

creating
value
through
technology
Heat Transfer Worldwide

CO₂ AC System Simulation with Kuli AC

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Kuli User Meeting, Steyr, 17.-18.10.01

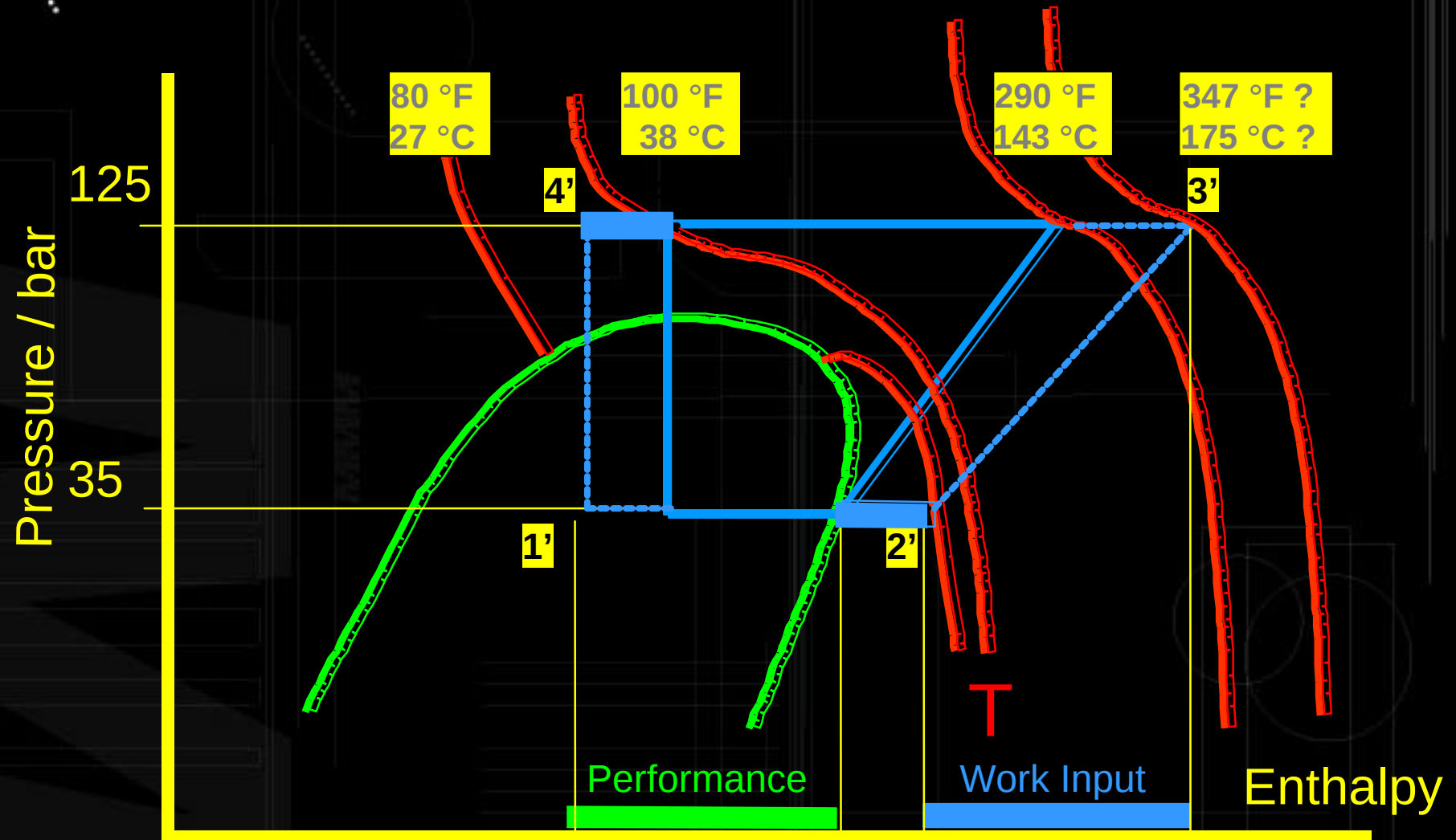


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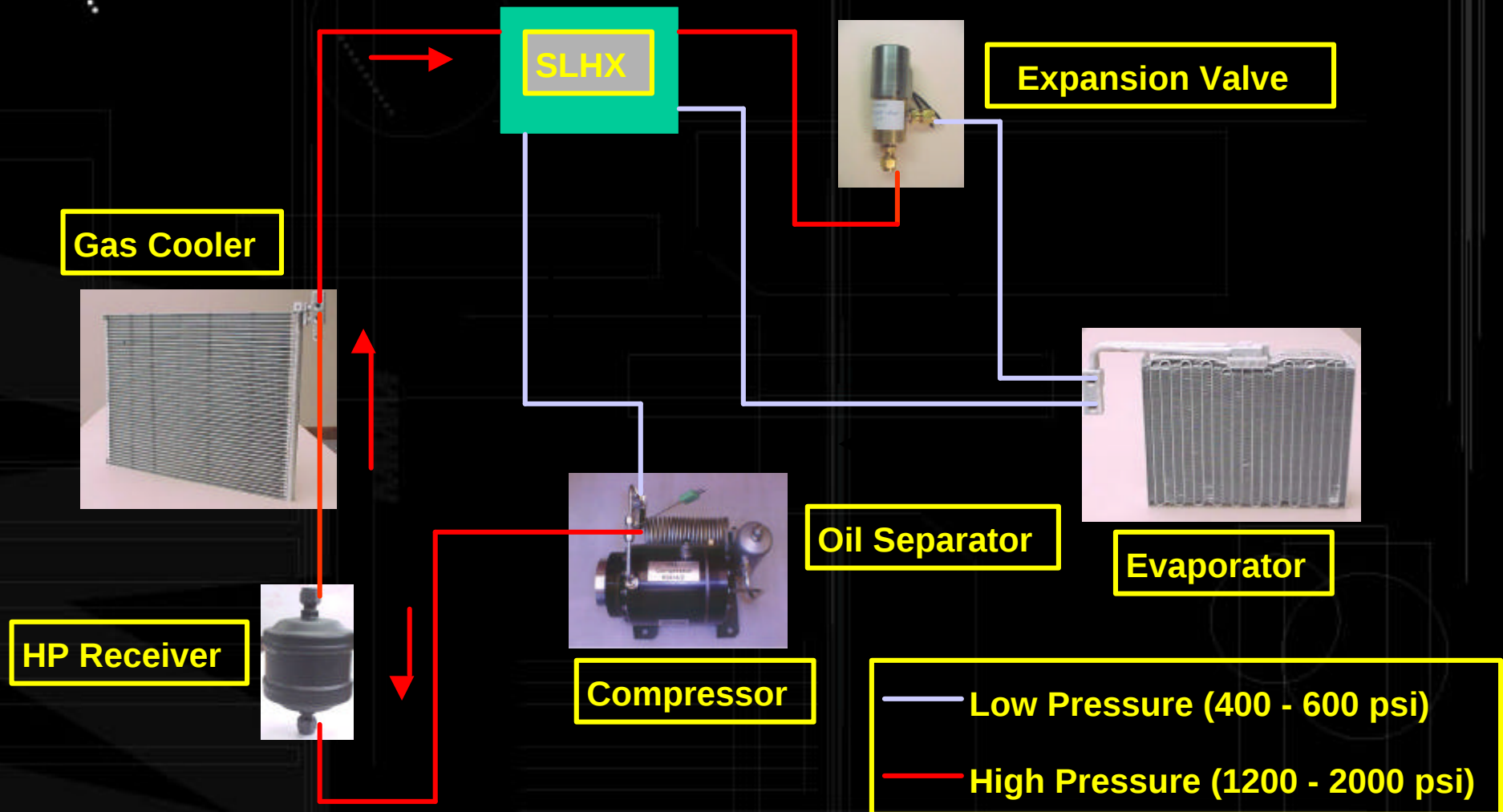
CO₂ advantages

- Enhanced cooling and heating performance compared to R134a
- Heat pump capability
- Good thermodynamic characteristics
- Environmentally friendly (no GWP)
- No recovery or recycling required
- Non-flammable, non-toxic

Typical p-h diagram



The Modine CO2 AC system



Kuli-AC benchmark

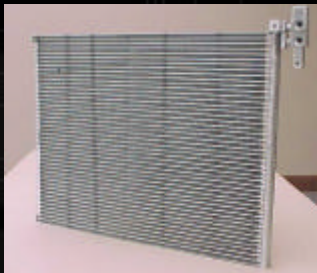
Evaluation of Kuli 4.0 AC capabilities for CO₂

