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Thermal Energy Theme Lead

WARWICK

GLOBAL RESEARCH PRIORITIES  
ENERGY

# Developing an Evacuated Flat Plate Collector

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# High Performance Vacuum Flat Plate Solar Thermal Collectors for Hot Water and Process Heat

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ENERGY

**EPSRC**

Engineering and Physical Sciences  
Research Council

EP/K009915/1

EP/K009230/1

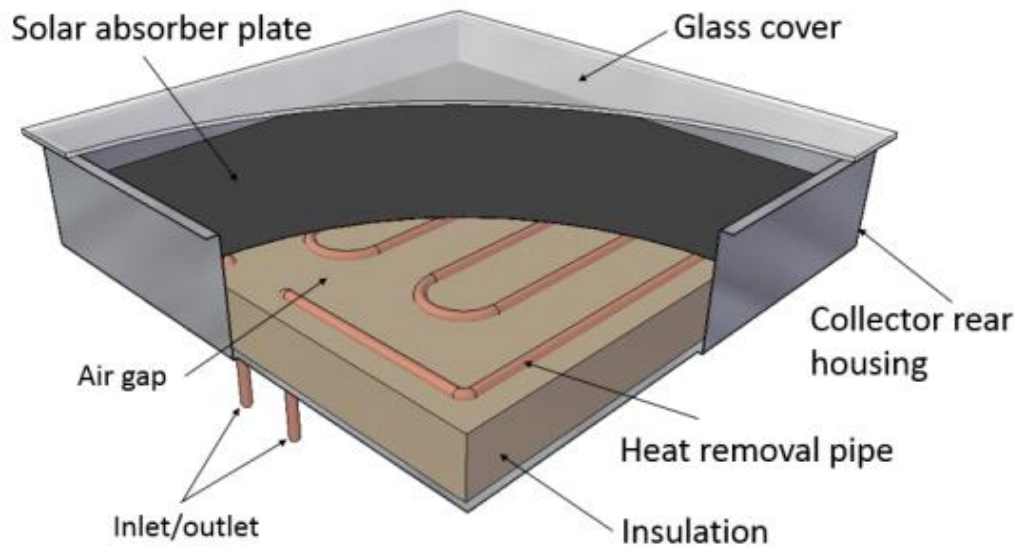
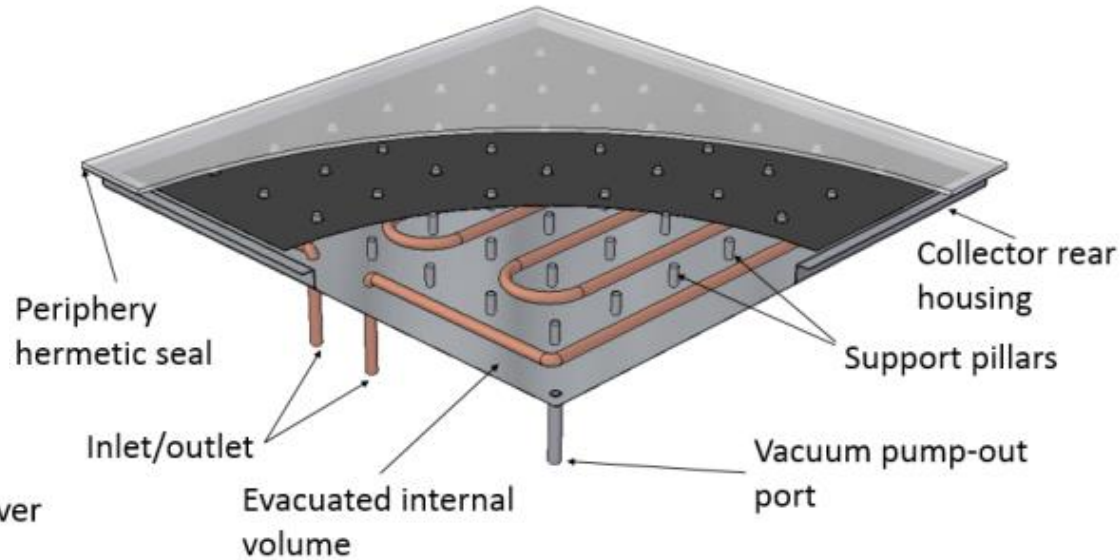
EP/K010107/1



Loughborough  
University

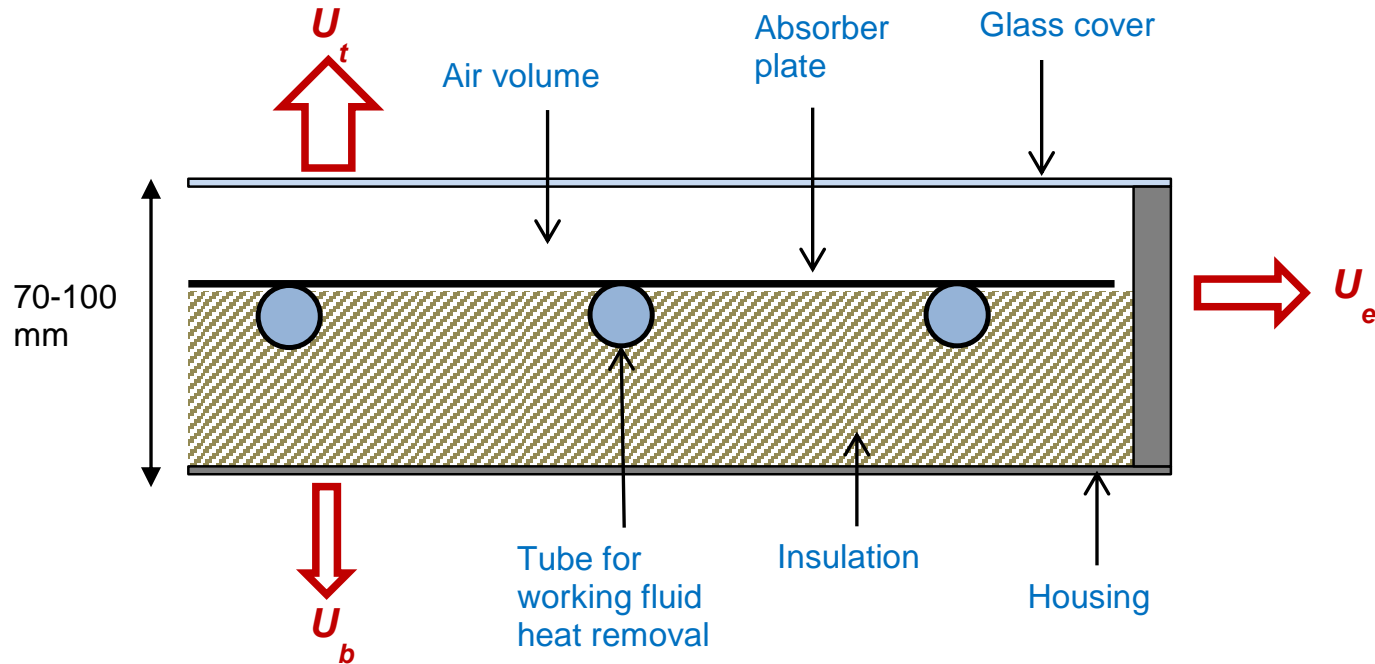
# Why?

Absorber fills up more of the installed collector area in comparison to evacuated tube collectors.



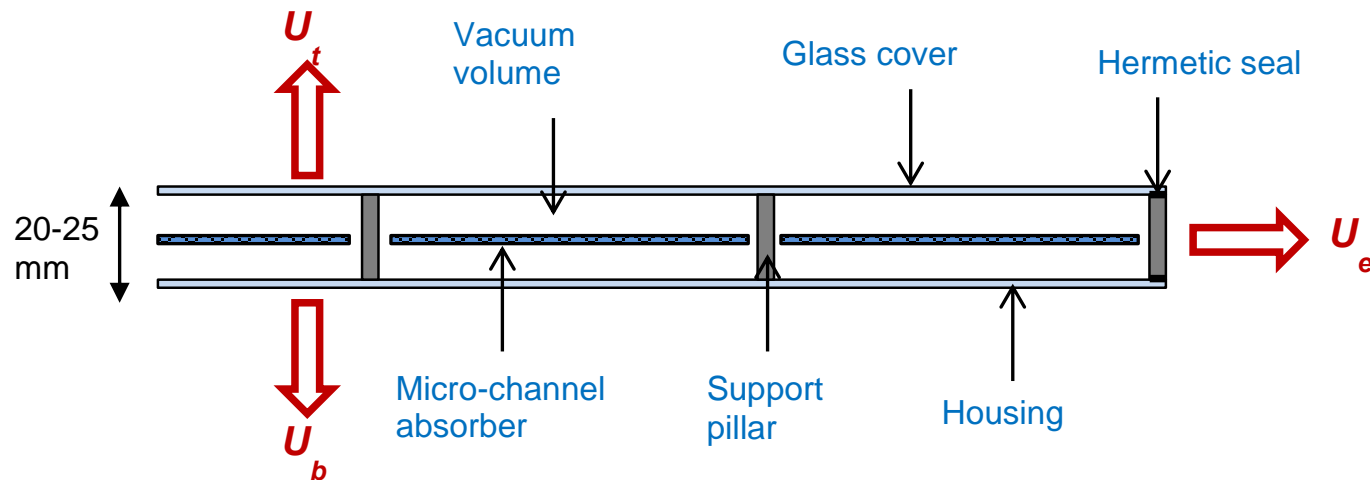
Vacuum provides greater insulation in comparison to convectional flat plate collectors.

