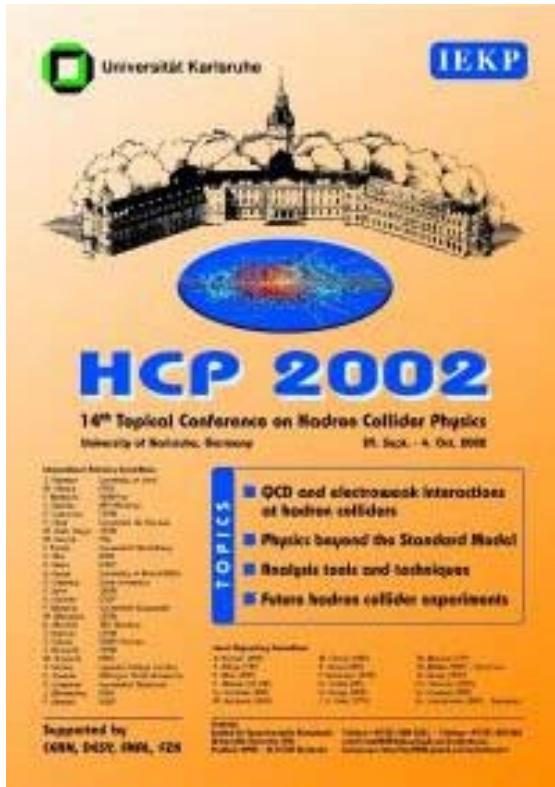




“Searches, discovery windows, expected signatures at Dzero”



HCP2002, Karlsruhe
Sept 30 - Oct 4, 2002

Andrei Nomerotski, Fermilab



Tevatron Luminosity

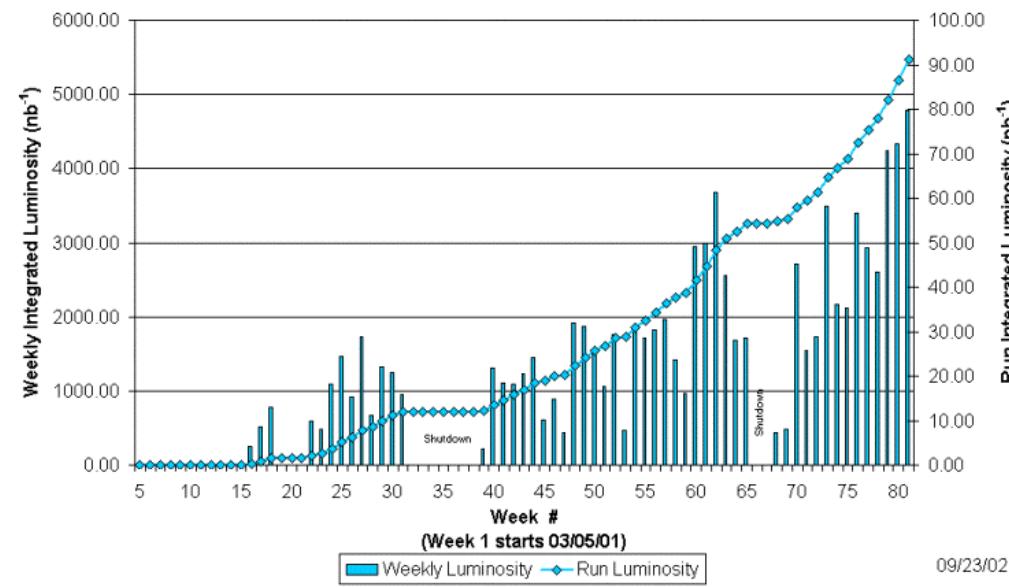
- Searches for rare events require high luminosity

- Run I 0.1 fb^{-1}
- RunIIa 2 fb^{-1}
- RunIIb 15 fb^{-1}

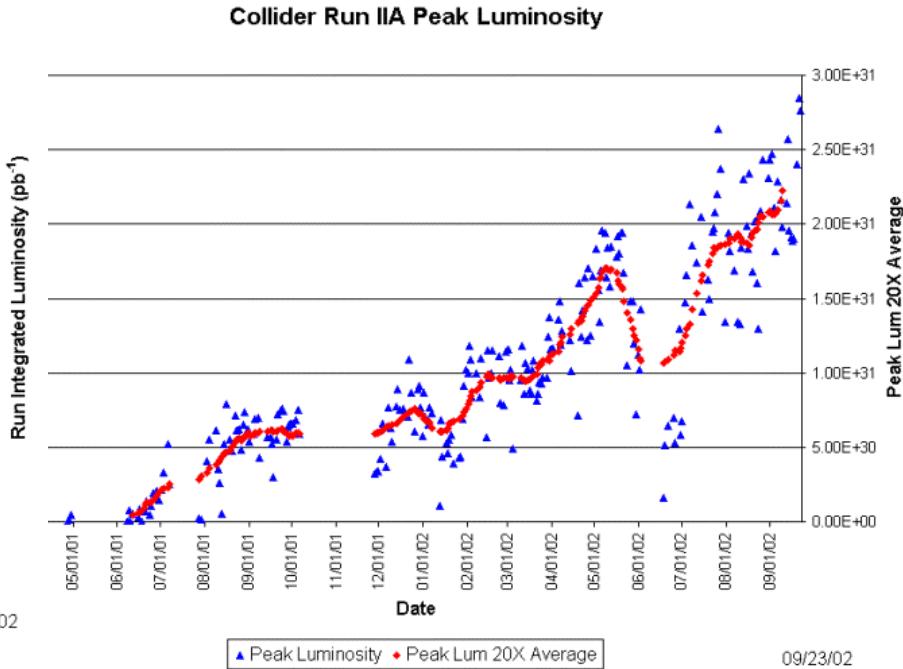
Currently

- ▲ $\sim 0.03 \text{ fb}^{-1}$ on tape / processed
- ▲ $\sim 0.01 \text{ fb}^{-1}$ analysed

Collider Run IIA Integrated Luminosity

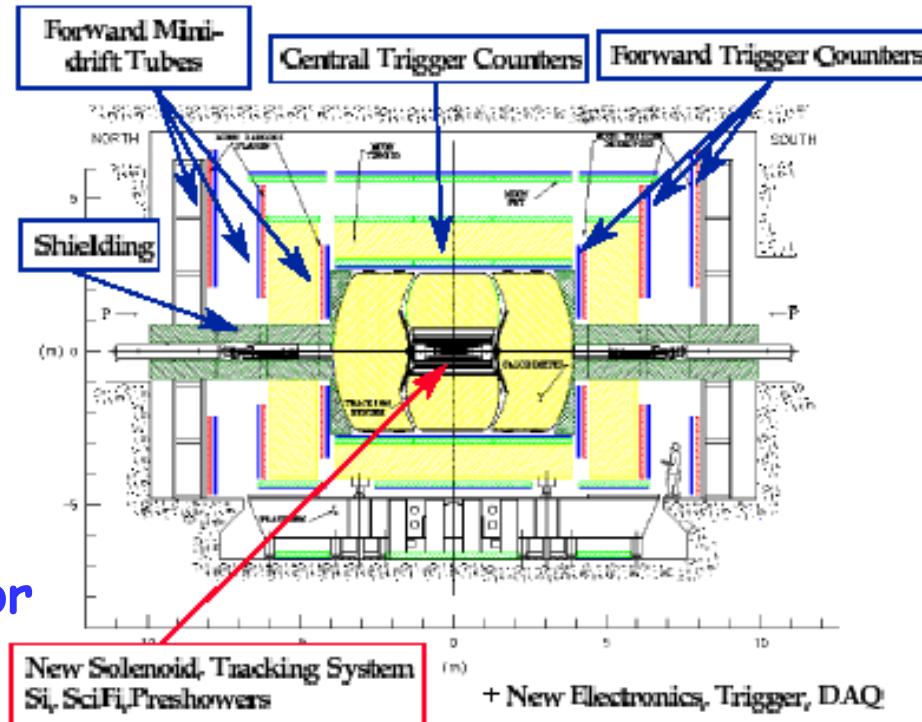


Collider Run IIA Peak Luminosity



DZero Detector in Run II

- Excellent calorimetry
 - ◆ New Preshower
- Hermetic muon system
 - ◆ End caps better shielded
- New Silicon and Fiber Trackers
 - ◆ Robust track reconstruction
 - ◆ Precise momentum measurement
 - ◆ Excellent b-tagging capabilities
- New Phenomena searches call for excellent understanding of
 - ◆ Backgrounds
 - ◆ Detector effects - fakes
- First results for Run II
 - ◆ Robust signatures
 - ◆ Better understood systems



- ▲ Too little data to find new physics or sensibly test theories beyond Run I
 - ▲ Enough data to establish data sets and analysis paths
- => My talk will be signature motivated



