



Current status of simulations in VXD and Si Tracker

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FNAL, November, 16th 2007



Working on geometry



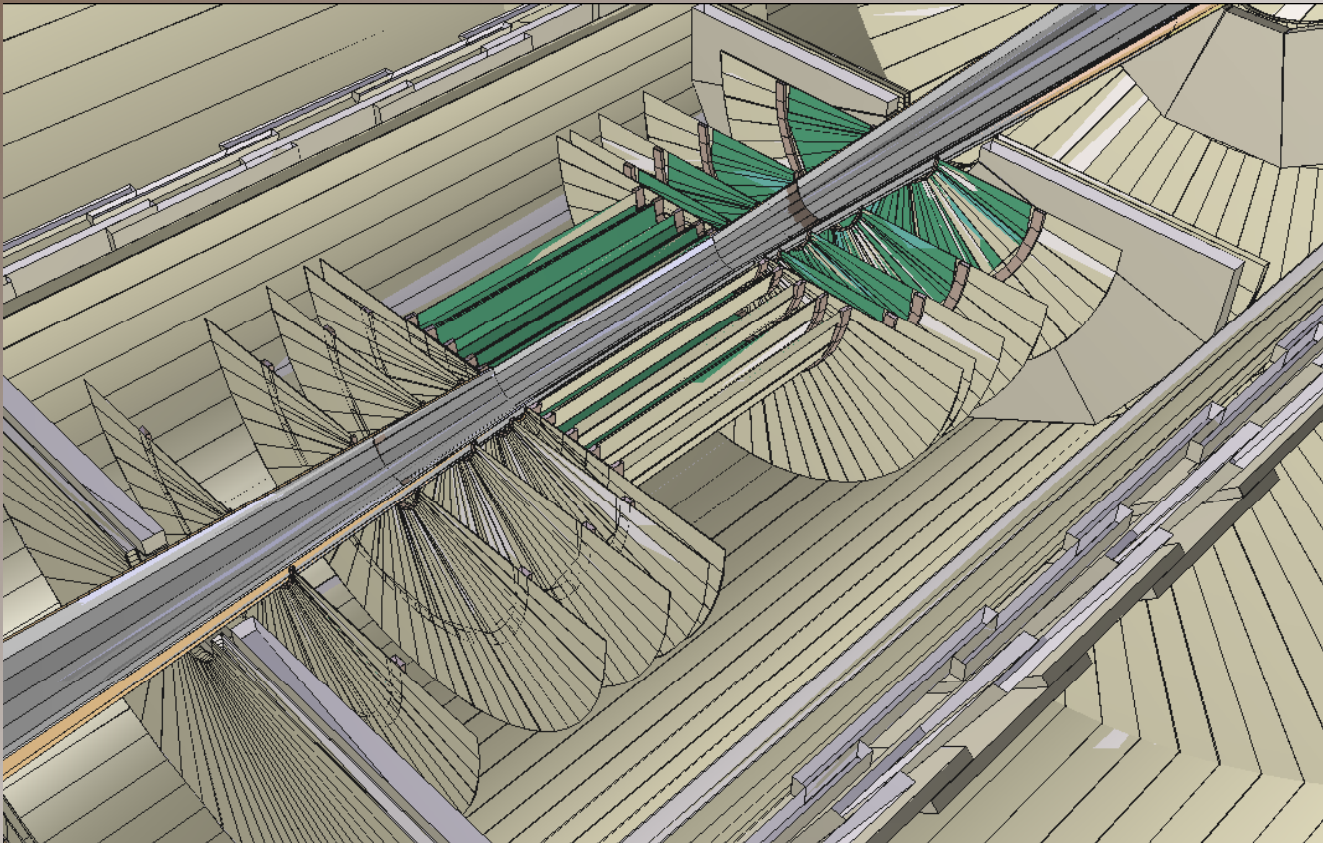
- many geometry files available in CVS repository in .gdml and .root format
 - VXD geometry file based on **sidmay06**
 - SiTracker geometry file based on **sid01_polyhedra** + **sid01** for the support materials from SiD concept
 - a **modified** geomconverter tool, implemented in slic framework, used to just select SiTracker geometry from compact.xml
 - .xml -> .lcdd -> .gdml -> .C -> **.root**
 - different conventions between IlcRoot (cm, degrees, ...) and slic (mm, radiant, ...)



Working on geometry(2)

VXD:

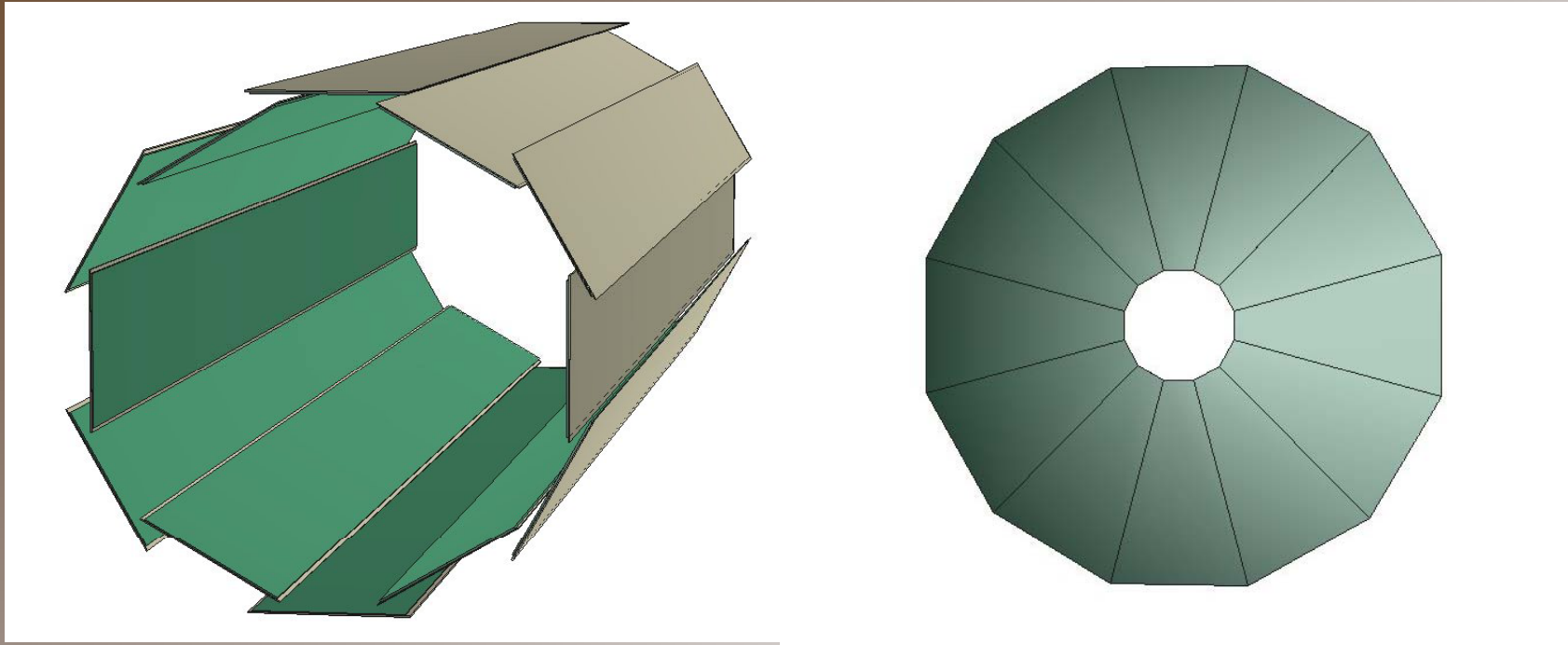
- 5 pixel barrels
- 4+4 pixel endcaps



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Working on geometry(3)



