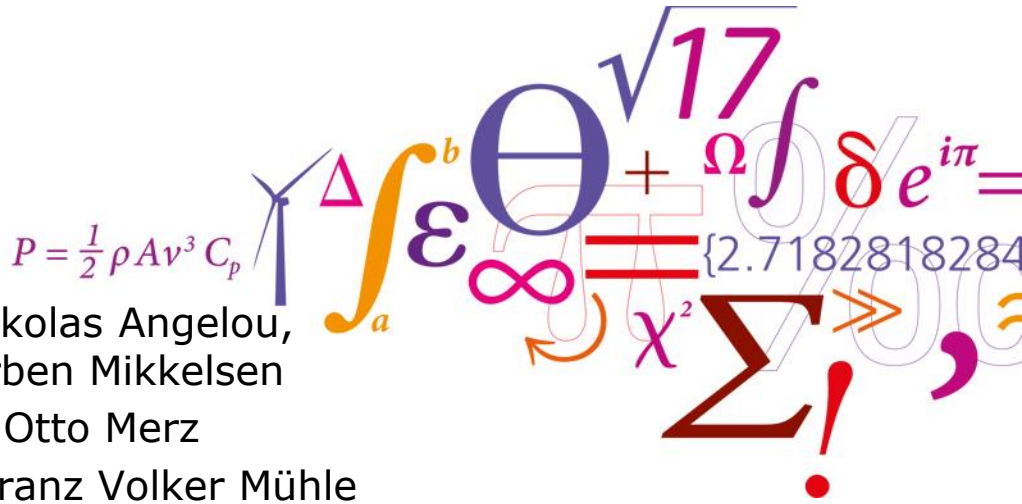
NTNU
Norwegian University of Science and Technology

VTT

SINTEF

DTU

Lidars for Wind Tunnels – an IRPWind Joint Experiment Project L4WT



DTU: Mikael Sjöholm, Andrea Vignaroli, Nikolas Angelou, Morten Busk Nielsen, Jakob Mann, and Torben Mikkelsen

SINTEF: Hans Christian Bolstad, and Karl Otto Merz

NTNU: Lars Roar Sætran, Jan Bartl, and Franz Volker Mühle

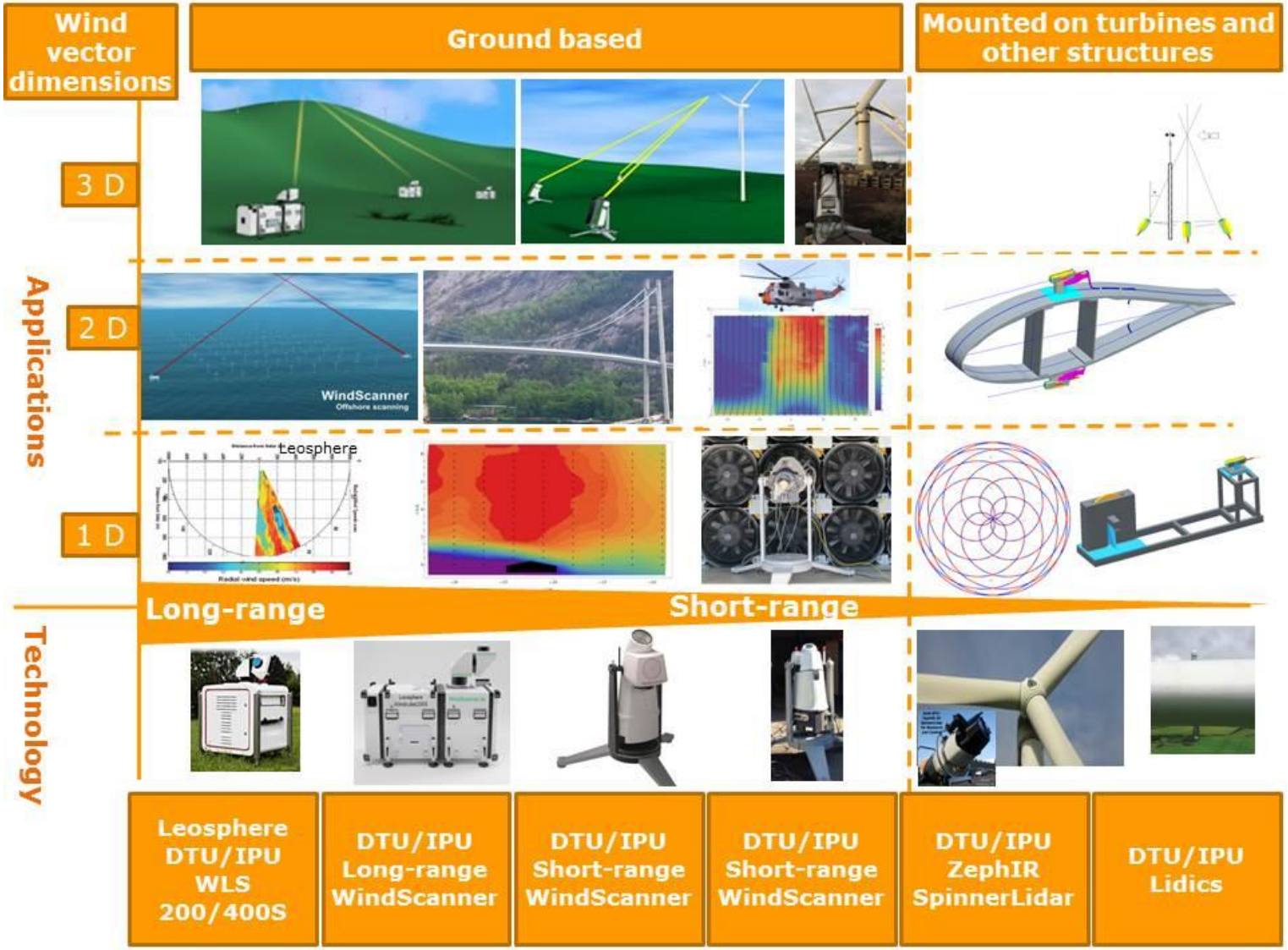
VTT: Mikko Tiihonen, and Ville Lehtomäki

DTU Wind Energy
Department of Wind Energy

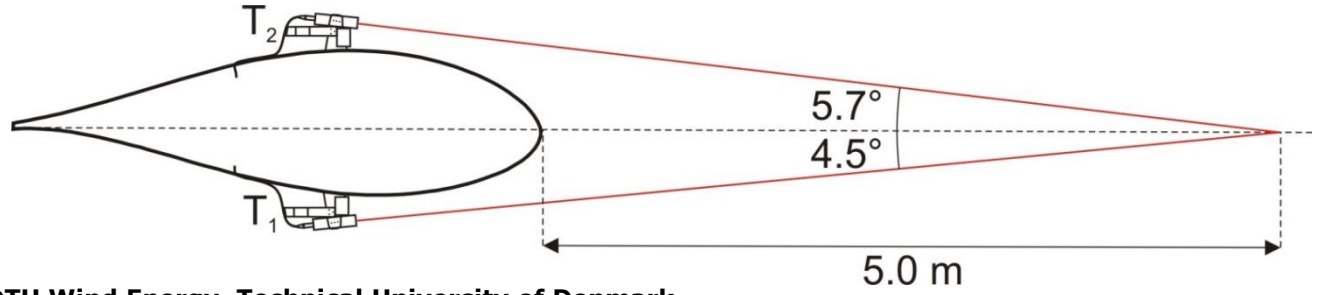
EERA
European Energy Research Alliance

IRPWind

The WindScanner, a distributed mobile research infrastructure



The Blade Lidar (Lidic)



The European WindScanner Facility

› ENERGY

WINDSCANNER The European WindScanner Facility

The facility

WindScanner is a unique, distributed Research Infrastructure providing fundamentally new knowledge about the wind, which will lead to more efficient, stronger and lighter wind turbines. Exploiting recent advances in laser wind measurement techniques, mobile 3-D remote sensing wind scanners will be deployed by seven large energy research institutes across Europe. This will provide an important catalysis for the future cooperation and integration of the European wind energy Research Infrastructures.

Background

The EU Directive on Electricity Production from Renewable Energy Sources demands a high rate of deployment of renewable energy, to which wind is expected to contribute significantly. This demand corresponds approximately to the installation of one large turbine every hour for the next decade. WindScanner contributes to the realization of the SET-Plan goals by establishing this new and truly distributed European facility. It is a scientific challenge to measure and understand the three-dimensional and time varying wind field as it passes through and interacts with the huge rotor of a modern wind turbine. Using traditional wind measurements made by anemometers mounted on meteorological masts, it is practically impossible to acquire the necessary 3-D wind information. Our present comprehension of the turbulent wind flow and its interaction with wind turbines is correspondingly limited. Conversely, WindScanner is based on remote sensing measurement concepts based on portable and easy deployable wind lidars and wind scanners. The new measurement technology will be disseminated and operated at both national and regional nodes, and interconnected throughout Europe via fast, scientific computer networks. The results obtained will foster improved computer models and permit a more optimal design of wind turbines. Ultimately, this will lead to better located, better wind turbines thus reducing the cost of renewable energy. Measurements with WindScanner facilities will therefore have a lower uncertainty than alternative wind tunnel scale testing or computer modelling.

Steps for implementation

WindScanners are based on portable and easy deployable wind lidars and wind scanners. During the preparation phase 2011-2013, the technology will be disseminated via the ESFRI process to the EERA participants' national and regional nodes. WindScanners will subsequently become operational and interconnected throughout Europe via fast, scientific computer networks.

PREPARATORY PHASE
Not yet started
Coordination: Denmark

TIMELINE
- Preparation phase: 2010-2012
- Construction phase: 2012-2015
- Operation phase: 2013 onwards

ESTIMATED COSTS
- Preparation: 8 M€
- Construction: 45-60 M€
- Operations: 4 M€/year
- Decommissioning: 0.1 M€

