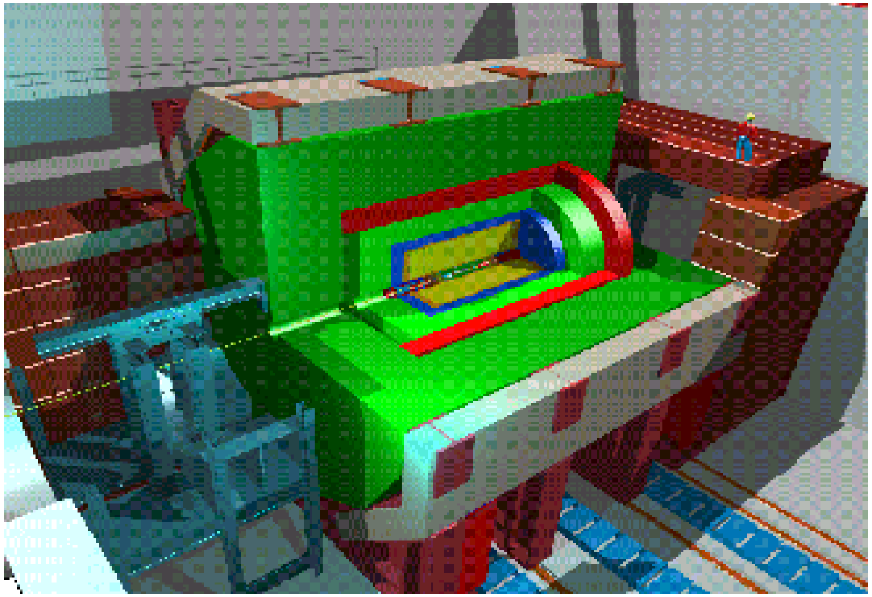
Precision Measurements of Beam Polarization at the LC (The Case of Single-W Production)

Filip Franco-Sollova

Contents

- Beam Polarization at the LC
- Measuring the Polarization
- Single-W production
- Background
- Results
- Conclusions and Outlook

Beam Polarization at the LC



High Lum. Linear Collider

+

Longit. Beam Polarization

=

Precision Measurements to test the SM

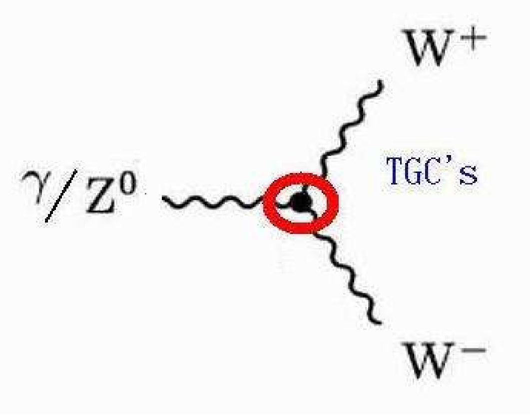
For some studies this is possible
ONLY if Beam Polarization is accurately determined