# Flat plate collector



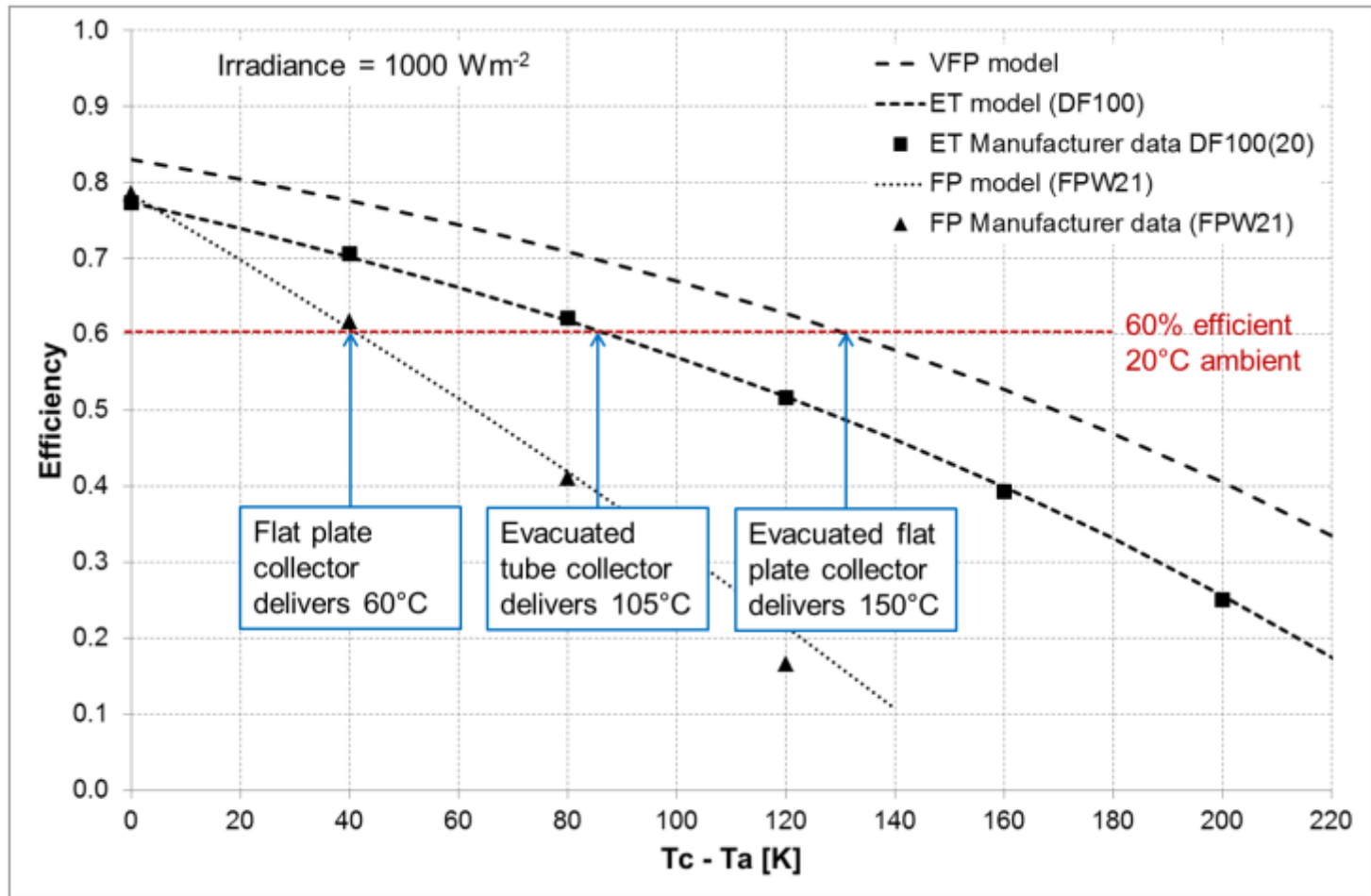
Tall profile, Large heat loss

# Vacuum flat plate collector



Low profile, Small heat loss

# Collector performance



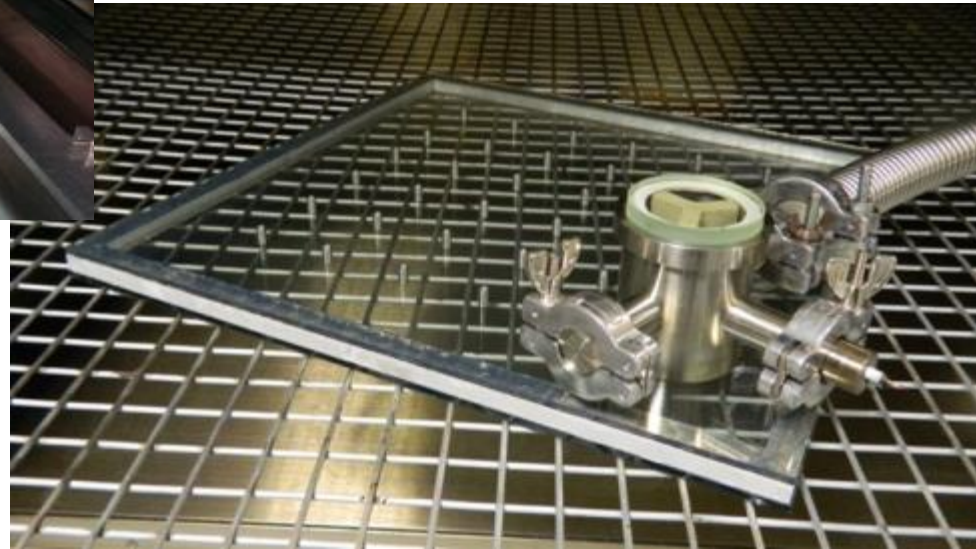


# Enclosure fabrication

Solder sealing  
in a furnace



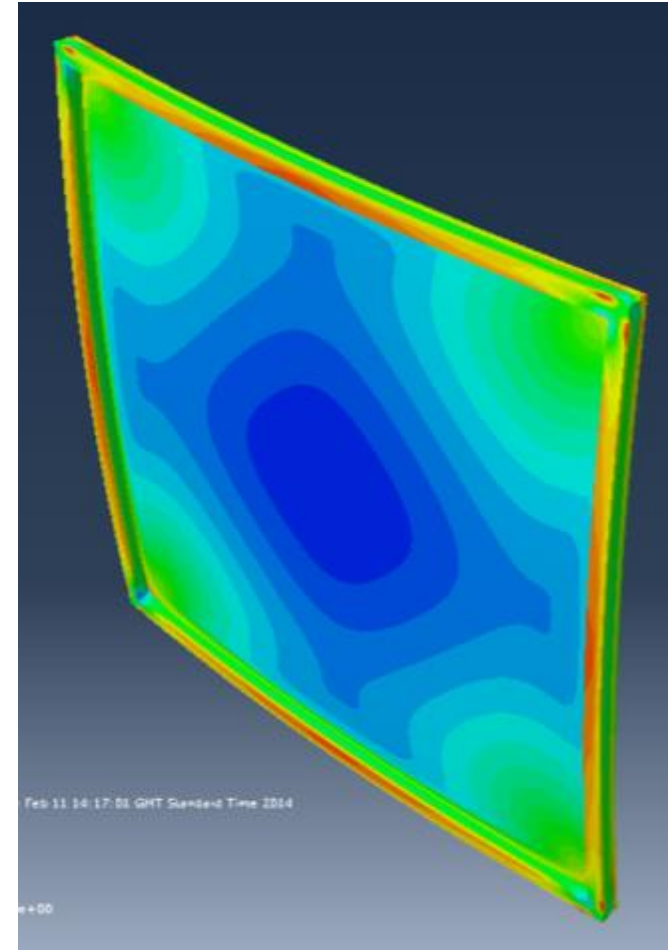
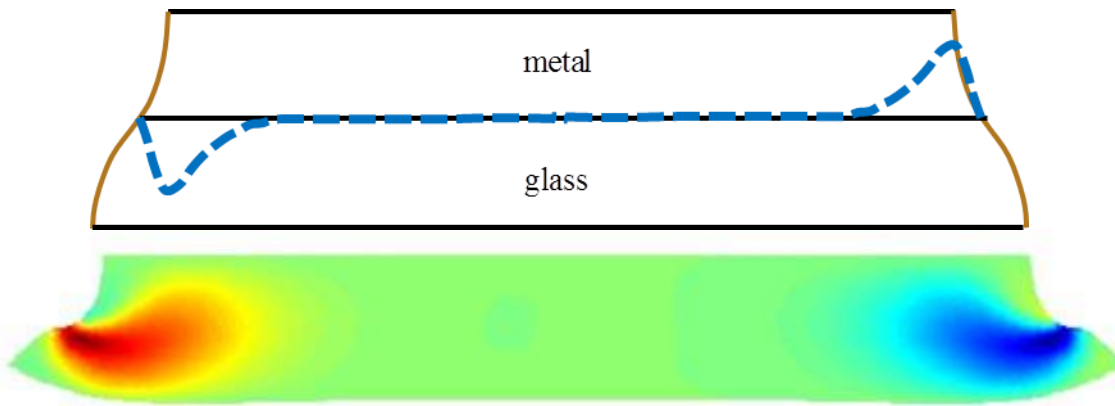
Evacuating  
the enclosure