www.windscanner.eu

PART 2 › Roadmap › Strategy Report on Research Infrastructures ESFRI 47

The WindScanner, a distributed mobile research infrastructure

EUROPEAN PARTNERS

WindScanner.eu

ESFRI

EERA

Website: www.windscanner.eu

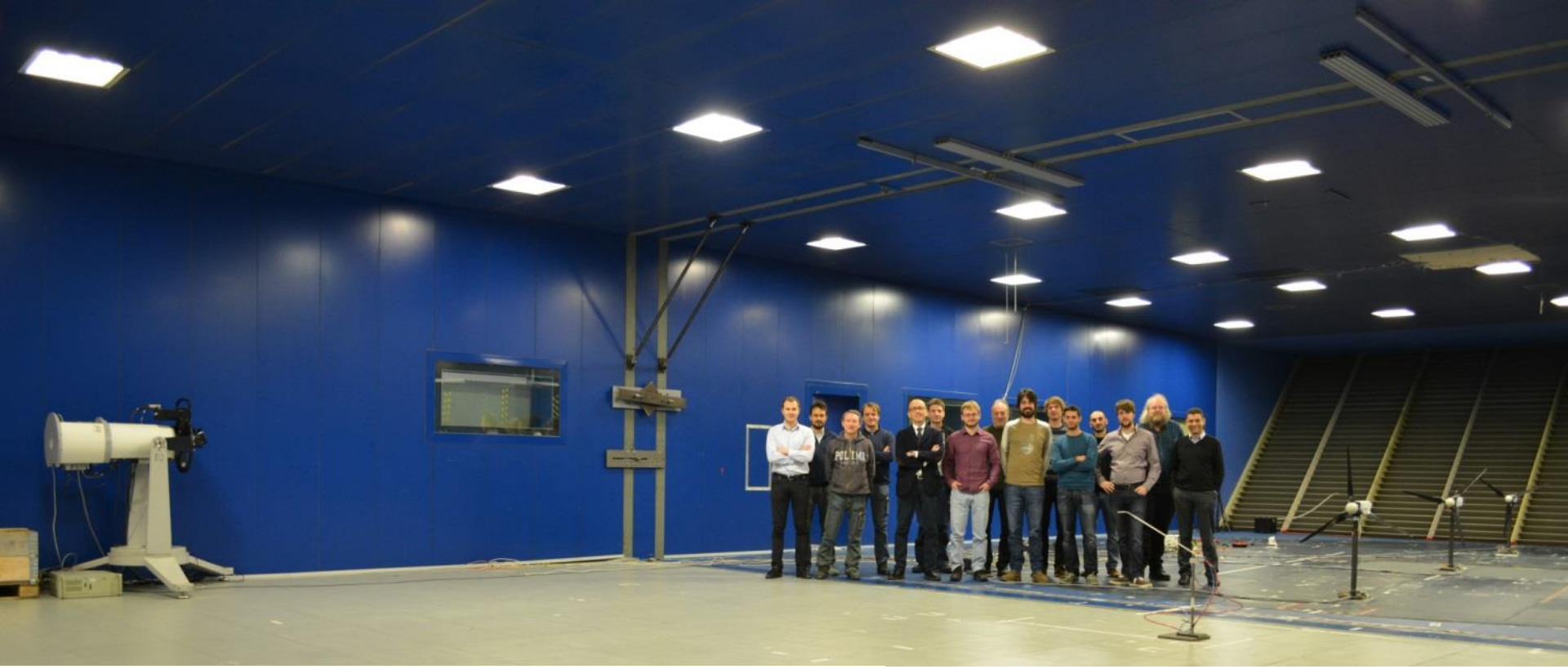
Contact: Søren Knudsen, (sknu@dtu.dk), DTU Wind Energy, coordinator for WindScanner.eu Preparatory Phase

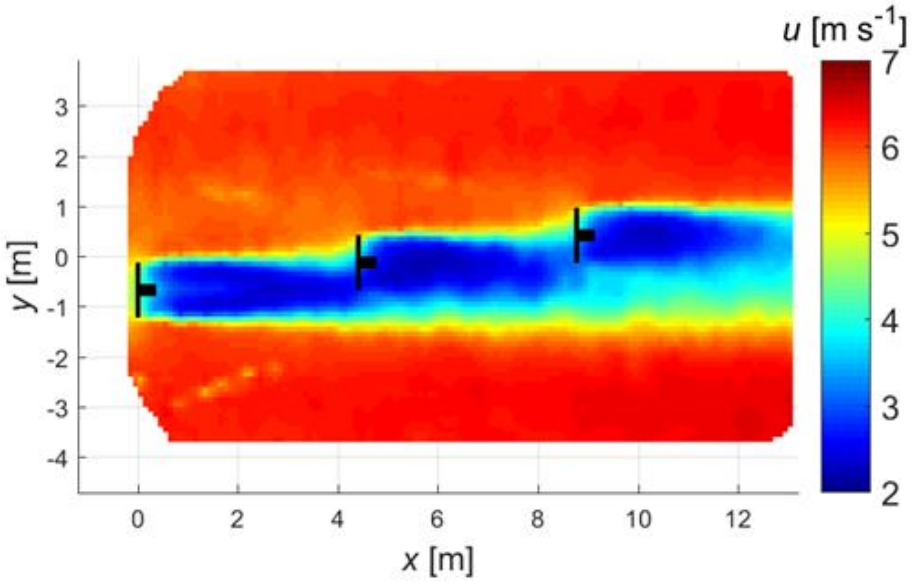
Pictures by: Mikael Sjöholm, Andrea Vignaroli, Torben Krogh Mikkelsen, Guillaume Lea & Lee Jay Fingersh

This brochure is developed as part of the WindScanner.eu Preparatory Phase project WINDSCANNER 312372 funded by the European Commission's FP7

http://www.windscanner.eu/


TUM.WIND



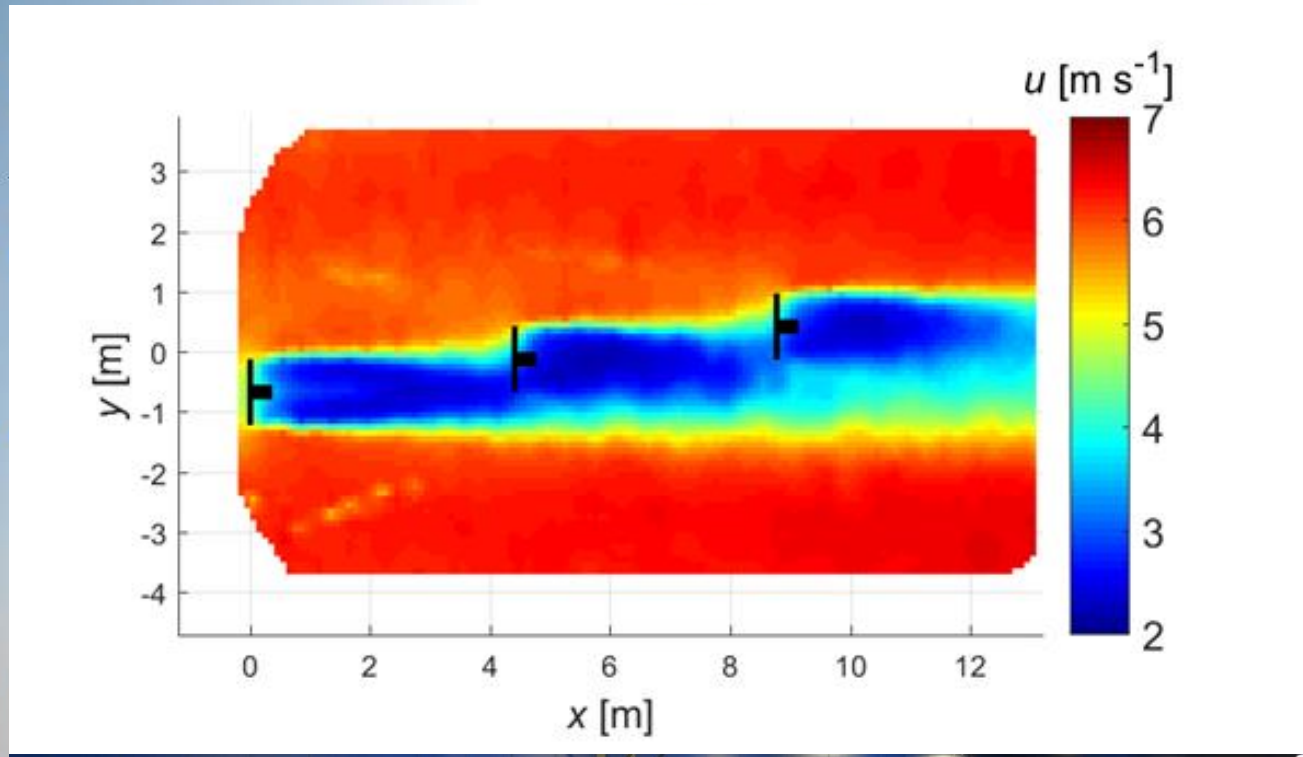


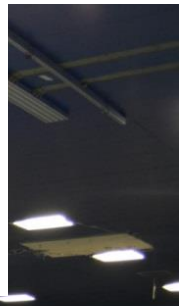
van Dooren, MF, Kühn, M, Petrovic, V, Bottasso, CL, Campagnolo, F, Sjöholm, M, Angelou, N, Mikkelsen, TK, Croce, A & Zasso, A, 2016, *"Demonstration of synchronised scanning Lidar measurements of 2D velocity fields in a boundary-layer wind tunnel"*, **Journal of Physics: Conference Series** (Online), vol 753, 072032. DOI: 10.1088/1742-6596/753/7/072032

The double Italian account

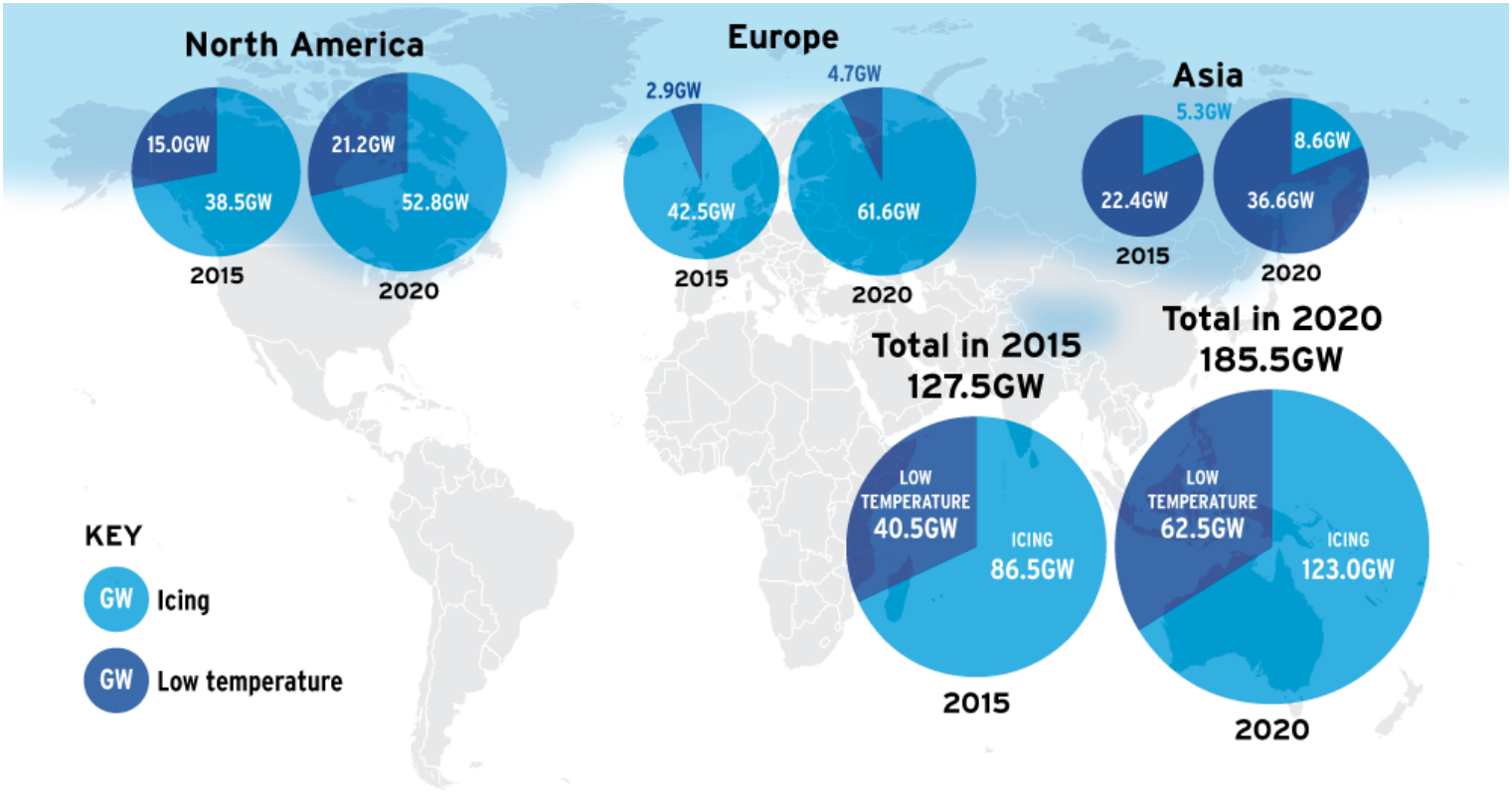
EXPERIMENTAL INVESTIGATIONS

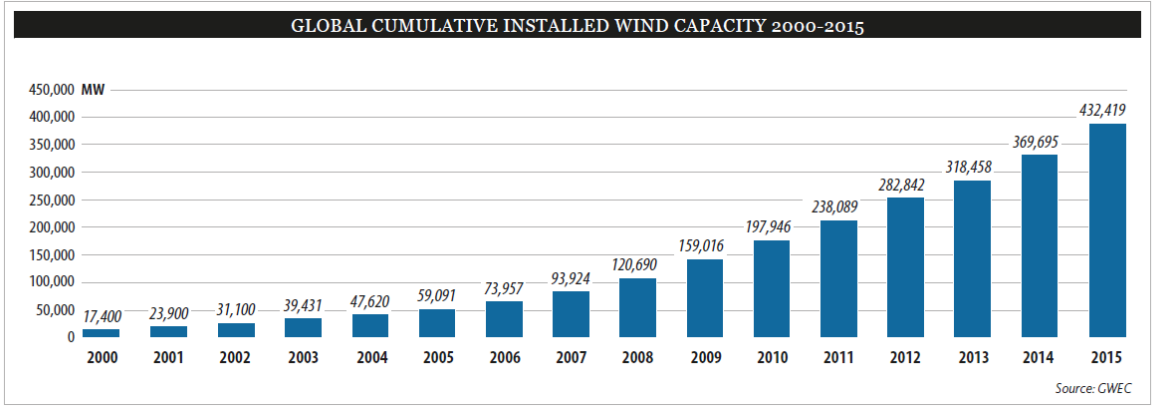
NO CLIMATE TOO COLD - NO CLIMATE TOO HOT