BEAM POLARIZATION AT THE LC

An Example: TGCs

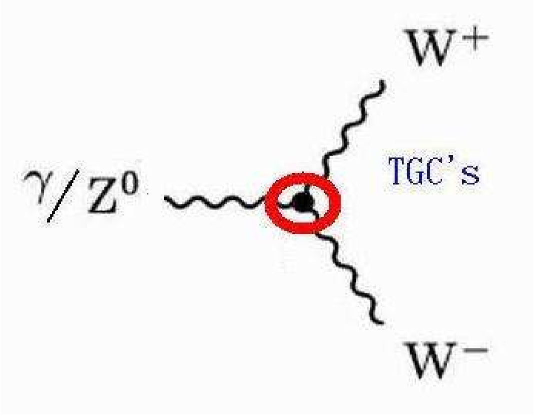
Errors from an uncertainty of

0.5% in the e− polarization



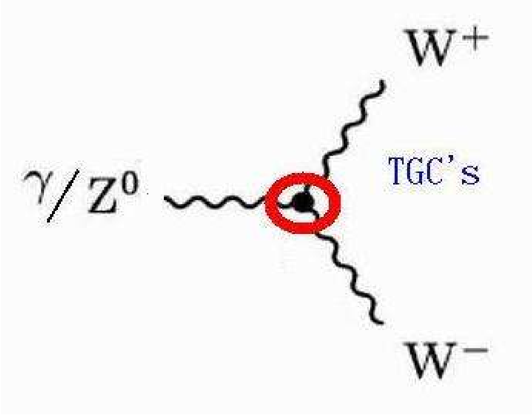
An Example: TGCs

Errors from an uncertainty of 0.5% in the e− polarization	≈	Statistical Errors



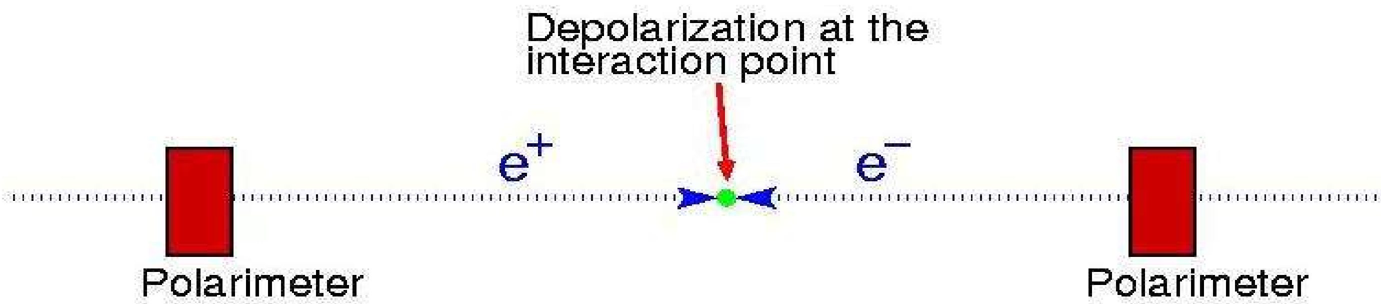
An Example: TGCs

Errors from an uncertainty of 0.5% in the e− polarization ≈ Statistical Errors



But ...

Using Polarimeter:



e− polarization accuracy (polarimeters)
&
depolarization effects (interaction point)

Precision coming from high luminosity is degraded !

ALTERNATIVE WAYS ? -->

Measuring the Polarization

A Solution: Measure the polarization directly using physical proceses.

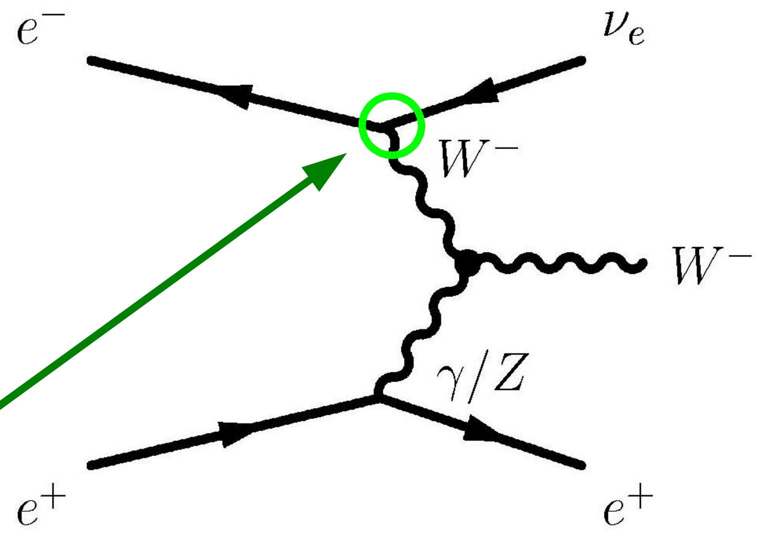
(It is not a replacement of the polarimeters !)

Advantage: No problem with depolarization effects !

(Measures the polarization directly at the interaction point)

SINGLE-W

- $\sigma_{\text{single-W}} \approx \sigma_{\text{W-pair}}$ (At 500 GeV)
- Single-W- only sensitive to e- polarization
- Single-W+ only sensitive to e+ polarization



How to measure the polarization ? .....

Measuring the Polarization

One can measure |P| following 2 approaches:

a) Asymmetry measurement

Measure 2 cross sections σ_+ and σ_- and

get P from:

$$|P| = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

Consider only electron beam polarization

requires to flip the sign of the electron beam polarization P

Measuring the Polarization

One can measure |P| following 2 approaches:

a) Asymmetry measurement

Measure 2 cross sections σ_+ and σ_- and get P from:

$$|P| = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

Consider only electron beam polarization

requires to flip the sign of the electron beam polarization P

	e-	e+
σ_{RR}	$\Rightarrow$	$\Leftarrow$
σ_{LL}	$\Leftarrow$	$\Rightarrow$
σ_{RL}	$\Rightarrow$	$\Rightarrow$
σ_{LR}	$\Leftarrow$	$\Leftarrow$

b) Rate measurement for fixed P :

Measure only one cross section σ

$$P_- = 1 - \frac{4\sigma}{(\sigma_{LL} + \sigma_{LR}) - P_+(\sigma_{LL} - \sigma_{LR})}$$

Measuring the Polarization

a) Disadvantages of measuring the asymetry:

$$|P| = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

- The luminosity must be split for measuring σ_+ and σ_-

b) Disadvantages of measuring one cross section σ:

$$P_- = 1 - \frac{4\sigma}{(\sigma_{LL} + \sigma_{LR}) - P_+(\sigma_{LL} - \sigma_{LR})}$$

