AWE NUCLEAR SECURITY TECHNOLOGIES

Broadband Laser Ranging development

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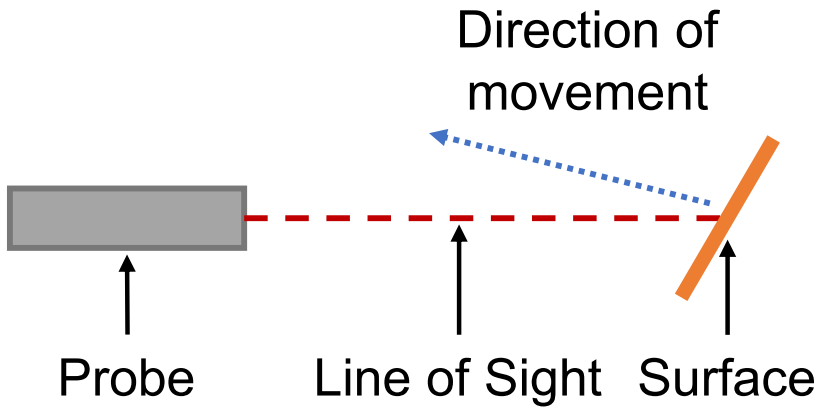
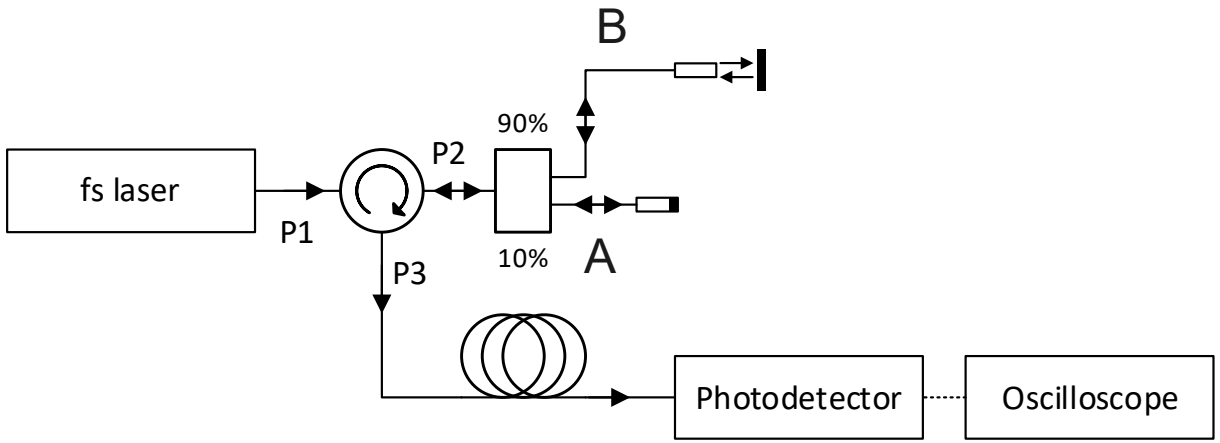
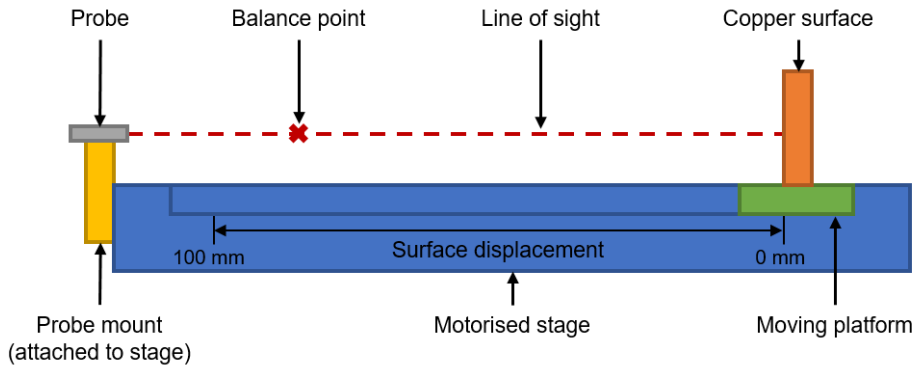
BLR at AWE

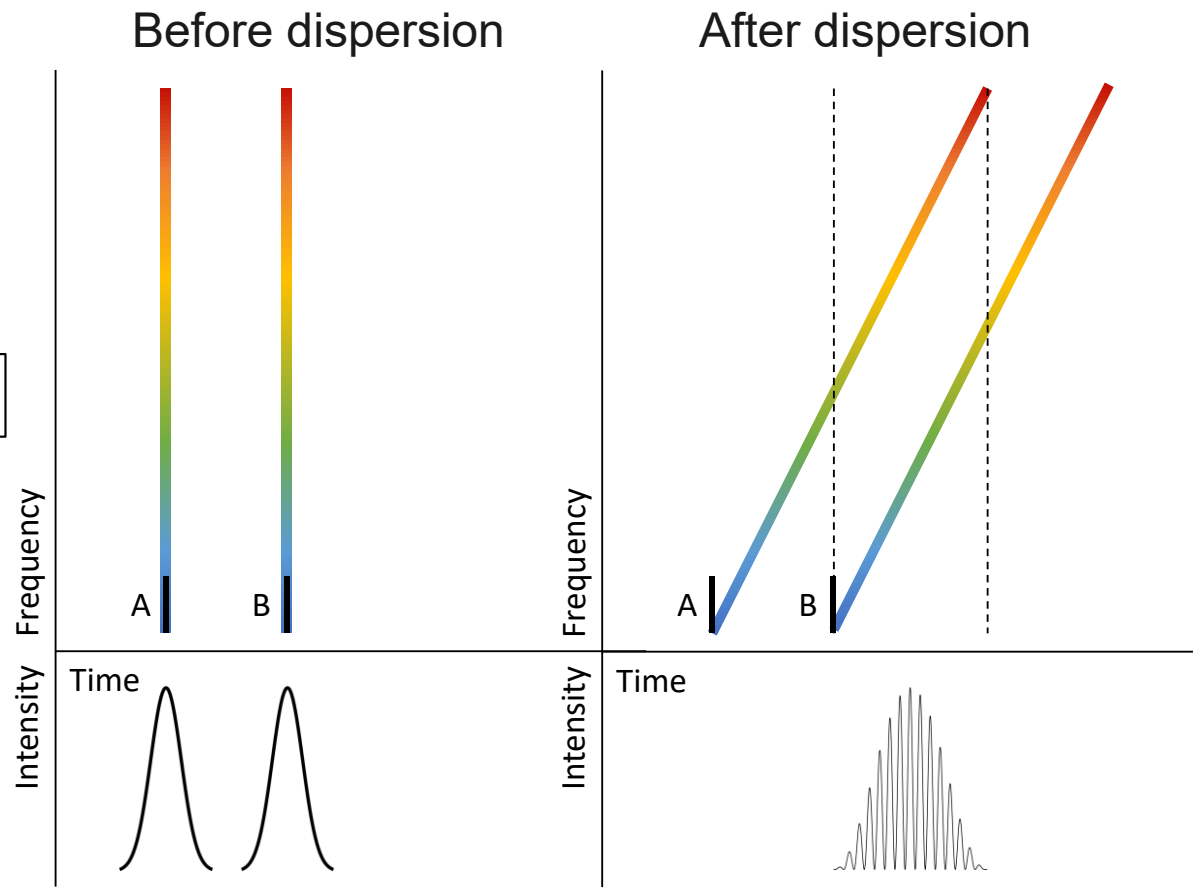


- Need ranging because of movement not along the line of sight of probe which integrating HetV cannot record
- Previously investigating ranging techniques and BLR was selected to develop further
- Prototype single channel BLR system built
- Complicated to set up and field, needed improvements for reliable and quicker setup but demonstrated technique
- Last couple of years, doubled the number of BLR channels available and made many improvements for both hardware and software
- Static lab testing showed an overall weighted mean and uncertainty 0.00 ± 0.02 mm between BLR and LUNA measured displacements of a surface

