Maximal number of events stored in SKIROC

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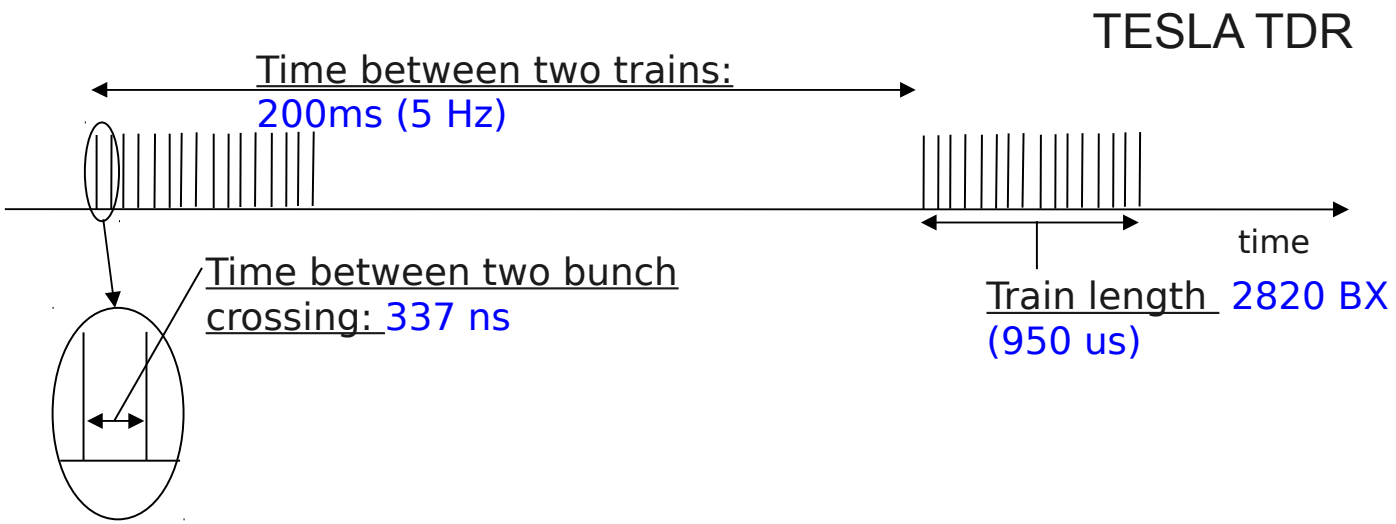
Outline

- Motivation & ILC accelerator parameters
- Occupancy study & main background
- 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

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

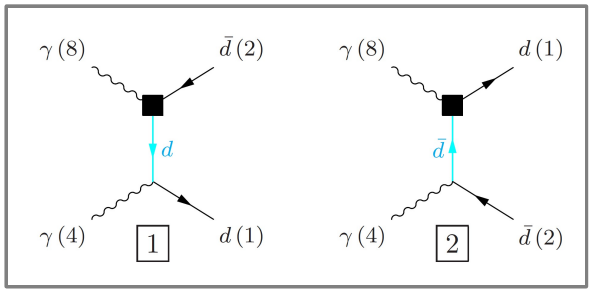
→ Spill luminosity ~ $2 \times 10^{34}\ cm^{-2}s^{-1} \times 200$ ms = 4 nb^{-1}.

High xsection processes at $\sqrt{s}$ = 500 GeV

Beam polarisation: eL, pR

Proc. name	Proc. Type	Pola1	Pola2	σ (pb)
γγ → ddbar	aa_lowpt	L80	R20	633224.0
γγ → μμ	aa_2f	B	B	832.0
eγ → eγ	1f_3f	L	B	547.0
γc → ee	aa_2f	B	B	425.8
eγ → eγ	1f_3f	L	W	345.4
γe → eγ	1f_3f	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

Pola1	Pola2	σ (pb)
B	B	230318.0
B	W	152207.0
W	B	152174.0
W	W	98525.1



Photon beam:

Very strong focused beam: large charge density → large EM field → beamstrahlung in the other beam

Interactions:

- electron-photon
- photon-photon

Beam induced background

Process name: ee pairs
Simulated for each bunch crossing.
→ main background. Not included yet.

Analysis procedure

- Geometry: ECAL is composed of barrel, endcap & endcap ring.
- Samples for DBD, `ILD_o1_v05`. 600K events in total.
- Get hit information from simulation (position, ID, energy, …)
- The chip is fired only if the Geant4 hit energy pass a 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)

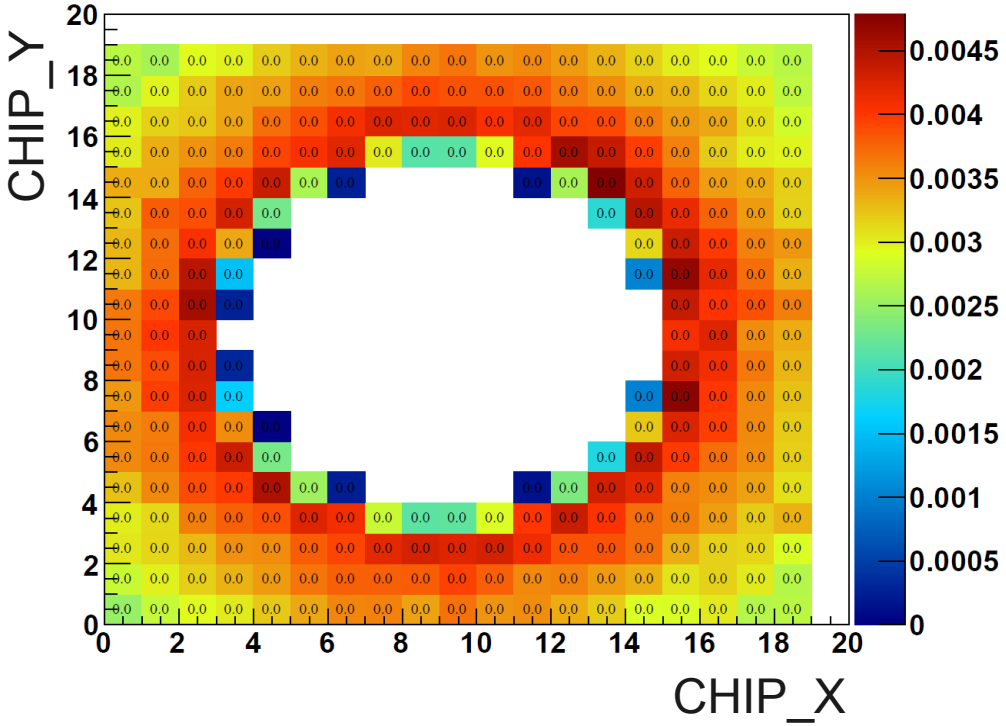
N_{MC}: total number of MC events which fire the chip corresponds to lumi L_{MC}

