Electronics Design

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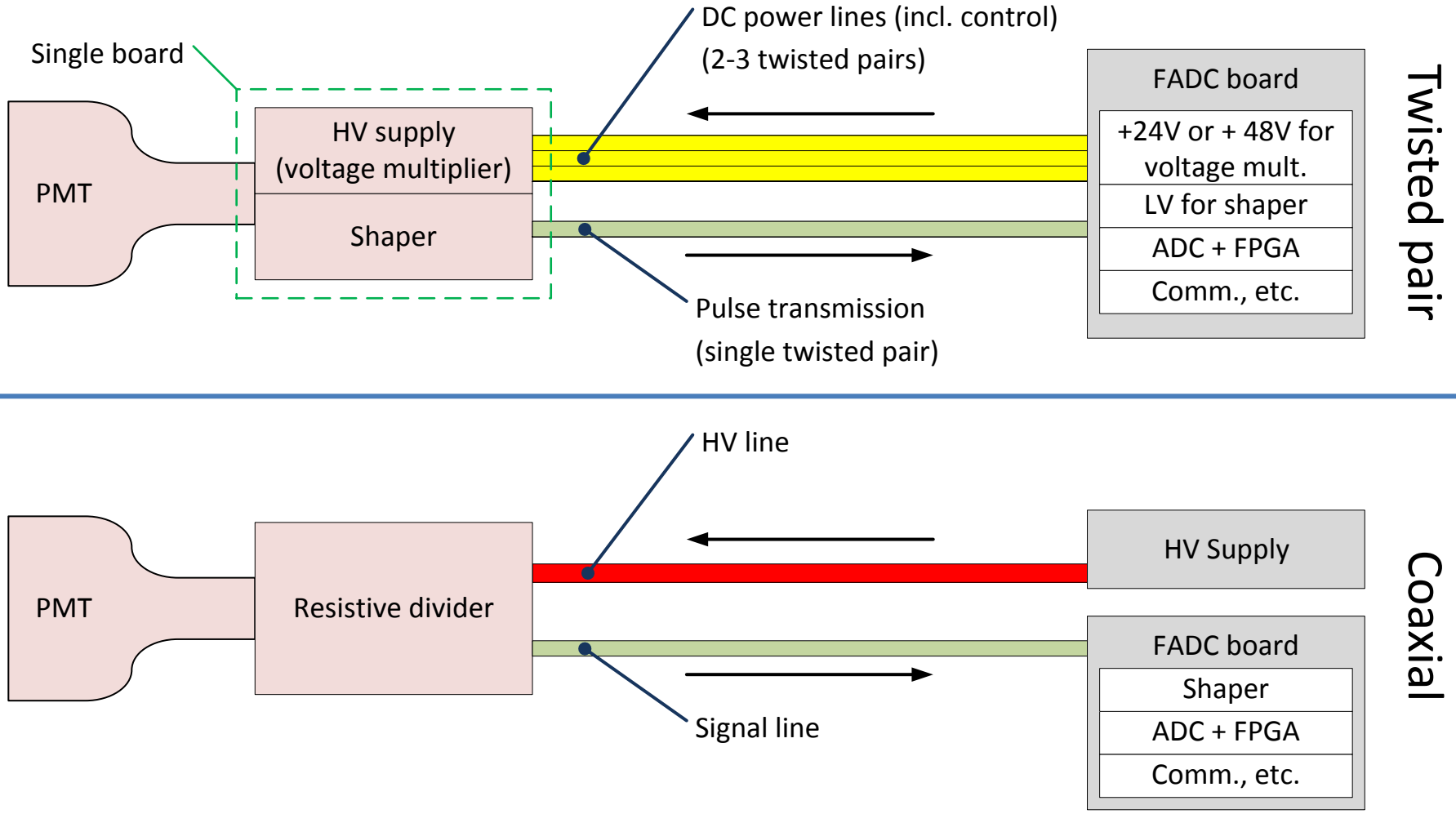
Possible Setups



Twisted Pair vs. Coax

Twisted pair - pros

- Fully differential signal transmission – better EMI performance
- Use standard UTP cable
- No HV connector in the water
- Shaper close to PMT
- Less cable weight (one cable per PMT)

Twisted pair - cons

- Active electronics in the water → potential reliability issues
- Possibly one needs to test cable in ultra-pure water & at the expected pressure

Coaxial - pros

- Already tested
- Only passive divider in the water – highly reliable
- All active electronics easily serviceable

