Search for Leptoquarks in the 2electron + 2jet channel at DØ

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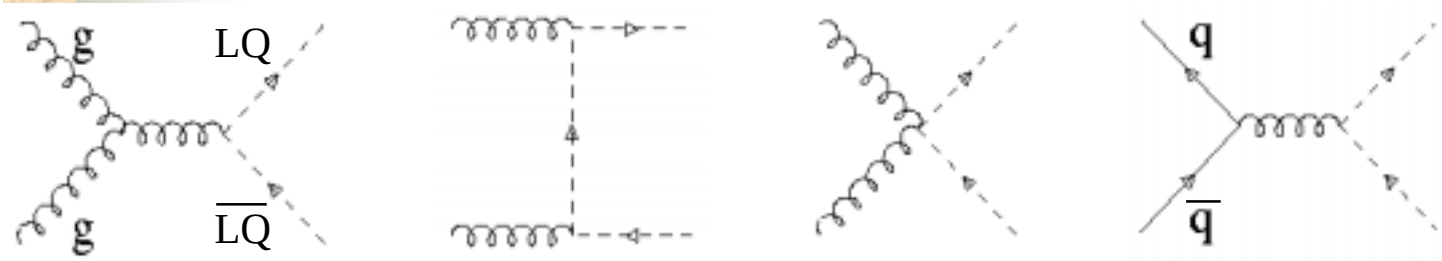
Outline

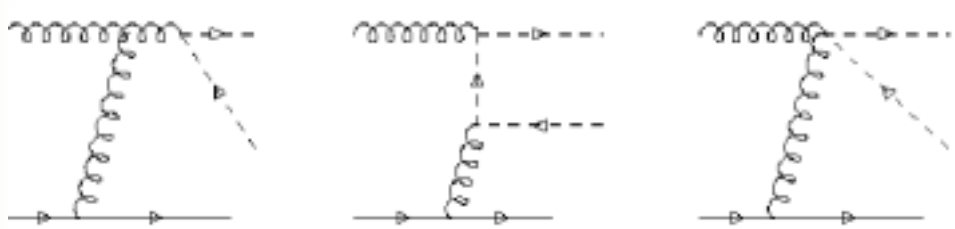
- Introduction to Leptoquarks
- DØ Detector
- Data Selection
- Background
- Signal
- Results

Introduction to Leptoquarks

- Leptoquarks are predicted in many SM extensions
  - Directly couple Leptons to Quarks
  - Carry color, fractional electric charge, lepton number and baryon number
  - Scalar (spin 0) or Vector (spin 1)
- LQ pair production at the Tevatron
  - Gluon fusion (dominant), quark anti-quark annihilation



  - Next-to-leading order sub-process



Introduction to LQ

- Leptoquark Decay
  - $LQ \rightarrow l^{\pm}q$ or νq

    $\beta \equiv$ Branching Ratio ($LQ \rightarrow l^{\pm}q$)
  - LQ has 3 generations, but no inter-generational decay
  - ➢ **1st generation LQ search in 2e2j channel with Run 2 data**
- Run 1 mass limits of 1st gen. LQ
  - DØ Run1 (Lum = 115 pb^{-1}) Phys. Rev., **D64**, 092004 (2001)

