Upgraded Pulsating Heat Pipe only for Space (U-PHOS): Results of the 22nd REXUS Sounding Rocket Campaign and Development of the ISS Prototype

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OUTLINE

1. INTRODUCTION: The Large Diameter Pulsating Heat Pipe.

2. U-PHOS: - Objectives.
   - The rocket module.
   - Results.

3. ISS PROTOTYPE: Developement of the Experimental apparatus.

4. CONCLUSIONS AND FUTURE WORK

1. INTRODUCTION

The Large Diameter Pulsating Heat Pipe

GROUND g = 9.81 m/s2

d

STRATIFIED FLOW

Does not work in horizontal position

LOOP THERMOSYPHON

$$d \leq d_{crit}$$
(Bo,We,Ga)

MILLI GRAVITY g = 0.01 m/s2

d

SLUG FLOW MANTAINED

$\dot{Q}$ ↑ R_{th} ↓

LARGE DIAMETER PULSATING HEAT PIPE

2. U-PHOS: Objectives

a) SPACE PHP ACTIVATION.

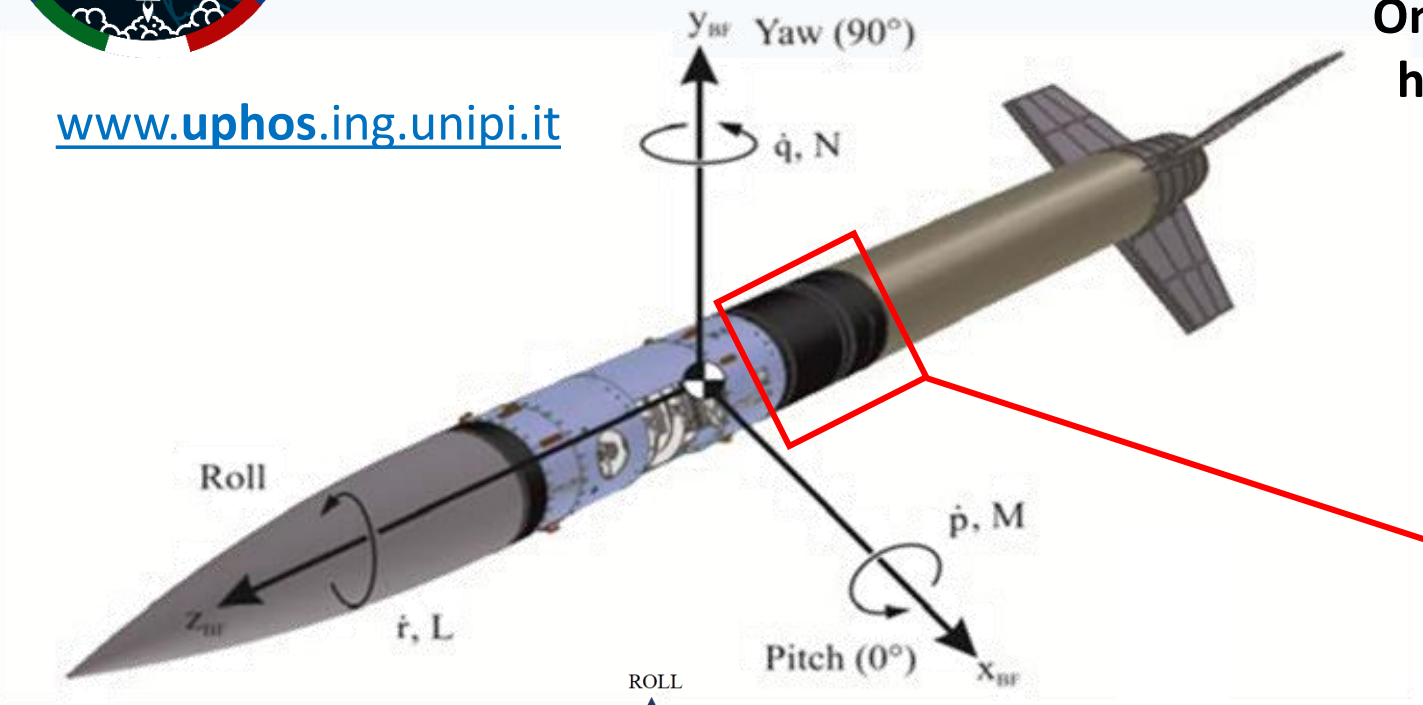
b) SPACE PHP PSEUDO STEADY STATE.

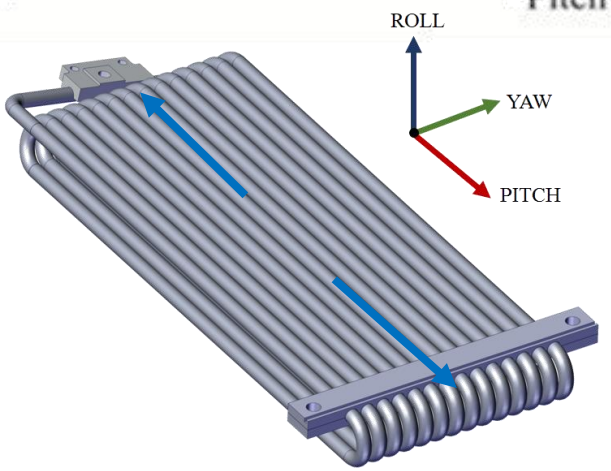
c) TEST METAL FOAM + PARAFFINE HEAT SINK.

