

Performance from Mass Testing of JUNO 20" PMTs

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Motivation

MOTIVATION

➢ 20k 20" tubes will be used in JUNO detector system to achieve the energy resolution $3\%/\sqrt{E_{vis}}$.

➢ The scanning station is designed to scan the uniformity of photocathode with point light, and define the global photon detection efficiency (PDE).

- Tested Parameters in container:
- Photon Detection Efficiency (PDE)
 - TTS
 - Risetime/Falltime
 - HV for 10⁷
 - dark count rate (DCR)
 - P/V ratio and charge resolution
 - Pre-pulse
 - After-pulse

SUMMARY

➢ Two containers are being used for the acceptance testing, and will cover most of the parameters.

➢ The system designed with ~1% absolute PDE (~3% relative uncertainty).

➢ More than 4200 tubes (received ~9000 tubes till now) have been tested.

Acknowledgements

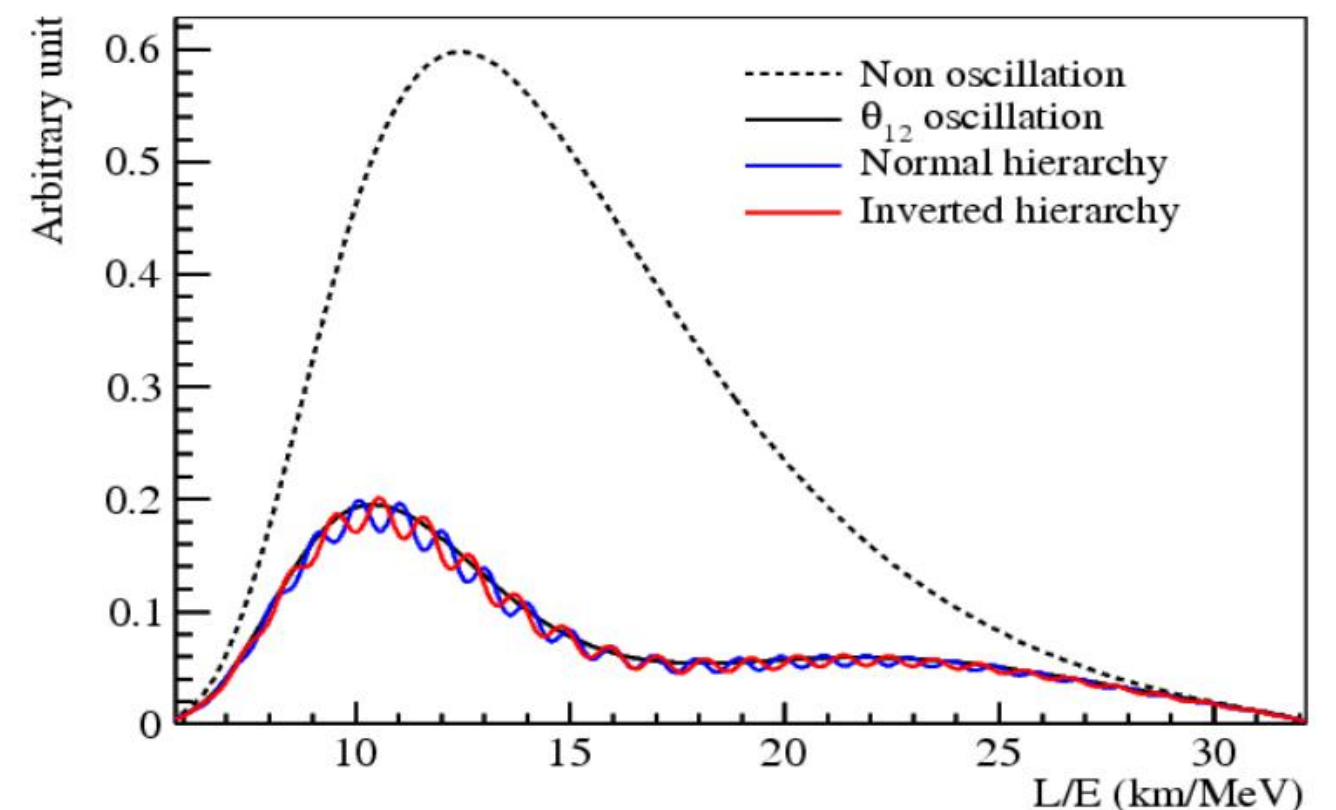
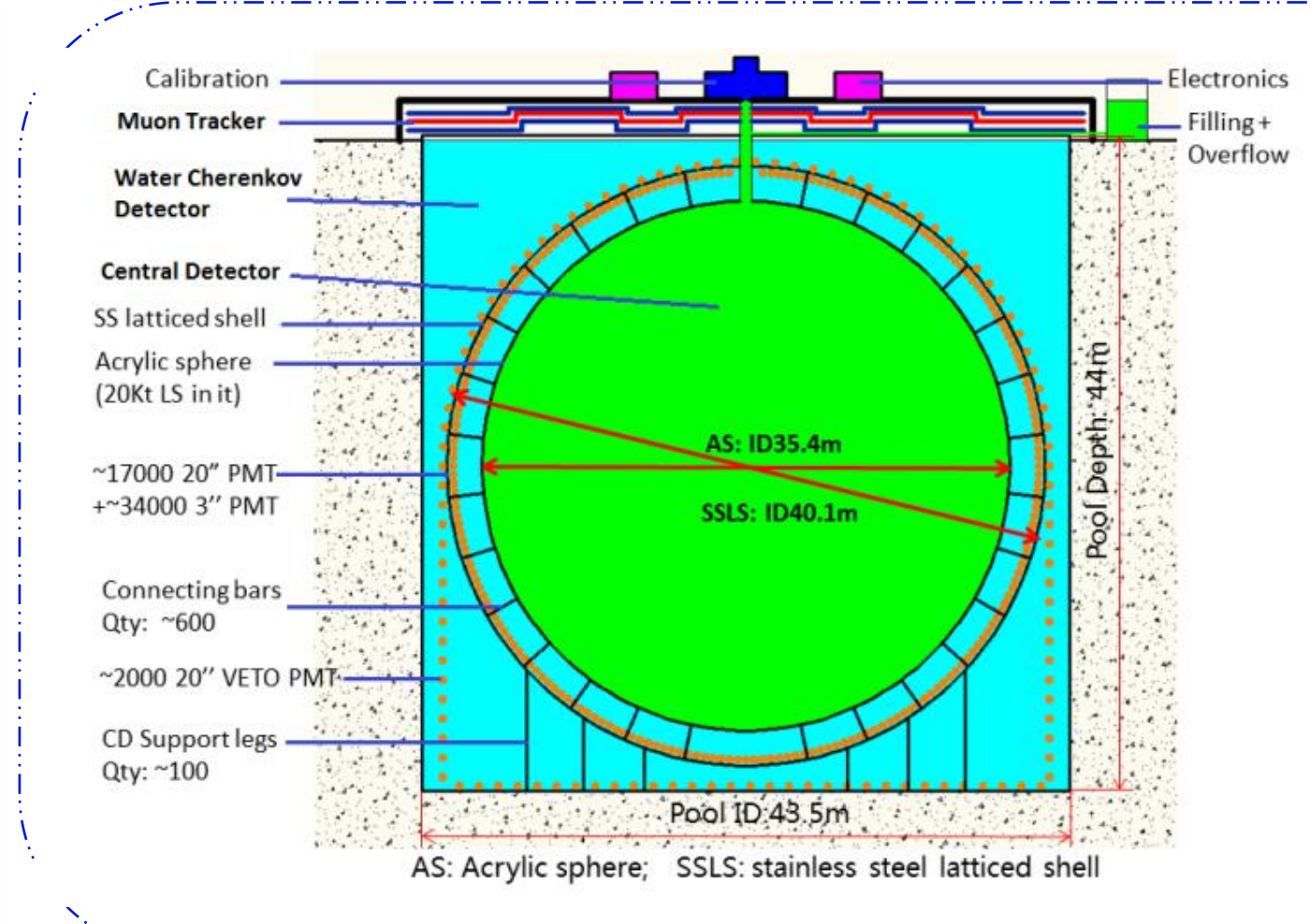
➢ The container system was supported by the Deutsche Forschungsgesellschaft (DFG).

