Brief Introduction
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traing and test of CNN
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Noise Spectrum and Photon Response of MCP-PMT

– based on the onsite PMT testing data

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School of Physics

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Outline

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photon response characters of MCP PMT

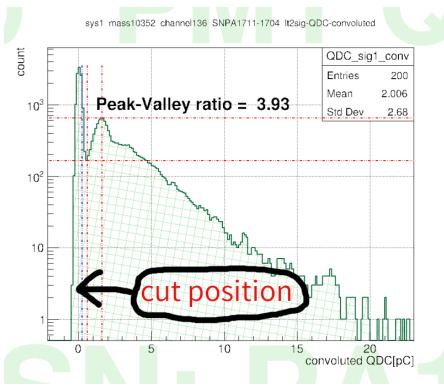The typical waveform and charge spectrum of MCP PMT@gain $=10^7$ [dark noise]

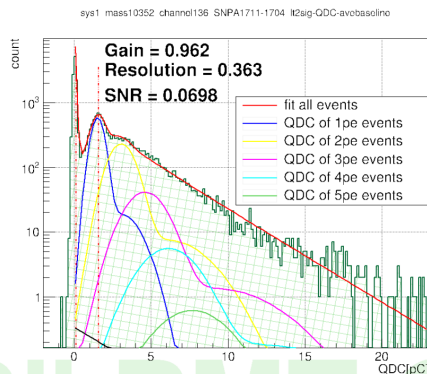图: "cut" the charge spectrum to count pedestal events

图: fit using a PMT photon response model

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the "long tail" of charge spectrum,unexpected "big signals"

图: HAMAMATSU

图: MCP

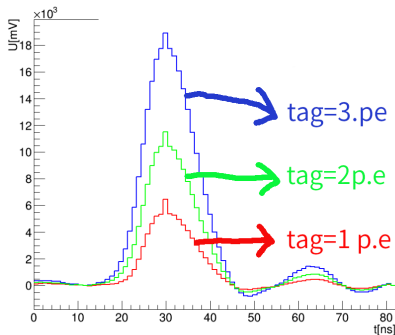**Brief Introduction**
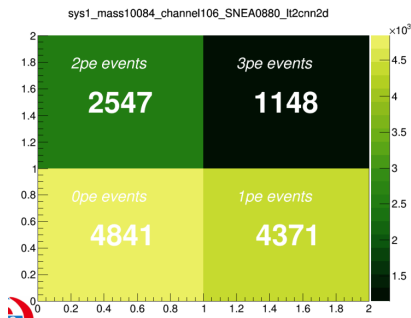OOO●OOO

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CNN

select the time interval before "trigger window".

图: tags of typical waveform from CNN

图: classification of events in one test

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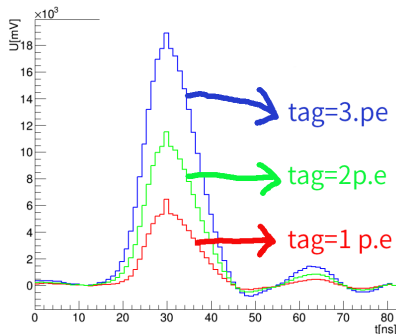**Summary**
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01pe

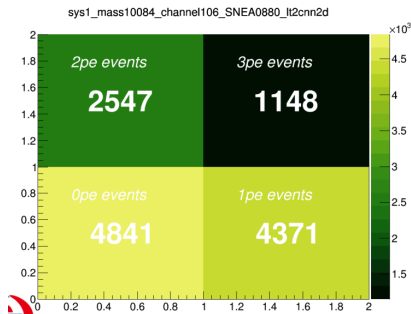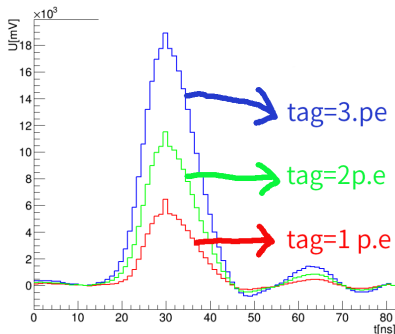the 0.1pe case

图: tags of typical waveform from CNN

图: classification of events in one test

01pe
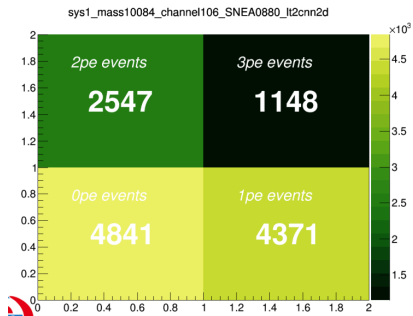
the 1pe case

图: tags of typical waveform from CNN
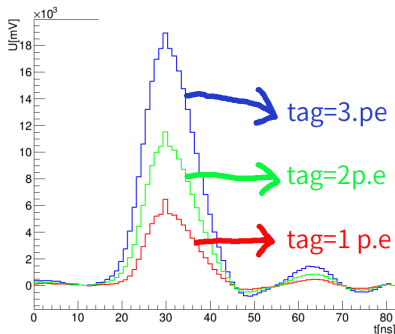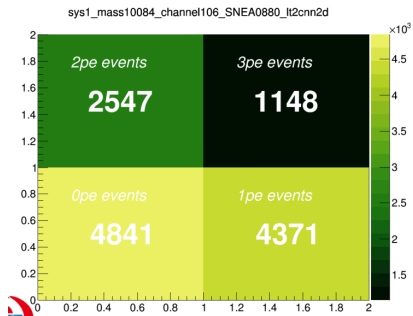

