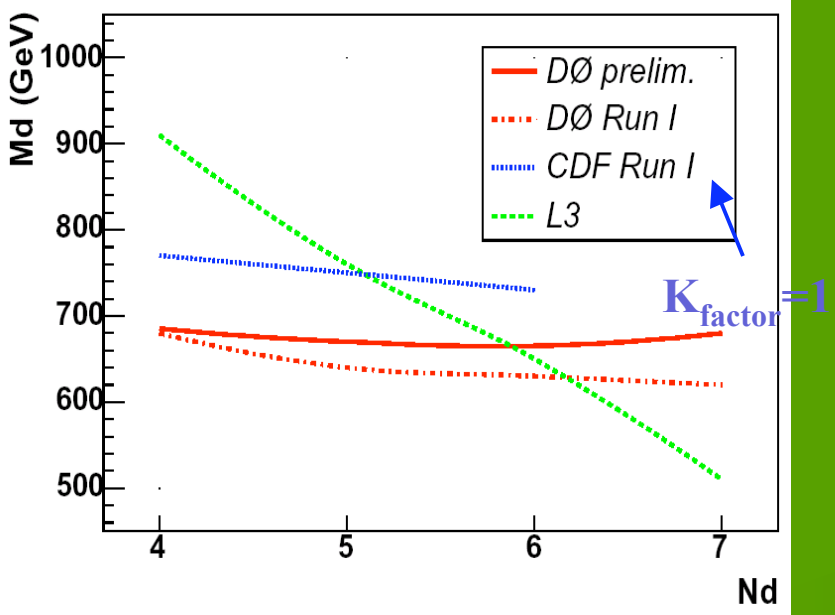
- ννjj channel (β=0)
  - 2,3 jets (leading jets in central region)
  - MET>60 GeV
  - Jets + MET not aligned
  - 80° <ΔΦ(j,j)<165°
  - Veto on leptons

Observed 124 events w/ 198pb^{-1}
Expects 118±14 events

Upper limit at 95%C.L
78< M_{LQ}<117GeV

Jet+Missing Transverse Energy





- **DØ has done a search Extra Dimensions**
  - Graviton is produced recoiling against a jet or gluon
  - Monojet like topology

$J_1 > 150$ GeV,
$J_2 < 50$ GeV,
MET > 150GeV
Δ(Met,jet)> 30°

Statistical theory

Observe 63 events; expect 100 ±6±7 in 85 pb^{-1}

Signal Limit at 95% C.L.= 84 events (expected limit 128 ± 28)

Includes large energy scale uncertainty

Both MC and Data scales

Efficiency: 20%

Background: +50% and –30%

Conclusions

- Tevatron is delivering record luminosities
- Detectors have collected ~200 pb^{-1} of good quality data until September 2003
- Data analyzed with sensitivity to many models
  - Leptoquarks (first, second generations)
  - Z' models (E6, Little Higgs)
  - Extra Dimension models (ADD, TeV-1, Randall-Sundrum)
  - Excited electrons
  - Technicolor
  - SUSY
- Stay Tune for more to come from Tevatron soon!!!

