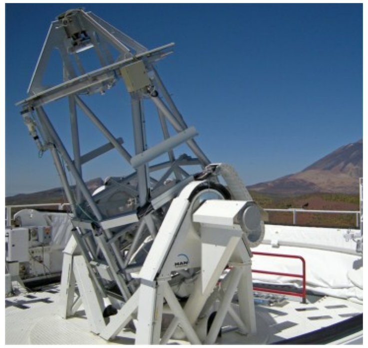
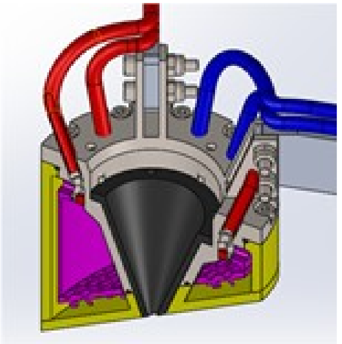
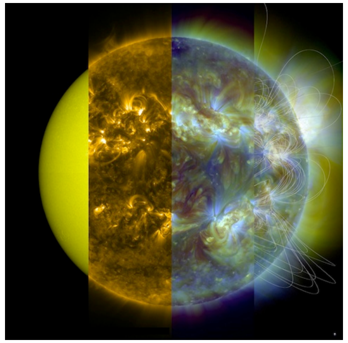
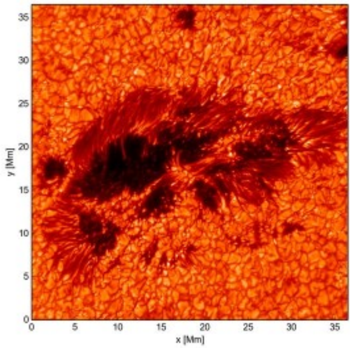
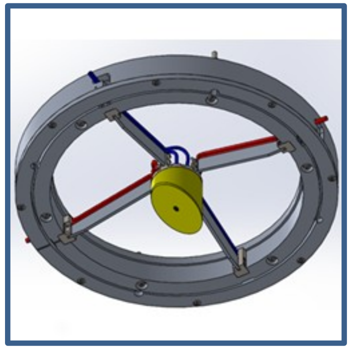
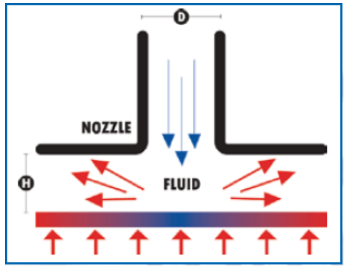




The Heat Rejecter for the GREGOR telescope: a prototype for the European Solar Telescope

Berrilli F., Manni F., Del Moro D., Giovannelli L., Fischer A., von der Lühe O., Soltau D., Mainella G., Caroli A.



https://www.fisica.uniroma2.it/~solare/en/

SOLARNET IV MEETING ***The Physics of the Sun from the Interior to the Outer Atmosphere***
Lanzarote, Spain, 16-20 January 2017

Two major issues of strategic importance, for large solar telescopes, came out from technical reviews:

1. **MCAO implementation** (demonstrated in medium size solar telescopes)

2. **Best available atmospheric & internal seeing**:
- Site
- Dome seeing mitigation
- Heat rejecter
- Mirror seeing & optical path thermal control

