ECAL-P pad-resizing and charge sharing

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[1]University of Warsaw

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Analysis setup

- File used in analysis: /nfs/dust/luxe/group/MCProduction/SinglePositron/elaser_positron/mc21.singlePositron_50GeV_ECALP_run2.G4gun.SIM.se0003.root,

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- data from Hits and Trajectory trees,
- 20k events with single positron hitting centre of ECAL-P perpendicularly,
- the same initial energy for each positron, following results obtained for e^+ energy equal to 5GeV

Analysis setup

- Analysis of deposits in first active layer only $\rightarrow$ minimization of electromagnetic showers effects,

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- Analysis of deposits in first active layer only $\rightarrow$ minimization of electromagnetic showers effects,
- no way to remove or correct for effects from positron passing $1X_0$ thick tungsten plate before hitting silicon,
- distribution of hits positions in first layer of silicon sensors is concentrated around point (314.13,0) in global coordinate frame,
- standard deviation of hits positions is around 0.5mm in X and Y direction.

Analysis setup

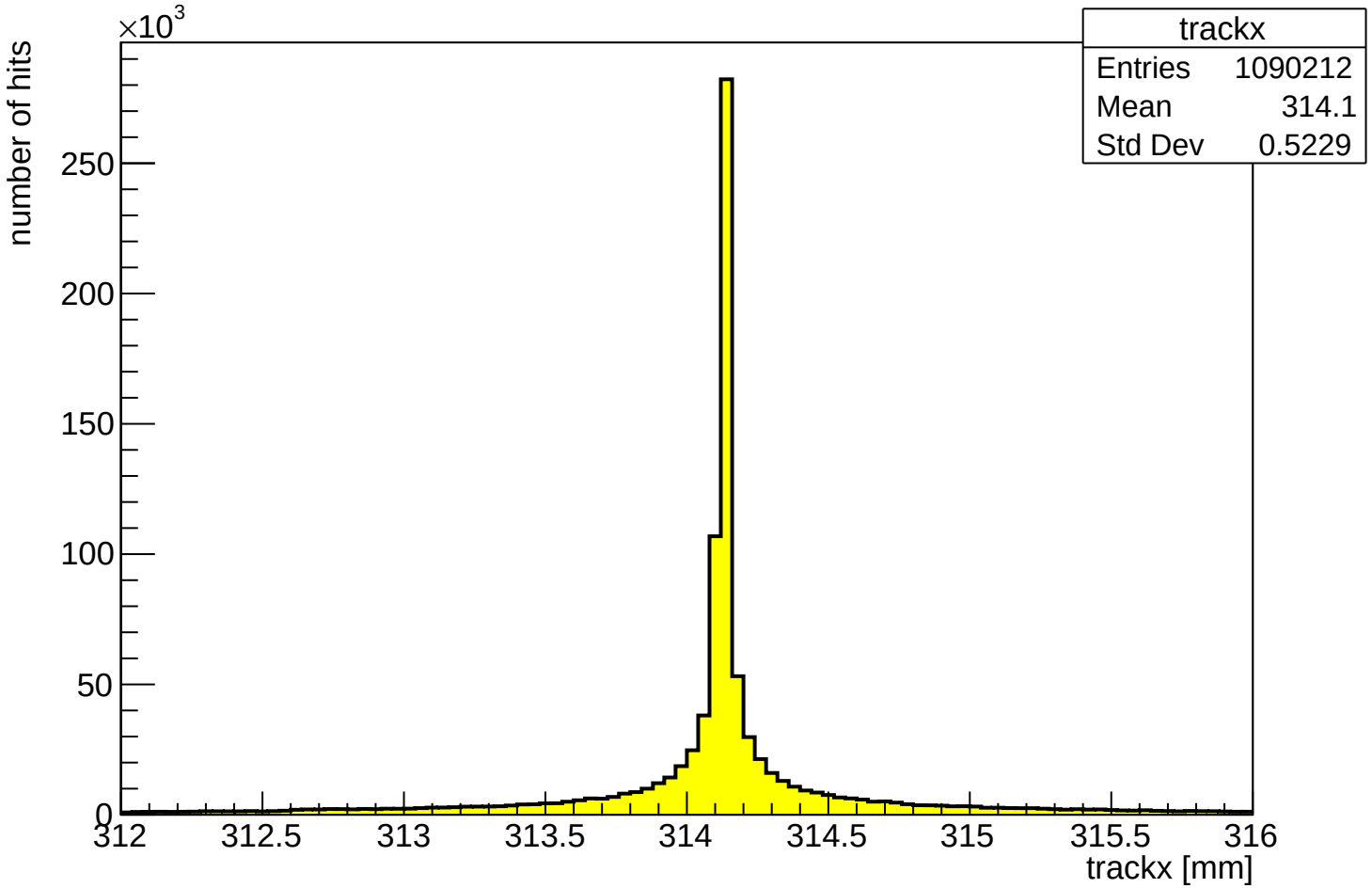


Figure: Distribution of x coordinate of positions of hits in first layer of silicon sensors

Analysis setup

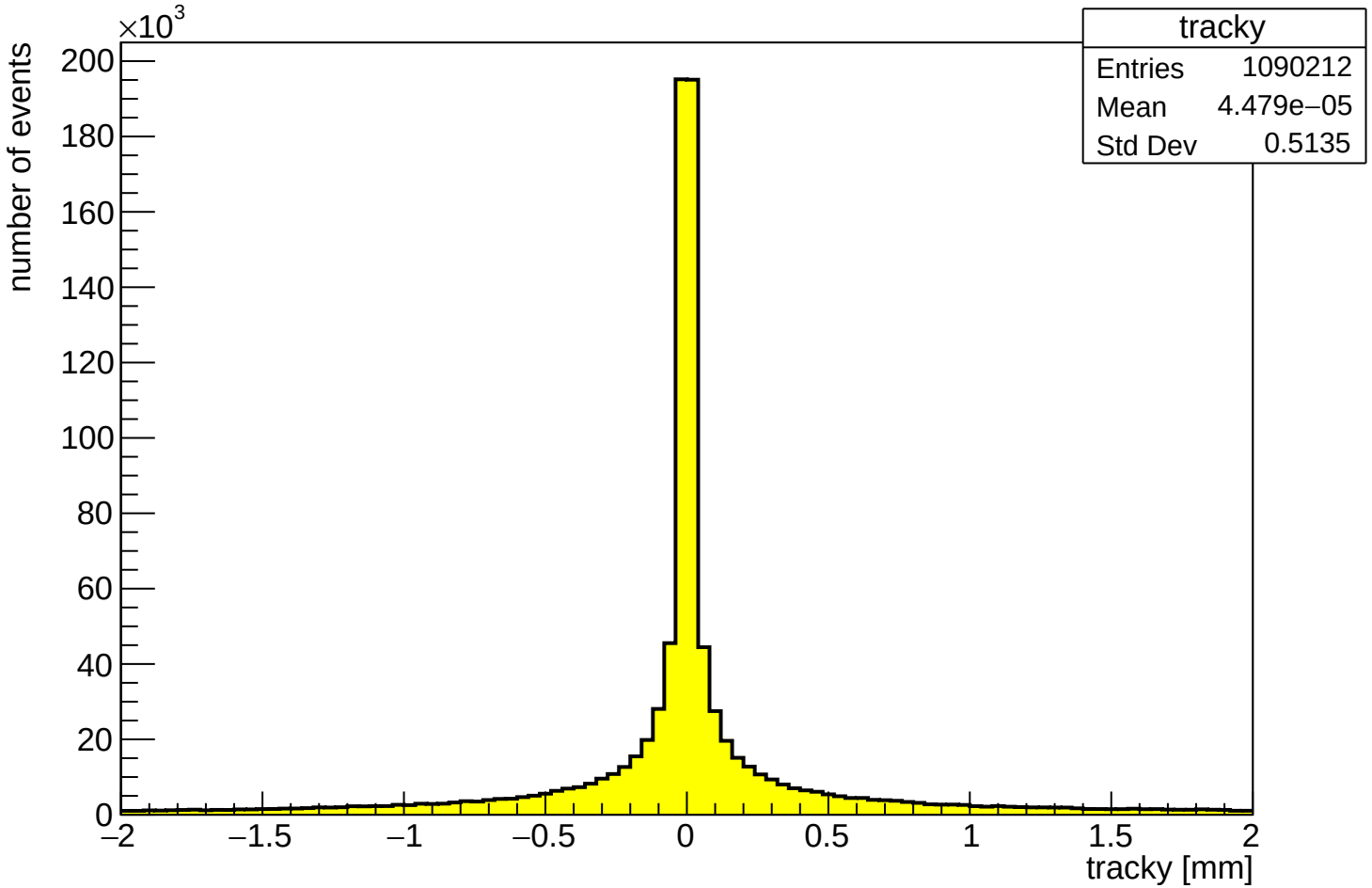


Figure: Distribution of y coordinate of positions of hits in first layer of silicon sensors

Pad-resizing

- Need for changing layout from monolithic 550mmx55mm silicon plane from Geant4 simulation to the one consisting of six CALICE sensors.

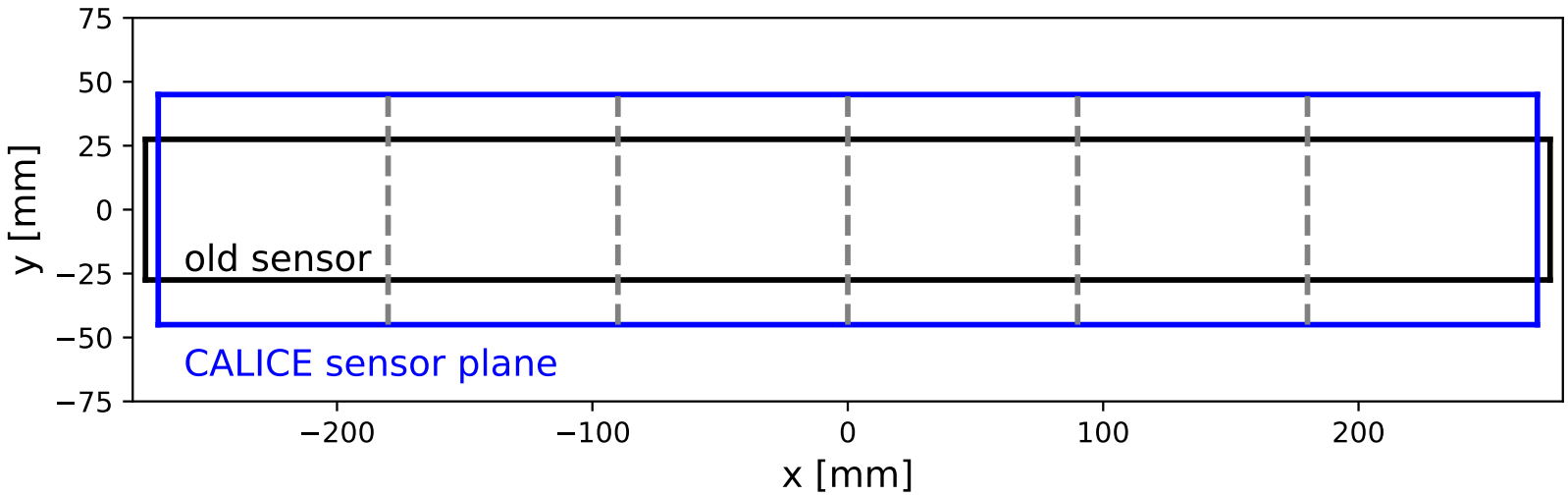


Figure: CALICE sensor plane dimensions in comparison with old sensor from Geant4 simulation.