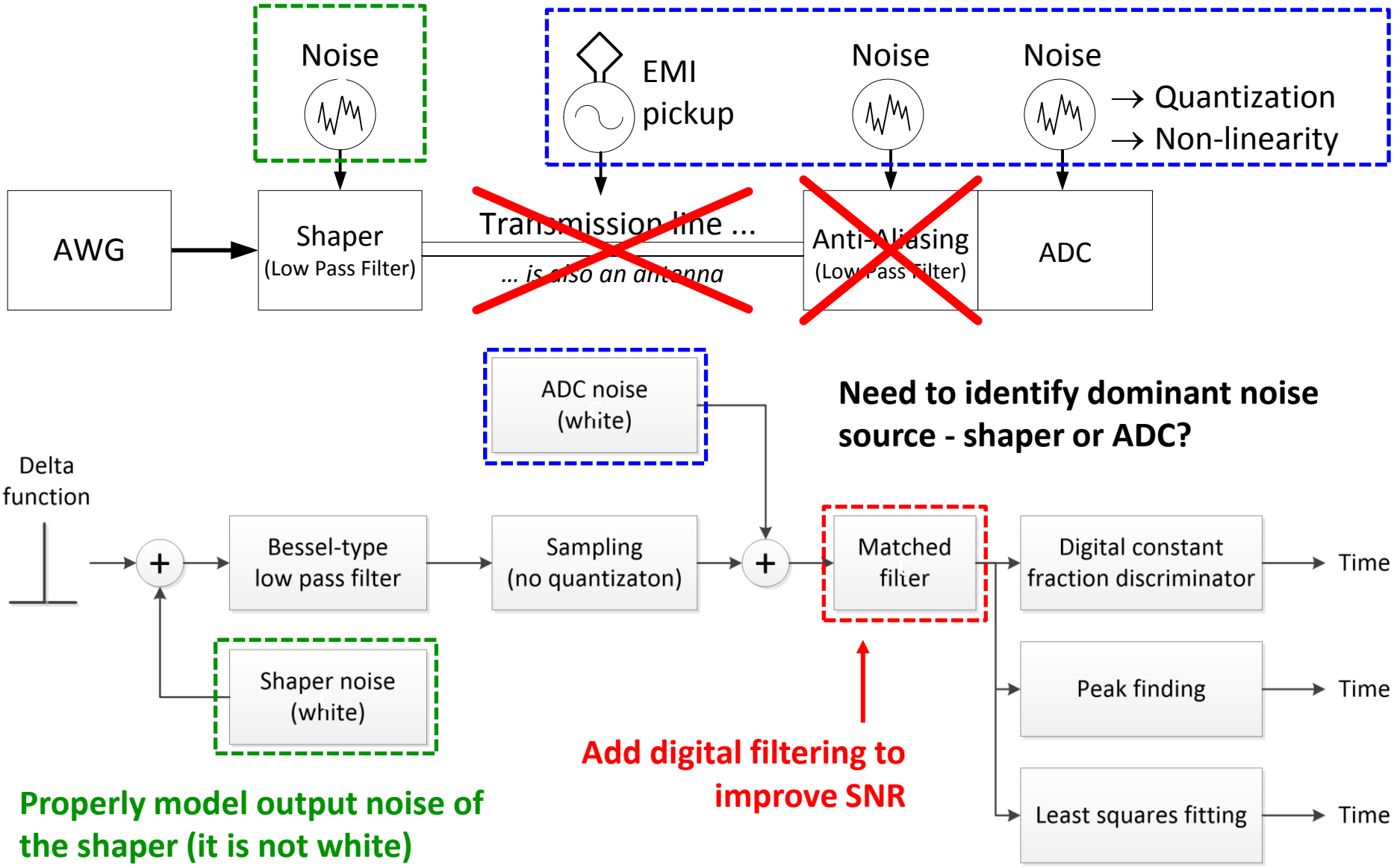
Coaxial - cons

- Water-tight HV connector needed
- Ground is part of signal transmission path → potential EMI issues
- Shaper far from PMT
- More cable weight (two cables per PMT)

Status & Planning (Feb. 2015)

- Finalize literature study concerning optimum methods of signal processing, i.e. filtering, pulse detection and time extraction.
- Setup data sharing between WUT and TRIUMF.
- Take additional data:
  - Step response of the shaper
  - Pure noise (ADC only and ADC+shaper).
- Analyze data, check noise spectrum and try various filters to maximize signal-to-noise ratio; then try various methods of time extraction and examine achieved timing resolutions.
- Write code to import MIDAS data into MATLAB (needed for WUT).
- Modify noise models in the simulation and make them match experimental data.
- Modify fit routines to better match shaper response and recheck test data.
- Try bipolar shaping (no problem of baseline estimation – it is always zero).
- Analyze possibility of using logarithmic amplifier in the shaper.