- Accuracy of component models
- Handling of steady state system simulation

Test data for Modine CO₂ AC system

- Split room tests

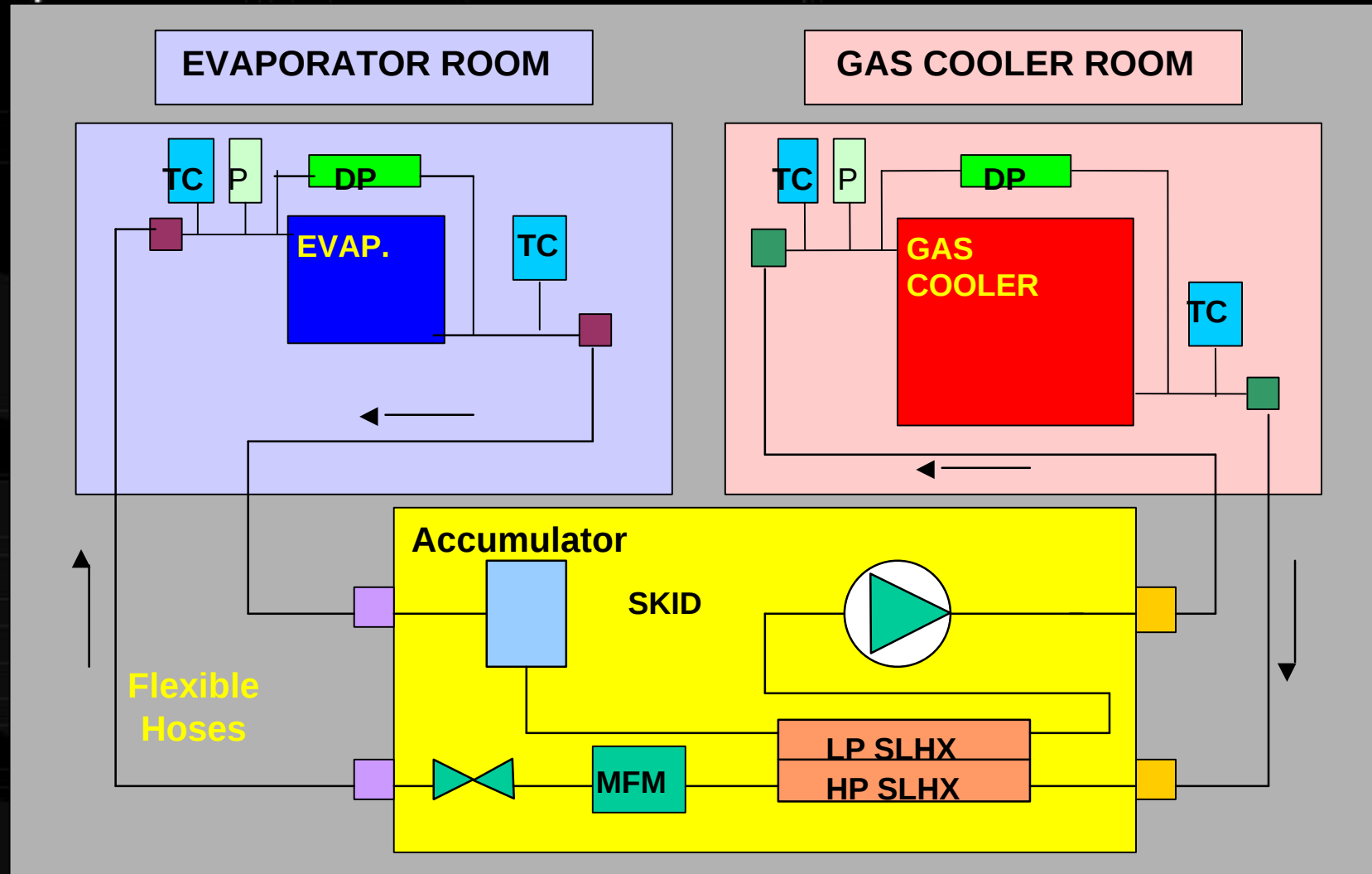
Gas cooler



Evaporator

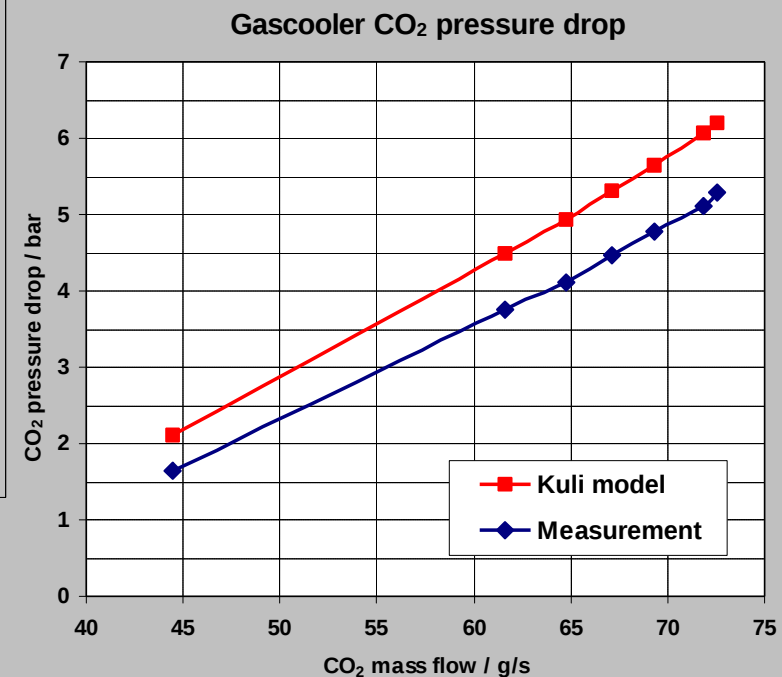
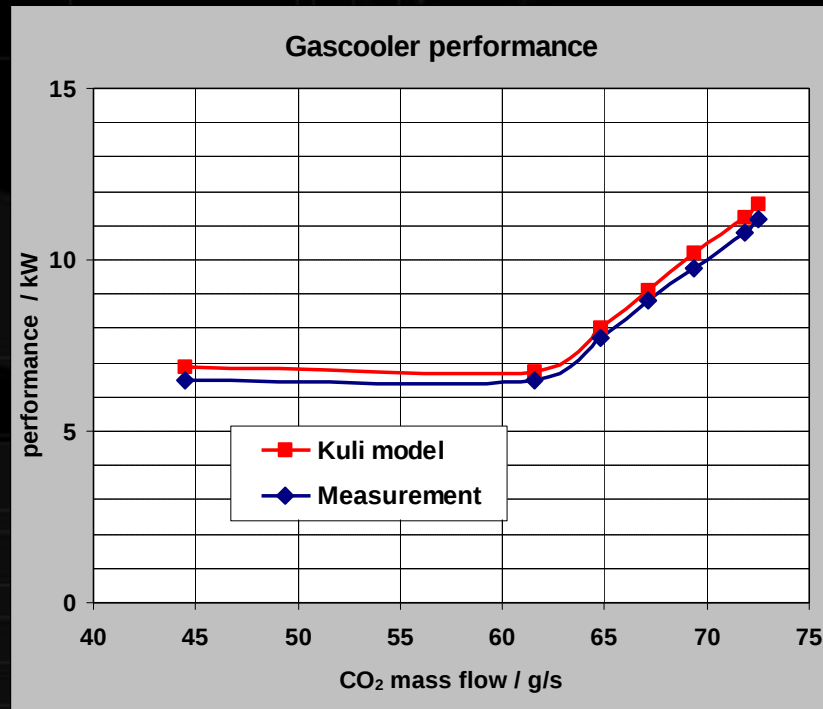
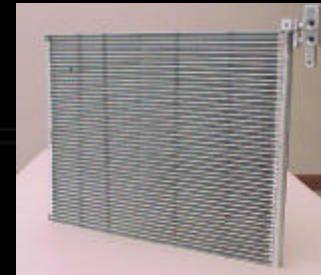


