CGEM-IRC MEETING INTRODUCTION AND MECHANICS

G. Cibinetto on behalf of the CGEM group

LAST TIME WE MET (DEC. 2018)

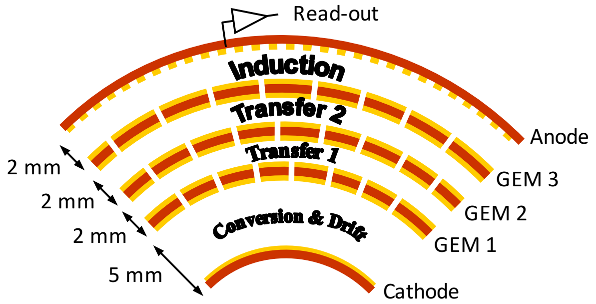
Lots of excitement for the arrival of the detector at IHEP…

Then we discovered that we couldn’t completely power on Layer 1 and Layer 3.

A different 2019 began. Manpower and activities have been heavily reorganized.

But let’s do a step backward.

LAYER 1



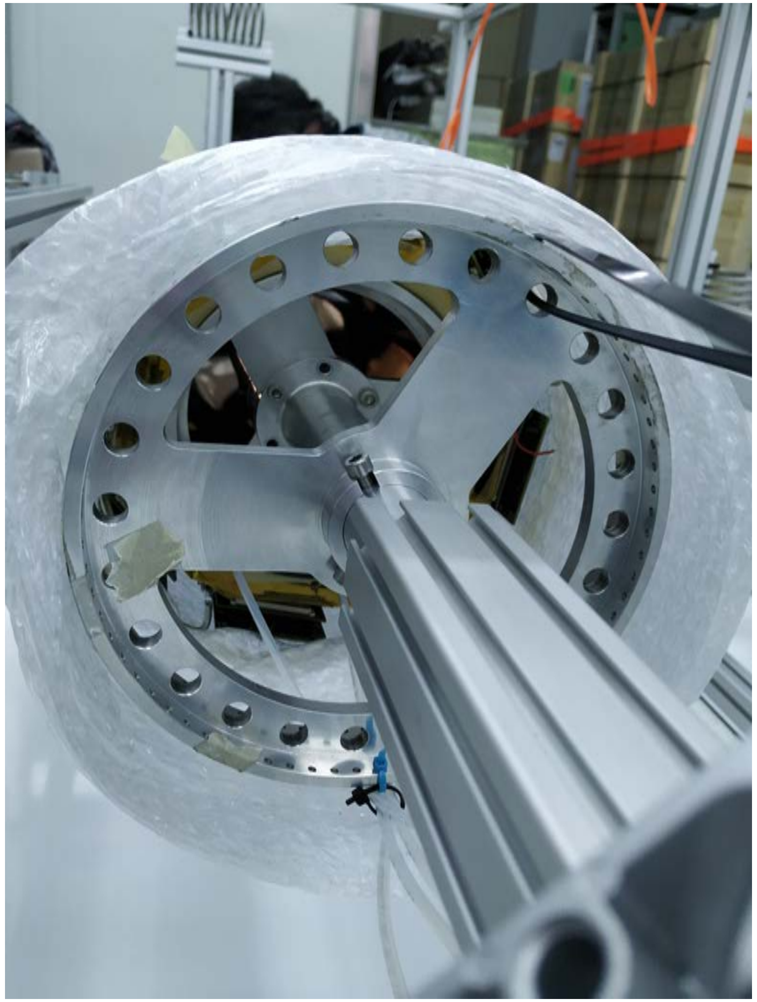
- Jun 2017 - Nov 2018
  Layer 1 (L1) working well in Italy for cosmics and at CERN for beam test.
- Early Nov 2018
  mechanical test of the assembly of L1 + L2 + L3. operation smooth with no problem.
- Nov. 2018
  L1 has been shipped to IHEP with the other layers.
- mid Nov 2018 - mid Dec 2018
  L1 on at nominal values, after few days from the arrival, for three weeks: no HV issues.
- mid Dec
  mechanical assembly L1 + L2: operation was performed smoothly by people who did it before in Italy.
- Dec 18-25
  HV issue turning on L1 after the assembly with Layer 2

INVESTIGATION ON LAYER 1

- cross checked and tested the procedure and the tooling for assembling L1 and L2 --> no anomalies found
- repeated the assembly operation --> smooth and no electrical issues
- tried to operate the detector while pulling the edges to remove the contact --> the HV stability slightly improved
- measure the detector shape with a laser arm --> ok
- perform a CT scan to see the interior of the detector → see next slide

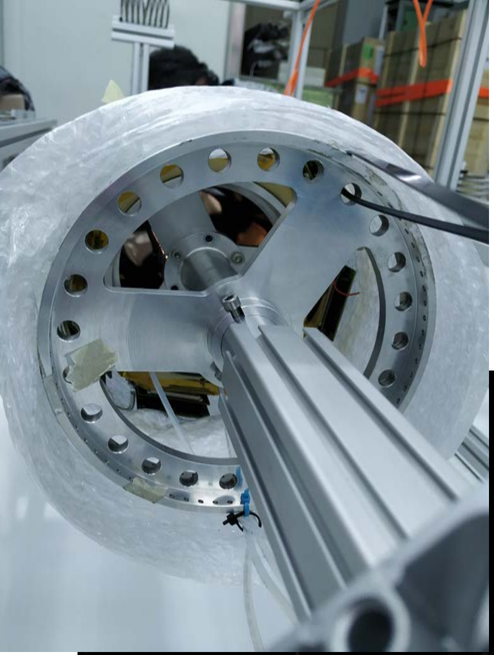
AFTER SHIPPING

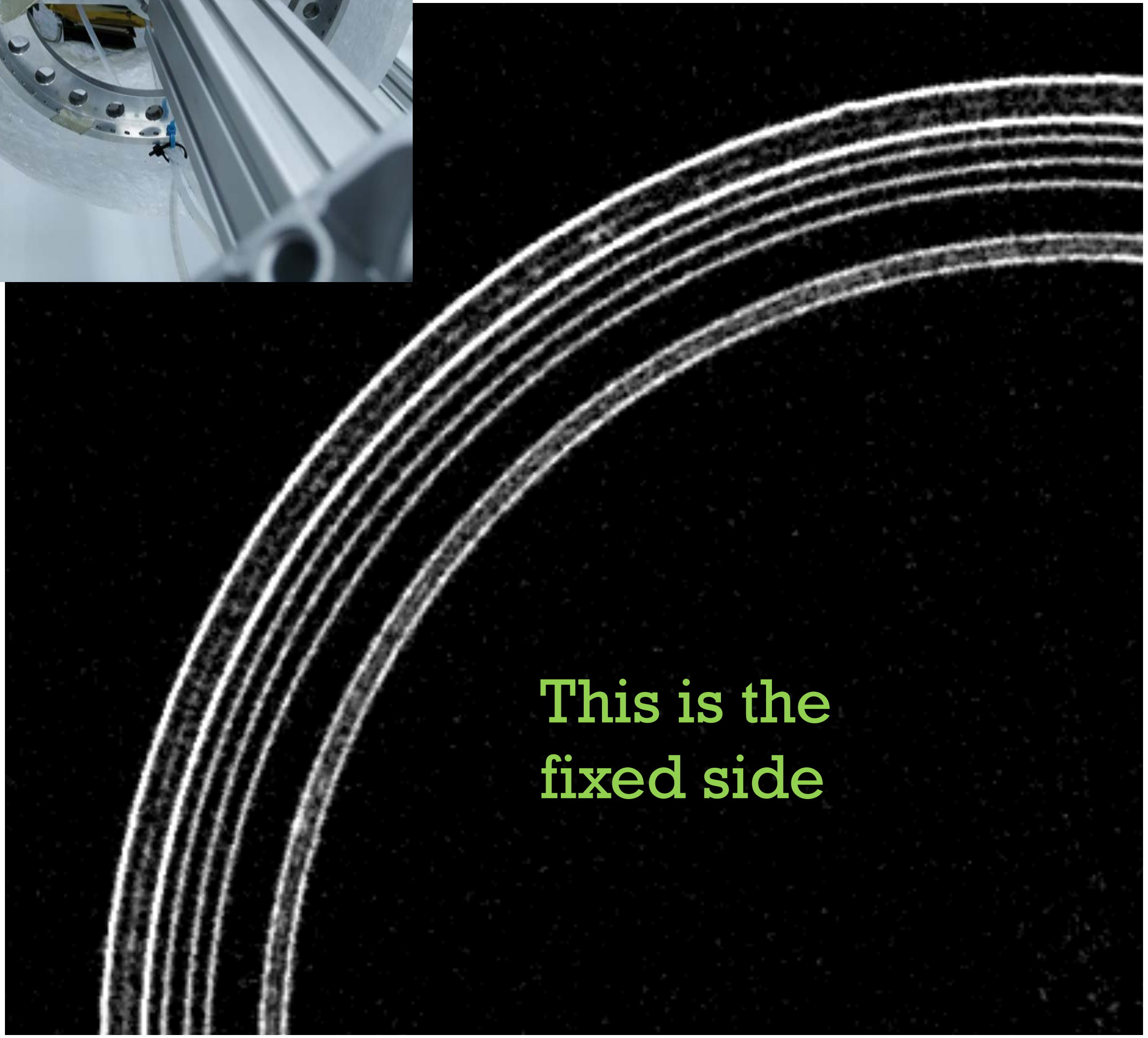
This remained fixed to the shipping structure

