# On the Aerodynamically Generated Sound in Centrifugal Compressors

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The present project aims at a physics-based understanding of the aerodynamically generated noise in centrifugal compressors and its propagation in turbocharging systems such as those employed by Volvo Cars.

An initial stage of the project focuses on using Reynolds Averaged Navier-Stokes (RANS) based formulations and available acoustic models implemented in commercial solvers. Given the unsteady nature of acoustics, the project will develop towards correlation of acoustic sources and far-field noise by means of compressible flow simulations using the Large Eddy Simulation (LES) approach. Enhanced understanding of the aerodynamic noise generation process in centrifugal compressors will open new avenues towards developing noise suppression technologies.

## Introduction and Motivation:

Increasing environmental concerns, along with demand for passenger safety and comfort, pressure the automotive industry to achieve competitive edges by pursuing, among others, lower noise levels for the power train system. The industrial need linked with the project is to reduce the acoustic impact of Volvo cars on the environment and increase the comfort of both driver and passengers.

The current research targets a quantification of the sound generating acoustic sources in centrifugal compressors for operating conditions of interest. The problem of noise propagation in the intake system will be assessed by considering the coupling between the compressor and the upstream/downstream installation elements (e.g. intercooler, ducts, resonators, bypass pressure valves). Noise suppression technologies at source will be proposed and analysed.

## Setup:

BorgWarner Turbo Systems (BWTS) - MP compressor, on CD-adapco STAR-CCM+, RANS simulations:

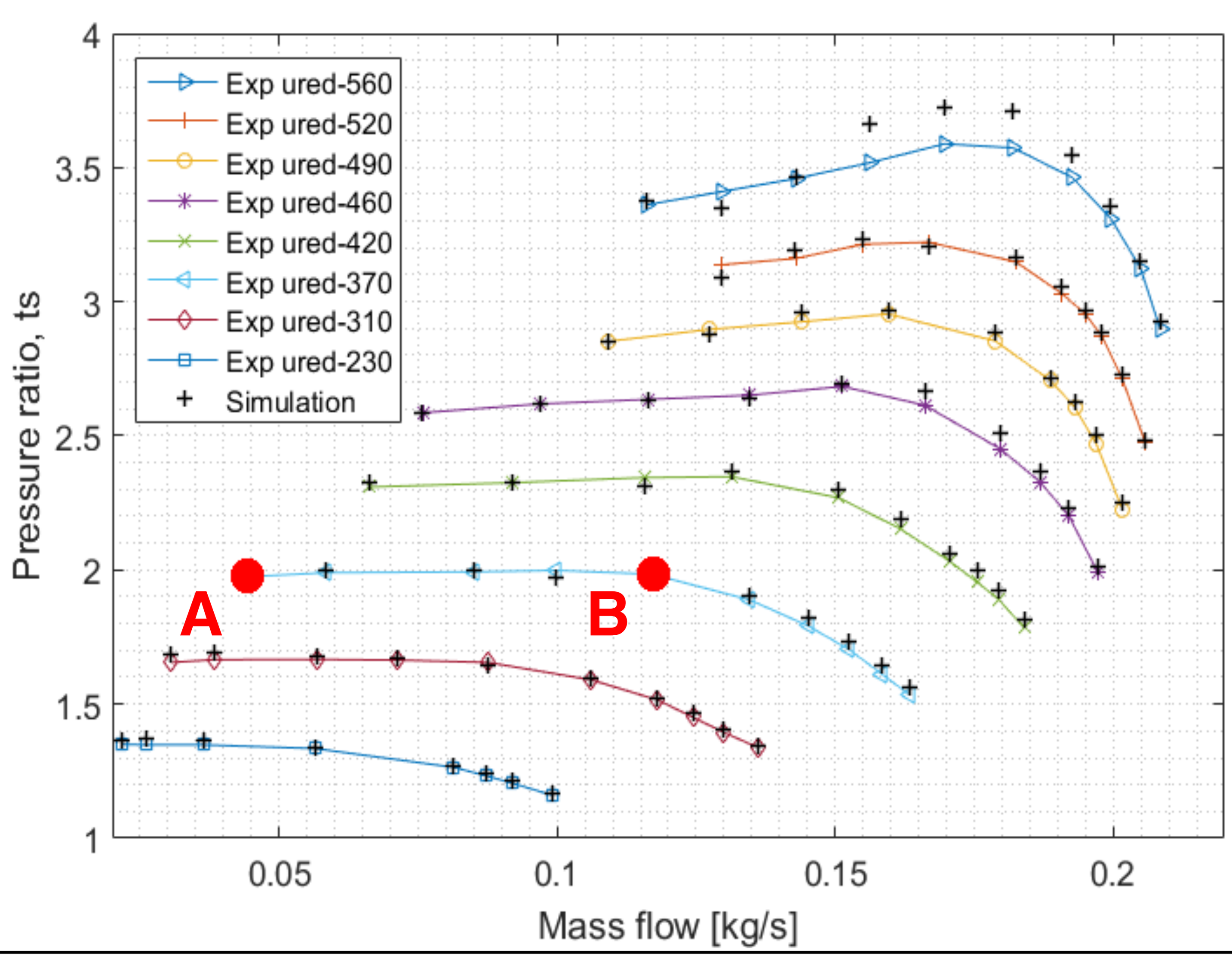
- Equations solved: Continuity, Momentum, Energy, Equation of State
- Turbulence modelling: SST k-ω
- Solver: Coupled flow (density based)
- Discretisation: 2nd order upwind
- Mesh: polyhedral, ~4.5 M cells, circumferential time averaged interface, moving reference frame

