RADIATIVE CORRECTIONS FOR DEEP INELASTIC SCATTERING IN THE PRESENCE OF AN ADDITIONAL Z'

10/90
ECFA
AACHEN

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ZEUTHEN

1. INTRODUCTION
2. METHOD OF CALCULATION
3. NUMERICAL RESULTS
   - $\delta_{NC} = \sigma_{NC}^{BORN+1L} / \sigma_{NC}^{BORN} - 1$
   - $A_{LR,SM}^{BORN+1L}$ vs. $A_{LR,SM+Z'}^{BORN+1L}$
4. CONCLUSIONS

1. INTRODUCTION

$$\mathcal{L} = e A_\mu J^\mu_\gamma + g_1 Z_\mu J^\mu_Z + g_2 Z'_\mu J^\mu_{Z'}$$

$$J^B_\mu = \sum_f \bar{f} \gamma_\mu [v^B(f) + \gamma_5 a^B(f)] f$$

$$\begin{pmatrix} Z_1 \\ Z_2 \end{pmatrix} = \begin{pmatrix} \cos\theta_M & \sin\theta_M \\ -\sin\theta_M & \cos\theta_M \end{pmatrix} \begin{pmatrix} Z \\ Z' \end{pmatrix}$$

$$\tan^2\theta_M = \frac{M_Z^2 - M_1^2}{M_2^2 - M_Z^2}$$

Here: $\cos\theta_M \to 1$

CONSIDER :

$$E_6 \longrightarrow SU_{3C} \otimes SU_{2L} \otimes U_{1Y} \otimes U_{1\chi} \otimes U_{1\psi}$$

QCD EWTHY Z'-BOSONS

$$Z' = \cos\theta_E \, Z'_\chi + \sin\theta_E \, Z'_\psi$$

3 CASES :

A: $Z'_\eta = \sqrt{\frac{3}{8}}\, Z'_\chi - \sqrt{\frac{5}{8}}\, Z'_\psi$

BINETRUY et al.
ELLIS et al. '86

B: Z'_χ

C: Z'_ψ

- RC TO $d^2\sigma$ MAY BE LARGE

BARDIN et al.
BÖHM et al.
BLÜMLEIN

- AS LARGE OR LARGER THAN
  Z'-EFFECTS

- CALCULATE : QED + LOOP CONTRIBUTIONS

2. METHOD OF CALCULATION

CORRECTIONS COME FROM:

1) BREMSSTRAHLUNG OF PHOTONS (QED)
2) STANDARD ELECTROWEAK LOOP CORRECTIONS AND RUNNING α_{QED}
3) LOOP CORRECTIONS : Z' EXCHANGE & EXTENDED HIGGS SECTOR (WILL BE IGNORED, BECAUSE ARE SMALL)

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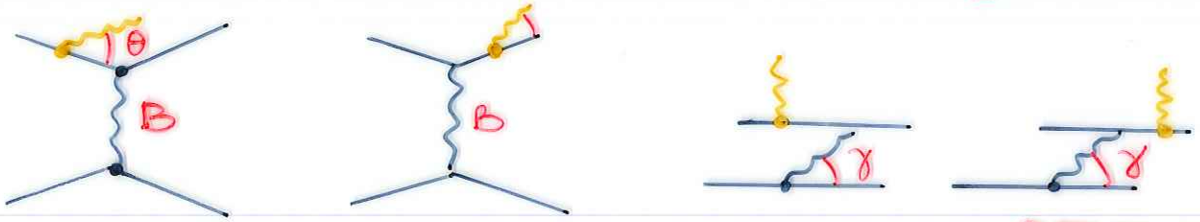
1) QED - BREMSSTRAHLUNG:

MAY BE DESCRIBED IN GOOD APPROXIMATION BY LLA. (JB's & HS's TALK). JB., Z.f.Phys. C47(1990) 89

$$\frac{d^2\sigma^{BORN}}{dx\,dy} = \frac{2\pi\alpha^2 S}{Q^4}\Big[\sigma^{\gamma\gamma}+\sigma^{\gamma Z}+\sigma^{ZZ}$$
$$+\sigma^{\gamma Z'}+\sigma^{ZZ'}+\sigma^{Z'Z'}\Big]$$



$B = \gamma, Z, Z'$ $\quad \sphericalangle$ coll. emission $\quad$ RELEVANT DIAGRAMS

$$\frac{d\sigma^{QED}}{dx\,dy} = \frac{\alpha}{2\pi}\ln\left(\frac{Q^2}{m_e^2}\right)\int_0^1 dz\,\frac{1+z^2}{1-z}\left\{\Theta(z-z_0)\,\frac{y}{\hat{y}}\,\frac{1}{z^a}\,\frac{d\sigma^B}{dx\,dy}\Big|_{\substack{x=\hat{x}\\ y=\hat{y}\\ s=\hat{s}}} - \frac{d\sigma^B}{dx\,dy}\right\}$$

$$+\frac{\alpha^3}{Sx}\ln\frac{Q^2}{\Lambda^2}\int_0^1 dz\,\frac{1}{z^3}\sum_i e_i^2\, z\left(q(z,Q^2)+\bar{q}(z,Q^2)\right)\cdot\frac{z^2+(x-z)^2}{x(1-y)}\left[1+(1-y)^2\right]$$

$$\frac{d\sigma^B}{dx\,dy} = \frac{d\sigma^{Born}}{dx\,dy}(y,z,z').$$

$\hat{x} = \hat{x}(z)$, $\hat{x}(z_0) = 1$

Fig.

