

# The NUBERISIM Simulation Platform

## Aero-Acoustic Fluid Flow Simulation as-a-Service

Dipl.-Phys. Carlos Falquez  
Dr.-Ing. Iris Pantle  
Dr.-Ing. Balazs Pritz



**Falquez, Pantle und Pritz GbR**

Karlsruhe, December 07, 2015

# Noise



Quellen: Webseiten WDR, Neff, AEG, ebm-Pabst

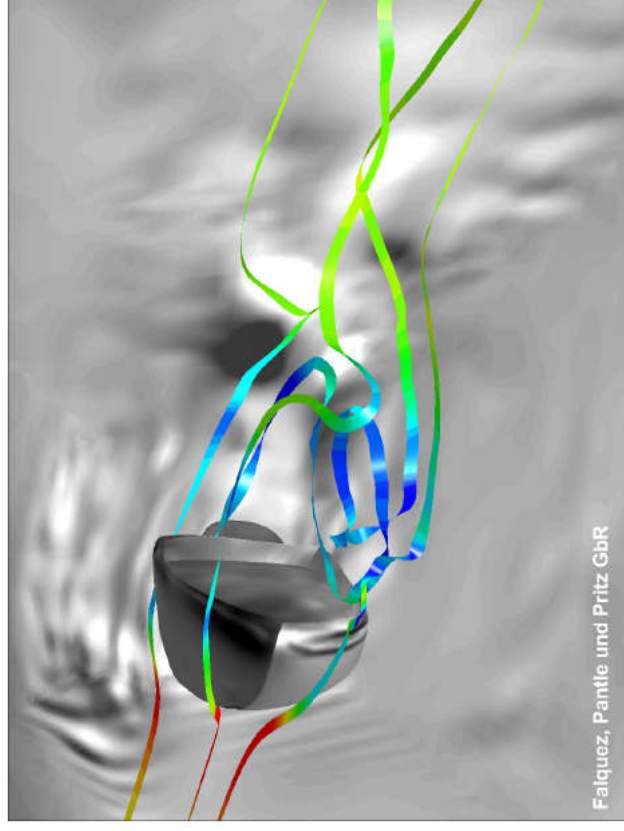
# Flow Induced Noise

Quelle: BMW & [www.asphaltandrubber.com](http://www.asphaltandrubber.com)



Experiment?

OR



Simulation?

# Challenges

- Noise regulations in place?
- Low-noise device has competitive advantage?
- Detailed insight in flow behaviour required?
- Acoustic analysis integrated in CFD software?
- Hardware infrastructure for high performance computations?
- Flexibility in use?

# Conventional Software-License Approach



Quelle: Creative Commons, Wikimedia, Iconfinder

Costs: Investments (Hard-/Software), Operation, Maintenance, Replacement, Personnel

# Our Solution - NUBERISIM



Source:  
 Tim Beckmann / pixelio.de  
 Alchimie National Laboratory / flickr.com  
 Jochen Frein / freinpages.com  
 IMZ / KT



# NUBERISIM

## Example of configuration pages:

The screenshot shows the NUBERISIM web interface. The browser address bar displays 'simulate.nuberisim.de/dashboard'. The navigation menu includes 'Home' and 'Projects'. The main content area is divided into several sections:

- Simulation Status:** Shows 'Simulation Running since Today at 1:02:29 PM'.
- Cores:** A dropdown menu is set to '2'. Below it is a 'Restart Simulation' button.
- Start/Stop:** A green 'Start' button and a red 'Stop' button.
- Grid Levels:** A table with columns 'Level', 'Iterations', 'Convergence', and 'Start on'. Level 2 is selected.

