Ideas on instrumenting the iron with a “scintillating” layer

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Our vanilla model

1. “Sparse” lead for the simplified ECAL (SpaCal) model without fibers: radiation length 6.720 mm, density 9.480 g/cm³;

2. SpaCal - without fibers - 30 cm thickness along the axis z and with dimensions 100x100 cm² in xy;

3. Air gap - 20 cm

4. Fe - 30 cm thickness along the z axis;

5. Were considered energy deposits from all particles in layers SpaCal (1cm) and Fe(1cm);

6. Sensitive layer - matrix 100x100 cells with various cell size: 3x3, 5x5, 10x10 cm²

Region	Module type	Cell size [cm^2]	Segmentation [mm]/[X_0]	R_M [mm]	$\sigma_E/E = A/\sqrt{E} \oplus B$ A/B [%]
1	SpaCal W/GAGG	1.5×1.5	45+105/7+18	14.5	9.1 / 1.4
2	SpaCal Pb/PS	3.0×3.0	80+210/7+18	29.5	10.4 / 0.6
3	Shashlik	4.0×4.0	Continuous fibres	35.0	10.0 / 1.0
4	Shashlik	6.0×6.0	Continuous fibres	35.0	10.0 / 1.0
5	Shashlik	12.0×12.0	Continuous fibres	35.0	10.0 / 1.0
1-5	W-Si	1×1	26 layers	16.1	21.2 / 0.6

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Material:       Pb    density:  9.480 g/cm3   RadL:   6.720 mm   Nucl.Int.Length:  21.847 cm
                      Imean: 823.000 eV   temperature: 293.15 K  pressure:   1.00 atm

  --->  Element: Pb (Pb)   Z = 82.0   N =   207   A = 207.217 g/mole
        --->  Isotope: Pb204   Z = 82   N = 204   A = 203.97 g/mole   abundance:  1.400 %
        --->  Isotope: Pb206   Z = 82   N = 206   A = 205.97 g/mole   abundance: 24.100 %
        --->  Isotope: Pb207   Z = 82   N = 207   A = 206.98 g/mole   abundance: 22.100 %
        --->  Isotope: Pb208   Z = 82   N = 208   A = 207.98 g/mole   abundance: 52.400 %
         ElmMassFraction: 100.00 %  ElmAbundance 100.00 %


Material:       Fe    density:  7.874 g/cm3   RadL:   1.757 cm   Nucl.Int.Length:  16.990 cm
                      Imean: 286.000 eV   temperature: 293.15 K  pressure:   1.00 atm