Scaled to spill luminosity of $4nb^{-1}$ by:

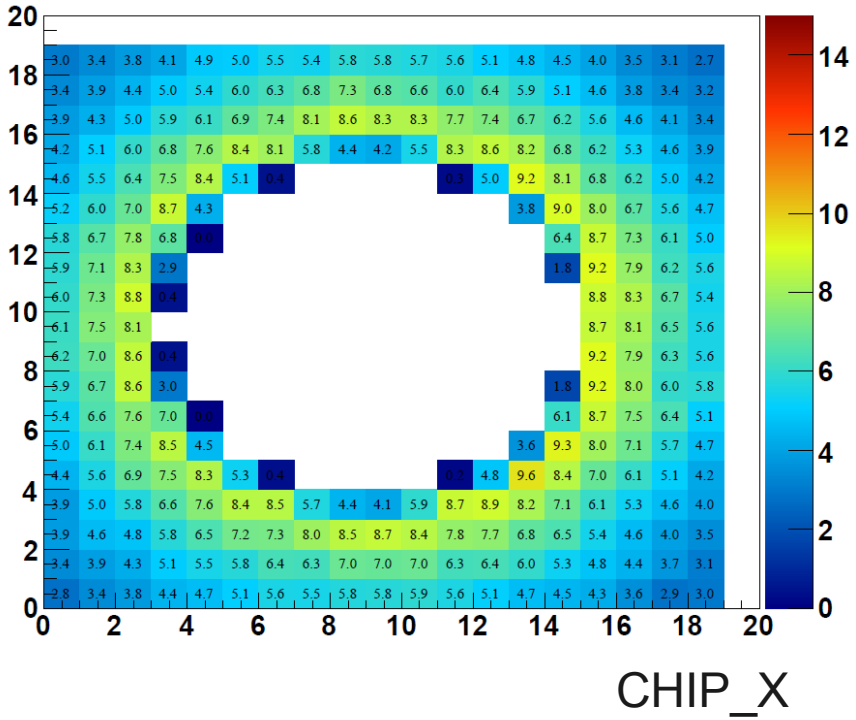
$N_{spill} = N_{MC} \times L_{spill} / L_{MC}$

Gamma-gamma at low pt is dominant

- double photon production (including beamstrahlung) process is the dominant source for ECAL in the forward region



