MIXED-MODE SYSTEMS FOR PULSE-SHAPE DISCRIMINATION

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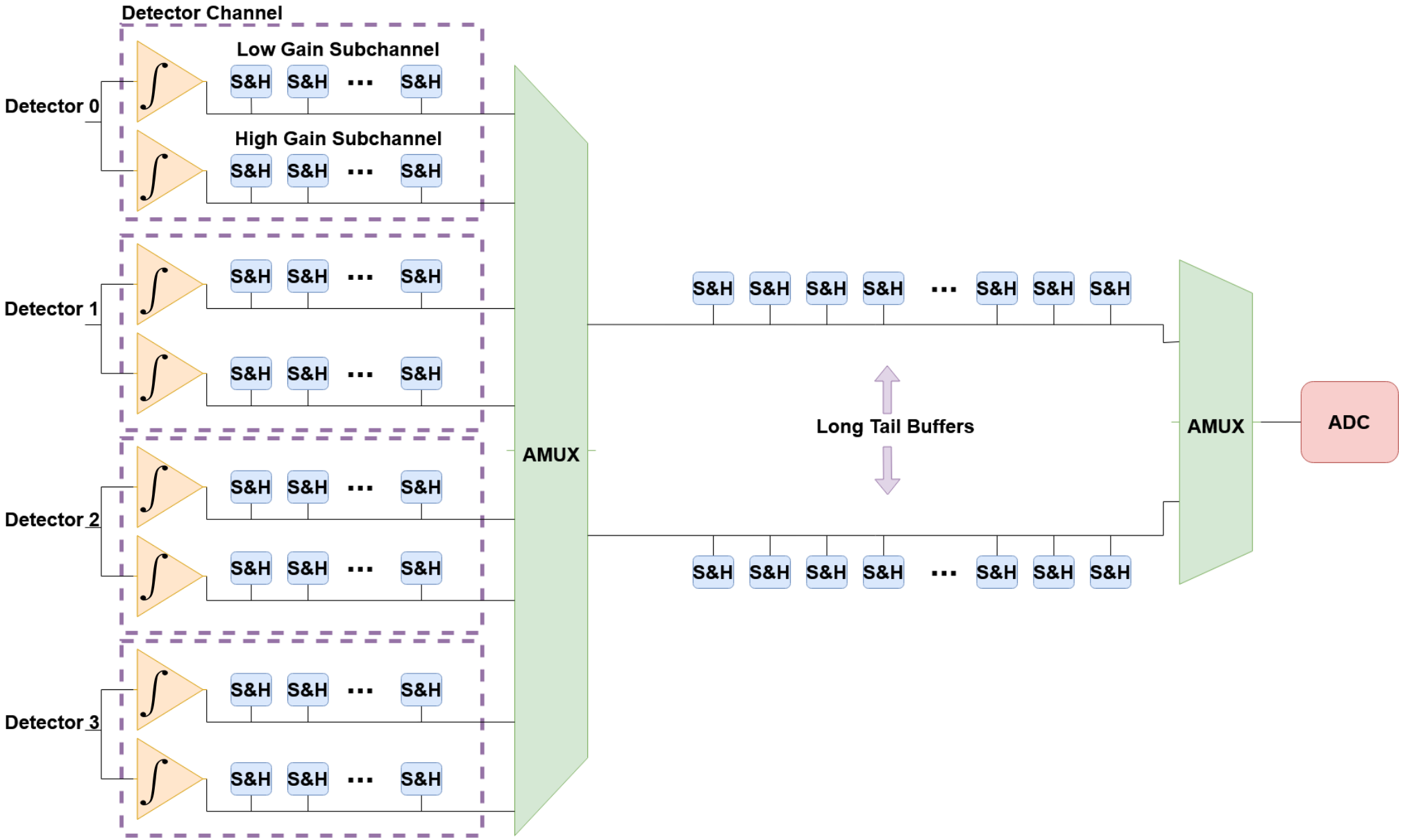
