

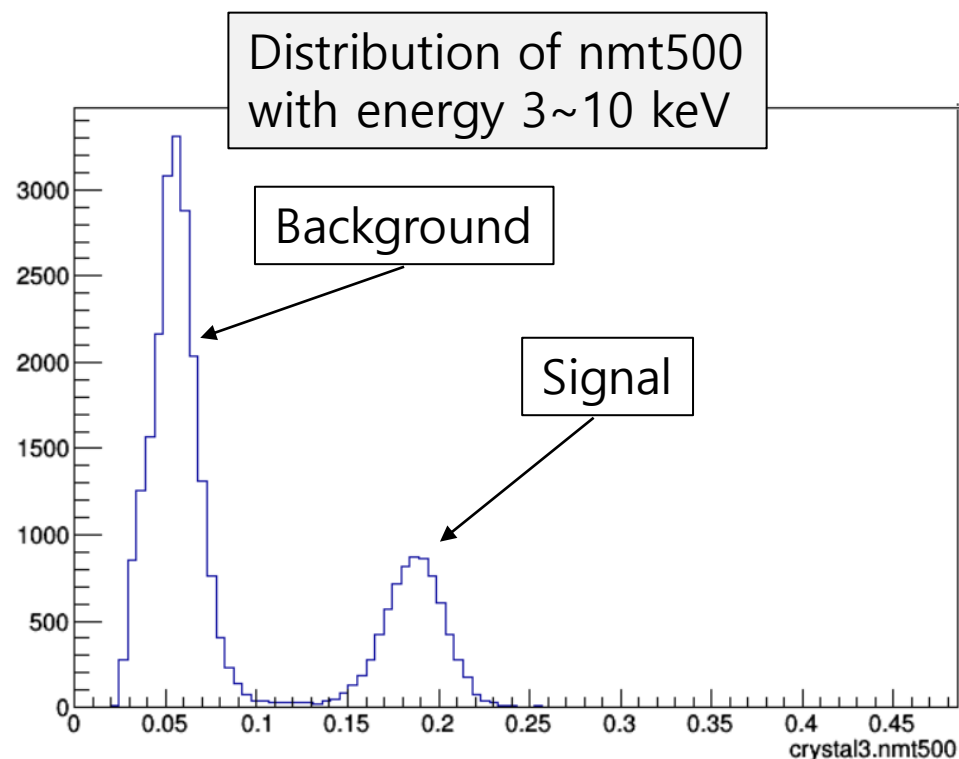
CNN For High Energy

2020.03.17

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Data Selection

- New data selection criteria for Cosine data was applied.
 - Signal tag
 - Runnum 1765, 1601 (Calibration run)
 - Have coincidence
 - Nmt500 > 0.12
 - Background tag
 - Runnum 1858, 1859 (Physics run)
 - No coincidence
 - Nmt500 < 0.12



Data Statistics

		Training data		Validation data		Test data	
		Background	Signal	Background	Signal	Background	Signal
Crystal 1	3~6 keV	146,089	414	18,264	47	18,273	38
	6~10 keV	62,381	452	7,805	48	7,806	47
Crystal 3	3~6 keV	142,487	1,367	17,815	164	17,792	187
	6~10 keV	50,477	1,909	6,322	226	6,326	222
Crystal 7	3~6 keV	146,834	1,892	18,365	224	18,371	218
	6~10 keV	63,592	2,761	7,959	333	7,980	312

