Technical University of Denmark

WindScanner systems

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WindScanner systems

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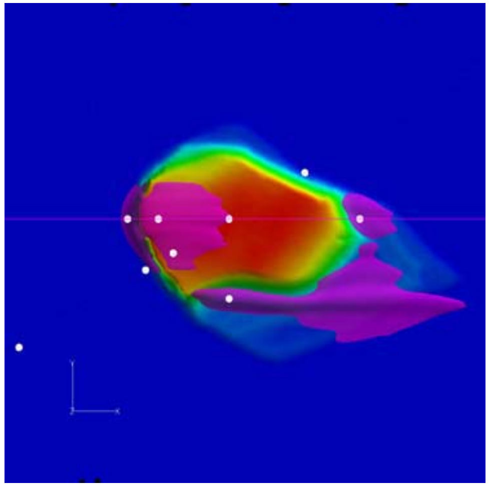
IRPWind conference, Amsterdam
25/09/2014

DTU Wind Energy
Department of Wind Energy

Why do we measure wind velocity?

- Performing experiments
- Establish confidence in CFD results
- Test turbulence models used in CFD
- Improving the theory
- **Basis for the advancement of our understanding of the atmospheric flows**



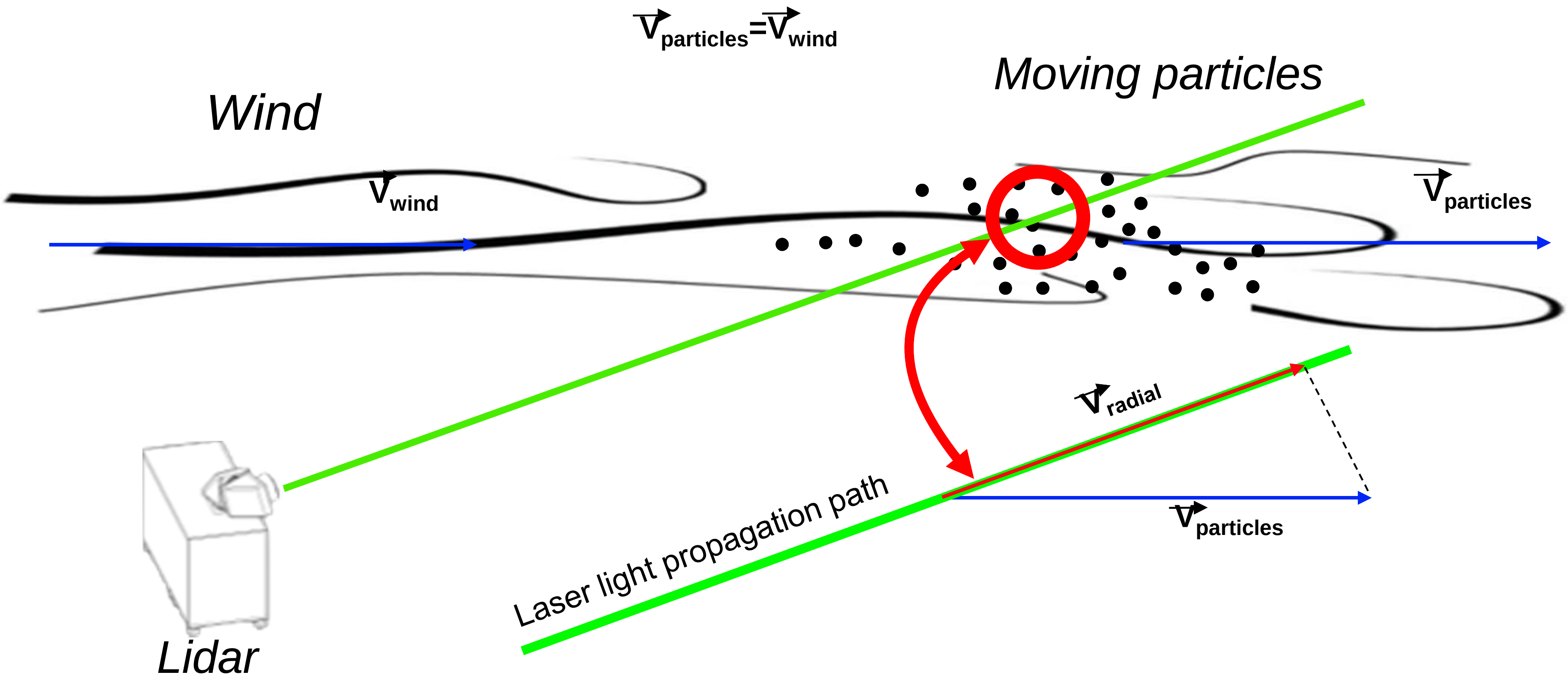
Necessity for in-situ measurement alternatives

- Tall masts are expensive
- Experiments at large scales are economically challenging
- Costs slow down the pace of the progress
- We need cost-effective and accurate alternatives to tall masts
- The most promising alternatives are **coherent Doppler lidars**

Offshore met masts	Costs	Max. height
FINO1	19 M€	100 m
Commercial met. mast	7-9 M€	100 m
Swimming met. mast	2-4 M€	60-80 m

