# Recent results on New Phenomena from D0

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# Topics covered in this talk

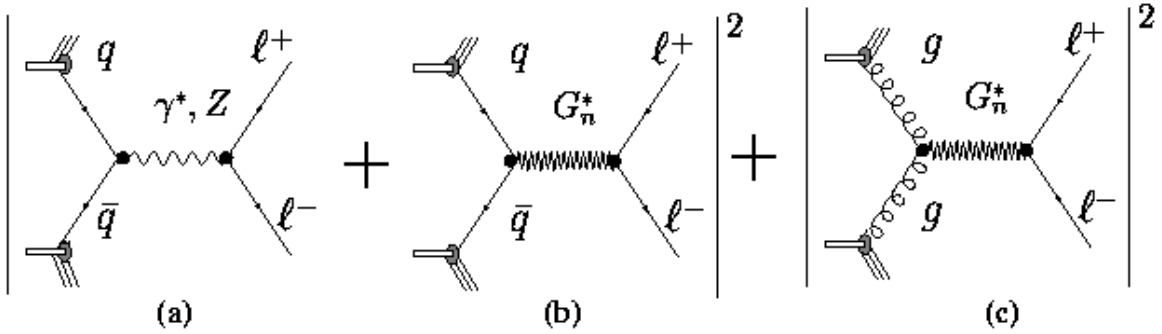
- Data taken between January and June 2002.
- Proton-antiproton collisions at a center of mass energy of 1.96 TeV.
- Total luminosity ~ 10 $pb^{-1}$

- Topics covered :

  - The search for large extra-dimensions : di-e/γ and di-μ
  - SUSY search with R-Parity Violation : di-electrons + jets
  - SUSY search with R-Parity conservation : tri-leptons, jets and Missing $E_T$
  - Gauge-Mediated SUSY breaking
  - Leptoquarks

# Search for Large Extra-Dimensions

Look for effect of virtual graviton exchange in the fermion/boson pair production




- Studies in the di-EM (e/γ) and di-μ channels
- The two variables :
  - invariant mass
  - cos θ* (where θ* is the scattering angle in the rest frame)

  yield optimum sensitivity to the contributions from extra-dimensions.

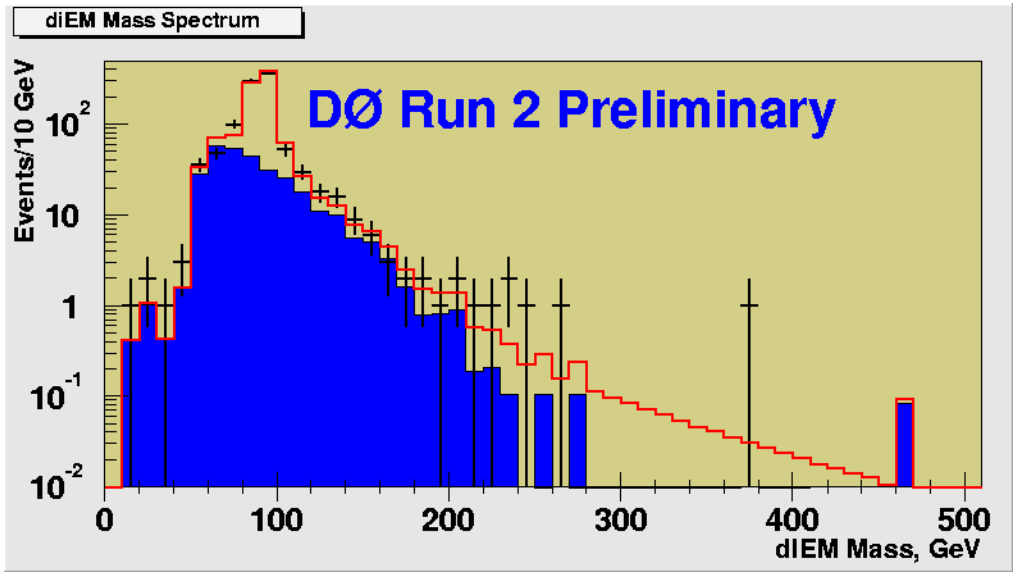
# E-D in the ee/γγ channel

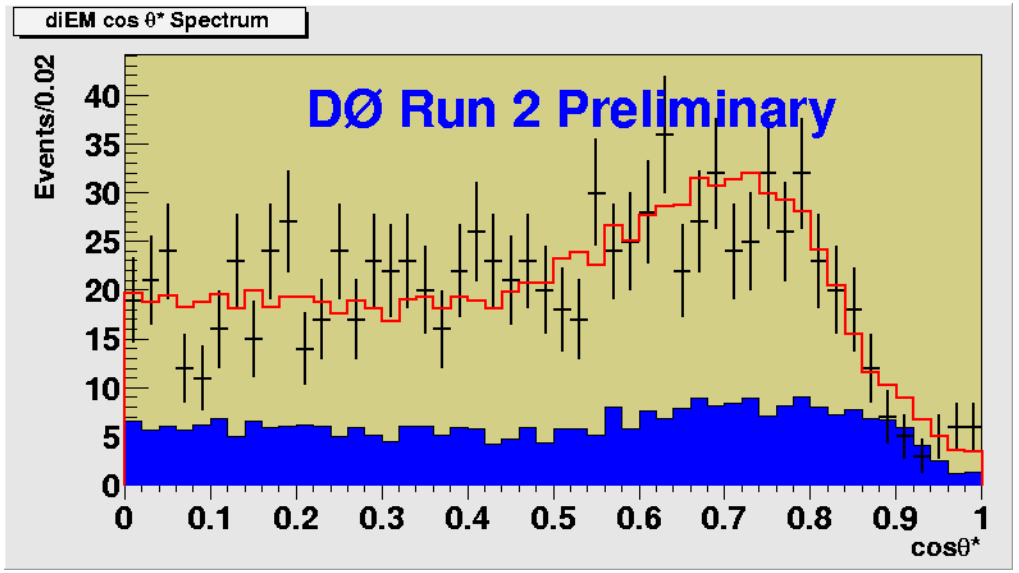
- Event selection :
  - Exactly two e/γ objects with $p_T > 25$ GeV
  - Missing $E_T < 30$ GeV
- Backgrounds :
  - Drell-Yan
  - Direct γγ production
  - EM mis-identifications