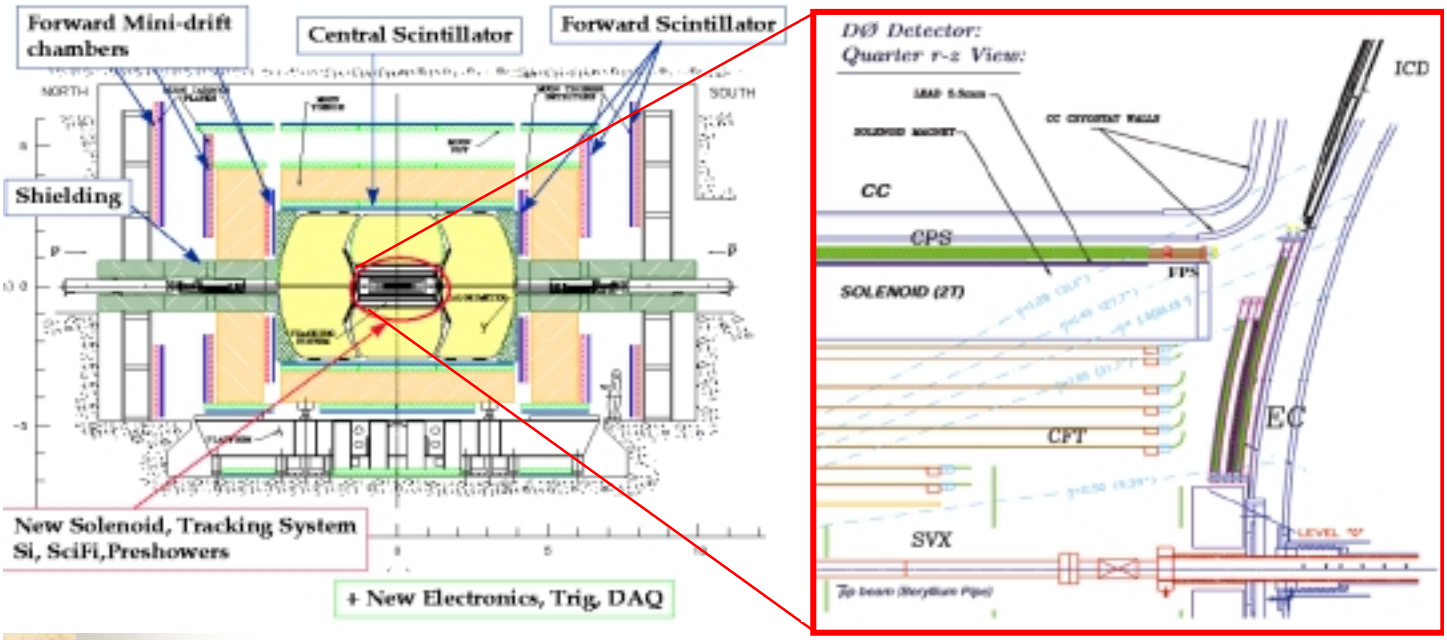
β = BR($LQ \rightarrow eq$)		**Scalar** Mass Limit GeV/c^2	**Vector Minimal Coupling** GeV/c^2	**Vector Yang-Mills Coupling** GeV/c^2
DØ	1	225	292	345
	0.5	204	282	337
	0	98	238	298

  - Run1 DØ / CDF combined result:

    β = 1, scalar LQ : 242 GeV hep-ex/9810015 (1998)

DØ Detector

- DØ experiment upgrade in Run 2
  - Tracking, Calorimeter electronics, Muon, etc.



Data Selection

- Data sample
  - †EM trigger sample (Sep 2002 – Jan 2003)
  - Integrated luminosity = 43 ± 4 pb^{-1}
- Event selection

Selection Criteria	*Events*
Pre-selection & Trigger selection	70873
2 EM objects (E_T > 25 GeV, in CC/EC, at least one EM has track match)	2093
2 or more jets (E_T > 20 GeV, $\|\eta\|$ < 2.5, ‡ΔR_{ej} > 0.5)	37
Z veto (M_{ee} < 75 GeV or M_{ee} > 105 GeV)	6

