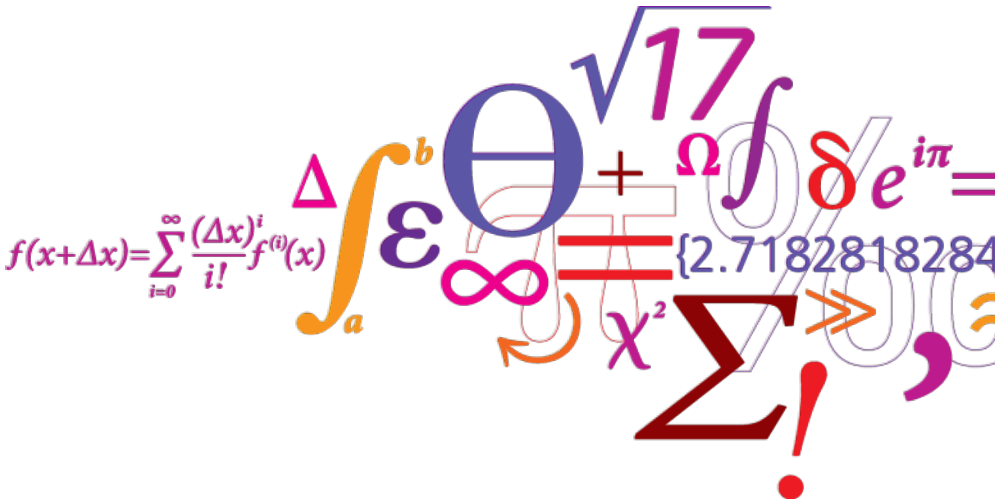
DOI: 10.5281/zenodo.1442592

(2.5 + 5.8) Years of successes and failures with long-range WindScanner system

Nikola Vasiljević

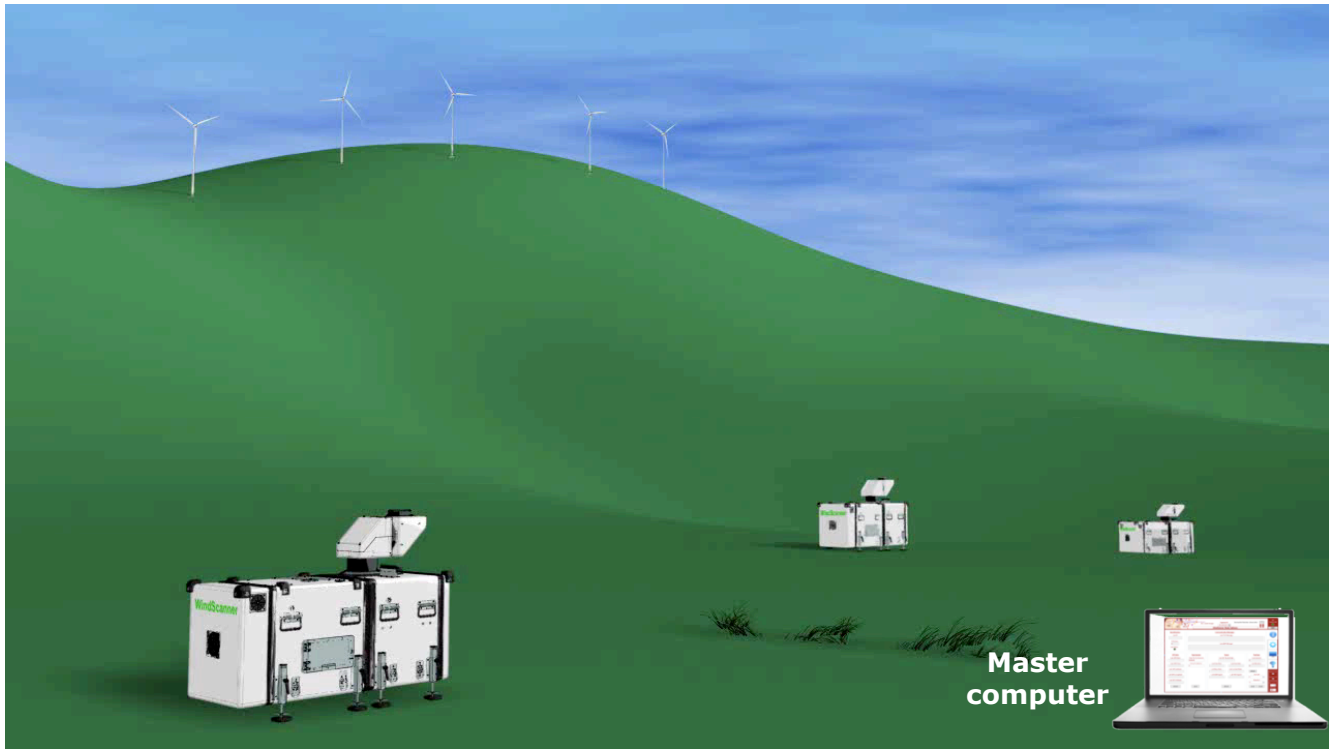
RECAST Workshop
Risø, Denmark
October 2nd 2018



DTU Wind Energy
Department of Wind Energy

Long-range WindScanner (LRWS) system

https://doi.org/10.3390/rs8110896



Coordinated by a remote master computer using any type of network (3G, WiFi,…)

WindScanners are synchronized in time and space
Any scanning trajectory within mechanical limits

Mean wind flow over an entire wind farm

History: Core development

06/2010 Development of LRWS initiated

12/2010 RSComPro developed

02/2011 First WindScanner assembled

03/2011 First trial outside lab failed

05/2011 Syncing motion, emission & acquisition

06/2011 WindScanner Client Software (WCS) Prototype

07/2011 First scanner head failed

04/2012 Prototype Master Computer Software

05/2012 Simple trajectory generator

06/2012 Second WindScanner assembled

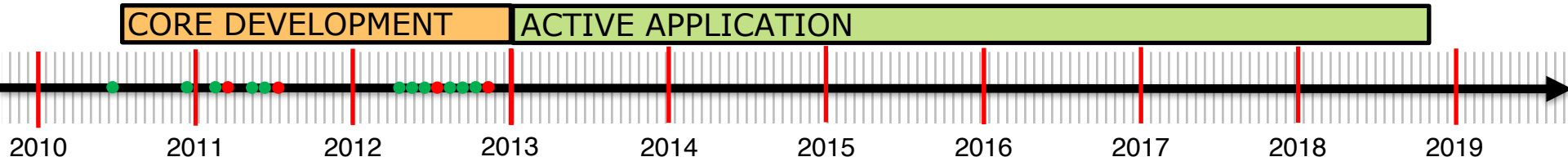
07/2012 First sync test failed

08/2012 WindScanner team became team of two people

09/2012 Third WindScanner assembled

10/2012 First trial of WindScanner concept outside of lab

11/2012 Failure of the trial - two laser pumps destroyed



History: Active application

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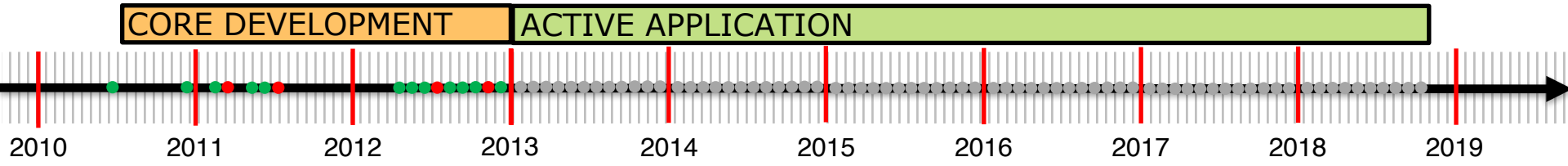
04/2017 Beacon calibration
10/2017 Lascar
03/2018 Alex
08/2018 Multi-rotor wake

Some facts:
21 campaigns in 6 countries
- Denmark (14)
- Norway (1)
- Germany (2)
- Spain (1)
- Portugal (2)
- UK (1)