➢ Many thanks to the University of Tuebingen and the University of Hamburg.

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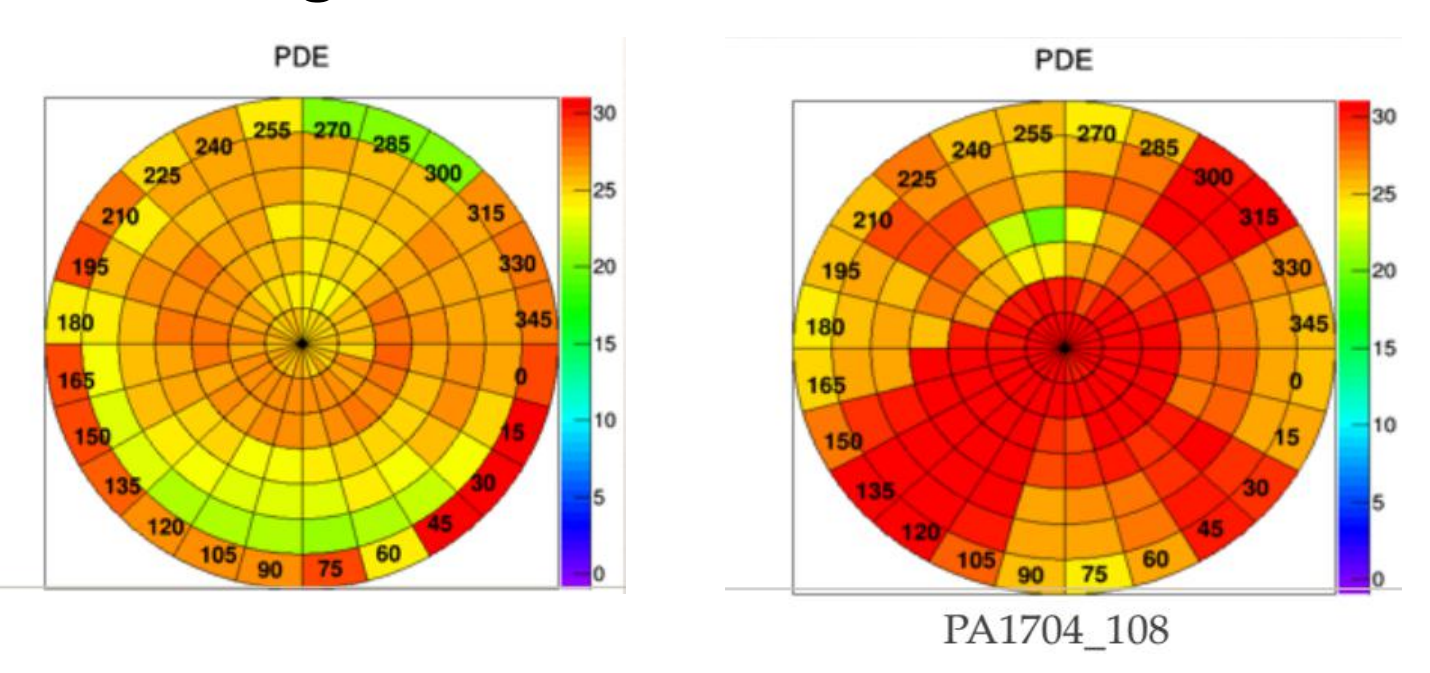
11th International Neutrino Summer School (a WE-Heraeus-Summer School)



- The energy resolution 3%@1MeV requires the central detector (CD) of JUNO with great PMT configuration
- ✓ 75% PMT coverage (20k 20" tubes)
- ✓ High PDE;
- ✓ High charge resolution and P/V;
- ✓ Low DCR;

