Design of A Fast Luminosity Monitor for the Super Tau-Charm Facility

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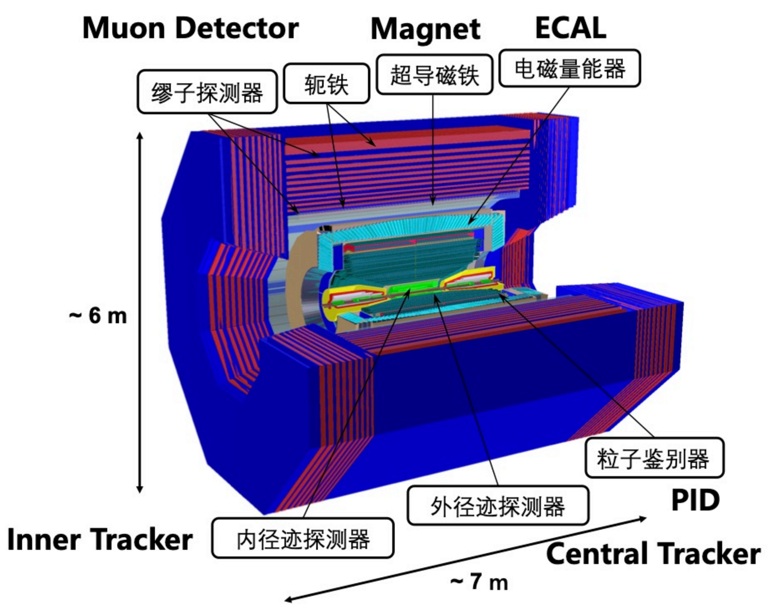
1. Abstract

A fast luminosity monitor is designed for the next generation Super Tau Charm Facility(STCF) for beam diagnostics and radiation monitoring. The simulation framework based on radiative Bhabha process is established. sCVD diamond and Cherenkov detector is proposed for the detection of the luminosity signals downstream the Interaction Point. We expect a relative precision better than 1% at peak luminosity with the current design.

2. Introduction

The **Super Tau-Charm Facility** (STCF) is a next-generation electron positron collider with center-of-mass energy 2-7 GeV and a peak luminosity exceeding $0.5 \times 10^{35} cm^{-2}s^{-1}$. The wide center-of-mass energy range and ultra-high luminosity of STCF present significant challenges to the physical design and development of the detector system.

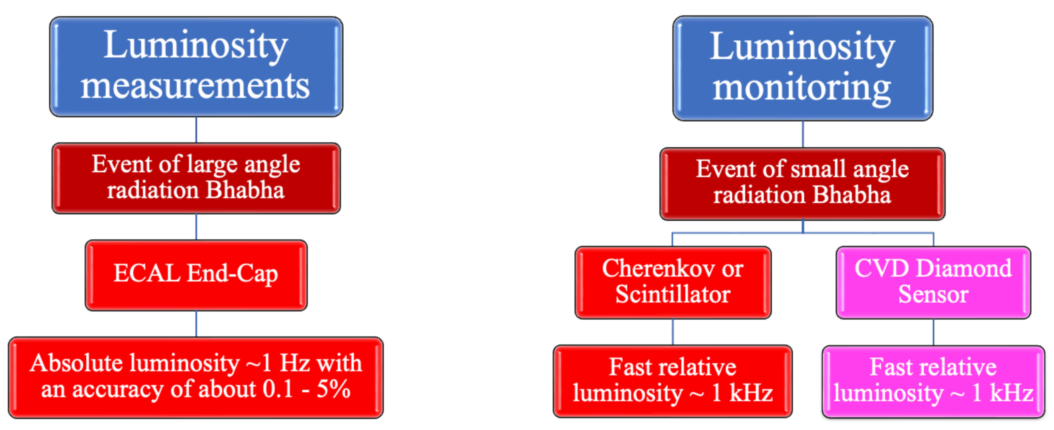


Because of the high luminosity, we need a **real time** and **fast** monitoring of beam luminosity and continuous **feedback** to accelerator control system. Meanwhile, luminosity monitor can support the **diagnostics of beam** and **radiation protection and monitoring**.

