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SOLAR THERMAL ENERGY RESEARCH GROUP

Hybrid Pressurized Air Receiver (HPAR)

STERG Symposium

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Fakulteit Ingenieurswese • Faculty of Engineering

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Objective

- increase allowable flux density [kW/m^2]
  - Smaller receiver size; lower cost; less thermal losses which are affected by receiver surface area
- increase max. fluid outlet temperature (T_{f_out})
  - higher system efficiency (carnot principle)
- increase receiver efficiency
  - higher system efficiency
  - decrease reflection, radiation and convection losses

$$\eta_{rec} = \alpha - \frac{(1-\alpha)\bar{F}}{\phi C} - \sigma\epsilon\bar{F}\frac{\left(\bar{T}_s{}^4 - T_{amb}{}^4\right)}{\phi C} - \bar{h}\frac{(\bar{T}_s - T_{amb})}{\phi C}$$

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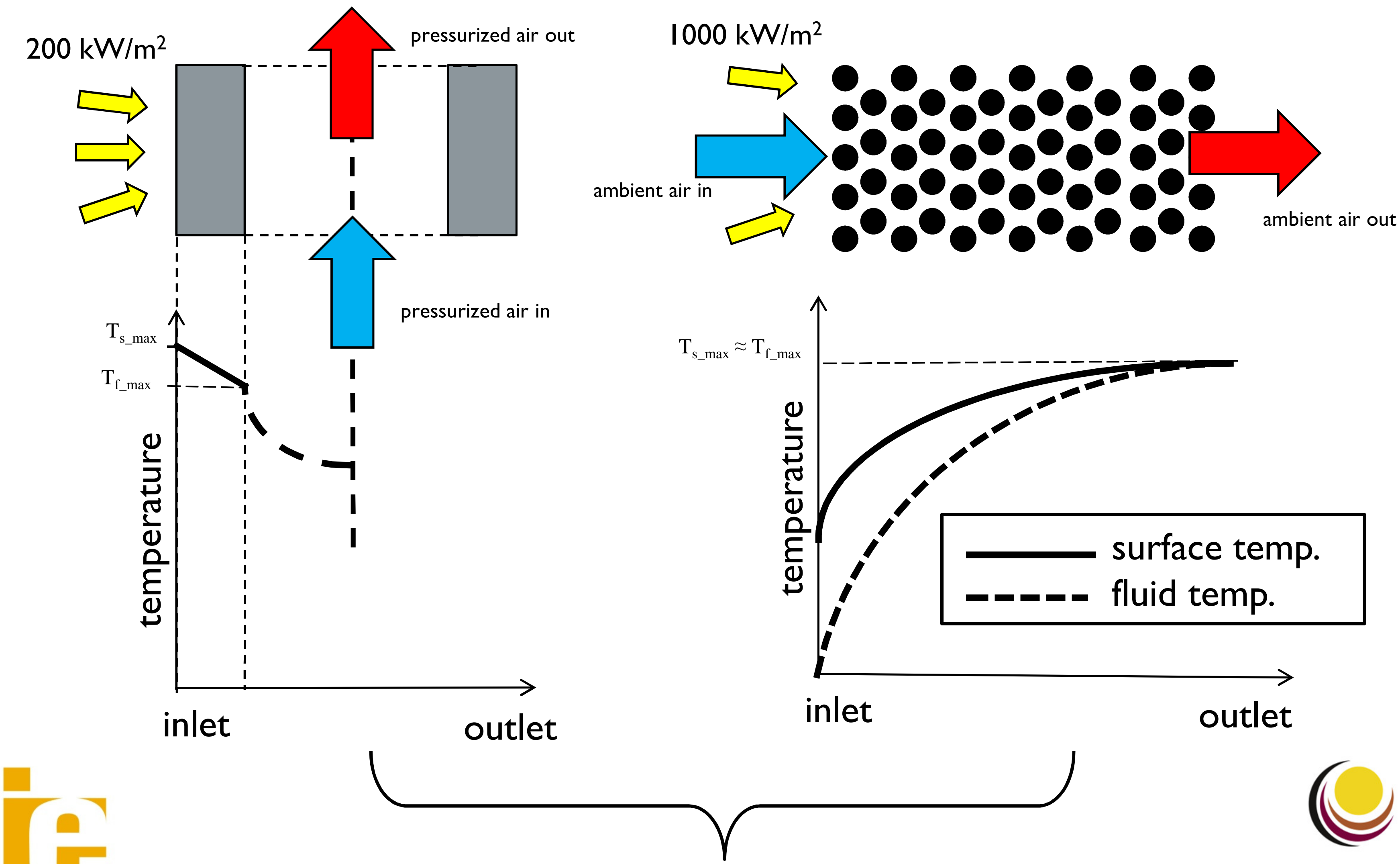
indirectly irradiated vs. directly irradiated



