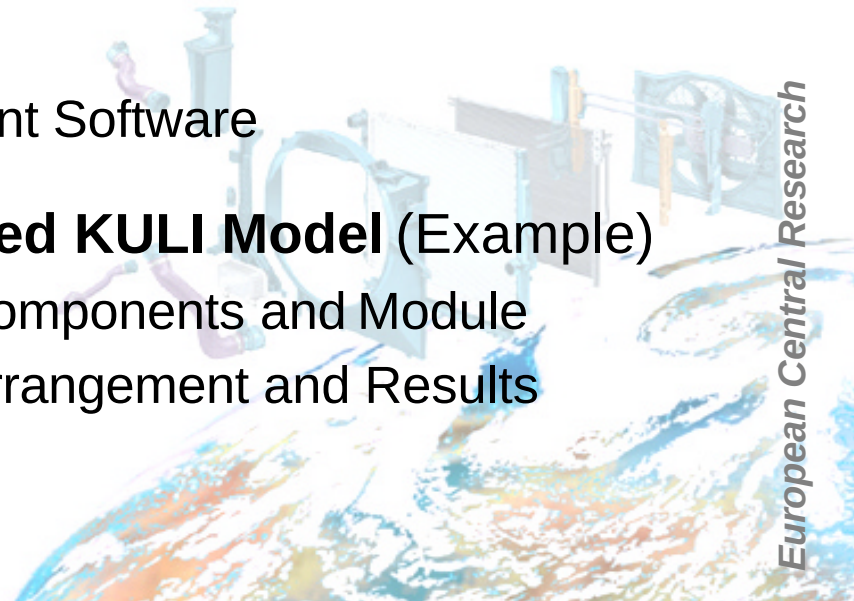


# **From Component Measurement to a tuned KULI Model of a Cooling System**

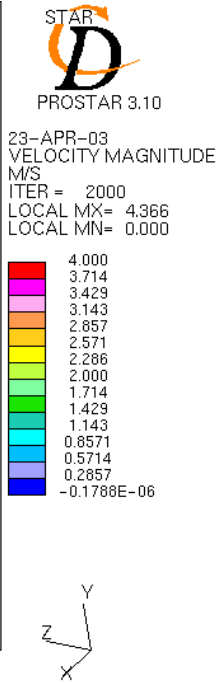
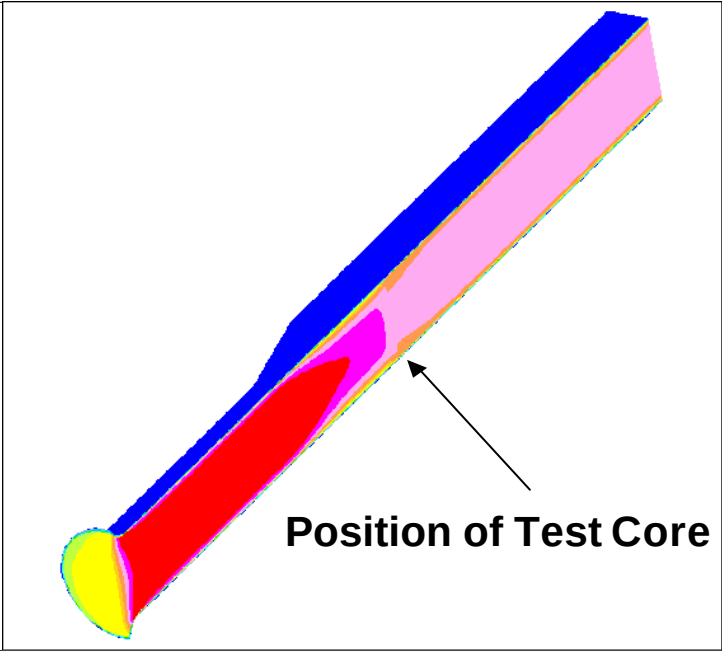
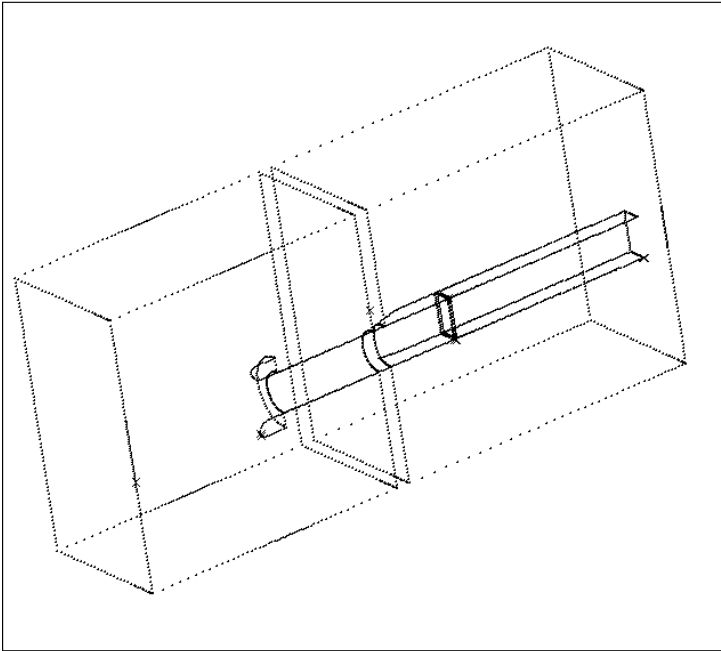
Klaus Mohrlök  
European Central Research  
Modine Europe GmbH, Dept. ESS



- **Measurement**
  - Components and Module
  - Uncertainties
- **Creating KULI-Input Data**
  - Regression
  - Heat Management Software
- **Tuned KULI Model (Example)**
  - Components and Module
  - Arrangement and Results

