CEPC Fast Luminosity Monitor with Silicon Carbide

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Introduction

To cope with the challenging beam condition at CEPC, we plan to build a fast luminosity monitor at CEPC with silicon carbide (SiC). By setting two detectors inside and outside the beam pipe, one can measure the Bhabha scattered particles and the secondary charged particles generated in the beam pipe. The luminosity is monitored by counting the number of Bhabha events with the goal of 2% accuracy at 1kHz rate.

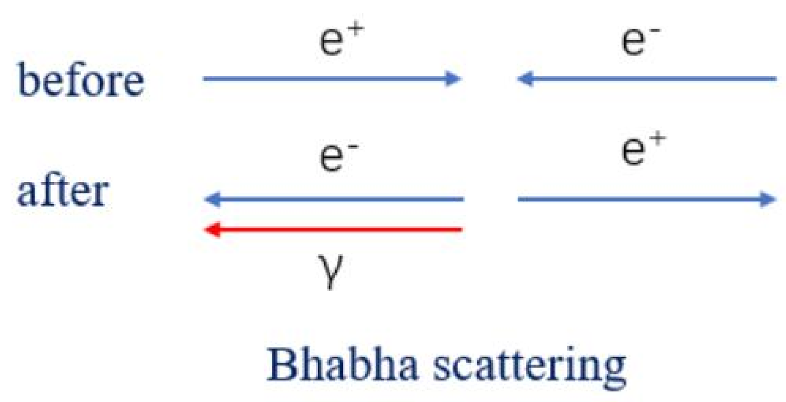
Detecting method

Bhabha scattering is the major particle loss, and we can calculate the luminosity by counting the number of Bhabha particles.

Once we get the number of Bhabha scattering electrons (N), we can calculate the luminosity(L):

$$L = \frac{N}{\sigma \times T}$$

where σ is the cross section, T is frequency.