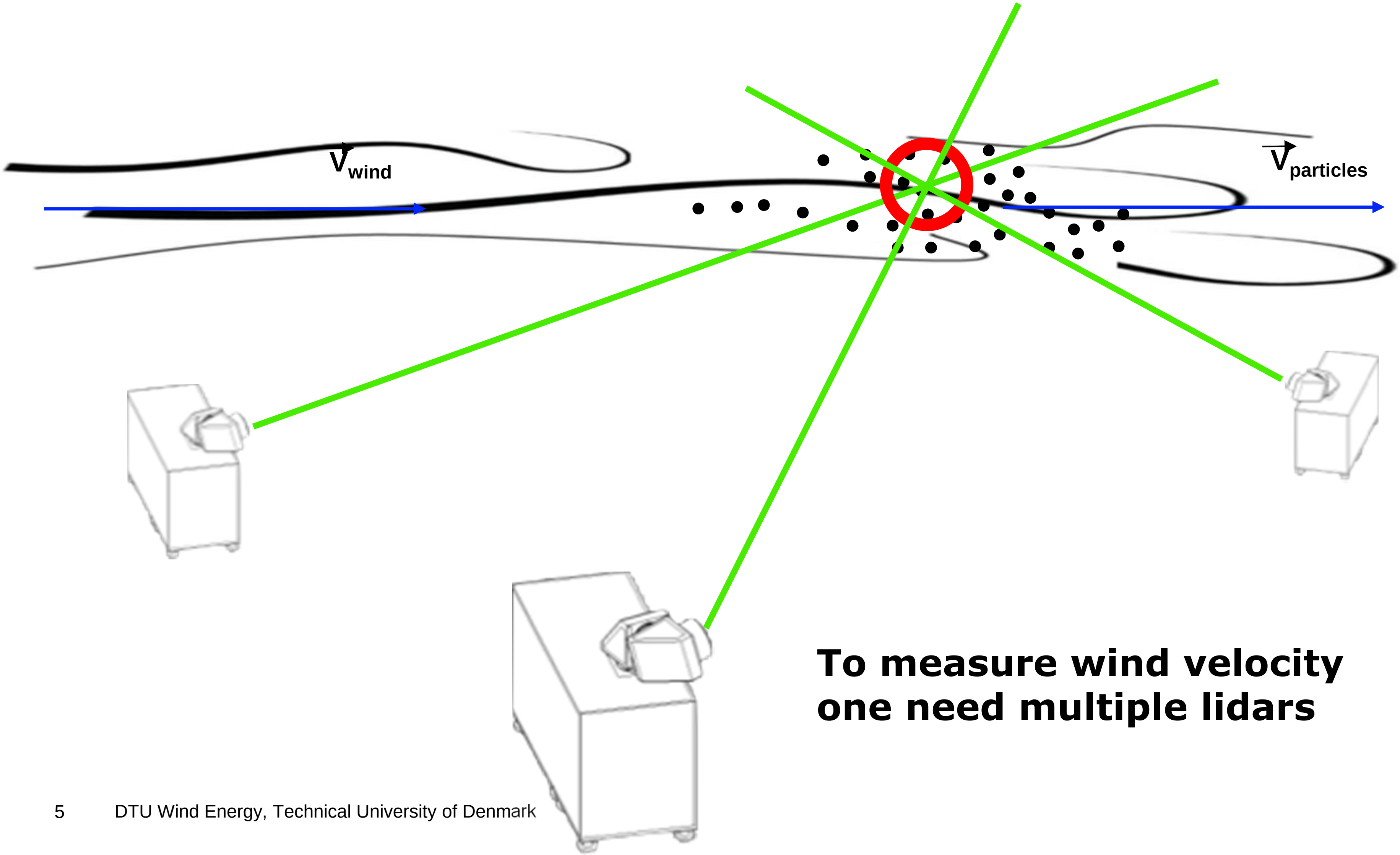
Source: Gerrit Wolken-Möhlmann and Julia Gottschall, ***Floating lidars***,
DTU Risø Campus, Roskilde, Denmark, March 21st, 2013 / MARINET short course

Lidar measurements background



Single lidar measure only radial velocity

Lidar measurements background

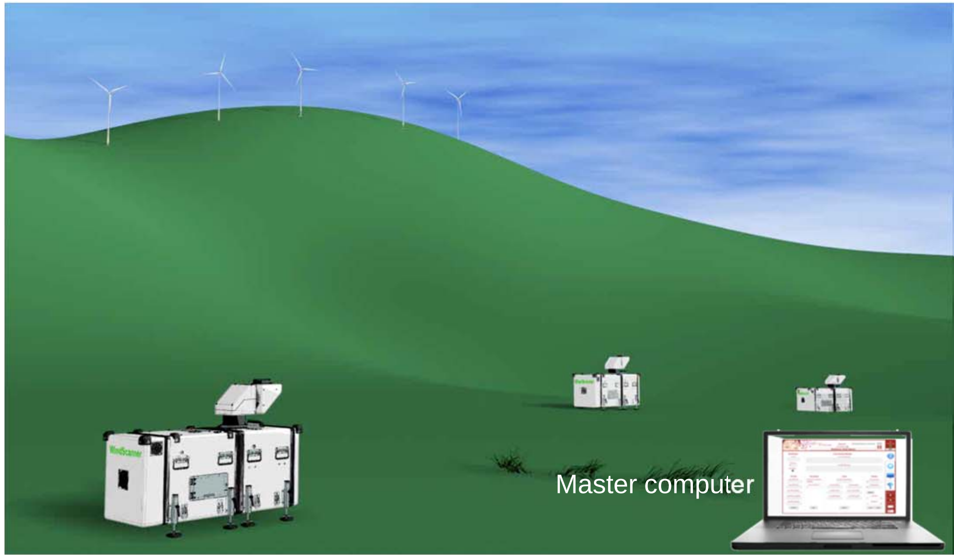


To measure wind velocity one need multiple lidars

WindScanner.DK

- In 2007, DTU Wind Energy, at that time Risø DTU, presented an ambitious idea about the development of the unified measurement systems, known as windscanner systems, which consist of three time-space synchronized scanning coherent Doppler lidars (i.e. WindScanners), specialized for detailed remote measurements of real-time wind velocity fields

