
Beam-Beam Background Study for VTX

~ Estimation of e^+e^- pair background ~

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Introduction

- Background for VTX
 - Synchrotron radiation (secondary particles)
 - Beam-Beam interaction (e^+e^- pair production)
 - Radiation damage due to charged particle increases CTI.
 - Depends on dose and particle energy.
 - Incoherent e^+e^- pair production
 - Processes included in CAIN, Beam-Beam interaction MC generator
 - Breit-Wheeler ($\gamma + \gamma \rightarrow e^- + e^+$)
 - Beth-Heitler ($\gamma + e^+ \rightarrow e^+ + e^- + e^+$)
 - Landau-Lifshitz ($e^+ + e^- \rightarrow e^+ + e^- + e^- + e^+$)
 - Bremsstrahlung ($e^+ + e^- \rightarrow e^+ + e^- + \gamma$)
- Beam parameter
 - TRC500 [Technical Review Committee]
 - Beam Energy 250GeV

Property of e^+e^- pair production

- e^+e^- pair production (CAIN incoherent pair data)

Fig.1: Pt vs |cos|

For all e^+/e^-

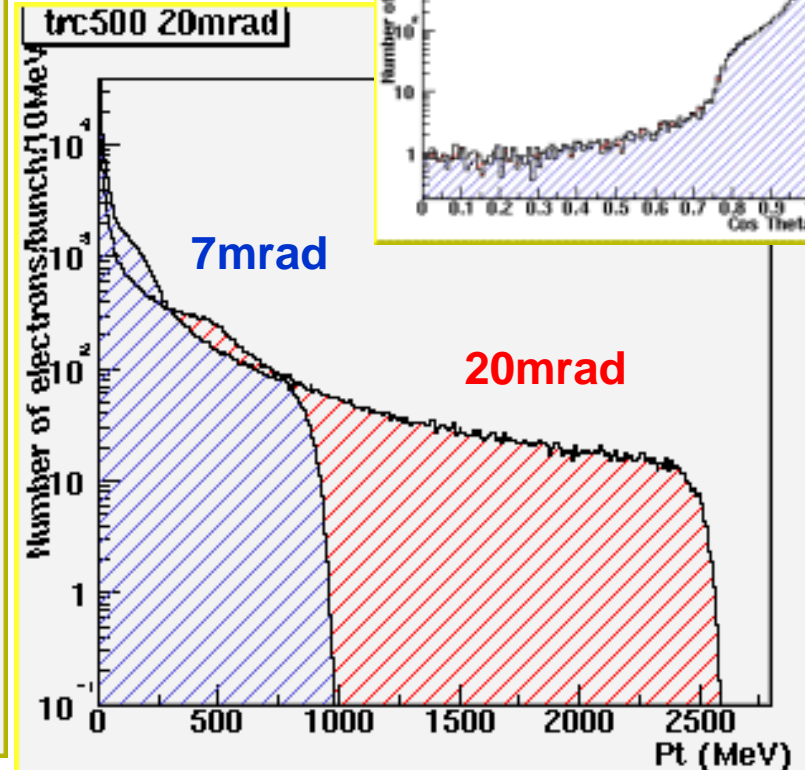
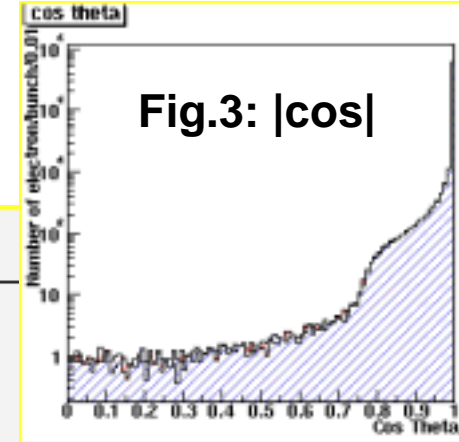
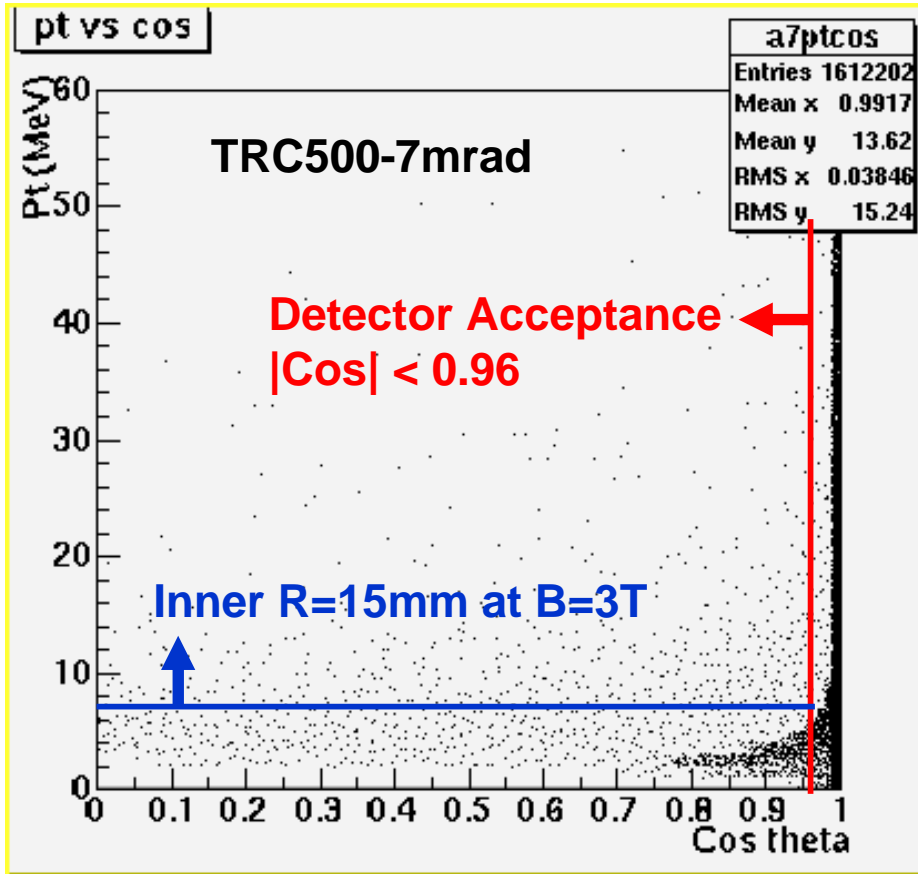