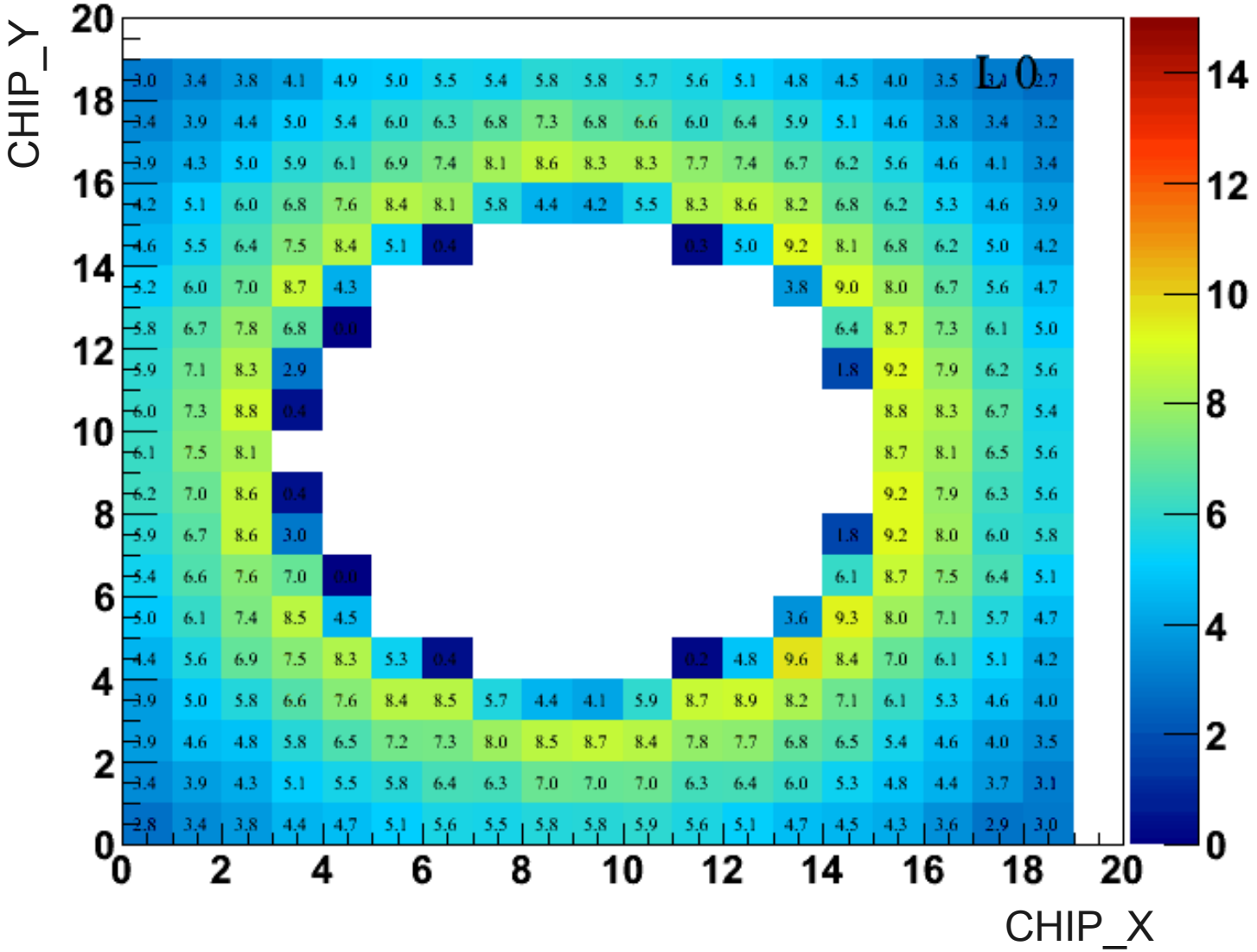
All process but gamma-gamma



All processes

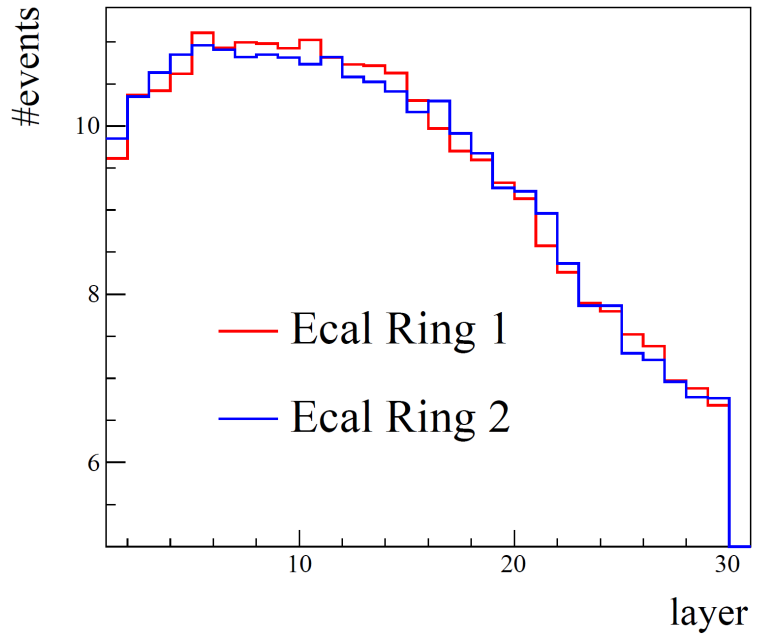
ECAL Ring occupancy (1)

2 Rings, each has 29 layers.



ECAL Ring occupancy (2)

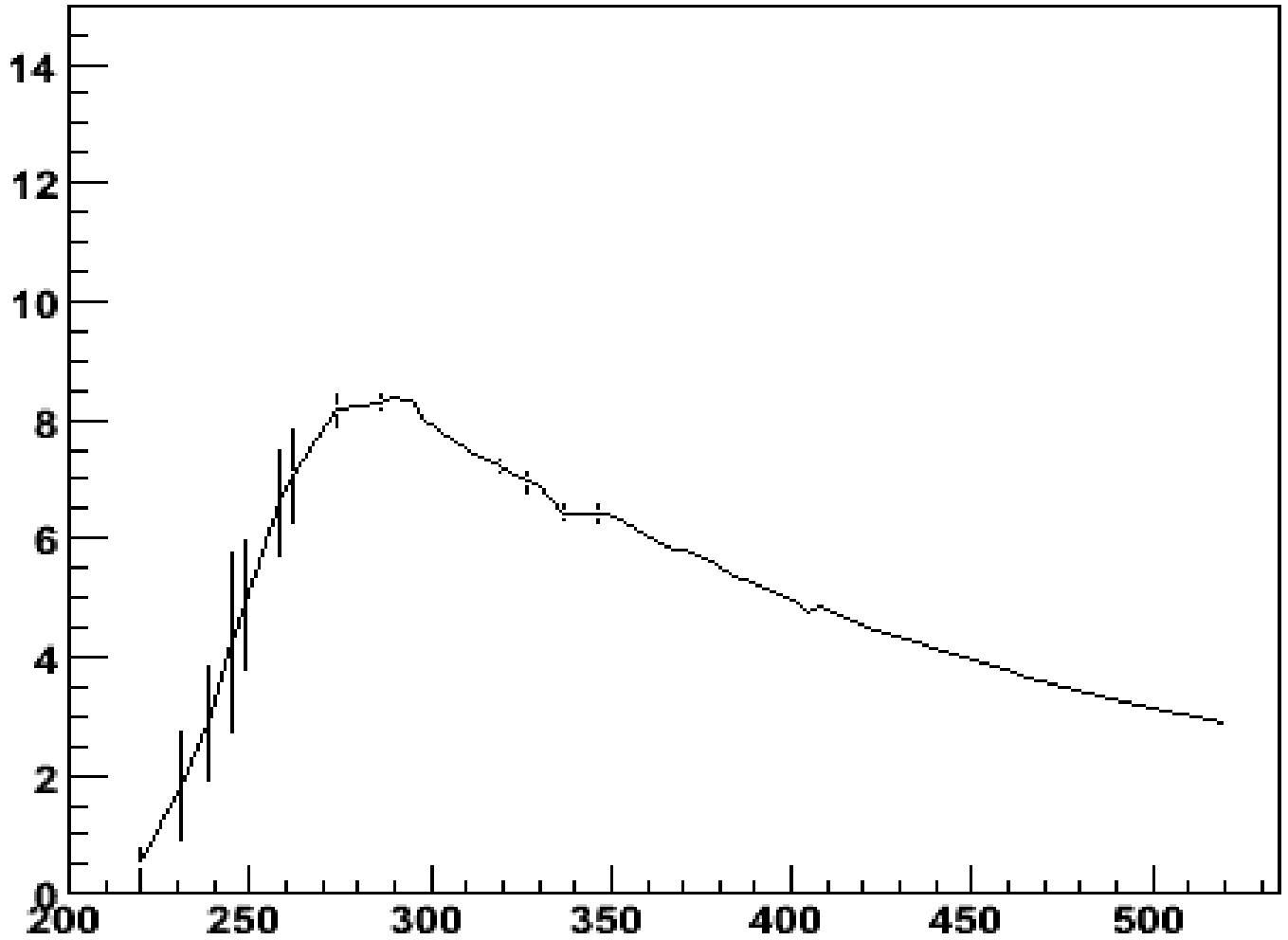
Reminder: Maximum 15 events can be carried by SKIROC 2 in one spill.



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

In Endcap ring, the maximum of average of recorded number of events can reach 11!