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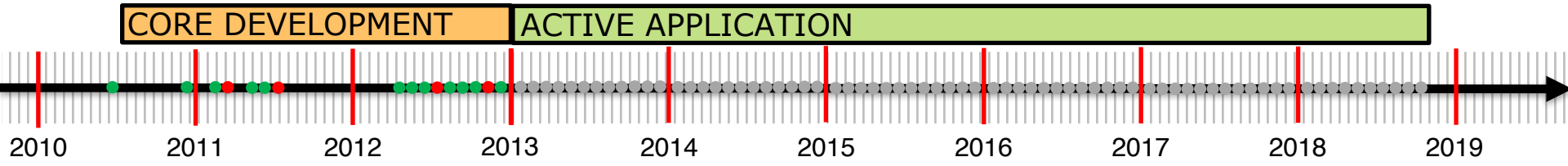
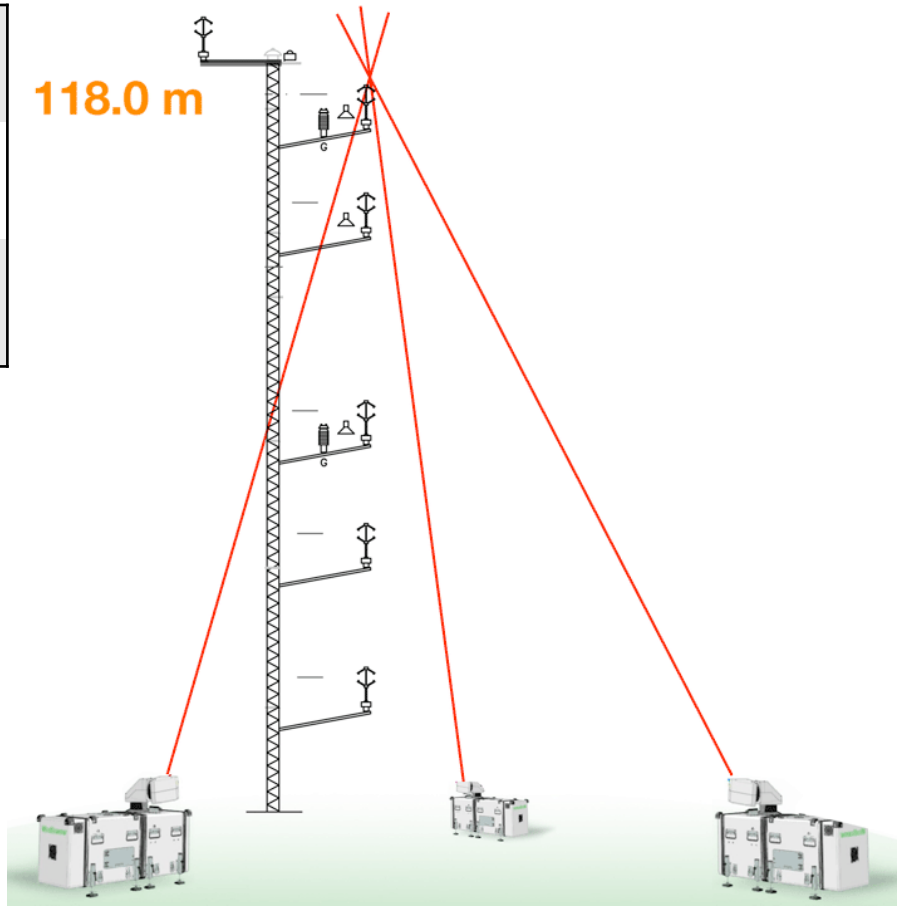


Swinging musketeer

Date	***February 2013***
Location	***Risø, Denmark***
Aim	***Test Multi-Lidar concept*** ***Validate measurements***



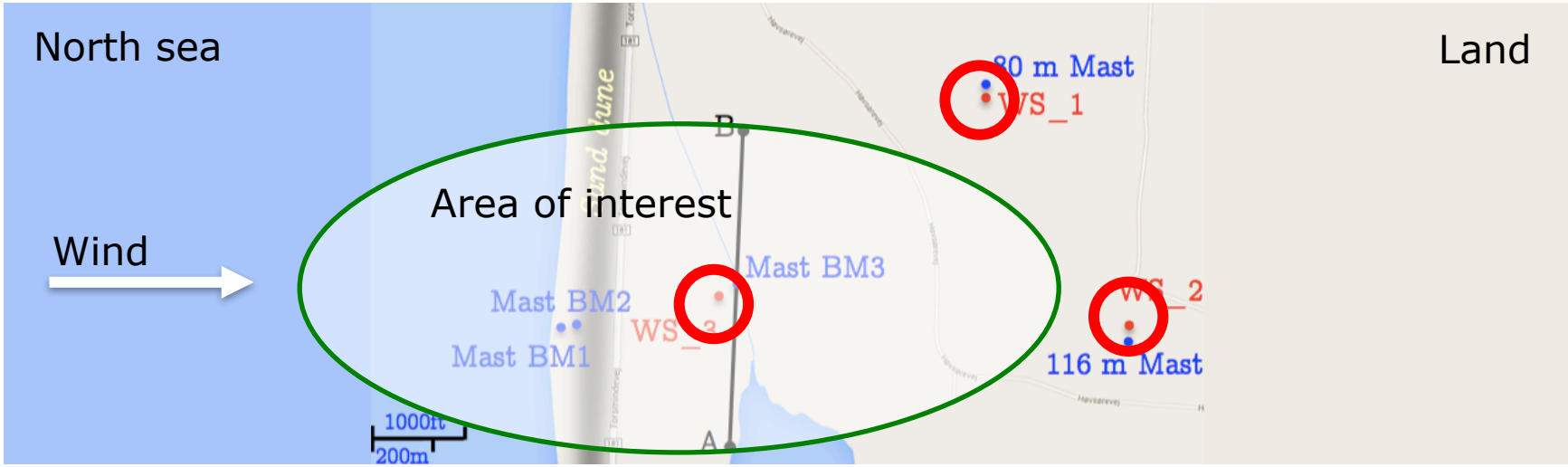
What went wrong

- Collected only 6 hours of good data (one WindScanner had hardware malfunction)

IBL WiSH

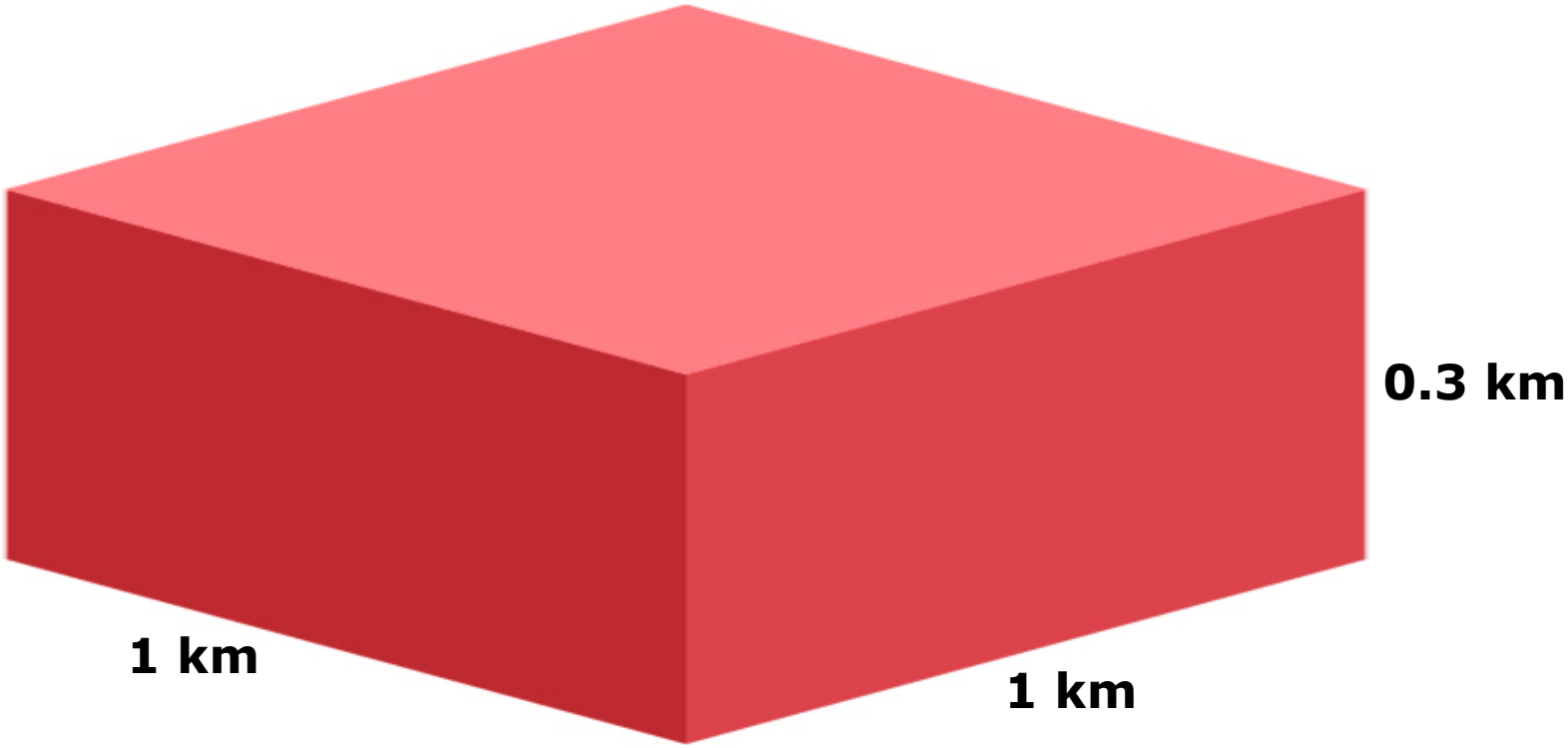
Date	***June-July 2013 (several weeks)***
Location	***Høvsøre, Denmark***
Aim	***Investigation of the sea-land Internal Boundary Layer development***