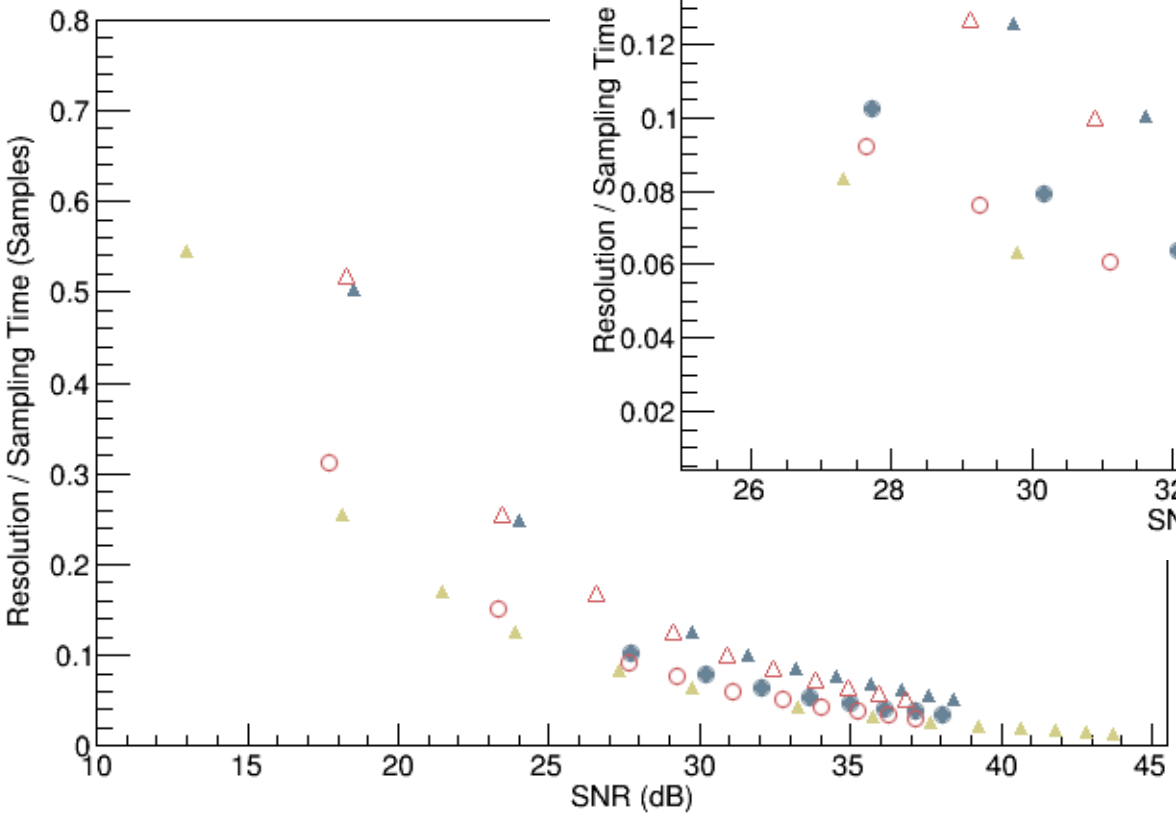
Electronics Simulation

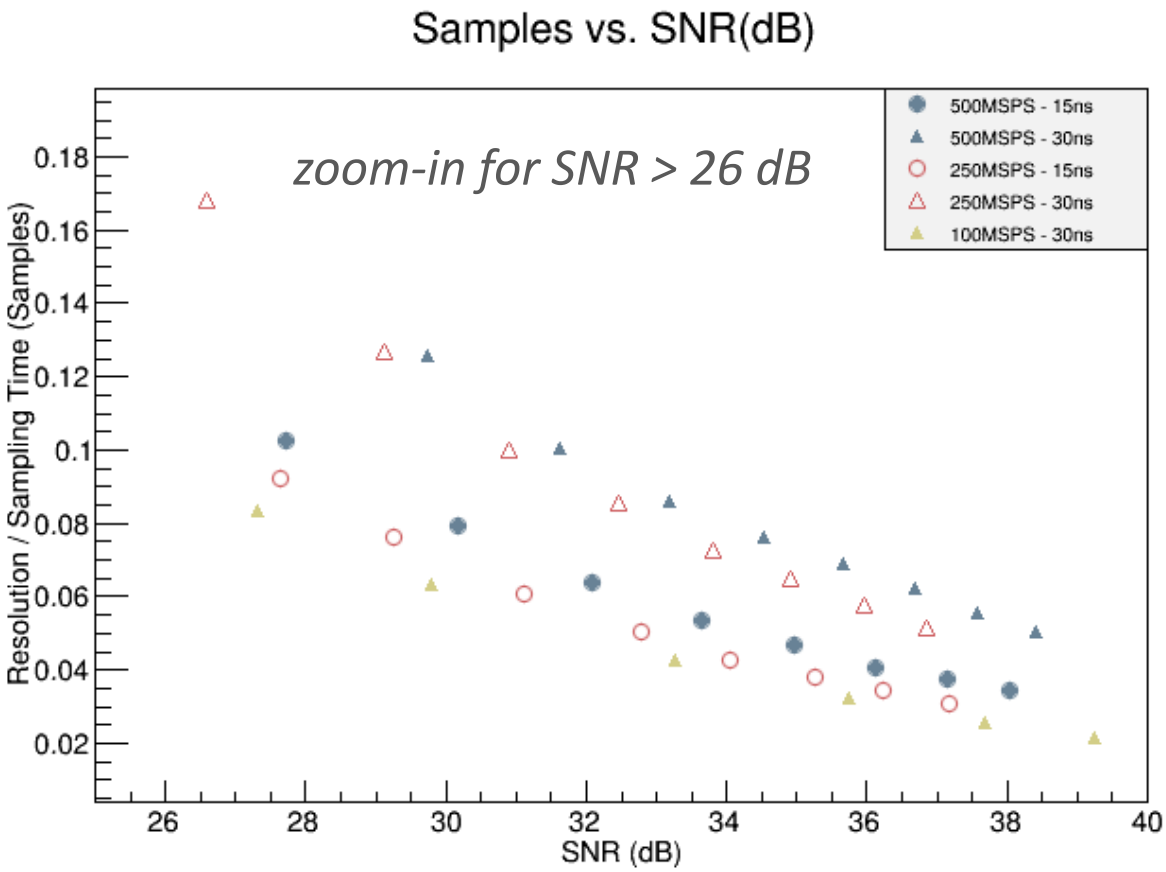


Michael's Results (direct fits)

Samples at the rising edge (15 ns shaper):

