Study of beam Background at GLC

Based on the studies at GLC Vertex Group includes contribution from BDS Group

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and BDS Group

Contents

- Beam-Beam background for VTX
  - Results from VTX Group
- Upstream background
  - Results from BDS Group
- Summary

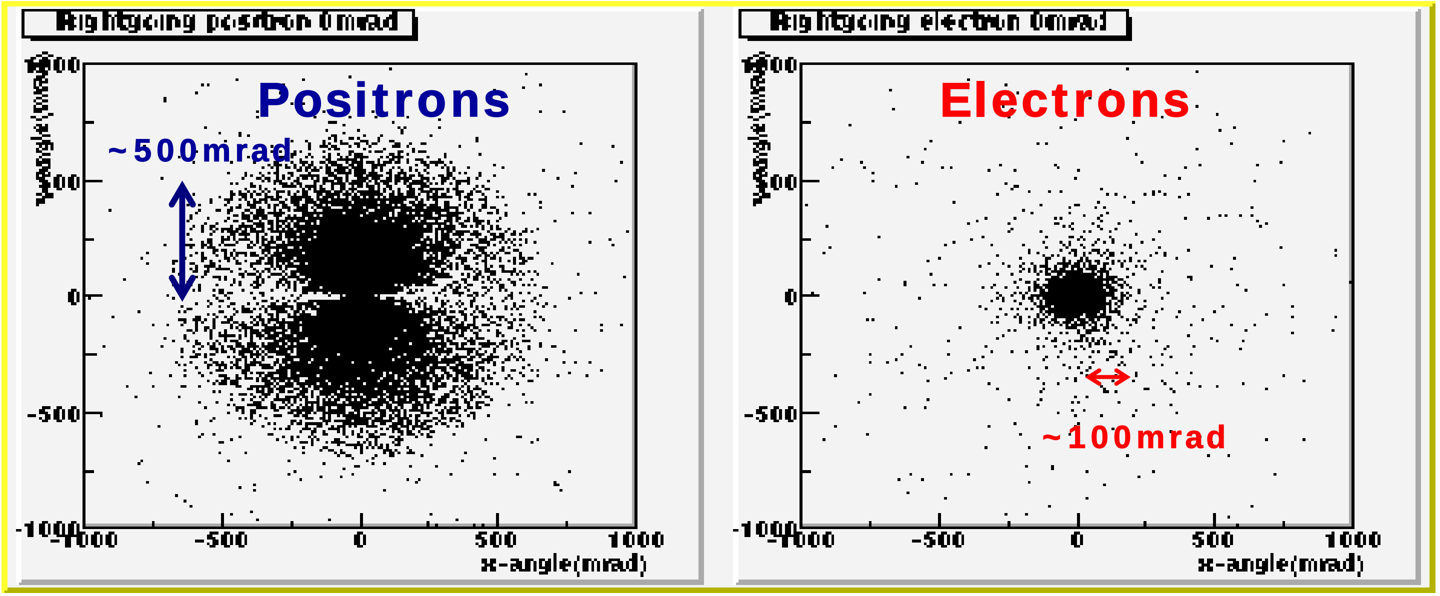
Beam-Beam Background

- Incoherent e^+e^- pair production
  - Studied with CAIN MC generator
    - Processes included in CAIN,
      Beam-Beam interaction
      - 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)
- Background situation depends on
    - Beam parameters
    - IP region design
    - Detector magnetic field
- We estimated the hit density on the VTX detector for some of the settings.

Property of Beam-Beam Interaction

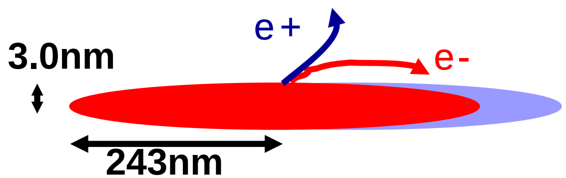
Head-on
Incoherent e+e- pair

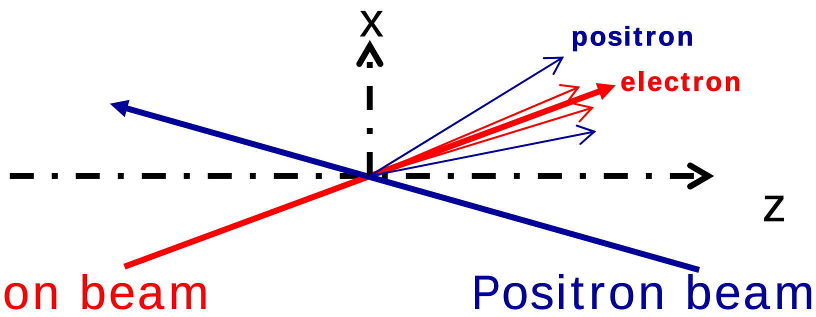
Right going electron beam produces spread-out positrons, since the same sign charge as the incoming positron beam.



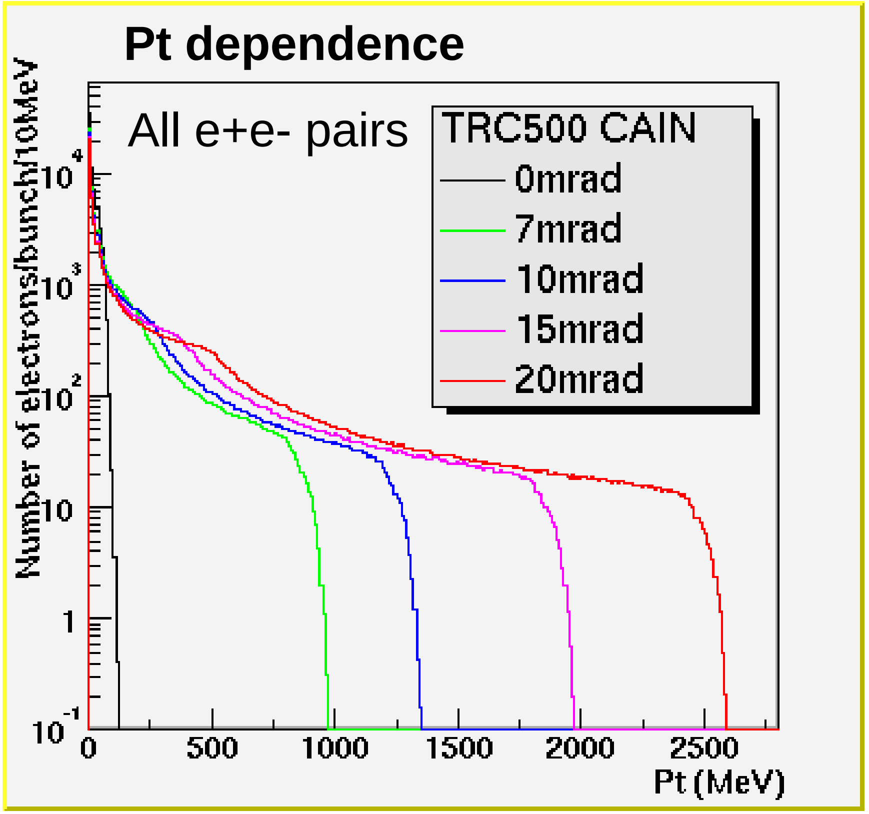
- TRC500 Beam parameter [Technical Review Committee]
  - Beam Energy 250GeV
  - Repetition rate 150 Hz
  - Bunch population 0.75×10^{10}
  - Normalized emittance 360/4 (10^{-8}rad m)
  - Beam size at IP 243nm/3nm/110um
- Crab crossing
  - 0mrad/7mrad/20mrad
    - Current interest of crossing angle is a larger crossing angle, because of the design of final focus systems as well as beam dump systems

Beam profile at IP

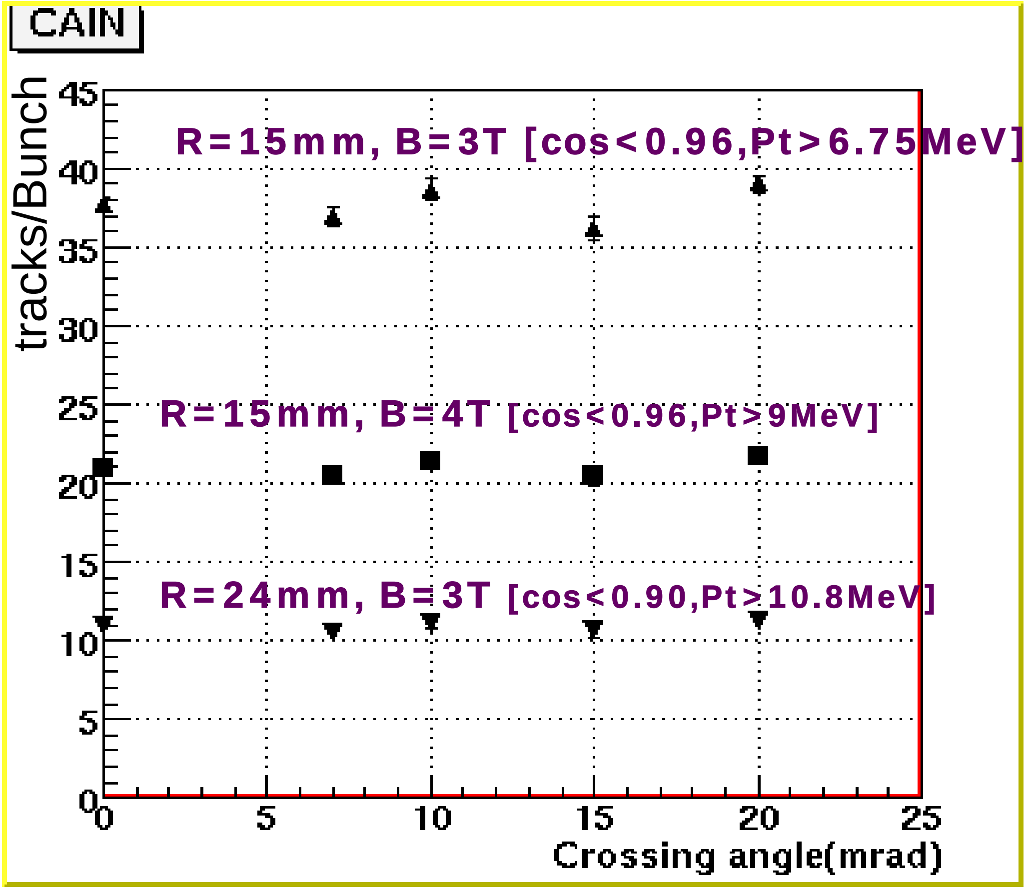




Property of e+e- pair production (cont.)