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Heat rejecter →

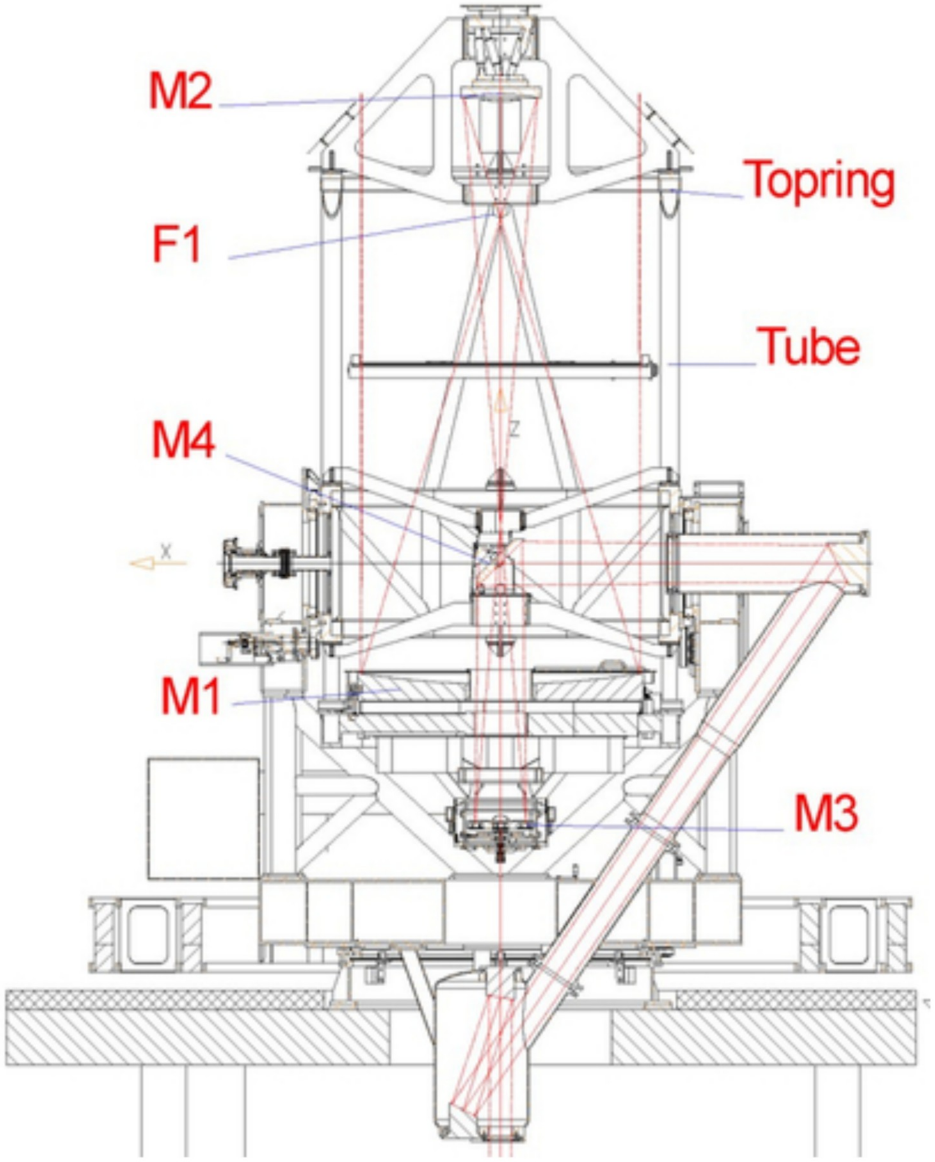
Design

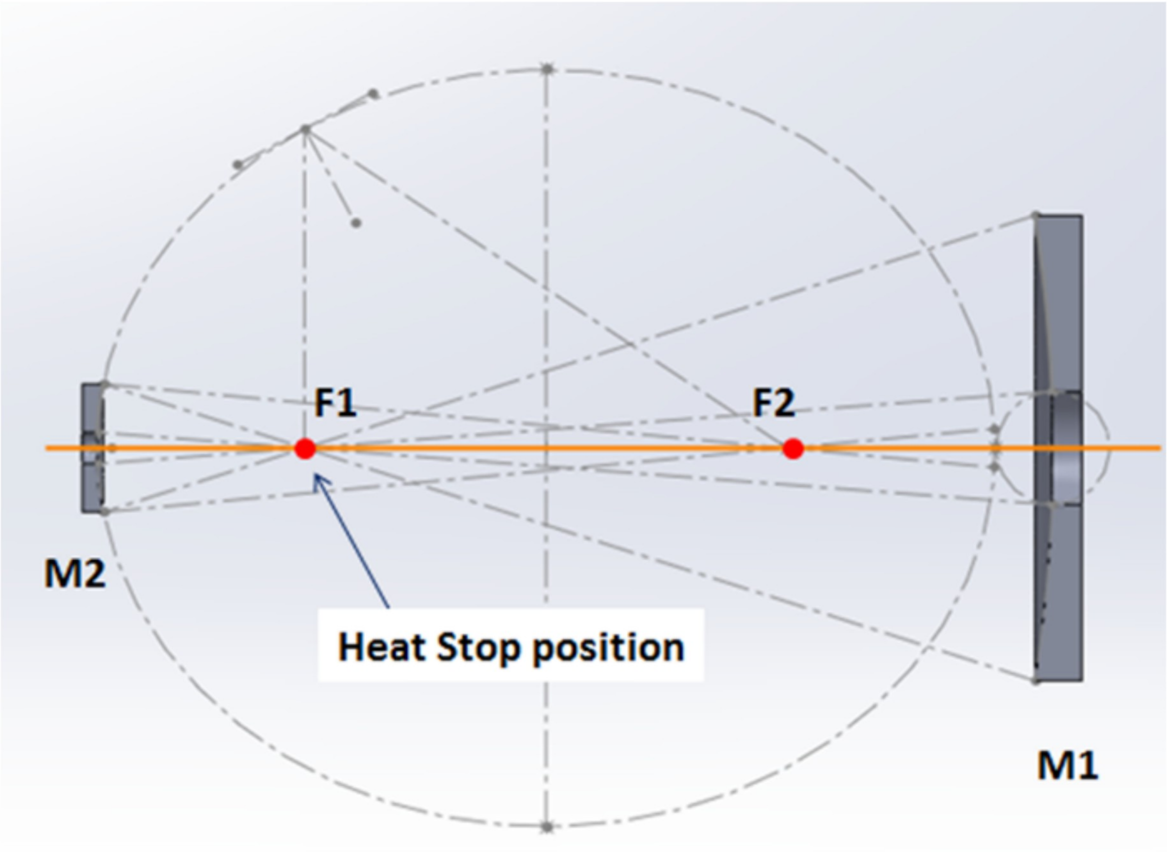
Heat Transfer Method

Demonstrator Model

Tests

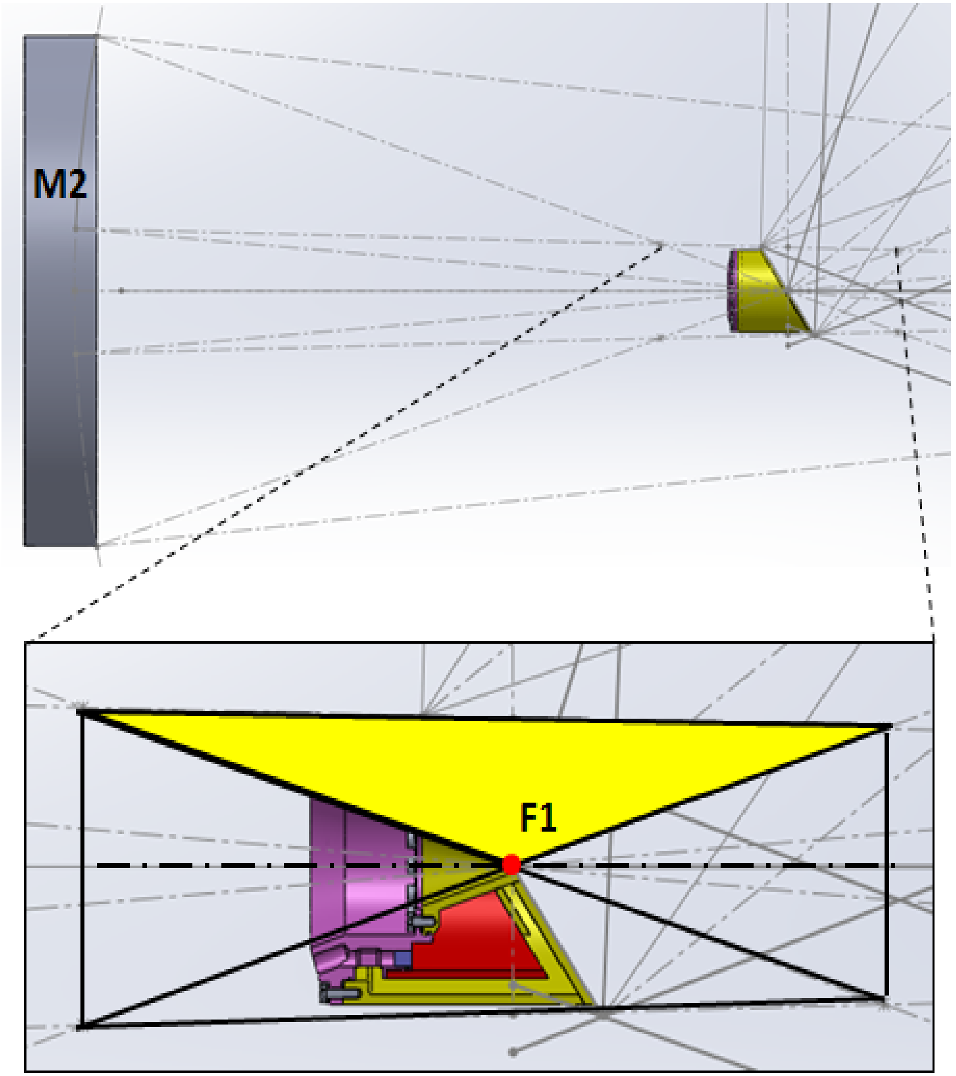
Design



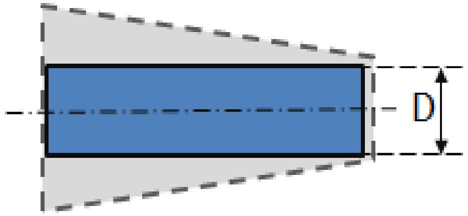


The GREGOR optical scheme defines the available space in F1: the Heat rejecter (HR) must not obstruct the light reflected by the secondary mirror (M2).

Design



(a)



(b)

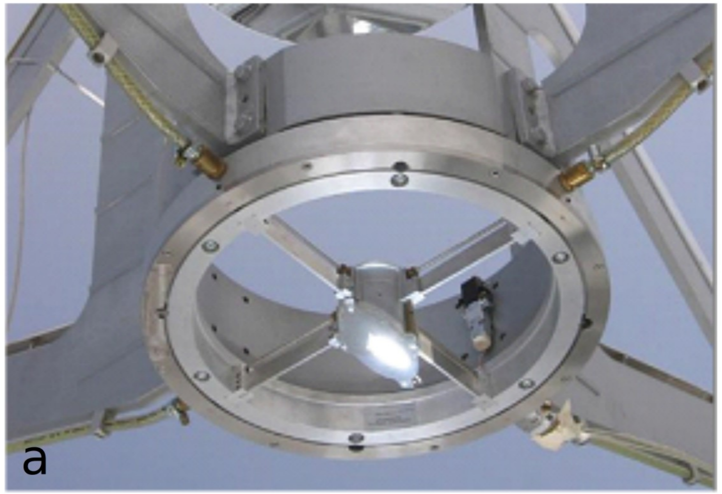
The available space for the HR is a solid of revolution obtained by rotating the yellow triangle, shown in figure (a), around the main optical axis.

