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Wind Engineering



## Aeroelastic measurements on a vertical axis wind turbine

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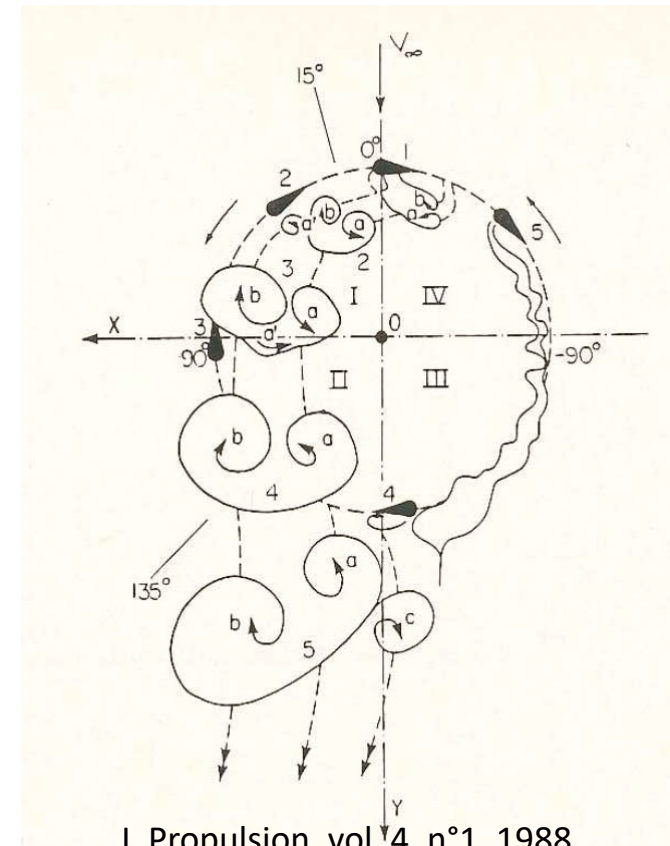


## Vertical Axis Wind Turbines (VAWT)

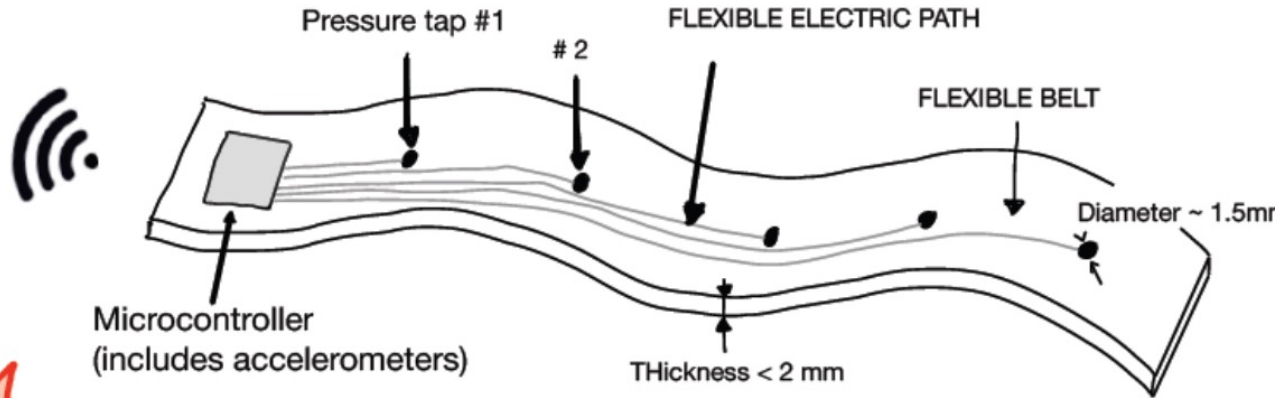
- Aerodynamic loading on the blade varies along the azimuth
- Risk of dynamic stall and/or torque fluctuation
- Resulting aeroelastic vibrations

## In this work

- Development & validation of a new type of measurement device  
**WAMB** = Wireless Aeroelastic Measurement Belt
- On site measurements on a VAWT
- Comparison with numerical results (Qblade)



