News from Frascati (INFN - LNF)

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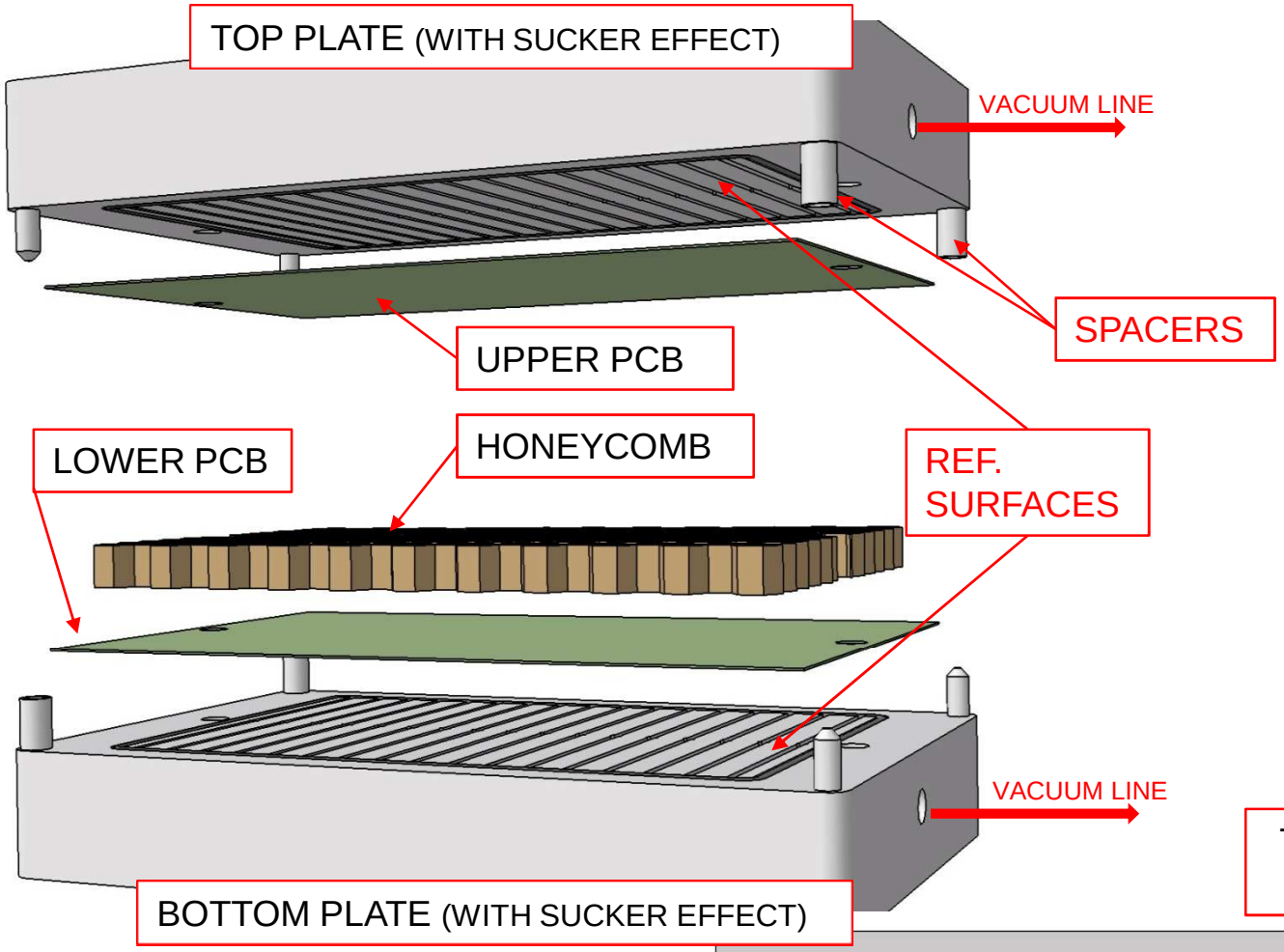
Gluing toolings

- Stiff-back method
- LHCb AL mold
- Dimensions (mm): 1600x390

- High precision surfaces (≈15μm)
- Vacuum line on both sides
- Environmental condition not controlled



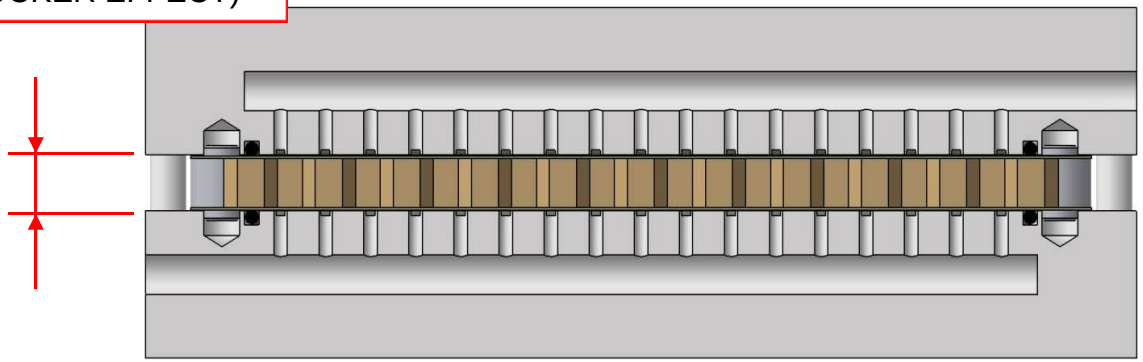
FACE (*REFER) TO* FACE *ASSEMBLY SCHEME*

a) The two PCB kept in plane and in Position by vacuum on Top and Bottom Plates.

b) The Sandwich Thickness is set by Positioning Spacers of Plates.

c) The Glue compensate the errors/tolerances on thickness of PCB and HoneyComb

TOOL CLOSED (Cut View)



The Sandwich Thickness is set by calibrated Spacers between Plates.

