

CNN For High Energy - Validation -

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Review – Training Data Selection

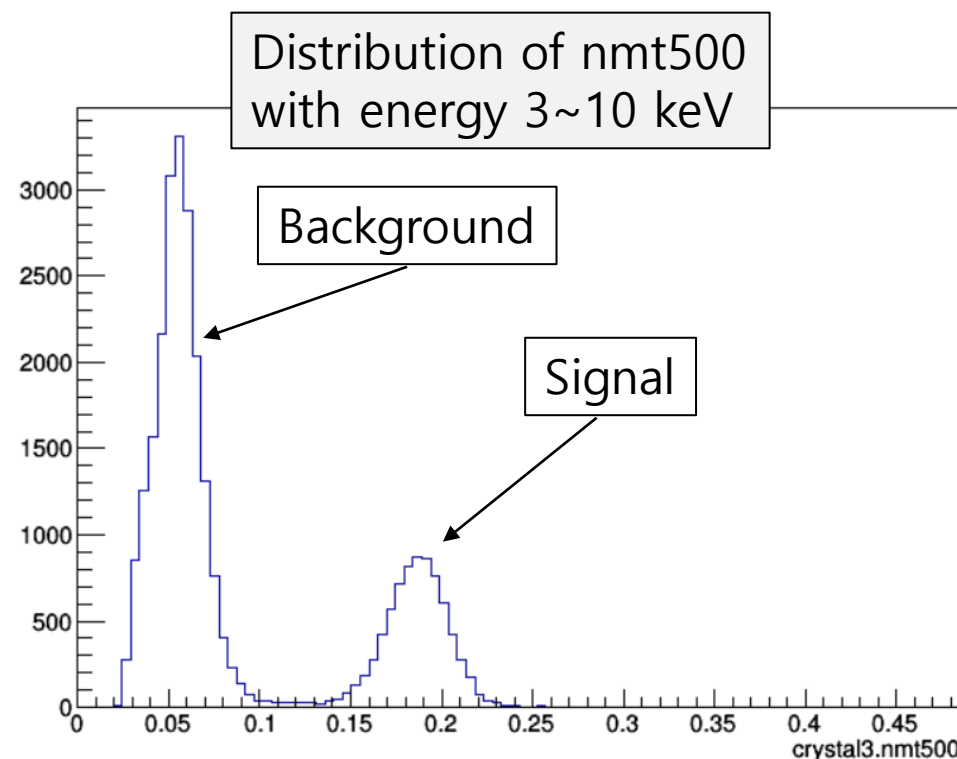
- Training data was selected using criteria below.

- Signal tag

- Runnum 1765, 1601 (Calibration run)
 - Have coincidence
 - $N_{mt500} > 0.12$

- Background tag

- Runnum 1858, 1859 (Physics run)
 - No coincidence
 - $N_{mt500} < 0.12$



Review – CNN Structure

- 1dimensional CNN motivated by AlexNet was successful!
- Batch norm., ReLU activation applied.

Input shape	Layer	Output shape
(4080, 2)	Conv1D(filters=96, kernel_size=39, strides=3)	(1348, 96)
(1348, 96)	MaxPool1D(pool_size=4)	(337, 96)
(337, 96)	Conv1D(filters=256, kernel_size=23)	(315, 256)
(315, 256)	MaxPool1D(pool_size=3)	(105, 256)
(105, 256)	Conv1D(filters=384, kernel_size=9)	(97, 384)
(97, 384)	Conv1D(filters=384, kernel_size=9)	(89, 384)
(89, 384)	Conv1D(filters=256, kernel_size=9)	(81, 256)
(81, 256)	MaxPool1D(pool_size=3, strides=2)	(40, 256)
(40, 256)	Flatten()	10240
10240	Dense(512)	512
512	Dense(512)	512
512	Dense(512)	512
512	Dense(512)	512
512	Dense(2)	2

Review – Performance

Trained Using		Tested on		Signal Eff. [%]	Background Eff. [%]	F1 Score [%]
Crystal	Energy [keV]	Crystal	Energy [keV]			
3	6~10	3	3~6	100	95.48	97.69
3	3~6	3	6~10	100	99.21	99.60
7	6~10	3	6~10	100	99.18	99.59
7	6~10	3	3~6	100	94.22	97.03
7	3~6	3	6~10	100	100	100
7	3~6	1	6~10	100	99.69	99.84
7	3~6	1	3~6	100	99.64	99.82
3	6~10	1	6~10	100	99.69	99.84
1	3~6	7	6~10	99.68	100	99.84

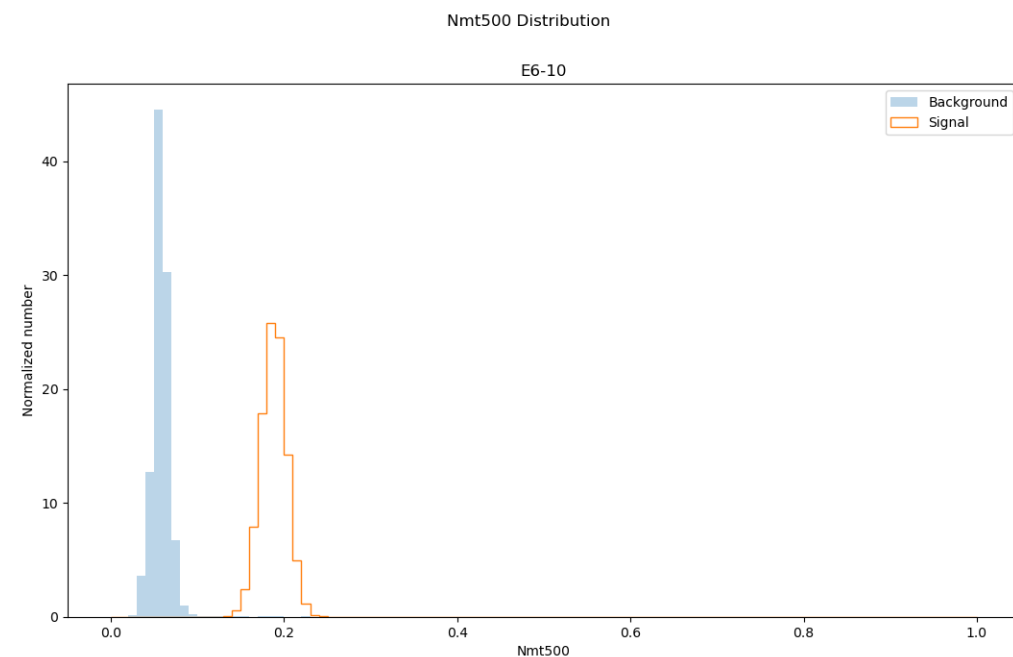
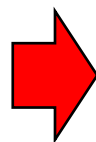
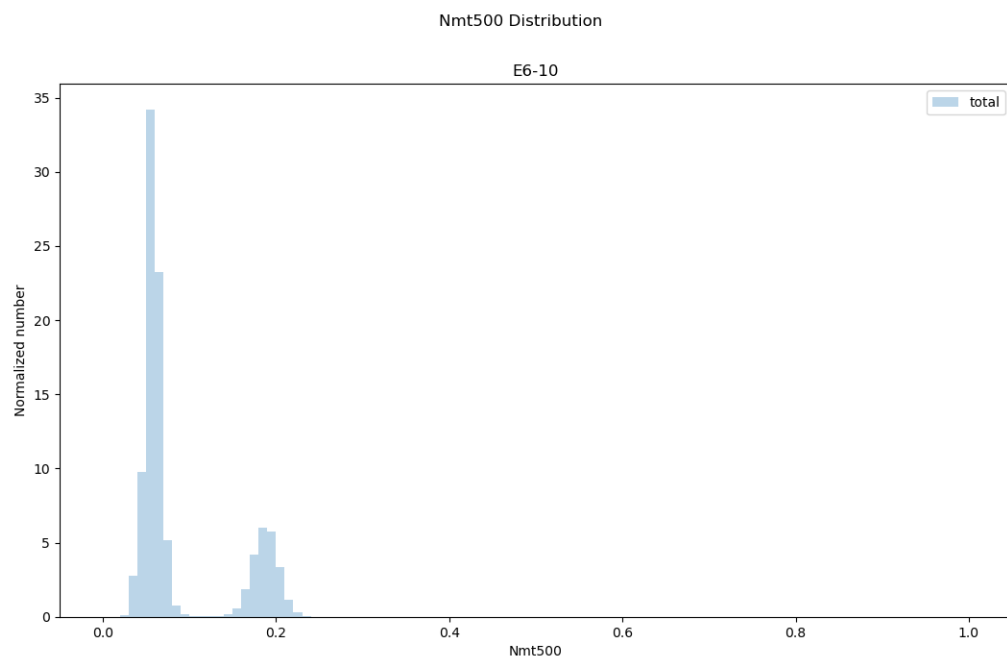
$$\ast F_1 \text{ score} = \frac{2}{\frac{1}{\text{Signal eff.}} + \frac{1}{\text{Background eff.}}}$$

Testing Data Selection

- Testing data was selected without nmt cut.
 - Runnum 1765, 1601 (Calibration run)
 - Have coincidence
 - Runnum 1858, 1859 (Physics run)
 - No coincidence
 - Not tagged. Crystal3 was used.