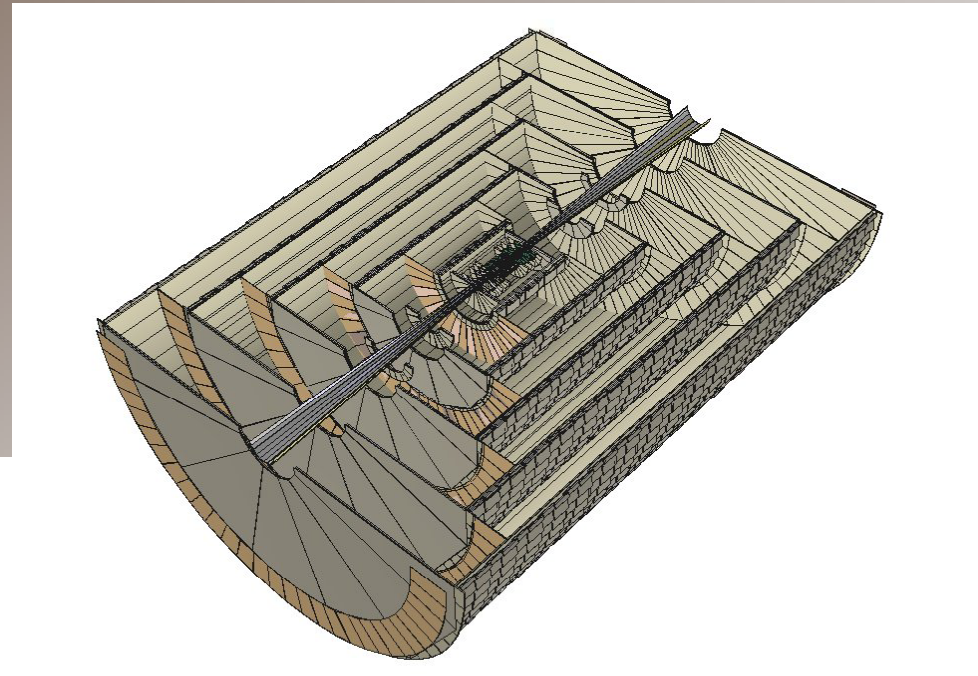
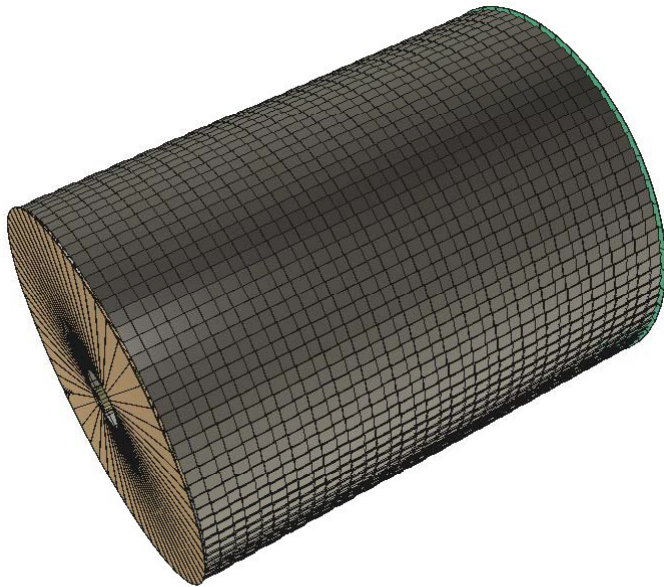
layer	ladders
1	12
2	12
3	18
4	24
5	30

endcap	sectors
1	12
2	12
3	12
4	12

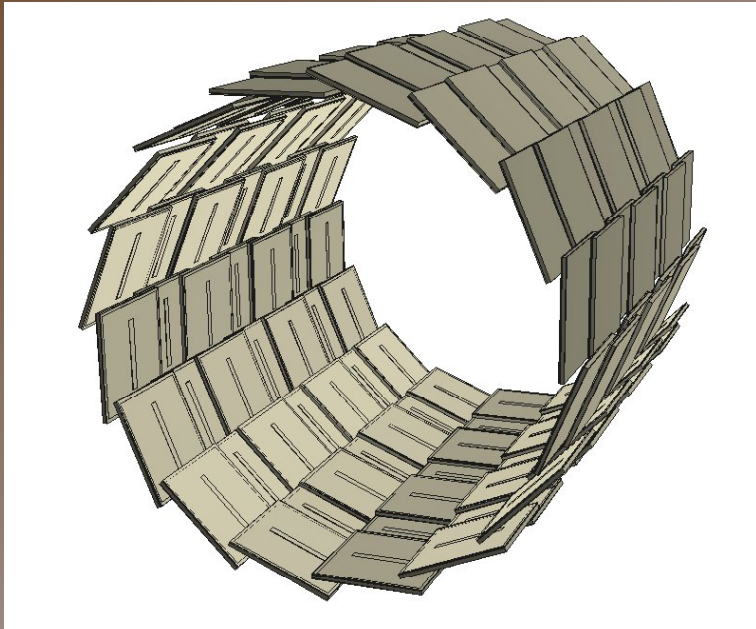
Working on geometry(4)

SiTracker:

- 5 single-sided strip barrels
- 4+4 double-sided strip endcaps
- 3+3 double-sided forward tracker disks

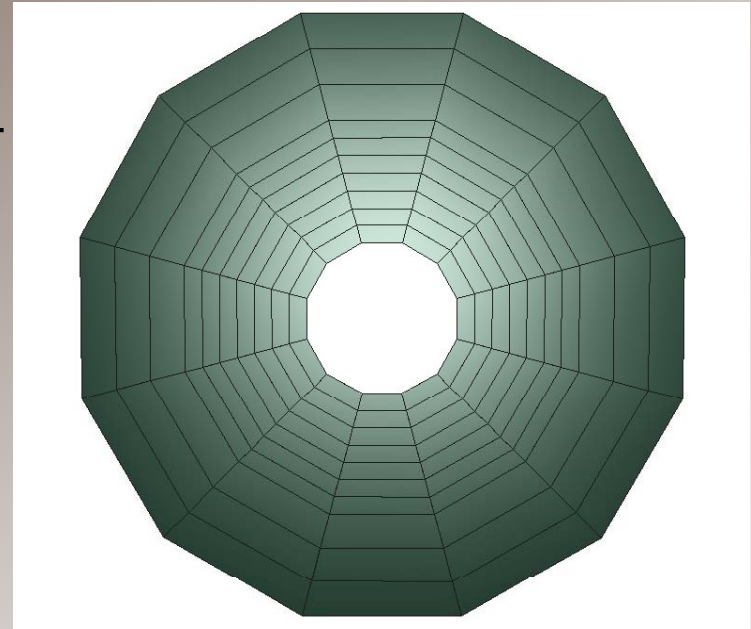


Working on geometry(5)