3. Principle

Luminosity:

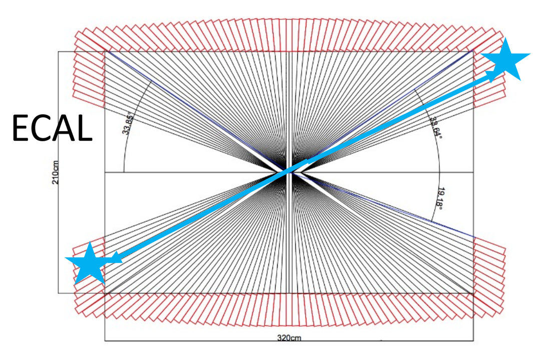
Luminosity is an important physical parameter that characterizes the number of physical events generated per unit time, and is one of the important parameters for measuring the performance of a collider.

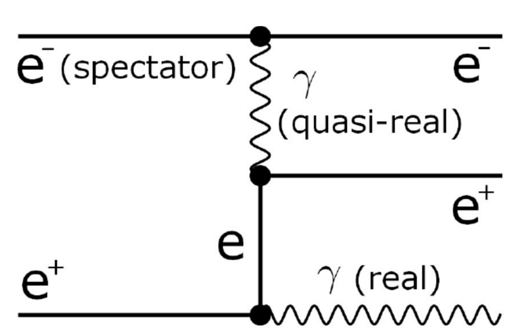


Method:

1.Using ECAL to complete absolute luminosity measurement by back-to-back Bhabha scattering events.

2.Using Luminosity Monitor to fast measure the relative luminosity by radiative Bhabha events. This poster focused on this method.





4. Simulation Framework

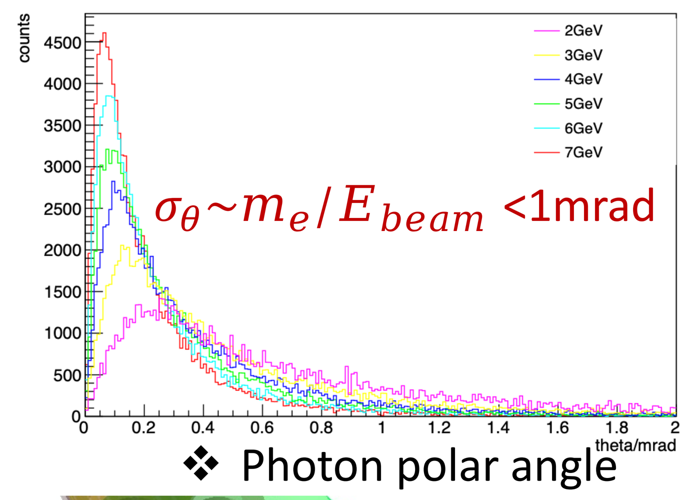
Based on STCF offline software system(OSCAR)

Event Generator:

$$e^+ + e^- \rightarrow e^+ + e + \gamma$$

1.Extremely **high cross-section**, The photon emission angle is concentrated within~ $1mrad$.

2.integrate **BBBREM** Generator to OSCAR

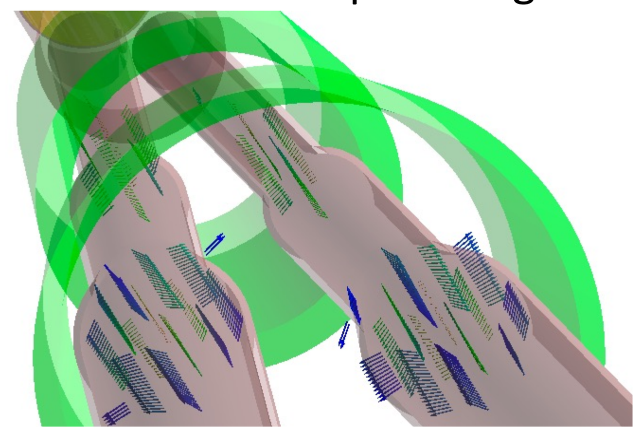


❖ Photon polar angle

Geometry and Field Setup:

QD,QF: Quadrupole, e^+/e^- will defocused(focused) in x/y

B0: Dipole, e^+/e^- will bend in x.