CNN Structure

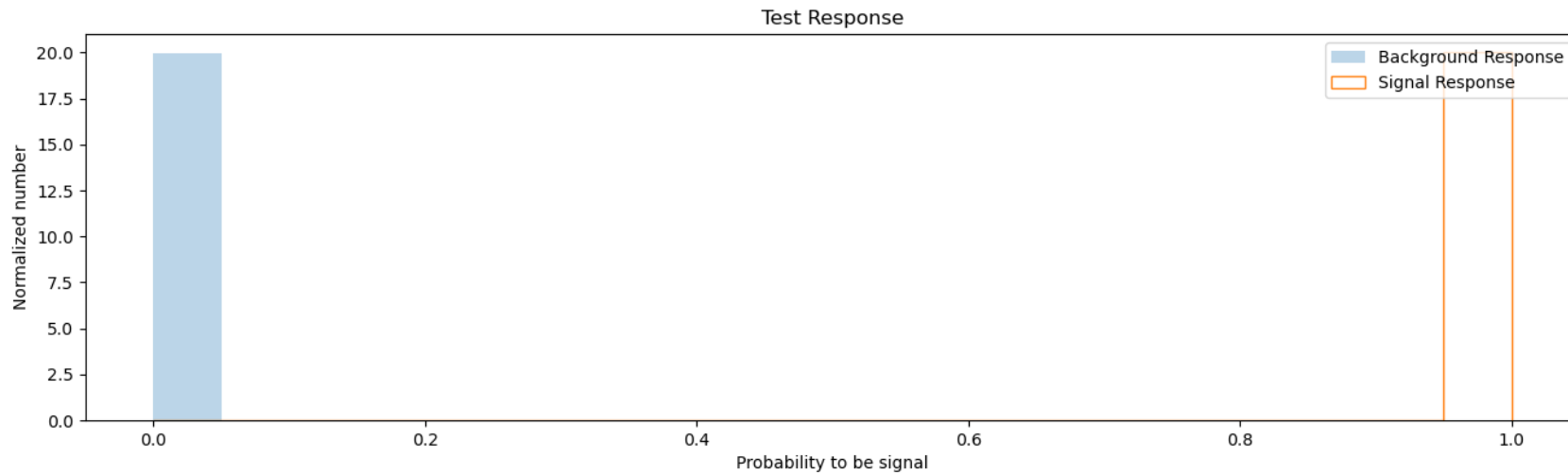
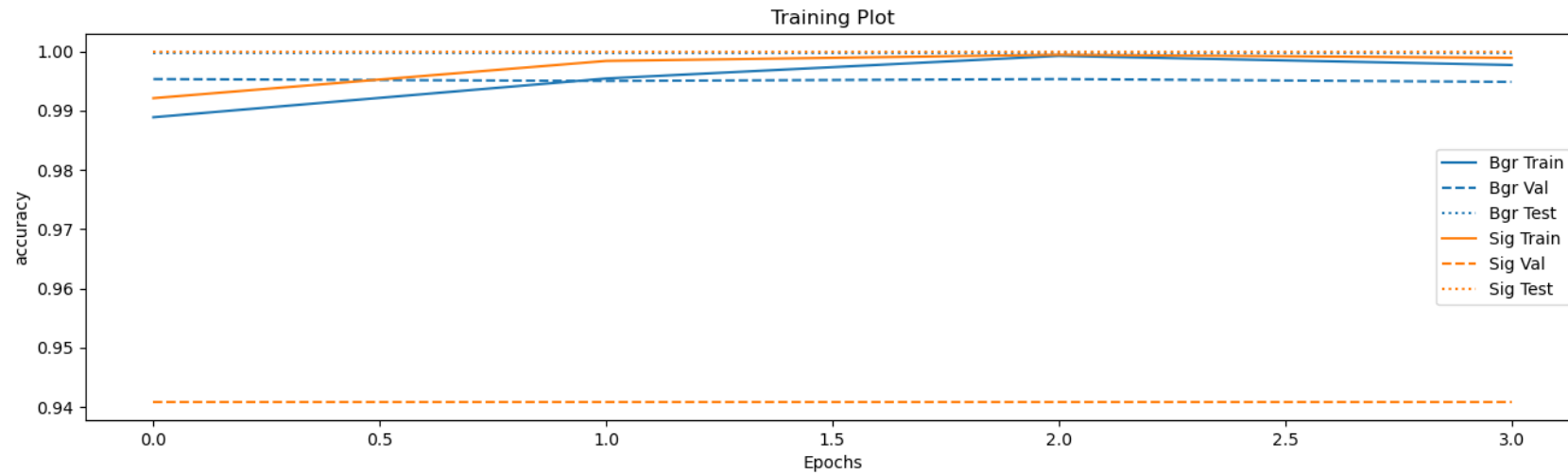
- 1dimensional CNN motivated by AlexNet was successful!
- Batch norm., ReLU activation applied.

