Tevatron Searches for Resonances Decaying to Fermion Pairs

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on behalf of the

and

Collaborations

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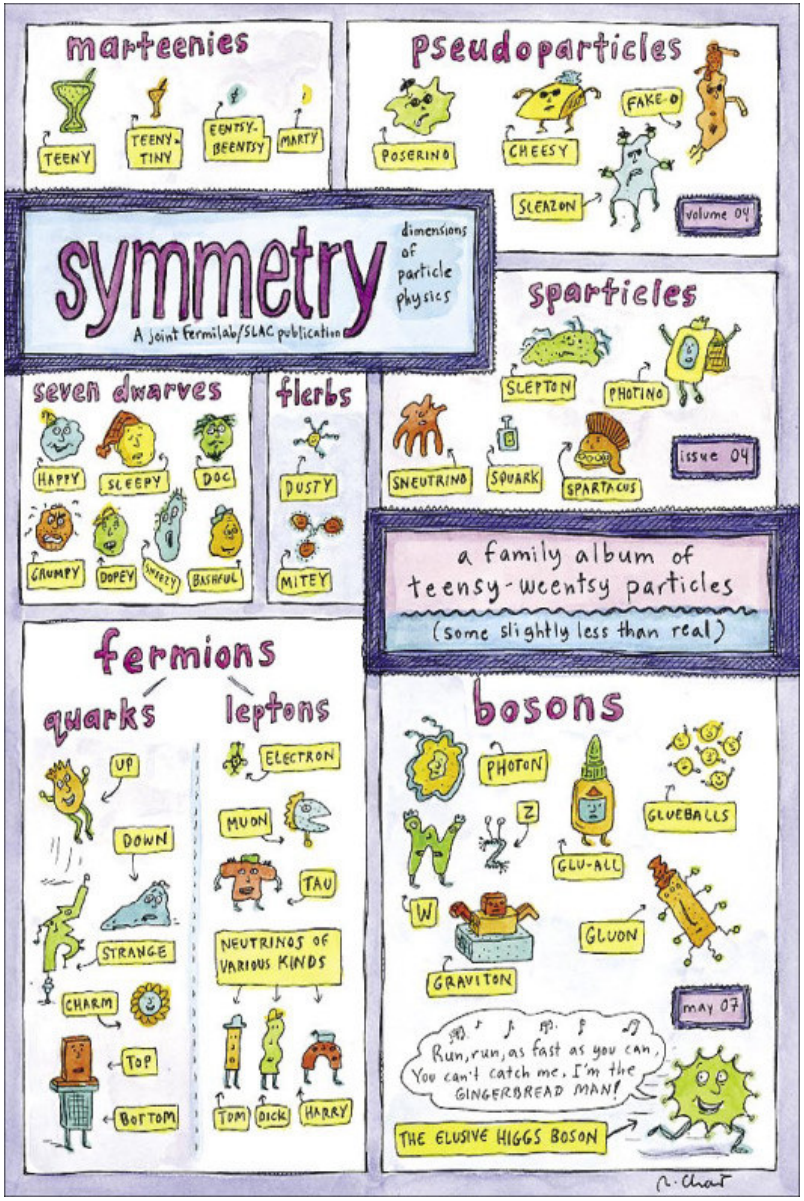
GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