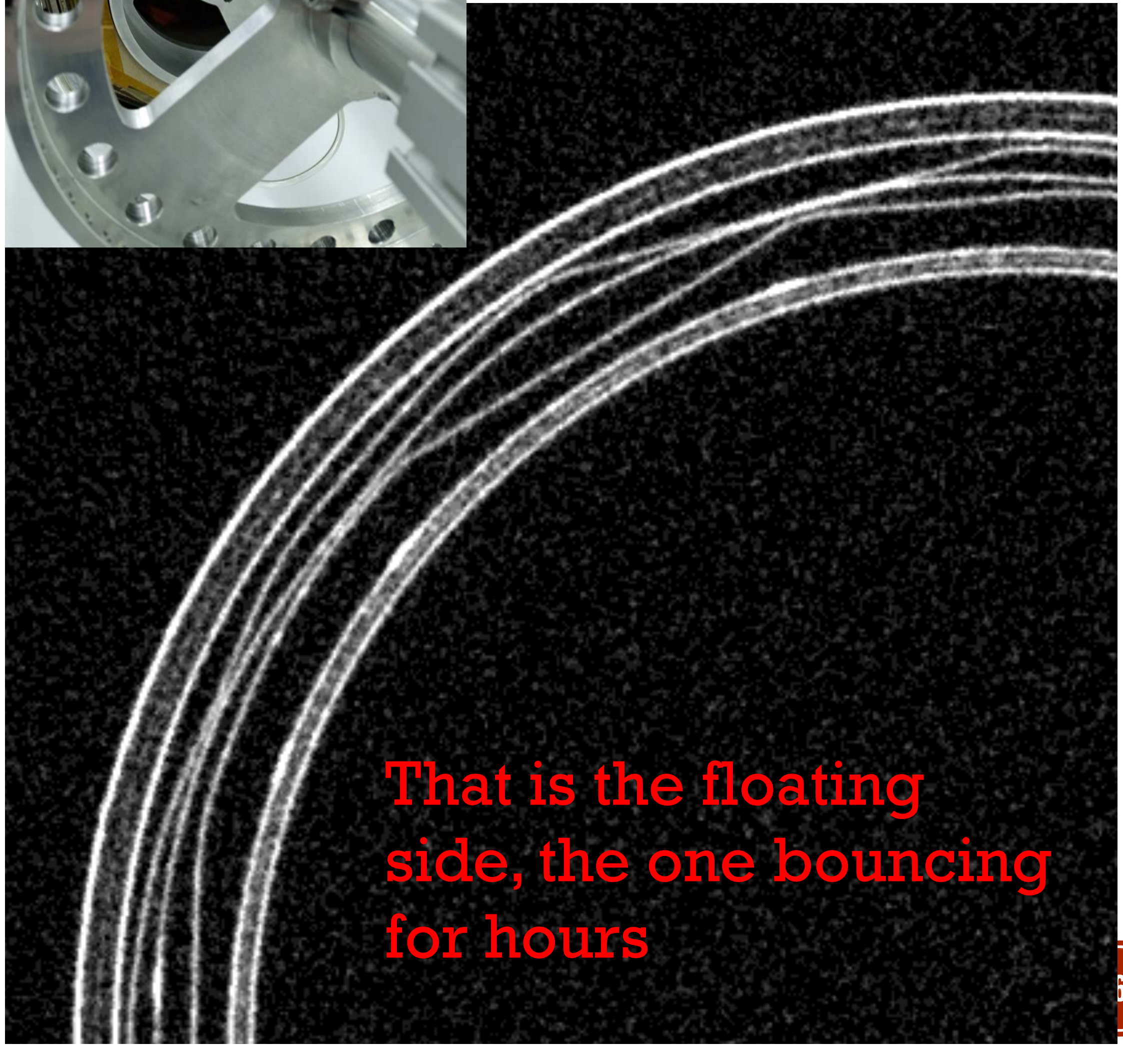


This side collapsed → vibrations removed the fixing screws

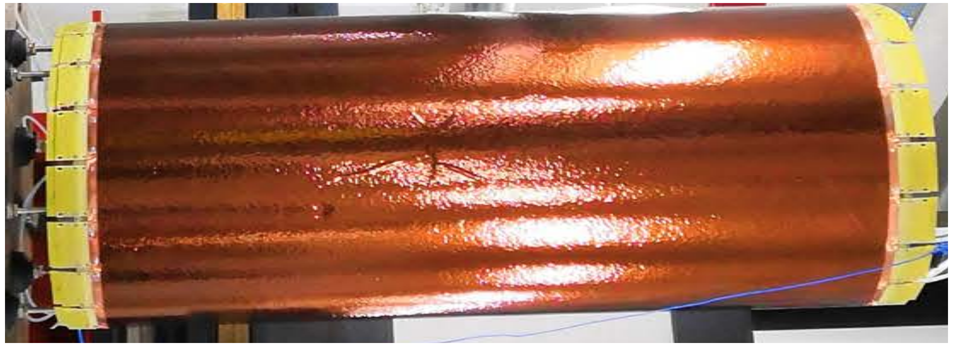
CT SCAN ON LAYER 1







LAYER 3

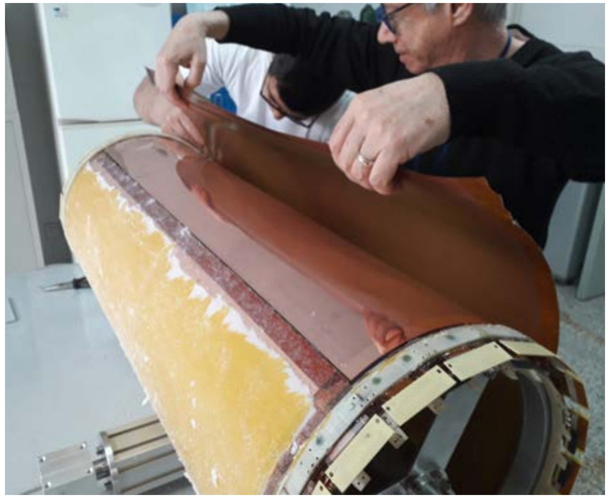


- damage to the external structure happened just after the construction
- big gas leak found and fixed after shipping
- spotted some defects to the inner face not present before shipping
- laser arm measurement → external shape not changed → but not enough resolution
- measured electrical contacts between different GEM foils
- CT scan to confirmed the contacts between GEMs. → see next slides

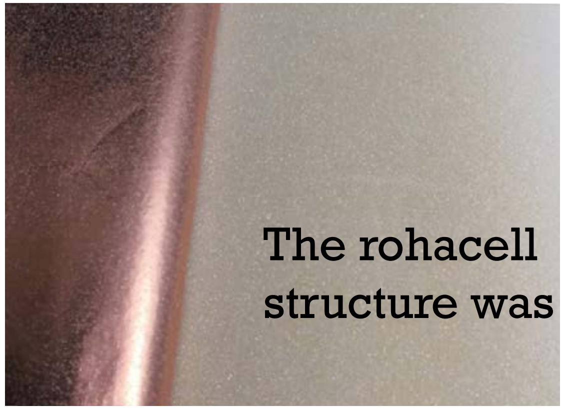
CT SCAN ON L3

PHYSICAL INSPECTION OF L3

opening the CGEM

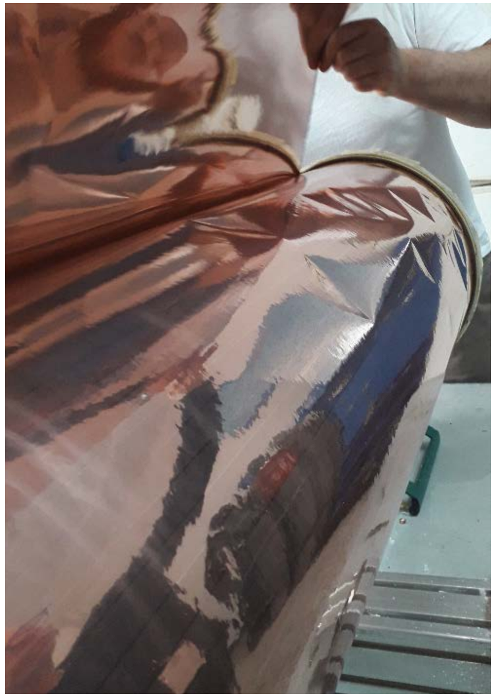


The external hit on the anode



The rohacell structure was fine

additional damages not related to the hit



The hit reached the GEM foil underneath the rohacell

INVESTIGATION ABOUT L3

- L3 internal structure was seriously compromised

- The initial damage was more serious than expected
- The initial not-perfect situation of L3 got worst after the shipping
  - → big gas leakage
- L3, due to its larger radius, is more sensitive to vibrations.

INTERNAL REVIEW OF THE ISSUES

- L1 → damaged by the shipping
- L3 → damaged by initial hit + shipping
- Mechanics for connecting the three layers → **OK**
  - details in the backup slides
- Tooling and procedure for assembly the three layers → **OK**
  - details in the backup slides
- Single layer design
  - the Rohacell structure is designed to keep the spacing within the external rings and for that purpose it works ok → L2 prototype works since 2015.
  - But during handling and shipping can transmit vibrations and mechanical stress to the electrodes inside which are less elastic. → highly recommended to improve the rigidity

MECHANICAL STRENGTHENING OF THE DETECTOR

The main issue is being able to design a long lasting CGEM and take it safely to IHEP.

Mechanical robustness < > **Material budget**

- Upgrade the design and the shipping box

>

Ideas:

- ~~add a grid to help the gap spacing~~
- add fiberglass layer to strengthen and protect the structure
- use honeycomb instead of Rohacell

- The total material budget must stay within 1.5% of a X0.
- Each of the modification suggested has some impact on the material budget.

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Time

- Make modification is time consuming.
- Possible alternative: move the production at IHEP → more time consuming.

MECHANICAL STRENGTHENING OF THE DETECTOR

The main issue is being able to design a long lasting CGEM and take it safely to IHEP.

What

Mechanical robustness

< >

Material budget

How much

- Upgrade the design and the shipping box

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Time

When

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PROCEDURE

How

Simulation on planar samples

Cylindrical simulation

Tune simulation with test results

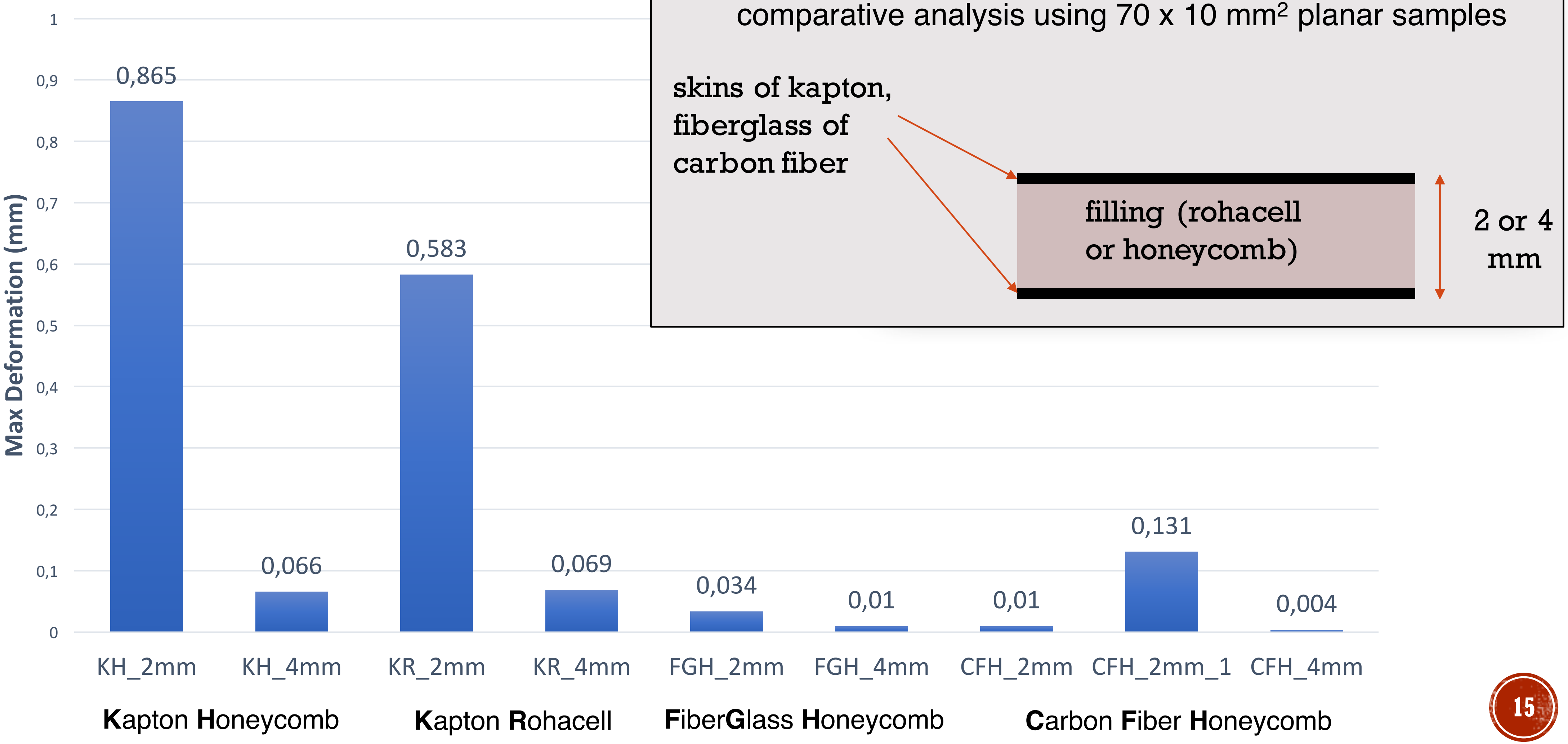
Test on planar samples

Design

comparative analysis using 70 x 10 mm² planar samples (cylindrical shape is supposed to be more robust)