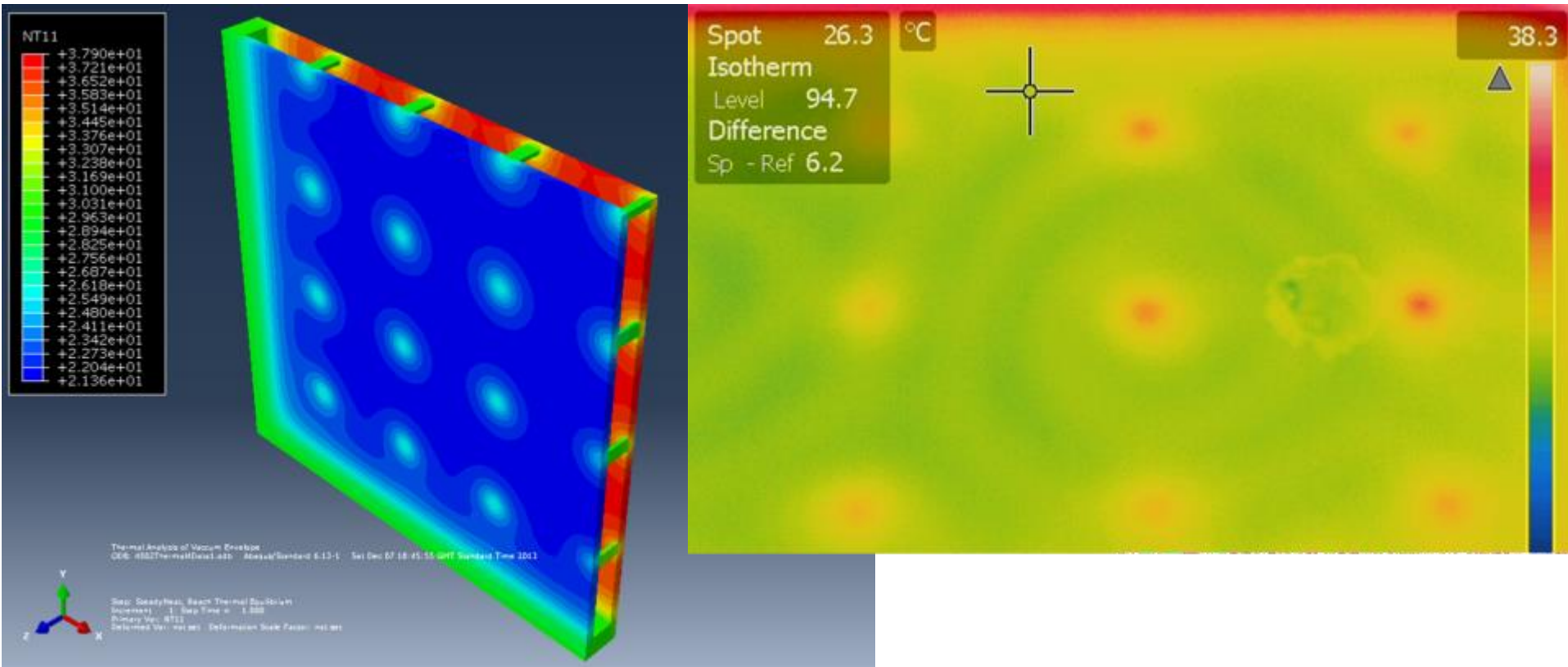


# Stress Analysis

Seal formed at 160°C  
will be stressed when  
materials cool

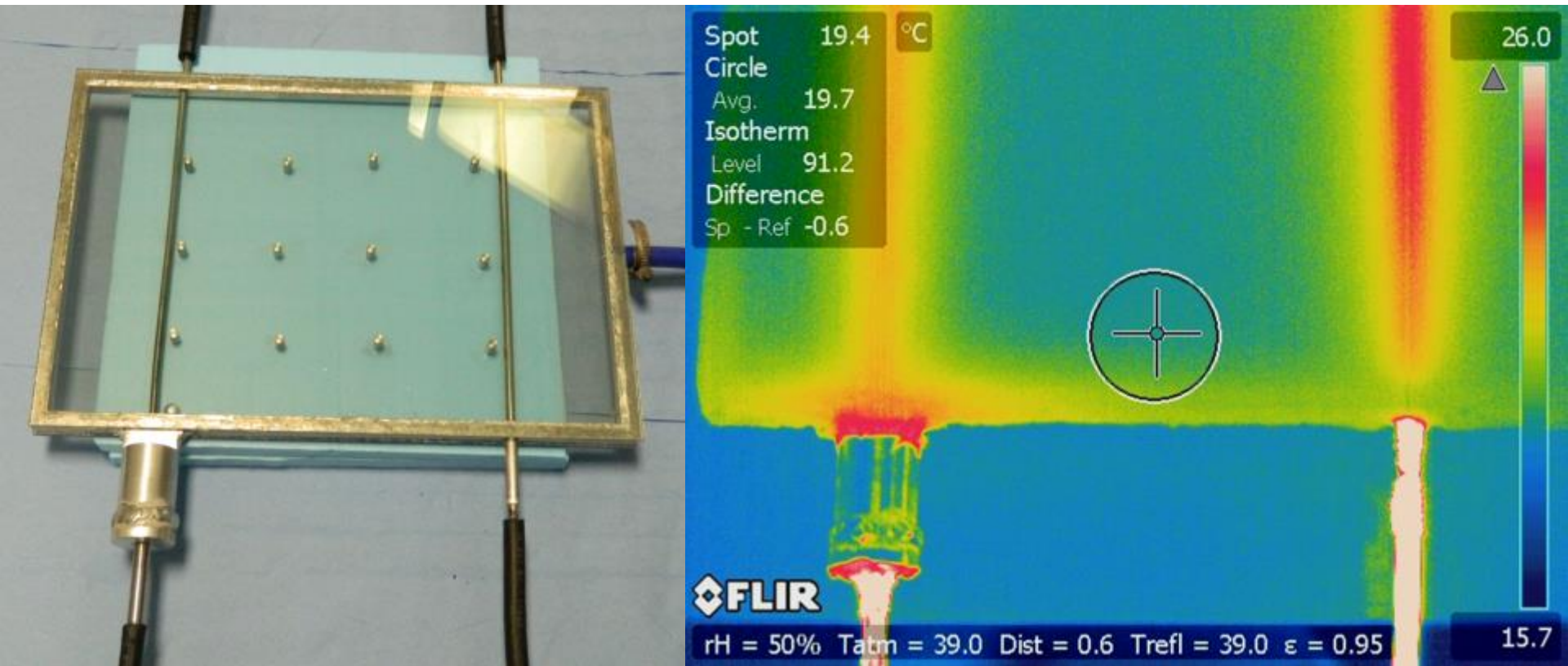


# Thermal Analysis



Thermal profile of panel heated from one side

# Flow connections



## Thermal bridging at flow ports

# Solar façade

**Collected heat for heating or A/C**

Useful heat

Controlled daylighting

**Collector surface has high reflectance of IR**

Reflected heat

Building heat

Solar radiation

Reflected light

Building heat loss?

**Collector surface has high absorptance of visible light**

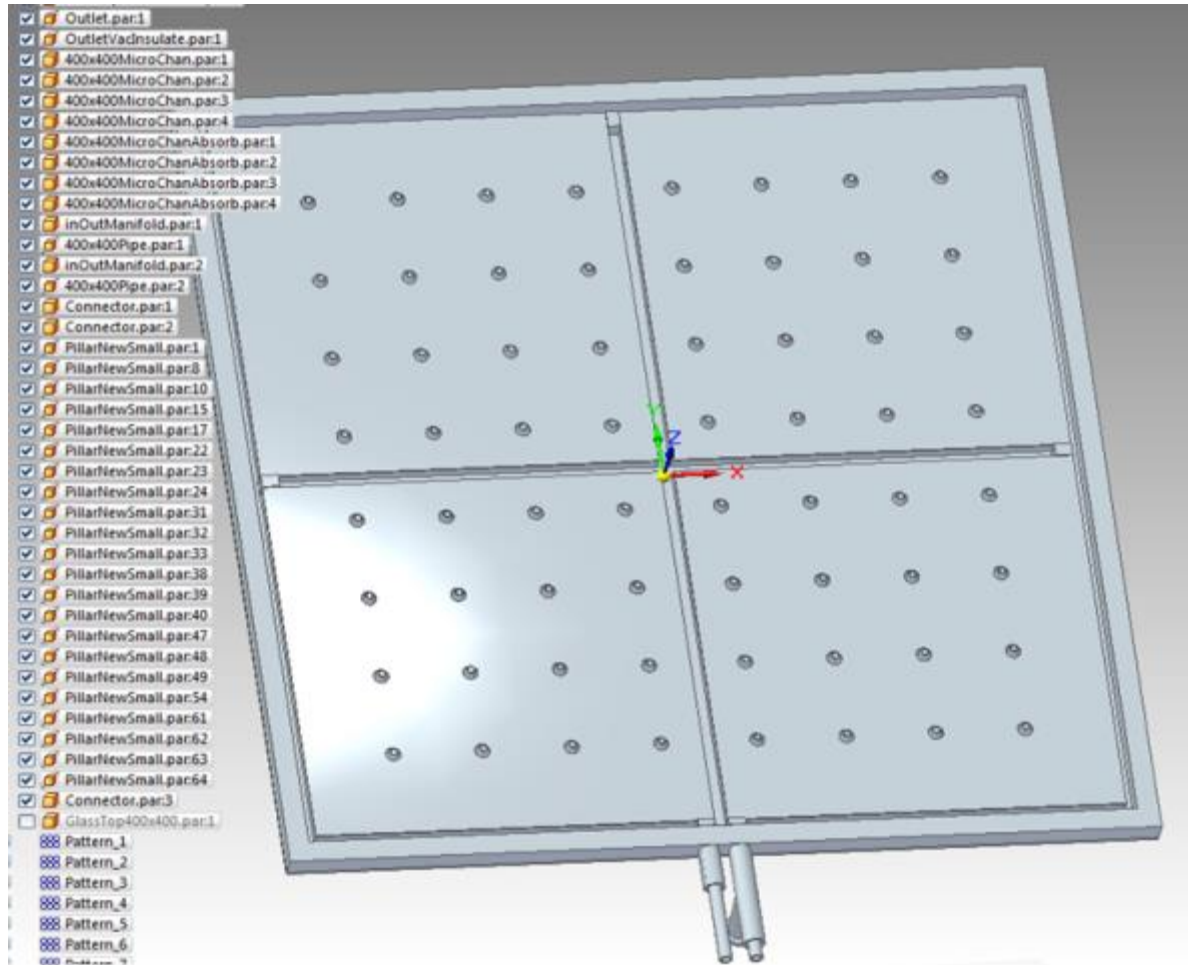
**Retrofit requires collector to be no thicker than double glazing**

