Container Data Analysis and Results

zhaor25@mail2.sysu.edu.cn

Rong Zhao

2018 年 7 月 24 日

Contents

Raw Data of Container System

raw data of container

For each PMT tested by container, the testing data includes:

- LED data with light intensity= $\sim$0.1p.e and $\sim$ 1p.e
- laser data with light intensity= $\sim$ 0.2pe and corresponding trigger data
- DCR results
- vendor data and other auxilary data

If you want to analyze the PMT testing raw data, please refer to DocDB file:
https://juno.ihep.ac.cn/cgi-bin/Dev_DocDB/ShowDocument?docid=3560
fort more details.

raw data of container

Generally, in the above document you can find:

- the raw data structure and explanation
- conventions about PMT parameters evaluation
- important logs during the PMT testing history
- how to fetch vendor data from PMT database and collect other auxilary information
- some known features of electronics and PMT waveforms, which may be useful when processing the waveforms

raw data of container

If you do not want to spend time collecting the auxilary infomation every PMT for data analysis, one choice is to read a txt file on the PMT onsite server:

/home/pmthome/zhaor/zhaorong/cont_v1/generatedata/meta_data.txt

The integrated variables are:

- path of different types raw data
- vendor parameters (PDE,DCR,HV,AP, etc.)
- testing condition paramaters
- other auxilary info

raw data of container

Also, I wrote a program and integrated the PMT parameters in a ROOT file, from which one can quickly access the general statistical information of PMTs.

The tree inside looks like:

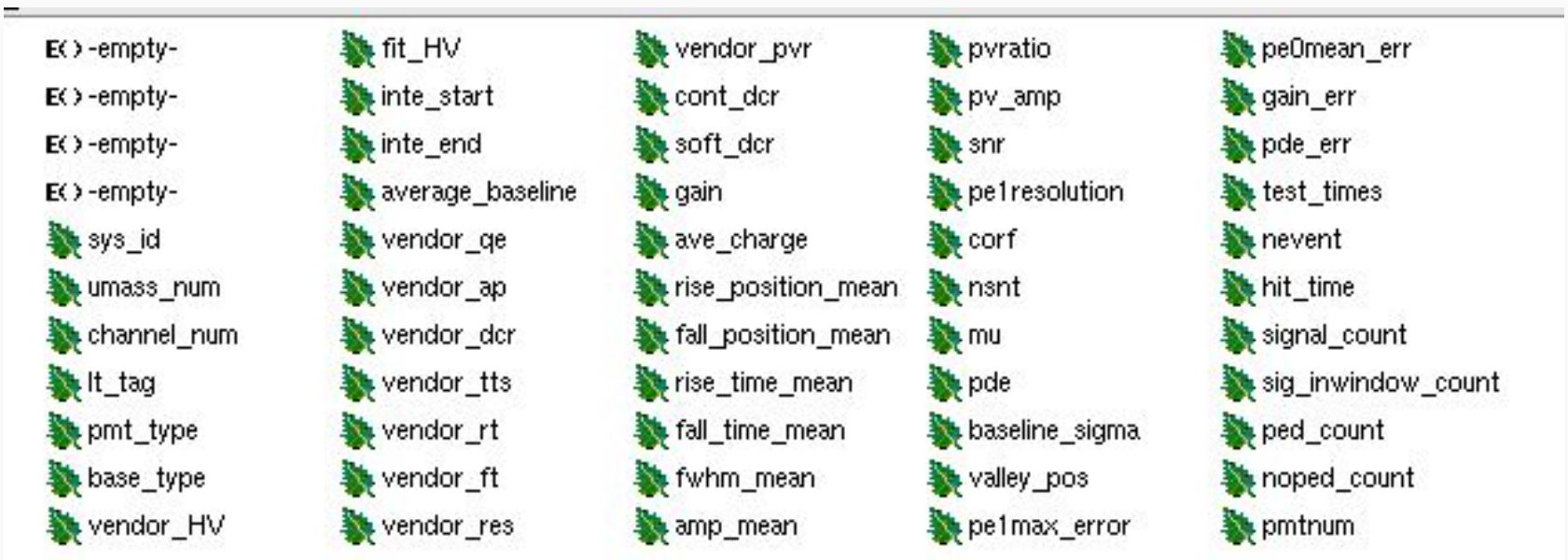


图 1: PMT parameters in ROOT file

raw data of container

Based on the above .root file, it is very convenient to access specific info of testing results.For example, one can use a simple command

pmt_tree->Draw("pde","lt_tag==2&&pmt_type==1&&

vendor_qe!=100pde>20test_times<2pmtnum>18031459")

to draw the PDE of MCP-PMTs with high QE or

pmt_tree->Draw("fit_HV:vendor_HV","lt_tag==2&&

pmt_type==0&&vendor_qe!=100&&pde>20&&test_times<2")

draw the correlation of container HV and vendor HV of all the HAMAMATSU PMTs.

raw data of container

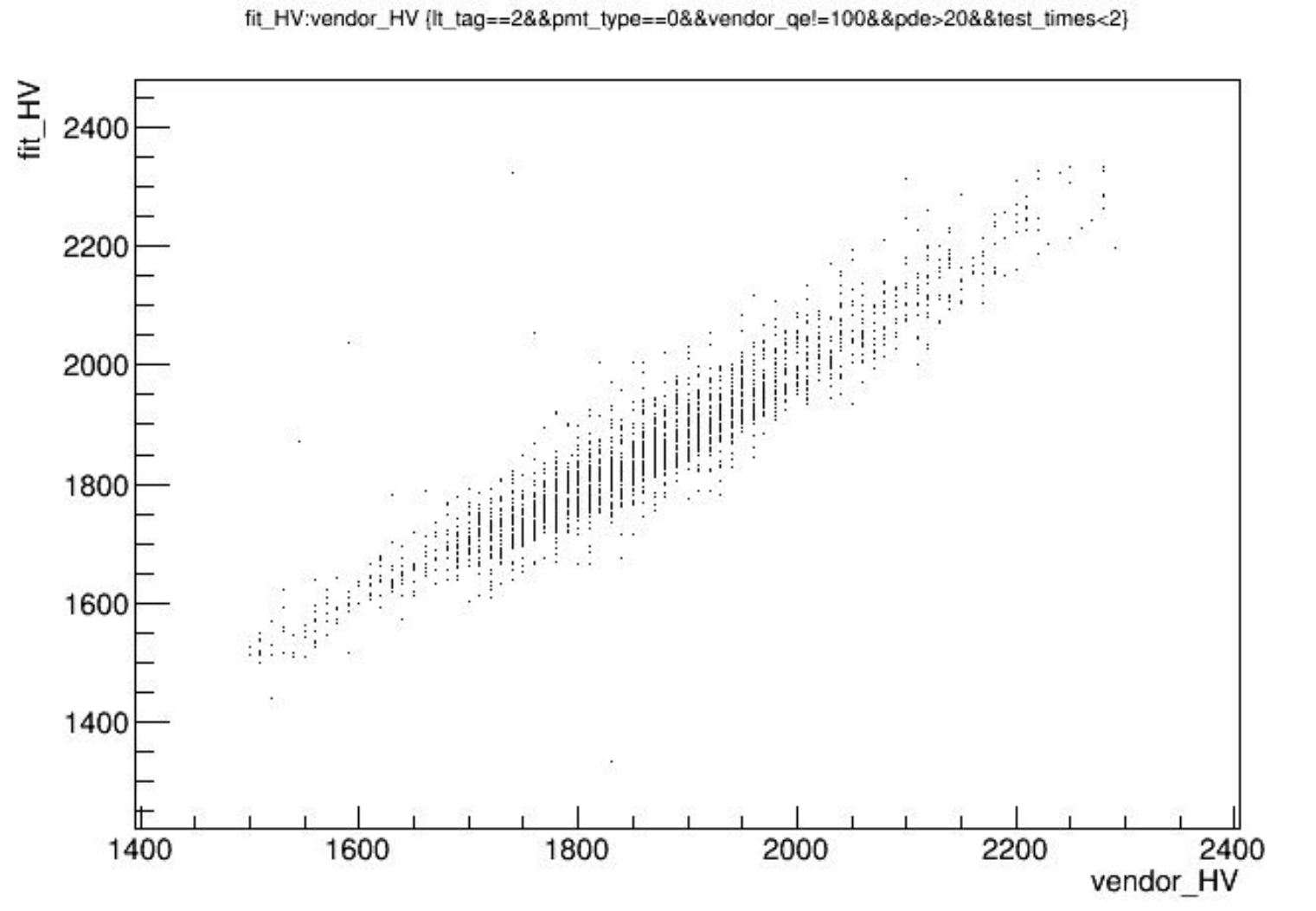


图 2: draw container HV and vendor HV from root file

raw data of container

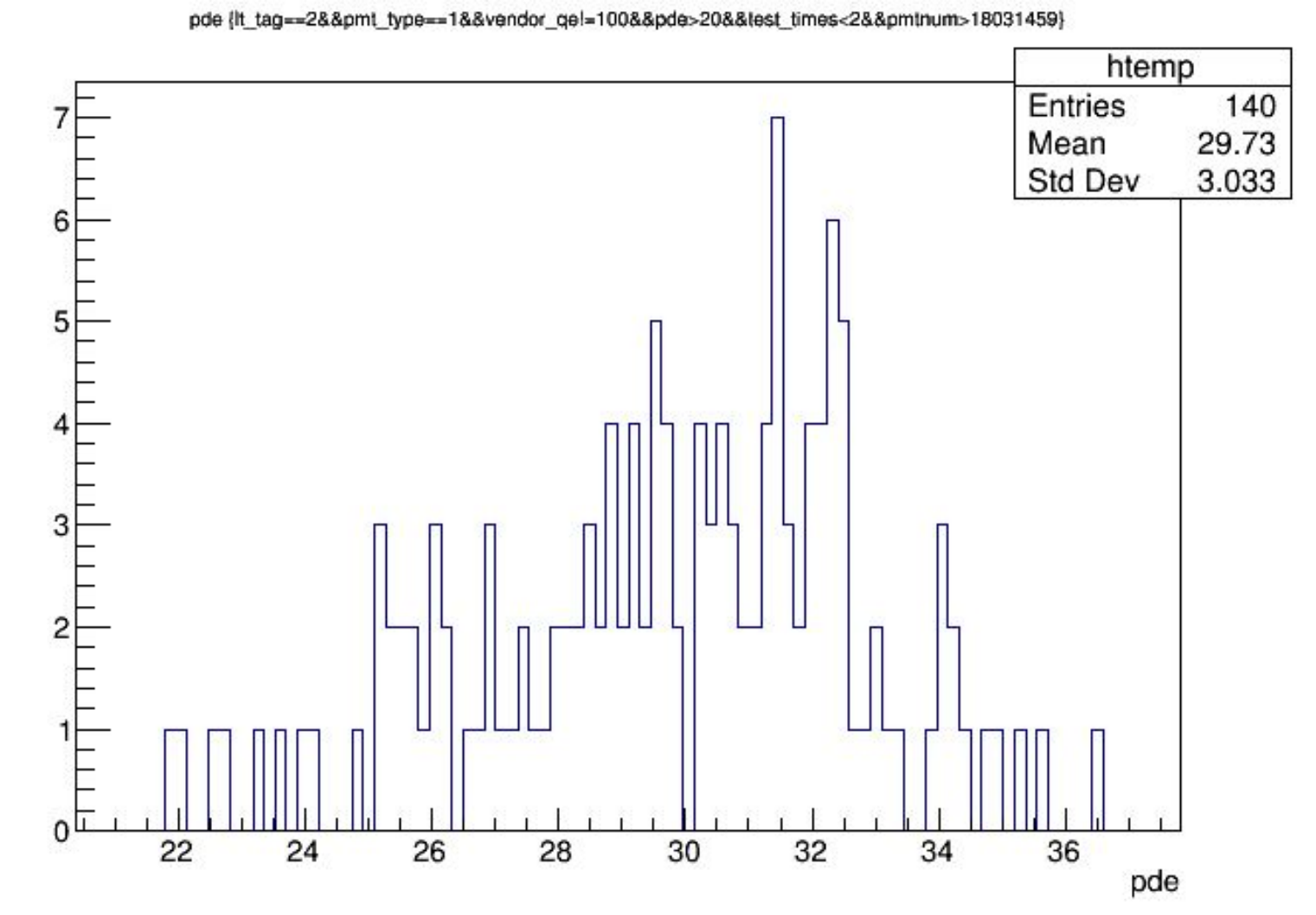


图 3: draw container HV and vendor HV from root file

PMT Testing Data Quality

typical single p.e waveform

MCP-PMTs have faster rise-edges but slower fall-edges, and their spe amplitudes are a little bit higher than HAMAMATSU PMTs.