It features a slightly conical outer shape (exaggerated in figure (b)) with a minimum diameter of 72 mm.

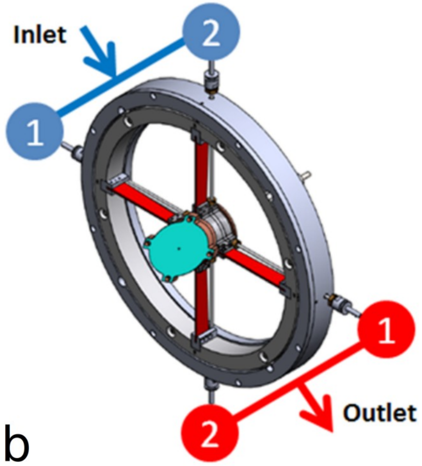
A cylindrical shape with a diameter of 65 mm has been chosen, equal to the outer diameter of the HR currently installed.

Design

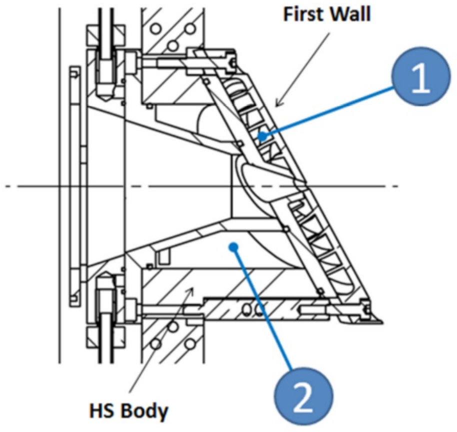
The current GREGOR HR (a) has a double coolant circuit (b). A circuit serves the First Wall (FW - the face illuminated by the sun light) which is cooled by the double-helical flow shown in figure d. Thermography tests were performed using the FLIR i40 IR camera.



