

Timing calibration using single pion events

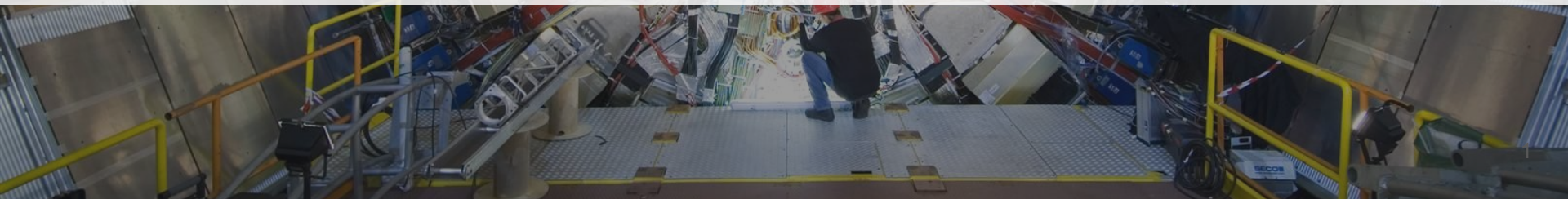
- *Intermediate stage slides*

2023, October 26

<https://indico.slac.stanford.edu/event/8516/>



Kim Doyeong 김도영



Overlapped cells within an event

We coincidentally found that there could be overlapped cells within an event

0	cellE = 1.0374	cellTime =	2.3166
1	cellE = 0.36766	cellTime =	1.9161
2	cellE = 0.3251	cellTime =	-0.24404
3	cellE = 0.25441	cellTime =	-0.64209
4	cellE = 0.22627	cellTime =	3.5027
5	cellE = 0.2012	cellTime =	-3.9121
6	cellE = 0.16394	cellTime =	12.035
7	cellE = 0.16394	cellTime =	12.035
8	cellE = 0.12405	cellTime =	9.5905
9	cellE = 0.10802	cellTime =	-1.4767

- Indeed, there are identical cells in pi0 samples
 - which is reasonable due to poor separation bwt two photons in the $\pi^0 \rightarrow \gamma\gamma$
- However, overlapped cells in an event are always clustered into two different clusters
- One of the examples (event number = 1029943) are shown in the next three slides
 - ROOT interactive mode print out to see overlapped cells in the event
 - Cells with non-zero cell time in the η - φ plane only with cluster #0
 - Cells with non-zero cell time in the η - φ plane only with cluster #1
- Confirmed in the topo-cluster algorithm paper
 - Overlapped cells are allowed within the first and the second energetic clusters and their energy is weighted to calculate the energy of two clusters

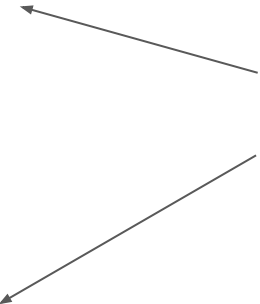
```
root [2] CellTree->Scan("eventNumber:cellTime:cellE:truthPt:nCluster:clusterIndex", "eventNumber==1029943&&cellTime!=0")
```