Long-range WindScanner system



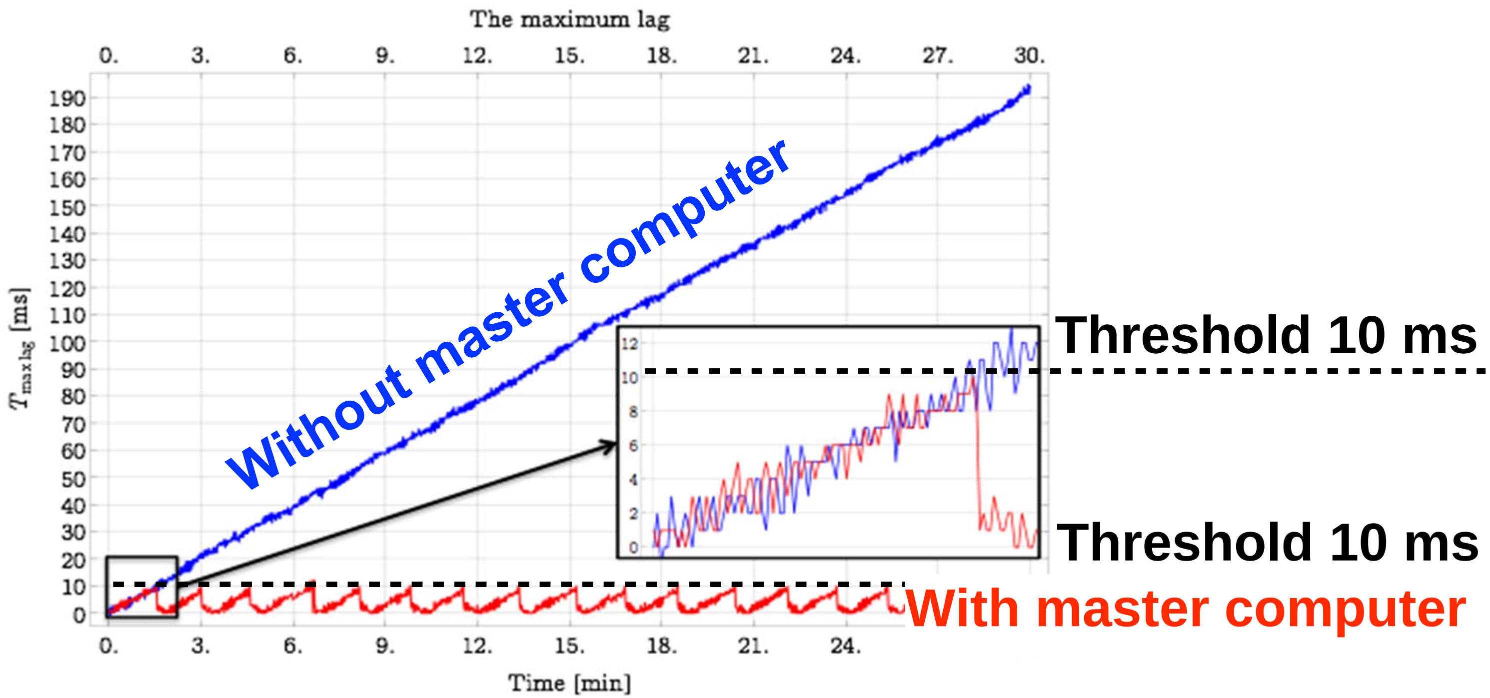
Short-range WindScanner system

WindScanners

WindScanners specs

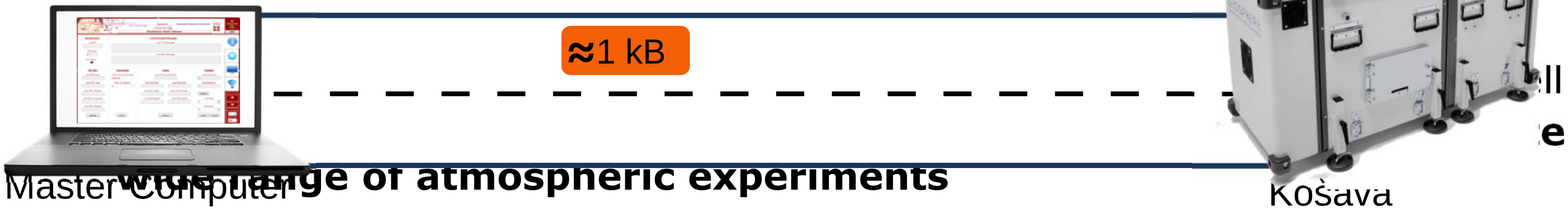
WindScanner	Short-Range	Long-Range
Laser type	Continuous wave	Pulsed
Range	10 - 200 m	25 - 8000 m
Maximum measurement rate	400 Hz	10 Hz
Simultaneous measurements	1	500
Dual axis scanner head	Double prism based	Triple or Dual mirror based
Mechanical rotation	Belt driven	Gear-box driven
Rotation	Endless	Endless
Atmospheric coverage	Cone with a full opening angle of 120°	Hemisphere
Maximum rotational speed	$2880°/s$	$50°/s$
Weight	120 kg	150 kg

Long-range WindScanner system



- WindScanners coordinated by a remote master computer
- Coordination can be achieved using any type of network
- WindScanners are synchronized
- Arbitrary scanning trajectories

