



Non SUSY Searches at the TEVATRON Run II



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OUTLINE

- I. INTRODUCTION
- II. FERMION SUB-STRUCTURE
 - Search for Leptoquarks
 - Search for Leptons or Quarks Compositeness
- III. EXTENDED GAUGE SYMMETRIES
 - Search for W'
 - Search for Z'
- IV. EXTENDED NUMBER OF SPACE DIMENSIONS
 - Search for Randall-Sundrum gravitons
 - Search for Large Extra Dimensions
- V. CONCLUSIONS
- VI. PROSPECTS FOR THE RUN II B



NOTICE

- This talk is a NON EXHAUSTIVE overview of the numerous searches for Exotic extensions of the SM at the TEVATRON Run II

Not covered:

- Technicolor
- Little Higgs
- Model independent searches
- CHAMPS
- Monopoles,...

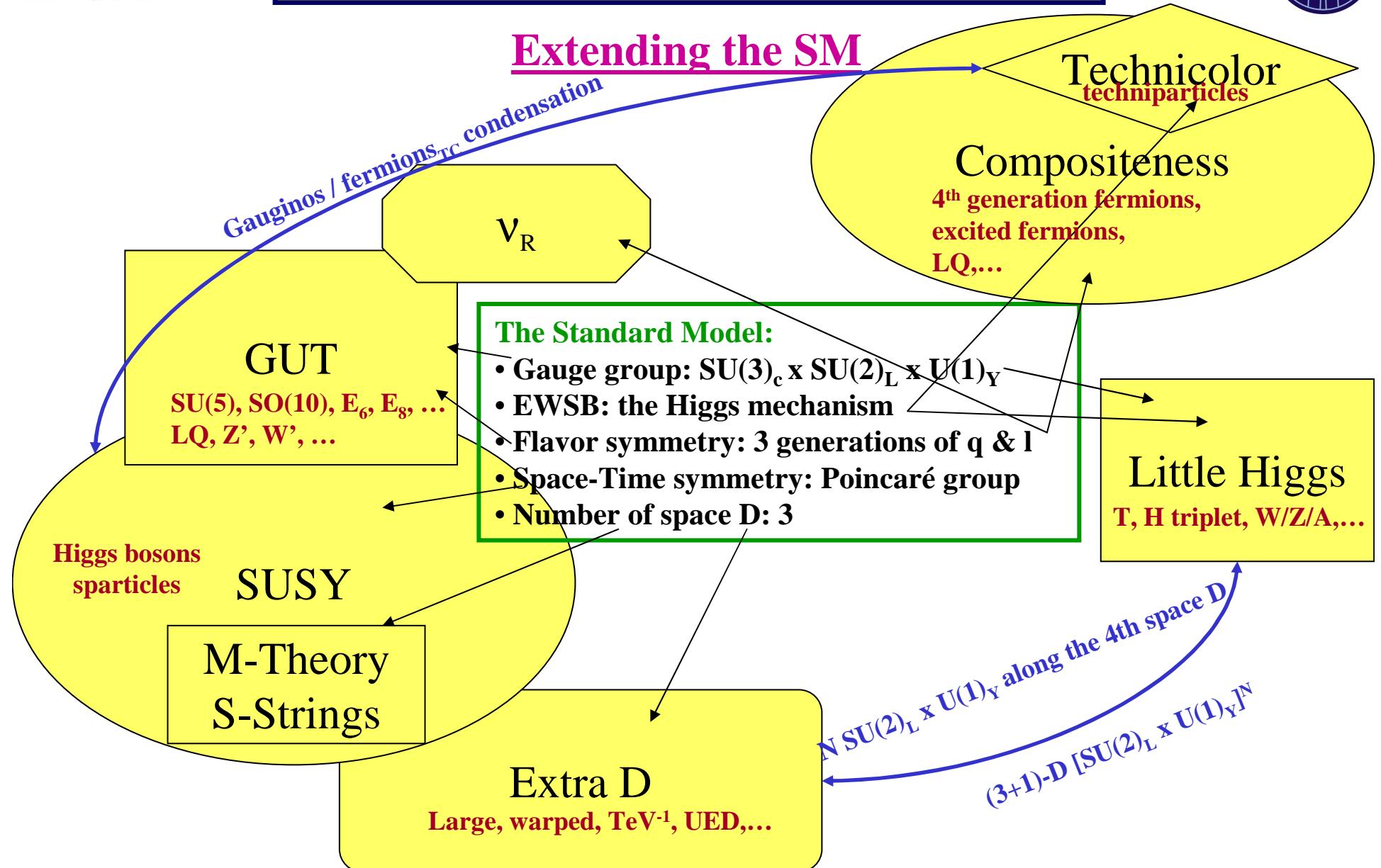
- Each analysis status:
 - Prel.: preliminary
 - Acc.: accepted for publication
 - Pub.: already published

is mentioned in the last column of the tables.

All **exclusion limits** are at the **95% CL**



I. INTRODUCTION

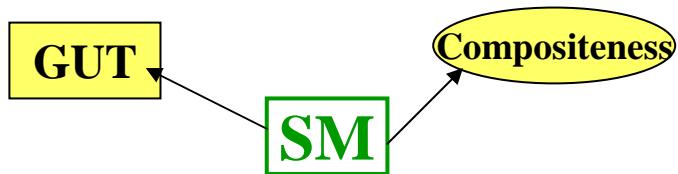




II. FERMIONS SUB-STRUCTURE



1. Search for LeptoQuarks



PRODUCTION @ HADRON COLLIDERS:

- $q + q\bar{q} \rightarrow LQ + LQ\bar{q}$
- $g + g \rightarrow LQ + LQ\bar{q}$
- $q + g \rightarrow LQ + l$ (smaller σ)
- σ independent of λ for SLQ
(except for single LQ)
=> $\sigma(\alpha_s, M_{SLQ})$
- σ depends on 2 parameters κ_G and λ_G for VLQ
=> $\sigma(\alpha_s, M_{VLQ}, \kappa_G, \lambda_G)$

DECAY MODES:

$$BR(LQ \rightarrow \ell^\pm q) = \beta$$

$$BR(LQ \rightarrow \nu_\ell q) = 1 - \beta$$

Main search channels at the TEVATRON:

$$p\bar{p} \rightarrow LQ_i + \overline{LQ}_i \rightarrow \ell_i^\pm \ell_i^\mp q_i \bar{q}_i \quad \beta^2$$

$$p\bar{p} \rightarrow LQ_i + \overline{LQ}_i \rightarrow \ell_i^\pm \nu_i q_i \bar{q}_i \quad 2\beta(1 - \beta)$$

$$p\bar{p} \rightarrow LQ_i + \overline{LQ}_i \rightarrow \nu_i \bar{\nu}_i q_i \bar{q}_i \quad (1 - \beta)^2$$

(0 < i < 4: generation index)



II. FERMIONS SUB-STRUCTURE



1. Search for LeptoQuarks

D0

Channel	$L_{int} (\text{pb}^{-1})$	Status
$\text{LQ}_2 \text{ pairs} \rightarrow \mu + \nu + 2\text{q}$	1050	07 Prel.
$\text{LQ}_3 \text{ pairs} \rightarrow 2\nu + 2\text{b}$	310	06 Prel.
$\text{LQ}_2 \text{ pairs} \rightarrow 2\mu + 2\text{q}$	300	06 Acc.
$\text{LQ}_2 + \mu \rightarrow 2\mu + \text{q}$		
$\text{LQ} \text{ pairs} \rightarrow 2\nu + 2\text{q}$	370	06 Pub.
$\text{LQ}_2 \text{ pairs} \rightarrow 2\mu + 2\text{q}$	290	06 Pub.
$\text{LQ}_1 \text{ pairs} \rightarrow 2e + 2\text{q}$	252	04 Pub.
$\text{LQ}_1 \text{ pairs} \rightarrow e + \nu + 2\text{q}$		

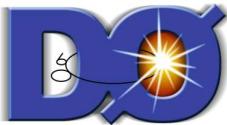
CDF

Channel	$L_{int} (\text{pb}^{-1})$	Status
$\text{VLQ}_3 \text{ pairs} \rightarrow 2\tau + 2\text{b}$	322	06 Prel.
$\text{LQ}_2 \text{ pairs} \rightarrow 2\mu + 2\text{j}$	198	04 Pub
$\text{LQ}_2 \text{ pairs} \rightarrow \mu + \nu + 2\text{j}$	198	04 Pub
$\text{LQ}_1 \text{ pairs} \rightarrow 2e + 2\text{j}$	200	04 Pub
$\text{LQ}_1 \text{ pairs} \rightarrow e + \nu + 2\text{j}$	200	04 Pub
$\text{LQ}_1 \text{ pairs} \rightarrow 2\nu + 2\text{q}$	191	03 Pub
Scalar LQ_1 pairs : <u>comb. 3 analyses above</u>	~200	05 Pub.
Scalar LQ_2 pairs : <u>comb. 2 analyses above</u>	~200	06 Pub.

Note

- most results concern **scalar LQ** (simply denoted **LQ**)
- just one result concerns **vector LQ** (denoted **VLQ**)

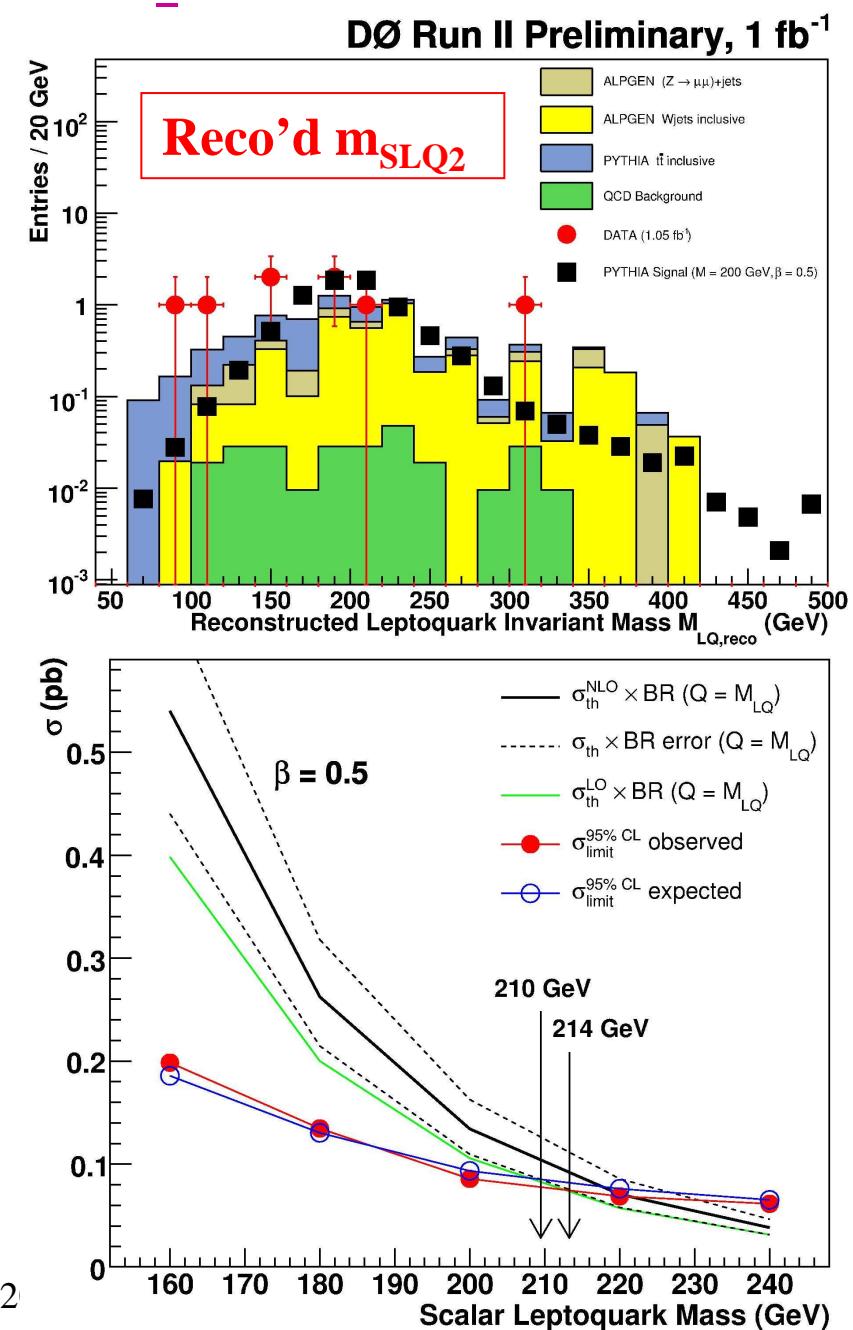
Detailed

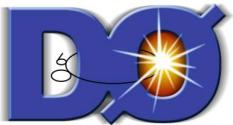


Search for SLQ₂



- D0:
 - Analysis: LQ₂ pairs → μν+jets
 - Triggers: single μ
 - Data sample: 1050 pb⁻¹
 - Instr. background: QCD from data
 - Event selection:
 - exactly 1 hard & isolated μ
 - 2 hard jets and large mE_T
 - large m_T(μ, mE_T) and large H_T
 - Main BKGD: W(→μν)+jets
 - Uncert.: int. L, ε(μ), B norm., ...
 - Results:
 - Hyp: 2β(1-β)=0.5
 - Signal window: |m_{LQ}| +/- 100 GeV
 - N_{obs}= 6
 - N_{exp}(B)=6.4+/-0.7 +/-0.8
 - ε(S)=7.9+/-0.1+/-0.7
(m_{SLQ2}=200 GeV)
 - m_{SLQ2}>214 GeV**





- CDF:

- Analysis:

VLQ_3 pairs $\rightarrow 2\tau+2b$

$1\tau \rightarrow \text{had.}, 1\tau \rightarrow e/\mu$

- Data sample: 322 pb^{-1}

- Triggers:

- lepton+tracks

- +1 hard e/μ

- +1 $\tau\text{-had}$

- Event selection:

- very large H_T :

$$\Sigma p_T(\tau_h) + p_T(l) + p_T(b) + p_T(b) + mE_T$$

- Uncert.: ISR, FSR, τ -ID, isolation,...