SiTracker barrels

layer	tiles along phi	tiles along z
1	16	7
2	36	15
3	54	23
4	72	29
5	90	37

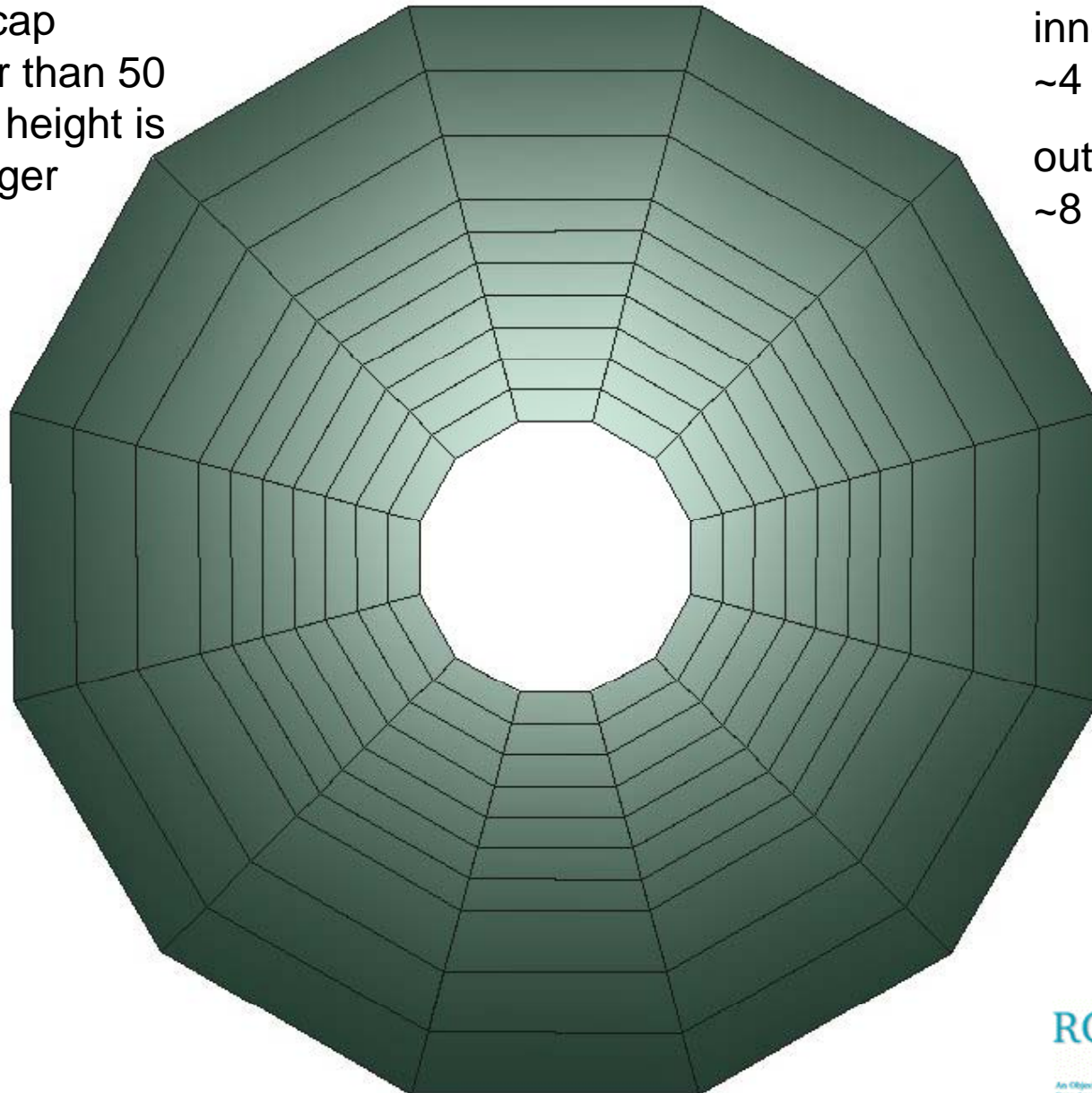


SiTracker endcaps

endcap	Radial sections	Azimuthal sectors
1	7	12
2	10	12
3	13	12
4	16	12
5	3	12
6	2	12
7	1	12 ⁶

Working on geometry(6)

from the endcap
radius greater than 50
cm, the band height is
two times bigger

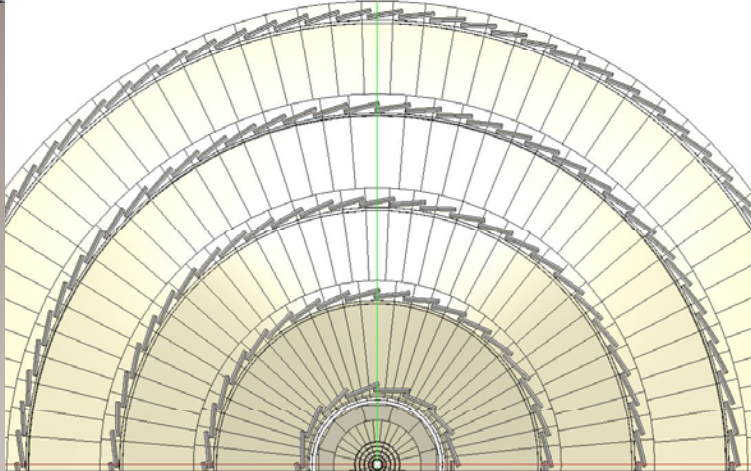
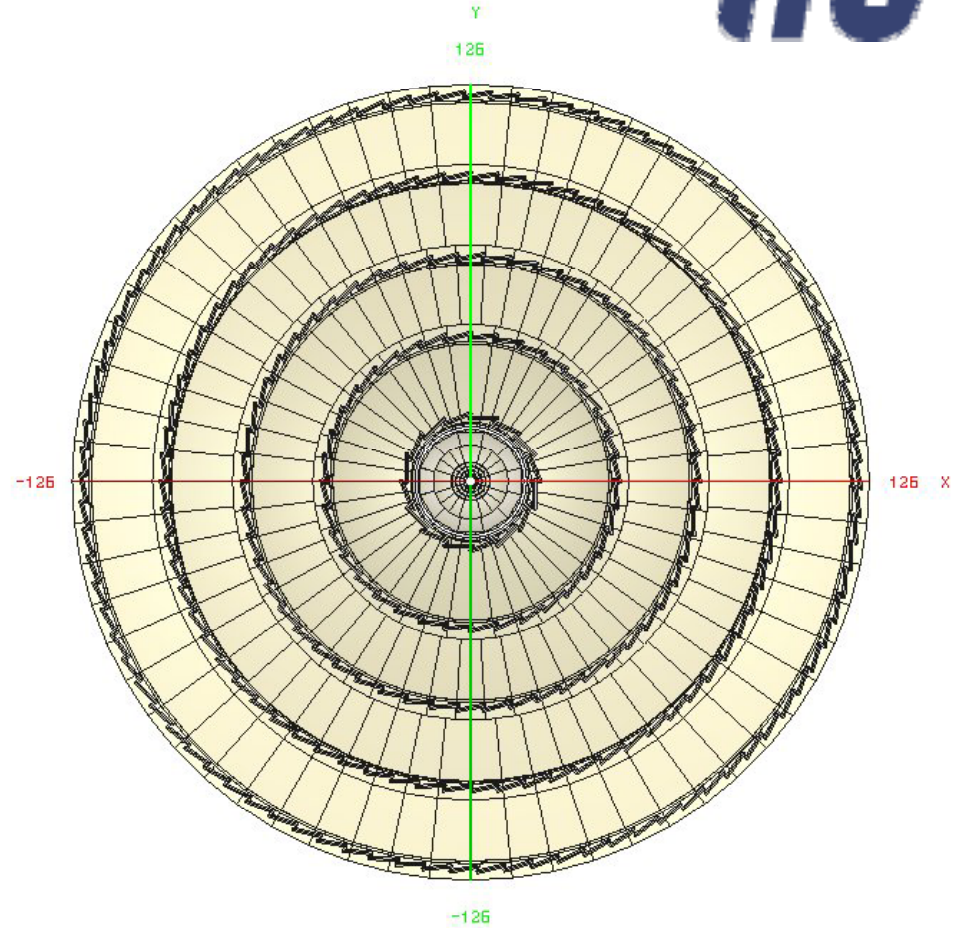
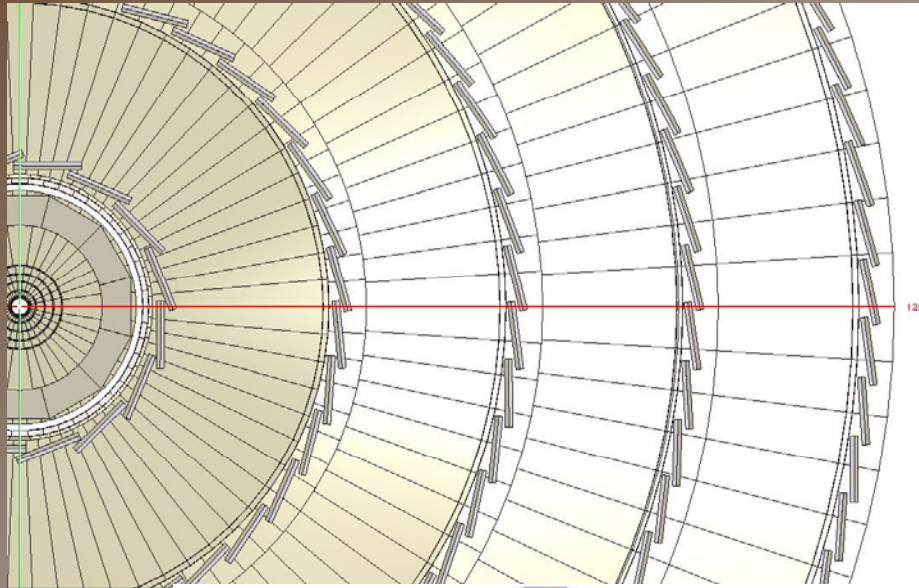