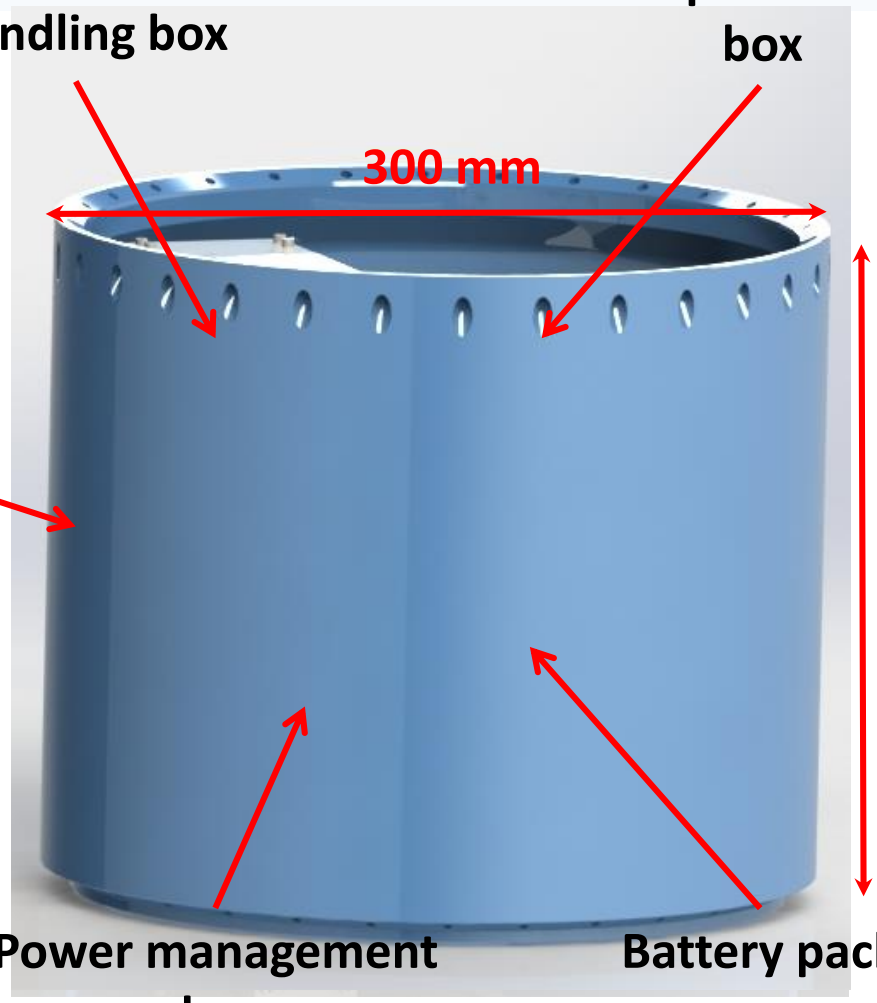
d) TEST OPTIC FIBRES FOR TEMPERATURE MEASUREMENT.