Pad-resizing

- Energy is not collected from the dead areas between each CALICE sensor,

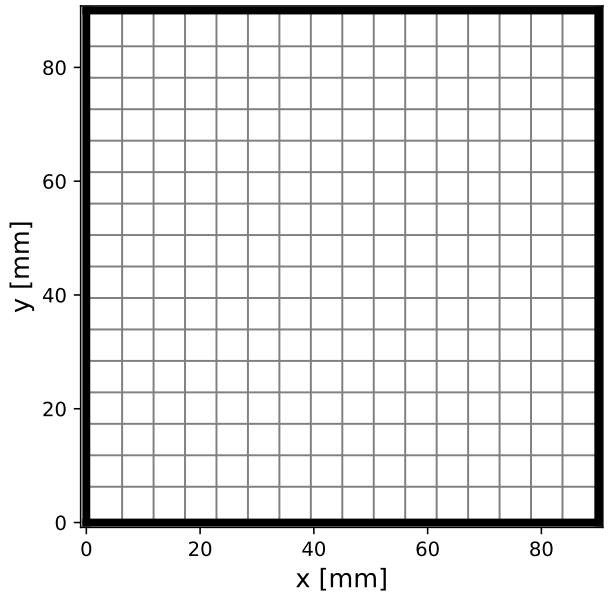
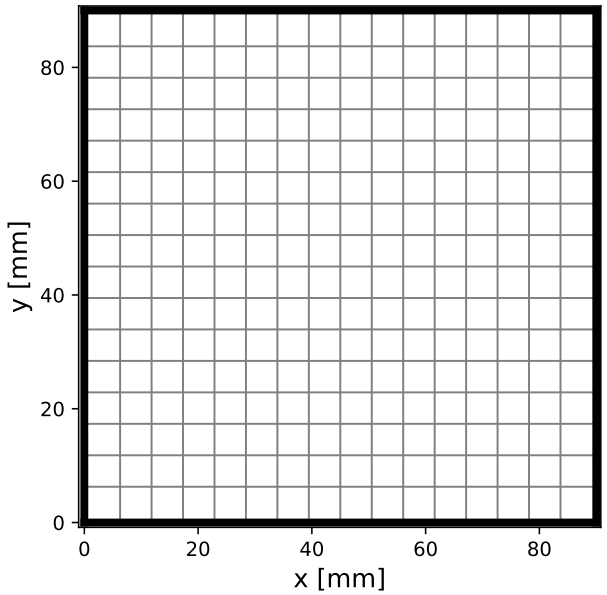


Figure: CALICE sensor divided into pixels.

Pad-resizing

- Energy is not collected from the dead areas between each CALICE sensor,
- CALICE sensor size: 89.7mm,



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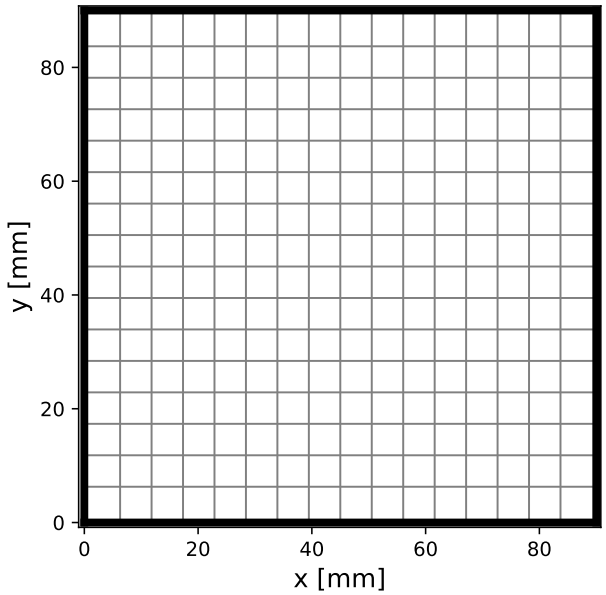
Pad-resizing

- Energy is not collected from the dead areas between each CALICE sensor,
- CALICE sensor size: 89.7mm,
- CALICE sensor active area: 88.48mm,



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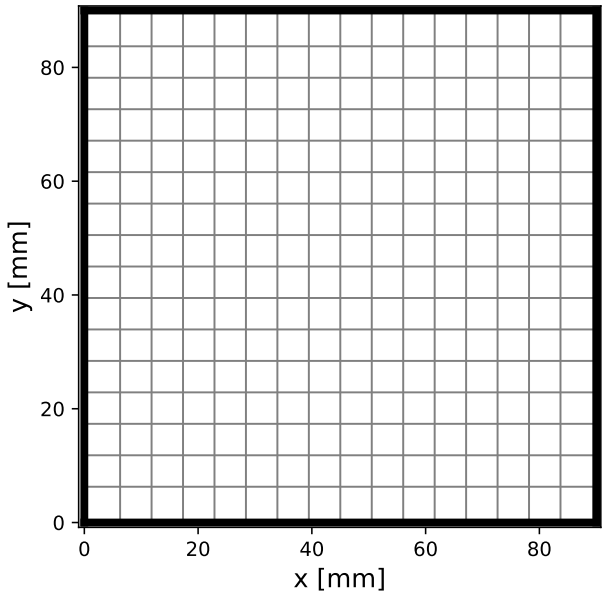
Pad-resizing

- Energy is not collected from the dead areas between each CALICE sensor,
- CALICE sensor size: 89.7mm,
- CALICE sensor active area: 88.48mm,
- other goal of the analysis: implementation the mechanism which allows charge deposited in one pixel to flow to neighbouring pixel.



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Charge sharing

- Charge can be shared between two neighbouring pixels in the same sensor,

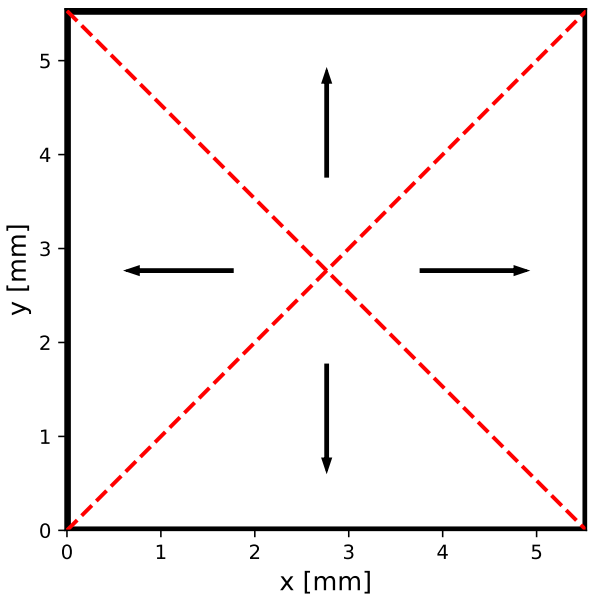
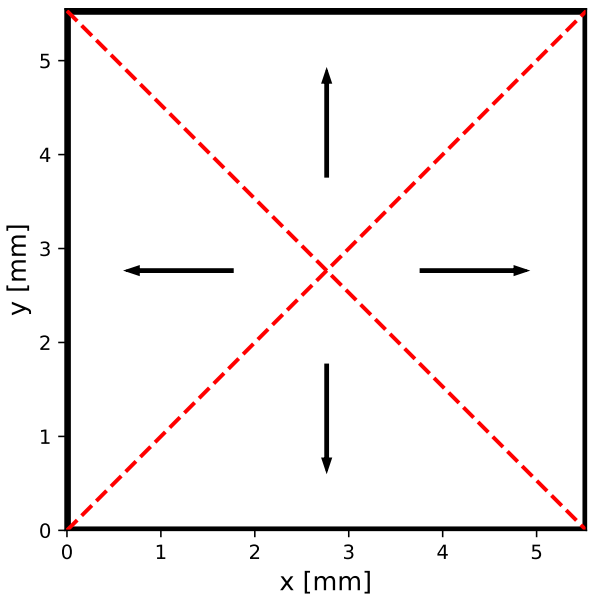


Figure: Charge sharing areas in the pixel

Charge sharing

- Charge can be shared between two neighbouring pixels in the same sensor,
- Each pixel is divided into four areas.



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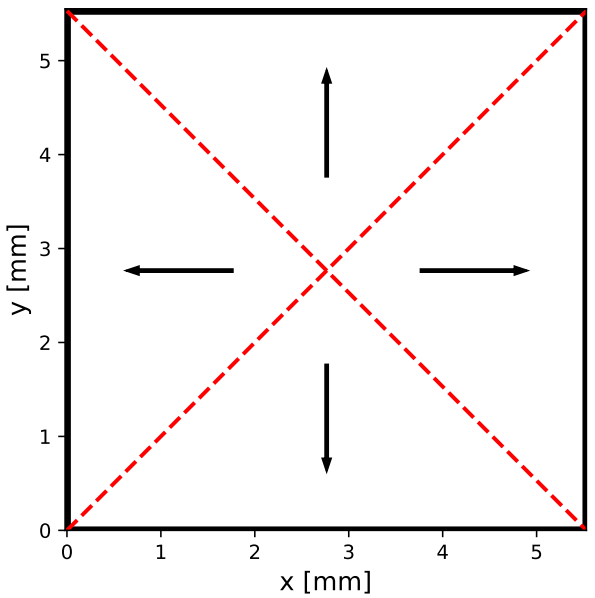
- Charge can be shared between two neighbouring pixels in the same sensor,
- Each pixel is divided into four areas.
- Charge can flow from particular area only to pixel pointed by the arrow.



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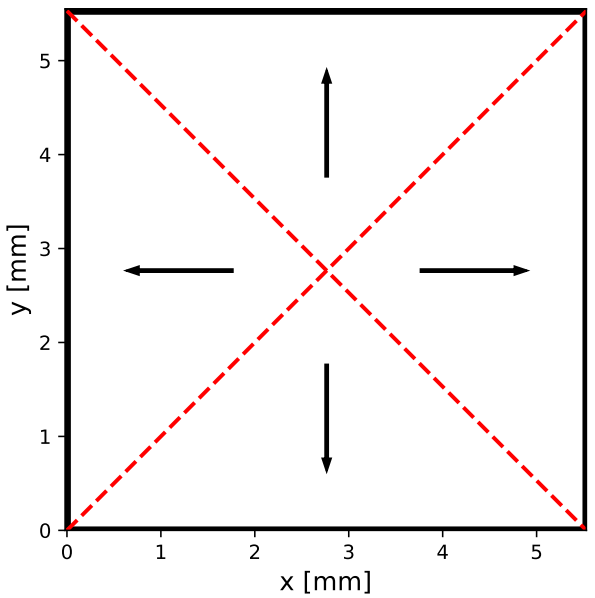
- Each pixel is divided into four areas.
- Charge can flow from particular area only to pixel pointed by the arrow.
- No charge flow to pixels on diagonal.