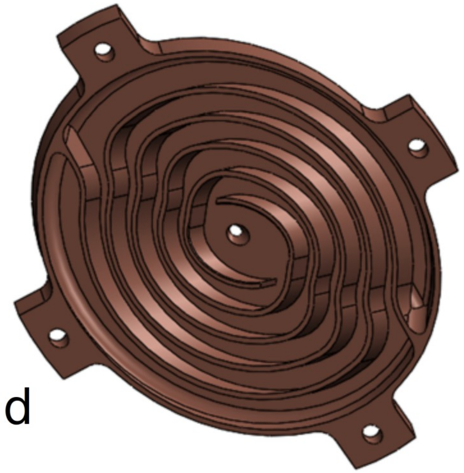
a



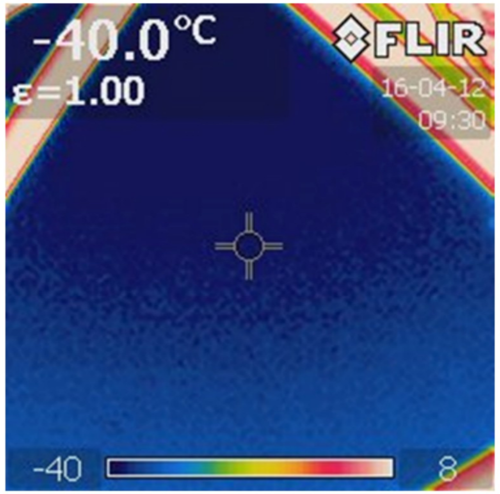
b



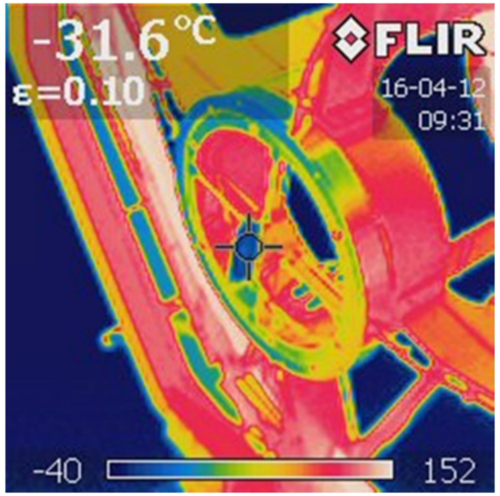
c



d



Upper: measure of the temperature of the sky.

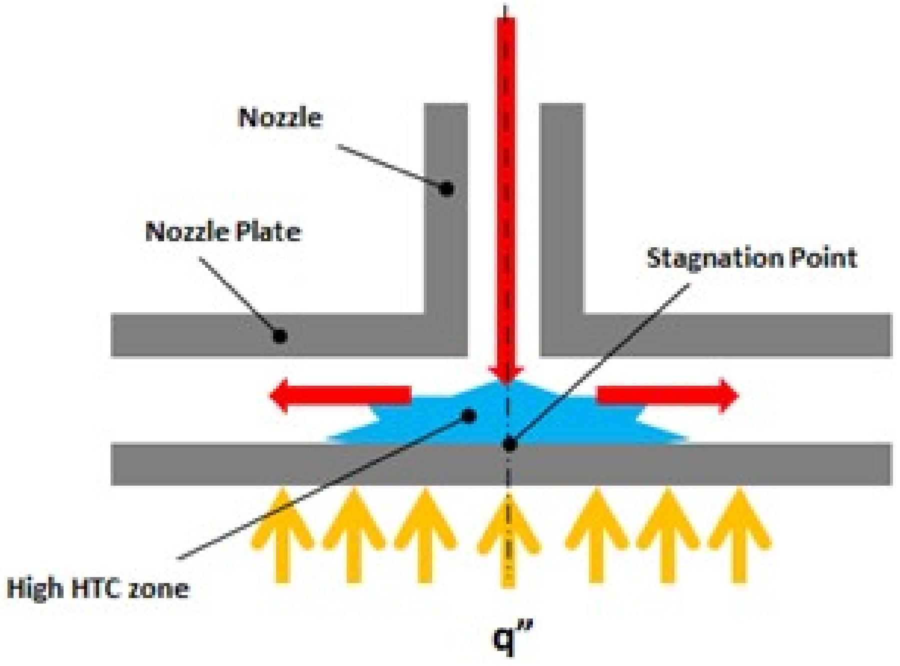


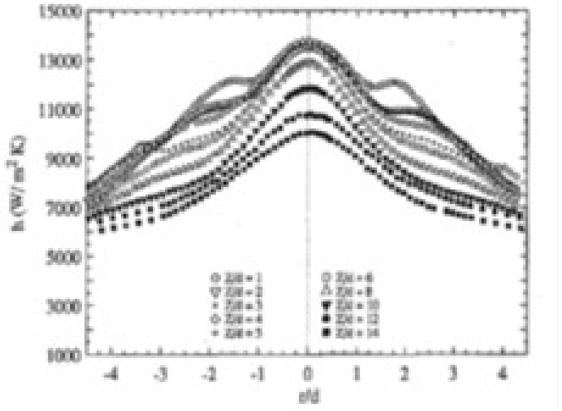
Heat Transfer Method

We could increase the Heat Transfer Coefficient (HTC) by simply increasing the Reynolds number (i.e. high turbulence) in the current HR using an extremely high coolant velocity.

