Back-scattering update

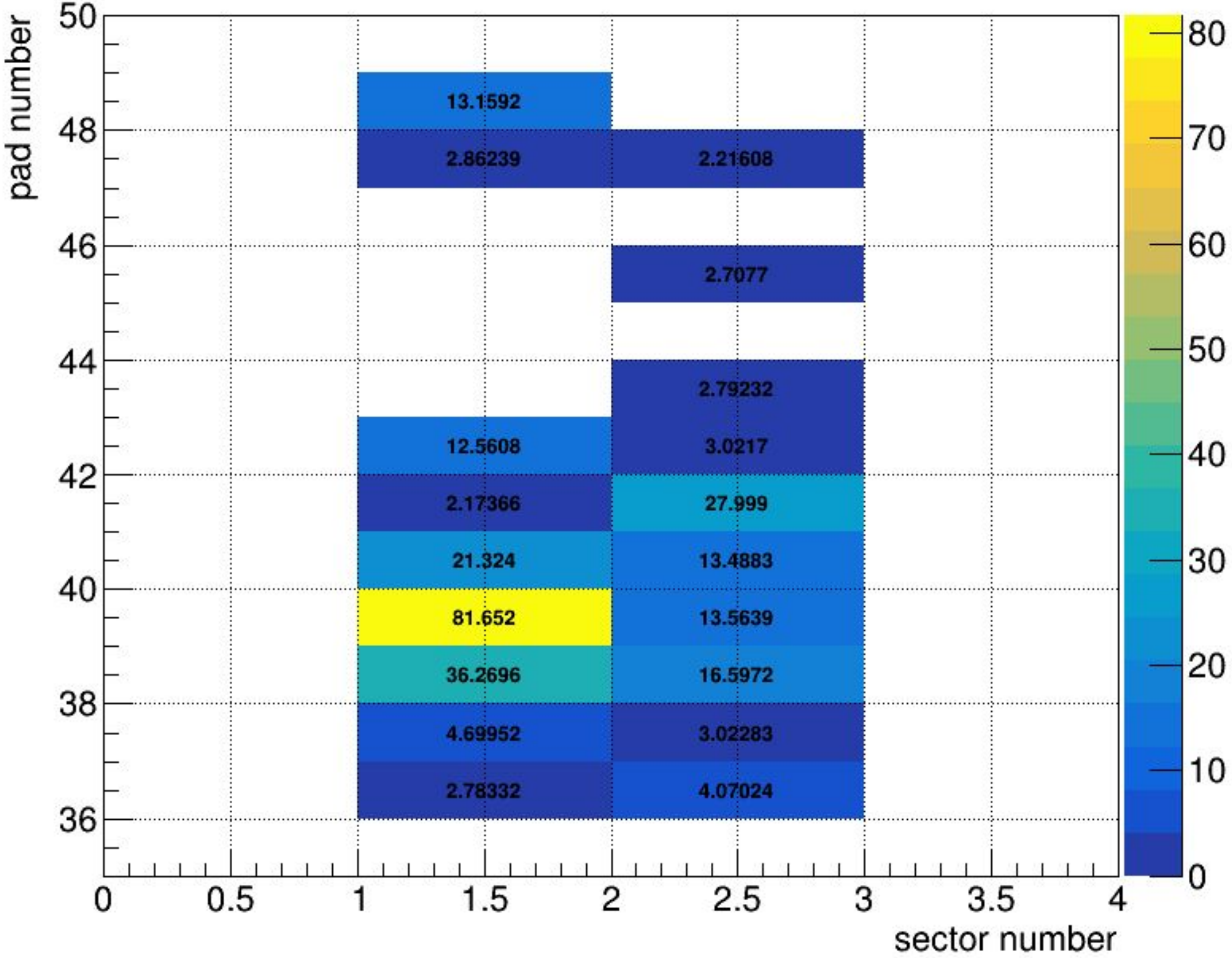
Bohdan Dudar

Clustering

1. A seed tower is defined as a local maximum of energy deposited in more than one pad inside the tower.
2. Neighbor towers with less but non-zero energy are attached to the seed tower to form a cluster.

VS

1. A seed tower is defined as a local maximum of energy deposited in more than one pad inside the tower.
2. In the loop on the towers that not attached to any cluster
   a. Find neighbor towers (±1 pad and±1 sector) which already attached to some cluster.
   b. If found: pick the most energetic neighbor tower which attached to some cluster X. Attach current tower to the same cluster X.
   c. If not found: skip and go to the next tower.
3. Repeat (2) till towers will stop attaching to new clusters.
4. Increase distance to accept tower as neighbor "+1" and repeat (3).
5. Repeat (4) till all towers will attach to some clusters.
6. Merge cluster pairs if condition is met.



pad number
50
48
46
44
42
40
38
36
13.1592
2.86239
2.21608
2.7077
2.79232
12.5608
3.0217
2.17366
27.999
21.324
13.4883
81.652
13.5639
36.2696
16.5972
4.69952
3.02283
2.78332
4.07024
0
0.5
1
1.5
2
2.5
3
3.5
4
sector number
80
70
60
50
40
30
20
10
0

Attach unassigned towers to already assigned towers.

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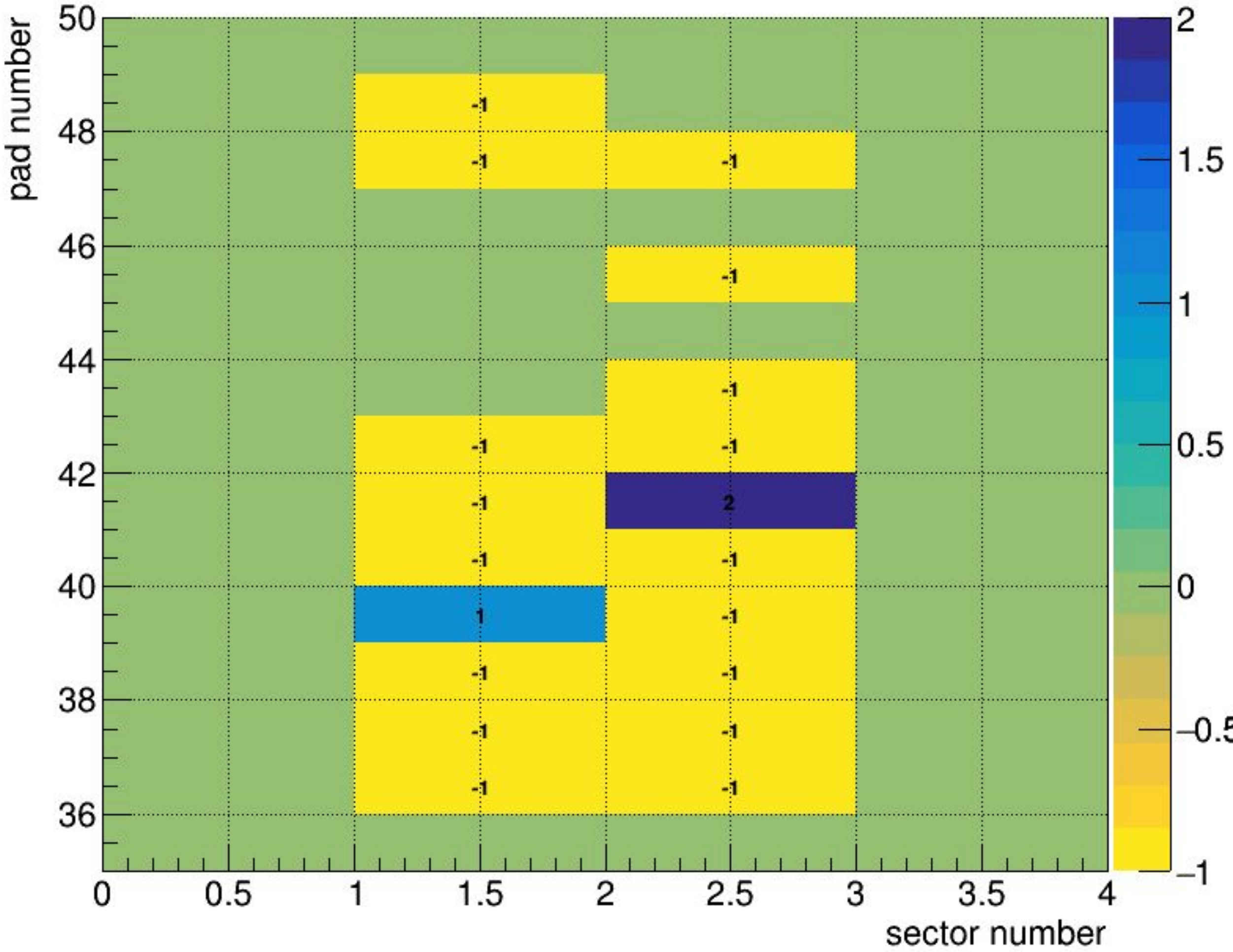