- The theoretical values of σ_{LL} and σ_{LR} can not be accurately determined
- Anomalous TGCs are problematic

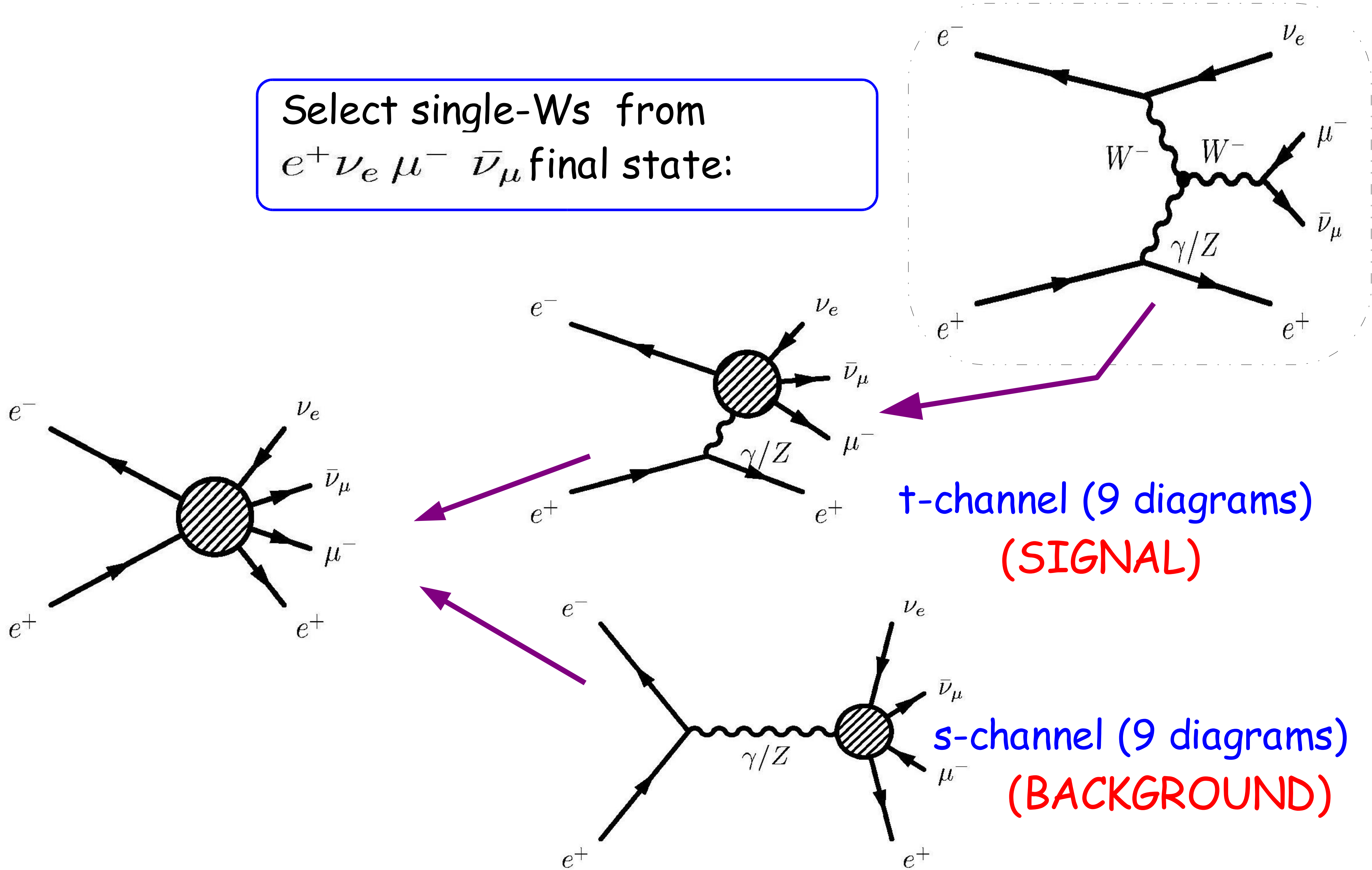
Aspects of the Study

Study of Leptonic Decay Channel: $e^+e^- \longrightarrow e^+\nu_e W^- \longrightarrow e^+\nu_e \mu^- \bar{\nu}_\mu$

- $\sqrt{s}$ = 500 GeV
- L = 500 fb^{-1}
- Longitudinal Polarization for e^- (80%)
- Effects of ISR and beamstrahlung
- The events are generated with Whizard (Wolfgang Killian)
- Detector simulation (SIMDET)
- Background from other processes