ECAL Ring occupancy (3)

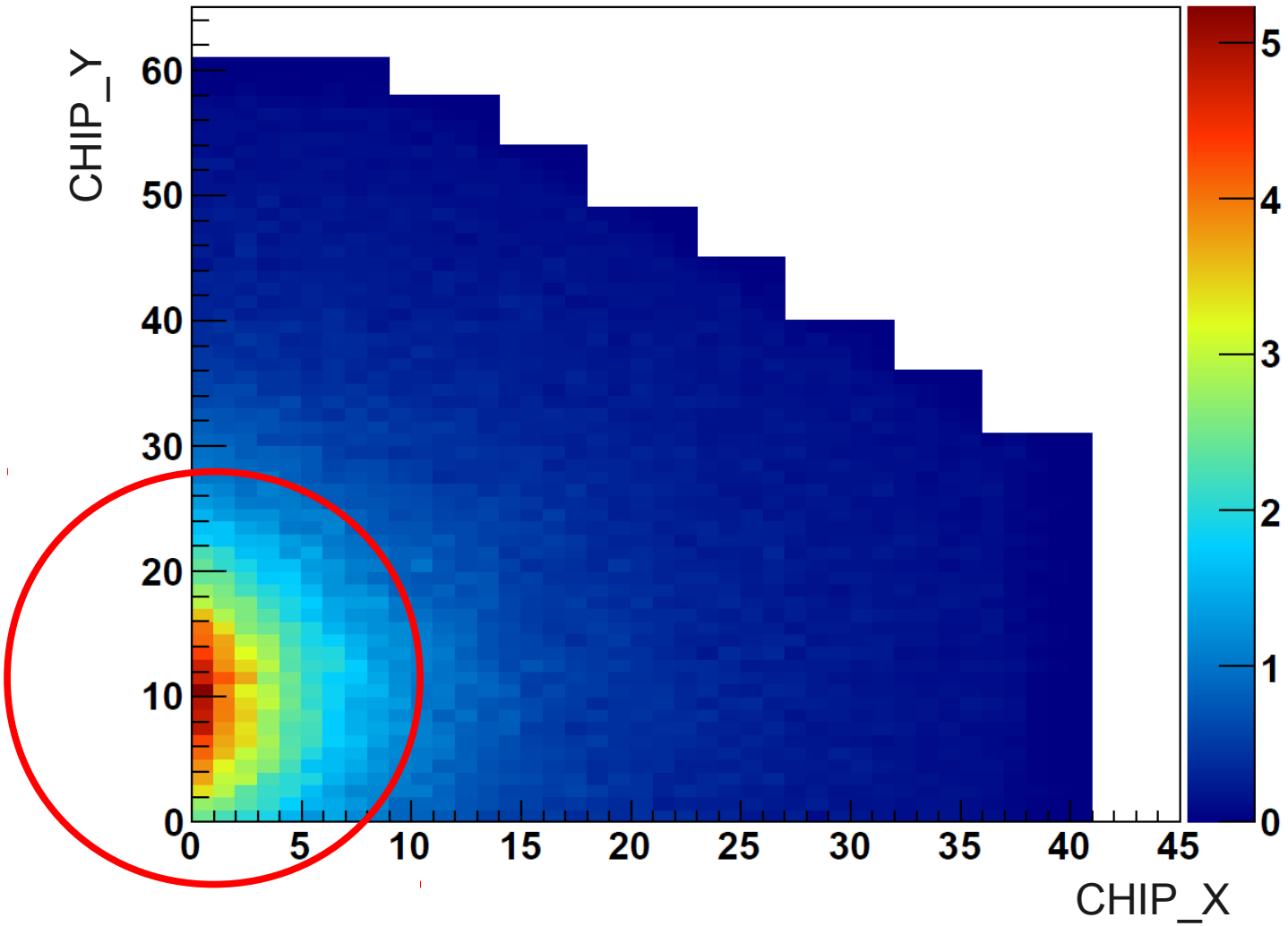


Mean value of number of events / chip /spill taken along R direction (position of chip)

Maximum at 10.

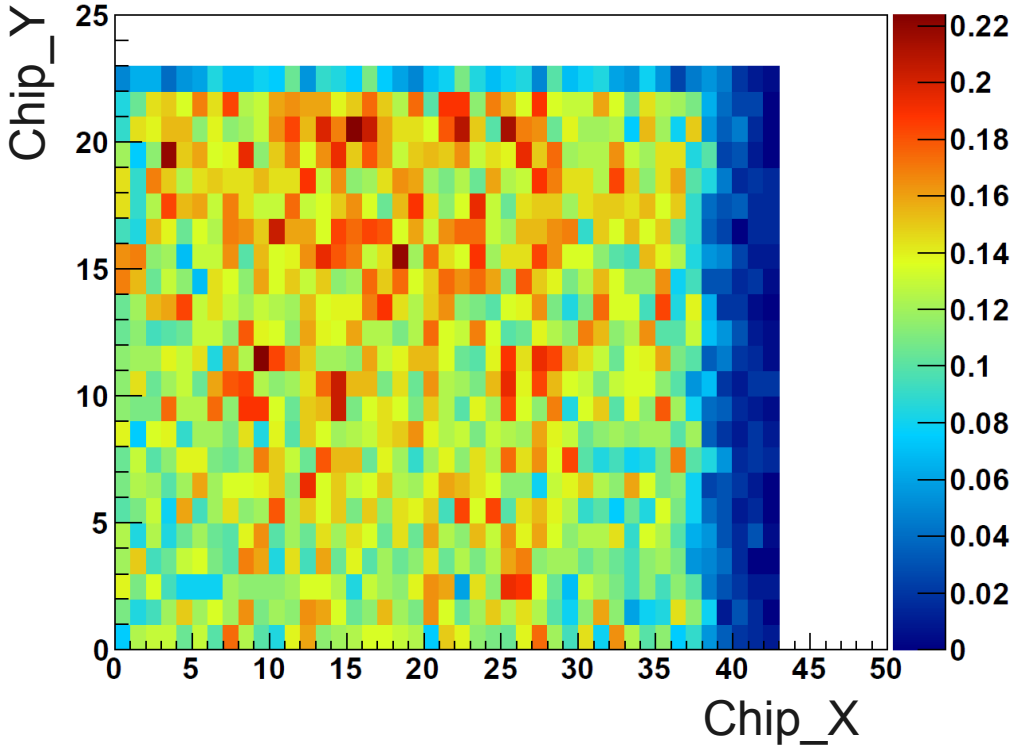
ECAL EndCap

Maximum number is ~5 in the Endcap.



