

Simulation of showers in SPD ECAL using Geant4

Andrei Maltsev

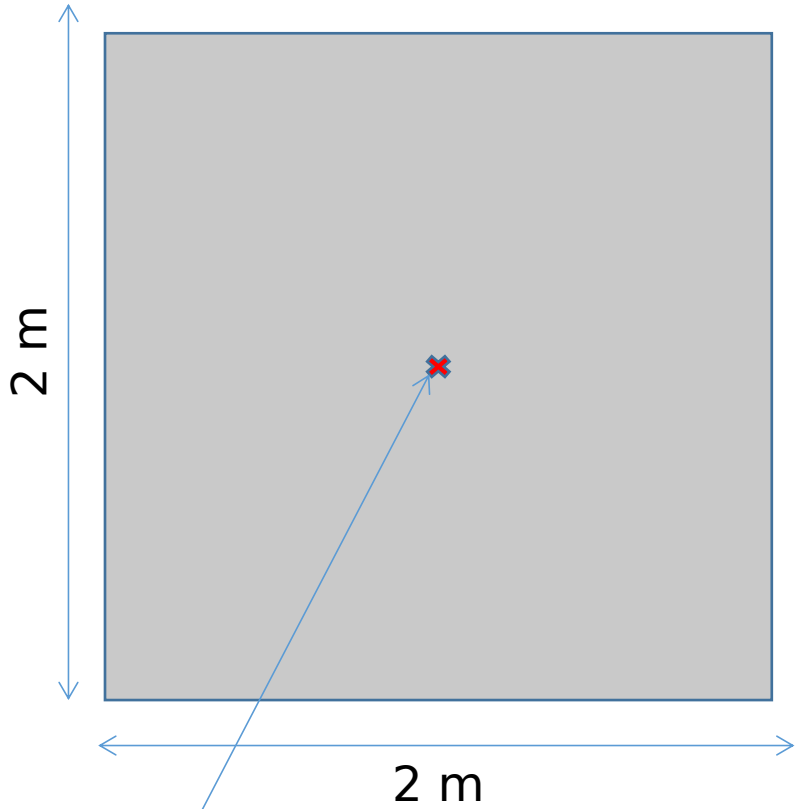
Goals

Obtain ECAL resolution for different setups (number of layers, thickness of lead layer, etc.)

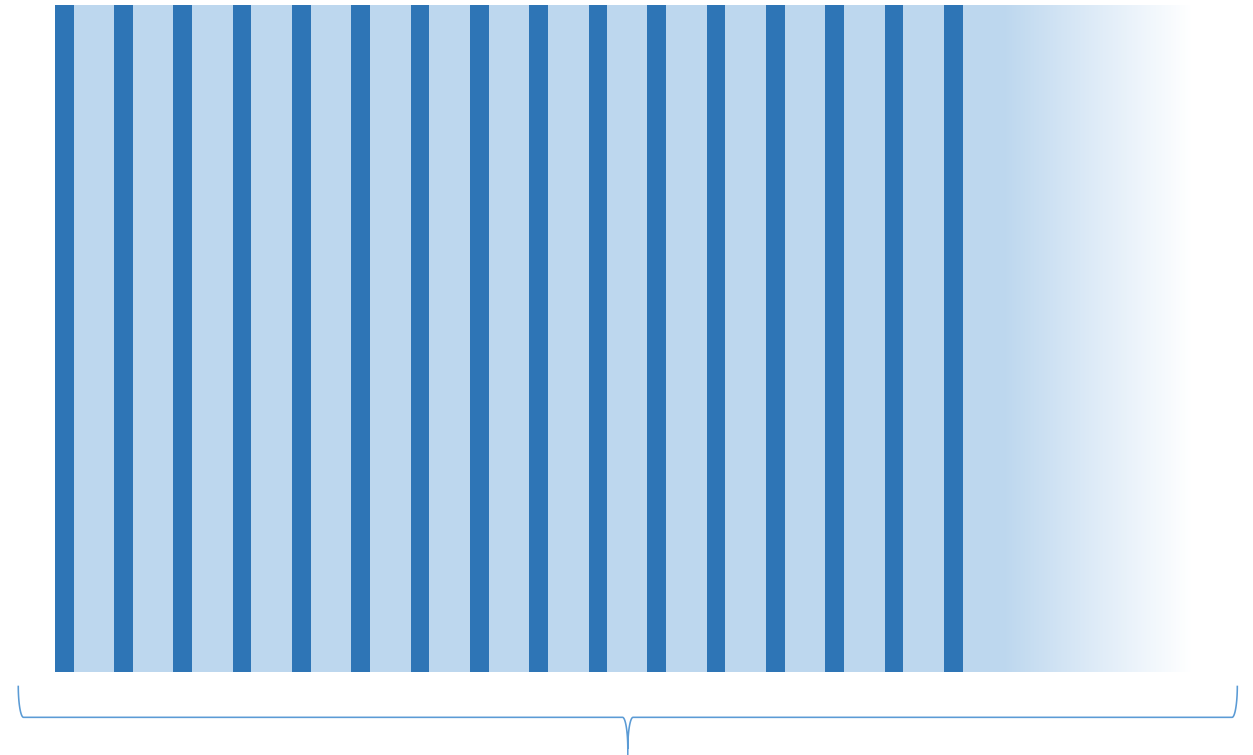
Estimate impact of light attenuation in light guides and photoelectron statistics

Obtain shower profiles for different values of cell size, energies, angles of incoming particle etc.

The setup



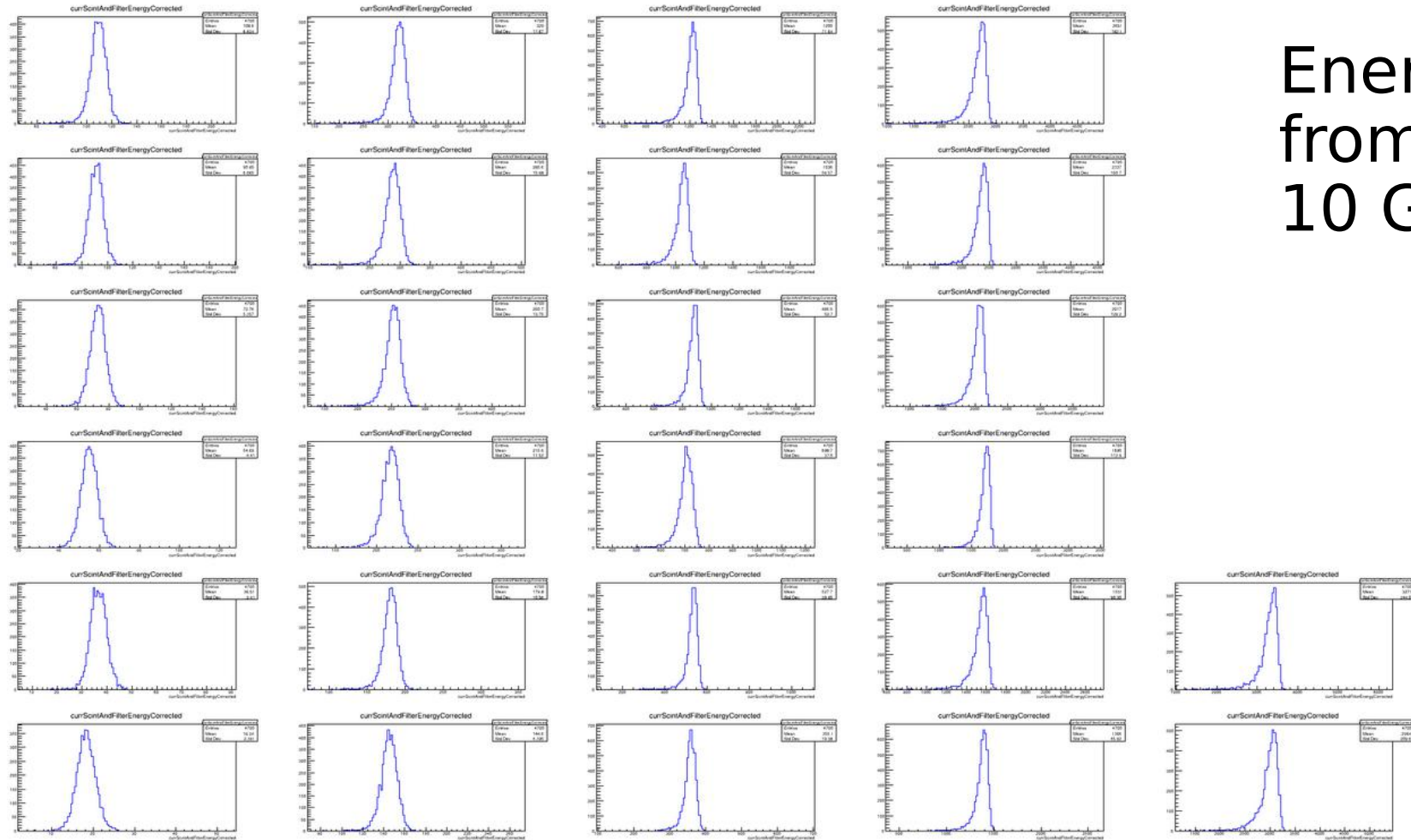
particle hitting center of ECAL
leakage from sides considered negligible



Input: number of layers, width of scintillator/lead,
particle energy/type/angle

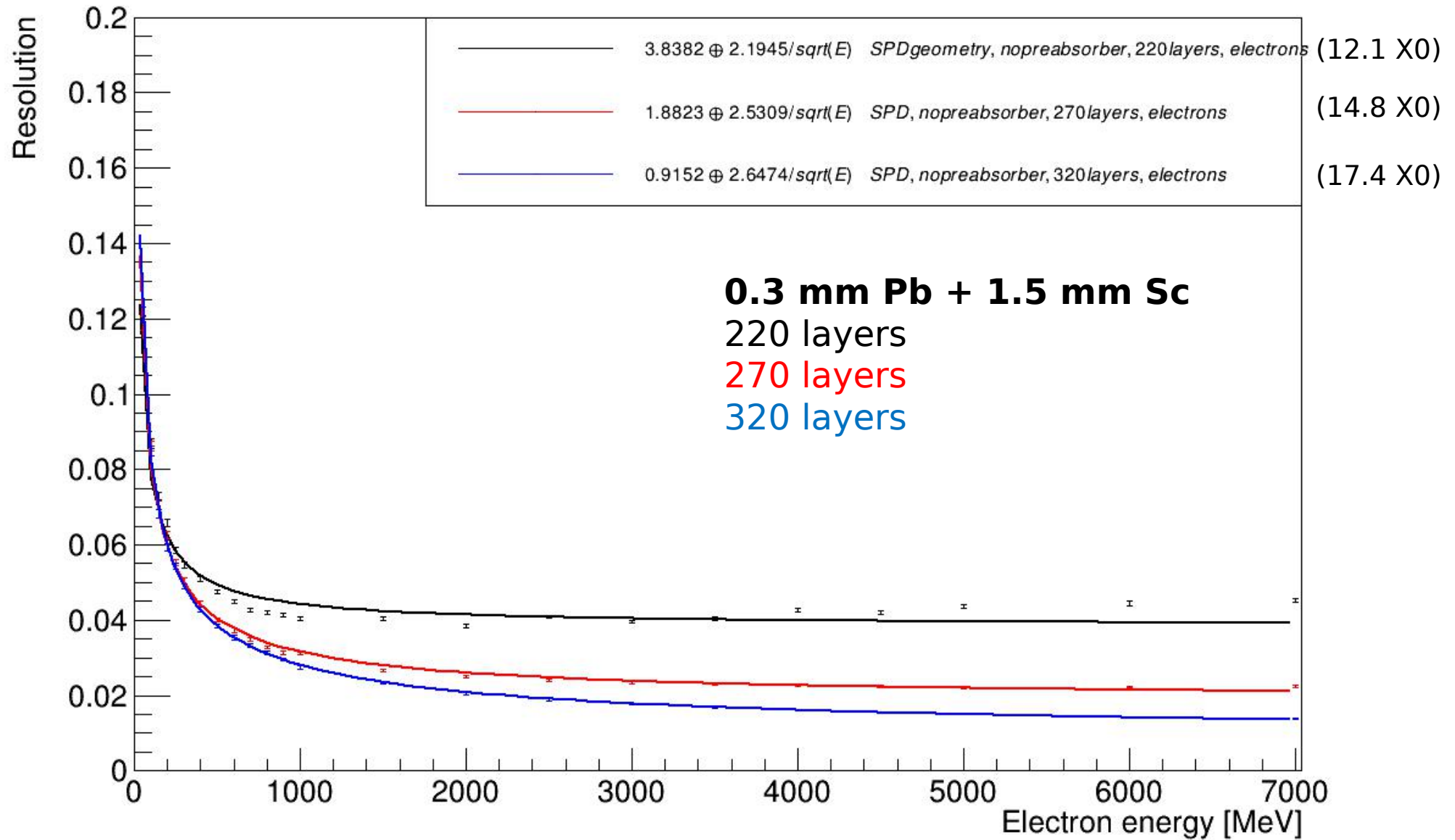
Scintillator: Polystyrene/Terphenyl (2.5%)/POPOP (0.01%)
Standard EM physics list

Resolution of ECAL

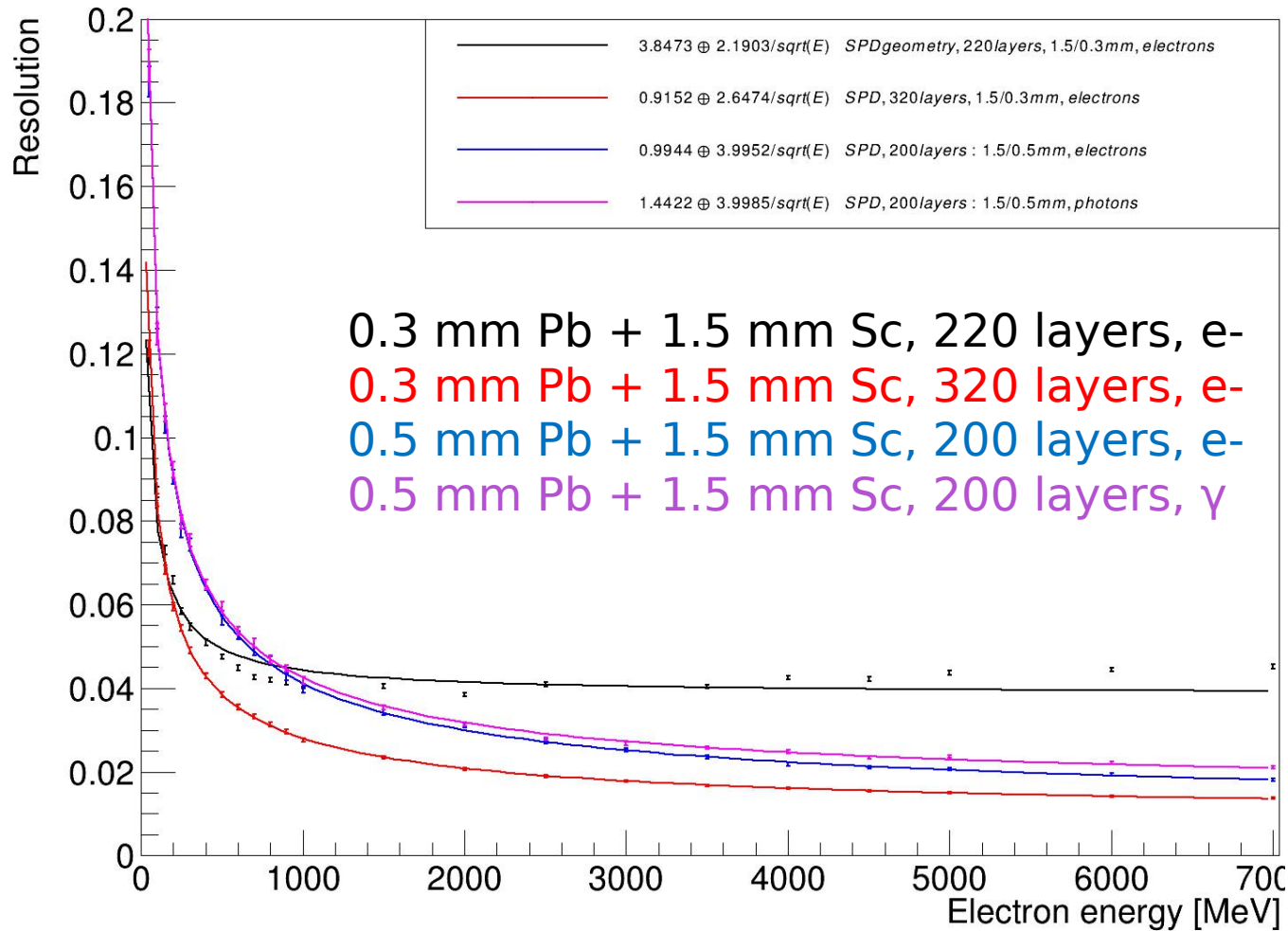


Energies ranging
from 50 MeV to
10 GeV

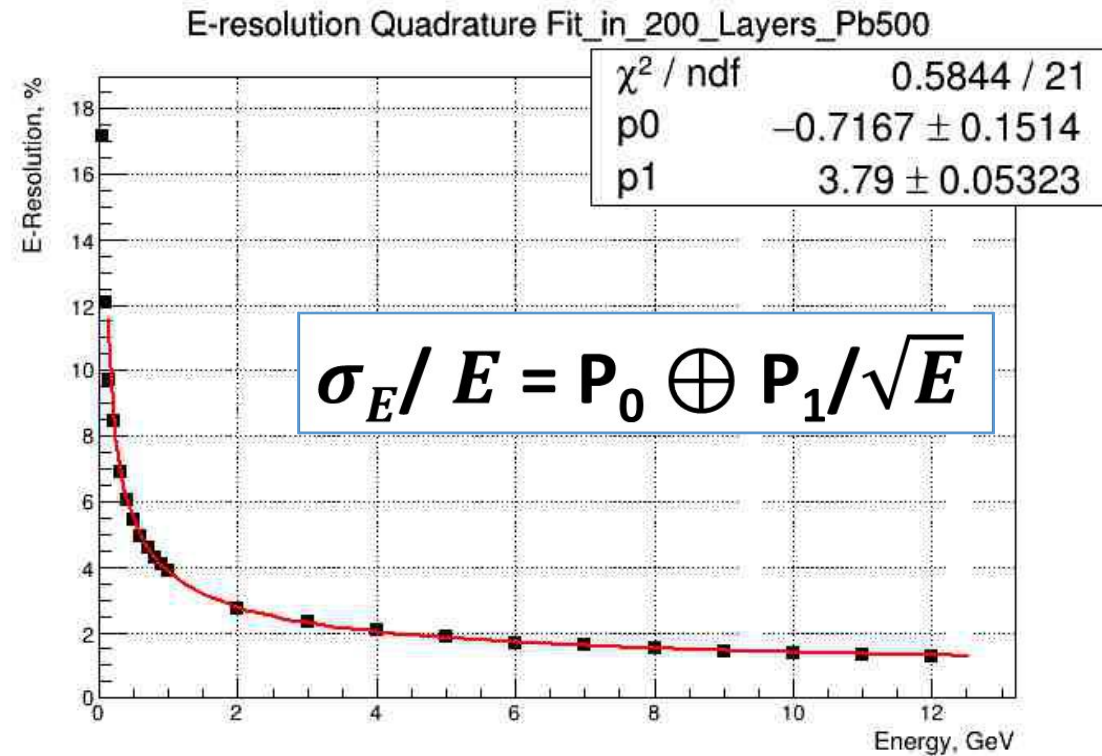
SPD ECAL resolution



SPD ECAL resolution



0.5 mm Pb + 1.5 mm Sc, 200 layers, e-
 (Result of O.Gavrishchuk)



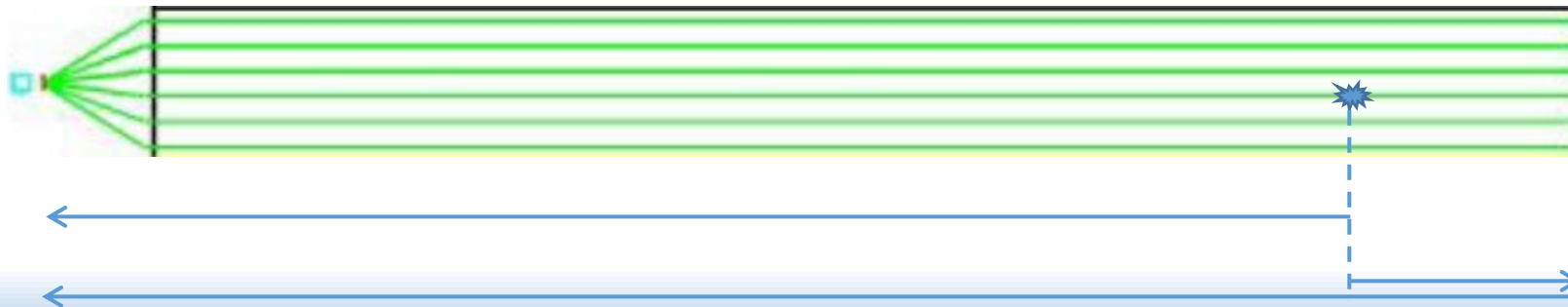
The results are consistent with the results of O.Gavrishchuk
 200 layers, 0.5 mm Pb + 1.5 mm Sc was taken for further studies

Corrections for ECAL resolution

- Number of photoelectrons:
~ 3000 per 1 GeV of energy deposition in scintillator → additional Poisson error
- Attenuation length: light attenuation depending on distance from PM and reflection coefficient

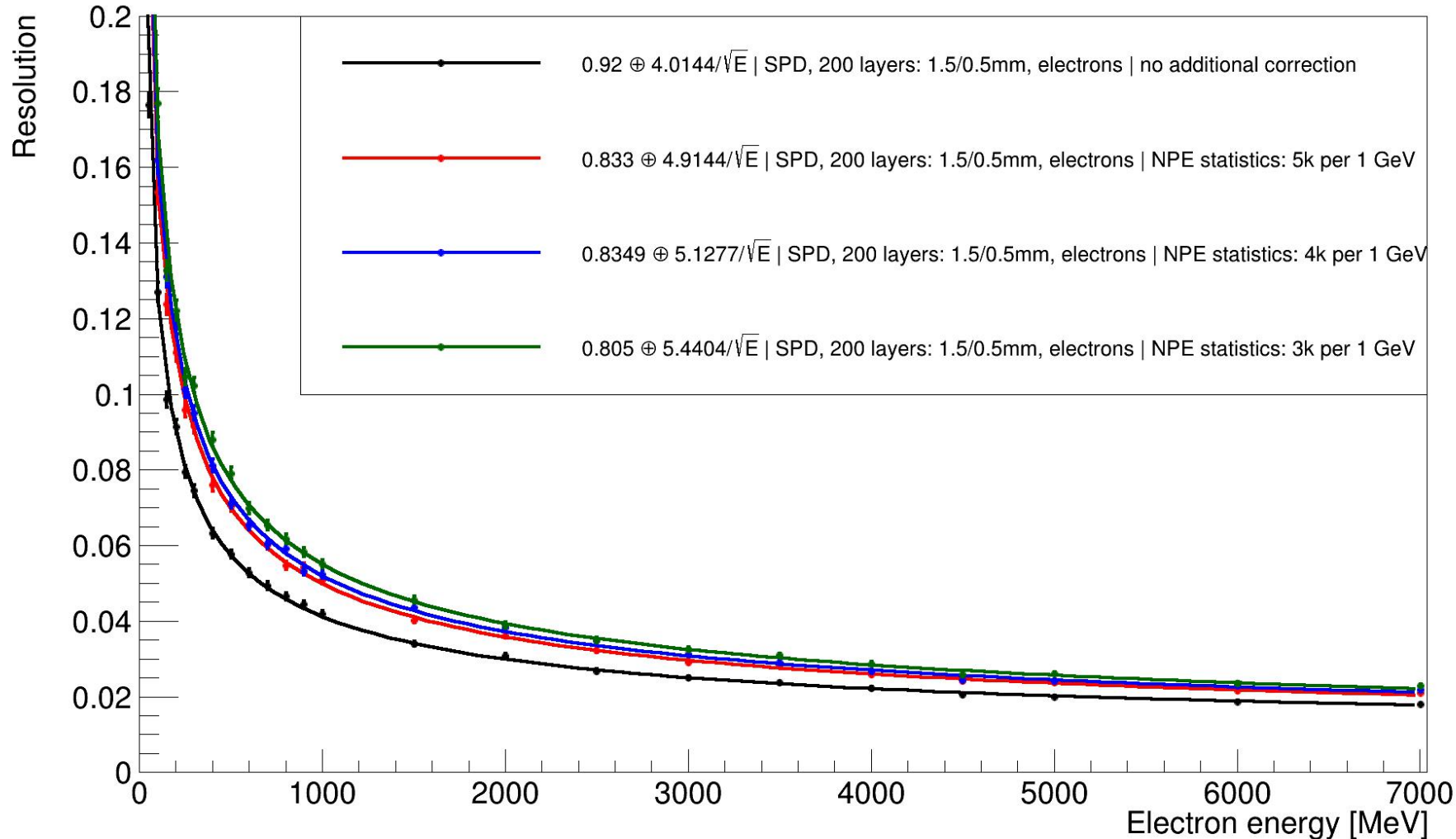
• mod= 1	Att_len= 163+/- 6 cm	NPE_mu=104
• mod= 2	Att_len= 148+/- 5 cm	NPE_mu= 99
• mod= 3	Att_len= 182+/- 9 cm	NPE_mu= 87
• mod= 4	Att_len= 167+/- 7 cm	NPE_mu=110

Result of O.Gavrishchuk on cosmic muons



Corrections for ECAL resolution

SPD ECAL resolution

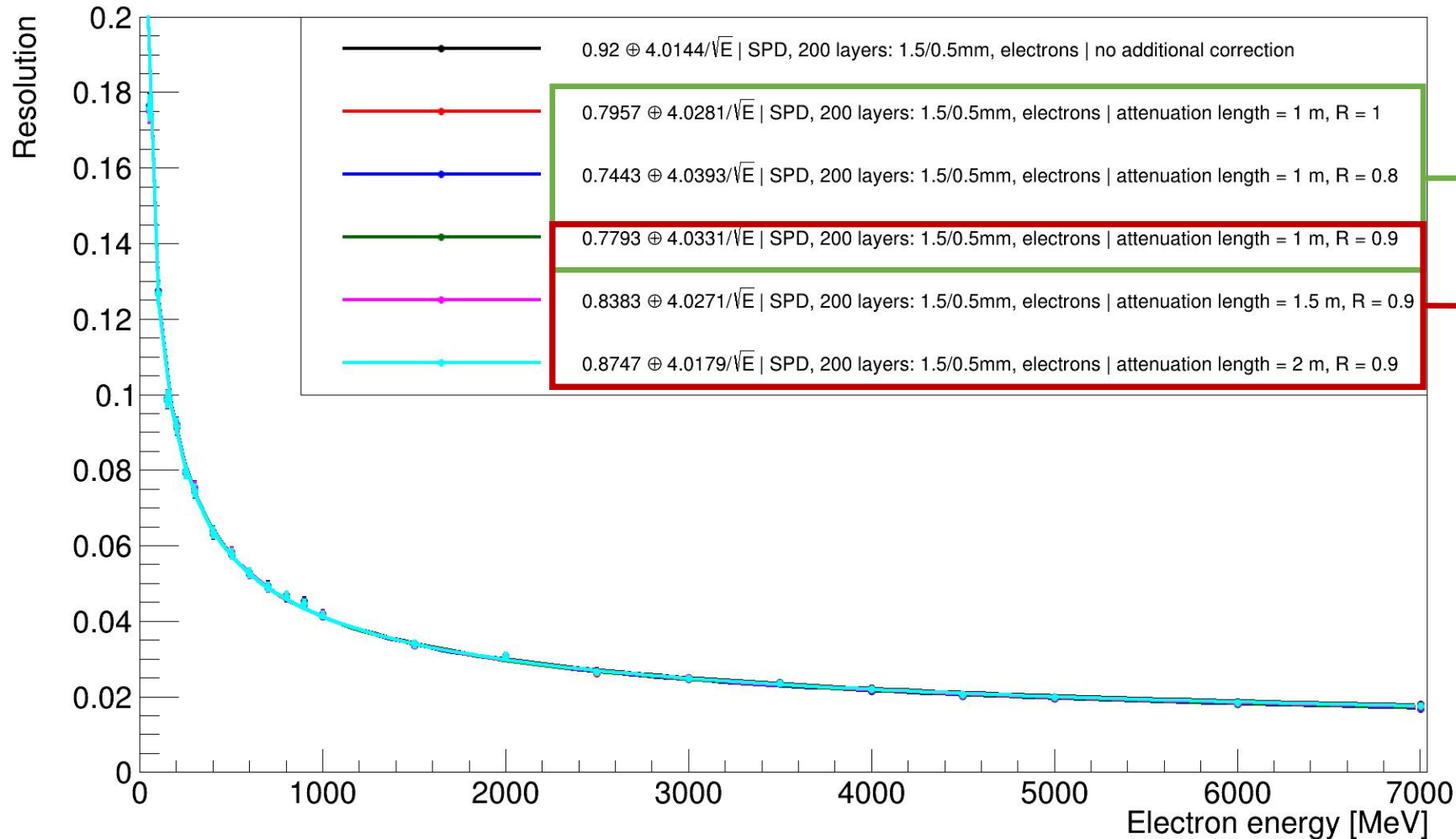


No correction
5000 P.E.
4000 P.E.
3000 P.E.