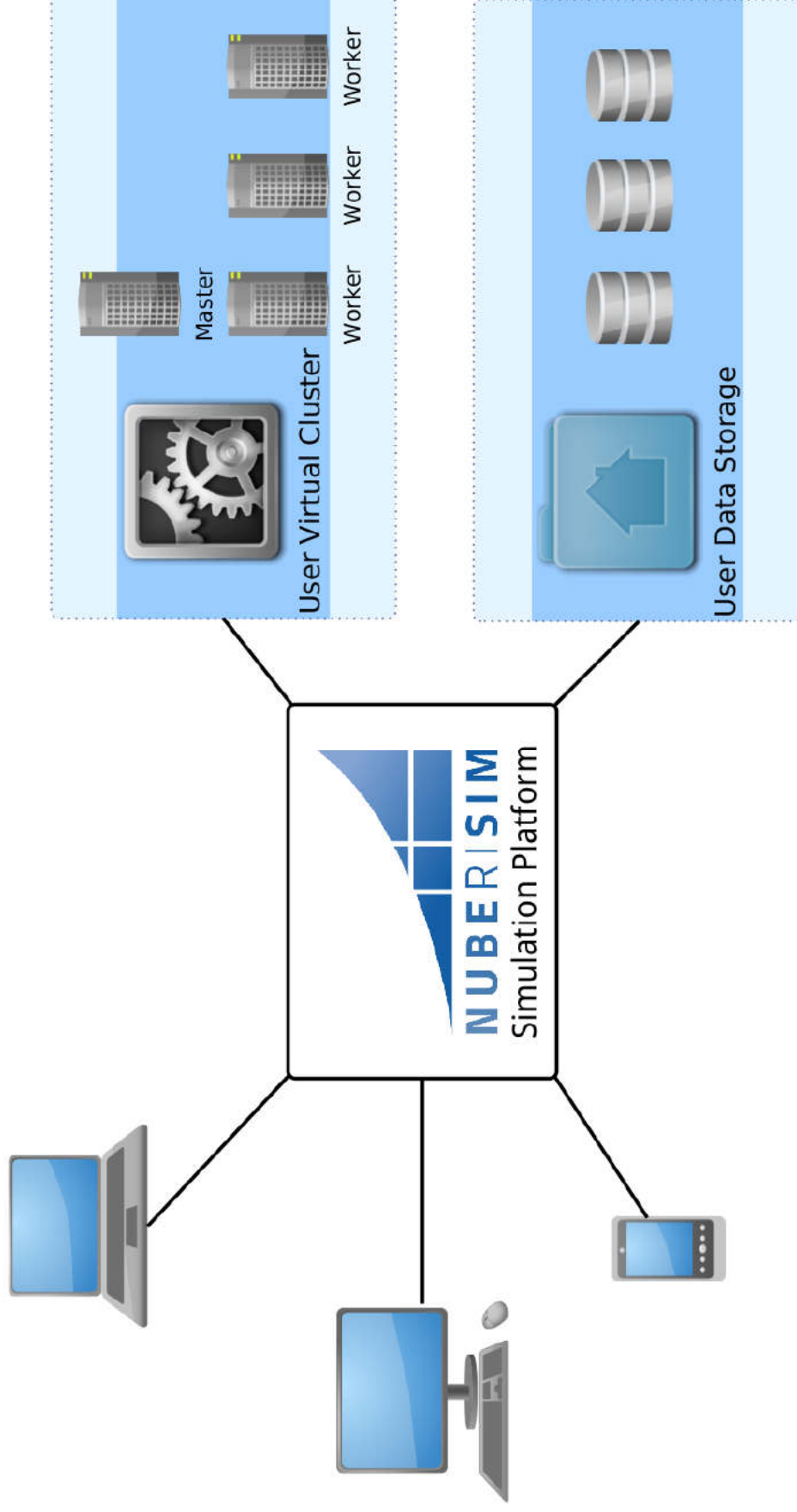
Level	Iterations	Convergence	Start on
1	0	-5.5	●
2	1000	-5	●
3	750	-4.5	●
4	500	-4	●
5	0	-3.5	●
6	0	-3	●

Below the configuration section, there are two line graphs under the heading 'Convergence':

- Density, Grid Level 3, 60 Iterations:** A line graph showing convergence values over 60 iterations. The y-axis ranges from -3.01 to -1.05. The x-axis shows time intervals from 5.016 to 60.00.
- Velocity X, Grid Level 3, 60 Iterations:** A line graph showing convergence values over 60 iterations. The y-axis ranges from -2.34 to -1.41. The x-axis shows time intervals from 5.016 to 60.00.

