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Supersymmetry at DØ and other new phenomena searches in Run II

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Abstract. The Run II of the DØ experiment was started in March 2001. The first preliminary results on searches for new physics are presented, with a luminosity of ~ 10 pb^{-1} from the data collected in 2001–2002. We report results in mSUGRA (jets + missing E_{T} channel), GMSB (diphotons), RPV (trileptons and like sign dileptons) and large extra dimensions (dielectrons and diphotons).

Keywords. DØ; Run 2; supersymmetry; new phenomena; large extra dimension.

1. The TeVatron and DØ upgrades

The energy of the TeVatron $p\bar{p}$ collider has been increased from 1.8 to 1.96 TeV. The luminosity has been enhanced thanks to a new injector (the main injector), an increased number of bunches (36×36), the increased antiprotons production and recycling of the antiprotons (not yet in operation). So far, $\sim$75 pb^{-1} have been recorded. The present peak luminosity is $\sim 3.6 \times 10^{31}$ cm^{-2} s^{-1}. The results presented here are mainly based on the first 10 pb^{-1} from the data collected in 2001–2002.

The DØ detector has also been fully upgraded [1,2]. The central detector has been completely replaced with a new silicon vertex detector, a new central fibre tracker, a solenoid (2T magnetic field) and pre-showers. In addition, other parts of the detector have been partly or fully replaced (electronics, trigger system, muon detectors, etc.).

We report here the first preliminary results on new physics searches in various models [3].

2. Squarks and gluino searches in MSSM

In MSSM and supergravity scenarios, SUSY particles are pair produced. Then the two produced sparticles decay leading to two LSP which escape from the detector.

The production of squarks and gluinos ($p\bar{p} \to \tilde{q}\,\tilde{q}$, $\tilde{q}\,\tilde{g}$, $\tilde{g}\,\tilde{g}$) can lead to a $\geq$2 jets + missing E_{T} (mE_{T}) signature. The significant cuts are performed on mE_{T}, p_{T} of the jets, scalar sum of E_{T} and acoplanarity. Around ~ 6 pb^{-1} of data have been

analysed so far. Figure 1a shows the comparison between data and standard model (SM) Monte Carlo for the $\Delta\phi$ angle between the two leading jets. More data are awaited to get the first significant limits.

3. GMSB

In GMSB scenarios, the final state depends mainly on the nature and on the lifetime of the NLSP. An analysis with $\widetilde{\chi}_1^0$ NLSP leading to a $\gamma\gamma + \mathrm{m}E_{\mathrm{T}}$ final state has been performed with the first 8.7 ± 1.2 pb^{-1} of data. $W\gamma$, Wj, Zee, WW and WZ are the main backgrounds. One required cuts on $p_{\mathrm{T}\gamma} > 20$ GeV, track veto, $M_{\gamma\gamma} \notin 80$–102 GeV, $\mathrm{m}E_{\mathrm{T}} > 25$ GeV. Figure 1b shows the $\mathrm{m}E_{\mathrm{T}}$ distribution for data and SM Monte Carlo.

A model independent limit on the cross-section of the $\gamma\gamma + mE_{\mathrm{T}}$ events has been set: $\sigma < 0.9$ pb^{-1} at 95% CL.

4. RPV searches

In R-parity violating models (RPV), the LSP (usually the $\widetilde{\chi}_1^0$) decays, leading to various final state depending on the λ Yukawa coupling considered. If λ is not too small, single SUSY production is also possible. Two different final states have been studied so far. First, with a λ_{ijk} coupling, each $\widetilde{\chi}_1^0$ decays to $1\nu + 2$ charged leptons. The main background is instrumental, when a jet mimics an electron (e-fake) or when a cosmic μ mimics a real μ in the event.

Secondly, in case of a dominant λ'_{ijk} coupling, the LSP decays to 1 lepton + 2 jets. Because of the Majorana nature of the $\widetilde{\chi}_1^0$, the two charged leptons of the final state have an equal probability to be like sign or an opposite sign. One concentrates on LS events because they have a very low SM background. The main background comes from a wrong sign assignment of the electric charge of one of the two electrons.

Results of GMSB and RPV searches are summarized in table 1.

Table 1. Preliminary results from DØ on GMSB and RPV.

