Simultaneous measurements of wind speed at multiple distances without range ambiguity

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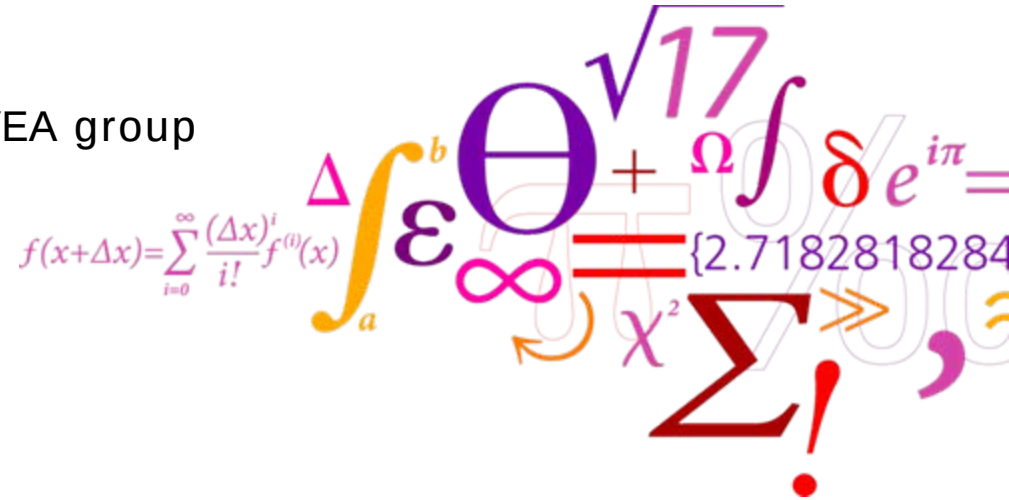

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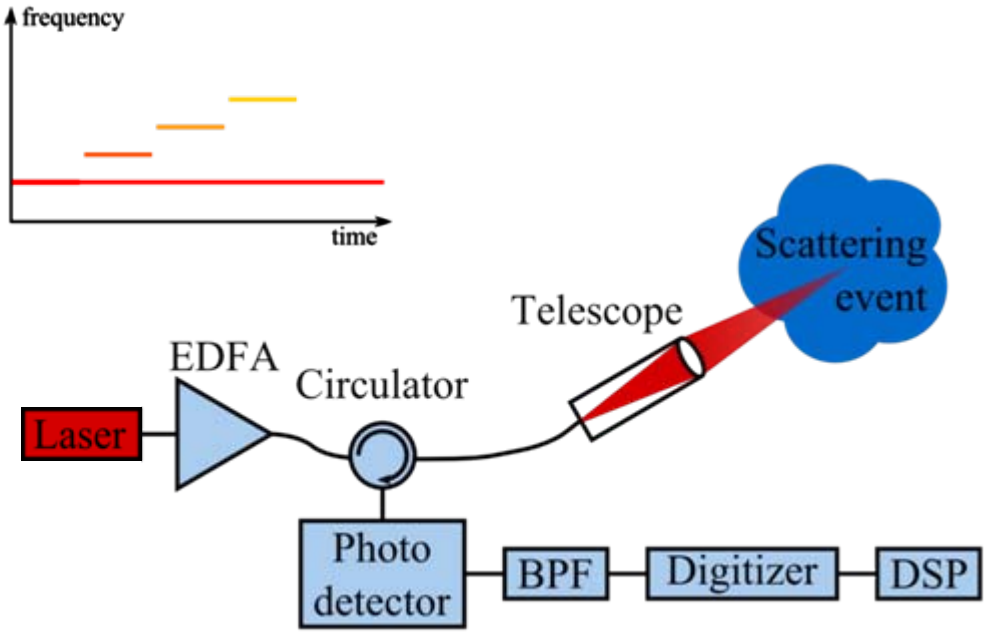
Motivation

- CW lidar
  - Measures continuously
  - Can have range ambiguity due to clouds and other high scatters
- Pulsed lidar
  - Has a low pulse repetition frequency
  - Does not have range ambiguity and can measure at multiple distances simultaneous
- Frequency Stepped Pulse Train (FSPT) modulated lidar
  - Theoretically capable of measuring continuously
  - Does not have range ambiguity and can measure at multiple distances simultaneous
- Proof of concept measurements