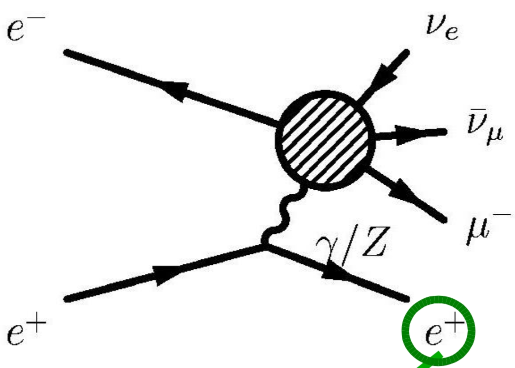
Single-W production

Select single-Ws from $e^{+}\nu_e\,\mu^{-}\ \bar{\nu}_\mu$ final state:

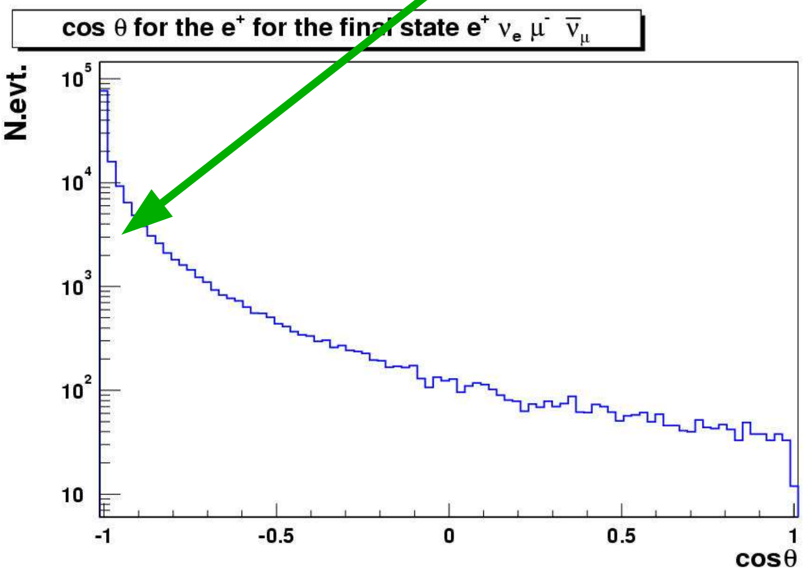


SINGLE-W PRODUCTION

Signal Definition for Single-W $^-$,



The positrons from the t-channel events are scattered in the forward direction cos θ -> -1



Look for:

- μ - plus an e+ at a low angle (cos θ -> -1)

  or

- μ - plus missing energy (e+ in the beam pipe)

Some Technical and problems

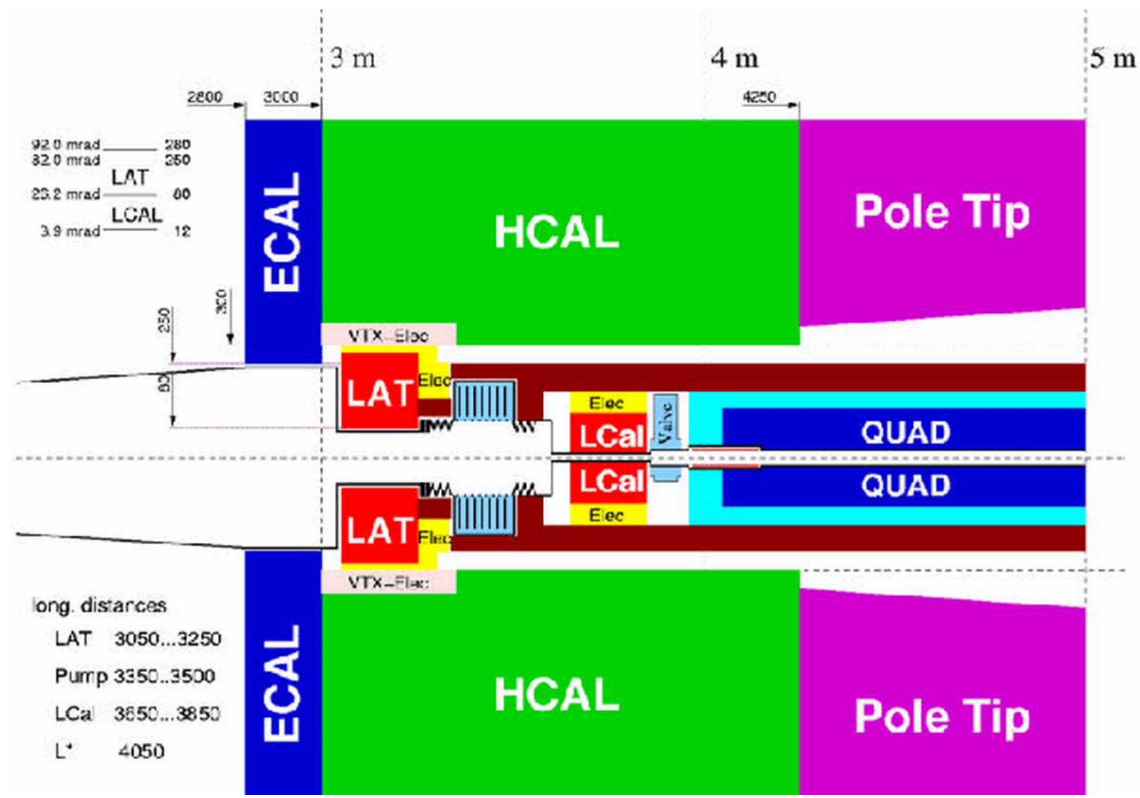
A) Simdet can reconstruct tracks only for $|\cos\theta| < 0.98$
(and $|\cos\theta| < 0.995$ for next studies)