inner height bands
~4 cm

outer height bands
~8 cm

SiTracker endcap with new segmentation in bands

Working on geometry(7)



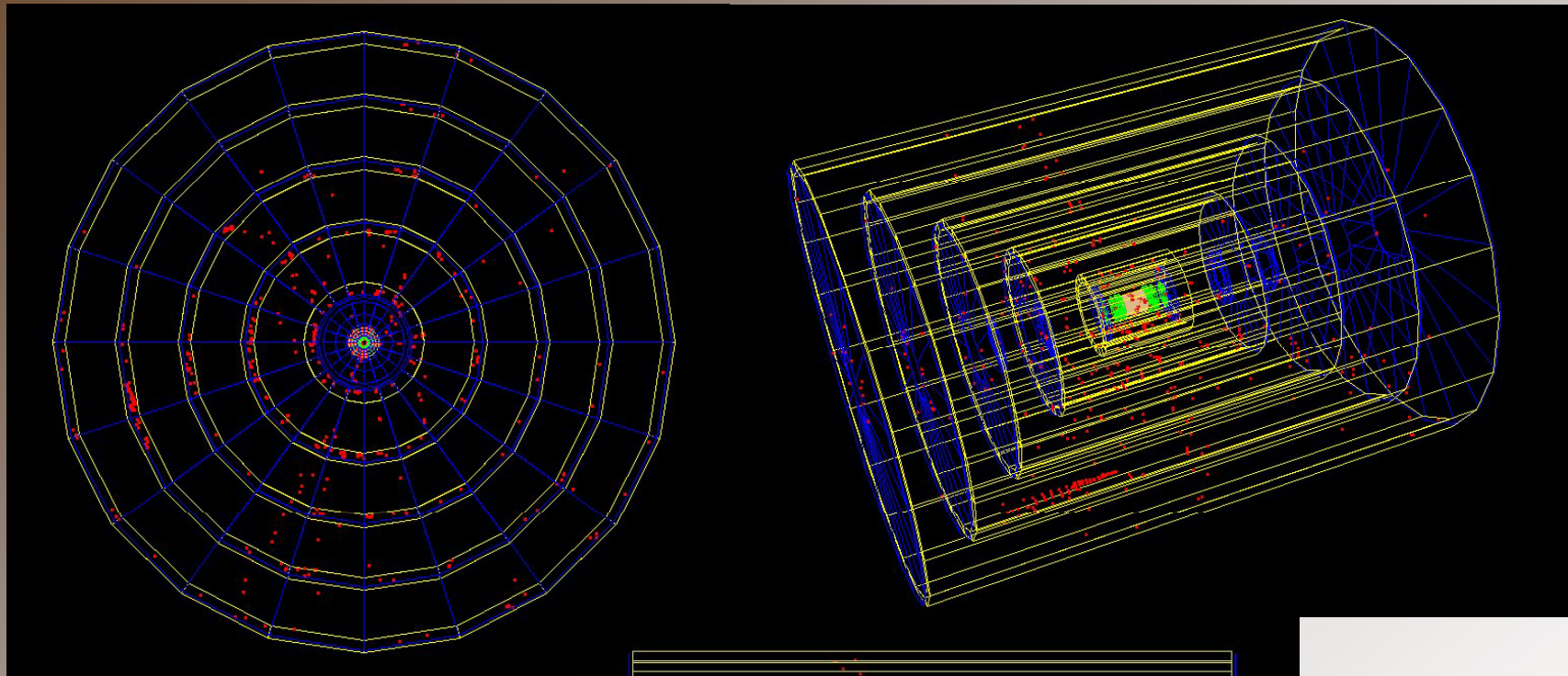
Hits production



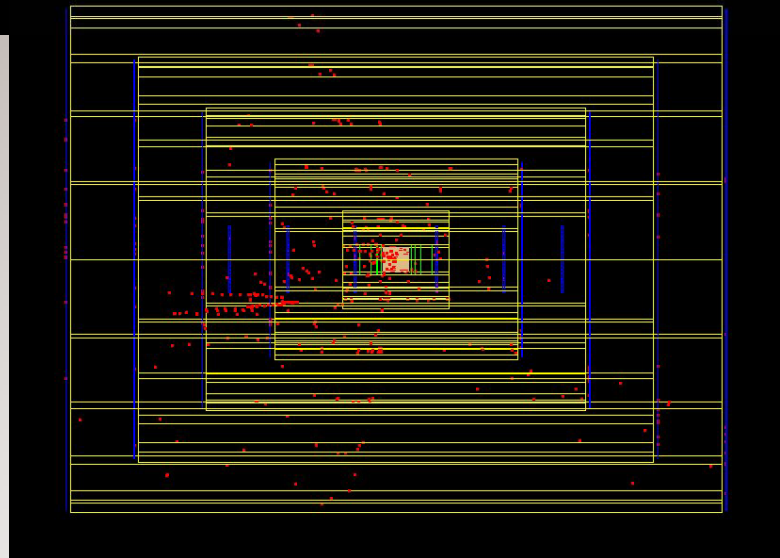
- Hits information for VXD and SiTracker are calculated and stored into a .root file by StepManager method
- Introduced hits efficiency
 - 99.5% for pixels
 - 99.9% for strips
 - currently hits data are stored in VXD.Hits.root
 - layer number, ladder number, detector number
 - x, y, z global coordinates
 - charge deposition
 - ...