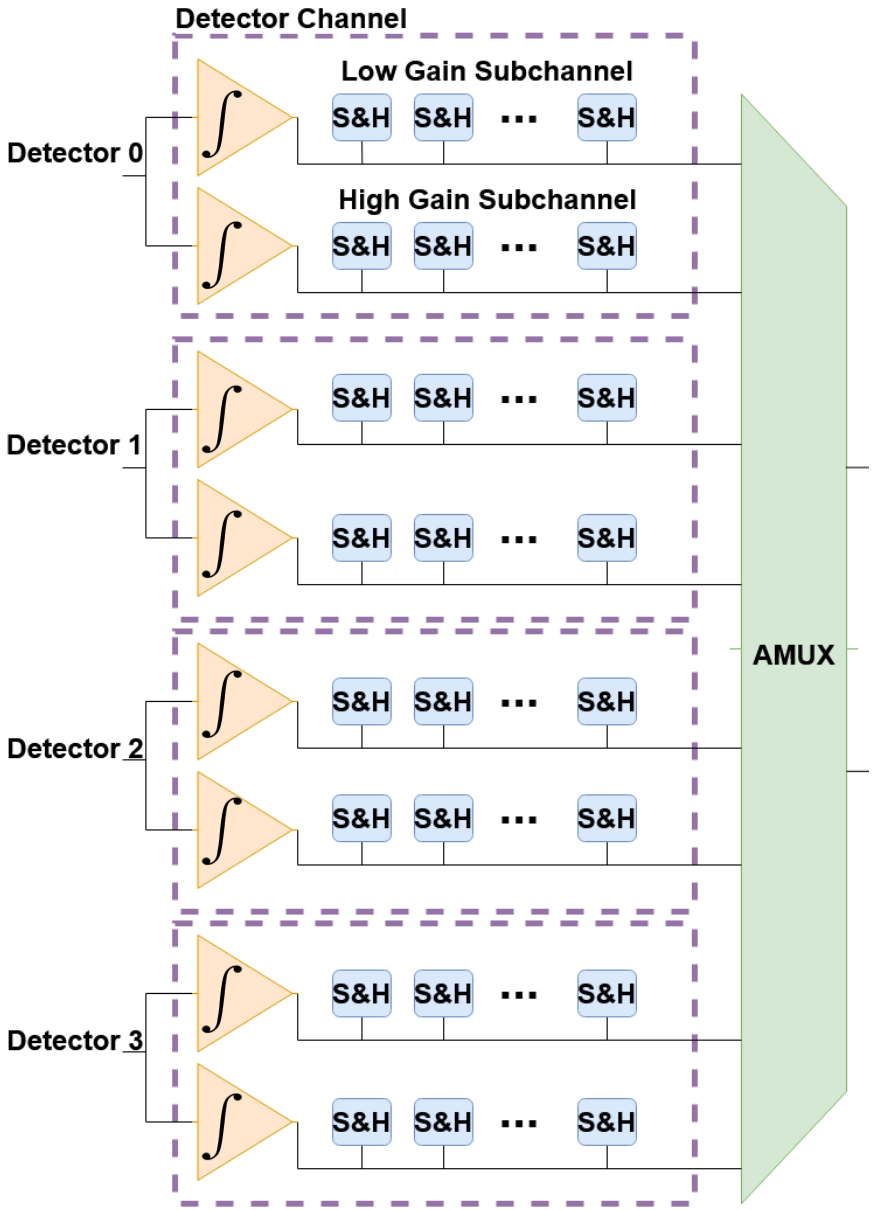
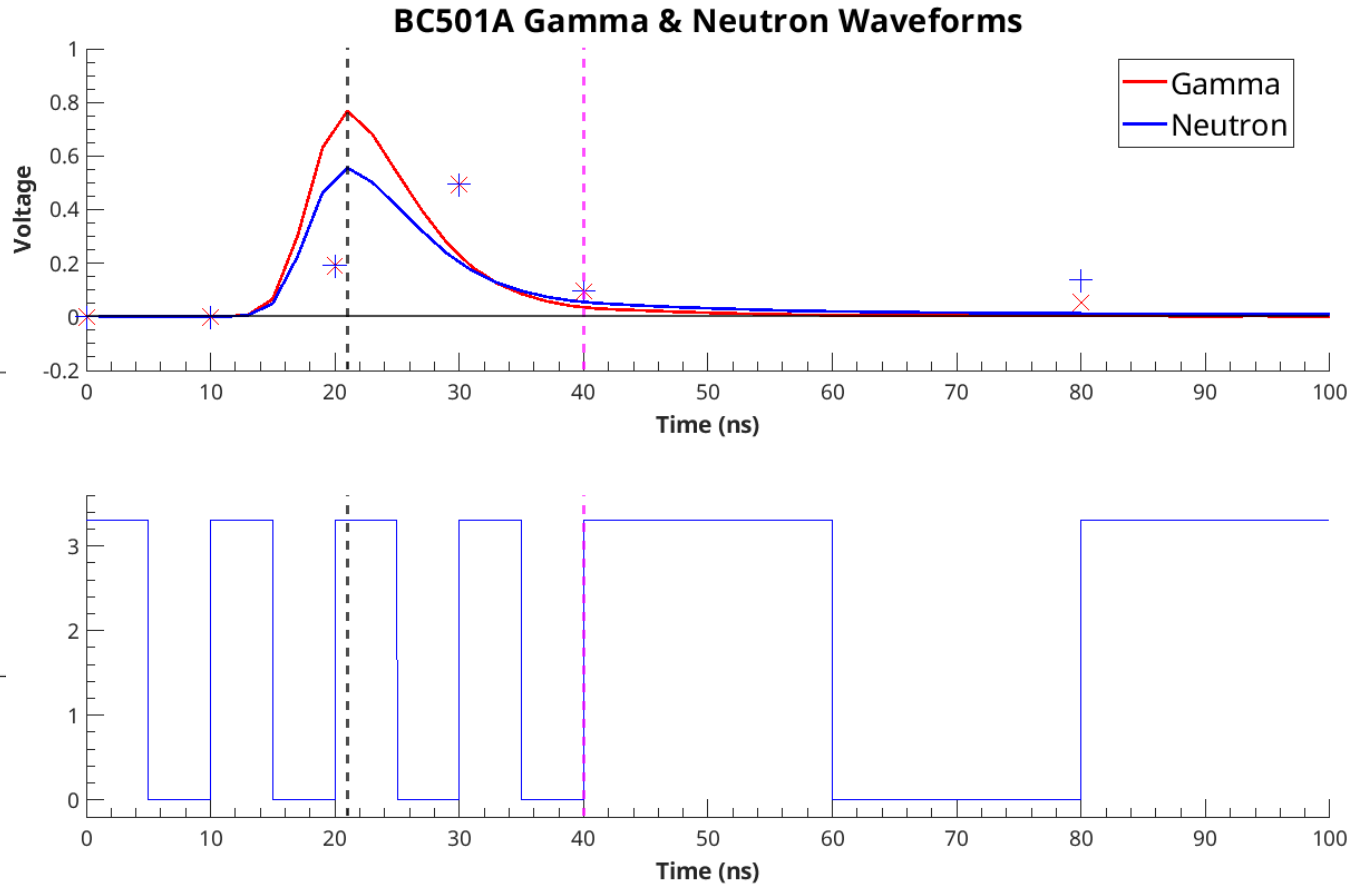
