UPDATE ON EXPERIMENTAL ASPECTS OF LEPTON-FLAVOUR VIOLATION

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① $\tau \to eee$

$\tau \to e\mu\mu$

$\tau \to \mu\mu\mu$ etc.

LC Z^0 FACTORY = A TAU FACTORY TOO

② $Z \to e\mu$

$Z \to e\tau$

$Z \to \mu\tau$

SEE FRASCATI TALK FOR DETAILS

(NB. hep-ph/9803322 is wrong)

NEUTRINOLESS TAU DECAYS

LC Z FACTORY $\mathcal{L} = 5.6 \times 10^{33}$ @ $\sqrt{s} = m_Z$

with $P_- = 0.8$, $P_+ = 0.6$ $\Rightarrow$ 4×10^9 Z^0's / 10^7s year

$\Rightarrow$ 3×10^8 τ's per 10^7s year too

(B-factories : 6×10^7 τ's per 10^7s year at peak luminosity of 3×10^{33}.)

Search for $\tau \to eee$
$\tau \to e\mu\mu$
$\tau \to \mu\mu\mu$ etc.

Can extend from present
$B(\tau \to \ell\ell\ell) < \simeq 2 \times 10^{-6}$ @ 90% CL
(CLEO 98)

to of order

$$\boxed{B(\tau \to \ell\ell\ell) < 2 \times 10^{-8}}$$ 90% CL

ε, b needs to be established.

(assuming $\varepsilon = 40\%$, bkgd negligible, no signal.)

(B-factory sensitivity $\simeq 2 \times 10^{-7}$) ($\varepsilon = 20\%$ like CLEO)

$$\Rightarrow \boxed{B(Z \to \ell\tau) \lesssim 8 \times 10^{-8}}$$ 95% CL

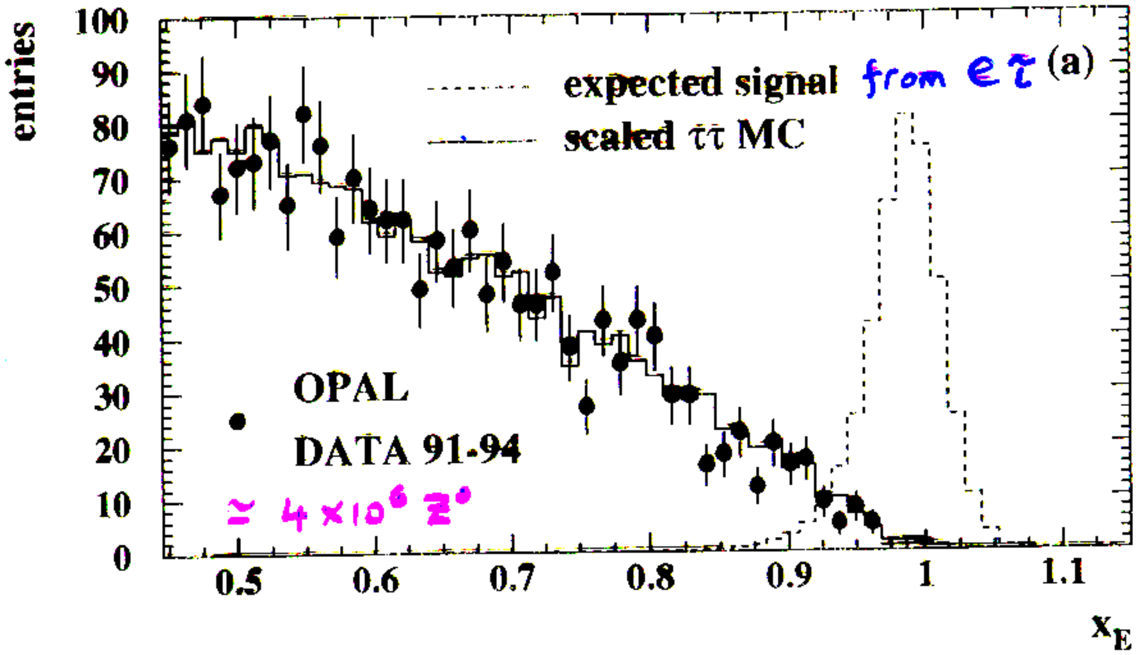
LEP1 SENSITIVITY

PDG 98 : 95% CL UPPER LIMITS ON

	$B(Z \to \mu\tau)$	$B(Z \to e\tau)$	$B(Z \to e\mu)$
ALEPH	100×10^{-6}	120	26
DELPHI	12×10^{-6}	22	2.5
L3	19	13	6
OPAL	17	9.8×10^{-6}	1.7×10^{-6}

(ALL DATA NOT YET ANALYSED!)

