# Impact of the cold regenerator meshes geometry on low temperature Pulse Tube performances

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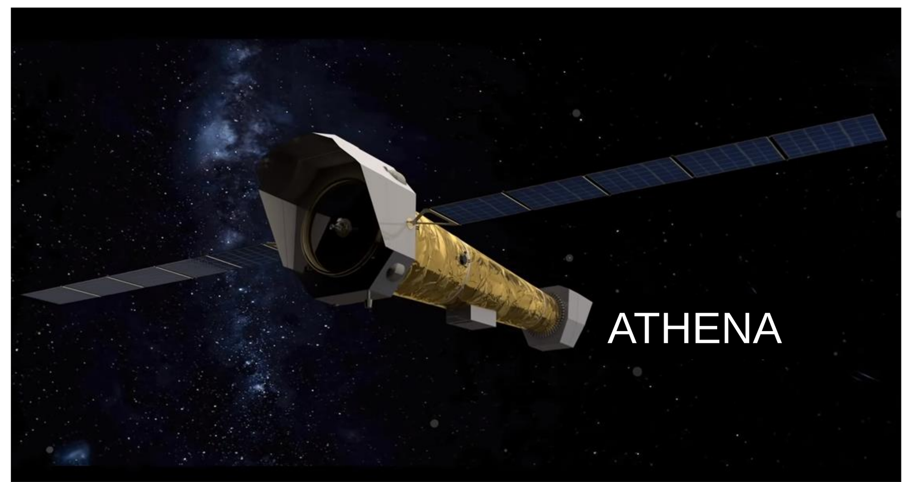
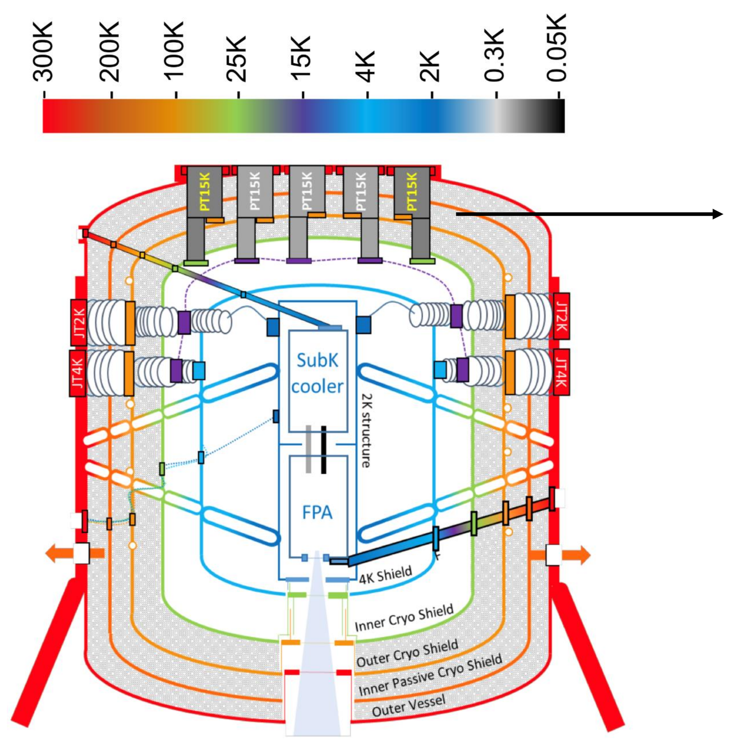
## CONTEXT – Pulse Tube coolers in space missions

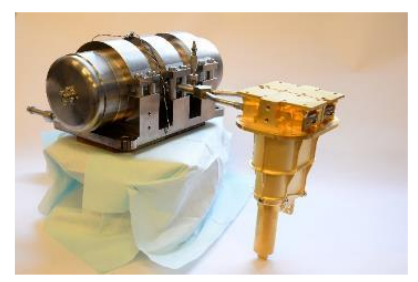



Scientific space missions use extremely sensitive detectors (X-Ray, infrared), requiring power at very low temperature (< 100 mK)