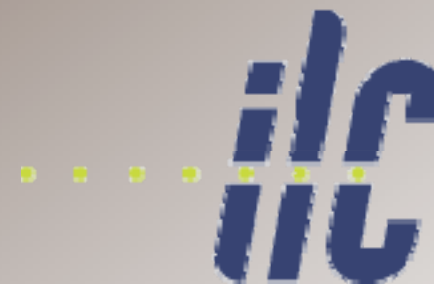
Hits production(2)



Event display shows hits for a $t\bar{t} \rightarrow 6\text{jets}$ event (5 Tesla)



Segmentation



- Segmentation in pixel for VXD layers of the barrel and endcaps and strips for SiTracker layers of the barrel and endcaps:
 - VXD
 - **possibility to set the pixel dimensions for each layer in the config file (20 μm by default)**
 - SiTracker
 - **possibility to set the strip pitch for each layer in the config file (25 μm pitch strips by default with readout every other strip)**



Pixel Digitization



- SDigitization
 - for each track crossing the silicon:
 - the segment is divided in steps
 - for each step is calculated the projection along pixel rows and columns
 - several pixels are fired by diffusion effect
 - the charge spread due to diffusion is calculated with following parameters:

$T=300^{\circ}$ K $Bvoltage=100$ Volts

Eccentricity=85% (asymmetric spreading)



- coupling effect taken into account (row probability=0.0, column probability=0.0)

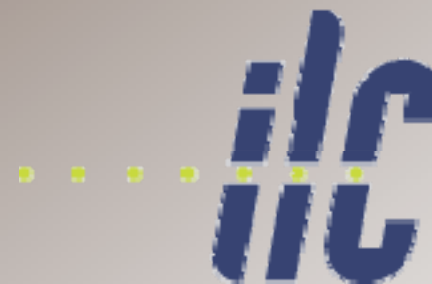
Pixel Digitization(2)



- Digitization
 - In this step electronic noise is added to signals (noise=0)
 - cut off on the threshold for zero suppression (threshold=0)



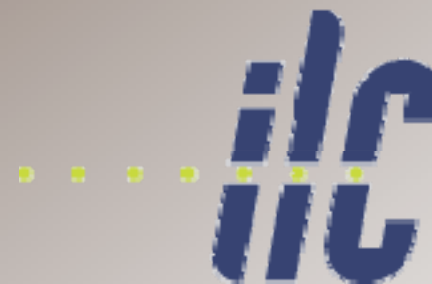
Strip Digitization



- SDigitization
 - for each track crossing the silicon:
 - the segment is divided in steps of $25 \mu\text{m}$
 - for each step is calculated the strip number
 - severals strips are fired by diffusion effect
 - diffusion constant for electrons set to $150 \text{ cm}^2/\text{s}$
 - diffusion constant for holes set to $300 \text{ cm}^2/\text{s}$
 - drift velocity for electrons set to $1.65\text{E}+06 \text{ cm/s}$
 - drift velocity for holes set to $2.3\text{E}+06 \text{ cm/s}$



Strip Digitization(2)



- Digitization
 - the electronic noise is added to signal, noise is gaussian (sigma=3.33 ADC count, 1 ADC unit = 2.16 KeV, S/N = 20)
 - the threshold for zero suppression is set to 3*sigma noise



Clusterization



- Pixel Cluster Finding
 - Create a initial cluster from adjacent pixels (no for diagonal)
 - Subdivide the previous cluster in smaller NxN clusters (default 25x25 cluster range)
 - Kalman filter picks up the best clusters



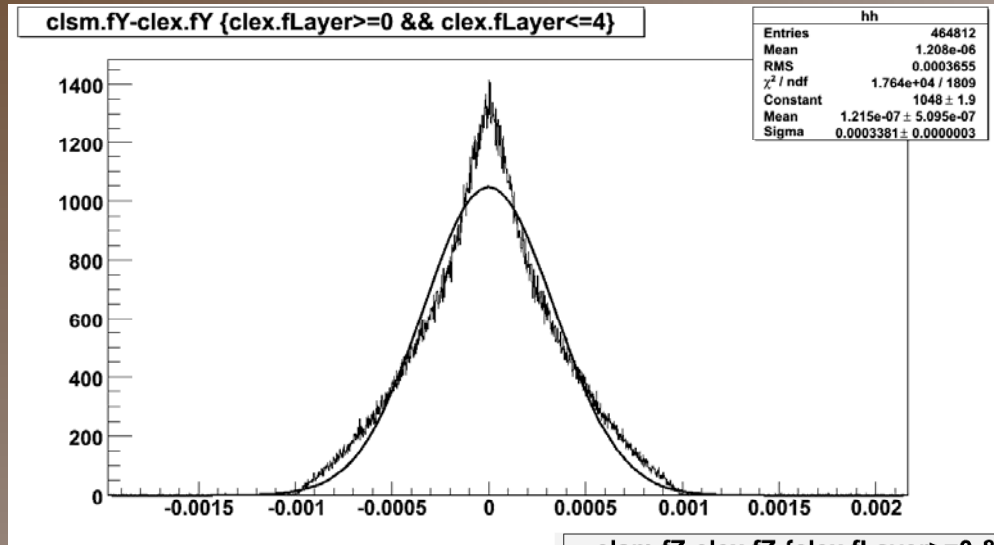
Clusterization(2)



- Strip Cluster Finding
 - Calculate the crossing points from P side strips and N side strips (stereo angle = 17.5 milliradian)
 - Take into account the possibility to have: 1:1, 1:N (ghost clusters) and N:M (ghost clusters) strips