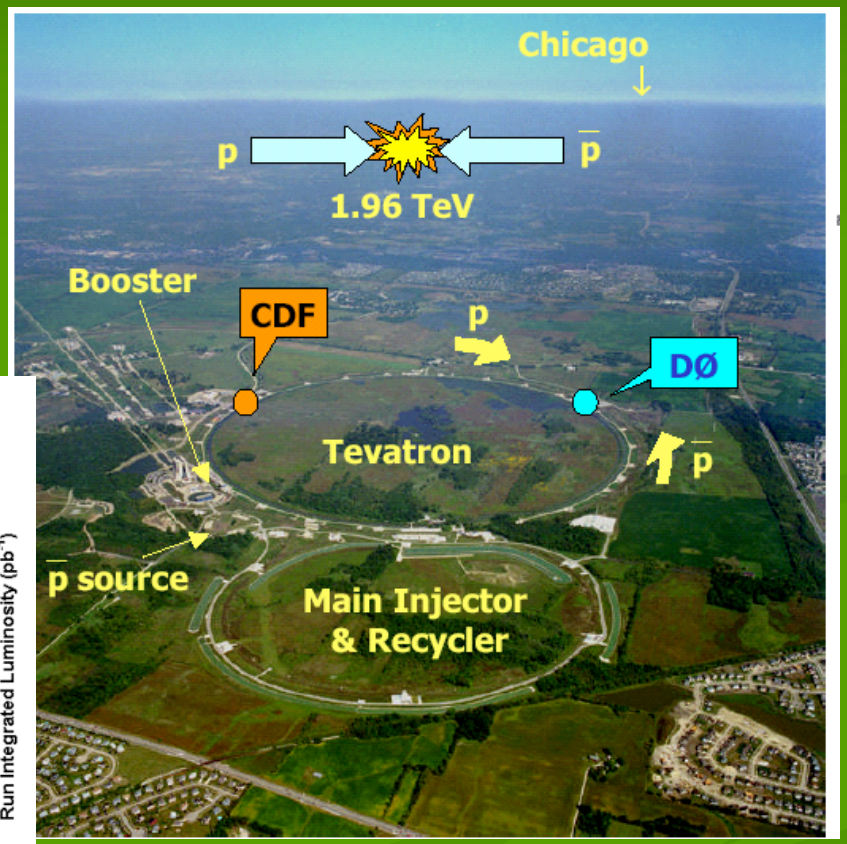
LQ summary

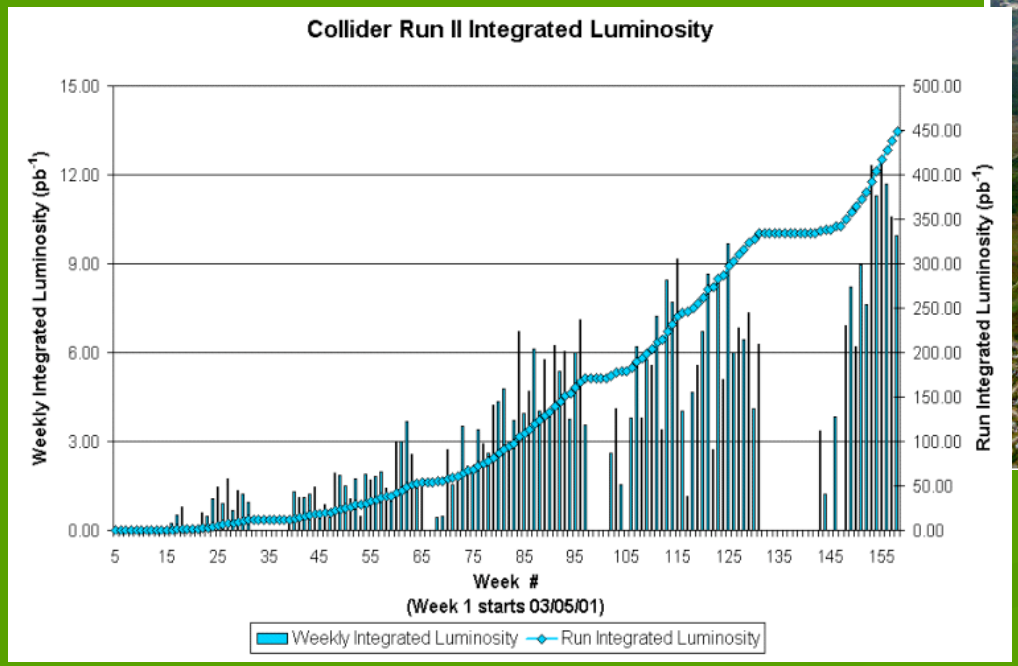
Scalar LQ		CDF		DØ	
Generation	β	M_{LQ} (GeV)		M_{LQ} (GeV)	
		Run 1	Run 2	Run 1	Run 2
1st	1	213	Update in progress	225	238
	0.5	182	166	204	194
	0		78-117	98	
2nd	1	202	241	200	186
	0.5	160		180	
	0		78-117	98	