Test facility - Split room



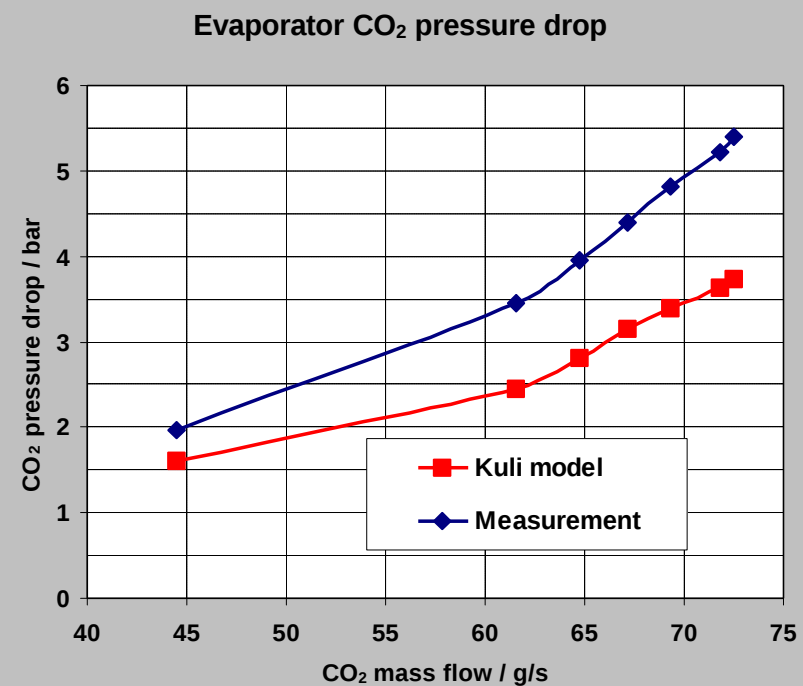
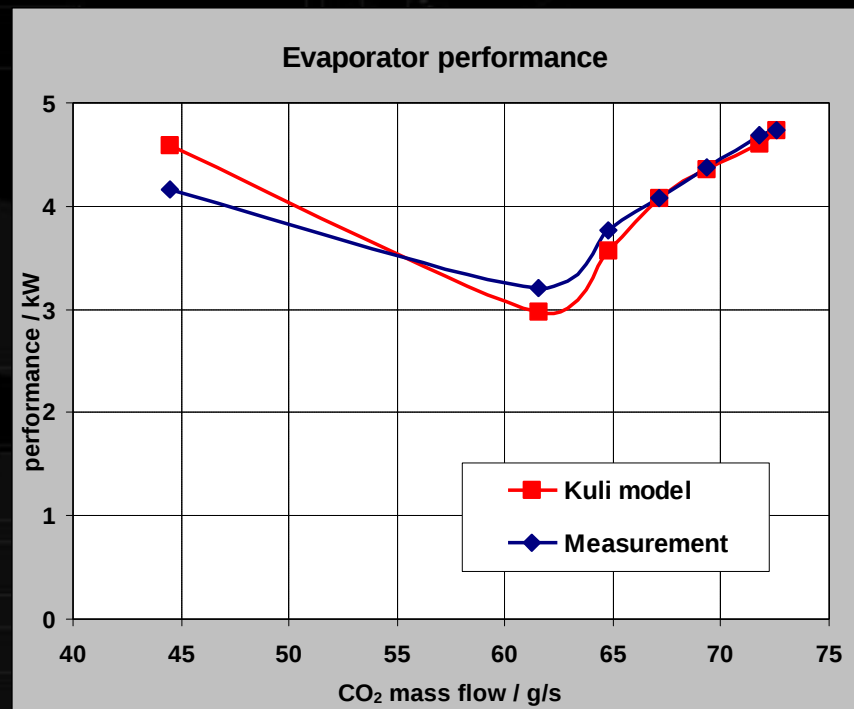
Component validation - 1