Quelle: Falquez, Pantle und Pritz GbR

# NUBERISIM



Quelle: Creative Commons, Wikimedia, Iconfinder

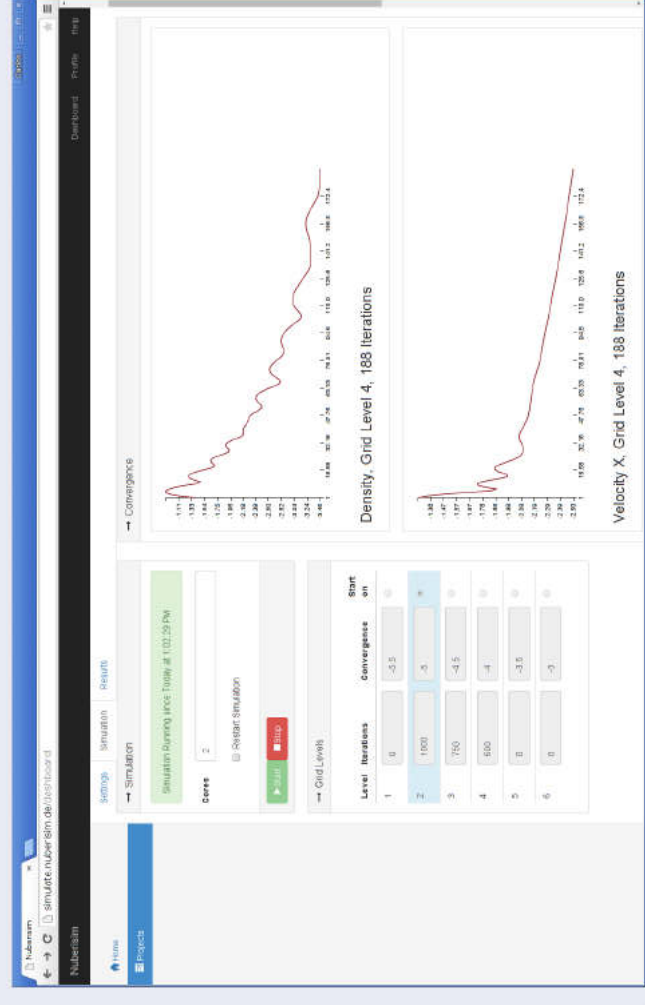


# NUBERISIM

## Main Features

- High scalability
- Pay-per-use
- Requirements: Browser
- No HPC hardware, no maintenance, no annual software licenses required
- Encrypted data transfer, splitted domain
- User specific adaptations/solvers possible

## Snapshot



# EXIST 05/2013-05/2014

Gefördert durch:



Bundesministerium  
für Wirtschaft  
und Technologie

aufgrund eines Beschlusses  
des Deutschen Bundestages

**eXIST**  **ESF**

Existenzgründungen  
aus der Wissenschaft

Europäischer Sozialfonds  
für Deutschland



EUROPÄISCHE UNION

From EXIST evaluators:

*Heart of [...] the platform is the simulation method, developed at the KIT [...], which enables the separated investigation of sound waves and sound sources [...]. In this way, simulation speed can be increased, required simulation capacity reduced. [...] Overall, this is an **innovative service**, where customers are offered modern CFD software coupled with acoustics software as **Simulation-On-Demand**. [...]*

## 03/2014-today

- March 2014: Founding of GbR
- April 2014: First prototype presented at HannoverMesse
- January 2015: Signed license contract between KIT and FPPG for NUBERISIM solver
- March 2015: Presentation and publication at HPSC Conference
- May 2015: NUBERISIM version 1.0
- June 2015: „Mass test“ with students at DHBW Karlsruhe
- Scheduled December 2015: NUBERISIM v2.0 release with full acoustic work-flow

# History of NUBERISIM Solver - KIT

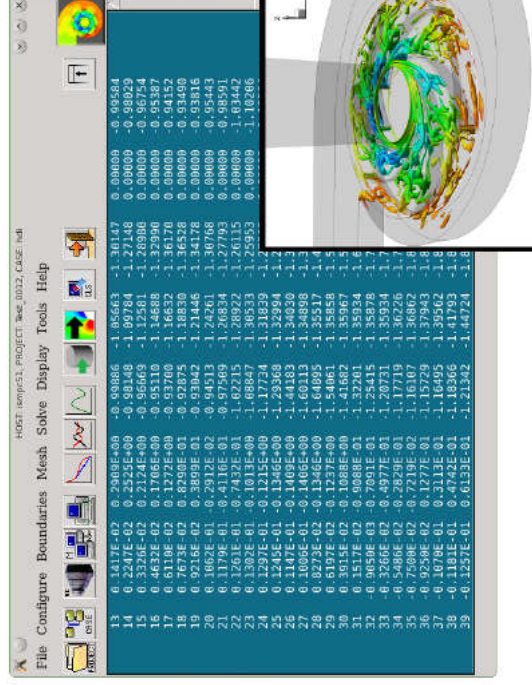


Universität  
Karlsruhe (TH)



Karlsruhe Institute of Technology

**10+ years**



Quelle Logos/Abbildungen: KIT

Developed by a group of 3+ researchers ...