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Charge sharing

- Charge sharing is described by the function presented on the right.

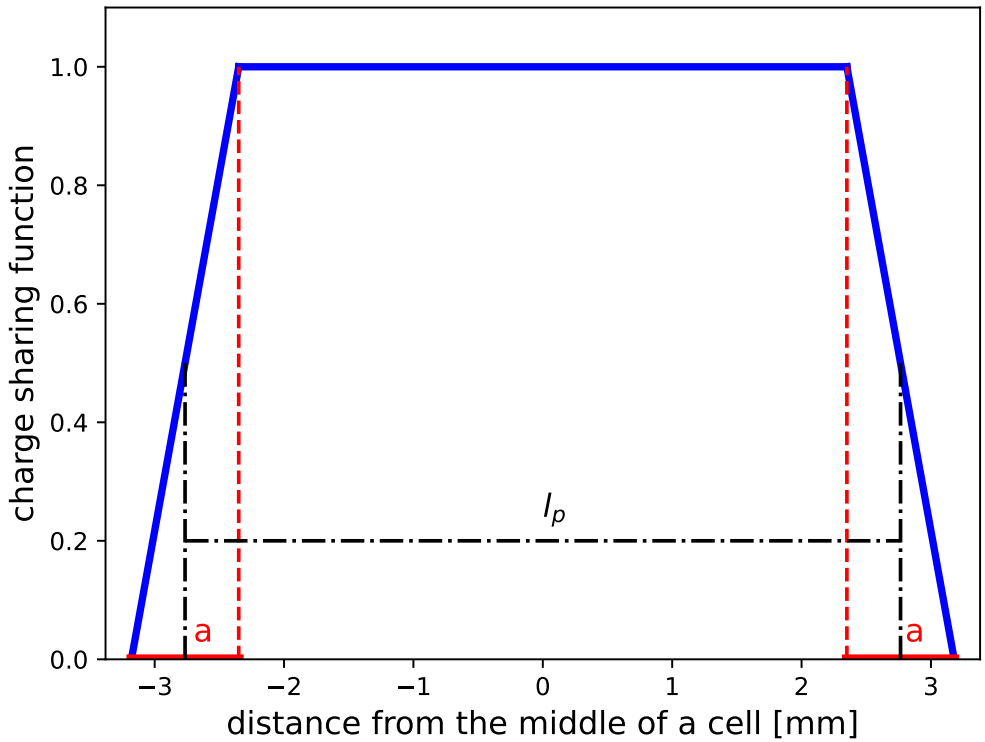

Figure: Charge sharing function

Charge sharing

- Charge sharing is described by the function presented on the right.
- Parameter *a* describes the size of the region, which charge is shared from.

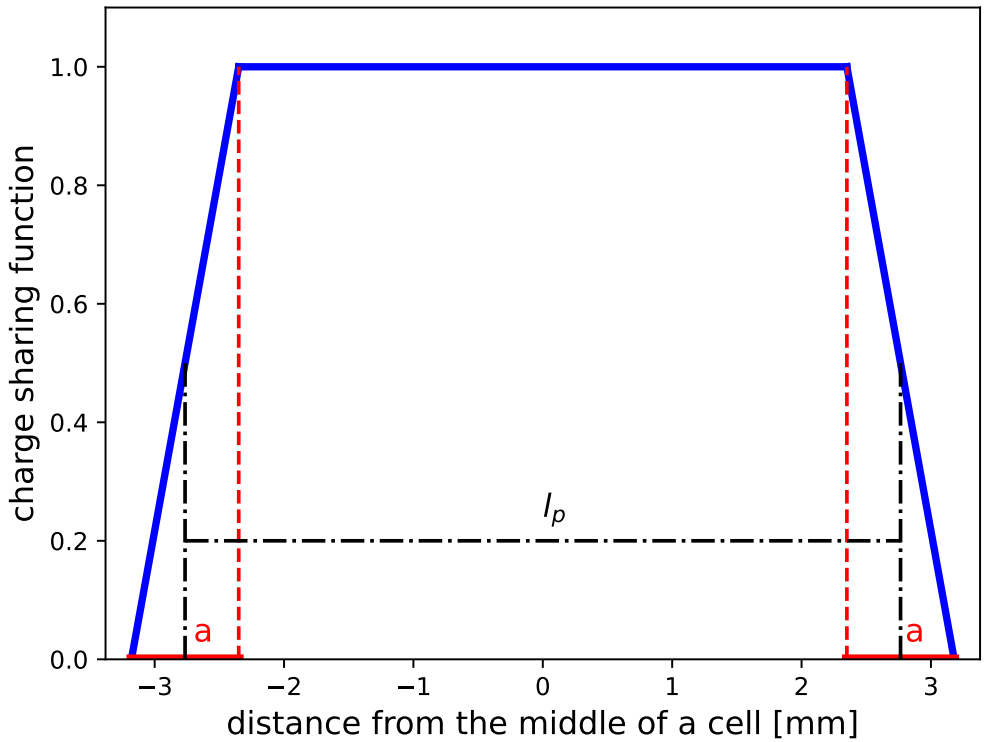

Figure: Charge sharing function

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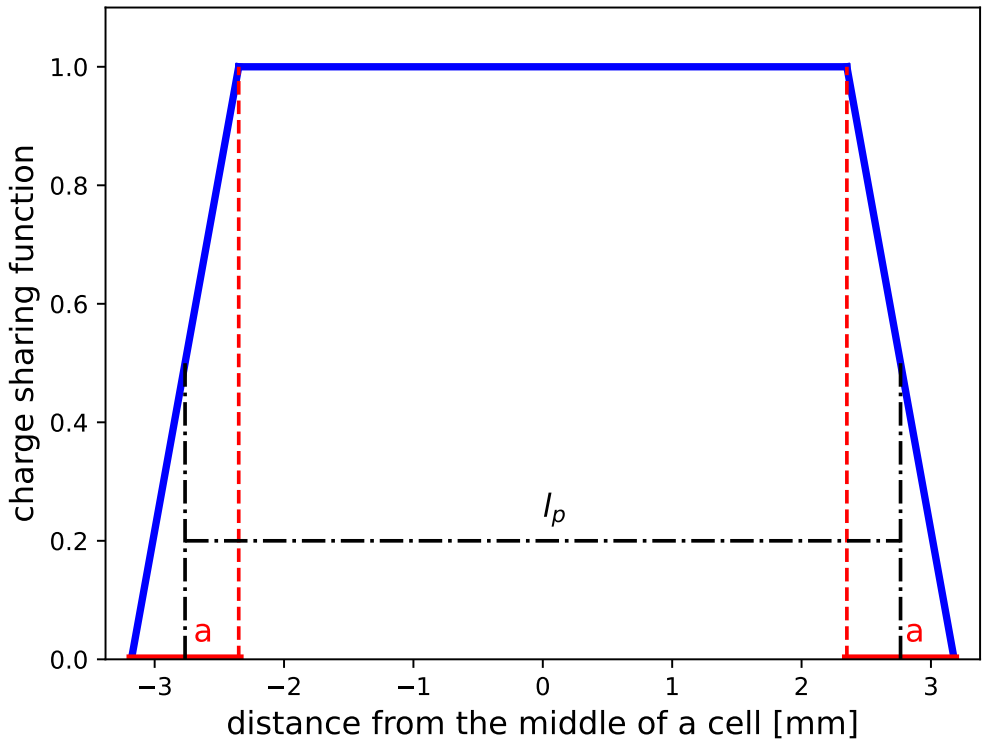
- Charge sharing is described by the function presented on the right.
- Parameter a describes the size of the region, which charge is shared from.
- Black dash-dotted line marked with l_p indicates the size of the pixel.



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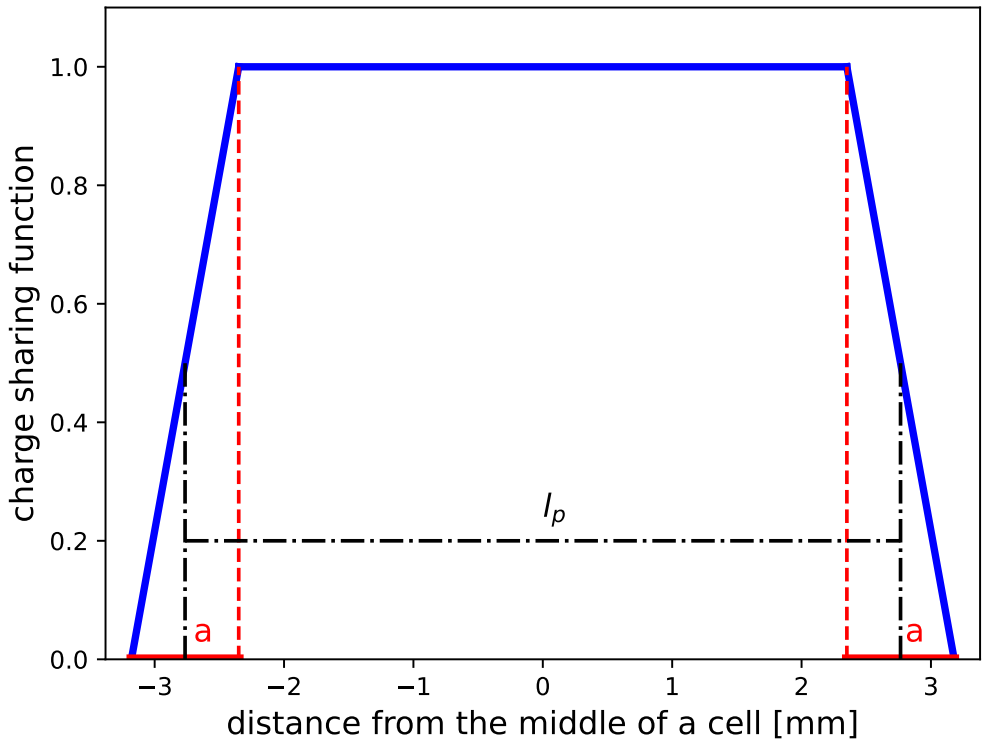
- Charge sharing is described by the function presented on the right.
- Parameter a describes the size of the region, which charge is shared from.
- Black dash-dotted line marked with l_p indicates the size of the pixel.
- l_p is set to 5.53mm but can be adjusted.



