Conceptual ideas for the ITS-3 mechanics and cooling: ultra-lightweight carbon fiber support structures

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Reported by V.I. Zherebchevsky at ITS3 Upgrade WP5 (Mechanics and Cooling) meeting 14.02.2023

https://indico.cern.ch/event/1253461/

Outline

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Measurements:

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2) **The rigidity measurements of modernized carbon fiber longerons**

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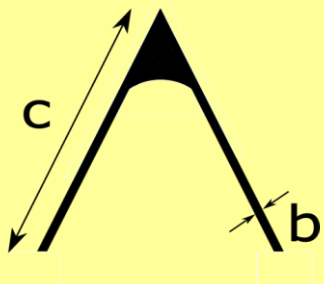
4) **Investigations of carbon fiber cradle and silicon dummy sheet properties**

Summary

Introduction

Motivation

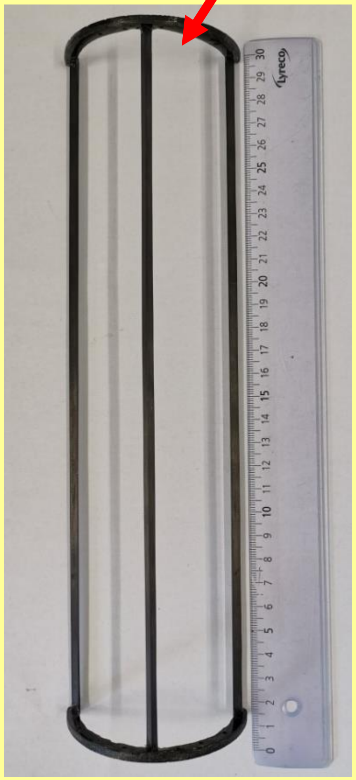
Application of 30 cm length ultra-lightweight (from 0.5 to 2 g) carbon fiber longerons of triangular profile .