2. U-PHOS: the roket module

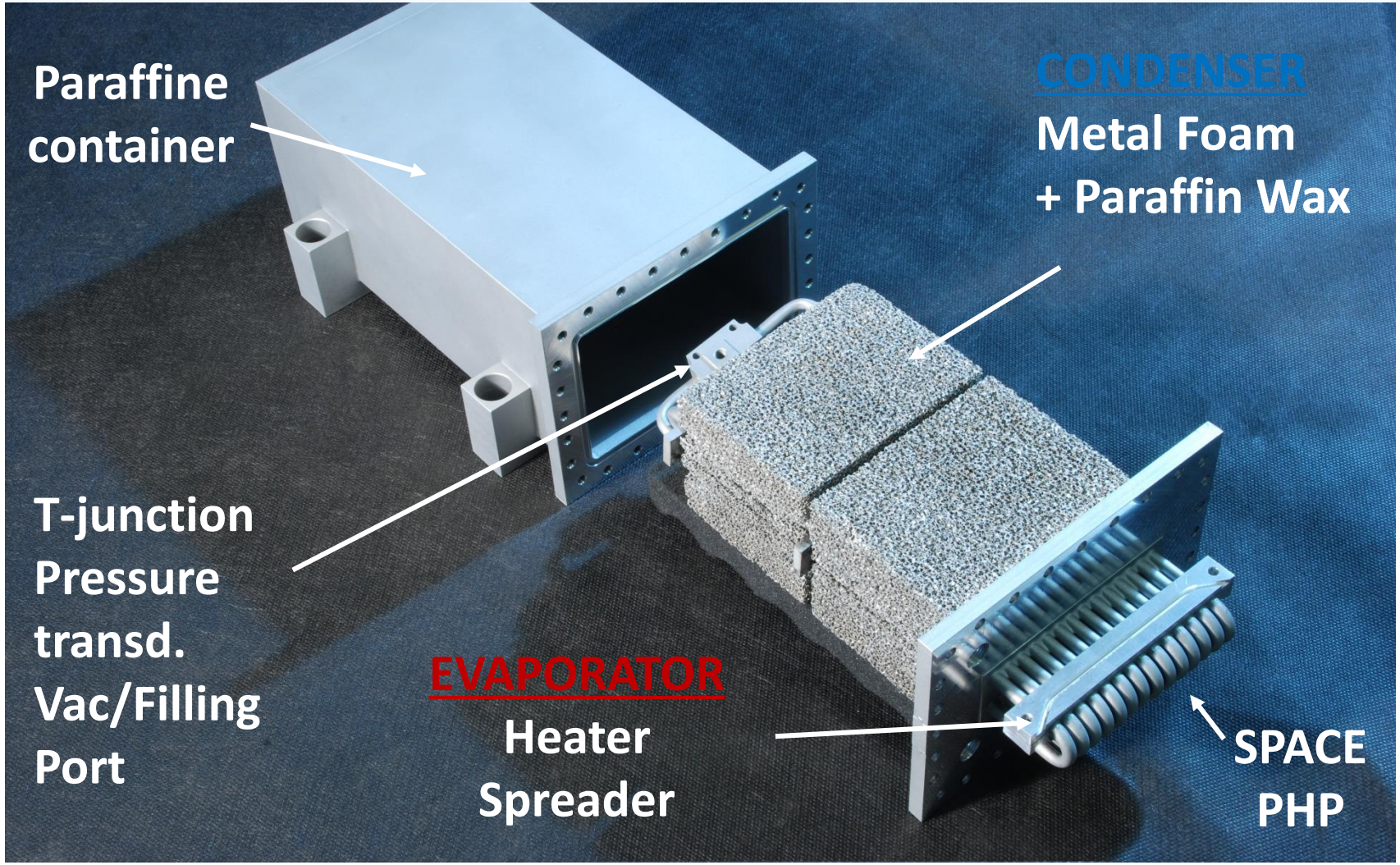
www.uphos.ing.unipi.it





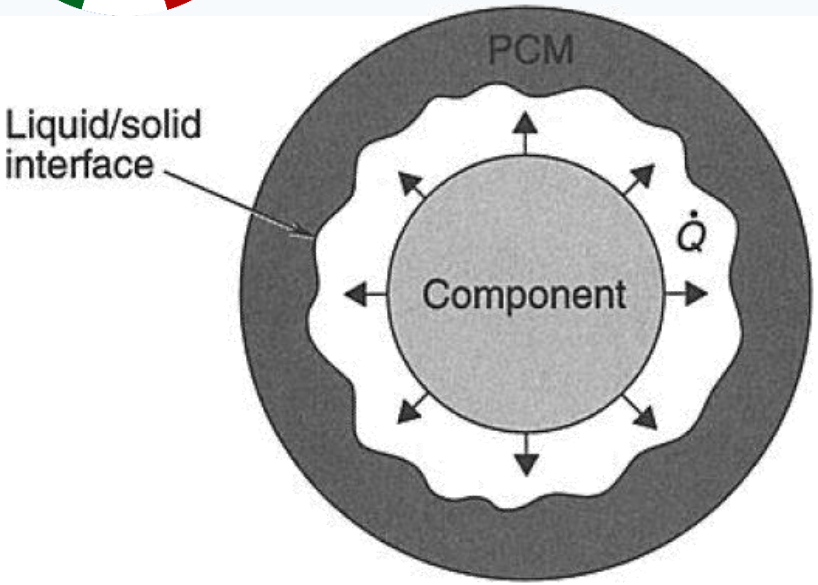


2. U-PHOS: Test Cell



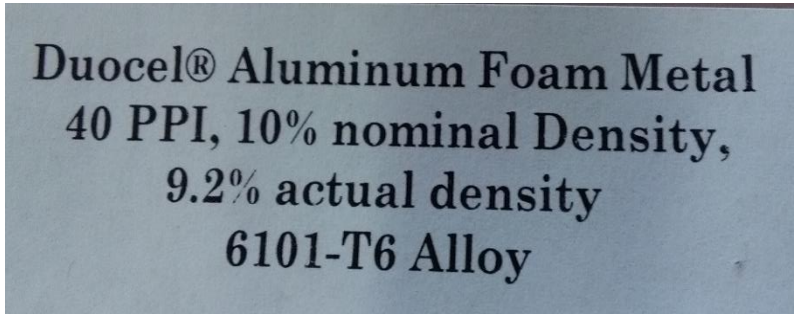
2. U-PHOS: Paraffine + Metal foam

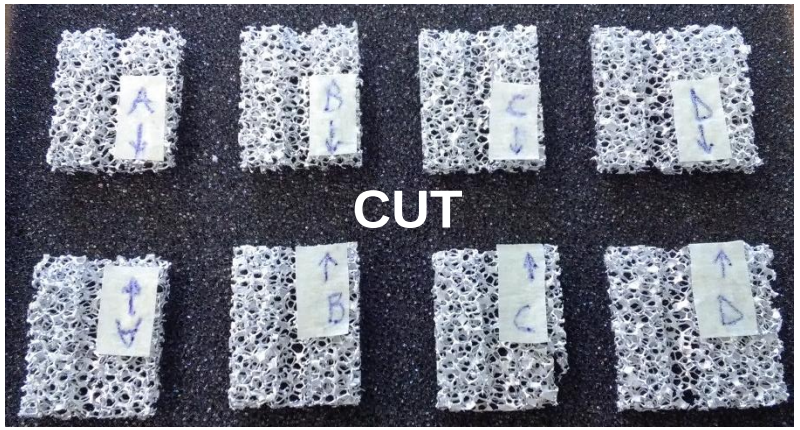
PCM ONLY?



Density	814 (s), 774 (l) [kg/m³]
Specific Heat	2160 [J/kg.K]
Melting Point	28.0 [°C]
Heat of Fusion	244 [kJ/kg]
Thermal Conductivity	0.15 [W/mK]