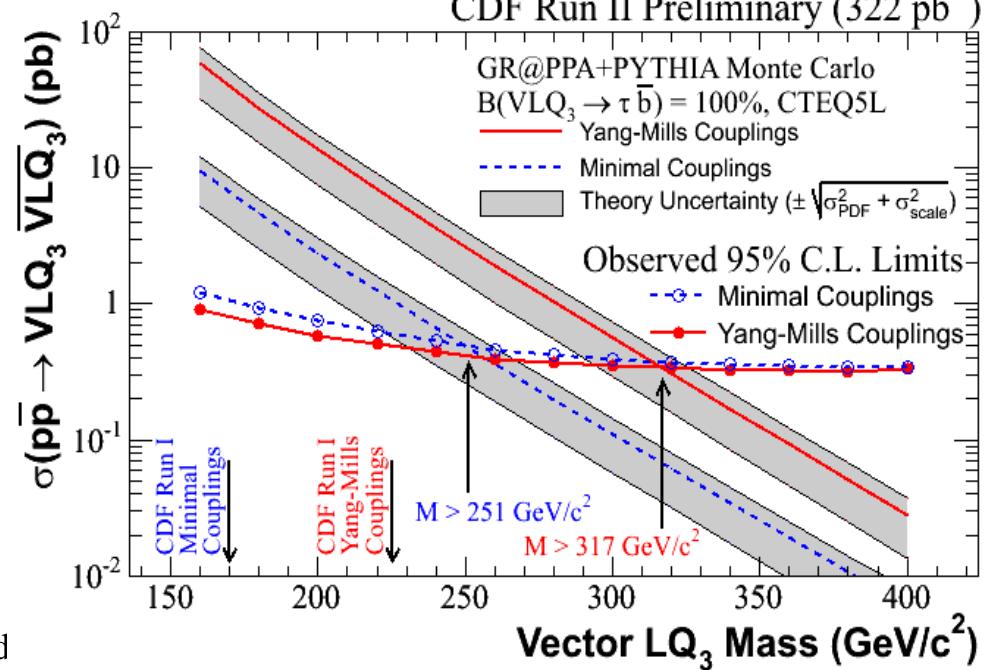
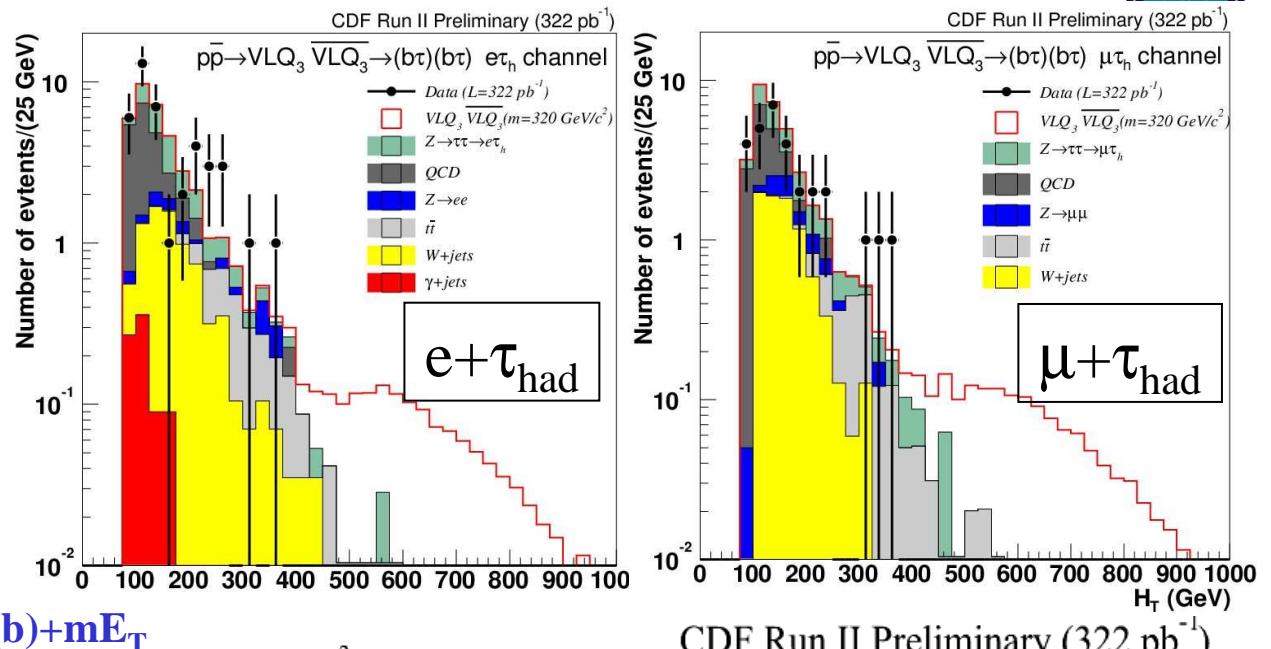
- Results: Hyp: Y-M couplings & $\beta=100\%$

Channel	N_{obs}	$N_{\text{exp}}(B)$
$e+\tau_{\text{had}}+2b$	0	$0.25^{+0.22}_{-0.08}$
$\mu+\tau_{\text{had}}+2b$	0	$0.24^{+0.23}_{-0.07}$

$m_{\text{LQ}_3} > 251 \text{ GeV}$ (Min. couplings)

$m_{\text{LQ}_3} > 317 \text{ GeV}$ (Y-M couplings)

Searches for VLQ_3 pairs



II. FERMIONS SUB-STRUCTURE

2. Search for Leptons & Quarks Compositeness

Contact Interaction O(99%)

$$\mathcal{L}_{CI} = \frac{g^2}{2\Lambda^2} j^\mu j_\mu$$

$$j_\mu = \eta_L \bar{f}_L \gamma_\mu f_L + \eta'_L \bar{f}_L^* \gamma_\mu f_L^* + \eta''_L \bar{f}_L^* \gamma_\mu f_L^* \\ + hc + (L \leftrightarrow R)$$

Ref.: U. Baur et al, Phys. Rev. D42 (1990) 815-824

- Parameters:

- Λ : comp. Scale
- $m(f^*)$: mass of excited fermion
- η_L : factors of left-handed currents

- Modifications of the γ^*/Z cross section:

$$\frac{d^2\sigma}{dM d\cos\theta^*} = f_{SM} + \frac{I}{\Lambda^2} + \frac{C}{\Lambda^4}$$

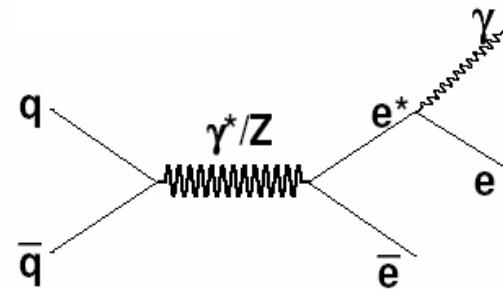
Compositeness

SM

O. Cakir et al., Eur. Phys. JC32S2 (2004) 1

Gauge Mediation O(1%)

$$\mathcal{L} = \frac{\bar{E}_R \sigma^{\mu\nu}}{2\Lambda} [fg \frac{\vec{\tau}}{2} \vec{W}_{\mu\nu} + f' g' \frac{Y}{2} B_{\mu\nu}] e_L + hc$$



- Parameters:

- compositeness scale Λ
- f and f' that depend on the composite dynamics
- M_{e^*}



II. FERMIONS SUB-STRUCTURE



2. Search for Leptons & Quarks Compositeness

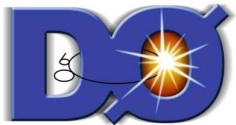
CDF

D0

Channel	L _{int} (pb ⁻¹)	Status
e* → e+γ	1000	07 Prel.
q* → q+Z(ee)	370	06 Pub.
μ* → μ+γ	380	06 Pub.
qqbar → μμ (CI)	400	05 Prel.
qqbar → ee (CI)	271	04 Prel.
QCD Incl. Jet σ	800	06 Prel.

Channel	L _{int} (pb ⁻¹)	Status
μ* → μ+γ	371	06 Pub.
QCD Incl. Jet σ	1040	06 Prel.

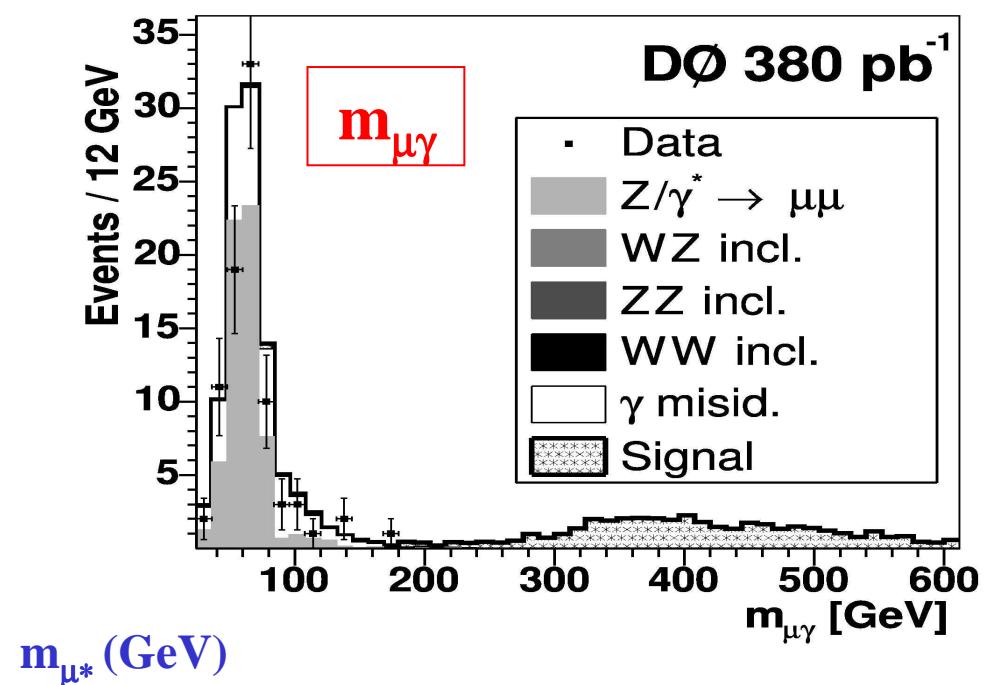
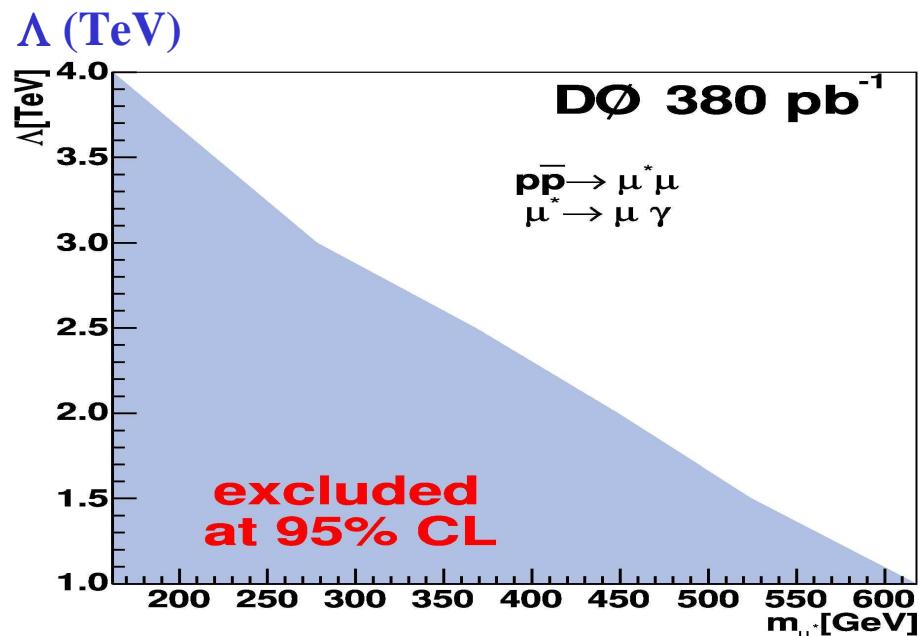
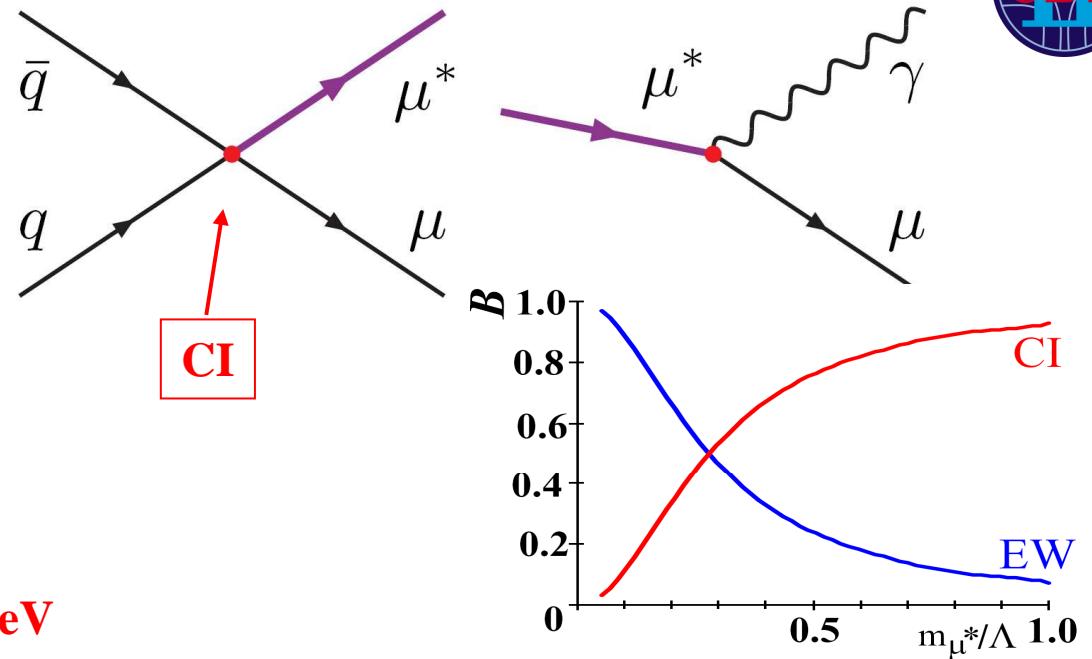
Detailed

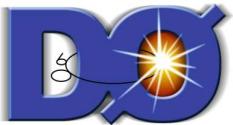


- D0:

- Analysis: $q\bar{q} \rightarrow \mu^*\mu \rightarrow \mu\mu + \gamma$
- Data sample: 380 pb^{-1}
- Triggers: di-muons
- Event selection:
 - 2 hard μ (at least 1 isolated)
 - +1 hard & isolated γ
- Uncert.: trigger ϵ , μ reco & ID,...
- Results:
 - $m(\mu^*) > 618 \text{ GeV}$ for $\Lambda = 1 \text{ TeV}$

Search for Excited μ



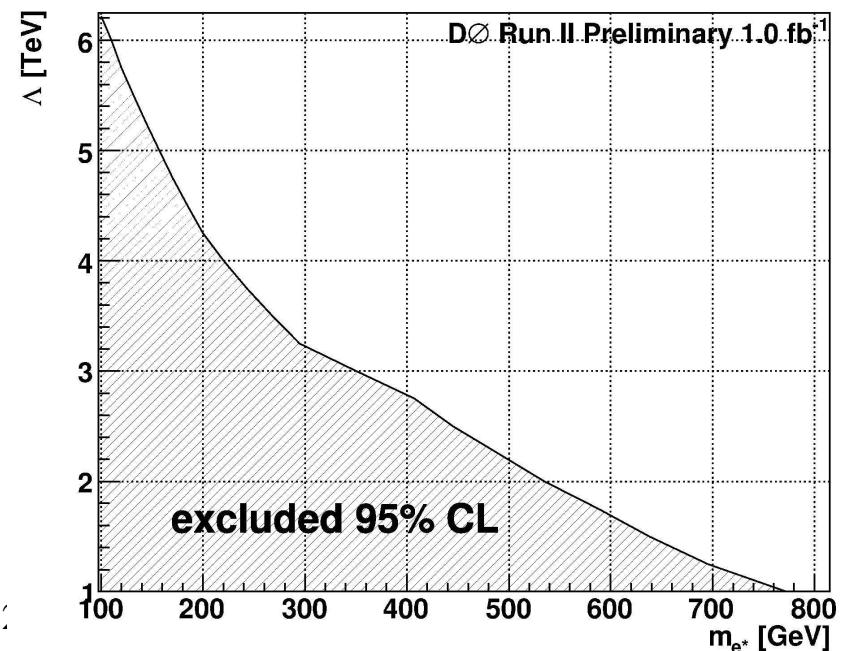
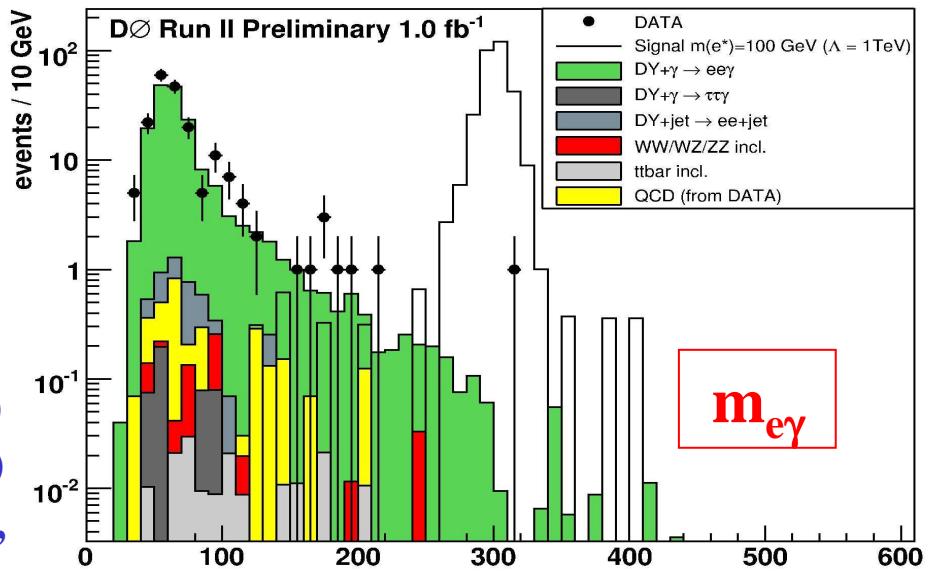


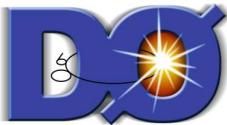
Search for Excited e



- D0:

- Analysis: $\text{qqbar} \rightarrow e^*e \rightarrow ee + \gamma$
- Data sample: 1 fb^{-1}
- Triggers: single e & di-e
- Event selection:
 - at least 2 hard & isolated e
 - +1 hard & isolated γ (CC or EC)
 - optimization: $m(e\gamma)$ and $\Delta R(e_2, \gamma)$
- Uncert.: QCD estimation, γ fake rate, PDF, ...
- Results:
 - $m(e^*) > 756 \text{ GeV}$ for $\Lambda = 1 \text{ TeV}$ (CI)
 - $m(e^*) > 793 \text{ GeV}$ for $\Lambda = m(e^*)$ (CI)



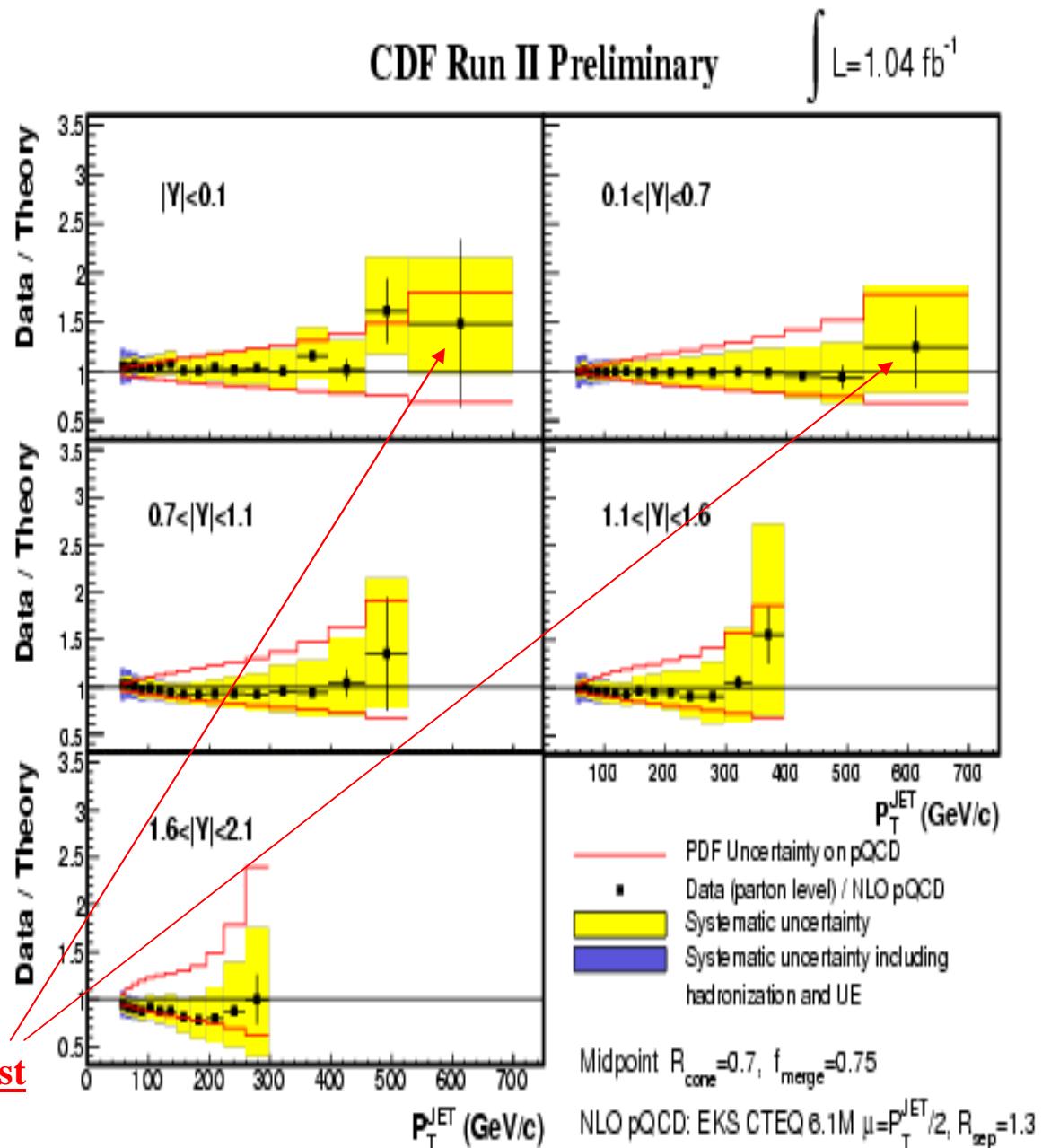


Inclusive Jet Cross Section



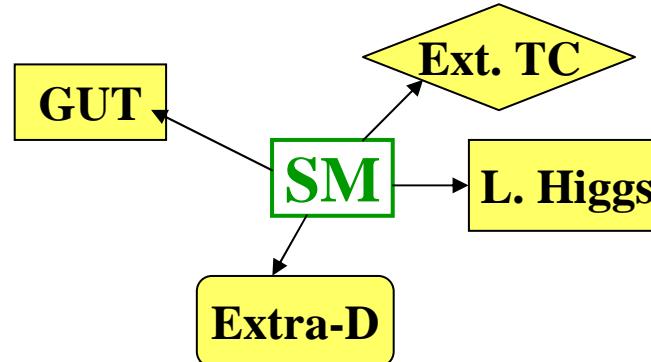
- CDF:

- Analysis: QCD $d\sigma/dydp_T$
- Data sample: 1.04 fb^{-1}
- Triggers: j20, j50, j70, j100
- Samples processing:
 - Theory: σ_{NLO} from EKS
 - Data:
 - particle lvl corr. + unfolding
 - parton lvl corr.
- Event reconstruction:
 - midpoint 0.7 cone jets
- Event selection:
 - $|y| < 2.1$
 - low mE_T significance
 - $|z_{PV}| < 60 \text{ cm}$
- Uncert.: PDF, scale, UE & fragm.,...
- Results:
 - no explicit limit on comp. scale or $m(q^*)$
 - yet, no excess at the highest p_T ever probed





III. EXTENDED GAUGE SYMMETRIES



1. Search for W'

- Larger gauge group (E_6 , $SO(10)$, ...)
- Hypotheses:
 - No gauge mixing
 - Same CKM as in SM
 - DK into light v
 - $\Gamma_{W'} = \frac{4}{3} \cdot \frac{m_{W'}}{m_W} \cdot \Gamma_W$

2. Search for Z'

- Larger gauge group: E_6
- $$E_6 \rightarrow SO(10) \times U(1)_\phi \rightarrow SU(5) \times U(1)_\chi \times U(1)_\phi$$
- $$SU(5) \rightarrow SU(3)_C \times SU(2)_L \times U(1)_Y$$
- $Z' = Z_\phi \cos \theta + Z_\chi \sin \theta$
 - suppose SM-like couplings

$$\Gamma_{z'} = \frac{m_{z'}}{m_z} \cdot \Gamma_z$$



III. EXTENDED GAUGE SYMMETRIES

1. Search for W'

D0

Channel	$L_{int} (pb^{-1})$	Status
$W' \rightarrow e\nu$	900	06 Prel.

CDF

Channel	$L_{int} (pb^{-1})$	Status
$W' \rightarrow e\nu$	205	06 Pub.

Detailed

2. Search for Z'

Channel	$L_{int} (pb^{-1})$	Status
$Z' \rightarrow ee$	200	04 Prel.
$Z' \rightarrow \mu\mu$	250	04 Prel.

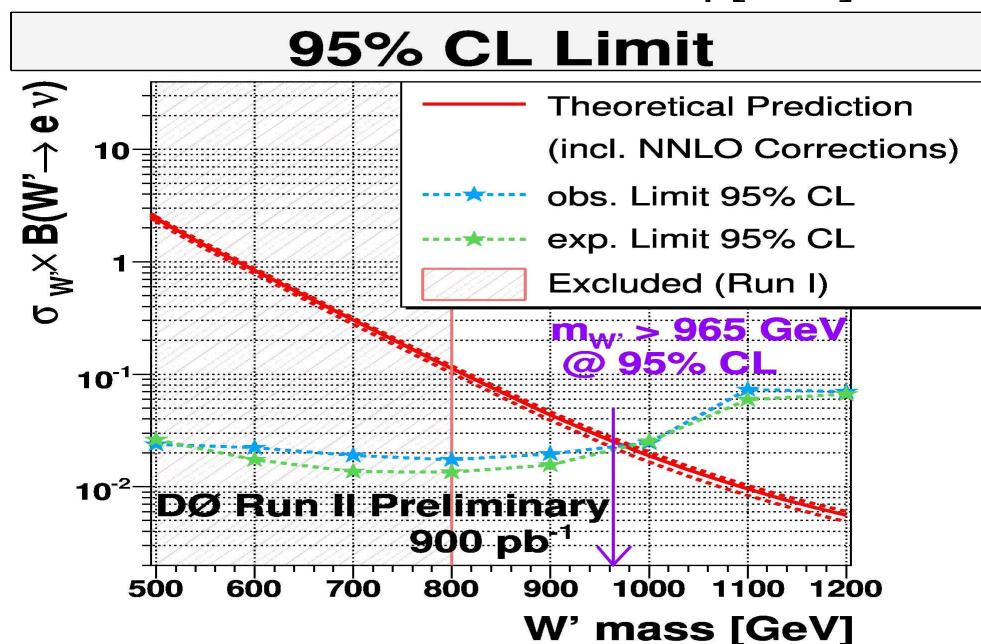
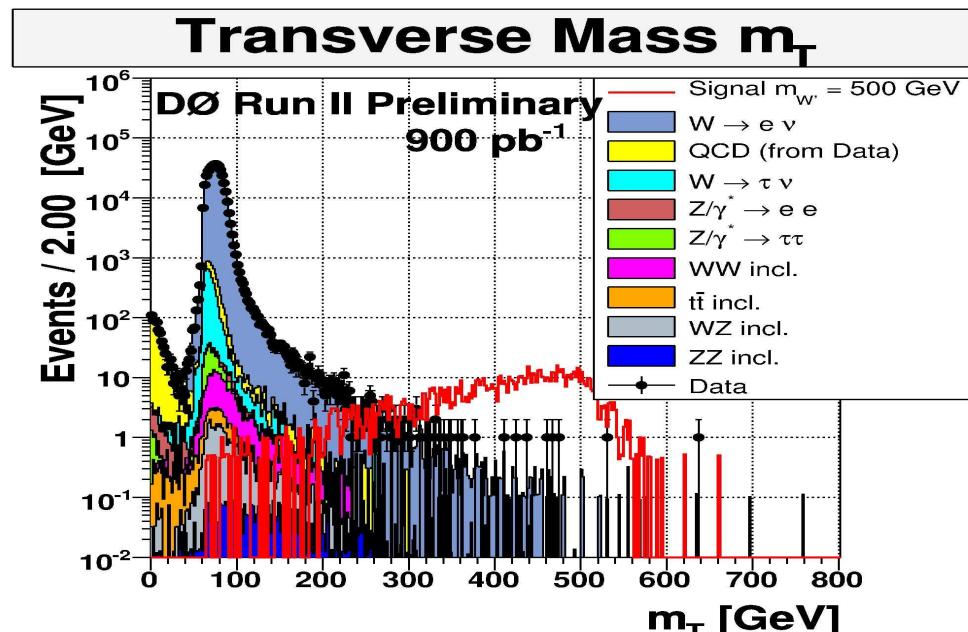
Channel	$L_{int} (pb^{-1})$	Status
$Z' \rightarrow ee$	1288	07 Prel.
$Z' \rightarrow \mu\mu$	200	04 Prel.
$Z' \rightarrow \tau\tau$	195	04 Prel.



Search for W'



- DØ:
 - Analysis: $W' \rightarrow e\nu$
 - Triggers: single e
 - Data sample: 900 pb^{-1}
 - Instr. background: QCD from data
 - Event selection:
 - at least 1 central, hard and isolated e
 - w/ track match (but no E/p)
 - large mE_T significance
 - Uncert.: norm., ϵ corr., PDF, EM scale, QCD scaling,...
 - Results:
 - shape of m_T tail above 150 GeV
 - $N_{\text{obs}} = 630$
 - $N_{\text{exp}}(B) = 622.93 \pm -17.91^{+82.65}_{-72.25}$
 - $N_{\text{exp}}(S) = 16.64 \pm -0.39^{+6.86}_{-6.06}$ ($m_{W'} = 900 \text{ GeV}$)
- $m_{W'} > 965 \text{ GeV}$



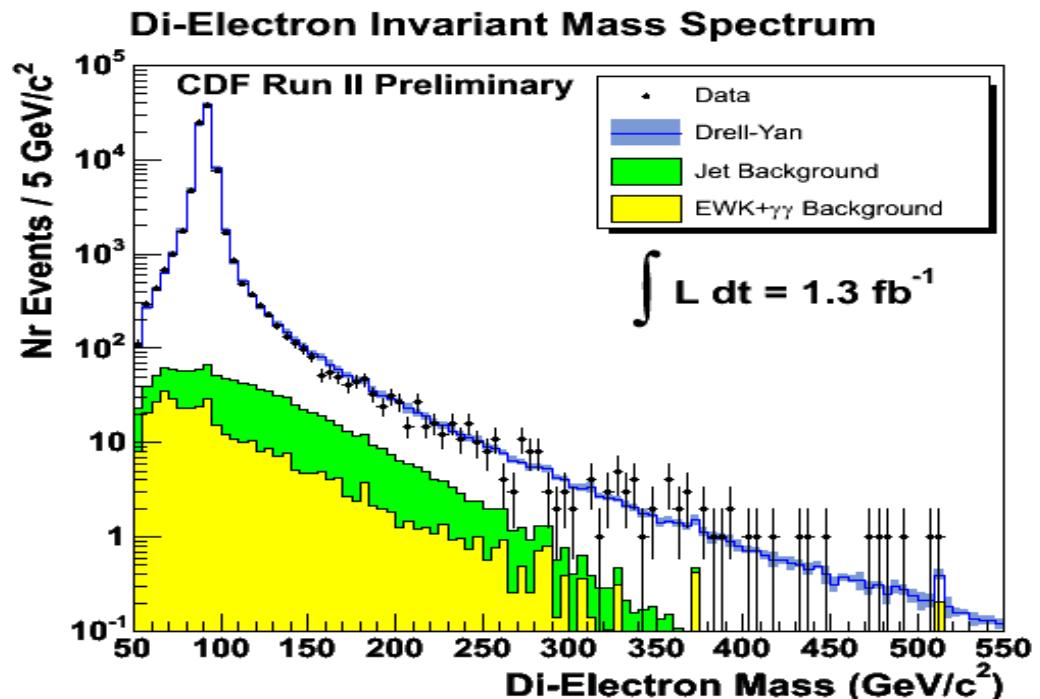
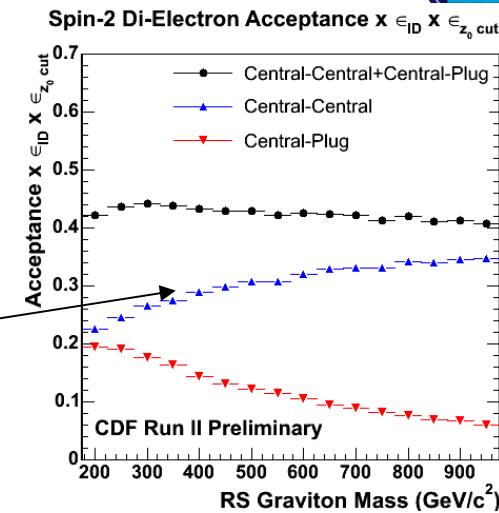
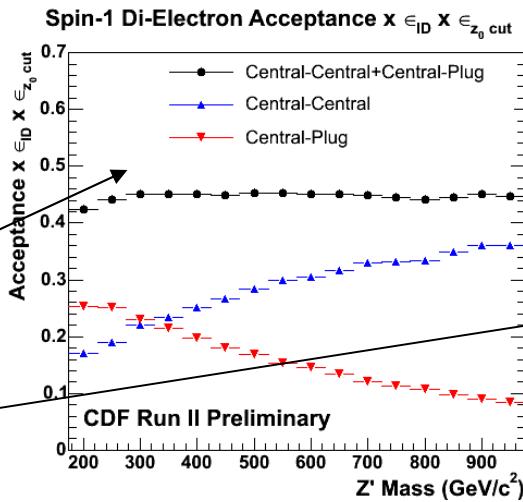