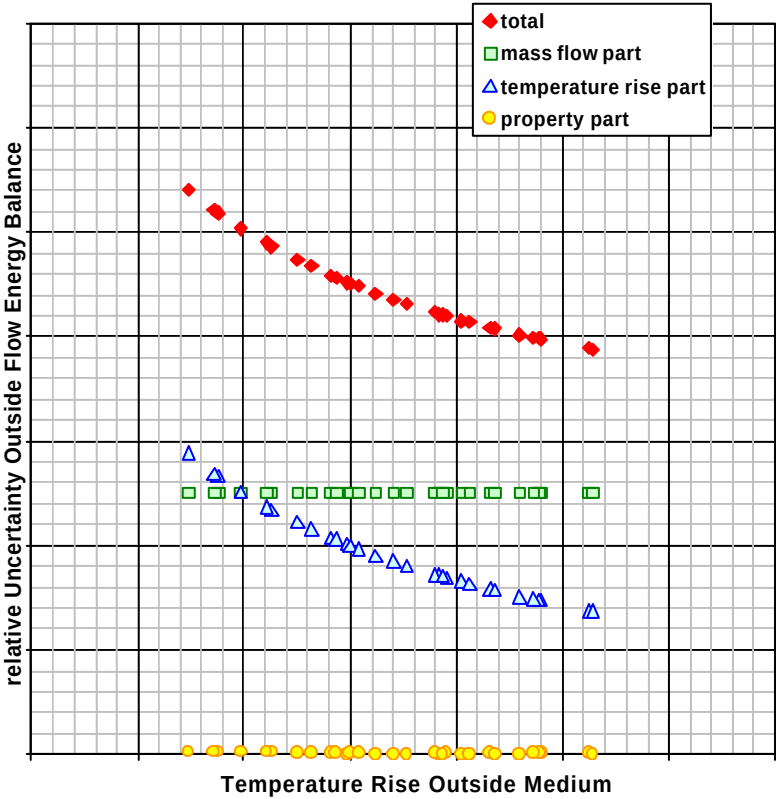


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Measurement - Components

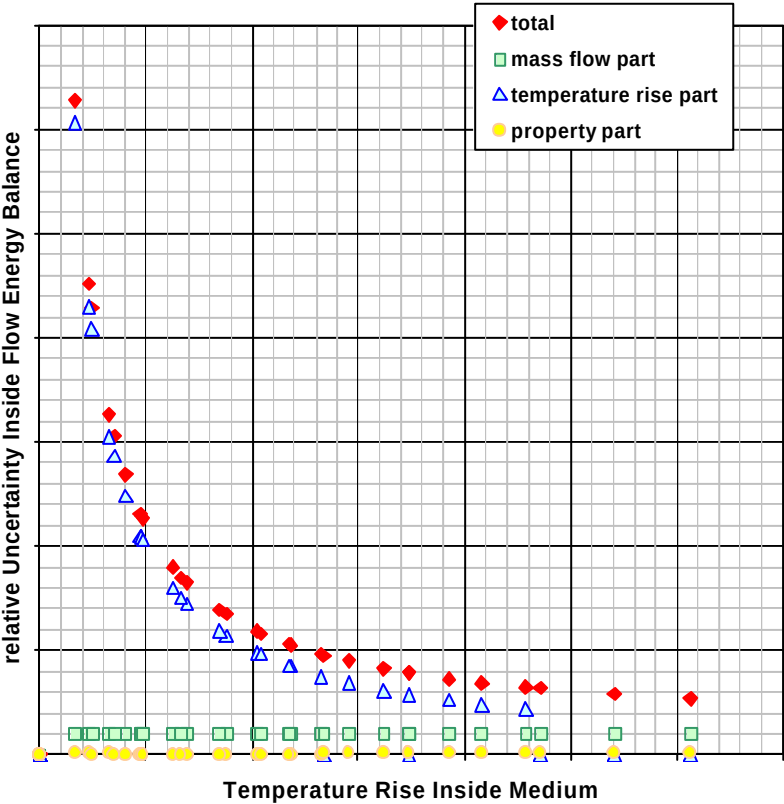


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Measurement - Uncertainties

Uncertainties of Outside Flow Energy Balance

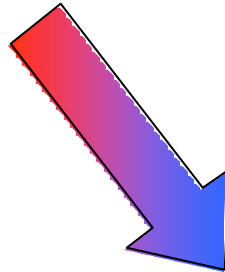


Uncertainties of Inside Flow Energy Balance

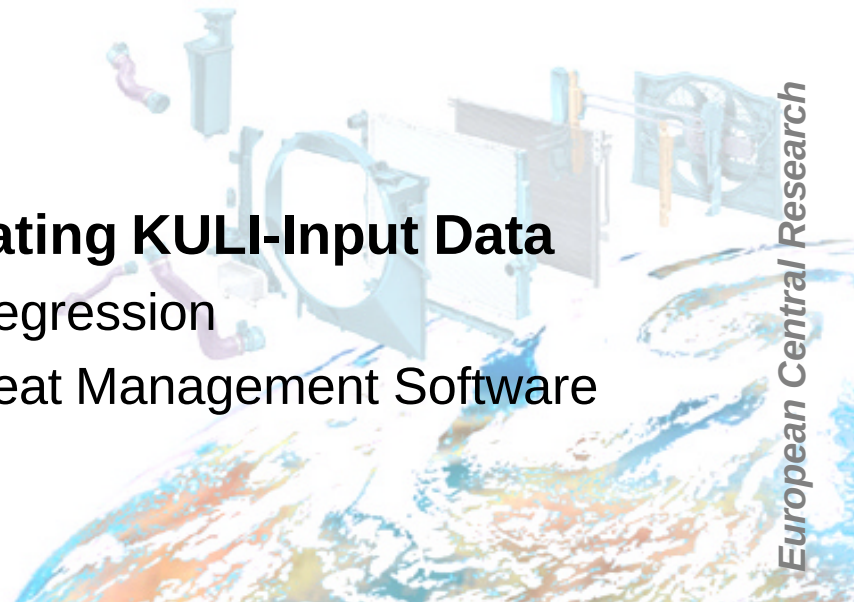


**From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data**

- **Measurement**
  - Components and Module
  - Uncertainties

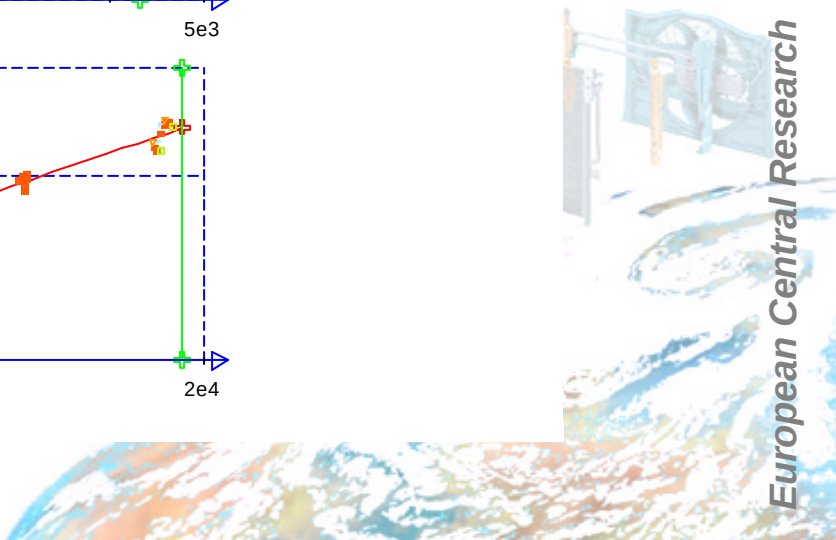
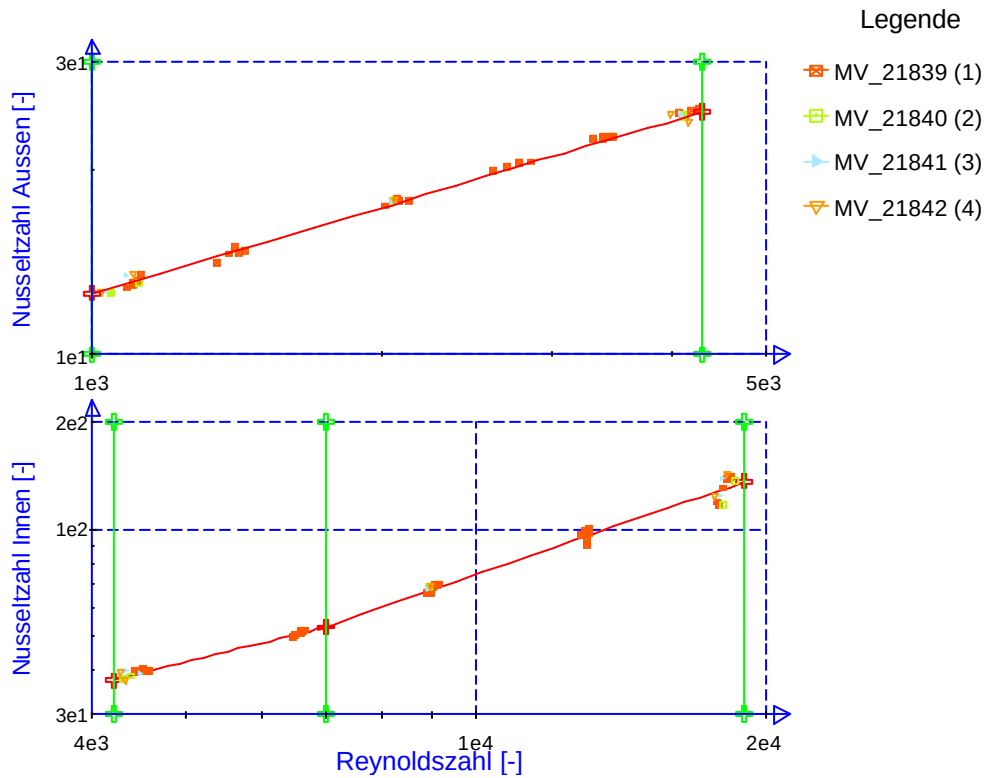