Crossing Angle dependence with VTX acceptance cut

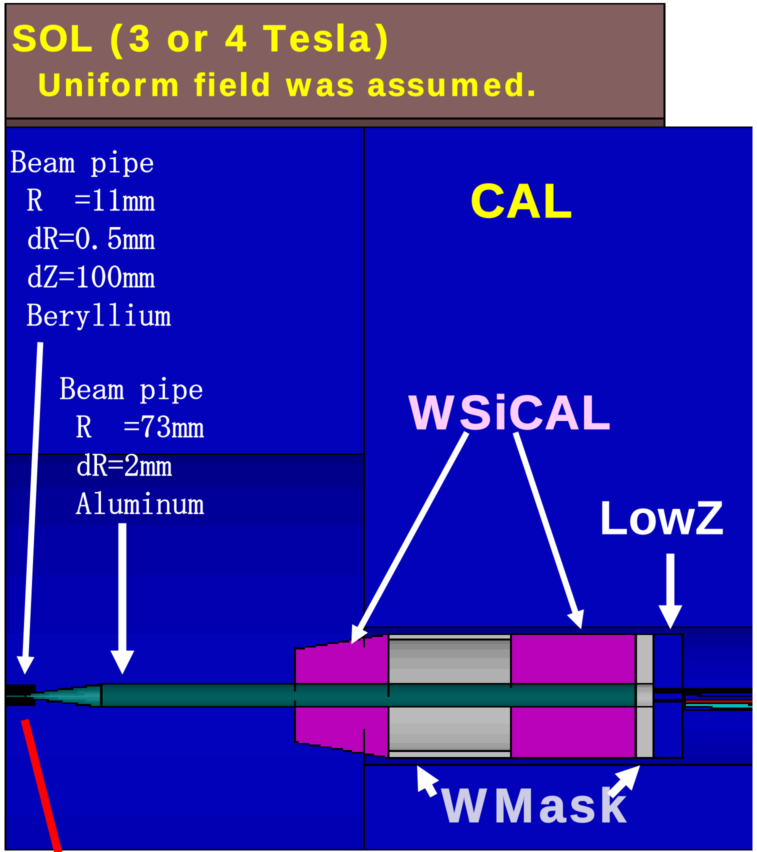


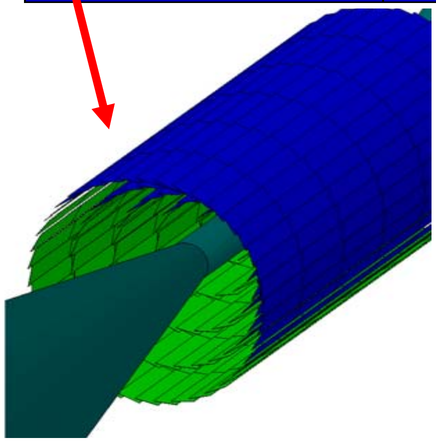
- **Not a significant dependency of crossing angle is observed.**
- **But, Hit at VTX involve effect of**
  (1)Geometrical effects
  (2)curling tracks
  (3)secondary particles produced in materials

Hits on the VTX detector

- CAIN+JUPITER: the detector simulator
- Study items
  - B-Field dependence (3Tesla/4Tesla)
  - Crossing angle dependence
    (0mrad/7mrad/20mrad)
- Interaction Region designs
  - L*=3.5m with Super-QC for small crossing angle
  - L*=3.5m with Compact-QC for large crossing angle

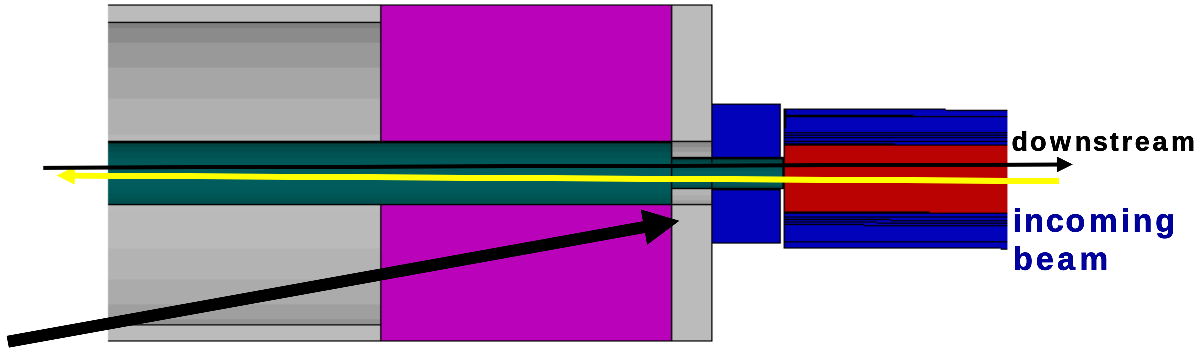
IR and VTX designs





- 5Layer
- 1st Layer
  R=15mm
  dZ= 50mm
- CCD based
  100um thick
  30um active layer

