Determination of T0 with Neural Nets

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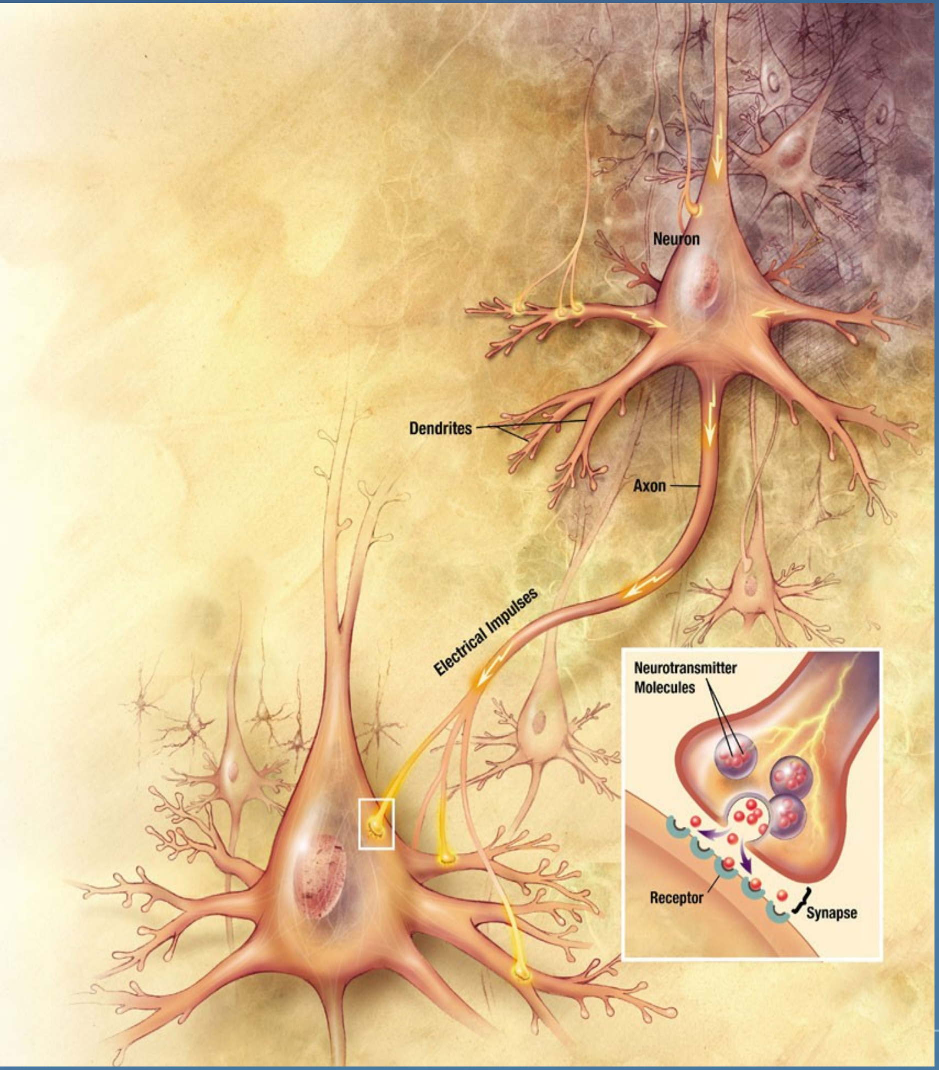
T_0 with Neural Nets