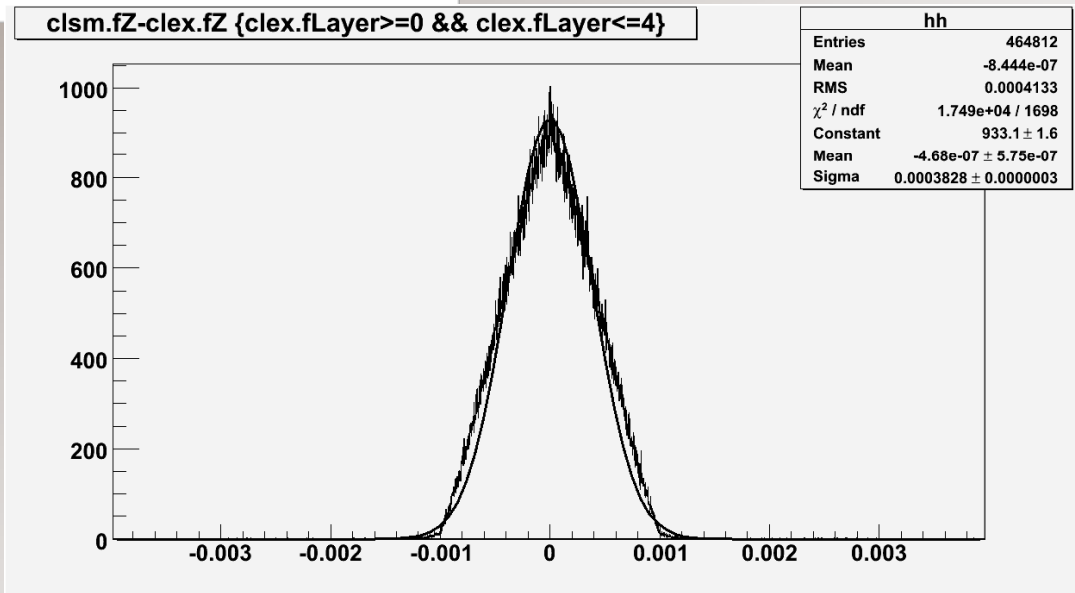


VXD space resolution

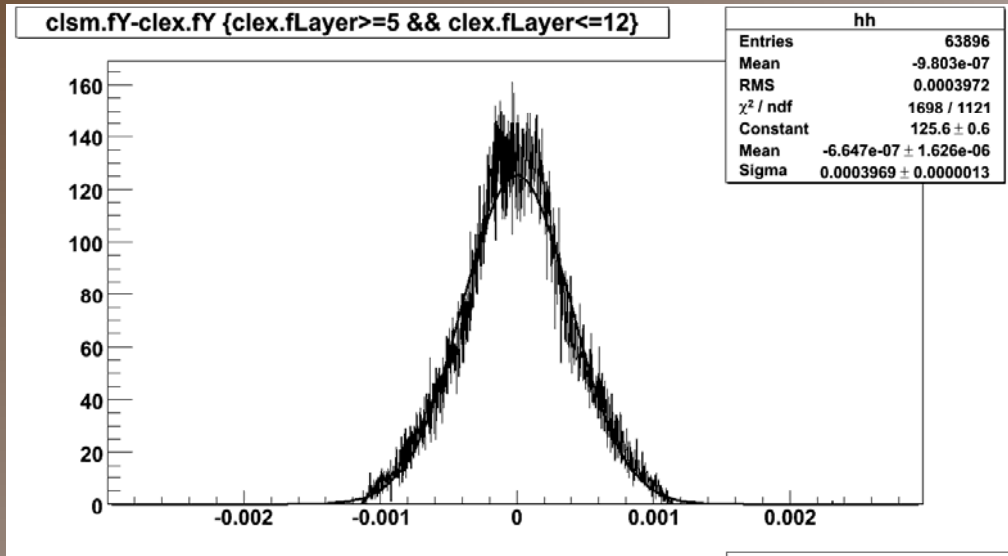


VXD barrel
Y coordinate

VXD barrel
Z coordinate

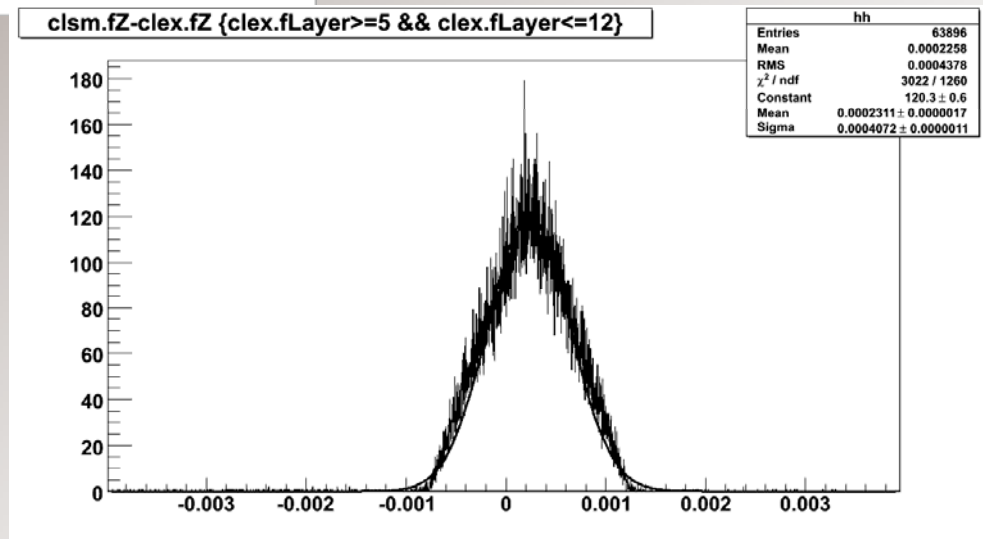


VXD space resolution

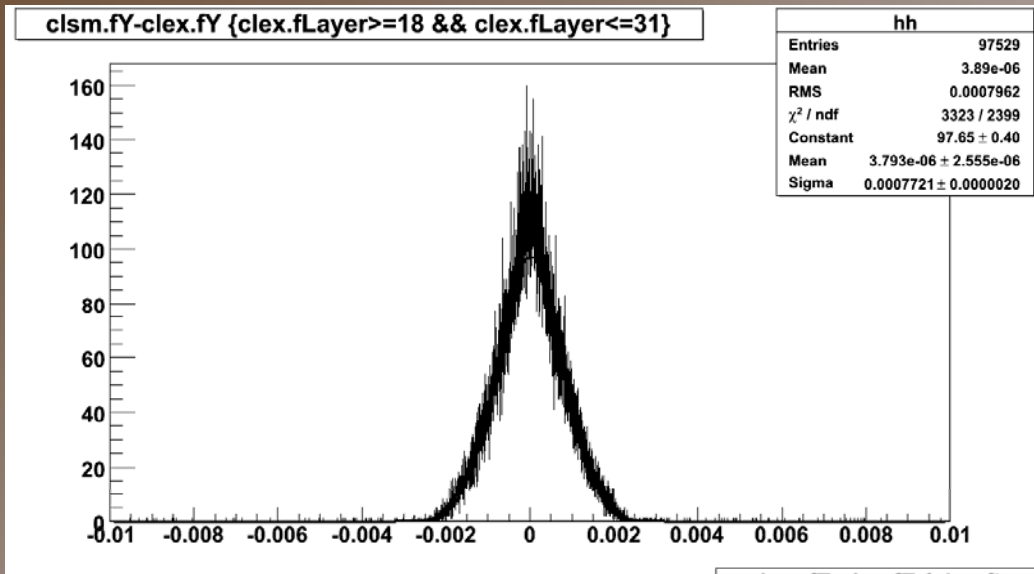


VXD endcap
Y coordinate

VXD endcap
Z coordinate



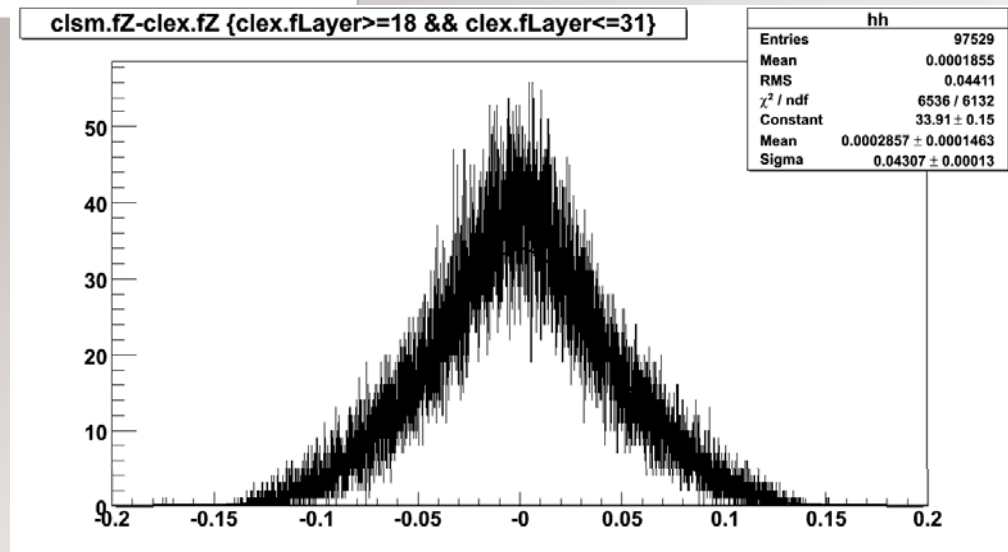
SiT space resolution



SiT endcap

Y coordinate
(same for barrel
apart the stereo
angle)

SiT endcap
Z coordinate



Background simulation



- IlcRoot has an interface to read Guinea Pig file format
- Guinea Pig file is a txt file containing the following fields
 - event number
 - particles number (e+ e-)
 - particles energy (positive value: electron, negative value: positron)
 - velocity in x, y, and z directions divided by the speed of the light