Tevatron performaces

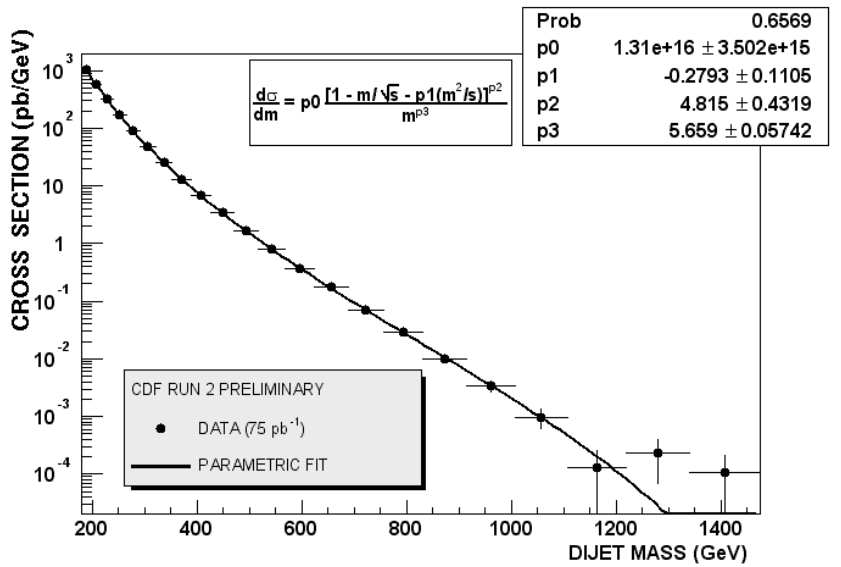
Tevatron successes in early 2004:

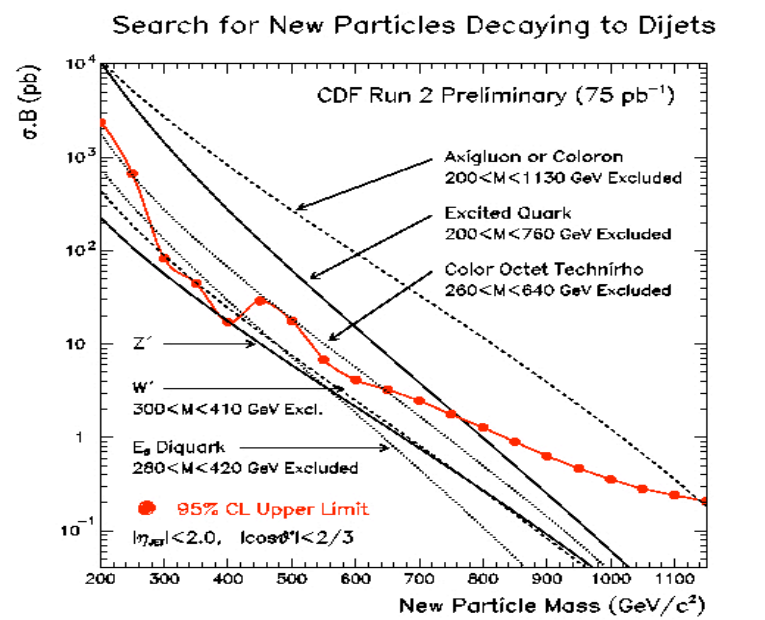
- Record luminosity 6.8E31
- 3.9pb^{-1} integrated in a single store
- First store w/ antiprotons from Recycler





Dijet High Mass Analyses





L = 75 pb $^{-1}$

At least 2 jets , $|\eta|<2$

Reduce background: $\cos\theta^*<2/3$

Search for resonances in the invariant mass of largest Et jets spectrum.