  --->  Element: Fe (Fe)   Z = 26.0   N =    56   A = 55.845 g/mole
        --->  Isotope:  Fe54   Z = 26   N =  54   A =  53.94 g/mole   abundance:  5.845 %
        --->  Isotope:  Fe56   Z = 26   N =  56   A =  55.93 g/mole   abundance: 91.754 %
        --->  Isotope:  Fe57   Z = 26   N =  57   A =  56.94 g/mole   abundance:  2.119 %
        --->  Isotope:  Fe58   Z = 26   N =  58   A =  57.93 g/mole   abundance:  0.282 %
         ElmMassFraction: 100.00 %  ElmAbundance 100.00 %
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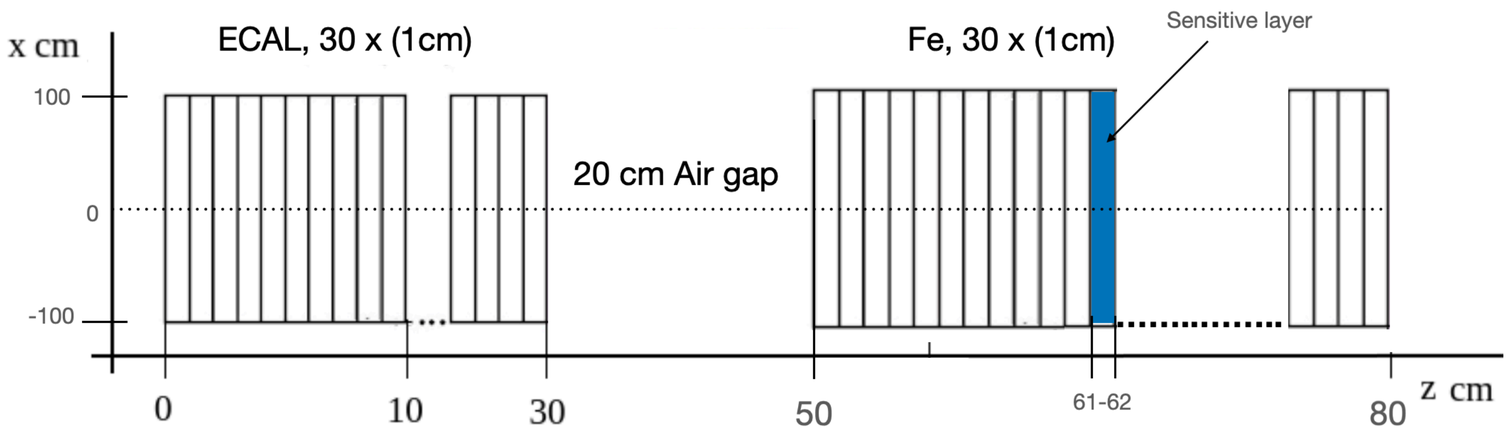
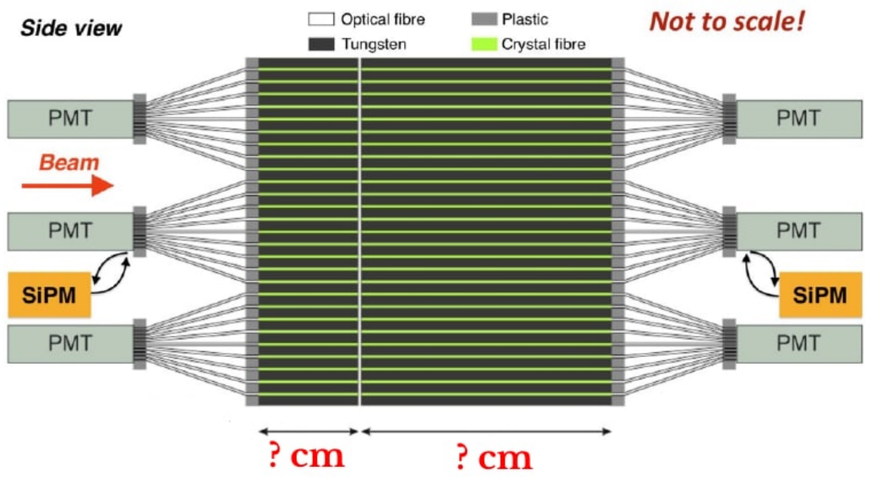
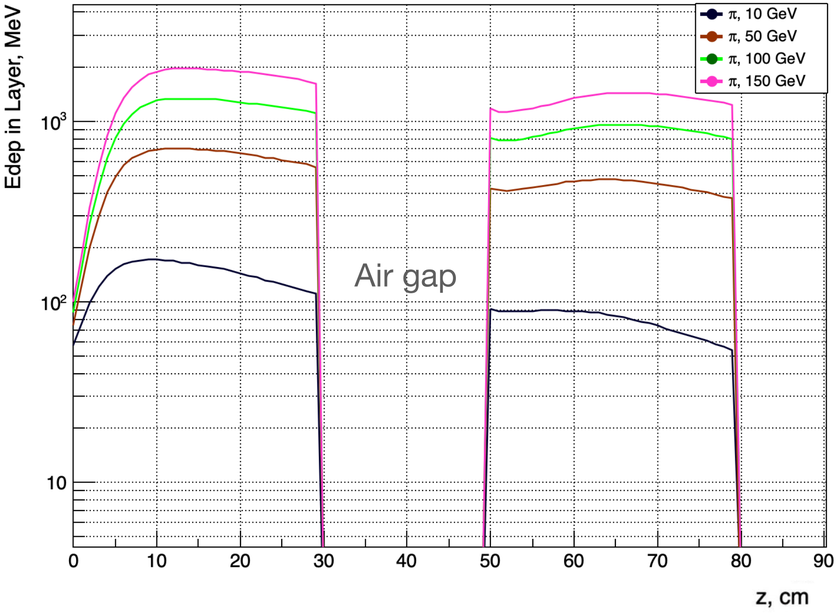


Longitudinal energy deposit distributions.

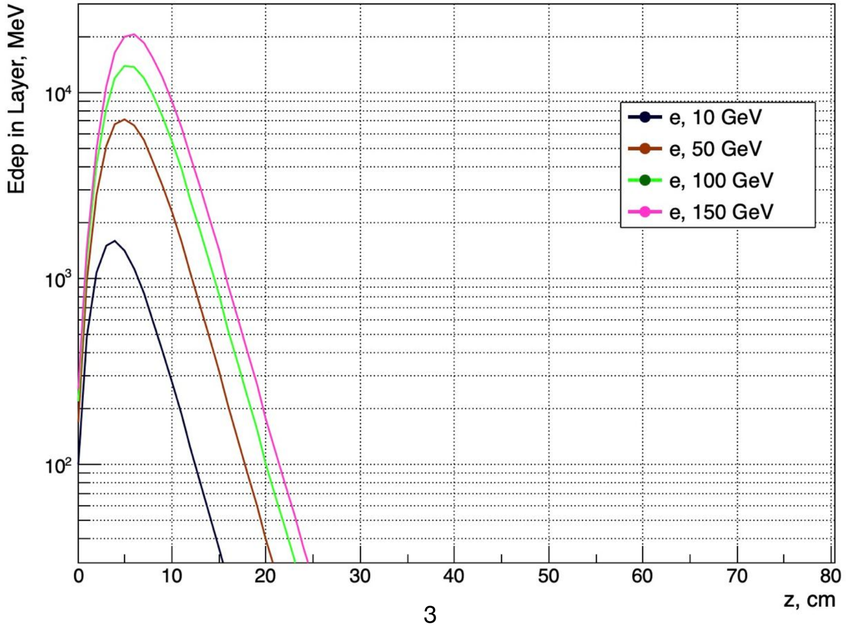
- The energy deposit in the SpaCal & Fe layers was calculated for different particles: pions, electrons, muons;
- All electron's shower was absorbed in SpaCal layers;
- Muons deposit a small amount of energy (MIP).
- Particles in hadron's shower leaves SpaCal layer, and deposit large amount of energy in Fe absorber.