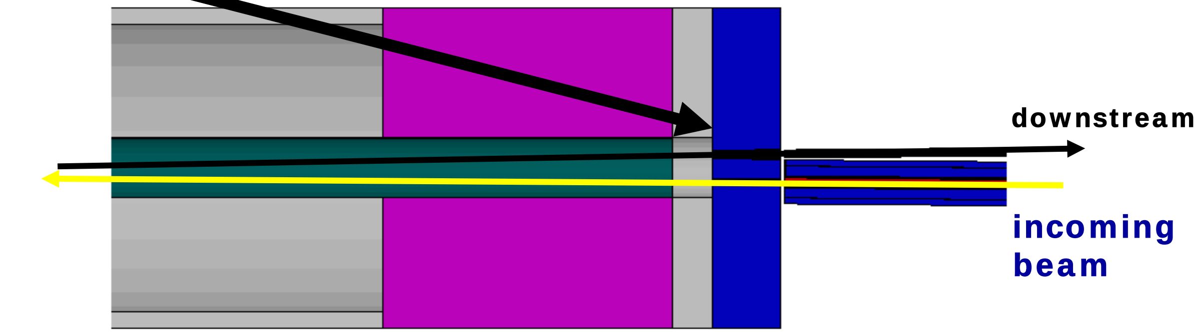
For small crossing,0mrad/7mrad



Inner/Outer radii
8cm/16.5cm QC

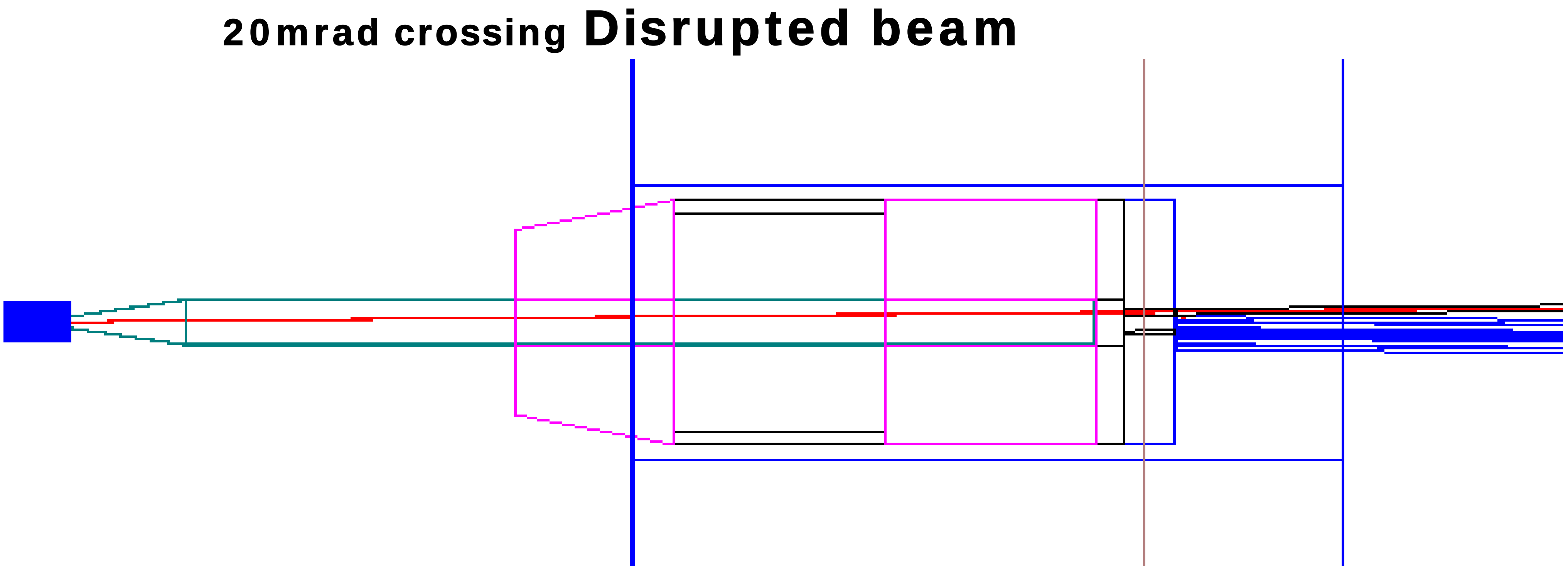
L*=3.5m

For large crossing, 20mrad



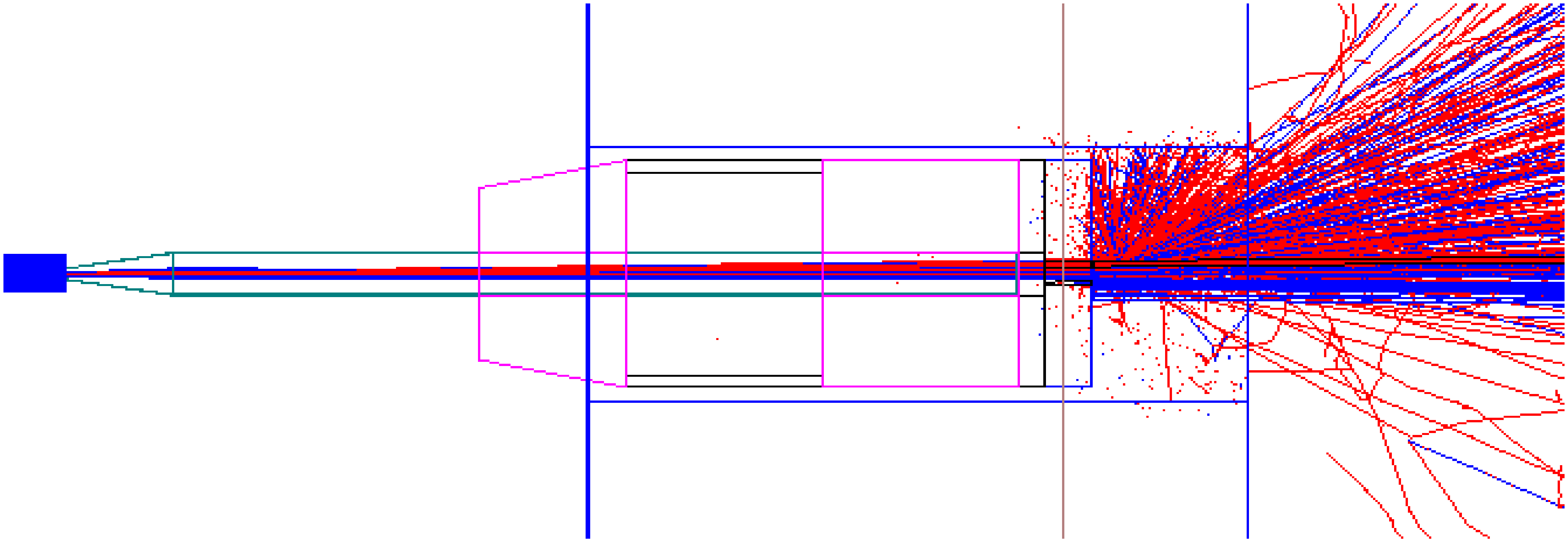
Inner/Outer radii
1cm/5.5cm QC

Example Event display



Example Event Display

20mrad incoherent ee-pair



Hit density at VTX

Hit densities are given
in the unit of **[/ mm² / train]**
(Number of hit, not pixels)

Hit density on 1st Layer

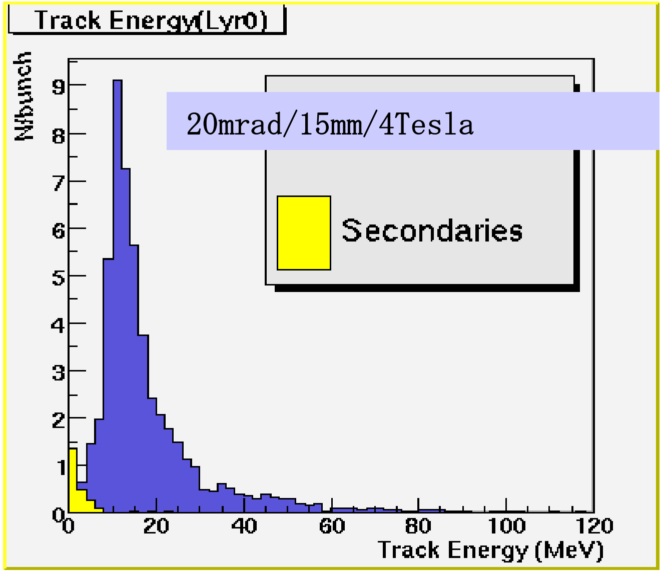
Crossing Angle	VTX Radius	Solenoid Field	Hit density
Head-on	15mm	4Tesla	0.99
7mrad	15mm	4Tesla	1.00
7mrad	24mm	3Tesla	0.38
20mrad	15mm	4Tesla	1.03
20mrad	15mm	3Tesla	1.71

Changing Solenoid field from 3 to 4 tesla can suppress background effectively.

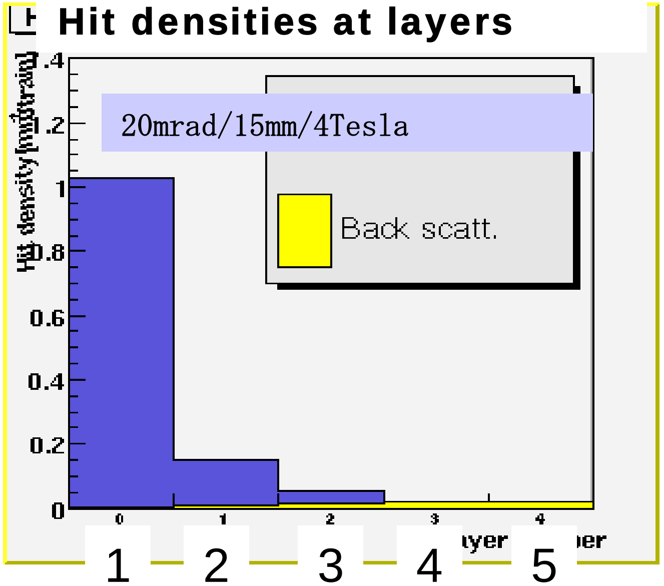
Estimated value of hit densities are similar. No significant crossing angle dependency has been observed.

Hit density at 1st layer is relatively high, but at outer layer is not a problem.

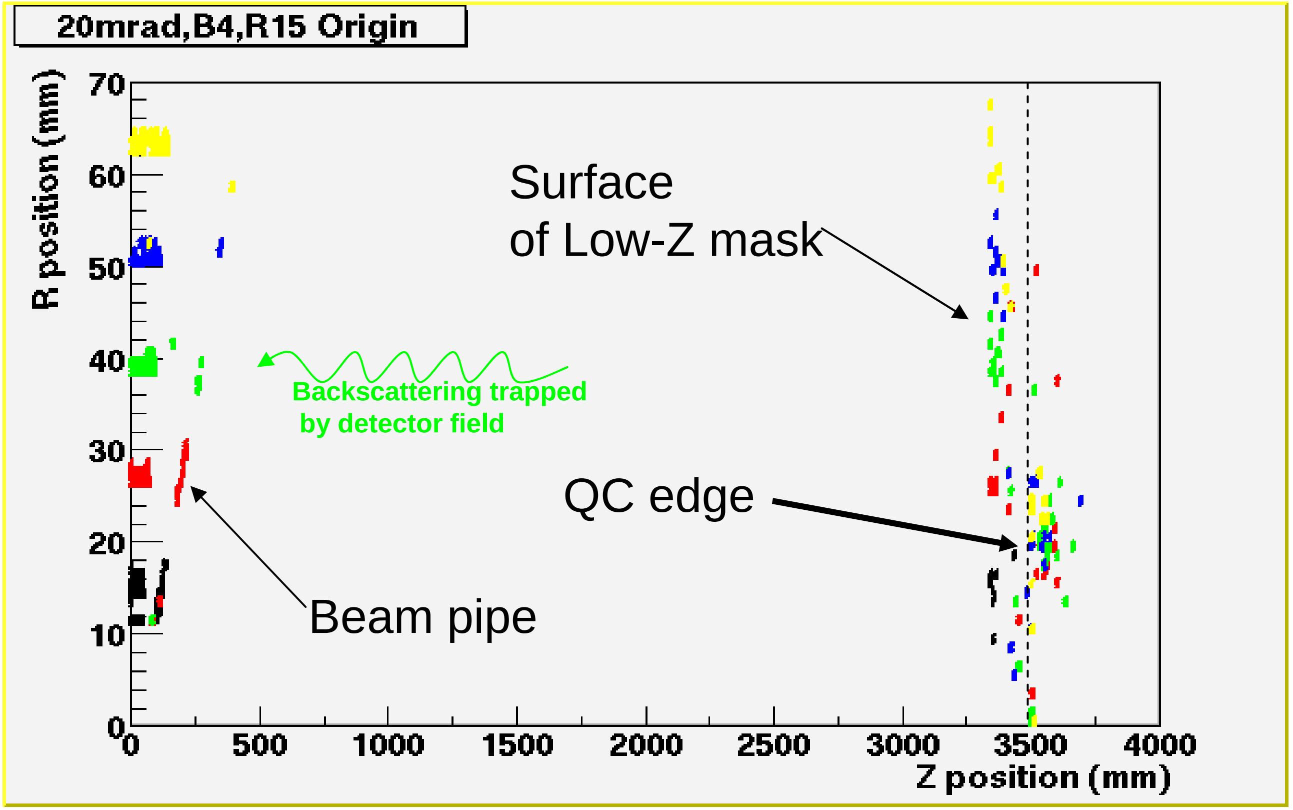
Electrons energy at 1st Layer



In 1 year operation(10^7s), 1.5×10^{11}/cm²/year at 1st Layer is estimated.



