# Status of the WW analysis at 1 TeV

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DESY

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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
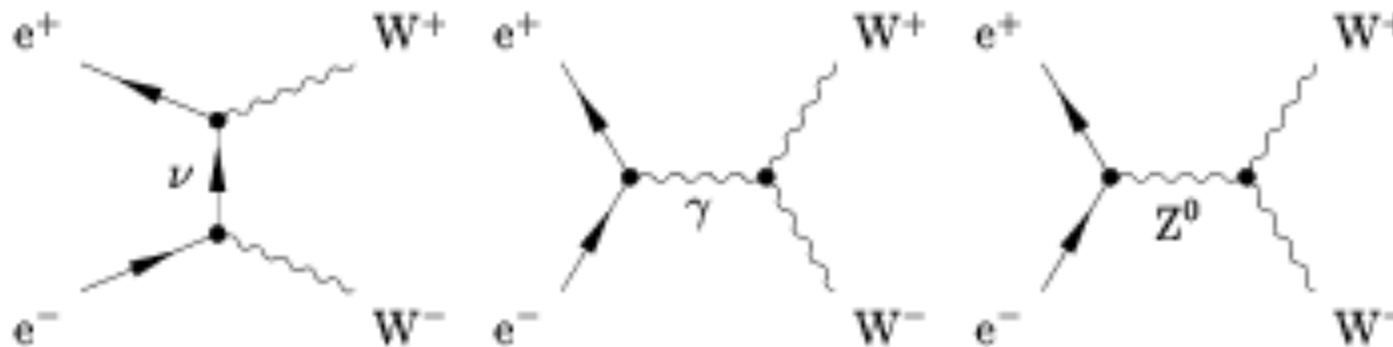
- Mixture of ν t-channel and Z, γ s-channel exchange.
- Cross section $\sigma = 7 - 3$ pb at E_{CM} = 500 GeV - 1 TeV.
- Decay modes:

# channels	process	BR
1	$W^+W^- \rightarrow qqqq$	45.6%
3	$W^+W^- \rightarrow qq\ell\nu$	43.8%
6	$W^+W^- \rightarrow \ell\nu\ell\nu$	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
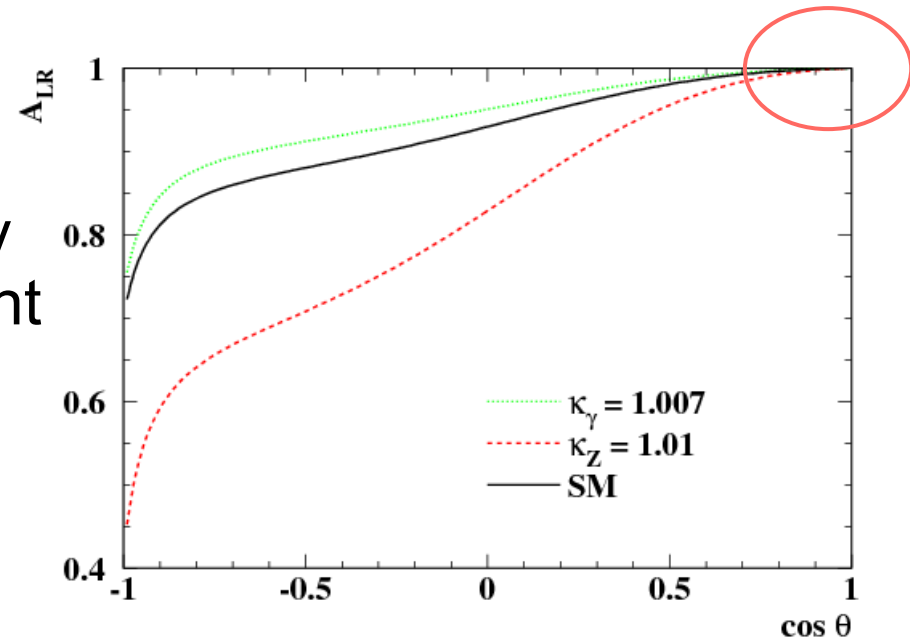
Blondel Scheme with Ws - Reminder

