

○
○
○○○

○
○
○○○○○○○○
○○

○
○○

Background studies for SiD

Anne Schütz

DESY Hamburg, Germany

05.November 2015



O
O
OOO

O
O
OOOOOOOO

O
OO

Introduction

The SiD Optimization group investigates possible improvements for the SiD detector.

My contribution so far includes:

Guinea-Pig

Converting pairs.dat

SiD simulation with SLIC

Hit maps of the SiD calorimeters

EcalEndcap

All calorimeters

Conclusion

Summary

Outlook - Neutron background from the beam dumps

Many of the developed and used tools are of general interest also for the MDI work and they are or will be available for the community.



Guinea-Pig¹

Simulation of background events in beam-beam interactions
(for example e^+e^- collisions in the ILC)

- Providing the accelerator parameters as input to Guinea-Pig
- Concentrating on the back-scatter from e^+e^- pairs



Guinea-Pig – Input

ILC-500GeV parameters

- Accelerator parameters from Glen White (SLAC) (see Backup)
- Using his parameters for ILC-500GeV ($n_b=1312$) and ILCUPGRADE-500GeV ($n_b=2625$)
- One bunch has about 200,000 background particles
- Guinea-Pig can only simulate one bunch at a time
→ Restart Guinea-Pig for every bunch (in a train)
- Guinea-Pig pairs.dat files for $n_b=2625$ bunches are available on the Grid as service to the community[**Grid**]



Guinea-Pig – Conversion

Converting pairs.dat to HEPEvt and Stdhep

Guinea-Pig output: pairs.dat files contain the kinematic information about the pair background particles

ASCII files can not be used as input to SLIC

→ conversion neccessary

Available tools from the CLIC group for converting Guinea-Pig output to HEPEvt and Stdhep:

- pairs.dat to pairs.HEPEvt:

<https://svnweb.cern.ch/trac/clicdet/browser/trunk/Users/sailer/Scripts/PairsToHEPEvt>

- pairs.HEPEvt to pairs.stdhep:

<https://svnweb.cern.ch/trac/clicdet/browser/trunk/tools/HEPEvtStdhepConverter>



Guinea-Pig – Conversion

Converting pairs.dat to LCIO (or Stdhep)

New available Java program **PairsToStdhepLCIO.java** that converts **pairs.dat to LCIO or Stdhep**

- Choice (between LCIO and Stdhep) is made by giving output name + file format (.slcio or .stdhep) as argument to program
- Number of particles that are to be converted can be set, also as argument of the program
- Cuts can be applied for p_T and θ
- Converting pairs.dat with a full bunch crossing to LCIO (without any cuts): ≈ 2.1 seconds on a desktop PC
- Such a converted slcio file has a file size of $\approx 3.3 \text{ MB}$
→ 1 Train $\approx 4.3 \text{ GB}$



Guinea-Pig – Conversion

PairsToStdhepLCIO.java

Command line tool

```
USAGE:  
>> java -cp bin:lib/* PairsToStdhepLCIO -i PATH/TO/input.dat -o output<.stdhep / .slcio> <more options>  
  
Required Arguments:  
  
-i: <GuineaPig input dat file>  
-o: <output filename.stdhep / .slcio>  
  
OPTIONS:  
  
-h / --help: Usage  
-n: <maximum number of particles that are to be converted>  
-pl / --ptcut_low: <lower limit for pT in GeV>  
-ph / --ptcut_high: <higher limit for pT in GeV>  
-tl / --thetacut_low: <lower limit for theta in degree>  
-th / --thetacut_high: <higher limit for theta in degree>  
  
For example:  
>> java -cp bin:lib/* PairsToStdhepLCIO -i pairs.dat -o pairs.slcio -n 3000 -pl 0.01 -ph 1 -tl 0.2 -th 30
```

Description and How-to of all the conversion programs can be found here:

<https://wikis.bris.ac.uk/display/sid/Simulation+of+the+background+events+for+the+SiD+detector>

-
-
-

-
-
-
-

-
-

Simulation studies of the pair background in the SiD detector

We have:

- Guinea-Pig files
- Conversion tools

We want to study the pair background by

- using the converted Guinea-Pig files as input to SLIC
- simulating the background in different SiD geometry variants
- creating hit maps of the calorimeter cells
- looking at the cell occupancy and hit distribution in the single calorimeter layers

Hit maps of the SiD calorimeters

Studying the hits of the calorimeter cells

- Unique cell ID out of geometry specific readout IDs (ID0 and ID1)
- Mapping the pair background hits of the single calorimeter for their single layers
- Mapping the energy of these hits
- Compare different SiD geometries in respect to this information

Different calorimeter components:

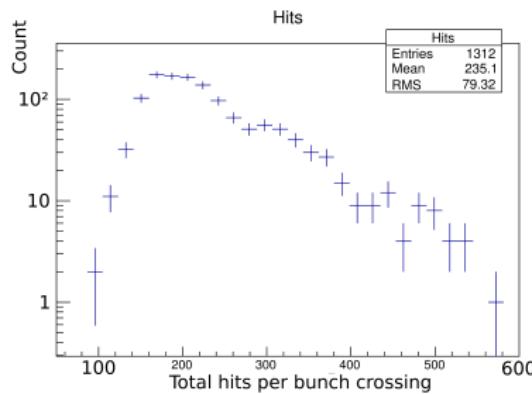
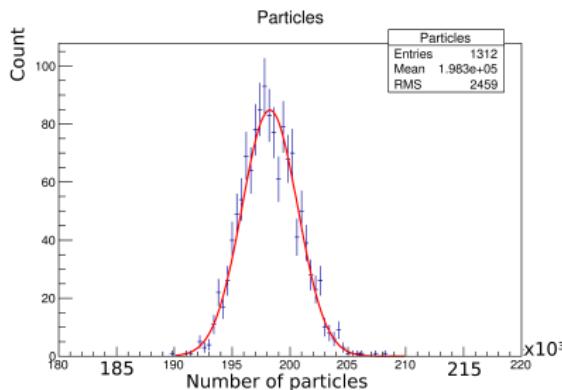
- EcalBarrel and EcalEndcap
- HcalBarrel and HcalEndcap
- BeamCal and LumiCal
- MuonBarrel and MuonEndcap

Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

For 1312 bunch crossings:

Number of pair background particles hitting the EcalEndcaps and total number of hits per bunch crossing in the EcalEndcap



⇒ Mean number of pair background particles $\approx 200,000$ per bunch crossing

Up to 600 hits in the EcalEndcap. Mean number of hits ≈ 235 per bunch crossing

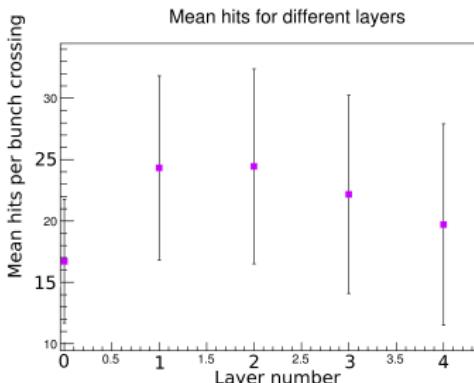
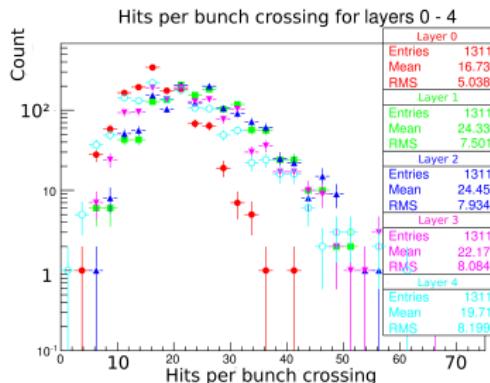
○
 ○
 ○○○

○
 ○
 ○○○○○○○
 ○○

Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

Total number of hits per bunch crossing for specific layers
(comparison between layers 0 - 4):



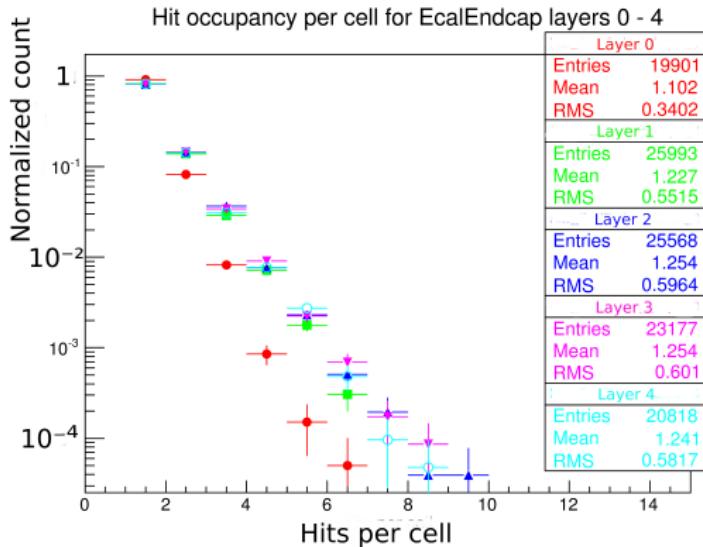
⇒ Layer 0 has the narrowest distribution. EM shower starts after layer 0.



Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

Hit occupancy in the EcalEndcap layers 0 - 4:



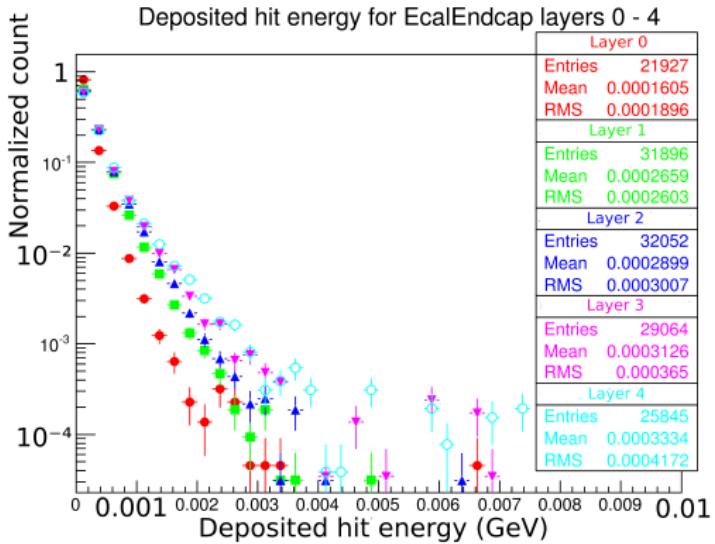
⇒ Up to 9 hits per cell, for layer 0 only up to 6 hits

A diagram consisting of two separate groups of circles. The left group contains four circles arranged in a 2x2 L-shape. The right group contains ten circles arranged in a 2x5 L-shape, with the fifth circle from the top being filled black.

Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

Deposited hit energy distribution in the EcalEndcap layers 0 - 4:



⇒ Up to 8 MeV hits, lower energy hits for layer 0

-
-
-

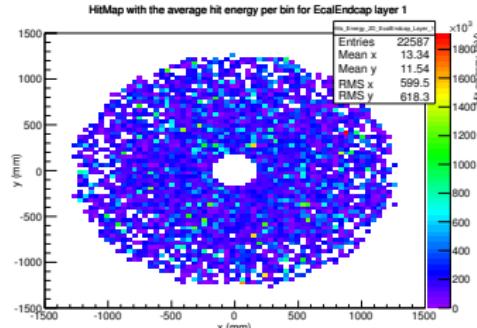
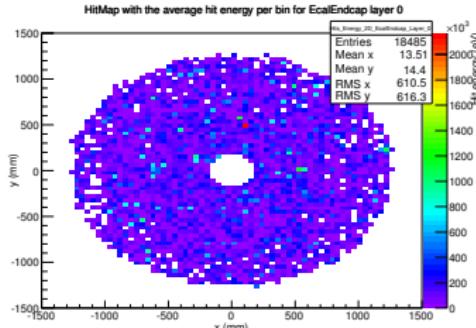
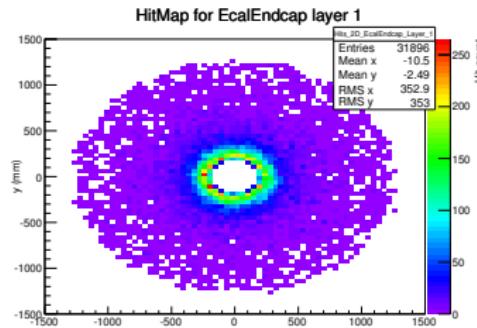
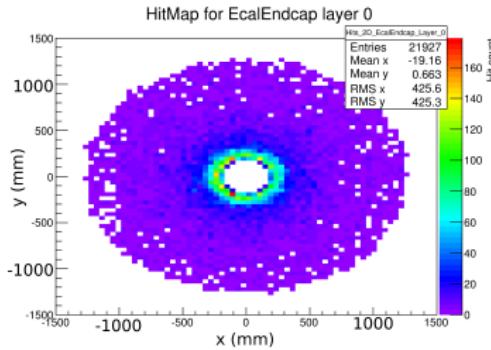
-
-
-
-

-
-

Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

Hit maps (with hit count and deposited energy) in **global coordinates**, for the EcalEndcap layers 0 and 1:



-
-
-

-
-
-
-

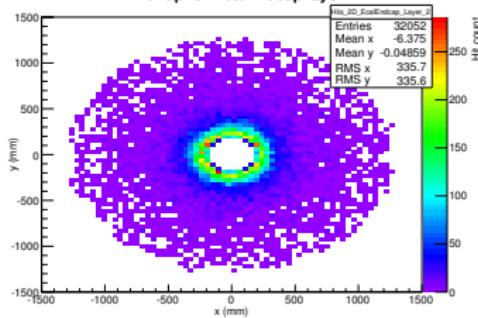
-
-

Hit maps of the SiD calorimeters

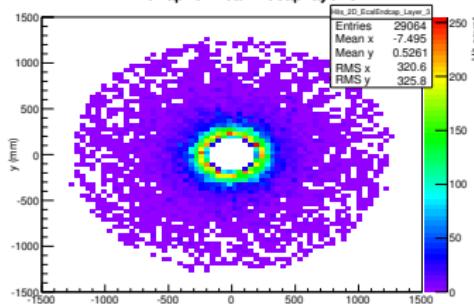
Studying the hits of the **EcalEndcap** cells

Hit maps (with hit count and deposited energy) in **global coordinates**, for the EcalEndcap layers 2 and 3:

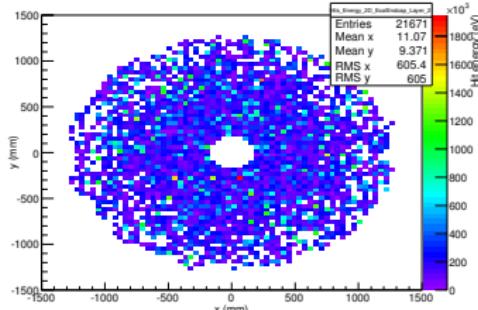
HitMap for EcalEndcap layer 2



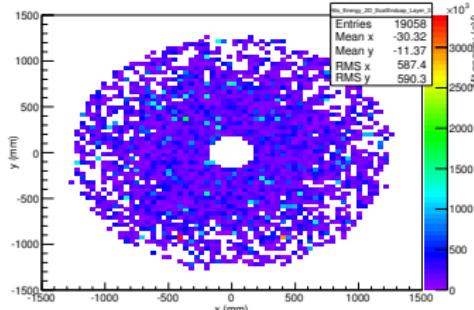
HitMap for EcalEndcap layer 3



HitMap with the average hit energy per bin for EcalEndcap layer 2



HitMap with the average hit energy per bin for EcalEndcap layer 3



-
-
-

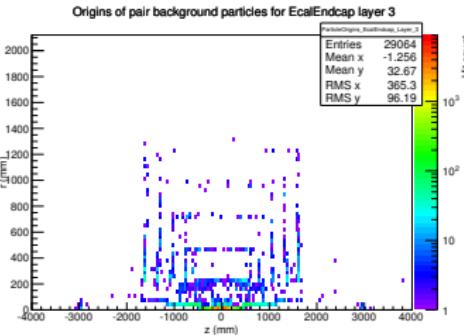
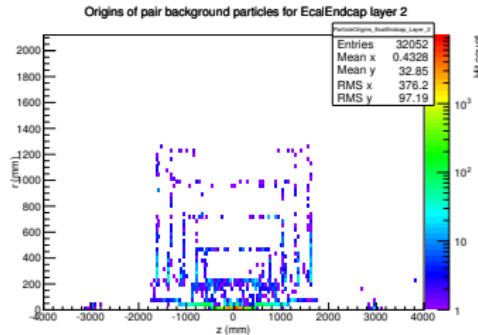
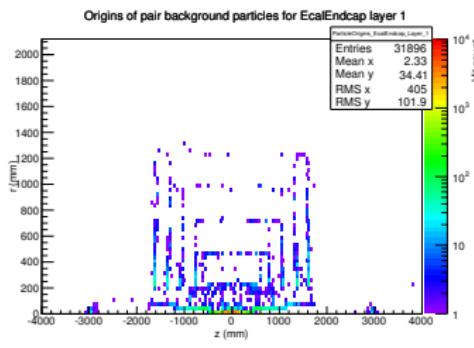
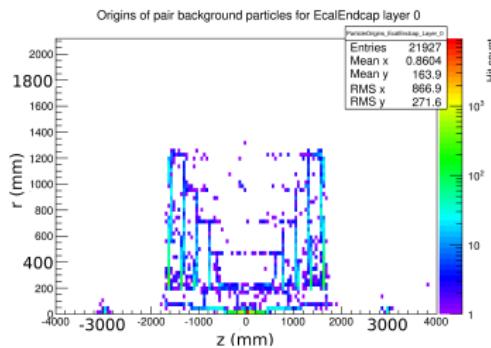
-
-
-

-
-

Hit maps of the SiD calorimeters

Studying the hits of the **EcalEndcap** cells

Maps of background particle origins for layers 0 - 3:



○
○
○○○

○
○
○○○○○○●
○○

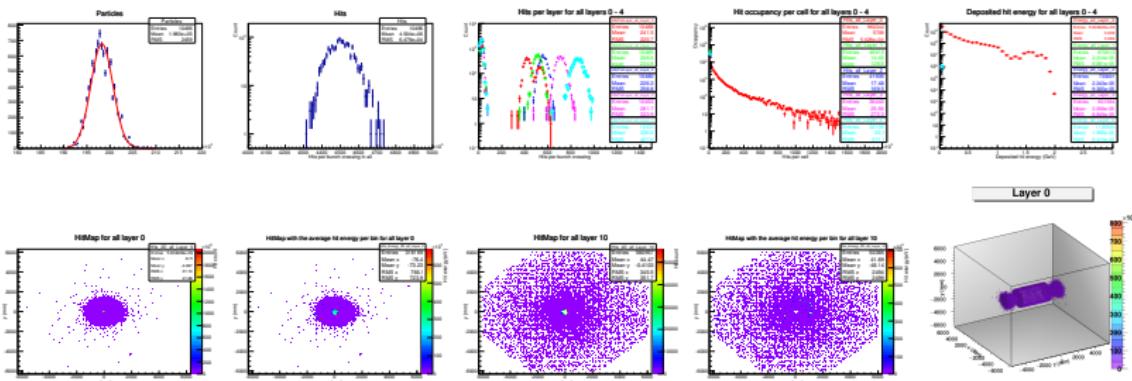
○
○○

3D hit map of the **EcalEndcap**

Hit maps of the SiD calorimeters

Studying the hits of all the calorimeter cells

See all these plots and more in the backup slides



Different calorimeter components:

- EcalBarrel and EcalEndcap
- HcalBarrel and HcalEndcap
- BeamCal and LumiCal
- MuonBarrel and MuonEndcap

○
○
○○○

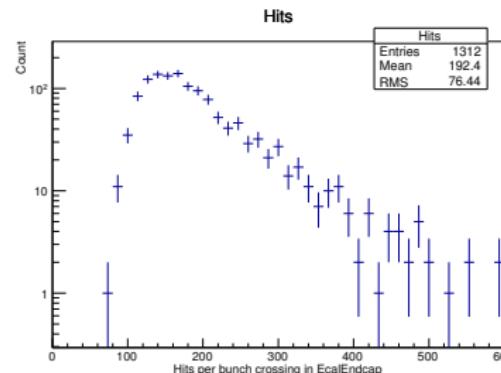
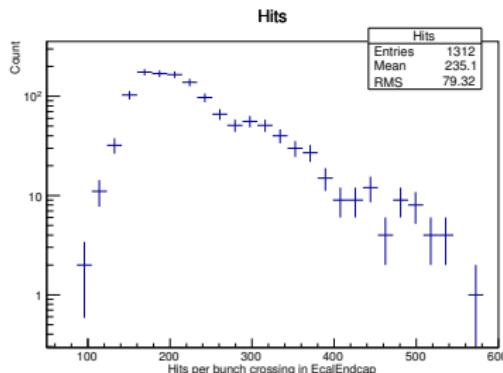
○
○
○○○○○○○○
○●

○
○○

More than 2500 bunches per SiD geometry variants were simulated.