Fig. 2: Pt of electron/positron

Property of e^+e^- pair production (cont.)

- With the acceptance cut of $|\cos\theta| < 0.96$

Fig.4 Pt dependence

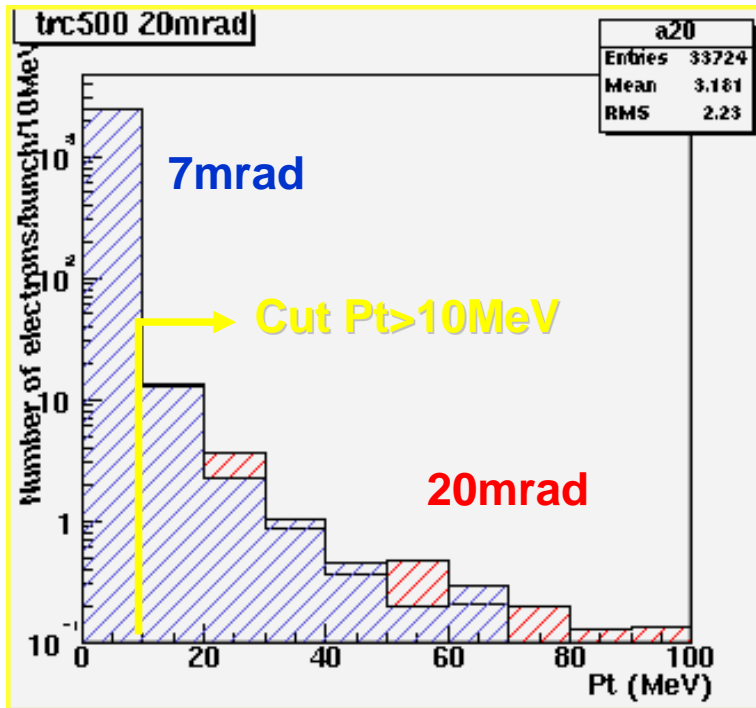
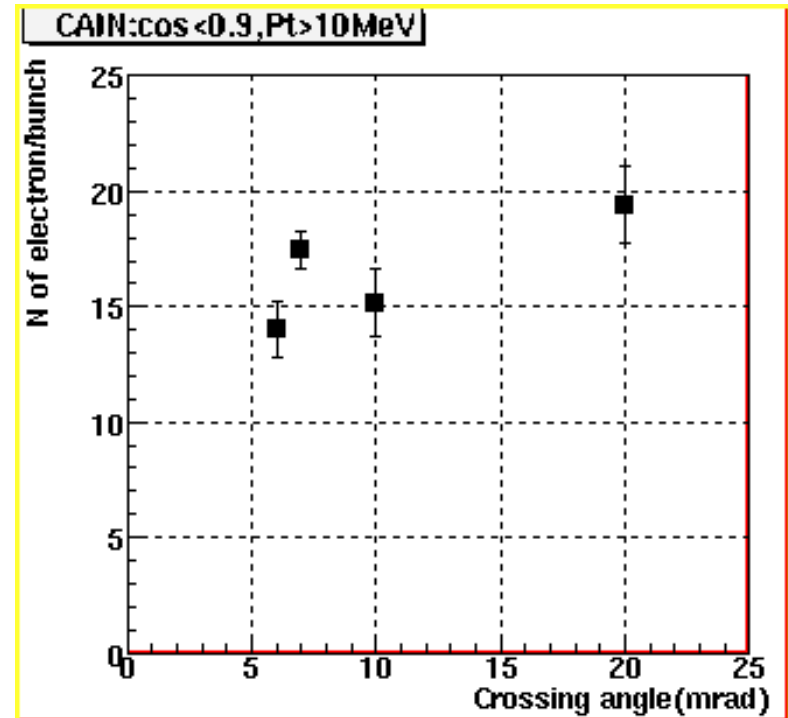