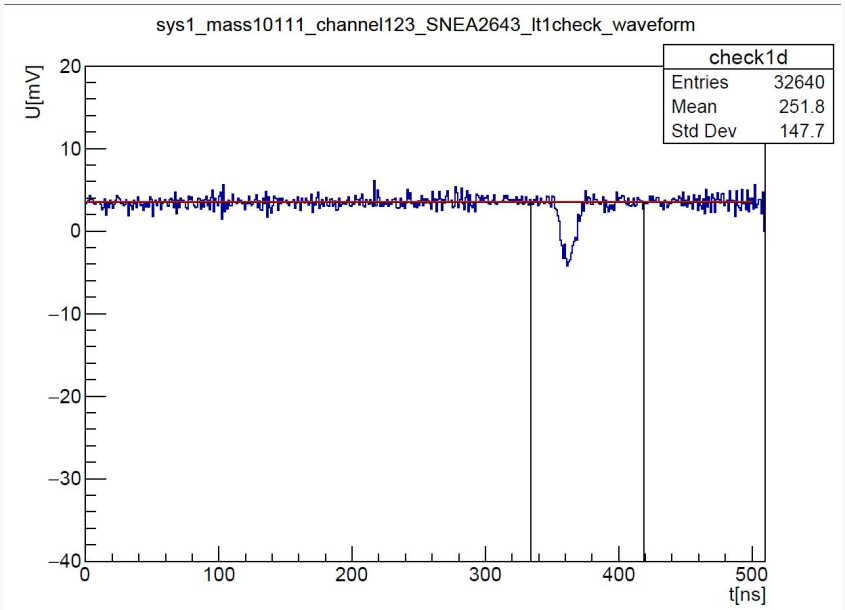


图 4: single pe waveform of HAMAMATSU PMT

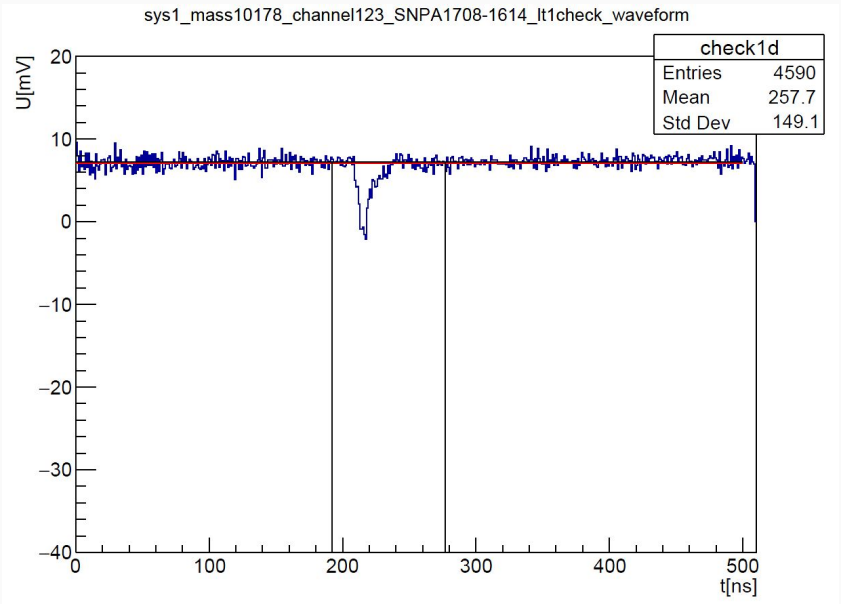


图 5: single pe waveform of MCP PMT

typical single p.e 2-D overlapped waveform

overlapped typical waveforms @0.1pe LED

the pink area is trigger window

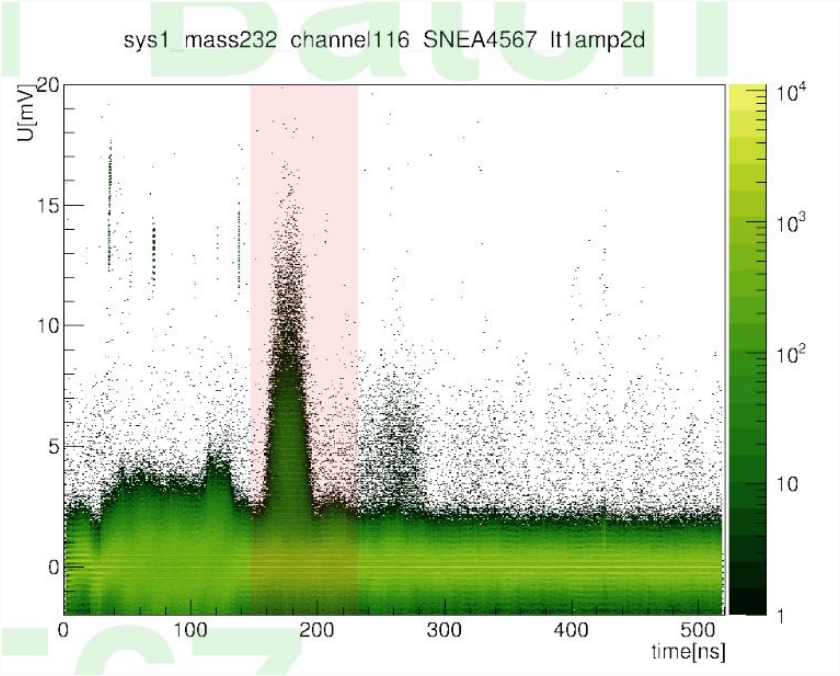


图 6: overlapped single pe waveforms of HAMAMATSU PMT

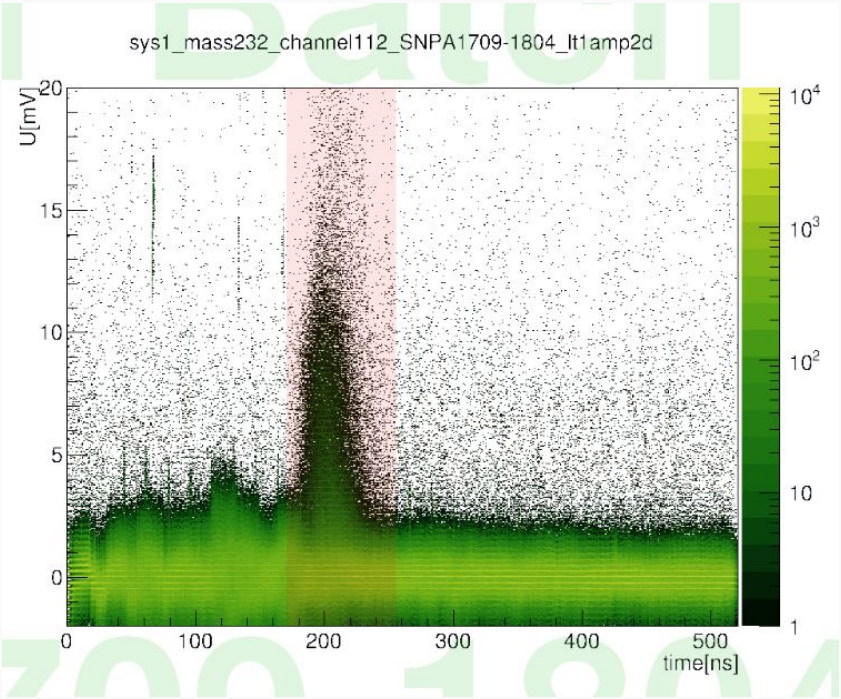


图 7: overlapped single pe waveforms of MCP PMT

typical single p.e(setpoint3000) 2-D overlapped waveform

overlapped typical waveforms @1pe LED(setpoint3000)

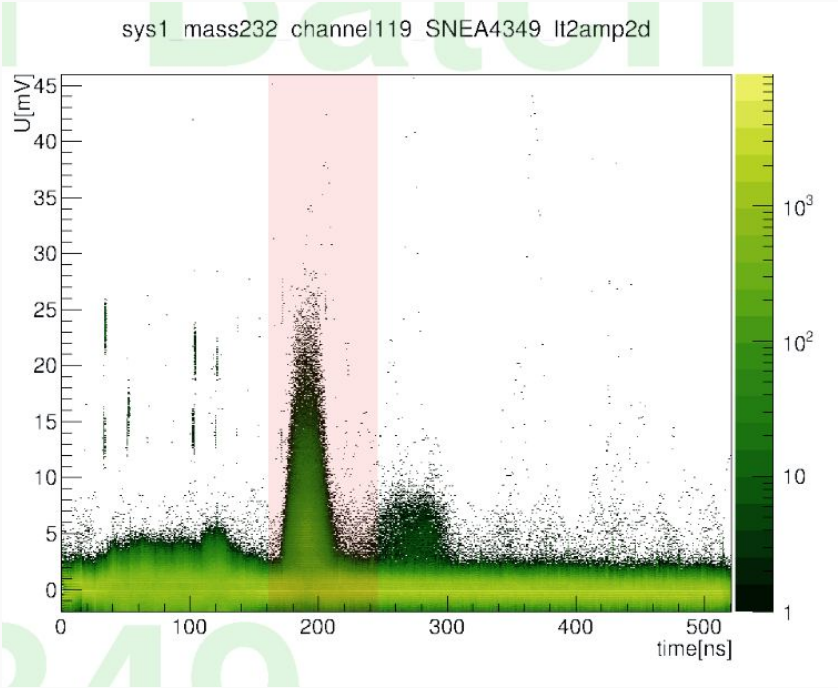


图 8: overlapped single pe waveforms of HAMAMATSU PMT

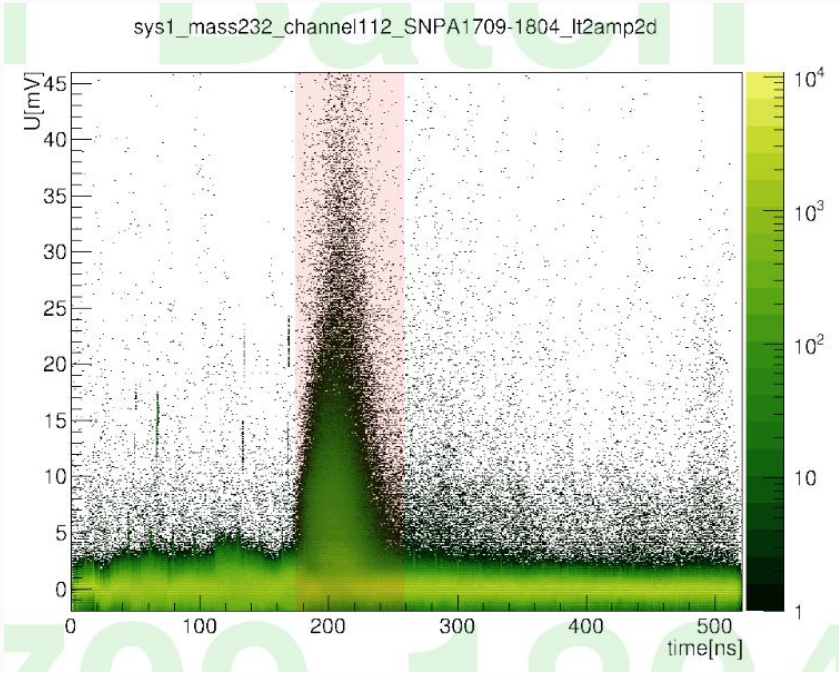


图 9: overlapped single pe waveforms of MCP PMT

These figures above clearly show the different characteristics of our PMTs: HAMAMATSU-PMTs have less dark counts and are more stable in amplitudes.

typical laser waveforms and trigger

the light intensity of laser is about 0.2pe($\mu \sim$0.2).

the laser triggers are not as good as our expectation(should be NIM signals in ideal), and will be improved.

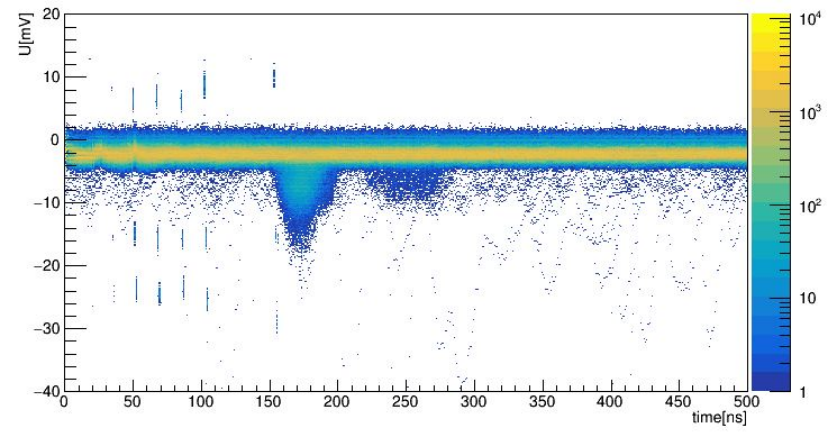


图 10: overlapped single pe waveforms of HAMAMATSU PMT

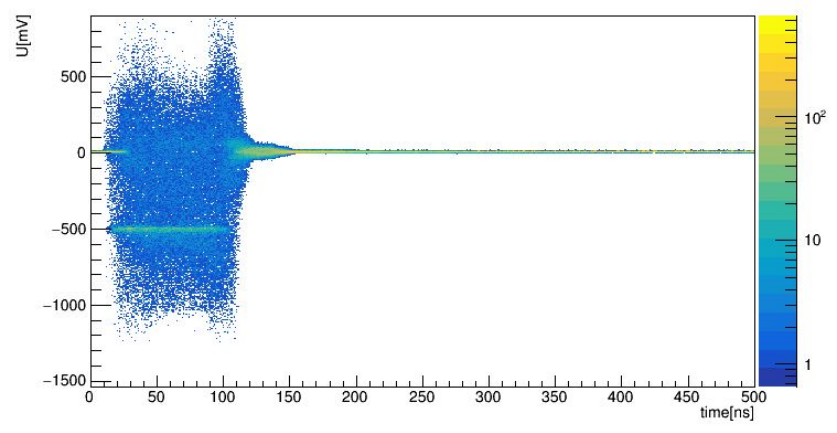


图 11: overlapped single pe waveforms of MCP PMT

waveform quality

Some EM noise still exist in drawers; They are not severe problem but need to be carefully handled when processing waveforms.