图: classification of events in one test

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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]

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

$$\mu = 1 \times n_1 + 2 \times n_2 + \cdots + N \times n_N$$ (2)

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

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

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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 → 9×9 2D image
- normalization

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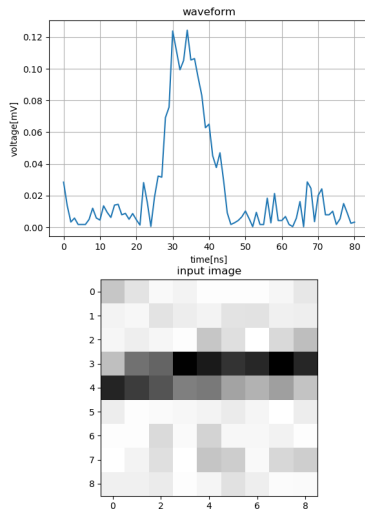
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CNN parameters

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

图: input data

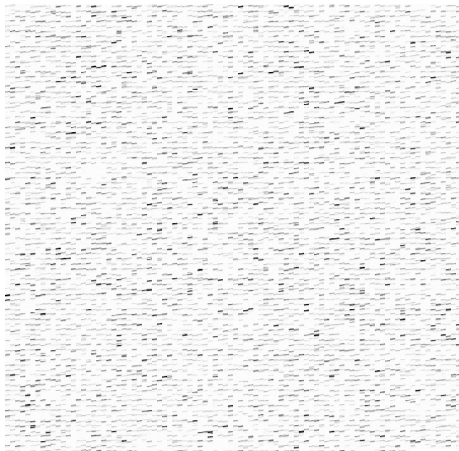Brief Introduction
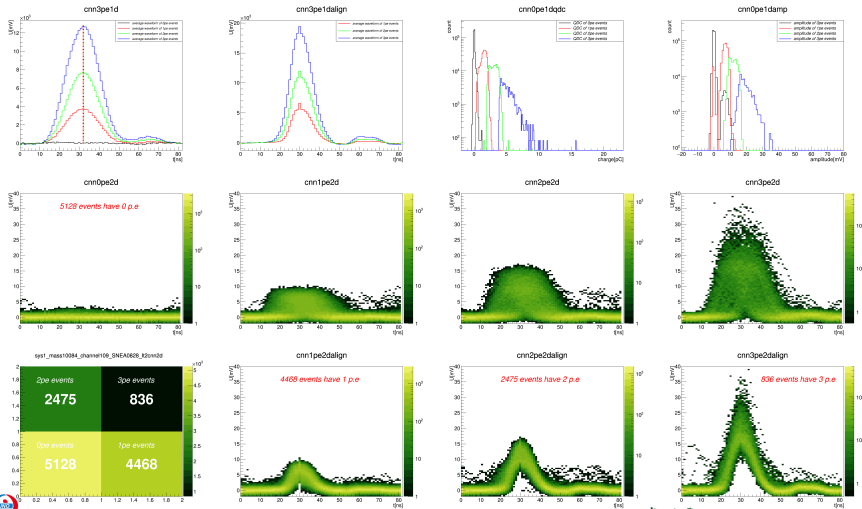○○○○○○

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results of cnn

图: HAMAMATSU PMT

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results of cnn

图: NNVT PMT

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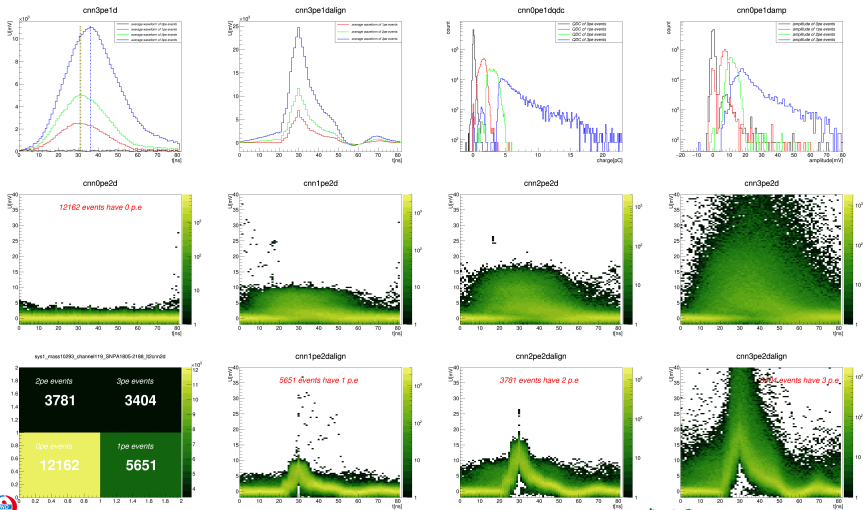## summary

- 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

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