Testing&Parameters

Scanning Station



$$PDE: \text{point light to surface light } DE = \sum_{i=1}^n DE_i * Weight_i$$

PDE: measured relative PDE (newCF) to defined PDE

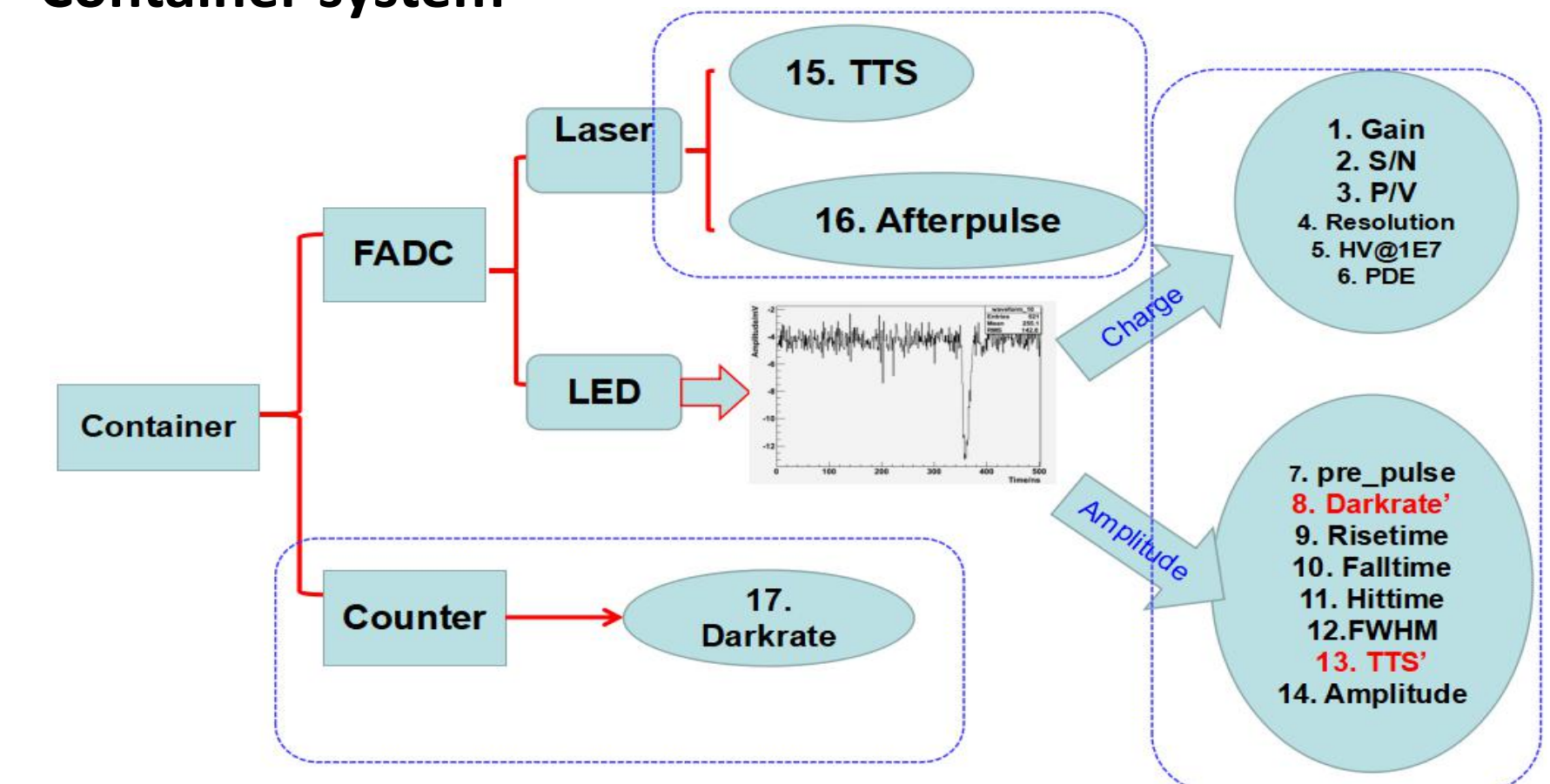
The detected average light intensity (photoelectron) is proportional to the photon detection efficiency.