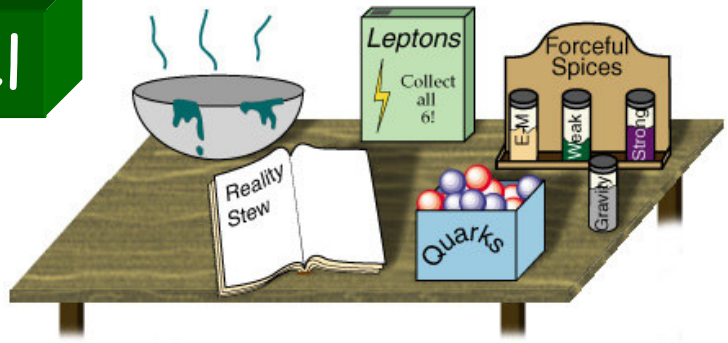
Introduction



Artist's view „Symmetry" Magazine, May 2007

Standard Model

-> incomplete
-> open issues

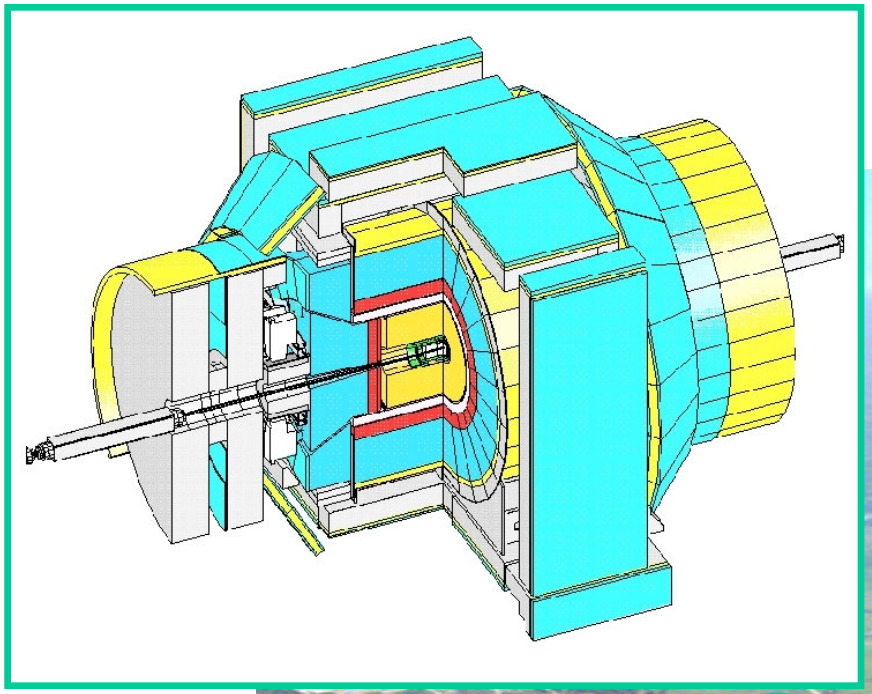


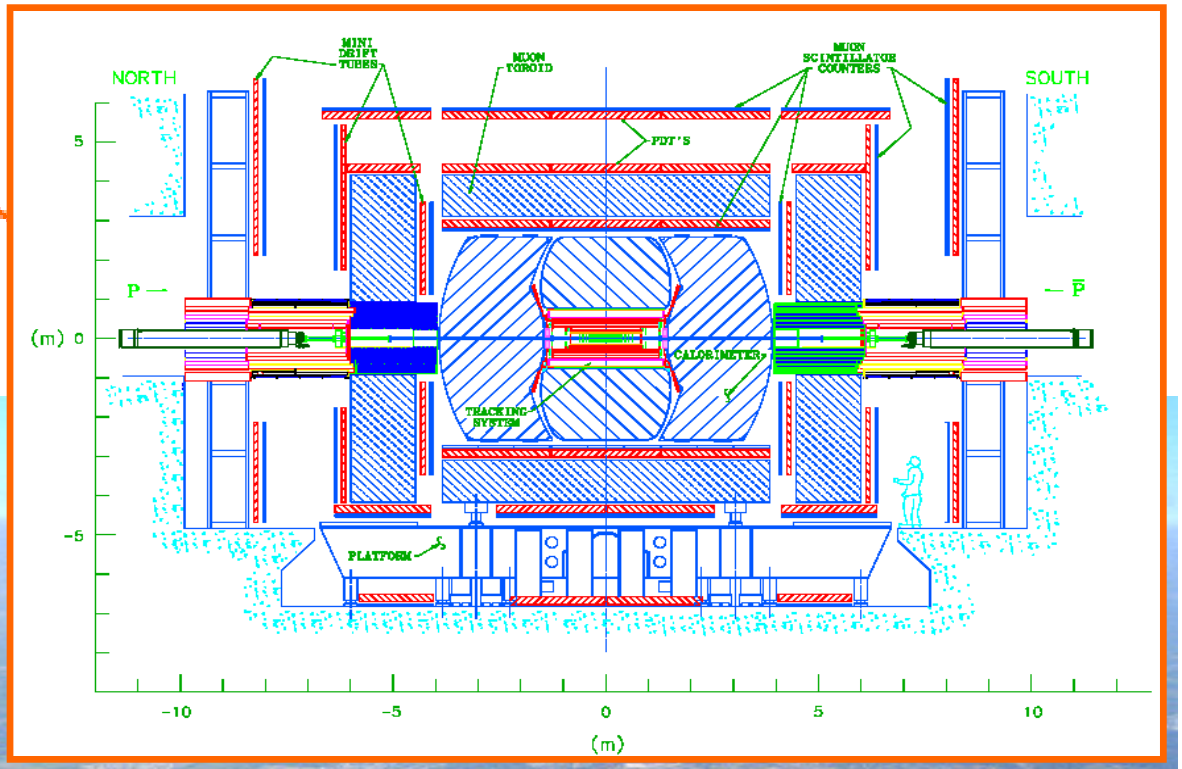
Broad variety of models beyond SM

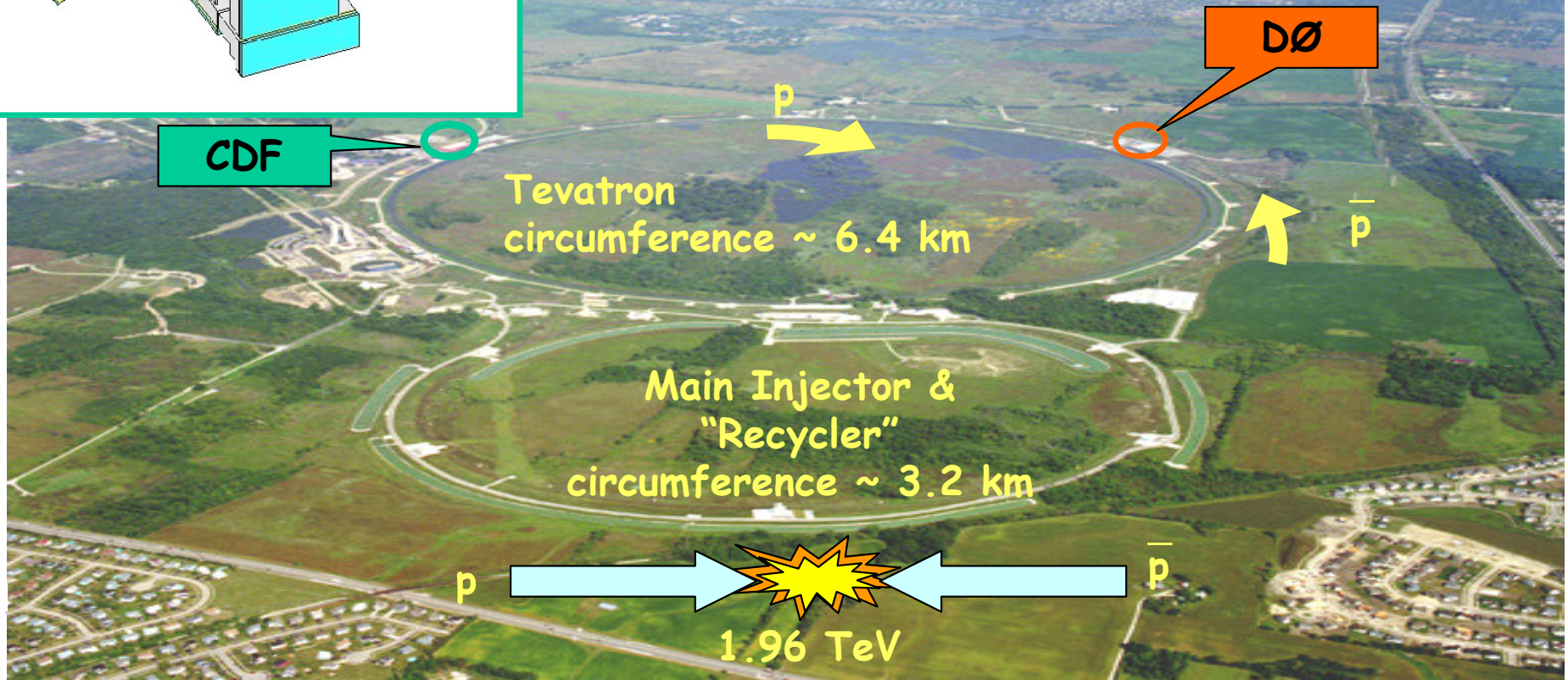
Searches for particular models :
- Extra Dimensions (ED), here:
  Randall-Sundrum (RS) Model with 1 ED
- GUT models (E_6, ...)

Signature-based searches :
- generic resonances

Tevatron, CDF & DØ







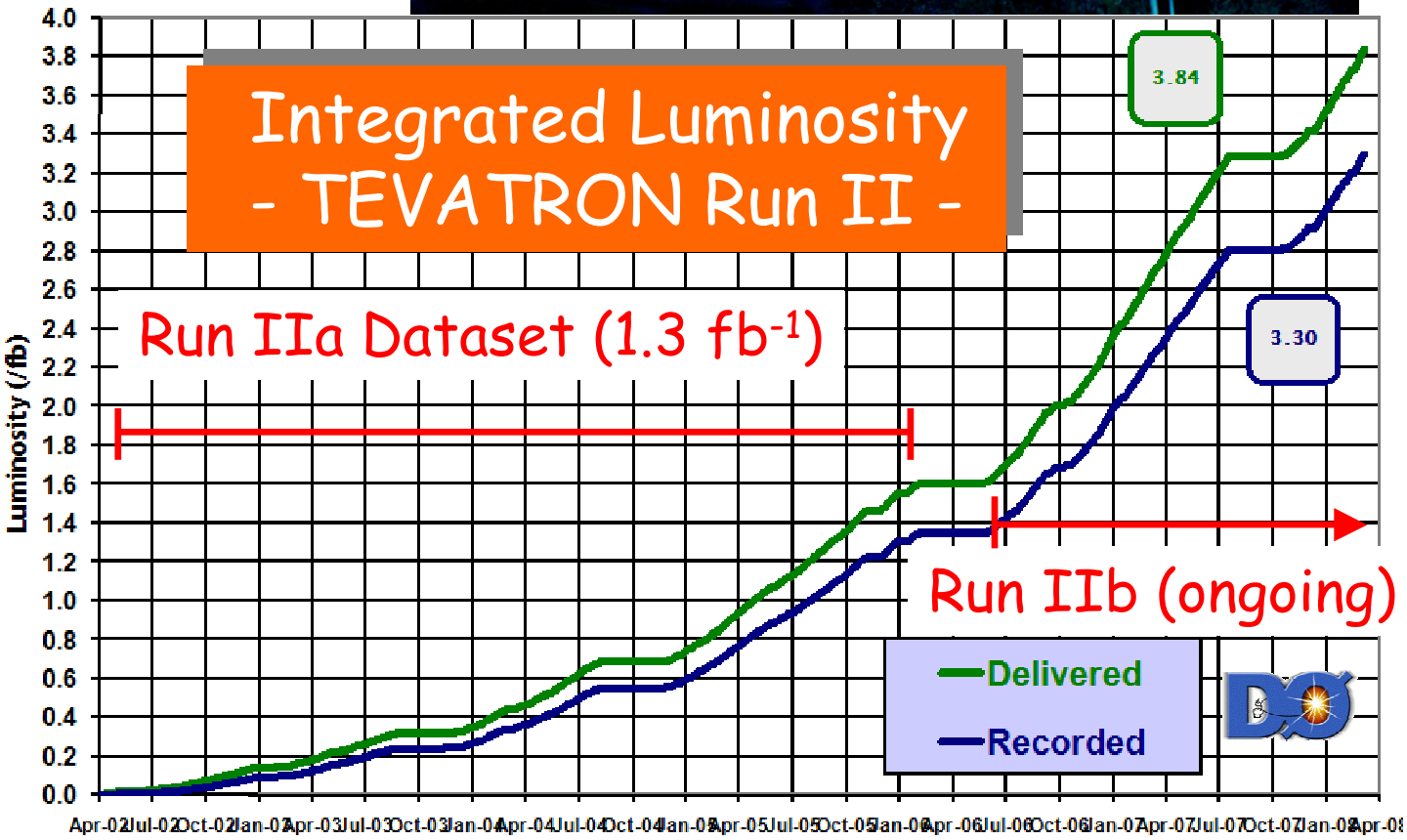
Overview

Featured Analyses :

Search for Resonances in

- dielectron
- diphoton
- dijet
- electron + MET
- four electron

Final States



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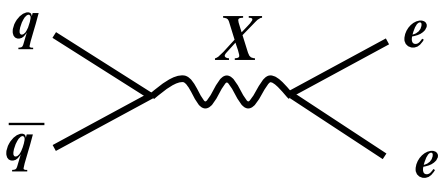
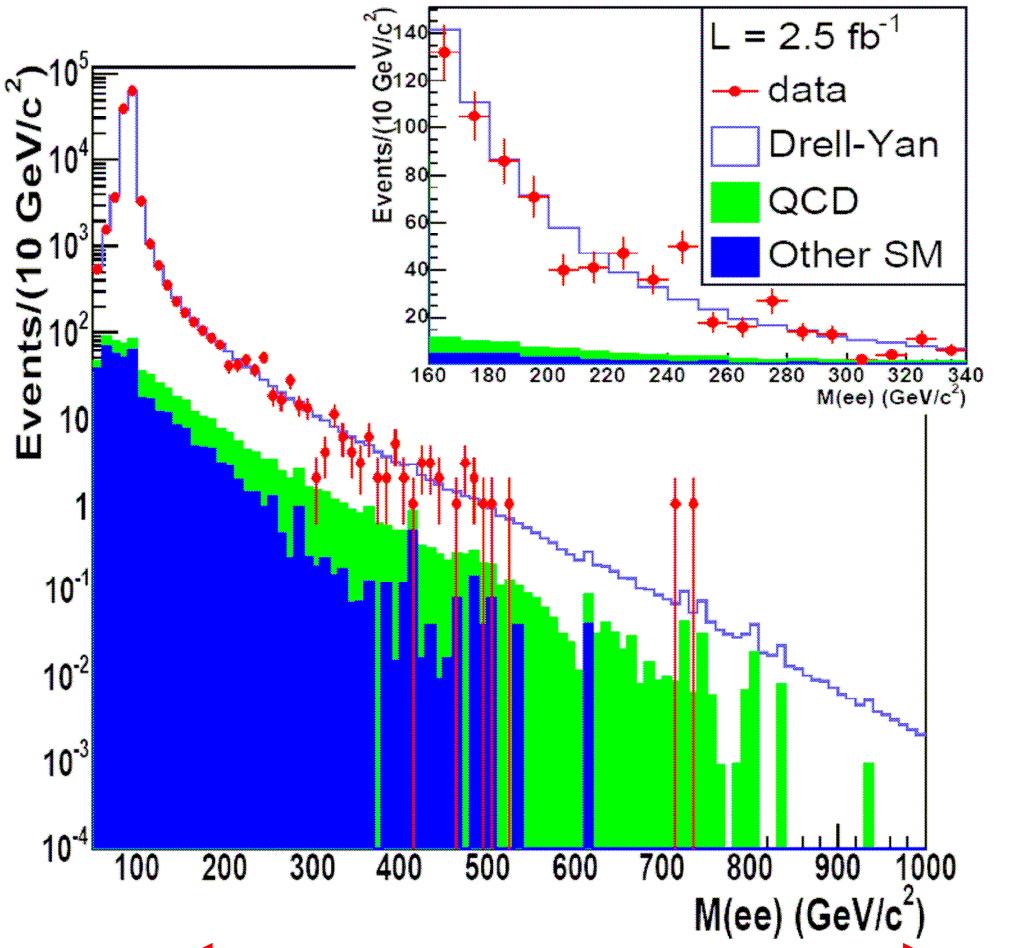
Dielectron Resonances (RS ED, Z´)



CDF Run II Preliminary $L = 2.5\ fb^{-1}$



Models for X :

Spin 1: two Z´ bosons in E_6
(6 mass eigenstates)

Spin 2: Randall-Sundrum
Extra Dimensions

Selection :

Two electrons with $E_T > 25$ GeV
within $|\eta| < 2$, at least one
within the central region $|\eta| < 1$

Backgrounds :

Main : Drell-Yan (PYTHIA)
QCD : estimated from data
Other (WW, WZ, ...)