The proposed solution is to create very high turbulence (just were it is needed, that is on the backside of the FW) by sweeping away the laminar boundary layer. The concept is shown in figure (a).

A nozzle convoys the coolant against the backside of the heated plate. This technique is called “Jet Impingement”.



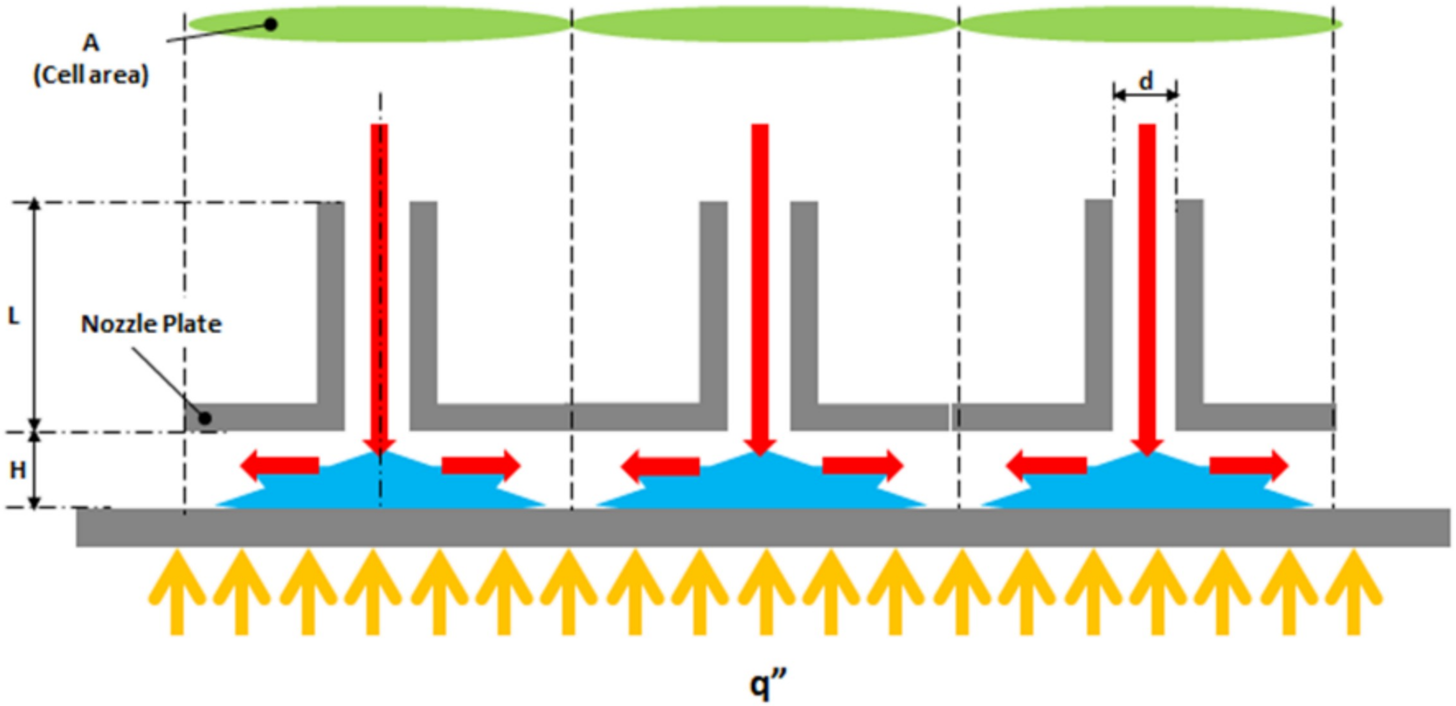


High HTC decreases with the distance from the impinging jet axis

Heat Transfer Method

High HTC can be reached (200,000 $W/m^2\,°C$] using high coolant velocities in the nozzles (50 m/s). This implies in impinged plate erosion and high coolant flow rates (possible mechanical vibrations).

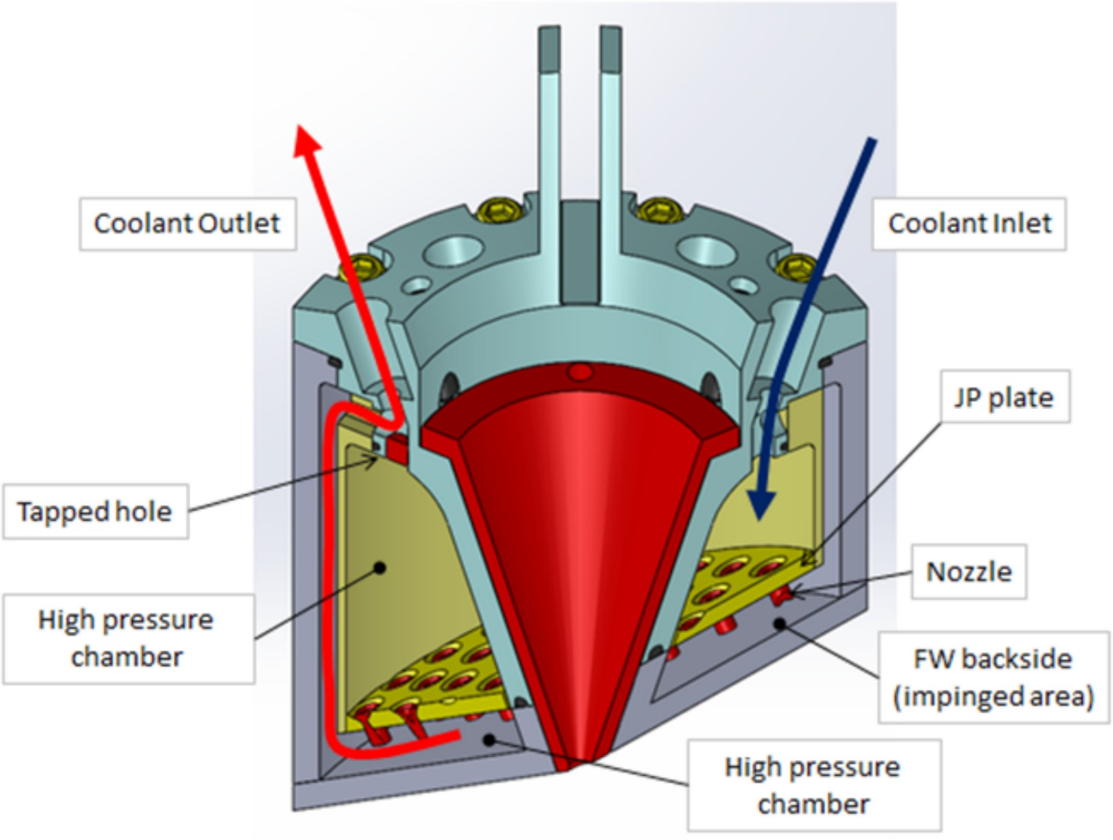
The required HTC for GREGOR and EST HRs (40,000 $W/m^2\,°C$) exclude such problems. The necessary velocity is lower by an order of magnitude.