THREE REGIONS:

a) e^+ has a track

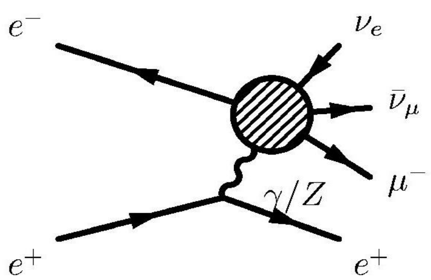
b) e^+ has no track
(only calorimeter object)

c) e^+ lost in beampipe



BACKGROUND

We have two kinds of background, depending on the polar angle θ of the e+



a) For all values of cos θ:

s-channel of $e^+ \nu_e \mu^- \bar{\nu}_\mu$ and

$$e^+e^- \longrightarrow \tau^+\tau^- \longrightarrow e^+ \nu_e \bar{\nu}_\tau \mu^- \bar{\nu}_\mu \nu_\tau$$

b) For large scattering angles (e+ in the beam pipe):

$$e^+e^- \longrightarrow \mu^+ \mu^-$$

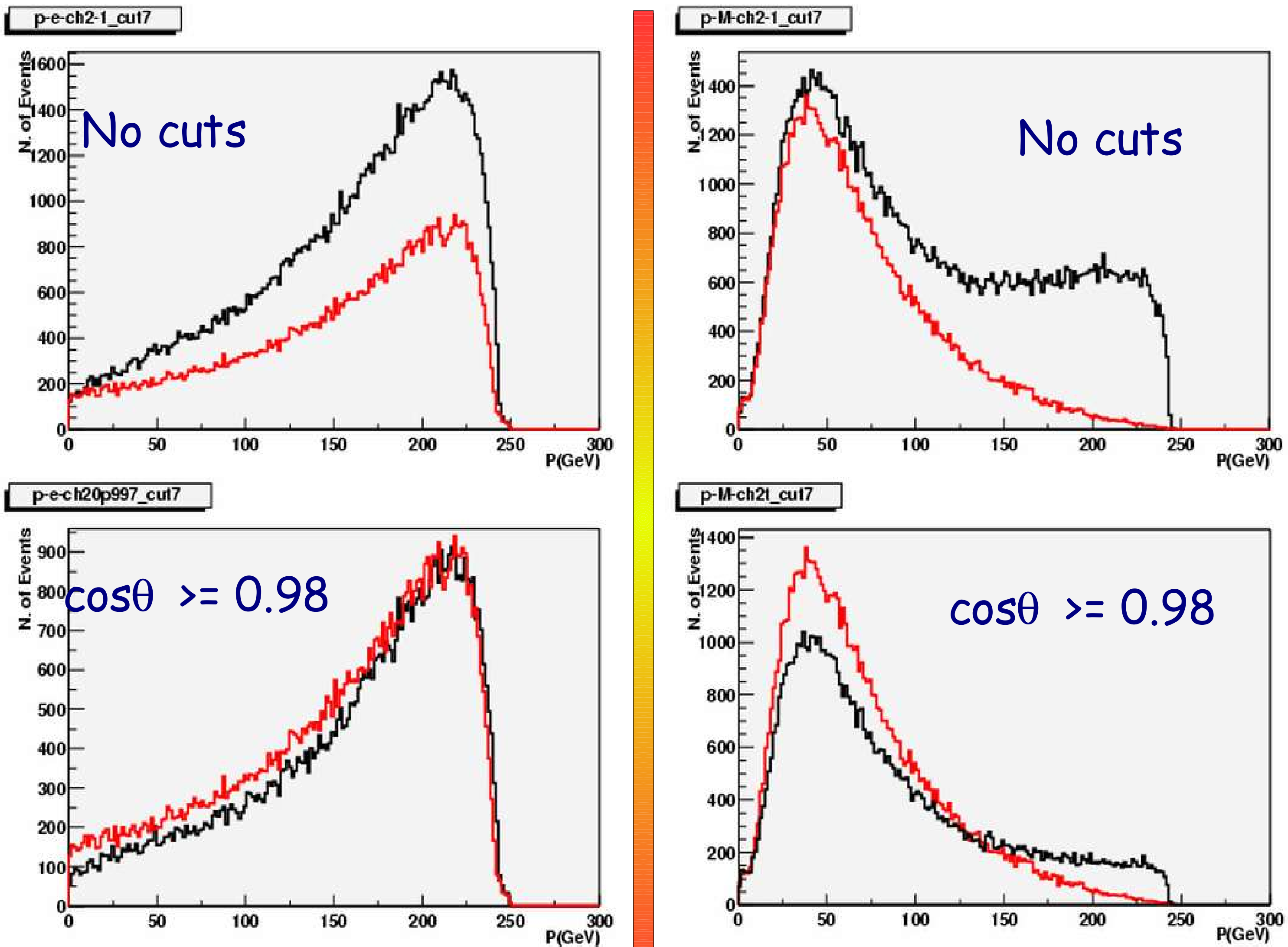
$$e^+e^- \longrightarrow \mu^+ \mu^- \gamma$$

