Beam-Beam Background Study for VTX
~ Estimation of e+e- pair background ~

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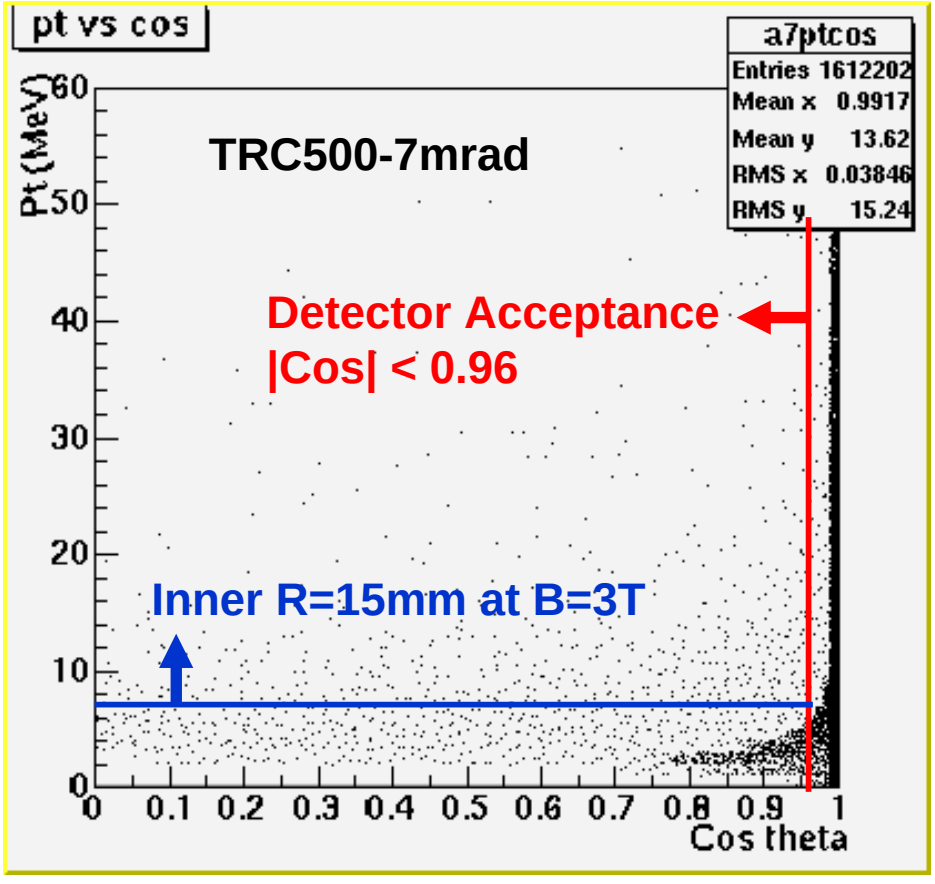
Introduction

- 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 -> e- + e+)
        - Beth-Heitler (gamma + e+- -> e+- + e- +e+)
        - Landau-Lifshitz (e + e -> e + e + e- + e+)
        - Bremsstrahlung (e + e -> 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-

