Instructions for the clustering tutorial

Setup and run instructions Instructions

1. Coding is to be done in **serc19_ecal_clustering.C**
2. You need to have CLHEP installed → Take the one inside G4 installation
3. Then source like I have sourced (with your correct paths)

```
source /usr/local/Caskroom/miniforge/base/envs/geant4env/share/Geant4/geant4make/geant4make.sh
export DYLD_LIBRARY_PATH=/Users/shilpi2015/geant4/geant4-v11.2.0-install/lib:$DYLD_LIBRARY_PATH
```

6. Correct the paths in the Makefile
7. Make [Do it everytime you change **serc19_ecal_clustering.C**]
8. There is a file **inputfiles**
9. **In this file, put a # sign in the beginning if you dont want to run over that file**
10. **Put the path of the file here, then number of events, then energy**
11. **In this case, the line in inputfile will become:**
    a. **test_gamma_5GeV_10k.root   10000 5**
12. To run: source run.sh

Hints for writing various clustering algorithms

First step of:

(a) Adding Gaussian noise to each hit
(b) Ordering hit in decreasing magnitude of energy

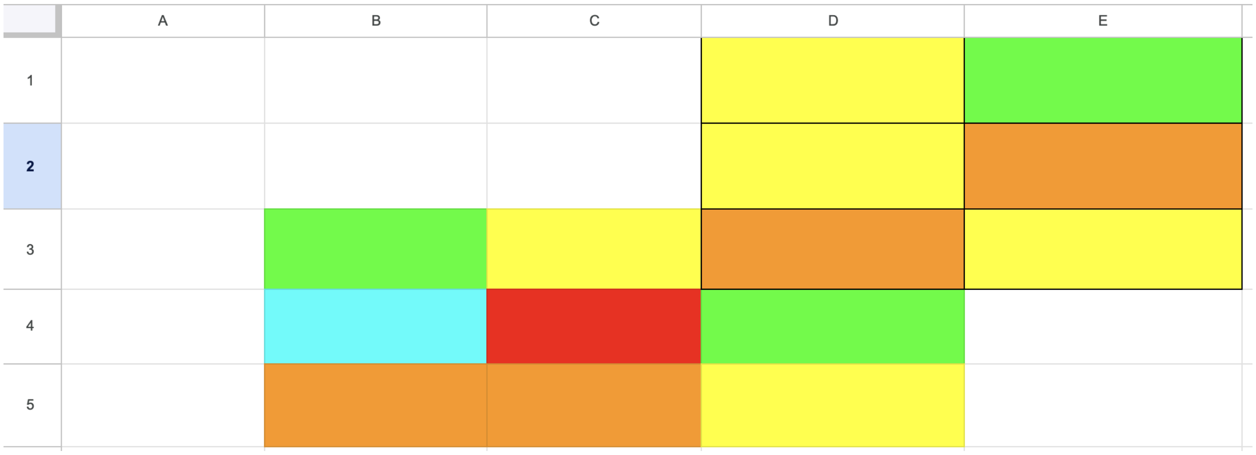
(Above task done by fill_digipos_array and the result is stored in digihitpos)
Now use digihitpos which is a Hep3Vector whose elements are (energy, theta, phi) of that hit

1. **Clustering algorithm that collects even those hits around** the seed are higher in energy compared to the ones in the immediate 3x3 (i.e. touching the sides) around the seed
    a. Loop over all the hits, if a hit crosses the seedThreshold (0.5GeV), start clustering hits around it.
    b. Consider only those hits around it which are within 3x3 around it OR around the hit which is its 3x3 neighbour.

c. The above concept is shown below. Color coding: RED is highest energy, then orange, then yellow, then green, then blue

d. Although the cells in black boundary are not immediate neighbour or RED still they should get collected as a part of the algorithm

e.