data

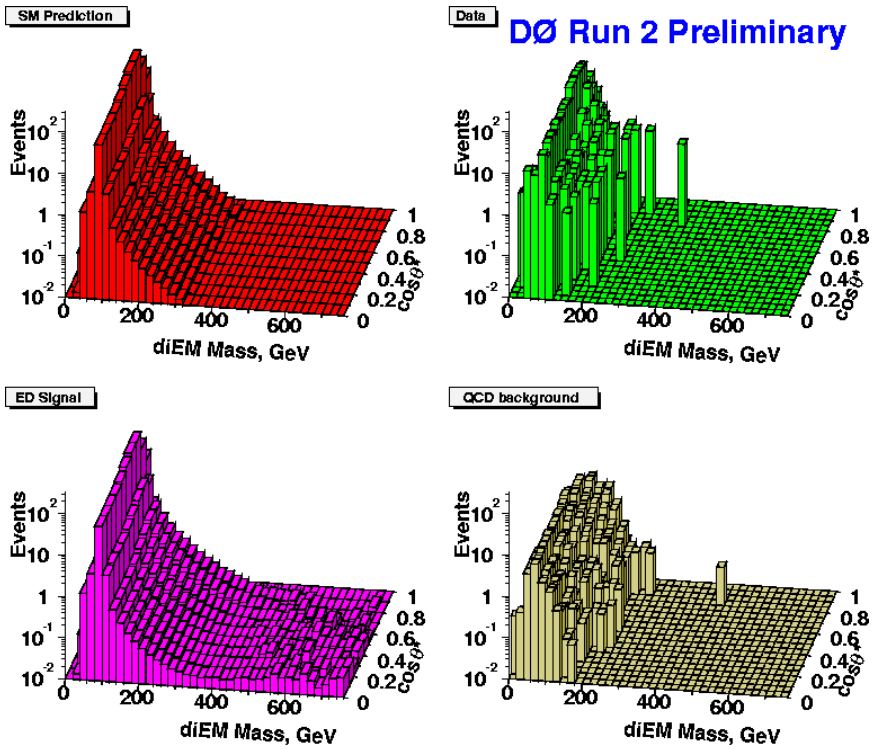
instrumental background

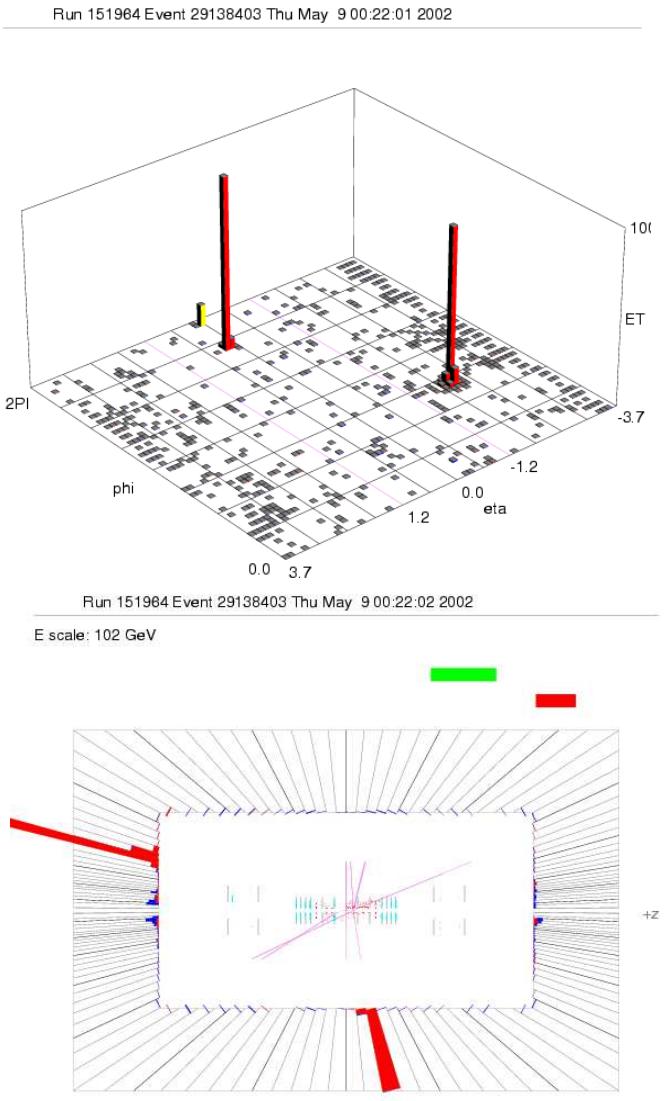
instrumental + SM background



# E-D in the ee/γγ channel




Run 2 preliminary limit with 10 $pb^{-1}$:

$M_s(GRW) > 0.92$ TeV

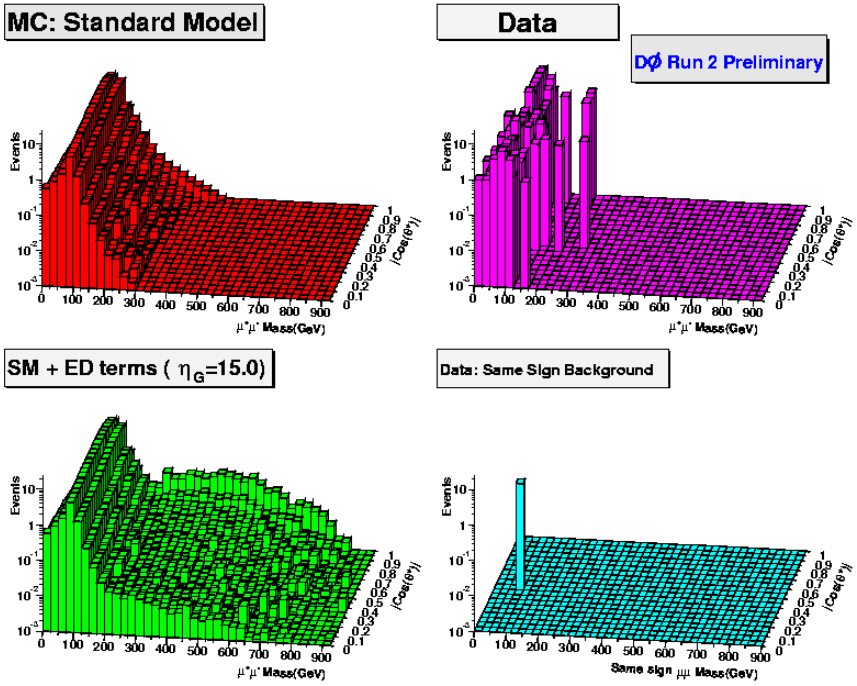
(where $M_s$ is the fundamental Planck scale)

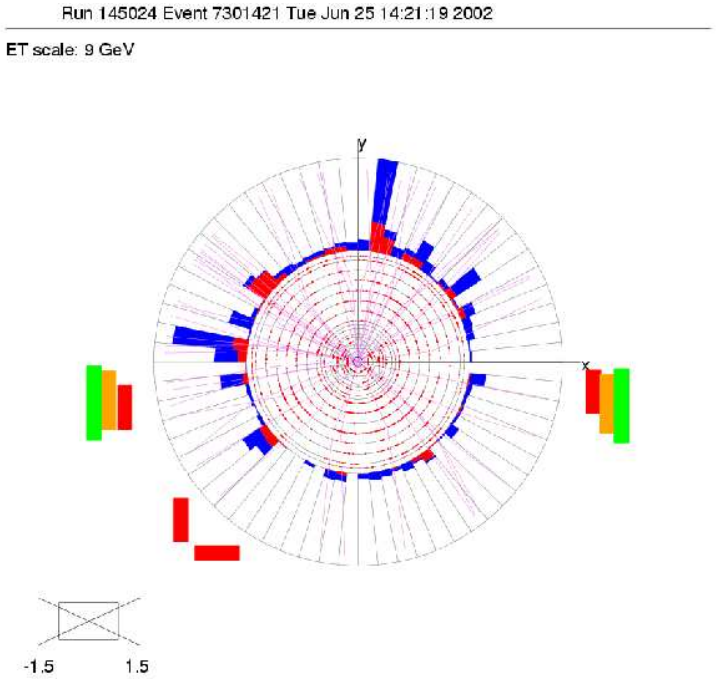
Run I with 127$pb^{-1}$ : 1.2 TeV

mass = 377 GeV  $\cos\theta^* = 0.77$

# E-D in the μμ channel

Two muons with pT > 15 GeV




Run 2 preliminary limit (with 4.5 $pb^{-1}$):