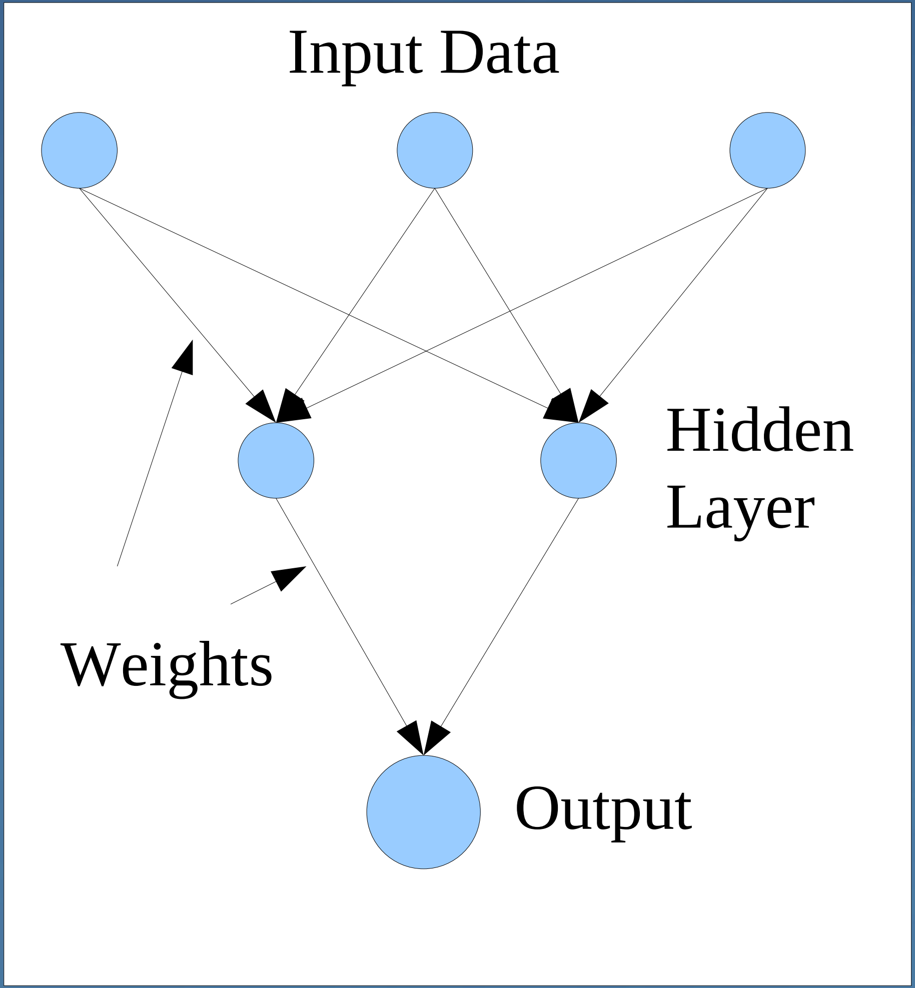
- Need good timing information for PSA
  - 10 ns Sampling
- Constant Fraction has ~ 15 ns FWHM
  - T_{CF} good first guess, not good enough for PSA
  - Corresponds to 5-8% noise (50-80 keV @1 MeV)
- Use Neural Nets for better precision
  - Use Core Signal
  - Take 5 samples before and 10 samples after T_{CF}
- First Test without noise
  - Single hidden layer seems enough
  - Encouraging results

Neural Networks: From Wetware to Software



- Building Blocks
  - Neurons
    - Process the information
  - Axons
    - Sends result to all connected neurons
    - ~4 km per mm³
  - Dendrites
    - Pre-process the input from the axon

Neural Networks: From Wetware to Software



- Several Types of NN
- Feed-forward NN:
  - Normalized Input
  - Neurons arranged in layers
    - Connected to all neurons from previous layer
    - Each connection has a weight
  - Activation of Neuron I

