Photon Response Model of MCP-PMT

– based on the onsite PMT testing data

Email： zhaor25@mail2.sysu.edu.cn

School of Physics

中山大學
SUN YAT-SEN UNIVERSITY

Outline

the "big signals" of MCP PMT

The "long tail" in charge spectrum.[1]

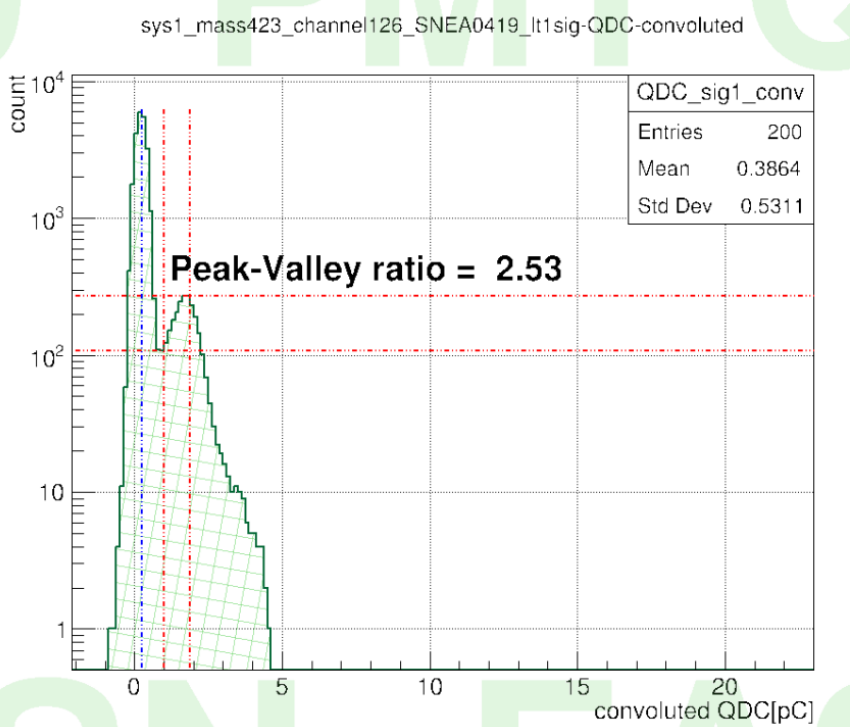


图: SPE of HAMAMATSU PMT

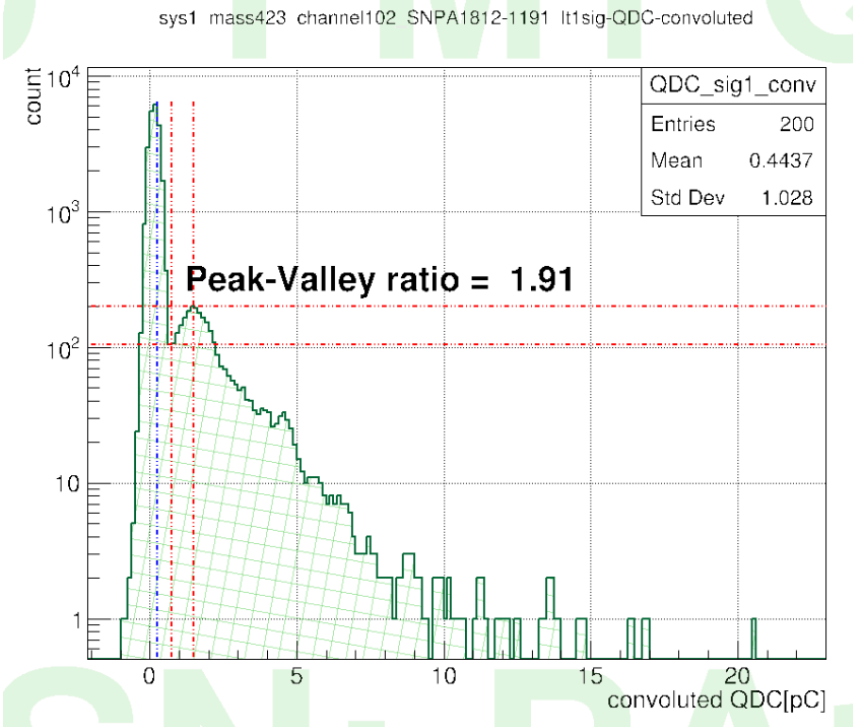


图: SPE of MCP PMT