When taking into account photoelectron statistics, resolution @ 1 GeV changes from 4% to 5-5.5%

Corrections for ECAL resolution

SPD ECAL resolution

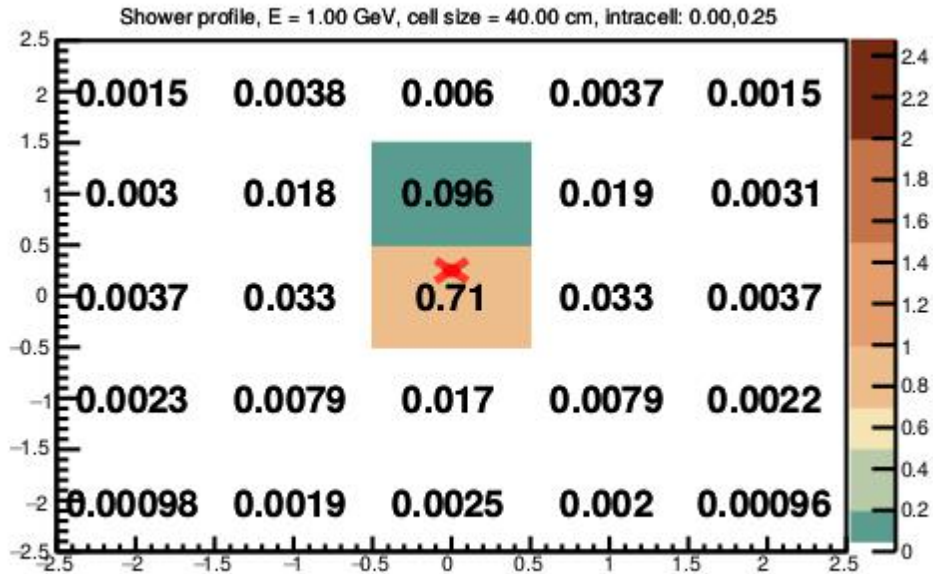


no significant effect from reflection coefficient

no significant effect from attenuation length in range (1m, 2m)

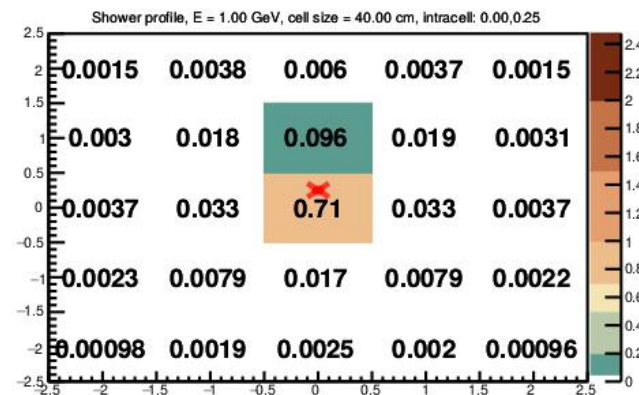
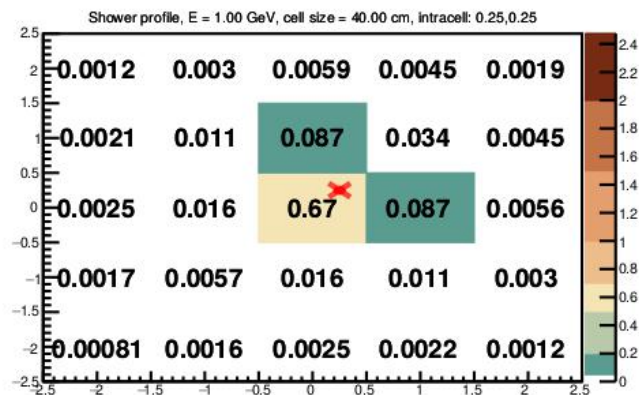
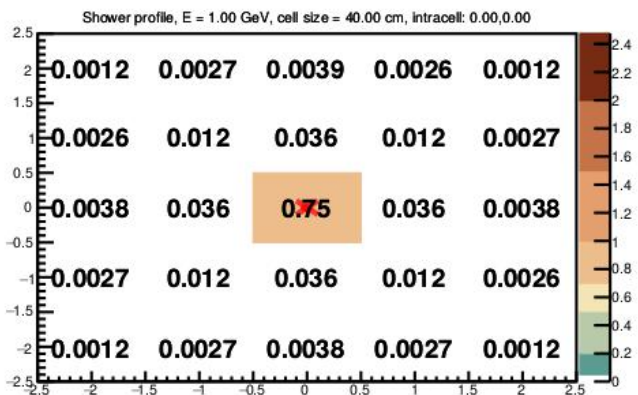
Accounting for attenuation length in sensible range (R from (0.9,1.0); L from (1m, 2m)) doesn't have significant impact

Shower profiles

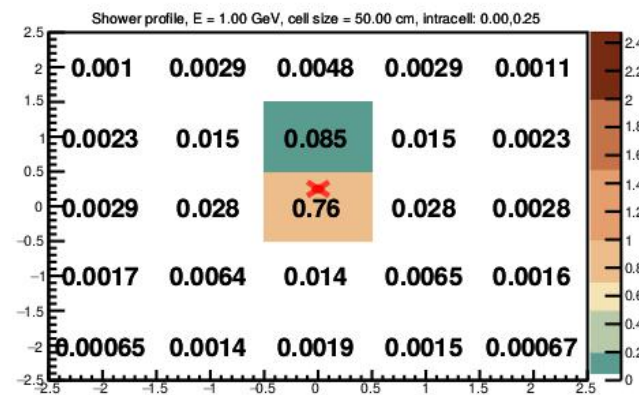
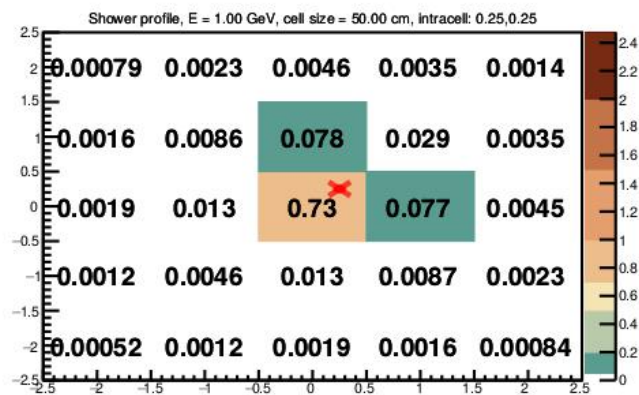
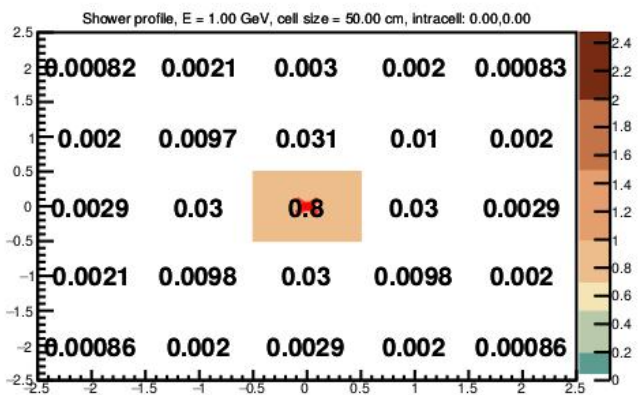


- Sum of energy deposition normalized to particle energy
- **x** indicates particle hit

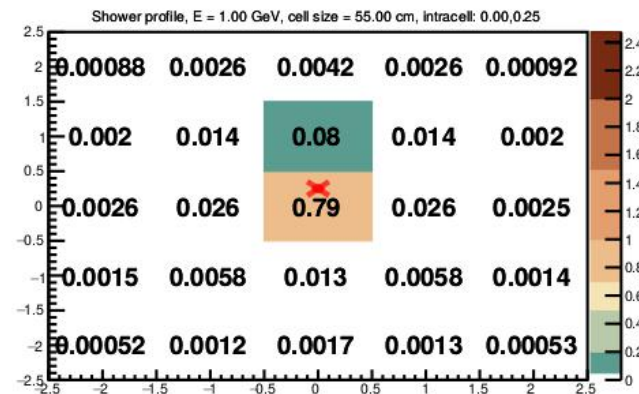
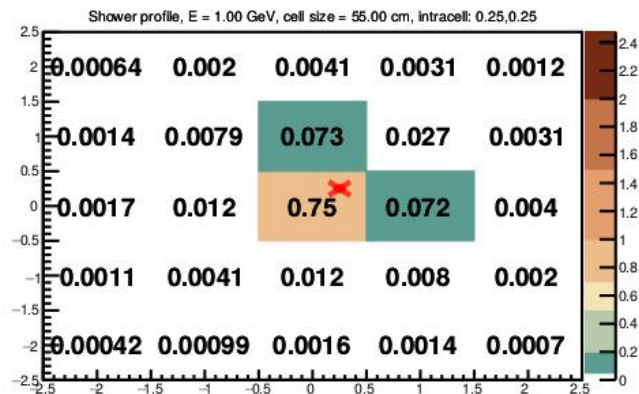
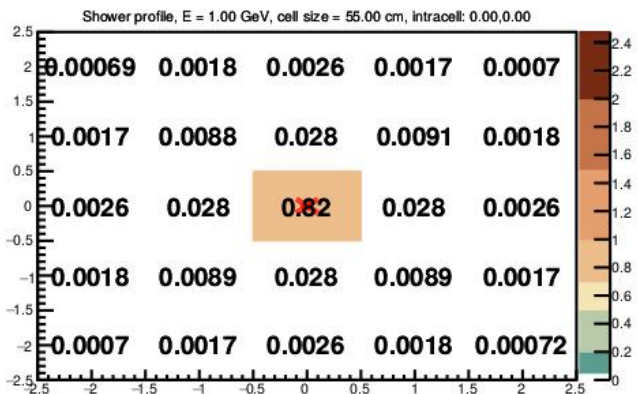
Shower profiles, electrons $E = 1$ GeV, angle = 0°



cell size:
4 cm

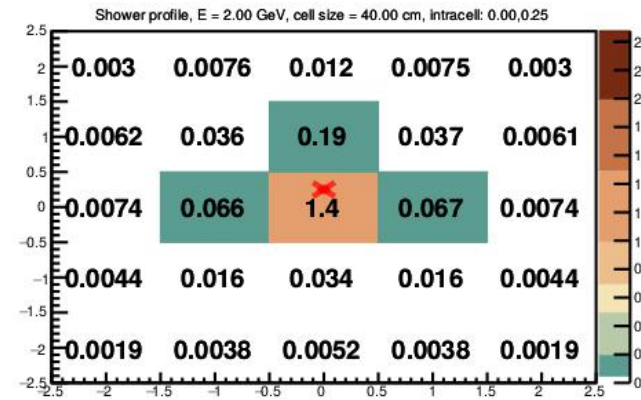
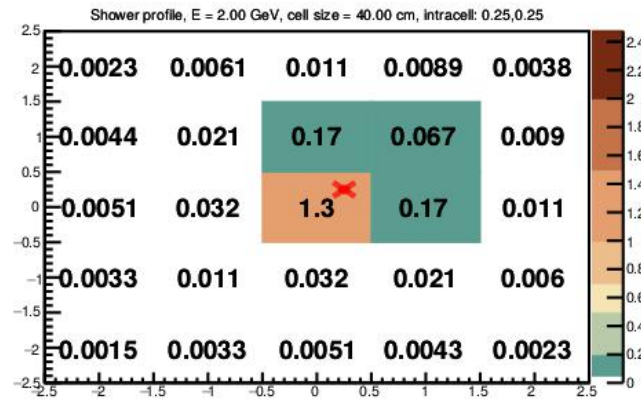
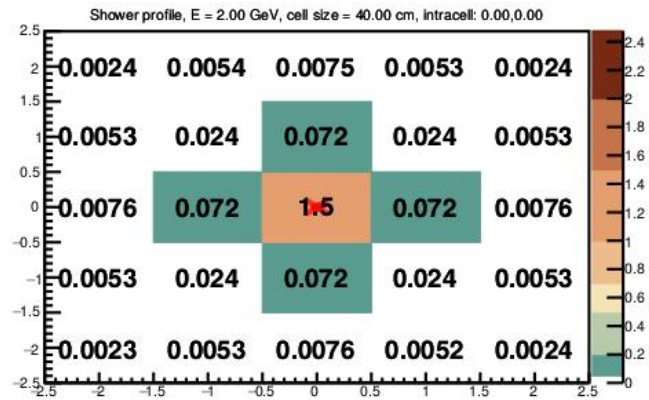


cell size:
5 cm

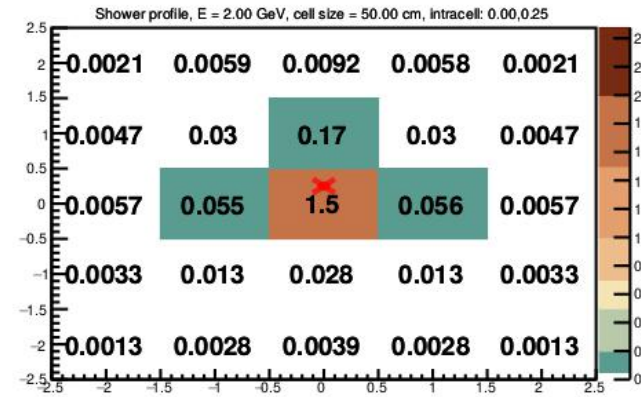
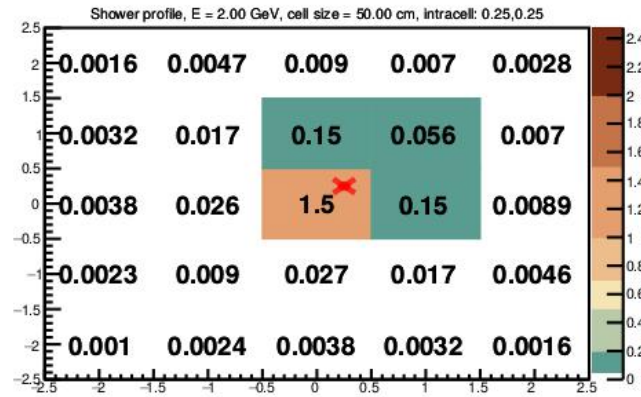
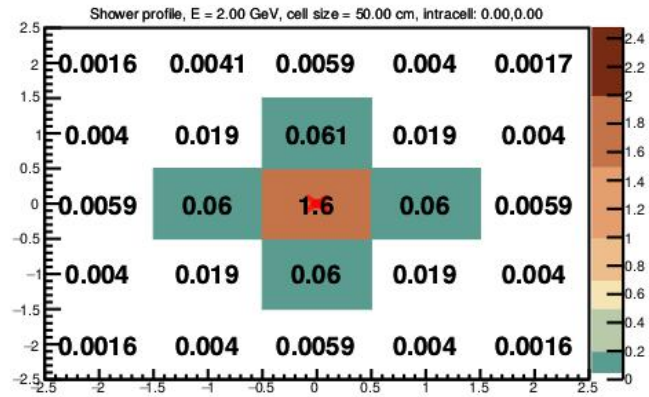


cell size:
5.5 cm

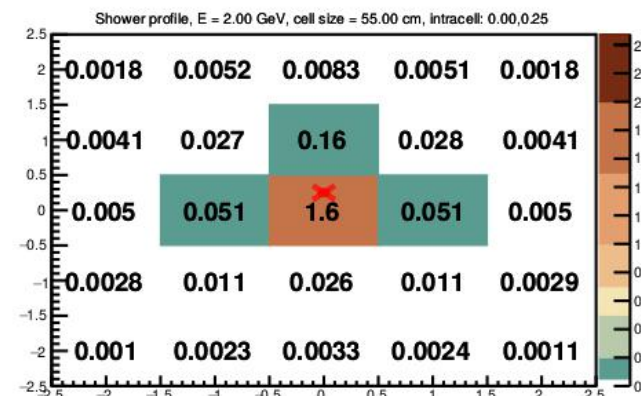
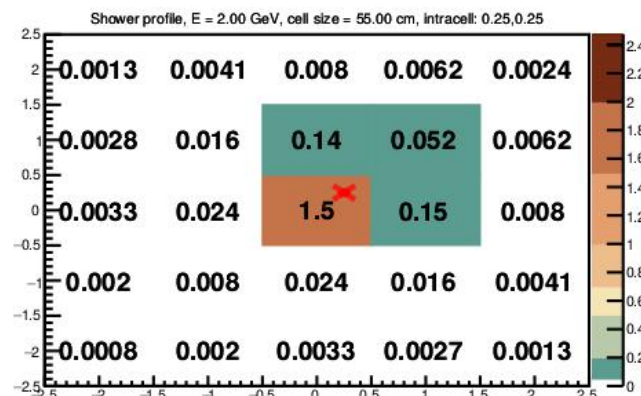
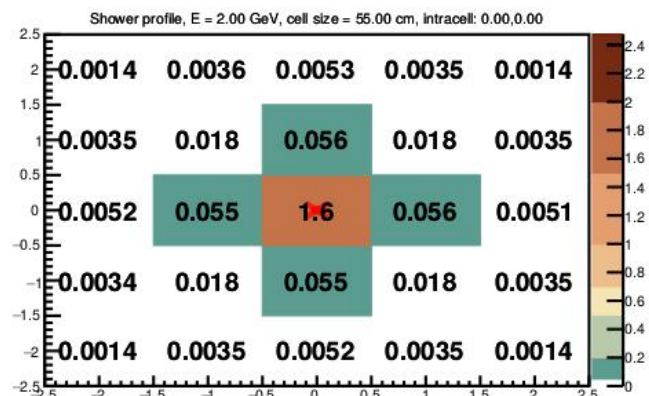
Shower profiles, electrons $E = 2$ GeV, angle = 0°



cell size:
4 cm

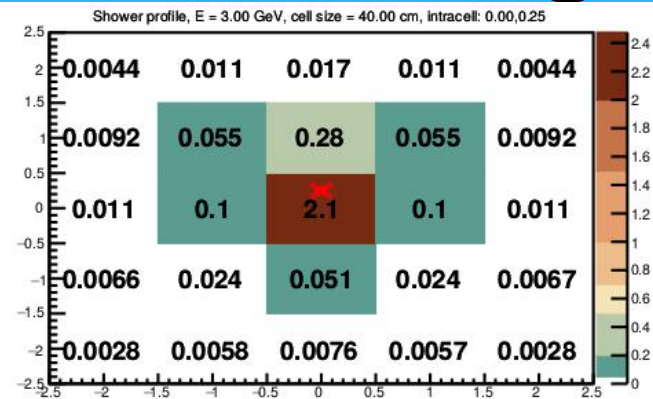
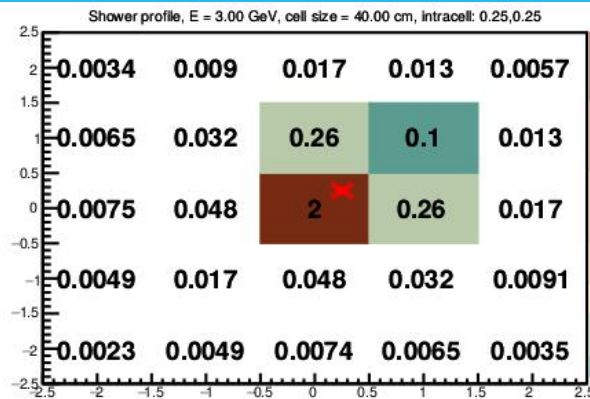
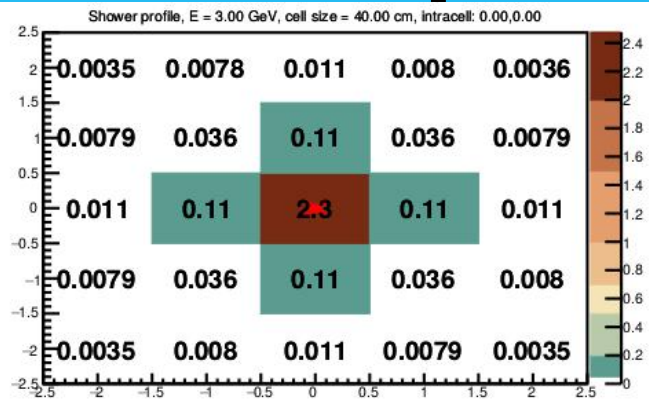


cell size:
5 cm

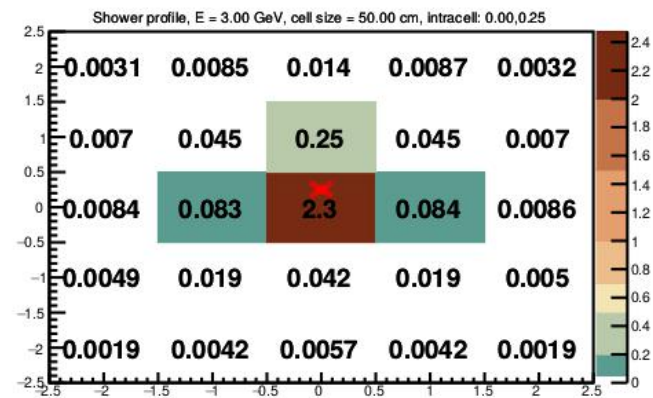
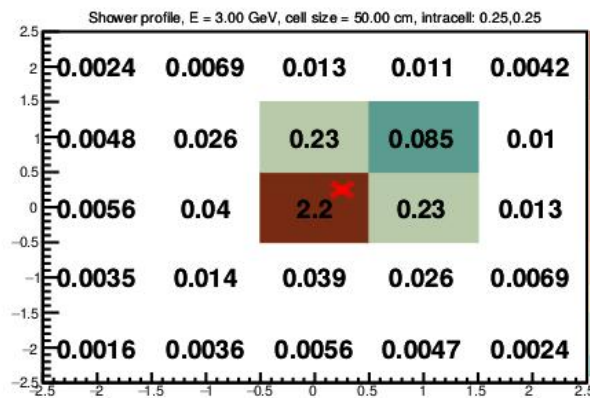
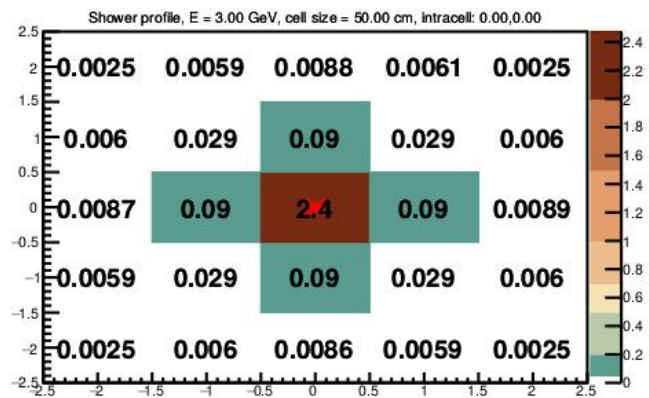


cell size:
5.5 cm

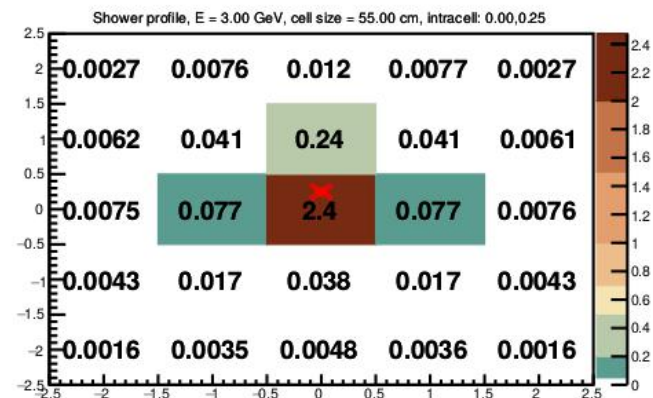
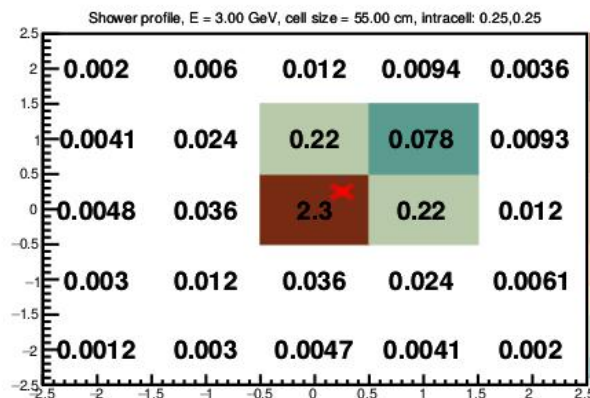
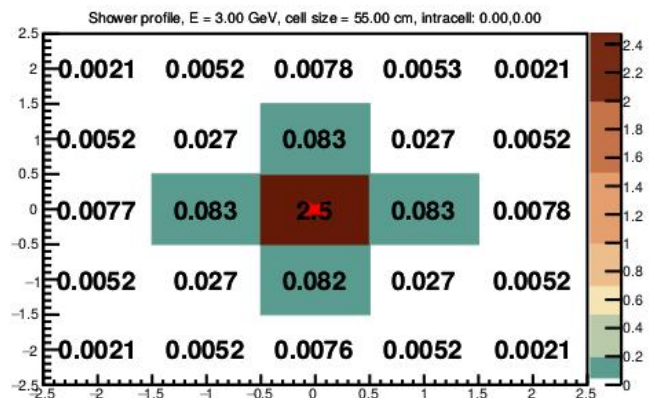
Shower profiles, electrons $E = 3$ GeV, angle = 0°