$\hat{y} = \dfrac{z+y-1}{z}$;

INITIAL STATE RADIATION:

$a = 1$, $\hat{x} = xyz/(z+y-1)$, $\hat{s} = zS$

FINAL STATE RADIATION:

$a = 2$, $\hat{x} = xy/(z+y-1)$, $\hat{s} = S/z$

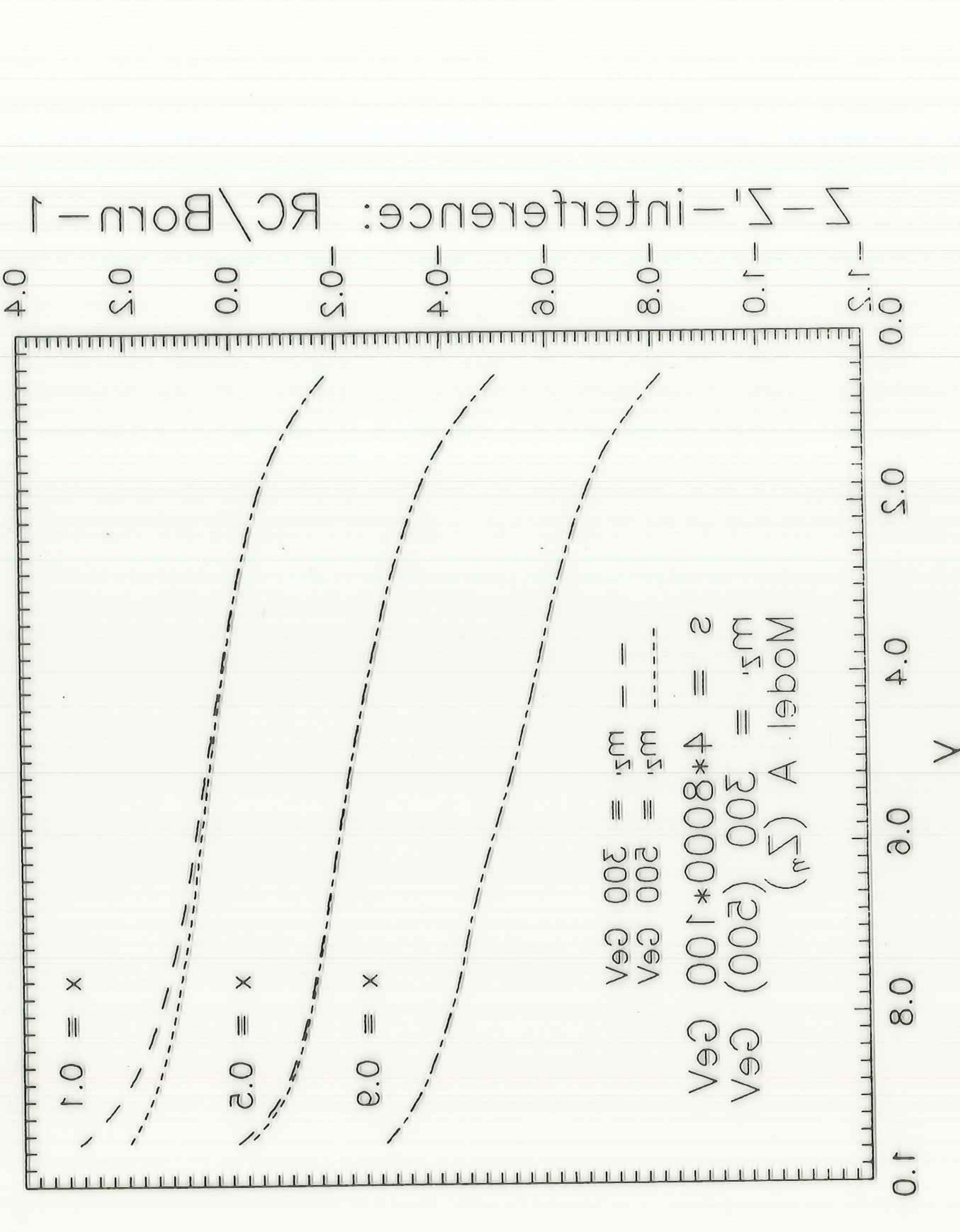
2.) EW- CORRECTIONS

FOLLOW: Bardin et al., Z. f. Phys. C44 (1989)
Bardin, Hollik, Riemann, MPI-PAE/PTh 32/90
PHE 90-09

$G_\mu \longrightarrow G_\mu\, \rho(\alpha, M_Z, M_H, m_t, \dots)$

$\sin^2\theta_W \longrightarrow \sin^2\theta_W \cdot \kappa(\alpha, M_Z, M_H, m_t \dots)$

$\kappa_e, \kappa_q, \kappa_{eq} = \kappa_i(s, Q^2, \text{flavour})$



Z−Z'−interference: RC/Born−1
y
x = 0.1
x = 0.5
x = 0.9
s = 4*8000*100 GeV
m_Z' = 300 (500) GeV
Model A (Z_η)
m_Z' = 300 GeV
m_Z' = 500 GeV

3. NUMERICAL RESULTS

1) RELATIVE CORRECTION TO THE CROSS SECTION:

$$\delta_{NC} = \frac{d^2\sigma^{0+1L}_{\gamma,Z,Z'}}{dx\,dy} \Big/ \frac{d^2\sigma^{0}_{\gamma,Z,Z'}}{dx\,dy} - 1$$

COMPARE : SM vs. SM + Z'

NEARLY UNCHANGED: $\therefore M_{Z'} = 300$ GeV , MODEL A.