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

Training Strategy

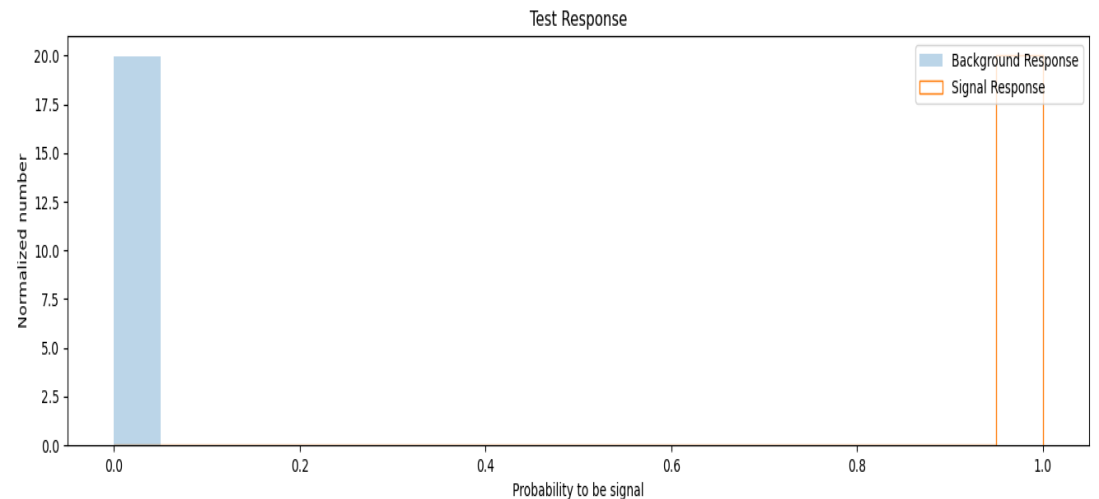
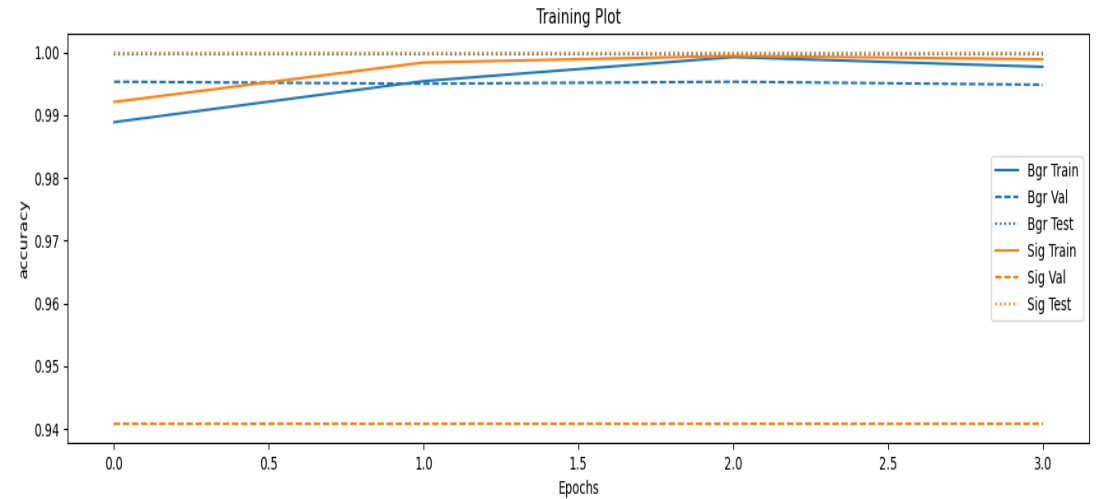
- Batch size = 64
 - Maximum value available in my laptop.
- Adam(lr=0.0015, beta_1=0.97)
 - A little high learning rate.
 - Train using latest ~30 batches.
 - 30 batches $\doteq$ 2,000 events $\doteq$ 5~80 signal events