BLR introduction





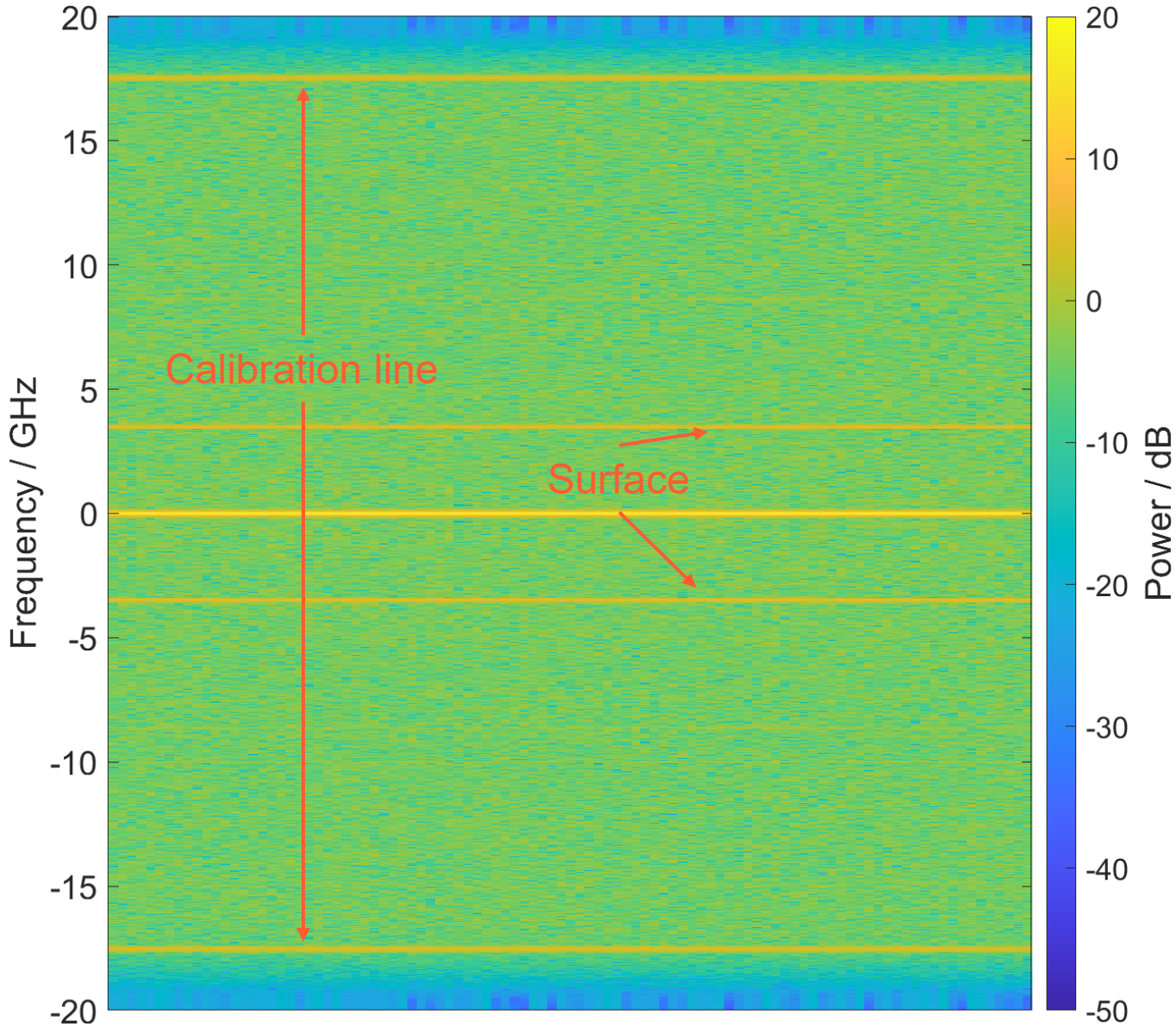


Static lab testing

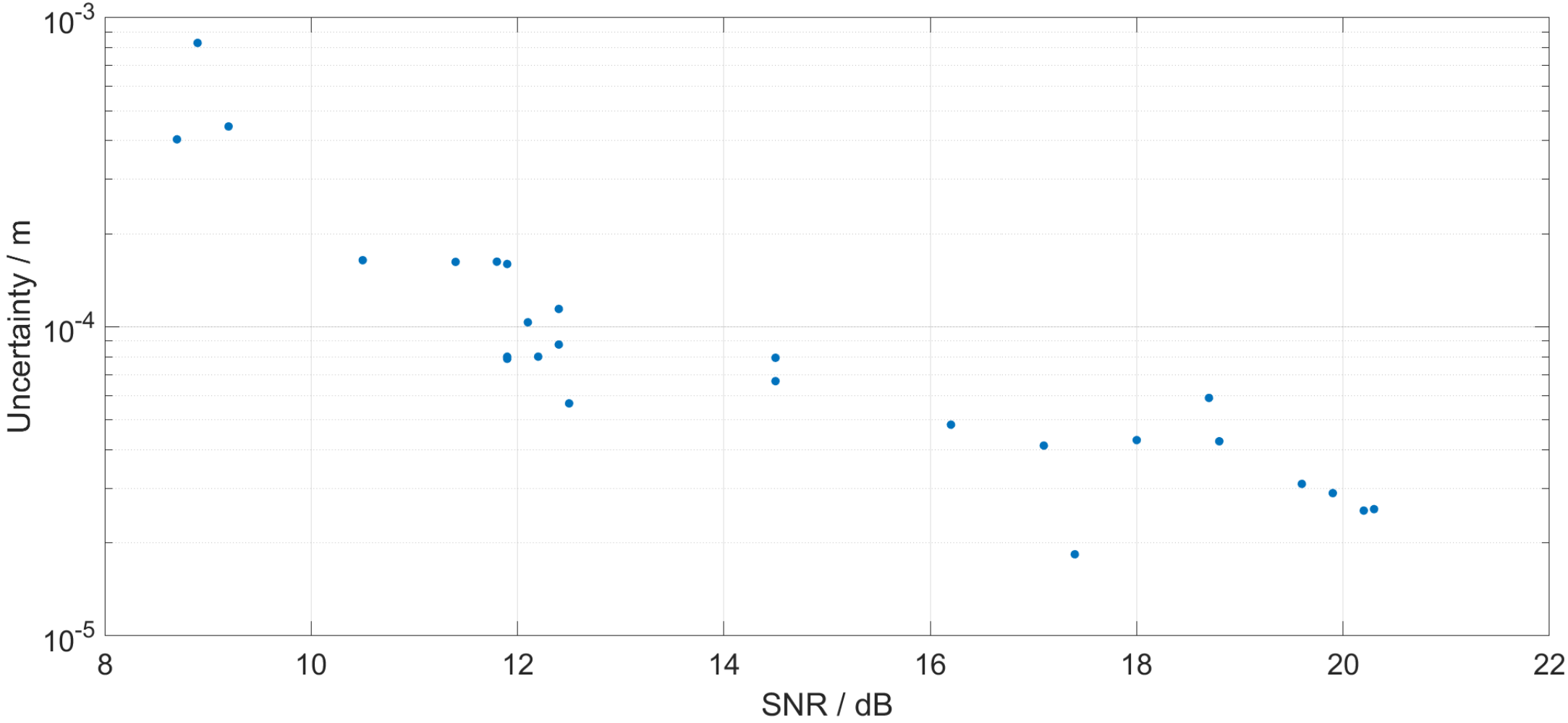
- Tested laser repetition rate
  - Small change in time between pulses would increase uncertainty if pulses not matched
    - With 1 pulse difference, no noticeable effects. Future testing will involve greater pulse difference or no pulse matching
- Polarisation dependence
  - Can control polarisation to increase SNR
    - Can also result in a decrease as the surface moves. Polarisation control not considered as hugely beneficial for now
- Time multiplexing
  - SMF and DCF components tested for a zero-dispersion delay module
    - ZDTDM required for time multiplexing for similar system sensitivities

Example static data

- Recorded 100 pulses to obtain mean and standard deviation of frequencies
- Use positive and negative frequencies out of FFT – easier when surface moves past 0 GHz balance point