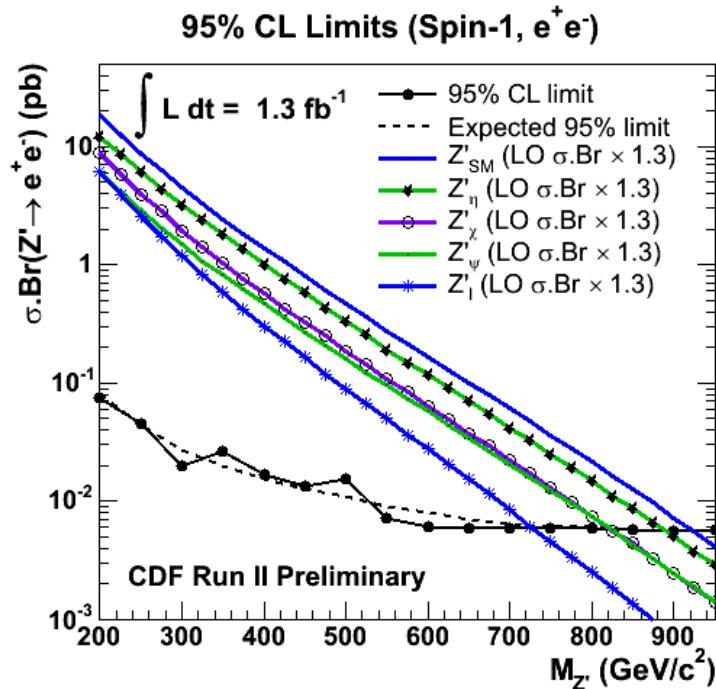
Search for Z'



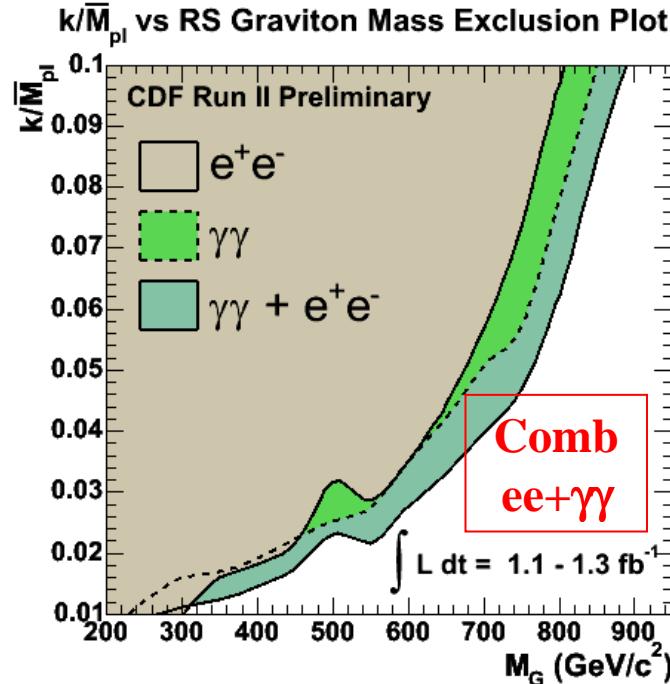
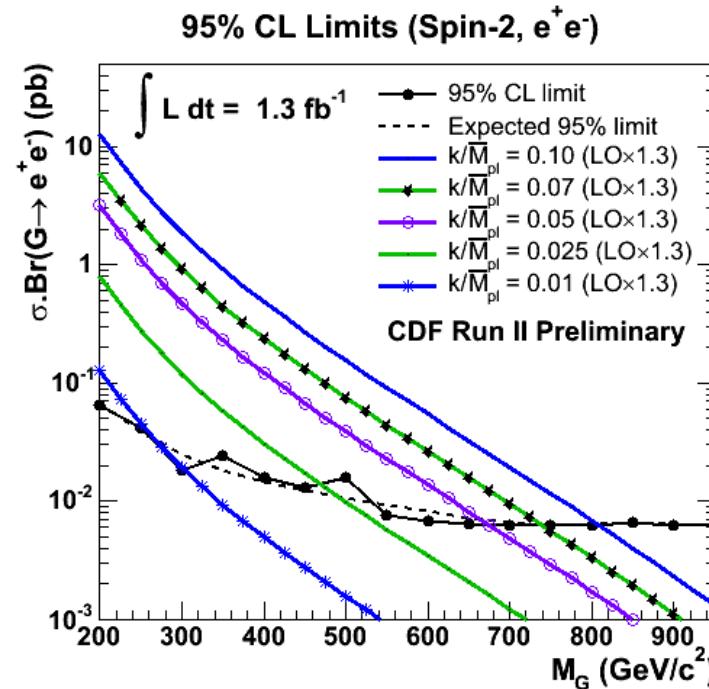
- CDF:

- Analysis: $Z' \rightarrow ee$ ($G \rightarrow 2\gamma$)
- Triggers: di-EM
- Data sample: 1288 pb^{-1}
- MC:
 - Signal (Pythia):
 - E_6 ($S=1$)
 - and separately RS ($S=2$)
 - Physics BKGD (Pythia)
 - Main BKGD: $\gamma^*/Z \rightarrow ee$
- Event selection:
 - 2 hard & isolated e (CC-CC or CC-EC)
 - track match for CC e
- Uncert.: lumi, PDF, ISR, $\epsilon(e \text{ ID})$, ...
- Results: M_{ee} tail above 150 GeV



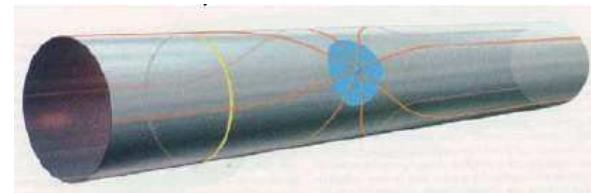


$m(Z') > 923 \text{ GeV SM-like}$





Extra-D



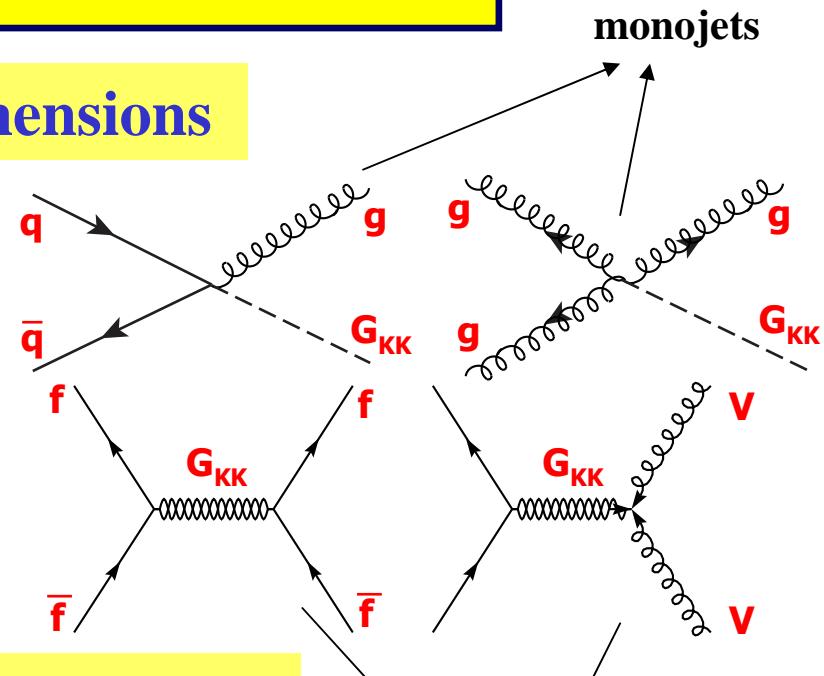
ADD

- 2 to 7 large (sub mm) EDs
- gravity propagates freely in the bulk
- KK excitations cannot be resolved
- parameter: $\eta_G = F/M_S^4$ (GRW: $F=1$)

IV. EXTENDED NUMBER OF SPACE DIMENSIONS



1. Search for Large Extra-Dimensions



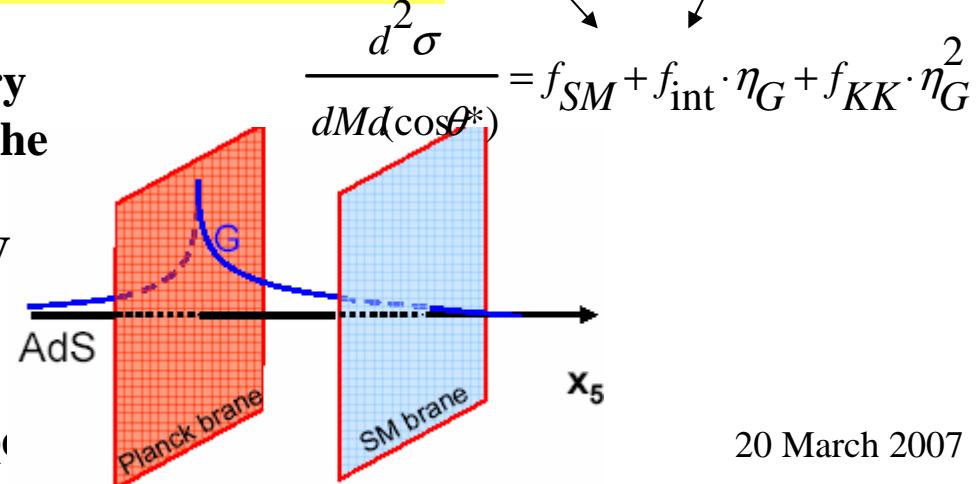
2. Search for Randall-Sundrum Gravitons

RS

- one 5th (infinite) ED with warped geometry
- gravity is localized on a brane other than the SM brane
- KK excitations have spacings of order TeV
- parameters:
 - M_1 : mass of the 1st KK excitation
 - $0.01 < \kappa(8\pi)^{1/2}/M_{Pl} < 0.1$

S. Muanza

Moriond QCD



20 March 2007



IV. EXTENDED NUMBER OF SPACE DIMENSIONS



1. Search for Large Extra-Dimensions

Channel	$L_{int} (pb^{-1})$	Date
$q\bar{q} \rightarrow G + g$	85	04 Prel.
$G \rightarrow ee/\gamma\gamma$	200	04 Prel.

Channel	$L_{int} (pb^{-1})$	Date
$q\bar{q} \rightarrow G + g$	1100	06 Prel.

2. Search for Randall-Sundrum Gravitons

D0

Detailed

CDF

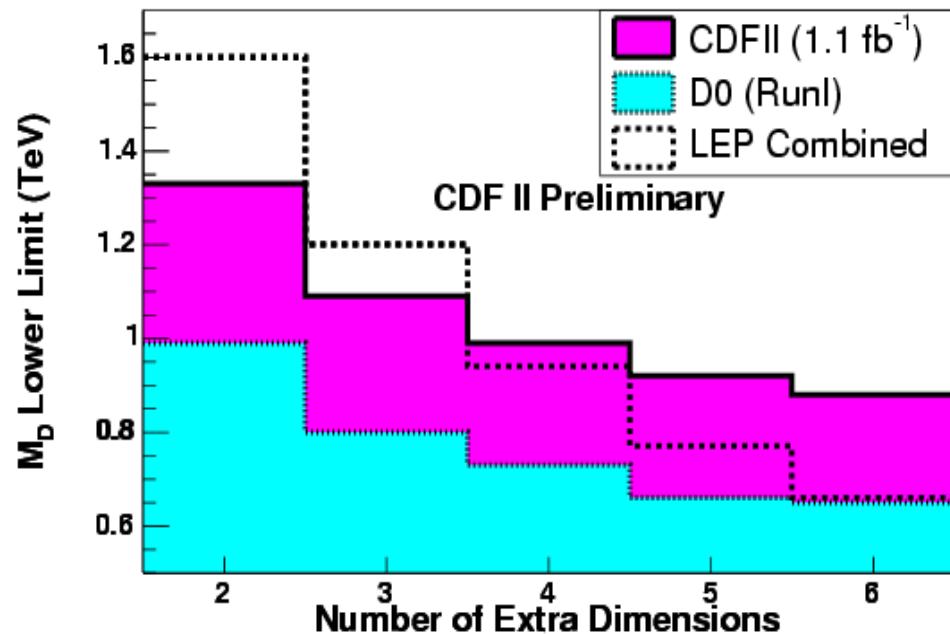
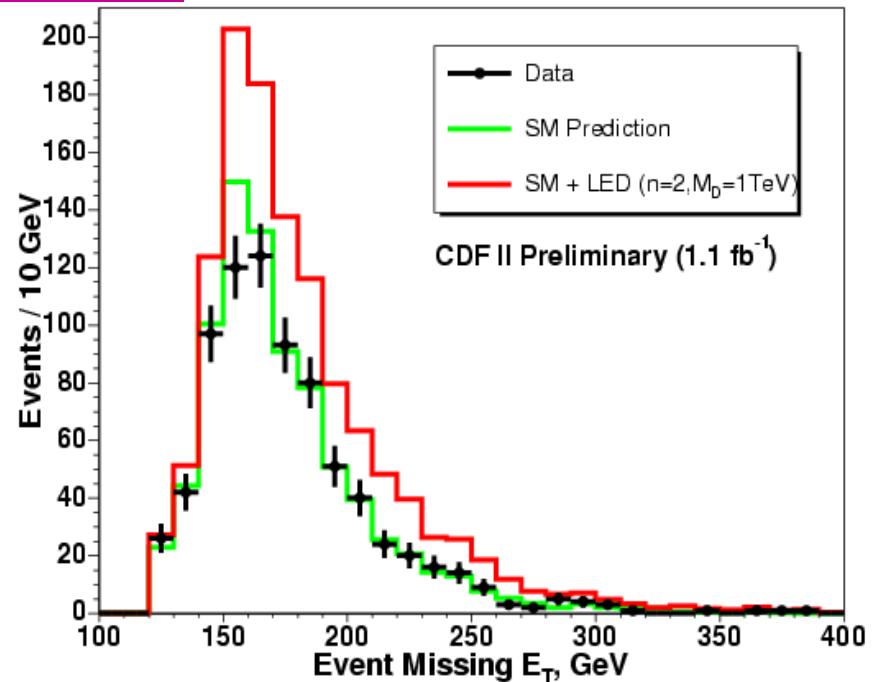
Channel	$L_{int} (pb^{-1})$	Date
$G \rightarrow ee/\gamma\gamma$	1000	06 Prel.

Channel	$L_{int} (pb^{-1})$	Date
$G \rightarrow ee$ (see Z')	1288	07 Prel.
$G \rightarrow \mu\mu$ (see Z')	200	04 Prel.
$G \rightarrow \gamma\gamma$	1200	06 Prel.



Search for LED

- CDF:
 - Analysis: $\text{qqbar/g+g} \rightarrow G+g, q+g \rightarrow G+q$
 - Triggers: **j100**
 - Data sample: **1100 pb⁻¹**
 - Event selection:
 - remove events from: beam halo, cosmics
 - 1 very high p_T jet: CC, track confirmed
 - $p_T(j2) < 60 \text{ GeV}$
 - Main BKGD: $Z(\rightarrow vv) + \text{jets}$
 - Uncert.: **PDF, ISR/FSR, JES,...**
- Results:
 - Nobs= **779**
 - Nexp(B)=**819 +/- 71**





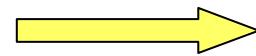
VII. CONCLUSIONS



- Many topologies have been covered
- Many analyses have been (or are being) updated to the full Run IIA dataset...



- Yet no evidence of New Physics...



Exclusion Limits



Search for LeptoQuarks Summary

D0

Channel	$L_{int} (\text{pb}^{-1})$	Limits (GeV)
$\text{LQ}_2 \text{ pairs} \rightarrow \mu + \nu + 2\text{q}$	1050	214 ($\beta=0.5$)
$\text{LQ}_3 \text{ pairs} \rightarrow 2\nu + 2\text{b}$	310	219 ($\beta=0$)
$\text{LQ}_2 \text{ pairs} \rightarrow 2\mu + 2\text{q}$ $\text{LQ}_2 + \mu \rightarrow 2\mu + \text{q}$	300	274 ($\beta=1$) 226 ($\beta=0.5$) ($\lambda=1$)
$\text{LQ} \text{ pairs} \rightarrow 2\nu + 2\text{q}$	370	136 ($\beta=0$)
$\text{LQ}_2 \text{ pairs} \rightarrow 2\mu + 2\text{q}$	290	251 ($\beta=1$) 204 ($\beta=0.5$)
$\text{LQ}_1 \text{ pairs} \rightarrow 2e + 2\text{q}$ $\text{LQ}_1 \text{ pairs} \rightarrow e + \nu + 2\text{q}$	252	241, 256 ($\beta=1$) 218, 234 ($\beta=0.5$)

Comb.