- **Creating KULI-Input Data**
  - Regression
  - Heat Management Software

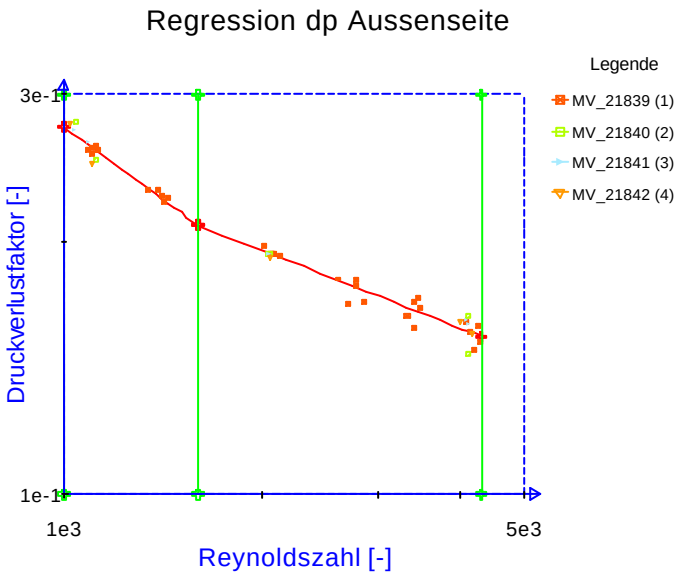
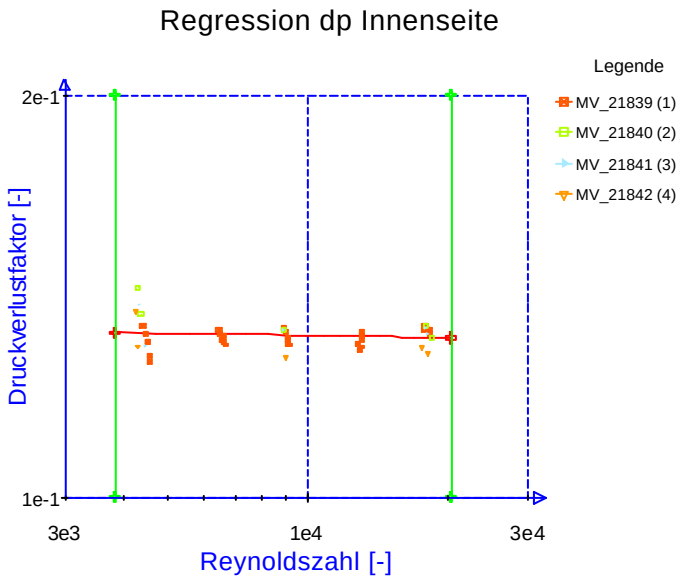