- 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 $|\mathcal{P}_{e^\pm}^R| - |\mathcal{P}_{e^\pm}^L|$ needs to be measured by polarimeters.
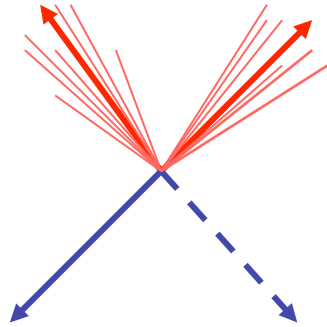
Fit of the W Production Angle

Obtain templates of dσ(cosθ,Pe-,Pe+) and fit data extracted from the templates for given Pe-,Pe+, in bins of cosθ
(from Ivan's thesis).
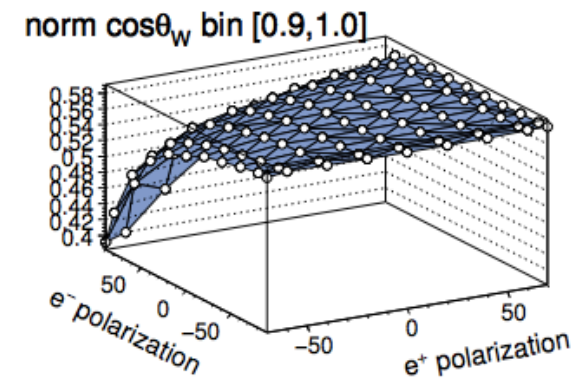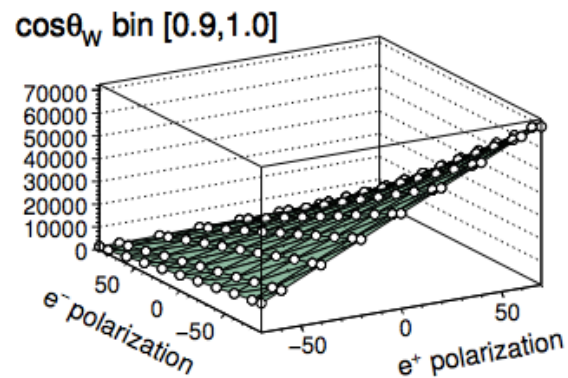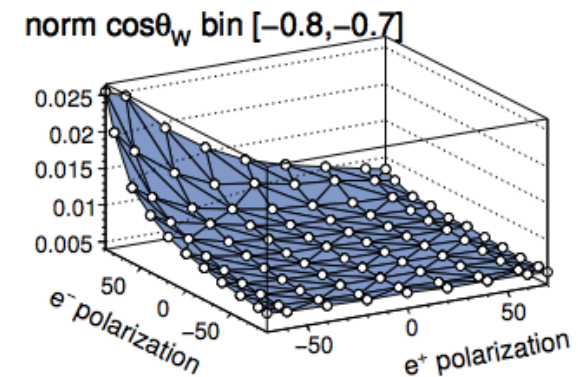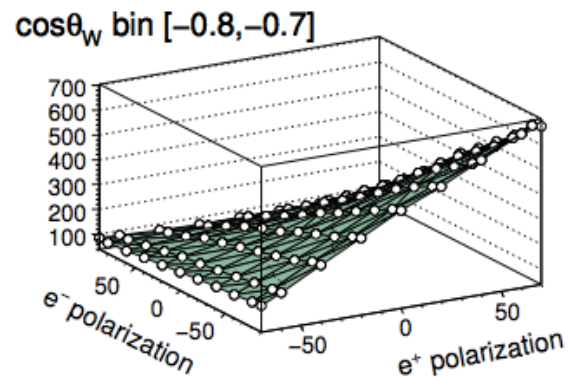
Selection of Semi-leptonic Final State

- 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: ~16%

Selected Results at E_{CM} = 500 GeV

- Data reduction at E_{CM} = 500 GeV (P_{e+} = +0.30, P_{e-} = -0.80, lumi = 80 fb^{-1})

Process	Selected events	Statistical Error (weight)
signal	71611	0.4% (1)
2f	875	3.4% (1)
4f	**2548**	**2.0% (1)**
$q\bar{q}\tau\upsilon$	**8287**	**1.1% (1)**
6f	256	6.3% (1)