Origin of hit (20mrad)



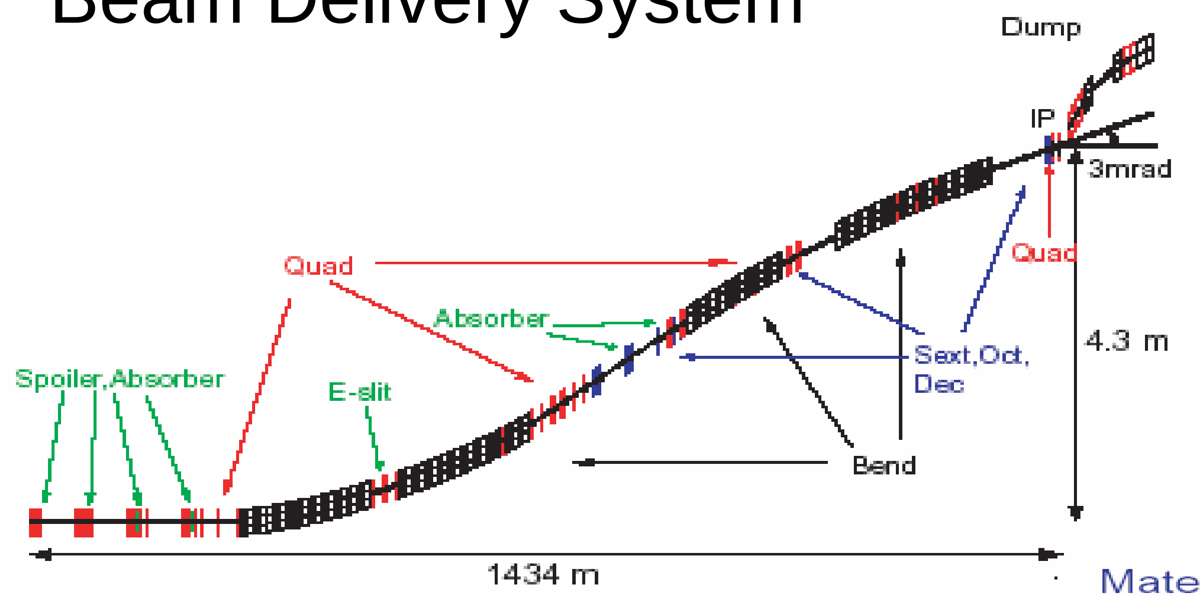
1st Layer hit origin (%)

Origin (%)	Head-on	7mrad	20mrad
IP	94	94	96
CCD	2	2	2
Beam pipe	2	1	2
Low Z,QC	2	3	<1

- Secondary particles are produced at CCD itself, Beam pipe, and downstream of the beam line.
  Those contaminations are small about 5%.
- Secondary particles have ~ a few MeV and are trapped by detector field, then back to the detector.
- QC edge is interference to the spread-out e+e- pair flow.

Roadmap 2003

Upstream background
Beam Delivery System



Crossing 6mrad.
L* = 3.5m

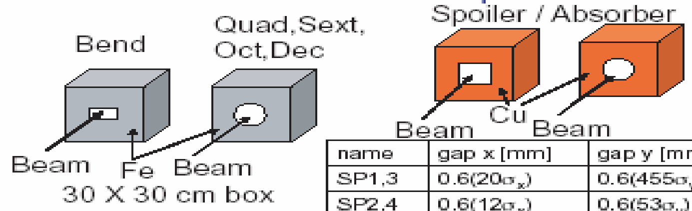
Background
(1) Synchrotron radiation photon
(2) Muon from lost halo electrons

The components ~ 200.

BDS-SIM

A full simulation program based on Geant4 has been developed to simulate the entire BDS.

Material and size of Components

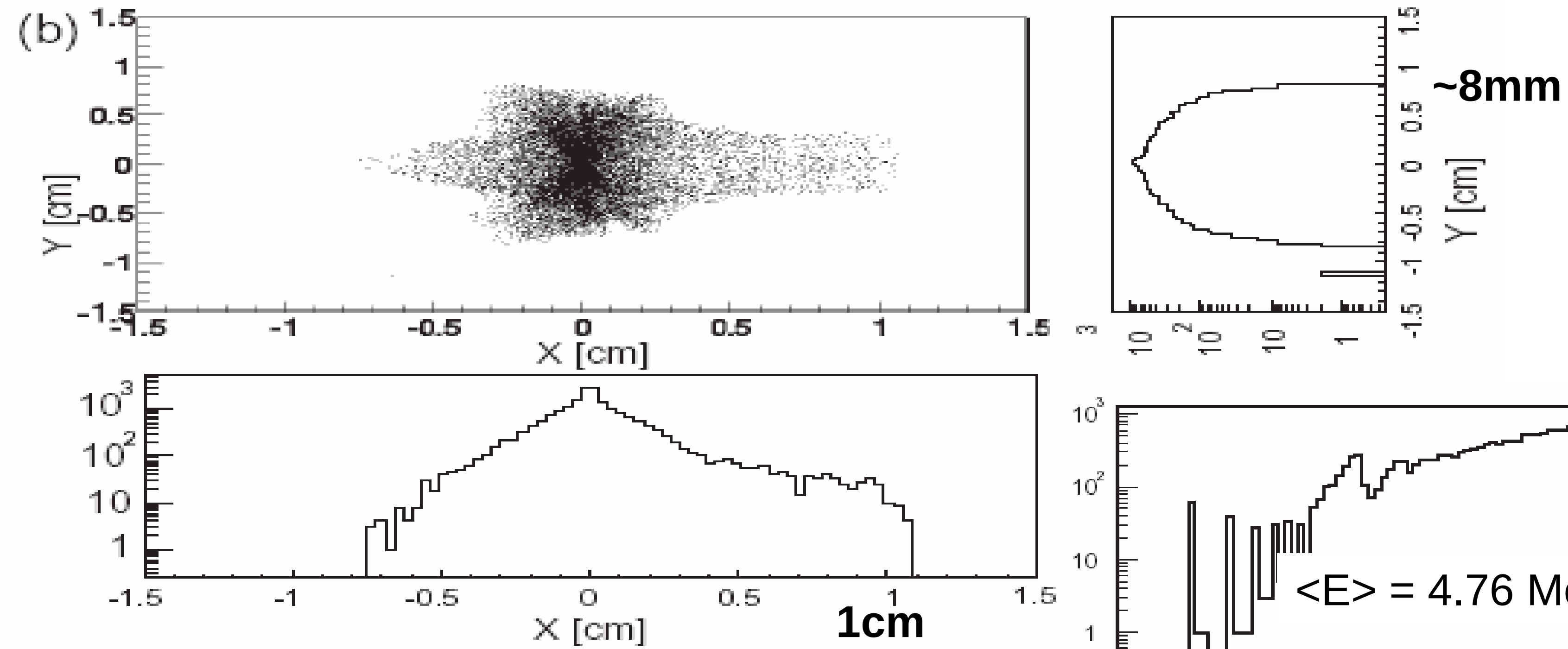


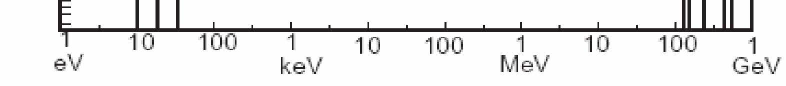
		X [cm]	Y [cm]
Bend	gap	10	2
		10	6
Multipole aperture radius		1	
		3	
		0.7	
		8 (ff-q super-con)	

name	gap x [mm]	gap y [mm]	length[cm]
SP1,3	0.6(20σ_x)	0.6(455σ_y)	0.858(0.6X_0)
SP2,4	0.6(12σ_x)	0.6(53σ_y)	0.858(0.6X_0)
SP5	0.86(22σ_x)	0.6(530σ_y)	0.858(0.6X_0)
SPE	3.2(80σ_x)	8(145σ_y)	0.858(0.6X_0)
AB2,4	1(40σ_x,170σ_y)		50(35X_0)
AB3	1(68σ_x,1520σ_y)		50(35X_0)
AB5	1.4(73σ_x,2460σ_y)		50(35X_0)
ABE	6.8(100σ_x)	8(160σ_y)	50(35X_0)
AB10	5.6(20σ_x,59σ_y)		50(35X_0)
AB9	8.6(18σ_x,148σ_y)		14.3(10X_0)
AB7	8.8(1900σ_x,5470σ_y)		14.3(10X_0)

BDS-SIM: Synchrotron Radiation

Spatial distribution of SR photons arising from beam halo, at IP.