The NUBERISIM Simulation Platform

# The Solver

## Main Features

- Finite Volume Method
- 2D/3D block- structured grids
- Fully compressible and incompressible
- Steady state/ unsteady
- RANS, LES, DNS
- Time integration: explicit and implicit
- 2nd and 4th order accuracy
- Full multi-grid
- Parallelized with MPI
- Easy integration in optimization process

# The Solver

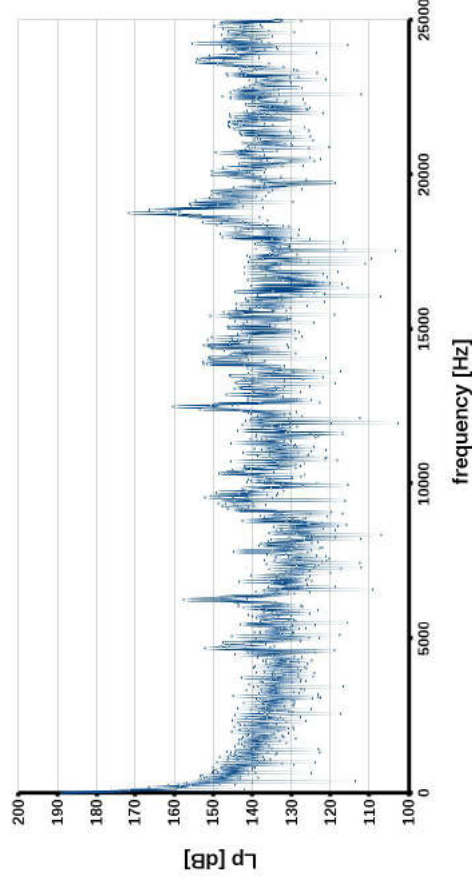
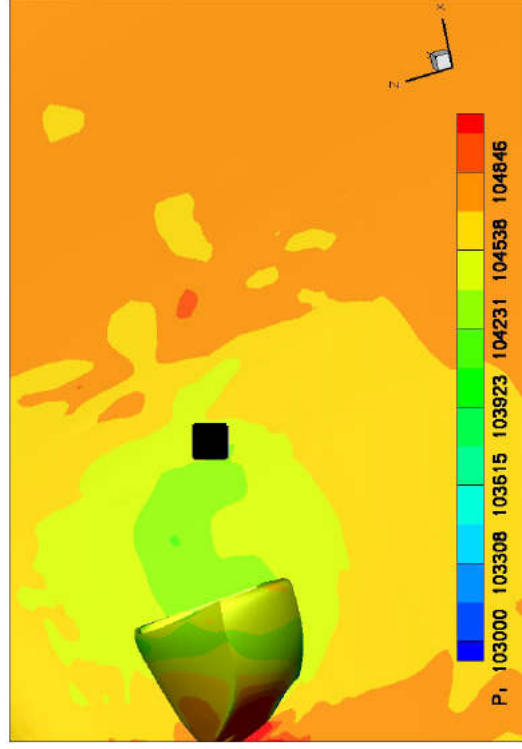
## Modules

- Rotating grids with Sliding Interface
- Acoustics - 3 types:
  - Fully compressible flow includes acoustics
  - Ffowcs-Williams and Hawkings integral acoustics
  - Perturbation equations (LEE)