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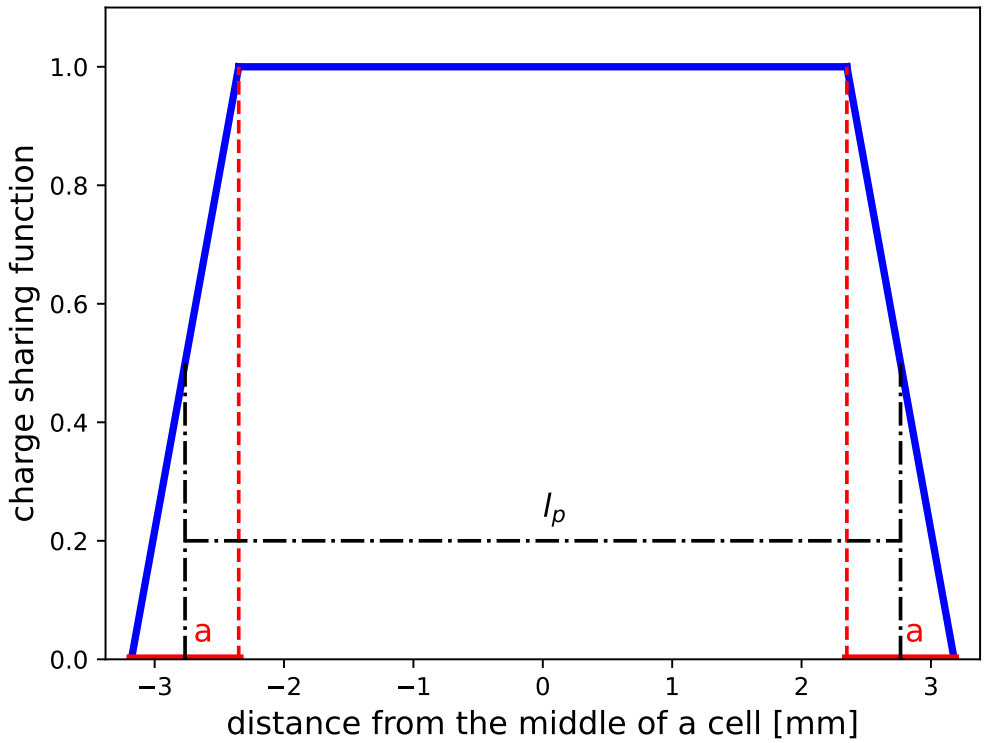
Charge sharing

- Charge sharing is described by the function presented on the right.
- Parameter a describes the size of the region, which charge is shared from.
- Black dash-dotted line marked with l_p indicates the size of the pixel.
- l_p is set to 5.53mm but can be adjusted.
- There is no charge loss implemented so far.



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Tests with MC

- Method to adjust the position of the layer so that initial positron hits chosen part of the sensor,

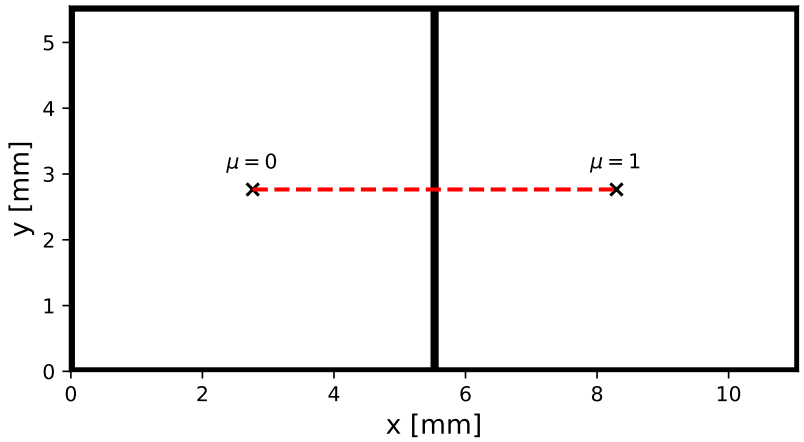

Figure: Parameterization of the section between middle of pixels (55,8) and (56,8)

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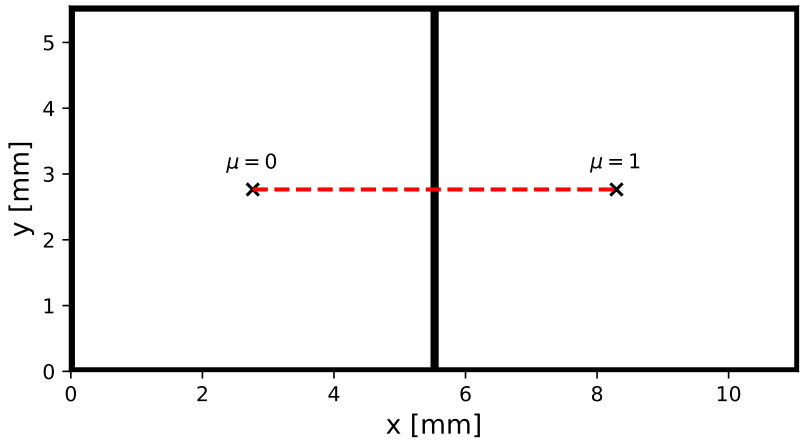
- Method to adjust the position of the layer so that initial positron hits chosen part of the sensor,
- Pixels (55,8) and (56,8) situated in 4^{th} CALICE sensor were chosen,



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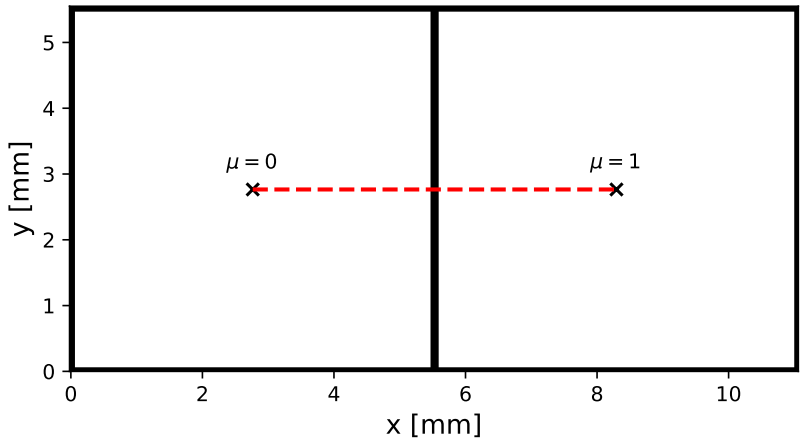
Tests with MC

- Method to adjust the position of the layer so that initial positron hits chosen part of the sensor,
- Pixels (55,8) and (56,8) situated in 4^{th} CALICE sensor were chosen,
- Parameterization of the position between two pixels with μ parameter: starting with $\mu = 0$ in the middle of pixel (55,8) and ending with $\mu = 1$ in the middle of pixel (56,8).



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- Energy to charge and charge to ADC units conversion has non been done yet.

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- Energy distributions in first layer of silicon sensors for different values of μ parameter and for two neighbouring pixels are presented in following slides.
- Parameter a was set to be equal 5% of pixel size (5.53mm).

Energy deposits distribution

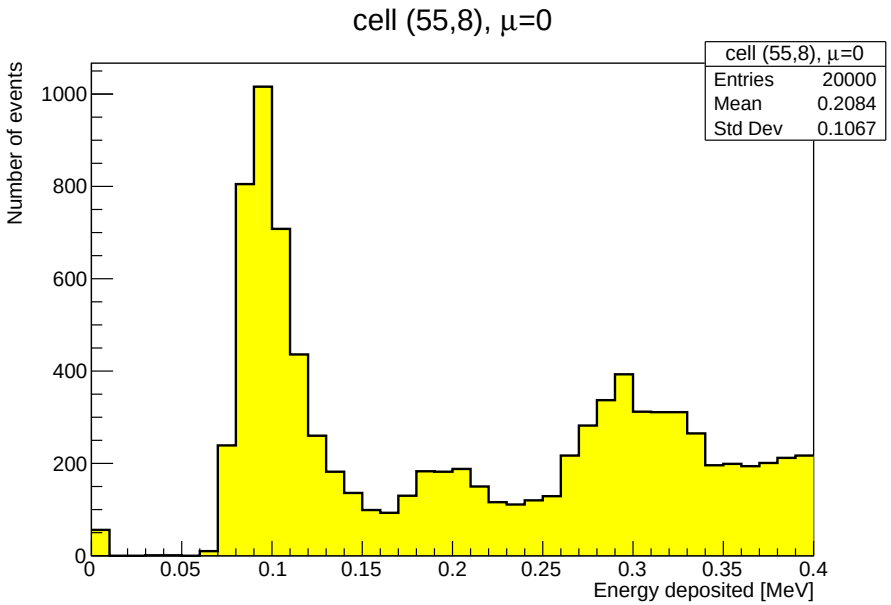
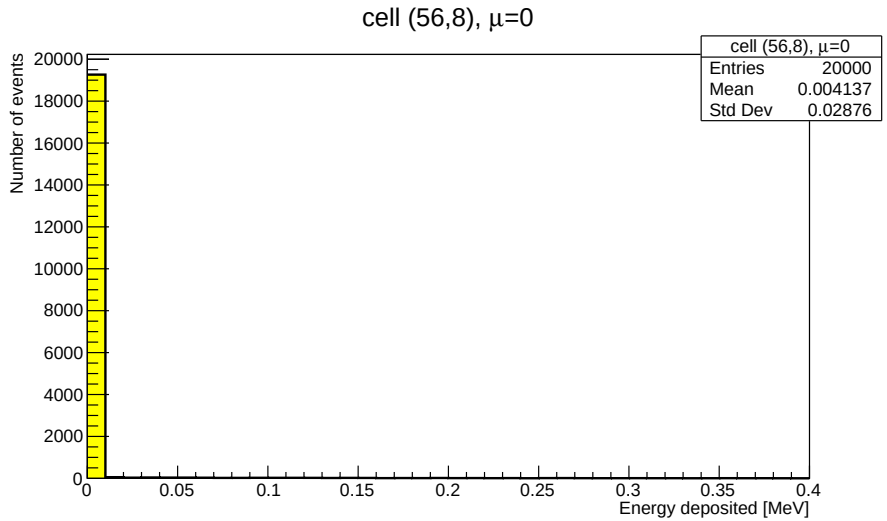


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0$



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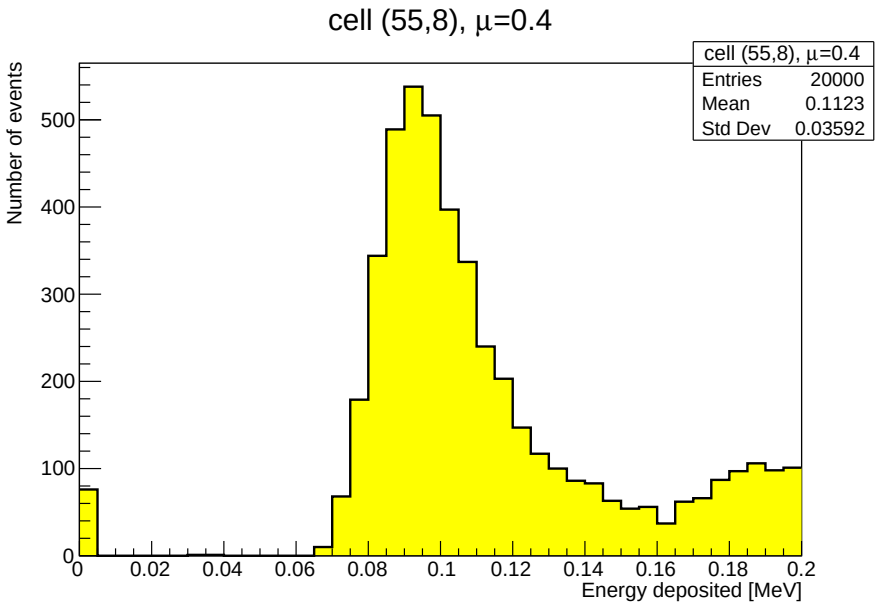


