LC-DET-2001-044

February 17, 2001

# Measurement of the integrated luminosity at TESLA

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**Abstract**

We report the outline of a precise measurement of the integrated luminosity at TESLA, based on the counting of the Bhabha scattering events in the acceptance of the Low Angle Tagger (LAT) calorimeter.

## 1 Introduction

The absolute luminosity will be measured at TESLA, as at previous $e^+e^-$ colliders, by counting the number of events of elastic scattering at low polar angles ( $\theta \leq 200$ mrad):

$$e^+e^- \to e^+e^-(n\gamma)$$

The reasons of considering this channel, known as Bhabha scattering, for the luminosity determination are both theoretical and experimental:

1. it is a pure QED process whose cross section can be calculated with a permill accuracy;

2. it allows an high statistical precision, because of the large forwardly peaked cross section:

$$\sigma \simeq \frac{1040\ nb}{s\ (GeV^2)}(\frac{1}{\theta^2_{MIN}} - \frac{1}{\theta^2_{MAX}})$$

3. it is characterized by a simple topology which allows a complete rejection of backgrounds and an accurate definition of the acceptance inside the detector.

The Bhabha events are selected by requiring two back-to-back electromagnetic showers at small angles with respect to the beamline and having the same energy as the beams.

A calorimetric event selection is preferred because it retains both non-radiative and radiative Bhabha events and therefore it improves the theoretical accuracy of the cross section calculation.

The proposed silicon-tungsten calorimeter, due to its fine granularity and excellent energy and position resolution, can easily isolate the high energy showers of Bhabha events from the backgrounds generated by the bunch crossing. It can also define very precisely the geometrical acceptance.

The following discussion is focused on the selection of the Bhabha events, the calculation of the accepted cross section and the sources of systematics in the luminosity measurement.

# 2 The event selection

The Low Angle Tagger (LAT) is the detector suitable for a precise measurement of the integrated luminosity.

The LAT design foresees a tungsten silicon calorimeter, placed at the tips of the tungsten mask (see fig 1), covering the low angle region (27.5 mrad $< \theta <$ 83.1 mrad).

The LAT is segmented into 14 rings in $\theta$, each covering about 4 mrad, and 24 wedges in $\phi$.

As the beam induced background is low, the high energy electromagnetic showers coming from the Bhabha events can be easily reconstructed.

The energy resolution can be evaluated to be about 20 % / $\sqrt{E}$, while the resolution in the radial coordinate at the border between 2 rings, assuming a segmentation pointing to the interaction point, can be considered to be better than 20 $\mu$m.

In order to select Bhabha events two back-to-back showers with energy compatible with the beam and a small acollinearity are requested. Due to the very clean signature of the Bhabha events, these cuts can be chosen to be rather loose like E $>$ 0.6 $E_{beam}$ and acollinearity $< 20^o$.

The acceptance is defined by applying to both showers radial cuts corresponding to borders between the rings.

In order to accept radiative events, the angular cuts applied to the two reconstructed showers are different on the two sides of the LAT and define a tighter and a looser acceptance.

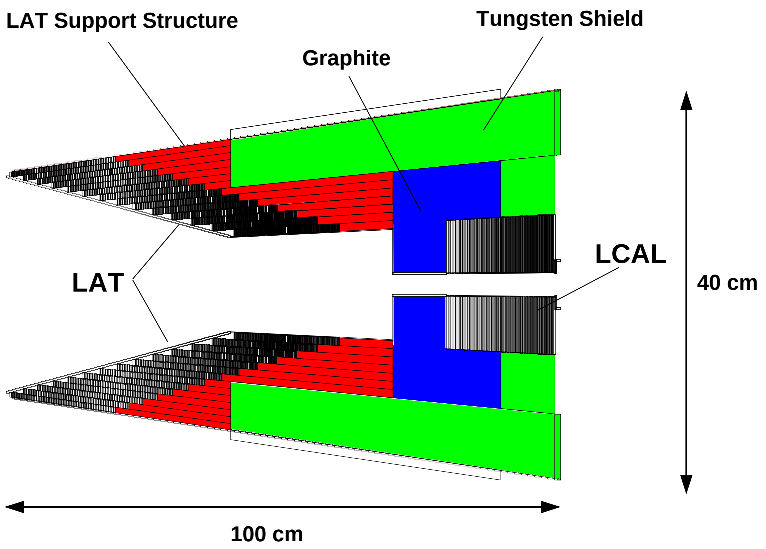


Figure 1: Scheme of the region around the Low Angle Tagger

# 3 The calculation of the accepted cross section

The evaluation of the Bhabha cross section accepted in the LAT calorimeter has to be performed in two steps:

1. generation of Bhabha events by the BHLUMI 4.04 generator;
2. tracking of the final states through a detailed description of the detector.

BHLUMI 4.04 [1] is a full scale multi-photon Monte Carlo event generator with the $\mathcal{O}(\alpha)$ Yennie-Frautschi-Suura exponentiation [2]. The total theoretical uncertainty amounts to $2.5 \times 10^{-3}$. This figure takes into account both the error coming from the truncation of the QED perturbative series and the technical precision of the Monte Carlo implementation.

A very important cross check of the calculated acceptance has to be performed by analytical calculations. Recent results [3] take into account all the leading logarithmic contributions to three loops and all the next-to-leading loops to two terms. They include all the radiative corrections due to photons and pair production.

The contribution of the events $e^+e^- \to \gamma\gamma(\gamma)$, which have the same experimental signature as Bhabha events, has to be subtracted from the accepted cross section. It can be evaluated by means of a Monte Carlo code based on reference [4].

# 4 Evaluation of systematics

The $1/\theta^3$ angular distribution of the Bhabha scattering makes the luminosity measurement particularly sensitive to biases in the cuts defining the acceptance.

A bias $\delta$R in the inner edge $R_{in}$ of the acceptance translates into an error in the luminosity $\delta L/L \simeq 2\delta R/R_{in}$.

Therefore the requirement of 1 permill precision in the luminosity translates into the request of controlling biases in the inner edge of the LAT with a precision better than 50 $\mu$m, which seems to be a feasible goal.

The systematics coming from the uncertainty in the position of the interaction point along the beam line is made negligible by alternating at each event the side of the calorimeter on which tighter cuts in the acceptance are applied.

The contribution to the systematics of the cuts selecting the Bhabha events is very small, because the selection efficiency is high and the signature is very clean.

Due to the dependence of the Bhabha cross section on the energy of the beam, another contribution to the error in the luminosity comes from uncertainty in the energy of the beam and can be expressed by $\delta L/L \simeq 2\delta E_{beam}/E_{beam}$. This term at TESLA is negligible with respect to 1 permill.

# 5 Conclusions

The measurement of the integrated luminosity can be performed at the precision level of 1 permill, by counting the events of Bhabha scattering inside the Low Angle Tagger calorimeter.

# References


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