Crystal3, 6~10 keV



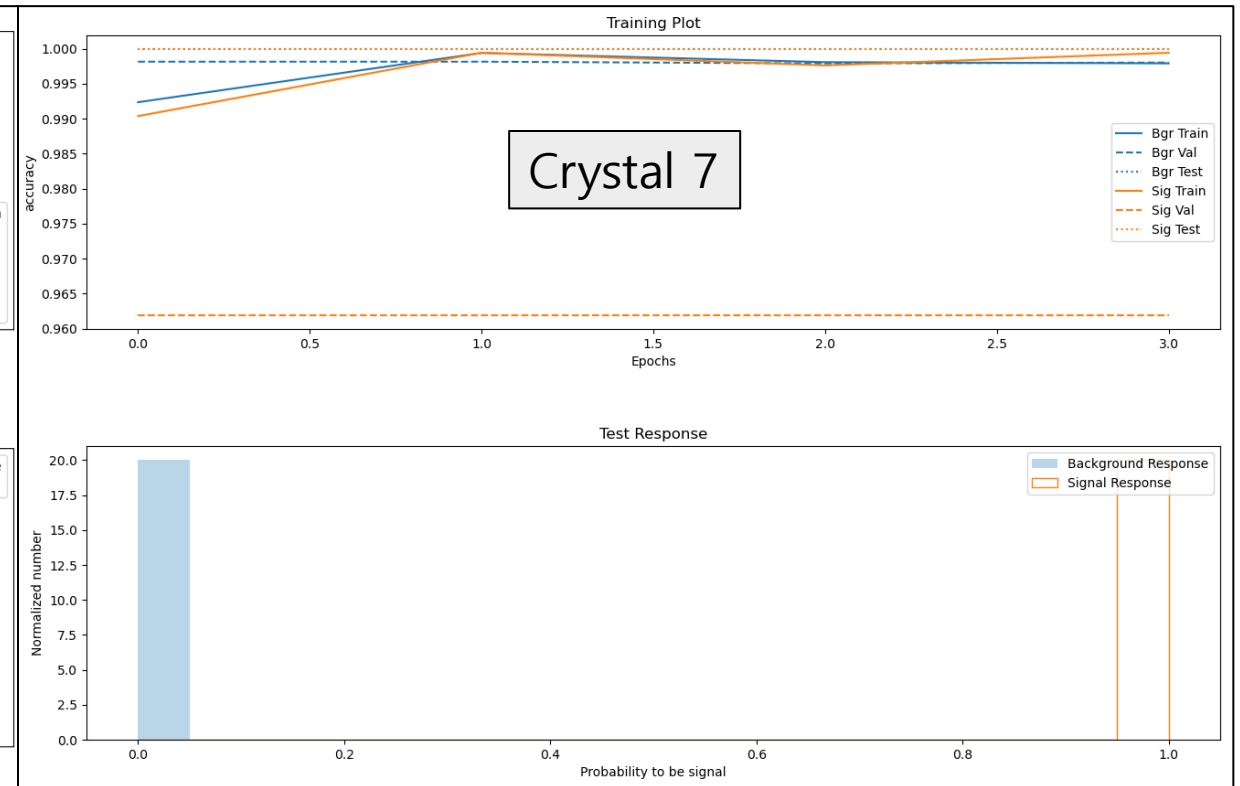