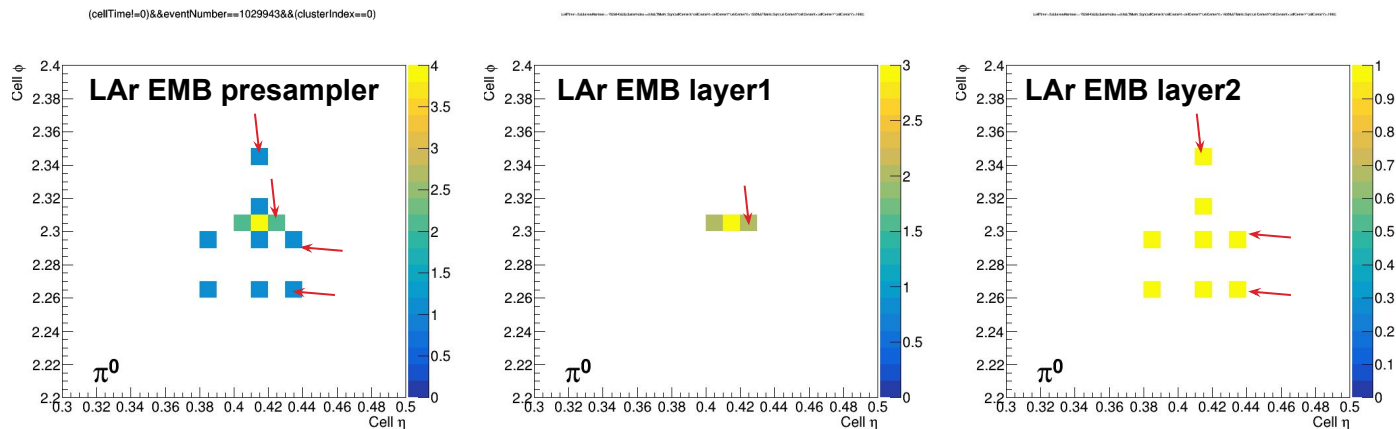
```
*****
*   Row   * eventNumb *   cellTime *     cellE *   truthPt *   nCluster * clusterIn *
*****
* 15444006 * 1029943 * -0.051002 * 4.4773607 * 18.928133 *      2 *      0 *
* 15444007 * 1029943 * 0.1209749 * 1.1254522 * 18.928133 *      2 *      0 *
* 15444008 * 1029943 * 0.3460252 * 0.3676609 * 18.928133 *      2 *      0 *
* 15444009 * 1029943 * 0.0330029 * 0.2203069 * 18.928133 *      2 *      0 *
* 15444010 * 1029943 * 0.1290044 * 0.1841076 * 18.928133 *      2 *      0 *
* 15444013 * 1029943 * -0.191986 * 0.1002538 * 18.928133 *      2 *      0 *
* 15444014 * 1029943 * 0.1199941 * 0.2232729 * 18.928133 *      2 *      0 *
* 15444015 * 1029943 * 0.0620064 * 0.6248078 * 18.928133 *      2 *      0 *
* 15444016 * 1029943 * 0.0089996 * 2.1793856 * 18.928133 *      2 *      0 *
* 15444017 * 1029943 * -0.004999 * 0.7265049 * 18.928133 *      2 *      0 *
* 15444018 * 1029943 * -0.017003 * 0.3989754 * 18.928133 *      2 *      0 *
* 15444044 * 1029943 * -0.083012 * 1.1080262 * 18.928133 *      2 *      0 *
* 15444045 * 1029943 * 0.2029828 * 1.0263322 * 18.928133 *      2 *      0 *
* 15444046 * 1029943 * -0.021996 * 0.7027812 * 18.928133 *      2 *      0 *
* 15444048 * 1029943 * -0.215992 * 0.3212919 * 18.928133 *      2 *      0 *
* 15444049 * 1029943 * 0.0599943 * 0.1893969 * 18.928133 *      2 *      0 *
* 15444054 * 1029943 * 0.0129976 * 1.6982902 * 18.928133 *      2 *      1 *
* 15444056 * 1029943 * -0.020000 * 1.0290801 * 18.928133 *      2 *      1 *
* 15444060 * 1029943 * 0.1030200 * 0.3845300 * 18.928133 *      2 *      1 *
* 15444061 * 1029943 * -0.148977 * 0.2721398 * 18.928133 *      2 *      1 *
* 15444062 * 1029943 * 0.0370025 * 0.4063319 * 18.928133 *      2 *      1 *
* 15444065 * 1029943 * 0.0019996 * 0.2039948 * 18.928133 *      2 *      1 *
* 15444066 * 1029943 * -0.153974 * 0.1379622 * 18.928133 *      2 *      1 *
* 15444086 * 1029943 * -0.083012 * 1.1080262 * 18.928133 *      2 *      1 *
* 15444087 * 1029943 * 0.2029828 * 1.0263322 * 18.928133 *      2 *      1 *
Type <CR> to continue or q to quit ==>
* 15444088 * 1029943 * -0.021996 * 0.7027812 * 18.928133 *      2 *      1 *
* 15444090 * 1029943 * -0.215992 * 0.3212919 * 18.928133 *      2 *      1 *
* 15444091 * 1029943 * 0.0599943 * 0.1893969 * 18.928133 *      2 *      1 *
*****
```

```
==> 28 selected entries
```