cell size:
4 cm

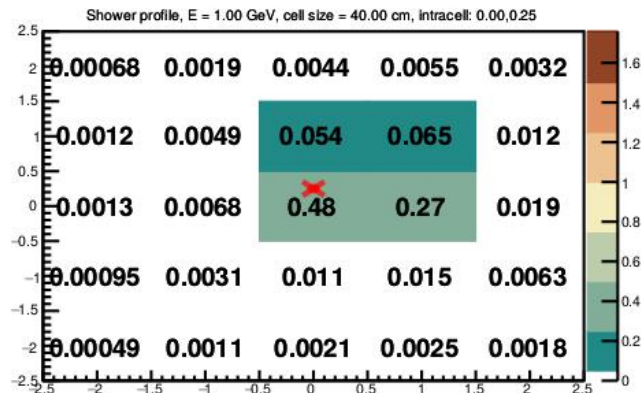
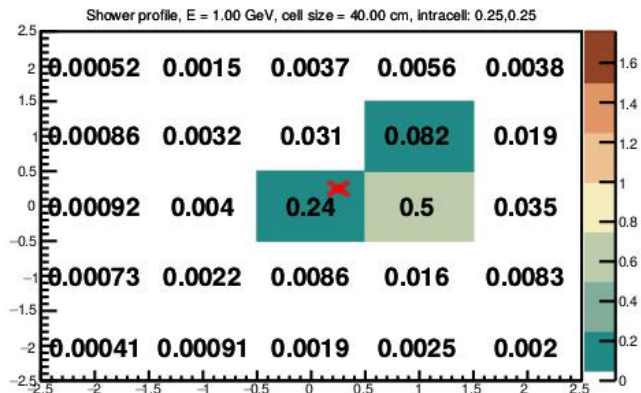
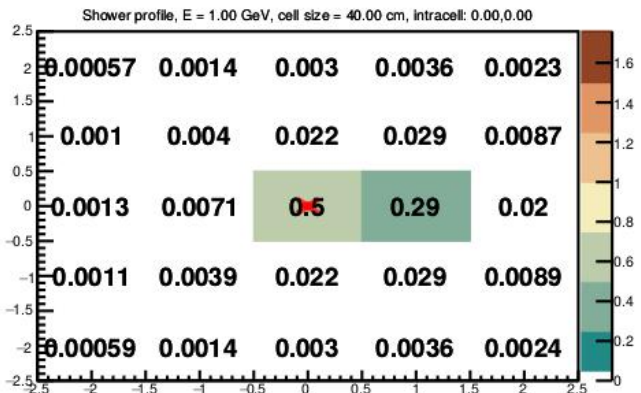


cell size:
5 cm

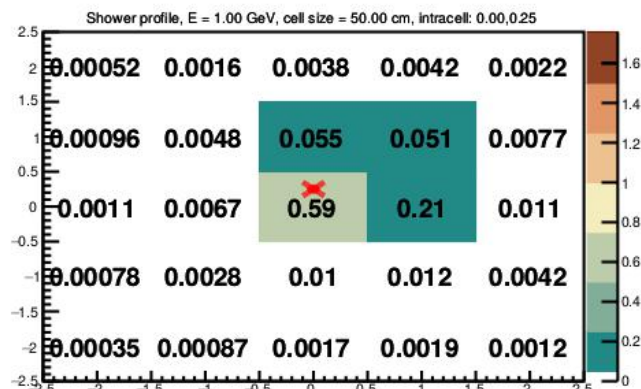
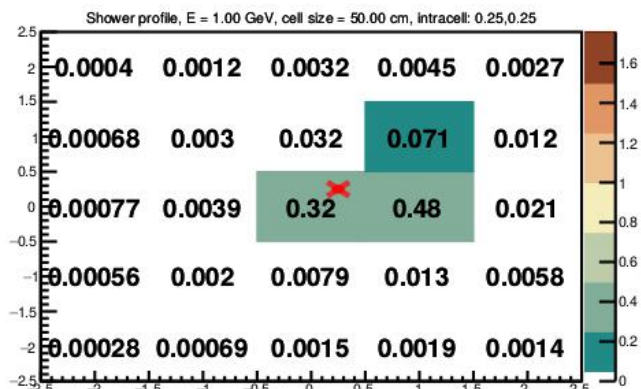
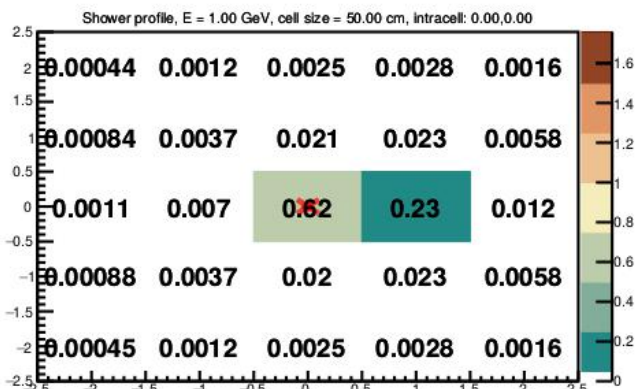


cell size:
5.5 cm

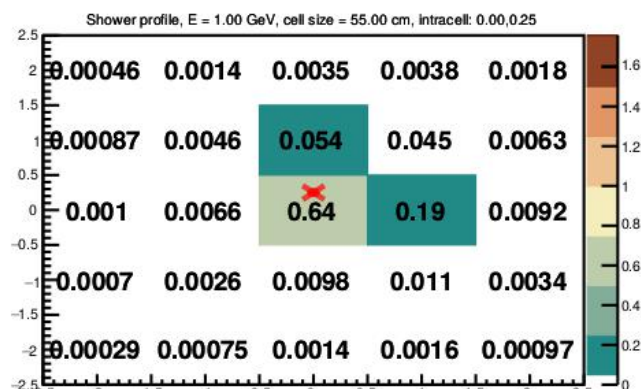
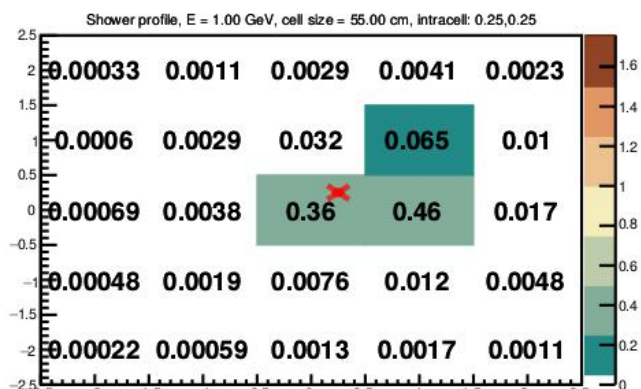
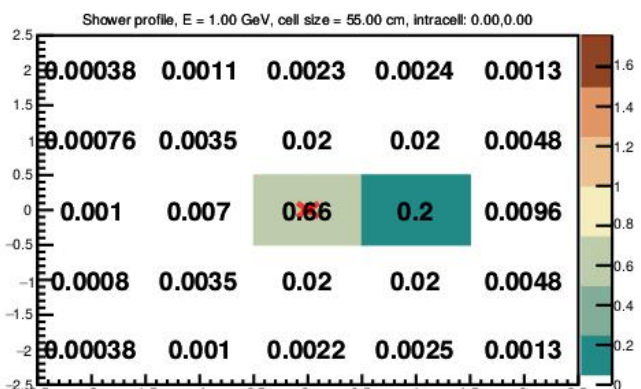
Shower profiles, electrons $E = 1$ GeV, angle = 10°



cell size:
4 cm

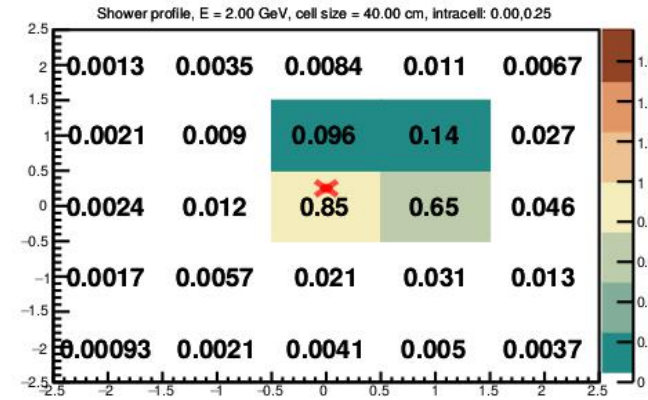
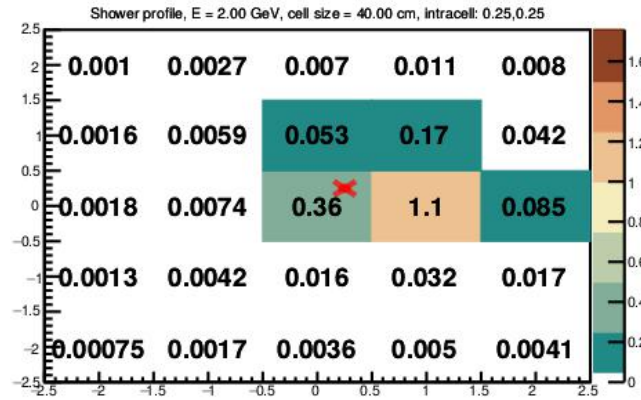
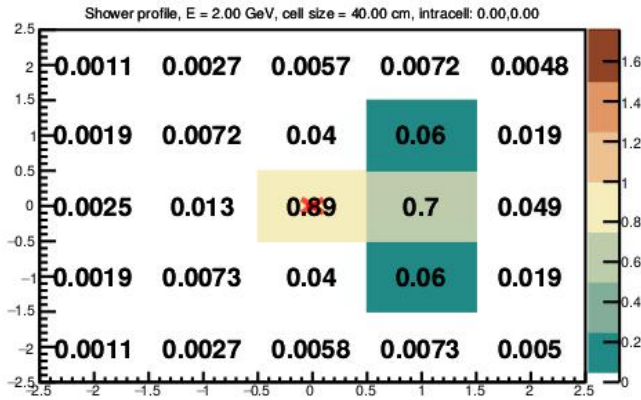


cell size:
5 cm

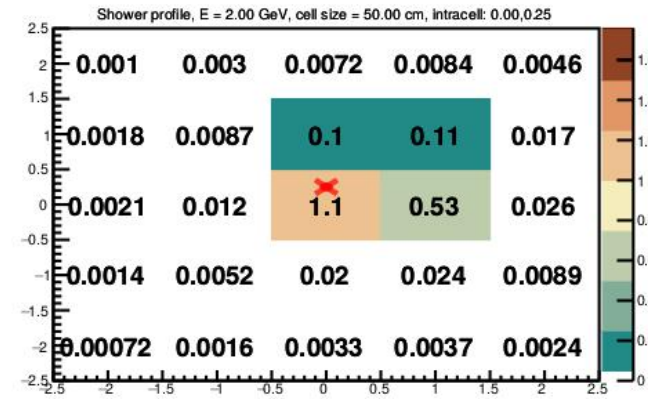
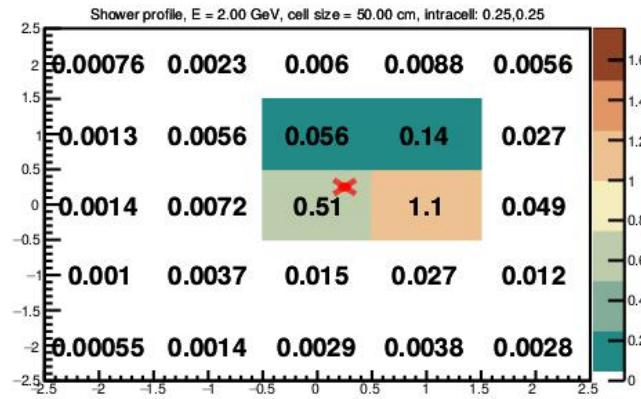
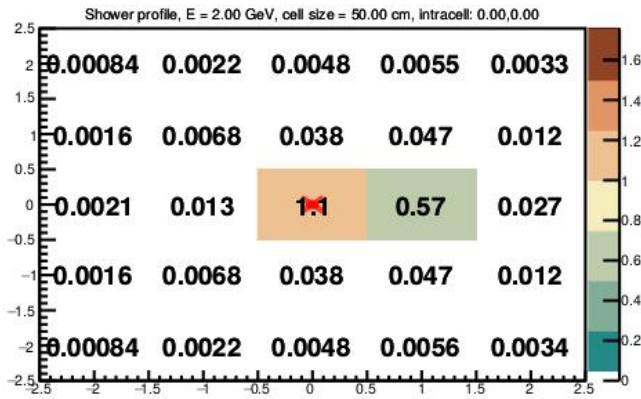


cell size:
5.5 cm

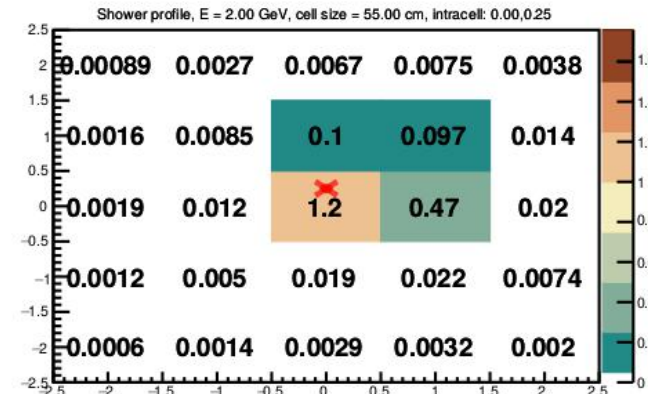
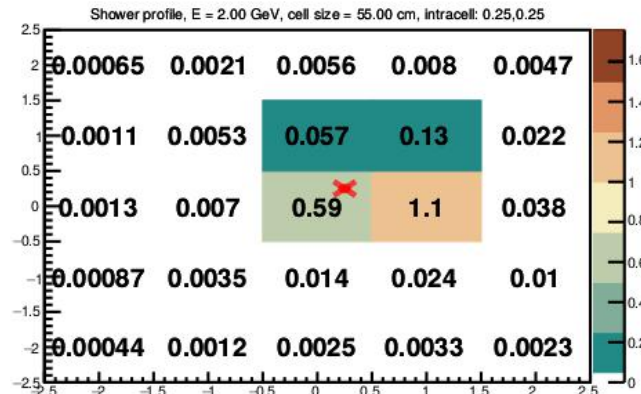
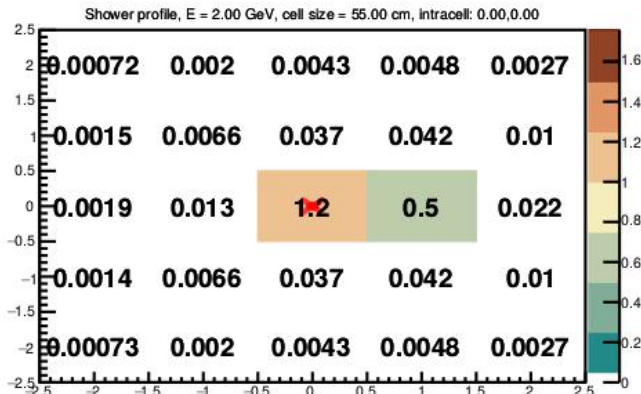
Shower profiles, electrons $E = 2$ GeV, angle = 10°



cell size:
4 cm

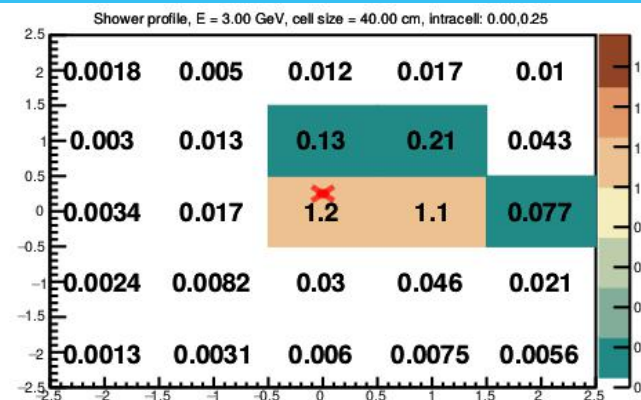
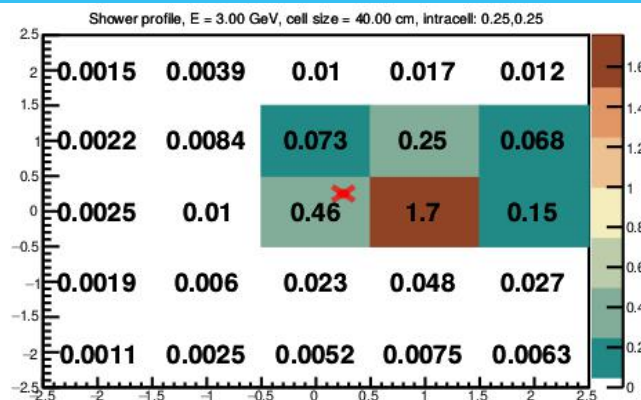
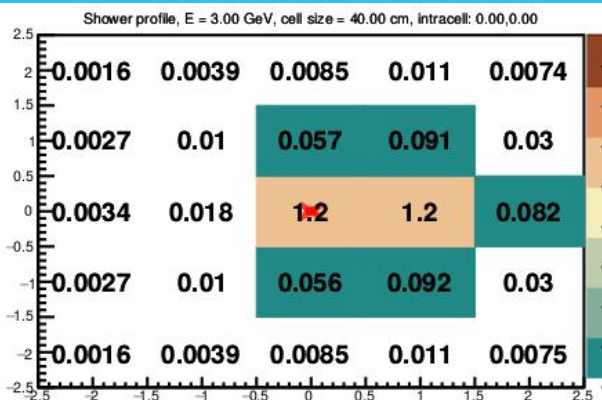


cell size:
5 cm

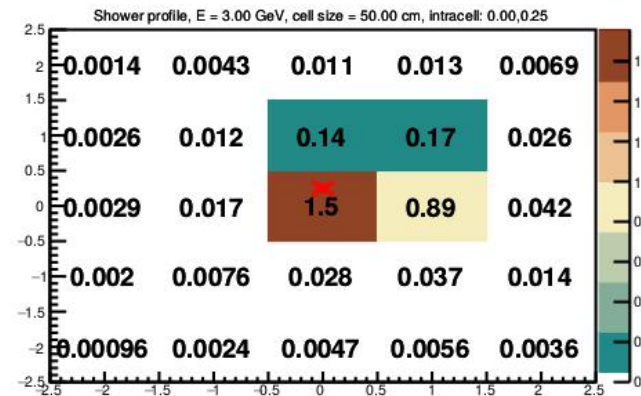
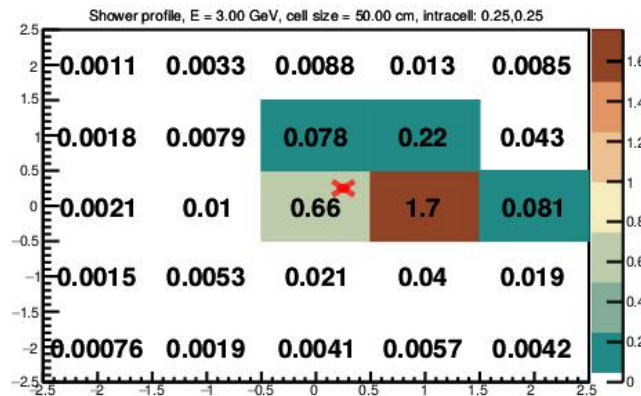
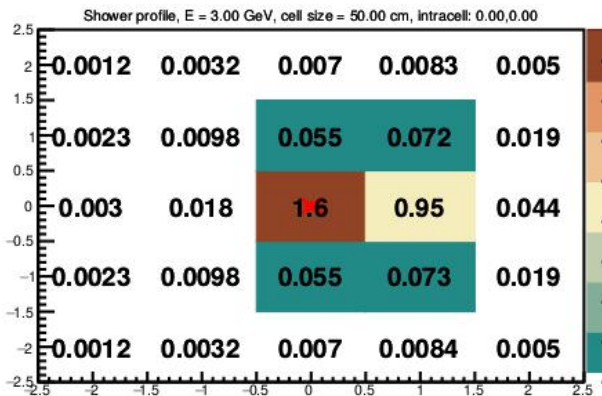


cell size:
5.5 cm

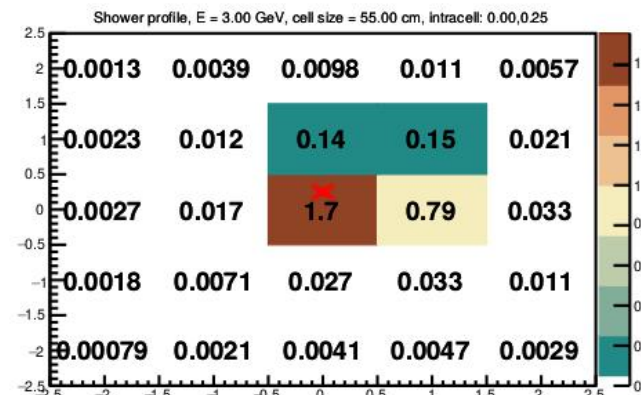
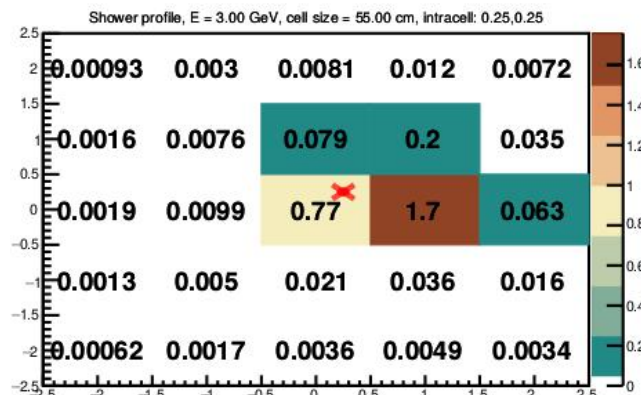
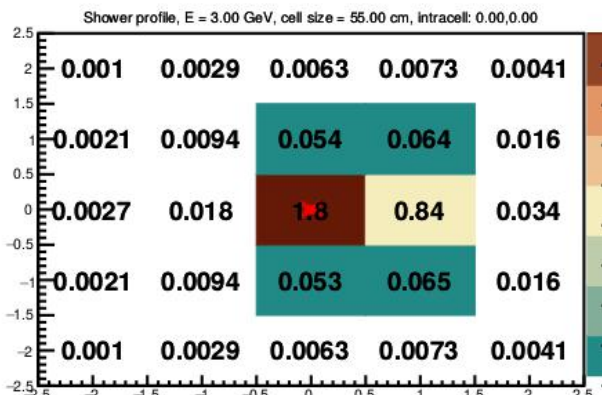
Shower profiles, electrons $E = 3$ GeV, angle = 10°



cell size:
4 cm

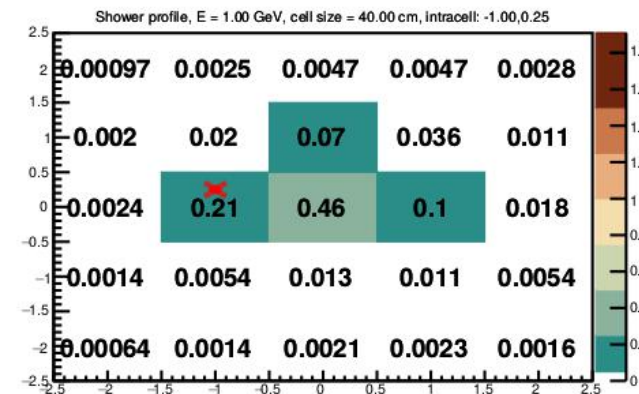
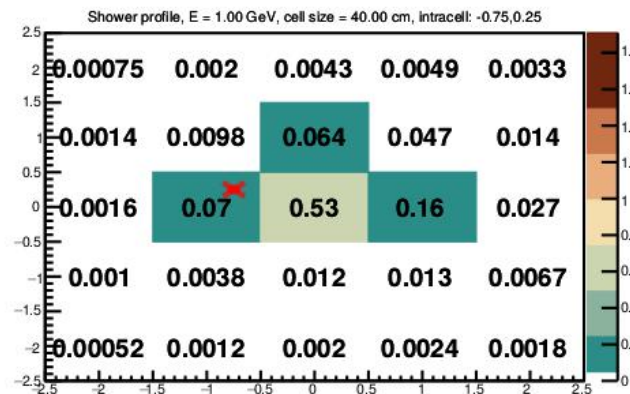
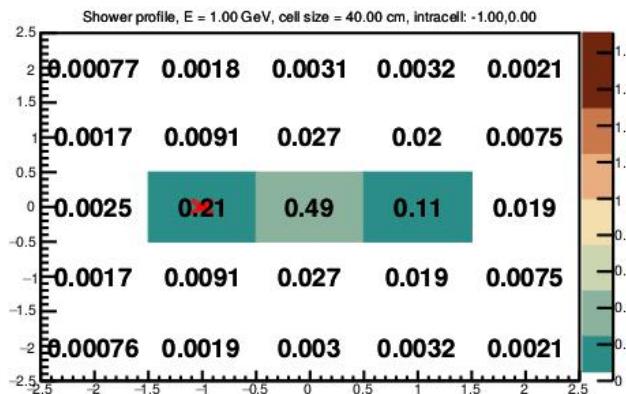


cell size:
5 cm

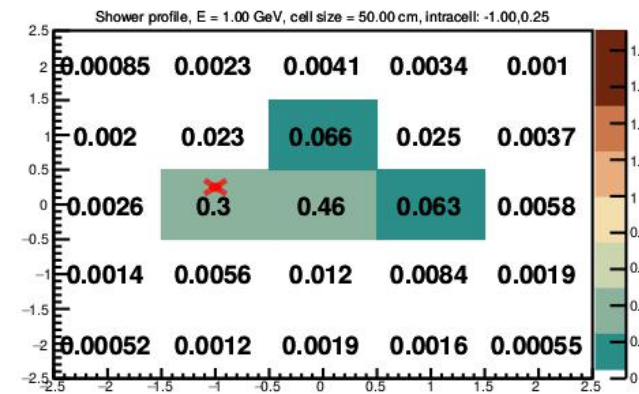
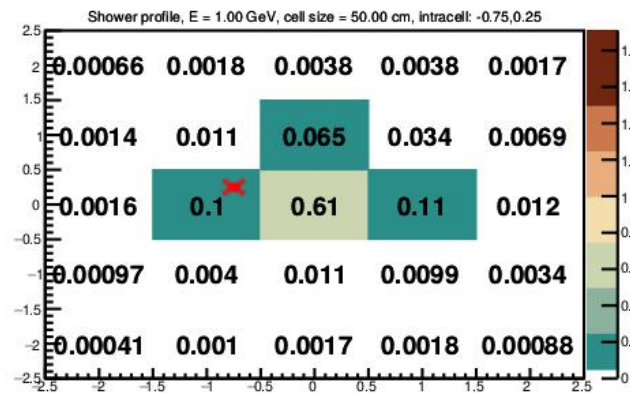
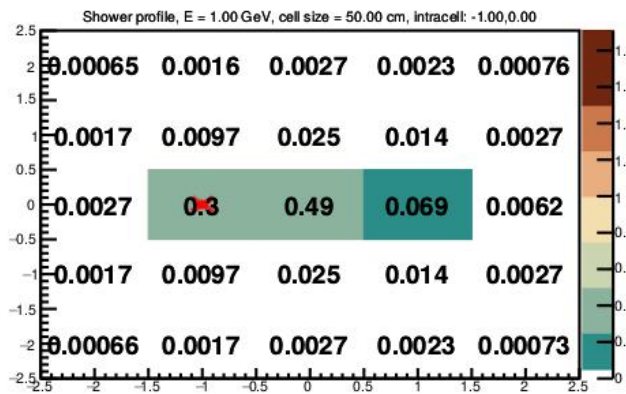