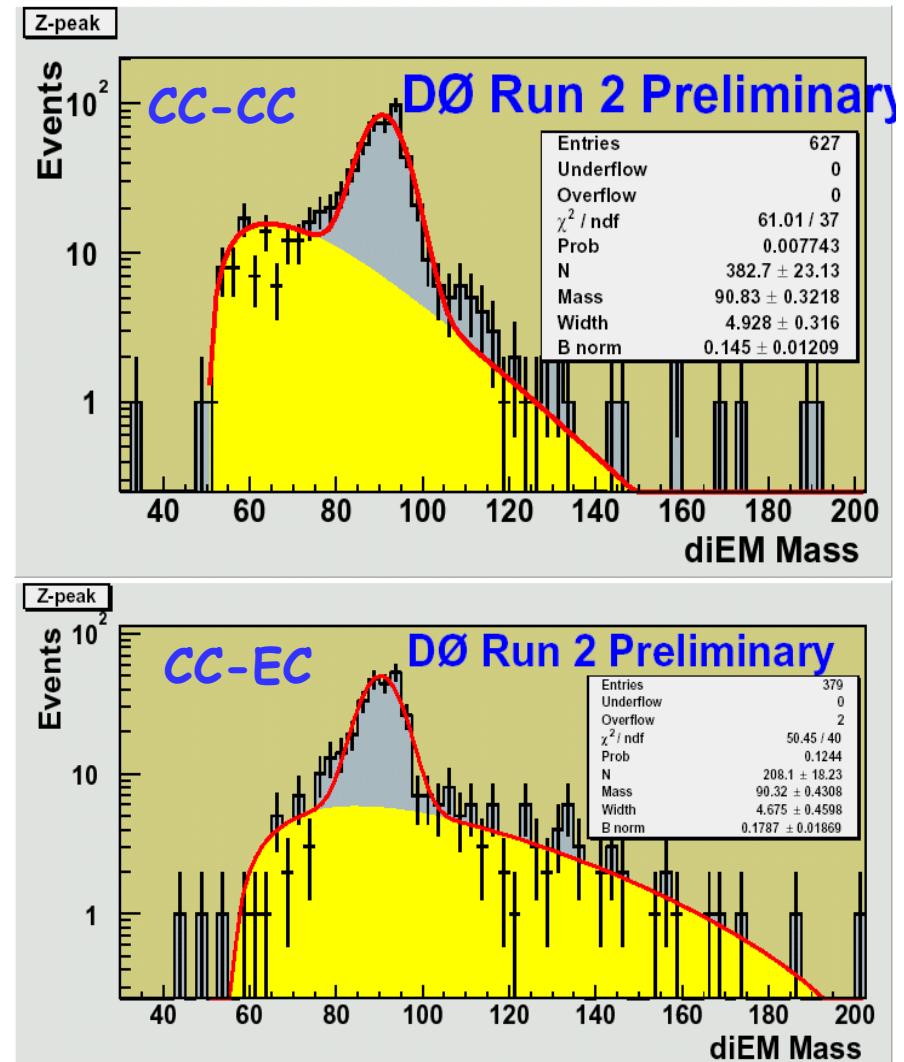
Talk Outline

- **Signatures**
 - ◆ Dielectrons (ExtD, SUSY, LQ, ...)
 - ◆ Dimuons (ExtD)
 - ◆ Diphotons + MET (GMSB SUSY)
 - ◆ Trileptons (SUSY)
 - ◆ Jets + MET (SUSY)
- **For each signature**
 - ◆ Run IIa data samples and results
 - ◆ Run II projections
- **Conclusions**



Di-electrons

- Triggers
 - ◆ One or two EM towers with $E_t > 10 \text{ GeV}$
- Data set 9.85 pb^{-1}
- EM objects (offline)
 - ◆ Central or EndCap Calorimeter
 - ◆ $E_t > 25 \text{ GeV}$
 - ◆ Loose isolation ($\text{ISO} < 0.2$)
 - ◆ EM fraction > 0.9
- Di - EM mass spectrum
 - ◆ Additional cut $\text{MET} < 30 \text{ GeV}$
 - ◆ See clean Z peak





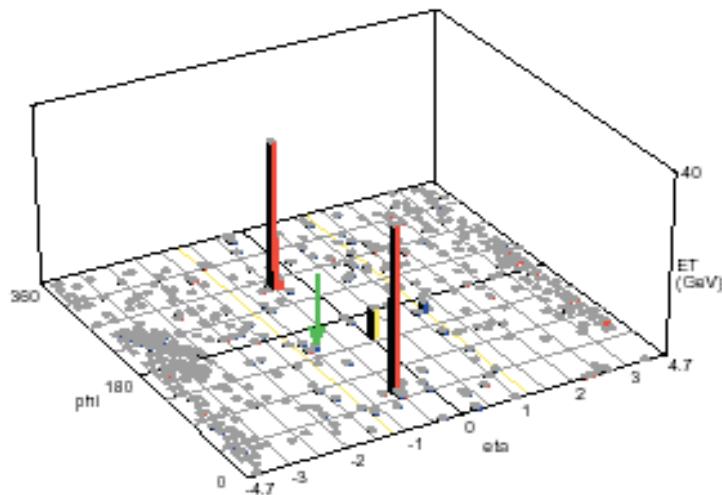
Di-electrons

- Z candidate, invariant mass 88.9 GeV

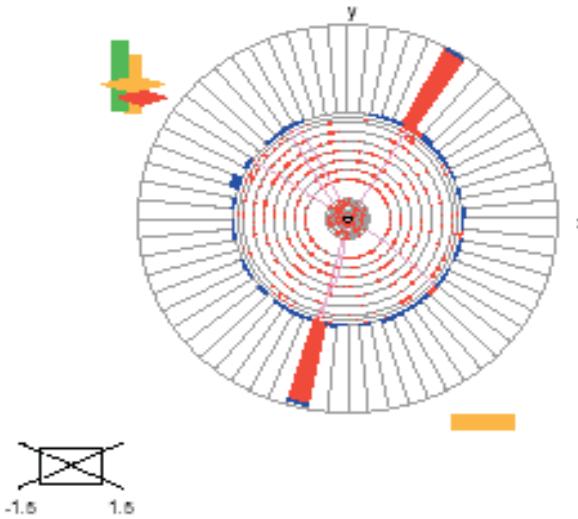
Run 148847 Event 4747032 Mon Jul 15 10:37:42 2002

Run 148847 Event 4747032 Mon Jul 15 10:37:48 2002

ET scale: 38 GeV



(a)



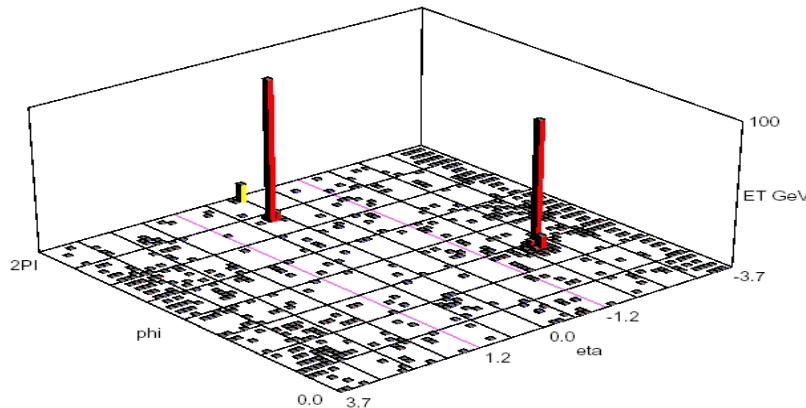
(b)

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



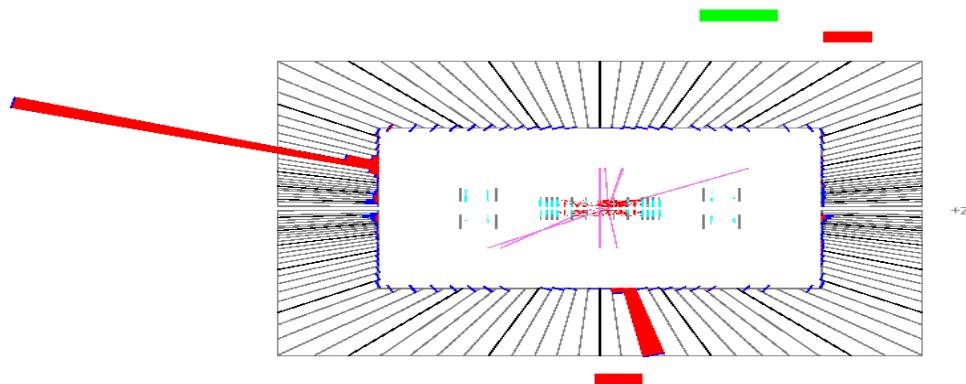
Di-electrons

Run 151964 Event 29138403 Thu May 9 00:22:01 2002



Run 151964 Event 29138403 Thu May 9 00:22:02 2002

E scale: 102 GeV

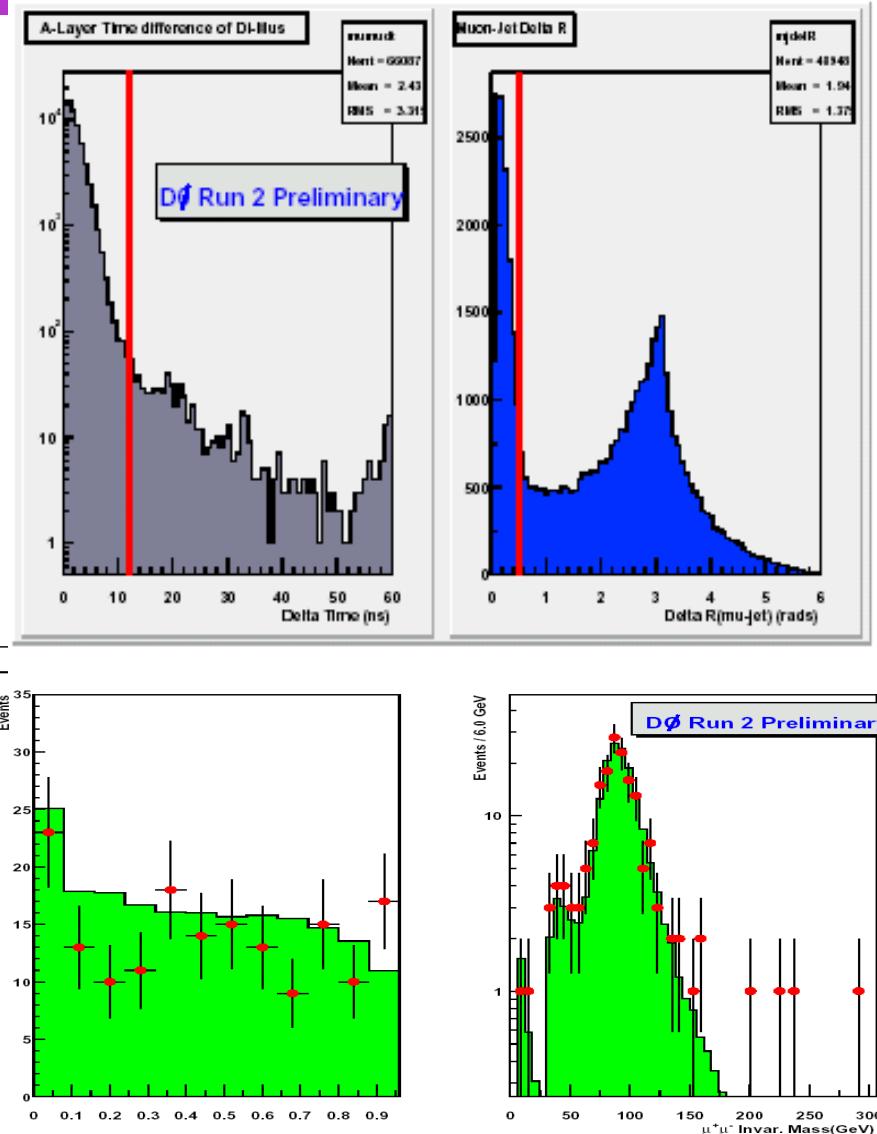


- Highest invariant mass di-EM candidate 377 GeV



Di-muons

- Triggers
 - ◆ Di-muon, $|\eta| < 2$
- Data set 4.5 pb^{-1}
- Muon ID
 - ◆ Tight quality criteria
 - ◆ $\Delta T < 12 \text{ nsec}$
 - ◆ Isolation cut
 - ◆ Matched to track with $P_T > 15 \text{ GeV}$
- Di - muon mass spectrum
 - ◆ See clean Z peak





