

New Method to Calibrate Drawers in Container1

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Outline

① Introduction

② new method to calibrate drawers

③ calculation of PDE using this method

④ summary

current PDE evaluation method

Currently, we calculate PDE with the formula:

$$PDE = \textcolor{red}{PDE}_c \cdot f_{cs} + \text{constant} \quad (1)$$

where PDE_c is the internal PDE result of container and f_{cs} is the correlation factor between two testing systems.¹

f_{cs} can be obtained by fitting the PDE results of PMTs which were tested in both systems, and it will more precise as the number of tested PMTs increasing.²

¹We believe the two systems are linear related.

²smaller statistical error

current method to calculate PDE_c

For each drawer, we get PDE_c using

$$PDE_c = \mu_{test} \cdot \text{drawer}_{factor} \quad (2)$$

where μ_{test} is the average photon-electron number detected by one PMT, and the drawer_{factor} linearly mapping the μ_{test} to PDE_c .

So, It is very important to precisely calibrate the drawer_{factor} .

current method to calibrate $drawer_{factor}$

Currently we tested 15 HAMAMATSU PMTs with known vendor QE³ in one drawer and fit the QE- μ_{test} results to calculate $drawer_{factor}$.

Another choice is to calibrate drawers with all the HAMAMATSU PMTs (with vendor QE) tested in that drawer.⁴

The advantage is: systematic error will decrease as we test more PMTs.
The potential risk: we use different PMTs to calibrate different drawers, which may introduce extra uncertainty.

³check the DocDB

file[https://juno.ihep.ac.cn/cgi-bin/Dev_DocDB>ShowDocument?docid=3646]

⁴

how to calibrate

The HAMAMATSU company has provided us with QE⁵ value of part of PMTs, which can be downloaded from the PMTtesting data-base.⁶

So, once a PMT with vendor QE was tested in the drawer, we can use it to calibrate the drawer. Also, only those PMTs passed the test will be selected.

After we have the container internal PDE results, we need to convert them to final PDE results according to equation 1.

⁵suppose all the PMTs have same collection efficiency

⁶wangjun [<http://pmtdb.juno.ihep.ac.cn/index.html>]

calibration result of one drawer

The fitting error will decrease as we test more PMTs, so the drawer factor will be more stable.

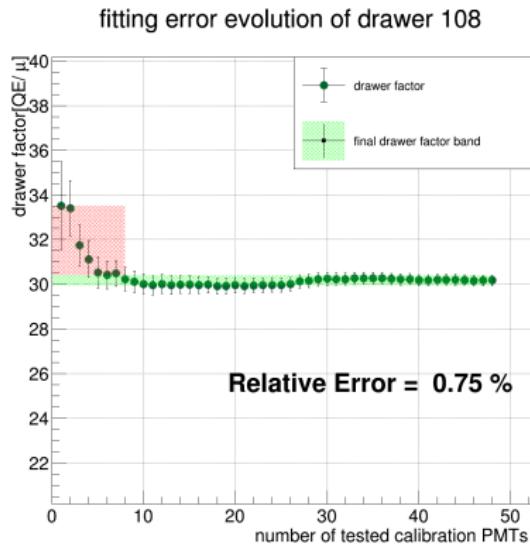
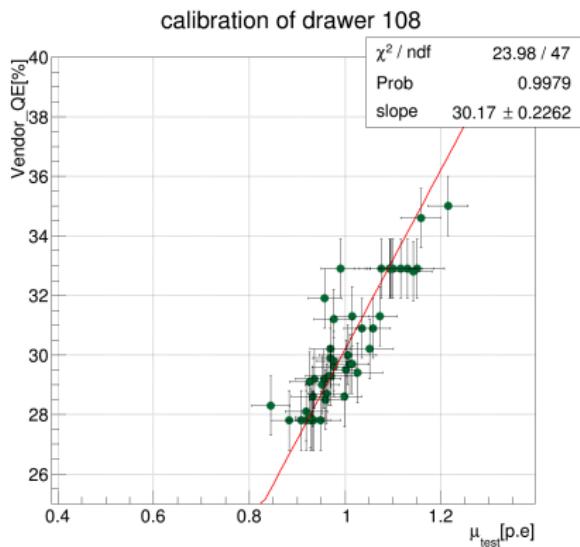
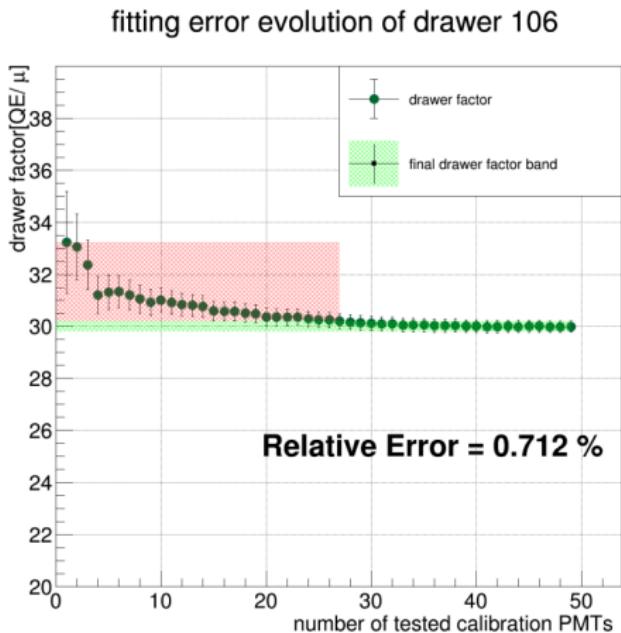


图: drawer 108-drawer_{factor}

the calibration results⁷



The $\text{drawer}_{\text{factor}}$ of some drawer will increase(or decrease) with time slowly(<1%), this indicates that light intensity of LED may drifted with time.

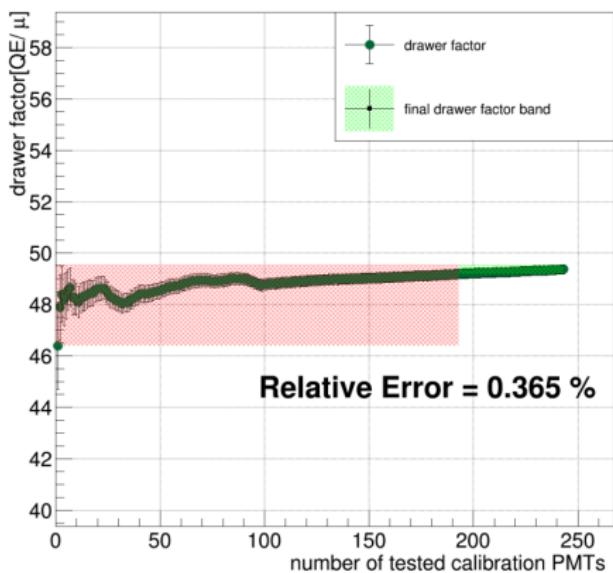
the fitting error of $\text{drawer}_{\text{factor}}$ are smaller than 1%.