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Regression

Regression Nusselt

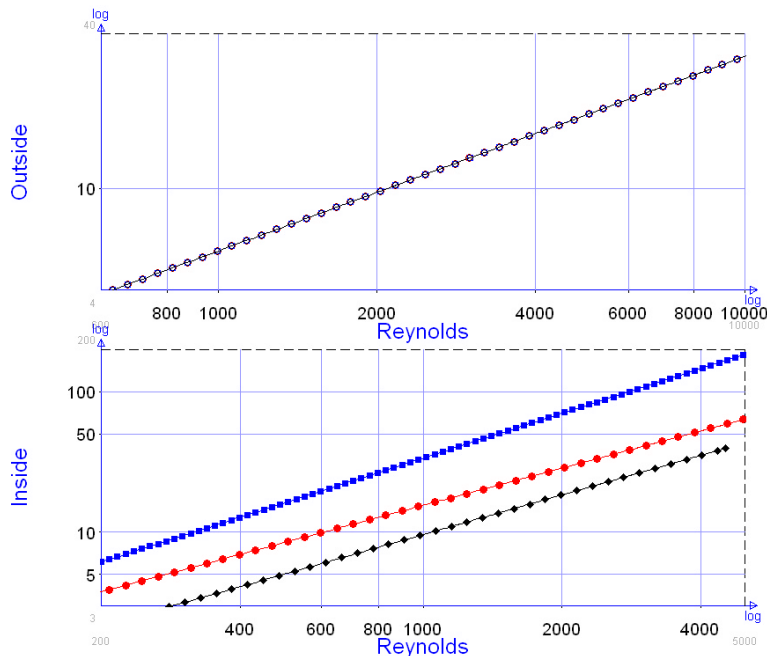


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Regression

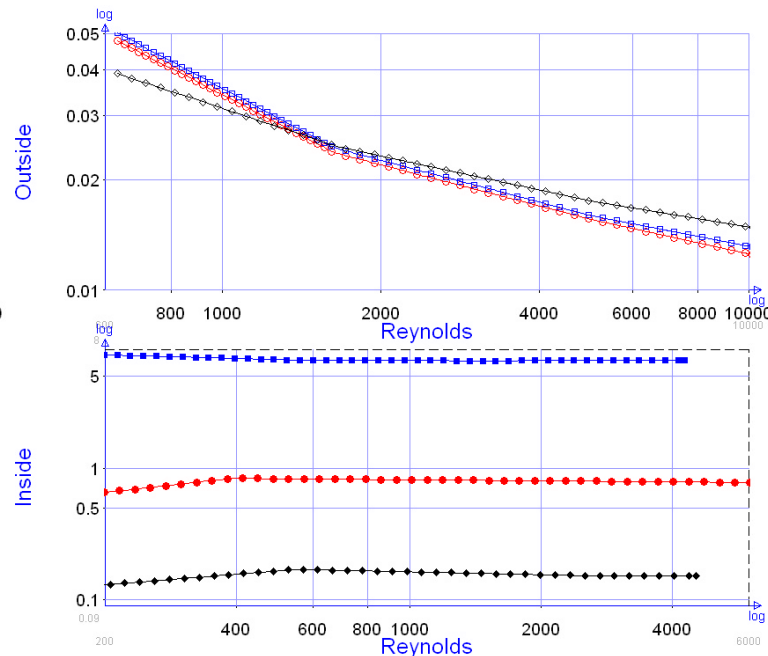


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Heat Management Software

Nusselt



Zeta



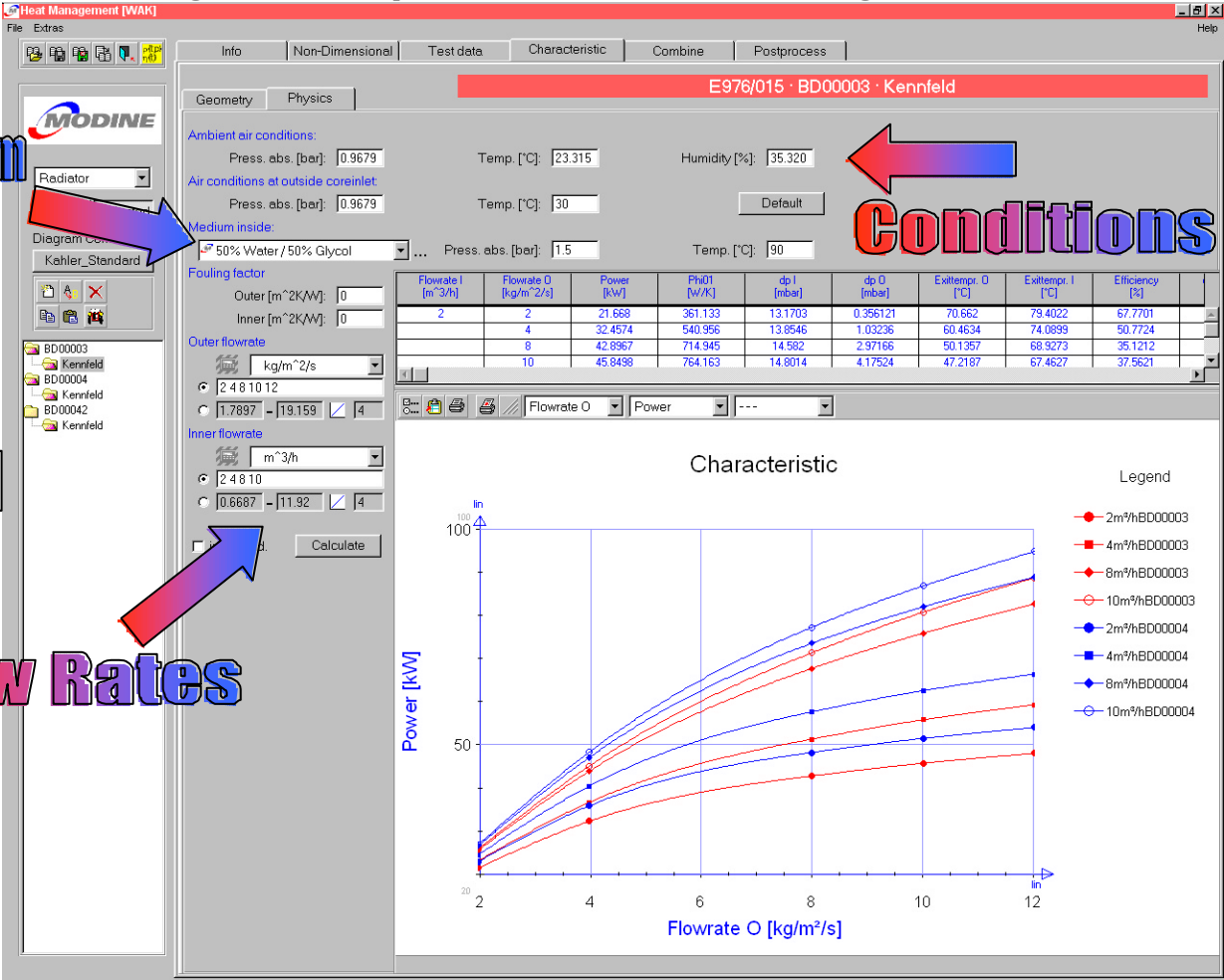
Legend

- O:TV22018
- I:TV22018
- O:TV22029
- I:TV22029
- O:TV22070
- I:TV22070





From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Heat Management Software



