DAMPE PARTICLE TRAJECTORY RECONSTRUCTION WITH DEEP LEARNING

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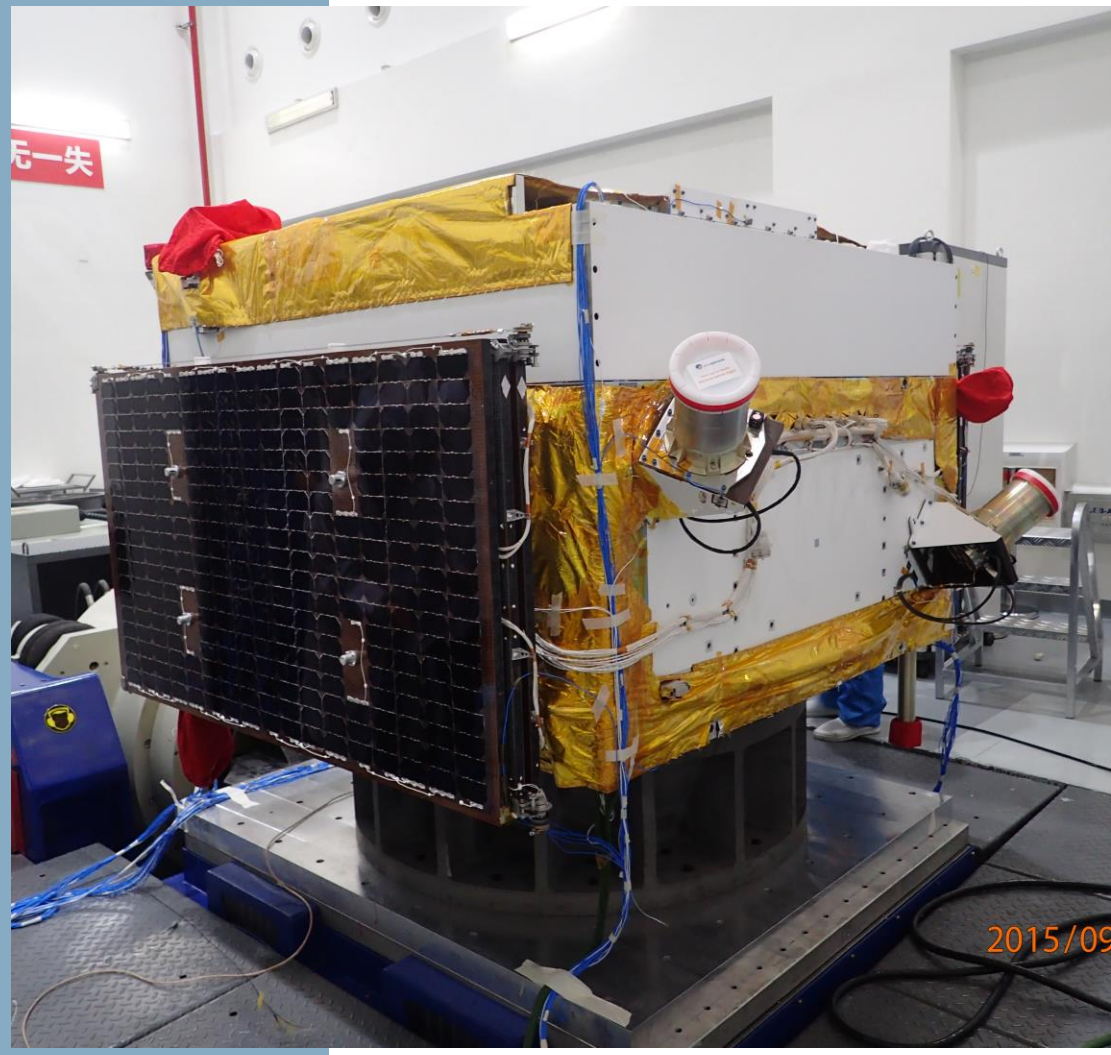
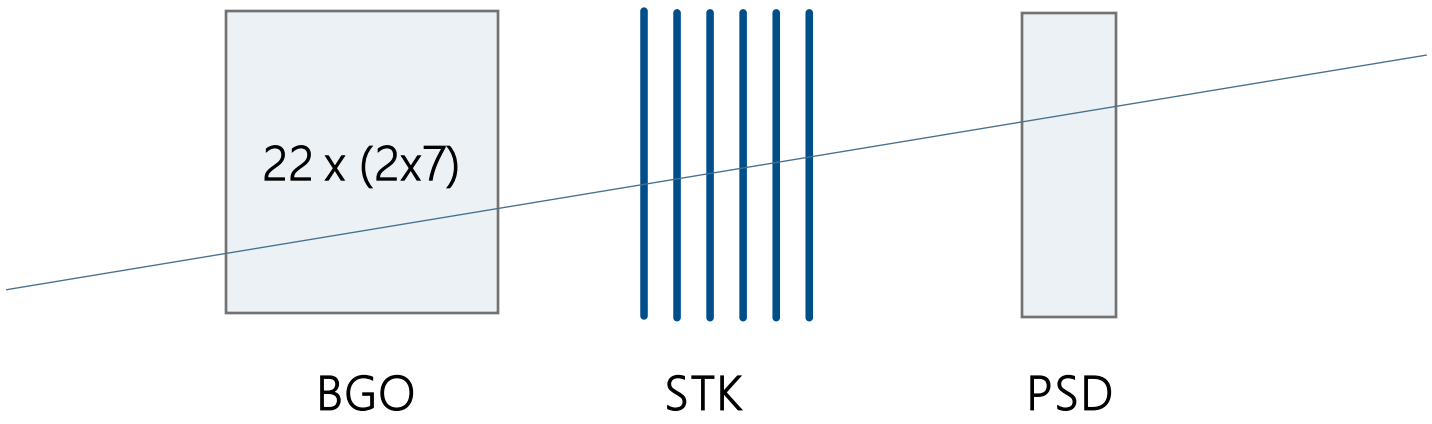