Di-muons

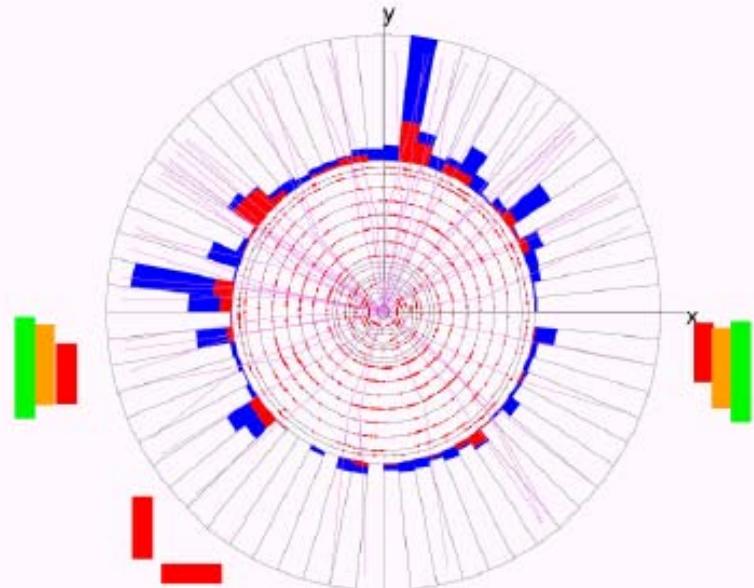
Run 145024 Event 7301421 Tue Jun 25 14:21:19 2002

ET scale: 9 GeV

Run:145024 Event:7301421

μ_1	μ_2
“333” GTrack	“333” GTrack
$p_T = 185.7 \pm 30.9$ GeV	$p_T = 115.8 \pm 13.8$ GeV
$\phi = 6.1 \pm (1.2 \times 10^{-4})$	$\phi = 3.3 \pm (1.2 \times 10^{-4})$
$\eta = -0.29 \pm (8.0 \times 10^{-4})$	$\eta = -0.44 \pm (8.0 \times 10^{-4})$
$\chi^2 = 22.4$	$\chi^2 = 62.7$

$d\mu$ mass = 289.9 ± 37.3 GeV and $|\cos(\theta^*)| = 0.48$

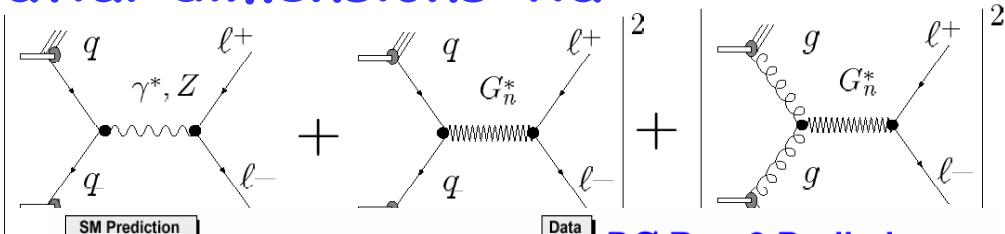


- Highest mass (290 GeV) di-muon event



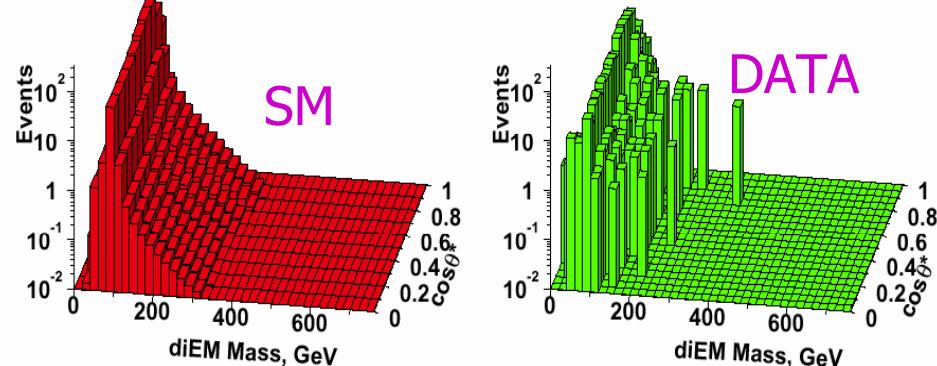
Search for Extra Dimensions

- Search for large extra spatial dimensions via virtual graviton effects
- e^+e^- , $\gamma\gamma$ and $\mu^+\mu^-$ events

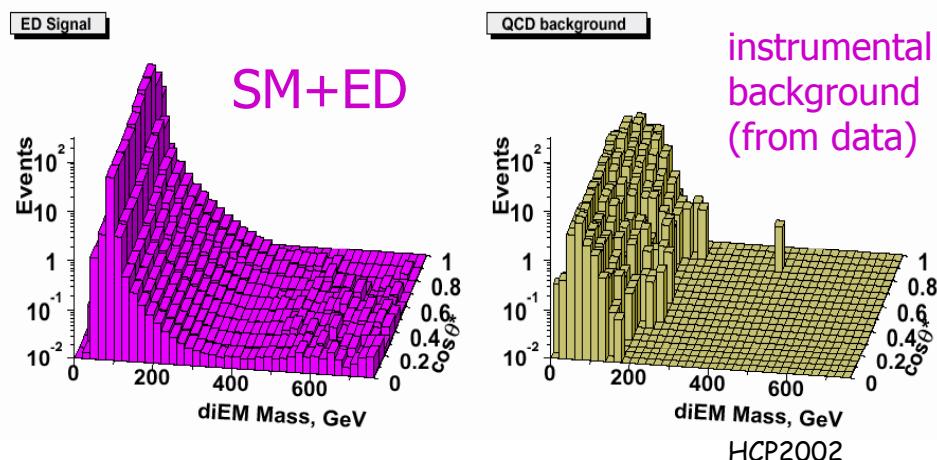


DØ Run 2 Preliminary

- Run2 Preliminary Limit:
 - $M_S(GRW) > 0.92 \text{ TeV} (ee, \gamma\gamma)$
 - $M_S(GRW) > 0.50 \text{ TeV} (\mu^+\mu^-)$
 - ▲ $\mu^+\mu^-$ channel: first limit at hadron collider!



- DØ Run 1 limits:
 - $M_S(GRW) > 1.2 \text{ TeV}$
 - Prospects for Run II:
 - ▲ 1.5-2.5 TeV (2fb^{-1})
 - ▲ 2.1 - 3.5 TeV (20 fb^{-1})

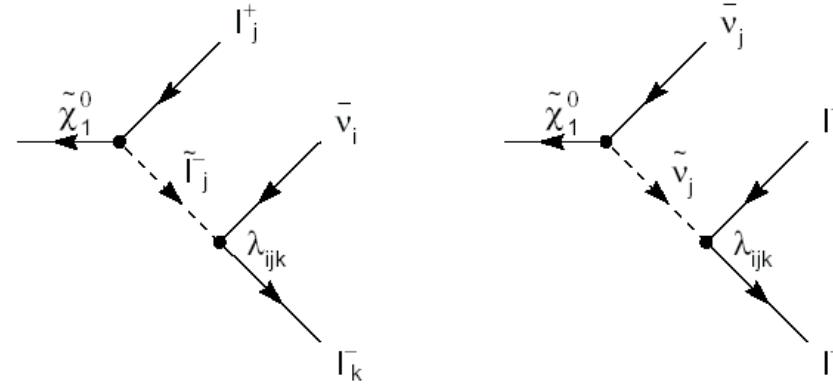


Tri-leptons

One of cleanest signatures of SUSY

- ◆ Chargino-neutralino
- ◆ RPV couplings

- Data set 5.2 pb^{-1}
- Two EM objects, $E_T > 30 \text{ GeV}$,
 15 GeV
- One muon candidate $P_T > 5 \text{ GeV}$,
- DR > 0.7 between
 - ◆ Any pair of leptons
 - ◆ Muon and any jet
- Backgrounds
 - ◆ Fake e in ee jets, e μ jets
 - ◆ ee gamma



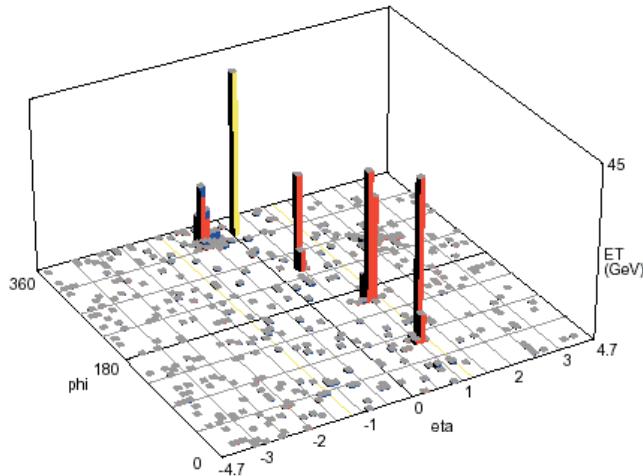
Event categories	eee	$ee\mu$
\mathcal{L}_{int} , pb^{-1}	5.2 ± 0.8	4.6 ± 0.7
Observed events	2	1
Background events	1.9 ± 0.4	0.7 ± 0.2

