Search for Quark-Lepton Compositeness in the Dimuon Channel

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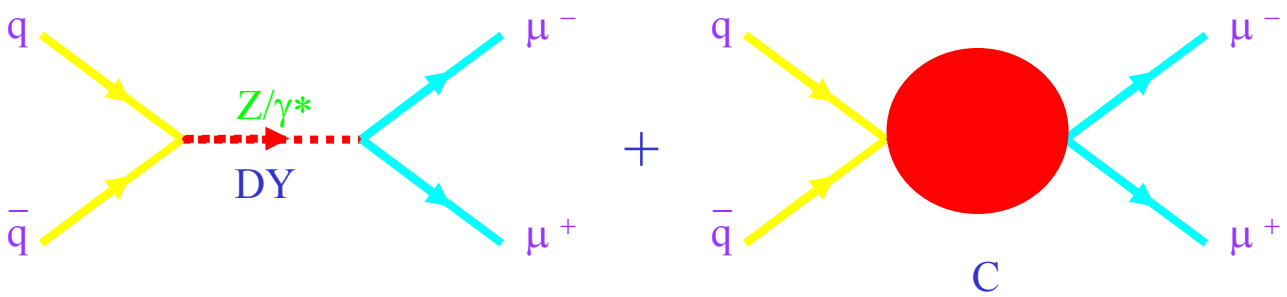
presented by Todd Adams

Introduction

- Are quarks and leptons elementary particles?
  - *Standard Model doesn't say*
- Even if scale is too small, scattering will act as a contact interaction
  - *can be observed (in $p\bar{p}$ collisions) in dilepton production*



Scattering Cross-Section

$$\frac{d^2\sigma^{\Lambda}}{dm\ d\cos\theta^*} = \frac{d^2\sigma}{dm\ d\cos\theta^*}(DY) + \beta_C I + \beta_C{}^2 C$$

Contact term

Interference term

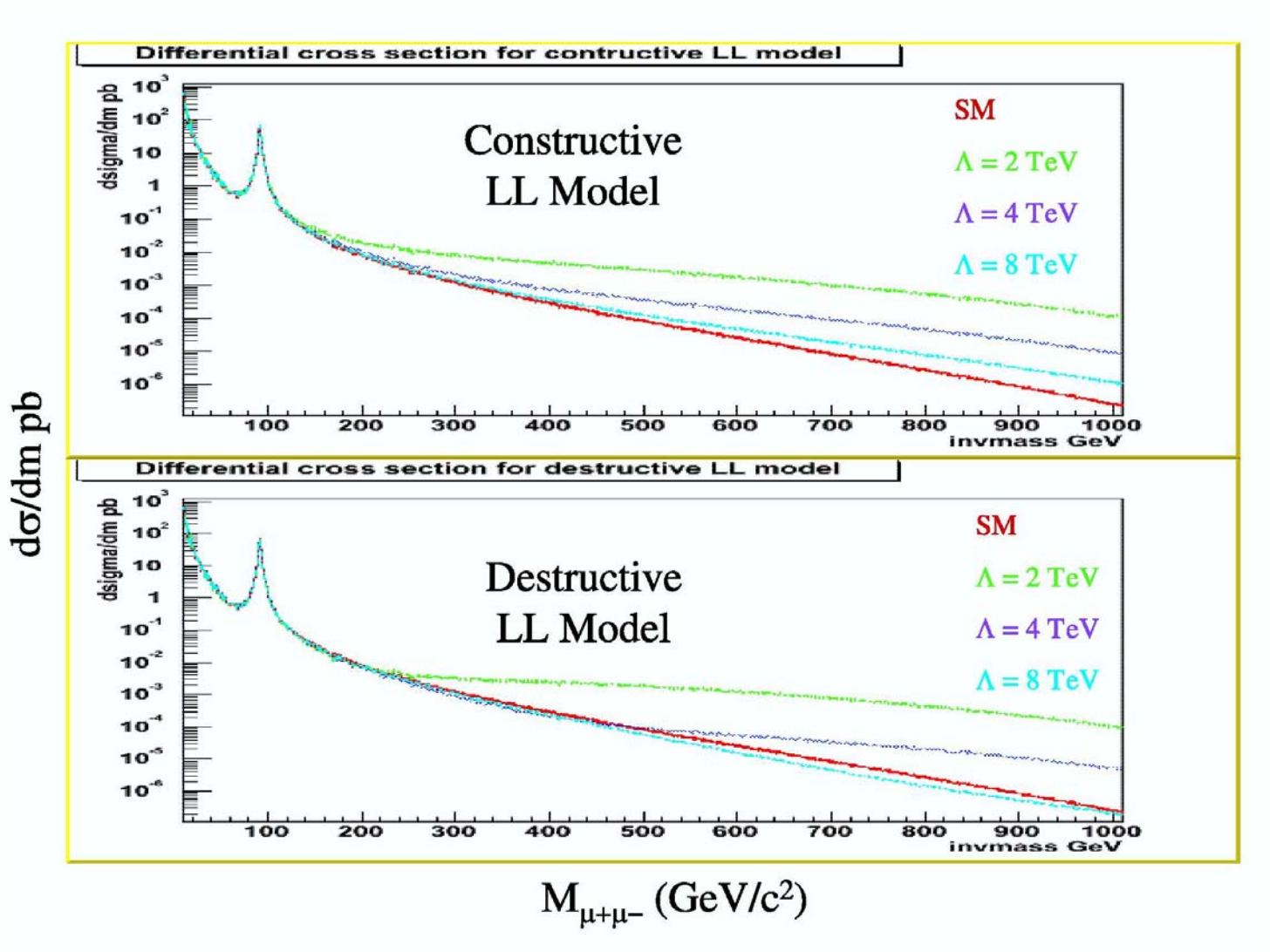
$\beta_C = 1/\Lambda^2$ Λ = compositeness scale