[1] gain= 1E7, $\mu = sim0.1$

photon response characters of MCP PMT

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

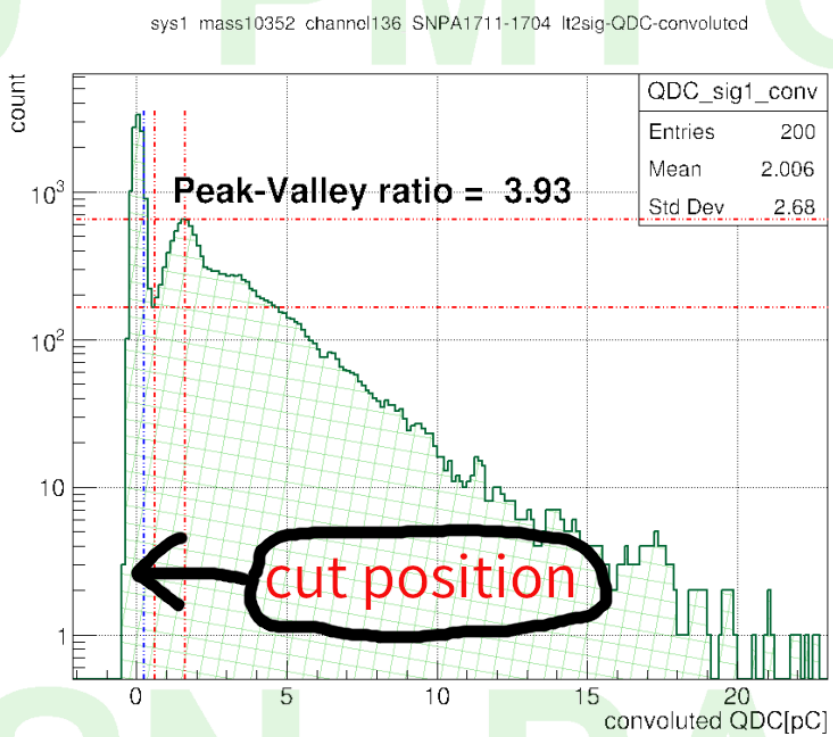


图: "cut" the charge spectrum to count pedestal events

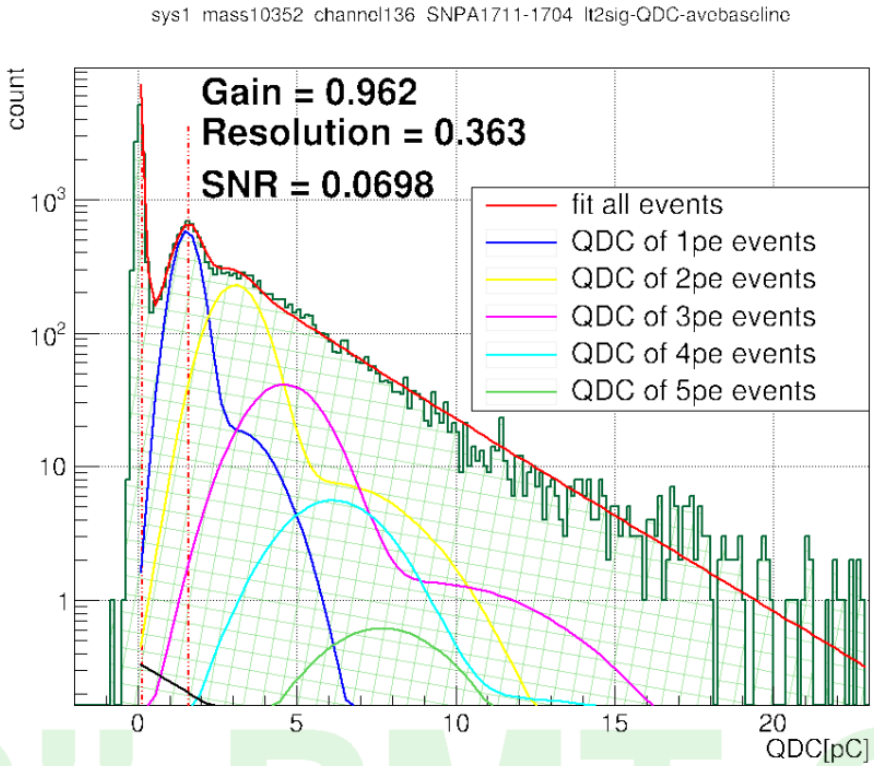


图: fit using a PMT photon response model

CNN

select the time interval before ”trigger window”.