In order to cover wider areas (such as the FW backside plate) multiple nozzles are necessary.

Demonstrator Model

The new GREGOR HR is based on a multi jet impingement technology (MJIT)

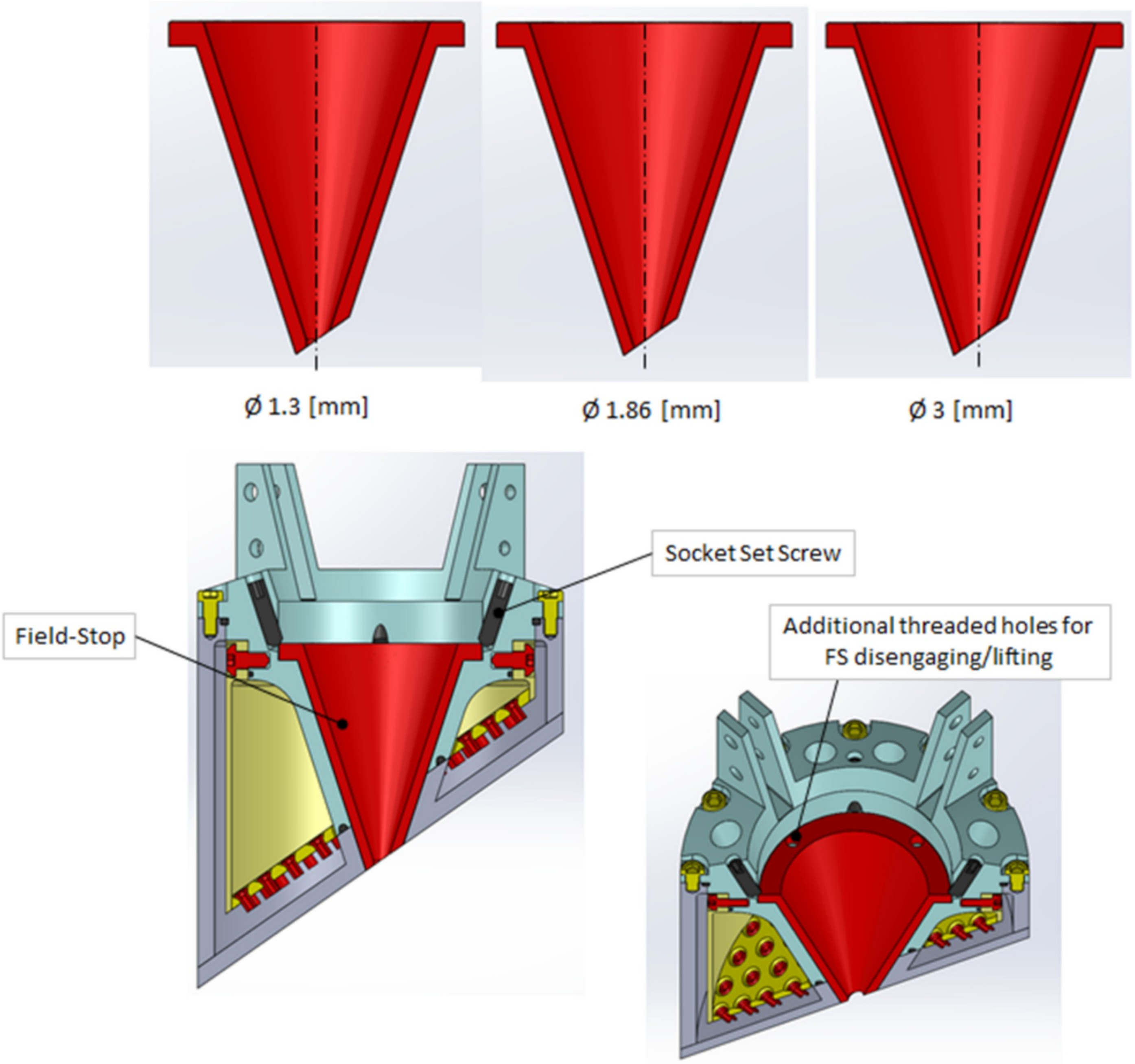


A sophisticated shower

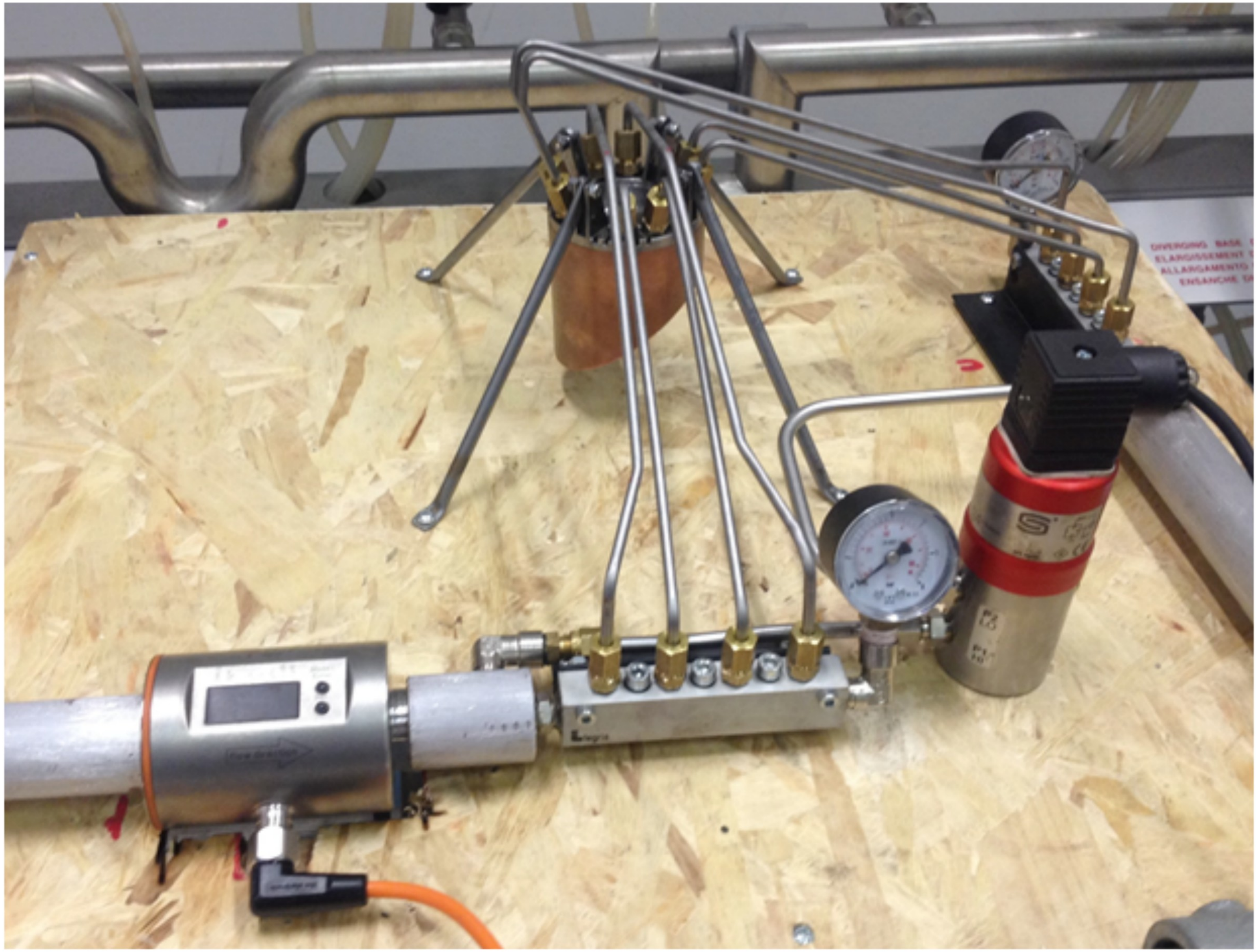
Demonstrator Model