$M_s$(GRW) > 0.50 TeV

(first limit at hadron collider in this channel)

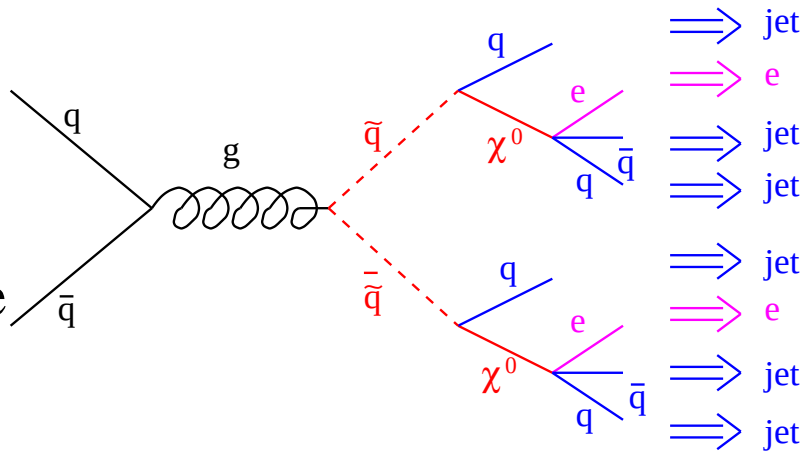
mass = 290 GeV  cos $\theta^*$ = 0.48

# RPV-SUSY search in the di-electron+jets channel

- RPV : the LSP decays.
- Here the $\lambda'_{1jk}$ coupling is considered

  The Neutralino is a Majorana particle

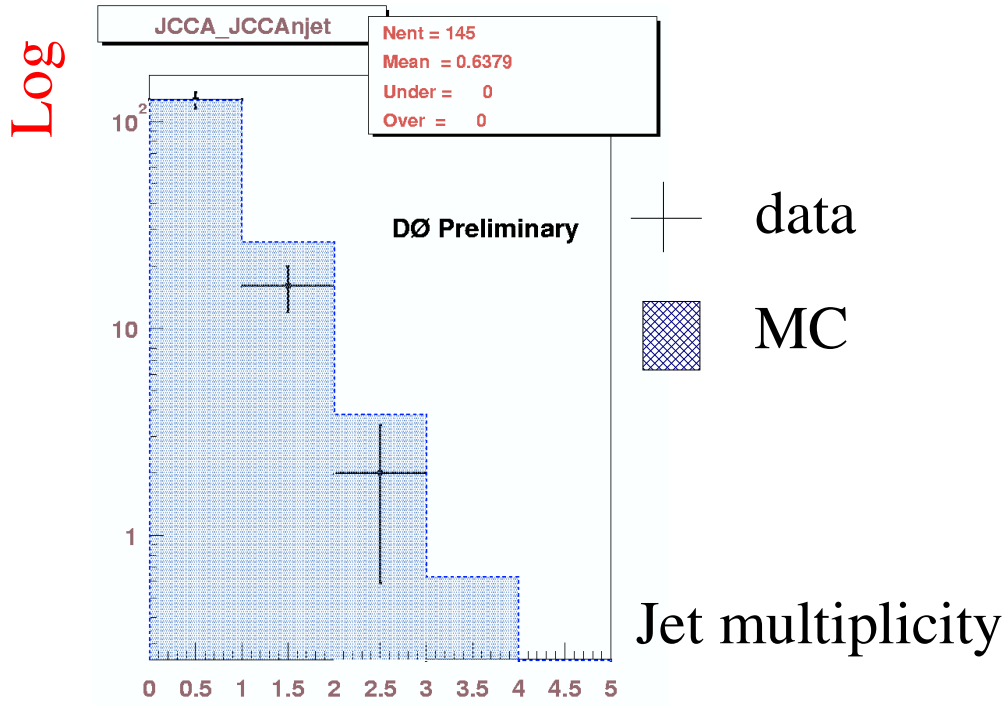
  → Like sign leptons pairs can be produced




- Data sample : 10 $pb^{-1}$

- Event selection
  - Electrons :

    $p_T$ > 15 GeV and 10 GeV
  - One central electron | η | < 0.8
  - Δ R (e-e) and Δ R(e-jet ) > 0.7
  - Jets : $p_T$ > 20 GeV | η | < 2.6