This means we can monitor the satblity of drawers using the fitting results.

⁷comparation with onsite results can be found in back-up section.

the reference tube EA0419

fitting error evolution of drawer 101



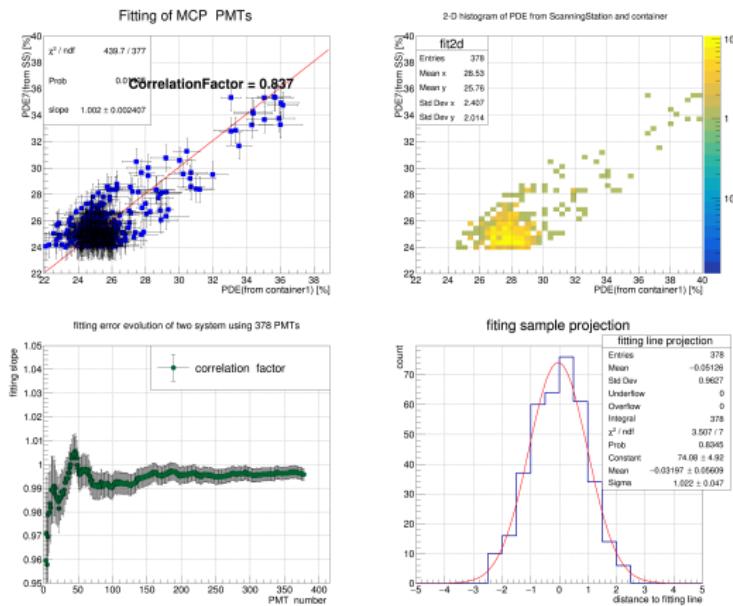
The reference PMT EA0419 was always tested in drawer 101, its fitted $\text{drawer}_{\text{factor}}$ drifts slightly with time:

There are two possible reasons:

- the LED light intensity decrease with time.
- PDE of this PMT decrease with time.

correlation of results from two testing systems

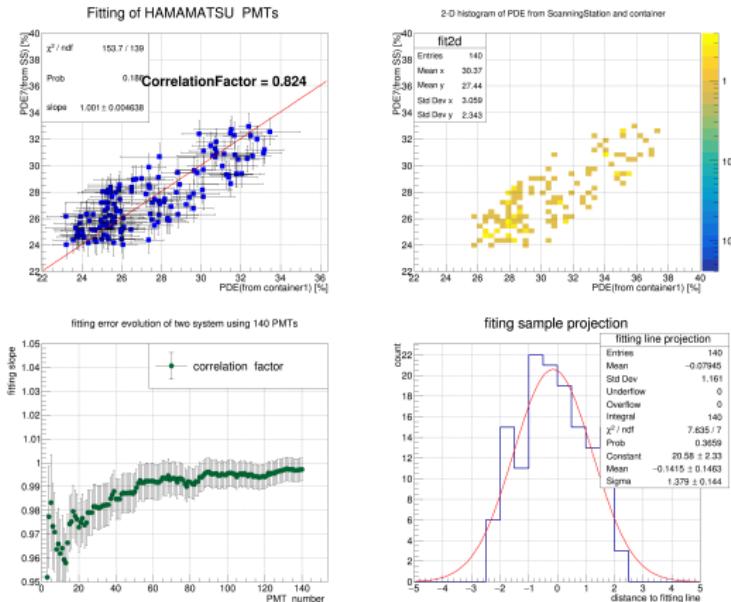
By linearly fitting the PDE_c and PDE_s for all the MCP-PMTs, the f_{cs} can be obtained.⁸



⁸selection criteria: $\Delta PDE < 5$

correlation of results from two testing systems

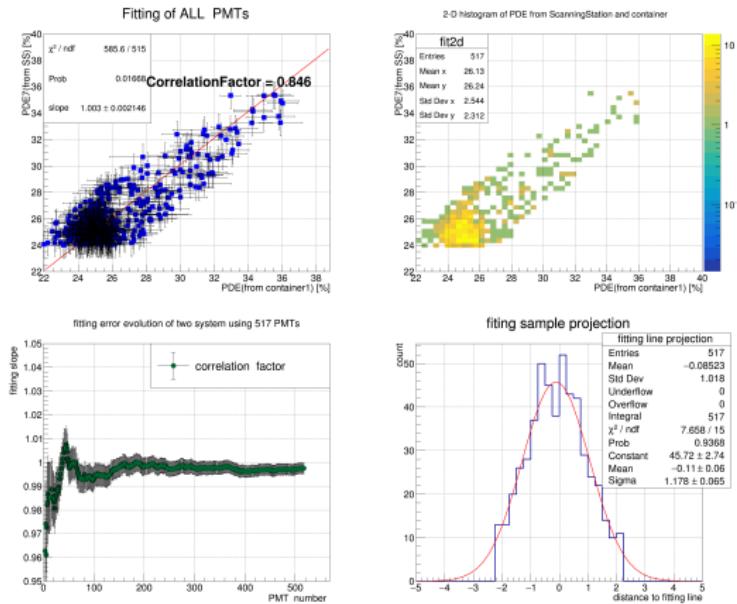
By linearly fitting the PDE_c and PDE_s for all the HAMAMATSU-PMTs, the f_{cs} can be obtained.⁹



⁹selection criteria: $\Delta PDE < 5$

correlation of results from two testing systems

By linearly fitting the PDE_c and PDE_s for all the PMTs, the f_{cs} can be obtained.¹⁰



¹⁰selection criteria: $\Delta PDE < 5$

PDE of PMTs

Once we have μ_{test} and fitted $drawer_{factor}, f_{cs}$ we could get the final PDE of container system:

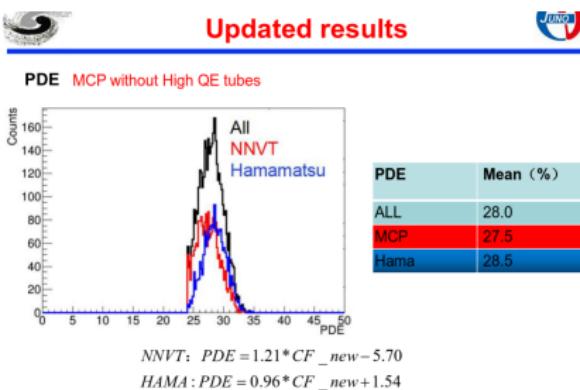
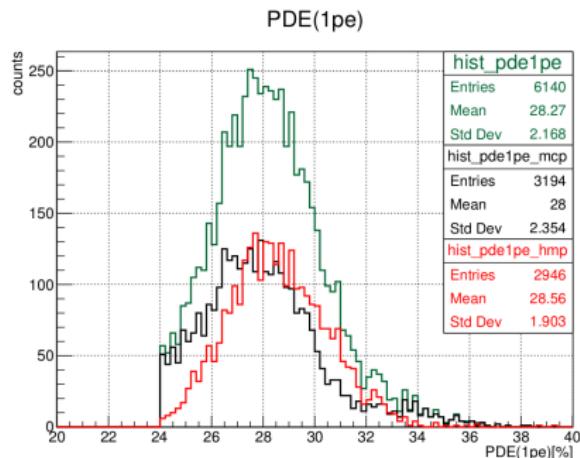


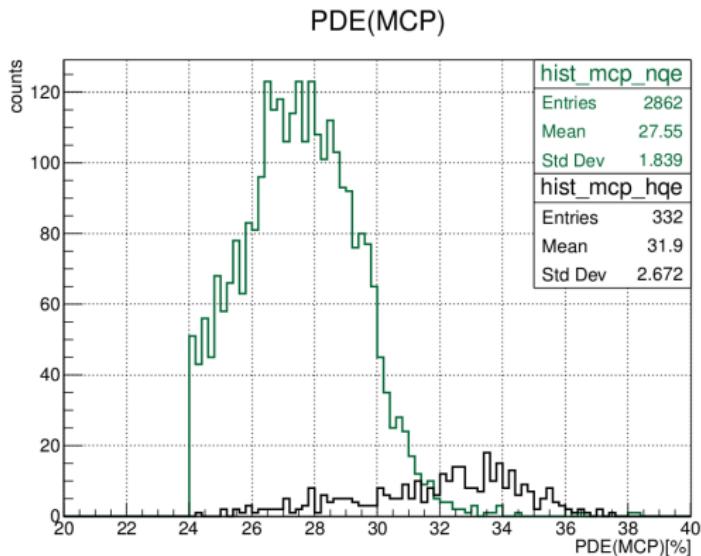
图: left figure shows the PDE results using the new calibration method, right figure shows the onsite PDE results.¹²

¹¹https://juno.ihep.ac.cn/cgi-bin/Dev_DocDB>ShowDocument?docid=3646

¹²https://juno.ihep.ac.cn/cgi-bin/Dev_DocDB>ShowDocument?docid=3646

PDE of MCP-PMTs

The PDE of MCP-PMTs tested in container1 is shown below:¹³:



PDE of High-QE MCP PMTs increase 15.8%(relative) than one ones.

PDE results are consistant with onsite results.

MCP: 27.5↔27.55

HAMAMATSU:28.5↔28.56

¹³updated to 2018-10-17

summary and conclusions

- fitting the $\text{drawer}_{\text{factor}}$ using PMTs tested in this drawer, fitting error <1%.
- this calibration method can decrease the drawer factor fitting error and could be used to monitor the stability of drawers.
- the PDE from this calibration is consistent with onsite results(relative error <1%).
- High-QE version MCP PMTs have relatively 17.78% higher PDE than old ones, the average PDE is about 31.9%¹⁴

¹⁴onsite result is 32.6%

THANKS

BACKUP

check of other parameters

HAMAMATSU-PMT:

parameters(average)	my results	onsite results
dark count rate(kHz)	17.8	16.6
rise time(ns)	7.3	6.9
fall time(ns)	10.36	10.2
peak-valley ratio	3.3	3.9
resolution	0.28	0.277
high voltage(V)	1861	1858
signal FWHM(ns)	9.08	11.6

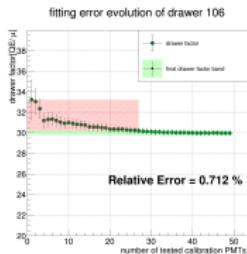
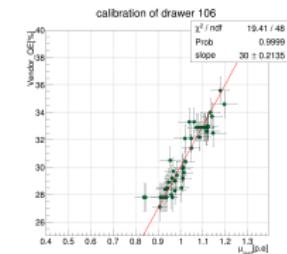
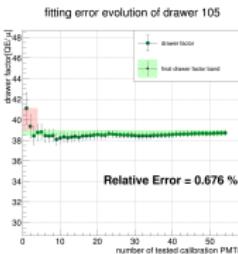
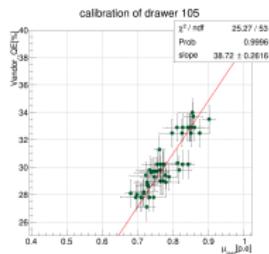
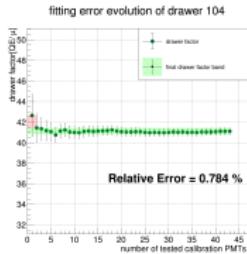
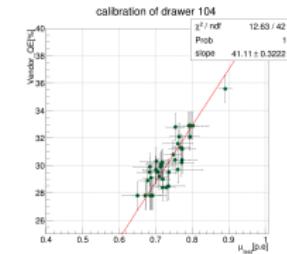
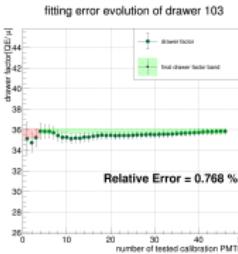
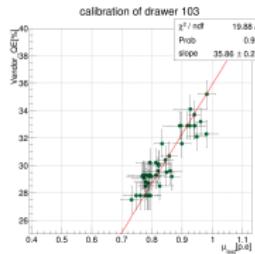
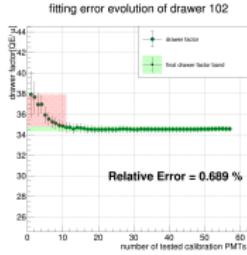
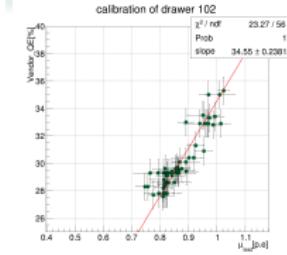
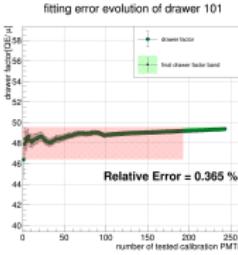
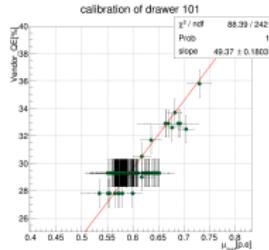
check of other parameters