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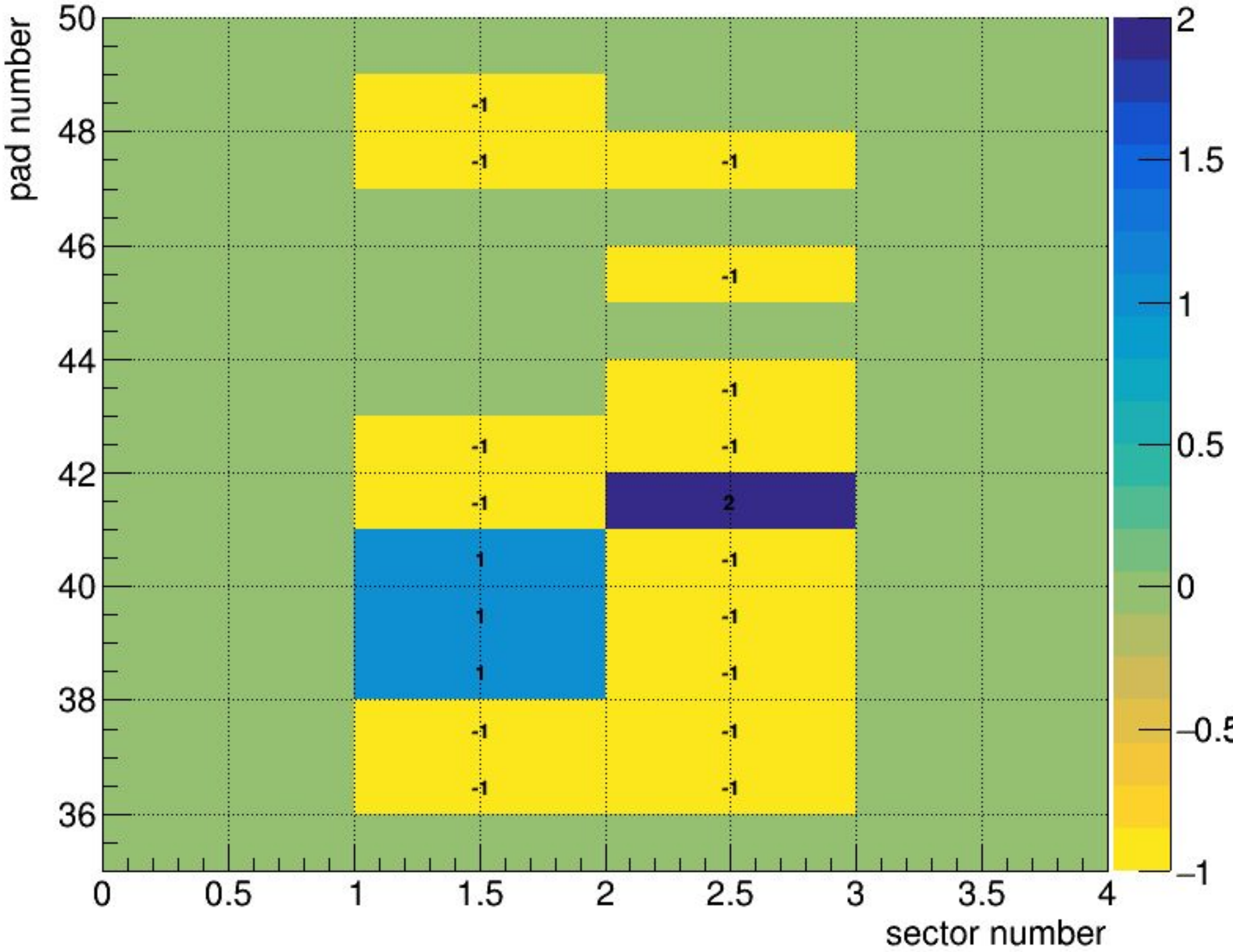

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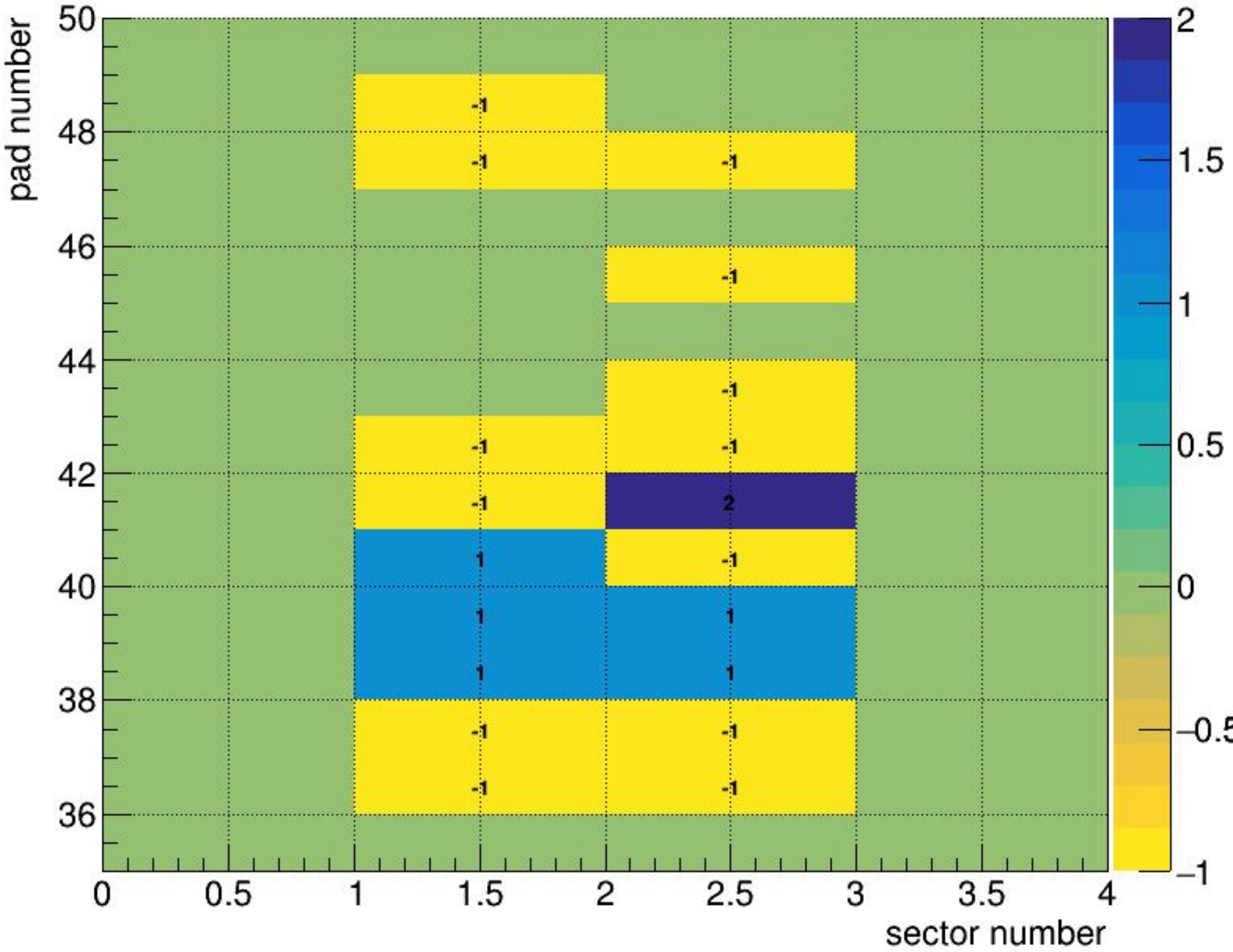

