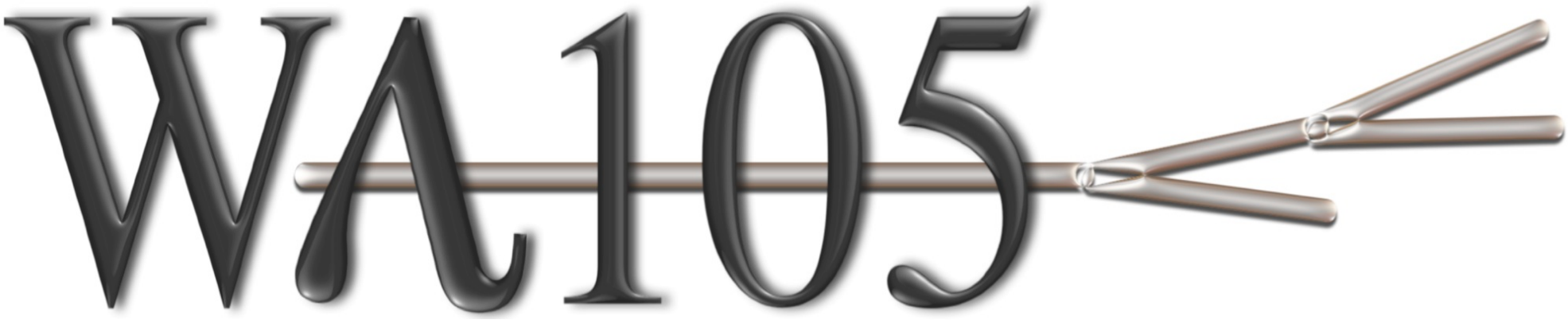
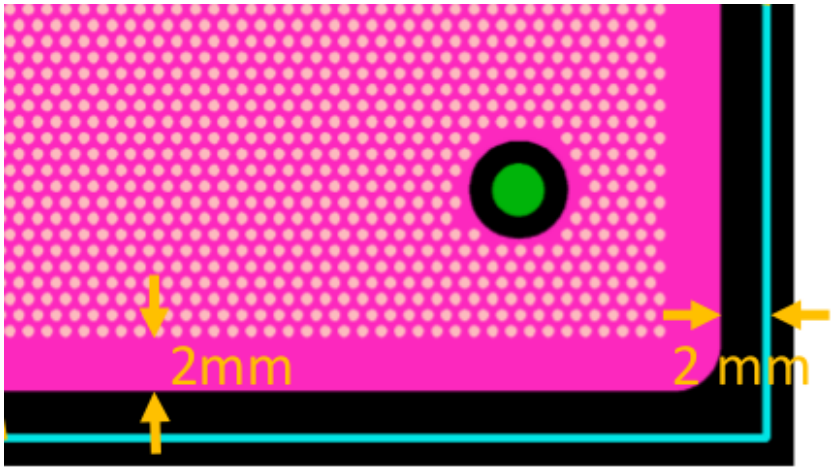


Effect of LEM blind regions on charge collection

Philippe COTTE

April 12, 2017

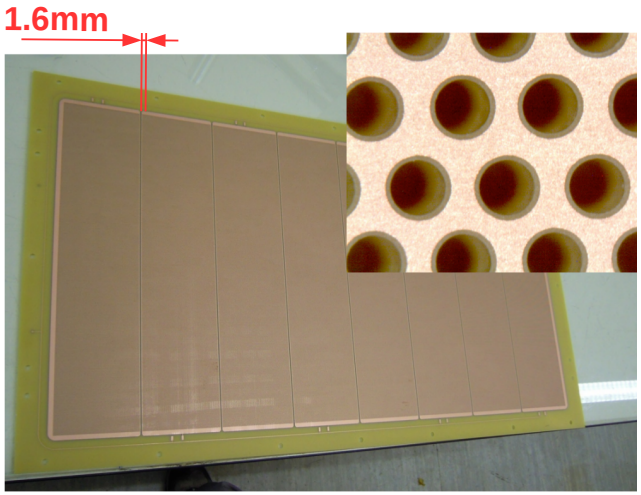
Main question
WA105 LEM geometry



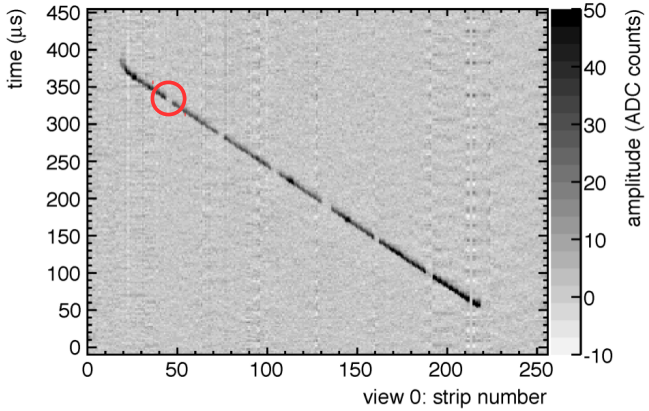
Study

Border, screw holes, HV connectors : What is their impact on charge collection and charge resolution?

Main question
Motivation : LAr LEM-TPC



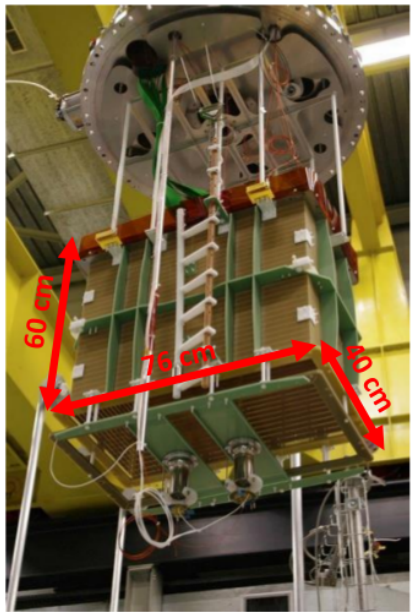
A. Badertscher, ArXiv:1301.4817v1 [physics.ins-det] 21 Jan 20



A. Badertscher, ArXiv:1301.4817v1 [physics.ins-det] 21 Jan 2013

A. Badertscher et al. JINST 8 (2013) P04012

200L DLAr LEM-TPC
40 × 76 cm² readout



Rectangular LEM with 1.6 mm gap between each LEM ⇒ Absence of charge at LEM border

How to

1. Simulate the electric field close to the border, screw holes and HV connectors (done with ANSYS)
2. Simulate the electrons drifting toward the LEM in those region, compute collection efficiency depending on initial electron position (done with GarField)
3. Create an efficiency map for a typical LEM of $49.95 \times 49.95 cm^2$ (done with Root)
4. Simulate events in $6 \times 6 \times 6$ and compare charge and charge resolution with/without efficiency (done with QScan)

Geometry : example of 2D model

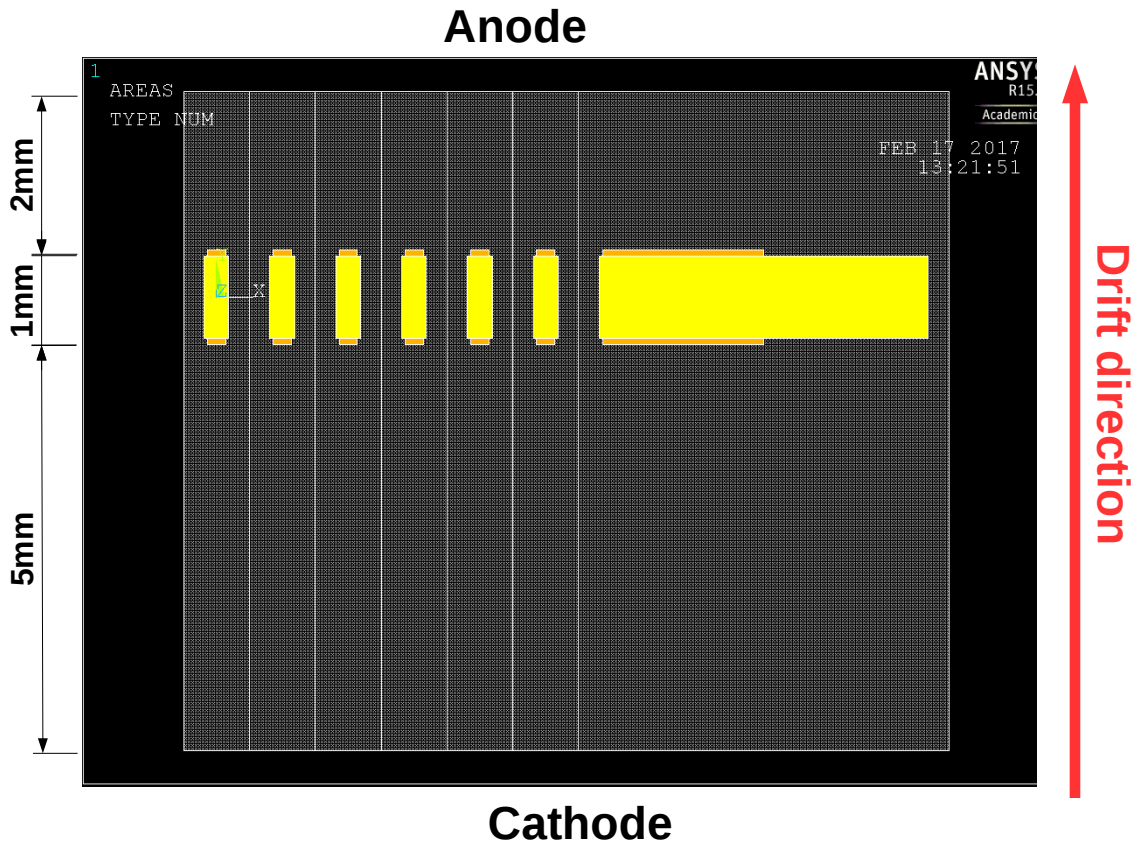
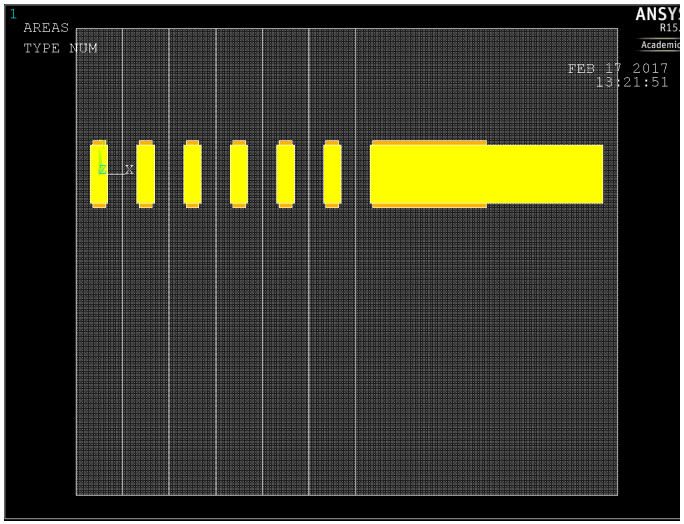
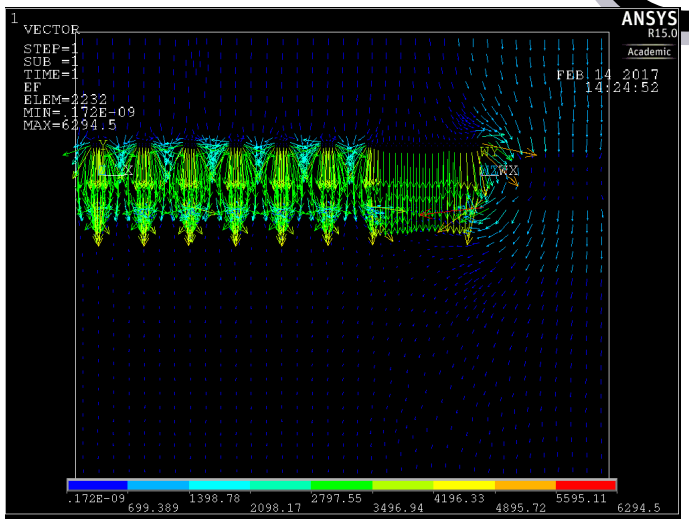