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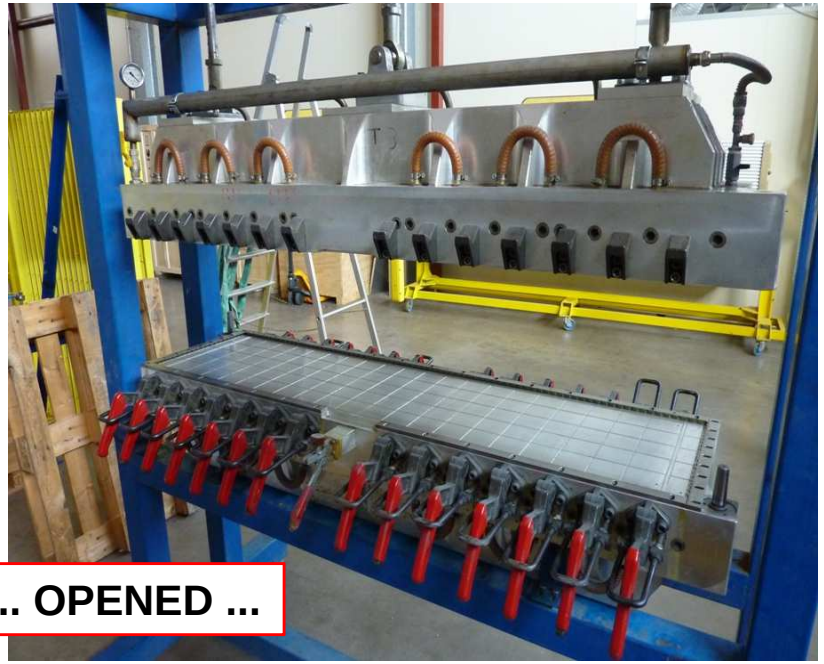
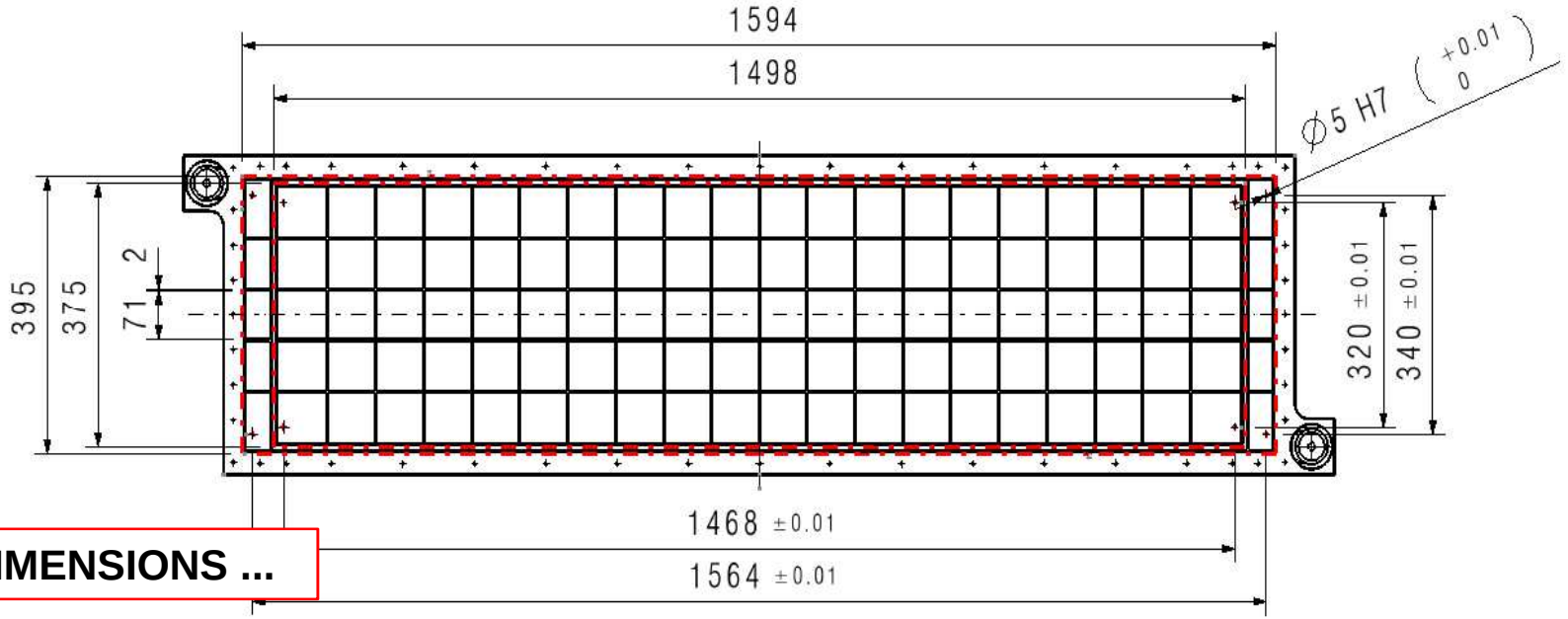
FACE *REFER TO* FACE *ASSEMBLY TOOL* ...

... CLOSED ...



... OPENED ...



... DIMENSIONS ...

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Gluing procedure

1. Both PCBs are kept in plane on both sides of the mold with vacuum

2. Glue is applied on bottom PCB

3. Honeycomb is layed on the PCB

4. 1st gluing: molds are separated by precision spacers

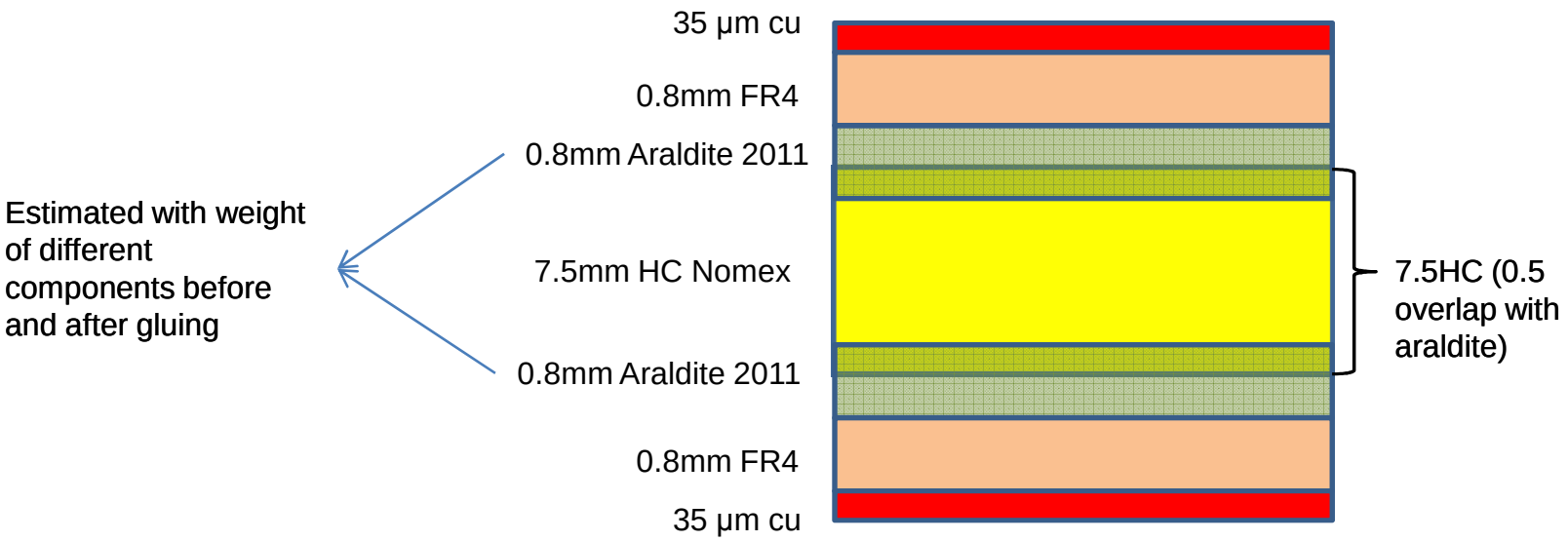
5. PCB are exchanged. Gluing is always on the bottom side