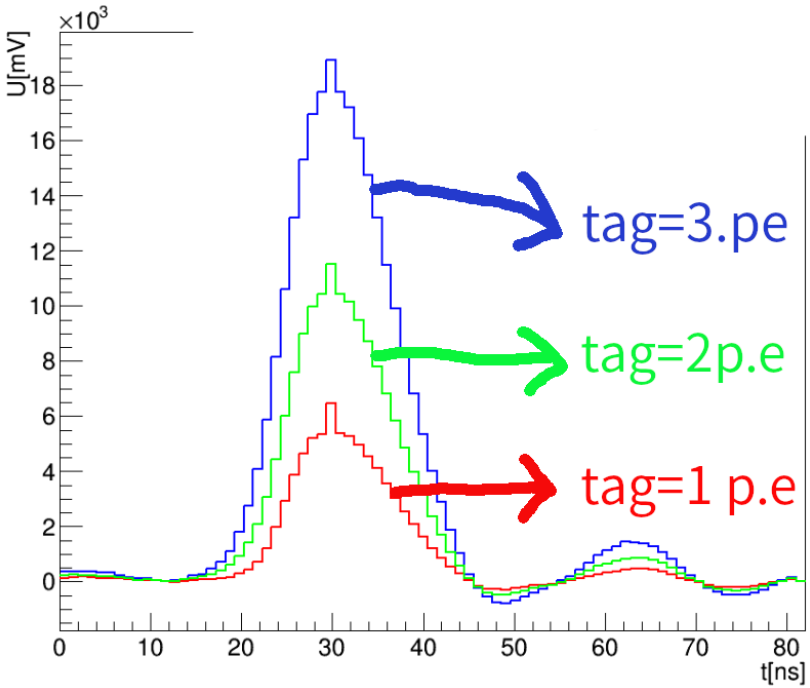


图: tags of typical waveform from CNN

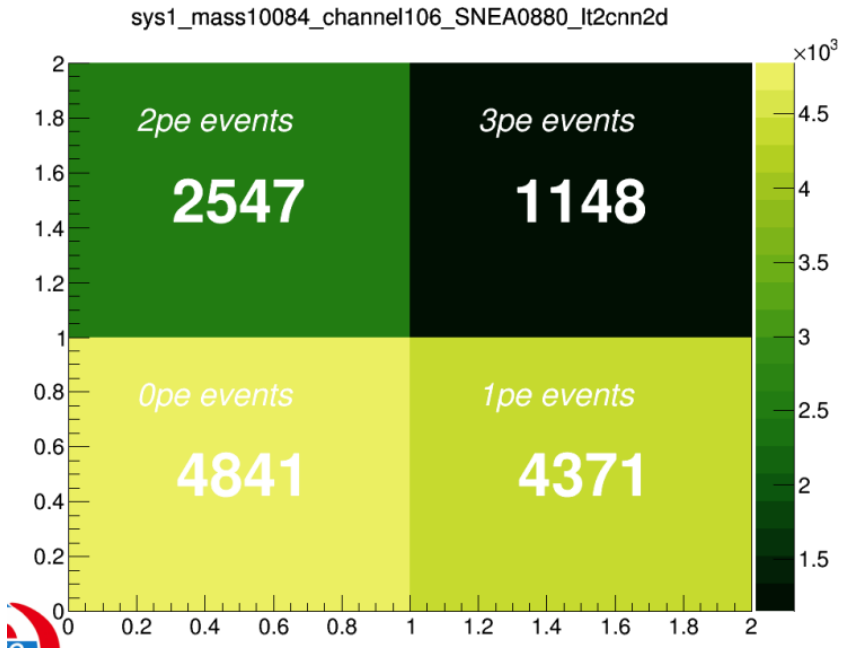


图: classification of events in one test

01pe

the 0.1pe case

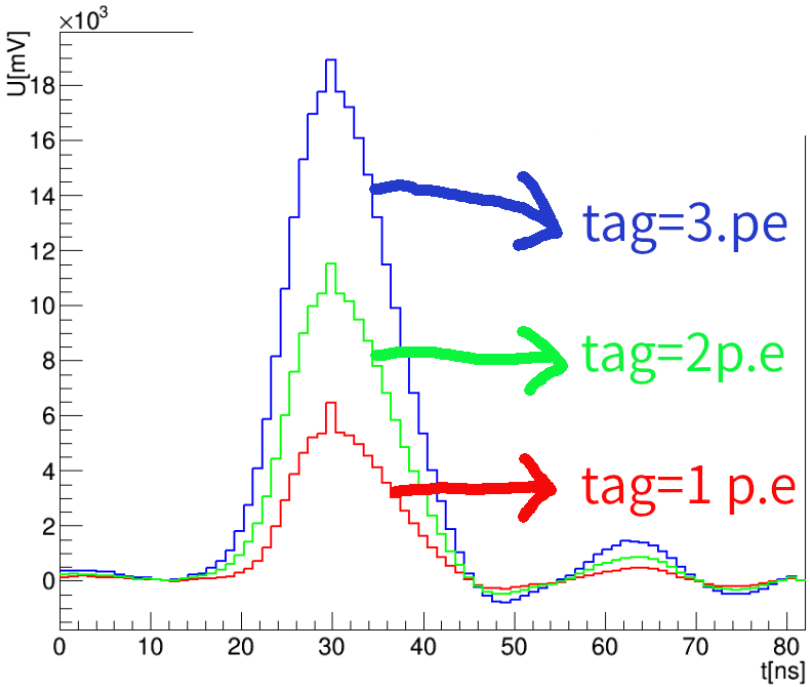


图: tags of typical waveform from CNN