DARK MATTER PARTICLE EXPLORER

- Bismuth Germanium Oxide (BGO) **Calorimeter** (14 layers and 22 bars | hodoscope).
- Silicon Tungsten tracKer-converter (STK) -> Trajectory reconstruction, absolute charge measurement.
- Plastic Scintillator Detector (PSD) -> absolute charge measurement.
- NeUtron Detector (NUD)



- Simulated data. Labbeled and Benchmarked (x,y) BGO entry and exit point.

OVERVIEW OF THE TASK

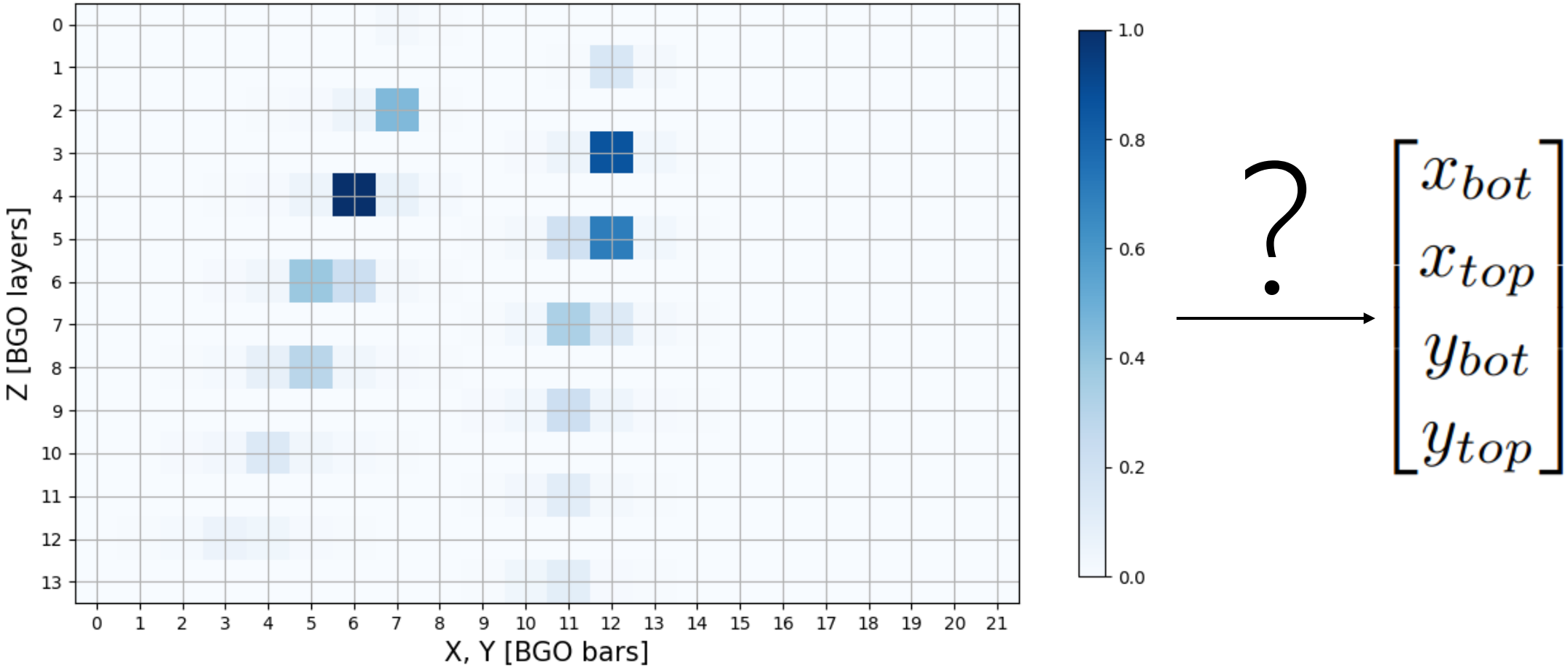


Figure 1 : BGO Calorimeter Shower

CONVOLUTIONAL NEURAL NETWORK