Wind Energy Capacity in Cold Climate

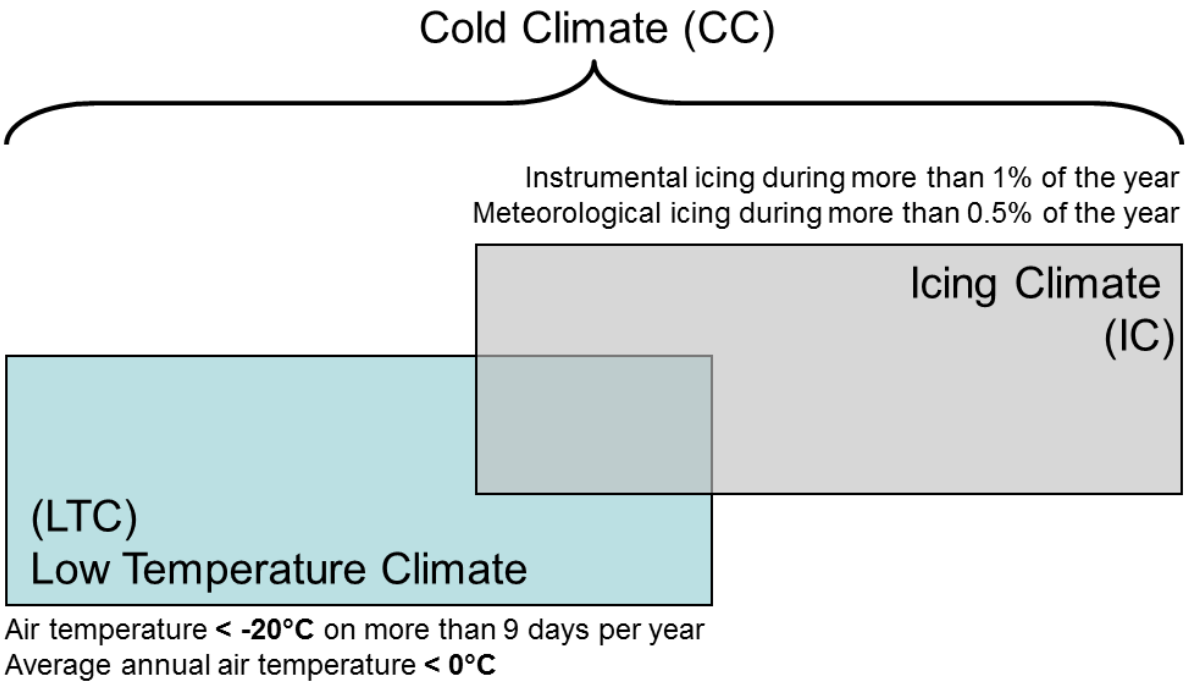




http://www.windpowermonthly.com/article/1403504/emerging-cold

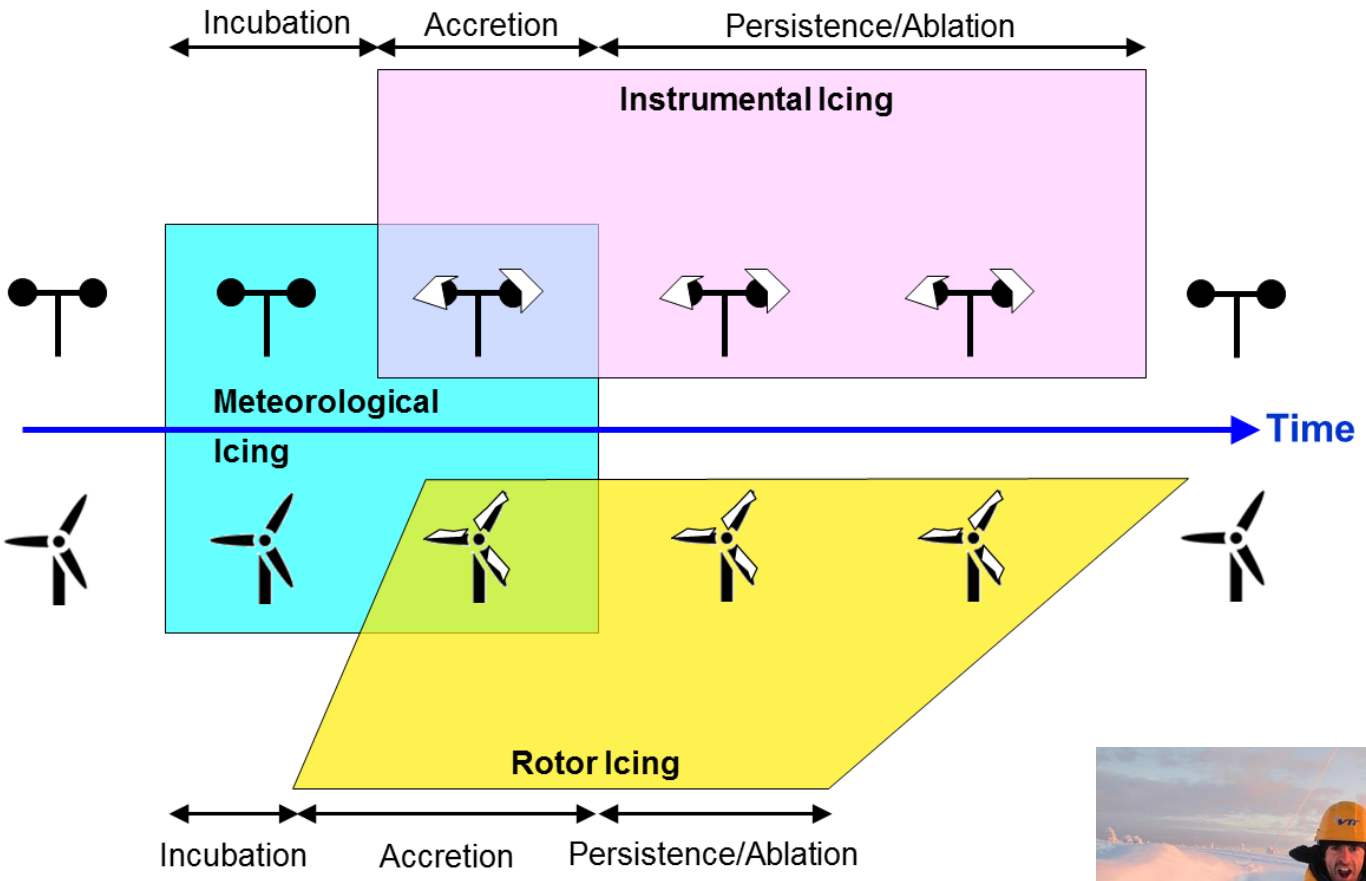
Cold Climate Definition

Wind Energy in Cold Climates (CC) refers to sites that may experience frequent icing events, temperatures below the operational limits of standard wind turbines (WT), or both.

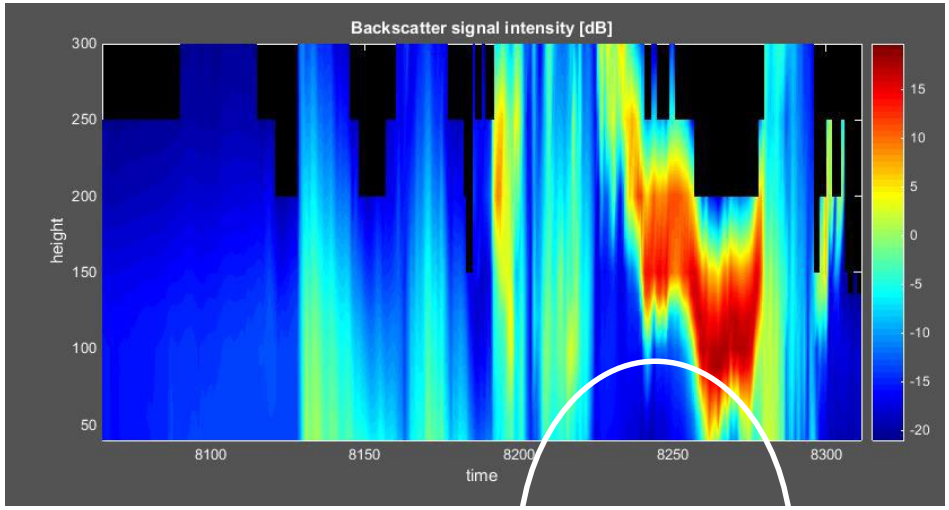


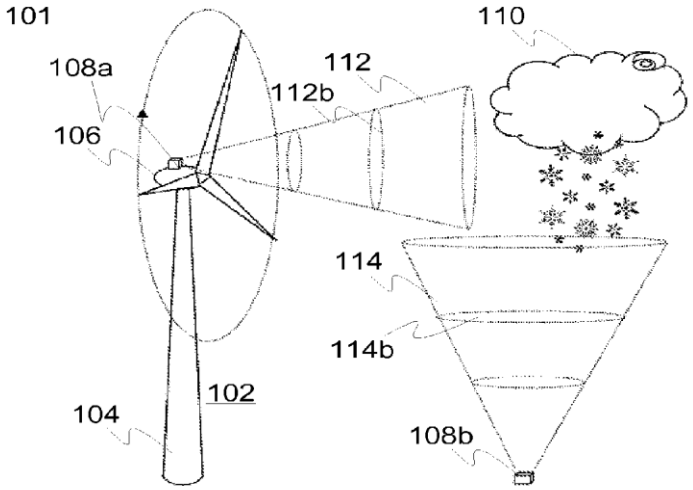
https://www.ieawind.org/task_19.html

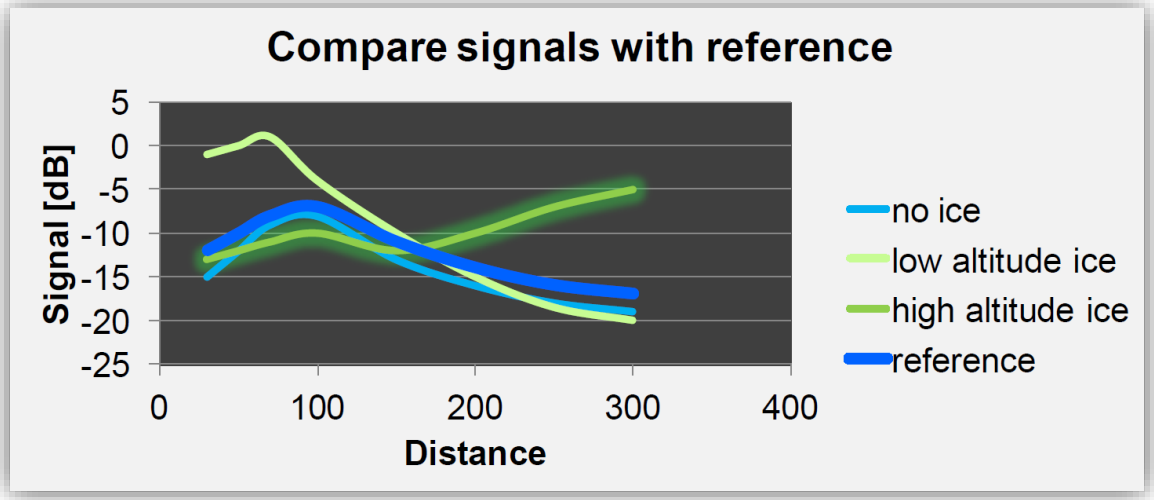
Atmospheric Icing Phases



Remote Sensing of Icing Conditions







US Patent 2014/0192356: Arrangement and method for icing detection (Esa Peltola, Petteri Antikainen, and Andrea Vignaroli)