Nmt500 Splitting Plot

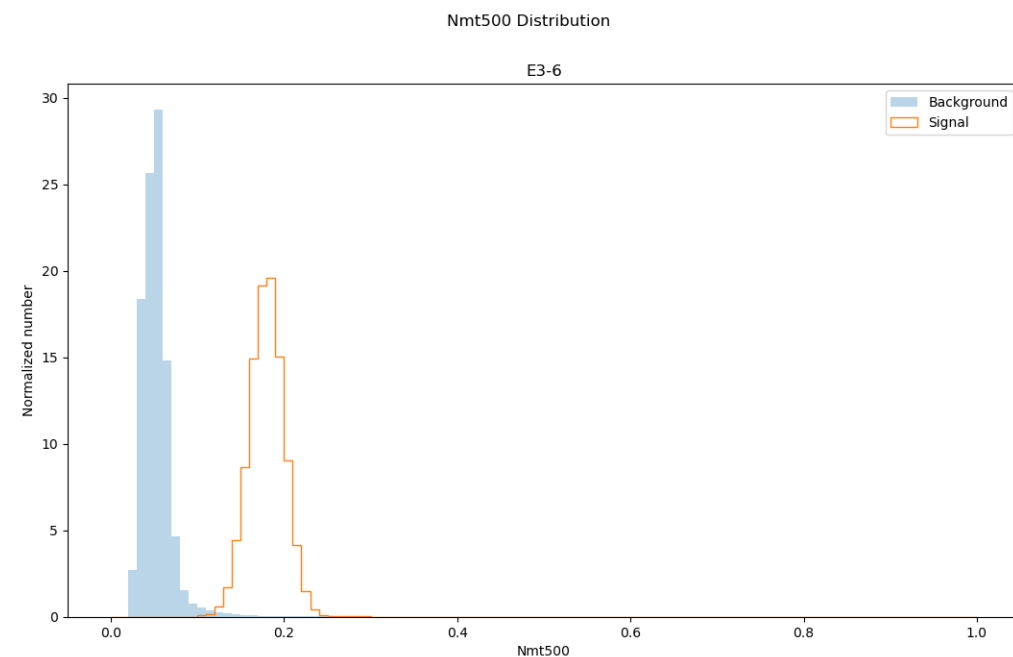
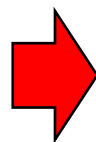
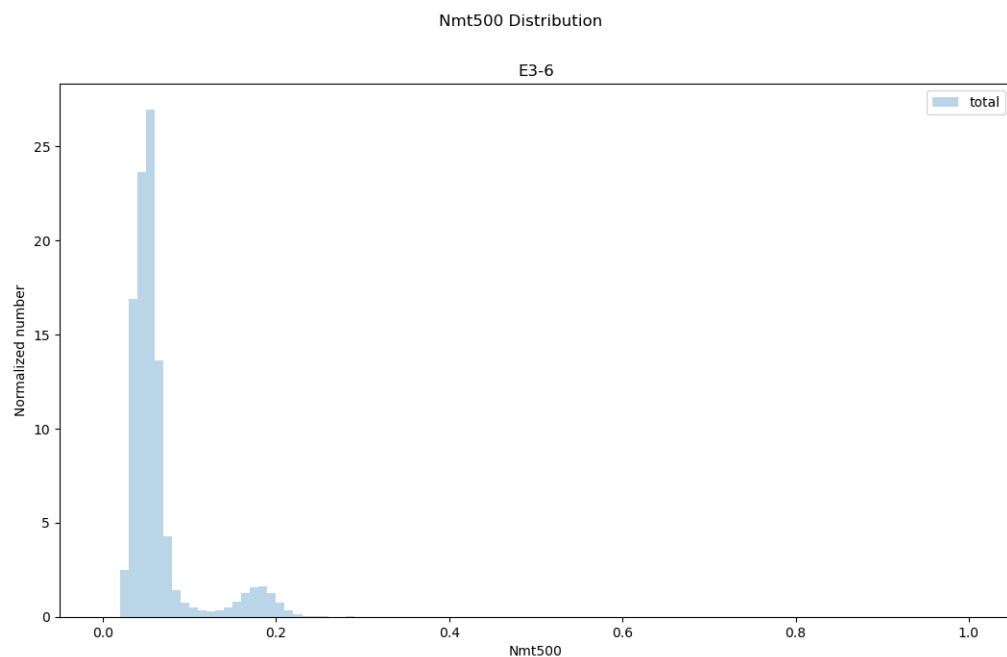
- Trained model could successfully split data without nmt cut.
 - Model was trained using crystal 7, energy 3~6 keV data.



※ Histograms are normalized.

Nmt500 Splitting Plot

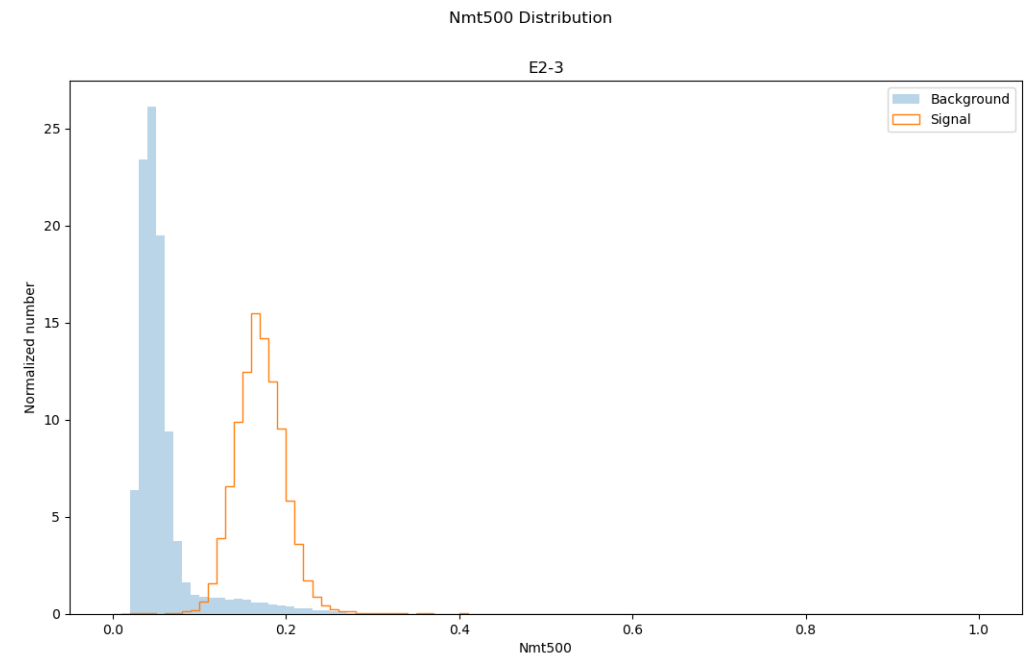
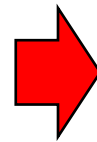
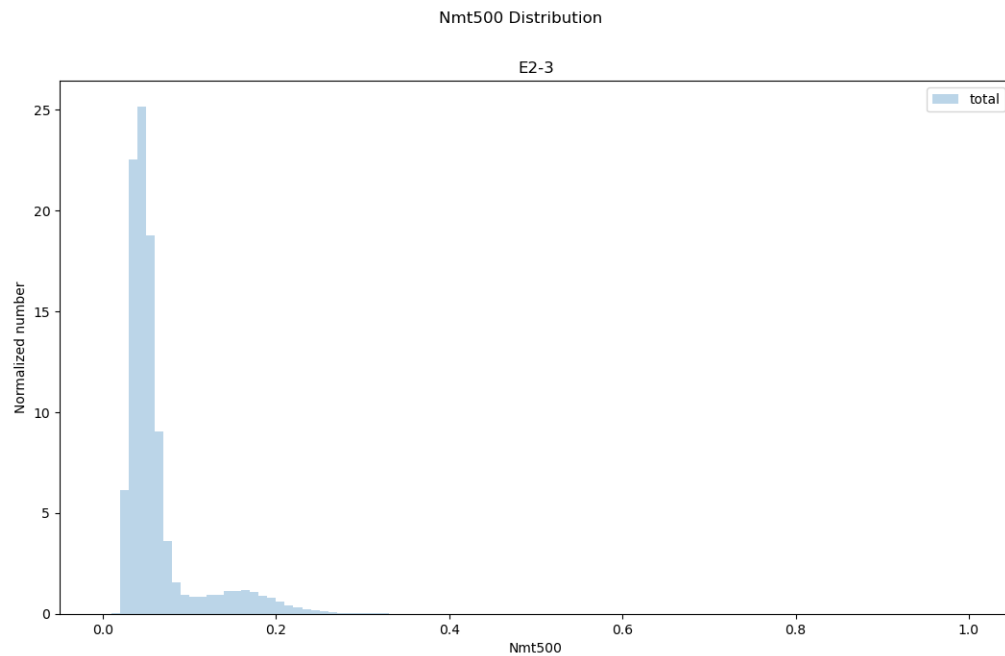
- 3~6 keV data showed very clear nmt distribution.
- It seems **not nmt-biased**.



※ Histograms are normalized.