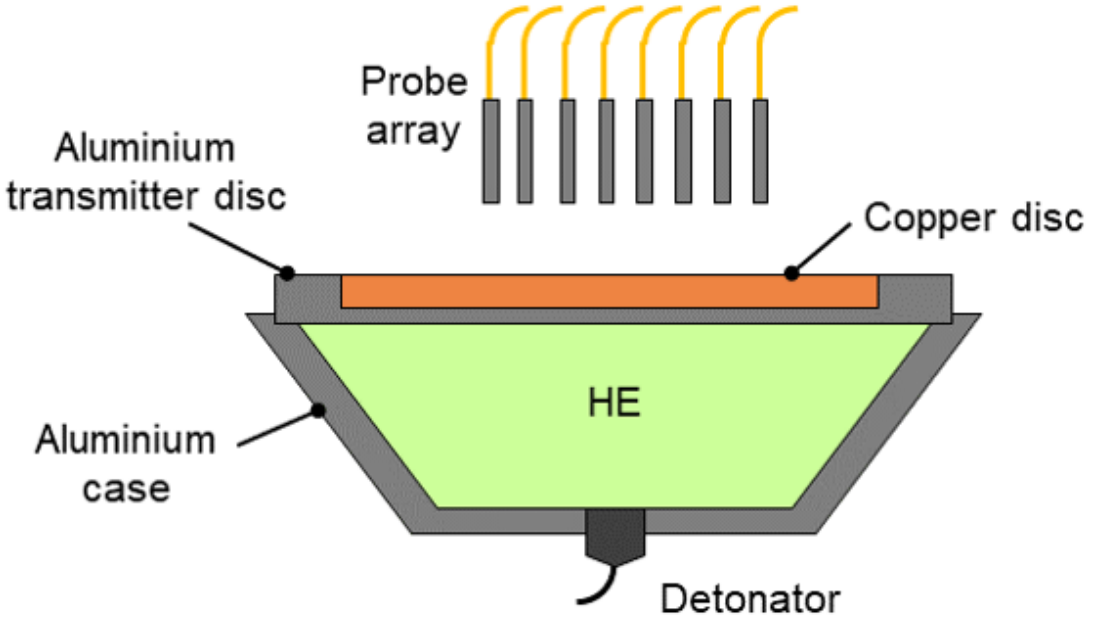


SNR

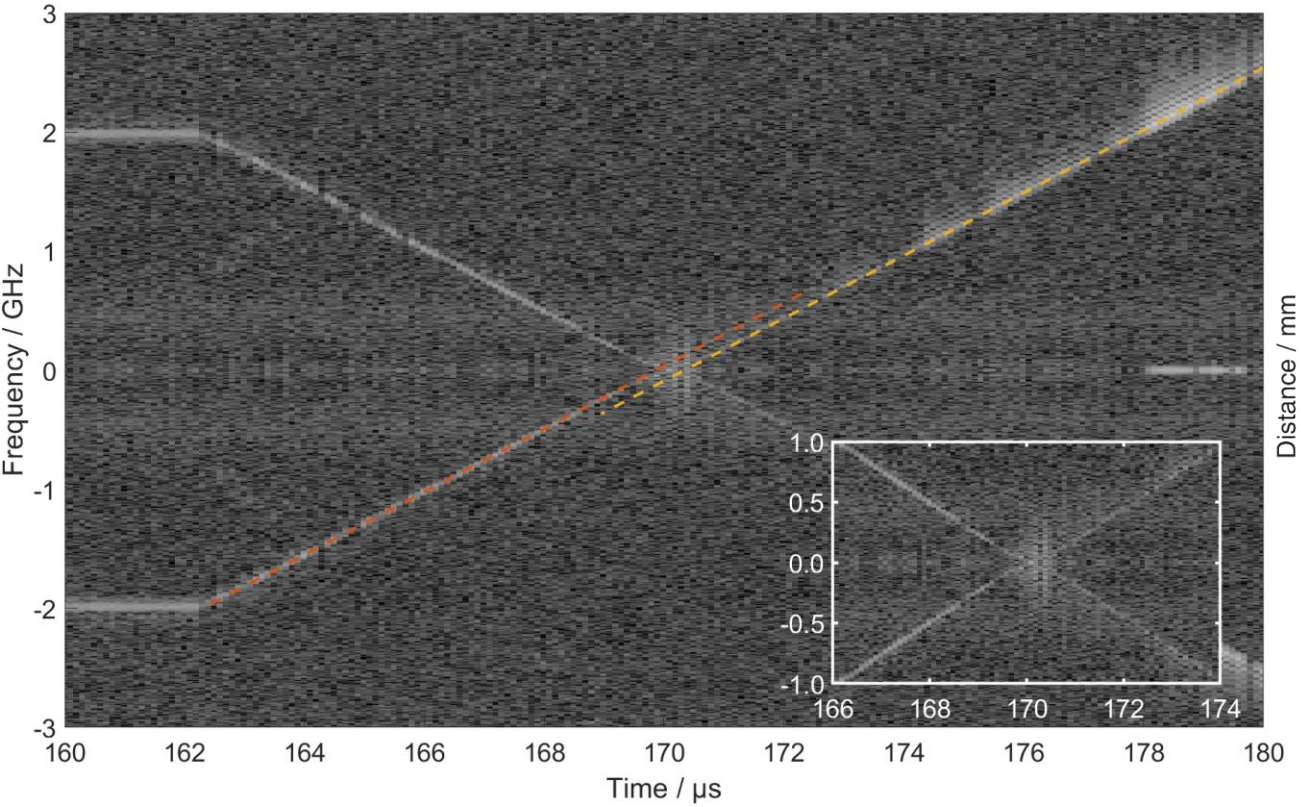


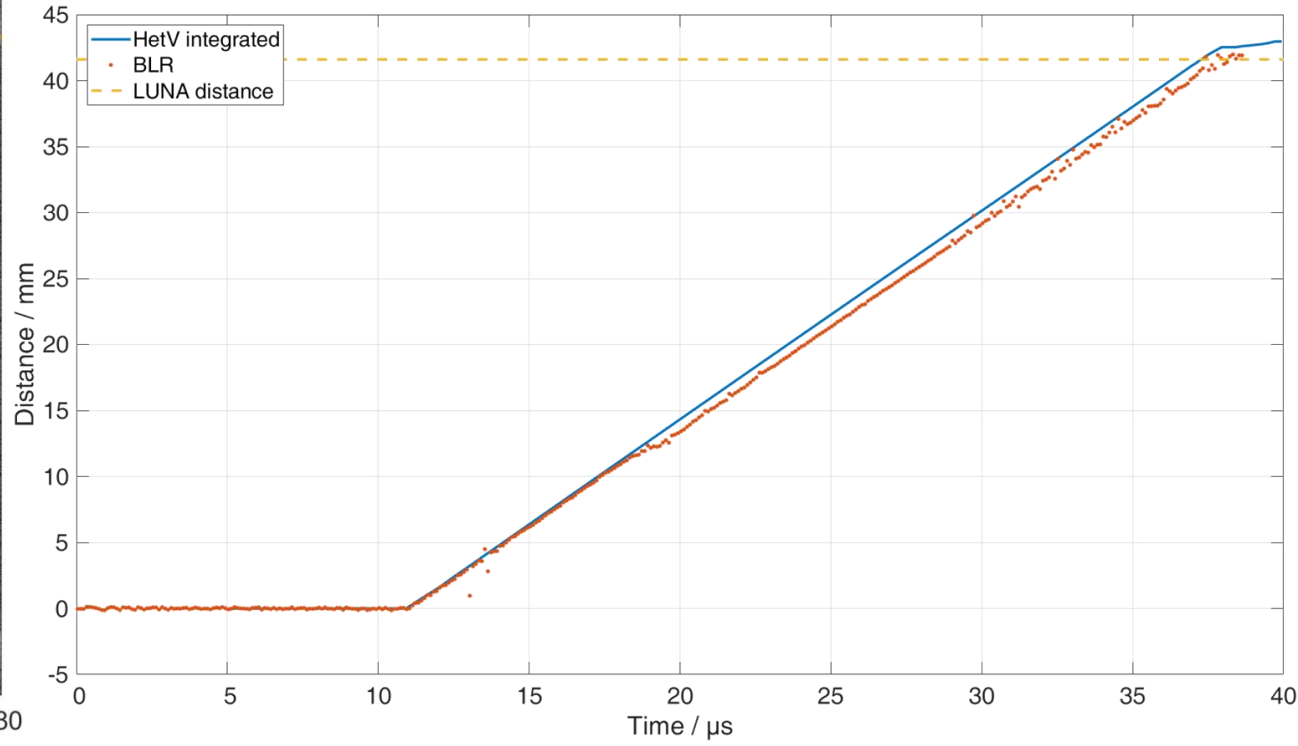
SURPOT 2

- Two channels of BLR fielded – first time fielded 2 channels at AWE. Multiplexed with HetV
- One channel was on a multipoint probe near centre
- Channel 2 was a discrete probe towards the edge