Lidar system design

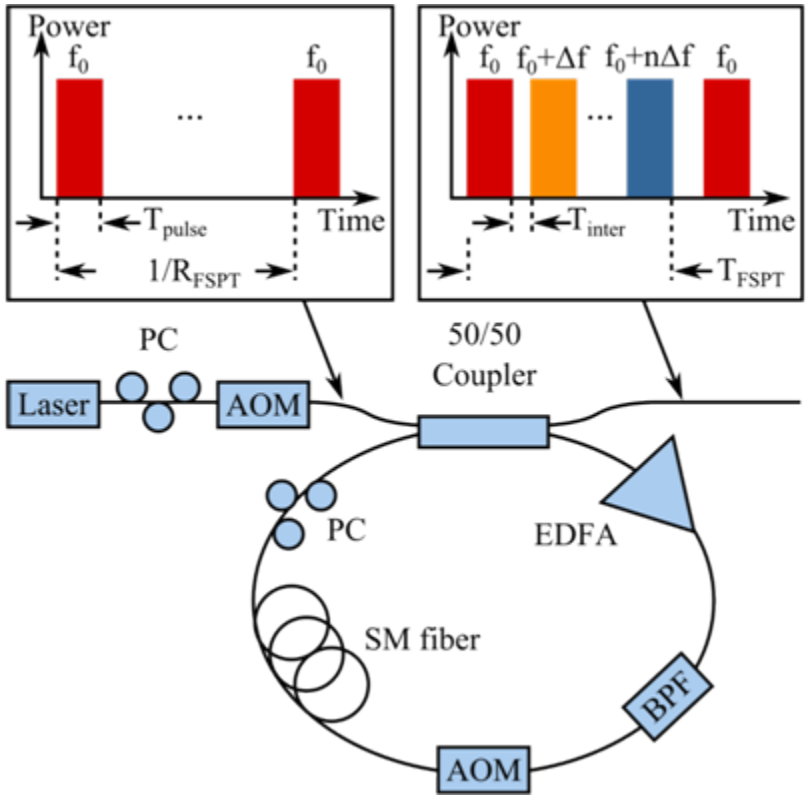
- An all fiber based lidar
  - wavelength: 1545 nm
  - Transmission power: 1 W
- Focused telescope
  - Aperture: 7 cm
- Coherent detection
- Signal processing by FFT and averaging



Schematic drawing of the Lidar setup.