FIG

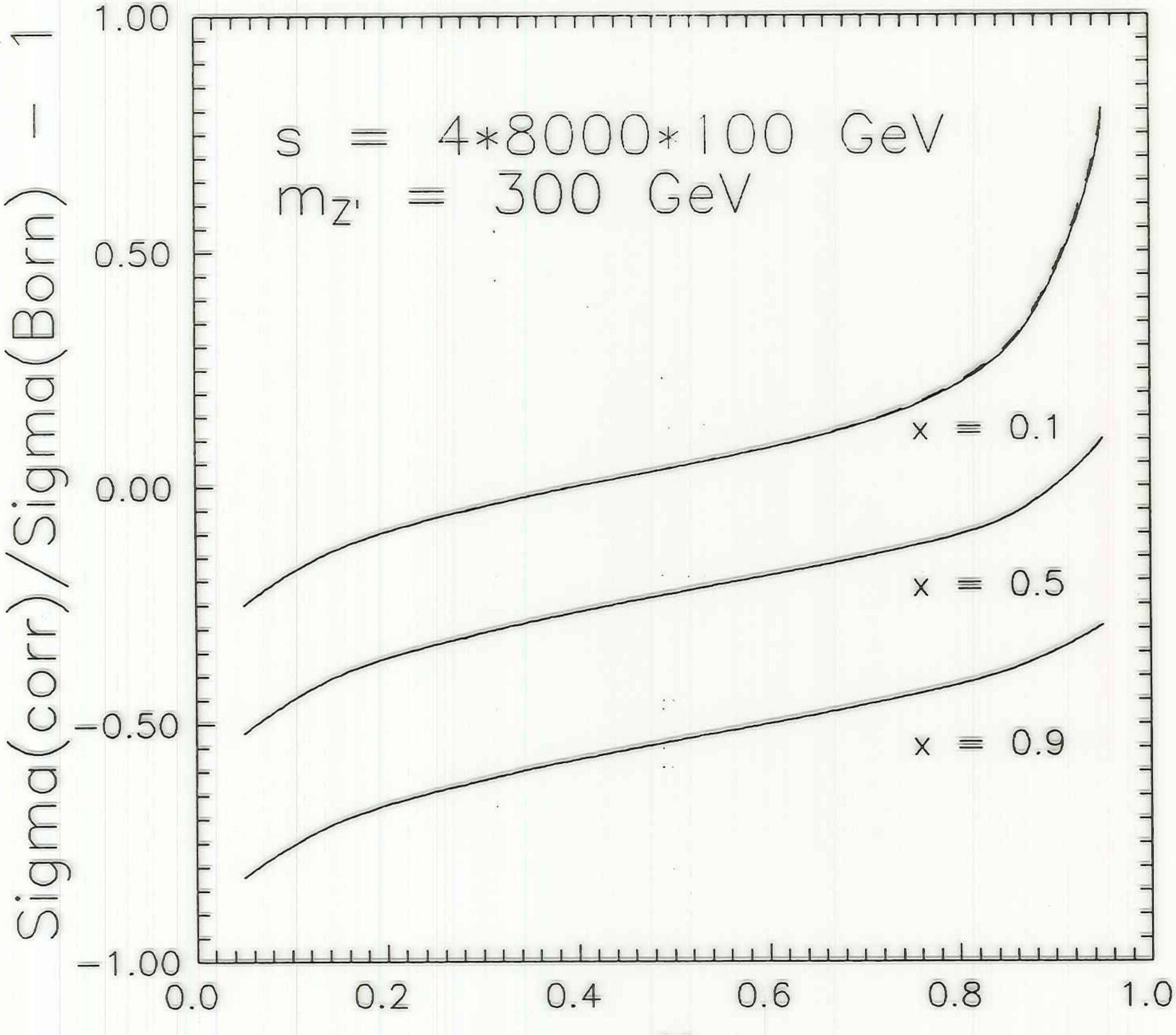
SIMILAR: MODEL B, C.

$\Longrightarrow$ RC TO $\frac{d^2\sigma}{dx\,dy}$ CAN BE CARRIED OUT IN THE WAY AS IN SM EVEN IF THERE IS A Z' ! (WE NEED THIS NOT TO KNOW BEFOREHAND.)

2) SEARCH FOR Z' VIA A^-_{LR}:

L/R =: $\lambda = -/+\,0.8$

$$A^-_{LR} = \frac{\frac{d^2\sigma^-}{dx\,dy}(\lambda=-.8) - \frac{d^2\sigma^-}{dx\,dy}(\lambda=+.8)}{\frac{d^2\sigma^-}{dx\,dy}(\lambda=-.8) + \frac{d^2\sigma^-}{dx\,dy}(\lambda=+.8)}$$


Sigma(corr)/Sigma(Born) − 1
1.00
0.50
0.00
−0.50
−1.00
0.0
0.2
0.4
0.6
0.8
1.0
y
s = 4*8000*100 GeV
m_Z' = 300 GeV
x = 0.1
x = 0.5
x = 0.9

WE DISCUSS THE MODELS A, B, C FOR

LEP2 × LHC AND $M_{Z'}$ = 300 & 500 GeV.

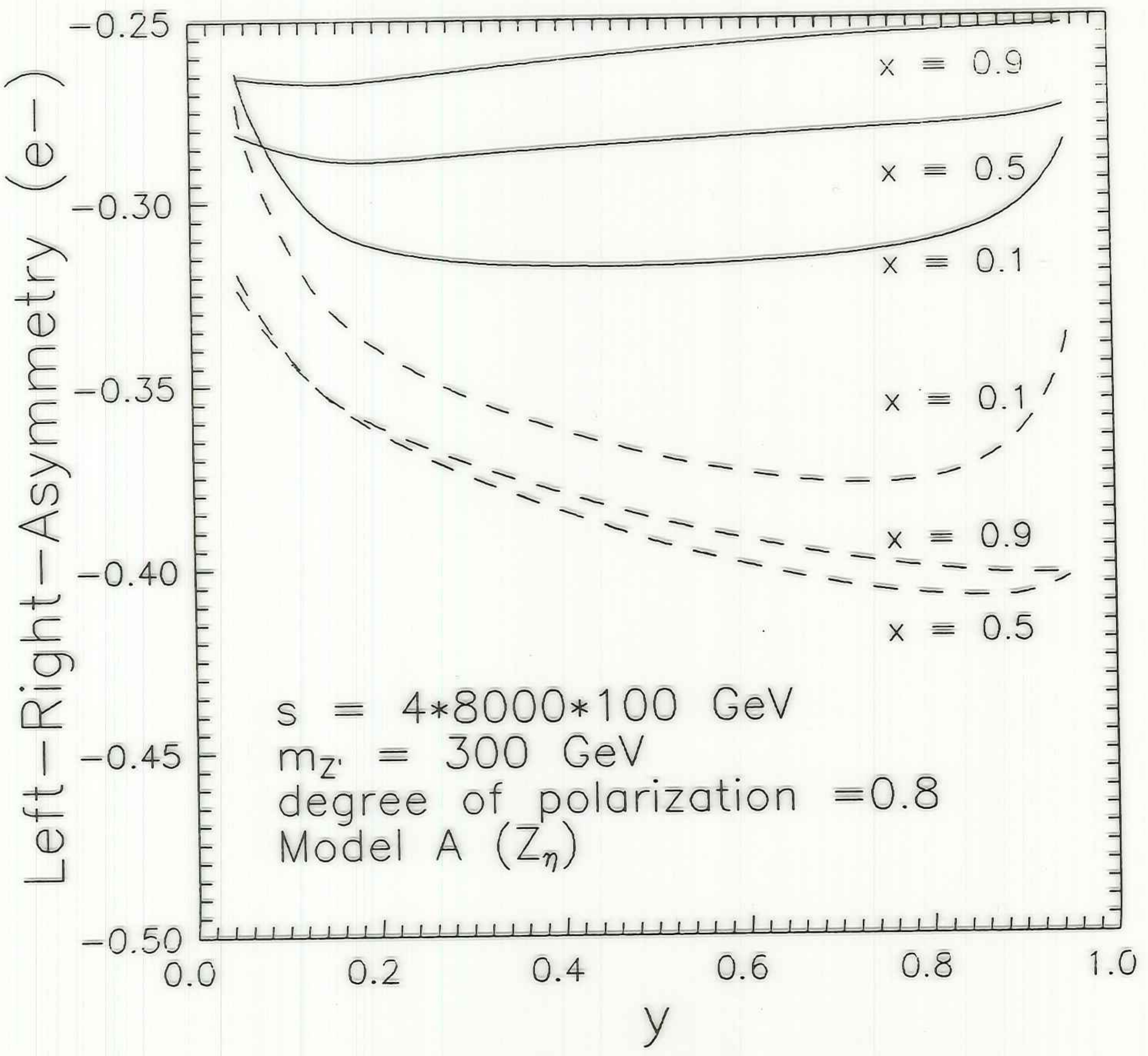
COMPARE: $\bar{A}_{LR}^{(0+1L)}\big|_{SM}$ VS. $\bar{A}_{LR}^{(0+1L)}\big|_{SM+Z'}$