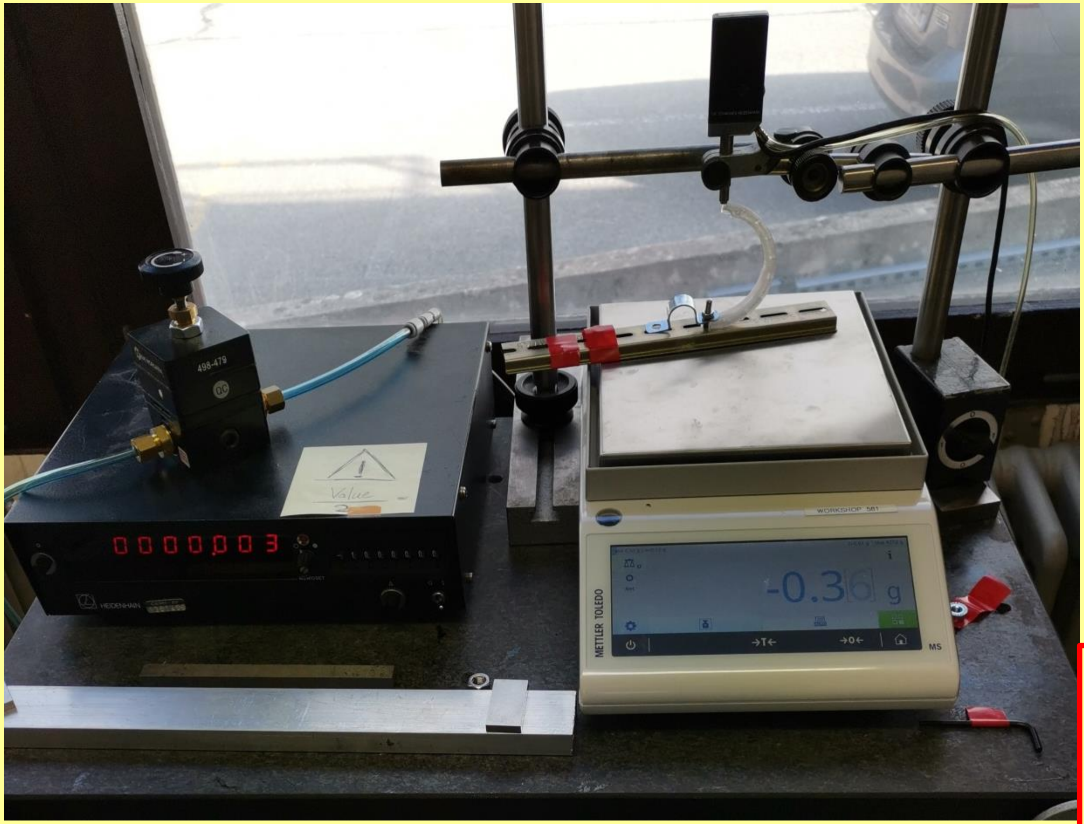


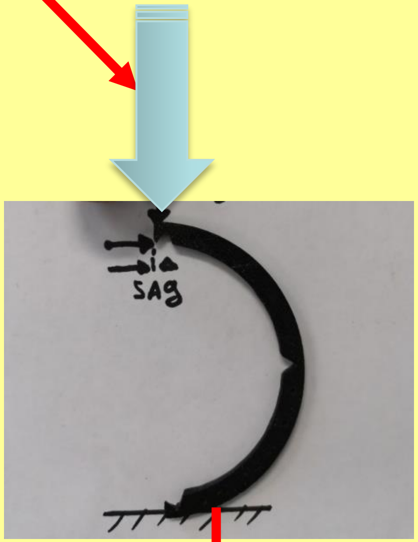
The support structures should guarantee thermomechanical stability for thin bent MAPS sheet. One can construct a system that has high rigidity with minimal material budget.

Rigidity measurements of CF composite samples: semi-rings

The carbon fiber semi-ring is used together with CF longerons to form the sensor support cradle. The load was on top of the sample.







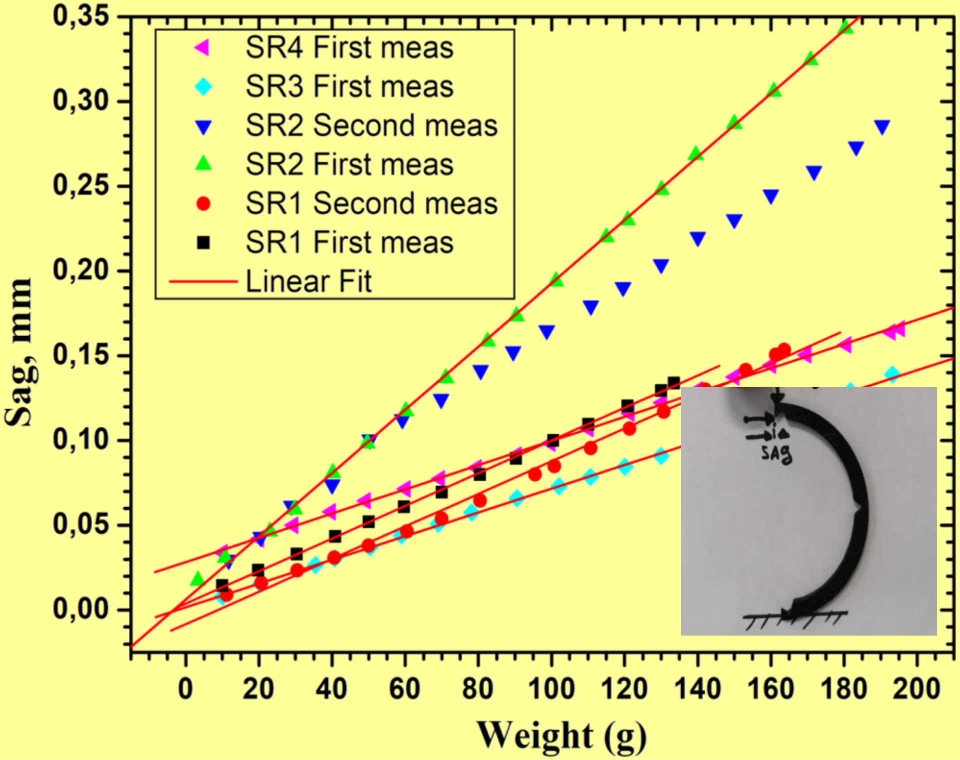
The sagging measurements of carbon fiber semi-ring done at CERN (at Piter's lab.)

The carbon fiber semi-ring was produced from carbon fiber and epoxy resin.

Rigidity measurements of CF composite samples: semi-rings

The sagging measurements under various central loads were peforemd for 4 samples of carbon fiber semi-rings: SR1(1,85 g), SR2 (2.05 g), SR3 (2.24 g) SR4 (2.05 g)

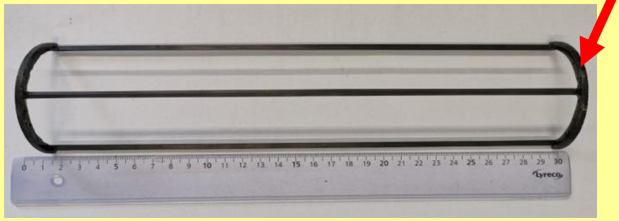
The load was made at the upper point. For additional verification, the samples SR1 and SR2 were investigated twice.