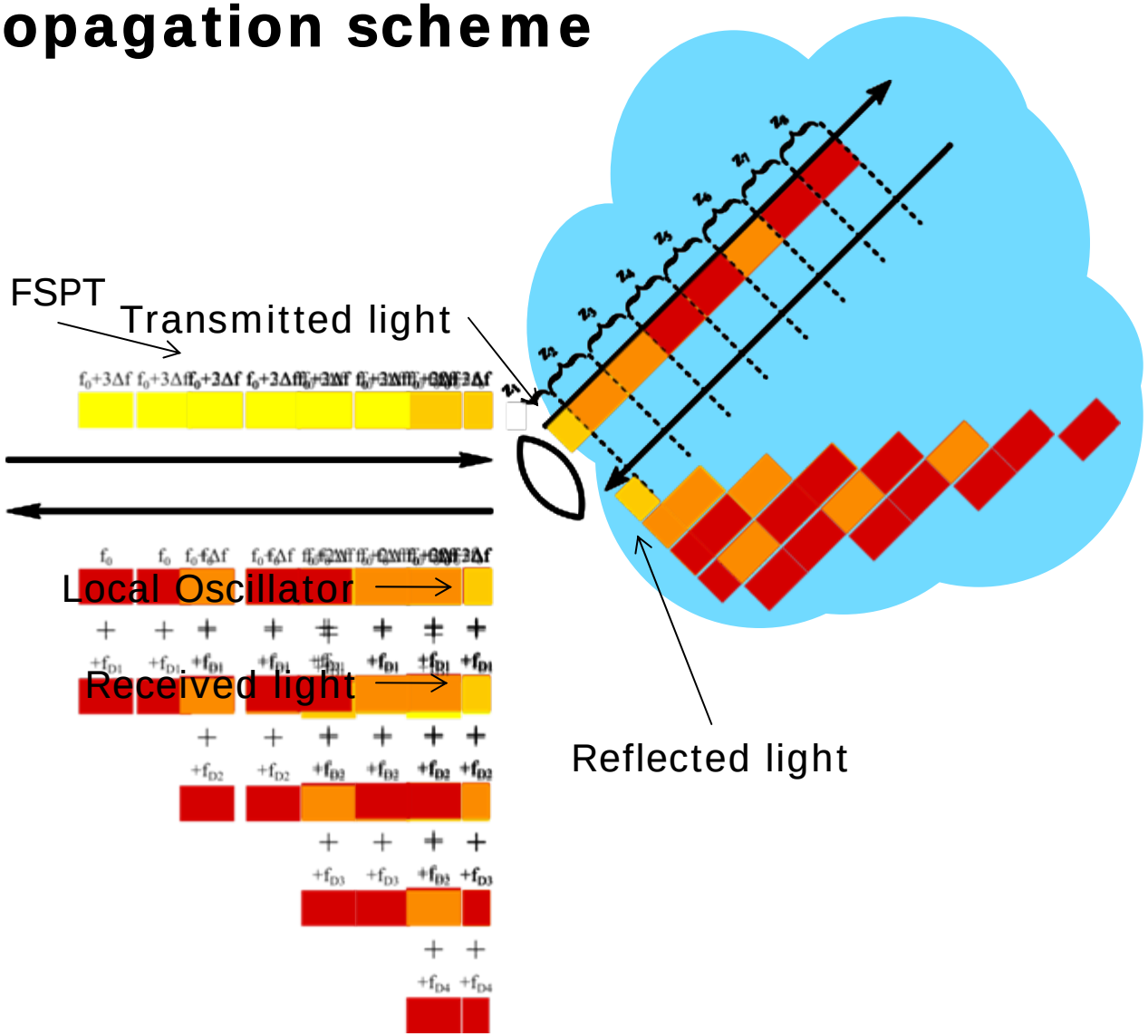
Lightwave Synthesized Frequency Sweeper

- Fiber based Frequency Stepped Pulse Train generator
- Generates FSPT by recirculation of a pulse in an fiber optical ring.
- Shifts the frequency by a fixed amount for each circulation



Schematic drawing of the LSFS setup.

Light propagation scheme



Time-space representation of the received scatter from an FSPT modulated lidar

Range cells are defined from

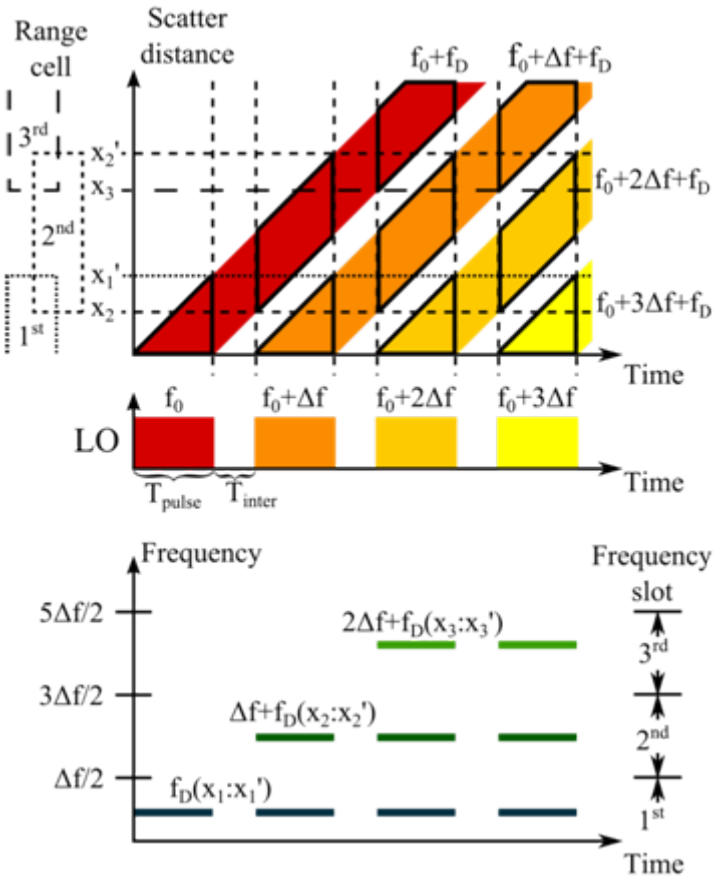
$$x_i = \left((i-2)T_{pulse} + (i-1)T_{inter}\right)\frac{c}{2}$$

