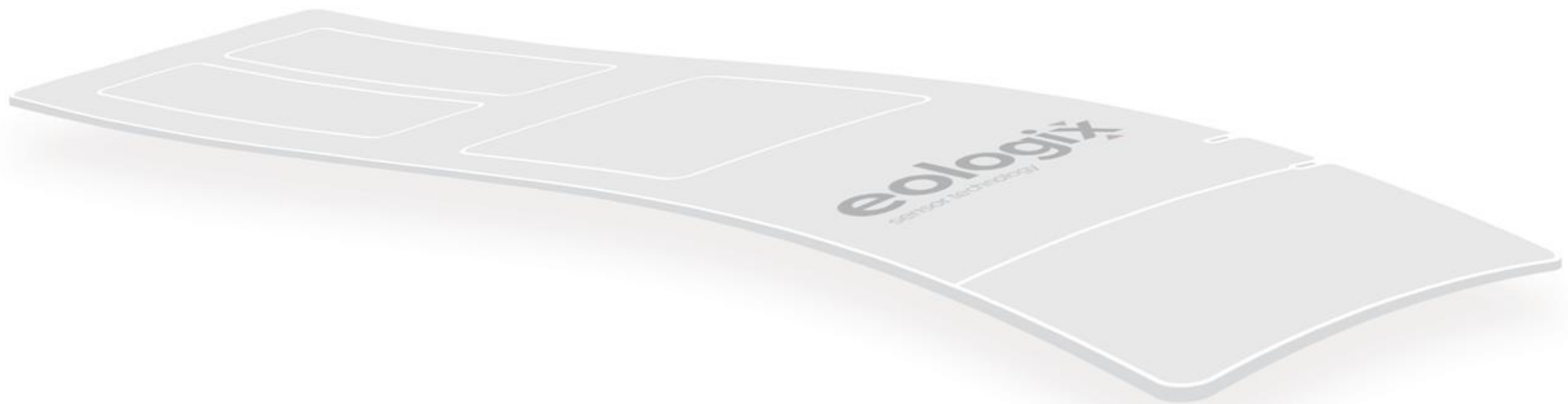


Retrofittable, autonomous and wireless icing and temperature monitoring on rotor blades for efficient anti- and de-icing



Michael Moser, Thomas Schlegl, Hubert Zangl
Science Park Graz / project: eologix

History



2011 (Umeå): Sensing Principle

2012 (Skellefteå): Sensor Fusion Approach

2013 (Östersund): System Concept

2014 (Sundsvall): Towards Real World Application

... retrofittable ...

- Mount within minutes (patch of Windtape)
- Mount over heater elements
- Mount on every surface point of blade, nacelle or tower
- No cutting/drilling in blades
- No limitation of number of sensors per turbine
- Device thickness: <2mm, flexible



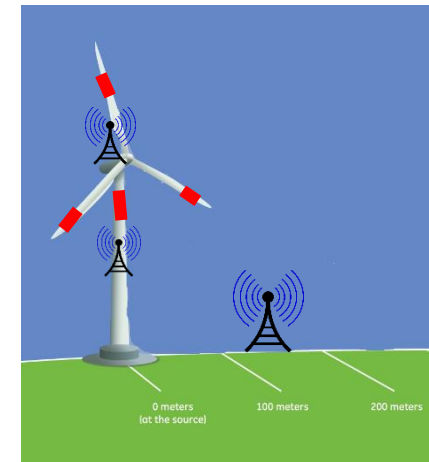
...autonomous and wireless...

- Wireless: integrated, encapsulated device
- Power source: daylight (dark time: weeks)
- Data transmission: active wireless RF data transmission

Possible base station locations:

- met mast
- hub or blade root (rotating receiver)
- ground or tower

No rotation required for sensing
(operation also during standstill)



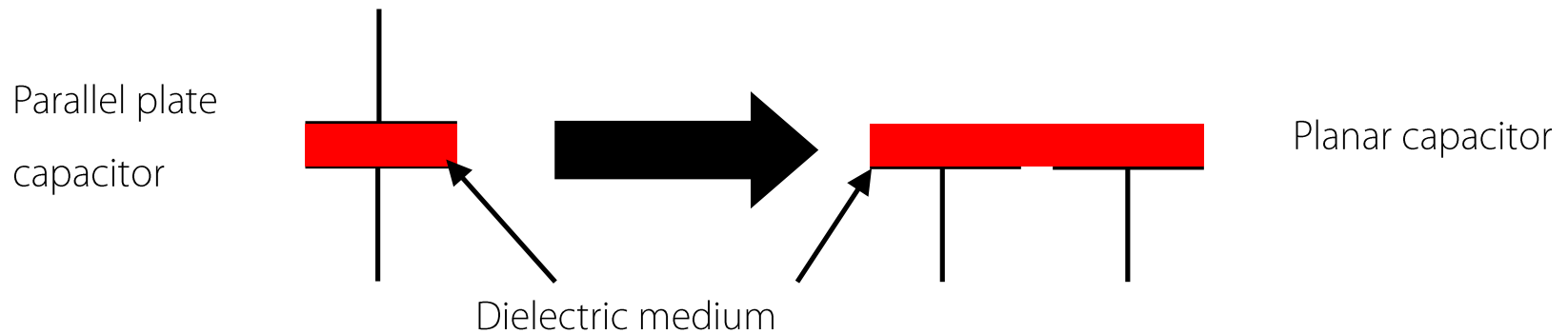
...Temperature and Icing...