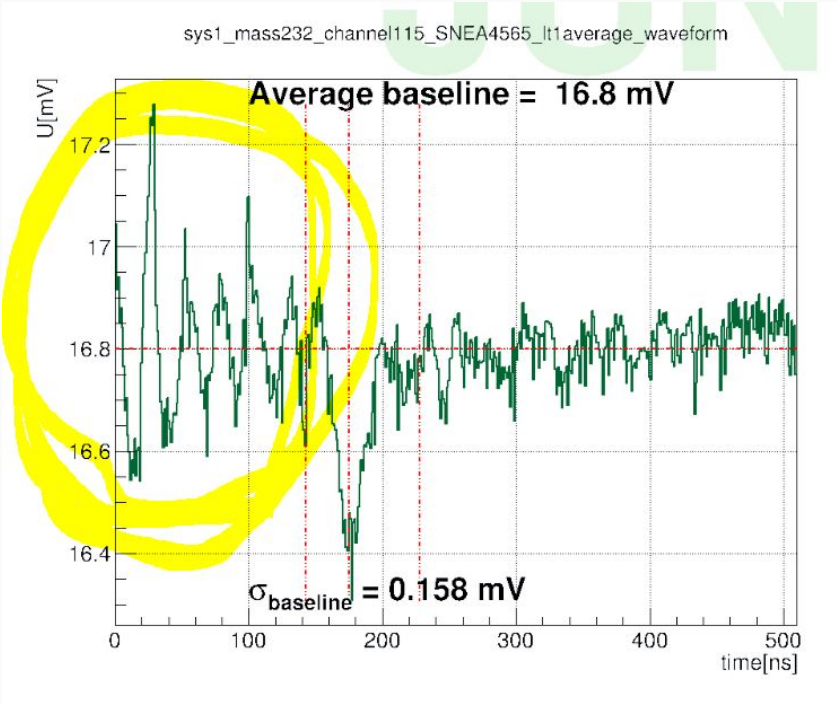


图 12: "cross-talk" in the baseline

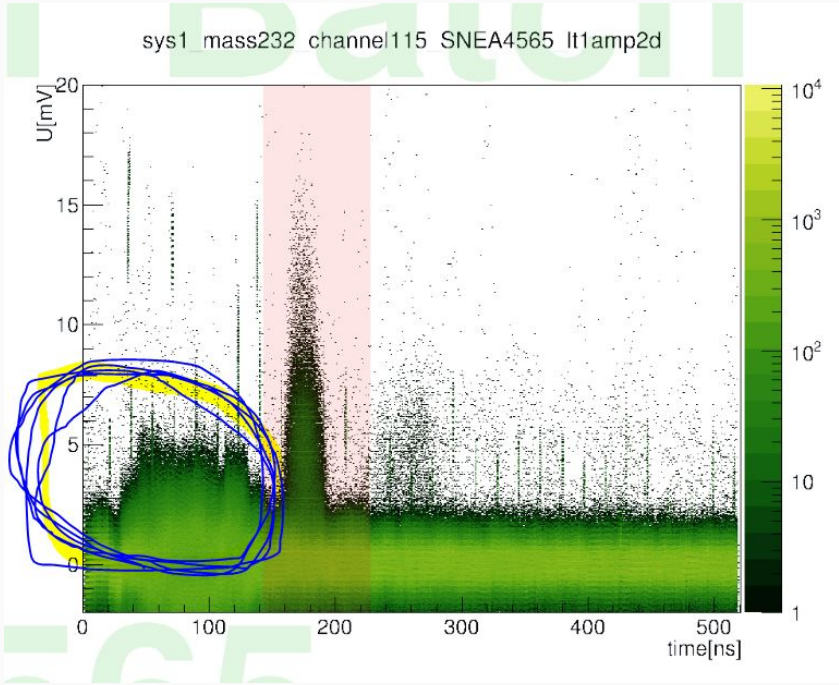


图 13: overlapped waveforms

waveform quality

The "gliches", have something to do with the imperfect EM shielding.

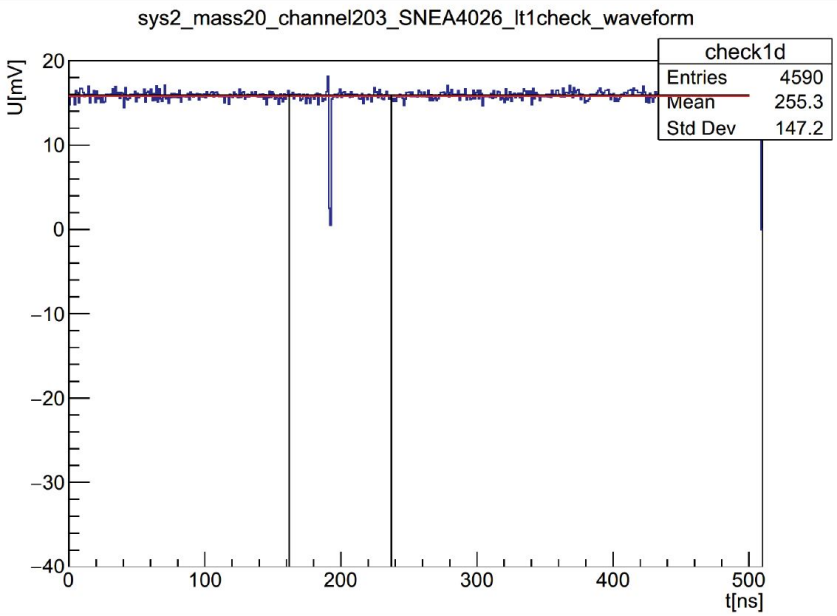


图 14: "glich" in single frame

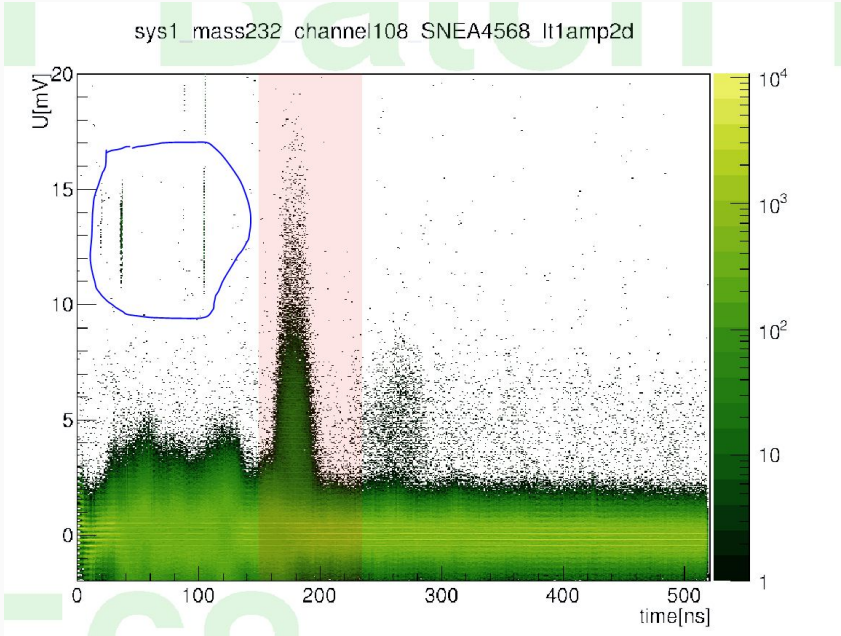


图 15: "gliches" in overlapped waveforms

waveform quality

We cound also occasionally encountered some abnormal waveforms, which we need to keep a watchful eye on.For example:

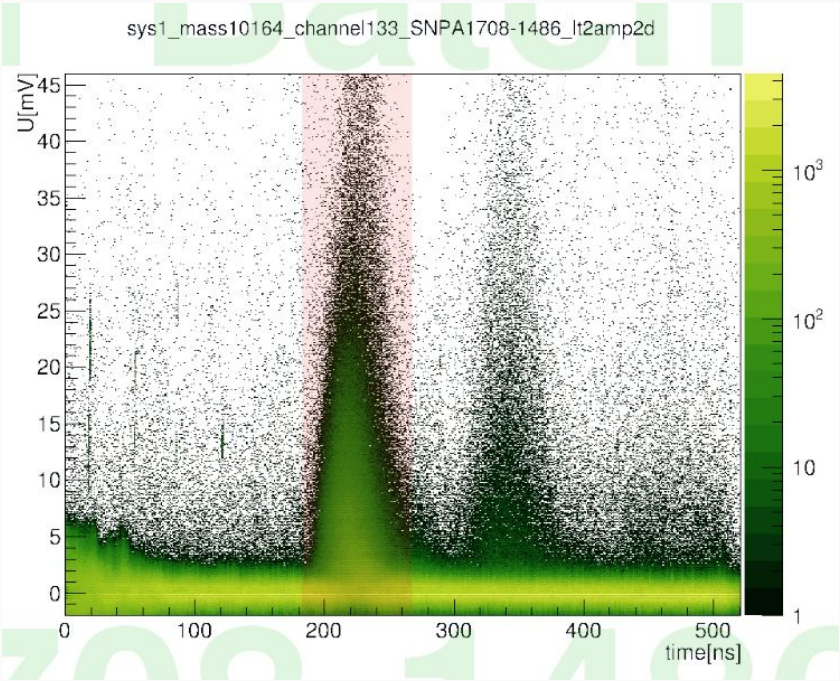


图 16: "reflection" waveforms

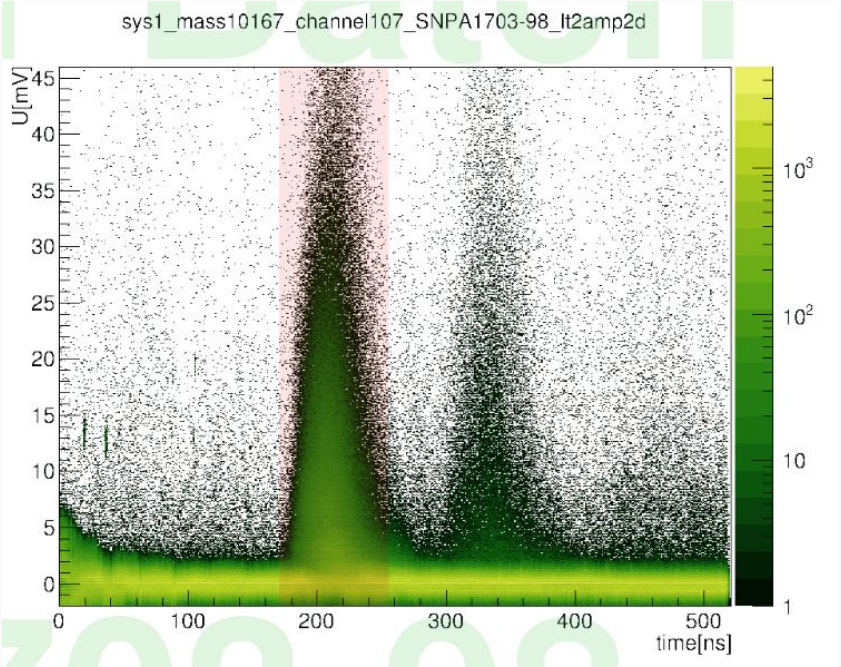


图 17: "reflection" waveforms

Need more study on whether they were from PMT itself or electronics.

waveform quality

PMTs with extremely high DCR or abnormal delay also need to be accuratelly identified.

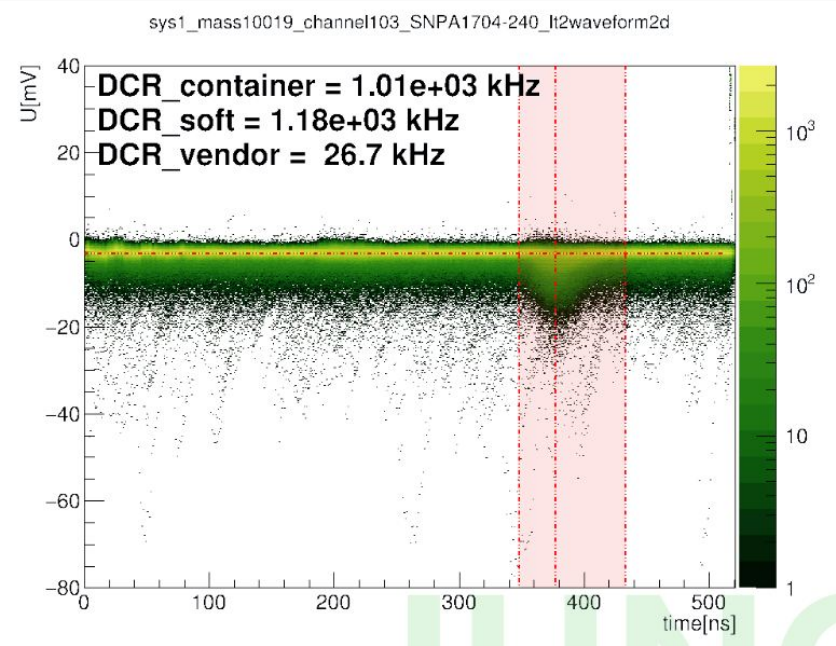


图 18: extremely high DCR

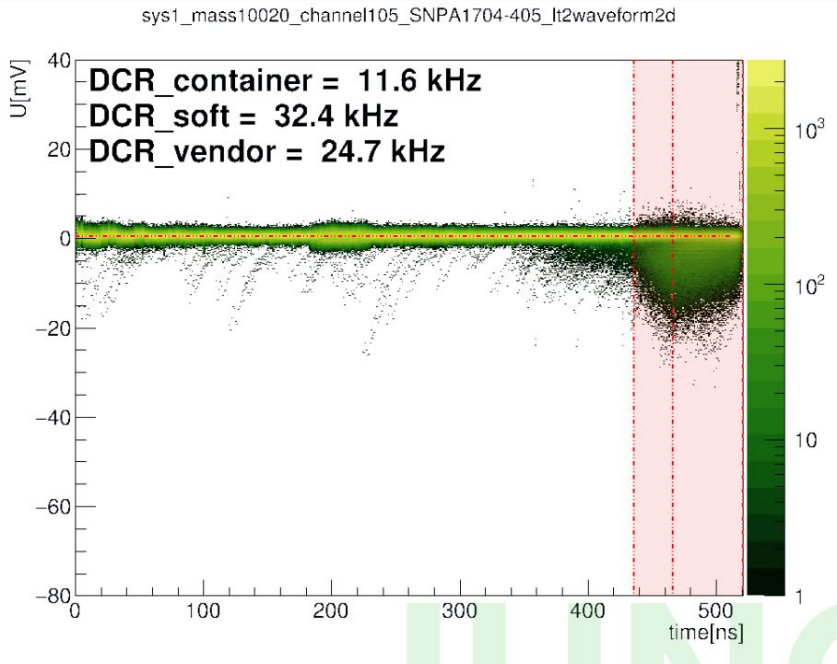


图 19: abnormal delay

Need more study on whether they were from PMT itself or electronics.

