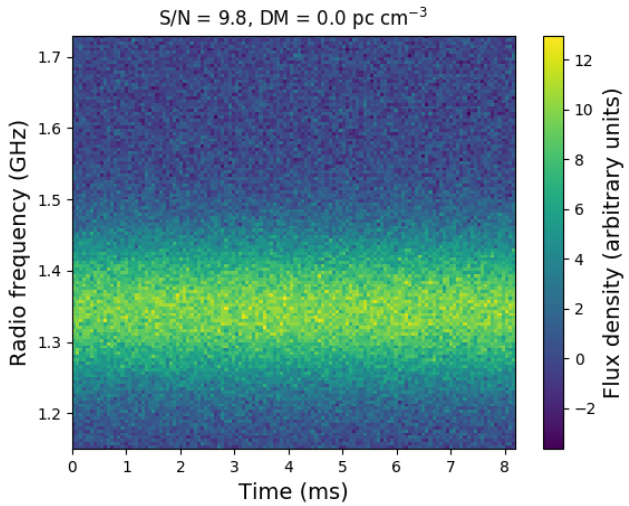
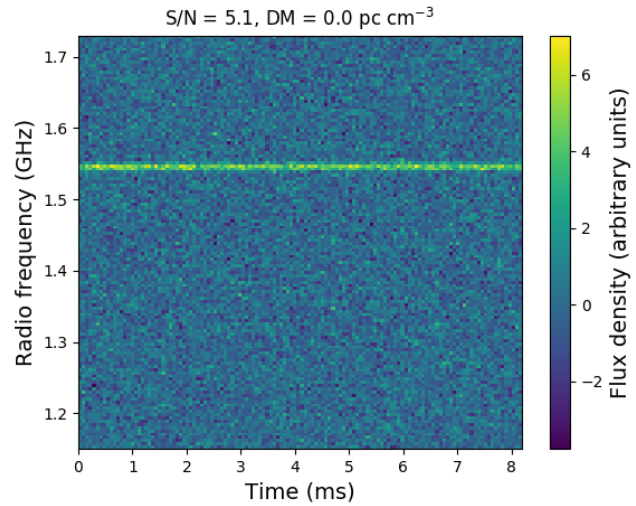
Broadband

Narrowband

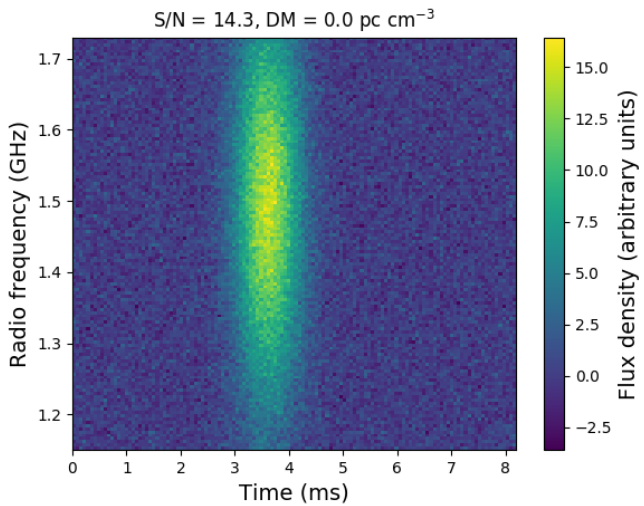
- 128 x 128
- time res = 64 µs
- freq res = 4.53 MHz

