

SDHCAL software update towards DBD

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Update on SDHCAL digitizer

- Goal : use SimCalorimeterHit Geant4 step position for proper digitization for DBD.
- Strategy :
 - ◆ First, code development before ILDsoft freeze.
 - ◆ Put parameters that need more work as parameter of the Marlin processor.

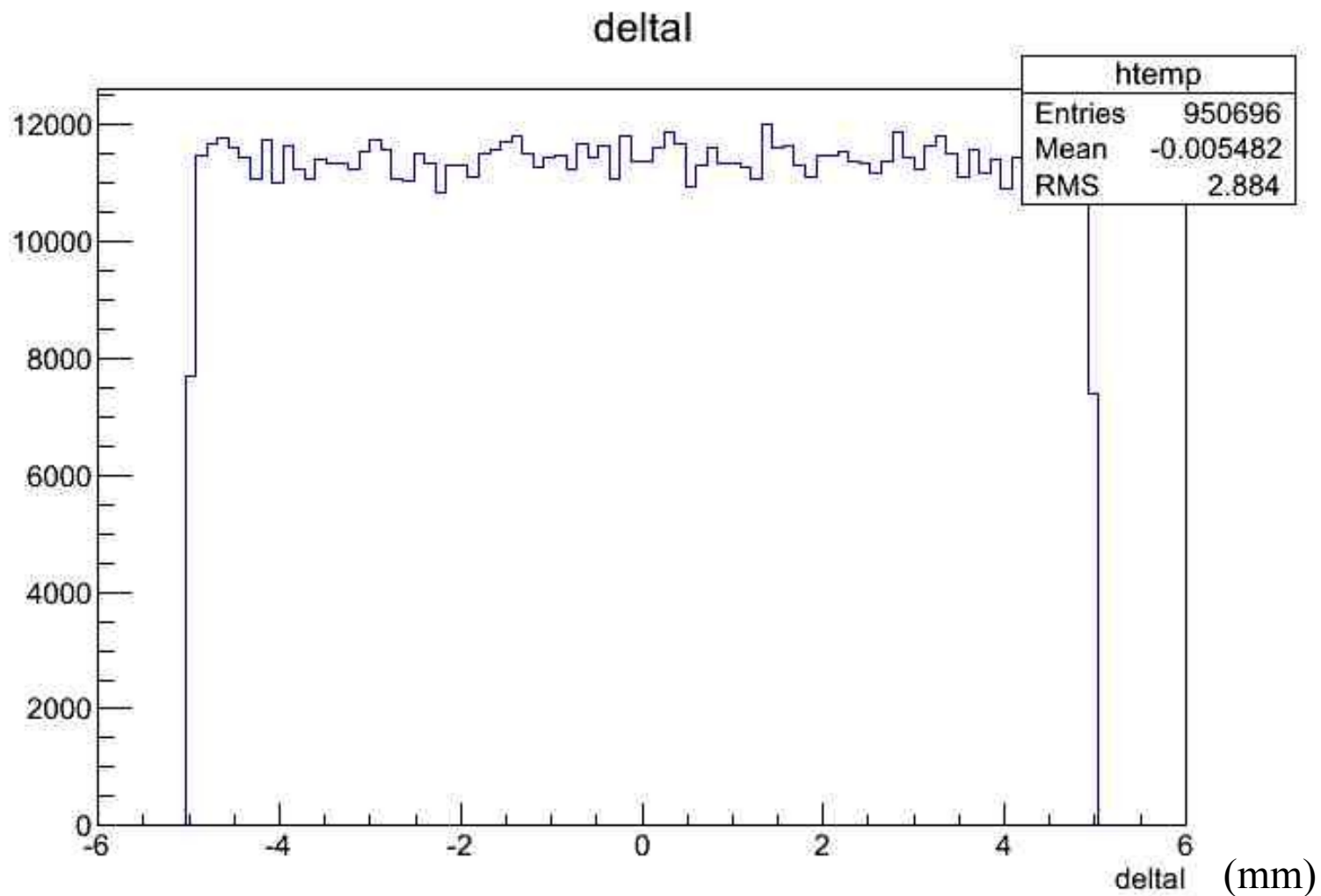
The digitization logic

- For each input SimCalorimeterHit
 - ◆ Get list of steps position in “cell frame”.
 - ◆ Filter out some steps.
 - ◆ For each kept step
 - ◆ Simulate induced charge.
 - ◆ Dispatch the charge on the cell and neighbour cells.
 - ◆ If a hit for this cell already exist, add the new charge.
 - ◆ Else create the hit and give it the charge.
 - ◆ Hits are stored in a `std::map[cellID0]=CalorimeterHit`
- Remove candidate hits below first threshold.
- Apply thresholds and store hits in output collection

