PDE Analysis of Container System Using Drawer "Self-calibration" Method

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PDE evaluation method

Based on our PMT testing equiptments, the traditional PDE of one PMT can be calculated from container's result:

$$PDE = {\color{red}PDE_c} \cdot f_{cs} + constant \tag{1}$$

where PDE_c is the internal PDE result from container, f_{cs} is PDE transform coefficient between Container and Scanning station[1].

The factor f_{cs} can be obtained by fitting the PDE results from both system, hence this factor will be more precise as we test more tubes[2].

[1]we believe that PDE from container and scanning station are linear related.

[2]also the constant

Determination of PDE_c

The parameter PDE_c is container's own PDE result and need to be mapped to a final PDE.

For each drawer in the container, we get PDE_c by:

$$PDE_c = \mu_{test} \cdot drawer_{factor} \tag{2}$$

where μ_{test} is the average photon number measured by one PMT, and drawer$_{factor}$ is the coefficient mapping the μ_{test} to PDE_c.

So the key step to access PDE_c is to calibrate each drawer by measuring the drawer$_{factor}$.

calibration of each drawer

Generally, we put several PMTs with known PDE value[3] into one drawer and linearly fit the PDE-μ_{test} data to get drawer_{factor}.

While an alternative way to access the drawer_{factor} is fitting PDE-μ_{test} data from all the PMTs tested in one drawer rather than the mannual selected ones. Then once we finish one PMT test in a drawer we will get one more statistical sample in the PDE-μ_{test} fitting, and we could expect that the fitted drawer_{factor} will get more stable as we testing more PMTs.

The advantage of this "self-calibration" method is that we could decrease the statistical error as much as possible; and the remained fluctuation of drawer_{factor} can be the system error.

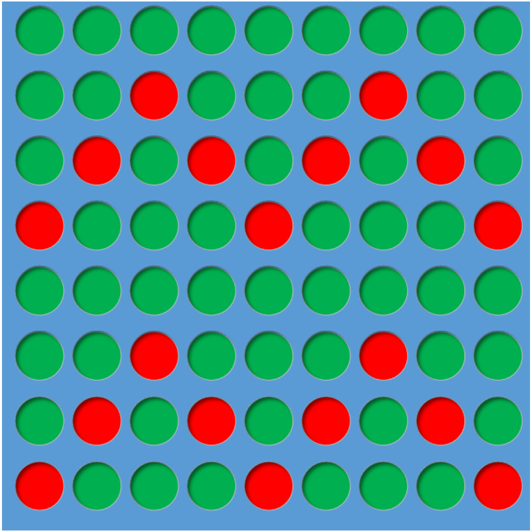
[3] or QE value

how to calibrate

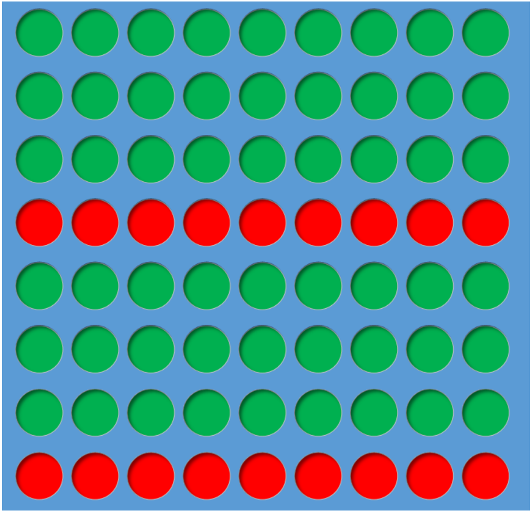
The HAMAMATSU company has provided us with QE value of part of the PMTs, If we suppose the collection efficiency is same for all the HAMAMATSU PMTs we could use these QE values to calibrate drawers in the container.

In order to make sure the PDE-μ_{test} fitting results reasonable, only the PMT pass the test will be used for fitting.

fitting example using 30 tubes



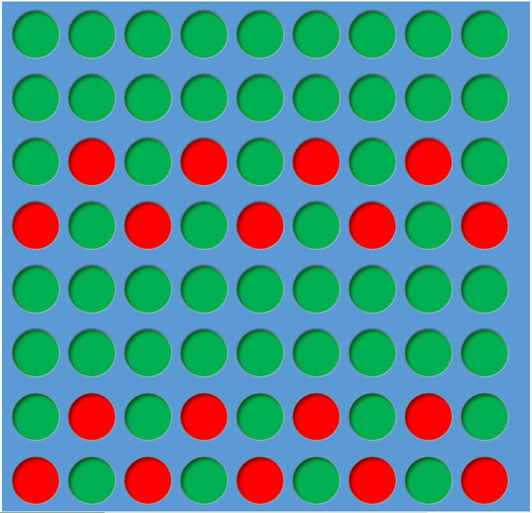
drawer$_{factor}$ vs. PMT number drawer



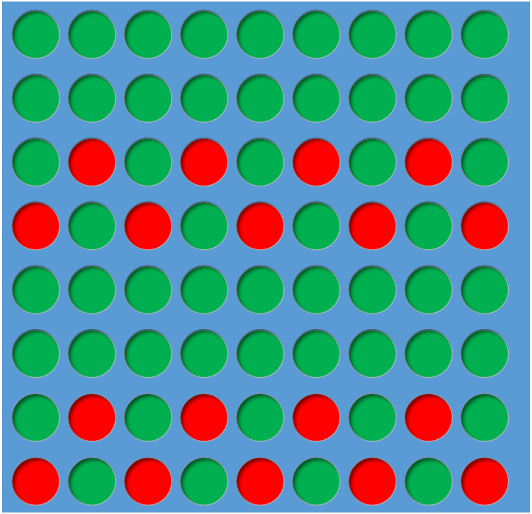
more results can be found in the back-up part.

discuss the results

the relative error $e_r = \frac{f_i - f_r}{f_r}$ of one draw:



discuss the results



This means we need to calibrate each drawer with at least 30 PMTs to

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compare detector performance with the different PMT paterns, especially the time and energy resolution and reconstruction results.

how to:add method to the PMT class then each PMT can get its performance according to the layout pattern and its own ID.

HAMAMATSU PMTs

the PDE uniformity of HAMAMATSU PMTs are not so good

we can artificially correct the PDE if these PMTs have fixed orientation and we can extract the light incident angle using reconstraction information.

Thank You