m = dimuon mass

cos(θ*) = cosine of scattering angle in the dimuon helicity frame

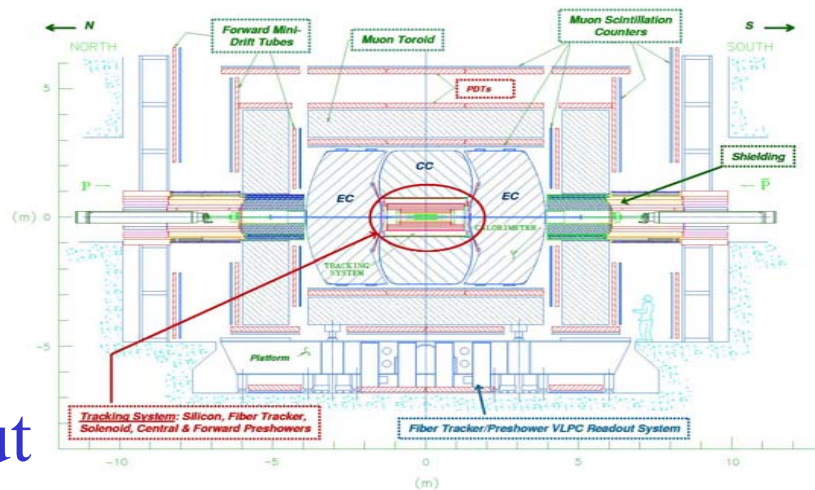
$$L_{ql} = \frac{g_0^2}{\Lambda^2}\{\eta_{LL}(\bar{q}_L\gamma^\mu q_L)(\bar{\mu}_L\gamma_\mu\mu_L) + \eta_{LR}(\bar{q}_L\gamma^\mu q_L)(\bar{\mu}_R\gamma_\mu\mu_R)$$
$$+ \eta_{RL}(\bar{u}_R\gamma_\mu u_R)(\bar{\mu}_L\gamma^\mu\mu_L) + \eta_{RL}(\bar{d}_R\gamma_\mu d_R)(\bar{\mu}_L\gamma^\mu\mu_L)$$
$$+ \eta_{RR}(\bar{u}_R\gamma^\mu u_R)(\bar{\mu}_R\gamma_\mu\mu_R) + \eta_{RR}(\bar{d}_R\gamma^\mu d_R)(\bar{\mu}_R\gamma_\mu\mu_R)\}$$