sensible to new physics

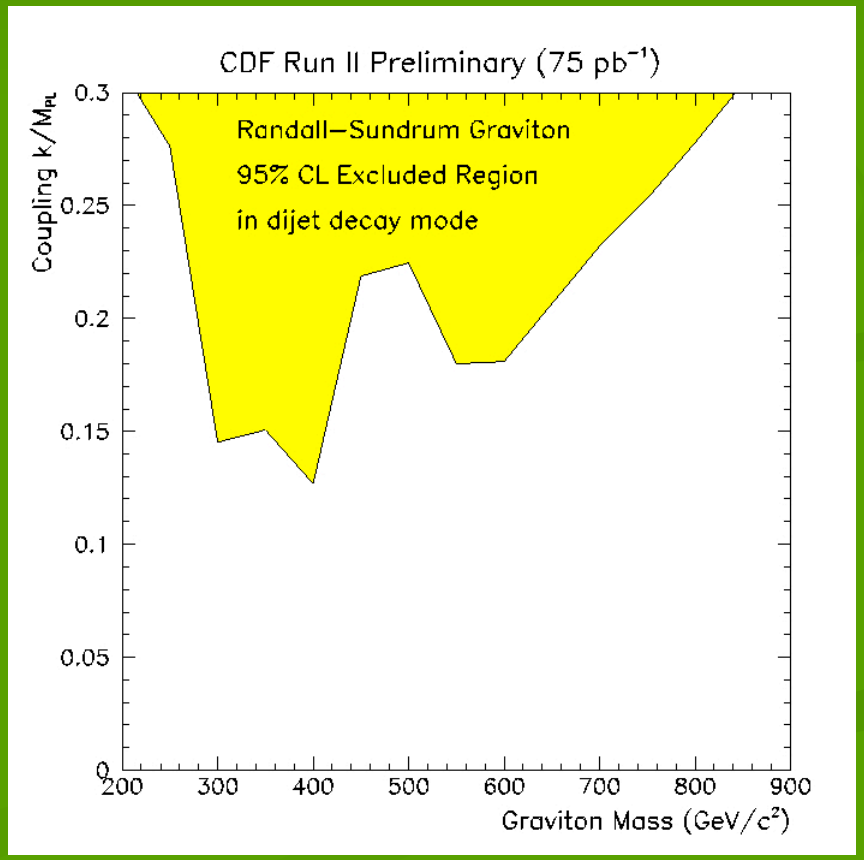
Particle	95% C.L. GeV
Axion/Coloron	200<M<1130
Excited Quark	200<M<760
E6 diquark	280<M<420
W′	300<M<410
Technirho	260<M<640

Dijet High Mass

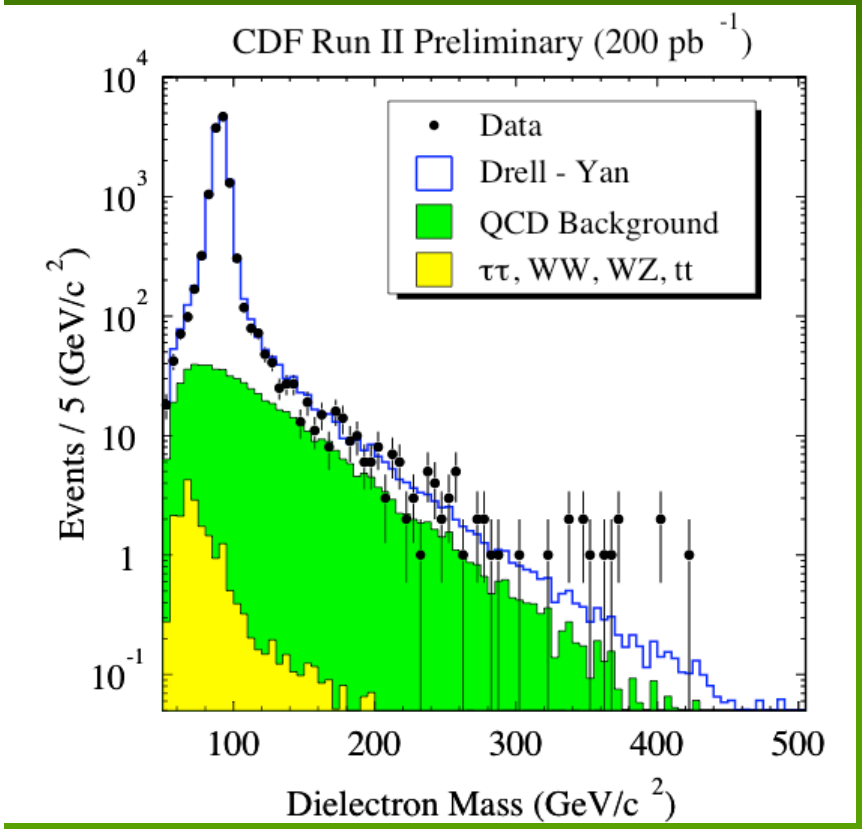
Sensitivity to high K/M_{pl} and M_G mass

