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APPLICATION OF OMA TO AN OPERATING WIND TURBINE:

NOW INCLUDING VIBRATION DATA FROM THE BLADES

Dmitri Tcherniak, Gunner Chr. Larsen

IOMAC'13

5th International Operational Modal Analysis Conference

2013 May 13-15 Guimarães - Portugal

RISØ DTU

Brüel & Kjær

Agenda

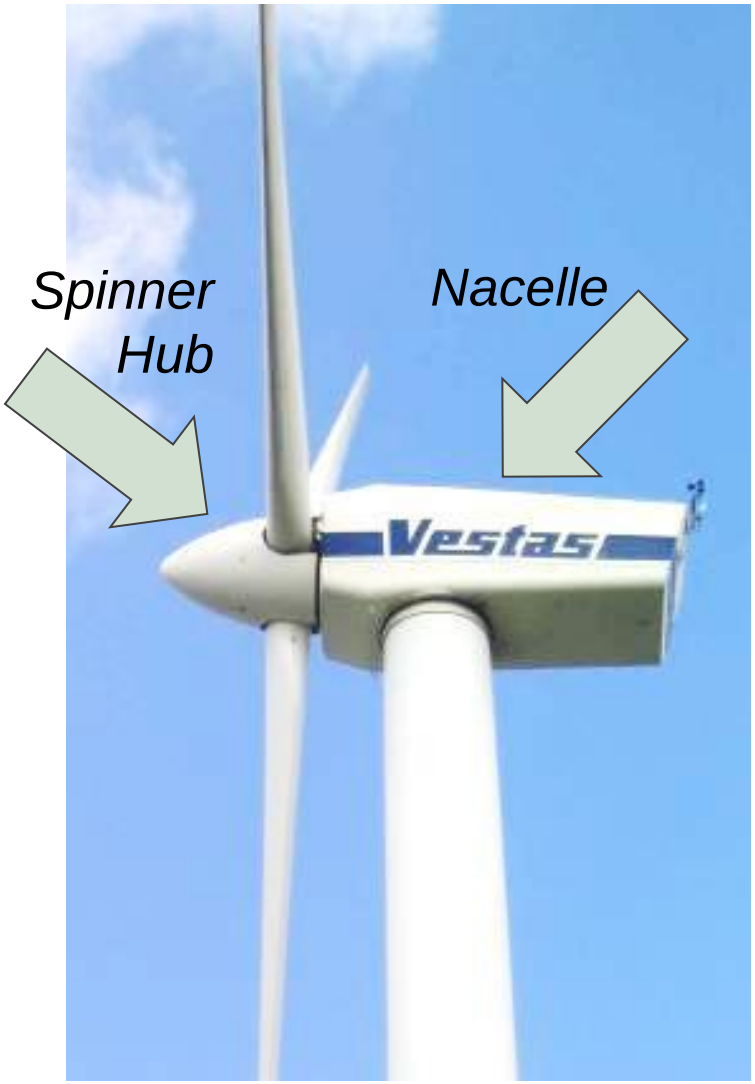
- Motivation
- Details on the measurement system (HW and SW)
- Preliminary results

Motivation

- Understanding dynamics of an operating WT
- Application of different post-processing techniques
- Future: Use for monitoring purposes:
  - Support from Danish Energy Development Programme (EUDP)
  - Designing robust HW and acquisition SW
  - Designing robust health monitoring algorithms

The system is…

- 42-ch frontend is placed in the hub, so it goes up to 43 RPM together with the rotor
- The data (4096 Hz sampling frequency) goes wireless to the nacelle (not rotating part)
- Another 12-ch module is placed in the nacelle. The data streams from the two modules are synchronized using IRIG-B signals (GPS)



The system is…

- The accelerometers are mounted on the outer surface of the blades
- The blade tip accels move with the speed of 65 m/s (235 km/h)
- The system is running 24/7 from the end of October 2012
- Currently the system it is still up and running, though we lost few sensors

Vestas V27 – the test object

V27

Old Vestas wind turbine

Horizontal axis

Pitch-regulated

225kW rated power

27m rotor diameter

30m high tower

46 RPM nominal RPM

V27 video

Meas. system – overall architecture

- 12 x monoaxial accels on each blade

- 2 x DC accels.
- Pitch sensor
- IRIG-B (sync.)