# WAMB - genesis



Proximus Tower



Fairwind VAWT



Arc majeur

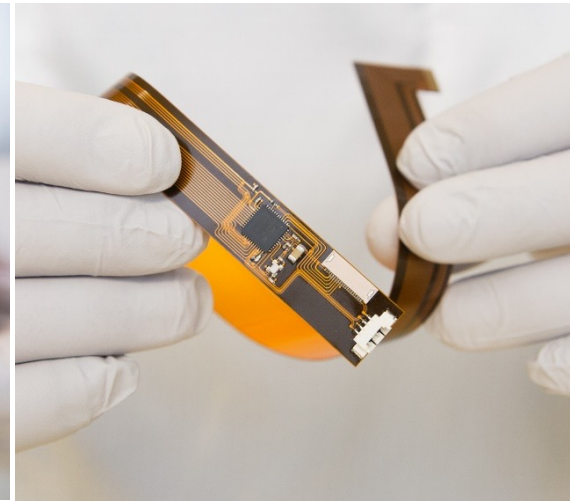
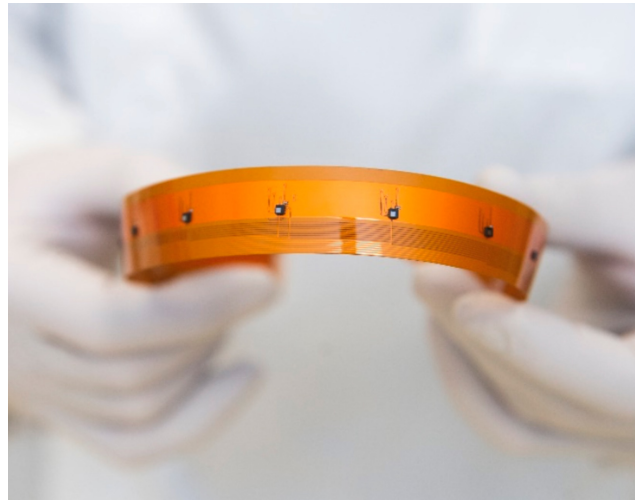
# WAMB – first prototypes

Flexible/Thin/Adaptable device including:

- 13 pressure taps
- One 3-axis accelerometer

Acquisition frequency = 60Hz

Excluding : cables !



# WAMB – wind tunnel validation



Blade from the VAWT fixed statically

NACA0018 airfoil profile

Comparison with pressure measurements from DPMS (TFI Ltd.)



WAMB

Taps from DPMS

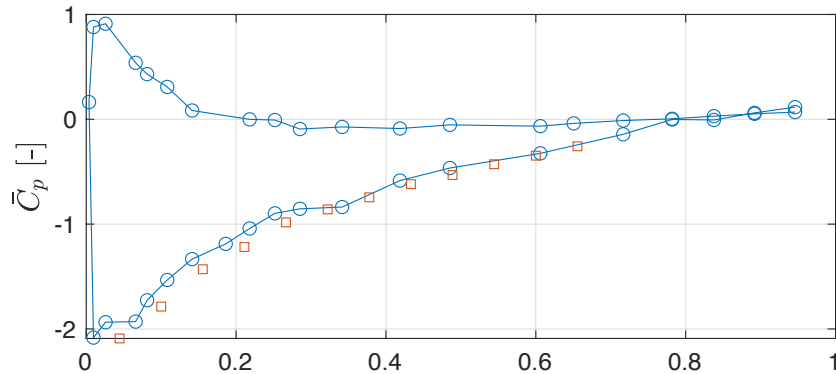


# WAMB – wind tunnel validation

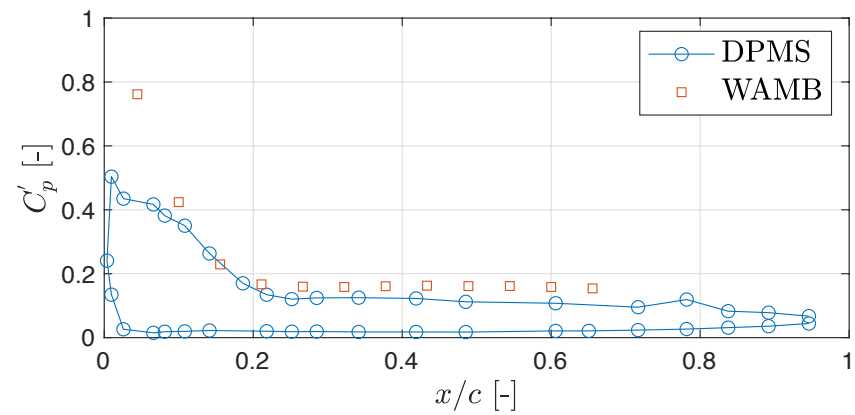
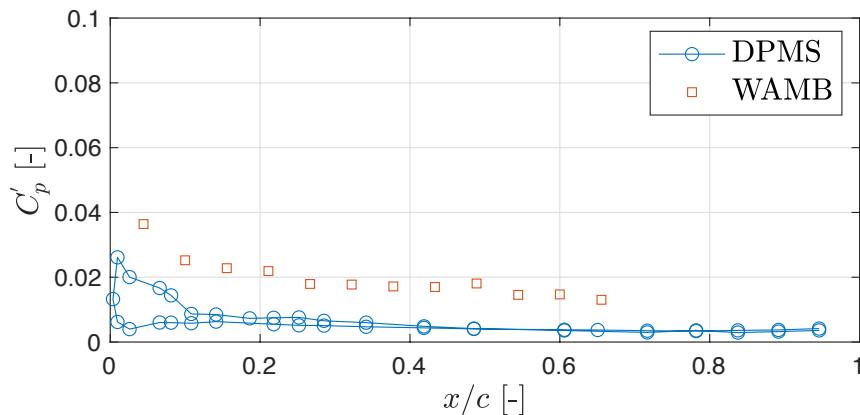
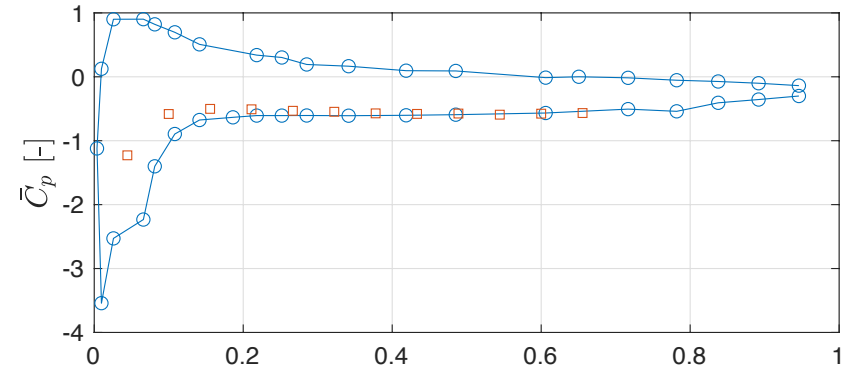