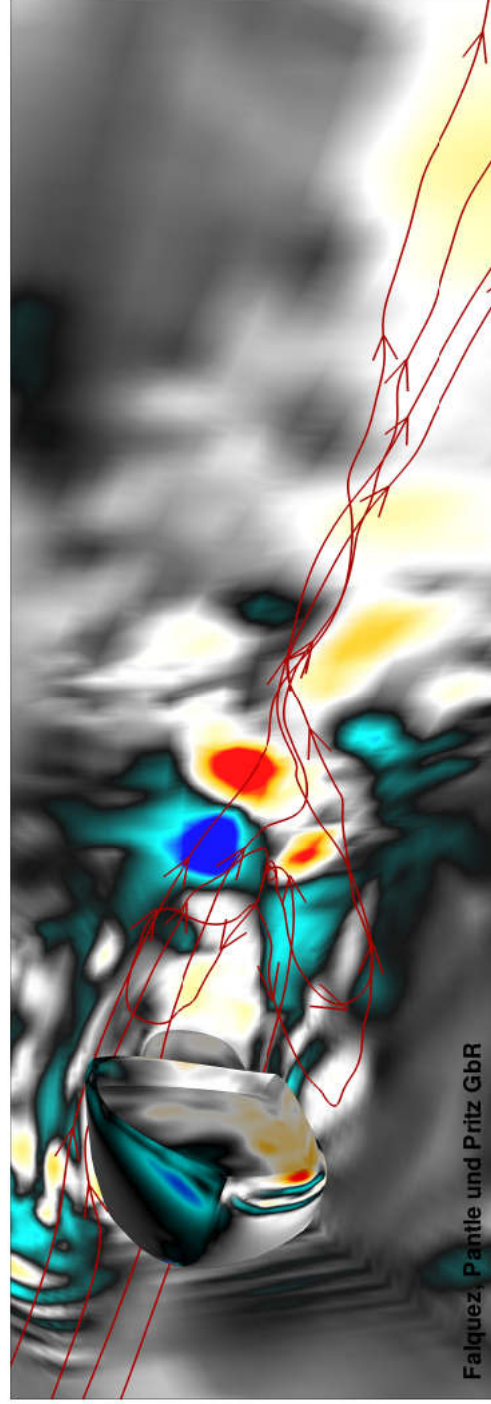
## Modules in Development

- Multi-phase flow
- Immersed Boundary Method
- Fluid-Structure Interaction
- Semi-Automated Meshing

# Fluctuations on Window

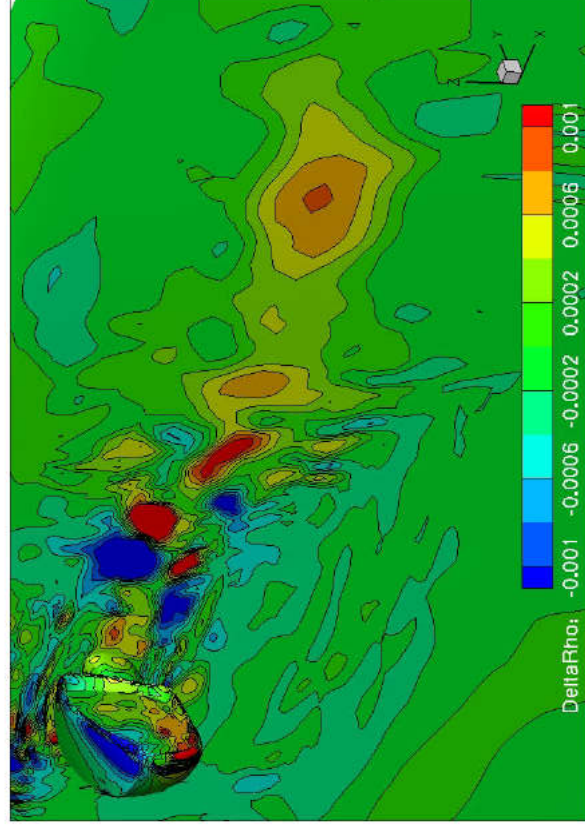
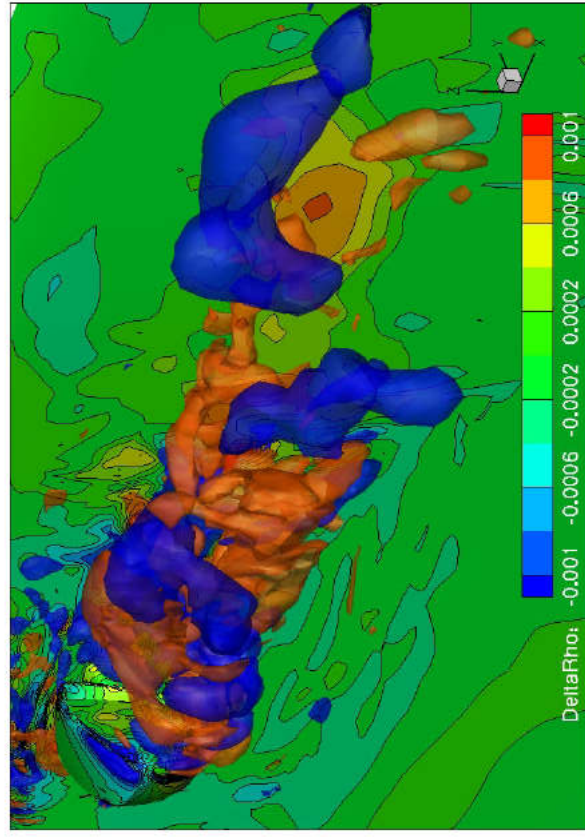