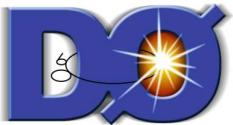
CDF

Th. Uncert. signal

Channel	$L_{int} (\text{pb}^{-1})$	Limits (GeV)
$\text{VLQ}_3 \text{ pairs} \rightarrow 2\tau + 2\text{b}$	322	317 \rightarrow 294 ($\beta=1$) Y-M couplings 251 \rightarrow 223 ($\beta=1$) Min. couplings
$\text{LQ}_1 \text{ pairs : comb.}$	~ 200 /channel	236 ($\beta=1$) 205 ($\beta=0.5$) 126 ($\beta=0$)
$\text{LQ}_2 \text{ pairs : comb.}$	~ 200 /channel	226 ($\beta=1$) 208 ($\beta=0.5$) 125 ($\beta=0$)

Run II Alone

Comb. w/ Run I



Search for Leptons & Quarks Compositeness Summary



D0

Channel	$L_{int} (pb^{-1})$	Limits (GeV)
$q^* \rightarrow q + Z(ee)$	370	510
$\mu^* \rightarrow \mu + \gamma$	380	618 $\Lambda = 1 \text{ TeV}$
$qq\bar{q} \rightarrow \mu\mu \text{ (CI)}$	400	$\Lambda > 4.2 \text{ TeV } (\Lambda^-)$ $\Lambda > 9.8 \text{ TeV } (\Lambda^+)$
$qq\bar{q} \rightarrow ee \text{ (CI)}$	271	$\Lambda > 3.6 \text{ TeV } (\Lambda^-)$ $\Lambda > 9.1 \text{ TeV } (\Lambda^+)$
QCD Incl. Jet σ	800	No excess

CDF

Channel	$L_{int} (pb^{-1})$	Limits (GeV)
$\mu^* \rightarrow \mu + \gamma$	371	~800 $\Lambda = 1 \text{ TeV}$
QCD Incl. Jet σ	1040	No excess

Search for W' Summary

Channel	$L_{int} (pb^{-1})$	Limit (GeV)
$W' \rightarrow e\nu$	900	965

Channel	$L_{int} (pb^{-1})$	Limit (GeV)
$W' \rightarrow e\nu$	205	788



D0

Search for Z' Summary



CDF

Channel	$L_{int} (pb^{-1})$	Limit (GeV)
$Z' \rightarrow ee$	200	780 (SM-like)
$Z' \rightarrow \mu\mu$	250	680 (SM-like)

E₆Z'

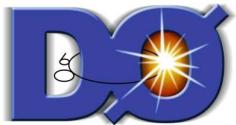
Channel	$L_{int} (pb^{-1})$	Limit (GeV)
$Z' \rightarrow ee$	1288	923 (SM-like)
$Z' \rightarrow ee/\mu\mu$ <u>Comb.</u>	200	815 (SM-like)
$Z' \rightarrow \tau\tau$	195	400 (SM-like)

Channel	$L_{int} (pb^{-1})$	M_1 Limit (GeV)
$G \rightarrow ee/\gamma\gamma$	1000	865 (0.1) 240 (0.01)

R-S

Channel	$L_{int} (pb^{-1})$	M_1 Limit (GeV)
$G \rightarrow ee/\gamma\gamma$ <u>Comb.</u>	~1288	889 (0.1) 267 (0.01)
$G \rightarrow ee/\mu\mu$ <u>Comb.</u>	200	700 (0.1) 200 (0.01)

$$k(8\pi)^{1/2}/M_{Pl}$$



D0

Search for Z' Summary



CDF

LED

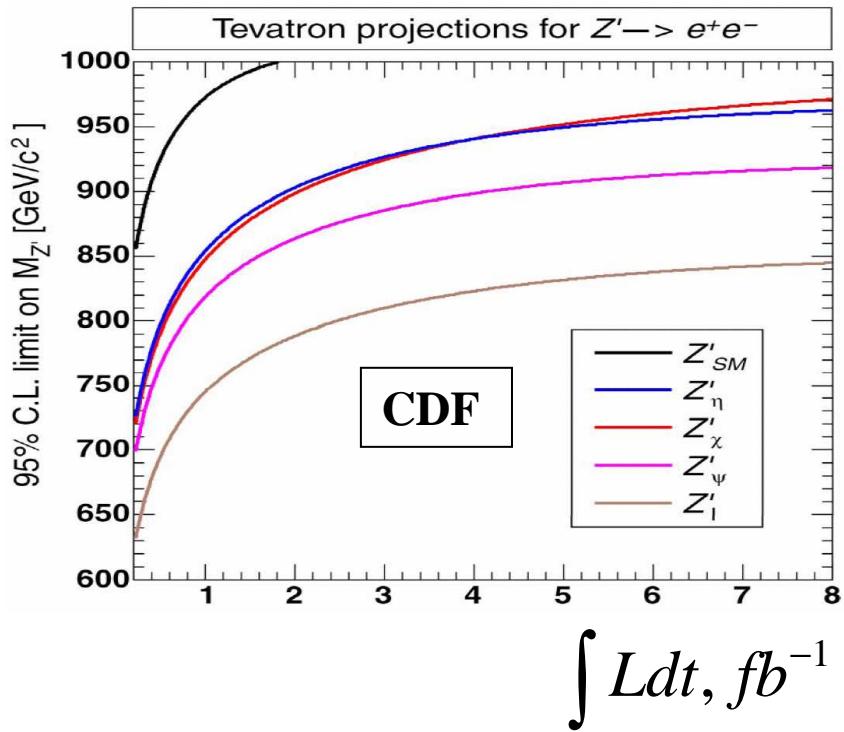
Channel	$L_{int} (pb^{-1})$	M_S Limit (TeV)
$G \rightarrow ee/\gamma\gamma$	200	1.36 (Run II A) 1.43 (Run I+IIA) N=2
$qqbar \rightarrow G+g$	85	0.68 (N=4) 0.67 (N=5) 0.66 (N=6) 0.68 (N=7)

Channel	$L_{int} (pb^{-1})$	M_S Limit (TeV)	R (mm)
		<	
$qqbar \rightarrow G+g$	1000	1.33 (N=2) 1.09 (N=3) 0.99 (N=4) 0.92 (N=5) 0.88 (N=6)	0.27 3.1x10 ⁻⁶ 9.9x10 ⁻⁹ 3.2x10 ⁻¹⁰ 3.1x10 ⁻¹¹

GRW Conventions



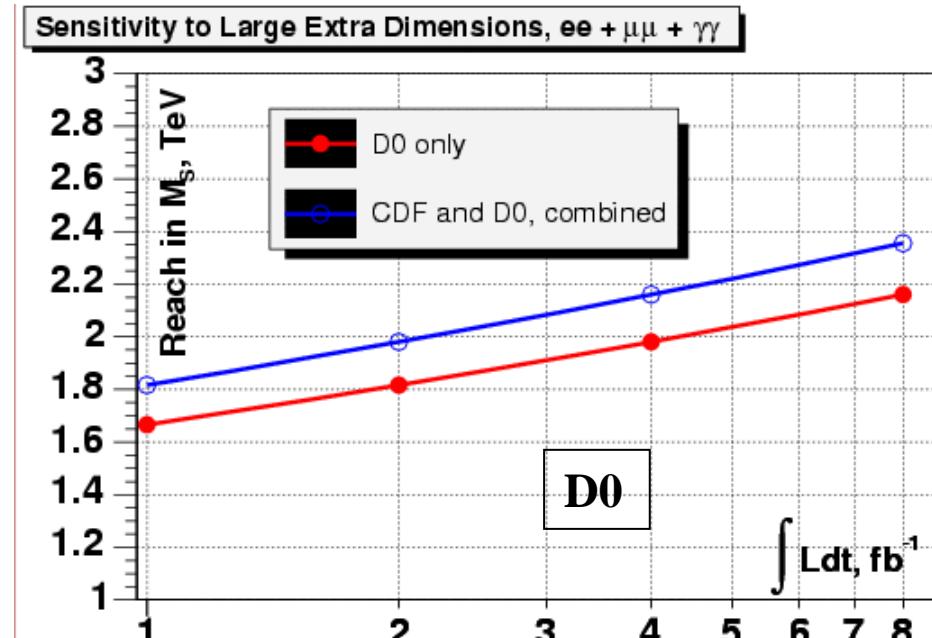
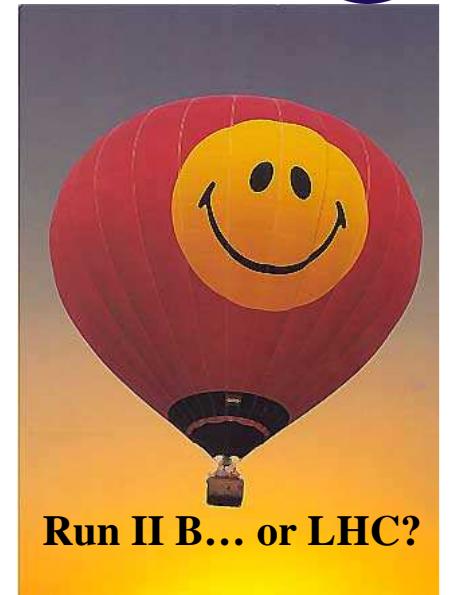
VI. PROSPECTS FOR THE RUN II B



As of sept. 05 (P5)

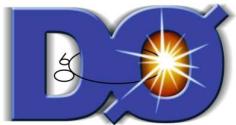
Z'

LED





BACK-UP



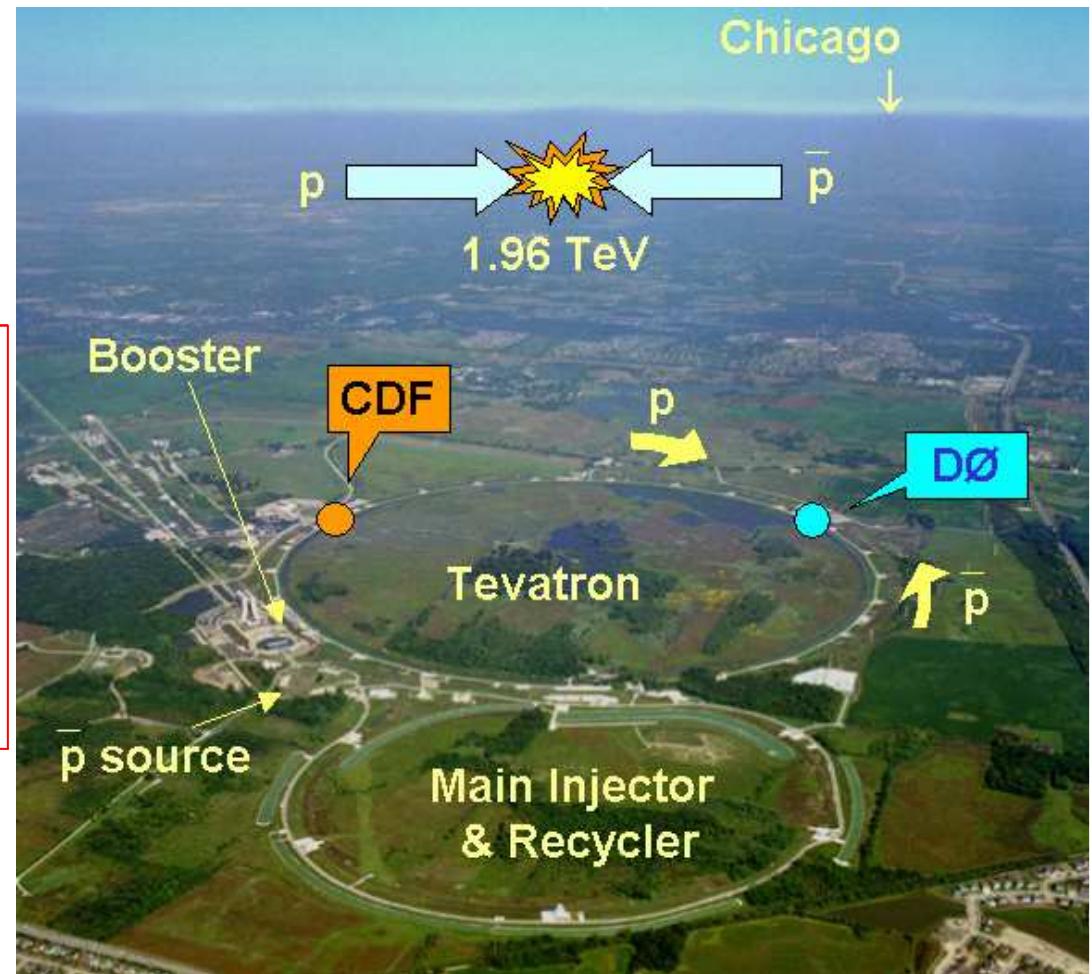
The TEVATRON



Run	\sqrt{S} (TeV)	$\int Ldt$ (fb $^{-1}$)	Δt_X
I 1992-1996	1.8	0.1	$3.5 \mu s$
II A 2001-2006	1.96	1.0	396 ns
II B 2006-2009	1.96	3.0-7.0	396 ns