CONCLUSION

- **For all samples, the deformation increases linearly in accordance with the load applied. The smallest sagging under the load of 200 g was obtained for samples SR3 and SR4: at range of 90 to 120 µm.**

As a result, samples of semi-rings SR3 and SR4 were selected for the cradle construction

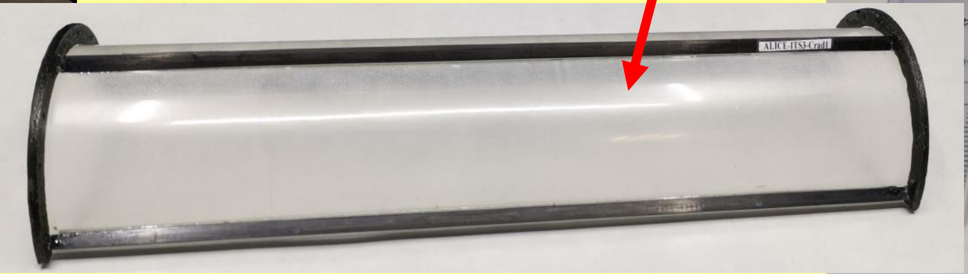


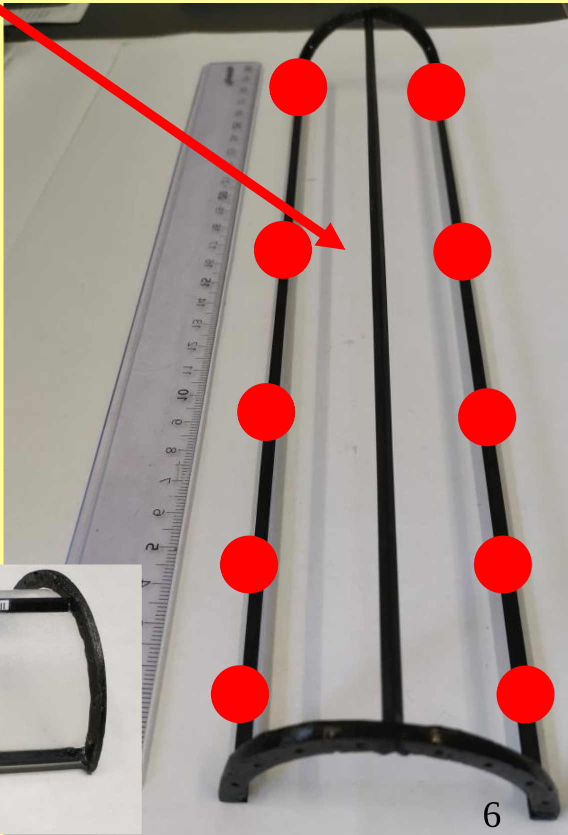
Investigations of the properties of carbon fiber cradle with new extra-thin carbon fiber longerons and aerospace fiberglass as emulator silicon layer.

Tests with new cradle (Cradle was prepared in St.-Petersburg-CERN in September 2022) which contains the extra-thin carbon fiber longerons (made from trusses of the unused ITS-2 OB samples) and carbon fiber semi-rings (see slides 4-5). Cradle was assembled by using especial cylindrical mandrel (from CERN composite lab). The Aerospace Fiberglass plate an emulator of thin curved silicon detector was used.

a) The first set of measurements: to check the geometry by Mitutoyo machine in five pair cradle points: cradle without dummy sheet .