- 42-ch LAN-XI data acq. frontend

- Access point Cisco AP1262
- 2 x omni-dir. antennas

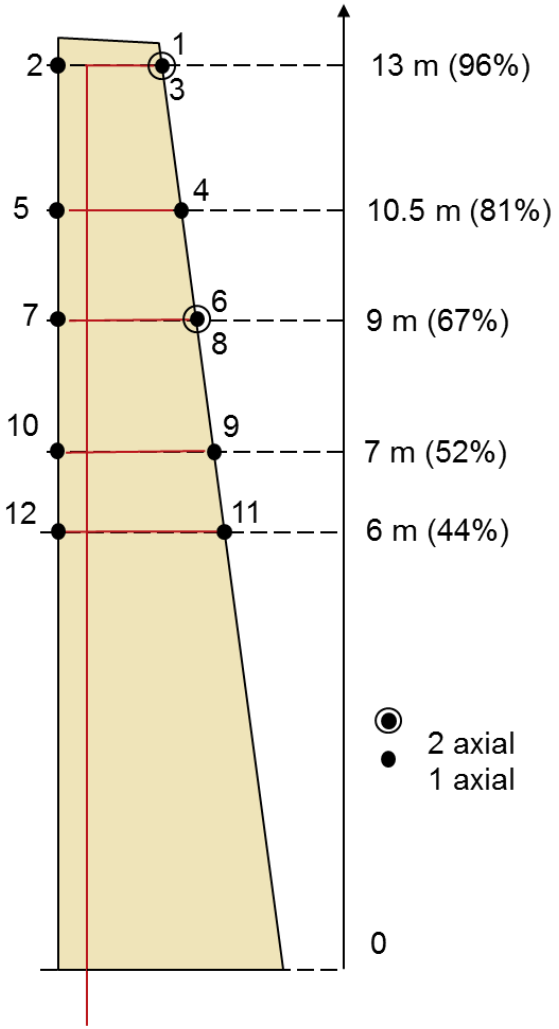
- 3 x triax accels
- Tachoprobe on HSS
- IRIG-B (synch.)