Tri-leptons

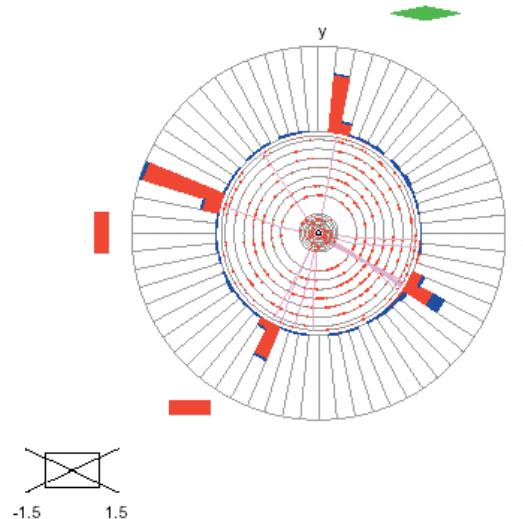
Run 152243 Event 35119440 Mon Jul 15 16:01:54 2002

ET scale: 64 GeV

Run 152243 Event 35119440 Mon Jul 15 16:01:46 2002



(a)



(b)

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

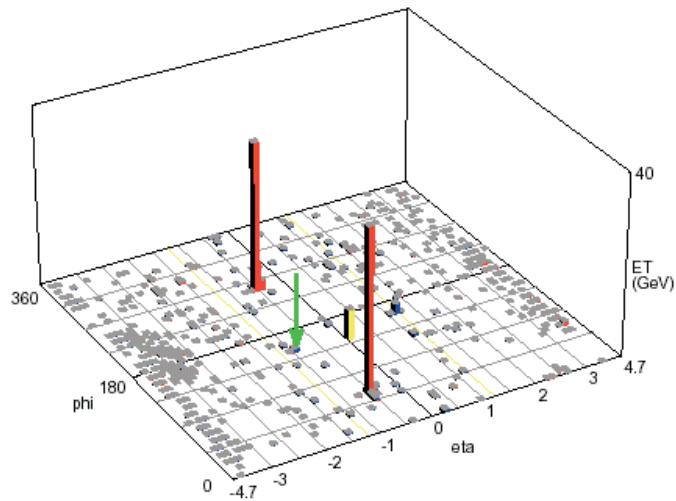
- **eee candidate event**

Tri-leptons

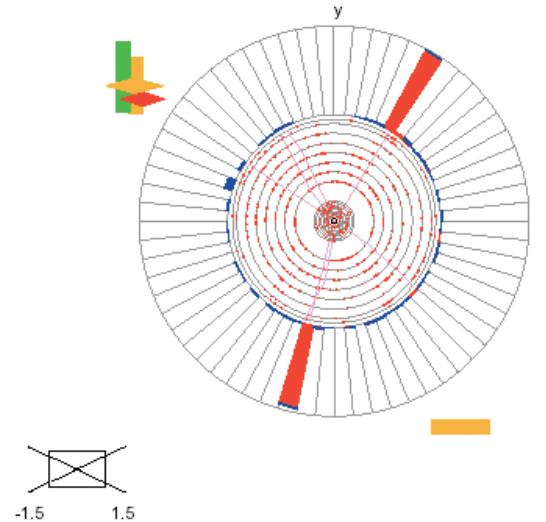
Run 148847 Event 4747032 Mon Jul 15 10:37:48 2002

ET scale: 38 GeV

Run 148847 Event 4747032 Mon Jul 15 10:37:42 2002



(a)



(b)

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

- $ee\mu$ candidate event

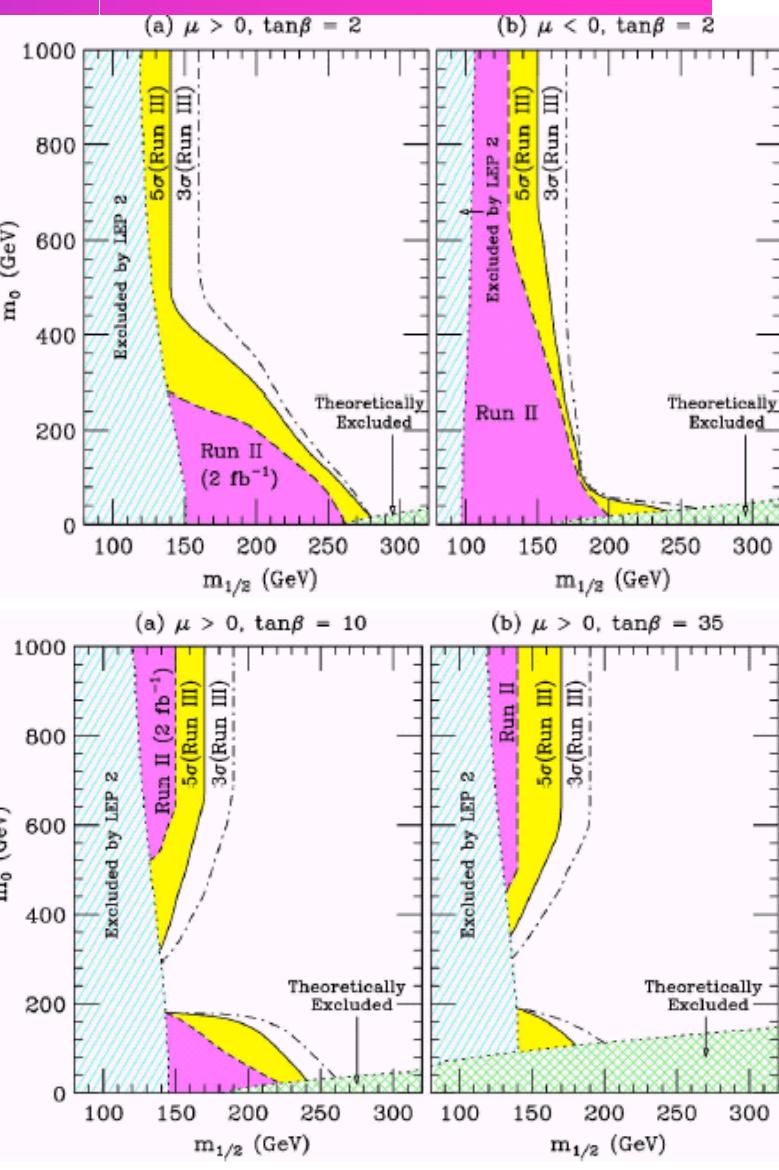


Tri-leptons

- Run II will explore considerable region of parameter space

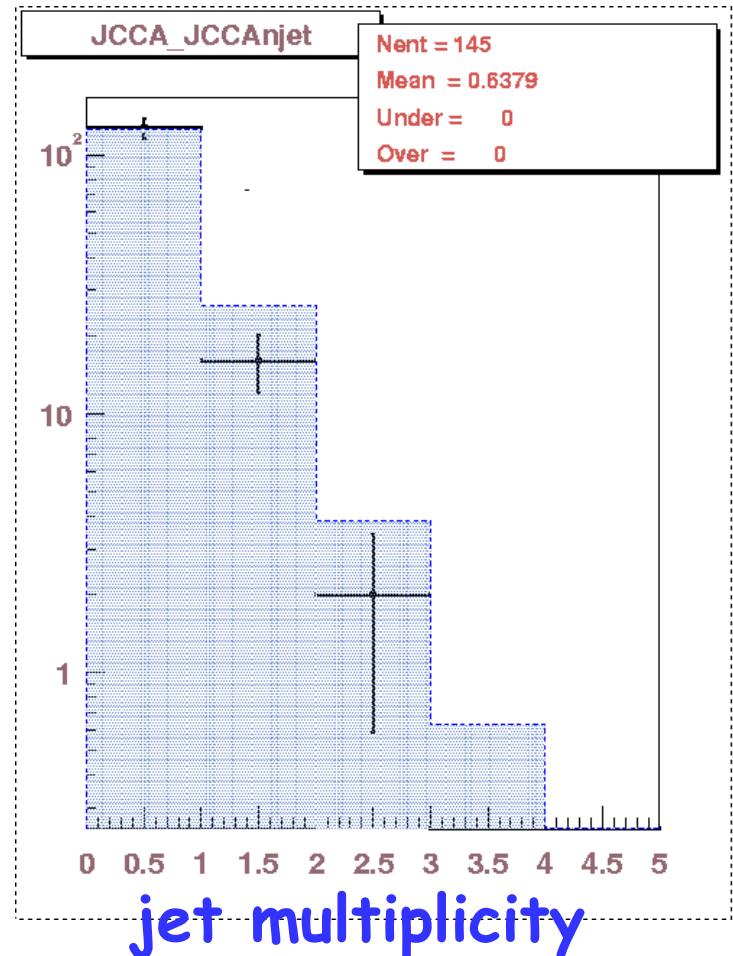
(M0-M1/2)

purple: 5σ significance w/ 2 fb^{-1} (Run2a)
yellow: 5σ significance w/ 25 fb^{-1} (Run2b)
dashed: 3σ significance w/ 25 fb^{-1}



LS di-electrons

- Clean SUSY signature : small SM background
 - ◆ RPV scenario : neutralinos are Majorana particles
=> produce like-sign lepton pairs
- Data set 9.7 pb^{-1}
- Selections
 - ◆ Two EM objects
 - ▲ $E_T > 15 \text{ GeV}$ and 10 GeV
 - ▲ central electron $|\eta| < 0.8$
 - ▲ $\Delta R > 0.7$
 - ▲ At least one vertex
 - ◆ Jets
 - ▲ $0.05 < \text{EMF} < 0.95$
 - ▲ $\text{CHF} < 0.4$
 - ▲ $P_T > 20 \text{ GeV}$, $|\eta| < 2.6$





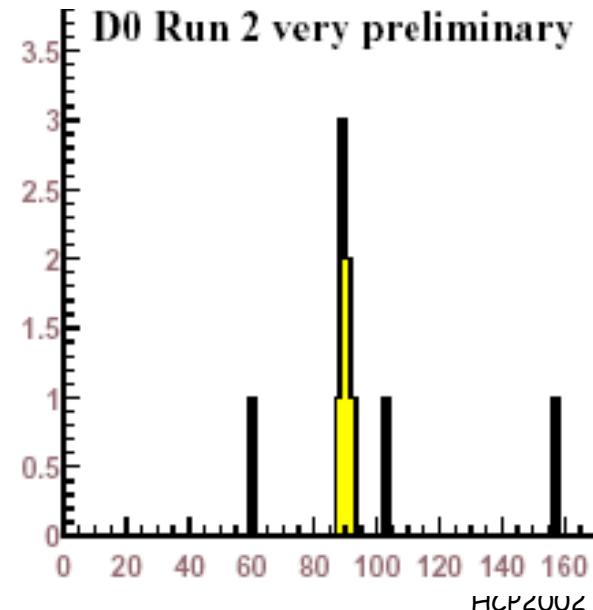
LS di-electrons

- Like sign selection

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

- Five ++ & five -- candidates
- Background
 - ◆ Standard Model
 - ◆ EM fakes
 - ◆ Wrong charge assignment