Nmt500 Splitting Plot

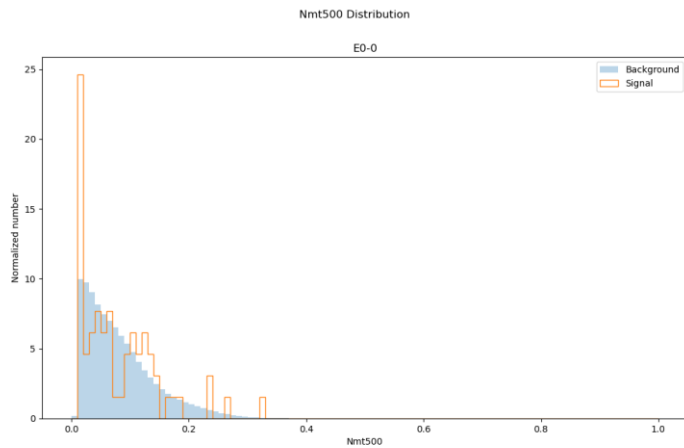
- 2~3 keV data showed clear nmt distribution, too.



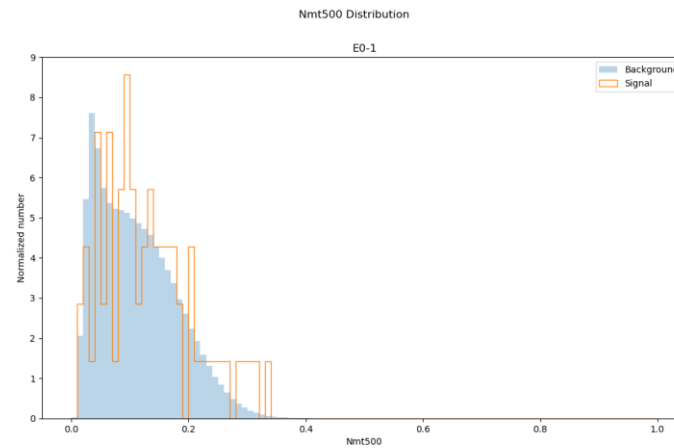
※ Histograms are normalized.

Nmt500 Splitting Plot

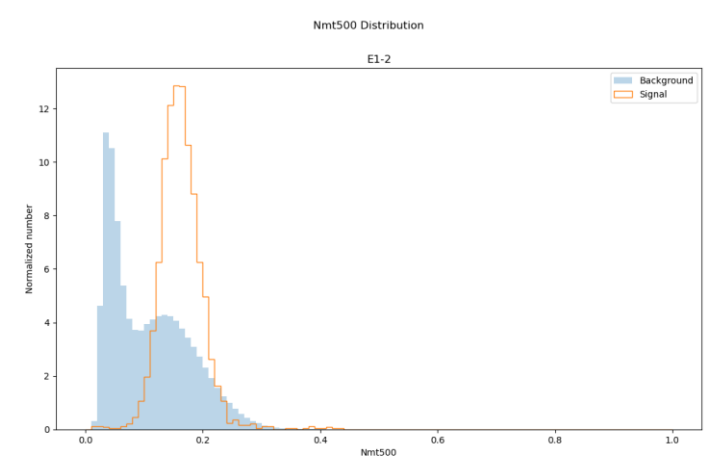
- Nmt distribution was not that clear in low energy.
 - Nmt is known to be unavailable in this low energy, so these are not intuitive.



E 0~0.5 keV



E 0.5~1 keV

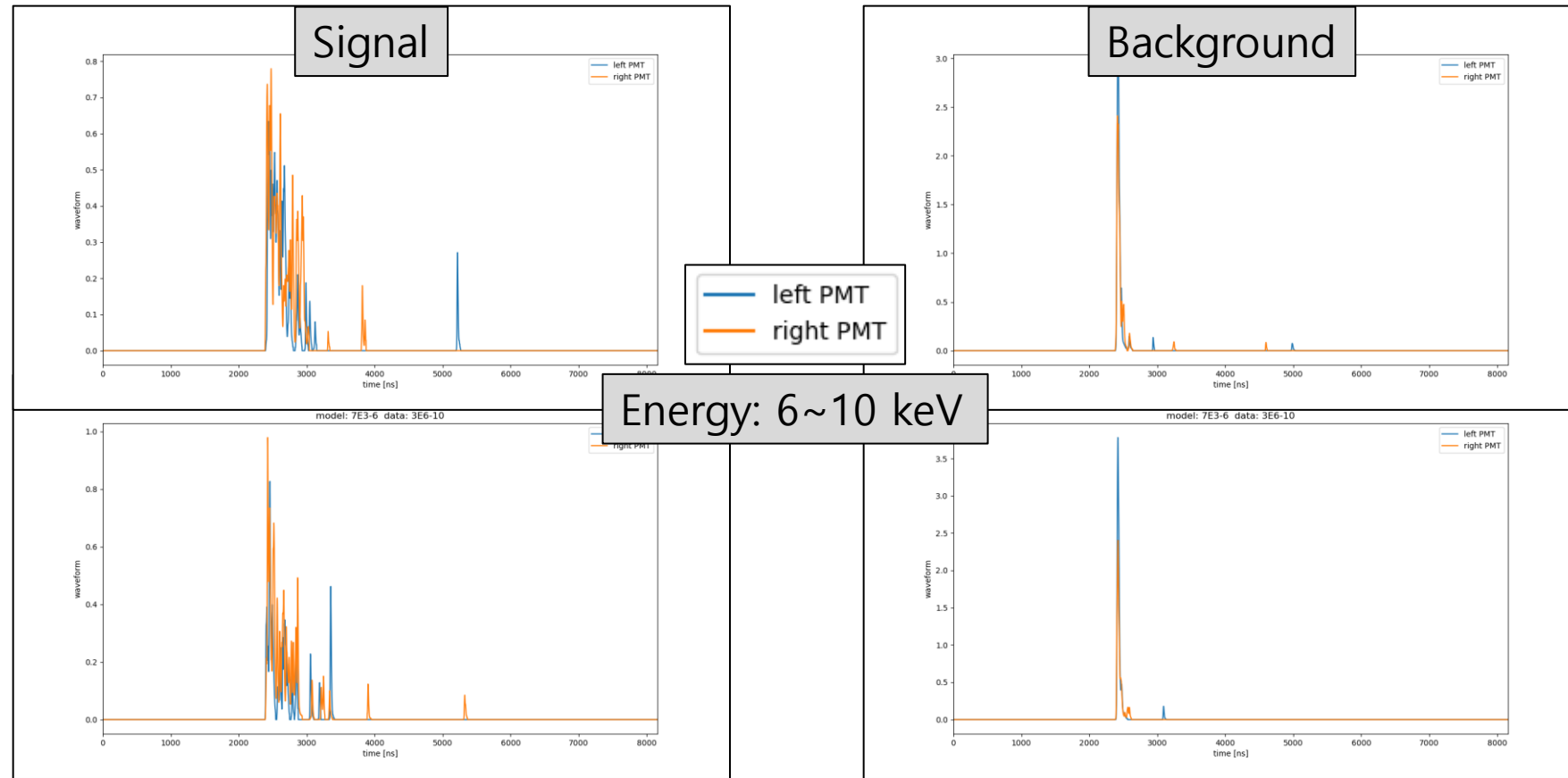


E 1~2 keV

※ Histograms are normalized.

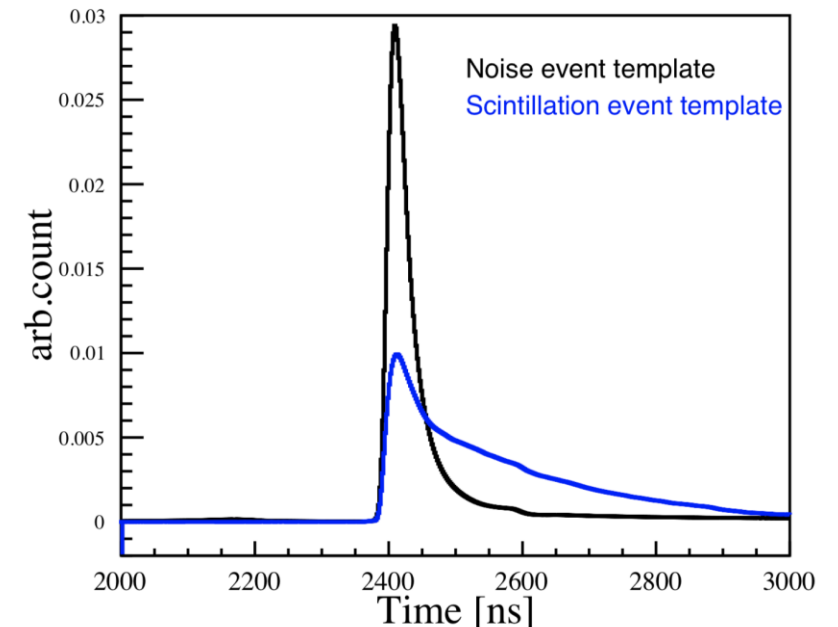
Validation – Accumulated Waveform

- Signal events (left) have longer decay time, while background events (right) have sharp peak.