Complex cryogenic chain to obtain such temperatures



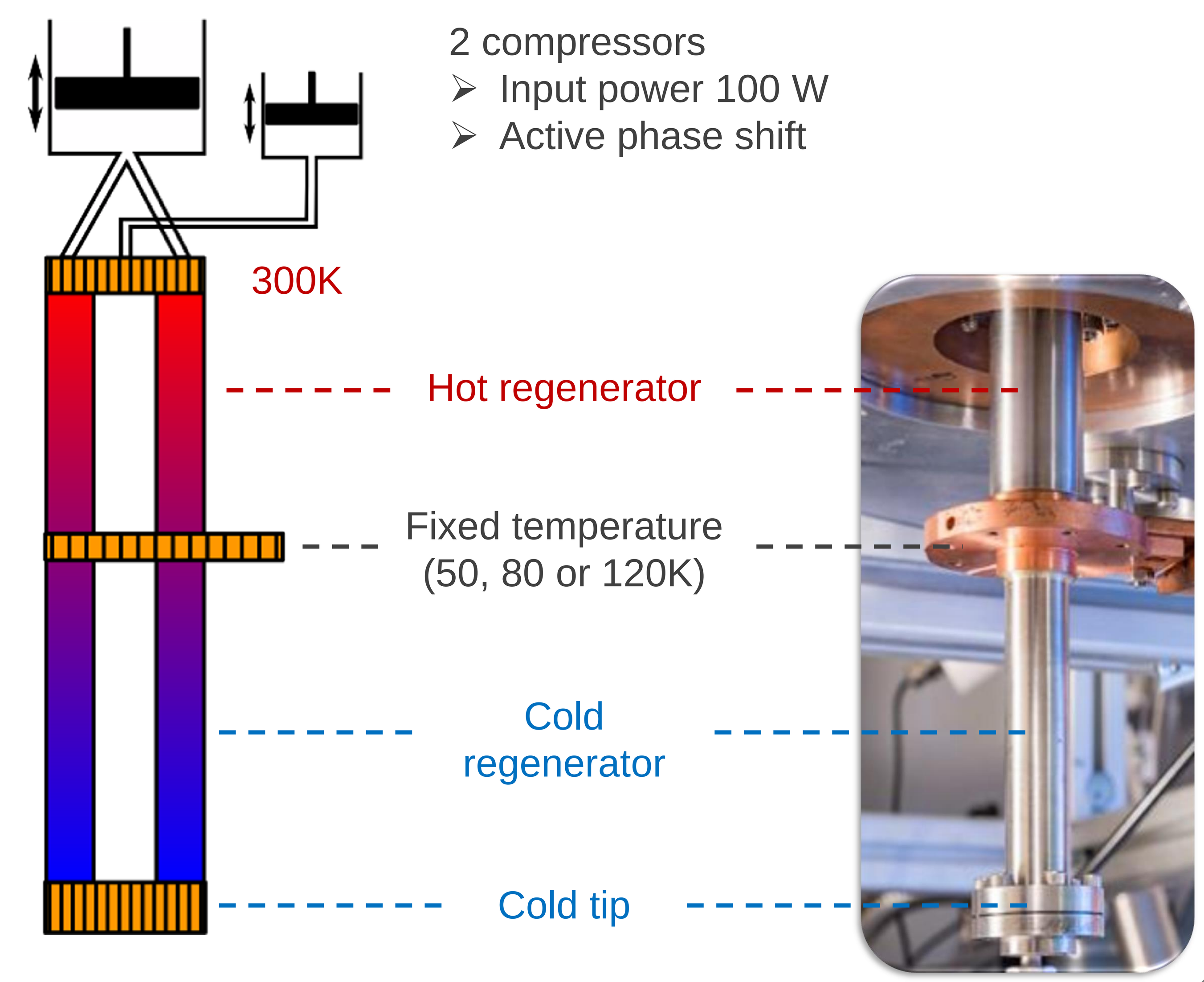

Precooling at 15 K with Pulse Tube coolers



