SUSY Search at HERA

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Abstract

Supersymmetric (SUSY) particle production at HERA : (1) $e^-p \to \tilde{e}^-\tilde{q}X$, (2) $e^-p \to \tilde{e}^-\tilde{\gamma}qX$ and (3) $e^-p \to \tilde{\gamma}\tilde{\nu}qX$ are investigated in the framework of the minimal SUSY standard model. Emphasis will be put on how to extract signals by minimizing noises coming from respective background processes. It is also pointed out that the differential left–right asymmetry using longitudinally polarized electron beam affords us usefull information on selectron masses.

Supersymmetry (SUSY) would be one of the promising idea to meet our expectations for "beyond the standard model". SUSY is a new kind of symmetry which relates bosons and fermions; there is an equal number of bosonic and fermionic degree of freedom in a multiplet forming one representation of SUSY. If all fundamental symmetries are local gauge symmetries, SUSY is also a local symmetry and it is inevitably led to include the gravity. In the low energy limit, $N = 1$ supergravity grand unified theories (GUT's) are reduced to the supersymmetric standard models with soft global SUSY breaking terms. Since the effective SUSY–breaking scale in the low energy supersymmetric standard model would be order of TeV, the superpartners of quarks and leptons, even if SUSY is broken, may reach within accelerators which are available presently or in near future. HERA will give us a favourable testing ground for SUSY partner searches.

The purpose of the present talk is to examine a scenario of SUSY unification scheme through phenomenological analyses of SUSY partner production at HERA energies. The main results are based on our present works whose details have been published elsewhere[1].

Our concerns are SUSY production processes

$$e^- p \longrightarrow \tilde{e}^- \tilde{q} X, \tag{1}$$

$$e^- p \longrightarrow \tilde{e}^- \tilde{\gamma} q X, \tag{2}$$

and

$$e^- p \longrightarrow \tilde{\gamma} \tilde{\nu} q X, \tag{3}$$

via charged currents as well as neutral currents. They are characterized by a quark jet and missing momentum/energy. In the reactions (1) and (2) the scattered electron is also helpful to identify the final state.

As for neutral current processes (1) and (2), the cross section $\sigma(e^- p \rightarrow \tilde{e}^- \tilde{q} X) > 0.1pb$ and $\sigma(e^- p \rightarrow \tilde{e}^- \tilde{\gamma} q X) > 0.01pb$ if $M_{\tilde{\gamma}} < 10GeV$ and $M_{\tilde{e}^-} + M_{\tilde{q}} < 150GeV$. An accoplanarity cut would be efficient to suppress the background process $e^- p \rightarrow e^- qX$. As shown in $Fig.1$ the scatter plots $\phi - \theta_e$ and $\phi - x$ have a wide distributions for SUSY partners in contrast to background events which concentrate on $\phi = 0$.

It is our finding that the x–distribution $d\sigma/dx$ serves to distinguishes the reaction (1) and (2) and gives us information on the squark masses and the neutralino parameters (see $Fig.2$). The left–right polarization asymmetry $A_{//}(E_{e\perp})$ is also appropriate to restrict mass difference of left– and right– handed selectron (see $Fig.3$).

Concerning the charged current process (3) our calculated total cross section $\sigma(e^- p \rightarrow \tilde{\gamma} \tilde{\nu} q X) > 0.1pb$ for $M_{\tilde{\chi}_1} < 40GeV$ if $M_{\tilde{\gamma}} < 10GeV$. The background process $e^- p \rightarrow \nu qX$ could be suppressed by cutting small x events in the x–distribution $d\sigma/dx$. We also found that the x–distribution is advantageous to restrict the mass of sneutrinos and squarks (see $Fig.4$).

Finally we would like to emphasize that the reactions $e^- p \rightarrow \tilde{e}^- \tilde{q} X$, $e^- p \rightarrow \tilde{e}^- \tilde{\gamma} q X$ and $e^- p \rightarrow \tilde{\gamma} \tilde{\nu} q X$ gives us a reasonable feasibility to observe the SUSY partners at HERA and bring us a new restriction on the SUSY parameters. The world first electron–proton collider HERA is an excellent machine producing rich final states which electron–positpron colliders will not attain. SUSY partner searches at HERA would meet our expectation in its big energy and a large coverage of accessible kinematic range.

References

1) Tadashi Kon, Keiichiro Nakamura and Tetsuro Kobayashi:
Phys.Lett.**223B**(1989)401 ; Z.Phys.C in press.
Other references are there in.