Comparison of  $C_p$  coefficients: Mean ( $\overline{C_p}$ ) and STD ( $C_p'$ )

$AoA = 10^\circ$



$AoA = 20^\circ$



# On site measurements on VAWT



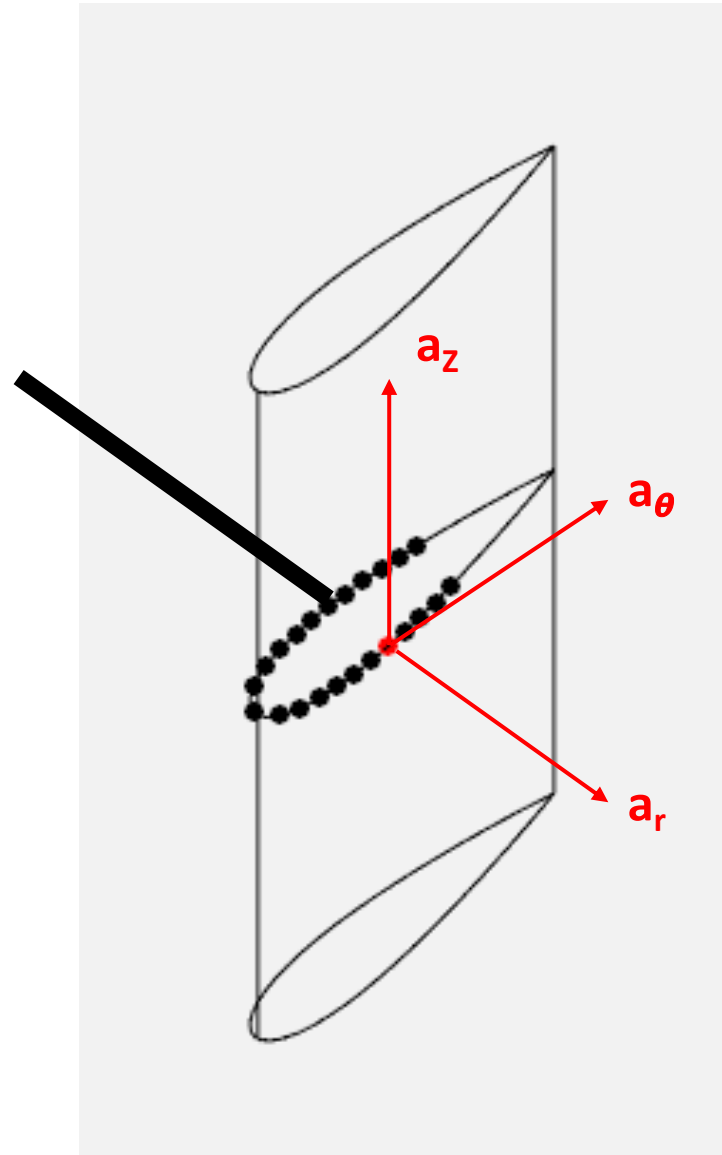
## Installation on one blade



# On site measurements