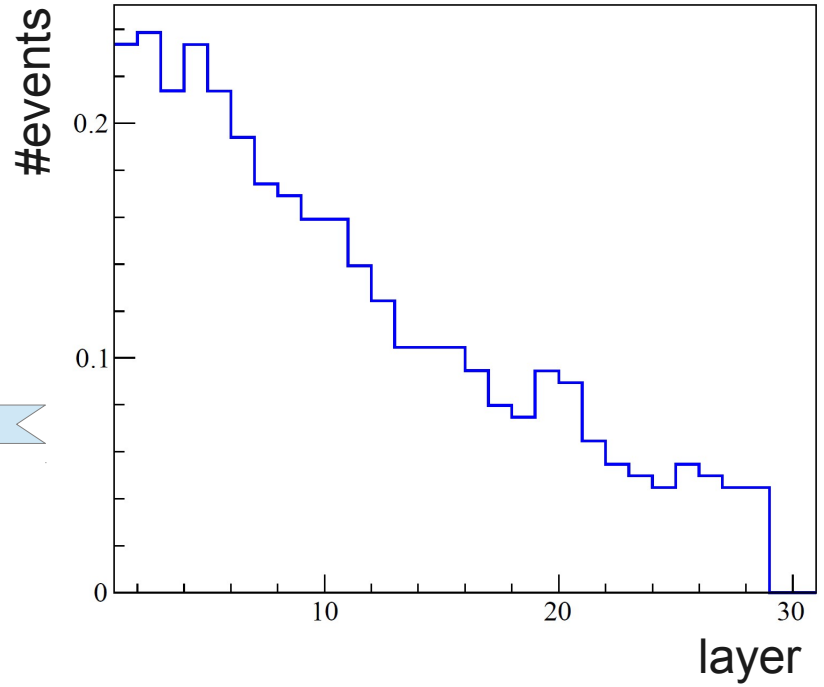
Example for one stave of 1 endcap, 1 layer

ECAL Barrel

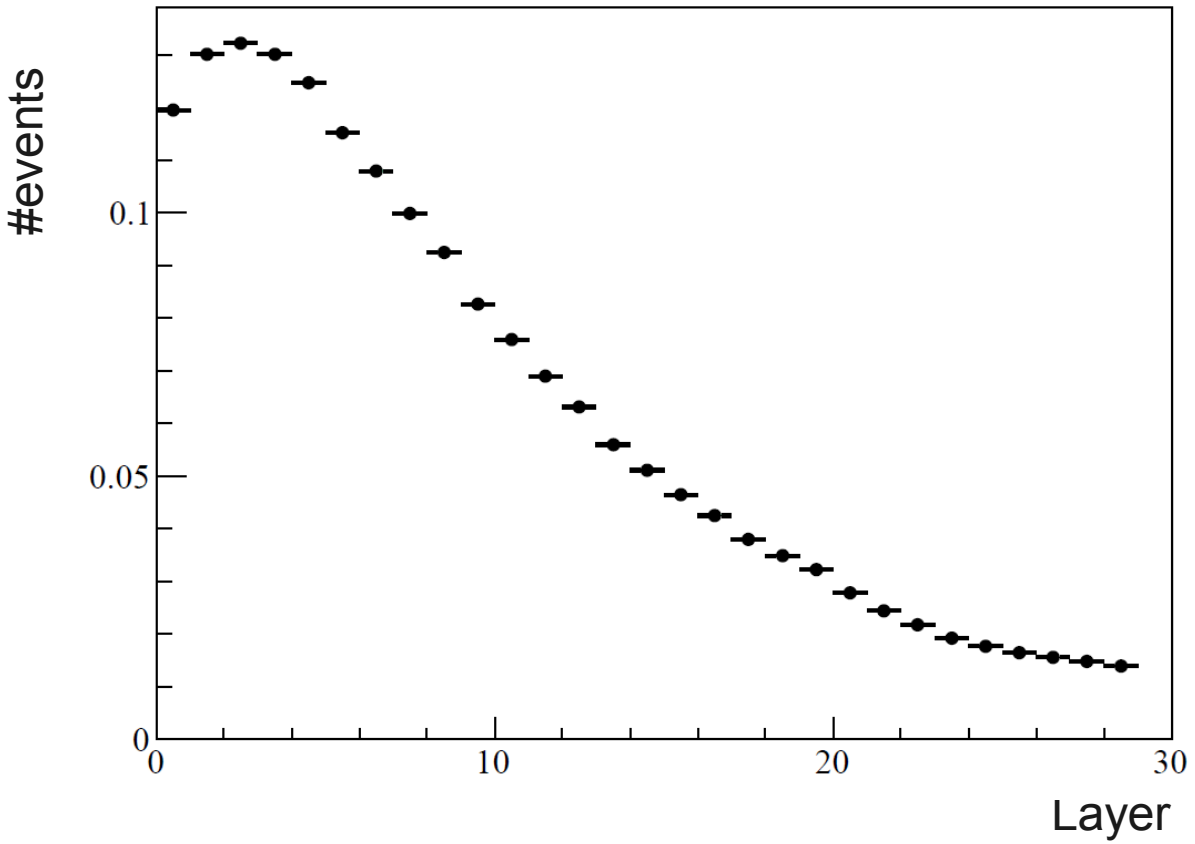


Example of occupancy for one layer of a module. (Similar for other modules, all staves are similar.

Maximum number of events in function of layer (for all modules, all staves)



ECAL Barrel (2)

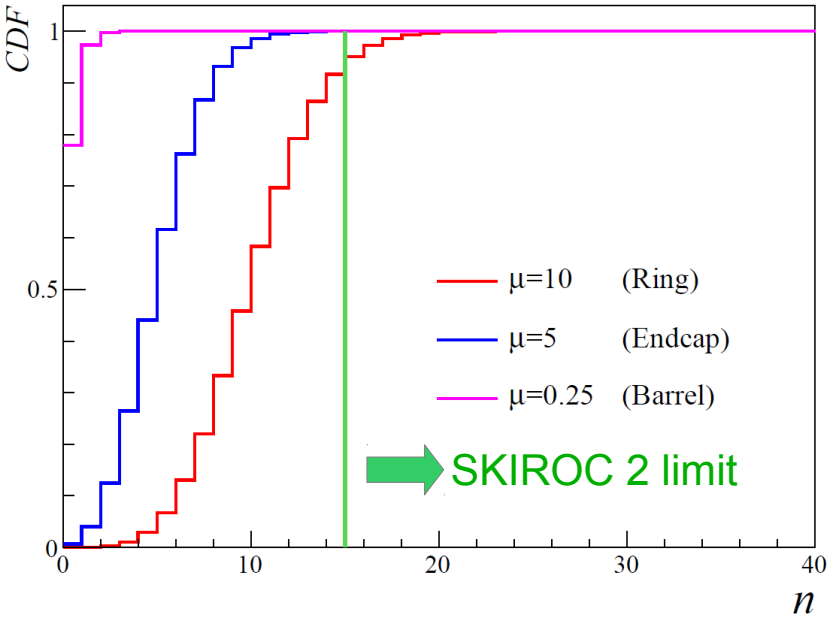


Mean number of events along layers.