- 100 MSPS → 1.5
- 250 MSPS → 3.7
- 500 MSPS → 7.5

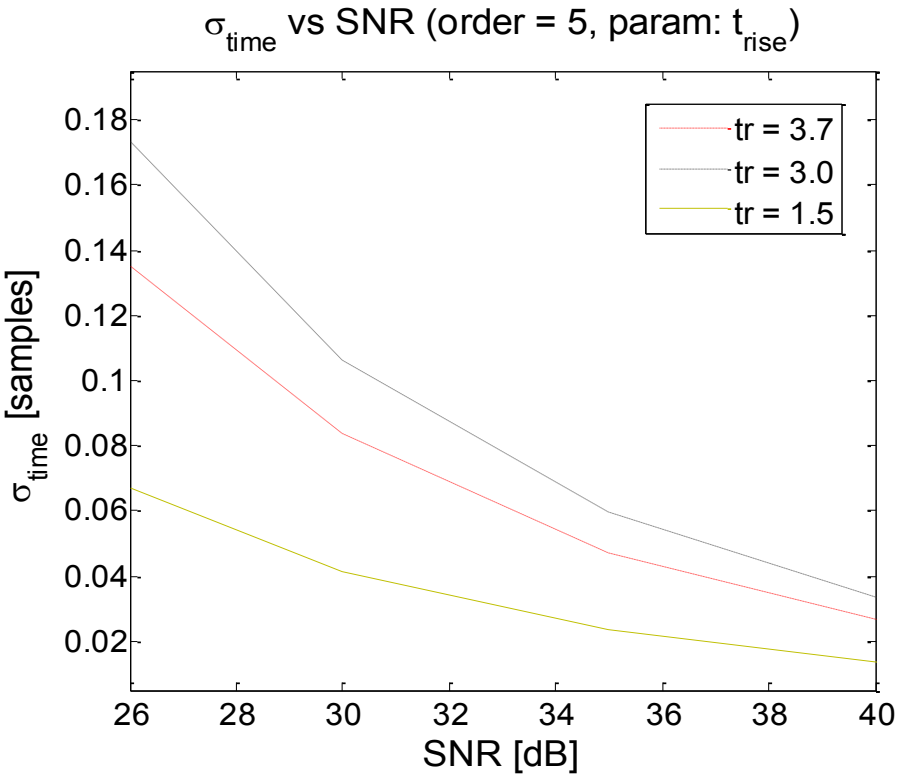


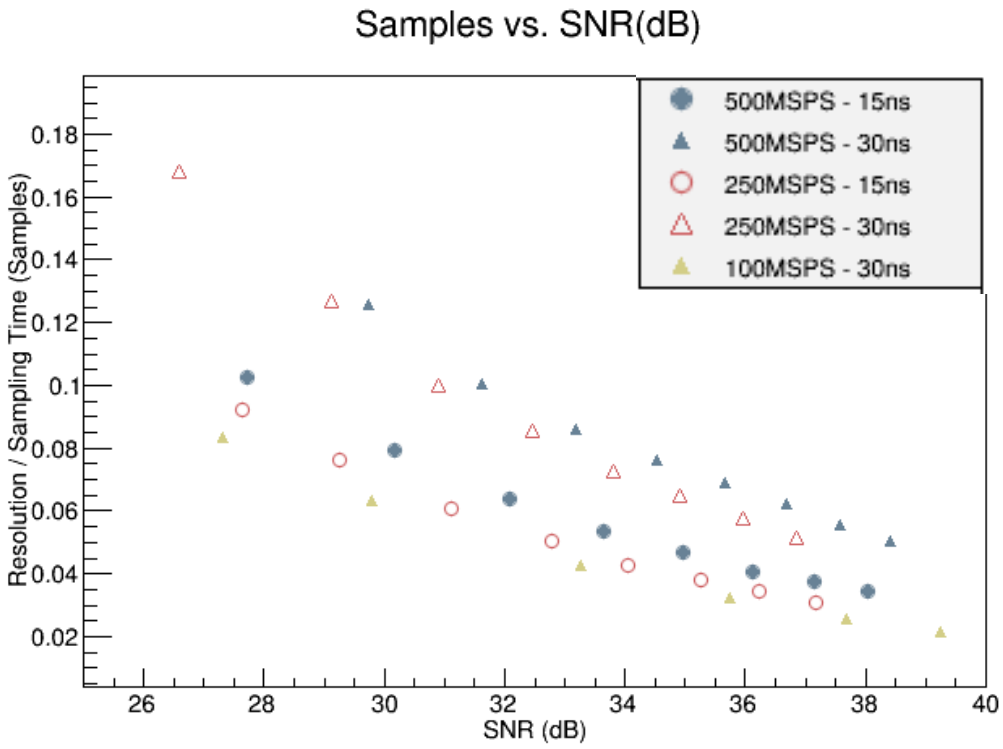


Samples at the rising edge (30 ns shaper):

- 100 MSPS → 3.0
- 250 MSPS → 7.5
- 500 MSPS → 15

Simulation vs Data





Samples at the rising edge (15 ns shaper):