Different SiD geometries:

- sidloi3 - baseline for the Detailed Baseline Design (DBD) simulation
- sidloi3 with realigned Interaction Region (IR) - L^* readjustments
- sidloi3 with realigned IR with circle cutout - material cutout between outgoing and ingoing beam pipe
- sidloi3 with realigned IR with wedge cutout
- sidloi3 with realigned IR with the anti-DiD - without cutout but with anti-DiD field



sidloi3

sidloi3, realigned IR, anti-DiD



Conclusion and outlook

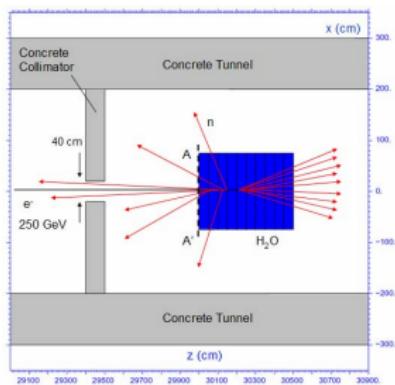
- Guinea-Pig pair background files for the ILC are easily created
- Such files for two full trains of the ILC-500GeV as well as the conversion tool are freely available
- Studying the pair background in the SiD detector in respect to hit maps and occupancy of the calorimeter cells

Future plans:

- Comparing the pair background in different SiD geometry variants
- Studying the neutron background from the beam dumps in the ILC detectors

Neutron background from the beam dumps

Simulating neutron background from the beam dump with
FLUKA



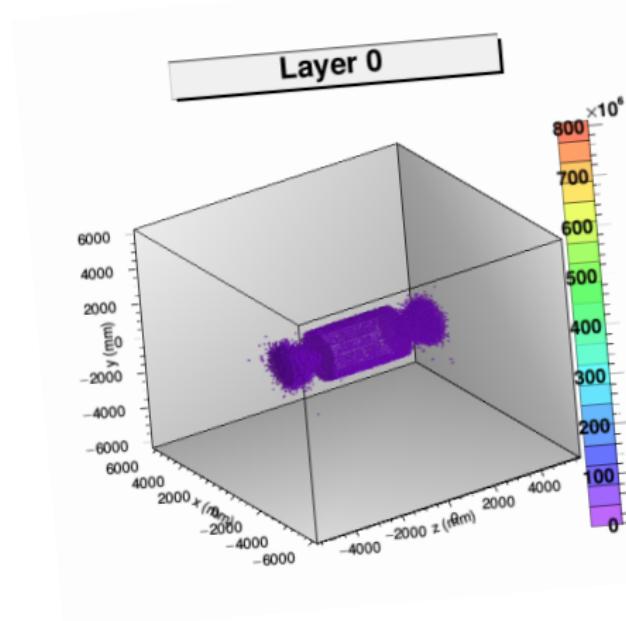
Geometry of the ILC extraction line in a previous simulation of the neutron background

"Simulation of Neutron Backgrounds from the ILC Extraction Line Beam Dump", 2007 [takashi]

Near future plan:

- Implementing geometry of the extraction line from up-to-date lattice plans from Benno List (IPP, DESY Hamburg)
- Studying neutron rate and spectra of neutrons reaching the detectors
- Studying doses on the surrounding

Thanks for your attention!



○
○
○○○

○
○
○○○○○○○○
○○

○
○○

References

-  [SLAC-TN-07-013, 2007, "Simulation of Neutron Backgrounds from the ILC Extraction Line Beam Dump"](#)
-  [/ilc/user/a/aschuetz/GuineaPig](#)



Backup

Abbreviations

Backup - Guinea-Pig input

Backup - Hit maps of the SiD calorimeters

EcalBarrel

HcalBarrel and HcalEncap

BeamCal and LumiCal

MuonBarrel and MuonEndcap

All calorimeters



Abbreviations

- ILC: International Linear Collider
- SiD: Silicon Detector
- Guinea-Pig: Generator of Unwanted Interactions for Numerical Experiment Analysis Program Interfaced to Geant
- SLIC: Simulator For The Linear Collider
- LCIO: Linear Collider Input/Output
- LoI: Letter of Intent
- DBD: Detailed Baseline Design
- IR: Interaction Region
- L*: Distance between Final Focus Quadrupole and the Interaction Point of the ILC
- Anti-DID: Anti-Detector Integrated Dipole (DID with reversed magnetic field)
- FLUKA: FLUkturierende KAskade (fluctuating cascade)

○○○○○
○○○○○○○○○○
○○○○○○○○○○○○
○○○○○○○○○○○○○○
○○○○○○

acc.dat

```
$ACCELERATOR:: ILC-500GeV
{energy=250.0;particles=2.0;beta_x=11.0;beta_y=0.48;emitt_x=10.0;emitt_y=0.035;sigma_z=300.0;
f_rep=5.0;n_b=1312;charge_sign=-1;scale_step=1.0;waist_y=250; espread.1=0.00124;espread.2=0.0007;which_espread=3; }
$PARAMETERS:: par
{n_z=12;n_t=6;n_m=80000;cut_z=3.5*sigma_z.1;n_x=256;n_y=256; cut_x=4*sigma_x.1;cut_y=4*sigma_y.1;
pair_ecut=1e-3;pair_q2=2;beam_size=1;grids=7;store_beam=1; do_pairs=1;track_pairs=1;store_pairs=1; do_photons=1;store_photons=1;
do_hadrons=1;do_jets=1;do_coherent=1; electron_ratio=1;photon_ratio=1; do_eloss=1;do_espread=1; rndm_seed=100; }
```

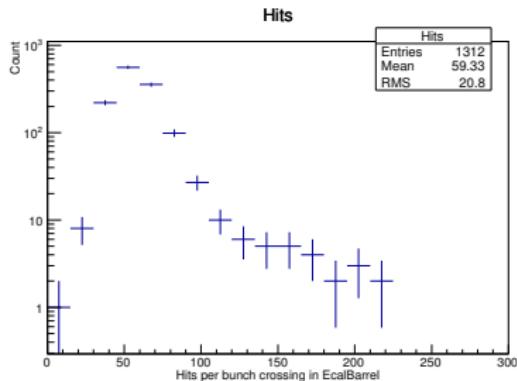


Hit maps of the SiD calorimeters

Studying the hits of the **EcalBarrel** cells

For 1312 bunch crossings:

Total number of hits per bunch crossing in the EcalBarrel



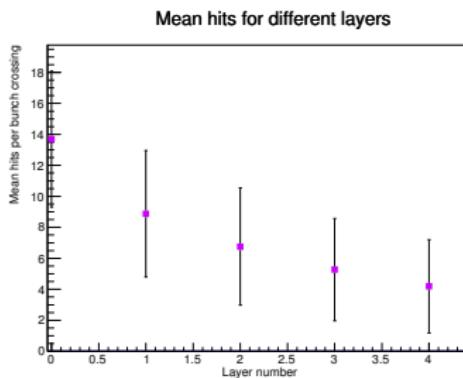
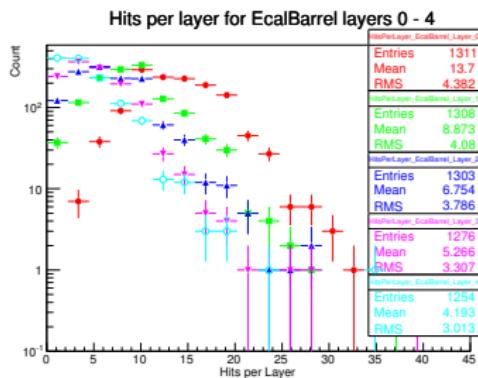
⇒ Mean number of hits in the EcalBarrel ≈ 60 per bunch crossing



Hit maps of the SiD calorimeters

Studying the hits of the **EcalBarrel** cells

Total number of hits per bunch crossing for specific layers (comparison between layers 0 - 4):



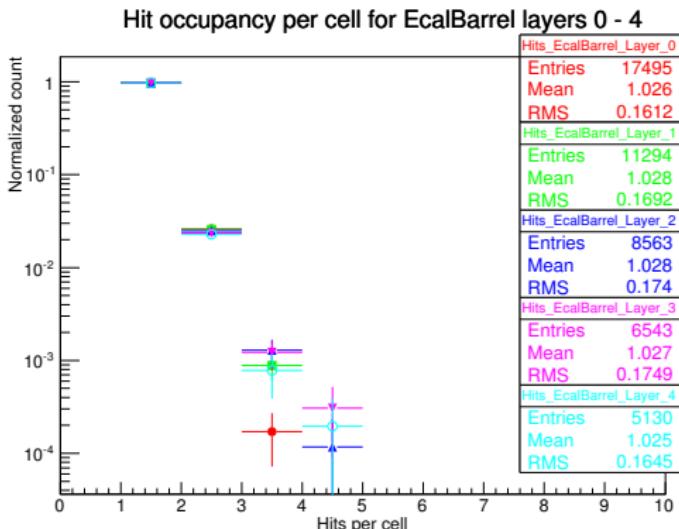
⇒ As expected, the inner layers have more hits. In all 1312 bunch crossing the layer 0 has in average 14 hits.



Hit maps of the SiD calorimeters

Studying the hits of the **EcalBarrel** cells

Comparison of the hit occupancy between EcalBarrel layers 0 - 4:



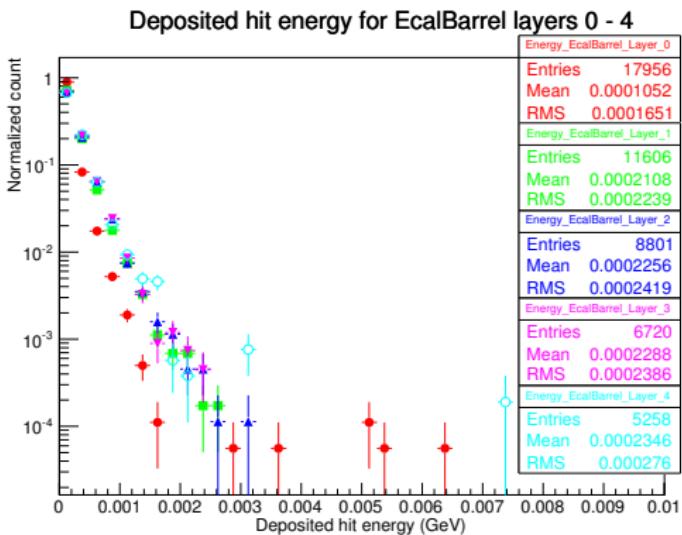
⇒ Only up to 4 hits per cell, in line with KPiX design of 4 buffers



Hit maps of the SiD calorimeters

Studying the hits of the **EcalBarrel** cells

Comparison of the deposited hit energy distribution between EcalBarrel layers 0 - 4:



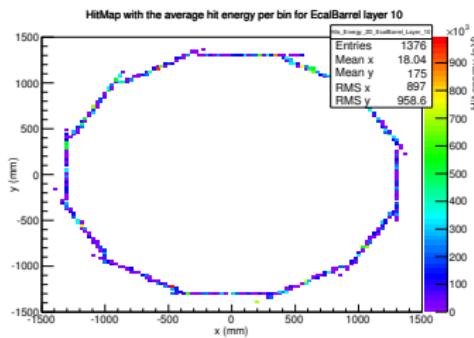
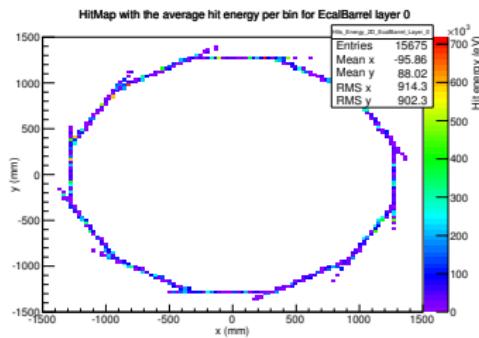
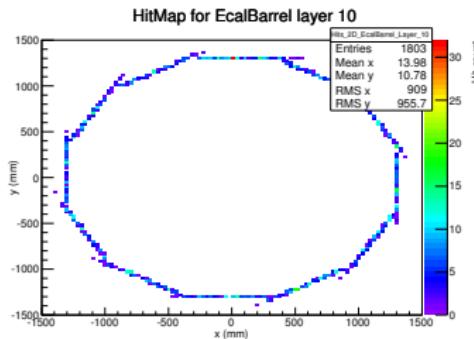
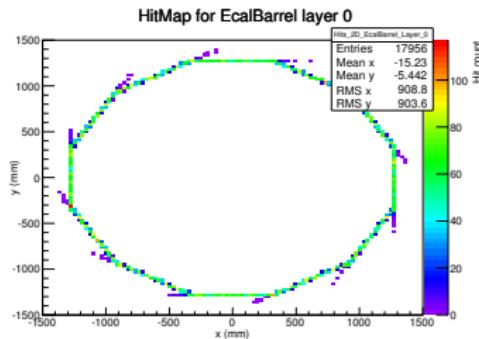
⇒ Up to 8 MeV hits