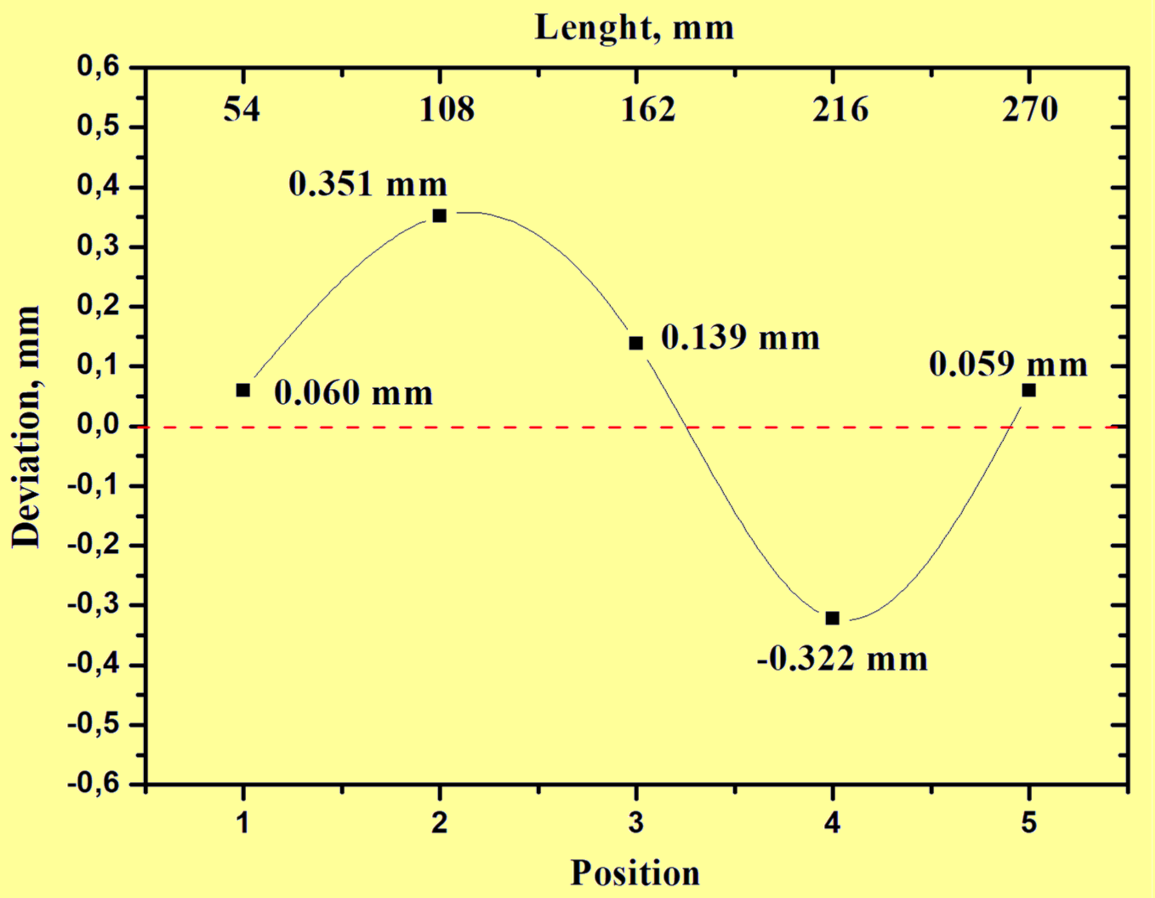
b) The second set of measurements. Coordinate measurements were done by Mitutoyo machine in the same five cradle points - cradle with Aerospace Fiberglass as an emulator of silicon layer





Investigations of the properties of carbon fiber cradle with new extra-thin carbon fiber longerons and aerospace fiberglass as emulator silicon layer.

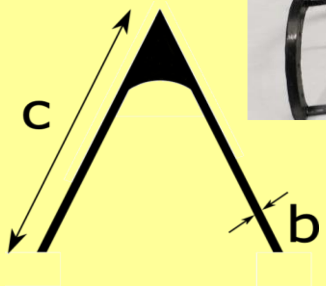
On this picture the mean deviation between initial (without Aerospace Fiberglass) and final (after the Aerospace Fiberglass gluing) stages is plotted.



One can see that after the Aerospace Fiberglass plate gluing the distance between the cradle longerons has changed: it is increased by 60 um in the region of the end of the cradle (i.e. near semi-rings). Maximal deviation was about 351 um in the region of the cradle centre.

The rigidity measurements of new extra-thin carbon fiber longerons.