FOR EXAMPLE :



$\frac{\sigma_E}{E} = 2.5\%$

SENSITIVITY IS LIMITED BY THE $\tau^+\tau^-$ BACKGROUND

WITH $\tau \to e \nu_e \nu_\tau$ FOR $Z \to e\tau$

AND $\tau \to \mu \nu_\mu \nu_\tau$ FOR $Z \to \mu\tau$

WHERE THE LEPTON FROM THE τ DECAY IS NEAR THE ENDPOINT.

$Z \to e\mu$

(N.B. $B(\mu \to eee)$ constraints $\Rightarrow$ $B(Z \to e\mu) < 6 \times 10^{-13}$!)

some caveats though

with exptl. resolution on 45 GeV e and μ

of $\left(\frac{\Delta p}{p}\right)_\mu = 0.5\%$ and $\left(\frac{\Delta E}{E}\right)_e = 1.5\%$

bkgd from $Z \to \tau^+\tau^- \to e^\pm \mu^\mp \nu_e \nu_\mu \nu_\tau \bar{\nu}_\tau$

is small

($< 2 \times 10^{-8}$ per Z^0 within $\simeq \pm 2\sigma$)

Expect 95% CL of about

$$B(Z \to e\mu) < 2 \times 10^{-9}$$

input $\varepsilon = 40\%$

bkgd $= 0.$

$\tau \to \mu\tau$, $\tau \to e\tau$

LIMITING FACTOR : $\tau^+\tau^- \to \ell^+ \nu_\ell \nu_\tau X^- \nu_\tau$

with ℓ near endpoint.

Example

Use $x_{mean} > 1.0$ as signal region ($\varepsilon \simeq 50\%$)

probability ($\tau^+\tau^- \to \ell$ with $x_{mean} > 1.0$)

$$= 5 \times 10^{-6} \left[\frac{\left(\frac{\Delta p}{p}\right)}{0.5\%} \right]^2$$

$$= \begin{array}{ll} 5 \times 10^{-6} & \mu \\ 4.5 \times 10^{-5} & e \end{array}$$

Expected 95% CL upper limits for $x_{mean} > 1.0$

(bkgd uncertainty = 0).