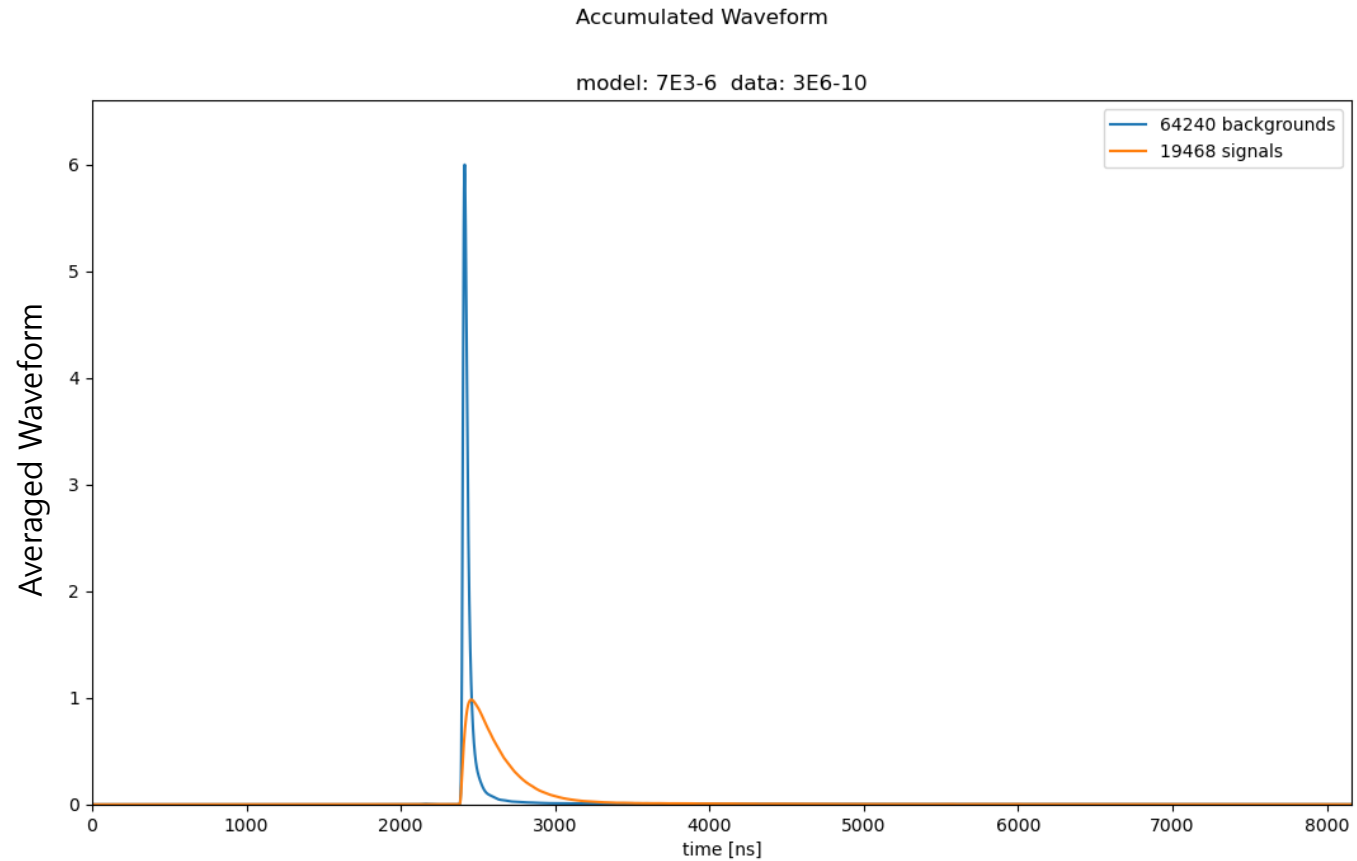
Validation – Accumulated Waveform

- Accumulating the waveforms helps to visualize overall property.
 - Figures after this slide were generated by model trained using crystal 7 energy 3-6 keV data.



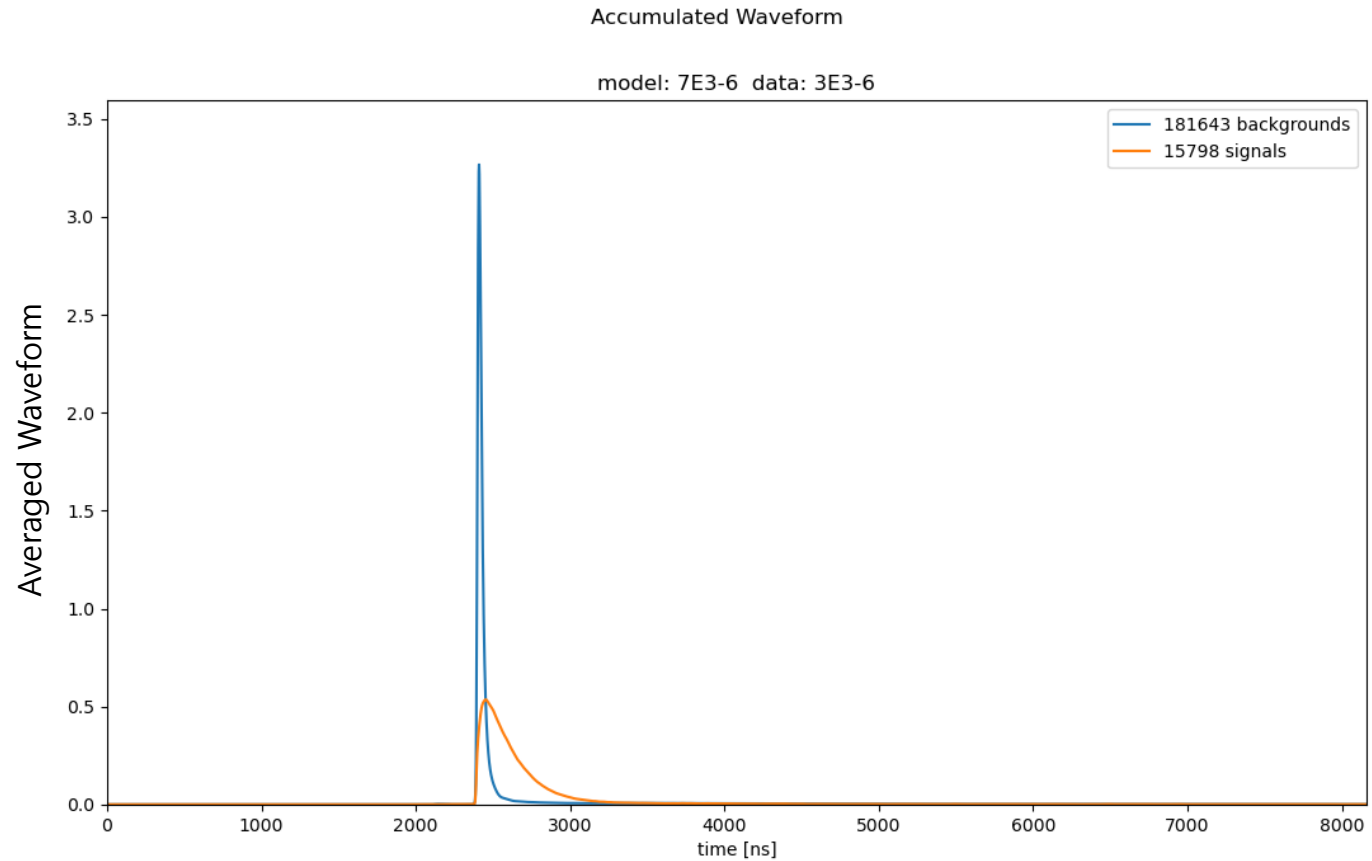
Validation – Accumulated Waveform

Crystal 3, energy 6-10 keV events were classified successfully.