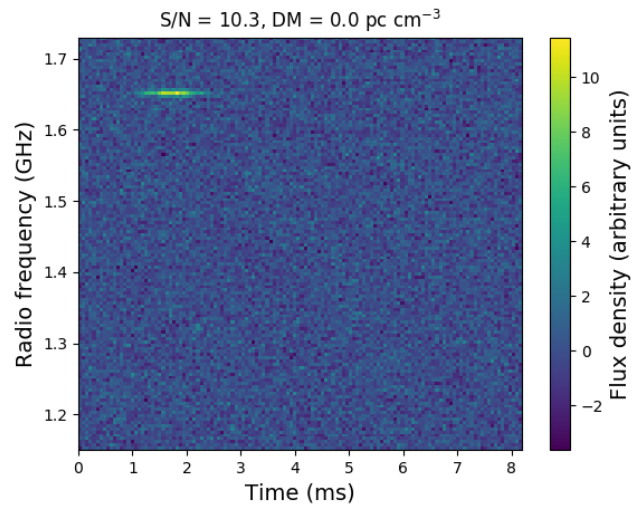
Long – Lived



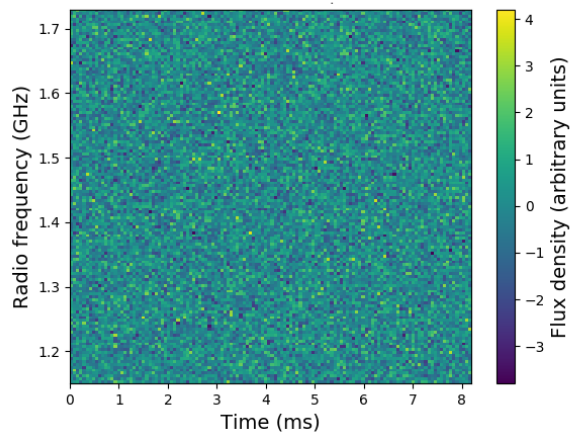


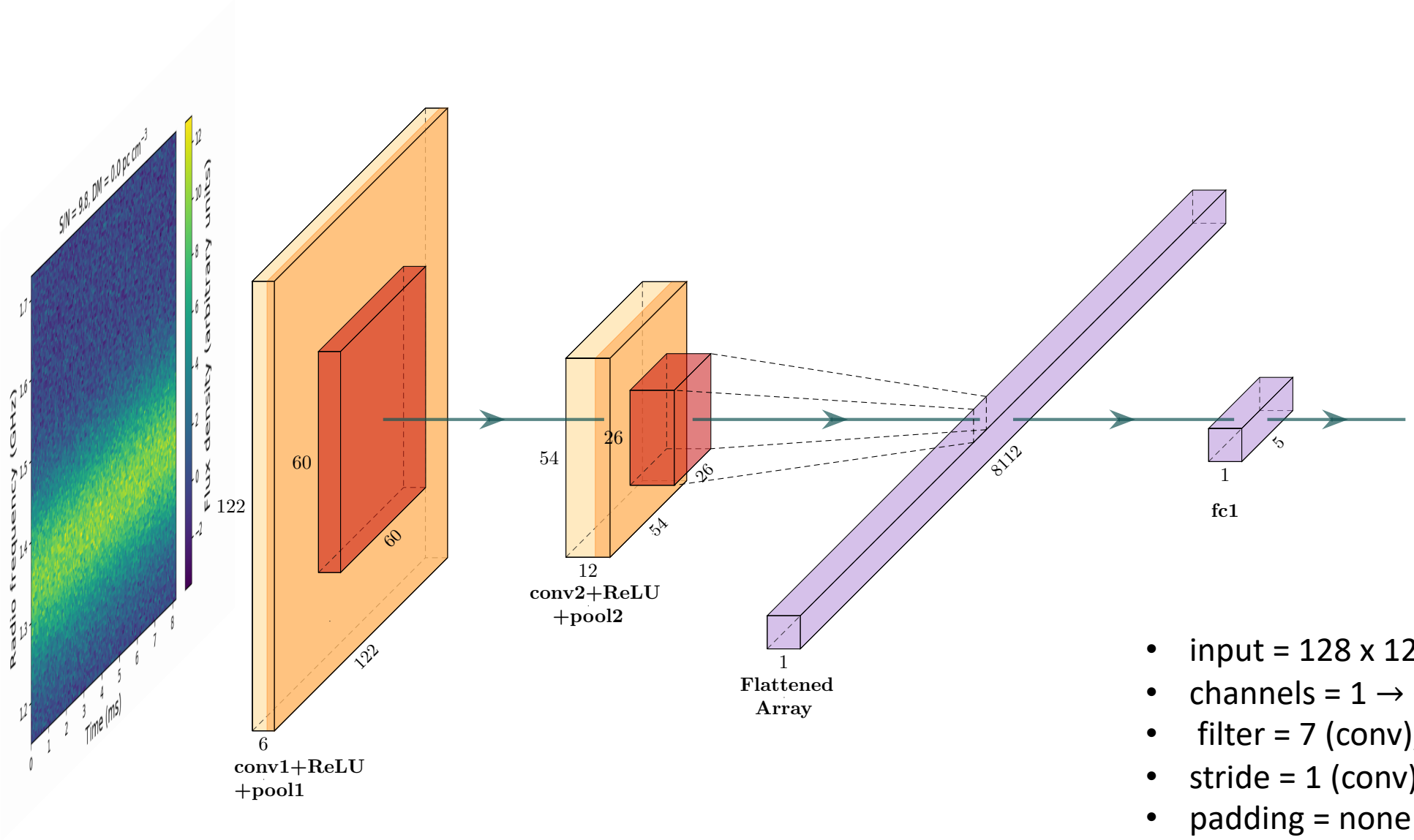
Short – Lived



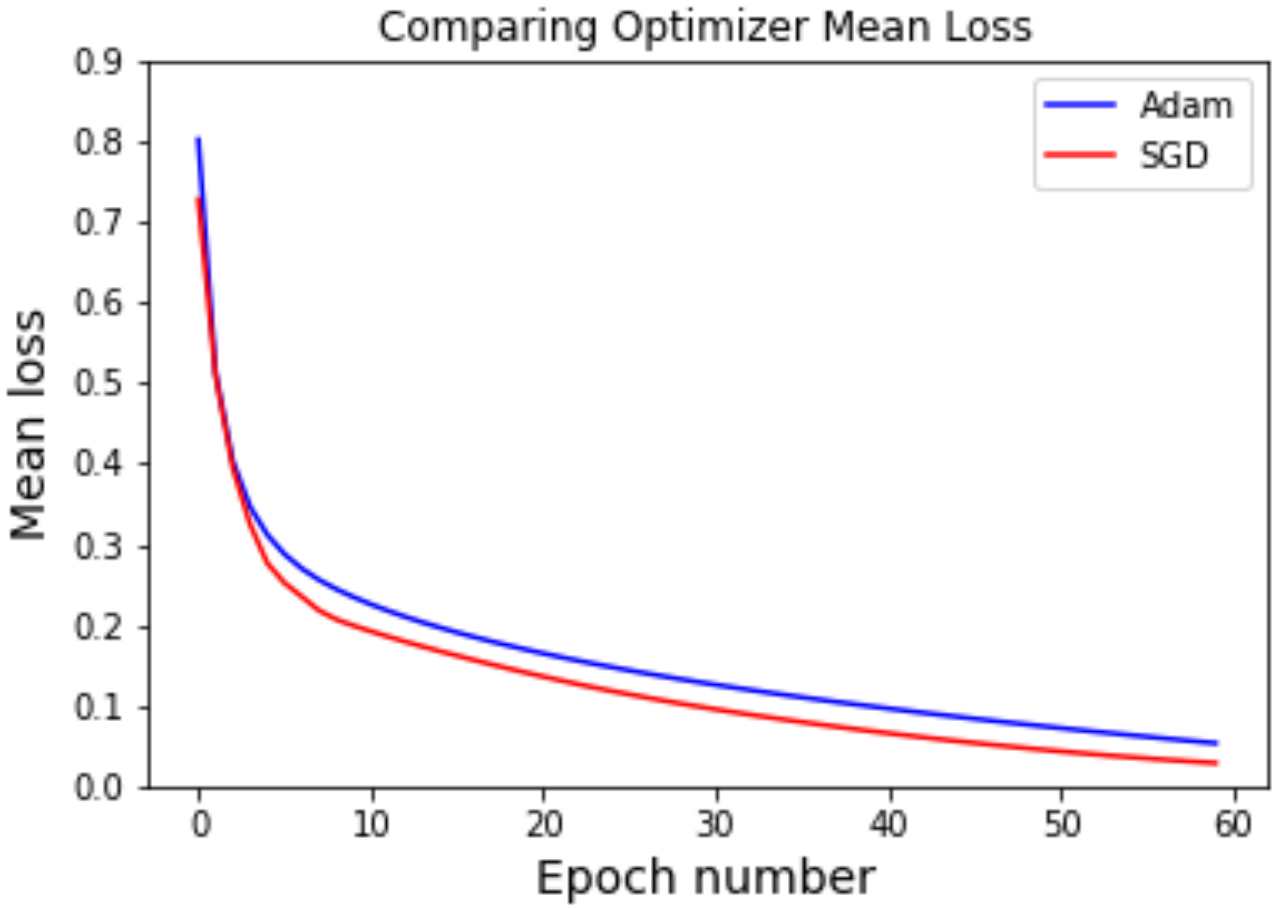


Noise





- input = 128 x 128
- channels = 1 → 6 → 12
- filter = 7 (conv), 4 (pool)
- stride = 1 (conv), 2 (pool)
- padding = none



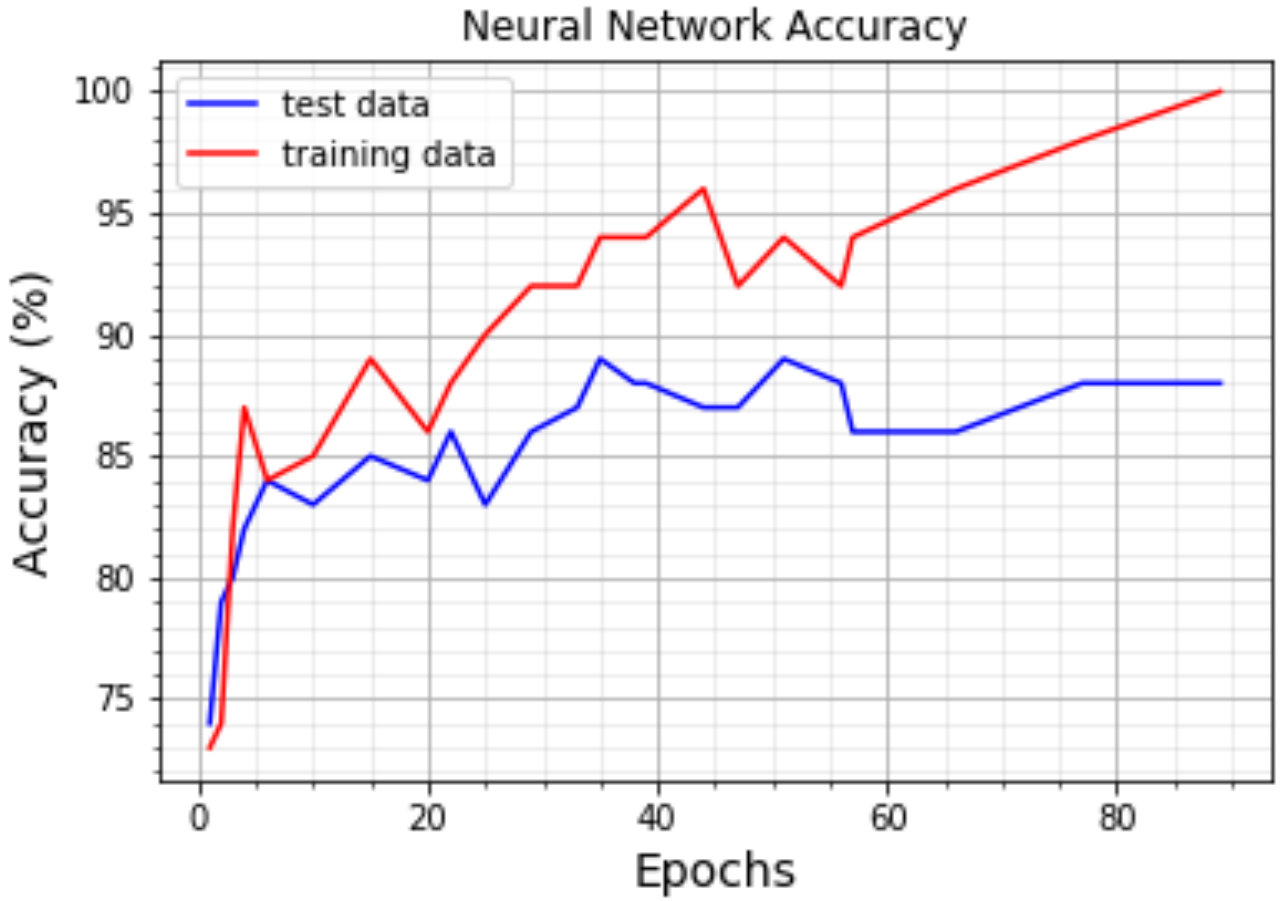
- 60 epochs
- 4,000 data points (no noise)
  - 1,000/class x 4 classes
- Learning rate = 1e-5
- 400 test images
- Adam = 92% accuracy
- SGD = 94% accuracy
- Cross entropy loss
  - Better for classification than MSE

Adaptive Movement Estimation (Adam)

- Computes adaptive learning rates for different parameters from estimates of the first and second moments of the gradients.

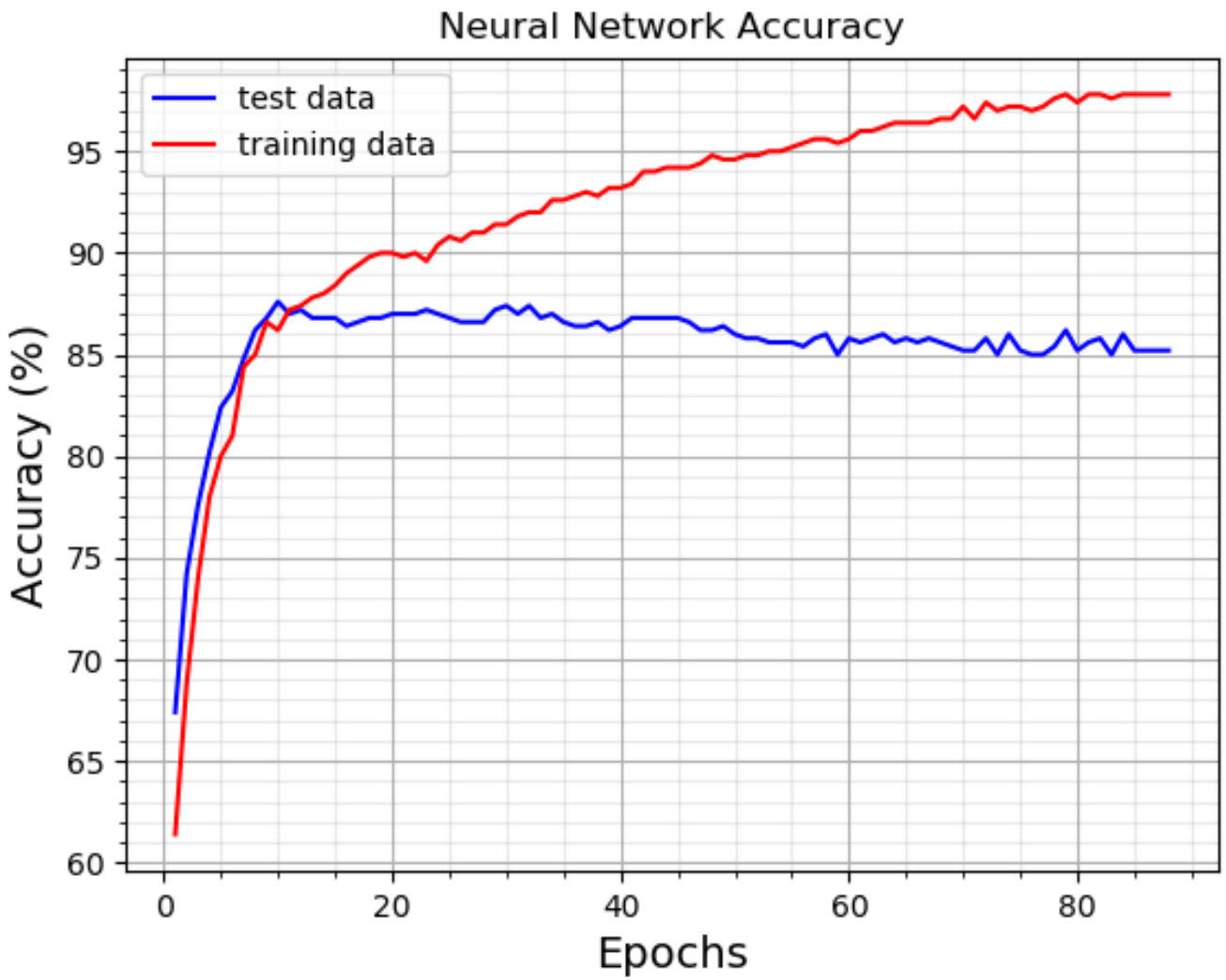
Stochastic Gradient Decent (SGD)

- Maintains a single learning rate for all weight updates. Learning rate does not change during training.



