



Beam induced backgrounds and ECAL occupancy

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ILD ECAL meeting



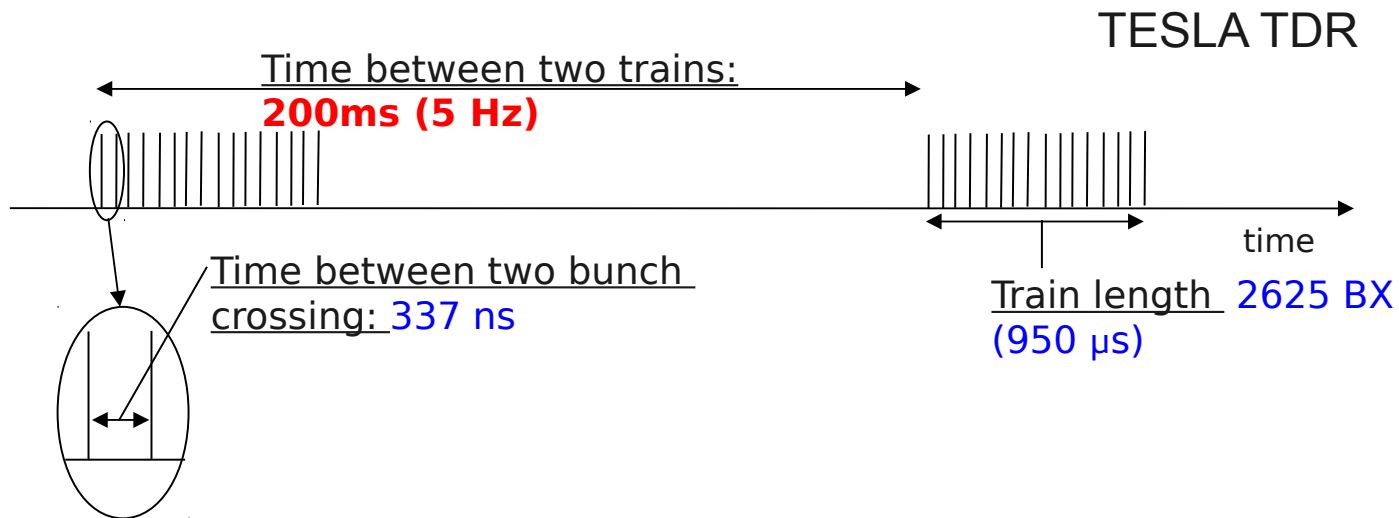
Paris, 3 - 4 June 2013

Outline

- ILC accelerator parameters
- Occupancy study & main background
- Investigation based on simulated files
- Summary

ILC - luminosity

- Current design of SKIROC 2:
 - ♦ each chip serves 64 channels
 - ♦ Buffer can carry up to 15 events in one spill, currently w/o zero-suppression



Luminosity

$$L \sim 2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$

$$\rightarrow \text{Spill luminosity} \sim 2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1} \times 200 \text{ ms} = 4 \text{ nb}^{-1}.$$

Processes at $\sqrt{s} = 500 \text{ GeV}$

Beam polarisation: eL, pR

Proc. name	Pola1	Pola2	σ (pb)
$\gamma\gamma \rightarrow \text{hadrons}$	L80	R20	633224.0
$\gamma\gamma \rightarrow \mu\mu$	B	B	832.0
$e\gamma \rightarrow e\gamma$	L	B	547.0
$\gamma c \rightarrow ee$	B	B	425.8
$e\gamma \rightarrow e\gamma$	L	W	345.4
$\gamma e \rightarrow e\gamma$	W	R	345.1
...			
2f_Z_hadronic	L	R	32.5
4f_WW_semileptonic	L	R	9.5
4f_WW_semileptonic	L	R	7.8
4f_WW_hadronic	L	R	7.7
4f_singleZee_leptonic	L	R	7.3

Very strongly focused beam: large charge density \rightarrow large EM field

\rightarrow **beamstrahlung** in the other beam

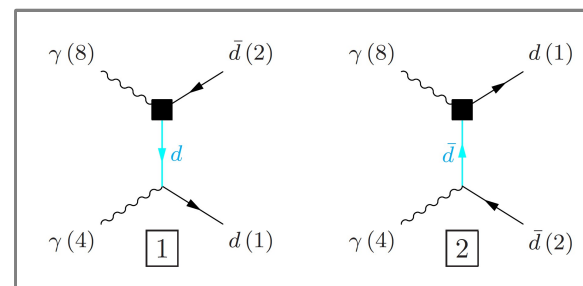
gamma gamma \rightarrow hadrons

Interaction between beam/virtual photon

e^+e^- pair creation

Beamstrahlung photon can create electron-positron pairs at the interaction point. Two possibilities:

- ◆ **Coherent pair creation (CPC)** : real ee pair in the collective electric field of the bunch (similar to usual process of photon conversion that can happen in e-field of nucleus)
- ◆ **Incoherent pair creation (IPC)** : two photons scatter to produce e^+e^- pair. **200k pairs/BX. Dominant background for ECAL.**



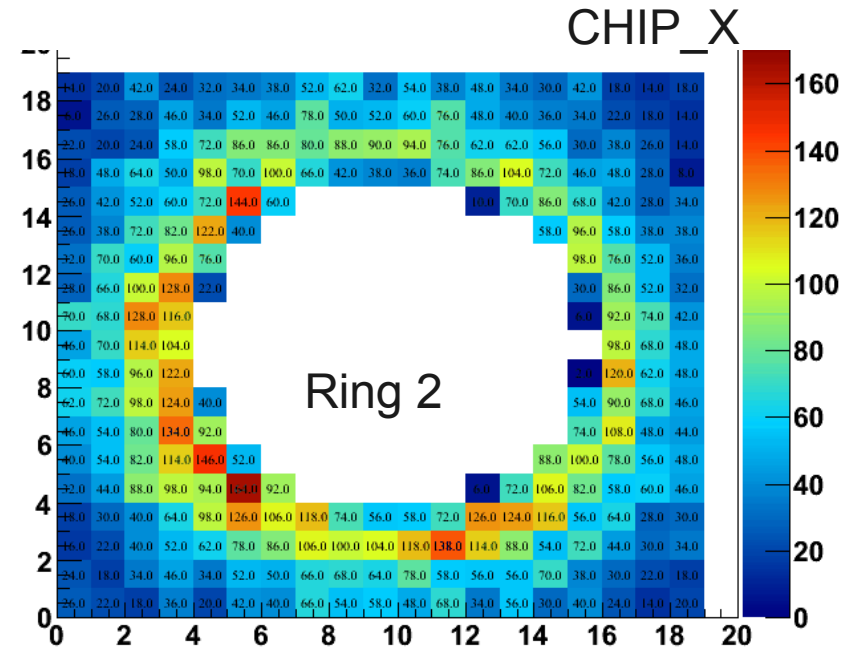
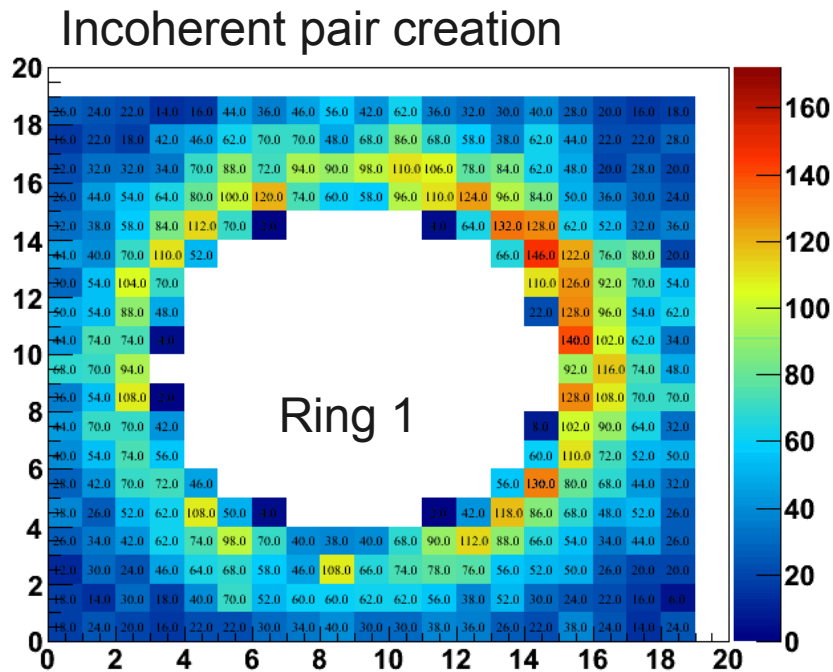
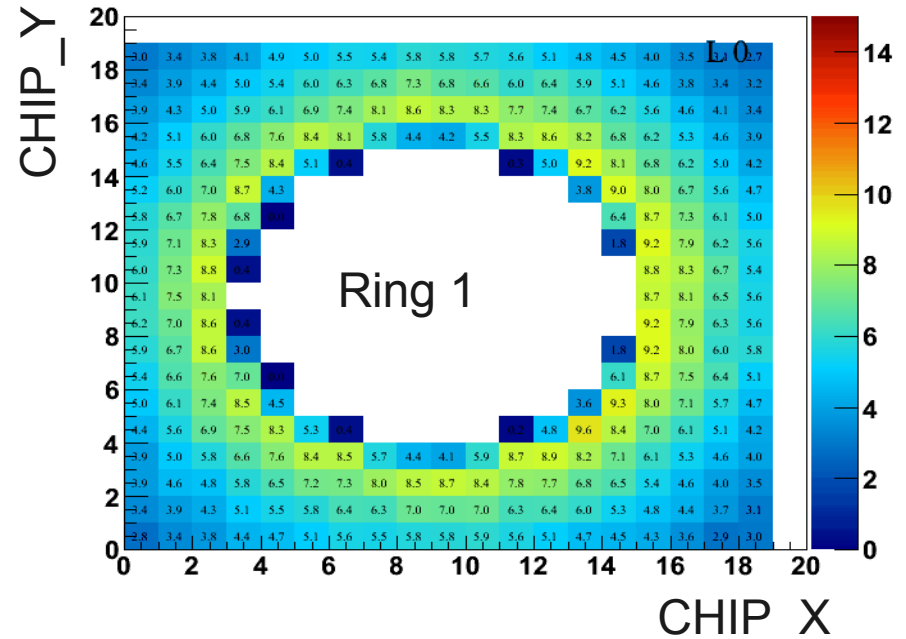
Analysis procedure