- With the same invariant mass
- Search for Randall-sundrum model
- Exclude a region on the $M_{graviton}$ K/M_{pl} plane

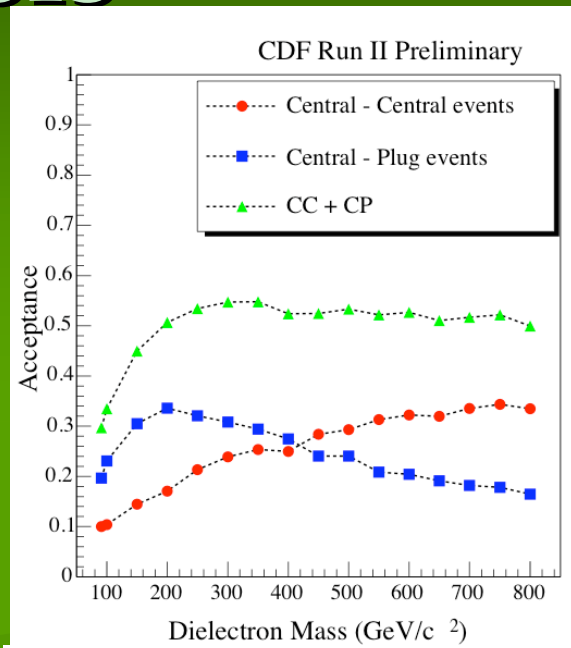
Excluded:
jj: $220<M_G<840$ GeV ($k/M_{pl}= 0.3$)