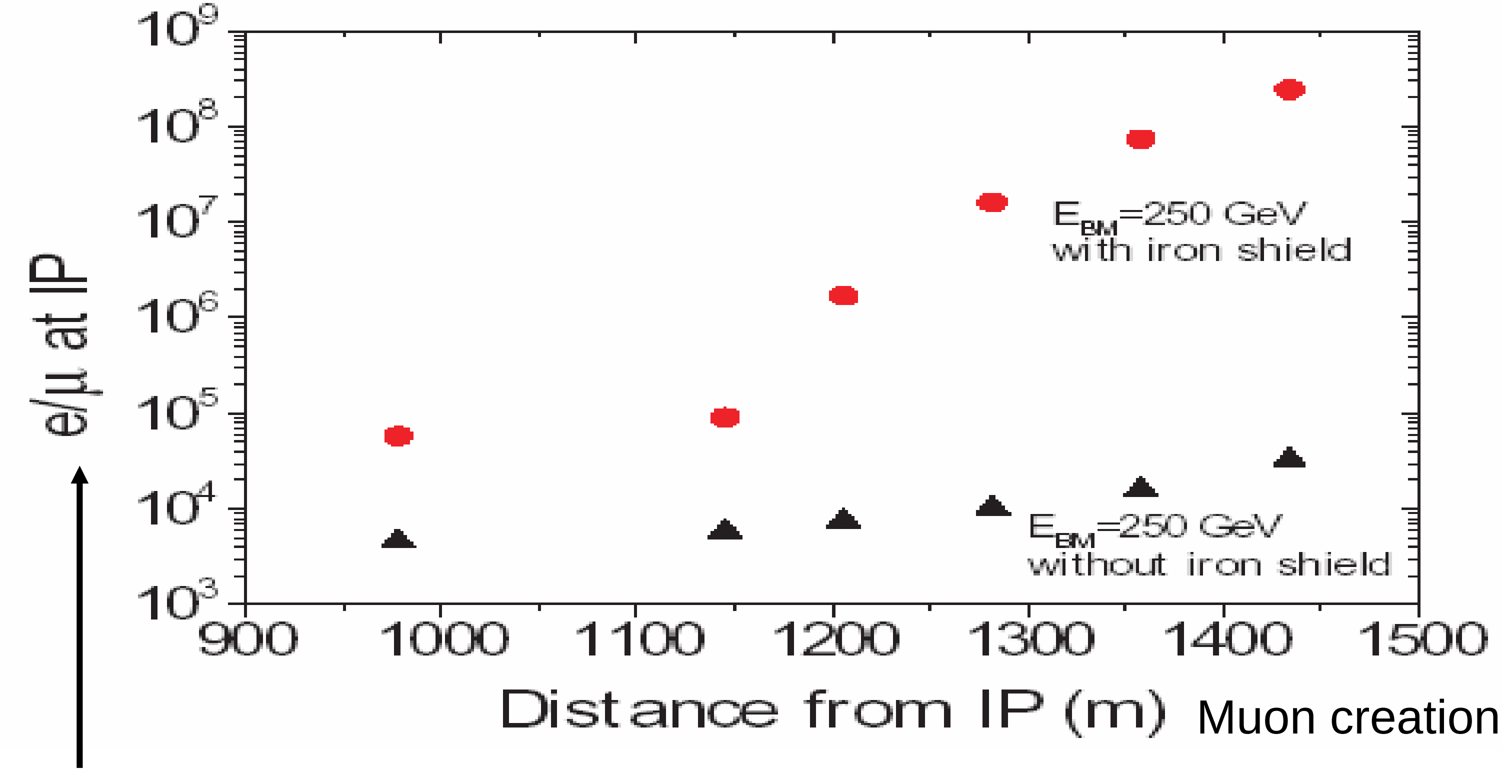
Beam halo is assumed to have a uniform distribution.

Photons reaches to IP are produced mainly at FF quadrupole and last bending magnet.

These photons are predominantly contained within beam pipe, normaly ~ 1.cm.

BDS-SIM: Muon Background

Muons are produced predominantly at collimator section,
but the most of the muons are absorbed before reaching the IP.



Muon creation point.

Number of electrons required to hit the collimators /Muons hits the detector(16x16x16m^3)

Iron pipes are effective to reduce muon backgrounds originating from collimators.

Summary

- e^+e^- pair background for the VTX detector has been studied.
  - At 20mrad crossing angle, hit density is estimated to be about $1.0/mm^2$/train. This is corresponding to $1.5x10^{11}/cm^2$/year.
  - Main background source of e^+e^- pair comes from interaction points directly.
  - There is no significant differences for the VTX, even crossing angle is widen up to 20mrad.
  - The e+e- pairs hit QC at downstream, so that the consideration of arrangement meight be necessary, as well as the design of beam dump line.
- Upstream background
  - Synchrotron radiation and Muon backgrounds has been studied using Geant4 based Beam delivery simulator.
  - Further study with updated BDS design and with detector simulator is desirable. This work will gives an answer about a precise estimation of neutron background from extraction line.

Introduction

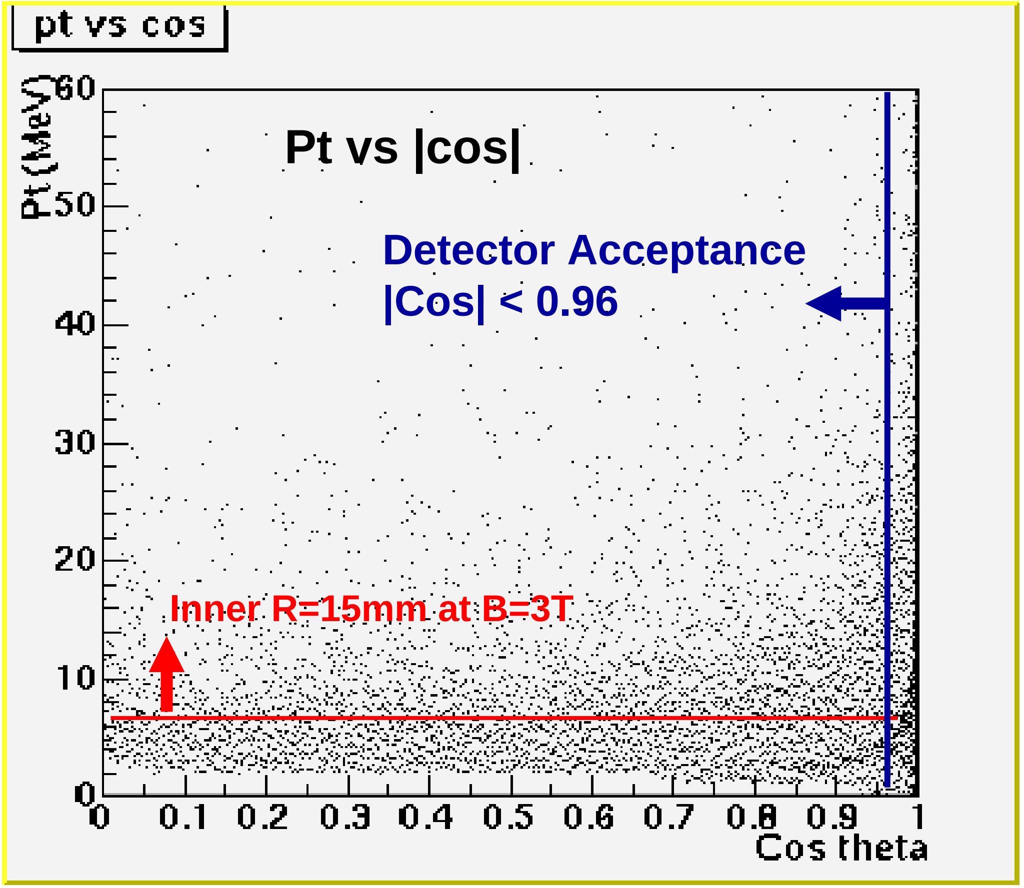
- **Background for Vertex detector**
  - Synchrotron radiation
    - Secondary particles, electrons and neutrons
  - Beam-Beam interaction
    - e^+e^- pair production
  - Two-Photon interaction
    - Charged hadrons
- **Influence of background on CCD based VTX**
  - **Radiation damage**
    - Non Ionizing Energy Loss increases CTI
      - Caused by high energy charged particles
      - Depends on the particle energy

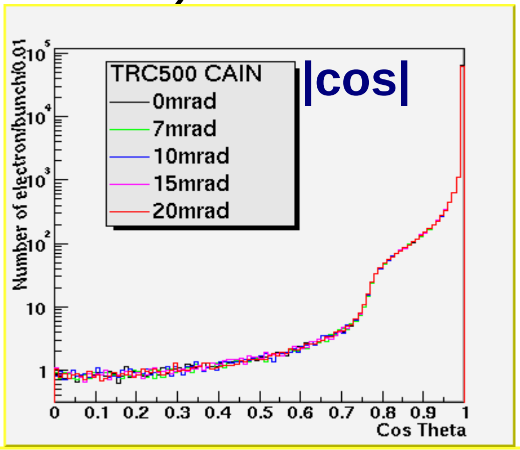
Property of e+e- pair production

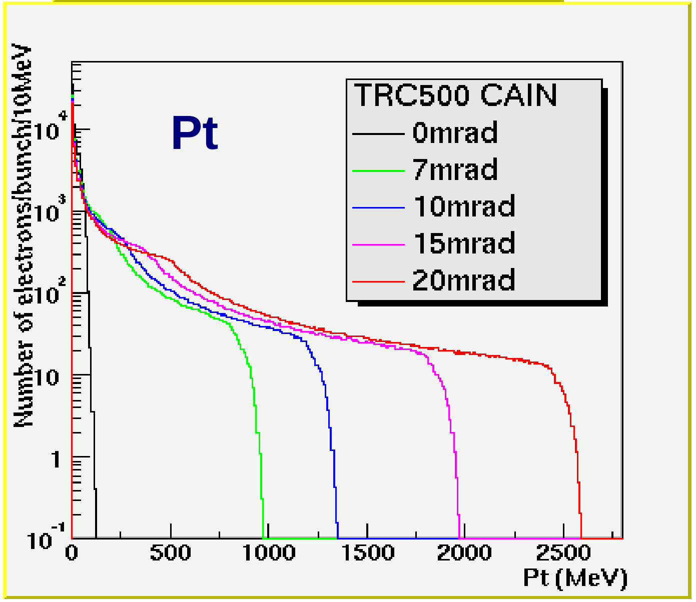
- e+e- pair production (CAIN incoherent pair data)