Hit maps of the SiD calorimeters

Studying the hits of the EcalBarrel cells

Hit maps (with hit count and deposited energy) in EcalBarrel layers 0 and 10:





3D hit map of the EcalBarrel

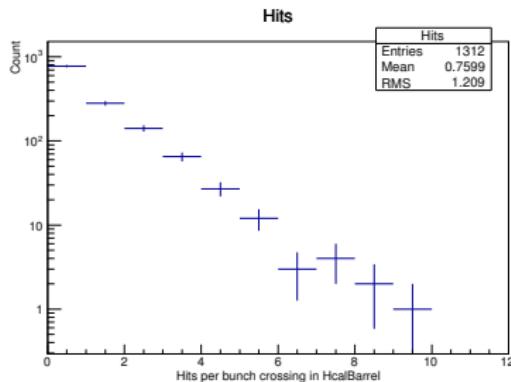
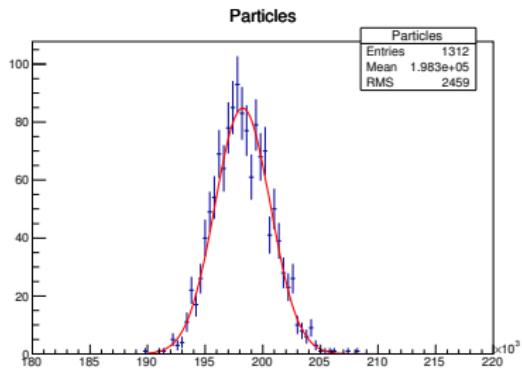


Hit maps of the SiD calorimeters

Studying the hits of the **HcalBarrel** cells

For 1312 bunch crossings:

Number of pair background particles and total number of hits in the HcalBarrel



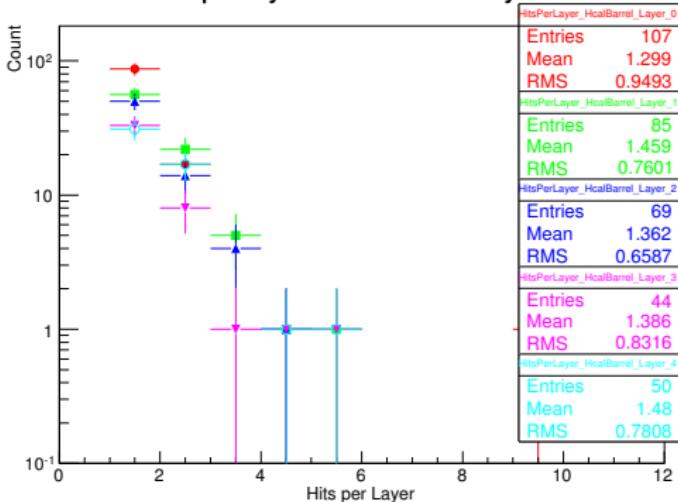


Hit maps of the SiD calorimeters

Studying the hits of the **HcalBarrel** cells

Comparison between HcalBarrel layers 0 - 4:

Hits per layer for HcalBarrel layers 0 - 4

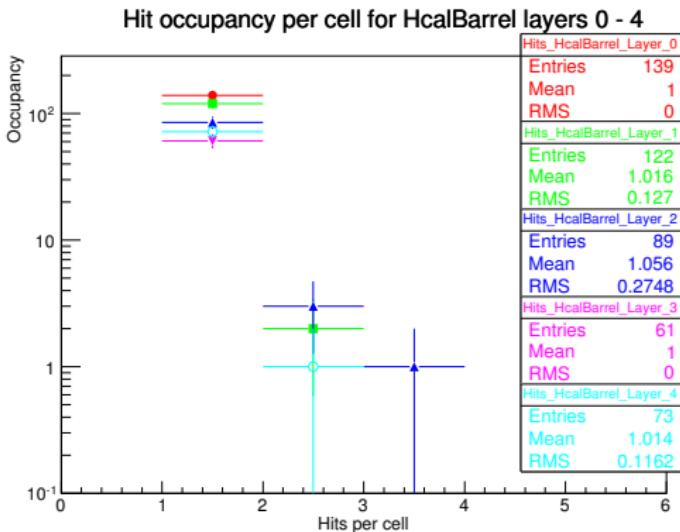




Hit maps of the SiD calorimeters

Studying the hits of the **HcalBarrel** cells

Comparison between HcalBarrel layers 0 - 4:

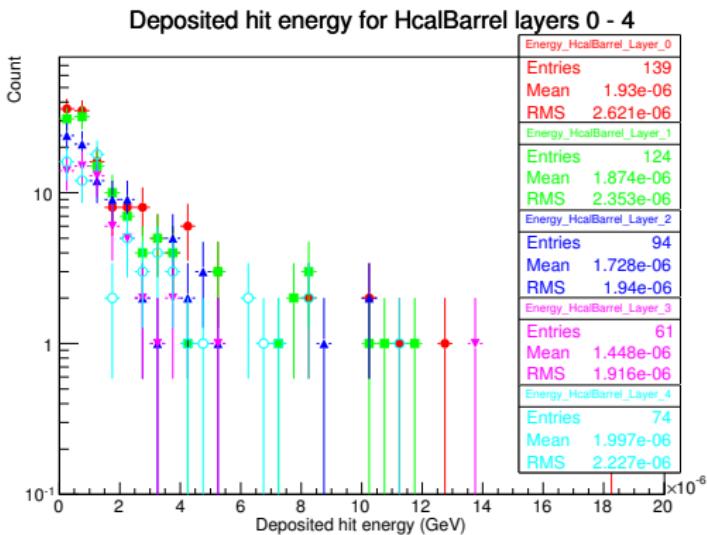




Hit maps of the SiD calorimeters

Studying the hits of the **HcalBarrel** cells

Comparison between HcalBarrel layers 0 - 4:

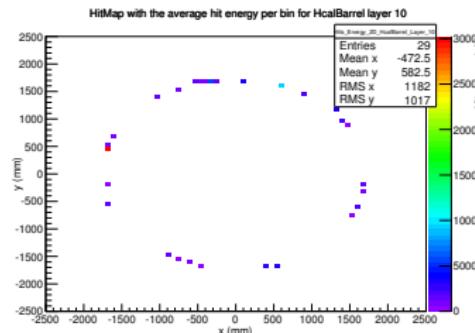
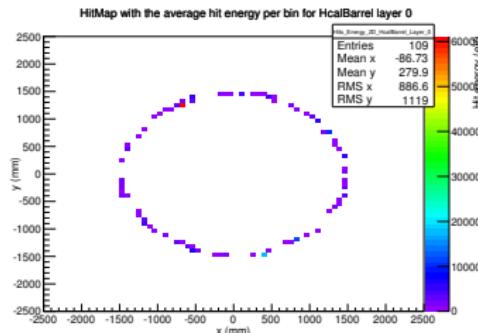
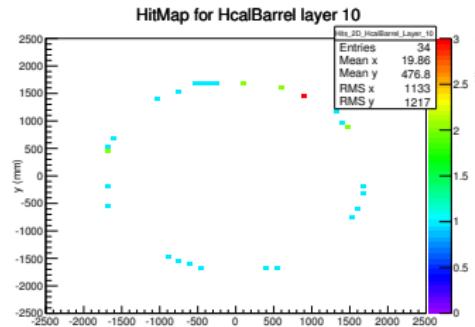
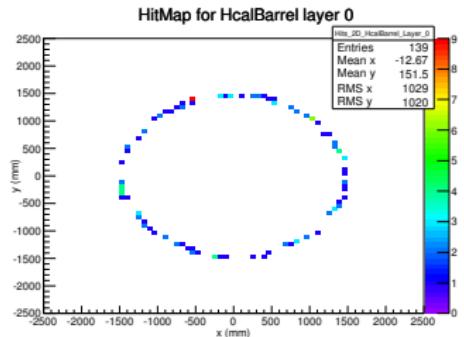




Hit maps of the SiD calorimeters

Studying the hits of the **HcalBarrel** cells

Comparison between HcalBarrel layers 0 and 10:





3D hit maps of the **HcalBarrel**

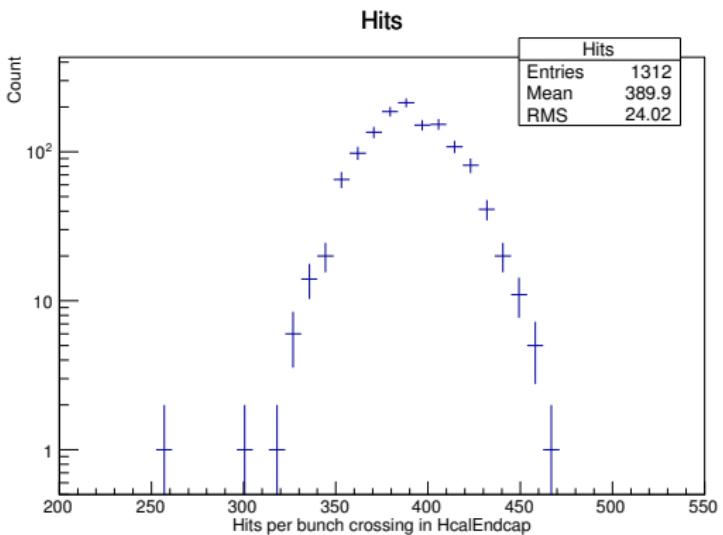


Hit maps of the SiD calorimeters

Studying the hits of the **HcalEndcap** cells

For 1312 bunch crossings:

Number of pair background particles and total number of hits in the HcalEndcap



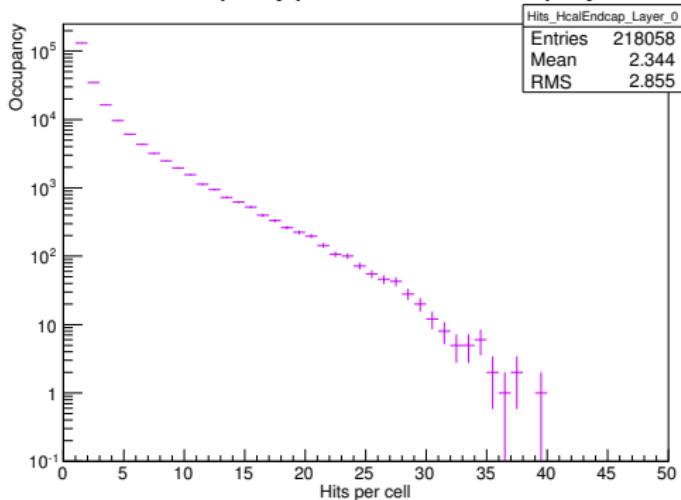


Hit maps of the SiD calorimeters

Studying the hits of the **HcalEndcap** cells

Hits HcalEndcap layers 0:

Hit occupancy per cell for HcalEndcap layer 0

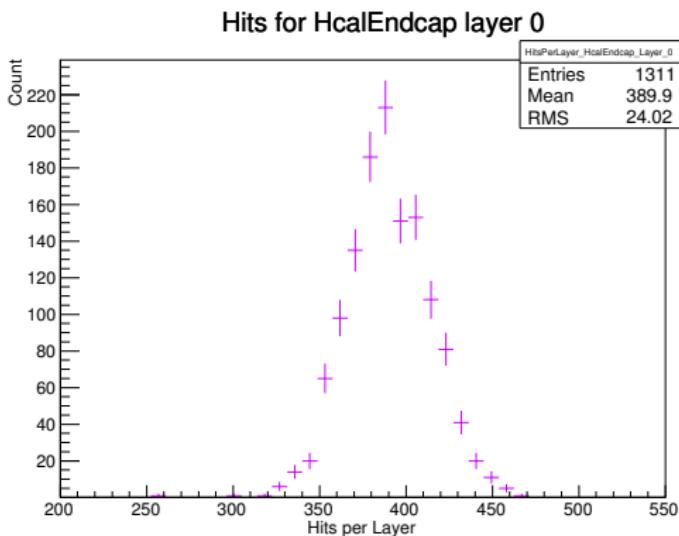




Hit maps of the SiD calorimeters

Studying the hits of the **HcalEndcap** cells

HitsPerLayer HcalEndcap layers 0:



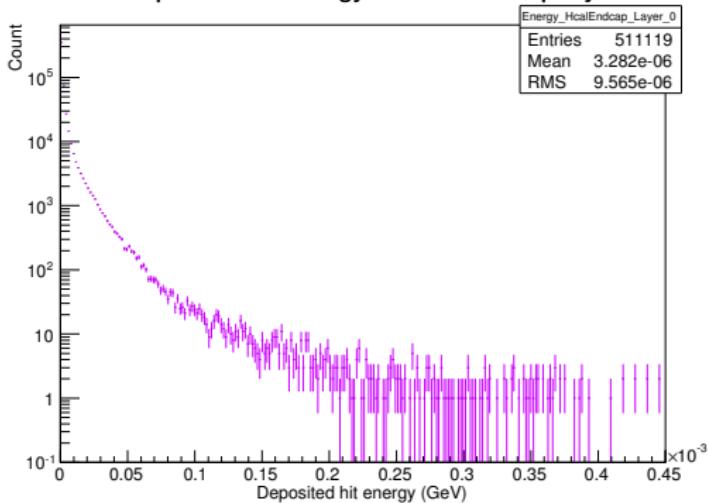


Hit maps of the SiD calorimeters

Studying the hits of the **HcalEndcap** cells

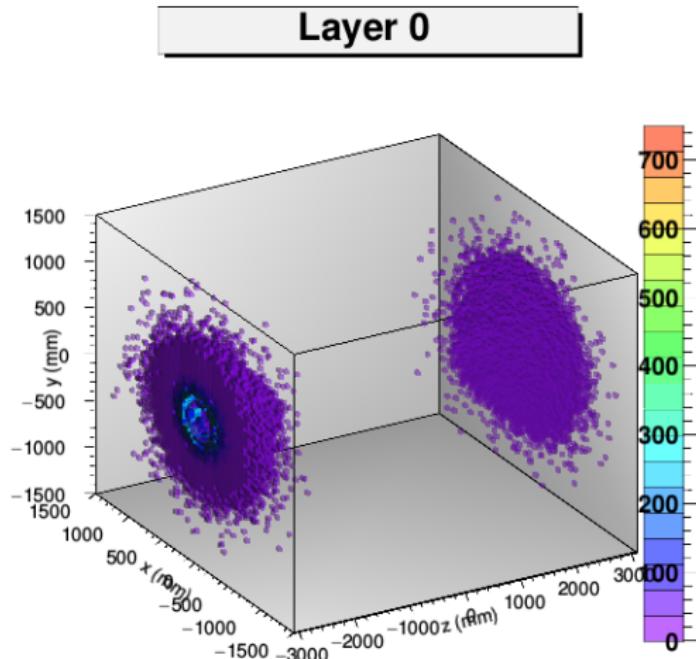
Energy HcalEndcap layers 0:

Deposited hit energy for HcalEndcap layer 0





3D hit map of layer 0 of the **HcalBarrel** and the **HcalEndcap**



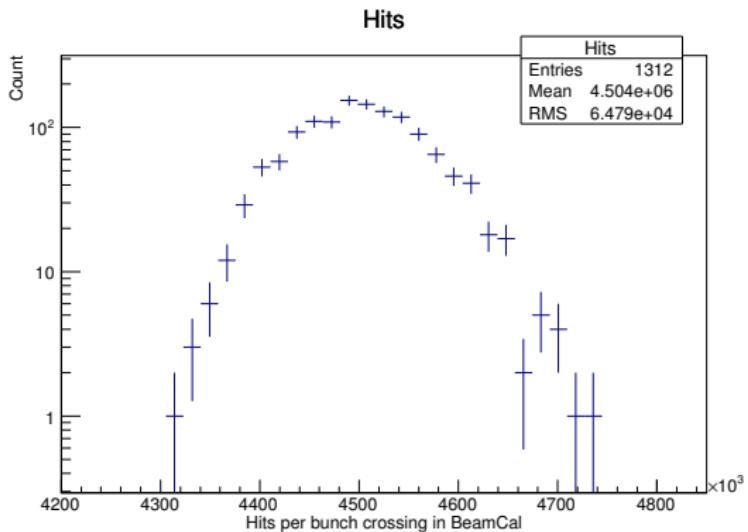


Hit maps of the SiD calorimeters

Studying the hits of the **BeamCal** cells

For 1312 bunch crossings:

Total number of hits in the BeamCal per bunch crossing



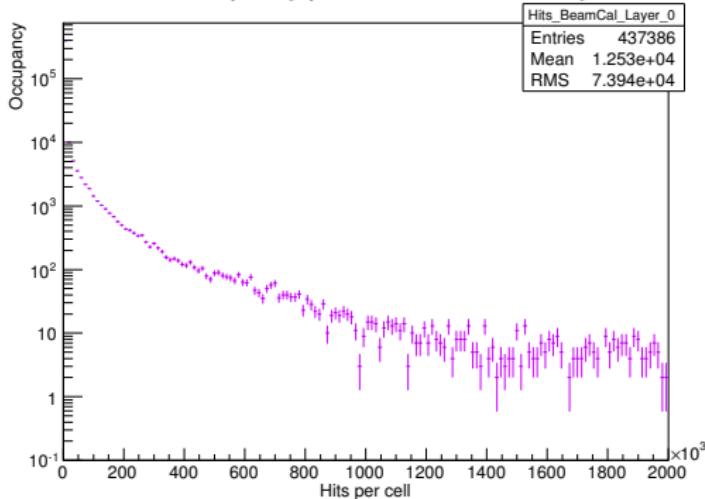


Hit maps of the SiD calorimeters

Studying the hits of the **BeamCal** cells

Hit distribution per bunch crossing in the BeamCal layer 0:

Hit occupancy per cell for BeamCal layer 0

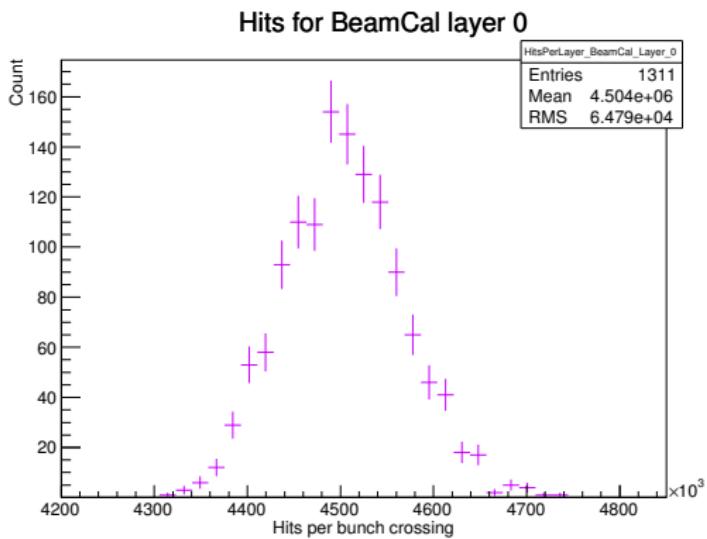




Hit maps of the SiD calorimeters

Studying the hits of the **BeamCal** cells

Cell occupancy in the BeamCal layer 0:



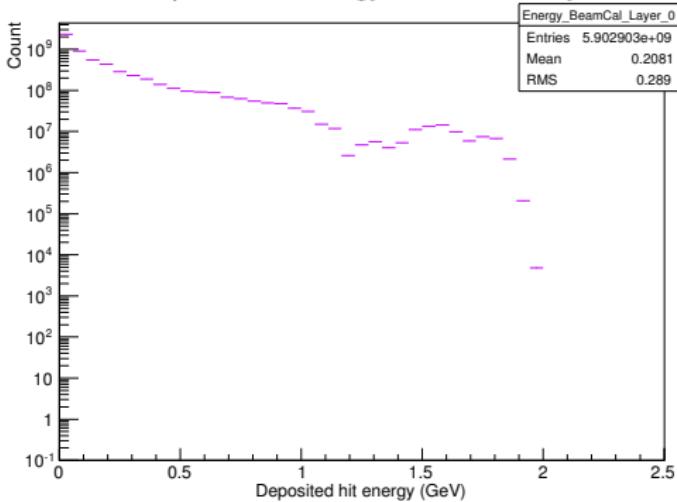


Hit maps of the SiD calorimeters

Studying the hits of the **BeamCal** cells

Deposited hit energy in the BeamCal layer 0:

Deposited hit energy for BeamCal layer 0

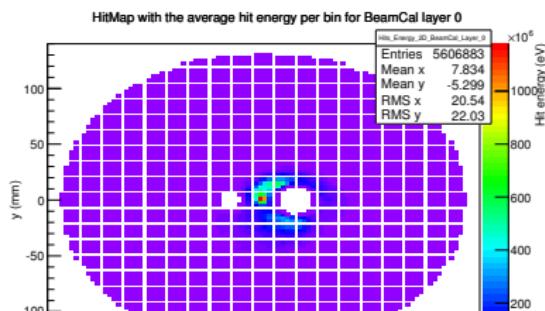
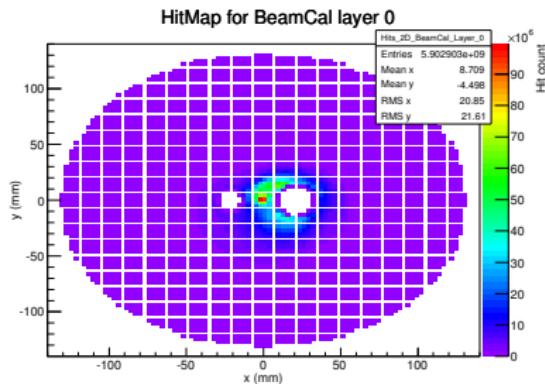