PHASE CHANGE MATERIAL + METALLIC FOAM

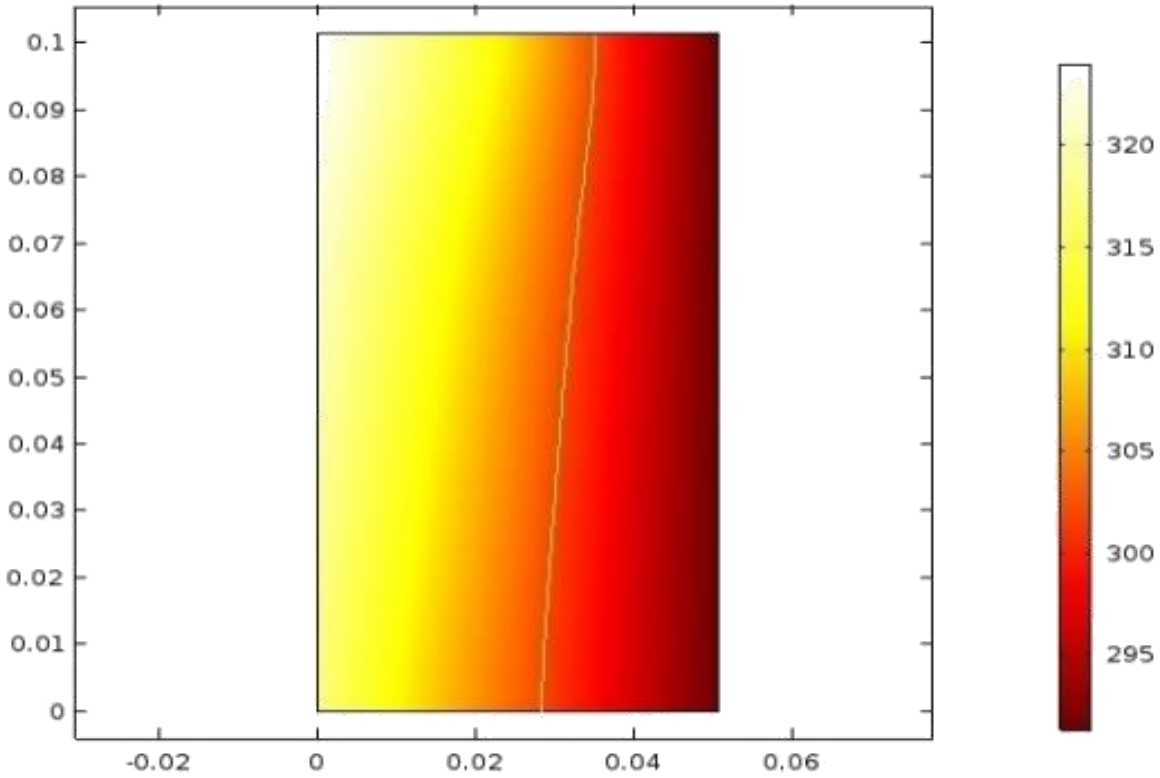




2. U-PHOS: Paraffine + Metal foam

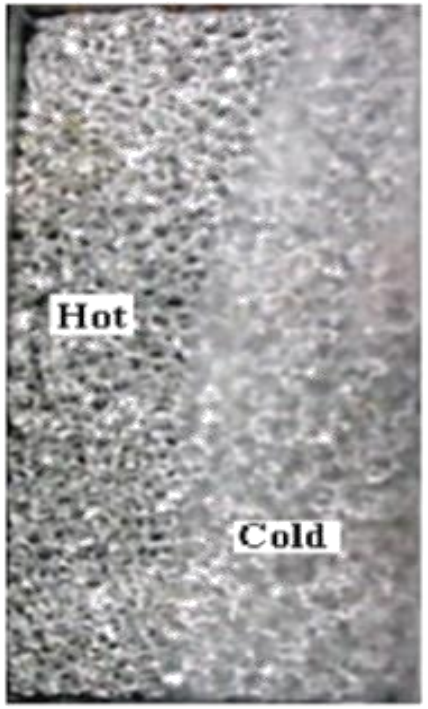
PHASE CHANGE MATERIAL + METALLIC FOAM

NUMERICAL



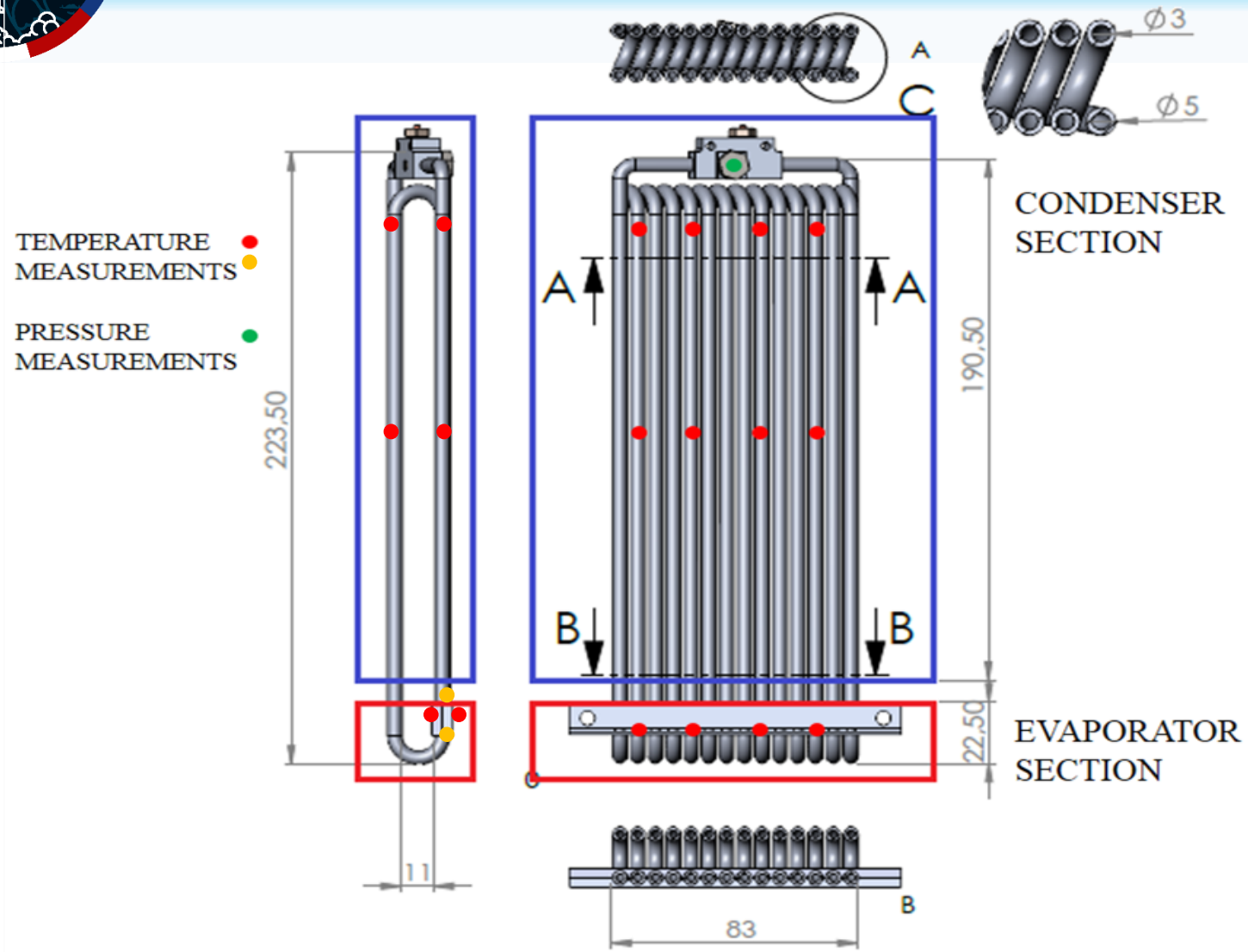
Di Giorgio et al. *"Embedded Paraffin/Metal foam Composite for Thermal Storage in Microgravity Conditions"*, 34th UIT Conference 4-6 July 2016, Ferrara, Italy.

EXPERIMENTS



Lafdi et al. Experimental study on the influence of foam porosity and pore size on the melting of phase change materials J. of App. Physics 2007.

2. U-PHOS: Geometry and Measurements



GEOMETRY

- AluminumTube
- FLUID: FC-72
- I.D./O.D. 3mm/5mm
- N° Turns: 14

EVAPORATOR

- 2 Alumina Heaters
- Q= 110W per heater

CONDENSER

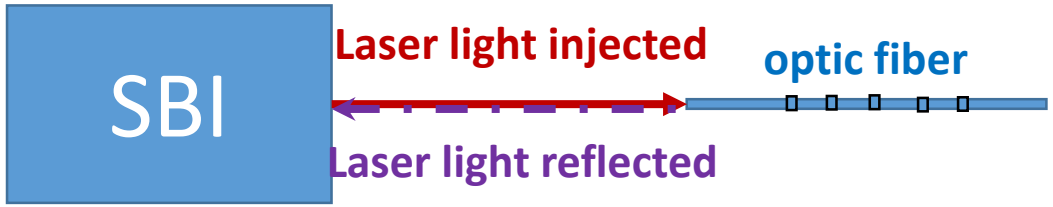
- Metal Foam + Paraffin

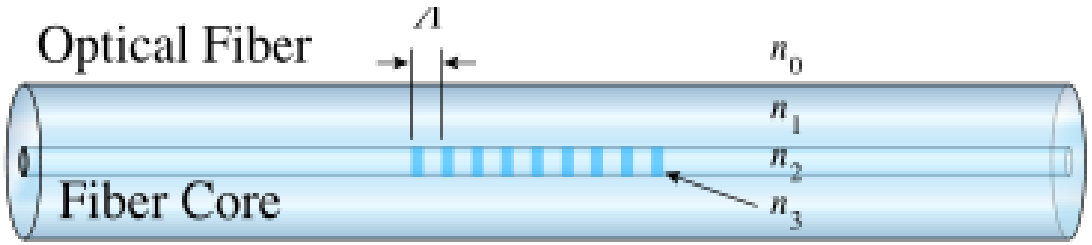
ACQUIRED:

- Tube Temper. (RTDs, Fibers)
- Fluid Press. (1 point static)

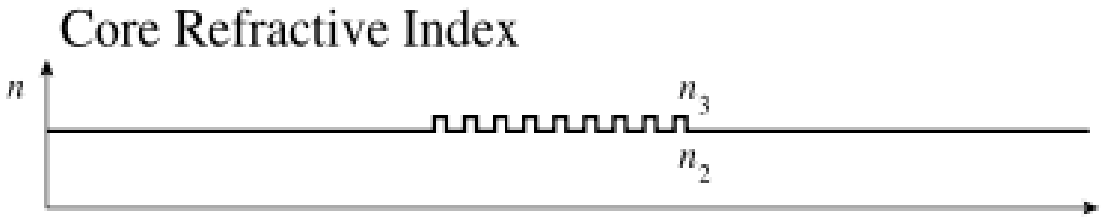
2. U-PHOS: Optical Fibers

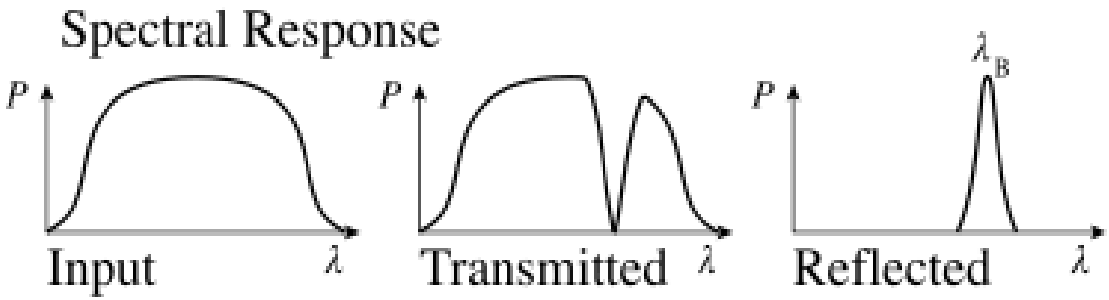
- **Temperature measurement by means of optic fibers**





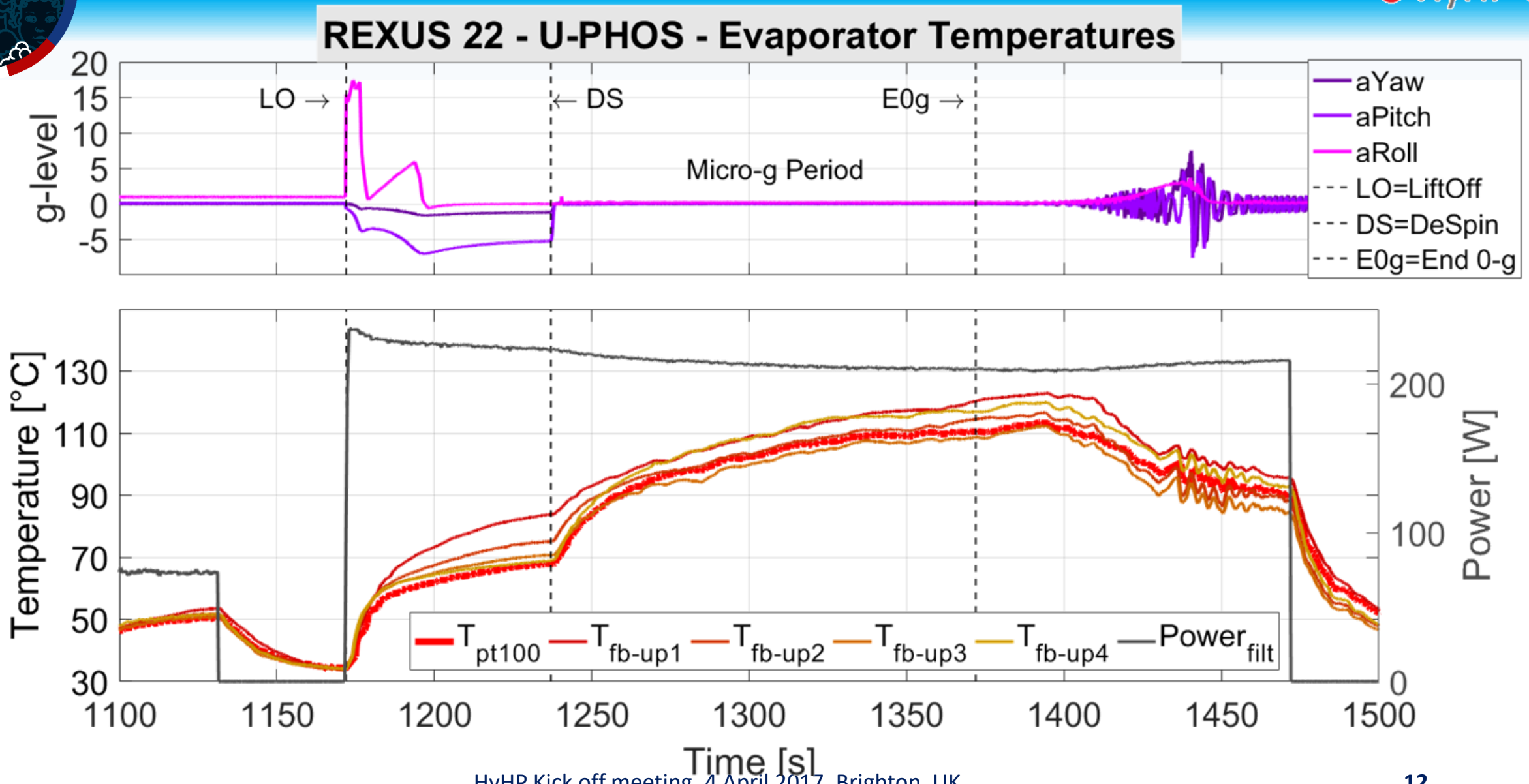
- SBI = Sensor Bragg Interrogator
- The optical fiber is doped in several locations obtaining small embedded sensors.
- A laser light is injected in the fiber and different wavelength spectra are reflected by the sensors depending on the sensor temperature.
- The SBI receptors measure the reflected wavelengths and calculate the temperatures for all the sensor locations.