- 100 MSPS → 1.5
- 250 MSPS → 3.7
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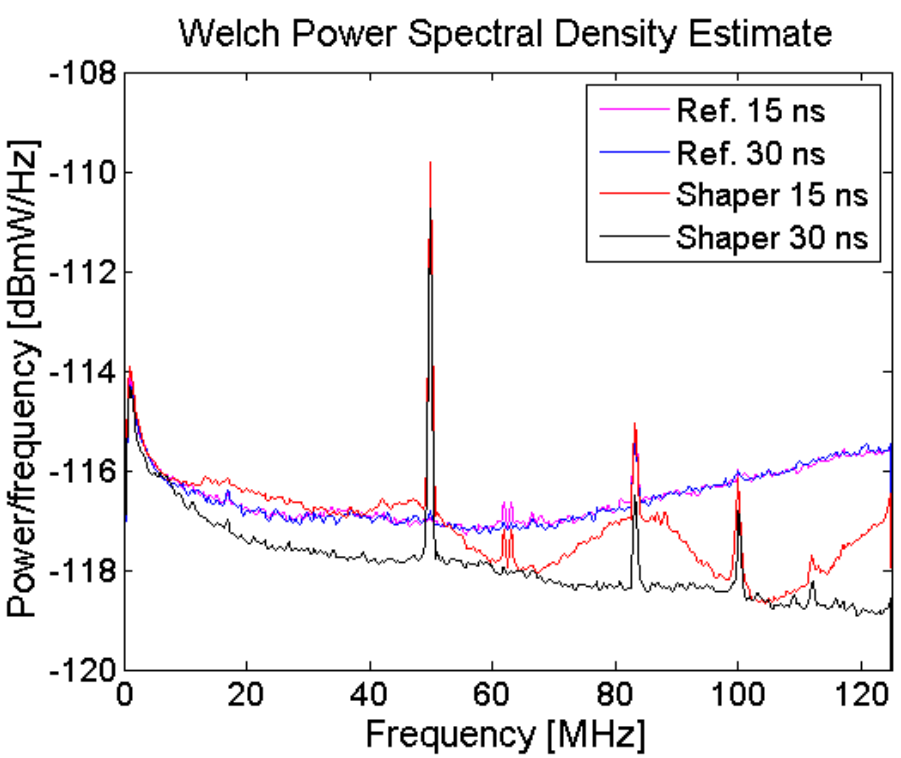
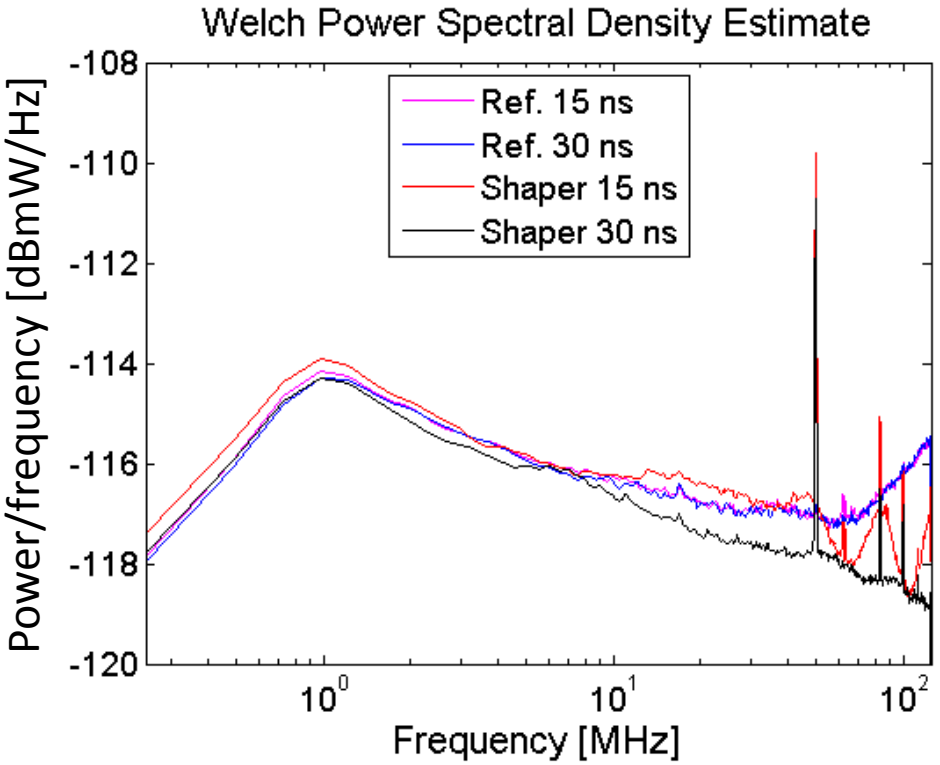
Samples at the rising edge (30 ns shaper):