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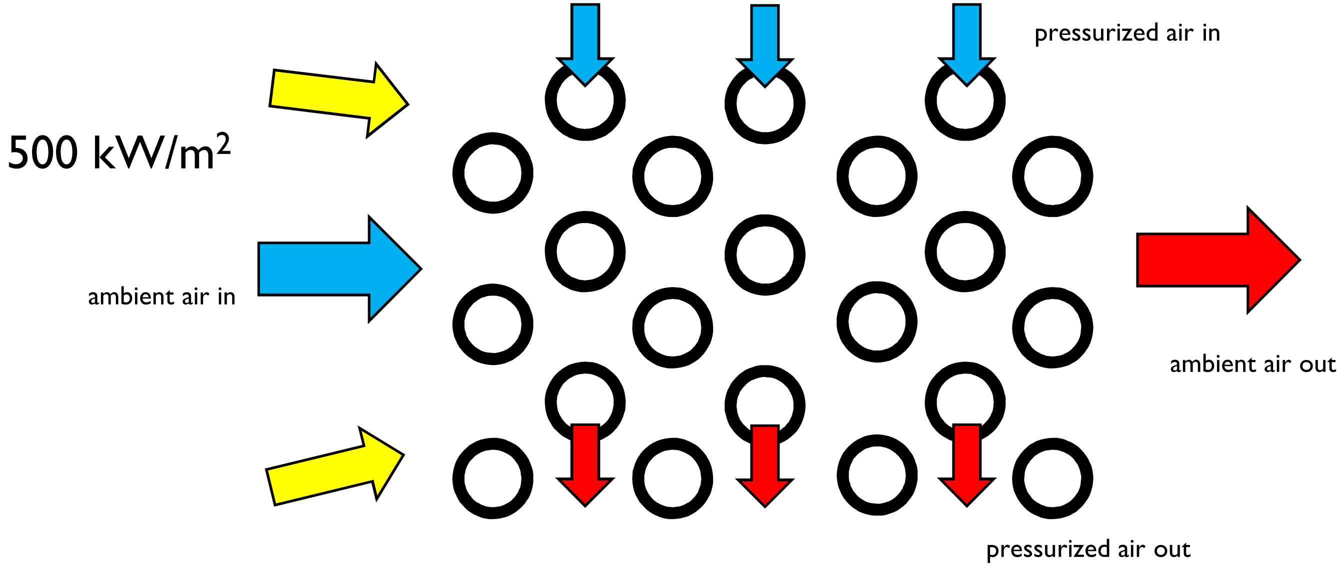
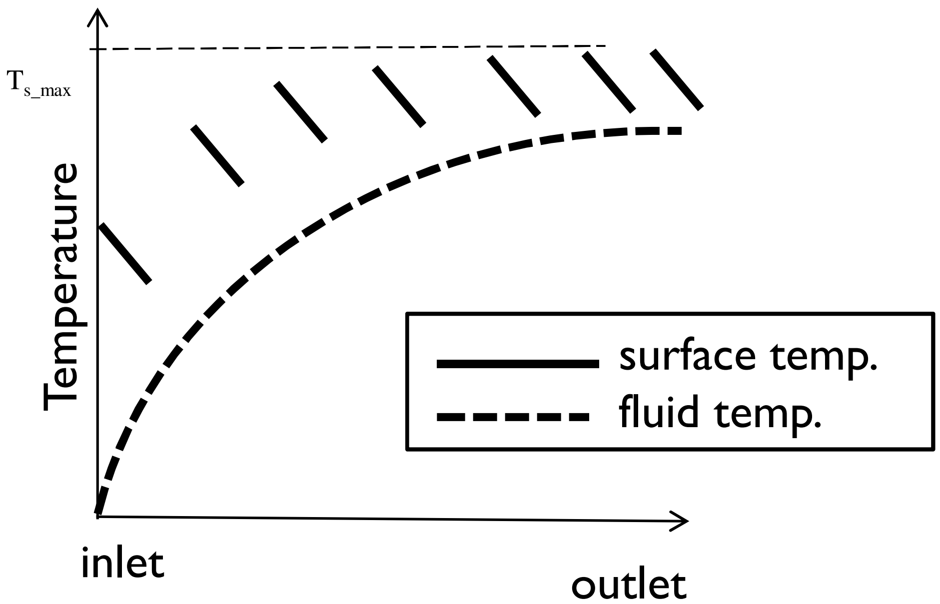