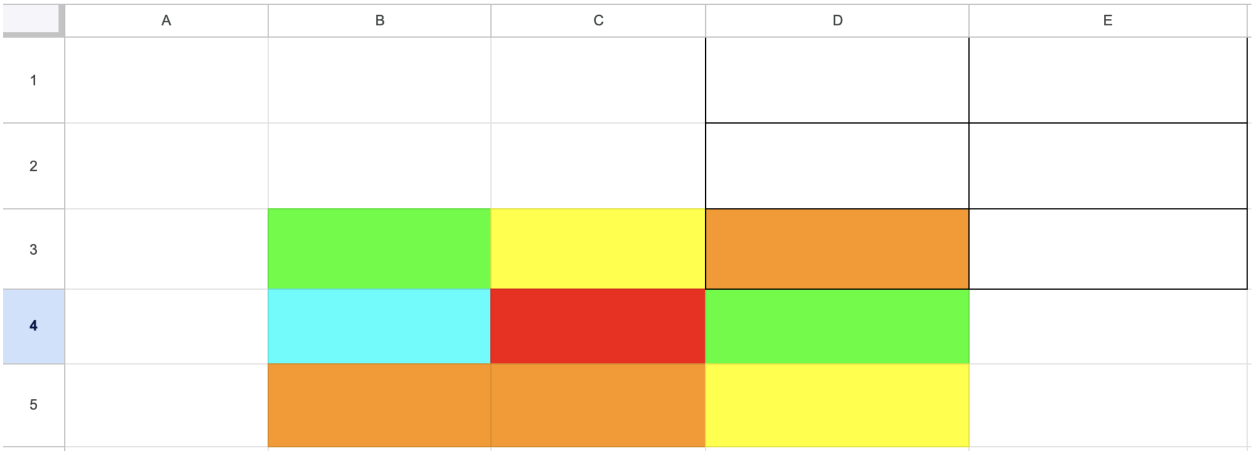


	A	B	C	D	E
1				🟨	🟩
2				🟨	🟧
3		🟩	🟨	🟧	🟨
4		🟦	🟥	🟩	
5		🟧	🟧	🟨	

NOTE: In above, Although there is rise in energy if we move from D2 to E2, the algorithm should still collect this hit. This is not a good step because if there are two different photons nearby, this algorithm will make it one photon. So this is not optimum. The next algorithm should treat this malady

2. **A clustering algorithm that is similar to above but DOES NOT** collect those hits around the seed are higher in energy compared to the ones in the immediate 3x3 (i.e. touching the sides) around the seed. I.e. if we are talking about the above scenario then only the following are clustered

3.



	A	B	C	D	E
1					
2					
3		🟩	🟨	🟧	
4		🟦	🟥	🟩	
5		🟧	🟧	🟨	

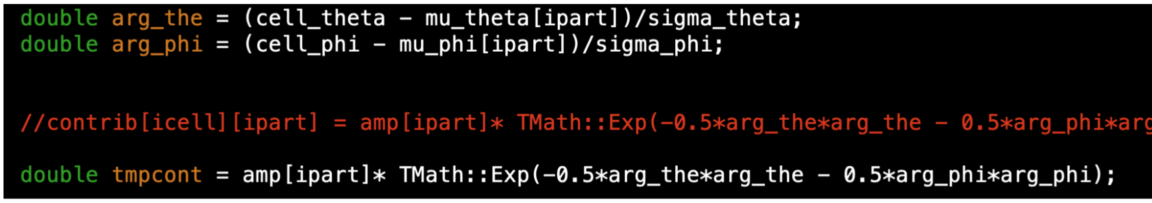
4. **EM algorithm**
    a. First make a list of seeds
    b. If the two seeds lie close to each other (within 3x3 neighbour, i.e. touching the sides) then remove the one with lower energy as seed (i.e. dont consider that one as seed)

c. Number of seeds == number of particles == number of gaussians

d. Make a list of 3x3 clusters around it (i.e. same as island algorithm)

e. Now consider seeds as Gaussian and use the expectation algorithm i.e.

    i. For every cells calculate (consider only those gaussians for that hit which are a part of that gaussian):



```
double arg_the = (cell_theta - mu_theta[ipart])/sigma_theta;
double arg_phi = (cell_phi - mu_phi[ipart])/sigma_phi;


//contrib[icell][ipart] = amp[ipart]* TMath::Exp(-0.5*arg_the*arg_the - 0.5*arg_phi*arg

double tmpcont = amp[ipart]* TMath::Exp(-0.5*arg_the*arg_the - 0.5*arg_phi*arg_phi);
```

    ii. Then Get the fractional contribution from each gaussian, i.e. fractional = Contribution from that Gaussian to the energy/(Sum over all the Gaussians)

f. Now do the maximization part:

    i. Loop over all the gaussians.

    ii. For each gaussian, recalculate its amp (i.e. its amplitude) and its position (i.e. mu_theta and mu_phi) in the above