Fig.5 Crossing Angle dependence for $Pt > 10$ MeV e^+e^-



- Hit at VTX involve effect of (1)curling tracks and (2)secondary particles produced in materials.
- e^+e^- background = (Beam property) x (Detector conf.)

Study items(1)

- What has to be studied?
 - Detector Configurations
 - Radius of inner most layer ($R=24\text{mm}$ or 15mm)
 - B-Field ($B = 3 \text{ T}$ or 4T)
 - Detector/Beam configurations
 - Crossing angle ($A = 7\text{mrad}$ --- 20mrad)
 - Beam configuration
 - Scraping collision
- Simulation
 - e+e- pair production generator (CAIN)
 - Detector simulator (JUPITER: $L^*=4.3$, SuperQC1)

Study items(2)

■ Definition of hit density

□ Hit counting

■ CCD VTX detector

□ Layer/Ladder/Sensor/Epitaxial,Substrate/**PixelArea**/Pixel

□ Counting number of e+/e- in the detector

- Not a pixel hit, yield of radiation damage.

■ Hit accumulation: Readout cycle = Every train interval

□ TRC500

▪ Repetition freq. 150Hz = 6.7ms

▪ 1train = 192 bunches

▪ 1bunch has 7.5E+9 electrons

■ Hit density

▪ $(\# \text{ of hit/bunch}) \times 192 \text{ bunches/train} / \text{Area} \quad [\text{hit/mm}^2/\text{train}]$