6. Final gluing. Two days for one sandwich

Goals and Materials

- Acquire experience in gluing sandwiches
- Validate the stiff-back solution and verify precisions (planarity and expected thickness)
- Investigate the possibility to join two or more preglued sandwiches (in progress)
- Make reproducibility tests on sandwiches (in progress)

	Dimension (mm^2)	Thickness (mm)
Sandwich 0	400x440	9.5
Sandwich 1	890x335	9.5
Sandwich 2	1595x340	9.5



Sandwich measurements

Systems of measurement

Laser tracker
INFN Frascati

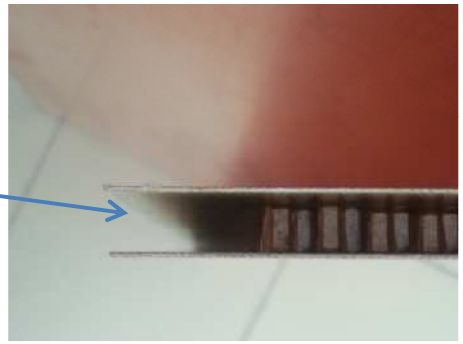
Coordinate-measuring machine
(CMM) – INFN PISA

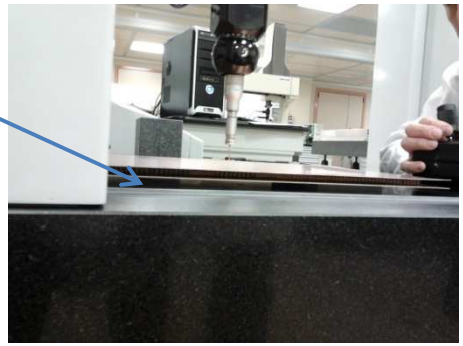
Measurement conditions

•Laser tracker and CMM don't allow to put sandwich in vertical position

• No frame in sandwich, free edges:
  • Edges are not flat, (PCB tends to bend on the copper side)

•In order to avoid effects on measures, sandwiches are suspended with 4 or 6 supports





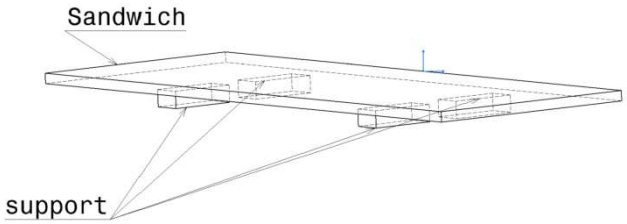
•Both sides of the sandwiches have been measured to understand macroscopic effect on the shape. Sandwich deformation is really sensitive to the supports position: relevance of this effect has been fully understood only after the measurements

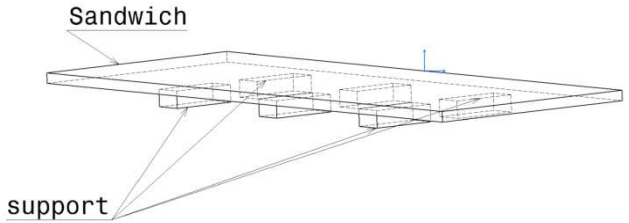
•Laser tracker CCR has a not negligible weight of 195gr

•CMM-probe apply only 4grams on measure point

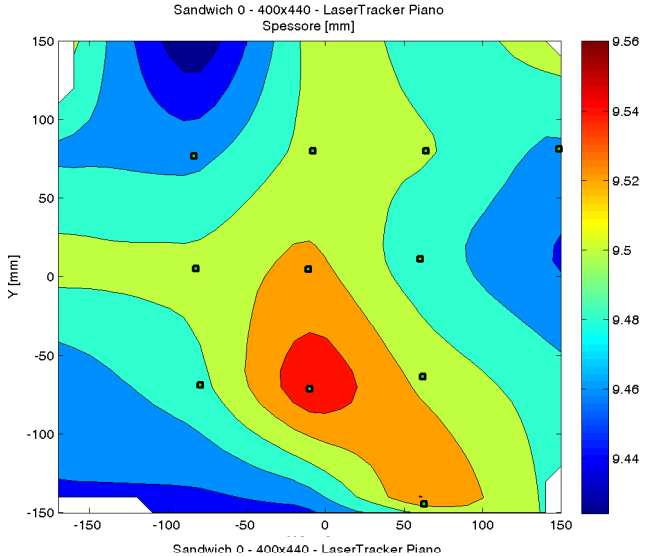
•CMM measures was done in controlled environment and after 24h conditioning

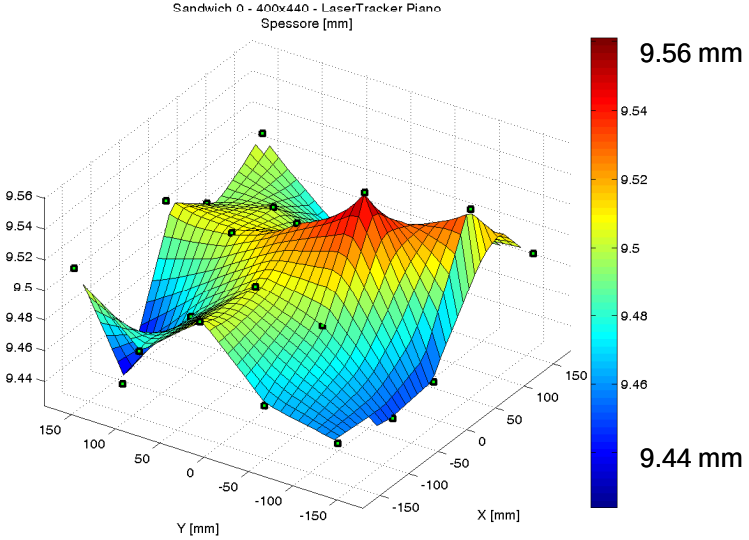
•Use of CMM with optical probe on vertical sandwich would be the best solution