The relative PDE from container (newCF) is corrected the drawer difference and will be converted to the defined final $PDE = A * newCF + B$ PDE following the definition.

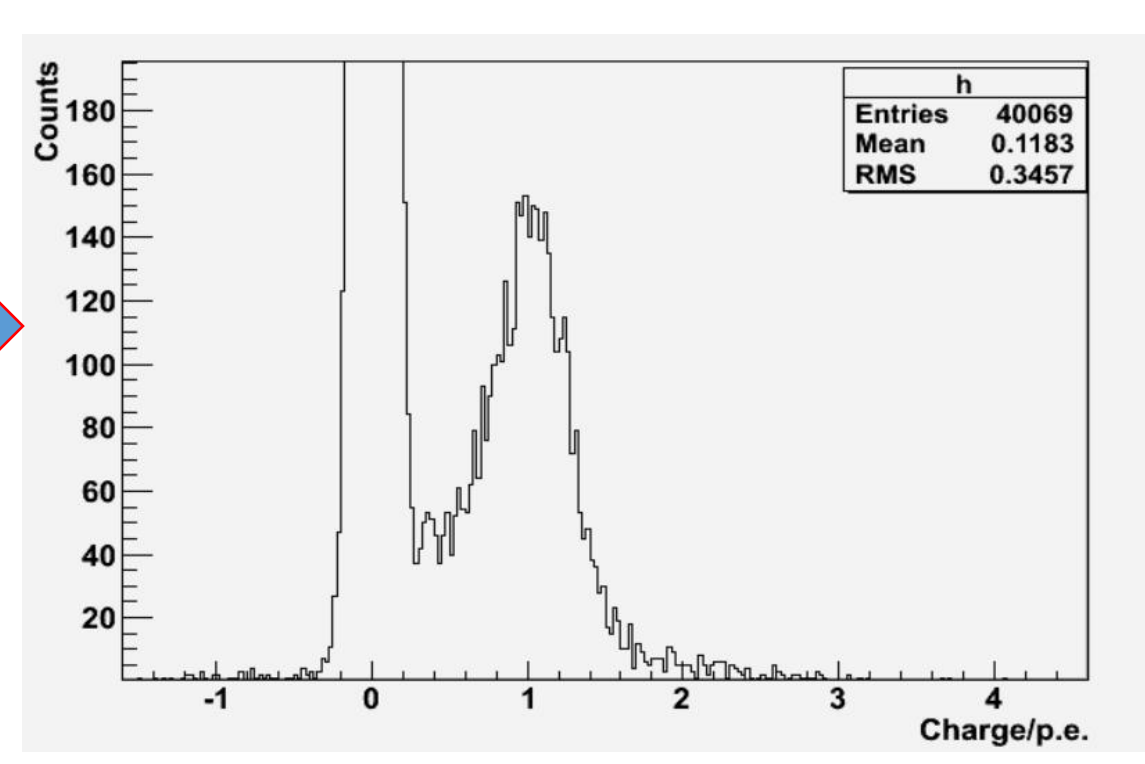
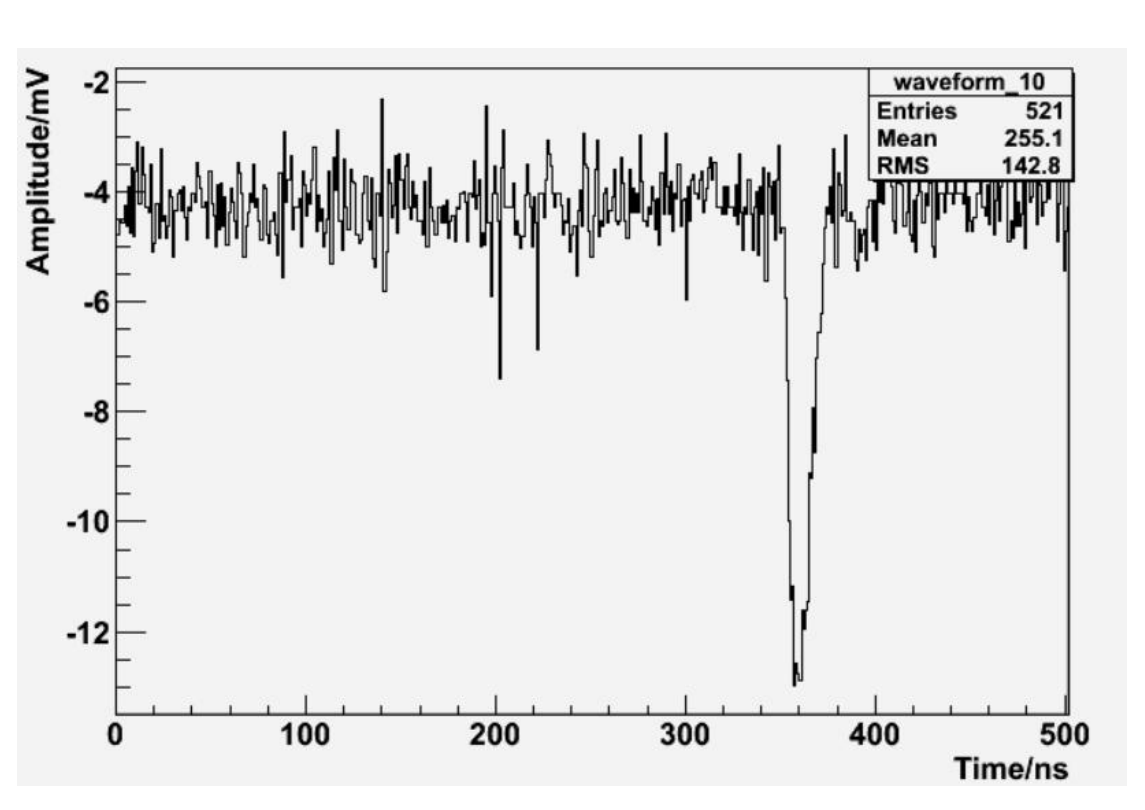
$$\mu = -\ln P(0) = -\ln \left(\frac{N_{ped}}{N_{total}} \right)$$