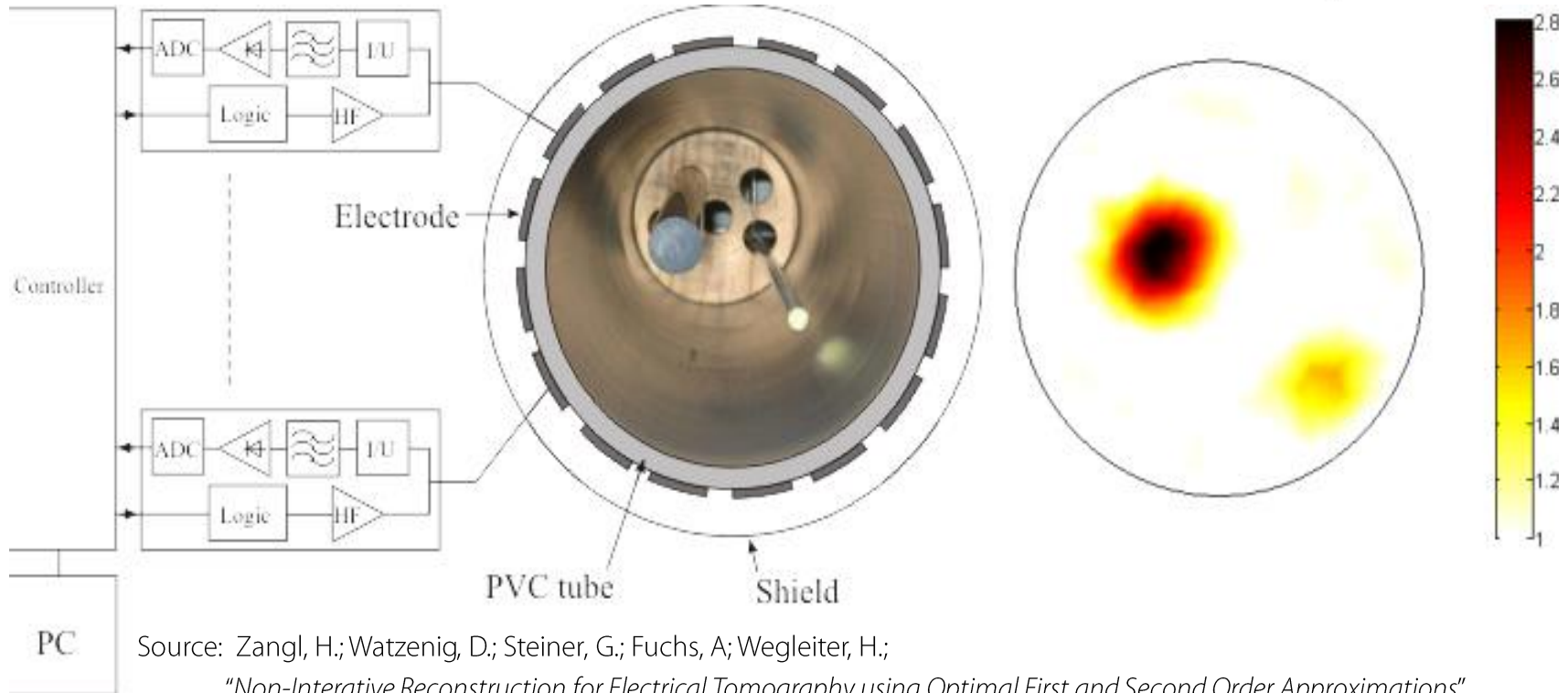
- Temperature measurement: accuracy +/- 0.25°C
- Impedance/Capacitance Icing Detection
 - high, adjustable sensitivity – early detection of icing
 - discrimination of wet and dry surface

Icing Sensor Principle

Evaluation of the variable impedance of a planar capacitor



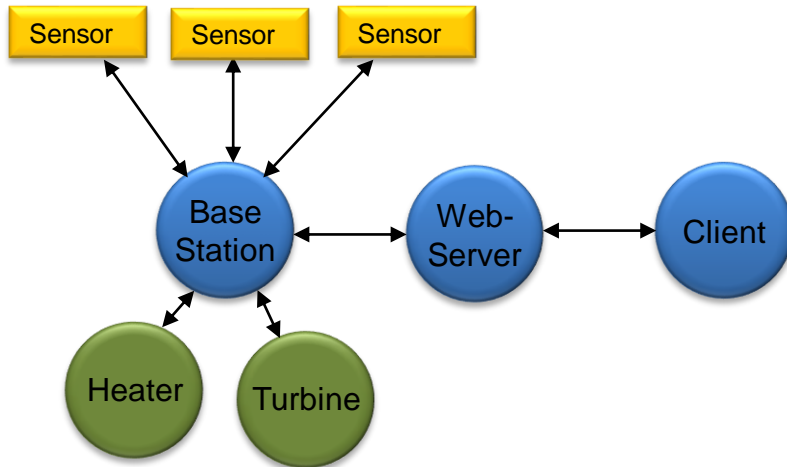
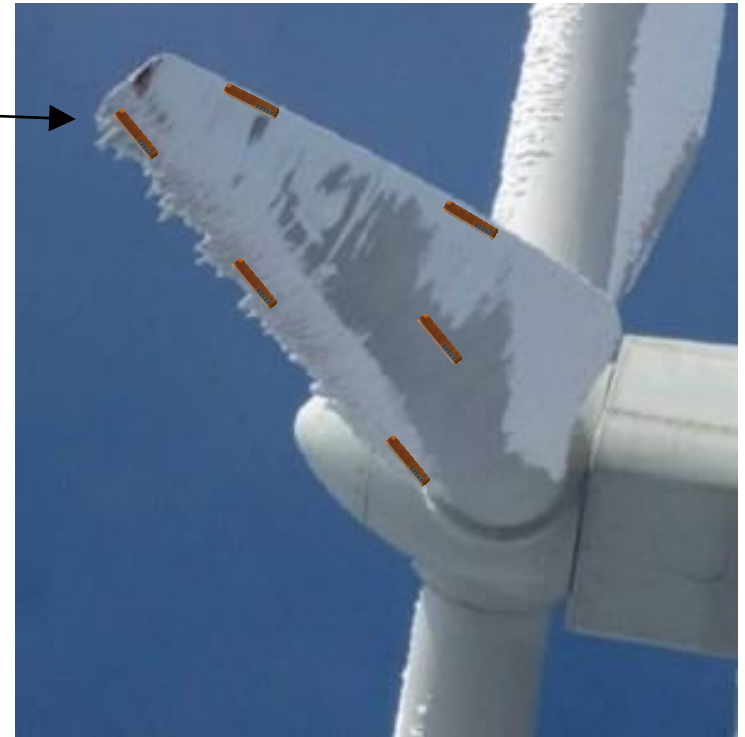
Measurement / ECT