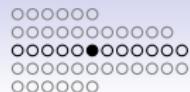


Hit maps of the SiD calorimeters

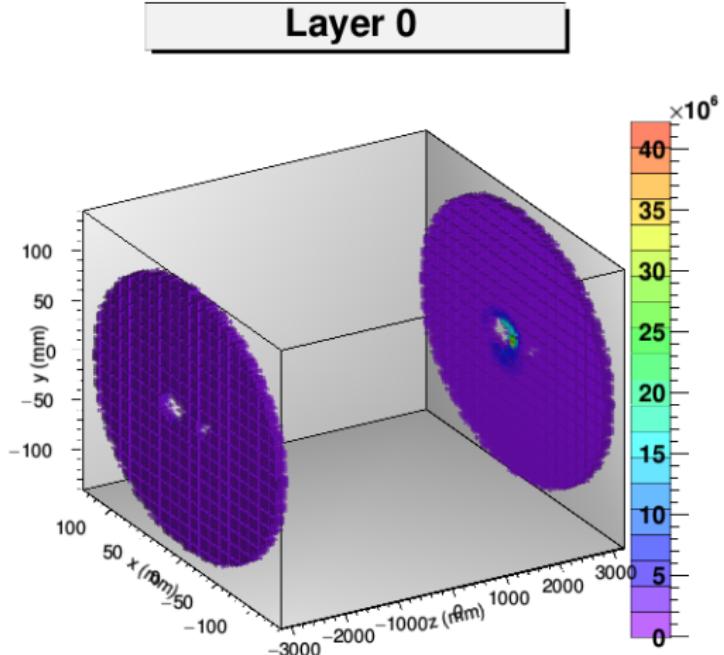
Studying the hits of the **BeamCal** cells

Hit maps (with hit count and deposited hit energy) of BeamCal layer 0:





3D hit map of layer 0 of the **BeamCal**



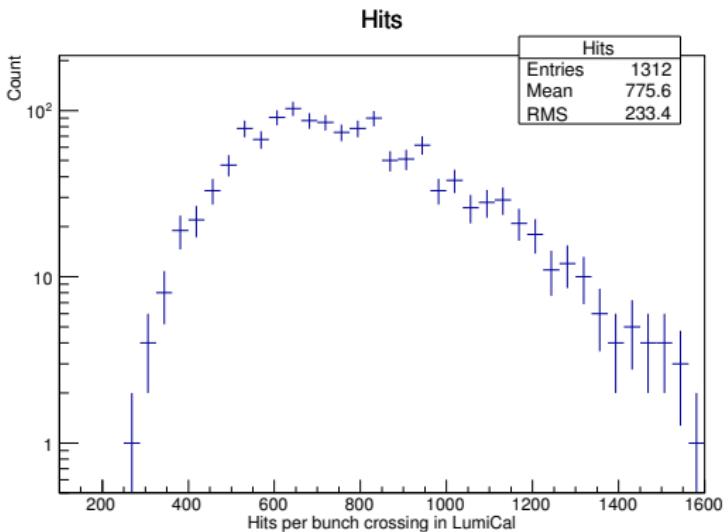


Hit maps of the SiD calorimeters

Studying the hits of the **LumiCal** cells

For 1312 bunch crossings:

Total number of hits in the LumiCal per bunch crossing

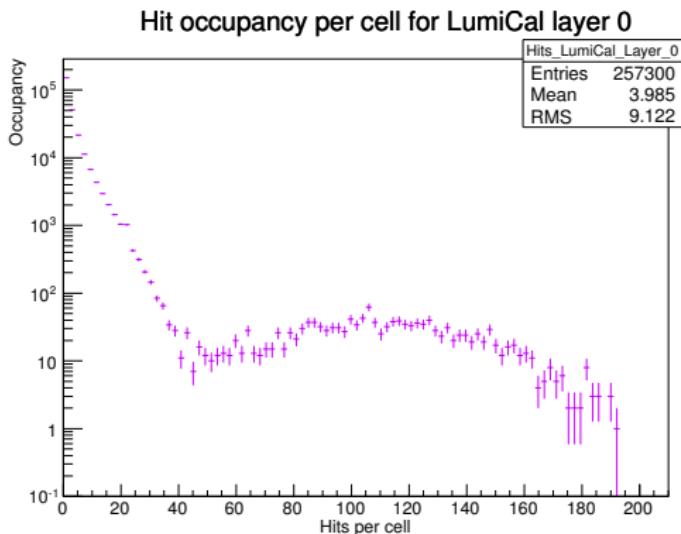




Hit maps of the SiD calorimeters

Studying the hits of the **LumiCal** cells

Hit distribution per bunch crossing in the LumiCal layers 0:

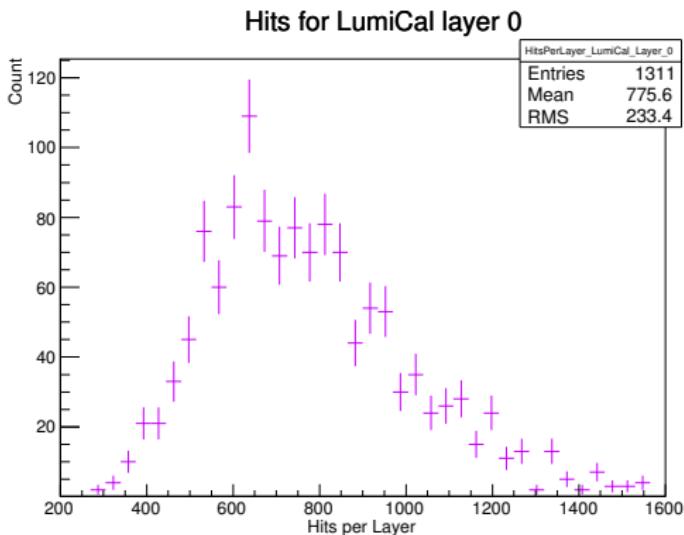




Hit maps of the SiD calorimeters

Studying the hits of the **LumiCal** cells

Cell occupancy in the LumiCal layers:



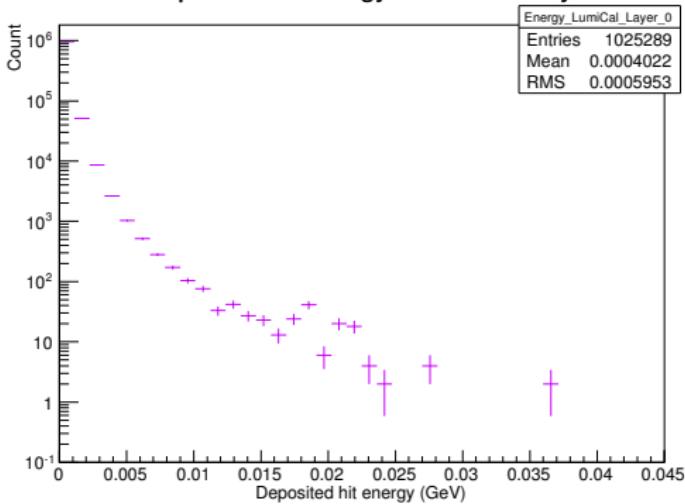


Hit maps of the SiD calorimeters

Studying the hits of the **LumiCal** cells

Deposited hit energy in the LumiCal layer 0:

Deposited hit energy for LumiCal layer 0



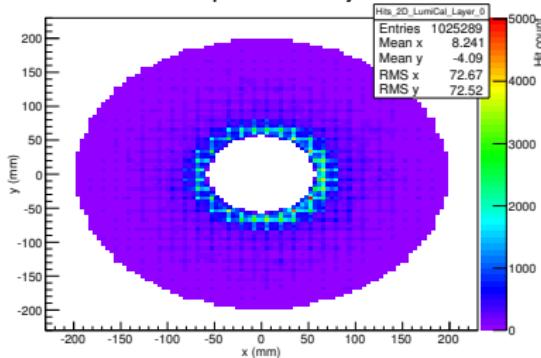


Hit maps of the SiD calorimeters

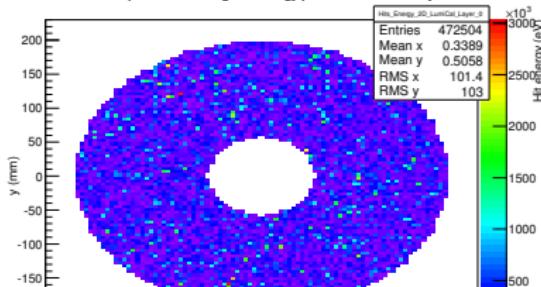
Studying the hits of the **LumiCal** cells

Hit maps (with hit count and deposited hit energy) of the LumiCal layer 0:

HitMap for LumiCal layer 0

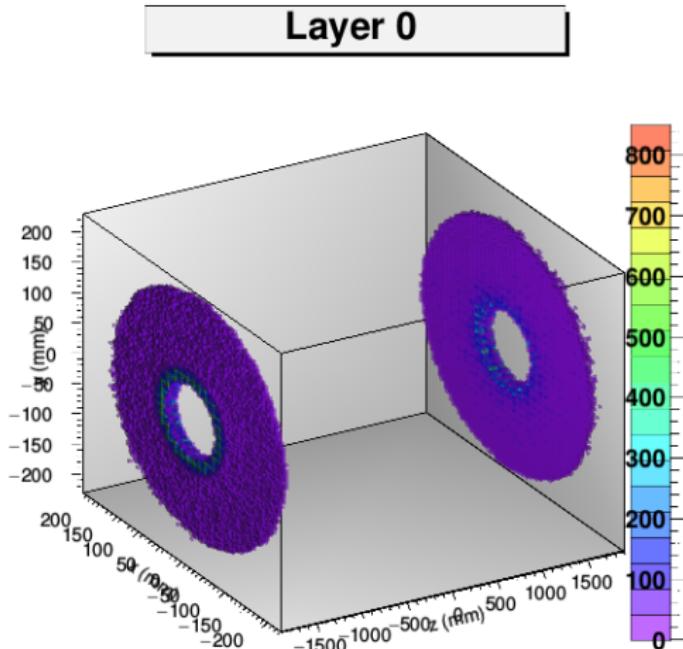


HitMap with the average hit energy per bin for LumiCal layer 0





3D hit map of layer 0 of the **LumiCal**



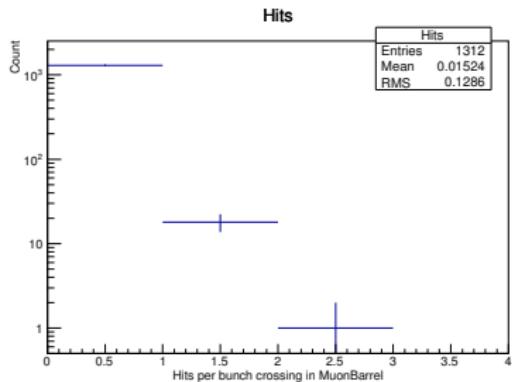


Hit maps of the SiD calorimeters

Studying the hits of the **MuonBarrel** cells

For 1312 bunch crossings:

Total number of hits in the MuonBarrel per bunchcrossing



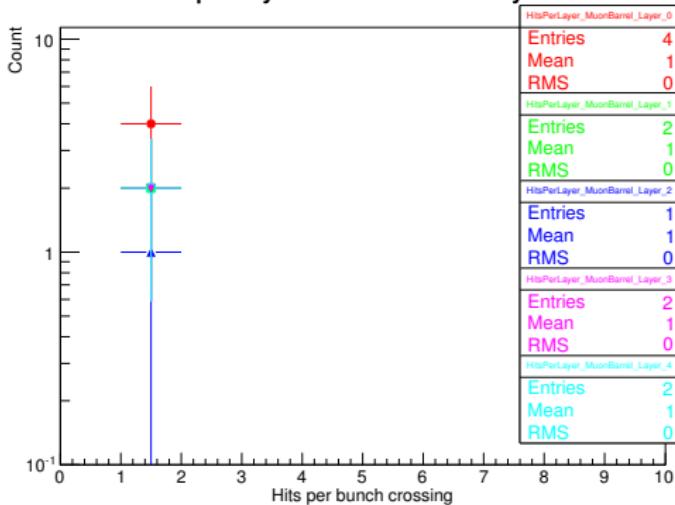


Hit maps of the SiD calorimeters

Studying the hits of the **MuonBarrel** cells

Hit distribution per bunch crossing in the MuonBarrel layers 0 - 4:

Hits per layer for MuonBarrel layers 0 - 4

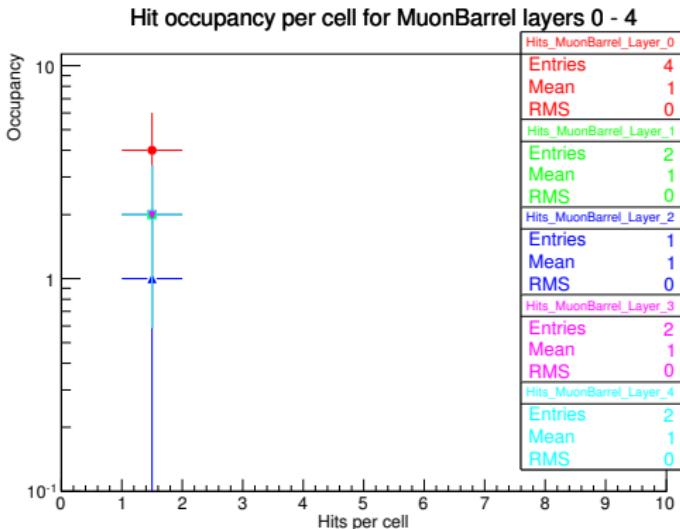




Hit maps of the SiD calorimeters

Studying the hits of the **MuonBarrel** cells

Cell occupancy in the MuonBarrel layers 0 - 4:

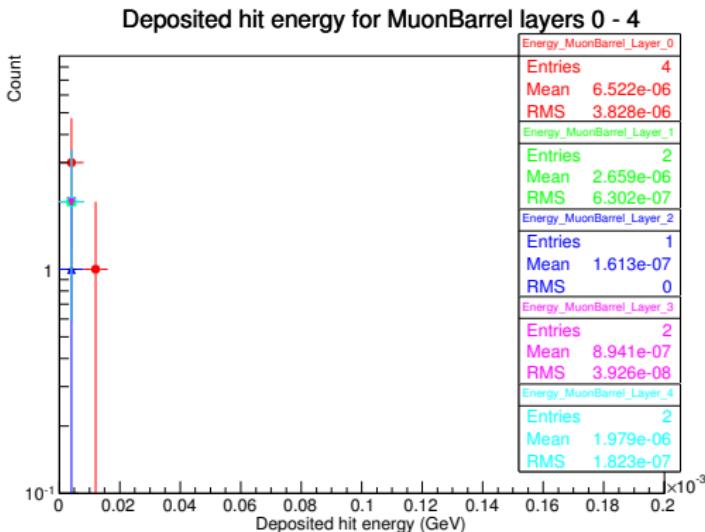




Hit maps of the SiD calorimeters

Studying the hits of the **MuonBarrel** cells

Deposited hit energy in the MuonBarrel layers 0 - 4:



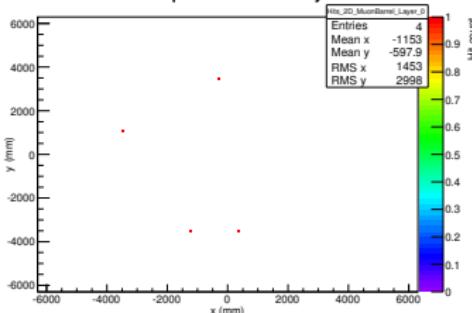


Hit maps of the SiD calorimeters

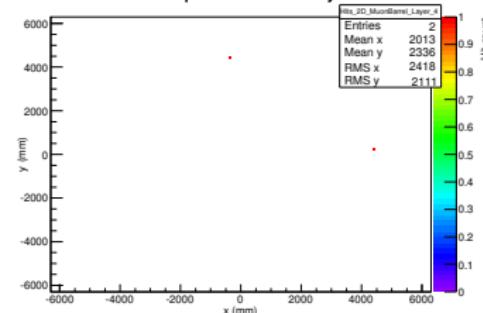
Studying the hits of the **MuonBarrel** cells

Hit maps (with hit count and deposited hit energy) of MuonBarrel layers 0 and 4:

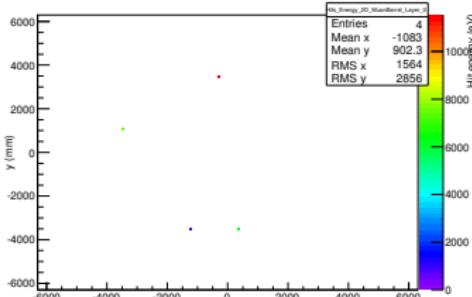
HitMap for MuonBarrel layer 0



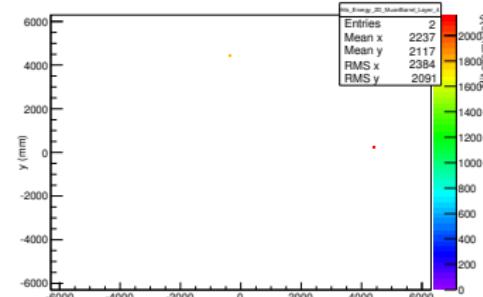
HitMap for MuonBarrel layer 4



HitMap with the average hit energy per bin for MuonBarrel layer 0



HitMap with the average hit energy per bin for MuonBarrel layer 4



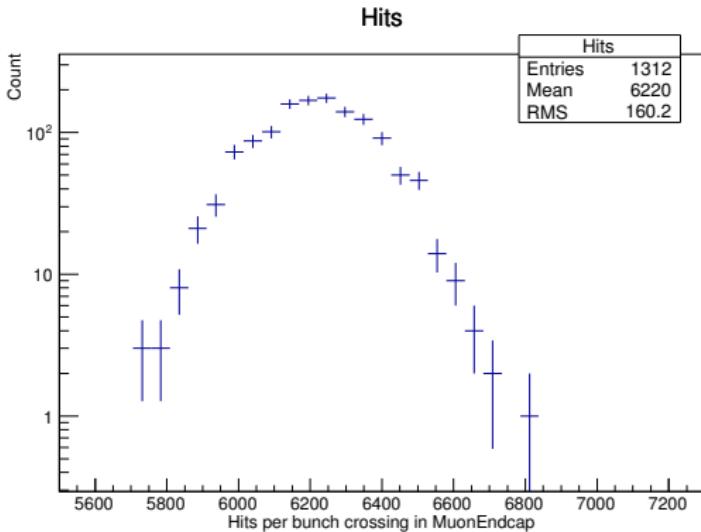


Hit maps of the SiD calorimeters

Studying the hits of the **MuonEndcap** cells

For 1312 bunch crossings:

Number of pair background particles hitting the MuonEndcaps and total number of hits in the MuonEndcaps

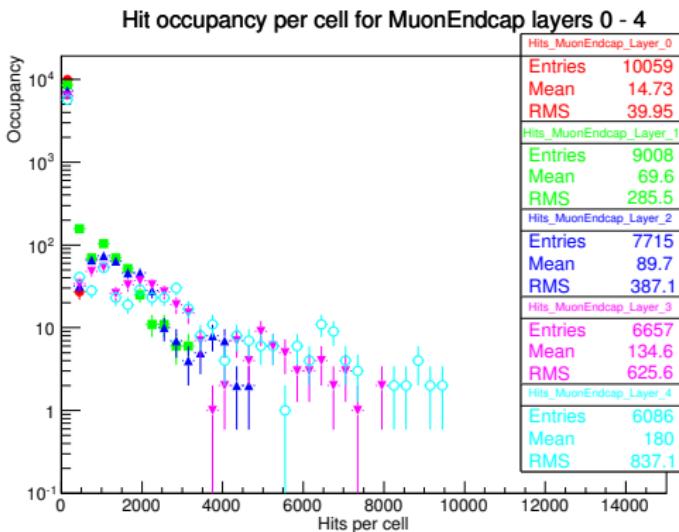




Hit maps of the SiD calorimeters

Studying the hits of the **MuonEndcap** cells

Hit distribution per bunch crossing in the MuonEndcap layers 0 - 4:



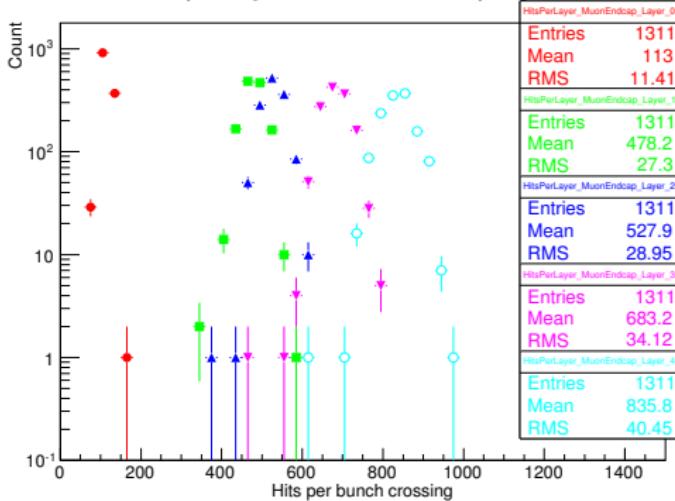


Hit maps of the SiD calorimeters

Studying the hits of the **MuonEndcap** cells

Cell occupancy in the MuonEndcap layers 0 - 4:

Hits per layer for MuonEndcap layers 0 - 4



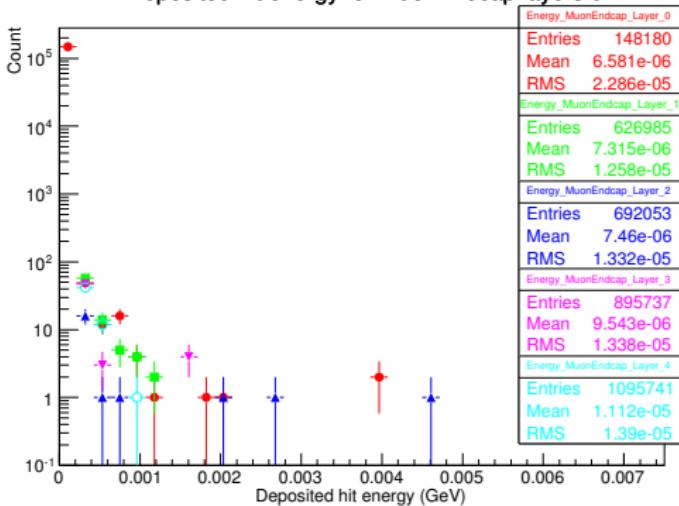


Hit maps of the SiD calorimeters

Studying the hits of the **MuonEndcap** cells

Deposited hit energy in the MuonEndcap layers 0 - 4:

Deposited hit energy for MuonEndcap layers 0 - 4



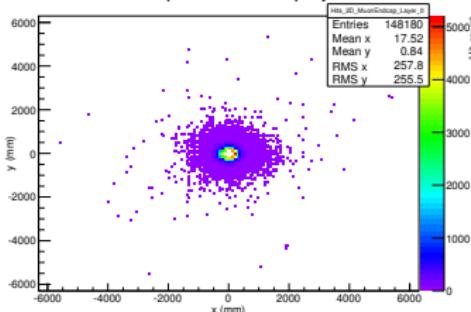


Hit maps of the SiD calorimeters

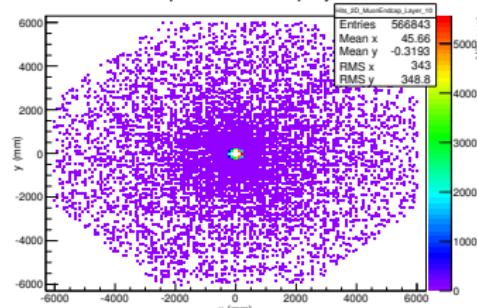
Studying the hits of the MuonEndcap cells