GMSB: $\gamma\gamma + mE_{\mathrm{T}}$ ($8.7 \pm 1.2\ pb^{-1}$)		RPV λ'_{122}: 2 like sign $e^{\pm} + \geq 1$ jets (9.7 ± 1.4 pb^{-1})	
Expected background	1.0 ± 0.3	SM background	0.1 ± 0.1
Data	2	Instrumental	2.8 ± 1.3
RPV λ_{ijk}: $e^{\pm}e^{\pm}\mu^{\pm}$ (5.2 ± 0.8 pb^{-1})		Data	2
SM background	0.13 ± 0.08	RPV λ_{ijk}: $e^{\pm}e^{\pm}e^{\pm}$ (5.2 ± 0.8 pb^{-1})	
$e + \mu + e$ fake	0.6 ± 0.2	SM background	0.9 ± 0.2
$e + e +$ cosmic μ	0.145 ± 0.014	Instrumental	1.0 ± 0.3
Data	1	Data	2

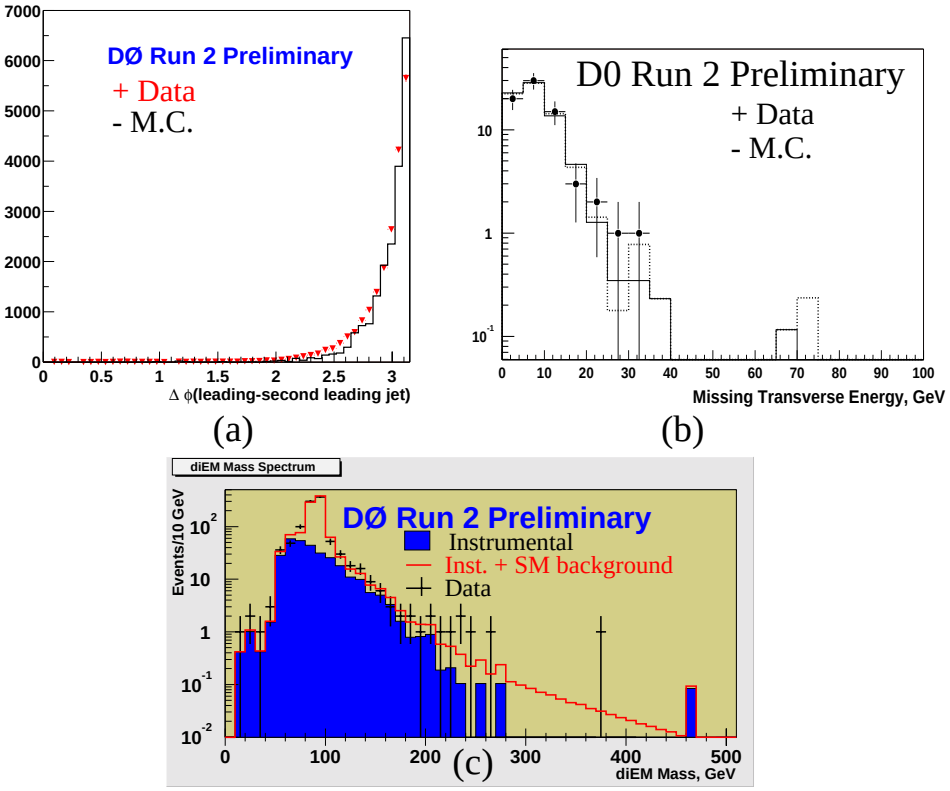

Figure 1. (**a**) Squarks and gluinos: $\Delta\phi$ angle of the two leading jets. (**b**) GMSB: mE_{T} for $\gamma\gamma$. (**c**) ED: di-electromagnetic invariant mass spectrum.

5. Large extra dimensions

Recent advances in the phenomenology of string theory suggest that some models could be tested at the TeV scale. In some of the large extra dimension models, two leptons or two γs can be produced through a virtual graviton.

In the diphoton channel, Drell–Yan and jets misidentified as EM objects are the main backgrounds. One performed a preliminary study with a luminosity of $\sim$10 pb^{-1} and set a 95% CL limit on the fundamental Planck scale: $M_S > 0.92$ TeV (GRW formalism).

Figure 1c shows the invariant mass distribution of the two electromagnetic objects.

6. Conclusion

We presented the first new physics searches results which show that the detector and the different background are well-understood.

All the presented studies are limited by statistics so that results will be improved dramatically in the coming months. We expect a luminosity of $\sim$200 pb^{-1} in summer 2003.

References

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[2] The DØ experiment, www-d0.fnal.gov
[3] DØ New Phenomena Group Run 2 Results for ICHEP and Fall 2002, DØ note 3995, and references therein (2002)