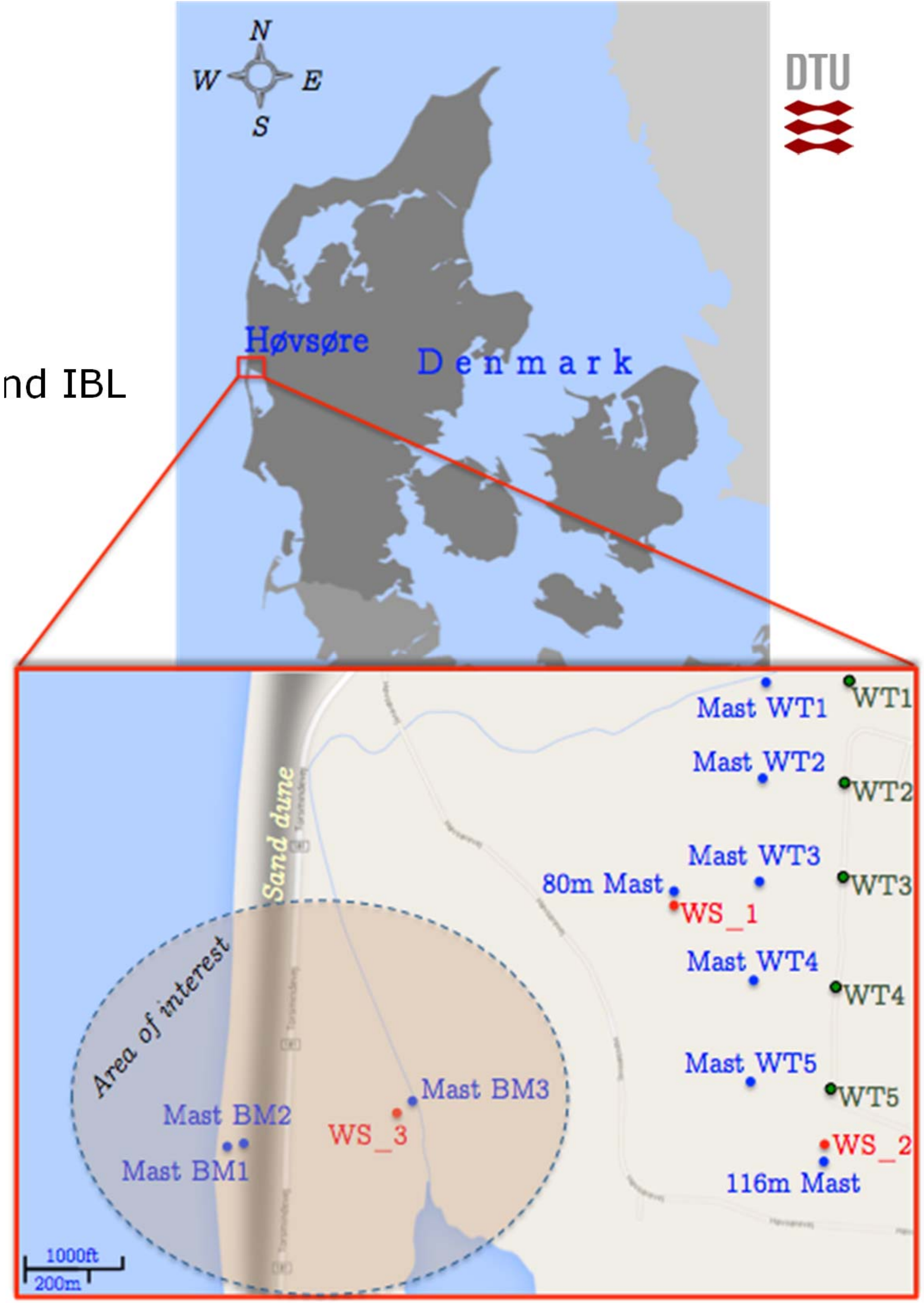
NETWORK



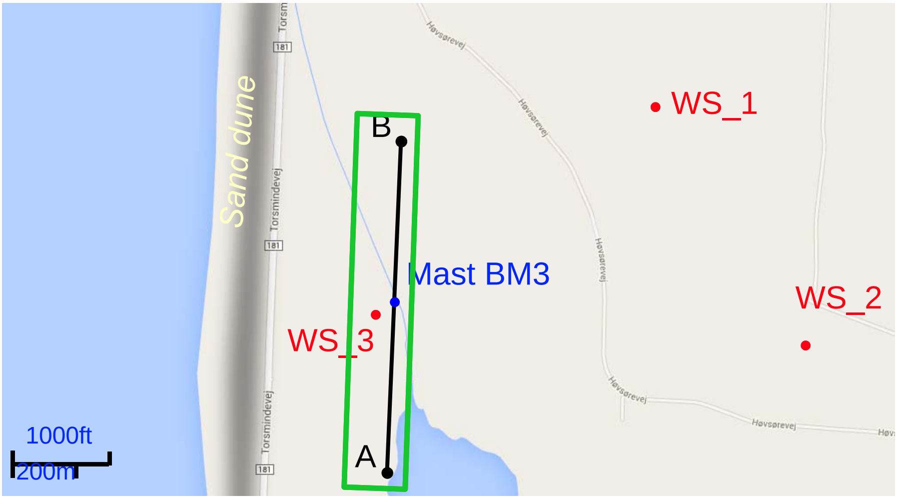
...ge of atmospheric experiments

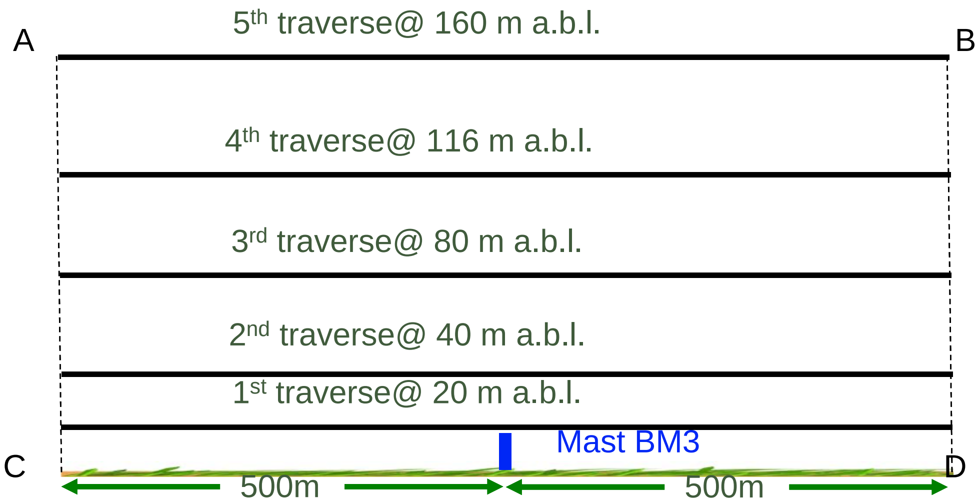
IBL WiSH

- June 2013
- Investigation of changes of sea-land IBL

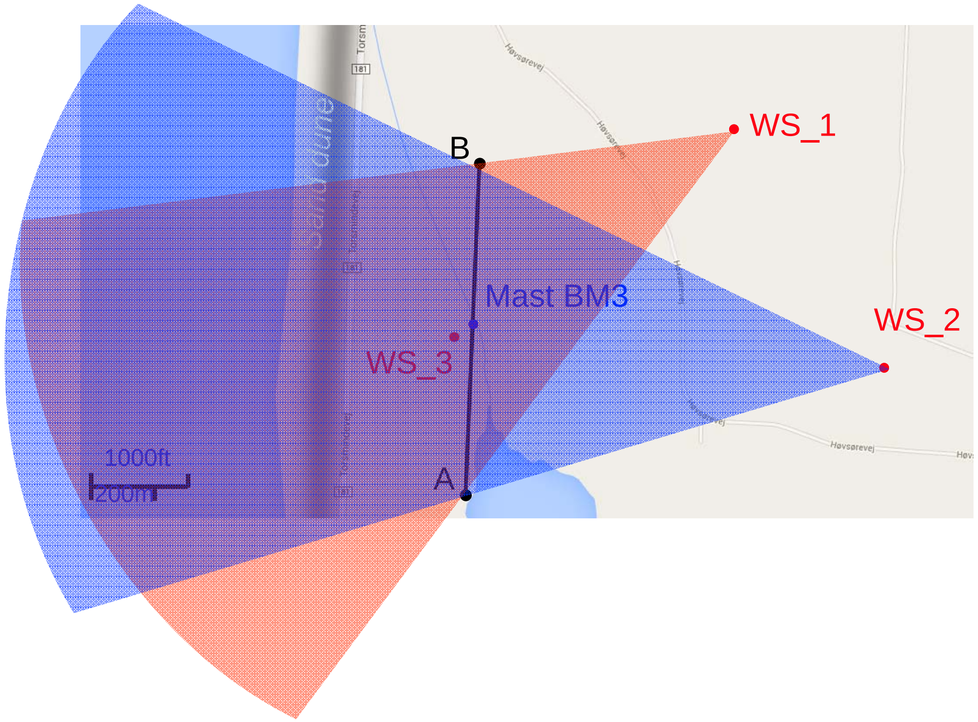


IBL WiSH experiment layout

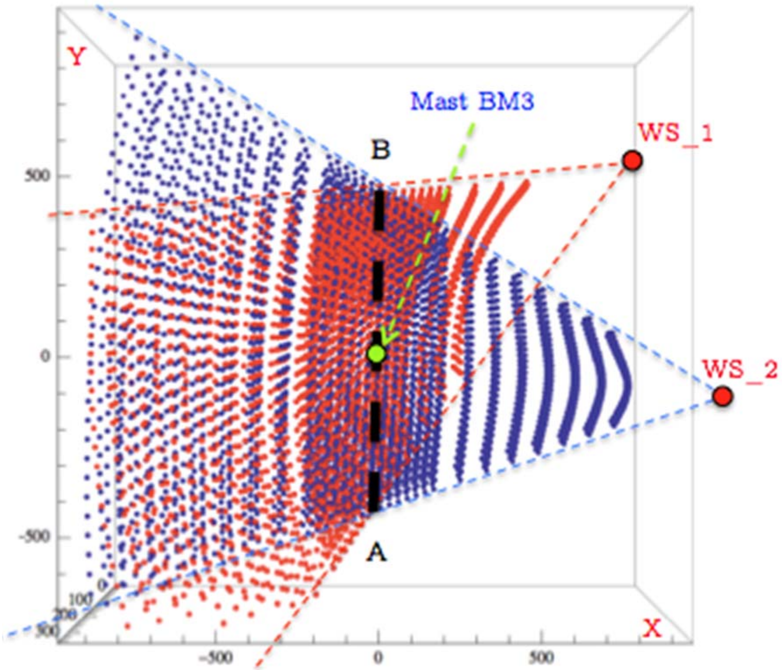