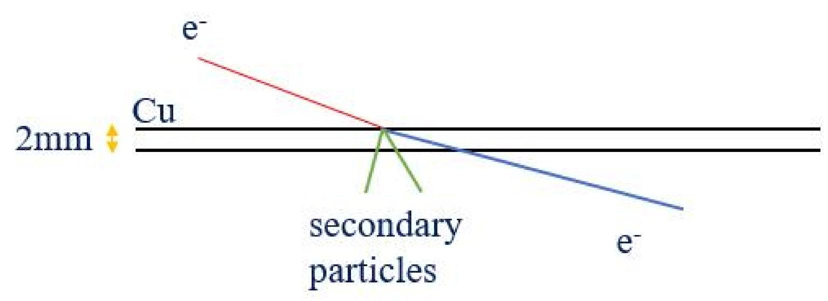


Bhabha scattering

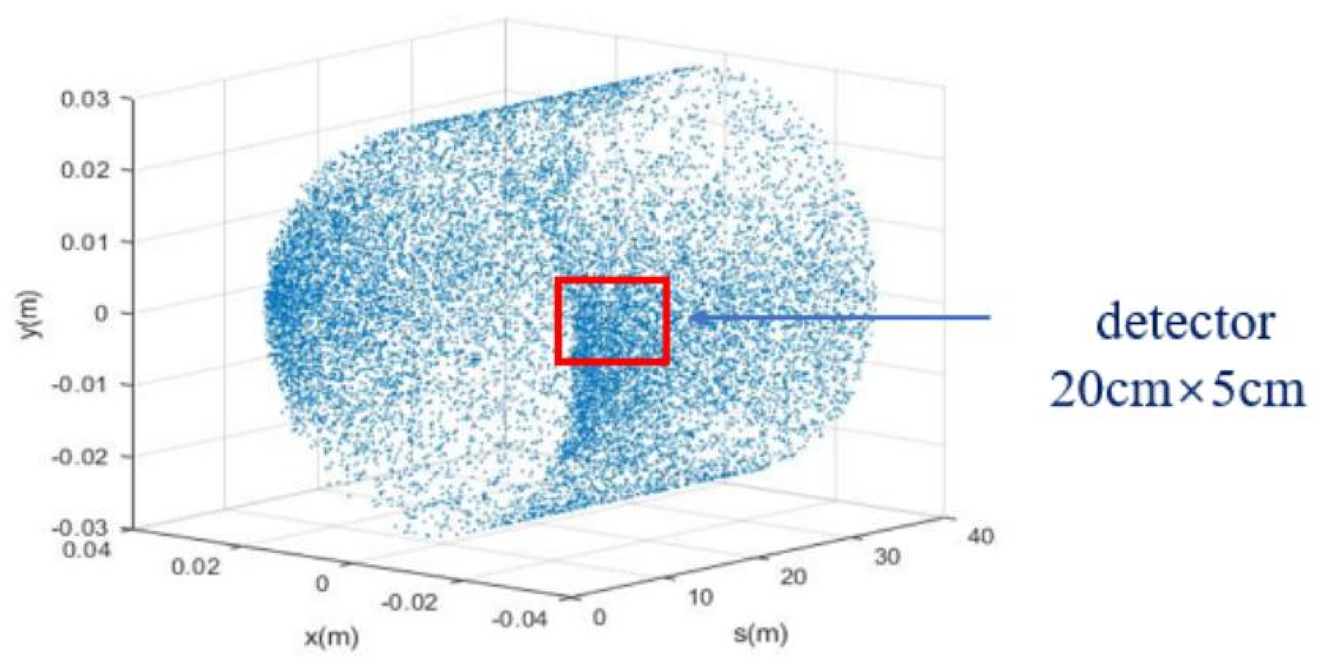
Preliminary design of the detector

Our goal is to build a detector with 2% accuracy at 1kHz counting rate. Parameters of the electron is shown in the table behind. The detector can detect radiative Bhabha particles(e-) at zero degree and secondary particles after the electrons going through the 2mm copper pipe like the figure shows

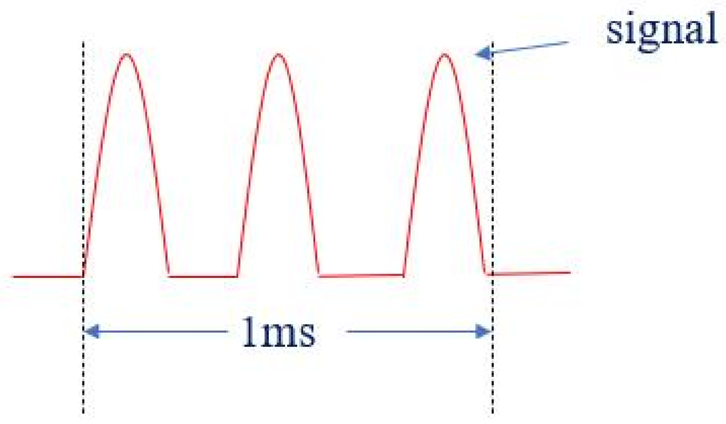
energy	24 GeV
angle	1 mrad
interval	600 ns (Higss) 23 ns (Z)



The detector is set at 10m downstream the IP. After preliminary simulation, 20cm×5cm is the best size.



We choose to use silicon carbide sensors in the detector. We are going to design a readout board to carry the 20cm×5cm SiC sensor and get the signal generated by the sensor. The readout board can get the signal waveform when an electron hits the sensor. In this way, we can get all the waveforms in 1ms and send them to the back-end electronics to analyze.



detector: generate signal by electrons

↓

readout board: get the waveform of the signal

↓

back-end electronics: calculate the number of electrons and luminosity

Readout system

We plan to use DRS4 chip to build readout system. The parameter of the chip is in the table below.