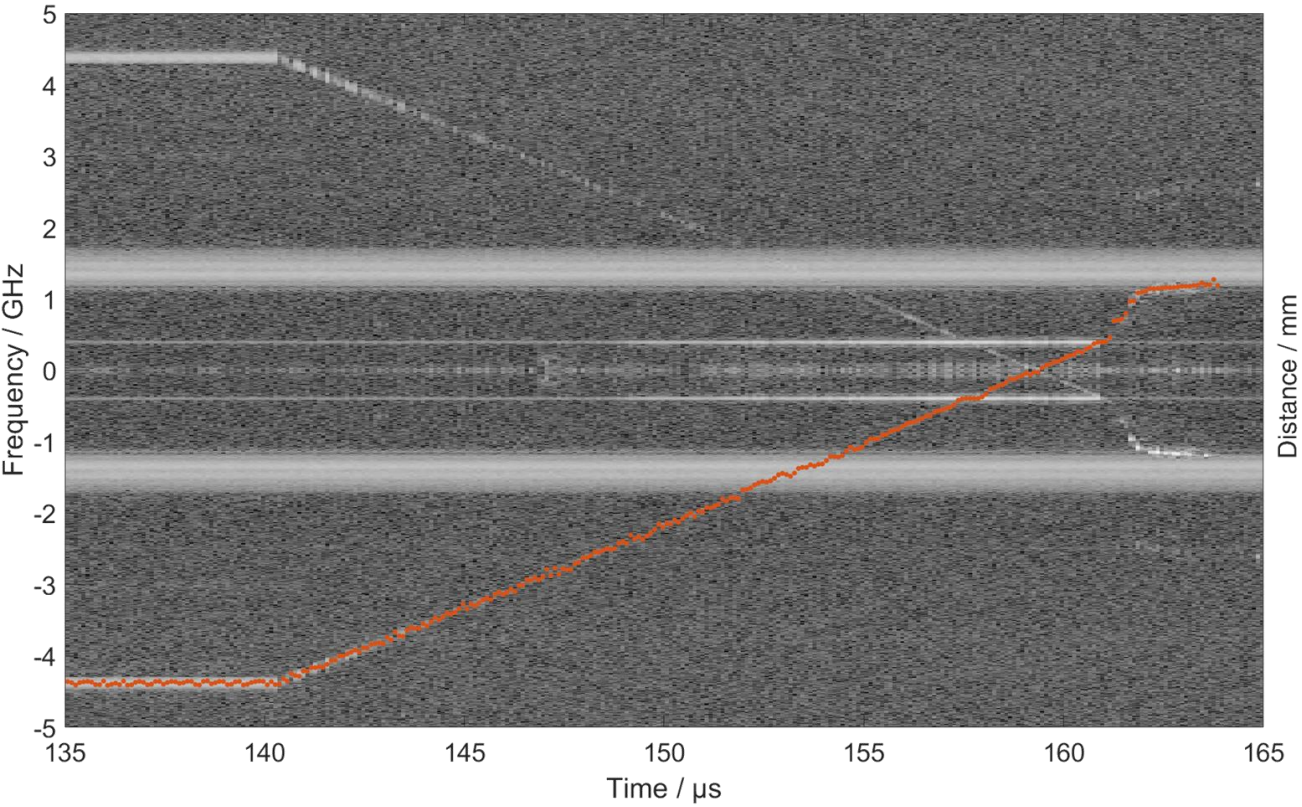


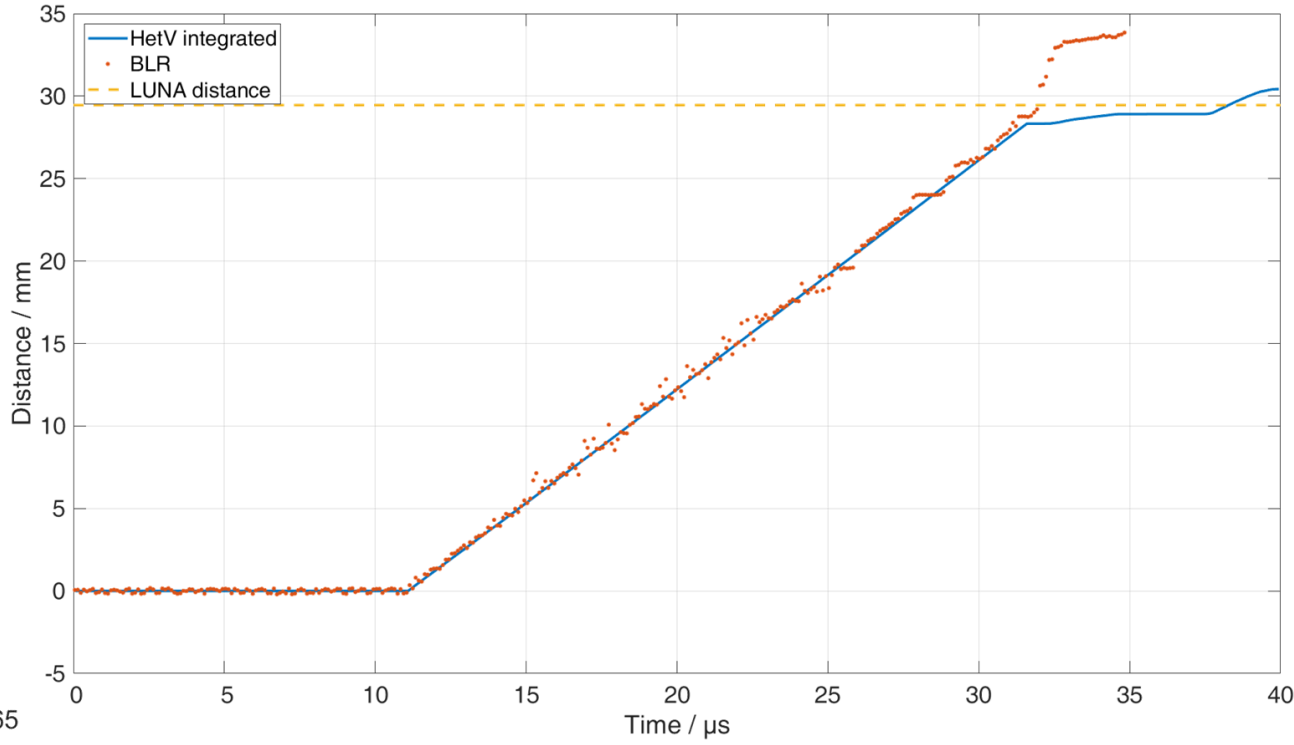
SURPOT 2 results – Channel 1





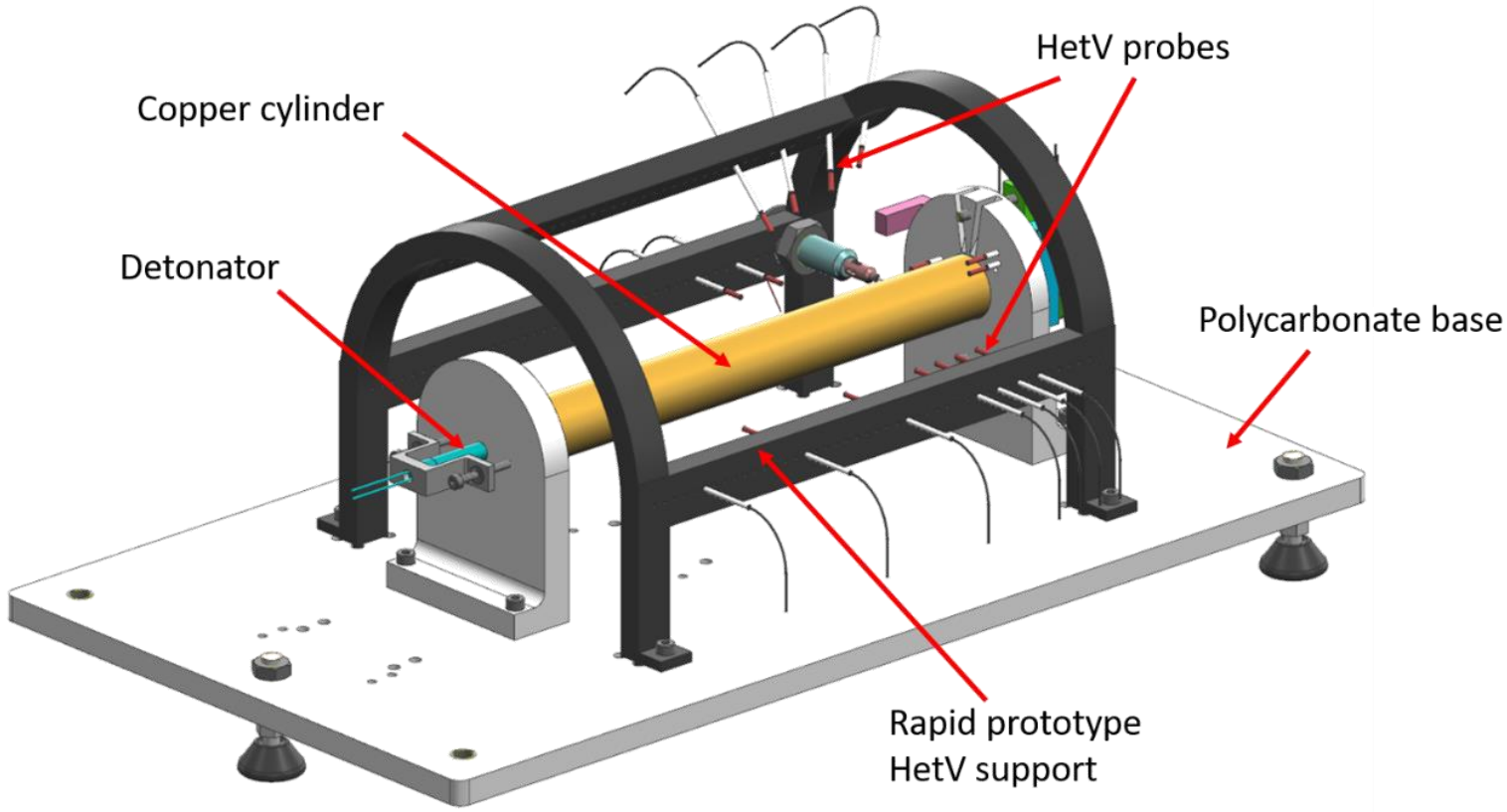
SURPOT 2 results – Channel 2



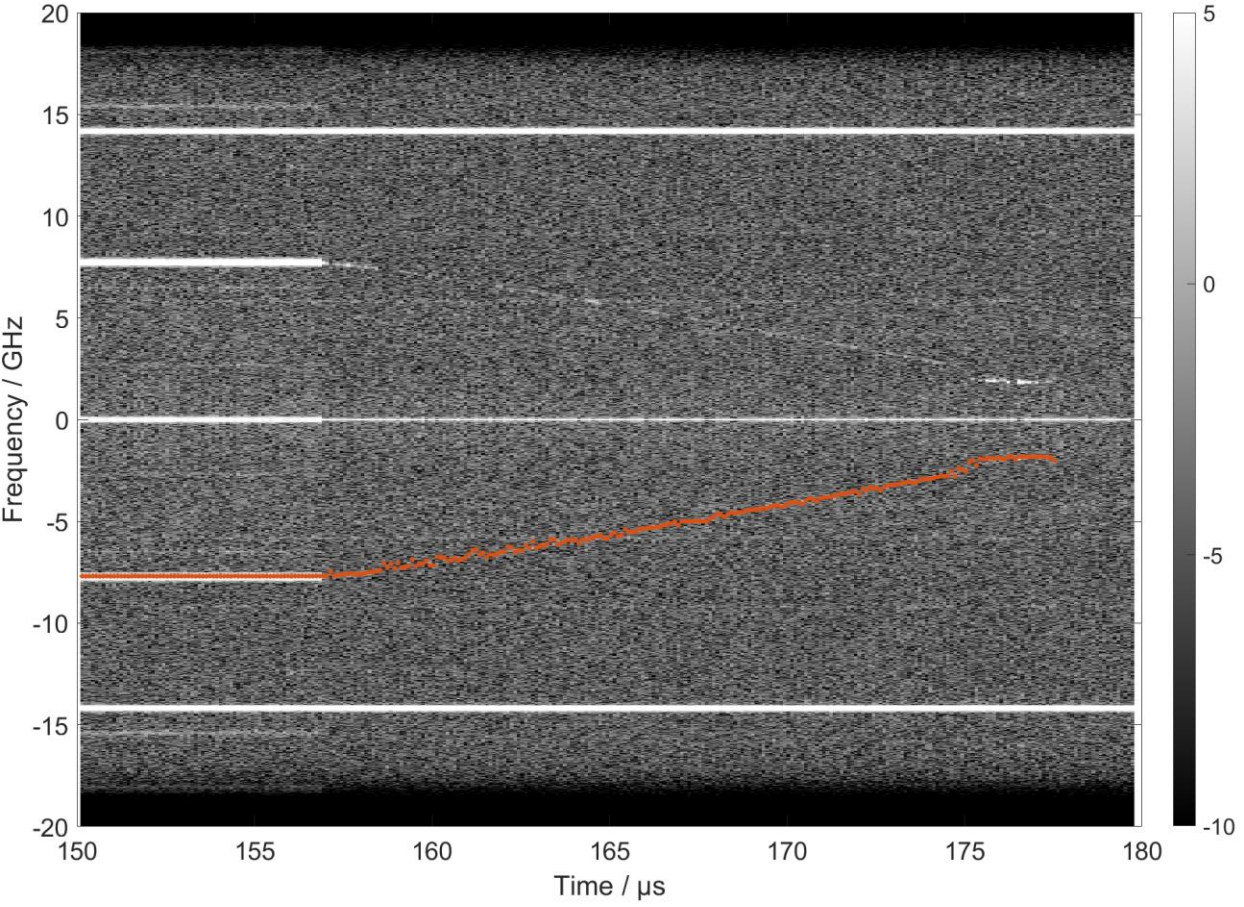