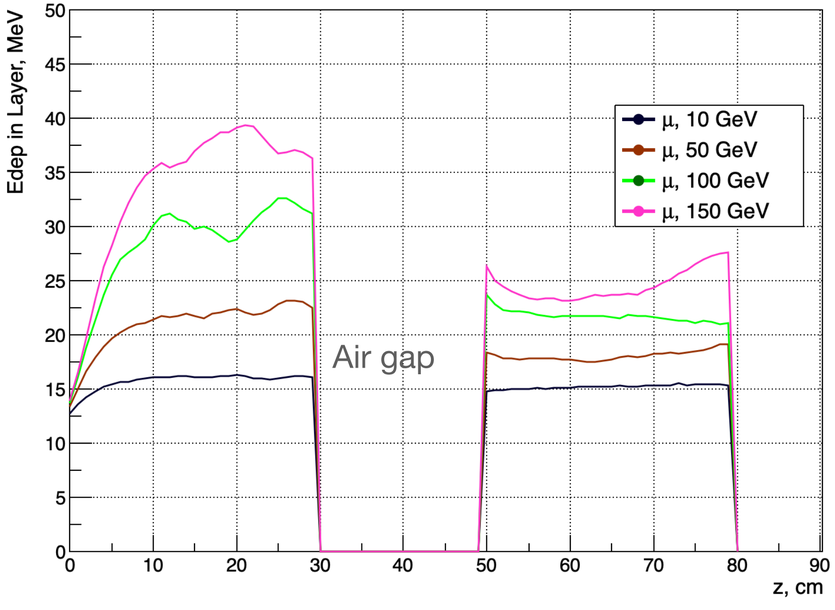
ECAL: SpaCal, primary pion, no threshold, in Pb & Fe.



ECAL: SpaCal, primary electron,no threshold, in Pb & Fe.