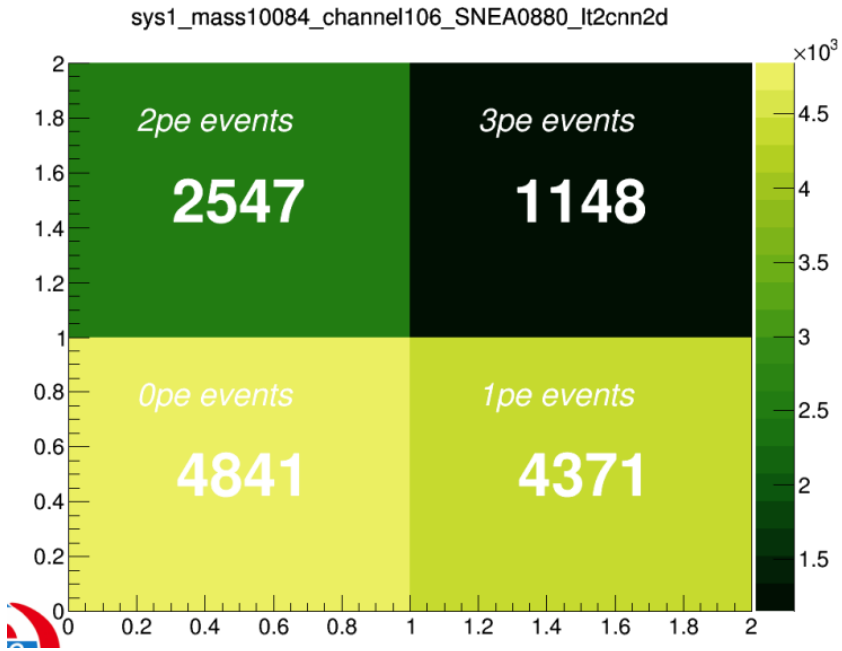


图: classification of events in one test

01pe

the 1pe case

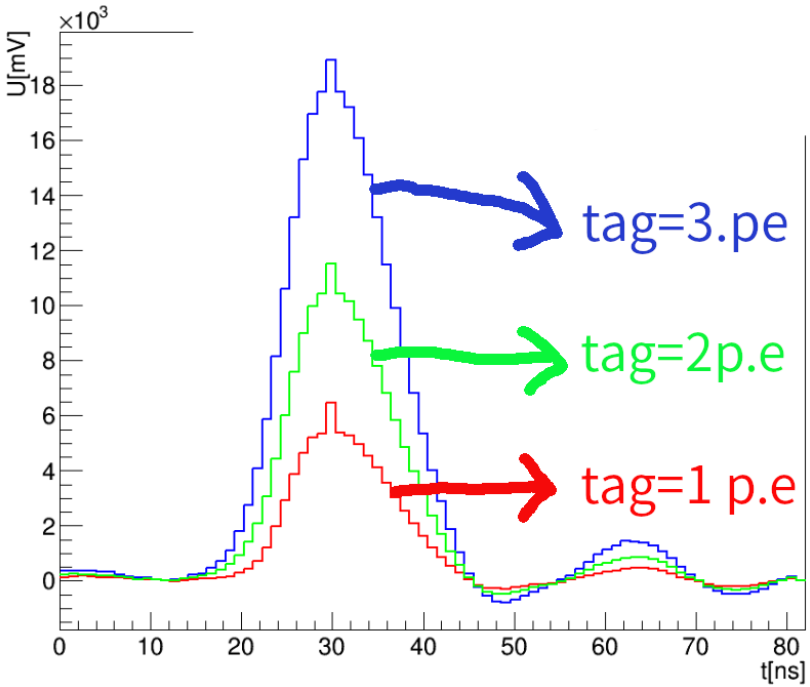


图: tags of typical waveform from CNN

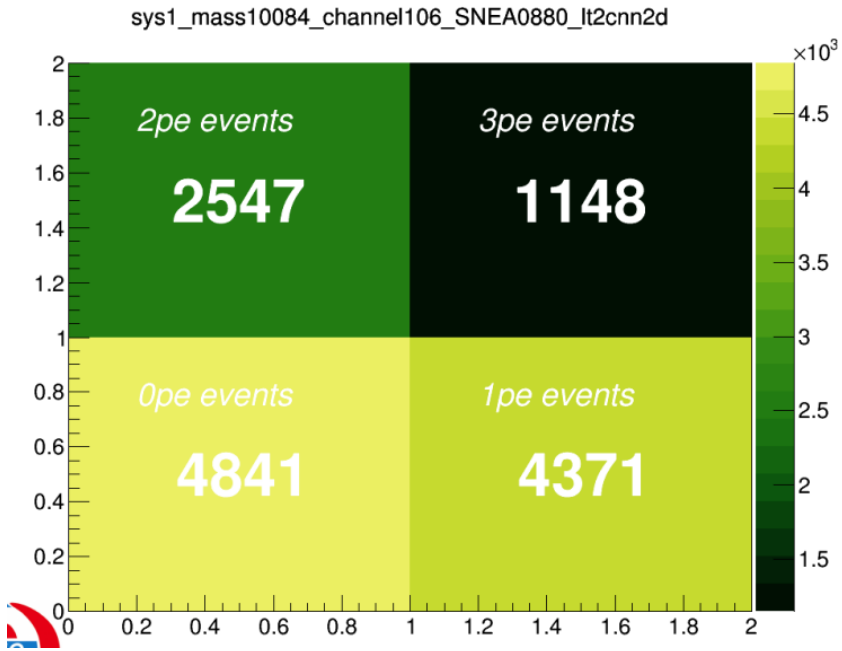


图: classification of events in one test