https://doi.org/10.1175/JTECH-D-14-00123.1



WindScanner

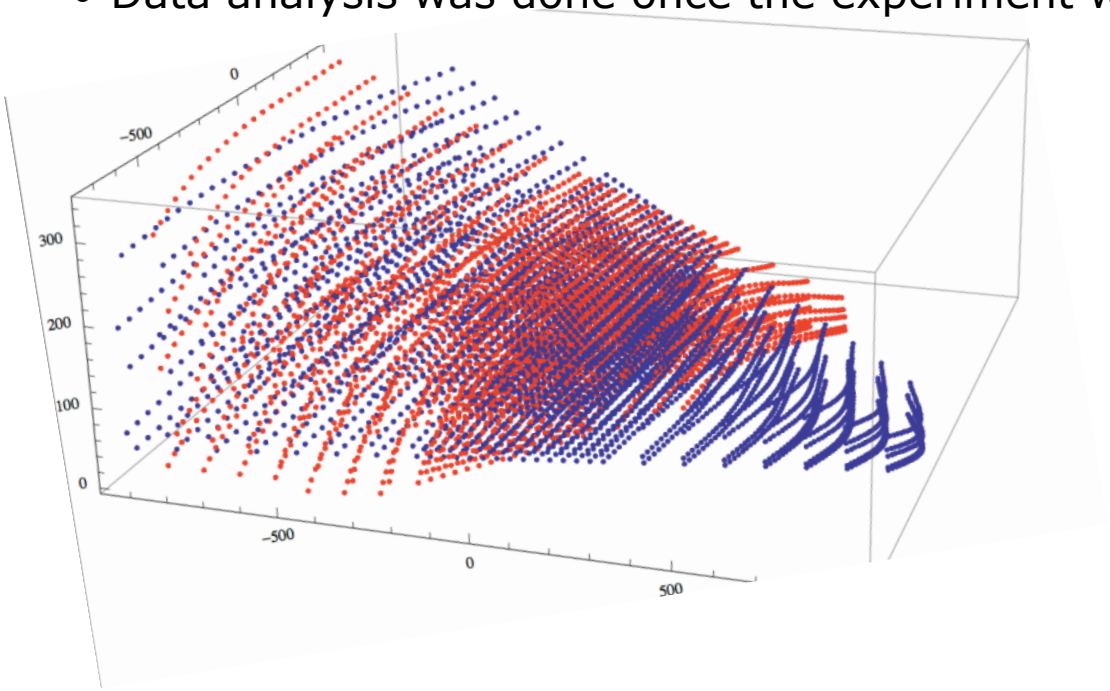
Scanning strategies

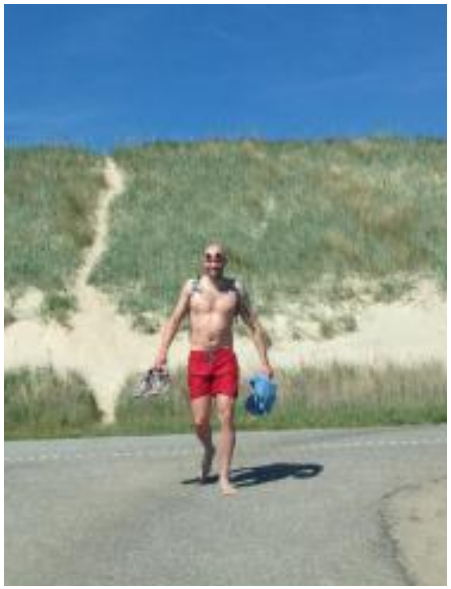


1 iteration of scan took 1 minute

What went wrong

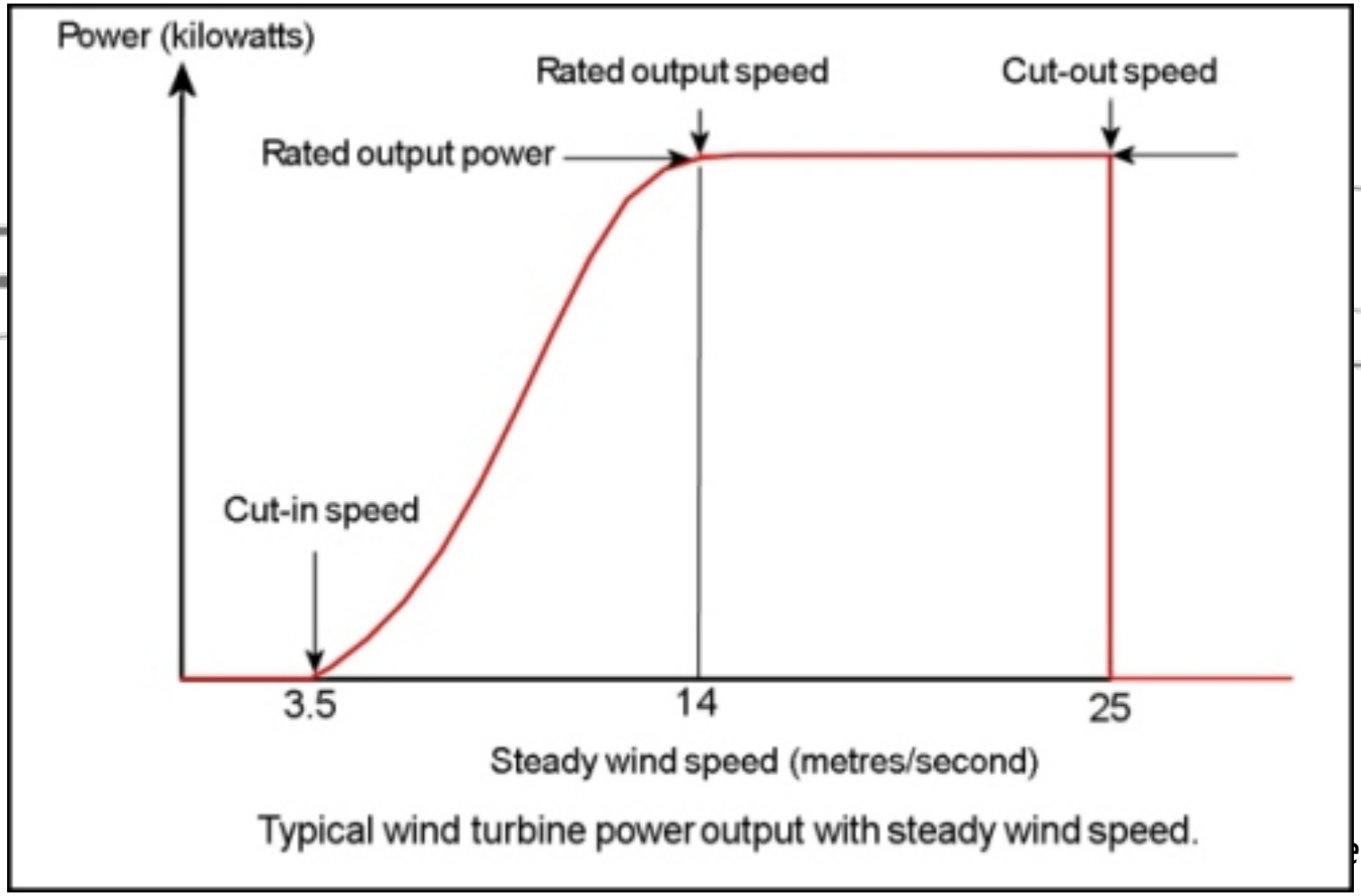
- Insufficient number of samples per averaging period
- We changed several times scanning strategies
- Complex scanning strategy = Complex data analysis
- Data analysis was done once the experiment was over