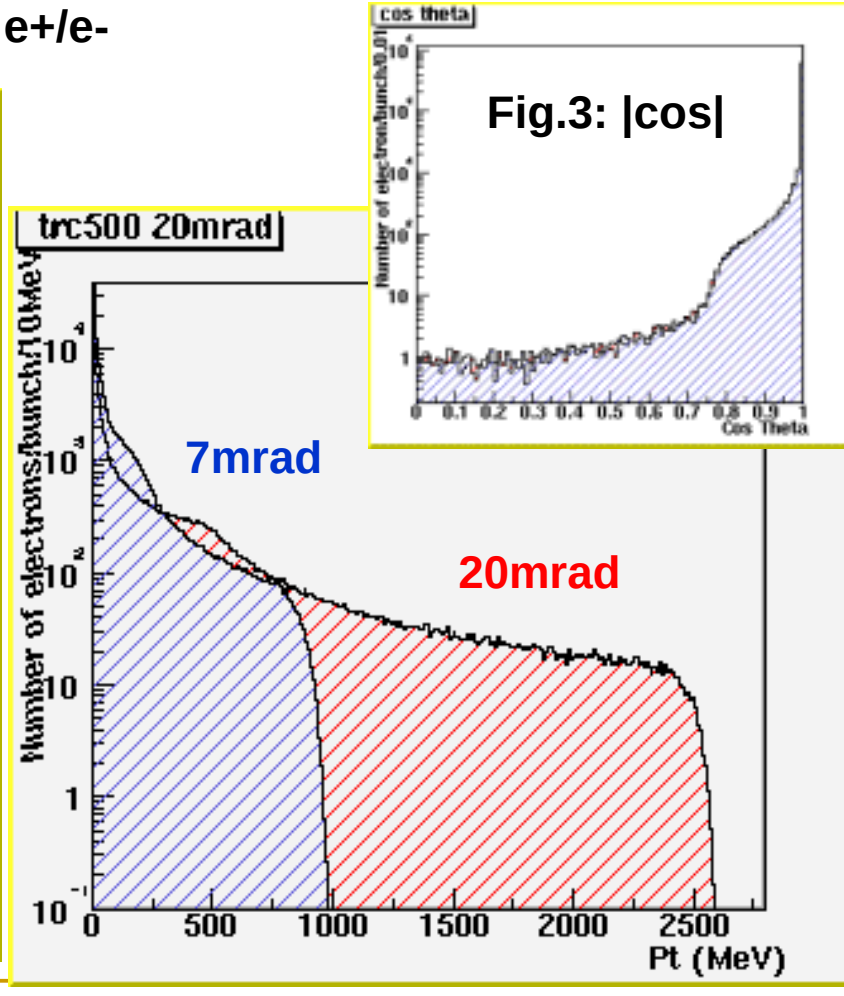


Fig.3: |cos|

Fig. 2: Pt of electron/positron

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