Variation of Medium

Conditions

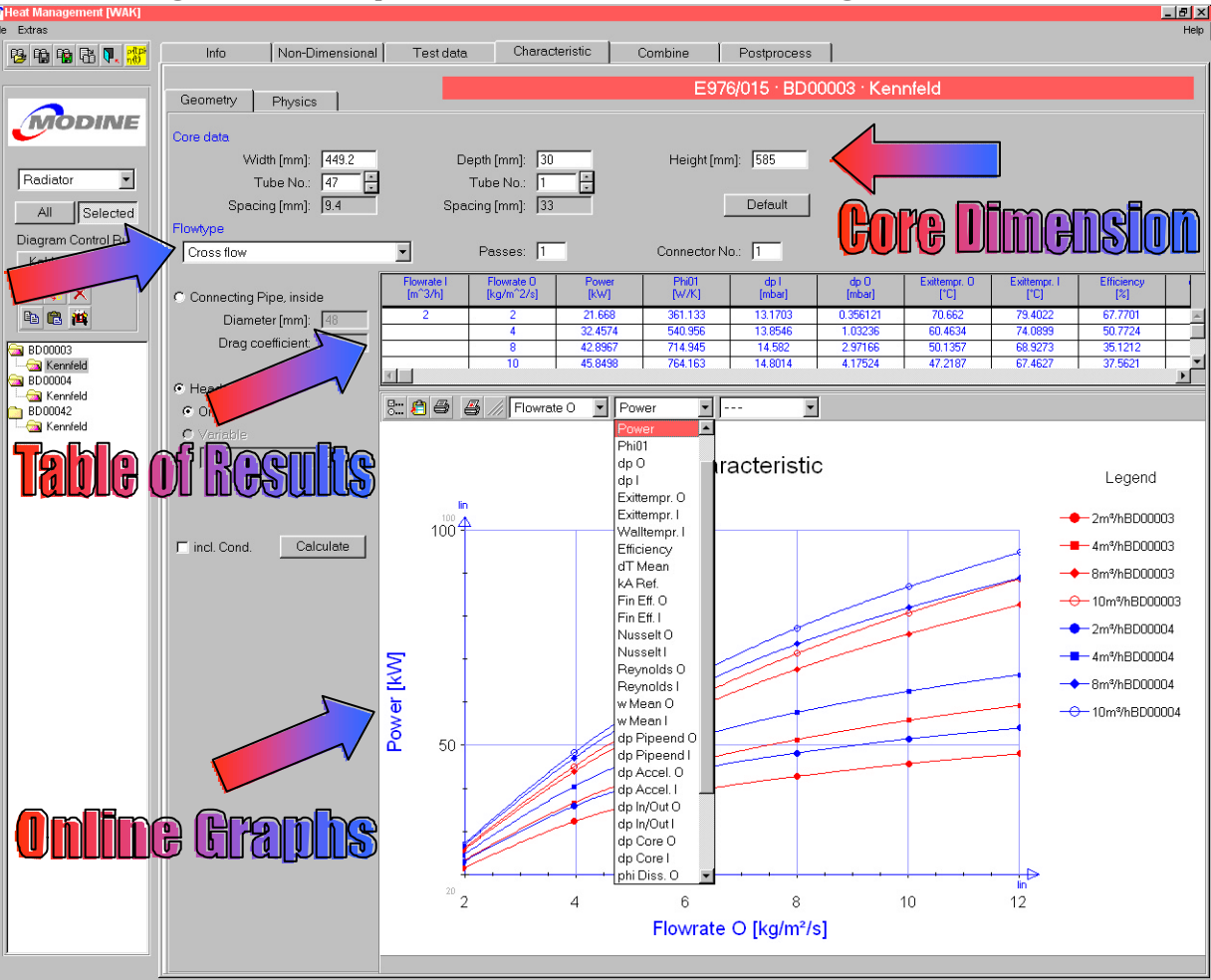
Data Set Control  
Cooler / HX

Flow Rates



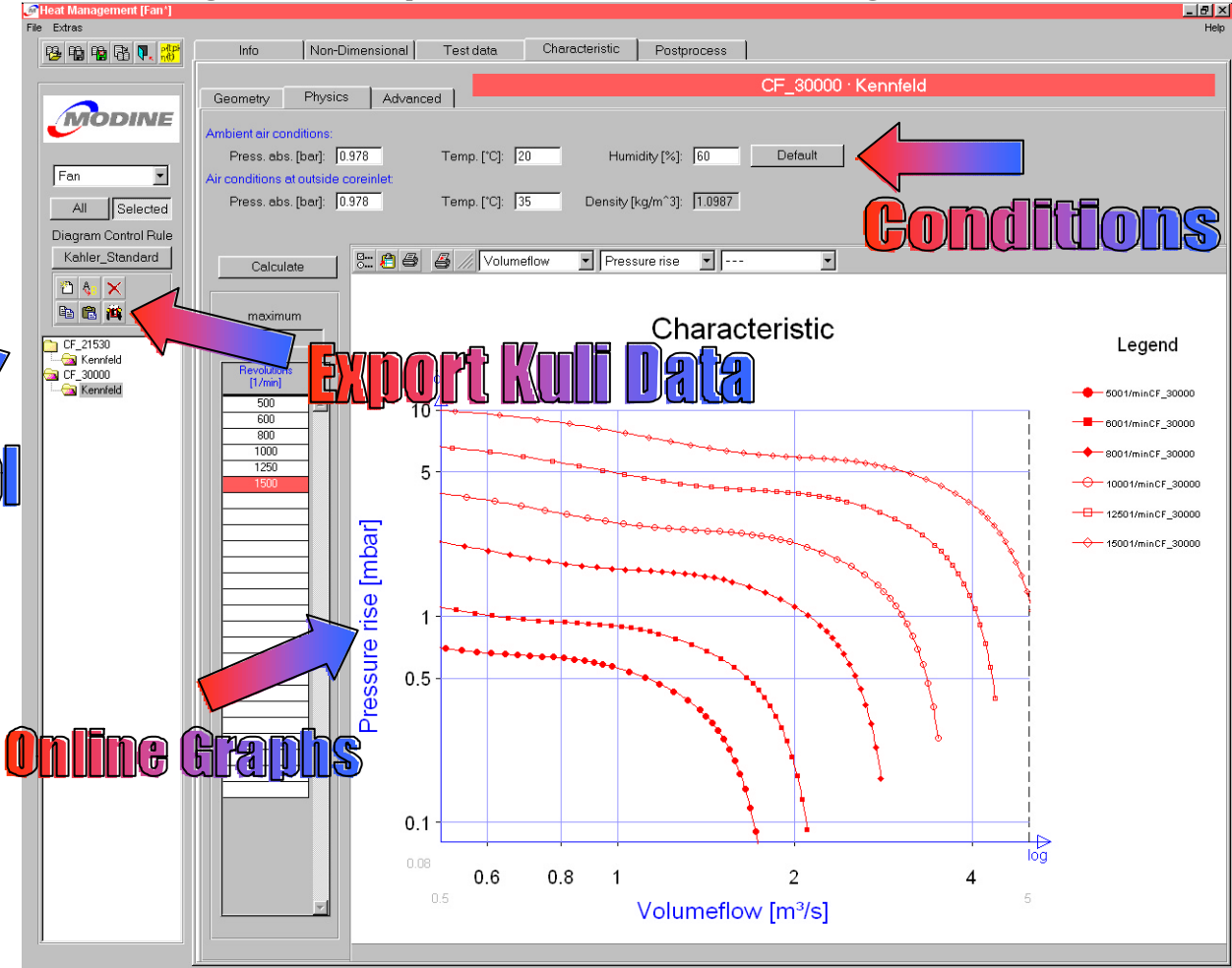
From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Heat Management Software

Flow Configuration

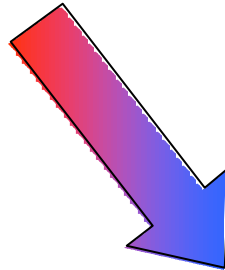


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Creating KULI-Input Data - Heat Management Software