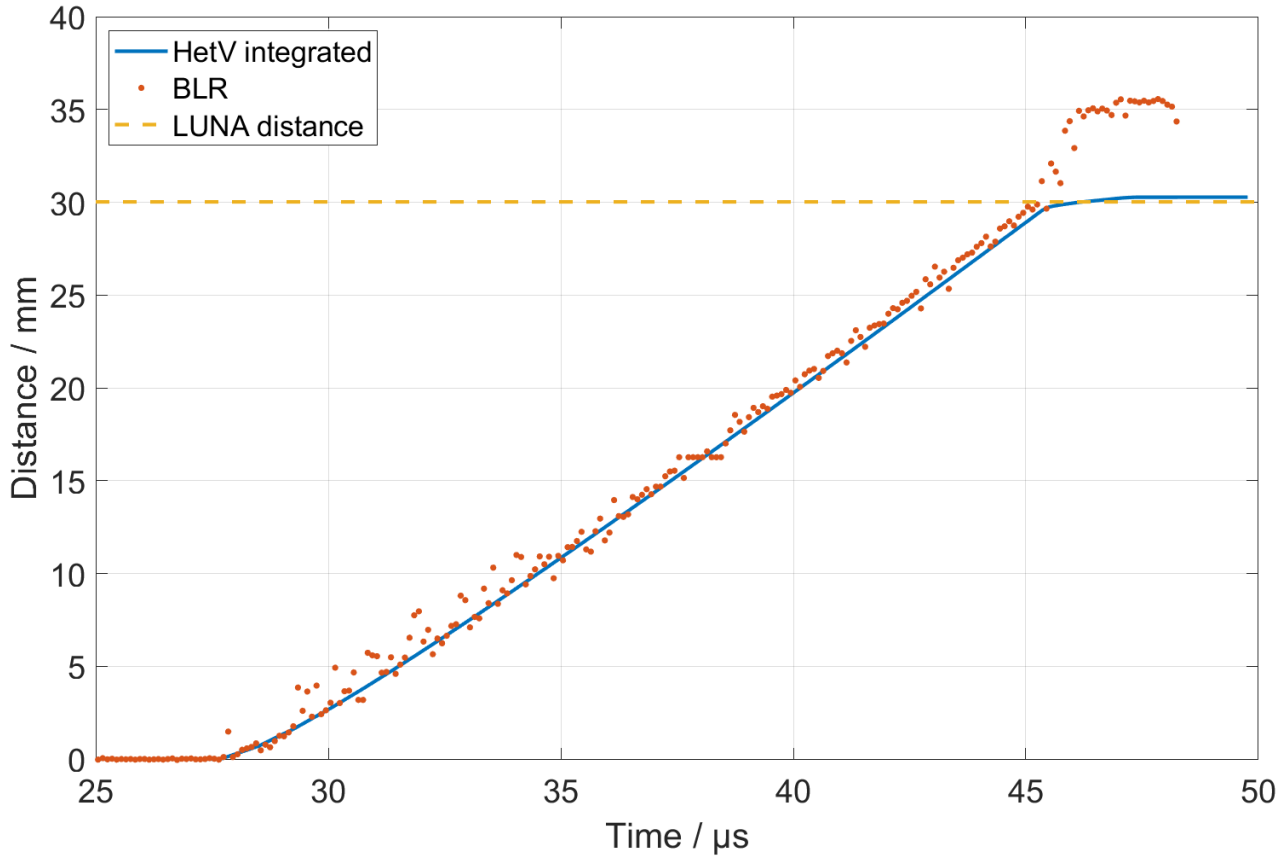
Cylinder test

- One channel of BLR on two different tests. Multiplexed with HetV

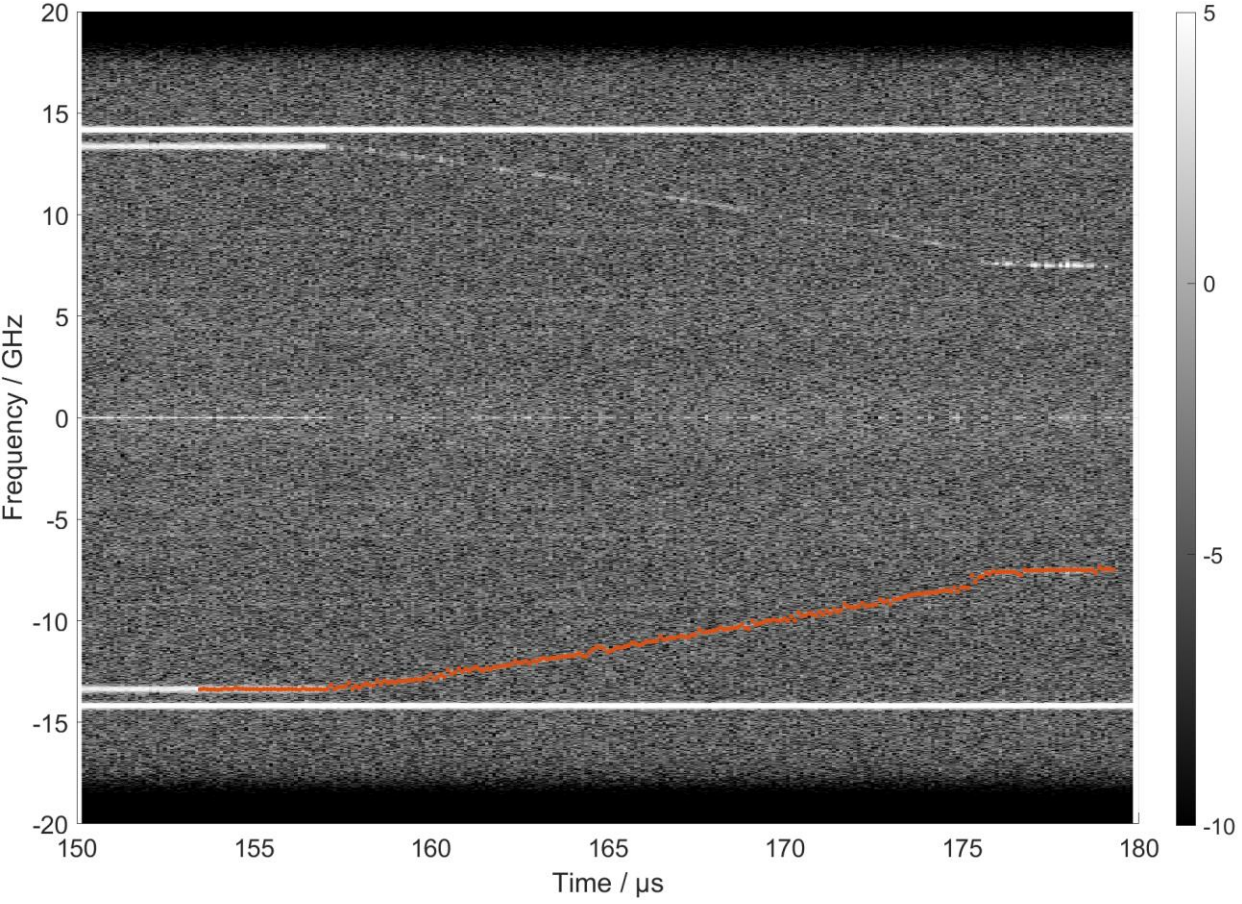


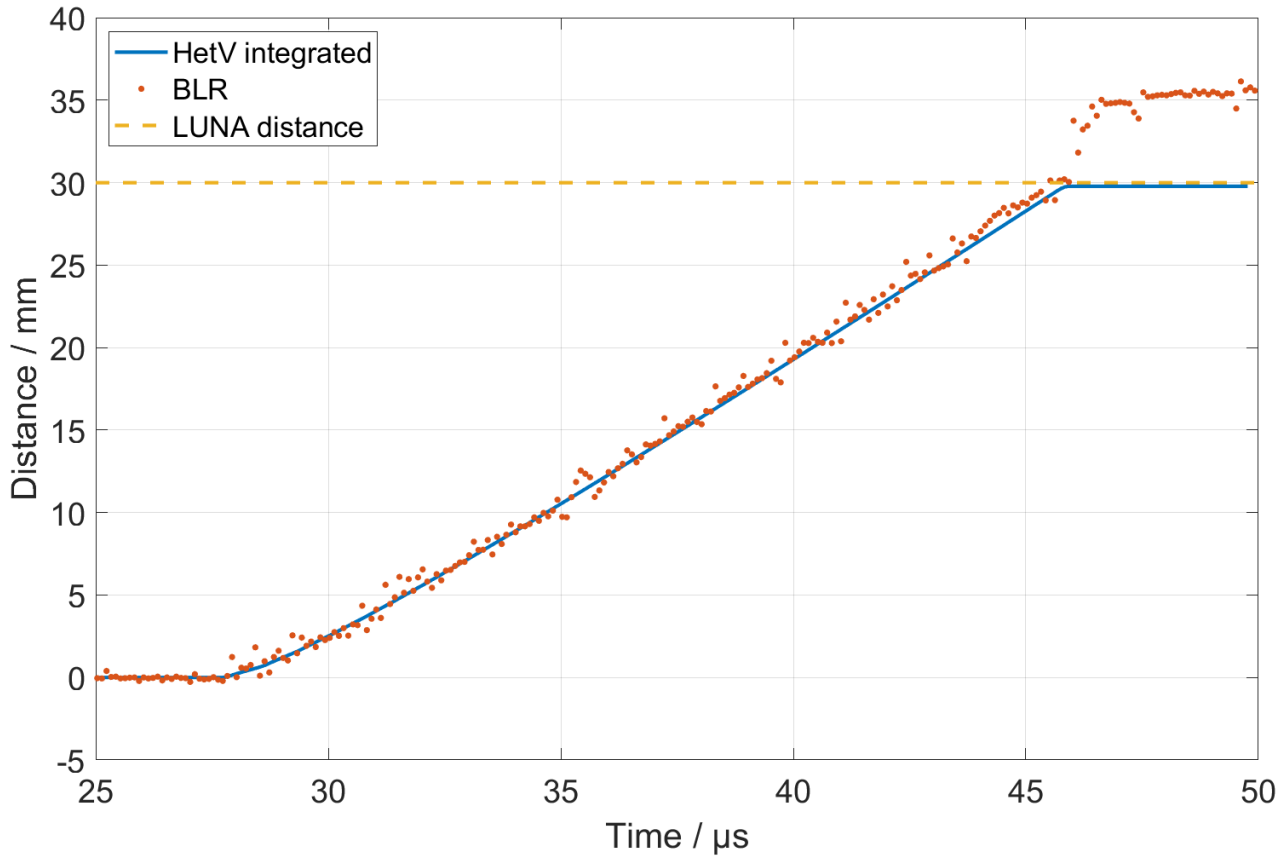