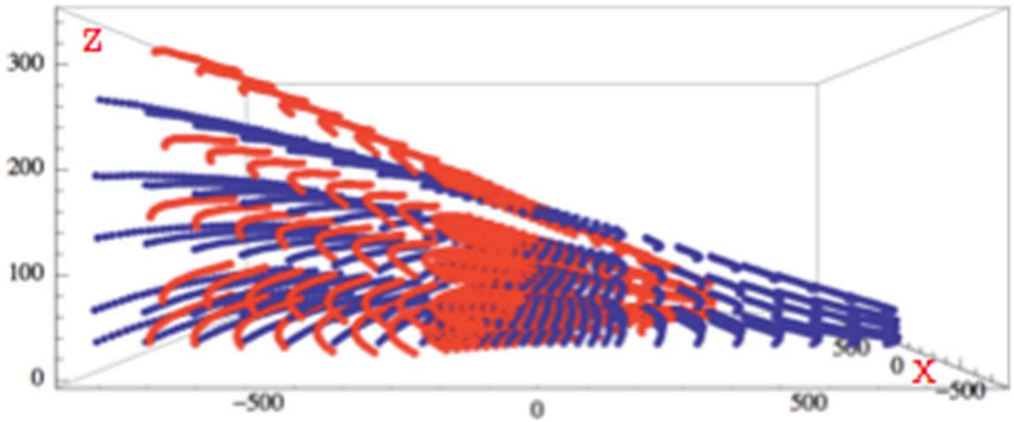


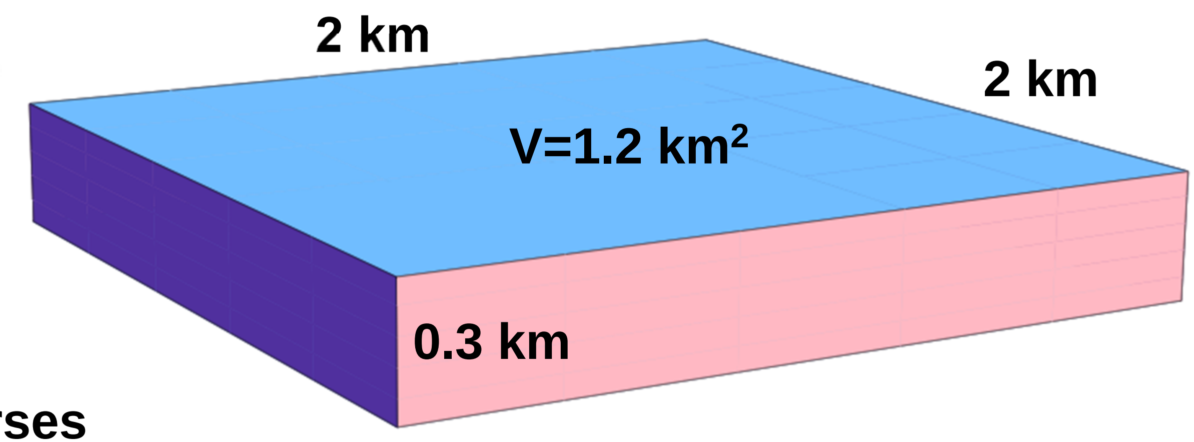
WindScanner 1 / WindScanner 2



WindScanner 1 / WindScanner 2

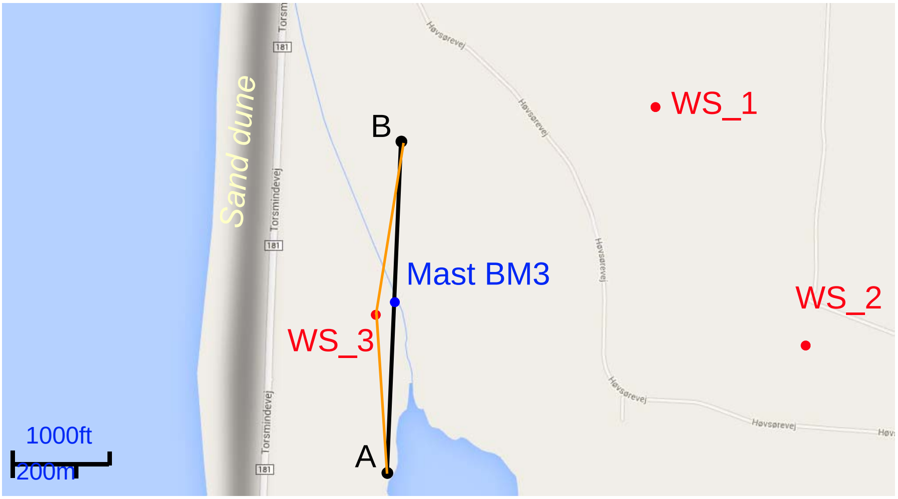


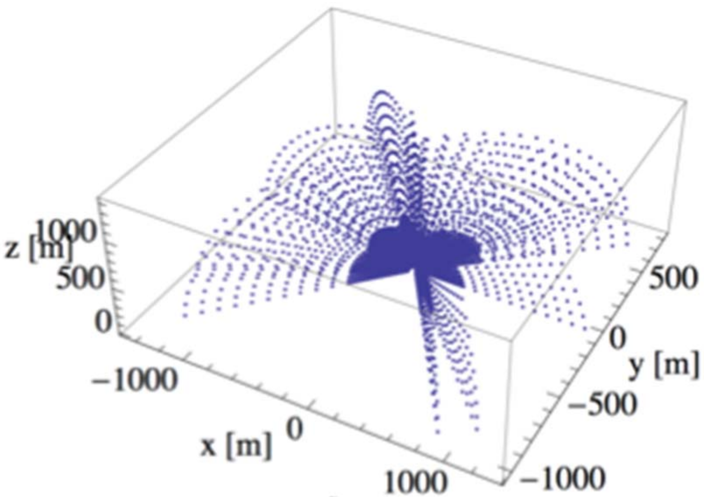


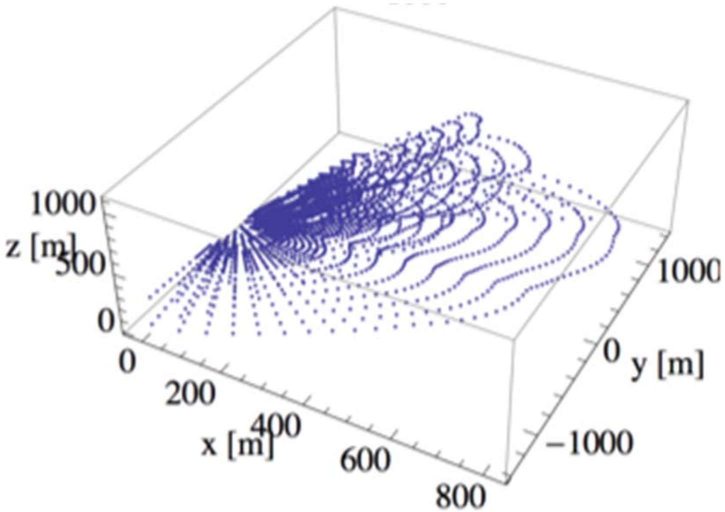


2*3000 radial velocities