- With the acceptance cut of |cos| < 0.96

Fig.4 Pt dependence

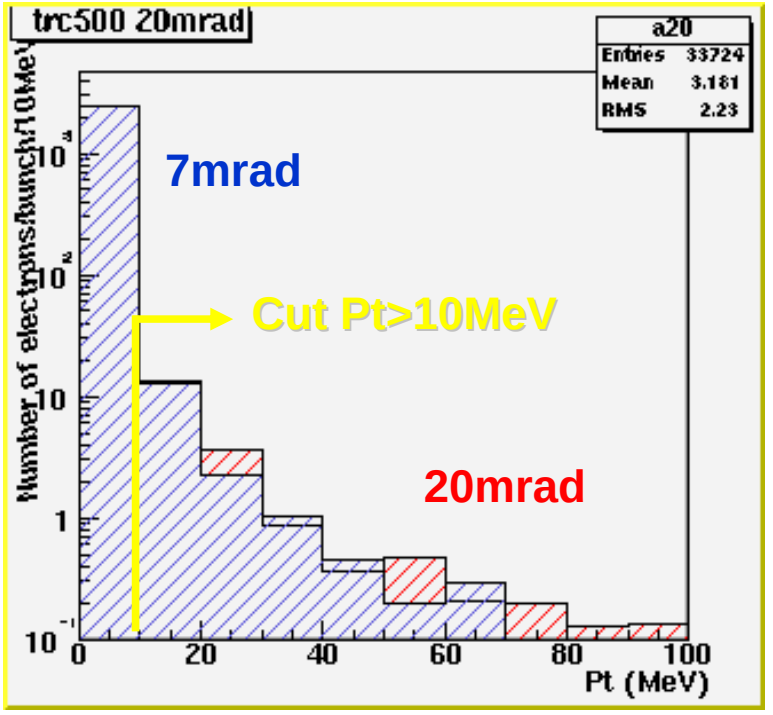
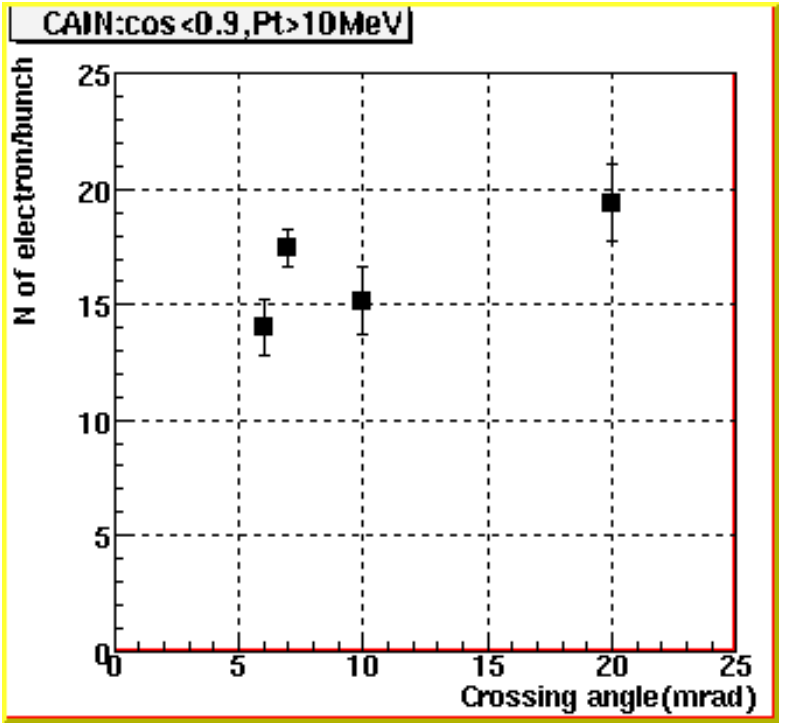