Data Set Control  
Fan

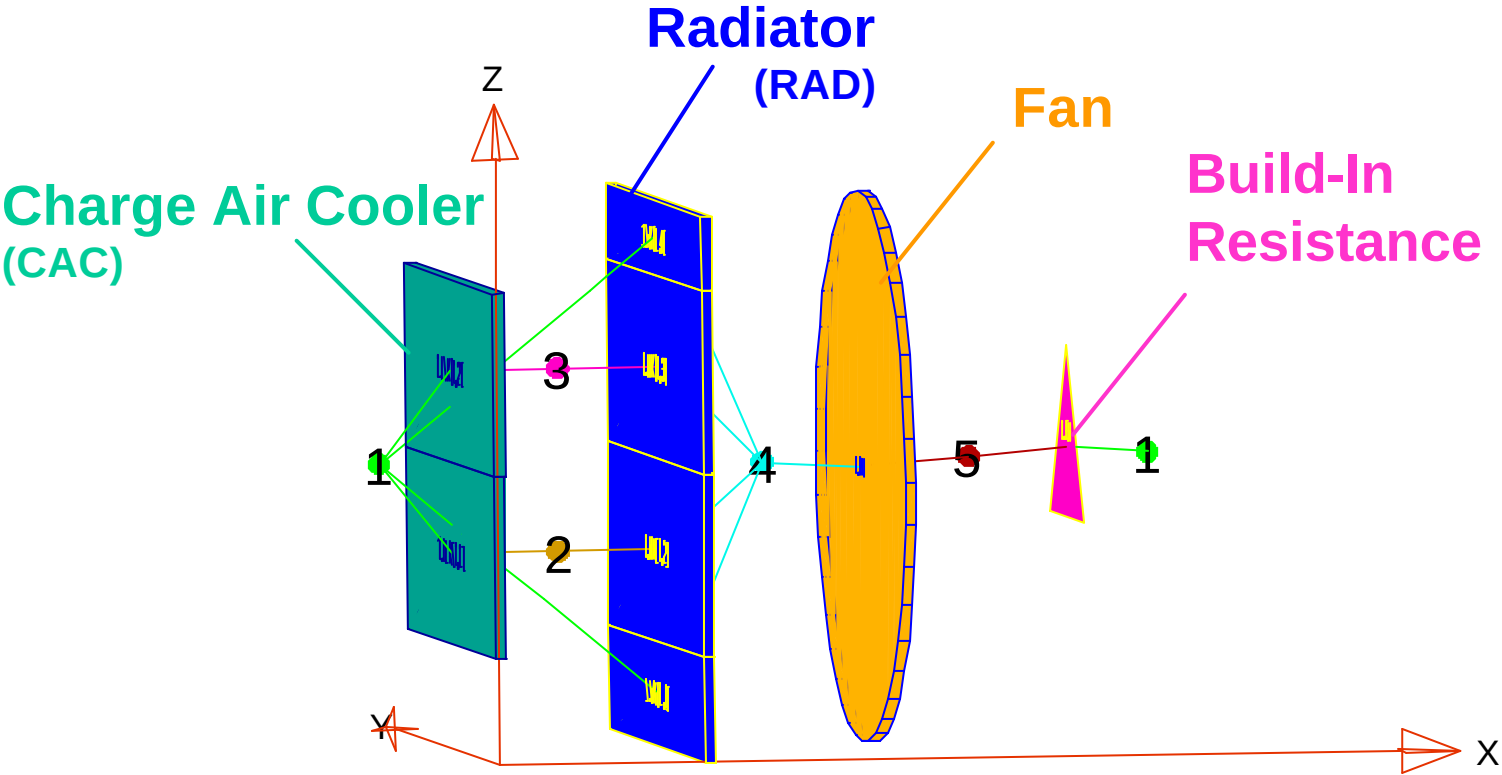


- **Creating KULI-Input Data**
  - Regression
  - Heat Management Software

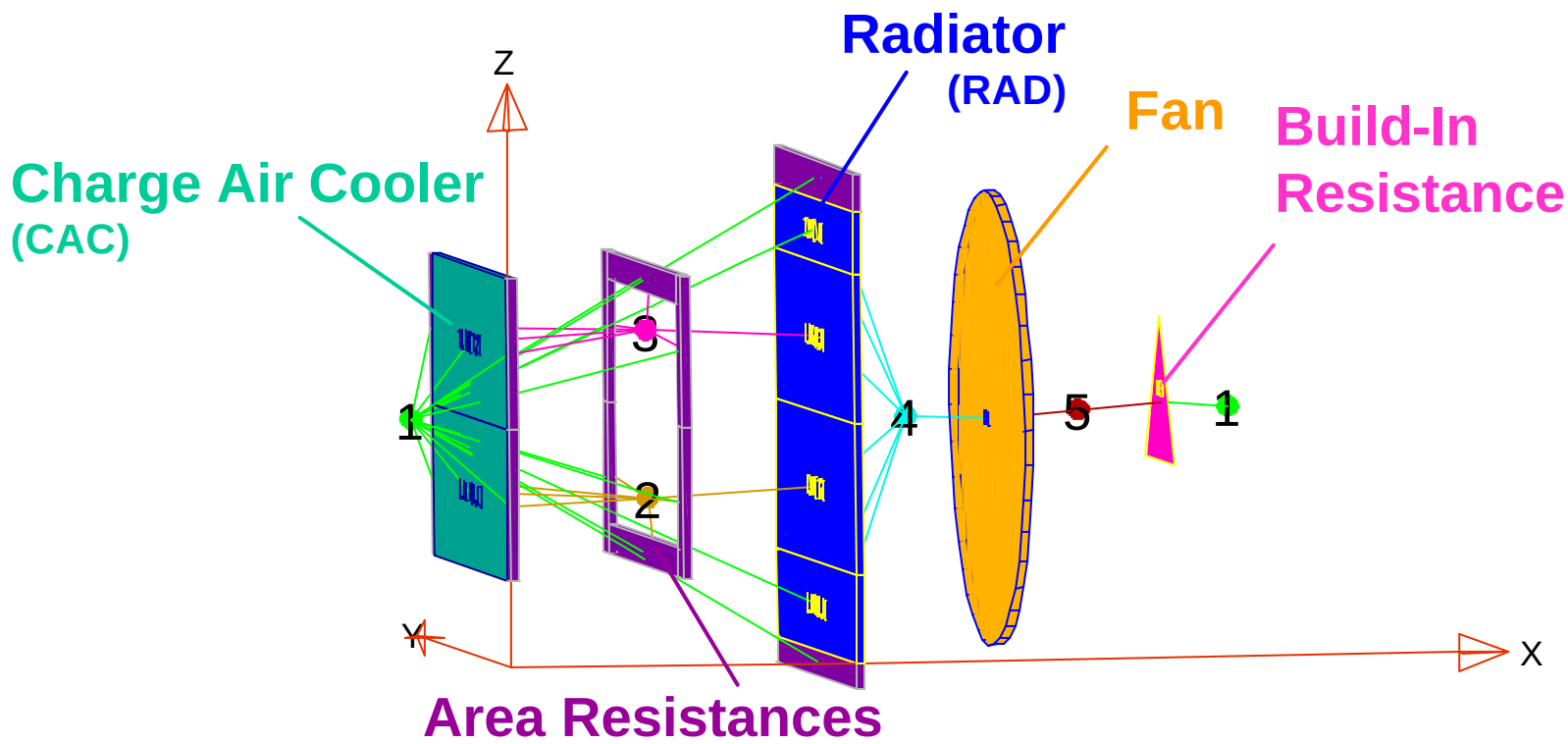


- **Tuned KULI Model of Front-to-Back-Module**
  - Components and Module
  - Arrangement and Results