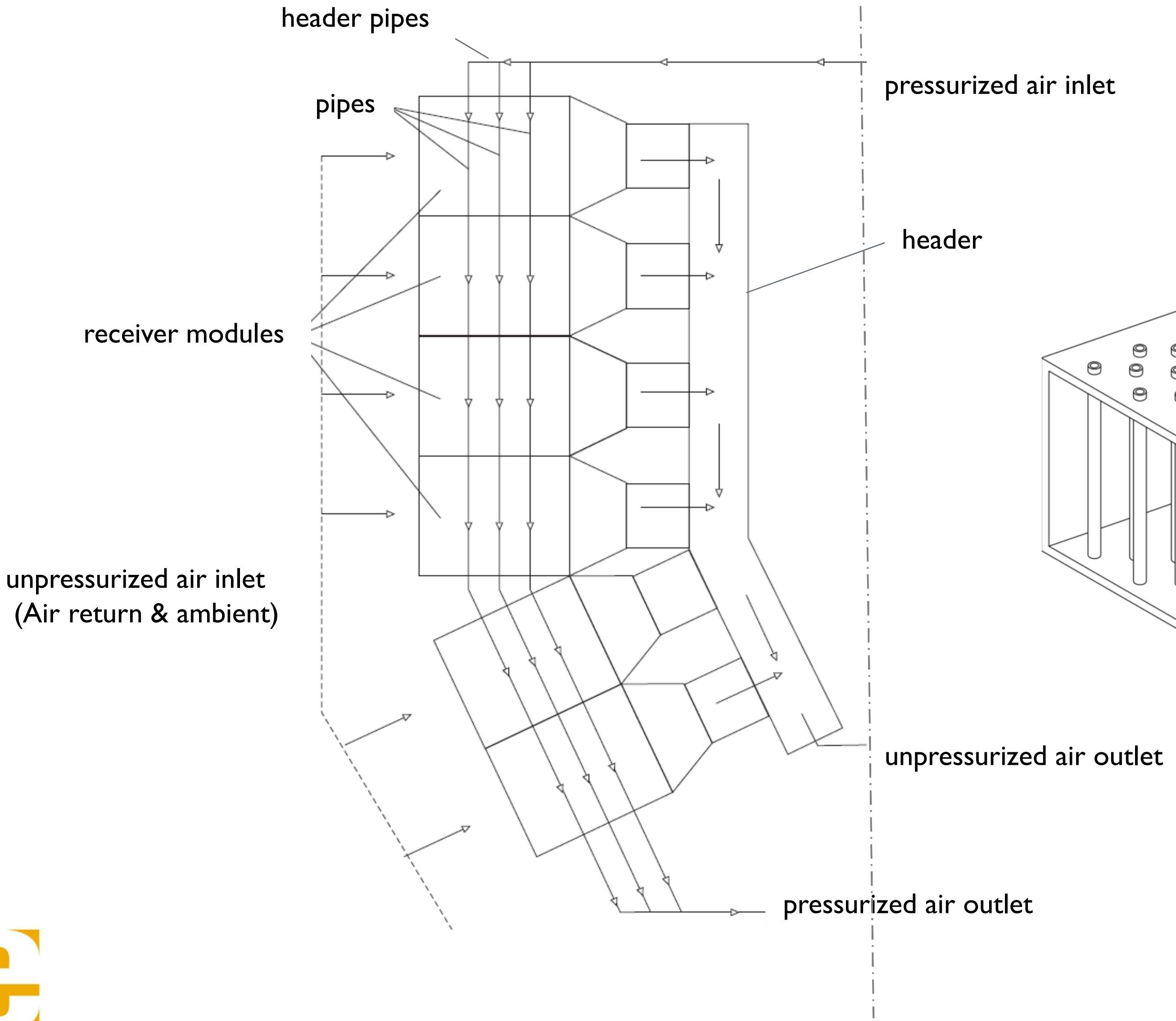
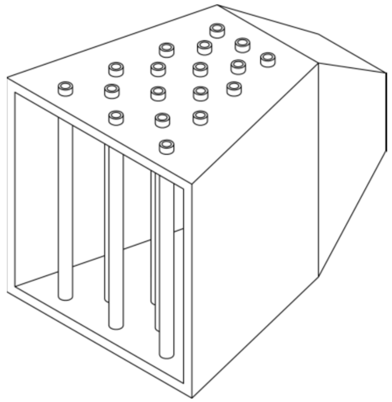
Hybrid Pressurized Air Receiver