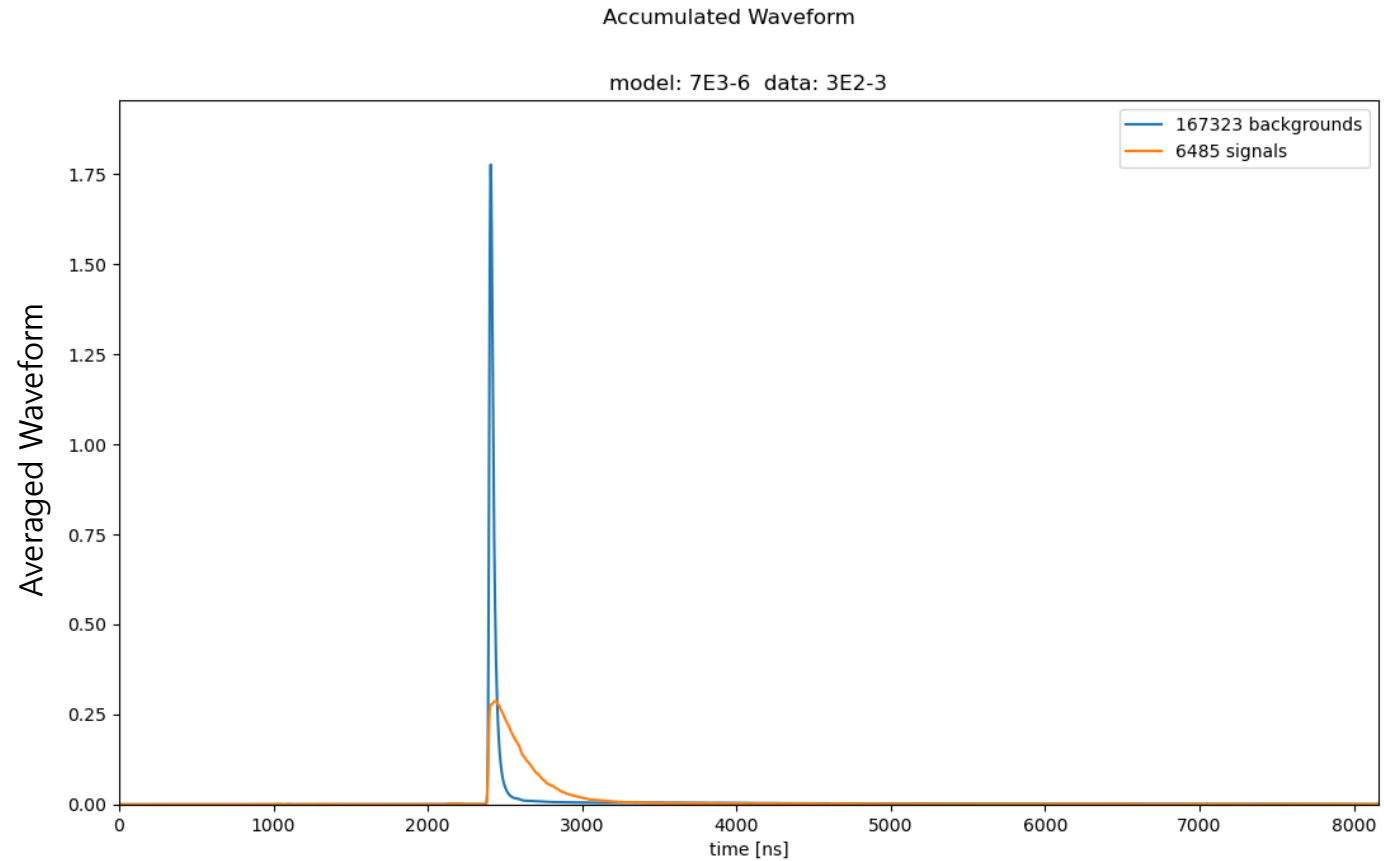
Validation – Accumulated Waveform

Crystal 3, energy 3-6 keV events were classified successfully, too.



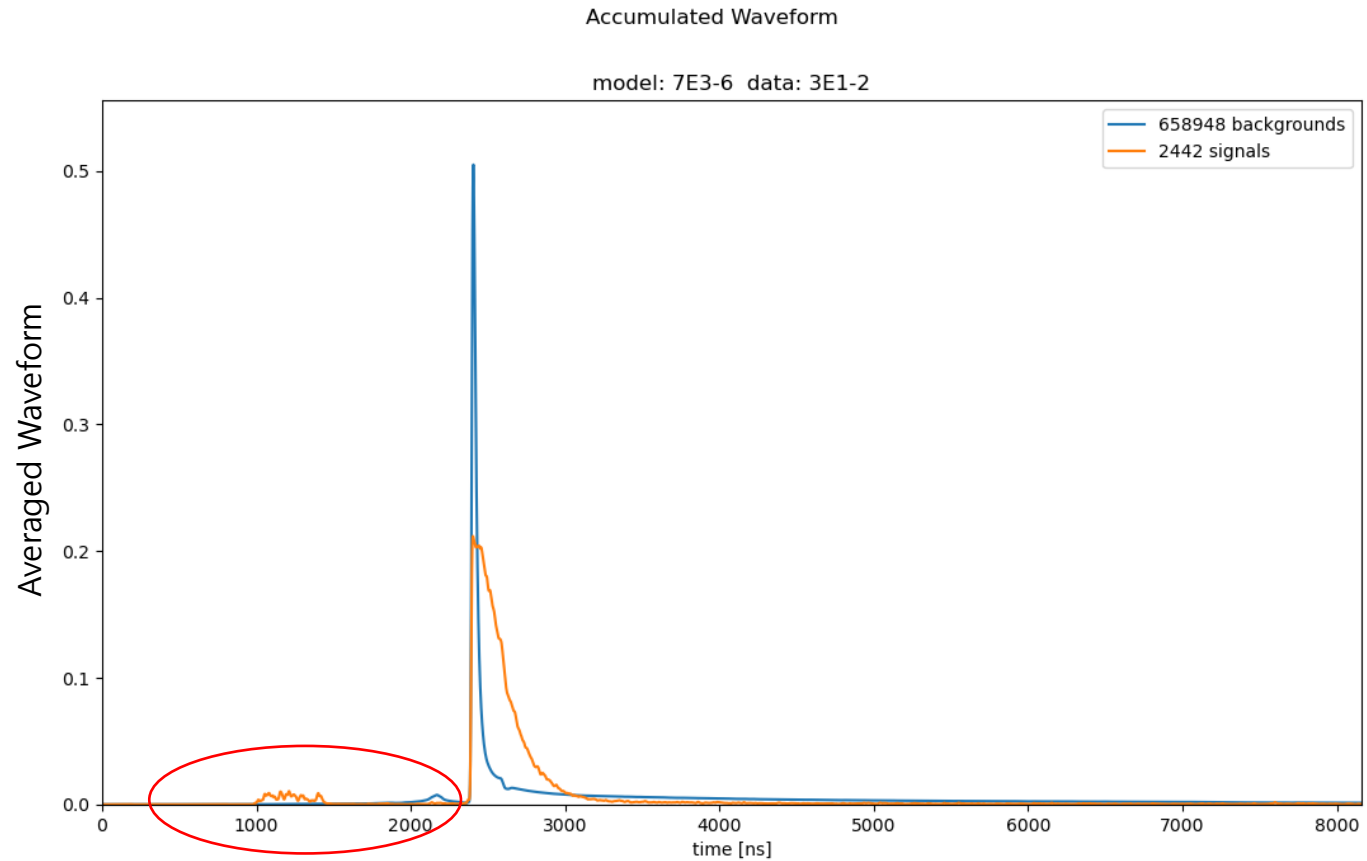
Validation – Accumulated Waveform

Crystal 3, energy 2-3 keV events were classified successfully, too.



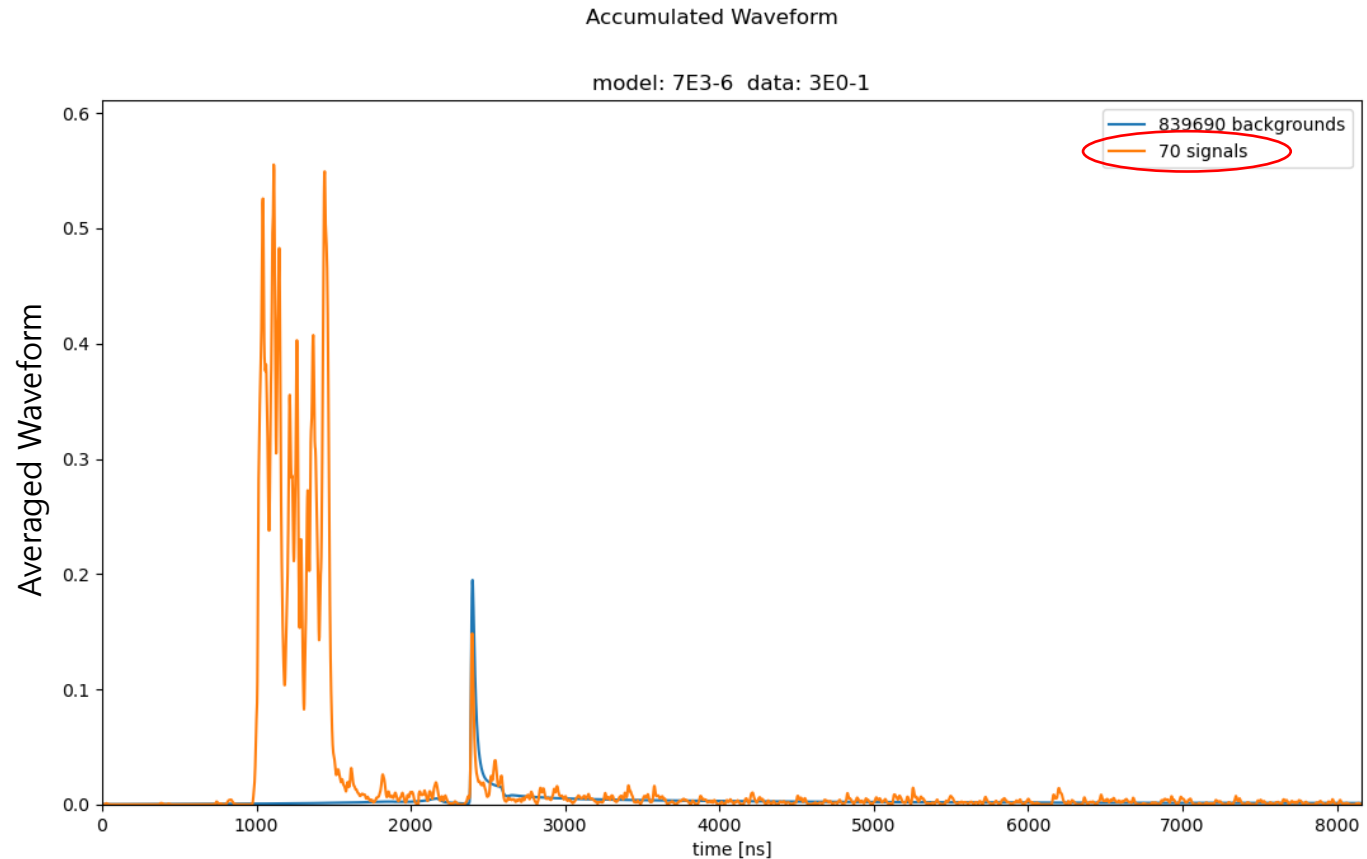
Validation – Accumulated Waveform

Crystal 3, energy 1-2 keV events classification result seems not bad, but 'something' arises at the front side.



