Luminosity measurement with the two-photon process at the LHC

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Abstract

The luminosity measurement of pp colliders based on the QED process of two-photon $e^+e^-$ pair production is investigated. In this process $e^+e^-$ pairs are produced in collisions of virtual photons surrounding the proton. The cross section of this process is calculated with high accuracy with QED. The total cross section is very large (~10 mb). The main signatures of this process are small transverse momentum and acoplanarity angle.

Signal events are generated with LPAIR program and PYTHIA 6.2 provides the background events. The modeling program simulates luminosity measurement using a dedicated detector (LUMI). That program calculates experimental environment effects. The first is the vertex smearing which is simulated from a general expression for the luminosity. It takes into account the fact that we don’t know precisely the vertex position. The spread of protons momenta inside bunches is also taken into account. The most important effects, which can contribute to the electron transversal momenta are electromagnetic effects. The trajectory of the electron, which was produced inside the bunch, can be curved in the electric field of this bunch. The contribution of this effect to transversal momenta strongly depends on the $e^+e^-$ vertex position inside the bunch. The next part of the modeling program is to simulate the bending magnet and the LUMI detector, which consists of a position detector and electromagnetic calorimeter.

The process of the two photon $e^+e^-$ pair production can be used for calibration of luminosity at the LHC. The expected precision of the measurement is 1-3%. For this it is necessary to build a dedicated detector.

The two-photon process $pp \rightarrow pp + e^+e^-$

$P_i(E,p)$

$q_i(w_i, q_i)$

$W_i(p_i, p_{i'})$

$e_i, e_i$

$P_i(E, -p)$

The parameters characterizing the process:

- small angle between $e^+e^-$ (~few mrad)
- very small pair $p_i$ (~few MeV)
- invariant mass (~few MeV)
- large cross section (~few mb)

Electromagnetic effect ($p_T$ of positron)

Electromagnetic effect ($p_T$ of electron)

Proposed beam pipe layout for IP1 at LHC