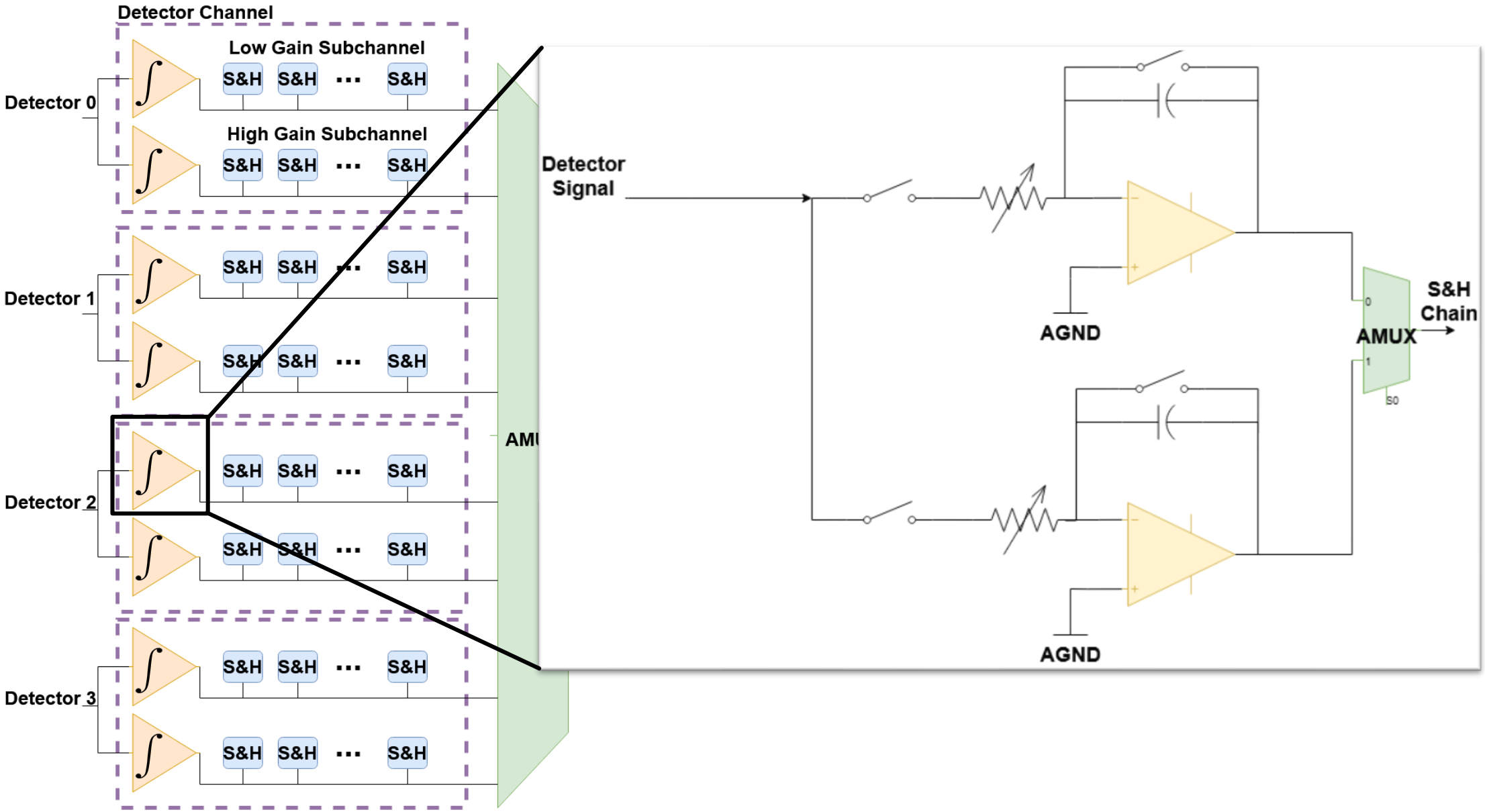
MIXED-MODE DATA ACQUISITION SYSTEMS