- 100 MSPS → 3.0
- 250 MSPS → 7.5
- 500 MSPS → 15

Noise Spectra – 250 MSPS ADC

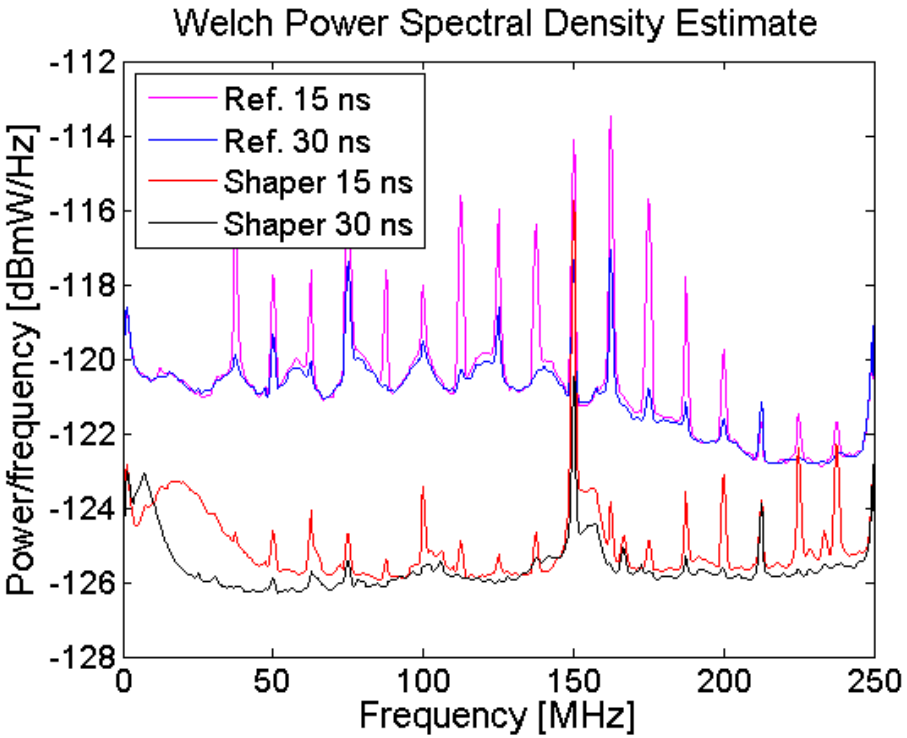


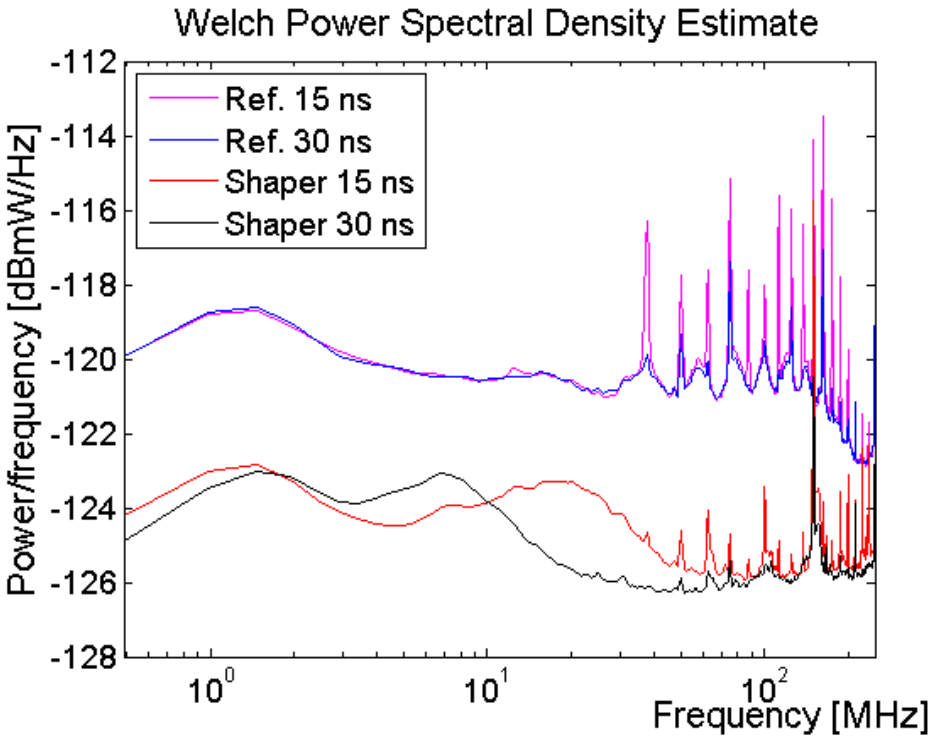


- Strange results for 15 ns shaper
- Large periodic signals seen (digital clocks, EMI pickup ???)
- Shaper signals show lower values possibly due to additional attenuation from cables