- Geometry: ECAL is composed of barrel, endcap & endcap ring.
- Samples for DBD, `ILD_o1_v05`, TDR. (Magnetic field for ee pair creation is correct.)
- Threshold, 0.3 MIP
- For each event, if one or more cell is fired, the corresponding chip will be activated (each chip is an OR for 64 channels)
 - N_{MC} : total number of MC events which fire the chip corresponds to lumi L_{MC}
Scaled to spill luminosity of 4nb^{-1} by:
$$N_{\text{spill}} = N_{MC} \times L_{\text{spill}} / L_{MC}$$
 - For ee pair creation, number of events is accumulated for each BX, reset for new BX

ECAL Ring occupancy (1)

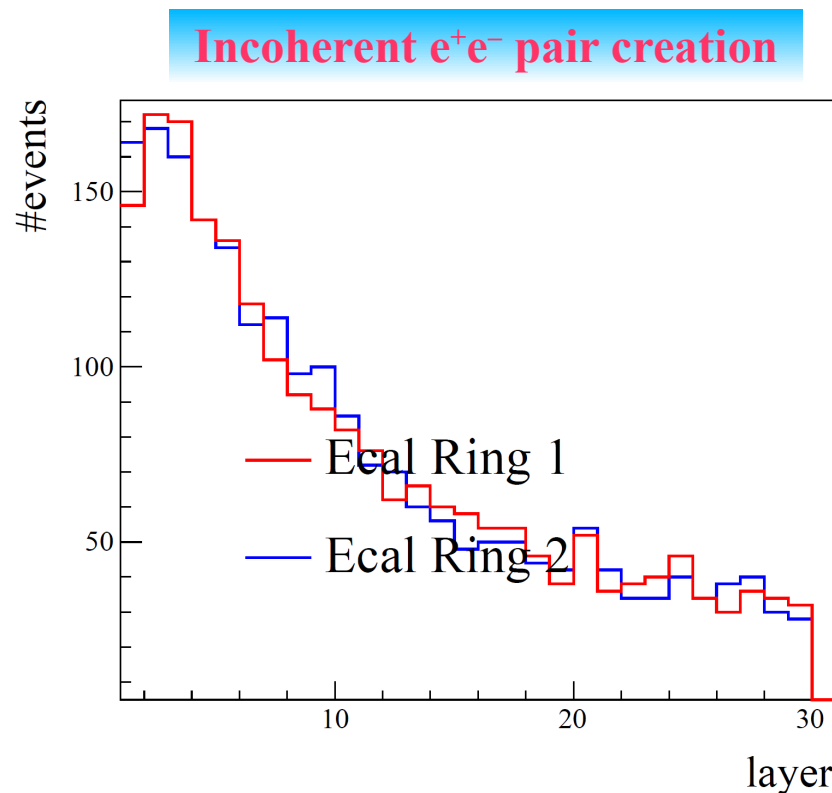
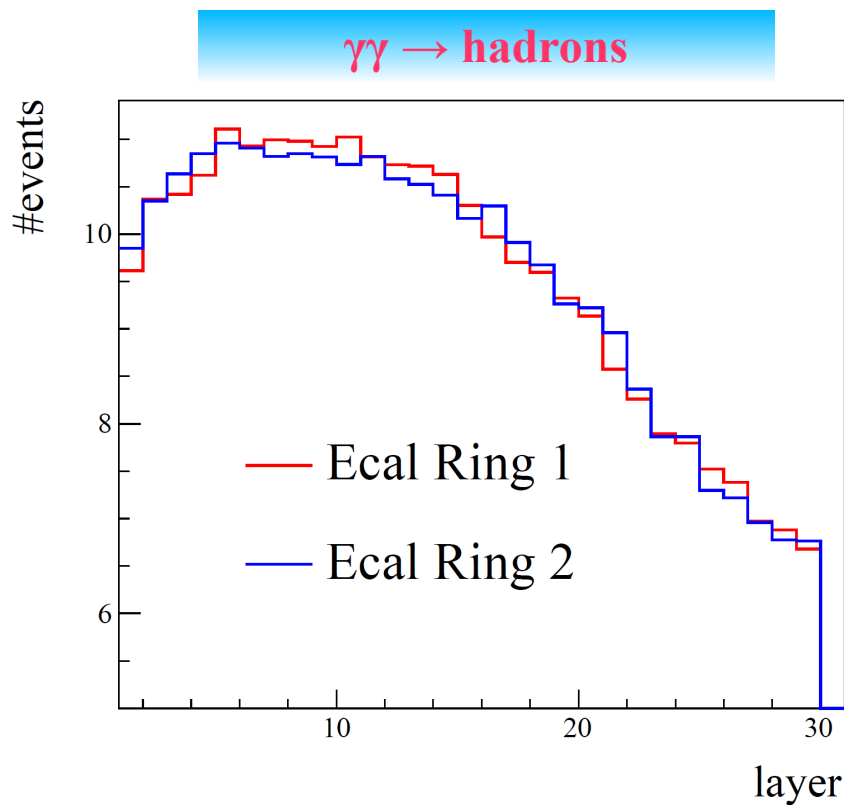
2 Rings, each has 29 layers.

gamma gamma \rightarrow hadrons



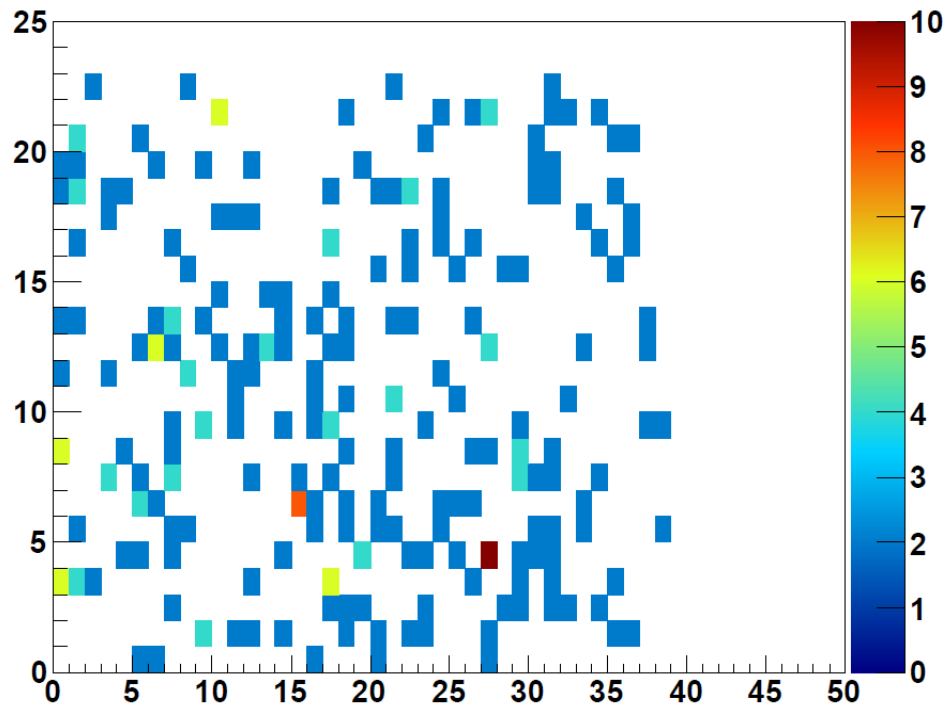
ECAL Ring occupancy (2)

Reminder: Maximum 15 events can be carried by SKIROC 2 in one spill.



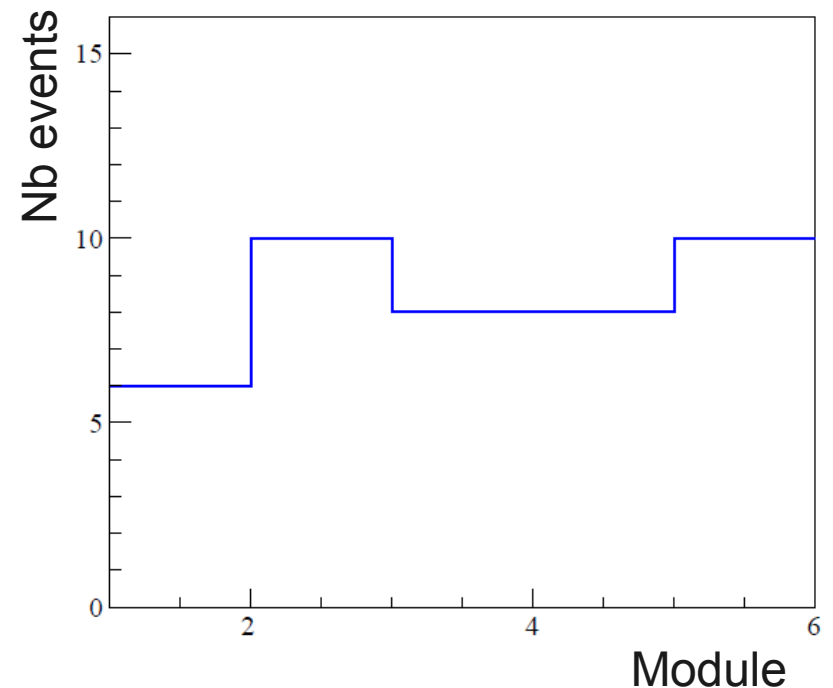
Maximum number of events firing a same chip in a layer.
(Boundary not included.)