MCP-PMT:

parameters(average)	my results	onsite results
dark count rate(kHz)	41.4	44.3
rise time(ns)	3.2	4.6
fall time(ns)	15.9	16.2
peak-valley ratio	3.19	4.4
resolution	0.35	0.32
high voltage(V)	1783	1784
signal FWHM(ns)	5.8	7.7

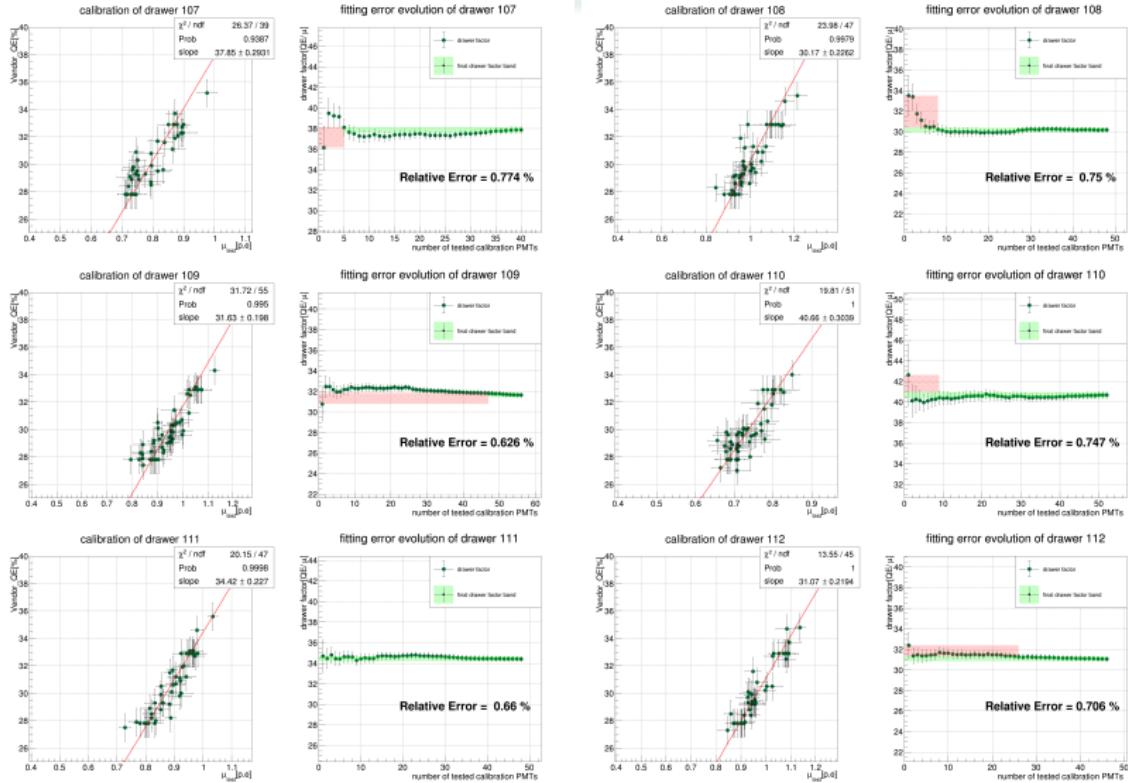


drawer-calibration



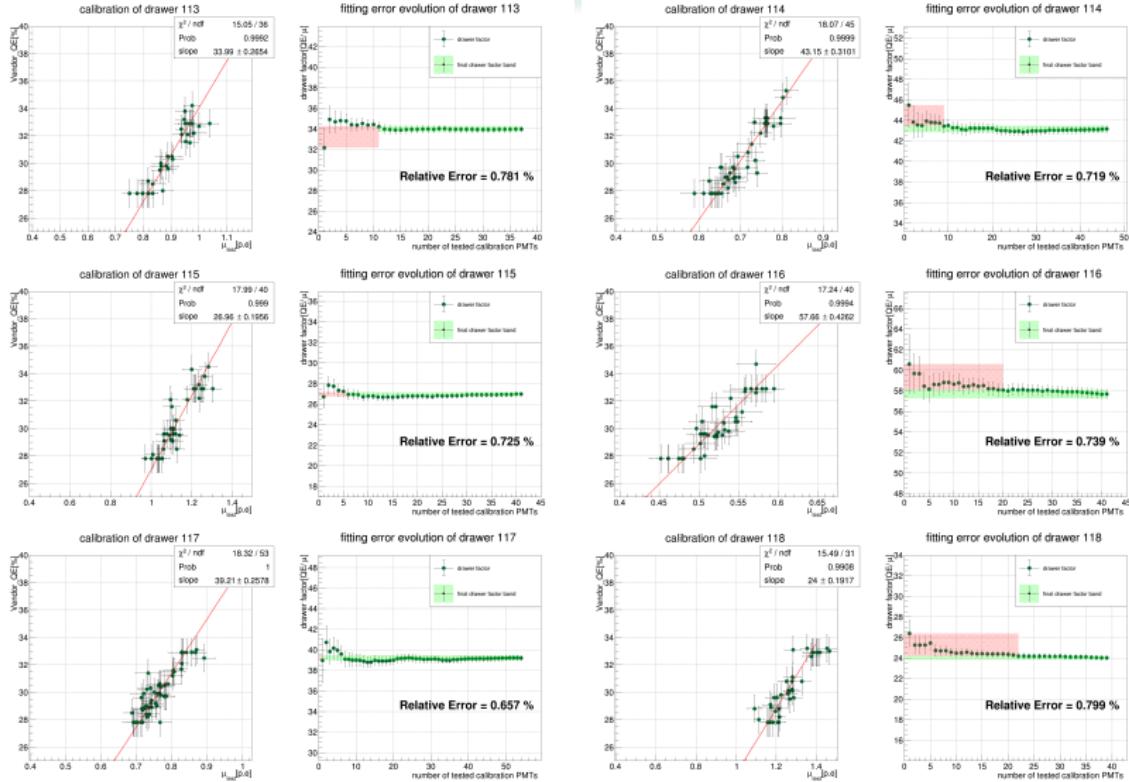


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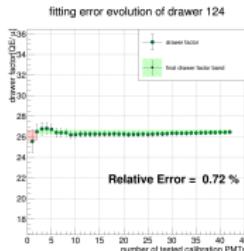
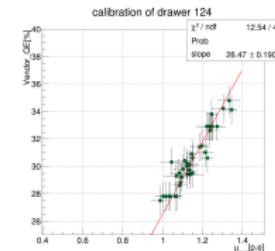
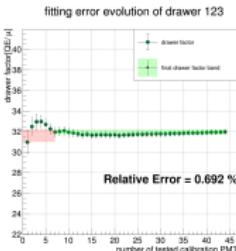
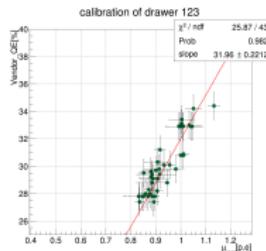
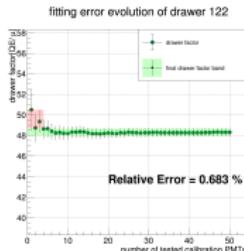
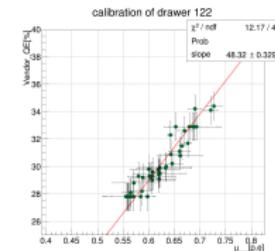
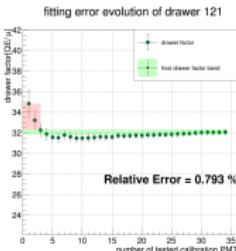
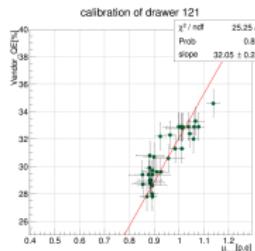
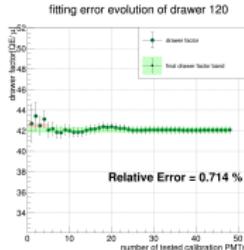
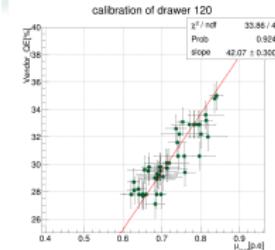
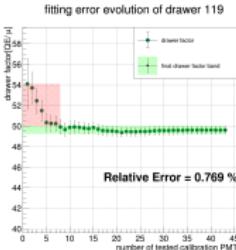
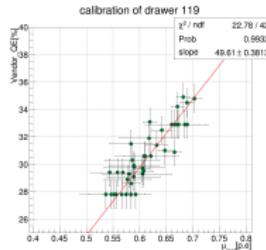




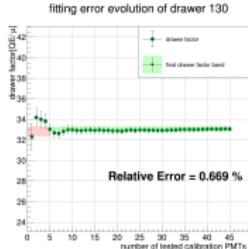