potential layout of HPAR





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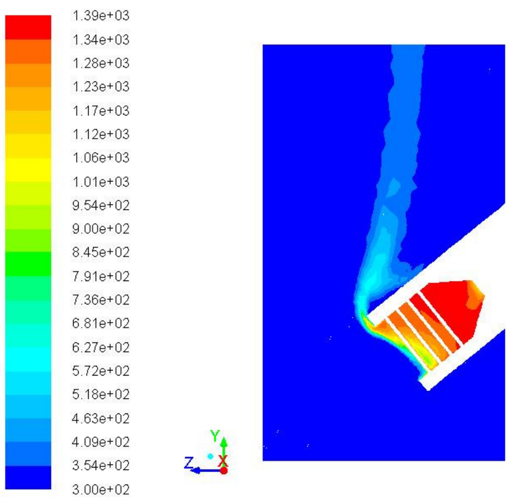
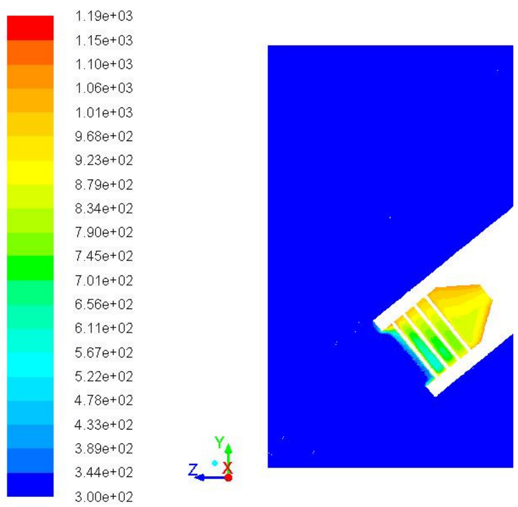
reverse air flow effect

- investigation of the effect of the reverse airflow on receiver efficiency and temperature distribution through receiver
- stagnation conditions in tube
- closed cavity versus reverse flow at 4 m/s
- result: convection losses negligible, radiation losses however remain significant