Slide extract from: Karlsson et al, Lidar as ice detector, Winterwind 2015

The IRPWind

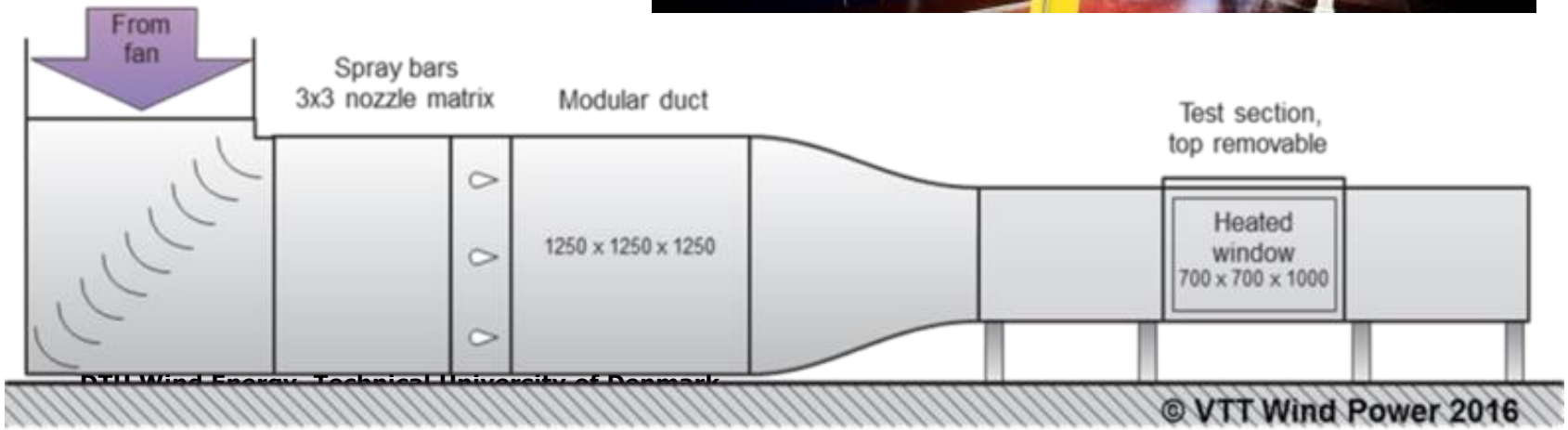
http://www.irpwind.eu/

IRPWIND Relevant Networks

1. Research Wind Turbines
2. **Wind Tunnels**
3. Grid Integration

NTNU
Boundary-Layer Wind Tunnel
Trondheim, Norway

VTT
Icing Wind Tunnel (IWT)
Espoo, Finland



NTNU
Norwegian University of
Science and Technology

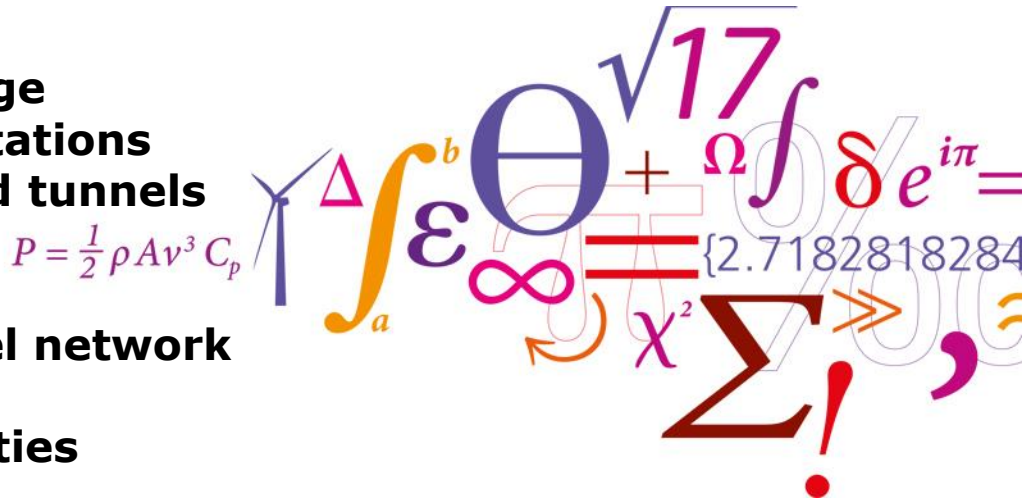
VTT

SINTEF

DTU

Lidars for Wind Tunnels – an IRPWind Joint Experiment Project L4WT

The aim of L4WT
is
to gain and share knowledge
about the possibilities and limitations
with lidar instrumentation in wind tunnels
and
to foster collaboration
in a prospective Nordic wind tunnel network
for
alignment of research activities
relevant to
wind conditions in cold climate