cell size:
5.5 cm

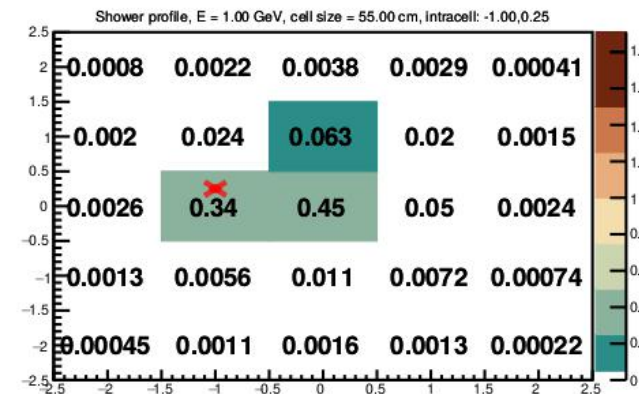
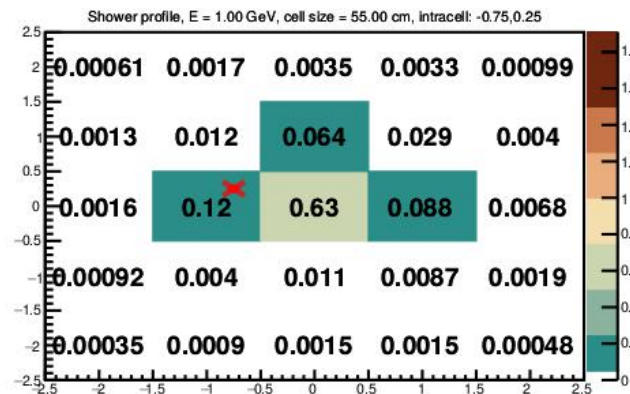
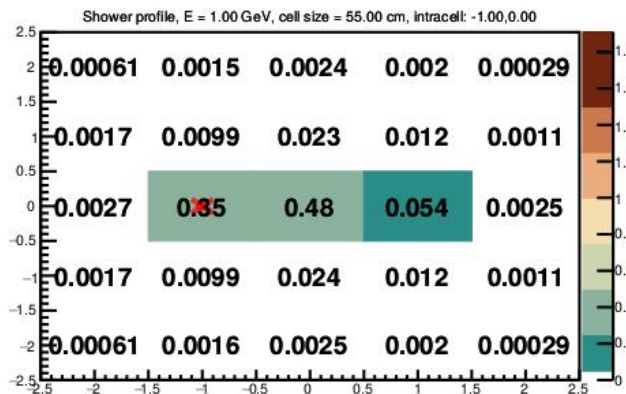
Shower profiles, electrons $E = 1$ GeV, angle = 20°



cell size:
4 cm

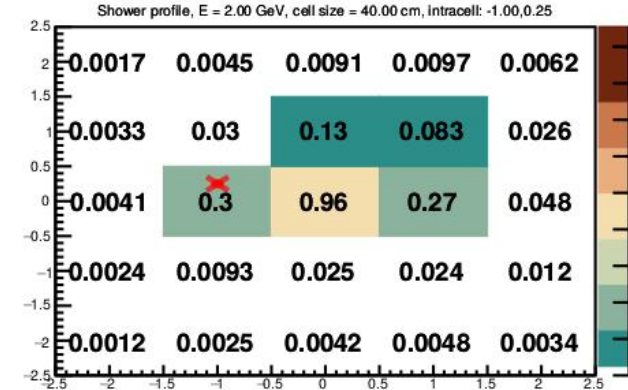
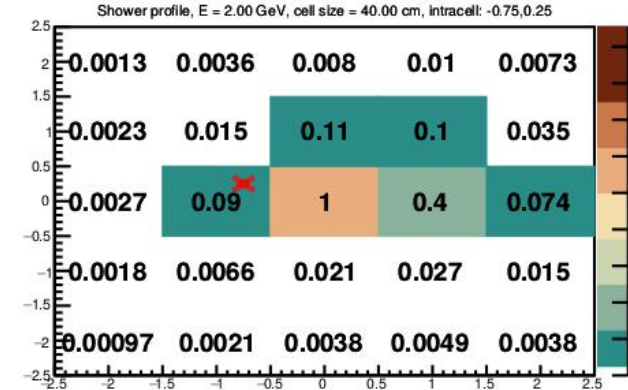
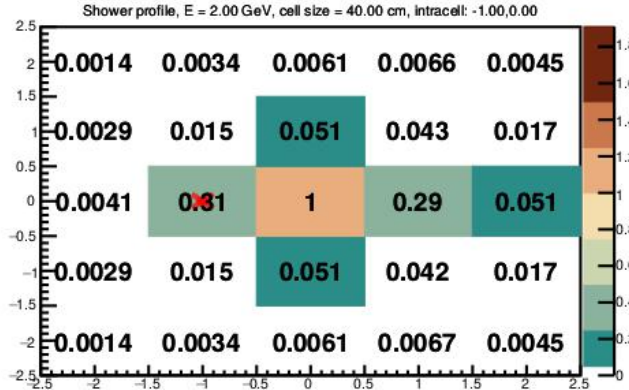


cell size:
5 cm

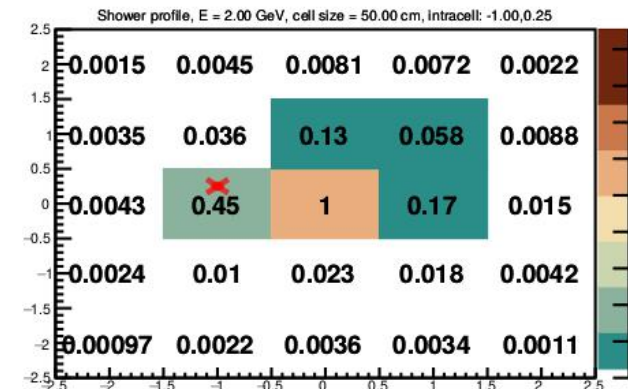
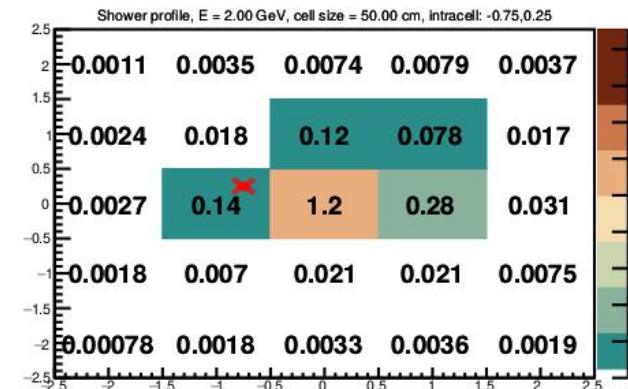
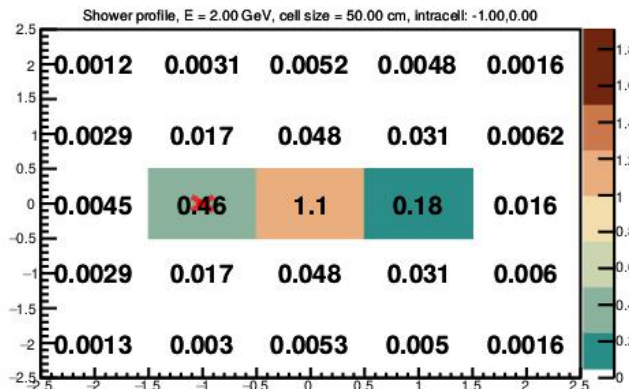


cell size:
5.5 cm

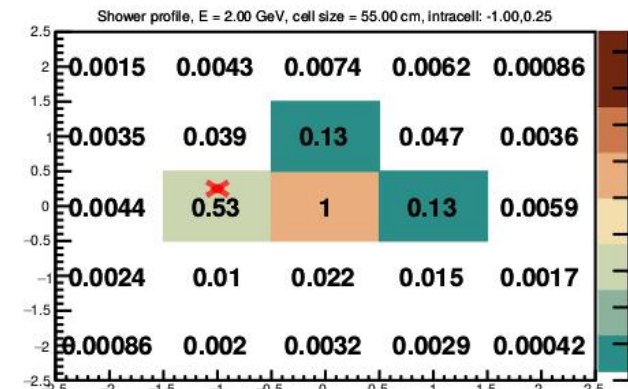
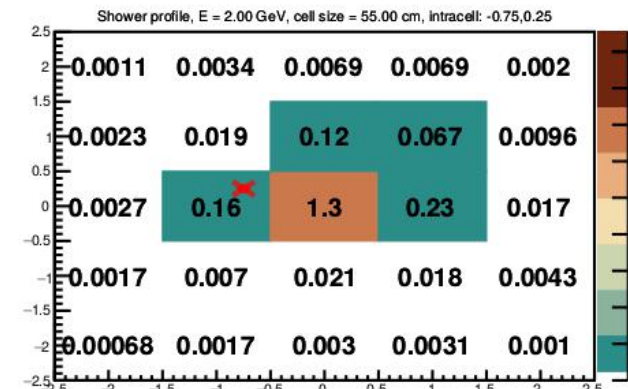
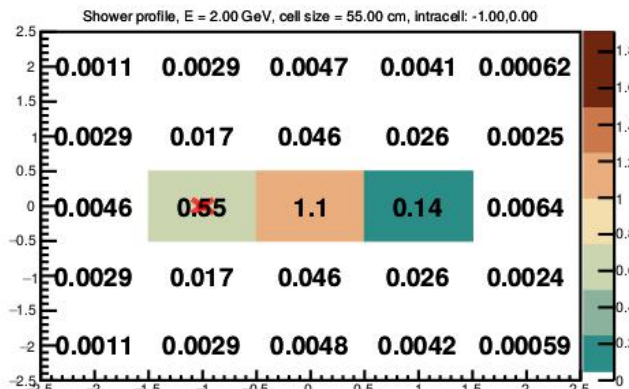
Shower profiles, electrons $E = 2$ GeV, angle = 20°



cell size:
4 cm

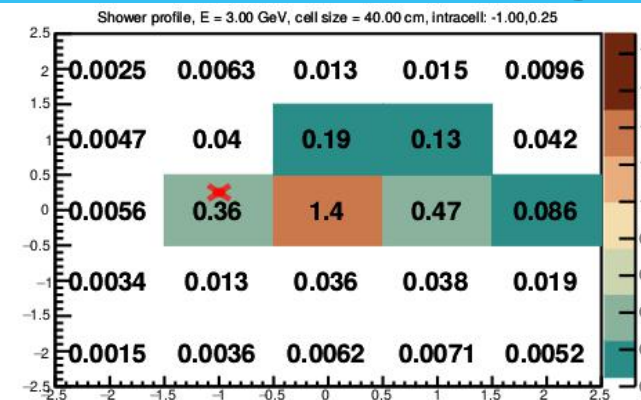
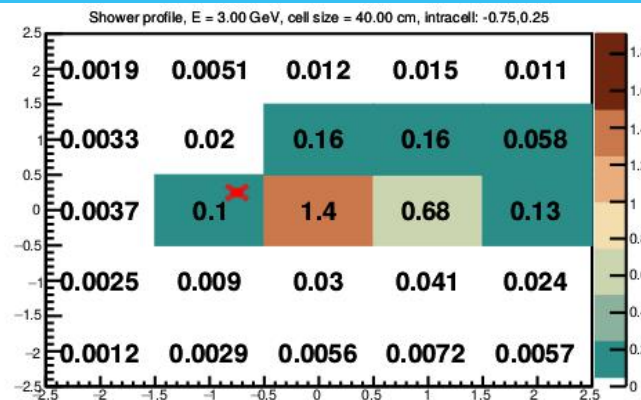
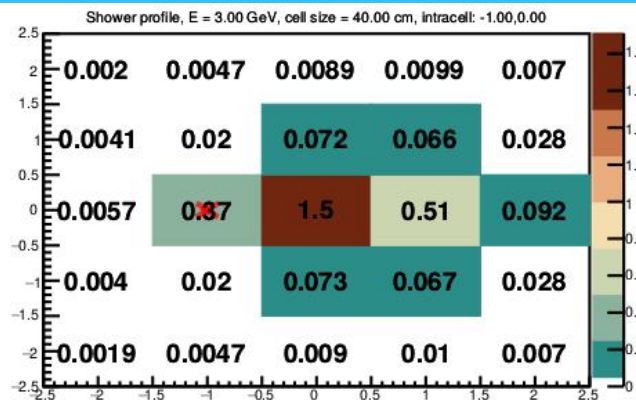


cell size:
5 cm

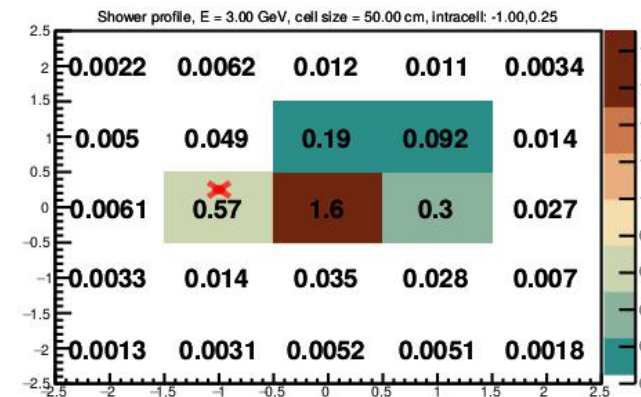
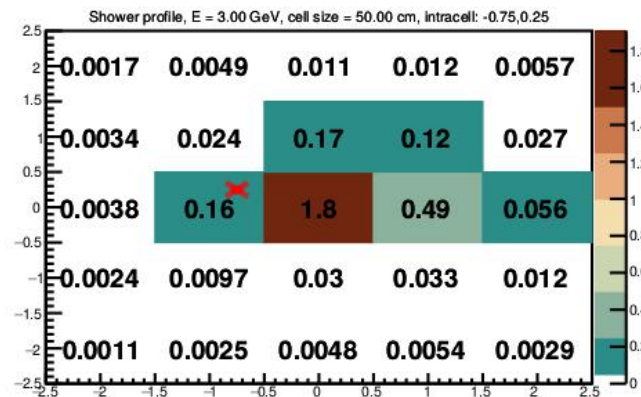
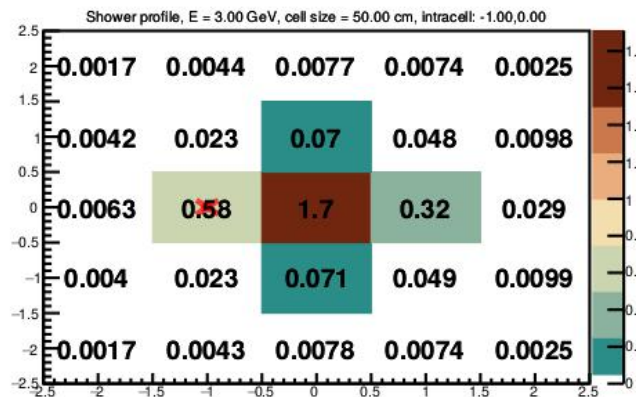


cell size:
5.5 cm

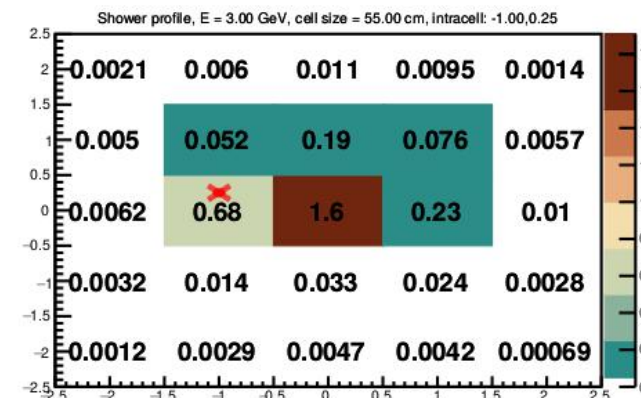
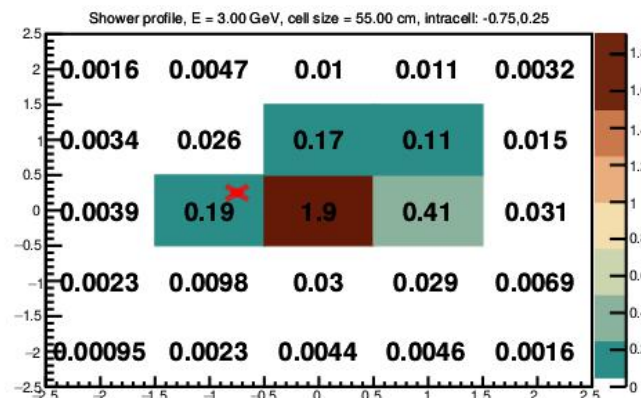
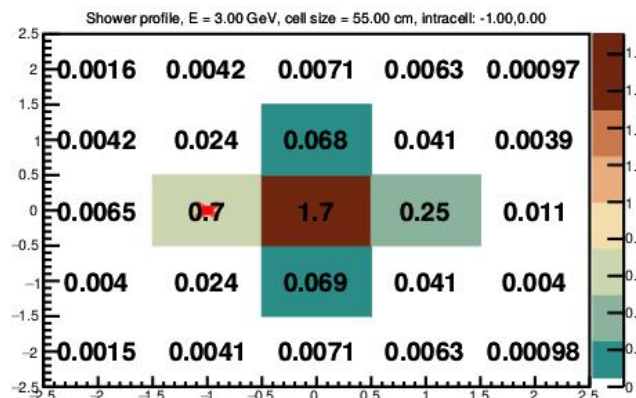
Shower profiles, electrons $E = 3$ GeV, angle = 20°



cell size:
4 cm

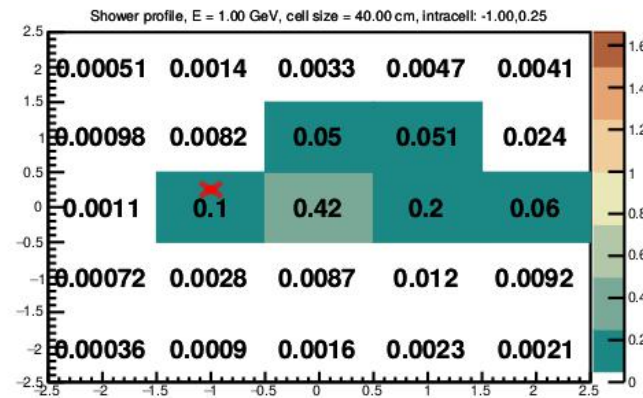
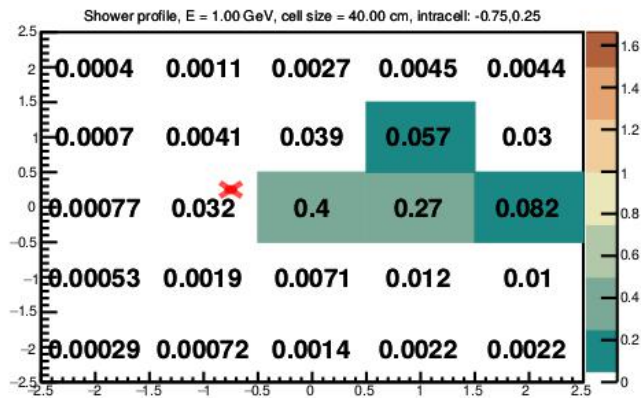
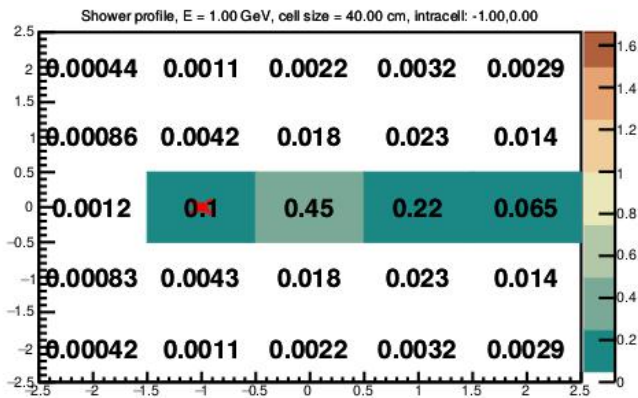


cell size:
5 cm

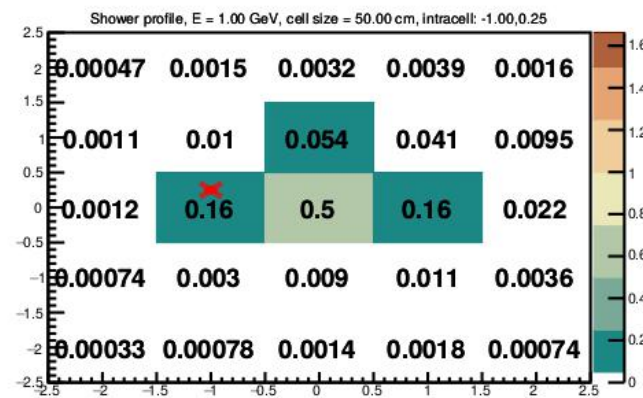
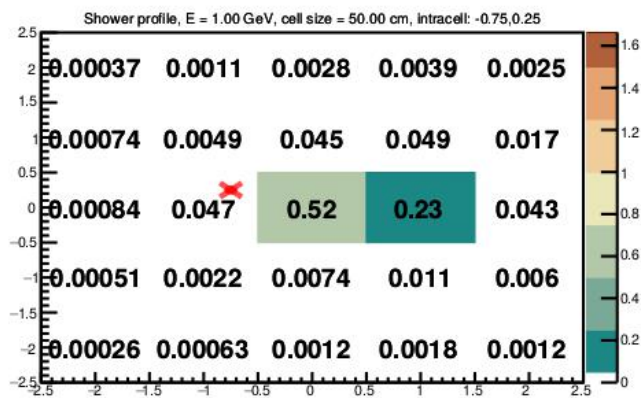
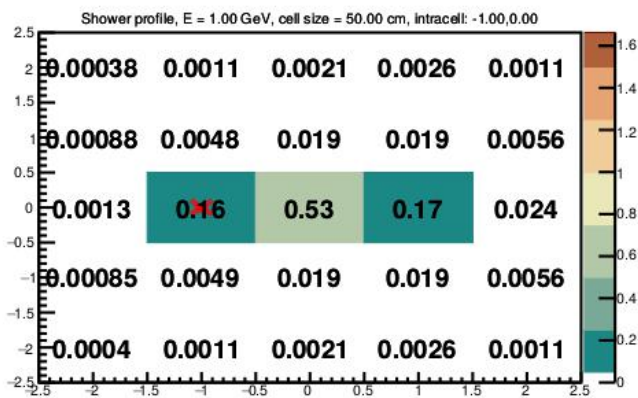


cell size:
5.5 cm

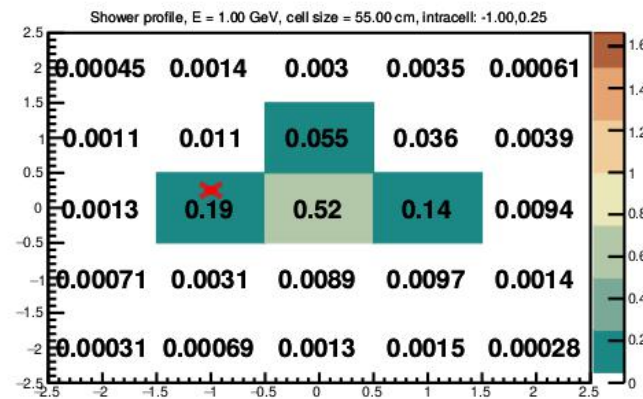
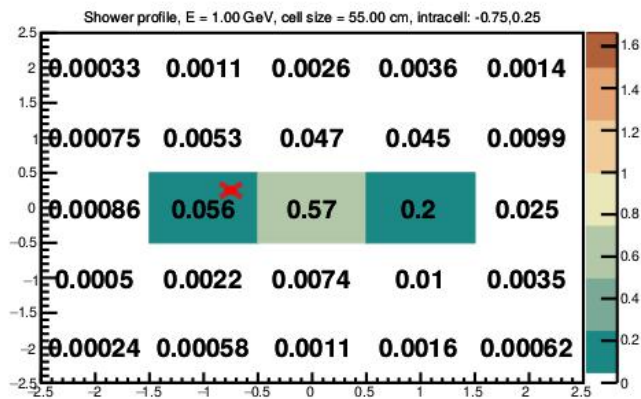
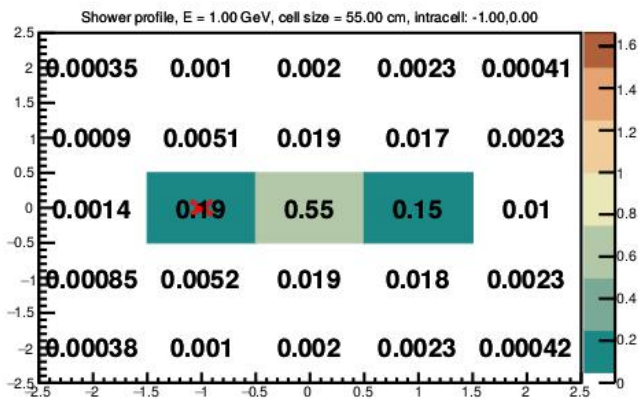
Shower profiles, electrons $E = 1$ GeV, angle = 30°



cell size:
4 cm

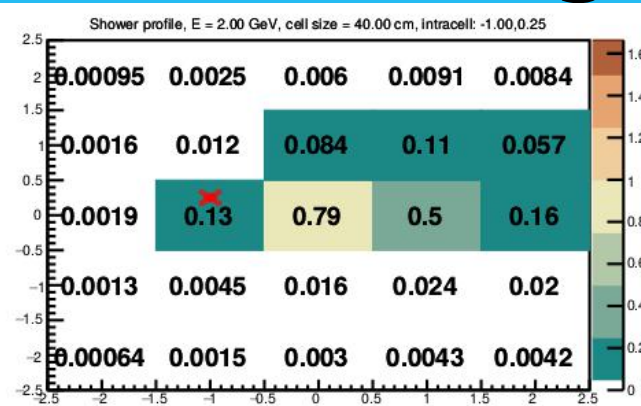
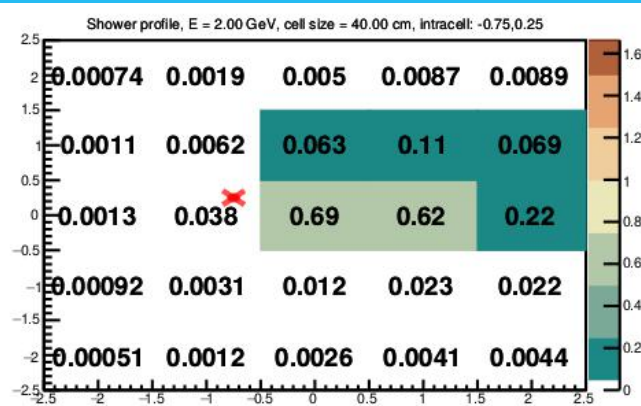
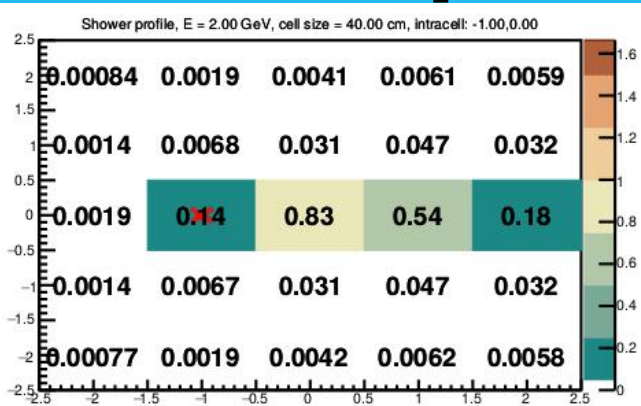