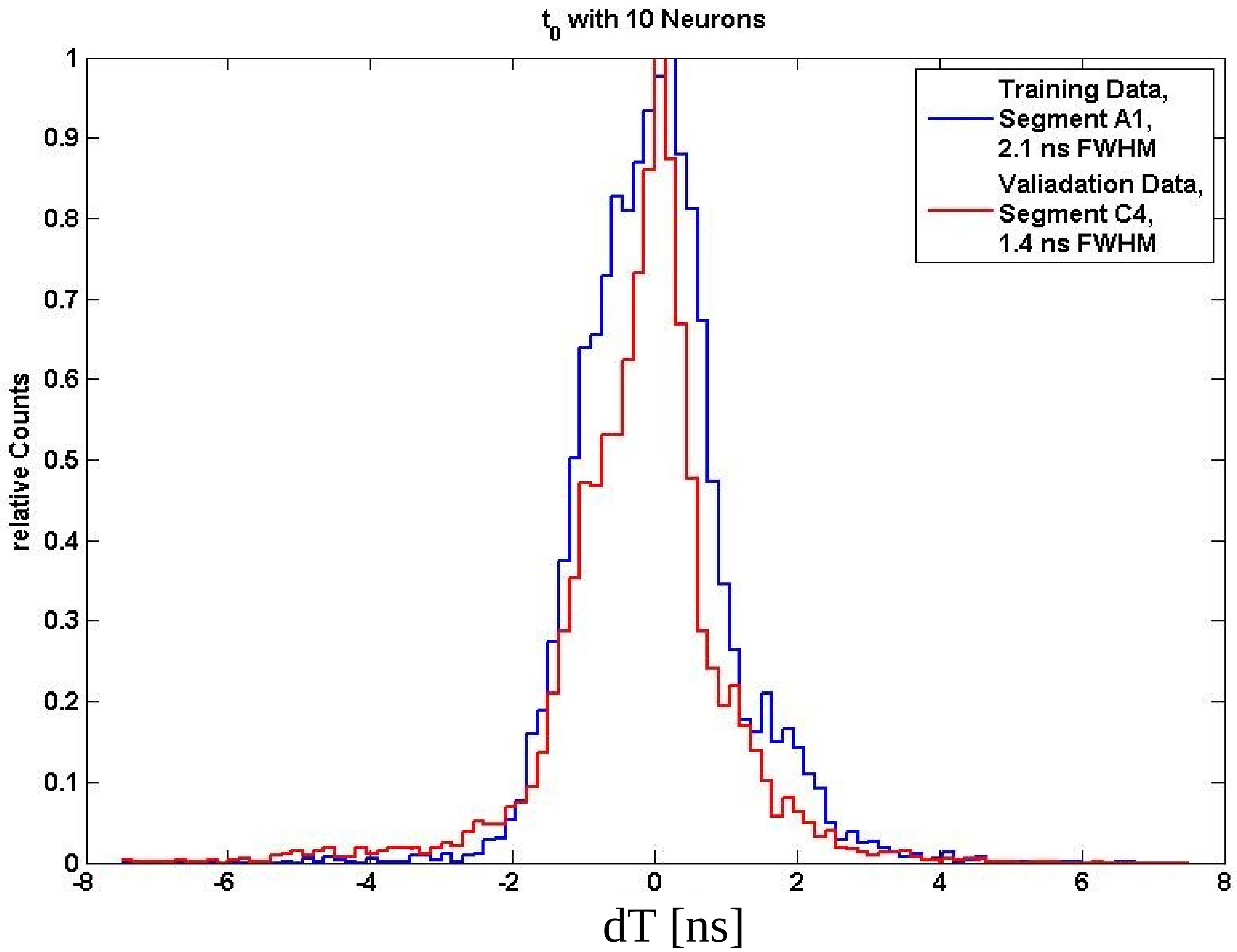
$$A_i = f\left(\sum_{j=0}^{j=n} w_{ij} \cdot A_j\right)$$