Ep	1	2	3	4	6	10	15	20	22	25	29	33	38	39	44	47	51	56	57	66	77	89
Tr	73	74	82	87	84	85	89	86	88	90	92	92	94	94	96	92	94	92	94	96	98	100
Te	74	79	80	82	84	83	85	84	86	83	86	87	88	88	87	87	89	88	86	86	88	88

23 data points


Neural Network Accuracy
test data
training data
Accuracy (%)
95
90
85
80
75
70
65
60
0
20
40
60
80
Epochs

Loss = 0.41

Epochs = 6

Total Accuracy = 81%, 85%

Expected vs Predicted Classification Table

= test data

= training data

Predicted / Expected	Long-lived broadband	Long-lived narrowband	Short-lived broadband	Short-lived narrowband	Noise
Long-lived broadband	1.0 1.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
Long-lived narrowband	0.0 0.0	0.77 0.79	0.0 0.0	0.10 0.07	0.13 0.14
Short-lived broadband	0.01 0.0	0.0 0.0	0.96 0.98	0.01 0.0	0.02 0.02
Short-lived narrowband	0.0 0.0	0.13 0.05	0.0 0.0	0.33 0.51	0.54 0.44
Noise	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	1.0 1.0

Loss = 0.28

Epochs = 20

Total Accuracy = 84%, 86%

Expected vs Predicted Classification Table

■ = test data

■ = training data

Predicted / Expected	Long-lived broadband	Long-lived narrowband	Short-lived broadband	Short-lived narrowband	Noise
Long-lived broadband	0.99 0.99	0.0 0.0	0.1 0.1	0.0 0.0	0.0 0.0
Long-lived narrowband	0.0 0.0	0.85 0.78	0.0 0.0	0.06 0.16	0.09 0.06
Short-lived broadband	0.1 0.0	0.1 0.0	0.97 1.0	0.1 0.0	0.0 0.0
Short-lived narrowband	0.0 0.0	0.09 0.08	0.0 0.0	0.66 0.76	0.25 0.16
Noise	0.0 0.0	0.0 0.0	0.0 0.0	0.28 0.17	0.72 0.83

Loss = 0.15

Epochs = 57

Total Accuracy = 86%, 94%

Expected vs Predicted Classification Table

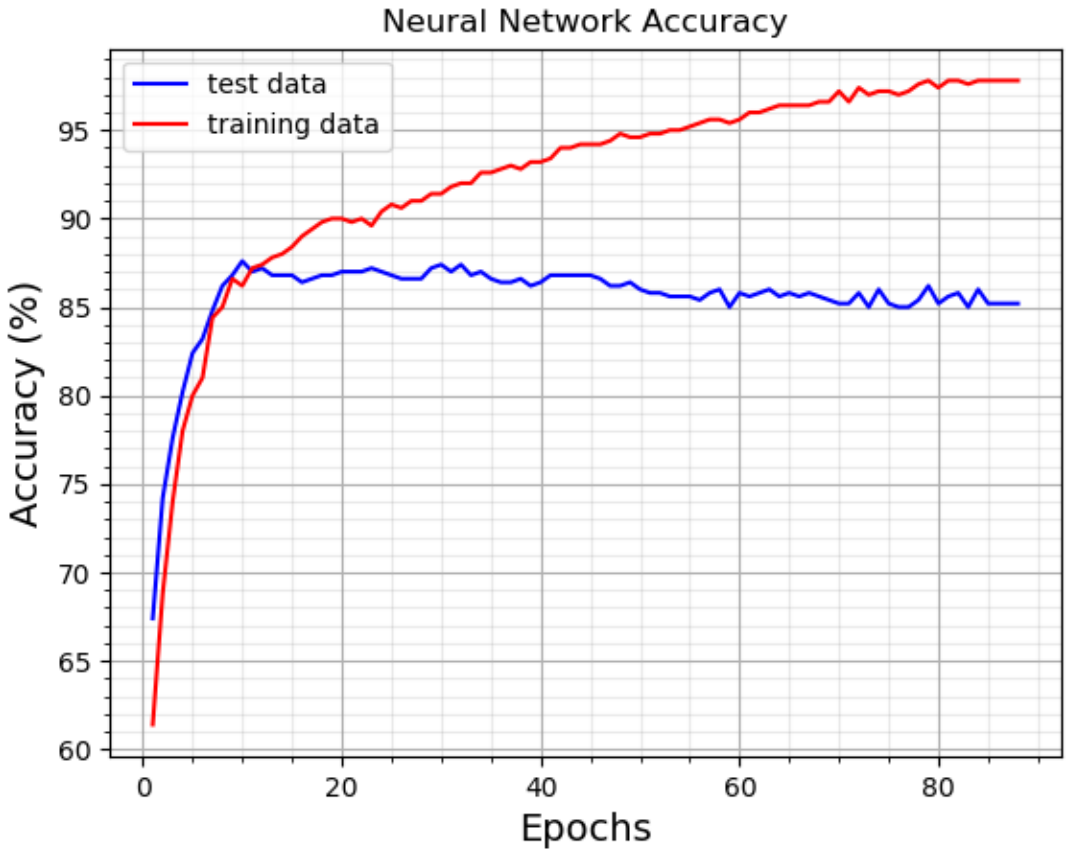
■ = test data

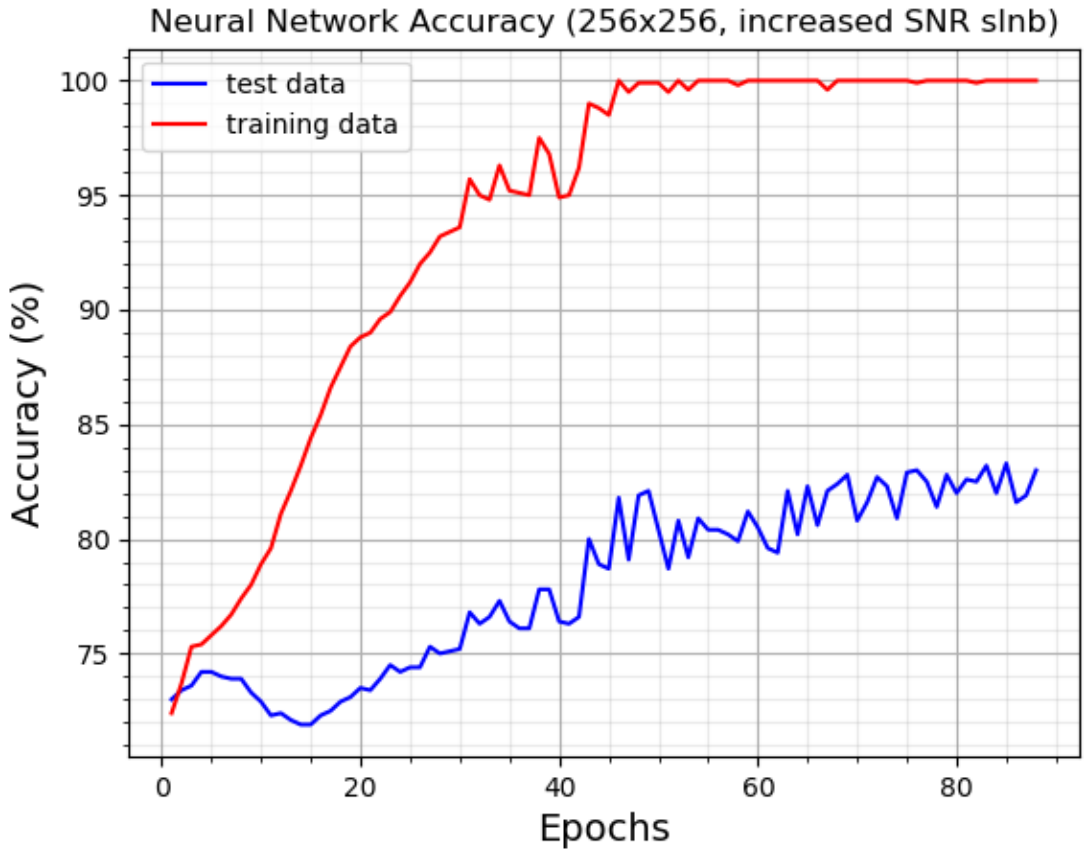
■ = training data

Predicted / Expected	Long-lived broadband	Long-lived narrowband	Short-lived broadband	Short-lived narrowband	Noise
Long-lived broadband	1.0 1.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
Long-lived narrowband	0.0 0.0	0.88 0.88	0.0 0.0	0.04 0.01	0.08 0.11
Short-lived broadband	0.01 0.0	0.0 0.0	0.98 1.0	0.01 0.0	0.0 0.0
Short-lived narrowband	0.0 0.0	0.07 0.04	0.0 0.0	0.67 0.85	0.26 0.11
Noise	0.0 0.0	0.02 0.0	0.0 0.0	0.22 0.02	0.76 0.98