$\varepsilon = 40\%$

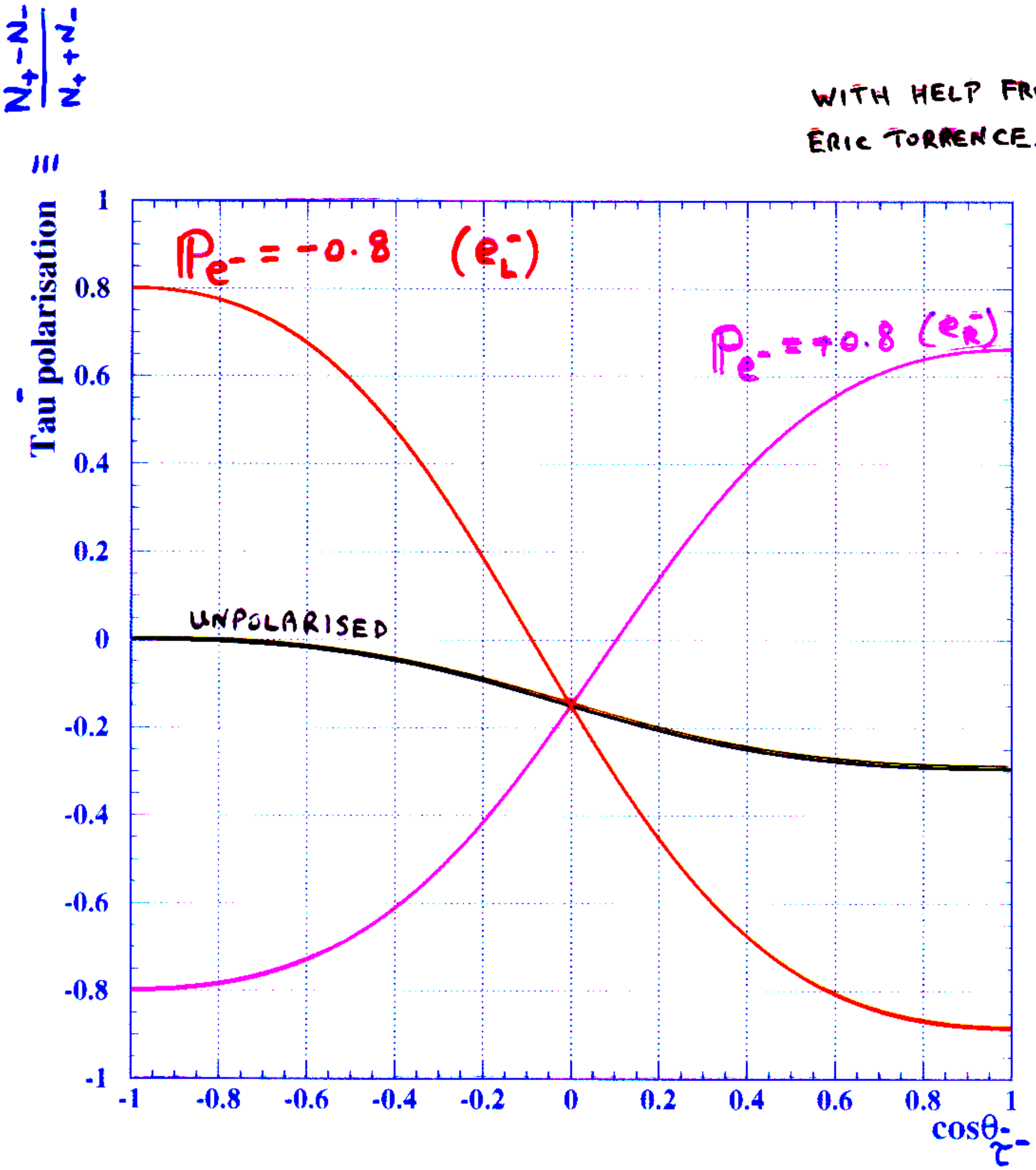
	$B(\tau \to \ell\tau)$ (95% CL)	S/B
$\mu\tau$	2.2×10^{-8}	0.05
$e\tau$	6.5×10^{-8}	0.017

NOT BAD !

BUT CAN DO BETTER AND PROBABLY NEED TO IMPROVE THE PURITY.

BEAM POLARISATION

WITH HELP FROM
ERIC TORRENCE.