on VAWT



## Sign conventions



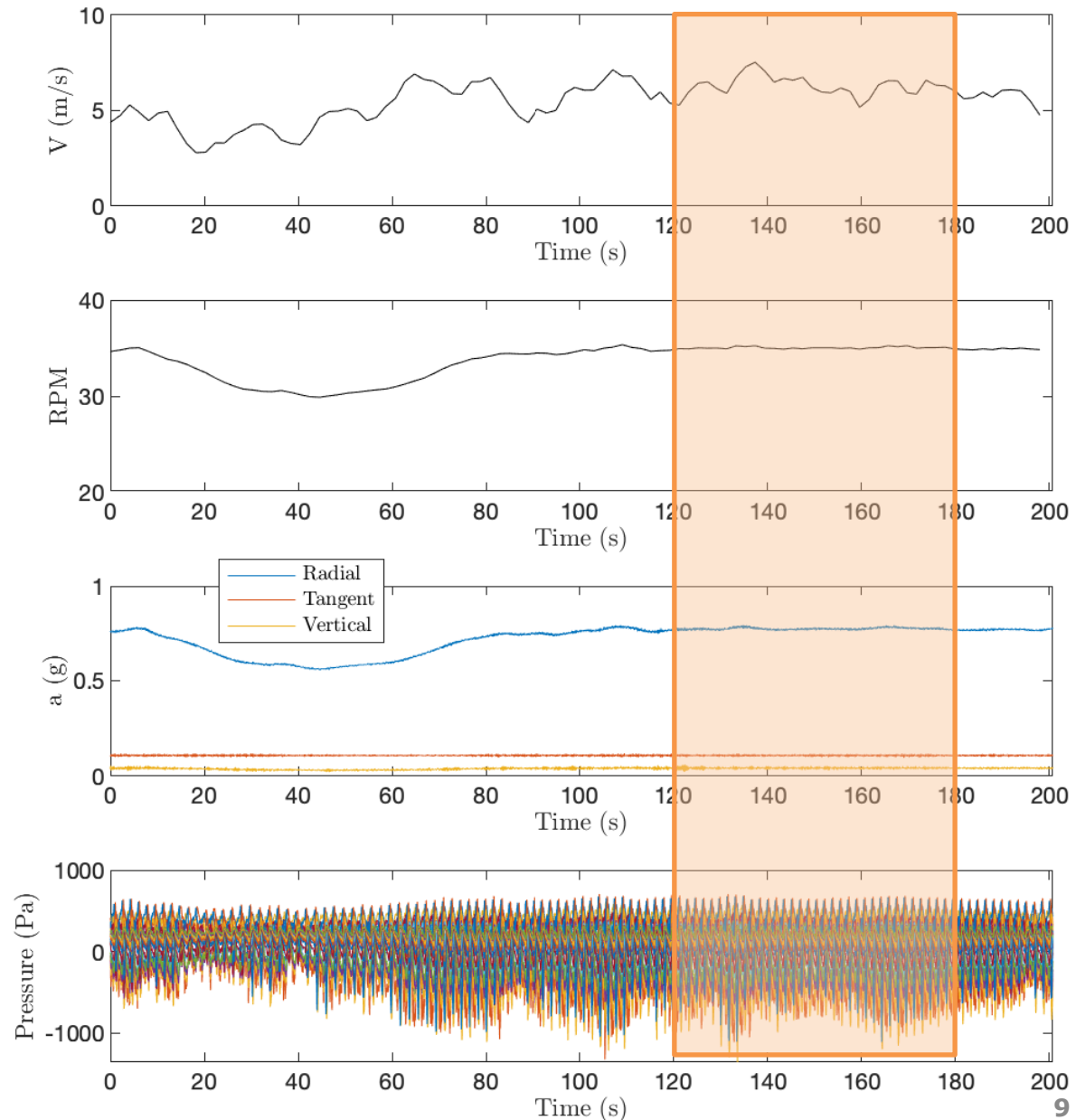


# On site measurements on VAWT



Example of data set

→ Extraction of events  
= cst rotating conditions



# On site measurements on VAWT



Selected events (60 sec)