ECAL Barrel

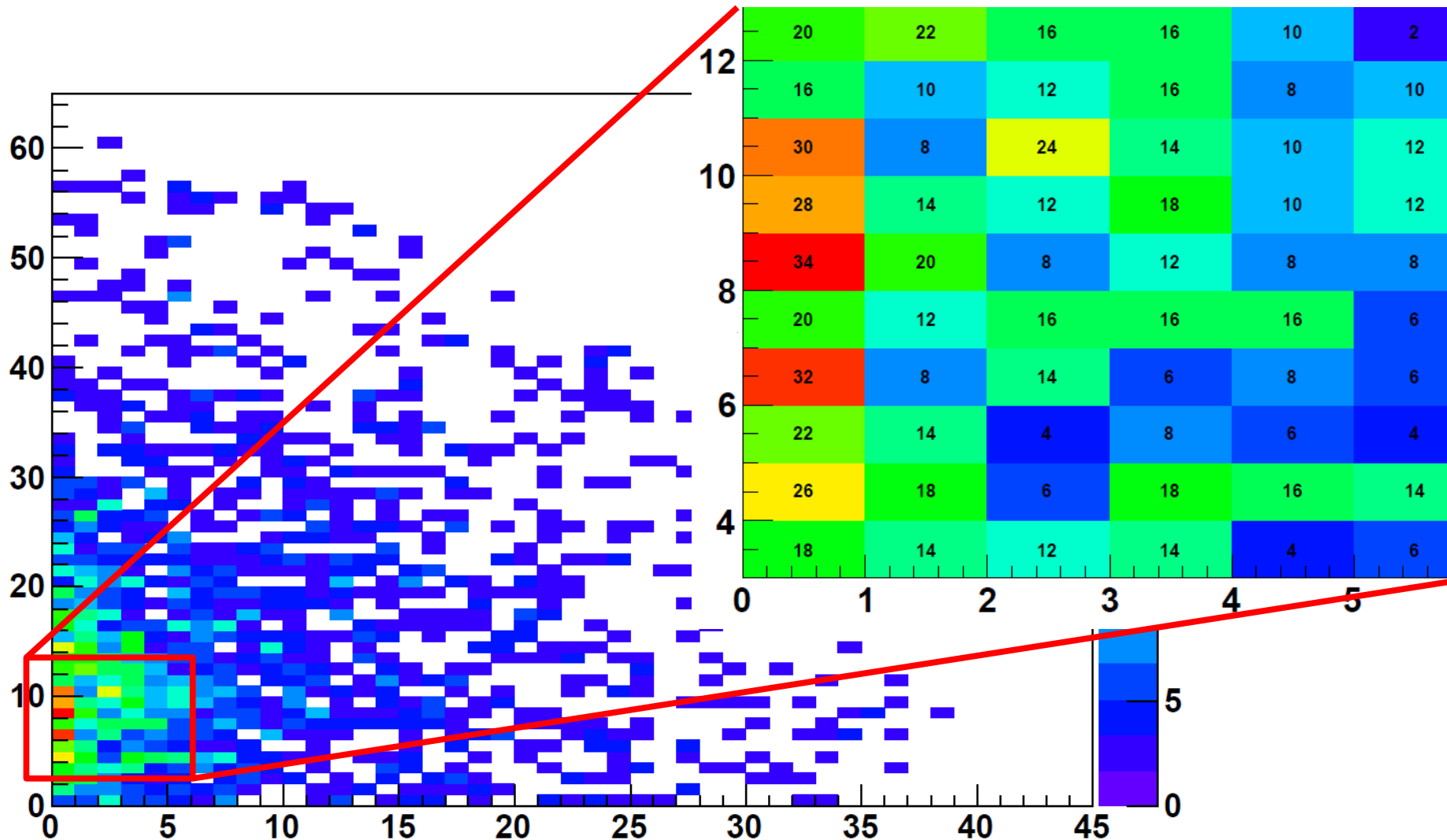


Number of events firing Barrel chips (shown in function of chip ID).
Example for one of most critical part:
Module 5, Stave 4, 1st layer.

Maximal number of events firing Barrel chips (shown in function of barrel module number).



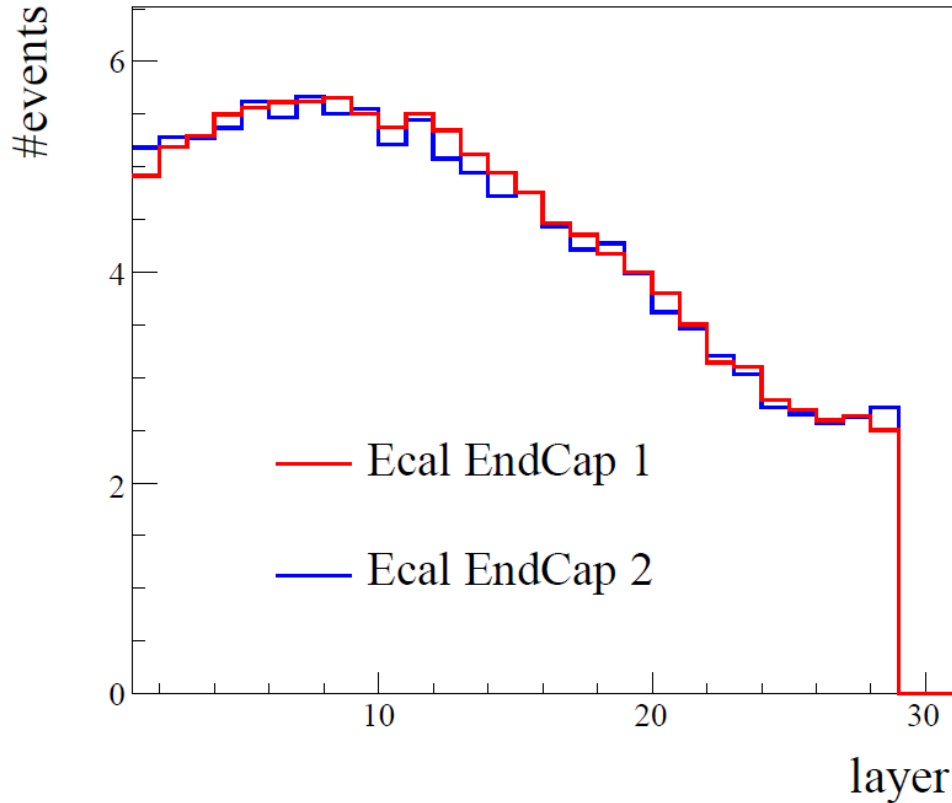
ECAL EndCap



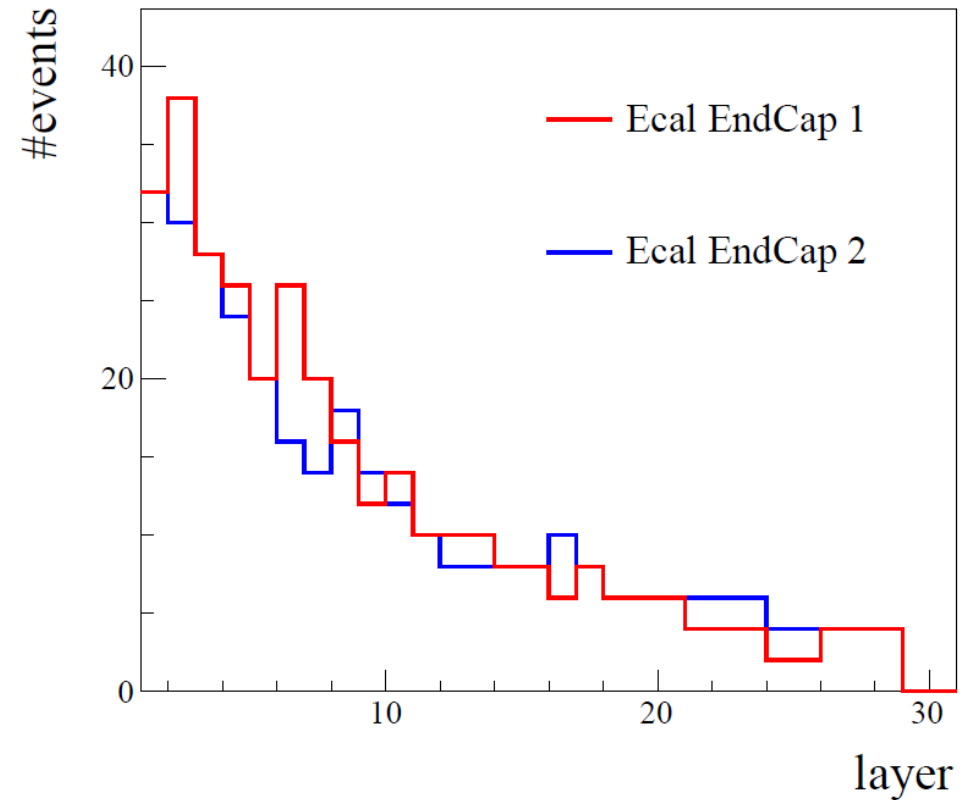
Example for one Endcap, one stave, first layer.
Maximal number of events reaches 35 (closest to beam pipe).