eg. with $P_{e^-} = -0.8$
for $\cos\theta_{\tau^-} > 0.5$

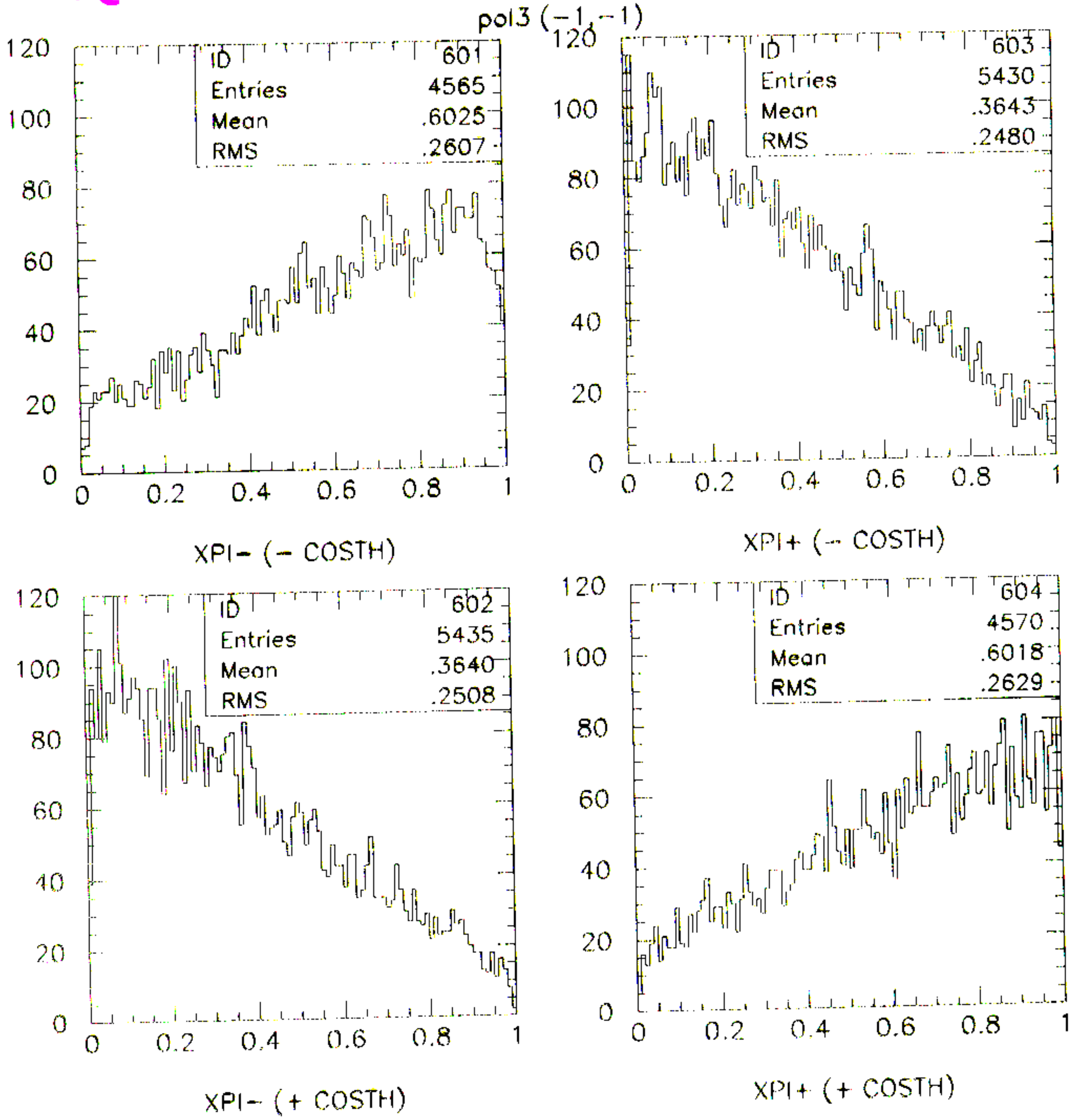
τ^- is $\approx$ 92% $\lambda = -1$
so $\tau^+ \to \ell^+$ with $x \approx 1$
reduced by $\approx$ a
factor of 12 !