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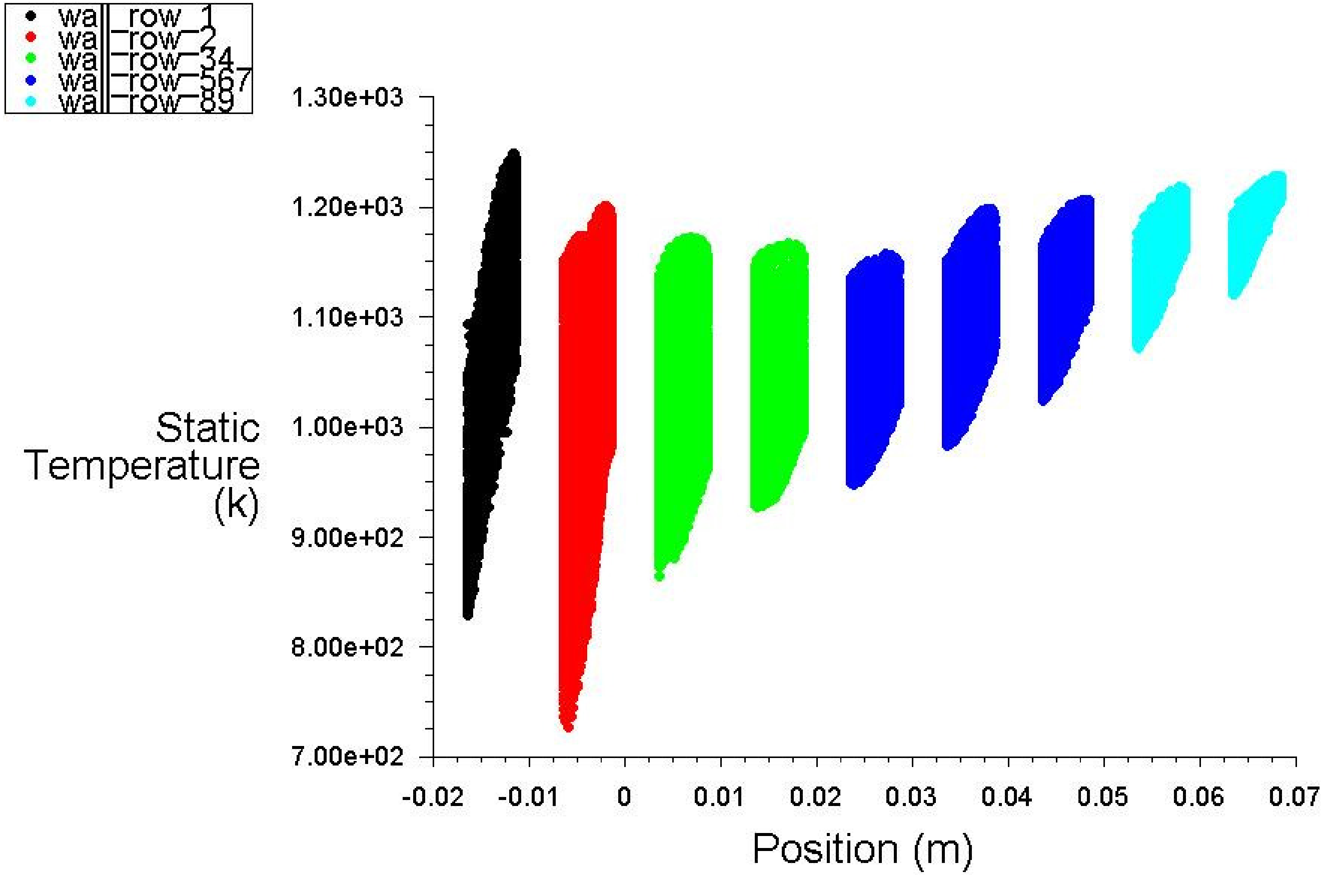