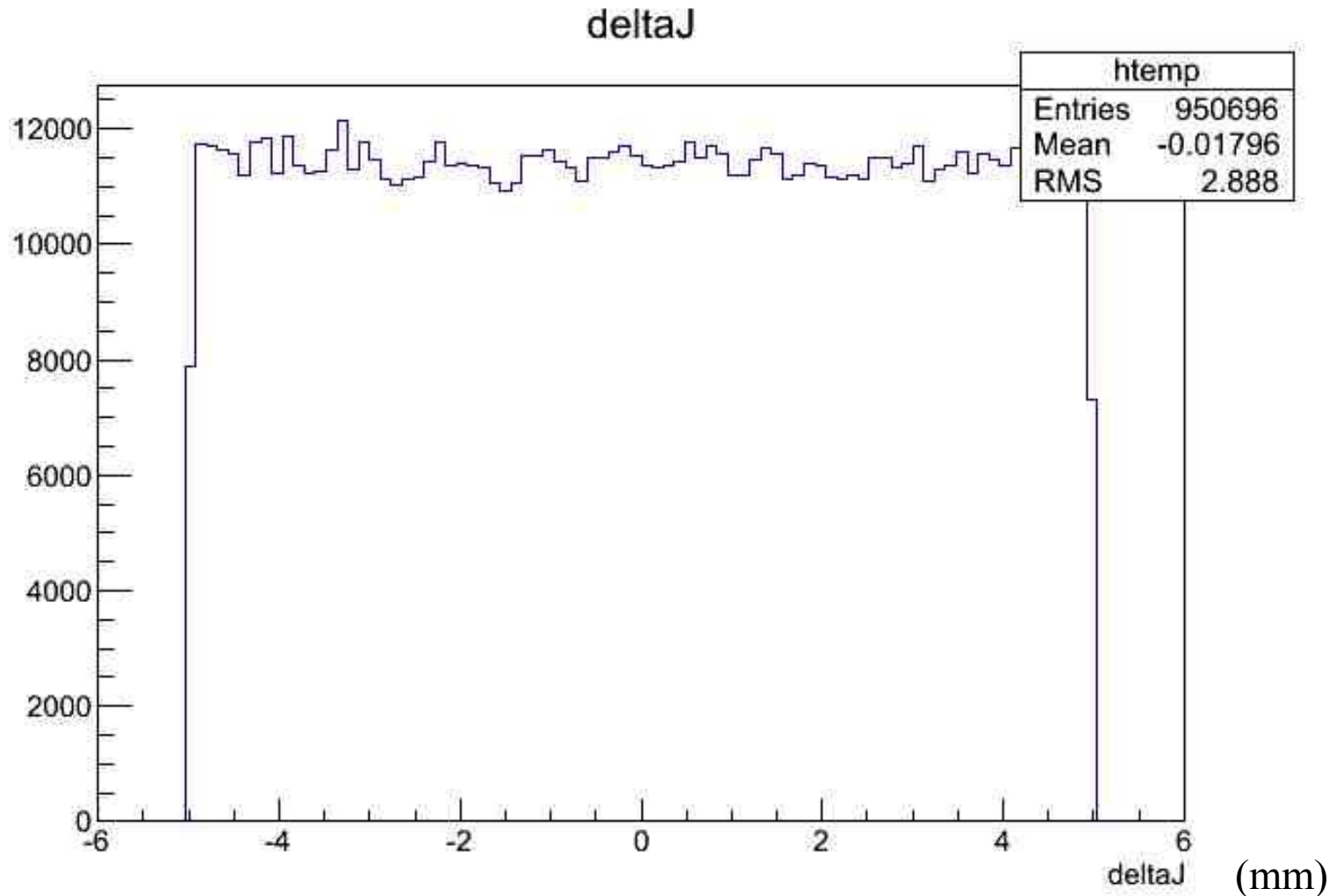
The “cell frame” for the step

- Express step 3D vector position in the “cell frame”
 - ◆ Frame origin is the cell center.
 - ◆ Axis directions are (increasing “I”, increasing “J”, increasing “layer number”).
 - ◆ I, J and layer are extracted from cellID
 - ◆ TESLA and VIDEAU geometry available.
 - ◆ Few bugs unearthed during this development :
 - ◆ MarlinUtil (fixed) :
 - ◆ layoutFromString replying hit type is endcap for endcapsring collection.
 - ◆ Mokka (fix written, will be tested) :
 - ◆ Endcap ($z > 0$) step positions rotated by π around y-axis.
 - ◆ No step position stored for TESLA geometry.