a small tool to check data quality

To help onsite container shifters to quickly check the testing data quality, I wrote a script on the server onsite, which

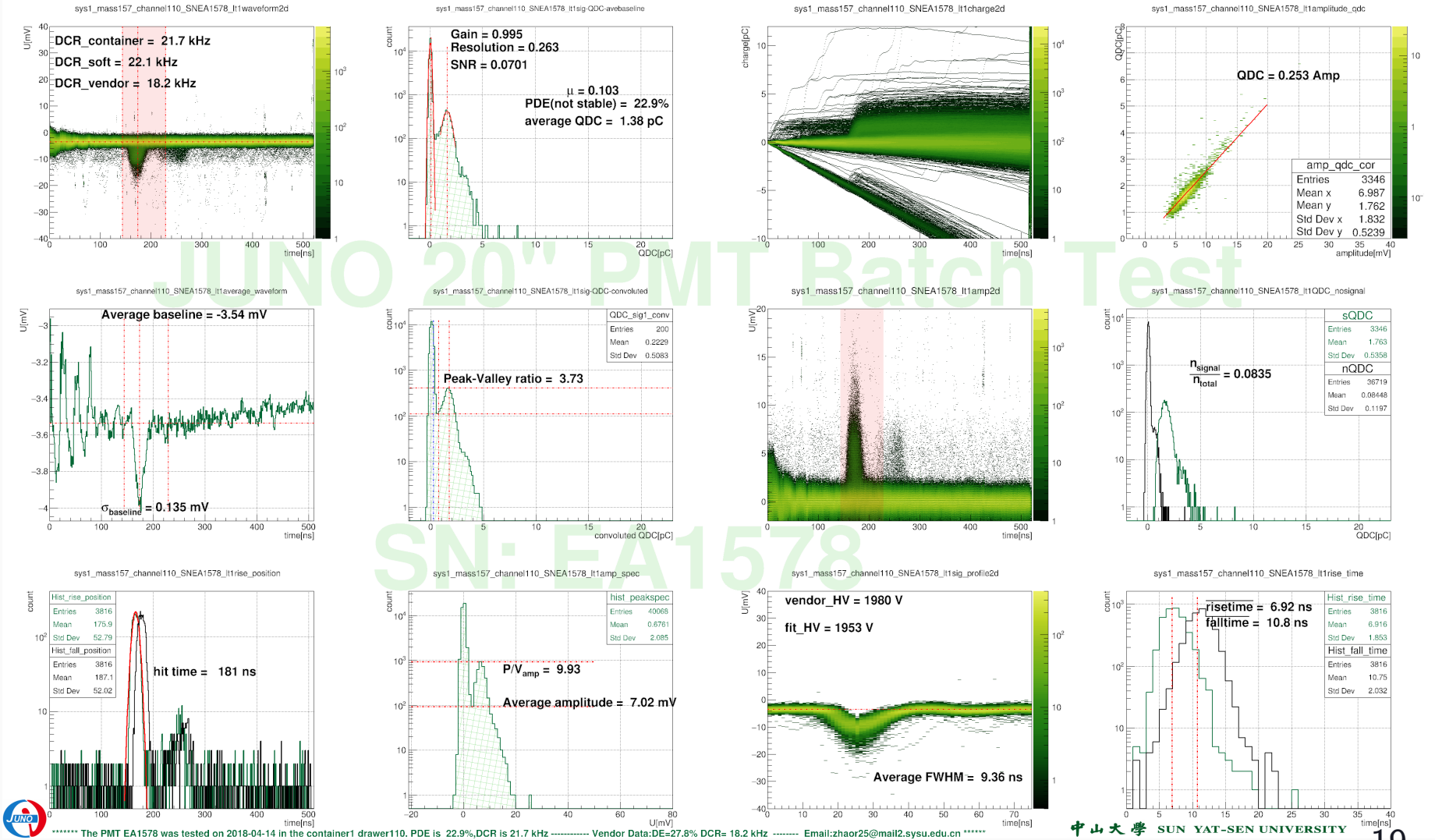
- take about 5 mins to run
- output the sample waveforms
- many histograms about signal waveform features
- final testing parameters

So, it is convenient to use this script as a supplement or check of the current onsite analyze programs.

---

the output png figure of one PMT looks like(next slide):

output png file of one PMT



******* The PMT EA1578 was tested on 2018-04-14 in the container1 drawer110. PDE is 22.9%,DCR is 21.7 kHz ---------- Vendor Data:DE=27.8% DCR= 18.2 kHz -------- Email:zhaor25@mail2.sysu.edu.cn ******

Data Analysis Results (of ContainerA)

”delay” signals of HAMAMATSU PMTs

Small proportion(<2%) of delayed signals appear at about 90ns after the main signals. This is common for HAMAMATSU PMTs and has not been well understood.

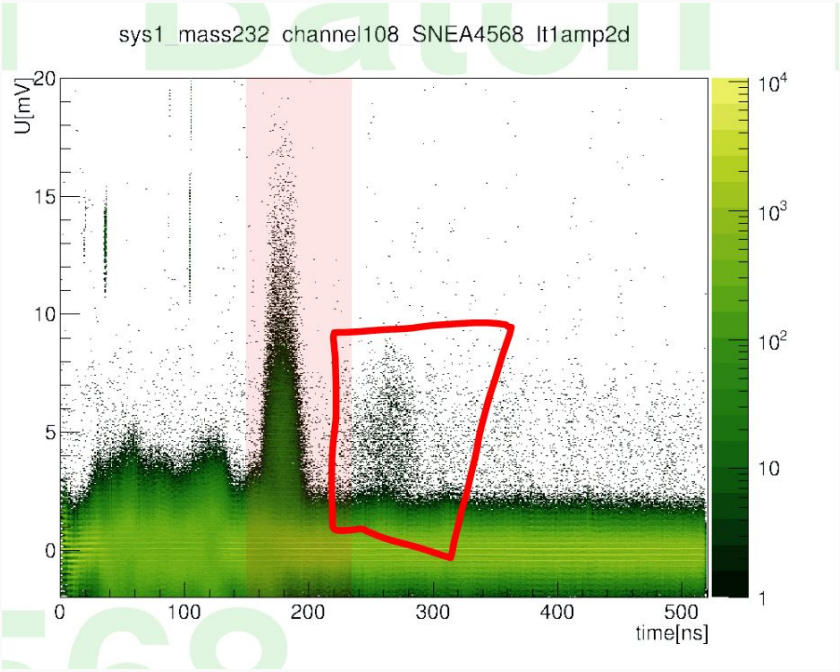


图 20: ”delayed” signals of HAMAMATSU PMT

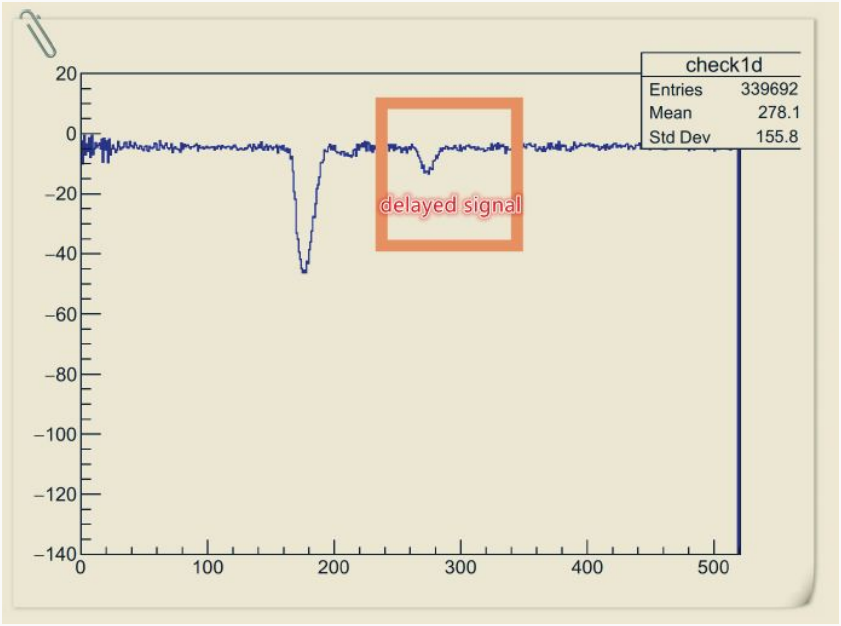


图 21: one ”delayed” signal of HAMAMATSU PMT

"big" signals of MCP PMTs

This is a "well-known" feature of MCP-PMT. It could worsen the p.e resolution and affect evaluation of other parameters.

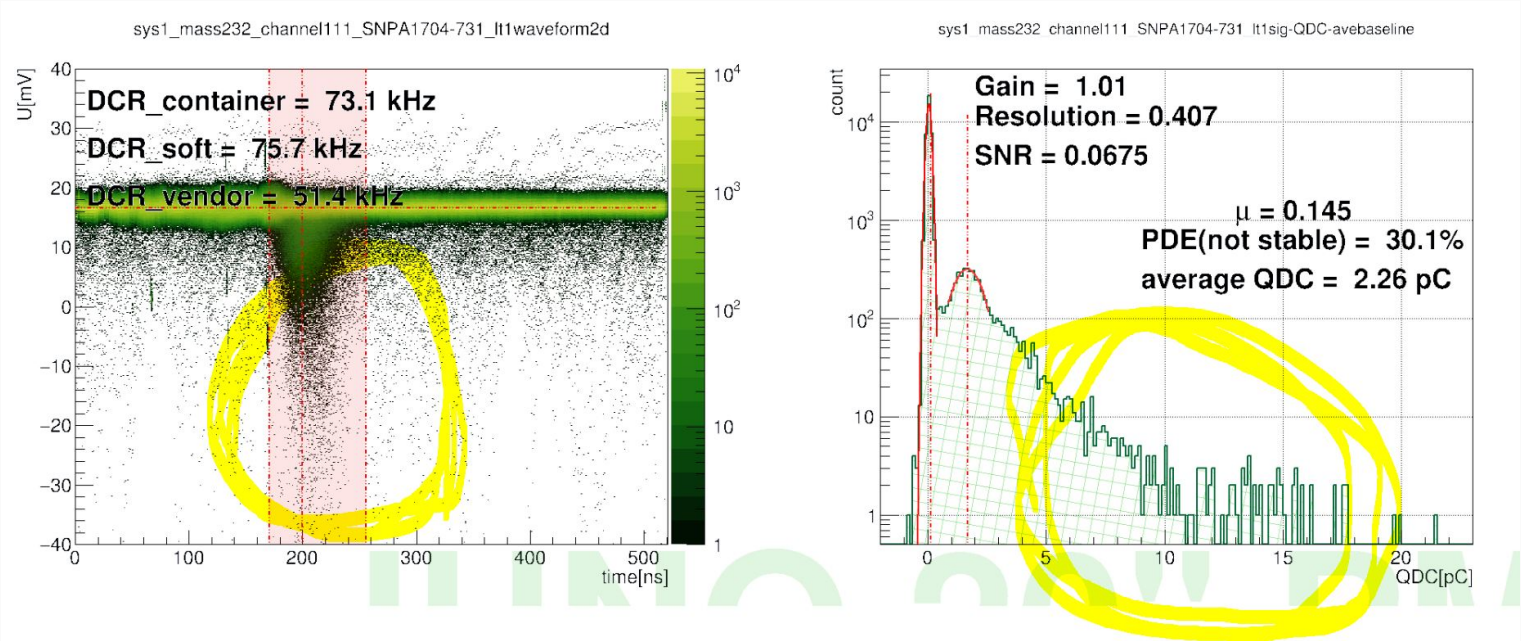


图 22: "big" signals

another suggestion: their performance under larger light intensity(instead of 0.1pe) need to be investigated.

high voltage of PMTs

The mean value of container HV of ∼7k tested PMTs is 1818.