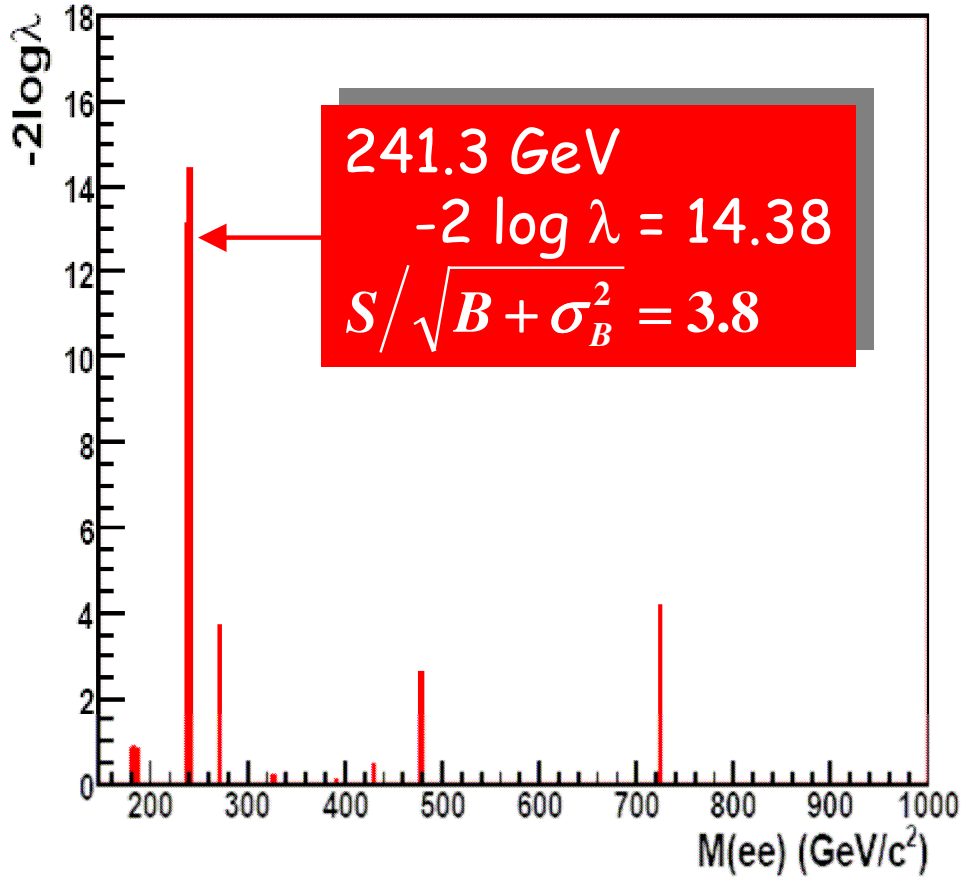
Methods :

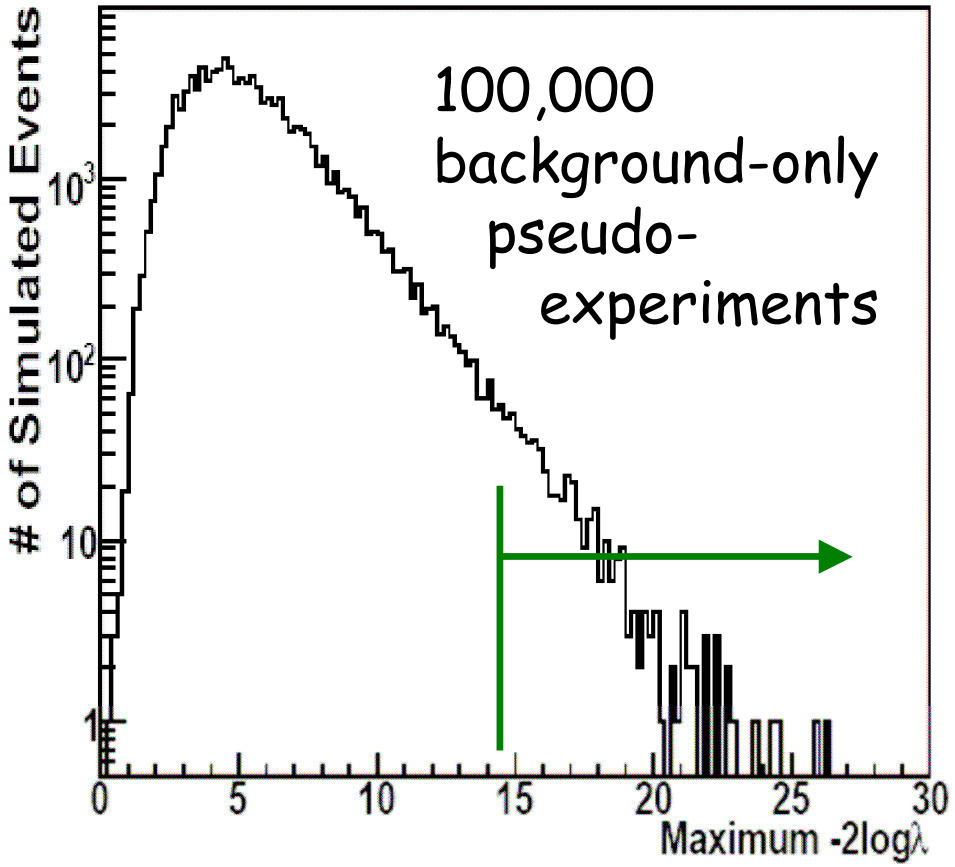
- Unbinned likelihood ratio
- Bayesian binned likelihood

Dielectron Resonances (RS ED, Z´)

Generic search for resonance

$$\lambda = \frac{\underset{n_b \geq 0}{max.\mathcal{L}_b}}{\underset{n_b \geq 0, n_s \geq 0}{max.\ \mathcal{L}_{s+b}}}, \quad 0 \leq \lambda \leq 1, \quad 0 \leq -2log\lambda \leq \infty$$