Fig.5 Crossing Angle dependence for Pt > 10 MeV e+e-



- **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=24mm or 15mm)
    - B-Field (B = 3 T or 4T)
  - Detector/Beam configurations
    - Crossing angle (A = 7mrad --- 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
      - (# of hit/bunch) x 192bunches/train / Area [hit/mm2/train]

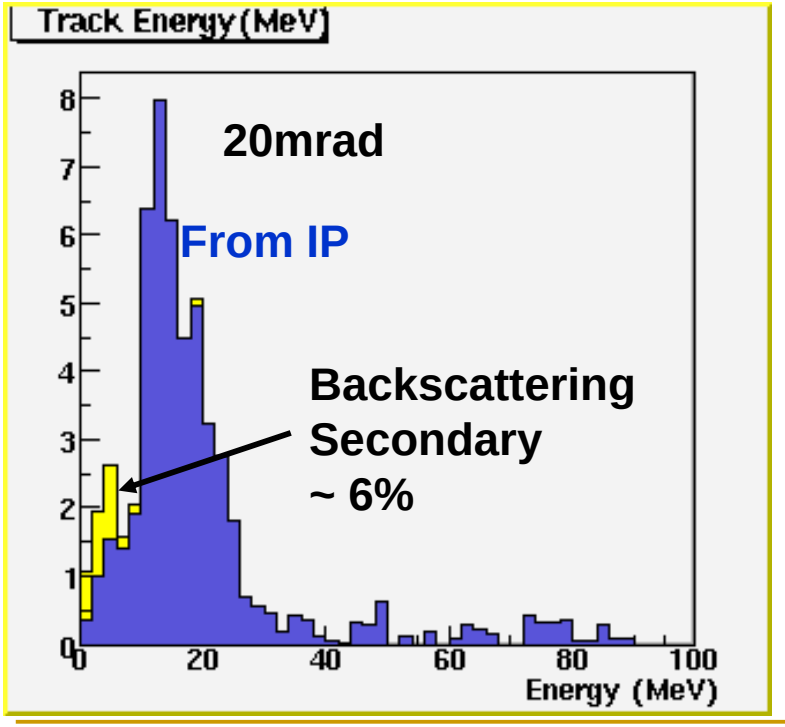
Result of simulation

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

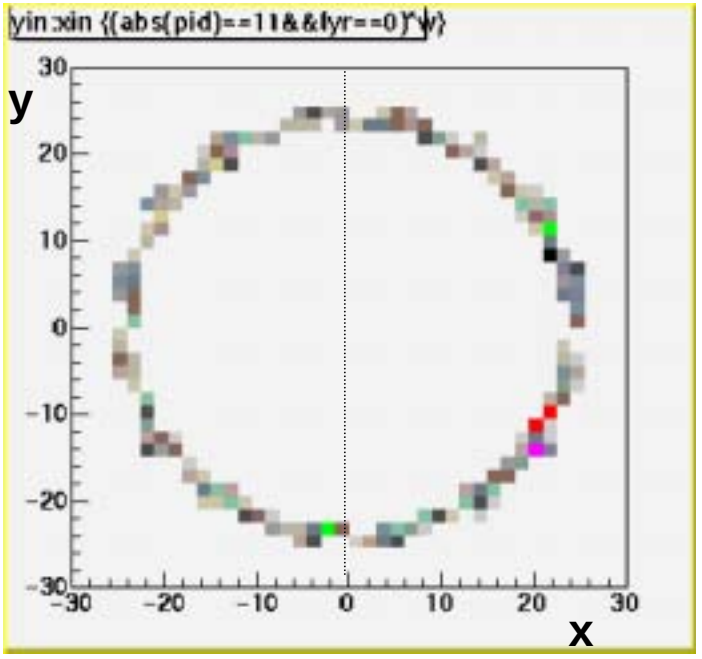


Final Focus system is not optimized for 20mrad crossing.
⇒Include backscattering(~ 4%)