$$newCF = \mu * factor$$

Container system

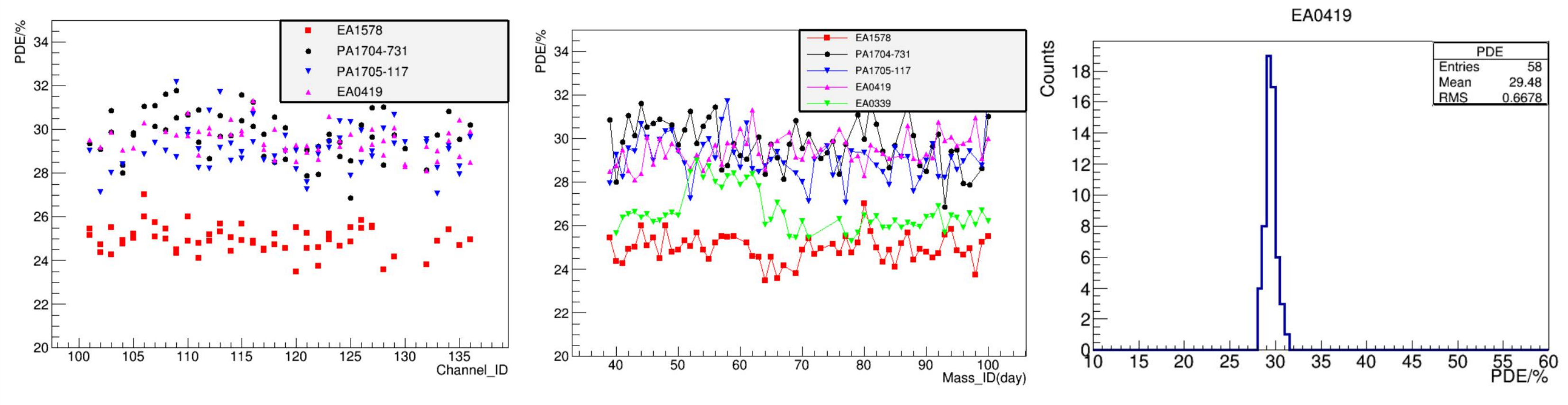


- Commercial electronics and automatic testing software
- followed by waveform reconstruction to charge spectrum to get all the parameters