to

$$x_i' = \left(iT_{pulse} + (i-1)T_{inter}\right)\frac{c}{2}$$

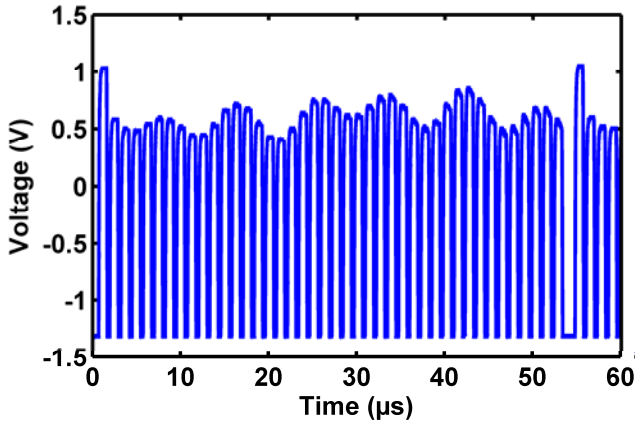
Line of sight velocity in a given range is calculated as:

$$V_{LOS,i} = \frac{\lambda}{2} f_D\left(x_i : x_i'\right)$$

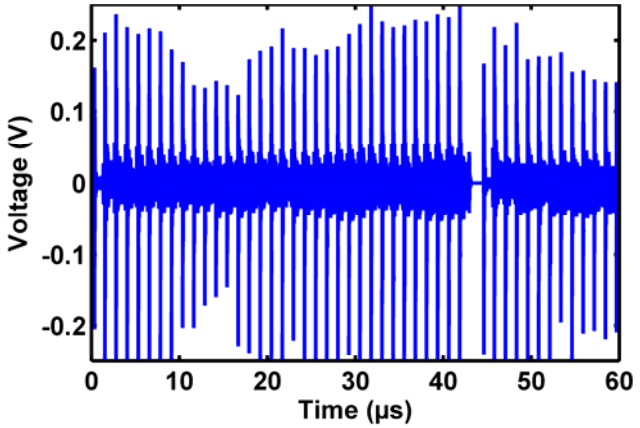


Signal processing

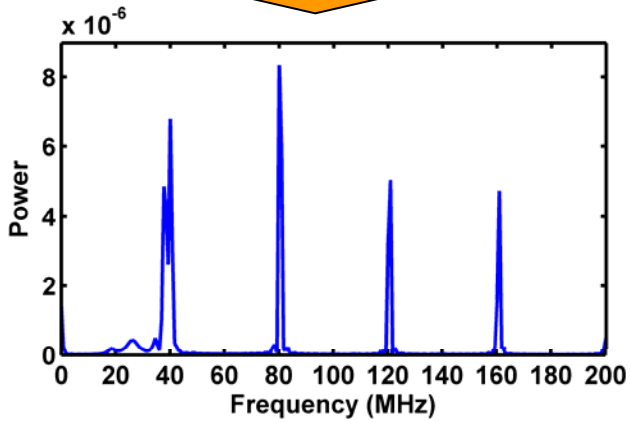
Detector