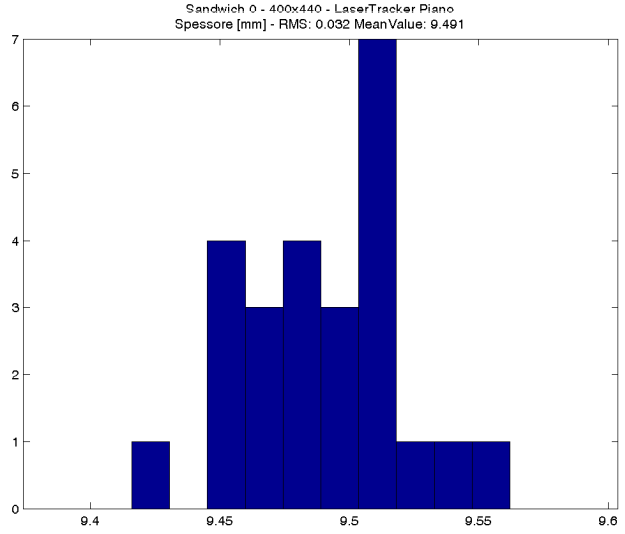
Sandwich 0 – 400x440 – Laser Tracker



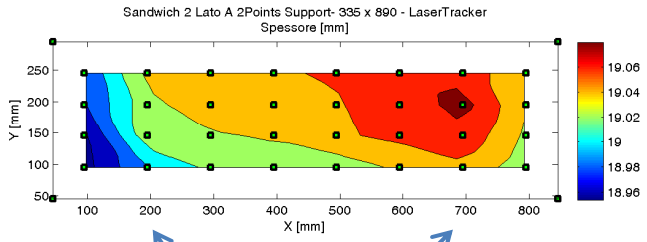


Optical plate, temperature not controlled

- Mean value: 9.491 mm (expected: 9.5mm)
- RMS: 0.032
- Max dev: 0.069mm



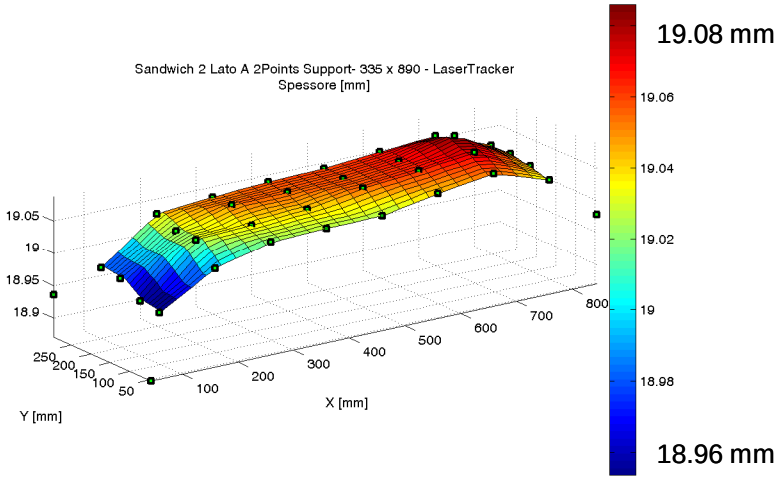
Sandwich 1 SideA – 890x335 – Laser Tracker
4 supports

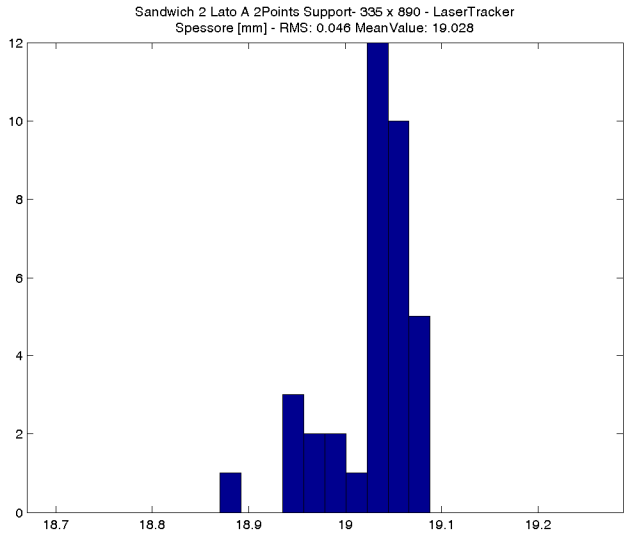


Supports position ≈ 200mm from edge*

Granite plate, temperature not controlled

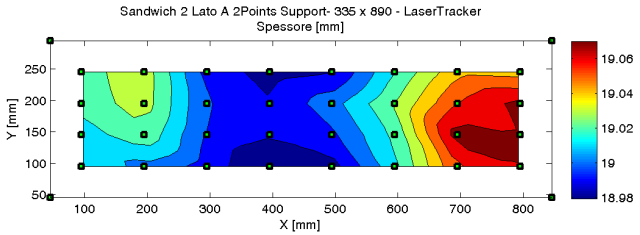
- Mean value: 19.028 mm (+ 9.5mm supports)
- Expected value: 19mm
- RMS: 0.046
- Max dev: 0.068





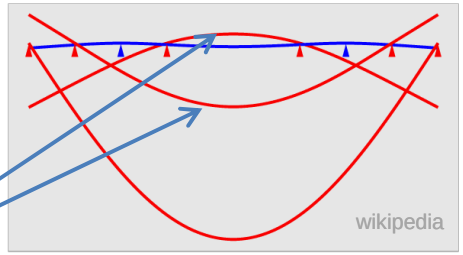
*Closest to the bessel points: in those points, displacements are minimal

Sandwich 1 SideB – 890x335 – Laser Tracker
4 support

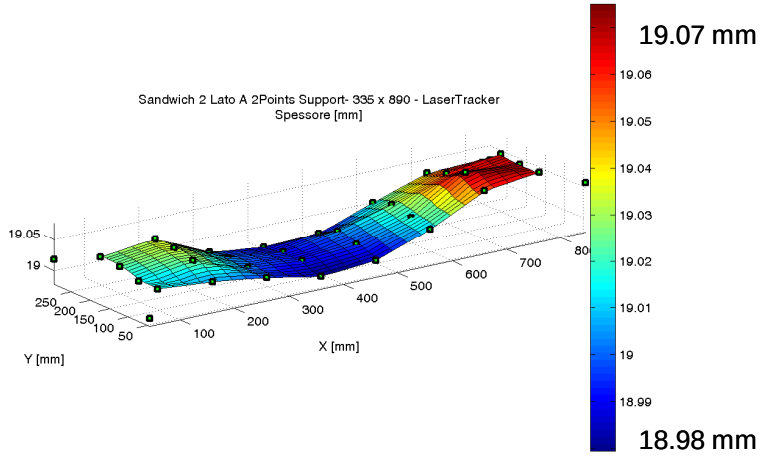


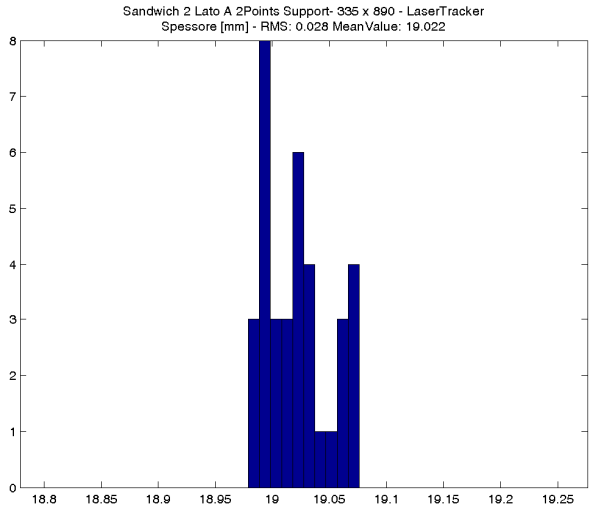
Supports position ≈ 200mm from edge*

- Granite plate, temperature not controlled
- Mean Value: 19.022 mm (+ 9.5mm supports)
- Expected value: 19mm
- RMS: 0.028 mm
- Max dev: 0.047 mm