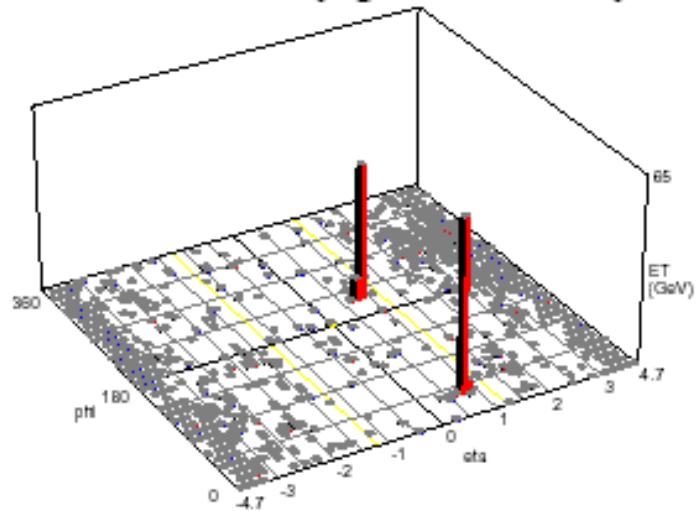
Di-electron invariant mass



LS di-electrons

Run 152300 Event 36803628 Wed Jul 10 10:32:54 2002

D0 Run 2 very preliminary

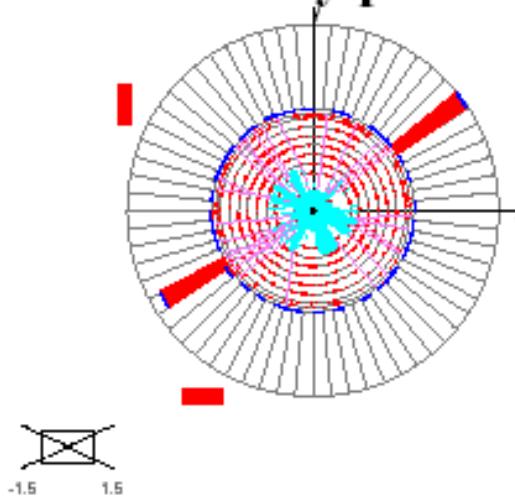


(a)

Run 152300 Event 36803628 Wed Jul 10 10:33:07 2002

ET scale: 66 GeV

D0 Run 2 very preliminary



(b)

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



Di-photons : GMSB SUSY

- GMBS 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 signatures complemented by two photons
 \Rightarrow inclusive search for $\gamma\gamma E_T + X$
- EM data set 8.7 pb^{-1}
- Selections
 - ◆ One CC EM object $> 25 \text{ GeV}$ or two CC EM $> 20 \text{ GeV}$
 - ◆ MET axis separation from jets > 0.5
- Samples to study background
 - ◆ Tracking efficiency

	$MET < 15 \text{ GeV}$	$MET > 25 \text{ GeV}$	$MET > 30 \text{ GeV}$	$MET > 35 \text{ GeV}$
$\gamma\gamma$ sample	65	2	1	0
fake $\gamma\gamma$ sample	562	9	6	3
$e\gamma$ sample	11	3	3	1
fake $e\gamma$ sample	61	6	2	1



Di-photons : GMSB SUSY

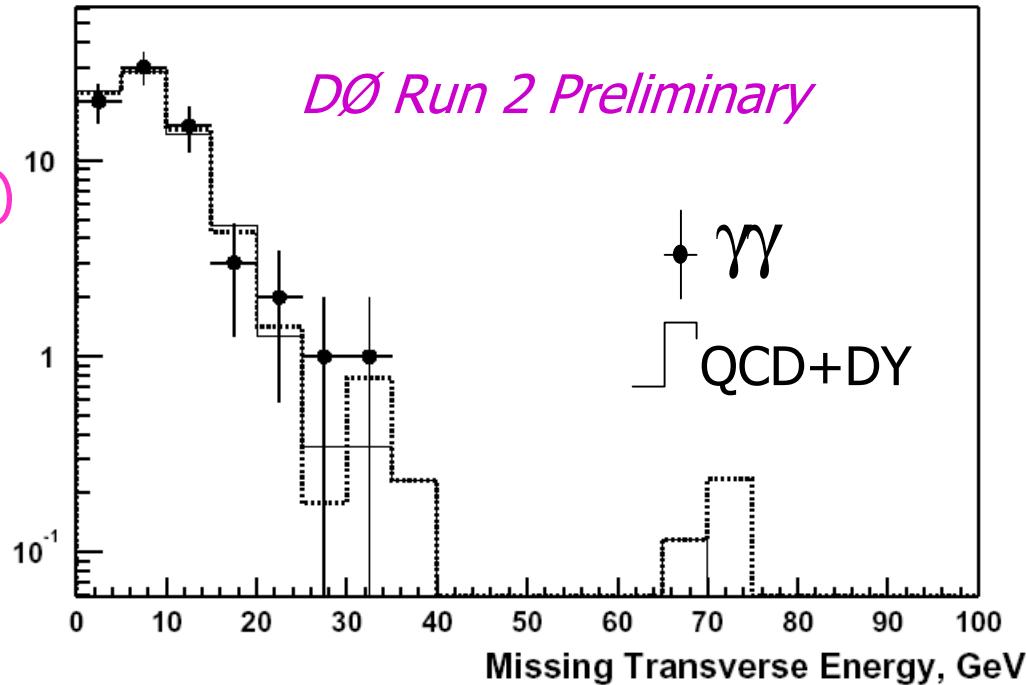
	$MET > 25 \text{ GeV}$	$MET > 30 \text{ GeV}$	$MET > 35 \text{ GeV}$
Data	2	1	0
Expected background	1.0 ± 0.3	0.7 ± 0.2	0.34 ± 0.20
95 % CL limit, pb	1.6	1.3	0.9

- **Backgrounds:**

- QCD: $\gamma\gamma$, $\gamma+j$
(w/ jet misidentified γ)
- $W\gamma \rightarrow e\gamma\gamma$ (track is lost)
- WW , WZ , DY ,

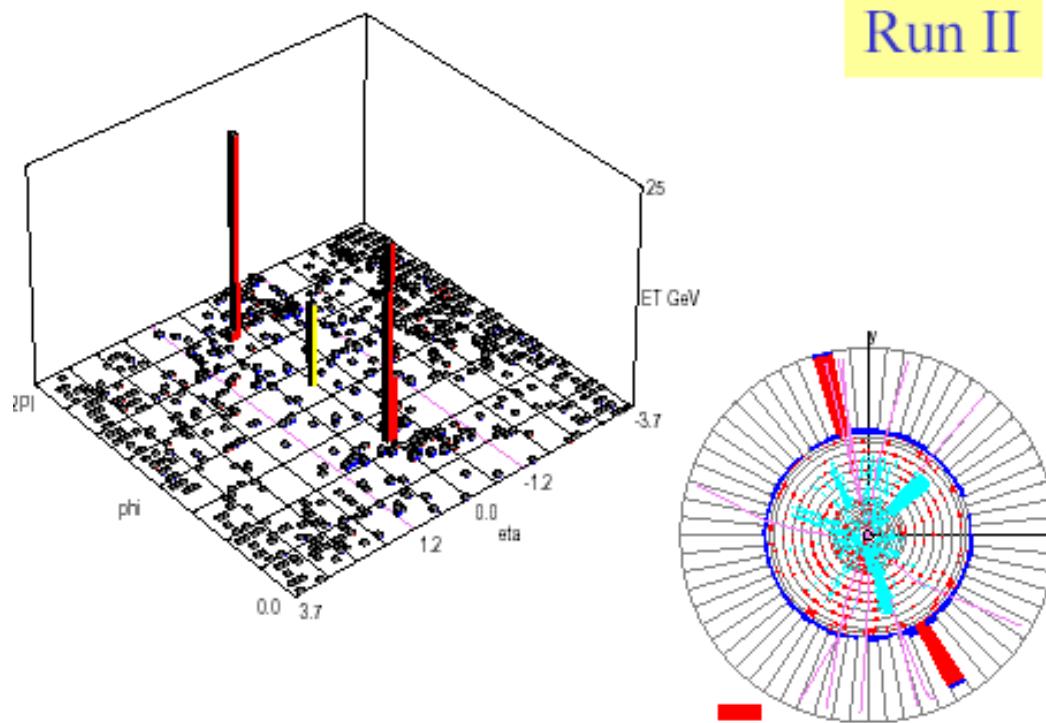
- **Cross section Limit**

$\sigma < 0.9 \text{ pb}$ @ 95% CL



Di-photons : GMSB SUSY

Run 151894 Event 24696678 Wed May 15 11:06:57 2002

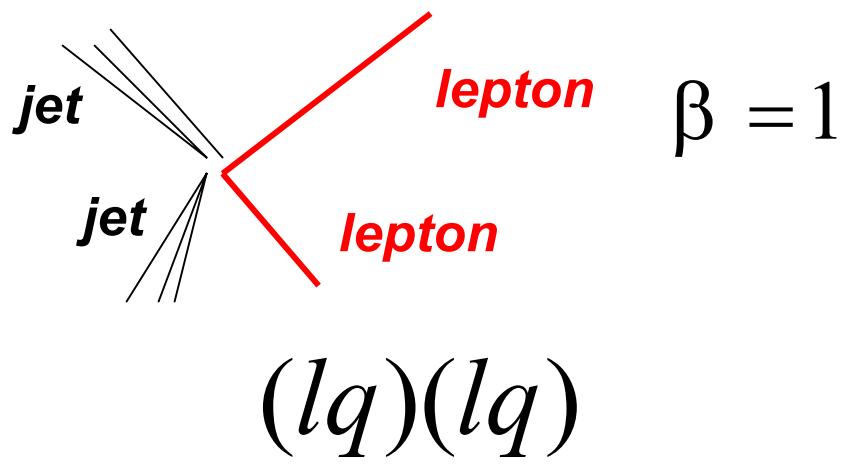
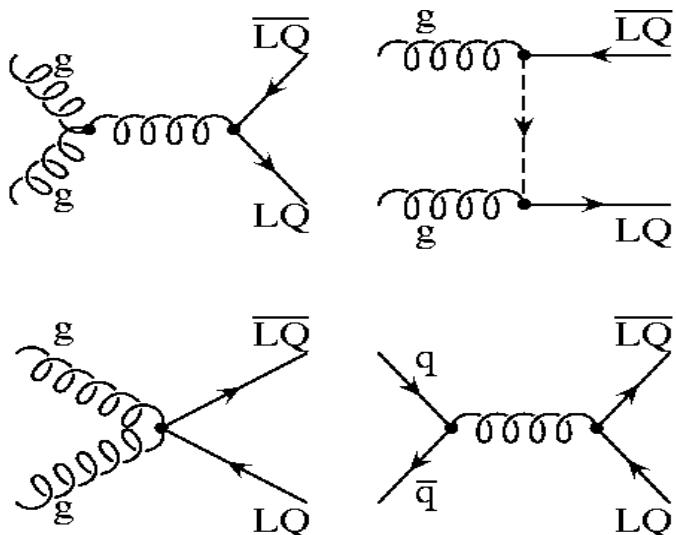