Gas cooler



Component validation - 2

Evaporator



Pull down test

CO₂ AC system

- in recirculation mode
- with branches in refrigerant circuit

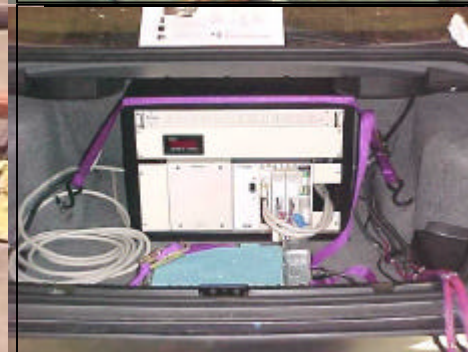
Transient Kuli simulation

Compartment model

- Heatsim
- KULI-Fluid substitution

Model generation in close cooperation with ECS

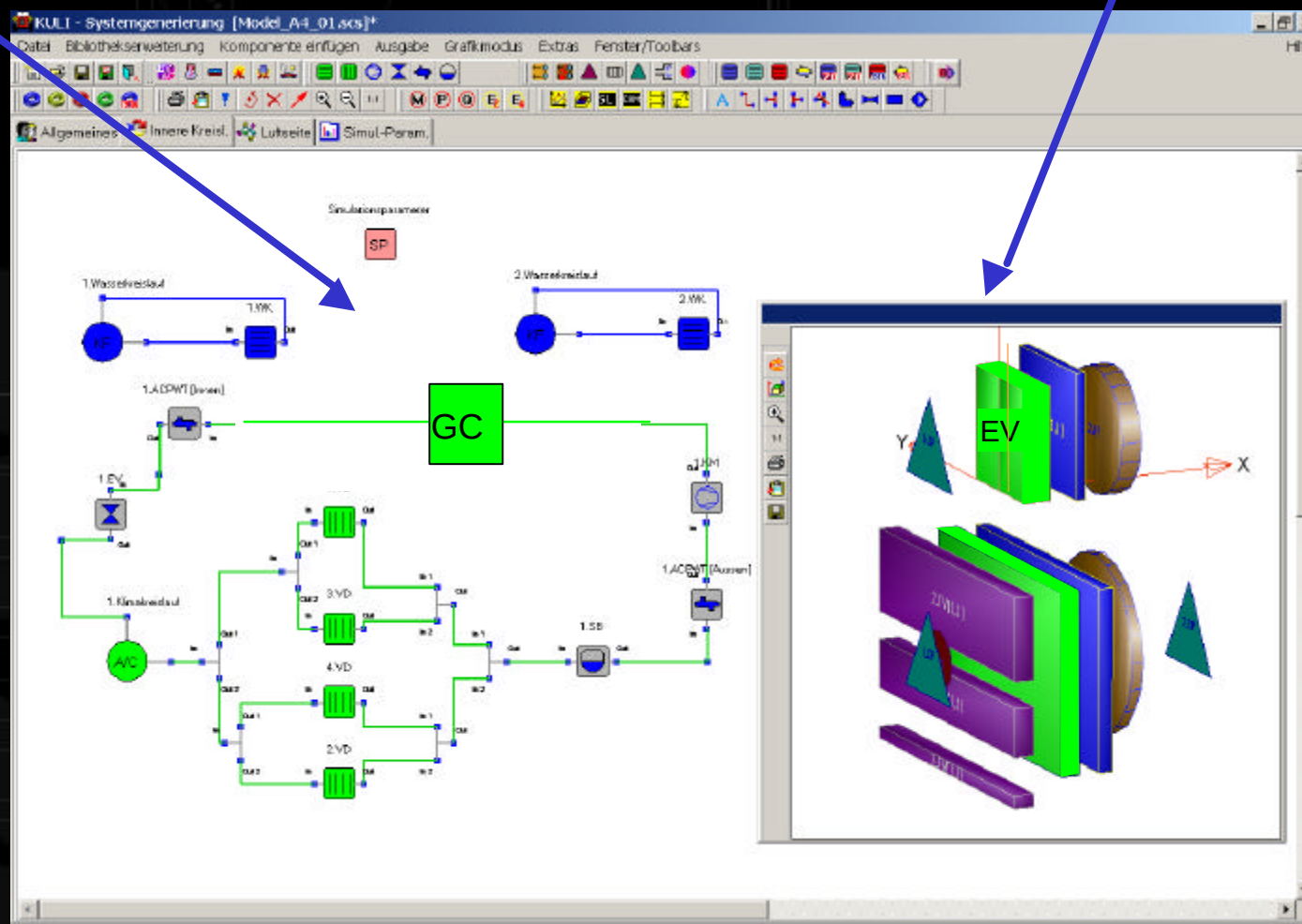