ECAL EndCap

$\gamma\gamma \rightarrow \text{hadrons}$



Incoherent e^+e^- pair creation



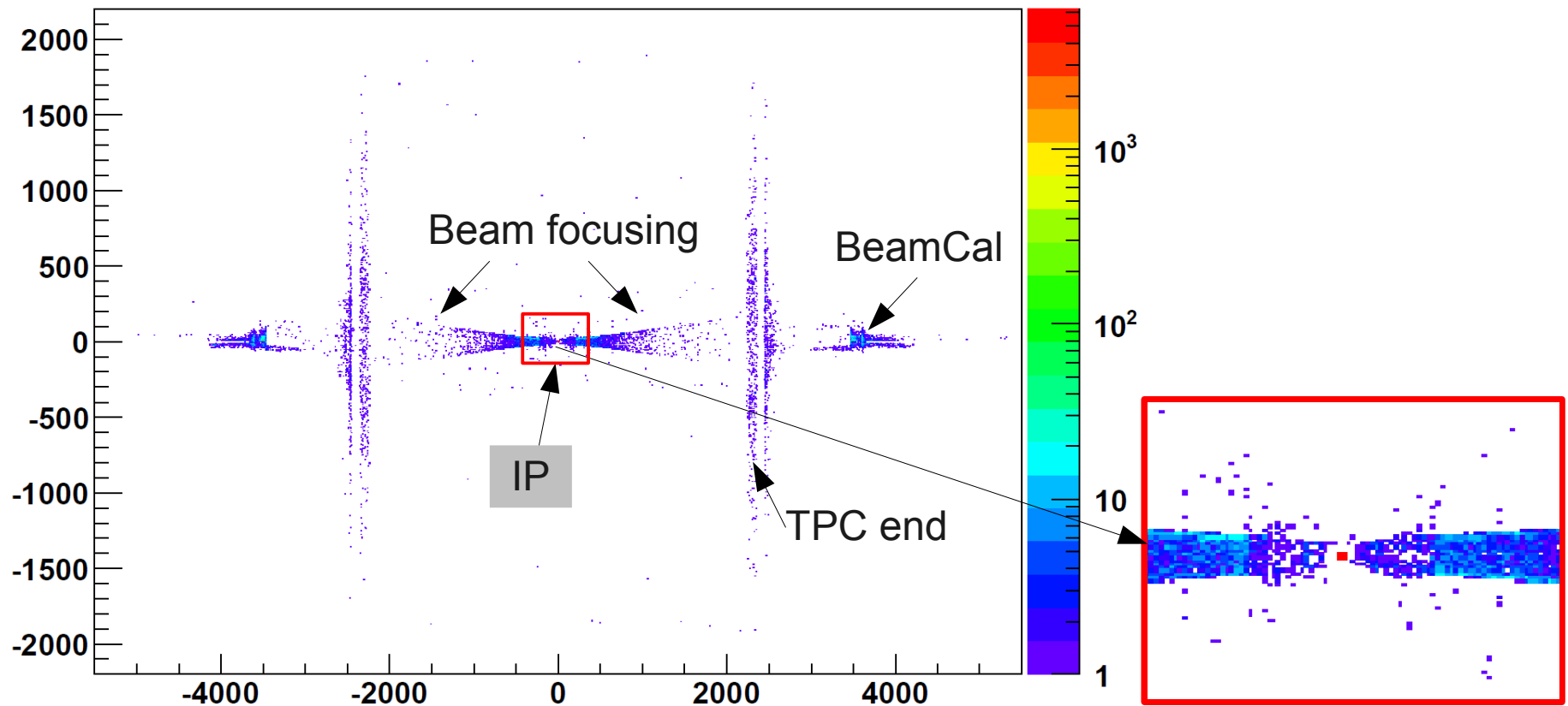
Maximum number of events firing a same chip in a layer.

Check of Simulation

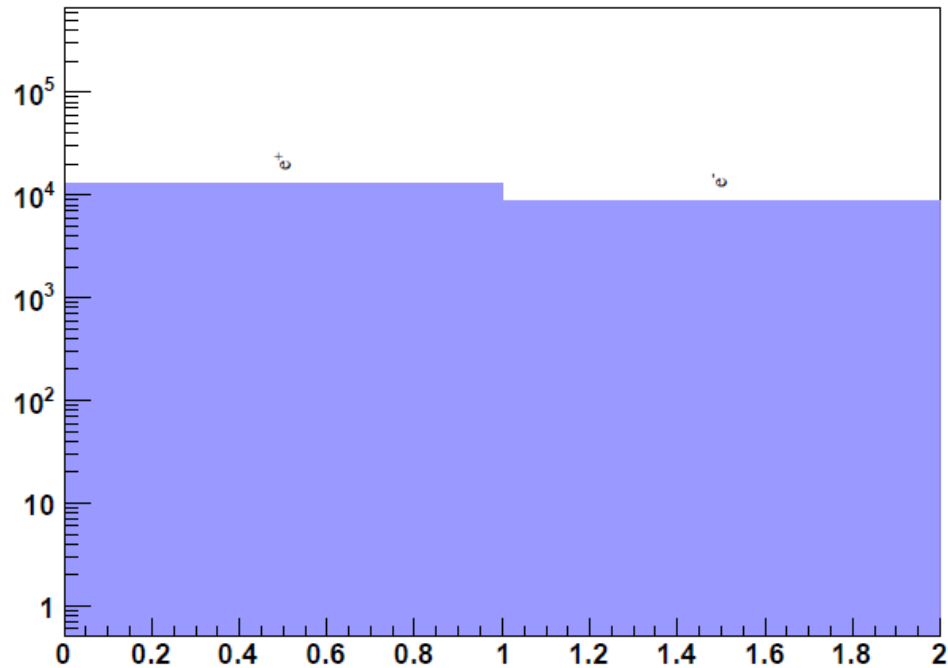
- ◆ Generator: Guinea-Pig, process: e^+e^- pair creation
- ◆ Simulation: Mokka, ILD_o1_v05, magnetic field map bug fixed

Secondary particles

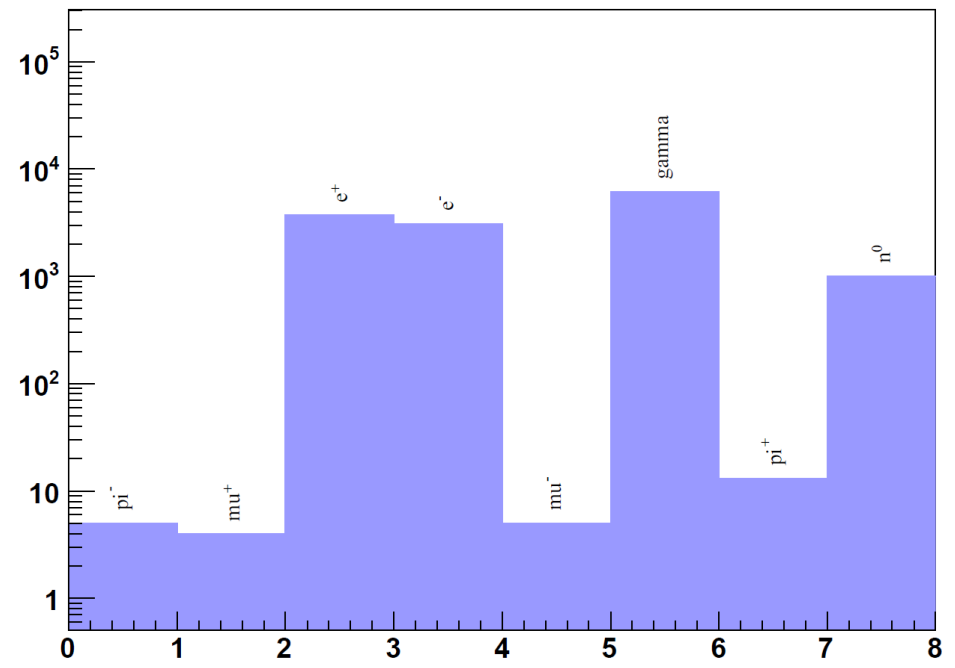
- Select particles which initiate showers in the ECAL.
- They are created either directly from e^+ , e^- (35%) or via secondary interaction (65%)



Particle composition



Direct

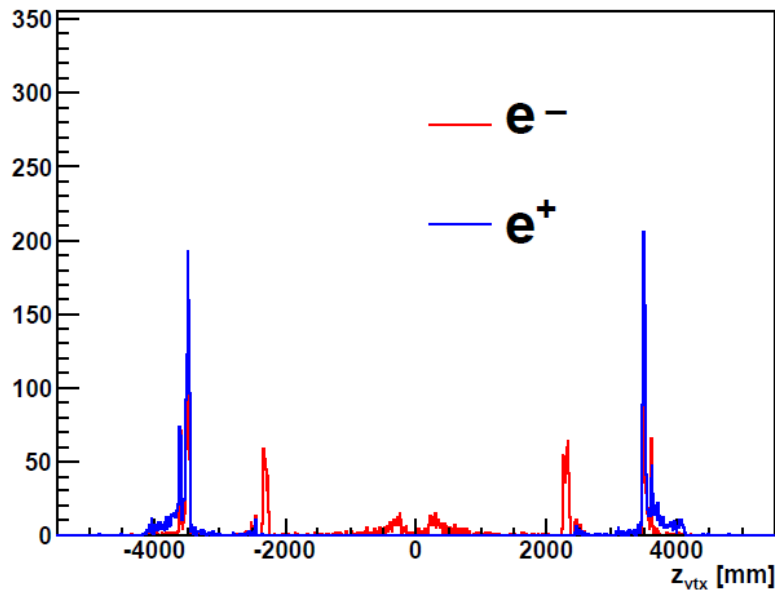


Secondary interaction

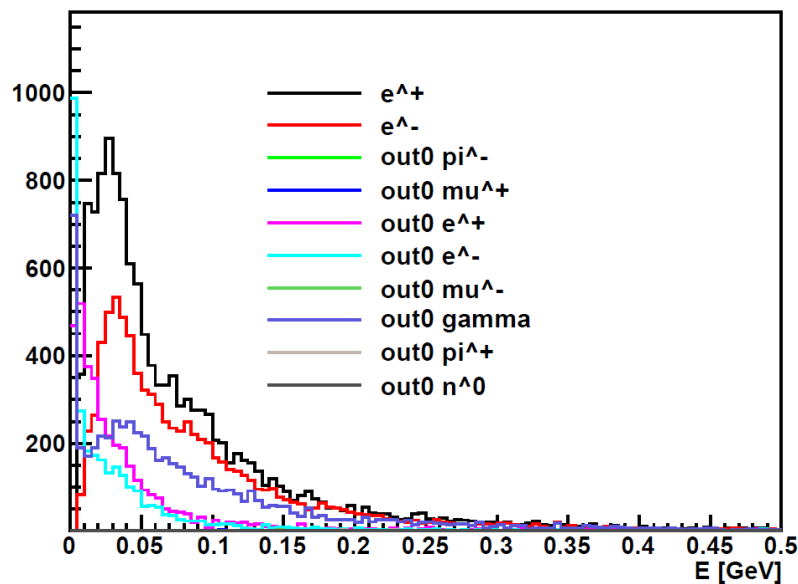
Largest contribution from gamma.