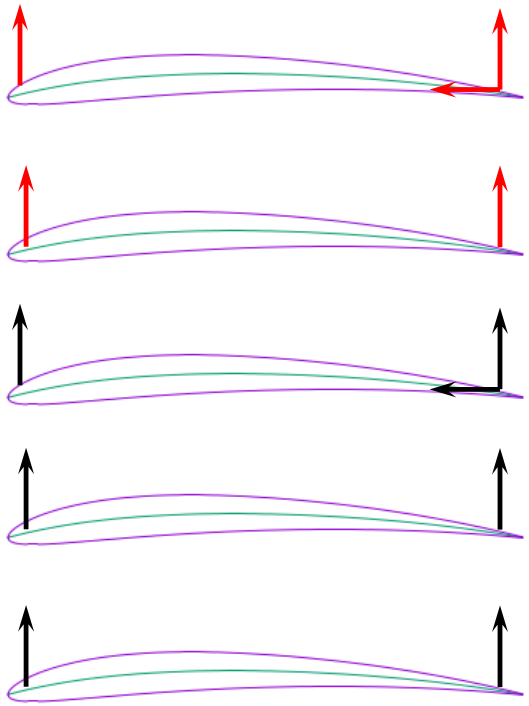
- 12-ch. LAN-XI data acq. module

- Access point Cisco AP1262
- 2 x directional antennas

- Meas. PC running PULSE Data Recorder

Blades instrumentation, 12 accels per blade





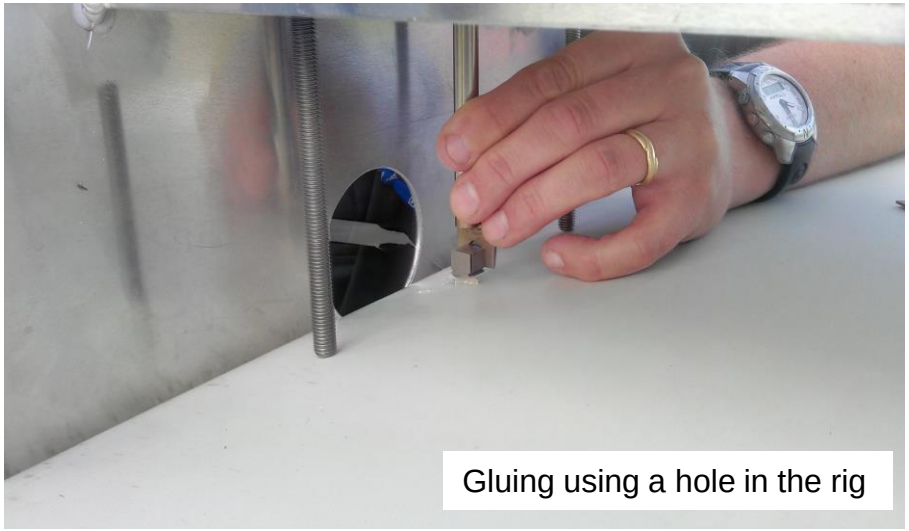
Rotor down

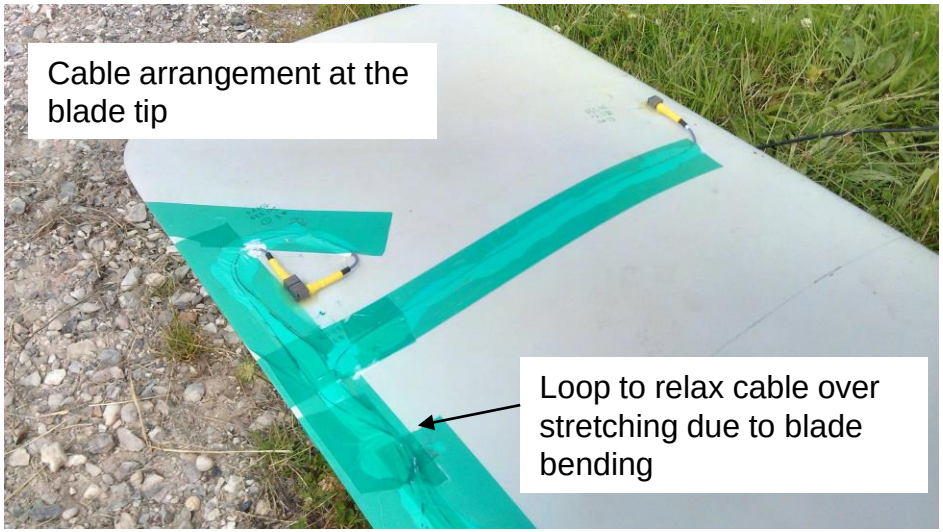
With the small V27 we had a luxury of taking the rotor off and placing it on the ground.

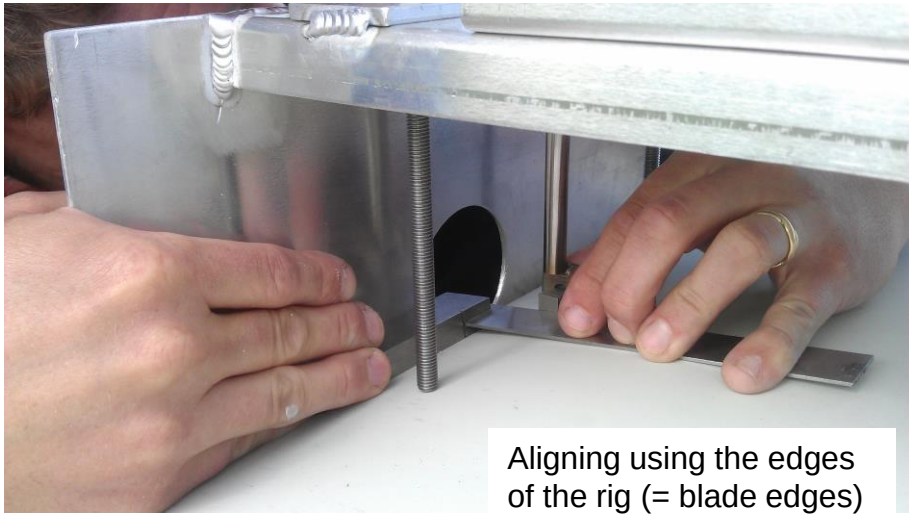
There will be no such a luxury for big wind turbines.