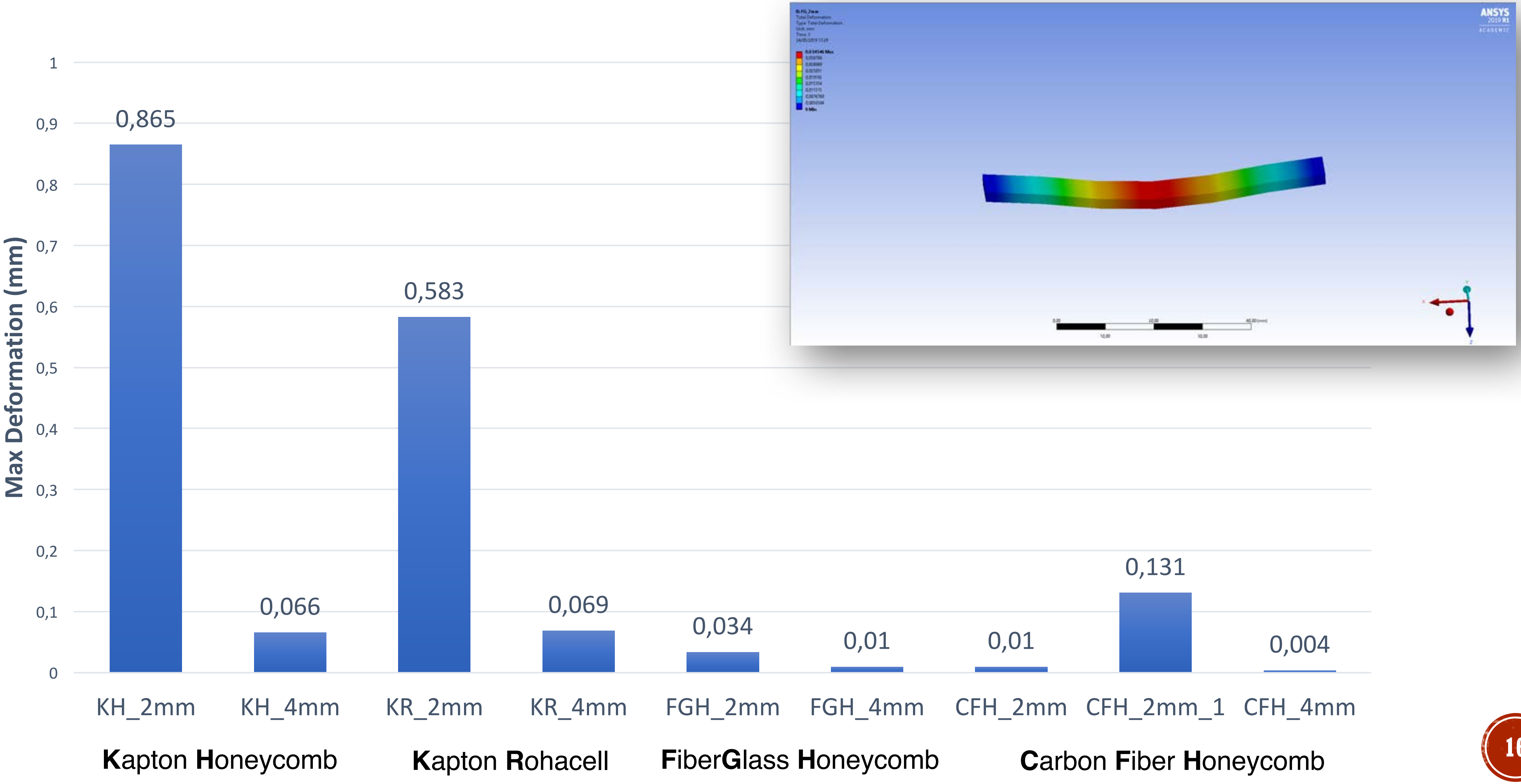
ALL SIMULATED CONFIGURATIONS

comparative analysis using 70 x 10 mm² planar samples

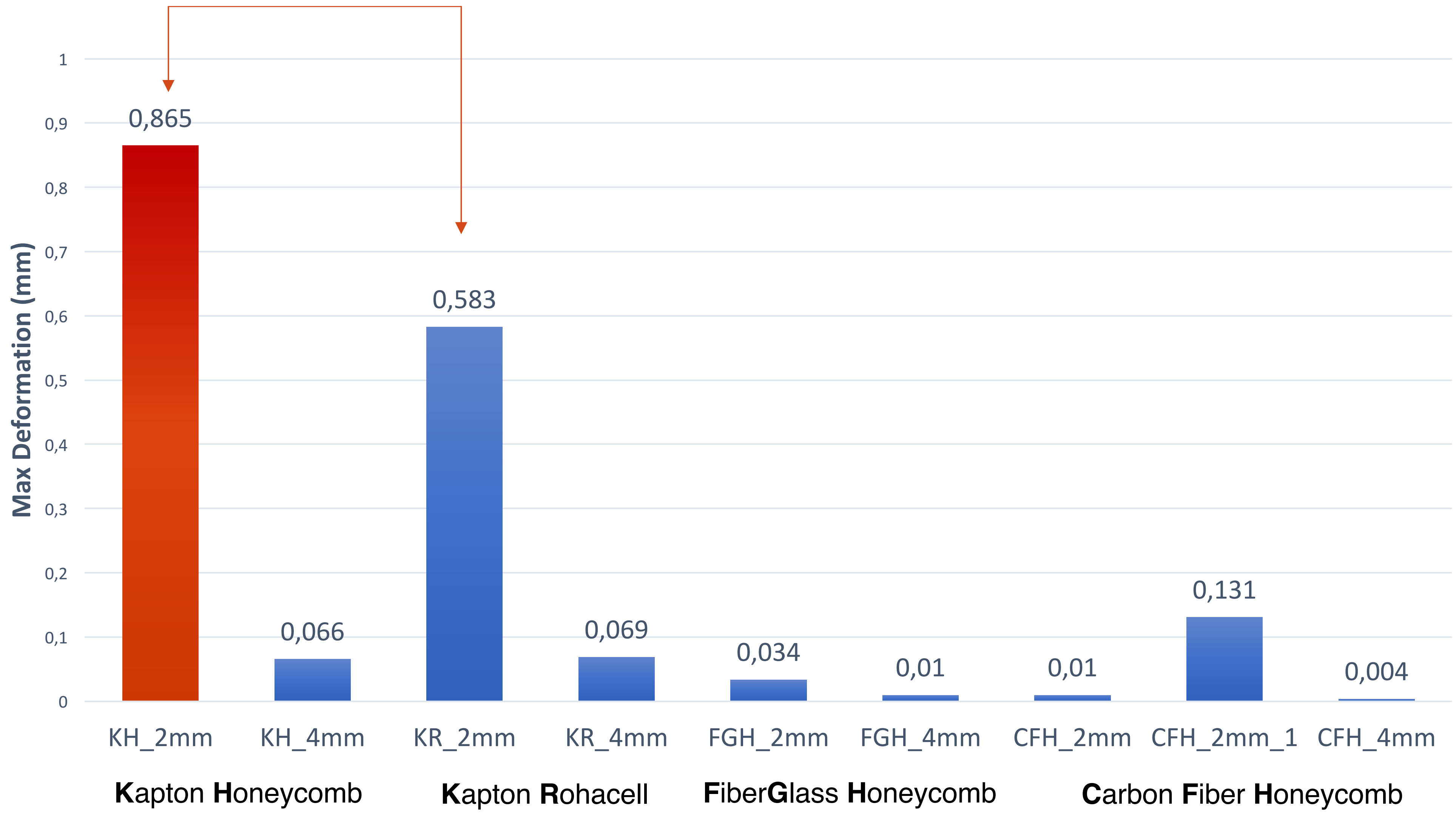


comparative analysis using 70 x 10 mm^2 planar samples (cylindrical shape is supposed to be more robust)