60 seconds per volume
Synchronized along 5 traverses

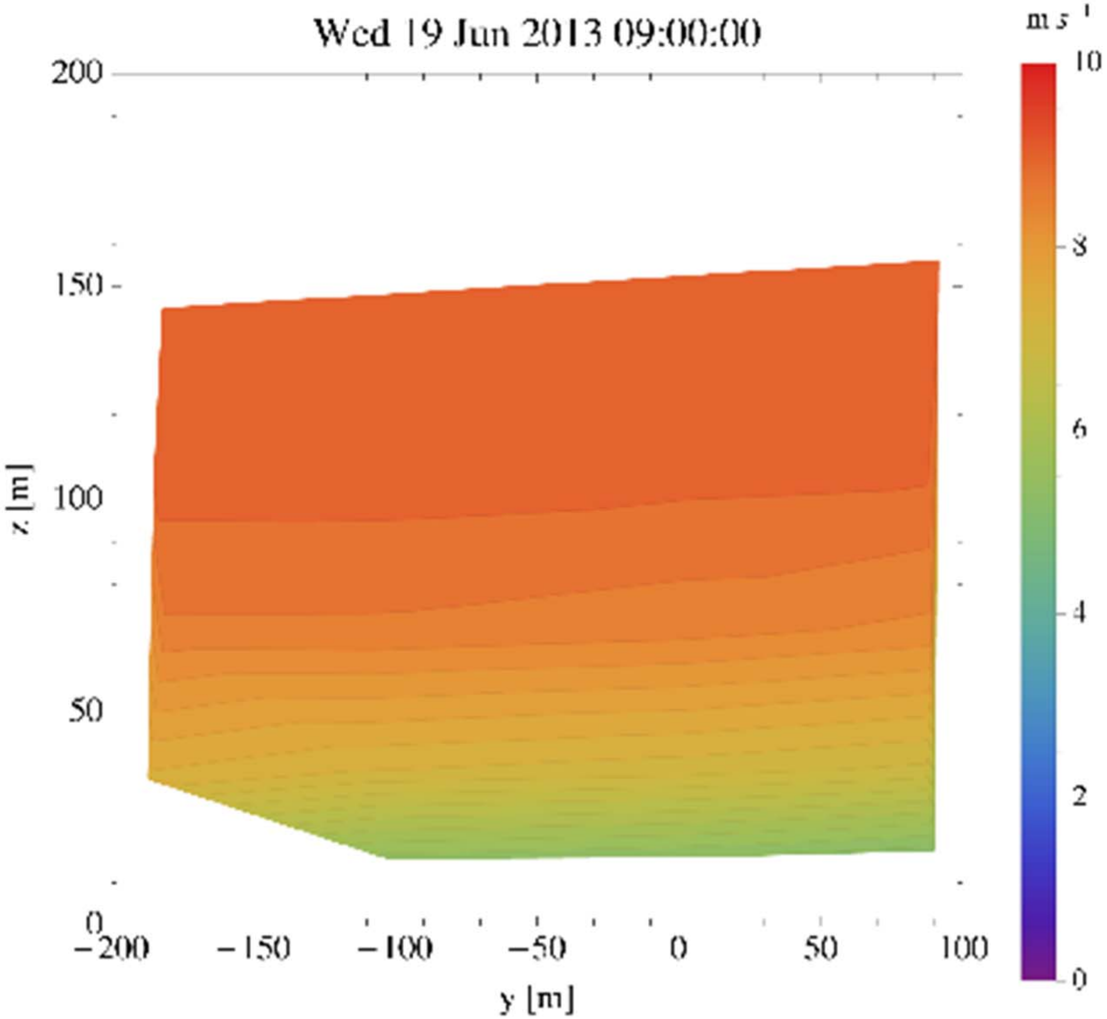
WindScanner 3







Results

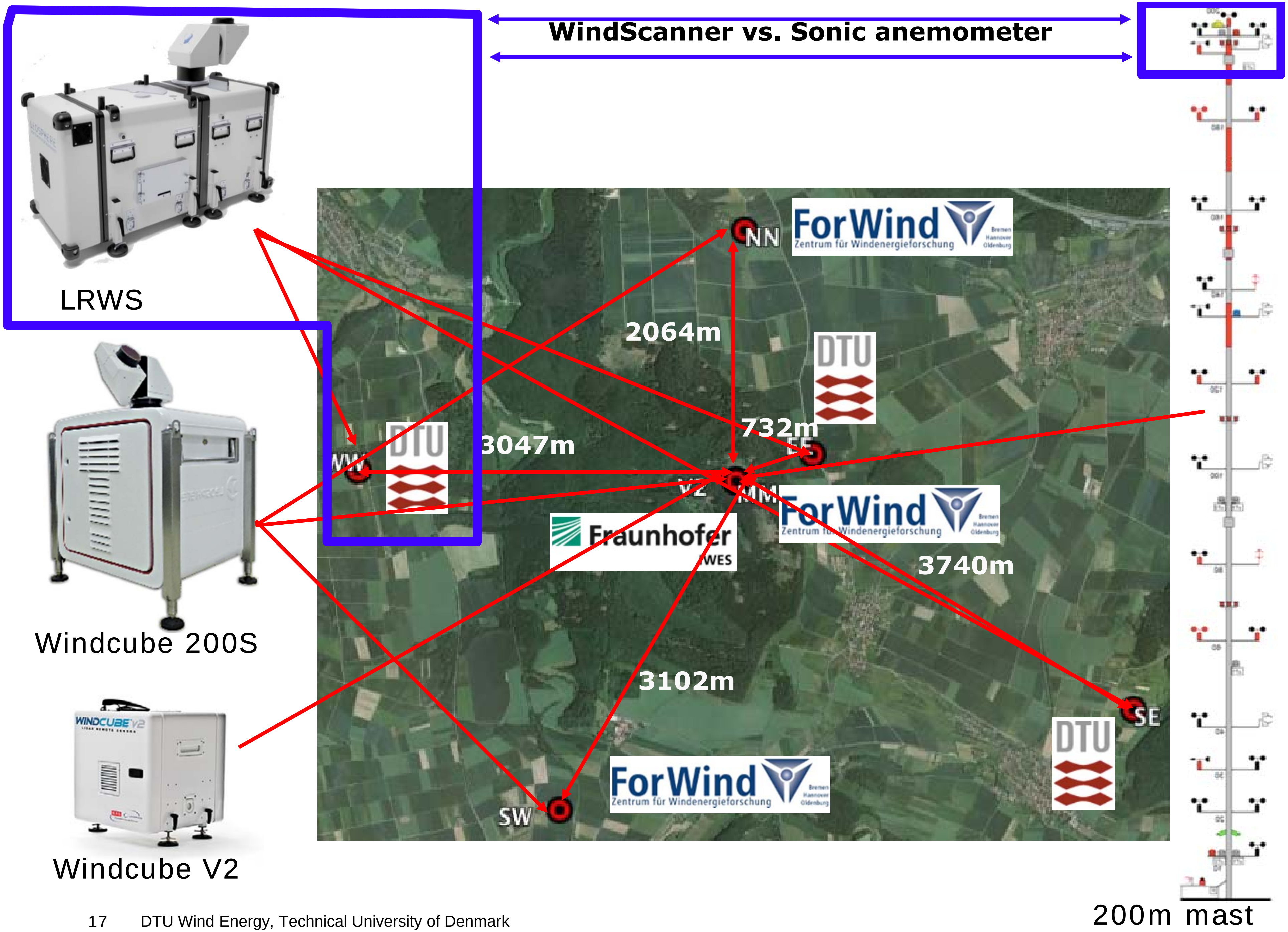


Wed 19 Jun 2013 09:00:00
m s⁻¹
10
8
6
4
2
0
200
150
100
50
0
z [m]
−200
−150
−100
−50
0
50
100
y [m]

Kassel experiment

WindScanner.eu

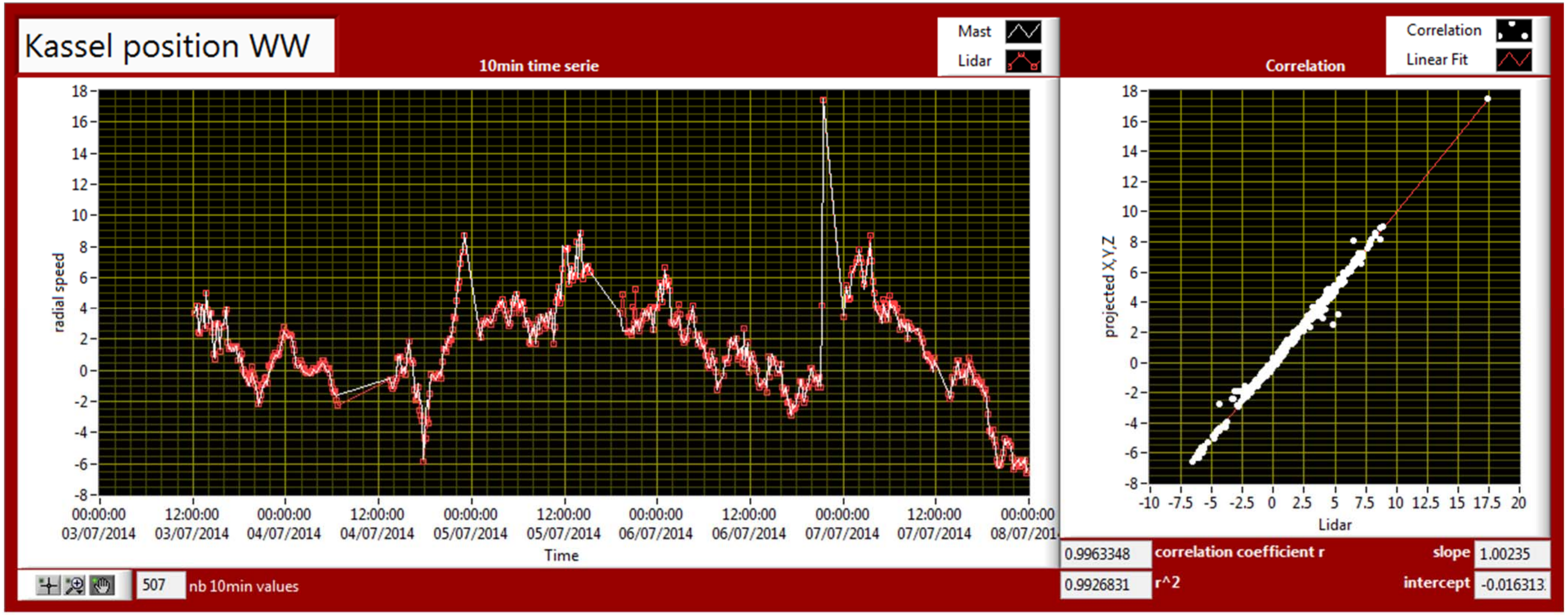