DTU Wind Energy
Department of Wind Energy

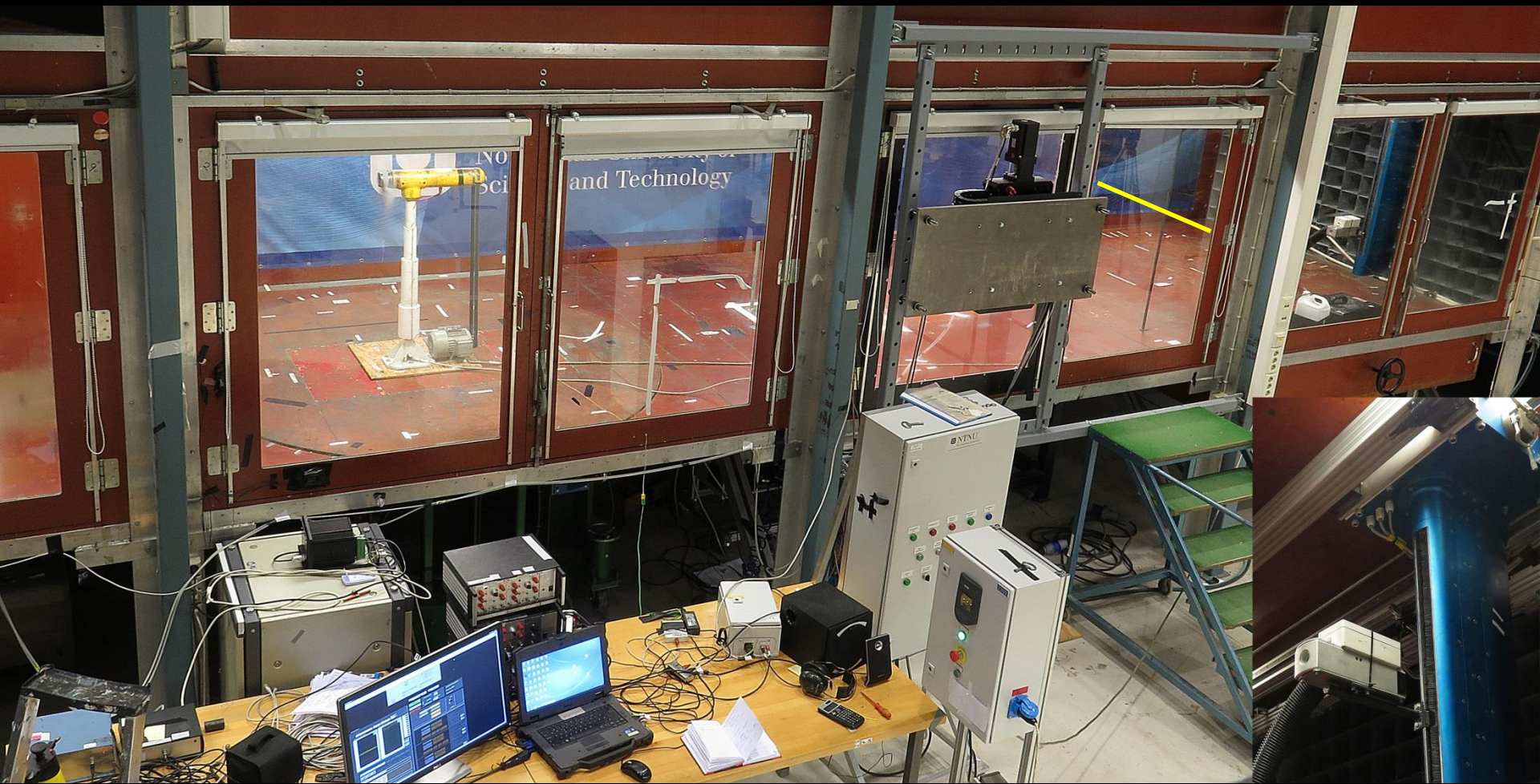
EERA
European Energy Research Alliance

IRPWind

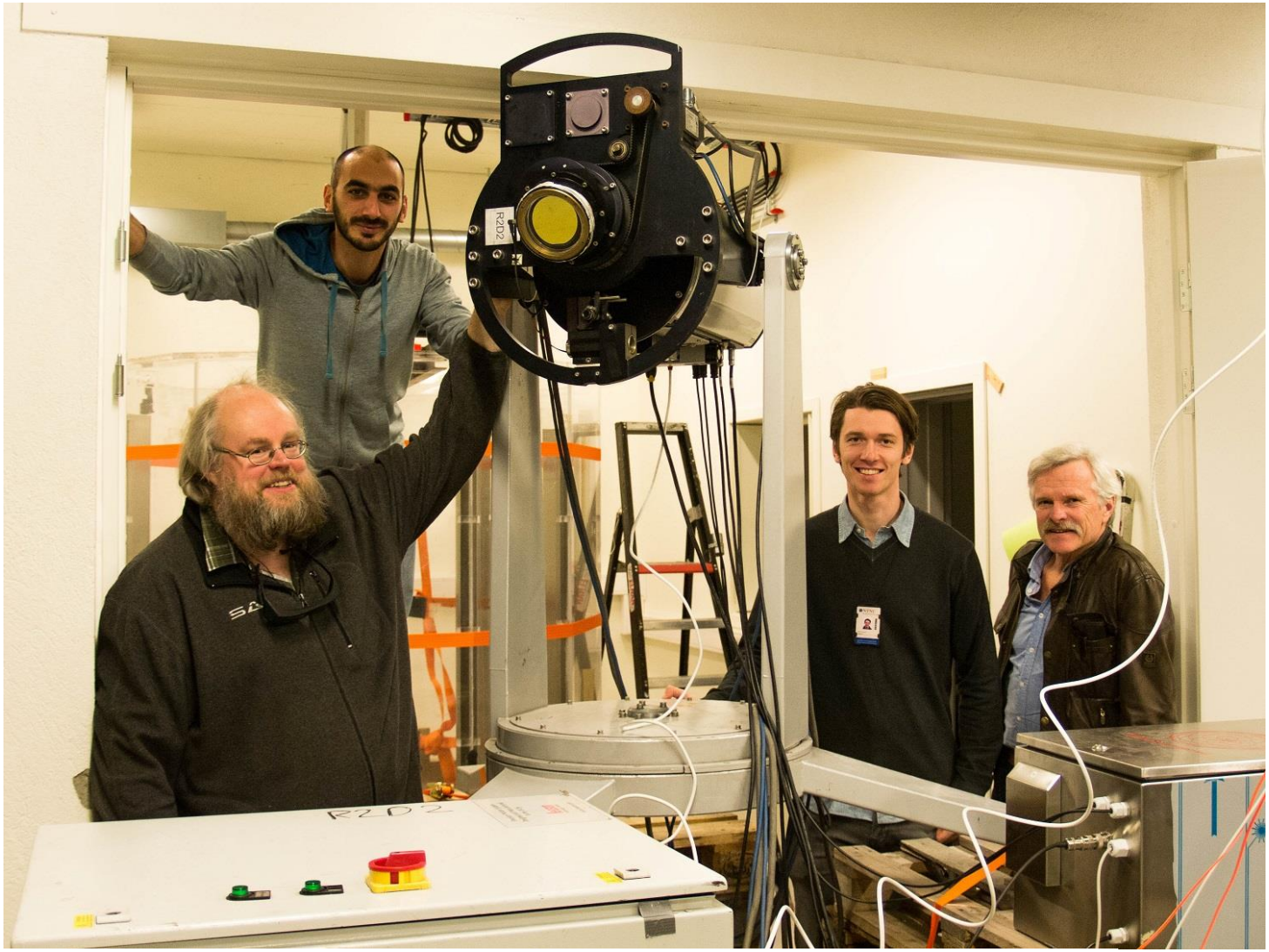
NTNU Boundary-Layer Wind Tunnel

Test section: 11 m long
2 x 3 m cross section
30 m/s max velocity

http://www.ntnu.edu/ept/laboratories/aerodynamic



Short-range WindScanners



http://www.ntnutechzone.no/2016/12/siste-skrik-i-visualisering-av-vind/

Blog dissemination

http://blog.sintefenergy.com/vindkraft/spennende-malinger-i-vindtunnel-laben-til-ntnu/

Renewable Energy 50 (2013) 325–333

Contents lists available at SciVerse ScienceDirect

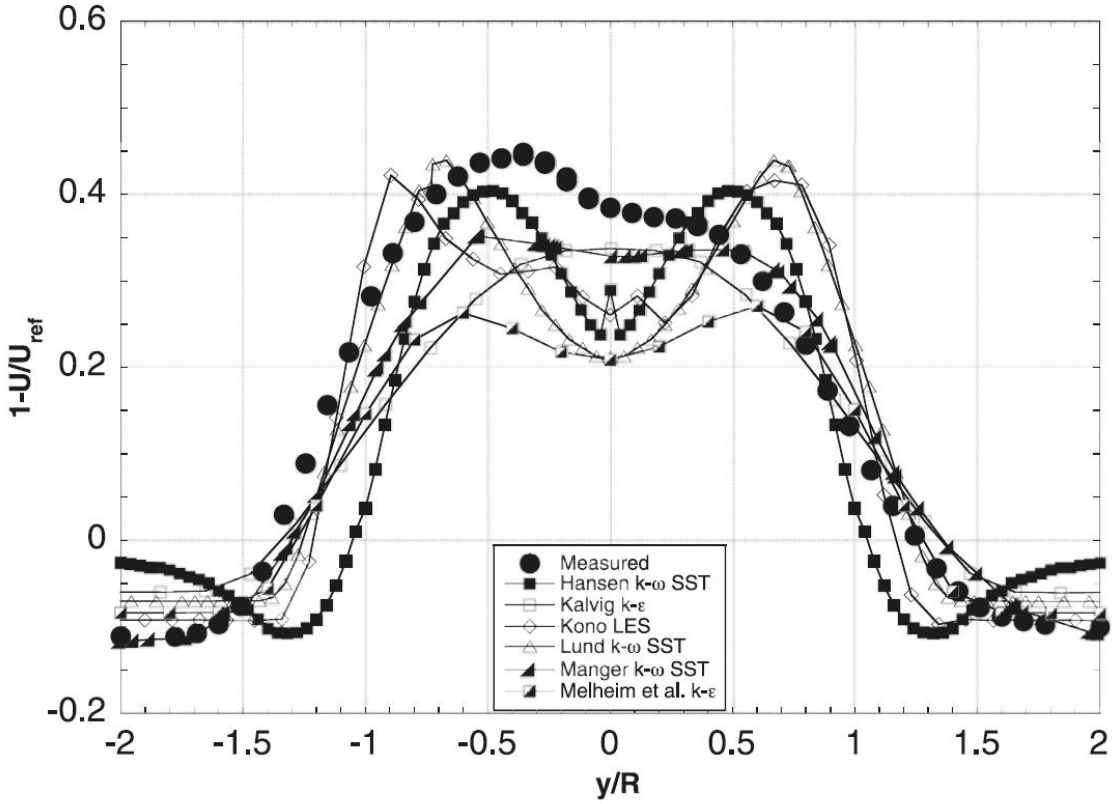
Renewable Energy

journal homepage: www.elsevier.com/locate/renene

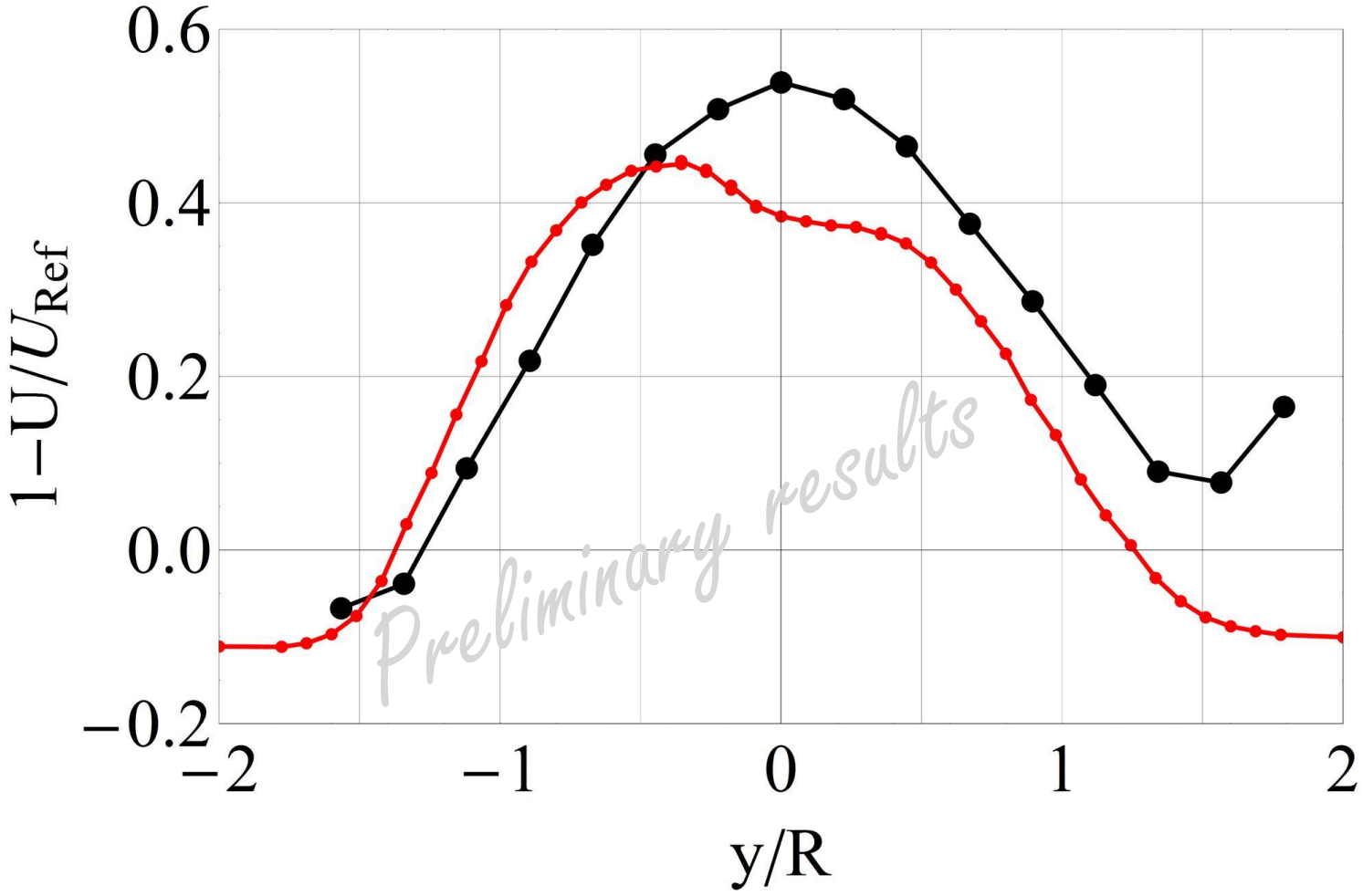
"Blind test" calculations of the performance and wake development for a model wind turbine