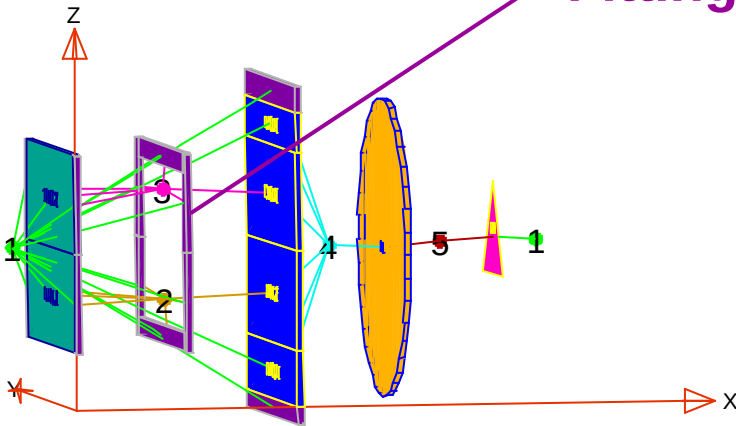
From Component Measurement  
to a tuned KULI Model of a Cooling System  
Front to Back Module - Simple KULI-Model



From Component Measurement  
to a tuned KULI Model of a Cooling System  
Front to Back Module - Improved KULI-Model



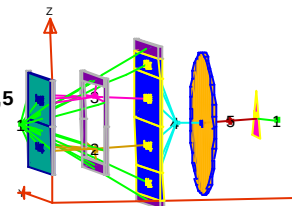
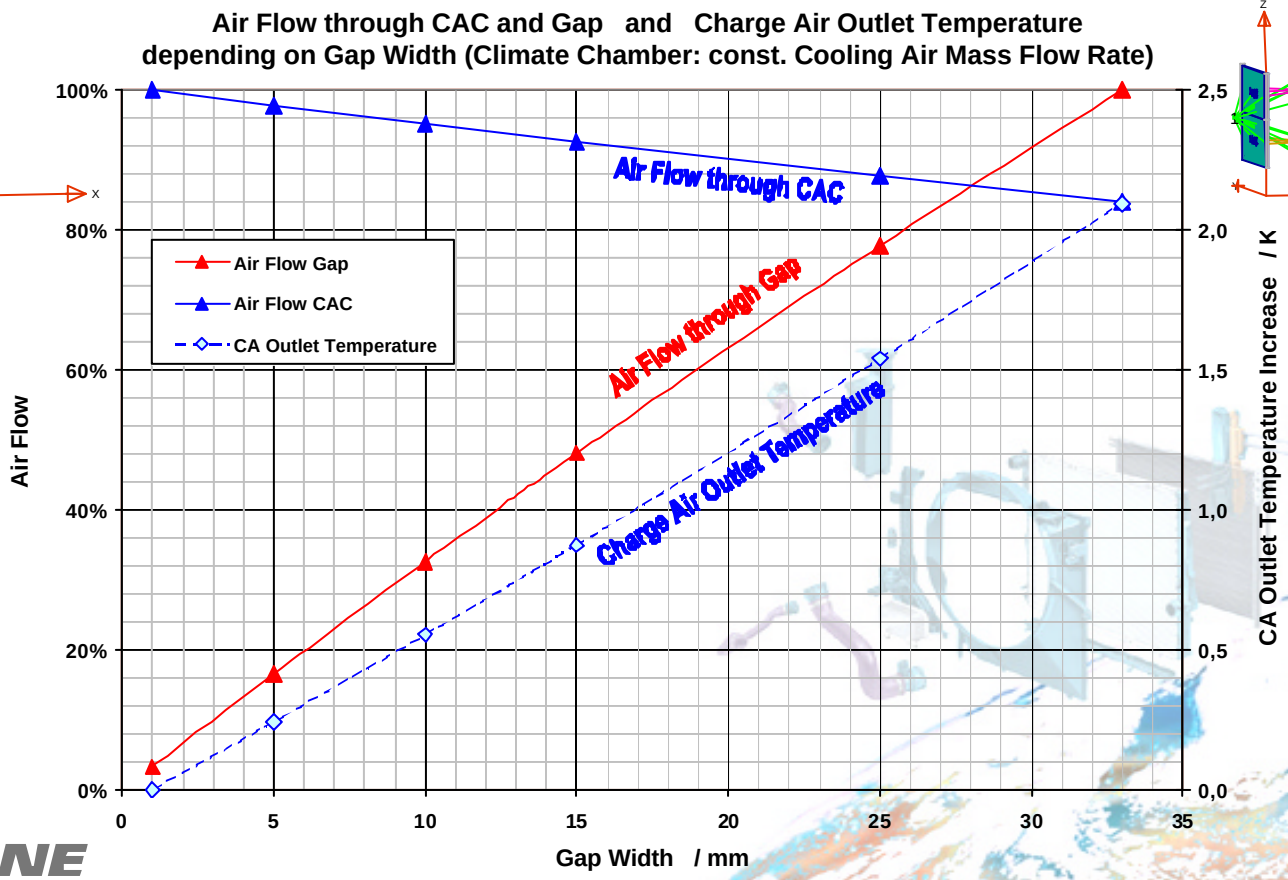
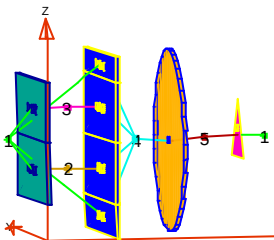
## Fitting Area Resistances



- Input for Fitting Vertical Area Resistances beside CAC: Measurement with closed Gaps
- Input for Fitting Horizontal Area Resistances above and below CAC: Measurement with open Gaps