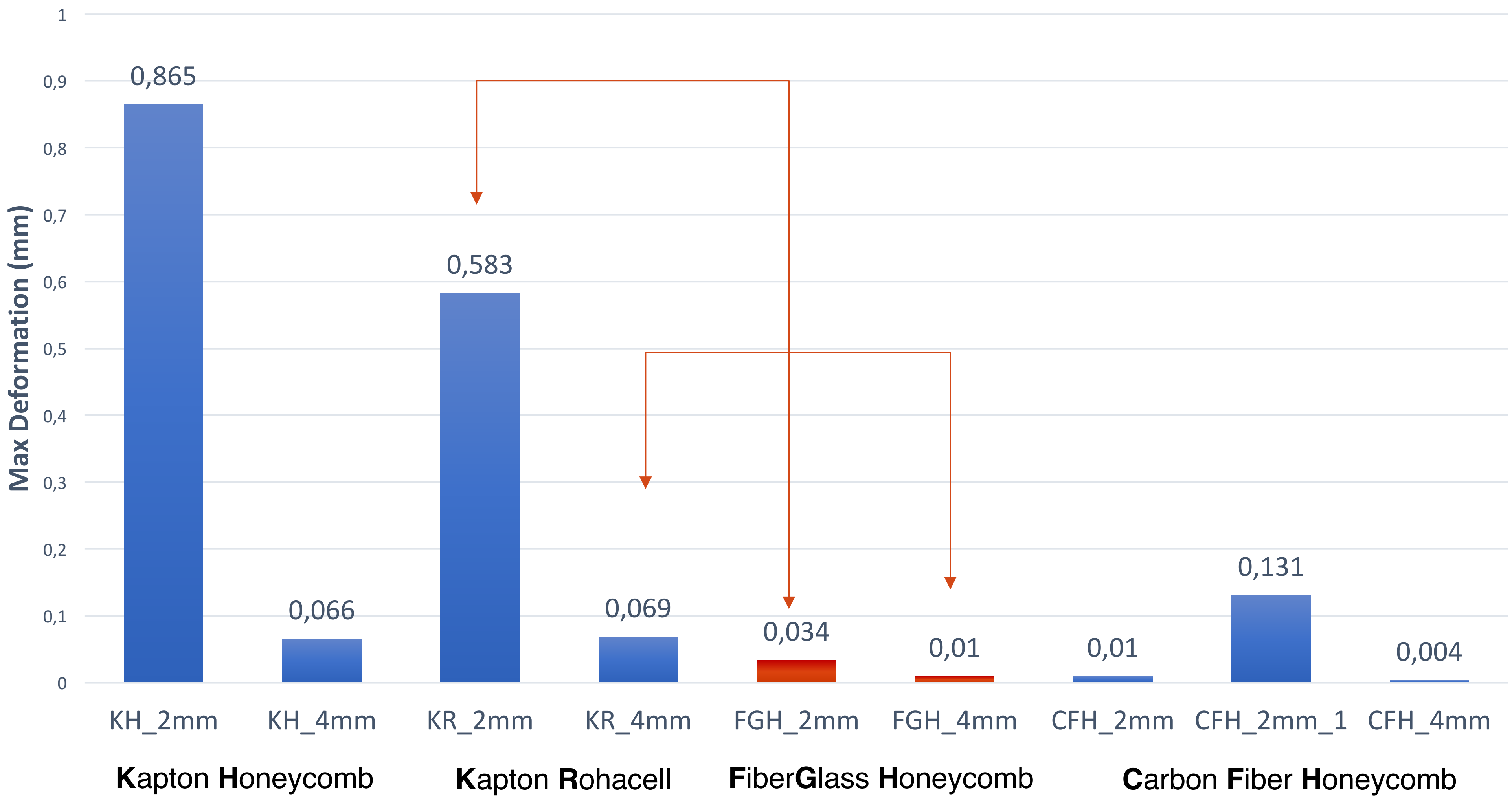
ALL SIMULATED CONFIGURATIONS



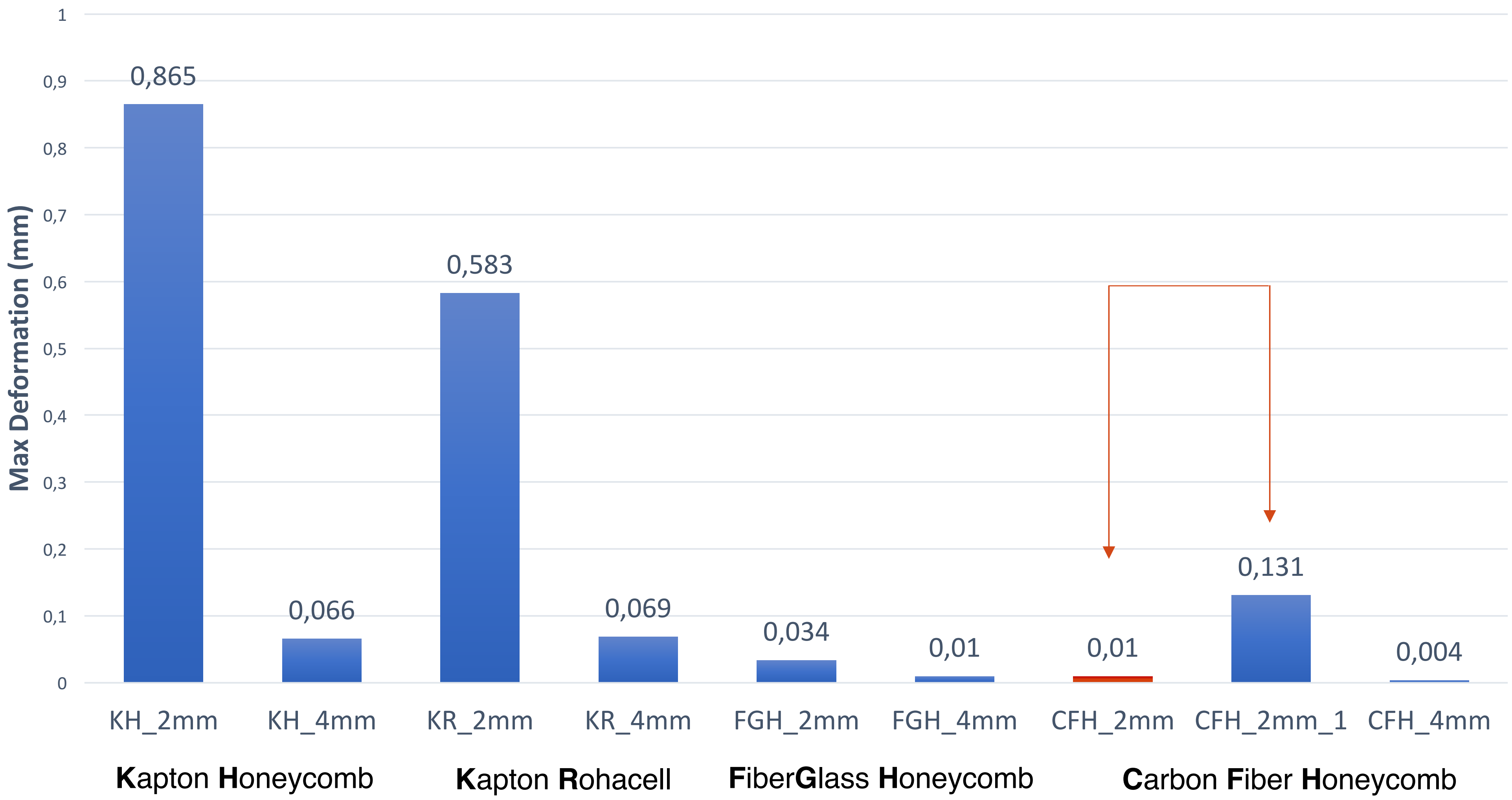
PLAIN HONEYCOMB VS ROHACELL



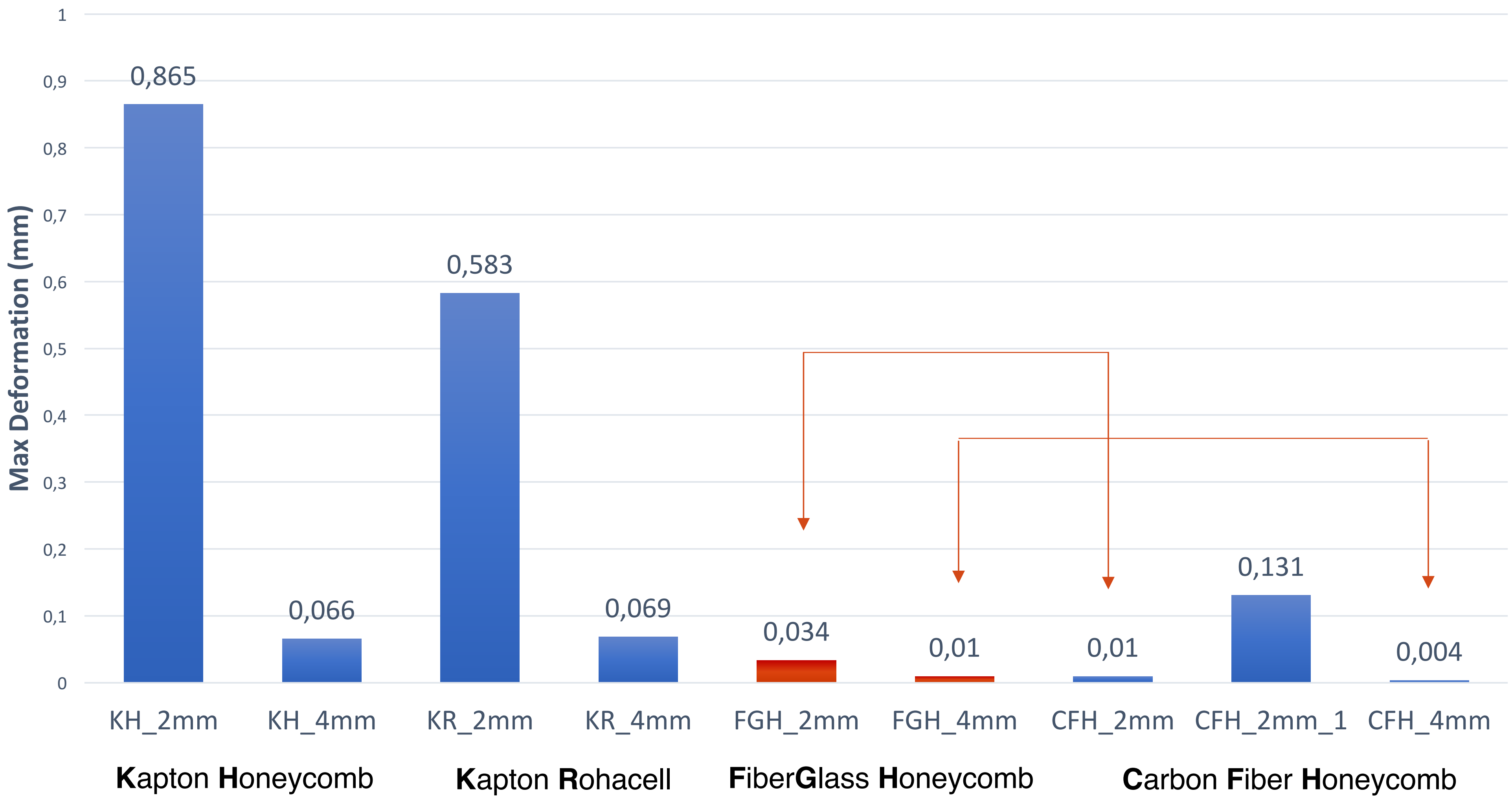
FIBER IMPROVEMENT EVIDENT



TWO SKINS X10 BETTER THAN ONE

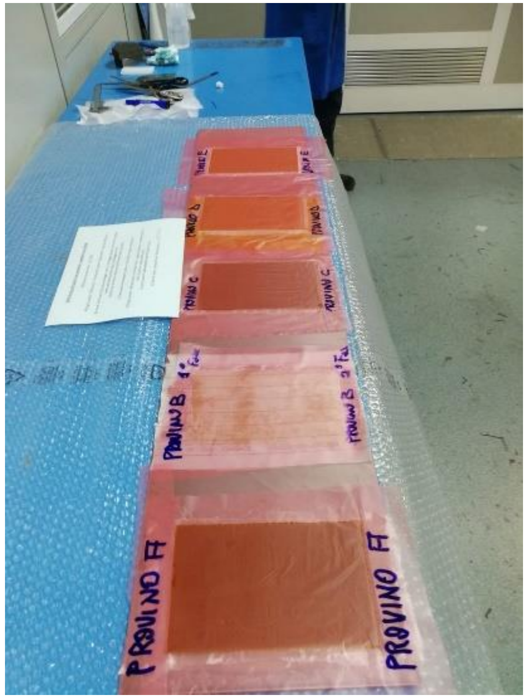


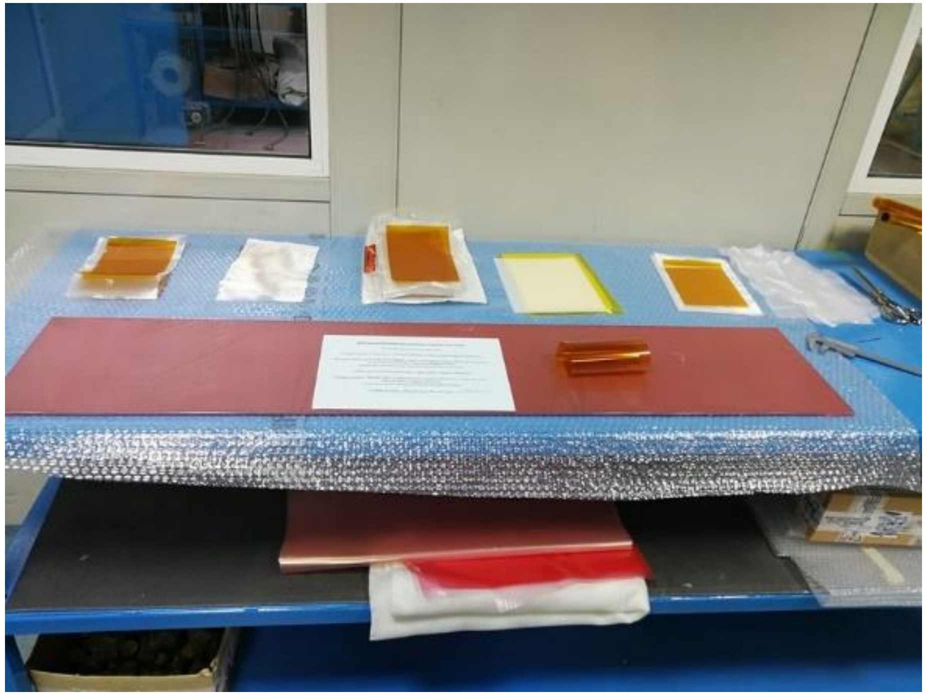
CARBON BETTER THAN GLASS



LOAD TEST ON SAMPLES (ASTM C393-00)

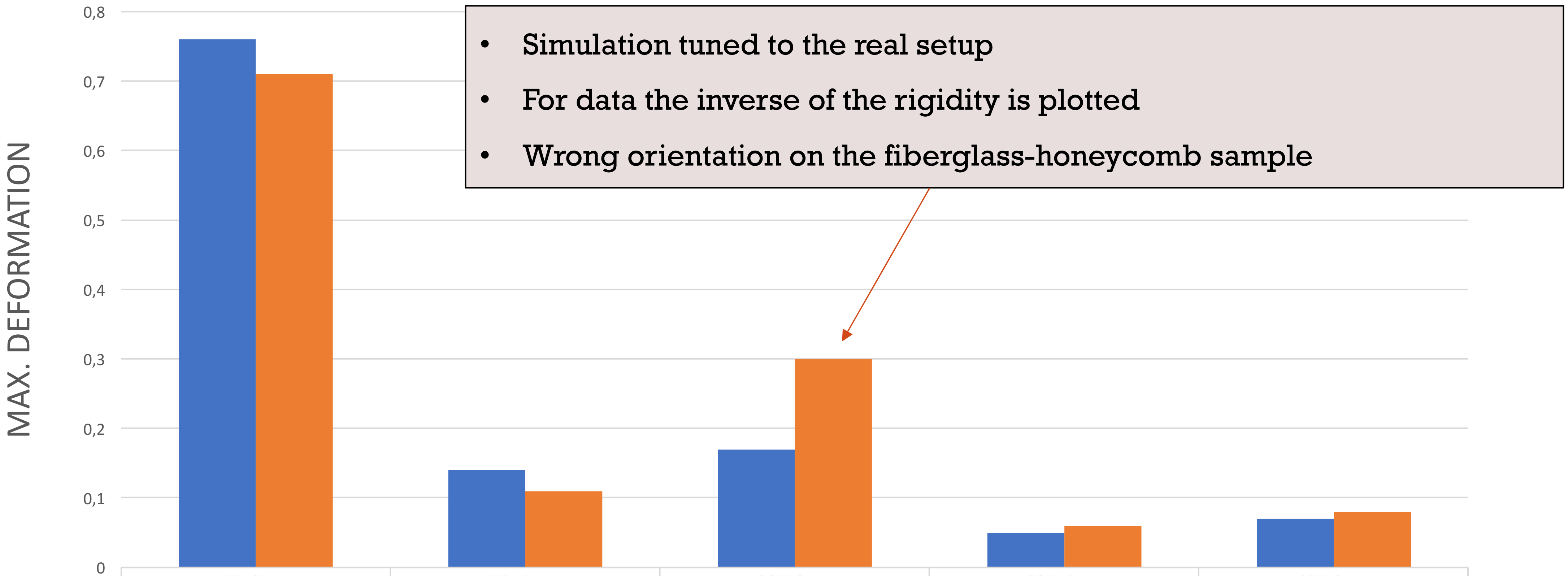
Cathode (2 mm) and Anode (4 mm) samples have been prepared by us and by LOSON personnel using different sandwiches of kapton, rohacell, honeycomb, fiber glass and carbon fiber.