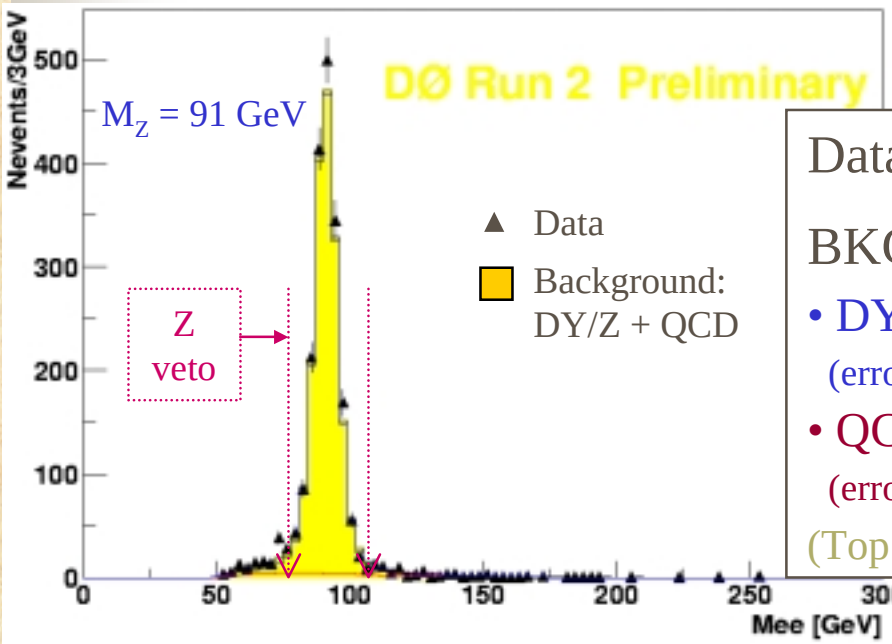
†EM – Electro-Magnetic

‡$\Delta R_{ej} = \sqrt{\Delta\eta_{ej}^2 + \Delta\phi_{ej}^2}$

Background

- Drell-Yan/Z background (dominant)
  - $Z/\gamma^* + jets \rightarrow e^+e^- + jets$
- QCD background
  - Multi-jet QCD, 2 jets fake EM objects
  - Fake rates are measured on data
- Top background
  - $t\bar{t} \rightarrow e^+e^- + jets$

2EM invariant mass
(no jet requirement)



Data : 2093 events

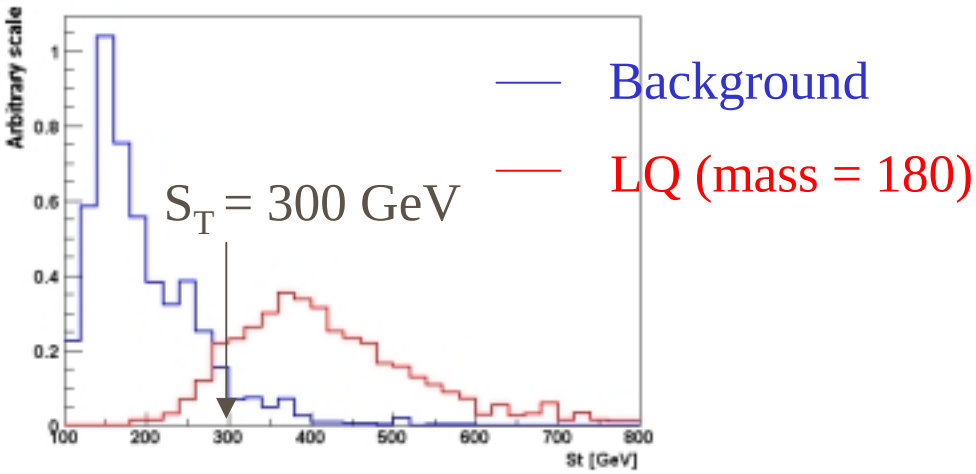
BKG : 1989 ± 172 events

- DY/Z : 1887 ± 170 events
  (error from EM ID efficiency)
- QCD : 102 ± 27 events
  (error from fake rate)

(Top background is negligible)