- **Signal:**

$$e^{+}e^{-} \rightarrow W^{+}W^{-} \rightarrow q\bar{q}e\upsilon, \ q\bar{q}\mu\upsilon$$

- **Main backgrounds:** 4 fermions
  - Tau-signal: ~10%
    - dominant background
    - cross section scales the same as the one of the signal
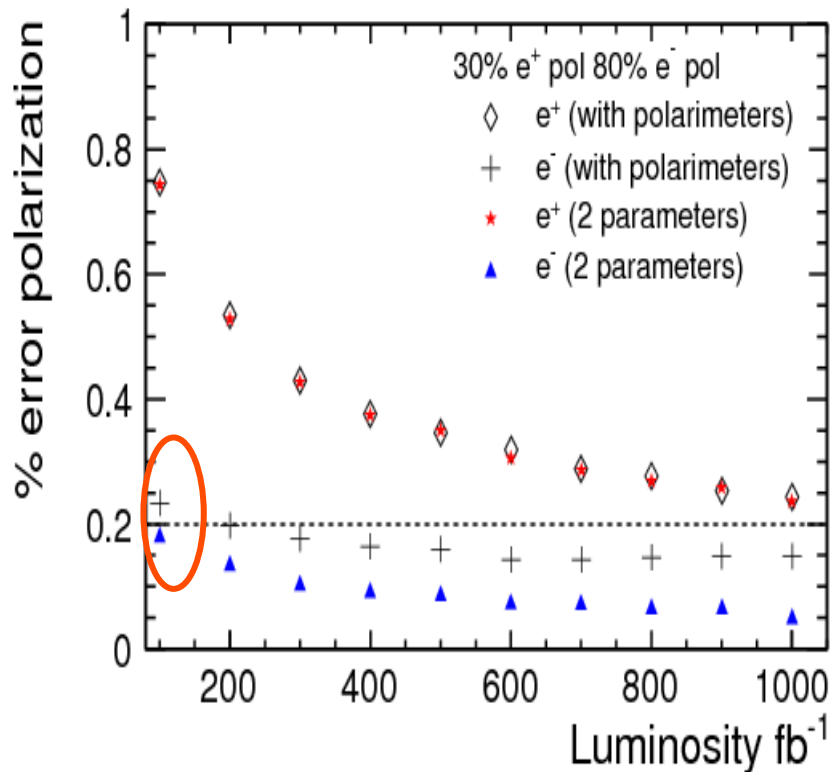 - Single W: ~3%
    - Cross section raises with energy

- Analysis needed lumi = 120 fb^{-1} to extract the polarization with the angular fit method.

Selected Results at E_{CM} = 500 GeV

- Precision achievable on polarization measurement:

- Lower statistical precision for positrons.
- For electrons, error limited by systematic uncertainty
  - Also, statistic and systematic errors are comparable for 100 fb^{-1}.

- Require not more than about ~260 fb^{-1} at 1 TeV.

Status at 1 TeV

- Signal and backgrounds (2 fermions and 4 fermions) were generated by Mikael Berggren.

- Analysis benefits from the framework set up by Ivan Marchesini. Some improvements expected from:

  - Lepton identification
  - Use of kinematic fit: 1C, 2C

W minus cos theta

WW signal + dominant background, lumi 260 fb^{-1}

- Framework taken over and tested on generator level data, with 260 fb^{-1}:
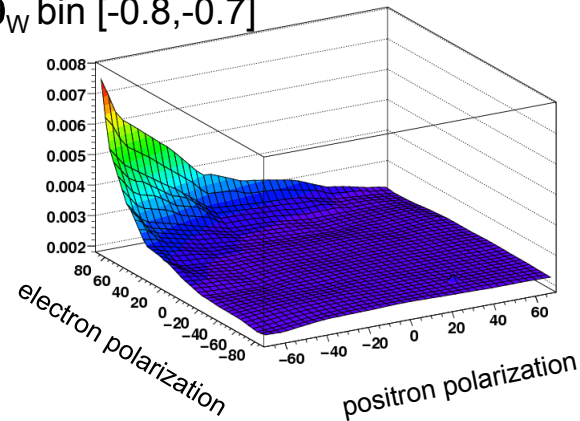
  - for now only semi-leptonic channel
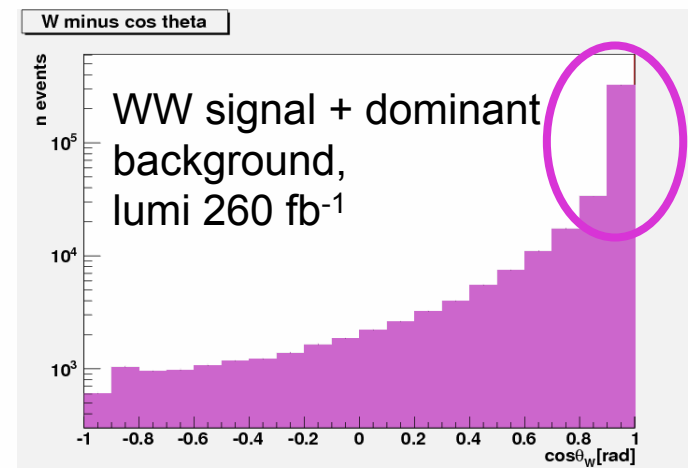
Status at 1 TeV

Look at the polarization dependence in bins of $\cos\theta_W$ with 260 fb^{-1}, equally divided between the 4 polarization configurations.
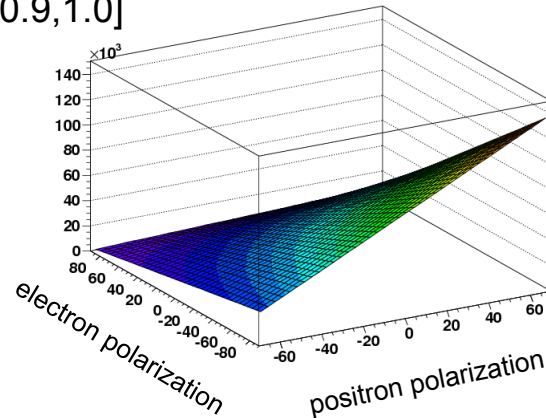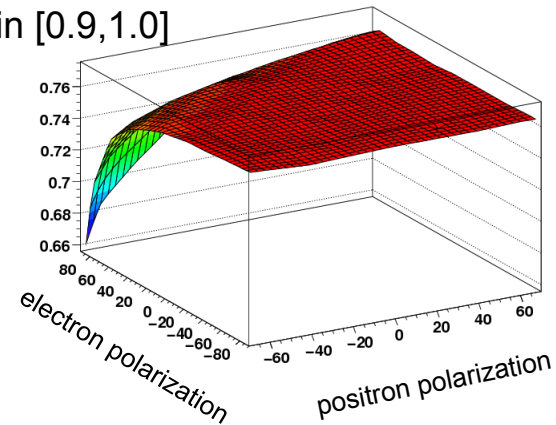

