

#### First mechanical study on a lightweight microconcentrator design for space applications

Victor Vareilles, Anderson Bermudez Garcia, Jérôme Francois, Yannick Veschetti, Mohamed Amara, Philippe Voarino, Fabien Chabuel

#### ▶ To cite this version:

Victor Vareilles, Anderson Bermudez Garcia, Jérôme Francois, Yannick Veschetti, Mohamed Amara, et al.. First mechanical study on a lightweight microconcentrator design for space applications. JNPV 2021, Nov 2021, DOURDAN, France. , 2020. cea-03482593

#### HAL Id: cea-03482593 https://cea.hal.science/cea-03482593

Submitted on 16 Dec 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



# FIRST MECHANICAL STUDY ON A

# LIGHTWEIGHT MICROCONCENTRATOR DESIGN FOR SPACE APPLICATIONS

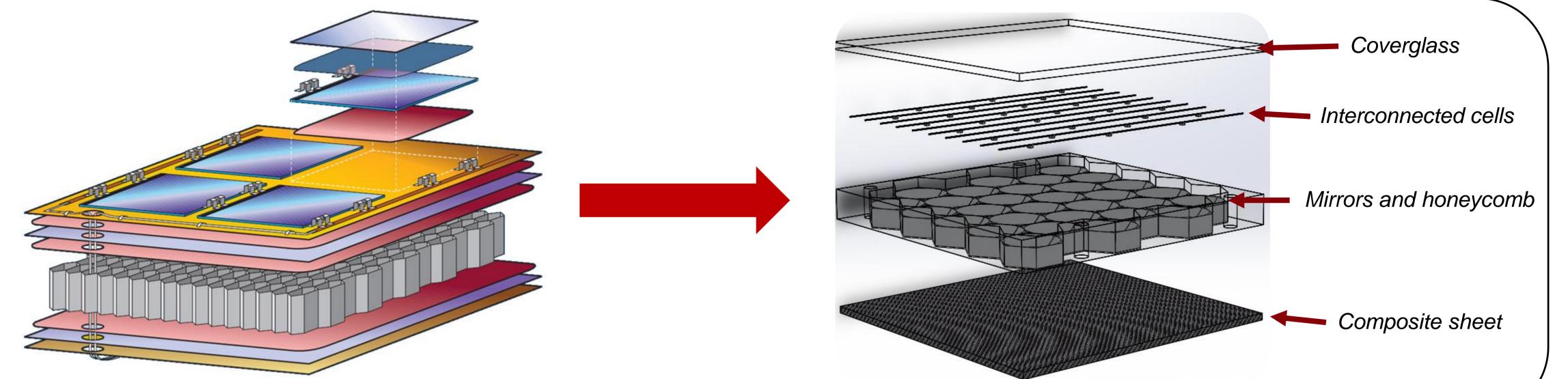
Victor Vareilles<sup>1</sup>\*, Anderson Bermudez-Garcia<sup>1</sup>, Jérôme François<sup>1</sup>, Yannick Veschetti<sup>1</sup>, Mohamed Amara<sup>2</sup>, Philippe Voarino<sup>1</sup>, Fabien Chabuel<sup>1</sup>

<sup>1</sup>Univ. Grenoble Alpes, CEA, Liten, victor.vareilles@cea.fr, Campus Ines, 73375 Le Bourget du Lac, France <sup>2</sup>Univ Lyon, CNRS, INSA Lyon, ECL, UCBL, CPE Lyon, INL, UMR5270, F-69621 Villeurbanne CEDEX, France \* Corresponding author: victor.vareilles@cea.fr +33 (0)4 79 79 28 72



Low cost trends in Space:

- Concentration to reduce cell cost
- Lightweight to reduce launch cost
- Innovative design proposal
- > Need to study the mechanical behaviour of the design





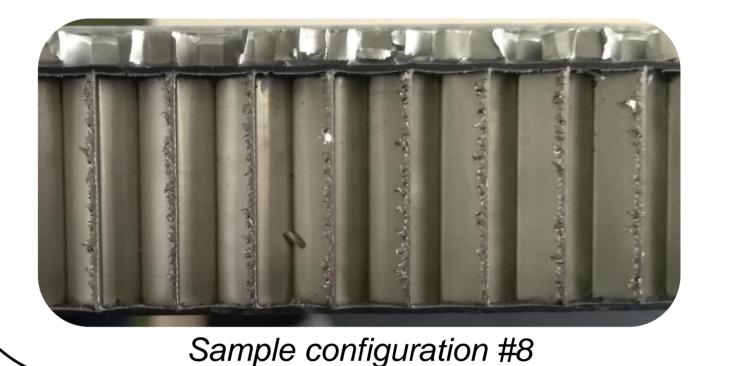
Standard rigid panel [1]