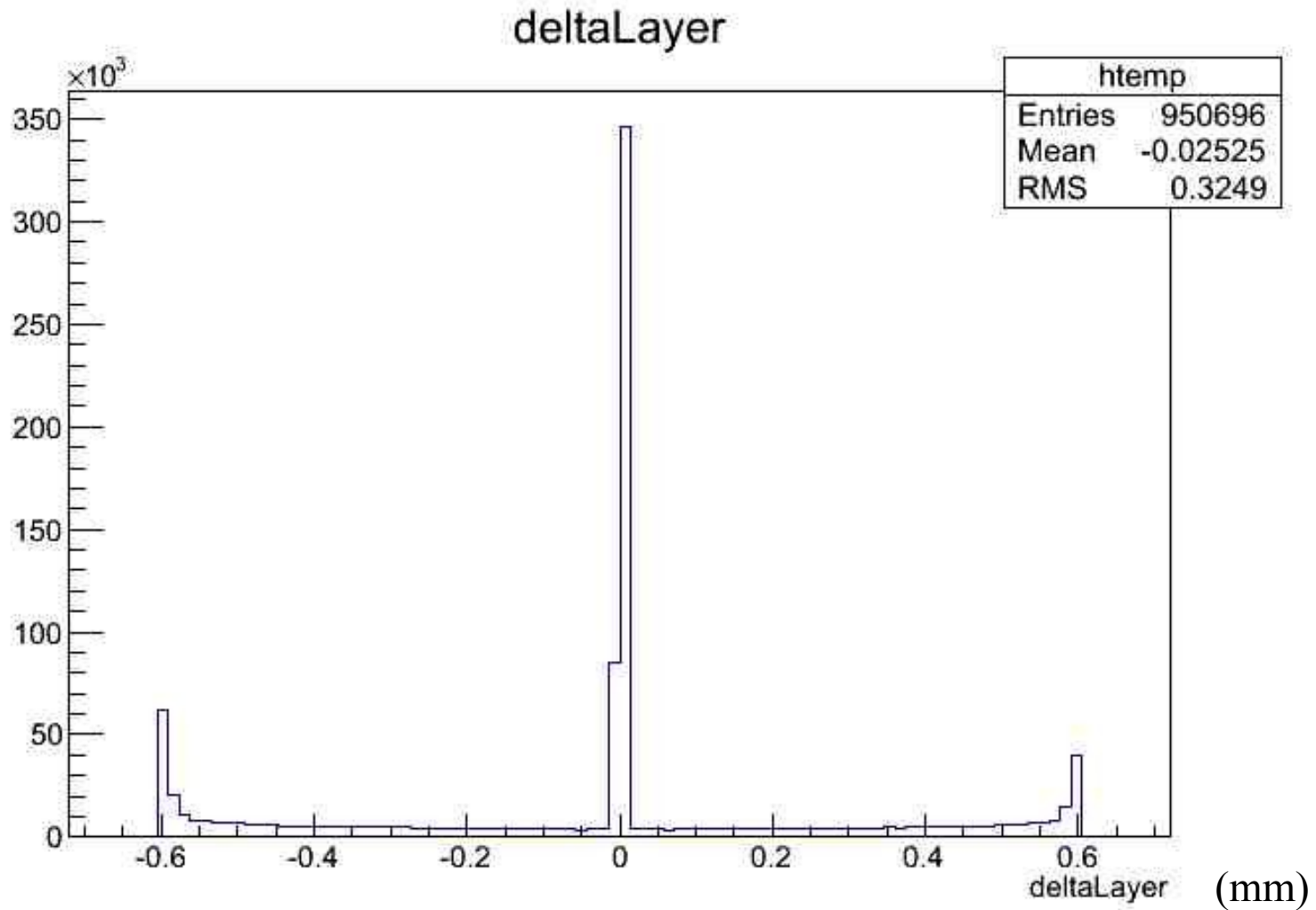
Step position in “cell frame” 1st axis



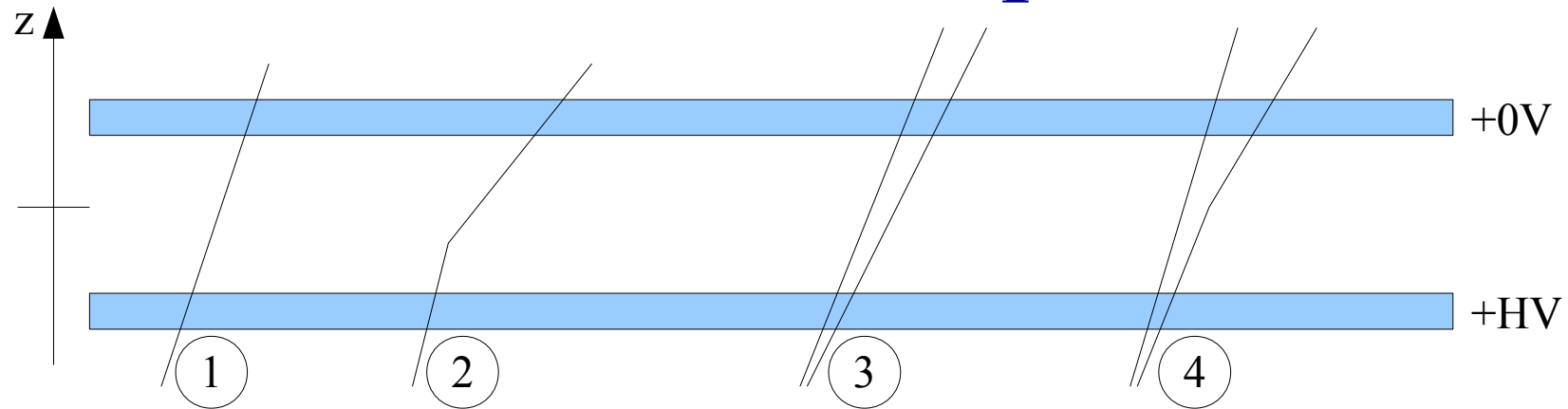
Step position in “cell frame” 2nd axis



Step position in “cell frame” 3rd axis

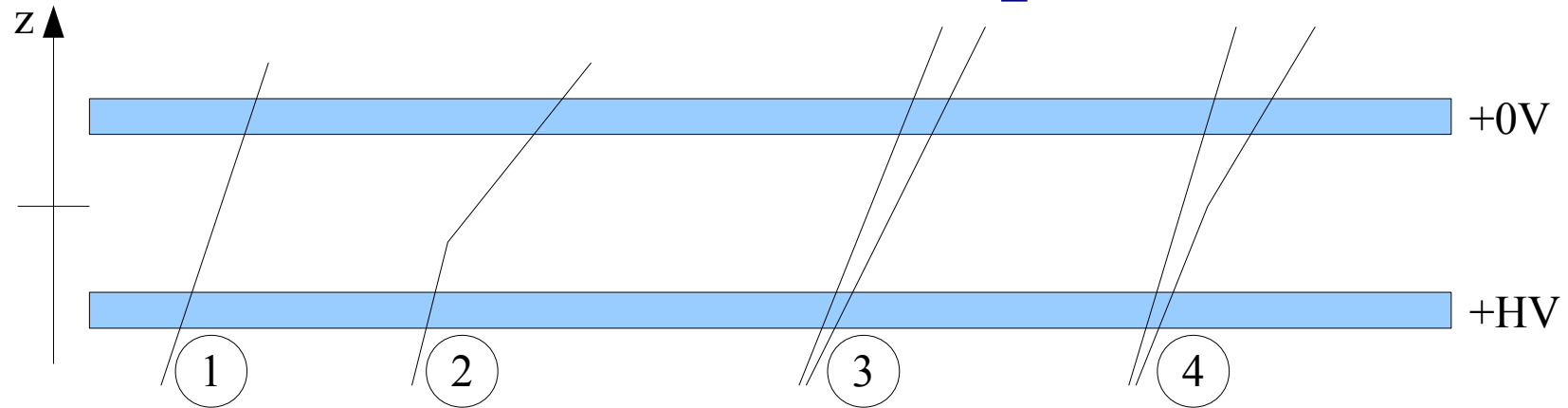


Filter out steps



- Step position from Mokka is the middle of the GEANT4 step
 - ◆ 1 : one particle and one step at $z=0$ (in “cell frame”)
 - ◆ 2 : one particle and two steps at $z \neq 0$