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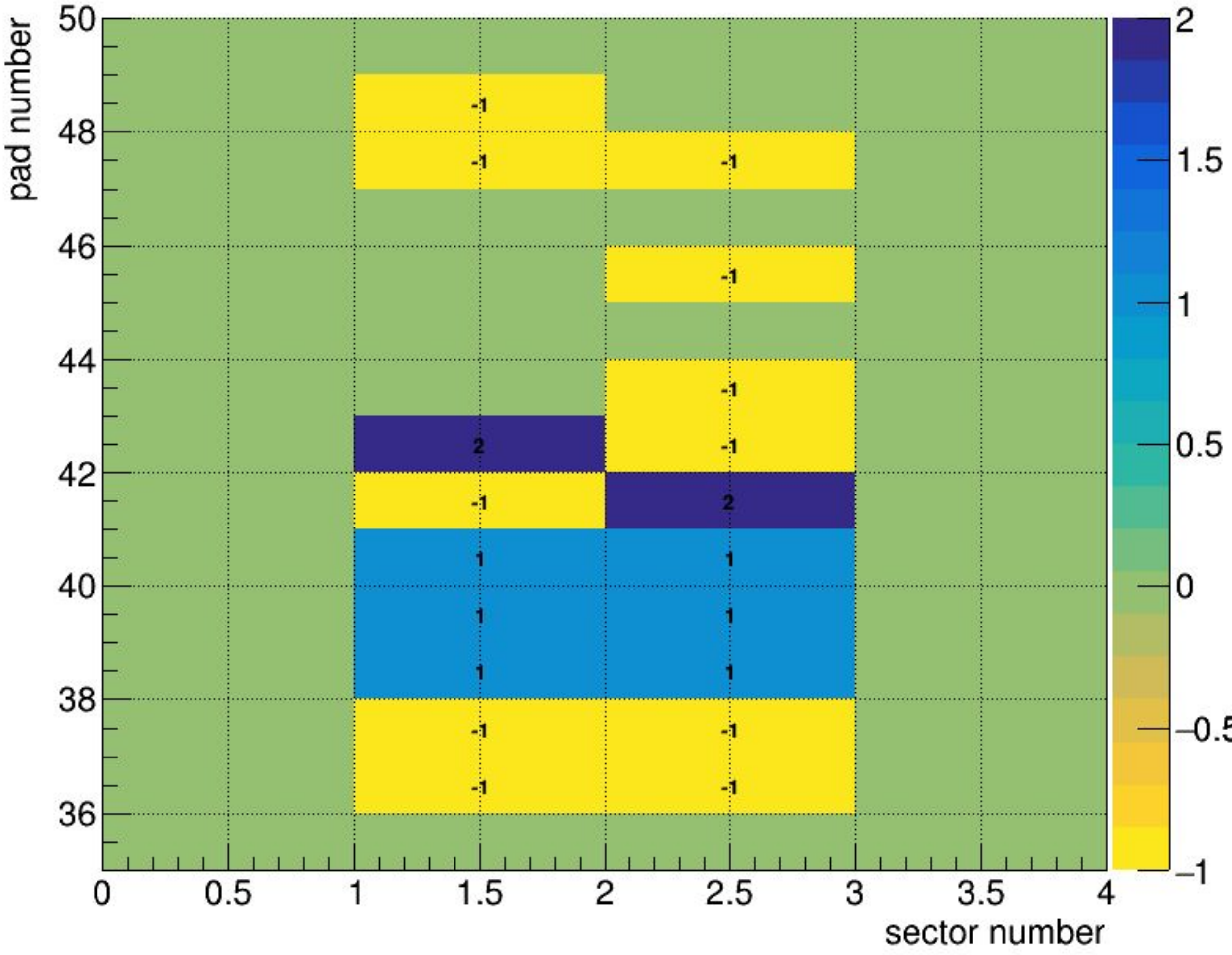

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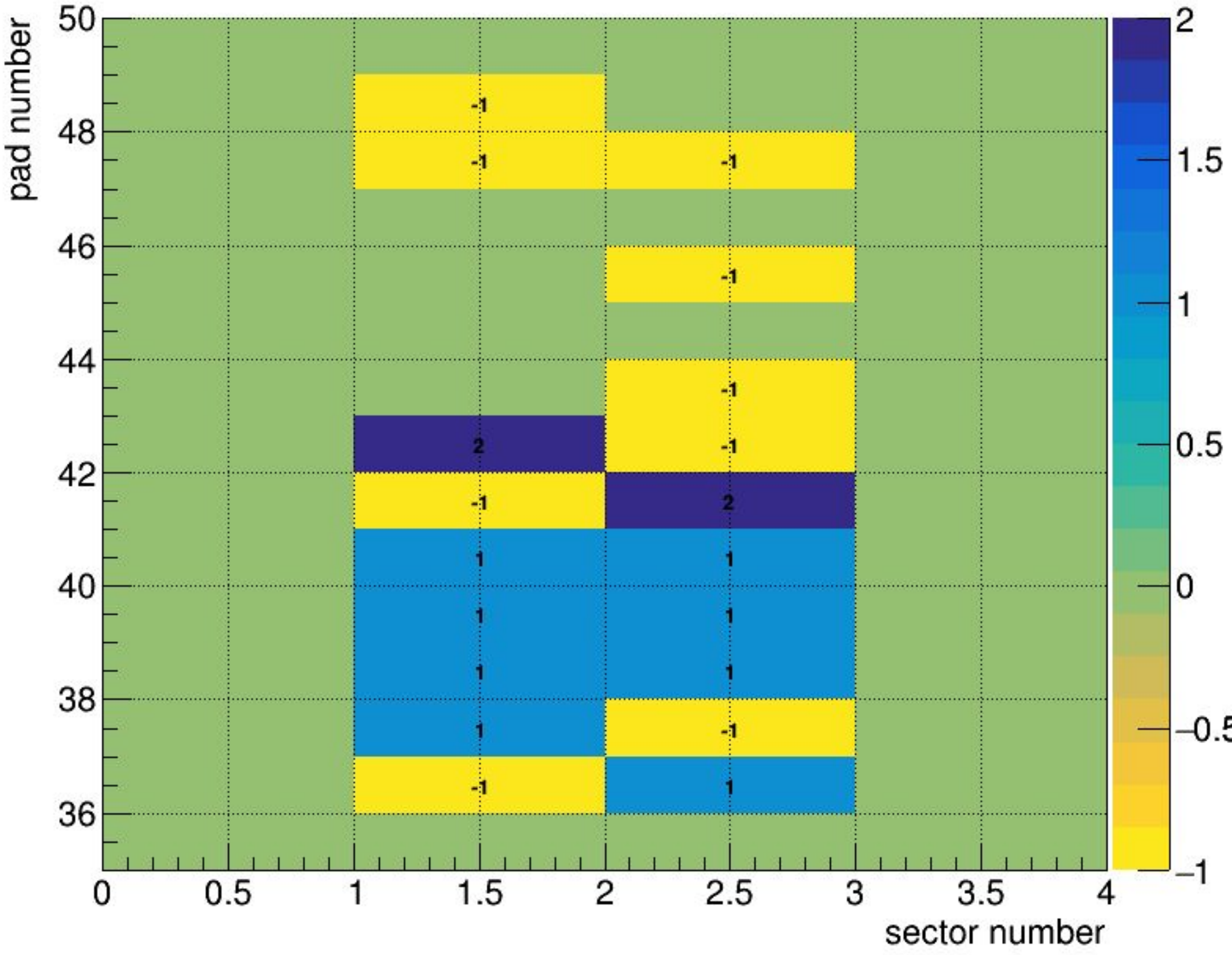

