

# WATCHMAL: TIME AS A CHANNEL

EXPERIMENTAL RESULTS

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# DATASET & SCALING CONSTANTS

Working with a **subset** of events from the original training set (14.75 million events):

- Total num. of events: 2,950,284
- Splitting: 85% Train - 5% Validation - 10% Test
- Balance of classes: 49.9% electrons (1s) – 50.1% photons (0s)

Scaling constants computed using 1,000,000,000 hits:

- $\mu_q = 2.49, \quad \sigma_q = 6.95$
- $\mu_t = 975.43, \quad \sigma_t = 47.54$

# CONSIDERED EXPERIMENTS

- Type of data: charge and/or time
- Channels per type of data: 19 channels (one per each PMT in the mPMT) or 2 channels ( $\mu$  and  $\sigma$  per mPMT)
- Scaling techniques: hit standardization or none.

# RESULTS

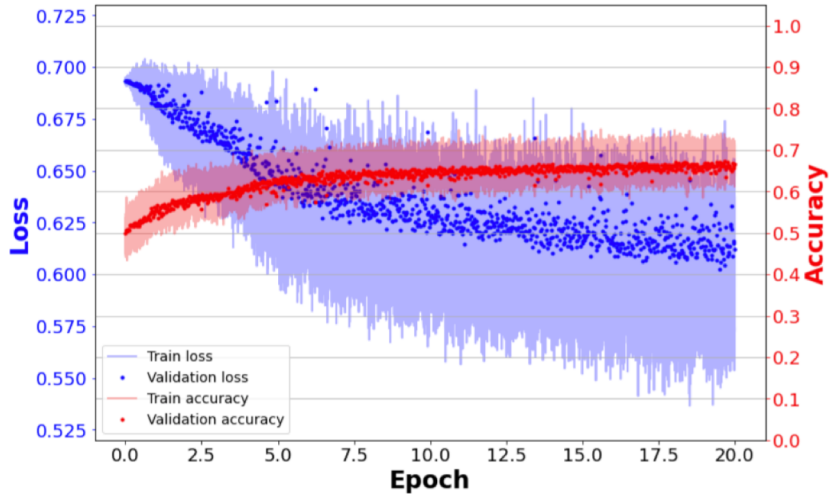
	model	charge	time	scaled	collapsed	log_loss	acc	f1	auc	opt_threshold	total_score
0	Quo	1	0	0	0	0.5940	0.6747	0.6579	0.7434	0.4833	1.4820
1	Q+Ts	1	1	1	1	0.6047	0.6696	0.6613	0.7327	0.4960	1.4590
2	Qs+Ts	1	1	1	1	0.6046	0.6712	0.6542	0.7337	0.4879	1.4546
3	Q+T	1	1	1	0	0.6105	0.6638	0.6488	0.7249	0.5029	1.4270
4	T	0	1	1	0	0.6304	0.6428	0.6308	0.6962	0.5042	1.3394
5	Qu	1	0	0	0	0.6271	0.6427	0.6203	0.7007	0.4866	1.3367
6	Q	1	0	1	0	0.6358	0.6313	0.6142	0.6862	0.4870	1.2959
7	Qs	1	0	1	1	0.6466	0.6186	0.6006	0.6680	0.4923	1.2406
8	Qu+Tu	1	1	0	0	0.6646	0.5906	0.5801	0.6295	0.5076	1.1355