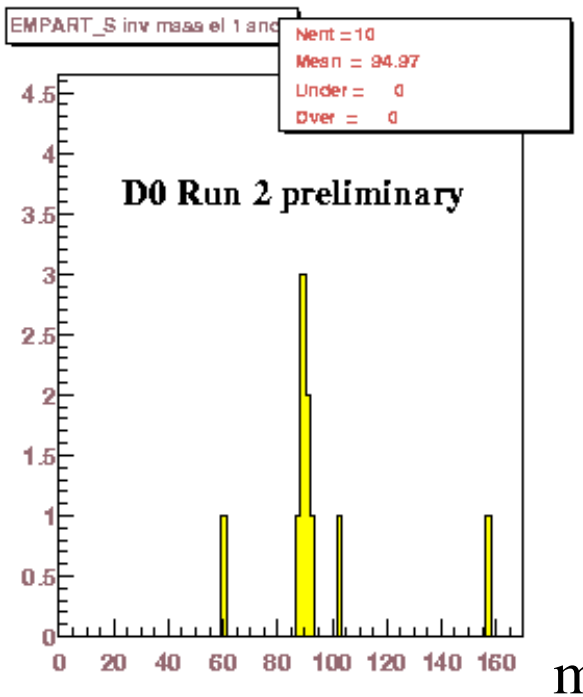



Opposite and Like sign

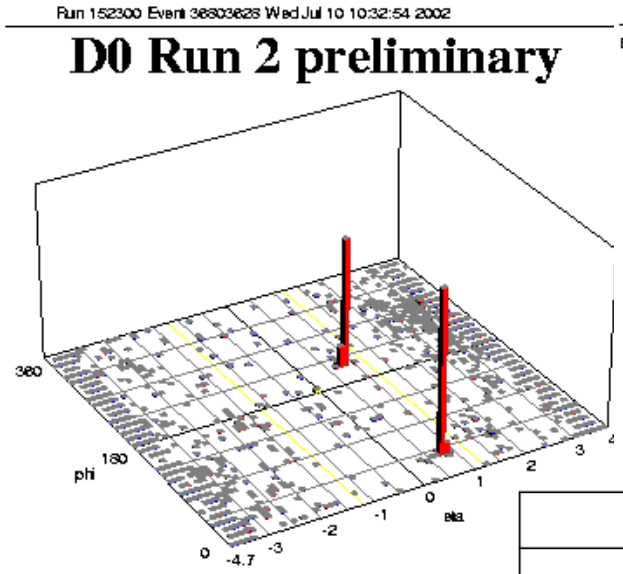
# Di-electron+jets channel

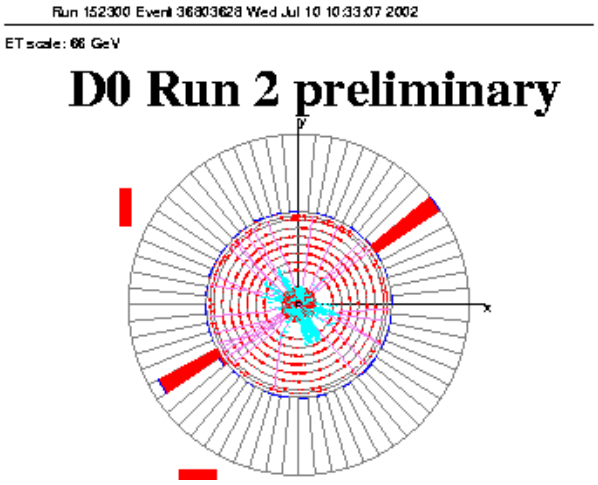
- Backgrounds
  - Standard Model
  - EM fakes
  - Wrong charge assignment

| D0 Preliminary | | | | | | |
|---|---|---|---|---|---|---|
| like sign | total | 0 jet | 1 jet | 2 jet | 3 jet | $\geq$ 4 jet |
| DATA | 10 | 8 | 1 | 1 | 0 | 0 |
| SM Monte-Carlo | 0.17 $\pm$ 0.16 | 0.16 $\pm$ 0.15 | 0.005 | 0.005 | 0.6 0 | 0 |
| Wrong charge assigt | 12.8 $\pm$ 3.4 | 10.3 $\pm$ 3.2 | 2.1 $\pm$ 1.2 | 0.3 $\pm$ 0.2 | 0.1 $\pm$ 0.1 | 0.05 $\pm$ 0.04 |
| Total background | 13.0 $\pm$ 3.4 | 10.5 $\pm$ 3.2 | 2.1 $\pm$ 1.2 | 0.3 $\pm$ 0.2 | 0.1 $\pm$ 0.1 | 0.05 $\pm$ 0.04 |




mass



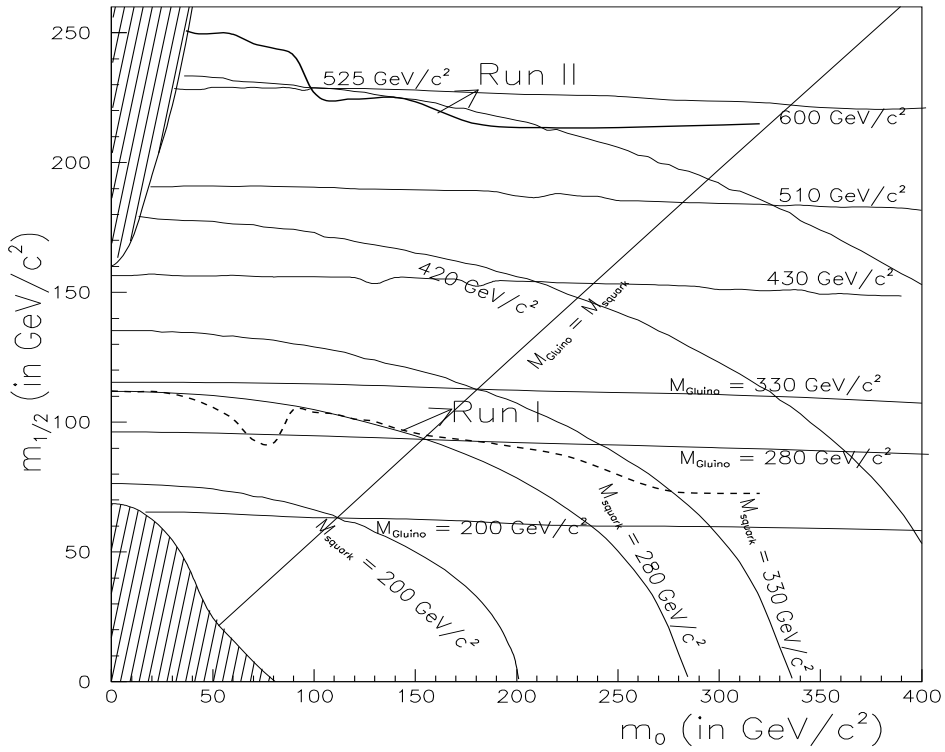

| D0 Preliminary | | |
|---|---|---|
| $e_1$ | $e_2$ | $0jet$ |
| $p_T$(cal) = 83.8 | $p_T$(cal) = 74.2 | |
| $\eta$ = 0.57 | $\eta$ = 0.60 | $M_{ee}$ = 157.5 GeV |
| $\varphi$ = 0.65 | $\varphi$ = 3.71 | $ME_T$ = 3.6 GeV |
| charge = -1 | charge = -1 | |

5 ++ and 5 -- candidates

# Di-electron+jets channel : prospects

D0 in Run I with 100 $pb^{-1}$
$m_{squark} < 250$ GeV excluded

Expected contour for D0 Run 2:
With 2 $fb^{-1}$
$m_{squark} < 500$ GeV can be excluded




$m_0$ common scalar mass at GUT scale
$m_{1/2}$ common gaugino mass at GUT scale
$A_0$ common trilinear coupling at GUT scale
$\tan\beta$ Higgs vev's ratio
sign of $\mu$ higgsino mass parameter

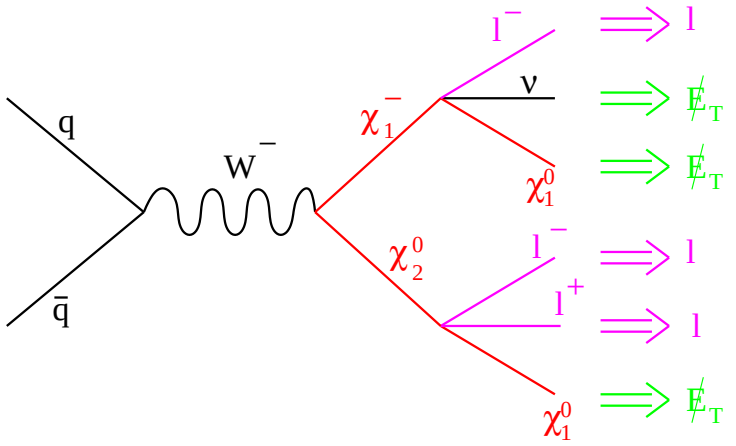
$\tan\beta = 2$
$A_0 = 0$
$\mu < 0$

# SUSY search in the tri-lepton channel

- *lll* (*l*=$e^{\pm}$ or = $\mu^{\pm}$)
  golden channel for SUSY
  discovery at the TeVatron

- eee and ee$\mu$ studied here.