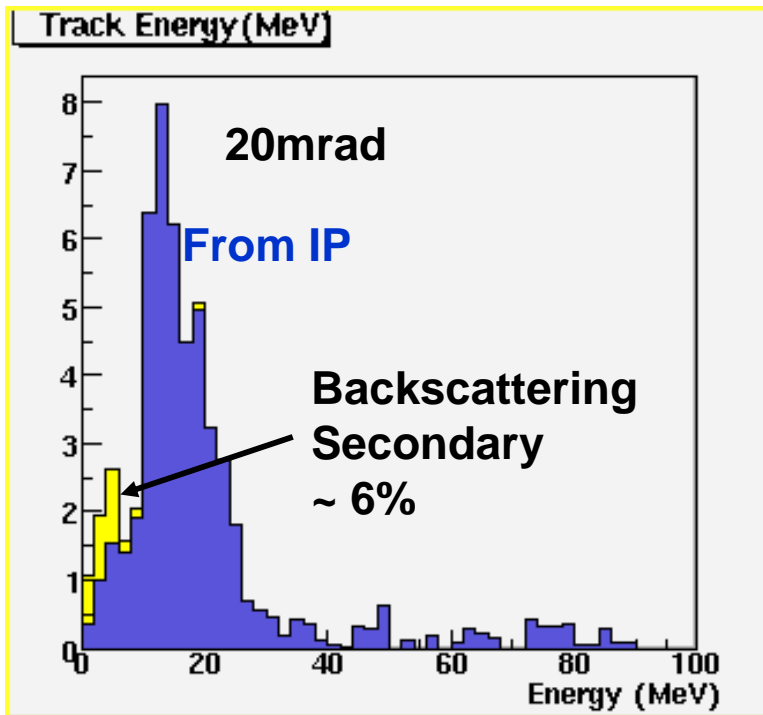
Result of simulation

Fixed to R=24mm, B=3T

■ Crossing Angle

Table.1 Hit density

Crossing Angle	6mrad	7mrad		20mrad	
Wafer Thick.(um)	330	330	100	330	100
Lyr0[/mm2/train]	0.35	0.33	0.37	0.49	0.53



Final Focus system is not optimized for 20mrad crossing.
⇒ Include backscattering(~ 4%)

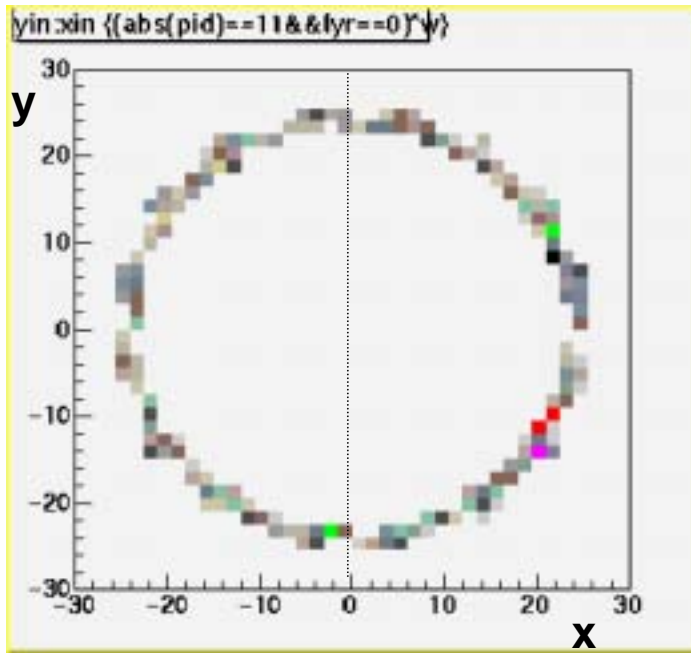
Fig.6 Energy of electron

2003/12/14

Mumbai Phone Meeting

- 20mrad crossing angle

Fig.7 X-Y Hit map. Layer=0



Left Right

Right/Left = 130 %

Fig.8 X Hit Position

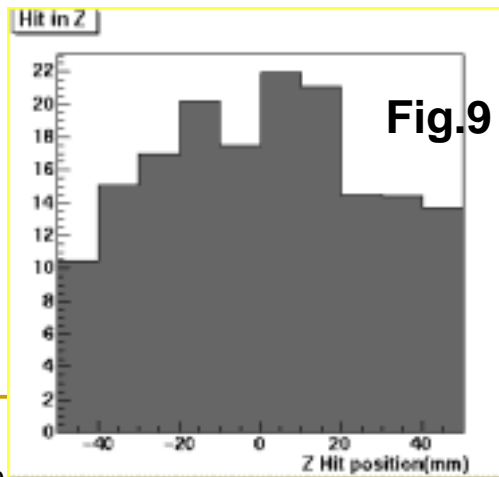
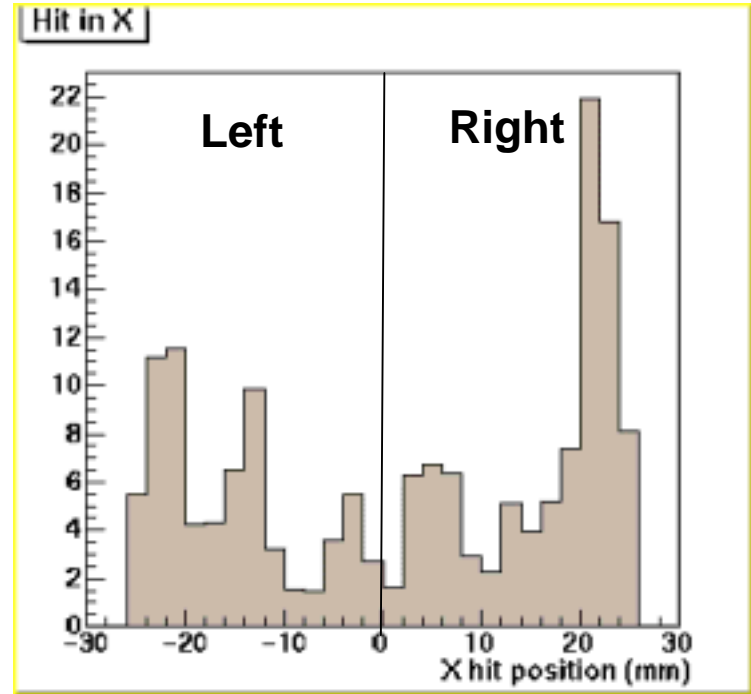