 - ◆ 3 : two particles and two steps at $z=0$
 - ◆ 4 : two particles and 3 steps.

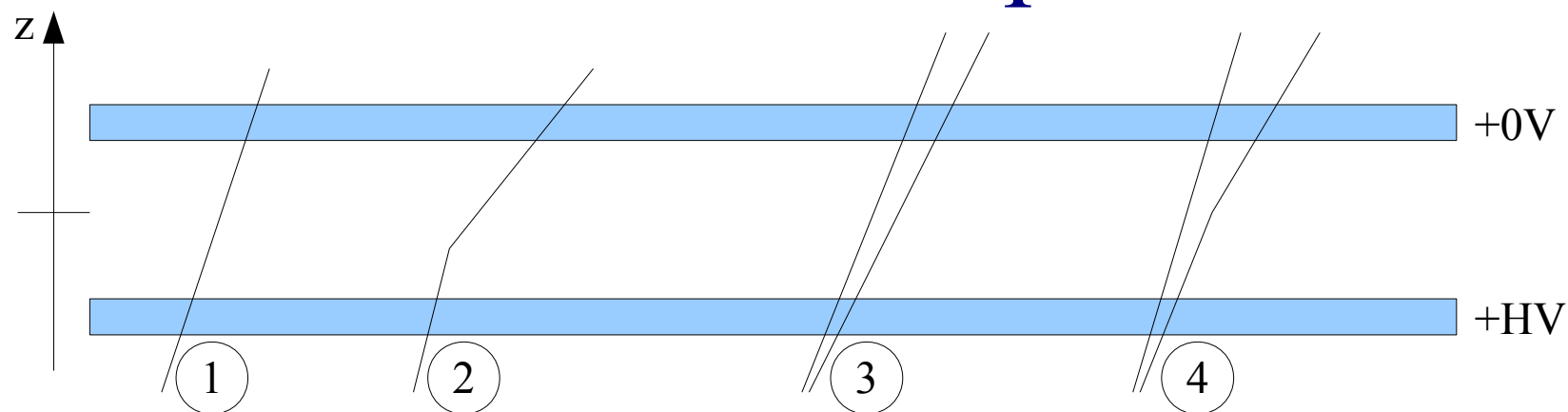
Filter out steps



- Processor parameters

- ◆ A=“StepCellCenterMaxDistanceLayerDirection”
 - ◆ Keep step if $\text{abs}(z) < A$, default=0.0005 mm
 - ◆ Ok for case 1 and 3
 - ◆ Remove non propagating steps at the RPC entrance
- ◆ B=“KeepAtLeastOneStep”
 - ◆ Default true : don't remove all steps
 - ◆ Retrieve case 2