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.4$

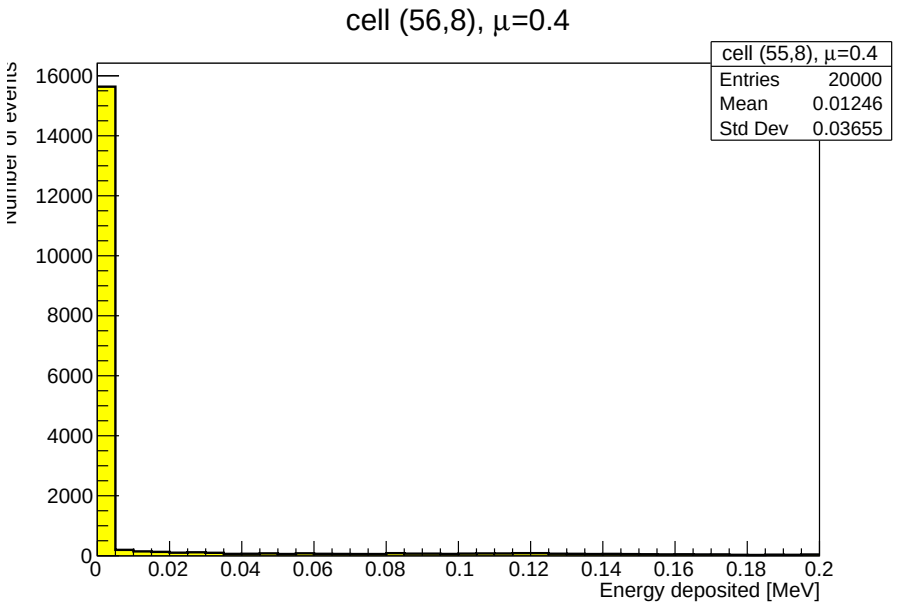


Figure: Energy distribution of hits in pixel (56,8) for $\mu = 0.4$

Energy deposits distribution

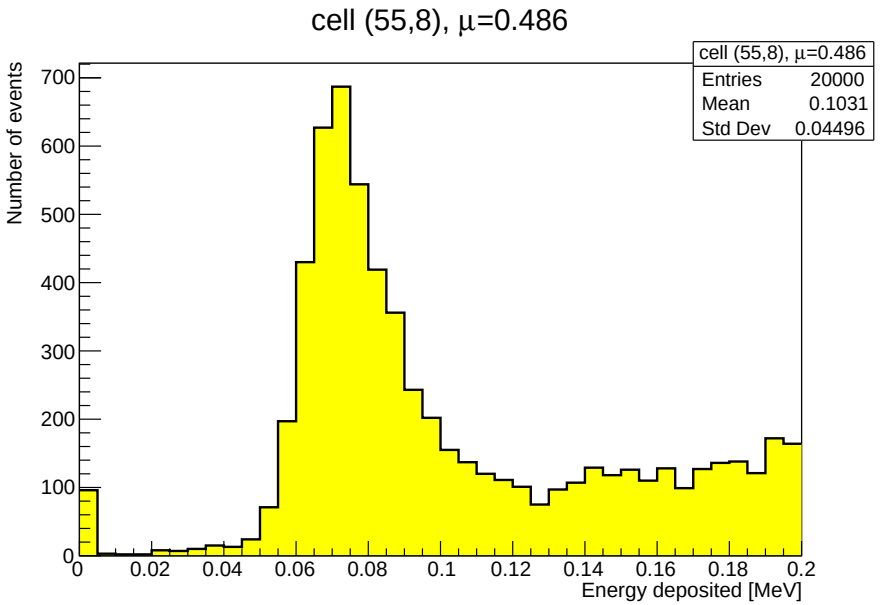
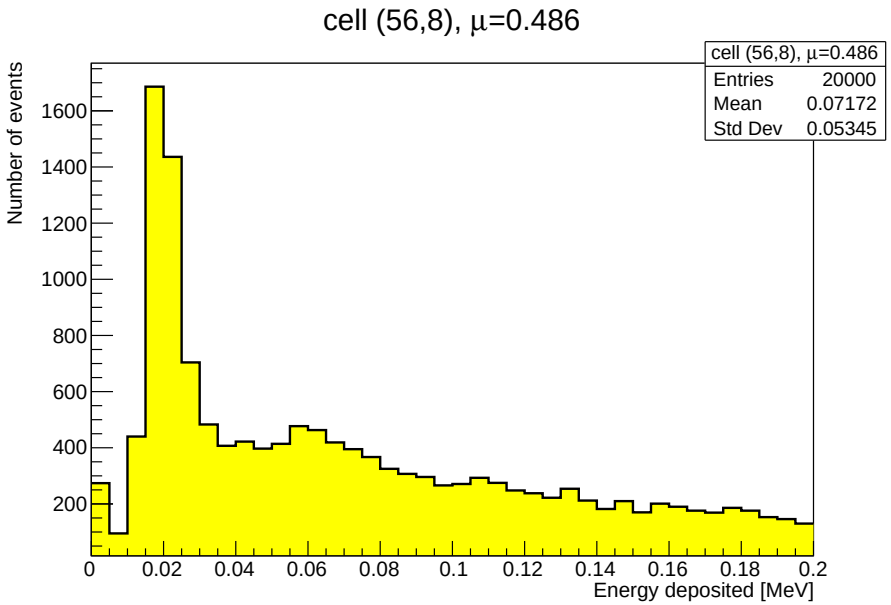


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.486$



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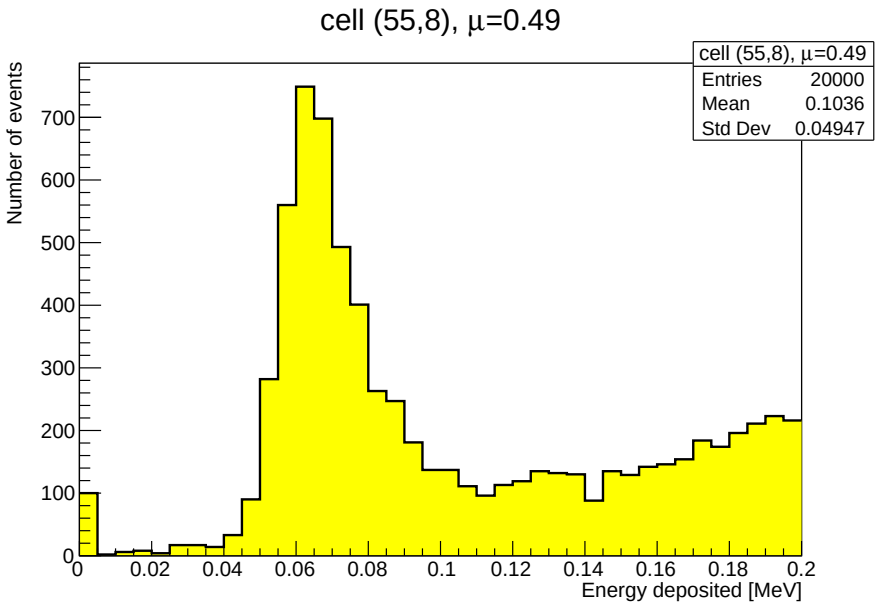
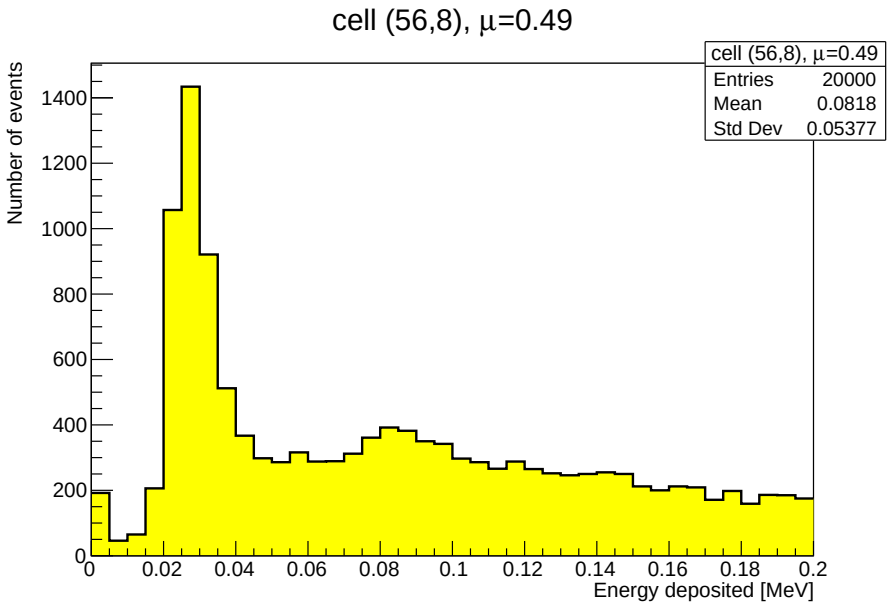


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.49$



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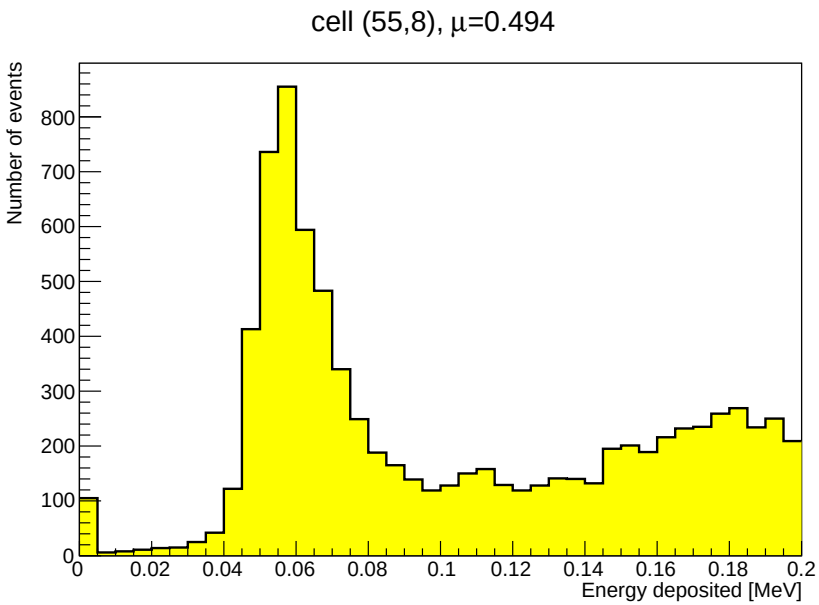
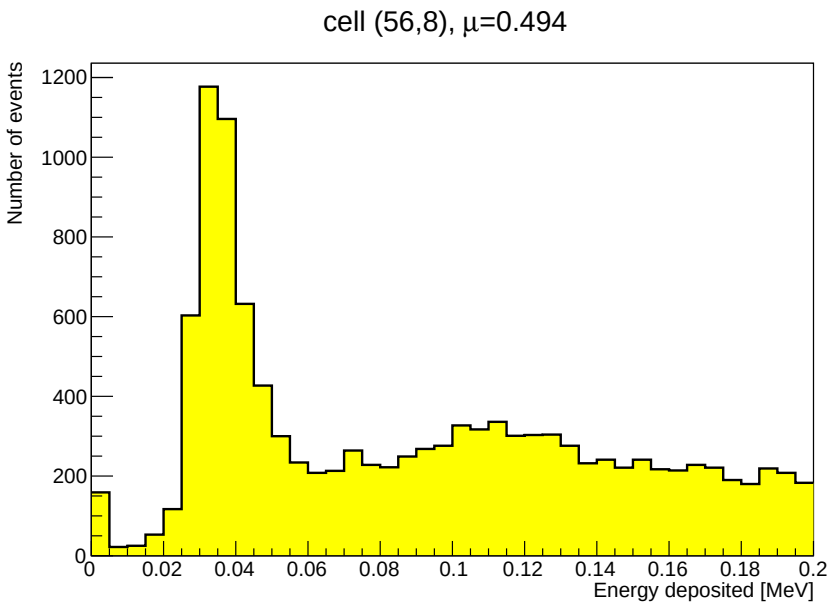