Test facility - Wind tunnel



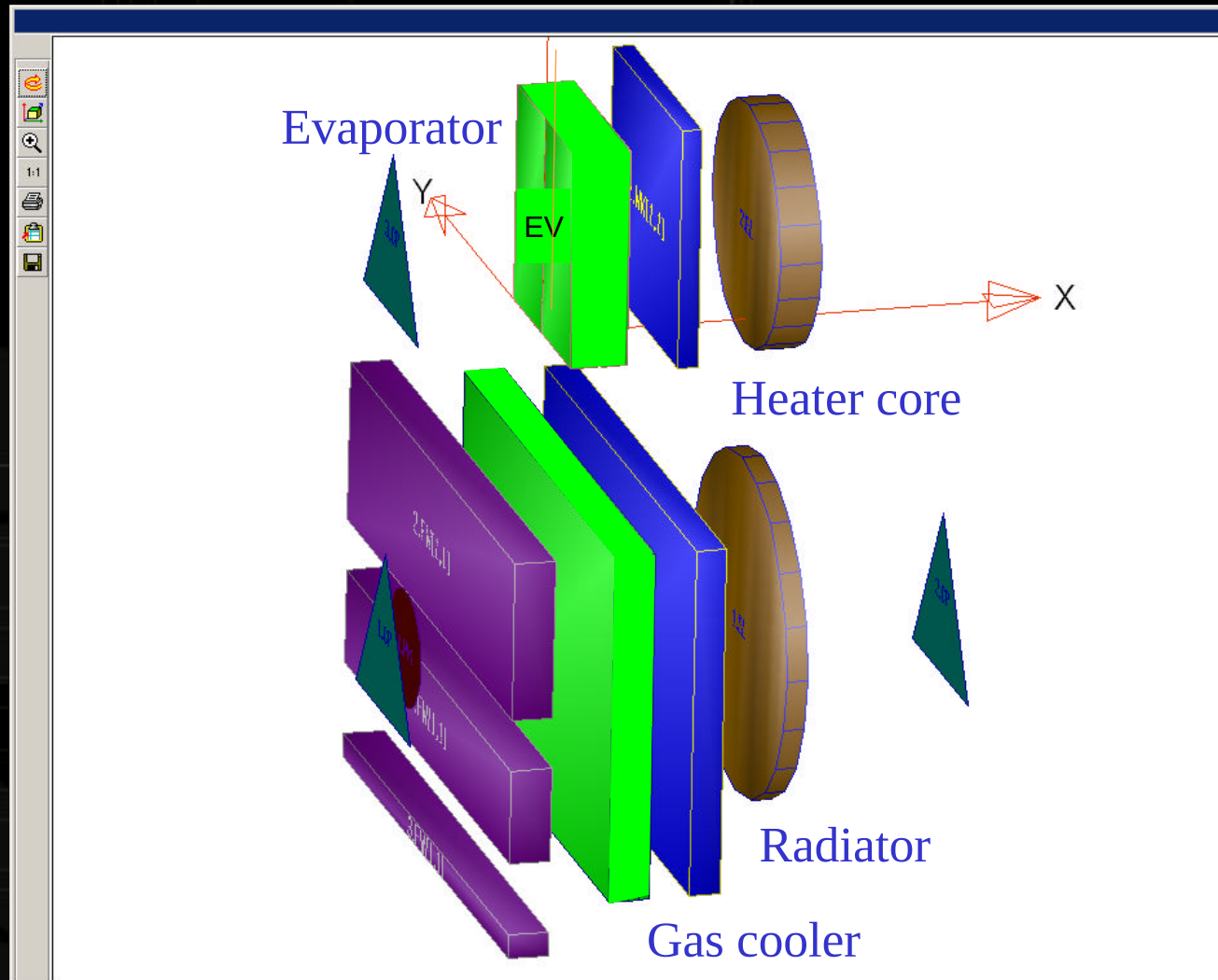
KULI system

Inner circuits

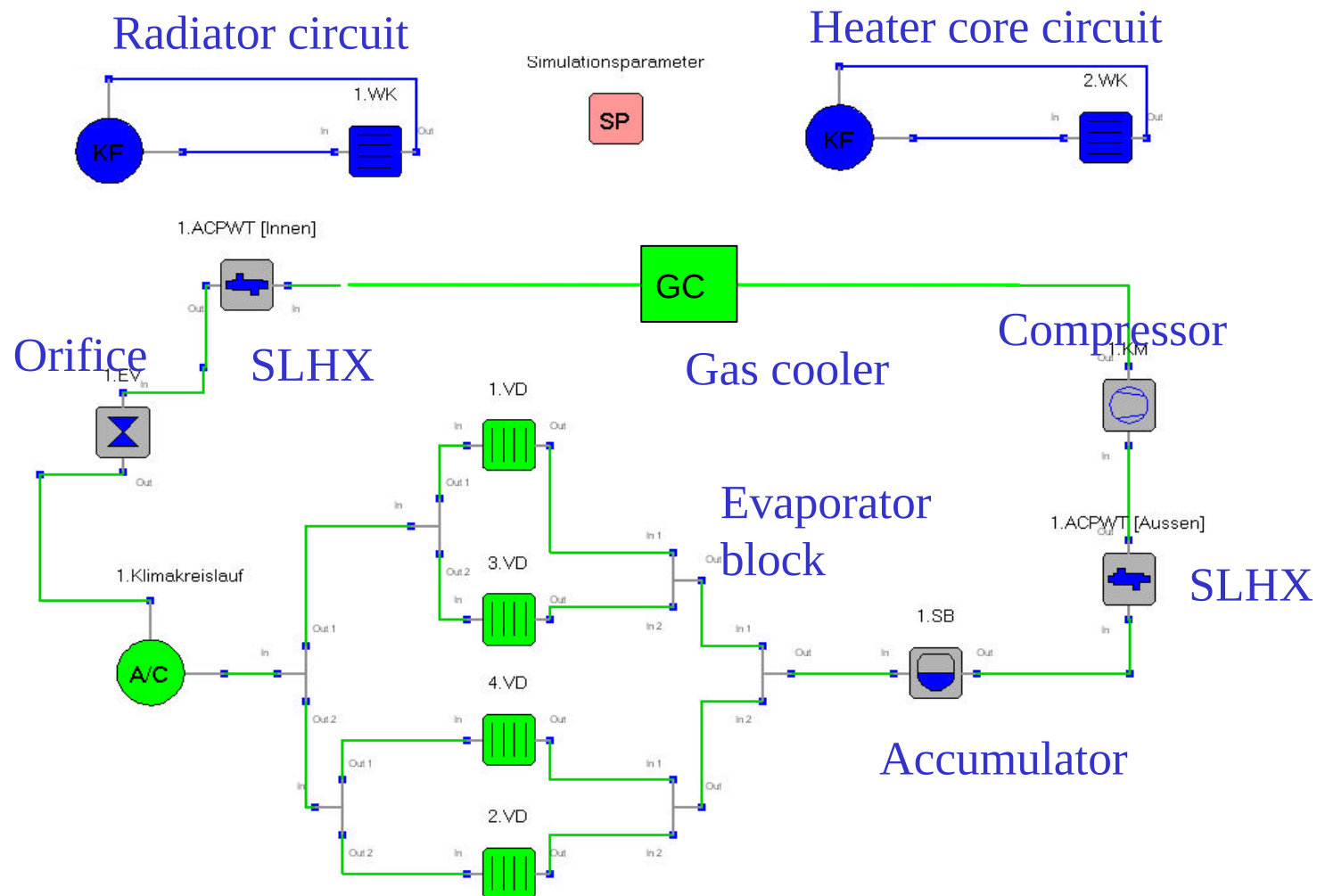
Air flow network



Cooling system

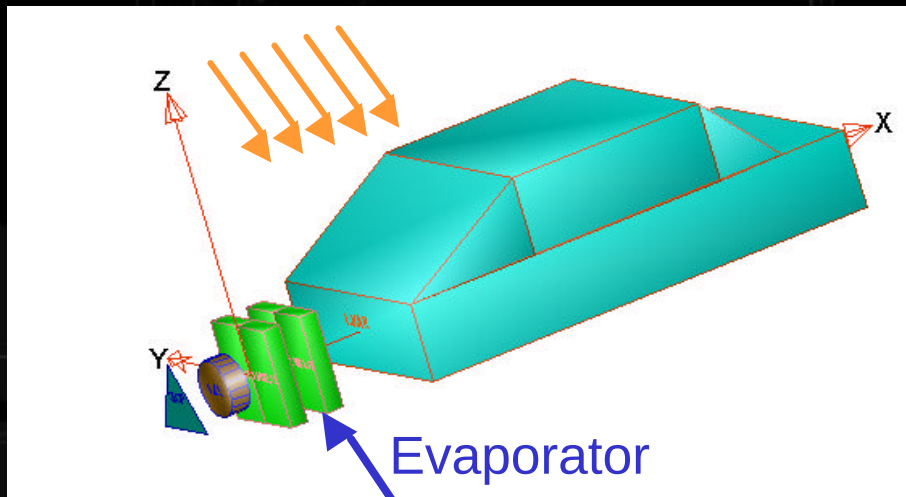


Refrigerant system



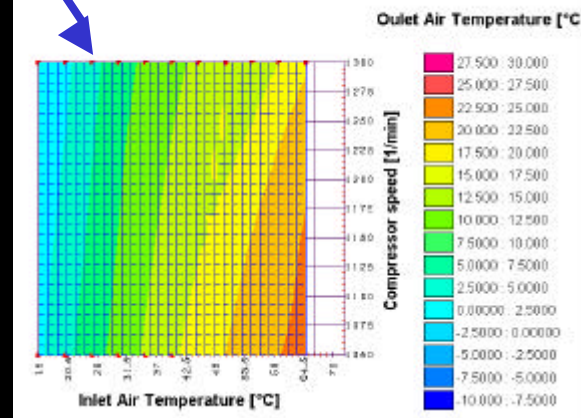
HEATSIM model

Radiation



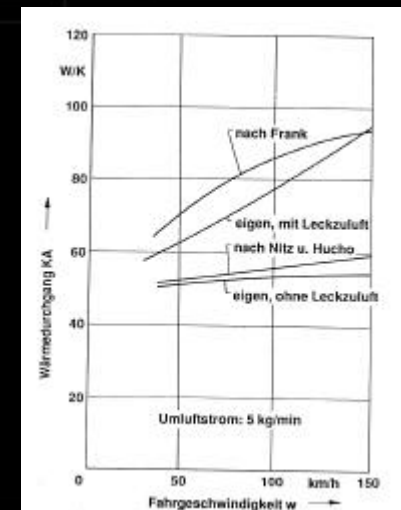
Evaporator

Performance map