Source: Zangl, H.; Watzenig, D.; Steiner, G.; Fuchs, A; Wegleiter, H.;

"Non-Interactive Reconstruction for Electrical Tomography using Optimal First and Second Order Approximations",
World Congress on Industrial Process Tomography, 2007, S. 216-223

System Concept



Tests (ongoing)



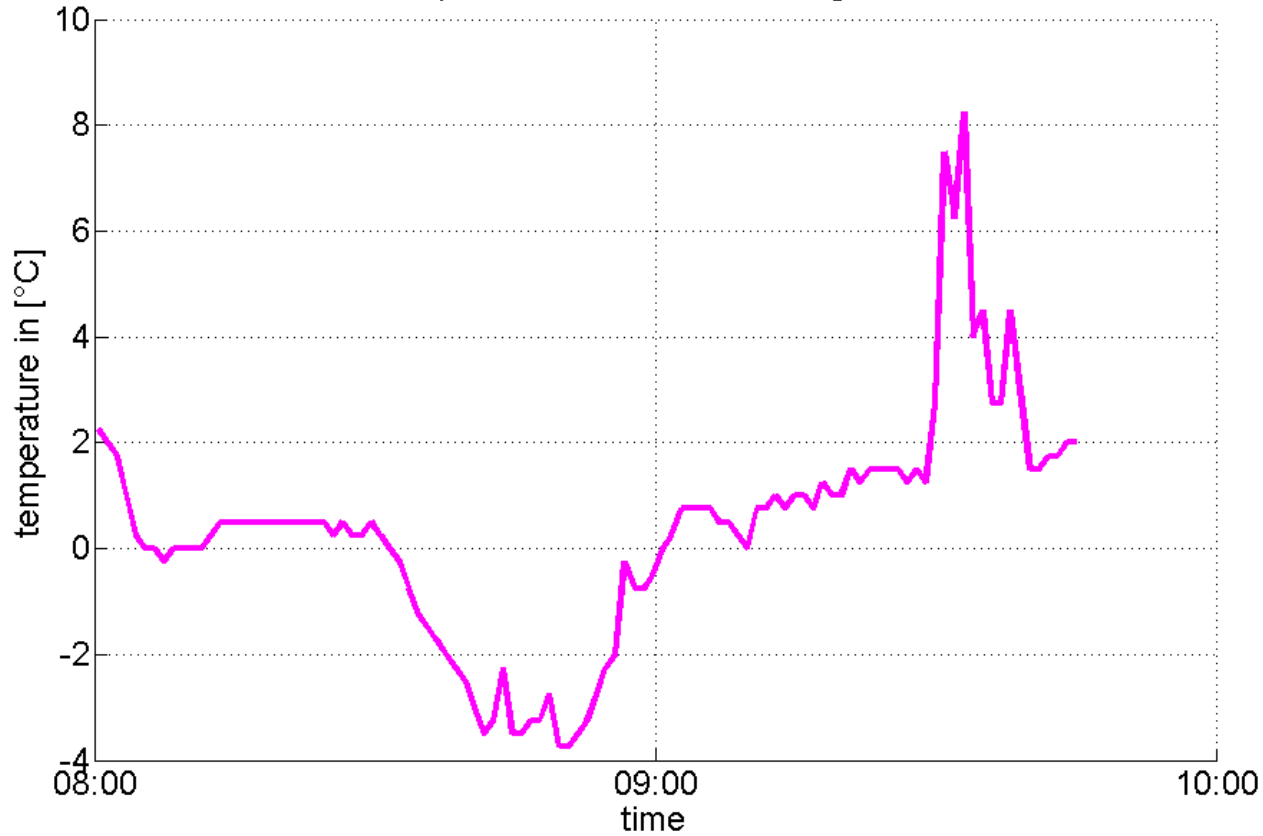
- Fatigue Tests: Wheel Trim
- Icing Channel Tests
- Field Test