Asymmetry e^+ / e^- : due to magnetic field?

Z-vertex & energy distributions



Secondary interaction
Difference between e^+ & e^-



Secondary interaction particles have smaller energy: expected.

Summary

- Occupancy estimated by number of events/chip in one spill

ECAL component	ee pair creation	$\gamma\gamma \rightarrow$ hadrons
Barrel	≤ 10	0.25
EndCap	38	5
EndCap Ring	175	12 (*)

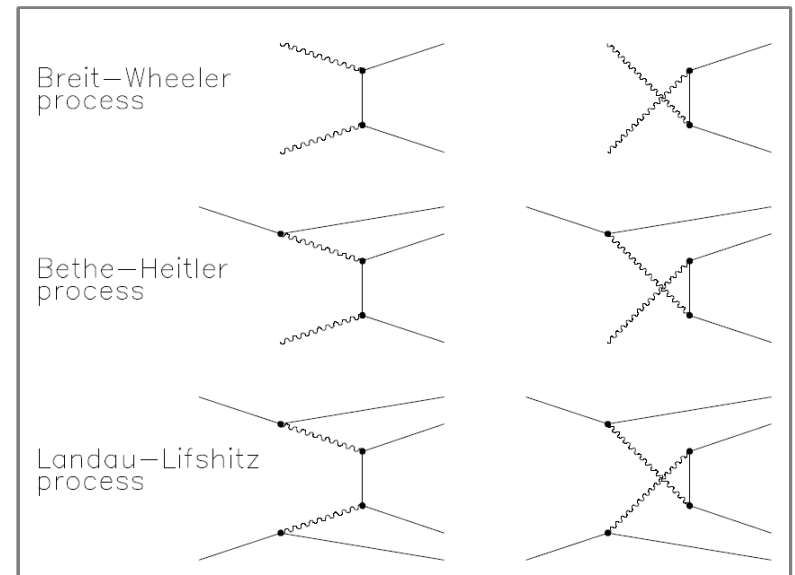
**Limit of Skiroc2:
15 events**

(*) Maximum. Average value is ~ 10

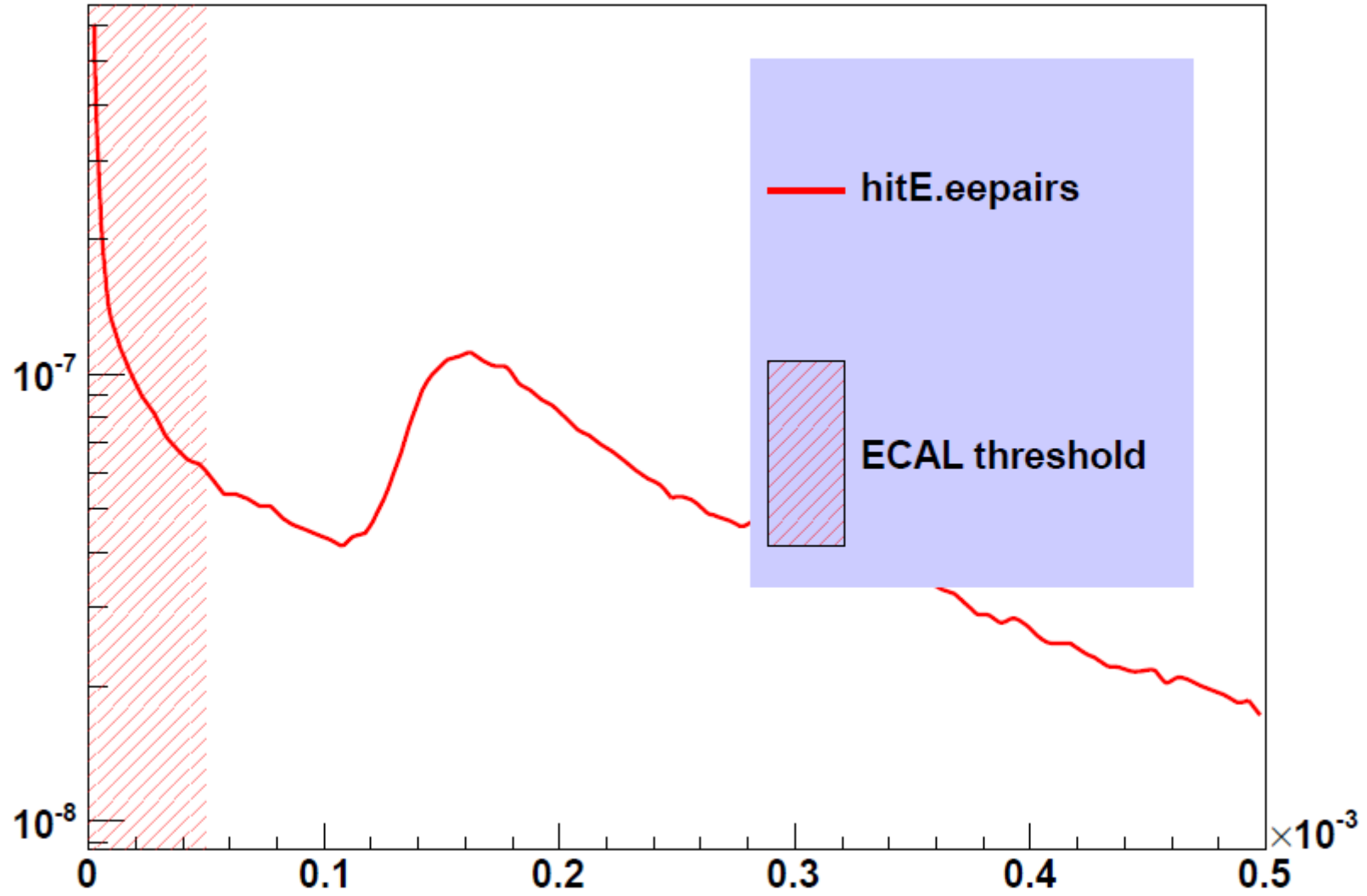
- Some features observed in simulation:**
 - asymmetry between e^+ and e^- (number of particles, z-vertex distribution)
- Safety margin needed for**
 - upgrade in luminosity (instantaneous or peak luminosity) or c.m. energy,
 - accelerator change, e.g. spill duration
 - etc.
- PFA can be affected?**
 - $175/N_{\text{BX}} = 175/2625 \sim 7\%$ in very forward regions, and less for other regions
- Beam optics not optimised for ECAL?**
-