Chargino-neutralino production

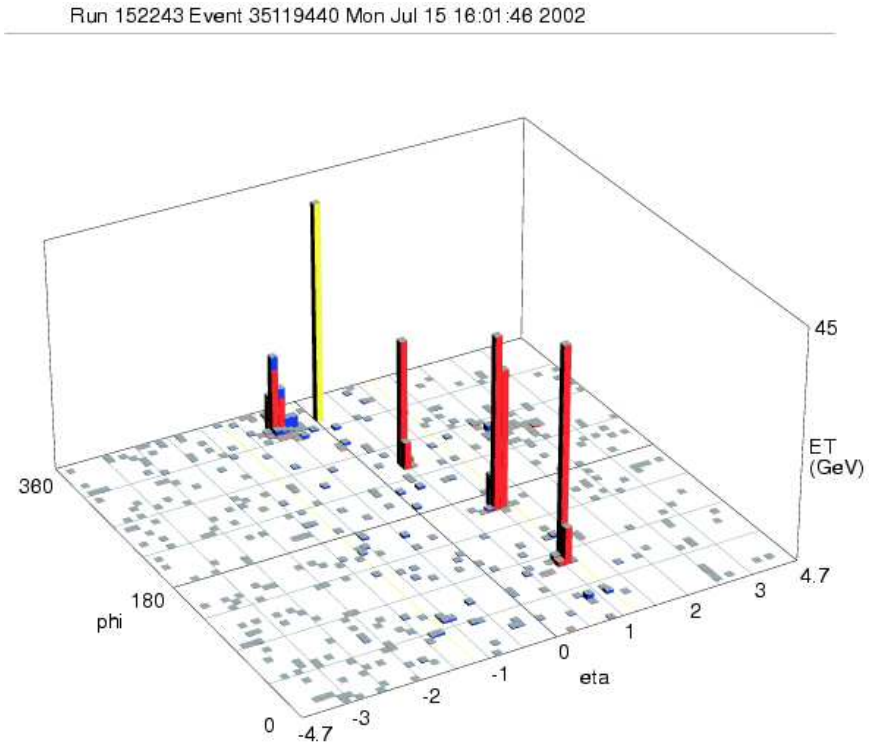


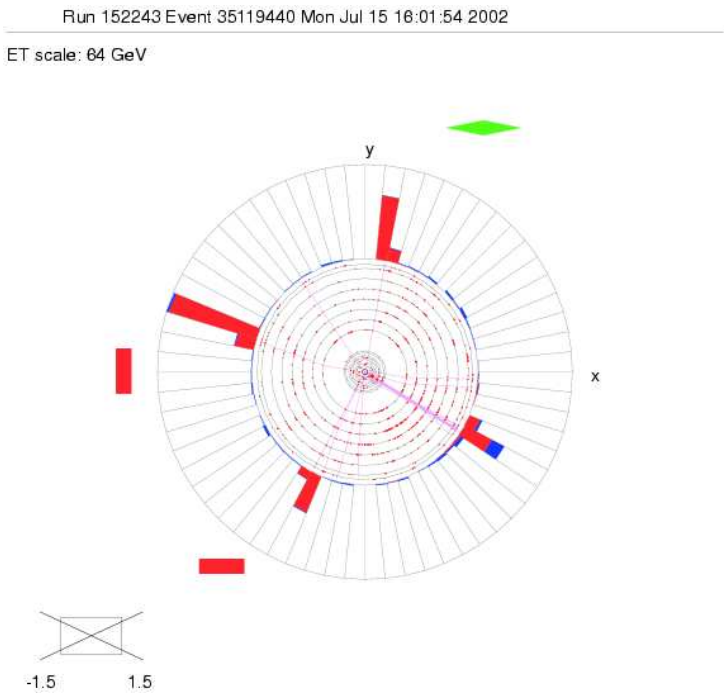

- Event selection:
  - Three leptons
  - Two electrons with $p_T$ > 30 GeV, 15 GeV
  - $\Delta R > 0.7$ between any pair of leptons
  - $\Delta R$ (muon-any jet) > 0.7, if any

| Event categories | *eee* | *ee$\mu$* |
|---|---|---|
| $\mathcal{L}_{\rm int}$, $\rm pb^{-1}$ | $5.2 \pm 0.8$ | $4.6 \pm 0.7$ |
| Observed events | 2 | 1 |
| Background events | $1.9 \pm 0.4$ | $0.9 \pm 0.2$ |

- Backgrounds
  - $\gamma^*/Z \rightarrow$ ee (+ radiated $\gamma$ / cosmic muon)
  - fake e in ee jets / e$\mu$ jets