$$e^+e^- \longrightarrow \mu^+ \bar{\nu}_\mu \mu^- \bar{\nu}_\mu$$

Background

S-channel Background

- Black: s+t channel
- Red: t-channel



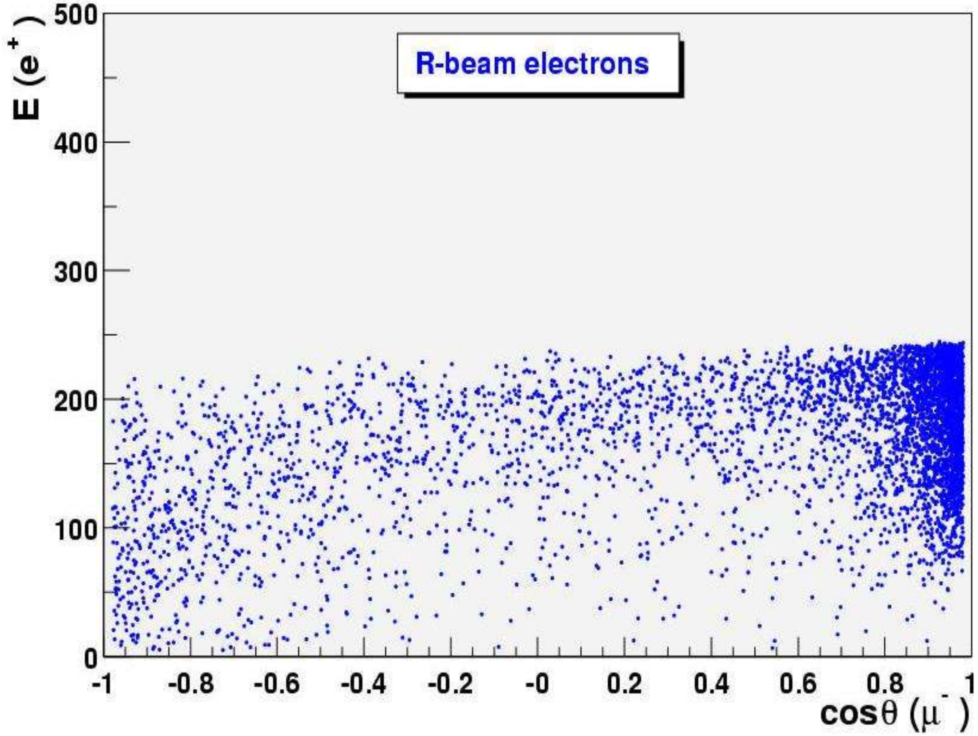
electrons

μ+

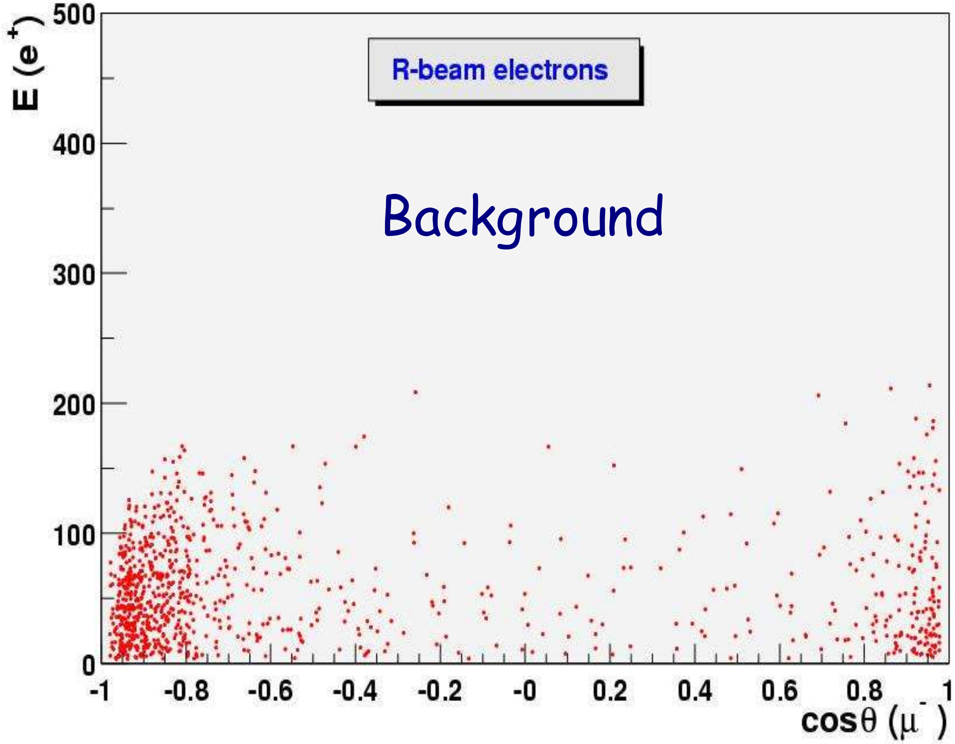
P-distribution from the final state: $e^- \bar{\nu}_e \mu^+ \nu_\mu$