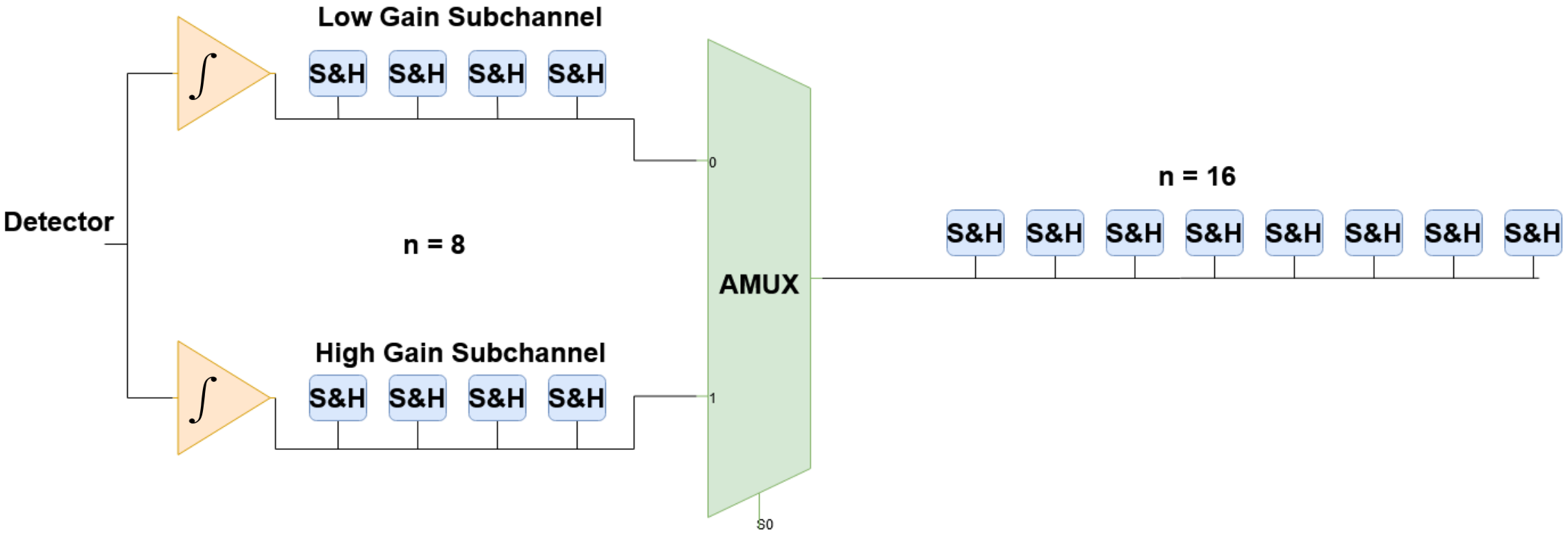
- Analog:
  - Inexpensive
  - Larger channel counts
  - Algorithm locked
- Digital:
  - Algorithm flexibility
  - Require fast digitization electronics (expensive)
- Mixed Mode:
  - Uses techniques from both analog and digital domains
  - Maintains algorithm flexibility
  - Does not require fast digitization electronics
  - Overcome dynamic range limitations