# Pseudo Sound at Window Plane



Falquez, Pantle und Pritz GbR

# Generic Car Mirror



Quelle: Falquez, Pantle und Pritz GbR

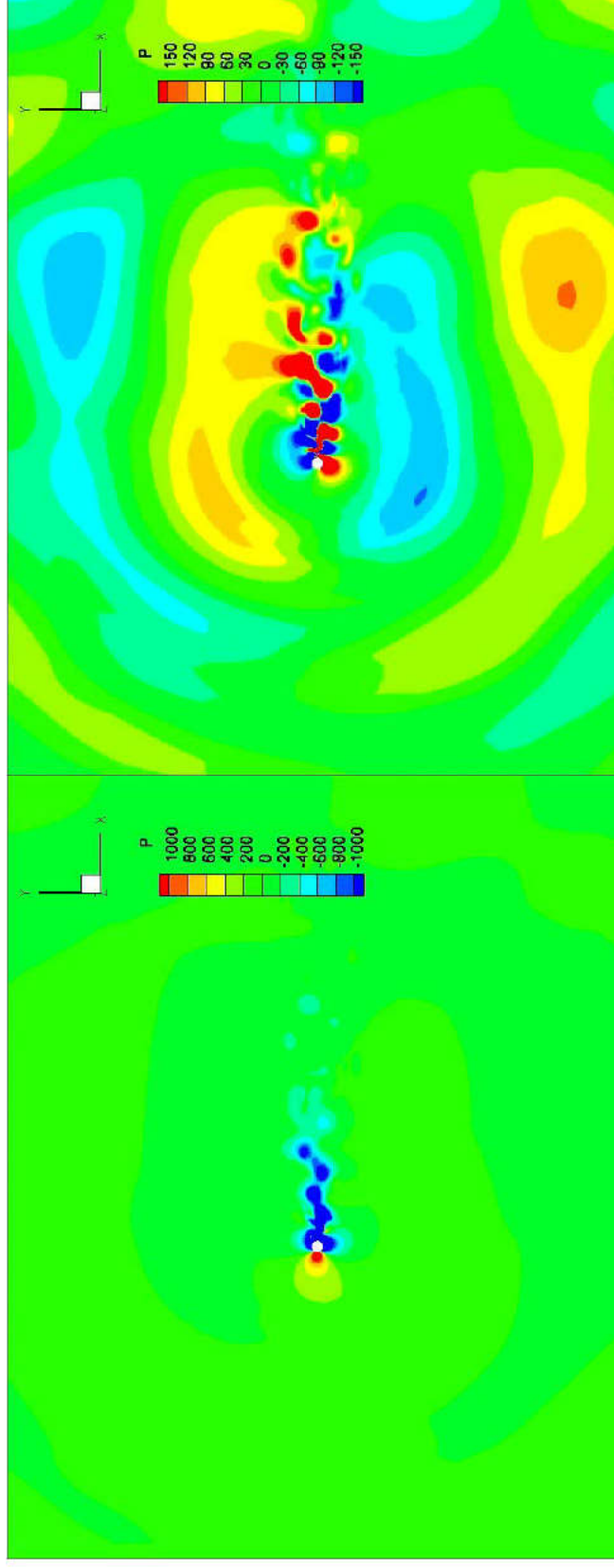


# Combustion Chamber - Resonator



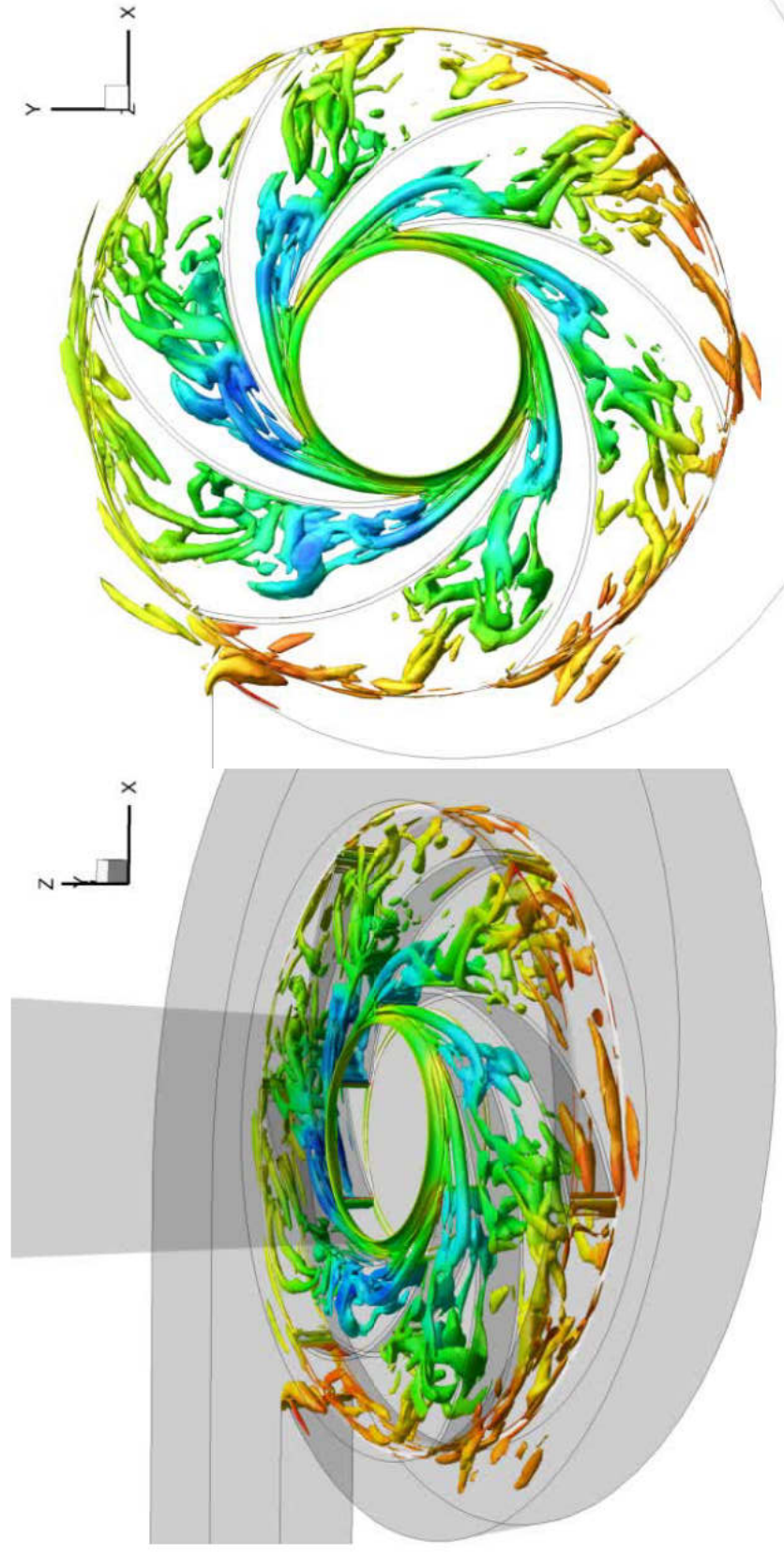
Quelle: Pritz, KIT

# Flow and Wave Propagation



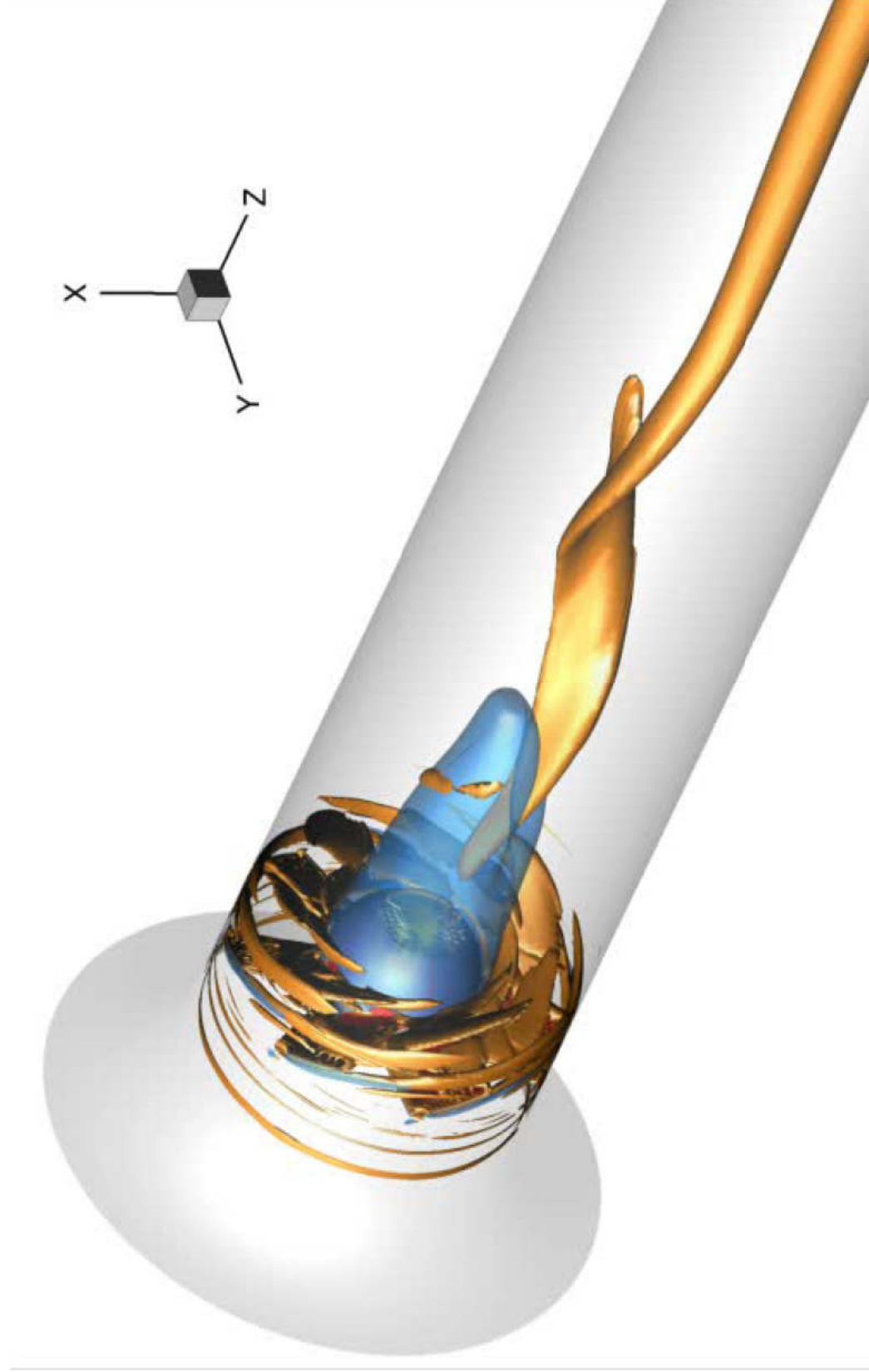
Quelle: Pantle, KIT

# Radial Fan



Quelle: Pritz, KIT

# Axial Fan



Quelle: Pritz, KIT

Check out . . .

. . . on YouTube:

<https://youtu.be/p5SD9iAUFPS>

. . . how to use Nuberisim:

The screenshot displays the Nuberisim web interface. At the top, there is a navigation bar with 'Dashboard' and 'Profile' links. Below this is a search bar