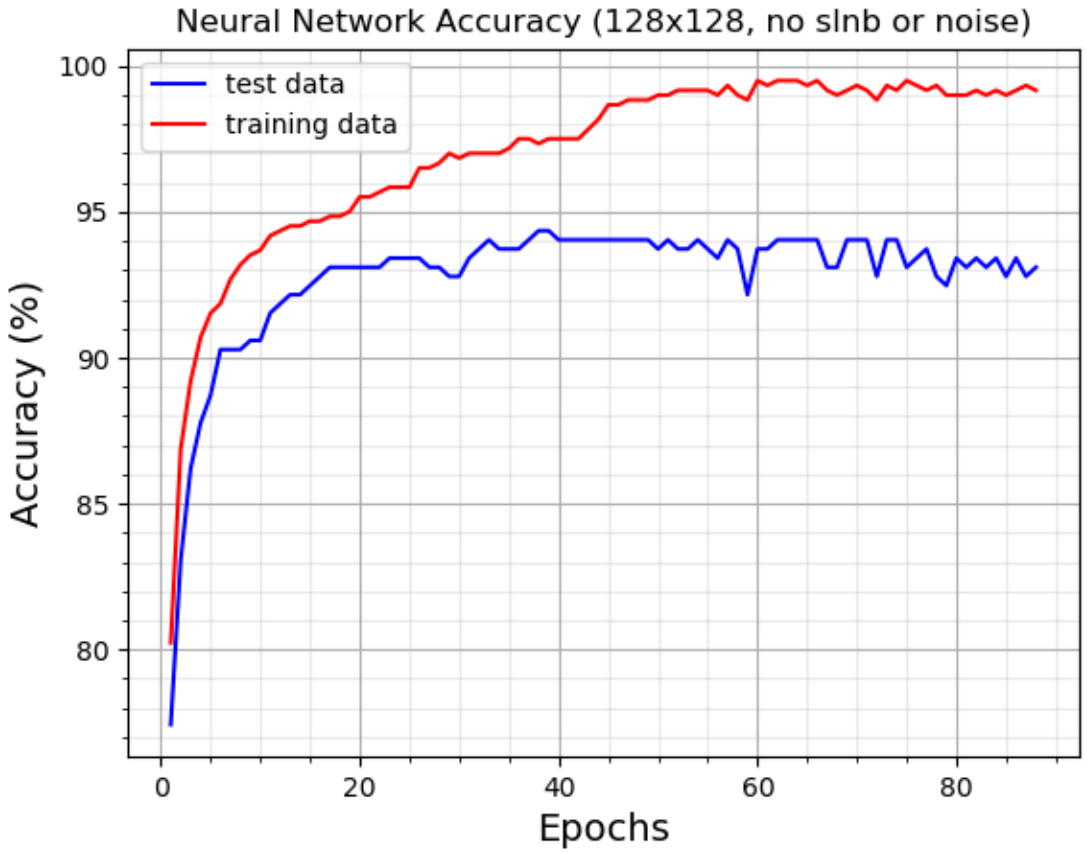
All Categories

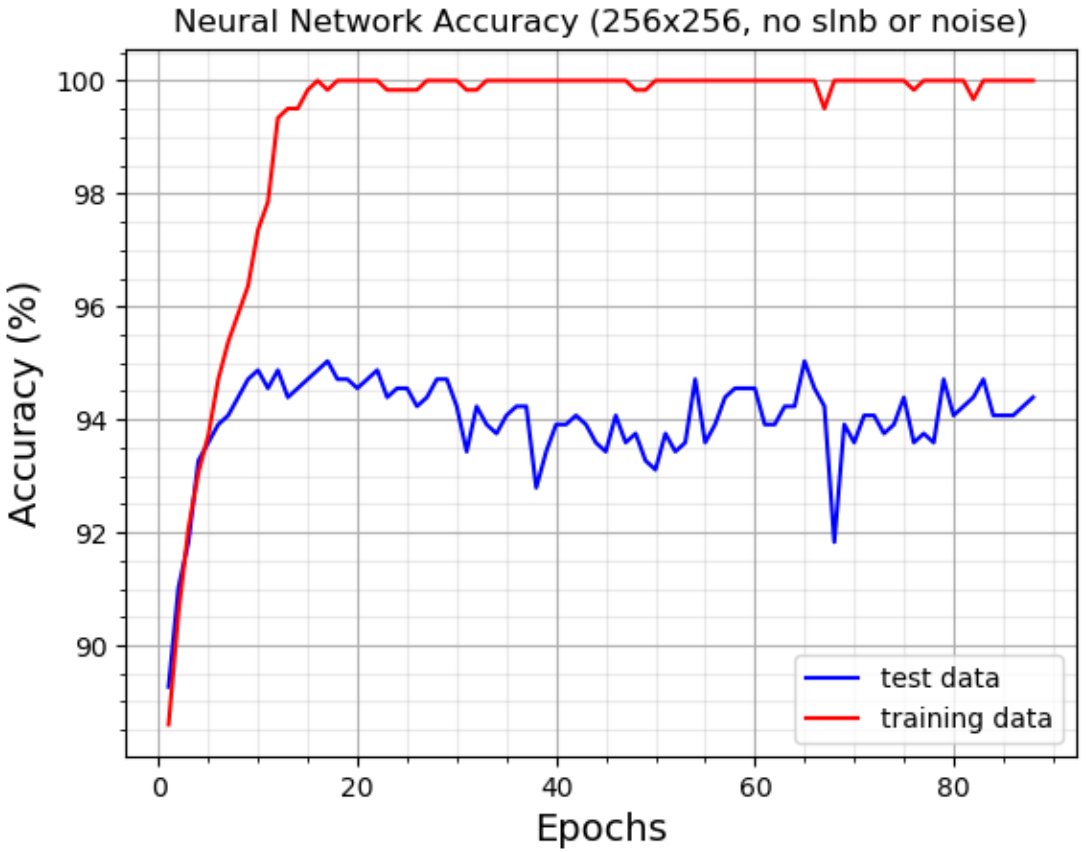
Increased SNR slnb



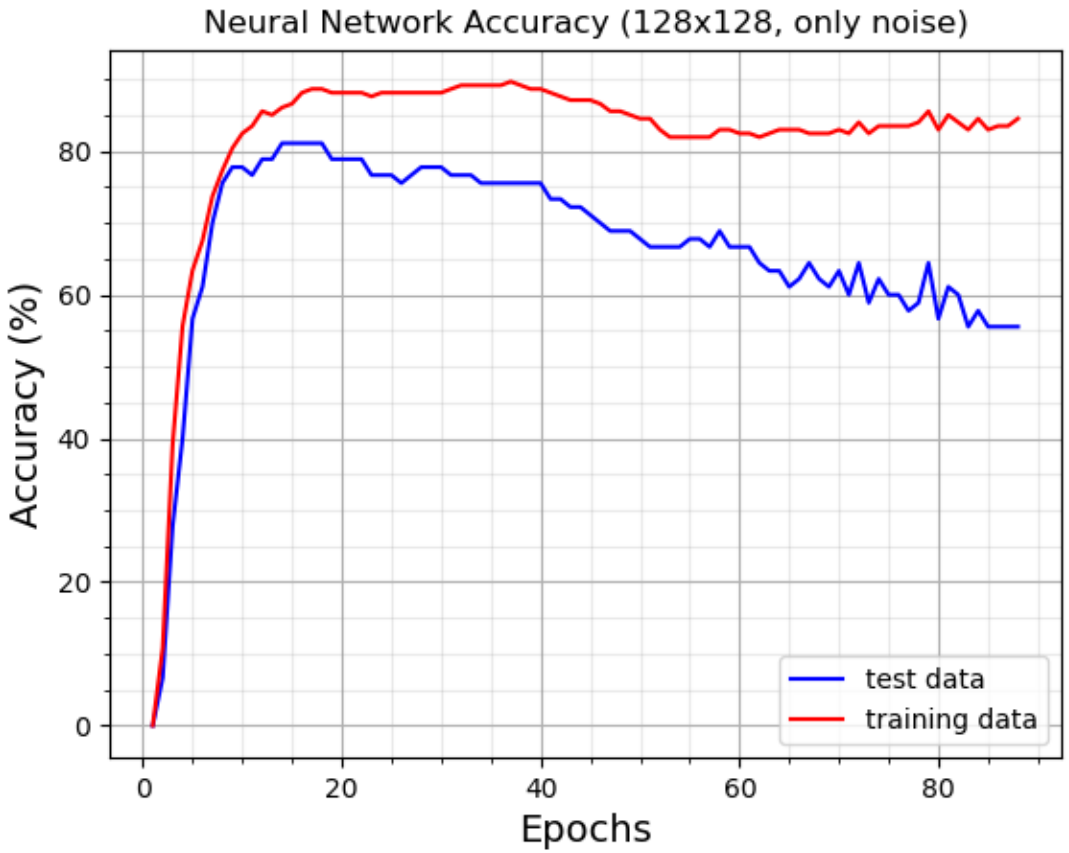


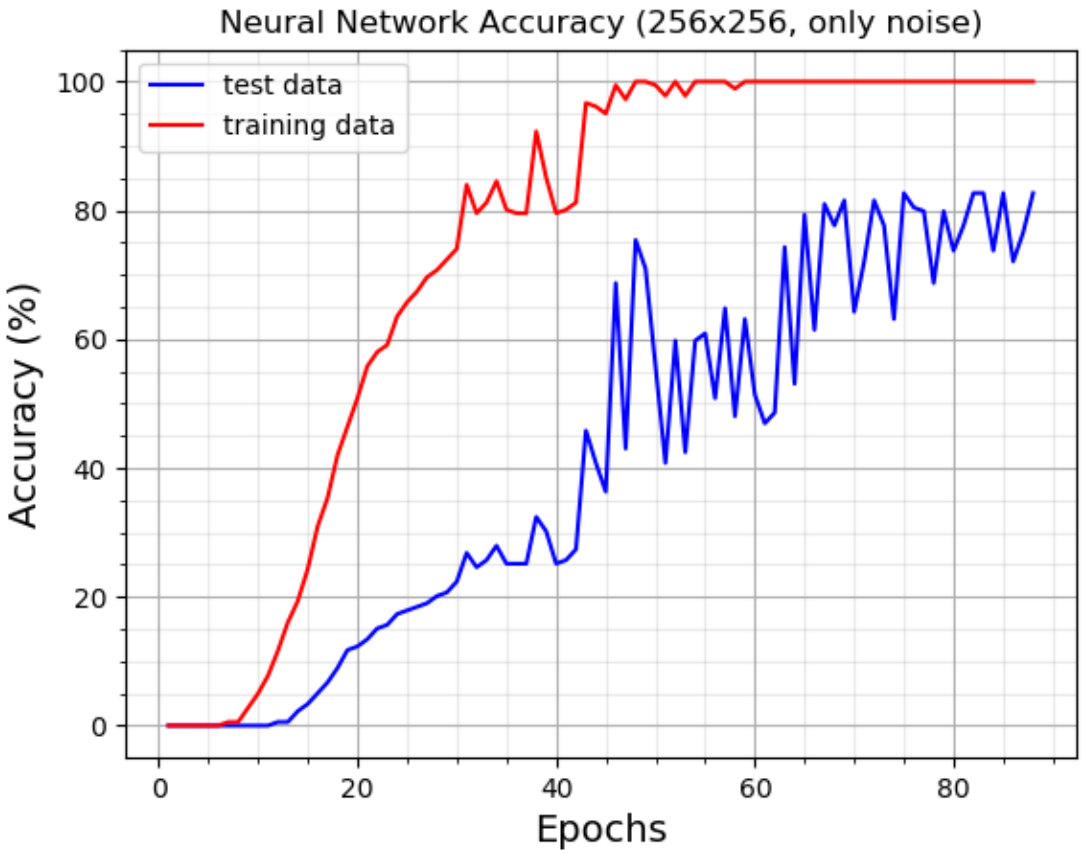
no SLNB, no noise





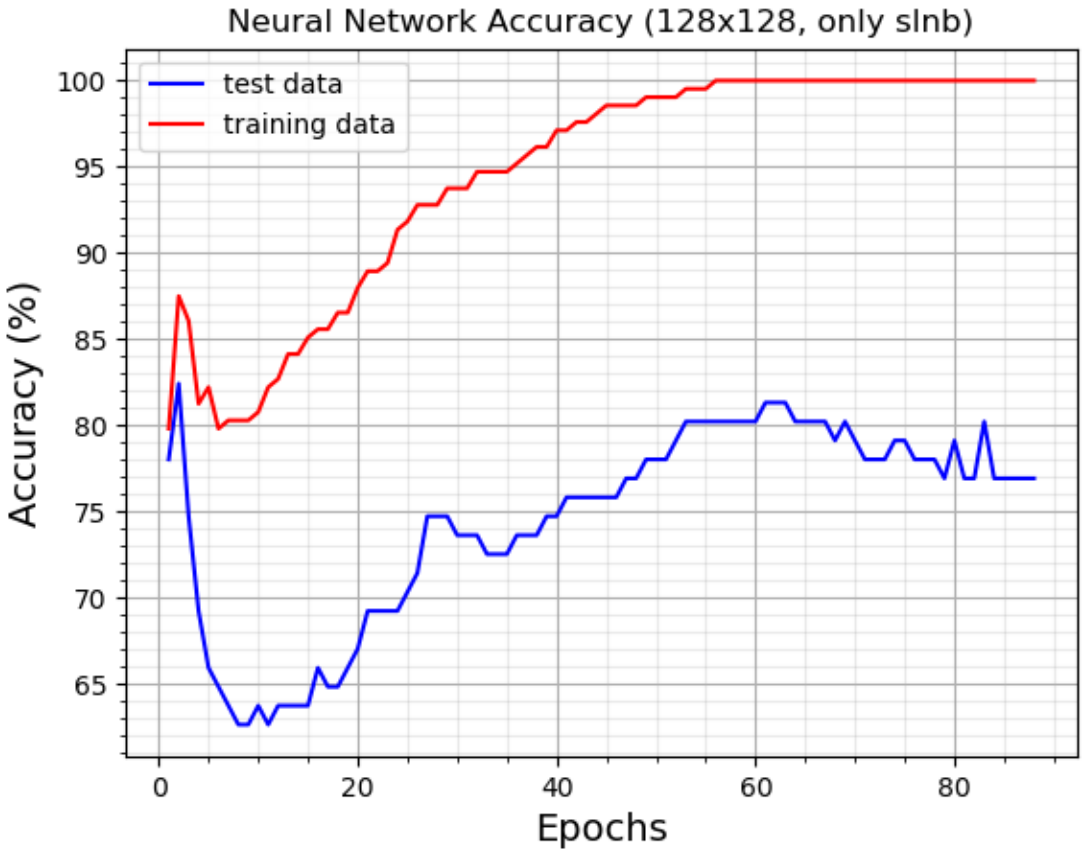
Only noise

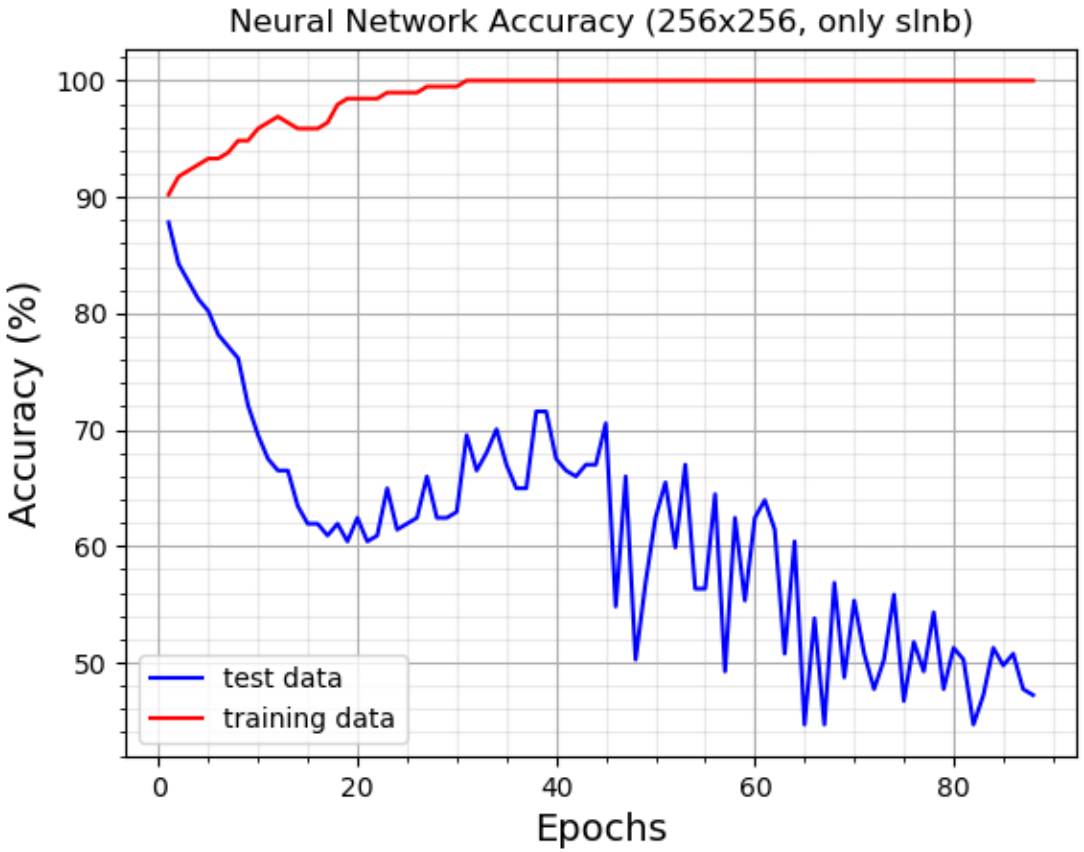

Neural Network Accuracy (128x128, only noise)
Accuracy (%)
Epochs
test data
training data
0
20
40
60
80


Neural Network Accuracy (256x256, only noise)
Accuracy (%)
Epochs
test data
training data
0
20
40
60
80
100

Only slnb

Increased SNR slnb





Loss = 0.21
Epochs = 10
Total Accuracy = 73%, 77%

Expected vs Predicted Classification Table
*Increased SNR slnb

■ = test data
■ = training data

Predicted / Expected	Long-lived broadband	Long-lived narrowband	Short-lived broadband	Short-lived narrowband	Noise
Long-lived broadband	1.0 1.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
Long-lived narrowband	0.0 0.0	0.88 0.92	0.0 0.0	0.12 0.08	0.0 0.0
Short-lived broadband	0.0 0.01	0.0 0.0	0.99 0.98	0.01 0.01	0.0 0.0
Short-lived narrowband	0.0 0.0	0.30 0.04	0.0 0.0	0.70 0.96	0.0 0.0
Noise	0.0 0.0	0.0 0.0	0.0 0.0	1.0 0.96	0.0 0.04