$\boxed{\text{FIG'S}}$

- Z' EFFECT DIMINUISHES FROM A → C FOR $m_{Z'}$ = const.
- DIMIN. WITH GROWING $m_{Z'}$. (COMP. $m_{Z'}$ = 300 GeV, $m_{Z'}$ = 500 GeV)

⟹ • RC'S HAVE TO BE CONSIDERED TO DETERMINE Z' EFFECTS

• SIZEABLE EFFECTS ON (x, y)-DEPENDENCE OF $\bar{A}_{LR}$.


Left-Right-Asymmetry (e-)
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0.0
0.2
0.4
0.6
0.8
1.0
y
x = 0.9
x = 0.5
x = 0.1
x = 0.1
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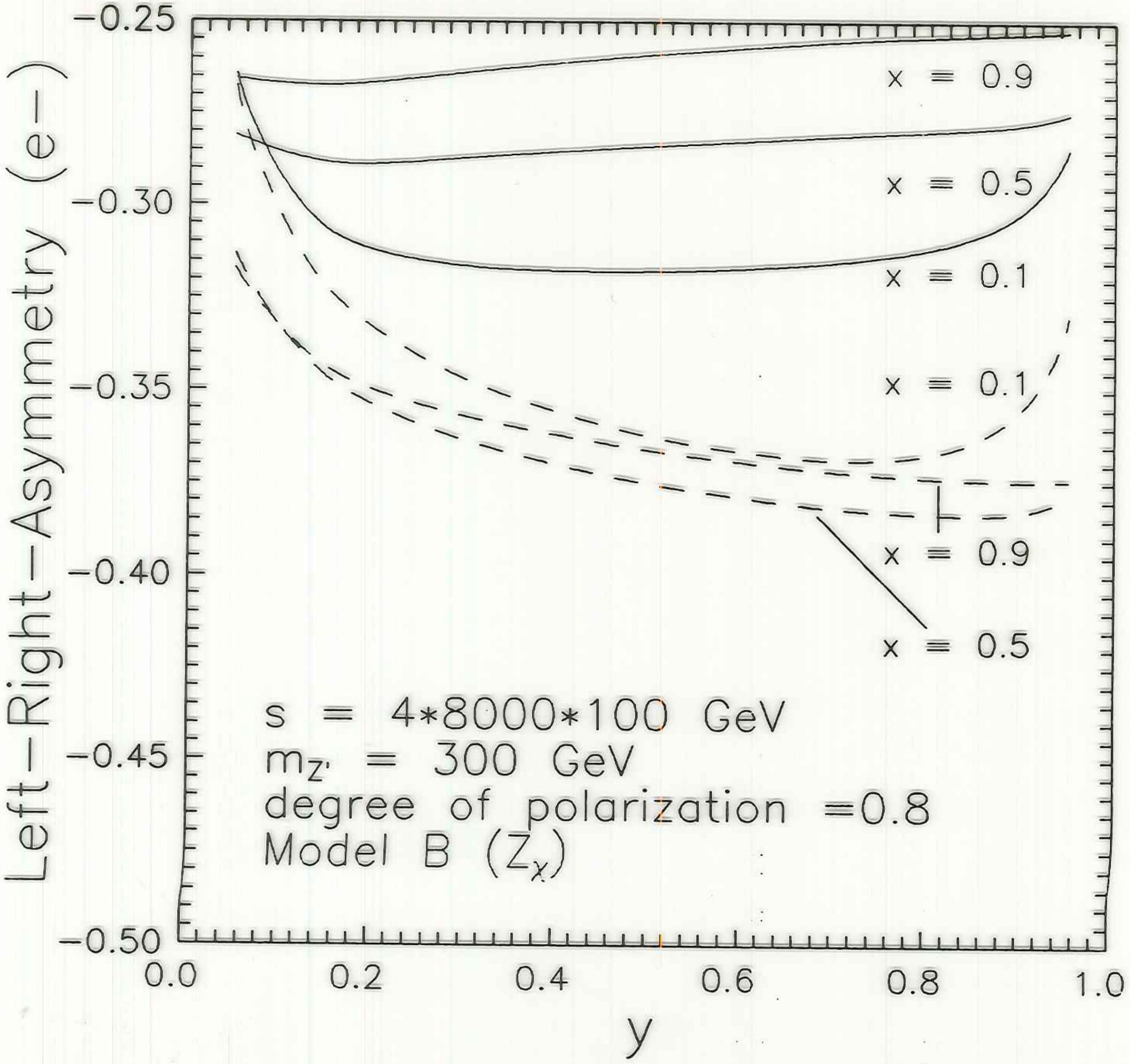
x = 0.5
s = 4*8000*100 GeV
$m_{Z'}$ = 300 GeV
degree of polarization =0.8
Model A (Z_η)