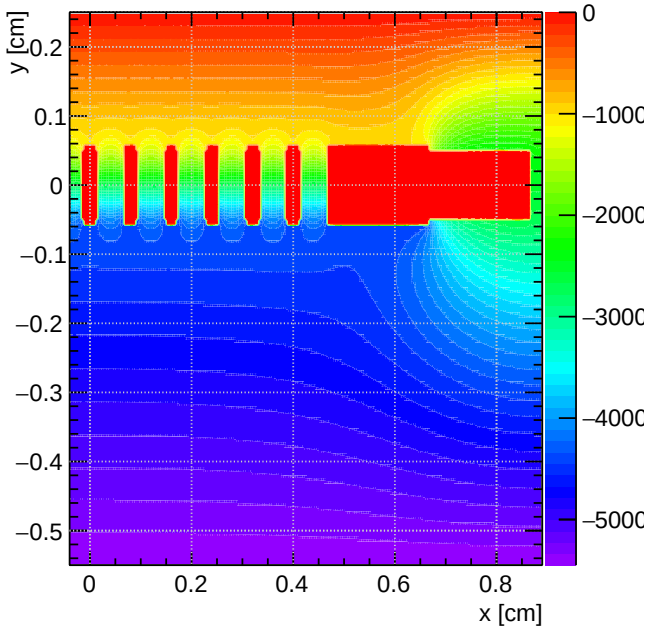
Figure: 2D modelisation of a LEM border

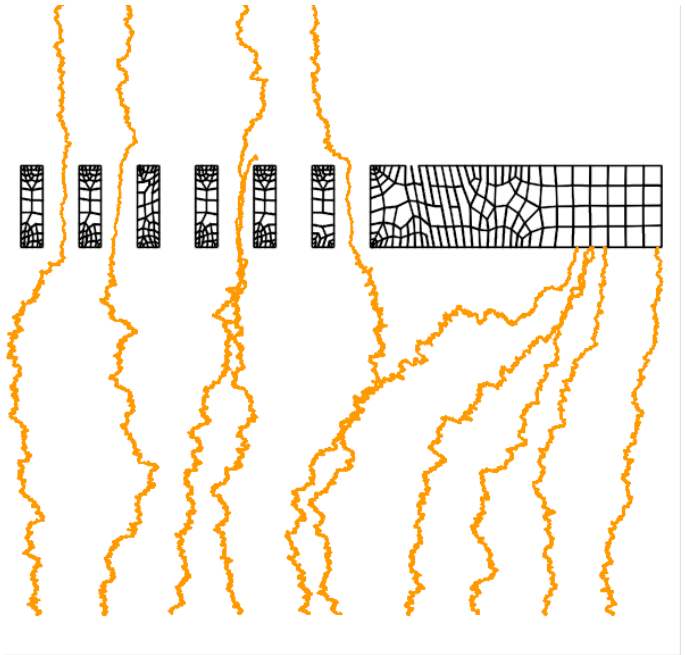
Geometry : example of 2D model

field, potential and drift of 10 electrons





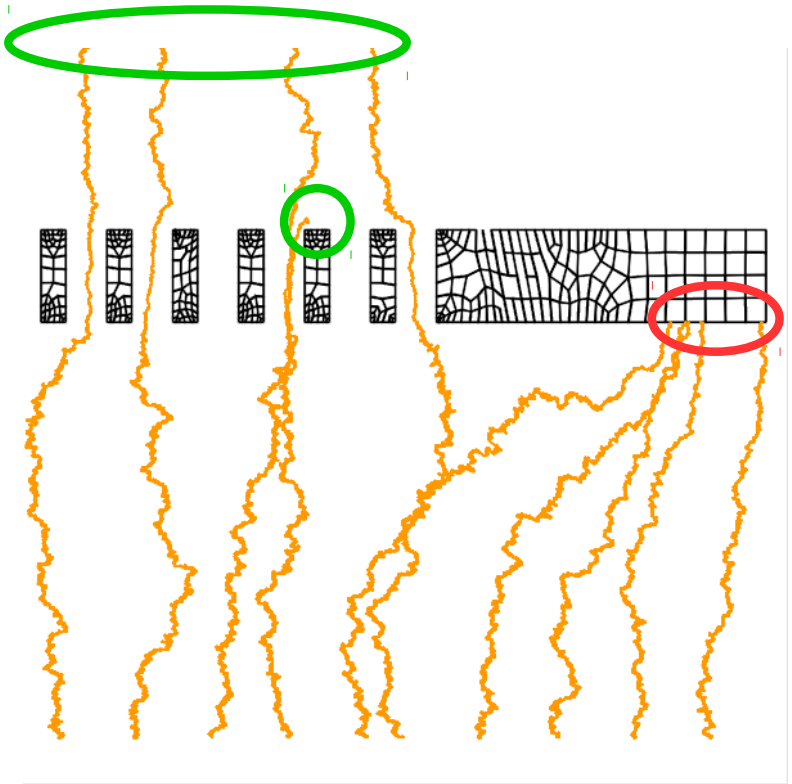




Calculating transmission efficiency

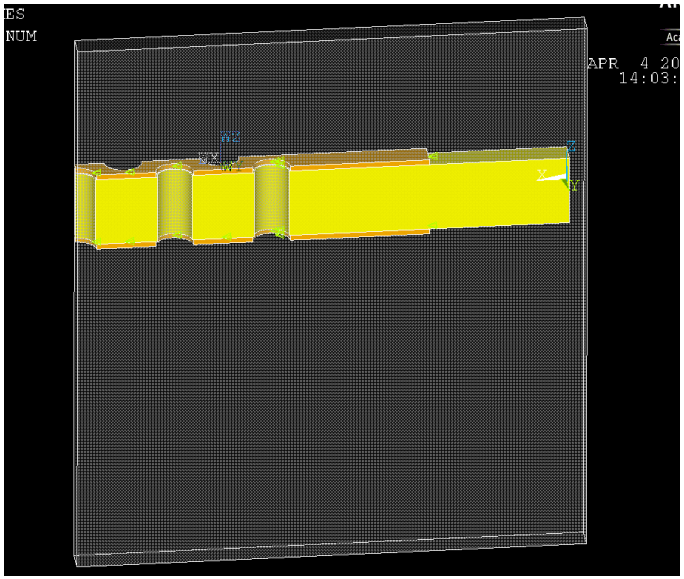
End point of electron path used as condition :

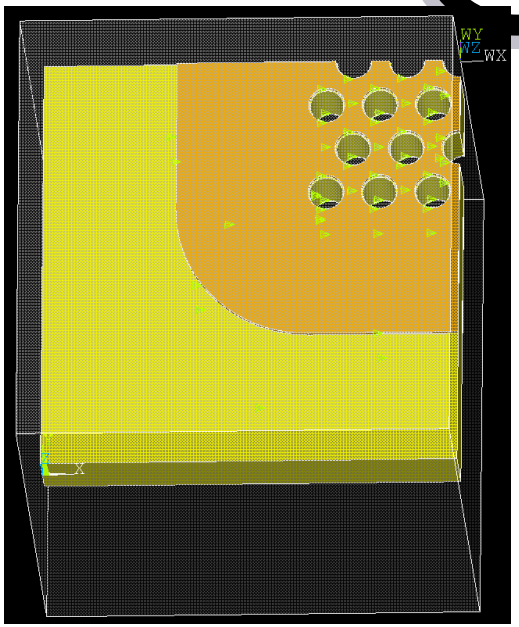
- Consider any electron reaching amplification zone as collected
- Kill electron reaching bottom LEM on dead zone (border, srew, HV connector)
- Compare initial position of all electrons to initial position of collected electrons (ratio of histograms collected/generated)

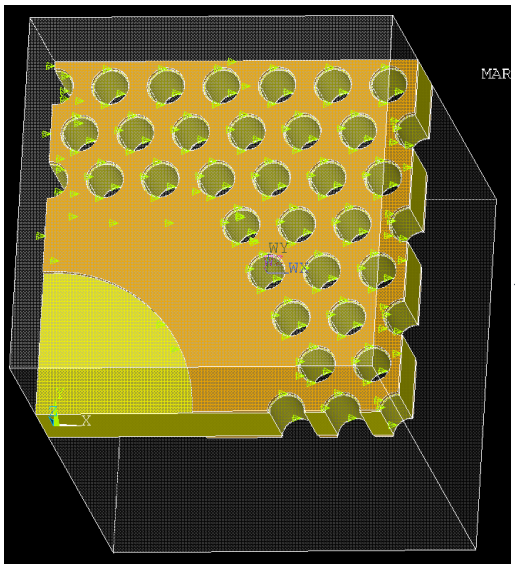


Geometry : 3D models

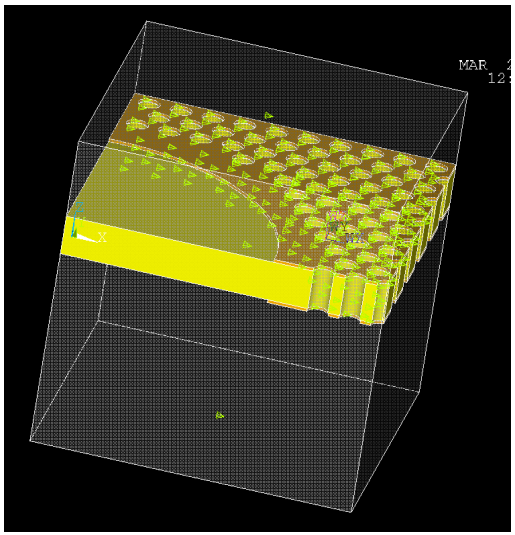
Border, corner, screw hole and HV connector