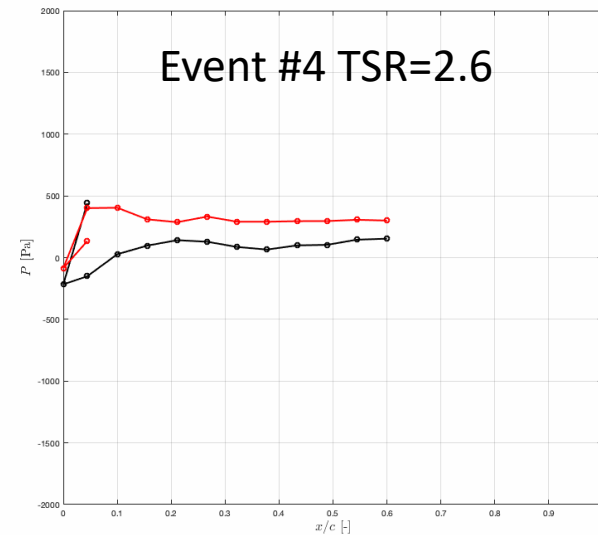
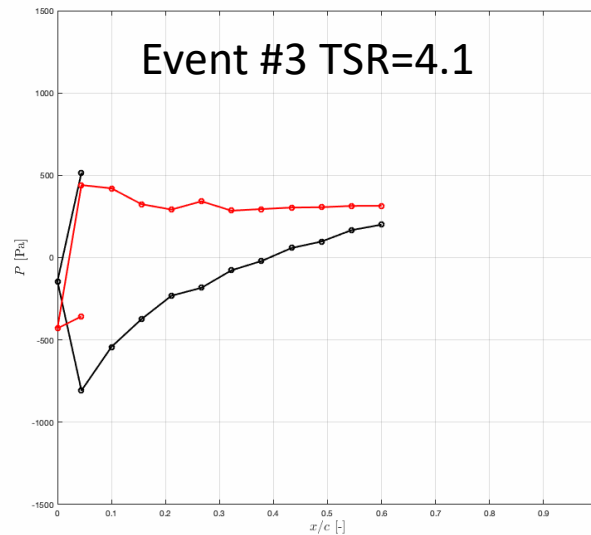
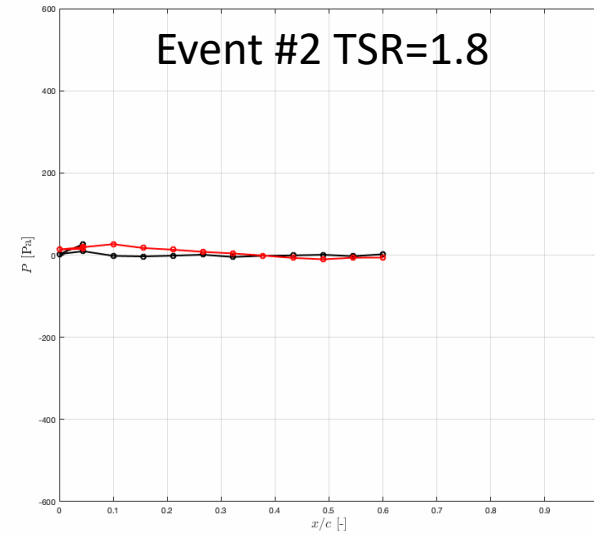
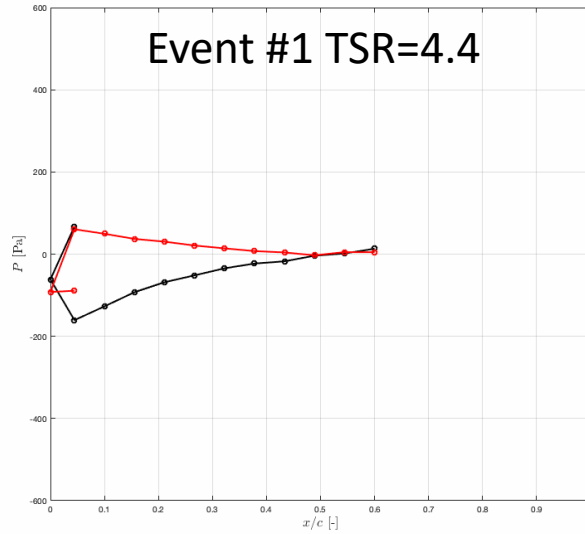
Event	Wind speed	Rotation speed	TSR
1	2m/s	15RPM	4.4
2	5m/s	15RPM	1.8
3	5m/s	35RPM	4.1
4	8m/s	35RPM	2.6