This Study: Single-W production

$$e^+e^- \longrightarrow \tau^+\tau^- \longrightarrow e^+\nu_e\,\bar{\nu}_\tau\,\mu^-\,\bar{\nu}_\mu\,\nu_\tau$$ Background



$e^+\nu_e\,\mu^-\;\bar{\nu}_\mu$



$e^+e^- \longrightarrow \tau^+\tau^- \longrightarrow e^+\nu_e\,\bar{\nu}_\tau\,\mu^-\,\bar{\nu}_\mu\,\nu_\tau$

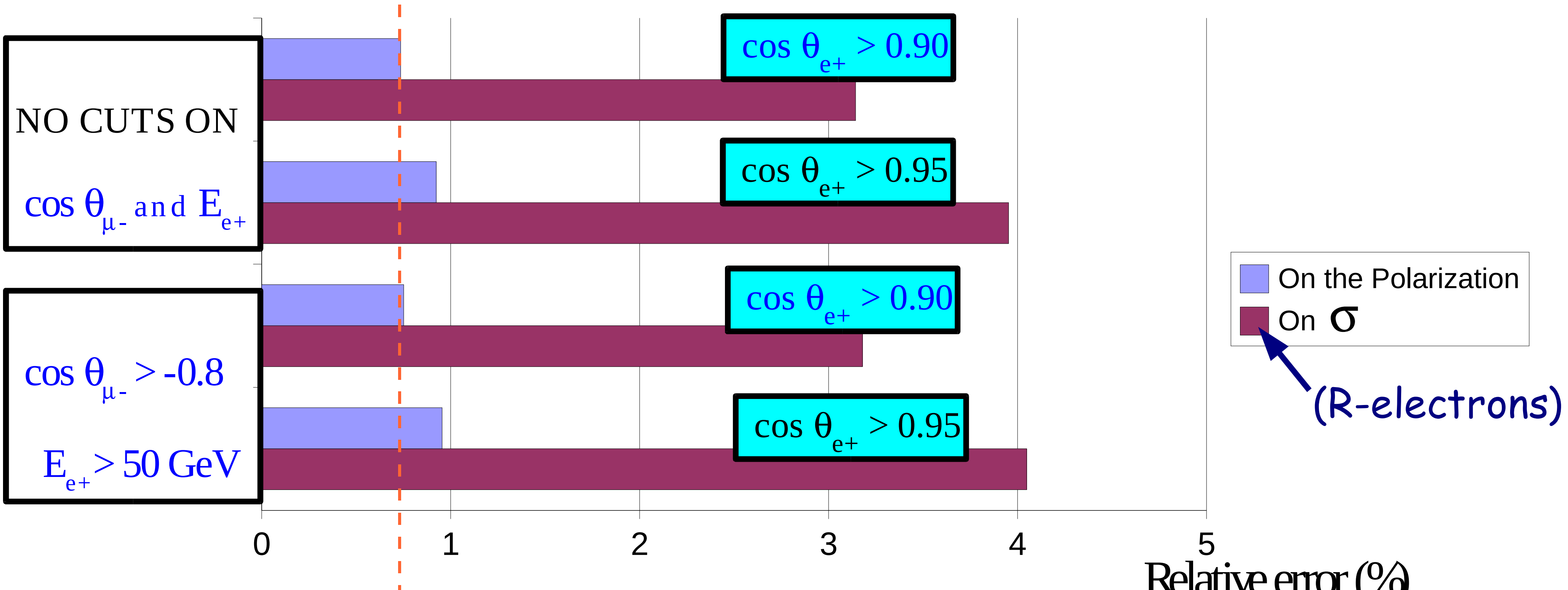
(Plots for cos θ >= -0.9)