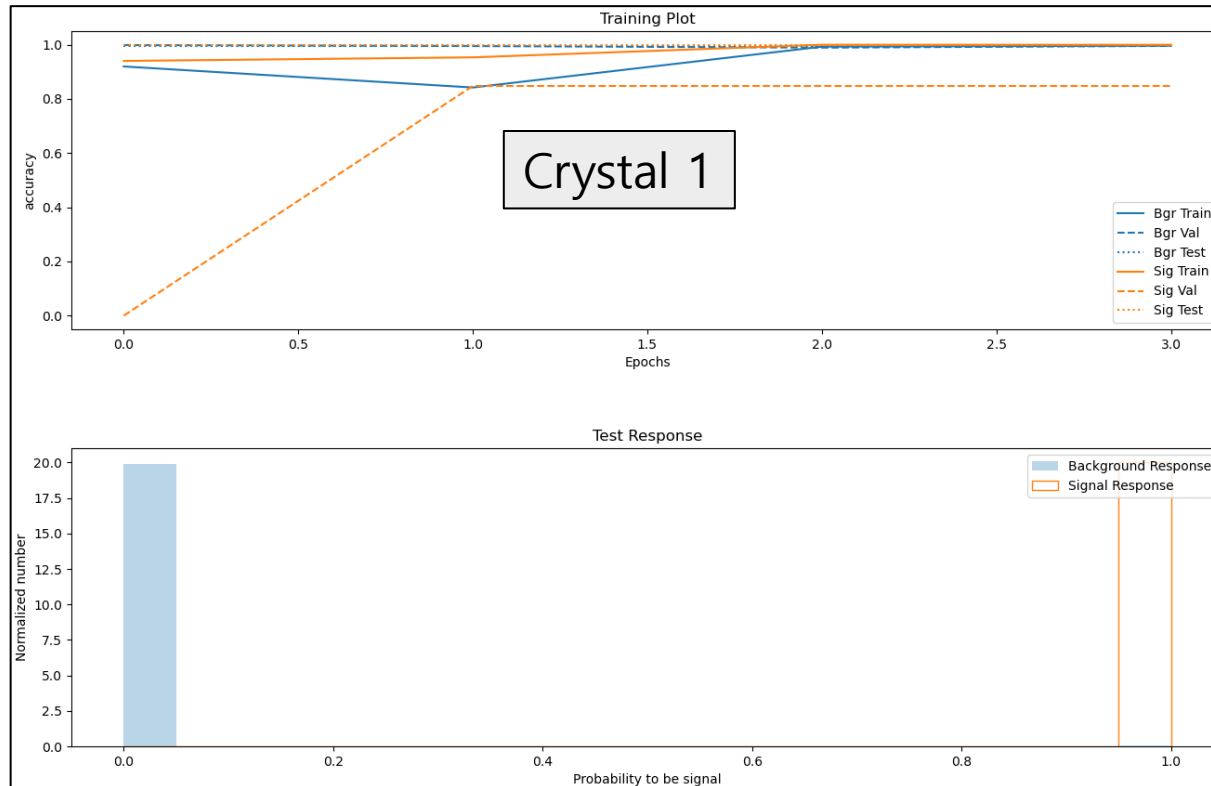
Crystal3, 6~10 keV