$\cos\theta_W$ bin [-0.8,-0.7]
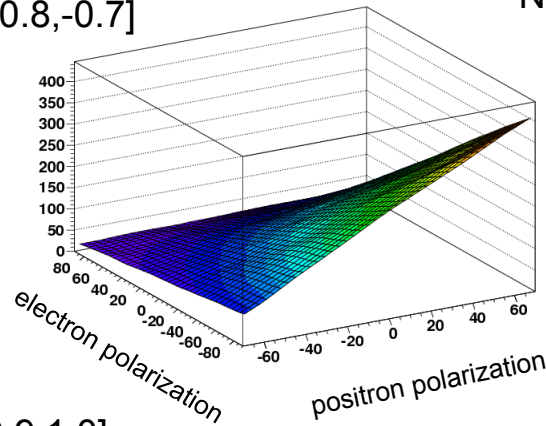
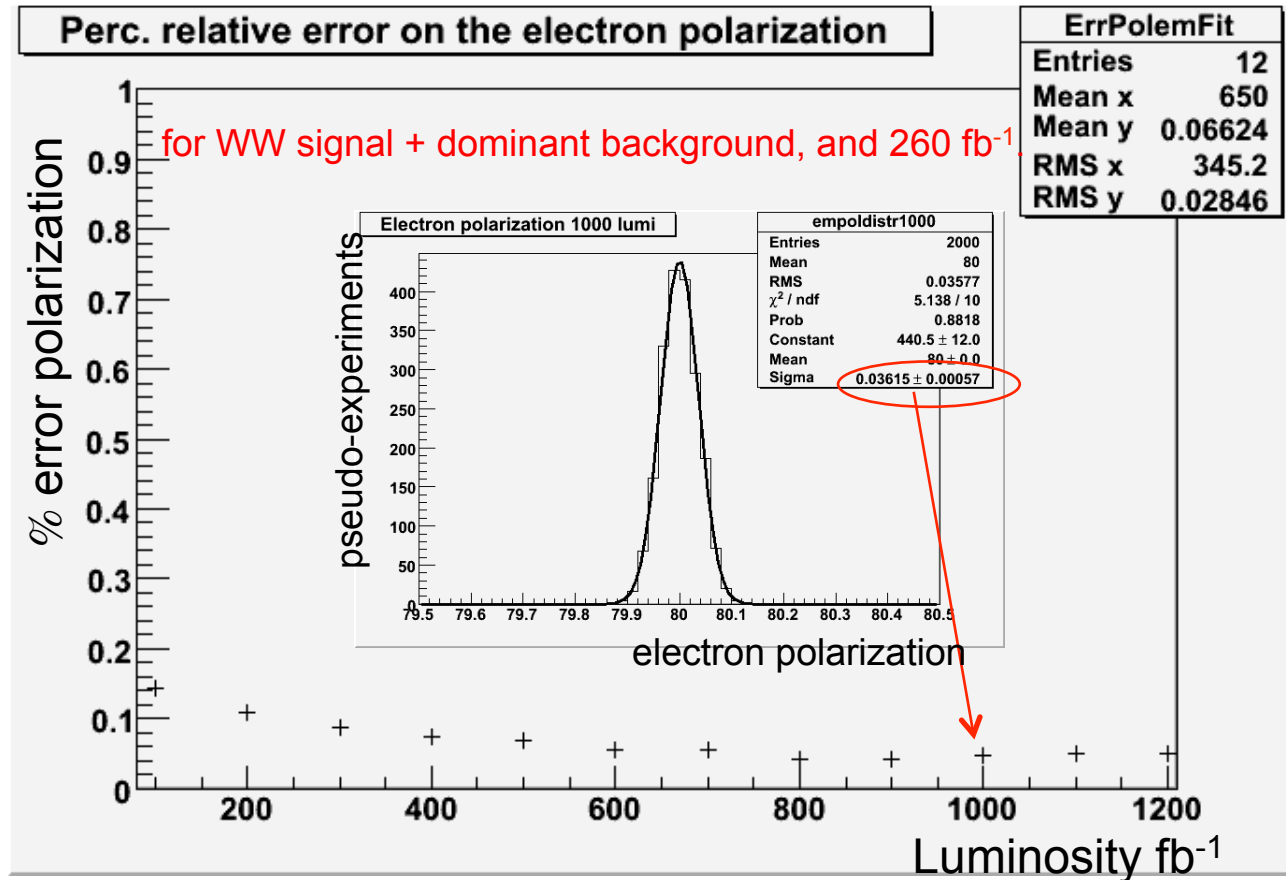Norm $\cos\theta_W$ bin [-0.8,-0.7]

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

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

Status at 1 TeV

- ## Fit results: electron polarization

Sample Request for WW at 1 TeV

- ## Signal: $q\bar{q}\ell\upsilon,\ \ell = e, \mu, \tau$

  - 260 fb^{-1}, equally divided between the 4 polarization configurations, 1.1M events (includes dominant backgrounds $q\bar{q}\tau\upsilon,\ We\upsilon$)

- ## Other background processes:

  - Zee, Z$\nu\nu$ have high cross section but should be harmless, so
    - could ask for a minimum of 100 fb^{-1}, ~1.2M events
  - Other 4 fermion processes, 200 fb^{-1}, ~0.8M events
  - 2 fermion processes, a minimum of 100 fb^{-1}, ~0.5M events

  Total background: 2.5M events

- Note that we need all polarization combinations.

Summary

- Signal and background are generated.

- Analysis chain is tested.

- Ready to start once simulated samples are available.