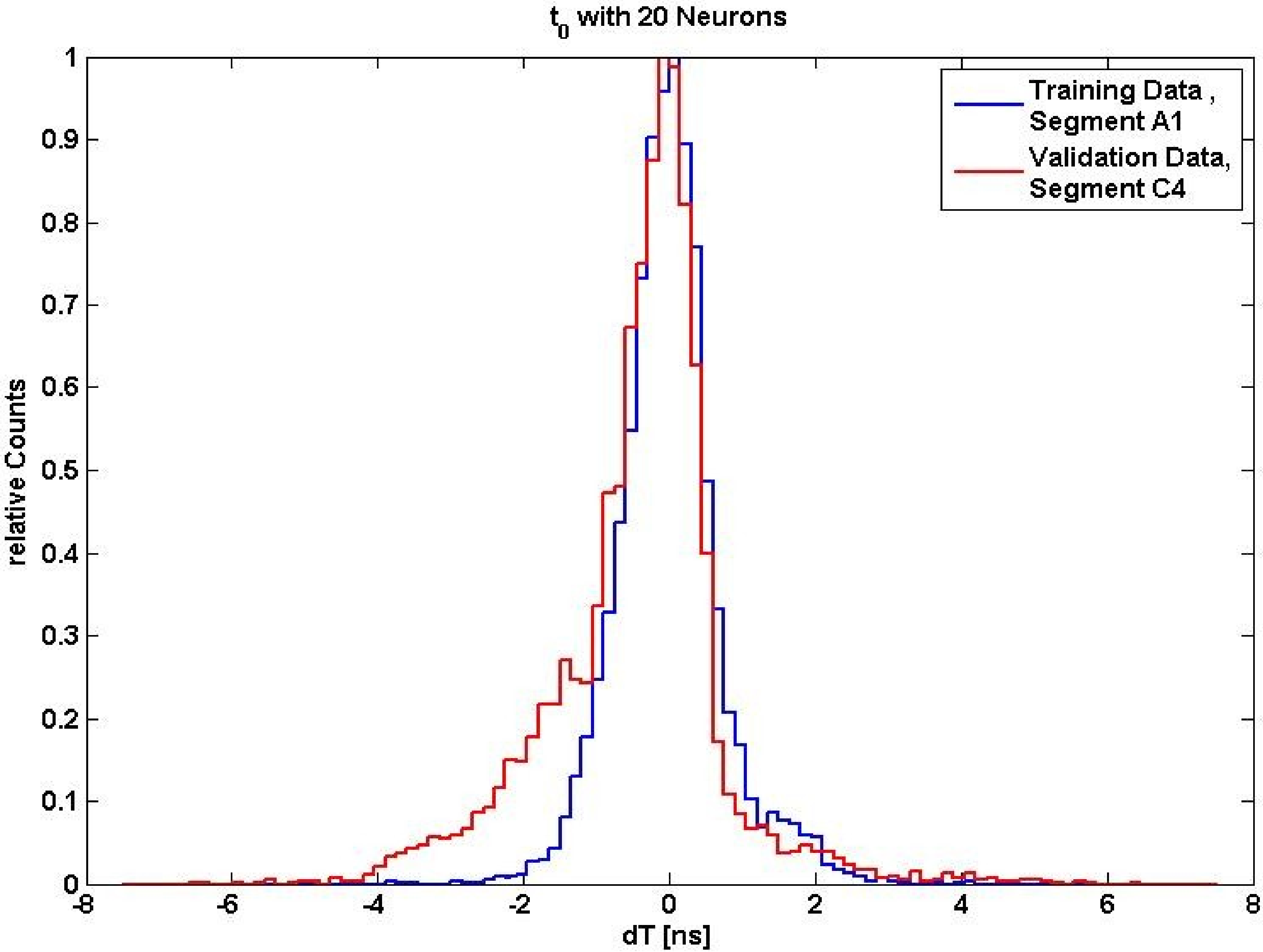
$$f(x) = \tanh(x)$$

$$f(x) = 1/(1+e^{-x})(Sigmoid)$$

Things to remember

- Curse of Dimensionality
  - Keep input data size small
  - Pre-process the data
- Size of Network
  - Large network only memorizes training data
  - Smaller network needs to generalize
- Training
  - Dataset with known output
  - Adjust weights to reduce errors
  - Backpropagation, Levenberg-Marquardt
  - FIPS, Genetic Algorithm
- Validation
  - Use different dataset with known output
  - Calculate the errors


t_0 with 10 Neurons
Training Data, Segment A1, 2.1 ns FWHM
Valiadation Data, Segment C4, 1.4 ns FWHM
relative Counts
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-8
-6
-4
-2
0
2
4
6
8
dT [ns]


t_0 with 20 Neurons
relative Counts
dT [ns]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
-8
-6
-4
-2
0
2
4
6
8
Training Data , Segment A1
Validation Data, Segment C4

Summary

- First Tests with Neural Networks succesfull
  - Resolutions are good enough to not having to do it in PSA Code
- Think about other ways of pre-processing
- Include variable amount of noise with data