Summary

- Maximal average occupancy in Ecal Ring region is in average ~10 ($\pm$ < 0.1^{stat}) events per chip per spill. Boundary not included.
- Number of events is Poisson distributed, can fluctuate above 15

$$CDF = \sum_{i>n}^{\infty} \frac{e^{-\mu}\mu^{i}}{i!}$$



- Beam induced background not included yet.
- We need safety margin for:
  - Upgrade in luminosity (instantaneous or peak luminosity) or in c.m. energy.
  - Accelerator change, e.g. duration of the spill
  - possible retriggering in events with BX+1, BX+2, …, BX+15.
- What to do with the Ecal Ring?
  - new chip? (matrix is expensive!)
  - one chip serves 32 channels (now 64)
    → new PCB, cooling, …

Backup

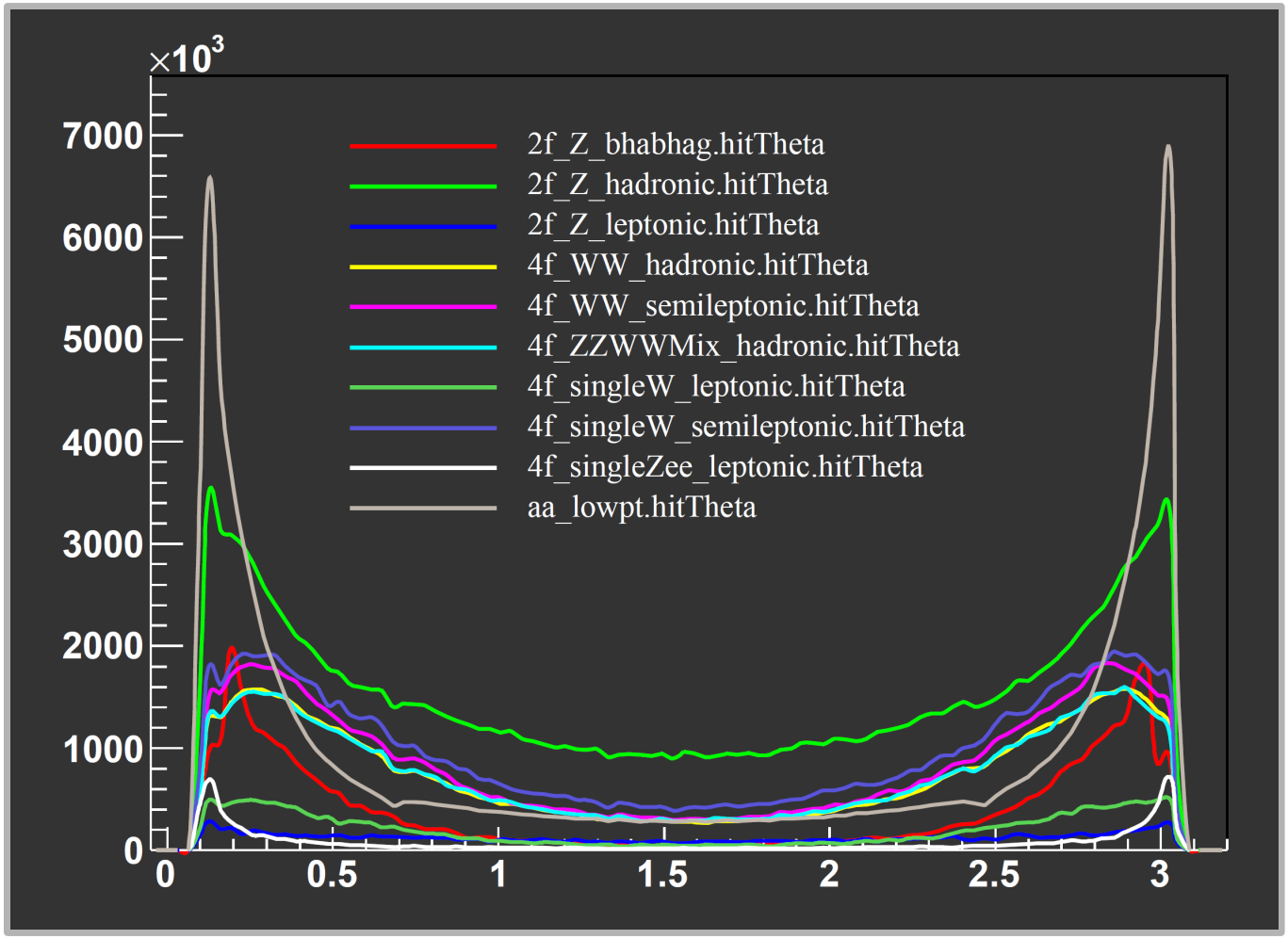
ILC parameters

Beam and IP Parameters for 500 GeV cms.

Parameter	Symbol/Units	Nominal	Low N	Large Y	Low P
Repetition rate	f_{rep} (Hz)	5	5	5	5
Number of particles per bunch	N (10^{10})	2	1	2	2
Number of bunches per pulse	n_b	2625	5120	2625	1320
Bunch interval in the Main Linac	t_b (ns)	369.2	189.2	369.2	480.0
in units of RF buckets		480	246	480	624
Average beam current in pulse	I_{ave} (mA)	9.0	9.0	9.0	6.8
Normalized emittance at IP	$\gamma\epsilon_x^*$ (mm·mrad)	10	10	10	10
Normalized emittance at IP	$\gamma\epsilon_y^*$ (mm·mrad)	0.04	0.03	0.08	0.036
Beta function at IP	β_x^* (mm)	20	11	11	11
Beta function at IP	β_y^* (mm)	0.4	0.2	0.6	0.2
R.m.s. beam size at IP	σ_x^* (nm)	639	474	474	474
R.m.s. beam size at IP	σ_y^* (nm)	5.7	3.5	9.9	3.8
R.m.s. bunch length	σ_z (μm)	300	200	500	200
Disruption parameter	D_x	0.17	0.11	0.52	0.21
Disruption parameter	D_y	19.4	14.6	24.9	26.1
Beamstrahlung parameter	Υ_{ave}	0.048	0.050	0.038	0.097
Energy loss by beamstrahlung	δ_{BS}	0.024	0.017	0.027	0.055
Number of beamstrahlung photons	n_γ	1.32	0.91	1.77	1.72
Luminosity enhancement factor	H_D	1.71	1.48	2.18	1.64
Geometric luminosity	$\mathcal{L}_{geo}$ $10^{34}/\mathrm{cm}^2/\mathrm{s}$	1.20	1.35	0.94	1.21
Luminosity	$\mathcal{L}$ $10^{34}/\mathrm{cm}^2/\mathrm{s}$	2	2	2	2