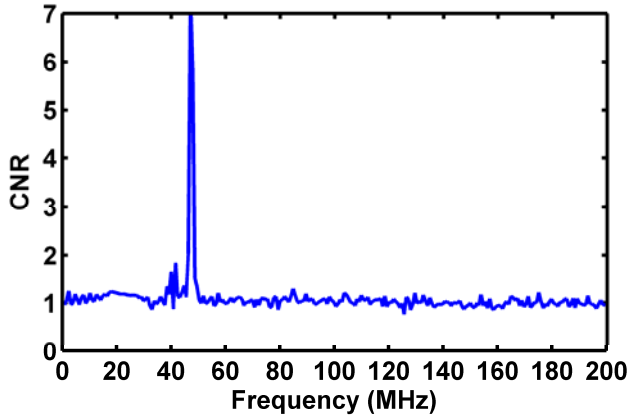
BPF



Digitizer, FFT, average

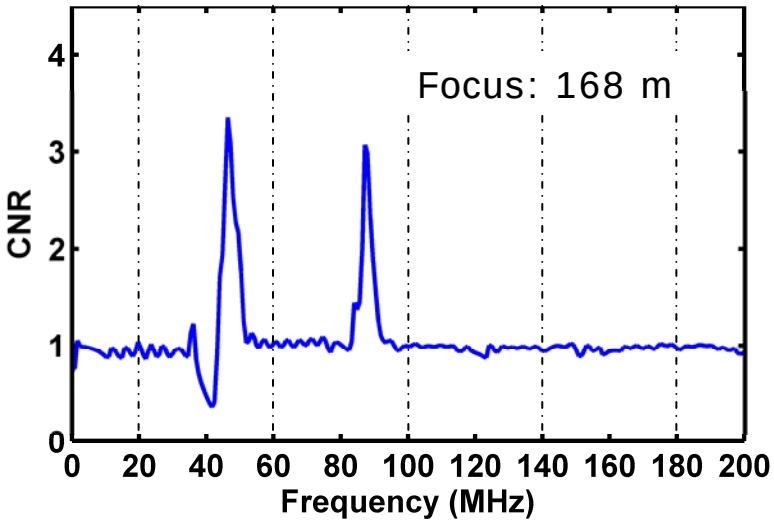


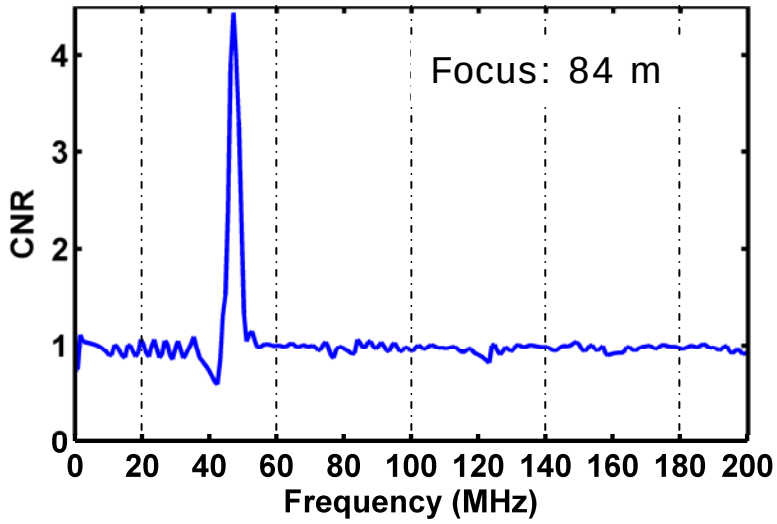
CNR

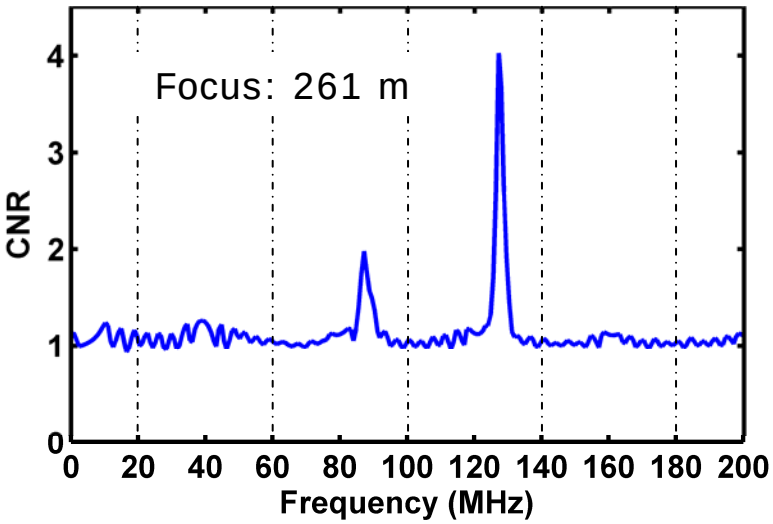


Wind speed measurements

- Proof of concept measurements
  - 550ns pulses
  - 30ns inter pulse time
  - 40MHz frequency shift
  - 1 W average power