Fig.6 Energy of electron

- 20mrad crossing angle

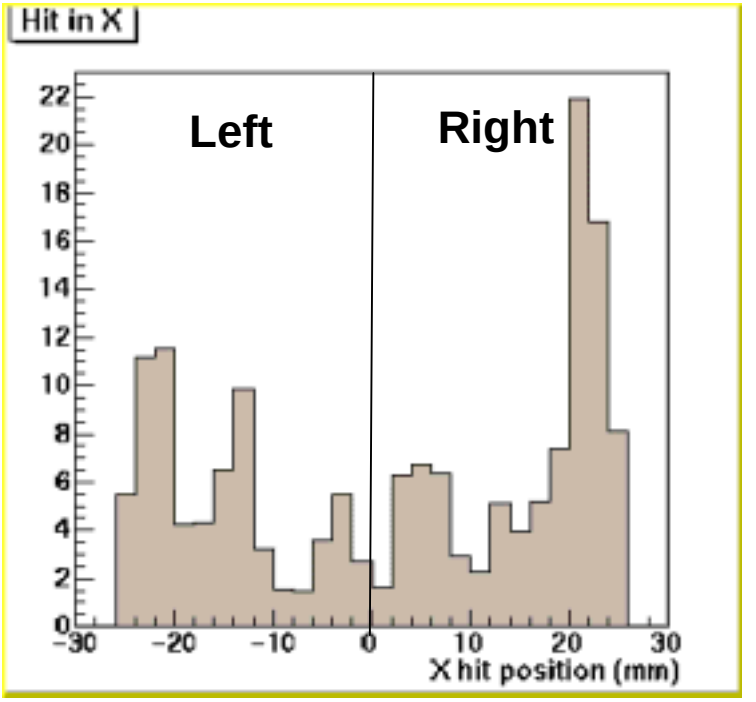
Fig.7 X-Y Hit map. Layer=0



Left Right

Right/Left = 130 %

Fig.8 X Hit Position



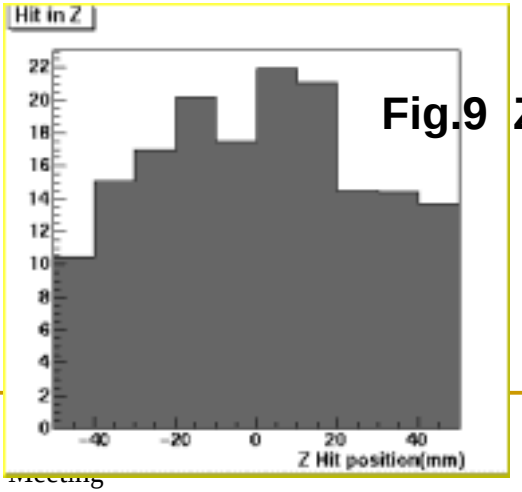


Fig.9 Z Hit Position

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

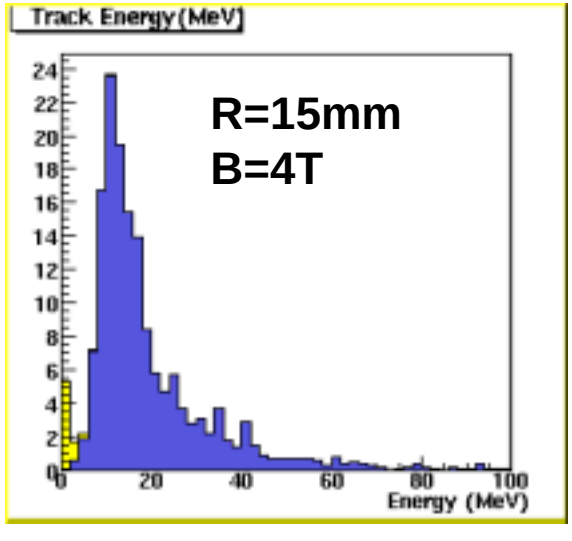
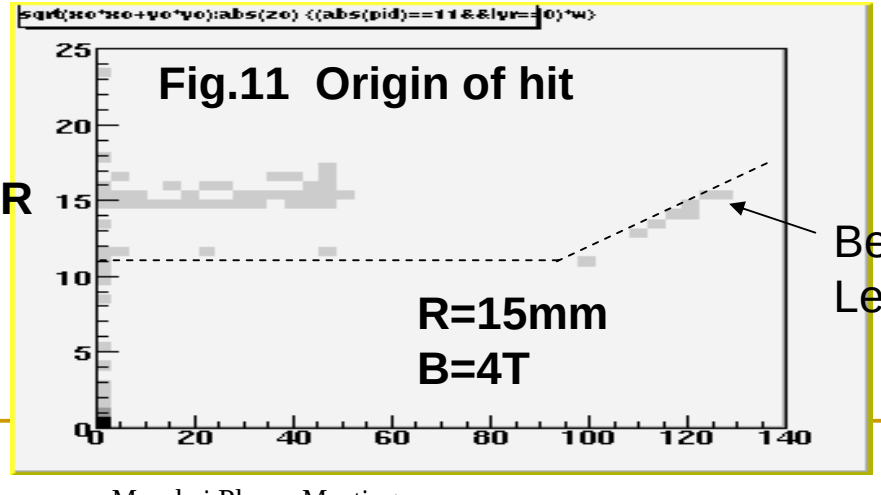


Fig.10 Energy of electron

B-Field can suppress background Effectively!!