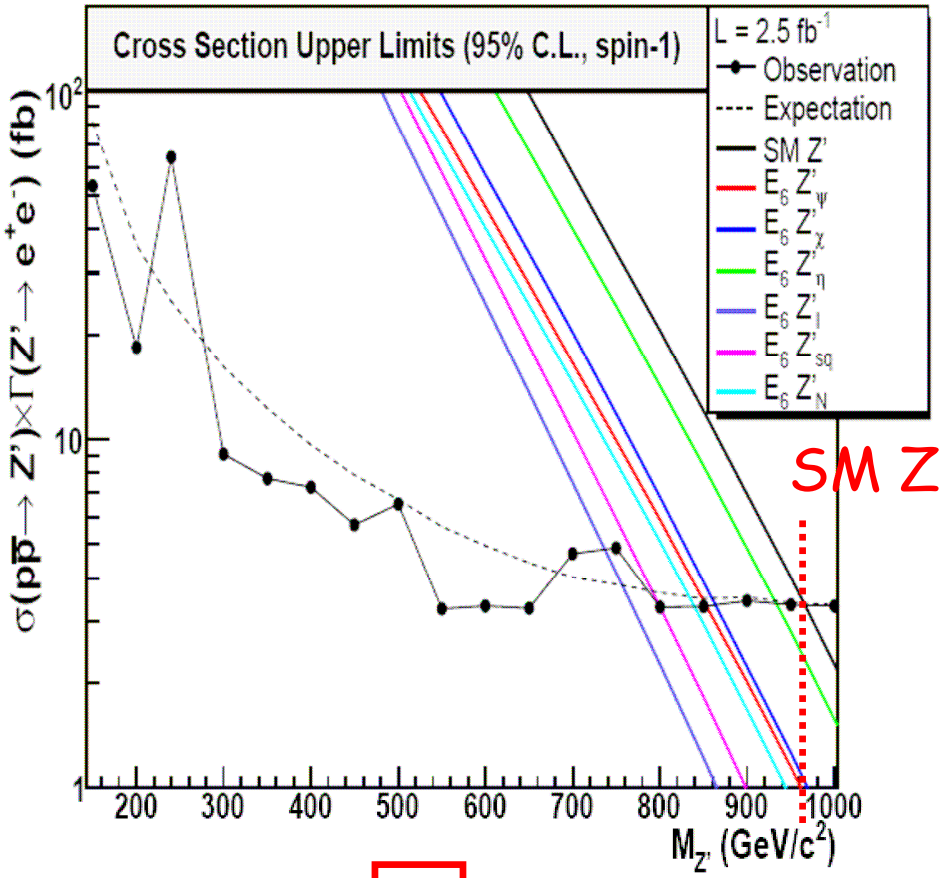




Probability for -2 log λ > 14.38 is 0.6%

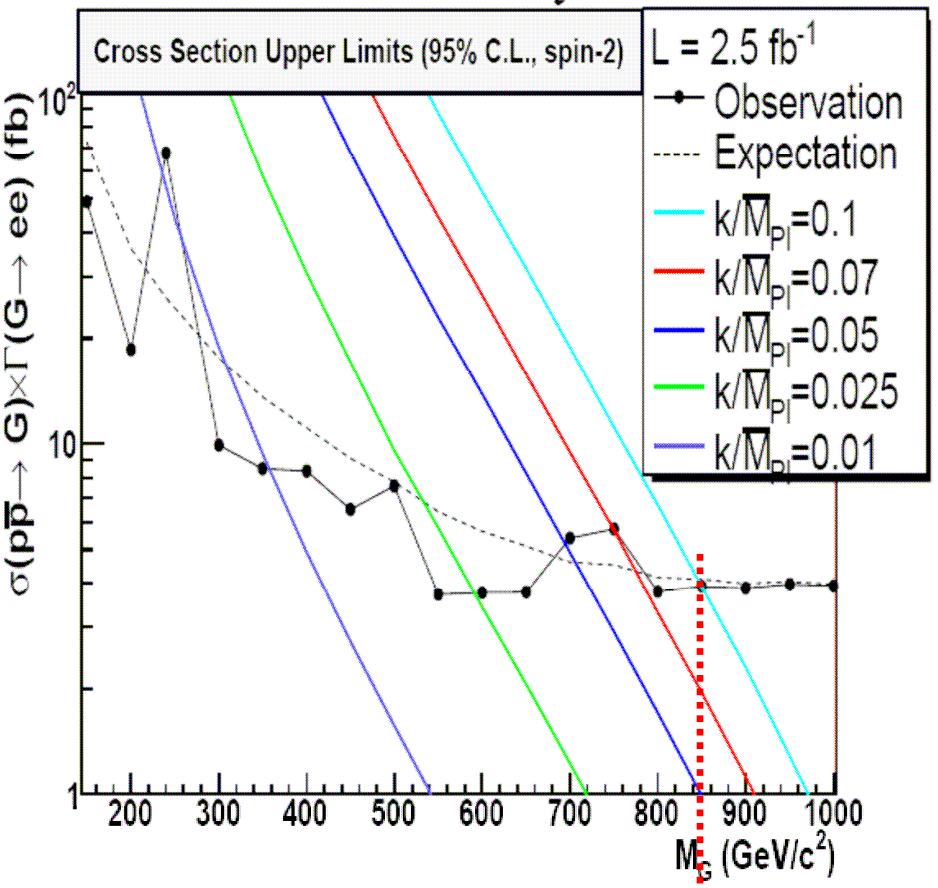
Dielectron Resonances (RS ED, Z´)

CDF Run II Preliminary



Z' Model	Z'_{SM}	Z'_{ψ}	Z'_{χ}	Z'_{η}	Z'_{I}	Z'_{sq}	Z'_{N}
Exp. Limit (GeV/c^2)	965	849	860	932	757	791	834
Obs. Limit (GeV/c^2)	966	853	864	933	737	800	840

CDF Run II Preliminary



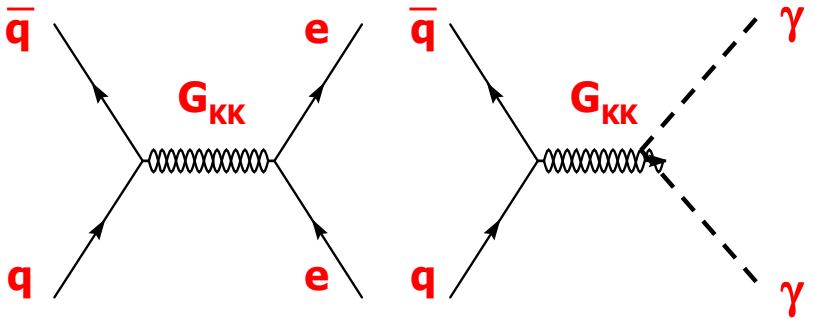
$k / \overline{M}_{Planck} = 0.1$: m (G) > 850 GeV

most stringent upper limits to date

Randall-Sundrum ED

$L = 1\ fb^{-1}$

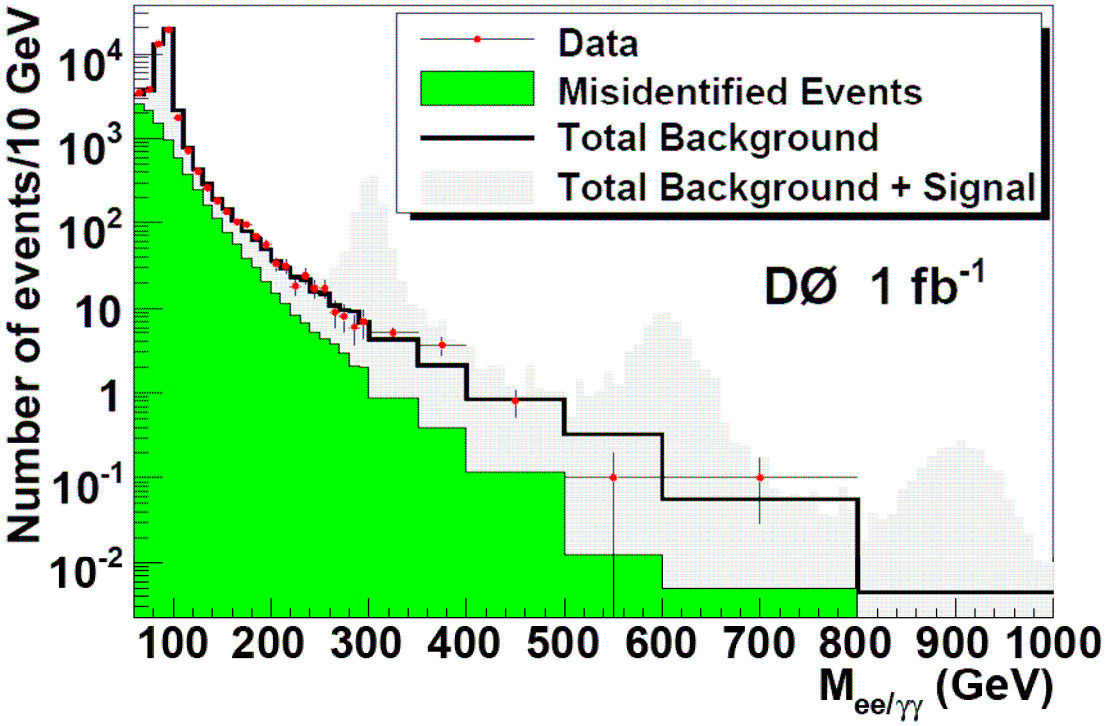
Note : Br($G \rightarrow \gamma\gamma$) = 2 Br($G \rightarrow ee$)



Idea : do not distinguish in final state between electrons and photons

Selection :

2 electromagnetic objects,
no track, both central $|\eta| < 1.1$,
$E_T > 25$ GeV, $m_{diEM} > 60$ GeV



Backgrounds :

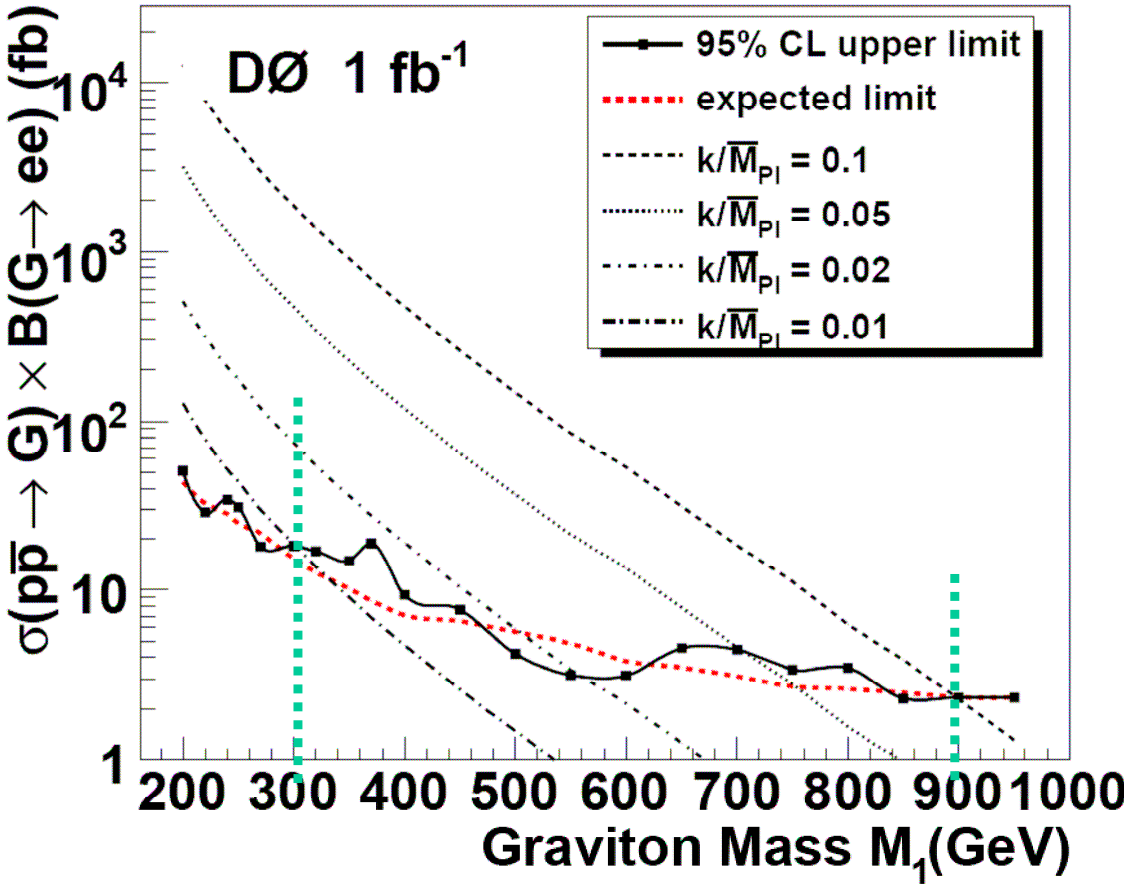
- Drell-Yan / Z & direct diphoton (Pythia)