For all e+/e-

TRC500-20mrad

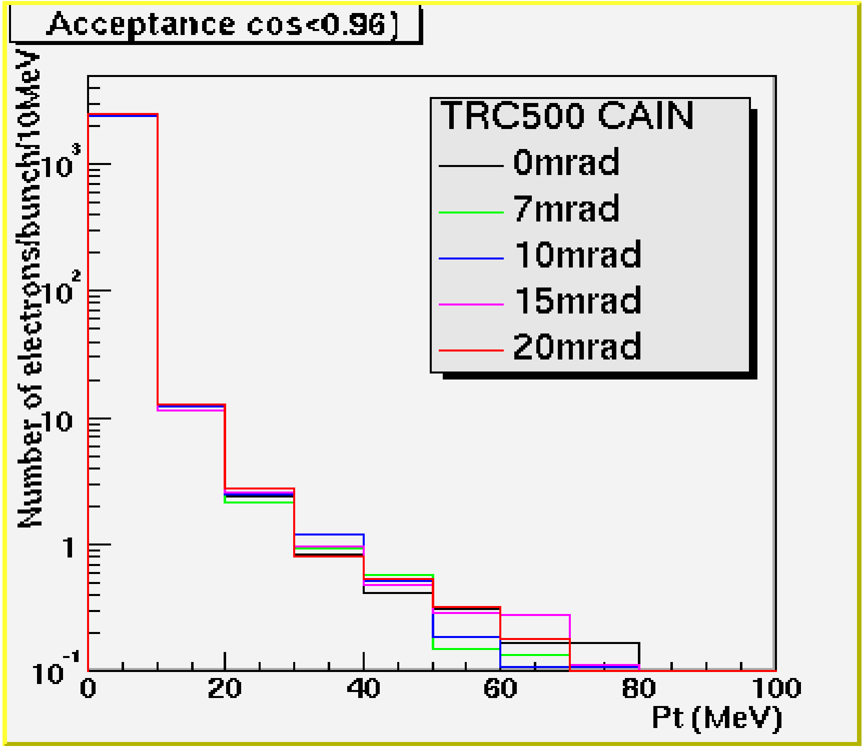




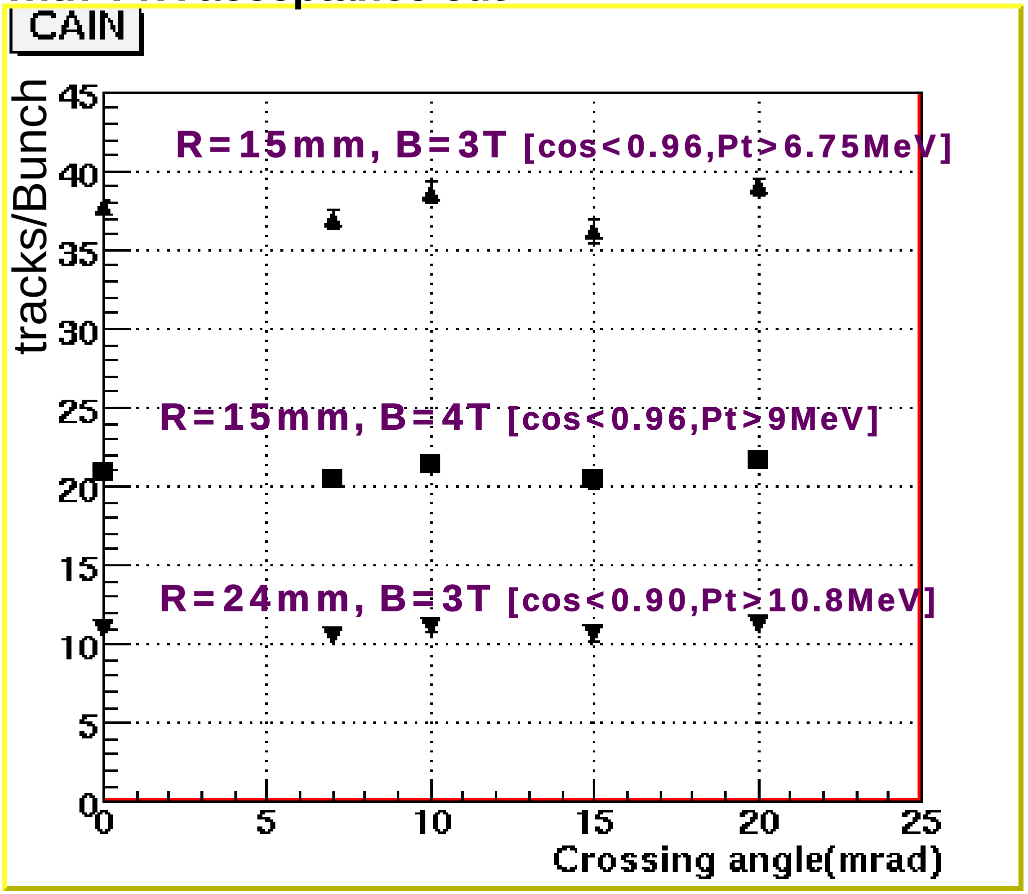


Property of e+e- pair production (cont.)

Pt dependence
with acceptance cut of |cos|<0.96



Crossing Angle dependence
with VTX acceptance cut



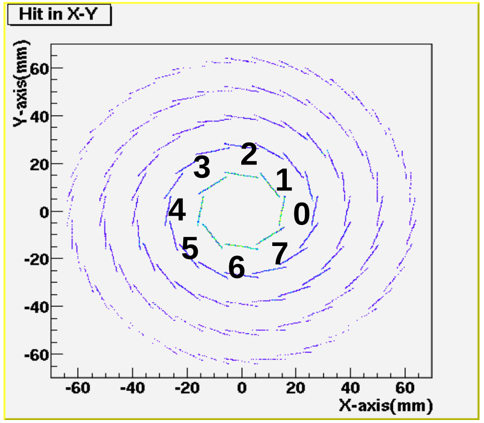
- **Not a significant dependency of crossing angle is observed.**
- **But, Hit at VTX involve effect of**
  (1)Geometrical effects
  (2)curling tracks
  (3)secondary particles produced in materials

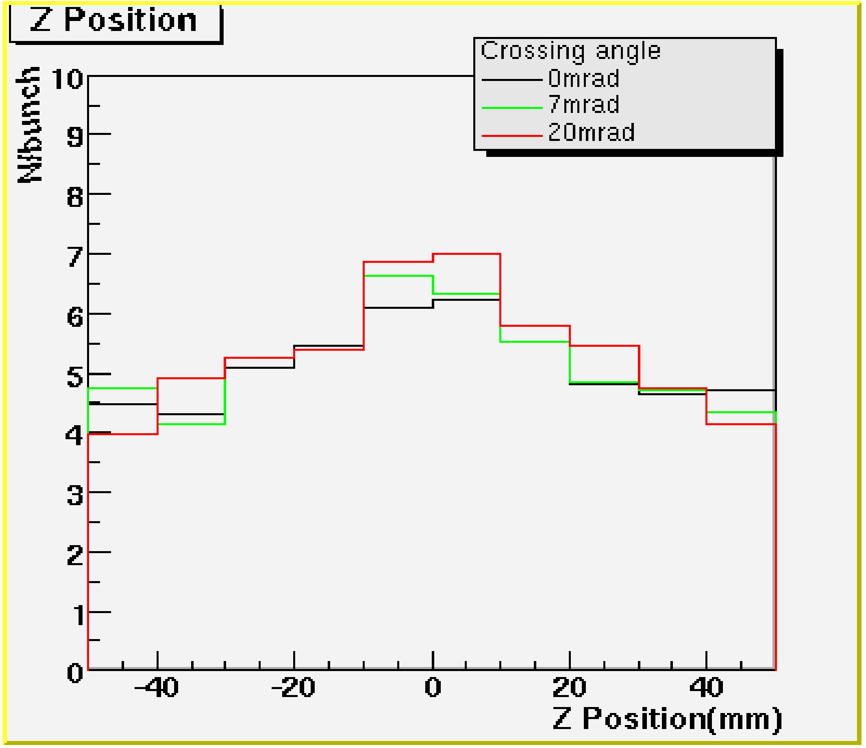
Hit position

Hit positions at 1st Layer (R=15mm)