Per-Åge Krogstad*, Pål Egil Eriksen

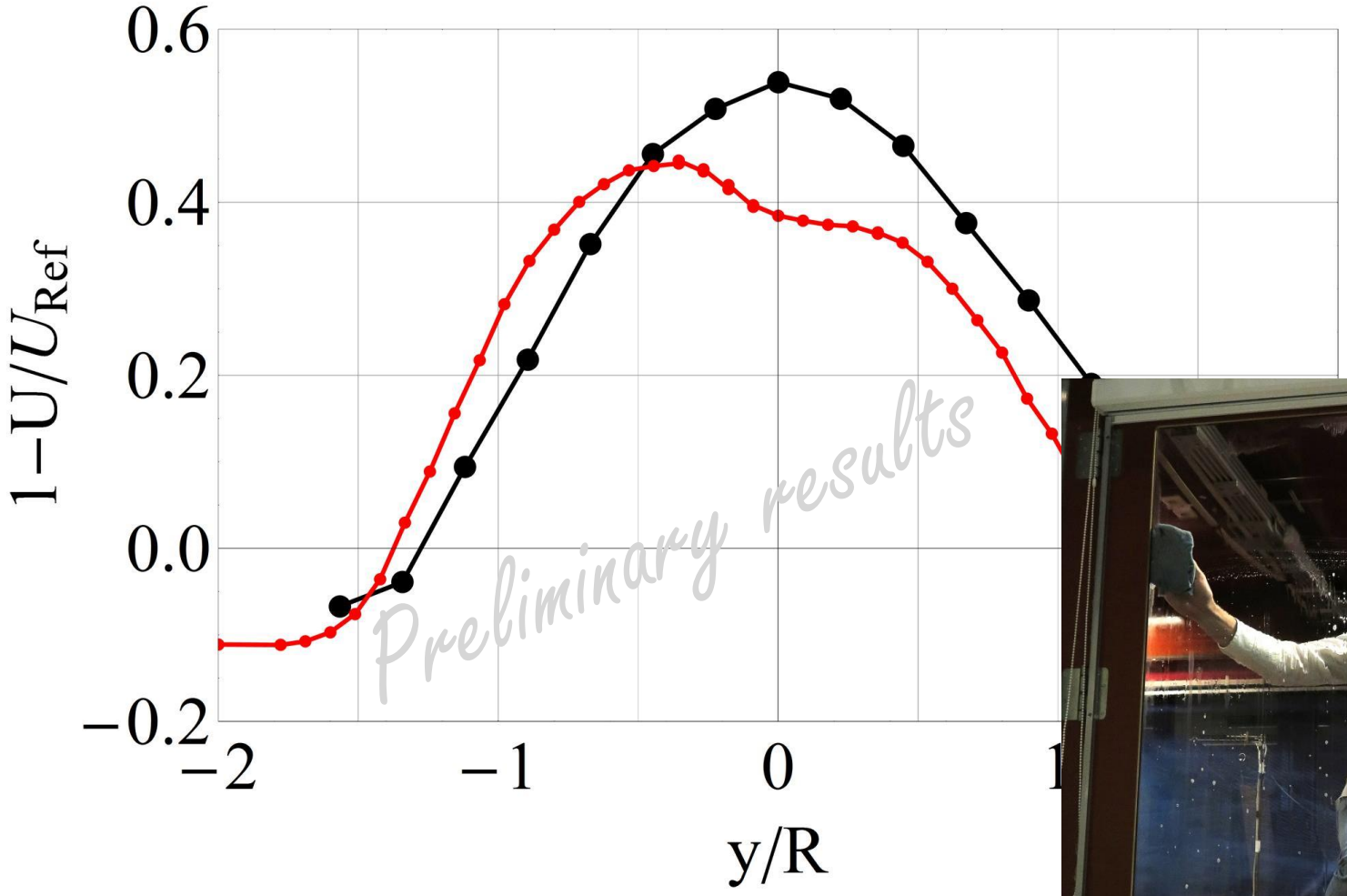
Department of Energy and Process Engineering, Norwegian University of Science and Technology NTNU, 7491 Trondheim, Norway



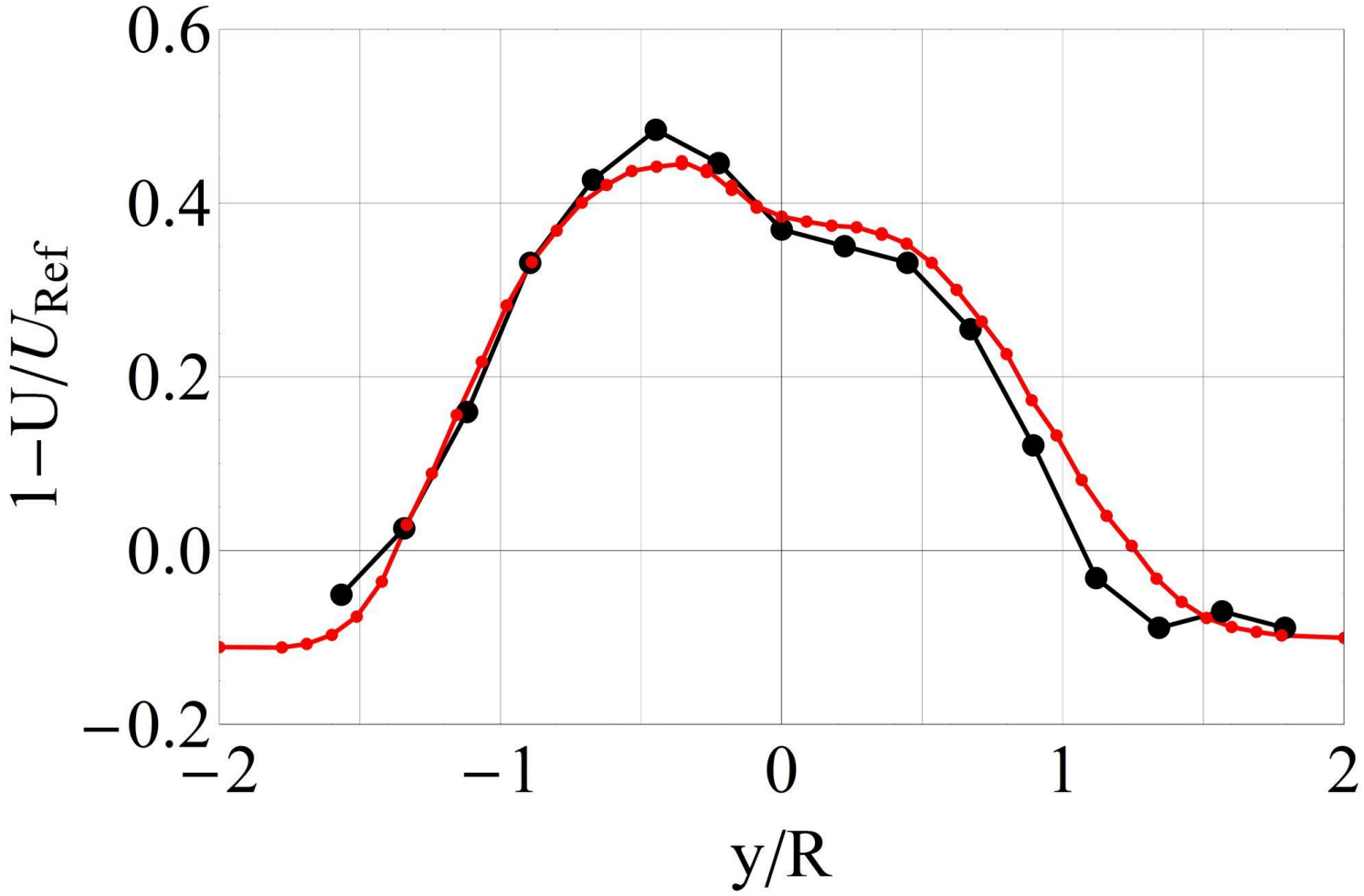
Blind Test Comparison With Lidar Outside the Tunnel



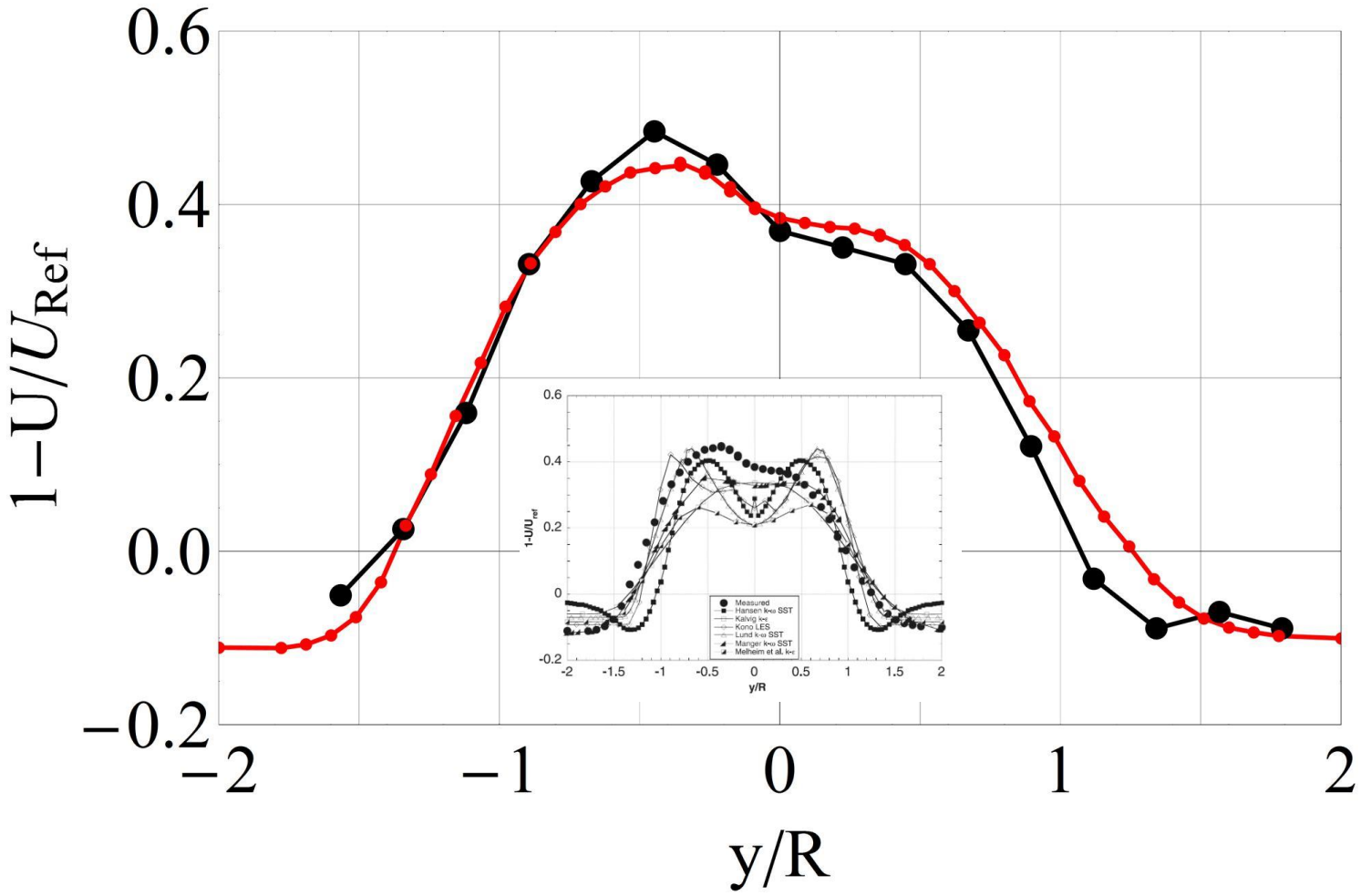
Blind Test Comparison With Lidar Scanner Outside the Tunnel