Detector Channel
Low Gain Subchannel
High Gain Subchannel
S&H
Detector 0
Detector 1
Detector 2
Detector 3
AMUX
Long Tail Buffers
AMUX
ADC


Detector Channel
Low Gain Subchannel
High Gain Subchannel
S&H
Detector 0
Detector 1
Detector 2
Detector 3
AMUX

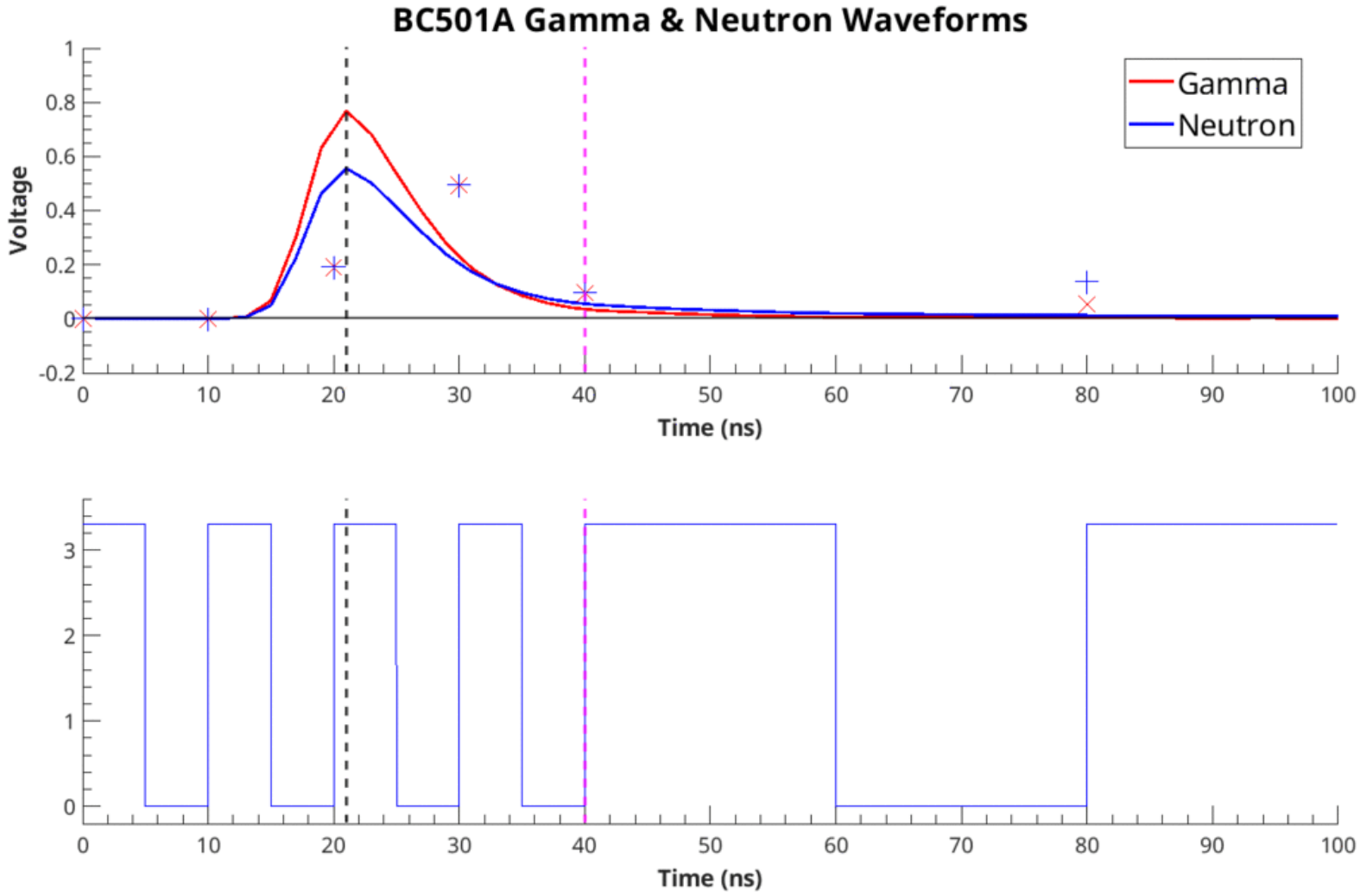

BC501A Gamma & Neutron Waveforms
Gamma
Neutron
Voltage
Time (ns)
Time (ns)


Detector Channel
Low Gain Subchannel
High Gain Subchannel
S&H
Detector 0
Detector 1
Detector 2
Detector 3
Detector Signal
AGND
AGND
AMUX
S&H Chain



- Data collected using a single channel modeled in Verilog-A
  - Short sample chain with 8 cells, 10 ns integration period
  - Long sample chain with 16 cells, 40 ns integration period
- Integration sample data saved and analyzed in MATLAB