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.494$



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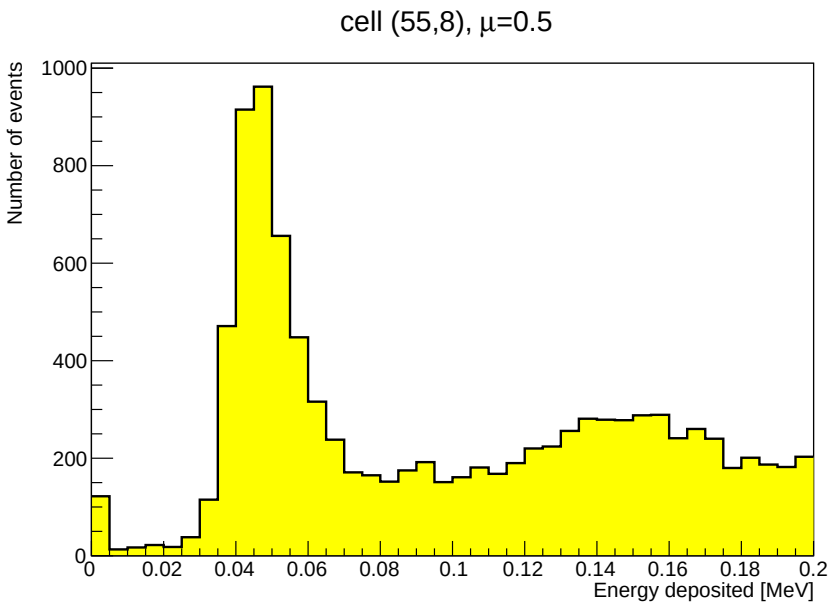
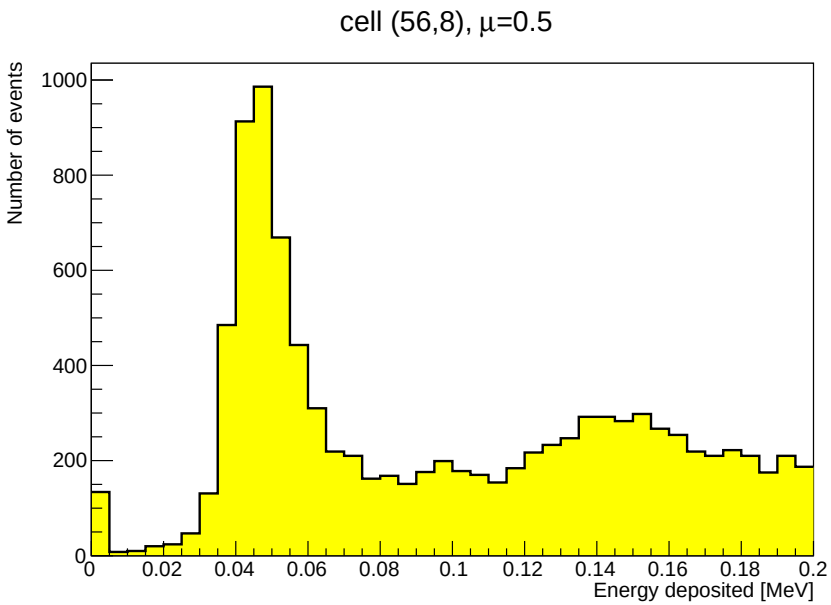


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.5$



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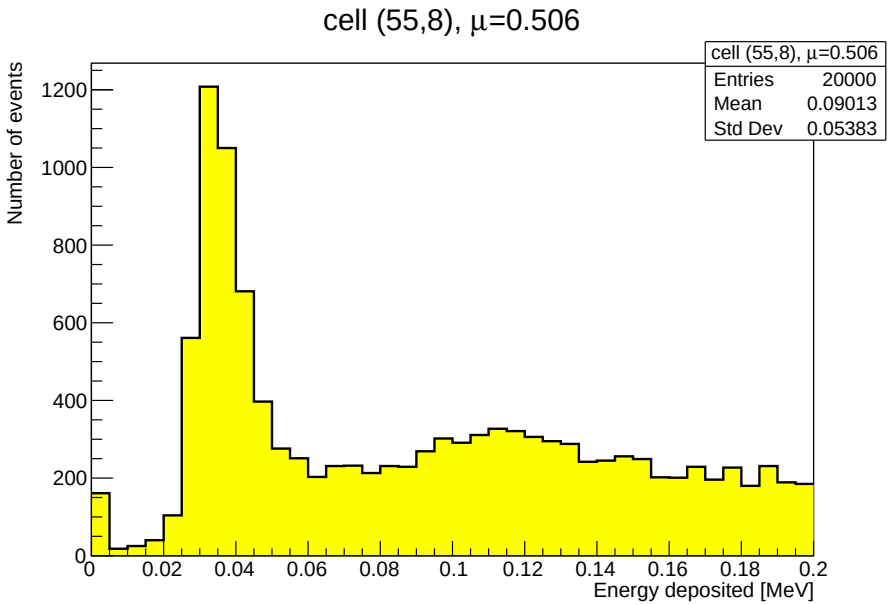
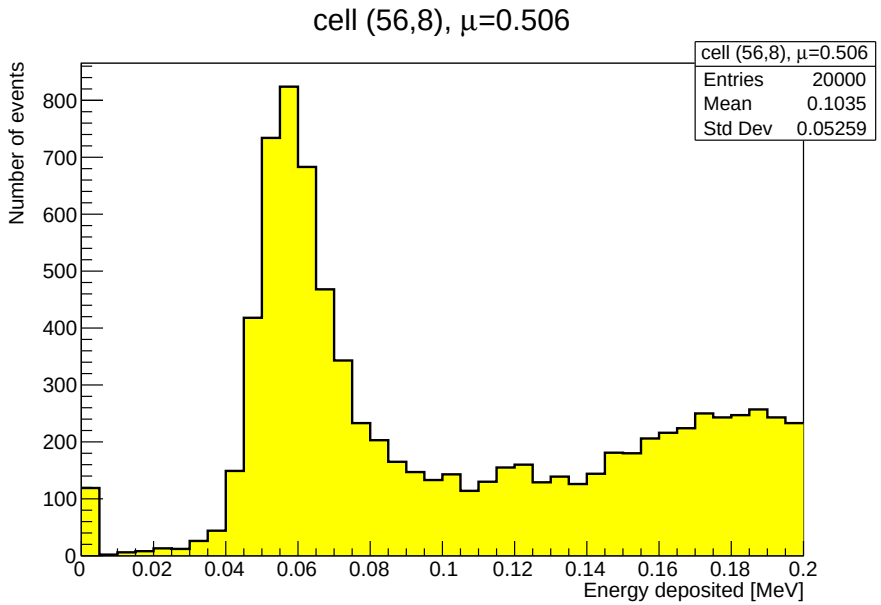


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.506$



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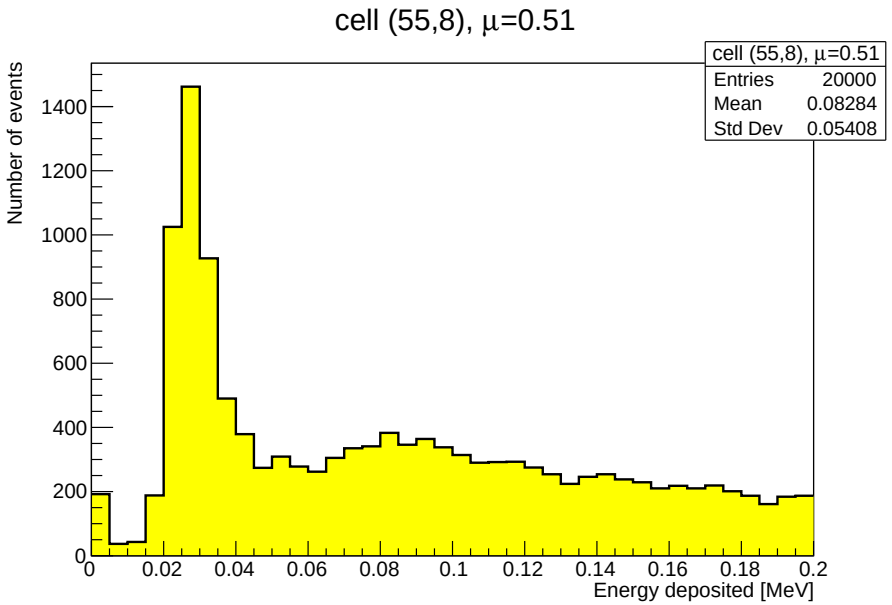
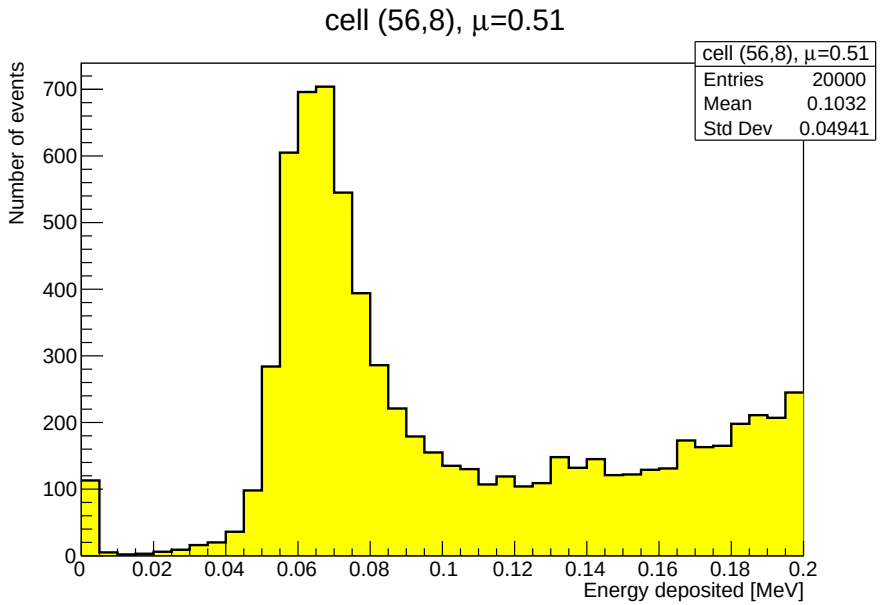