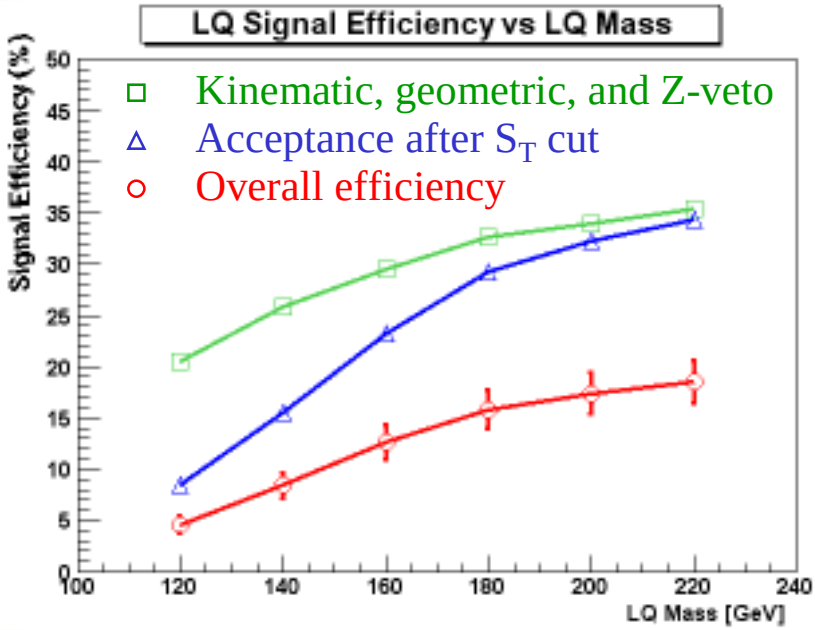
LQ Signal

- Additional cut $S_T \equiv \sum E_T$(of 2e2j)



  - Chose cut S_T > 300 GeV which optimizes sensitivity to LQ mass 160~200 GeV/c^2

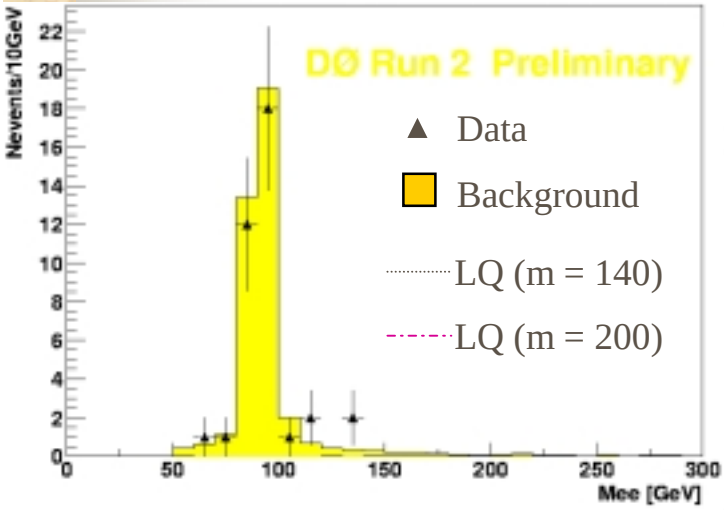
- Acceptance and overall efficiency



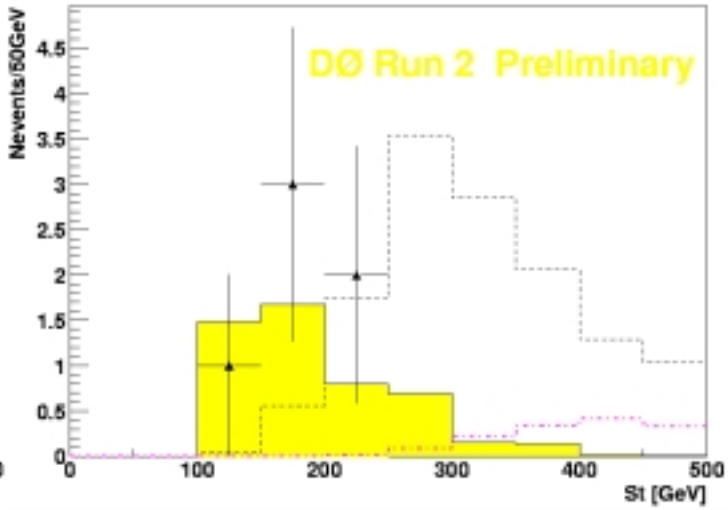
Results

- Compare data and background (bkg)