# Solar thermal façade?



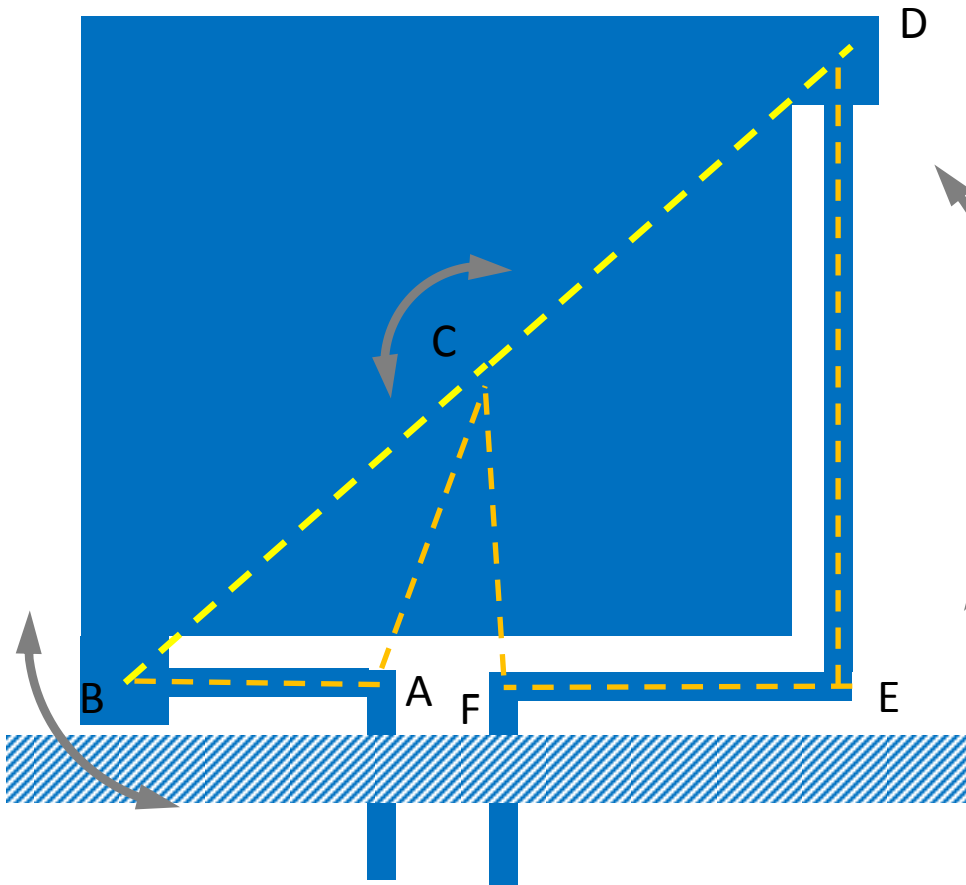


# Collector design





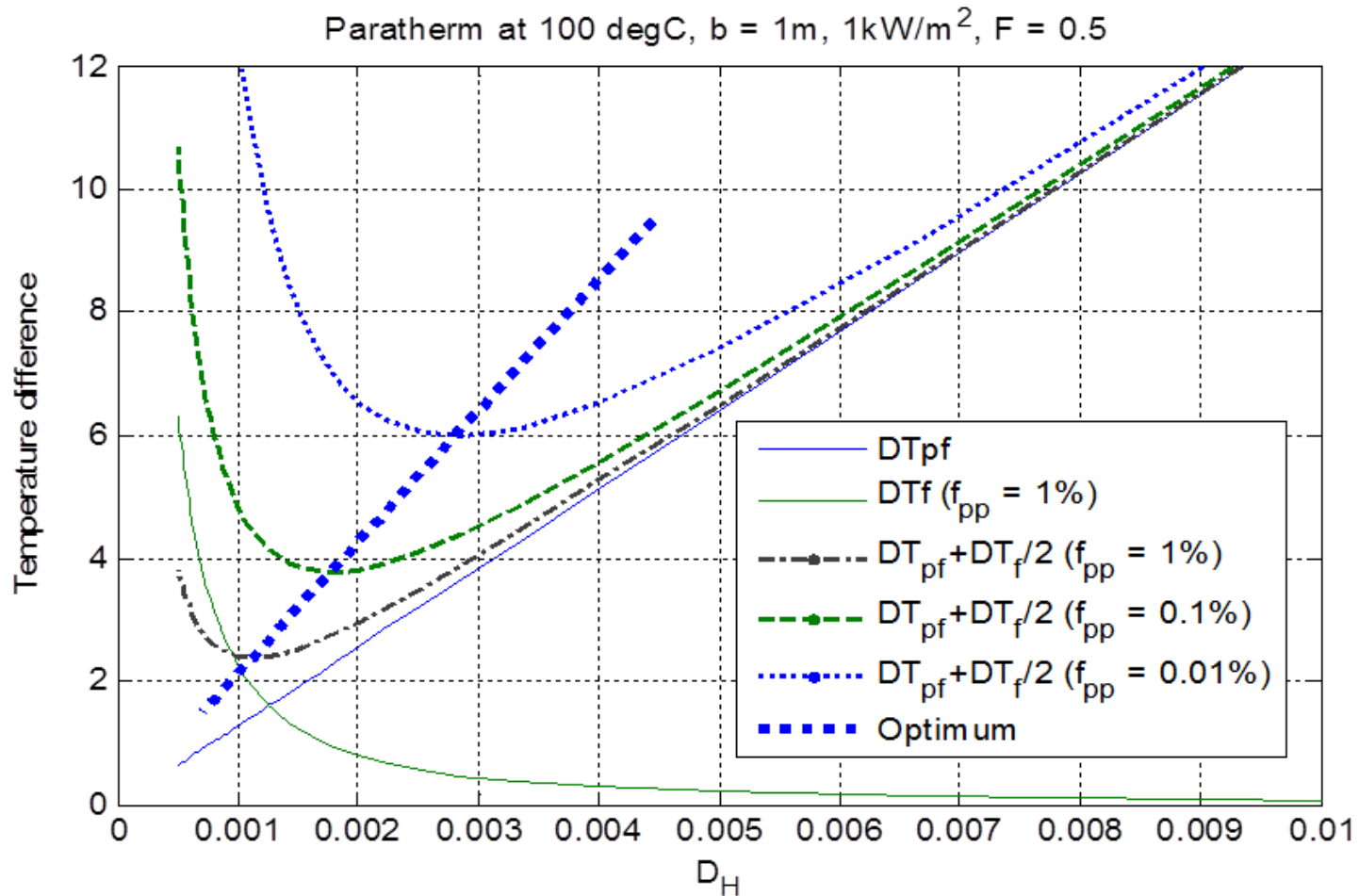
# Flexibility analysis



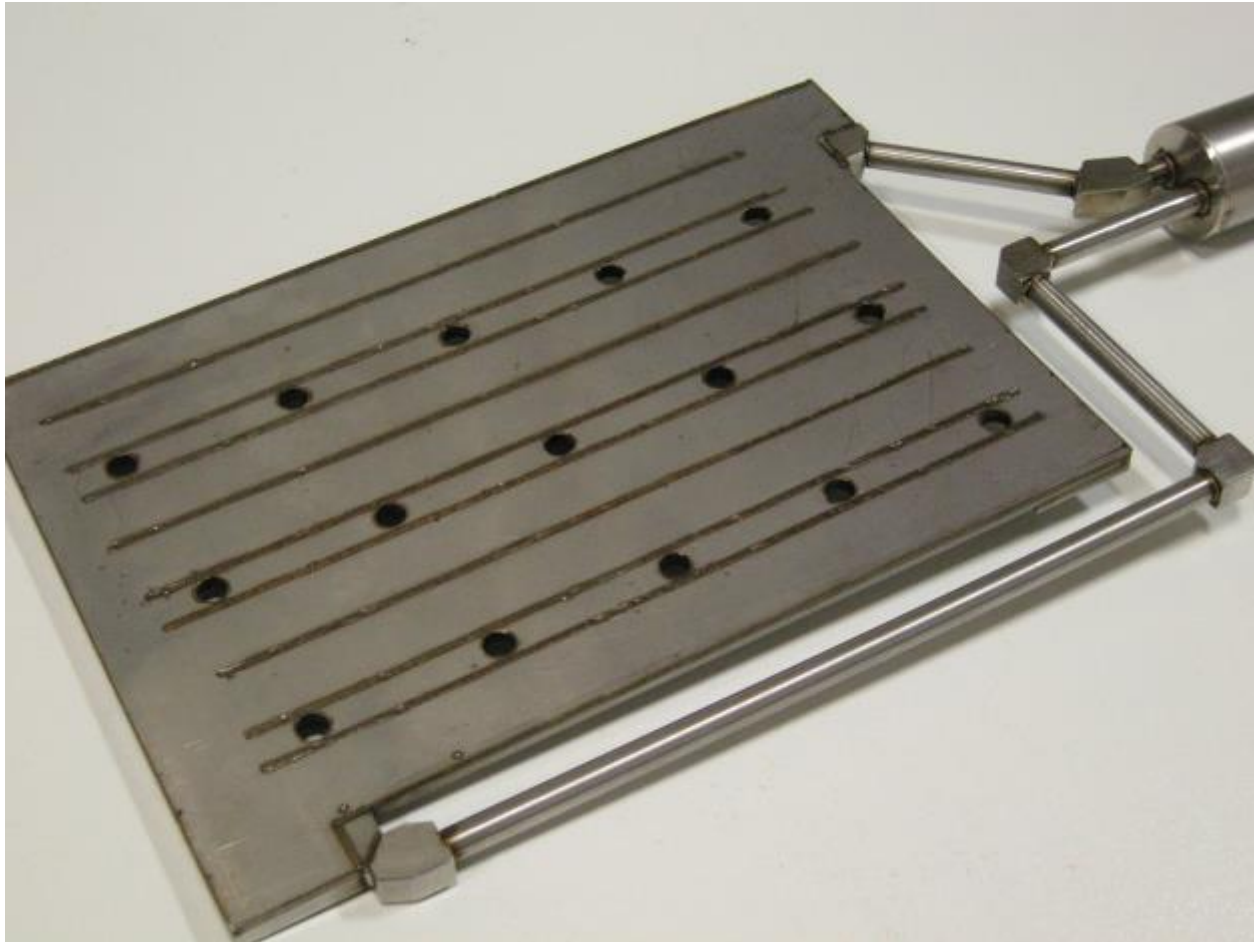
- ABC is a 3-bar linkage; plate is free to rotate about central pin C; some rotation occurs with expansion; the pipes can flex.
- CDEF is a 4-bar linkage, allows the plate to rotate slightly.