PHASE PROBLEM



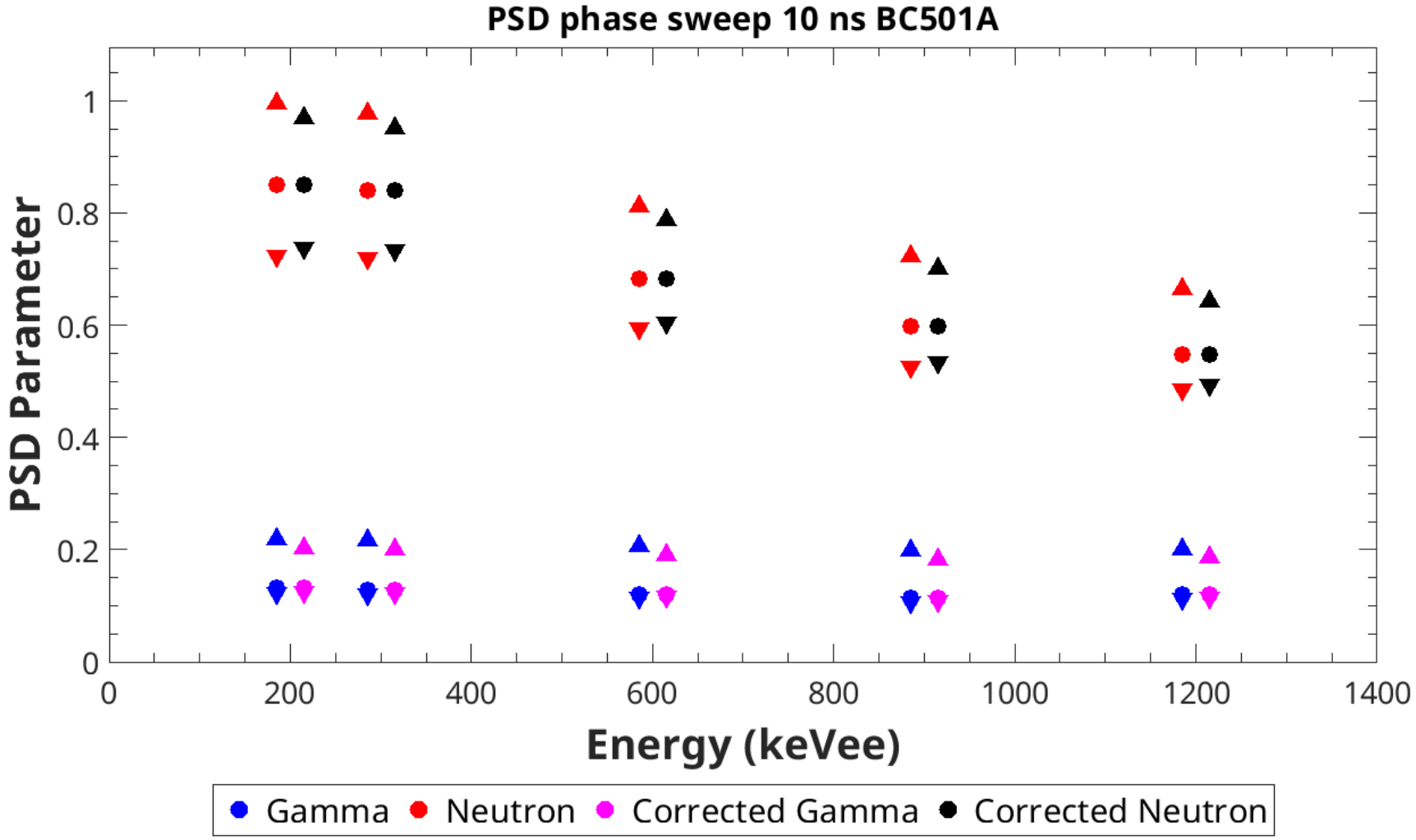
ALGORITHMS

- Clearly phase has a major impact on the ability to do PSD
- We can use software algorithms to correct for phase error
  - Linear interpolation
  - Curve fitting to theoretical pulse shape
  - Machine Learning

$$PSD = \frac{\sum s_n}{\sum f_n}$$

slow integral = 20 ns after peak

PSD done using averages of 1000 waveforms[1]



[1]SÉNOVILLE, M., DELAUNAY, F., PÂRLOG, M., ACHOURI, N., & ORR, N. (2020). NEUTRON-Γ DISCRIMINATION WITH ORGANIC SCINTILLATORS: INTRINSIC PULSE SHAPE AND LIGHT YIELD CONTRIBUTIONS. NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH SECTION A: ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, 971, 164080. DOI:10.1016/J.NIMA.2020.164080

CONCLUSION & FUTURE WORK

- Mixed mode systems are PSD capable and offer some advantages over analog or DSP.
- New simulations will be run using raw data and true electrical models
- Determine most effective PSD algorithms
- Perform design optimization on the system topology
  - Maximize dynamic range
  - Minimize dead time
  - Maximize detector channel count

QUESTIONS?