Measurement of the beam polarization using the semileptonic W^+W^- process

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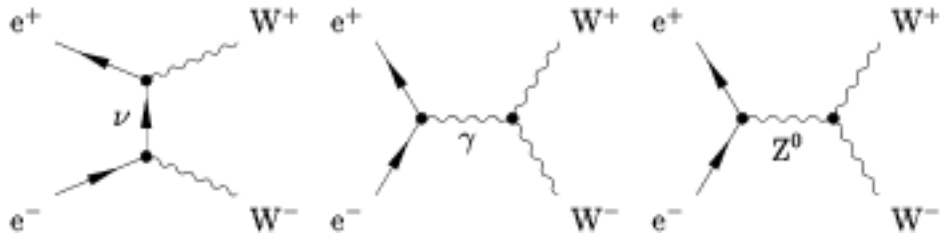
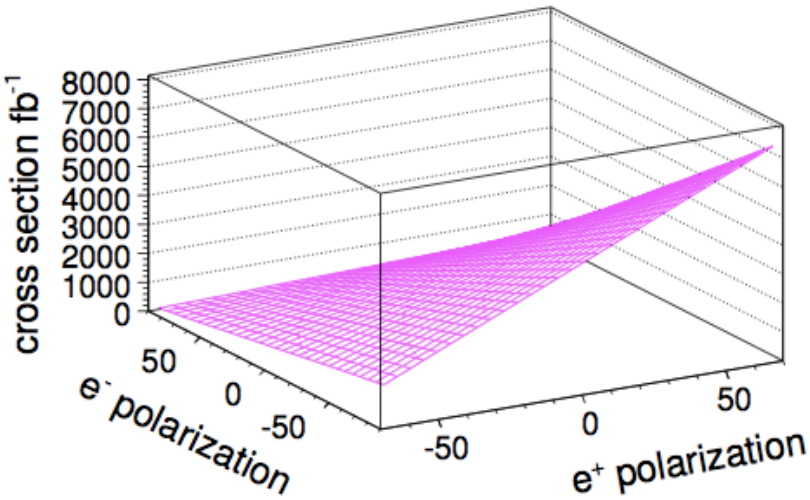
Introduction

- Beam polarization can be measured with polarimeters to a precision of $2.5 \cdot 10^{-3}$.
  - however, not the luminosity-weighted polarization

- Large luminosity at the ILC allows an accurate measurement of the luminosity-weighted polarization from the data, for example using the process $e^+e^- \rightarrow W^+W^-$.
  - also, calibration of the absolute polarization scale