2. U-PHOS: Launch

2. U-PHOS: Results



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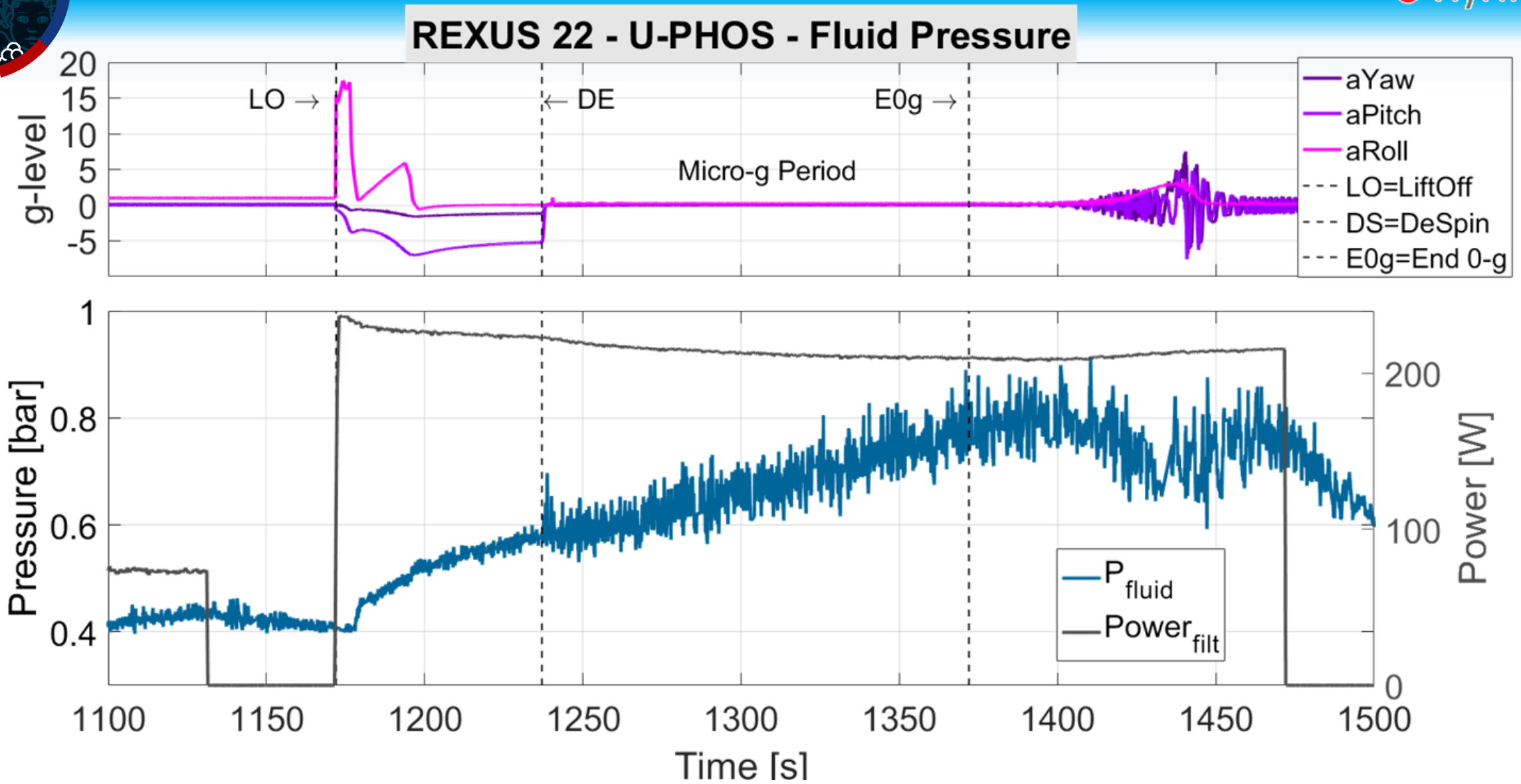

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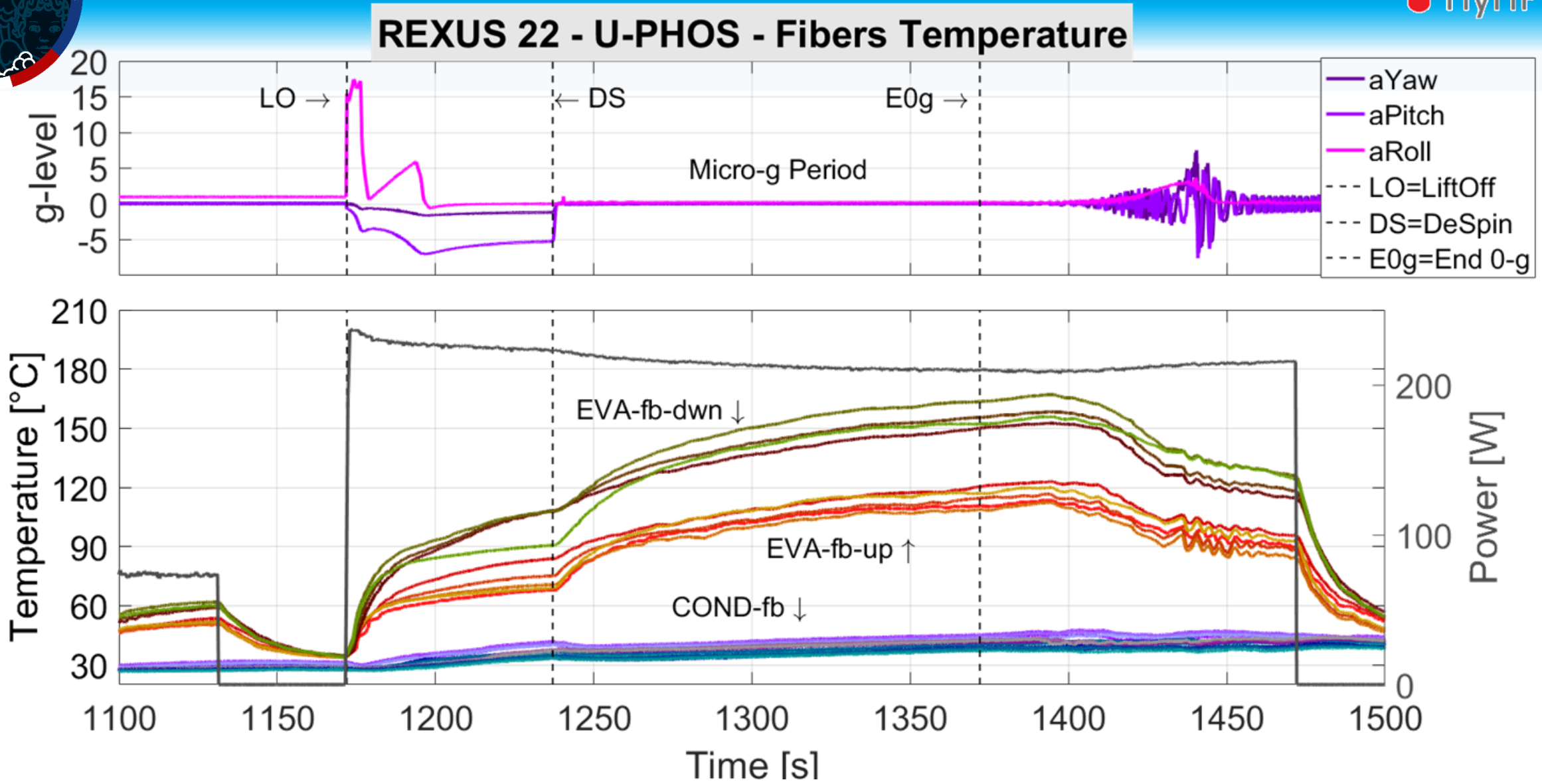