Left-Right-Asymmetry (e-)
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x = 0.1
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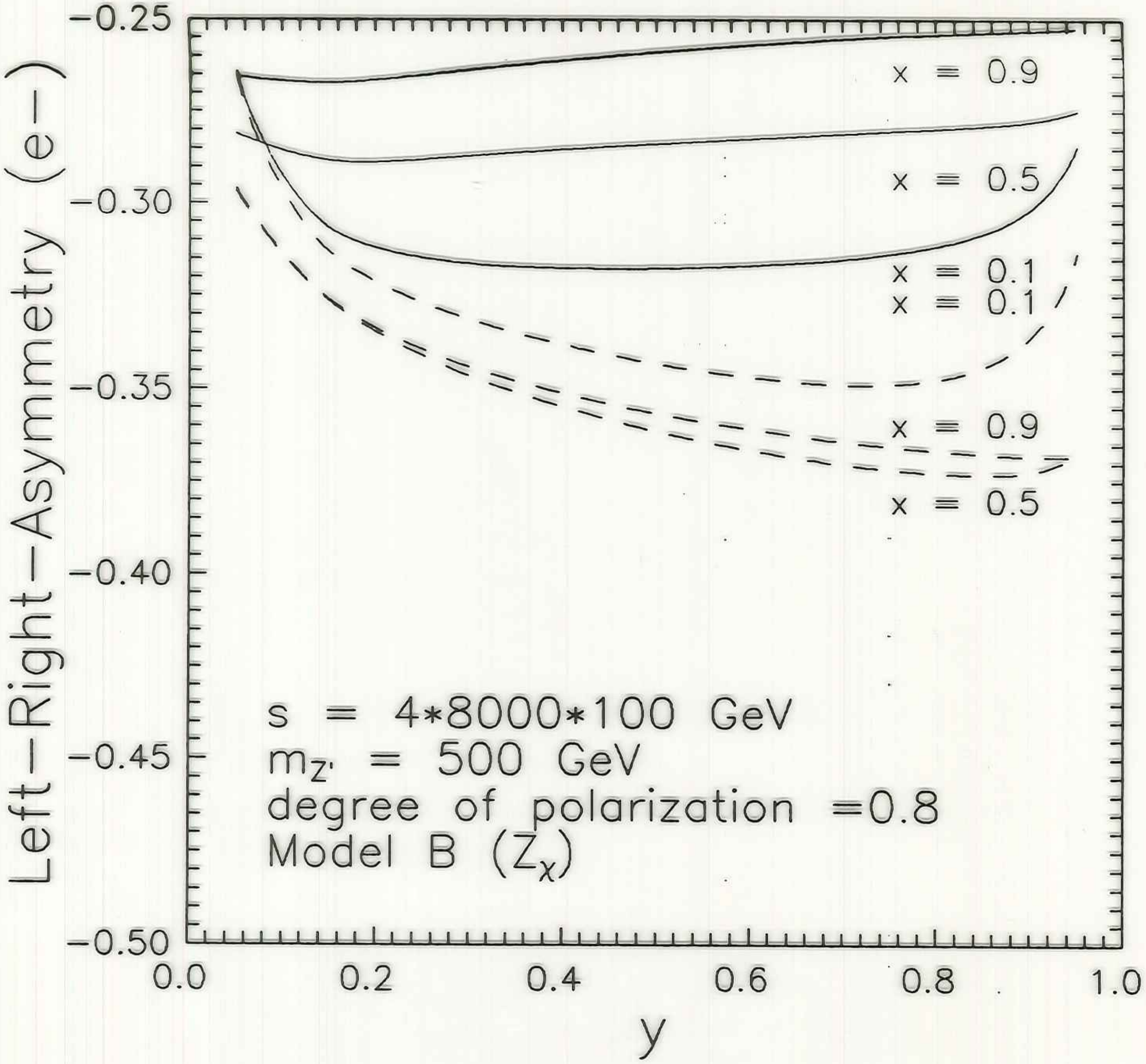
x = 0.5
s = 4*8000*100 GeV
$m_{Z'}$ = 300 GeV
degree of polarization =0.8
Model B (Z_χ)


Left−Right−Asymmetry (e−)
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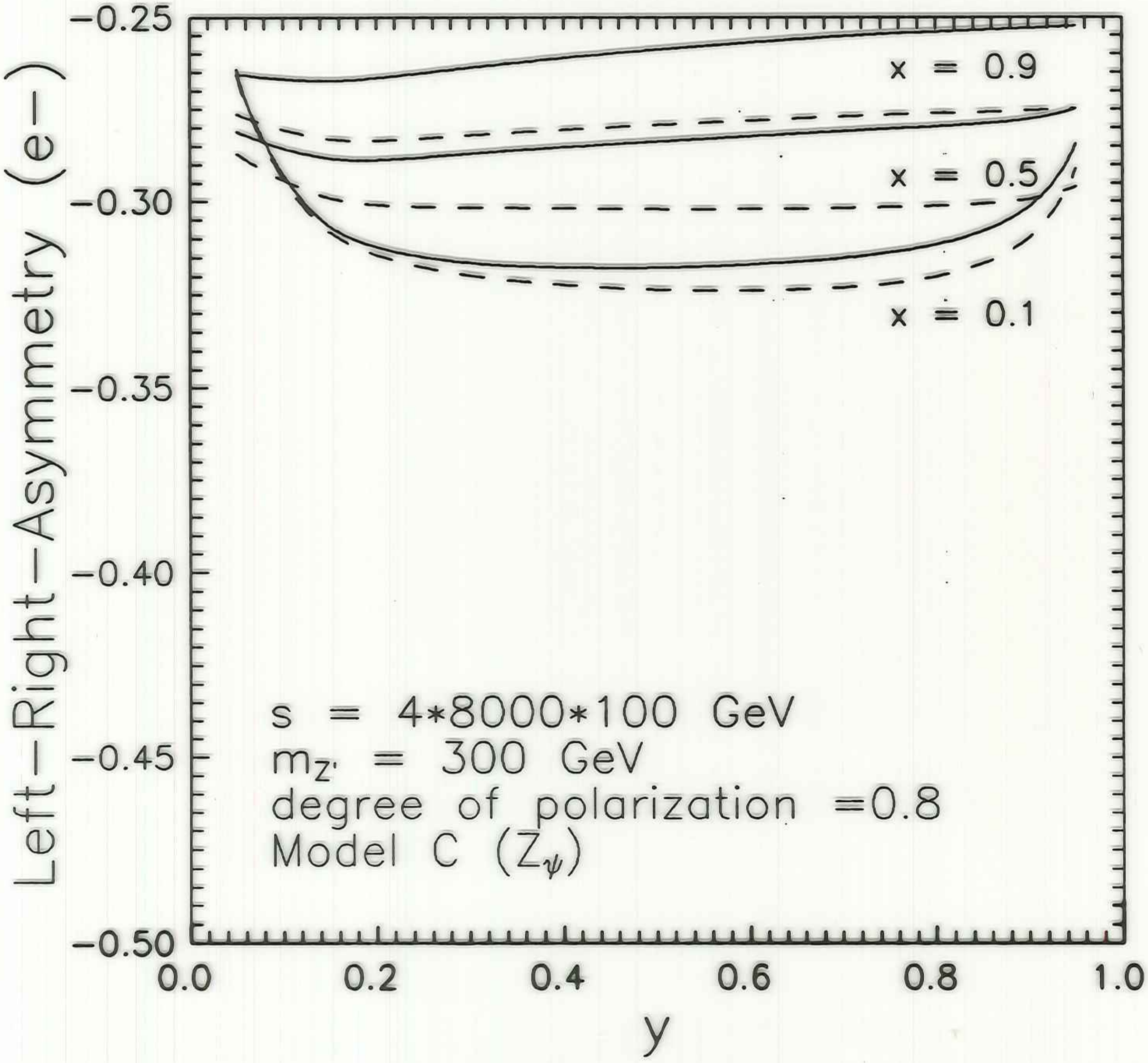