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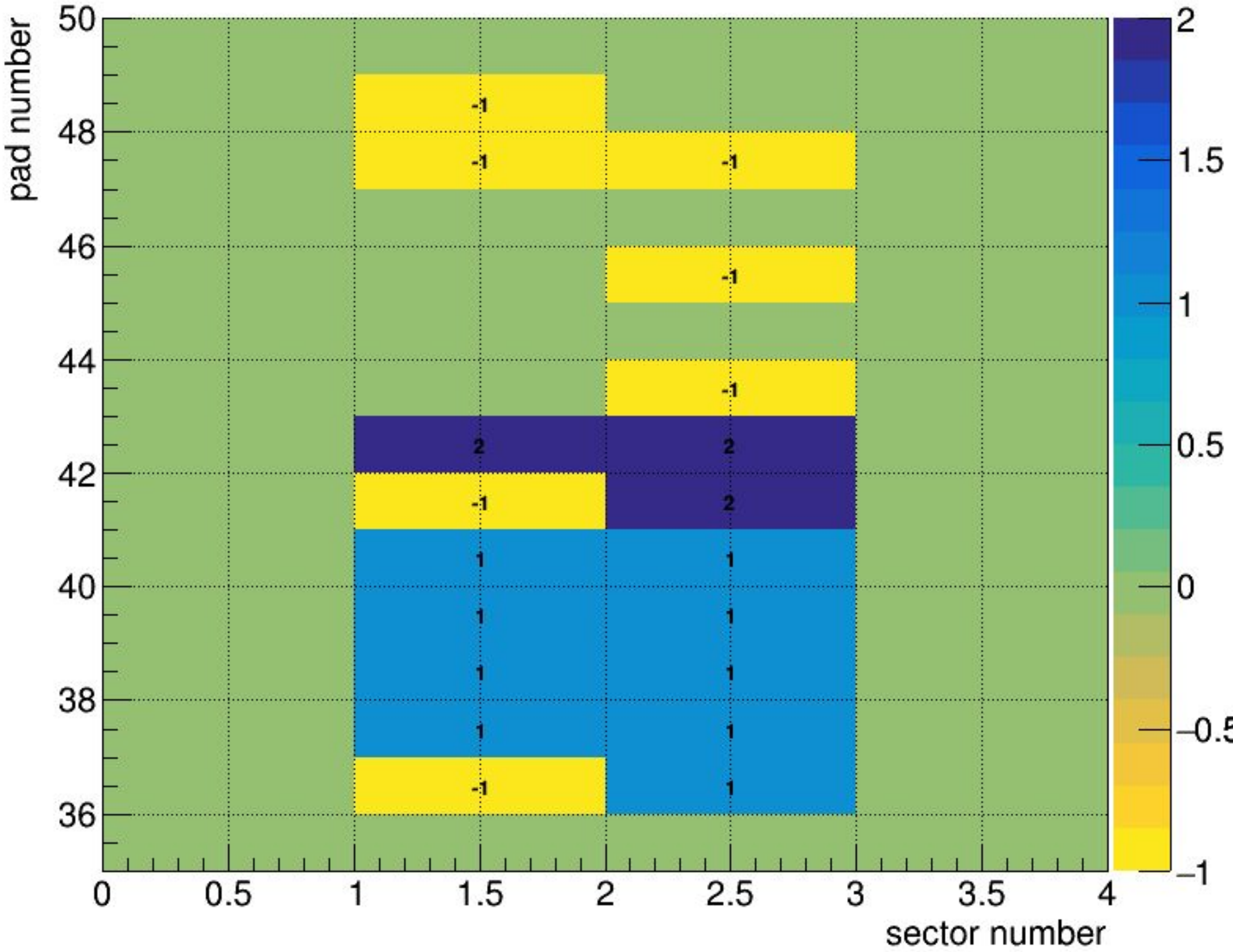