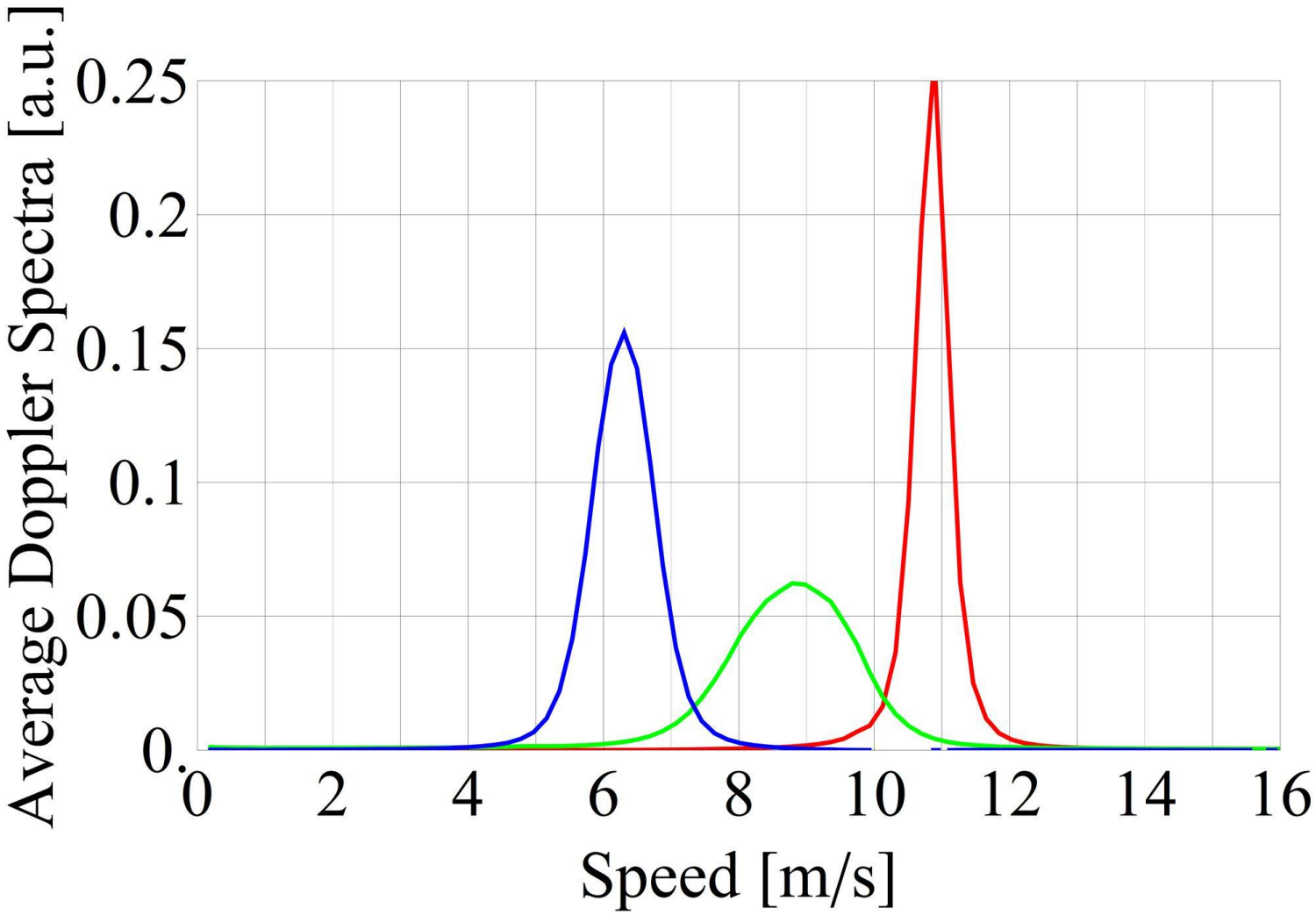
Blind Test Comparison With Lidar Lidic Inside the Tunnel



Blind Test Comparison With Lidic Inside the Tunnel

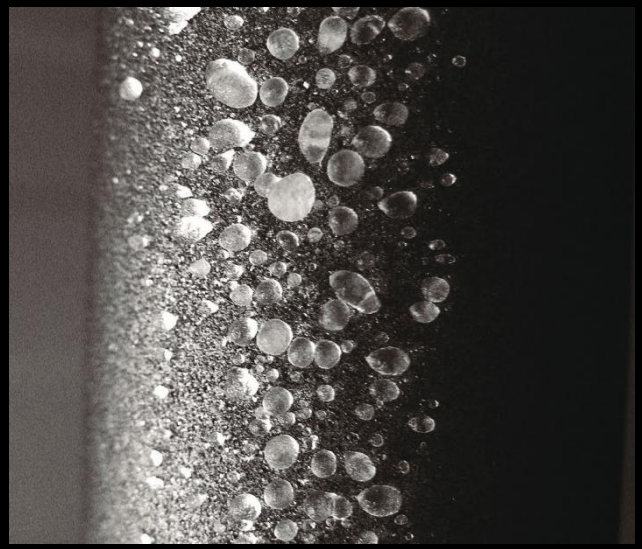


Doppler Spectra in The Wake



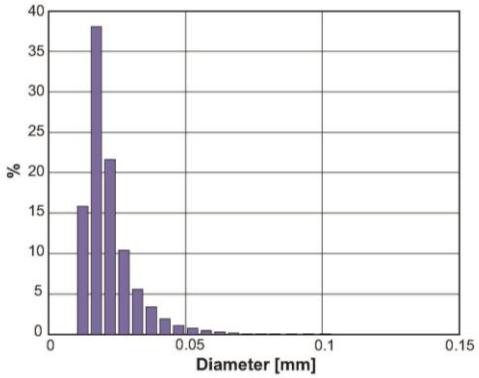
VTT Icing Wind Tunnel

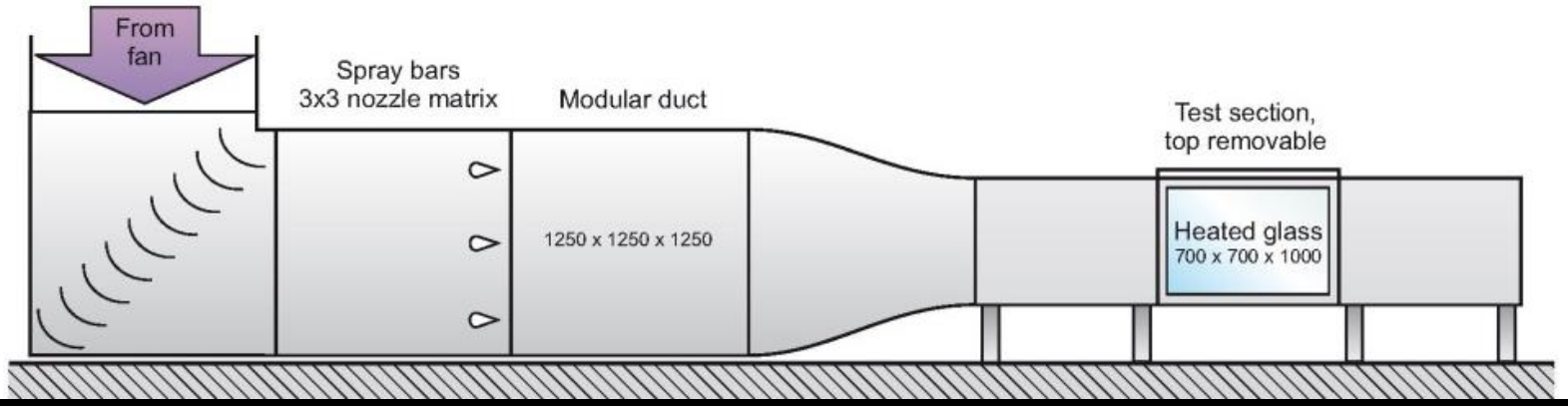
http://www.vttresearch.com..



Property	Range in the facility	VTT's Reference conditions	
		In-cloud icing, stationary components	In-cloud icing, wind turbine rotor blades
Temperature [°C]	-20…+30	-5	-5
Wind speed [m/s]	0…45	7	40
Water content [g/m³]	0.1…1.0	0.2	0.2
Droplet size, MVD [µm]	20…50	20	20

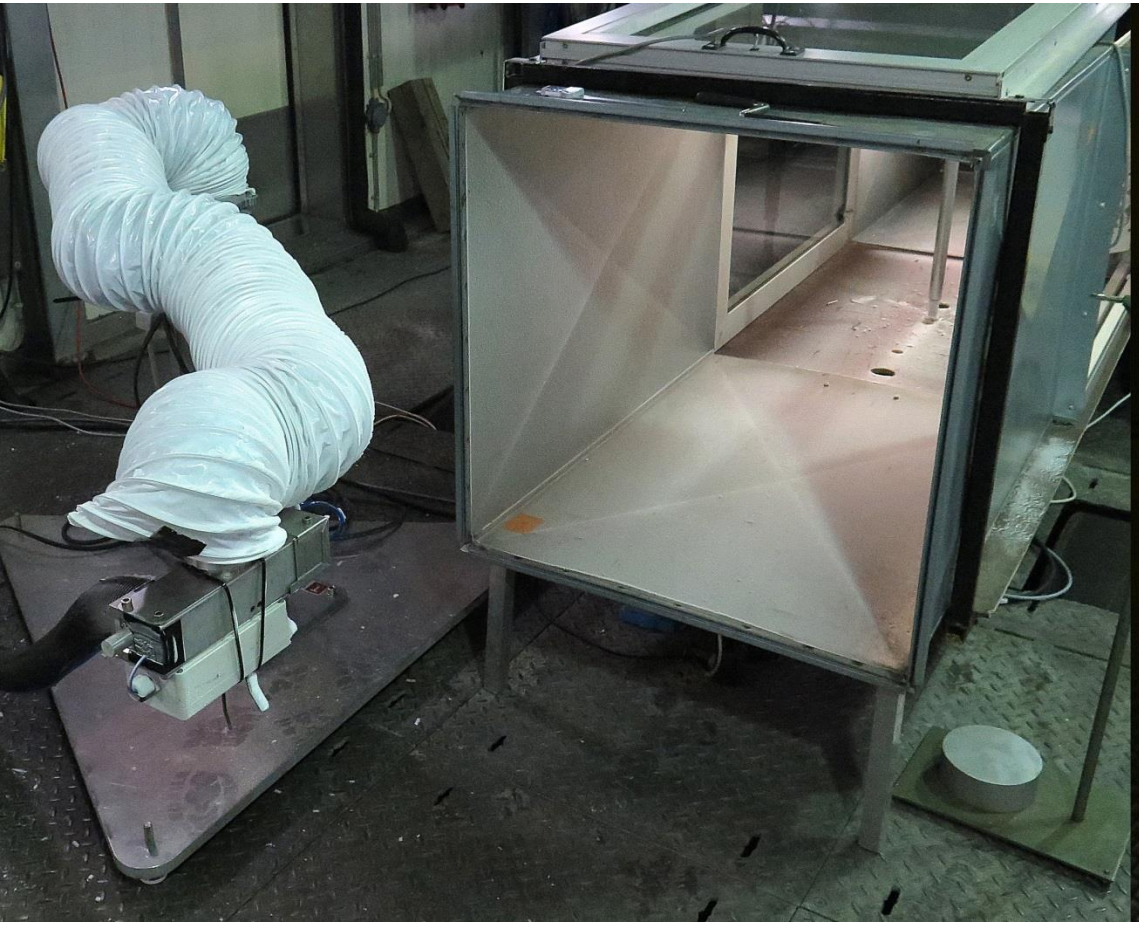
Droplet size and wind speed profile have been verified using shadow imaging.