W-pair Production and Decay



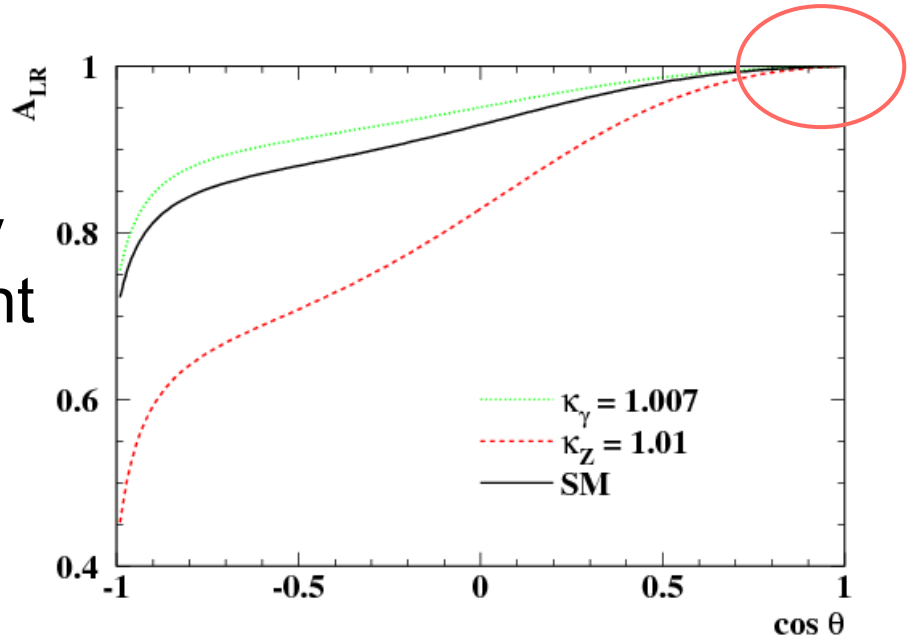


- Mixture of υ t-channel and Z, γ s-channel exchange.
- High cross section σ = 7 – 3 pb at E_{CM} = 500 GeV - 1 TeV, highly dependent on polarization.
- Decay modes:

# channels	process	BR
1	$W^+W^- \rightarrow qqqq$	45.6%
3	$W^+W^- \rightarrow qq\ell\upsilon$	43.8%
6	$W^+W^- \rightarrow \ell\upsilon\ell\upsilon$	10.6%

Polarization Measurement with W-pairs

- Total cross section and differential cross section $d\sigma/d\theta_W$ strongly sensitive to the polarization:
  - use the Blondel technique
  - fit the W production angle
- Forward peak dominated by ν exchange and independent of anomalous couplings:
  - fit simultaneously the polarisation and anomalous couplings



Blondel Scheme with Ws

- Four independent measurements: σ_{RR}, σ_{LL}, σ_{RL}, σ_{LR}.
- Can measure $\mathcal{P}_{e^+}$ and $\mathcal{P}_{e^-}$, if $|\mathcal{P}^R| = |\mathcal{P}^L|$ for each beam:

$$\mathcal{P}_{e^\pm} = \sqrt{\frac{(\sigma_{RL} + \sigma_{LR} - \sigma_{RR} - \sigma_{LL})(\mp\sigma_{RL} \pm \sigma_{LR} - \sigma_{RR} + \sigma_{LL})}{(\sigma_{RL} + \sigma_{LR} + \sigma_{RR} + \sigma_{LL})(\mp\sigma_{RL} \pm \sigma_{LR} + \sigma_{RR} - \sigma_{LL})}}$$

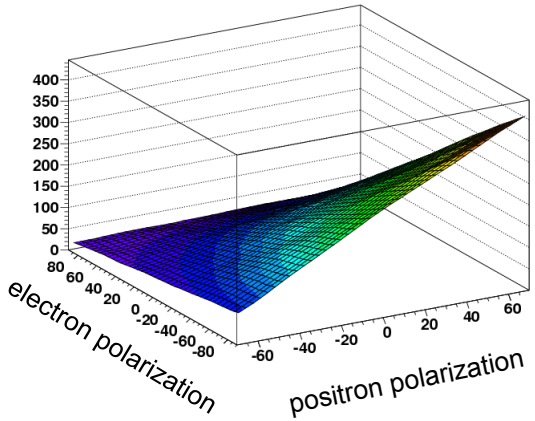
- Polarisation asymmetry $|\mathcal{P}^R_{e^\pm}|$ - $|\mathcal{P}^L_{e^\pm}|$ needs to be measured by polarimeters.

Fit of the W Production Angle

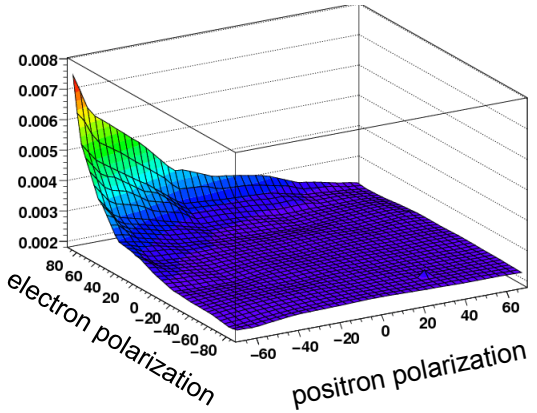
Look at the polarization dependence in bins of $\cos\theta_W$:

Obtain templates of $d\sigma(\cos\theta, P_{e-}, P_{e+})$ and fit data extracted from the templates for given P_{e-}, P_{e+}, in bins of $\cos\theta$.