Figure CP vs TSR

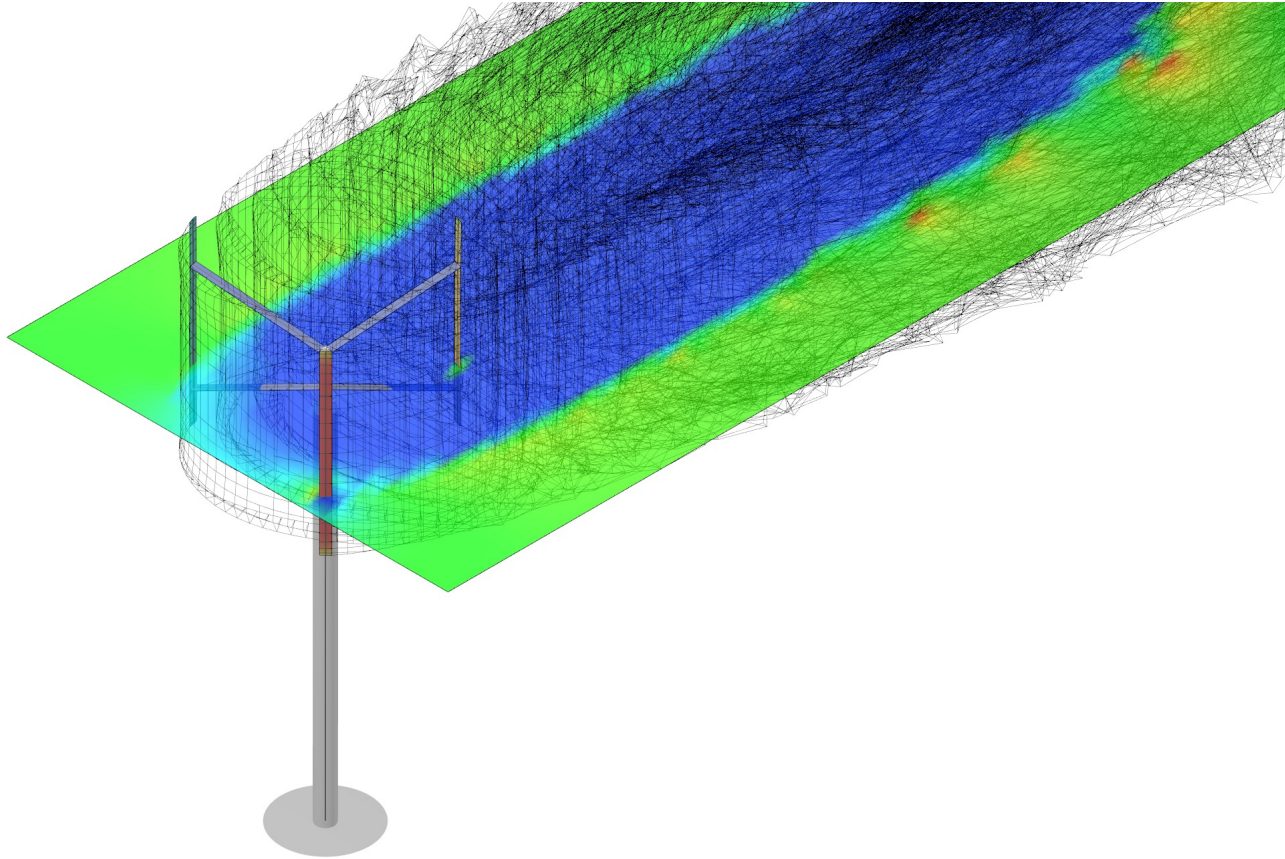
# On site measurements on VAWT



## Unsteady pressure distributions of events



# Comparison with Qblade



Qblade = Multiphysic numerical tool developed by TUBerlin

In this work: Aeroelastic simulations of events

Aerodynamic model = Lifting Line Free Vortex Wake (LLFWW)