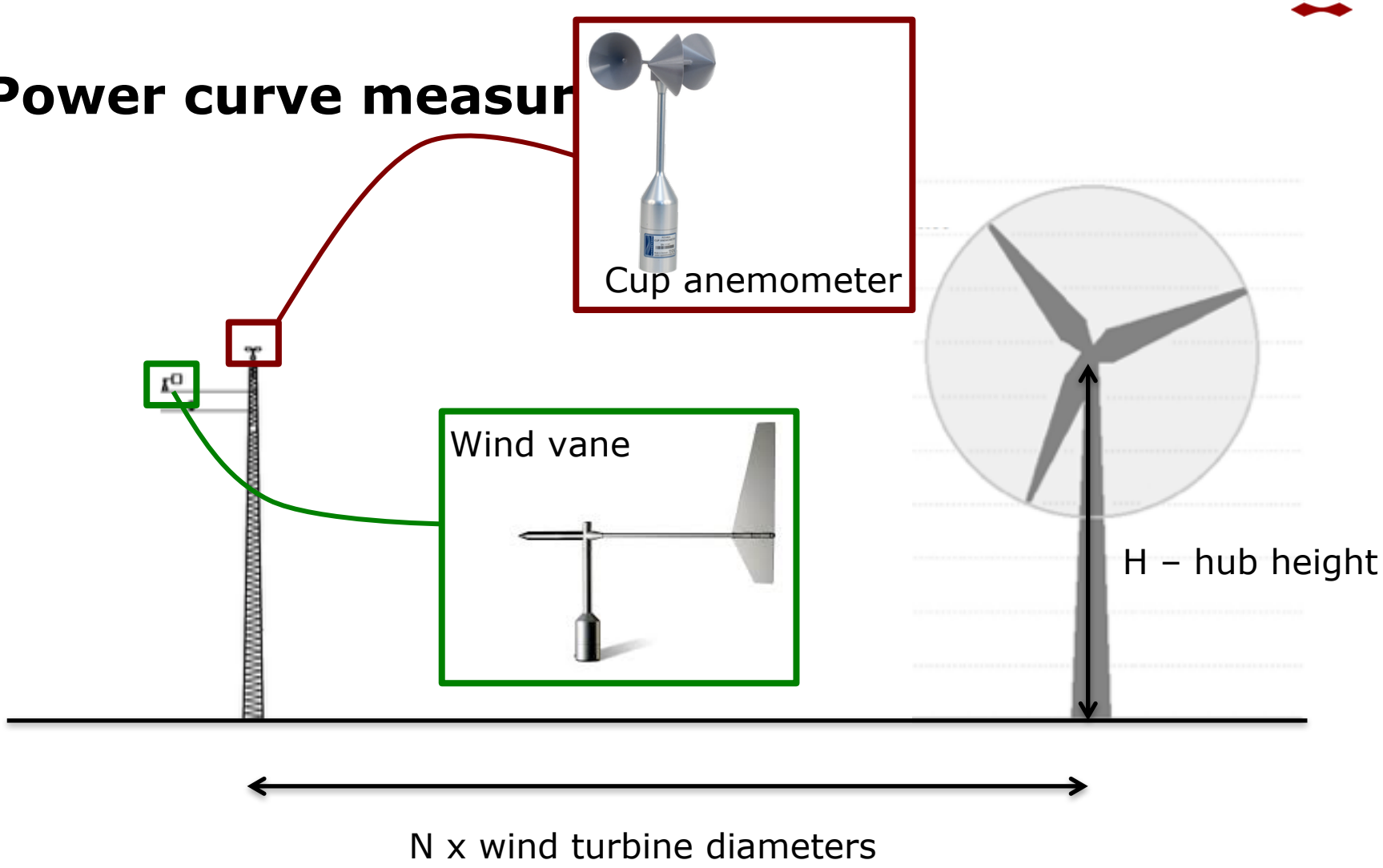
Jacob Berg abandon **WindScanners** and moved to **LES**

Wind turbine power curve

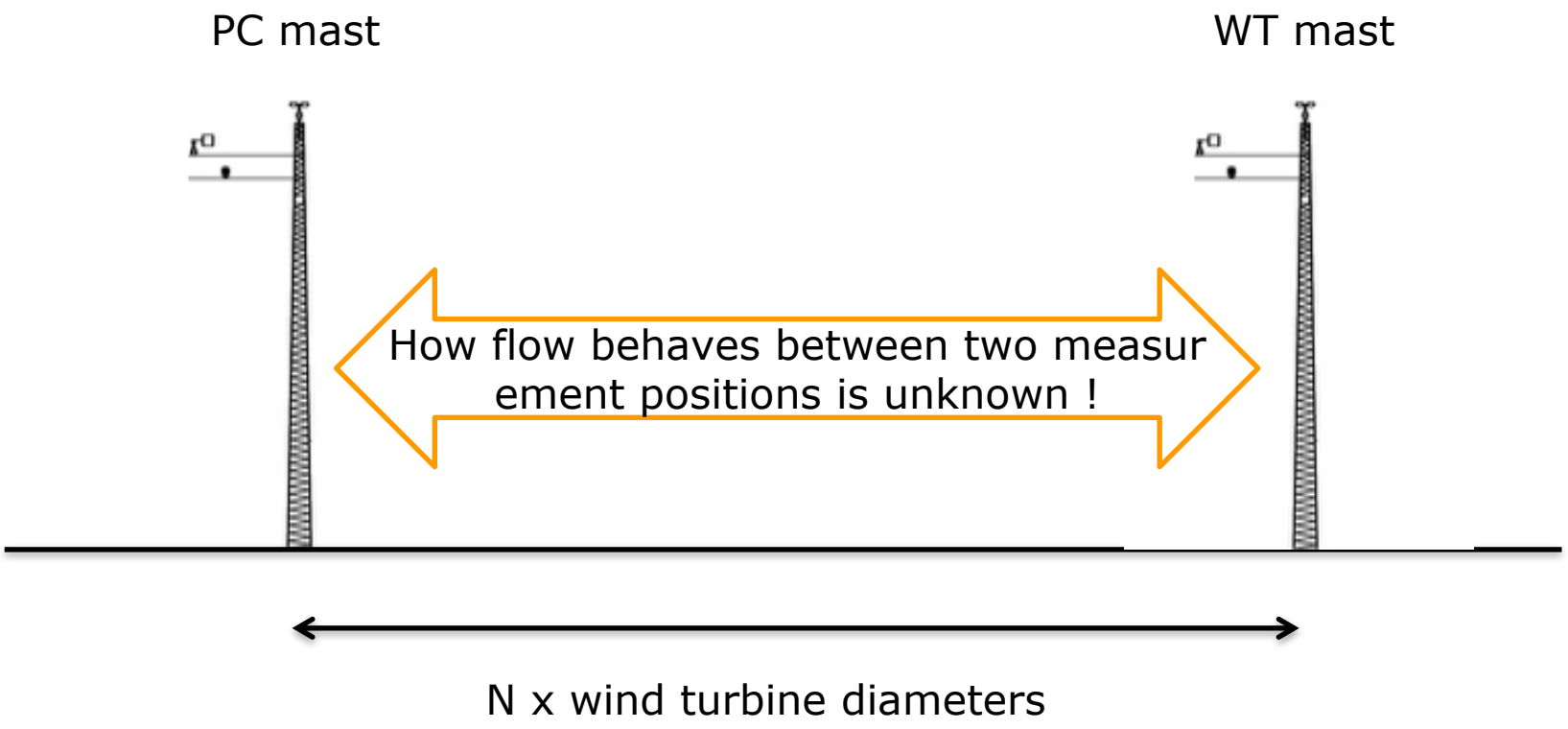


Typical wind turbine power output with steady wind speed.

