Noise Spectrum and Photon Response of MCP-PMT

– based on the onsite PMT testing data

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Outline

1. Brief Introduction
2. traing and test of CNN
3. Summary

photon response characters of MCP PMT

typical waveform and charge spectrum of MCP PMT@gain $=10^7$ [dark noise]

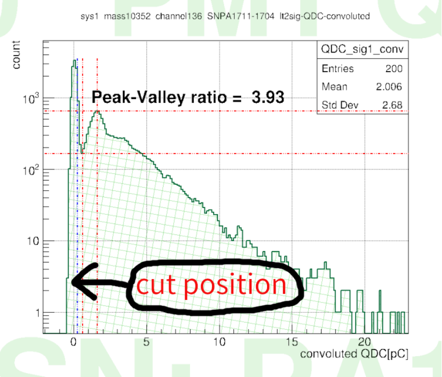


图: "cut" the charge spectrum to count pedestal events

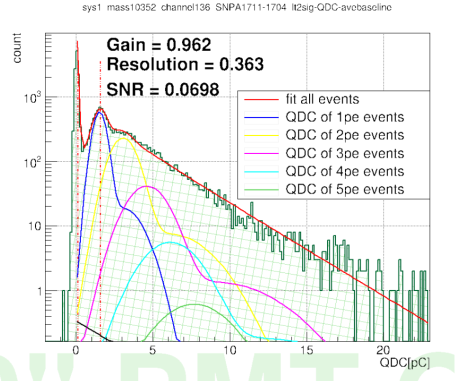


图: fit using a PMT photon response model

CNN

CNN can perform a powerful PSD and classify the waveforms, then we could get explicit p.e during one test.

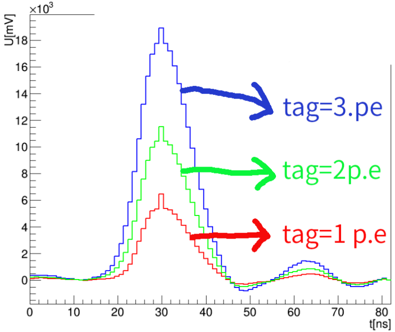


图: tags of typical waveform from CNN

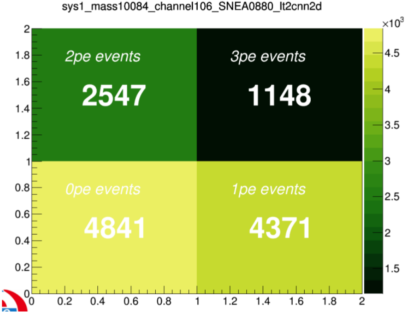


图: classification of events in one test

the expected photon number

If we do a "cut" is the charge spectrum@0.25 spe, the averager photon number μ can be acquired by[1]

$$\mu = -ln(\frac{N_0}{N}) \tag{1}$$

where N_0 is the number of pedestal(0 p.e) events, N is the total event number.

However, if we know explicitly the photon number of specific event, the μ value is :

$$\mu = 1 \times n_1 + 2 \times n_2 + \cdots + N \times n_N \tag{2}$$

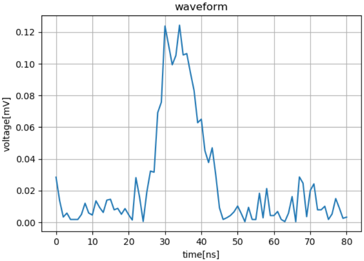
where n_N is the number of N p.e events.

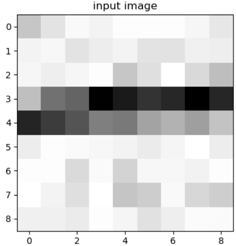
[1] E. H. Bellamy et al /Nucl. Instr. and Meth. m Phys . Res. A 339 (1994) 468-476

input of CNN

training data slecetion and pre-process:

- random selection from different PMTs
- 1.5<QDC<1.7 for 1p.e
- 3.1<QDC<3.3 for 2p.e
- 4.7<QDC<4.9 for 3p.e
- 81ns ROI $\rightarrow 9 \times 9$ 2D image
- normalization





CNN parameters

- 30k training waveform samples
- 2 convolution layers
- 4 output tags
- accuracy$\simeq 0.95$