To be checked - values on vertical axis

Noise Spectra – 500 MSPS ADC





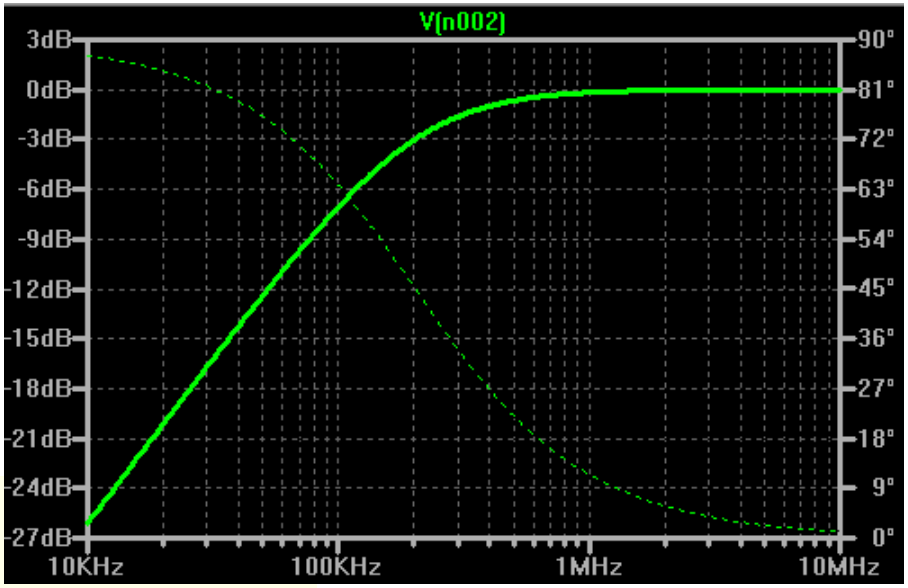
- Both shapers look reasonable
- Lots of periodic signals seen (digital clocks, EMI pickup ???)
- Shaper signals show lower values possibly due to additional attenuation from cables

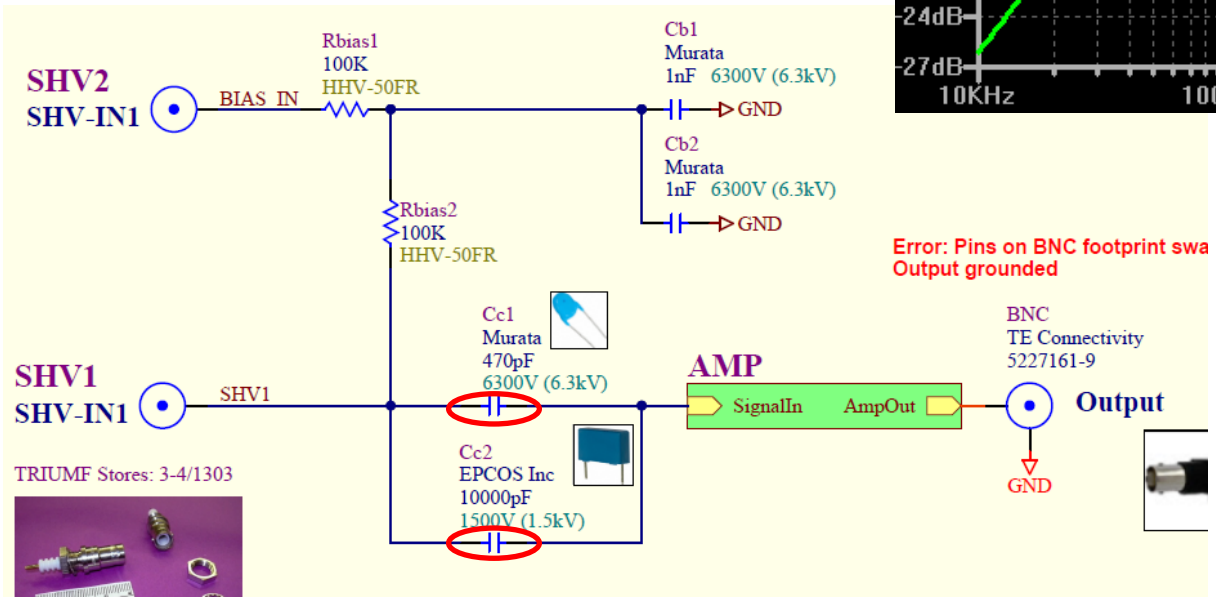
To be checked - values on vertical axis

Noise – Preliminary Conclusions

- It seems that the dominant source of noise is AWG
- Does not affect work on simulations, just needs to be modeled properly
- For proper modeling, we will need noise data of pure ADC and ADC+shaper configurations, with AWG disconnected.
- Roll-off is different between digitizers – why?

LTSpice simulation of the input





RC high pass at the input (shaper has 75 ohm termination)

← Actual schematic

Summary

- At some point we will need to decide whether we adopt the twisted pair or the coaxial approach.
- Lots of test data recorded, thanks to people from TRIUMF.
- Still studying literature to devise optimum signal processing methods.
- Matched filter does not give significant improvement over fitting (Michael's conclusion).
- Even simple model with constant fraction algorithm is not so far from reality.
- Possibly need to pay closer attention to simulating EMI pickup.
- Need to examine noise contribution from the AWG.