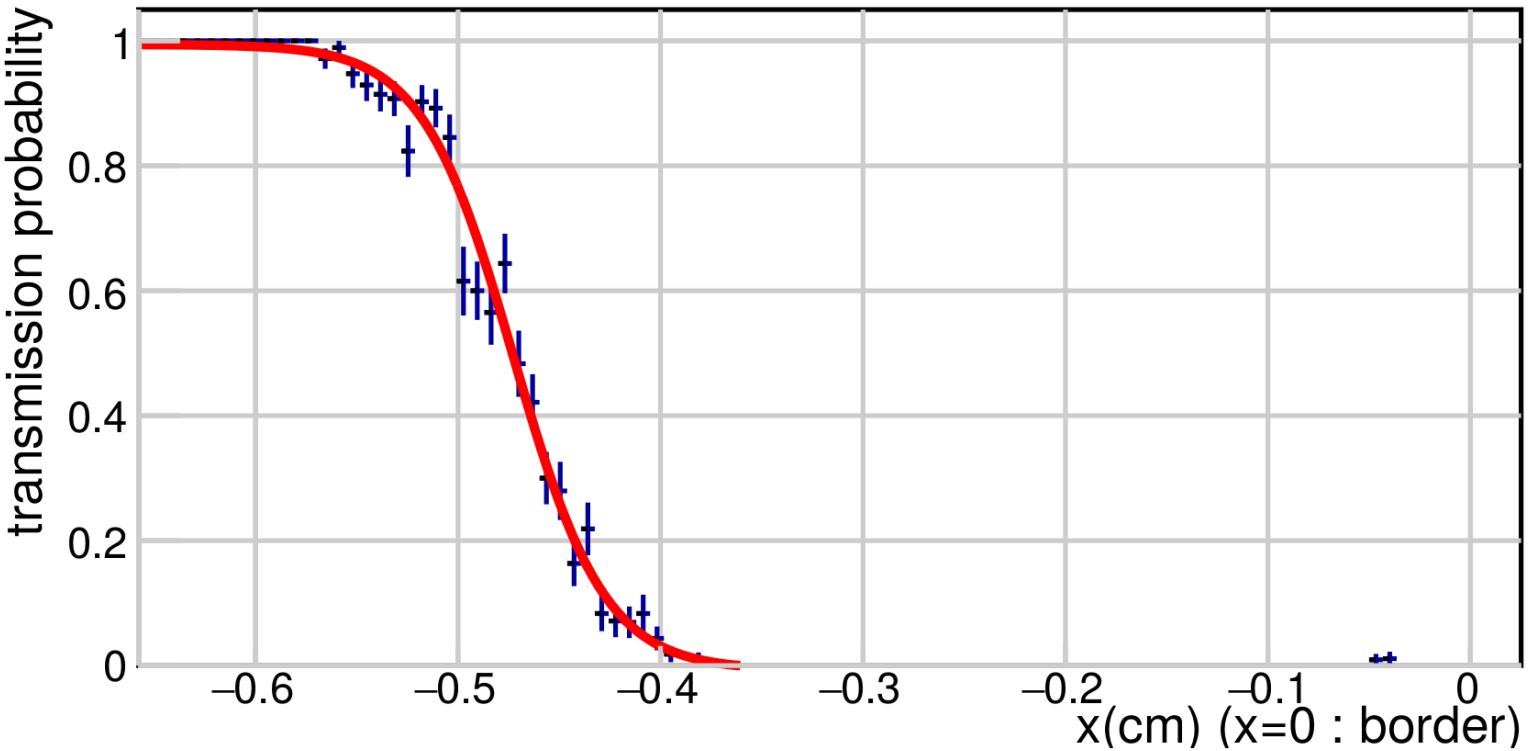


← Screw Hole HV connector →



Drift of 10000 electrons on LEM border

uniformly distributed at bottom of the geometry



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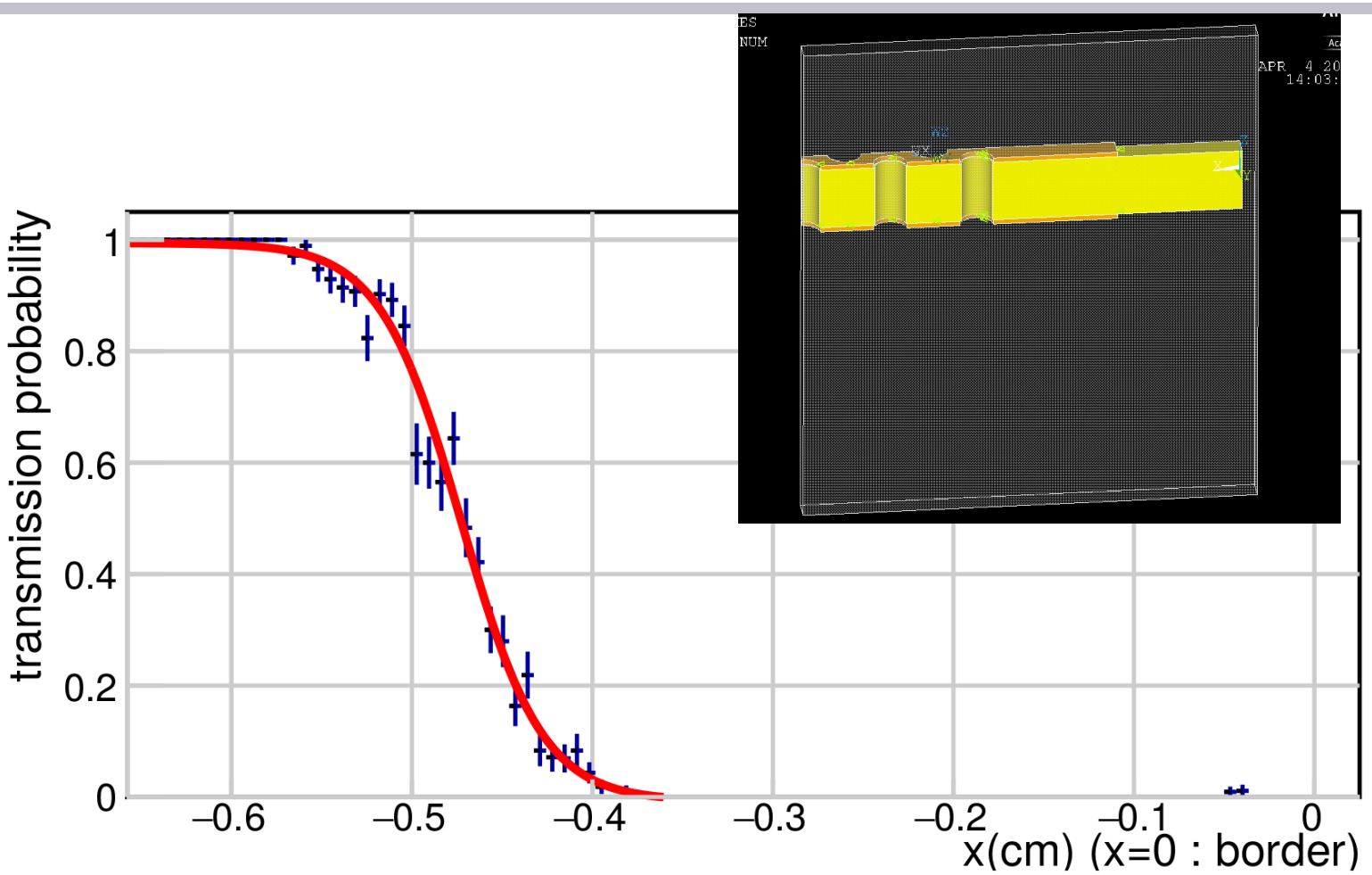
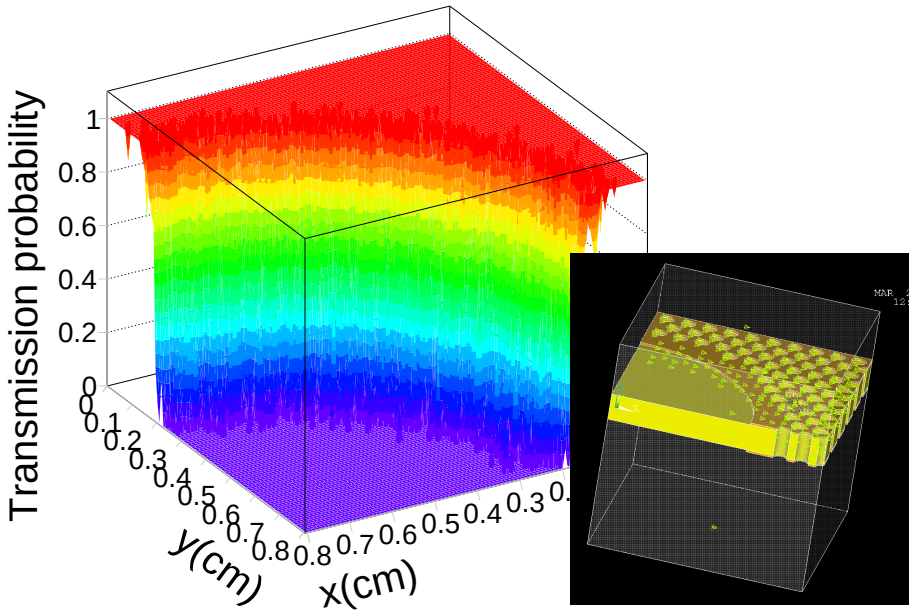


Fit function : $\sim arctan(-x)$

Results for 3D models

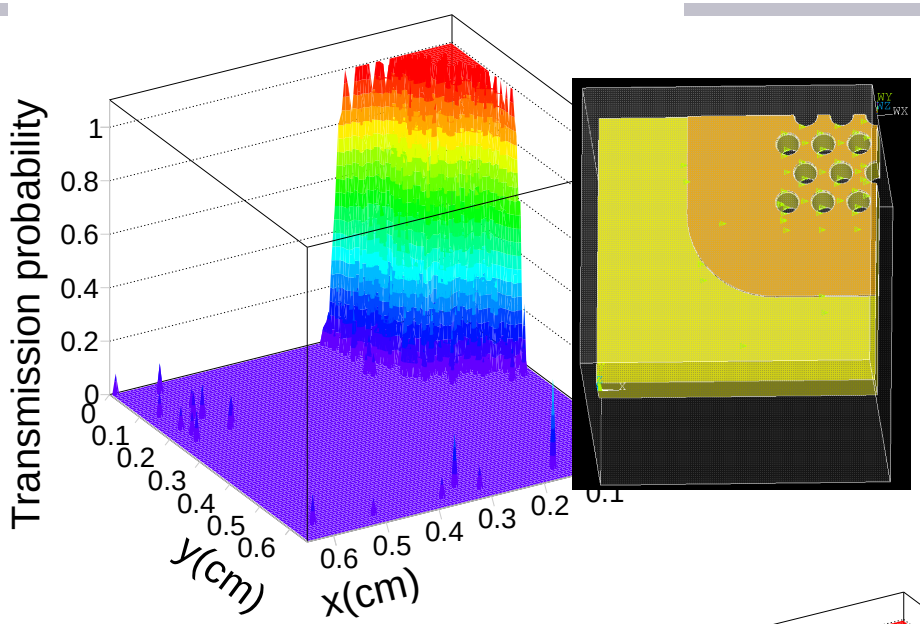
Border, corner, screw hole and HV connector