- Highest MET di-photon event, MET = 33 GeV



Di-electrons + jets : Leptoquarks

- Particles coupled to quarks and fermions
- Predicted in many Grand Unification extensions of SM
- Carry both lepton and color quantum numbers
- Family diagonal coupling to avoid FCNC beyond CKM mixing



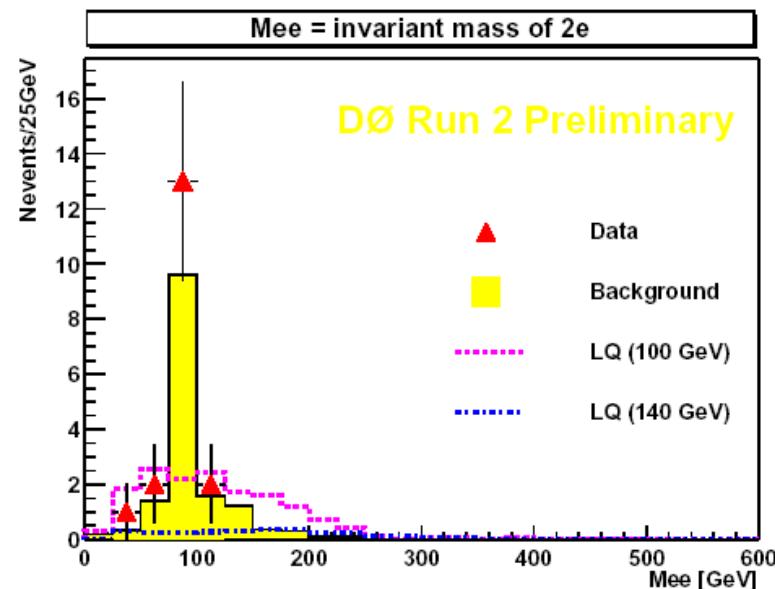
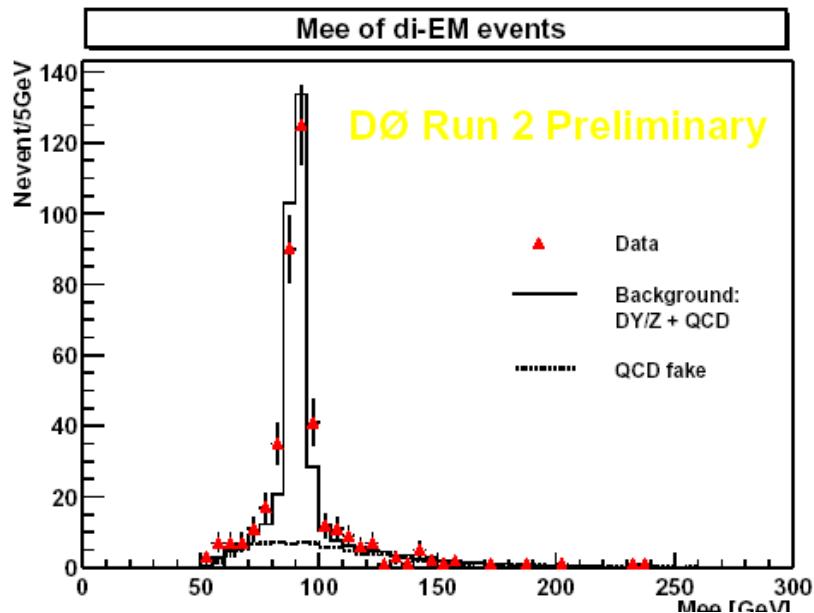


Di-electrons + jets : Leptoquarks

- EM data sample, 8.0 pb^{-1}
- Selections

Selection Criteria	Number of Events
Trigger Selection	23001
2 EM objects ($E_T > 25 \text{ GeV}$)	408
2 or more jets ($E_T > 20 \text{ GeV}, \eta < 2.5, \delta R > 0.7$)	19
Z veto ($82 \text{ GeV} < M_{ee} < 100 \text{ GeV}$)	6

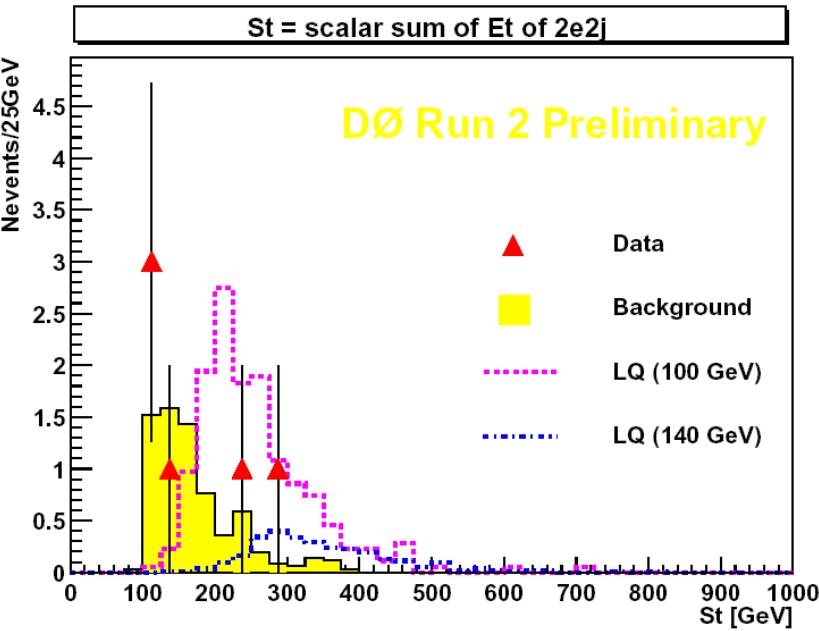
- BG from QCD and DY





Di-electrons + jets : Leptoquarks

- Signal systematic errors $\sim 20 - 10\%$ ($M(LQ) 60-160 \text{ GeV}$)
 - ◆ Jet energy scale