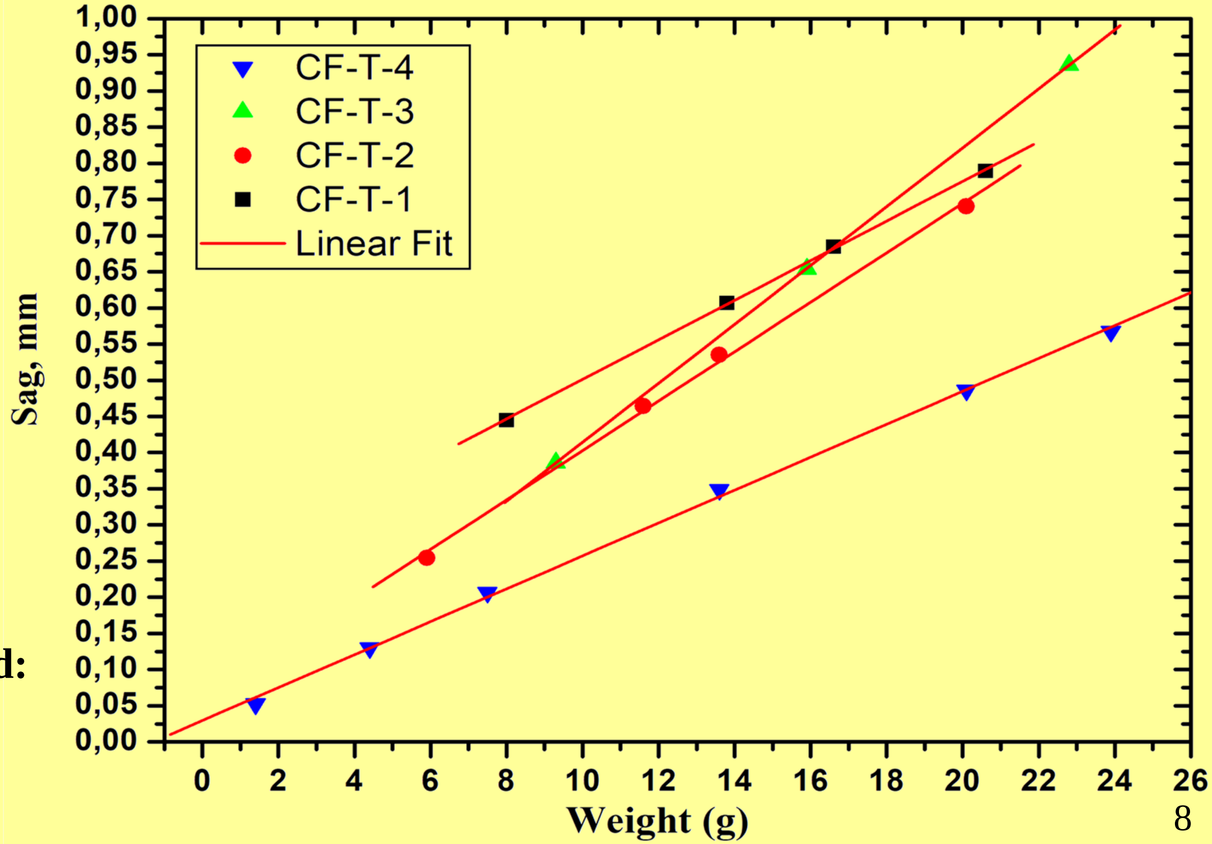
The sagging characteristics of new thin carbon fiber longerons (produced at SPbSU, see the characteristics in the table) have been investigated. The CF material: russian



The measurement scheme was the same as previous one.

The sagging measurements for 4 samples of thin carbonlongerons: CF-T-1, CF-T-2, CF-T-3, CF-T-4

Description of new longerons	Values
Length, mm	288±2
Width (c), mm	2,85±0,20
Thickness (b), mm	0,40±0,05
Weight, g	0,49±0,03
Production	SPbSU