cell size:
5 cm

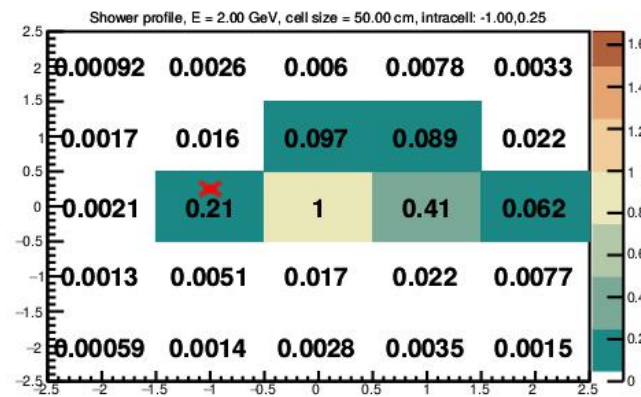
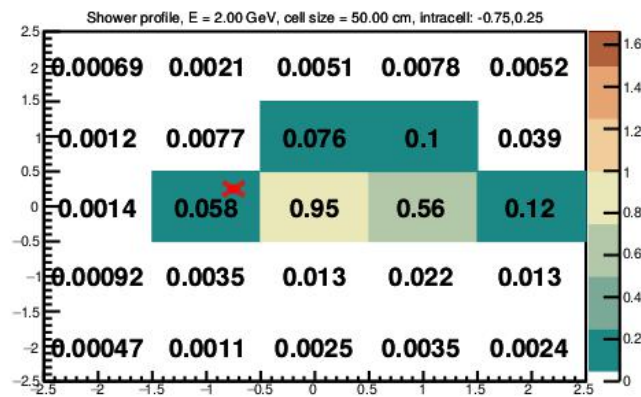
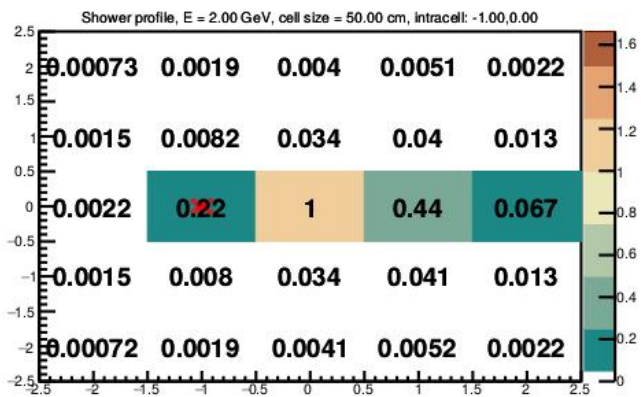


cell size:
5.5 cm

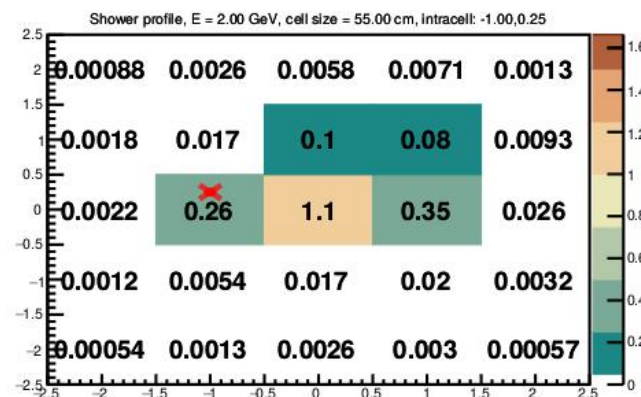
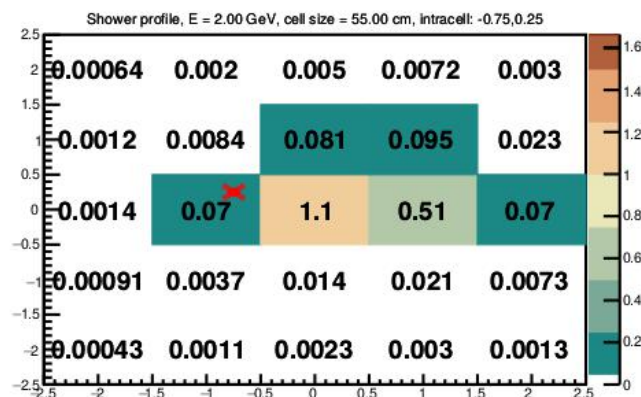
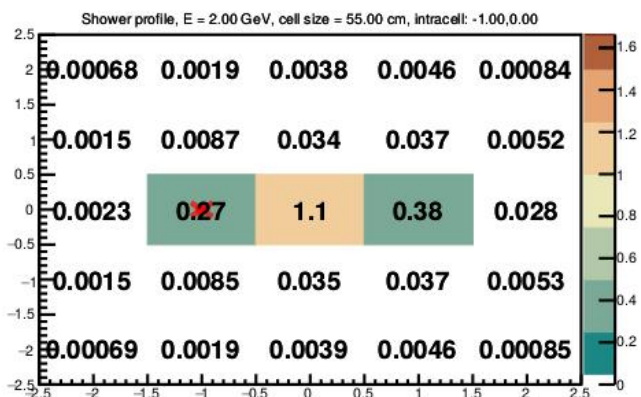
Shower profiles, electrons $E = 2$ GeV, angle = 30°



cell size:
4 cm

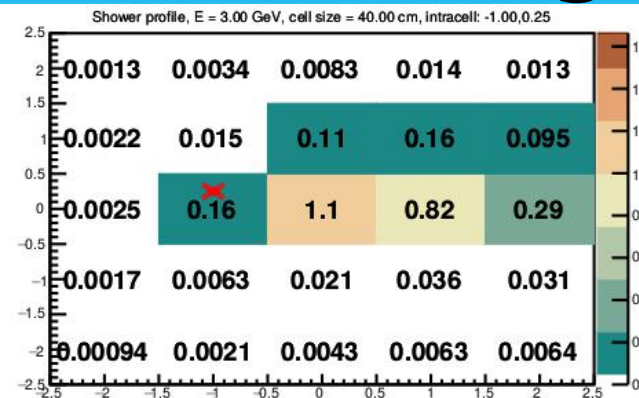
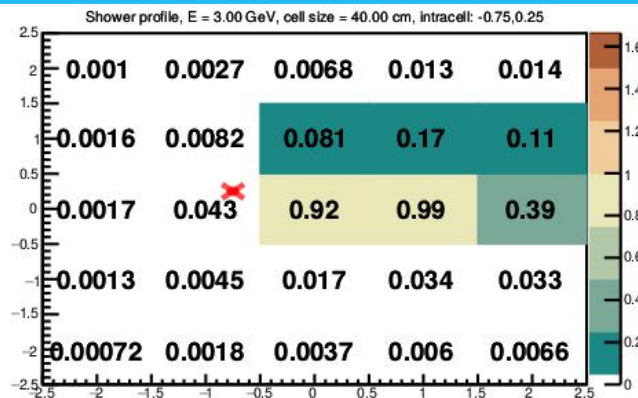
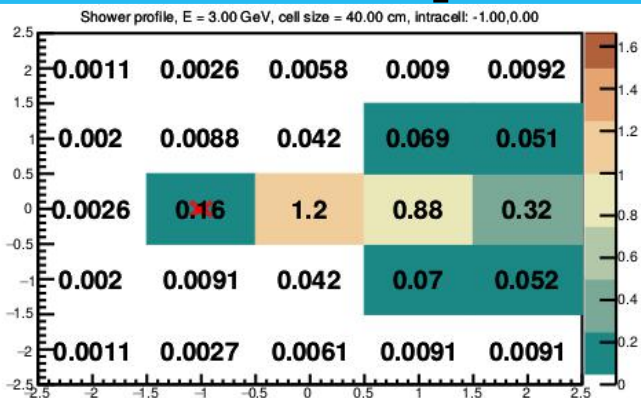


cell size:
5 cm

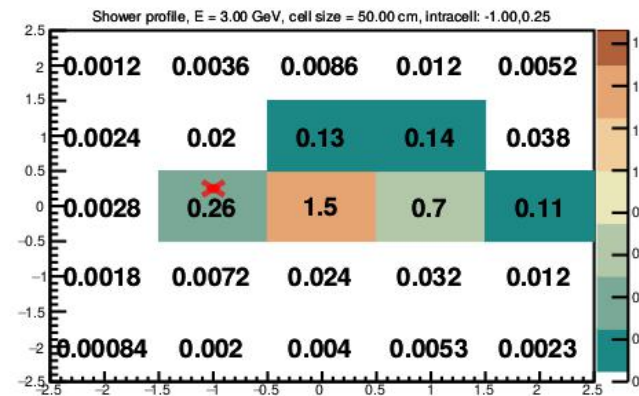
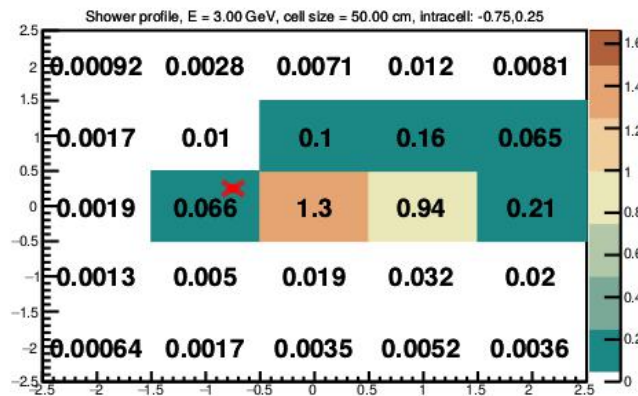
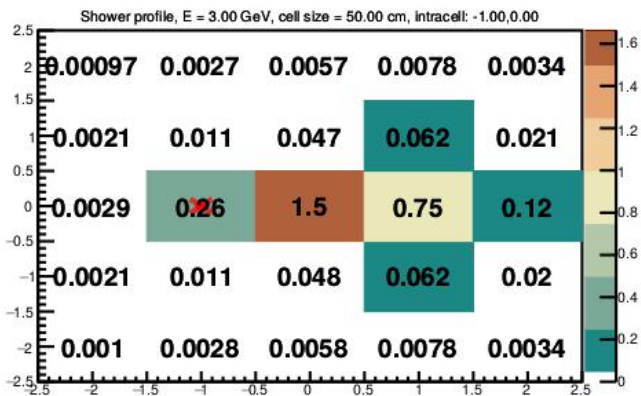


cell size:
5.5 cm

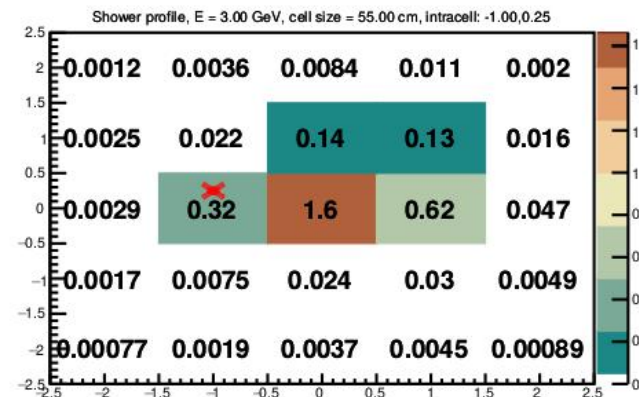
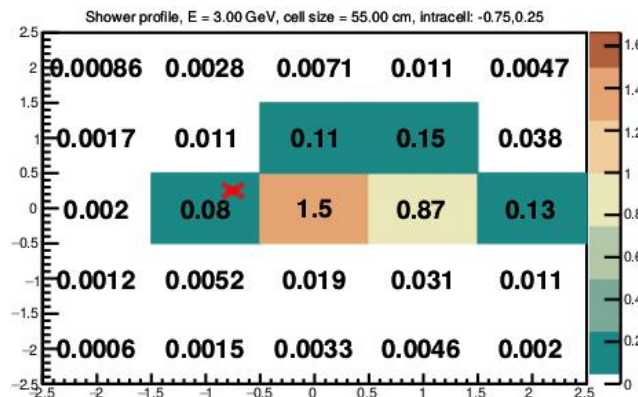
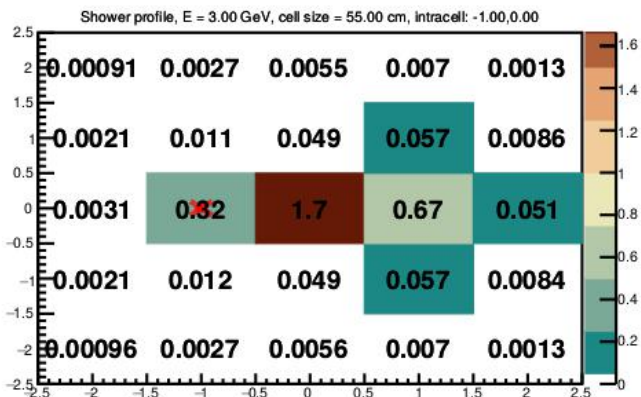
Shower profiles, electrons $E = 3$ GeV, angle = 30°



cell size:
4 cm

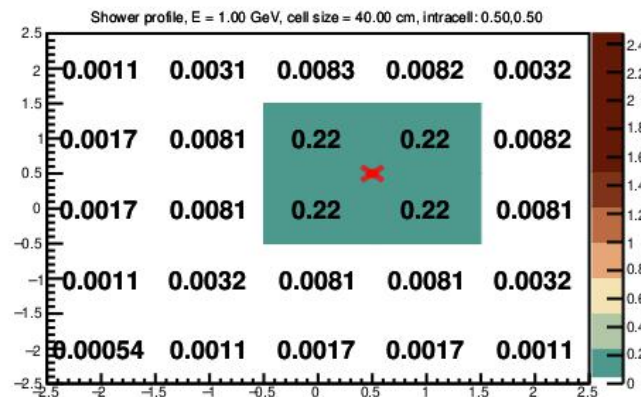
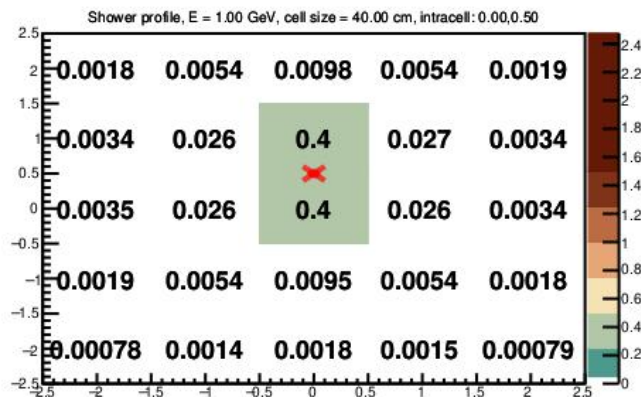
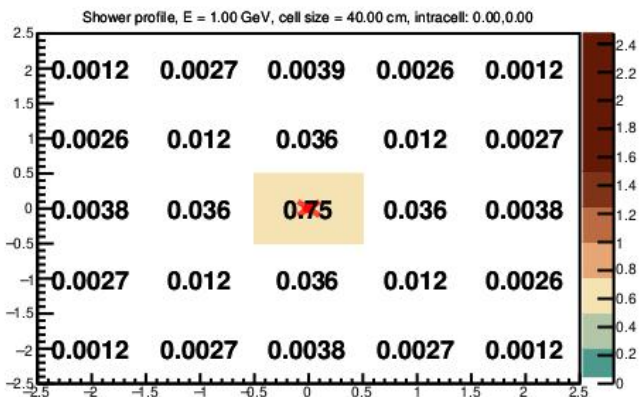


cell size:
5 cm

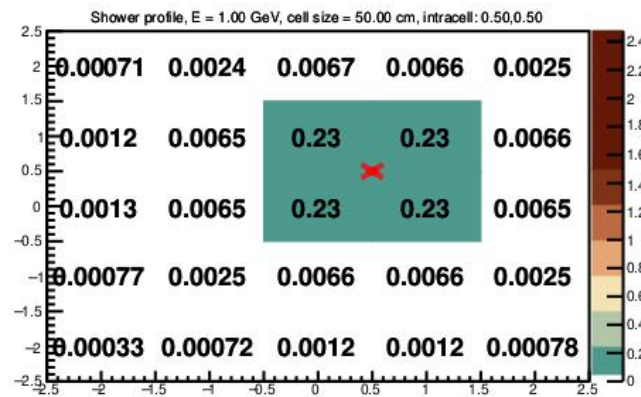
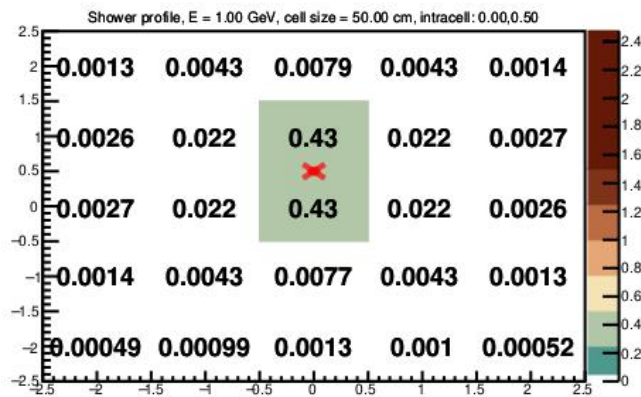
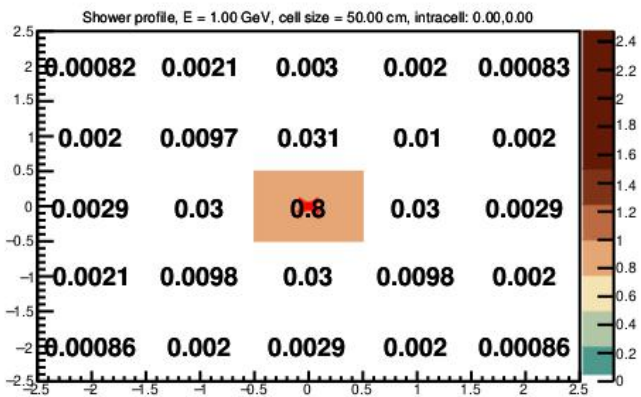


cell size:
5.5 cm

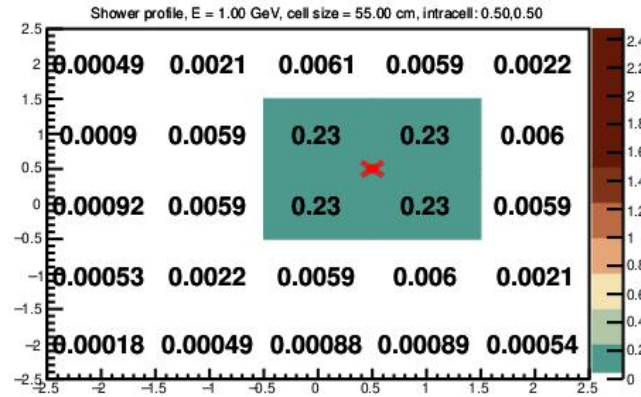
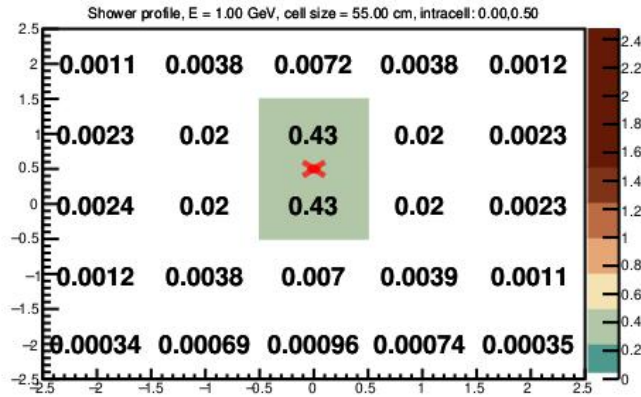
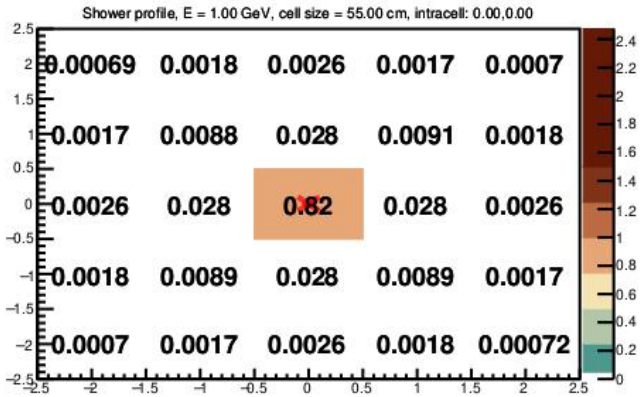
Shower profiles, electrons $E = 1$ GeV, angle = 0°



cell size:
4 cm

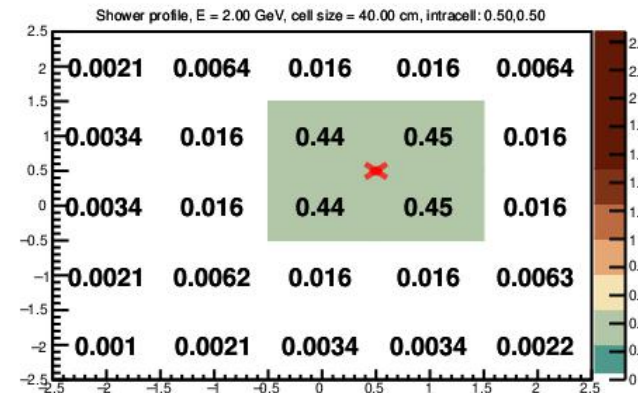
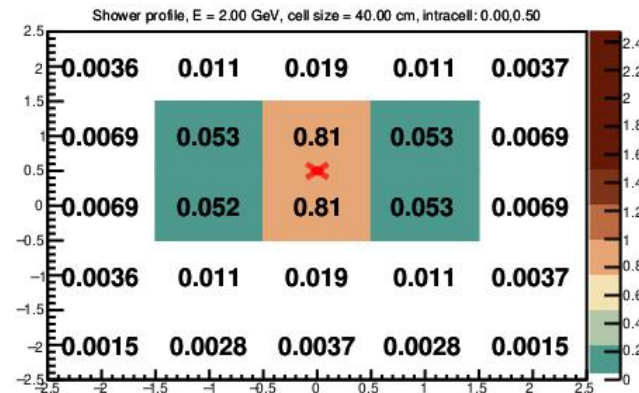
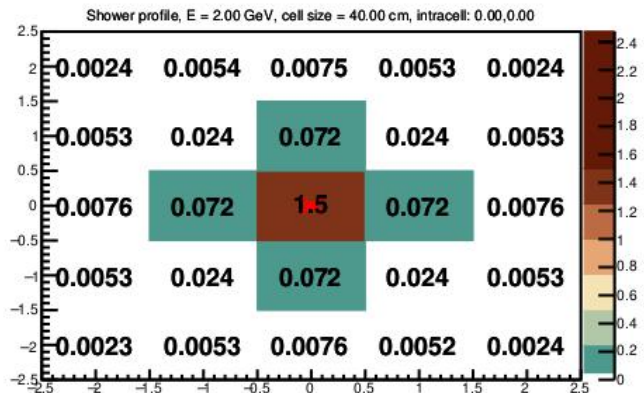


cell size:
5 cm

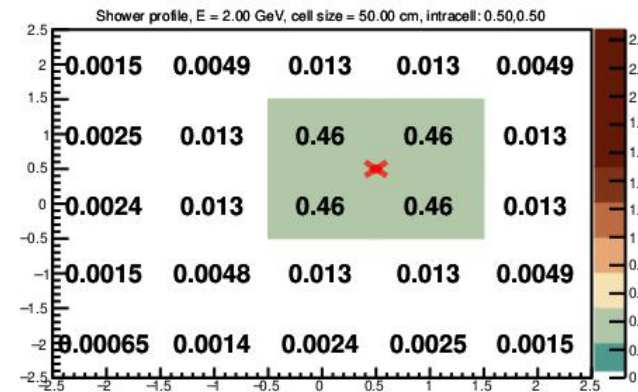
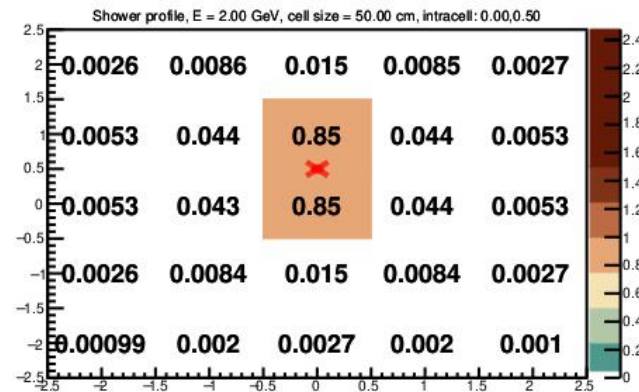
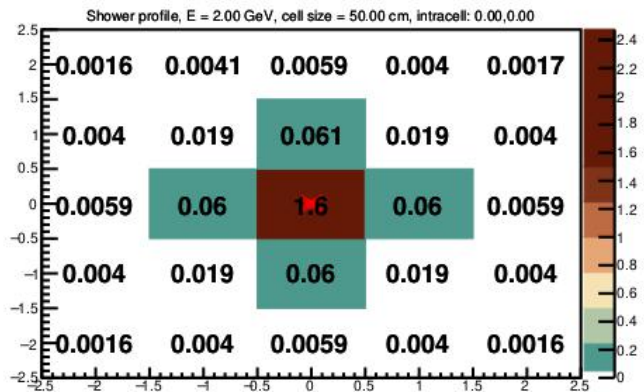