INSTRON
4467 machine

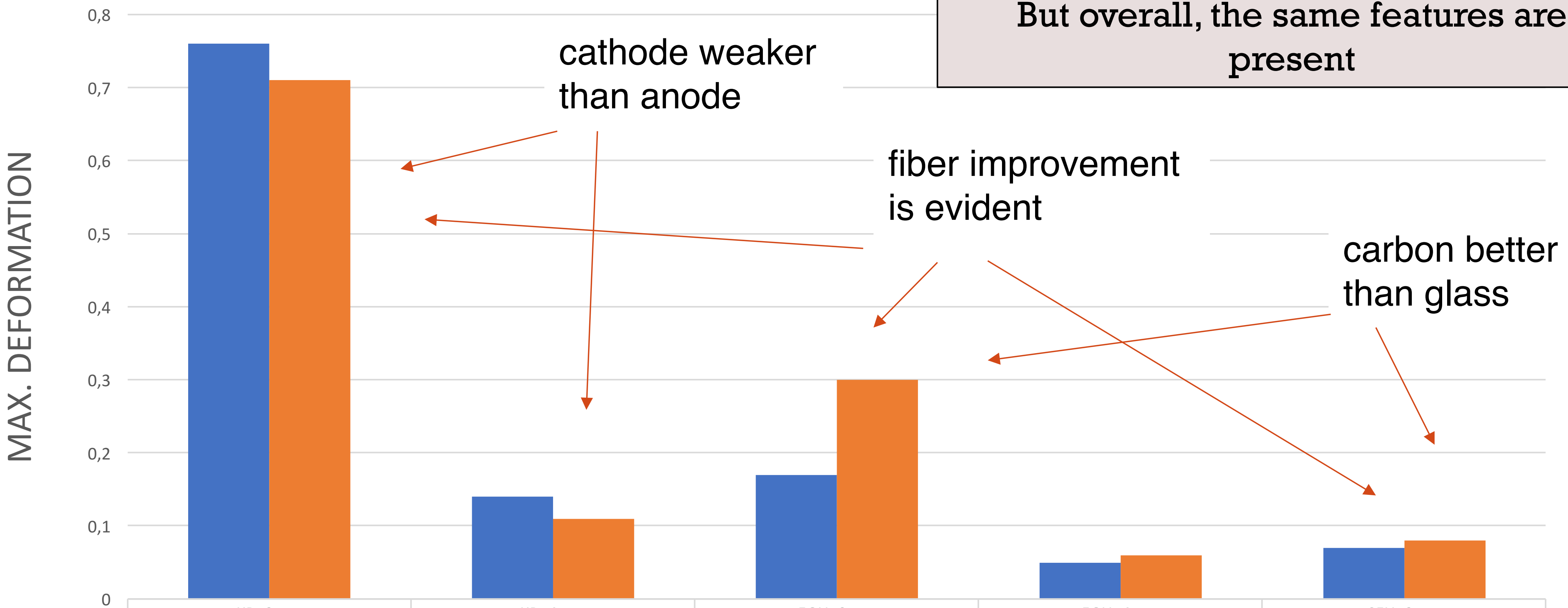
DATA/SIMULATION COMPARISON



	KR_2mm	KR_4mm	FGH_2mm	FGH_4mm	CFH_2mm
Simulation	0,76	0,14	0,17	0,05	0,07
Test Sample	0,71	0,11	0,3	0,06	0,08
	cathode kapton rohacell	anode kapton rohacell	cathode fiberglass honeycomb	anode fiberglass honeycomb	cathode carbon fiber honeycomb

DATA/SIMULATION COMPARISON

But overall, the same features are present



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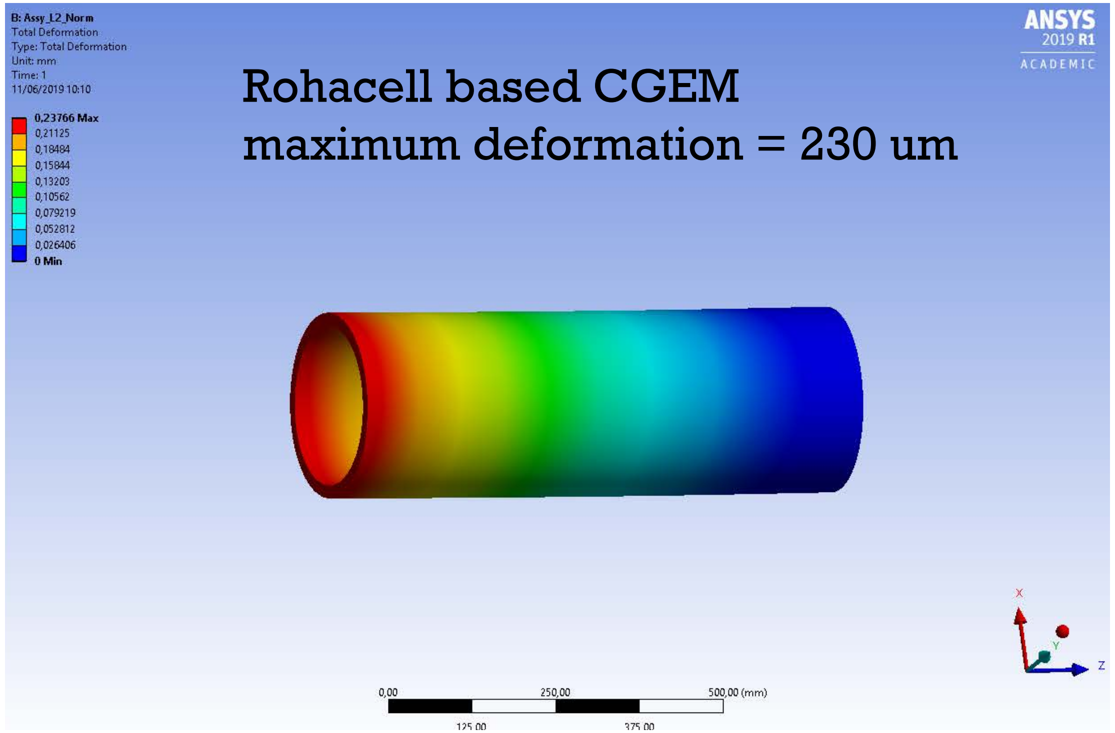
COMMENT ON TESTS AND SIMULATIONS

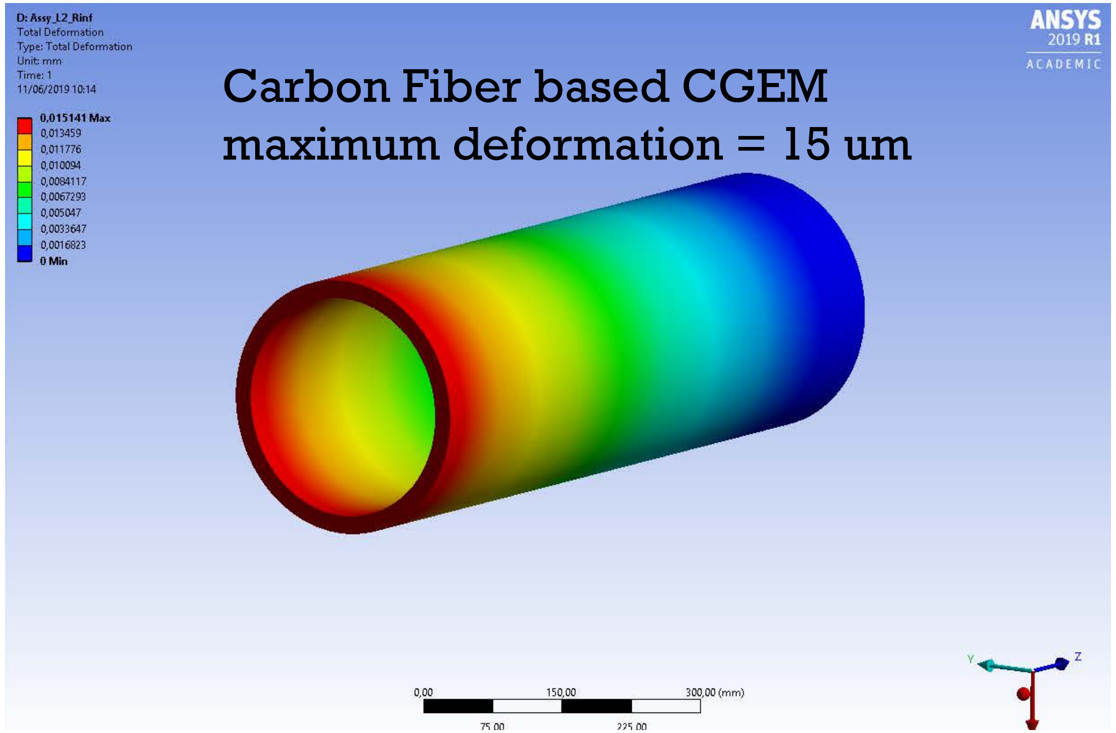
- Two skins of carbon fibers are the best solution to reinforce the CGEM structure.
  - almost 10 times more rigid w.r.t. the present design from test sample
  - more than 50 times more rigid from simulations

- Is that enough? See next slides

- Additional modification to the permaglass rings will be added in order to improve the grip of the gluing.
  - for the rings already ordered the modifications will be done at LNF.