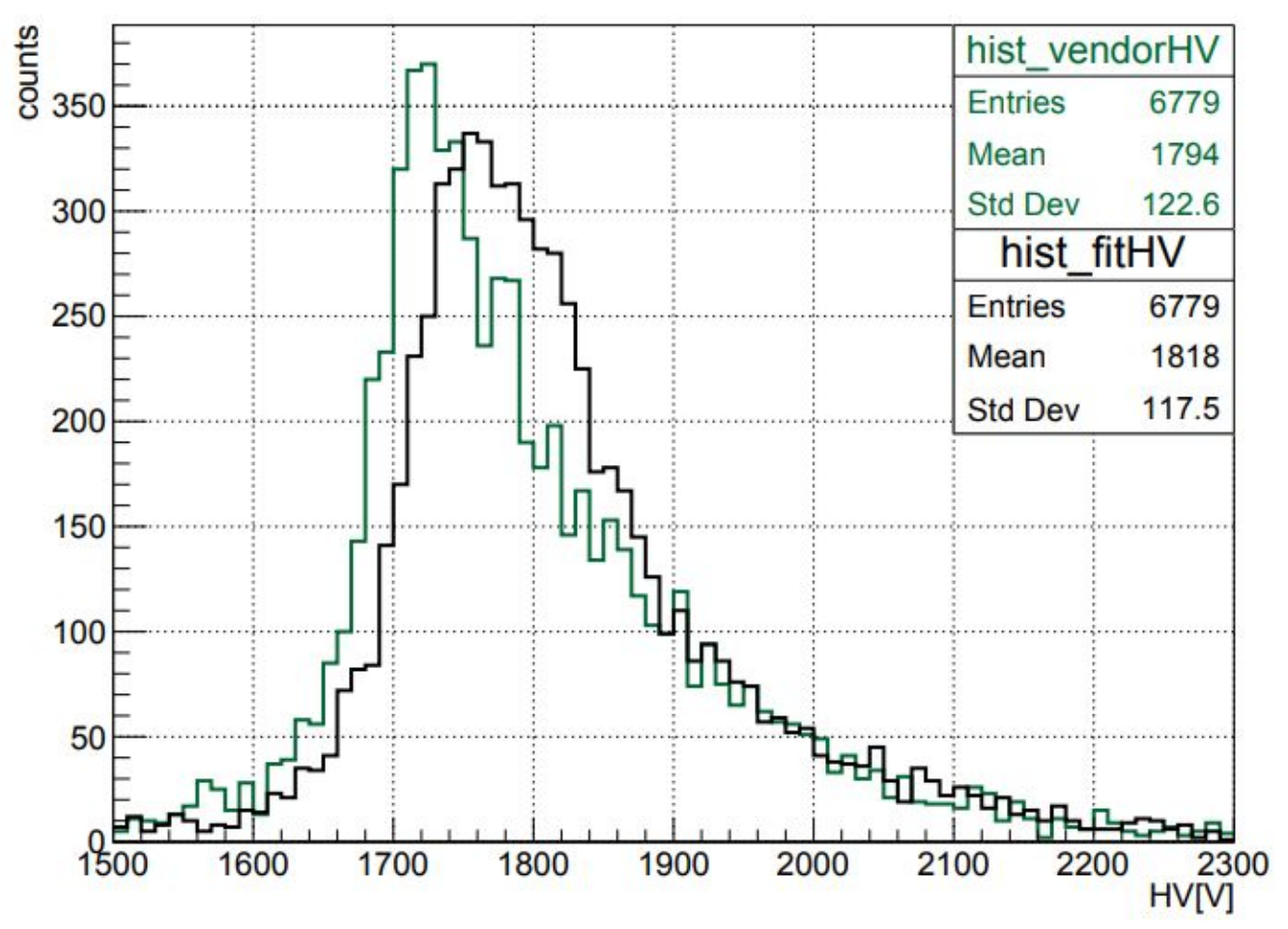


图 23: HV of all PMTs

high voltage of PMTs

Container HV of HAMAMATSU PMT is consistent with vendor HV (the mean value is ∼1850V).

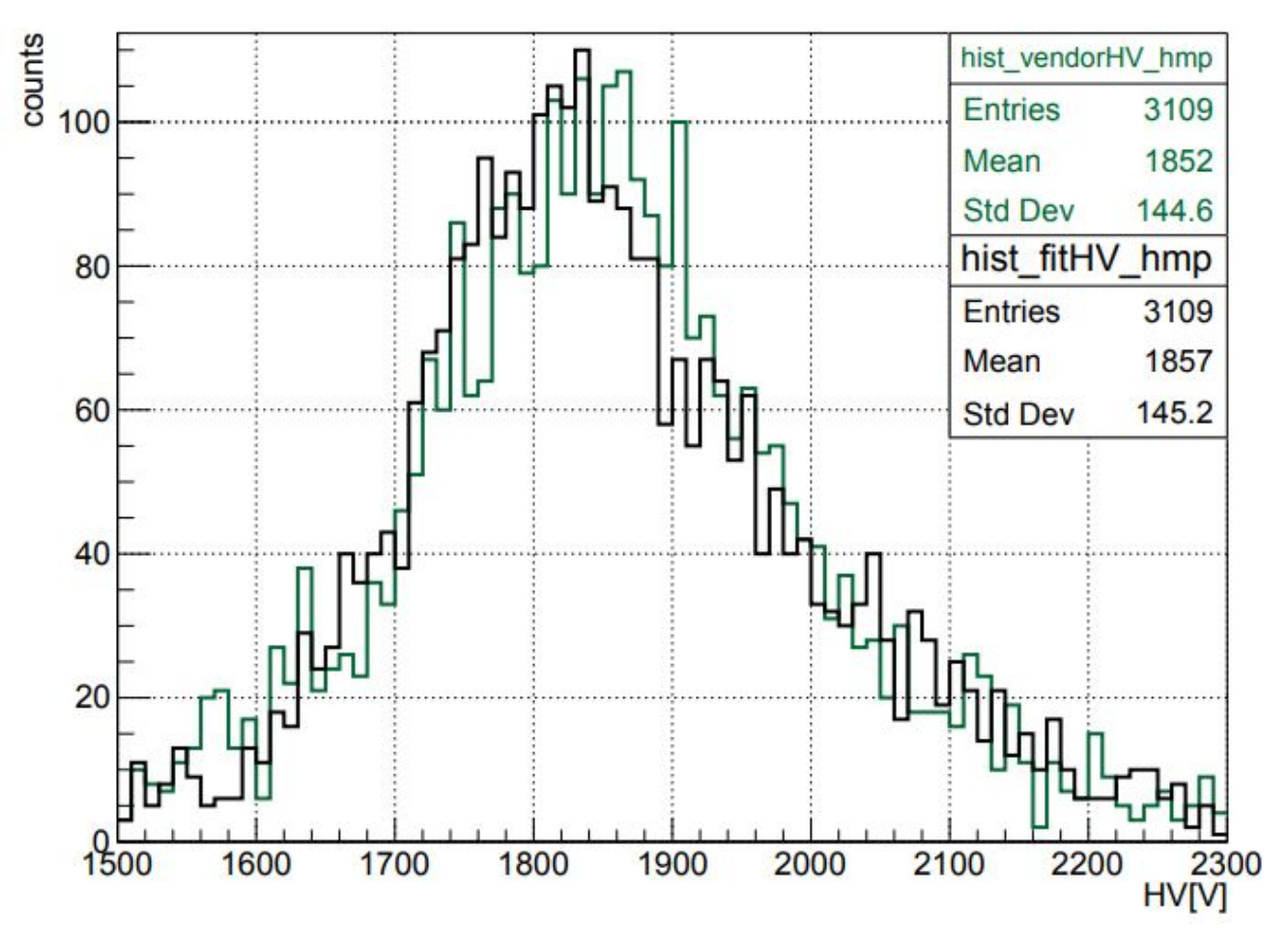


图 24: HV of HAMAMATSU PMTs

high voltage of PMTs

The mean value of container HV of MCP PMTs is (~ 40V) higher than vendor data. But their (gain=1E7)HV variation is smaller than HAMAMATSU PMTs.

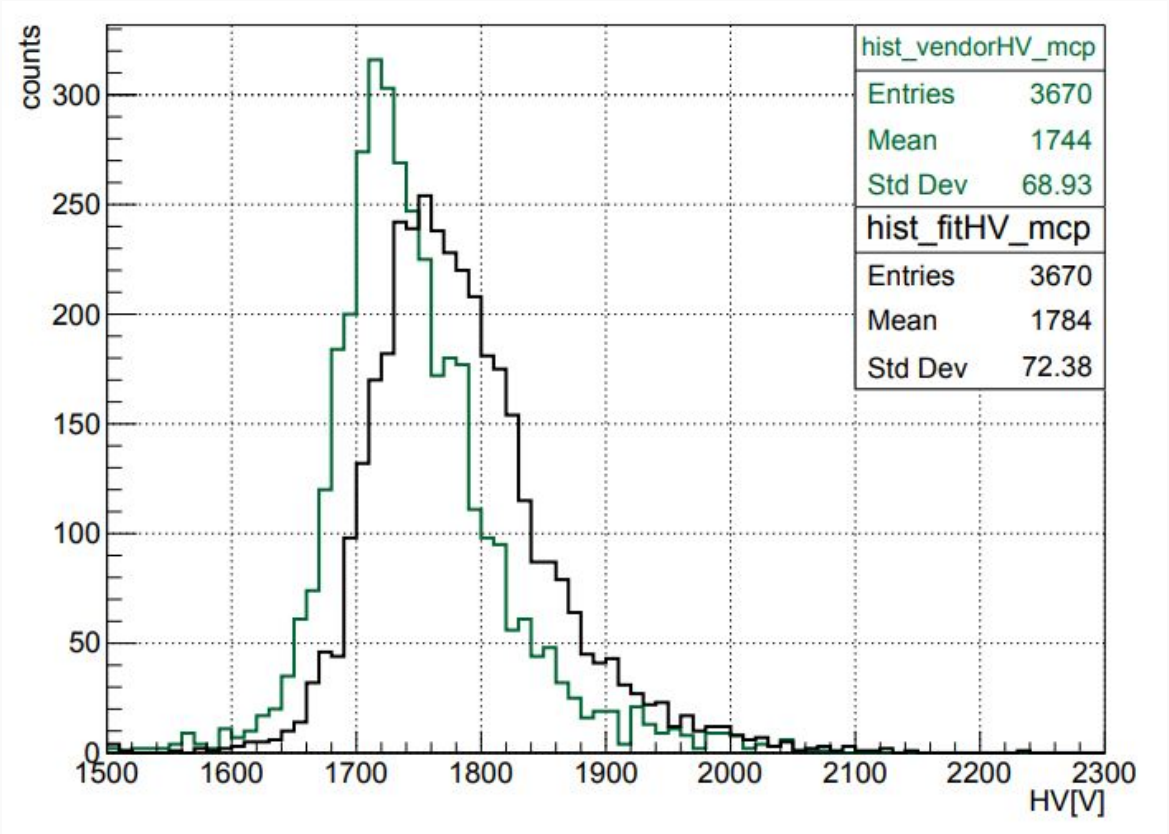


图 25: HV of MCP PMTs

DCR of PMTs

Average DCR of our PMTs is about 28kHz.

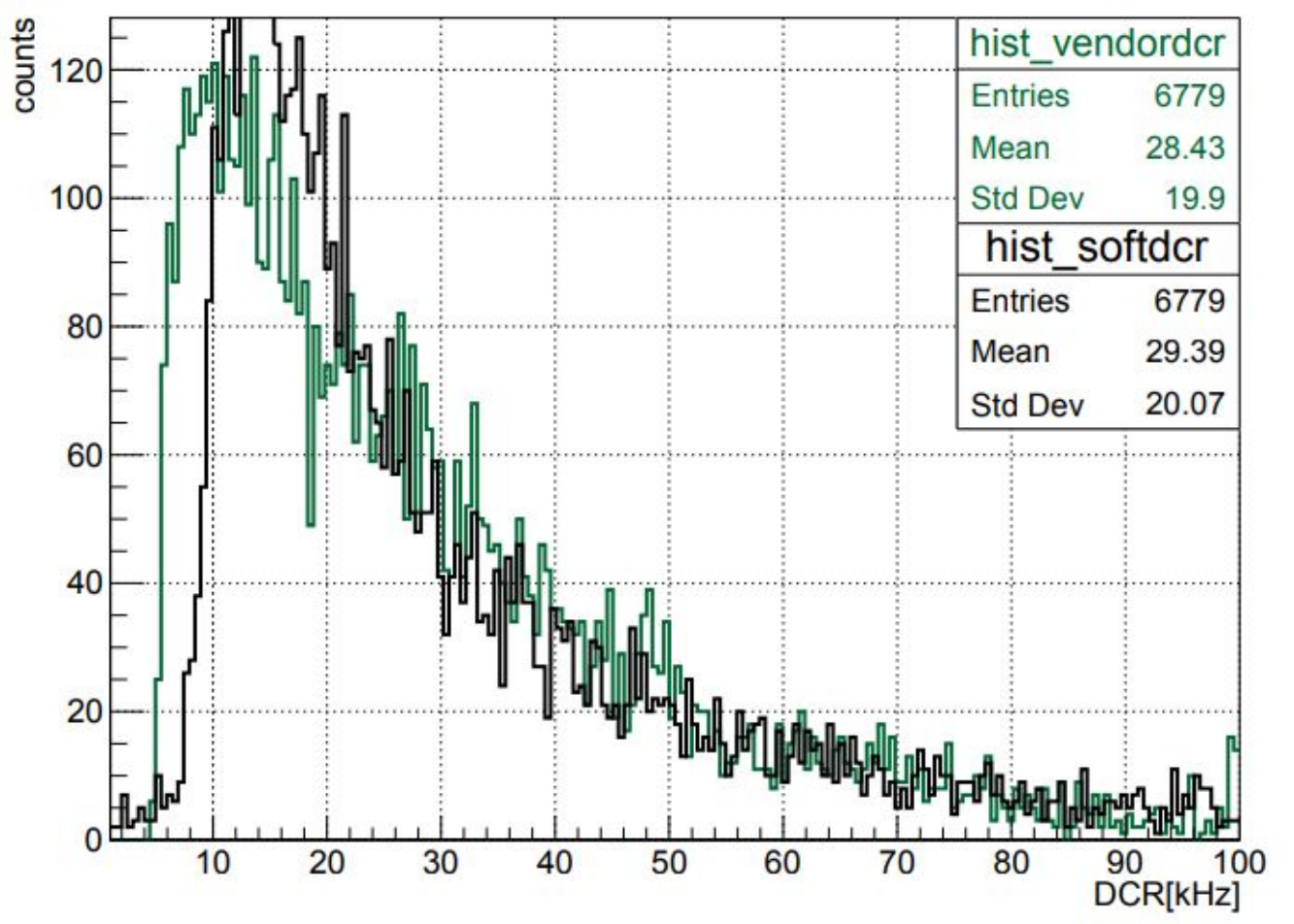


图 26: DCR of ALL PMTs

DCR of PMTs

Container DCR of MCP PMT is consistent with vendor data while container DCR of HAMAMATSU PMT is a little bit higher than vendor data.