- Should ABC be a 4-bar linkage too?
- Are the pipes flexible enough?
- Should pin C locate in  $(x,y)$  or just  $x$ ?
- Should C be the plate centre, or where?

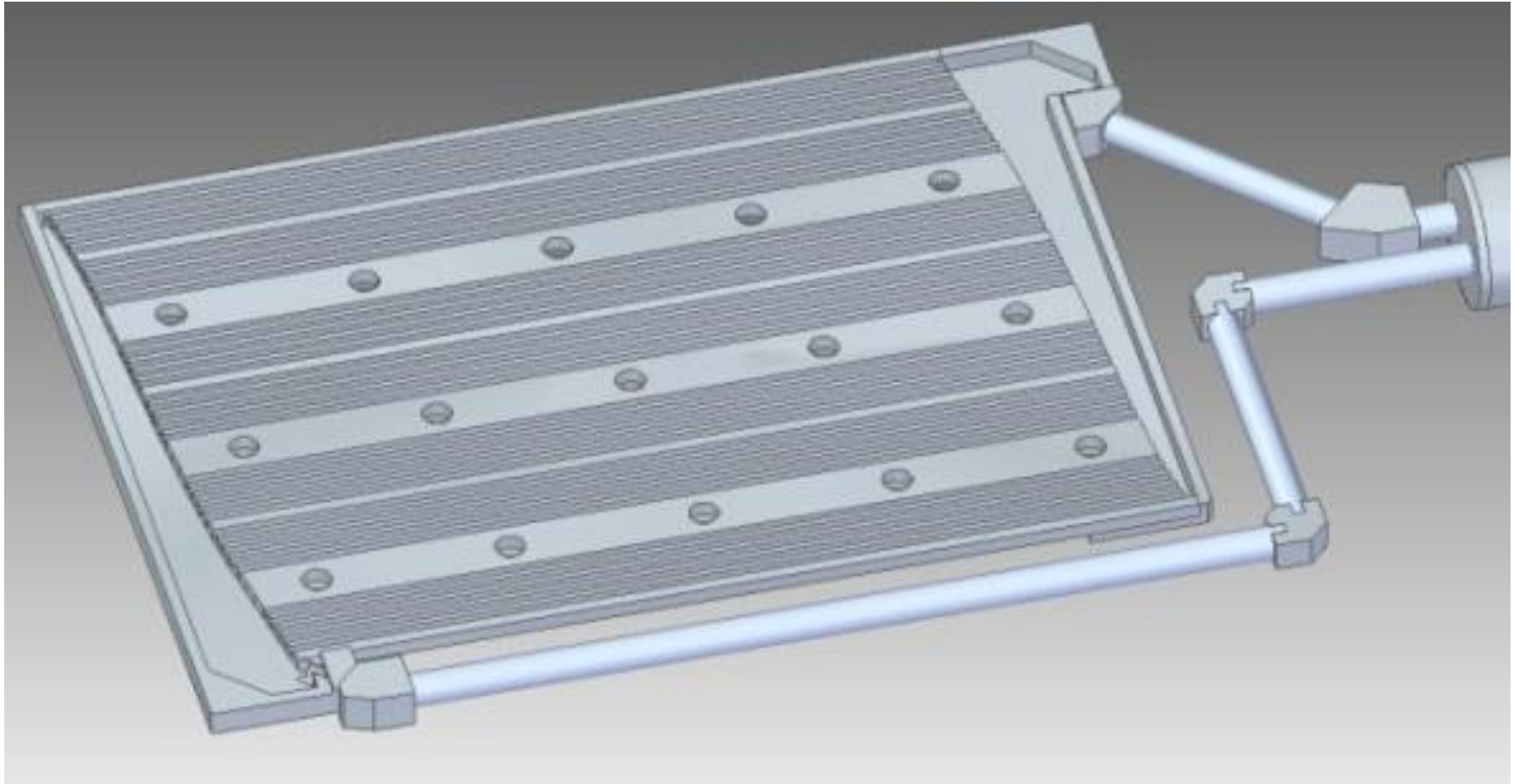
# Thermal-fluid analysis



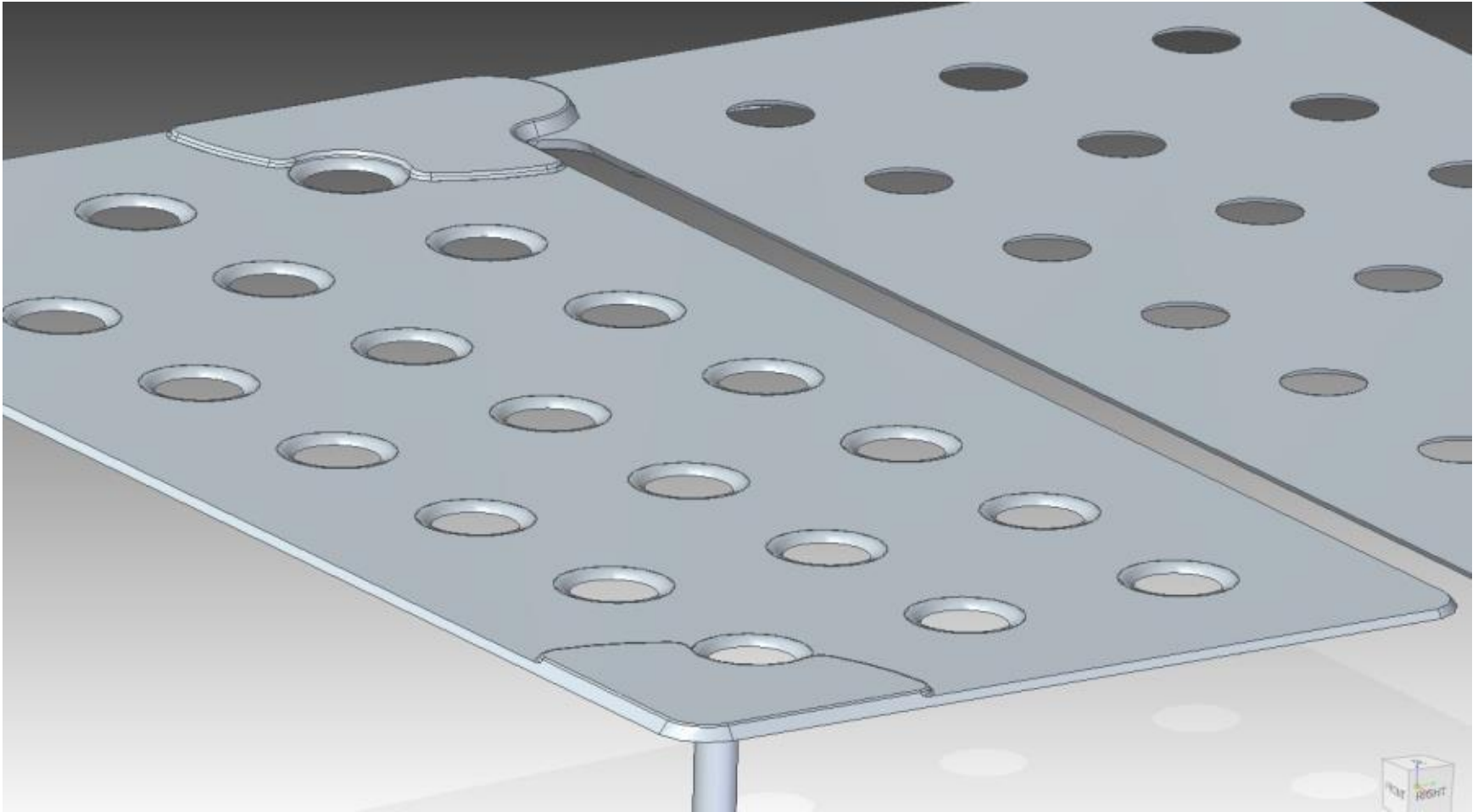