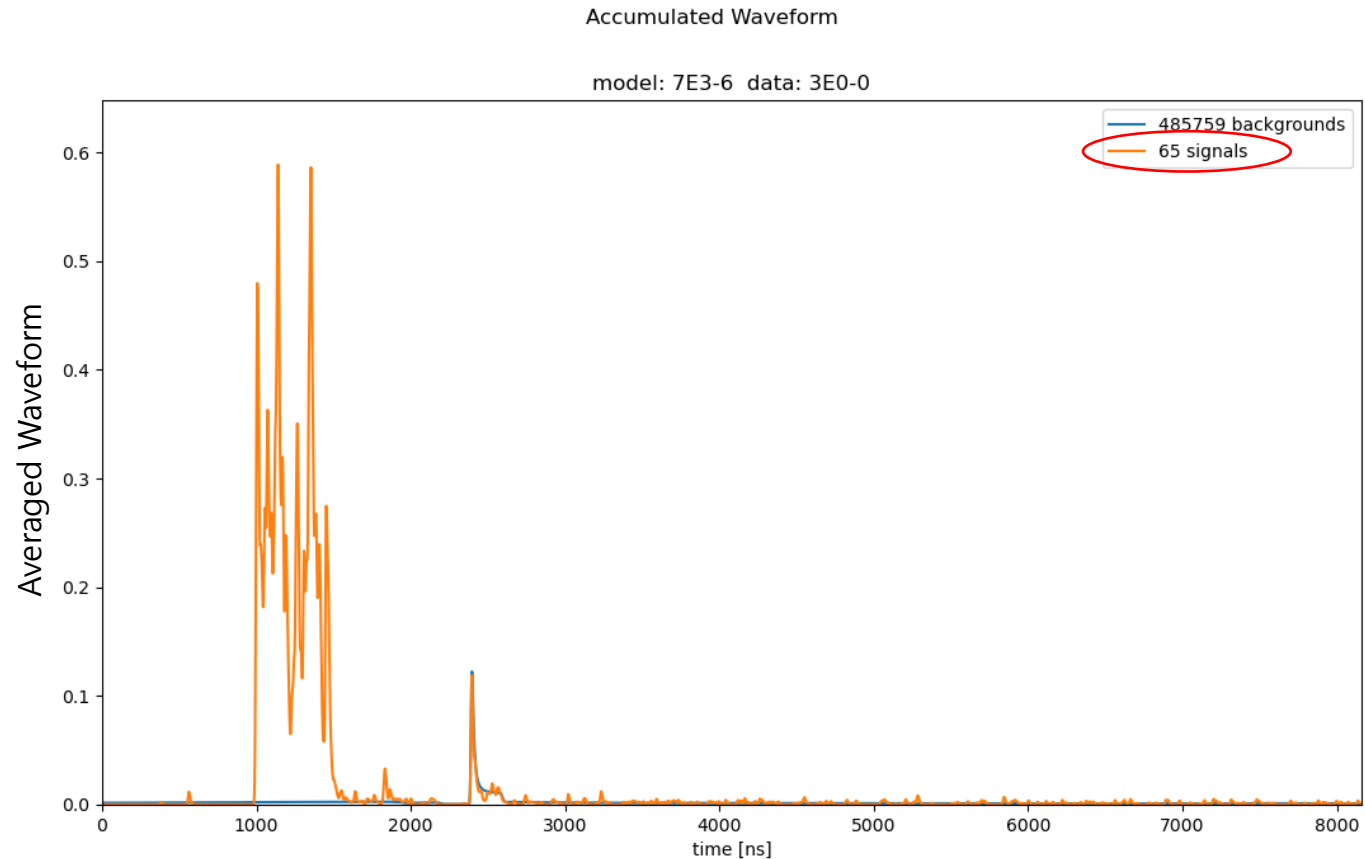
Validation – Accumulated Waveform

Crystal 3, energy 0.5-1 keV events classification seems not that good. However, signal-classified event number is too small.



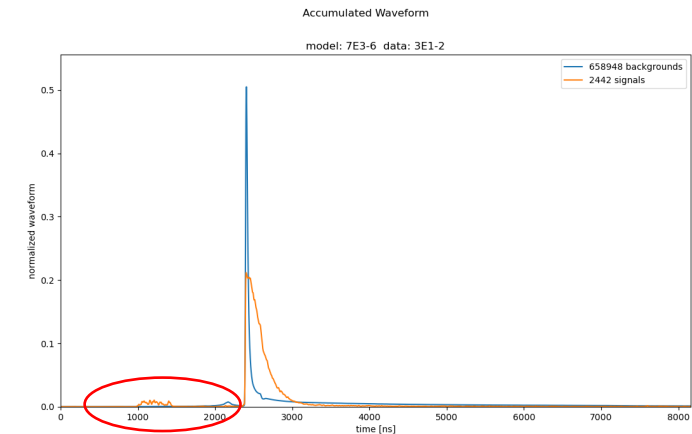
Validation – Accumulated Waveform

Crystal 3, energy 0-0.5 keV events classification seems also not that good. However, signal-classified event number is too small.



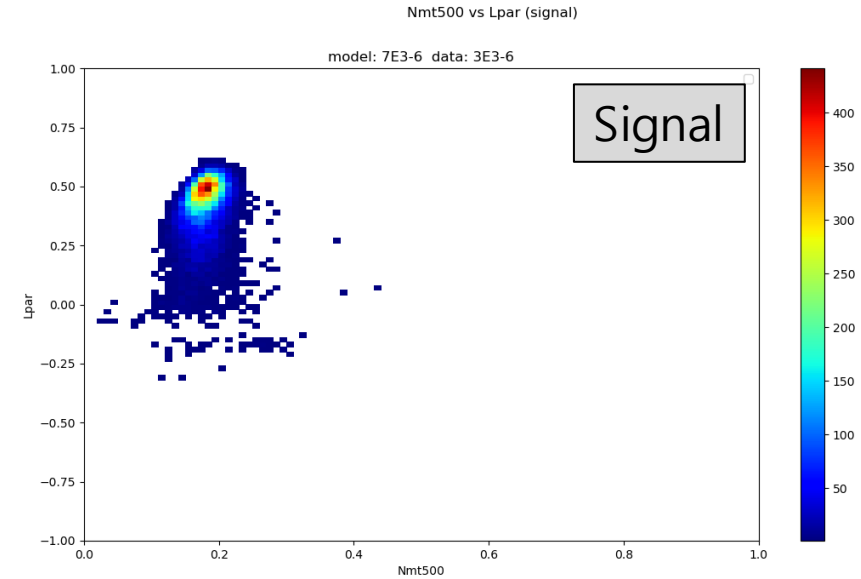
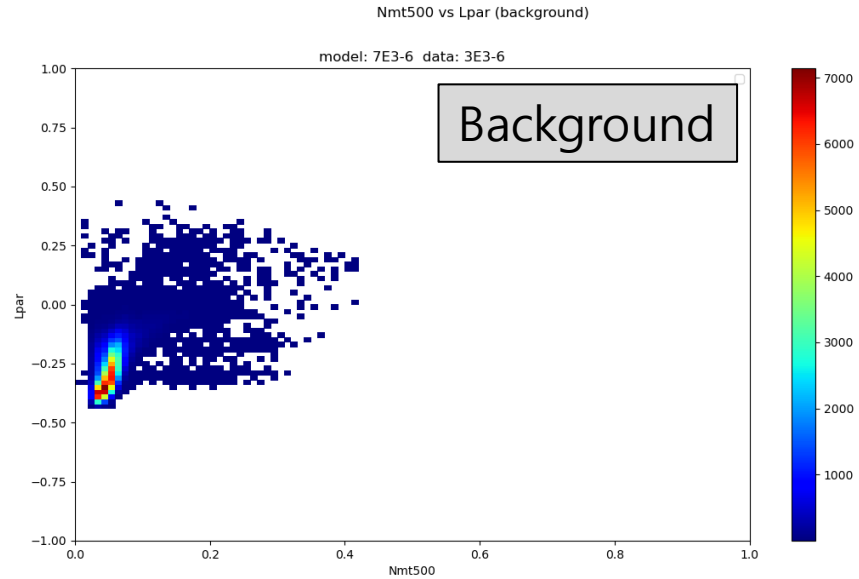
Conclusion – Accumulated Waveform

- Model trained using 3~6 keV dataset generated with nmt500 cut is successfully classifying 2~10 keV events.
- It seems something is happening below 2 keV.
- Classifying 0~1 keV energy data seems not that successful.