Boundary Conditions: Mass Flow Inlet, Pressure Outlet

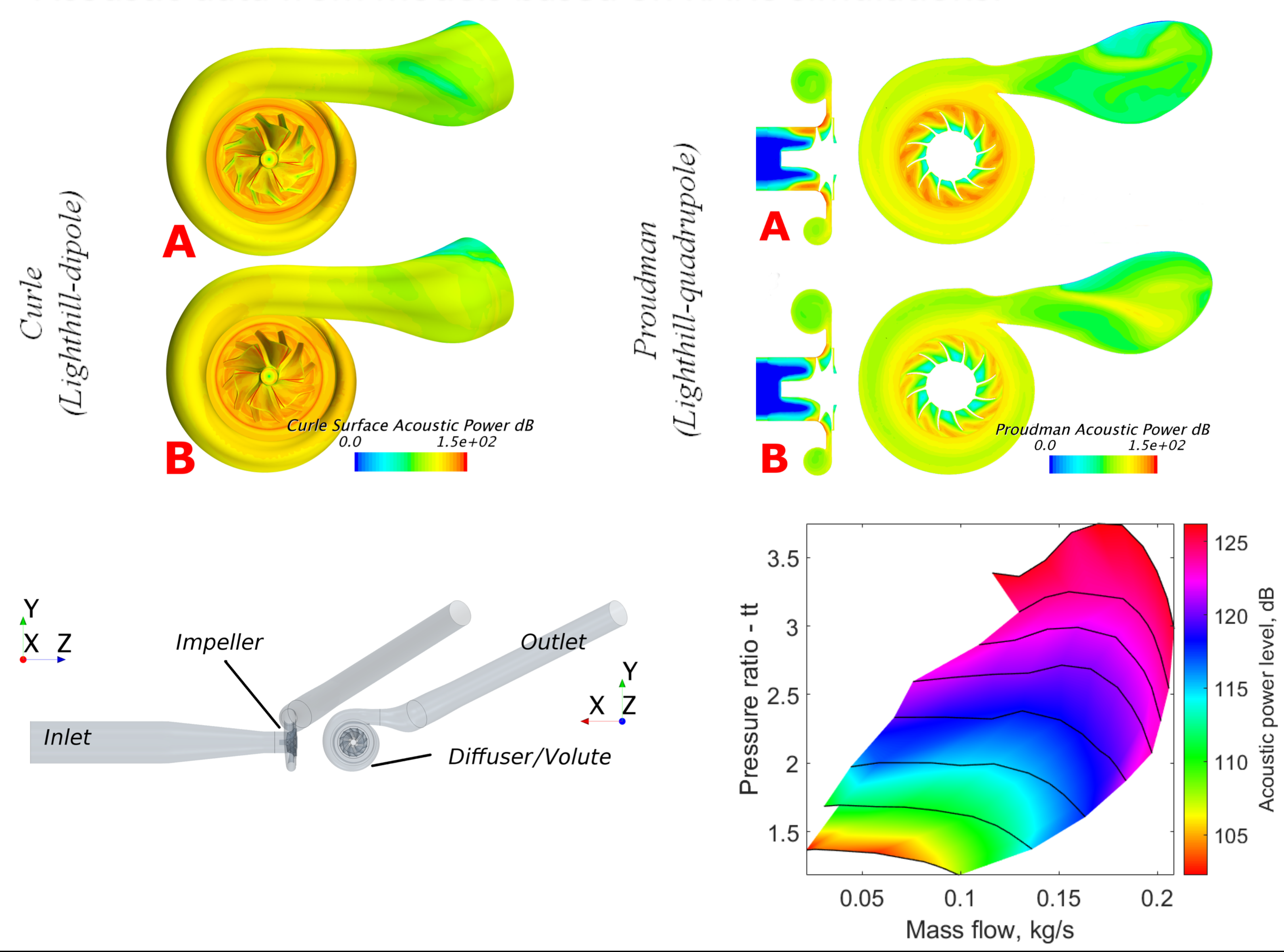
Initial conditions: velocity (depending on operating point)

Convergence was assessed monitoring residuals, pressure ratio, and mass flow rate.

## Results:




## Acoustic data from models based on RANS simulations:




## Summary and Conclusion:

A full compressor map was simulated. The extracted RANS results showed good match with the experimental data from BWTS. Acoustic models (Proudman, Curle) were implemented on RANS data, in order to find trends in the acoustic behaviour of the specific compressor and to compute a noise map. Unsteady simulations, such as Unsteady RANS (URANS) and LES will be carried out in the future, to verify the initial RANS findings and to extend the analysis to direct noise calculation and correlation of acoustic sources with far field noise.

## Acknowledgement:

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