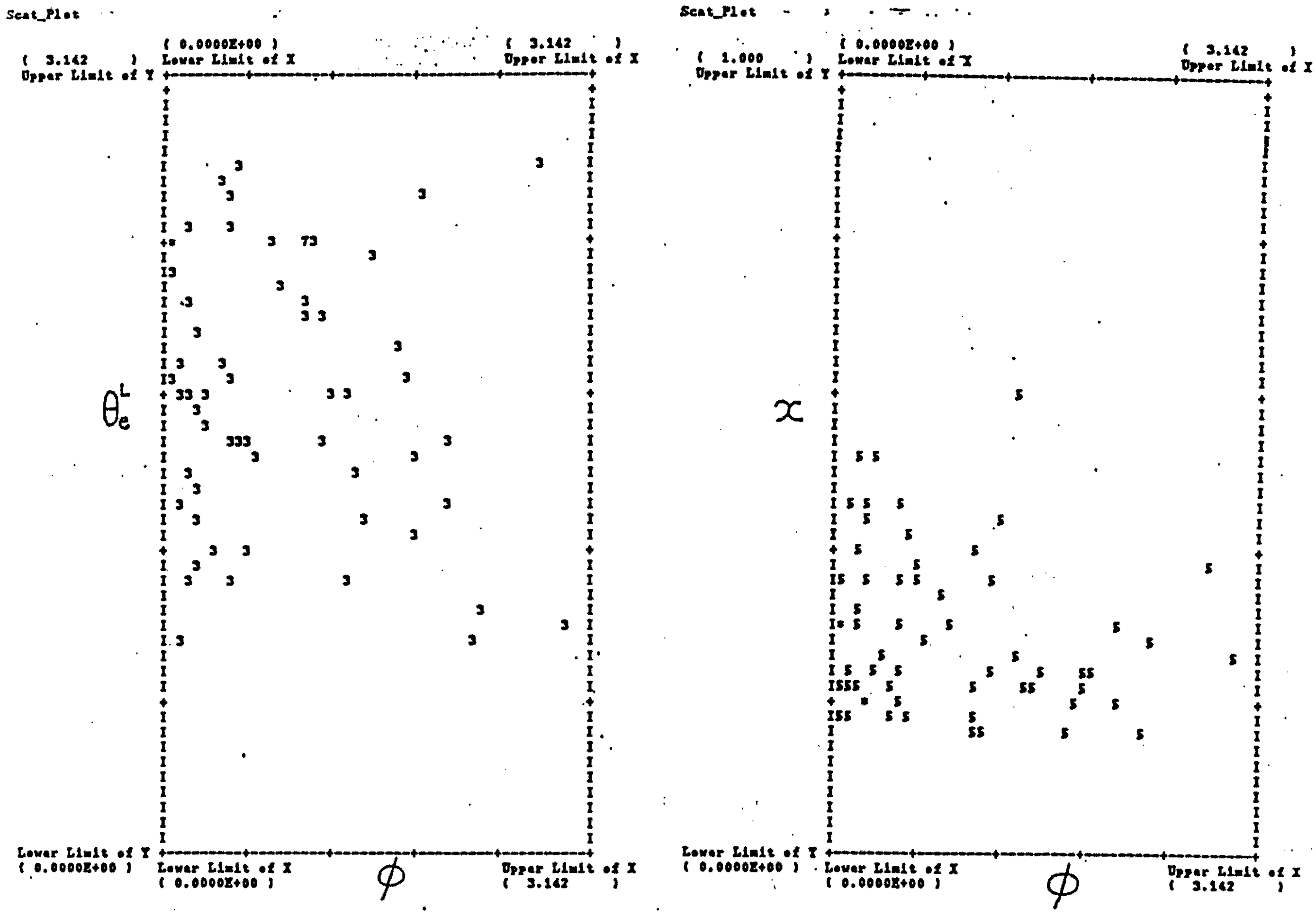
Figure Captions

Fig.1 Scatter plots $\phi - \theta_e^L$ and $\phi - x$ for $e^- p \rightarrow \tilde{e}\tilde{q}X$ for SUSY parameters: $M_{\tilde{\gamma}} = 10GeV, \mu = 100GeV$ and $tan\theta_v = 1$. $M_{\tilde{e}} = 40GeV$ and $M_{\tilde{q}} = 80GeV$ are assumed.

Fig.2 x distribution $d\sigma/dx$ for (1.1) $e^- p \rightarrow \tilde{e}^- \tilde{q}X$ and (1.2) $e^- p \rightarrow \tilde{e}^- \tilde{\gamma}X$. Parameters are $M_{\tilde{e}} = 50GeV$ and $M_{\tilde{q}} = 150GeV$ for (1.1) and $M_{\tilde{\gamma}} = 10GeV$ and $M_{\tilde{e}} = 40GeV$ for (1.2). SUSY parameters are $\mu = 100GeV$ and $tan\theta_v = 1$.