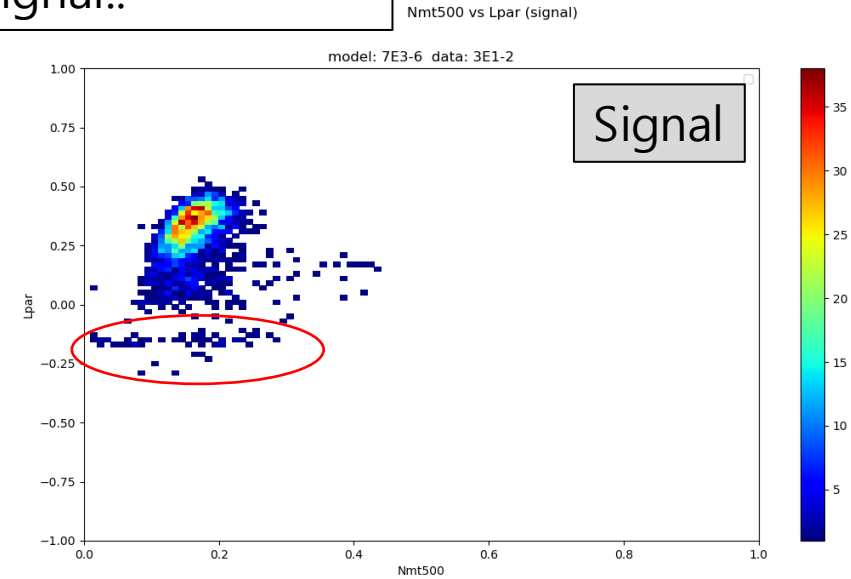
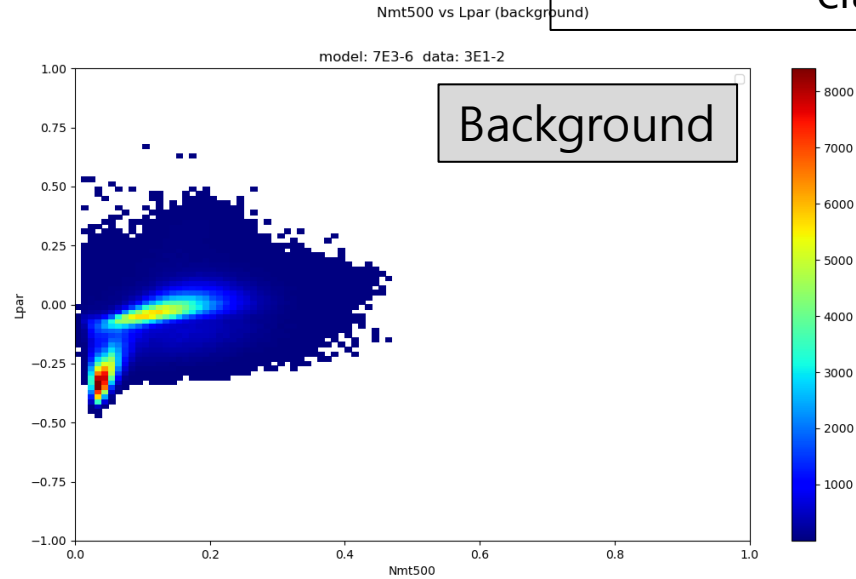
Validation – lpar:nmt500 Plot

Energy 3~6 keV data is split clearly.



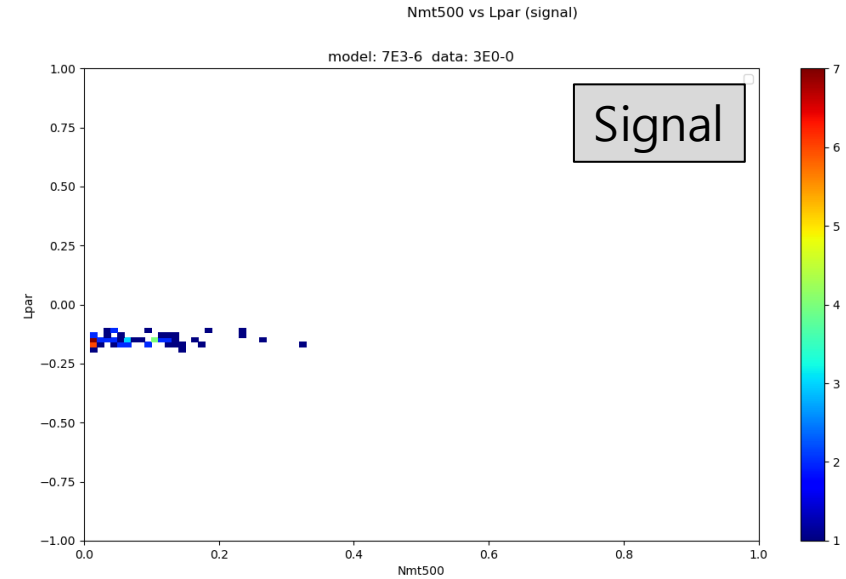
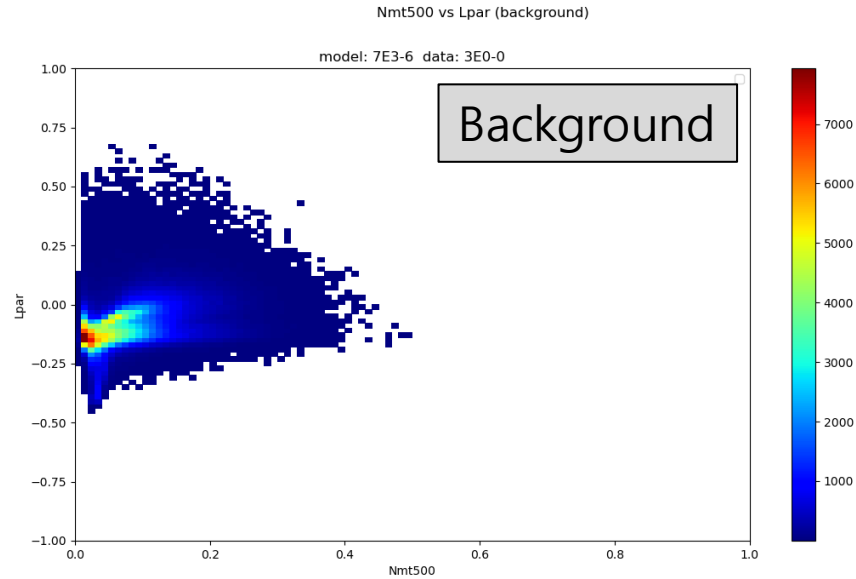
Validation – lpar:nmt500 Plot

Energy 1~2 keV data is split not clearly,
and some low lpar events are being
classified as signal..



Validation – lpar:nmt500 Plot

Energy 0~0.5 keV data is not split. But
signal data is too rare.

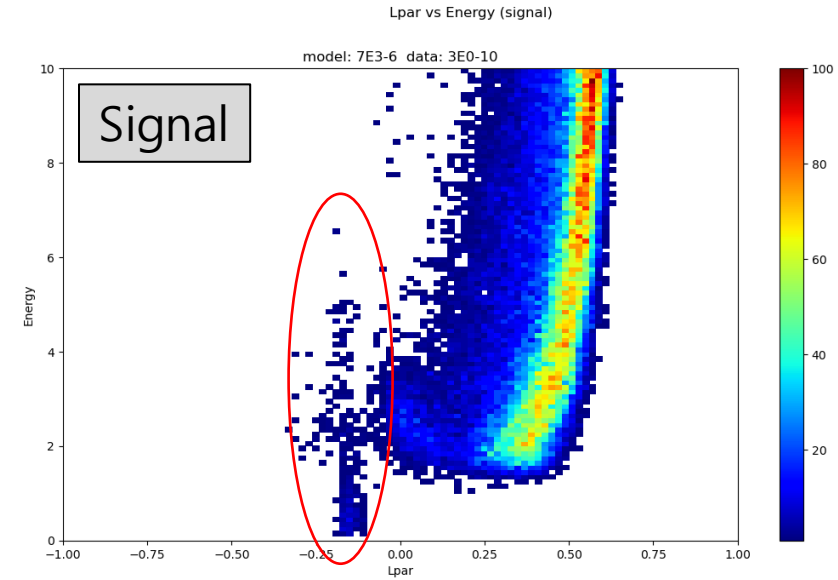
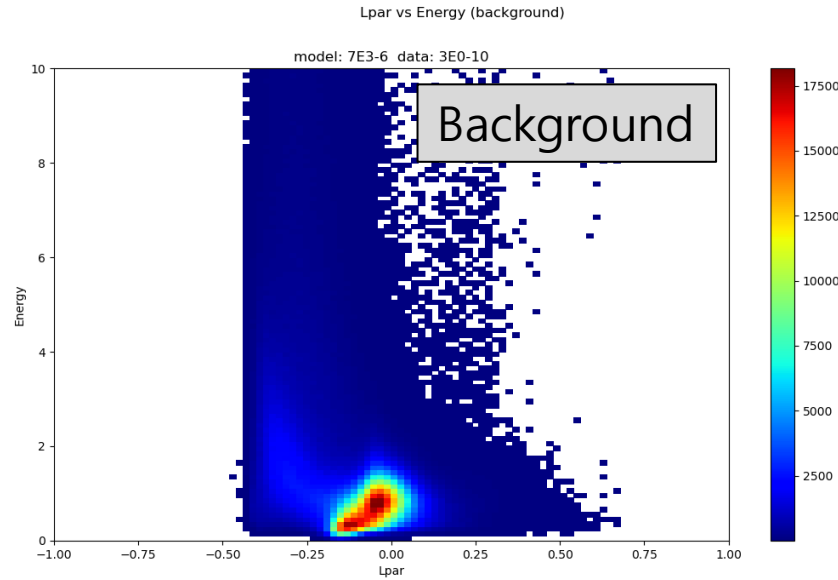


Conclusion – lpar:nmt500 Plot

- Some of '**low lpar**' events are classified as signal now.
- Too small number of events are classified as signal in low energy (<1 keV) region.