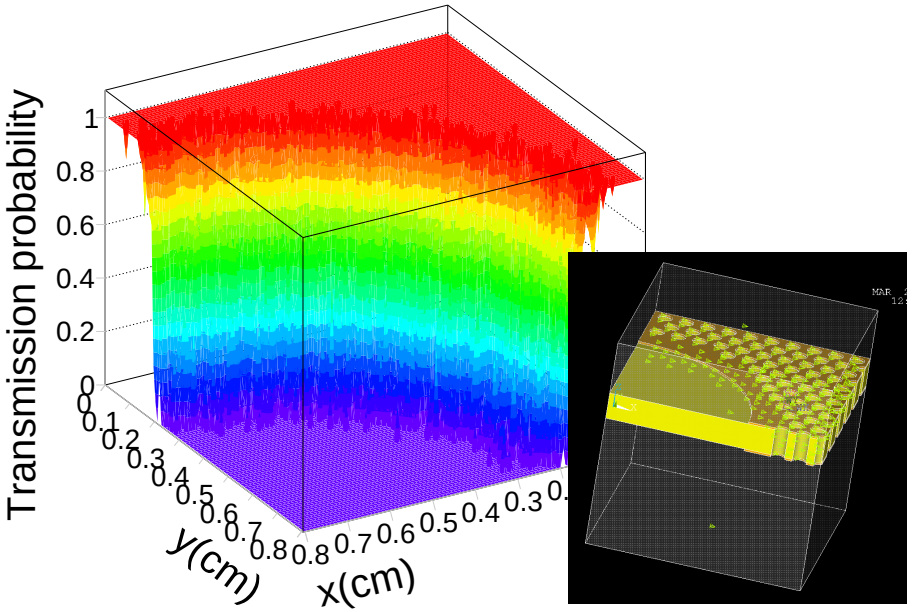


HV connector

Results for 3D models

Border, corner, screw hole and HV connector

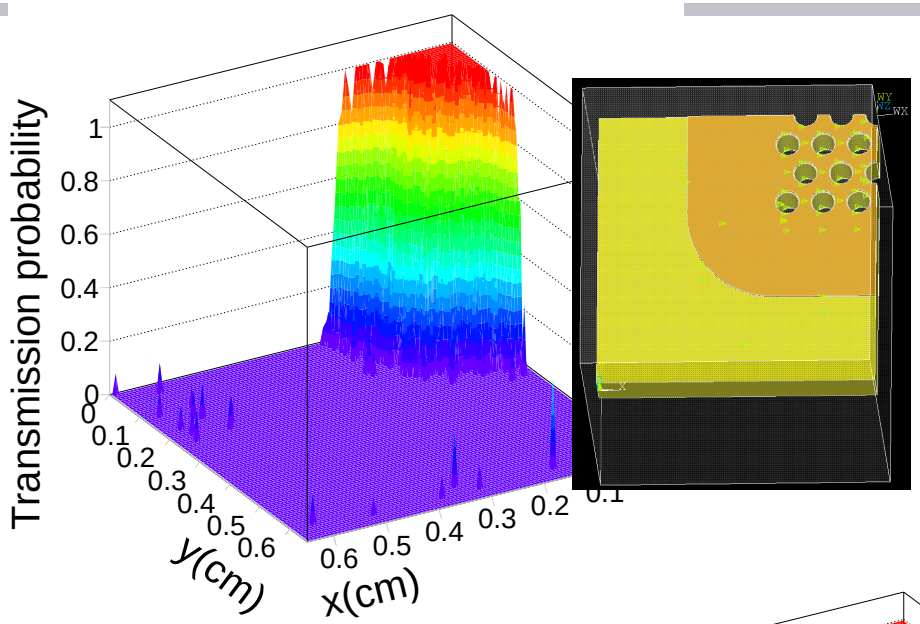


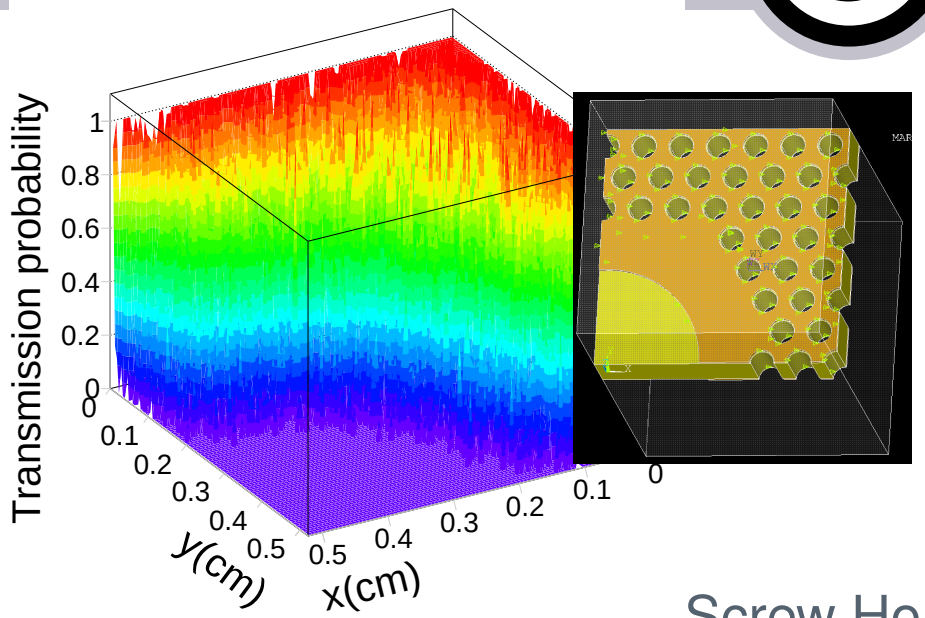


HV connector

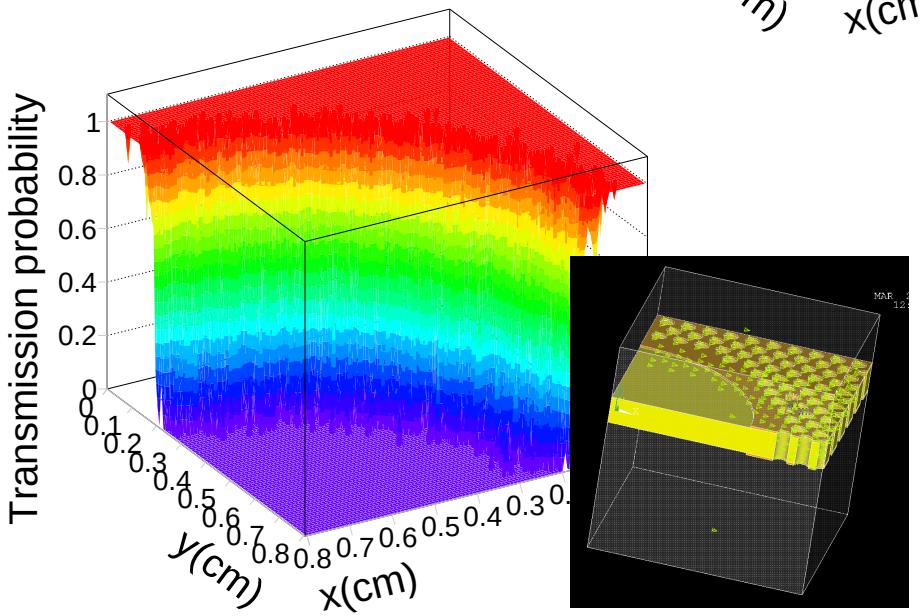
Results for 3D models

Border, corner, screw hole and HV connector



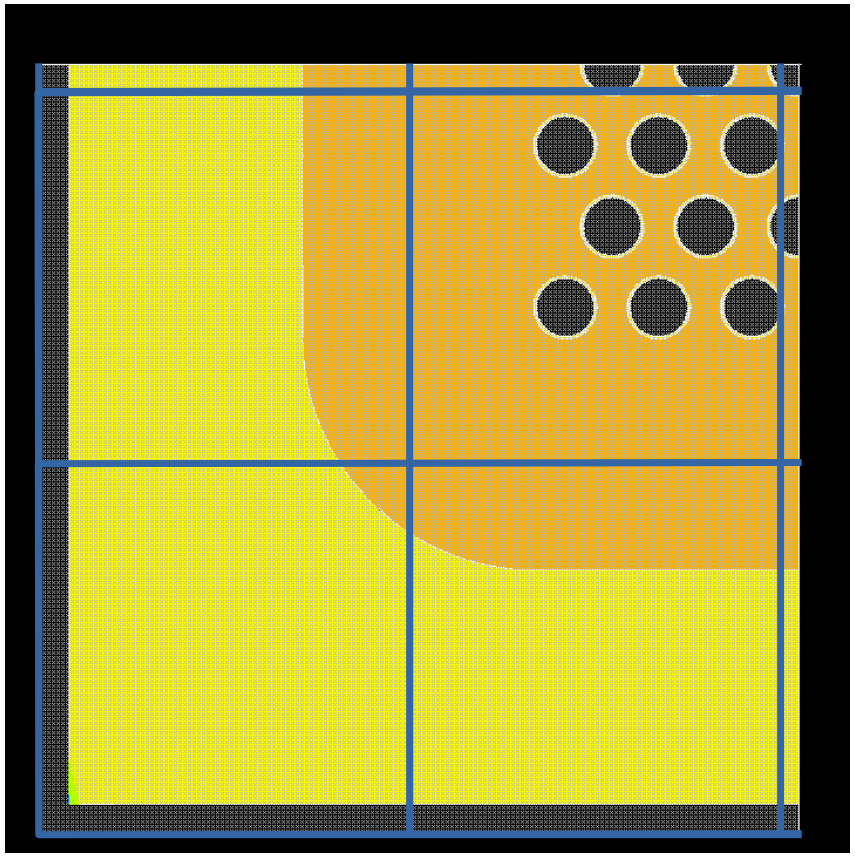


Screw Hole



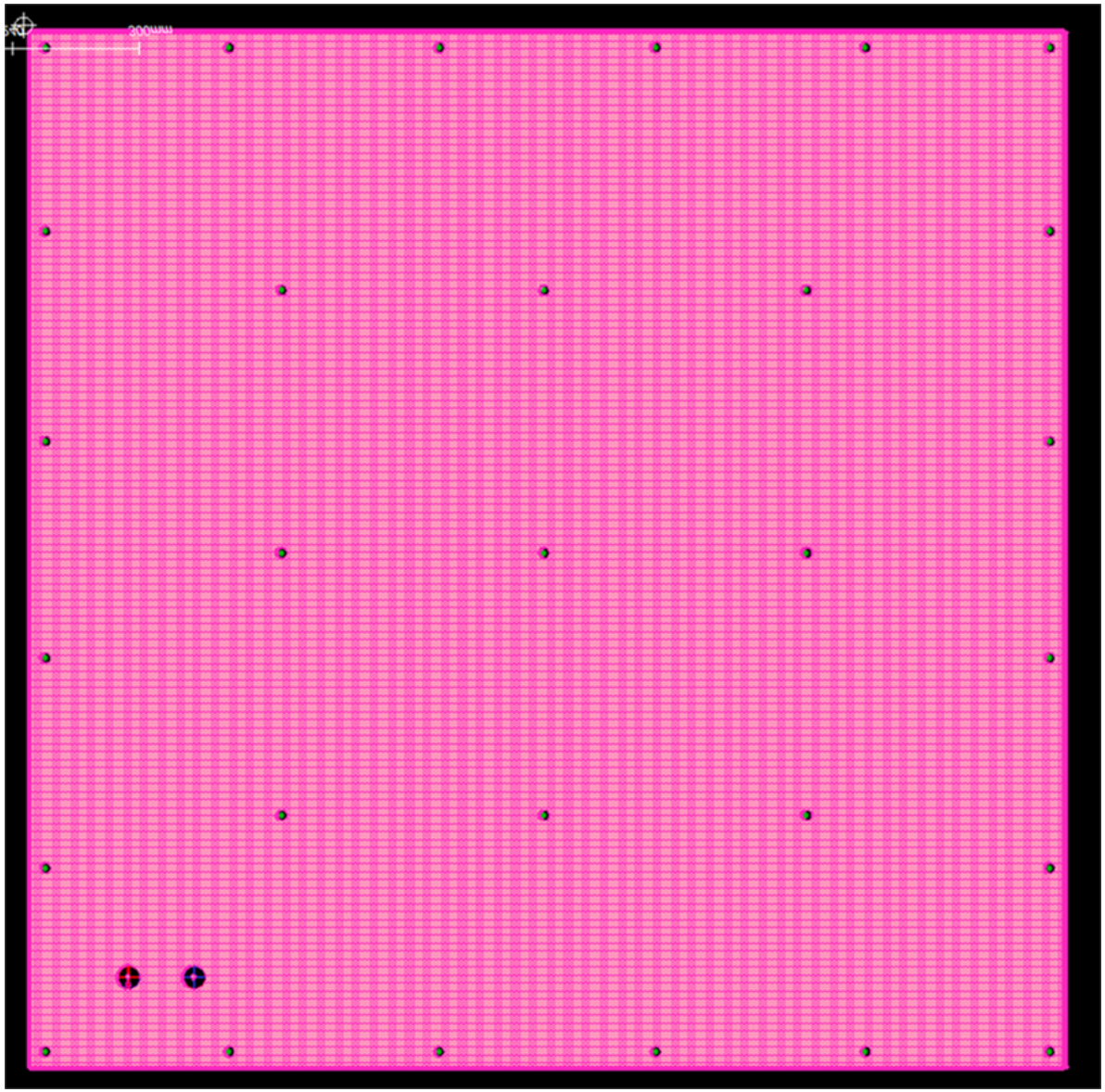
HV connector

Computing efficiency in pixels

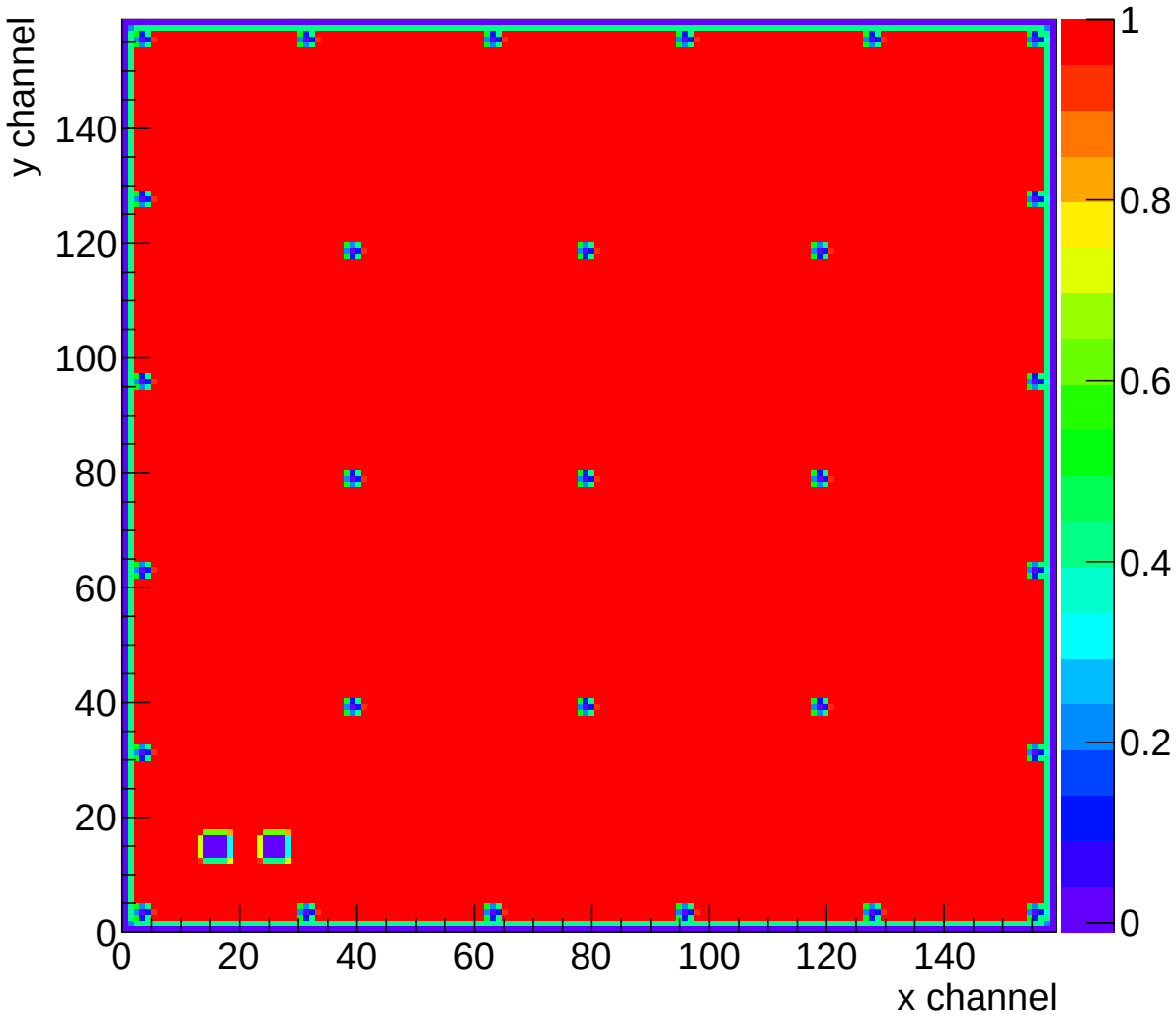


- Pixel efficiency computed by integrating histogram pixel by pixel (pixel=$3.125 \times 3.125 mm^2$)