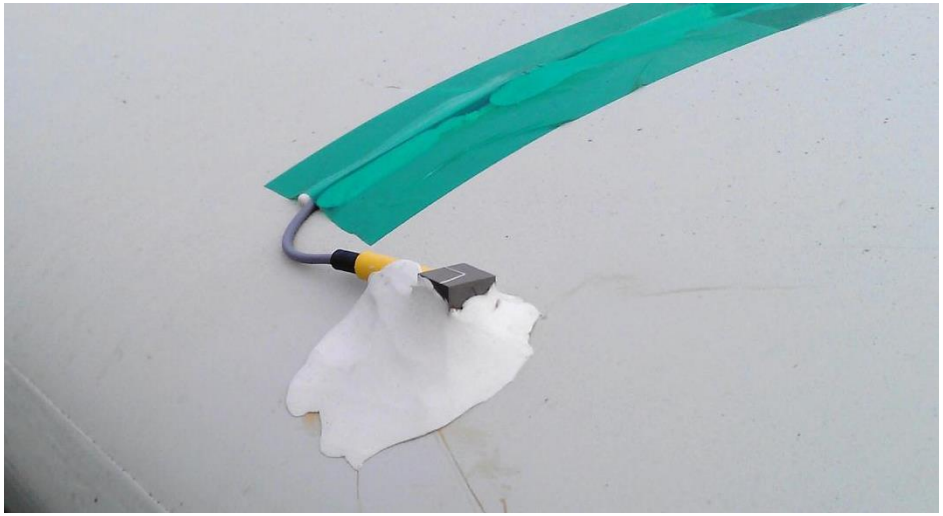
Template for mounting accels

Mounting process

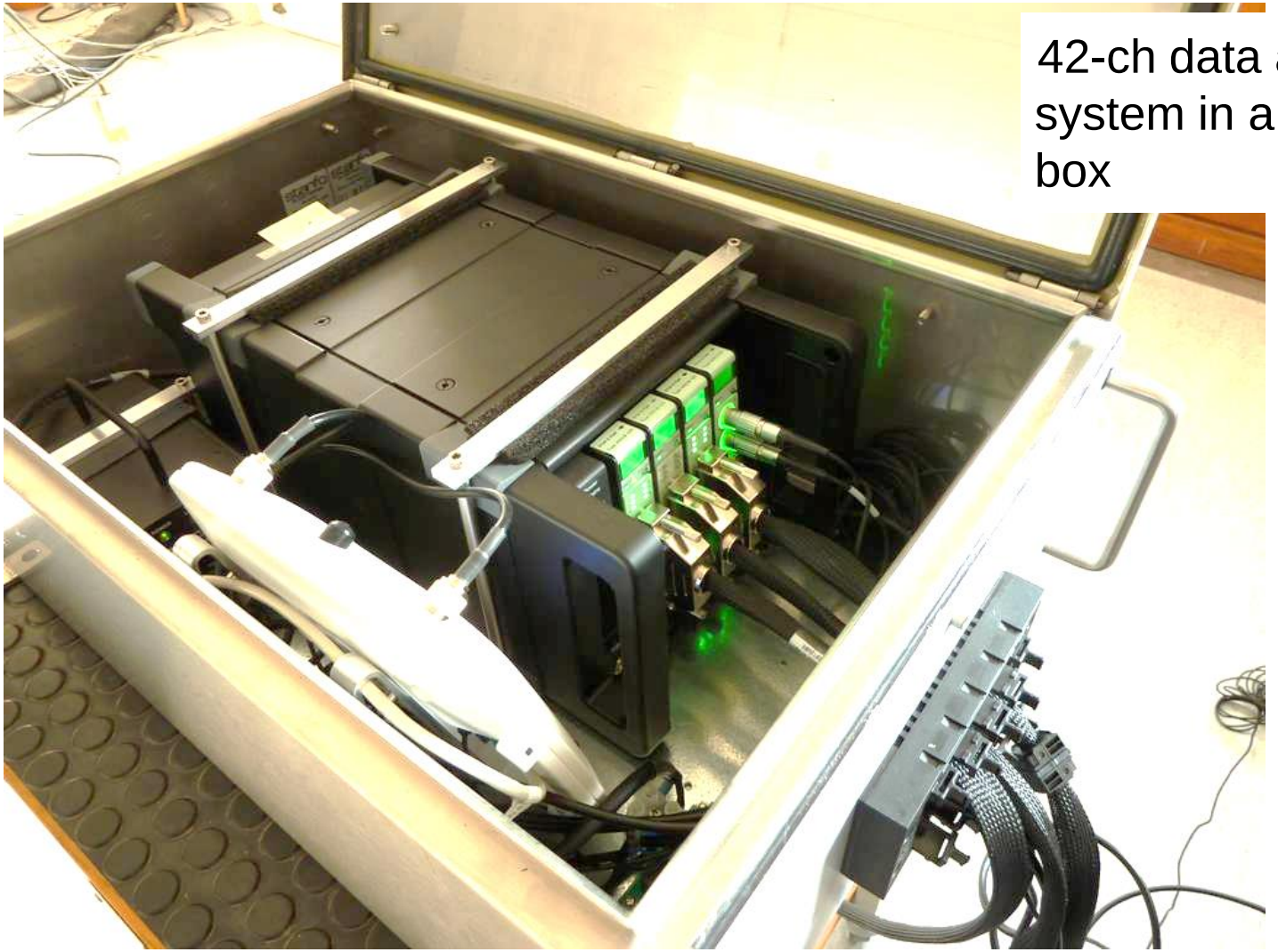






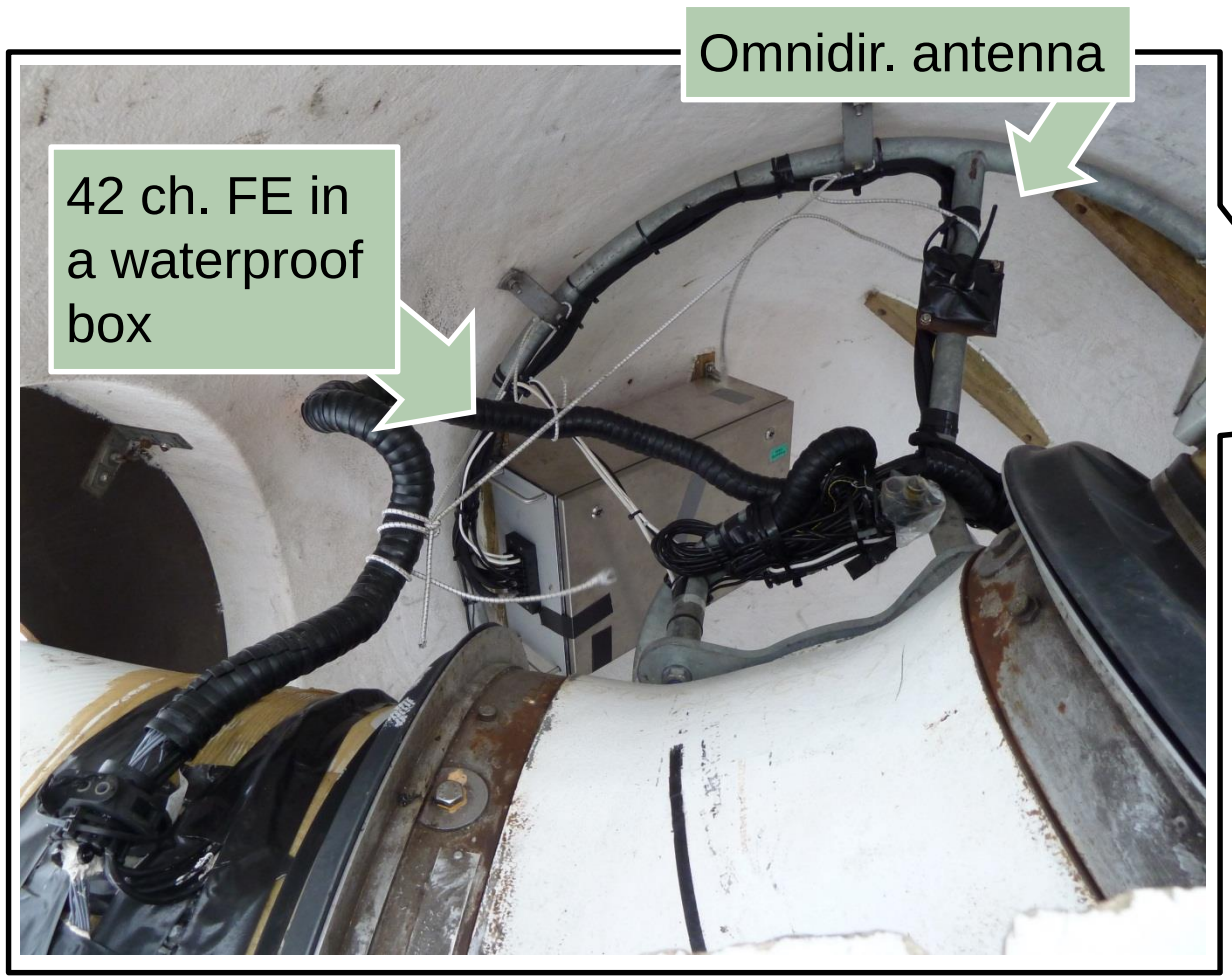


Data acquisition system