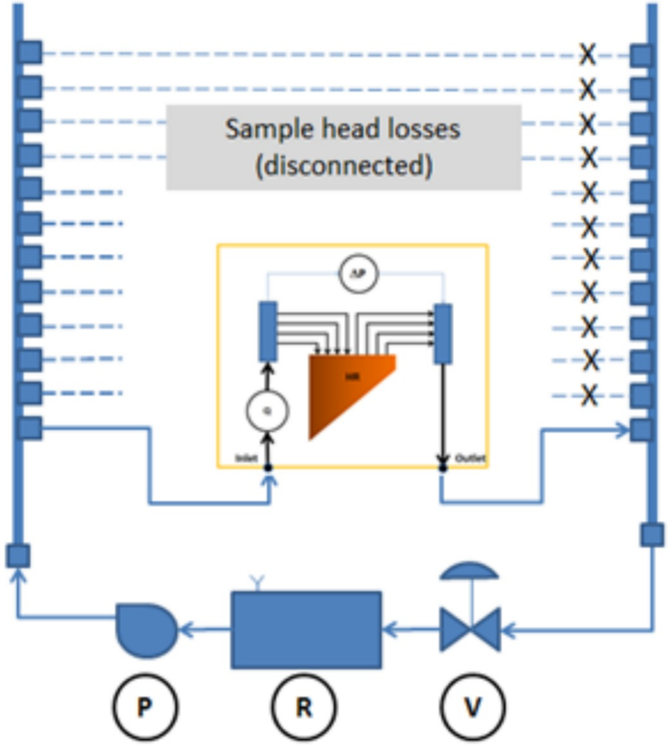
Four Socket Set Screws are used to lock the FS inside the HR body. Centering pins, and additional threaded holes for disengaging and lifting are present as well.

Thermally Conductive Grease must be put in the small gap (0.1 mm) between the FS and the HR body.