- 22 x 14 x 1 | 8-bits encoded pixels. Relatively big input.
- Most of the pixels contain no information
- Sharp edge and vicinity effect -> Use of Kernel filter

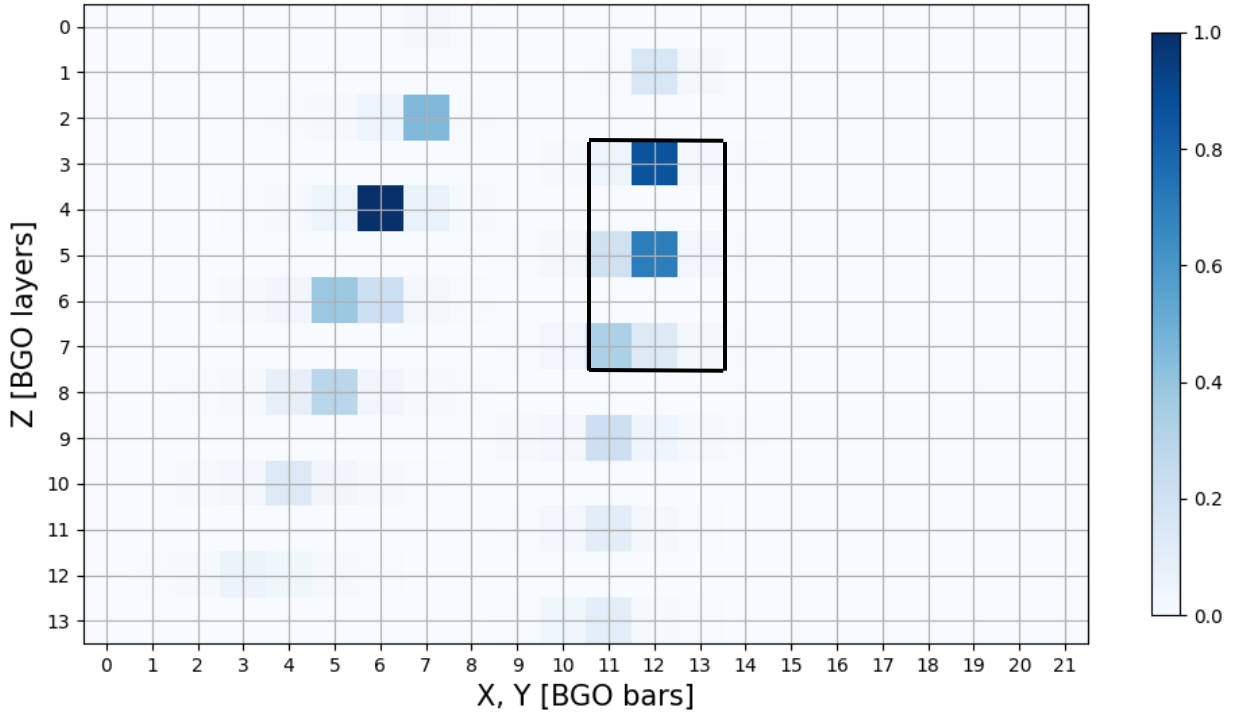
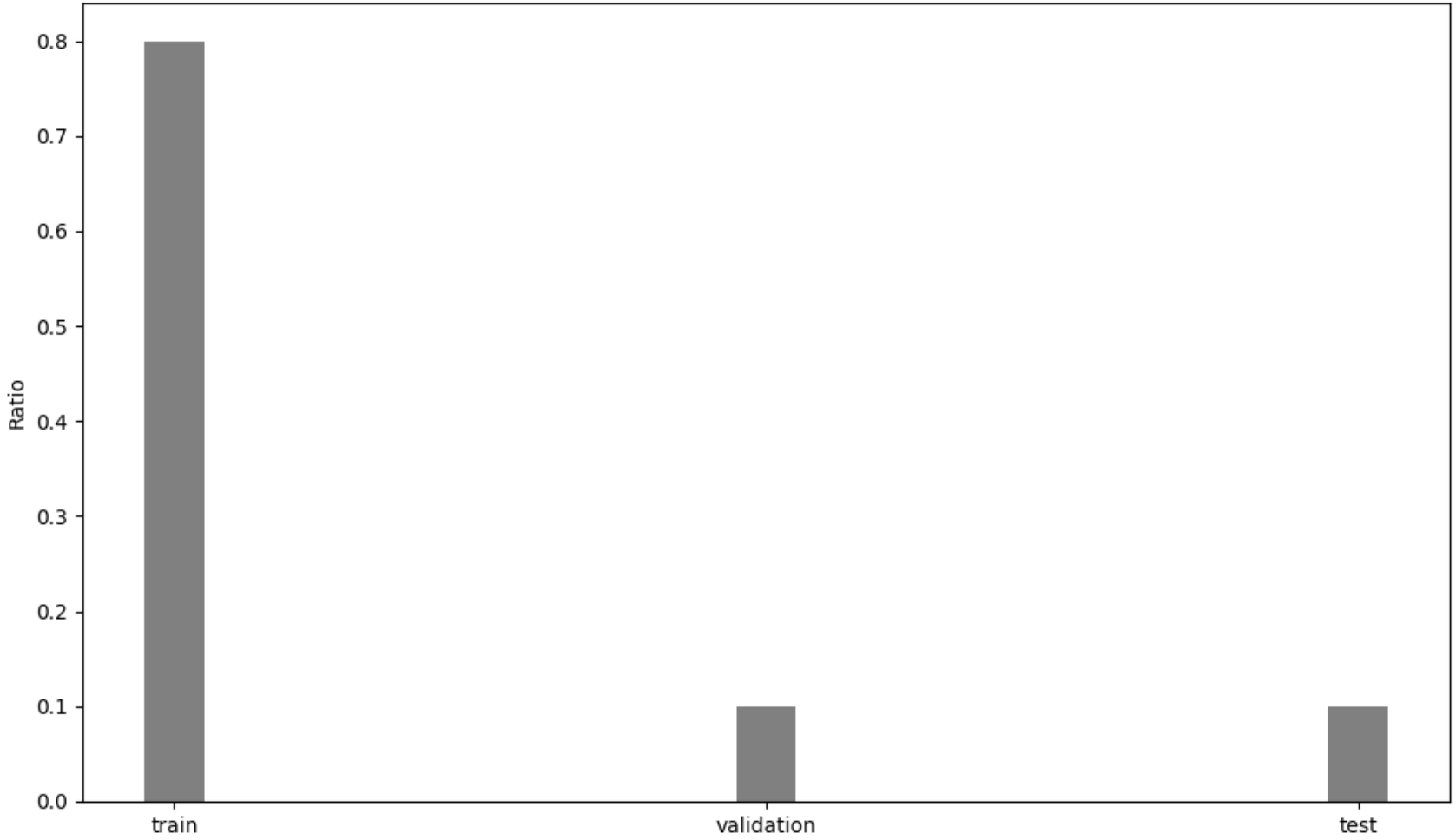