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0.2
0.4
0.6
0.8
1.0
y
x = 0.9
x = 0.5
x = 0.1
s = 4*8000*100 GeV
$m_{Z'}$ = 300 GeV
degree of polarization =0.8
Model C (Z_ψ)

4. CONCLUSIONS

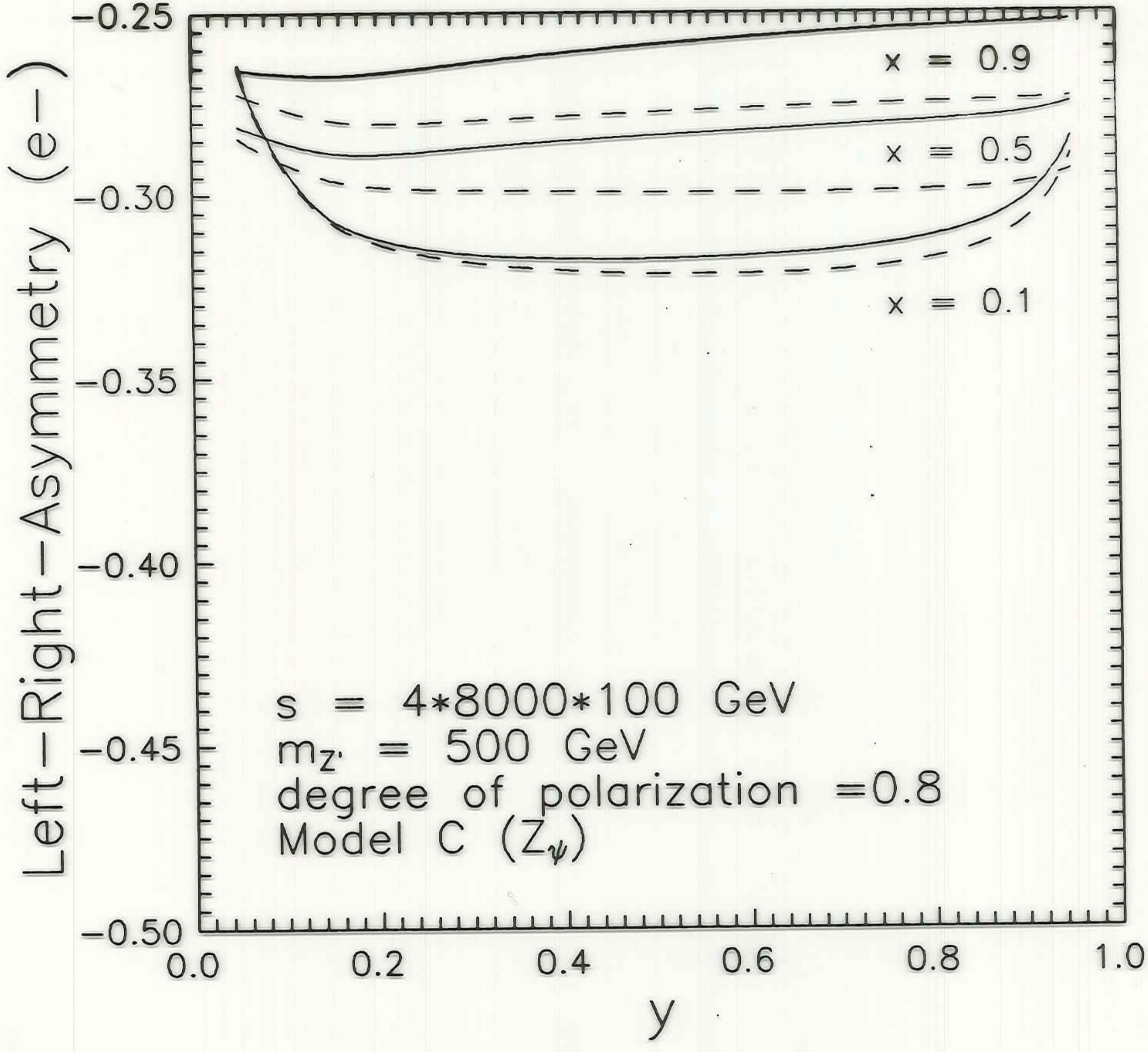
1) QED & LOOP CORR. (SM) FOR

$$ep \longrightarrow eX\,(\gamma)$$

INCLUDING Z' EFFECTS HAVE BEEN CALCULATED FOR SOME MODELS (A, B, C).