Fig.3 Differential left-right asymmetry $A_{//}(E_{e\perp})$ for $e^- p \rightarrow \tilde{e}^- \tilde{q}X$. Averaged selectron mass $M_{\tilde{e}} = 40GeV$ is commonly adopted. Dotted line is for the background process $e^- p \rightarrow eqX$.

Fig.4 x distributio $d\sigma/dx$ for $e^- p \rightarrow \tilde{\gamma}\tilde{\nu}qX$. Solid curve corresponds to a parameter set $M_{\tilde{\nu}} = 10GeV$, $M_{\tilde{\gamma}} = 10GeV$ (set I) and $tan\theta_v = 2$ and dashed line is for a set $M_{\tilde{\nu}} = 40GeV$, $M_{\tilde{\gamma}} = 10GeV$ and $tan\theta_v = 1$ (set II).


Scat_Plot
(0.0000E+00)
Lower Limit of X
(3.142)
Upper Limit of X
(3.142)
Upper Limit of Y
θ_e^L
Lower Limit of Y
(0.0000E+00)
ϕ
Scat_Plot
(1.000)
Upper Limit of Y
x
ϕ

(a) Fig. 1 (b)

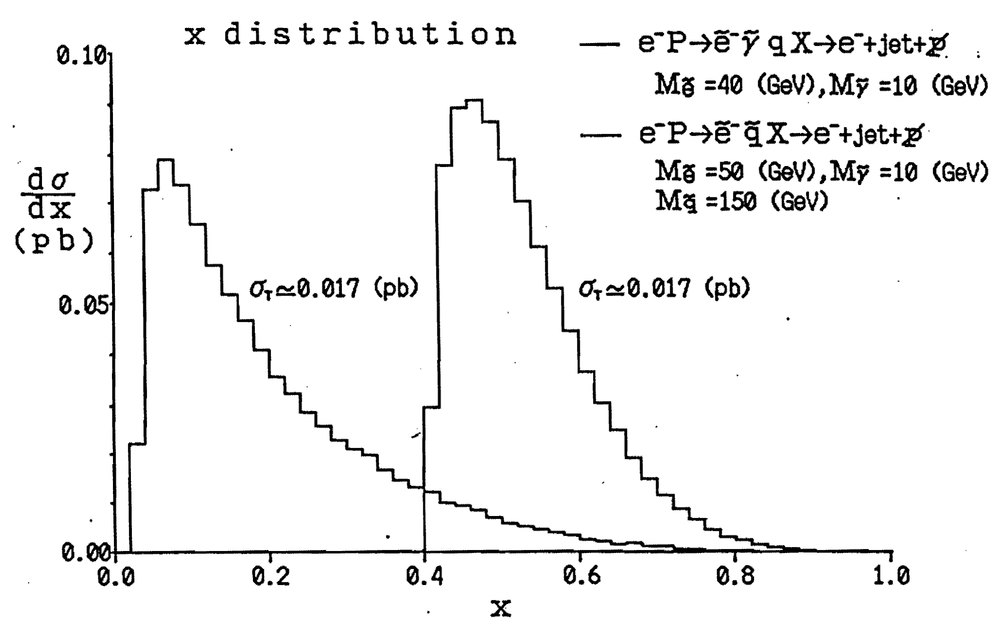
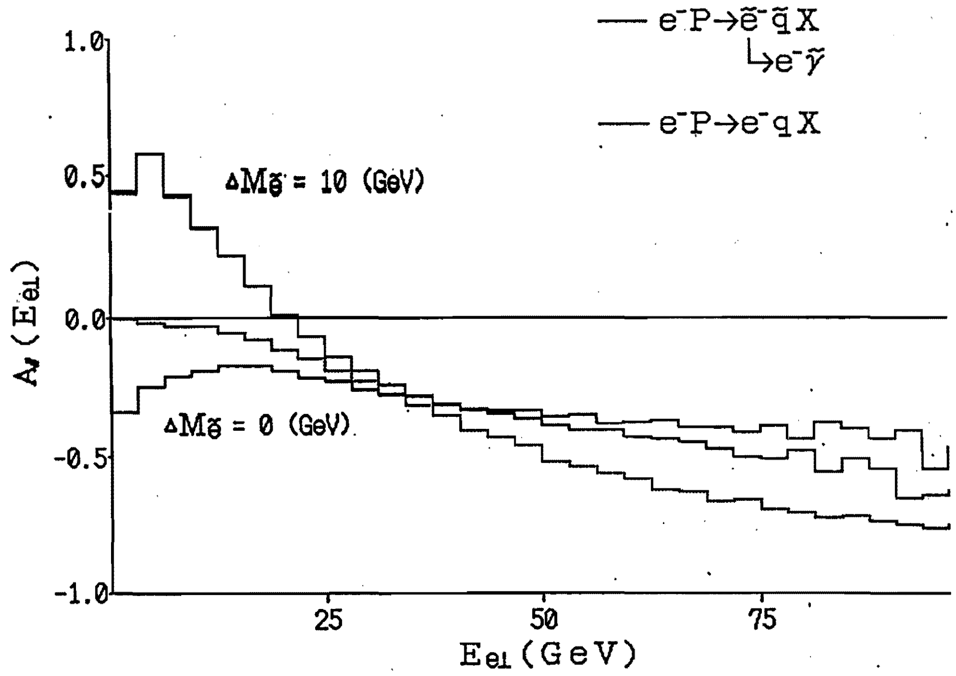
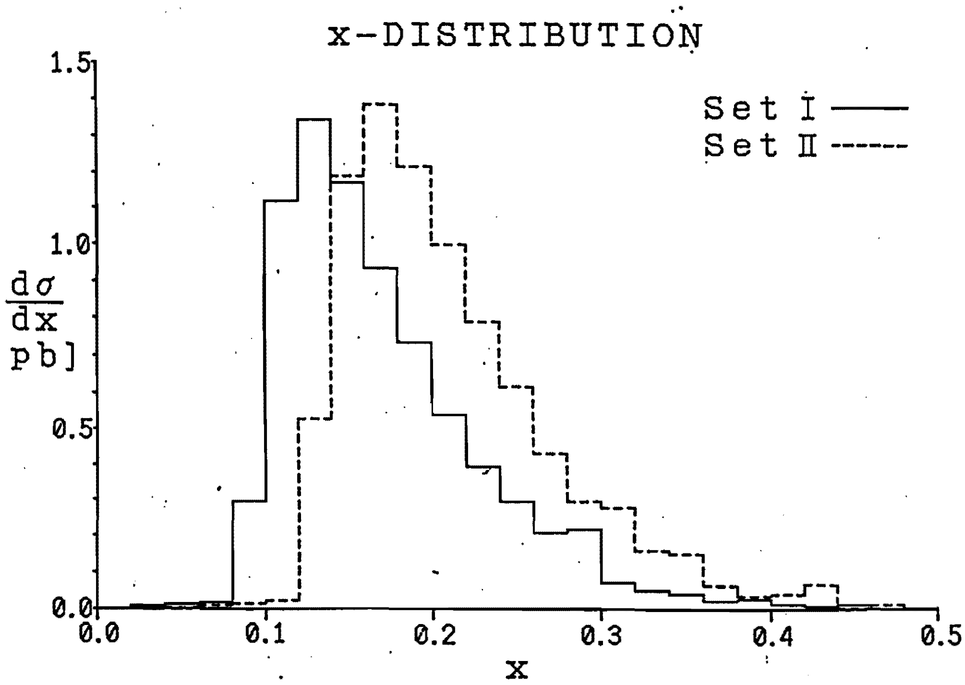

x distribution
$e^-P \to \tilde{e}^- \tilde{\gamma}\, q X \to e^- + \text{jet} + \not{p}$
$M_{\tilde{e}}$ =40 (GeV), $M_{\tilde{\gamma}}$ =10 (GeV)
$e^-P \to \tilde{e}^- \tilde{q} X \to e^- + \text{jet} + \not{p}$
$M_{\tilde{e}}$ =50 (GeV), $M_{\tilde{\gamma}}$ =10 (GeV)
$M_{\tilde{q}}$ =150 (GeV)
$\frac{d\sigma}{dx}$ (pb)
$\sigma_T \simeq 0.017$ (pb)
$\sigma_T \simeq 0.017$ (pb)
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8
1.0
x

Fig. 2


e⁻P→ẽ⁻q̃X
└→e⁻γ̃
e⁻P→e⁻qX
ΔMẽ = 10 (GeV)
ΔMẽ = 0 (GeV)
A(Eel)
1.0
0.5
0.0
-0.5
-1.0
25
50
75
Eel(GeV)

F i g. 3


x-DISTRIBUTION
Set Ⅰ
Set Ⅱ
dσ/dx
pb]
1.5
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
x

F i g. 4