Cylinder test 1 results





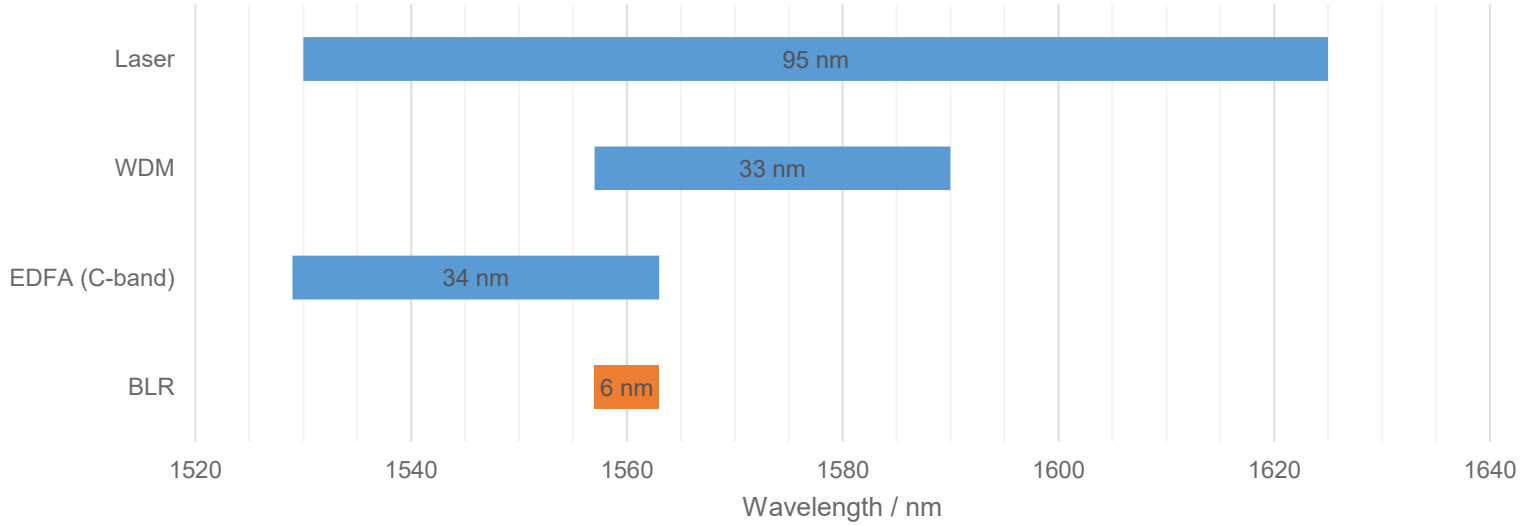
Cylinder test 2 results



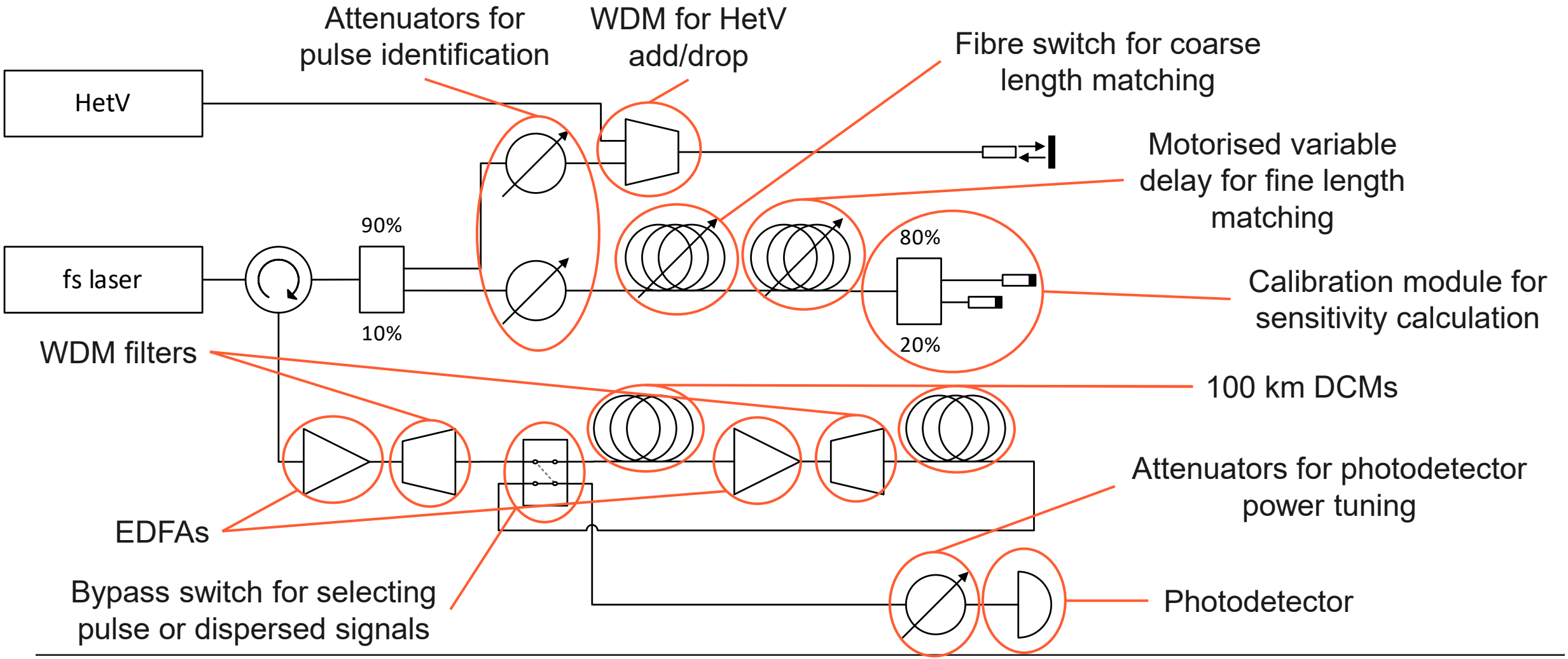


Required improvements

- View pulses without and with dispersion for setup
- Verify pulses seen are from probe / reflector
- Easier tuning for path length matching. Setup time is increased by finding / splicing fibres of correct lengths
- More light
- Parameter prediction
- Improved analysis software