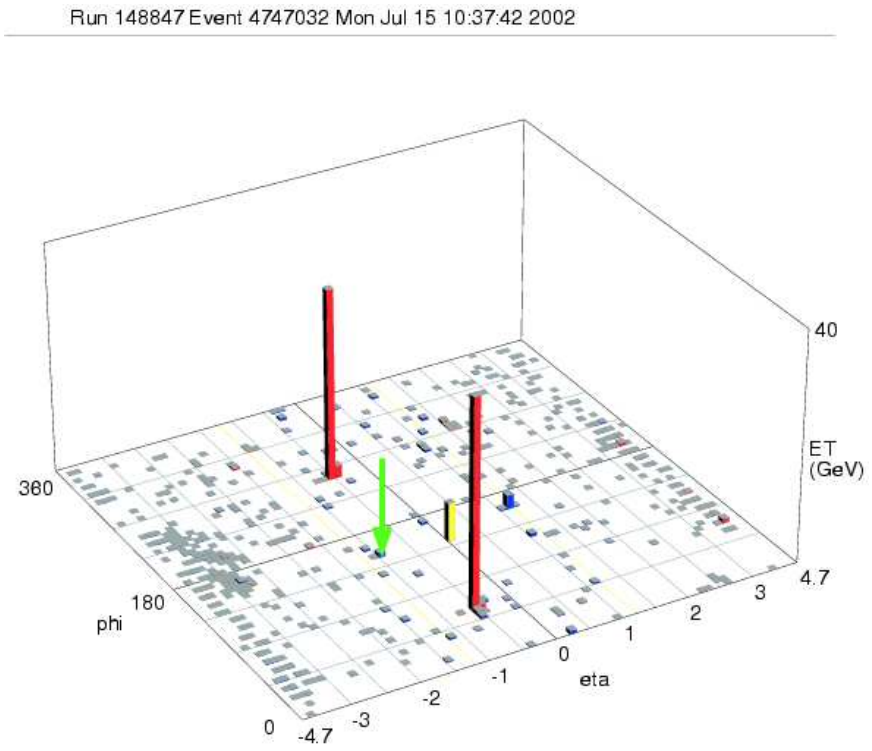
# Tri-leptons : eee candidate

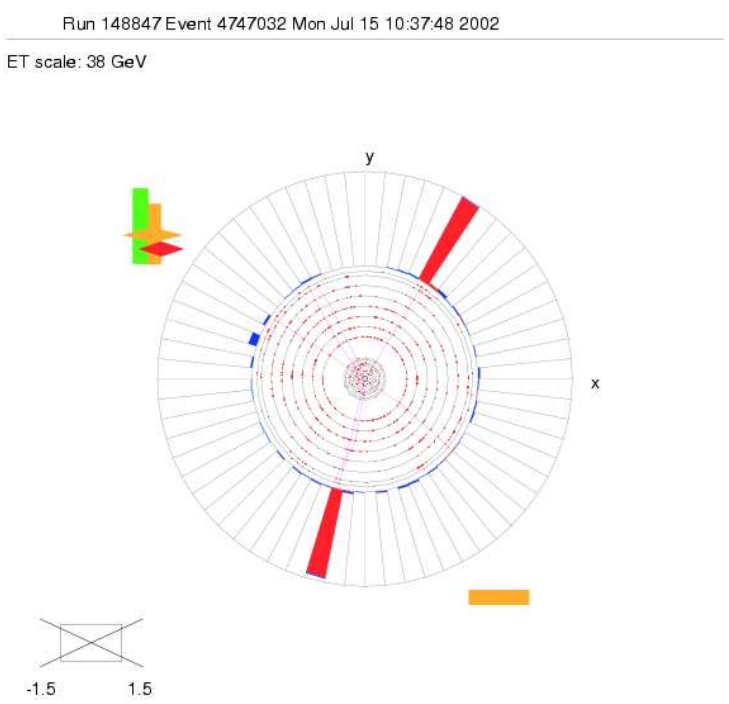



| $e_1$ | $e_2$ | $e_3$ |
|---|---|---|
| $p_T$(cal) = 76.0 GeV/c | $p_T$(cal) = 56.0 GeV/c | $p_T$(cal) = 33.4 GeV/c |
| $\eta = 1.12$ | $\eta = 1.15$ | $\eta = 0.65$ |
| $\varphi = 2.8$ | $\varphi = 1.4$ | $\varphi = 4.2$ |
| no track match | charge = -1 | charge = -1 |
| $m_{e_1e_2} = 86.6$ GeV/c$^2$ | $m_{e_1e_3} = 68.9$ GeV/c$^2$ | $m_{e_2e_3} = 88.3$ GeV/c$^2$ |
| $m_{e_1e_2e_3} = 142$ GeV/c$^2$ | | $\mathrm{ME_T} = 10.2$ GeV |

# Tri-leptons : eeμ candidate



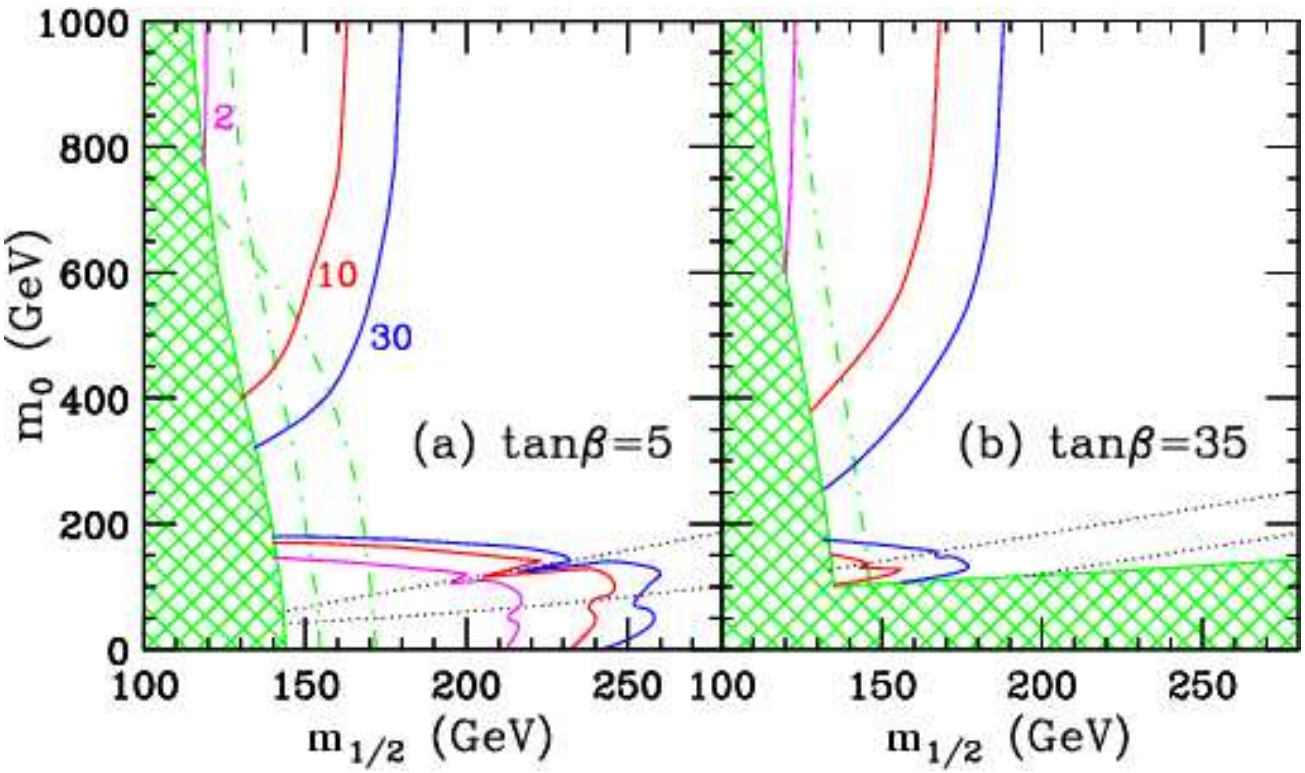




| $e_1$ | $e_2$ | $\mu$ |
|---|---|---|
| $p_T$(cal) = 46.5 GeV/c | $p_T$(cal) = 43.5 GeV/c | $p_T$ = 12.9 GeV/c |
| $\eta = -0.36$ | $\eta = -0.33$ | $\eta = -0.92$ |
| $\varphi = 1.02$ | $\varphi = 4.47$ | $\varphi = 2.59$ |
| no track match | no track match | charge = -1 |
| $m_{e_1e_2} = 88.9$ GeV/c$^2$ | | $\mathrm{ME_T} = 11.9$ GeV |

# Tri-leptons : prospects

TeVatron reach in the trilepton channel for for 2, 10 and 30 $fb^{-1}$ integrated luminosity.