Compositeness Signal

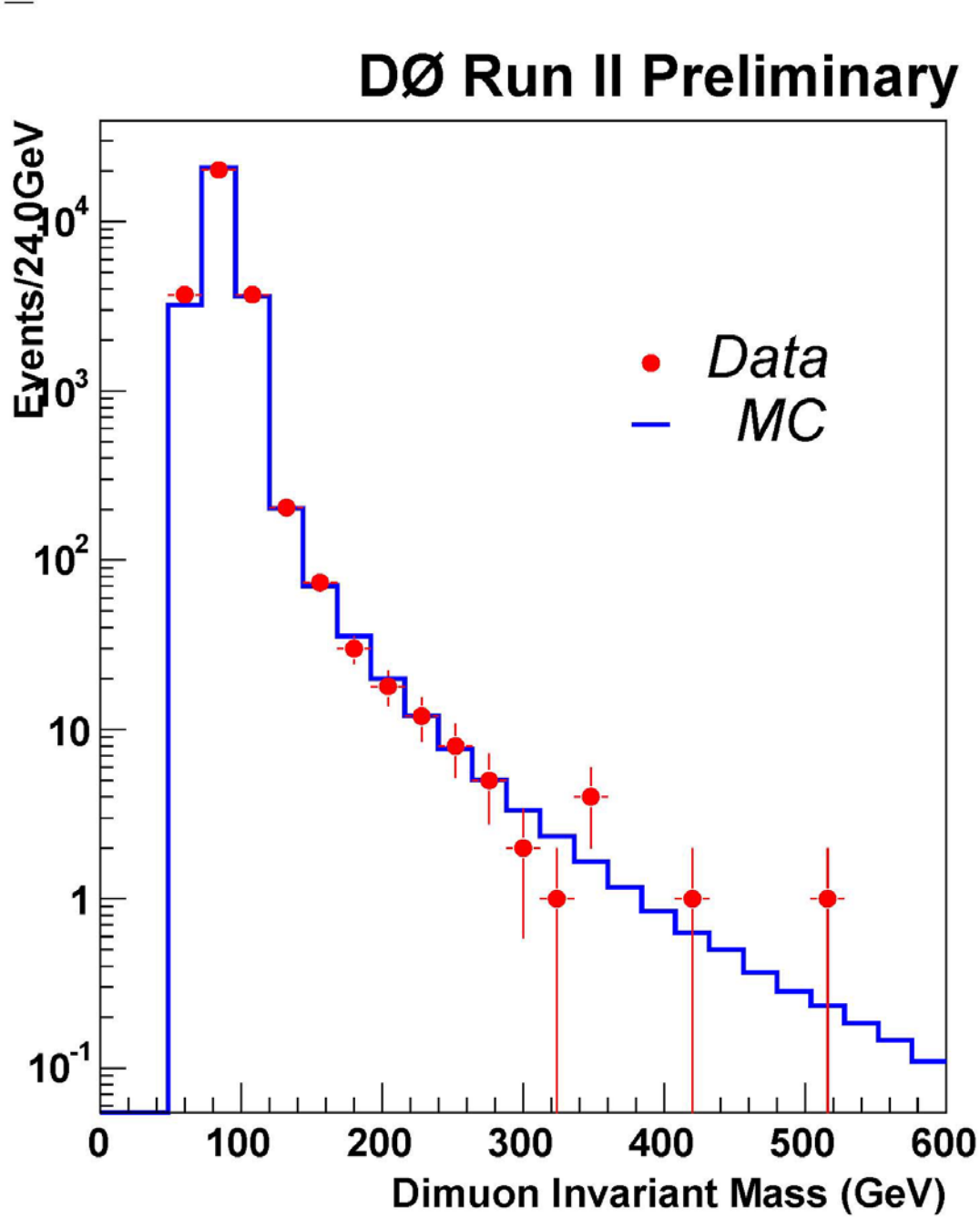


Event Selection

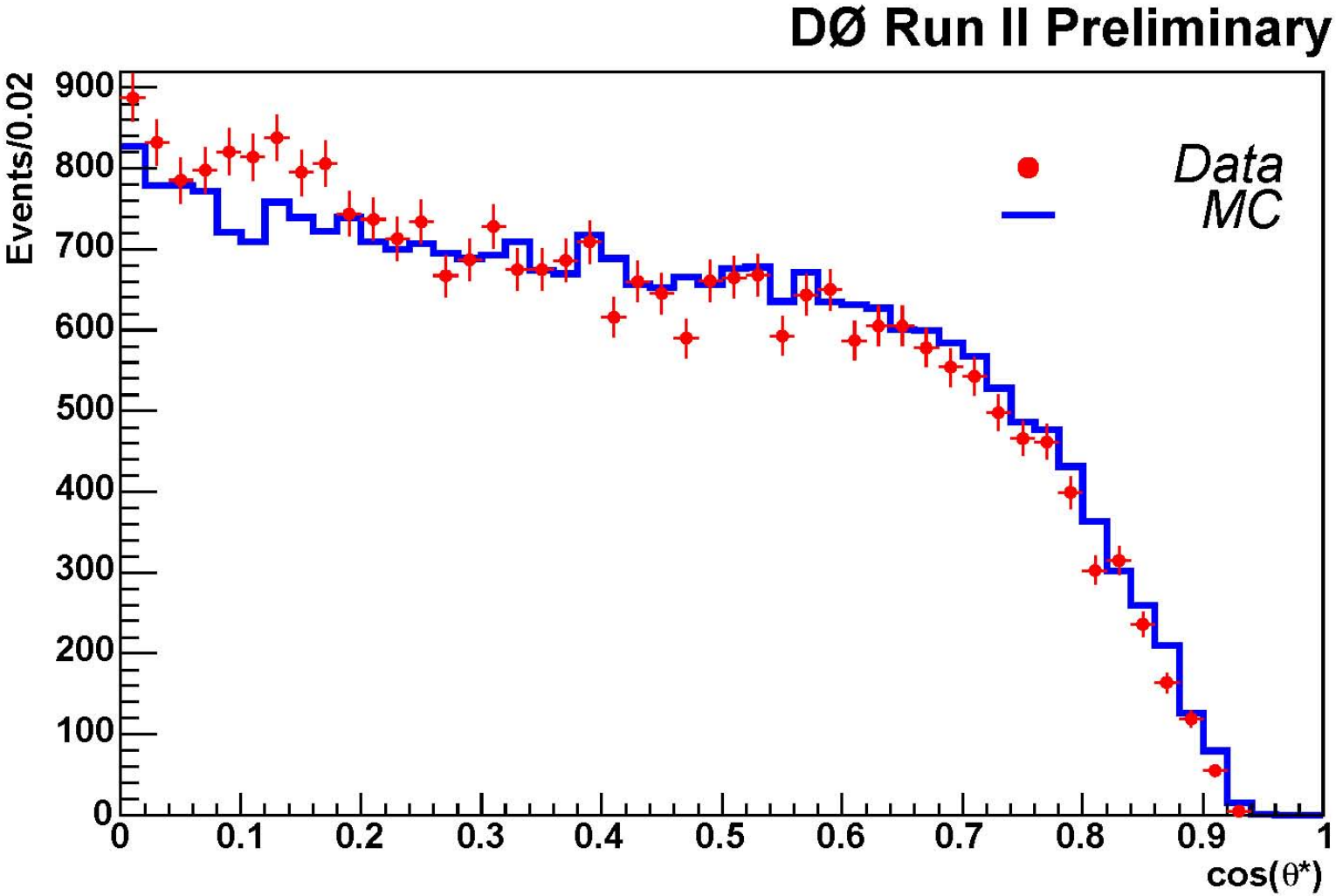
- Data recorded August 2002 to August 2004
  - 400 pb^{-1} integrated luminosity
- Require at least one single or dimuon trigger to fire
- At least two muons with matched central track and $p_T > 15$ GeV
- $|\eta| < 2.0$
- Isolated muons
  - calorimeter and track p_T
- Cosmic ray rejection
- Invariant mass > 50 GeV cut