Wheel trim



Temperature

Temperature from Graz to Klagenfurt

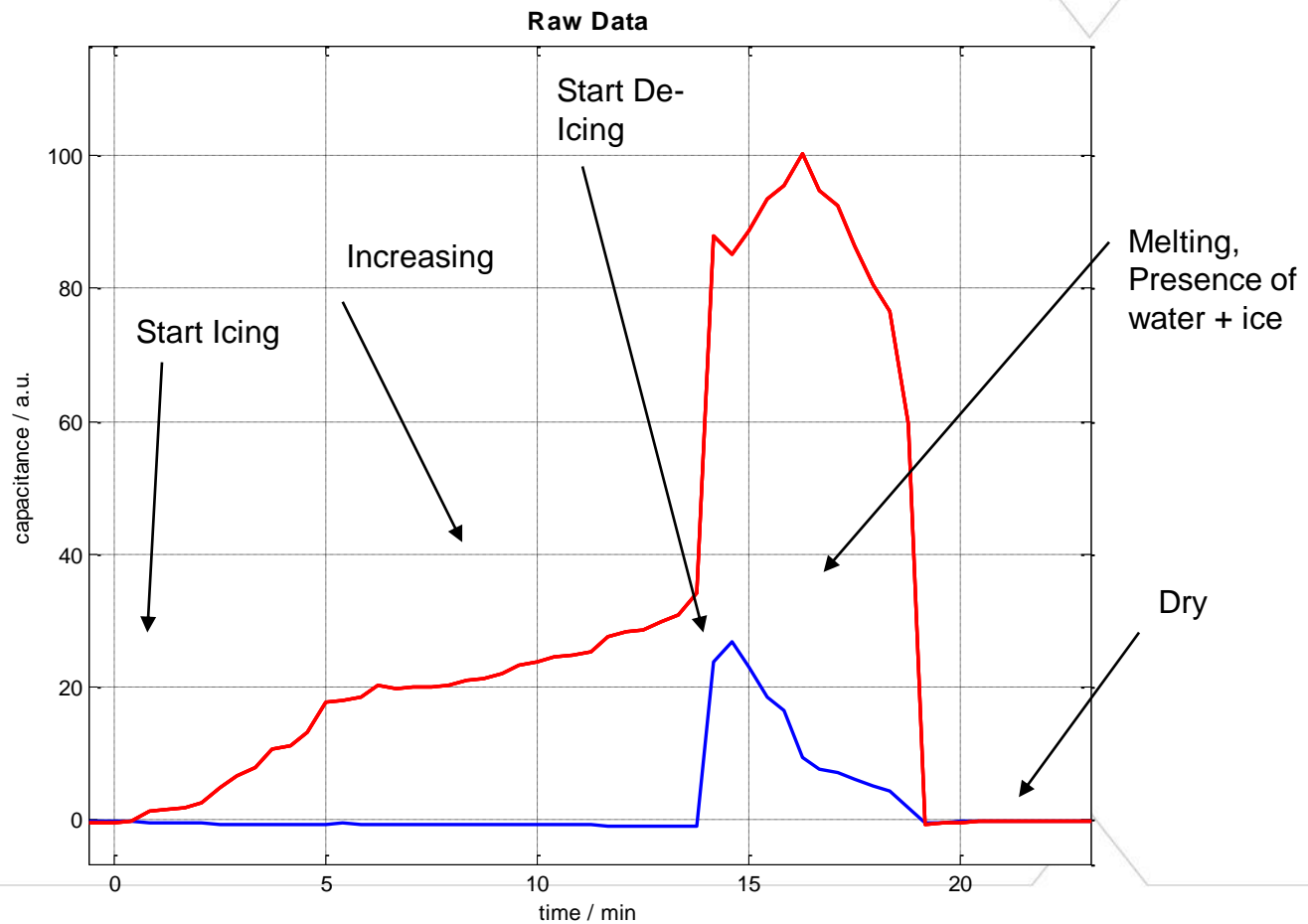


Icing Wind Tunnel 2012



Milky Ice, hard rime
-8°C for ~15 minutes
Wind speed: 10m/s
Ice thickness ~2mm