DTU



WindScanner vs. Sonic anemometer
LRWS
Windcube 200S
Windcube V2
200m mast
2064m
3047m
732m
3740m
3102m
NN
WW
EE
V2
MM
SE
SW
ForWind
Zentrum für Windenergieforschung
DTU
Fraunhofer
IWES

Lidar at West position (WW):

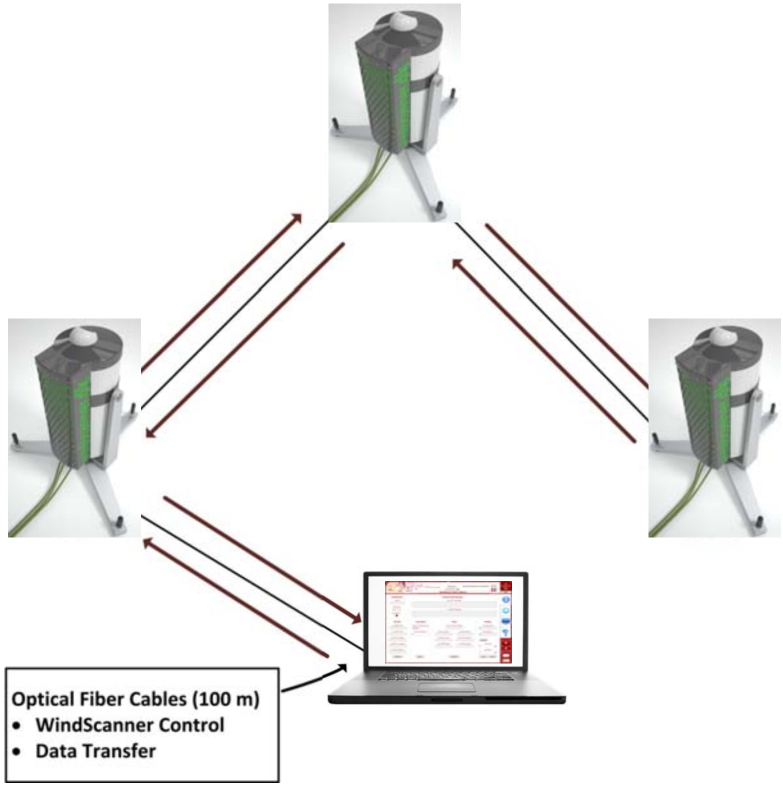
Azimuth: 90,99°
Elevation: 5,69°
Distance: 3102m