Filter out steps



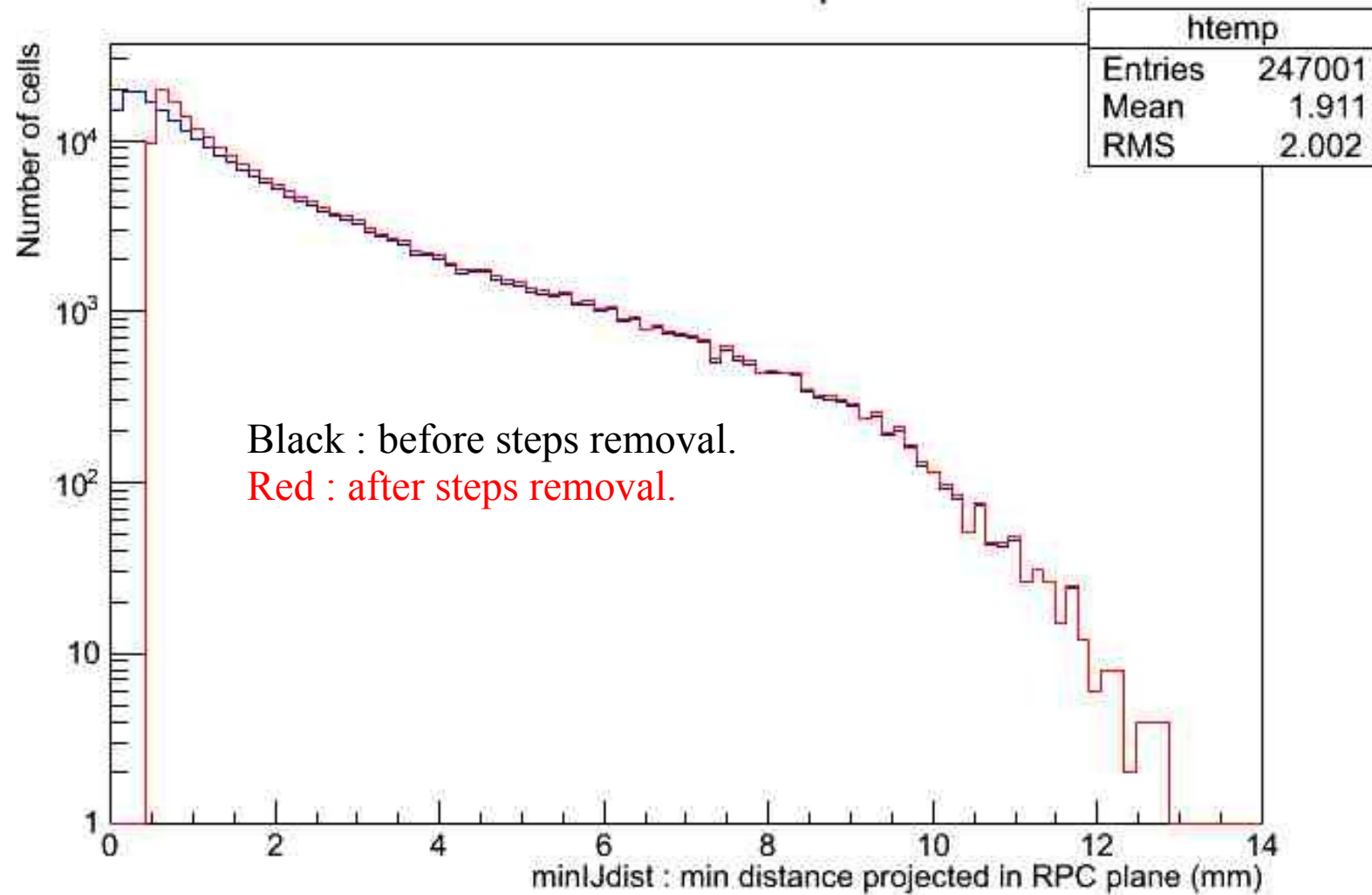
- Other option (thought, not implemented yet)
 - ◆ Modify Mokka
 - ◆ Don't store all the steps in the SimCalorimeterHit.
 - ◆ Store beginning of step instead of middle.
 - ◆ Modify the SDHCAL digitizer accordingly
 - ◆ Likely not for DBD.

Filter out steps

- Screening effect
 - ◆ Avalanches overlap if ionizing particles too close
 - ◆ Typical avalanche size 1 mm
 - ◆ Parameter processor
 - ◆ C="StepsMinDistanceRPCplaneDirection"
 - ◆ Default=0.5 mm
 - ◆ If distance projected in the RPC plane between 2 steps is smaller than C, then remove one step.