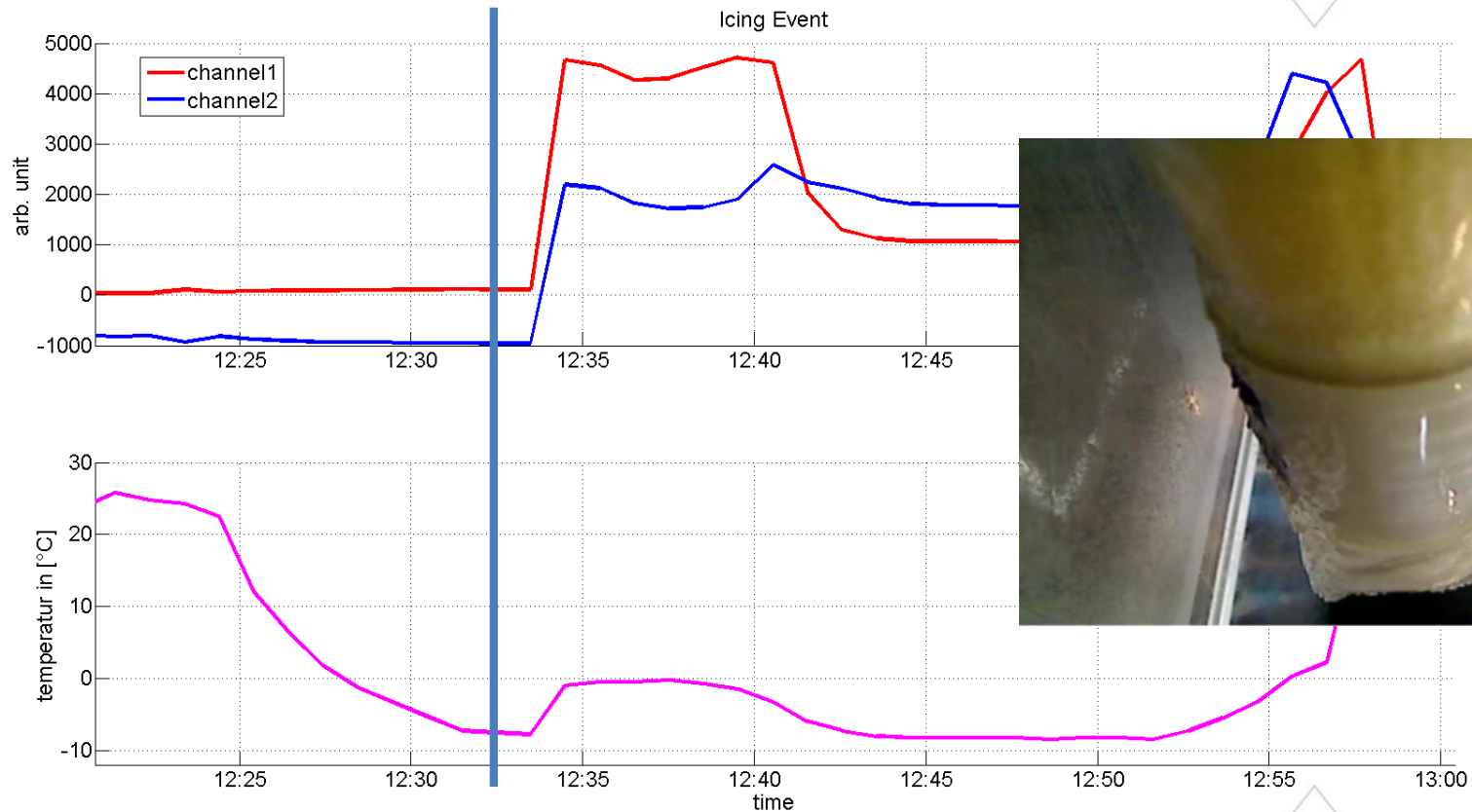
Icing Wind Tunnel 2012



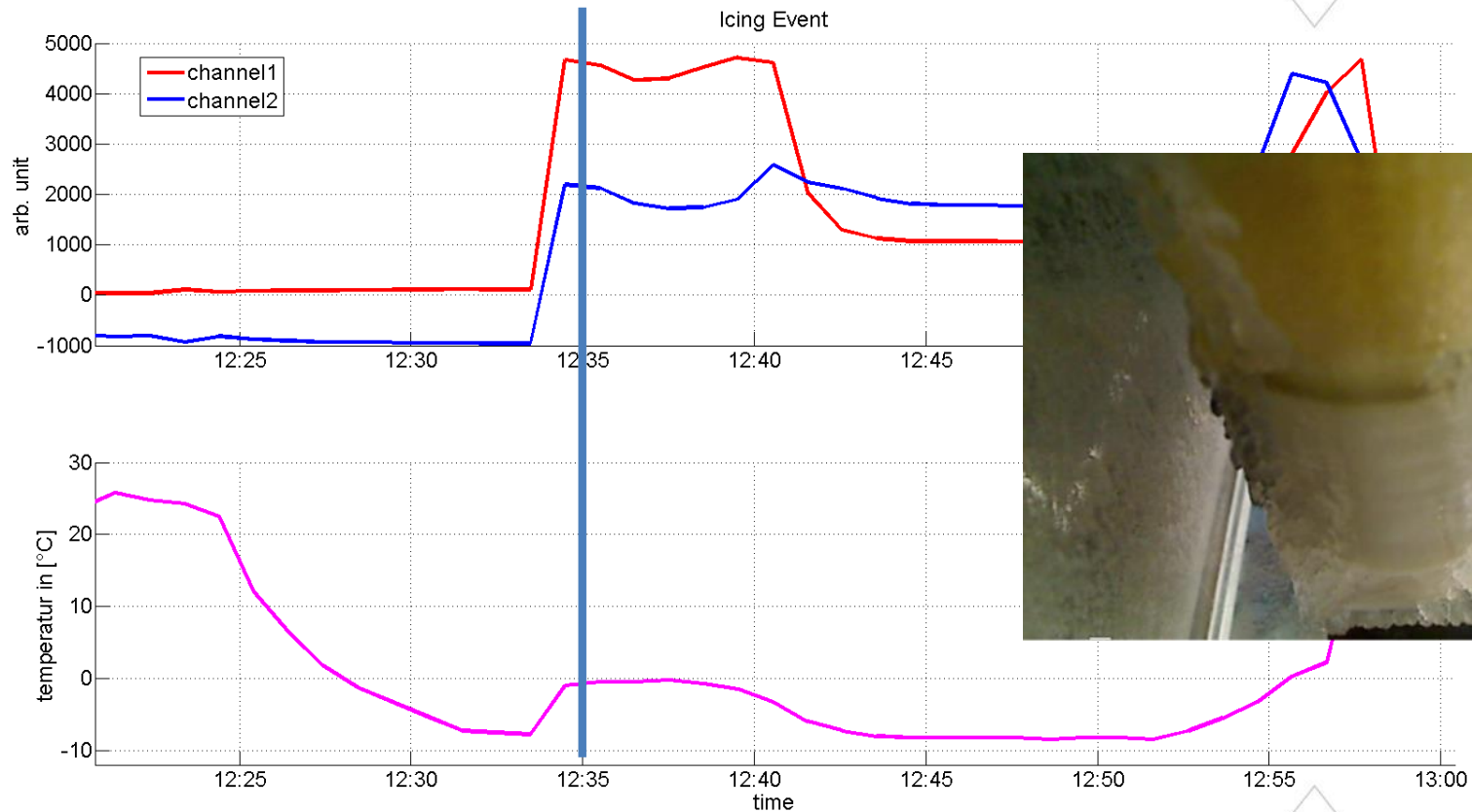
Icing Wind Tunnel 2014 (1)



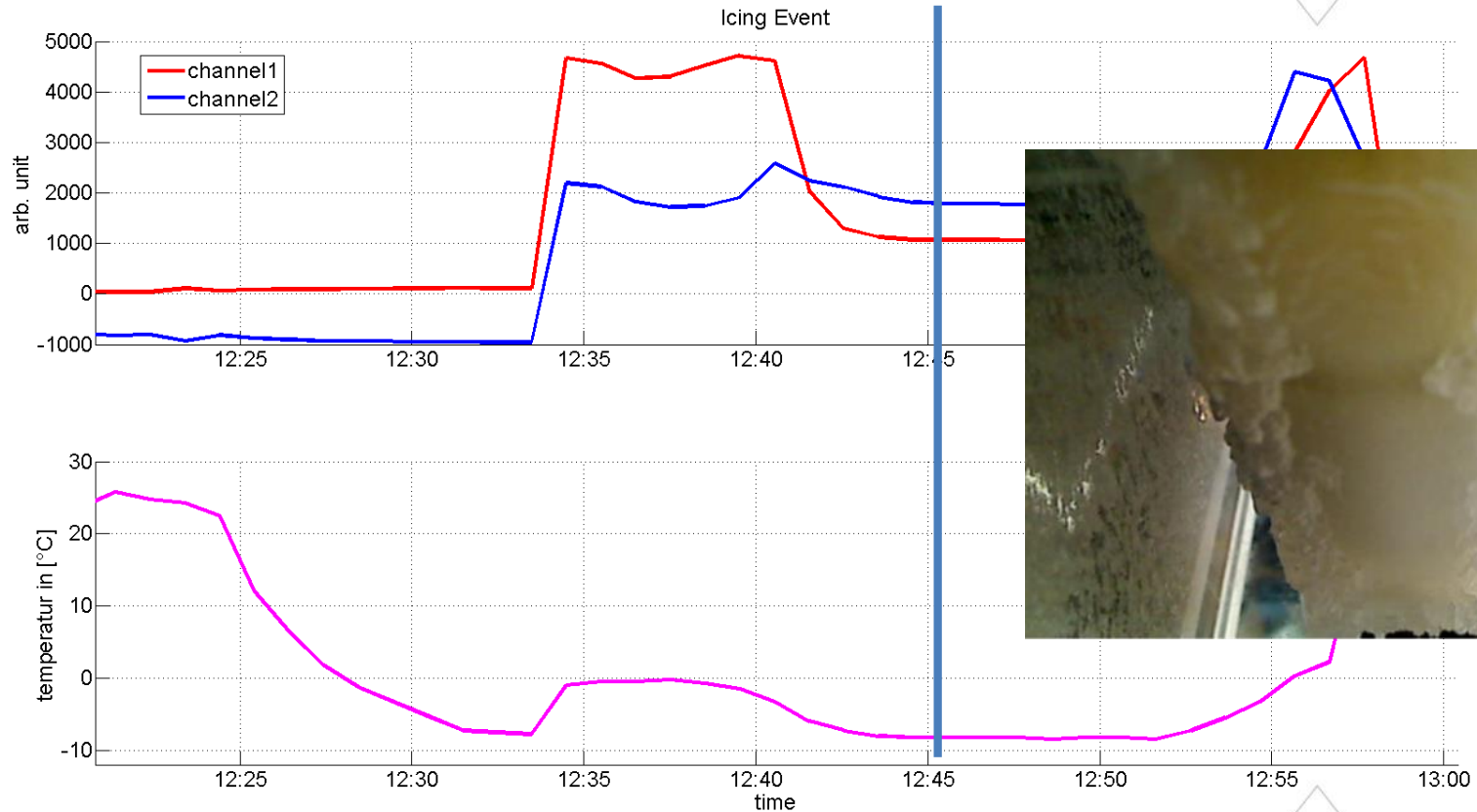
Icing Wind Tunnel 2014 (2)