Power curve measur

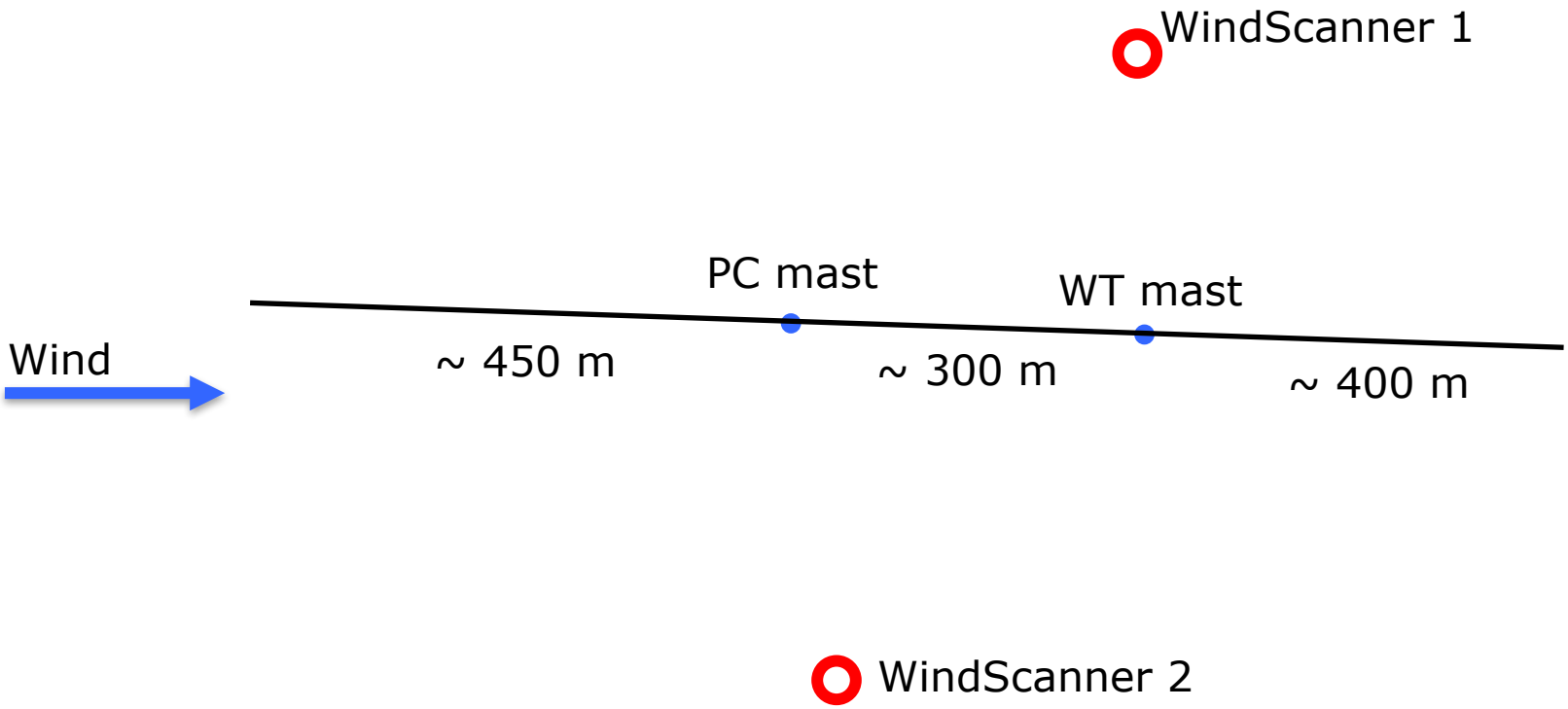


Site calibration



Site calibration

Date	***November 2013 – January 2014***
Location	***Høvsøre, Denmark***
Aim	***Spatial characterization of the wind field***