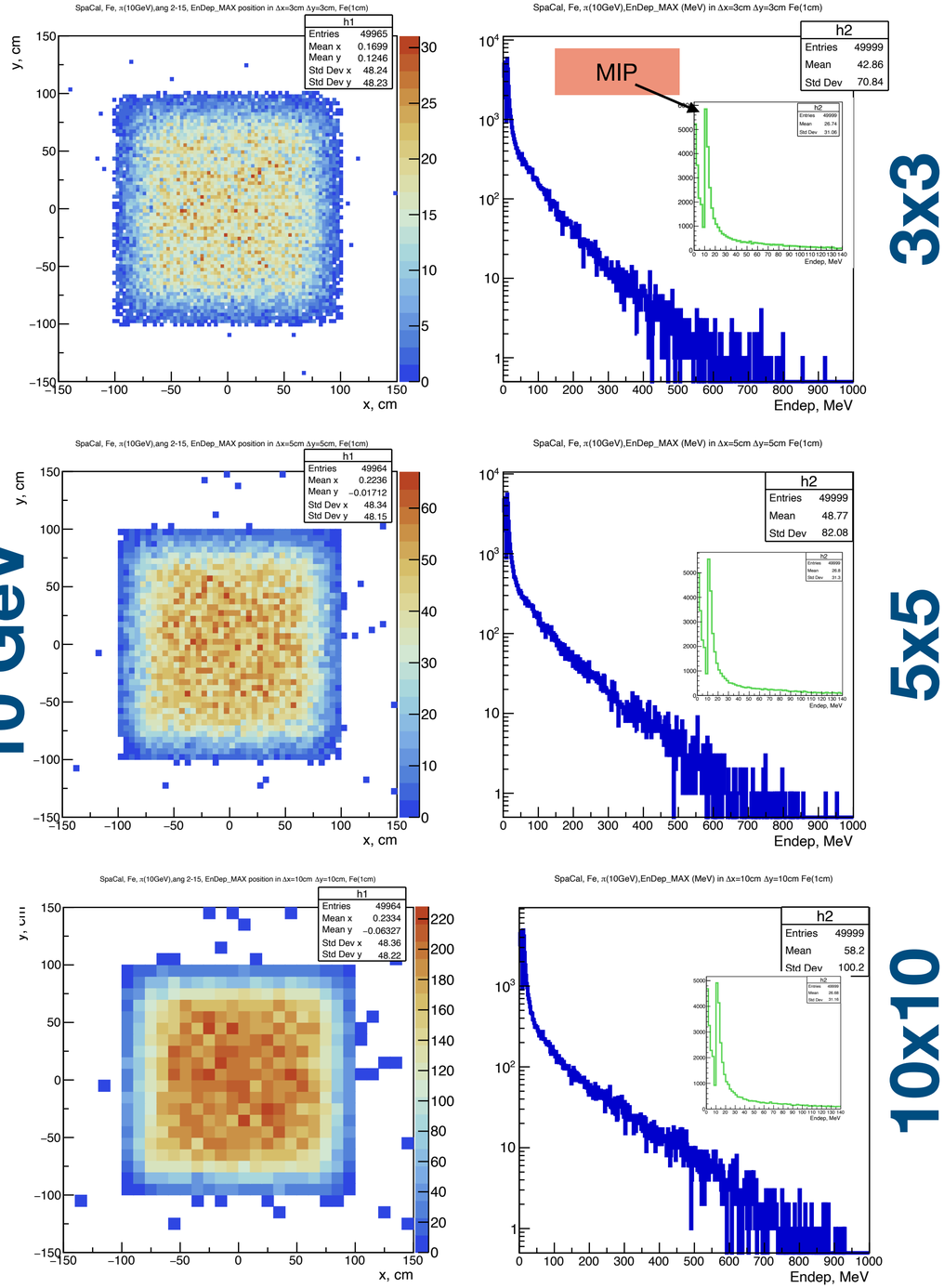


ECAL: SpaCal, primary muon,no threshold, in Pb & Fe.



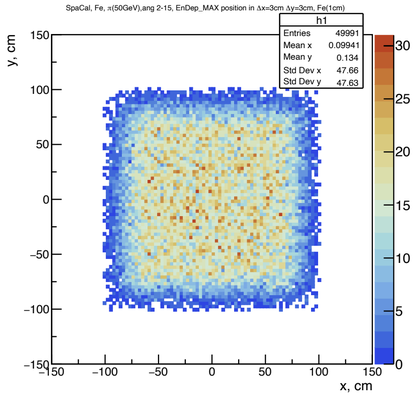
Granularity studies - 3x3 5x5 10x10 cm²

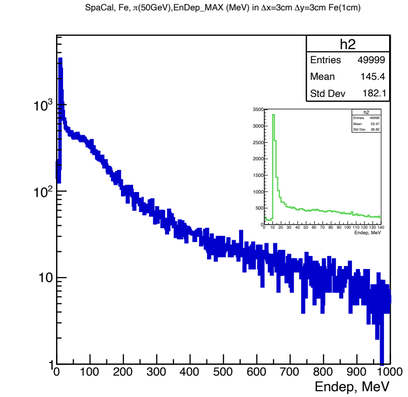
- Particle gun: 50.000 primary pions with energies: 10 GeV, 50 GeV, 100 GeV, 150 GeV;
- Pion starting point was generated uniformly in xy plane: ± 8cm;
- Uniform angular distribution in solid angle: 2-15 degree;
- For sensitive layer for each pion event we considered 100x100 energy deposit matrix;
- For each pion event we defined the cell with maximum energy deposit (the right hist (blue&green(different scale)) shows maximum energy deposit in cells);
- We outputted information about cells coordinates with maximum energy deposit for each pion event (the left hist).

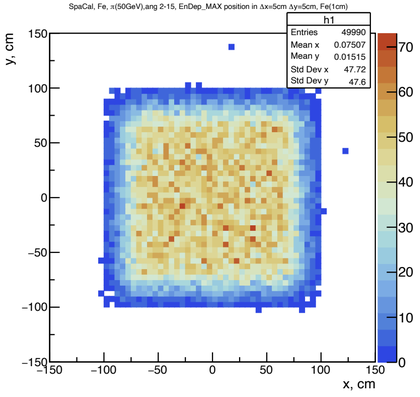


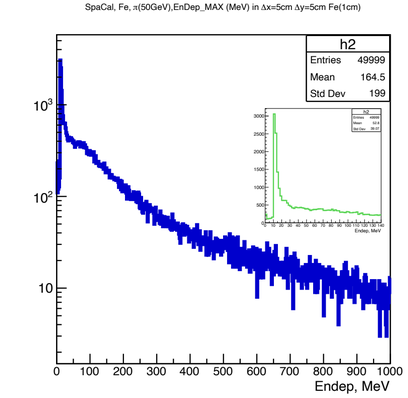
All datasets for cells 3x3 5x5 10x10 from top to bottom in increasing order.