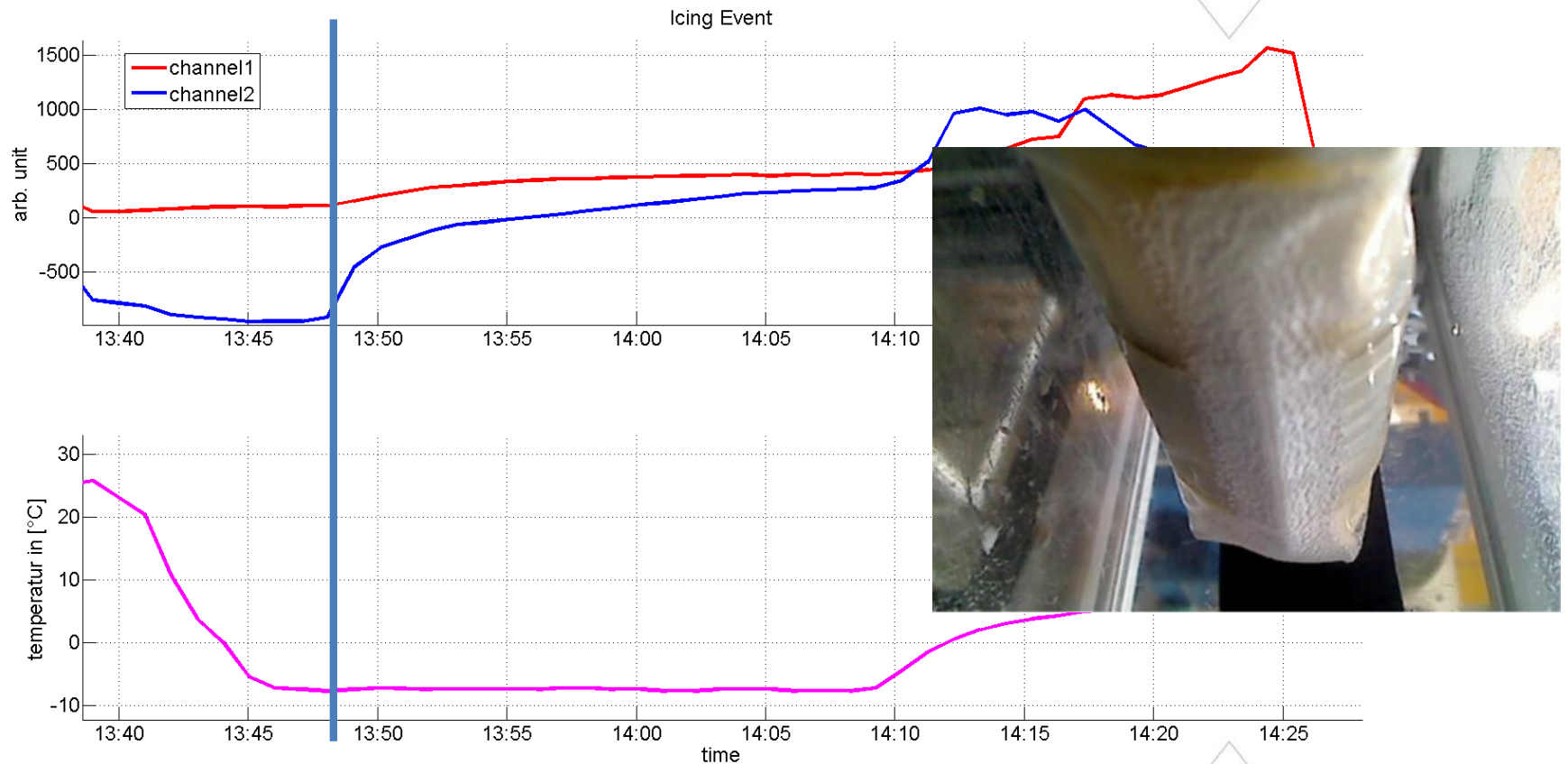
Icing Wind Tunnel 2014 (3)