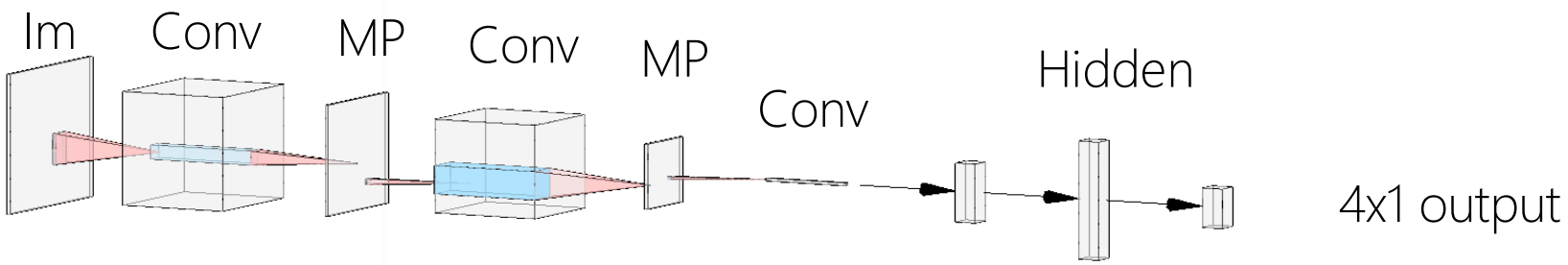
Figure 2 : BGO Calorimeter Shower

DATA PREPROCESSING

Figure 3 : Train, Test, Validation Data Split Proportions



CNN ARCHITECTURE – MODEL 1



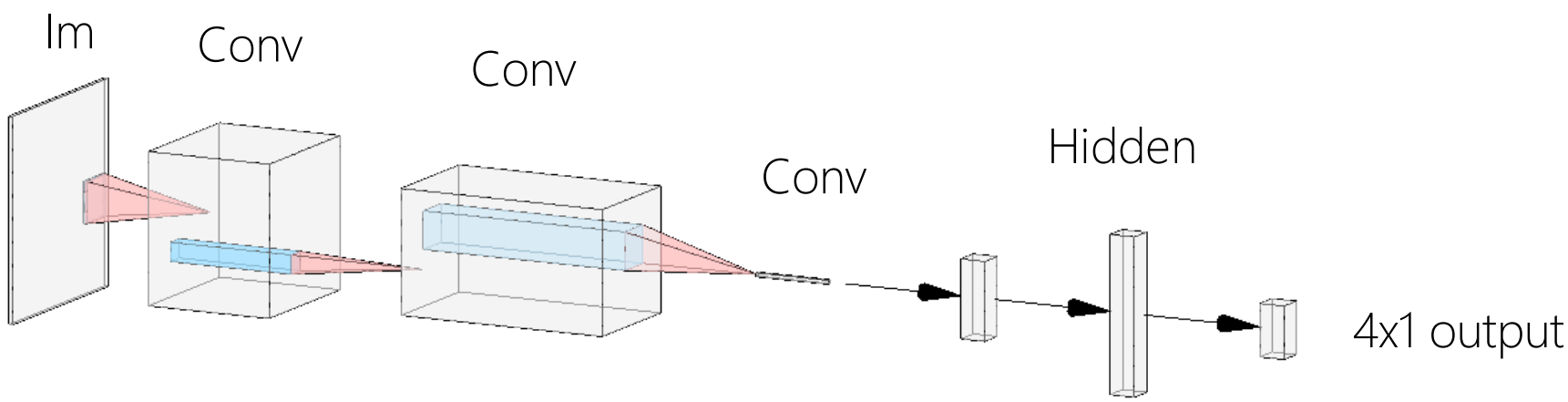
Layer	Shape	Filter type	Flter (Z x (X / Y))	Params
Input	14 x 22 x 1	Convolution	5 x 3	-
Conv 1	10 x 20 x 52	Max Pooling	2 x 2	832
Max Pooled 1	5 x 10 x 42	Convolution	5 x 3	-
Conv 2	1 x 8 x 42	Max Pooling	1 x 2	32802
Max Pooled 2	1 x 4 x 32	Convolution	1 x 4	
Conv 3	1 x 1 x 32	Flatten and Feed-Forward	-	5408
Dense	64	Feed-Forward	-	2112
Output	4	-	-	260
				41'414

Table 1 : Model 1 details

CNN ARCHITECTURE – MODEL 2

Layer	Shape	Filter type	Flter (Z x (X / Y))	Params
Input	14 x 22 x 1	Convolution	5 x 4	-
Conv 1	10 x 19 x 32	Convolution	5 x 4	672
Conv 2	6 x 16 x 32	Convolution	6 x 16	20512
Conv 3	1 x 1 x 8	Flatten and Feed-Forward	-	24584
Dense	64	Feed-Forward	-	576
Output	4	-	-	260
				46'604