- 3~4 epochs were enough to train the network.
- Test passed!
 - Signal efficiency 100%
 - Background efficiency 99.97%

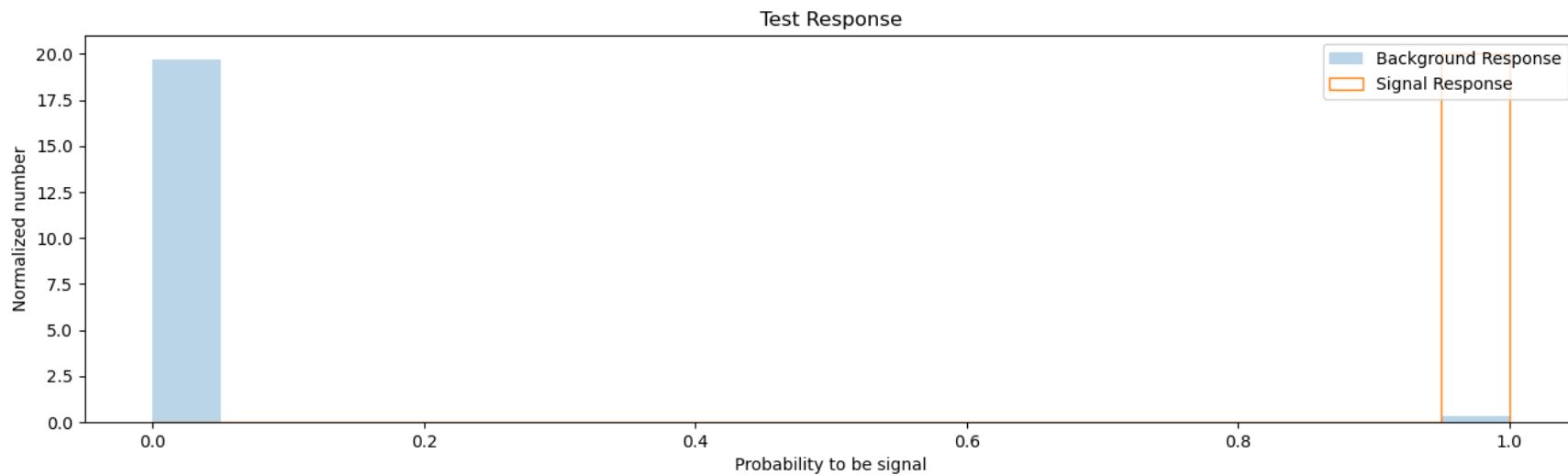
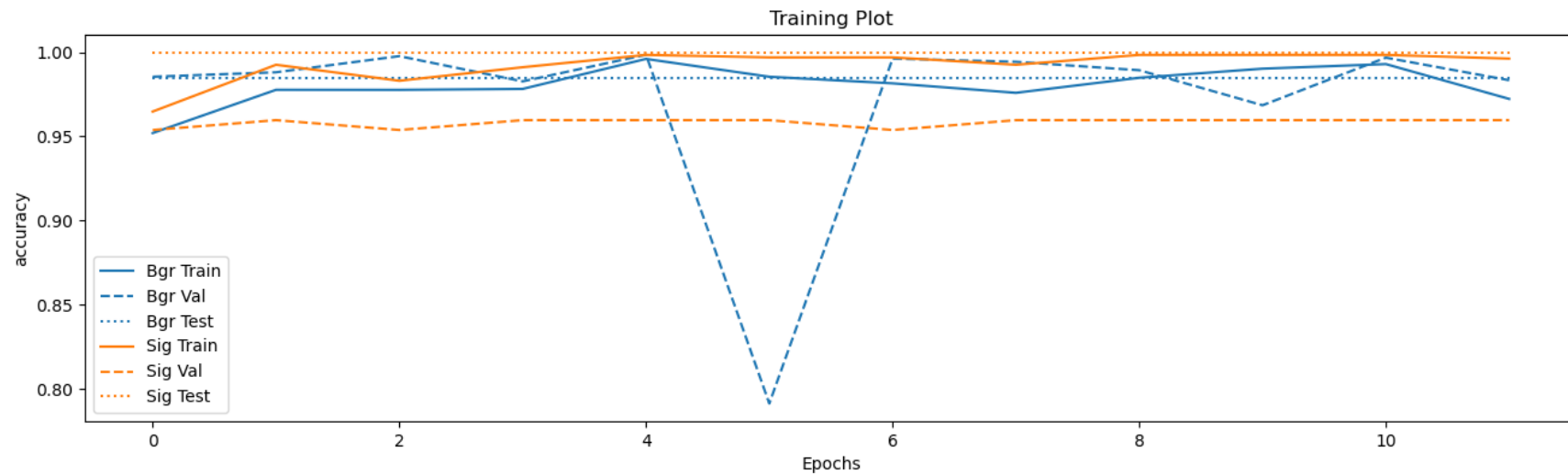