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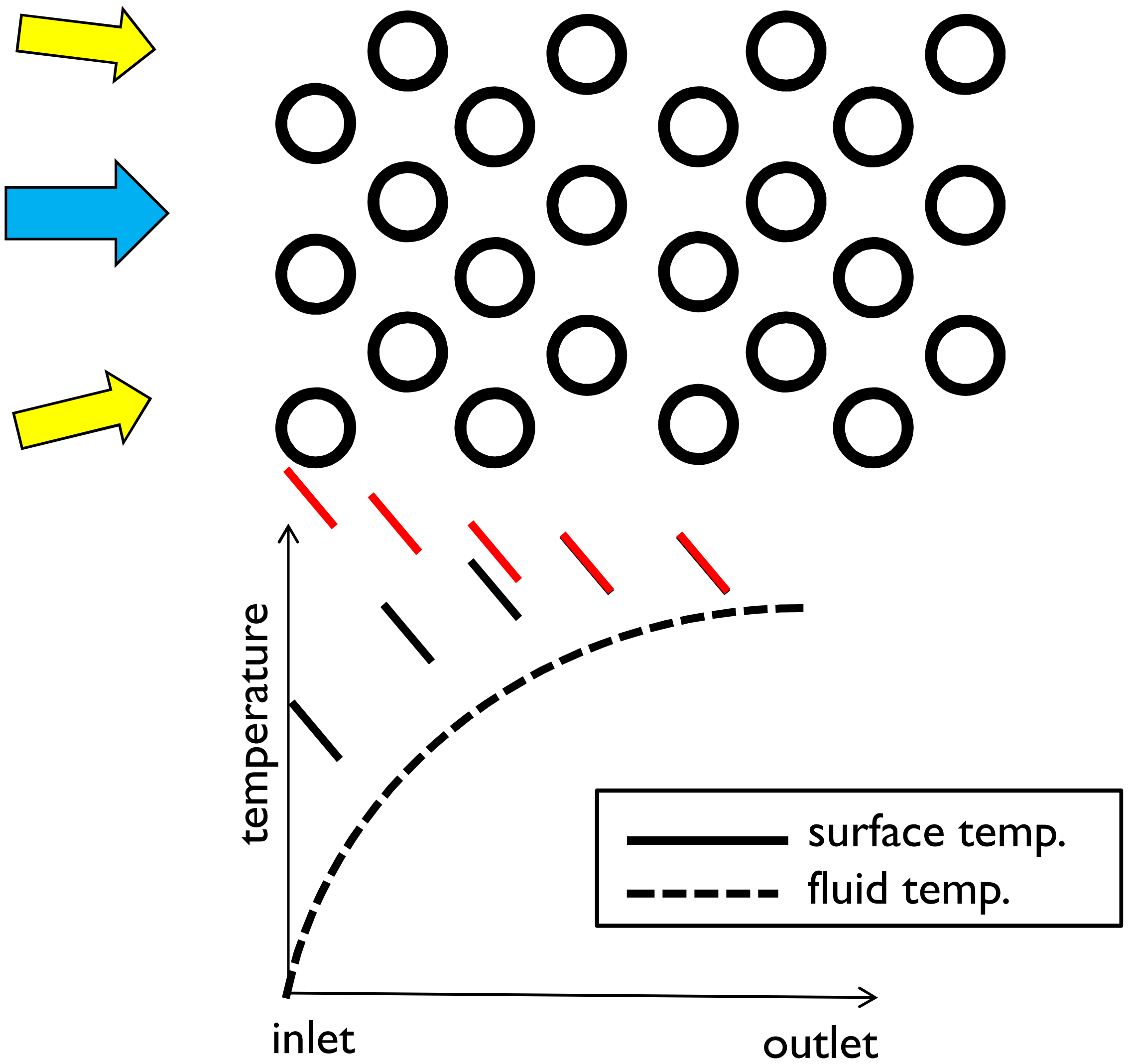
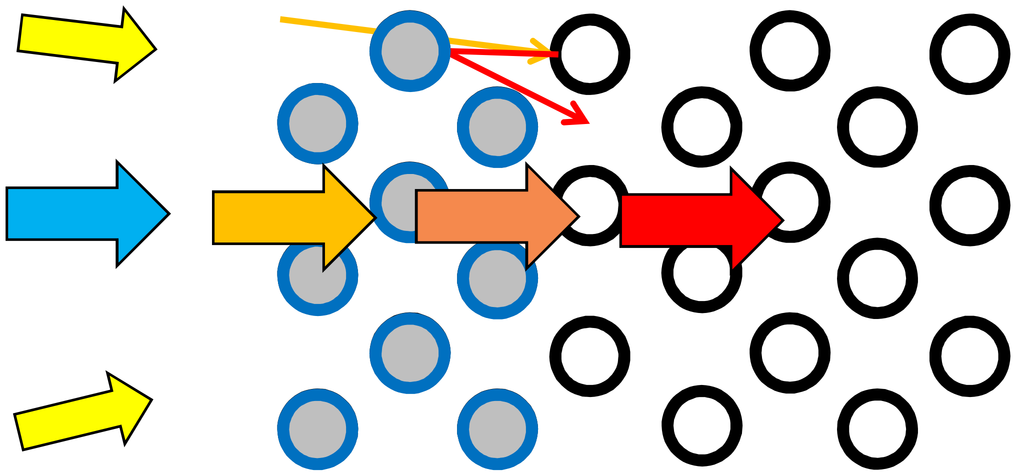
non-ideal volumetric effect



quartz glass wafers

- fused silica quartz glass
  - max. allowable temperature: 1050 °C (unpressurized)
  - transparent within visible light spectrum (λ = 400 nm to λ = 700 nm)
  - opaque within infra-red spectrum (λ = 700 nm to λ = 1 mm)
  - shape: round or triangular to reduce reflection losses