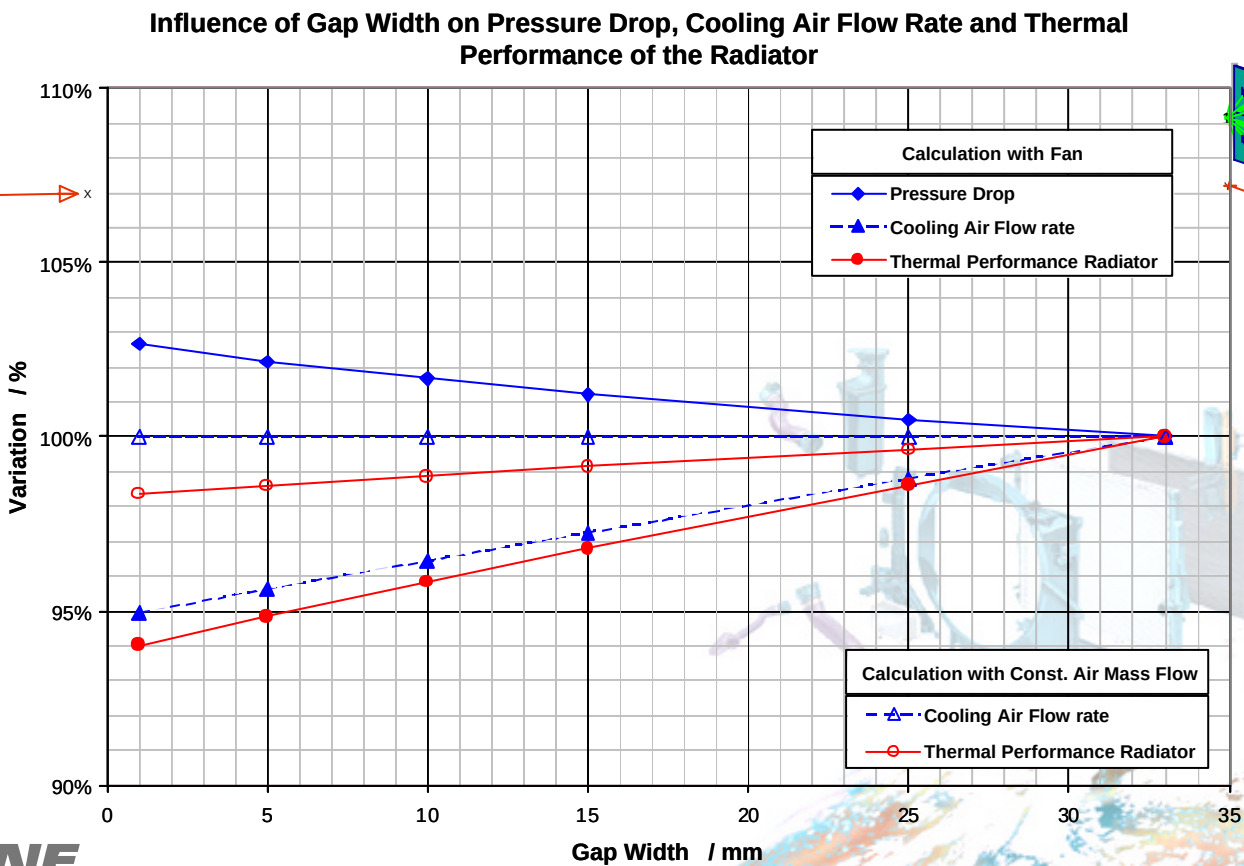
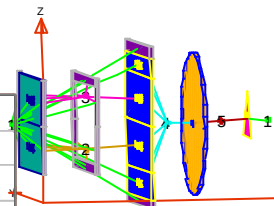
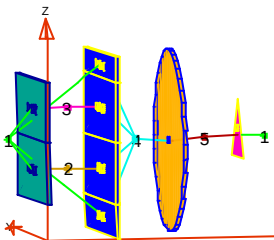


From Component Measurement  
to a tuned KULI Model of a Cooling System  
Results of the tuned KULI Model

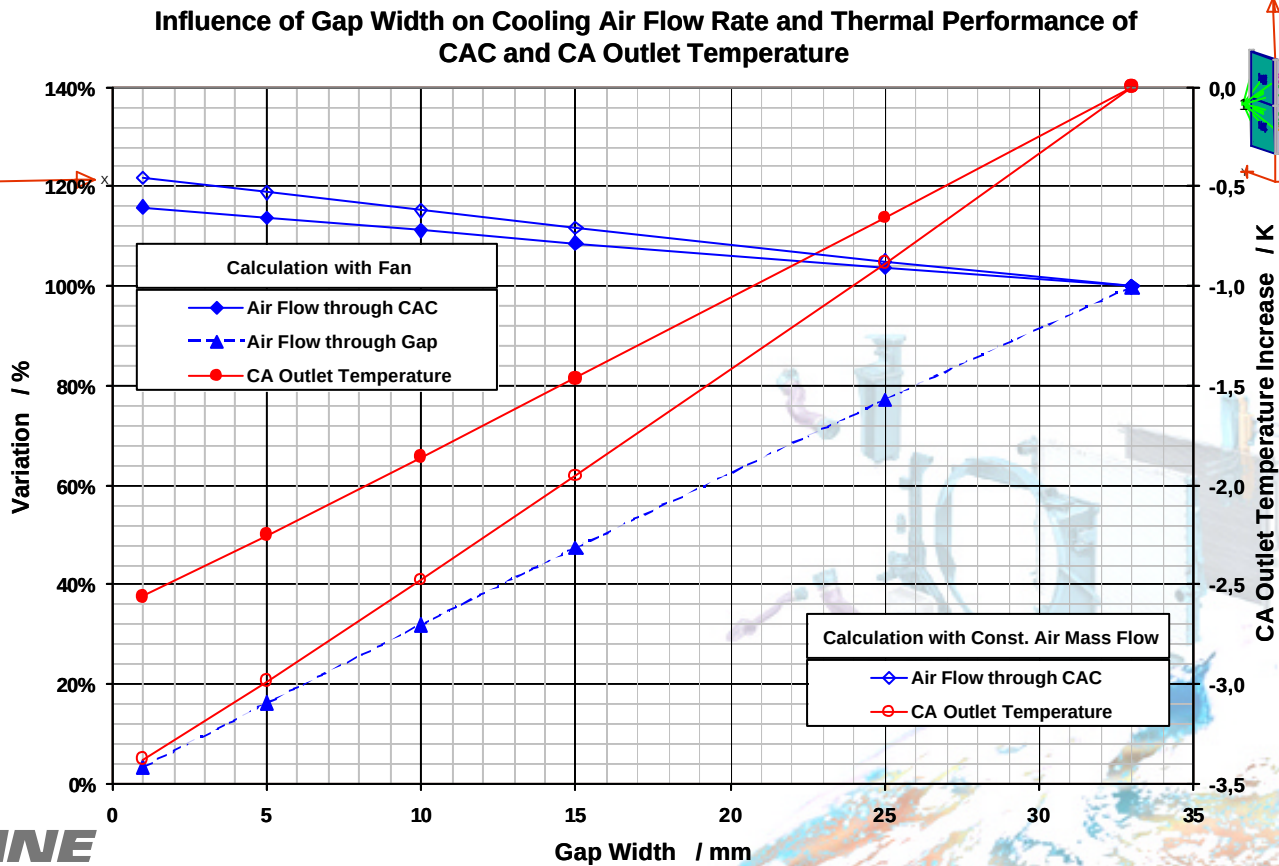
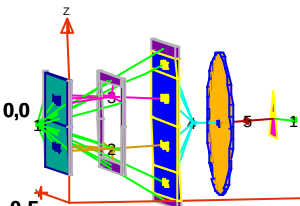
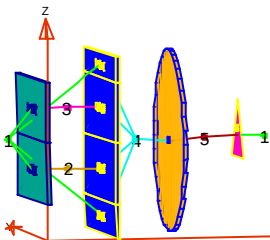




From Component Measurement  
to a tuned KULI Model of a Cooling System  
Results of the tuned KULI Model



From Component Measurement  
to a tuned KULI Model of a Cooling System  
Results of the tuned KULI Model



- **Measurement of Components and Modules**
- **Preparing Measurement Data for KULI-Input by**
  - **Regression (Nu, Zeta vs. Re) and**
  - **MODINE Heat Management Software**
- **Simple KULI-Model of Front-to-Back-Module**
- **Improved KULI-Model of Front-to-Back-Module**
- **KULI-Results: Influence of Gap Width on**
  - **Outside Pressure Drop and Cooling Air Flow Rate**
  - **Thermal Performance of Radiator and Charge Air Cooler**