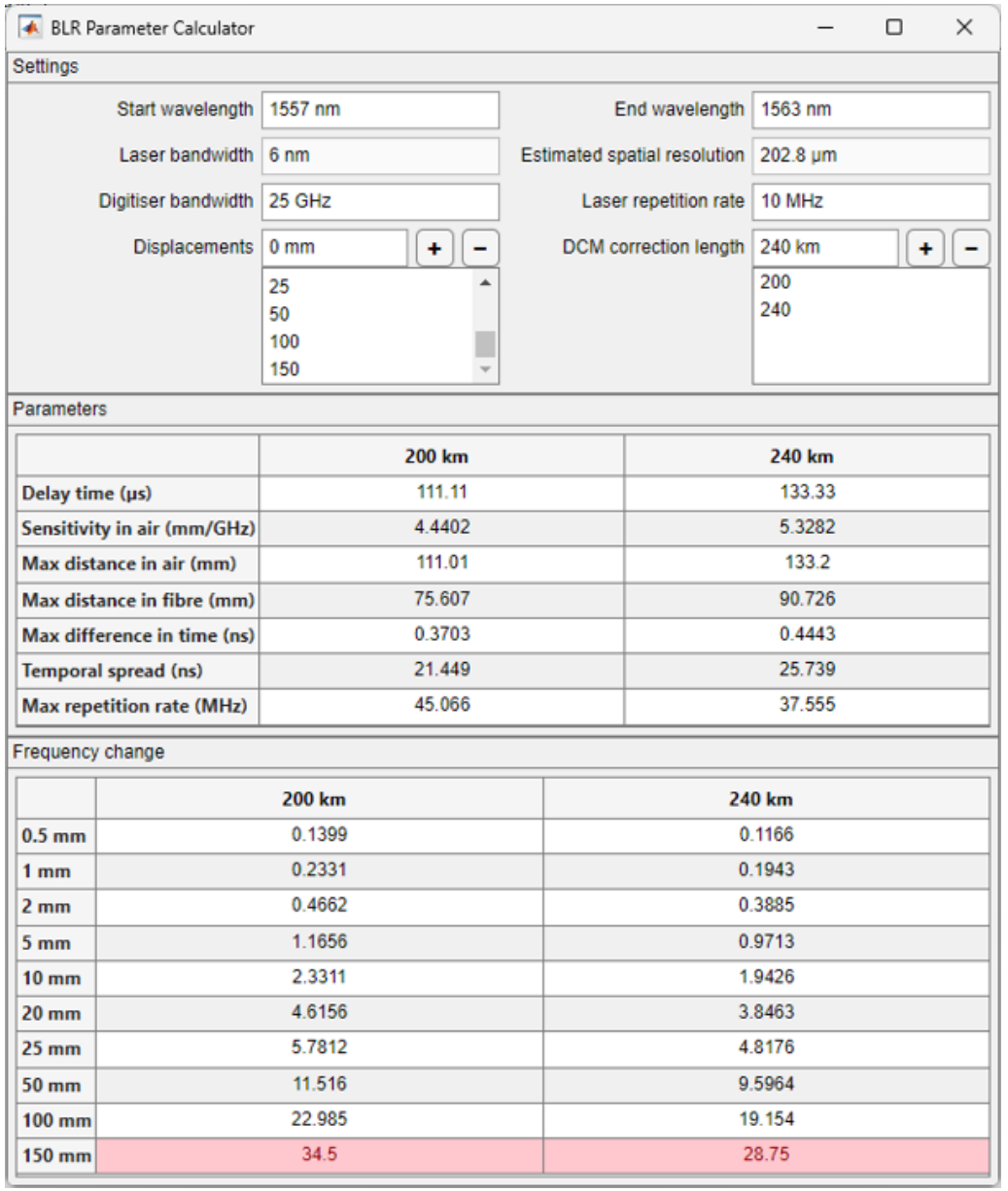


System design



System parameters

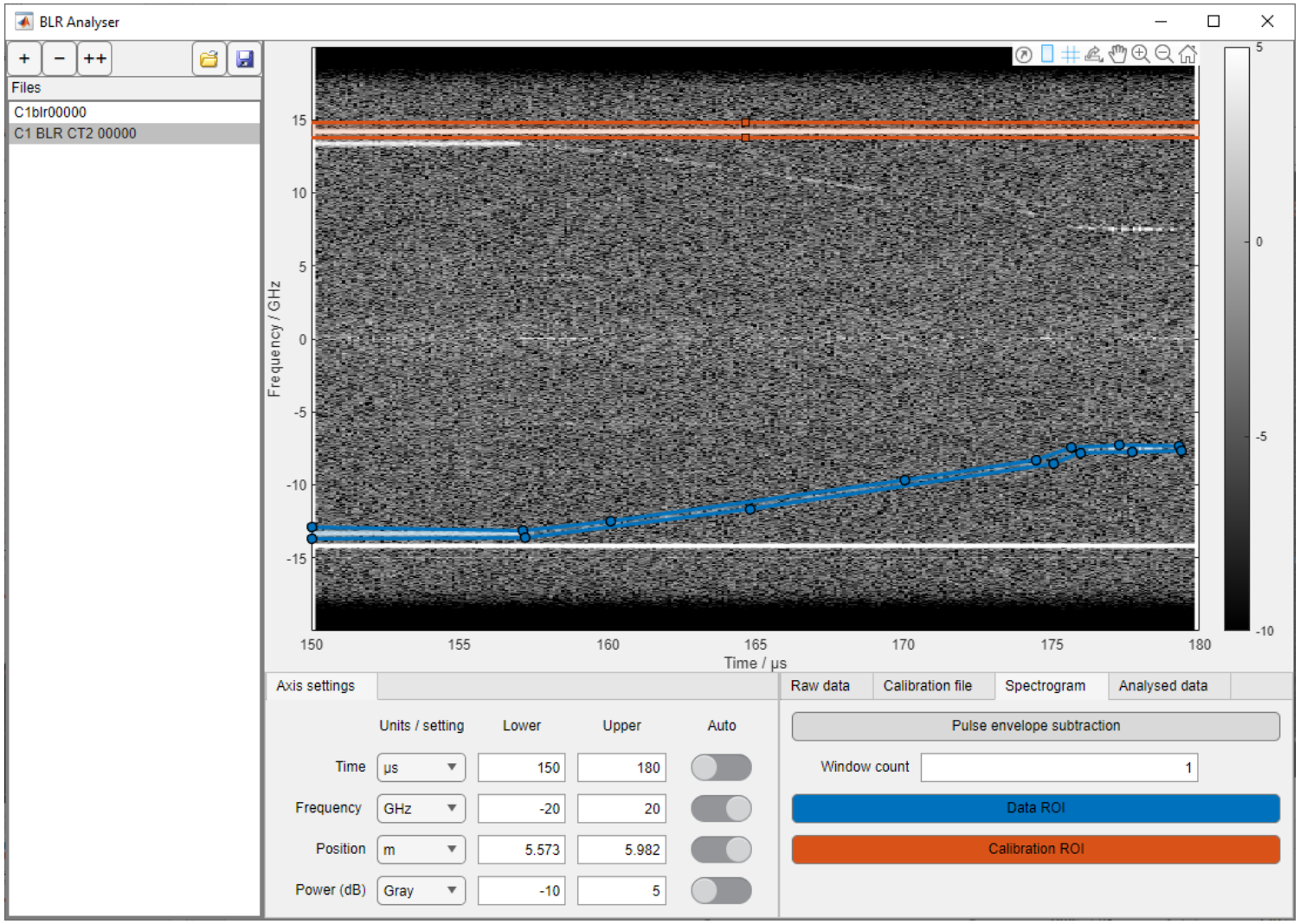
- Parameter calculator application built
- Will use a 25 GHz oscilloscope
  - Can reduce DCM length down to 200 km
  - Can increase repetition rate from 10 MHz to 40 MHz



	200 km	240 km
Delay time (µs)	111.11	133.33
Sensitivity in air (mm/GHz)	4.4402	5.3282
Max distance in air (mm)	111.01	133.2
Max distance in fibre (mm)	75.607	90.726
Max difference in time (ns)	0.3703	0.4443
Temporal spread (ns)	21.449	25.739
Max repetition rate (MHz)	45.066	37.555

	200 km	240 km
0.5 mm	0.1399	0.1166
1 mm	0.2331	0.1943
2 mm	0.4662	0.3885
5 mm	1.1656	0.9713
10 mm	2.3311	1.9426
20 mm	4.6156	3.8463
25 mm	5.7812	4.8176
50 mm	11.516	9.5964
100 mm	22.985	19.154
150 mm	34.5	28.75

Analysis software



Summary

- Developed and demonstrated use of BLR in static lab testing and hydrodynamic experiments
- Easier and more reliable setup of BLR for trials
- Calculator for testing BLR parameters
- GUI for analysis and simple to use
- Future work to reduce uncertainty
  - Low noise amplification techniques – Raman amplifiers & SOAs
  - Software improvements – dechirping?