CYLINDRICAL SIMULATIONS

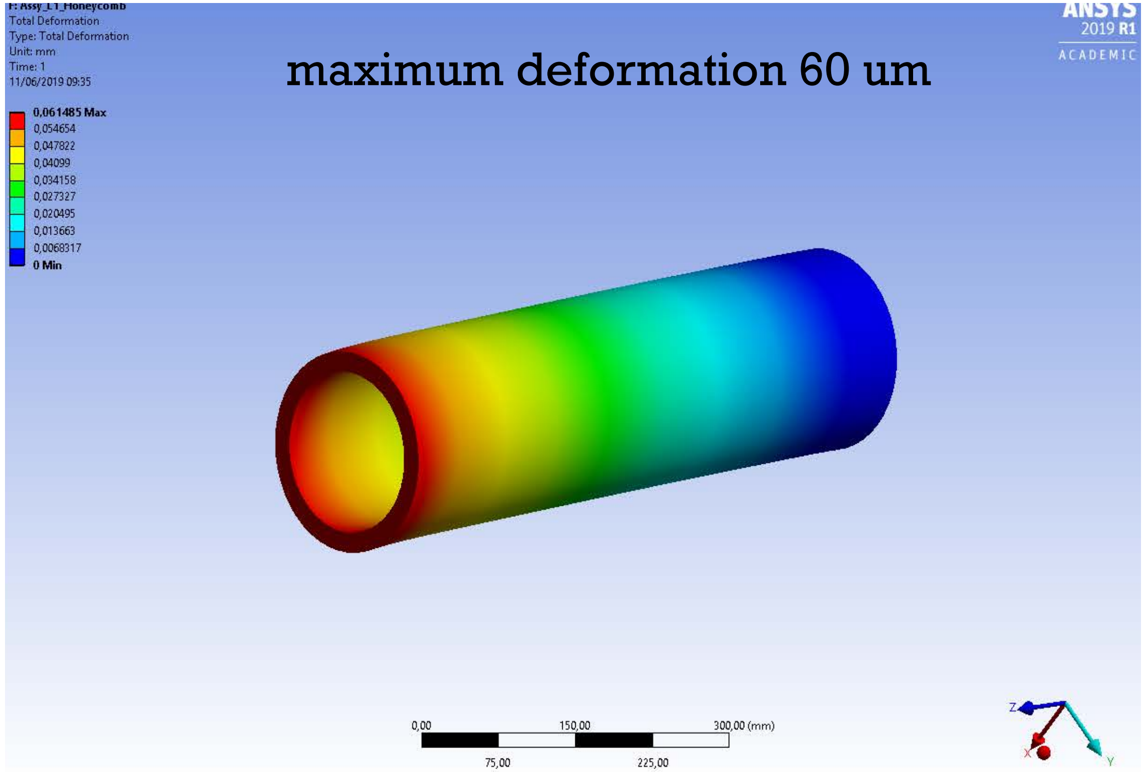




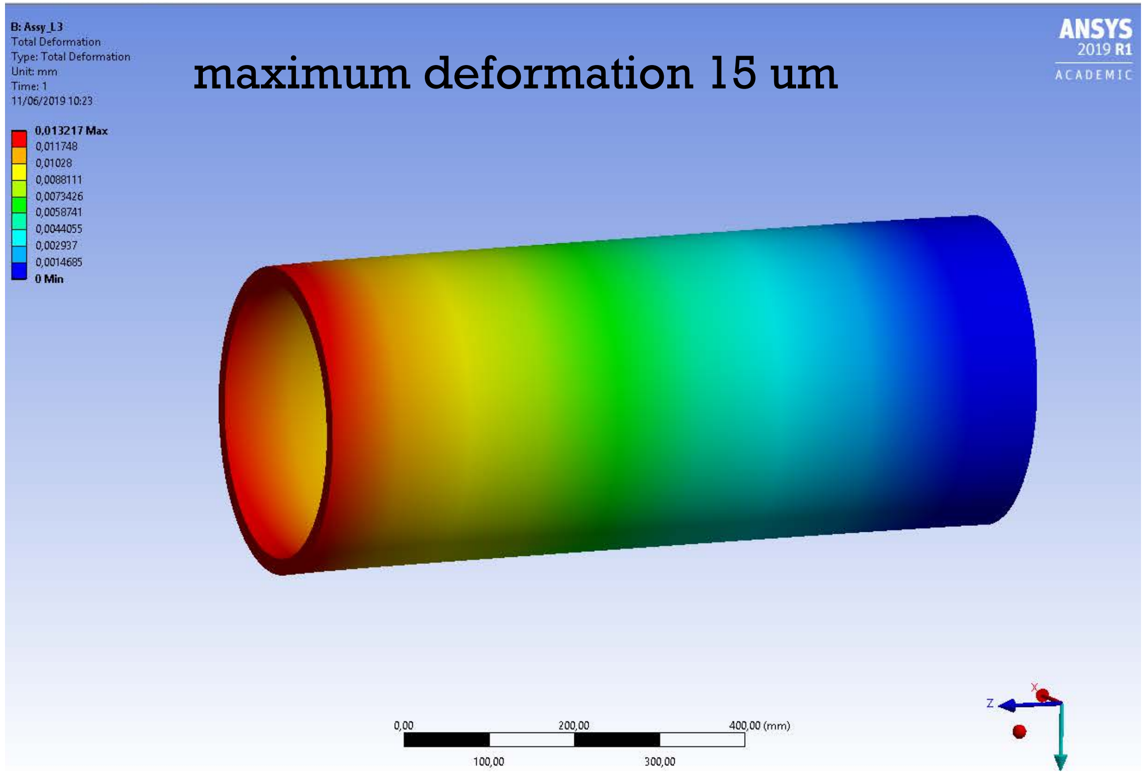
Maximum deformation when a force of 10 N is applied on one side and the other side is fixed.
Mechanical tolerances of the assembly and installation mechanics is about 100 um.
During the vertical assembly the GEM cylinder are free to move within the tolerance with no damage.

CYLINDRICAL SIMULATIONS

Layer 1 with carbon fiber



Layer 3 with carbon fiber



NEW DESIGN

What

- Layer 1
  - add 2 skins of carbon fiber (70 microns each) to the anode;
  - use honeycomb instead of Rohacell as “filling material” for anode and cathode
  - the cathode has the faraday cage on its internal part
- Layer 2
  - it will remain as it is
  - carbon fiber reinforcement will be added to the external structure, outside the active area, between the rings and the Rohacell
- Layer 3
  - add 2 skins of carbon fiber (70 microns each) to the anode
  - add 1 skin o carbon fiber (70 microns) to the cathode
  - the anode has the faraday cage outside the ground plane

How much

MATERIAL BUDGET

Material	Rad. Len.	unit
copper	1.43	cm
kapton	28.6	cm
rohacel	1425	cm
honeycomb	1250	cm
epoxy	33.5	cm
carbon fiber	28	cm
fiberglass	16	cm

- Rohacell based CGEM (layer 2)
  - total material budget for one layer ~0.45% of X0
- With carbon fiber for L1 and L3
  - total material budget for one layer ~0.49% of X0

+0.0004 X_0

Layer 3 stratigraphy

Cathode	honeycomb + carbon		
material	thickness	fill factor	% of X0
carbon fiber	70	1	0.024997
epoxy	10	1	0.00293333
honeycomb	2000	1	0.016
		1	0
epoxy	10	1	0.00293333
kapton	50	1	0.0175
copper	3	1	0.021
		Tot. cathode	0.08536367

GEM			
material	thickness	fill factor	% of X0
copper	5	0.77	0.02695
kapton	50	0.77	0.013475
copper	5	0.77	0.02695
		Tot GEM1	0.067375
		Tot 3 GEM	0.202125

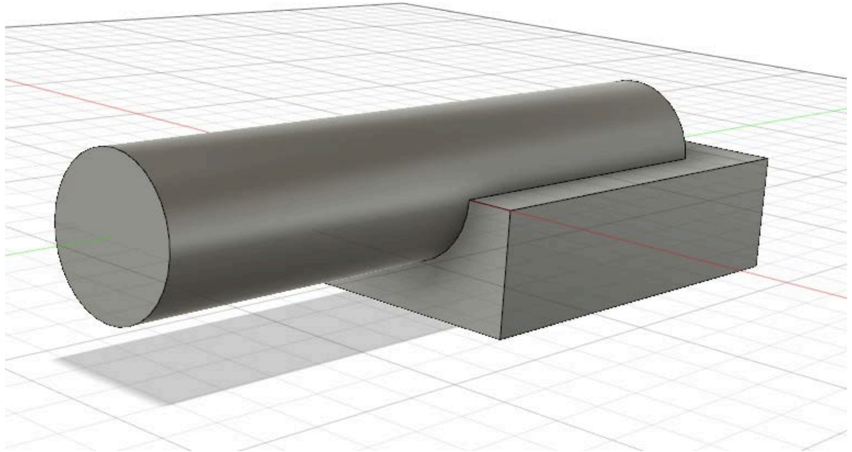
Anode			
material	thickness	fill factor	% of X0
		0	0
kapton	50	1	0.0175
copper	5	1	0.035
epoxy	20	1	0.00586667
carbon fiber	70	1	0.024997
honeycomb	4000	1	0.032
carbon fiber	70	1	0.024997
epoxy	20	1	0.00586667
kapton	25	1	0.00875
epoxy	25	1	0.00733333
copper	5	0.87	0.03045
kapton	50	0.2	0.0035
copper	5	0.2	0.007
		Tot Anode	0.20326067

+ Faraday cage → total material budget for the CGEM-IT ~1.48% of X0

SHIPPING

- The detector will be immerged in a dumping foam and not hang to damping springs