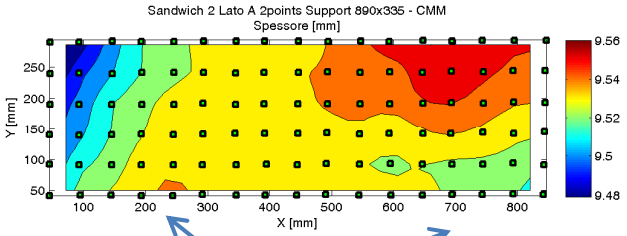
- Sandwich shape very critical vs. supports position (compare to previous slide)





*Closest to the bessel points: for those points, displacements are minimal

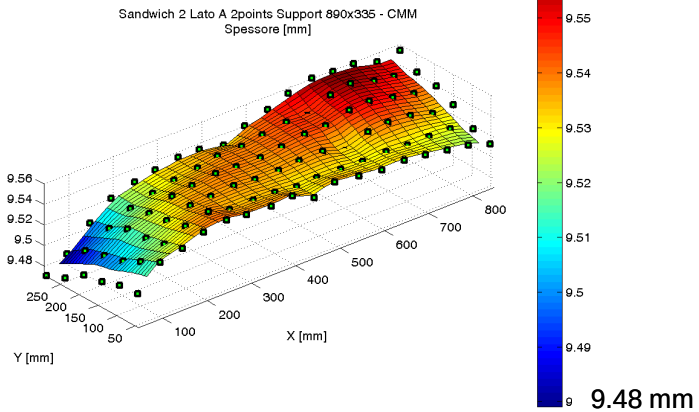
Sandwich 1 SideA PISA CMM – 890x335
4 supports

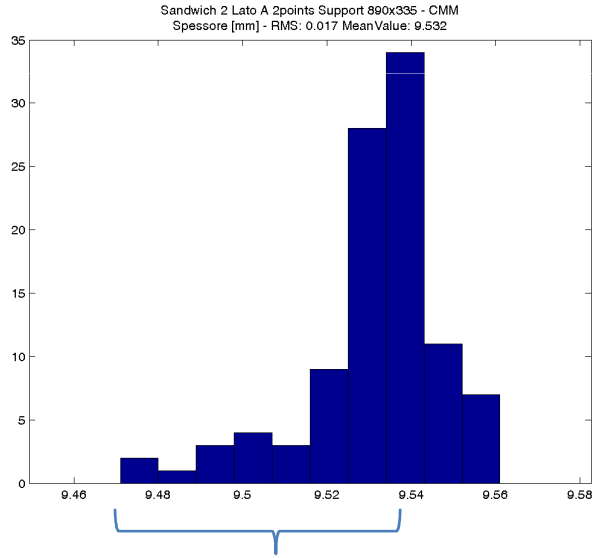


Supports position ≈200mm from edge*

Granite plate, temperature controlled, 24h conditioning

- Mean Value: 9.532 mm (Expected 9.5 mm)
- RMS: 0.017 mm
- Max dev: 0.051 mm

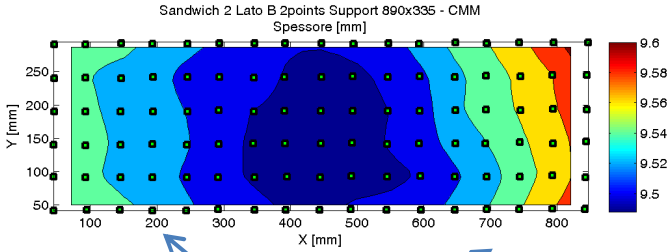




Effect of supports and weight

*Closest to the bessel points: for those points, displacements are minimal

Sandwich 1 SideB PISA CMM – 890x335
4 supports



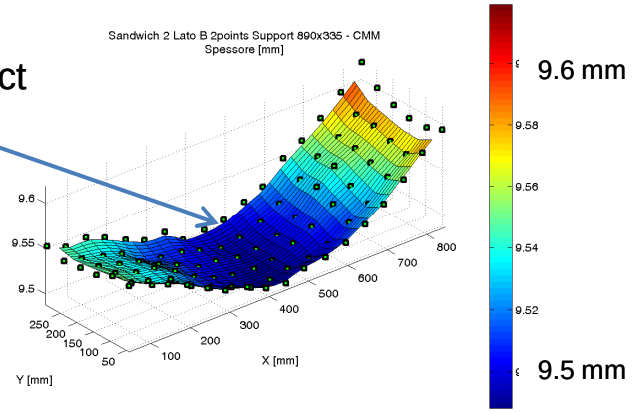
Supports position ≈ 200mm from edge*

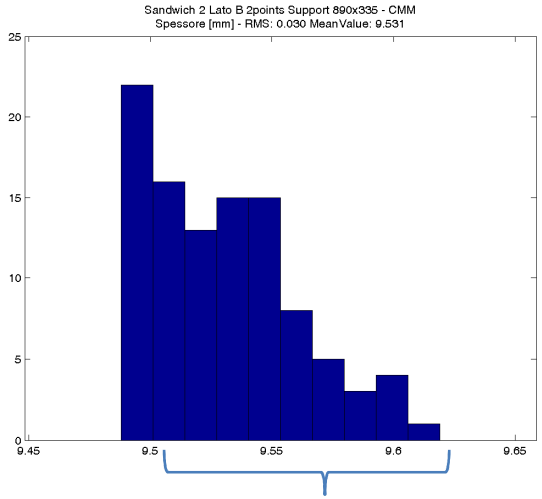
Granite plate, temperature controlled, 24h to stabilize materials

- Mean value: 9.531 mm (expected: 9.5mm)
- RMS: 0.030 mm
- Max dev: 0.1 mm

Sandwich shape very critical vs. supports position (compare to previous slide)

Self weight effect

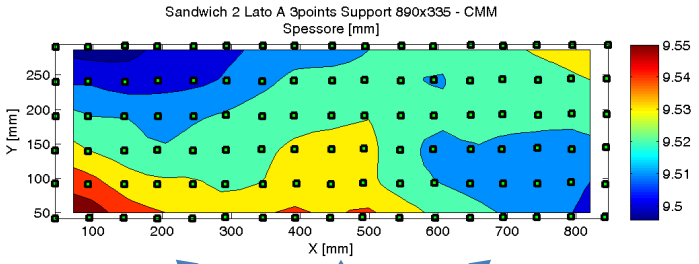




Effect of supports and weight

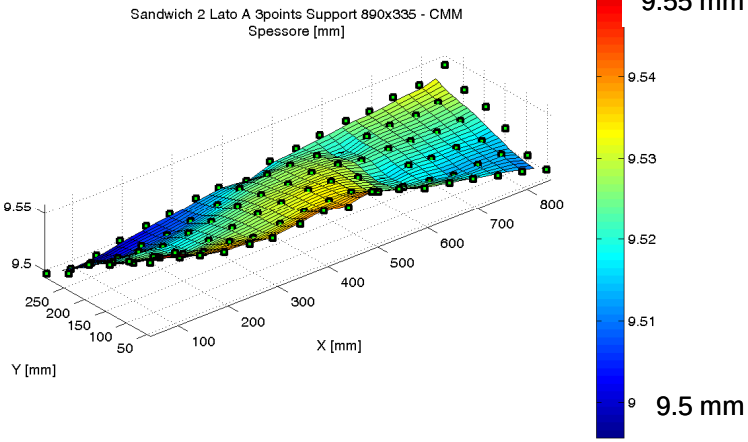
*Closest to the bessel points: for those points, displacements are minimal