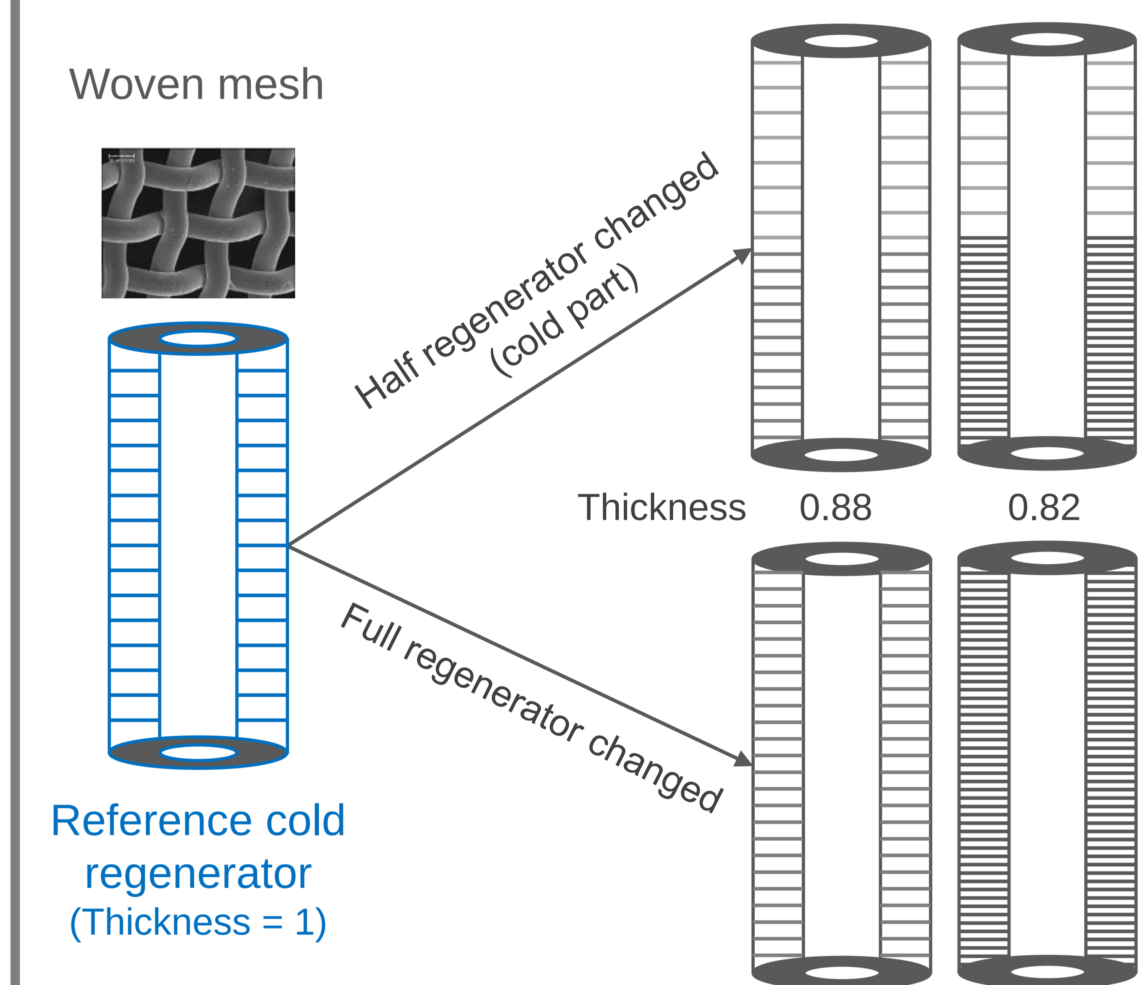
➢ **Project: Fundamental work on the PT performances based on a 15 K PT design**