- The dumping structure has been designed by the Angst+Pfister company



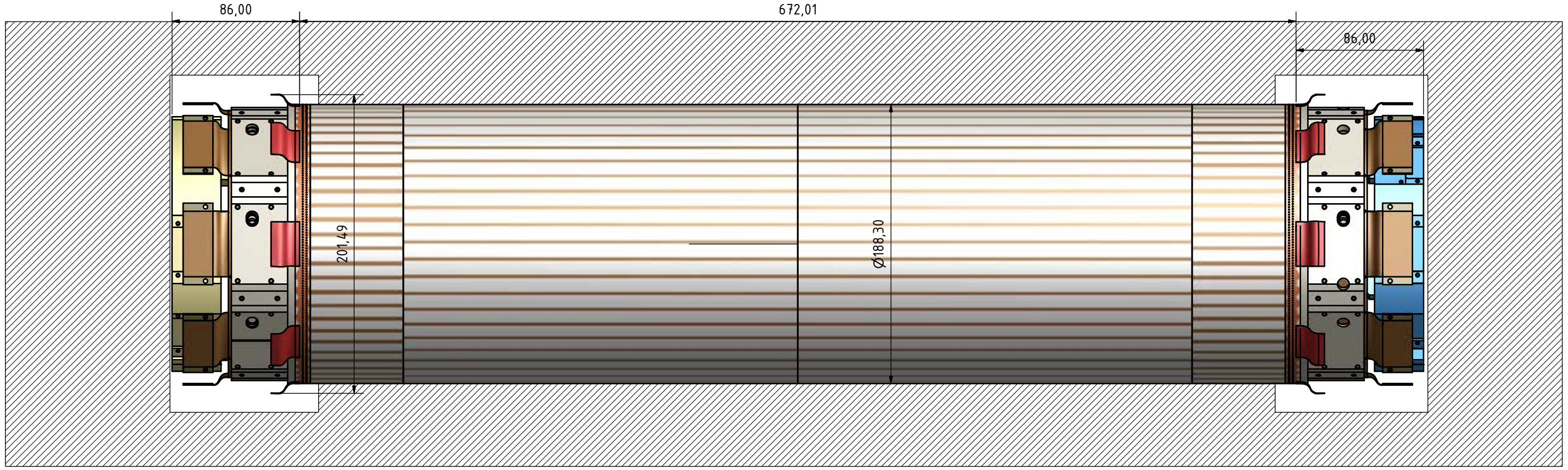
DUMPING MATERIAL

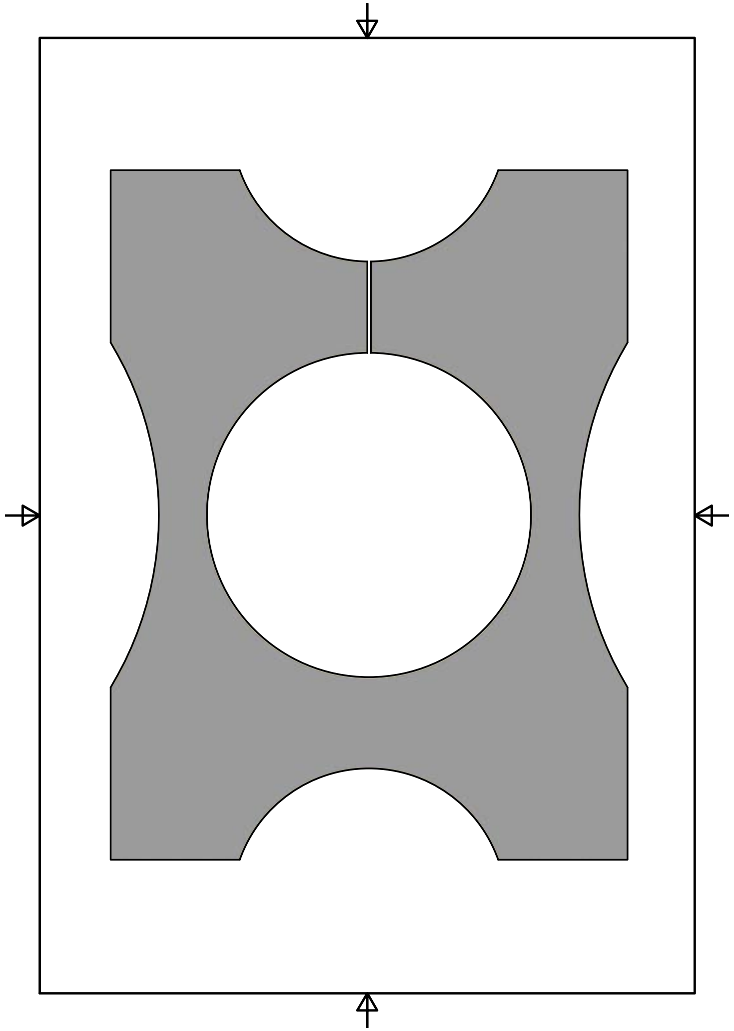
APSOPUR®

Material	mixed cellular polyurethane
Color	green

Standard dimensions on stock

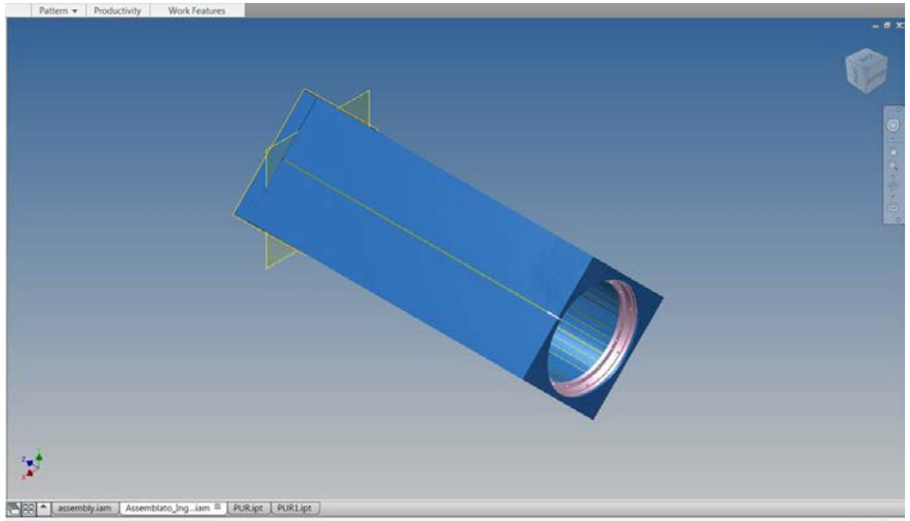
Thickness	12.5 mm with APSOPUR® NC L11–12 25 mm with APSOPUR® NC L11–25
Rolls	1.5 m wide, 5.0 m long
Stripes	max. 1.5 m wide, up to 5.0 m long





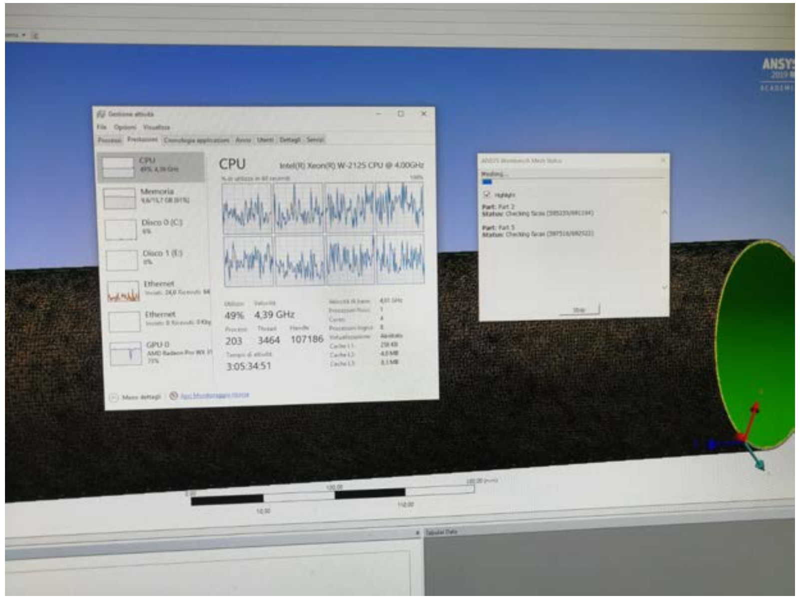
SHIPPING BOX

- dimensions 40x40x120 cm^3
- will be shipped as cabin baggage
- with Air China direct flight



will be

- simulated
- characterized using a vibrating machine



SCHEDULE

- The schedule is still an issue.
- The Lab management asked us to deliver to IHEP the new detector by December - January 2020.
- Not impossible, but no contingency accounted for L3 construction.
- Layer 1 construction started, ready by mid September.

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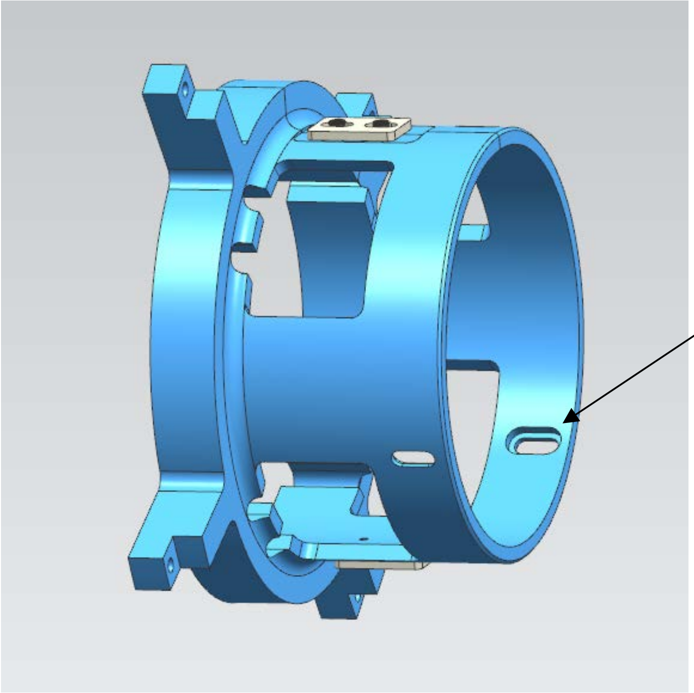
THANKS

THE ASSEMBLY PROCEDURE

WEST
SIDE

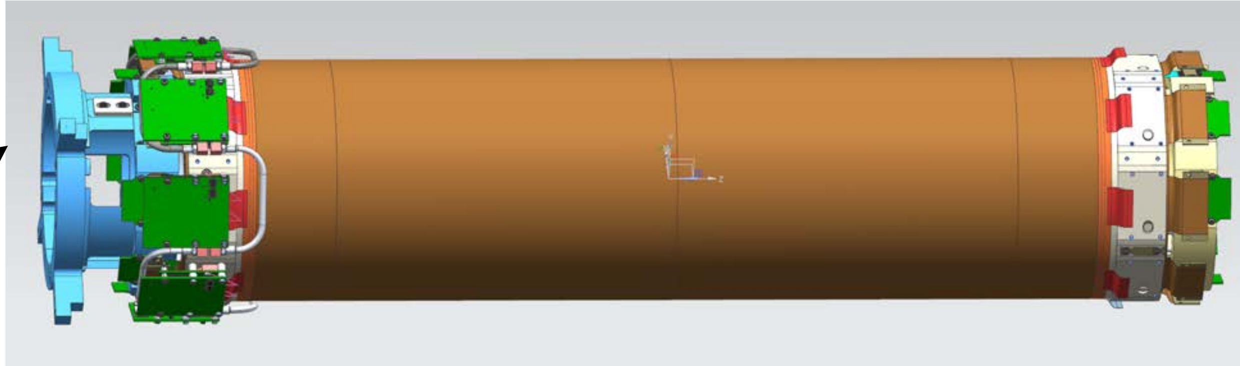


Positioning of the interconnecting flange on the west side

buttonhole made to compensate mechanical tolerances.

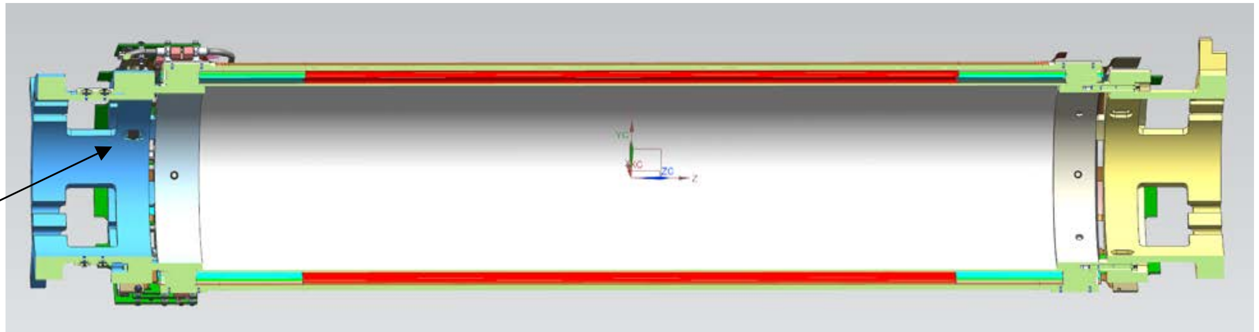
WEST
SIDE

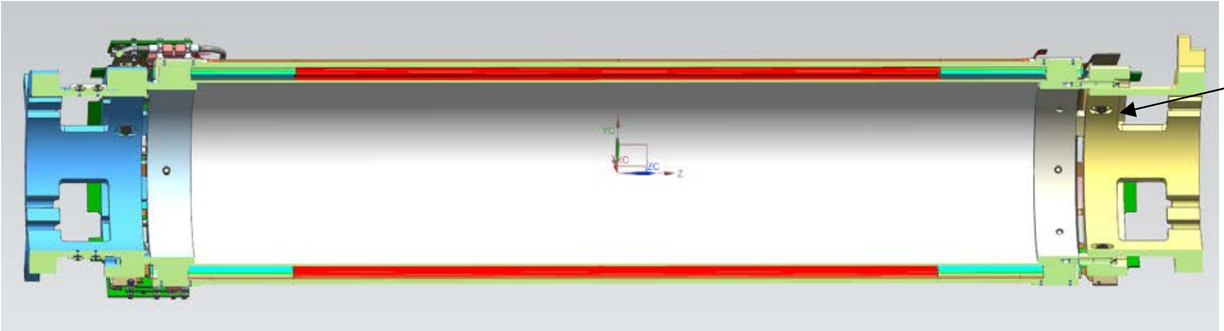
Inser L1 up to the edge of the
interconnecting flange



EAST
SIDE

Fasten L1 on the west side
in phi direction.
The screws are not tight
to prevent deformation of the CGEM





WEST
SIDE

EAST
SIDE

Insert the east flange without fixing the screw.
By means of buttonholes the flange and L1 have no constrain in the longitudinal direction.