❖ quadrupola field

5. Conceptual Design

Luminosity Signal:

1.monitor luminosity by collecting **recoil** e^+/e^-

2.Low energy e^+/e^- will be bent in **B0** downstream of the IP. After passing through **QD2** , e+/e- will be bent again in the x direction

3.The distribution of position is related to particle **energy**

Window shaped beam pipe : reduce electromagnetic shower

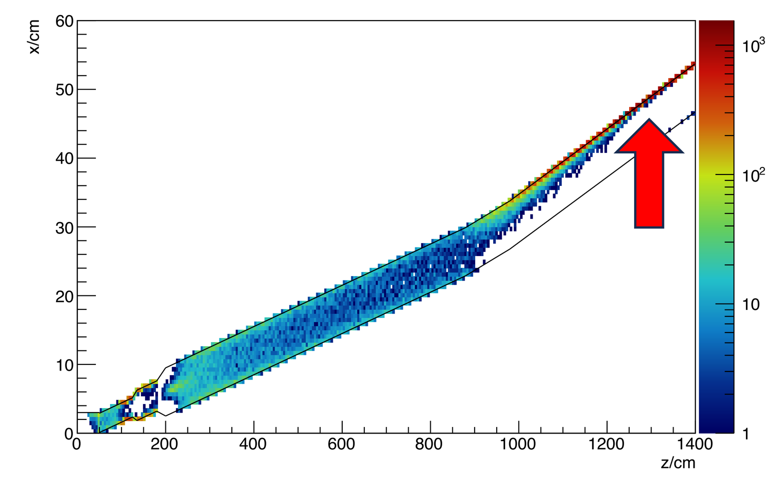
Diamond : Good radiation resistance, fast signal collection, Good SNR; size: $4.5 \times 4.5 \times 0.5mm^3$, Using broadband current amplifier, turn ionization energy to the current signal

Preliminary Luminosity Simulation:

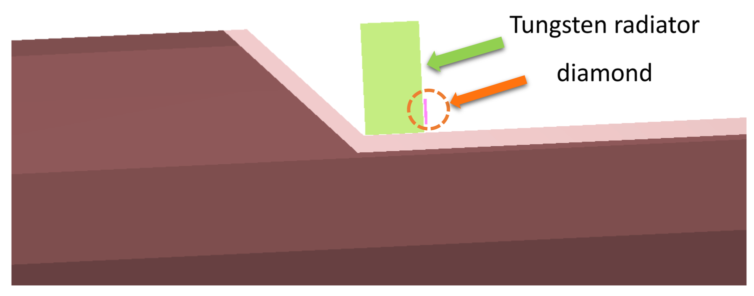
Train Integrated Luminosity signals(TIL): integrate the deposition energy signal over all the bunches in 1 ms.

Preliminary Simulation shows at the peak luminosity condition, the relative precision will reach 1% when luminosity reaches $0.5 \times 10^{35} cm^{-2}s^{-1}$. The linear relationship between TIL on different channel.

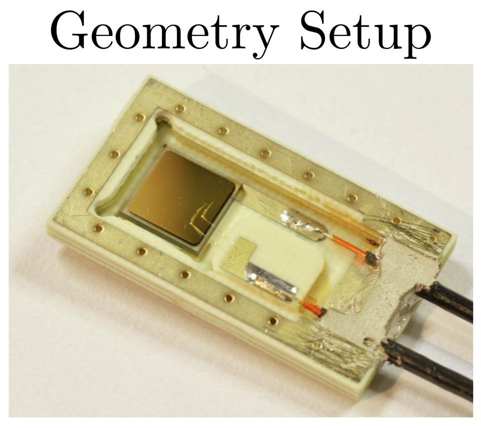
Background Simulation Considering touschek effect and beam-gas effect as main background input. Ongoing simulation work.