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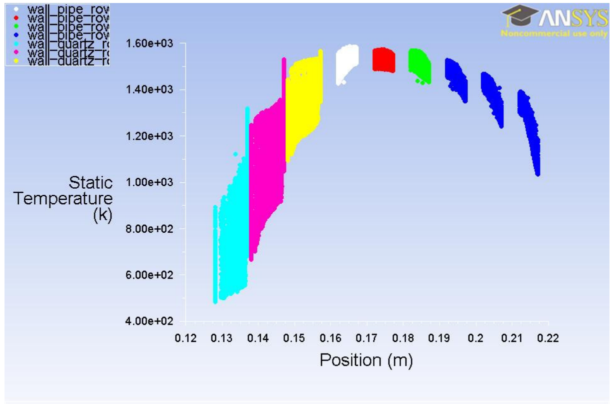
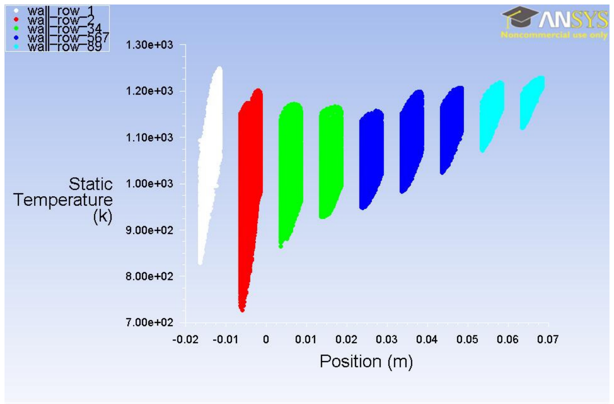
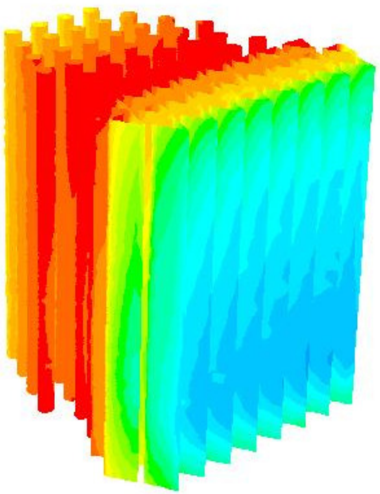
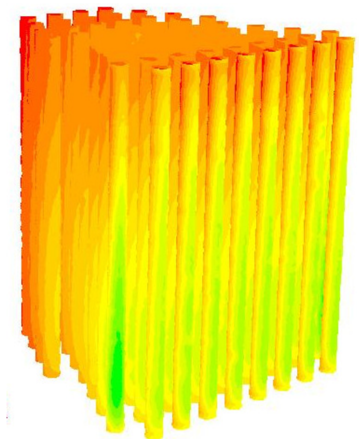
effect of quartz wafers

- radiation losses significantly reduces. Convection losses remain low; Thus temperatures of tubes increased