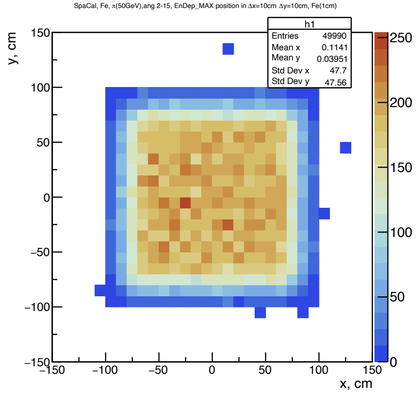
50 GeV

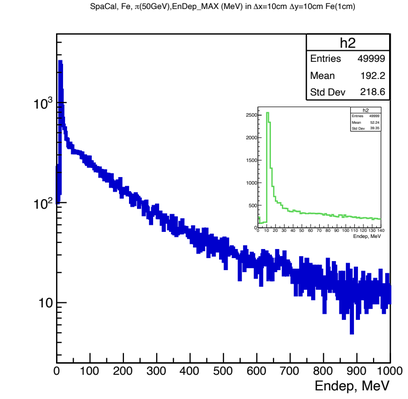




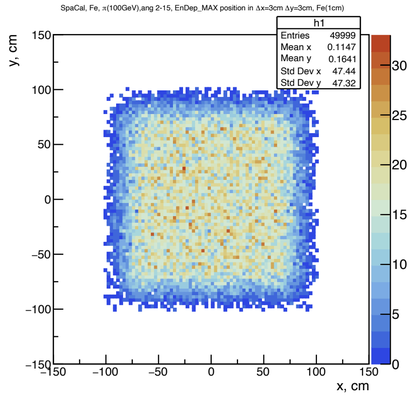


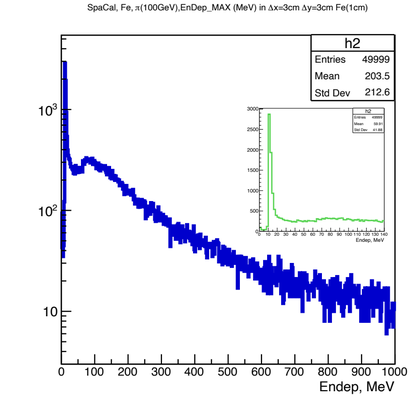


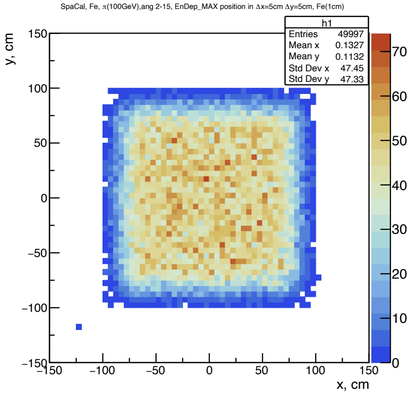


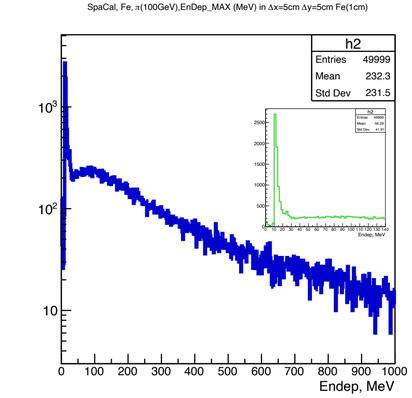


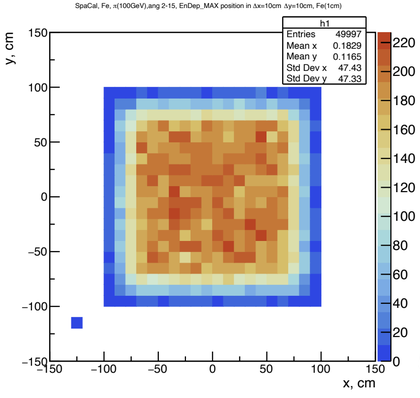
100 GeV

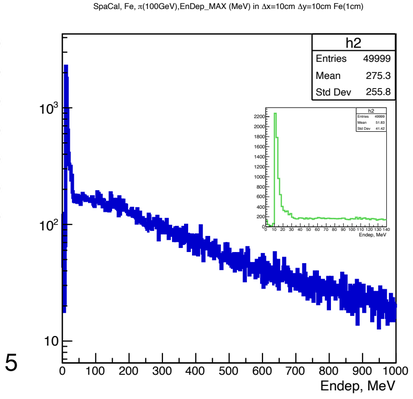




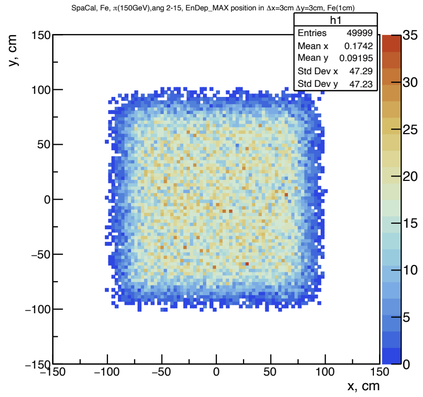


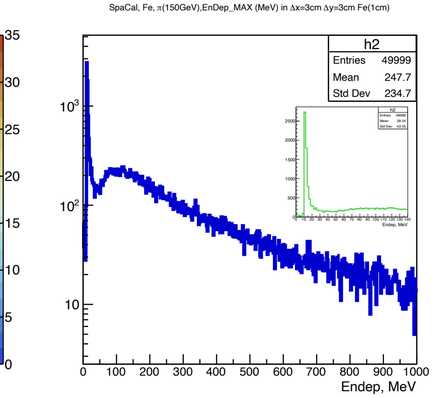


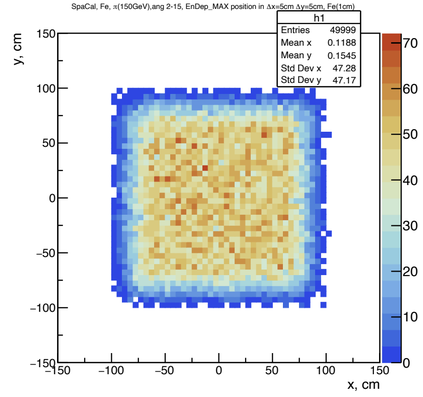