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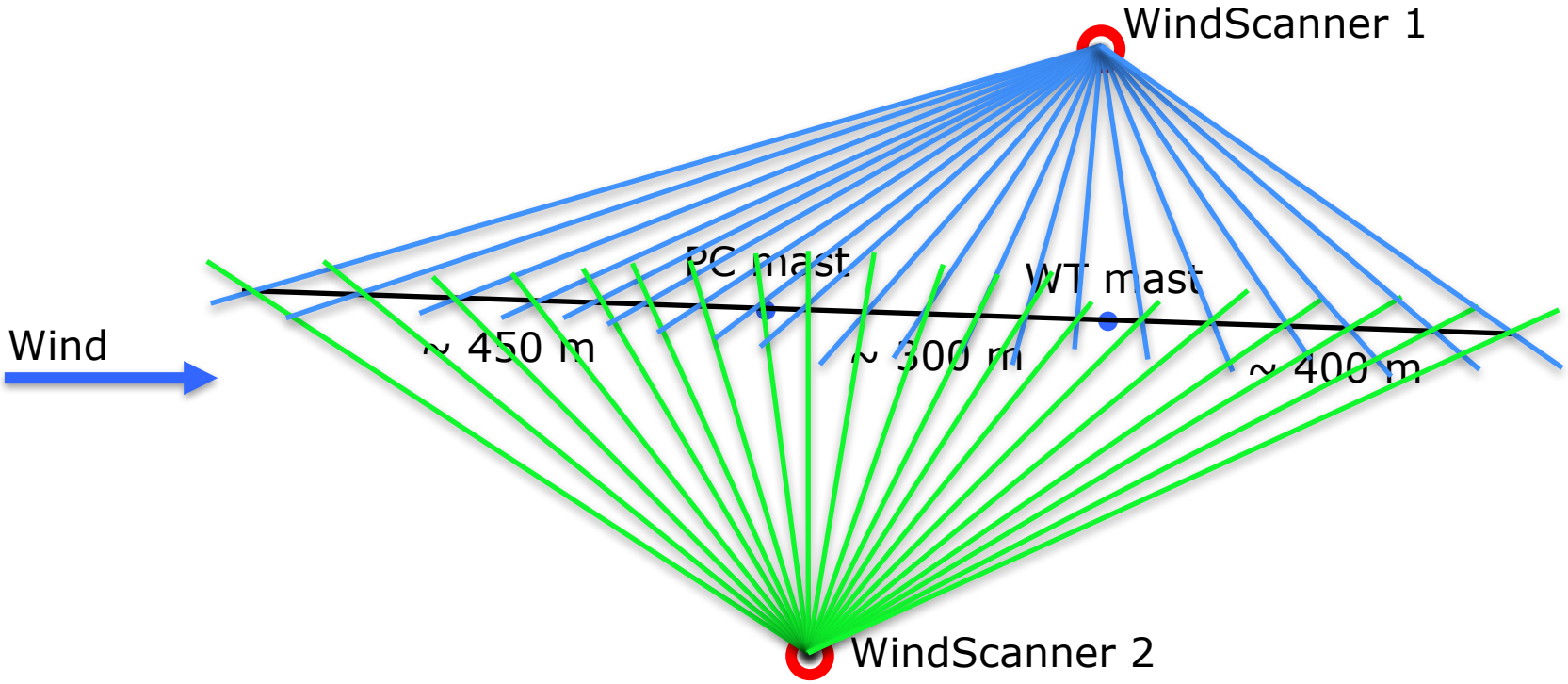
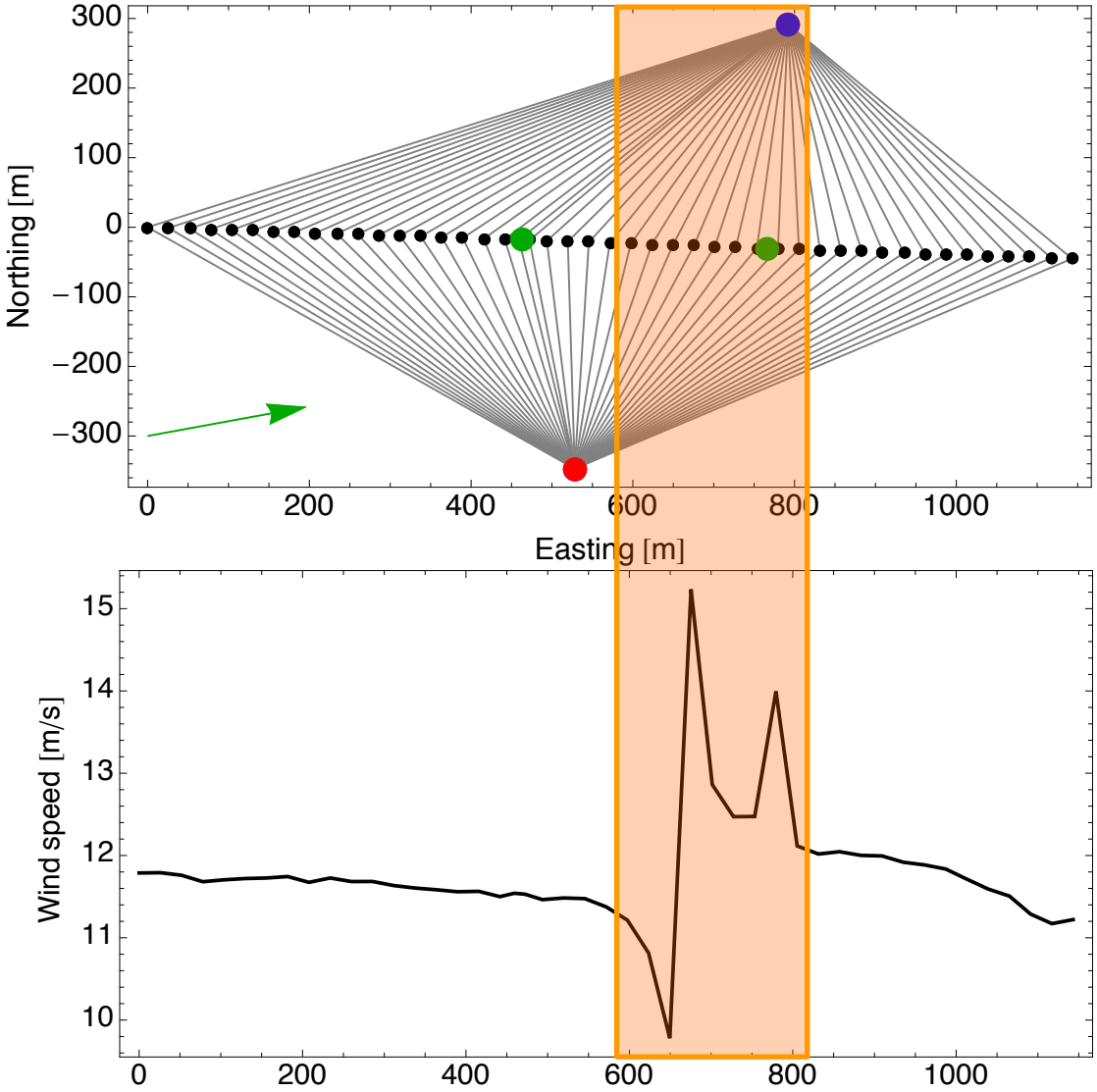
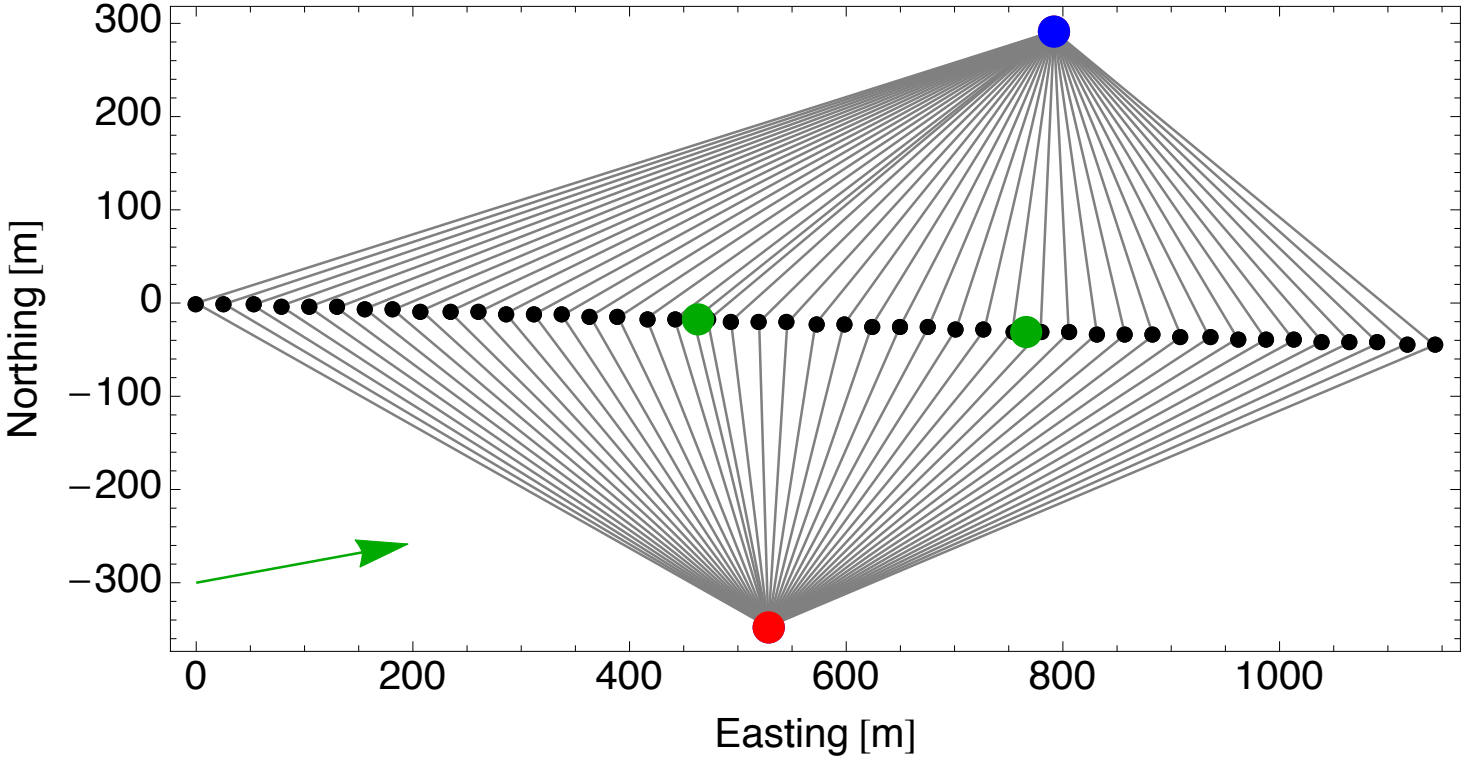


What went wrong



What went wrong

- Beams parallel to each other between two mast locations
- Erroneous reconstruction of horizontal wind speed and wind direction



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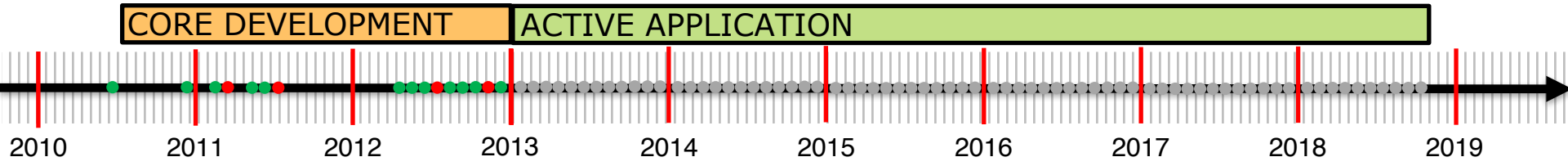
☺
Impressive pointing accuracy
Multi-lidar vs Mast fantastic comparison
Moved the whole lab from DK to DE
Running campaign via mobile network

☹
Low clouds = data availability
Low mobile coverage for some spots
Hitting hard targets (mast guidewires)

https://doi.org/10.3390/rs8090782



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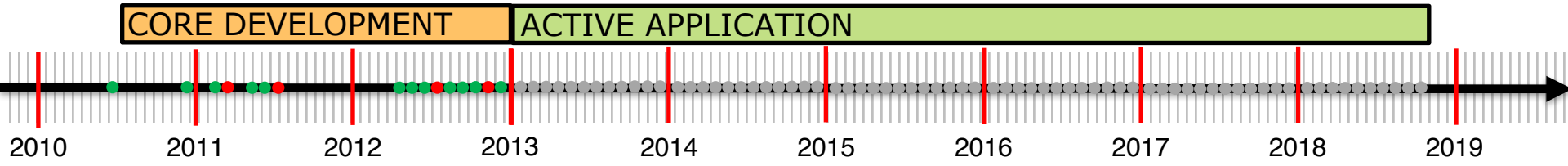
☺
First hard-core installation
Running WindScanners using generators
Scanned wind resources along a ridge