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[2]

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

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 :

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

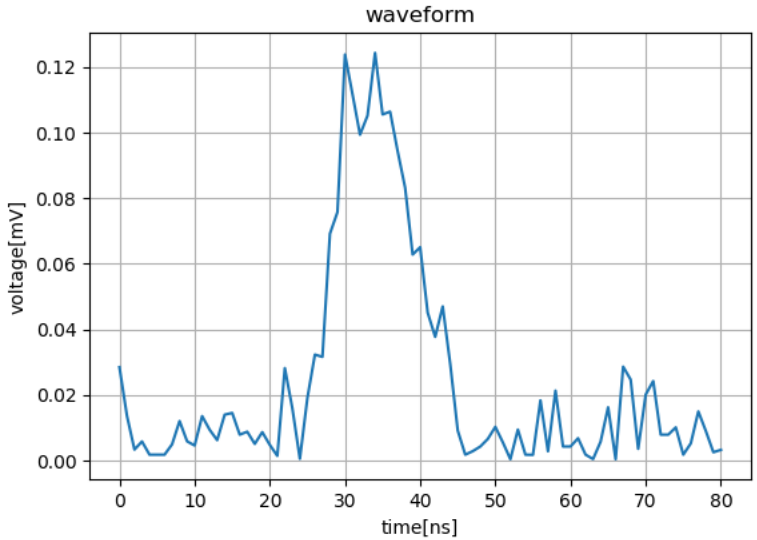
where n_N is the number of N p.e events.