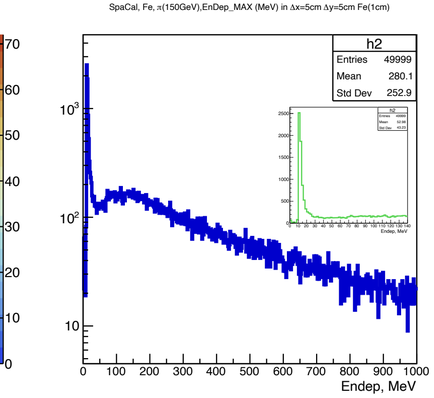


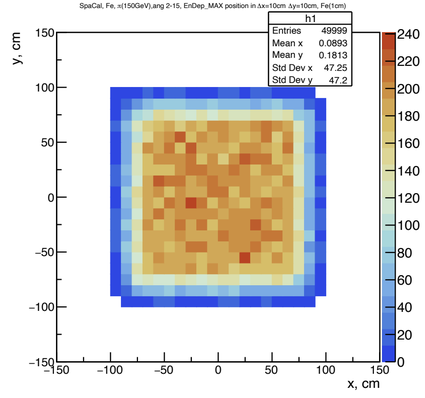
150 GeV

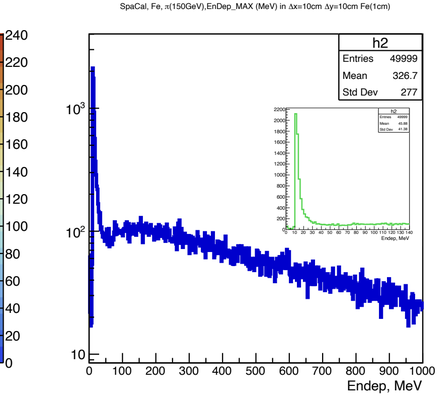




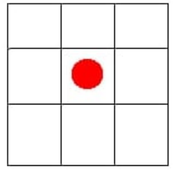


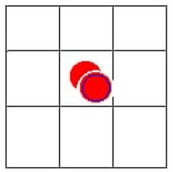






Occupancy estimation



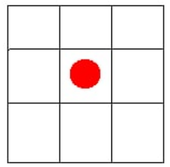


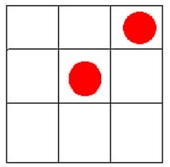
break

- We considered 2 criteria for estimation of maximum pion numbers for overlapping (EnDep in cell > 50 MeV):