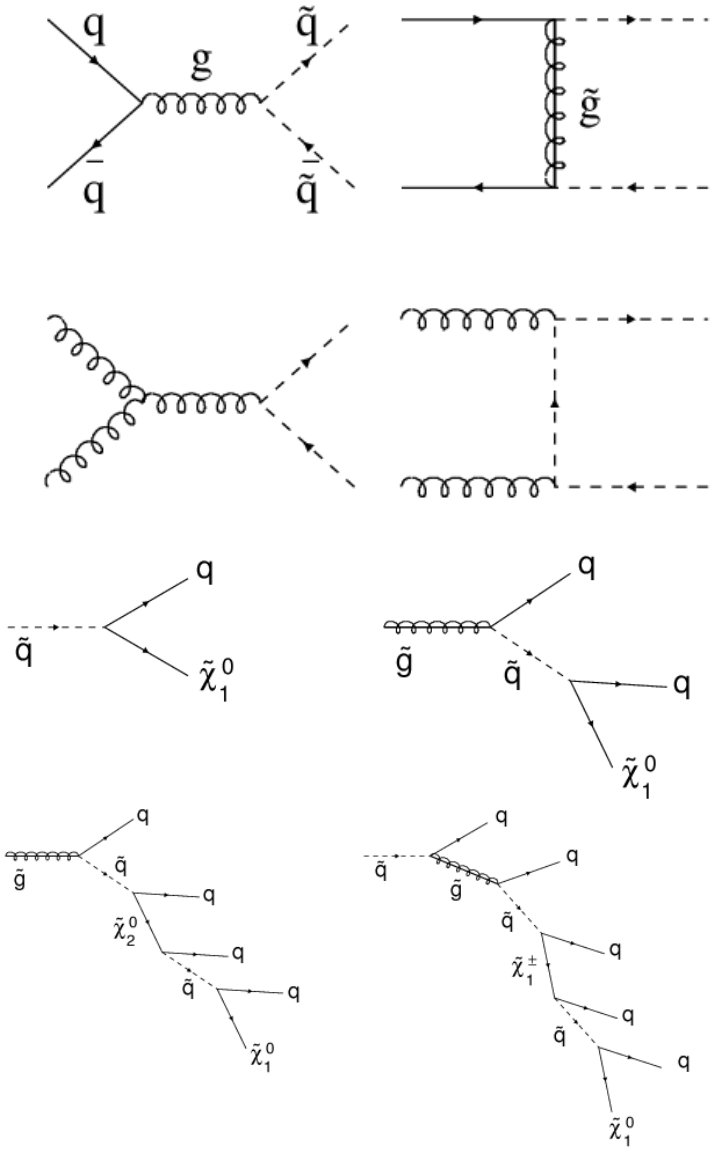
$A_0=0$ and $\mu > 0$



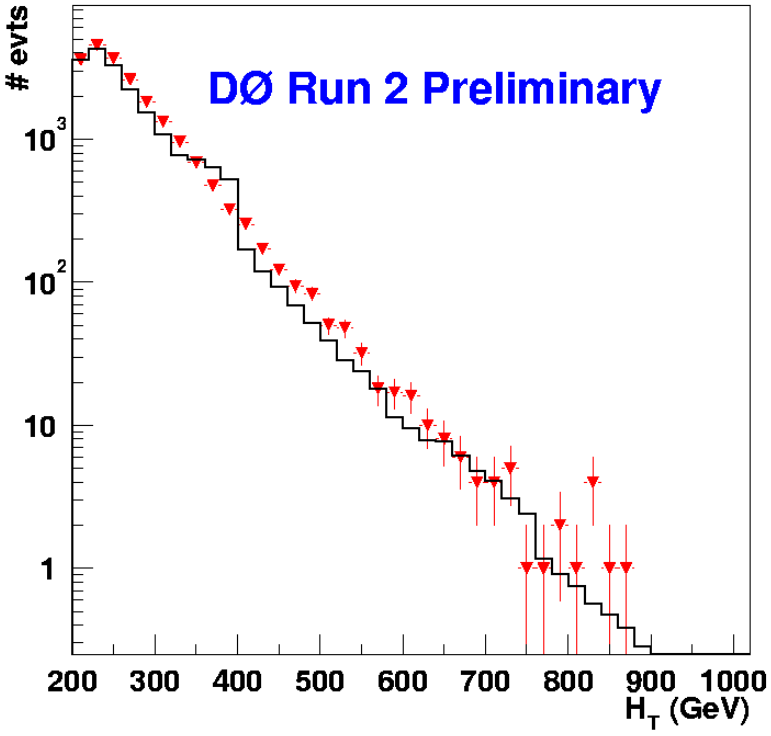
# Squarks and gluinos

- Classical SUSY signature at hadron colliders : Jets and Missing $E_T$
  - Squarks and gluinos not especially light but produced strongly
- Present study luminosity : 6 $pb^{-1}$
- Event selection
  - $H_T > 200$ GeV

    where $H_T$ is the sum of pT of central jets
- Major background : QCD



# Squarks and gluinos : jets properties

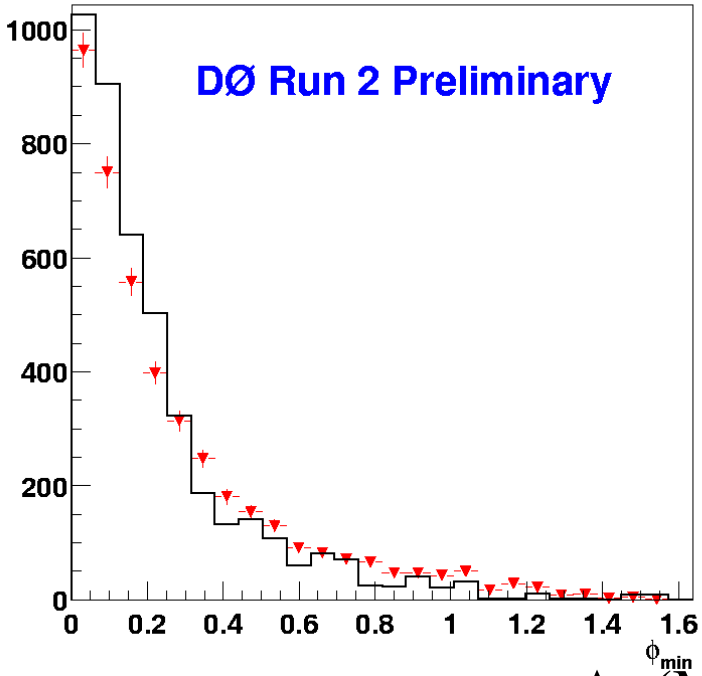



data

Monte-Carlo

Absolute normalization

The angular variables are powerful to discriminate the signal from the QCD background.