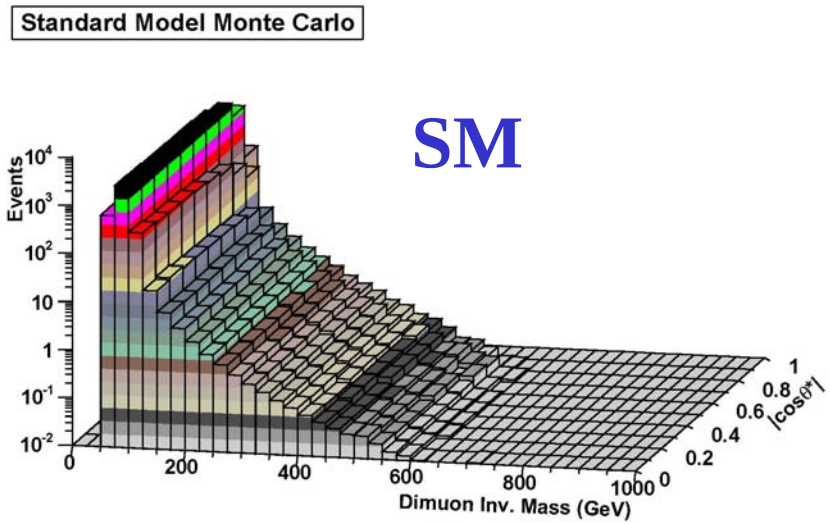
Dimuon Invariant Mass

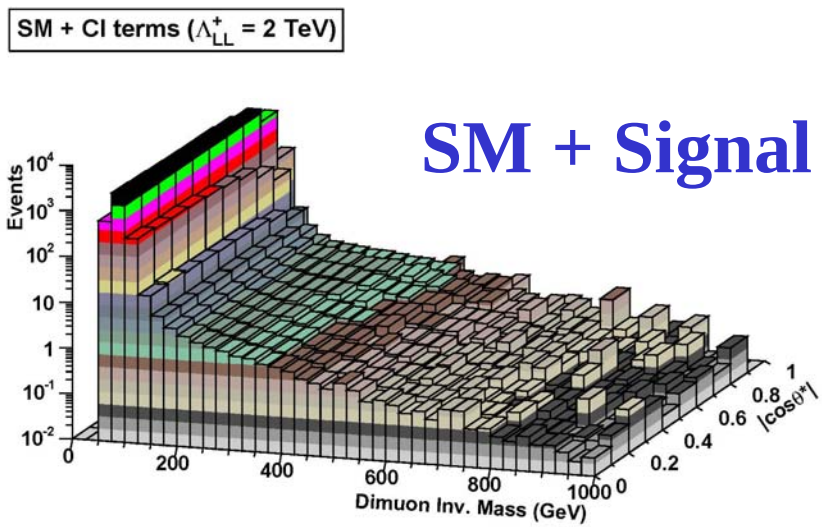


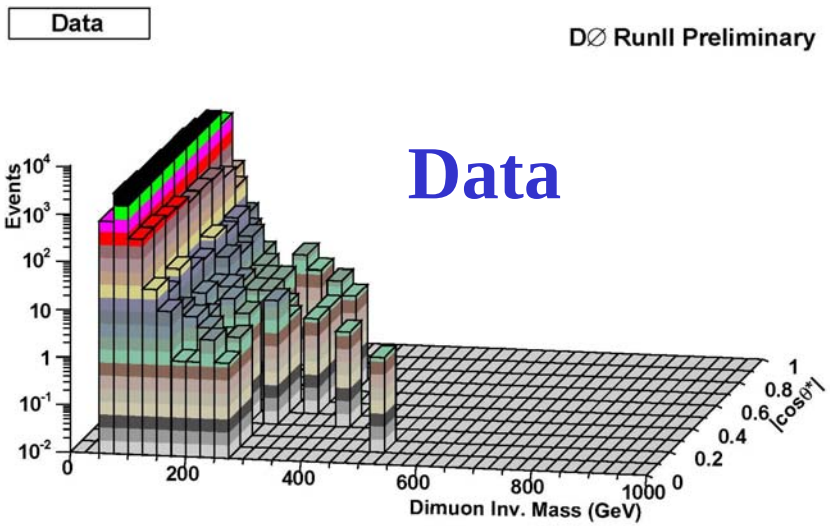
cos(θ*) Distribution



Mass vs. cos(θ*)







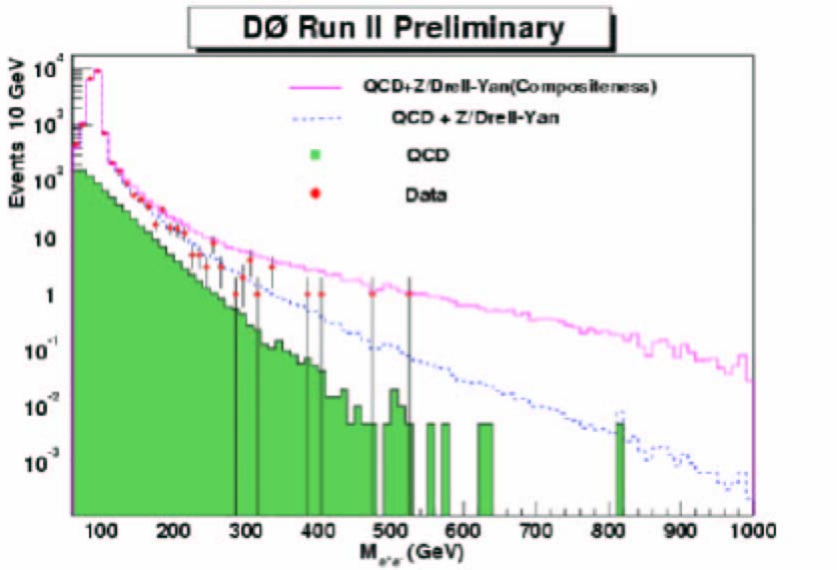
- Two dimensional fit in invariant mass vs cos(θ*)
- Determine best β_C value
  - Measure cross-section contribution or limit
- No obvious signal

Data vs expected background as a function of invariant mass

Minimum $M_{\mu\mu}$ (GeV)	Expected background	Data
120	366.2	361
150	140.7	119
180	72.5	59
210	41.4	37
240	25.2	22
270	16.2	13
300	10.8	7
330	7.4	7
360	5.2	2
390	3.8	2
420	2.9	1
450	2.2	1
480	1.7	1
510	1.4	1
540	1.1	0

Compositeness in Dielectrons

- A similar search has been done in di-electrons using D0 Run II data with 271 pb^{-1}.



M_{ee} (GeV)	Expected background	Data
120-160	350 ± 29	343
160-200	107 ± 9	99
200-240	40.8 ± 3.3	36
240-290	20.1 ± 1.5	15
290-340	8.3 ± 0.8	10
340-400	4.3 ± 0.3	1
400-500	2.2 ± 0.2	2
500-600	0.69 ± 0.05	1
600-1000	0.31 ± 0.02	0

- No evidence for compositeness was found

Limits

- Run II 95% CL lower limit in dielectron channel (271 pb^{-1})

	LL	LR	RL	RR	LL+RR	LR+RL	LL-LR	RL-RR	VV	AA
Λ^{+}(TeV)	3.6	4.5	3.8	4.3	4.1	5.0	4.8	4.7	4.9	5.7
Λ^{-}(TeV)	6.2	4.8	5.8	5.0	7.9	6.0	6.4	6.8	9.1	7.8