Table 2 : Model 2 details



CNN MODEL COMPARISON

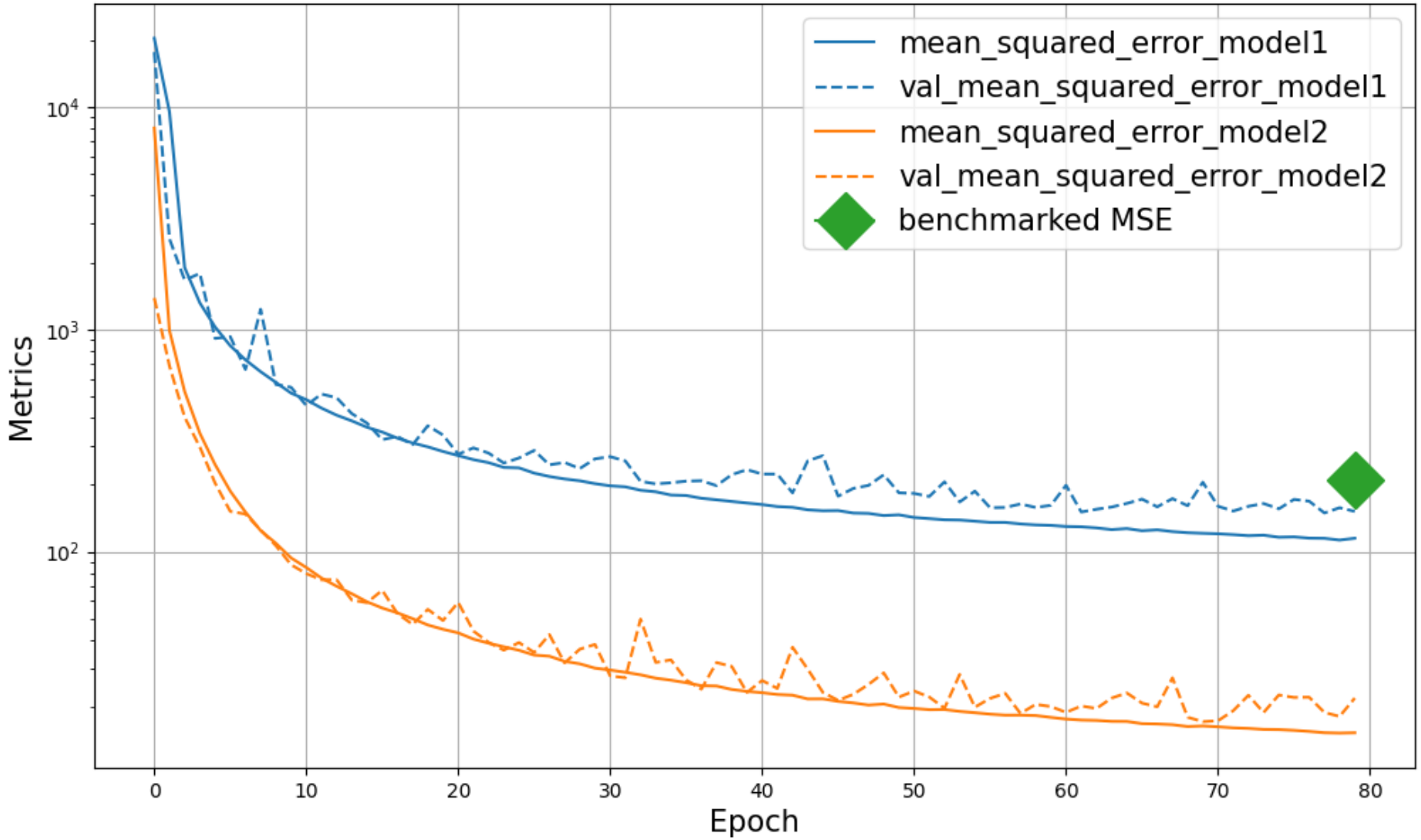


Figure 4 : Model 1 and 2 History compared to benchmarked data

USING PARTICLE ENERGY

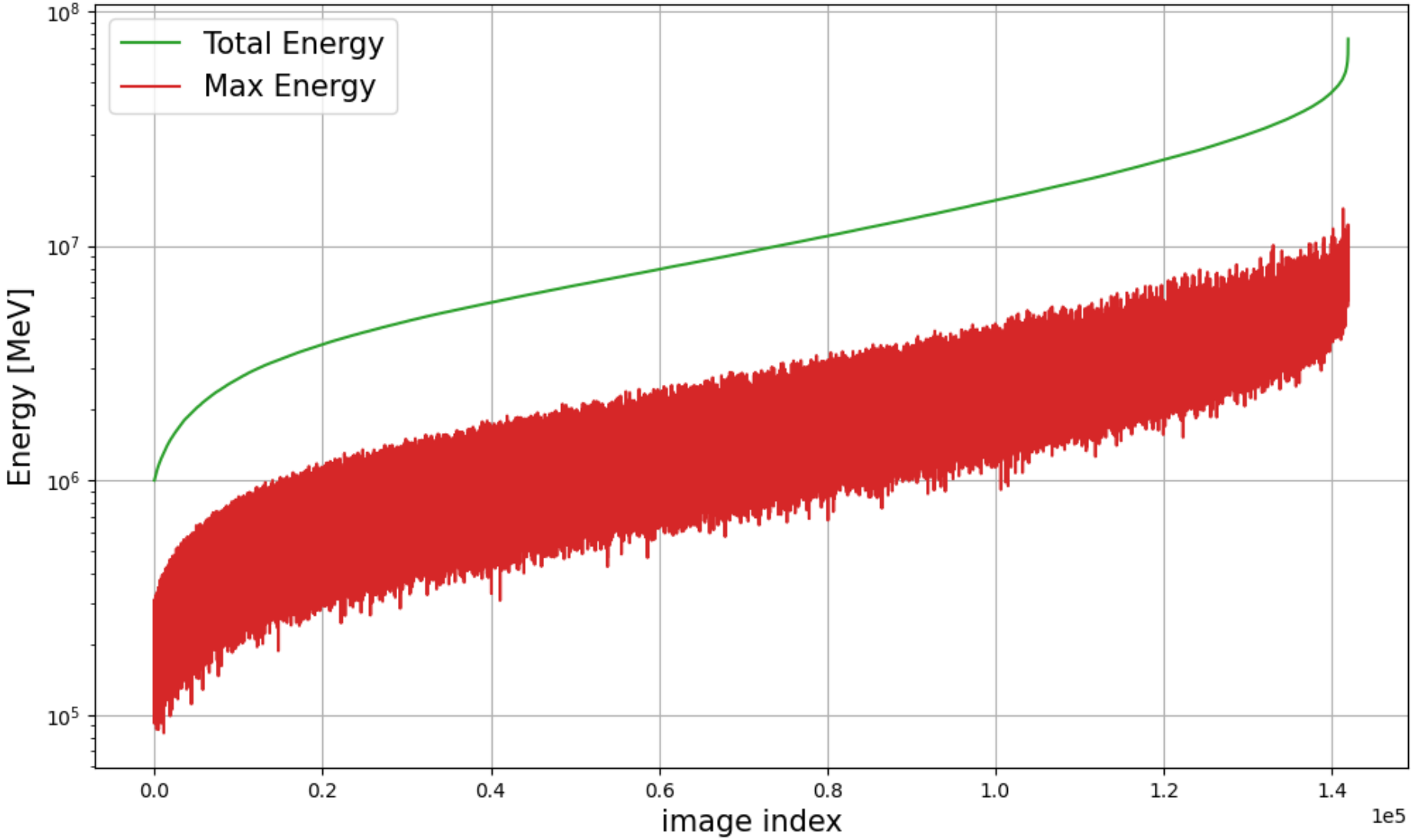