$e^+e^- \to \tau^+\tau^- \to \pi^+\nu_\tau \pi^-\bar{\nu}_\tau$

KORALZ

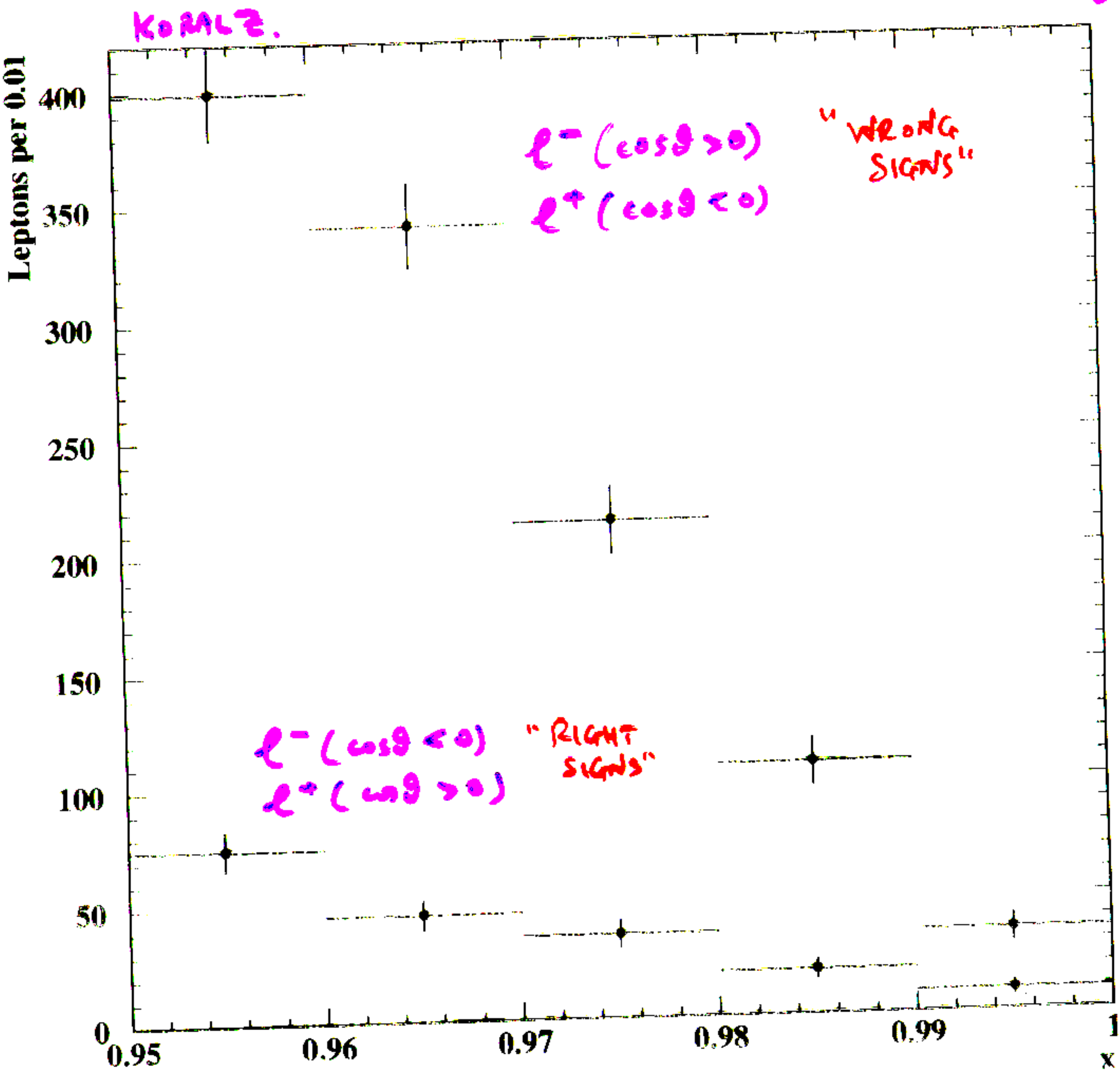
$P_{e^-} = -1 \quad (e_L^- e_R^+)$

$P_{e^+} = +1$



$$e^+_R e^-_L \to \tau^+\tau^- \to \mu^+ \nu_\mu \bar{\nu}_\tau \, e^- \bar{\nu}_e \nu_\tau$$

6×10^5 $\tau \to$ lepton decays



For $x > 0.98$

$$x = \frac{P_{e,\mu}}{E_b}$$

$$\frac{\text{WRONG SIGNS}}{\text{RIGHT SIGNS}} = \frac{5}{1}$$

$\Rightarrow$ CAN REDUCE BKGD BY 5 FOR $\varepsilon \simeq 45\%$.

.... TO BE OPTIMISED.

SENSITIVITY ESTIMATES

$B(\tau \to \ell\ell\ell) < 2 \times 10^{-8}$ 90% CL

$B(\tau \to e\mu) < 2 \times 10^{-9}$ 95% CL

$B(\tau \to \mu\tau) < f \cdot 2.2 \times 10^{-8}$

$B(\tau \to e\tau) < f \; 6.5 \times 10^{-8}$

95% CL

$f = 0.5^{+0.5}_{-0.3}$ FROM IMPROVED METHODS.