Real LEM

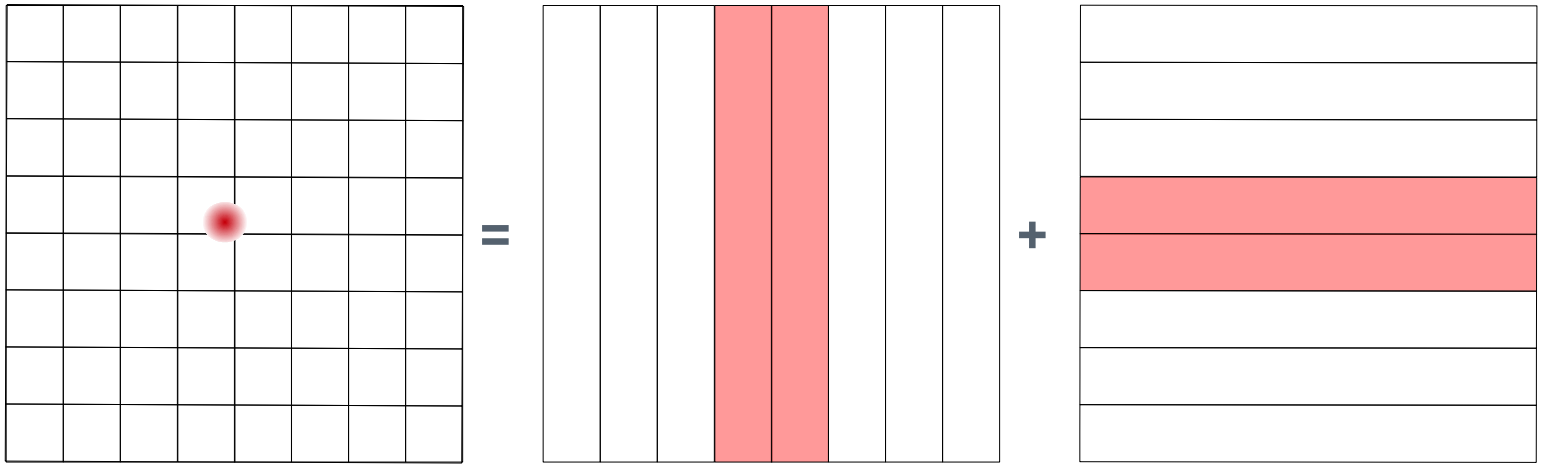


Efficiency map for one LEM



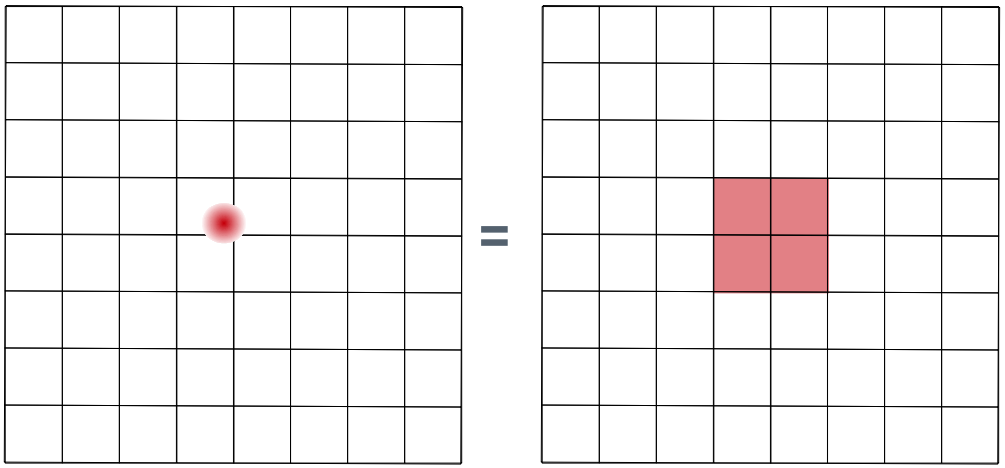
Modification of Qscan
in WA105Soft/crp/src/QProjector.cc

Originally :



Modification of Qscan
in WA105Soft/crp/src/QProjector.cc

Now :



And then again split in strips (since it is what the detector will eventually give us)

Simulating events with Qscan

- Possibility to specify efficiency pixel by pixel (computation time +15%)

Simulating events with Qscan

- Possibility to specify efficiency pixel by pixel (computation time $+15\%$)
- Efficiency map read as TH2D once for each event (no impact on computation time)

Simulating events with Qscan

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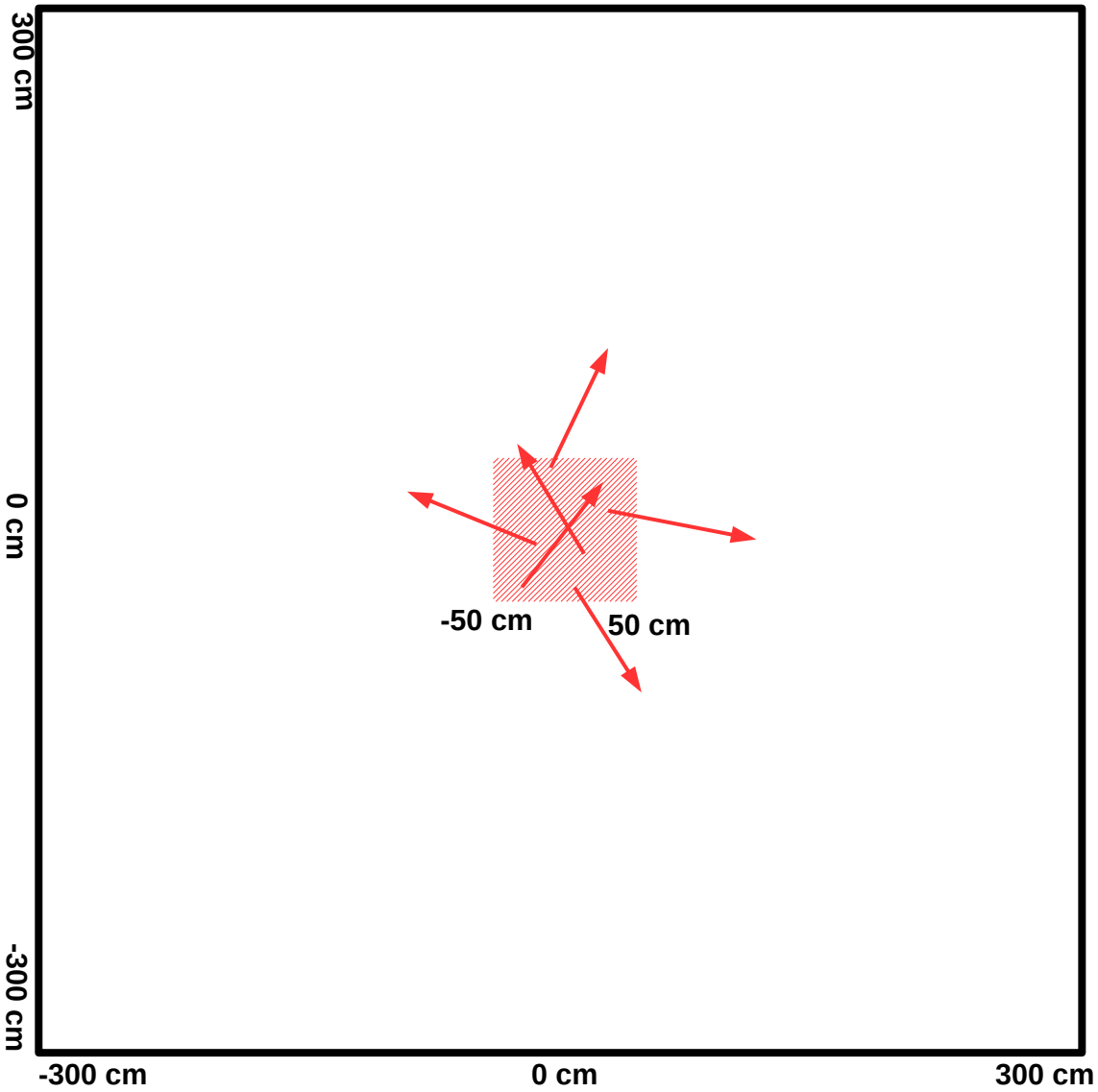
- Possibility to record charge with or without efficiency map

Simulating events with Qscan

- Possibility to specify efficiency pixel by pixel (computation time $+15\%$)
- Efficiency map read as TH2D once for each event (no impact on computation time)
- Possibility to record charge with or without efficiency map
- Compare charge distribution with "perfect" (**no efficiency map**) and "real" (**with efficiency map**) LEM for different particles and momenta

1000 particles simulated

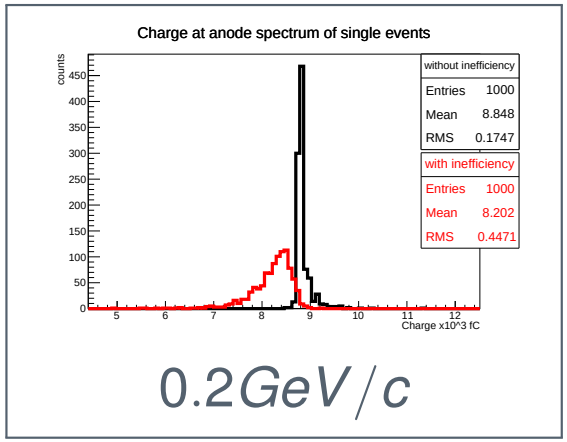
Electrons, muons, kaons, pions and protons



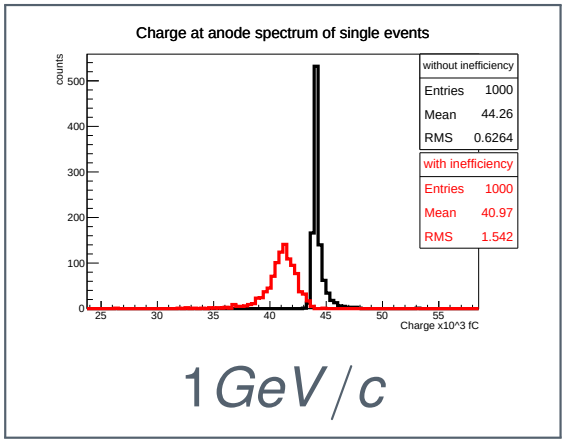
- Initial momentum fixed
- Direction random in 4π
- Initial position at $z = 0$
- and $(x, y) \in [-50; 50] cm$

Results

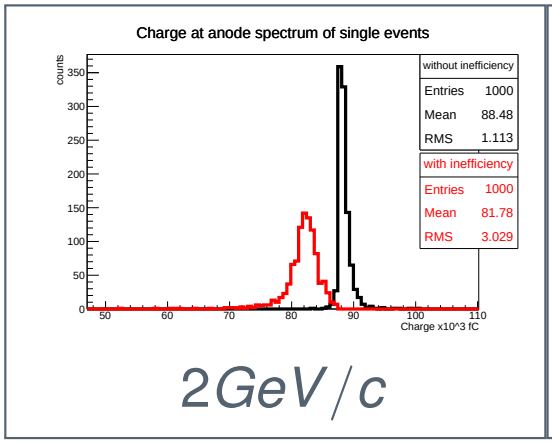
Charge distribution for **electrons** at different momenta