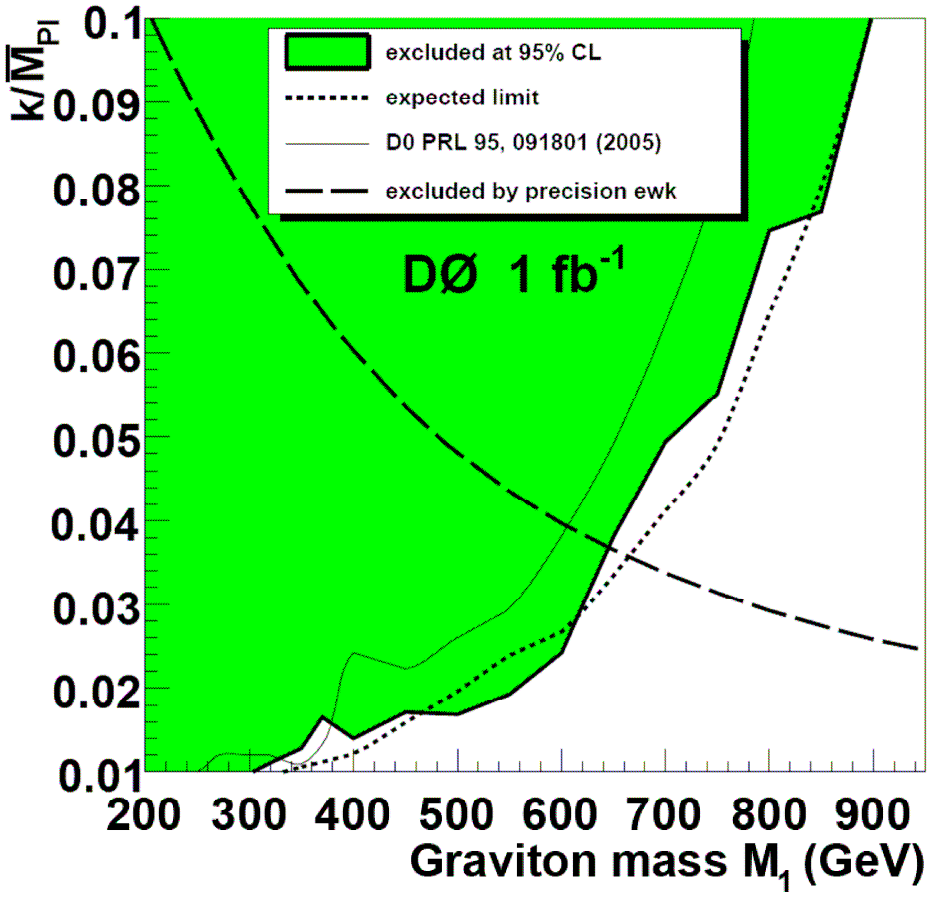
- instrumental (fakes from QCD) estimated from Data

Randall-Sundrum ED

PRL 100, 091802 (2008)

- Bayesian approach with a flat prior
- Systematic uncertainties are represented by Gaussian priors





For $k\sqrt{8\pi}/M_{Planck} = 0.1(0.01)$ mass limit on RS Graviton is 900 (300) GeV

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Randall-Sundrum ED

PRL 100, 091802 (2008)

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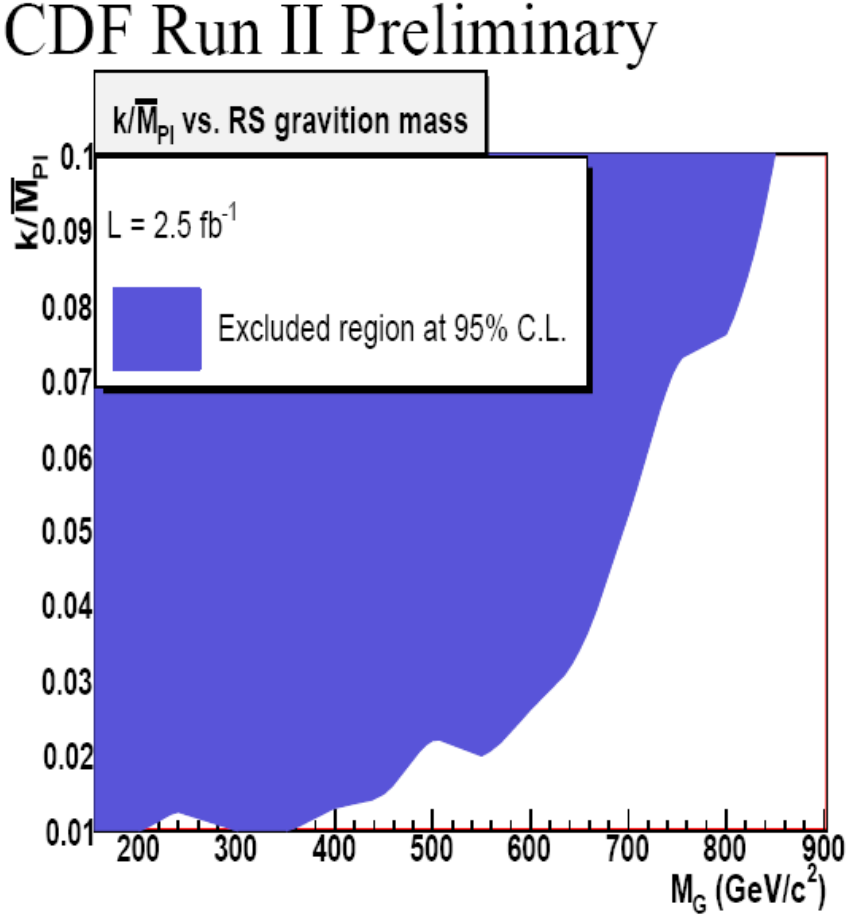

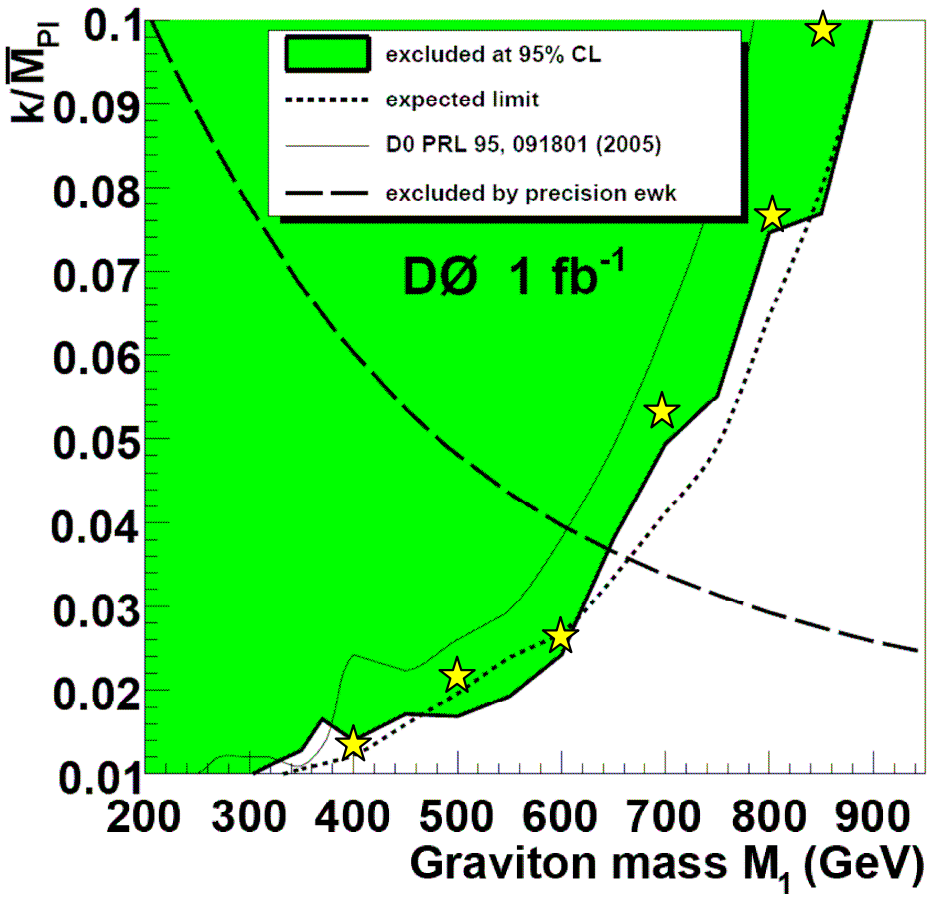

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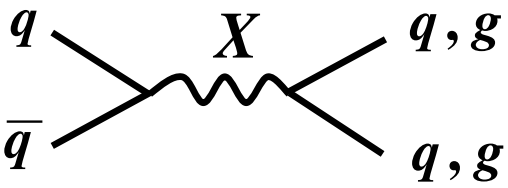
Dijet Resonances

L = 1.1 fb^{-1}

Many Models for X :