cell size:
5.5 cm

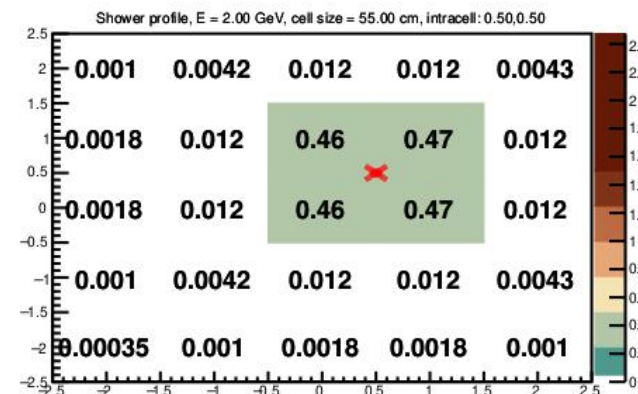
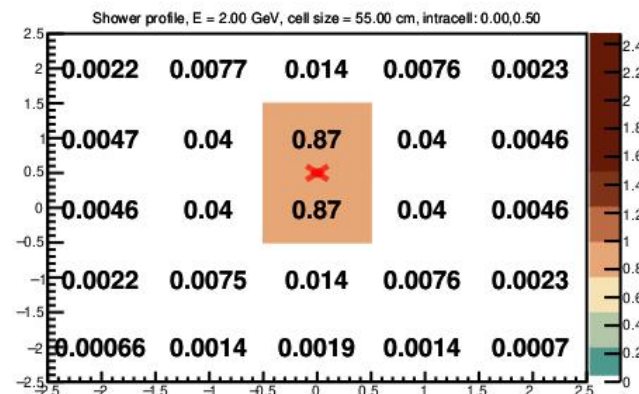
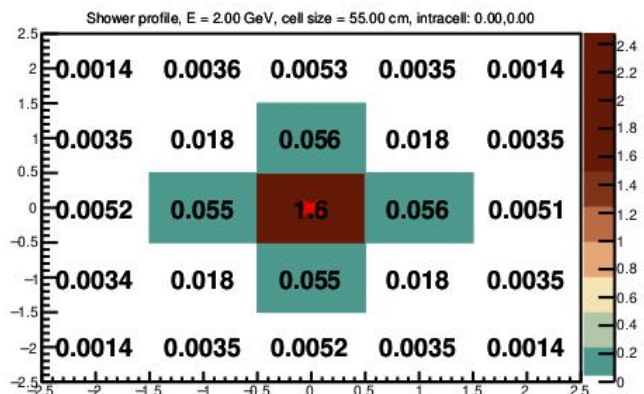
Shower profiles, electrons $E = 2$ GeV, angle = 0°



cell size:
4 cm

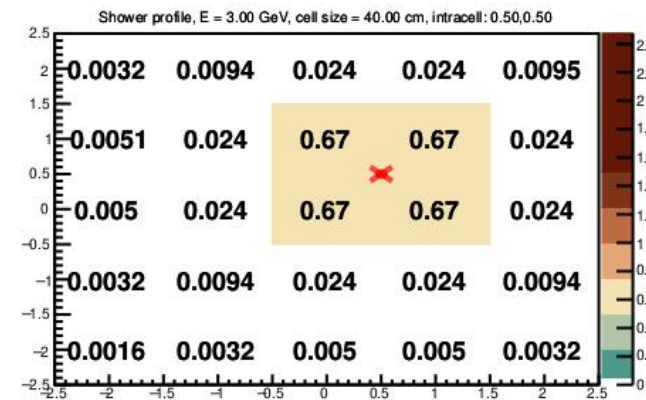
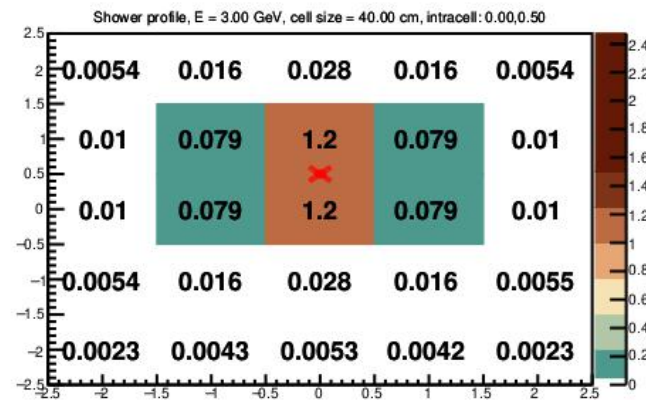
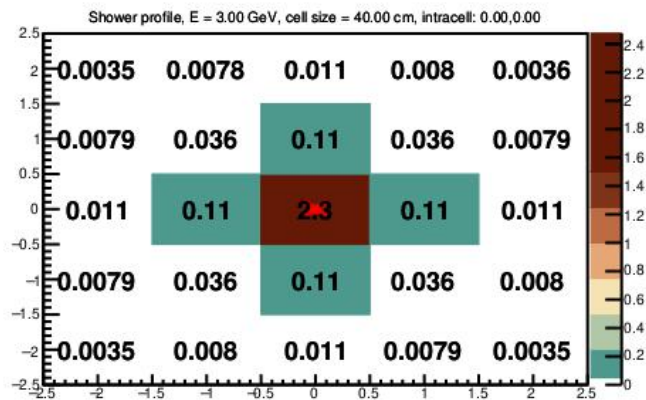


cell size:
5 cm

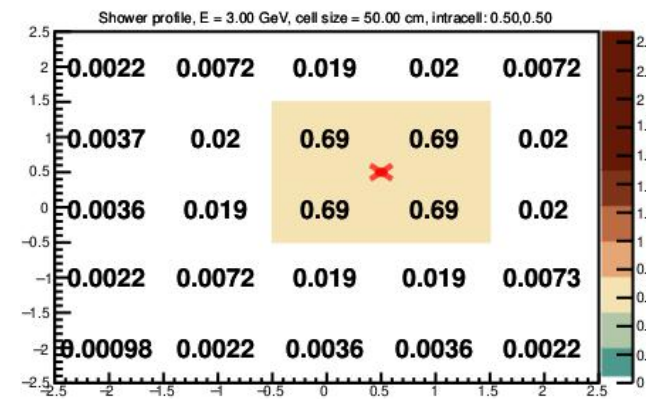
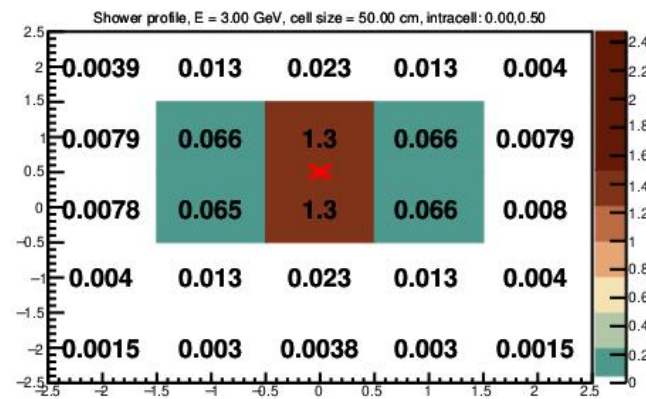
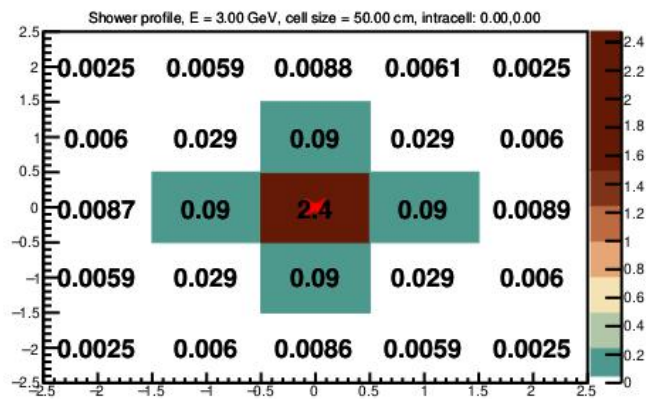


cell size:
5.5 cm

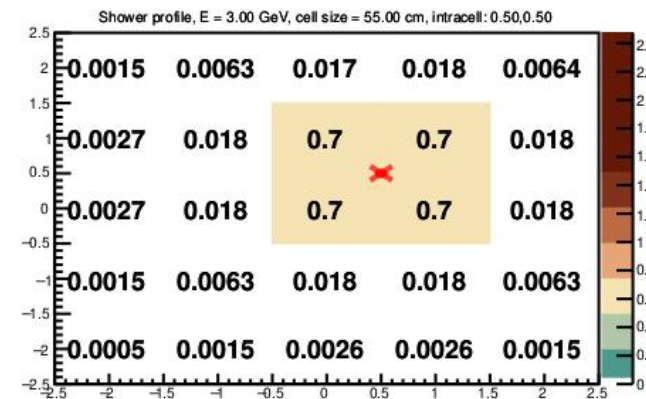
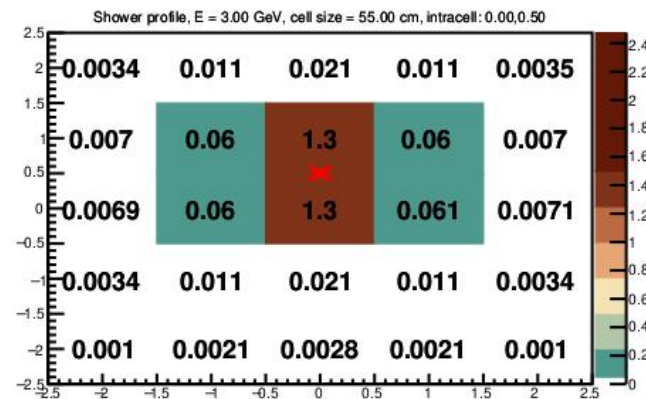
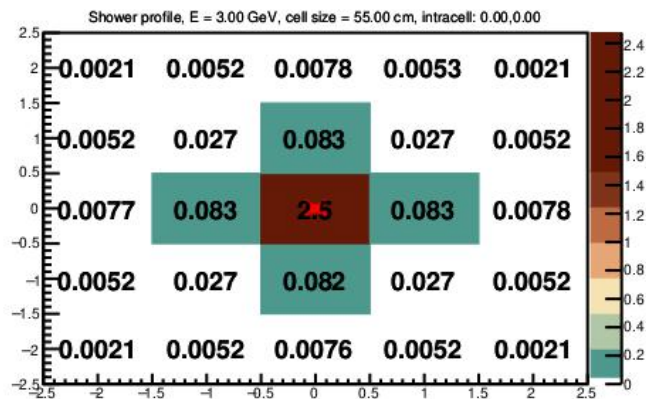
Shower profiles, electrons $E = 3$ GeV, angle = 0°



cell size:
4 cm

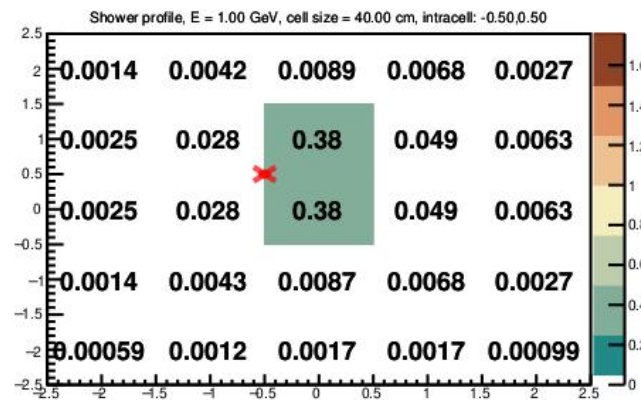
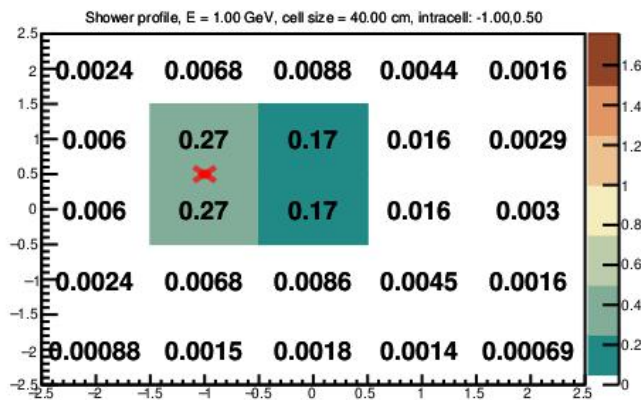
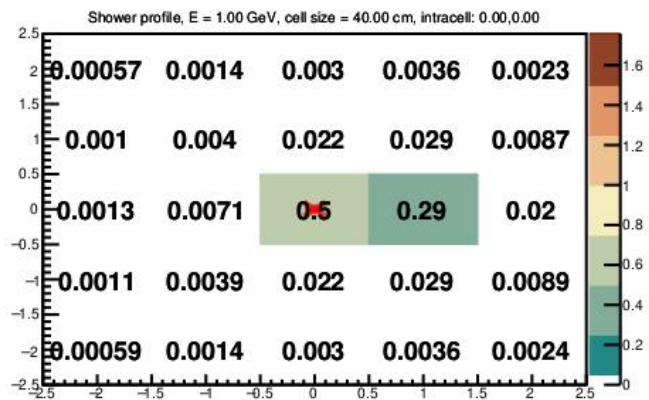


cell size:
5 cm

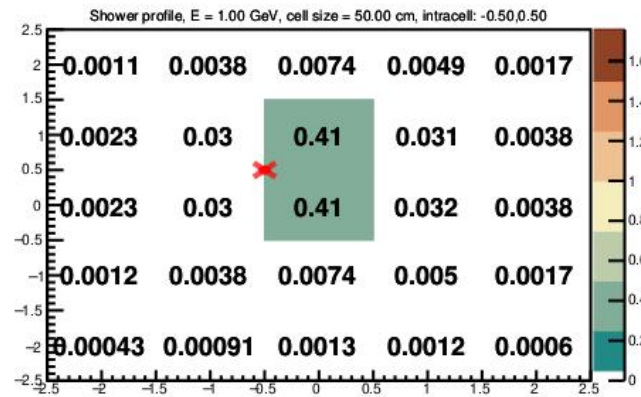
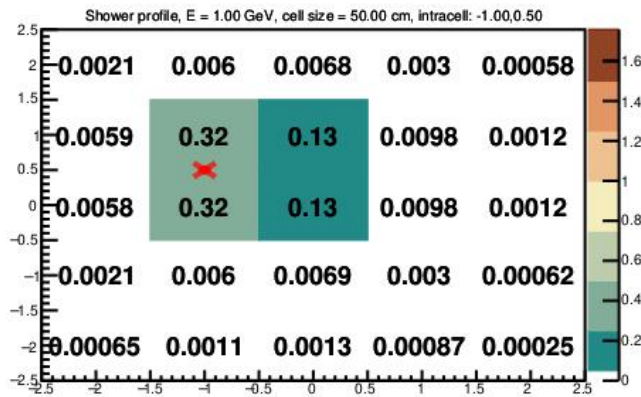
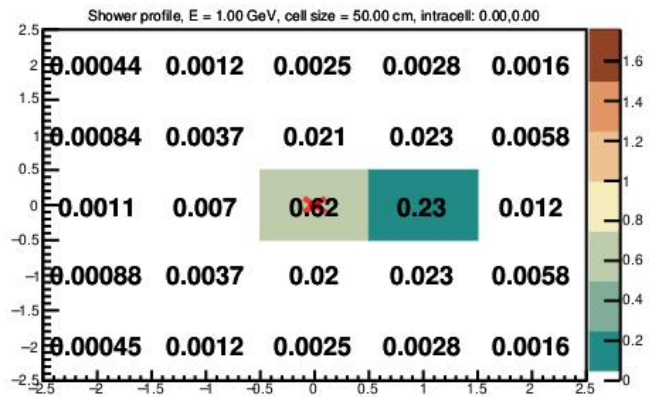


cell size:
5.5 cm

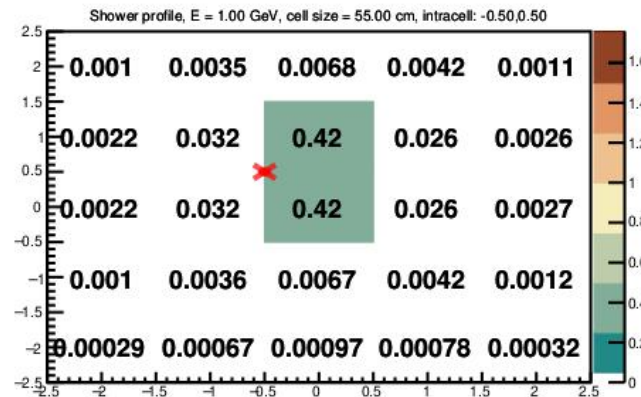
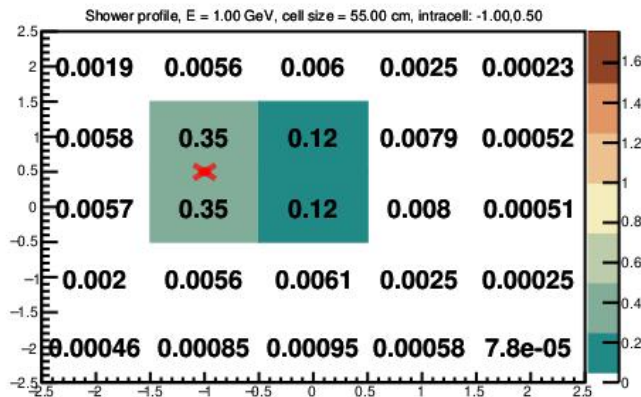
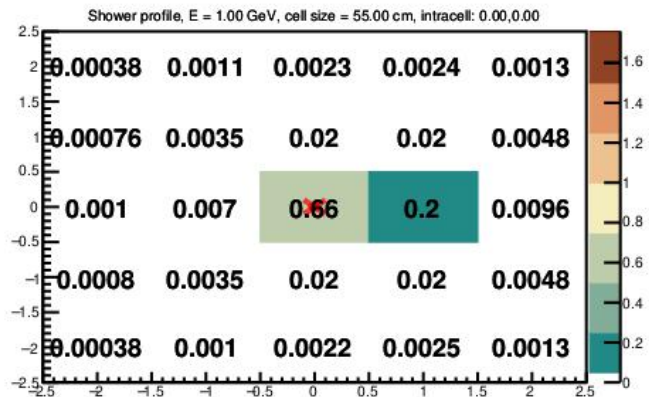
Shower profiles, electrons $E = 1$ GeV, angle = 10°



cell size:
4 cm

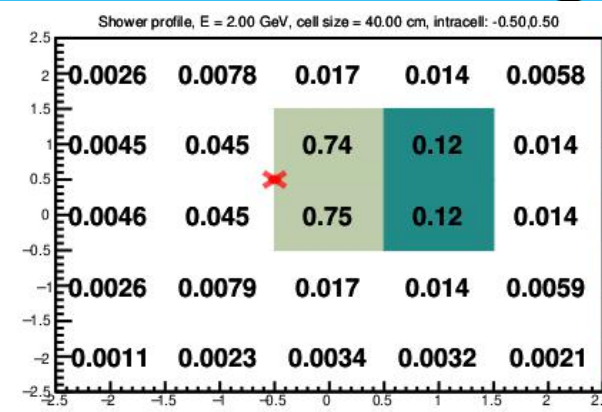
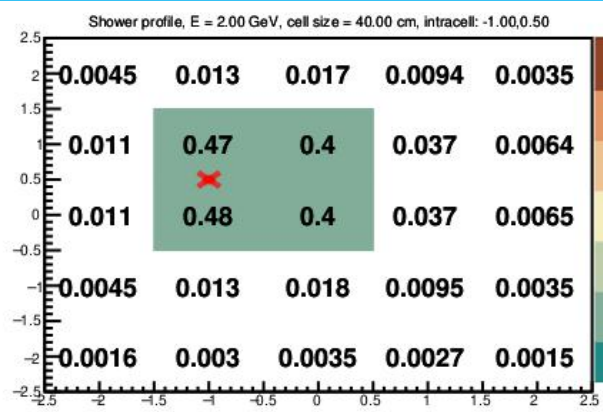
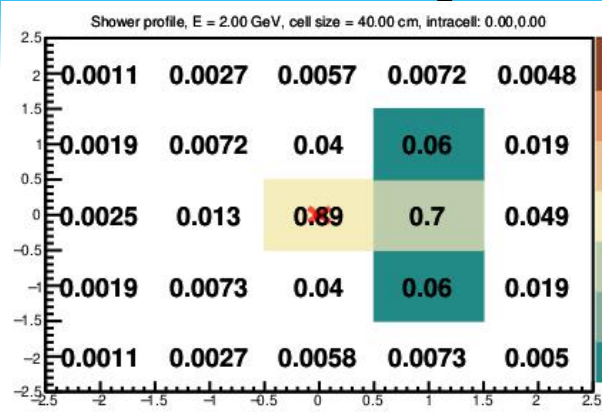


cell size:
5 cm

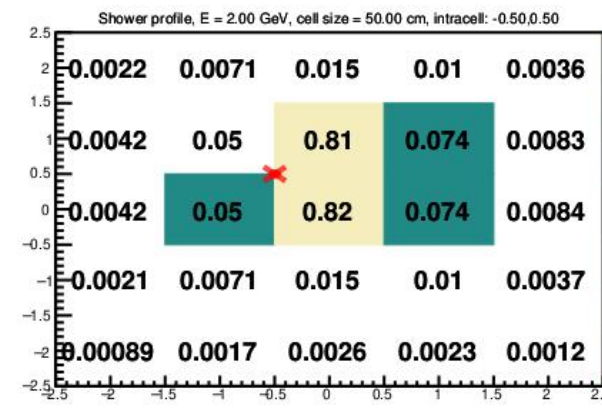
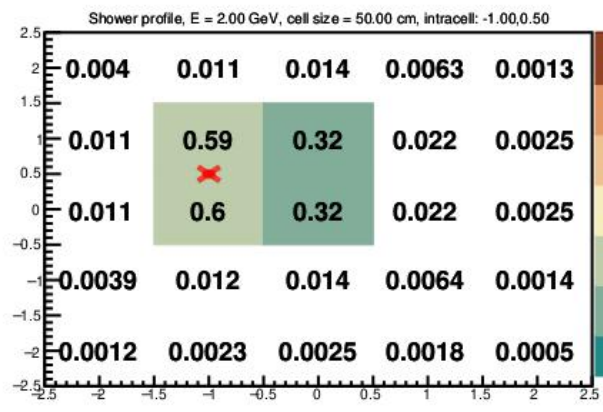
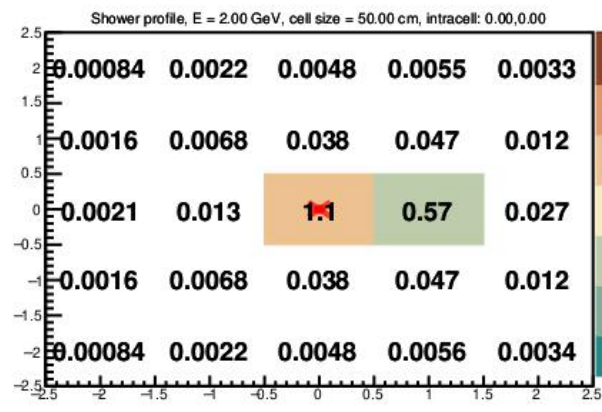


cell size:
5.5 cm

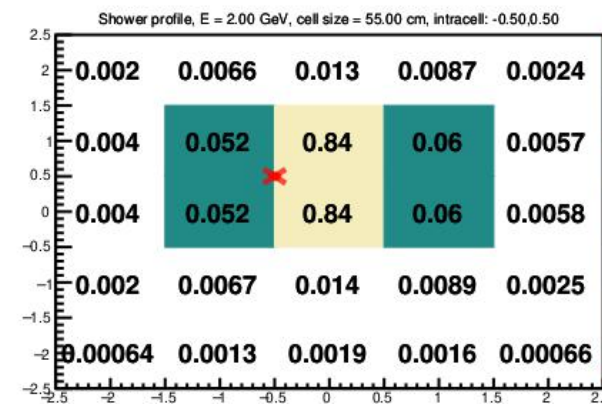
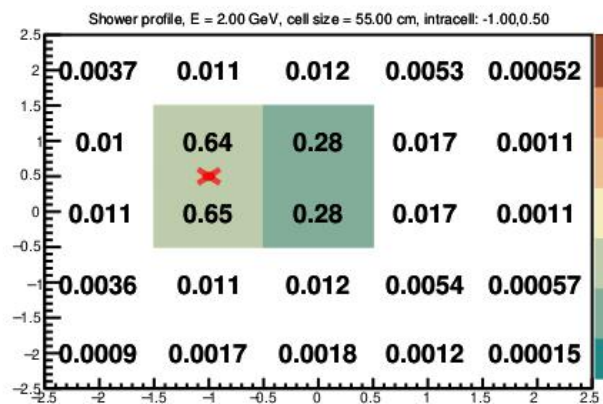
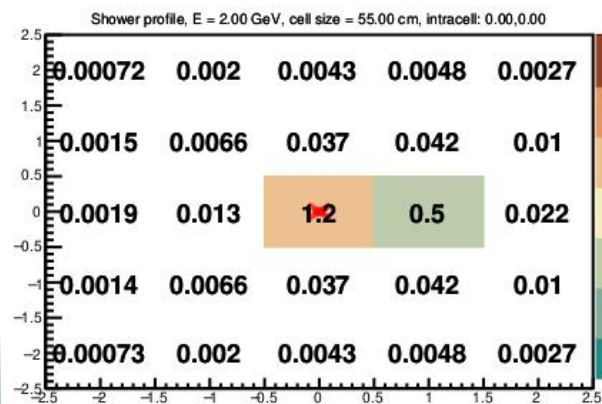
Shower profiles, electrons $E = 2$ GeV, angle = 10°



cell size:
4 cm

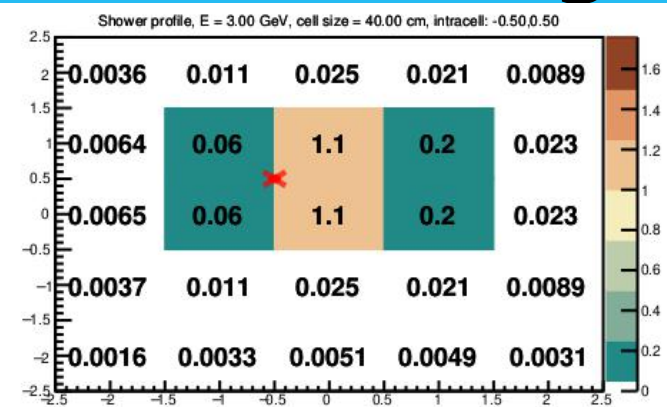
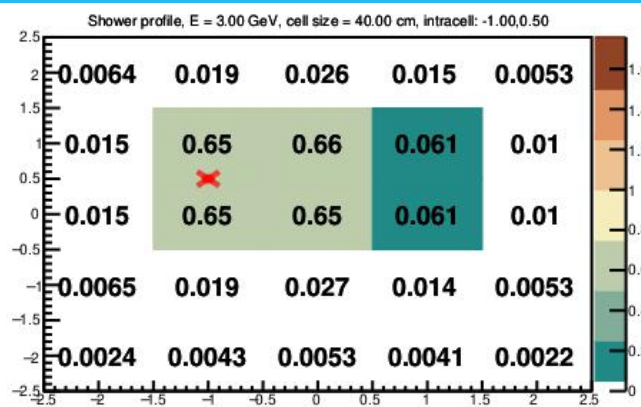
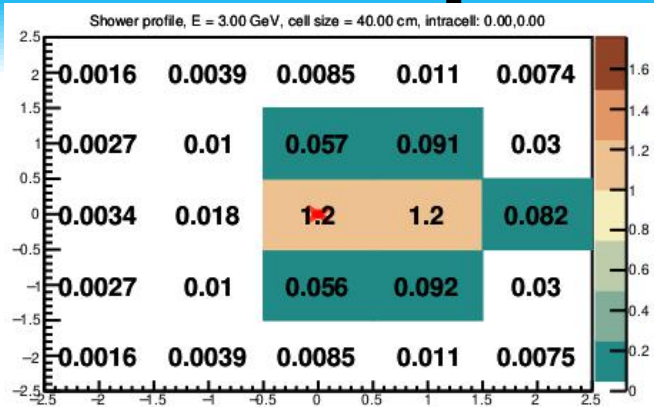