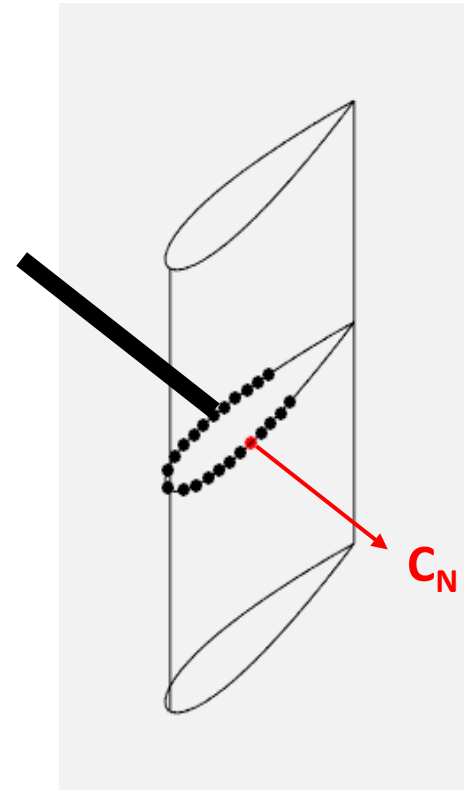
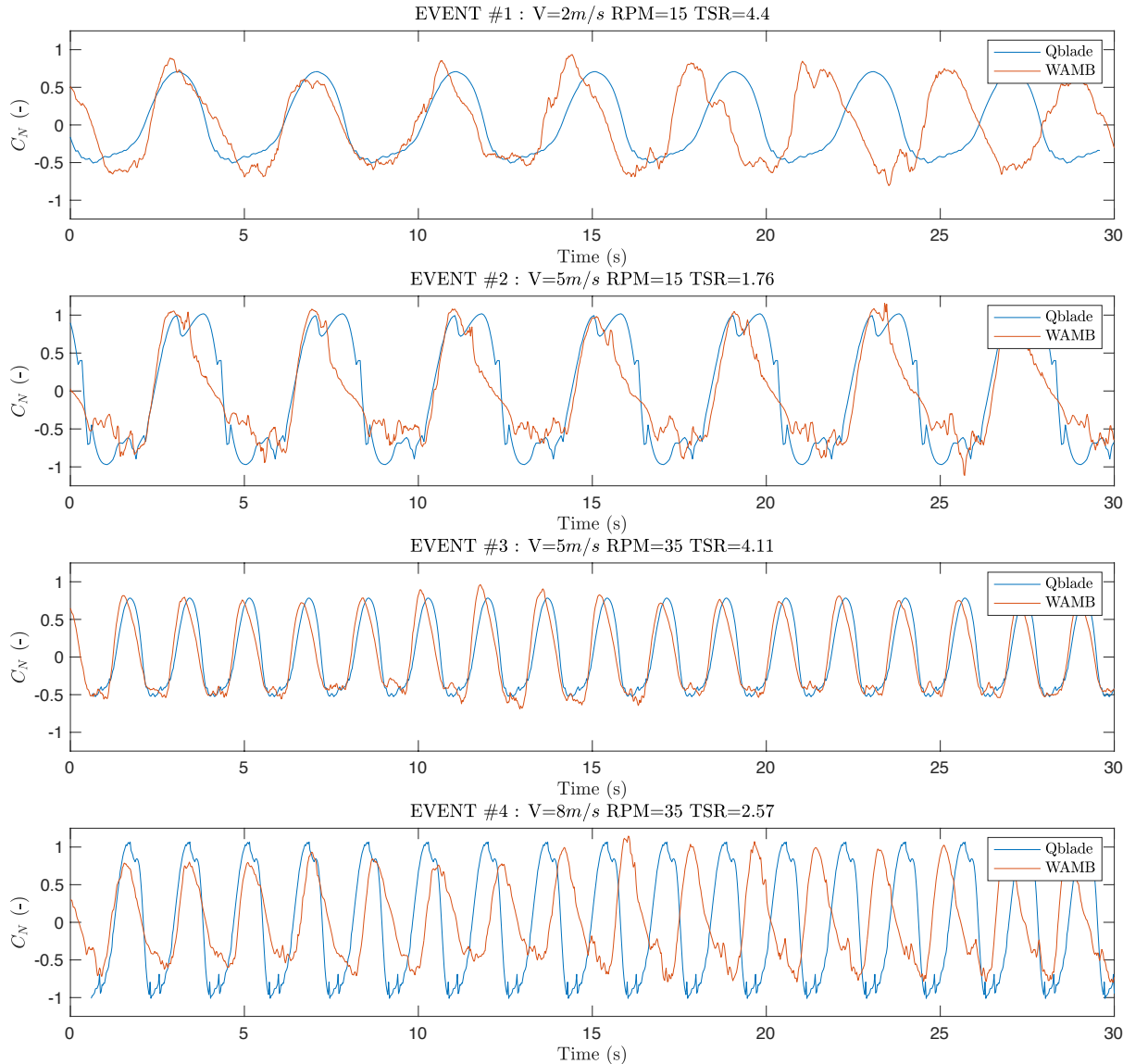
Structural model = Multi-body with rigid and flexible non-linear beams<sub>12</sub>