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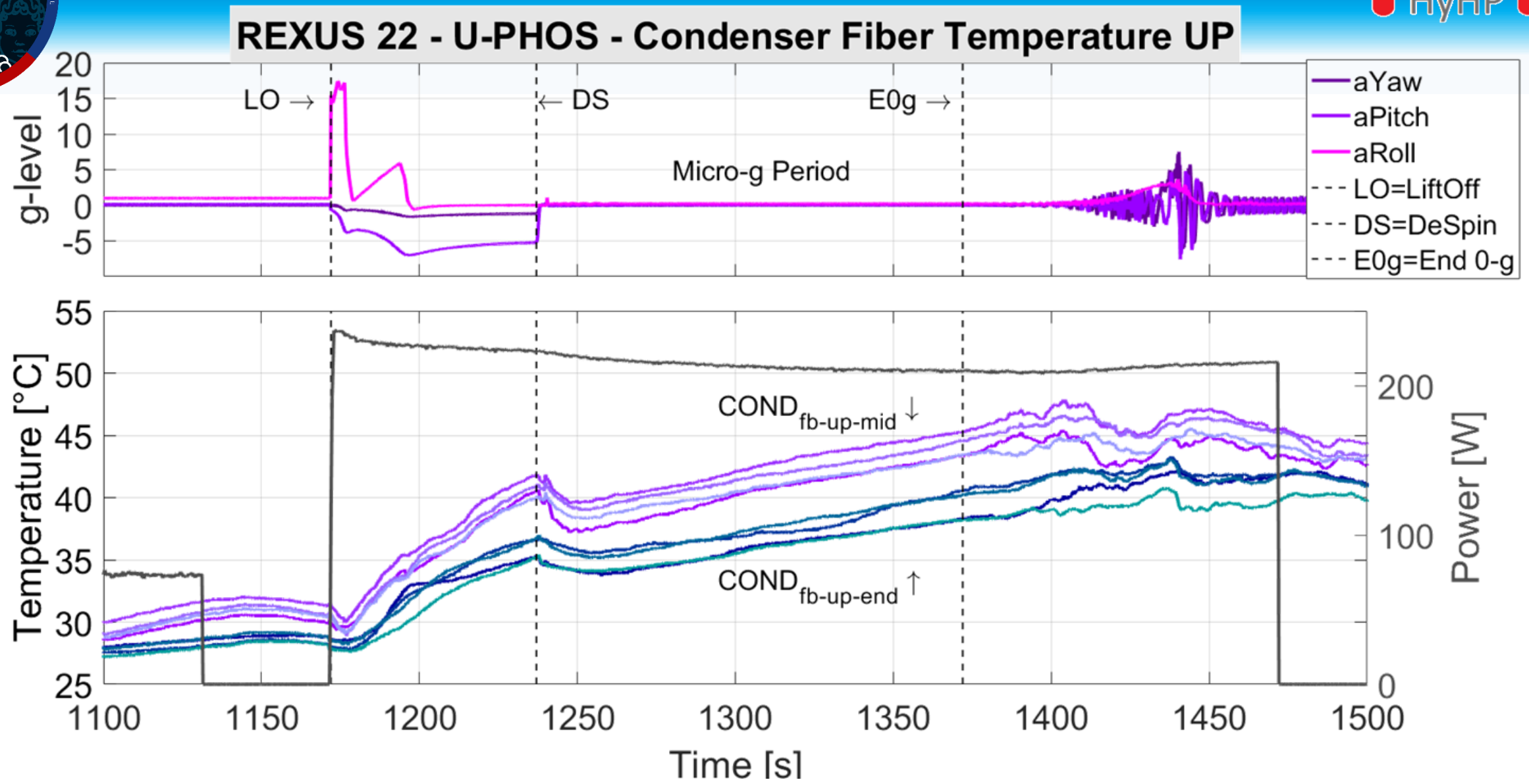
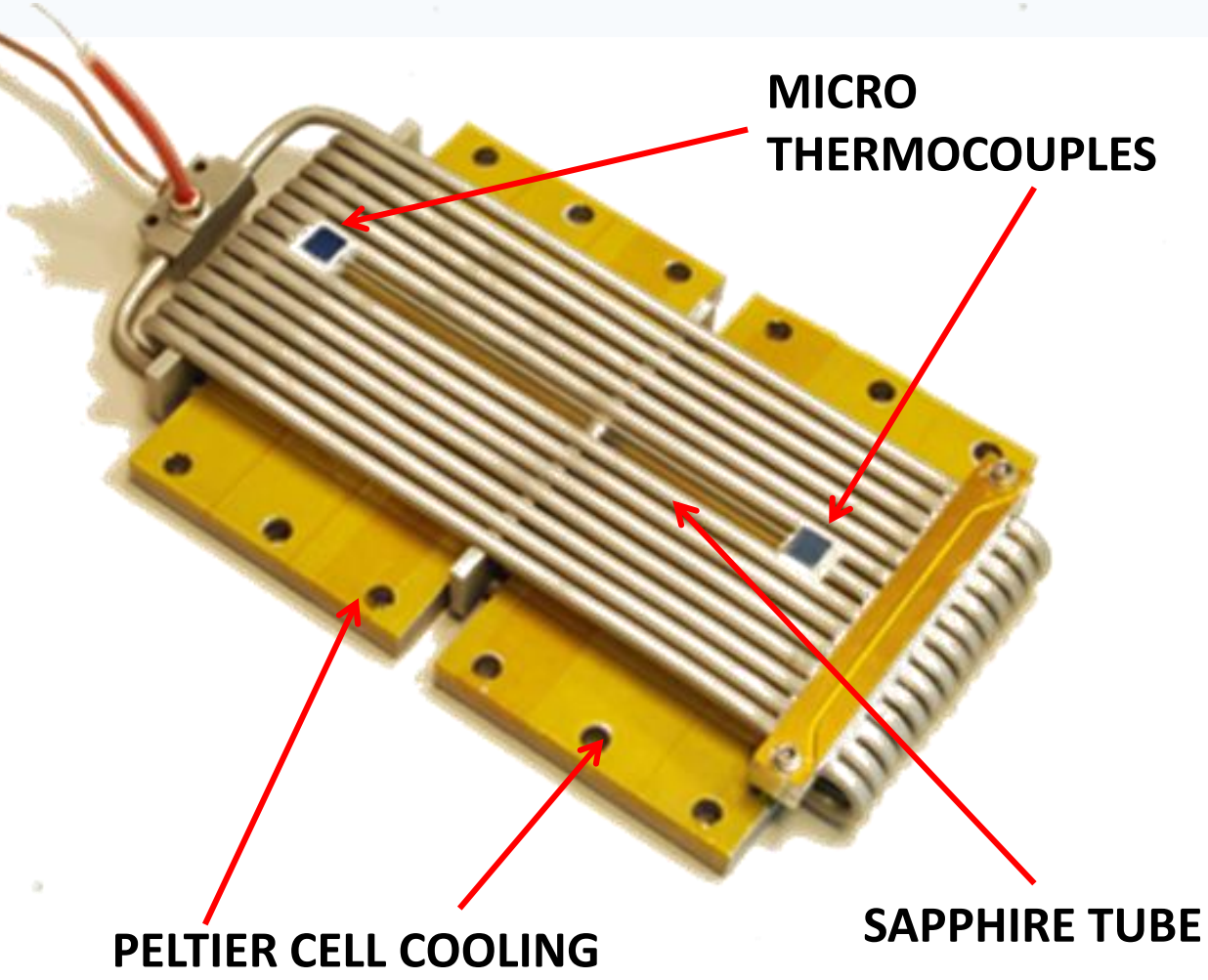
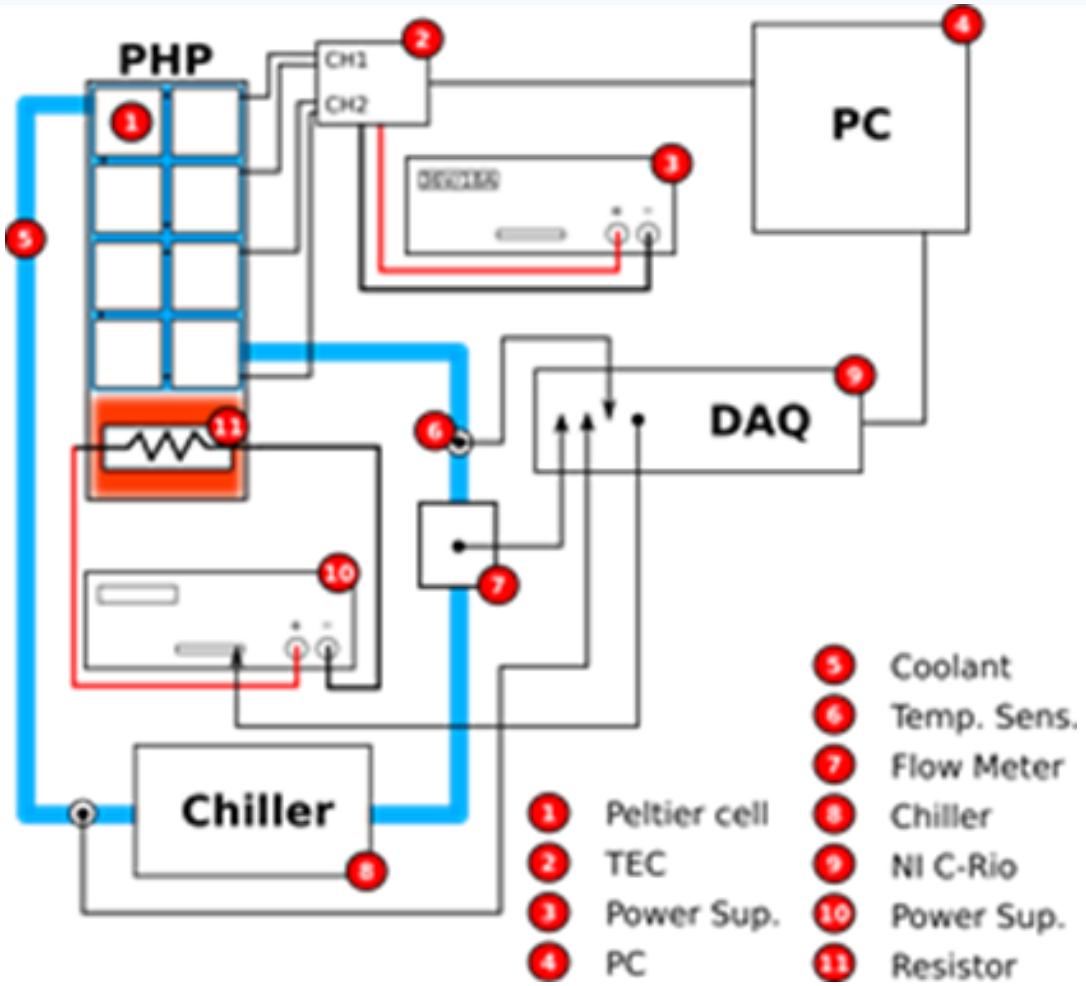