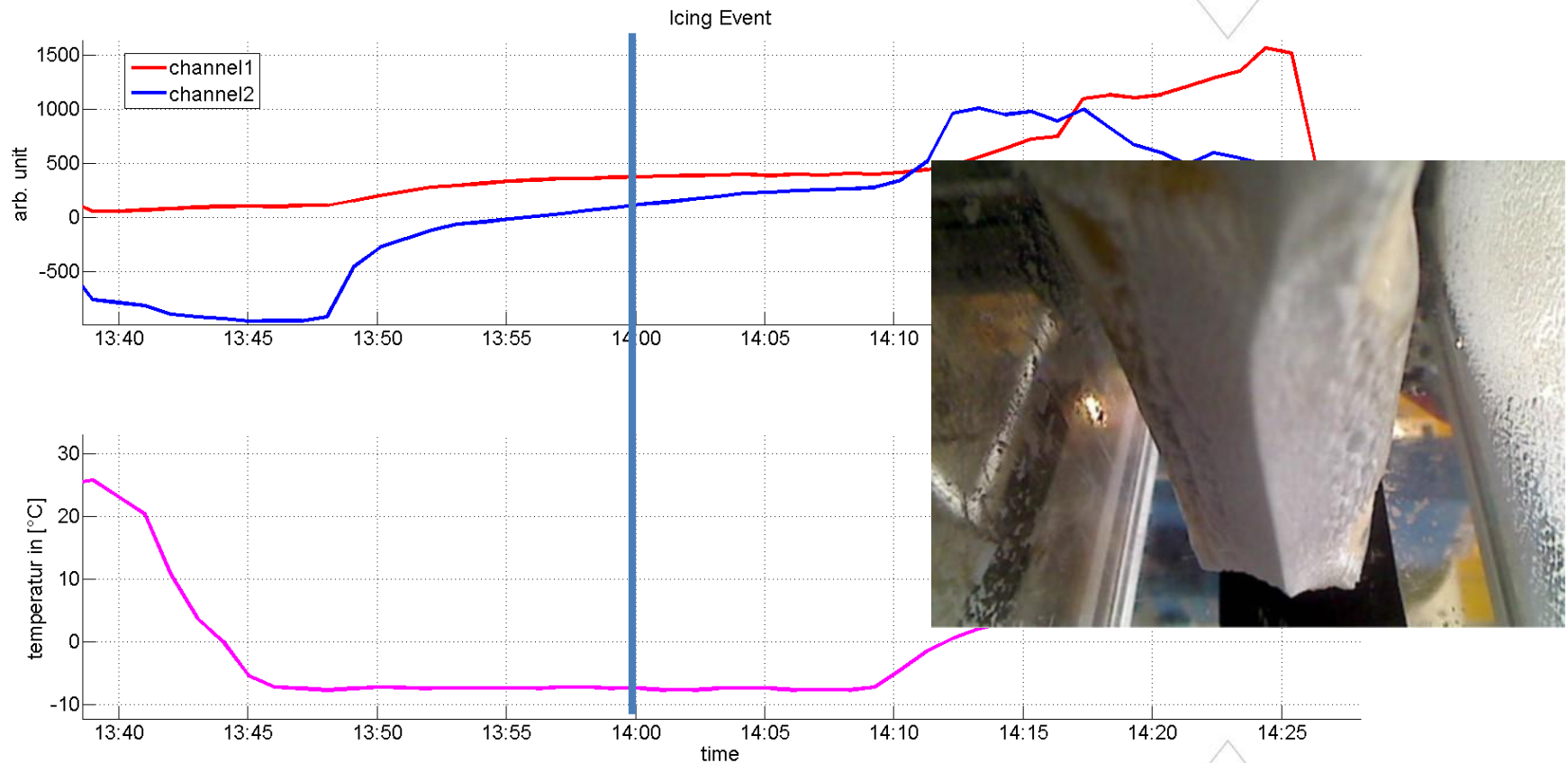
Icing Wind Tunnel 2014 (4)



Icing Wind Tunnel 2014 (5)



Icing Wind Tunnel 2014 (6)