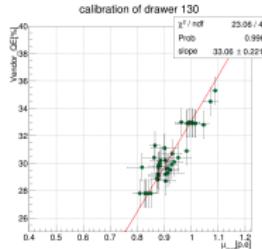
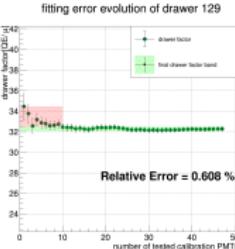
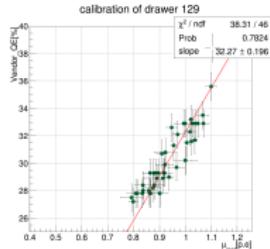
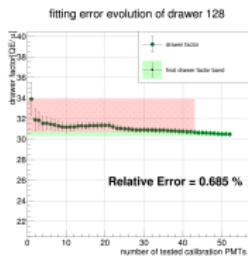
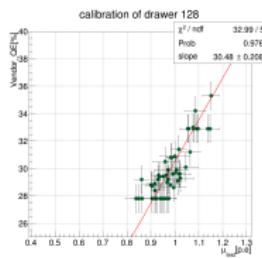
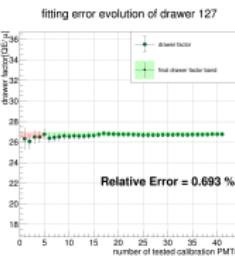
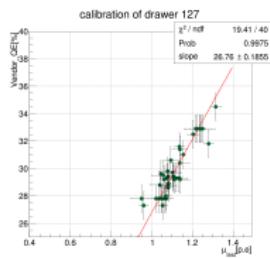
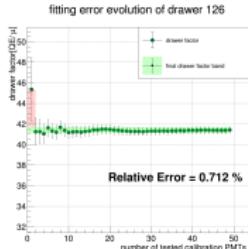
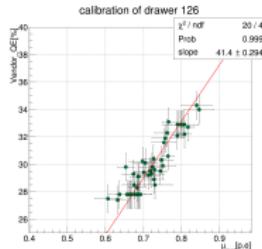
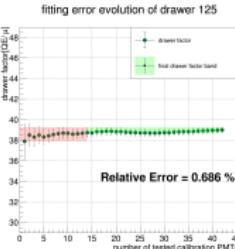
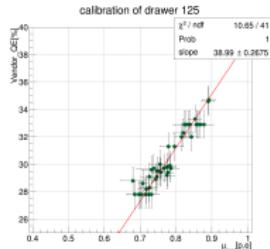
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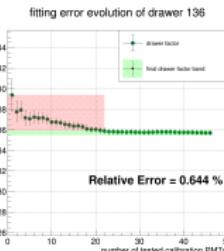
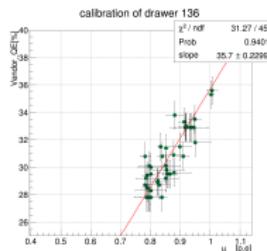
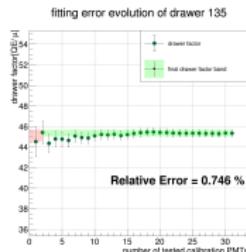
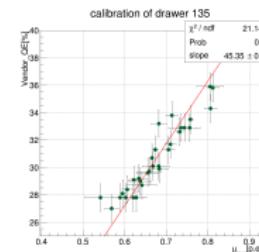
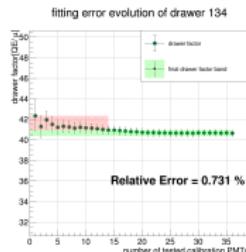
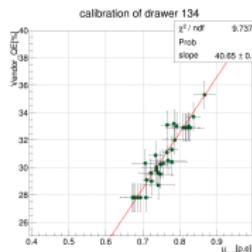
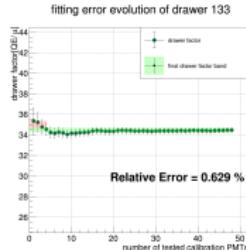
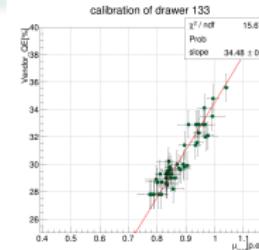
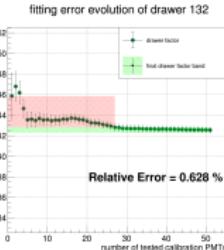
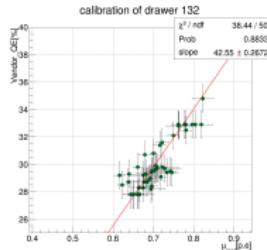
drawer-calibration



