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Advanced technologies of radiation transparent support structures for novel thin silicon detectors.

V. Misheneva, V. Zherebchevsky, D. Nesterov, S. Igolkin, T. Lazareva, N. Maltcev, N. Prokofiev, A. Rakhmatullina, G. Feofilov.

Introduction

In the giving report we present results of mechanical issues of several configurations of extremley lightweight carbon fiber structures for support of the large area (up to 280x94mm^2), ultrathin(~20 um), bent silicon sensors proposed for the innermost layers of the new vertex detector.

The current baseline for ALICE ITS3 – a next generation vertex detector based on bent, wafer-scale CMOS sensors is developed by ALICE (see Fig. 1, JPS Conf.Proc. 34 (2021) 010011). Here, 3 layers of bent silicon sensors, with carbon foam spacers, are glued inside the outer support shell. We propose a different approach to meet a challenge of design a self-support module of large area bent thin silicon sensor. Extremely low-weight rigid carbon fiber (CF) bars with high thermo and mechanical stability are used. Results of deformation measurements under the load are presented below as a first estimate of feasibility study.

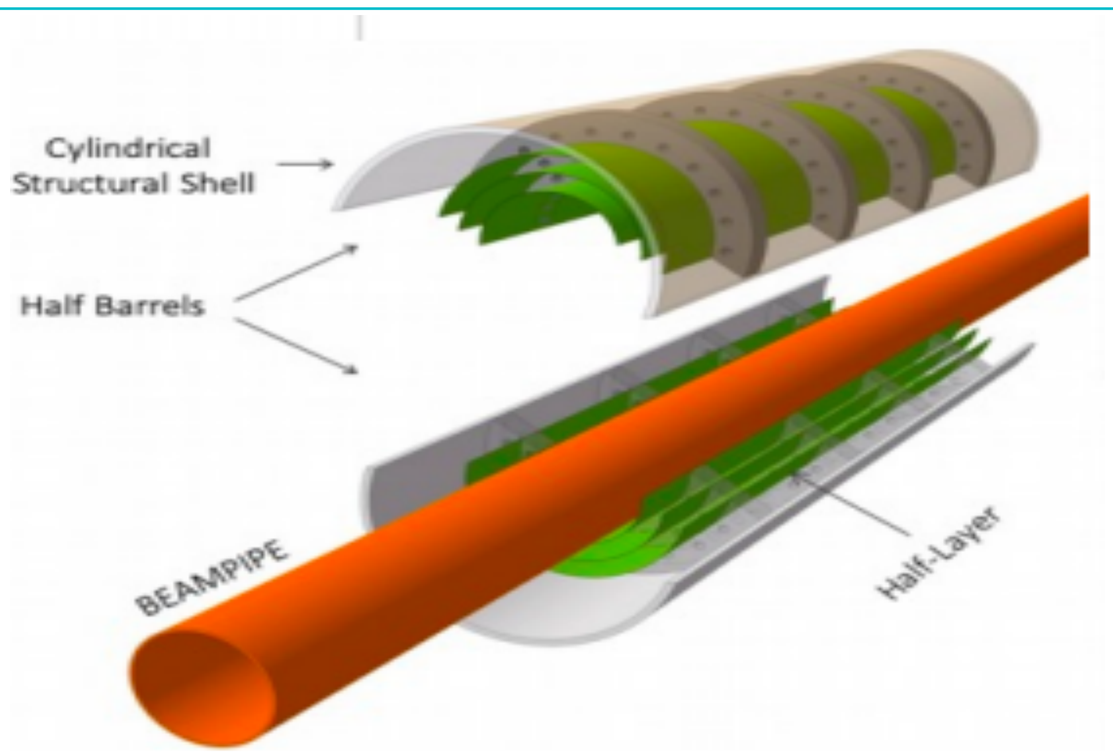

Figure 1. ALICE Collab., JPS Conf.Proc. 34 (2021) 010011

Methods and schemes

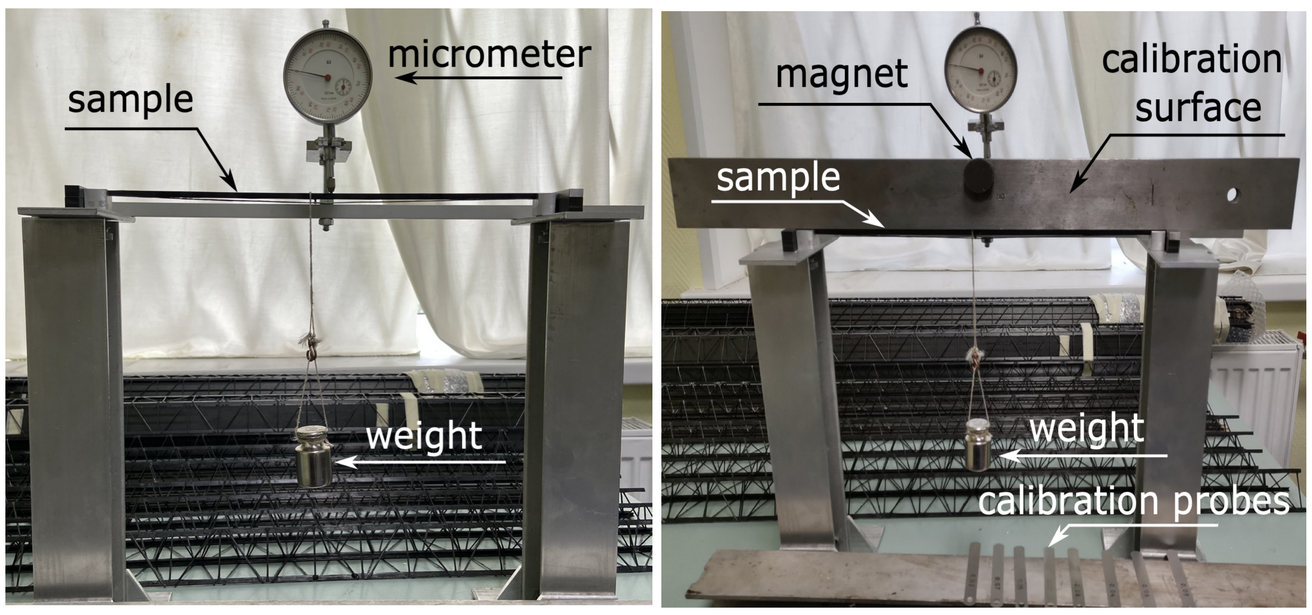

Figure 2.illustrations for methods, left - for experiment-1, right - for experiment-2.

An experiment-1 to measure the deformation value of carbon fiber edges under the influence of different weights(in the range from 100g to 400g) was carried out by micrometer. The samples were two edges with additional elements for increasing the stiffness and two simple edges. It was noticed that the micrometer shows a value of 0.06 mm instead 0 after removing any weight. We consider this value(0.06mm) as an error of this method. It was decided to repeat the experiment using another method due to the occurrence of this error.