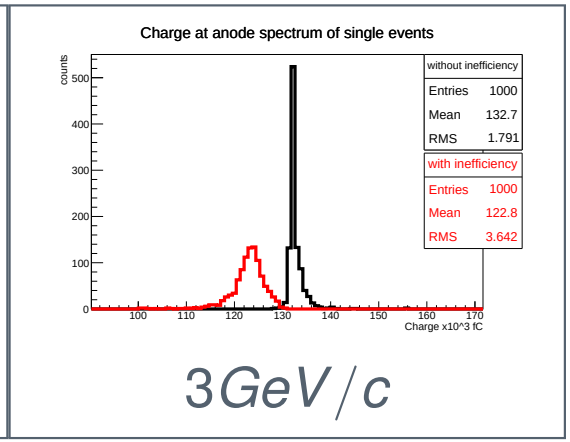
$0.2 GeV/c$



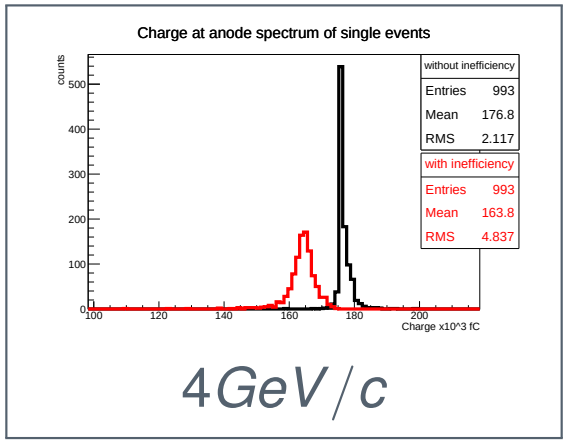
$1 GeV/c$



$2 GeV/c$



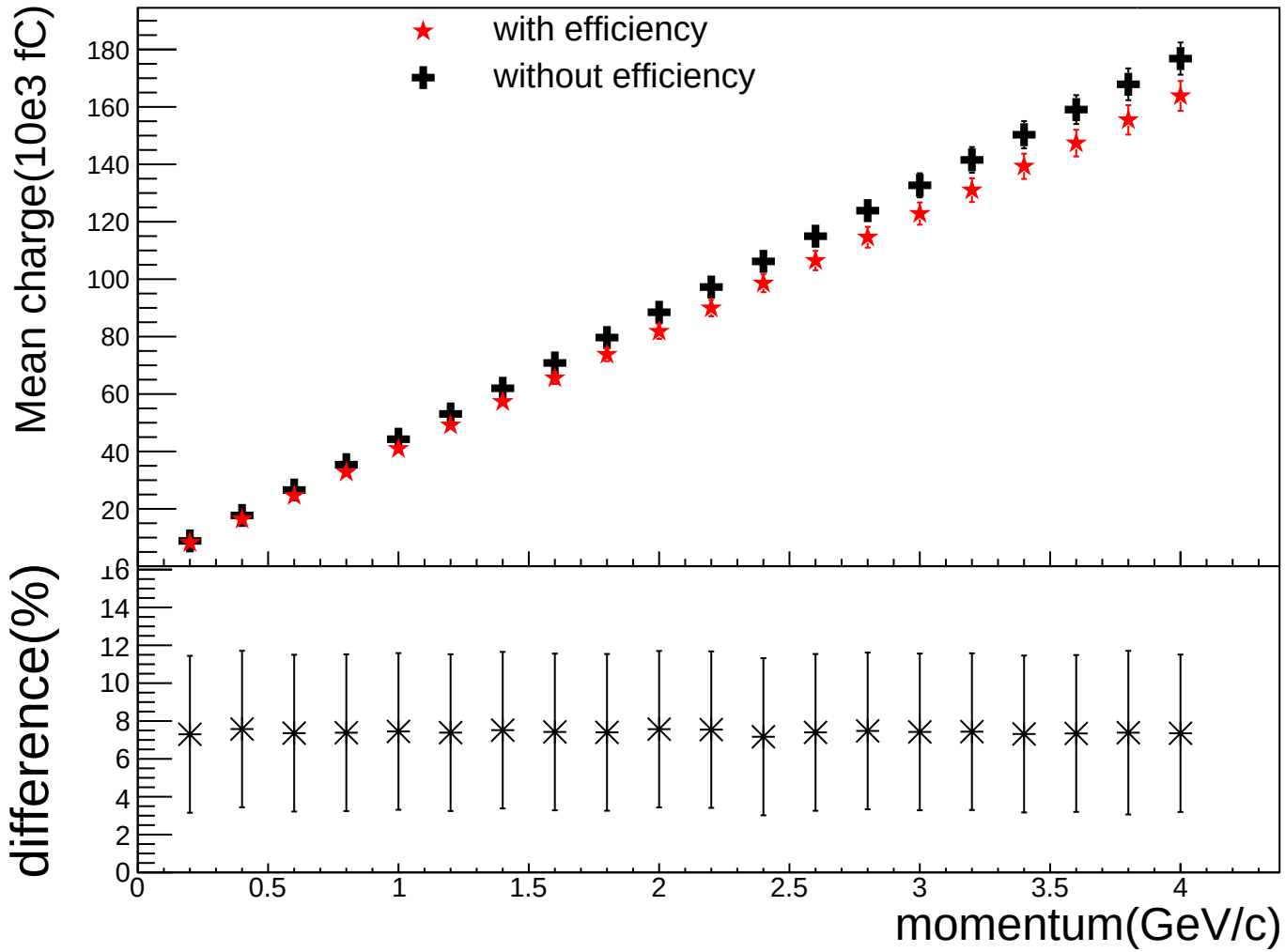
$3 GeV/c$



$4 GeV/c$

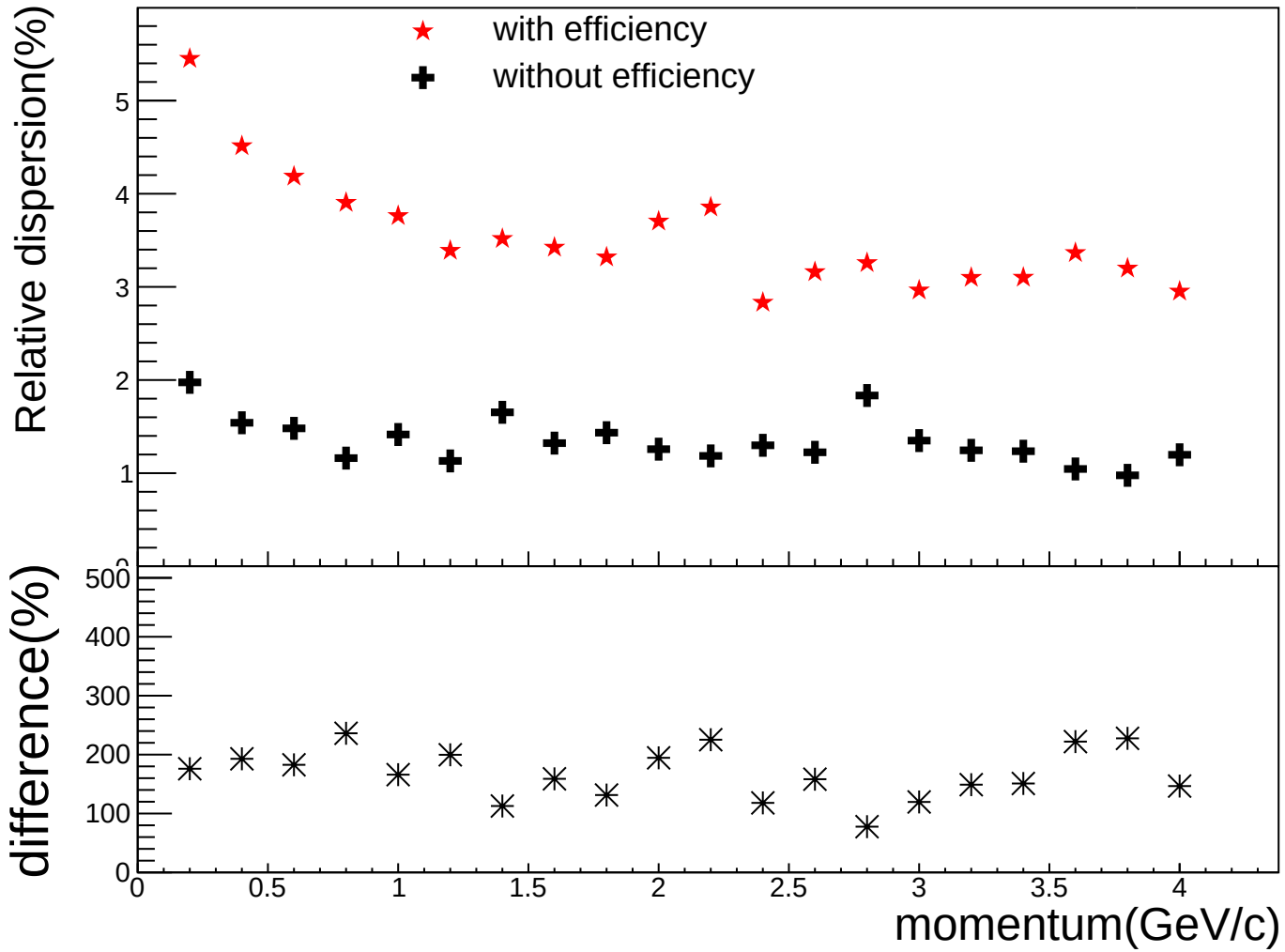
Results

Charge difference of **electrons** for different momenta



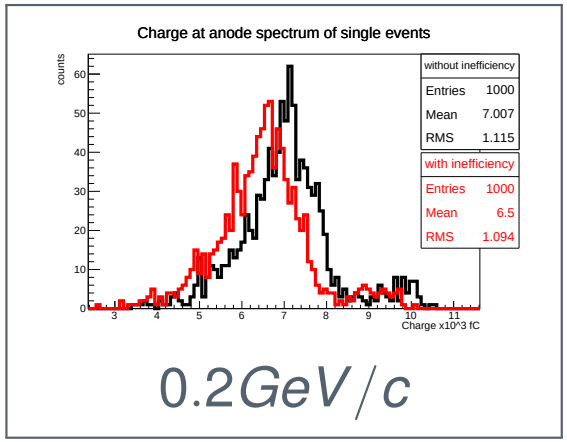
Results

Charge dispersion of **electrons** for different momenta

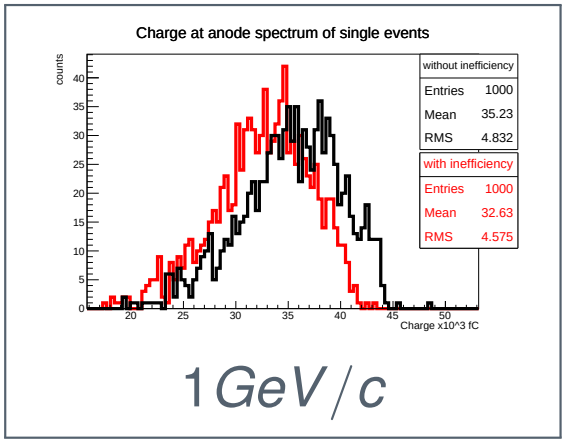


Results

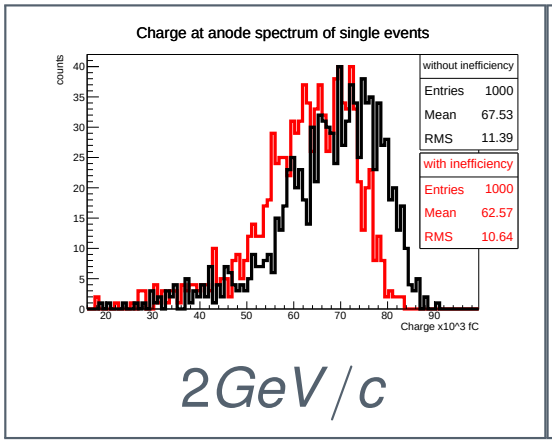
Charge distribution for **negative pions** at different momenta