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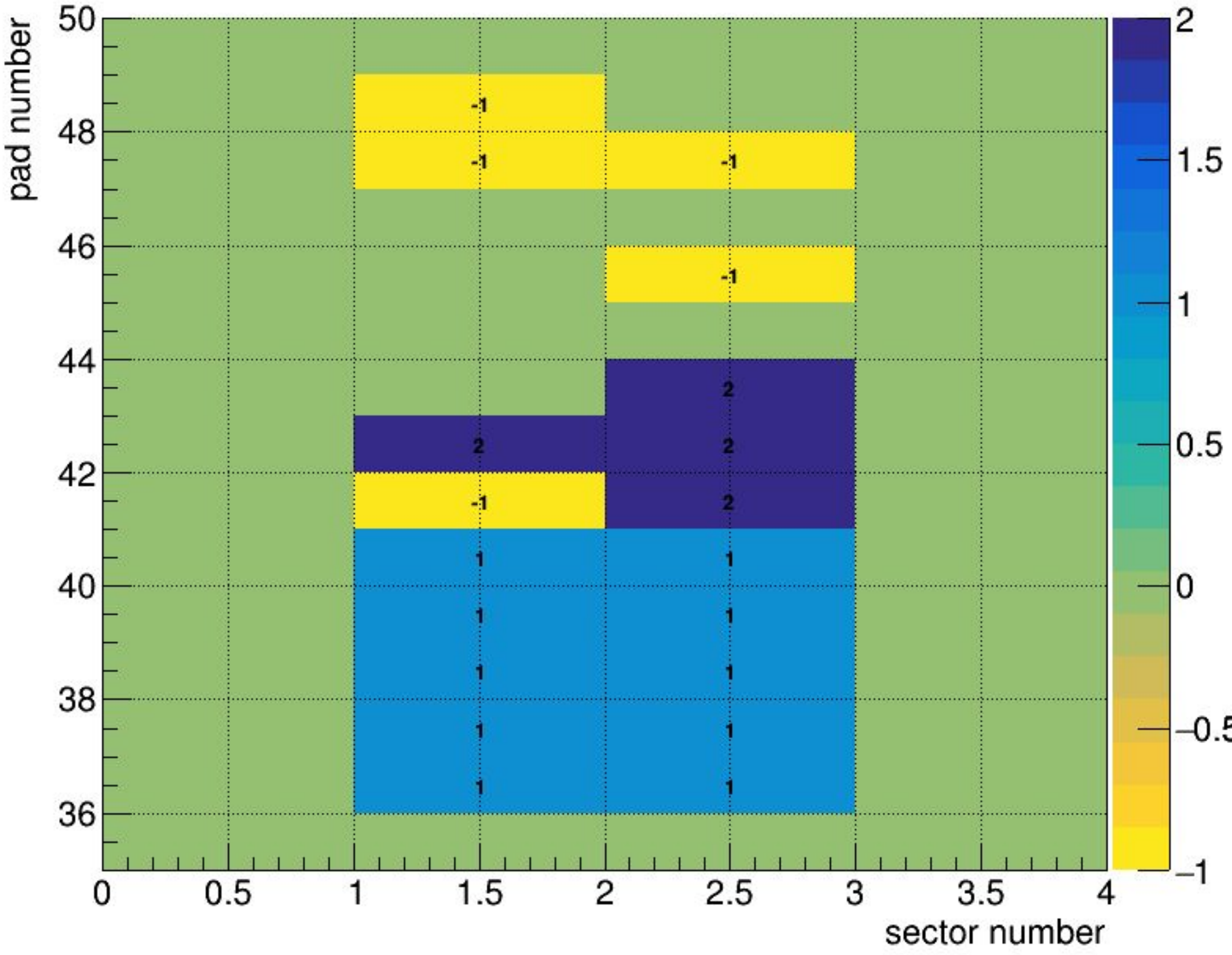
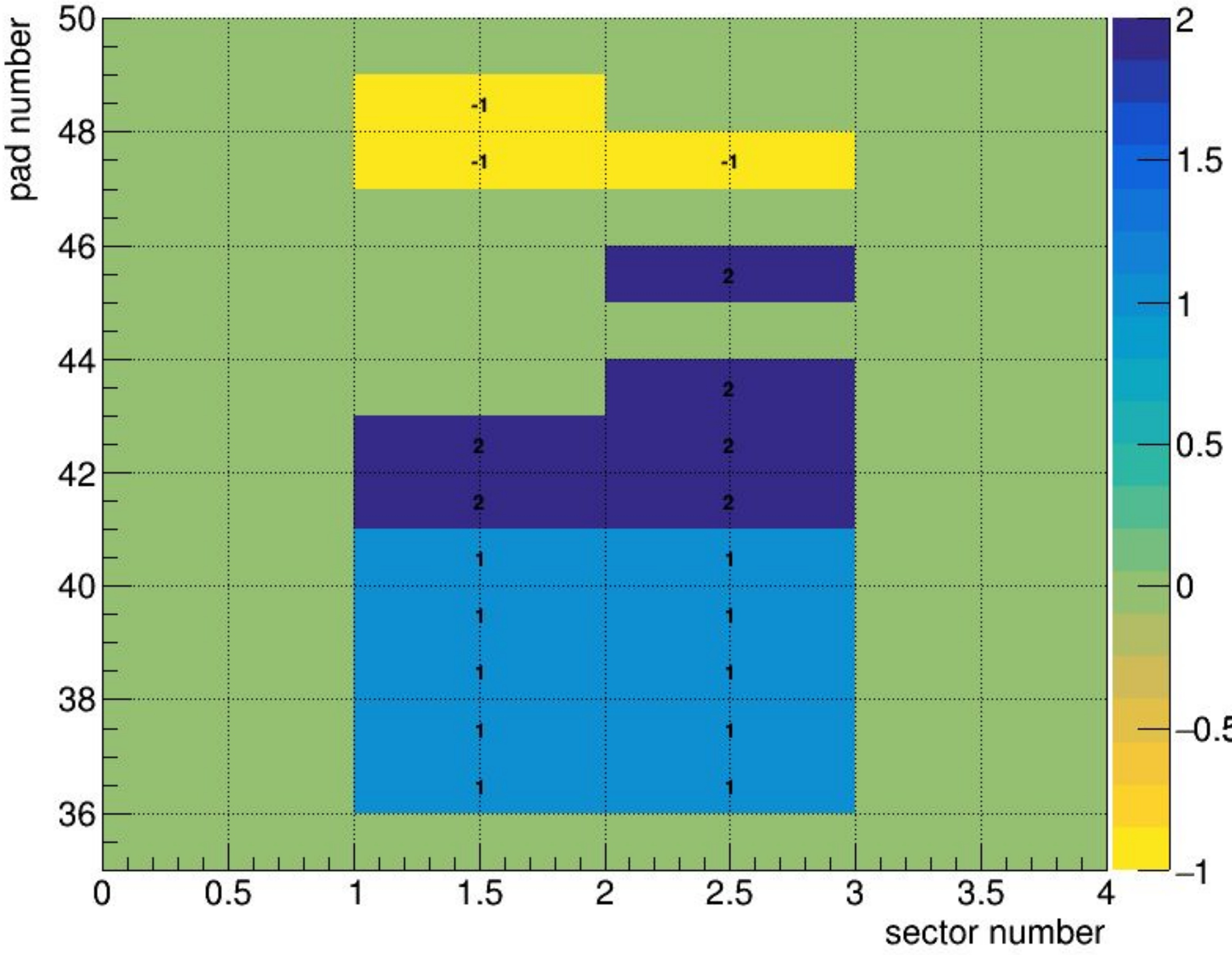


Attach unassigned SEPARATED towers to already assigned towers.