cell size:
5 cm

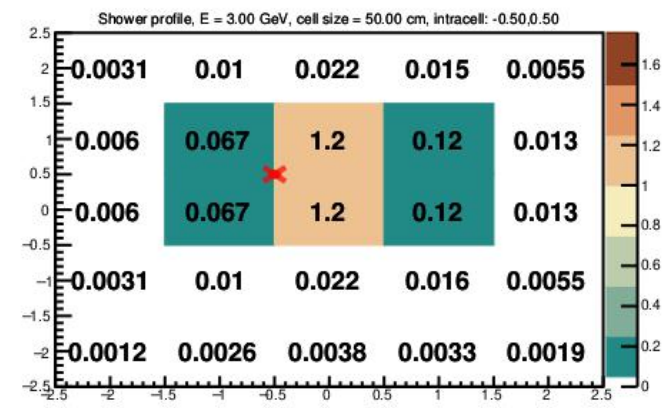
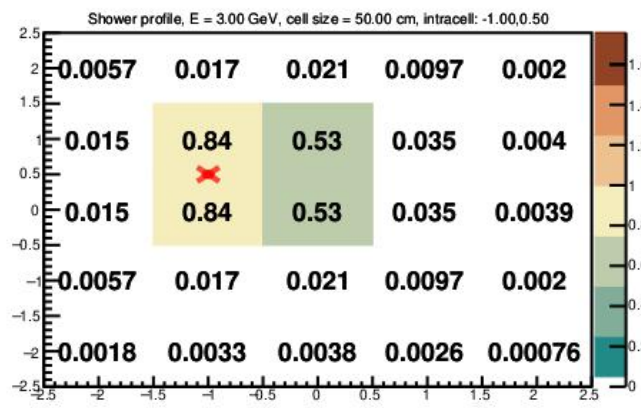
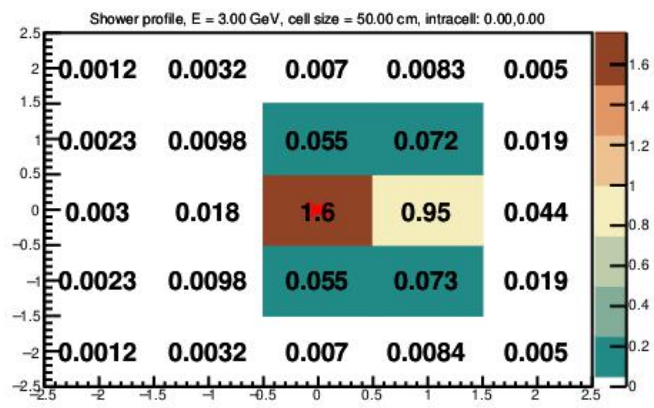


cell size:
5.5 cm

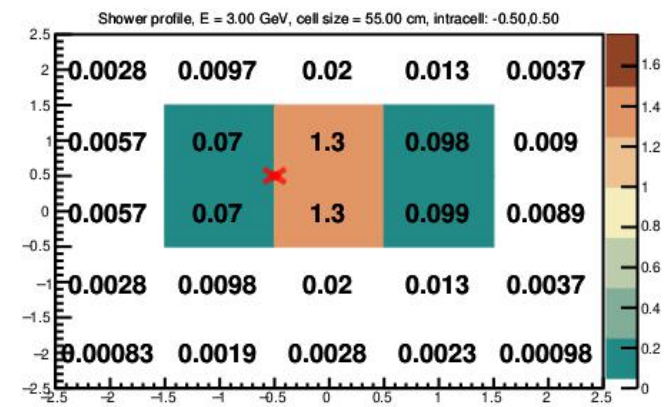
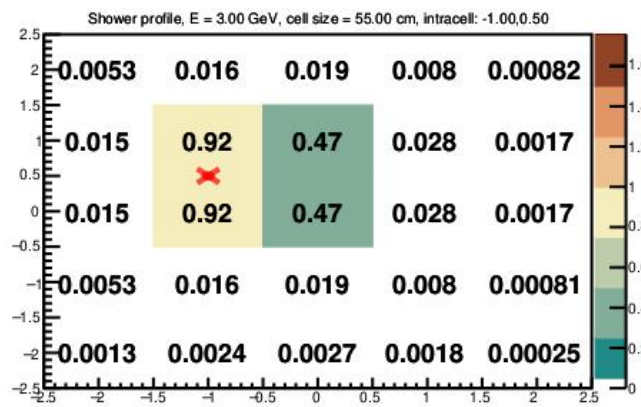
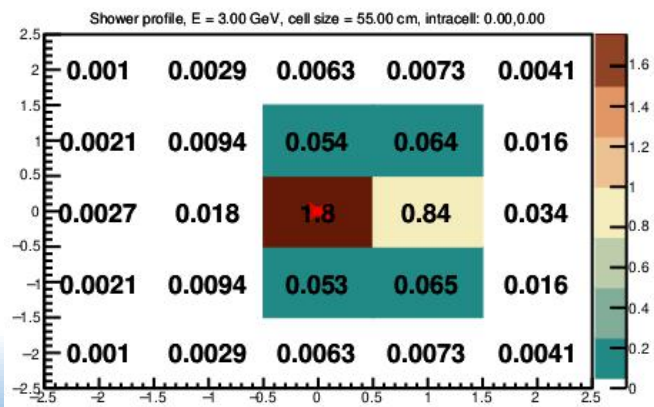
Shower profiles, electrons $E = 3$ GeV, angle = 10°



cell size:
4 cm

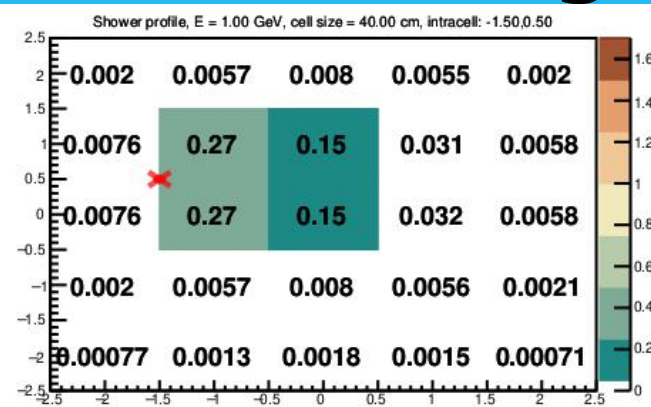
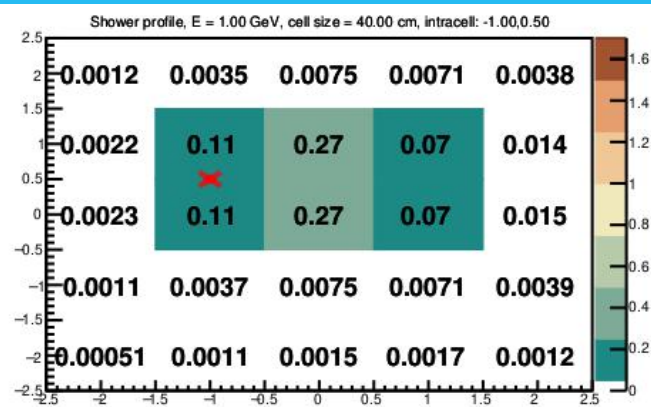
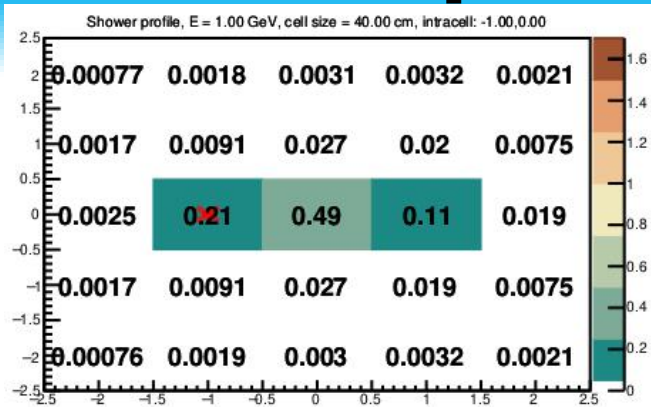


cell size:
5 cm

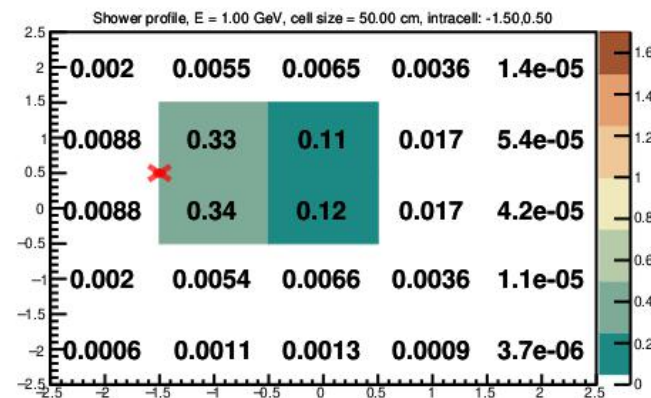
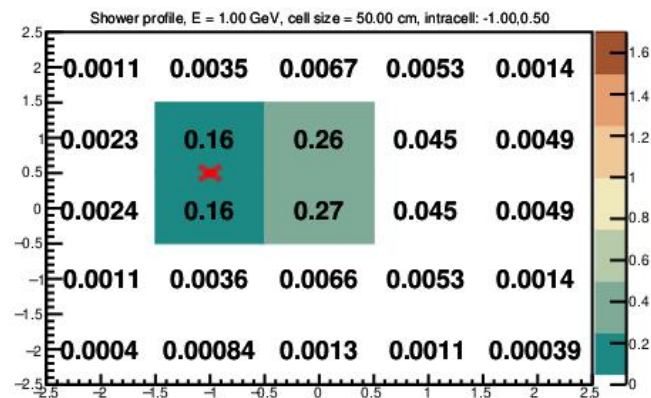
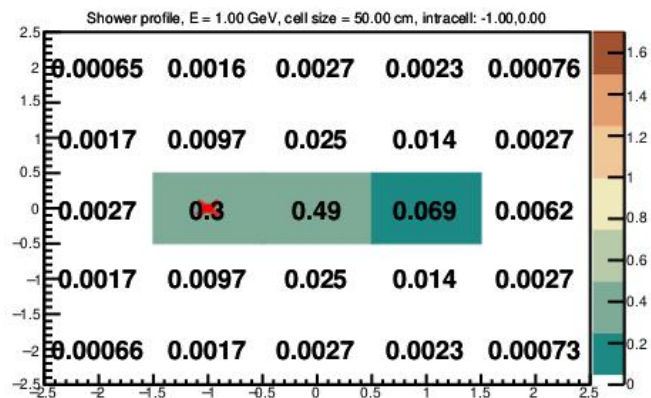


cell size:
5.5 cm

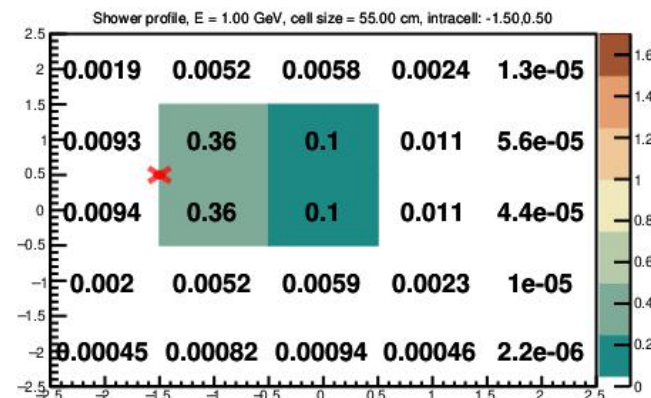
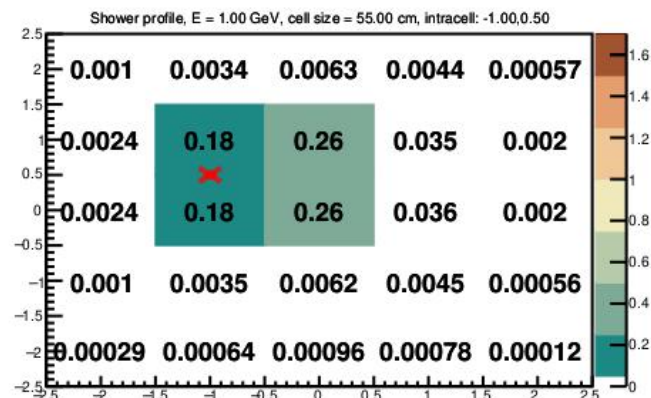
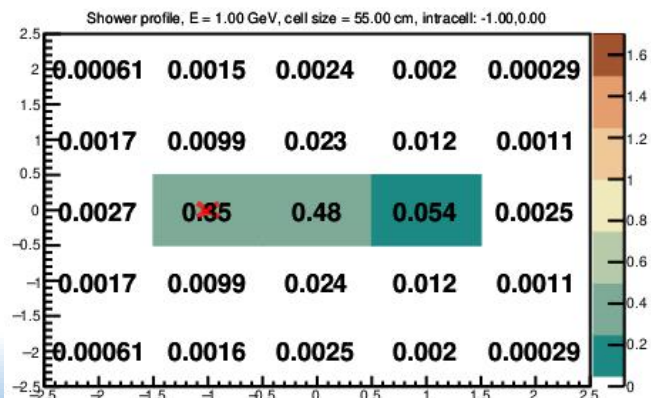
Shower profiles, electrons $E = 1$ GeV, angle = 20°



cell size:
4 cm

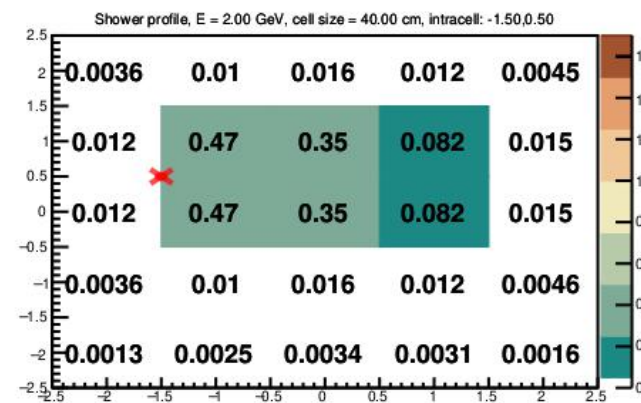
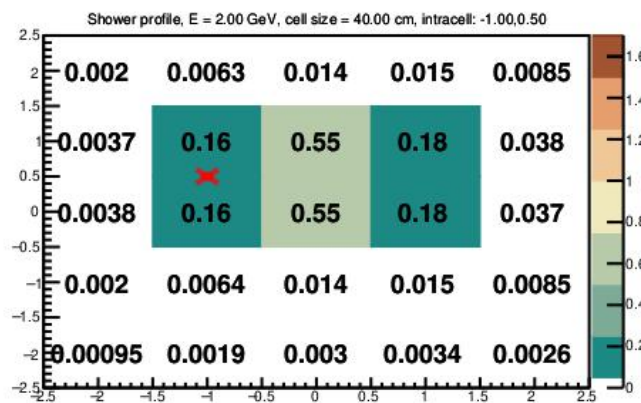
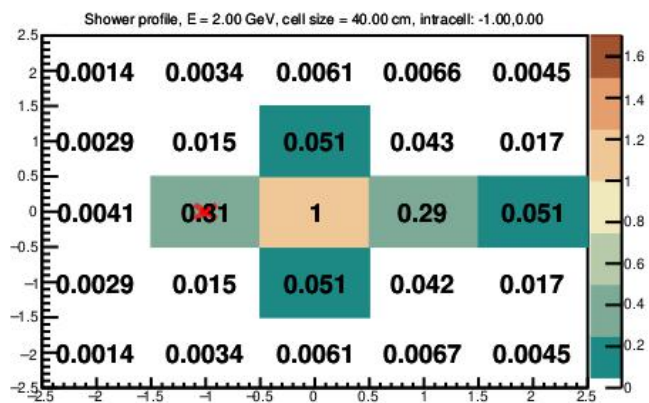


cell size:
5 cm

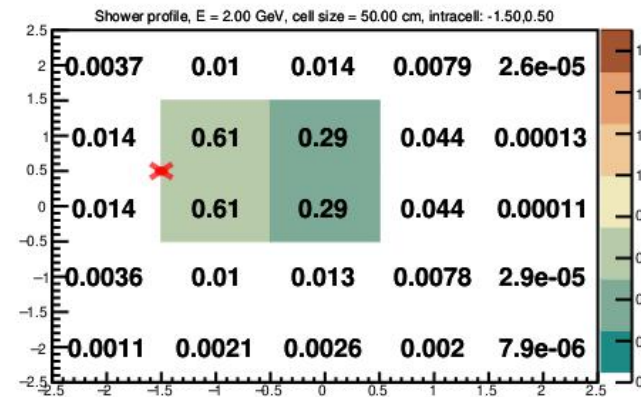
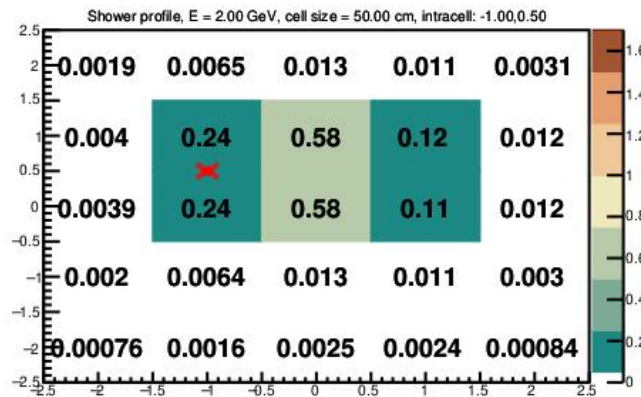
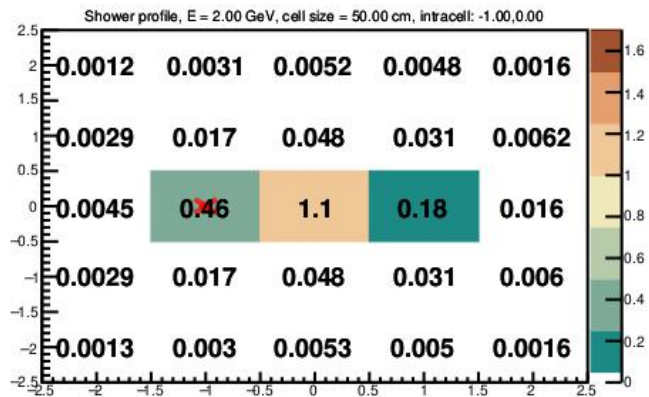


cell size:
5.5 cm

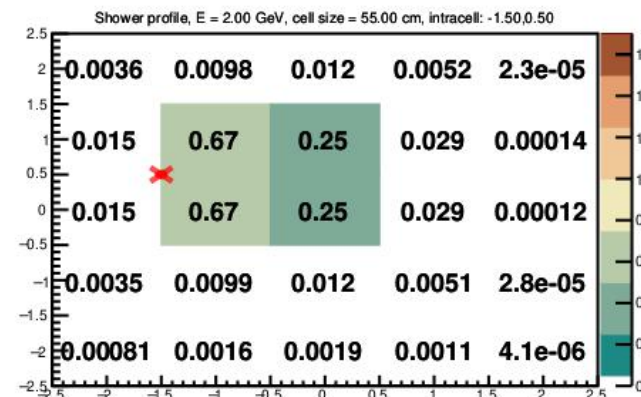
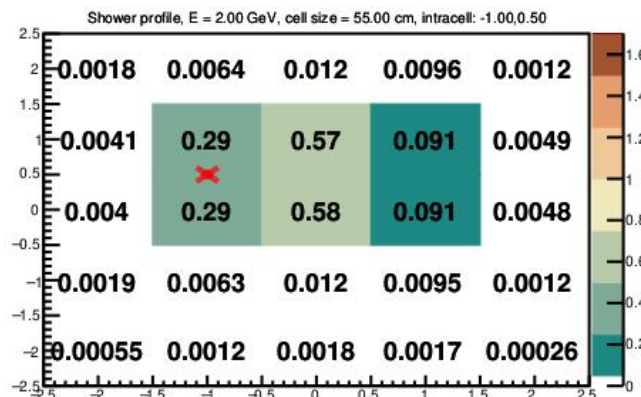
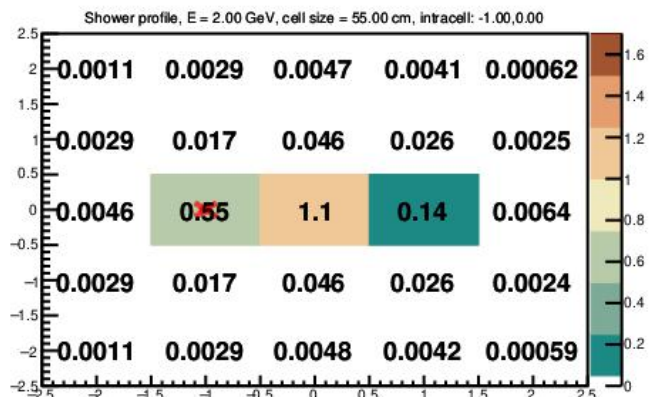
Shower profiles, electrons $E = 2$ GeV, angle = 20°



cell size:
4 cm

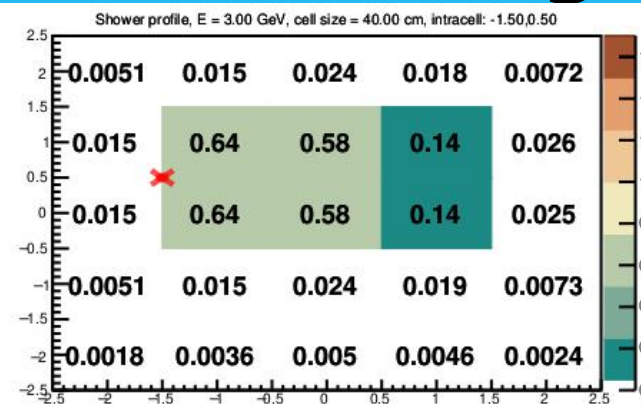
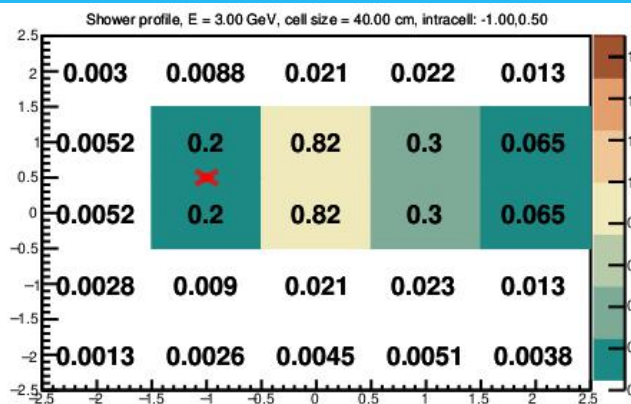
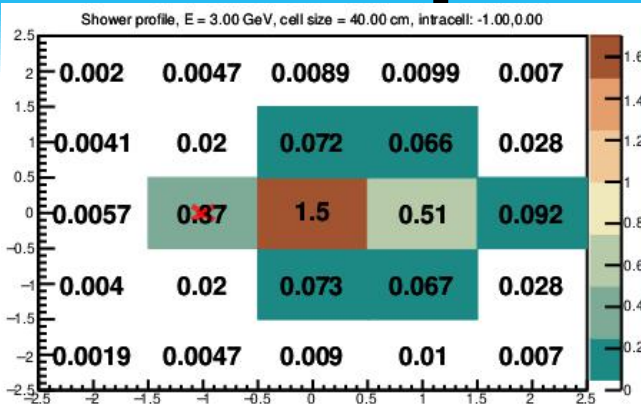


cell size:
5 cm

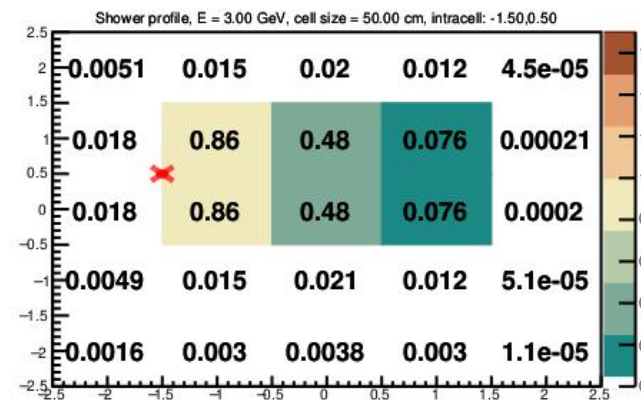
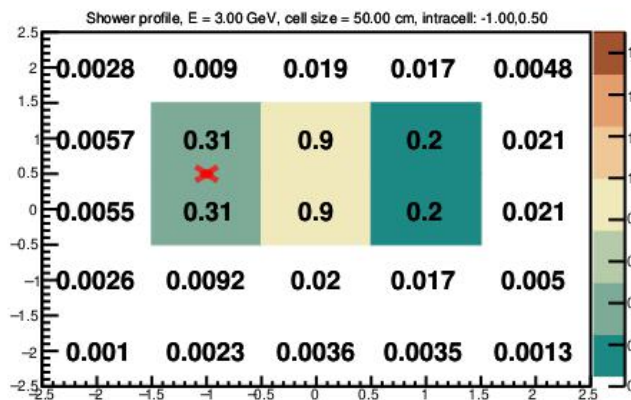
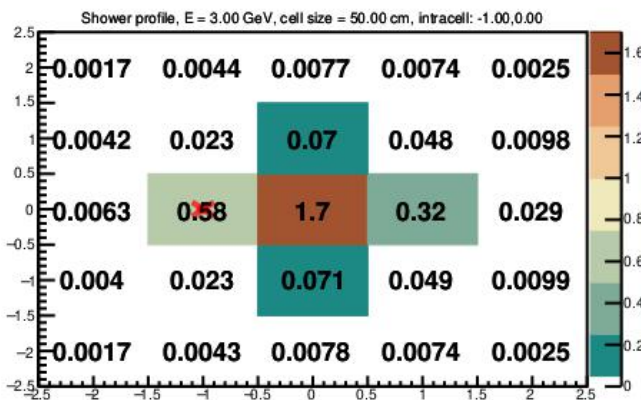