W´ , Z´ , diquarks in E_6, RS Gravitons, excited quarks, techni-ρ, axigluons

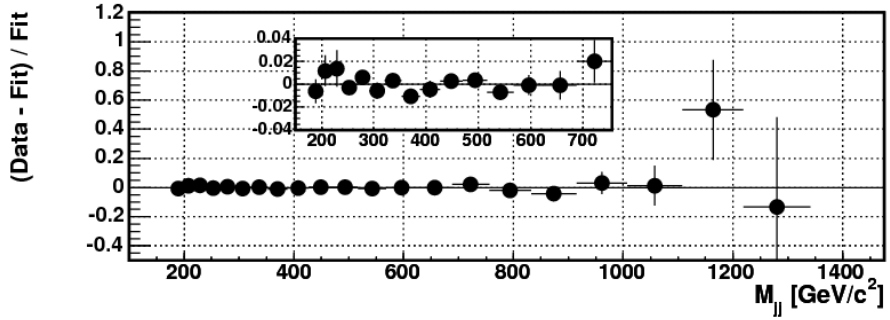


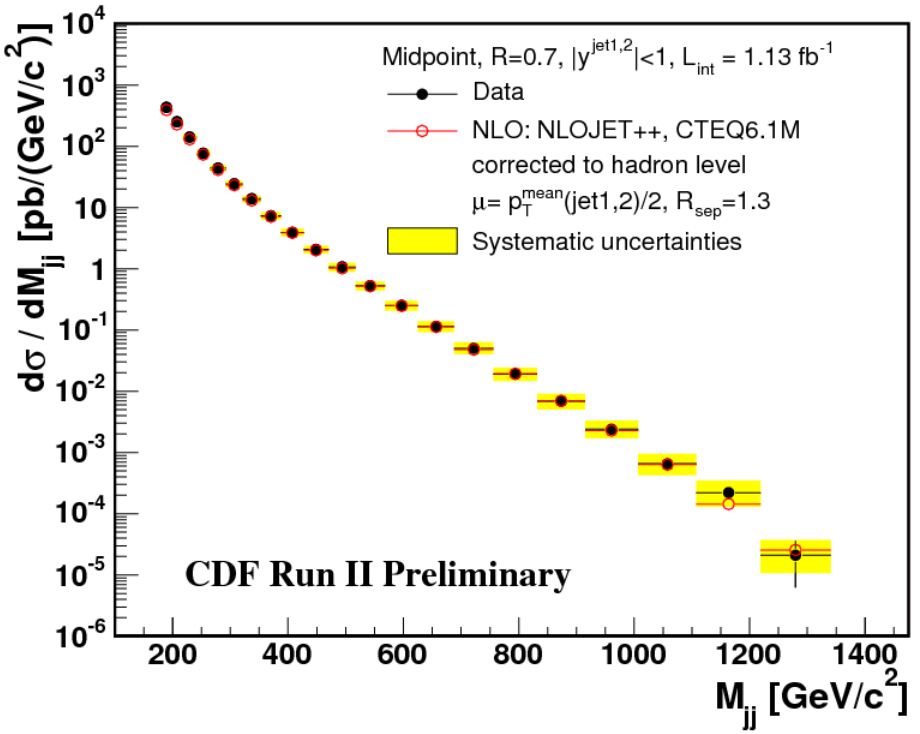
Selection :

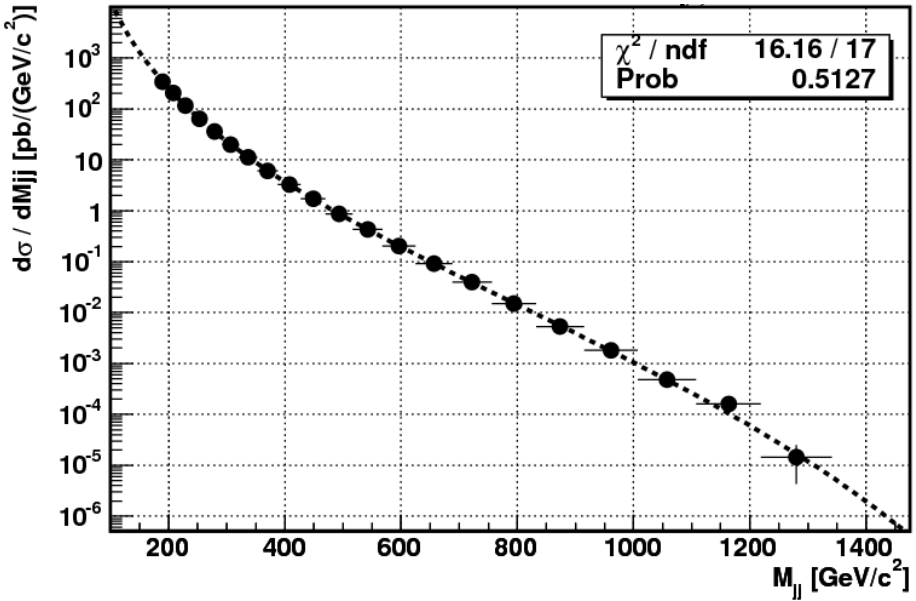
At least two jets (Midpoint, R = 0.7) within |y| < 1, m (jj) > 180 GeV

Method : Fit and look for deviations

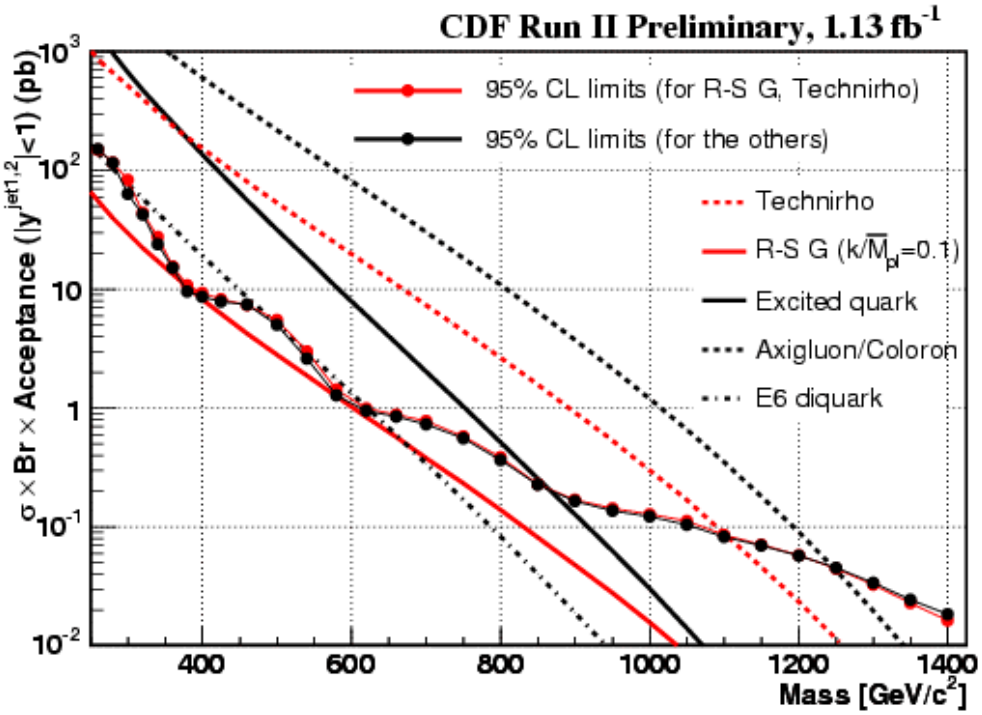
$$\frac{d\sigma}{dm} = p_0(1-x)^{p_1}/x^{p_2+p_3\cdot\ln(x)}, \quad x = m_{jj}/\sqrt{s}$$

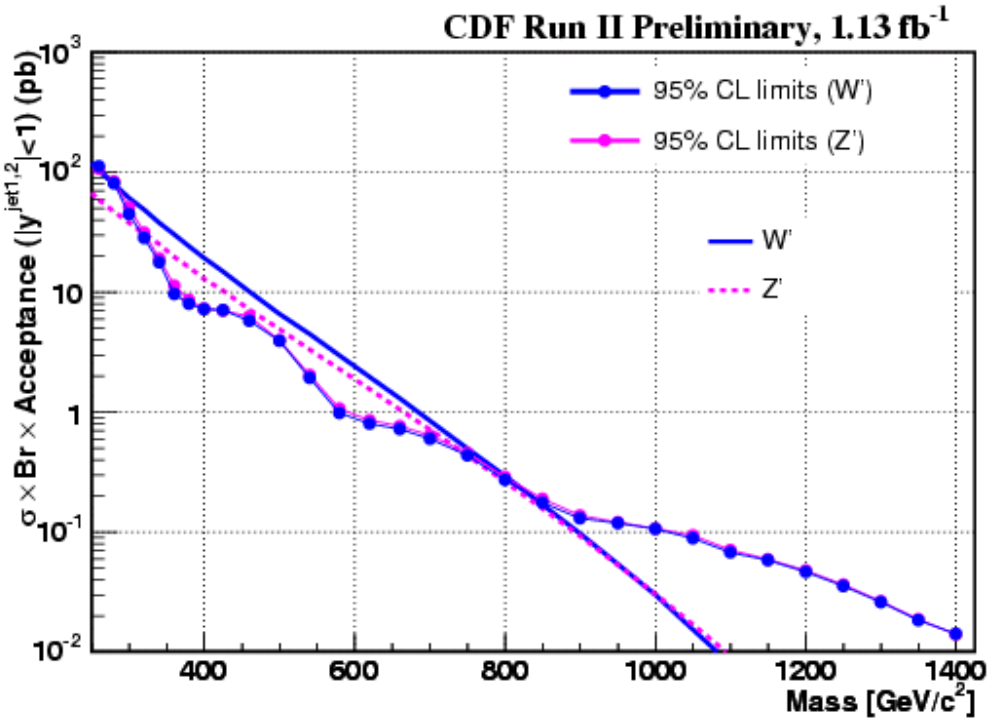






Dijet Resonances





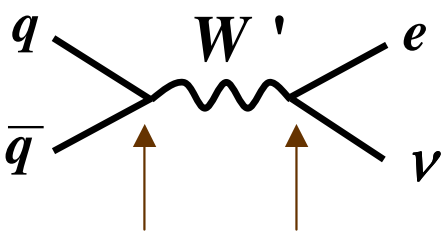
Excited Quarks : 260 – 870 GeV
Diquark E_6 : 290 – 630 GeV
Color-octet techni-ρ : 260 – 1100 GeV
Axigluon &
flavor-universal coloron : 260 – 1250 GeV