42-ch data acquisition system in a waterproof box

Instrumented rotor is up in the air

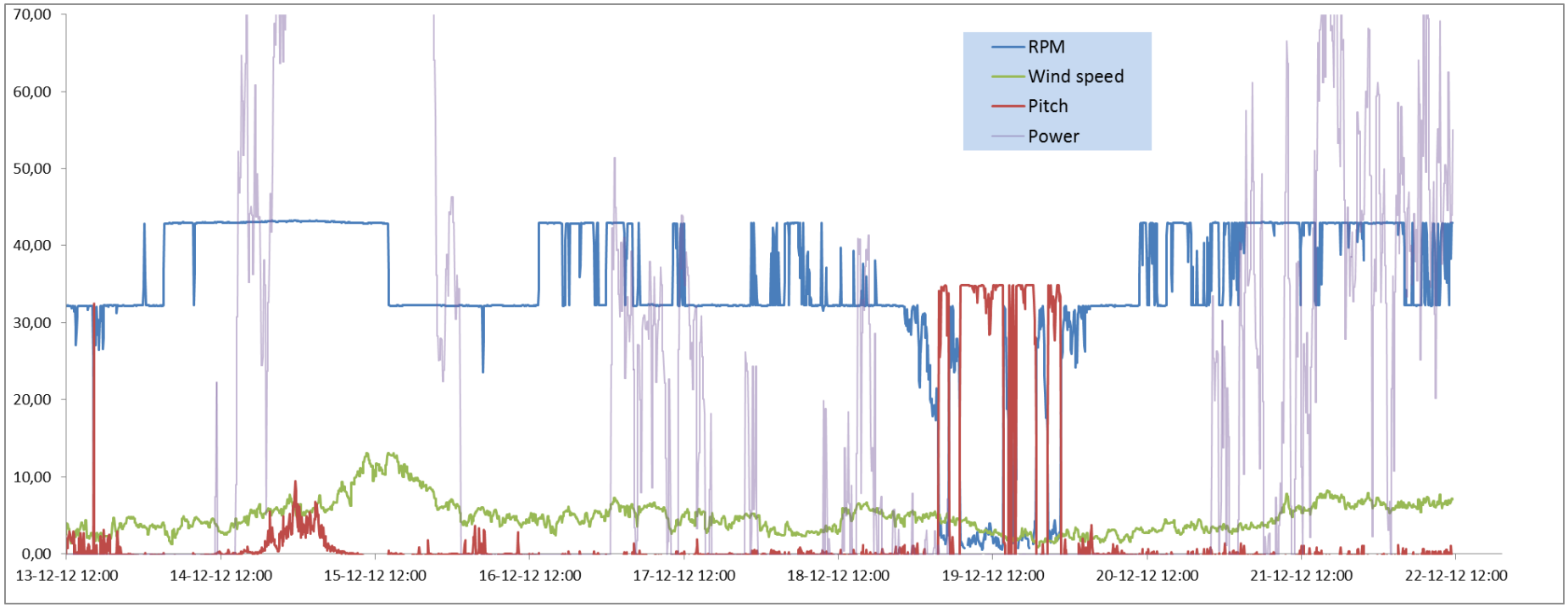


Wireless data transmission

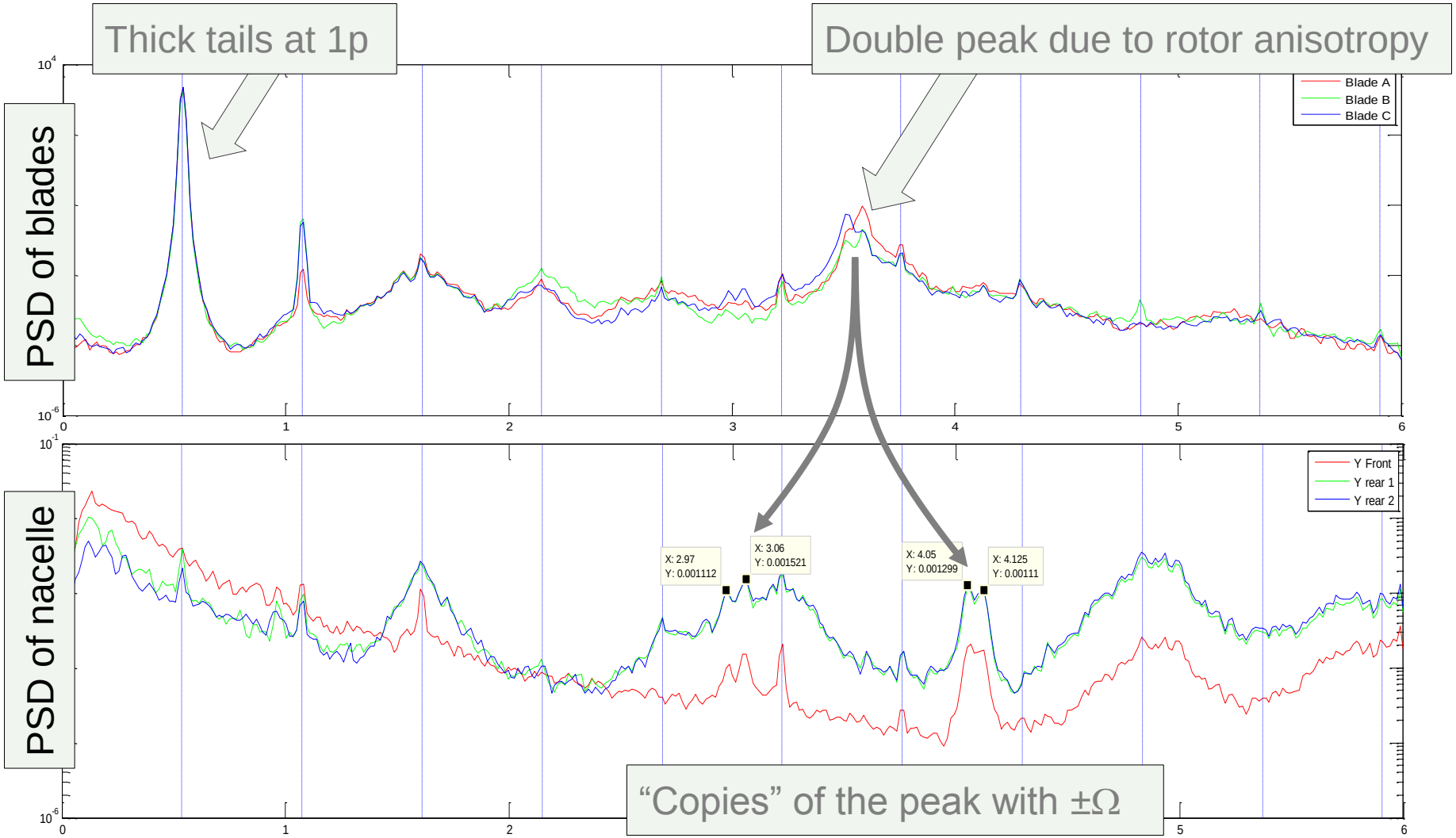