Loss = 0.0

Epochs = 89

Total Accuracy = 81%, 100%

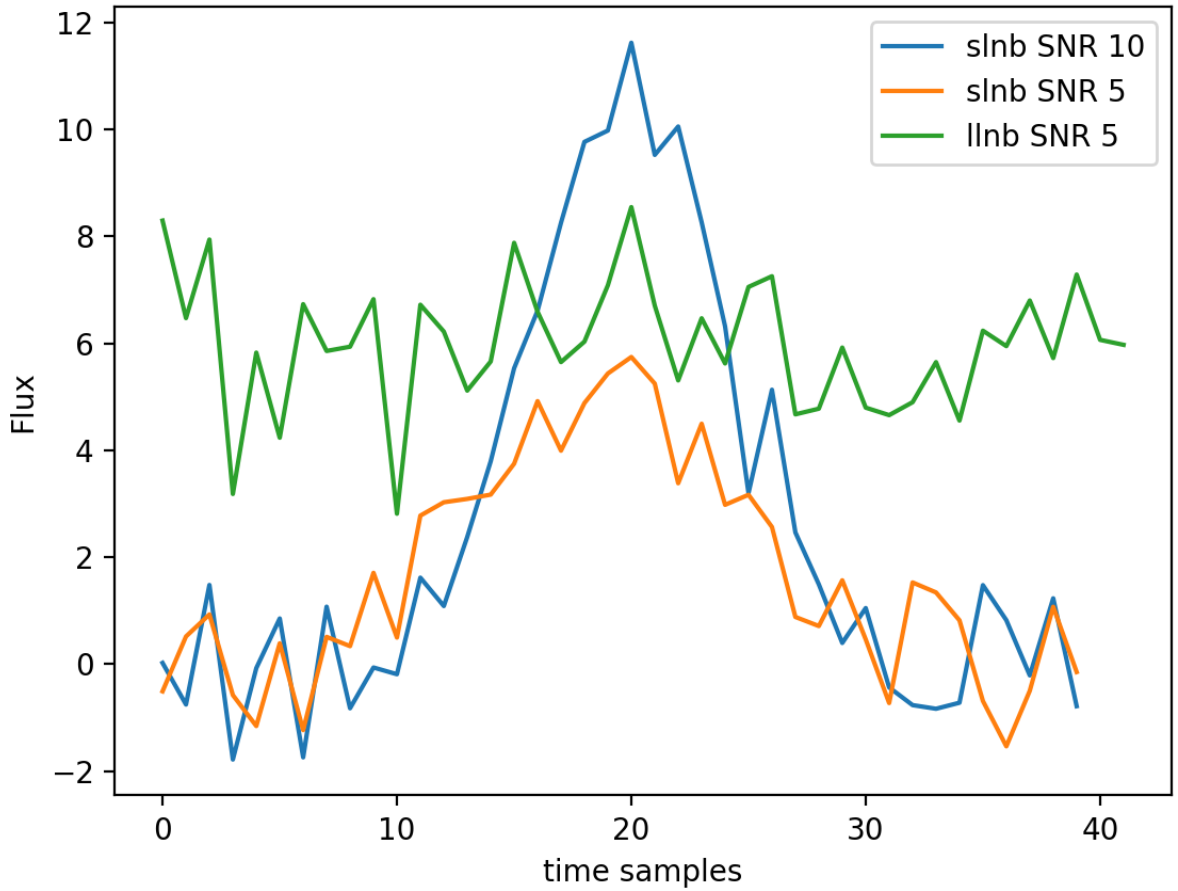
Expected vs Predicted Classification Table

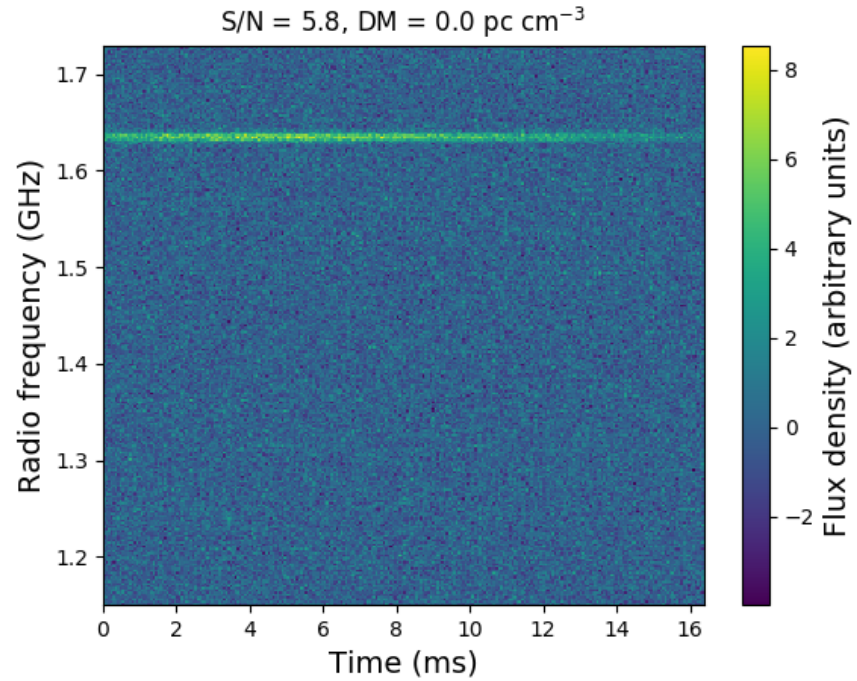
*Increased SNR slnb

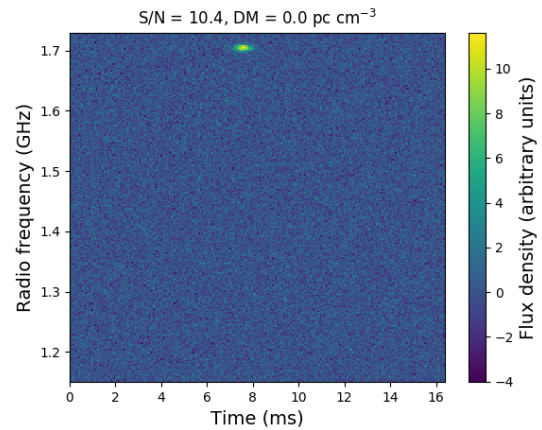
= test data

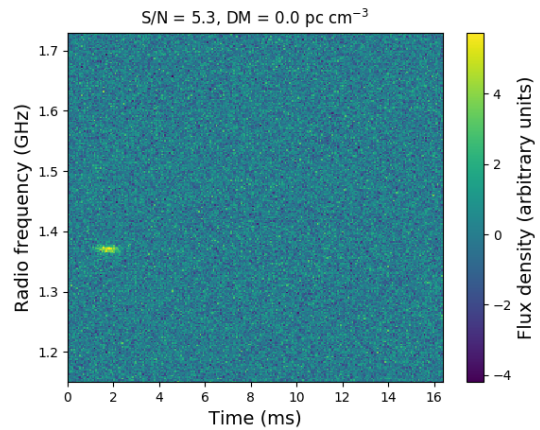
= training data

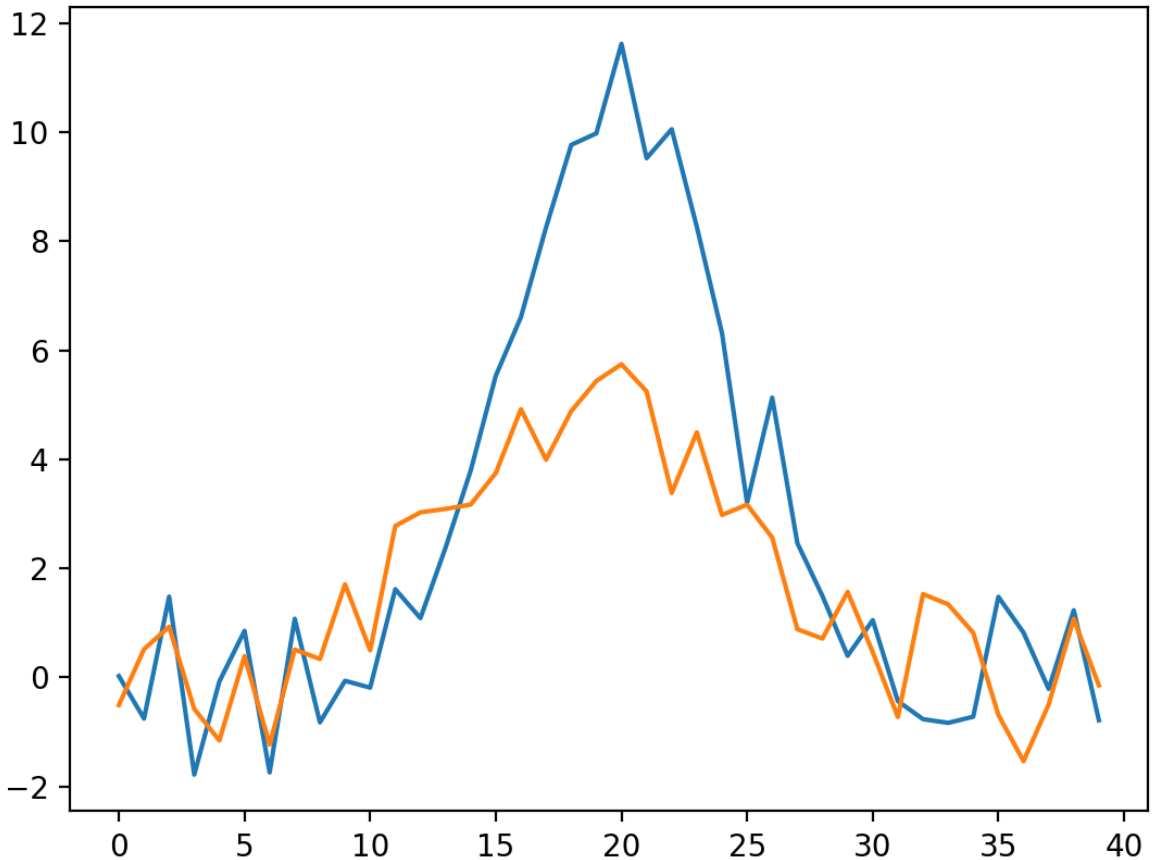
Predicted / Expected	Long-lived broadband	Long-lived narrowband	Short-lived broadband	Short-lived narrowband	Noise
Long-lived broadband	1.0 1.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
Long-lived narrowband	0.0 0.0	0.85 1.0	0.0 0.0	0.10 0.0	0.05 0.0
Short-lived broadband	0.0 0.0	0.0 0.0	0.98 1.0	0.01 0.0	0.01 0.0
Short-lived narrowband	0.0 0.0	0.22 0.0	0.01 0.0	0.51 1.0	0.26 0.0
Noise	0.0 0.0	0.03 0.0	0.0 0.0	0.27 0.0	0.7 1.0