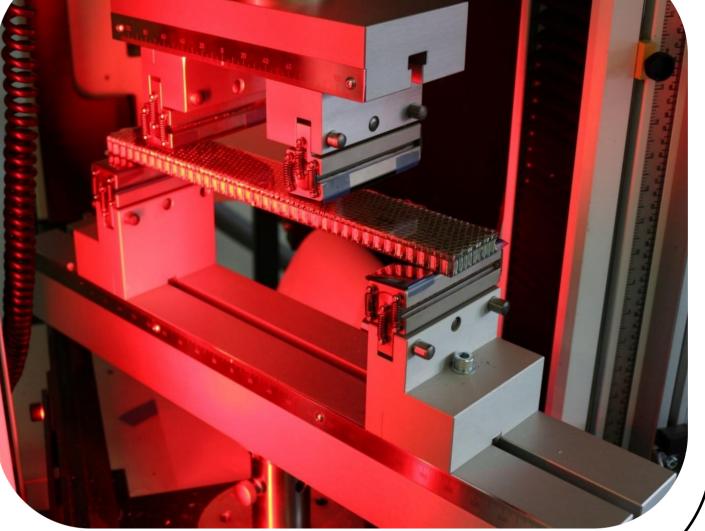


## **Materials**

## 4 - point bending tests

- ASTM D7250 [3] conforming machine
- Video extensometer
- 5 samples for each configuration  $\bullet$





4-point bending setup

 $(kg^{-1})$ 

m<sup>3</sup>

Ľ.

1500

1000 🔾

500

#### Area density of the configurations Bending stiffness for each configuration **Results: bending stiffness** 2500 Top honeycomb: Tested experimentally 2 plies CFRP: 4 plies Deduced Dn (N.mm) 1×10<sup>7</sup> High density honeycombs were used and proved 500µm 300 µm 400µm Glass: Dρ (N.m<sup>3</sup>.kg⁻¹) Bot honeycomb: 10 mm to be quite heavy 2000 Tested experimentally

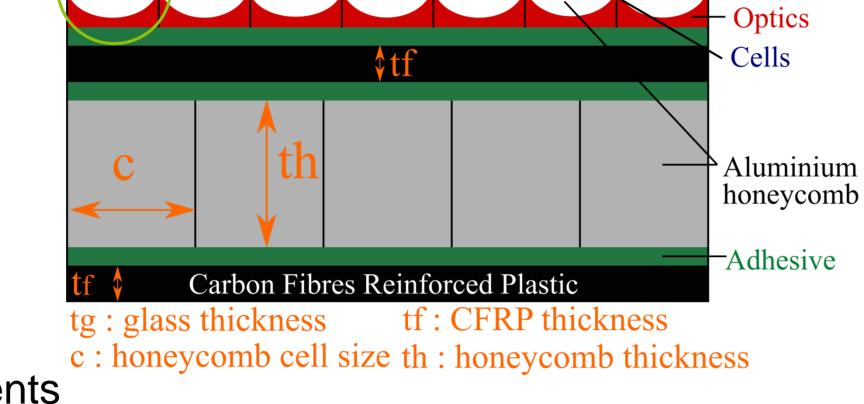
Transparent adhesive

## **Parametric study**

CFRP thickness (*tf*)

Methodology

- Glass thickness (tg)
- Honeycomb thickness and cell size (*th*, *c*)
- Design of experiments  $\succ$ Get the main effects Limit the number of experiments