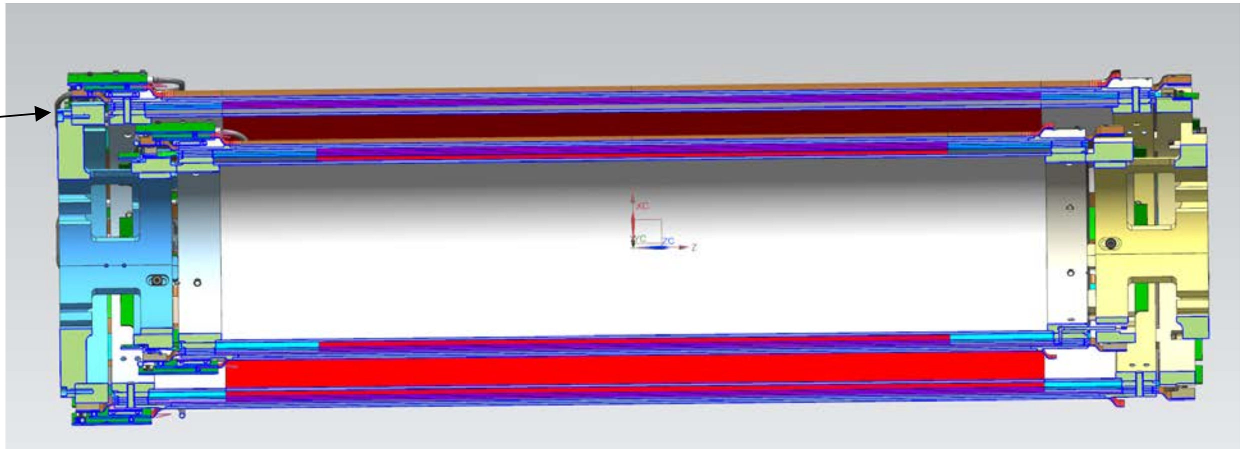
isostatic condition

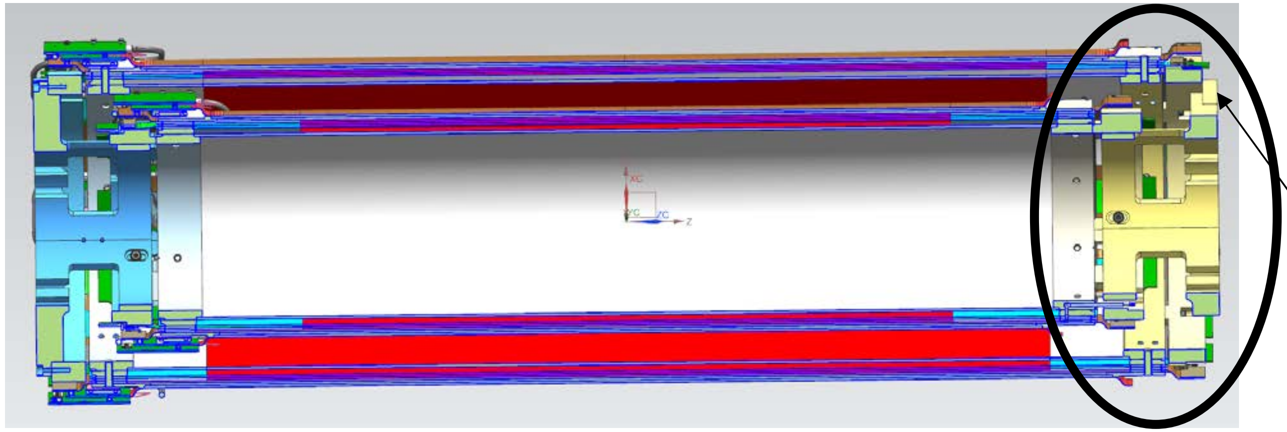
Buttonholes gives the correct phi orientation.

WEST
SIDE

Fix L1 longitudinally on west side

EAST
SIDE





WEST
SIDE

EAST
SIDE

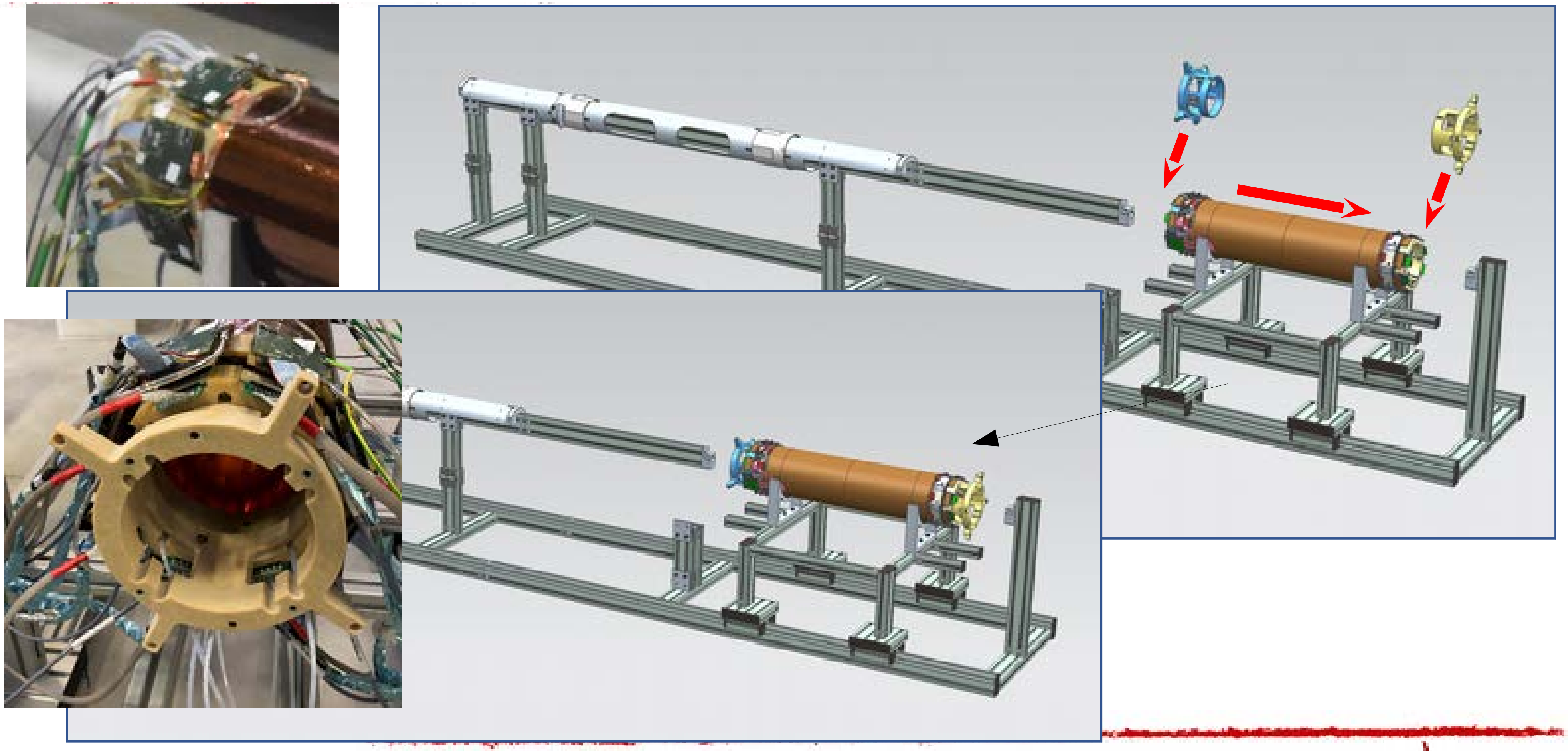
Connect longitudinally the EAST flange.

The flange and L1 have no constrain in the longitudinal direction.

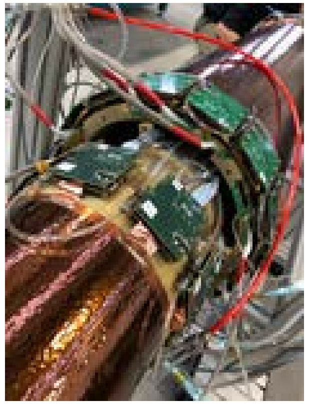
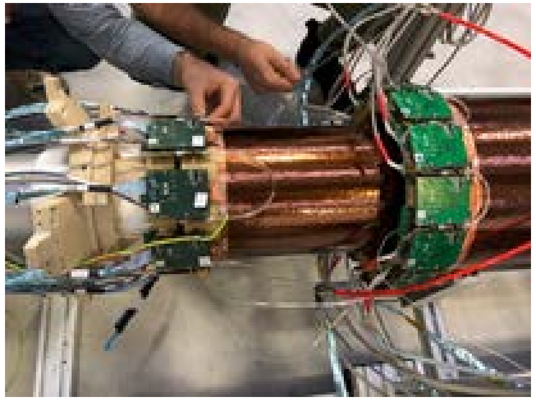
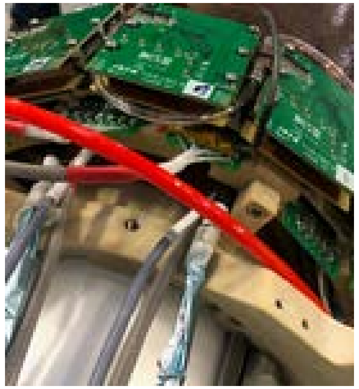
The friction is very small and the alignment operation is done pushing with just one finger.

No fastening on EAST side done at IHEP during these operations since layer 2 is supposed to be replaced.

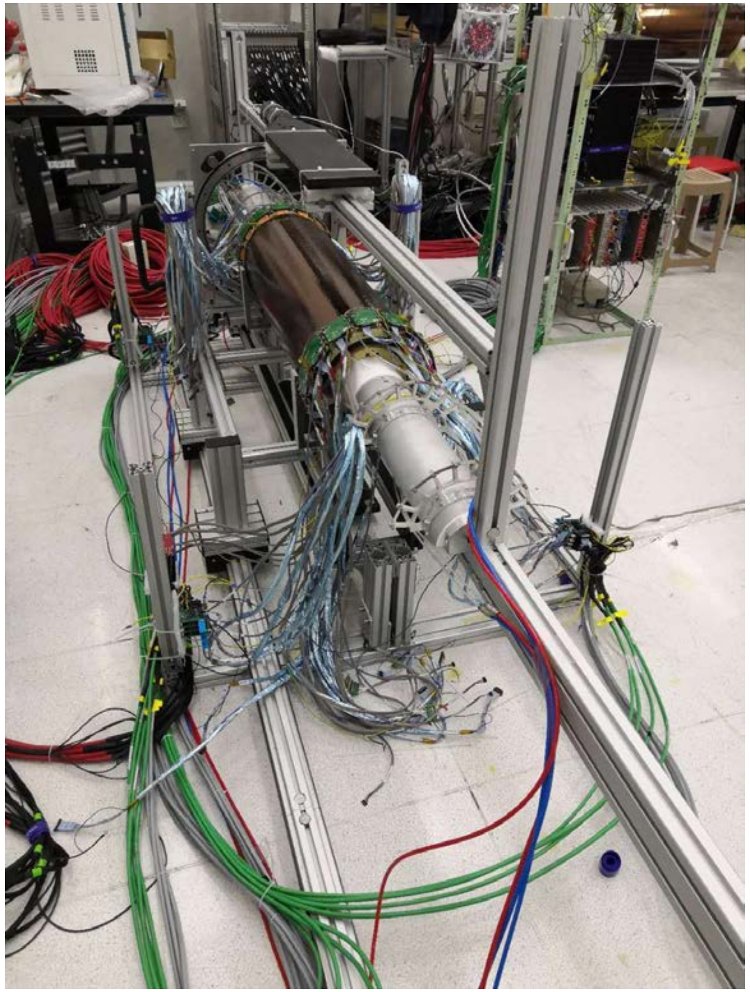
TOOLING FOR THE CGEM-IT ASSEMBLY



PICTURE OF THE FERRARA MECHANICAL TEST

PICTURES OF THE FINAL SETUP



CATHODE WEAKER THAN ANODE