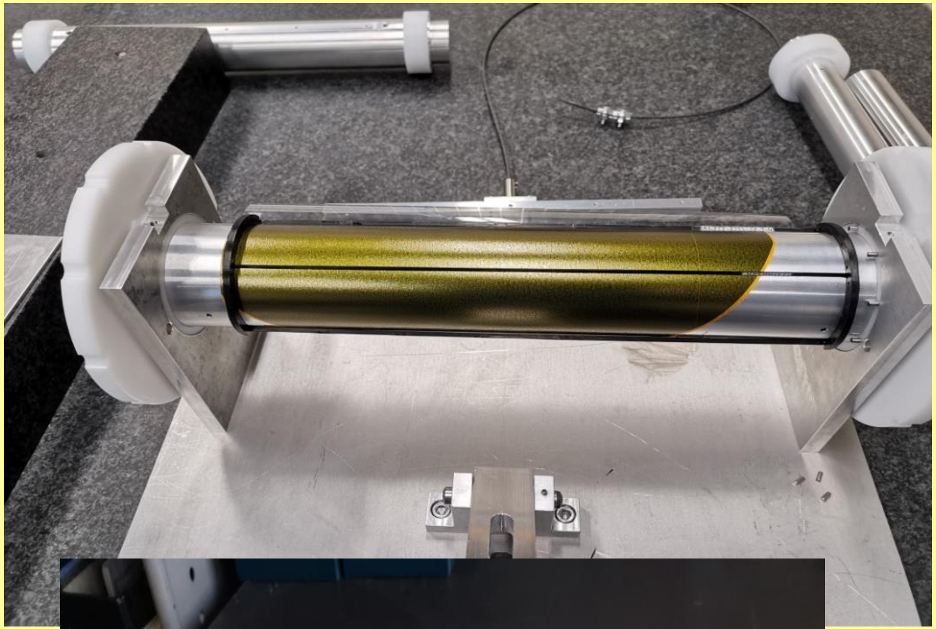


CONCLUSION

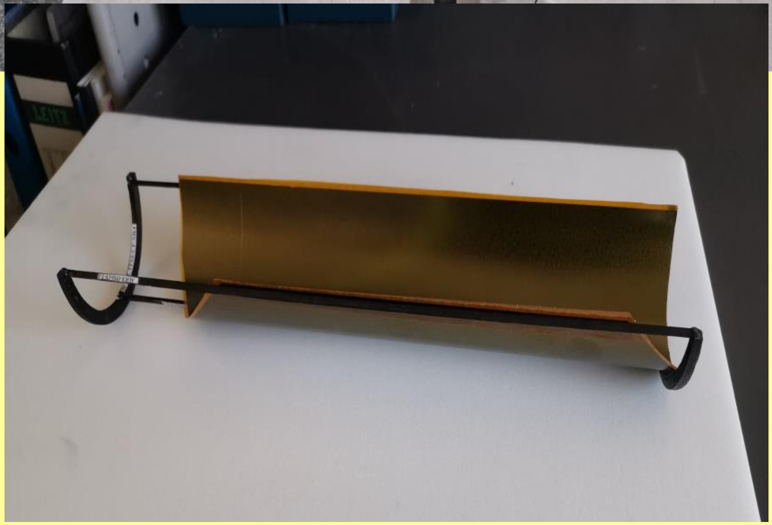
For all samples, the deformation increases linearly. However, these samples has big sagging at small load: the smallest sagging at a load of 24 g was 567 µm and the biggest sagging was 935 µm

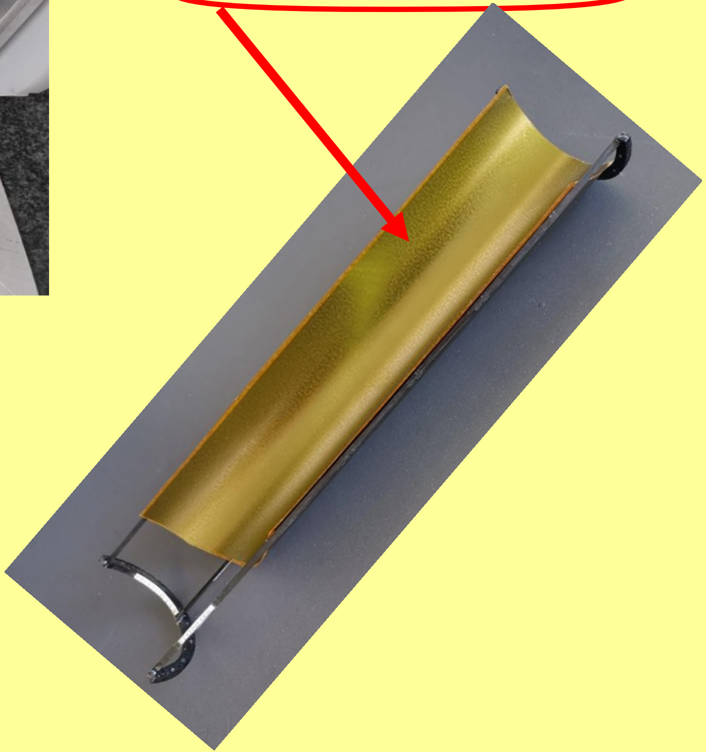
Investigations of the properties of carbon fiber cradle with Si dummy sheet

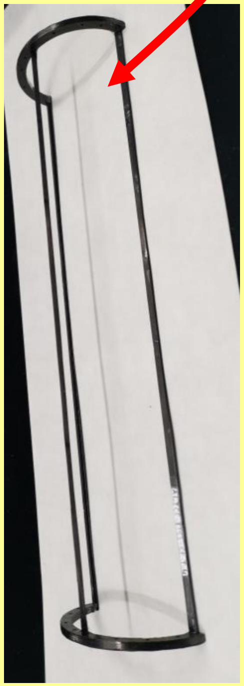
Tests with new cradle which contains very thin carbon fiber longerons have been done. Cradle was assembled by using especial cylindrical mandrel (from Piter's lab). The Si dummy sheet as an emulator of thin curved Si detector was used. This Si dummy, in a kapton shell, was bended by especial mandrel at Piter's Lab at CERN and then glued inside the cradle.