2) δ_{NC} REMAINS NEARLY UNCHANGED, IF SM VS. SM + Z' IS COMPARED : i.e. ONE MAY FIND Z' EFFECTS CORRECTLY IN GOOD APPROXIMATION EVEN IF SM RC'S ARE APPLIED TO $d\sigma/dx\,dy$

3) THE INFLUENCE OF THE RC'S ON THE (x, y) DEPENDENCE OF $A^-_{LR}\,(\lambda = .8)$ IS RATHER STRONG. THE Z'-EFFECT IS AFFECTED COMPARED TO $A^-_{LR}|_{SM}$ STRONGEST FOR MODEL (A > B > C). THE EFFECT IN $A^{-\,(0+1L)}_{LR}(\lambda)$ DIMINUISHES WITH GROWING $m_{Z'}$.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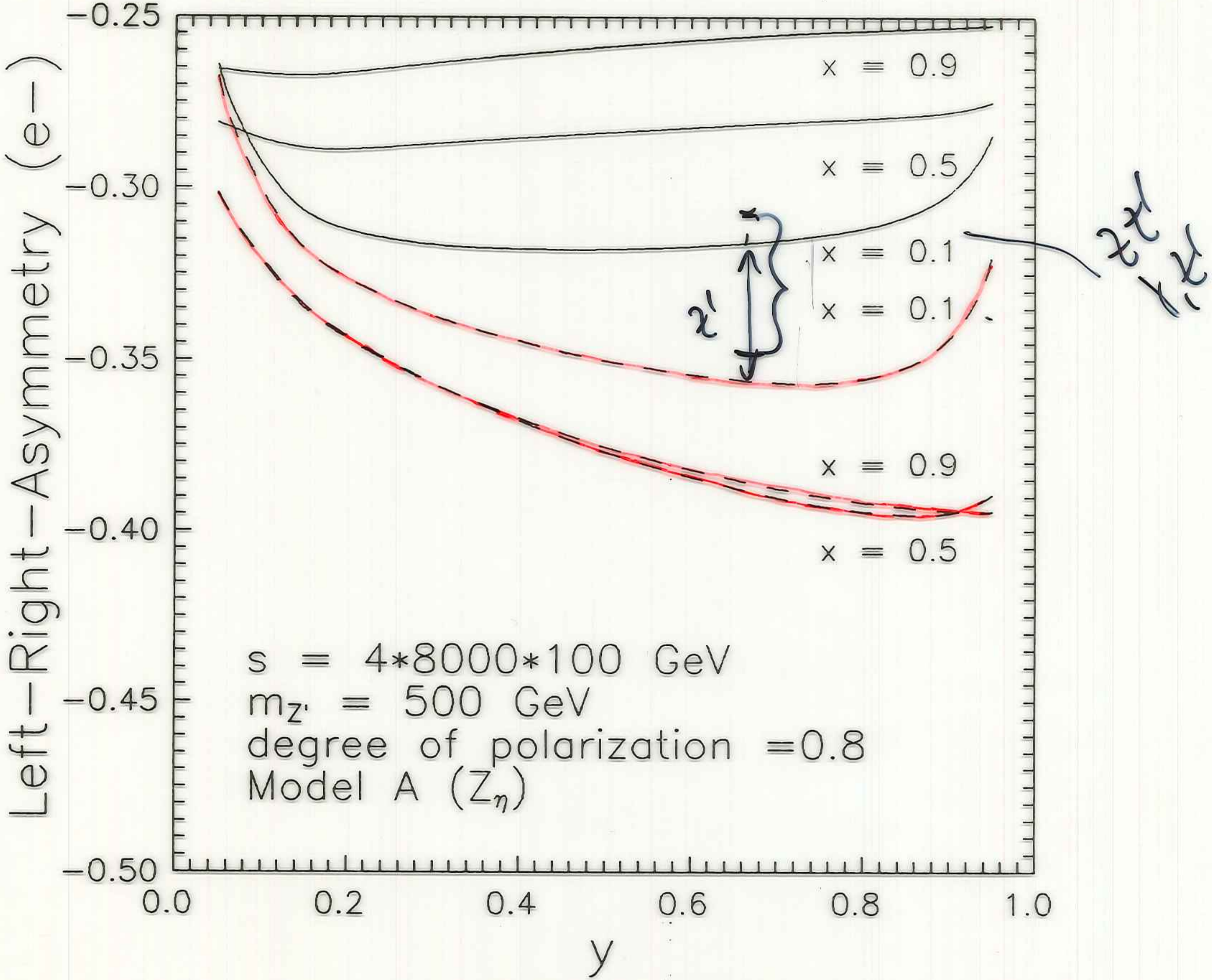