and a table of projects. The table has columns for 'Project', 'Created', 'Size', 'Case', and 'Updated'. The first project listed is 'ESIMA', created on 'Tue, Jan 20, 2015 7:45 AM', with a size of '2.49 MB' and case 'ESIMA Case 1', updated on 'Tue, Jan 20, 2015 7:45 AM'. Below the table, there are tabs for 'Settings', 'Simulation', and 'Results'. The 'Simulation' tab is active, showing a 'Net Running' status, 'Cores' set to 2, and a 'Restart Simulation' button. There are also 'Start' and 'Stop' buttons. At the bottom, there are 'Grid Levels' and 'Level Iterations' controls, with 'Level Iterations' set to 0 and 'Convergence' set to -5.5. The 'Start on' dropdown is set to 'Convergence'.

# Contact us:



Dipl.-Phys. Carlos Falquez (KIT)  
Development Platform (Cloud, IaaS)



Dr.-Ing. Iris Pantle (KIT)  
Development Fluid-Flow-Acoustics, CFD



Dr.-Ing. Balázs Pritz (KIT)  
Development CFD

## Address:

Falquez, Pantle und Pritz  
GbR  
Technologiefabrik Karlsruhe  
Haid-und-Neu-Str. 7  
D-76131 Karlsruhe  
Germany

## Internet:

E-mail:  
[contact@nuberisim.de](mailto:contact@nuberisim.de)  
Web: [www.nuberisim.de](http://www.nuberisim.de)

## Fon/Fax:

Fon: 0721 / 13 28 30 12  
Fax: 0721 / 38 14 39 39

# Thank you ...

... for your attention!

## More links

<https://www.nuberisim.de>

<https://youtu.be/HaF00aDGR3w>

<http://fiware.nuberisim.de>