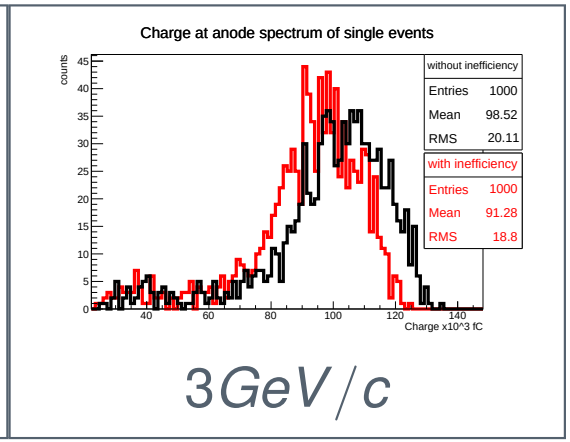
$0.2 GeV/c$



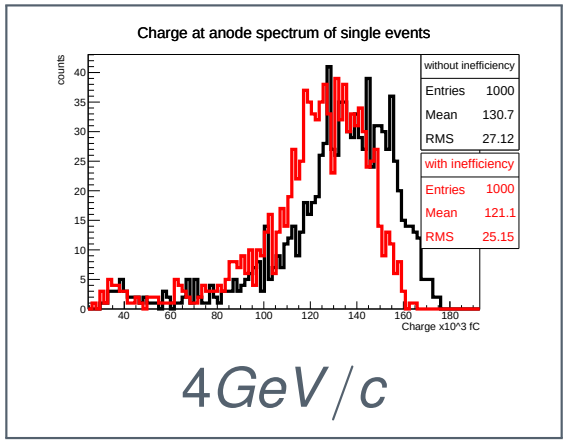
$1 GeV/c$



$2 GeV/c$



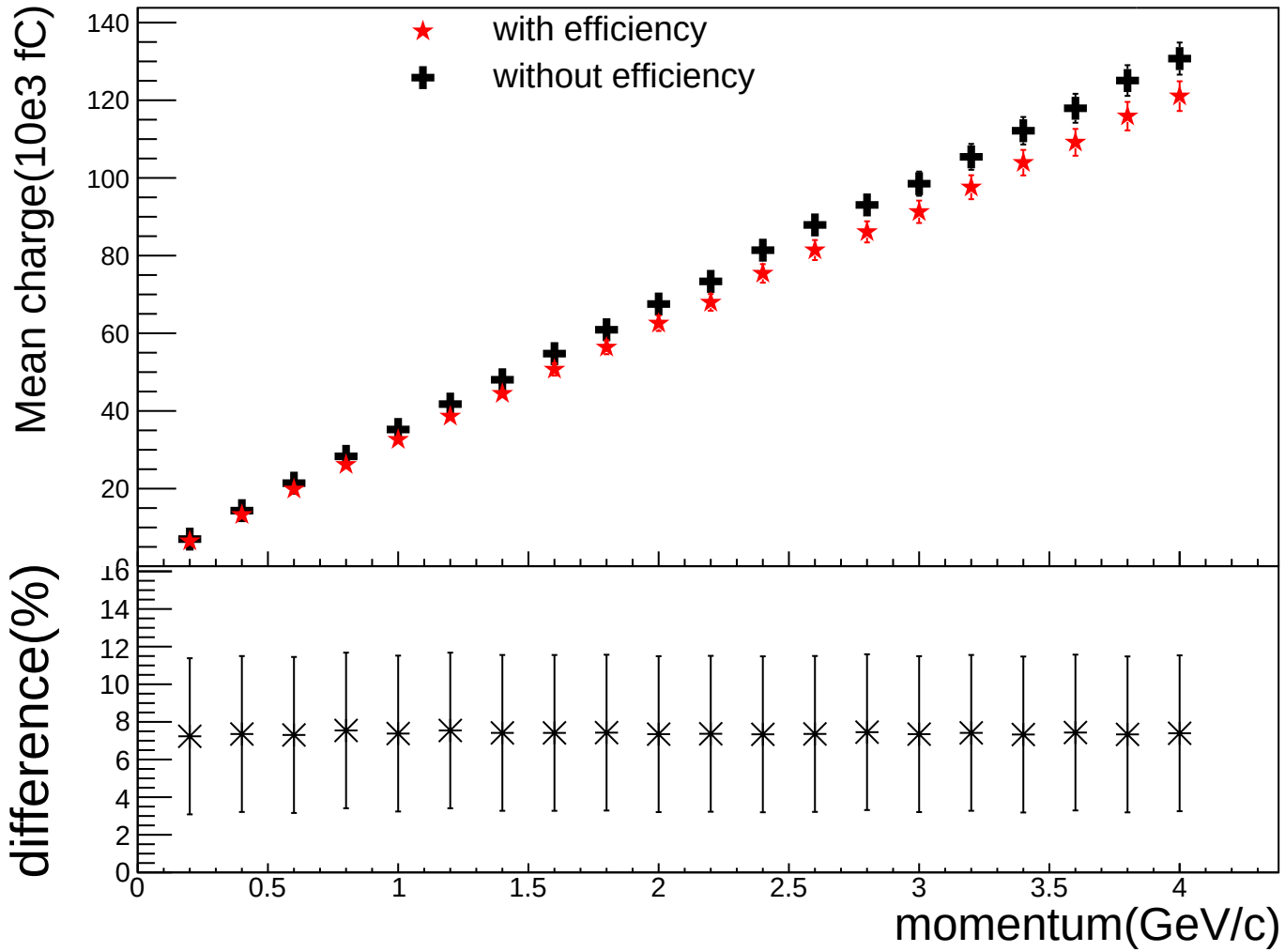
$3 GeV/c$



$4 GeV/c$

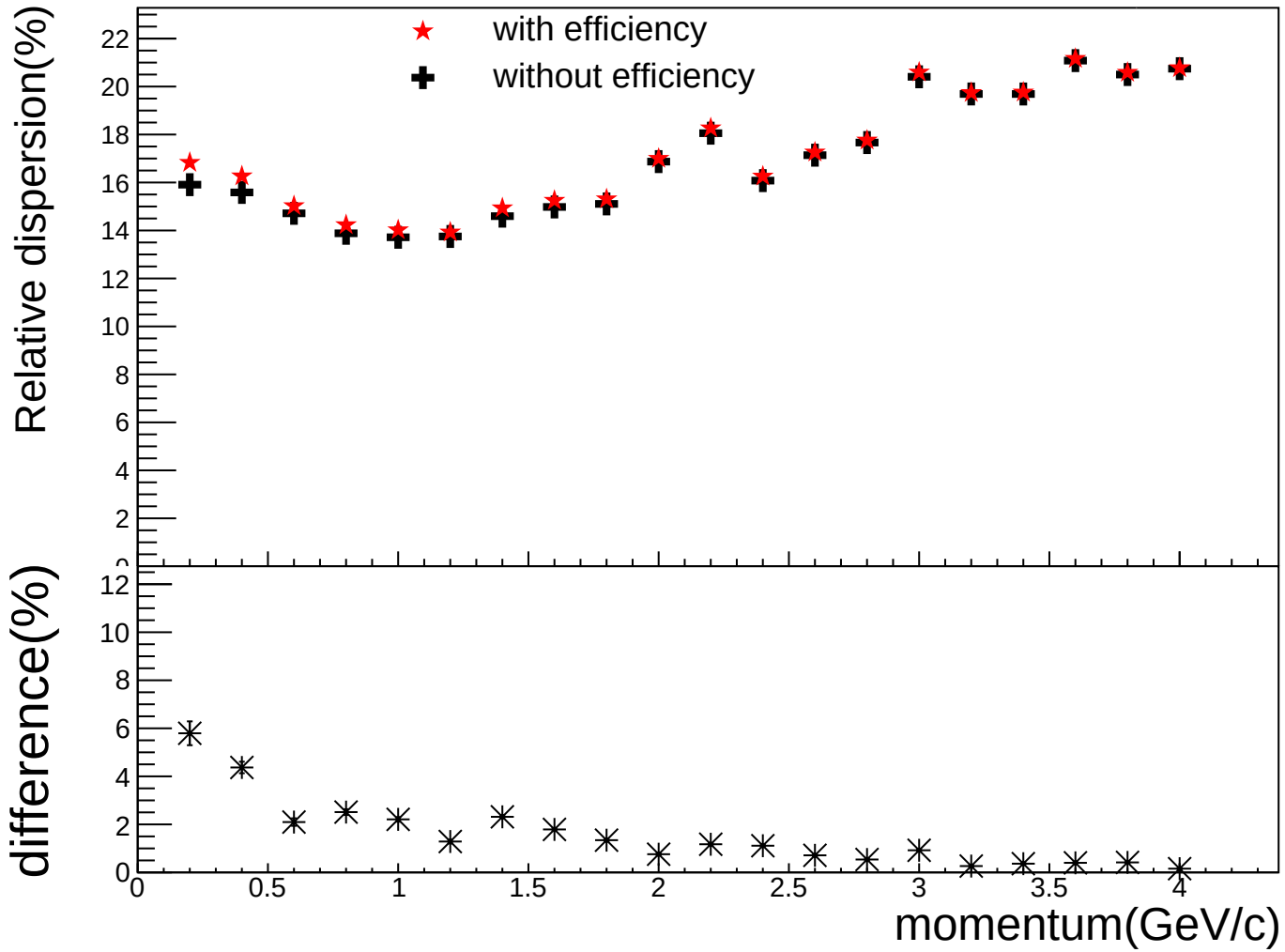
Results

Charge difference of **negative pions** for different momenta



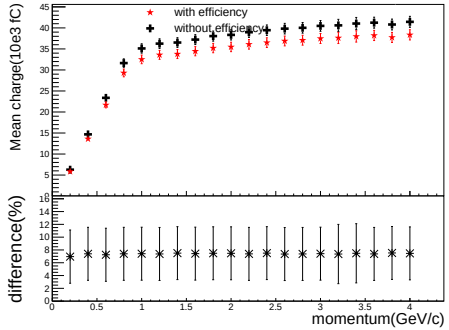
Results

Charge dispersion **negative pions** for different momenta

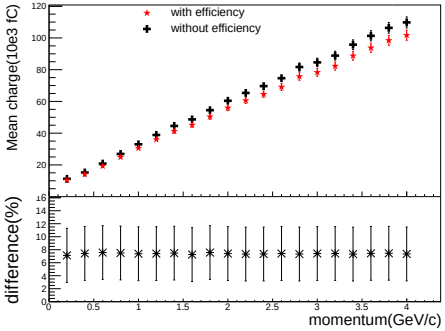


Results

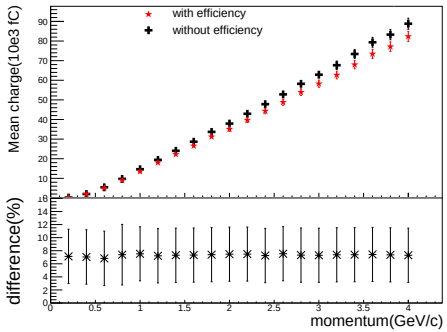
Charge difference of different particles



$\mu-$



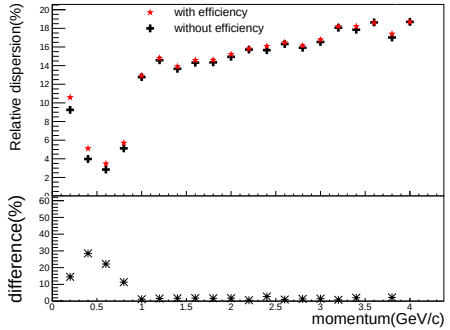
Kplus



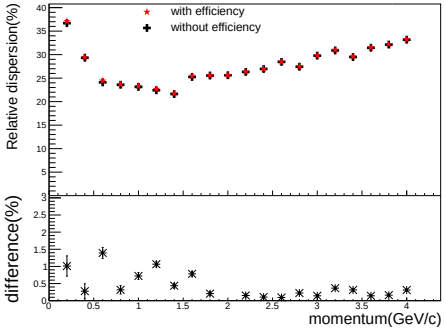
proton

Results

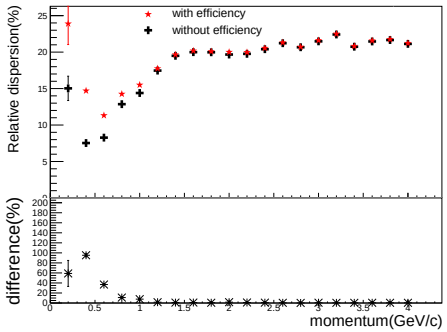
Charge dispersion of different particles



$\mu-$



Kplus



proton

Conclusion

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  Except electrons : resolution doubled