calculated in
advance

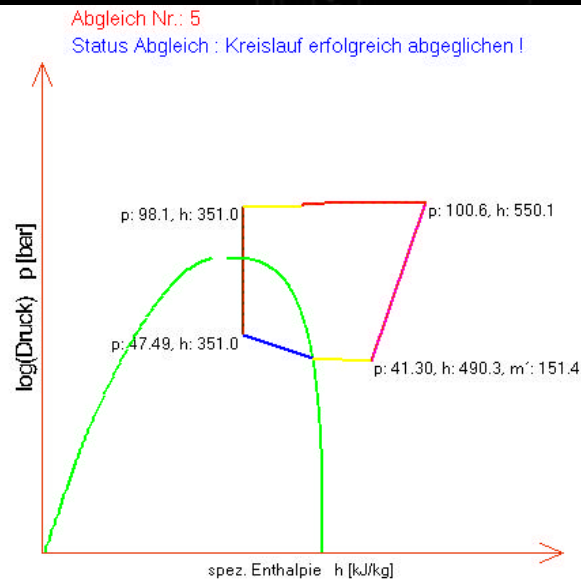


Additional thermal
compartment masses

Passenger
compartment,
Heat transfer model

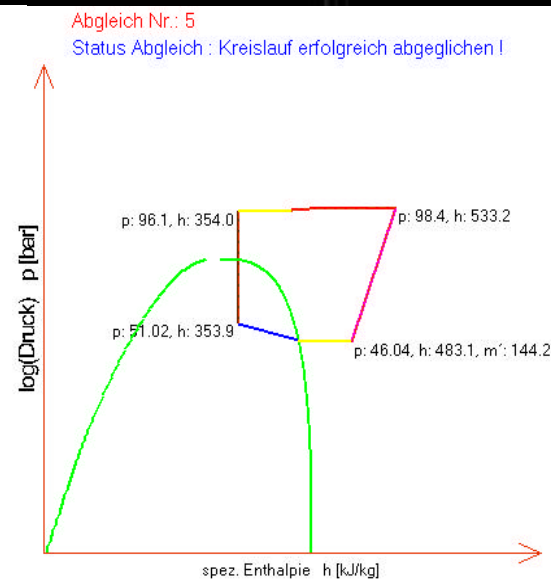


Refrigerant circuit results



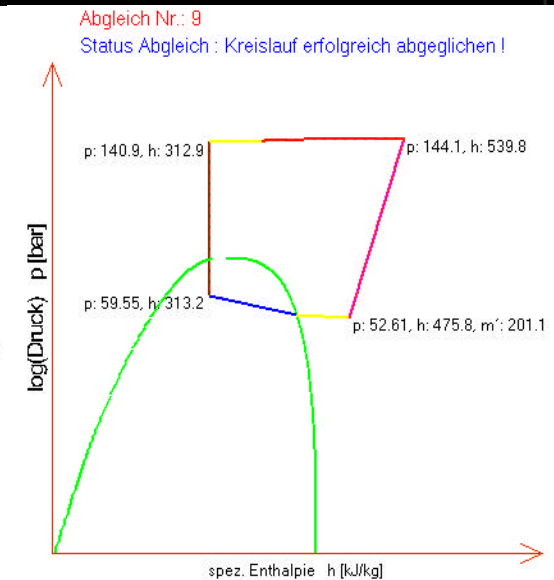
1300 RPM

$T_{\text{air,in}} = 35^\circ\text{C}$



1050 RPM

$T_{\text{air,in}} = 35^\circ\text{C}$