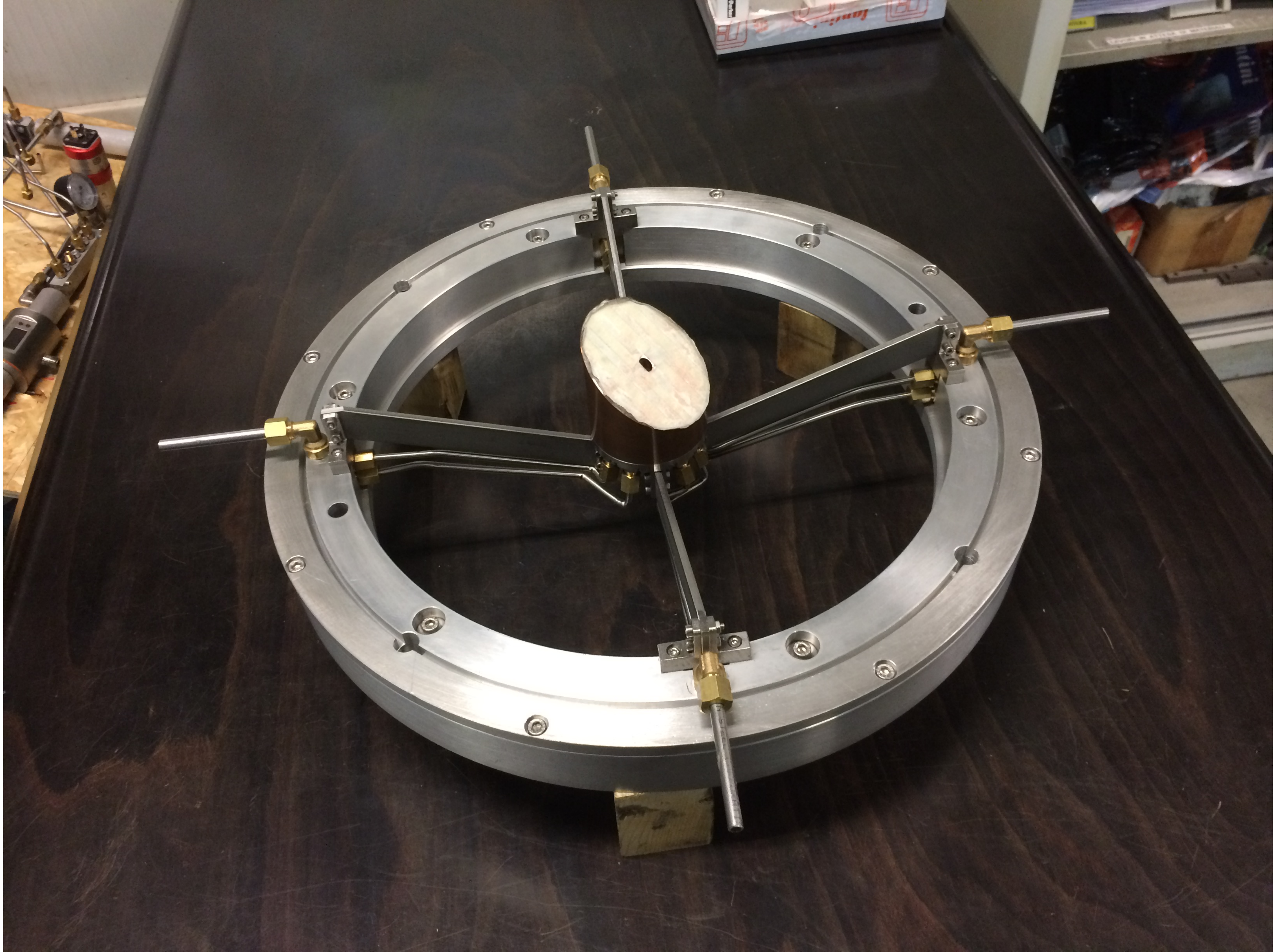


Demonstrator Model

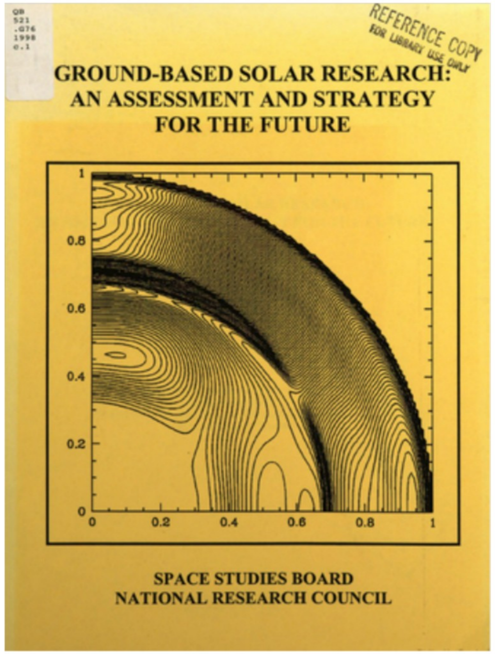




The hosting circuit consists of a regulating valve V, a water reservoir R, and pump P which works at fixed speed and can provide a maximum ΔP of 1.8 bar. The liquid flows in the local hydraulic in the HR. The control system (not shown), acting on the valve V, allows the user to vary the flow.




The remarkable performance of the Dutch open tower telescope on the Canary Islands indicates that a simple flow of air over the primary mirror goes a long way toward controlling the internal seeing.



In the most detailed empirical study of dome seeing to date, *Racine, et al.* (1991) derives a relationship between image quality and dome air temperature relative to outside air temperature, of the form $(0.1'' + 0.05'')/K^{6/5}$ FWHM