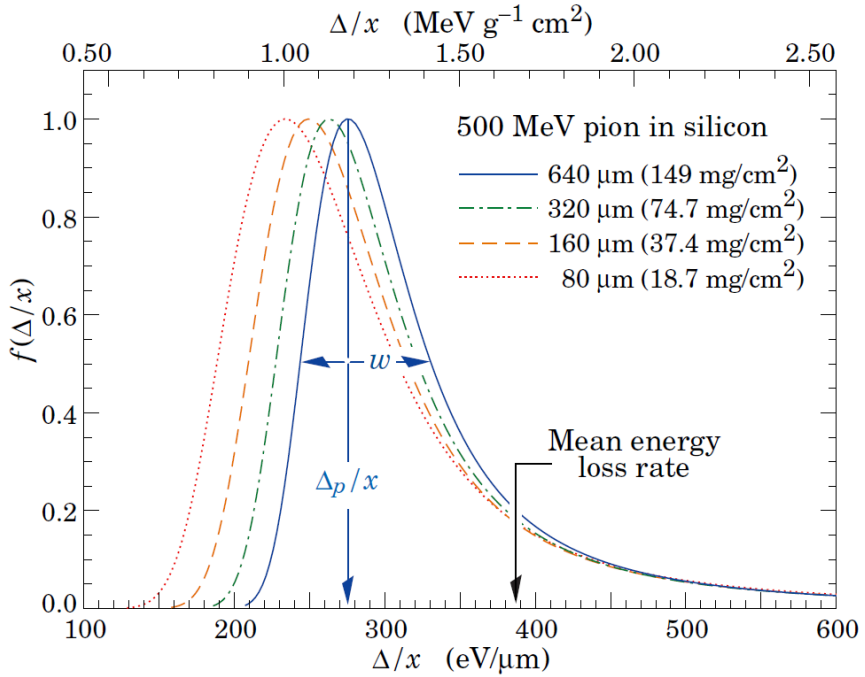
Hit distrubution in theta

In these processes the events tend to has higher cross section toward beam pipe.



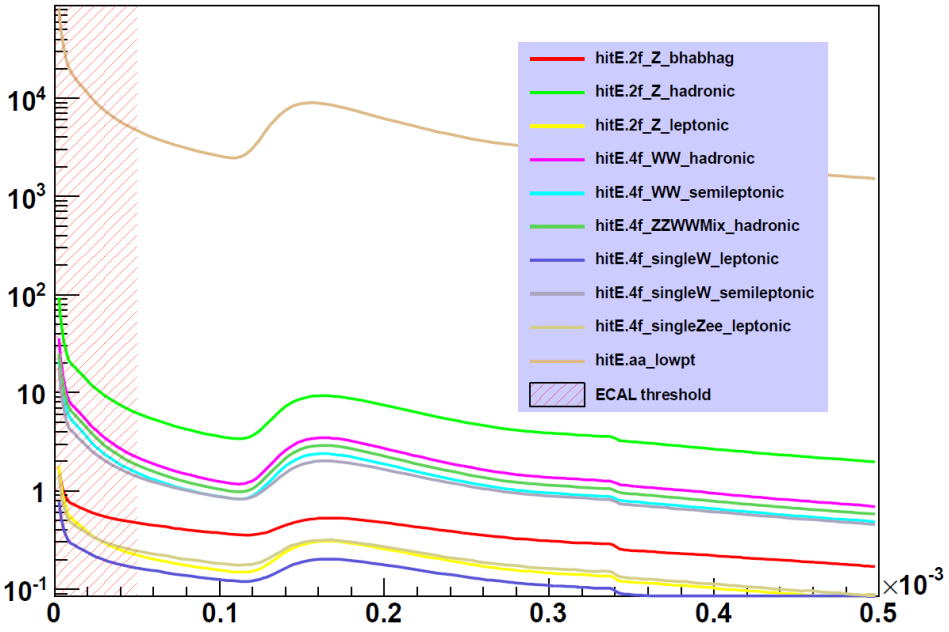
(Histograms are not normalised neither absolutely nor relatively.)

Threshold



PDG: Straggling functions in silicon for 500 MeV pions, normalized to unity at the most probable value δp/x.