Model C (Z_ψ)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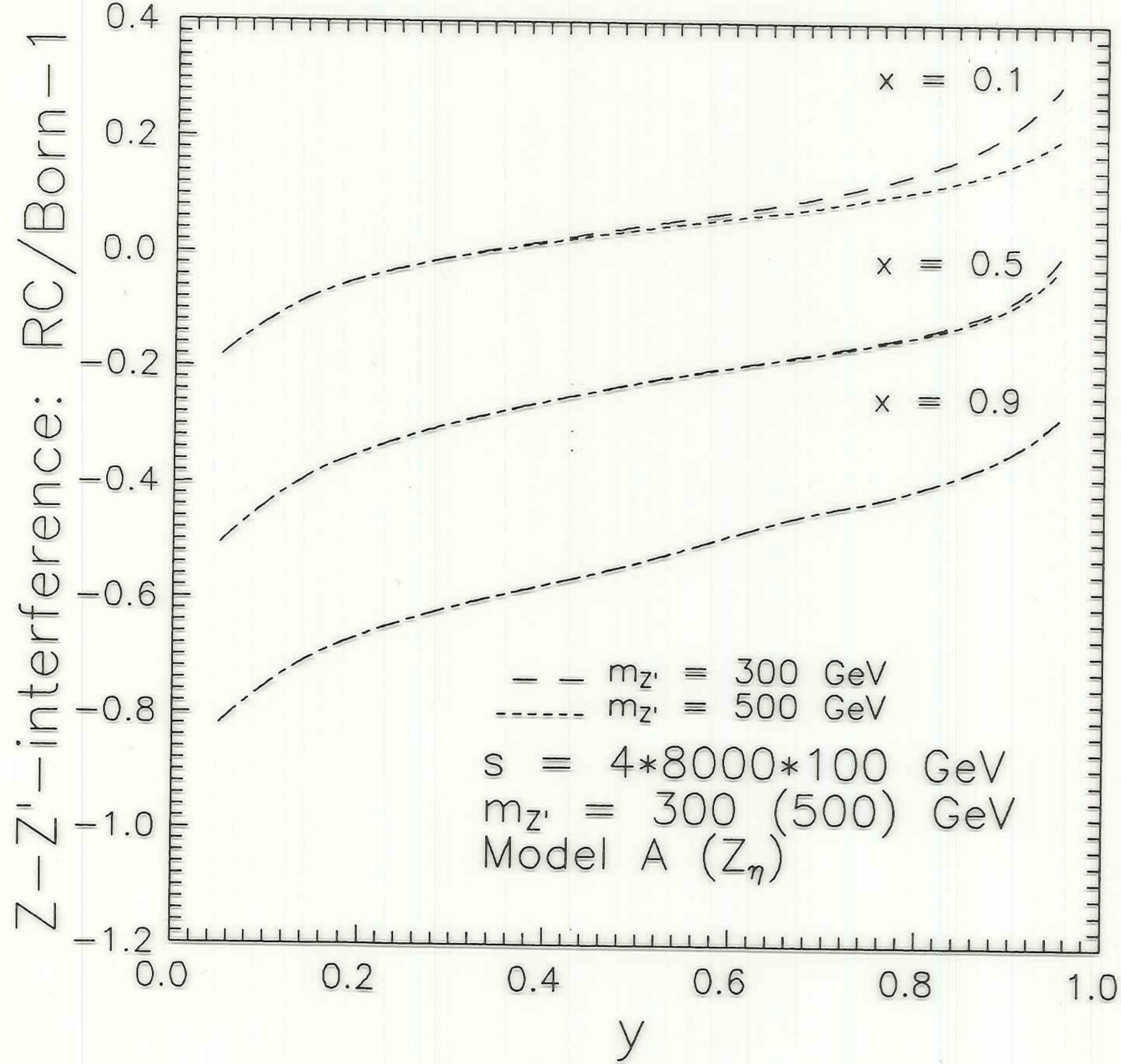
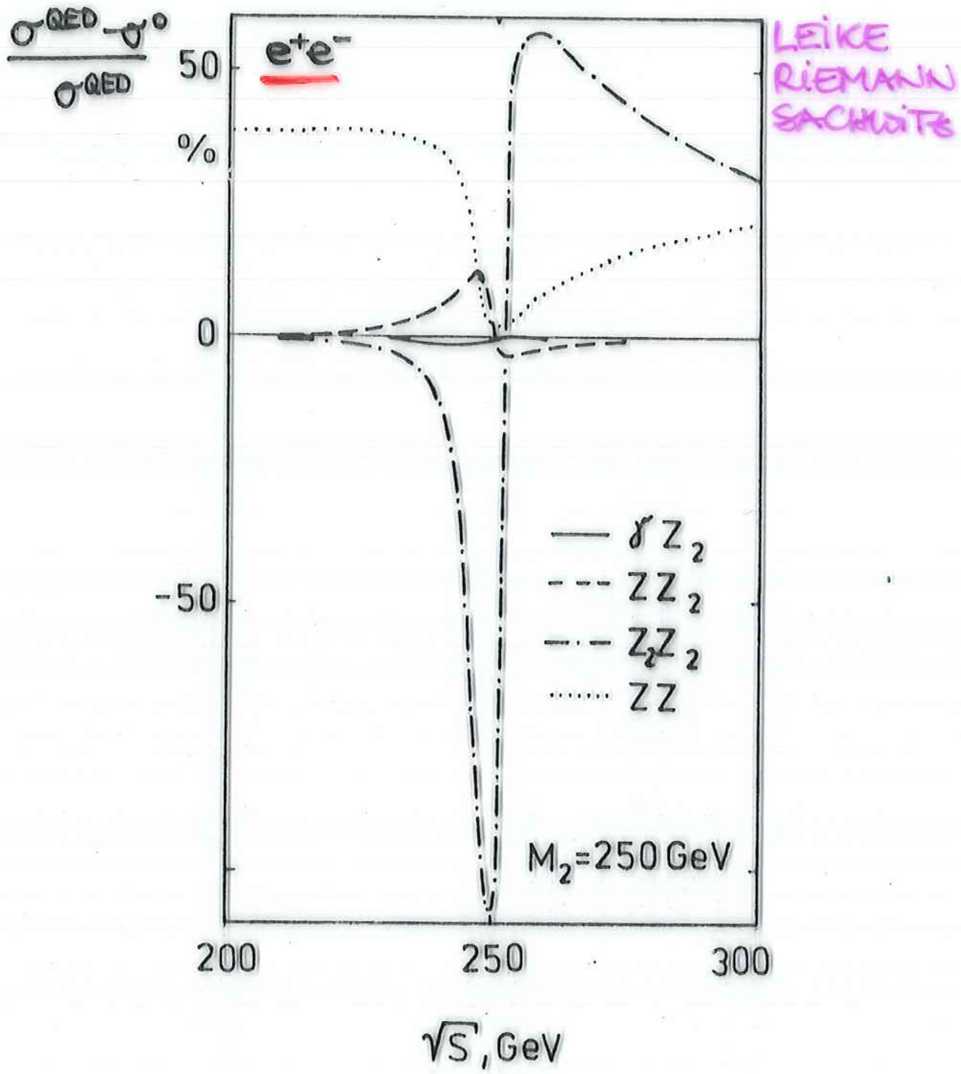


Z−Z'−interference: RC/Born−1
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
0.0
0.2
0.4
0.6
0.8
1.0
y
x = 0.1
x = 0.5
x = 0.9
$m_{Z'}$ = 300 GeV
$m_{Z'}$ = 500 GeV
s = 4*8000*100 GeV
$m_{Z'}$ = 300 (500) GeV
Model A (Z_η)



$\frac{\sigma^{QED} - \sigma^{0}}{\sigma^{QED}}$
%
50
0
-50
e^+e^-
γZ_2
ZZ_2
Z_2Z_2
ZZ
M_2=250 GeV
200
250
300
$\sqrt{S}$, GeV
LEIKE
RIEMANN
SACHWITZ

Fig. 2