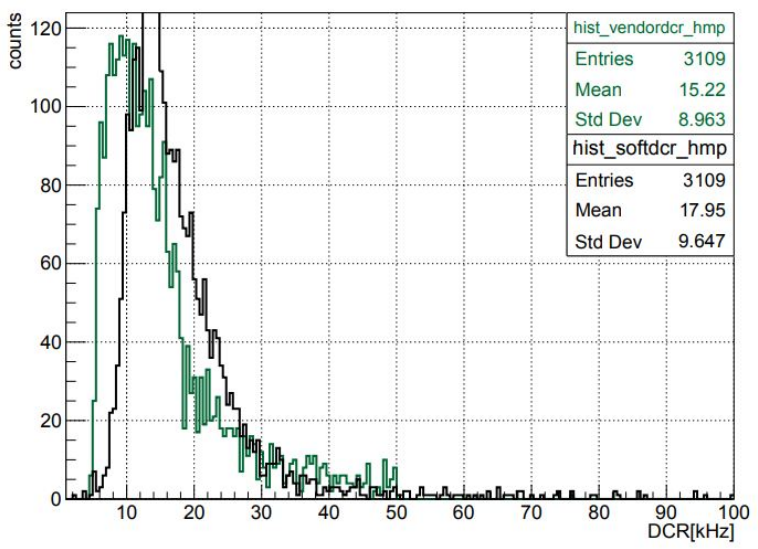


图 27: DCR of HAMAMATSU PMTs

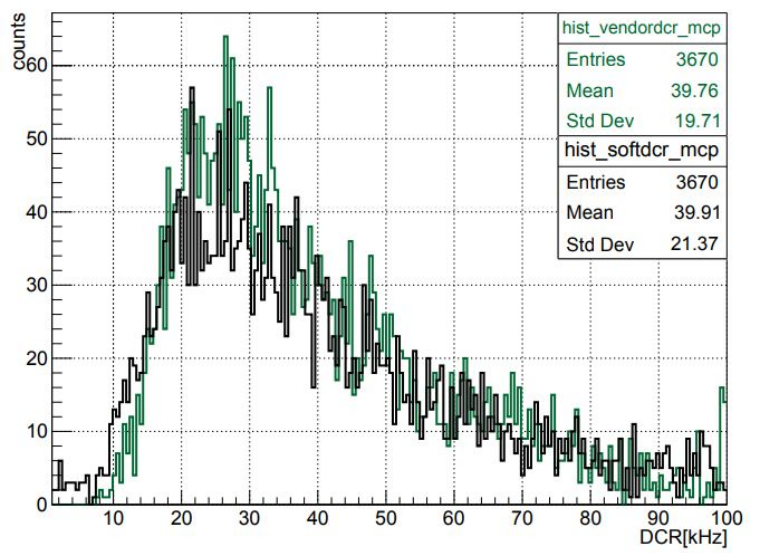


图 28: DCR of MCP PMTs

The DCR of HAMAMATSU(MCP) PMTs is about 17(40)kHz.

GAIN of PMTs

Due to the "long tail" in charge spectrum of MCP PMTs, their gain values are somehow algorithm dependent.