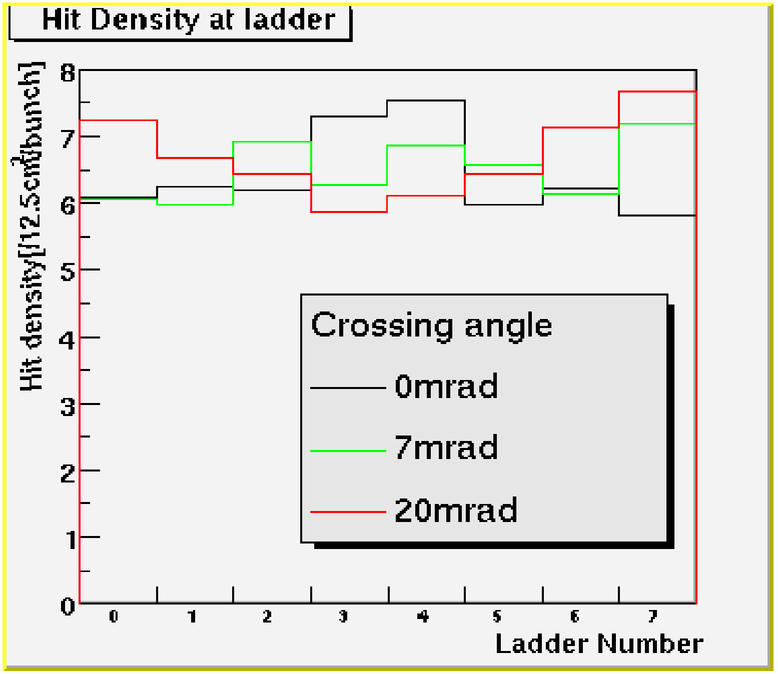
Z position

X-Y view





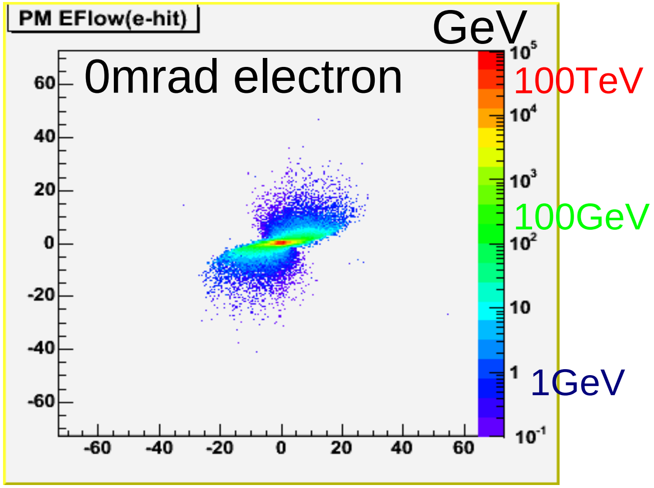
Ladder

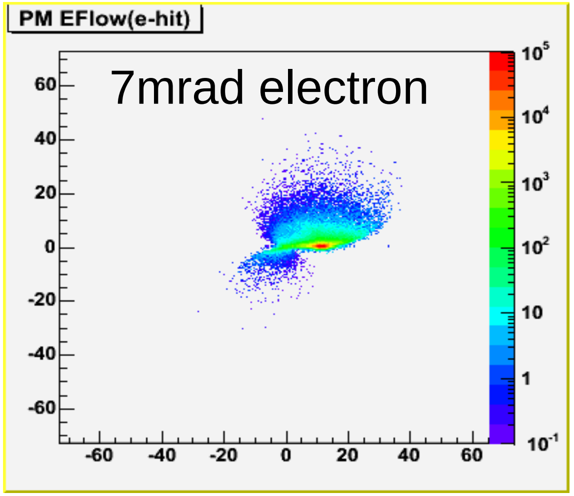


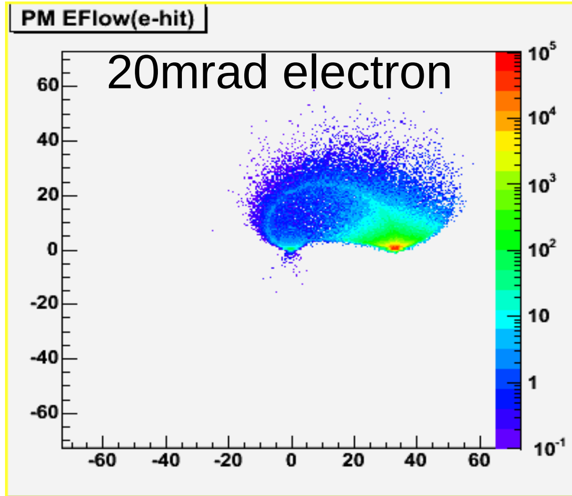
- **Hit density is smaller at the Z edge of detector, because the main source of electron come from IP. (small backscattering contamination)**

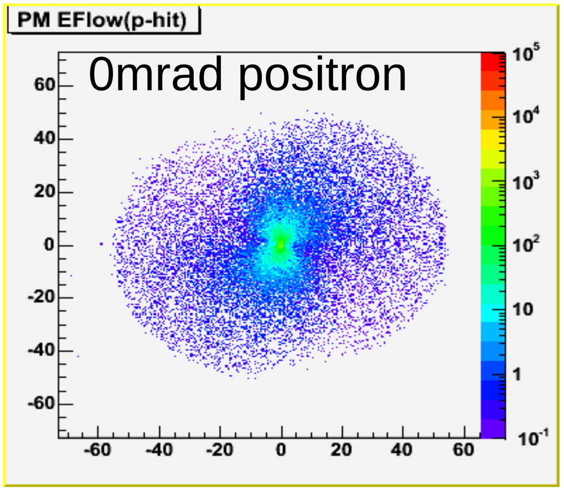
Pair distribution at Z=330cm, B=4T

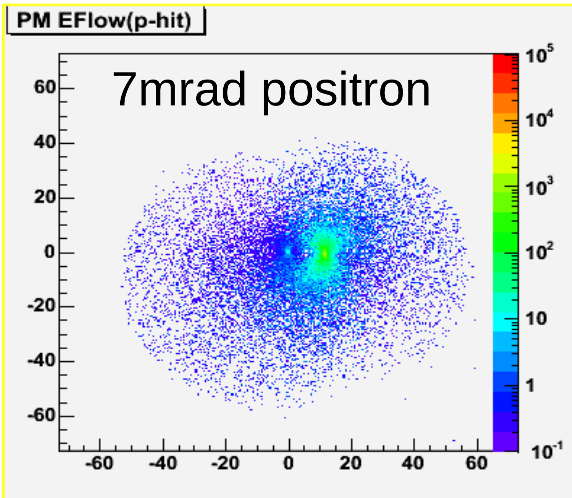
TRC500 Energy flow in 0.5mm square mesh / bunch