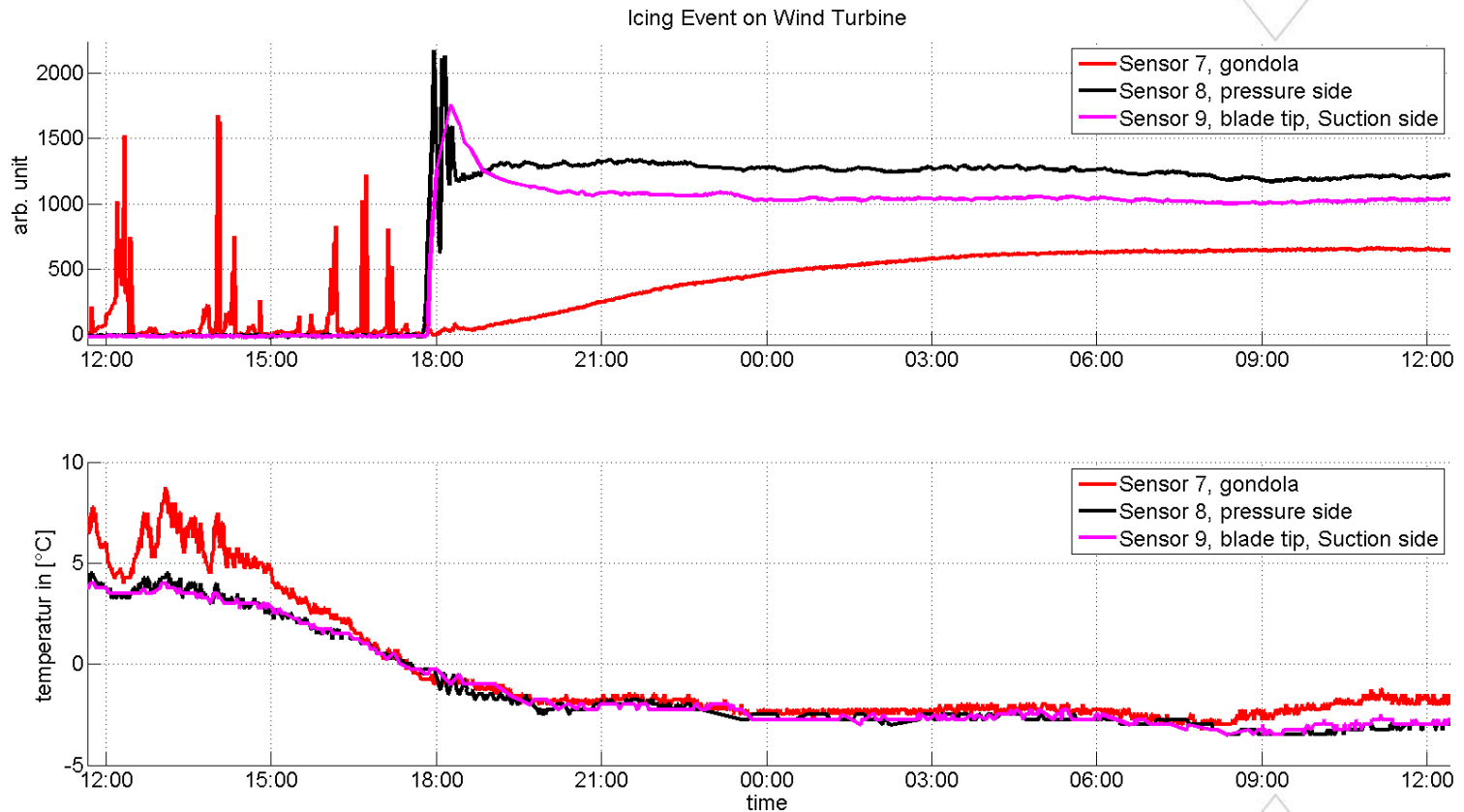


Field Test

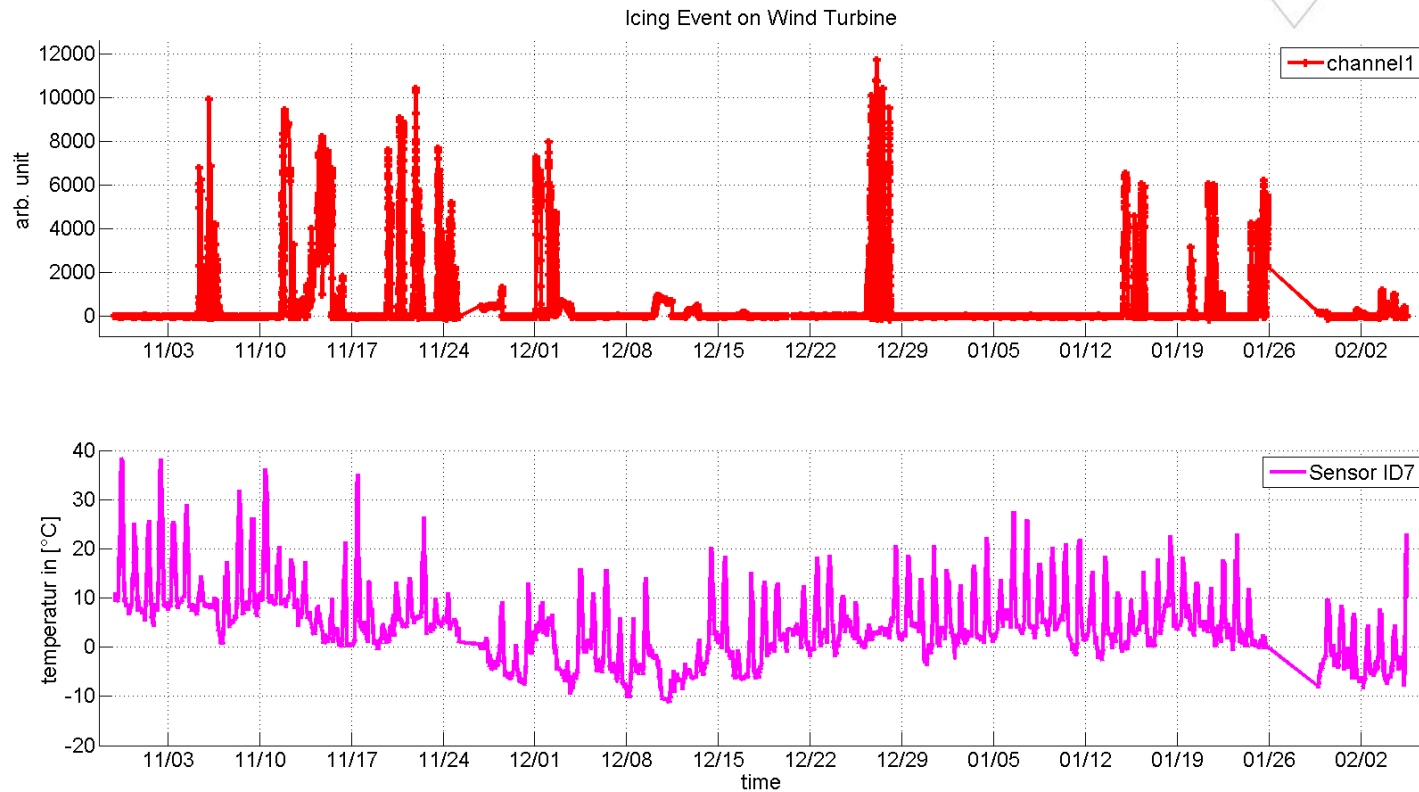


Prototype Installation
(August 2013)

First Detected Icing Event



Long Term Data



Next Activities



- Founding (Q2/2014)
- Specifications (data interfaces) with reference customers
- First Installations (reference customers, Q3/2014)
- Certifications
- Icing Channel Tests - Investigations on Ice Qualities

Summary



- Wireless, retrofittable, thin, flexible, autonomous device
- Icing detection based on capacitance sensing technology
- Fatigue, icing tunnel and field tests (ongoing)
- Promising results
- Available Q3/2014

Thank you for your attention!



Further questions? Meet us at Stand #5!

This project is supported by



Austria Wirtschaftsservice GmbH

Interface Specification



According to customers

(Online / Modbus / Ethernet / Voltage / Current 4-20mA /
Serial / OPC / Alarms...)

Signals e.g.: Ice detected (0/1), Ice layer
decreasing/stable/increasing (0/1/2),

Melting scenario detected (0/1),

Surface Temperature (-40°C -> +85°C)