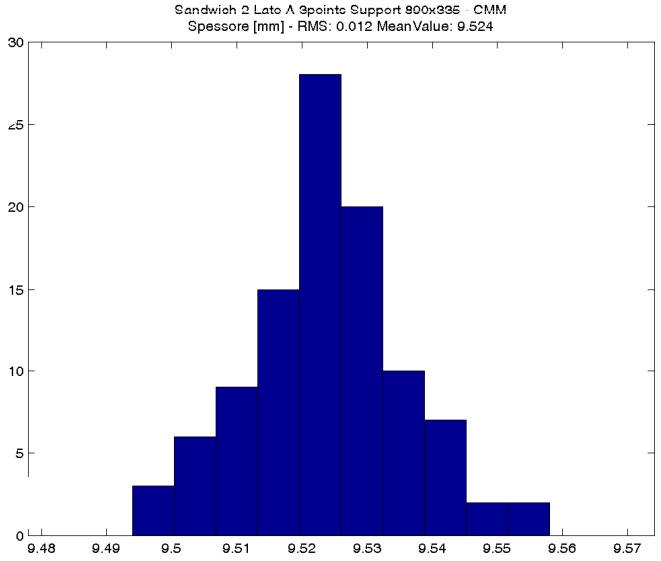
Sandwich 1 SideA PISA CMM – 890x335
6 supports



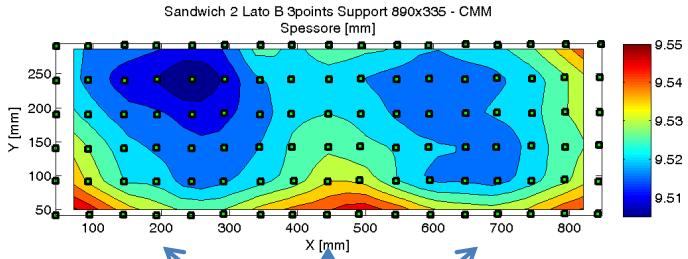
Supports position ≈ 190mm from edge, center

- Granite plate, temperature controlled, 24h to stabilize materials
- Mean value: 9.524 mm (Expected 9.5mm)
- RMS: 0.012 mm
- Max dev: 0.035mm



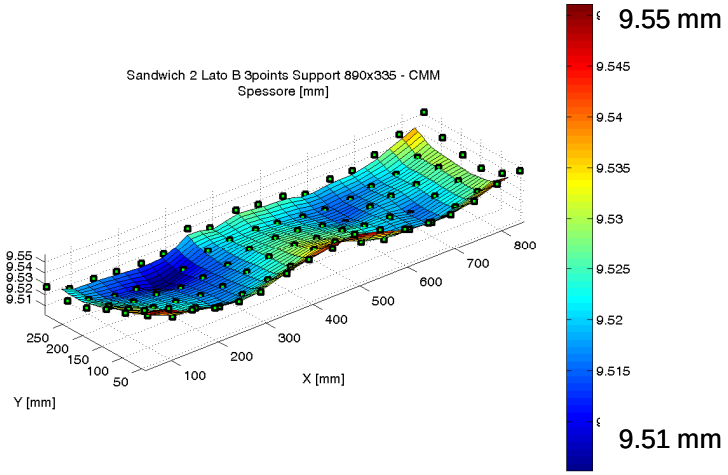


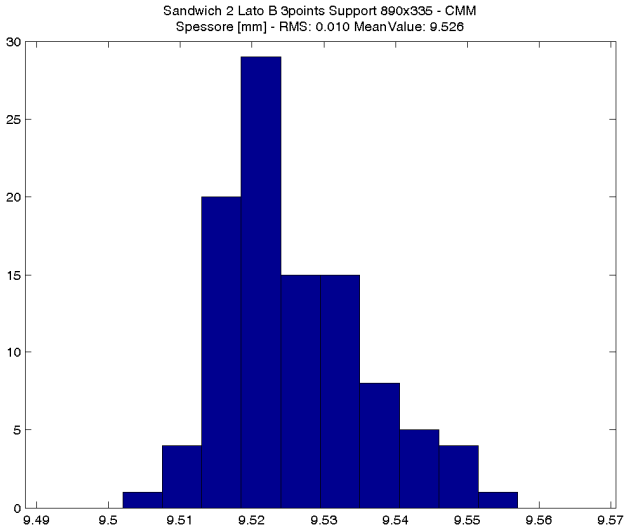
Sandwich 1 LatoB PISA CMM – 890x335
6 supports



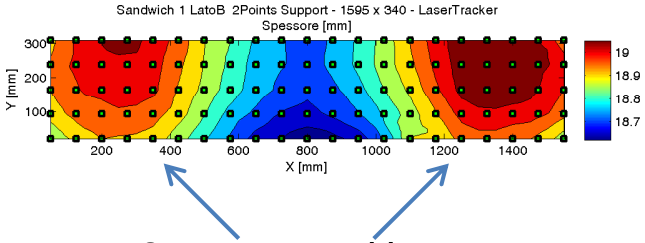
Supports position ≈ 190mm from edge, center

- Granite plate, temperature controlled, 24h to stabilize materials
- Mean value: 9.524 mm (expected 9.5mm)
- RMS: 0.010 mm
- Max dev: 0.034 mm





Sandwich 2 SideB – 1595x340 – Laser Tracker
4 supports



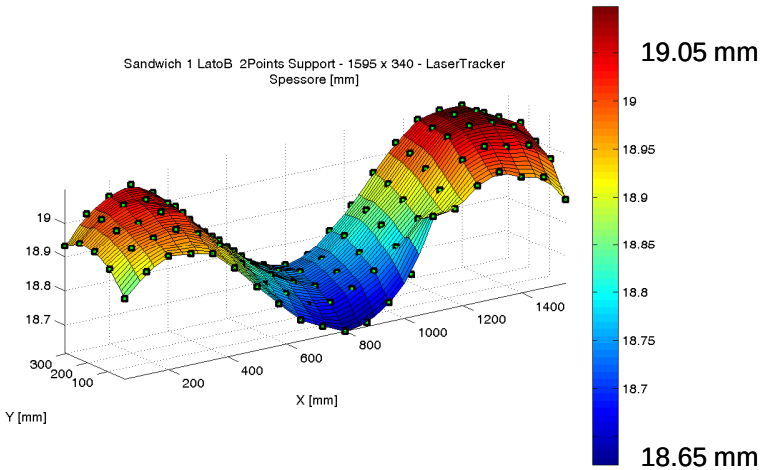
Supports position
L1=330mm
L2=1220mm

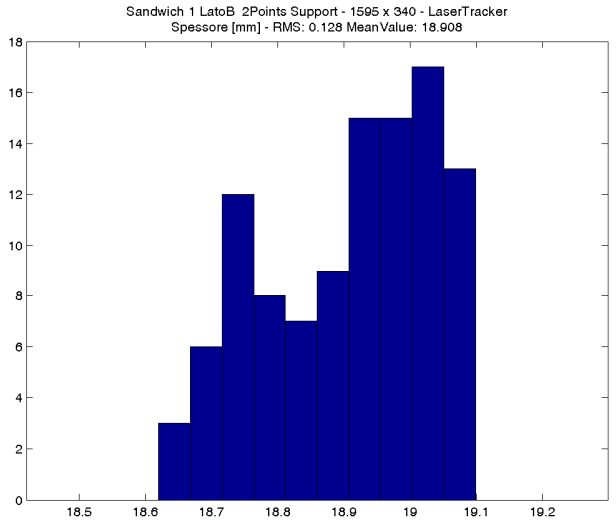
Granite plate, temperature not controlled
Wait to produce others sandwiches before measure with CMM