Beam Pipe
Less than 1%

Scraping collision

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

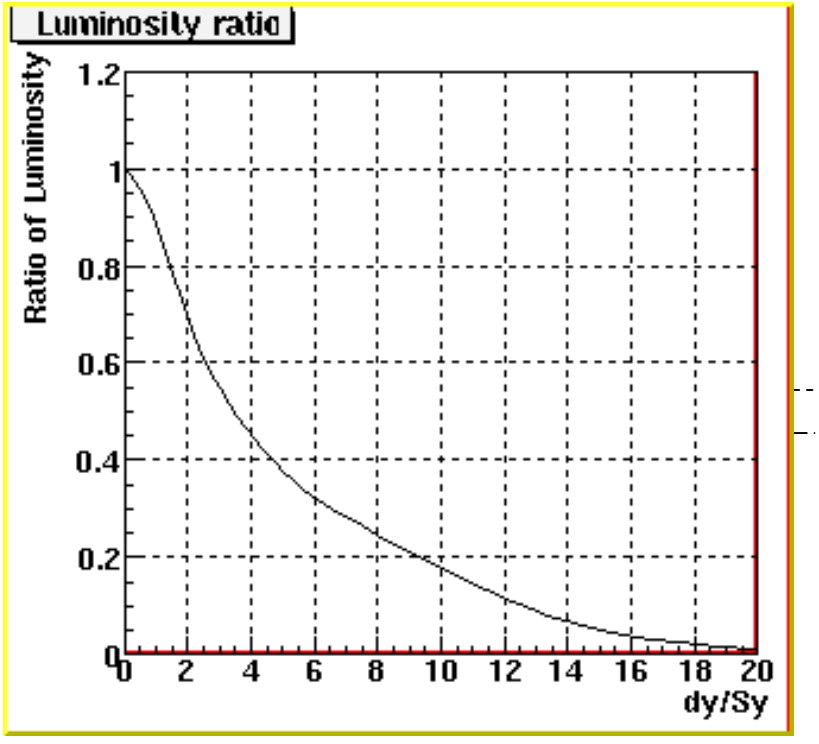


Fig.12 Luminosity. (Normal=1.)

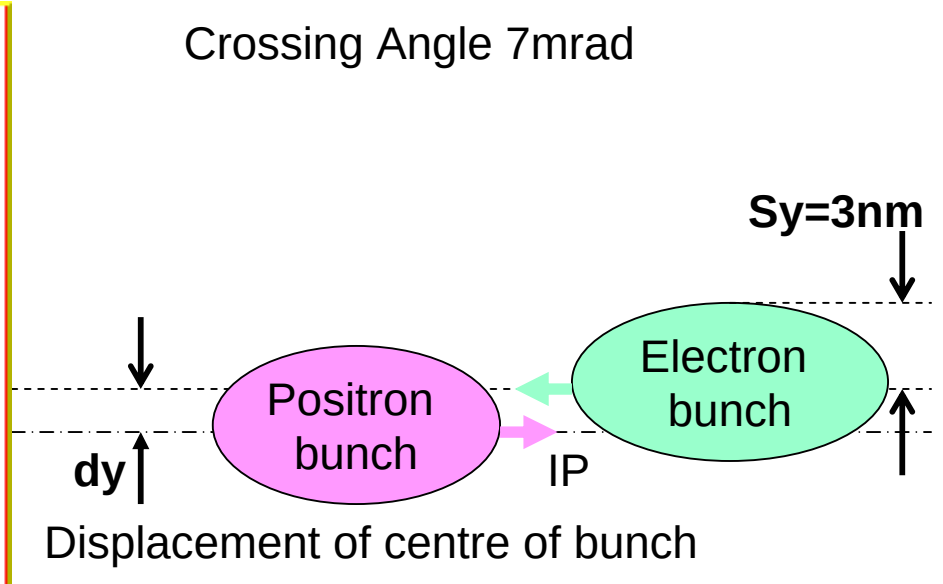


Fig.13 Scraping collision

Scrapping collision

Very preliminary

- Hit density (TRC500-7mrad)