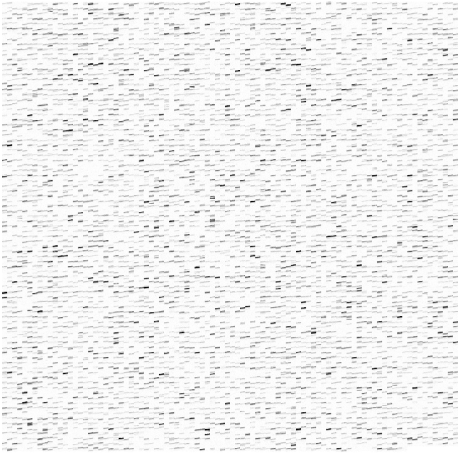


图: input data

results of cnn

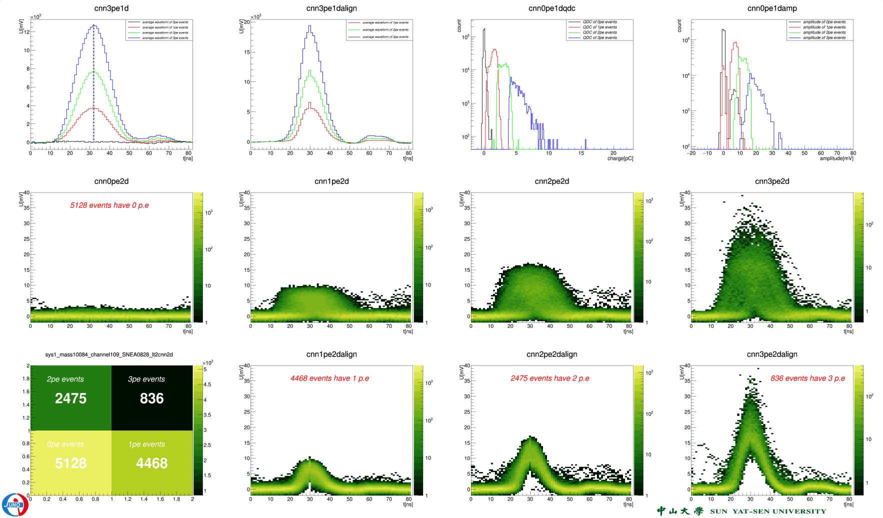


图: HAMAMATSU PMT

results of cnn

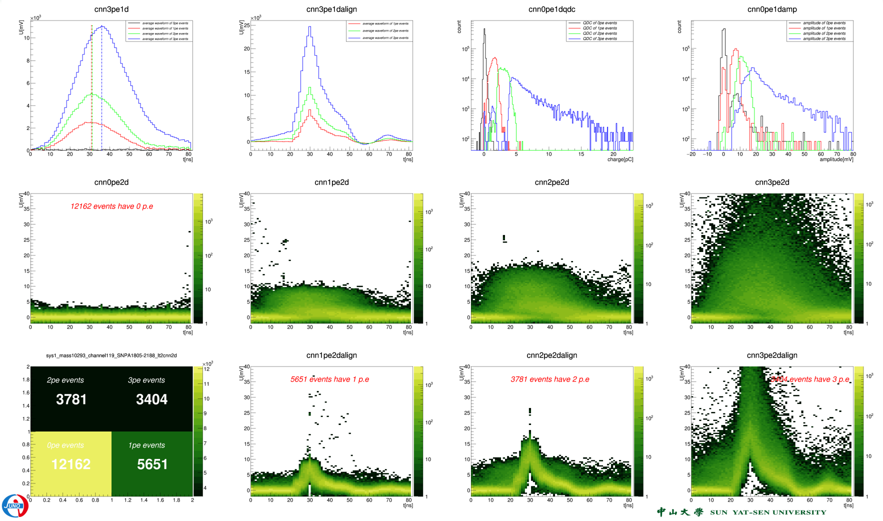


图: NNVT PMT

summary

- PSD by CNN provide a new option for PDE evaluation.
- can achieve *sim*0.95 acuuracy with the traditional method using simple NN.
- much faster than traditionl methods in PDE evaluation.
- CNN can ectract more infromation from waveforms.

to list:

- refine the training samples and network structure.
- compare the accuracy in more details, for example using the reference tubes in container system.
- improve the input data quality.

THANKS

BACK-UP