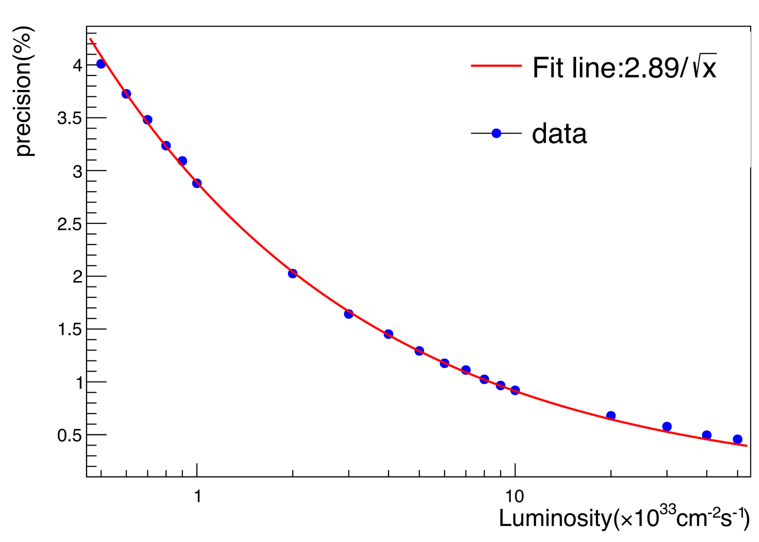
e^+ Distribution

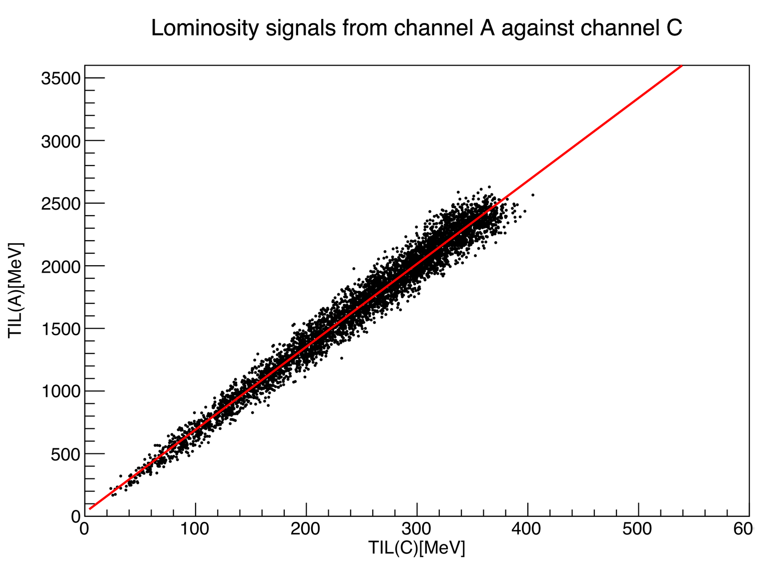


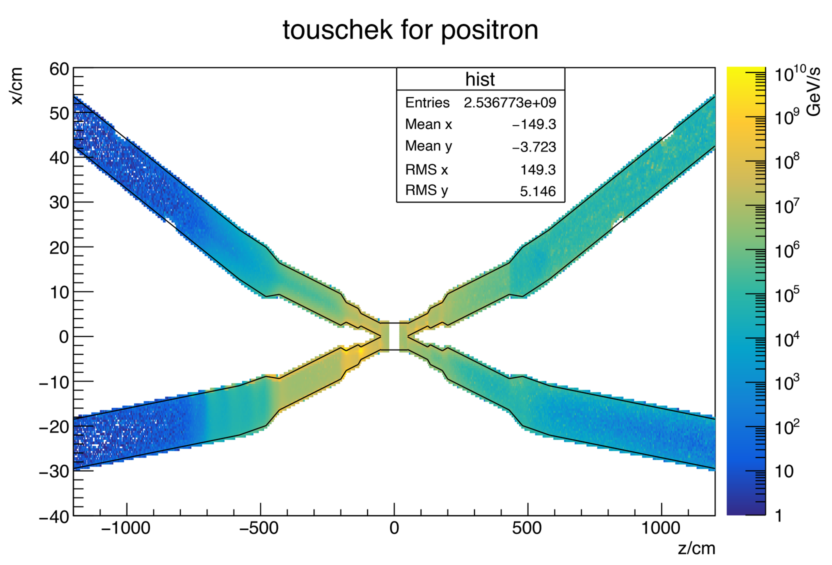
Geometry Setup



sCVD Diamond







6.References

[1] 薛镇. 北京正负电子对撞机重大改造工程（BEPCII）的亮度监测 [D]. 中国科学技术大学, 2010

[2] C.G. Pang, P. Bambade, S. Di Carlo, Y. Funakoshi, D. Jehanno, A fast luminosity monitor based on diamond detectors for the SuperKEKB collider, Nucl. Instrum. Meth. A 931 (2019) 225-235