# Absorber design



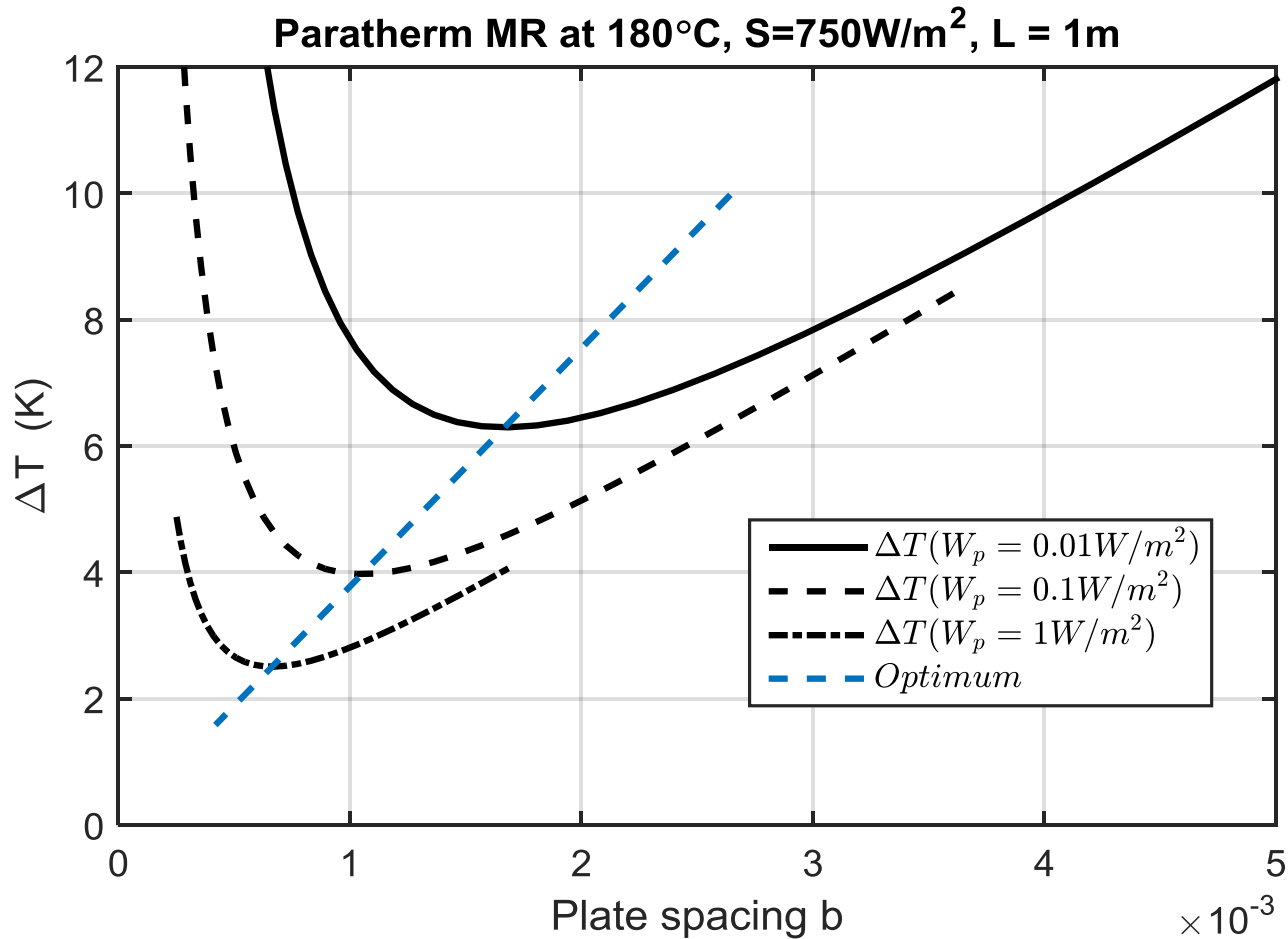
# Flow channel design



# Are channels necessary?



# Flow between plates





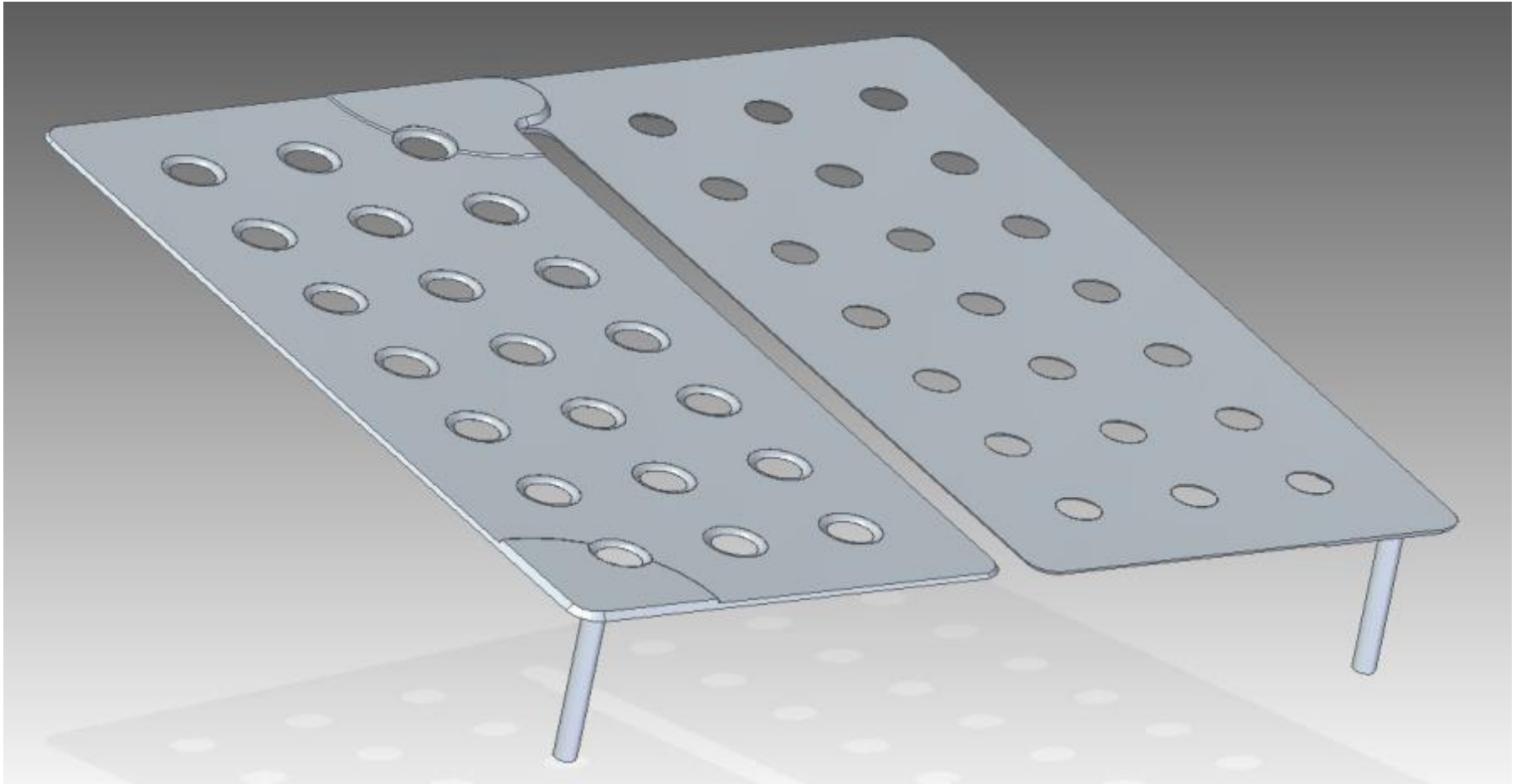
# Hydro-formed samples



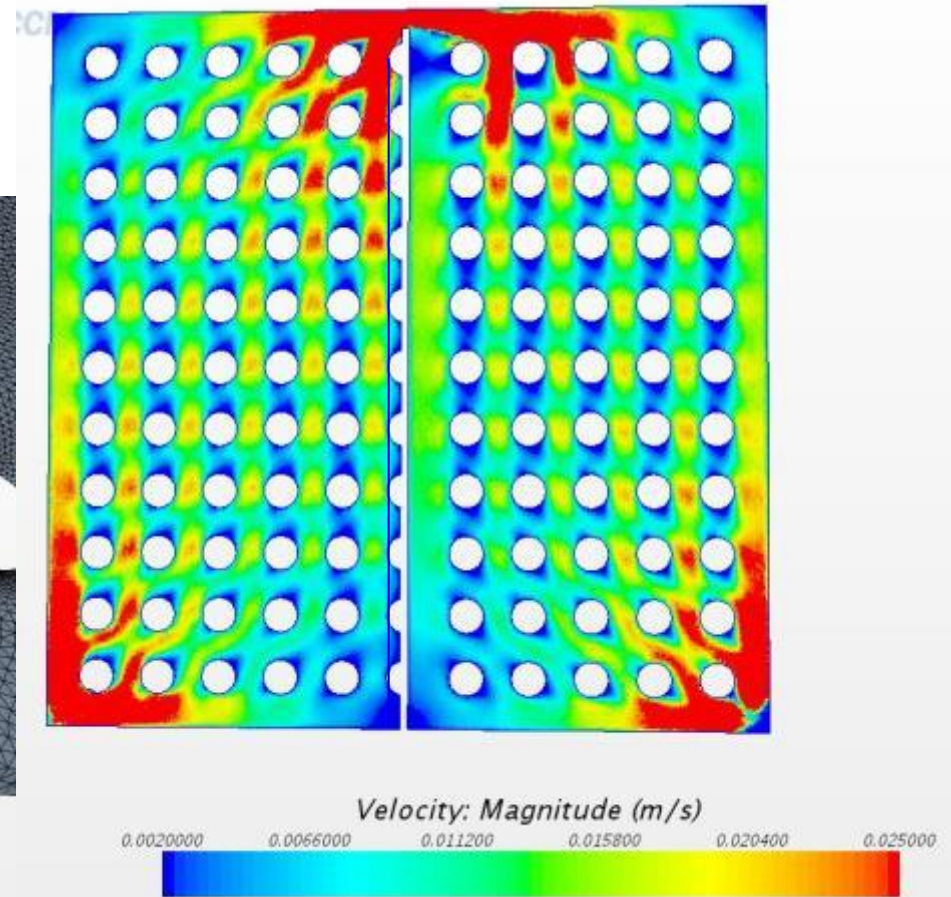
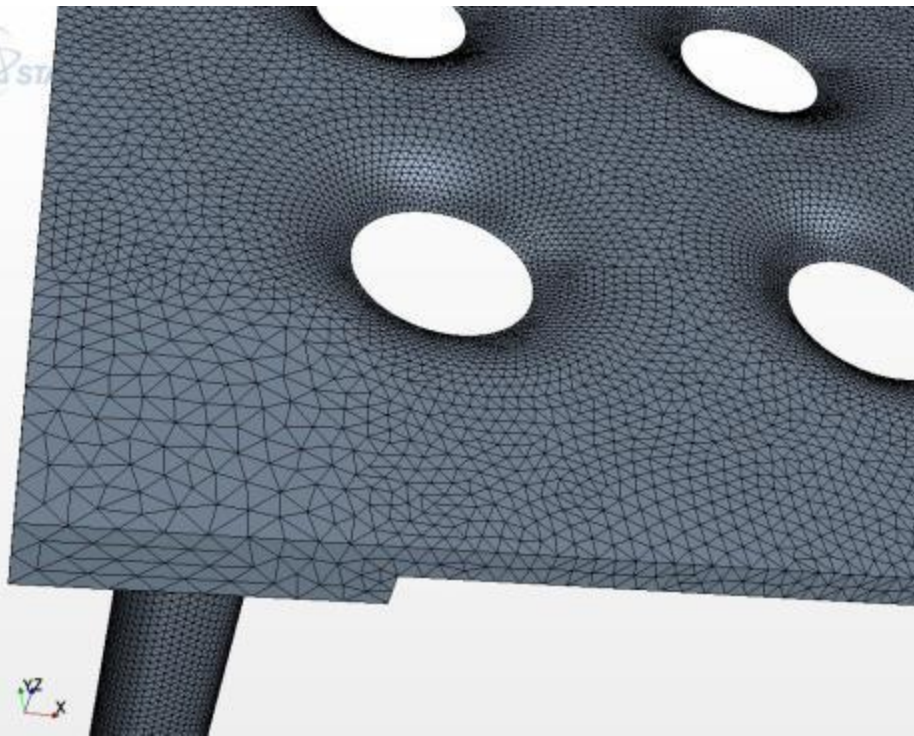
# Hydroforming: sample plate