Fig.9 Z Hit Position

Result cont.

Crossing angle = 7mrad

Inner radius and detector field

Table.2 Hit density

Radius	24mm		15mm		
B Field	3T		3T	4T	
Wafer thick (um)	330	100	330	330	100
Lyr0[/mm2/train]	0.33	0.37	2.05[6mrad]	0.94	0.95

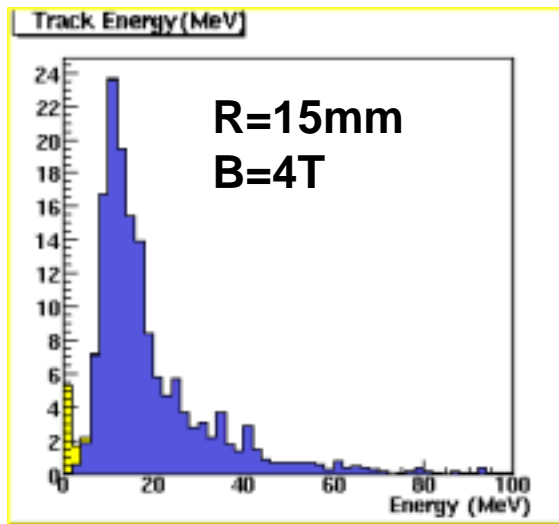
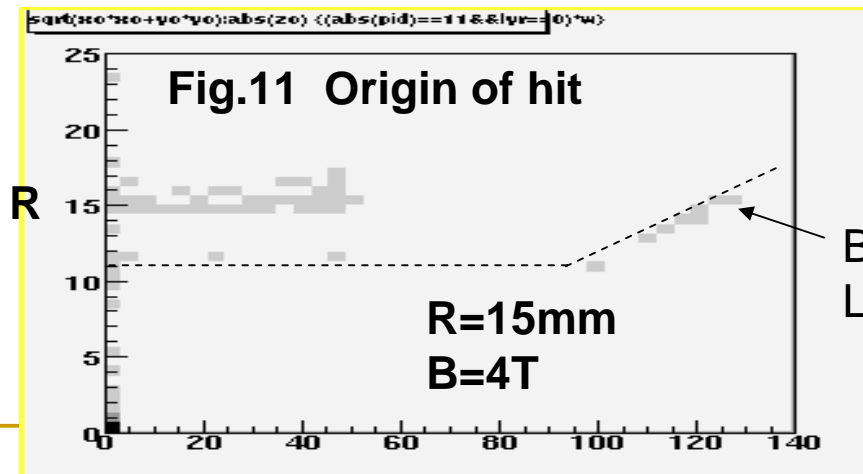


Fig.10 Energy of electron



B-Field can suppress background Effectively!!



Scraping collision

- Displacement of the one of the bunch at IP.
 - Electron beam position at IP was changed to $+dy$.