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.51$



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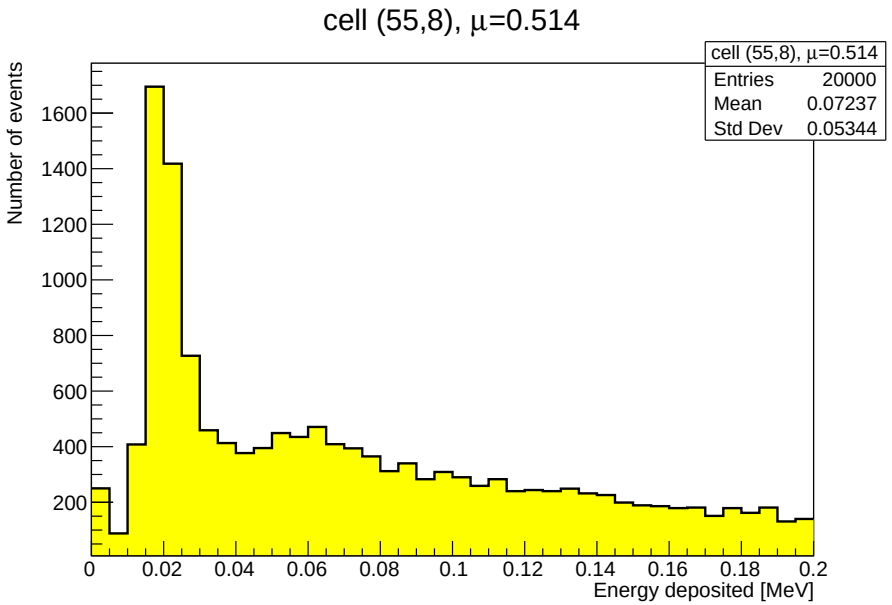
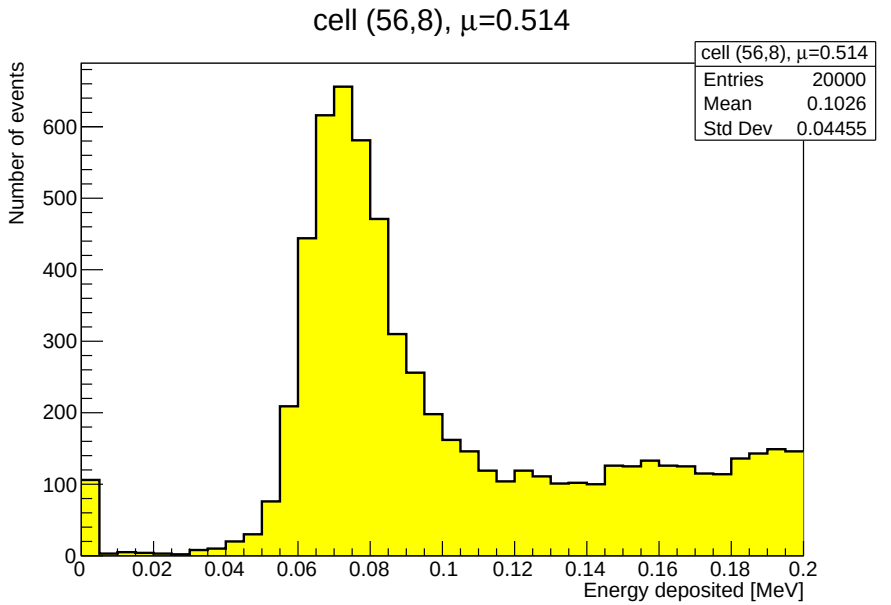


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 0.514$



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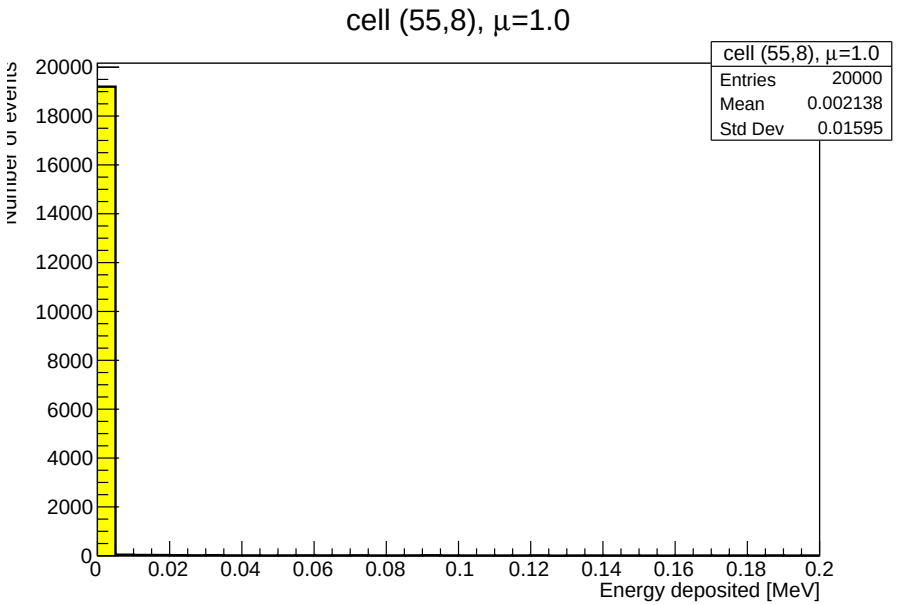
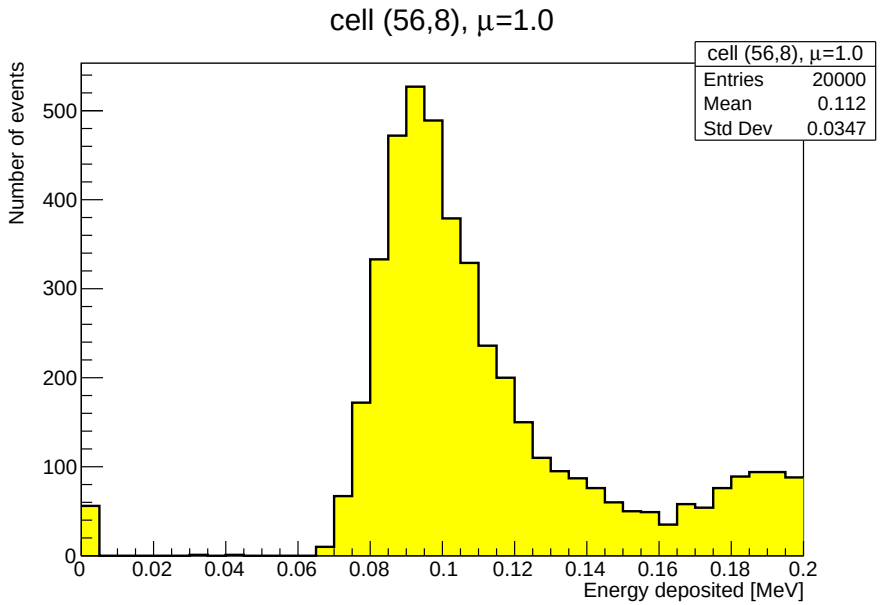


Figure: Energy distribution of hits in pixel (55,8) for $\mu = 1$



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- Multiple peaks appear because of electromagnetic showers in tungsten.
- For μ around 0.5 the peaks are moving towards lower energies in pixel hit by initial positron.
- Energy is shared to neighbouring cell.
- For $\mu = 0.5$ distributions have the same shape and peaks are in the same positions.
- The effect is symmetric for $\mu > 0.5$.

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- It was done by fitting Landau distribution in the area of first MIP signal.
- Cut was applied to energy lost in tungsten plate (data from Trajectory tree).
- Two cuts: first on total energy loss in tungsten and second on energy lost on Bremsstrahlung.

Choosing deposits from primary particle

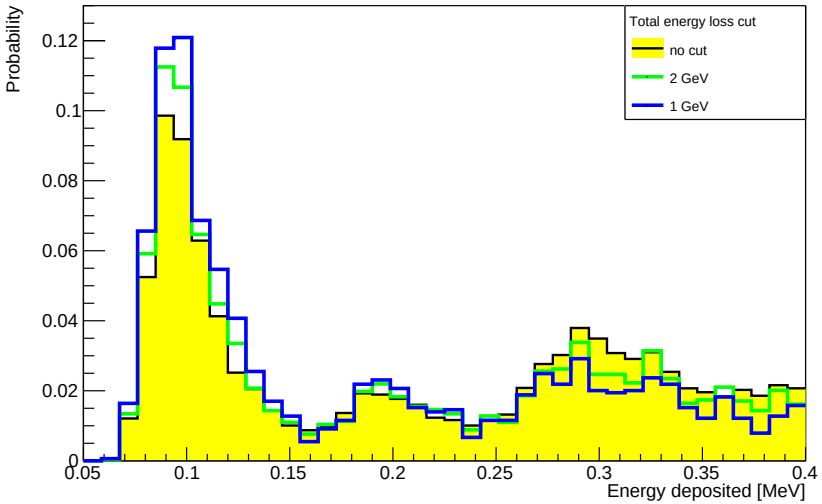

Figure: Energy distrubution in pixel (55,8) with cut on total energy lost in tungsten plate before silicon sensors. Positron gun was set to hit centre of the pixel, $\mu = 0$.

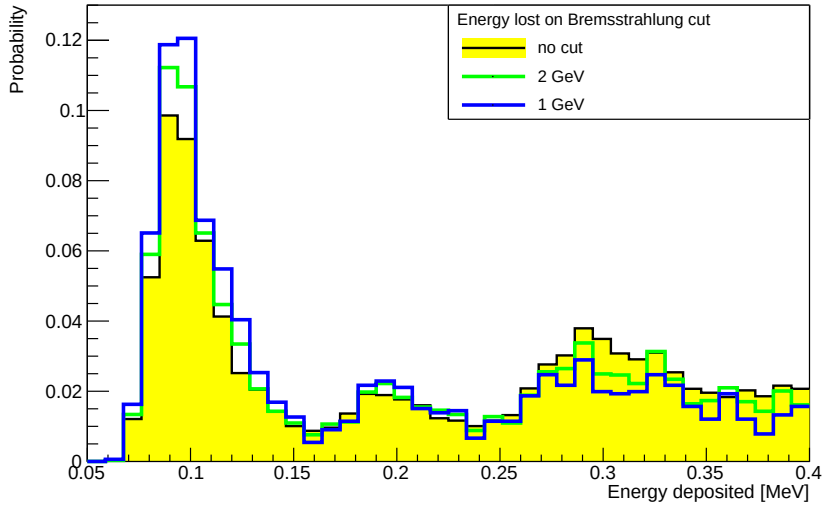

Figure: Energy distrubution in pixel (55,8) with cut on energy lost on Bremsstrahlung in tungsten plate before silicon sensors. Positron gun was set to hit centre of the pixel, $\mu = 0$.

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- Relative height of the first peak increases when cut is applied $\rightarrow$ impact of events when there is an electromagnetic shower in tungsten plate is reduced,
- Following pictures present results from fitting Landau distribution to first peak from histograms from slide 16, $\mu = 0.494$.