Backup

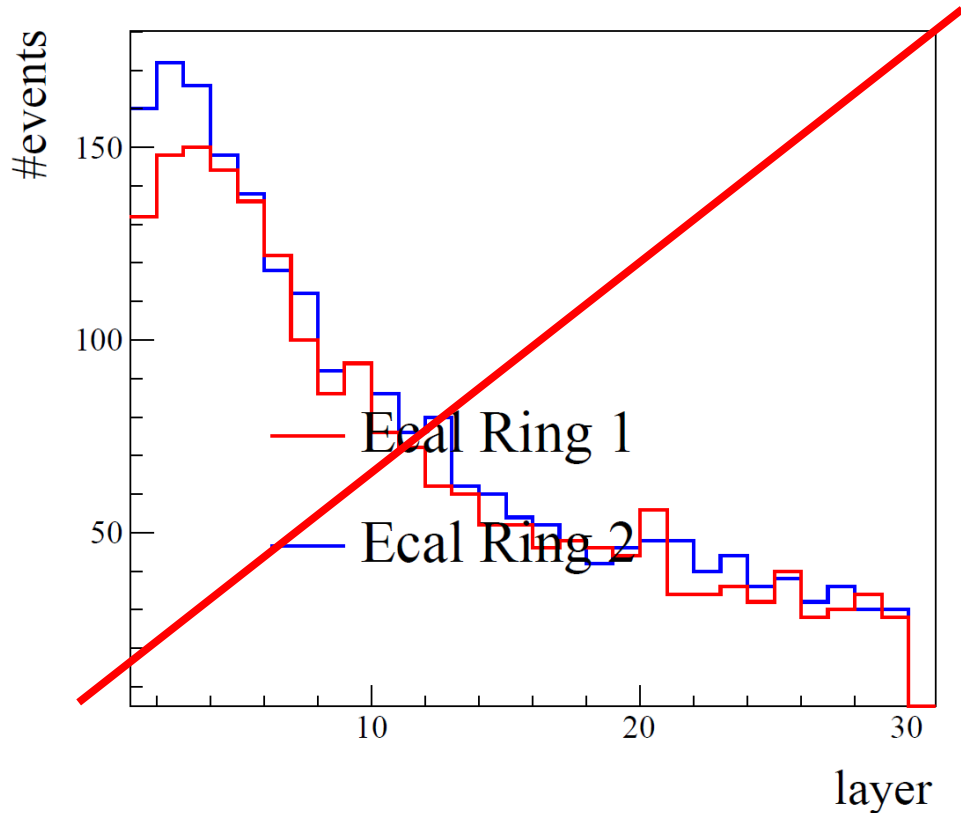
Incoherent pair creation



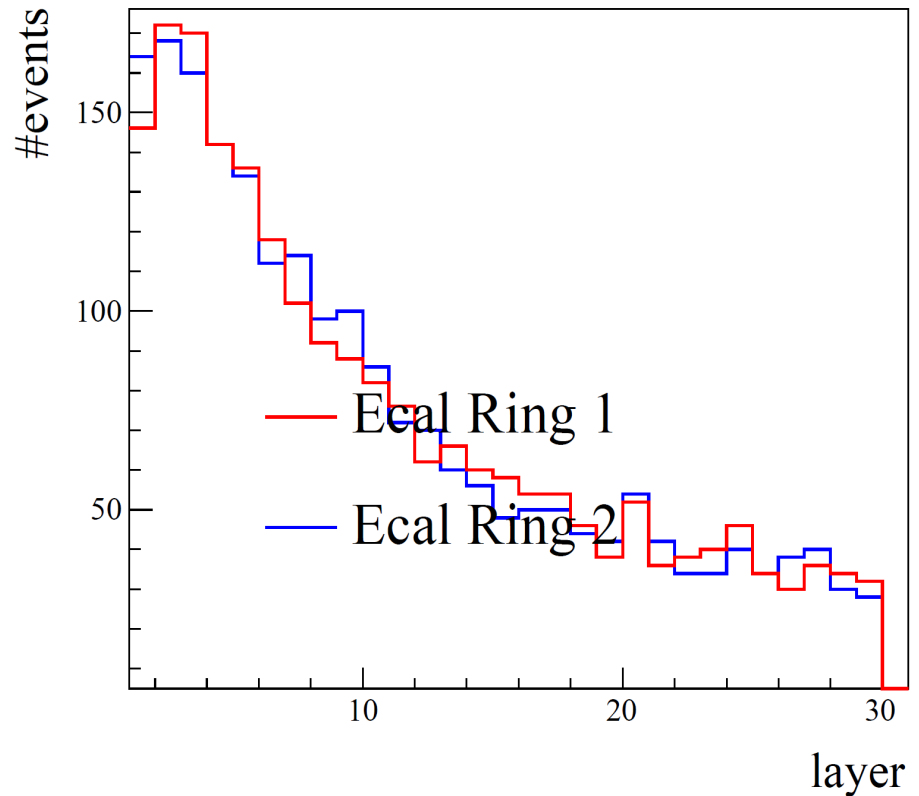
Threshold 0.3 MIP



Occupancy comparison



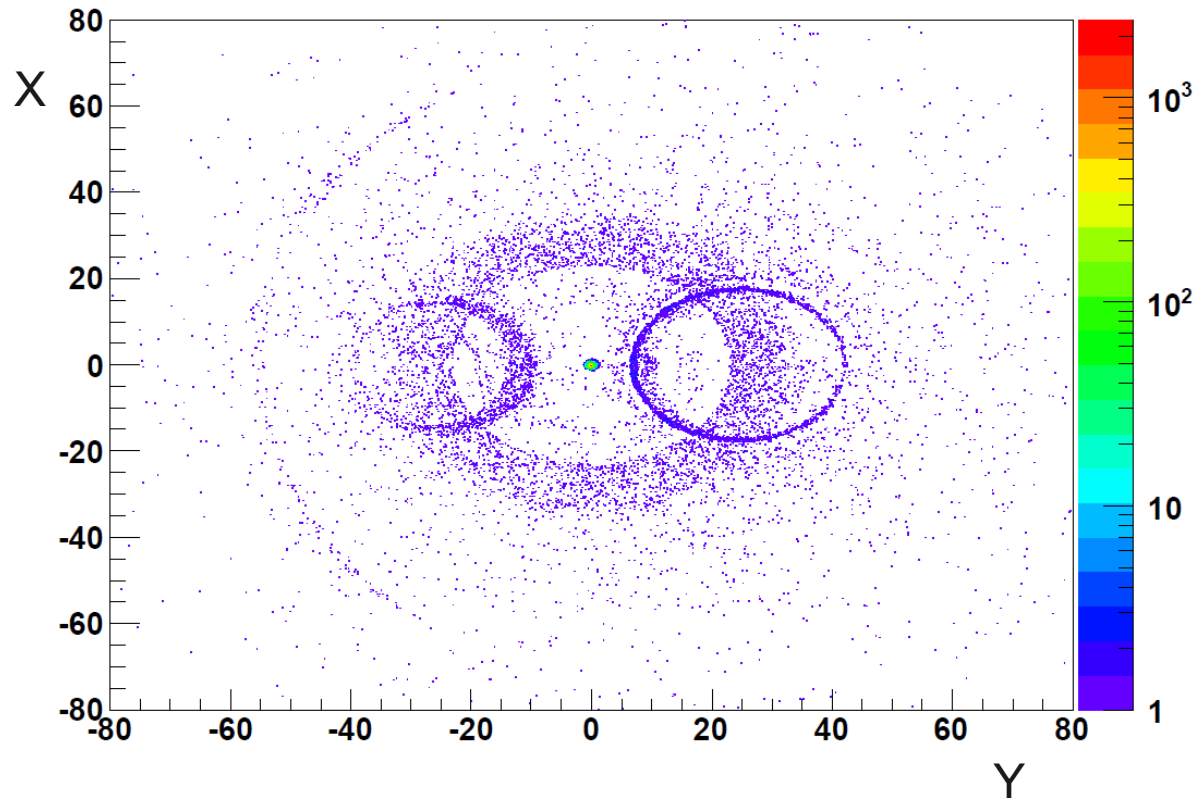
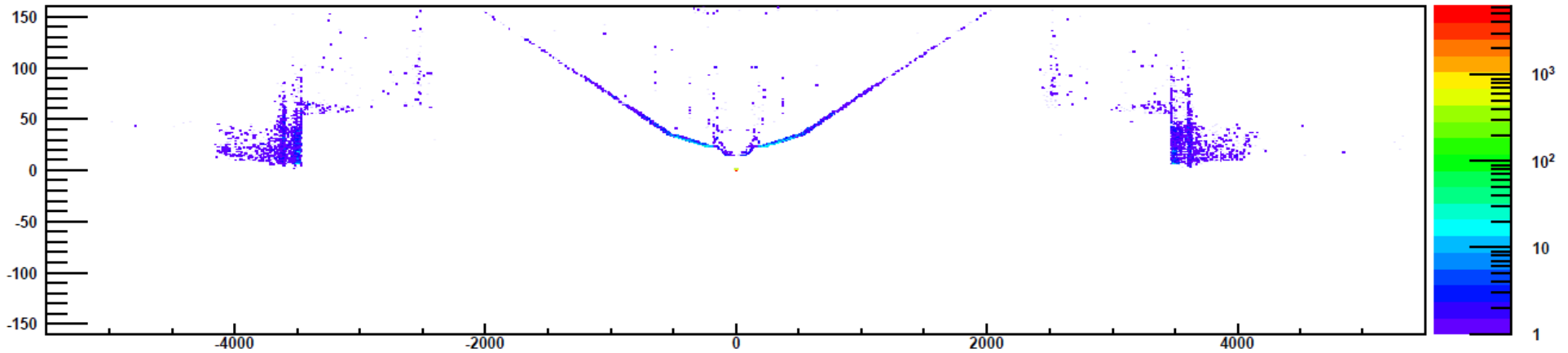
eepairs, wrong magnetic field map