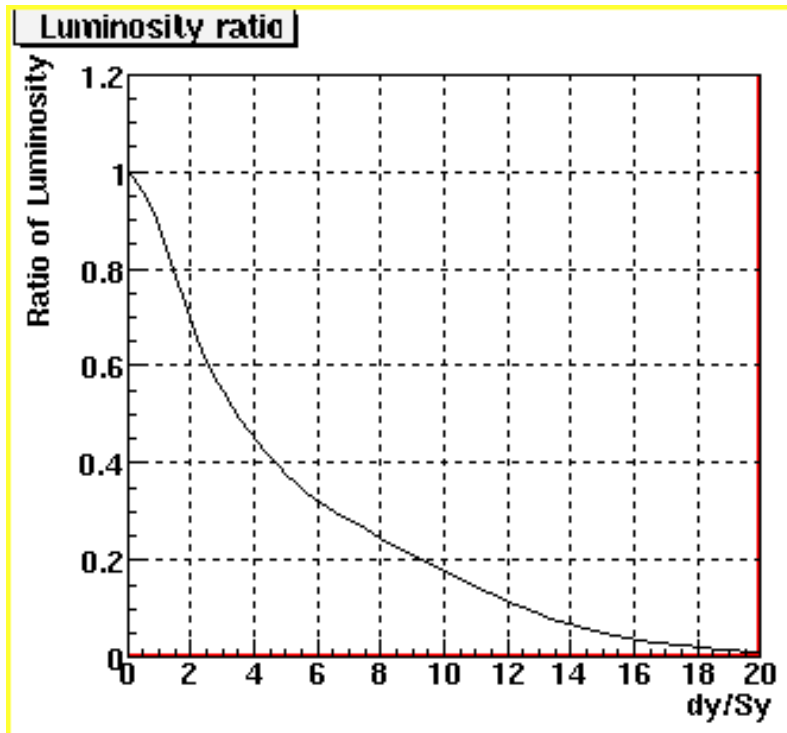


Fig.12 Luminosity.
(Normal=1.)

Crossing Angle 7mrad

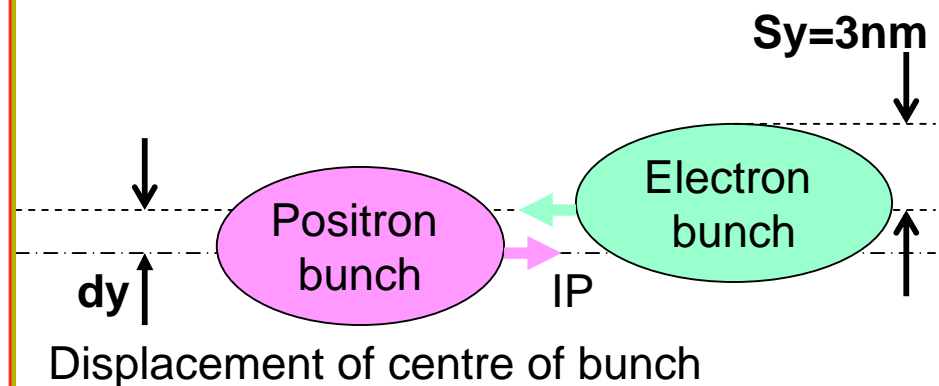


Fig.13 Scraping collision

Scrapping collision

Very preliminary

- Hit density (TRC500-7mrad)