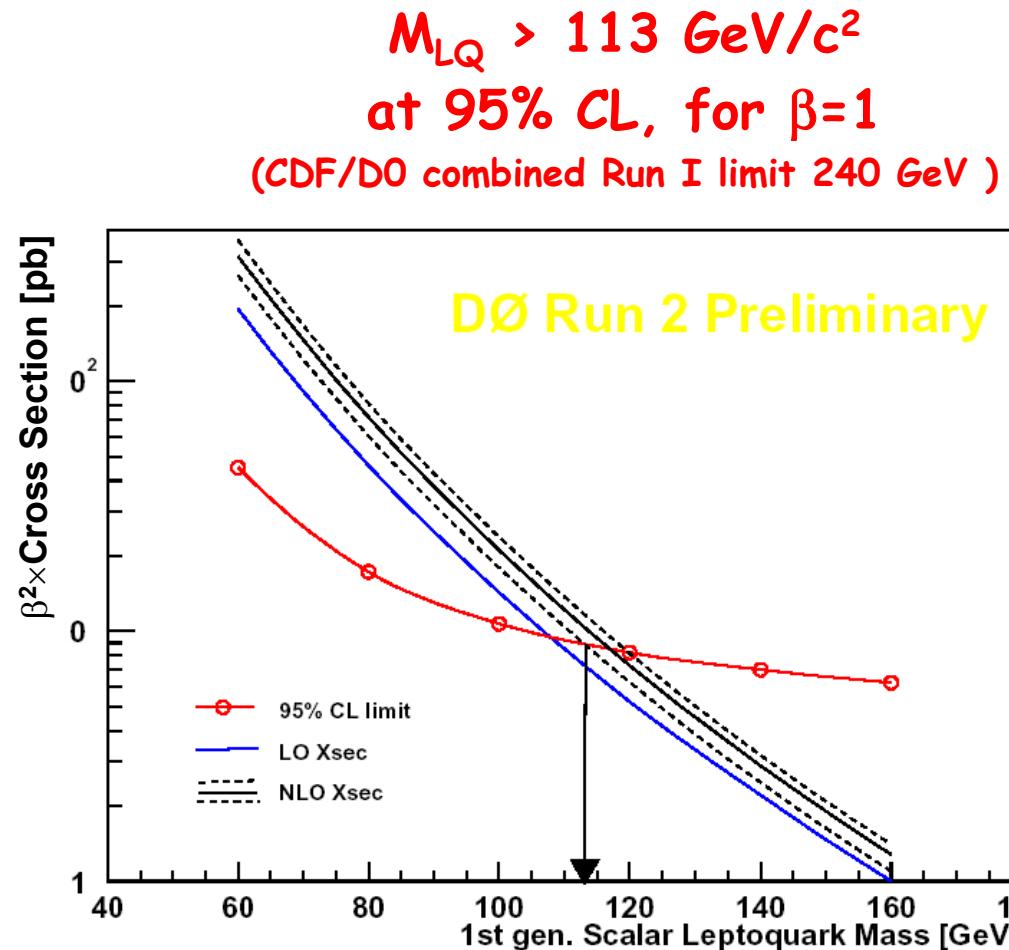


Data : **6 events**

Background : **6.9 ± 2.9 events**

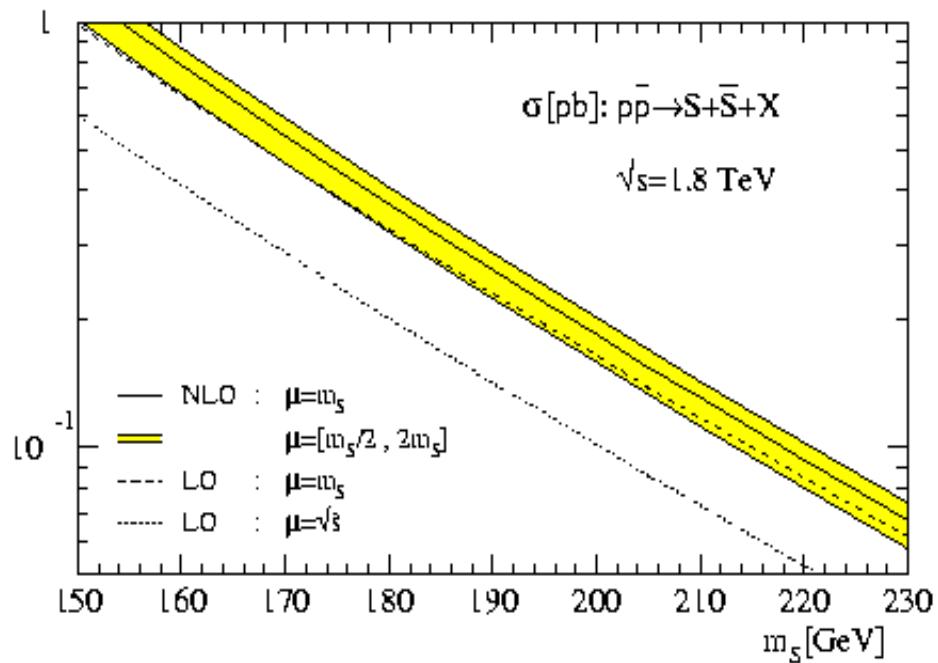
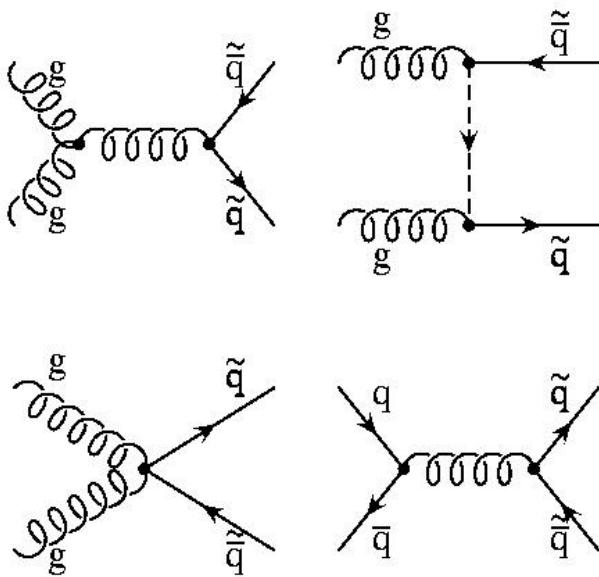
LQ ($m = 100 \text{ GeV}$) : **13.8 ± 1.8 events**

LQ ($m = 140 \text{ GeV}$) : **2.9 ± 0.3 events**

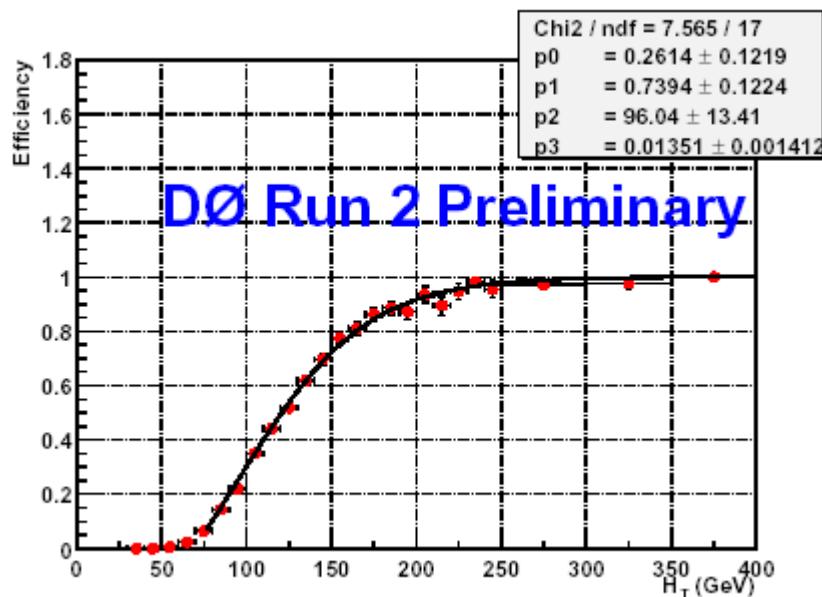


Jets + MET

- Classical SUSY signature at hadron colliders
 - ◆ Assume R-parity conserved
 - ◆ Squarks and gluinos are not expected to be light but
 - ▲ Produced strongly => Large cross section

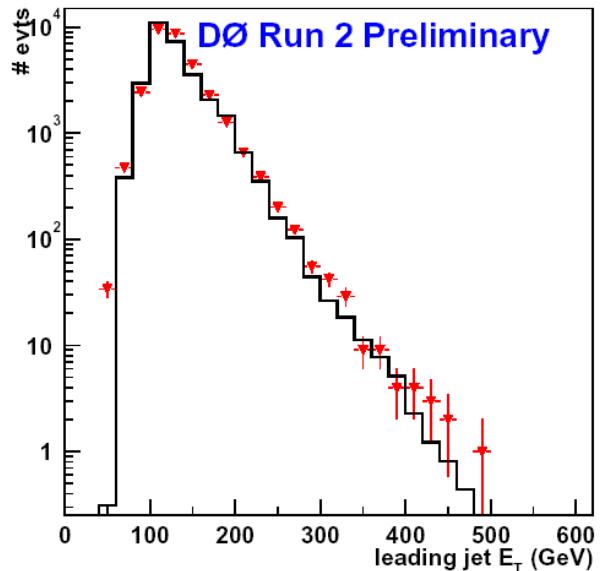
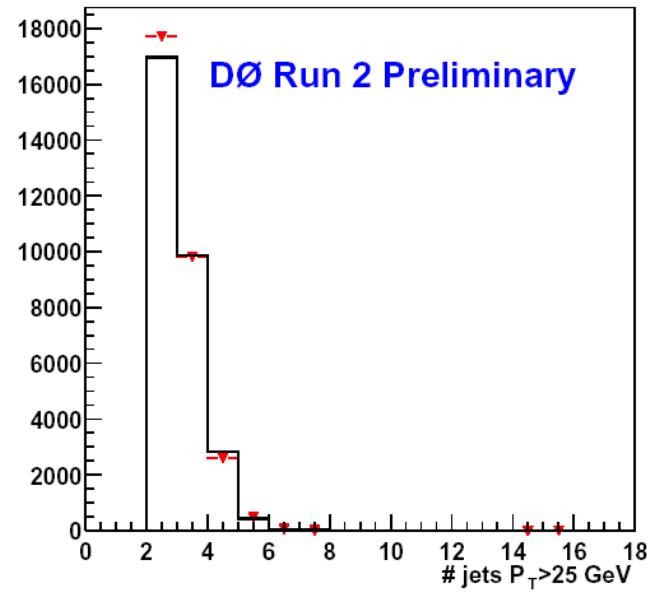


- Data set 6 pb^{-1}
- Multijet trigger : 3 towers with $E > 7 \text{ GeV}$
 - ◆ Fully efficient for $H_T > 200 \text{ GeV}$
 - ▲ H_T is sum of E_T of central jets
 - ▲ MET trigger being commissioned

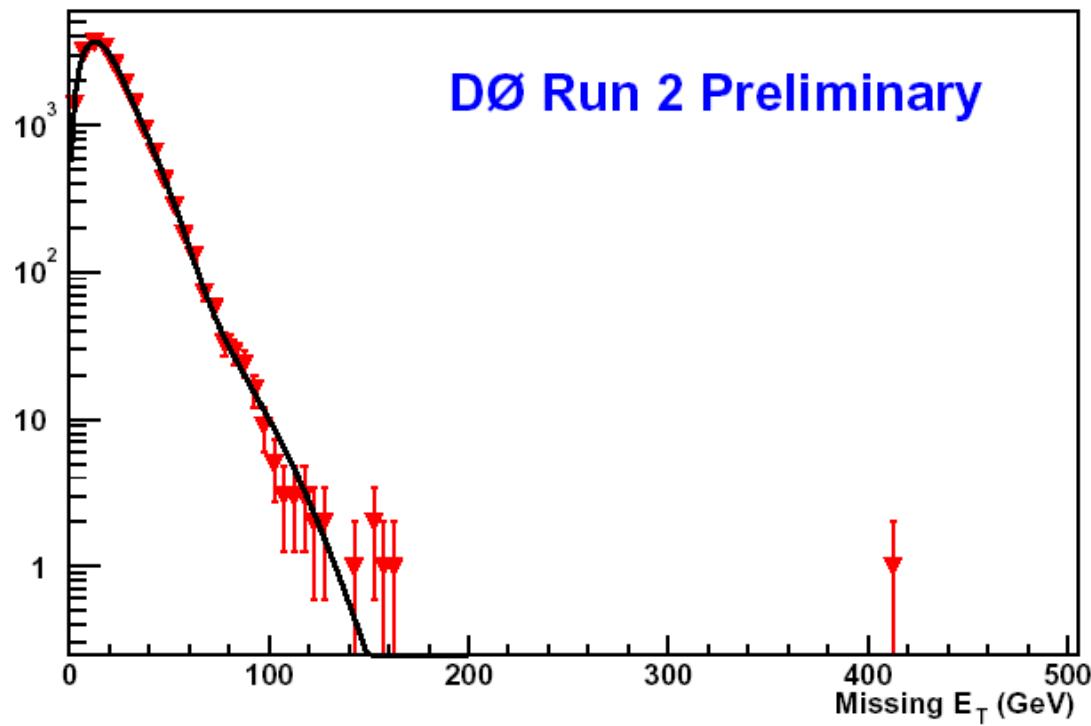


- Efficiency turn-on curve measured using muon sample
- Background dominated by QCD