W´: 280 – 840 GeV
Z´: 320 – 740 GeV

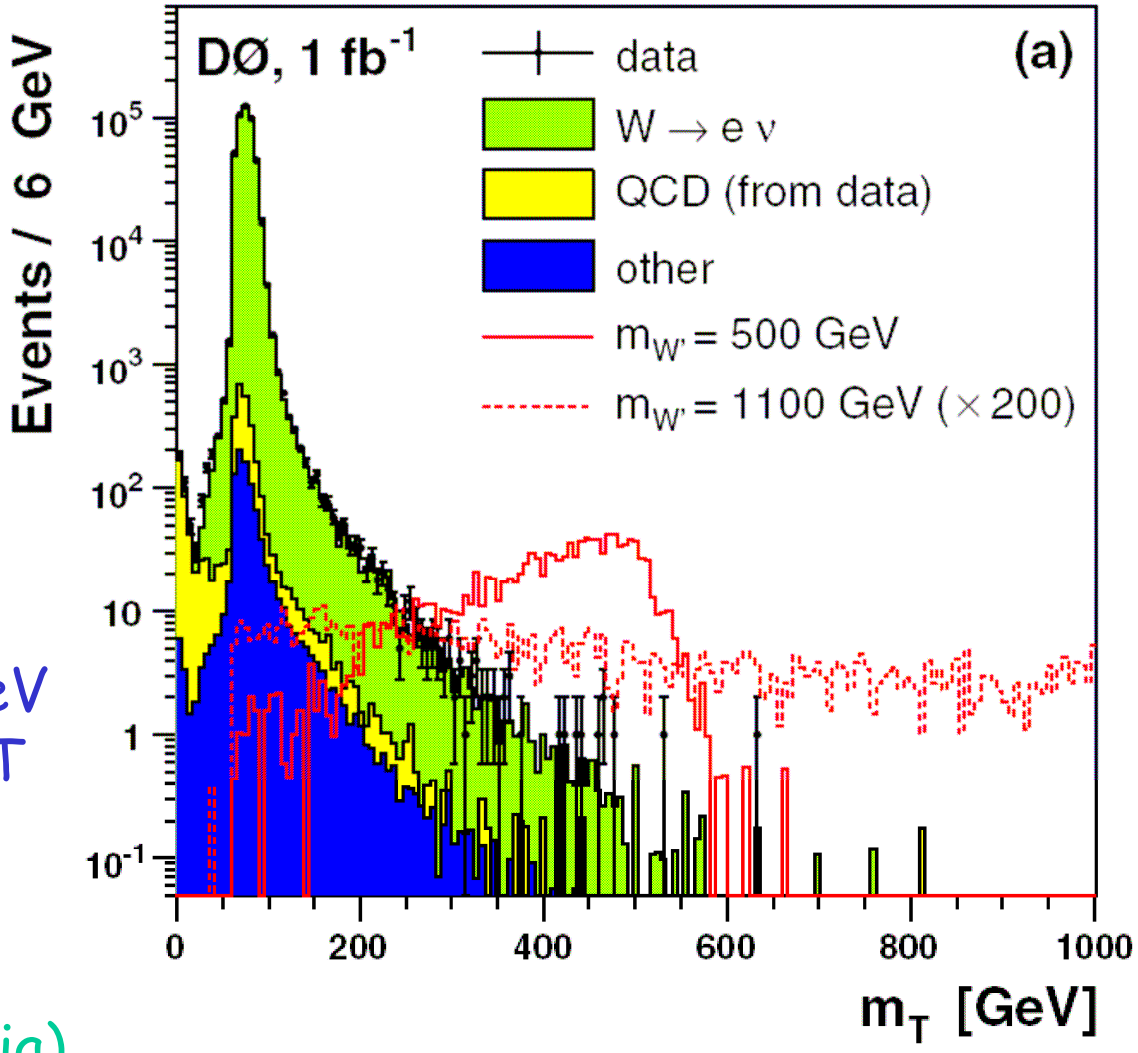
most stringent upper limits to date

W´ Bosons

L = 1 fb^{-1}



Standard Model couplings



Selection :

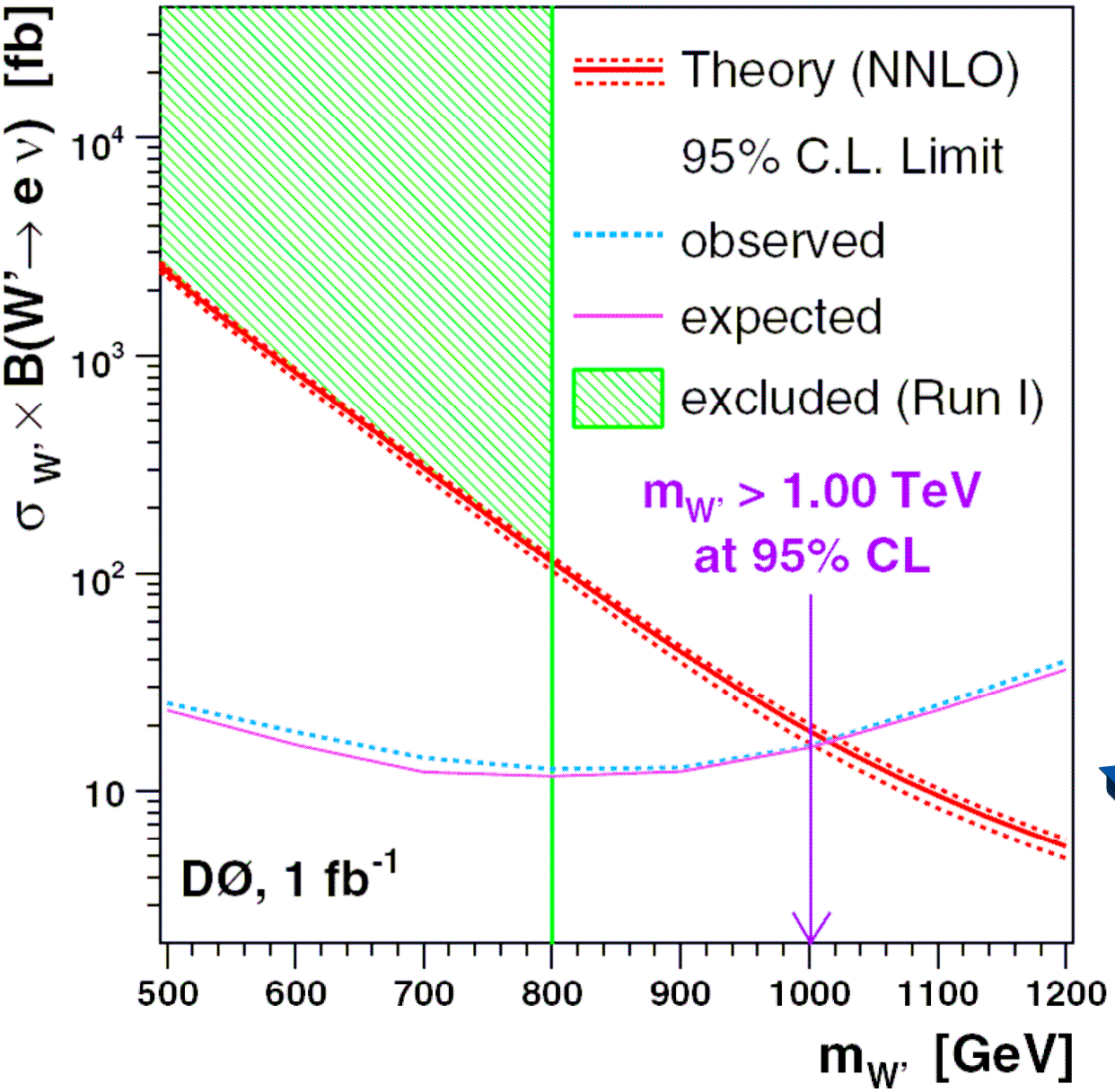
- missing transverse energy
  MET > 30 GeV
- one electron candidate
  within $|\eta| < 1.1$ with $E_T > 30$ GeV
- cleaning cuts against fake MET

Backgrounds :

- dominant : W (Pythia)
- minor : WW, ZZ, WZ, Z (Pythia)
- QCD multijet from Data (‚fake electrons ')

W´ Bosons

PRL 100, 031804 (2008)

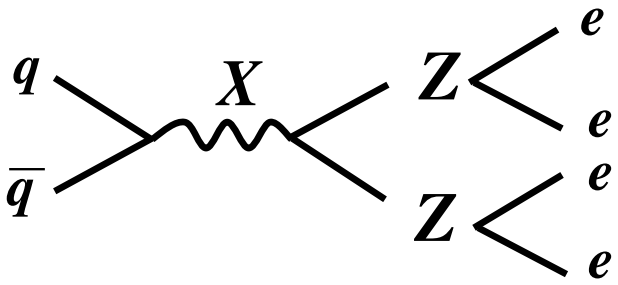


Assuming SM couplings and no mixing with new gauge groups the mass limit is **1 TeV**

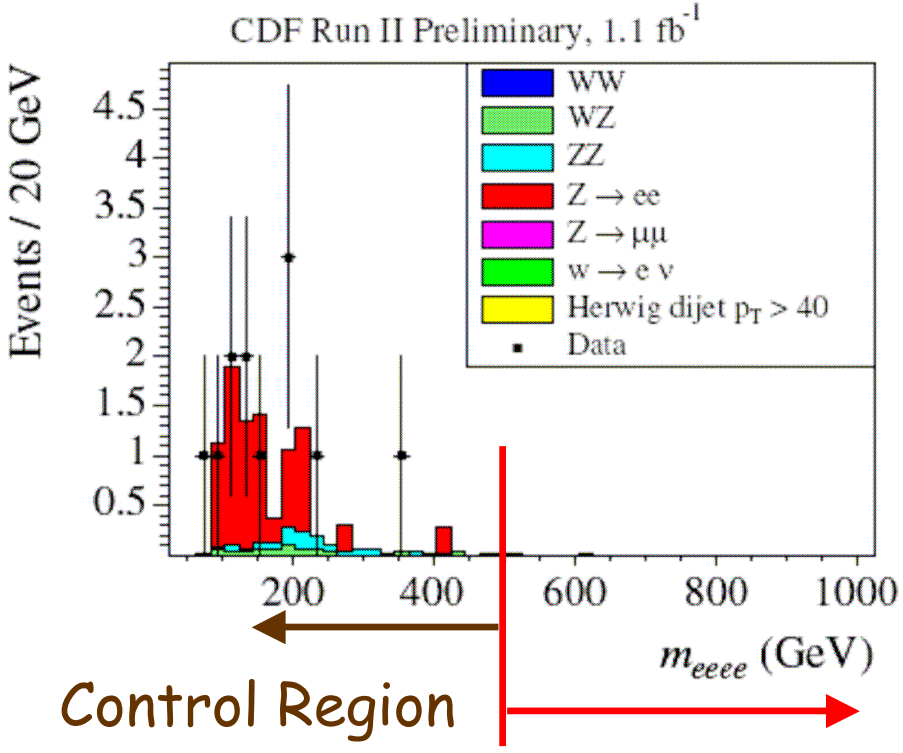
most stringent upper limit to date

Four-Electron Resonances

L = 1.1 fb^{-1}



Model-independent
use RS Gravitons as a reference model



Event Selection :
- One ‚seed' electron with E_T > 20 GeV and isolated track p_T > 10 GeV
- calorimeter electron candidates E_T > 5 GeV
- isolated tracks as electron candidates to enhance sensitivity