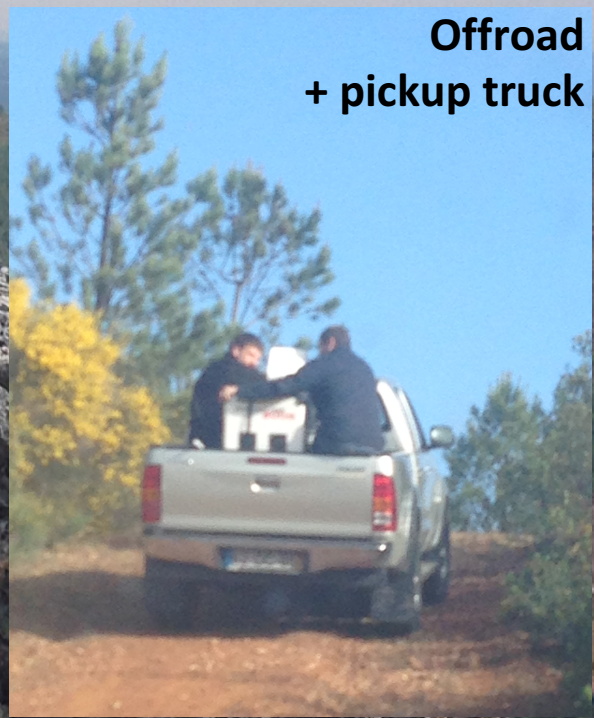
☹
Air too clean = data availability ?
Too hot = WindScanners needed siesta

https://doi.org/10.5194/amt-10-3463-2017



Installation of NW WindScanner

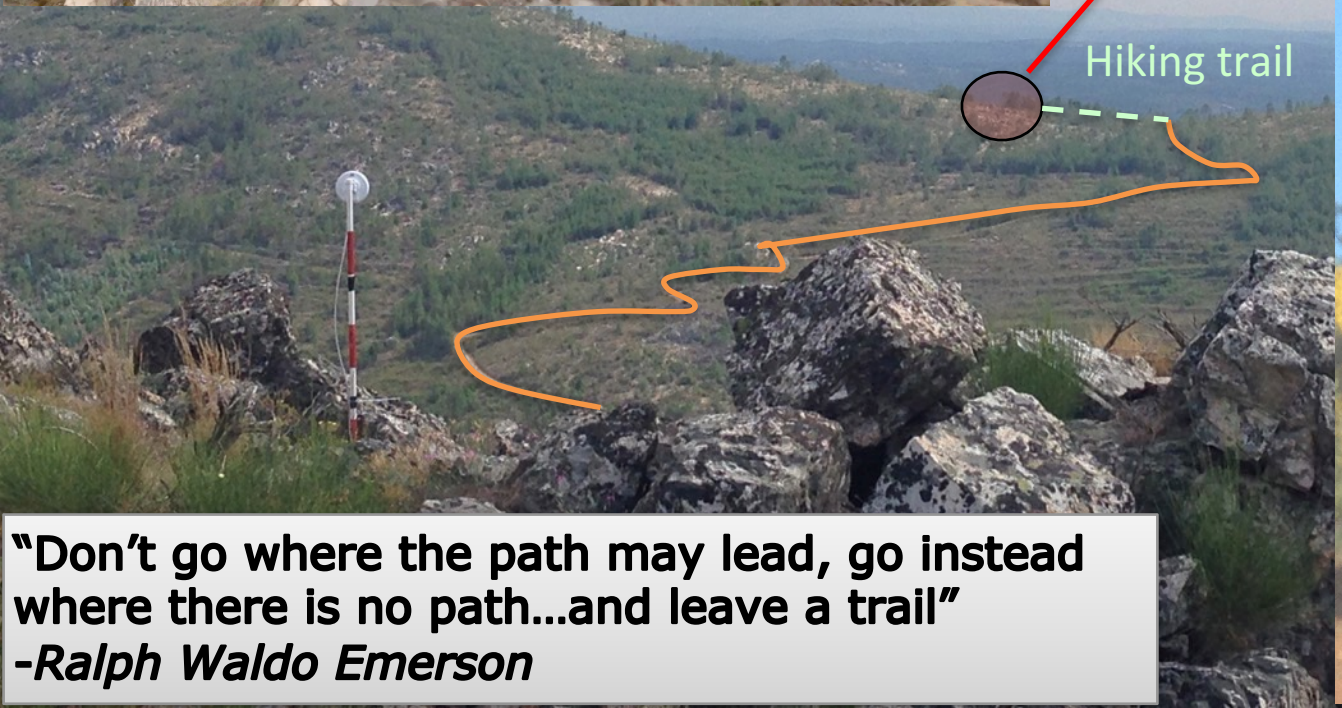
Hiking trail

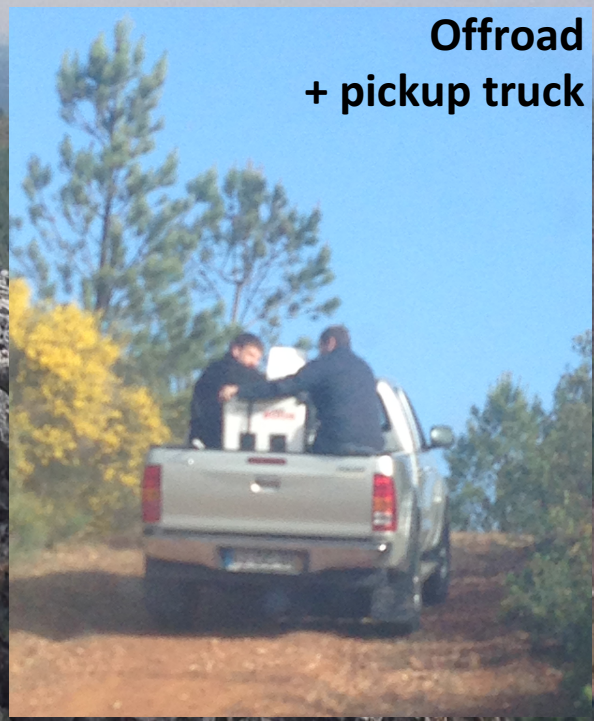


Offroad
+ pickup truck

VILA VELHA DE RODÃO

Installation of NW WindScanner





"Don't go where the path may lead, go instead where there is no path...and leave a trail"
-Ralph Waldo Emerson

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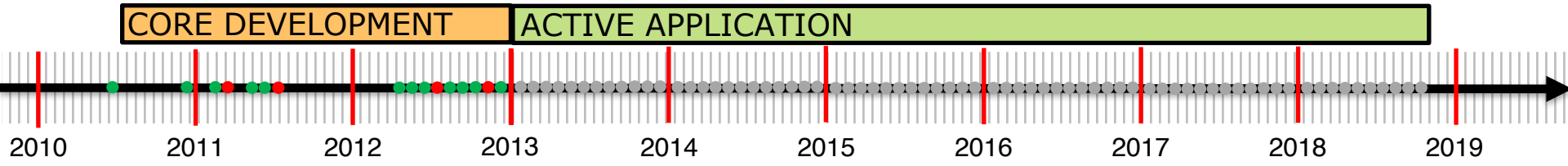
☺
Flow measurements in the coastal zone

☹
Too much particles (limited range)
Often needed cleaning of glass window
Too humid (desiccants 'roasted' often)

https://doi.org/10.3390/rs8110884



Beware!!!
We worked and
we are still working with prototype units!