In the experiment-2 the special surface was used as a zero deformation mark. A gap between surface and the CF sample edge was formed after weights were suspended on the sample. The value of this gap was measured by special probes of fixed certifed thickness. We use a magnet on the calibration surface to avoid an influence of probes' weight. The error of this method is the minimum value of probes' thickness(0.03mm).

Results and discussion

Method	by micrometer, mm			
Type of edge	simple edge		edge with additional elements	
Number of sample Weight	1	2	3	4
100g	0,35	0,37	0,20	0,20
200g	0,65	0,70	0,50	0,50
300g	1	1,05	0,75	0,70
400g	1,35	1,40	0,97	0,95
Method	by calibration probes, mm			
Type of edge	simple edge		edge with additional elements	
Number of sample Weight	1	2	3	4
100g	0,40	0,37	0,22	0,22
200g	0,70	0,72	0,50	0,50
300g	1,03	1,17	0,75	0,72
400g	1,38	1,27	1	1

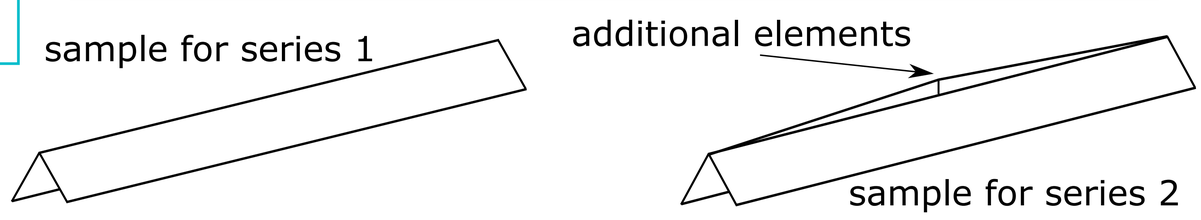

Figure 3. Two types of extremely low-weight rigid carbon fiber 30 cm length bars of : A- corner type cross-section; B-the same as A but with the additional strengthening CF element.

The results of our experiments are shown at the table above and in the Fig.4 below. A significant gain in the stiffness of CF samples type B is achieved by introducing very little amount of extra CF matter (CF thread). CF samples A and B are both radiation transparent: X/Xo ~ 0,37%. Thus, with ultrathin(~20 um), bent silicon sensors one can expect the following azimutal distribution of X/Xo that is shown in the Fig.5 below.