Crystal1 and 7, 6~10 keV

Test Efficiency	Crystal 1	Crystal 7
Signal [%]	100	100
Background [%]	99.62	100



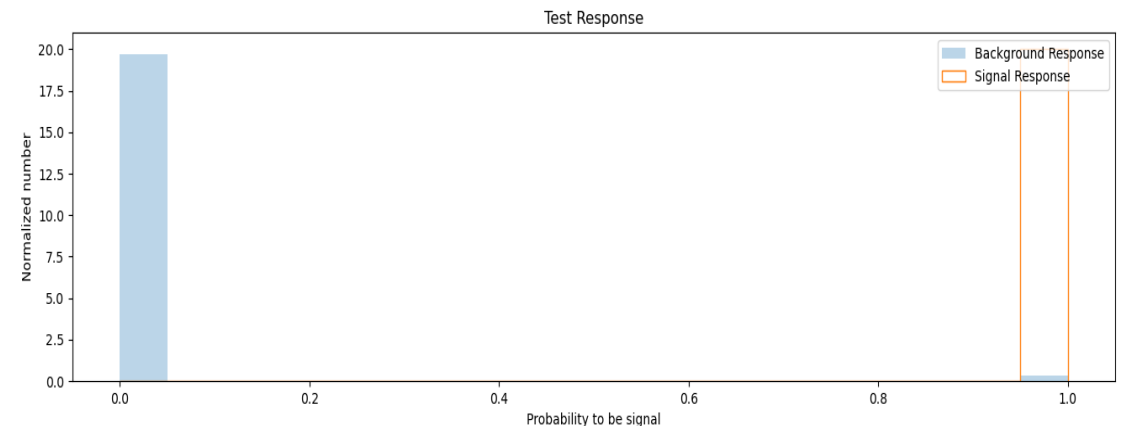
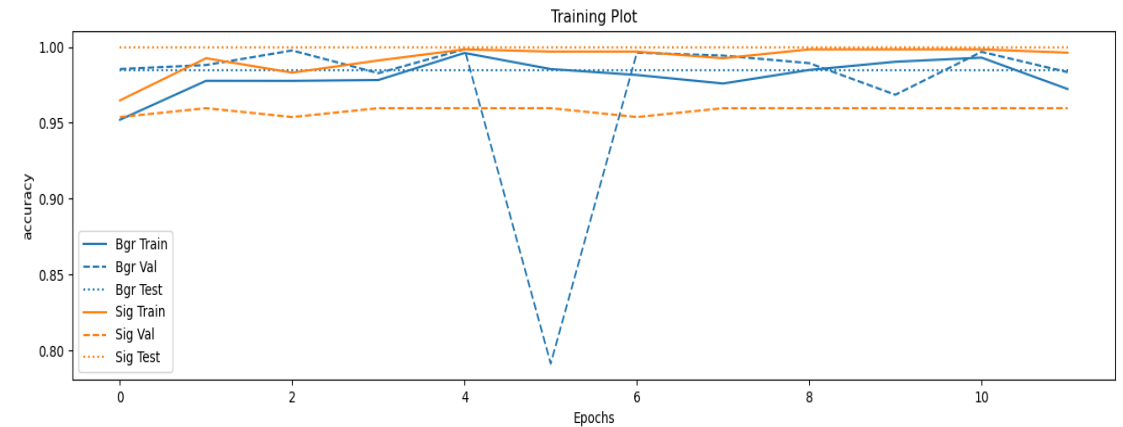
Crystal3, 3~6 keV



Crystal3, 3~6 keV

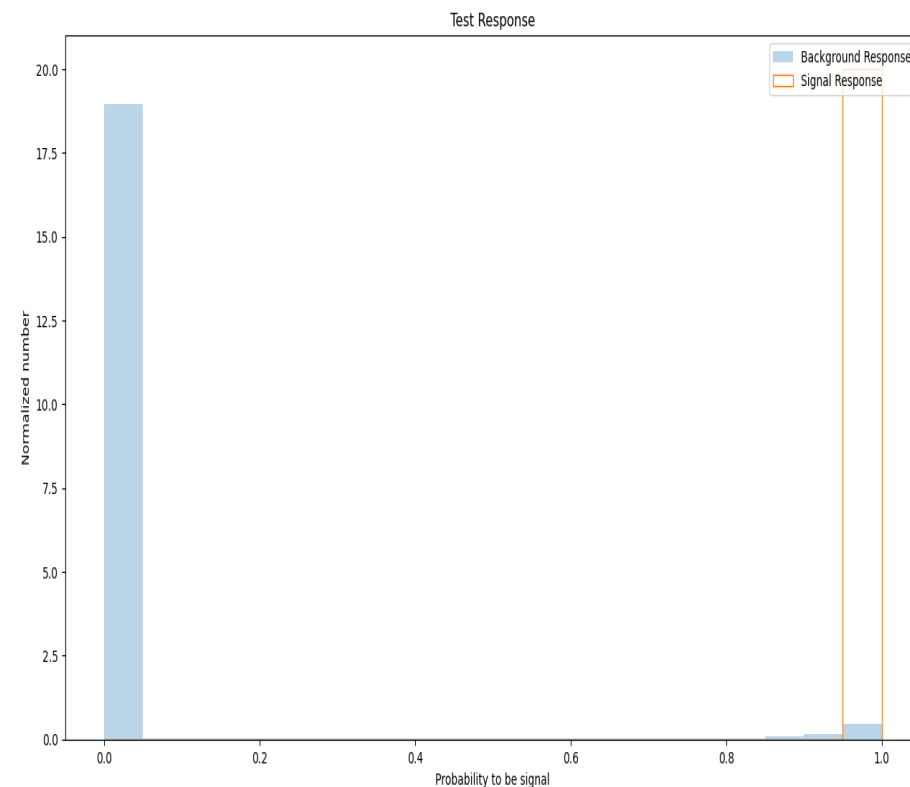
- More (6~12) epochs were needed for training.
- Test passed!
 - Signal efficiency 100%
 - Background efficiency 98.47%
- Also successful for crystal 1 and 7.