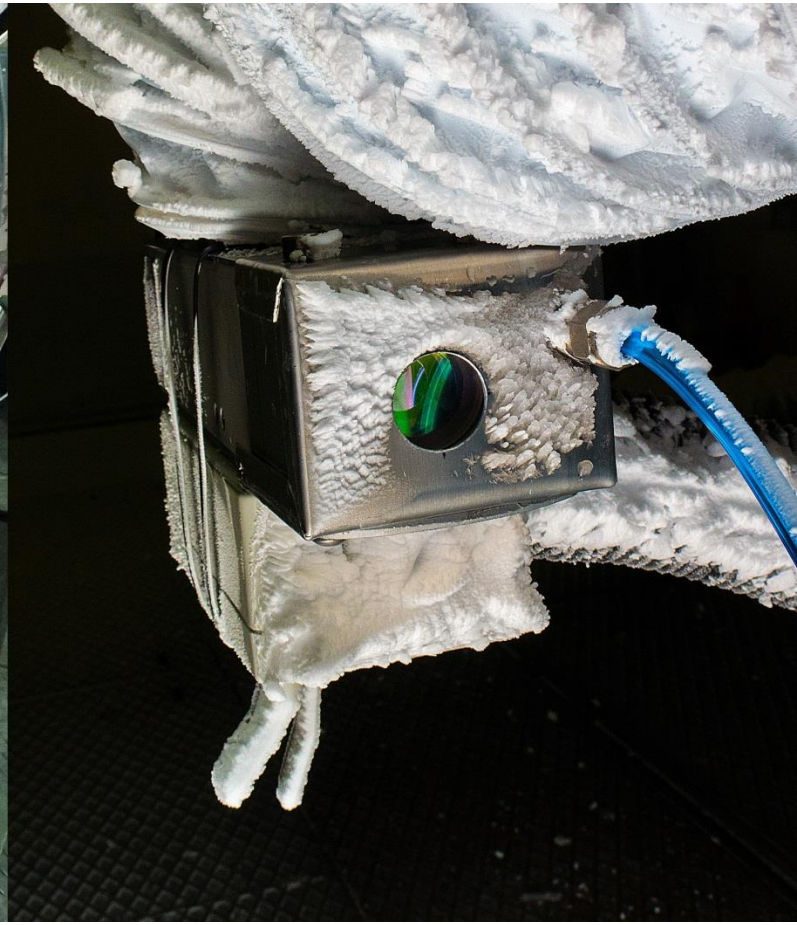




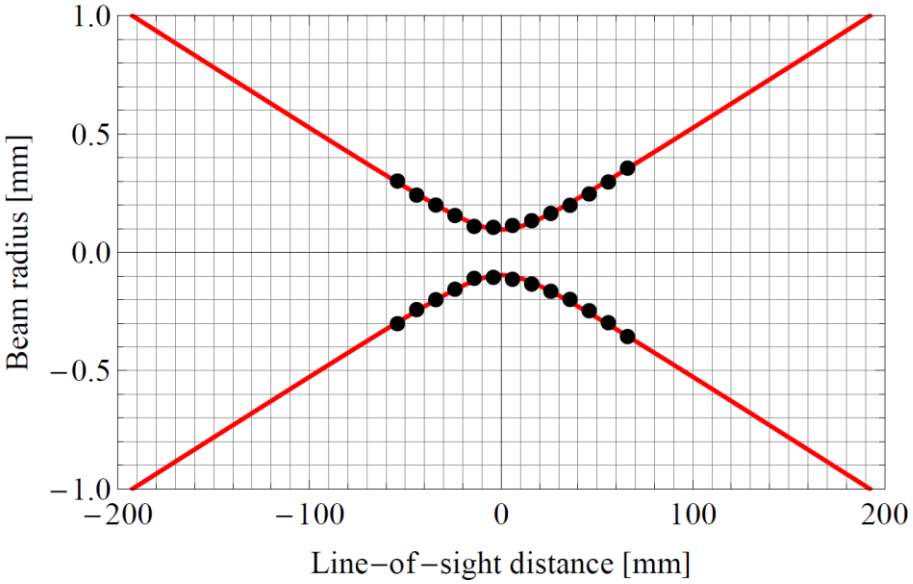
Measurement Campaign in VTT Icing Wind Tunnel

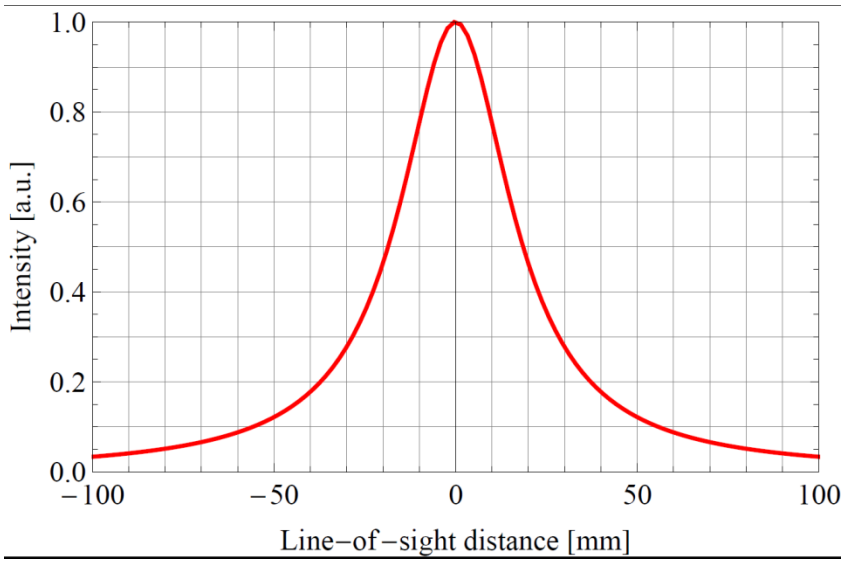
Protective measures in the Icing Wind Tunnel



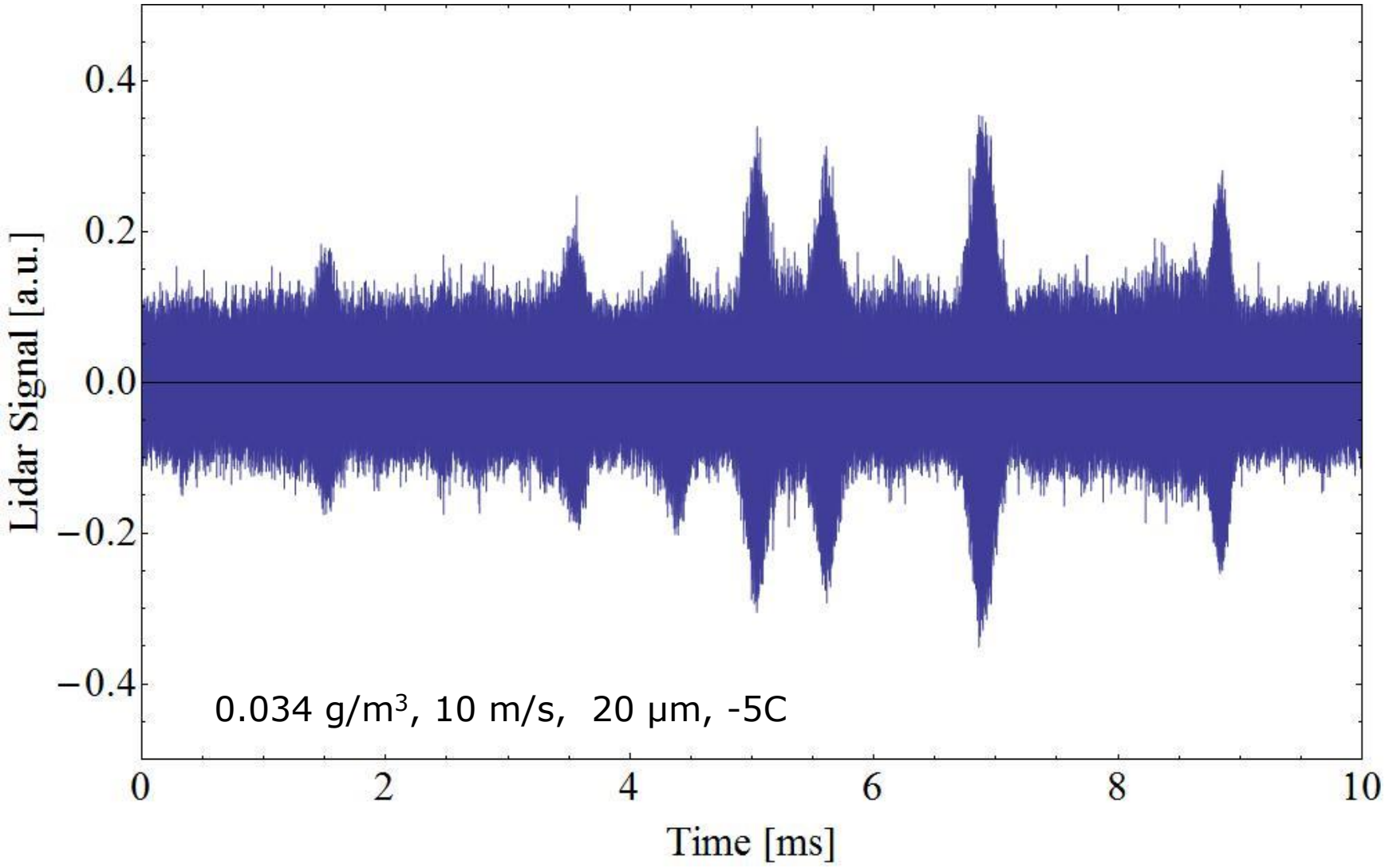


The sampling volume at 1.5 meter



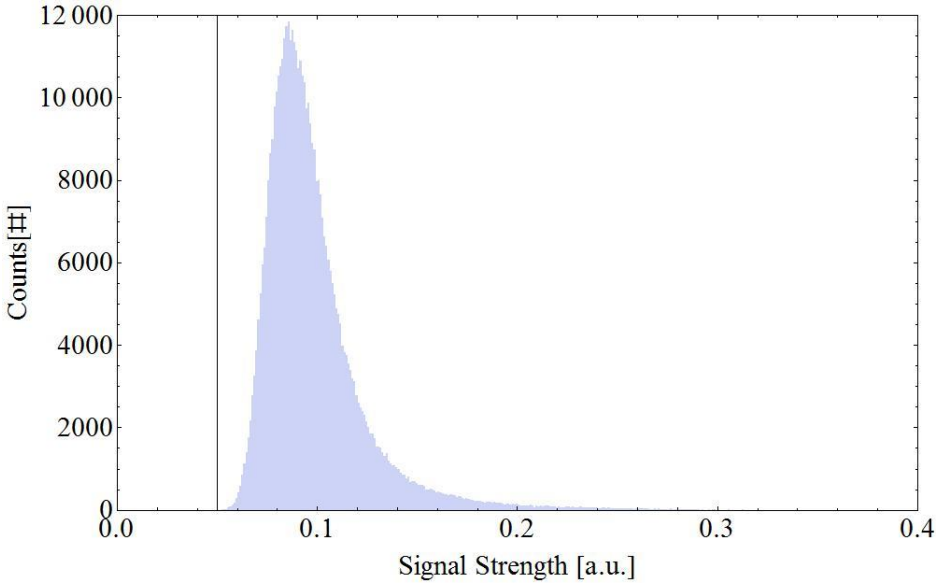


Lidar high frequency time series along the wind

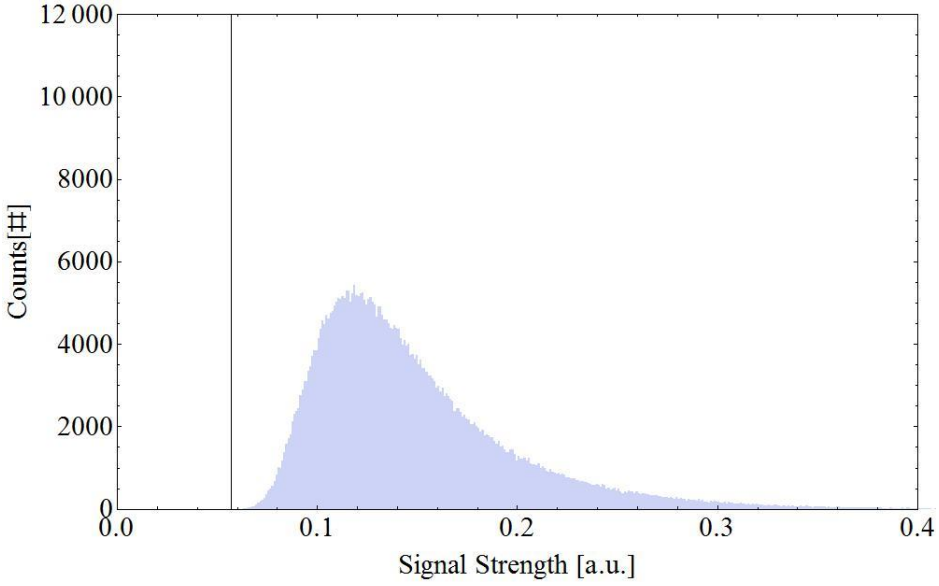


Lidar signal strength distributions

0.034 g/m³



0.18 g/m³



This very morning at the ECN test site in The Netherlands in another IPRWind Joint Experiment called ScanFlow


Thank you for listening!
misj@dtu.dk