drawer-calibration

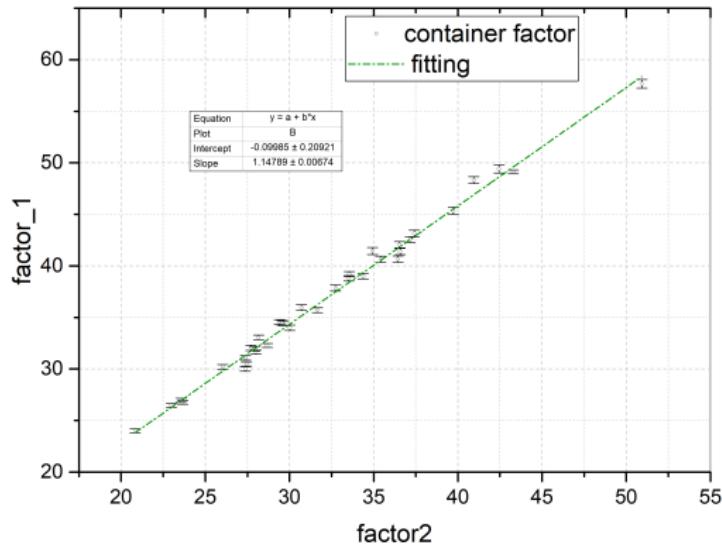


drawer-calibration



comparasion of drawer factor

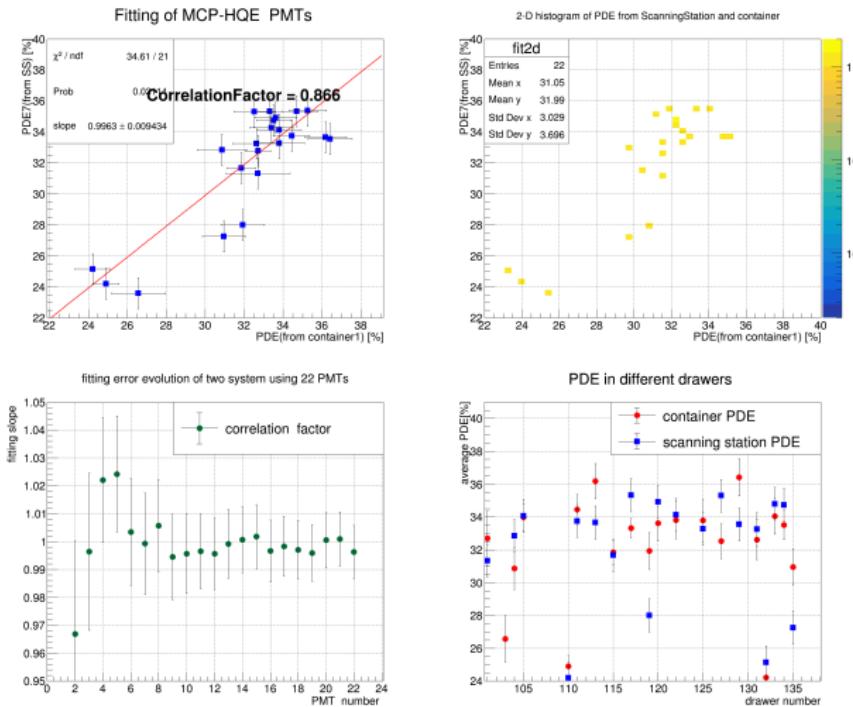
factor_1 is my result, factor_2 is onsite result¹⁵.



¹⁵ $y = 1.148x + 0.998$

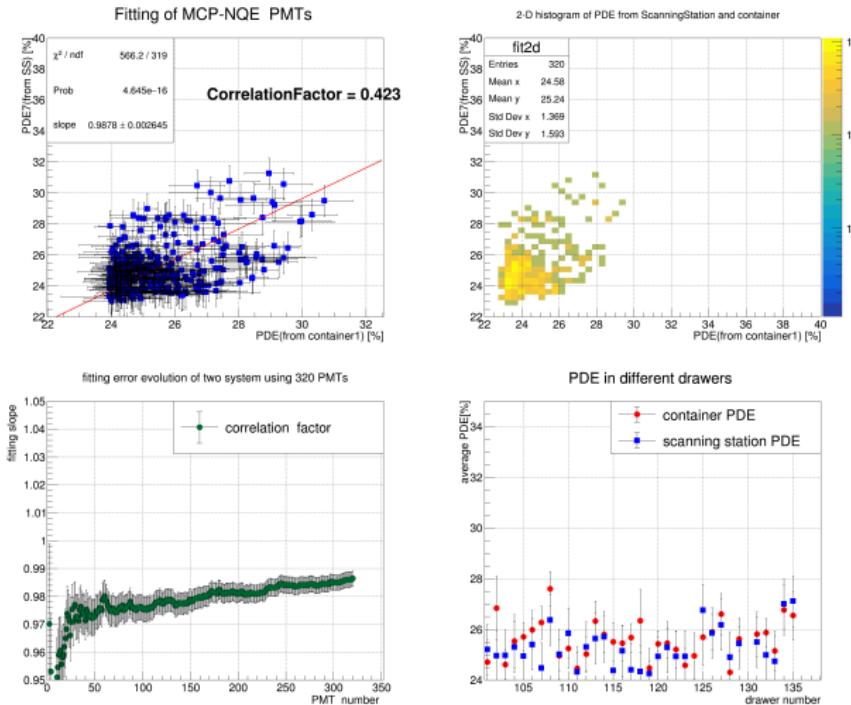
correlation of results from two system

fitting PDE_c and PDE_s for high-QE MCP PMTs.