Mee – require 2e2j



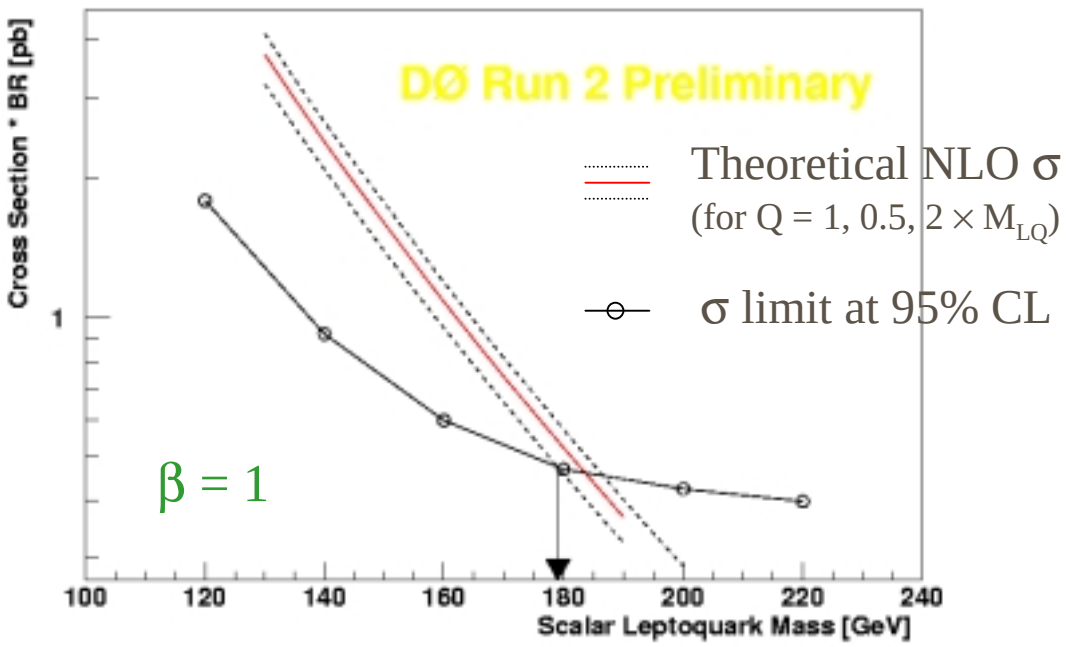
S_T – after Z-veto



	Require 2e2j	*After Z-veto*	*After S_T cut*
Data	**37**	**6**	**0**
Total BKG	**39 ± 10**	**5.0 ± 1.1**	**0.34 ± 0.06**
Drell-Yan	36 ± 10	3.1 ± 0.9	0.17 ± 0.05
QCD	2.9 ± 1.0	1.6 ± 0.6	0.09 ± 0.03
Top	0.51 ± 0.14	0.37 ± 0.10	0.08 ± 0.02
LQ (m = 140)		**14.4 ± 1.7**	**8.7 ± 1.0**
LQ (m = 200)		**2.09 ± 0.24**	**1.98 ± 0.22**

Results

- The data are consistent with SM bkg, and no evidence for LQ is observed.



- A lower mass limit of 179 GeV/c^2 can be set for Scalar Leptoquarks, assuming LQ decay BR β = 1.
  - For integrated luminosity 43 ± 4 pb^{-1}

Error Estimation (back-up)

- Signal uncertainties

Source of Uncertainty	*Uncertainty*
Particle ID efficiency	8.4 %
Jet Energy Scale (JES)	15.7 % – 6.9 % – 2.0 % (for M_{LQ} = 120 – 160 – 220 GeV)
PDF and Q^2	2.1 %
Gluon Radiation	7 %
MC Statistics	1.4 %
Total	**19.3 % – 13.2 % – 11.4 %** (for M_{LQ} = 120 – 160 – 220 GeV)

- Background uncertainties

Background	*Uncertainty*
Drell-Yan	**28 %** (JES and EMID eff.)
QCD	**36 %** (JES and fake rates)
Top	**28 %** (top cross section)

- Luminosity uncertainty: **10 %**