3. ISS-PHP


MICRO
THERMOCOUPLES
PELTIER CELL COOLING
SAPPHIRE TUBE


PHP
CH1
CH2
PC
DAQ
Chiller
1 Peltier cell
2 TEC
3 Power Sup.
4 PC
5 Coolant
6 Temp. Sens.
7 Flow Meter
8 Chiller
9 NI C-Rio
10 Power Sup.
11 Resistor

4. CONCLUSIONS AND FUTURE WORK

https://www.facebook.com/Hympactproject/

a) SPACE PHP ACTIVATION.
(Compare pressure signal with Mangini et al.)

b) SPACE PHP PSEUDO STEADY STATE.
(confirm that ISS is needed… once again!)

c) TEST METAL FOAM + PARAFFINE HEAT SINK.
(further check on data and hypergravity experiments)

d) TEST OPTIC FIBRES FOR TEMPERATURE MEASUREMENT.
(post calibration mandatory!!)

THANKS FOR YOUR ATTENTION!

FINMECCANICA

KAYSER ITALIA

PEC Italia

AAVID THERMALLOY

VICOR The Power Behind Performance

ELEMASTER GROUP

SITAEL

Henkel

INFIBRA TECHNOLOGIES

SMART FIBRES SENSE THE FUTURE

B.P.Laj

sportika

2. U-PHOS: Results