Energy threshold at 5×10^{-5} GeV ~ 0.3 Mip

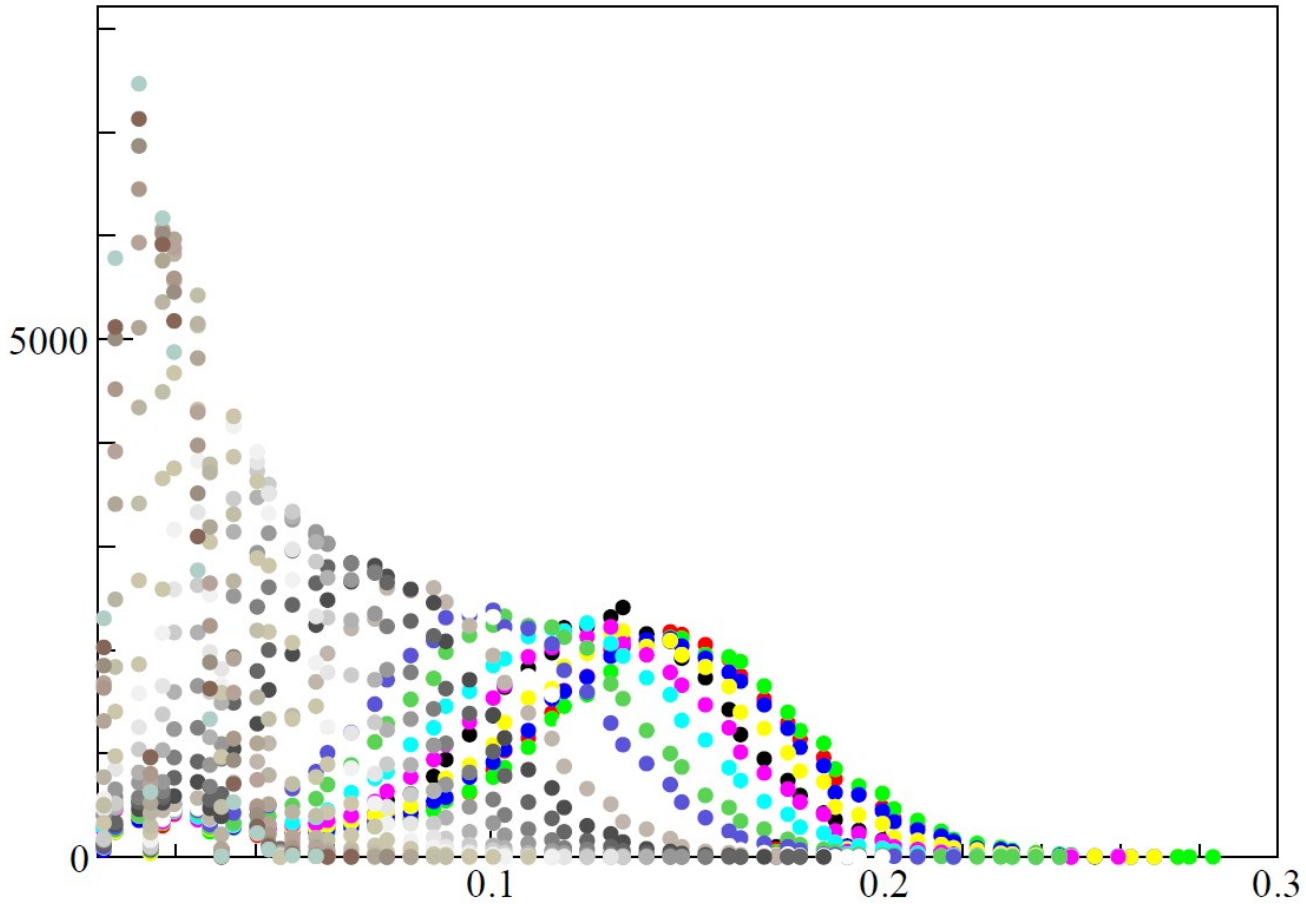


Number of hits in function of hit energy for one train.

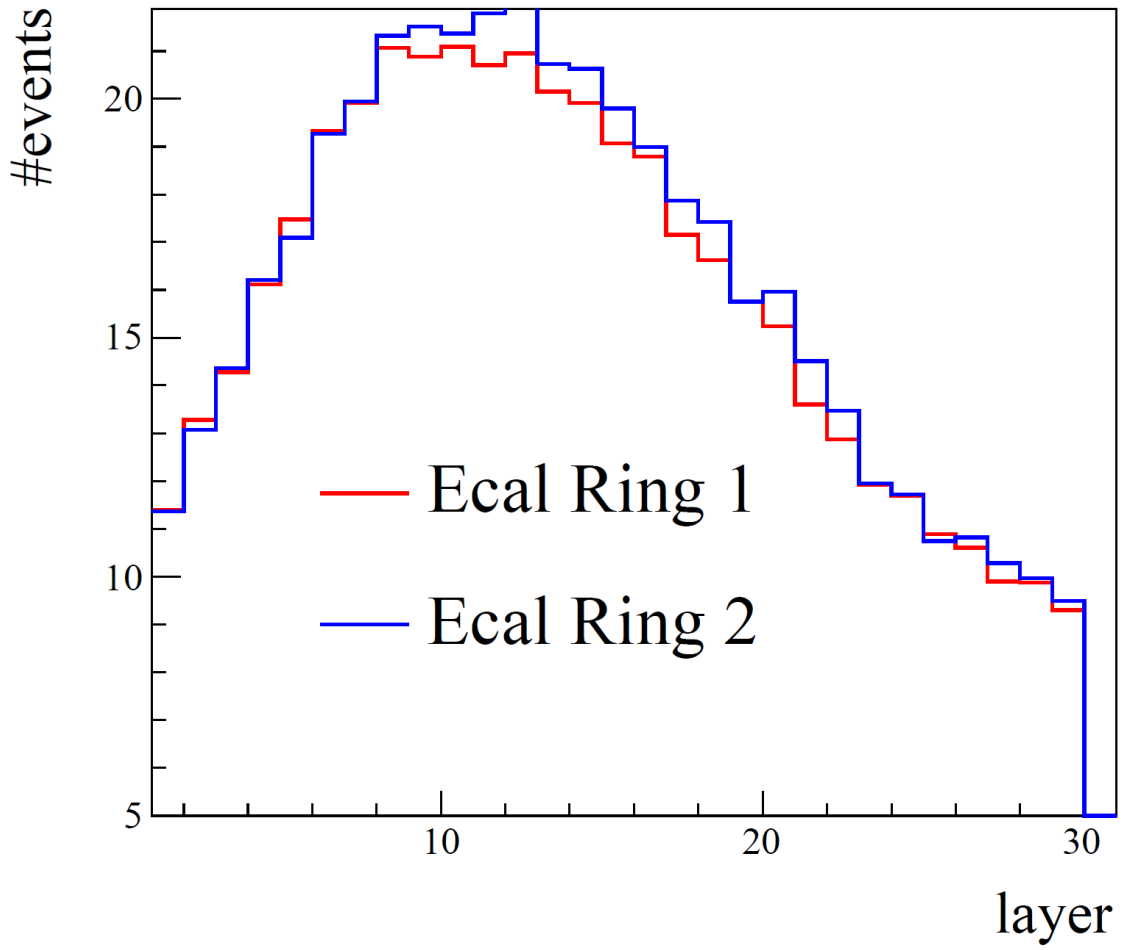
Histograms are scaled by luminosity & X-section.

ECAL Barrel

Number of events per chip for each layer.



Nb of events per chip / spill



Zero suppression.
Only fired channels are stored.