Hit maps (with hit count and deposited hit energy) of MuonEndcap layers 0 and 10:

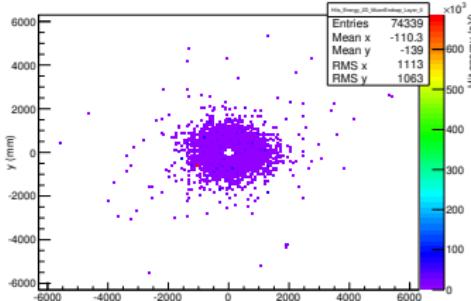
HitMap for MuonEndcap layer 0



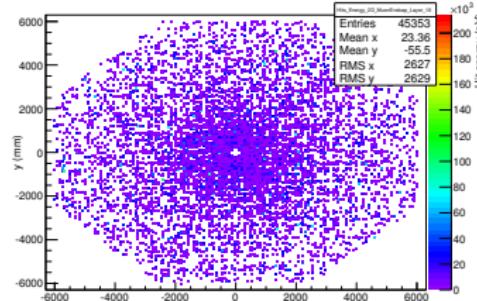
HitMap for MuonEndcap layer 10



HitMap with the average hit energy per bin for MuonEndcap layer 0

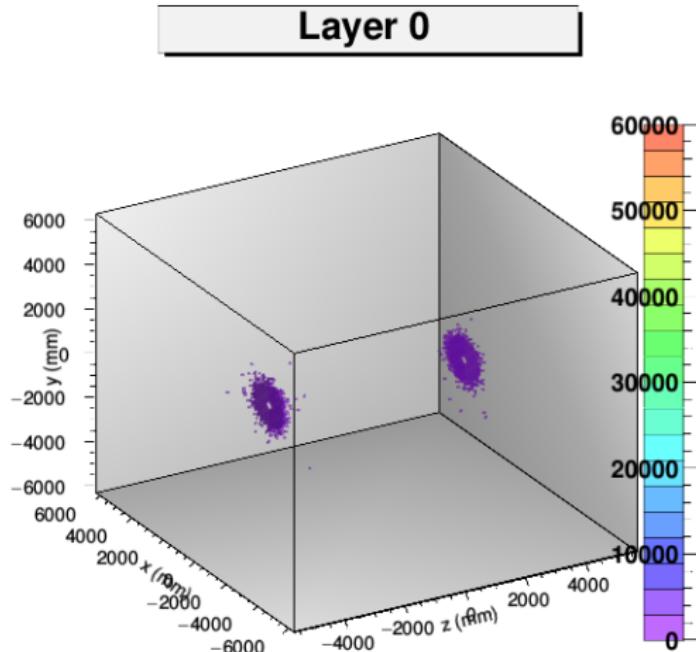


HitMap with the average hit energy per bin for MuonEndcap layer 10





3D hit map of layer 0 of the MuonBarrel and the MuonEndcap





3D hit map of the **MuonBarrel** and **MuonEndcap**

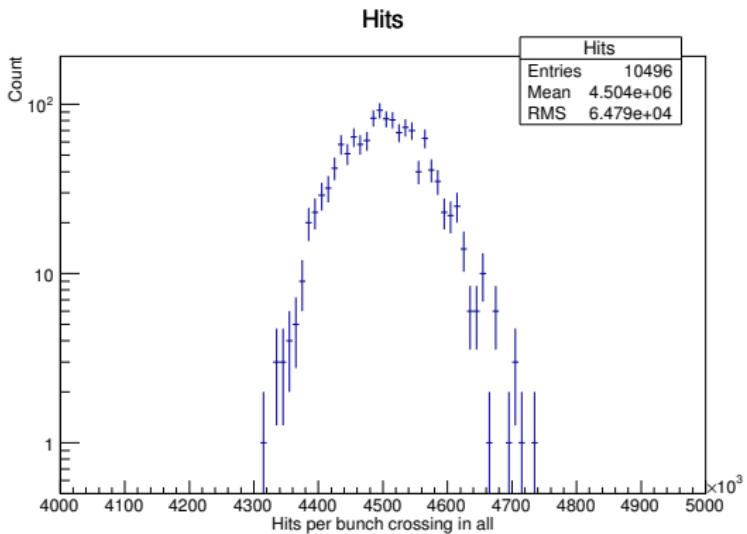


Hit maps of the SiD calorimeters

Studying the hits of the cells in all calorimeters

For 1312 bunch crossings:

Number of pair background particles hitting the calorimeters and total number of hits in all the calorimeters:



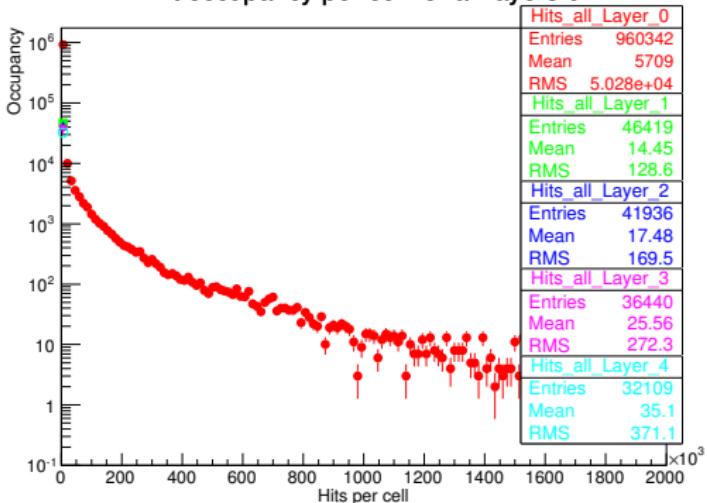


Hit maps of the SiD calorimeters

Studying the hits of the cells in all calorimeters

Hit distribution per bunch crossing in the layers 0 - 4:

Hit occupancy per cell for all layers 0 - 4

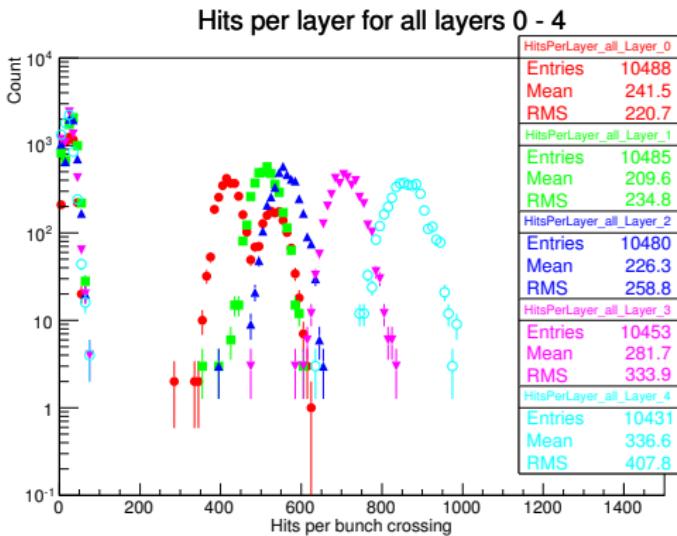




Hit maps of the SiD calorimeters

Studying the hits of the cells in all calorimeters

Cell occupancy of layers 0 - 4:

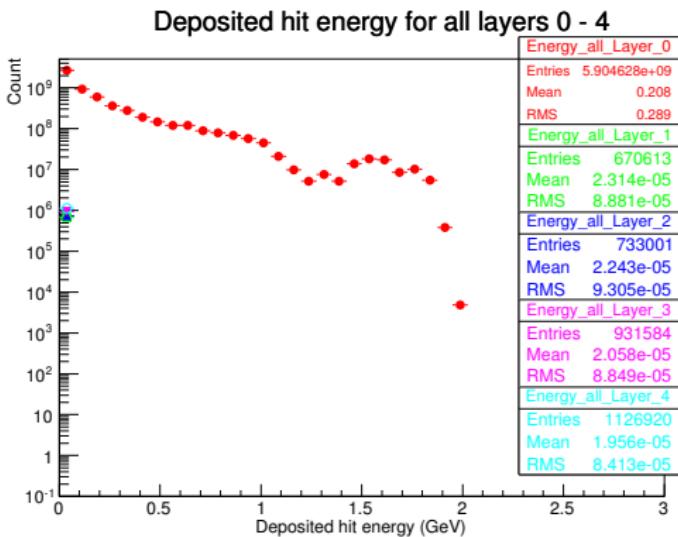




Hit maps of the SiD calorimeters

Studying the hits of the cells in all calorimeters

Deposited hit energy of layers 0 -4:



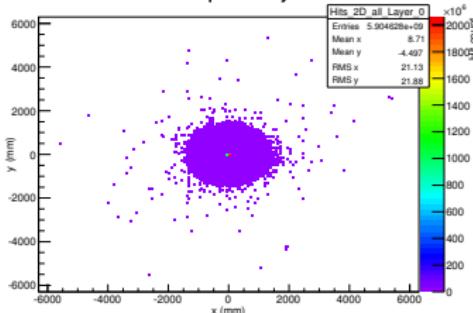


Hit maps of the SiD calorimeters

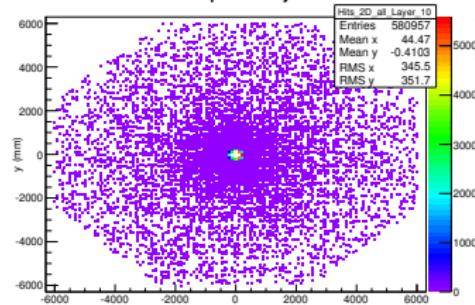
Studying the hits of the cells in all calorimeters

Hit maps (with hit count and deposited hit energy) of layers 0 and 10 in all calorimeters:

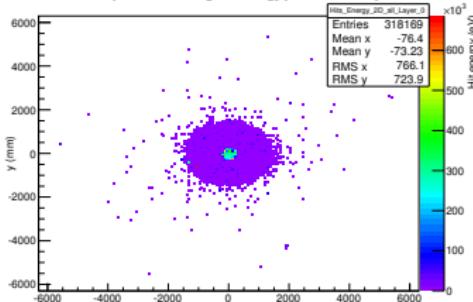
HitMap for all layer 0



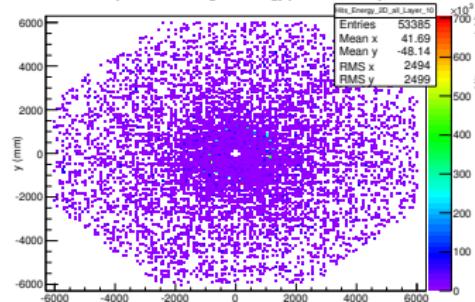
HitMap for all layer 10

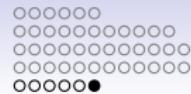


HitMap with the average hit energy per bin for all layer 0



HitMap with the average hit energy per bin for all layer 10





Hit maps of the SiD calorimeters

Studying the hits of the cells in all calorimeters