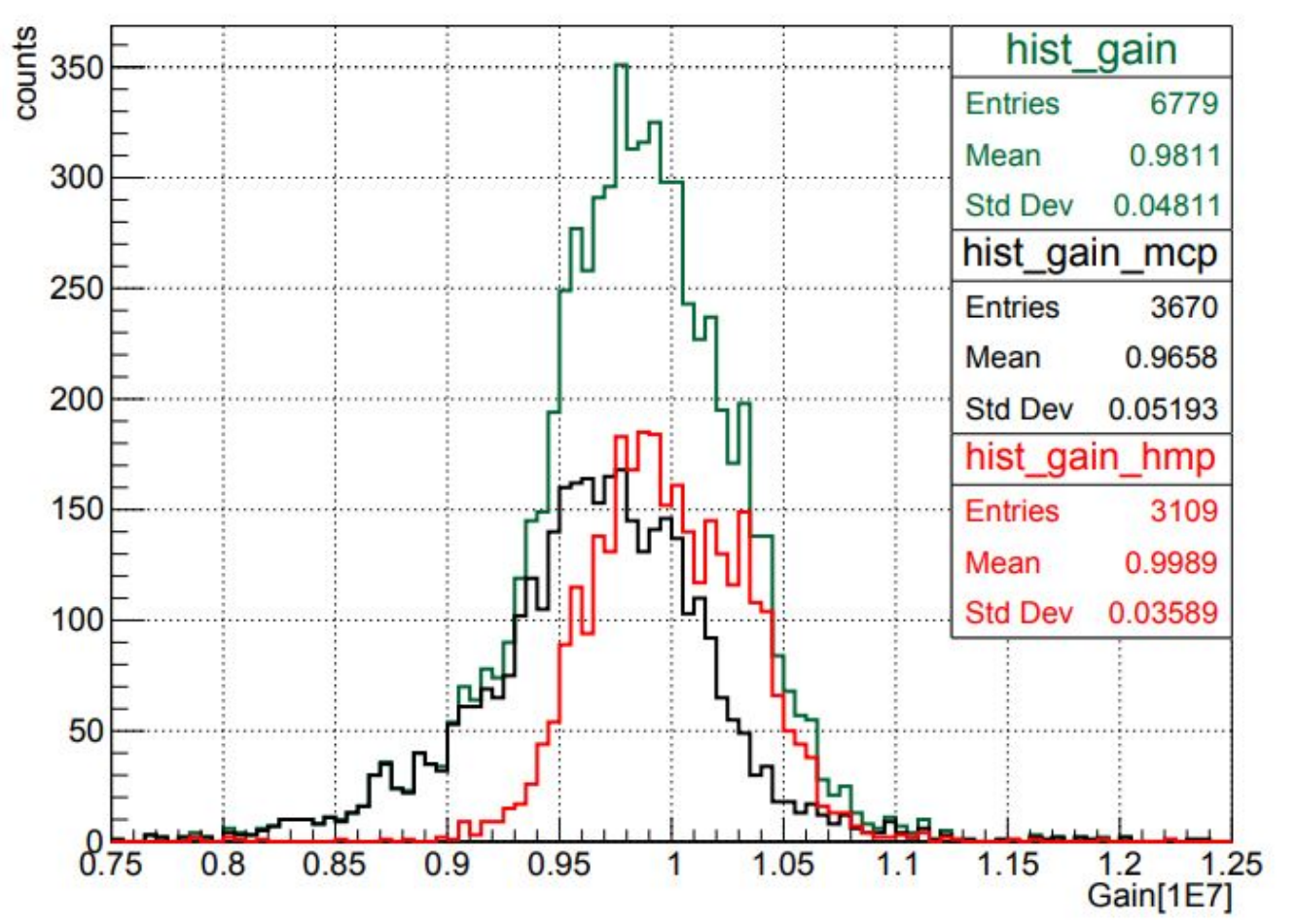


图 29: gain of PMTs

rise-time of PMTs

The risetime of MCP PMT with new base is ∼3.2ns

The risetime of HAMAMATSU PMT is ∼7.2ns

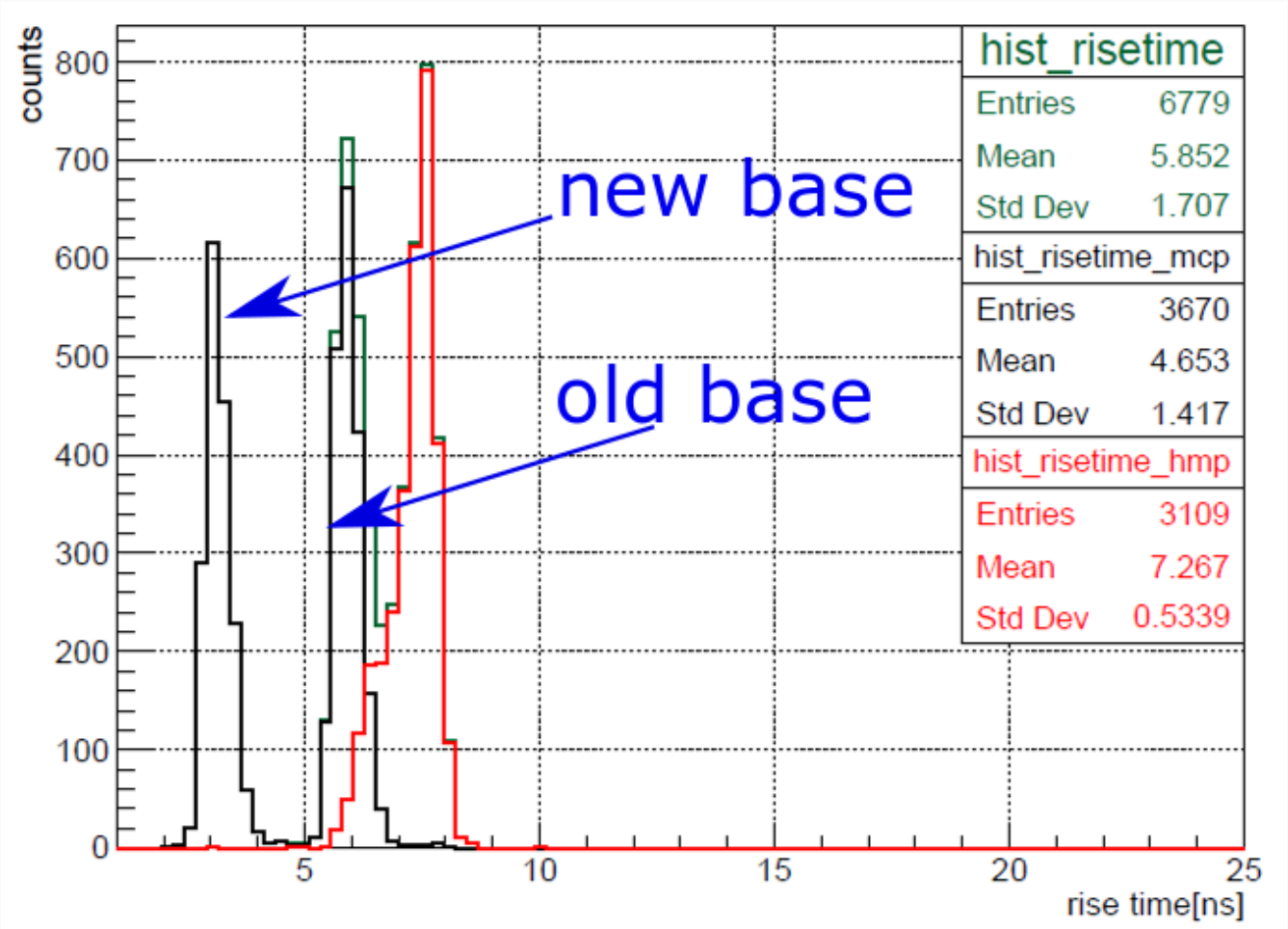


图 30: risetime distribution of PMTs

fall-time of PMTs

The falltime of MCP PMT with new base is ∼15ns

The falltime of HAMAMATSU PMT is ∼10ns

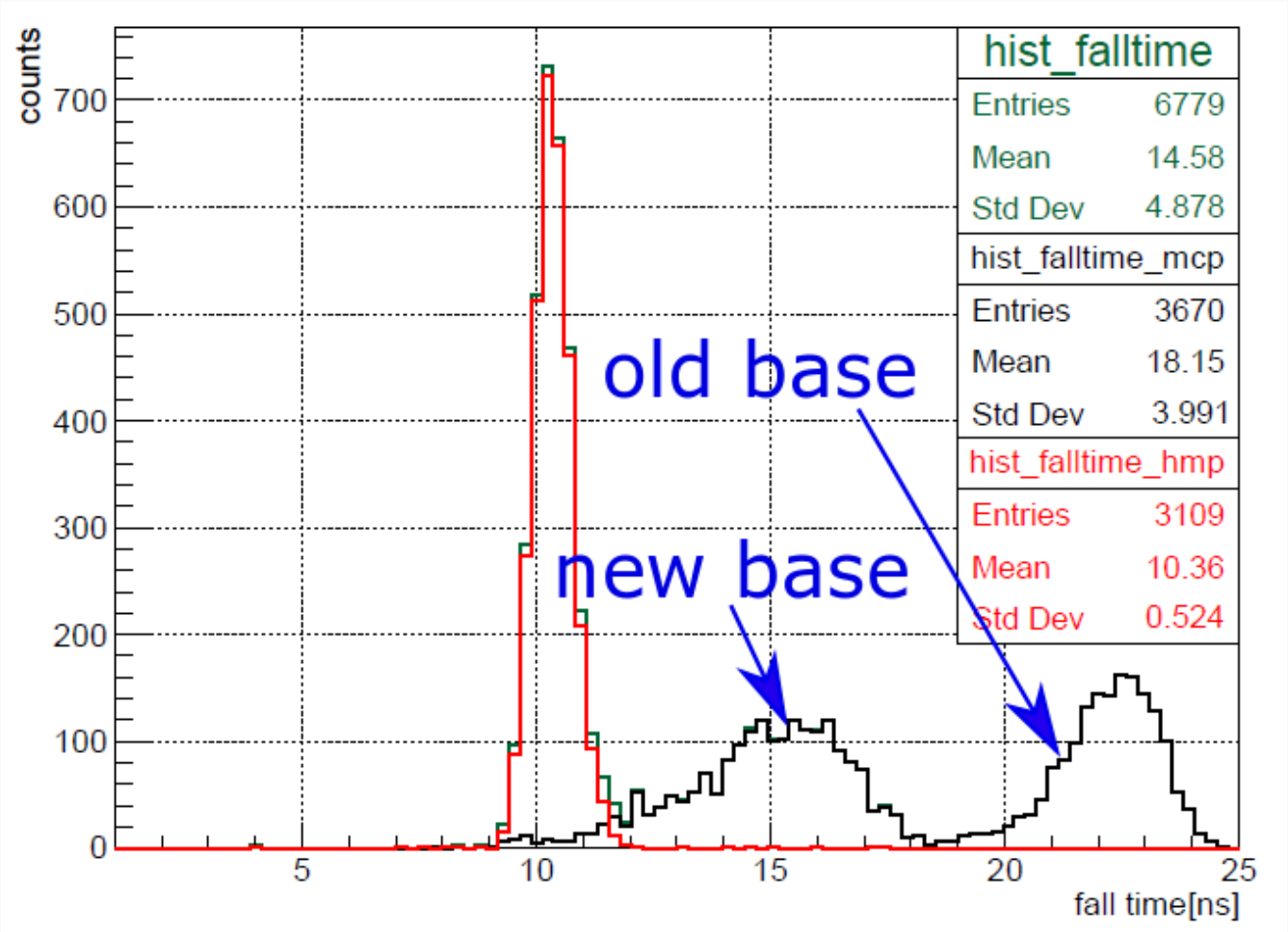


图 31: falltime distribution of PMTs

FWHM of PMTs

The fwhm of MCP PMT signal with new base is ∼5.8ns

The fwhm of HAMAMATSU PMT signal is ∼9ns

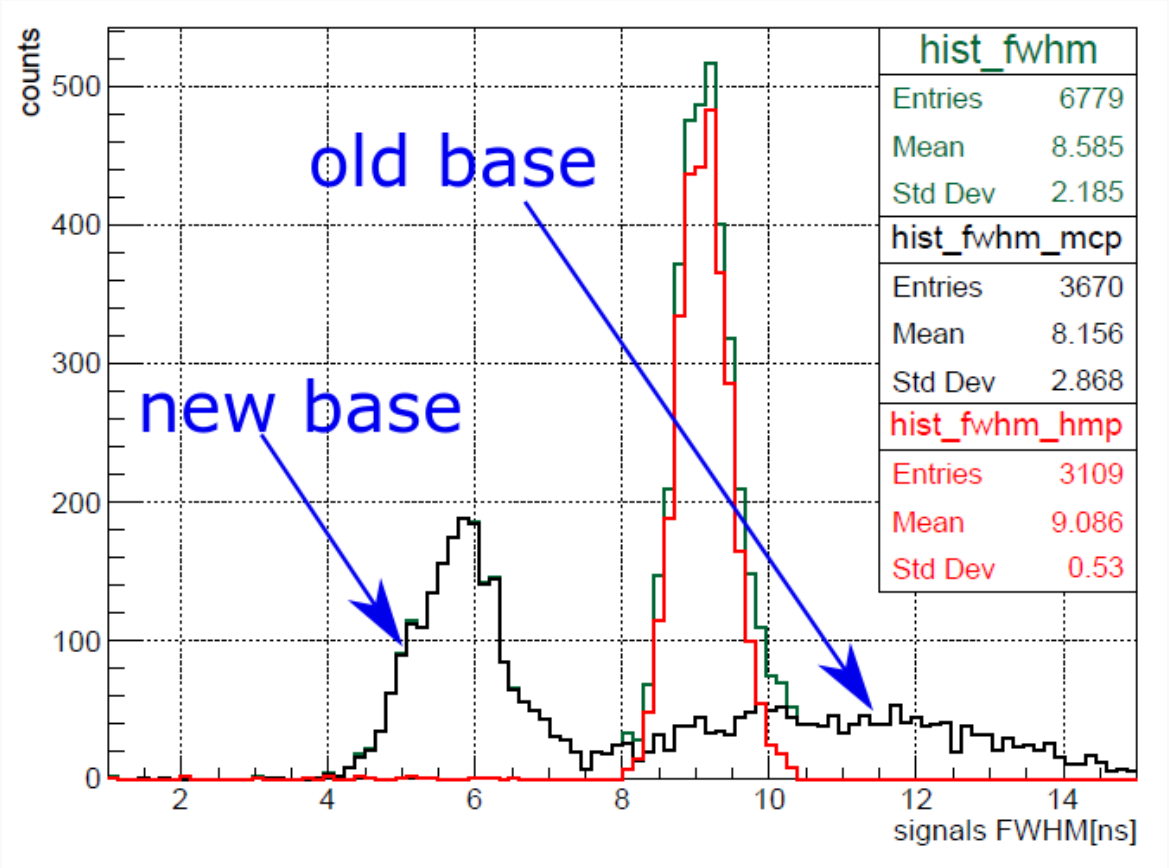


图 32: fwhm distribution of PMTs

spe amplitude of PMTs

The average single pe amplitude of MCP(with new base) is 9.2mV

The average single pe amplitude ofHAMAMATSU is 7.3mV

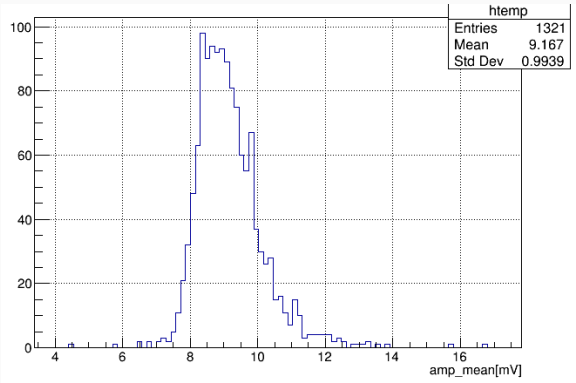


图 33: average spe amplitude of MCP PMTs (old base)

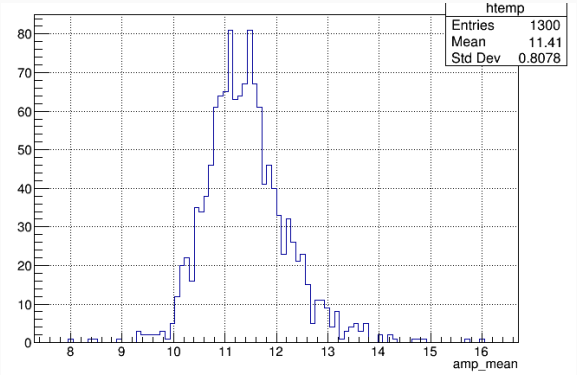


图 34: average spe amplitude of MCP PMTs (new base)

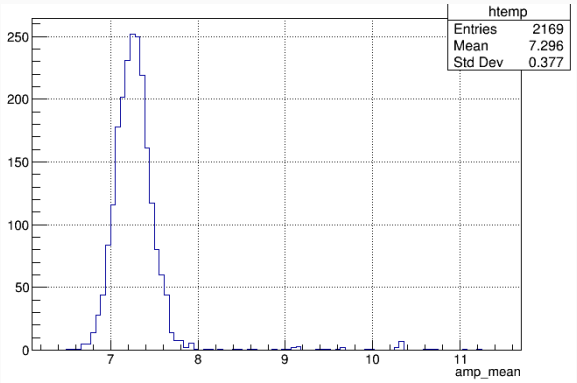


图 35: average spe amplitude of HAMAMATSU PMTs

The single p.e amplitude of HAMAMATSU PMT is more stable.

rsolution of PMTs

single p.e resolution is defined as $\frac{\sigma_{1pe}}{gain}$

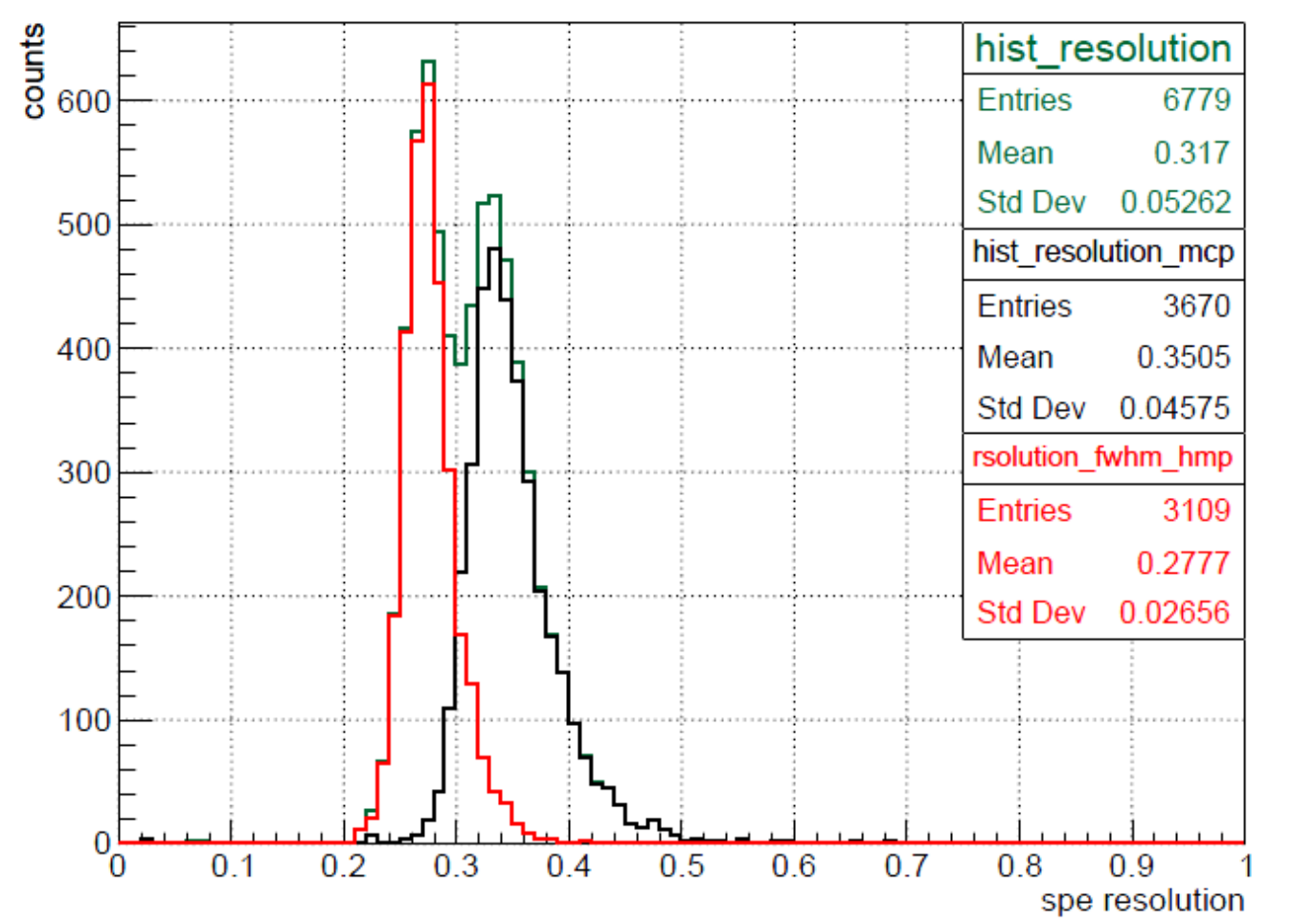


图 36: spe resolution of PMTs

PVR of PMTs

peak-valley ratio in the single p.e charge spectrum.

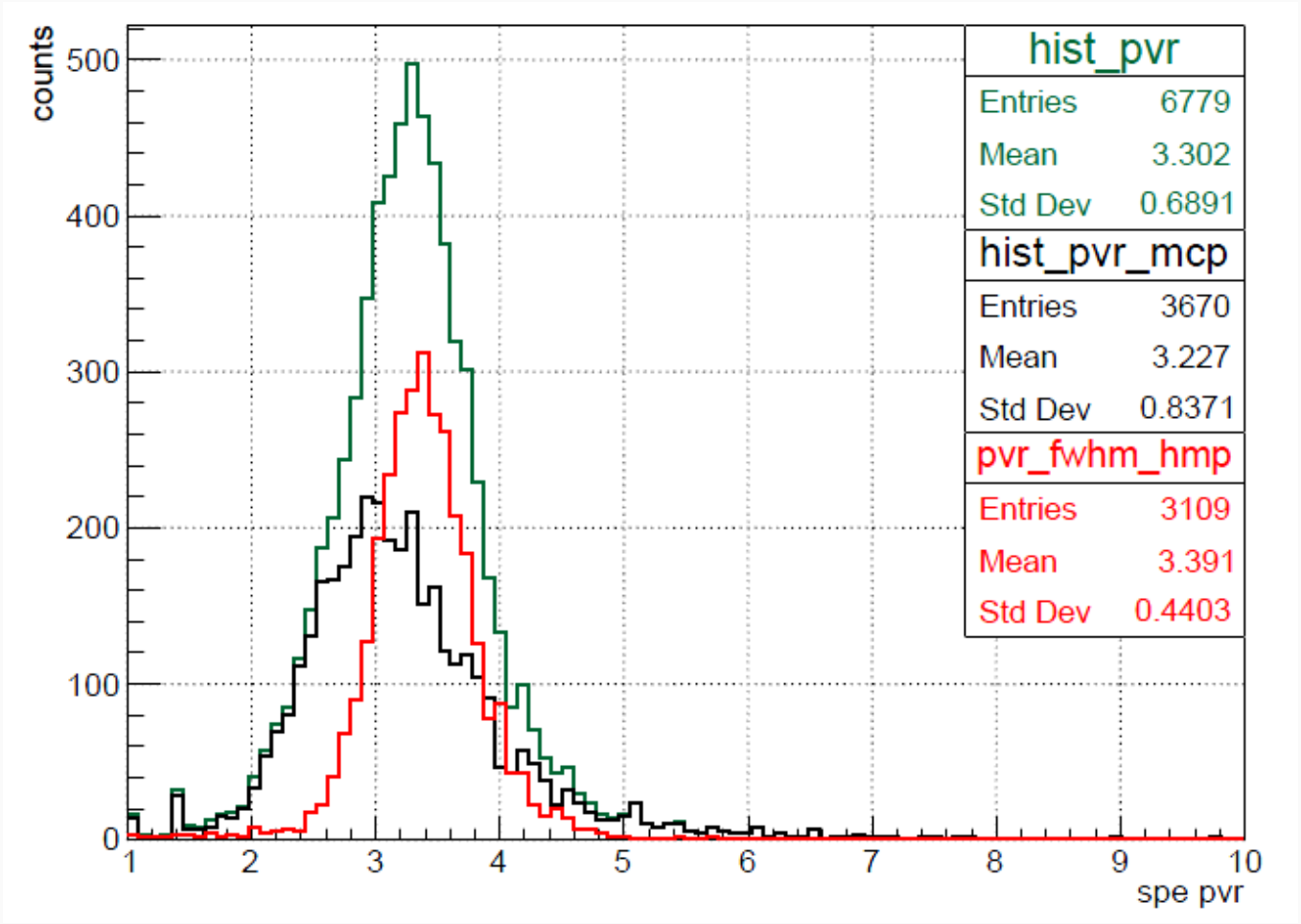


图 37: spe peak-valley ratio of PMTs

PDE of PMTs

Based on the vendor PDE value of HAMAMATSU PMTs.