cell size:
5.5 cm

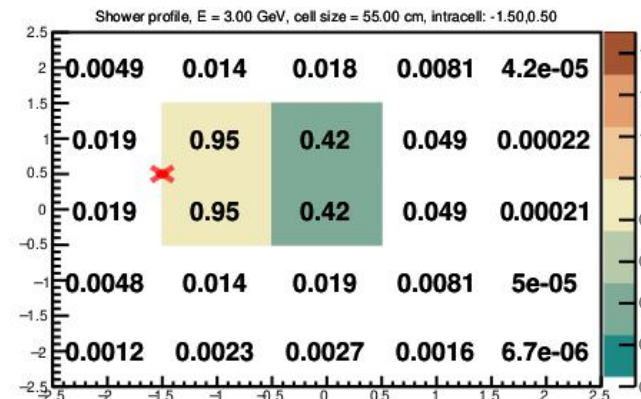
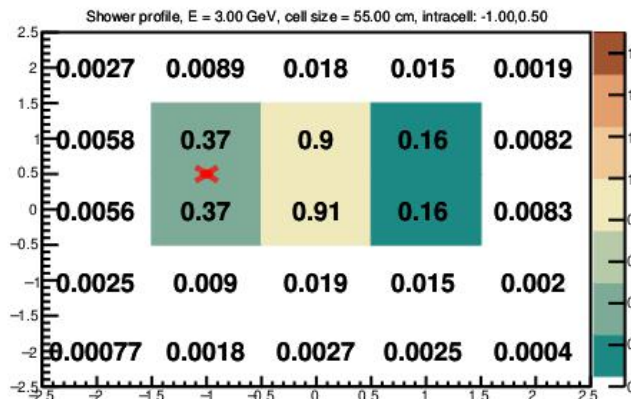
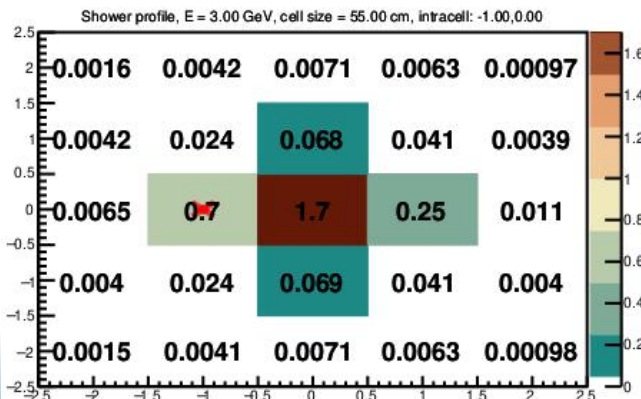
Shower profiles, electrons $E = 3$ GeV, angle = 20°



cell size:
4 cm

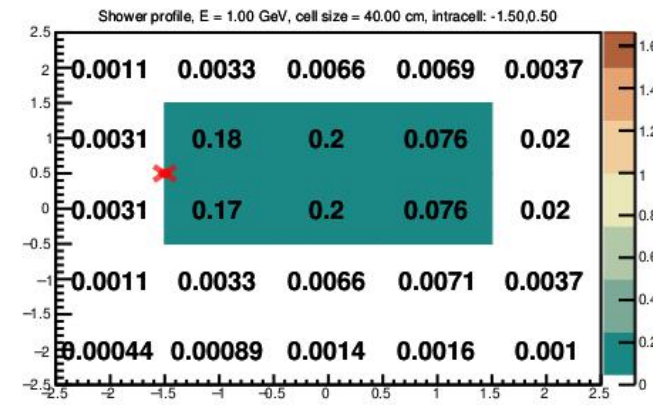
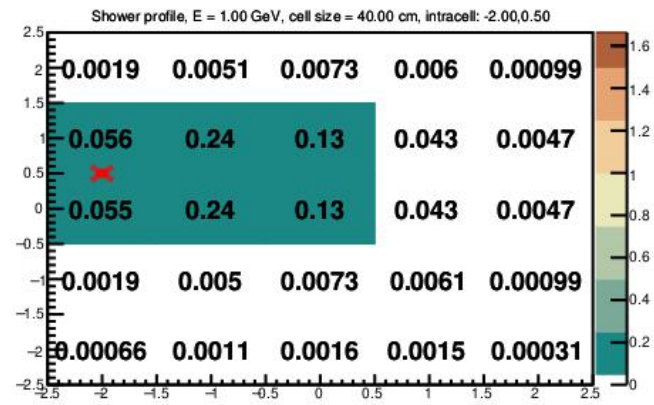
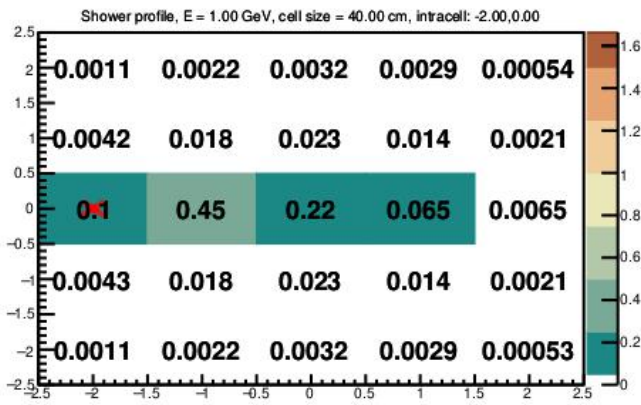


cell size:
5 cm

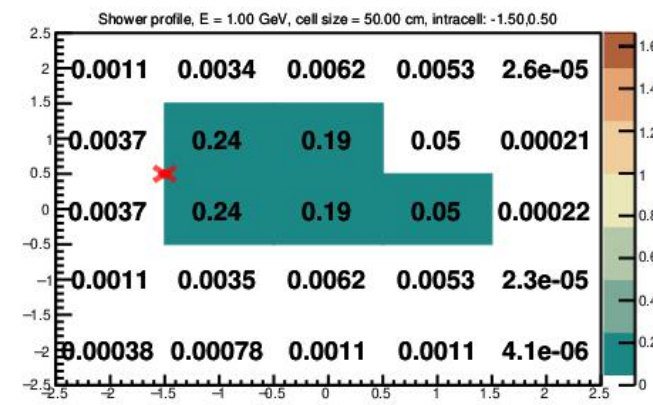
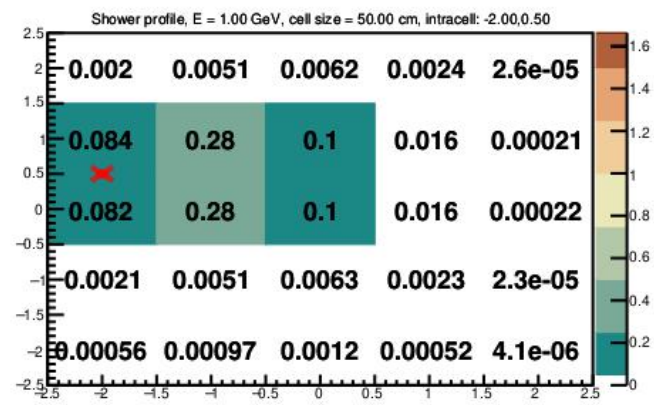
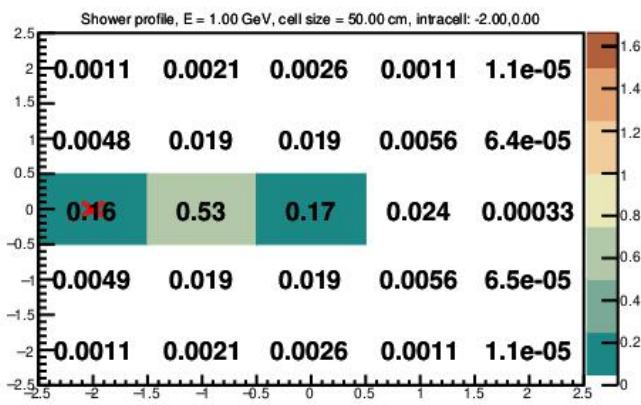


cell size:
5.5 cm

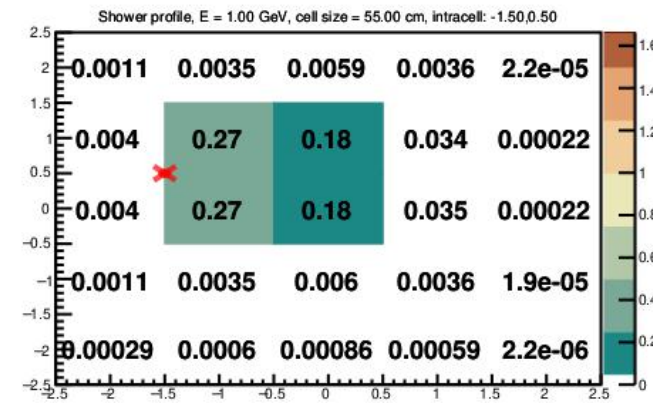
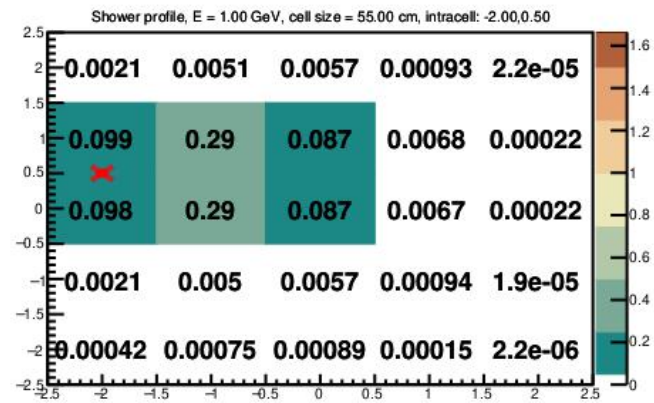
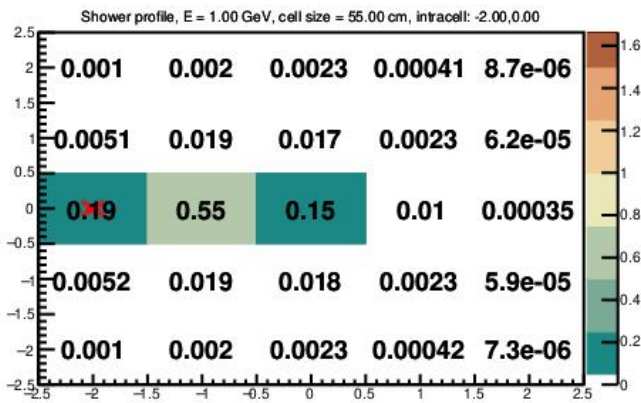
Shower profiles, electrons $E = 1$ GeV, angle = 30°



cell size:
4 cm

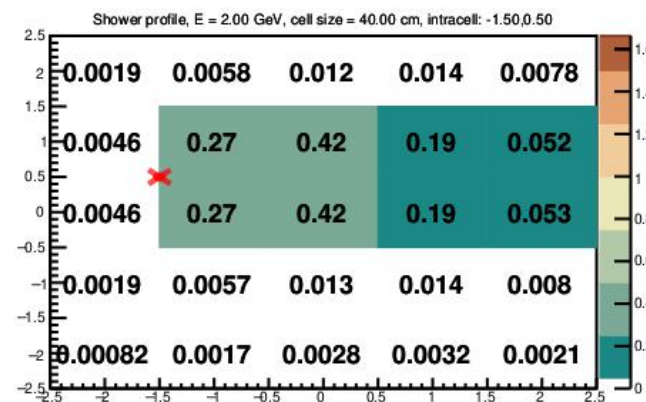
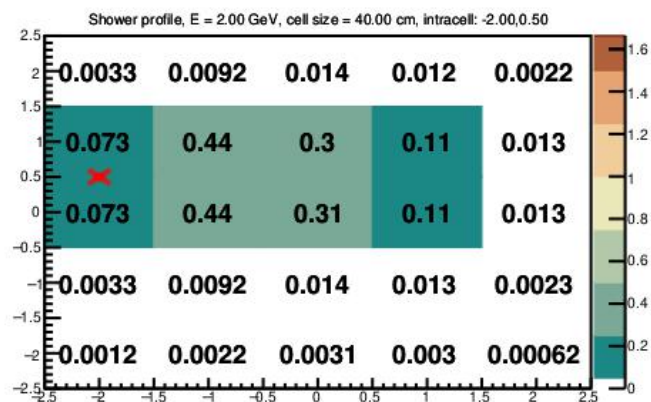
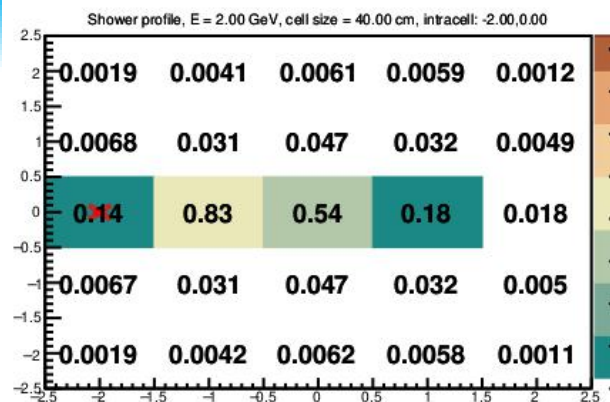


cell size:
5 cm

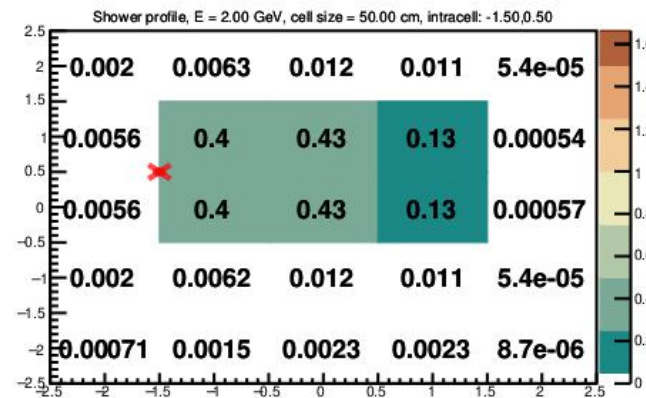
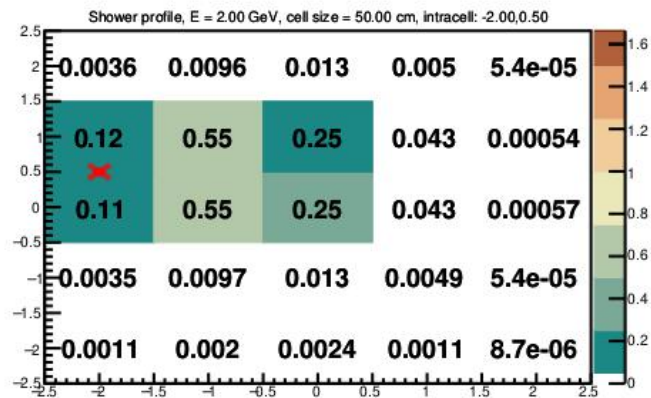
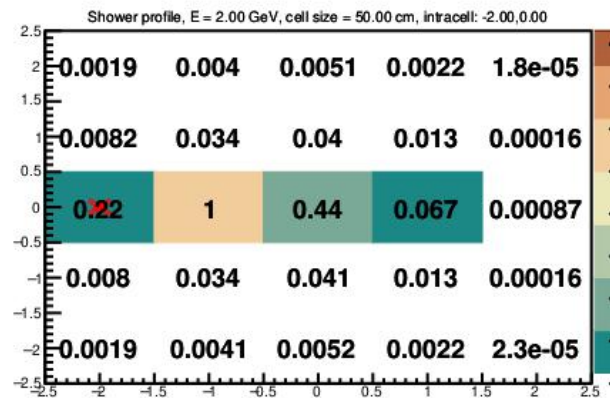


cell size:
5.5 cm

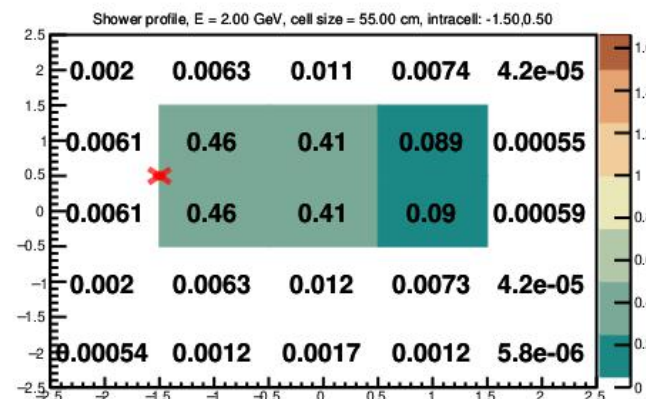
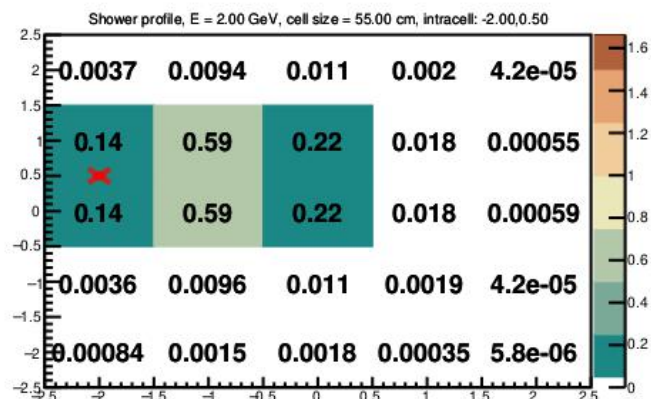
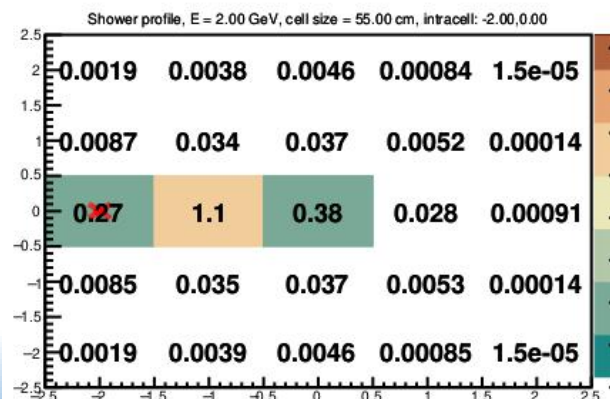
Shower profiles, electrons $E = 2$ GeV, angle = 30°



cell size:
4 cm

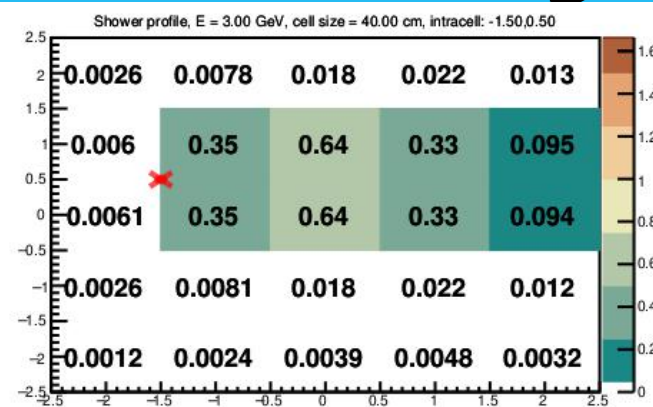
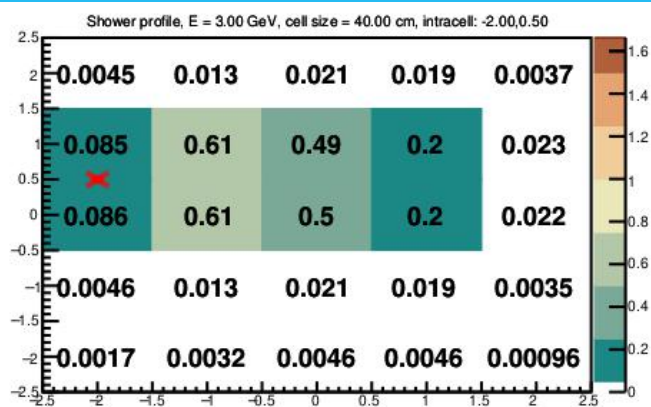
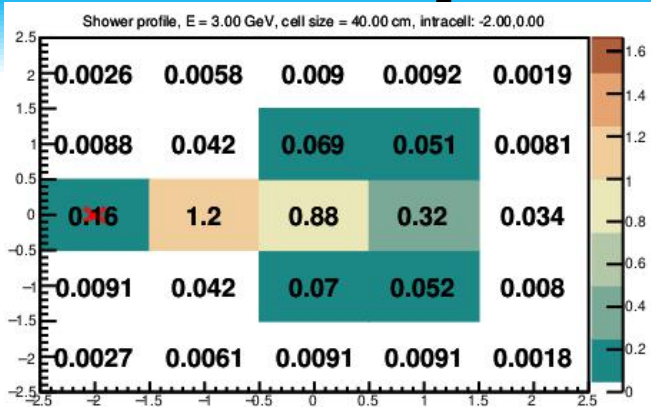


cell size:
5 cm

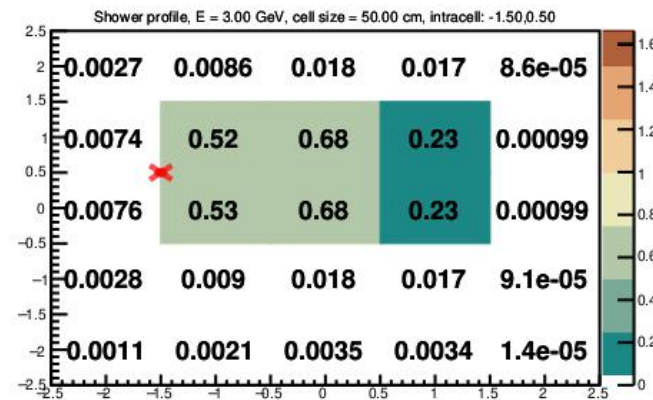
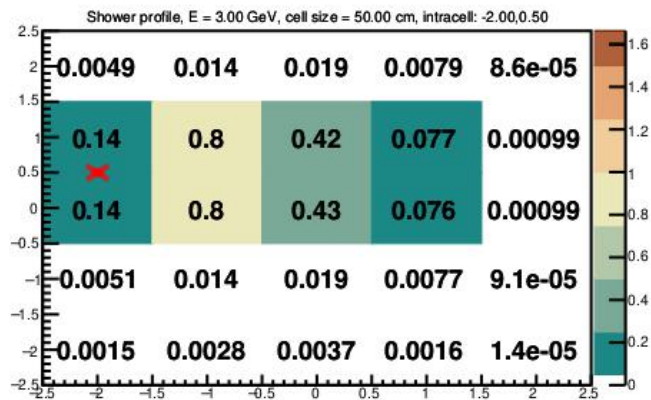
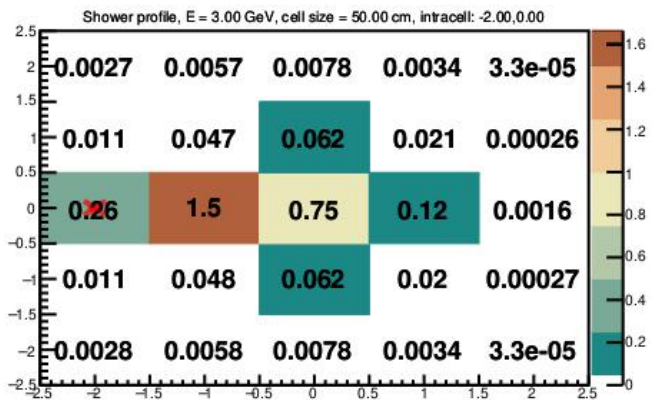


cell size:
5.5 cm

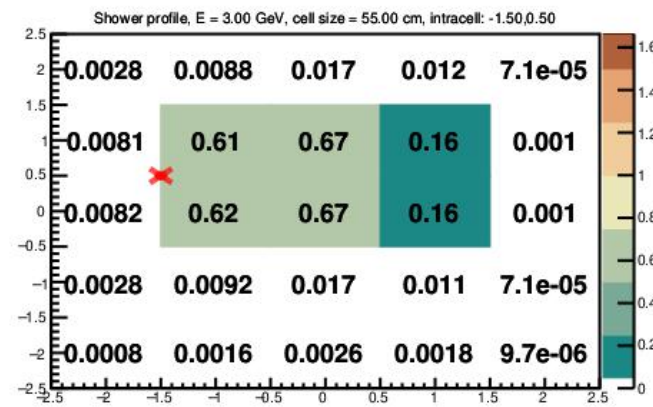
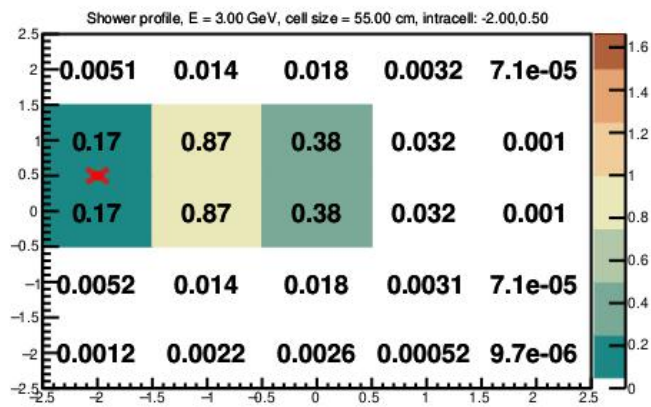
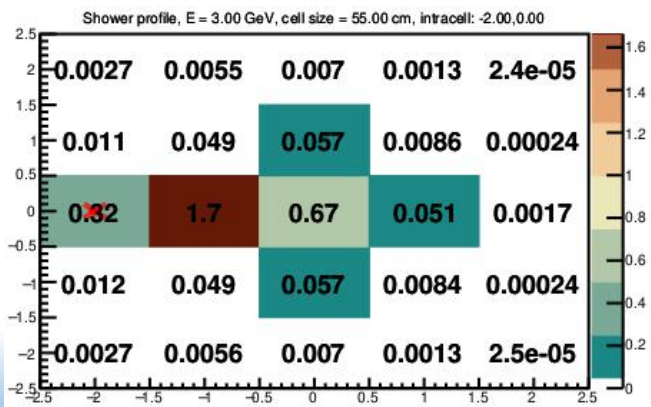
Shower profiles, electrons $E = 3$ GeV, angle = 30°



cell size:
4 cm

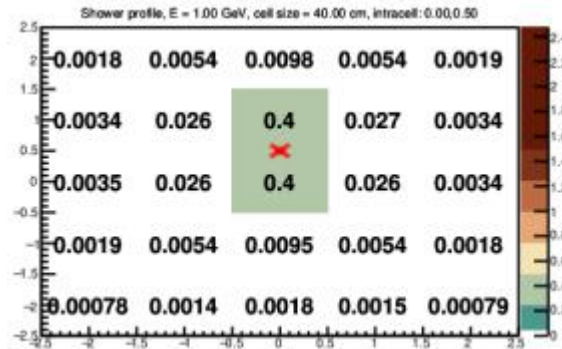


cell size:
5 cm

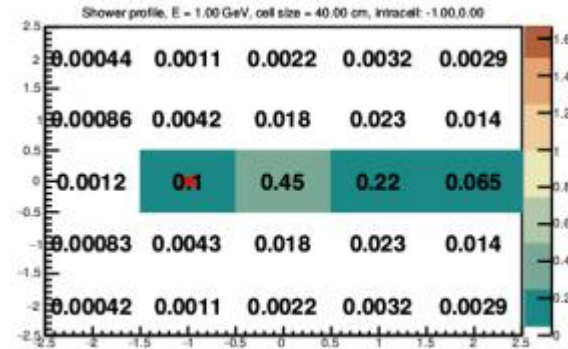


cell size:
5.5 cm

Highlights



zero angle, 1 GeV



30° angle, 1 GeV

Do we know angle before shower reconstruction?

Summary

- Using Geant4 simulation, resolution of SPD ECAL was studied, the results are consistent with O.Gavrishchuk's results
- Additional error from photoelectron statistics increases energy resolution at 1 GeV from 4% to 5%
- Shower profiles, which will be later used for shower reconstruction, were obtained.

BACKUP

SPD ECAL resolution