- DØ Run II Preliminary 95% CL in dimuon channel (400 pb^{-1})

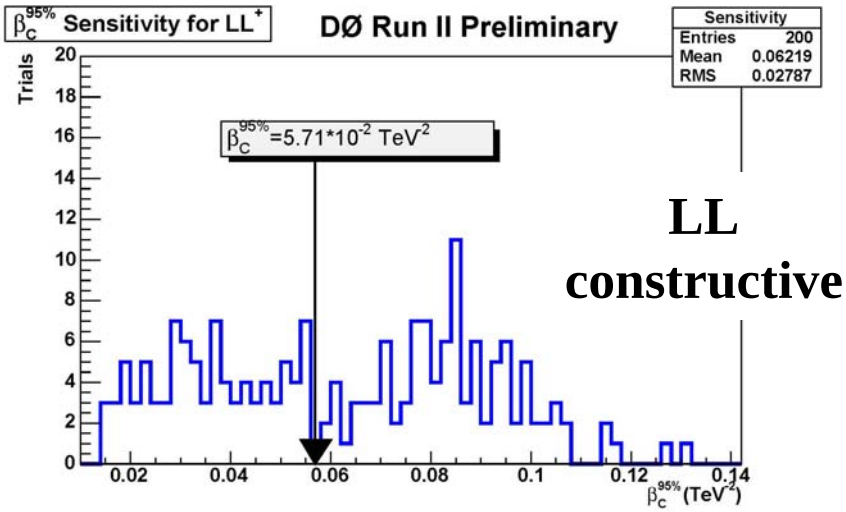
	LL	LR	RL	RR	LL+RR	LR+RL	LL-LR	RL-RR	VV	AA
Λ^{+}(TeV)	4.19	5.32	5.31	4.15	5.05	6.45	4.87	5.07	6.88	5.48
Λ^{-}(TeV)	6.98	5.10	5.17	6.74	9.05	6.12	7.74	7.41	9.81	9.76

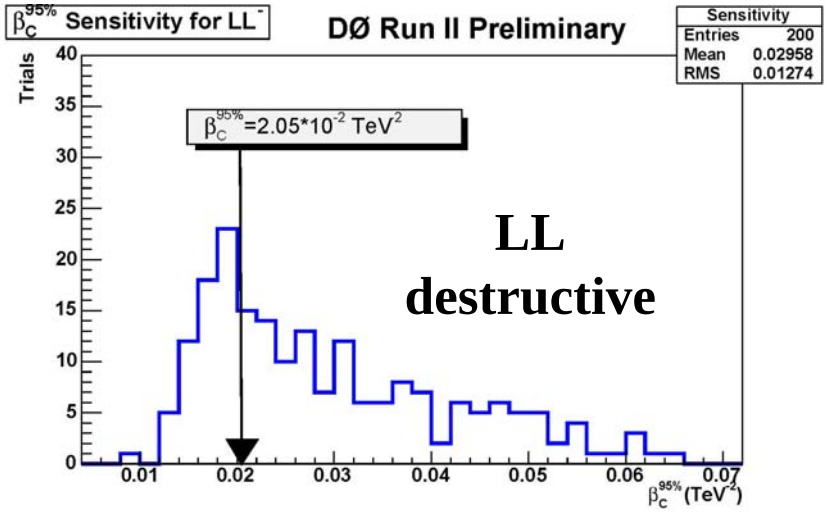
Summary

- First study of quark compositeness through dimuon channel at DØ.
- First study of quark compositeness in 2-dimensions: mass vs. cos(θ*)
- Good agreement between Standard Model and data
- No evidence for quark-lepton compositeness is found.
- Set 95% CL limits of Λ (characteristic energy scale) for different constructive and destructive chirality channels

MC Trials

- Test limit sensitivity
  - 200 trials with Poisson statistical variations





  - result is consistent with sensitivity test