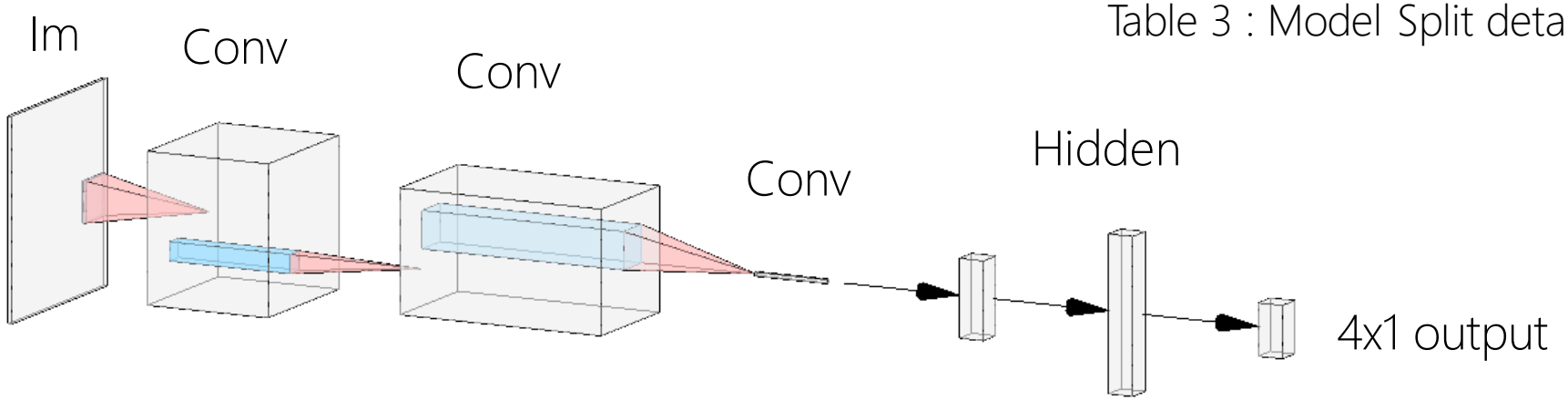


Figure 5 : Shower total energy and pixel maximum energy

ENERGY SPLIT MODEL

- One model with different training set (split on low and high energy)