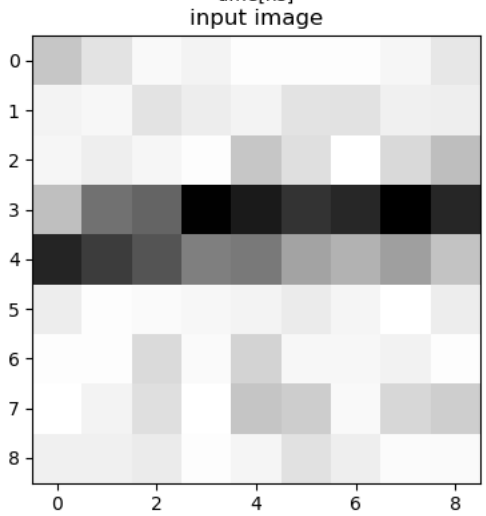
[2] E. H. Bellamy et al /Nucl. Instr. and Meth. m Phys . Res. A 339 (1994) 468-476

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 $\rightarrow$ 9×9 2D image
- normalization





CNN parameters

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

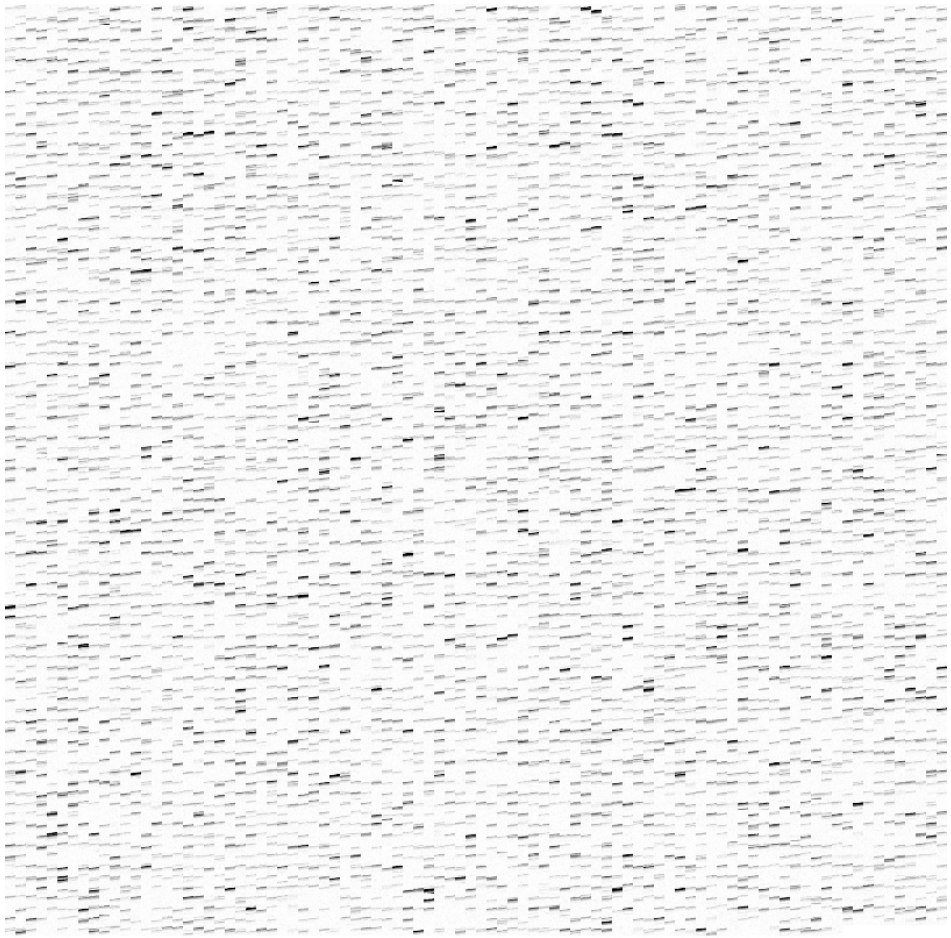


图: input data

results of cnn