3. Increase distance to accept tower as neighbor "+1" and repeat (3).

4. Repeat (4) till all towers will attach to some clusters.



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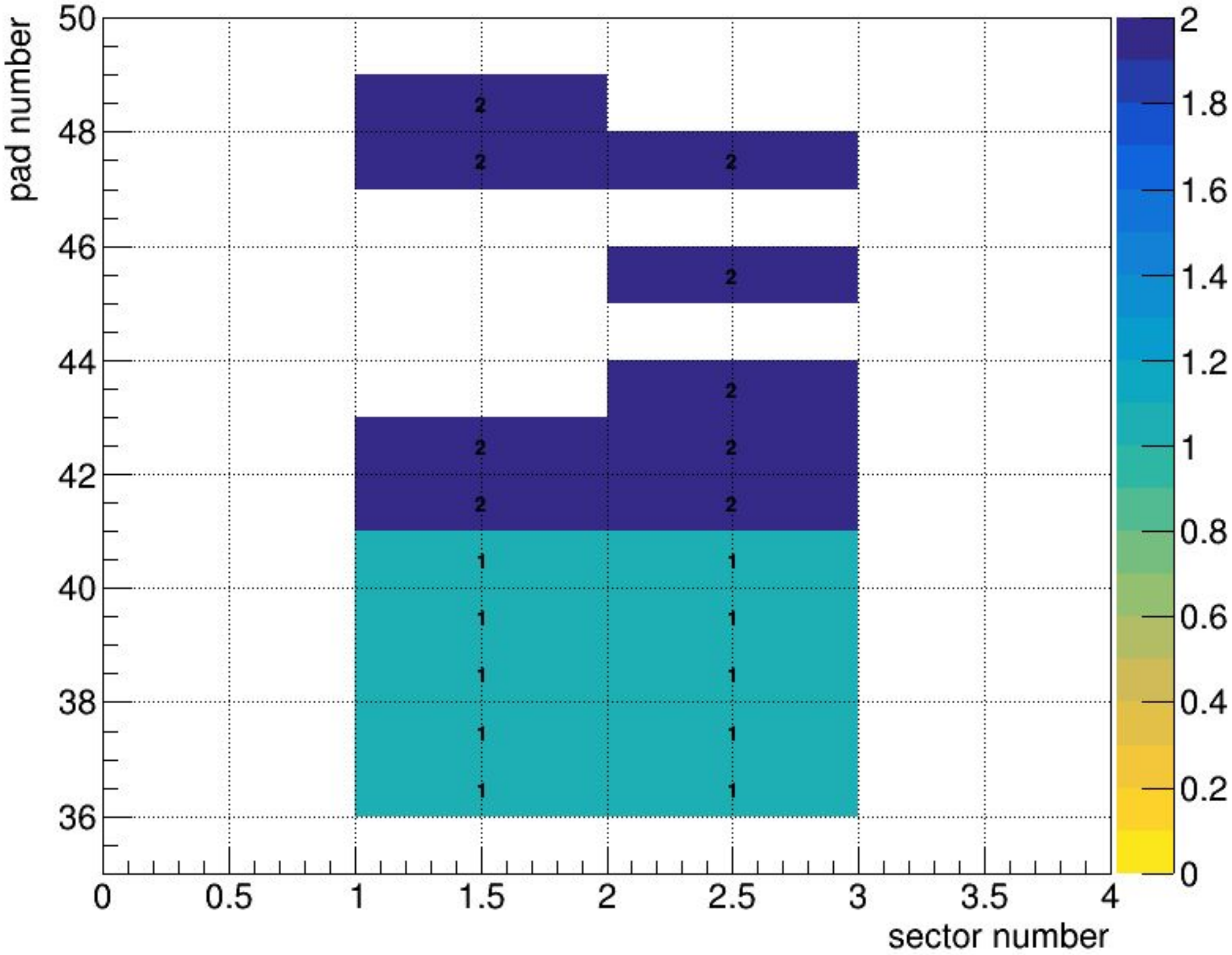
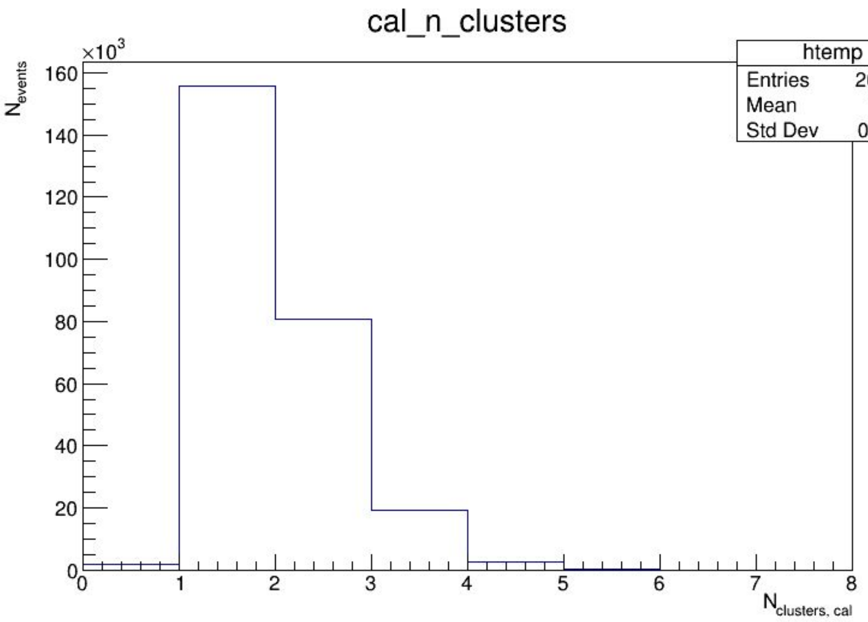
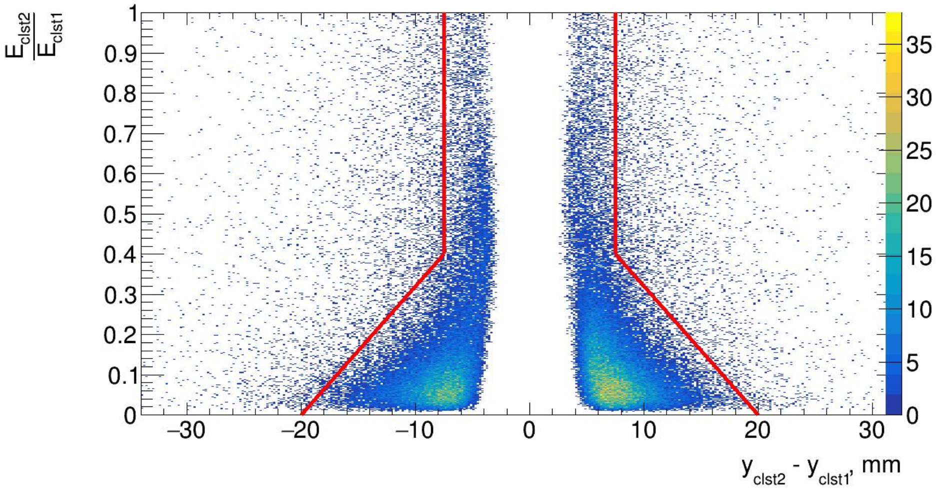


Merging



cal_n_clusters
htemp
Entries 260221
Mean 1.487
Std Dev 0.7013
N_{events}
$\times 10^3$
$N_{clusters, cal}$



$\frac{E_{clst2}}{E_{clst1}}$
y_{clst2} - y_{clst1}, mm

pID algorithm

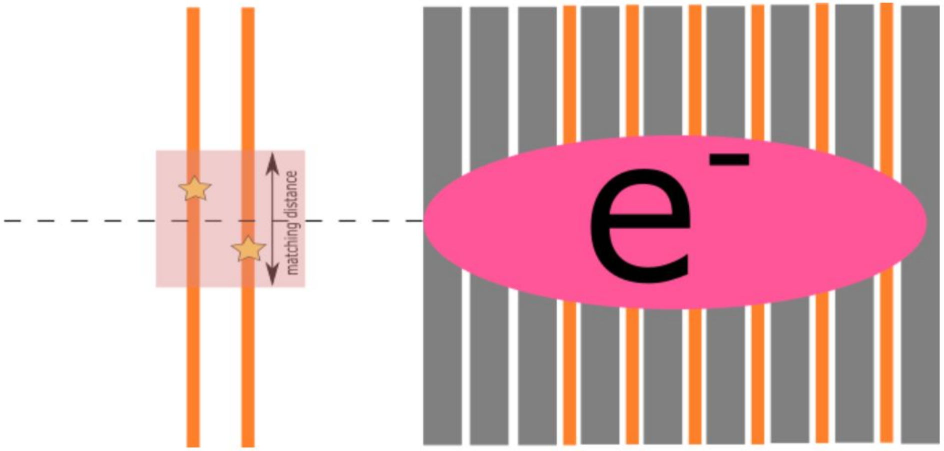


Figure 1: Example of identified electron.