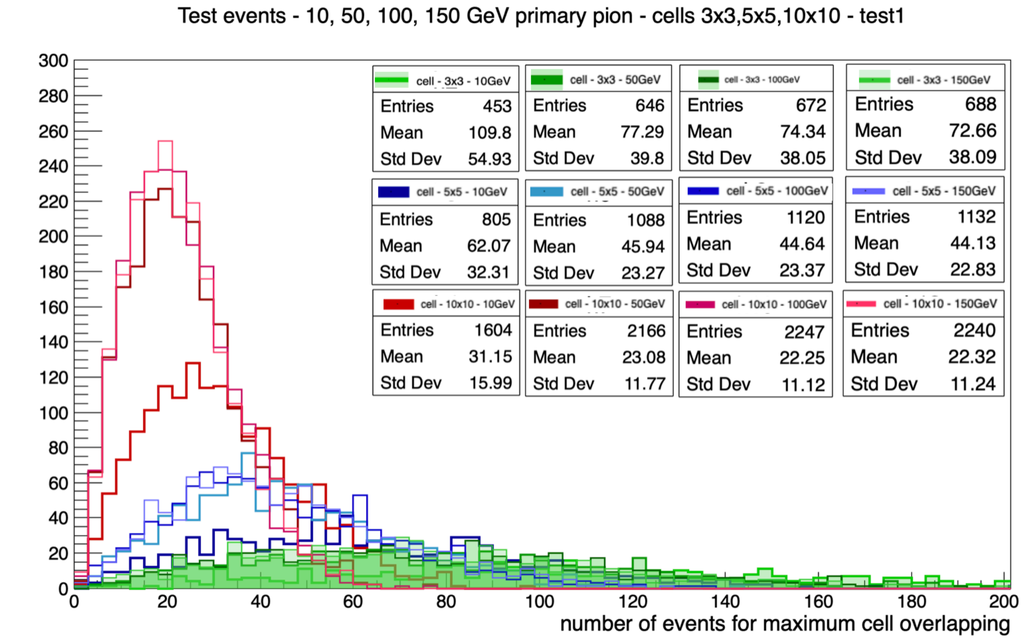
1. Matching maximum energy deposit cells for 2 events;

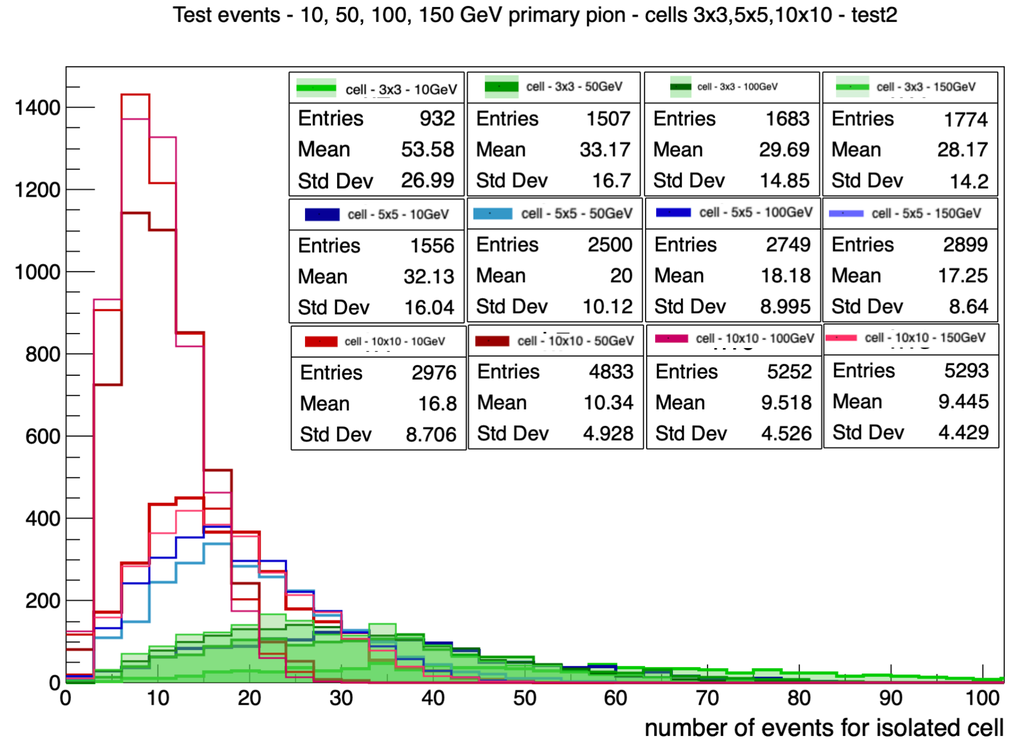
2. Maximum energy deposit cells from 2 pion events not separated by full cell.