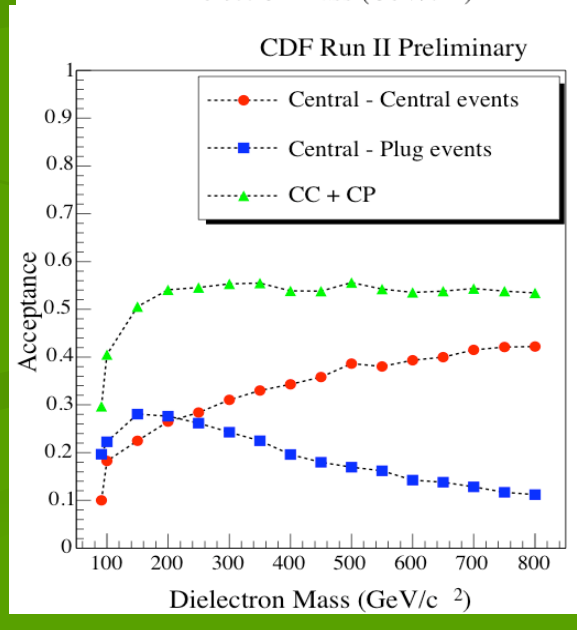
More ee analysis



Acceptance for Spin 1

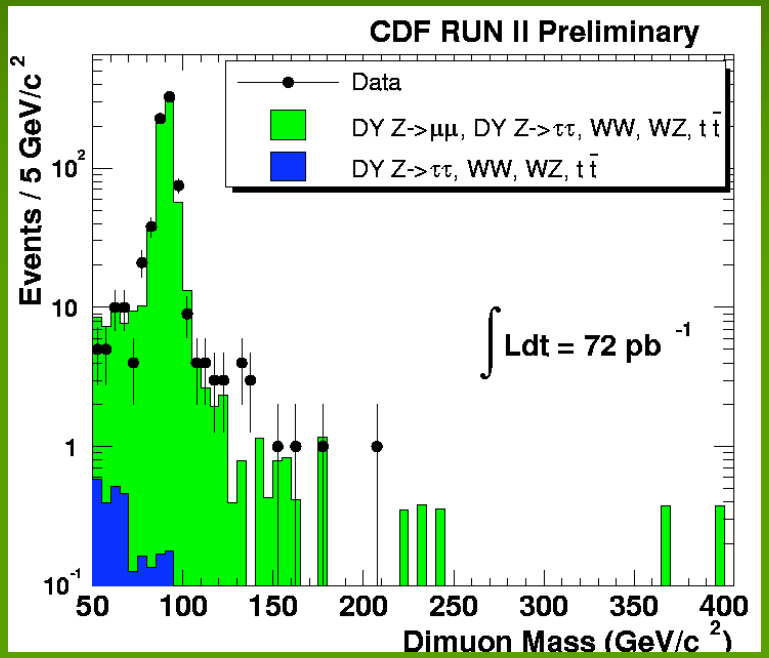


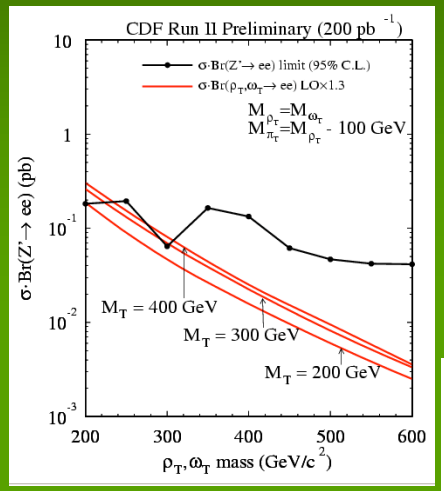
Acceptance for Spin 0

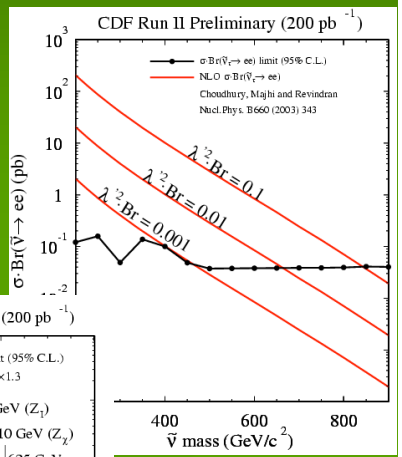


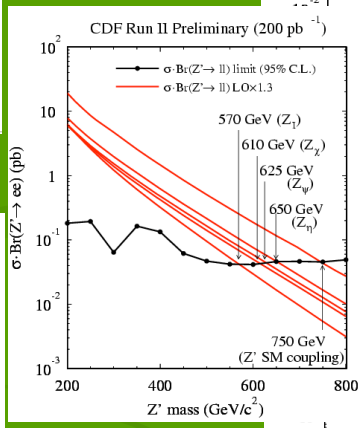