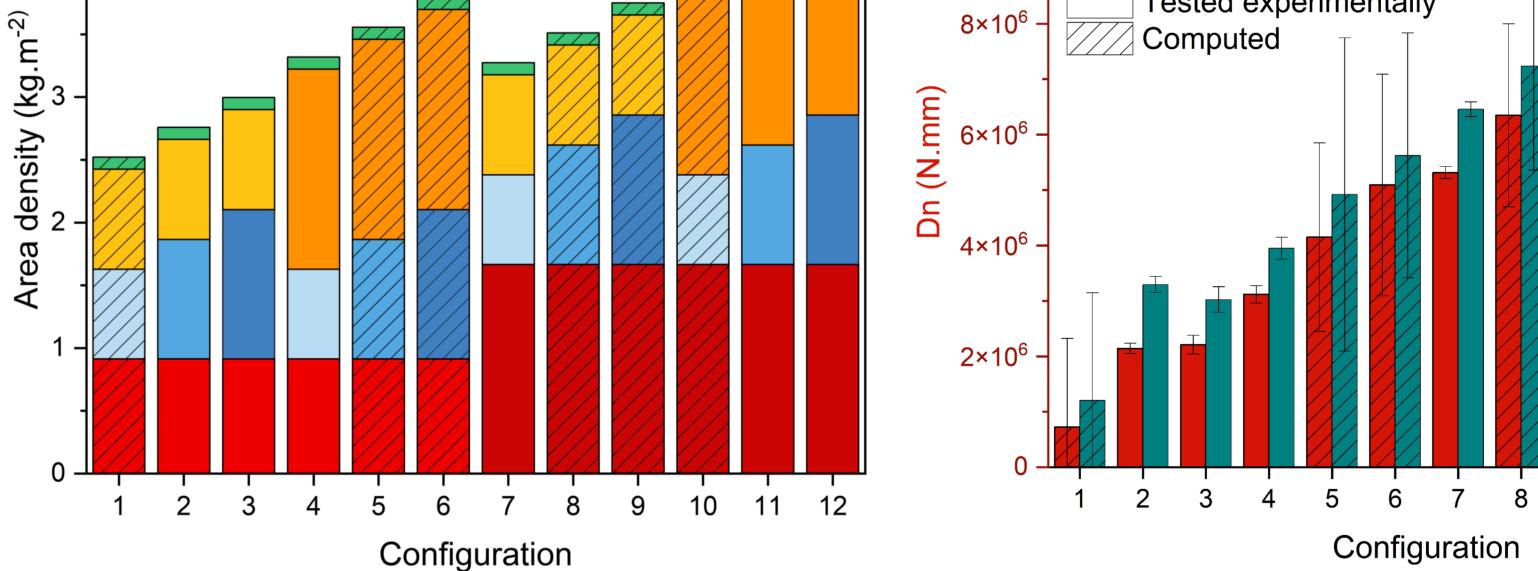
Glass

### Higher specific stiffness with a thicker honeycomb

• Possibility to decrease its density without changing the mechanical behaviour a lot

Glass thickness has a lower influence than the other two parameters

 Possible way to decrease the mass of the structure



# **Results: failure modes**

## Different phenomena were observed:

- Glass failure below the loading areas: local compressive stress lacksquare
- Glass failure on the edges of the loading areas: local shear stress
- Crushing of the top honeycomb
- Failure of the top CFRP  $\rightarrow$  compressive stress
- Failure of the bottom CFRP  $\rightarrow$  tensile stress

For some samples with thicker glass and thinner CFRP, the

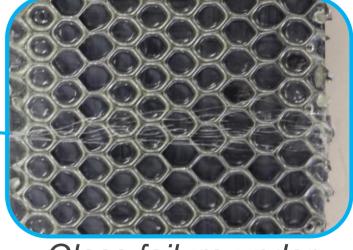


Zone with

shear

Zone with

shear



Glass failure under compressive stress

### glass did not break during the test

#### Wrinkling of the top honeycomb during test

## **Conclusion & Perspectives**

- The bending stiffness and area density of different µ-concentrator designs was determined with 4-point bending tests
- Thicker glass (400, 500 µm) and thinner CFRP (2 plies) is useful to prevent glass failure
- A thicker honeycomb (20 mm) and a thinner glass (300 µm) help decreasing the mass
- $\succ$  Compromise to be determined: configurations 8 and 11 seem be to the most promising ones
- Prospect: Finite Element Method simulations in progress

#### **References:**

[1] R. W. Francis, C. Sve, and T. S. Wall, "Thermal Cycling Techniques for Solar Panels", Crosslink Fall, Vol. 6, No. 3, 2005 [2] A. Bermudez-Garcia, P. Voarino, O. Raccurt, patent pending, Concentrateur optique à structure alvéolaire, FR2013856, 21/12/2020. [3] ASTM D7250/D7250M standards: Standard Practice for Determining Sandwich Beam Flexural and Shear Stiffness, 2020

#### **Acknowledgments:**

Institut Carnot Energie du Futur



Commissariat à l'énergie atomique et aux énergies alternatives 150 avenue du lac Léman | 73375 Le Bourget-du-Lac www-liten.cea.fr