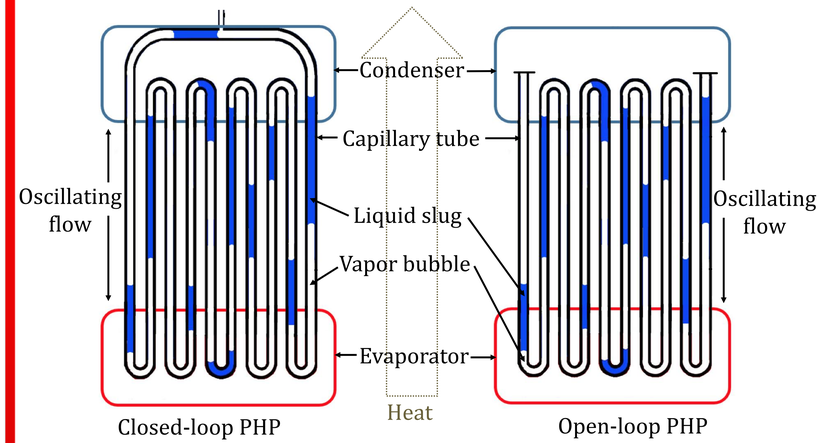
# Experimental study of Large-scale cryogenic Pulsating Heat Pipes

*Maria Barba, Romain Bruce, Antoine Bonelli, Bertrand Baudouy*

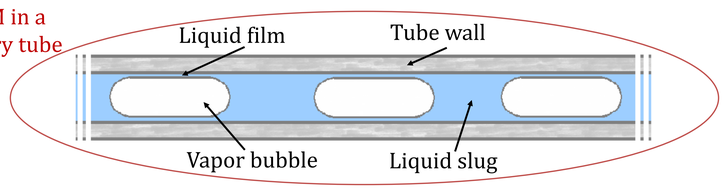
CEA Paris - Saclay, IRFU/DACM, 91191 Gif-sur-Yvette, France

## Pulsating Heat Pipes

- Pulsating or Oscillating Heat Pipe (PHP or OHP)
- Passive heat transfer device (without pumping system)
- Tube with capillary dimensions and serpentine shape
- At least one heating part and one cooling part
- Temperature and pressure conditions close to phase-change
- Different possible positions of the heating part: bottom-heating mode, top-heating mode and horizontal position




ZOOM in a capillary tube




Inner tube diameter (Bond number)

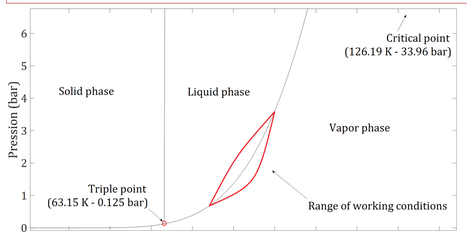
$$Bo = \frac{(\rho_l - \rho_v) g D^2}{\sigma} \leq 4$$

Maximum inner tube diameter

$$D_{crit} \leq 2\sqrt{\frac{\sigma}{g(\rho_l - \rho_v)}}$$

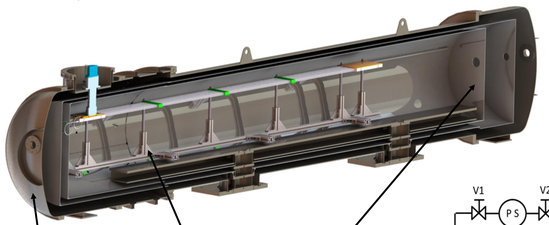
## Experimental facility

| Characteristics | | | | |
|---|---|---|---|---|
| PHP | Position | Parallel tubes | Inner Ø | Outer Ø |
| 3 | Horizontal | 12, 22 and 36 | 1.5 mm | 2 mm |
| Material | Working fluid | Total length | Liquid filling ratios | Heat load |
| Stainless Steel | $N_2$ | 3.7 m | 20-90 % | 5-10 W |

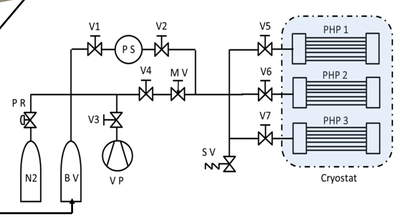









### Inlet gas system



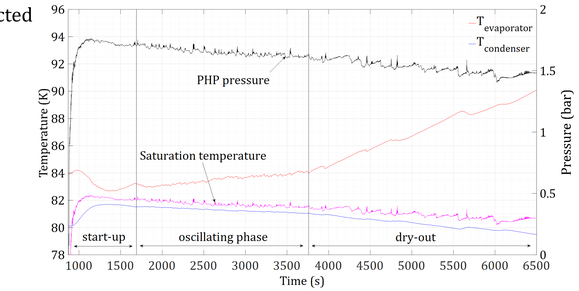

## Tests results

PHP with 36 parallel channels (Heat load of 10 W and liquid filling ratio of 33 %)

- Buffer volume connected to the PHP

**Results:**

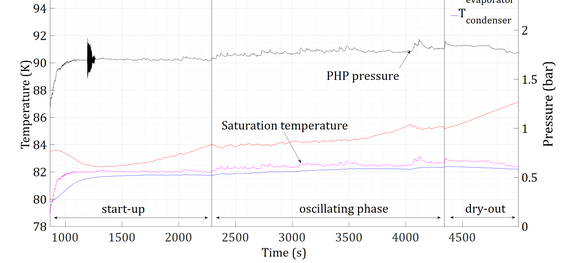
- **Oscillating phase: 35 min**
- **Equivalent thermal conductivity: 350-160 kW/m.K**




- Buffer volume not used

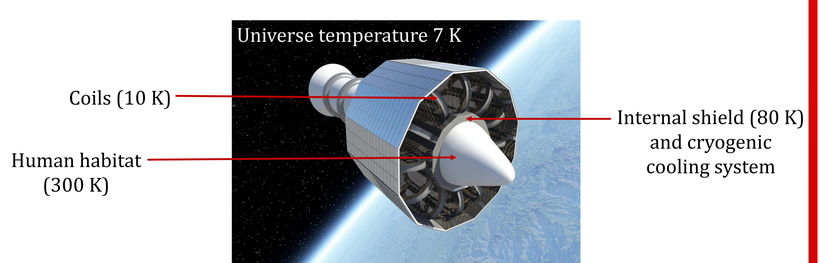
**Results:**

- **Oscillating phase: 35 min**
- **Equivalent thermal conductivity: 290-190 kW/m.K**




## Application

To cool down a superconducting toroid magnet (10 m long and 12 m of diameter) to protect the human habitat from the ionizing radiations during long term missions in deep space. (SR2S European project)




European Union's Seventh Framework Programme (FP7/2007-2013)
Grant agreement n° 313224 - SR2S

Presented at the CEC / ICMC 2017, Madison, Wisconsin, USA, 2017 July 9 – 13