Now

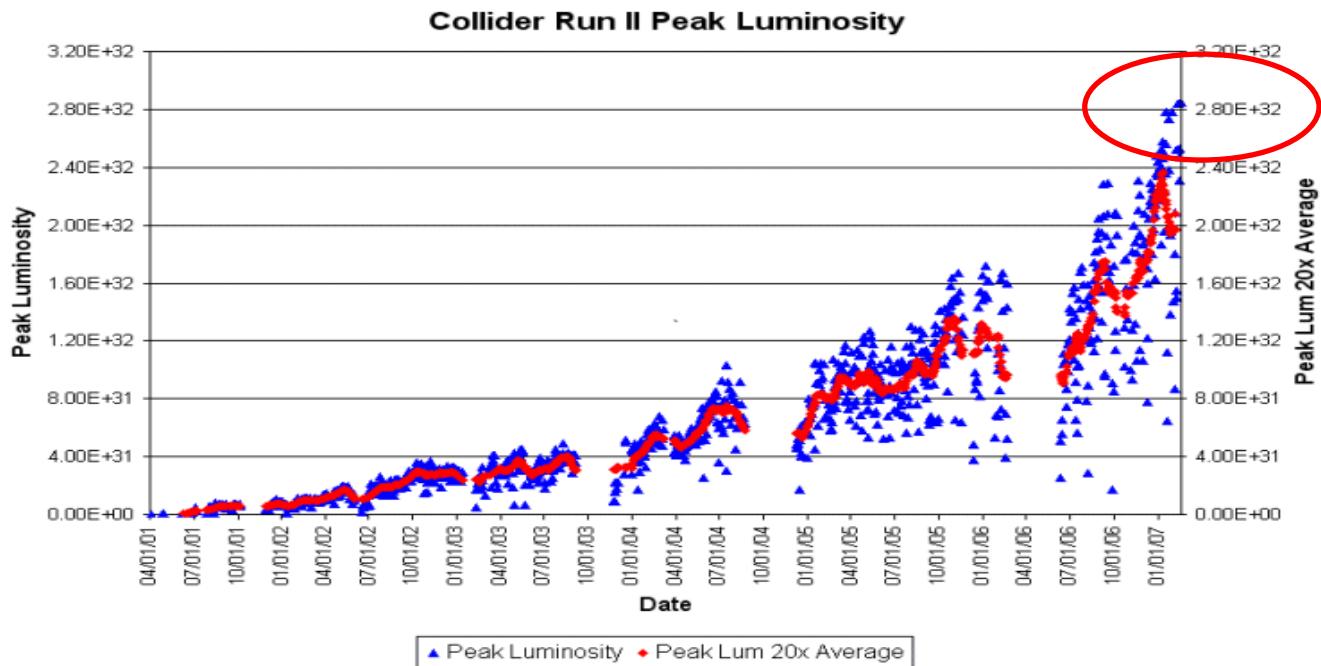
This talk



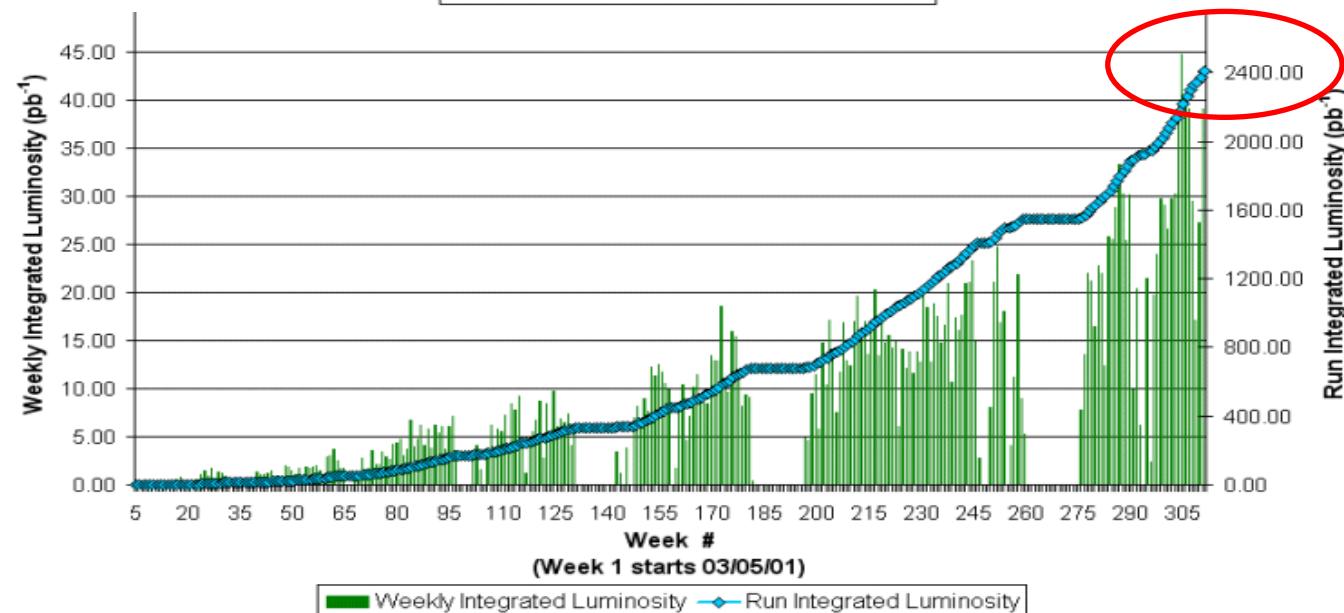


TEVATRON Luminosity

Instantaneous



Integrated





The D0 Detector

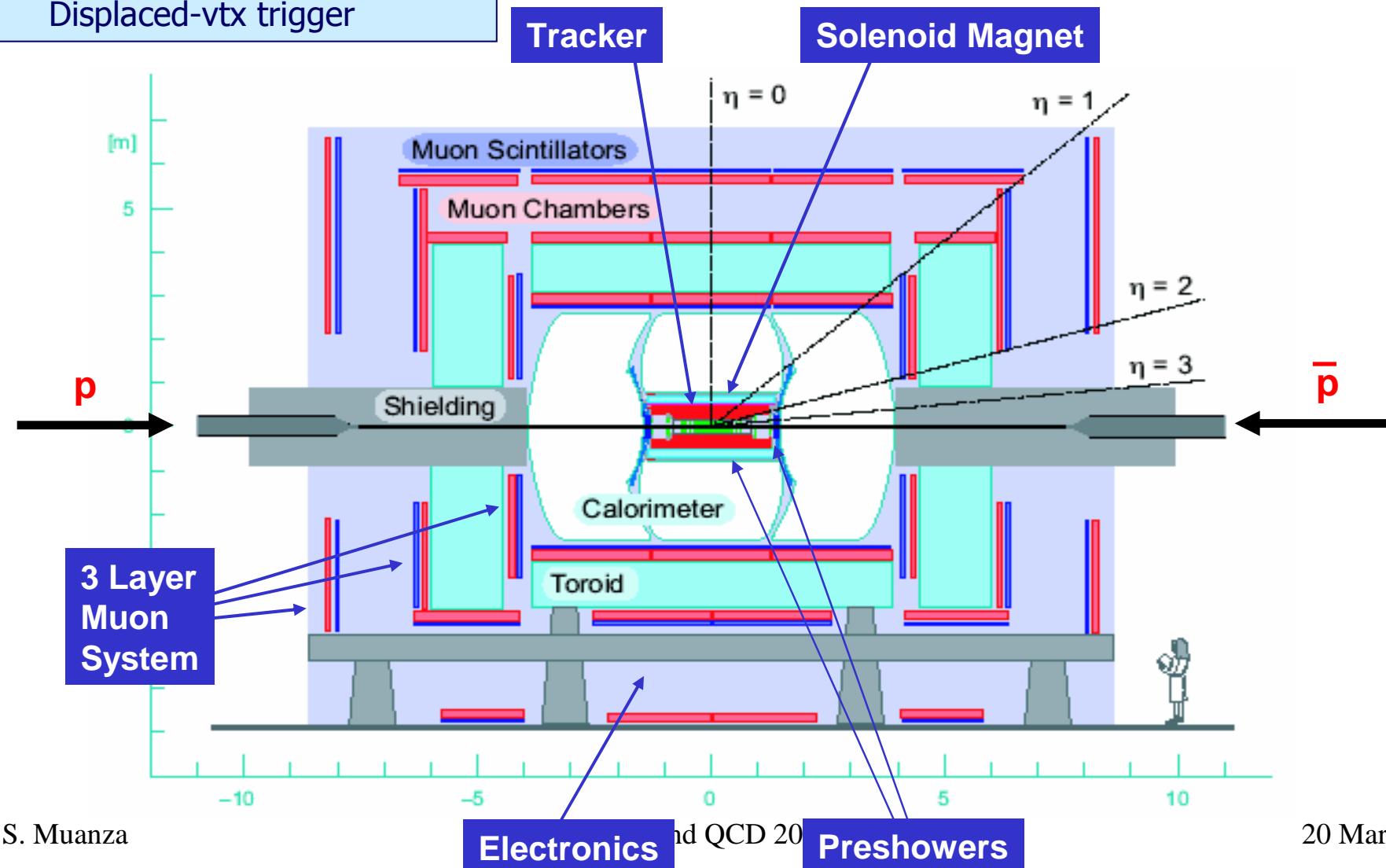


Upgraded @ Run IIa

Muon system, CAL Electronics
DAQ, (track) trigger system
Displaced-vtx trigger

New @ Run IIa (tracking in B-field)