$\Delta\varphi$(MET,jets)

Basic distributions are understood, but more luminosity is eagerly awaited

# Gauge Mediated SUSY Breaking

- GMSB SUSY
  - Light Gravitino (<< eV) is LSP, NLSP can be neutralino or slepton

- If neutralino NLSP : $\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$

→ All standard SUSY signature complemented by two photons

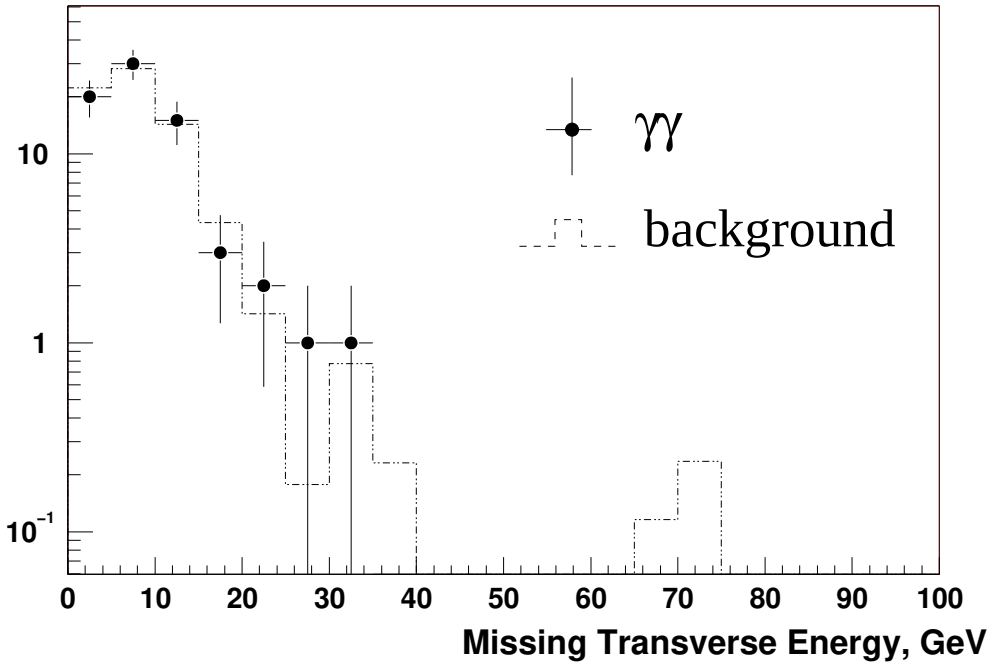
→ Inclusive search for γγ missing $E_T$ +X

- Event selection:
  - Two γ with $p_T > 20$ GeV
  - missing $E_T > 35$ GeV
  - missing $E_T$ not aligned with leading jet

- Backgrounds:
  - QCD: γγ,γ+j
  - Wγ→ eνγ
  - WW, WZ, Drell Yan

# GMSB: di-photons

| | $MET > 25\ GeV$ | $MET > 30\ GeV$ | $MET > 35\ GeV$ |
|---|---|---|---|
| Data | 2 | 1 | 0 |
| Expected background | $1.0 \pm 0.3$ | $0.7 \pm 0.2$ | $0.34 \pm 0.20$ |
| 95 % CL limit, pb | 1.6 | 1.3 | 0.9 |

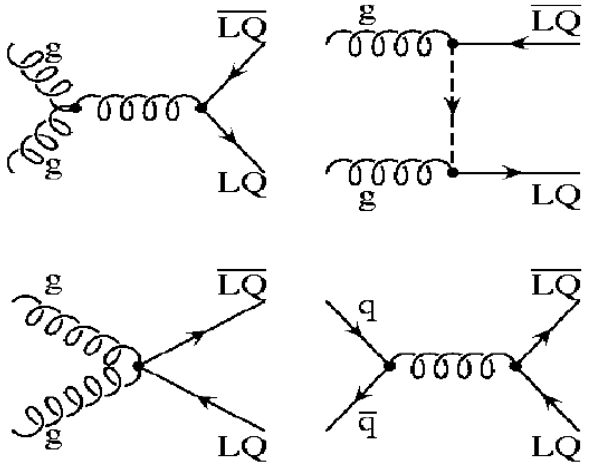



The background is estimated from the data

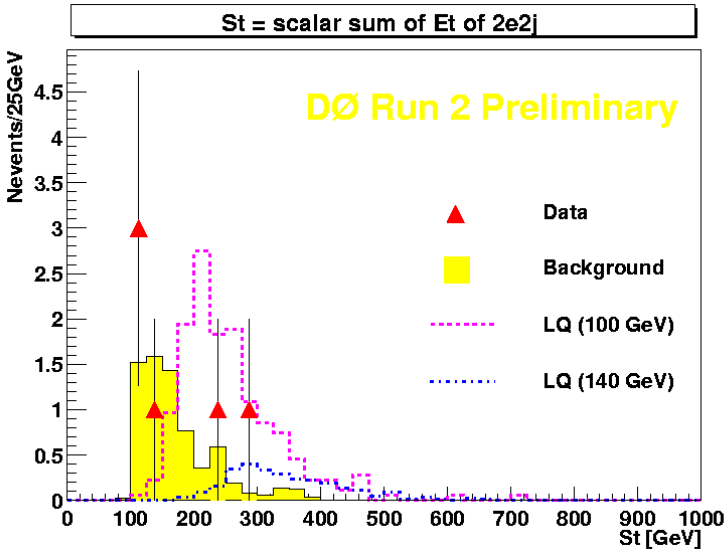
Cross section limit (with 9 $pb^{-1}$):
$\sigma < 0.9$ pb at 95 % confidence level

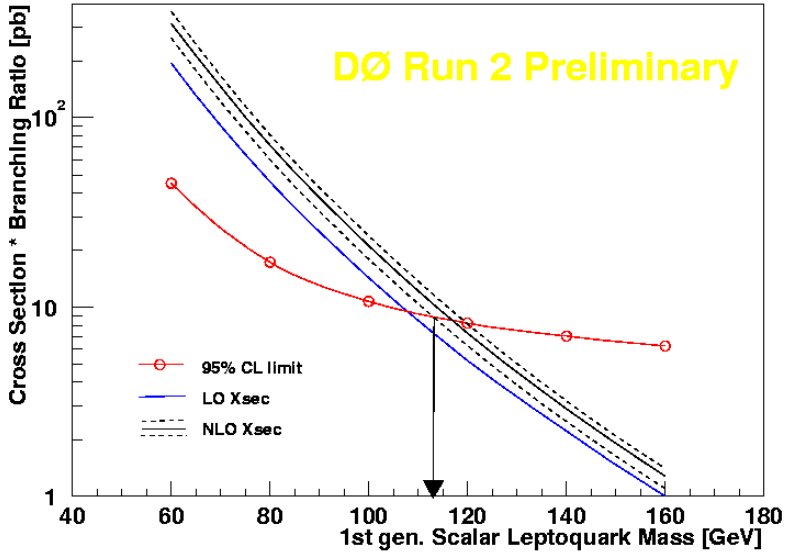
# Leptoquarks

- Particles coupled to quarks and fermions
- Predicted in many G-U extensions of the SM
- Carry both lepton and color quantum numbers
- Only coupling to e,ν and u,d considered here (1st generation)




- Two isolated electrons pT > 25 GeV
- Z-veto
- At least two jets pT > 20 GeV




$M_{LQ} > 113$ GeV/$c^2$ at 95 % (with 8 pb$^{-1}$) for BR(LQ→e j)=1

# Conclusions

- Some of the very first analysis based on 10 $pb^{-1}$ have been presented.
- 50 $pb^{-1}$ with a fully instrumented detector are beeing analysed
  - Results in the coming weeks
- 1.8 TeV (Run 1) $\rightarrow$ 1.96 TeV (Run 2) leads to a 30% increase of most cross sections
- A total integrated luminosity equivalent to Run I should be reached before summer