Jets + MET



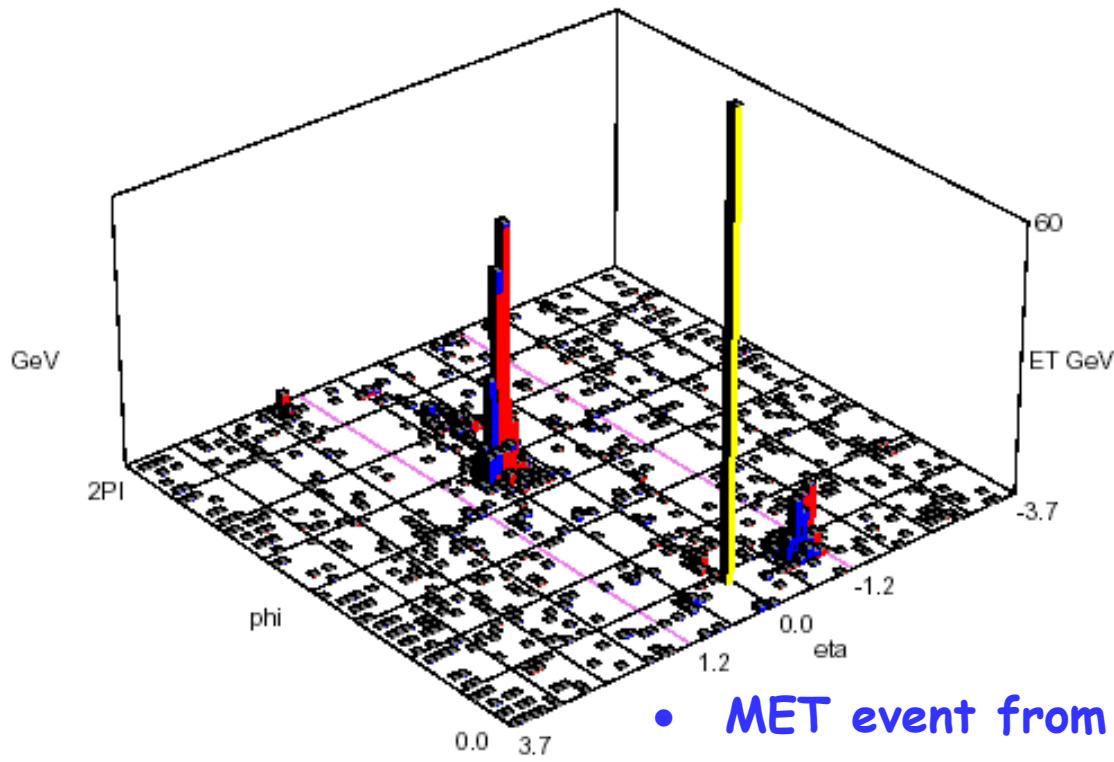
- Selection $H_T > 200 \text{ GeV}$
- Event kinematics
 - ◆ Data normalized to MC
 - ◆ MC shapes adequate





Jets + MET

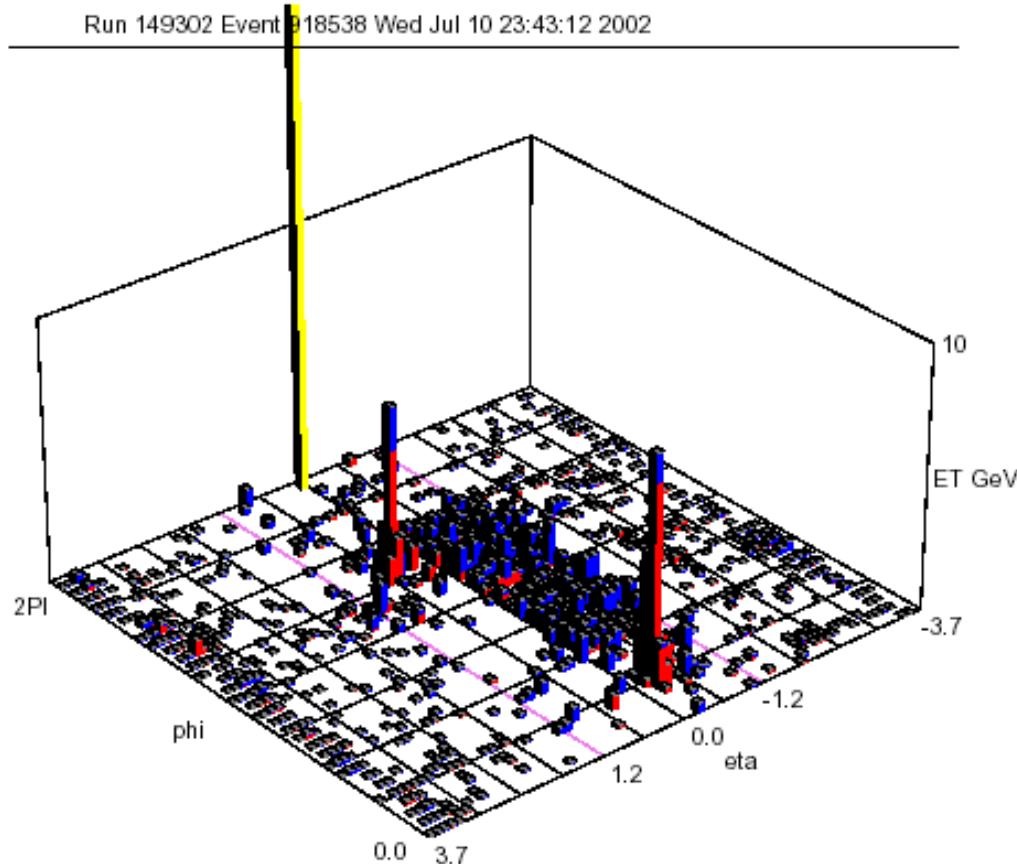
Run 146610 Event 961014 Thu Jul 11 11:12:39 2002



- MET event from the tail
 - Met aligned with second jet

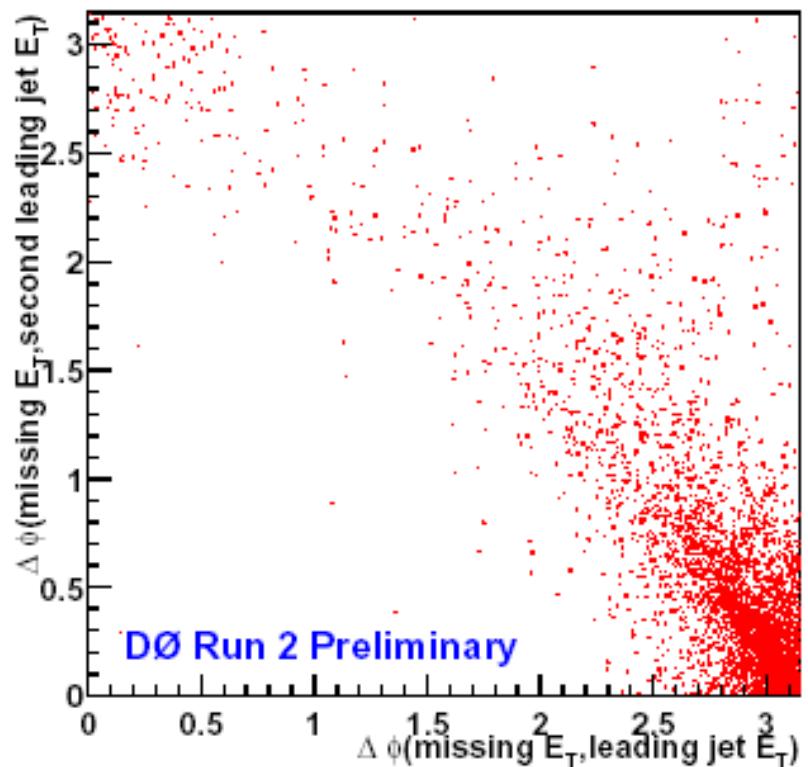
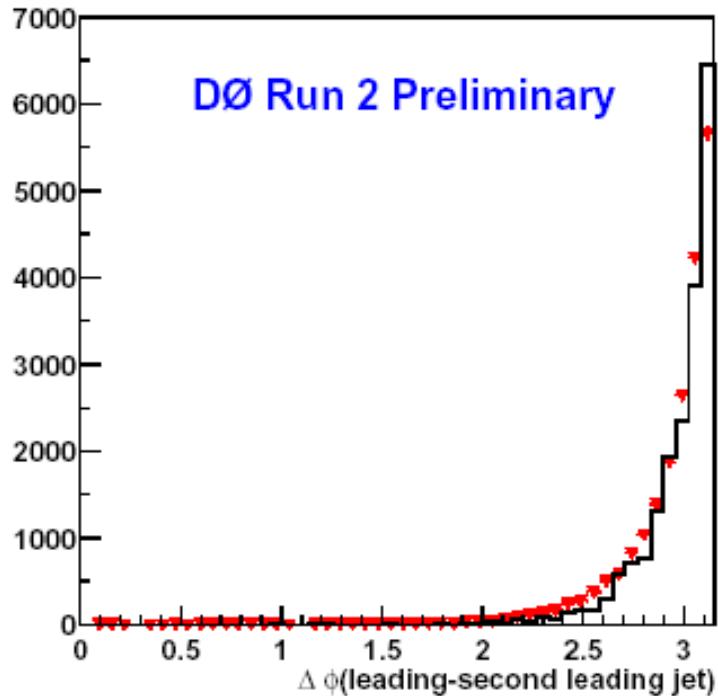


Jets + MET



- Highest MET event (~410 GeV)
 - ◆ Traced to a hardware problem

- Further kinematical selections
 - ◆ Angle correlations



- ◆ Work in progress
 - ▲ EW backgrounds
 - ▲ Errors / Limits



Conclusions

- First results at 1.96 TeV : No surprises
 - ◆ Samples $\sim 10 \text{ pb}^{-1}$ analysed
 - ◆ More analyses coming along
- Enormous progress made over the last year
 - ◆ Commissioning of detector
 - ◆ Analysis tools
- Improvements
 - ◆ More luminosity
 - ◆ More efficient data taking
 - ◆ Improved triggers
 - ◆ Improved reconstruction and selection
 - ◆ Further calibration and alignment of the detectors
- Looking forward to
 - Run I size samples by spring 2003
 - and beyond!