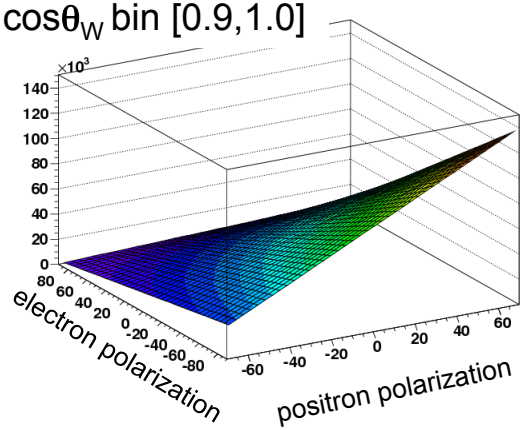
$\cos\theta_W$ bin [-0.8,-0.7]



Norm $\cos\theta_W$ bin [-0.8,-0.7]



$\cos\theta_W$ bin [0.9,1.0]



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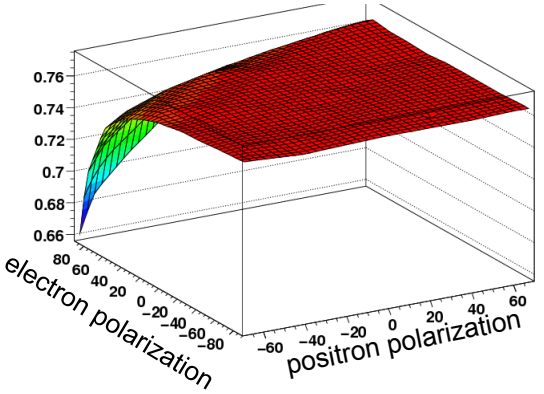
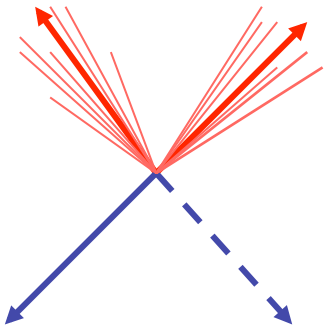