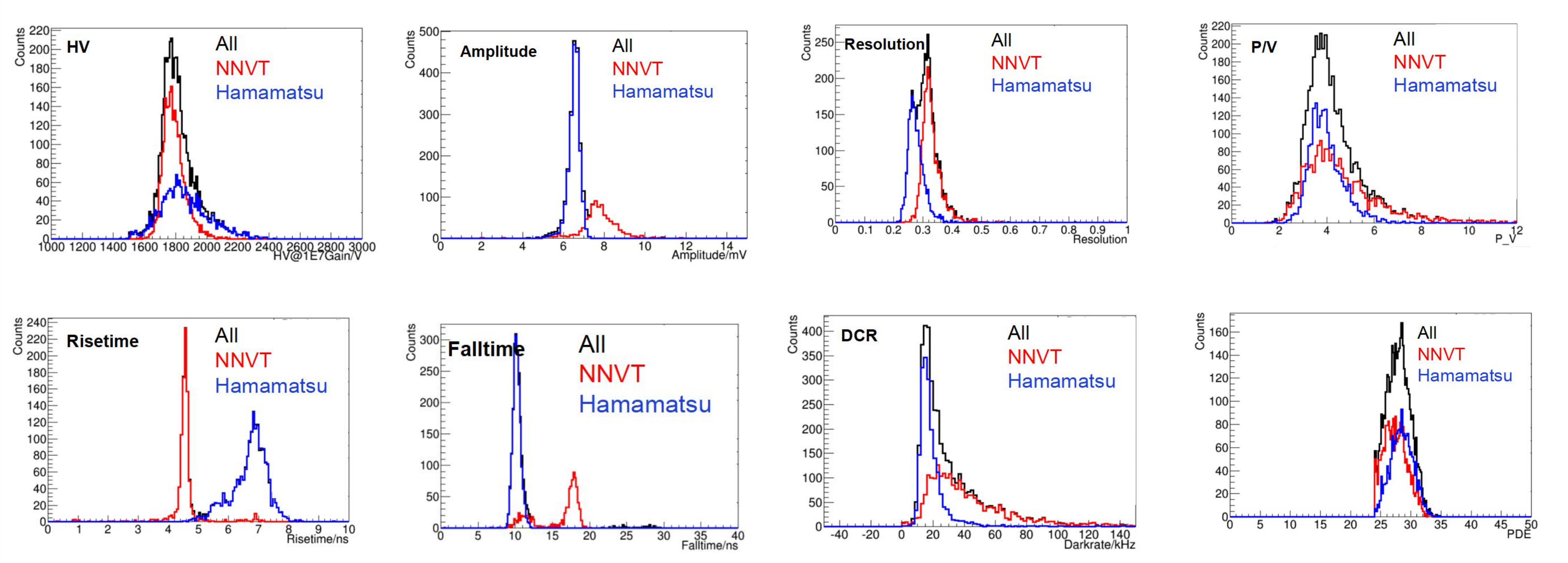
Uncertainty

➢ The relative uncertainty of PDE test less than 4% for container system, which means the absolute uncertainty of PDE is about 1%.



PMT_ID	Relative Uncertainty of PDE RMS/MEAN(%)
PA1704-731	3.65
PA1705-117	3.42
EA1578	2.51
EA0419	2.27
EA0339	3.51

Pre-results



PMT TYPE	HV(V)	Amplitude(mV)	Resolution(%)	P/V	Risetime(ns)	Falltime(ns)	DCR(KHz)	PDE(%)
NNVT	1790	7.66	32.95	4.62	4.54	15.85	42.51	27.45
Hamamatsu	1859	6.51	27.67	3.99	6.70	10.21	19.10	28.49

- Amplitude: peak amplitude of SPE
- Resolution: charge resolution of SPE