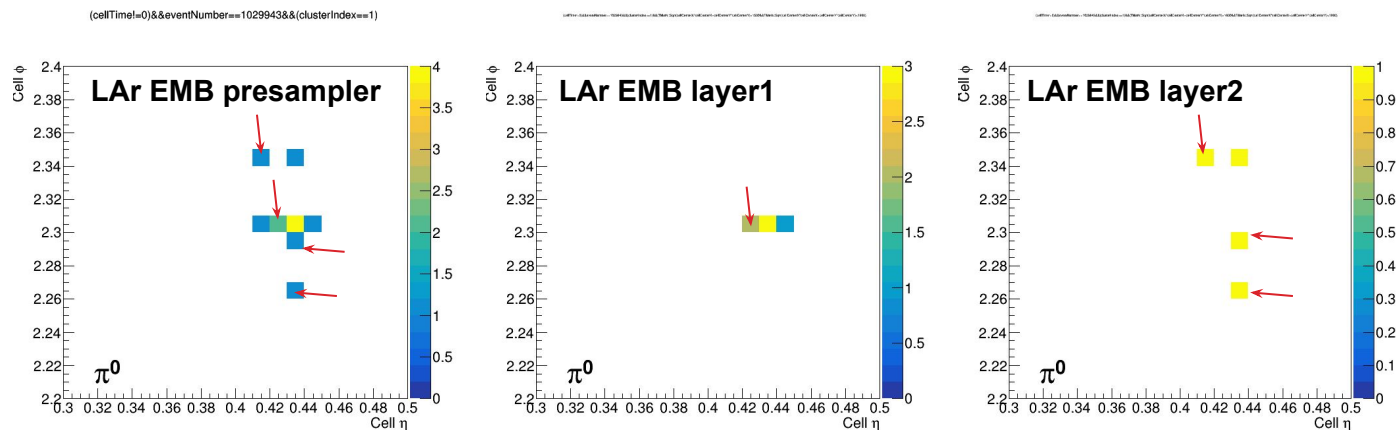
```
(long long) 28
```

The same cells clustered in
two different clusters





- Cells with non-zero cell time in the η - ϕ plane only with cluster #0
- No other selections are applied
- Red arrows indicate the overlapped cells



- Cells with non-zero cell time in the η - ϕ plane only with cluster #1
- No other selections are applied
- Red arrows indicate the overlapped cells

The cluster splitting algorithm can find cells which are neighbours to two or more signal maxima. In this case, the cell is assigned to the two highest-energy clusters after splitting of the original topo-cluster it is associated with. This means that each cell is only shared once at most, and, even then, is never shared between more than two clusters.

The sharing of its signal between the two clusters with respective energies $E_{\text{clus},1}^{\text{EM}}$ and $E_{\text{clus},2}^{\text{EM}}$ is expressed in terms of two geometrical weights $w_{\text{cell},1}^{\text{geo}}$ and $w_{\text{cell},2}^{\text{geo}}$. These weights are calculated from the distances of the cell to the centre of gravity of the two clusters (d_1, d_2), measured in units of a typical electromagnetic shower size scale in the ATLAS calorimeters,⁶ and the cluster energies,

$$w_{\text{cell},1}^{\text{geo}} = \frac{E_{\text{clus},1}^{\text{EM}}}{E_{\text{clus},1}^{\text{EM}} + r E_{\text{clus},2}^{\text{EM}}} , \quad (6)$$

$$w_{\text{cell},2}^{\text{geo}} = 1 - w_{\text{cell},1}^{\text{geo}} , \quad (7)$$

$$r = \exp(d_1 - d_2) . \quad (8)$$

<https://arxiv.org/pdf/1603.02934.pdf>
page.18

Correlation btw cell time in a single pion

Baseline selection

- $1 \text{ GeV} < \text{Truth pion } pT < 20 \text{ GeV}$
- Only non-zero cell time cells
- LAr EM Barrel ($|\eta| < 0.8$)
- Only layer2(where most of the energy is deposited) is considered
- After the above selection #cell in the first cluster(cluster 0) of a pion ≥ 9
- At least one cell in a pion has reco cell E $> 1 \text{ GeV}$

The correlation coefficients btw 1st to 9th energetic cells in each pion are plotted
 Three are a weak correlation btw a few energetic cells