Layer	Shape	Filter type	Flter (Z x (X / Y))	Params
Input	14 x 22 x 1	Convolution	5 x 4	-
Conv 1	10 x 19 x 8	Convolution	5 x 4	168
Conv 2	6 x 16 x 16	Convolution	6 x 16	2576
Conv 3	1 x 1 x 16	Flatten and Feed-Forward	-	24592
Dense	64	Feed-Forward	-	1088
Output	4	-	-	260
			Table 3 : Model Split details	28'684



ENERGY SPLIT CNN MODEL RESULT

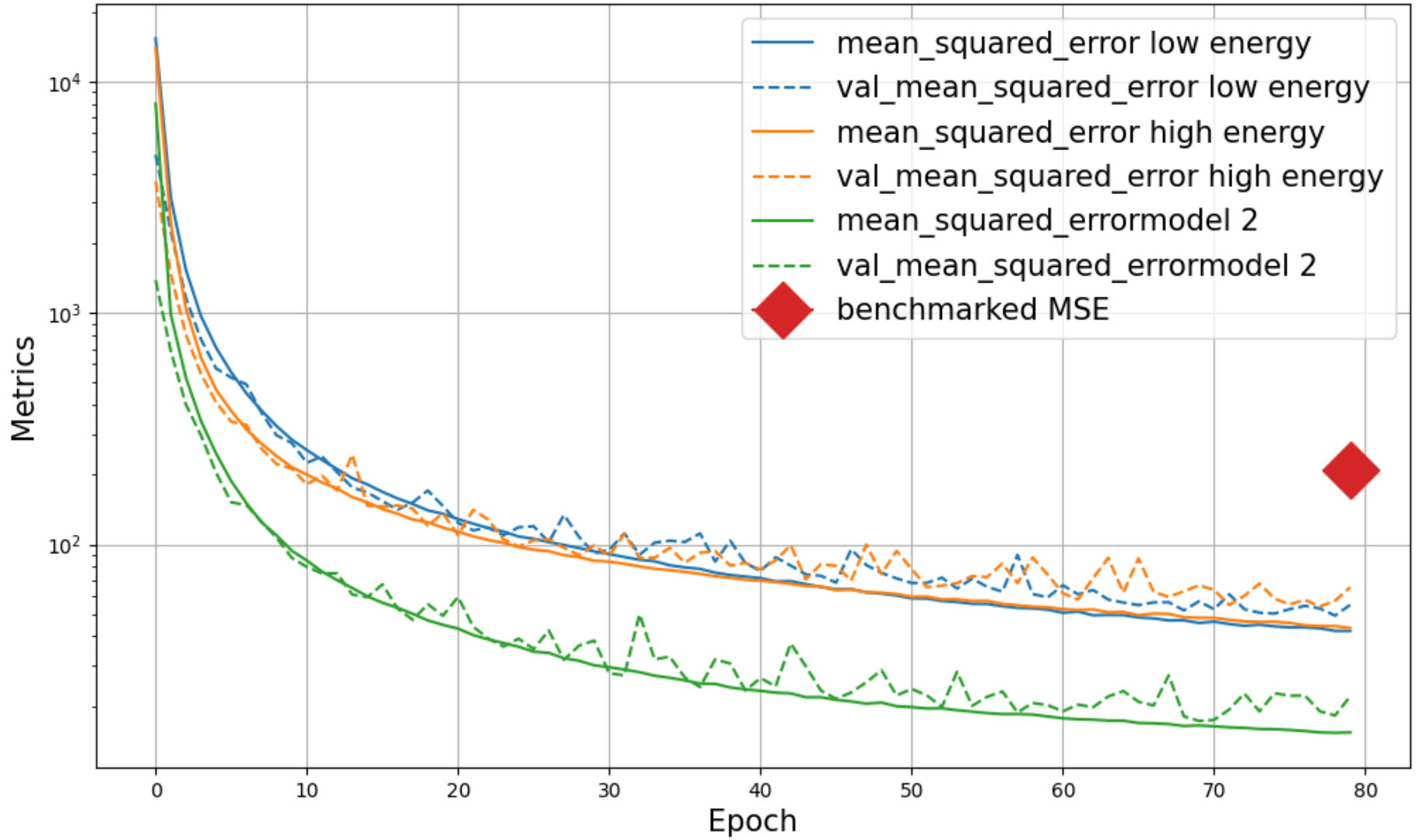


Figure 6 : Split models and Model 2 History compared to benchmarked data

CONCLUSION

- Adding more layers in the feed-forward deteriorates the results.
- Increasing the filter size at each convolution yields poorer result.

- Image of size 14 x 22 -> Input of size 36 * 1e6 : Try a model with more parameters.
- Split on the maximum pixel energy instead of total energy.
- Do not fully flatten the image in the convolutional network.
- Use transformers to include attention between X and Y.