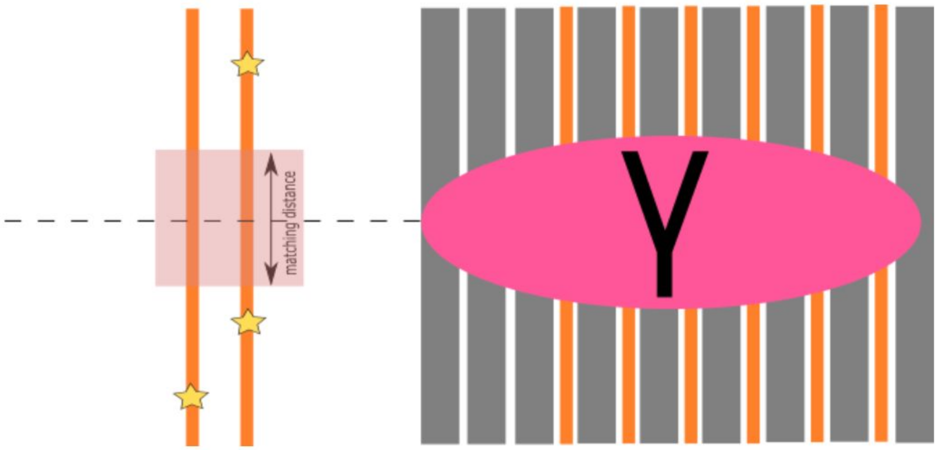


Figure 2: Example of identified photon.

BS effect on pID: Larger statistics + excluded PS

Before:

	Number of events
Total MC generated	400 000
Have clear separate 2 clusters	55 935
+ without PS	51 166
+ without BS	49 346
Total BS events	1820

Now:

	Number of events
Total MC generated	19 600 000
Have clear separate 2 clusters	2 751 040
+ without PS	2 515 161
+ without BS	2 424 860
Total BS events	92 301

Clear separate 2 clusters means:
Most energetic cluster at: 27.8< pad <38.9 (bent electron)
2nd most energetic cluster at: 43.4< pad <54.4 (photon)

BS effect on identification: Uncertainties of Eff/Put

Before: Poisson

$$\delta\epsilon = \frac{k}{N}\sqrt{\frac{1}{k} + \frac{1}{N}}$$

Now: Binomial

$$\delta\epsilon = \frac{k}{N}\sqrt{\frac{1}{k} - \frac{1}{N}}$$

BS effect on identification: Uncertainties of the diff

Before: assumed uncorrelated

$$\sigma_{x-y} = \sqrt{\sigma_x^2 + \sigma_y^2}$$

Now: if correlated

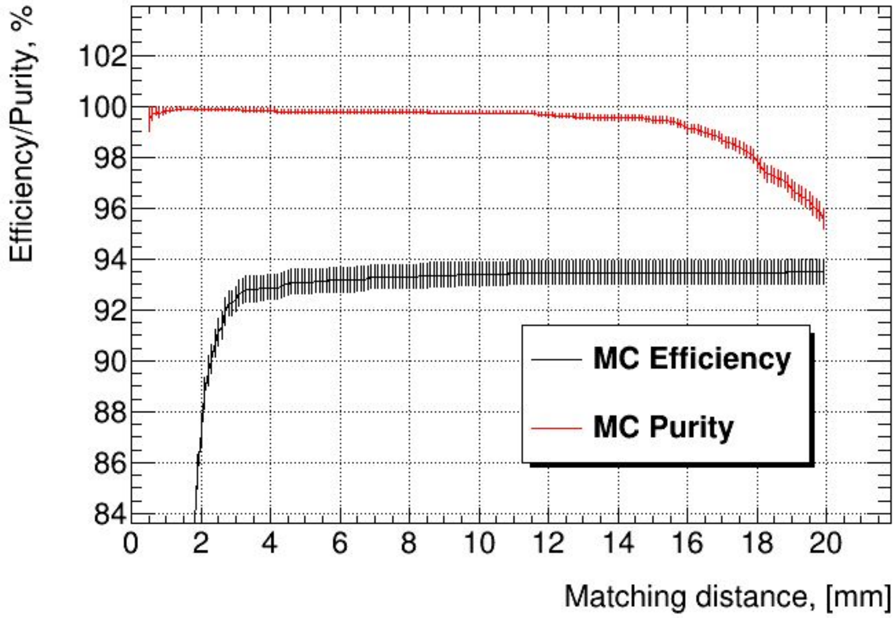
$$\sigma_{x-y} = \sqrt{\sigma_x^2 + \sigma_y^2 (1 - \frac{2N_y}{N_x})}$$

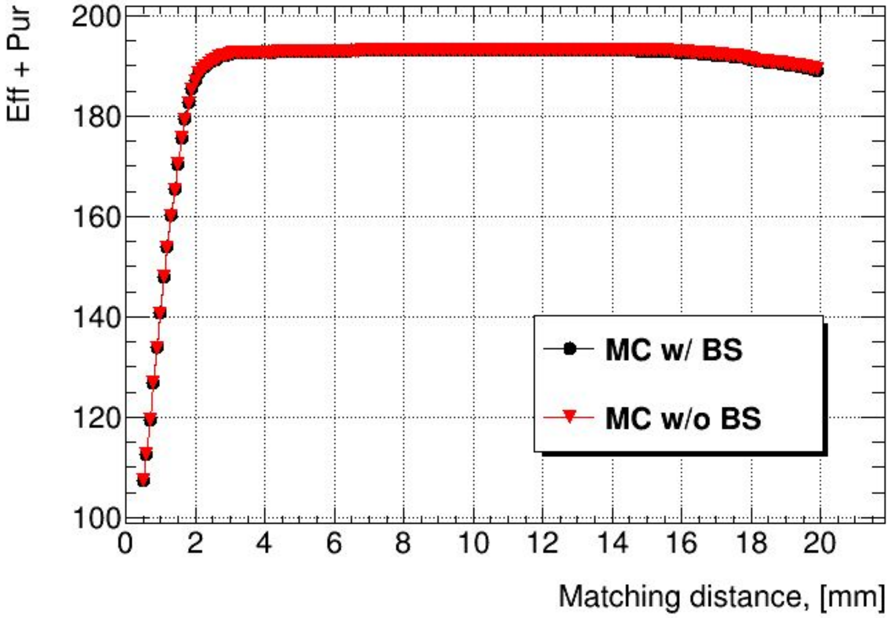
x - Total MC; y - w/o BS

BS effect on **electron** identification:

Electron identification	Efficiency, %	Purity, %	optimal matching distance
MC w/ BS	90.966 ± 0.018	99.803 ± 0.003	3 mm
MC w/o BS	90.941 ± 0.018	99.813 ± 0.003	3 mm
BS effect (difference)	0.025 ± 0.018	-0.01 ± 0.003	