Original model trained  
with full dataset

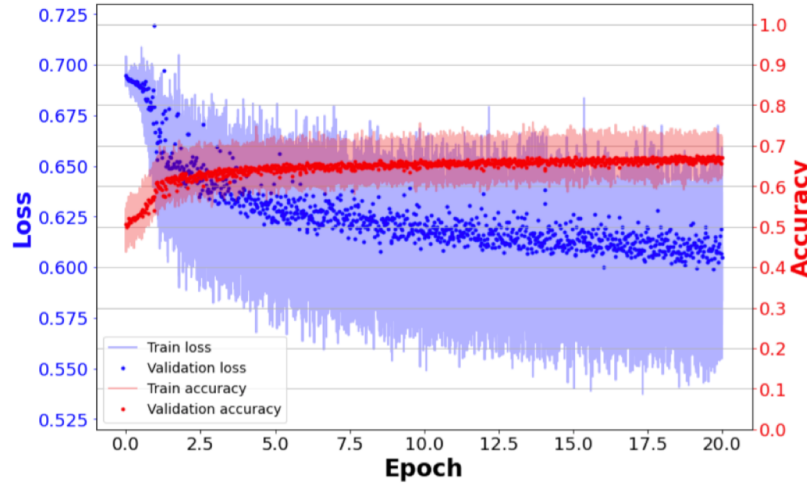
Original model trained  
with subset

Top 3 experiments  
trained with subset

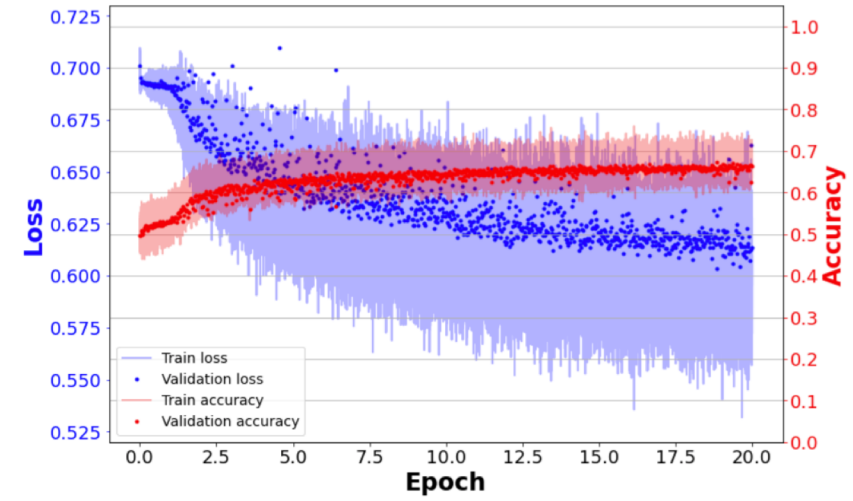
Q+Ts



Qs+Ts

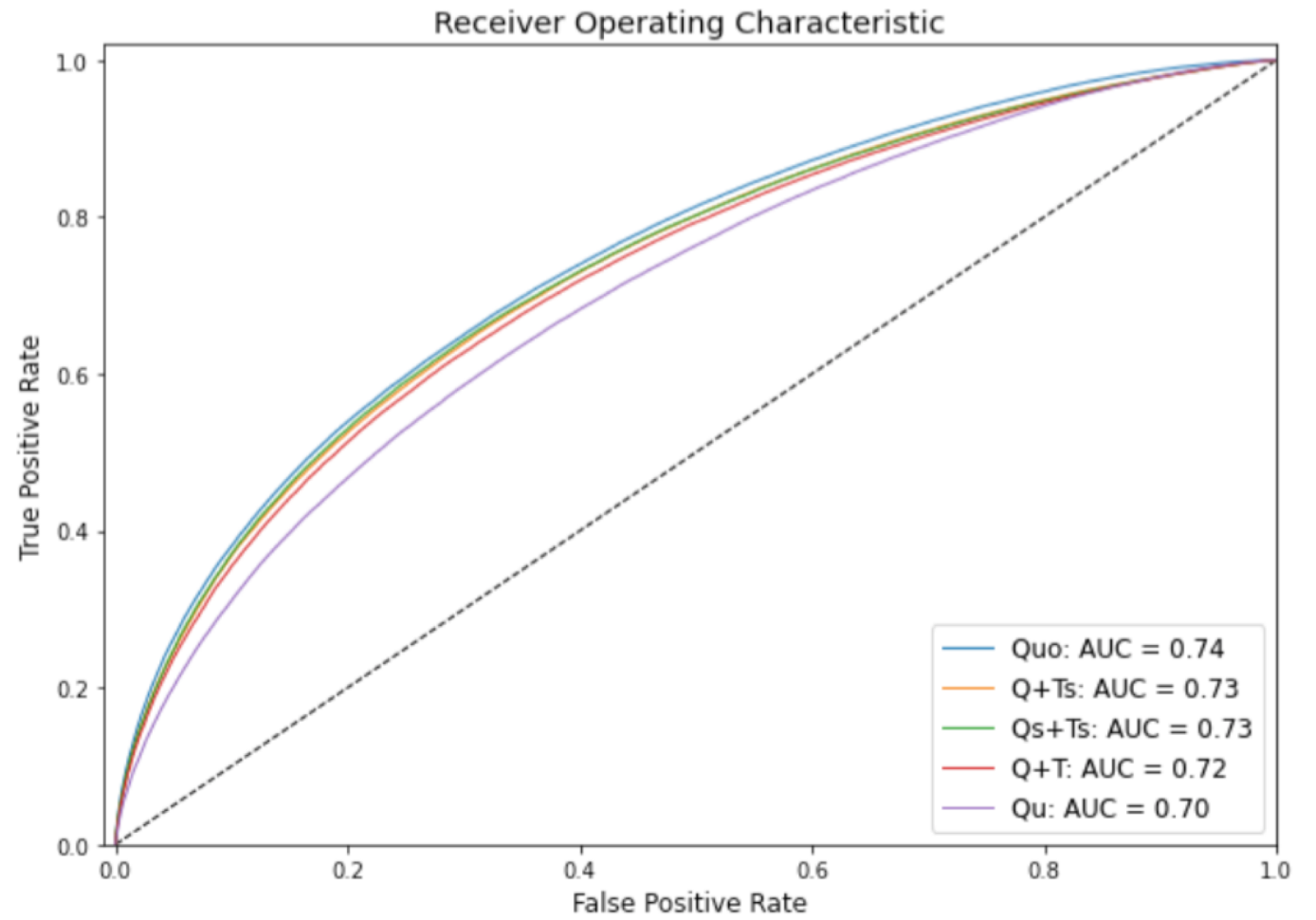


Q+T



# TOP 3 - LEARNING CURVES

# ROC CURVES



## NEXT STEPS

- Use time to order the 19 charge channels
- Increase ResNet size
- Higher definition (one PMT per pixel)
- Explore other alternatives to include time
- Transform CNN to [Bayesian CNN](#) (model prediction uncertainty)
- Fine-tuning hyperparameters (optimizer weight decay, batch size, epochs, dropout, more transformations, etc.)
- Bias analysis wrt. metadata (energy, position, direction)

## TIME TO ORDER Q CHANNELS

- Each pixel is a mPMT, that has 19 PMTs
- Q detected by PMTs inside a given mPMT is distributed along 19 channels
- Goal: use time info of every PMT in the mPMT to order the Q channels

- Example: a mPMT with 4 PMT in it

$$\begin{array}{l} t = [0.2, 0.9, 0.5, 0.8] \\ q = [20, 85, 50, 15] \end{array} \quad \Rightarrow \quad \tilde{q} = [20, 50, 15, 85]$$