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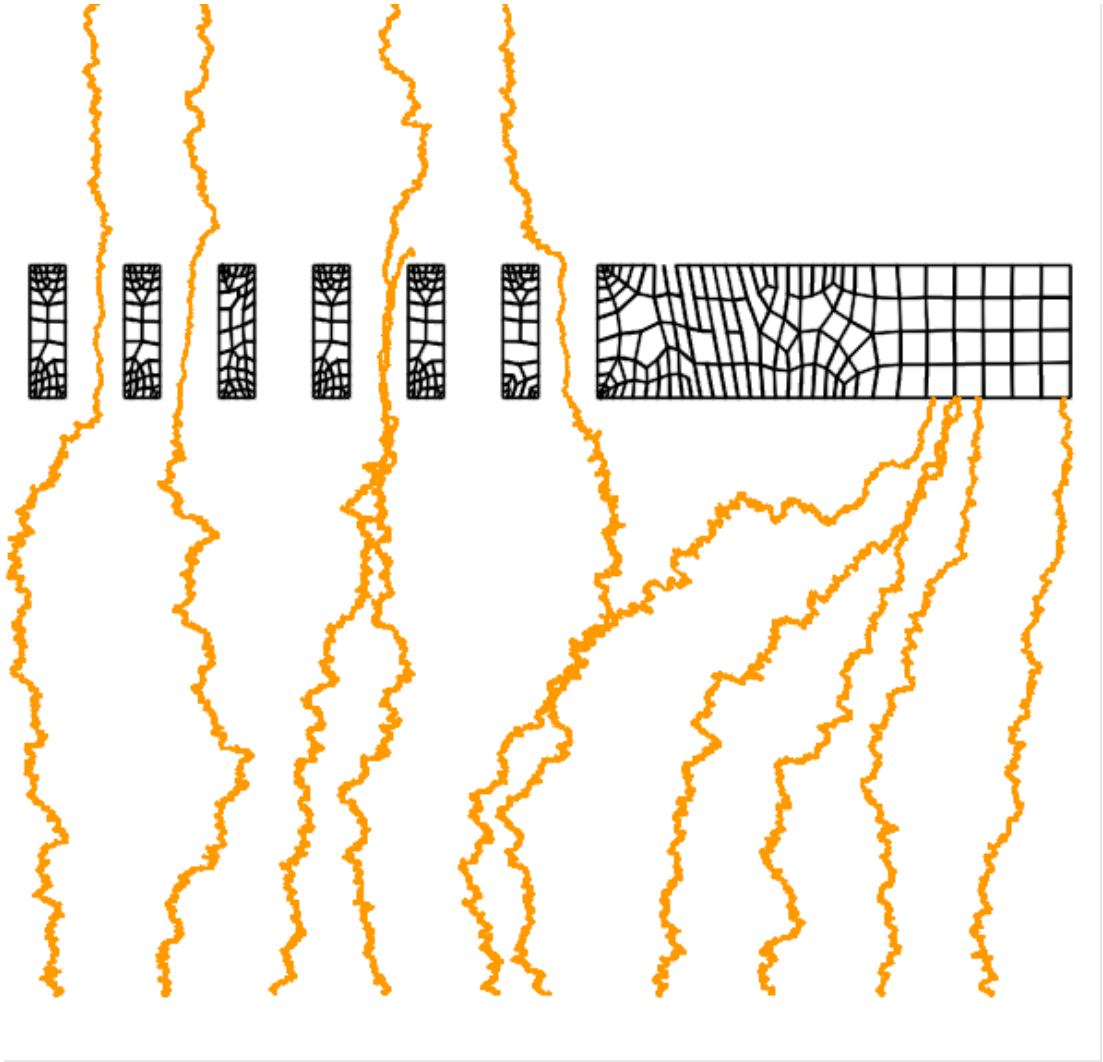
Conclusion

- Electrons can be lost completely on blind regions
- Effect on resolution small on most particles above $1 GeV/c$
  Except electrons : resolution doubled
- Effect on total charge can be well known
- Dead zone between LEMs : $4 + 4 + 0.5 = 8.5 mm$, screw holes : 6mm, HV connectors : 10mm $\Rightarrow$ vertex happening in those zones can be difficult to analyse, especially showers

Effect of LEM border on the path of drifting electrons

Electron deviation due to border

Drift of 10 electrons on border



⇒ Border can deviate electrons: impact on amplified electrons?

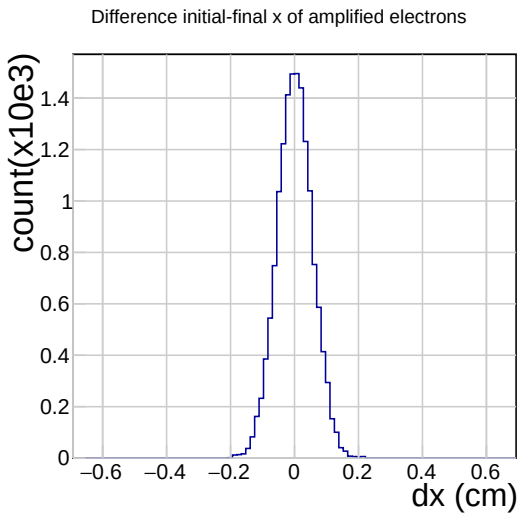
Electron deviation due to border

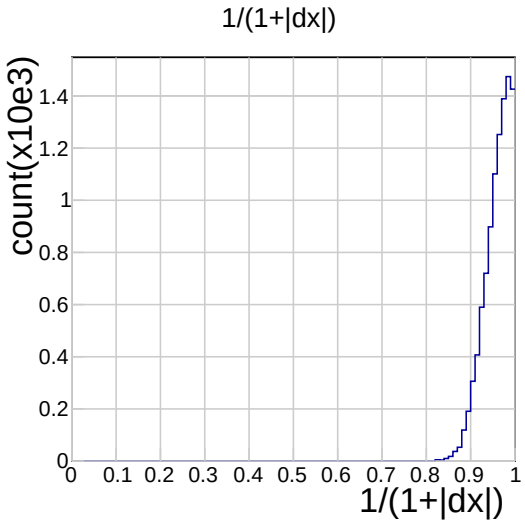
How to

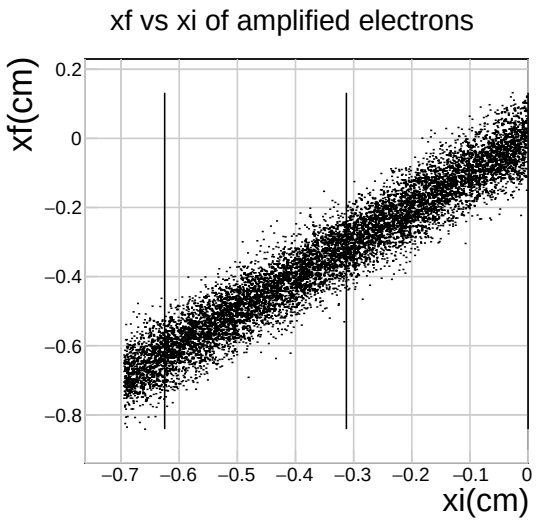
- Simulate LEM region without blind region and drift electrons on it
- Compute $dx = x_{initial} - x_{final}$ of each electron
- Do the same on border region and compare

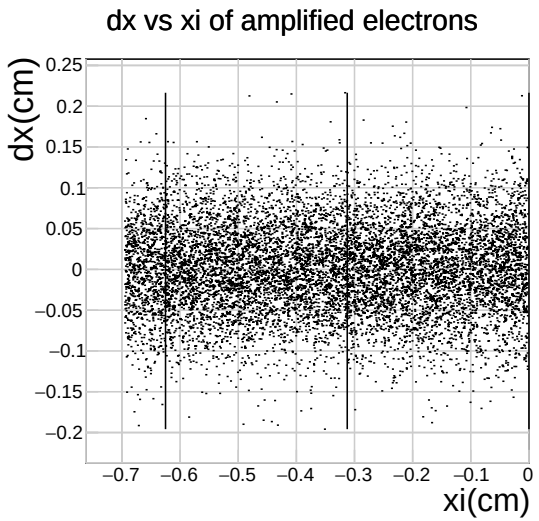
Electron deviation due to border

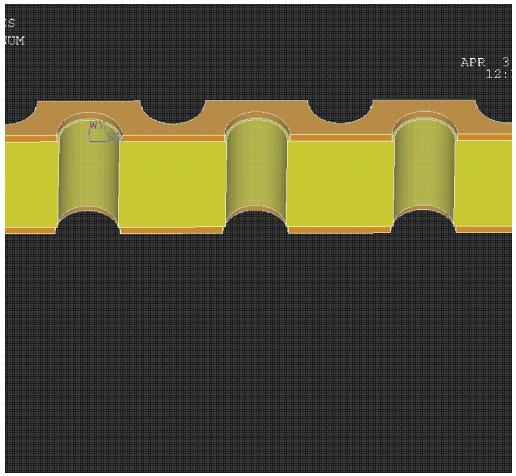
Area without blind region





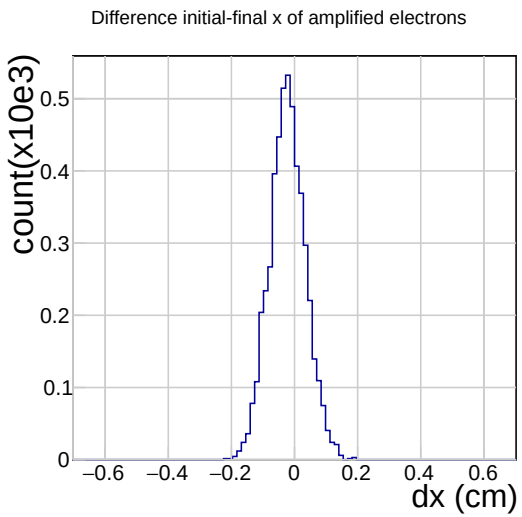


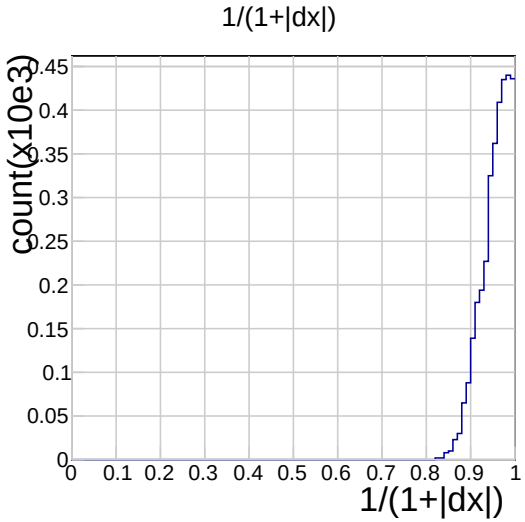


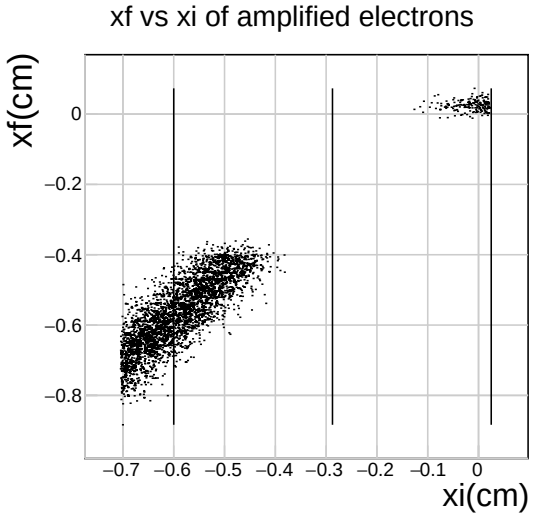


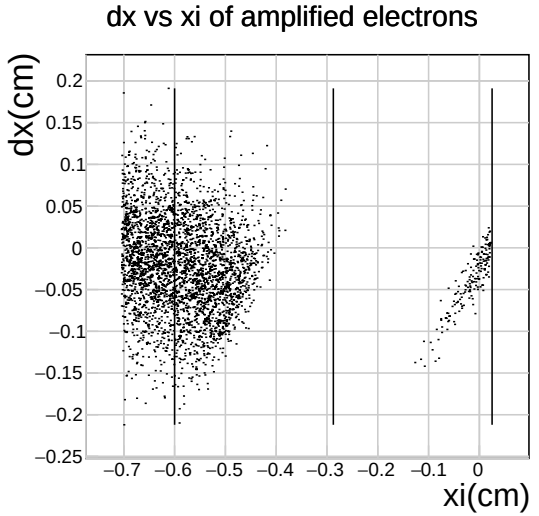
Electron deviation due to border

Border

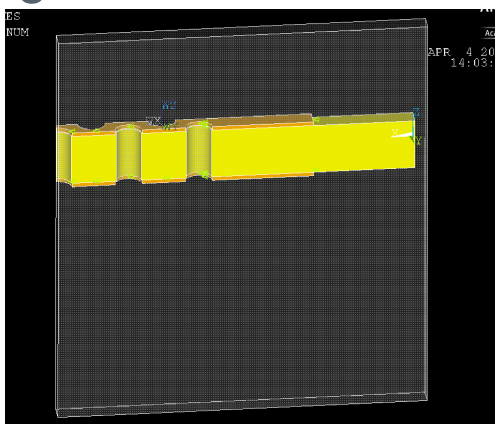








Note: The cloud on the left of the bottom pictures are electrons that passed between two LEMs and did not get amplified. They can be ignored.



Conclusion

- Borders induce a clean cut in the spatial charge distribution
- The deviation of the path is at most of 0.2 cm, inferior to strip size (0.3125 cm)
- Same thing expected for other blind regions

The End

Thank you!