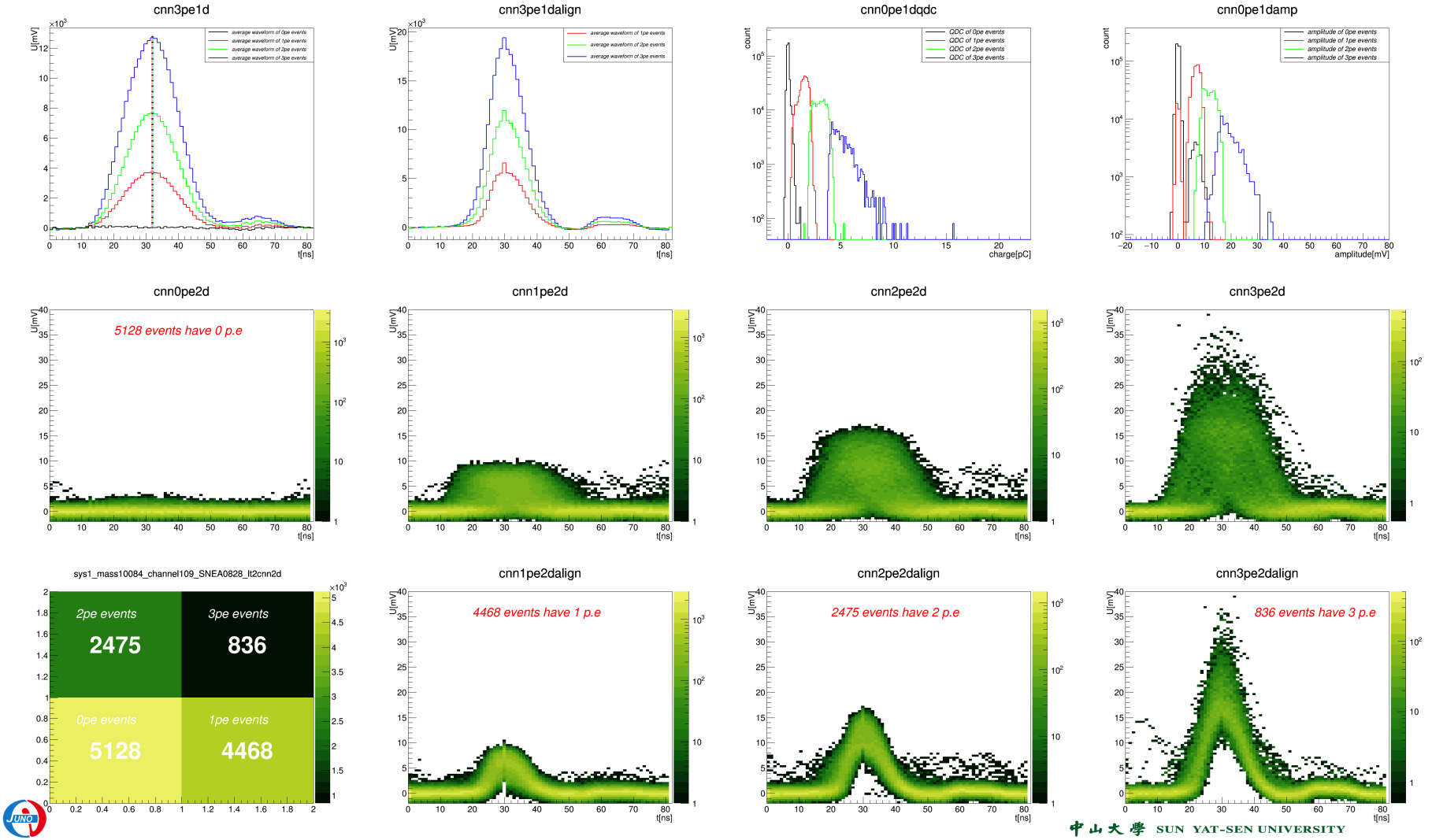


图: HAMAMATSU PMT

results of cnn

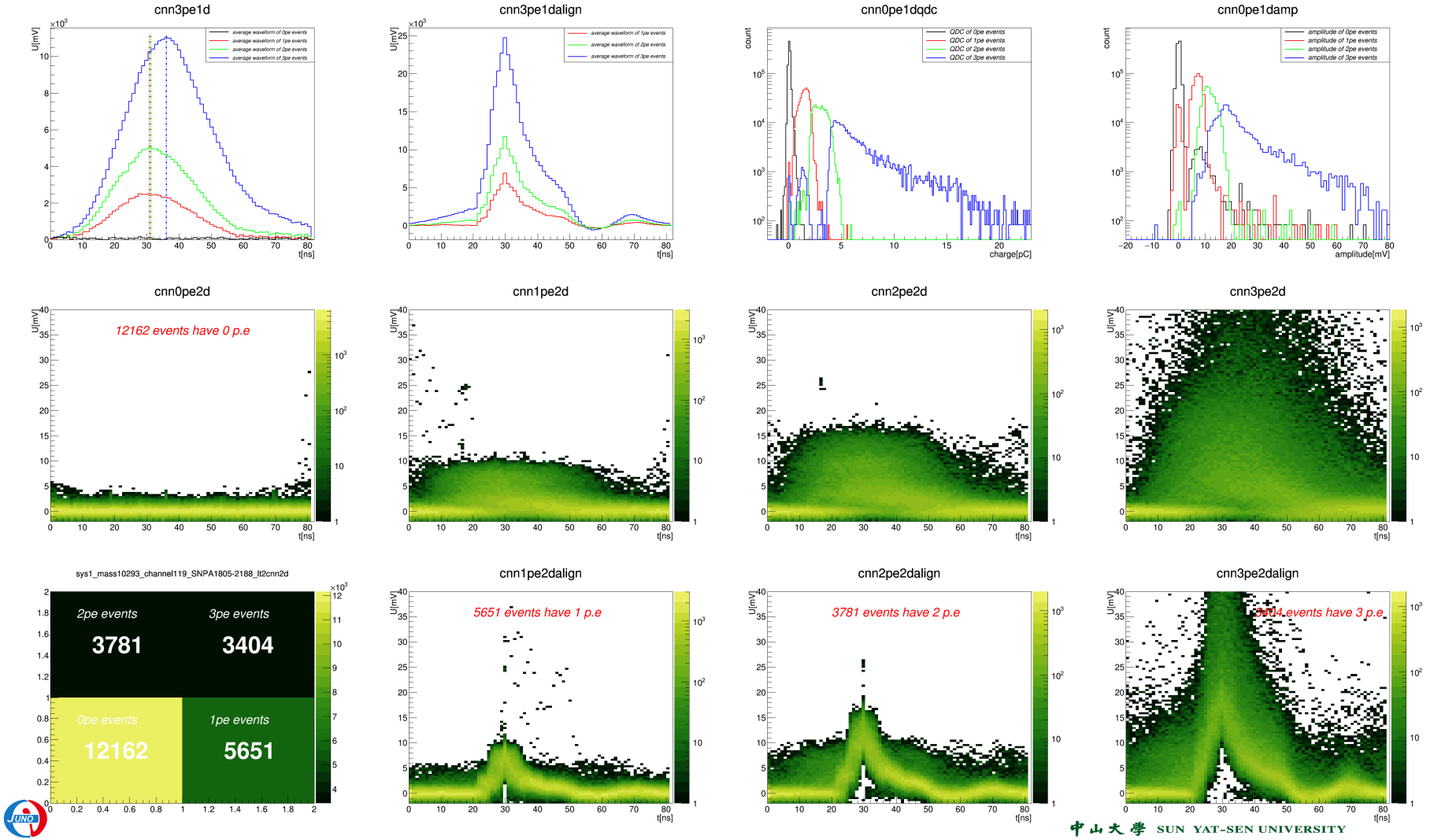


图: NNVT PMT

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