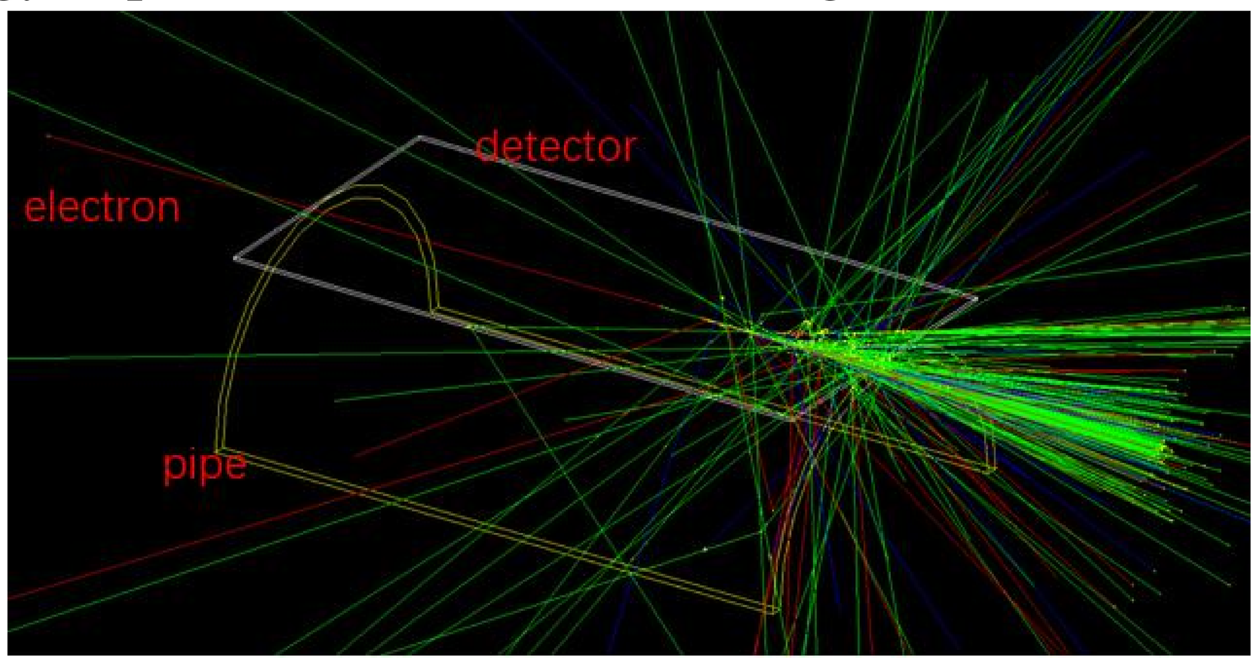
The DRS4 chip can change analog signal into digital signal which can be analyzed in the back-end electronics and send the digital signal to FPGA. Then we can calculate the luminosity.

Parameter of DRS4 chip

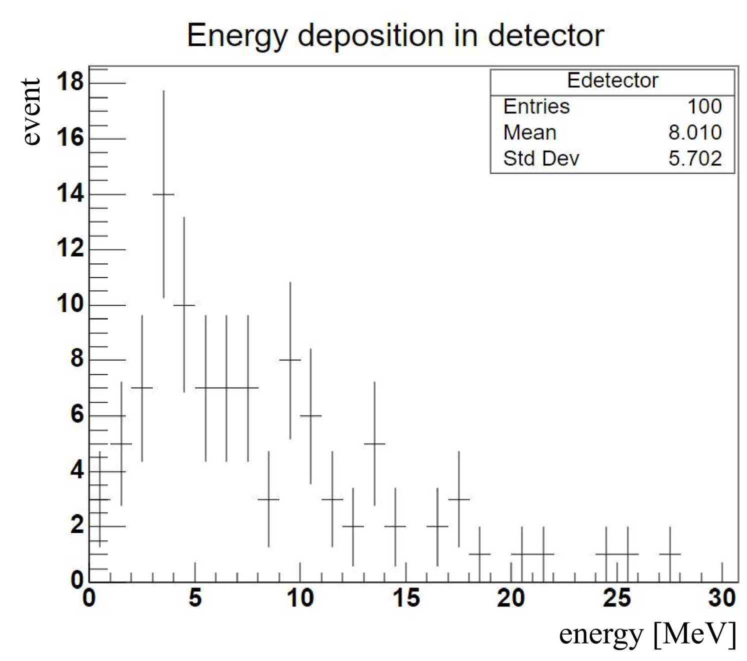
Bandwidth	950 MHz
channel	8
sampling rate	6 G/s
readout time	30ns

GEANT4 simulation

We use GEANT4 to simulate one 24 GeV hitting the 2mm copper pipe and use a 500μm silicon carbide sensor to detect it. The result and energy deposition are shown in the figures:



The mean value of energy deposition from single electron is 8 MeV, which means every 8 MeV energy in the SiC sensor represents an electron event. So we can calculate the total number of electrons by total energy deposition.



Summary and prospect

We introduce a fast luminosity monitor with silicon carbide which can be used in CEPC in this poster. We have finished preliminary design of the detector and have done GEANT4 simulation. Our goal is 2% accuracy at 1kHz counting rate and apply the fast luminosity monitor to CEPC successfully.