# Simplified flow volume



# Flow distribution

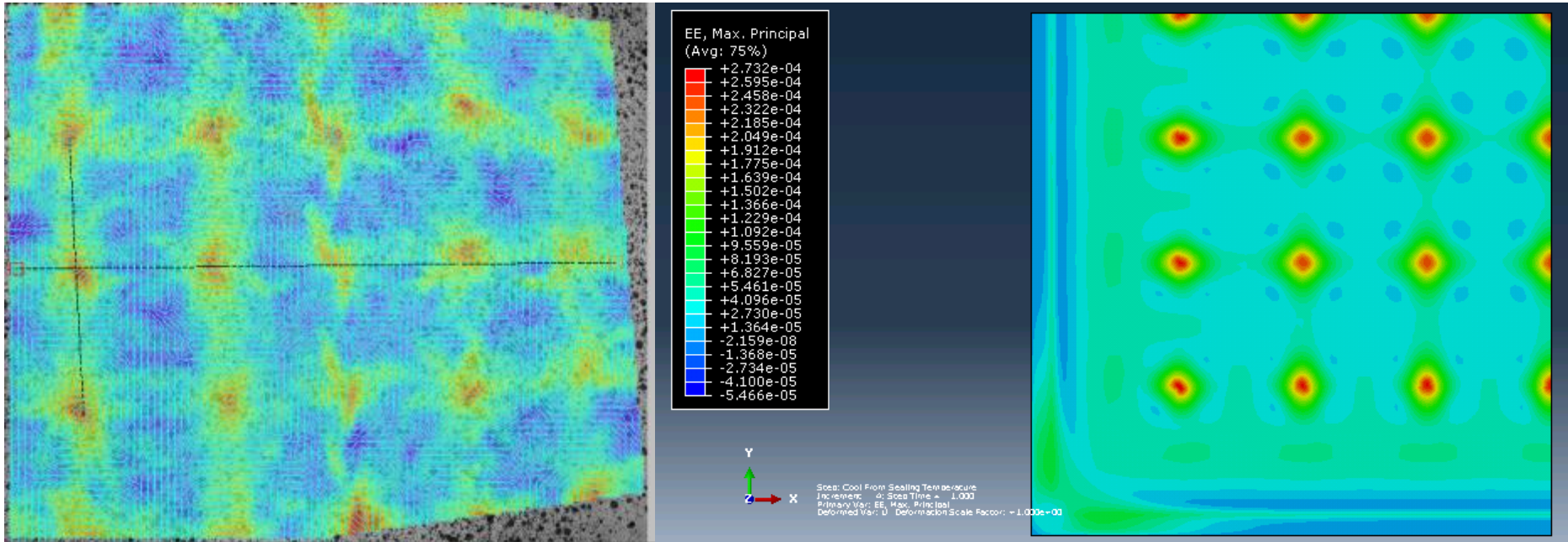




# Steel back enclosure



# Stress analysis

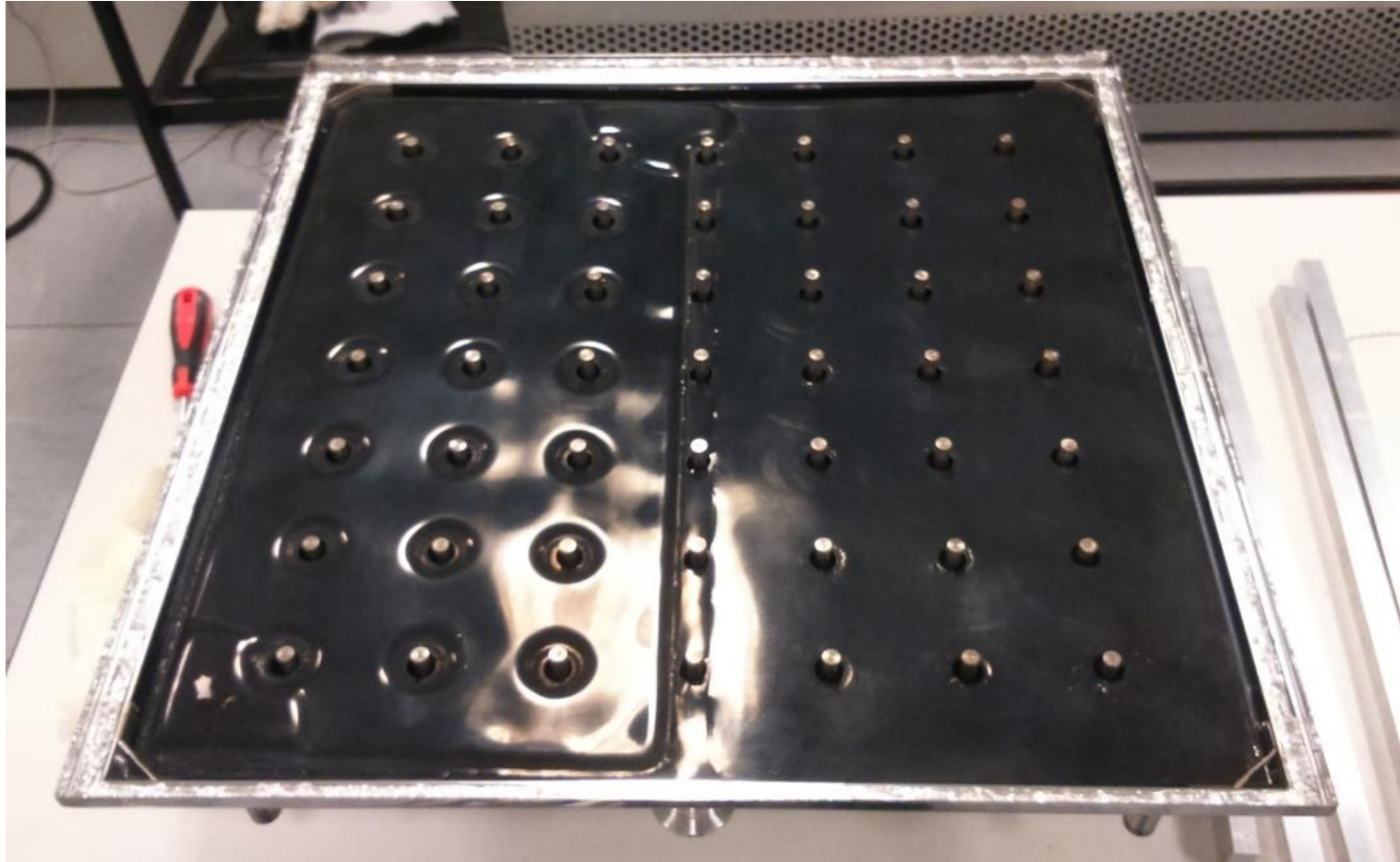


Measured strains via DIC

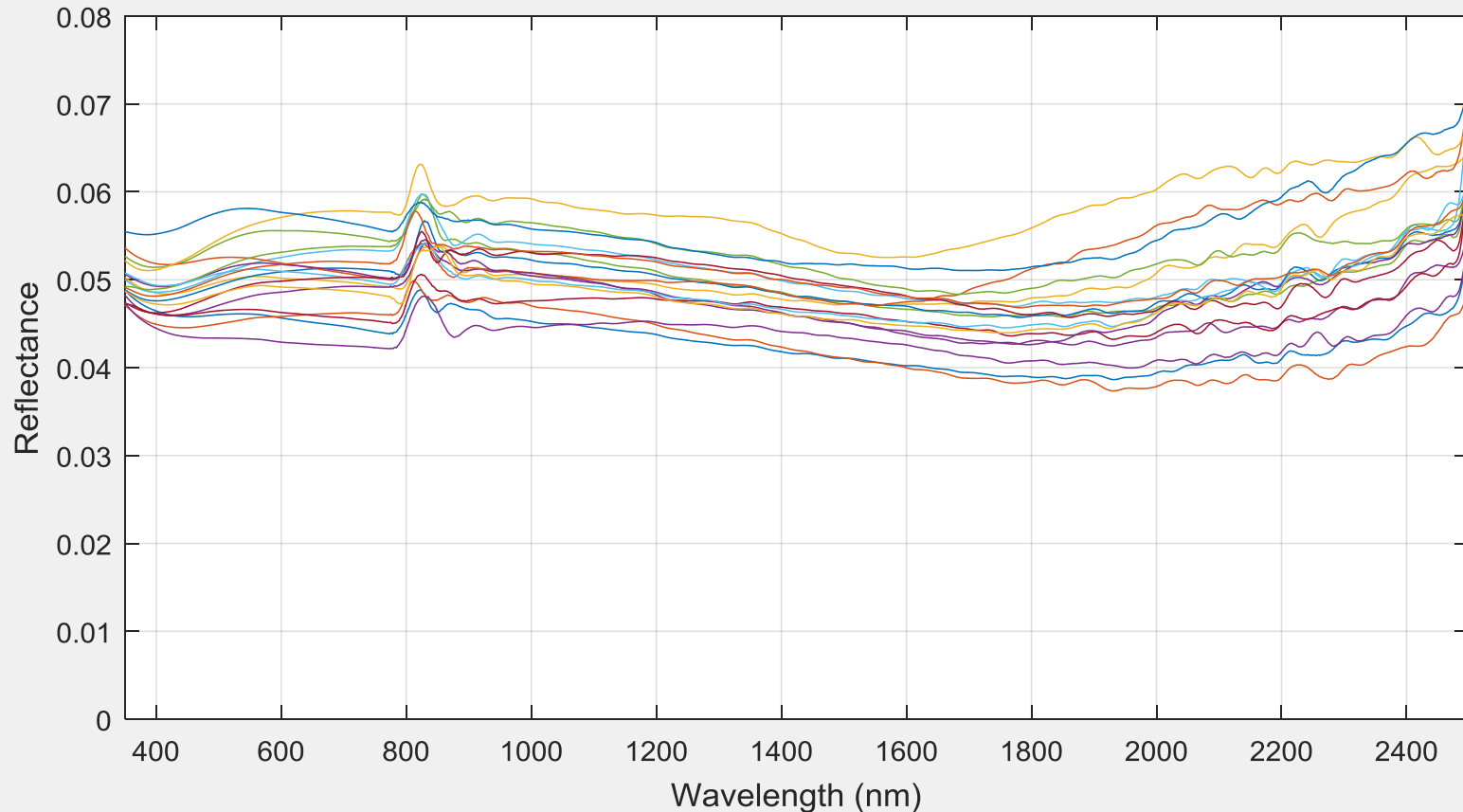
Modelled strains with Abaqus finite element software