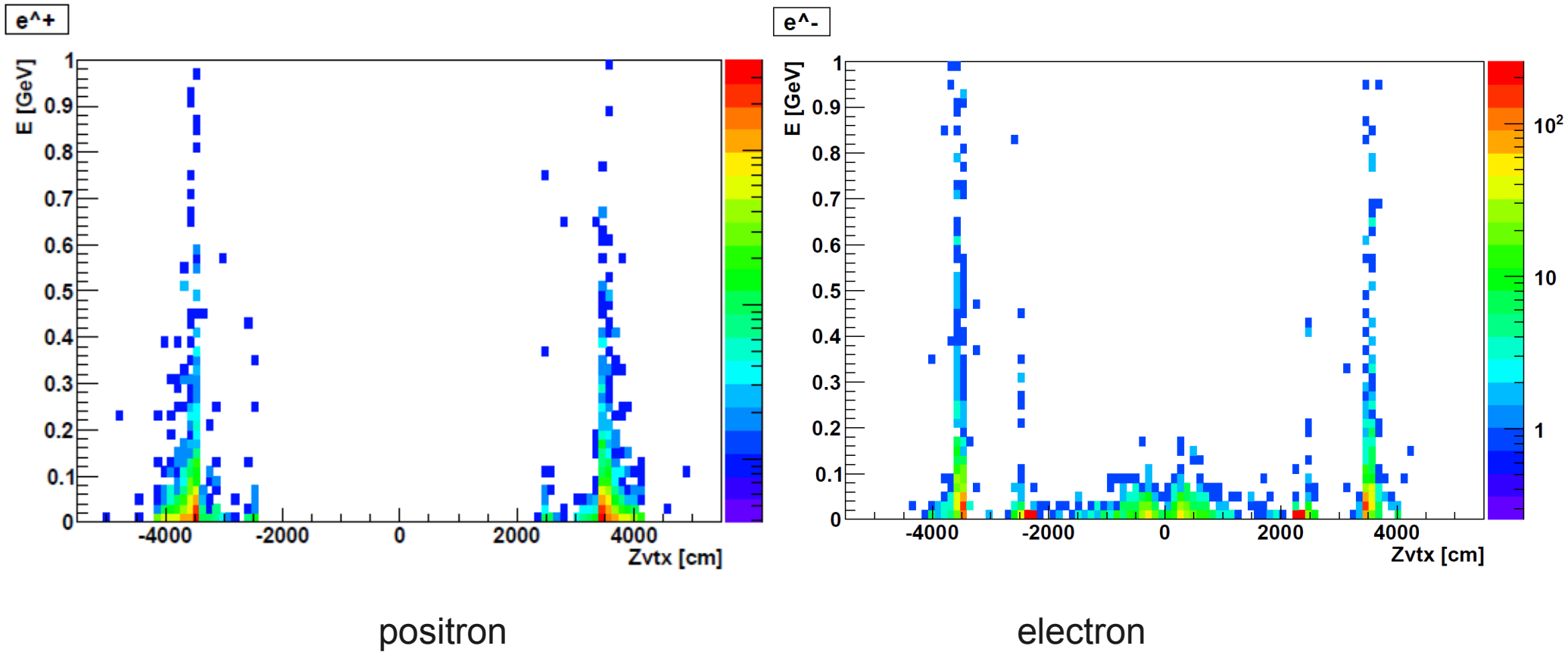
eepairs

Maximal nb of events recorded by chip for different layers

R vs Z (vertex), X vs Y



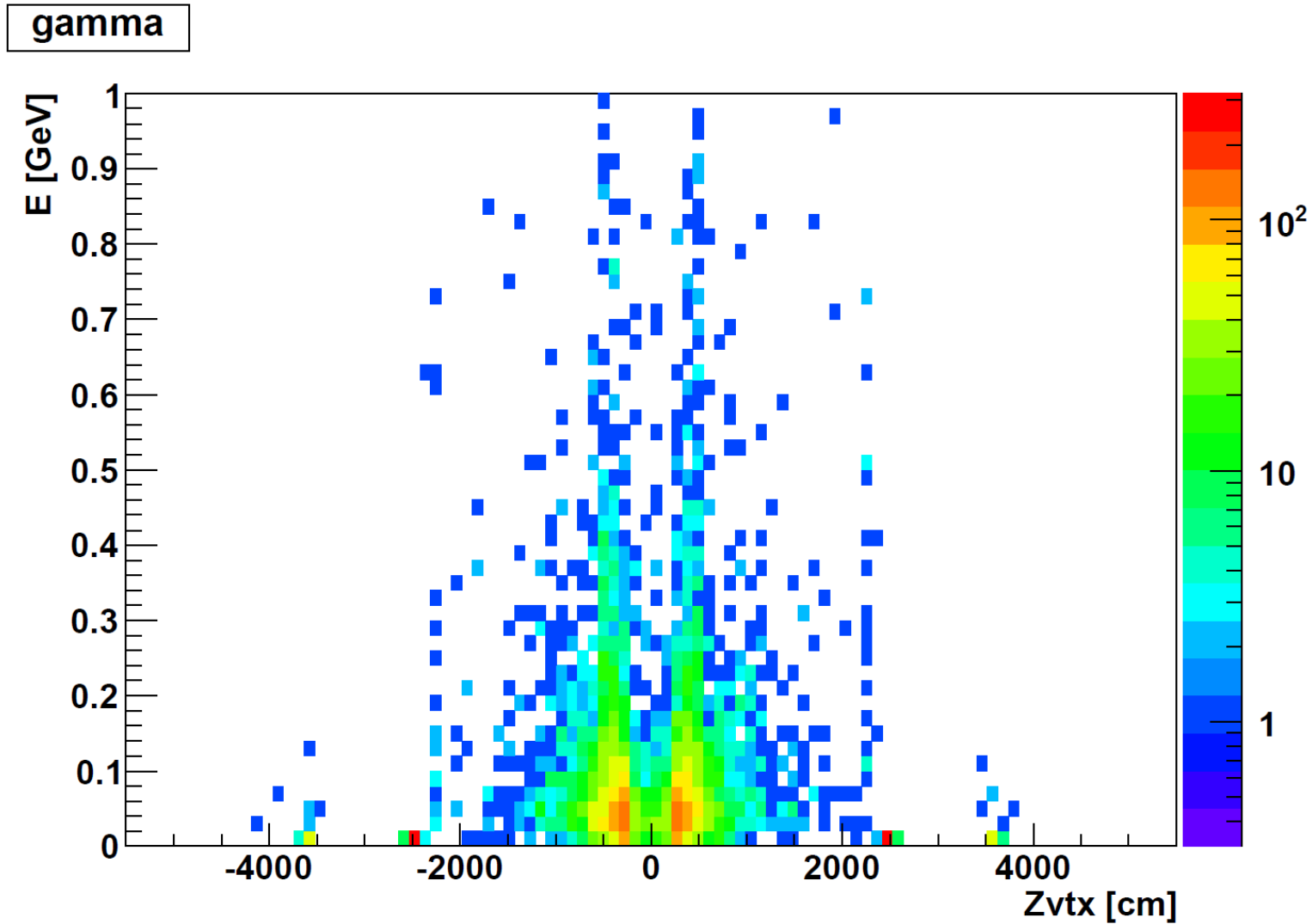
Energy vs Z-vertex



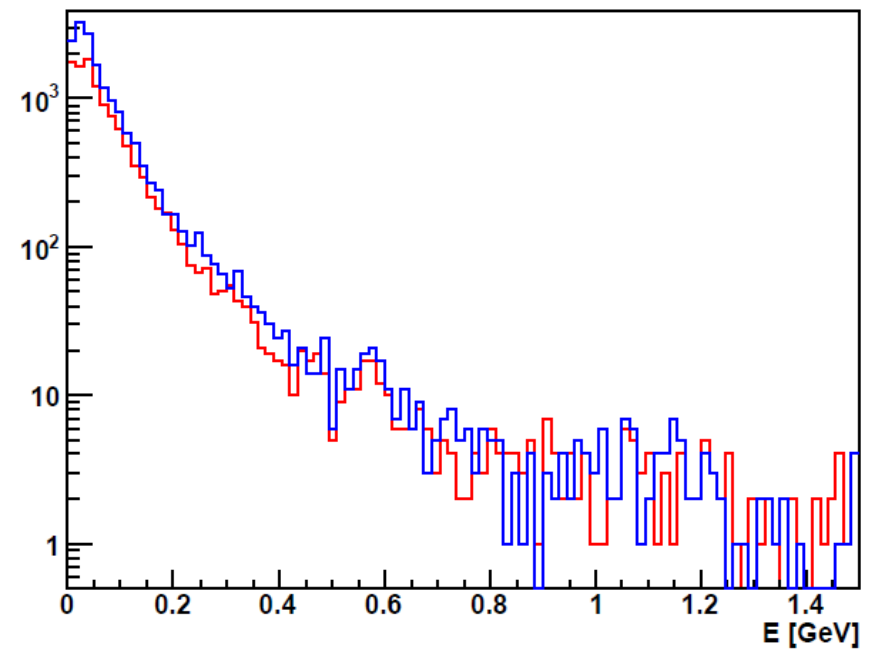
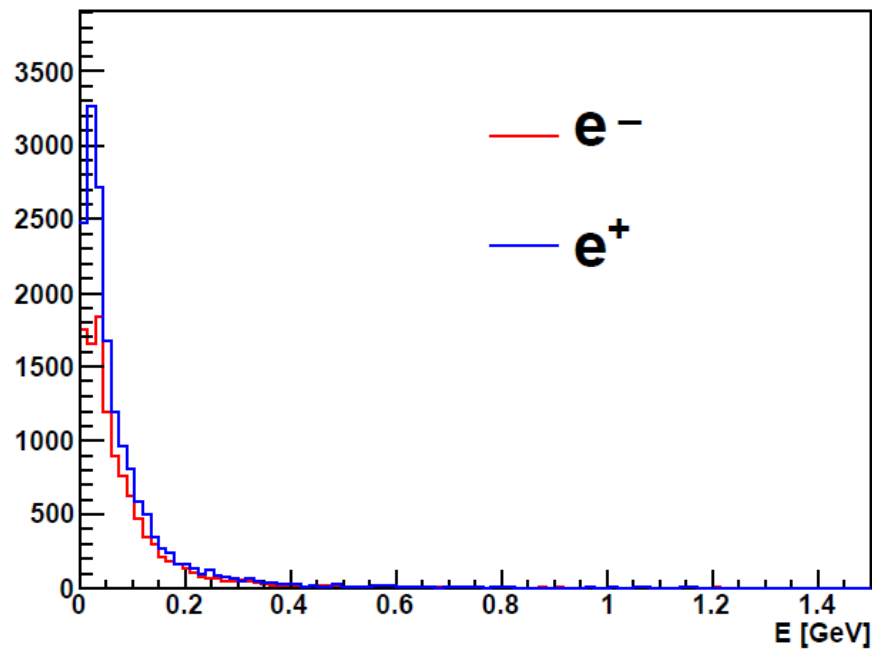
positron