Selection of Semi-leptonic Final State

- Topology

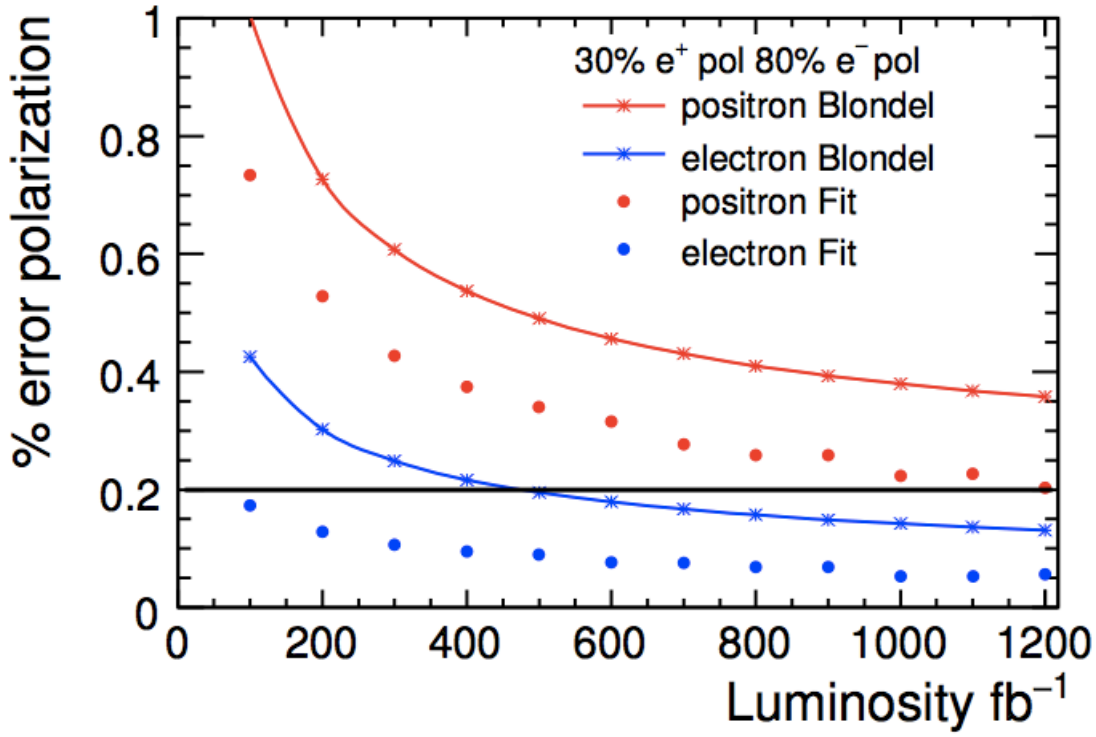


  - 2 jets
  - 1 charged lepton
  - 1 neutrino
- Straightforward reconstruction
- Low background

- Selection at 500 GeV
  - Cut based selection
  - Durham algorithm to force the event in three jets
  - Isolation cuts for the lepton
  - Cut on the reconstructed W mass
  - Cut on the W production angle
- Performance at 500 GeV:
  - Efficiency: 67%
  - Backgrounds: ~13%

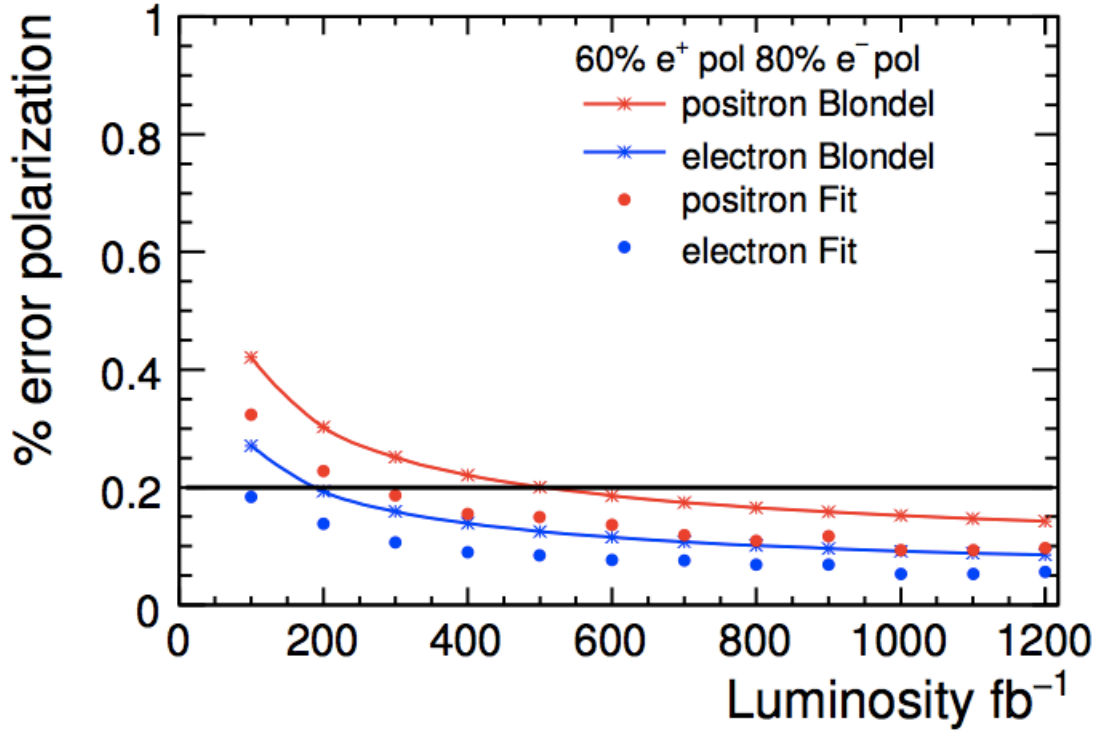
Selected Results at E_{CM} = 500 GeV

- Precision achievable on polarization measurement:
  - Lower statistical precision for positrons.