R=24mm, B=3T
Wafer=100um

Fig.14 Hit density

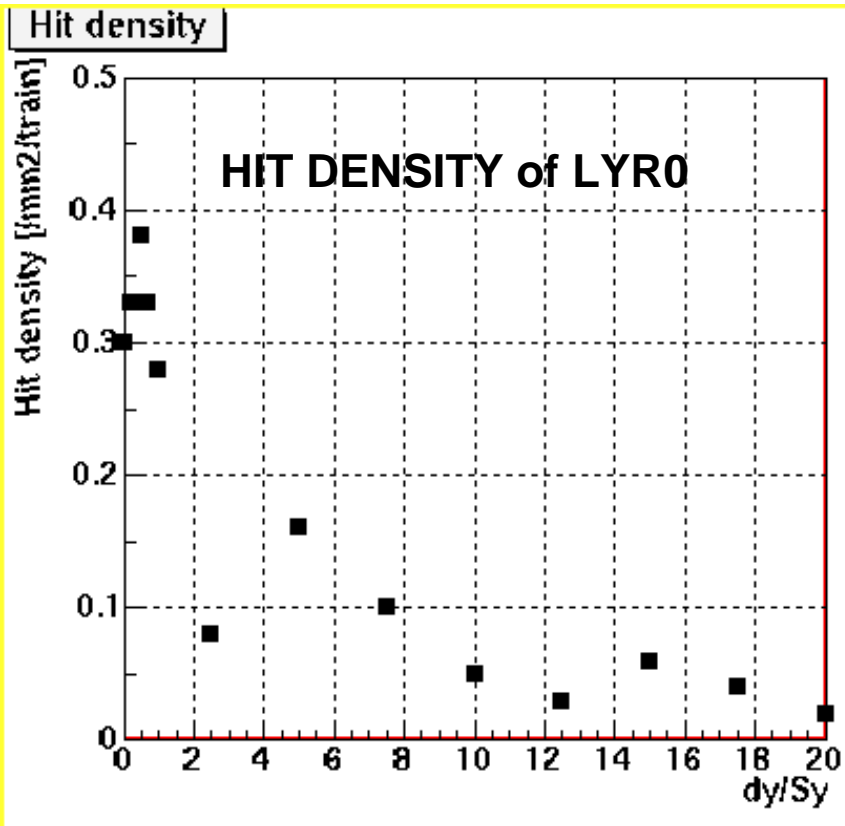
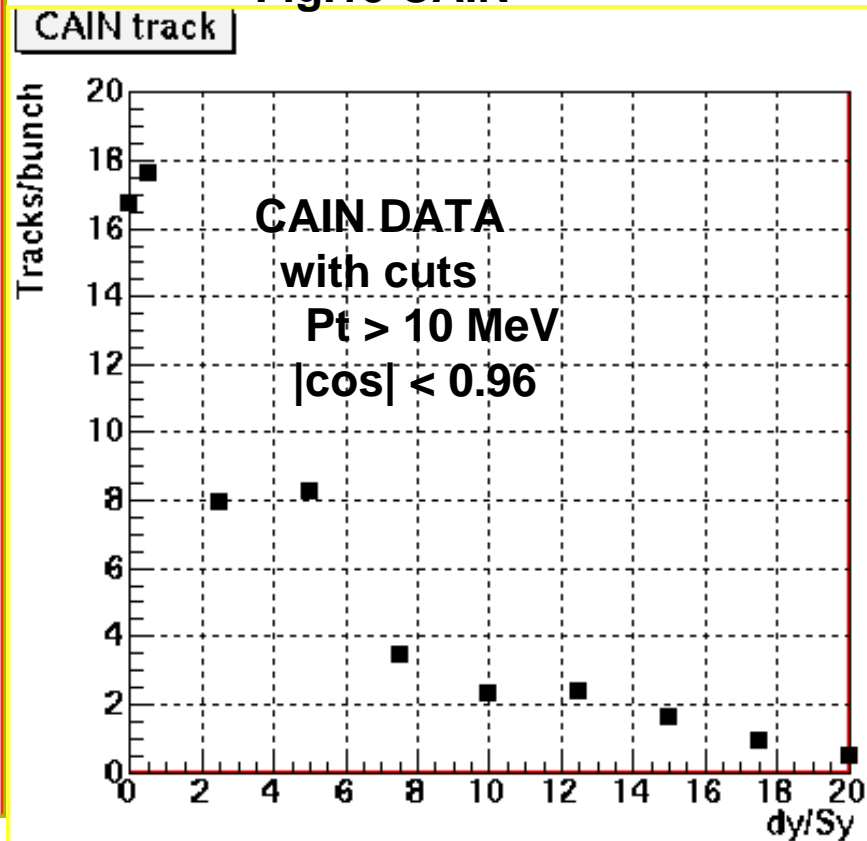


Fig.15 CAIN



Summary

Very Preliminary

- Background from e^+e^- pair production has been estimated with CAIN and Jupiter simulations.
 - Larger crossing angle will make a background rate higher.
 - 20mrad crossing 0.53/mm²/train. (+40% from 7mrad)
 - The option R=15mm will be possible by applying stronger magnetic field.
 - R=15mm/B=4T 0.95/mm²/train (-50% from B=3T)
 - If R=15mm/B=4T/20mrad crossing was chosen, rough estimation: $1.40 \times 0.95 = 1.4$ /mm²/train
(1year operation 10^7 s: 2×10^{11} e/cm²/year)
 - Scrapping collision has been studied.
 - Even if the one of the beam is displaced 5sigma from IP, the hit density become about a half of nominal collision, while luminosity is suppressed to less than 50%.
- => More Study with high statistics is needed.