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

Fig.14 Hit density

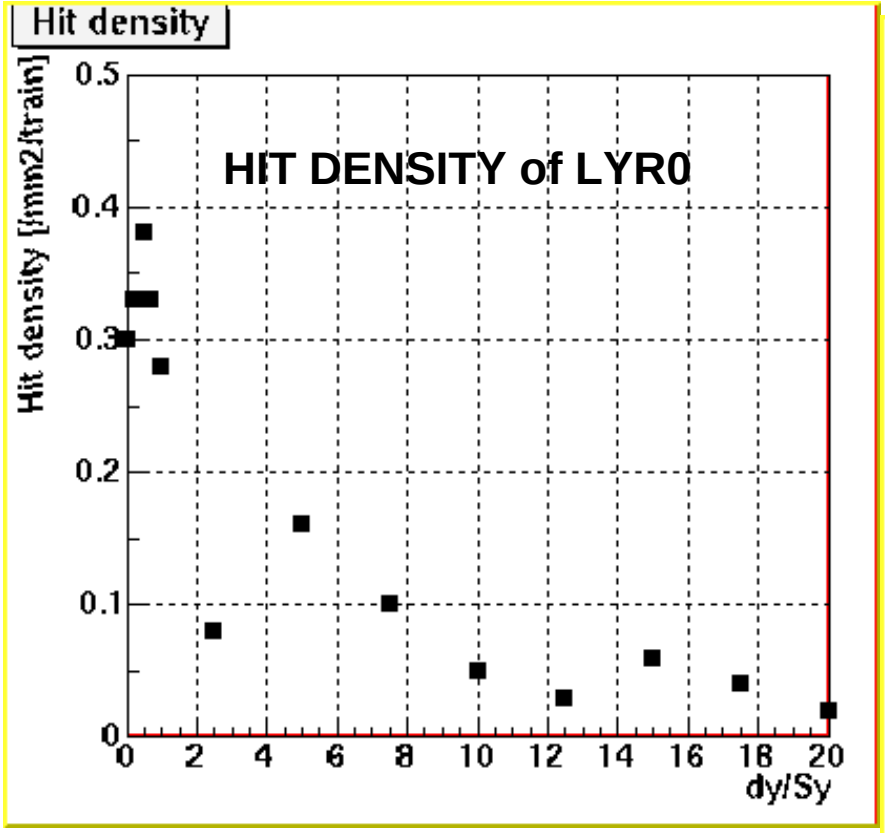
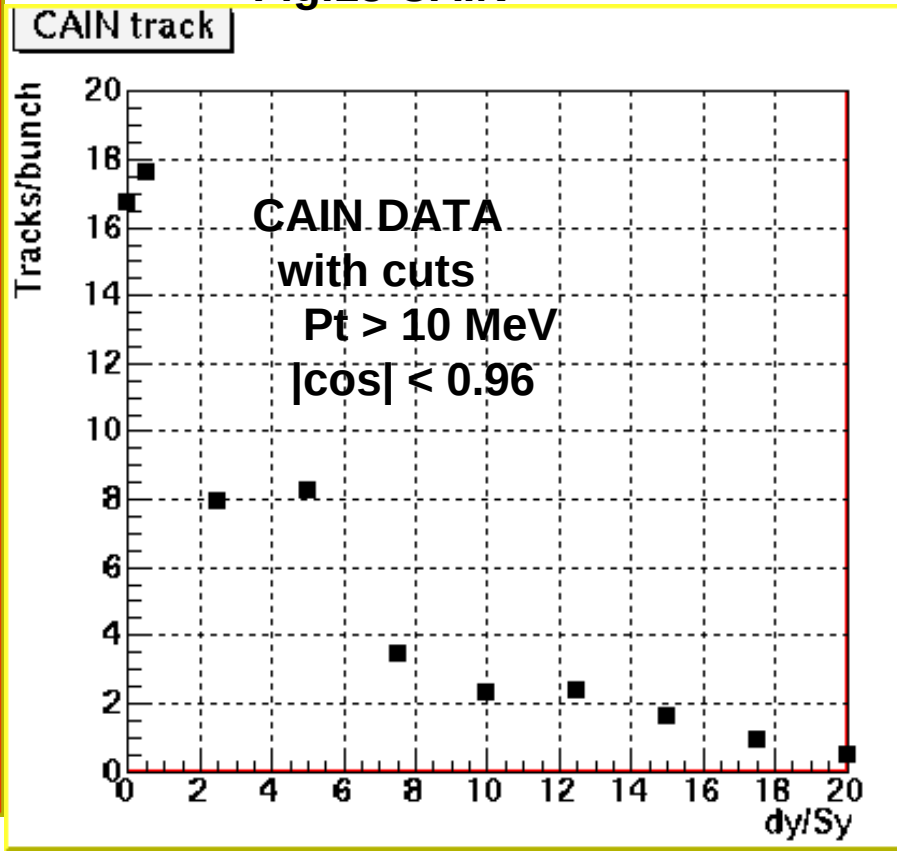


Fig.15 CAIN



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*0.95=1.4/mm2/train
    (1year operation 10^7s: 2x10^11e/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.