Selected Results at E_{CM} = 500 GeV

- For the 60% e+ polarization it gets better for the positron, while unaltered for the electron. A 0.2% error on the positron polarization can be reached with 300fb-1.



Status at 1 TeV

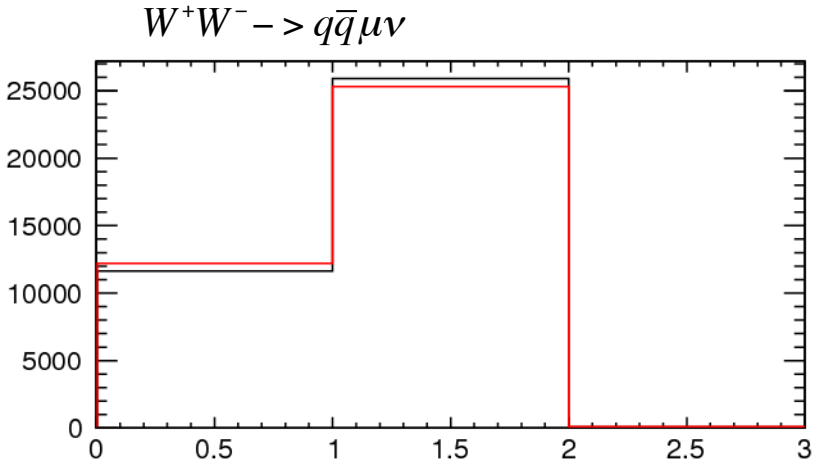
- At E_{CM} = 1 TeV, there are fewer signal events and lower positron polarization:
  - higher statistical error.
- Also, events are more forward and machine backgrounds increase at higher energies:
  - expect higher systematics.
- Need to improve on the analysis at 500 GeV, mainly:
  - Lepton ID
  - Use of kinematic fit: 2C
  - Inclusion of the $\gamma\gamma$ -> hadrons background. Use different jet algorithms to reduce the influence of this background.

Lepton Identification

- Lepton ID

For e+/e- : $(En_{ECAL}+En_{HCAL})/P > 0.8$
$En_{ECAL}/(En_{ECAL}+En_{HCAL})>0.9$
Charge not-zero

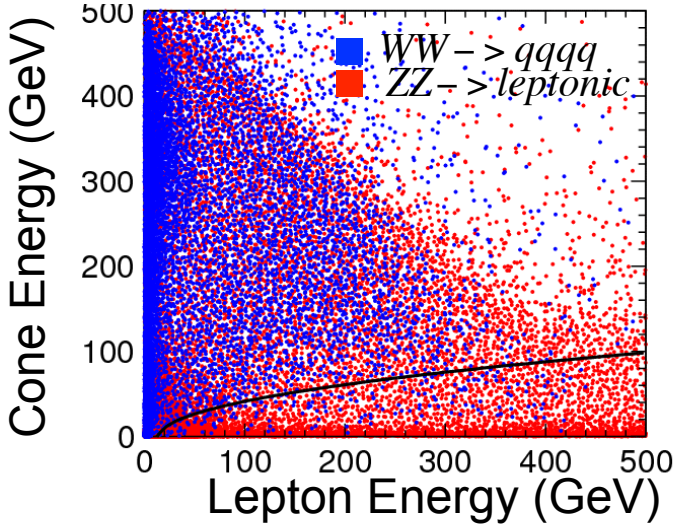
For μ+/μ-: $(En_{ECAL}+En_{HCAL})/P < 0.4$
$En_{ECAL}/(En_{ECAL}+En_{HCAL})<0.5$
Charge not-zero