Test Efficiency	Crystal 1	Crystal 7
Signal [%]	100	100
Background [%]	99.21	99.96



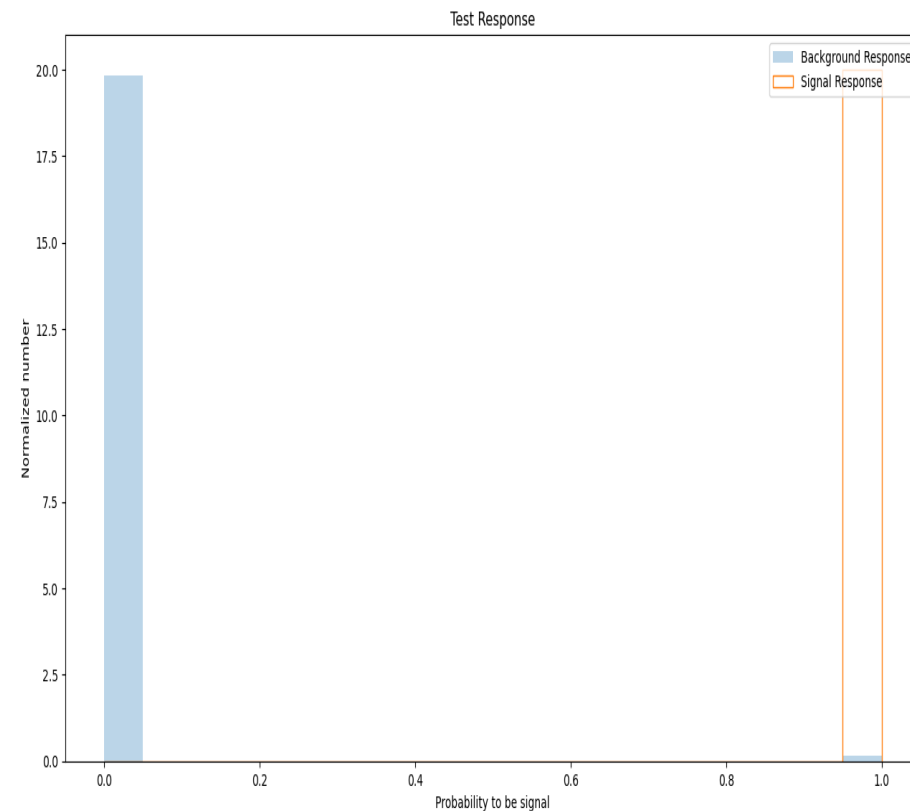
Applying Other Data

- Training
 - crystal 3, 6~10 keV data.
- Test
 - crystal 3, 3~6 keV data.
- Result
 - Signal efficiency 100%
 - Background efficiency 95.48%



Applying Other Data

- Training
 - crystal 3, 3~6 keV data.
- Test
 - crystal 3, 6~10 keV data.
- Result
 - Signal efficiency 100%
 - Background efficiency 99.21%



Applying Other Data

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

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