ee invariant mass

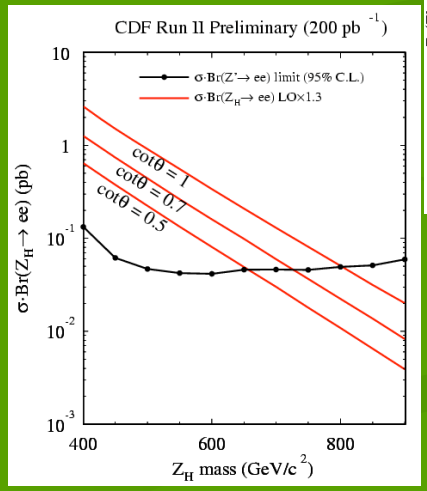
cont'd) More ee

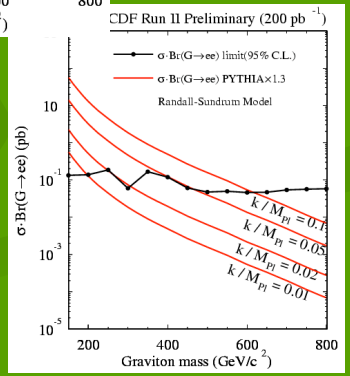


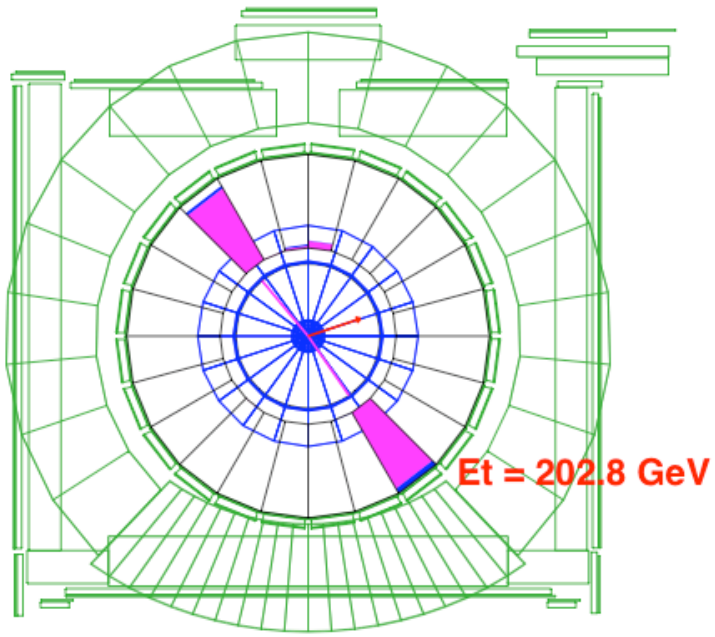
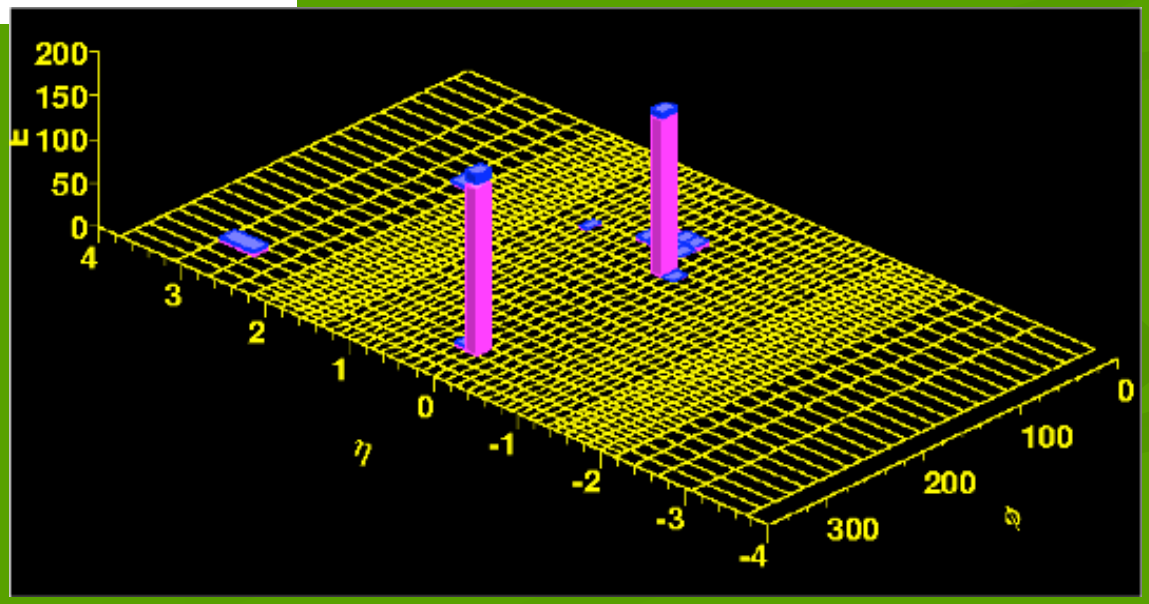








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