## BREADBOARD - Coaxial heat intercepted PT

2 compressors
➢ Input power 100 W
➢ Active phase shift

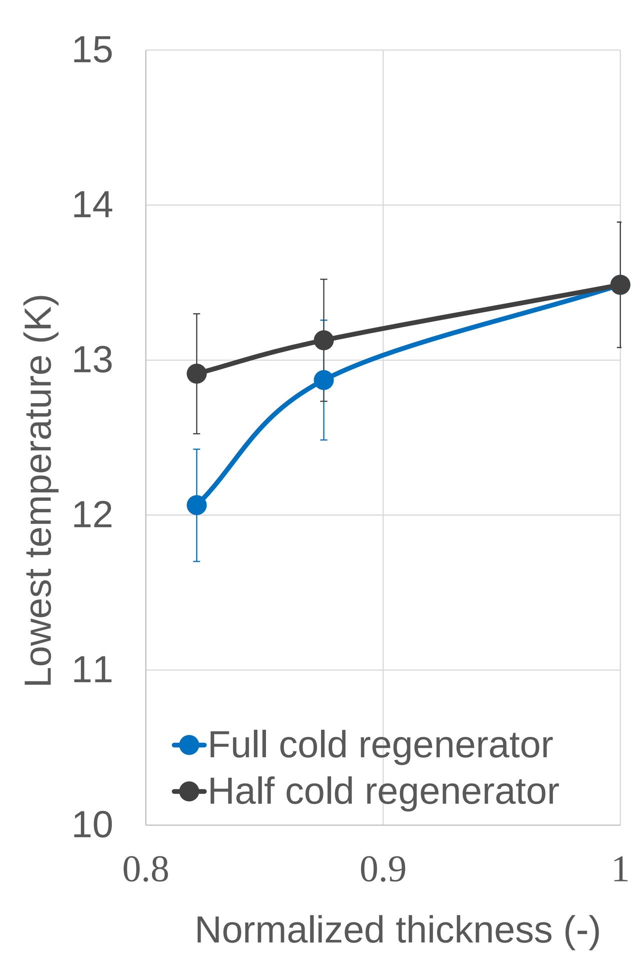


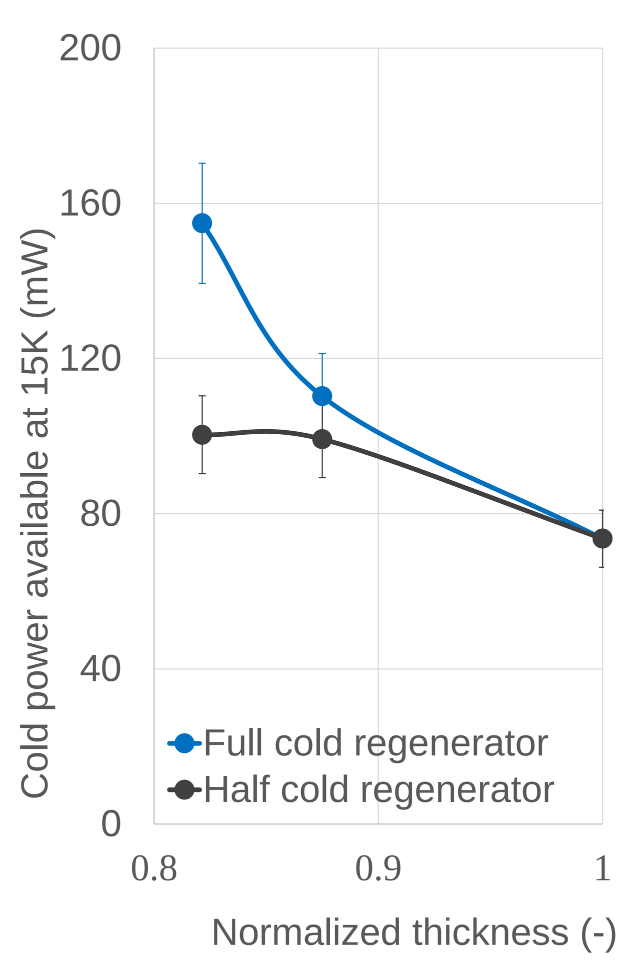

## GEOMETRY - Cold regenerator

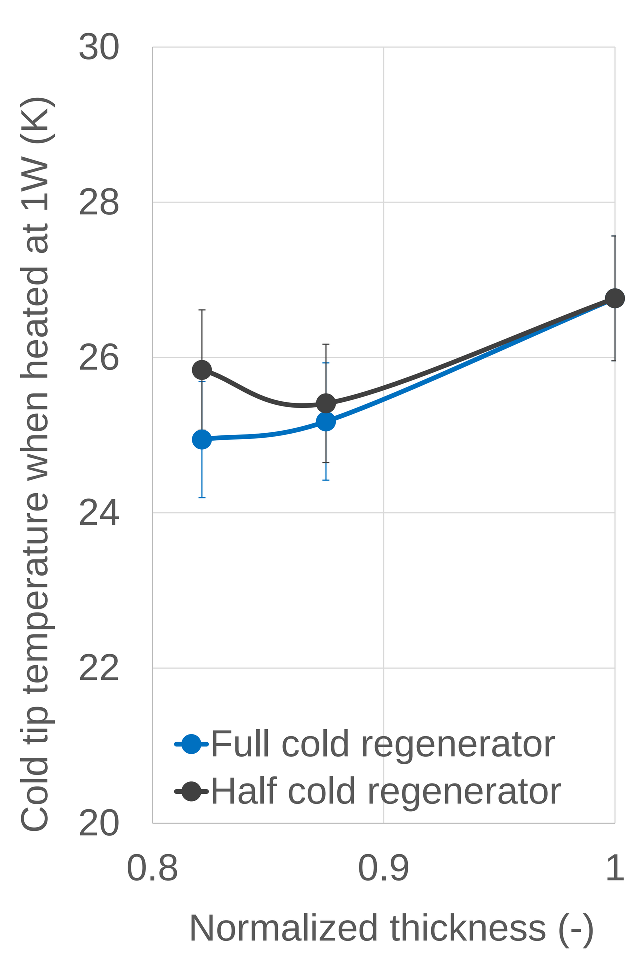



Study on the geometry of the cold regenerator meshes (decreasing thickness = increasing meshes number)

## RESULTS - Impact on performances




➢ Optimal thickness of the half cold regenerator depends on the temperature
< 0.8 at low temperatures, around 0.85 at 15 K and about 0.9 up to 25 K
➢ Optimal thickness of the upper part of the cold regenerator always < 0.8

Decreasing thickness = more meshes
→ Competition between physical effects

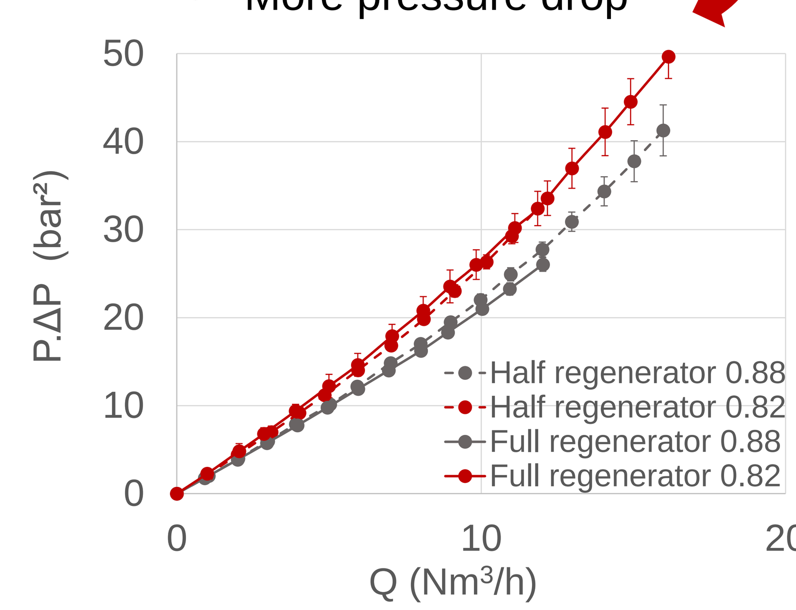
- Less dead volume

| Comparison with reference | Half cold regenerator | Full cold regenerator |
|---|---|---|
| Thickness 0.88 | - 3.2 % | - 8.6 % |
| Thickness 0.82 | - 8.2 % | - 9.9 % |

- More thermal capacity
- Extended exchange surface

| Comparison with reference | Half cold regenerator | Full cold regenerator |
|---|---|---|
| Thickness 0.88 | + 5.6 % | + 15.6 % |
| Thickness 0.82 | + 14.6 % | + 18.4 % |

- More pressure drop




- Increasing conduction ?

| Parasitic heat losses | Half cold regenerator | Full cold regenerator |
|---|---|---|
| Thickness 0.88 | 157 mW ± 10 mW | 151 mW ± 10 mW |
| Thickness 0.82 | 152 mW ± 10 mW | 170 mW ± 10 mW |

## CONCLUSION

This fundamental project studied the cold regenerator meshes geometry influence on the PT performances. An optimal meshes thickness has been highlighted, depending on the operating conditions (temperature).

When the meshes thickness is optimized, the order of magnitude of the power gain (50 mW) is not negligible compared to the operating conditions of the initial 15 K pulse tube cooler (400 mW).

A combination of this results with regenerator materials studies would much more improve the basic 15 K pulse tube cooler performances.

## ACKNOWLEDGEMENTS

This work is being conducted with a partial support of CNES. The experimental work at CEA/SBT has been shared by Camille Choupin, Thibault Romand and Julien Inigo whose contributions to this project are greatly appreciated.