<u>Summary</u>

1. The first estimates of deformation under the different load were performed for extremely low-weight rigid carbon fiber (CF) 30 cm bars
2. Studies of the acceptable limits of deformation will be continued using other low-weight CF structures of B-type

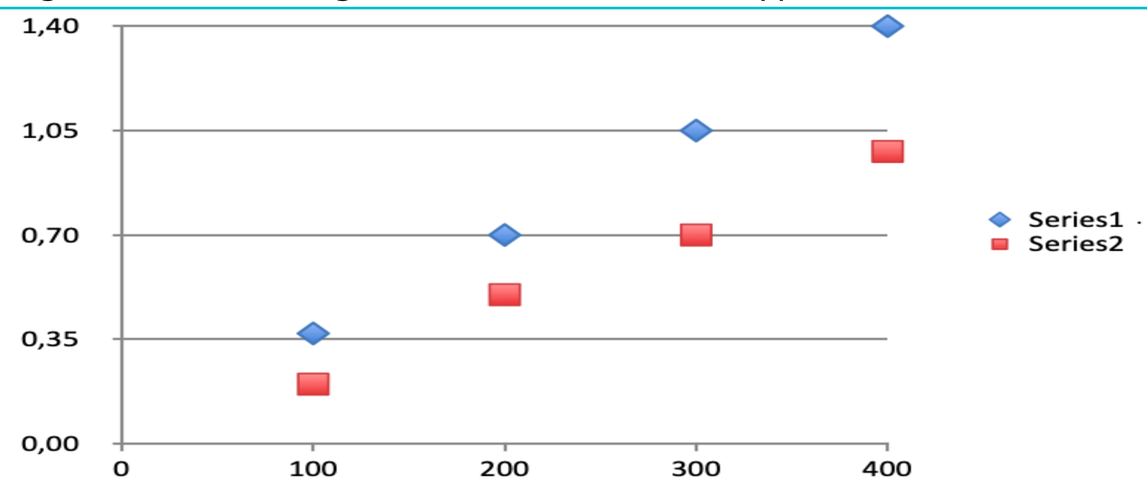

Figure 4.deformation value of CF edges, blue - type A, red - type B

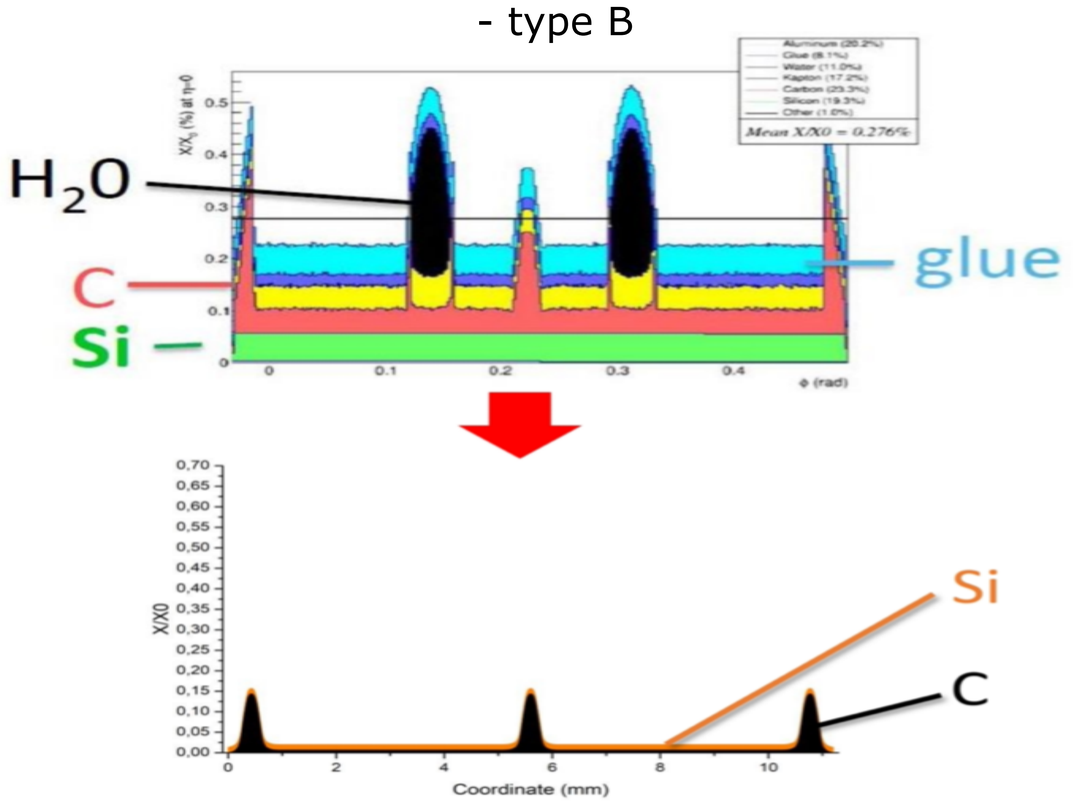

Figure 5. Comparison of radiation transparent for ITS-2(top) and our model for ITS-3(bottom)