Exemplary fit

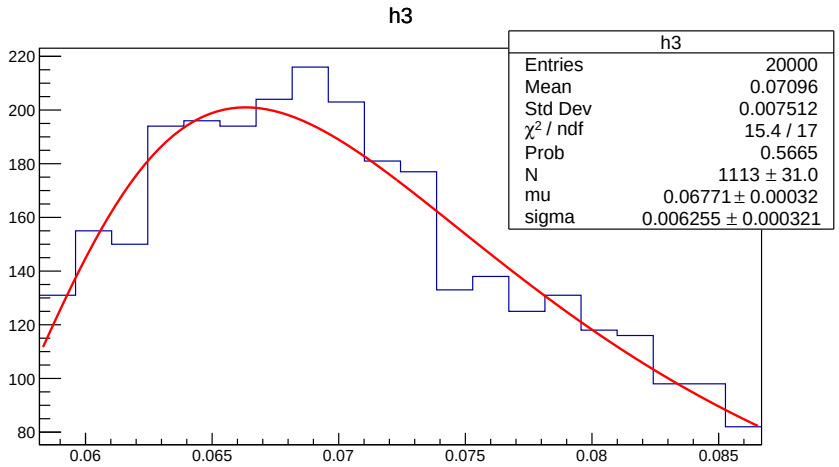
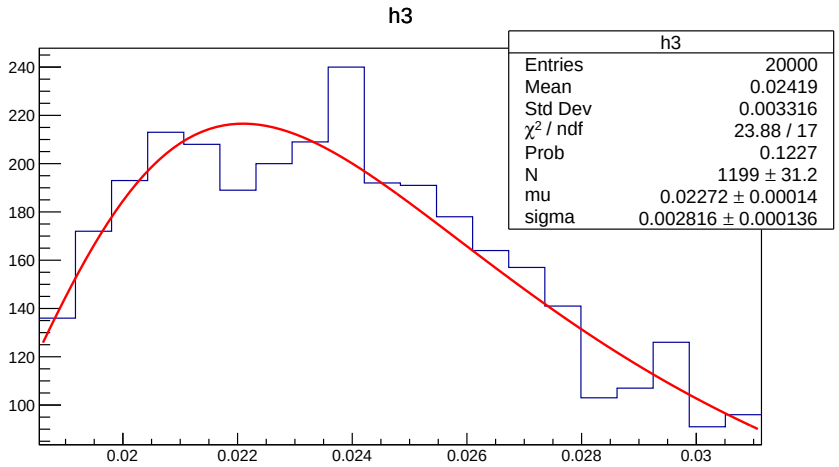


Figure: Exemplary fit of Landau distribution to energy deposits distribution for $\mu = 0.488$, pixel (55,8)



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Final result

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- Each plot contains the dependance of MPV from the fit on μ parameter.

Final result

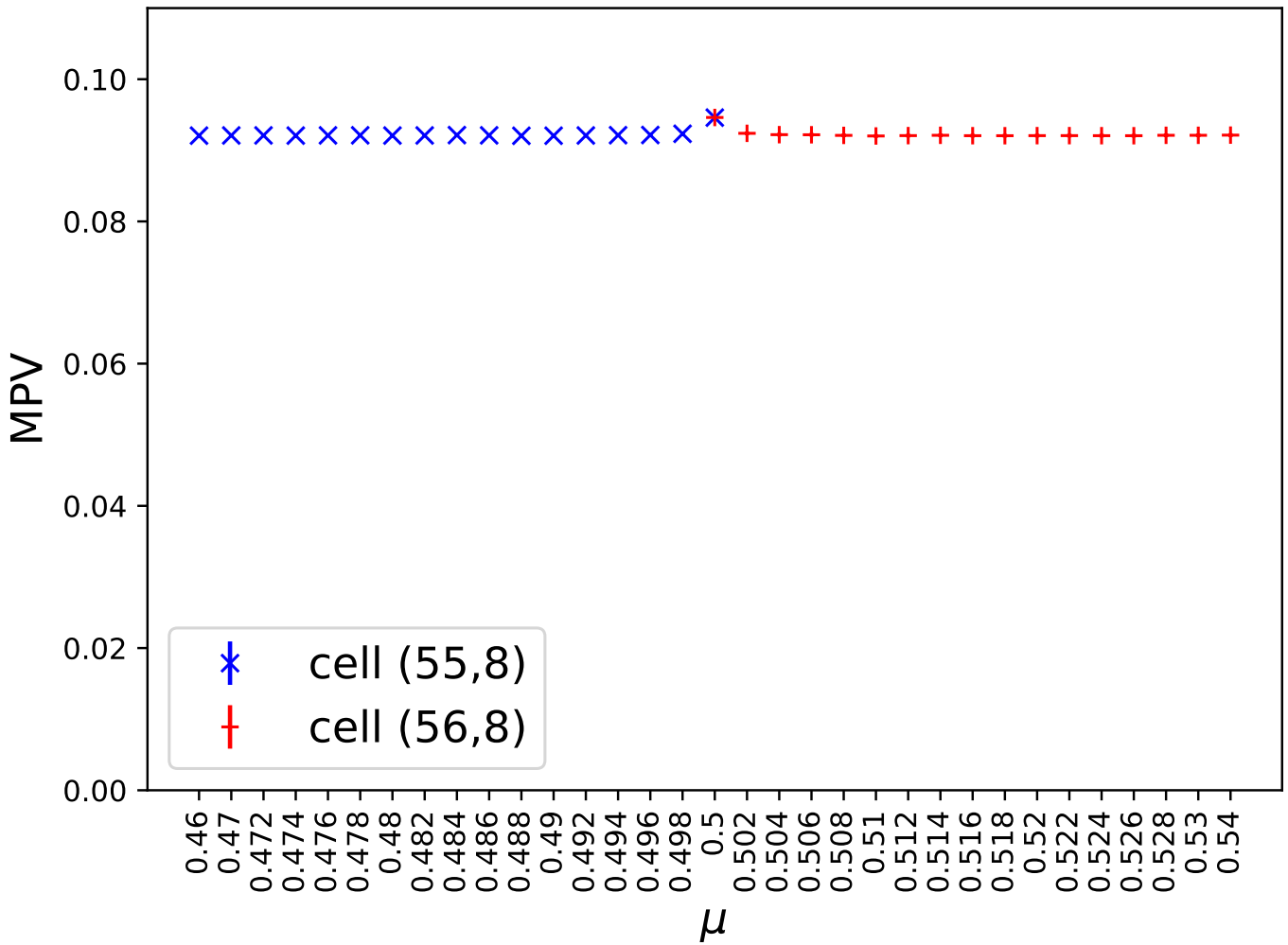

Figure: MPV as a function of μ, $a = 0mm$, without charge sharing.

Final result

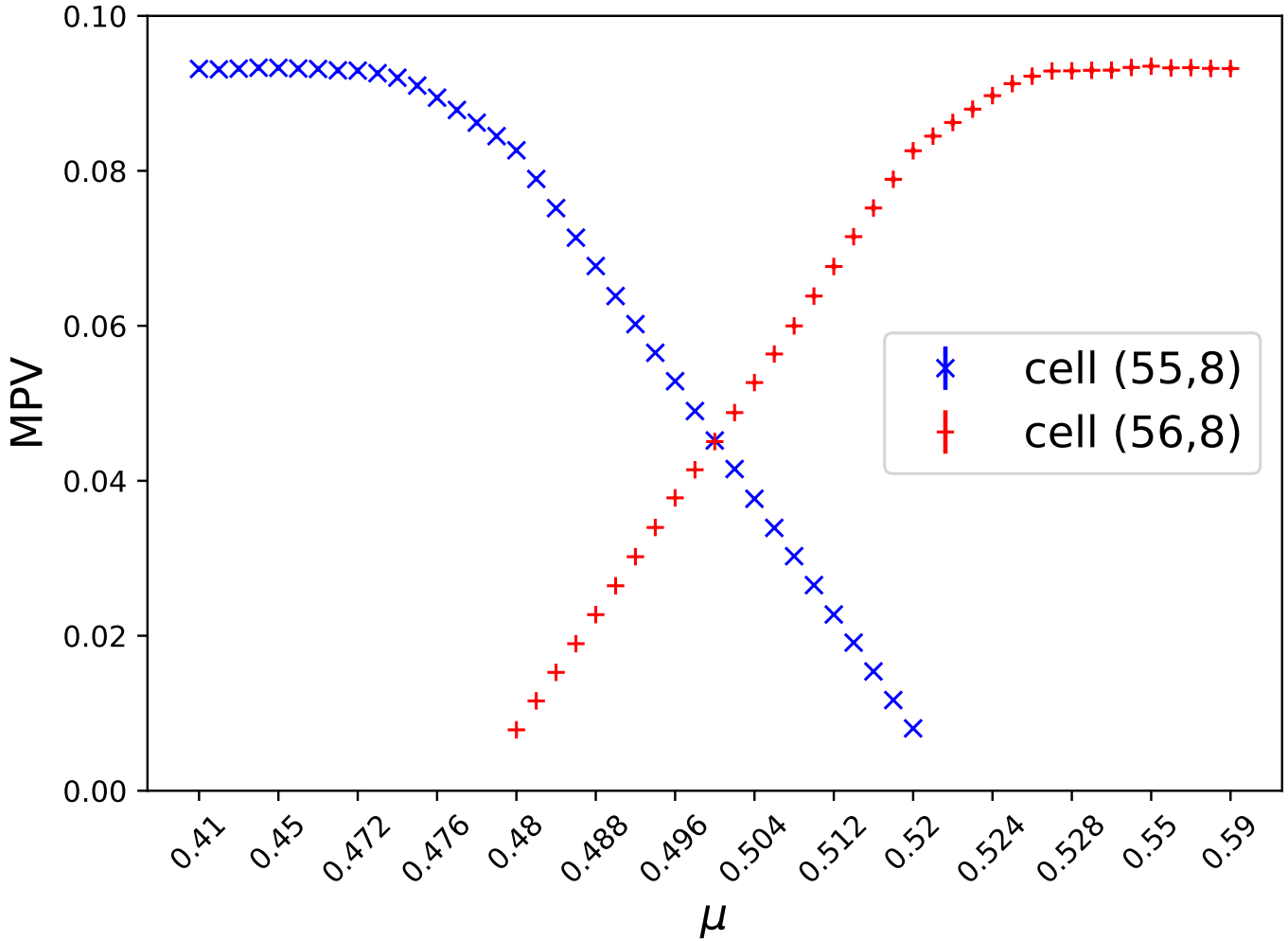

Figure: MPV as a function of μ, $a = 0.05 \cdot 5.53mm = 0.2765mm$, with charge sharing.

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- Procedure for pad-resizing in MC simulation results was prepared.
- Proper structure of silicon sensors was implemented, inluding inter sensor gaps.
- Procedure for charge sharing between pixels was implemented and validated.
- It is possible to study more realistic charge sharing mechanism.
- MC simulation of the beam test setup would be needed to test charge sharing details.

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- conversion from deposited energy to charge and further to ADC units,
- finding optimal charge sharing function shape and its parameters in order to simulation results be consistent with test-beam data,
- adding charge sharing from pixel to diagonal neighbours,
- further analysis after pad-resizing, for example reconstruction of impact point of initial positron.