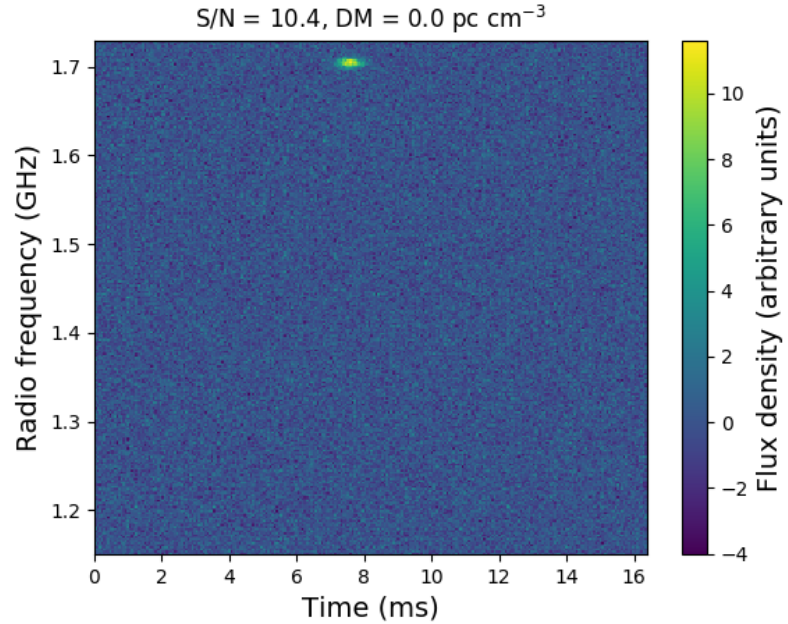

slnb SNR 10
slnb SNR 5
llnb SNR 5
Flux
time samples

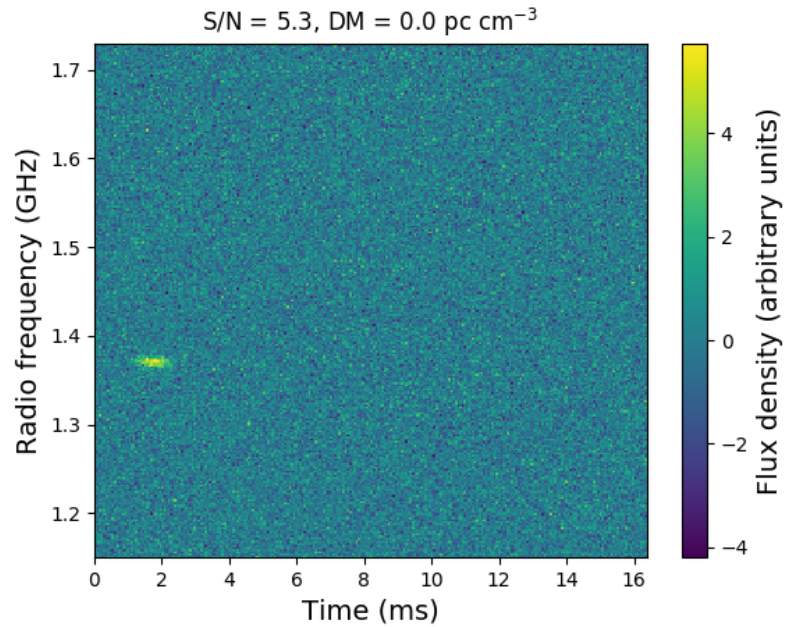

S/N = 5.8, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
Time (ms)
Flux density (arbitrary units)

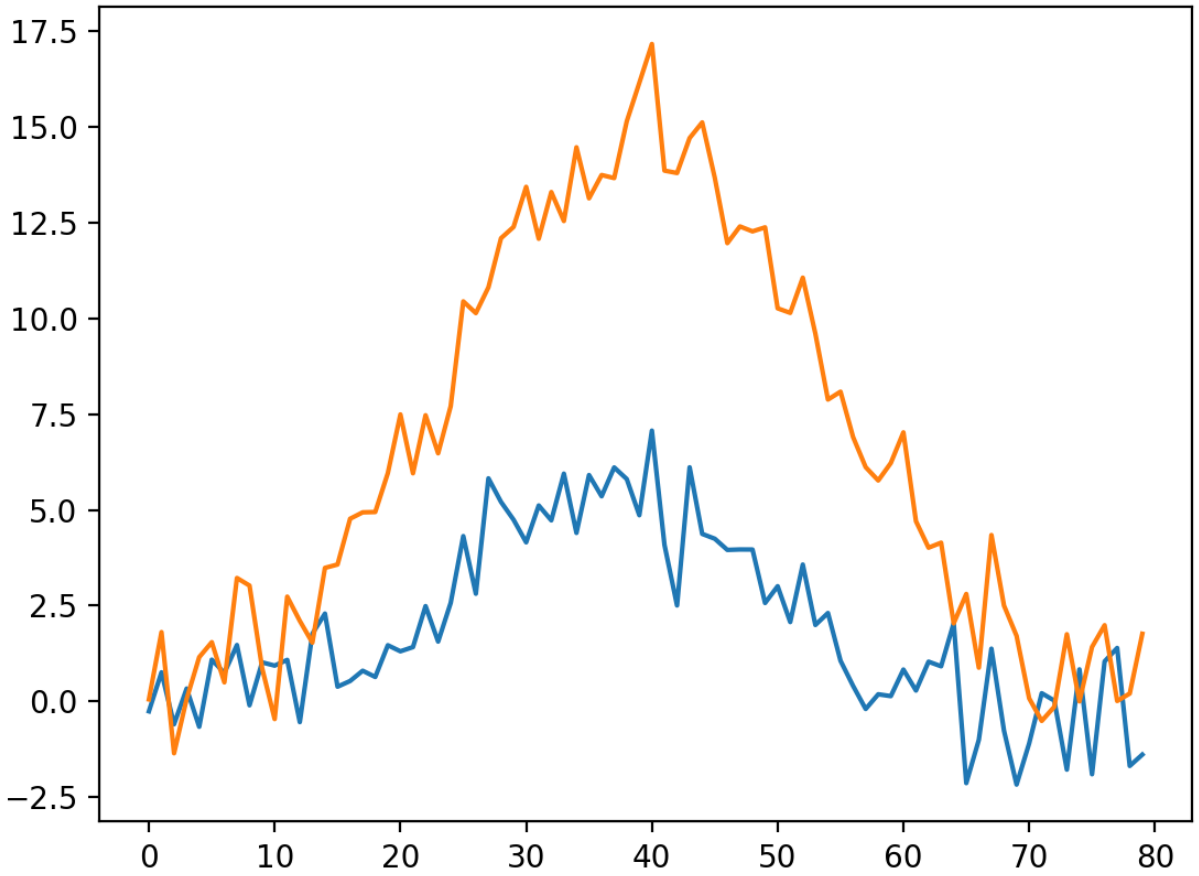

S/N = 10.4, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
Time (ms)
Flux density (arbitrary units)

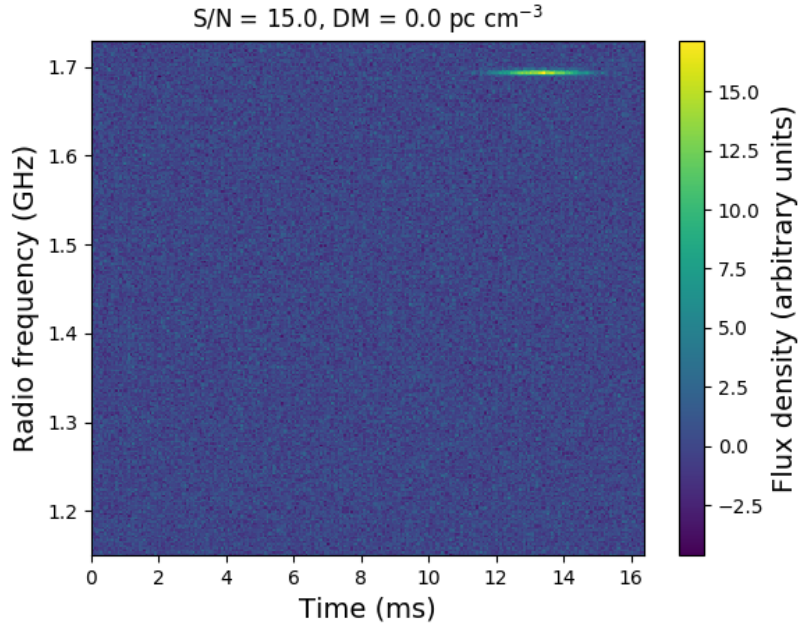

S/N = 5.3, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
Time (ms)
Flux density (arbitrary units)