40 ch. x 4096 smpl/s.. data transmitted from the rotating part with the line of sign sometimes blocked: need for professional (though standard) WiFi equipment

Recordings database

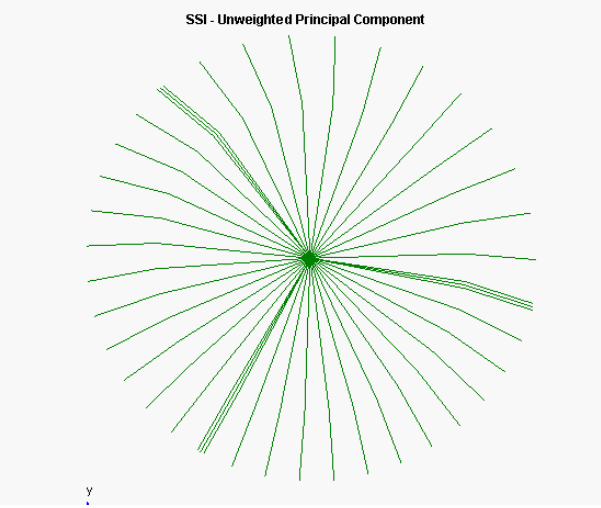
- Recording database synchronized with weather data
- The database has sorting/filtering capabilities; it is useful for selection of data for analysis