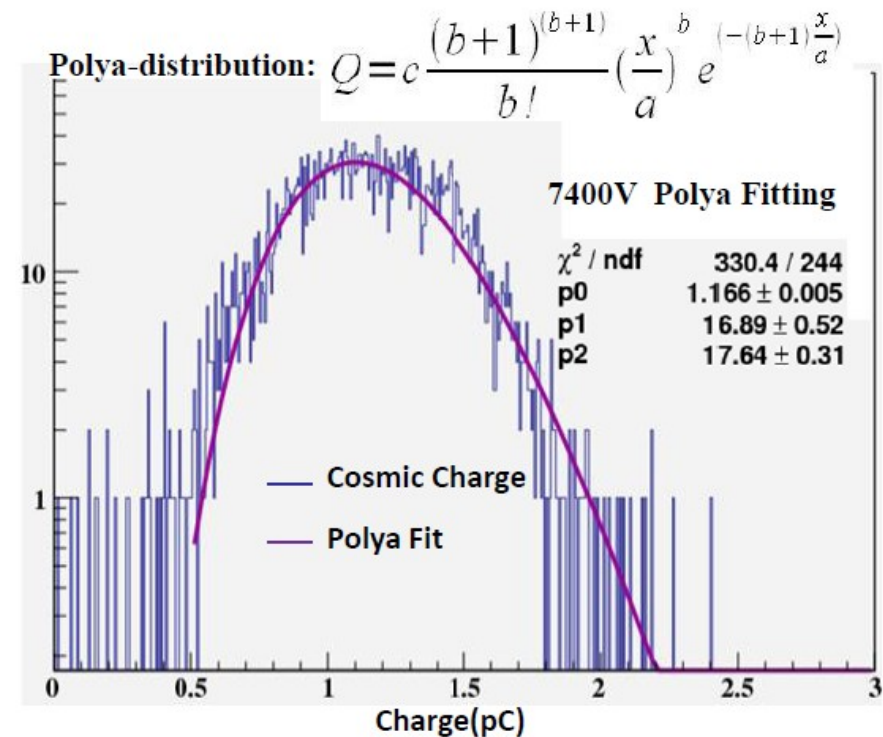
Filter out steps : screening effect

Min distance between 2 steps within a cell



Simulate induced charge

- ◆ Each step produced a random induced charge according to a Polya distribution.
 - ◆ Charge measured analogically on a small GRPC cathode
- ◆ Processor parameters :
 - ◆ "PolyaAverageCharge"
 - ◆ Parameter 'a'
 - ◆ "PolyaWidthParameter"
 - ◆ Parameter 'b'
 - ◆ Parameters might need tuning depending on GAS mixture used.



Dispatch charge

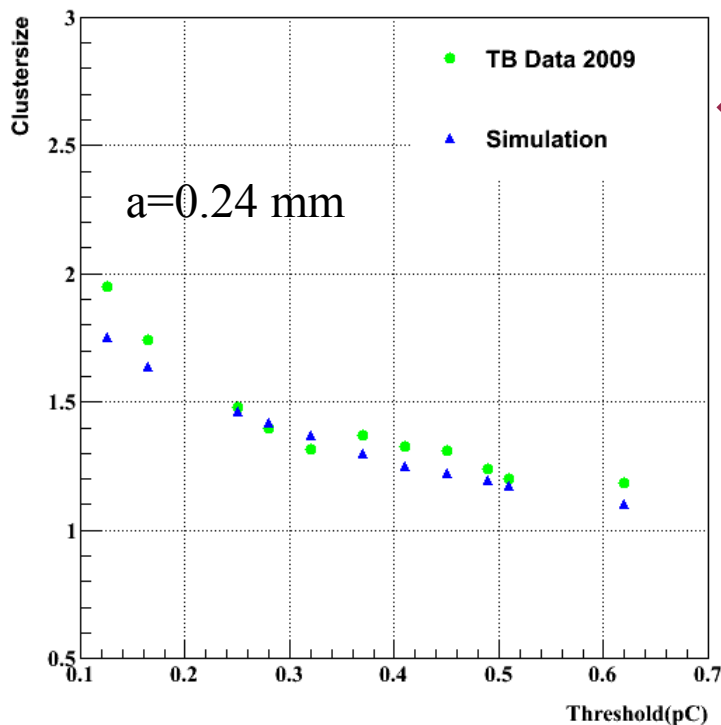
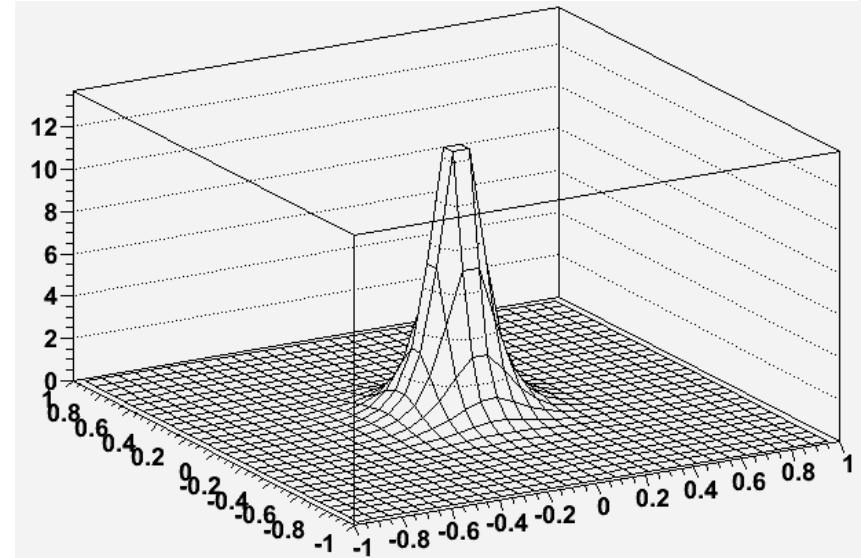
- Two options :
 - ◆ Uniform splitting (see backup)
 - ◆ Integrate charge spatial distribution (new)
 - ◆ Select with boolean processor parameter :
 - ◆ "UseFunctionForChargeSplitting"
 - ◆ default=true