Results

Expected **relative errors** for beam polarization measurements using the asymmetry :

$$|P| = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

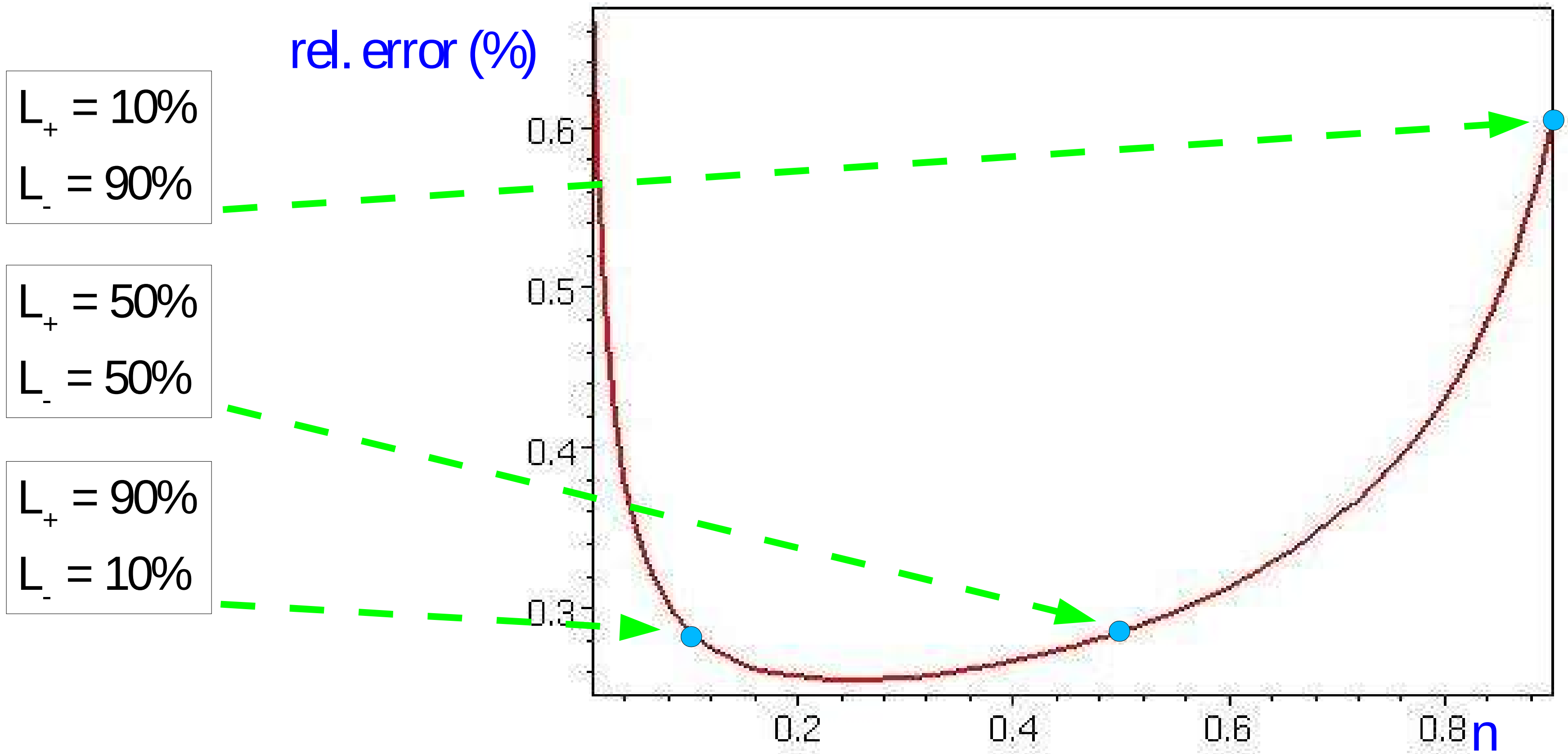
Results for 50% left electrons and 50% right electrons



Precision on Polarization ≈ 0.73%

Results

How to share the Luminosity ?



(where $n = 1 - L_+$ and $L_+ + L_- = 1$)

Error obtained without background !

R-polarized electrons are desired;
for instance, they suppress the t-channel of W-pair production

CONCLUSIONS AND OUTLOOK

- From the conditions considered in this stage of the study, the best value for the polarization measurement error is ≈ 0.73% (for $\cos\theta_{e+} > 0.90$)

- The best value of luminosity sharing is:
  Left electrons ≈ 25% Right electrons ≈ 75%
  (considering only the $e^+\nu_e\,\mu^-\ \bar{\nu}_\mu$ final state)

- Optimization of the signal selection

- Untagged events ($\mu\mu$ background)

- Solve technical isues:
  - Detector forward region
  - Problem of ISR and beamstrahlung in Whizard (not mentioned in the talk)

- Simultaneous measurement of electron and positron polarization