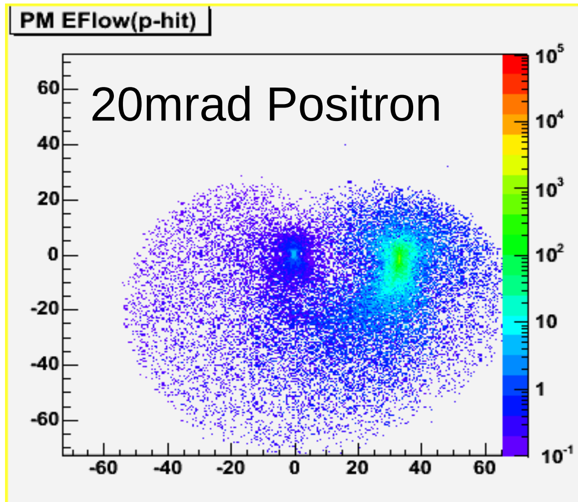




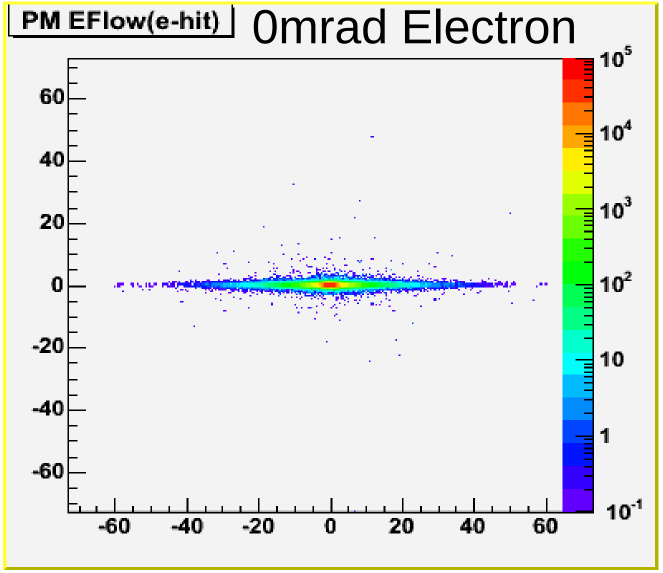


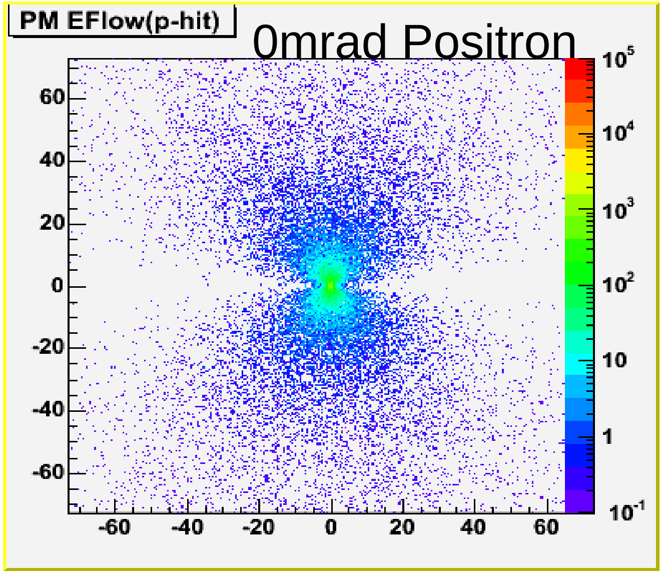






Pair distribution at Z=330cm,B=0T





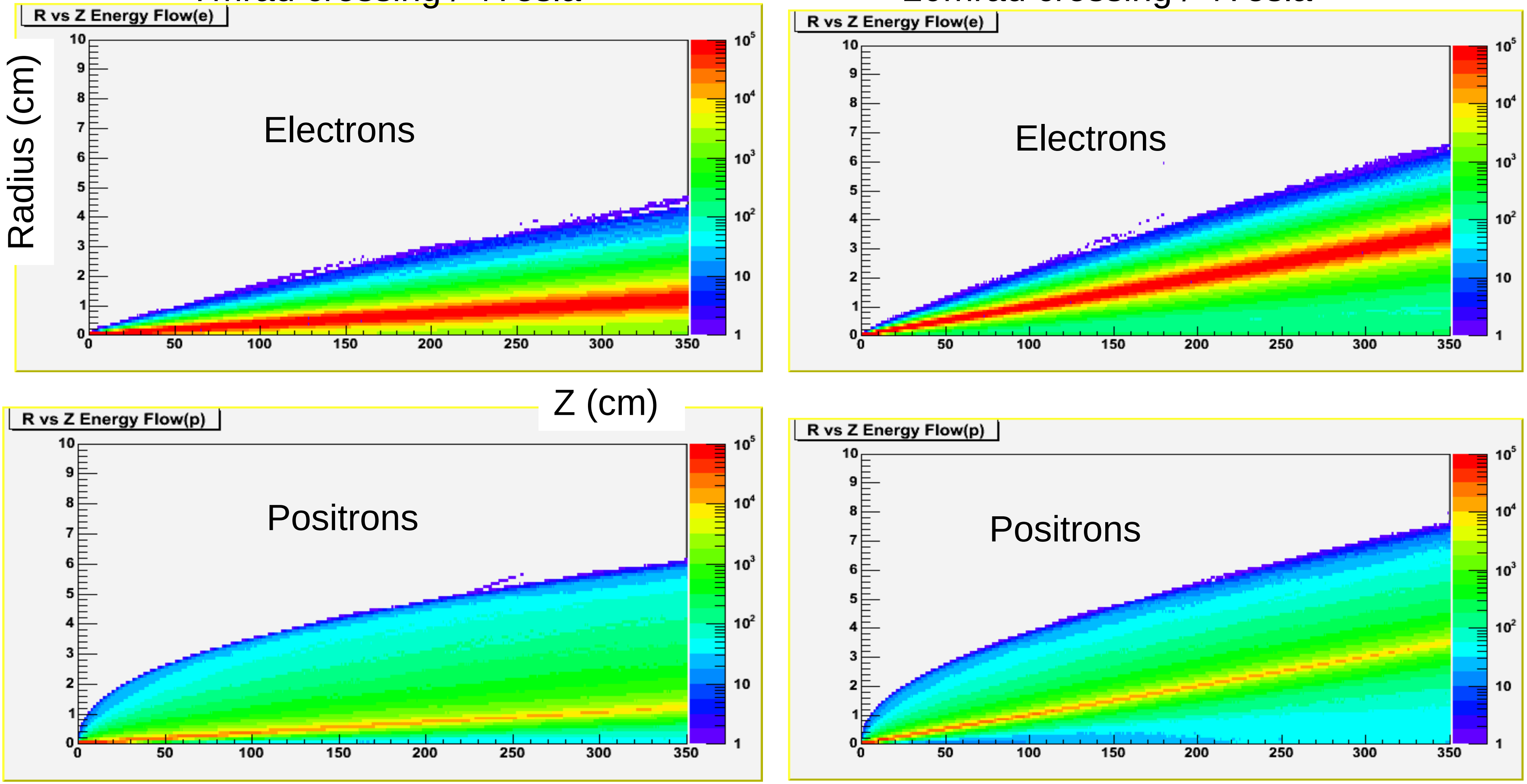
Track Energy density

GeV/mm²/train

TRC-500

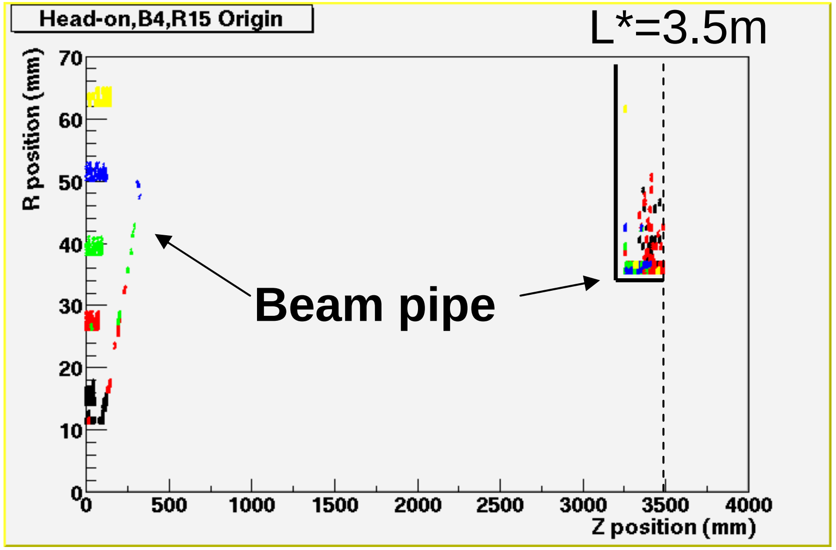
7mrad crossing / 4Tesla

20mrad crossing / 4Tesla



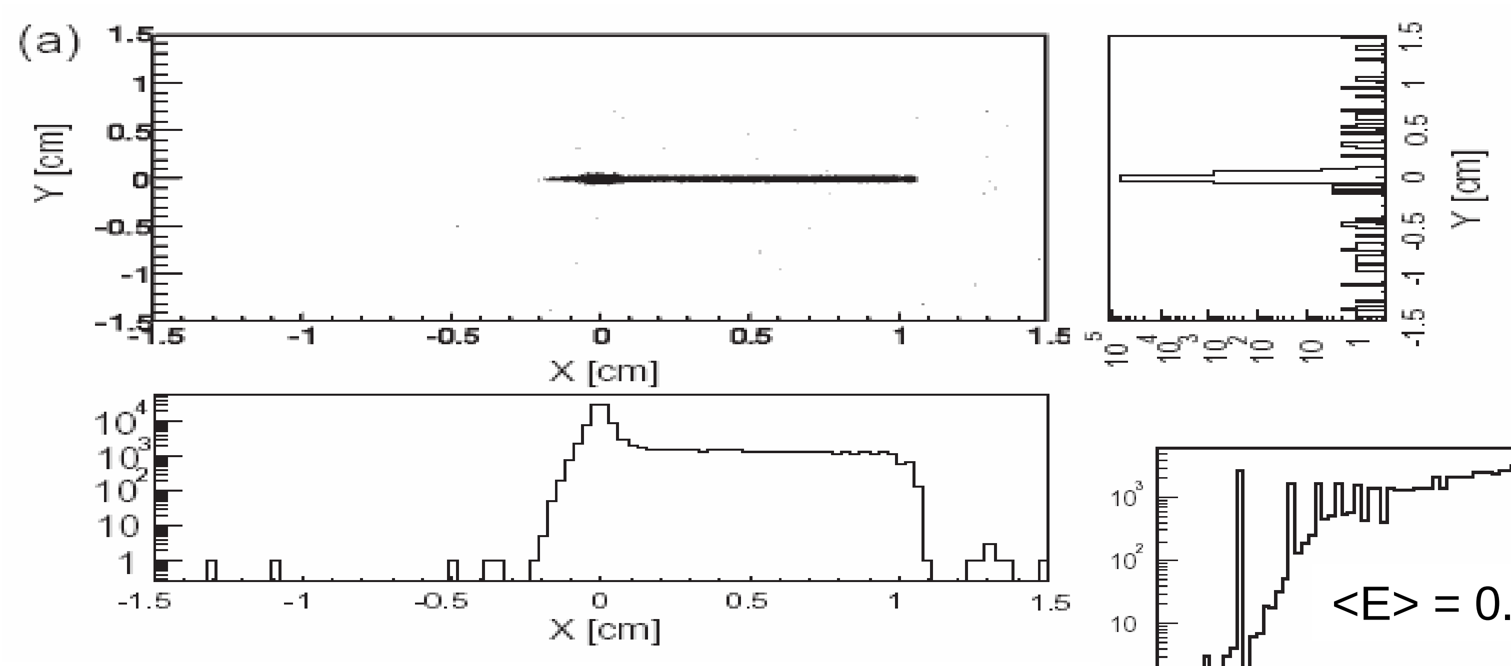
Hit origin

- 0mrad,B4,R15

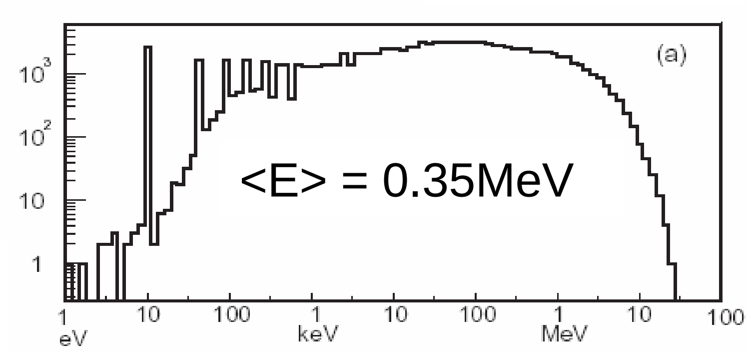


BDS-SIM: Synchrotron Radiation

Spatial distribution of SR photons arising from nominal beam at IP



width ~ 0.5mm



Wider and long tail distribution in x-direction is due to photons generated at the bending magnets.

Photons reaches to IP are mainly produces at FF quadrupole and the last bending magnet.

Photons are predominantly contained within beam pipe.