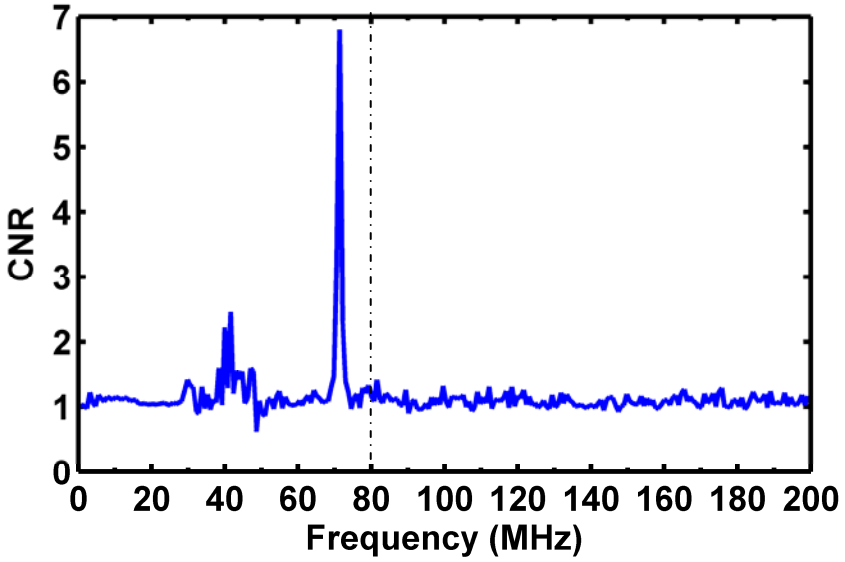




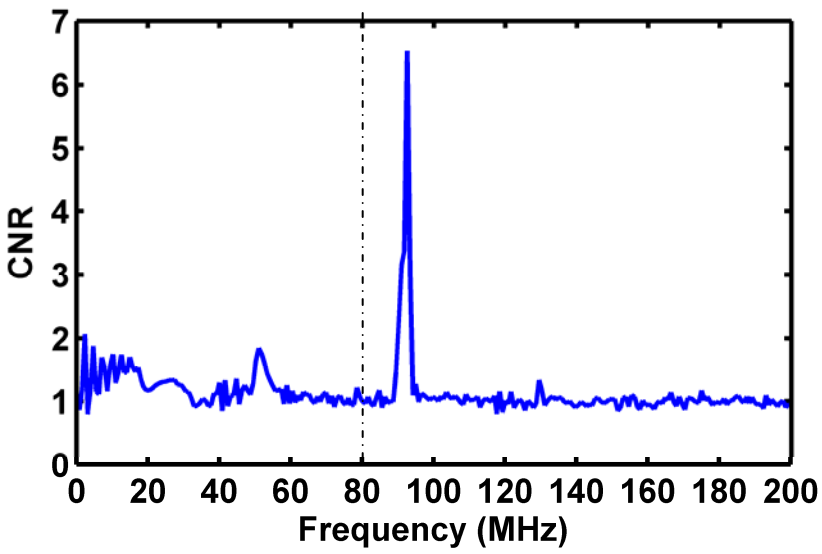


Wind speed direction

Headwind



Tailwind



Conclusion

- We have demonstrated the FSPT modulated lidar and achieved proof of concept measurements
- We hope that this method in the future will help lidars overcome some of their problems
  - Range ambiguity for CW lidars
  - Low PRF for pulsed lidars
- The goal is to achieve detection in multiple range cells from 15m to 200m with a spacing of 30m and with a high measuring rate