# Physics background in luminosity measurement at ILC

# and

# measurement of the proton b-content at H1

# using multivariate method

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**Abstract**

The International linear collider (ILC) is a proposed electron-positron collider operating at the centre-of-mass energy of 500 GeV, and a peak luminosity of $2 \cdot 10^{34}$ $cm^{-2}s^{-1}$. Such a machine, colliding a point like particles, with well defined initial state and low background environment, would be an ideal complement to the Large Hadron Collider (LHC) which is operational since 2009. This machine would allow precision measurement of the new physics phenomena that are likely to be discovered at TeV energy scale.

In order to perform rich physics program of physics beyond the Standard Model, the ILC detector is faced with unprecedented challenge for the most of the subsystems. One of the most important aspects that should be considered is measurement of the integral luminosity because its uncertainty affects many precision measurements, and limits some of them as the additional component of a systematic error. Precision of luminosity measurement is driven by physics requirements for the cross-section measurements (i.e. the total hadronic cross-section at $Z^0$ resonance, 2-fermion production at high energy) and precision EW measurements (EWSB - anomalous gauge boson couplings). ILC physics program sets the minimal precision of the luminosity measurement to be of order of $10^{-3}$. This may be accomplished by construction of fine granulated electromagnetic calorimeter, which will measure the rate of Bhabha scattering process at small angles at one hand and by the experimental control of various systematic effects at the other.

The first part of this thesis is dedicated to the study of four-fermion processes $e^+e^- \rightarrow e^+e^- f \; \bar{f}$, as a physics background in the luminosity measurement. This SM process comes as one of the major systematic effects in luminosity measurement at ILC due to the high cross-section and the fact that electron spectators emitted at low polar angles can be misidentified as a signal. It has been demonstrated that the event selection can be performed in a way that the overall relative systematic uncertainty does not exceed 2.3 $10^{-3}$. Selection efficiency of the Bhabha signal is maintained to limit the statistical uncertainty of the measurement at 1.2 $10^{-4}$. In addition, background suppression potential is discussed for various selection setups.

Results of this thesis, as an integral part of the study of instrumentation of the very forward region at ILC have been published by the FCAL Collaboration in 2010 JINST 5 P12002.

The second part of the thesis is dedicated to the physics of heavy quarks at the H1 experiment at the accelerator HERA at DESY, Hamburg, Germany. The HERA experiments H1 and ZEUS gave an important experimental insight of the proton structure in the wide phase space of photon virtuality and Bjorken scaling variable. By far the most important results of HERA experiments are measurements of structure functions of proton and further extraction of parton density functions. This knowledge is of the utmost importance for LHC colliding protons as composite objects. Also, the precise knowledge of PDF's of *b*-quark is an important input in order to predict the rates of the Higgs production at LHC in its dominant channel. In this thesis the *b*-content of the proton is measured that can be further used for $F_2^b$ and the corresponding cross-section measurements.

With the sample of 54.4 $pb^{-1}$ of HERA II data the proton *b*-content is measured, using the $e^-p$ neutral current events of deep inelastic scattering in the kinematic region of $Q^2 > 6$ $GeV^2$ and the Bjorken scaling variable $0.0002 < x < 0.32$. The data was recorded in 2006 with the H1 detector, at the centre-of-mass energy of approximately 319 GeV.

The heavy quark tagging method is based on an inclusive approach exploiting the different lifetime signatures as well as the mass difference of the charm and beauty flavoured hadrons compared to the light ones. Thus there are several sensitive observables like impact parameter based significances of tracks, transverse momenta of tracks and jets, jets masses and multiplicities, that can be used to distinguish between events containing heavy flavours with respect to the light ones. These observables are combined in the most optimal way using the multivariate analysis techniques (TMVA). Output of the chosen multivariate method is further used in the Barlow-Beeston fit to fit the data with the corresponding b, c and light-flavor Monte Carlo samples. In this way, a proton *b*-content is determined in different $Q^2$ bins. The measured values are found to be in agreement with the LO theory prediction. The dominant component of the systematic error is coming from the choice of a QCD production model of heavy quarks as well as from the choice of a fragmentation function. Although the systematic error is somewhat larger than in the previous measurements at H1, this method allows statistics of the sample to be better preserved with the statistical error below one percent in all $Q^2$ bins.

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