electron

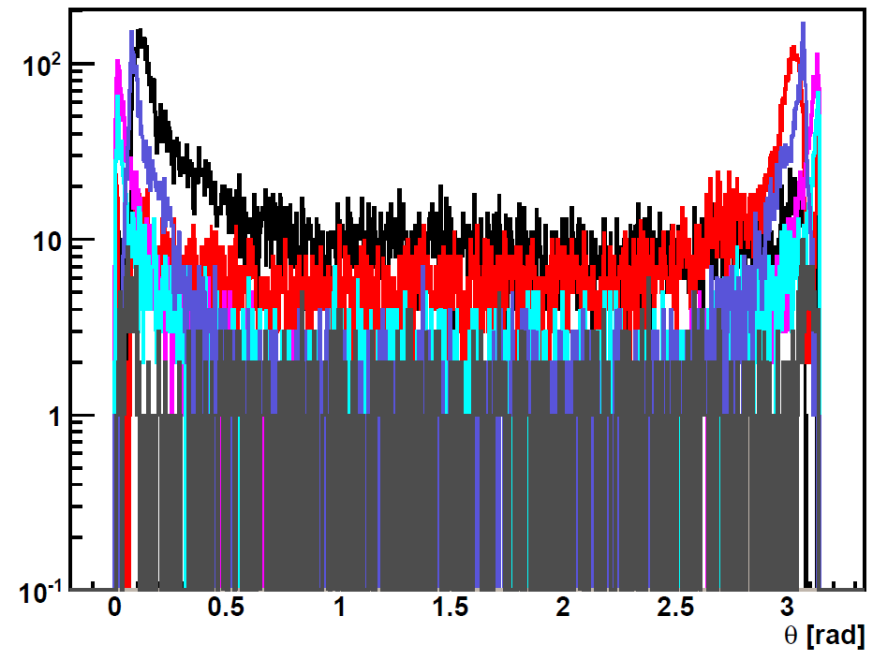
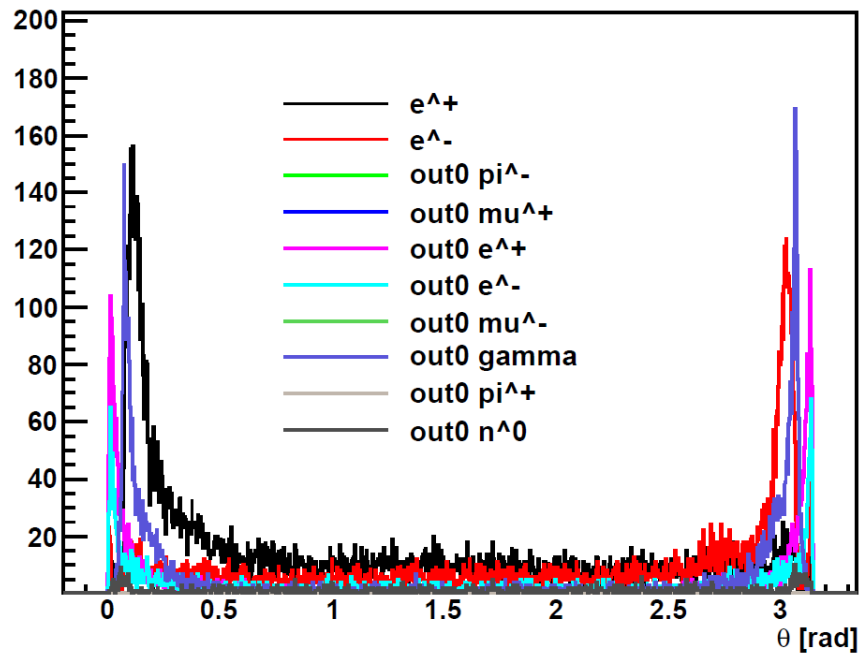
Energy vs Z-vertex - gamma



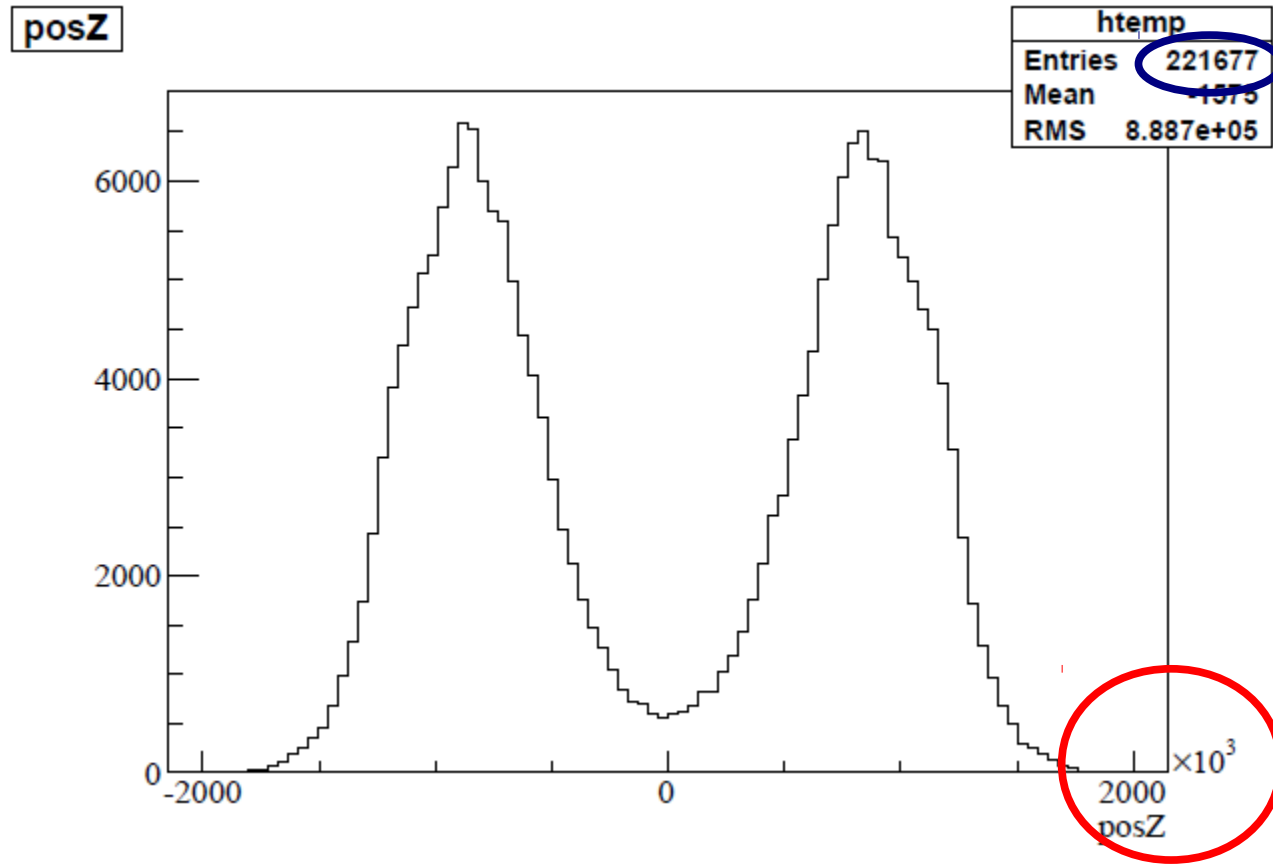
Energy: all electrons & positrons



Theta (direction)

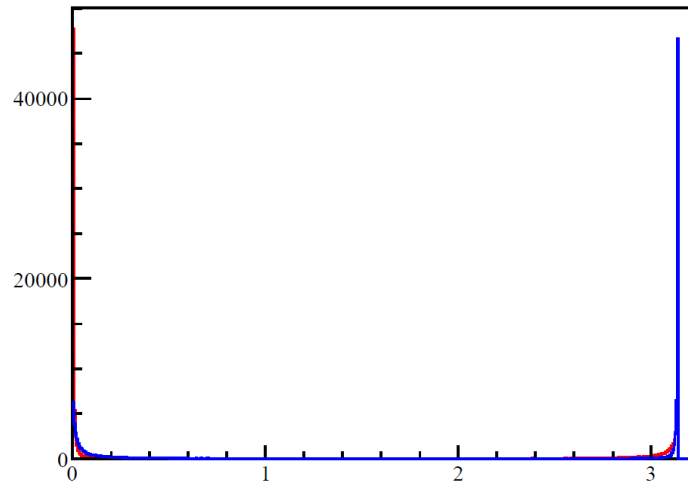


Generated files (1)

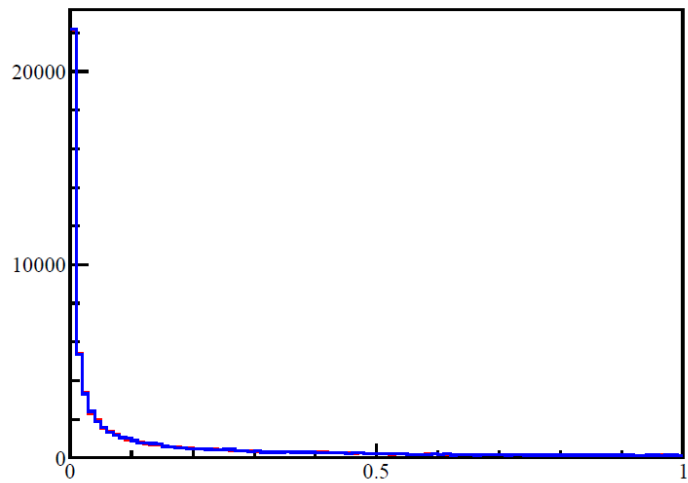
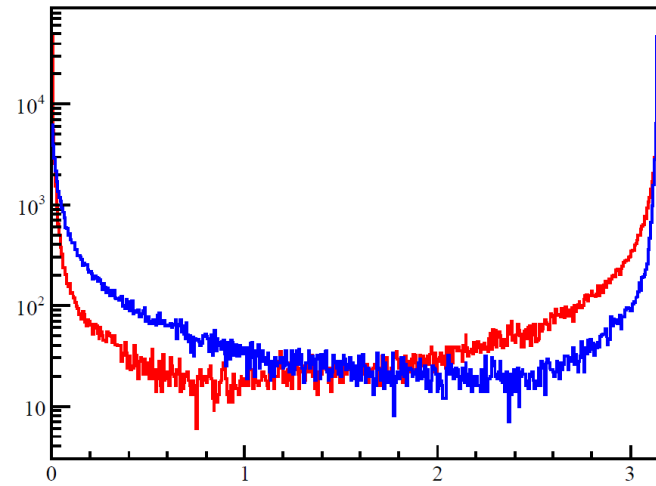


Nb of pairs
created in
one single
BX

Generated files (2)



Theta_gen electron & positron



Energy_gen electron & positron