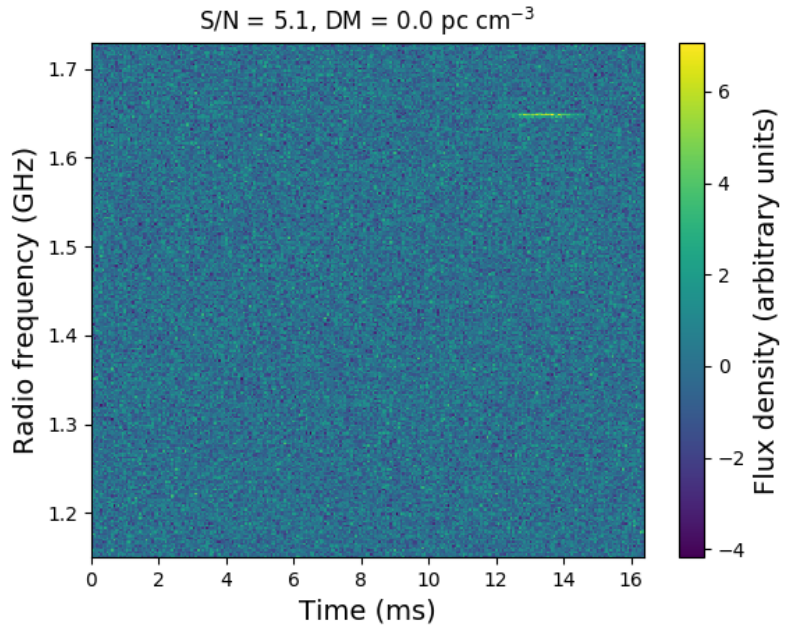

12
10
8
6
4
2
0
−2
0
5
10
15
20
25
30
35
40

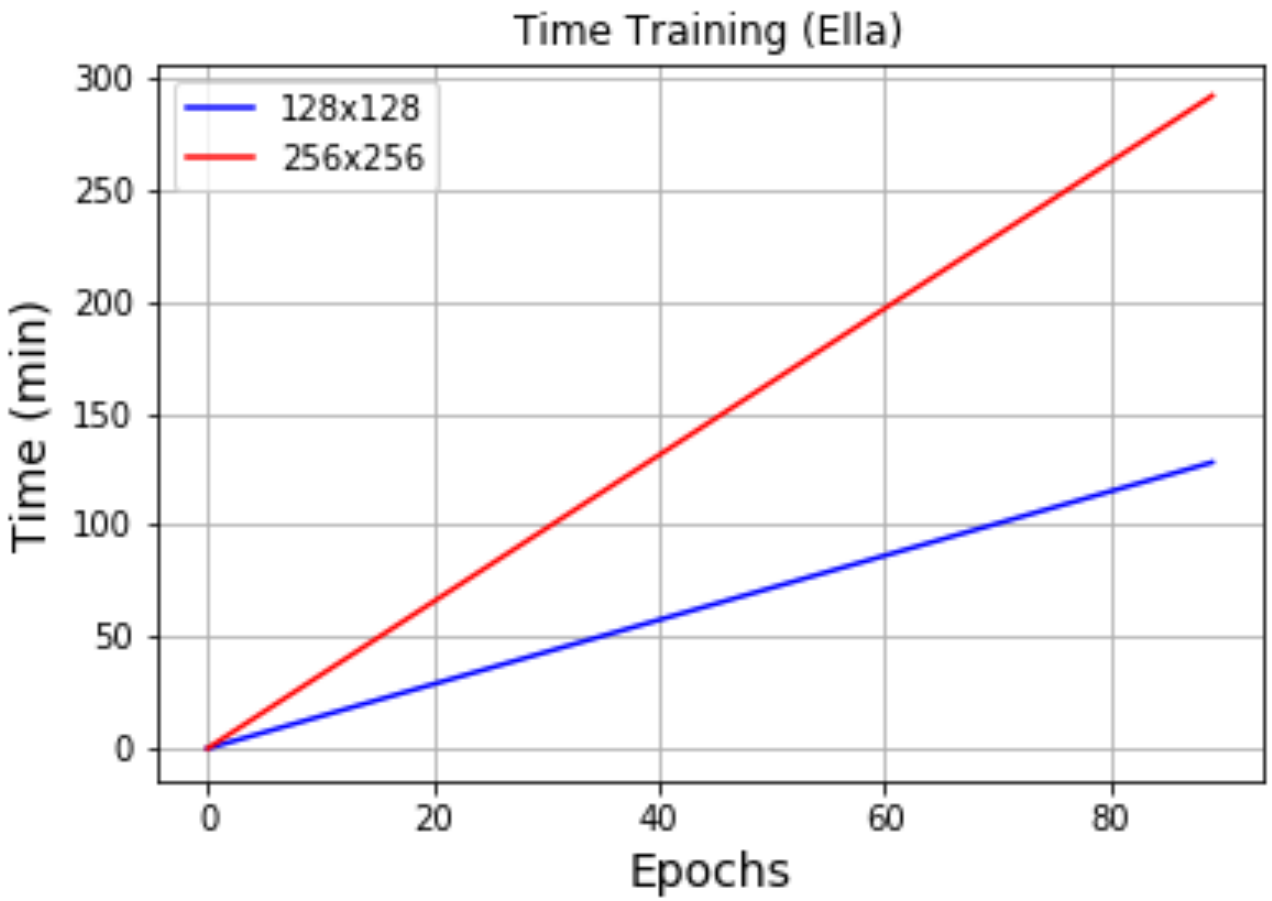

S/N = 10.4, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
1.7
1.6
1.5
1.4
1.3
1.2
Time (ms)
0
2
4
6
8
10
12
14
16
Flux density (arbitrary units)
10
8
6
4
2
0
−2
−4


S/N = 5.3, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
1.7
1.6
1.5
1.4
1.3
1.2
Time (ms)
0
2
4
6
8
10
12
14
16
Flux density (arbitrary units)
4
2
0
−2
−4


17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
0
10
20
30
40
50
60
70
80


S/N = 15.0, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
1.7
1.6
1.5
1.4
1.3
1.2
0
2
4
6
8
10
12
14
16
Time (ms)
Flux density (arbitrary units)
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5

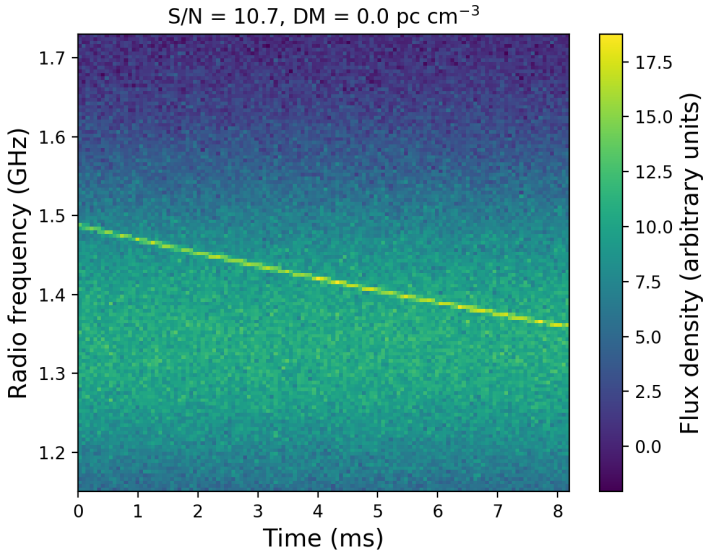

S/N = 5.1, DM = 0.0 pc cm^{-3}
Radio frequency (GHz)
1.7
1.6
1.5
1.4
1.3
1.2
0
2
4
6
8
10
12
14
16
Time (ms)
Flux density (arbitrary units)
6
4
2
0
−2
−4

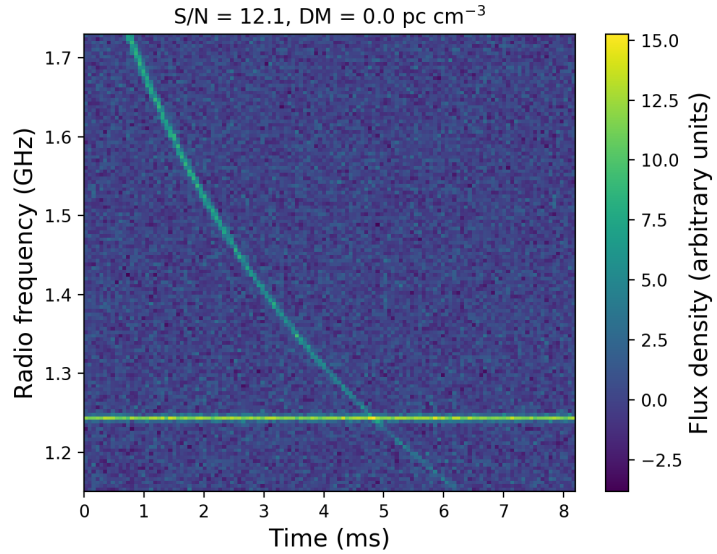

Time Training (Ella)
128x128
256x256
300
250
200
150
100
50
0
Time (min)
0
20
40
60
80
Epochs

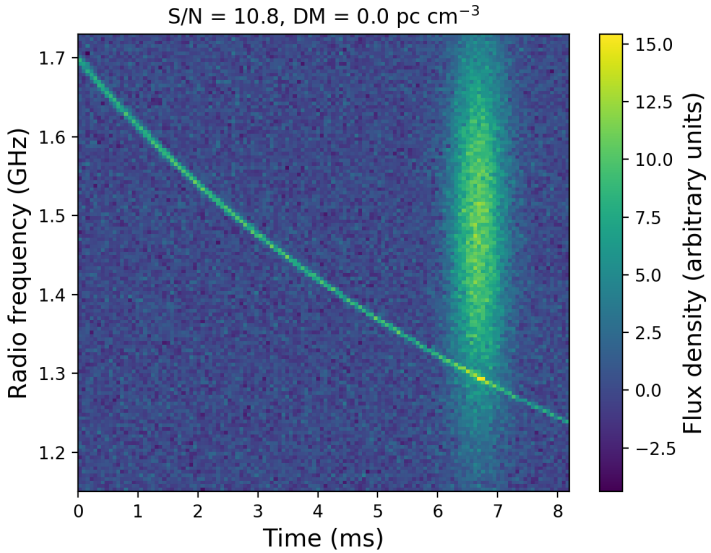
Next

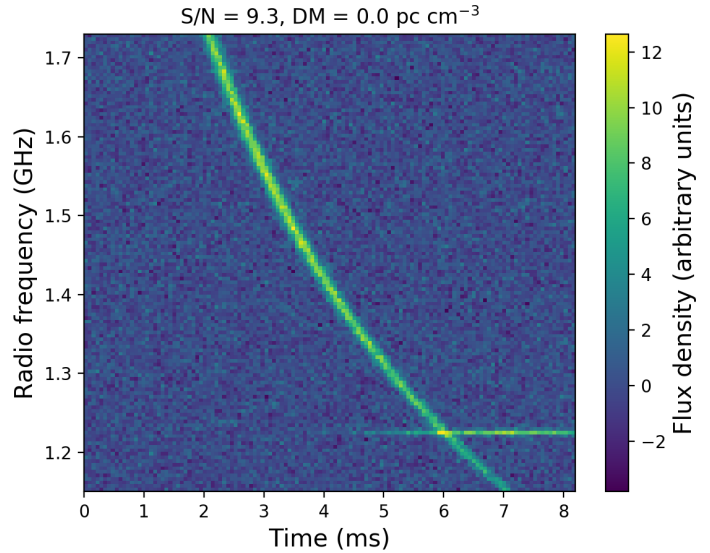
- Incorporate real-world data (FRB 121102) http://seti.berkeley.edu/frb121102/technical.html
- Split up data arrays to fit into network
- Using smoothing techniques outlined by Akshay in jupyter notebook to identify label bursts for training

pulse + RFI









just pulse