1300 RPM

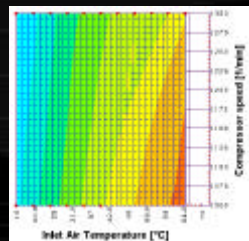
$T_{\text{air,in}} = 65^\circ\text{C}$

Air side results at evaporator ➡ Input for performance map

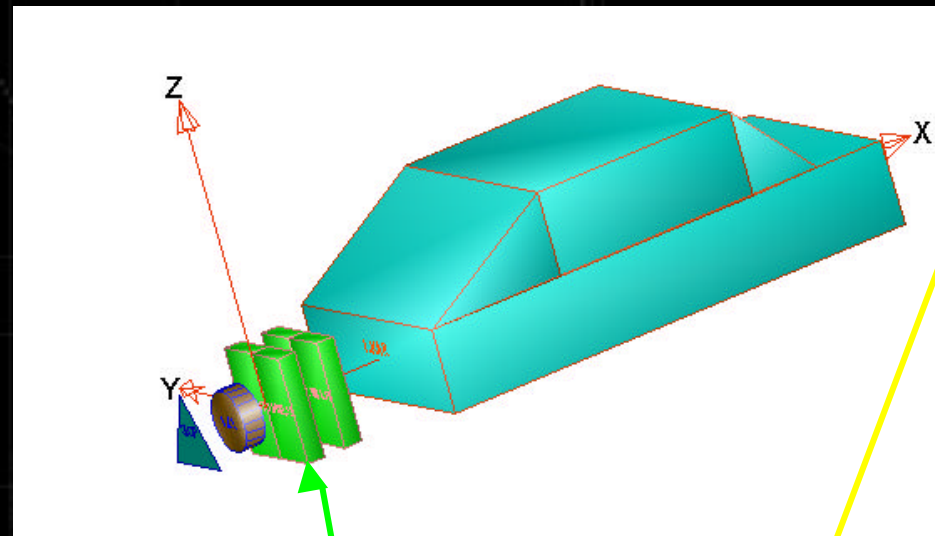
Substitute model

HEATSIM-Model

KULI-Fluid substitute



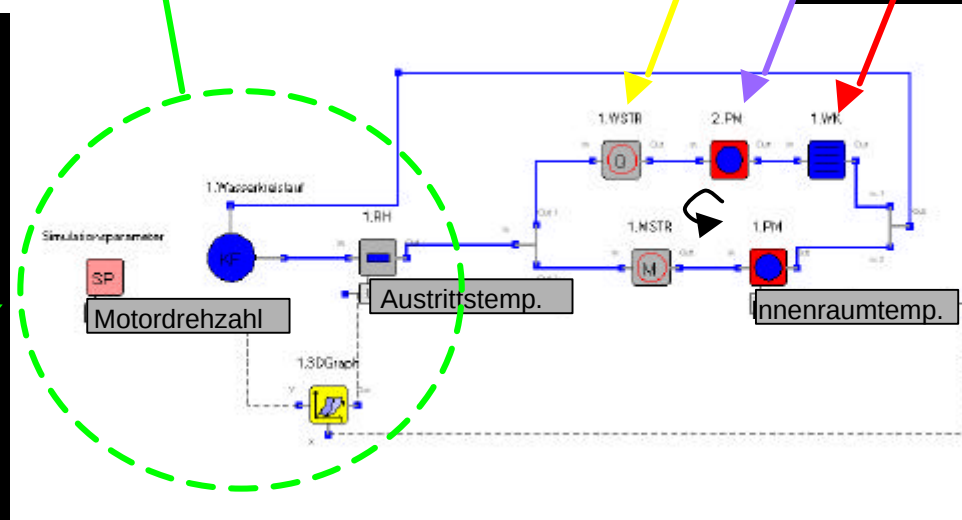
Evaporator model



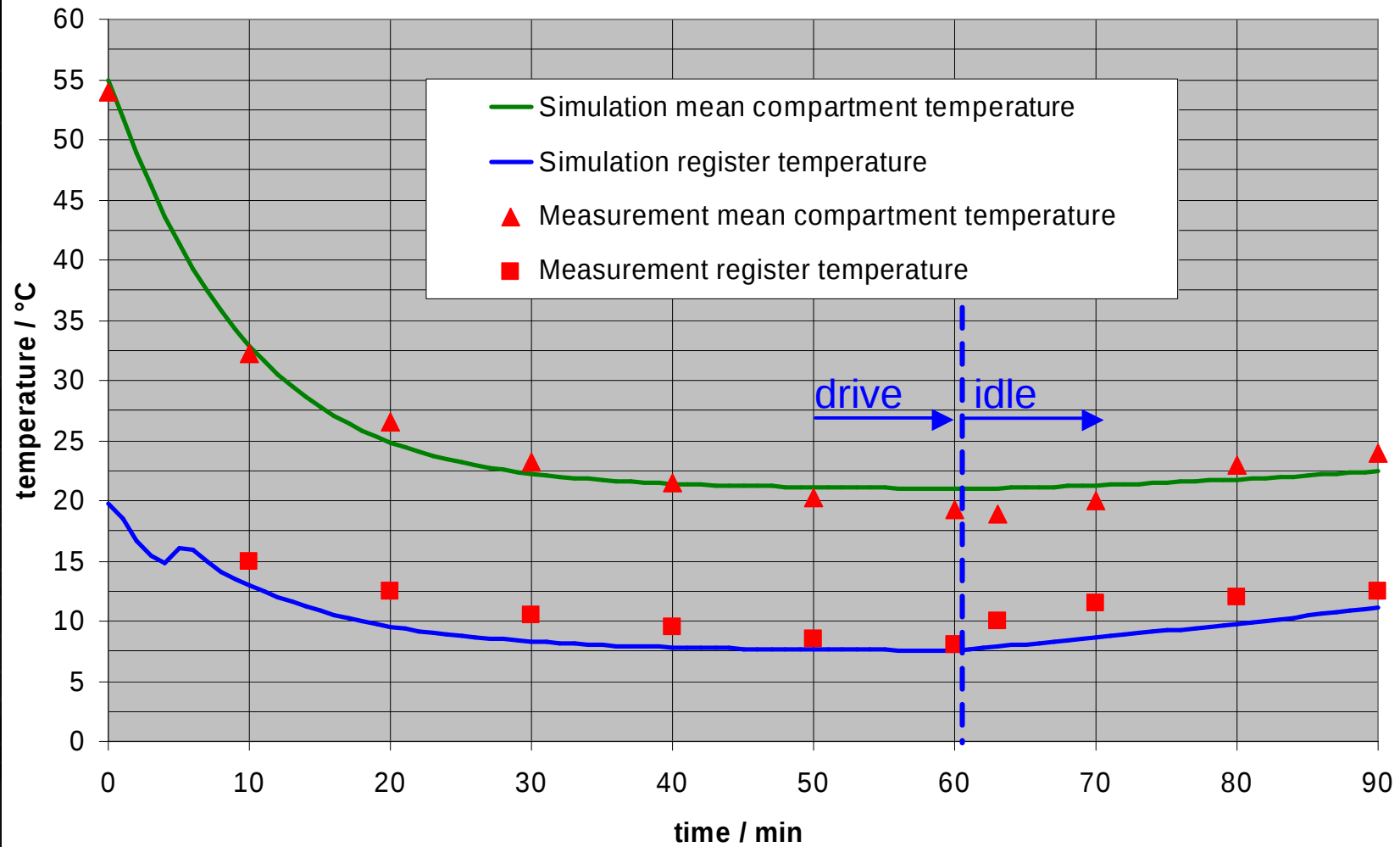
Radiation

Compartment masses

Cabin model



Pull down results



Conclusion

- Accuracy of component models in Kuli-AC is satisfying.
- Pull down model is in reasonable agreement with measurement.
- Kuli-AC is flexible
 - ➔ AC branches
- Powerful air side model
 - ➔ link to engine cooling
 - ➔ air flow / temperature distribution

Advantage: **1** tool for engine cooling and AC simulation.