Number of Muons

- Isolation

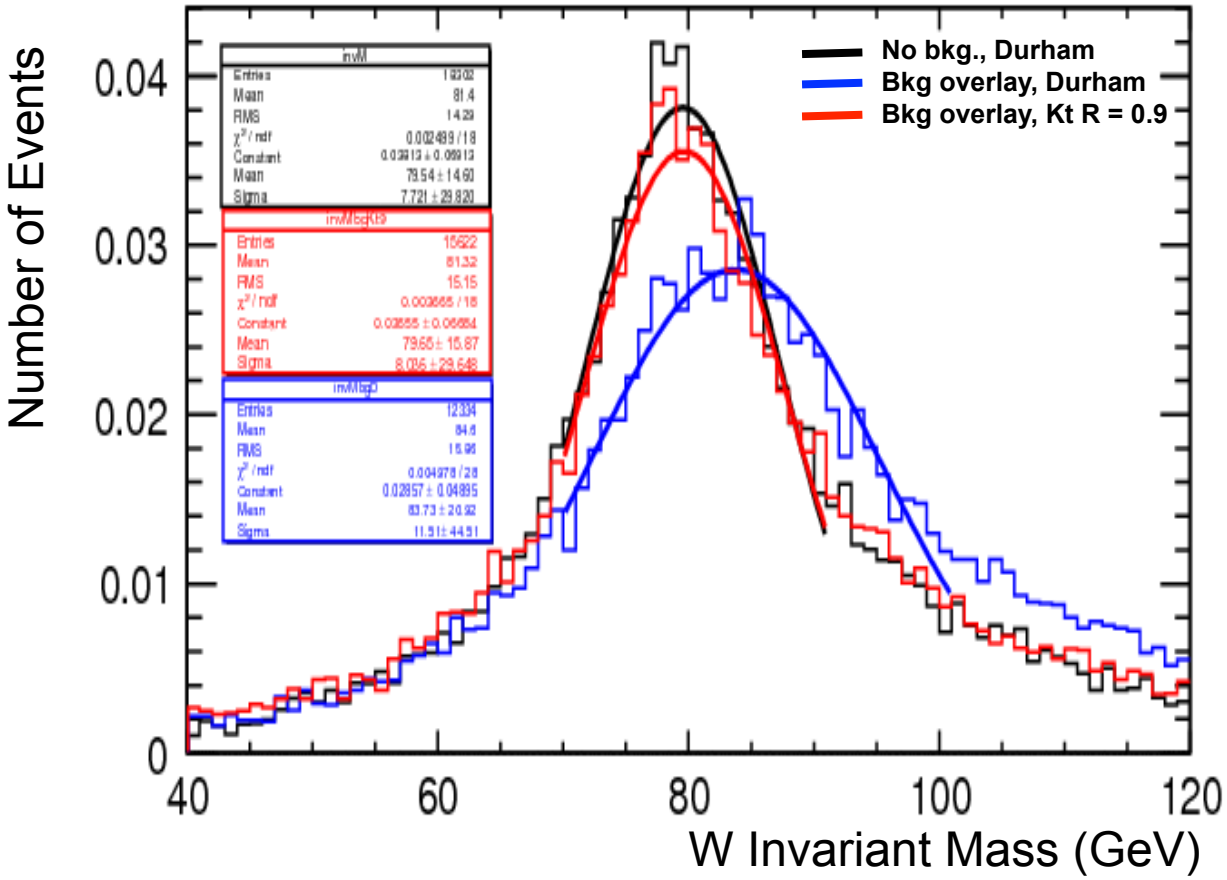
$$E_{cone} < \sqrt{20E_{\ell} - 300}$$



Efficiency: 93%

Effect of γγ-> hadrons Background

- Can be dealt with by using an appropriate jet clustering algorithm: K_t instead of Durham.



Summary

- Beam polarization can be measured from the data with high precision using the WW process at 500 GeV.
- Higher positron polarization is beneficial for the polarization measurement.
  - With 60% positron polarization an **error** ≈ 0.2% on both polarizations is achievable with ≈ 300 fb^{-1}at 500 GeV .
- Several methods can be used: Blondel scheme, fit of W production angle.
- An assessment of the precision at 1 TeV is ongoing.