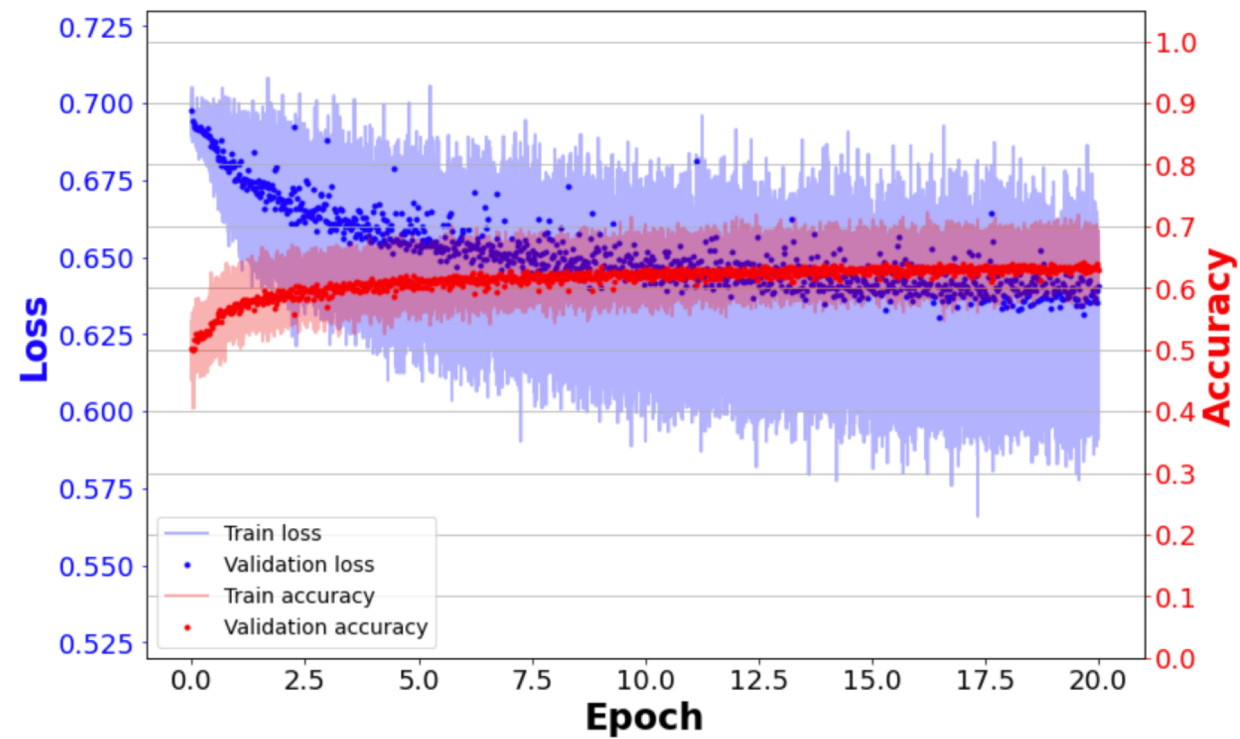
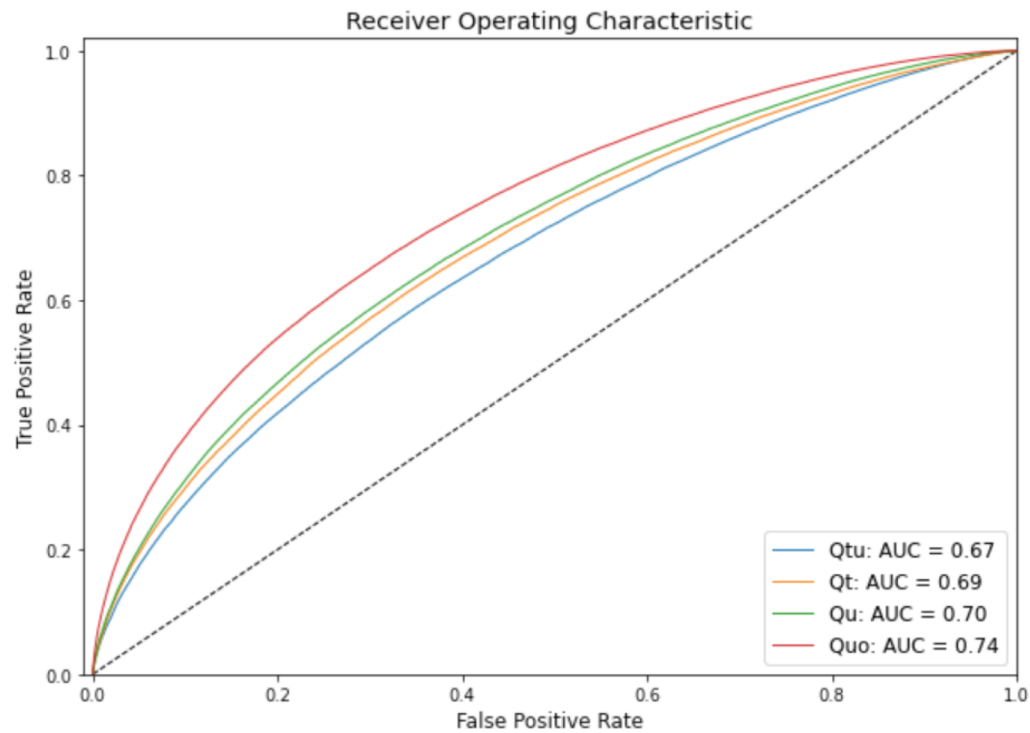


# FIRST RESULTS

	model	scaled	log_loss	acc	f1	auc	opt_threshold	total_score
0	Quo	0	0.5940	0.6747	0.6579	0.7434	0.4833	1.4820
1	Qu	0	0.6271	0.6427	0.6203	0.7007	0.4866	1.3367
2	Qt	1	0.6352	0.6358	0.6216	0.6891	0.4934	1.3113
3	Qtu	0	0.6463	0.6192	0.6043	0.6679	0.5012	1.2451

Original model trained  
with full dataset

Original model trained  
with subset



FIRST RESULTS