break





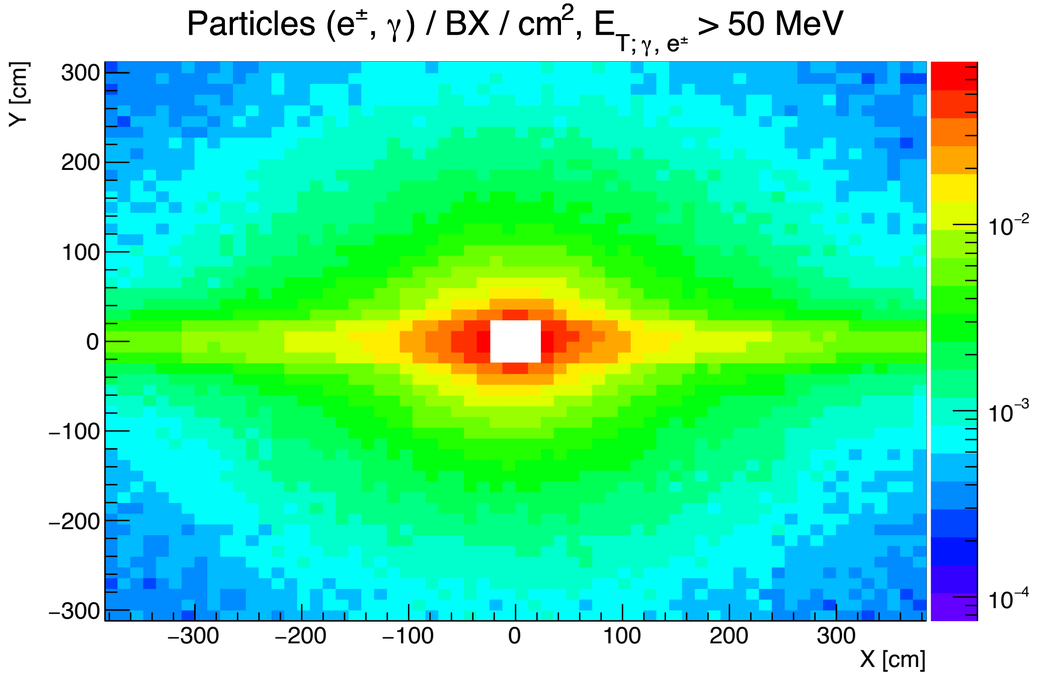
Considering occupancy of ECAL

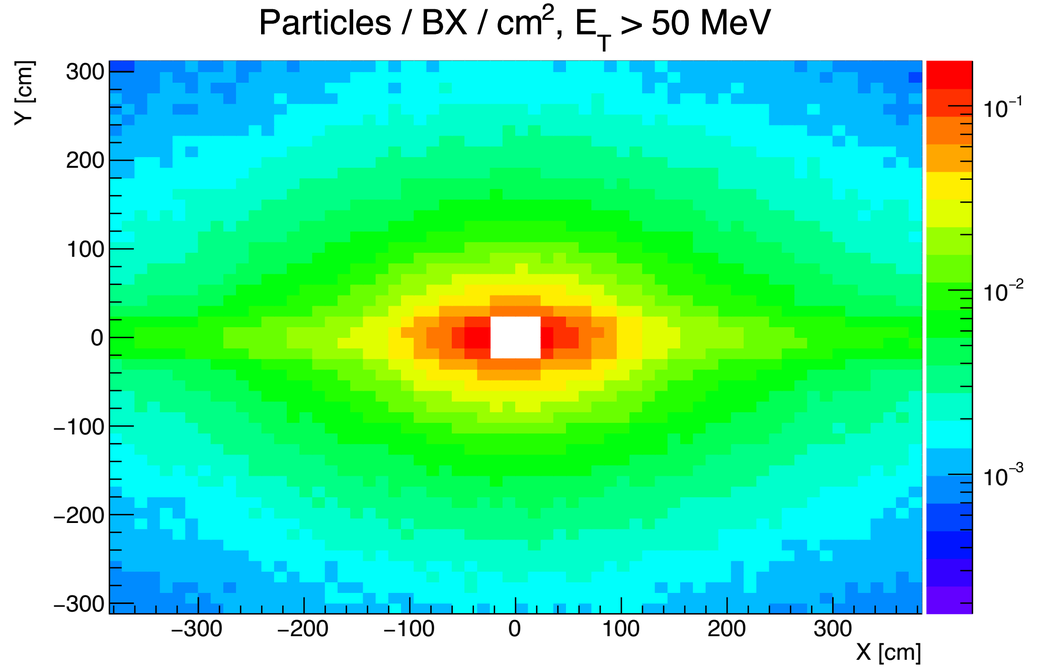
Thanks to Philipp Gerhard Roloff and Davide Zuliani!

- Hadron occupancy: 0.035 events/(cm²*BX);

The pion events on ECAL entrance layer per cm² that we can accept according to occupancy

10 GeV		
3x3	5x5	10x10
0,21	**0,13**	**0,07**
50 GeV		
3x3	5x5	10x10
0,13	**0,08**	**0,04**
100 GeV		
3x3	5x5	10x10
0,12	**0,07**	**0,04**
150 GeV		
3x3	5x5	10x10
0,11	**0,07**	**0,04**





colors don't illustrate any physical properties

Conclusion

- According to occupancy map all size of cells are acceptable for MEAN ESTIMATED OVERLAPPING EVENTS;
- The distribution for overlapping events are wide: that’s why we shouldn’t consider mean value (overlapping can occur for less pion events);
- the current HCAL granularity 5x5 seems be sufficient.