•Mean Value: 18.908 mm (+ 9.5mm support)

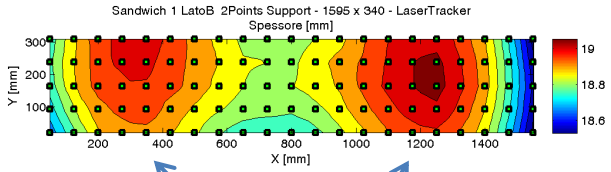
•RMS: 0.128 mm

•<u>Very clear effect due to the increased panel length. Deformation up to 0.250mm</u>





Sandwich 2 SideA – 1595x340 - LT
4 supports

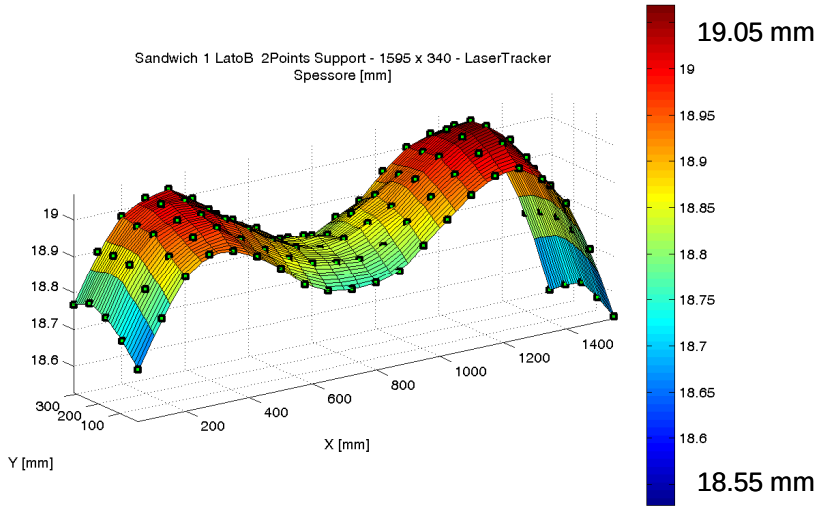


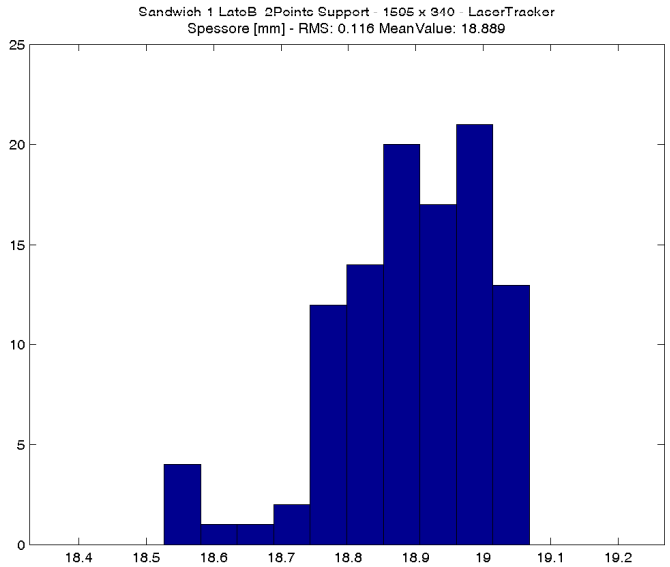
Supports position
L1=330mm
L2=1260mm

Granite plate, temperature not controlled
Wait to produce others sandwiches before measure with CMM

•Mean Value: 18.889 mm (+9.5mm support)
Expected :19mm

•RMS: 0.116 mm





Systematic effects on measurements

•Use observed deformation to have a preliminary indication on panel properties and correct the measurements

• Measurement setup effects:

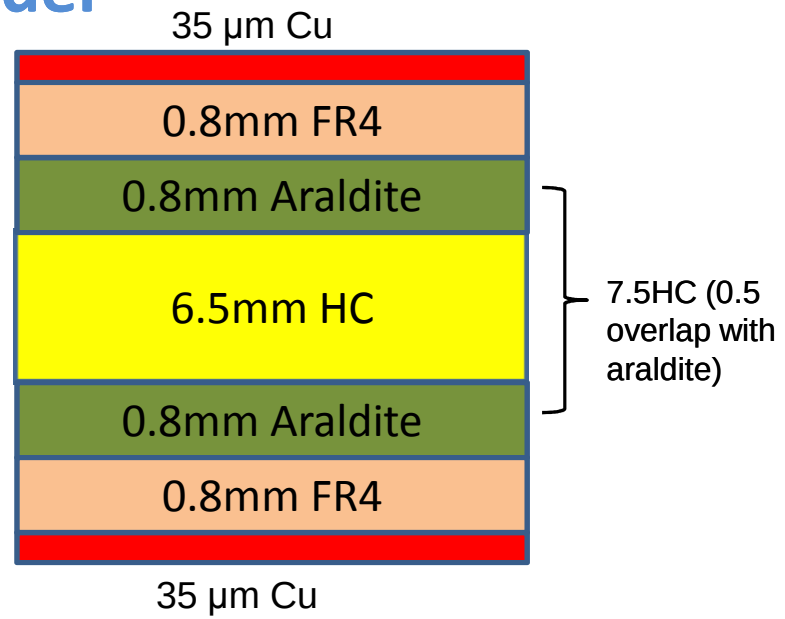
- Deformation of sandwiches due to self weight
- CCR weight (195gr) when using laser tracker measuring system

- Correct measurements with ANSYS model, taking into account CCR weight and support position

Sandwich lay-up and properties for FE model

FR4		ρ = 1740 kg/m^3
Ex = 24.3 GPa	νxy = 0.11	Gxy = 3.2 GPa
Ey = 24.3 GPa	νxz = 0.3	Gxz = 3.1 GPa
Ez = 8 GPa	νzy = 0.3	Gzy = 3.1 Gpa

Honeycomb HRH-78-1/4-3		ρ = 48 kg/m^3
Ex = 0 GPa	νxy = 0.5	Gxy = 0 Gpa
Ey = 0 GPa	νxz = 0	Gxz = 0.02 GPa
Ez = 0.131 GPa	νzy = 0	Gzy = 0.03 GPa