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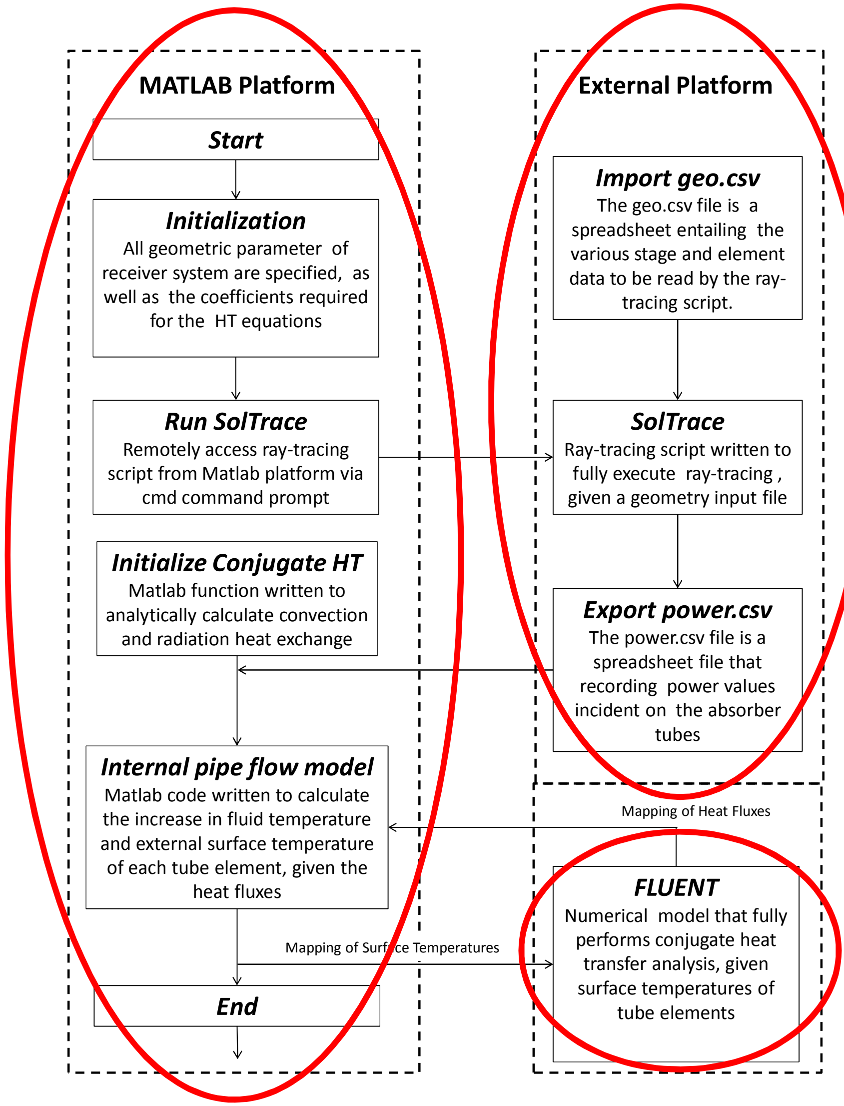
coupled numerical CHT model



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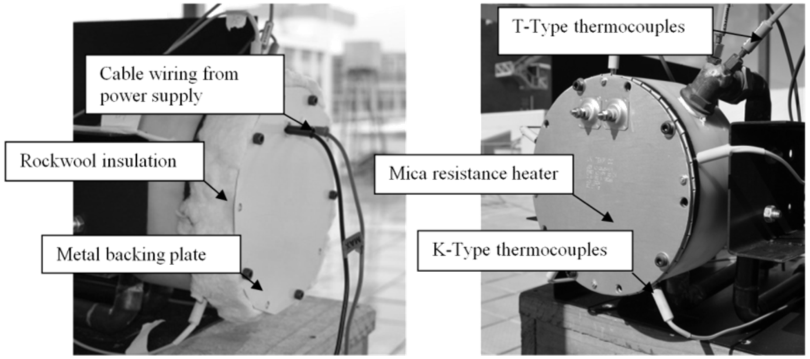
empirical validation

30 suns

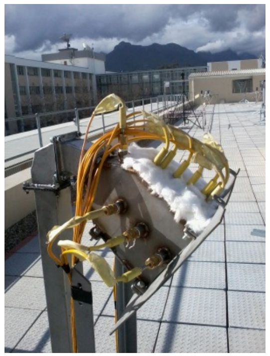
150 suns

rig modification

flux characterisation



receiver module testing



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future work

- complete empirical validation
- thesis write-up

Conclusion

- HPAR concept developed from combined tubular and volumetric receiver technologies
- high receiver efficiencies expected: reflection, radiation and convection losses minimized
- modelling and empirical validation strategy presented