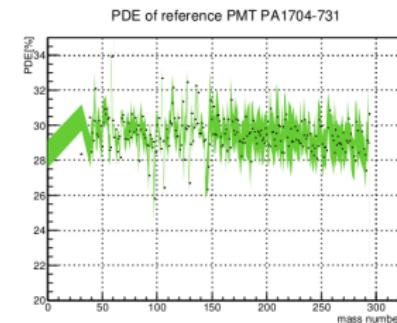
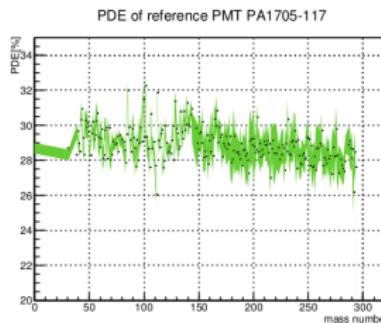
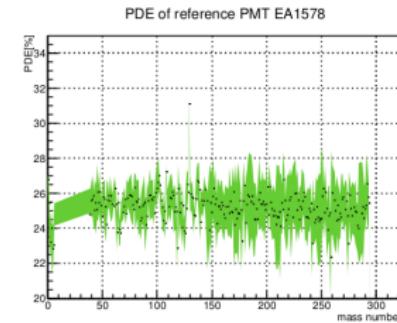
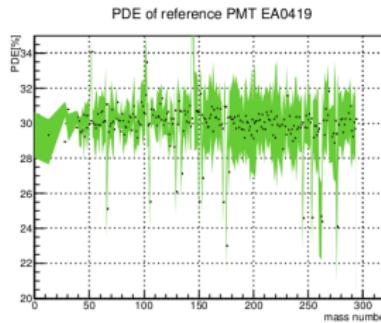


correlation of results from two system

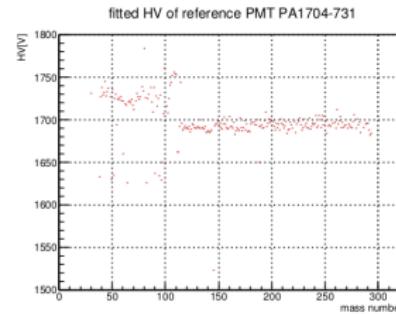
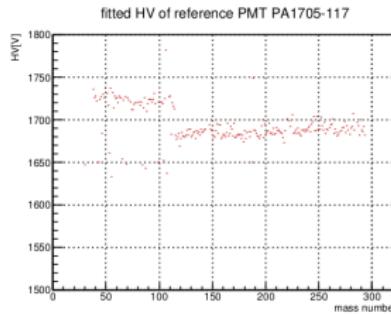
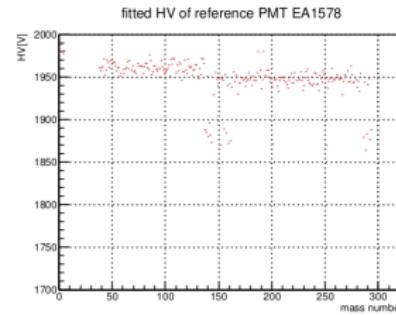
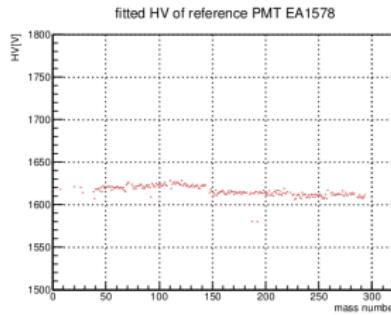
fitting PDE_c and PDE_s for low-QE PMTs.



PDE of reference PMTs

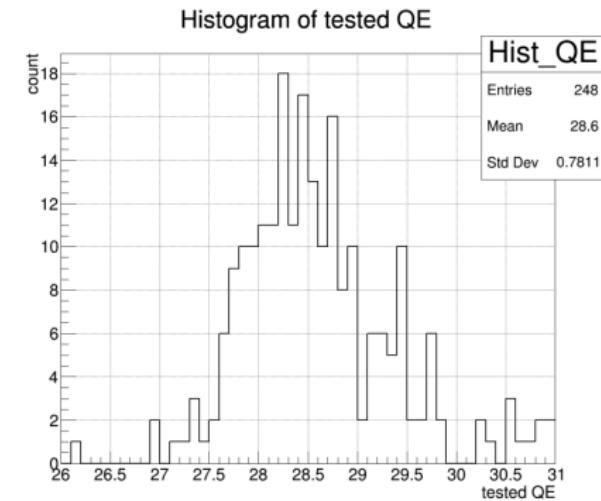
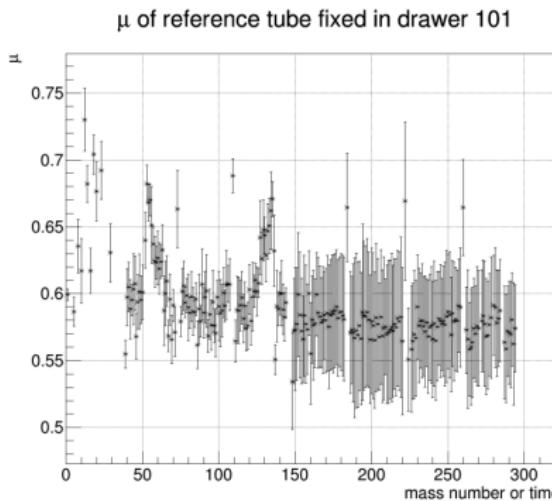