 - x,y and z vertex position in nanometers
- for this studies, incoherent pairs are simulated with acc.dat (accelerator parameters) set by Adrian Vogel
- background is merged with Physics events during Digitization step



Background simulation(2)



- acc.dat contains following parameter for beam background simulation:

accelerator parameters

```
energy = 250;  
espread = 0.003;  
which_espread = 0;  
particles = 2.0;  
f_rep = 5;  
charge_sign = -1;  
emitt_x = 10;  
emitt_y = 0.040;  
beta_x = 21;  
beta_y = 0.4;  
sigma_x = 655;  
sigma_y = 5.7;  
sigma_z = 300;
```

pairs parameters

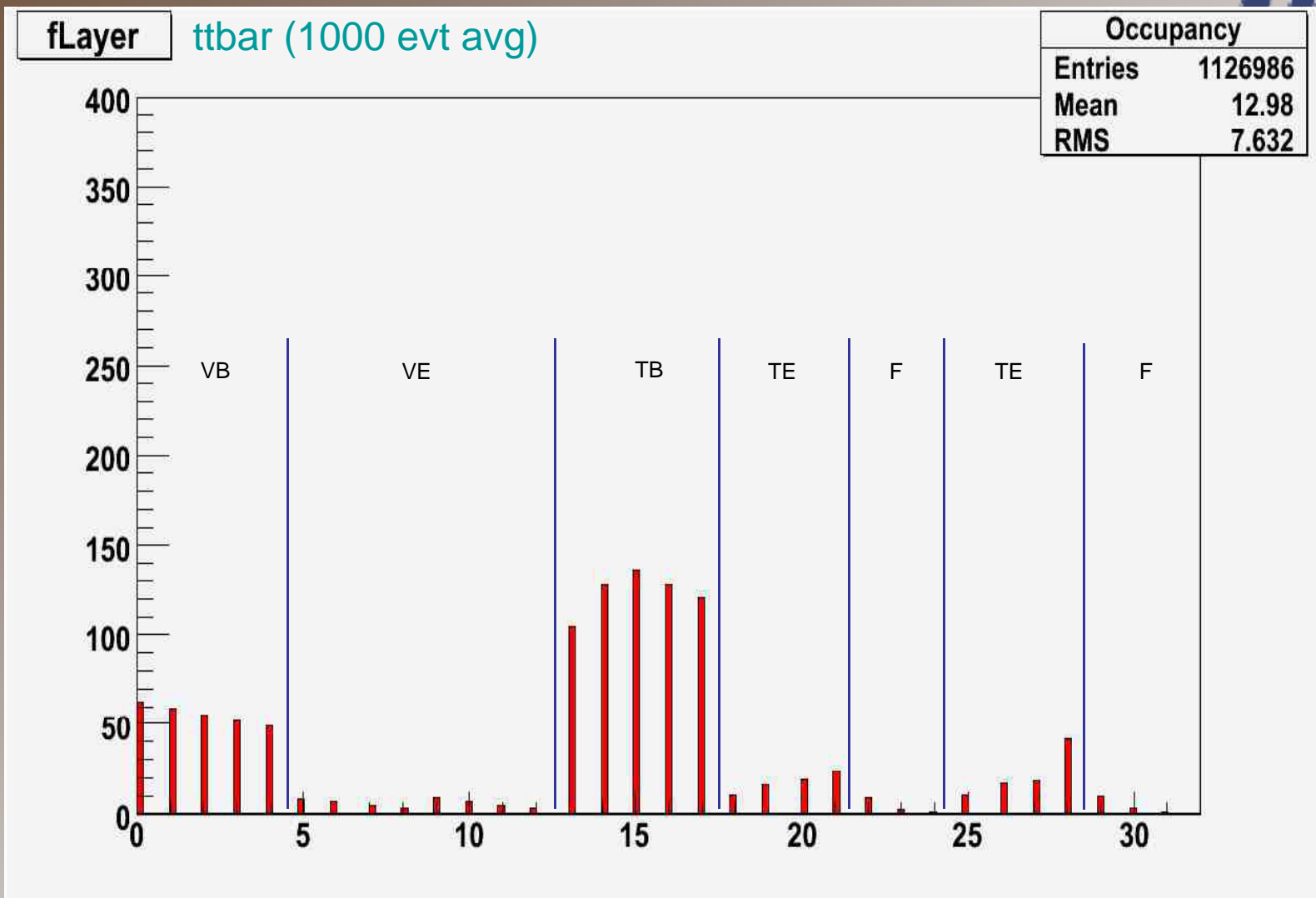
```
n_x = 64;  
n_y = 64;  
n_z = 36;  
n_m = 200000;  
cut_x = 6.0 * sigma_x.1;  
cut_y = 6.0 * sigma_y.1;  
cut_z = 3.0 * sigma_z.1;  
pair_ecut = 5e-3;
```

For further details see Guinea Pig manual:

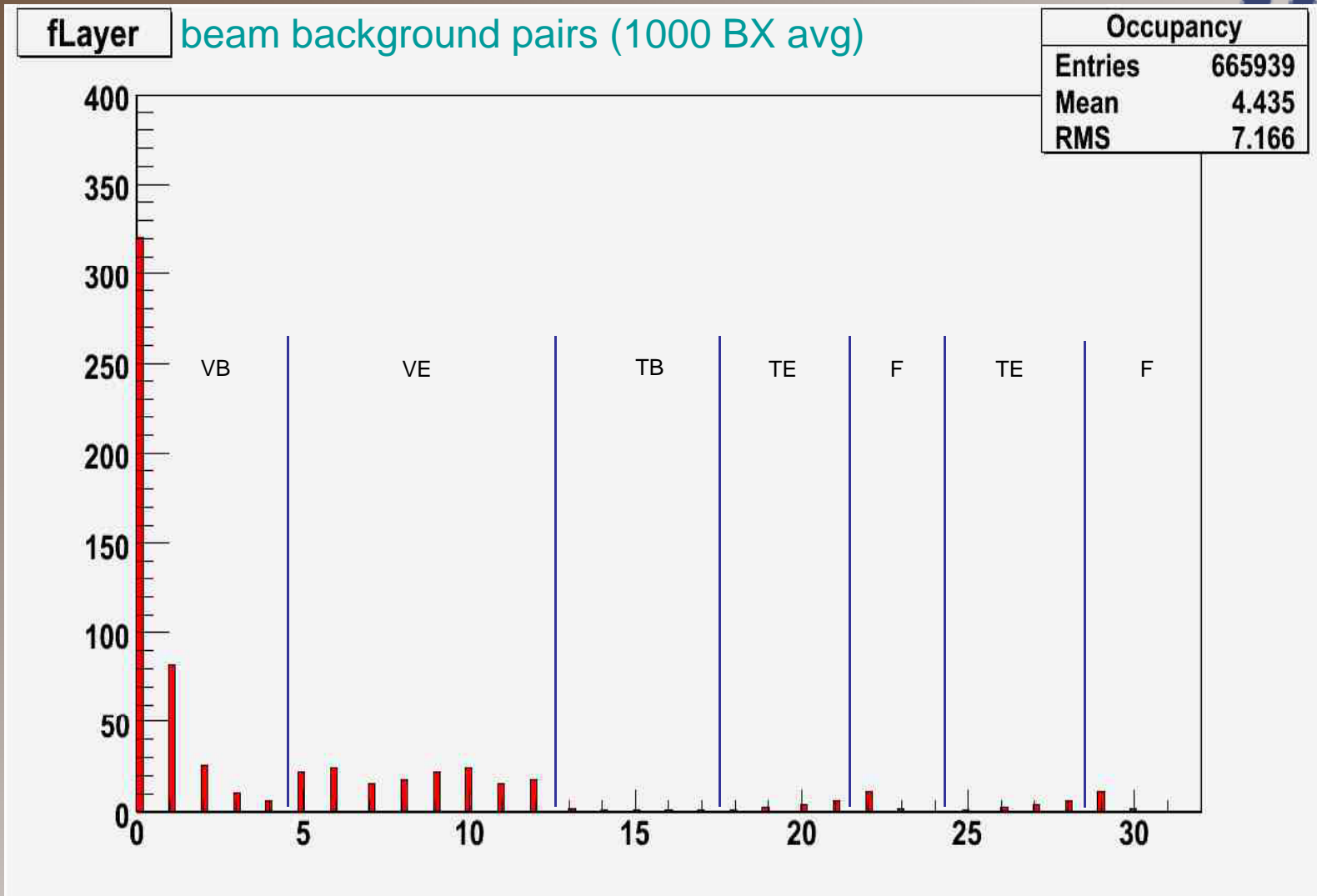
<http://dschulte.web.cern.ch/dschulte/gp.html>



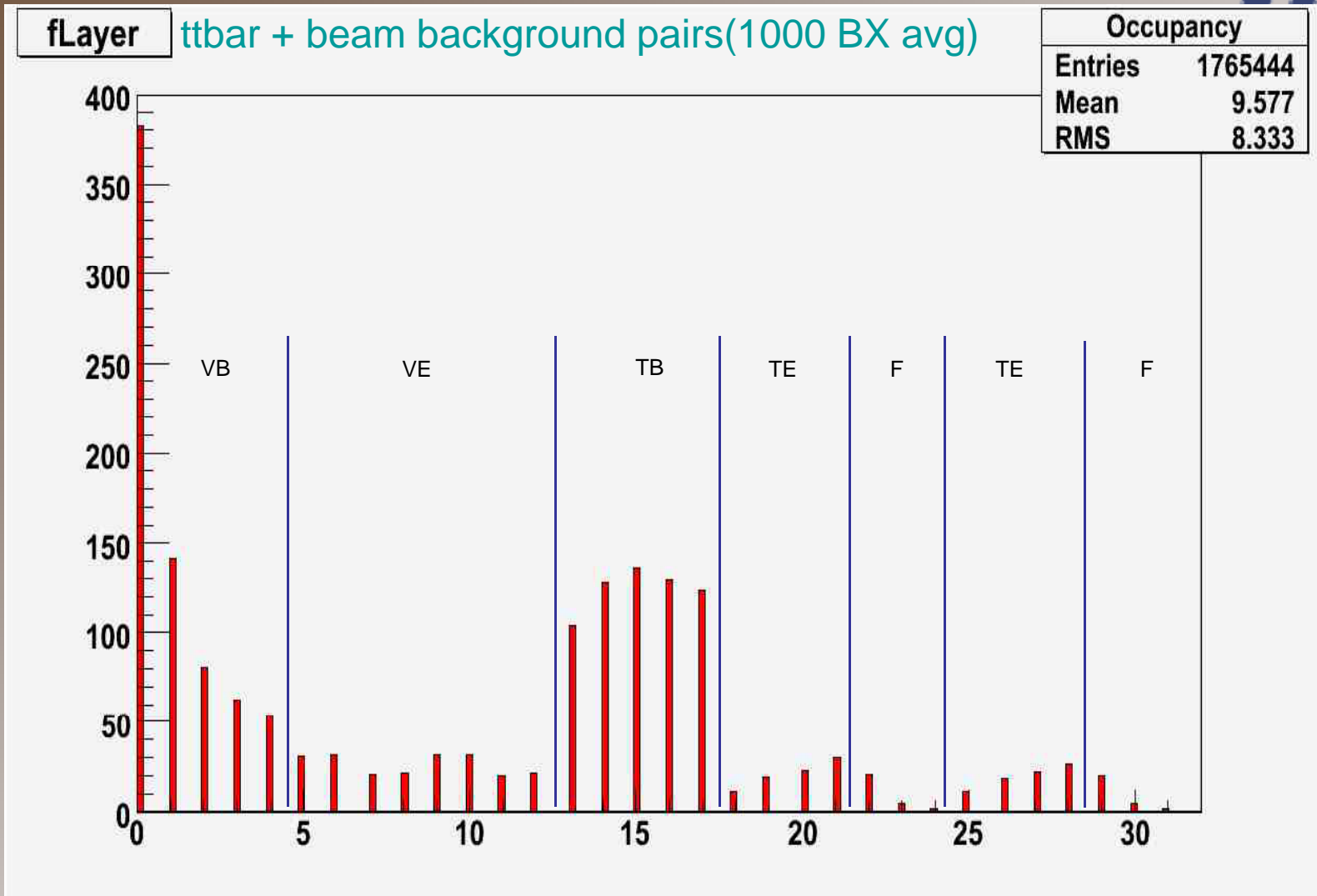
Cluster occupancy in VXD + SiT



Cluster occupancy in VXD + SiT



Cluster occupancy in VXD + SiT



Conclusion



- all digitization/clusterization machinery is in place for pixel and strip detector
- parameters need to be set according to the technology to be simulated

- I enjoyed to stay at Fermilab in these 5 months
- thanks to Hans for his help during geometry design (also for hosting in his office in the first month)
- thanks to G.P. and Marcel for all other stuff