Charge splitting with function

• Spread of the induced charge

KIRK T. MCDONALD's lecture

$$\sigma(x, y) = c \frac{-q}{2a} \frac{1}{\cosh\left(\pi \frac{\sqrt{(x-x_0)^2 + (y-y_0)^2}}{a}\right)}$$



◆ Processor parameters

◆ "functionFormula"

- ◆ ROOT TF2 formula

- ◆ Default = "1/cosh([0]*sqrt(x*x+y*y))"

◆ "functionParameters"

- ◆ Vector of parameters for the TF2

◆ Integrate on 'active' cell surface

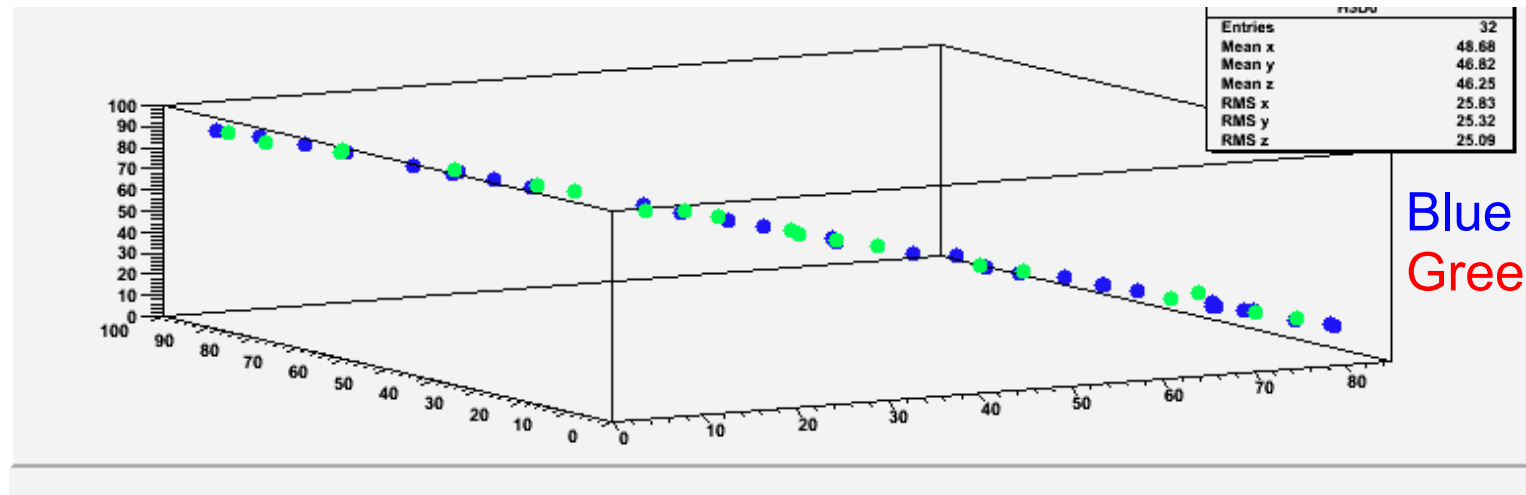
- ◆ See backup for details on parameters.

Apply thresholds

- Processor parameters :
 - ◆ "HCALThreshold"
 - ◆ Vector of thresholds in pc
 - ◆ "CalibrHCAL"
 - ◆ Vector of energy values
 - ◆ "doThresholds"
 - ◆ Bool flag, if true, replace output hit energy by value given by CalibrHCAL depending on the bigger HCALThreshold they exceed.
 - ◆ In any case, hits below the lowest threshold are removed.