Silicon detector
Fiber tracker, preshower



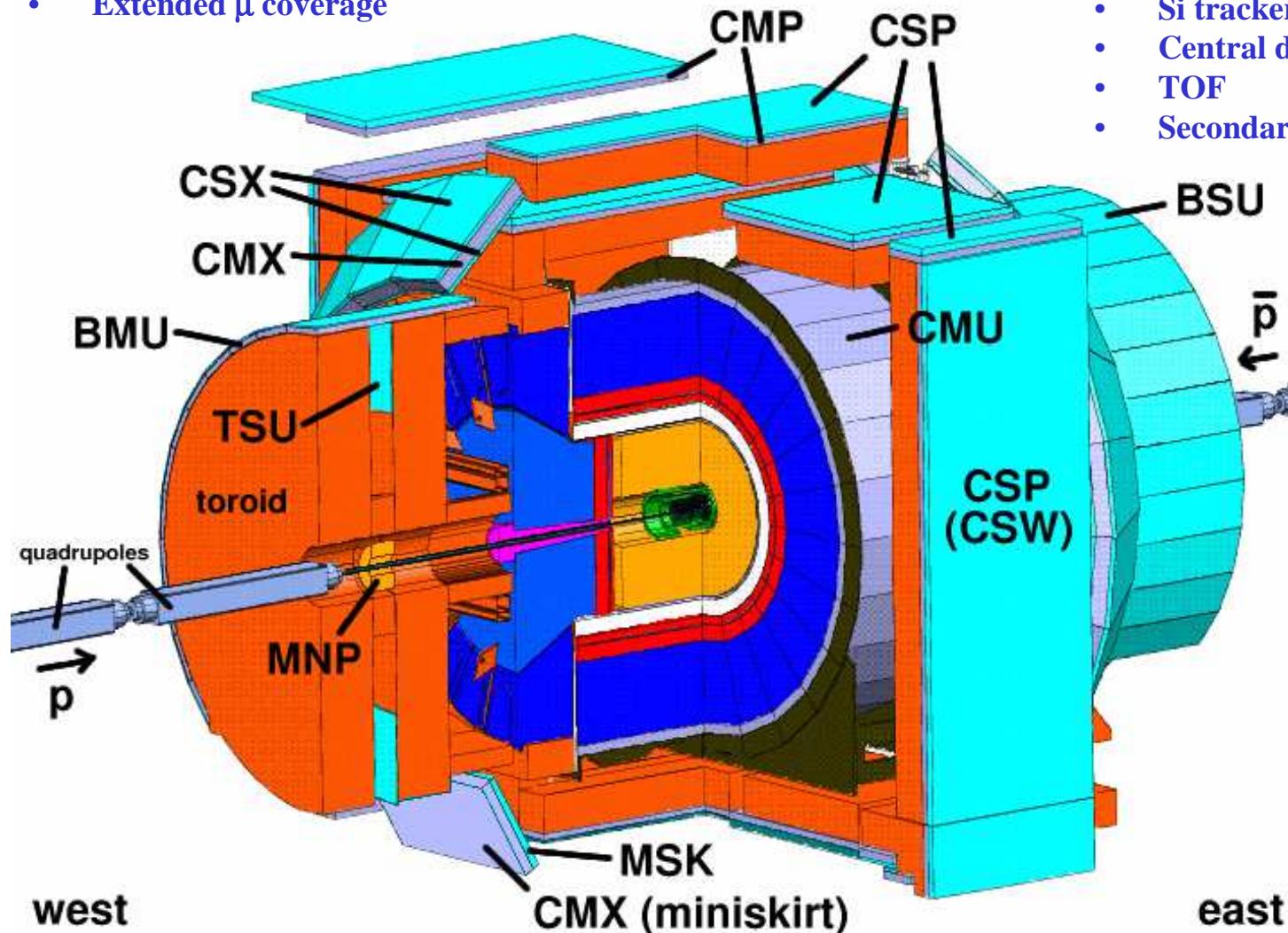


The CDF Detector



Addition or Improvements for the Run IIA

- Forward calorimeters: "plugs" ($1 < |\eta| < 3$)
- Extended μ coverage



Addition or Improvements for the Run IIA

- Si tracker
- Central drift chamber
- TOF
- Secondary vertex trigger



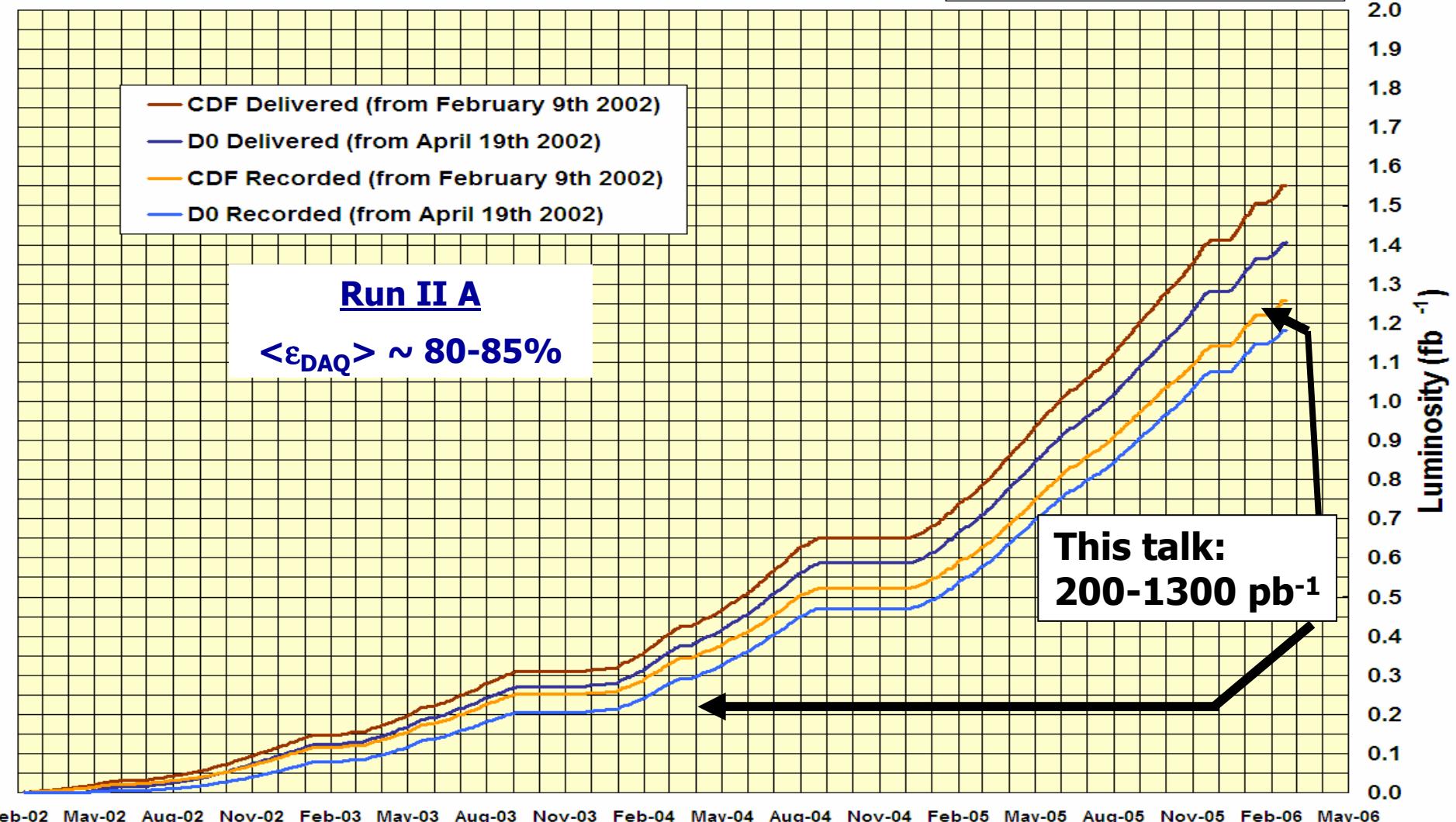
I. INTRODUCTION

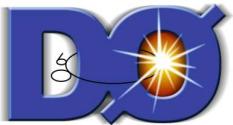


The TEVATRON Performances

D0 & CDF Run II Integrated Luminosity

through 18 February 2006

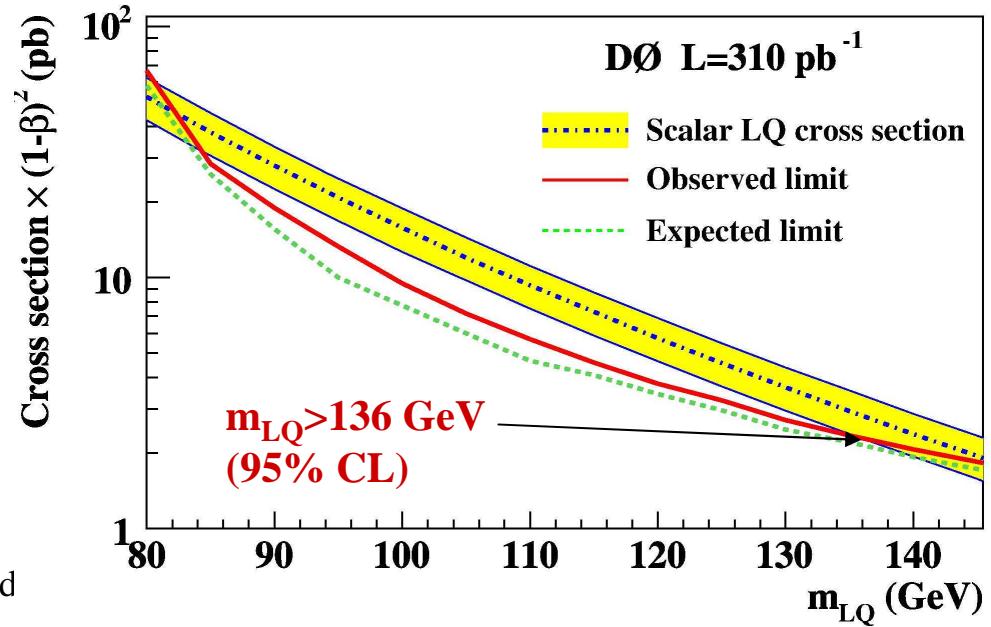
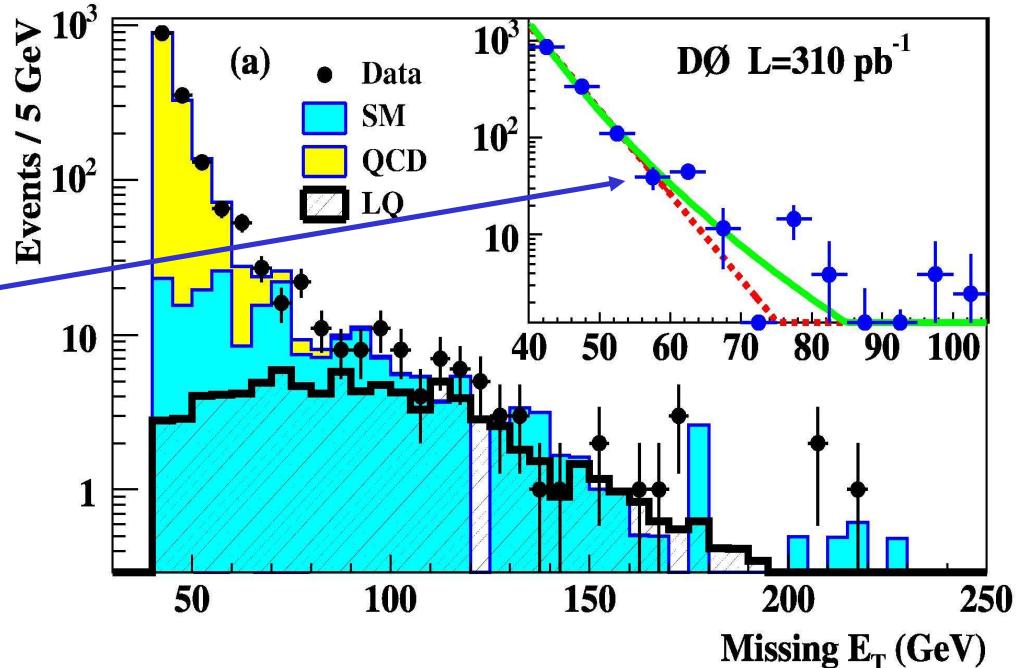




Searches for $\text{SLQ}_{1/2}$ pairs



- D $\bar{\theta}$:
 - Analysis: LQ pairs $\rightarrow 2\nu+2q$
 - Triggers: jets+mE_T
 - Data sample: 310 pb⁻¹
 - Instr. background: QCD estimated from data
 - Event selection:
 - at least 2 hard and acoplanar jets
 - no flavor tagging
 - large mE_T & H_T
 - Uncert.: Syst(B) ~ Stat(B) (JES),...
 - Results:
 - N_{obs}=86
 - N_{exp(B)}=75.2^{+14.6}_{-15.5}
 - N_{exp(S)}=51.8^{+5.9}_{-4.9}
(m_{LQ}=140 GeV)





Searches for SLQ_{1/2} pairs



- CDF Combination:

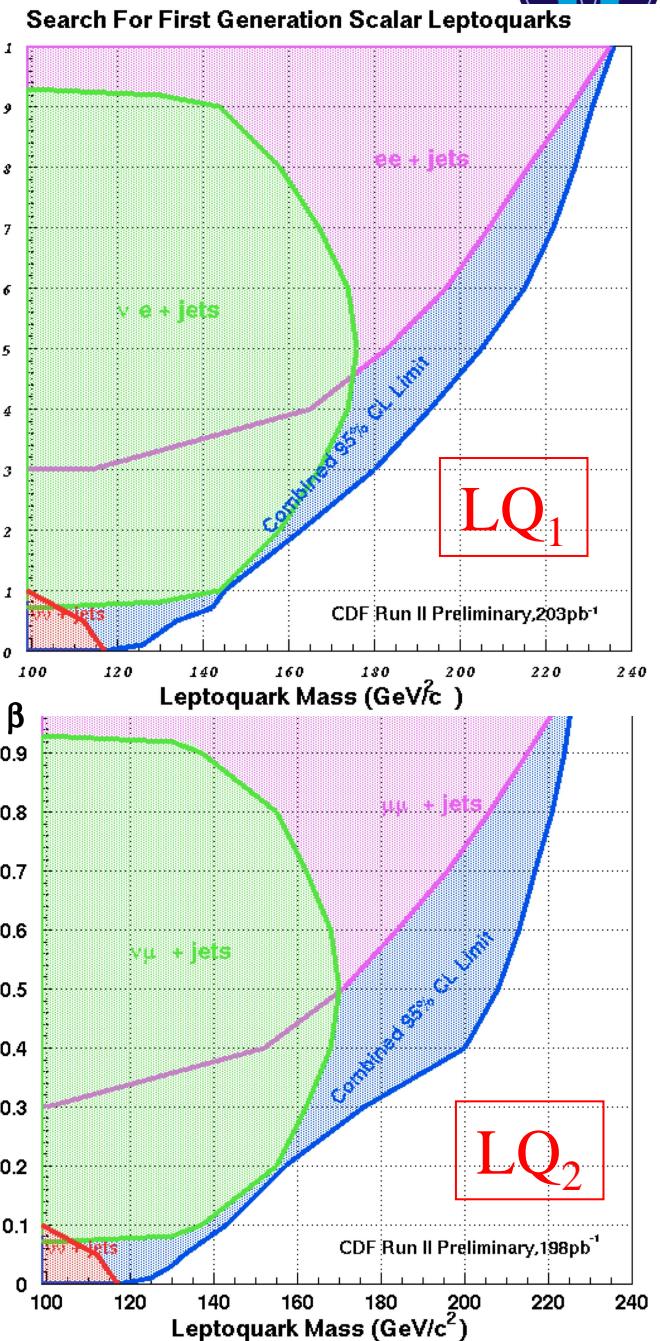
- Analyses:

- 3 topologies 2l+jets, l+jets+mE_T, jets+mE_T
- for both LQ₁ and LQ₂ pair production
- Bayesian combined likelihood

- Data samples: each ~200 pb⁻¹

- Results:

Channel	N _{obs}	N _{exp(B)}	Main BKGD
2e+2q	4	6.24+/-2.16	ttbar Z+jets
e ν +2q m _{LQ} = 160 GeV	4	5.4+/-1.2	ttbar
2 μ +2q	2	2.87+/-1.0	Z+jets
$\mu\nu$ +2q m _{LQ} = 160 GeV	3	3.74+/-0.62	ttbar
$\nu\nu$ +2q	124	118.5+/-14.5	Z+jets





Searches for SLQ_3 pairs



- D0:

- Analysis: SLQ_3 pairs $\rightarrow 2\nu+2\text{b}$
- Data sample: 310 pb^{-1}
- Triggers: jets+m E_T & $\mu+\text{jets}$
- Instr. background: QCD from data
- Event selection:
 - at least 2 hard acoplanar jets
 - large m E_T & H T
 - reject isolated EM-clusters & isolated μ
 - 2 jets b-tagged
- Uncert.: BKGD σ , $\epsilon(\text{b-tag})$, JES,...
- Results:

$N_{\text{obs}}=1$

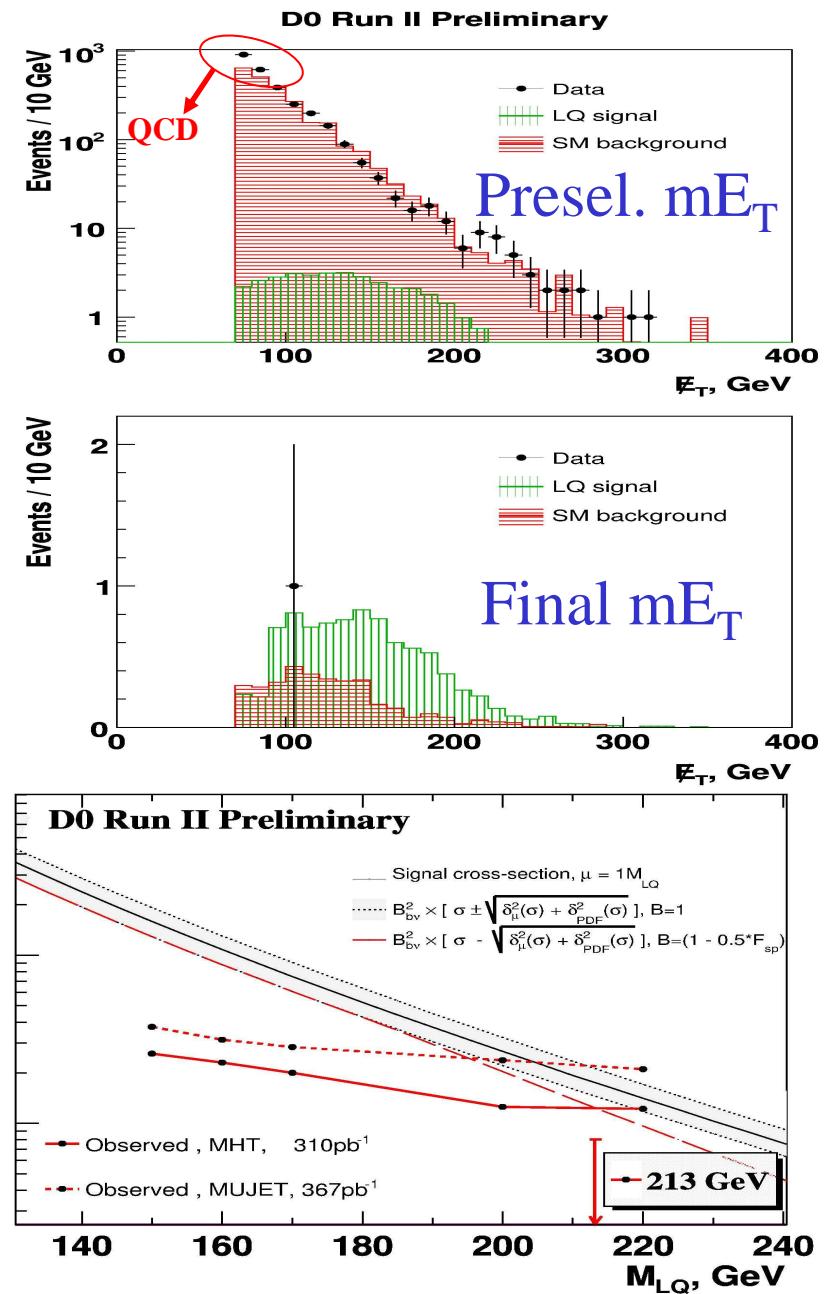
$N_{\text{exp}}(B)=3.47+/-0.24$

$N_{\text{exp}}(S)=8.8+/-0.2, \epsilon=10.6\%$
($m_{\text{LQ}}=200 \text{ GeV}$)

$m_{\text{LQ}3}>213 \text{ GeV}$

S. Muanza

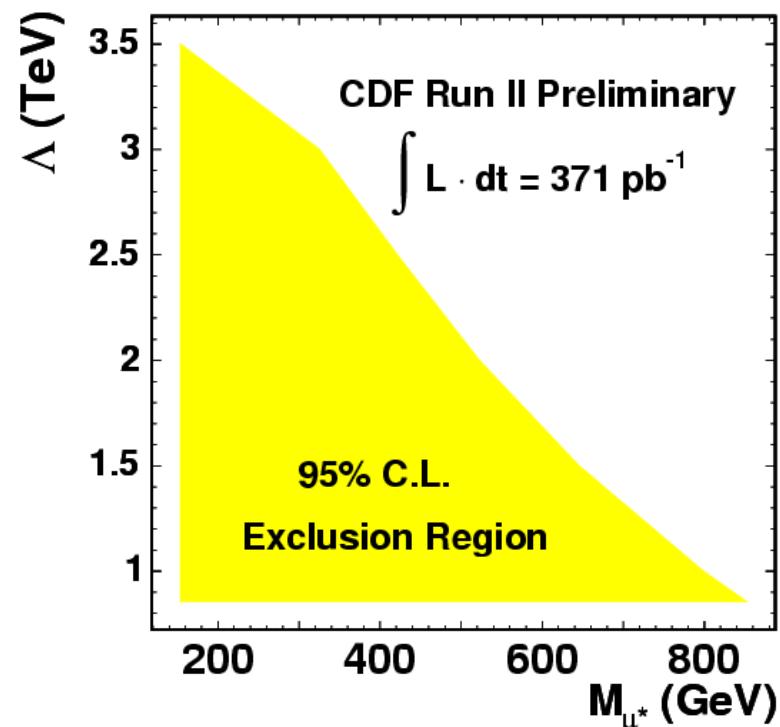
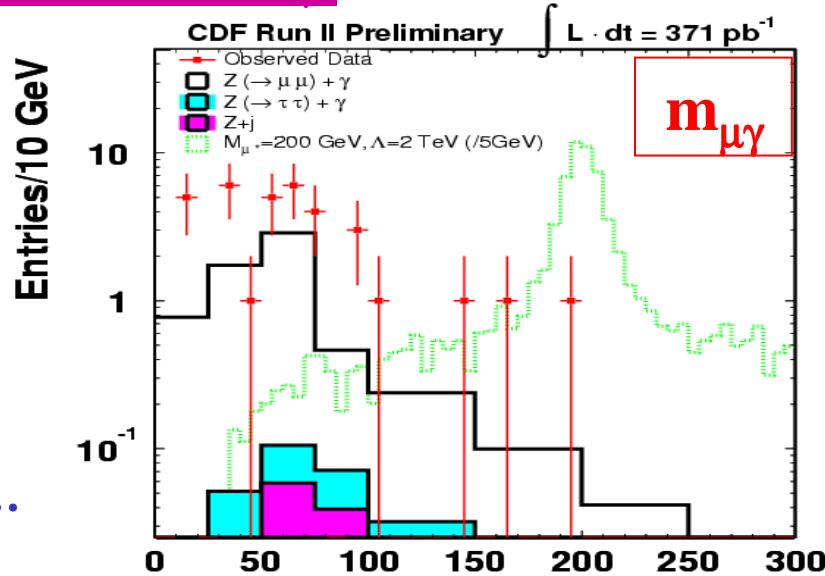
Moriond C





- Analysis: $q\bar{q} \rightarrow \mu^*\mu \rightarrow \mu\mu + \gamma$
- Data sample: 371 pb^{-1}
- Triggers: incl. μ
- Event selection:
 - 2 hard & isolated μ
 - +1 hard & isolated γ
- Uncert.: μ and γ ID, PDF, trigger ϵ ,...
- Results:
 - Hyp: CI $\text{BR}(\mu^* \rightarrow \mu\gamma)$ same as in GM
 - $m(\mu^*) > 853 \text{ GeV}$ for $\Lambda = m(\mu^*)$ in CI
 - $m(\mu^*) > 237 \text{ GeV}$ for $\Lambda = m(\mu^*)$ in GM
- Comparison wrt D0:
 - Hyp: $\text{BR}(\mu^* \rightarrow \mu\gamma)$ includes CI
 - CDF: $m(\mu^*) > 696 \text{ GeV}$ for $\Lambda = m(\mu^*)$
 - D0: $m(\mu^*) > 688 \text{ GeV}$ for $\Lambda = m(\mu^*)$