Preliminary results: PSD, blades and nacelle

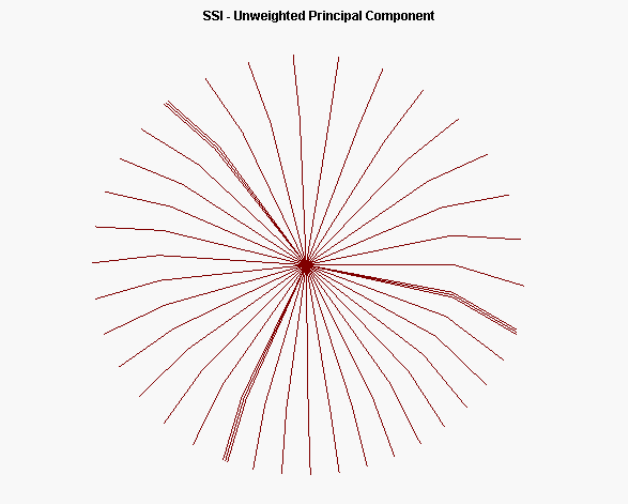


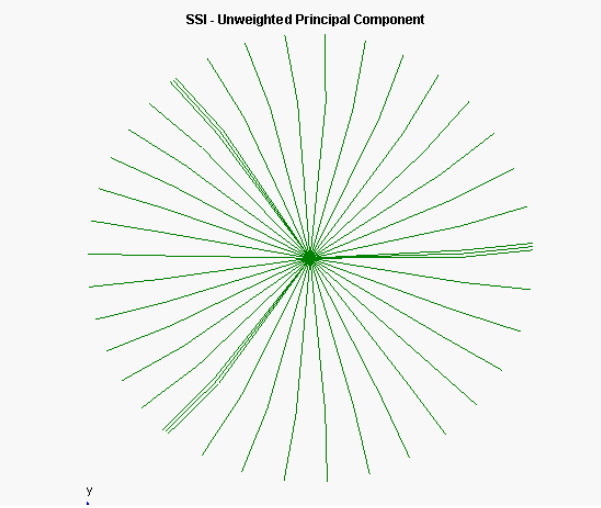
Preliminary results: in-plane whirling rotor modes



Measured
I1FW,
3.53Hz

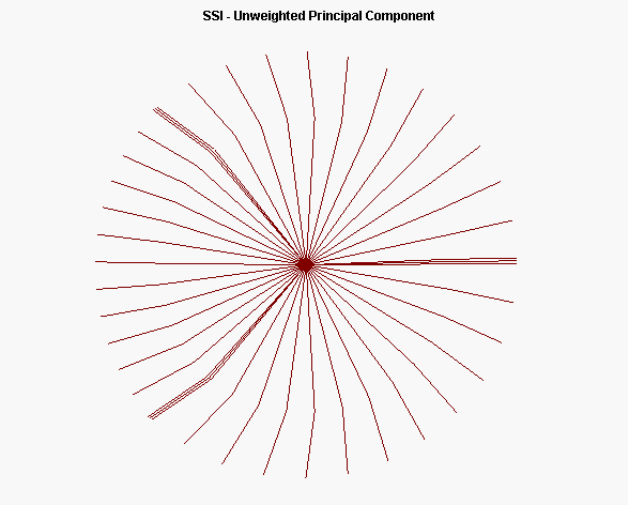
Simulated
I1FW





Measured
I1BW,
3.61Hz

Simulated
I1BW



Preliminary results: in-plane rotor modes

V27 I1FW mode (CCW)

V27 I1BW mode (CW)

V27 I2 Collective mode

Simulated I1FW mode

Simulated I1BW mode

Conclusion

- The system is up and running in quite harsh environment during the last 6 months:
  - Data acquisition system
  - Wireless data transmission
  - GPS synchronization
  - Accelerometers/cabling on the blades – I lost quite few! – something to learn.

- Data analysis started
  - Different techniques to be tried out, including MBC and Lyapunov-Floquet, harmonic removal, maybe… TOMA?
  - I hope, we could present some results at IMAC 2014