# Plated absorber



# Reflectance tests



# Sealed collector

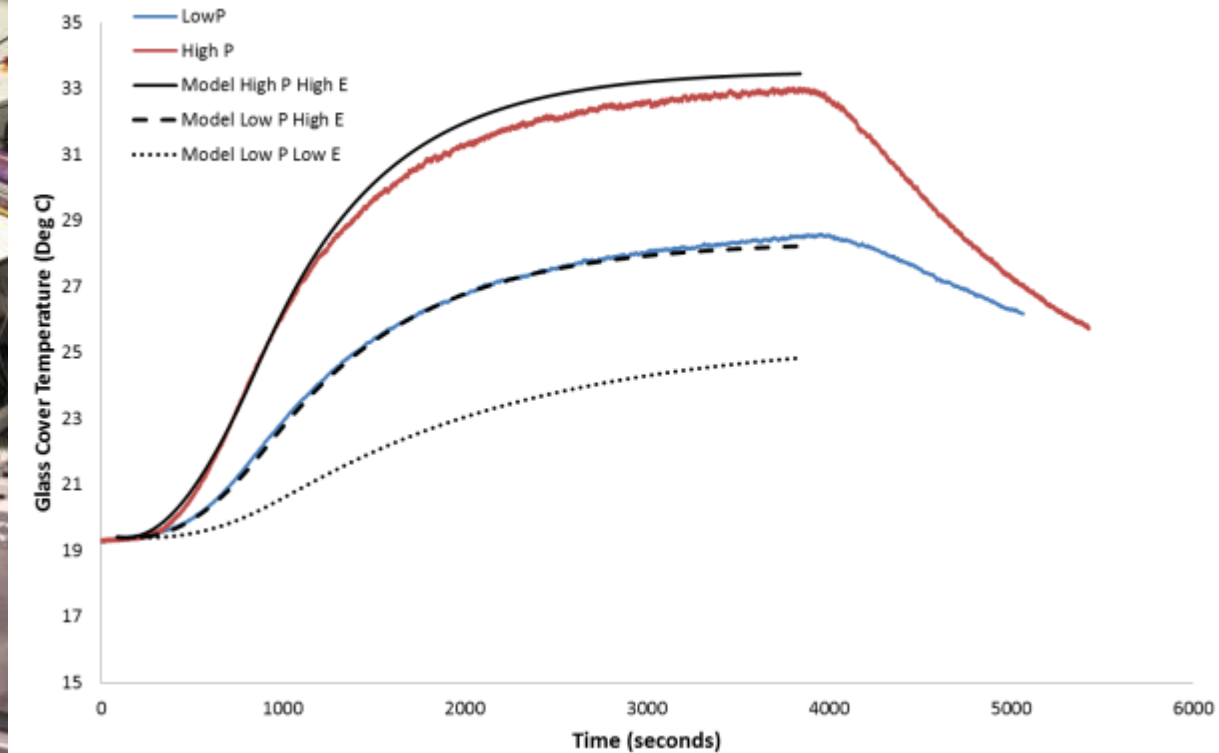
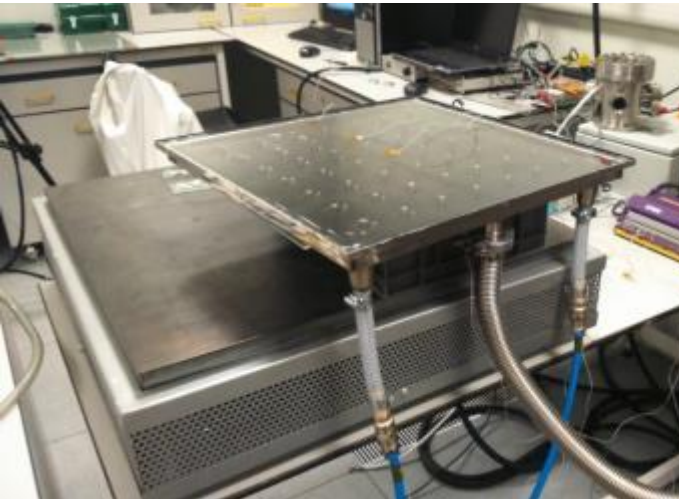


# Sealed collector



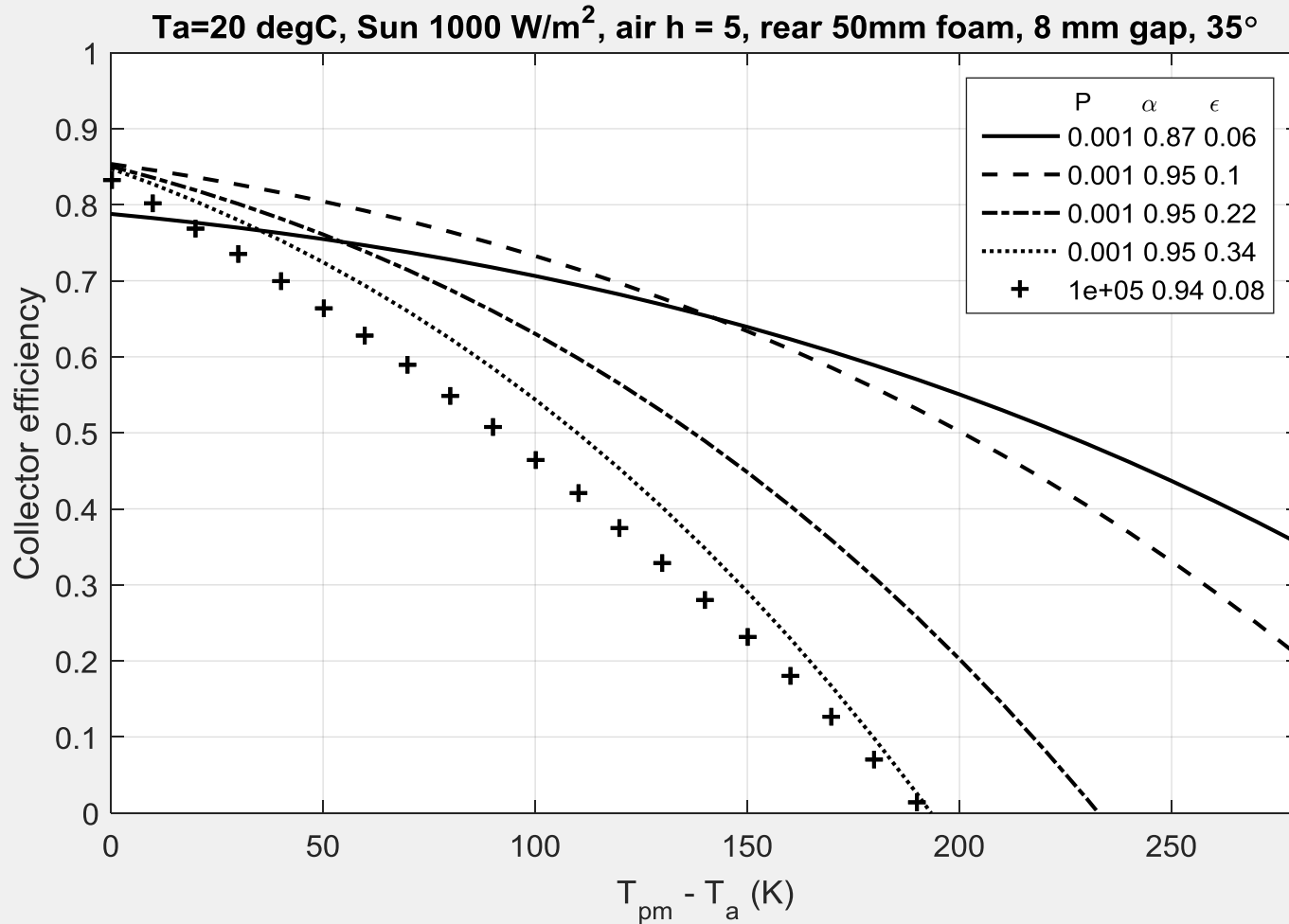


# Collector tests



Experimental testing has verified level of insulation attainable

# Influence of emissivity



# Where are we?

- 1 collector built and being tested
- 1 collector ready for sealing
- 4 absorbers awaiting cutting and welding
  
- Long list of partners with lesser or greater abilities to cut/join/plate stainless steel to our requirements!



# What next?

- Further evaluation of plating process
- Fabrication of 6 complete collectors
- Testing and demonstrating collectors
  
- Writing a proposal for InnovateUK funding to develop a product
  - Industrial partners please!



With thanks to:

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GLOBAL RESEARCH PRIORITIES

ENERGY

Solar Thermal and Concentrating Solar Power: Technology and Applications.



Tuesday 1 December 2015, Cranfield University, UK