Search for Excited μ





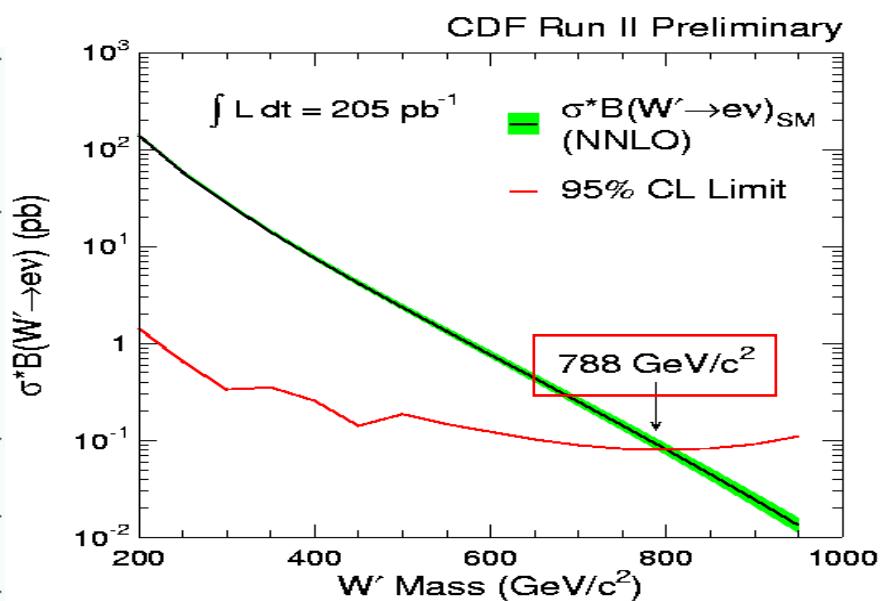
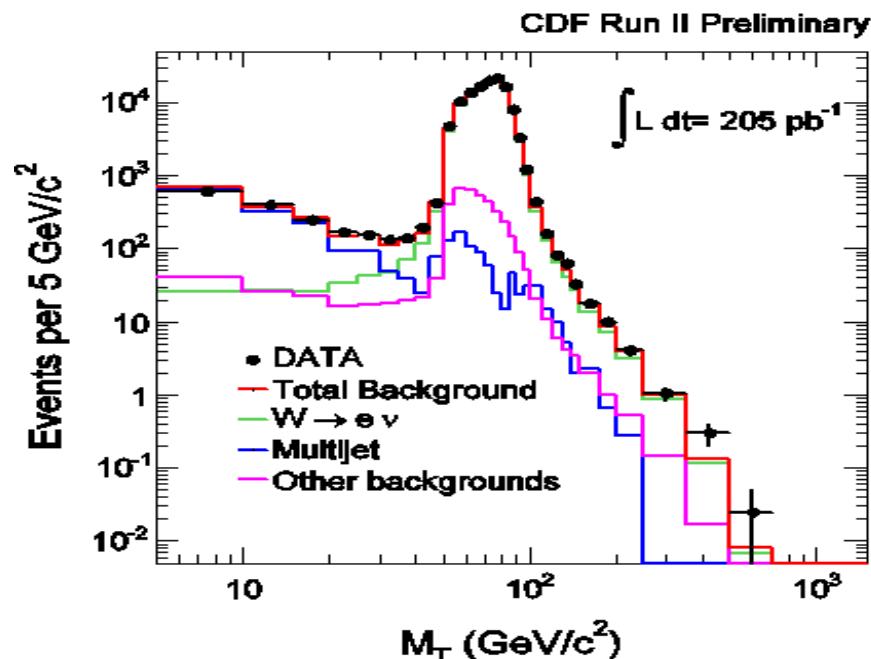
- CDF:

- Analysis: $W' \rightarrow e\nu$

- Triggers: incl. e
- Data sample: 205 pb^{-1}
- Instr. background: QCD from data
- Event selection:
 - 1 hard & isolated e
 - large m_{ET}
 - cut on $p_T(e)/m_{\text{ET}}$
- Uncert.: PDF, e E-scale & resolution, ISR,...
- Results:
 - shape of m_T tail above 200 GeV

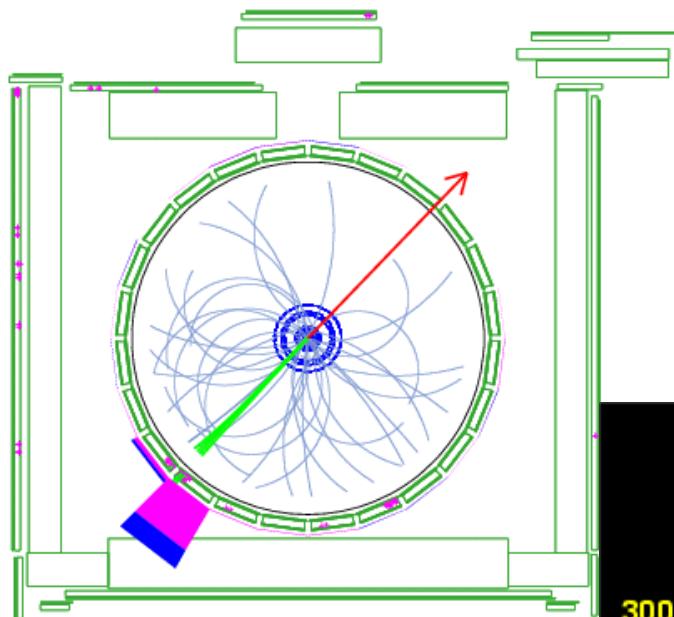
	Events in Each M_T Bin (GeV/c^2)				
	200 - 250	250 - 350	350 - 500	500 - 700	700 - 1000
$W \rightarrow e\nu$	30.8 ± 5.7	17.0 ± 4.0	3.52 ± 1.70	0.27 ± 0.45	0.00 ± 0.00
Multijet	2.7 ± 6.1	0.0 ± 3.3	0.00 ± 0.29	0.00 ± 0.01	0.00 ± 0.00
Other Backgrounds	5.2 ± 1.0	3.0 ± 0.9	0.51 ± 0.22	0.06 ± 0.08	0.00 ± 0.03
Total Background	38.7 ± 8.9	20.0 ± 5.9	4.03 ± 1.97	0.33 ± 0.53	0.01 ± 0.03
Data	41	21	9	1	0

Search for W'

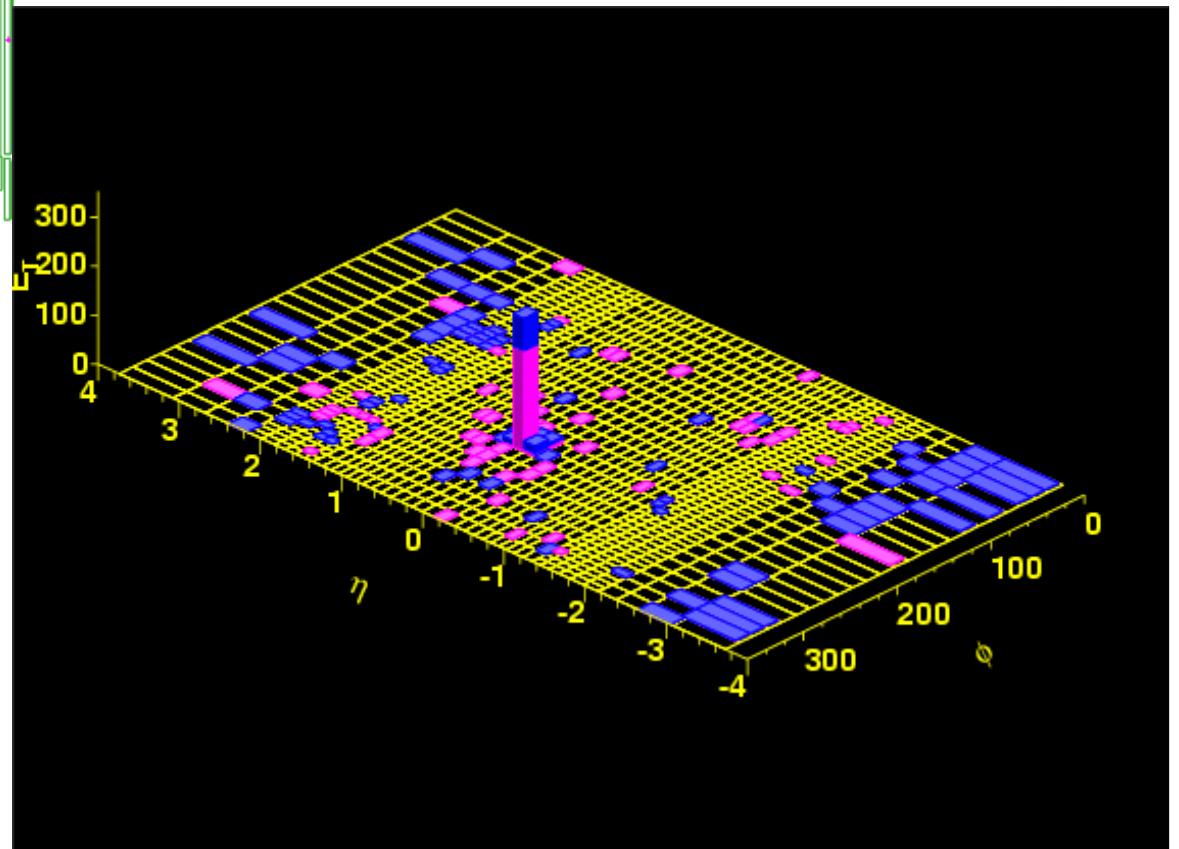




Search for LED



Very nice CDF monojet candidate
 $p_T(j) = 384 \text{ GeV}$ & $mE_T = 390 \text{ GeV}$
Run 155313, Event 273486





Large ED Searches at Colliders



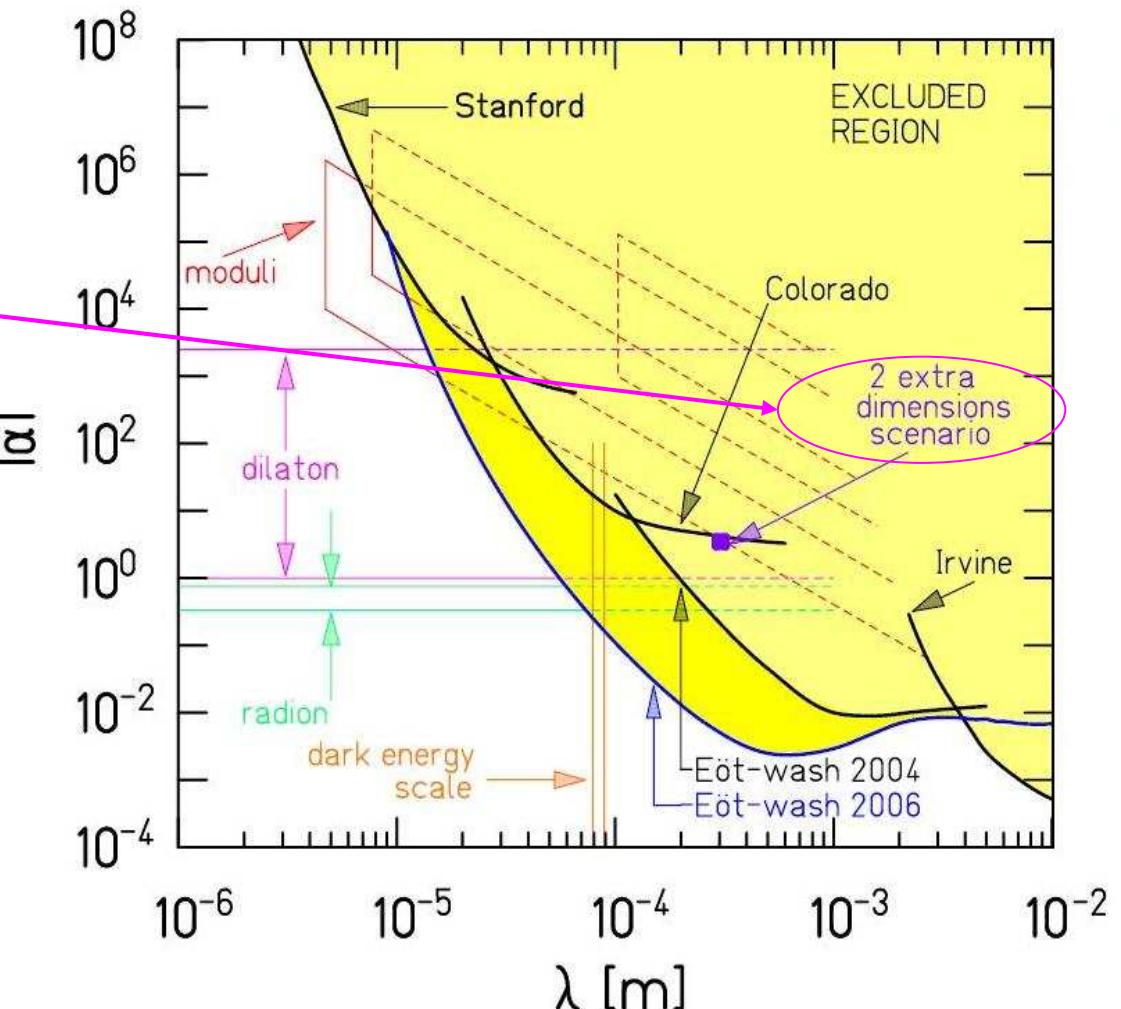
ED Nbers and Radii

$$M_D \approx 1 \text{TeV}$$

$$R = \begin{cases} 1.2 \times 10^{12} \text{m} & n = 1 \\ 0.48 \text{mm} & n = 2 \\ 3.6 \text{nm} & n = 3 \\ 9.7 \times 10^{-12} \text{m} & n = 4 \end{cases}$$

Eöt-Wash Experiment
Test Newton's Law down to
 $O(200 \mu\text{m})$

Ref: Adelberger et al, PRL 86 (2001)



$$R_n = \frac{1}{8\pi} \left(\frac{M_{Pl}}{M_S}\right)^2 \frac{1}{M_S^n}$$

Parameterising breakdowns of $1/r^2$ law

- old-fashioned way

$$F(r) = G \frac{m_1 m_2}{r^{2+\epsilon}}$$



no theoretical basis

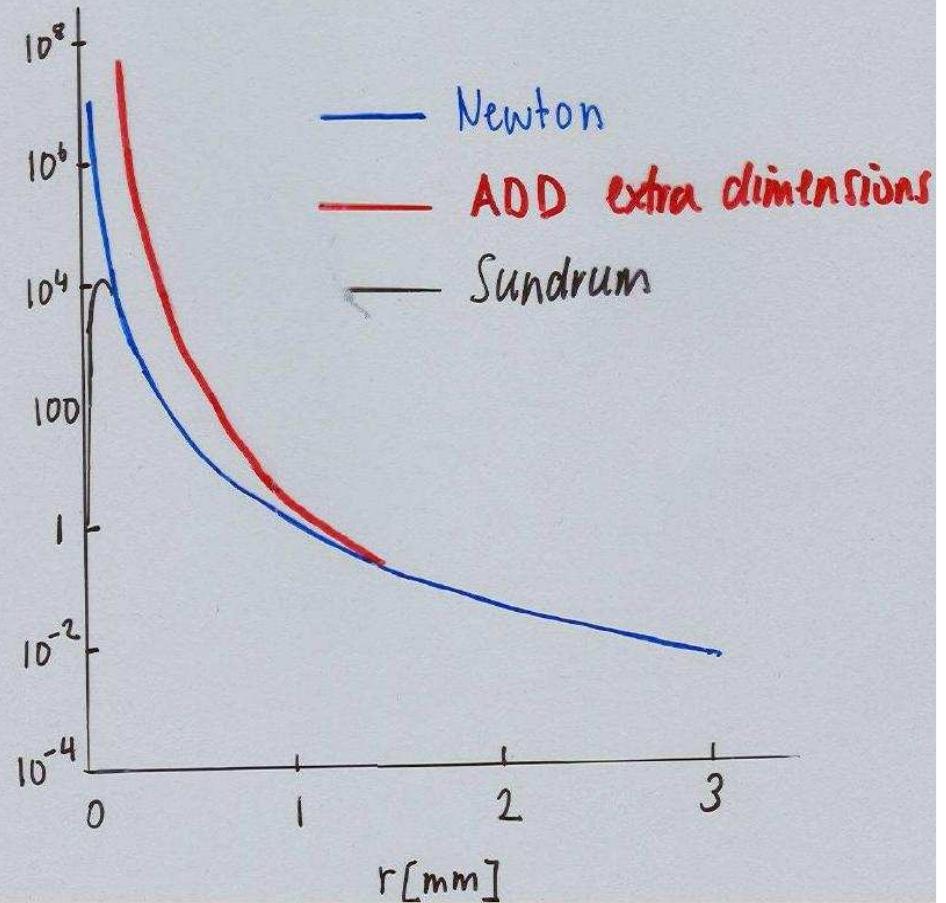
- modern way

$$F(r) = G \frac{m_1 m_2}{r} \left[1 + \alpha / \left(1 + \frac{r}{\lambda} \right) e^{-r/\lambda} \right]$$



- exchange of boson with $m > 0$
- extra dimensions scenario
when $r \approx R^*$

Force [arbitrary units]



Courtesy of Eot-Wash group