HV of reference PMTs

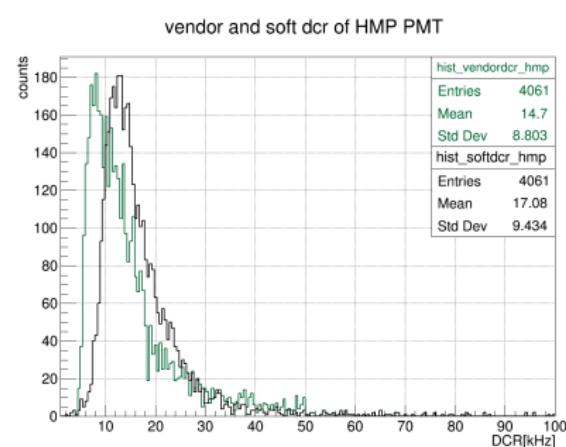
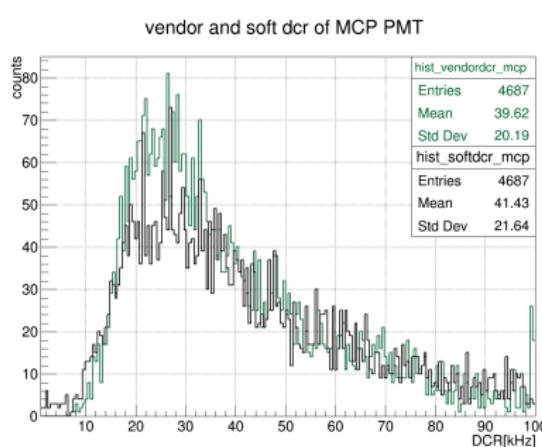


EA0419

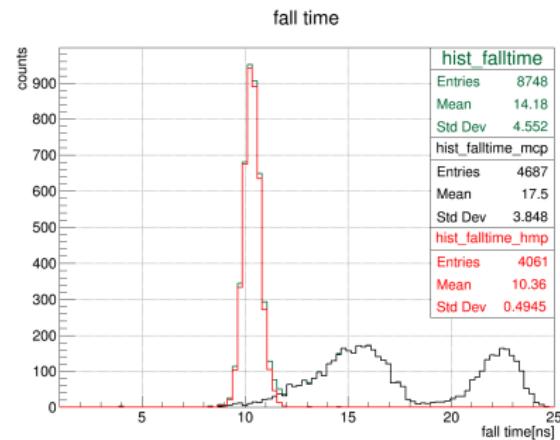
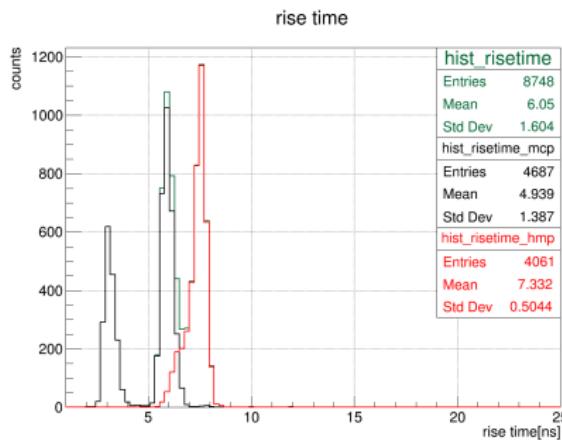
The reference PMT EA0419 was kept in drawer 101:



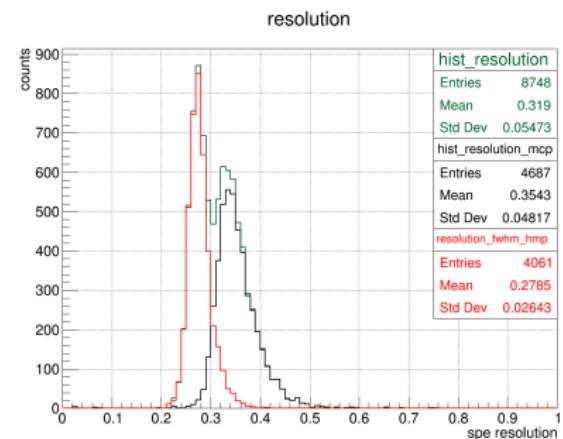
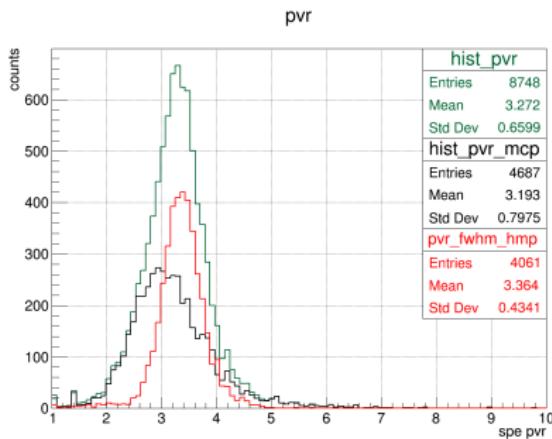
DCR



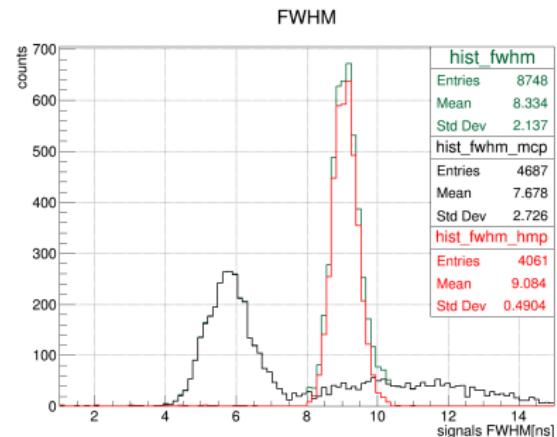
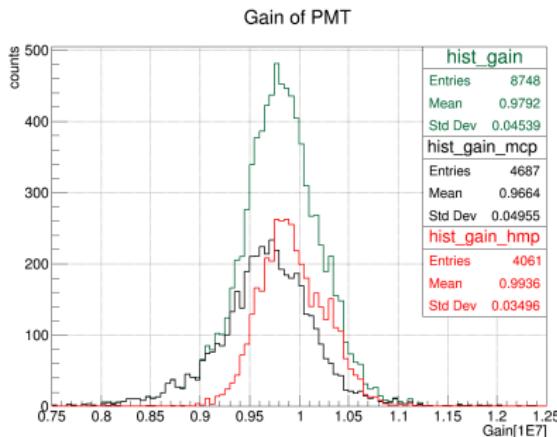
rise time and fall time



PVR and resolution



Gain and FWHM



average PDE

average PDE in each drawe:

average PDE(MCP)