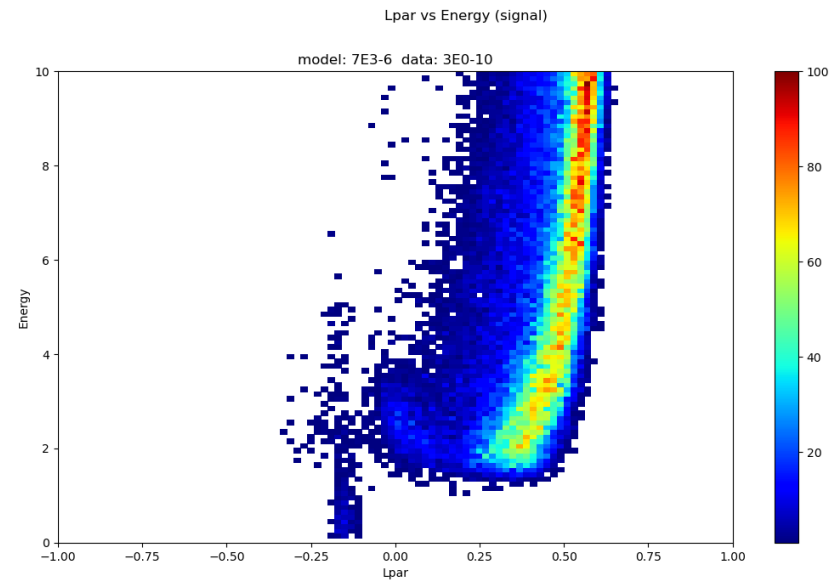
Validation – energy:lpar Plot

Some low lpar samples were classified as signal.
These samples should be studied more.



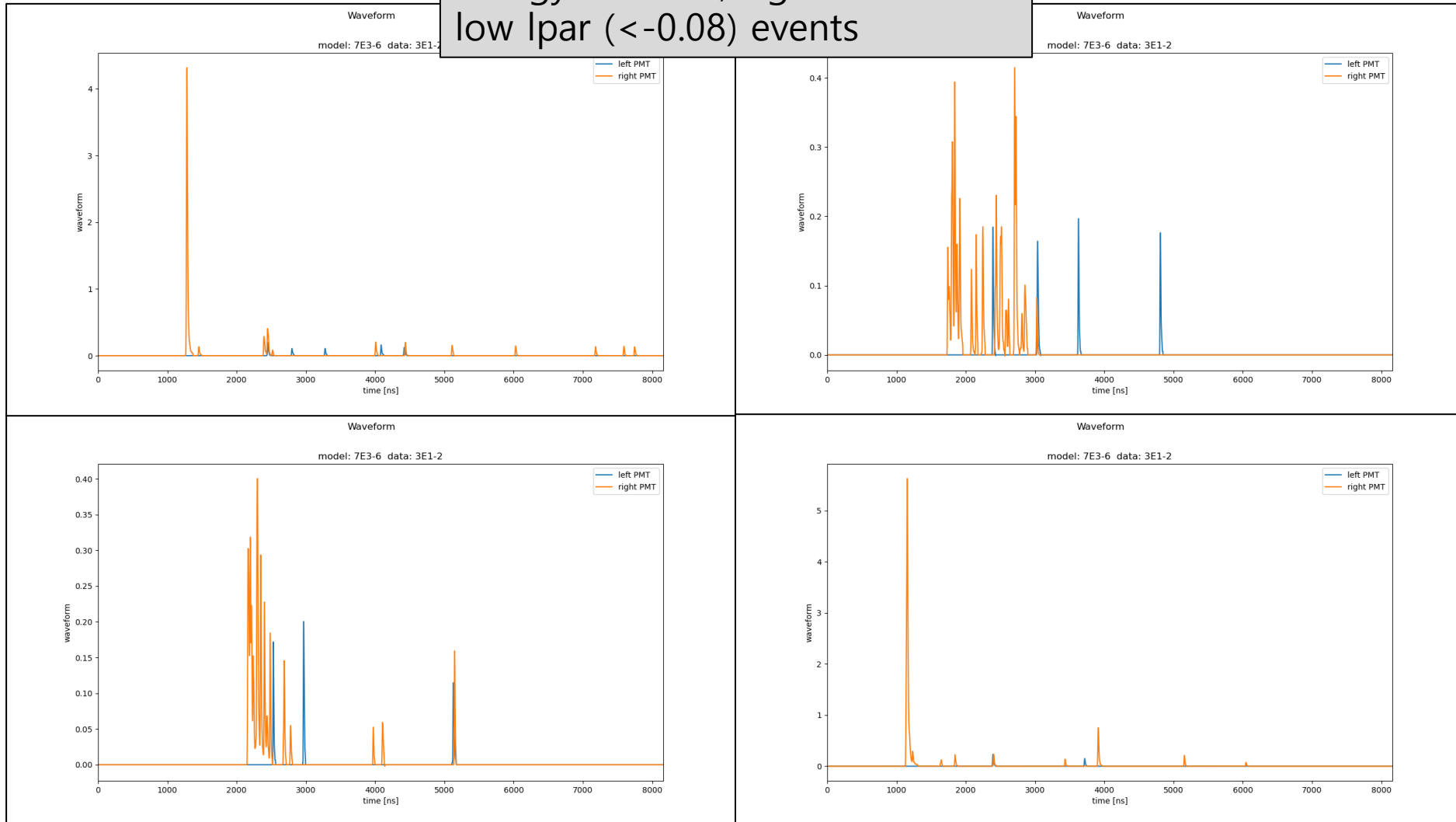
Conclusion – energy:lpar Plot

- There are some 'low lpar signal classified' events also in high energy region (~ 5 keV).
- 'High lpar' events stop to be classified at ~ 1 keV.



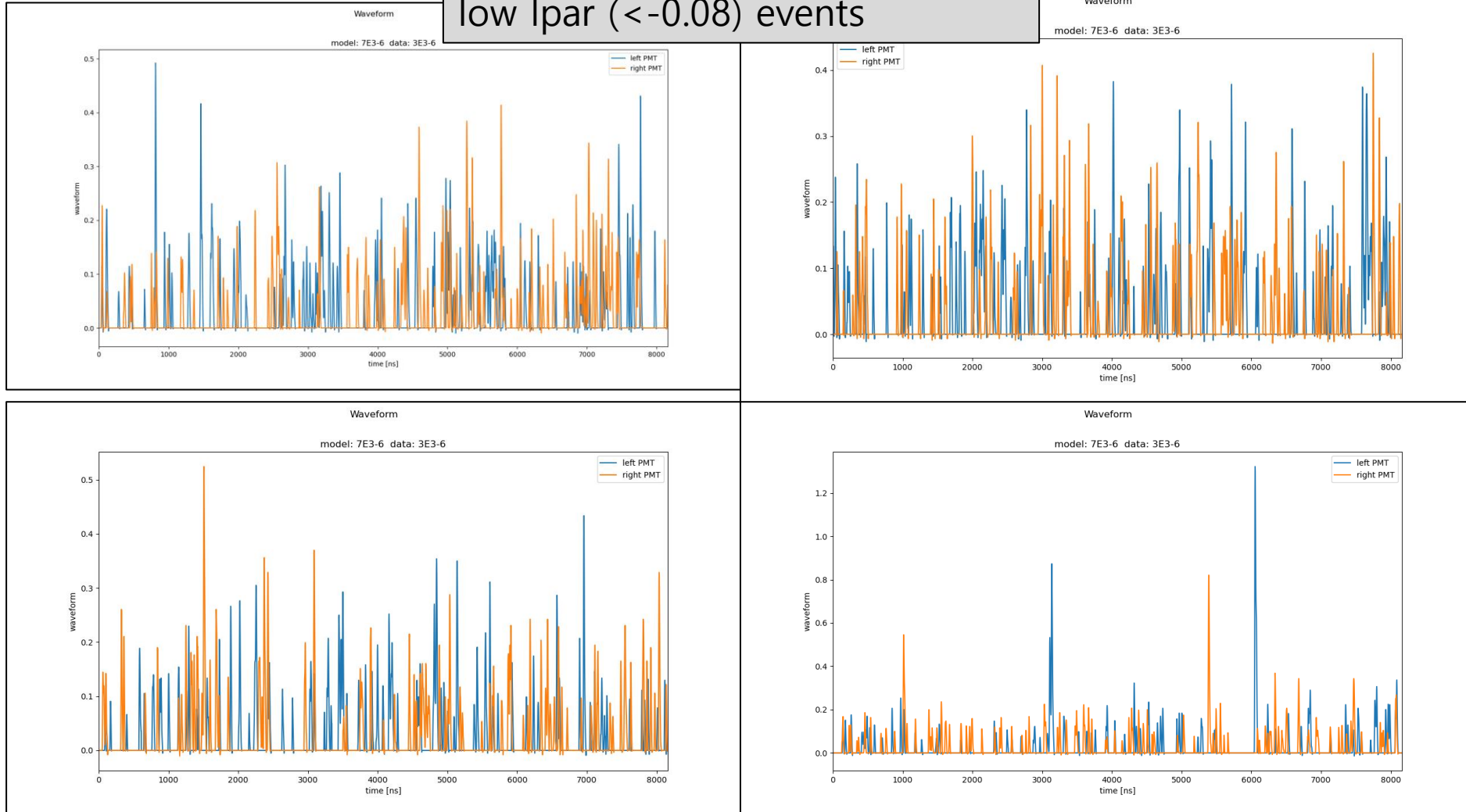
Validation – Low Ipar Waveform

Energy 1~2 keV, signal classified
low Ipar (< -0.08) events



Validation – Low Ipar Waveform

Energy 3~6 keV, signal classified
low Ipar (< -0.08) events



Conclusion

- CNN trained on crystal 7, energy 3~6 keV data is working well on energy 2~10 keV.
- Some of 'low lpar' events are classified as signal now.
 - Signal and background seems mixed.
- Training using 2~10 keV data can be useful. I'll try it.