Again two sets of the measurements by using Mitutoyo machine without silicon dummy sheet and after the Si dummy sheet gluing were carried out.

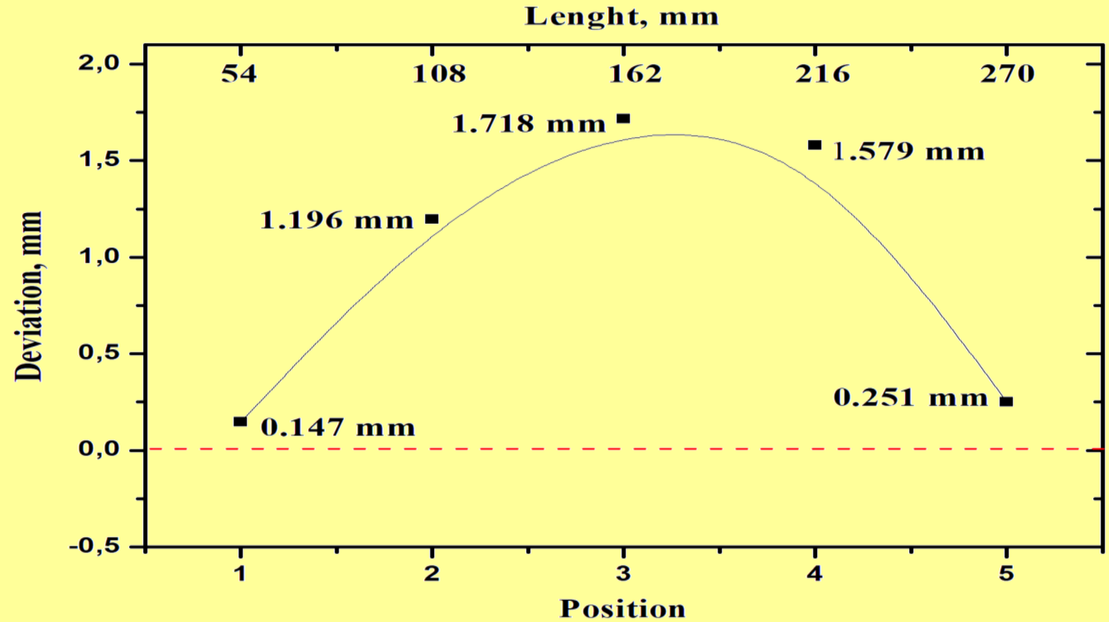






Investigations of the properties of carbon fiber cradle with extra-thin longerons and Si dummy sheet glued inside

The deviation in geometry between initial (without Si dummy) and final (with the Si dummy inside the cradle) is shown in the figure below. After gluing of the Si dummy with kapton shell inside the cradle, the distance between the cradle longerons was increased to 150 -250 um in the regions close to the cradle support semi-rings). The maximum in this spread was observed of about 1718 um (in the region close to the cradle center).



- **Conclusion №1 with extra-thin longerons: one can need more thick longerons and semi-rings in case of the given radius (30mm) of bent Si-sensor.**
- **Conclusion №2 with extra-thin longerons: they could be considered useful for applications with bent thin Si –sensors at large radii (or with flat thin sensors in future)**

Summary

1. The CF composite technology for production of low-mass longerons and carbon fiber supporting semi-rings was developed and tested.
2. The carbon fiber semi-rings with CF low-mass longerons could be used to form a cradle to support thin large area Si-sensors.
3. The low mass CF composite cradle has sufficient rigidity and thermo-mechanical stability to house thin large area Si detector sheets. Rigidity could be improved further by using the longerons produced with higher modulus carbon fibers.

Next Plans of studies at SPbSU:

2. Further investigations of the mechanical properties of new low-mass carbon fiber structures produced using the available carbon fibers and resin.