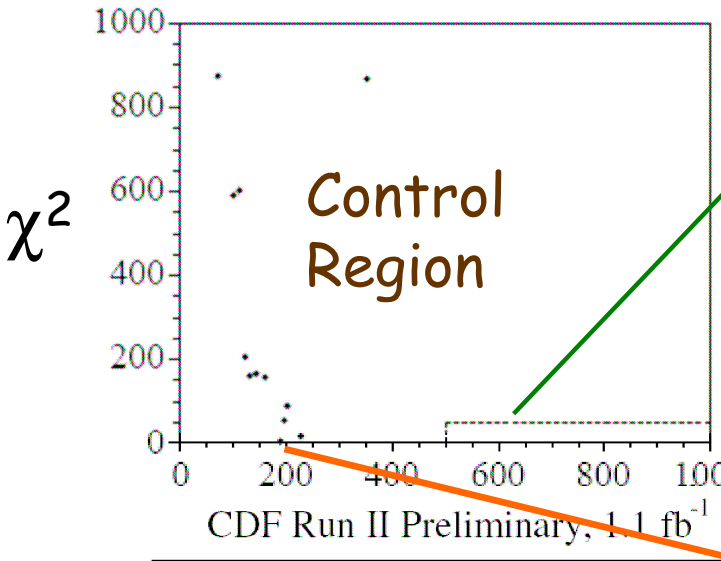
Use all combinations, put into χ^2 :

$$\chi^2 = \sum_{i=1,2} \left(\frac{m_i - m_{Z^0}}{\sigma_i} \right)^2$$

Backgrounds at high masses estimated from data (jets faking electrons)

Four-Electron Resonances

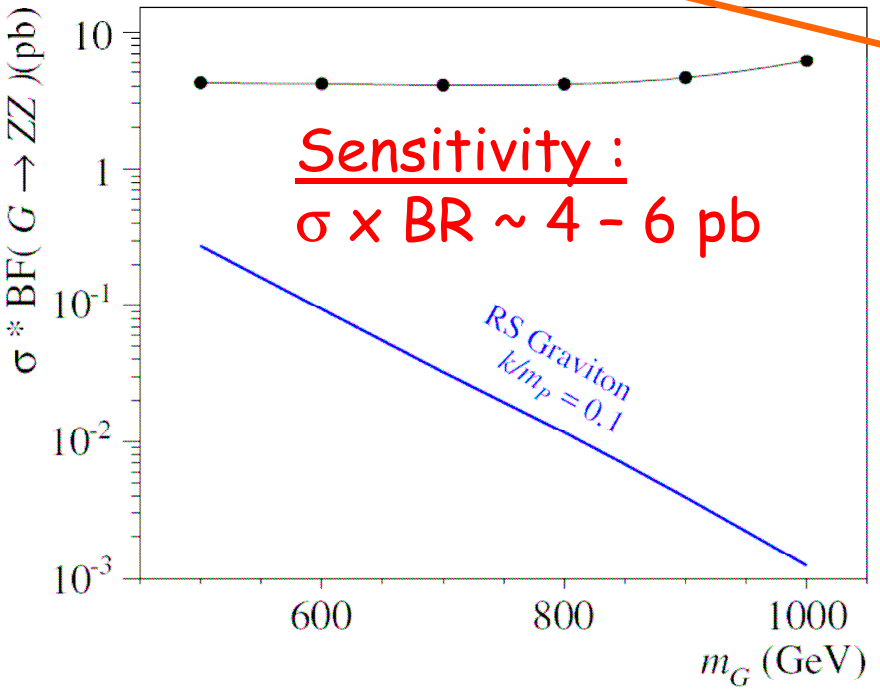
arXiv:0801.1129

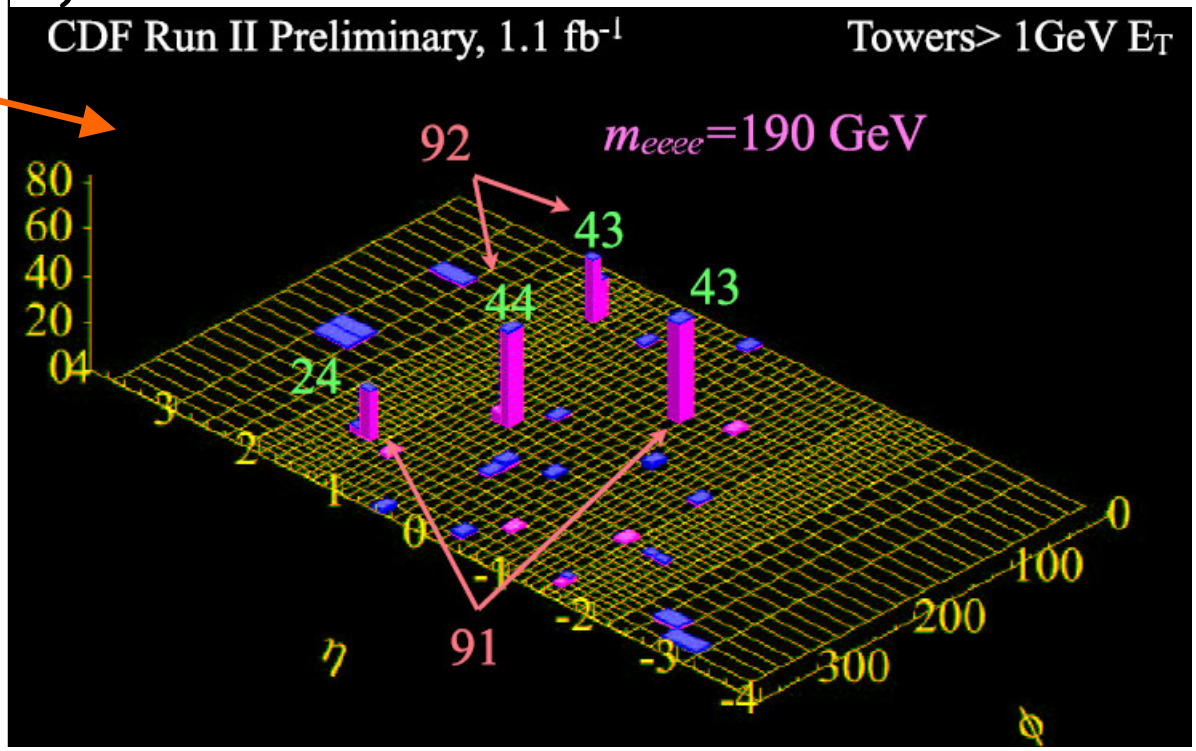


Search Region :

- Two electrons have Z mass ($\chi^2 < 50$)
- m (eeee) > 500 GeV

Data	Background
0	0.028 ± 0.009 (stat) ± 0.011 (sys)

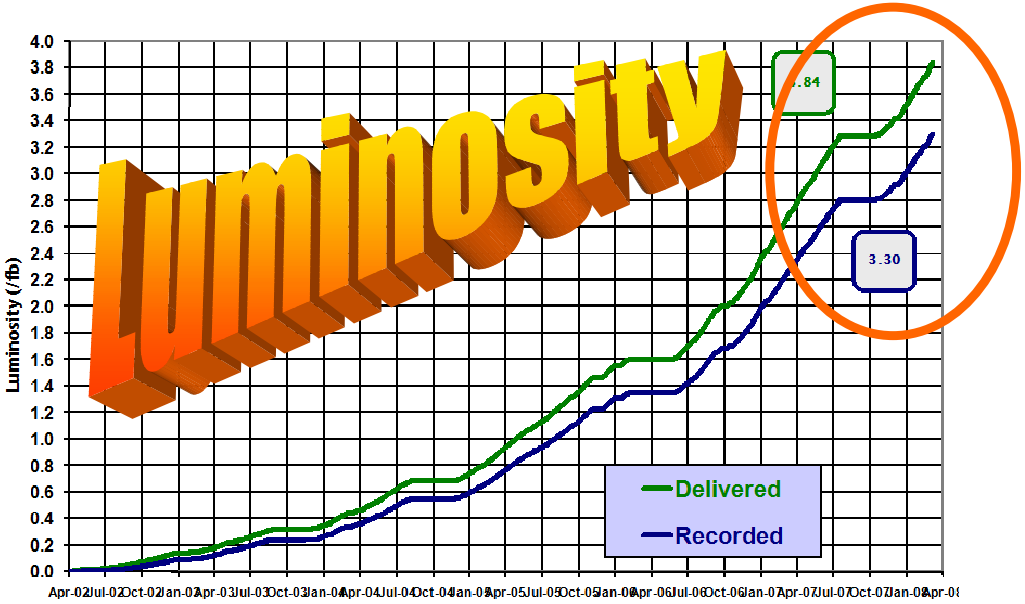




Conclusion & Outlook

- interesting signatures to look for at the Tevatron
- presented analyses with dielectron, diphoton, dijet, electron + MET and four electron final states, interpreted in various models
- no evidence for 'New Physics' found -> new restrictive limits

✓ CDF very sensitive to Z´ → ee and dijet resonances; four electron final state looks promising
✓ DØ strong in W´ → ev and Gravitons due to combination with diphoton final state



Run IIb ongoing with improved accelerator & detector

→ Hope to reveal 'New physics' with higher luminosity ???