Laser beam pointing accuracy

Accuracy of 0.05°azimuth/elevation (1m over 1km)

Short-range WindScanner system



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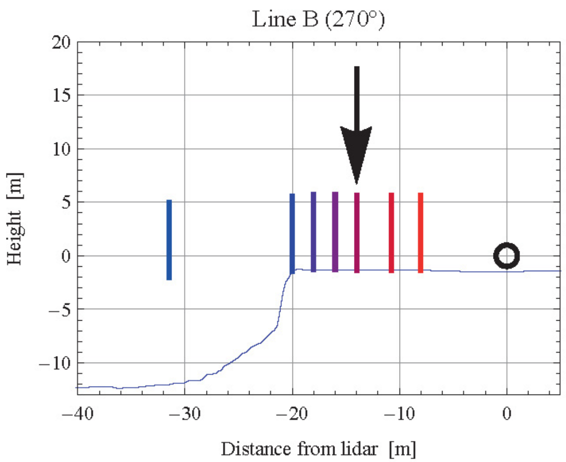
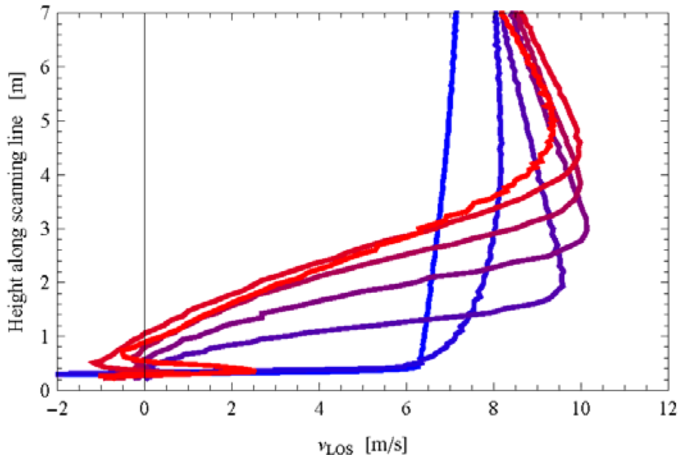
- WindScanners controlled via a near-by master computer
- Control achieved using network based on optical fibre cables
- WindScanners are synchronized
- Arbitrary scanning trajectories
- Appropriate for detail measurements in a small volume of interest

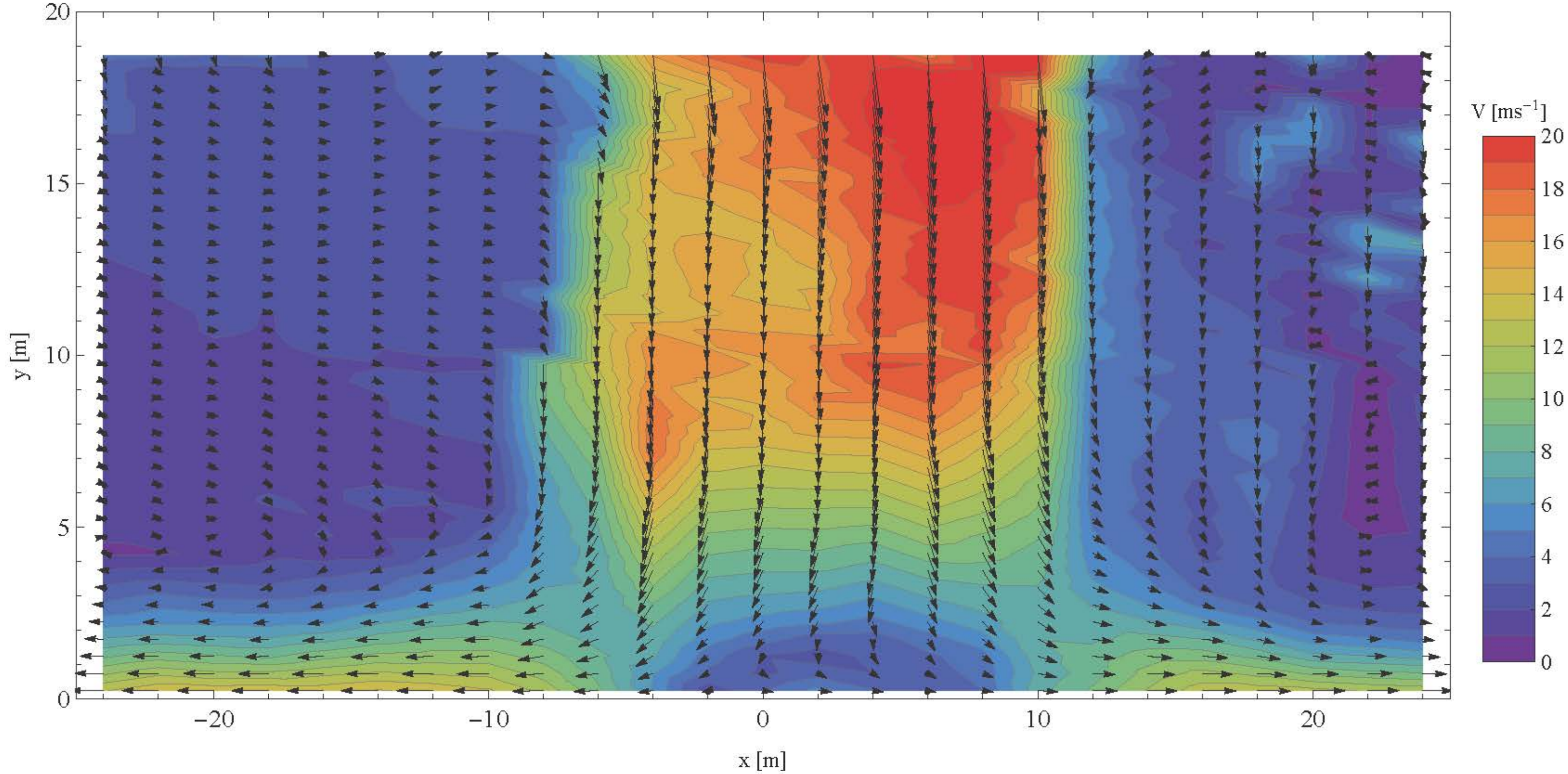
Applications

1. Laser scanning of a recirculation zone on the Bolund escarpment (Mann et. al, 2012)





Helicopter downwash: 2D vertical scan



Summary

- Two WindScanner system have been developed
- Two different lidar technology
- Two different approaches how we are forming the system
- Systems are complementary
- They have a great freedom in deployment
- They are flexible in terms of measurements scenarios
- They can provide synchronous 3D measurements of wind velocity fields

Thank you!

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