2. Thermo-mechanical measurements for Si sheets glued to carbon fiber composite longerons .

Back-up

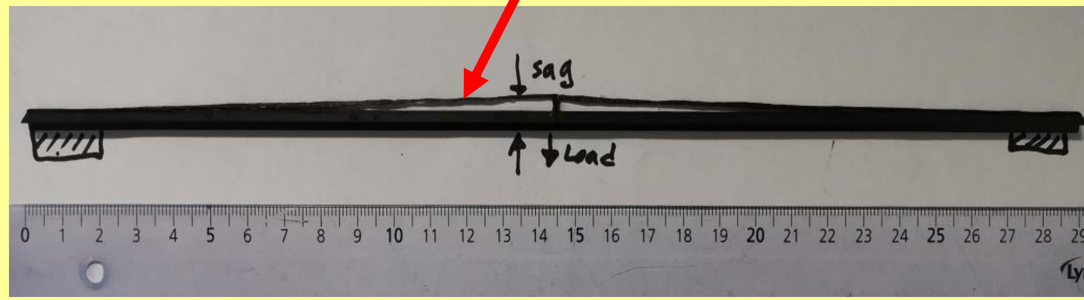
Rigidity measurements of CF composite samples: modernised longerons

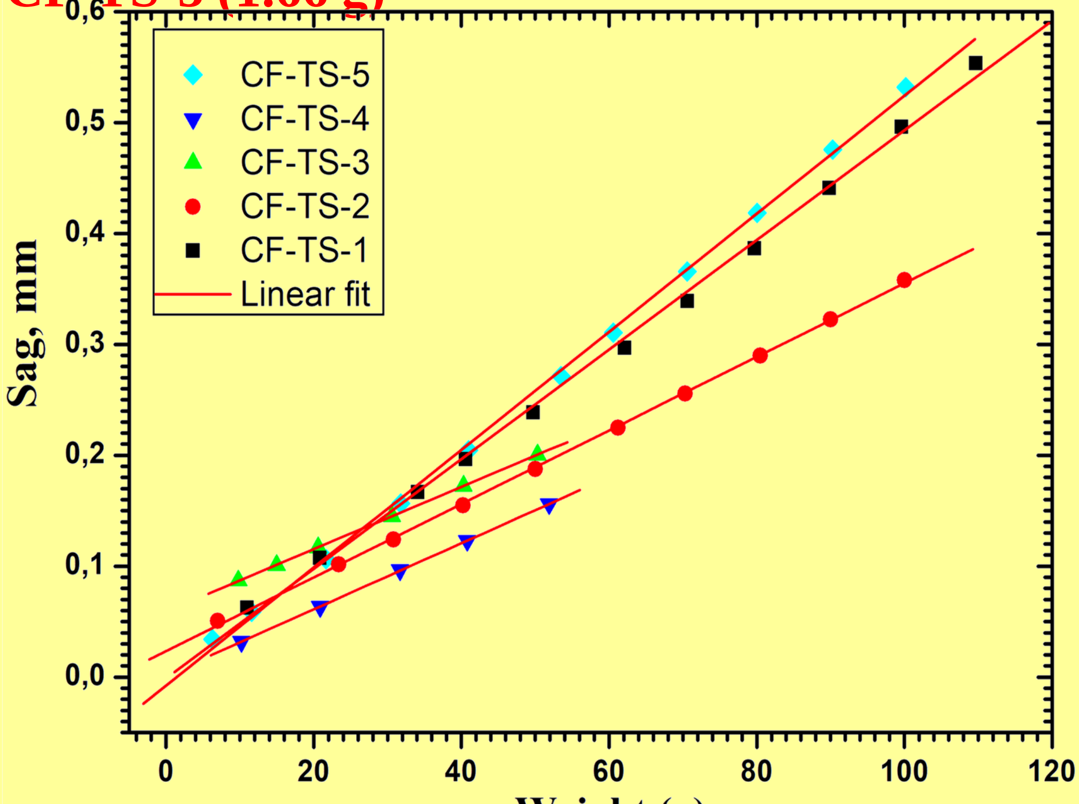
The sagging characteristics of the ultra-lightweight carbon longerons (from ITS-2 OB stave) reinforced by carbon fibers on top have been investigated.

The measurement scheme was the same as previous one.

The sagging measurements for 5 samples of carbon modernised longerons:

CF-TS-1 (1.70 g), CF-TS-2 (2.10 g), CF-TS-3 (2.0 g), CF-TS-4 (2.0 g), CF-TS-5 (1.66 g)





CONCLUSION

For all samples, the deformation increases linearly in accordance with the load applied to them. The smallest sagging at a load of 100 g was obtained for sample CF-TS-2: at 358 µm.
The biggest sagging at a load of 100 g was obtained for sample CF-TS-1: at 532 µm.