Electron efficiency and purity plots and their sum

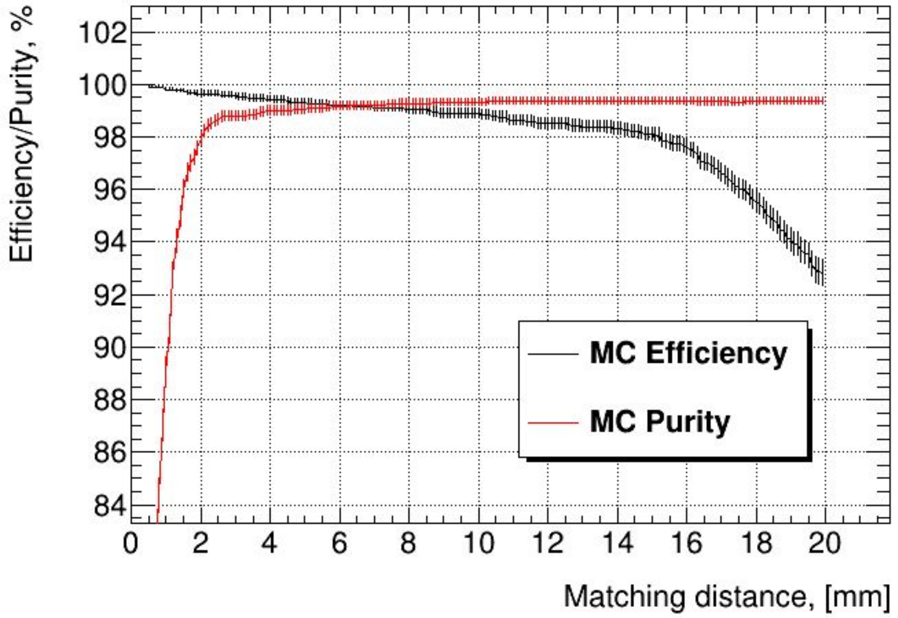


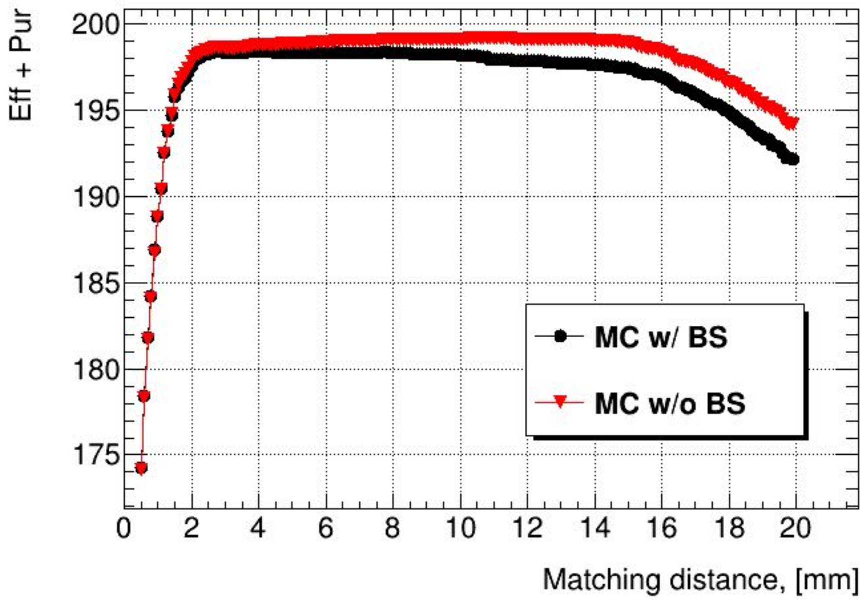


BS effect on **photon** identification:

Photon identification	Efficiency, %	Purity, %	optimal matching distance
MC w/ BS	99.571 ± 0.004	98.228 ± 0.008	2.5 mm
MC w/o BS	99.820 ± 0.003	98.226 ± 0.008	2.5 mm
BS effect (difference)	-0.249 ± 0.004	0.002 ± 0.008	

Photon efficiency and purity plots and their sum





Take into mind:

- Different clustering algorithm → another result
- Different pID algorithm → another result
- >2 showers cases are not studied
- Overlapping showers are not studied

Summary

- Back scattering affects photon identification efficiency for 0.25 % at 2.5 mm matching distance

Derivation of Poisson formula:

$$\Delta k = \sqrt{k}$$

$$\Delta N = \sqrt{N}$$

$$\Delta \epsilon = \Delta(\frac{k}{N}) = \sqrt{(\frac{\partial \epsilon}{\partial k}\Delta k)^2 + (\frac{\partial \epsilon}{\partial N}\Delta N)^2} =$$

$$= \sqrt{(\frac{1}{N}\Delta k)^2 + (\frac{k}{N^2}\Delta N)^2} =$$

$$= \sqrt{\frac{k}{N^2} + \frac{k^2}{N^3}} = \frac{k}{N}\sqrt{\frac{1}{k} + \frac{1}{N}}$$

Derivation of Binomial formula:

Assume that k events passing the cut distributed Binomially: Bin(∈, N);
∈ - true efficiency, as we don't know it, we put our estimate into formula.

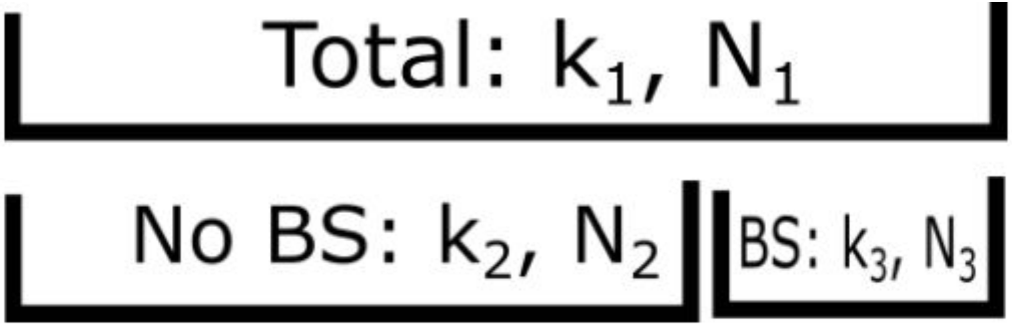
$$\Delta k = \sqrt{Var(k)} = \sqrt{\epsilon(1-\epsilon)N}, \text{(aka: npq)}$$

$$\epsilon = \frac{k}{N}$$

$$\Delta\epsilon = \Delta\left(\frac{k}{N}\right) = \frac{\Delta k}{N} = \frac{1}{N}\sqrt{\epsilon(1-\epsilon)N} =$$

$$= \frac{1}{N}\sqrt{\frac{k}{N}\left(1-\frac{k}{N}\right)N} = \frac{k}{N}\sqrt{\frac{1}{k}-\frac{1}{N}}$$

Derivation of correlation formula:



$$Cov(k_1, k_2) = Cov(k_2 + k_3, k_2) = Cov(k_2, k_2) + Cov(k_3, k_2) = Var(k_2) + 0 = Var(k_2) \quad (4)$$

$$Var(\epsilon_1 - \epsilon_2) = Var(\frac{k_1}{N_1} - \frac{k_2}{N_2}) \quad (5)$$

$$= Var(\epsilon_1) + Var(\epsilon_2) - \frac{2}{N_1 N_2} \cdot Cov(k_1, k_2) \quad (6)$$

$$= Var(\epsilon_1) + Var(\epsilon_2) - \frac{2}{N_1 N_2} \cdot Var(k_2) \quad (7)$$

$$= Var(\epsilon_1) + Var(\epsilon_2)(1 - \frac{2N_2}{N_1}) \quad (8)$$

Therefore:

$$\sigma_{1-2} = \sqrt{\sigma_1^2 + \sigma_2^2 \cdot (1 - \frac{2N_2}{N_1})} \quad (9)$$