Data analysis

- Need to use data to adjust digitizer parameters.
- Preparation for the coming april testbeam.
 - ◆ A cosmic muon recorded recently at Lyon



Conclusion

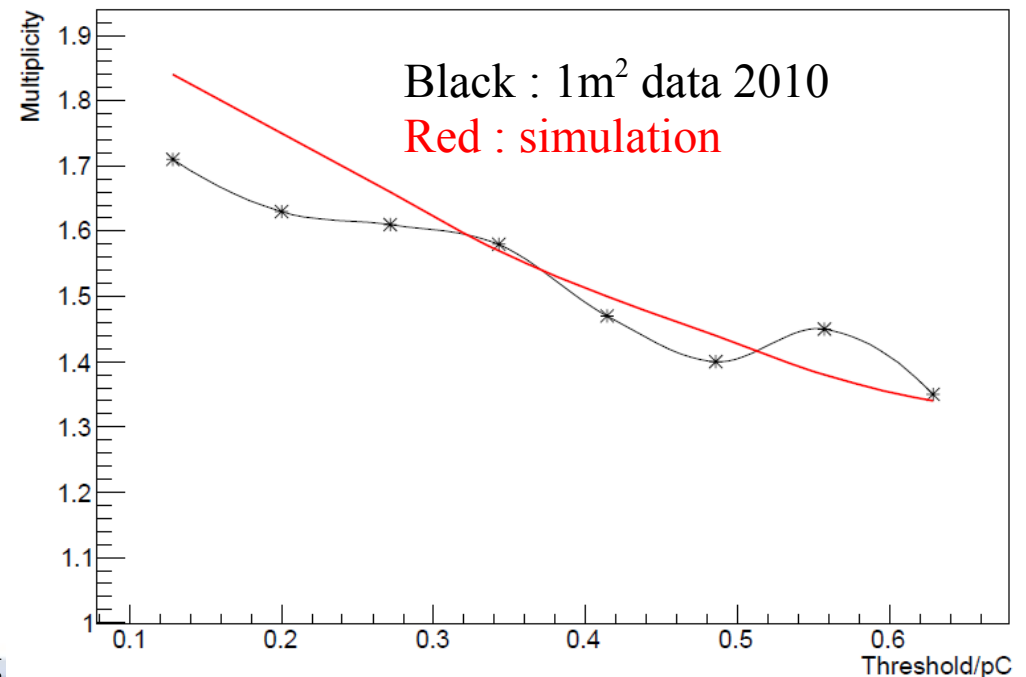
- Preparing SDHCAL software for the DBD.
 - ◆ Get the code ready for ILDsoft freeze.
 - ◆ Prepare Marlin setup xml file based on data.
- A couple of fixes for Mokka commit.
 - ◆ Then, though not perfect, SDHCAL ready for DBD software freeze.
- Marlin setup xml file for SDHCAL reconstruction will be prepared as the next step.
 - ◆ Will use data to tune it.

BACKUP

Other digitizer

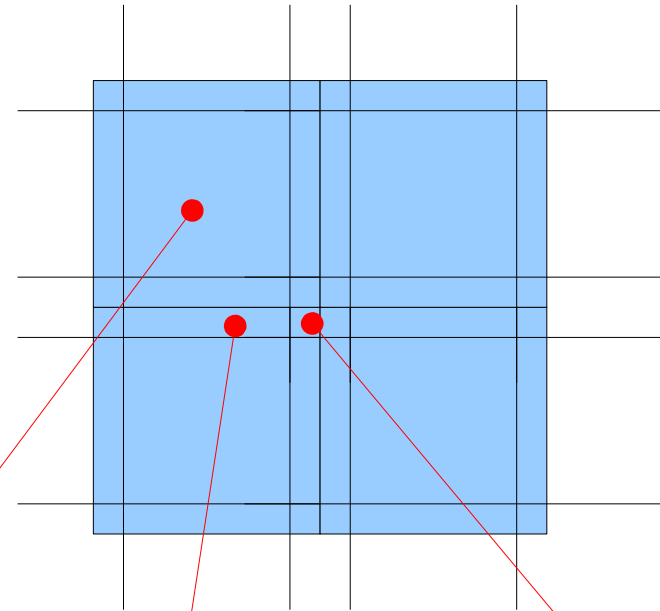
- Mokka simulation with 1 mm² cell size
 - ◆ Marlin processor rebuilds 1 cm² cells
 - ◆ No need of step position.
 - ◆ Need Marlin able to cope with varying geometry (cell size).
 - ◆ Also tunable to data.

Expected Multiplicity Curve Vs Measured



Uniform charge splitting

- Processor parameter :
 - ◆ "CellEdgeDistance"
 - ◆ Distance from cell border under which charge should be dispatched.



If step is here,
put all the
charge in one
cell

If step is here,
split the charge
half-half
between the 2
neighbouring
cells

If step is here,
put a quarter of
the charge in
each of the 4
neighbouring
cells

Charge splitting with function

- $f(x,y)$ is a function describing the induced charge spatial distribution for a step.

- ◆ (x,y) = coordinate in the “cell frame”.

- ◆ Fraction of charge attributed to a cell :

$$\frac{\int_{x_{\min cellBorderPos}}^{x_{\max cellBorderPos}} dx \int_{y_{\min cellBorderPos}}^{y_{\max cellBorderPos}} dy f(x, y)}{\int_{-R}^R dx \int_{-R}^R dy f(x, y)}$$

- ◆ Processor parameters :

- ◆ "functionRange" : R above

- ◆ "RPC_PadSeparation" :

- ◆ Simulate interpad by reducing surface of integration per cell.