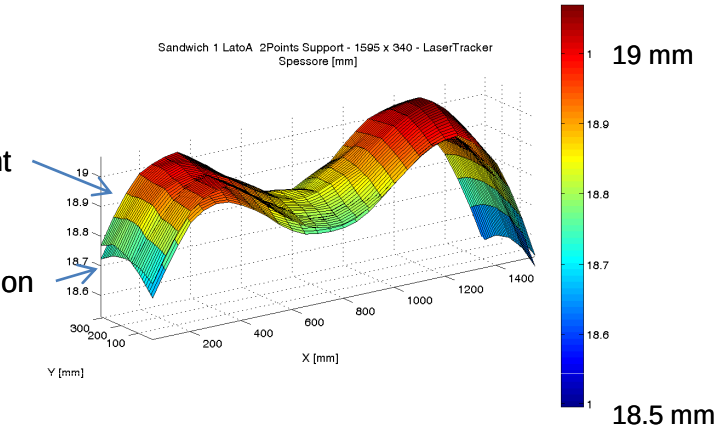
Glue Araldite 2011		
E = 1.904 GPa	ν = 0.35	ρ = 1000 kg/m^3

Copper		
E = 128 GPa	ν = 0.35	ρ = 8960 kg/m^3

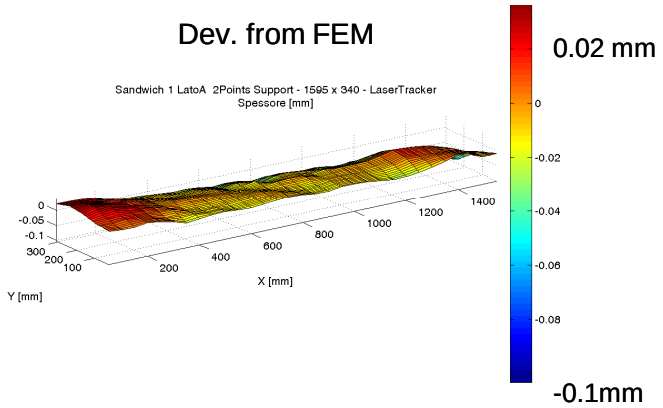
Sandwich 2 SideA – 1595x340
4 supports

Measurement

FEM simulation



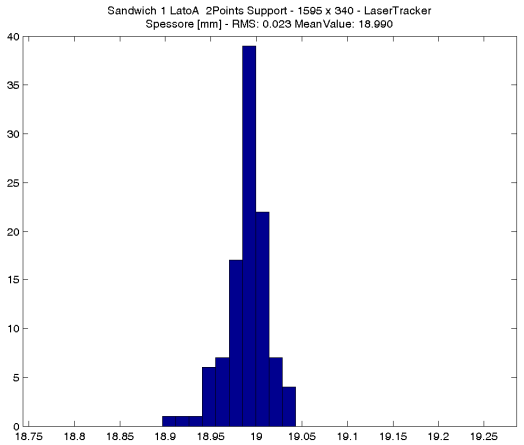
Dev. from FEM



- Mean value: 18.990 mm (+9.5mm spacer)
- Expected :19mm

- RMS: 0.023

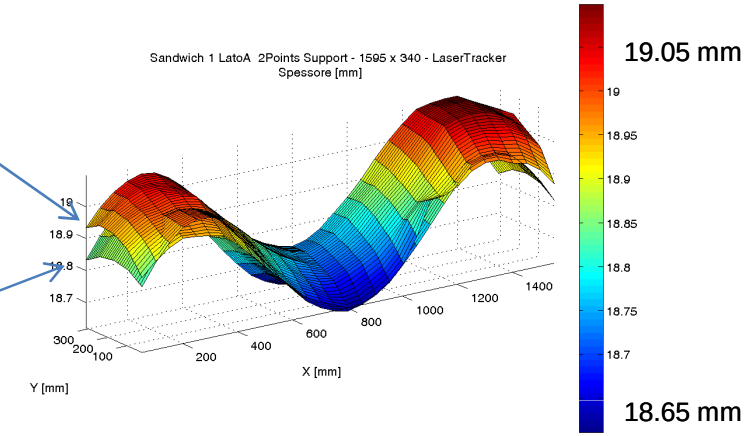
Max dev: 0.050mm



Sandwich 2 SideB – 1595x340
4 supports

Measurement

FEM simulation

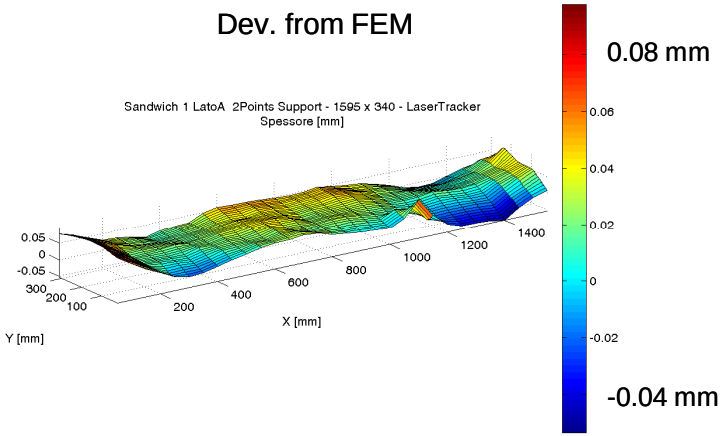


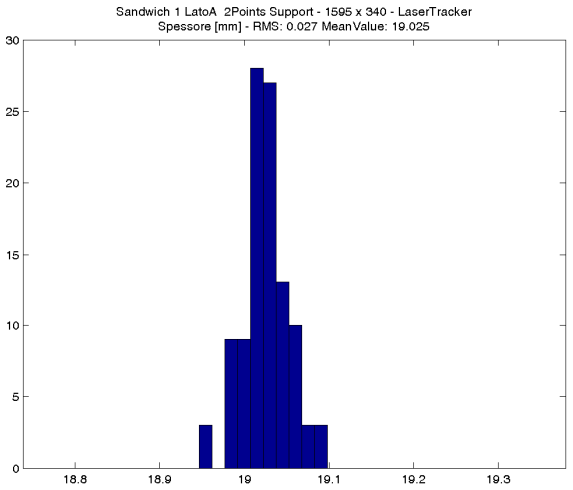
•Mean value: 19.025 mm (+9.5mm spacer)
Expected :19mm

•RMS: 0.027

Max dev: 0.070mm

Dev. from FEM





Conclusions

- Various sandwiches built up from 400x440 mm^2 to 1600x340 mm^2.
- Sandwiches have been measured with different methods and condition (controlled / not controlled, different supports)
- All sandwiches produced completely fulfill the requirements validating the stiff-back approach.
- The best accuracy (RMS≈12μm) obtained with CMM and in controlled environment (we are experiencing some limitation due to the measurement method)
- We would expect better results with panel built in clean and temperature controlled room

Plans

- Optimize gluing procedure, test different materials (AL HC, 0.5mm FR4/G10, glue)
- Join preglued sandwiches
- Optimize measurement methods
- Produce more sandwich 1600x340 mm^2 and measure them with CMM to repeat the quality of measures