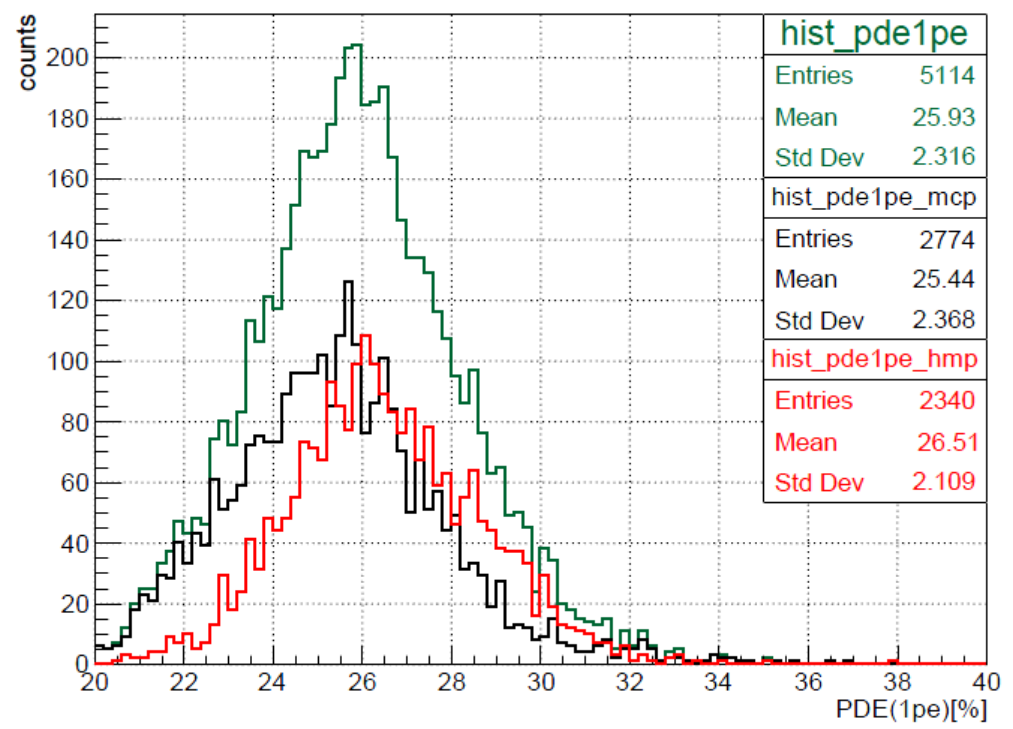


图 38: PDE of PMTs

Note that these PDEs are not final(approvaled) PDEs; they need to be mapped to scanning scanning results

TTS and AP

covered by haiqiong and yu chen's report.

Performance of High QE MCP Tubes

PDE of high-QE PMTs

From the 140 high QE tubes tested in containerA, high QE tubes have PDE ∼12% higher than the normal ones.

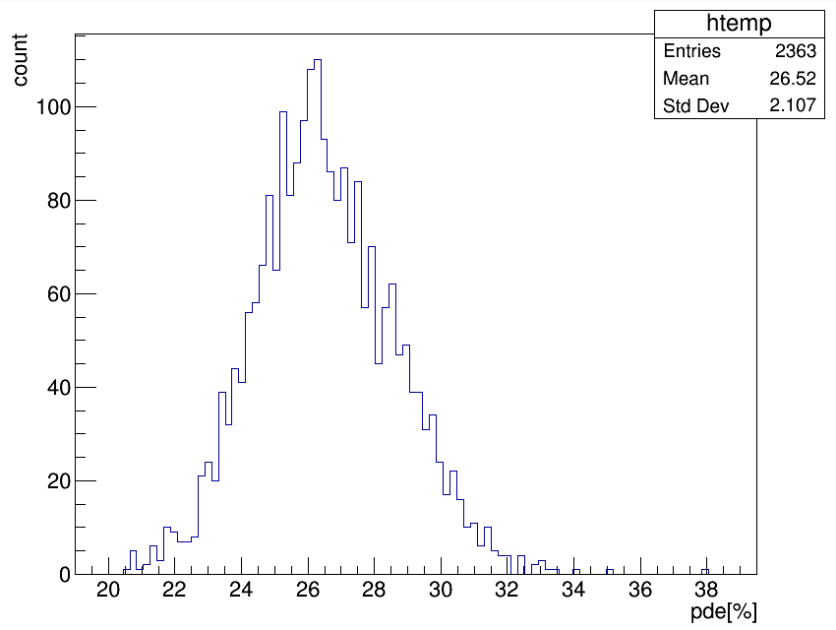


图 39: PDE of MCP PMT with normal QE

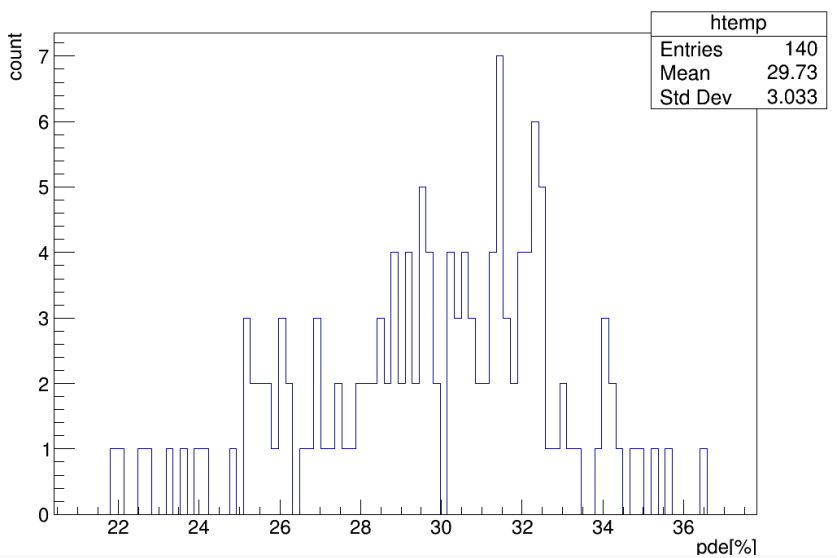


图 40: PDE of MCP PMT with high QE

DCR of high-QE PMTs

Correspondingly, theie average DCR result increase from ∼41kHz to ∼ 50kHz.

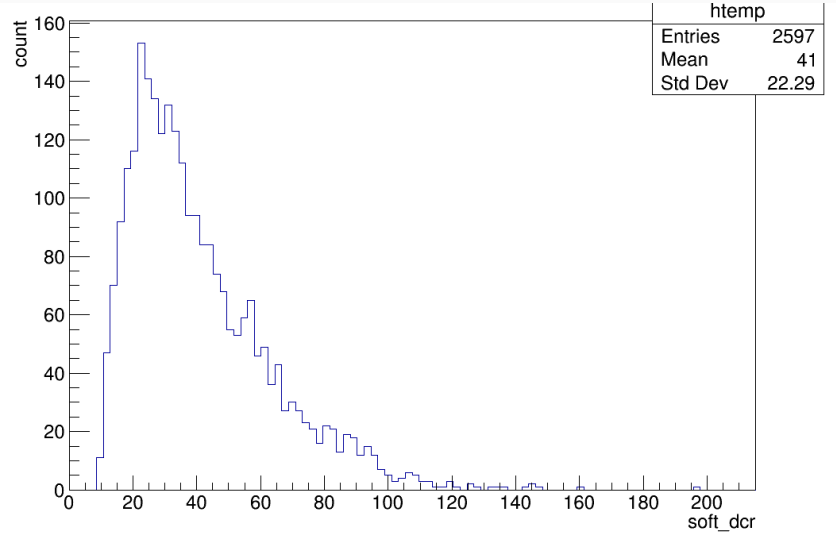


图 41: DCR of MCP PMT with normal QE

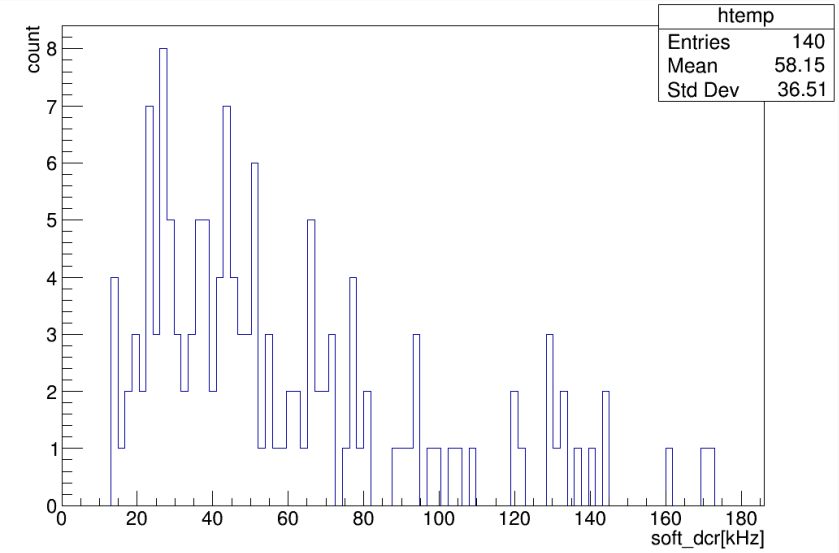


图 42: DCR of MCP PMT with high QE

summary

- more peolple are encouraged to join the PMT testing data analysis.
- some features of our PMTs are still not well understood.
- new batches of MCP PMTs have ($\sim$ 12%)higher PDE than previous ones.

BACK-UP

pde vs. dcr

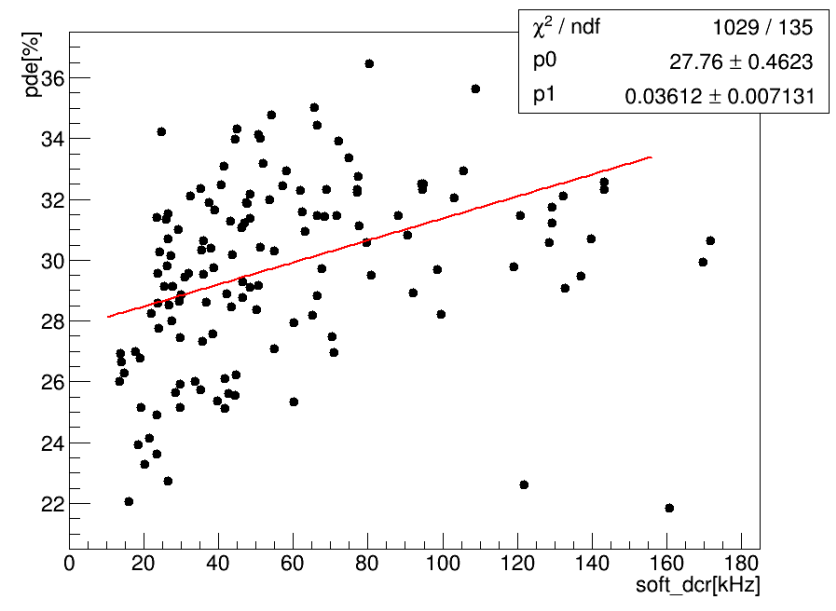


图 43: DCR vs. PDE of MCP PMT with high QE

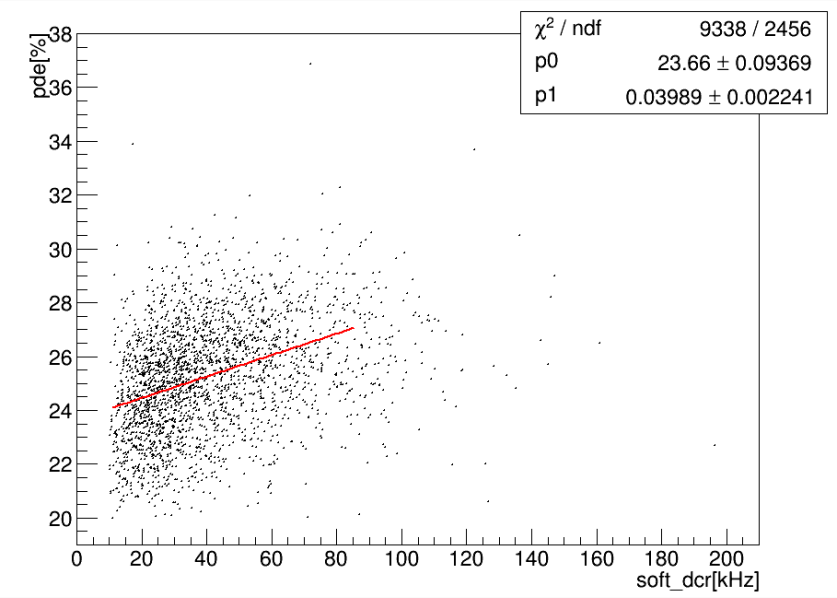


图 44: DCR vs. PDE of MCP PMT with normal QE