# Comparison with Qblade



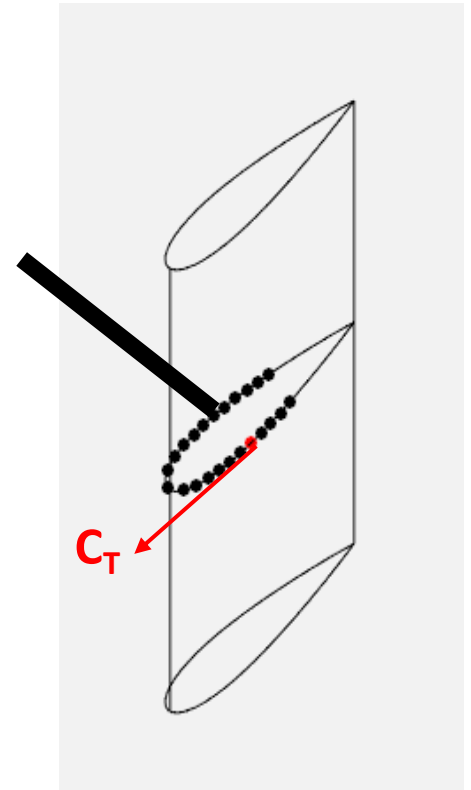
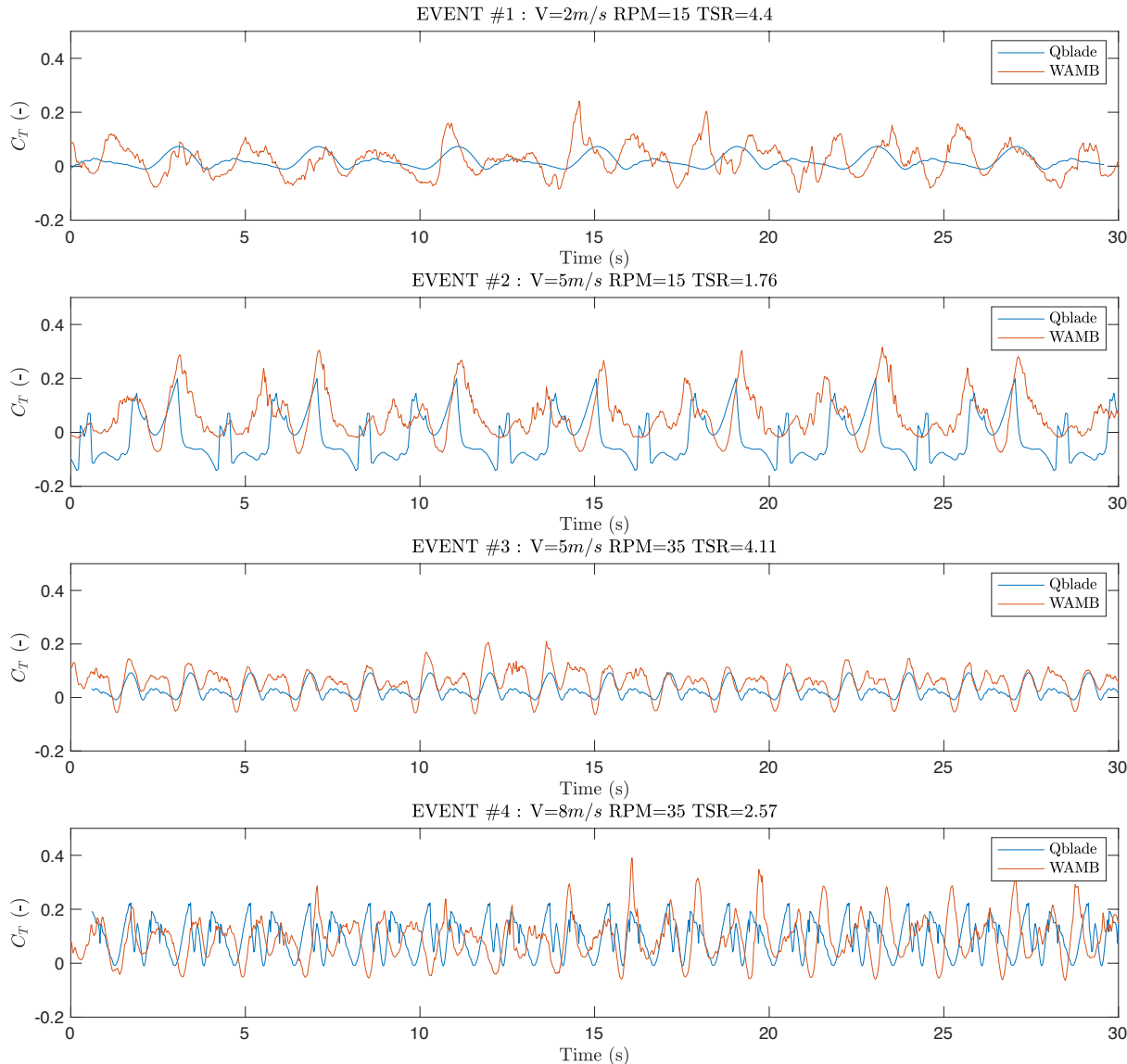
## Calculation of a “partial normal force” ( $C_N$ )



# Comparison with Qblade



## Calculation of a “partial tangent force” ( $C_T$ )



# Conclusions and perspectives

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## Until now:

- Instrumentation of a blade
- 4 events : 2 stalled, 2 attached
- Comparisons with Qblade

## In the future:

- WAMB covering the blade up to the trailing edge
  - Access to  $C_T$  and the torque
- Measurement in configurations leading to stall
  - Measurement of vibration with accelerometers of the WAMB
- Additional Qblade aeroelastic simulations
  - Comparison of pressures, forces and accelerations