RUNE campaign

More info: https://www.linkedin.com/pulse/seasons-greetings-nikola-vasiljevic/

Dissemination & Outreach

Who else is using WindScanner solutions

since 2012

ForWind
Zentrum für Windenergieforschung

3 x WLS200S

since 2016

Fraunhofer IEE

3 x WLS200S

since 2017

DLR

3 x WLS200S

since 2017

KJELLER VINDTEKNIKK

4 x WLS400S

since 2018

cmr
Christian Michelsen Research

3 x WLS100S

since 2018

KIT
Karlsruher Institut für Technologie

2 x WLS200S

What we learned

- Chose an adequate site
- Simple is sexy
- Look at data from day one
- If you need two lidars for experiments, then you actually need three lidars
- Don’t do an experiment for the experiment sake
- Develop and use methodology for multi-lidar experiments: https://doi.org/10.5194/amt-10-3463-2017
- Make a simple uncertainty model use it to guide your lidar placement: https://doi.org/10.5281/zenodo.1441178
- **Scanning lidars / multi-lidars are complex to handle:** https://doi.org/10.5281/zenodo.1175211

https://doi.org/10.5281/zenodo.1146326

New methods of measurements: where are we today, and where are we heading towards

Nikola Vasiljević

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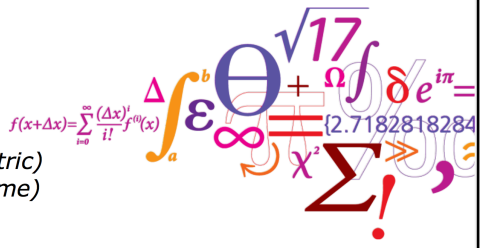
Peter Clive (Wood Group)
Mike Hardesty (NOAA)
Mike Harris (Zephir)
Shumpei Kameyama (Mitsubishi Electric)
Raghu Krishnamurthy (UNI Notre Dame)
David Schlipf (UNI Stuttgart)
Elliot Simon (DTU)
Rozenn Wagner (DTU)



DTU Wind Energy
Department of Wind Energy

"There is a need to make the technology "dummy proof" for a larger audience, but also quite "open" for power users." – Lidar expert group

https://doi.org/10.3390/rs10030406

remote sensing

MDPI

Project Report

IEA Wind Task 32: Wind Lidar Identifying and Mitigating Barriers to the Adoption of Wind Lidar

Andrew Clifton [1,*], Peter Clive [2], Julia Gottschall [3], David Schlipf [4], Eric Simley [5], Luke Simmons [6], Detlef Stein [7], Davide Trabucchi [8], Nikola Vasiljevic [9] and Ines Würth [10]

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5 Envision Energy USA Ltd., 1201 Louisiana St. Suite 500, Houston, TX 77002, USA; eric.simley@envision-energy.com
6 DNV GL—Measurements, 1501 9th Avenue, Suite 900, Seattle, WA 98001, USA; Luke.Simmons@dnvgl.com
7 Multiversum GmbH, Shanghaiallee 9, 20457 Hamburg, Germany; d.stein@multiversum.consulting
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10 Stuttgart Wind Energy, University of Stuttgart, Allmandring 5b, 70569 Stuttgart, Germany; wuerth@ifb.uni-stuttgart.de
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Received: 24 January 2018; Accepted: 23 February 2018; Published: 6 March 2018

Abstract: IEA Wind Task 32 exists to identify and mitigate barriers to the adoption of lidar for wind energy applications. It leverages ongoing international research and development activities in academia and industry to investigate site assessment, power performance testing, controls and loads, and complex flows. Since its initiation in 2011, Task 32 has been responsible for several recommended practices and expert reports that have contributed to the adoption of ground-based, nacelle-based, and floating lidar by the wind industry. Future challenges include the development of lidar uncertainty models, best practices for data management, and developing community-based tools for data analysis, planning of lidar measurements and lidar configuration. This paper describes the barriers that Task 32 identified to the deployment of wind lidar in each of these application areas, and the steps that have been taken to confirm or mitigate the barriers. Task 32 will continue to be a meeting point for the international wind lidar community until at least 2020 and welcomes old and new participants.

Keywords: wind energy; resource assessment; power performance testing; wind turbine controls; complex flow; Doppler lidar

1. Introduction

Wind lidar can measure the line of sight (LOS) wind speed at distances from a few centimeters to several kilometers. Depending on their deployment, the LOS speed is obtained by means of lidar systems firmly sitting on the ground, floating in the water or orbiting around the Earth. The first commercial wind lidar systems targeted at wind energy applications appeared in the early 2000s [1].

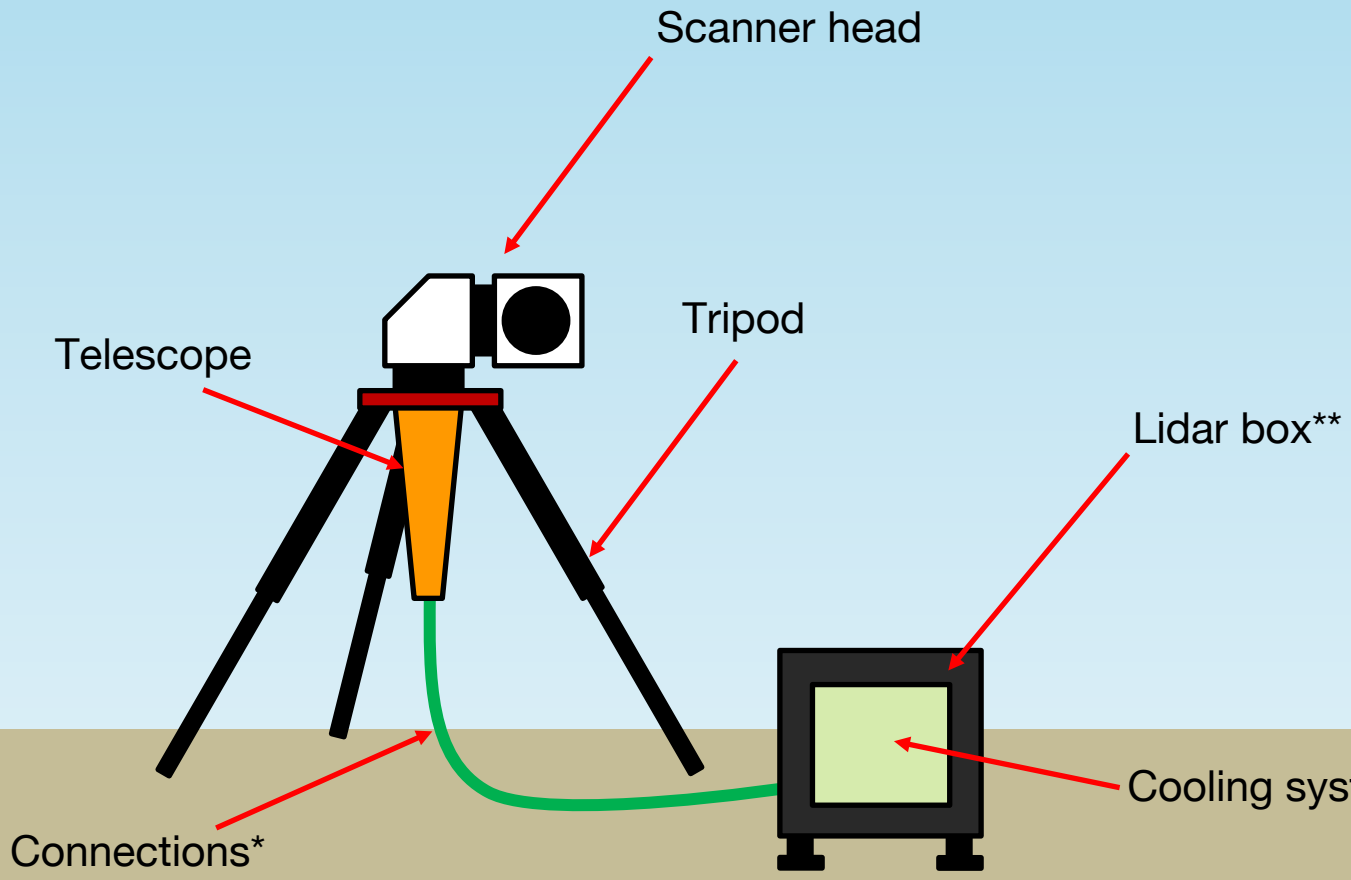
"Future challenges include the development of lidar uncertainty models, best practices for data management, and developing community-based tools for data analysis, planning of lidar measurements and lidar configuration. *" – IEA Wind Task 32*

"Future challenges include the development of lidar uncertainty models, best practices for data management, and developing community-based tools for data analysis, planning of lidar measurements and lidar configuration. *" – IEA Wind Task 32*

Tomorrow IEA Wind Task 32 Workshop:

"Future challenges include the development of lidar uncertainty models, **best practices for data management, and developing community-based tools for data analysis,** planning of lidar measurements and lidar configuration. *" – IEA Wind Task 32*

Compact lidar – DTU OpenLidar concept



*light, digital and analog cables
**photonics, computer and control rack

Thank you!

Nikola Vasiljević
niva@dtu.dk
https://dk.linkedin.com/in/nvasiljevic
https://www.youtube.com/user/cadenza83/videos